**“Eau Magistra”: Investigating Binders for Sand-casting**

**Bnf. Ms. Fr. 640, folio 84v, *“Eau Magistra”***

Aulcuns trouvent que l’eau sel n’est pas bonne, pource que le sel pette au foeu, & par consequent doibt faire soufler. Il n’y a que le vin bouilly avecq racine d’orme.

Le charbon pour poncer faict bien despouiller, mays on trouve que celuy de saule faict soufler; celuy de chaisne ou fayan faict bien sans soufler.

[Note] Essaye huitres bruslées.[[1]](#footnote-2)

**Bnf. Ms. Fr. 640, folio 84v, *“Eau Magistra”***

Some people think that salt water is not good, because the salt releases gas when heated and as a result causes bubbles. [In this case], there is only wine boiled with elm root.

Sanding charcoal makes [things] come off well. But one finds that willow charcoal creates bubbles, but oak or beech charcoal does the job without making bubbles.

[Note] Try burned oysters.[[2]](#footnote-3)

**Bnf. Ms. Fr. 640, 82r, *“Glaire d’oeufs”***

La glaire d’oeufs donne force au sable pour en faire plusieurs gects.

**Bnf. Ms. Fr. 640, 82r, *“Egg white”***

Egg white gives strength to sand so that many casts [can be] made from it.

Bnf. Ms. Fr. 640 contains many recipes that describe sand-casting processes. To make a successful mold, often a dry sand and a wet binding agent are combined to create a mixture that is able to take and hold an impression as well as withstand the heat or pressure of a molten material. A “sand” might consist of many materials; indeed, the author of the manuscript lists, among many options, calcined ox hooves, crushed glass, and burned felt as potential materials for sand.[[3]](#footnote-4) Similarly, many materials may be used as “wet” binding agents, which are also called “Magistry” or *magistra* in early modern craft recipes. Biringuccio writes about making a magistery of salt and water in his *Pyrotechnia*; Hugh Plat also uses this term within the context of a recipe, but one that does not describe a sand casting process.[[4]](#footnote-5) The very term “Magistry” is enigmatic in itself; how does this word connect to the binding agents described in the manuscript? What properties are exhibited in these binding agents? What do they have in common? Do they operate in similar ways, or do certain binders perform better than others? By thinking more broadly about the materials used in the manuscript’s mold-making recipes and investigating the materials themselves, it is possible to understand why an early modern craftsman may have preferred one binding agent to another: in the examples of egg whites and wine-elm-root decoctions, egg whites may have been used for their strength, and an elm root decoction for its similar properties as well as the ability to make it in larger quantities.

Before considering the specifics on each material, it is helpful to briefly consider the term *magistra* and what it might have meant to the author and potential readers of Bnf. Ms. Fr. 640. *Magistra* seems to have been derived from the Latin word *magisterium*, used in Classical Latin to refer to the office of a magistrate, and used later in medieval Latin to refer to the philosopher’s stone.[[5]](#footnote-6) *Magistra* does not appear in Randle Cotgrave’s seventeenth-century French-English dictionary, though a related word *magistère* is defined as “Maistership, authoritie, sway, cheefe rule, also, maisterie, a maisters part, or maisterpeece.”[[6]](#footnote-7) This entry is followed by several words that may relate to the author’s use of *magistra:* the adjective *magistral* implies both mastery and trickery in its description: “Magistrall; of a maister, or magistrate, or maister; also, maister-like; artificiall, skilfull, cunning.”[[7]](#footnote-8) Similarly, the adverb *Magistralement* suggests a similar dual meaning of skill and trickery: “Maister-like, expertly, artificially, cunningly.”[[8]](#footnote-9) Turning to English usage, the Oxford English Dictionary defines “Magistry” as both a chemical and alchemical term, with most usage of the word appearing in seventeenth century texts.[[9]](#footnote-10) Magistry might refer to a “master principle of nature, free of impurities...a substance, such as the philosopher’s stone, capable of transmuting or changing the nature of other substances,” but can also refer to the “residuum obtained by an acid solution; a precipitate; a resinous extract.”[[10]](#footnote-11) While *magistra* or magistery may carry many meanings, some of them mysterious and difficult to access, the key to our study seems to that *magistra* was capable of enacting material transformation; it could make a dry substance wet, a lean substance fat. As the French entries suggest, this material transformation was enveloped in mystery: perhaps only those skilled in the making of *eau magistra* could access its transformative powers. Binding agents in sand-casting seem to have been one of the many sub-categories of *magistra*. Bnf. Ms. Fr. 640 mentions *magistra* on folio 68r in a recipe for casting: “It releases very cleanly, and needs not to be dampened with magistra or anything else...”[[11]](#footnote-12) *Magistra* seems to indicates a mixture; both wine and egg white are mentioned in the manuscript in cases where a binder is needed to moisten the sand, but the author writes, “wine *or magistra*” and “*magistra or* egg white.”[[12]](#footnote-13) The author seems to prefer to differentiate between *magistra* and substances that do not require additional ingredients to act as binding agents. The recipes for *magistra,* on the other hand, call for mixtures of more than one substance: salt and water, for example, or wine and elm root.

Turning to folio 84v, the recipe “Eau Magistra” recommends boiling elm root in wine in order to make a mixed *magistra*. This mixture, the author implies, is a better alternative to salt water, which “some people” say is “not good.”[[13]](#footnote-14) This elm root binding agent is mentioned in a number of recipes for sand-casting,[[14]](#footnote-15) including “Sand” on folio 69v: “Lean sand needs to be more moistened than others, that’s to say with...wine boiled with elm tree roots or something similar.”[[15]](#footnote-16) The elm root-wine decoction is mentioned on folio 72r in the recipe “Copper casting” (“Moisten your sand with wine boiled with elm root”)[[16]](#footnote-17) as well as “Sand Experiments” on 86r: “Then I molded burned bull’s foot bone, pulverized & strained through a double sieve and wet with egg white or wine boiled with the root of an elm.”[[17]](#footnote-18) Like “Eau Magistry” on folio 84v, the recipe “Magistry” on folio 87v also describes how the decoction should be made: “Founders harvest the roots of a young elm when it is sappy, and boil it in wine, or better yet vinegar. They prepare a year’s worth of it and store it in a cask.”[[18]](#footnote-19) It is interesting to note the lack of distinction between wine and vinegar in this recipe; the author implies that the qualities of both are sufficient for the needs of the binder. The description of the elm root harvest is also notable; notice that the author writes that “Founders” do this, implying that he himself (or whoever wrote the recipe) is not a founder. Finally, it is notable that the elm root mixture could be made and stored in large quantities; perhaps this was useful when casting objects from a large box mold.

In our experiments making *magistra*, we were able to make a substance that performed well in sand-casting and behaved similarly in its material properties to egg white. The manuscript simply instructs to boil wine with elm root; we chose an inexpensive Cabernet Sauvignon, remembering that the manuscript did not exactly discriminate between wine and vinegar.[[19]](#footnote-20) While we were unable to harvest sappy elm root as described in the manuscript, we did find slippery elm inner bark powder, which is still used in modern medicinal recipes.[[20]](#footnote-21) We substituted this substance for the freshly harvested elm root. It remains an open question, however, what quantity of elm root is needed to make the *magistra*; with the scarcity of early modern sources on this issue,[[21]](#footnote-22) we consulted modern medicinal recipes to determine the quantity. Boiling one cup of wine with two teaspoons of powdered slippery elm bark resulted in a viscous liquid that smelled of fruit and had the thick, mucilaginous texture of egg whites. The substance coheres to itself in globules, much like the mucus of egg whites, but with a more uneven texture. [fig. 1]

As briefly discussed above, egg whites were also used as a binding agent and are mentioned in several recipes in Bnf. Ms. Fr. 640;[[22]](#footnote-23) it remains an open question, however, if the author considered egg whites to be *magistra* or, as the aforementioned “Sand experiments” recipe implies, if it was an alternative to using *magistra*.[[23]](#footnote-24) In the recipe “Egg white,” the author suggests that the particular advantage of the substance as a binding agent is its strength: “Egg white gives strength to sand so that many casts [can be] made from it.”[[24]](#footnote-25) Egg white also appears in the recipe “Other sand,” which recommends mixing well-beaten egg white with clay earth mixed with charcoal.[[25]](#footnote-26) In the recipe “Sand, for the most excellent lead of all…” egg whites are suggested to moisten crushed white lead.[[26]](#footnote-27) On folio 85v in the recipe “Casters,” the author writes that beaten egg white should be mixed with earth: “They mix beaten egg white with earth of which they make the first layer of the crown [of a bell] in pieces.”[[27]](#footnote-28) The recipe “Excellent sand for lead, tin and copper” on folio 86v, which mentions many materials for sand such as burned bone and burned felt, also mentions egg white as a binder in sand casting.[[28]](#footnote-29) In this recipe, the author writes that he was able to do several casts in this particular mold: “Two times, I cast copper…”[[29]](#footnote-30)

We tested both egg whites and the elm-root wine decoction as binders in sand casting, using box molds and sand made from crushed, used molds.[[30]](#footnote-31) While they have their own differences, the sand mixture with egg white and sand mixture with elm root decoction were more similar to one another in tactile handfeel properties. When mixed with the sand, the consistency was almost more oily than wet; the sand clumped like moist brown sugar rather than a soft, wet clay. It was easy to tell when the sand was ready for the molds, using a squeeze-test described in the manuscript on folio 118v: the sand should give “a nice hold,” but should come apart easily.[[31]](#footnote-32) To test this, we took a handful of the sand mixture and squeezed it into the palm. If it held together, but could also be easily dissolved by applying pressure to it with a fingertip, it was ready for molding. [fig. 2, fig. 3, fig. 4] Both sands packed exceptionally well when building the molds; the sand mixtures did not seem too moist or too dry, and both produced detailed impressions.[[32]](#footnote-33) [fig. 5, fig. 6] Just as the recipes in the manuscript indicate, the mold made with egg white was strong enough to endure two castings of molten tin.[[33]](#footnote-34) [fig. 7] The mold made with the elm root *eau magistra* produced a fine product, but the mold did not hold up well enough to produce two castings.[[34]](#footnote-35) [fig. 8]

In the research briefly presented here, we have demonstrated that altering one part of a sand casting recipe can yield different results, and different ingredients might have been used in a workshop to make molds with different characteristics. The mold made with the egg whites was strong enough to cast two objects in molten tin and could have possibly cast a third. The durability of molds made with egg white is also reflected in several recipes in Bnf. Ms. 640. The *magistra* made with elm root also performed well, and might have had the added benefit of being able to be made in large quantities and stored for long periods of time. Depending on what materials were available and potentially the size of the mold, the craftsman could have worked with either substance. *Magistra* played an important role in transforming substances from one material state to another; in the case of sand-casting, *magistra* moistened the wet sand and made it strong enough to withstand casting molten metal.

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**List of illustrations**

Figure 1: Pouring elm root *magistra* into sand. Its consistency is thick and reminiscent of mucus.

Figure 2: “Squeeze” test of elm root *eau magistra* mixture. Notice how the sand packs tightly, but comes apart easily when a little pressure is applied.

Figure 3: “Squeeze” test of egg white sand mixture.

Figure 4: “Squeeze” test of another sand mixture that was too wet. Notice how muddy the sand is and how it sticks to the hand; this particular mixture would not break apart easily. This mixture was made in a previous sand casting experiment, consisting of pulverized molds (1:1 brick dust and plaster), ammonium chloride, and brandy.

Figure 5: Impression made from plaster model in egg white mold.

Figure 6: Impression made from plaster model in elm root mold.

Figure 7: Two tin objects made from the egg white mold. The object on the right is from the first cast, the left object is from the second cast.

Figure 8: One tin object made from the elm root mold.

**Bibliography**

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Randle Cotgrave, *A Dictionary of the French and English Tongues* (London: Adam Islip, 1611).

Plat, Hugh. *The jewel house of art and nature: containing divers rare and profitable inventions, together with sundry new experiments in in [sic] the art of husbandry, with divers chymical conclusions concerning the art of distillation, and the rare practises and uses thereof.* (London: Printed by Elizabeth Alsop, 1653). *The Making Of The Modern World*. Web. 19 Dec. 2014.

"Making Up the Renaissance." Making Up the Renaissance. University of Edinburgh: 2012. Accessed December 18, 2014. <https://sites.eca.ed.ac.uk/renaissancecosmetics/>.

1. Marc Smith, Professor of Paleography, École des chartes, has noted that this marginal note does not necessarily belong to the “Eau Magistra” entry, but rather part of the preceding entry titled “Sand” [*“Sable”*]. [↑](#footnote-ref-2)
2. See note 1. [↑](#footnote-ref-3)
3. See Bnf. Ms. Fr. 640, folios 84v, 68r, and 83r, respectively. [↑](#footnote-ref-4)
4. Vannoccio Biringuccio, *The Pirotechnia of Vannoccio Biringuccio. The Classic Sixteenth-Century Treatise on Metals and Metallurgy*, trans. and ed. by Cyril Stanley Smith and Martha Teach Gnudi (New York: Dover Publications, 1990), 345. [↑](#footnote-ref-5)
5. *Oxford English Dictionary Online*, s.v. “magistry.” [↑](#footnote-ref-6)
6. Randle Cotgrave, *A Dictionary of the French and English Tongues* (London: Adam Islip, 1611), s.v. “magistère.” [↑](#footnote-ref-7)
7. Cotgrave, *Dictionarie*, s.v. “magistral.” [↑](#footnote-ref-8)
8. Cotgrave, *Dictionarie,* s.v. “magistralement.” [↑](#footnote-ref-9)
9. The earliest English usage of the term “Magistry” as it is defined in alchemy and chemistry is by Hugh Plat, “Howe to keepe the juice of Oranges, and Lemons all the yeare, for sauce, julepps, and other purposes” in *Jewell House of art and nature*, (1594), 37: “But because such secrets are fitter for a philosophers laboratory, then a gentlewomans closet, I wil not...discover any magistery upon so base an occasion.” [↑](#footnote-ref-10)
10. OED, s.v. “Magistry.” [↑](#footnote-ref-11)
11. Bnf. Ms. Fr. 640, 68r: “Elle despouille fort net, ne veult poinct estre humectée de magistra ne d’aulcune chose…” [↑](#footnote-ref-12)
12. “magistra ou glaire d’oeuf...du vin ou magistra…” Bnf. Ms. Fr. 640, fol. 69r. [↑](#footnote-ref-13)
13. “Eau Magistra.” Bnf. Ms. Fr. 640, fol. 84v. [↑](#footnote-ref-14)
14. For recipes containing wine boiled with elm root, see Bnf. Ms. Fr. 640, folios 69r, 72r, 84v, 85v, and 87v. [↑](#footnote-ref-15)
15. “Il fault que les sables maigres soient plus humectés que les aultres, sçavoir de magistra ou de bon vin pur ou de vin bouilly avecq de la racine d’orme & semblable.” Bnf Ms Fr 640, fol. 69v. [↑](#footnote-ref-16)
16. “Humecte ton sable avecq vin bouilly avecq racine d’orme, et gecte letton qui vient bien…” Bnf. Ms. Fr. 640, fol. 72r. [↑](#footnote-ref-17)
17. “Despuys j’ay moulé d’os de pied de bœuf bruslé, pulverisé & tamisé par un double tamys, & humecté avecq glaire d’oeuf ou vin bouilly avecq racine d’orme.”Bnf. Ms. Fr. 640, fol. 86r. [↑](#footnote-ref-18)
18. “Les fondeurs prenent de la racine de jeune orme quand il est en sabe, & le font bouillir en vin ou pour mieulx vinaigre, et en font provision pour tout l’an dans un barriquet.” Bnf. Ms. Fr. 640, fol. 87v. [↑](#footnote-ref-19)
19. See Bnf Ms. Fr 640, fol. 87v, “Magistry.” [↑](#footnote-ref-20)
20. Slippery Elm is a North American tree, but the elm root mentioned in the manuscript likely came from the European White Elm, *ulmus laevis*. [↑](#footnote-ref-21)
21. Inner bark of elm root is mentioned as an ingredient for a recipe “to make hair grow long” in Caterina Sforza’s late fifteenth century collection of recipes *Gli Experimenti:* “*Piglia el scorzo interior della Radice Delolmo et pesta et falla Bollir longamente in acqua…”* Making Up the Renaissance Project, Accessed 18 December 2014. <https://sites.eca.ed.ac.uk/renaissancecosmetics/>. [↑](#footnote-ref-22)
22. Eggs have many uses in Bnf. Ms. Fr. 640 and are mentioned often, but for recipes that mention egg white in sand casting processes, see folios 49r, 68r, 69r, 82r, 83r, 84v, 85v, 86v, and 87v. [↑](#footnote-ref-23)
23. See Bnf. Ms. Fr. 640, fol 85v, “Sand experiments.” [↑](#footnote-ref-24)
24. “La glaire d’oeufs donne force au sable pour en faire plusieurs gects.” Bnf. Ms. Fr. 640, fol. 82r. [↑](#footnote-ref-25)
25. Bnf. Ms. Fr. 640, fol. 83r. [↑](#footnote-ref-26)
26. Bnf. Ms. Fr. 640, fol. 84v. [↑](#footnote-ref-27)
27. “Ils meslent de la glaire d’oeufs battue avecq la terre de quoy ilz font la premiere couche de la chappe de pieces & cloches & toutes aultres pieces, disant que ladicte glaire faict venir nect & faict poser & asseoir la matiere. En noyau pour petit ouvraige, la glaire est bonne aussy.” Bnf. Ms. Fr. 640, fol. 85v. [↑](#footnote-ref-28)
28. See “Excellent sand for lead, tin, and copper,” Bnf. Ms. Fr. 640, fol. 86v. [↑](#footnote-ref-29)
29. “Je y gectay deulx foys…” Bnf. Ms. Fr. 640, fol. 86v. [↑](#footnote-ref-30)
30. We are grateful for the expertise of Tonny Beentjes, [Official Title], who guided us as we reconstructed sand casting techniques from Bnf. Ms. Fr. fol. 118v, “Casting in a box mold.” Our sand was made from re-used, crushed molds made of 1:1 brick dust and plaster. We used ammonium chloride and brandy as binding agents. The sand mixture took on moisture in a different way than it did with the egg white and elm root binders; our resulting sand was muddy and full of moisture. See Cataldo and Visco Field Notes, 14-15 October 2014. [↑](#footnote-ref-31)
31. Bnf. Ms. Fr. 640: “Casting in a box mold.” [↑](#footnote-ref-32)
32. The elm root decoction underwent significant shrinkage, whereas the mold made with the egg binder had only changed slightly in size. See Cataldo and Visco Field Notes, 2 December 2014. [↑](#footnote-ref-33)
33. Interestingly, the addition to egg whites in bread molding also makes for successful casts with great detail. See Cataldo and Visco Field Notes, 29 September 2014. [↑](#footnote-ref-34)
34. For more on the sand casting process, see Cataldo and Visco Field Notes, 25 November 2014. [↑](#footnote-ref-35)