



# Inorganic substances and their uses in Nikolaos Myrepsos' *Dynameron*. Recent applications in modern therapy

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## ABSTRACT

Inorganic compounds have been known and used since antiquity. *Dynameron* is the largest Byzantine medical manuscript divided into 24 sections, in accordance with the letters of the Hellenic alphabet, which contains 2667 recipes. The majority of them contain ingredients of plant origin, followed by animal origin, while fewer inorganic substances are quoted. In the present study, the latter ones are listed. Moreover, the information on the uses of inorganic ingredients in the treatment of many diseases in the late Byzantine era is presented and their evaluation in light of the modern Pharmacology and Toxicology.

## 1. Introduction

Since archaic period, several minerals, metals, clays, and rocks were among the natural products used by the healers in different civilizations. Later on, inorganic medicinal substances can be found in the writings of Hippocrates, Dioscorides, Galen and many other physicians of classic Hellenic, Hellenistic and Byzantine eras.

In continuation to our previous reports [18,19,22], the present study aims to the documentation and assessment of the information concerning the inorganic ingredients quoted in Nikolaos Myrepsos' *Dynameron*, which remains largely understudied. Our main source material is its recent digital edition [20]. This treatise was written in Greek on the late Byzantine period (13th century) and includes 2667 recipes, where more than 300 plants are quoted, as well as 93 animals, 16 anatomical parts of different animals and 34 animal by-products. The influence of previous medical Hellenic, Roman and Byzantine treatises is obvious. Also, some Arabic drugs are incorporated.

The present study focuses on the use of inorganic substances, such as chemical elements, mineral salts, some semi-precious and precious stones and earths present in the formulations described in *Dynameron*, one of the most extensive medical treatises ever been. In ancient times,

mineralogy existed as a Chaldean custom. Magicians used gemstones and as they believed in their beneficial effect, they used to place them on the body for protection against various diseases. This belief, as a remnant of much older times, has been maintained for centuries and it was especially favored in middle age and later on by a lot of physicians and alchemists.

## 2. Material and methods

In our study, we used the critical editions, published in two volumes with a German [20] or with an English introduction [21], which are also available in a digitalized form.

Only a few Hellenic codices of *Dynameron* rescued to our days [20] and a printed Latin translation [8]. The book contains 2667 recipes and it is divided into 24 sections, named "Elements" from "Alpha to Omega", according to the letters of the Greek alphabet. Each recipe contains information on the indication(s), the ingredients and also instructions for their mixing in order to be used by the patient or the physician.

Most of the ingredients are plants [18,19], but there are several recipes containing also ingredients of animal origin [22] and proportionally a few minerals.

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**Table 1**  
Metals.

Name in the book	Common name/ Symbol	Indications as in the book	Indications translated
1. ἄργυρος [argyros]	silver Ag	a φθίσις b βήξ c στομαχόπονος d ἀδυναμία σώματος e ἀτονία καὶ ἀδυναμία νεφρῶν f ἀφροδίσια	a Tuberculosis b cough c stomach pain d body weakness e kidneys' atony and weakness f venereal diseases
2a. ἄρσενικόν [arsenikon]	arsenic As	a ἦλοι b χοιράδες c χαλάζαι d ἀποστήματα e φύγεθλα f δῆγματα, θηρίου πληγῆ g στεατώματα h αἰμορροῖδες i ἐξοχάδες j ὑποχύσεις k ἀμβλυωπία l τύλοι m πέψις n εὐχροία o νομή p σηπεδών q ἄνθραξ r πτερύγια s ὠτα πυορροοῦντα t ὑπερσάρκωμα	a Applied to puncture wounds caused by nails b scrofula c chalazion d abscesses e swelling of the glands, esp. of the groin or armpit; blister f beast bites g steatoma h hemorrhoids i external piles j cataract k amblyopia l callus m digestion n fresh and healthy look o noma (cancrum oris) p decay, putrefaction q hence, carbuncle, malignant pustule (acc. to some, small-pox) r disease of the eye (when a membrane grows over it from the inner corner) s purulent ears t overgrown flesh
2b. σαυδράχη, σαυδαράχη [sandrace; sandarache]	arsenic As	Id.	
3. χρυσός [chryssos]	Gold Au	a φθίσις, b βήξ, c στομαχικός, d ἀδυναμία σώματος, e ἀτονία καὶ ἀδυναμία νεφρῶν f ἀφροδίσια g ψύχρα σώματος h λιποθυμία εἰς ἐγκυμονούσας γυναῖκας i καρδίας συγκοπή j μελαγχολία k μανία	a Tuberculosis b Cough c Digestive d asthenia e renal failure f sexually transmitted infections g body cold h collapse i to pregnant woman j heart attack k melancholy l mania
4. χαλκός	Copper Cu	a σκίρροι b καταγματικόν c τραῦμα d ἔλμιθες ἐν τῷ στομάχῳ e τοῦ φάρυγγα καὶ τῶν ρινῶν φλεγμοναί f ἔμετος g σινάγχα h κολλῶν νεῦρα i μυῶν διακοπές j κολλῶν κόλπους k ἔλκος l μελικηρίς m θηριόδηγμα n πᾶν πάθος o θλάσματα p νεύρων πόνους q ὀφθαλμιάσις r κεφαλαλγία s νευροτρῶσις t καρκίνωμα u στεάτωμα v χοιράδες	a Cirrhosis b fractures c wounds healing d worms in the stomach e pharynx and nose inflammations f emetic g angina h nerve adhesive i muscle collapse j sinus adhesive k ulcers l cysts m beast bites n every disease o fracture p nerve pains q eye disturbances r headache s nerve suffering t carcinomas u steatoma v scrofula
Nonmetal			
5. θείου (ἄπυρον)	Sulfur S	a ἄλωπεκίαν b Ψώρας c ἔλμιθας d ἐρυσίπελα e πλευρίσις f ὄζαινα g ἀνίβρωσις h νομή i πάχυμα j ἐρυθρότης προσώπου k ὕδρωπικία	a alopecia b scabies c antheminthic d erysipelas e pleurisy f a fetid polypus g corrosion h nomas i thickening j redness of the face k dropsy

**Table 2**  
Mineral salts.

Name in the book	Common name/Symbol	Indications as in the book	Indications translated
1. ἀλαβαντινόν [alavantinton]	almadine Fe <sub>3</sub> Al <sub>2</sub> Si <sub>3</sub> O <sub>12</sub>	ἔμμηνα	emmenagogue
2. ἀλάβαστρος [alavastros]	alabaster probably onyx marble; type of carbonate mineral	ὑστερικά και νεφρικά πάθη	hysteria and renal ailments
3a. ἄλας γάγγρινον [alas gaggrinon]		a ὑπακτικόν b ἐσογὰς και ἐξογὰς c κακὸς χροια προσώπου d ὑπὸ ἀγχολήσεως e λῆπτυνσις φλέγματος f πνευμάτων διαλυτική g κινούσα τὰς ὀρέξεις	a Laxative b external piles, haemorrhoids c bad complexion d anxiolytic e reduces phlegm f carminative g appetizer
3b. σάλτζεμα [saltzema]	halite (rock salt) NaCl	a δυσπεψία b ἀνορεξία c τέμνει ψυχρούς, παχεῖς και γλίσχρους χυμούς, τοὺς ἐν τῷ στομάχῳ d ἡμικρανία, e κεφαλαλγία f ἀναθυμιάσεις ἀνερχομένης ἀπὸ στόματος g ἔμετος h κάθαρσις χολῆς i φλέγμα j πεπτικόν k διαύγεια ὀφθαλμοῦ ἕως γήρατος l ἀναλγησία ὀδόντων m οὐ βήξ ἔχον, n οὐ τρίχαι βεῦσαι, o νοῦν ὀξύνει p ὀξυδορκίαν ποιεῖ, q οὐκ φλέγμα ἐν τῷ στομάχῳ ἔχον r οὐ χυμόν s οὐ ποδαλγίαν t οὐ σπλήναν a παραλυτικούς, b πρὸς πᾶσαν νευρικήν διάθεσιν c τρέμους d ἰσχυαλγία e ἀρθρῆτις f οἰδημα g σκληροῦς ὄγκους h ὑδρωπικία i πελῖωμα j φακοὶ ἐν προσώπῳ k οὐλαί l ἠλιοκαῖα m λειχίνες n ψαχνίδες o ἔλμινς p βήξ, ἀσθμα q δύσπνοια r διαφόρησις s δοθιήν t ἀπόστημα u συνάγχη v ἐμπνευμάτωσις ἄρθρων, πόρρω ποιησάντων w σπλήν x ὑδρωπικία y καχεξία	a dyspepsia b anorexia c reduces cold, thick and slippery stomach humors d migraine e headache f breath smells g emetic h cholagogue i phlegm cleanser j digestive k ophthalmia since old age l without toothache m antitussive n without hair loss o sharpe mind p sharp -sightedness q eliminating phlegm from the stomach r eliminating humors s eliminating podalgia t eliminating spleen ailments
4. ἄλας ἀμμωνιακόν [alas ammoniakon] ἀμμωνιακόν [ammoniakon]	Sal ammoniac (NH <sub>4</sub> Cl?) or soda	a ἀναλγησία ὀδόντων m οὐ βήξ ἔχον, n οὐ τρίχαι βεῦσαι, o νοῦν ὀξύνει p ὀξυδορκίαν ποιεῖ, q οὐκ φλέγμα ἐν τῷ στομάχῳ ἔχον r οὐ χυμόν s οὐ ποδαλγίαν t οὐ σπλήναν a παραλυτικούς, b πρὸς πᾶσαν νευρικήν διάθεσιν c τρέμους d ἰσχυαλγία e ἀρθρῆτις f οἰδημα g σκληροῦς ὄγκους h ὑδρωπικία i πελῖωμα j φακοὶ ἐν προσώπῳ k οὐλαί l ἠλιοκαῖα m λειχίνες n ψαχνίδες o ἔλμινς p βήξ, ἀσθμα q δύσπνοια r διαφόρησις s δοθιήν t ἀπόστημα u συνάγχη v ἐμπνευμάτωσις ἄρθρων, πόρρω ποιησάντων w σπλήν x ὑδρωπικία y καχεξία	a paralytatics, b nervous temperament, c trembling, d ischiadic, e arthritic, f edematic, g solid tumors, h dropsy, i lividness, j face freckles, k scars, l sun burns, m lichen, n worms, o dandruff, p cough, q asthma, r dyspnea, s diaphoretic, t furuncles, u abscesses, v angina, w splenic disorders, x dropsy, y cachexia
5a. νίτρον [nitron]	soda ash (natron) In antiquity: sodium carbonate; modern nitron: nitric salts mainly potassium nitrate & sodium nitrate	Id. a πόλυψ b οὐλα πλαδαρά c οὐλα τὰ ἐν τῷ στόματι και ἐξαθήματα d ὀδόντας ἀπόνους ἔλκυσαι e ὀφρύας μέλαιας ποιήσαι f ἐγκαυθῖς g δυσεντερία h κοιλιακὸς πόνοσ i ἐρυσίπελας j χειρῶνια ἔλκη k σαρκώματα ἐν ὠσὶ l ὑπερσάρκωσις	a polyps b shrinking gums c gums and mouth rashes d painless tooth extraction e black eyebrow tint f encanthus g dysentery h abdomen disorders i erysipelas j malignant ulcers k ear tumors l tumor
5b. ἐρυθρόν νίτρον [erythron nitron]	νιτροπηγικά ἄλατα = νιτρώδη		
6. μίσυος ὀπτῆς -μίσυ [misyos optis; misy]	iron pyrite FeS <sub>2</sub> or Chalcopyrite CuFeS <sub>2</sub> or copper sulphates with ferrous sulphate and zinc impurities		

(continued on next page)

Table 2 (continued)

Name in the book	Common name/Symbol	Indications as in the book	Indications translated
7. στουπτηρία σχιστή [steptyria schisti]	Potassium alum commonly encountered as KAl(SO <sub>4</sub> ) <sub>2</sub> ·12H <sub>2</sub> O	a πόλυψ b ούλα πλαδαρά c ούλα τὰ ἐν τῷ στόματι καὶ ἐξαθήματα d ὀδόντας ἀπόρους ἔλκυσαι e ὄφρυας μέλαινας ποιήσαι f ἐγκαυθίς g δυσεντερία h κοιλιακός πόνος i ἐρυσιπέλας j χειρώνια ἔλκη k σαρκώματα ἐν ὠσὶ l ὑπερσάρκωσις	a polyps b shrinking gums c gums and mouth rashes d painless tooth extraction e black eyebrow tint f encanthus g dysentery h abdomen disorders i erysipelas j malignant ulcers k ear tumors l any tumor

Table 3

Salts and/or oxides of copper produced during clearing.

Indications: Heating; wound healing; against erysipelas, herpes, metrorrhagia; as collyrium to treat swollen and hard eyelids	
ἡ χαλκάνθη	chalkanthe; fem.
τό χαλκανθόν	chalkanthon; neutr.
τό χαλκεῖον	chalkeion; neutr.
ἡ χαλκίτις	chalkitis; fem.
ὁ χαλκίτης	chalkitis; masc.
ἡ χαλκή	chalki; fem.
τό χαλκίον	chalkeion; neutr.
χαλκίτιδα	chalkitida
σπόδιον	spodion
σπόδι	spodi
σπόδιος, -α, -ον	spodios, spodia, spodion
σποδός, ἡ	spodos; fem.

For the interpretation of the inorganic material, we used Dioscorides' *Materia Medica* [23], Stephanides' *The Theophrastus Mineralogy* (1897) [16] and Caley & Richards' *Theophrastus On Stones* (1956) [5], as well the NIST database [12]. Actually, the first three books were useful, while by the database, we confirmed that most of the encountered names used in the past do not exist anymore.

We have also quoted in the Tables the pathological conditions for which these materials were proposed in *Dynameron* trying to determine the nosological conditions according to the modern medical terminology. In the manuscript, there are several pathological conditions with terms originating from antiquity, which can be found in texts of earlier authors [1]. It is noteworthy that these terms are not always clear and are not used by all authors in the same way. However, earlier descriptions facilitated the work of scientists during the 18th and the 19th centuries, who studied and classified the diseases [3]. Additionally, it should be noticed that the ancient name of a specific illness or ailment does not necessarily correspond to the one used by modern medicine, despite apparent similarities.

### 3. Results and discussion

The research presented in this article focuses on the inorganic substances applied as remedies in *Dynameron*, which are presented in Tables 1–5. Of the 2667 recipes of *Dynameron*, 822 includes inorganic ingredients, at least 54 different ingredients in total.

Most of the inorganic substances do not concern minerals properly, but stones and earths; actually, they do not belong to mineralogy, but to petrology, being igneous materials or sedimentary. The separation of petrology to mineralogy took place at the end of the 19th century. Aristotle (4th c. B.C.) in his manuscript *Meteorologica*, as well as his discipline Theophrastus (4th c. B.C.) in his work *on Stones* [5,16] placed together the inorganic products of human industry with the minerals and stones [10].

In *Dynameron*, 5 metals, i.e. arsenic, silver, gold, iron and copper; and one nonmetal element, sulphur, are quoted (Table 1). Silver was mentioned in the Hippocratic Corpus, under the name flos of silver (*ἀνθός ἀργύρου*) and dust of silver (*σκωρία ἀργύρου*) [16]. In addition, several mineral salts (Table 2) are found under different names, as progressively the Greek language incorporated latinized and mixo-barbarian words. Special portion of the inorganic materials constitute the salts and oxides of copper (Table 3). Stones and earths (Table 4) from different areas around the East Mediterranean basin, mainly from the Aegean islands and the Hellenic colonies in Asia Minor, are mentioned. In most cases, the names of the stones are derived either from their physical properties, either from the name of the place of their origin, e.g. achate stone from Acate of Sicily. Similarly, the names of the earths coincide with the name of the areas where the certain earth is abundant, e.g. Samiou asteros, earth from the island of Samos [16]. The differentiation in their inorganic content resulted a plethora of indications, which allowed the physicians to treat several skin and eyes lesions and other ailments (Tables 1–5).

Finally, in Table 5, amber and pearl are categorized as miscellaneous inorganic products. Amber is fossilized tree resin with inorganic elements. Pearl, although composed of inorganic compounds, such as calcium carbonate (mainly aragonite or a mixture of aragonite and calcite), is produced within the soft tissue of a living shelled mollusk or another animal.

In all Tables, information is given on each quoted inorganic substance, including the name, the potential interpretation and the therapeutic indications.

The most cited elements were arsenic/sandarach, sulphur and copper, followed by gold, while silver was mentioned few times. Ammonia salt and sandarach were ingredients used in the preparation of *trochisci*, drying powders applied to wounds, soaps, poultices and liniments. Copper, gold and silver were similarly used excluding soaps, but also in collyria and antidotes. Sulphur was mostly incorporated in patches, *trochisci*, pessaries, in recipes used for the treatment of alopecia, in drying powders applied to wounds, in lichen smears, in sprinklings, collyria, patches, against sebum and as antidotes.

*Ammonia sal*, *nitron* and *misy* were widely used, while fewer refers are found for halite (*sal gagrionon*) and alum. Among medicinal salts, *ammonia sal* was always used in every recipe; these salts were used mainly as laxatives. The dominant ingredients in ointments against inflammations were *ammonia sal*, *nitron* (saltpetre) and nitric components. *Misy* was the ingredient used in ear patches and medicines, *trochisci*, powders, lichen smears, poultices and in sprinklings. Alum was ingredient in suppositories, sprinklings, poultices, against hemorrhoids, sebum, as well as in powders, dental medicines, pessaries, soaps, *trochiscus* and ear patches.

Copper oxides run through all *Dynameron*, as recipes ingredients reported for the treatment of specific diseases such as heating, wound healing, erysipelas, herpes, metrorrhagia. Moreover, they were included in *collyria* to treat swollen and hard eyelids. Among the stones and

**Table 4**  
Stones & Earths.

	Name in the book/Mentioned in the text (Page/Line):	Common name/Symbol	Indications as in the book	Indications translated
1	ινδικόν & Ἰνδικὸς λίθος [indikón & indikos lithos]	Indian agate	a φλεγμονή b ἀπόστημα c ἔλκη	a against inflammations b abscesses c ulcers
2a	αιματίτης [haematitis]		a αἰμοστατικό δειγμάτων b δερματικά ἐξαθημάτα d ἐρυσιπέλατα e ἔλκη f νομή	a astringent, b in poultices c against skin rashes j erysipelas k ulcers
2b	μίλτος Σινοπίτις, (=αιματίτης) [miltos Sinopitis (= haematitis)]	haematite [Fe <sub>2</sub> O <sub>3</sub> ]	g ῥευματισμούς ὄζαινας h ὀδόντας ἄπνοιος ἔλκυσαι i δυσεντερία a ἥπαρ b ῥεύματα στομάχου καὶ θώρακος c ἔλκωσις d φθίσις e κοιλίας ἐμπνευματώσεις, f λιθοθρυπτικόν g δυσουρία h μελαγχολία i ἐκβολλαὶ νεκρῶν ἐμβρύων j πληγὴ ἰοβόλου καὶ δηλητηρίου φαρμάκου k περιοδικῶν, τεταρταίων καὶ ἀ<μ>φημεριῶν πυρετῶν	m rheumatism pustules n painless tooth extraction o dysentery a hepatic failure, b carminative, c ulcers, d tuberculosis, e abdomen ailments, f nephrolithiasis g dysuria h melancholy i abortive, poisonous and venomous j bites k tertiary and periodic fevers
2c	μίλτος Λημνίτις			
3a	Ἀρμένιος [armenios]		a δυσεντερία, λειεντερία, κοιλία b ἀρθρίτις c στομαχόπονος d σπλῆν e μελαγχολία f κεφαλαλγία g ὀφθαλμιάσις h τεταρταῖος (πυρετός)	a dysentery, apepsy (defective digestion) b arthritis c disordered in the stomach d splenic ailments e melancholy f headache g eye ailments h tertiary fever
3b	Ἀρμενιακός [armeniakos]	Bright red mineral colorant		
4a	Ἄσιος [asios]		a σκίρρους b περιωδυνία ὀφθαλμῶν c ἀναξήρραισις d διαφῶρησις e κολλοῦσα κόλπους f ῥευματιζομένους συριγγώδεις g κατὰ τῆς κεφαλῆς h τῶν ἄρθρων i τῶν ὀφθαλμῶν j λειχίνιας k πρὸς λευκώματα καὶ ἀμβλυωπίας l σπληνικῶς m ὕδρωπικῶς n ἰσχιαδικῶς o ἀρθριτικῶς p νομᾶς καὶ σηπεδόνιας q πρὸς ἀνθρακᾶς τε καὶ περιύγια	a scirrhus (hard dense cancerous growth) b eye excessive pain c desiccant d diaphoretic e scrofula, gout, sinus and joints adhesive, f rheumatism g against head h joints i eyes ailments j lichens k amblyopia l splenic ailments m dropsy n sciatic pain o arthritis, p noma and sepsis q anthrax
4b	Ἀσιανός [asianos]			
5	ἀχάτης [achatis]	Agate SiO <sub>2</sub> (Chalcedony variety)	Διαφοροῦσα καὶ μαλάσσοῦσα	diaphoretic, emollient
6	βοράχιος [borahios]:	Borax [Na <sub>2</sub> B <sub>4</sub> O <sub>5</sub> (OH) <sub>4</sub> · 8H <sub>2</sub> O]	a πελίομα b φακοὺς ἐν προσώπῳ c οὐλάς d ἠλιοκαΐας	a lividness b face freckles c scars d sun burns e lichens,

(continued on next page)

Table 4 (continued)

	Name in the book/Mentioned in the text (Page/Line):	Common name/Symbol	Indications as in the book	Indications translated
7	Γαγάτης [gagatis]	Gagate stone; the name derives from the ancient city Gagai of Lycia	e λειχήνας ἐν τῷ σώματι καὶ ψαχνίδα a πρὸς ἐπιληπτικοῖς b κεφαλαλγίαν καὶ ἡμικρανίου πόνον καὶ πρὸς ἄγρυπνίαν c ἐν αἰδοίοις ἔσχαρῶν καὶ νομῶν d Ὑπνωτικὸν θυμίαμα	f dandruff a epilepsy b headache, migraine, insomnia c vulva scars and noma d incense for insomnia
8	Γεράνεος [geraneos] = λάπις λάζουλι		a πρὸς μελαγχολικοῦς b πρὸς συγκοπτομένους c πρὸς λιποθυμίαν d πρὸς πᾶσαν καρδιακὴν διάθεσιν e πρὸς στομαχικοῖς f πρὸς σπληνικοῖς g πρὸς καθαρτικά h ἐνδυναμοῦντα	a melancholy b heart attack c fainting d any cardiac temperament e stomach ailments f splenic ailments g laxative h tonic
9a	Ζάμφυρος [zampfyros]		a πρὸς ἐλεφαντιῶντας	a elephantiasis (filariasis)
9b	Ζέφυρος [zephyros]		b βηχικοῖς c ἀρτηριακοῖς d πρὸς ἀτοιμίαν σώματος καὶ λιποθυμίαν καὶ συγκοπήν e καρδιακοῖς f διαφορητικοῖς g ὕπνον ἐπάγει h δάκρυα στέλλει i βήχα λύει j ἔμετον αἵματος ἀναστέλλει	b cough c high blood pressure d asthenia, fainting e heart attack f diaphoretic g sleep-inducing h reduces lacrimation
9c	Σάπφειρος [sapphiros]	Sapphire	k πάθη στήθους καὶ πνεύμονος καὶ σπλάγχθων l τῶν νεφρῶν πόνους καὶ κοιλιακοῖς βοηθεῖ m στραγγουρίαν καὶ δυσουρίαν λύει n καυλοῦς ἐν νεφροῖς καὶ κύστεως λύει καὶ θρῦπτει o ροὴν αἵματος σφίγγει p ἀνέμοις φύσεως διαφορεῖ q ἰδρώτας φέρει	k chest, lung, viscera l kidneys pains m straguria (droplet urination), dysuria n kidney and bladder stones o hemostatic p carminative q sudorific
10	Ἴασις [iaspis]	Jasper	a εἰς ψύχραν τοῦ σώματος b καρδιακοῦς c λιποθυμοῦντας d εἰς γυναικας ἐγκυμοιούσας e πρὸς ὕστερικὰς πύξεις f πρὸς καρδίας συγκοπήν g εἰς ἀδυναμίαν τοῦ σώματος h πρὸς αἰμορραγίαν ῥινός	
11	Ἰουδαϊκόν [ioudaikon]	Judaic/ Jerusalem stone	a πρὸς τοὺς ἐν τοῖς νεφροῖς λίθους ἔχοντας	a kidney stones
12	Λαζούριον [lazourion] = λάπις λάζουλι	Lapis lazuli [mixture of minerals mainly of lazurite: tectosilicate mineral with sulfate, sulfur and chloride]	a μελαγχολία b συγκοπή c λιποθυμία d μανία e κατὰλυσις σαρκός f κακόχροια ἐκ μελαγχολικοῦ χυμοῦ	a melancholy b heart attack c fainting d mania e necrosis f bad skin color due to excess of black bile g tertian fever

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Table 4 (continued)

	Name in the book/Mentioned in the text (Page/Line):	Common name/Symbol	Indications as in the book	Indications translated
			g τεταρταίος <πυρετός>	
			h στομαχόποιος, σπλήν	h stomach and splenic ailments
13	Λίτζι [litzi]=, λίθος λαζουρίος		a μελαγχολία b συγκοπή c λιποθυμία d καρδιακή διάθεση e μαινώδης f κατάλυσις σαρκός g κακόχροια έκ μελαγχολικού χυμού	a melancholy b heart attack c fainting d sanguine temperament e mania f necrosis g bad skin color due to excess of black bile
14	Μαγνήτης [magnitis]	Magnet	a πώροι και σκιρῶδεις ὄγκοι	a bone porosis and scirrhus
15a	Μπαλάζι [mpalazi]		a μελαγχολία b συγκοπή c λιποθυμία d καρδιακή διάθεση e μαιία f κατάλυσις σαρκός g κακοχρόους έκ μελαγχολικού χυμού	a melancholy b heart attack c fainting d sanguine temperament e mania f necrosis g bad skin color due to excess of black bile
15b	Μπαλάξιος [mpalaxios]= σμάραγδος λίθος	Sapphire	a πώροι και σκιρῶδεις ὄγκοι	a bone porosis and scirrhus
16	Περδικίτης [perdikitis]:		a λιθοθρυπτικόν, ἐν τῇ κύστει	a renal stones b applied to the kidneys
17	Περσικός [persikos]	Persian stone	b κατὰ νεφρῶν a ἀρθρίτις b φλέγμα c μελαγχολία d ποδάγια e νεφρούς, ἐν τῇ κύστει πάθη f τὰ ἀπὸ ψυχρότητος γινόμενα g ψύχραν σώματος h καρδία i λιποθυμία j γυναικας ἐγκυμοιούσας k ὕστερικὰς πιλξεις l συγκοπήν καρδίας m ἀδυναμία σώματος	a arthritis b reducing the excess phlegm c melancholy d gout e kidney and urinary bladder f disorders produced by cold temperament, g whole body coldness h cardiac failure i fainting j of pregnant women k hystery l heart attack m asthenia
18	Πράσινος [prasinos] = λάπις λίτζι	Green stone	a στομάχι b σπλήν c νεφροί d ἥπαρ e κεφαλαλγία f πάθος ὑποχονδρίου g ἀρθρίτις a στραγγουρία b δυσουρία c λιθίωσις d λιθοθρυπτικόν e πορολυτικόν f ἀποστηματικόν g καρκίνοι h φύγεθλα i νάρκωσις σώματος j εὐθυμία, εὐσαρκία καὶ βῶσις σώματος k διαφῶρησις χοιράδων καὶ ποδάγρας l σκιρῶδεις ὄγκοι	a stomach b spleen c kidney d liver disorders, e headache f any illness of hypochondriasis g arthritis a straguria, b dysuria, c urinary bladder stones d applied to kidneys e bone porosis f abscesses, g carcinomas h favus i necrosis, j for good temperament, corpulence, beautiful color, k diaphoretic, scrofula and gout l scirrhus
19	Πράσιος [prasios]= λάπις λίτζι		l σκιρῶδεις ὄγκοι a πορολυτικόν b σκιρῶδεις ὄγκοι a ῥεῦμα χρονίας ὀφθαλμίας a καρδία b συγκοπήν καρδίας καὶ λιποθυμίας c ἐλεφαντίωσις	a porosis b any carcinoma a chronic ophthalmia a cardiac disorders b myocardial infraction, fainting c elephantiasis
20	Πυρίτης [pyritis]	Iron pyrite (mineral FeS <sub>2</sub> ). It could be attributed to <i>diphryges</i> ; the name was also used for any sulfide mineral of iron and copper.	a πρὸς πάντα τὰ πάθη b τραχώματα	a effective in difficult disorders b trachoma,
21	Σκυθικός [skythikos]	Scythian stone		
22	Σκυλάκειος [skylakios]			
23	Σμάραγδος [smaragdos]	Emerald [Be <sub>3</sub> Al <sub>2</sub> (SiO <sub>3</sub> ) <sub>6</sub> ] and in Antiquity, any green beryl variety with inclusions		
24	Σχιστός [schistos]			

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Table 4 (continued)

Name in the book/Mentioned in the text (Page/Line):	Common name/Symbol	Indications as in the book	Indications translated
25	Συριακός [syriakos] Syrian stone	c συκώσεις d λευκώματα e πᾶσαν φλεγμονήν καὶ περιωδυνίαν f ἐπὶ κεφαλῆς πόνον g τῷ μετώπῳ ἐγχριόμενον h Ἐλκη i τραύματα j χρονίας διαθέσεις k μοκέφαλον a ἀπορρίπτει τοὺς ἐν τῇ κύστει λίθους b στραγγουρία, δυσουρία καὶ λιθίασις	c sycosis scars, d vitiligo, e any inflammation and excessive pain, f headache g if sprinkled in the forehead h ulcers i wounds j in chronic diseases k collyrium, any wound l eye complaint a kidney stones removal, b droplet urination, dysuria
27	Ἵπόχλωρος [hypochloros]	a ἀτονία σώματος b λιποθυμία c συγκοπή καρδίας d καρδία e διαφόρησις	a asthenia (weakness), b fainting, c myocardial infraction, d cardiac disorders, e diaphoretic
28	Φρύγιος [phrygios] Phrygian stone, used by the ancients in dyeing and believed to have been a sort of pumice	a πρὸς τὰ ρευματικά πάρθη b πρὸς ἀποστήματα c πρὸς καρκινώματα d φύγεθλα e ναρκώσεις σώματος f παρέχει εὐσαρκίαν καὶ ῥώσιν σώματος g πρὸς πύρους καὶ ἄλλους παντοίους σκιρῶδεις ὄγκους h πρὸς αἰδοῖα, ἠλκομένα a δυσεντερικούς b λειεντερικούς c κοιλιακούς καὶ εἰς πᾶσαν κοιλιακὴν διάθεσιν d Ἐμπλαστρον πρὸς κοιλιακούς, σπληνικούς καὶ στομαχικούς e πρὸς νευροτρώτους f ἐπὶ αἱμοποϊκῶν g πρὸς κεφαλαλγίαν καὶ ἡμικρανίου πόνον h θυμώμενον ἀπελαύνει i ἀκάθαρτον πνεῦμα j πρὸς βασκανίαν καὶ πρὸς πάντα φθόνον k πρὸς ῥοῦ γυναικεῖου καὶ αἱμορραγίαν ὕστέρας l καταστέλλει τὰ ἐν ὤσσι σαρκώματα m ὑπερσάρκωσιν a δυσεντερικοῖς κοιλιακοῖς b αἱμοστατικὴ κατὰ τῆς αἱμορραγίας c πρὸς νευροτρώτους d πρὸς αἱμοποϊκούς e τιθεμένη κατὰ τοῦ θώρακος f κολλητικὴ κόλπων g πρὸς φλεγμονάς καὶ ἔλκη h πρὸς ἀρχομένας ὀφθαλμίας ἔλκη i φλυκταίνιας j χυμώσεις	a rheumatism, b abscesses c carcinomas d favus, e body necrosis, f for good temperament, corpulence, beautiful color, g cirrhosis, h vulva ulcers a dysentery b lientery c apepsy (defective digestion), d plasters for abdominal, splenic, stomachic e ailments, nerve related diseases, external use in chest f against hemoptysis, g headache, migraine, as incense for insomnia, h removes any dirty spirit, i against evil eye and envy j menstruation, metrorrhagia, k removes ear tumors l tumors
29	Λημνίας σφραγιδος [Lemnias sphragis] Terra sigillata Mixture consisted mainly of silicate salts, iron oxide, aluminum oxide, calcium oxide etc.	a πρὸς ῥοῦ γυναικεῖου καὶ αἱμορραγίαν ὕστέρας l καταστέλλει τὰ ἐν ὤσσι σαρκώματα m ὑπερσάρκωσιν a δυσεντερικοῖς κοιλιακοῖς b αἱμοστατικὴ κατὰ τῆς αἱμορραγίας c πρὸς νευροτρώτους d πρὸς αἱμοποϊκούς e τιθεμένη κατὰ τοῦ θώρακος f κολλητικὴ κόλπων g πρὸς φλεγμονάς καὶ ἔλκη h πρὸς ἀρχομένας ὀφθαλμίας ἔλκη i φλυκταίνιας j χυμώσεις	a dysentery, abdominal ailments b hemostatic, antihemorrhagic, c nerve related ailments d against hemoptysis e applied in chest f vagina adhesive g inflammations and ulcers h starting ophthalmia i purulent ulcers j pustules k bruises l bites m dropsy n colic o womb ailments
30	Σαμίου ἀστήρ [Samiou astir] Earth from the island of Samos. Probably kaolin, hydrated aluminum silicate, or a clay composed mostly of kaolin	a δυσεντερικοῖς κοιλιακοῖς b αἱμοστατικὴ κατὰ τῆς αἱμορραγίας c πρὸς νευροτρώτους d πρὸς αἱμοποϊκούς e τιθεμένη κατὰ τοῦ θώρακος f κολλητικὴ κόλπων g πρὸς φλεγμονάς καὶ ἔλκη h πρὸς ἀρχομένας ὀφθαλμίας ἔλκη i φλυκταίνιας j χυμώσεις	a dysentery, abdominal ailments b hemostatic, antihemorrhagic, c nerve related ailments d against hemoptysis e applied in chest f vagina adhesive g inflammations and ulcers h starting ophthalmia i purulent ulcers j pustules k bruises l bites m dropsy n colic o womb ailments

(continued on next page)



Table 4 (continued)

Name in the book/Mentioned in the text (Page/Line):	Common name/Symbol	Indications as in the book	Indications translated
		κ πρὸς τοὺς μὴ ὑποφέροντας δῆξιιν ι ὕδρωπικούς μ κωλικούς ν πρὸς ὑστέραν	

Table 5

## Miscellaneous inorganic products.

1a	ἤλεκτρον [elektron]		a Νεφριτική b πρὸς κεφαλαλγικούς c πρὸς κοιλιακούς d πρὸς δυσεντερικούς e πρὸς ῥοῦν γυναικείων a πρὸς δυσεντερικούς b κοιλιακούς, c τεινισμόν κοιλίας d κατάλυσιν σαρκὸς καὶ νέκρωσιν σώματος e καρδιακούς f συνεχεῖς πυρετούς g ψύχραν σώματος h λιποθυμία i εἰς ὑστερικές γυναικᾶς ἐγκυμονούσας j πρὸς πνίξεις καρδίας k συγκοπὴν καὶ εἰς ἀδυναμίαν πλειστην τοῦ σώματος l πρὸς φθισικούς m βηχικούς n στομαχικούς o ἀτονίαν καὶ ἀδυναμίαν νεφρῶν p πρὸς τὰ ἀφροδίσια q ὑπακτικόν	a kidney ailments, b headache, c stomachache, d dysentery, e dysmenorrhea a dysentery, b abdominal ailments, c flatulence d body and skin necrosis e cardiac disorders, f continuous fevers g hypothermia, h fainting i hysteria during pregnancy j myocardial infarction k asthenia l tuberculosis m cough n stomach ailments o renal failure p venereal diseases q laxative.
1b	ἐρυθρόν ἤλεκτρον [erythron elektron]	amber fossilized tree resin with inorganic elements		
2a	Μαργαριτάριον (neutr.) [margaritarion] Μαργαριτάρι (neutr.) [margaritari]			
2b	ὁ μαργαρίτης (masc.) [o margaritis]	pearl		

earths, the most frequent quoted were the Indian stone, the lapis lazuli and the Lemnian earth. Stones and earths were mainly used for kidney diseases, in antidotes, in poultices and patches, in incenses, eye drops, granules, emollients, and drying powders.

In Antiquity, three well known scientists, whose manuscripts survived, used inorganic substances as healing agents, Nicander of Colophon (2nd c. B.C.), Dioscorides (1st c. A.D.) and Galen (2nd c. A.D.), being all of them Greek. Also, Pliny the Elder's (1st c. A.D.) encyclopedia *De Historia Naturalis* refers to minerals and other inorganic compounds, but the section on these materials derives from a lost treatise of Xenocraetes of Ephesos (1 st c. A.D.) [10].

Comparing the inorganic substances of Tables 1–5 with those described in Dioscorides' *Materia Medica* [23], the matching is remarkable, although there is a time distance of more than thousand years. Moreover, many references to minerals and chemicals are also found in the Muslim medical literature of the Eastern and Western Caliphates [9]. It is also noticeable the similarity in number and nature of the inorganic ingredients used for medicinal purposes in the Levant Medieval and early Ottoman periods [9]. Most of the mentioned fifteen inorganic substances, namely alum, arsenic, sulfides, asphalt, jew's stone, earth sp., galena, haematite, iron, lead, pyrite, salt, sulphur, thermal water, green vitriol, and zinc, can be also found in Tables 1–5. A notable tendency to use these substances for treating diseases of the skin, the eyes, the sexual organs, and haemorrhoids was detected in the Muslim medical literature [9], as well as in Nikolaos Myrepsos' *Dynameron*. In the latter byzantine manuscript, most of them were used as ingredients of poultices for treating diseases of the skin and the eyes. Moreover, sulphur (Table 1), halite (Table 2), sapphire (Table 3), earth from Samos (Table 4) were part of antidotes against snakes, scorpions and other venomous bites (Tables 1–5). Only in few cases, they were

added in preparations for internal use. Although, in archaic Antiquity, stones were used according to their so-believed "magic" properties, there is only two such cases, namely of *iaspis*, used as exorcism against rhinorrhagia and of terra sigillata used against evil eye and envy. The name *iaspis* is not clear that refers to jasper or according Plinius to a stone translucent and green. The Dioscorides' descriptions show that this name does not correspond to an opaque stone. Moreover, Theophrastus considered it close to *smaragdus* (emerald green) [16].

Taking into consideration that the traditional Hellenic medicine is very well documented in a considerable number of texts since the 8th century BC, the Byzantine physicians had a well-established arsenal of medical manuscripts as sources, dating from the Hippocratic period (5th c. BC) until their epoch [6].

The introduction of inorganic materials in medical preparations, alone or mixed with herbal or animal ingredients was continuous during the next centuries. In the 17th century, semi-precious stones and gold were considered important medicines, e. g. topaz prevented intoxication, agate protected against sudden death, zirconium protected against epidemics etc. The healing properties of gemstones were written in books even of reliable for their time scientists. Unfortunately, these beliefs, remnants of medieval darkness, prevailed in the next century. For example, the *Codex medicamentarius, seu pharmacopœa Parisiensis* of 1758 describes "praeparatio fragmentorum lapidum pretiosorum" in the form of pills (*trochisci*) [7]. It is worth mentioning that all inorganic elements quoted in *Dynameron* can be toxic depending of their doses and formulations. Taking in consideration their concentrations in the recipes, it is obvious that the medieval physicians knew their dose-dependent intoxication. The significance of the right dose has been recognized for centuries [17]. Moreover, most remedies including inorganic ingredients were administered externally for the short period

that lasted the disease, thus reducing the possibility of toxic effects.

Metal has obvious importance in our modern way of life. Inorganic substances are still in the arsenal of therapeutic agents. Nowadays, ferric hydroxide polymaltose complex is a medicine to improve the hemoglobin level. It is a good source of iron for the human body.

Sandarac (realgar = arsenic sulfide), named upon the Hellenic *Sandaracha*, is a poisonous mineral. This product should not be confused to the resin produced by trees of the Cupressaceae family, as Sandarach Arabica, which is the gum of *Juniperus L.* (e. g. *Juniperus oxycedrus* resin), also called sandarac or vernix. Arsenic was taken as a by-product 5000 years ago during the processing of copper. Arsenic sulfides have been used since antiquity as a yellow (arsenic trisulfide) and red dye (arsenic disulfide) [15]. Both Hippocrates (5th c. B.C.) and Galen (2nd c. A.D.) recommended a naturally occurring arsenic disulfide for treating ulcers and skin lesions [23]. However, the first arsenic compound for medical use was arsenic trioxide [15]. In the 11th century, ibn Sina recommended it for the treatment of cancer both topically and internally. Since then, various ointments containing arsenic have been the basis of folk remedies for cancer. Although Paracelsus (16th c. A.D.) considered arsenic trioxide to be effective in treating cancer, ulcers and wounds, he used it only externally because he considered it to be too toxic for internal use [15]. In the 18th century, Thomas Fowler (1736–1801), English pharmacist and physician in London and Edinburgh, introduced the *Liquor arsenicalis Fowleri*, an arsenic solution (1 % arsenic trioxide) for the treatment of leukemia, which was used until the 1950s in cases of malaria, although less effective than quinine, syphilis, skin diseases, chorea, dropsy and rabies. Even in the 1940s, Fowler's solution was prescribed as a tonic to treat malignant anemia, probably due to the increased pigmentation of the cheeks, as chronic arsenic poisoning induces increased capillary fragility [15]. In the 1990s, there were reports from China of its intravenous administration to achieve remission in patients with acute promyelocytic leukemia [24,2]. In the beginning of 2000s, FDA and EMA approved an injectable solution of arsenic trioxide for all stages of acute promyelocytic leukemia, relapsed cases, or as first-line treatment. It is very potent against this rare form of leukemia caused by a genetic 'translocation' (when there is a swap of genes between two chromosomes). Another medicine based to arsenic discovered in 1910 by Dr. Paul Ehrlich, salvarsan (also known as arsphenamine), was used to treat syphilis until the launch in market of penicillin after the World War II. In 1949, melarsoprol was introduced for the treatment of human African trypanosomiasis (sleeping sickness) and still the World Health Organization (WHO) is recommending it in combination with other drugs [15]. Actually, melarsoprol is donated by WHO to the countries where the disease is common. Today, both inorganic and organic arsenic preparations are still manufactured for medical and veterinary uses.

Gold-based remedies have been used against several diseases since ancient times; they were also produced by many alchemists of Middle Age. The main interest of the alchemists in this element was related to their efforts to induce material transformations of one less precious element into the others and finally to gold [11]. Before the alchemical era, gold was administered as solid gold leaves suspended in wine, "Spiritus" (distilled alcohol) and this preparation was appeared in official Pharmacopoeias. However, the alchemists came to the conclusion that a liquid gold preparation could be more active and safer [15, 14]. Gold therapy in the 17th century was systematically advertised and all forms of gold were used. Gold dominated for some time and displaced other effective drugs. Electuaries composed of gold, pearls and precious stones were remedies for restoring and maintaining health and preventing disease. Moreover, gold medicaments were thought to have rejuvenating properties because of their shine. It is reported that Louis XI, who was epileptic, used gold in drinks, enemas, liniments to treat epileptic seizures. Louis XIV tried with gemstones to regain his youthful vigor and in his old age paid exorbitant sums for gold preparations [7]. Some gold thiolate drugs, first introduced in the 1920s, are still clinically used today and are included in the class of disease-modifying

antirheumatic drugs (DMARDs), that primarily slow the progression of the disease [4]. Auranofin, an oral gold salt was approved for clinical use in 1985. Although, it may no longer be the drug of choice for rheumatoid arthritis, it has the potential to be repurposed for some cancers, parasitic infections, bacterial infections, HIV and even neurodegenerative disorders, such as Parkinson's disease and Alzheimer's [13].

Moreover, a considerable number of new metallodrug candidates have been developed as new anticancer drugs and anti-infectives. In addition, inorganic substances at concentrations below the threshold of toxicity are used for drug delivery systems and diagnosis [25]. Furthermore, by offering historical context and discussion about the ingredients of ancient and medieval medical manuscripts, we bring in light their perpetual presence hitherto in some modern medicines.

#### 4. Conclusion

Inorganic compounds have been known and used for medical purposes since antiquity. The present study focuses on the inorganic ingredients quoted in *Dynameron*, an enormous Byzantine medical manuscript, which contains 2667 recipes of which 822 include inorganic substances. In total, at least 54 different inorganic ingredients are referred. In comparison with herbal and animal products their number is considerably lower. The most cited elements were arsenic/sandarach, sulphur and copper, followed by gold, while silver was mentioned few times. Most encountered disorders were mainly ophthalmic and ear diseases and skin lesions. It is also important that the concentration of these inorganic substances was at sub-toxic levels for a short period avoiding both chronic and acute intoxication.

#### Conflict of Interest

The authors declare no conflict of interest.

#### Declaration of Competing Interest

The authors report no declarations of interest.

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