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► **To cite this version:**

Frédéric Davidovits. The Making of Ptolemaic Egyptian Blue Pigment in Latin Texts. Ninth International Congress of Egyptologists - Neuvième congrès international des égyptologues, Sep 2004, Grenoble, France. pp.367-371. hal-04049404

**HAL Id: hal-04049404**

**<https://hal.science/hal-04049404>**

Submitted on 28 Mar 2023

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# THE MAKING OF PTOLEMAIC EGYPTIAN BLUE PIGMENT IN LATIN TEXTS

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<sup>a</sup> *Conference paper* : September 2004

<sup>b</sup> *Published in 2007* :

Frederic DAVIDOVITS. "The making of Ptolemaic Egyptian blue pigment in Latin texts". In *Proceedings of the Ninth International Congress of Egyptologists - Actes du neuvième congrès international des égyptologues : Grenoble, 6-12 Septembre 2004*, edit. by Jean Claude Goyon and Christine Cardin, *Orientalia Lovaniensia Analecta 150*, pp. 367-371 (2007). Leuven, Paris, Dudley : Peeters Publishers.

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## Abstract

The text of the Roman architect Vitruvius (7, 11, 1) is the only text which outlines the manufacture stages of this artificial blue pigment used during the Ptolemaic and Roman periods. During the first century B. C., Vestorius, a rich banker of Puozzoli, imported and perfected in Italy the Alexandrine methods. Egyptian blue is a calcium-sodium disilicate of copper,  $(\text{CaO}, \text{Na}_2\text{O}) \text{CuO} 4 \text{SiO}_2$  shaped into blue or green balls. Grinding sand (*harena*) with natron (*flos nitri*) and adding copper yields a mixture shaped into a ball dried in air and fired in earthenware pots. Yet, the scientific analyses of Egyptian blue show the presence of a high amount of calcium. But Vitruvius's text does not mention any addition of limestone or lime. How was the calcium brought into the mix? The source for the calcium might be the natural sand like the one extracted near Alexandria. It is a silico-calcareous sand. An other calcium source is the *flos nitri*, which is usually washing soda or natron, and acts as a flux. Pure natron does not contain lime. However, Pliny (*Nat.* 31, 114), states that in Egypt, natron is falsified with some lime, a forgery detected by its taste. It can be assumed that the *flos nitri* described by Vitruvius was imported from Alexandria and contained a fraudulent amount of lime, which seems to be common habit at that time in Egypt.

*Keywords*: Vitruvius, Vestorius, Roman architecture, Egyptian Blue, Ancient Pigment, Material provenance

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## Introduction

C. Vestorius, a rich banker, businessman, and correspondent of Cicero, perfected at Puozzoli, the Alexandrine method of manufacturing the pigment " Egyptian blue ".<sup>1</sup> The Roman architect Vitruvius (7, 11, 1) may have visited his factory :

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††. The present author must express his sincere gratitude to the Geopolymer Institute, Saint-Quentin, France ([www.geopolymer.org](http://www.geopolymer.org)) for providing the financial support for the author's attending the Congress. The opportunity to perform the linguistic parts of the study was afforded to the author by the CERLAM at Université de Caen, France (CERLAM, M.R.S.H., Université de Caen, 14032 Caen Cedex, France.).

1. H. Gundel, *s. v.* " Vestorius " in A. Pauly, G. Wissowa (eds.), *Real-Encyclopädie der klassischen Altertumswissenschaft* (Stuttgart, 1958), Volume 8, A 2, 1789-90; A. Tchernia, " Premiers résultats des fouilles de juin 1968 sur l'épave 3 de Planier ", *Etudes classiques* 3 (1968), 51-82; G. Camodeca, " L'ordinamento in *regiones* e i *vici* di Puteoli ", *Puteoli* 1 (1977), 62-98; V. A. Sirago, " La personalità di C. Vestorio ", *Puteoli* 3 (1979), 3-16; J. H. D'Arms, " Republican Senators' Involvement in Commerce in the Late Republic : Some Ciceronian Evidence " in *The Seaborne Commerce of Ancient Rome : Studies in Archaeology and History*, Memoirs of the American Academy in Rome (36) (Rome, 1980), 78-80; J. H. D'Arms, *Commerce and Social Standing in Ancient Rome* (Cambridge, 1981), 49-55; J. Andreau, " A propos de la vie financière à Pouzzoles : Cluvius et Vestorius " in *Les " bourgeoisies " municipales italiennes aux IIe et Ier siècles avant J.-C.*, (*Colloque international du CNRS, Naples, 7-10 déc. 1981*), (Paris - Naples, 1983), 9-20; J.-P. Morel, " Aspects de l'artisanat dans la Grande-Grèce romaine " in *La Magna Grecia nell'età romana, Atti del XV Convegno di studi sulla Magna Grecia, Taranto, 1975* (Napoli, 1979), 291-320; H. Lavagne, 1988, *Operosa Antra. Recherches sur la grotte à Rome de Sylla à Hadrien*, Bibliothèque des Écoles Françaises d'Athènes et de Rome (272) (Roma, 1988), 430-6.

“The processes for making blue were first discovered at Alexandria ; afterwards also Vestorius founded a factory at Puteoli. His method and his ingredients are sufficiently noteworthy. Sand is ground with flowers of soda to such fineness that it becomes like flour. Cyprian copper is sprinkled from rough files like fine dust so that it combines with the mixture. Then, it is rolled by hand into balls and they are put together to dry. When dry they are collected in an earthenware jar, and the jars are put in a furnace. In this way, the copper and the sand burning together owing to the vehemence of the fire dry together, and, interchanging their vapours, lose their properties ; and their own character being overcome, they acquire a blue colour.”<sup>2</sup>

No other text describes the steps of manufacturing this artificial pigment (based on copper oxide and an alkali) which was made, at a consistent level of quality, from the early Egyptian periods to the Roman, when it was used for frescoes and other paintings<sup>3</sup>. In this paper, we will study Vitruvius’ text from a linguistic and technical point of view.

## Definition of Egyptian blue

Egyptian blue is an artificial product : a calcium-sodium disilicate of copper. It was an expensive pigment, unaltered by lime in wall painting,<sup>4</sup> and commonly shaped into blue or green balls called *caerulea*<sup>5</sup>. The modern theoretical process for its fabrication is as follows : siliceous sand is mixed with sodium carbonate, calcium carbonate, and copper, obtaining crystals of the disilicate, surrounded by green sodic silicate glass<sup>6</sup>. Lime (calcium carbonate) lowers the melting point of the mixture : the blue crystalizes better. “Egyptian blue” can be defined as a ceramic, surrounded with a glass matrix<sup>7</sup>.

Archaeometrists distinguish two products with the same appearance but differing chemically : Egyptian blue and Hubert’s blue<sup>8</sup>.

## Egyptian blue

1 unit of calcium oxide (CaO) + 1 unit of copper oxide (CuO) + 4 units of silicon oxide (SiO<sub>2</sub>) + 0,6 unit sodium carbonate (natron : Na<sub>2</sub>CO<sub>3</sub> · H<sub>2</sub>O). The mixture is calcined at 850 °C for 24 hours. The result is calcium-sodium disilicate of copper (CaO, Na<sub>2</sub>O) CuO 4 SiO<sub>2</sub>.

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2. Vitruvius, *On architecture, Books VI-X*, F. Granger (ed.), Volume 2, Loeb Classical Library (Cambridge : Harvard University Press, 1985) ; Vitruve, *De l’architecture, Livre 7*, B. Liou, M. Zuinghedau, M.-T. Cam (eds.), Collection des Universités de France (Paris : Les Belles-Lettres, 1995). Vit. 7, 11, 1 : *Caeruli temperationes Alexandriae primum sunt inuenta, postea item Vestorius Puteolis instituit faciendum. Ratio autem eius, e quibus est inuenta, satis habet admirationis. Harena enim cum nitri flore conteritur adeo subtiliter ut efficiatur quemadmodum farina ; ea aes cyprum limis crassis uti scobis facta mixta conspargitur, ut conglomeretur ; deinde pilae manibus uersando efficiuntur et ita conligantur ut inarescant ; aridae componuntur in urceo fictili, urcei in fornaces : ita aes et ea harena ab ignis uehementia conferuescendo cum coaluerint, inter se dando et accipiendo sudores a proprietatibus discedunt suisque uiribus per ignis uehementiam confectis caeruleo rediguntur colore.*

3. Theophrastus *Lap.* 55 ; E. R. Caley, “ Ancient Greek Pigments from the Agora ”, *Hesperia* 14 (1945), 152-6 ; R. J. Gettens, G. L. Stout, *Painting Materials, A Short Encyclopedia* (New-York, 1946), 112-3 ; D. Ullrich, “ Egyptian Blue and green Frit : Characterization, History and occurrence, Synthesis ”, (*PACT*) *Revue du groupe européen d’études pour les techniques physiques, chimiques, biologiques et mathématiques appliquées à l’archéologie* 17 (Bruxelles, 1987), 323-332.

4. Pliny, *N. H.* 33, 161-2 ; 35, 45 ; 35, 49 ; Cetiuv Faventinus 27, 10.

5. H. Blümner, *Technologie und Terminologie der Gewerbe und Künste bei Griechen und Römern*, Volume 4 (Leipzig, 1887), 499-508 ; J. André, *Etude sur les termes de couleurs dans la langue latine* (Paris : Klincksieck, 1949), 162-171 ; R. J. Forbes, *Studies in Ancient Technology*, Volume 3 (Leiden : E. J. Brill, 1955), 214-9 ; S. Augusti, *I colori pompeiani* (Roma : Ministero della pubblica istruzione, Direzione generale delle Antichità e Belle Arti, 1967), 45 ; A. Reinach, A. Rouveret, *Textes grecs et latins relatifs à l’histoire de la peinture ancienne, Recueil Millet*, (Paris, 1985), 13. Several types of Egyptian blue : S. Augusti, *op. cit.*, 47, 62-70, 72, 147.

6. D. Ullrich, *op. cit.*, 323-6.

7. F. Delamare, “ Sur les processus physiques intervenant lors de la synthèse du bleu égyptien, réflexion à propos de la composition de pigments bleus gallo-romains ”, *Revue d’archéométrie* 21 (1997), 103-15.

8. G. Onoratini, G. Conrad, L. Michaud, 1987, “ Identification de deux silicates de cuivre de synthèse, confondues sous l’appellation générique de bleu égyptien et définition des céramiques bleu antique retrouvées dans les fresques ”, *Comptes-rendus de l’académie des sciences de Paris*, tome 304, série II, 12, (1987), 650-4 : 651-3.

## Hubert's Blue

1 unit of copper oxide (CuO) + 1 unit of sodium oxide (Na<sub>2</sub>O) + 4 units of silicon oxide (SiO<sub>2</sub>). The mixture is calcined at 800 °C for 2 hours. The result is a triclinic crystal of anhydrous sodium copper silicate Na<sub>2</sub>CuSi<sub>4</sub>O<sub>10</sub>.

Analyses of eight *caerulea*, found in Fréjus (France) and in two roman shipwrecks, describe them as a ceramic, porous, product, in which there are crystals of Egyptian blue, quartz, impurities, and glass (calcium-sodium copper silicate)<sup>9</sup>.

## Lack of calcium in Vitruvius' recipe

Vitruvius' ingredients are : sand (*harena*) : flowers of soda (*flos nitri*) : Cyprian copper (*aes cyprium*). In the Middle-Ages, artisans who followed this Vitruvian recipe obtained "green frit" and not "Egyptian blue"<sup>10</sup> because it apparently contains no calcium (calcium carbonate/lime). However, there are two possible hidden sources of calcium in the recipe :

### 1) *Harena* " sand "

Cetius Faventinus (27, 10) summarizes Vitruvius' recipe :

"The processe for making blue were first discovered at Alexandria ; now it is made at Puteoli and it is a combination of crushed sand (*harenae pulvere*) and flower of soda (*nitri flore*) ; but (if) copper is calcined. . ." <sup>11</sup>

" Sand of Alexandria " used in glass- and blue-making processes has 35% calcium oxide (CaO)<sup>12</sup>. Vestorius' factory was near the Volturnus river, sand from which was used in glass manufacture so it can be assumed that Vitruvius' *harena* meant a silico-calcareous sand extracted from this river. *Harena* is therefore a possible source of calcium.

### 2) *Flos nitri* " flowers of soda "

In Egyptian blue and glass-making processes, soda is used as a flux agent. But pure soda (Na<sub>2</sub>O<sub>3</sub> Greek *nitron* or *litron*, Latin *nitrum*)<sup>13</sup> does not contain calcium. On the other hand, Pliny (*N. H.* 31, 114) writes :

"The tests of soda are that it should be very fine and as spongy and full of holes as possible. In Egypt, it is *adulterated with lime*, which can be detected by the taste (***Adulteratur in Aegypto calce, deprehenditur gustu***) for pure soda melts at once, but adulterated soda stings because of the lime, and gives out a strong, bitter odour." <sup>14</sup>

Therefore, it can be assumed that the *flos nitri* described by Vitruvius was imported from Alexandria, and contained a certain amount of lime.

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9. G. Onoratini *et al.*, *op. cit.*, 652-3.

10. D. Ullrich, *op. cit.*, 327.

11. Cetius Faventinus, *Abrégé d'architecture privée*, M.-T. Cam (ed.), Collection des Universités de France (Paris : Les Belles-Lettres, 2002) : *Caerulei temperationes Alexandriae primo sunt inuentae ; nunc autem Puteolis ex harenae pulvere et nitri flore temperatur ; aes cyprium adustum <...>. Op. cit.*, 146-7 : the rest of the latin text is uncertain and a correction would be : *si et Cyprium adustum < fuerit cum hac mixtione, caeruleo redigetur >* " but if copper is calcined with this mixture, it becomes blue."

12. P. Piganiol, *Le verre, son histoire — sa technique* (Paris, Hachette, 1965), 81.

13. Dioscorides 5, 113 ; Pliny *N. H.* 31, 106-122 ; 33, 93 ; R. J. Forbes, *op. cit.*, 174-9 ; R. J. Forbes, *Studies in Ancient Technology*, Volume 5, (Leiden : E. J. Brill, 1957), 110-8.

14. Pliny, *Natural History, Books XXVIII-XXXII*, W. H. S. Jones (ed.), Volume 8, Loeb Classical Library (Cambridge : Harvard University Press, 1963) ; Plin. *N. H.* 31, 114 : *Nitri probatio ut sit tenuissimum et quam maxime spongiosum fistulosumque. Adulteratur in Aegypto calce, deprehenditur gustu. Sincerum enim statim resoluitur, adulteratum pungit calce et aspersione reddit oderem vehementer.*

## Conclusions

- 1) Vestorius would have built his factory in Puzzoli for several reasons :<sup>15</sup>
  - Puteoli was the biggest port in Italy (before the organization of Ostia under Claudius' administration) and an important commercial and industrial area .
  - Local *harena* from the Volturnus river naturally contains a sufficient quantity of calcium oxide, as in Alexandria.
  - Egyptian blue and glass manufacture require the same raw materials.
  
- 2) There are two possible sources of calcium in Vitruvius' text :
  - silico-calcareous sand.
  - adulterated natron commonly sold in Egypt.

Taking these two sources of calcium into consideration as part of Vitruvius' recipe, provides the correct ingredients and procedure for the manufacture of " Egyptian blue." In this paper, we have pointed out that archaeometrical studies alone are not sufficient to understand antical technology. It is only when archaeometry becomes associated with linguistic and technical study of the ancient texts that it is possible to discover the original ingredients and processes used in the related antique technology. Both investigation methods (the scientific one and the linguistic one) are complementary from each other and should be practiced accordingly in any study of ancient technology.

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15. Ch. Dubois, *op. cit.*, 70-1; J. P. Morel, " Les producteurs de biens artisanaux en Italie à la fin de la République " in *Les "bourgeoisies" municipales italiennes aux II<sup>e</sup> et I<sup>er</sup> siècles avant J.-C. (Colloque international du CNRS, Naples, 7-10 déc. 1981)*, (Napoli, 1983) 21-39; P. M. Fraser, *Ptolemaic Alexandria* (Oxford, 1986), 156-7.