

Review

The Persistence of Memory. Exploring the Significance of Glass from Materiality to Intangible Values

Sara Fiorentino *  and Tania Chinni 

Department of Cultural Heritage, University of Bologna—Ravenna Campus, 48121 Ravenna, Italy

* Correspondence: sara.fiorentino2@unibo.it

Abstract: As a material, glass has been linked with knowledge and skill mastery for at least three millennia, reflecting the use of traditional tools and technologies inherited from the past. The history of glass speaks of know-how, technological transitions, and contaminations among preferences and raw materials. An increase in the awareness of traditional knowledge underlying the tradition of glass manufacturing has recently been observed with the inscription of the art of Venetian glass beads on the UNESCO list of Intangible Cultural Heritage of Humanity, which has been recognized as a repository of knowledge and mastery of skills, reflecting the use of traditional tools and technologies inherited from the past. However, the potential that glass holds to rediscover the flows and exchanges of technological knowledge in the past has only been explored marginally, and issues linked to the intangible values and the socio-cultural significance of glass are still only sporadically addressed. This review aims to stimulate reflection on the diversity of the significance underlying glass as a material that has marked the cultural and technological history of man. This study will establish the foundation for a methodological reflection in the approach to the study of ancient glass that is intended to help uncover the intangible values that it is an embodiment for.

Keywords: glass; archaeology; art history; archaeometry; material culture; intangible heritage



Citation: Fiorentino, S.; Chinni, T. The Persistence of Memory. Exploring the Significance of Glass from Materiality to Intangible Values. *Heritage* **2023**, *6*, 4834–4842. <https://doi.org/10.3390/heritage6060257>

Academic Editor: Artemios Oikonomou

Received: 2 May 2023
Revised: 14 June 2023
Accepted: 16 June 2023
Published: 19 June 2023



Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The development of glass technology over time has been accompanied by changes in the raw material and manufacturing processes that have arisen all over the world [1]. The skilled craftsmen experienced in glass making and manufacturing were the leaders of these flows, influenced by historical events, political facts, economic drivers, and environmental factors that impacted on the movements of workers, materials and, finally, objects [2]. While the year of discovery or the culture that first used this material has still not been determined with certainty, archaeological finds and historical texts have revealed that glass, as a luxury item, played an important social role in ancient societies [3]. Probably in the land, which is now known as Syria, the technique of blowing glass was invented two millennia ago, and it changed the way this material was conceived: glass vessels became necessary items for transportation, trade, and storage of food, beverages, and other goods.

When molds were introduced to control the shape, artisans were free to create larger, more dynamic, and intricate objects, which were collected, traded, and given as diplomatic gifts [4]. The role of glass in our shared human cultural and material heritage has further grown over the last millennium: church windows have spanned the length of religious buildings, allowing light to flood the interior of sacred spaces [5,6]; highly decorated goblets have celebrated a dynasty's reign, and mosque lamps communicated a patron's generosity [7]; float glasses have come to dominate our architectural skyline in the last century, while in the art world it has transcended its classification as a craft material, becoming integrated into the fine arts.

In terms of manufacturing techniques, forms, and raw materials, glass has experienced significant changes throughout the history of humanity. Therefore, to ascertain whether and

how much of human technological and cultural knowledge is concealed in material culture, glass has the potential to therefore be a comprehensive source of information. Despite being one of the oldest pyro-technologies with ceramics and metals, glass has received limited attention due to its appearance on archaeological excavations generally being viewed as sparse and uninformative. This mistaken belief of glass being less informative than other materials—such as ceramics, which are frequently used as a “guide fossil” in the dating of archaeological stratigraphy—may have been influenced by the fact that the majority of glass recovered from archaeological sites is frequently in a high-fragmented state. A misclassification of this material, often resembling faience, ceramic, or stone, could also result from the severe weathering that glass can undergo, thereby compromising its conservation and appearance [8].

Although, as more extensively discussed in the following sections, research over the past decades have provided a better clarification of production cycles, economic regions, and technical aspects underlying the history of glass manufacture, and the potential that this material holds in rediscovering the flows and exchanges of technological knowledge in the past has been explored marginally. Therefore, issues more closely linked to the relationship between the objects and the people who made, used, and re-used them, as well as to the intangible values and the socio-cultural significance of glass, remains occasionally addressed for specific productions.

This paper aims to stimulate discussions on how glass is a repository of knowledge and values that go far beyond its materiality. An examination of how the meaning of our cultural artifacts—including the intangible values and the significance that underlie the manufacture of such objects—evolved over time will serve as the basis for this reflection. The discussion will then move on to how glass as a material is currently becoming part of those expressions of ancient manufacture that are also being recognized by UNESCO as a tangible and intangible evidence of the history of mankind, to finally focus on a concise review of the main aspects investigated so far in the history of glass, with a focus on the methodological approach.

2. Relevant Sections

2.1. *Material Culture as an Archive of Intangible Values*

Objects belonging to our material culture are the most effective and direct means of understanding past societies, as they give access to the vectors of knowledge, ideas, and relationships. In doing so, objects strengthen the comprehension of the aspects of daily life, preferences, and needs that would otherwise be challenging to access in the past [9,10].

Material culture can be defined as the objects that represent or were created by a group of people within a particular culture. Although scholars have been examining objects, their functions, and their meanings ever since the advent of modern social science scholarship, “material culture studies” has only recently been defined as a disciplinary field, encompassing a variety of scholarly research into the functions and significance of these objects [11,12]. Due to its specific significance, material culture, as part of our cultural heritage, holds the hidden potential to show how tangible and intangible features of cultural objects are two sides of the same coin. The legacy of cultural heritage is, in fact, not only tangible: it also includes testimonies of the living, intangible heritage of humankind, witnessing its evolution and development. Oral traditions, performing arts, rituals, knowledge, and practices concerning skills to produce crafts define these so-called intangible heritage, and therefore must be preserved as memories of humankind.

The definition of intangible heritage and its better appreciation as a source of identity, creativity, and diversity has greatly contributed to drawing a more comprehensive approach to the study of cultural heritage. The signing of the UNESCO Convention for the Safeguarding of Intangible Cultural Heritage (<https://ich.unesco.org/en/convention> (accessed on 31 May 2023)) has encouraged the establishment of a new vision, centered on the connection between tangible and intangible expressions. Instead of solely focusing on cultural products, the emphasis has been shifted to the processes that must be preserved.

In this view, heritage is identified not with tangible manifestations, but with the human activities that underpins and enables their production [13]. Intangible cultural heritage values include dexterity, know-how, the skilled use of tools, and the selection of raw materials, as well as tradition, and the identity of the communities in which they are, or were, practiced. All these immaterial components have the same dignity as the material ones since they define the significance of material culture.

As far as glass is concerned, an increase in the awareness of the intangible values beyond its millenary tradition has been observed in recent years, the most remarkable example being the recent inscription of the art of Venetian glass beads in the UNESCO list of Intangible Cultural Heritage of Humanity (<https://ich.unesco.org/en/RL/the-art-of-glass-beads-01591> (accessed on 28 May 2023)). Besides being tangible objects, the Murano beads were recognized as a repository of knowledge and mastery of skills, reflecting the use of traditional tools and technologies inherited from the past. Mainly transmitted informally from masters to apprentices, Venetian glass bead making promotes social cohesion and a collective identity among practitioners through shared memories and spaces.

It should be emphasized, nonetheless, that the history of glass as a whole, not just the production of Murano beads, is representative of traditional knowledge and know-how, of technological advancements, and of the relationships and contacts between different cultures. The outcomes of the Horizon 2020 Mingei project (<https://www.mingei-project.eu/> (accessed on 28 May 2023)), which investigated novel approaches for expressing and making both accessible tangible and intangible components of three traditional crafts—glass, mastic, and silk—were deemed as notable in this regard. To preserve and illustrate the skills and gestures of the craftspeople, Mingei captured the motion and tool usage of heritage craft practitioners from the Living Human Treasures and archive documentaries. For a variety of audiences, multimedia contents, interactive museum installations, events, and seminars were developed with the goal of focusing attention not only on the final object, but rather on the meanings and knowledge for which it is the custodian.

2.2. *Understanding Glass: Where Are We Now and What Is Still Missing?*

Over the past few decades, our knowledge of the distribution of glass through time and space has undoubtedly increased, and major progresses have been made in understanding this material and its story, leading to the emergence of a multifaceted picture [1,2]: the growing number of case studies has contributed to the development of a broader scenario from a geographical and chronological perspective, and the increasing accessibility to analytical equipment has further incremented the amount of available data [14]. From an archaeological perspective, the approach taken in the field of applied research to the study of glass has primarily been geographical or chronological in nature, with two main scopes: targeting, through excavations and technical sites where production and/or working remains were unearthed [15–17], and tracing the development of the specific shapes and typologies of the objects through the ages. From an archaeometry perspective, there are a number of major “families” of glass composition that have been identified, such as plant-ash based glass in Late Bronze Age Egypt, Mesopotamia [18,19], and the Islamic World [20–22]; mineral natron glass in the Greek [23–25], Roman [4], and Byzantine Empires [26]; mineral-based lead- and lead-barium glass during the Han period in China [27]; and wood-ash and plant ash-lime glass in medieval Europe [28–30]. New challenges have also been posed by the expanding accessibility of analytical equipment: glass materials have been tried to be provenanced to their primary production centers due to the ability to distinguish their production groups based on the chemical features of their raw materials, and the use of LA-ICP-MS has, for instance, significantly improved analytical resolution [31]. This has undoubtedly opened a window into trace element signatures, the meaning of which still needs to be fully explored as new issues to be faced emerge, with specific reference to certain compositional categories of glass [20].

More recently, the body of knowledge has increased thanks to ERC-funded projects. The ARCHGLASS project (FP7-IDEAS-ERC, agreement ID 240750) investigated the pro-

duction and consumption locations of raw glass obtained from the Hellenistic and Roman worlds. Isotope geochemical analysis were conducted by ARCHGLASS to characterize raw glass and mineral resources at primary production sites as well as finished glass artefacts at consumer sites [25]. More recently, the GlassRoutes project (H2020-EU.1.1. EXCELLENT SCIENCE—European Research Council, agreement ID 647315) explored how glass production, trade, and consumption constituted a significant portion of the medieval Mediterranean economy between the 4th and the 12th century AD [20]. These projects enabled the creation of large databases of reliable chemical data, from which models of the distribution of specific groups of glass production were proposed. The obtained results have undoubtedly allowed for the clarification of the economic regions and technical aspects underlying the selection of specific raw materials, as well as the exploration of the political impact on glass trade in various historical periods. Nevertheless, issues more closely linked to the relationship between the object and the people who made and used them either remain unexplored, or only addressed for specific elitist productions, such as mosaics [32]. To better understand the socio-cultural context in which these objects were produced, as well as examine the relationships between the objects and the ancient societies, it is essential to go forward in order to recover the many intangible meanings and values that glass, as a millennium-old material, is the depositary for. In addition to increasing the knowledge of the history of glass as a material, applied research to archaeological and historical-artistic glass has the potential to contribute to the rediscovery and revitalization of this ancient manufacturing art. To accomplish this, it is therefore crucial that research in this field provide understandings into the socio-cultural context in which the glass product is an expression, rather than having the analysis of an object or assemblage of objects as its ultimate goal.

2.3. Rethinking the Methodological Approach

While the interest of a growing number of academics in studying ancient glass has, on the one hand, resulted in a significant expansion of the datasets available, it has also given rise to a variety of methodological approaches. Although there has been an increasing trend towards the integration of humanities and science in recent decades [33,34], this has not always resulted in a long-term and well-integrated cooperation among these disciplines. What occurs more frequently in the field of glass studies is that, on the one hand, archaeologists and/or art historians frequently turn to applied sciences to answer open questions primarily related to the provenance and dating of the objects, or as a scientific support to confirm previously formulated hypotheses; on the other hand, scientific analyzes leave a space that is not always adequate for archaeological, historiographic, and anthropological considerations, occasionally leading to a discussion of extreme detail regarding numerical data. All this works against a genuine joint research effort, which is essential for understanding material culture as vector of knowledge and know-how from the past to the present.

The definition of a shared language is undoubtedly one of the most important concerns that needs to be addressed. In fact, the employment of an inhomogeneous lexicon is a problem that jeopardizes not only the communication between academics and professionals from other disciplinary fields, but also—and perhaps most importantly—the various research areas applied to the study of glass. In terms of archaeometry, the nomenclature and color coding of mosaic tesserae may serve as an example. As a chrono-typological study is unfeasible for this category of object, color and opacity are the only features that can be used to define chromatic coordinates in an objective way, and to support a scientific-based selection among the copious assemblages of samples to be analyzed. As more extensively discussed elsewhere [35,36], a combined standard color system chart (such as NCS Index or PANTONE) and visible reflectance spectroscopy (VIS-RS) approach can be used to support an objective definition of the chromatic hues and shades of deeply colored glass, thereby avoiding any subjective nomenclature.

Analogously, the naming of the various components and—if applicable—decorative features of a glass object, which are an essential starting point in identifying fragments, and the fine-tuning of a full chrono-typological study, highly depends on the usage of a shared and validated lexicon in the archaeological field. Viewed in perspective, this will help to facilitate an inter-typological comparison and reduce the risk of comparing pieces referring to distinct objects, thereby allowing for more precise comparisons between fragments pertaining to the same types of objects.

The study of degradation morphologies, with specific reference to archaeological glass, raises significant challenges that are related to the lack of a shared terminology. The onset and development of many forms of degradation affecting archaeological glass are still unknown according to current knowledge, as well as the extent to which these elements can jeopardize the durability of glass. To date, most research on glass deterioration and their associated mechanisms has focused on European medieval window glass, while very little attention has been paid to the degradation morphologies affecting archaeological artefacts [37–43]. Additionally, there is a lack of a common and tailored vocabulary among academics and specialists from various fields working on degraded archaeological glass and their related conservation strategies [8]. This prevents a uniform and objective description of the degradation morphologies affecting glass, thereby making comparisons of data pertaining to various assemblages of artefacts extremely complicated.

In terms of re-thinking the methodological approach, the need to shift away from the conventional descriptive and frequently fragmented data collection phase (which is typically based on understanding the single case study and/or a set of objects) and move towards a more interpretative phase, which focuses on the “why” and “how” of cultural and technical developments, was emphasized in a pivotal paper [1]. Here, the authors highlighted the need to combine data more effectively from different disciplines, incorporating analytical data into useful frameworks for anthropological, archaeological, social, and economic studies. To achieve this, a significant shift in perspective is necessary in how research on archaeological and historical-artistic glass is conducted, with a focus on developing more comprehensive research questions as opposed to a single case study. Furthermore, it is crucial that these questions concern “how” and “why”, and not only “where” and “when”. However, there is still a noticeable level of fragmentation in applied research, and the successful conversation between many disciplines is still frequently failing to materialize, as more recently shown by a reflection on the possibilities of synergistic research methodologies in the study of glass [35]. Moving from a critical-thinking perspective upon previously performed research, the authors reflected on the potential of fostering the integration of archaeological and historical knowledge with data-driven scientific analyzes. The relevance of approaching the study of glass objects beginning with an in-depth understanding of the physical and socio-cultural context that they were found in emerged as a key requisite for setting up inter-disciplinary study approaches aimed at answering specific research questions.

To understand the socio-cultural context in which objects are found/made, as well as the relationships between these objects and the ancient societies, it is therefore necessary to move beyond the notion that the primary goal of the chemical characterization of glass is to assess commercial exchanges under a specific political influence, and to hypothesize contacts between different geographical areas. Other socio-cultural factors must be included as variables in the equation to avoid a partial and potentially erroneous scenario. Archaeological and historical glass is, in fact, an enormously heterogeneous class of materials, encompassing objects made for different uses, and manufactured in different periods and geographic areas with a variety of tools and working techniques. If all these factors are not adequately considered, we are therefore only looking at part of the scenario, and we are only telling part of the story.

This notion has already started to clearly emerge based on a study conducted on everyday drinking glass beakers sold in the 14th century in the northern Adriatic region [44]. The study has, in fact, demonstrated that the production of everyday objects does not

univocally reflect what was established by political influences dominating the commercial trades. According to official documents, Levantine ashes should have been the only type of ashes permitted in the manufacture of glass for the Doge's political will, and other types were expressly forbidden [45]. However, the chemical analysis of common glass beakers found in the Venetian-influenced north Adriatic region revealed the use of other kinds of ashes for making glass. Expanding the research to archives in other parts of the Adriatic region, an exchange of letters between the Florentine and Spanish merchants in the Venetian-influenced city of Ancona in 1406 were also found, attesting the purchase of Spanish ashes for making glass. This decision might have been made for "other" reasons besides the Doge's political agenda, such as the glass masters' preference for a better raw material, the finished product's affordability on the local market, or the desire to stick to a recipe that has been passed down through the generations in a particular workshop. This case seems not to have been unique, as demonstrated by preliminary data from the region surrounding the ancient city of Samarkand in Uzbekistan [46]. This study focused on two glass assemblages, one from the Kafir Kala citadel, which was strategically situated to control a local passageway along the Silk Roads, and the other from Cholaktepa, a site about 21 km northwest of Kafir Kala where a furnace's ruins and glass wastes were discovered, leading to the theory that a local glass-working operation existed there. Results of the chemical analyzes demonstrated that the glass vessels recovered in the citadel of Kafir Kala were, on the contrary, not locally made, as the raw materials used differ from that in Cholaktepa. Possible explanations include the theory that Kafir Kala served as the pre-Islamic king's rural residence, and the administrative role that the citadel of Kafir Kala performed at the time of the Arab conquest. On the one hand, it is highly likely that the glass vessels discovered here were not made locally, but rather imported to meet the demands of an elite customer. On the other hand, the glass-working debris found at Cholaktepa suggested that local manufacturing may have been targeted at a different population group. These two case studies have been brought in to show how not exclusively political influences and commercial routes, but also socio-cultural and technological factors dominated glass manufacturing; moreover, such factors do not appear to have impacted only specific geographic areas nor historical periods.

The potential of synergistic and cross-disciplinary approaches to the study of window glass and stained glass, with a focus on religious buildings, is another interesting example. Initially used, almost exclusively in civil construction and residential buildings, from the Constantinian age onwards, window glass became an integral part of the architectural system. In the Byzantine period and the Middle Ages, the use of window glass in religious architecture was invested with a symbolic meaning, linked to the genesis of lighting and chromatic effects for accentuating the sacredness of the liturgical space and emphasizing the decorative apparatuses [5,6]. The interaction between light and matter needs to be fully explored for a comprehensive study of window glass: from the production and manufacturing technology, to socio-cultural, archaeological, and historical-artistic factors, and religious symbolism [47]. From a technological point of view, the very interesting aspect linked to the practice of reusing glass tesserae from dismantled mosaics for making colored window glass, as attested at the Monastic Complex of San Vincenzo al Volturno (Isernia, Italy) in accordance with the practice described by Theophilus Presbyter in *De Diversis Artibus*, remains to be explored [48,49]. It is unclear, with the current state of knowledge, how widespread this practice was. Unresolved issues include whether this practice had unique cultural connotations, or was solely motivated by economic concerns and the scarcity of materials as a result of the decline in trade that impacted the Mediterranean basin between the eighth and ninth century [47,50].

Comprehensive studies of the material features of objects can lay the groundwork to shed light on the technical knowledge and socio-cultural practices underpinning their production. However, only a well-integrated, transdisciplinary approach can pave the way for a thorough understanding of the historical, socio-cultural, and technological issues for which glass objects of our past were witnesses. An actual co-participatory

approach between disciplines related to different research fields is, in fact, the only tool capable of overcoming these limits that, by its intrinsic nature, each discipline considered individually has.

An interesting key to the approach to this topic could be the investigation of processing techniques through the ages, carried out through the contribution of humanistic and scientific disciplines. The manufacturing process, which entails the choice and manipulation of raw materials, as well as gestures, technological know-how, technical skills, and the transmission of knowledge, includes meanings that flow into the historical, socio-cultural, geographical, and economic dimensions, and go far beyond the materiality of the finished objects. Working techniques, tools, and gestures have the power to reflect the genuine meaning of items as an archive of intangible legacy and knowledge, as the Mingei project revealed in relation to a few forms of traditional crafts. In the specific case of glass, adopting—and adapting—a similar method to the study of historical objects may help reveal the technical and cultural information (lexicon, gestural proficiency, technological awareness, and know-how) that went into the manufacture of these objects by looking at their materiality. When observing from a larger perspective, this kind of study approach might help close the gap between tangible and intangible legacy.

3. Conclusions

The purpose of this review was to provide a broad framework for understanding the role of archaeological and historical-artistic glass as an expression of our material culture. It emerged how glass must be considered as a proper locus of meaning, a material that for at least three millennia has been the repository of traditional knowledge and technological know-how for humankind. Glass production and manufacture are thus custodians of intangible values that tell the cultural and technological histories of man through the transmission of gestures, know-how, technical knowledge, reasoned tool use, and careful raw material selection.

Applied research to ancient glass can play a fundamental role in encouraging the rediscovery, preservation, and transmission of these intangible values. To achieve this aim, it is therefore necessary to rethink the methodological approach, with a shared view of directing future research perspectives towards aspects that have only been tangentially explored so far, fostering a 360 degree cognitive approach. The need to move away from the traditional data collection phase—which is typically descriptive, based on understanding a single case study and/or a set of objects—and towards a more interpretative phase, which focuses on the “why” and “how” of cultural and technological development, has been emphasized. Glass objects can tell stories of movements and relationships, the knowledge of which cannot be ignored if the goal is to understand the actors and engines of economic mechanisms behind past societies. Hence, these objects are proper archives of knowledge from the past that cannot be understood without a strong transdisciplinary research effort.

The lack of a common and tailored vocabulary among the academics and specialists working on glass is also a major gap that needs to be filled through close collaboration between disciplinary fields dealing with the study of glass (i.e., archaeology, art history, architecture, archaeometry, anthropology, material culture studies, etc.). Such a coordinated effort will improve data and information sharing, supporting, for instance, the identification and comparison of specific shapes and decorative features that are relevant to the chrono-typological studies, or for the nomenclature, identification, and characterization of degradation morphologies affecting glass conservation.

To conclude, a joint effort is needed to implement synergistic and complementary approaches between different disciplinary fields, which is functional for a better understanding of the multiplicity of meanings underlying the production and distribution of glass objects. Shifting the focus away from objects per se and emphasizing the process, and the intangible aspects behind their manufacture will result in the preservation and better understanding of intangible cultural components, such as lexicon, gestures, materials and recipes, working techniques, and the exchange of ideas. Framed in a broadened

scenario, this will lead to a better understanding of the relationships between people and objects, a connection that has shaped human history and given physical objects the ability to signify things.

Author Contributions: Conceptualization, S.F.; methodology, S.F. and T.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: No new data were created for this review.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Rehren, T.; Freestone, I. Ancient glass: From kaleidoscope to crystal ball. *J. Archaeol. Sci.* **2015**, *56*, 233–241. [CrossRef]
2. Rosenow, D.; Phelps, M.; Meek, A.; Freestone, I. *Things That Travelled. Mediterranean Glass in the First Millennium CE*; UCL Press: London, UK, 2018.
3. Henderson, J. *Ancient Glass: An Interdisciplinary Exploration*; Cambridge University Press: Cambridge, UK, 2013.
4. Bayley, J.; Freestone, I.; Jackson, C. *Glass of the Roman World*; Oxbow Books: Oxford, UK, 2015.
5. Dell'Acqua, F. Enhancing luxury through Stained Glass, from Asia Minor to Italy. *Dumbart. Oaks Pap.* **2005**, *59*, 193–211. [CrossRef]
6. Dell'Acqua, F. *Illuminando Colorat. La Vetrata tra l'età Tardo Imperiale e l'alto Medioevo: Le Fonti, L'archeologia*; Centro Italiano di Studi sull'alto Medioevo: Spoleto, Italy, 2003.
7. Carboni, S.; Whitehouse, D. *Glass of the Sultans*; Metropolitan Museum of Art: New York, NY, USA, 2001.
8. Fiorentino, S.; Chinni, T.; Galusková, D.; Mantellini, S.; Silvestri, A.; Berdimuradov, A.E.; Vandini, M. On the Surface and Beyond. Degradation Morphologies Affecting Plant Ash-Based Archaeological Glass from Kafir Kala (Samarkand, Uzbekistan). *Minerals* **2021**, *11*, 1364. [CrossRef]
9. Sainsbury, V.A.; Bray, P.; Gosden, C.; Pollard, A.M. Mutable objects, places and chronologies. *Antiquity* **2021**, *95*, 215–227. [CrossRef]
10. Chinni, T. *Produzione e Circolazione dei Manufatti In Vetro in Romagna nel Medioevo (V-XV sec.)*. Doctoral Thesis, University of Bologna, Bologna, Italy, 2017. Available online: <https://amsdottorato.unibo.it/8243/> (accessed on 5 April 2023).
11. Dant, T. *Material Culture in the Social World*; Open University Press: Buckingham, UK, 2007.
12. Woodward, I. *Understanding Material Culture*; SAGE: London, UK, 2007.
13. Bortolotto, C. From objects to process: UNESCO's Intangible Cultural Heritage. *J. Museum Ethnogr.* **2007**, *19*, 18–19.
14. Janssens, K. *Modern Methods for Analysing Archaeological and Historical Glass*; John Wiley & Sons Ltd.: Hoboken, NY, USA, 2013.
15. Gorin-Rosen, Y. The ancient glass industry in Israel: Summary of the finds and new discoveries. In *La Route du Verre. Ateliers Primaires et Secondaires du Second Millénaire av. J.-C. au Moyen Âge*; Colloque organisé en 1989 par l'Association française pour l'Archéologie du Verre (AFAV), Lyon, France; Nenna, M.D., Ed.; Maison de l'Orient et de la Méditerranée Jean Pouilloux: Lyon, France, 2000; pp. 49–63.
16. Nenna, M.-D.; Picon, M.; Vichy, M. Ateliers primaires et secondaires en égypt a l'époque gréco-romaine. In *La Route du Verre. Ateliers Primaires et Secondaires du Second Millénaire av. J.-C. au Moyen Âge*; Colloque organisé en 1989 par l'Association française pour l'Archéologie du Verre (AFAV), Lyon, France; Nenna, M.D., Ed.; Maison de l'Orient et de la Méditerranée Jean Pouilloux: Lyon, France, 2000; pp. 97–112.
17. Pusch, E.; Rehren, T. *Rubinglas für den Pharao. Forschungen in der Ramses-Stadt, Band 6*; Gerstenberg Verlag: Hildesheim, Germany, 2007; Volume 1.
18. Rehren, T.; Pusch, E.B. Late Bronze Age glass production at Qantir-Piramesses, Egypt. *Science* **2005**, *308*, 1756–1758. [CrossRef]
19. Smirniou, M.; Rehren, T. Direct evidence of primary glass production in late bronze age amarna, Egypt. *Archaeometry* **2011**, *53*, 58–80. [CrossRef]
20. Schibille, N. *Islamic Glass in the Making: Chronological and Geographical Dimensions*; Leuven University Press: Leuven, Belgium, 2022.
21. Phelps, M. *An Investigation into Technological Change and Organisational Developments in Glass Production between the Byzantine and Early Islamic Periods (7th–12th Centuries) Focussing on Evidence from ISRAEL*. Doctoral Thesis, University College of London, London, UK, 2017. Available online: <https://discovery.ucl.ac.uk/id/eprint/1551577/> (accessed on 5 April 2023).
22. Henderson, J.; Evans, J.; Barkoudah, Y. The roots of provenance: Glass, plants and isotopes in the Islamic Middle East. *Antiquity* **2009**, *83*, 414–430. [CrossRef]
23. Kordas, G. *Hyalos Vitrum Glass: History, Technology and Conservation of Glass and Vitreous Materials in the Hellenic World*; Glasnet Publications: Athens, Greece, 2002.
24. O'Hea, M. Greeks and glass; the role of Hellenistic Greek settlements in the Eastern Mediterranean in glass production and consumption. *Mediterr. Archaeol.* **2006**, *19–20*, 141–150.
25. Degryse, P. *Glass Making in the Greco-Roman World: Results of the ARCHGLASS Project*; Leuven University Press: Leuven, Belgium, 2014.
26. Entwistle, C.; James, L. *New Light on Old Glass: Recent Research on Byzantine Mosaics and Glass*; The British Museum: London, UK, 2013.
27. Fuxi, G.; Brill, R.H.; Shouyun, T. *Ancient Glass Research along the Silk Road*; World Scientific Publishing Company: Singapore, 2009.

28. Adlington, L.W.; Freestone, I.C.; Kunicki-Goldfinger, J.J.; Ayers, T.; Gilderdale Scott, H.; Eavis, A. Regional patterns in medieval European glass composition as a provenancing tool. *J. Archaeol. Sci.* **2019**, *110*, 104991. [[CrossRef](#)]
29. Zimmermann, M. Natronhandel und Glasherstellung im Frühmittelalter [Production of glass in early middle ages]. *Sudhoffs Archaeol.* **2011**, *95*, 94–114. [[CrossRef](#)]
30. Vandini, M.; Chinni, T.; Fiorentino, S.; Galusková, D.; Kaňková, H. Glass production in the Middle Ages from Italy to Central Europe: The contribution of archaeometry to the history of technology. *Chem. Pap.* **2018**, *72*, 2159–2169. [[CrossRef](#)]
31. Gratuze, B. Glass characterization using Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry methods. In *Recent Advances in Laser Ablation ICP-MS for Archaeology*; Dussubieux, L., Golitko, M., Gratuze, B., Eds.; Springer: Amsterdam, The Netherlands, 2016; pp. 179–196.
32. Schibille, N.; Lehuédé, P.; Biron, I.; Brunswic, L.; Blondeau, É.; Gratuze, B. Origins and manufacture of the glass mosaic tesserae from the great Umayyad Mosque in Damascus. *J. Archaeol. Sci.* **2022**, *147*, 105675. [[CrossRef](#)]
33. Artioli, G. *Scientific Methods and Cultural Heritage: An Introduction to the Application of Materials Science to Archaeometry and Conservation Science*; Oxford University Press: Oxford, UK, 2010.
34. Edwards, H.; Vandenaabeele, P. *Analytical Archaeometry: Selected Topics*; Royal Society of Chemistry: London, UK, 2012.
35. Fiorentino, S.; Chinni, T.; Vandini, M. Materials Inspiring Methodology: Reflecting on the Potential of Transdisciplinary Approaches to the Study of Archaeological Glass. *Appl. Sci.* **2021**, *11*, 8049. [[CrossRef](#)]
36. Fiorentino, S. A tale of two legacies: Byzantine and Egyptian influences in the manufacture and supply of glass tesserae under the umayyad caliphate (661–750 AD). *Heritage* **2021**, *4*, 2810–2834. [[CrossRef](#)]
37. Davidson, S. *Conservation and Restoration of Glass*, 2nd ed.; Butterworth-Heinemann: London, UK, 2003.
38. Freestone, I.C. Post-depositional changes in archaeological ceramics and glasses. In *Handbook of Archaeological Science*; Brothwell, D.R., Pollard, A.M., Eds.; Wiley: Hoboken, NJ, USA, 2001; pp. 615–620.
39. Silvestri, A.; Molin, G.; Salviulo, G. Archaeological glass alteration products in marine and land-based environments: Morphological, chemical and microtextural characterization. *J. Non. Cryst. Solids* **2005**, *351*, 1338–1349. [[CrossRef](#)]
40. Gulmini, M.; Pace, M.; Ivaldi, G.; Ponzi, M.N.; Mirti, P. Morphological and chemical characterization of weathering products on buried Sasanian glass from central Iraq. *J. Non. Cryst. Solids* **2009**, *355*, 1613–1621. [[CrossRef](#)]
41. Majérus, O.; Lehuédé, P.; Biron, I.; Alloteau, F.; Narayanasamy, S.; Caurant, D. Glass alteration in atmospheric conditions: Crossing perspectives from cultural heritage, glass industry, and nuclear waste management. *Mater. Degrad.* **2020**, *4*, 27. [[CrossRef](#)]
42. Gueli, A.M.; Pasquale, S.; Tanasi, D.; Hassam, S.; Lemasson, Q.; Moignard, B.; Pacheco, C.; Pichon, L.; Stella, G.; Politi, G. Weathering and deterioration of archeological glasses from late Roman Sicily. *Int. J. Appl. Glas. Sci.* **2020**, *11*, 215–225. [[CrossRef](#)]
43. Lombardo, T.; Gentaz, L.; Verney-Carron, A.; Chabas, A.; Loisel, C.; Neff, D.; Leroy, E. Characterisation of complex alteration layers in medieval glasses. *Corros. Sci.* **2013**, *72*, 10–19. [[CrossRef](#)]
44. Chinni, T.; Fiorentino, S.; Silvestri, A.; Vandini, M. Gambassini on the road. Underpinning evidence for a medieval widespread glass production in the north Adriatic area. *J. Archaeol. Sci. Rep.* **2021**, *37*, 103039. [[CrossRef](#)]
45. Ashtor, E.; Cevidalli, G. Levantine alkali ashes and european industries. *J. Eur. Econ. Hist.* **1983**, *12*, 475–522.
46. Chinni, T.; Fiorentino, S.; Silvestri, A.; Mantellini, S.; Berdimuradov, A.E. Glass from the Silk Roads. Insights into new finds from Uzbekistan. *J. Archaeol. Sci. Rep.* **2023**, *48*, 103841. [[CrossRef](#)]
47. Fiorentino, S.; Tronca, D. Heaven is a Place on Earth. Un progetto sul significato del vetro dalla storia dell’oggetto alla storia dell’immaginario. In Proceedings of the La Multidisciplinarieta Nella Ricerca sul Vetro. XX Giornate Nazionali di Studio sul Vetro, Ravenna, Italy, 18–19 May 2019; Fantigrafica Srl: Cremona, Italy, 2022; pp. 261–265.
48. Schibille, N.; Freestone, I.C. Composition, Production and Procurement of Glass at San Vincenzo al Volturno: An Early Medieval Monastic Complex in Southern Italy. *PLoS ONE* **2013**, *8*, e0076479. [[CrossRef](#)] [[PubMed](#)]
49. Chinni, T.; Silvestri, A.; Fiorentino, S.; Vandini, M. Once upon a Glass—Cycles, Recycles and Reuses of a Never-Ending Material. *Heritage* **2023**, *6*, 662–671. [[CrossRef](#)]
50. James, L.; Soproni, E.; Bjornolt, B. Mosaics by Numbers. Some Preliminary Evidence from the Leverhulme Database. In *New Light on Old Glass: Recent Research on Byzantine Mosaics and Glass*; Entwistle, C., James, L., Eds.; The British Museum: London, UK, 2013; pp. 310–328.

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.