EDICIONES COMPLUTENSE

De Medio Aevo
ISSN-e 2255-5889

MONOGRÁFICO

Innovation and Byzantine Alchemy in Context: The Constantinian *Solidus* and the Chrysopoetic Goal[1]

Gerasimos Merianos
Senior Researcher, Institute of Historical Research, National Hellenic Research Foundation (Greece)

https://dx.doi.org/10.5209/dmae.95753 Received: April 30, 2024 • Accepted: August 10, 2024 • Published: September 1, 2024

Abstract: The concept of innovation has not been thoroughly explored in the context of Byzantine science, much less so concerning Byzantine alchemy. This article argues that persisting historiographical biases depicting Byzantium as a stagnant culture also influence perceptions of Byzantine science as anti-innovative. Building on recent advancements in the study of innovation in Byzantine culture, this article begins with a preliminary examination of the relationship between science and innovation in Byzantium, revealing intriguing dynamics between the concepts of "tradition" and "innovation". Next, it investigates a case study of innovation in Byzantine alchemy, namely how a monetary and economic innovation, the introduction of the *solidus* by Constantine the Great, likely influenced the perception of alchemy as primarily a chrysopoetic art. In essence, it explores how an external innovation can impact a scientific field, potentially leading to innovative conceptions and change within it.
Keywords: Byzantine science; Byzantine alchemy; innovation; *solidus*; *chrysopoeia*

ES La innovación y la alquimia bizantina en contexto: el *solidus* constantiniano y el objetivo crisopoético

Resumen: El concepto de innovación no ha sido explorado a fondo en el contexto de la ciencia bizantina, y mucho menos en lo que respecta a la alquimia bizantina. Este artículo sostiene que los persistentes sesgos historiográficos que describen a Bizancio como una cultura estancada también influyen en las percepciones de la ciencia bizantina como antiinnovadora. Aprovechando los avances recientes en el estudio de la innovación en la cultura bizantina, este artículo comienza con un examen preliminar de la relación entre ciencia e innovación en Bizancio, revelando dinámicas intrigantes entre los conceptos de "tradición" e "innovación". A continuación, investiga un estudio de caso de innovación en la alquimia bizantina, concretamente cómo una innovación monetaria y económica, la introducción del *solidus* por Constantino el Grande, probablemente influyó en la percepción de la alquimia como un arte principalmente crisopoético. En esencia, explora cómo una innovación externa puede impactar en un campo científico, conduciendo potencialmente a concepciones innovadoras y cambios dentro de él.
Palabras clave: Ciencia bizantina; alquimia bizantin; innovación; *solidus*; *chrysopoeia*

How to cite: Merianos, G. (2024). Innovation and Byzantine Alchemy in Context: The Constantinian *Solidus* and the Chrysopoetic Goal. *De Medio Aevo* 13/2, 307-319. DOI: https://dx.doi.org/10.5209/dmae.95753

[1] I would like to thank Matteo Martelli and the anonymous *DMAE* reviewers for their valuable remarks and suggestions.

1. Introduction

The recent increase in academic interest in Byzantine alchemy is fascinating, especially when compared to the past. This heightened attention gradually establishes Byzantine alchemy as a distinct presence within the broader field of the history of alchemy. The increasing academic output, including research projects, doctoral dissertations, scholarly events, collected volumes, and research articles, contributes to this growing engagement significantly and helps us delineate and understand the phenomenon of alchemy in Byzantium in an unprecedented manner.

Despite its strengthened appeal of late, however, mainstream historiographical views on Byzantine alchemy remain virtually unchanged. True, it is indisputable that alchemy in Byzantium systematizes and creatively expands upon the Graeco-Egyptian chemical tradition.[2] However, Byzantine alchemical texts are often regarded as a minor version of the Graeco-Egyptian alchemical discourse, which is problematic. This prompts the question of whether Byzantine alchemy warrants recognition as a distinct tradition or should be viewed merely as an adaptation of the great Graeco-Egyptian tradition.

If they mention it at all, histories of alchemy make only brief and superficial reference to the Byzantine tradition, usually ending the analysis in the 7th century.[3] Furthermore, Western alchemy has been examined mainly in connection with the Arabic tradition, although Byzantine alchemy gradually assimilated external vocabulary, ideas, and practices, revealing an interchange with the Islamic and medieval Latin traditions.[4] Thus, mainstream historiography overlooks the cultural exchanges among the three traditions and, primarily, the contributions of Byzantine alchemy. Innovative aspects of alchemy, such as the application of mathematical principles to alchemical processes, originated in Byzantium.[5] Moreover, a unique example of innovation at the intersection of science, technology, and art is found in Byzantine alchemical recipes for enamel. This brings cloisonné enameling, an artistic technique distinctive to Byzantium, into an intriguing dialogue with alchemy.[6]

2. Innovation and Byzantine Science: A Preliminary Approach

The issues discussed above are associated, by and large, with a persisting historiographical view cultivated within the political setting of European colonialism in the late 19th and early 20th centuries, in which Byzantium, as a whole, is often viewed as the "subaltern".[7] Consistent with this perspective, Byzantium is portrayed as playing a minor role in the development of Western thought and science. Its primary contributions are perceived as limited to (a) preserving the body of scientific knowledge from Greek Antiquity; and (b) disseminating Greek manuscripts brought by Byzantine immigrants to the West, before or, particularly, after the fall of Constantinople to the Ottoman Turks in 1453. This permitted direct European access to ancient Greek heritage without relying on Arabic translations. Consequently, Byzantium is deemed to have played a significant role solely as a preserver and disseminator of ancient inherited knowledge, initially to the Islamic East (after the Arab conquests of the 7th c.) and later to the West (after the 12th c.), gradually contributing to the Renaissance.[8]

---

2 On Byzantine alchemy, see Michèle Mertens, "Graeco-Egyptian Alchemy in Byzantium", in *The Occult Sciences in Byzantium*, ed. Paul Magdalino and Maria Mavroudi (Geneva: La Pomme d'or, 2006), 205-230; Gerasimos Merianos, "Alchemy", in *The Cambridge Intellectual History of Byzantium*, ed. Anthony Kaldellis and Niketas Siniossoglou (Cambridge: Cambridge University Press, 2017), 234-251; Vangelis Koutalis, Matteo Martelli, and Gerasimos Merianos, "Graeco-Egyptian, Byzantine and Post-Byzantine Alchemy: Introductory Remarks", in *Greek Alchemy from Late Antiquity to Early Modernity*, ed. Efthymios Nicolaidis (Turnhout: Brepols, 2018), 17-40; Cristina Viano, "Byzantine Alchemy, or the Era of Systematization", in *The Oxford Handbook of Science and Medicine in the Classical World*, ed. Paul T. Keyser and John Scarborough (Oxford: Oxford University Press, 2018), 943-964.

3 See, e.g., Lawrence M. Principe, *The Secrets of Alchemy* (Chicago, IL: The University of Chicago Press, 2013), 24-26.

4 For specific texts and codices manifesting a crucial interaction between the Byzantine, Islamic, and medieval Latin alchemical traditions, see the overview in Merianos, "Alchemy", 236. For Islamic influences on Byzantine alchemy, see Alexandre M. Roberts, "Byzantine Engagement with Islamicate Alchemy". *Isis* 113.3 (2022): 559-580; Maria Mavroudi, *A Byzantine Book on Dream Interpretation: The* Oneirocriticon of Achmet *and Its Arabic Sources* (Leiden: Brill, 2002), 400-403; Andrée Colinet, "Le *Travail des quatre éléments* ou lorsqu'un alchimiste byzantin s'inspire de Jabir", in *Occident et Proche-Orient: contacts scientifiques au temps des Croisades*, ed. Isabelle Draelants, Anne Tihon, and Baudouin van den Abeele (Turnhout: Brepols, 2000), 165-190. On the Latin and Arabo-Latin sources of the *Anonymous of Zuretti*, see Andrée Colinet, *Les Alchimistes grecs*, X: *L'Anonyme de Zuretti ou l'Art sacré et divin de la chrysopée par un anonyme* (Paris: Les Belles Lettres, 2000), introduction; Andrée Colinet, "L'*Anonyme de Zuretti*. Un traité alchimique italo-grec de 1300", in *L'alchimie et ses racines philosophiques. La tradition grecque et la tradition arabe*, ed. Cristina Viano (Paris: Vrin, 2005), 135-152. For the Latin influence on great part of alchemical recipes included in the 15th-century manuscripts *Par. gr.* 2419 and *Holkh. gr.* 109 (the language of the latter also reveals some contemporary Turkish influences), see Andrée Colinet, *Les Alchimistes grecs*, XI: *Recettes alchimiques (Par. gr. 2419; Holkhamicus 109) – Cosmas le Hiéromoine, Chrysopée* (Paris: Les Belles Lettres, 2010), introduction. Regarding John Kanaboutzes' view of alchemy and his familiarity with Latin technical terms, see Sandy Sakorrafou and Gerasimos Merianos, "John Kanaboutzes' Commentary on Dionysios of Halikarnassos: A Perception of Alchemy in a Fifteenth-Century Greek Text", in *Scientific Cosmopolitanism and Local Cultures: Religions, Ideologies, Societies*, ed. Gianna Katsiampoura (Athens: National Hellenic Research Foundation, Institute of Historical Research, 2014), 86-94.

5 Gerasimos Merianos, "The Christianity of the Philosopher Christianos. Ethics and Mathematics in Alchemical Methodology". *ARYS* 20 (2022): 271-322.

6 Shannon Steiner, *Byzantine Enamel and the Aesthetics of Technological Power, Ninth to Twelfth Centuries* (Unpublished Ph.D. diss., Bryn Mawr College, 2020).

7 Averil Cameron, *Byzantine Matters* (Princeton, NJ: Princeton University Press, 2014), 9, 115. See now Benjamin Anderson and Mirela Ivanova, eds., *Is Byzantine Studies a Colonialist Discipline? Toward a Critical Historiography* (University Park, PA: The Pennsylvania State University Press, 2023).

8 Maria Mavroudi, "Science, Byzantine", in *The Encyclopedia of Ancient History*, ed. Roger S. Bagnall *et al.* (Chichester: Wiley-Blackwell, 2013), 6063-6065; Maria Mavroudi, "Translations from Greek into Latin and Arabic during the Middle Ages: Searching for the Classical Tradition". *Speculum* 90.1 (2015): 33-36. See also Maria Mavroudi, "Byzantine Translations from Arabic into Greek: Old and New Historiography in Confluence and in Conflict". *Journal of Late Antique, Islamic and Byzantine Studies* 2.1-2 (2023): 215-288.

According to this narrative, Byzantium's independent contribution to scientific thought is negligible. Byzantine science is viewed as an adapted or, at most, an updated version of its Greek and Roman predecessors. Crucial for this argument is the supposed absence of "innovation" in Byzantine science and its adherence to "tradition". In 1956, Kenneth M. Setton made the following statement regarding the Byzantine stance toward the inherited classical tradition: "The Byzantines maintained tradition and resisted innovation; they were custodians, not experimenters".[9] Decades later, the entry of the *Oxford Dictionary of Byzantium* on innovation clings to a similar view, while recognizing the possibility of innovation in Byzantium in the context of art:

> [...] the Byz. did not appreciate innovation and claimed to have stuck to tradition. Imitation or repetition of the standard authorities was praiseworthy. [...] This negative attitude toward innovation does not mean that Byz. culture totally lacked originality. For example, there were remarkable novelties of both content and style, esp. in monumental painting, [...].[10]

At first glance, Byzantine scientific discourse is entrenched in tradition. However, it is essential to recognize that the Byzantines appeared much more conservative in their ideological declarations than they were in practice, as has been pointed out elsewhere.[11] In reality, it could be argued that Byzantium oscillated between tradition as an ideal and innovation as a practice. Acknowledging that progress and development are vital for the survival of any civilization, innovation must have played a central role in premodern societies, including Byzantium.

But what does "innovation" mean? Navigating the concept itself and its perception over time is challenging. While the term appears self-evident in contemporary language, it remains elusive, much like concepts such as "ideology" or "religion". The notion of "innovation" has undergone dynamic transformations throughout history, as illuminated by the modern field of innovation studies. Historically, it has been a contested religious and political concept, perceived as deviant behavior in pre-industrial societies, being forbidden and punished. Conversely, in early modernity, it became associated with political revolutions and, particularly in the 19th century, with social reformers. Over time, innovation has evolved from a "private" and subversive affair to a social and progressive force.[12] Nowadays, innovation is considered to serve goals intended to advance society, presented as a panacea. Sometimes it designates the fruit of technological and scientific research; other times it refers to the marketing of new products, or the changes induced in societies and, finally, the objective that guides the transformation of research organizations.[13]

The complexity of the concept of "innovation" is also evidenced in societies of the past, although it is often not examined through a lens specifically tailored to the society and era under consideration. The study of innovation as a concept in Byzantium is a recent development primarily attributed to the pioneering work of Apostolos Spanos. In two articles[14] and several working papers,[15] Spanos discusses the conceptions of innovation in Byzantium. In the most recent of his published papers, he conducts a preliminary study on innovation terminology related to historical writing, lexicography, political life, and religion in Byzantium. He shows that the terminology related to innovation during the Byzantine period was often contested, particularly within the spheres of politics and religion. For example, the term *kainotomia* carried both positive and negative connotations, whereas *neōterismos* appears to have been predominantly, if not exclusively, used in a negative sense.[16]

Of course, and Spanos is aware of this, an inquiry into innovation cannot be confined to the pursuit of distinct labels for innovation. It is imperative to transcend specific terms and move beyond mere lexicographic searches. In my opinion, the primary interest should focus on assessing how innovations were accepted, applied, or rejected within Byzantine culture and everyday life, rather than solely relying on lexicographic repetition, theological approaches, or rhetorical models. Similar to other facets of Byzantine culture, explicit definitions of scientific innovation are absent, even though numerous instances of innovation, improvement, and development are described. Thus, the challenge remains to heuristically align Byzantine notions, descriptions, and applications of innovation with modern conceptualizations, despite the absence of explicit references.

---

9 Kenneth M. Setton, "The Byzantine Background to the Italian Renaissance". *Proceedings of the American Philosophical Society* 100.1 (1956): 76.

10 Alexander Kazhdan and Anthony Cutler, "Innovation", in *The Oxford Dictionary of Byzantium*, 3 vols., ed. Alexander P. Kazhdan (New York: Oxford University Press, 1991), II, 997-998.

11 Angeliki E. Laiou, "Economic Thought and Ideology", in *The Economic History of Byzantium: From the Seventh through the Fifteenth Century*, 3 vols., ed. Angeliki E. Laiou (Washington, D.C.: Dumbarton Oaks Research Library and Collection, 2002), III, 1124.

12 Benoît Godin, *Innovation Contested: The Idea of Innovation over the Centuries* (New York: Routledge, 2015), 281-282.

13 Vincent Bontems, *Au nom de l'innovation. Finalités et modalités de la recherche au XXIe siècle suivi de L'intention réparatrice* (Paris: Les Belles Lettres, 2023), 14. The approach to innovation that links the concept to economic and managerial purposes holds epistemological dominance. This is evident, for example, in Jan Fagerberg, David C. Mowery, and Richard R. Nelson, eds., *The Oxford Handbook of Innovation* (Oxford: Oxford University Press, 2005), which emphasizes the commercialization of technological innovation.

14 Apostolos Spanos, "'To Every Innovation, Anathema'(?): Some Preliminary Thoughts on the Study of Byzantine Innovation", in *Mysterion, strategike og kainotomia. Et festskrift til ære for Jonny Holbek*, ed. Harald Knudsen *et al.* (Oslo: Novus, 2010), 51-59; Apostolos Spanos, "Was Innovation Unwanted in Byzantium?", in *Wanted: Byzantium. The Desire for a Lost Empire*, ed. Ingela Nilsson and Paul Stephenson (Uppsala: Uppsala Universitet, 2014), 43-56.

15 See, e.g., Apostolos Spanos, Working Paper [hereafter: WP] 1: "Rethinking Innovation in Historical Studies", May 2015, https://www.academia.edu/17509179/Rethinking_innovation_in_historical_studies; WP 2: "Rethinking Innovation in Byzantium", October 2015, https://www.academia.edu/16992939/Rethinking_Innovation_in_Byzantium; WP 4: "Innovation as a Mode of Historical Existence", February 2020, https://www.academia.edu/42135932/Innovation_as_a_mode_of_historical_existence.

16 Spanos, "Innovation Unwanted", 53.

The discussion inevitably arrives at the following question: how do we distinguish between innovation, originality, novelty, and other, at first glance, similar concepts? Indeed, "innovation", "originality", "novelty", "creativity", and "invention" are often used interchangeably in scholarly discourse. A relevant example perhaps suffices. Anthony Cutler, summarizing the volume *Originality in Byzantine Literature, Art and Music*, acknowledges that the contributors treat originality as synonymous with creativity, invention, or innovation.[17] This example illustrates that there is sometimes an awareness of the challenges in identifying these terms, though it does not go beyond recognizing the complexity. The papers in the volume *Originality in Byzantine Literature* do not examine the sciences, yet they serve as an example of the common tendency to conflate the meaning of innovation with that of originality, without providing a clear methodological approach to these concepts. In her review of the volume, Averil Cameron notes: "Many of the essays, like Alexander Kazhdan's introduction, discuss change rather than originality".[18] It is worth mentioning that Kazhdan's essay, despite the overall focus of the volume being on "originality", is titled "Innovation in Byzantium".[19]

This tendency is not unique to the volume mentioned just above. There are monographs and articles on scientific topics in Late Antiquity and the Byzantine period that, while they clearly acknowledge the significance of innovation (as evident in their titles), do not approach it from a historiographical standpoint.[20] Thus, they do not proceed to conceptualize the idea, often assuming its meaning. Key considerations absent from these attempts include, for instance, the lack of a clear demonstration of how these authors employ and interpret the term "innovation", as well as an exploration of the ways in which "innovation" was perceived in Late Antiquity and Byzantium. However, it is only fair to admit that this absence does not suggest any "deficiency" in comprehending the meaning and modes of innovation; far from it. Instead, it reflects the modern familiarity with the term to the extent that its meaning is often assumed to be self-evident.

Spanos has proposed a functional distinction, at least between innovation and originality, which could also serve as a starting point in attempting to conceptualize innovation. What is crucial about Spanos' view is that innovation could involve the creative adaptation of an old idea, among other things, within a new context. This disassociates the supposedly mandatory connection between "innovation" and "originality".

> These concepts are not identical, neither in modern times nor in a historical perspective. This can be made clear by focusing only on originality: it is not an axiomatic truth that every innovation by default is an *original* idea, practice, or artefact. There are cases in which an innovation indicates simply the creative use or realization of an old idea, or a newly-imported or transplanted idea or practice, that was originally invented or set up by another unit, as for example an individual, a group, a state, a civilization etc. (it is also possible that two or more old ideas add up to an innovation). The adaptation of this(-ese) old idea(s) and its appropriation, transformation or reinvention by the new unit may result in so great a change that the new product or practice becomes an innovation, even though the idea on which it is based is not original.[21]

Of equal importance is the observation that not every innovation should necessarily be spectacular. Therefore, the degree of radicalness is an important analytical criterion, with the typical distinction being between "radical" and "incremental" innovations. Radical innovations necessitate a high degree of new knowledge and skills, leading to fundamental and, at times, revolutionary changes. On the other hand, incremental innovations can be achieved with a lower degree of new knowledge, introducing minor improvements or simple adjustments to current ideas.[22] It is important to note, however, that a series of incremental innovations might eventually culminate in a radical innovation. In modern scholarship, references to Byzantium's anti-innovative stance likely pertain to the alleged skepticism the Byzantines held toward radical innovation, especially in the realms of politics and religion.[23]

On the other hand, we must bear in mind that the definition of "tradition" is nearly as complex as that of innovation, signifying, in its simplest sense, "anything which is transmitted or handed down from the past to the present".[24] The historiographical tendency that exclusively links Byzantium with tradition in various intellectual fields persists and even modern Byzantinists sometimes seem to endorse it.[25] A characteristic case study concerns the arguments presented in an article on science and technology

17 Anthony Cutler, "Originality as a Cultural Phenomenon", in *Originality in Byzantine Literature, Art and Music: A Collection of Essays*, ed. Anthony R. Littlewood (Oxford: Oxbow, 1995), 203.

18 Averil Cameron, "Review of A. R. Littlewood, ed. *Originality in Byzantine Literature, Art and Music: A Collection of Essays*". *The Journal of Hellenic Studies* 117 (1997): 267.

19 Alexander Kazhdan, "Innovation in Byzantium", in *Originality in Byzantine Literature*, ed. Littlewood, 1-14.

20 Concerning alchemy, see, e.g., Olivier Dufault, *Early Greek Alchemy, Patronage and Innovation in Late Antiquity* (Berkeley, CA: California Classical Studies, 2019); cf. Gerasimos Merianos, "Review of O. Dufault. *Early Greek Alchemy, Patronage and Innovation in Late Antiquity*". *Ambix* 67.3 (2020): 320.

21 Spanos, "Innovation Unwanted", 45.

22 Spanos, "Innovation Unwanted", 45; Godin, *Innovation Contested*, 2, 100 n. 18, 226, 227.

23 Spanos, "Innovation Unwanted", 45.

24 Edward Shils, *Tradition* (Chicago, IL: The University of Chicago Press, 1981), 12. On the concept of "tradition", see also Josef Pieper, *Tradition: Concept and Claim*, trans. by E. Christian Kopff (South Bend, IN: St. Augustine's Press, 2010).

25 See, e.g., Marie-Hélène Blanchet, "Theology, Philosophy, and Politics at Ferrara-Florence", in *Cambridge Intellectual History of Byzantium*, ed. Kaldellis and Siniossoglou, 557: "There was a clear contrast between the modes of thinking and the values of the majority of the Byzantines [i.e. members of the Greek delegation at the Council of Ferrara-Florence], founded as they were on an absolute reverence for tradition, and those of their Latin interlocutors, who were much more favourably disposed to innovation in all domains".

in Byzantium by Juan Signes Codoñer. He rightly suggests that the Byzantine conception of the sciences should be assessed on its own terms. However, Signes Codoñer argues that Byzantine science served the purpose of reconstructing and harmonizing existing scientific knowledge, rather than innovating or exploring new scientific territories. He attributes this alleged stance to the Byzantine religious mentality that all knowledge necessary for human salvation had been received from Christ and transmitted to subsequent generations; thus, it was futile to think outside of tradition. He further suggests that any original knowledge produced by the Byzantines, such as what is now known as "pure mathematics", emerged incidentally from their efforts to reconcile tradition, rather than from a deliberate pursuit of innovation.[26]

Several critical points in Signes Codoñer's argumentation should be considered, as these considerations can be extended to analogous perspectives shared by other scholars. (a) Religion does not necessarily inhibit innovation; otherwise, Church Fathers, for instance, would not have had the mentality to reinterpret the original Christian teachings in an innovative manner. (b) The reconstruction and harmonization of existing scientific knowledge, to which Signes Codoñer refers, are often driven by socio-cultural and politico-religious factors, responding to specific requests. It is not an introverted process devoid of other influences. (c) The process of reconstructing scientific knowledge itself often constitutes a form of "innovation". Sometimes we tend to overlook that the very act of organizing and adapting existing knowledge involves innovative thinking, even if it may not manifest in groundbreaking discoveries. (d) There is a common misconception that the generation of innovative outcomes always entails a deliberate effort to achieve innovation, much like how we perceive it today. The modern sense of innovation, regarded as an end in itself, does not align with Byzantine mentality. Innovation in Byzantine science was frequently viewed as an improvement of traditional theories and practices rather than a radical departure from the past. It could be argued that the Byzantines frequently achieved innovative results within the framework of tradition, even in the name of tradition.[27] (e) Ultimately, as Benoît Godin states, commenting on Edward Shils' views, tradition can be seen as past innovations, and innovation, in turn, relies on tradition.[28]

It should be noted that, although the interplay of Byzantine culture and innovation is almost absent in current scholarship, some studies aptly demonstrate an initial recognition of the broader issue of achieving innovation in Byzantine culture within the framework of tradition. A most telling example, concerning the reception of Neoplatonism in Byzantium, is given by Tuomo Lankila:

> Ostensible continuity often contained within it, and even masked, innovation. The late ancient ideal of interpretation was to refrain from adding anything to a presumed original doctrine and to focus on the correct interpretation of what the founders taught. Interestingly, this task of "correct" interpretation became itself an inevitable channel for innovation. Better explication and more intelligent exegesis opened ways to renewal and new proposals. In a similar way, the Church Fathers expanded and transformed the original teaching of the first Christians. Of course, with their Trinitarian and Christological doctrines they introduced radically new ideas, yet they thought they were only explicating the Scriptures.[29] The relation of Middle and Late Platonists to Plato's dialogues is analogous.[30]

In this light, the much-advertised adherence of Byzantine culture to "tradition" – both by the Byzantines themselves and by modern scholars – no longer seems incompatible with innovation. For instance, in Byzantine alchemy, while a profound familiarity with the Greek chemical tradition is considered indispensable, there is room for innovative interpretation through exegetical analysis. This flexibility allowed the alchemical philosopher Christianos (late 6th-8th c.), influenced by the Neoplatonic mathematization of philosophical ideas, to creatively comment on the works of the great authorities of the past, particularly Pseudo-Demokritos (1st c. A.D.) and Zosimos of Panopolis (late 3rd-4th c.). Explicitly setting himself within the Pseudo-Demokritean tradition, Christianos articulated a precise method for classifying alchemical productions using arithmetical and geometrical language, a contribution embraced by later Byzantine alchemists. The "mathematization" of the classes of substances and the feasible productions suggests his view of alchemy as sharing traits with the sciences of the quadrivium

26 Juan Signes Codoñer, "Ciencia y técnica en Bizancio", in *Ciencia y cultura en la Edad Media. Actas VIII y X* (Canary Islands: Consejería de Educación, Cultura y Deportes del Gobierno de Canarias, 2003), 248-250, 251. Signes Codoñer's arguments are favorably referenced in Inmaculada Pérez Martín and Divna Manolova, "Science Teaching and Learning Methods in Byzantium", in *A Companion to Byzantine Science*, ed. Stavros Lazaris (Leiden: Brill, 2020), 56.

27 Gerasimos Merianos, "Το *Περὶ προνοίας* του Θεοδώρητου Κύρρου ως καινοτόμος προσέγγιση της συνεργασίας πλούσιων και φτωχών". *Icon: Journal on Byzantine Philosophy* 1.1 (2021): 33.

28 Godin, *Innovation Contested*, 228, commenting on Shils, *Tradition*.

29 In a similar way, Shils, *Tradition*, 108, presents the different conceptions of innovation in religious and scientific knowledge respectively: "Thus, innovation occurs in both religious and scientific knowledge. In the former it occurs in the process of improving interpretation or the understanding of the sacred text or of the nearly sacred interpretations and it is not put forward as innovation; in the latter, innovation is sought in the understanding of nature and it is acknowledged as such, once it meets the criteria of validity and is really a significant innovation".

30 Tuomo Lankila, "The Byzantine Reception of Neoplatonism", in *Cambridge Intellectual History of Byzantium*, ed. Kaldellis and Siniossoglou, 315. Cf. John Lowden, "Book Production", in *The Oxford Handbook of Byzantine Studies*, ed. Elizabeth Jeffreys, John Haldon, and Robin Cormack (Oxford: Oxford University Press, 2008), 467: "Like other aspects of Byzantine religious culture, the production of illuminated manuscripts quite often involved the disguise of innovation as long-established tradition. This is demonstrated most clearly in the pictorial decoration of newly composed texts by means of traditional-looking visual formulas". See also Kathleen Corrigan, "Iconography", in *Oxford Handbook of Byzantine Studies*, ed. Jeffreys, Haldon, and Cormack, 70.

(arithmetic, geometry, astronomy, and music). Later, the Anonymous Philosopher (8th-9th c.)[31] attempted to demonstrate the same, emphasizing similarities between alchemy and music through analogical reasoning. The affinity of alchemy to the sciences of the quadrivium underscores the idea that alchemical practice should be conceived and rooted in concrete (mathematical) principles and rigorous, logical procedures, forming a precise methodology.[32]

Indeed, the various techniques of exegesis in alchemical contexts across different eras and cultures are receiving increasing attention. For example, Jennifer Rampling has highlighted the process she labels "practical exegesis", through which early modern English alchemists studied, tested, and reinterpreted the works of past authorities, often in a manner that would have surprised the original writers.[33] In this undertaking, "[...] specific processes and products [...] are forcibly reinterpreted to accommodate such considerations as the availability of local materials and compatibility with the practitioner's own empirical observations".[34] However, Rampling notes pertinently to our discussion, "[p]ractical exegesis – the reinvention of earlier practices through successive cycles of testing and reinterpreting written sources – has made many of these transformations invisible, creating an *illusion of stasis* [emphasis mine] through repetition of the same terms and topoi".[35] Of course, the need for interpretative methodologies was not limited to the field of alchemy, nor was it confined to early modernity.[36]

The discussion about innovation in Byzantine science is not only timely but could serve as an indispensable springboard to alter historiographical tendencies concerning Byzantine culture broadly. Modern historians often tend to conceive the existence of scientific activity as a criterion for the overall advancement of a past civilization. Consequently, the still prevailing perception of Byzantine science as imitative and unoriginal sustains and reinforces the view of Byzantium as a stagnant and anti-innovative culture.

Be that as it may, further steps are required to understand how the concept of "innovation" was perceived and applied in Byzantium, particularly in science, since the modern sense of the concept can only be employed heuristically in our endeavor to understand the Byzantine perspective. One significant step would be the establishment of analytical criteria to examine the concept and its applications within Byzantine science. These criteria could include aspects such as the content, origin, level of radicalness, and diffusion of an innovation.

The preceding reflections on the relationship between Byzantine science and innovation introduce the following section, which focuses on an often-overlooked catalyst for change and innovation in science: social, political, cultural, and religious developments. This approach aligns with contemporary historiographical trends in the history of science, viewing science as a social and cultural phenomenon in constant interaction with other domains of human activity while retaining its unique characteristics. Therefore, this article does not aim to highlight spectacular innovations in the theory and practice of Byzantine alchemy. Its purpose is to illustrate through a case study how the cultural, social, and economic context can shape concepts within a scientific field such as alchemy. Specifically, it will examine how a monetary and economic innovation, the introduction of the *solidus* by Constantine I the Great, likely influenced the prevalence of the perception of alchemy as primarily a chrysopoetic art. In other words, it will explore how an external innovation can impact a scientific field, potentially leading to innovative conceptions and development.

3. The Constantinian *Solidus*: A Lever for Alchemical Redefinition?

The term "alchemy" is conventionally employed to refer to a science, discipline, or art that lacked a single name during Byzantine times. Throughout the Byzantine era, there was no single conception or term for it.[37] It is noteworthy, however, that the most renowned and synoptic answer to what "alchemy" meant for the Byzantines comes from the late-10th century *Souda* lexicon, where *chēmeia* (a term roughly aligning with "alchemy") is defined as "the preparation of silver and gold."[38] This means that *chēmeia* is equated with *argyropoeia* and *chrysopoeia*, respectively. Of these ancient terms,[39] *chrysopoeia* was more commonly used. Indeed,

31 According to Jean Letrouit ("Chronologie des alchimistes grecs", in *Alchimie: art, histoire et mythes*, ed. Didier Kahn and Sylvain Matton [Paris and Milan: S.É.H.A. and Archè, 1995], 63-65), the name "Anonymous Philosopher" applies to two different authors, dating to the 8th-9th century.

32 Merianos, "Philosopher Christianos", 294-302.

33 Jennifer M. Rampling, *The Experimental Fire: Inventing English Alchemy, 1300-1700* (Chicago, IL: The University of Chicago Press, 2020), 6.

34 Rampling, *Experimental Fire*, 98.

35 Rampling, *Experimental Fire*, 354.

36 Concerning Byzantine medicine, for example, there are late antique/early Byzantine medical compilations, also known as medical "encyclopedias". These compilations, which incorporate material from earlier medical authors, were once thought to evidence the alleged stagnation of medicine in that era but are now being reevaluated. As Philip van der Eijk stresses, the principles and methods of selection, abbreviation, and summary used by Oribasios, Aetios of Amida, and Paul of Aegina show that these authors were far from being mere mechanical cutters and pasters. They reflected on their practice critically and considered the expectations of their patrons and readers, as well as the practical purposes their work was intended to serve. Notably, they also "[...] disagreed among each other about the best and most effective way of achieving their aims, adopting different literary and subject-specific standards and different criteria for condensation and re-arrangement". They were guided by their professional judgment, along with their medical experience and expertise. See Philip van der Eijk, "Principles and Practices of Compilation and Abbreviation in the Medical 'Encyclopaedias' of Late Antiquity", in *Condensing Texts – Condensed Texts*, ed. Marietta Horster and Christiane Reitz (Stuttgart, F. Steiner, 2010), 553; also Philip van der Eijk *et al.*, "Canons, Authorities and Medical Practice in the Greek Medical Encyclopaedias of Late Antiquity and in the Talmud", in *Wissen in Bewegung. Institution – Iteration – Transfer*, ed. Eva Cancik-Kirschbaum and Anita Traninger (Wiesbaden: Harrassowitz, 2015), 195-221.

37 Merianos, "Alchemy", 238-240.

38 *Souda*, ed. Ada Adler, *Suidae lexicon*, 5 vols. (Leipzig: B. G. Teubner, 1928-1938), *s.v.* Χημεία (Χ 280): ἡ τοῦ ἀργύρου καὶ χρυσοῦ κατασκευή, [...]; see also *s.v.* Διοκλητιανός (Δ 1156); *s.v.* Χειμεία (Χ 227). See Merianos, "Alchemy", 238 and n. 42.

39 See these terms, e.g., in Pseudo-Demokritos, *On the Making of Purple and Gold: Natural and Secret Questions* 20.215, 229, ed. Matteo Martelli, *The* Four Books *of Pseudo-Democritus* (Leeds: Maney Publishing, 2013), 100, 102.

alchemy was predominantly considered an aurific art. Although it was not exclusively engaged with transformation into gold, metallic transmutation was perceived as its objective par excellence.

However, since the earliest phases of alchemy, there existed two tendencies concerning its conception: one regarded it as an art encompassing a variety of techniques for gold- and silver-making, dyeing of stones, and purple dyeing of wool. This is attested in the four topics originally covered in the books of Pseudo-Demokritos, the most ancient alchemical author (1st c. A.D.), which point to a fourfold division of alchemical objectives. It is not without importance that of the Pseudo-Demokritean work, only the sections dealing with gold and silver have been preserved.[40] This broader conception of alchemy is also attested in the recipes of the Leiden (P. Leid. X) and the Stockholm (P. Holm.) chemical papyri, which date to around 300 A.D. and represent the technical phase of Graeco-Egyptian alchemy.[41] In turn, a narrower view of alchemy focused solely on the making of precious metals. This view is found in works such as the *Letter of Isis to Horus* (late 2nd/early 3rd c.), presenting alchemy as a secret knowledge of divine origin.[42] It is no coincidence that a variation of the phrase "the preparation of silver and gold" found in the *Souda* lexicon, appears already in the *Letter of Isis* as "the preparation of gold and silver".[43] This second, narrow notion of alchemy as an art for metallic transmutation was relatively dominant in Byzantium (as shown by *Souda*'s definition), which explains the loss of much of the alchemical literature that was not about making precious metals.

The prevalence of this narrow conception of alchemy was relative, as the Greek alchemical corpus includes texts on *chrysopoeia* alongside works that incorporate a broader range of dyeing techniques for treating various materials.[44] This indicates the contradictions and multilayered meanings of alchemical practices in Byzantium, thus justifying Stanton Linden's suggestion to speak of "alchemies" rather than "alchemy", recognizing the complexity of the discipline.[45] The preeminence of the chrysopoetic goal did not follow a linear course, nor did it sideline the wider conception of alchemy completely. For instance, in the 11th century, Michael Psellos (1018 - late 1070s) in his *On How to Make Gold*, dedicated to the Patriarch Michael I Keroularios (1043-1058), states that he would have liked to have written a general treatise and explained every operation on matter, including the making and treatment of precious stones and pearls, however, the patriarch's preference for gold-making limited Psellos to this topic.[46] There is an implied tension here between the breadth of the philosophical conception of alchemy and the obsession with the aurific art, ultimately raising suspicions of greed. The chrysopoetic aspect of alchemy was dominant in non-alchemical literature, although there are also some exceptions. For example, John Kanaboutzes in his *Commentary on Dionysios of Halikarnassos* (first half of the 15th c.) refers to alchemy (*chymia*) and describes it as the art of transmuting metals, dyeing stones and crystals in any color, and the dissolution and reconstitution of pearls.[47] Be that as it may, a learned Byzantine individual of the middle period would have probably thought of alchemy as an aurific art, if we are to judge by the *Souda*'s definition of *chēmeia*.

Could socio-economic developments have contributed to the consolidation of gold-making as the primary objective, as Greek alchemy evolved from its Graeco-Egyptian to its Byzantine phase? I believe it is worth exploring the socio-economic conditions that emerged from the reign of Constantine I the Great (306-337) onward, considering whether they could have played a role in enhancing the conception of alchemy in terms of metallic transmutation, that is, as an art aimed at making primarily gold.

Constantine's rule signifies a new era for the late Roman society and economy.[48] A significant change took place from his reign onward with far-reaching repercussions that led to the transformation of social hierarchies: money surpassed land as the general form and indication of wealth.[49] It is now a consensus that Constantine and his successors "flooded" the

40 Martelli, *Four Books*, 58-59.

41 Robert Halleux, *Les Alchimistes grecs*, I: *Papyrus de Leyde. Papyrus de Stockholm. Fragments de recettes* (Paris: Les Belles Lettres, 1981).

42 For the edition of the text, see *The Letter of Isis to Horus*, ed. Michèle Mertens, *Un traité gréco-égyptien d'alchimie: la* Lettre d'Isis à Horus*. Texte établi et traduit avec introduction et notes* (Unpublished Ph.D. diss. Université de Liège, 1983-1984). On this work, see Michèle Mertens, "Une scène d'initiation alchimique: la 'Lettre d'Isis à Horus'". *Revue de l'histoire des religions* 205.1 (1988): 3-23; Fabiana Lopes da Silveira, "In the Melting Pot: Cultural Mixture and the Presentation of Alchemical Knowledge in the *Letter from Isis to Horus*". *Ambix* 69.1 (2022): 49-64; Miriam Blanco Cesteros, "(De)Constructing an Authoritative Narrative. The Case of *The Letter of Isis*". *ARYS* 20 (2022): 227-269.

43 *The Letter of Isis to Horus* 1.3, ed. Mertens, 129,12-13: [...] πυνθάνεσθαι βουλομένη τὴν τοῦ χρυσοῦ καὶ ἀργύρου κατασκευήν. Cf. Martelli, *Four Books*, 61; Matteo Martelli, "The Alchemical Art of Dyeing: The Fourfold Division of Alchemy and the Enochian Tradition", in *Laboratories of Art: Alchemy and Art Technology from Antiquity to the 18th Century*, ed. Sven Dupré (Cham: Springer, 2014), 8-9.

44 See Martelli, *Four Books*, 62-63; Martelli, "Alchemical Art", 17.

45 Stanton J. Linden, *The Alchemy Reader: From Hermes Trismegistus to Isaac Newton* (Cambridge: Cambridge University Press, 2003), 4.

46 Michael Psellos, *On How to Make Gold* 5, ed. Joseph Bidez, *Catalogue des manuscrits alchimiques grecs*, VI: *Michel Psellus, Épître sur la Chrysopée, opuscules et extraits sur l'alchimie, la météorologie et la démonologie* (M. Lamertin: Brussels, 1928), 30,19-32,9. Cf. Martelli, "Alchemical Art", 3.

47 John Kanaboutzes, *Commentary on Dionysios of Halikarnassos* 13, ed. Maximilian Lehnerdt, *Ioannis Canabutzae magistri ad principem Aeni et Samothraces in Dionysium Halicarnasensem commentarius* (Leipzig: B. G. Teubner, 1890), 11,1-16. For an English translation of the work, see Anthony Kaldellis, *Byzantine Readings of Ancient Historians: Texts in Translation, with Introductions and Notes* (London: Routledge, 2015), 113-170. On Kanaboutzes' discussion of alchemy, see Sakorrafou and Merianos, "Kanaboutzes' Commentary".

48 What follows is based on Gerasimos Merianos and George Gotsis, *Managing Financial Resources in Late Antiquity: Greek Fathers' Views on Hoarding and Saving* (London: Palgrave Macmillan, 2017), ch. 6.

49 Jairus Banaji, "Economic Trajectories", in *The Oxford Handbook of Late Antiquity*, ed. Scott Fitzgerald Johnson (Oxford: Oxford University Press, 2012), 597 (= "The Economic Trajectories of Late Antiquity", in Jairus Banaji, *Exploring the Economy of Late Antiquity: Selected Essays* [Cambridge: Cambridge University Press, 2016], 61).

market with gold[50] in the form of *solidi*.[51] The *solidus* (also known as *nomisma*) was introduced in 309, by which Constantine successfully established a stable gold coinage.[52] Actually, the Constantinian *solidus* represents an innovation, particularly within the framework proposed by Spanos (see the previous section), wherein innovation involves the adaptation of an existing idea by a new "adoption unit". The *solidus* weighed approximately 4.50 g, corresponding to 1/72 of the Roman *libra* / *litra* (pound),[53] replacing Diocletian's gold coin, the *denarius aureus* (or simply *aureus*), which weighed around 5.45 g and corresponded to 1/60 of the pound.[54] This means that Constantine's gold coin was actually a debasement in comparison to the Diocletianic one, but Constantine's victories and the reminting of the heavier *aurei* of his rivals rather led to the imposition of the *solidus* in the Roman world.[55] The foundation of the Byzantine monetary system was thus established and essentially maintained until the early 11th century.

Modern literature has extensively analyzed the monetary, economic, and social impacts resulting from the successful introduction of the Constantinian *solidus*. A key text shedding light on this turning point in economy is the anonymous fourth-century treatise *De rebus bellicis* ("On Military Affairs"). The text reproaches Constantine I for his economic policy, which led to devastating social consequences, particularly for the lower social strata.[56] Santo Mazzarino drew attention to the significant correlation outlined in this work between the expansion in the circulation of gold and the emergence of a new aristocracy under Constantine and his successors. Moreover, he observed that the new salaries being paid in gold and their high purchasing power were fundamental elements of the transformed hierarchical social order. In simple terms, there were those who had regular access to gold coinage and those who did not.[57] The anonymous author of the *De rebus bellicis* claims that the expanding flow of gold was partly made possible by the pillaging of pagan temples. This "massive dishoarding of gold [...] led to the (renewed) accumulation of monetary wealth in private hands and sparked a veritable 'passion for spending gold'".[58] The new elite eagerly displayed their association with gold, as well as with the emperor who bestowed it upon his officials and officers. Possessors of wealth had to demonstrate it so as to convince others that they truly held it.[59] As a result, luxury and conspicuous consumption must have reached great heights of excess. Asterios, bishop of Amasea in Pontus (*ca.* 330/35-420/25), criticized in his homily *Against Avarice* those who "dwell under roofs overlaid with gold", indicating that the use of gilding was not uncommon for architectural details.[60]

The introduction of the *solidus* had a significant consequence: gold became the "immediate representative of value". This does not mean that values could not be expressed in other currencies or units of account, but rather that expressing value in lower currencies implied their underlying expression of value in terms of gold. Silver and bronze currencies became symbols for gold, representing various quantities of it.[61] The gold *solidus* seems to have become the embodiment of wealth. It is noteworthy that contemporary economic reality was depicted in the writings of the Church Fathers: fourth- and fifth-century patristic works are replete with references to the *chrysion*, a term meaning gold in general and gold coin in particular (depending on the context).[62]

Not only the state but also the Church could not avoid being associated with gold, as

> [...] Church splendour was associated with the patronage of emperors. They wished to associate themselves with divinity and associate the Church with their government. For that to work, the two institutions needed to adopt the same styles, otherwise a bare religious style of the church would seem an explicit criticism of the golden style of the Empire. In tandem, each could do honour to the other.[63]

---

50 For the discussion of the policy of gold coining in the Constantinian Empire, see Patrick Bruun, *Studies in Constantinian Chronology* (New York: The American Numismatic Society, 1961), 76-77; also Lars Ramskold, "Constantine's Vicennalia and the Death of Crispus". *Niš & Byzantium* 11 (2013): 412, 415-418.

51 Jairus Banaji, *Agrarian Change in Late Antiquity: Gold, Labour, and Aristocratic Dominance*, 2nd edn. (Oxford: Oxford University Press, 2007), 41, 47; Peter Brown, *Through the Eye of a Needle: Wealth, the Fall of Rome, and the Making of Christianity in the West, 350-550 AD* (Princeton, NJ: Princeton University Press, 2012), 14.

52 Banaji, *Agrarian Change*, 45.

53 Kenneth W. Harl, *Coinage in the Roman Economy, 300 B.C. to A.D. 700* (Baltimore, MD: The Johns Hopkins University Press, 1996), 159; Richard Abdy, "Tetrarchy and the House of Constantine," in *The Oxford Handbook of Greek and Roman Coinage*, ed. William E. Metcalf (Oxford: Oxford University Press, 2012), 591.

54 Harl, *Coinage*, 149; Abdy, "Tetrarchy", 589.

55 Harl, *Coinage*, 159.

56 *De rebus bellicis* 2.1-4, ed. Andrea Giardina, *Anonimo, Le cose della guerra* (Milan: A. Mondadori, 1989), 12; Eng. trans. by Edward Arthur Thompson, *A Roman Reformer and Inventor, Being a New Text of the Treatise* De rebus bellicis (Oxford: Clarendon Press, 1952), 110: "It was in the age of Constantine that extravagant grants assigned gold instead of bronze (which earlier was considered of great value) to petty commercial transactions; but the greed I speak of is thought to have arisen from the following causes. When the gold and silver and the huge quantity of precious stones which had been stored away in the temples long ago reached the public, they enkindled all men's possessive and spendthrift instincts. And while the expenditure of bronze itself [...] had seemed already vast and burdensome enough, yet from some kind of blind folly there ensued an even more extravagant passion for spending gold, which is considered more precious. This store of gold meant that the houses of the powerful were crammed full and their splendour enhanced to the destruction of the poor, the poorer classes of course being held down by force". See Banaji, *Agrarian Change*, 46-49; cf. Filippo Carlà, *L'oro nella tarda antichità: aspetti economici e sociali* (Turin: S. Zamorani, 2009), 125-131.

57 Santo Mazzarino, *Aspetti sociali del quarto secolo. Ricerche di storia tardo-romana* (Rome: "L'Erma" di Bretschneider, 1951), 114-115; also Brown, *Eye of a Needle*, 15.

58 Jairus Banaji, "Precious Metal Coinages and Monetary Expansion in Late Antiquity", in *idem*, *Exploring the Economy of Late Antiquity*, 112.

59 Brown, *Eye of a Needle*, 16.

60 Asterios of Amasea, *Homily* III 12.2, ed. Cornelis Datema, *Asterius of Amasea, Homilies I-XIV* (Leiden: Brill, 1970), 35,5. See Merianos and Gotsis, *Managing*, 172.

61 Banaji, *Agrarian Change*, 40.

62 Merianos and Gotsis, *Managing*, 173.

63 Dominic Janes, *God and Gold in Late Antiquity* (Cambridge: Cambridge University Press, 1998), 91-92.

In the realm of symbolism, the association of gold with spiritual radiance, the sun, and even with Christ himself made the use of gold in liturgical objects and icons exceedingly common. The symbolic significance of liturgical splendor aimed to facilitate the believer's visualization of the heavenly realm, even if only a "pale likeness" of it.[64]

Gold was esteemed as the perfect and most valuable metal, embodying not only symbolism but also serving as evidence of authority and wealth. Its very presence evoked associations of beauty, purity, divinity, largesse, incorruptibility (due to its resistance to corrosion), and, inevitably, scarcity.[65] The Byzantines used gold for purposes beyond coinage, but it was the latter that was highly coveted not only within Byzantium but also by less-monetized foreign societies.

Although the value and symbolism of gold did not leave societies of earlier periods unmoved, an unprecedented and insatiable "thirst" for gold emerged, at both the real and the imaginary levels, since the reign of Constantine. The Byzantines did not invent alchemy, nor did the perception of it as an exclusively aurific art originate in Byzantium. Yet alchemy, a known "art" with diverse objectives (the making of gold, silver, precious stones, and purple dye), was viewed from a new perspective in response to Byzantium's socio-economic and cultural obsession with gold. The alchemical discourse and practice – especially that related to making gold – probably became increasingly attractive to the Byzantines from the early period onward. Alchemy's aurific objective seemed now to respond to the demand for gold of an entire society. Of course, the direct link between the introduction of the *solidus* and the redefinition of alchemical objectives should not be exaggerated. This redefinition of alchemy, nevertheless, was likely prompted by the complex social, economic, and cultural outcomes of introducing the said gold coin issue, which shaped a society's craving for gold.

4. Concluding Remarks

This hypothesis offers a potential starting point and a credible socio-cultural rationale for the prevalence of the tendency to conceive alchemy in terms of metallic transmutation in Byzantium. It also explains why part of the alchemical literature not related to the making of precious metals was not of primary interest to the Byzantines, leading to its loss. As the pursuit of gold became a widespread ideal and its demand was also expressed at the symbolic level, alchemy's appeal increased. We could understand this phenomenon better if we factor in the origin of real gold. Apart from gold mining, some of the sources that supplied the Byzantine state with gold over the centuries must have included the use of already coined metal, the exploitation of captured or hoarded metals,[66] and imports.[67] To these conventional ways, one could now add alchemical practice, which was supposedly able either to create gold or increase its existing quantity. Could we speculate that this "art", known for its imitative and counterfeiting techniques, held particular appeal to those without regular access to gold, offering them the possibility to participate in the visual language of wealth and status in a society that coveted this precious metal?

As always, caution is required. Judging by the references to alchemy in non-alchemical texts, we cannot draw any firm conclusions yet about the appeal of alchemy in early Byzantine society. Nevertheless, such references increase continually due to our current tendency to scrutinize texts of various genres more critically. Moreover, we cannot rely on the surviving alchemical texts themselves for this purpose, especially because the earliest extant witness to the Greek alchemical corpus, *Marcianus graecus* 299, dates to the second half of the 10th century.[68] However, we should not overlook the fact that Zosimos of Panopolis himself, dated around 300 A.D., could have lived contemporaneously or near the time of the introduction of the *solidus*. This is not to associate Zosimos with this gold coin issue, but rather aims to show that alchemical literature and its objectives must have already been known, at least to some extent, by a broader public of the Empire around the time of the introduction of the *solidus*.

The likelihood of an impact of the *solidus* upon the development of alchemy increases when we examine references to coinage and its manipulation within alchemical discourse. In his *First Book of the Final Abstinence* (also known as the *Final Count*), Zosimos remarks that "craftsmen who know how to strike imperial coinage (*nomisma*) do not strike it for themselves, for they are punished".[69] Additionally, the Greek alchemical corpus includes recipes for and references to making *phourmai* – molds used for imitating evidently gold coinage – indicating the importance of these techniques.[70] Even *Souda*'s entry on *chēmeia* provides insights into the monetary context. After defining *chēmeia*, the entry recounts how Diocletian in Egypt ordered the burning of books written by the ancients on the *chēmeia* of gold and silver to prevent the rebellious Egyptians from accumulating wealth and becoming emboldened against the Romans in the future. This suggests that the burning of the Egyptian alchemical books, following a local rebellion, was part of Diocletian's

64 Janes, *God and Gold*, 74-79.

65 Liz James, *Light and Colour in Byzantine Art* (Oxford: Clarendon Press, 1996), 107; Janes, *God and Gold*, 18.

66 Klaus-Peter Matschke, "Mining", in *Economic History of Byzantium*, ed. Laiou, I, 117.

67 Maria Gerolymatou, *Αγορές, έμποροι και εμπόριο στο Βυζάντιο (9ος-12ος αι.)* (Athens: National Hellenic Research Foundation, Institute for Byzantine Research, 2008), 193-194.

68 For the dating of this manuscript, see Alexandre M. Roberts, "A Greek Alchemical Epigram in Its Middle Byzantine Context". *Journal of the Warburg and Courtauld Institutes* 83 (2020): 11-25, 35. Cf. Inmaculada Pérez Martín, "Byzantine Books", in *Cambridge Intellectual History of Byzantium*, ed. Kaldellis and Siniossoglou, 45 n. 36.

69 Zosimos of Panopolis, *First Book of the Final Abstinence* 1, ed. André-Jean Festugière, *La révélation d'Hermès Trismégiste*, I: *L'astrologie et les sciences occultes* (Paris: Les Belles Lettres, 1944), 364,6-9 (**A** and **M**): ὥσπερ <γὰρ> οἱ τεχνῖται οἱ ἐπιστάμενοι βασιλικὸν τύπτειν νόμισμα οὐχ ἑαυτοῖς τύπτουσιν, ἐπεὶ τιμωροῦνται, [...].

70 See Gerasimos Merianos, "Insights on Alchemy, Deception, and Artisanal Knowledge in Byzantium", in *Byzanz am Rhein. Festschrift für Günter Prinzing anlässlich seines 80. Geburtstags*, ed. Antje Bosselmann-Ruickbie *et al.* (Wiesbaden: Harrassowitz, 2024), 147-148 and n. 16.

efforts to enforce his numismatic reform (introduced around 293/4), to consolidate political and monetary unity, and to suppress any local resistance. In this context, he aimed to eliminate techniques for manipulating silver and gold, especially those enabling the imitation or production of currency in an insurgent Roman province.[71] These examples demonstrate that part of the alchemical discourse was associated with the manipulation of coinage, and this link may justify, at least in some phases of alchemy, the centrality of *chrysopoeia*.

Concerning the aspect of innovation in this narrative, it is intriguing to note that we can trace innovative characteristics both in the *solidus* itself and in how the social and economic conditions following its introduction served as a catalyst for the prevalence of the conception of alchemy as *chrysopoeia*. Among the traditional objectives of alchemy, *chrysopoeia* became synonymous with the discipline itself, largely due to an entire society's heightened demand for and association with gold. *Chrysopoeia*, the most sought-after objective, reflects a shift in emphasis among enthusiasts of alchemy and laymen alike, from the broader discipline to a specific goal and its related methods. If this hypothesis is plausible enough, alchemical innovation resides in the widespread conception of alchemical practice primarily as gold-making. Although this idea is not new, it is now driven by an external cause to the discipline itself. In short, the Byzantine alchemical discource appears to have "reintroduced" the emphasis on *chrysopoeia* in light of the aforementioned socio-economic circumstances, which had deep and long-standing effects.

This case study, apart from highlighting one of the potential conditions that led to the conception of alchemy as *chrysopoeia*, shows that seemingly irrelevant events can impact the course of scientific disciplines. Emphasizing the largely overlooked social character of science within Byzantine studies, it showcases how external factors – which sometimes amount to innovations – can spark innovative developments within scientific fields. But, above all, this proposal underscores the importance of contextualizing Byzantine texts related to science.

71 *Souda*, ed. Adler, *s.v.* Χημεία (Χ 280): ἡ τοῦ ἀργύρου καὶ χρυσοῦ κατασκευή, ἧς τὰ βιβλία διερευνησάμενος ὁ Διοκλητιανὸς ἔκαυσεν. ὅτι διὰ τὰ νεωτερισθέντα Αἰγυπτίοις Διοκλητιανῷ τούτοις ἀνημέρως καὶ φονικῶς ἐχρήσατο. ὅτε δὴ καὶ τὰ περὶ χημείας χρυσοῦ καὶ ἀργύρου τοῖς παλαιοῖς αὐτῶν γεγραμμένα βιβλία διερευνησάμενος ἔκαυσε πρὸς τὸ μηκέτι πλοῦτον Αἰγυπτίοις ἐκ τῆς τοιαύτης προσγίνεσθαι τέχνης μηδὲ χρημάτων αὐτοὺς θαρροῦντας περιουσία τοῦ λοιποῦ Ῥωμαίοις ἀνταίρειν. [...]; cf. *s.v.* Διοκλητιανός (Δ 1156). On the burning of the Egyptian alchemical books, the Byzantine sources that record the incident, and the monetary context, see Merianos, "Alchemy", 238 and n. 42, 248; also Edmund O. von Lippmann, *Entstehung und Ausbreitung der Alchemie*, I (Berlin: J. Springer, 1919), 288-293; Halleux, *Alchimistes grecs*, I, 23-24; Principe, *Secrets of Alchemy*, 22-23, 61. For the possible links between alchemy and late Roman minting, see Paul T. Keyser, "Greco-Roman Alchemy and Coins of Imitation Silver". *American Journal of Numismatics* 7-8 (1995-1996): 209-234; cf. Constantina Vlachou, *The Manufacturing and Plating Technology Used in the Production of Mid-3rd/4th Century AD Roman Coins – An Analytical Study* (Unpublished Ph.D. diss. University of Bradford, 2004), 103-104, 366, 368.

5. References

5.1. Primary Sources

Asterios of Amasea, *Homilies*. Ed. Cornelis Datema, *Asterius of Amasea, Homilies I-XIV*. Leiden: Brill, 1970.

De rebus bellicis. Ed. Andrea Giardina, *Anonimo, Le cose della guerra*. Milan: A. Mondadori, 1989. Eng. trans. by Edward Arthur Thompson, *A Roman Reformer and Inventor, Being a New Text of the Treatise* De rebus bellicis. Oxford: Clarendon Press, 1952.

John Kanaboutzes, *Commentary on Dionysios of Halikarnassos*. Ed. Maximilian Lehnerdt, *Ioannis Canabutzae magistri ad principem Aeni et Samothraces in Dionysium Halicarnasensem commentarius*. Leipzig: B. G. Teubner, 1890. Eng. trans. by Anthony Kaldellis, *Byzantine Readings of Ancient Historians: Texts in Translation, with Introductions and Notes*, 113-170. London: Routledge, 2015.

Michael Psellos, *On How to Make Gold*. Ed. Joseph Bidez, *Catalogue des manuscrits alchimiques grecs*, VI: *Michel Psellus, Épître sur la Chrysopée, opuscules et extraits sur l'alchimie, la météorologie et la démonologie*, 26-43. M. Lamertin: Brussels, 1928.

Pseudo-Demokritos, *On the Making of Purple and Gold: Natural and Secret Questions*. Ed. Matteo Martelli, *The* Four Books *of Pseudo-Democritus*, 78-103. Leeds: Maney Publishing, 2013.

Souda. Ed. Ada Adler, *Suidae lexicon*, 5 vols. Leipzig: B. G. Teubner, 1928-1938.

The Letter of Isis to Horus. Ed. Michèle Mertens, *Un traité gréco-égyptien d'alchimie: la* Lettre d'Isis à Horus*. Texte établi et traduit avec introduction et notes*. Unpublished Ph.D. diss. Université de Liège, 1983-1984.

Zosimos of Panopolis, *First Book of the Final Abstinence*. Ed. André-Jean Festugière, *La révélation d'Hermès Trismégiste*, I: *L'astrologie et les sciences occultes*, 363-368. Paris: Les Belles Lettres, 1944.

5.2. Bibliography

Abdy, Richard. "Tetrarchy and the House of Constantine". In *The Oxford Handbook of Greek and Roman Coinage*, ed. William E. Metcalf, 584-600. Oxford: Oxford University Press, 2012.

Anderson, Benjamin, and Mirela Ivanova, eds. *Is Byzantine Studies a Colonialist Discipline? Toward a Critical Historiography*. University Park, PA: The Pennsylvania State University Press, 2023.

Banaji, Jairus. *Agrarian Change in Late Antiquity: Gold, Labour, and Aristocratic Dominance*, 2nd edn. Oxford: Oxford University Press, 2007.

Banaji, Jairus. "Economic Trajectories". In *The Oxford Handbook of Late Antiquity*, ed. Scott Fitzgerald Johnson, 597-624. Oxford: Oxford University Press, 2012.

Banaji, Jairus. *Exploring the Economy of Late Antiquity: Selected Essays*. Cambridge: Cambridge University Press, 2016.

Banaji, Jairus. “Precious Metal Coinages and Monetary Expansion in Late Antiquity”. In Banaji, *Exploring the Economy of Late Antiquity*, 110-140.

Banaji, Jairus. “The Economic Trajectories of Late Antiquity”. In Banaji, *Exploring the Economy of Late Antiquity*, 61-88.

Blanchet, Marie-Hélène, “Theology, Philosophy, and Politics at Ferrara-Florence”. In *Cambridge Intellectual History of Byzantium*, ed. Kaldellis and Siniossoglou, 557-572.

Blanco Cesteros, Miriam. “(De)Constructing an Authoritative Narrative. The Case of *The Letter of Isis*”. *ARYS* 20 (2022): 227-269.

Bontems, Vincent. *Au nom de l’innovation. Finalités et modalités de la recherche au XXIe siècle suivi de L’intention réparatrice*. Paris: Les Belles Lettres, 2023.

Brown, Peter. *Through the Eye of a Needle: Wealth, the Fall of Rome, and the Making of Christianity in the West, 350-550 AD*. Princeton, NJ: Princeton University Press, 2012.

Bruun, Patrick. *Studies in Constantinian Chronology*. New York: The American Numismatic Society, 1961.

Cameron, Averil. “Review of A. R. Littlewood, ed. *Originality in Byzantine Literature, Art and Music: A Collection of Essays*”. *The Journal of Hellenic Studies* 117 (1997): 266-267.

Cameron, Averil. *Byzantine Matters*. Princeton, NJ: Princeton University Press, 2014.

Carlà, Filippo. *L’oro nella tarda antichità: aspetti economici e sociali*. Turin: S. Zamorani, 2009.

Colinet, Andrée. *Les Alchimistes grecs*, X: *L’Anonyme de Zuretti ou l’Art sacré et divin de la chrysopée par un anonyme*. Paris: Les Belles Lettres, 2000.

Colinet, Andrée. “Le *Travail des quatre éléments* ou lorsqu’un alchimiste byzantin s’inspire de Jabir”. In *Occident et Proche-Orient: contacts scientifiques au temps des Croisades*, ed. Isabelle Draelants, Anne Tihon, and Baudouin van den Abeele, 165-190. Turnhout: Brepols, 2000.

Colinet, Andrée. “L’*Anonyme de Zuretti*. Un traité alchimique italo-grec de 1300”. In *L’alchimie et ses racines philosophiques. La tradition grecque et la tradition arabe*, ed. Cristina Viano, 135-152. Paris: Vrin, 2005.

Colinet, Andrée. *Les Alchimistes grecs*, XI: *Recettes alchimiques (Par. gr. 2419; Holkhamicus 109) – Cosmas le Hiéromoine, Chrysopée*. Paris: Les Belles Lettres, 2010.

Corrigan, Kathleen. “Iconography”. In *Oxford Handbook of Byzantine Studies*, ed. Jeffreys, Haldon, and Cormack, 67-76.

Cutler, Anthony. “Originality as a Cultural Phenomenon”. In *Originality in Byzantine Literature*, ed. Littlewood, 203-216.

Dufault, Olivier. *Early Greek Alchemy, Patronage and Innovation in Late Antiquity*. Berkeley, CA: California Classical Studies, 2019.

Fagerberg, Jan, David C. Mowery, and Richard R. Nelson, eds. *The Oxford Handbook of Innovation*. Oxford: Oxford University Press, 2005.

Gerolymatou, Maria. *Αγορές, έμποροι και εμπόριο στο Βυζάντιο (9ος-12ος αι.)*. Athens: National Hellenic Research Foundation, Institute for Byzantine Research, 2008.

Godin, Benoît. *Innovation Contested: The Idea of Innovation over the Centuries*. New York: Routledge, 2015.

Halleux, Robert. *Les Alchimistes grecs*, I: *Papyrus de Leyde. Papyrus de Stockholm. Fragments de recettes*. Paris: Les Belles Lettres, 1981.

Harl, Kenneth W. *Coinage in the Roman Economy, 300 B.C. to A.D. 700*. Baltimore, MD: The Johns Hopkins University Press, 1996.

James, Liz. *Light and Colour in Byzantine Art*. Oxford: Clarendon Press, 1996.

Janes, Dominic. *God and Gold in Late Antiquity*. Cambridge: Cambridge University Press, 1998.

Jeffreys, Elizabeth, John Haldon, and Robin Cormack, eds. *The Oxford Handbook of Byzantine Studies*. Oxford: Oxford University Press, 2008.

Kaldellis, Anthony, and Niketas Siniossoglou, eds. *The Cambridge Intellectual History of Byzantium*. Cambridge: Cambridge University Press, 2017.

Kazhdan, Alexander. “Innovation in Byzantium”. In *Originality in Byzantine Literature*, ed. Littlewood, 1-14.

Kazhdan, Alexander, and Anthony Cutler. “Innovation”. In *The Oxford Dictionary of Byzantium*, 3 vols., ed. Alexander P. Kazhdan, II, 997-998. New York: Oxford University Press, 1991.

Keyser, Paul T. “Greco-Roman Alchemy and Coins of Imitation Silver”. *American Journal of Numismatics* 7-8 (1995-1996): 209-234.

Koutalis, Vangelis, Matteo Martelli, and Gerasimos Merianos. “Graeco-Egyptian, Byzantine and Post-Byzantine Alchemy: Introductory Remarks”. In *Greek Alchemy from Late Antiquity to Early Modernity*, ed. Efthymios Nicolaidis, 11-43. Turnhout: Brepols, 2018.

Laiou, Angeliki E., “Economic Thought and Ideology”. In *Economic History of Byzantium*, ed. Laiou, III, 1123-1144.

Laiou, Angeliki E., ed. *The Economic History of Byzantium: From the Seventh through the Fifteenth Century*, 3 vols. Washington, D.C.: Dumbarton Oaks Research Library and Collection, 2002.

Lankila, Tuomo. “The Byzantine Reception of Neoplatonism”. In *Cambridge Intellectual History of Byzantium*, ed. Kaldellis and Siniossoglou, 314-324.

Letrouit, Jean. “Chronologie des alchimistes grecs”. In *Alchimie: art, histoire et mythes*, ed. Didier Kahn and Sylvain Matton, 11-93. Paris and Milan: S.É.H.A. and Archè, 1995.

Linden, Stanton J. *The Alchemy Reader: From Hermes Trismegistus to Isaac Newton*. Cambridge: Cambridge University Press, 2003.

Littlewood, Anthony R., ed. *Originality in Byzantine Literature, Art and Music: A Collection of Essays*. Oxford: Oxbow, 1995.

Lopes da Silveira, Fabiana. “In the Melting Pot: Cultural Mixture and the Presentation of Alchemical Knowledge in the *Letter from Isis to Horus*”. *Ambix* 69.1 (2022): 49-64.

Lowden, John. “Book Production”. In *Oxford Handbook of Byzantine Studies*, ed. Jeffreys, Haldon, and Cormack, 462-472.

Martelli, Matteo. *The* Four Books *of Pseudo-Democritus*. Leeds: Maney Publishing, 2013.

Martelli, Matteo. "The Alchemical Art of Dyeing: The Fourfold Division of Alchemy and the Enochian Tradition". In *Laboratories of Art: Alchemy and Art Technology from Antiquity to the 18th Century*, ed. Sven Dupré, 1-22. Cham: Springer, 2014.

Matschke, Klaus-Peter. "Mining". In *Economic History of Byzantium*, ed. Laiou, I, 115-120.

Mavroudi, Maria. *A Byzantine Book on Dream Interpretation: The* Oneirocriticon of Achmet *and Its Arabic Sources*. Leiden: Brill, 2002.

Mavroudi, Maria. "Science, Byzantine". In *The Encyclopedia of Ancient History*, ed. Roger S. Bagnall *et al.*, 6063-6065. Chichester: Wiley-Blackwell, 2013.

Mavroudi, Maria. "Translations from Greek into Latin and Arabic during the Middle Ages: Searching for the Classical Tradition". *Speculum* 90.1 (2015): 28-59.

Mavroudi, Maria. "Byzantine Translations from Arabic into Greek: Old and New Historiography in Confluence and in Conflict". *Journal of Late Antique, Islamic and Byzantine Studies* 2.1-2 (2023): 215-288.

Mazzarino, Santo. *Aspetti sociali del quarto secolo. Ricerche di storia tardo-romana*. Rome: "L'Erma" di Bretschneider, 1951.

Merianos, Gerasimos. "Alchemy". In *Cambridge Intellectual History of Byzantium*, ed. Kaldellis and Siniossoglou, 234-251.

Merianos, Gerasimos. "Review of O. Dufault. *Early Greek Alchemy, Patronage and Innovation in Late Antiquity*". *Ambix* 67.3 (2020): 319-321.

Merianos, Gerasimos. "Το *Περὶ προνοίας* του Θεοδώρητου Κύρρου ως καινοτόμος προσέγγιση της συνεργασίας πλούσιων και φτωχών". *Icon: Journal on Byzantine Philosophy* 1.1 (2021): 31-44.

Merianos, Gerasimos. "The Christianity of the Philosopher Christianos. Ethics and Mathematics in Alchemical Methodology". *ARYS* 20 (2022): 271-322.

Merianos, Gerasimos. "Insights on Alchemy, Deception, and Artisanal Knowledge in Byzantium". In *Byzanz am Rhein. Festschrift für Günter Prinzing anlässlich seines 80. Geburtstags*, ed. Antje Bosselmann-Ruickbie *et al.*, 145-164. Wiesbaden: Harrassowitz, 2024.

Merianos, Gerasimos, and George Gotsis. *Managing Financial Resources in Late Antiquity: Greek Fathers' Views on Hoarding and Saving*. London: Palgrave Macmillan, 2017.

Mertens, Michèle. "Une scène d'initiation alchimique: la 'Lettre d'Isis à Horus'". *Revue de l'histoire des religions* 205.1 (1988): 3-23.

Mertens, Michèle. "Graeco-Egyptian Alchemy in Byzantium". In *The Occult Sciences in Byzantium*, ed. Paul Magdalino and Maria Mavroudi, 205-230. La Pomme d'or: Geneva, 2006.

Pérez Martín, Inmaculada. "Byzantine Books". In *Cambridge Intellectual History of Byzantium*, ed. Kaldellis and Siniossoglou, 37-46.

Pérez Martín, Inmaculada, and Divna Manolova. "Science Teaching and Learning Methods in Byzantium". In *A Companion to Byzantine Science*, ed. Stavros Lazaris, 53-104. Leiden: Brill, 2020.

Pieper, Josef. *Tradition: Concept and Claim*, trans. by E. Christian Kopff. South Bend, IN: St. Augustine's Press, 2010.

Principe, Lawrence M. *The Secrets of Alchemy*. Chicago, IL: The University of Chicago Press, 2013.

Rampling, Jennifer M. *The Experimental Fire: Inventing English Alchemy, 1300-1700*. Chicago, IL: The University of Chicago Press, 2020.

Ramskold, Lars. "Constantine's Vicennalia and the Death of Crispus". *Niš & Byzantium* 11 (2013): 409-456.

Roberts, Alexandre M. "A Greek Alchemical Epigram in Its Middle Byzantine Context". *Journal of the Warburg and Courtauld Institutes* 83 (2020): 1-36.

Roberts, Alexandre M. "Byzantine Engagement with Islamicate Alchemy". *Isis* 113.3 (2022): 559-580.

Sakorrafou, Sandy, and Gerasimos Merianos. "John Kanaboutzes' Commentary on Dionysios of Halikarnassos: A Perception of Alchemy in a Fifteenth-Century Greek Text". In *Scientific Cosmopolitanism and Local Cultures: Religions, Ideologies, Societies*, ed. Gianna Katsiampoura, 86-94. Athens: National Hellenic Research Foundation, Institute of Historical Research, 2014.

Setton, Kenneth M. "The Byzantine Background to the Italian Renaissance". *Proceedings of the American Philosophical Society* 100.1 (1956): 1-76.

Shils, Edward. *Tradition*. Chicago, IL: The University of Chicago Press, 1981.

Signes Codoñer, Juan. "Ciencia y técnica en Bizancio". In *Ciencia y cultura en la Edad Media. Actas VIII y X*, 215-252. Canary Islands: Consejería de Educación, Cultura y Deportes del Gobierno de Canarias, 2003.

Spanos, Apostolos, "'To Every Innovation, Anathema'(?): Some Preliminary Thoughts on the Study of Byzantine Innovation". In *Mysterion, strategike og kainotomia. Et festskrift til ære for Jonny Holbek*, ed. Harald Knudsen *et al.*, 51-59. Oslo: Novus, 2010.

Spanos, Apostolos, "Was Innovation Unwanted in Byzantium?". In *Wanted: Byzantium. The Desire for a Lost Empire*, ed. Ingela Nilsson and Paul Stephenson, 43-56. Uppsala: Uppsala Universitet, 2014.

Spanos, Apostolos. Working Paper 1: "Rethinking Innovation in Historical Studies", May 2015, https://www.academia.edu/17509179/Rethinking_innovation_in_historical_studies.

Spanos, Apostolos. Working Paper 2: "Rethinking Innovation in Byzantium", October 2015, https://www.academia.edu/16992939/Rethinking_Innovation_in_Byzantium.

Spanos, Apostolos. Working Paper 4: "Innovation as a Mode of Historical Existence", February 2020, https://www.academia.edu/42135932/Innovation_as_a_mode_of_historical_existence.

Steiner, Shannon. *Byzantine Enamel and the Aesthetics of Technological Power, Ninth to Twelfth Centuries*. Unpublished Ph.D. diss., Bryn Mawr College, 2020.

van der Eijk, Philip. "Principles and Practices of Compilation and Abbreviation in the Medical 'Encyclopaedias' of Late Antiquity". In *Condensing Texts – Condensed Texts*, ed. Marietta Horster and Christiane Reitz, 519-554. Stuttgart: F. Steiner, 2010.

van der Eijk, Philip, *et al.* “Canons, Authorities and Medical Practice in the Greek Medical Encyclopaedias of Late Antiquity and in the Talmud”. In *Wissen in Bewegung. Institution – Iteration – Transfer*, ed. Eva Cancik-Kirschbaum and Anita Traninger, 195-221. Wiesbaden: Harrassowitz, 2015.

Viano, Cristina. “Byzantine Alchemy, or the Era of Systematization”. In *The Oxford Handbook of Science and Medicine in the Classical World*, ed. Paul T. Keyser and John Scarborough, 943-964. Oxford: Oxford University Press, 2018.

Vlachou, Constantina. *The Manufacturing and Plating Technology Used in the Production of Mid-3rd/4th Century AD Roman Coins – An Analytical Study*. Unpublished Ph.D. diss. University of Bradford, 2004.

von Lippmann, Edmund O. *Entstehung und Ausbreitung der Alchemie*, I. Berlin: J. Springer, 1919.