MEDIEVAL TECHNICAL TEXTS AND EXPERIMENTAL APPROACHES. A THEORETICAL PERSPECTIVE ON THE VALUE OF TECHNICAL RECIPES AS SOURCES TO RECONSTRUCT THE HISTORY OF MEDIEVAL GLASSMAKING PRACTICES

TEXTOS TÉCNICOS MEDIEVALES Y ENFOQUES EXPERIMENTALES. UNA PERSPECTIVA TEÓRICA SOBRE EL VALOR DE LAS RECETAS TÉCNICAS COMO FUENTES PARA RECONSTRUIR LA HISTORIA DE LAS PRÁCTICAS VIDRIERAS MEDIEVALES

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ABSTRACT
This paper aims to present a theoretical perspective on the use of experimental approaches to enhance the value of medieval 'technical' recipes as sources for the study of broader craft practices in the past. After presenting the nature of some of these texts and reviewing previous experimental studies related to medieval glassmaking, we explain several experiments based on the *Epistola Abbreviatoria*, a glassmaking-focused late medieval text from the Iberian Peninsula, to illustrate the potential of combining the study of these recipes and the experimental approach for a better understanding of wider glassmaking practices in the Middle Ages.

KEYWORDS
Middle Ages; Iberian Peninsula; Practice; Experimental Approach; Glassmaking.

RESUMEN
El presente artículo aspira a presentar una perspectiva teórica sobre el uso del método experimental para incrementar el valor de las recetas 'técnicas' medievales como fuente para el estudio de las prácticas artesanales del pasado. Tras presentar la naturaleza de algunos de estos textos y repasar anteriores trabajos experimentales relacionados con la producción de vidrio, explicamos varios experimentos basados en la *Epistola Abbreviatoria*, un texto sobre la producción de vidrio producido en la península ibérica en la Baja Edad Media, para ilustrar el potencial que la combinación del estudio de estas recetas y el método experimental tiene para el estudio de las prácticas de producción de vidrio en la Edad Media.

PALABRAS CLAVE
Edad Media; península ibérica; Práctica; Método Experimental; Producción de Vidrio.

1. SETTING OUT THE PROBLEM

Recent decades have witnessed the steady growth of two originally unrelated historiographical fields, that of the application of experimental approaches to historical and

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archaeological studies, and that of the examination of medieval 'technical documents' as a source for the study of past technological practices. The obvious points of contact between these fields made it inevitable that they would end up converging fully, but it is these very obvious conditions of 'mutual attraction' that must make us extra wary of obvious answers.

In essence, experimentation in historical and archaeological studies aims at trying to replicate past practices or processes to understand them better. Experiment must be based on what historical and archaeological evidence is available for those practices or processes and seeks to reveal those variables evidence for which has not survived. This is a wide definition, which covers from palaeolithic knapping techniques to the pace at which irrigation channels clog up and require maintenance.

On the other hand, what we have termed above (not capriciously, between quotation marks), as medieval 'technical documents' is in fact a heuristic category which embraces highly miscellaneous and elastic collection of texts brought together by the fact that they provide some degree of technical information about past technological practices.[3] This category can be said to range, without overstretching the seams too much, from Isidore of Seville's *Etymologies*,[4] to early modern systematic treatises such as Vannocio Biringuccio's famous *Pirotechnia*.[5] It is important to note that, while both Isidore's and Biringuccio's intentions were clear (the former aimed to make an erudite compendium of knowledge, heavily based on Classical authorities, and the other tried to bring together the most up-to-date practical knowledge of his own trade, a phenomenon that became widespread in the Early Modern Period),[6] the purpose behind some other works is not. Specifically, we are referring to compendia of technical recipes that become particularly common in the Late Middle Ages (although some of them are significantly earlier).[7] Some of these compilations have some degree of thematic coherence, but most appear to include recipes related to disparate and unrelated practices in no apparent logical order. As noted, there is no agreement concerning the function of most of these compilations, notably, with regard to their role in the transmission of technological practices. Ricardo Córdoba de la Llave, for instance, has argued that the practice of especially complex trades, such as gold assaying and cloth dyeing, could not have been taught without written support,[8] while Daniéle Alexandre-Bidon and Didier Lett hold the, perhaps more widely shared, view that the learning of trades was largely, if not entirely, empirical in nature;[9] David Govantes-Edwards and co-workers have recently argued that, as far as glassmaking in the Iberian Peninsula is concerned, the existing recipes are missing too much essential information to have served as a functional guide to make

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[3] We do not wish to get bogged down in trying to provide excessively precise definitions of such evasive concepts as «technical» and «technology», so for the purpose of this article we assume a relatively well-informed «common-sense» knowledge on the part of the reader. *Our* common sense position, it must be said, decisively departs from the so-called «Standard View on Technology» in a similar sense to Pfaffenberger, see Pfaffenberger, B. «Social Anthropology of Technology», *Annual Review of Anthropology*, 21 (1992), pp. 491-516. See also Ingold, T., *The Perception of the Environment. Essays on livelihood, dwelling and skill*, Routledge, London and New York, 2000; Latour, B., *We Have Never Been Modern*, Harvard University Press, Cambridge, MA, 1993; Latour, B., «Pragmatogonies. A Mythical Account of How Humans and Nonhumans Swap Properties», *American Behavioral Scientist*, 37 (1994), pp. 791-808.

[4] Isidore of Seville, *The Etymologies*, (eds). S. Barney and M. Hall, Cambridge University Press, Cambridge, 2006.

[5] Biringuccio, V., *Pirotechnica*, Stanley Smith, C. and Gnudi, M. T. (eds.), MIT Press, Cambridge, MA, 1959.

[6] Other early modern examples of this trend include Agricola's *De Re Metallica* and Barba's *Arte de los Metales*; Agrícola, G. *De Re Metallica*, Hoover, H. C. and Hoover, L. H. (eds.), Dover Publications, New York, 1950; Barba, A., *Arte de los metales*, Escuela de Ingenieros de Minas, Madrid, 1932.

[7] For instance, the so-called *Mappae Clavícula*, some of whose recipes can confidently be traced back to the 1st millennium AD; Smith, C. S. and Hawthorne, J. G., «*Mappae Clavicula*: A Little Key to the World of Medieval Techniques», *Transactions of the Americal Philosophical Society*, 64 (1974), pp. 1-128.

[8] Córdoba de la Llave, R., *Los oficios medievales*, Síntesis, Madrid, 2017, p. 206.

[9] Alexandre-Bidon, D. and Lett, D., *Les enfants au Moyen Age. Ve-XVe siècles*, Hachette, Poitiers, 1997, pp. 134-136.

glass, and that their role was, in fact, not to act as means to transmit technological practices.[10] For clarification, by 'recipe' we refer to texts or fragments within larger texts that explicitly aim to provide instructions to carry out, or describe the process of, a technical procedure of some sort, such as making glass or glazing pottery. As noted, the purpose of these is often unclear, so it must not be assumed that the author or copyist of the recipe intended for their instructions to be implemented in practice.

From a certain perspective, the experimental approach presents us with a ready-made answer to this problem: test the recipes experimentally and, if they work, they can be held to have been used to transmit technological practices in the past because they *do* transmit valid technological knowledge. This, naturally, becomes a circular argument when the success of the experiment is measured by the results aligning with what the recipe *claims* to do.[11] In turn, this implies assuming that the aim of the text is to transmit technological practices, which makes the experimental exercise in itself totally redundant, as well as ignoring the number of gaps in the recipe that we, as a rule, need to fill to make the experiment workable in the first place.[12]

We want to propose an entirely different approach, which, rather than ending in the recipe/experiment relationship, it begins with it, using it as a platform to try to understand broader aspects of technological practice in the past, using glassmaking to illustrate our perspective.

The purpose of this paper, therefore, is not to present new experimental methodologies, but simply to muse on experimentation as a research tool, the value of which goes much further than simply putting historical texts to the test. By viewing experiment as a process, rather than as a closed question, we can gain much greater insight into the historical process that we are analysing, in this instance glassmaking.

2. EXPERIMENTAL APPROACHES TO MEDIEVAL GLASSMAKING

One of the advantages (from a certain point of view) of the approach that we suggest is that the recipe must be seen in combination with all the archaeological, archaeometric, and historical evidence at our disposal; when the research question is circumscribed to the recipe/experiment relationship the recipe can be seen in nearly-total isolation from its context (as its nature is self-explanatory), perhaps only drawing more or less clear links with other texts that fall within its own category. We, in contrast, purport to use all the evidence at our disposal to, with the aid of the experiment, address questions of raw material selection, scale and range of craft production, techniques used, and degree of craft specialism. This rests on the premise that *if* those that wrote at least some of the recipes were not expert glassmakers they had *direct* experience of the practice of glassmaking, perhaps as spectators at the workshop or even as amateur collaborators of a master glass-worker.[13] This premise is the result of our impressionistic assessment of these

[10] Govantes-Edwards, D. J., López Rider, J. and Duckworth, C., «Glassmaking in medieval technical literature in the Iberian Peninsula», *Journal of Medieval Iberian Studies,* 12 (2020), p. 281. See also Fossier, R., *El trabajo en la Edad Media*, Crítica, Barcelona, 2002, p. 72.

[11] See for instance Palomar, T., Díaz Hidalgo, R. J. and Vilarigues, M., «Pigments, vinegar and blood: Interpretation and reproduction of glassy materials from the medieval manuscript H-490», *International Journal of Applied Glass Science,* 9 (2018), p. 556.

[12] Govantes-Edwards, D. J., Duckworth, C. and Córdoba de la Llave, R., «Recipes and experimentation? The transmission of glassmaking techniques in Medieval Iberia», *Journal of Medieval Iberian Studies,* 8 (2016), p. 180; Govantes-Edwards, D. J. *et al*. «Glassmaking…», pp. 277-278.

[13] This certainly appears to be the case with Theophilus Presbyter and his description of 12th century northern European craft practices, including glassmaking, and Guillaume Sedacer, a 14th-century Catalonian alchemist working under the protection of the royal house of Aragon. See Hawthorne, J. and Smith, C., *Theophilus: On Divers Arts. The Foremost Medieval Treatise on Painting, Glassmaking and Metalwork*, Dover Publications, New York, 1979; Barthélémy, P., *La Sedacina ou l'Ouvre au Crible: L'alchimie de Guillaume Sedacer, carme Catalan de la fin du XIVème siècle*, SEHA-Archè, Paris, 2002.

recipes in light of what we know about glassmaking and it is open to revision if the results of the experiments recommend it.

It is important to note that experimentation is not a newcomer to historical glass studies, and is in fact one of our primary sources of ideas about glass furnace design and construction, for which our archaeological, historical, and iconographic evidence is far too fragmentary to be particularly helpful.[14] An experimental mudbrick glass furnace was used to test the interpretation of some of the kilns/furnaces found in Tel-el-Amarna (Egypt), dated to the 14th century BC; using local sand and a substitute for halophytic plant ashes to act as flux, the furnace was successful at producing glass, upholding the archaeological interpretation of the remains.[15] The reproduction of glass-working furnaces (the shaping of fully formed glass, as separate from glassmaking, which is the process that leads to the production of glass from the raw materials), inspired by the archaeological remains of Roman and Anglo-Saxon glass workshops, were revealing in other ways. The reproduction of a couple of Roman glass-working furnaces by Mark Taylor and David Hill (http://www.theglassmakers.co.uk/) was indicative of the large volume of fuel necessary to operate even small facilities; continuously fired for three-week sessions at a maximum of 1050 ºC, the furnaces consumed 24 tons of hardwood;[16] in addition, these experiments also provided a wealth of experience and knowledge about stoking and firing methods, thermal performance, and structural vulnerabilities,[17] as well as much-needed information about the chemical processes undergone by glass and its interaction with furnace atmosphere during melting.[18] More recently, the reconstruction of an Anglo-Saxon furnace informed current experimental research into the practices of recycling by glassworkers in mid-late Anglo-Saxon England. A circular clay-built wood-fired furnace of c. 1.4 m external diameter was used to repeatedly recycle a Roman-type glass composition. The furnace was fired continuously in two sessions of five days aiming to keep a steady temperature around the glass crucible of c. 1000 ºC for the two hours preceding a gather being taken from the melt for sampling and test working. While the glass was being brought up to and held at temperature during working the furnace required stoking every seven minutes, and every fifteen minutes at other times, consuming approximately 1.5 cubic meters (c. 1050 kg) of native hardwood per day (see Figure 1).[19]

[14] Pearson, J., Duckworth, C., López Rider, J. and Govantes-Edwards, D. J., «Text, practice, and experience: an experimental approach to the archaeology of glassmaking in medieval Iberia», *Journal of Medieval Iberian Studies*, 13 (2021), p. 120.
[15] Nicholson, P. and Jackson, C., «The Furnace experiment», in Nicholson, P. (ed) *Brilliant things for Akhenaten: The Production of Glass, Vitreous Materials and Pottery at Amarna Site 045.1*, Egyptian Exploration Society, London, 2007, pp. 83-99.
[16] Taylor, M. and Hill, D., «Experiments in the Reconstruction of Roman Wood-Fired Glassworking Furnaces», *Journal of Glass Studies,* 50 (2008), pp. 271-290.
[17] *Idem.*
[18] Paynter, S., «Experiments in the Reconstruction of Roman Wood-Fired Glassworking Furnaces: Waste Products and Their Formation processes», *Journal of Glass Studies*, 50 (2008), pp. 271-290.
[19] Lucas, V. Project Glass Recycling: Week 2: EXARN Experimental Archaeology Newcastle, weblog. https://exarnewcastle.wordpress.com/2019/05/29/project-glass-recycling-week-1/

Fig. 1. Experimental Anglo-Saxon furnace in use. The furnace is shown here immediately after charging with fuel through the stoking hole (bottom left), the glass crucible containing the melt stood on a siege or shelf above and to one side of the fire chamber and could be accessed through the 'glory-hole' (centre-right) covered with a clay door.

A model of separation between glass-working and large-scale glassmaking was supported by ethnographic observation in the 1990s in Uttar Pradesh, India, of the firing of a 4.5 external diameter circular clay-brick-built furnace for thirty days at an estimated maximum of 900 ^{o}C using local raw materials and fuel, to produce a large quantity of inexpensive glass for use in local potteries for glazing. This study demonstrated that temperature and time are related variables which can be adjusted – in this example, a longer time period was employed to compensate for the lower melting temperature achieved by the furnace.[20] Finally, Paynter and Dungworth experimentally reproduced 17th-century English glass in order to determine the crystalline phases that formed during the fritting process (the formation of a semi-vitrified compound as a previous step in glass-melting) with a view to facilitating the recognition of frits in the archaeological record.[21]

In addition to this, written accounts of glassmaking have been subject to scholarly analysis and experimental reproduction, for instance cuneiform texts from the library of Assurbanipal,[22] for their reassessment and reinterpretation in light of modern archaeological or archaeometric data,[23] and for the reappraisal of the processes described, which were regarded as unintelligible and incomplete, suggesting greater complexity of practice.[24] David Govantes-Edwards and co-

[20] Sode, T. and Koch., J., «Traditional Raw Glass Production in Northern India: the final stage of an ancient technology», *Journal of Glass Studies*, 43 (2001), pp. 155-169.

[21] Paynter, S. and Dungworth, D., «Recognising Frit: Experiments Repdoducing Post-Medieval Plant Ash Glass», in Turbanti-Memmi, I. (ed.), *Proceedings of the 37th International Symposium on Archaeometry*. Springer-Verlag, Berlin, Heidelberg, 2011, pp. 133-138.

[22] Brill, R., «The Chemical Interpretation of the Texts», in Oppenheim, A., Brill, R., Barag, D. and von Saldern, A, (eds) *Glass and Glassmaking in Ancient Mesopotamia*, Corning Museum of Glass, Corning, NY, 1970, pp. 111-114.

[23] Freestone, I., «Pliny on Roman Glassmaking», in Martinón-Torres, M. and Rehren, T. (eds), *Archaeology, History and Science: Integrating Approaches to Ancient Materials*, Left Coast Press, Walnut Creek, CA, 2008, pp. 96-97.

[24] Shortland, A., «Cuneiform Glass Texts: A Question of Meaning», in Martinón-Torres, M. and Rehren, T. (eds.), *Archaeology, History and Science: Integrating Approaches to Ancient Materials*, Left Coast Press, Walnut Creek, CA, 2008, pp. 61-62; 69-70.

workers carried out exploratory experiments with one of the recipes presented in the so-called *Epistola Abbreviatoria* (of which more shortly), and tried to link the conclusions of the experiments with what is known about glassmaking in medieval southern Spain;[25] and Palomar and co-workers[26] applied the glass- and glaze-related recipes contained in Ms. H-490 at the Faculty of Medicine of the University of Montpellier,[27] but in this case the answer sought was binary (does the recipe work? Yes/No), and the full potential of the experiments was not realised.[28]

3. THE EPISTOLA ABBREVIATORIA. SECOND EXPERIMENTAL ROUND

After the initial experimental exploration of one of the glassmaking recipes contained in the *Epistola Abbreviatoria*, John Pearson, a member of the Post-Disciplinary and Experimental Glass Group (PEGG) based on Newcastle University (United Kingdom) (https://research.ncl.ac.uk/pegg/), undertook to carry out a deeper and broader experimental approach to this same recipe, with which we hope to be able to illustrate the full potential of this sort of approximation to the evidence.

The *Epistola Abbreviatoria* is a truncated manuscript copy of a letter by a Don Christophoro de Sotomayor to his friend Juan de Alcalá, describing the «traditional» way of making glass. David Whitehouse, the first glass scholar to take an interest in this letter, dated the recipe to the early 16th century,[29] but David Govantes-Edwards and co-workers have argued that the original text is likely to been significantly earlier, probably no later than the first half of the 15th century.[30] Neither Sotomayor nor Juan de Alcalá have been historically identified. The letter purports to introduce three ways of making glass, employing the typical ingredients for glassmaking suggested in the existing medieval and early modern Iberian and European texts,[31] the use of which is being confirmed by ongoing archaeometric studies.[32]

The aim of the round of experiments conducted at Newcastle University's Wolfson Archaeological Laboratory was, at a basic level, to test the recipe's veracity and usefulness for making glass – seeking an answer to the fundamental question «does this recipe offer a credible guide to the basic technology of glassmaking»? Should the answer be «yes», it becomes easier to see the recipe as a valid source to examine other issues related to glassmaking. Second, the

[25] Govantes-Edwards, D. J. *et al*. «Recipes and…».
[26] Palomar, T. *et al.*, «Pigments, Vinegar…».
[27] Córdoba de la Llave, R., «Un recetario técnico castellano del siglo XV: el manuscrito H490 de la Facultad de Medicina de Montpellier», *En la España Medieval,* 28 (2005), pp. 7-48.
[28] In all fairness to the authors, they made a very plausible identification of the evasive ingredient «genolí» (one of the problems with working with ancient recipes is that the words used to refer to ingredients are not always easy to associate to a known compound) as a pigment based on lead stannate (Pb_2SnO_4).
[29] Whitehouse, D., «The "Epístola Abbreviatoria": a description of glassmaking in Renaissance Spain», in Janssens, K., Degryse, P., Cosyins, P, Caen, J., and Van't Dack, L. (eds) *Annales du 17e Congrés,* AIHV, Antwerp, 2006, pp. 355-358.
[30] Govantes-Edwards, D. J. *et al*., «Glassmaking…», p. 272. See also Luanco, J. R., *La alquimia en España*, vol. I, Fidel Giró, Barcelona, 1889, pp. 137-138.
[31] These include the above noted *Sedacina* and Theophilus's *De Diversis Artibus*, but also Pedro Gil's *Historia Natural de Catalunya*, George Agricola's *De Re Metallica* and Biringuccio's *Pirotechnia*. See Govantes-Edwards, D. J. *et al*., «Recipes and…»; Hawthorn, J. and Smith, C., *Theophilus*…; Guidol, J., *Els vidres Catalans,* Alpha, Barcelona, 1936, p. 156. For a full list of all known 'technical documents' to address glassmaking in the Iberian Peninsula in the Late Middle Ages and the beginning of the Early Modern Age see Govantes-Edwards, D. J. *et al*., «Glassmaking…».
[32] See for instance Carmona, N., Villegas, M. A., Jiménez, P., Navarro, J., and García-Heras, M., «Islamic glasses from al-Andalus. Characterisation of materials from a Murcian workshop (12th century AD, Spain)», *Journal of Cultural Heritage,* 10 (2009), pp. 439-45; Duckworth, C., Córdoba de la Llave, R., Faber, E., Govantes-Edwards. D. J. and Henderson, J., «Electron microprobe analysis of 9th-12th century Islamic glass from Córdoba, Spain», *Archaeometry,* 57 (2015), pp. 27-50; De Juan, J. and Schibile, N., «Glass import and production in Hispania during the early medieval period: the glass from Ciudad de Vascos», *PlosOne,* 12 (2017), pp. 1-19.

reproduction of the recipe involves a *process*, which inevitably raises questions of technology – what raw ingredients to use (let us not forget that these recipes are seldom as clear as could be expected, and that medieval terminology is not necessarily straightforward to interpret); how closely must the instructions laid out in the recipe be followed, and how are they to be interpreted. These questions are relevant for the recipe as a self-contained piece of information but, much more importantly, for contemporary glassmaking practices.[33] Third, conversely, we need to view the recipes 'from the other end of the telescope', asking whether contemporary glassmaking practices might suggest they contain gaps and why such gaps exist[34] – was it for reasons of secrecy? That does not seem to tally with the very act of putting down a recipe in writing, so it must be because these were variables that were not of interest for the writer, which brings us closer to understanding the motivation behind the text (see above).[35] Finally, the experiment also intends to generate experience through *practice*, creating new pathways to understand the wider context of the practice of glassmaking in a given socio-historical setting such as medieval Spain, the place it took in the economic and intellectual life and, crucially, the traces that glassmaking practice may leave in the archaeological record.

This final point is worth expanding a little further. It has been argued that, before the so-called Scientific Revolution (although the very concept of this is now hotly debated), sensory perception was, by and large, the overriding concern of those who pursued a better understanding of the nature of materials.[36] As such, if we want to fully understand the engagement of the author of a recipe like those contained in the *Epistola Abbreviatoria*, in which sensorial impressions take quite a prominent role, a more comprehensive consideration of sensory perception is vital, not least because archaeology overwhelmingly relies on it to assess the material record.[37] It is therefore an inescapable responsibility of current archaeology to complement scientific analysis of materials, which can reveal information that was beyond the powers of observation of past peoples, with the practical, sensory-driven exploration of these same materials, including not only finished products but also the process that led to their production.[38] A word of caution may, however, be in order. This experiential work must be guided by the text, which should never be disqualified or over-interpreted on the basis of phenomenological approaches such as those advocated by Collingwood;[39] while uniformitarianism may be a sound guide for the understanding of physical processes, this does not apply to phenomenological experiences.[40]

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[33] It has been argued – e.g. Smith, C. S. and Hawthorne, J. G. , «*Mappae Clavicula*…», p. 1 – that medieval recipe books may include many recipes that do not reflect contemporary but obsolete workshop practice, but based on what we know about glassmaking in medieval Iberia this does not seem to apply to the *Epistola Abbreviatoria*.

[34] Even Theophilus's *De Diversis Artibus*, by any account the most systematic medieval technical treatise, shows not insubstantial gaps. See Smedley, J. W., Jackson, C. M. and Booth, C. A. , «Back to the roots: the raw materials, glass recipes and glassmaking practices of Theophilus», in McCray, W. P. and Kingery, W. D. (eds.), *The Prehistory and History of Glassmaking Technology*, Ohio, American Ceramic Society, 1999, pp. 150-152.

[35] For a more detailed discusión of this see Govantes-Edwards, D. J. *et al*., «Glassmaking…», pp. 277-278.

[36] Martinón-Torres, M. and Rehren, T., «Post-medieval crucible production and distribution: A study of materials and materialities», *Archaeometry*, 51 (2009), p. 67.

[37] Hurcombe, L., «A sense of materials and sensory perception in concepts of materiality», *World Archaeology*, 39-4 (2007), p. 534.

[38] Martinón-Torres, M., «Why Should Archaeologists Take History and Science Seriously?», in Martinón-Torres, M. and Rehren, T. (eds.), *Archaeology, History and Science: Integrating Approaches to Ancient Materials*, Left Coast Press, Walnut Creek, CA, 2008, p. 23; Duckworth, C., «Sensory perception and experience of glass», in Skeates, R. and Day, J. (eds.), *The Routledge Handbook of Sensory Archaeology*, Routledge, Oxford, 2020, pp. 233-247.

[39] Colingwood, R. G., *The Idea of History*, Oxford University Press, New York, 1946.

[40] Van der Lewuw, S. E., «Archaeology, Material Culture and Innovation», *SubStance*, 19 (1990), p. 96; Lucas, G., *The Archaeology of Time*, London & New York, Routledge, 2005, p. 55. Nevertheless, current ongoing research within PEGG is seeking to explore how much flexibility there might be in the relationship between 'experience' and other forms of evidence, especially where the latter is very fragmentary.

The experiments followed Christophoro de Sotomayor's recipe for *infima* glass, allegedly a low-quality glass (although Sotomayor does not explain what his criteria for quality were). The steps established by the recipe to produce this glass are as follows:

1. Take three parts of *soda* free from *salicornia* (the glassmakers' *barrilla*).
2. Pound one part of sand or very fine ground pebbles.
3. Mix them with plain water and form «loaves» with this mixture.
4. Dry the loaves in the furnace and let them cool.
5. Melt them inside a crucible, leaving them in the furnace for at least a night or 24 hours.
6. While in the furnace, regularly use an iron spoon to remove the scum that rises to the surface, which in the vernacular is known as *anitron* salt.
7. The glass will be ready when it sticks to the tip of an iron rod and stays clear.
8. For every 100 pounds of the melt, add one ounce of manganese (the glassmakers' *tinta spiritorum*).
9. Mix the manganese well with the melt, which will immediately become violet in colour; wait until the colour settles at the bottom of the crucible and the result will be «white» (*i.e*. colourless) glass.

In order to meet the objectives set out above, a total of ten experiments was devised, each of which presented different combinations of the variables, including elements mentioned by the recipe that could be interpreted in different ways (*e.g*. ingredients that are only generically described; ingredients that might be obtained from different sources; the way to measure the different ingredients) and things that the recipe did not mention at all, but which can have a direct impact on the result (*e.g*. heating regime). In practice, this meant following ten different recipes. This in no way exhausts the possibilities, but it was believed that the recipes *chosen* were the most likely to yield relevant information. It is important to keep this in mind, because these recipes, whatever they are, are not comparable to modern technical manuals, which go through every step systematically and in full detail; only by opening a number of possibilities for every variable can we use the recipe as a source of information of a given technical practice in the past.

Fig. 2. Wet loaves, by volume and weight.

Giving a full and comprehensive account of all the experiments is beyond the scope of this paper,[41] but Table 1 presents an extensive summary of their basic specifications (figures 2, 3 and 4 show different experimental steps).[42] It is, therefore, recommended that the reader complements this paper with Pearson et al.'s earlier publication, in which the experiments are described in full detail.

Fig. 3. EXP1 (step 6 of the recipe). Scum removal from the glass melt using an iron tool.

Fig. 4. EXP1. Final result of the experiment. Transparent, pale green-yellow glass, including some iron scale from the scrapper tool (in the large fragment, slightly left of centre.

[41] Pearson, J., *Text, Transformation and Practice. Experimental experience and the archaeology of glassmaking in medieval Spain*, Unpublished MA Dissertation, Newcastle University, 2019. A more elaborate version of Table 1 can also be found in this paper.
[42] Figures after Pearson, J. *et al.*, «Text, Practice…».

Table 1. Summary account of all experiments

Exp. number	**Type of experiment**		**Maximum firing temperature ºC**	**Combined raw ingredients dry weight g**	**Plant ash flux type**[43]	**Purpose of experiment**	**Comments**	**Batch or melt product and waste products**
	3 parts flux: 1 part sand by							
	Weight	Volume						
EXP1	X		1150	200.0	*Barrilla* (40g of JLR1; 110 g of CD1)	Test recipe using 3 parts *barrilla* : 1 part sand by weight	Note mixed sources of *barrilla*; pattern 1 crucible used	Transparent pale violet glass + scum
EXP2		X	1150	186.6	*Barrilla* (80 g JLR1)	Test recipe using 3 parts *barrilla* : 1 part sand by volume	«Parts» measured by volume resulted in lower combined raw ingredients weight than for EXP1; pattern 1 crucible used	Unreacted batch
EXP3	X		1150	200.0	Seaweed powder[44]	Replicate EXP1 but using seaweed powder ash as *barrilla* substitute	Pattern 1 crucible and improvised lid used	Unreacted batch with vitreous crust
EXP4	X		1150	160.0	Sea purslane[45]	Replicate EXP1 using sea purslane ash as *barrilla* substitute	160 g combined raw ingredients, to make a smaller loaf to fit pattern 2 crucible. Fired together with EXP5. EXP4 as used for testing and sampling during firing and EXP5 left batch undisturbed	Opaque dark green glass + scum
EXP5	X		1150	160.0	Sea purslane	Replicate EXP1 using sea purslane ash as *barrilla* substitute	160 g combined raw ingredients, to make a smaller loaf to fit pattern 2 crucible. Fired together with EXP5. EXP4 as used for testing and sampling during firing and EXP5 left batch undisturbed	Opaque dark green glass + scum
EXP6	X		950	120.0	*Barrilla* (90 g JLR2)	Repeat EXP1/EXP5 format at lower temperature to test whether glass or frit would form	120 g combined raw ingredients to conserve *barrilla*. Fired together with EXP7. EXP6 was used for testing and sampling during firing and EXP7 left batch undisturbed	Unreacted batch

[43] A number of different sources of ash was used. Key: JLR 1: *Salicornia ramosissima* harvested near Córdoba in June 2019 (supplied by Javier López Rider, Universidad de Córdoba); JLR 2: *Salicornia ramosissima* harvested near Córdoba in July 2019 (supplied by Javier López Rider, Universidad de Córdoba); CD 1: Various halophytic plants harvested in several locations in southern Spain in 2015 which may have included *Halogetons sativus*; *Salicornia fruticosa*; *Salicornia europaea*; *Salicornia S.*; *Sarcoconia perennis* (supplied by Chloe Duckworth, Newcastle University); CD 2: artificial plant ash (supplied by Chloe Duckworth). The full details of the fluxes used are set out in Pearson, J., *Transformation…*, pp. 211-214.

[44] *Ascophyllum nodosum*.

[45] *Halimione portucaloides*.

EXP7	X		950	99.6	Artificial ash (59.6 g CD2)	Repeat EXP1/EXP5 format at lower temperature to test whether glass or frit would form	Using artificial ash, combined raw ingredients weight is equivalent to 160g if using natural ash. Fired together with EXP6. EXP6 was used for testing and sampling during firing and EXP7 left batch undisturbed	Frit-like material + scum (?)
EXP8	X		1050	120.0	Barrilla (90 g JLR2)	Repeat EXP1/EXP4/EXP6 format at lower temperature to test whether glass or frit would form	120 g combined raw ingredients to conserve *barrilla*. Fired together with EXP9. EXP8 was used for testing and sampling during firing and EXP9 left batch undisturbed	Unreacted batch
EXP9	X		1050	99.6	Artificial ash (59.6 g CD2)	Repeat EXP1/EXP5/EXP7 format at lower temperature to test whether glass or frit would form	Using artificial ash, combined raw ingredients weight is equivalent to 160g if using natural ash. Fired together with EXP8. EXP8 was used for testing and sampling during firing and EXP9 left batch undisturbed	Transparent pale green glass; no scum
EXP10	X		1150	120.0	Barrilla (90 g JLR2)	Replicate EXP1 using new *barrilla* supply	Batch left undisturbed during firing	Unreacted batch

A number of limitations of the experimental programme must be pointed out. First, the small scale of the experimental batches may not constitute a limitation concerning the recipe itself (which is eminently alchemical in nature, and thus refers to a laboratory exercise, not a workshop-scale operation), but it certainly calls for caution in any extrapolation of results for the interpretation of glassmaking practices in the Middle Ages. All of the medieval glass workshops known archaeologically in the Iberian Peninsula are much more substantial undertakings.[46] More obviously, there were some deviations from medieval practice. The furnace was an electric Vecstar furnace with a clean and oxygen-rich atmosphere, whereas historical furnaces used firewood, the combustion gases of which interacted with the glass during firing as well as leading to more reduced atmospheres.[47] The choice was made to use this furnace rather than a wood-fired one in order to keep the number of variables under control.

4. CONCLUSIONS

As previously noted, the experiments carried out at the Wolfson Laboratory in Newcastle were a second step, building on the knowledge of the first exploratory experiments undertaken by David Govantes-Edwards, Chloe Duckworth, and Ricardo Córdoba de la Llave in 2016.[48] In this, more ambitious, phase in the long-haul experimental process planned by the PEGG group with the *Epistola Abbreviatoria*, the plan was to take the conclusions closer to begin answering broader questions about medieval glassmaking, for instance with regard to raw material selection, scale and range of craft production techniques, and degree of craft specialisation.

Of the ten experiments conducted, four (EXP 1, EXP4, EXP5, EXP 9) reacted to form a glass. Thanks to experiments EXP1 and EXP9, which both made clear glass, we know that one-stage glassmaking at temperatures not far above 1000 ºC is feasible, but at the same time the failure of some batches to react (EXP2, EXP3, EXP6, and EXP8), despite the use in some of them of, at least apparently, the same fluxes used in 'successful' experiments (*e.g.* EXP1 and EXP6), makes it obvious that the subtleties of ash selection were lost to the recipe. It is well known that the composition of plant ash is affected by a large number of variables, including soil conditions, climate, weather, harvest season, etc.[49] so no guarantee exists that the composition of ash from a single plant species harvested in the same location in two different years will not vary significantly.[50] In fact, the difficulty of establishing the quality of a given plant, perfectly illustrated by the experiments, may support some evidence that the harvesting and ashing of glass-worthy plants may have been, at least in some areas, a specialised task; it is well known that Venice imported depurated ash for glassmaking from the Near East;[51] similarly, late-15th century Sevillian glassmakers bought their flux in the form of *mazacote* (compacted ash) from peasants working in the vicinity of the city.[52] This is another dimension of the profound

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[46] Duckworth, C. N and Govantes-Edwards, D. J., «Medieval glass furnaces in southern Spain: Report», *Glass News* 38 (2015), pp. 9-12; Govantes-Edwards, D. J. and Duckworth, C., «Two new glass furnaces in Spain», *Glass News* 41 (2017), pp. 8-10.

[47] Paynter, S. «Experiments…».

[48] Govantes-Edwards, D. J. *et al.*, «Recipes and…».

[49] Ashtor, E. and Cedivalli, G., «Levantine Alkali Ashes and European Industries», *Journal of European Economic History,* 12 (1983), pp. 475-522.

[50] For a review of the use of plant ashes and the chemistry of different plant species see Ortuño, J. A. *et al.*, «Halophytes in Art and Crafts: Ethnobotany of Glassmaking», in Grigori, M. N. (ed.), *Handbook of Halophytes.* Springer-Verlag, Cham, 2020, pp.1-32.

[51] Jacoby, D., «Raw materials for the glass industries of Venice and the Terraferma about 1370-about 1460», *Journal of Glass Studies,* 35 (1993), pp. 65-90.

[52] Govantes-Edwards, D., *El papel social y político de las pirotecnologías en la Edad Media hispana y fórmulas de transmisión: vidrio y cerámicas vidriadas*, unpublished PhD Dissertation, Universidad de Córdoba, 2021, p. 381.

transformations undergone by glassmaking practices with the change from mineral- to plant-based fluxes around the 8th-9th centuries AD.[53]

The issue of scale also needs addressing if we want to gain a better understanding of workshop practice. For this reason, a project is already in motion to reproduce some of these experiments and more in a wood-fired reproduction of one of the 12th-century glass furnaces found in Casón de Puxmarina (Murcia, Spain),[54] which will also help us to explore the effect of the interaction of the glass melt with combustion gases. Importantly, this experiment will have a significant sensorial element to it that could not be gauged with the use of the electric furnace, for instance, sensory cues that glassmakers followed to monitor temperature (which will be tracked by the use of thermocouples in different sections of the furnace). This is potentially one of the most important aspects of the third experimental round, as one of the most revealing conclusions of the second was the extent to which all the activities of the long days in which glass was being made revolved around an overriding need for regular human interventions, even with the use of a modern electric furnace that allows heating regimes to be precisely programmed and precludes the need for nearly incessant stoking.

This paper aimed to argue for the potential of bringing together experimental approaches and medieval 'technical' recipes. We contend that the focus should not be on the recipes in themselves but on the recipes as potential wells of information for a broader understanding of craft practices in the past. Rather than as a discrete piece of cultural history, recipes should be adopted as a heuristic tool to, interactively, access matters of craft *practice* for which other forms of historical and archaeological information are largely silent, and experimental approaches can take us a long way in this direction.

BIBLIOGRAPHY

ALEXANDRE-BIDON, D., LETT, D. (1997), *Les enfants au Moyen Age. Ve-XVe siècles*, Hachette, Poitiers.

ASHTOR, E., CEDIVALLI, G. (1983), «Levantine Alkali Ashes and European Industries», *Journal of European Economic History*, 12, pp. 475-522.

BARTHELEMY, P. (2002), *La Sedacina ou l'Ouvre au Crible: L'alchimie de Guillaume Sedacer, carme Catalan de la fin du XIVème siècle*, SEHA-Archè, Paris.

BRILL, R. (1970), «The Chemical Interpretation of the Texts», in OPPENHEIM, A., BRILL, R., BARAG, D. and VON SALDERN, A, (eds.), *Glass and Glassmaking in Ancient Mesopotamia*, Corning Museum of Glass, Corning, NY, pp. 103-128.

CARMONA, N., VILLEGAS, M. A., JIMÉNEZ, P., NAVARRO, J., GARCÍA-HERAS, M. (2009), «Islamic glasses from al-Andalus. Characterisation of materials from a Murcian workshop (12th century AD, Spain)», *Journal of Cultural Heritage.* 10, pp. 439-45.

COLINGWOOD, R. G. (1946), *The Idea of History*, Oxford University Press, New York.

CÓRDOBA DE LA LLAVE, R. (2005), «Un recetario técnico castellano del siglo XV: el manuscrito H490 de la Facultad de Medicina de Montpellier», *En la España Medieval*, 28, pp. 7-48

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[53] Shortland, A., Schachner, L., Freestone, I. and Tite, M. S., «Natron as flux in the early vitreous materials industry: sources, beginnings and reasons for decline», *Journal of Archaeological Science*, 33 (2006), pp. 527-528. For the implications of this change-over for the study of glassmaking in the Iberian Peninsula during the Middle Ages see Govantes-Edwards, D., Duckworth, C., Córdoba de la Llave, R., Aparicio Sánchez, L. and Camacho Cruz, C., «El vidrio andalusí y su composición química: primeros resultados y posibilidades de estudio», *Boletín de Arqueología Medieval*, 18 (2014), p. 41; Duckworth, C. and Govantes-Edwards, D., «Producción y tecnología del vidrio en al-Andalus», in Delgado, M. and Pérez Aguilar, L. M. (eds.), *Economía y Trabajo. Las bases materiales de la vida en al-Andalus*, Alfar, Sevilla, 2019, pp. 242-243.

[54] Jiménez, P., Navarro, J. and Thiriot, J., «Taller de vidrio y casas andalusíes en Murcia. La excavación arqueológica del Casón de Puxmarina», *Memorias de Arqueología*, 13 (1998), pp. 419-458.

CÓRDOBA DE LA LLAVE, R. (2017), *Los oficios medievales,* Síntesis, Madrid.

DE JUAN, J., SCHIBILE, N. (2017), «Glass import and production in Hispania during the early medieval period: the glass from Ciudad de Vascos», *PlosOne,* 12, pp. 1-19.

DUCKWORTH, C. N., GOVANTES-EDWARDS, D. (2015), «Medieval glass furnaces in southern Spain: Report», *Glass News,* 38, pp. 9-12.

DUCKWORTH, C., CÓRDOBA DE LA LLAVE, R., FABER, E., GOVANTES-EDWARDS D., HENDERSON, J. (2015), «Electron microprobe analysis of 9th-12th century Islamic glass from Córdoba, Spain», *Archaeometry,* 57 (2015), pp. 27-50.

DUCKWORTH, C., GOVANTES-EDWARDS, D. (2019), «Producción y tecnología del vidrio en al-Andalus», in DELGADO, M. and PÉREZ AGUILAR, L. M. (eds.), *Economía y Trabajo. Las bases materiales de la vida en al-Andalus,* Alfar, Sevilla, pp. 235-262.

DUCKWORTH, C. (2020), «Sensory perception and experience of glass», en SKEATES, R., DAY, J., (eds.), *The Routledge Handbook of Sensory Archaeology,* Routledge, Oxford, pp. 233-247.

FOSSIER, R. (2002), *El trabajo en la Edad Media*, Crítica, Barcelona.

FREESTONE, I. (2008), «Pliny on Roman Glassmaking», in MARTINÓN-TORRES, M., REHREN, T. (eds.), *Archaeology, History and Science: Integrating Approaches to Ancient Materials*, Left Coast Press, Walnut Creek, CA, pp. 77-100.

GOVANTES-EDWARDS, D., DUCKWORTH, C., CÓRDOBA DE LA LLAVE, R., APARICIO SÁNCHEZ, L., CAMACHO CRUZ, C. (2014), «El vidrio andalusí y su composición química: primeros resultados y posibilidades de estudio», *Boletín de Arqueología Medieval*, 18, pp. 31-50.

GOVANTES-EDWARDS, D. J., DUCKWORTH C. N., CÓRDOBA DE LA LLAVE, R. (2016), «Recipes and experimentation? The transmission of glassmaking techniques in Medieval Iberia», *Journal of Medieval Iberian Studies,* 8, pp. 176-195.

GOVANTES-EDWARDS, D. J., DUCKWORTH, C. (2017), «Two new glass furnaces in Spain», *Glass News*, 41, pp. 8-10.

GOVANTES-EDWARDS, D. J., LÓPEZ RIDER J., DUCKWORTH, C. (2020), «Glassmaking in medieval technical literature in the Iberian Peninsula», *Journal of Medieval Iberian Studies*, 12, pp. 267-291.

GOVANTES-EDWARDS, D. (2021), *El papel social y político de las pirotecnologías en la Edad Media hispana y fórmulas de transmisión: vidrio y cerámicas vidriadas*, unpublished PhD Dissertation, Universidad de Córdoba.

GUIDOL, J. (1936), *Els vidres Catalans,* Alpha, Barcelona.

HAWTHORNE, J. and SMITH, C. (1979), *Theophilus: On Divers Arts. The Foremost Medieval Treatise on Painting, Glassmaking and Metalwork*, Dover Publications, New York.

HURCOMBE, L. (2007), «A sense of materials and sensory perception in concepts of materiality», *World Archaeology,* 39-4 (2007), pp. 532-545.

INGOLD, T. (2000), *The Perception of the Environment. Essays on livelihood, dwelling and skill*, Routledge, London and New York.

JACOBY, D. (1993), «Raw materials for the glass industries of Venice and the Terraferma about 1370-about 1460», *Journal of Glass Studies*, 35, pp. 65-90.

JIMÉNEZ, P., NAVARRO J., THIRIOT, J. (1998), «Taller de vidrio y casas andalusíes en Murcia. La excavación arqueológica del Casón de Puxmarina», *Memorias de Arqueología*, 13, pp. 419-458.

LATOUR, B. (1993), *We Have Never Been Modern*, Harvard University Press, Cambridge, MA.

LATOUR, B. (1994), «Pragmatogonies. A Mythical Account of How Humans and Nonhumans Swap Properties», *American Behavioral Scientist*, 37, pp. 791-808.

LUANCO DE, J. R. (1889), *La alquimia en España*, vol. II, Fidel Giró, Barcelona.

LUCAS, G. (2005), *The Archaeology of Time*, London & New York, Routledge.

MARTINÓN-TORRES, M. (2008), «Why Should Archaeologists Take History and Science Seriously?», in MARTINÓN-TORRES, M. and REHREN, T. (eds.), *Archaeology, History and Science: Integrating Approaches to Ancient Materials*, Left Coast Press, Walnut Creek, CA, pp. 15-36.

MARTINÓN-TORRES, M., REHREN, T. (2009), «Post-medieval crucible production and distribution: A study of materials and materialities», *Archaeometry*, 51, pp. 49-74.

NICHOLSON, P., JACKSON, C. (2007), «The Furnace experiment», in NICHOLSON, P. (eds.) *Brilliant things for Akhenaten: The Production of Glass, Vitreous Materials and Pottery at Amarna Site 045.1*, Egyptian Exploration Society, London, pp. 83-99.

ORTUÑO, J. A, VERDE, A., FAJARDO, J., RIVERA, D., OBÓN, C., ALCARAZ, F. (2020) «Halophytes in Art and Crafts: Ethnobotany of Glassmaking», in GRIGORI, M.N. (ed.), *Handbook of Halophytes.* Springer-Verlag, Cham

PALOMAR, T., DÍAZ HIDALGO R. J., VILARIGUES, M. (2018), «Pigments, vinegar and blood: Interpretation and reproduction of glassy materials from the medieval manuscript H-490», *International Journal of Applied Glass Science*, 9, pp. 555-565.

PAYNTER, S. (2008), «Experiments in the Reconstruction of Roman Wood-Fired Glassworking Furnaces: Waste Products and Their Formation processes», *Journal of Glass Studies*, 50, pp. 271-290.

PAYNTER, S., DUNGWORTH. D. (2011). «Recognising Frit: Experiments Repdoducing Post-Medieval Plant Ash Glass», in TURBANTI-MEMMI, I. (eds.) *Proceedings of the 37th International Symposium on Archaeometry*. Springer-Verlag, Berlin, Heidelberg, pp. 133-138.

PEARSON, J. (2019), *Text, Transformation and Practice. Experimental experience and the archaeology of glassmaking in medieval Spain*, Unpublished MA Dissertation, Newcastle University.

PEARSON, J., DUCKWORTH, C. N., LÓPEZ RIDER, J., GOVANTES-EDWARDS, D. J. (2021), «Text, practice, and experience: an experimental approach to the archaeology of glassmaking in medieval Iberia», *Journal of Medieval Iberian Studies*, 13, pp. 119-144.

PFAFFENBERGER, B. (1992), «Social Anthropology of Technology», *Annual Review of Anthropology*, 21, pp. 491-516.

SHORTLAND, A. (2008), «Cuneiform Glass Texts: A Question of Meaning», in MARTINÓN-TORRES, M., REHREN, T. (eds.), *Archaeology, History and Science: Integrating Approaches to Ancient Materials*, Left Coast Press, Walnut Creek, CA, pp. 61-75.

SHORTLAND, A., SCHACHNER, L., FREESTONE I., TITE, M. S. (2006), «Natron as flux in the early vitreous materials industry: sources, beginnings and reasons for decline», *Journal of Archaeological Science*, 33, pp. 521-530.

SMEDLEY, J. W., JACKSON C. M., BOOTH, C. A. (1999), «Back to the roots: the raw materials, glass recipes and glassmaking practices of Theophilus», in MCCRAY, W. P. and KINGERY, W. D. (eds.) *The Prehistory and History of Glassmaking Technology*, Ohio, American Ceramic Society, pp. 145-164.

SMITH, C. S., HAWTHORNE, J. G. (1974), «*Mappae Clavicula*: A Little Key to the World of Medieval Techniques», *Transactions of the American Philosophical Society*, 64, pp. 1-128.

SODE, T. and KOCH, J. (2001), «Traditional Raw Glass Production in Northern India: the final stage of an ancient technology», *Journal of Glass Studies*, 43, pp. 155-169.

TAYLOR, M. and HILL, D. (2008), «Experiments in the Reconstruction of Roman Wood-Fired Glassworking Furnaces», *Journal of Glass Studies*, 50, pp. 249-270.

VAN DER LEWUW, S. E. (1990), «Archaeology, Material Culture and Innovation», *SubStance*, 19, pp. 92-109.

WHITEHOUSE, D. (2006), «The "Epístola Abbreviatoria": a description of glassmaking in Renaissance Spain», in JANSSENS, K., DEGRYSE, P., COSYINS, P, CAEN, J; VAN'T DACK, L. (eds.) *Annales du 17e Congrés, AIHV*, AIHV, Antwerp, pp. 355-8.

PRIMARY SOURCES

AGRICOLA, G. (1950), *De Re Metallica*, (eds.) HOOVER, H. C., HOOVER, L. H., Dover Publications, New York.

BARBA, A. (1932), *Arte de los Metales*, Escuela de Ingenieros de Mina, Madrid.

BIRINGUCCIO, V., (1959), *Pirotechnica*, STANLEY SMITH, C., GNUDI, M. T. (eds.), MIT Press, Cambridge, MA.

ISIDORE OF SEVILLE, (2006), *The Etymologies*, BARNEY, S., HALL, M. (eds.), Cambridge University Press, Cambridge.