Sven Dupré

The Art of Glassmaking and the Nature of Stones

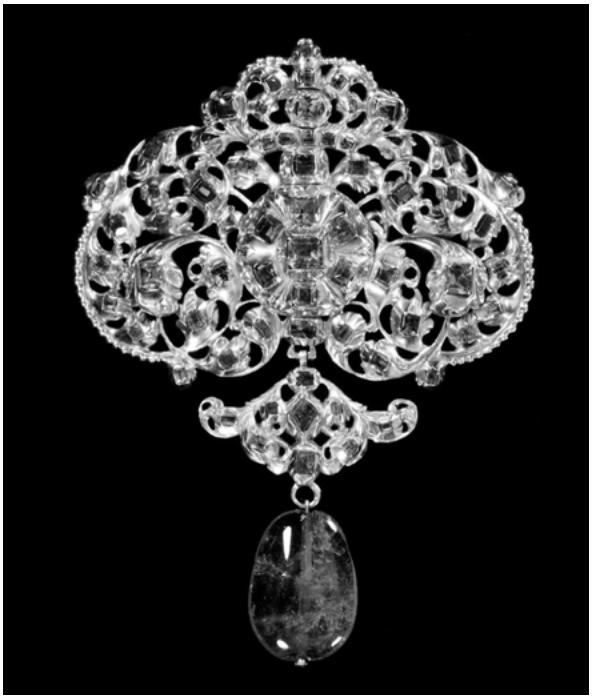
The Role of Imitation in Anselm De Boodt's Classification of Stones

In *Gemmarum et lapidum historia*, published in 1609, and arguably the most important work on stones of the seventeenth century, the Flemish physician Anselm De Boodt included precious stones, such as diamonds, lapis lazuli, emeralds (fig. 1), jade, nephrite and agate imported to Europe from Asia and the New World.[1] The book was illustrated with specimens from the collection of Rudolf II in Prague where De Boodt was court physician, and the successor of Carolus Clusius as overseer of Rudolf's gardens.[2] De Boodt also included stones mined and sculpted in Europe, such as various marbles, porphyry, alabaster and rock crystal, as well as stones of organic origin, such as amber and coral (fig. 2), some fossils and a diversity of animal body stones, the bezoar stone being the most famous.[3] Beyond simply listing stones across the lines between the organic and the inorganic, the vegetative and the mineral, the natural and the artificial, as was standard practice in the lapidary tradition stretching back to Theophrastus and Antiquity, De Boodt also offered a classification of stones. Despite his importance, little work has been done on De Boodt. One exception is work by Annibale Mottana, who argues that "De Boot (sic) wanted to show his contempt for the merchant approach to gemstones in an attempt to

1 This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 648718), and has been supported by a Robert H. Smith Scholarship in Residence for Renaissance Sculpture in Context at the Victoria and Albert Museum in London.

2 Charles Parkhurst: A Color Theory from Prague. Anselm de Boodt, 1609, in: Allen Memorial Art Museum Bulletin 29 (1971), p. 3–10; Marie-Christiane Maselis, Arnout Balis and Roger H. Marijnissen: De albums van Anselmus De Boodt (1550–1632). Geschilderde natuurobservatie aan het Hof van Rudolf II te Praag, Tielt 1989.

3 There is an extensive literature on each of these stones. See, for example, Suzanne B. Butters: The Triumph of Vulcan. Sculptors' Tools, Porphyry, and the Prince in Ducal Florence, Florence 1996; Aleksandra Lipinska: Alabastrum, id est, corpus hominis. Alabaster in the Low Countries, a cultural history, in: Netherlands Yearbook for Art History 65 (2012), p. 84–115; Marlise Rijks: 'Unusual Excrescences of Nature'. Collected Coral and the Study of Petrified Luxury in Seventeenth Century Antwerp, in: Dutch Crossing. Journal of Low Countries Studies 41 (2017), http://dx.doi.org/10.1080/03096564.2017.1299931; Peter Borschberg: The Trade, Use and Forgery of Porcupine Bezoars in the Early Modern Period, in: Revista quadrimestral da Fundacao Oriente (2006), p. 60–78.



1 Pendant, emeralds, made in Spain, 1680–1700, London, Victoria and Albert Museum, Museum Number: M. 138–1975

2 Spoon, made in Germany, 1530–1540, London, Victoria and Albert Museum, Museum Number: 2268–1855

base gemology on more durable and reliable scientific criteria".[4] He also speaks of "De Boot's opposition of the practical trend in gem appraisal".[5] However, Mottana's qualification of De Boodt's work on stones seems to miss the point of De Boodt's intellectual enterprise. I will argue that, rather to the contrary, De Boodt's classification of stones was defined by the use, transformation and imitation of materials by jewellers, glassmakers and goldsmiths and by the knowledge of stones in the early modern marketplace as much as by the categories and concepts of Aristotelian natural philosophy and history. In particular, I will point out the importance of the changing epistemic status, as well as the value of glass imitations of gemstones at the time to De Boodt's classification of stones (pl. 22). This issue should be considered in the context of the ever-present concern with fraudulent practices and deceptive imitations of stones at the time.

4 Annibale Mottana: Italian gemology during the Renaissance. A Step Toward Modern Mineralogy, in: Gian B. Vai and W. Glen E. Caldwell (ed.): The Origins of Geology in Italy, Boulder, Co. 2006, p. 1–21, here p. 17.

5 Mottana 2006 (see n. 4), p. 17.

The Knowledge of Stones in the Marketplace

Knowledge was essential in order to be able to judge the quality and the value of stones in the early modern marketplace. In networks of commercial exchange, a particular kind of knowledge of stones focusing on the visible qualities and properties of stones thrived. There had been a constant concern with fake stones across Europe since at least the thirteenth century. Goldsmiths often used imitation stones to set in jewels and bejewelled objects, such as the *Westminster Retable*.[6] Medieval guild statutes for goldsmiths forbade or regulated the use of fake stones in jewellery, especially in rings, and other forms of goldsmiths' work.[7] For example, the mercers of Paris were forbidden to use fake pearls (and also Scottish pearls, obtained from fresh-water mussels in Scottish rivers) as cheap substitutes for oriental pearls. By 1355, the new statutes of the Paris goldsmiths' guild forbade the use of crystal (berill) cut to resemble diamonds. In Venice, a new ordinance of the later 1280s forbade goldsmiths to make imitations of natural stones or to enhance a natural stone by tinting it. The very first document concerning the Antwerp diamond trade, dated 1447, is a proclamation against the sale of false stones. It concerned diamonds, rubies, sapphires and emeralds, and proclaimed that it was punishable to produce, process, trade or pawn false stones.[8] This constant concern with false stones indicates that their counterfeiting was common and widely practiced. Knowledge to discern real from fake stones was thus necessary for merchants and consumers alike to be able to successfully operate in the marketplaces of Europe before 1500.

Making the provenance of stones more difficult to judge, global trade after 1500 made the issue of fake stones only more pressing. Gem trade became truly global when the Portuguese arrived in the Indian Ocean in the sixteenth century. This marked the beginning of the movement of emeralds and other precious stones from the Americas to India.[9]

6 For examples of imitation and fake gems, see Marjolijn Bol: Coloring Topaz, Crystal and Moonstone. Factitious Gems and the Imitation of Art and Nature, 300–1500, in: Marco Beretta and Maria Conforti (ed.): Fakes!? Hoaxes, Counterfeits and Deception in Early Modern Science, Sagamore Beach 2014, p. 108–129, here p. 124–128, discussing the imitation gemstones set on the *Westminster Retable*, ca. 1250; Hazel Forsyth: The Cheapside Hoard. London's Lost Jewels, London 2013, p. 68–76. The Cheapside Hoard includes counterfeit balas rubies (red dyed rock crystal) and a jewel with red and green pastes (glass).

7 The following examples are discussed in Ronald W. Lightbown: Mediaeval European Jewellery with a Catalogue of the Collection in the Victoria & Albert Museum, London 1992, p. 11–22.

8 "No one within the city of Antwerp was to buy, sell, pawn, or pass any false stones imitating a stone mounted in gold, silver or gilded copper, or imitating diamonds, rubies, emeralds or sapphires; under a penalty of a fine of 25 riders, of which one third had to be payed to the Lord, one third to the city, and one third to the person reporting it." Felixarchief (Antwerp), PK 913: Plakkarten van den Hove, quoted and translated in Iris Kockelbergh, Eddy Vleeschdrager and Jan Walgrave: The Brilliant Story of Antwerp Diamonds, Antwerp 1992, p. 31.

9 Kris Lane: Colour of Paradise. The Emerald in the Age of Gunpowder Empires, New Haven et al. 2010; Tijl Vanneste: Global Trade and Commercial Networks. Eighteenth-Century Diamond Merchants, London 2011; Karin Hofmeester: Shifting Trajectories of Diamond Processing. From India

Merchants involved in this global gem trade in the sixteenth and seventeenth centuries showed themselves concerned with the provenance, authenticity and quality of gemstones. In his *Diamond Manual* Gisberto van Coolen, related to the De Groote family in Antwerp, specialised in the India trade in silk, damask, diamonds and rubies, mentioned that it was difficult to keep track of the provenance of diamonds and how they had been marketed in Lisbon.[10] One way to deal with the issue was by building trust through personal relationships between merchants. Personal relationships, supported by family connections, were indeed characteristic of the gem trade. Until the 1640s the gem trade was dominated by Portuguese New Christian merchant families moving gems between Antwerp, Lisbon and Goa as part of a larger trade of goods, especially textiles and dyes.[11] The Portuguese merchants relied on extensive family networks distributed over several cities in Europe and India to facilitate this traffic. These networks were especially important in a trade so dependent upon trust. As Edgar Samuel emphasised: "Large gemstones cannot be sold by sample and take considerable time to sell to advantage. The trade therefore calls for much mutual trust and long-term credit. […] The ideal unit for the conduct of the international gemstone trade is an ethnic minority living within a major trading city and connected by language and kinship with similar communities in other major cities."[12] Otherwise, expertise to judge stones was a condition for trade. Boyajian has argued that

to Europe and Back, from the Fifteenth Century to the Twentieth, in: Journal of Global History 8 (2013), p. 25–49; Kim Siebenhüner: Kostbare Güter globaler Herkunft. Der Juwelenhandel zwischen Indien und Europa, in: Michael North (ed.): Kultureller Austausch. Bilanz und Perspektiven der Frühneuzeitforschung, Cologne et al. 2009, p. 327–342; Kim Siebenhüner: Europäische Juwelenhandler auf indischen Beschaffungsmärkten, in: Angelika Westermann and Stefanie von Welser (ed.): Beschaffungs- und Absatzmärkte oberdeutscher Firmen im Zeitalter der Welser und Fugger, Husum 2011, p. 237–251; Kim Siebenhüner: Where did the Jewels of the German Imperial Princes Come From? Aspects of Material Cultural in the Empire, in: Robert J.W. Evans and Peter H. Wilson (ed.): The Holy Roman Empire, 1495–1806. A European Perspective, Leiden 2012, p. 333–348; Joao Teles e Cunha: Hunting the Riches. Goa's Gem Trade in the Early Modern Age, in: Pius Malekandathil and Jamal Mohammed (ed.): The Portuguese, Indian Ocean and European Bridgeheads 1500–1800, Tellicherry 2001, p. 269–304; Nuno Vassalo e Silva: Jewels for the Great Mughal. Goa as a Centre of the Gem Trade in the Orient, in: Jewellery Studies 10 (2004), p. 41–51; James C. Boyajian: Portuguese Trade in Asia under the Habsburgs, 1580–1640, Baltimore et al. 1993.

10 Kockelbergh / Vleeschdrager / Walgrave 1992 (see n. 8), p. 113.

11 Boyajian 1993 (see n. 9); José A. Rodrigues da Silva Tavim: In the Shadow of the Empire. Portuguese Jewish Communities in the Sixteenth Century, in: Liam M. Brockey (ed.): Portuguese Colonial Cities in the Early Modern World, Farnham et al. 2008, p. 17–39. One example of a Portuguese New Christian family is the Ximenez; see Sven Dupré and Christine Göttler: Reading the Inventory. The Material Possessions of the Portuguese Merchant-Banker Emmanuel Ximenez in Early Seventeenth-Century Antwerp, forthcoming. For the role of Arminian diasporic families in the gem trade, see Evelyn Korsch: The Scerimans and Cross-Cultural Trade in Gems. The Arminian Diaspora in Venice and its Trading Networks in the First Half of the Eighteenth Century, in: Andrea Caracausi and Christof Jeggle (ed.): Commercial Networks and European Cities, 1400–1800, London 2014, p. 223–239.

12 Edgar R. Samuel: At the End of the Earth. Essays on the History of the Jews of England and Portugal, London 2004, p. 228.

the "diamond trade was the most specialized of all the Asian trades, requiring the greatest skills of its merchants. The merchants carefully evaluated the stones to avoid false and imperfect stones that were current in Asian markets."[13]

As merchants needed to reach agreement on the value of gemstones, what kind of knowledge did they think relevant for the purpose of trade, and necessary for judging the quality of precious stones? It is interesting to see how diamonds were assessed according to the manual of Gisberto van Coolen.[14] Merchants used a scale to determine the weight of the diamond. The stones were also different in size. According to the manual, there were diamonds circulating in Antwerp ranging from 1 to 40 carats in size. A magnifying glass was necessary to analyse the stone and describe its clarity, translucency and purity. Faults were known as 'grains of sand'. The stone was placed on black velvet to evaluate its colour, which could range from white-blue and white-white to yellow and brown. Underscoring the importance of trust, the stones were presented in person for sale to make these assessments possible.

Similar complications are evident in the *Couzas de pedraria*, a Portuguese handbook on the precious stones trade in India and the Americas circa 1600, probably solicited by and prepared for king Philip II.[15] It includes descriptions of the stones and the trade, instructions for distinguishing false stones from genuine ones, and perfect stones from imperfect ones, and tables of valuation. The valuation took place on the basis of visible qualities also mentioned by Van Coolen: colour, translucency, purity, and size. This is the description of emeralds:

> "There are emeralds that in India if they are oriental and fine and of good birth, and of a dense greenness and wholeness, are worth half the price of perfect ones; thus is the price of stones of the second grade and cleanness. There are other emeralds called Peruvian ones that have a clear greenness that many take from Portugal to India as merchandise, and thus have many been purchased only to [have their owners] return with them to this kingdom well deceived. It is better not to buy and sell such emeralds unless one is an expert or it will not be a profitable business."[16]

Since it is difficult to communicate visible qualities like colour, personal assessments in the presence of the gemstone were preferred. However, if this was not possible, correspondence communicated the stones' weight and quality.[17] For large diamonds a life-size drawing was included. Sometimes even a lead model was made, on which the faults were indicated. Judgement of size and purity was made possible by these tools.

13 Boyajian 1993 (see n. 9), p. 49.
14 Kockelbergh / Vleeschdrager / Walgrave 1992 (see n. 8), p. 115.
15 Lisbon, Biblioteca Nacional de Portugal, Codex 8571, f. 231–239.
16 Cited and translated in Lane 2010 (see n. 9), p. 101.
17 Kockelbergh / Vleeschdrager / Walgrave 1992 (see n. 8), p. 115.

This sort of empirical knowledge was largely absent from the science of stones as found in the lapidary tradition which built upon Pliny and Theophrastus. Up to the eighteenth century, gemstones had a recognised place in learned and vernacular medicine and magic.[18] Gemstones were considered to be related to planets and it was from these connections to other elements in the cosmos that their effectiveness, either as worn on the body, or as a powder or tincture, in medicine derived. Their rarity, making them expensive and exotic, also contributed to their attraction in pharmacy. While in lapidaries gems were caught in webs of associations with magical powers and cosmological meanings, the trade in precious stones featured only the stones' visible qualities, such as colour and size, as the knowledge that mattered. This shift is clearly visible in one lapidary source of the period, *Questo è 'l libro lapidario*, a manuscript compiled in 1587 by the Sienese merchant Niccolò Costanti. The lapidary consists of two markedly different parts. The first part of the text derives from ancient lapidary sources, leading, via Marbode, back to the ancient lapidary by Damerigon and Evax. In this section the compiler relates what 'the philosophers' had to say on gemstones. For example, Costanti writes that diamonds "have many other properties and virtues against malign spirits and phantasms", and that "it is good for men who go to the battleground because it makes them brave and audacious" and that amethysts are "good to mortify lust and against bad spirits".[19] The second part of the text is copied from a manuscript by Alessandro Vanocci, and is very different. It gives the 'rule' and 'reason' of gemstones for merchants, and relates the visual and physical properties of gemstones to their price in the marketplace. The emphasis on these properties of gemstones is clearly of mercantile inspiration, especially in comparison to the ways in which gemstones continued to be used and conceived in other spheres.

Glass Imitations of Gemstones

The visual properties of gemstones, on which merchants focused, elicited artisanal ways of enhancing and imitating gems. Oiling and polishing gemstones were well-accepted practices to bring out the natural qualities of brilliance, transparency and colour of a stone. Glass was widely used to imitate gemstones. Not all practices to enhance or imitate gemstones were fraudulent. Nor were all glass imitations intended as deceptive fakes. "The

18 Joan Evans: Magical Jewels of the Middle Ages and the Renaissance: Particularly in England, Oxford 1922; Tom Blaen: Medical Jewels, Magical Gems. Precious Stones in Early Modern Britain, Devon 2012, especially chapters 3 and 4. See also the contribution of Nicolas Weill-Parot in this volume.

19 "Ancora dicono i filosofi che son molt' altre proprietà e virtute contra li spiriti maligni, contro le fantasme; è buono agli huomini che vanno in battaglia, per chè gli dà ardimento e audacia" (7r); "Molti filosofi dicono che son buono a mortificare la lussuria e contra i mali spiriti" (14r), in: Carlo Paganini and Gabriella Poli (ed.): Questo è 'l libro lapidario. Riproduzione di un codice inedito del 1587, Milan 1987.

boundary with fraud became fluid whenever the same materials and processes were used for the production of glass imitations.[20]

Natural historians and philosophers also traded on and across this fluid boundary whenever they used materials and processes of the art of glassmaking to understand the nature of stones. In his *Book on Minerals*, perhaps the most influential work on the science of stones before De Boodt and a point of reference for numerous medieval and early modern lapidaries, the twelfth century natural philosopher Albertus Magnus considered translucent gemstones a type of "glass produced by the operations of nature", comparing the processes of nature with those used for making glass.[21] He argues that transparency is the most important defining characteristic of the class of stones known as gems. With reference to the Aristotelian framework of the elements, their common material and the cause of their transparency, is water. Through the application of fire, the moisture is solidified, analogous according to Albertus Magnus, to the processes of the art of glassmaking. However, gemstones are not pure water, but a mixture of water with other elements, hence their different degrees of transparency. Nevertheless, "they are of a more subtle mixture and a clearer transparency than glass made artificially. For although art may imitate nature nevertheless it cannot reach the full perfection of nature."[22] Thus, for Albertus Magnus, glass and gemstones were made by the same processes from the same material. The analogy of the making of glass and the generation of gemstones was widely accepted in natural philosophy, alchemy and the arts. Moreover, the analogy was sometimes also extended to the Philosophers' Stone of transmutational alchemists.[23]

Albertus Magnus is the most important source for the *Trésorier de philosophie naturelle des pierres précieuses* by the fourteenth-century natural philosopher Jean d'Outremeuse. The first three books follow the format of the learned lapidary tradition. The second book contains descriptions of stones which are alphabetically listed. The first significant issue to point out is that the description of stones is exclusively based on colour.[24] For each stone d'Outremeuse lists its medical virtues and magical uses as was common practice in the lapidary tradition. The third book is entirely devoted to the astrological virtues of engraved stones. A second significant issue is that d'Outremeuse is concerned with the distinction between real and fake stones and he includes several procedures for testing gemstones, and devotes the entirety of book IV of the *Trésorier* to recipes for imitating gemstones in glass. The idea of imitation is based solely on transformation by colour; it is the colour of the

20 Bol 2014 (see n. 6), p. 108–129.

21 Albertus Magnus: Book of Minerals, translated by Dorothy Wyckoff, Oxford 1967, p. 14.

22 Albertus Magnus 1967 (see n. 21), p. 14.

23 Sven Dupré: The Value of Glass and the Translation of Artisanal Knowledge in Early Modern Antwerp, in: Bart Ramakers, Christine Göttler and Joanna Woodall (ed.): Trading Values in Early Modern Antwerp, Leiden 2014, p. 138–161, especially p. 147f.

24 Anne-Françoise Cannella: Gemmes, verre coloré, fausses pierres précieuses au Moyen Age. Le quatrième livre de 'Trésorier de philosophie naturelle des pierres précieuses' de Jean d'Outremeuse, Geneva 2006, p. 48.

gemstones which the glass imitates. Moreover, there was a tendency in the period to also attribute the same symbolic properties to imitation glass as to gems as long as they had an identical colour.[25]

In *De natura fossilium* (1546) Georg Agricola agrees that gemstones should be primarily classified by colour.[26] Interestingly, extending Albertus Magnus' argument that artificial glass is simply a less perfect natural gemstone one step further, Agricola classifies glass as a stone. In particular, for Agricola, glass is one of the three kinds of stones which liquefy in the furnace or by fire. Of the other two kinds, one stone is similar to transparent gems, and the other not. Also, these stones, in the form of sands, can be used for the making of glass.[27] Agricola emphasises that the only difference with gemstones lays in their hardness. The only way to distinguish glass imitations, being "soft and fragile", from real gemstones is by scratching them by file.[28] The only exceptions are "topazius" and "smaragdus" because these gemstones are less hard than glass. However, for these stones, detection of fakes or imitations is possible by touching and holding the gemstones; glass is warmer and lighter than the gemstones.

We encounter similar ideas about glass and stones in Vannoccio Biringuccio's *Pirotechnia*.[29] Published posthumously in 1540, *Pirotechnia* was one of the first technical treatises on metallurgy detailing practices such as mining, assaying and casting. It also deals with minerals and semi-minerals. According to Biringuccio, gemstones' primary nature is watery, and depending upon the mixture with other elements, they assume different degrees of transparency. Their other characteristic, colour, varies according to the position and proximity of metals, Biringuccio maintains. The invention of glass is attributed to the alchemists and their desire to make gems: "for when they could not bring them to perfection (as also happened with the metals) they made this beautiful and attractive product, glass".[30] Biringuccio relates that the Venetian glassmakers brought the art to such perfection that the discovery of falsifications became difficult even for experts:

25 Cannella 2006 (see n. 24), p. 112–119.

26 See especially the discussion of gems in book VI of *De natura fossilium*: Georg Agricola: De natura fossilium (Textbook of Mineralogy), translated by Mark Chance Bandy and Jean A. Bandy, New York 1955, p. 112–147.

27 Agricola 1955 (see n. 26), p. 108–111.

28 Agricola 1955 (see n. 26), p. 115.

29 For the similiarity of ideas of Biringuccio and Agricola, see John A. Norris: Early Theories of Aqueous Mineral Genesis in the Sixteenth Century, in: Ambix 54 (2007), p. 69–86. For Biringuccio, more generally, see Andrea Bernardoni: La conoscenza del fare. Ingegneria, arte scienza nel 'De la pirotechnia' di Vannoccio Biringuccio, Rome 2011; Andrea Bernardoni: Artisanal Processes and Epistemological Debate in the Works of Leonardo da Vinci and Vannoccio Biringuccio, in: Sven Dupré (ed.): Laboratories of Art. Alchemy and Art Technology from Antiquity to the 18th Century, Cham 2014, p. 53–78.

30 Vannoccio Biringuccio: The Pirotechnia, translated by Cyril S. Smith and Martha T. Gnudi, New York 1959, p. 126.

> "From this body [glass] are also made very fine enamels, colored and so beautiful that they are not only used when ground up beautifying paintings and for ornamenting objects of gold, silver, or copper but they are also used to counterfeit emeralds, diamonds, rubies and all other gems of any color whatsoever. I have seen some of these that, even though they were examined and judged by the eyes of very experienced and practiced men, could not be distinguished by them as false."[31]

Biringuccio adds that glass should not be given too much love, because "it must be used and kept in mind as an example of life of man and of the things of this world which, though beautiful, are transitory and frail."[32]

In *L'arte vetraria* (1612) Antonio Neri repeats Biringuccio's attribution of the invention of glass to alchemists imitating gemstones.[33] However, he is even more taken by malleable glass, a famously lost ancient invention he appreciated because of its incorruptibility and durability. "Indeed if such a thing were to be known today," Neri writes, "without any doubt it would be more valued than Silver or Gold for its beauty, and incorruptibility, since glass does not give rise to rust, or taste, or smell, or any other adverse quality."[34] A concern with durability is evident from his inclusion of a recipe from the alchemist Isaac Hollandus to make a glass imitating all gemstones on the basis of the "true sulphur of Saturn".[35] Glass imitations of gemstones produced according to this recipe have the advantage that, unlike when prepared with ordinary minium, they do not become yellowish and thus, with time, ugly. Clearly concerned with the effects of ageing, it is hardness first and foremost which again defines the difference between glass and gemstone. Confident of his art of glassmaking, and in contrast to Albertus Magnus' dictum that art cannot reach Nature's perfection, Neri argues his imitations' qualities surpass all those of natural stones, though with the exception of hardness.[36] Thus, in the early modern period, hardness replaces colour and transparency as the most important defining characteristic of gemstones.

31 Biringuccio 1959 (see n. 30), p. 132.
32 Biringuccio 1959 (see n. 30), p. 132.
33 Paul Engle: TheArt of Glass by Antonio Neri, 3 vols., Hubbardston 2003–2007, see vol. 1, p. 5.
34 Engle 2003–2007 (see n. 33), vol. 1, p. 6.
35 Engle 2003–2007 (see n. 33), vol. 3, p. 17f. Highly poisonous, it also precipitated Neri's death. See Paul Engle: Conciatore. The Life and Times of 17th Century Glassmaker Antonio Neri, Hubbardston 2014, p. 239.
36 Engle 2003–2007 (see n. 33), vol. 2, p. 23, where he makes this claim specifically with respect to chalcedony glass; for his search for a recipe of glass imitation gems coming close to the hardness of natural stones, see vol. 3, p. 18–20.

Artisanal Knowledge and the Science of Stones: De Boodt

Appropriating artisanal and mercantile knowledge of stones, De Boodt transforms the natural history of stones building on a lapidary tradition reaching back to Theophrastus. De Boodt's *Gemmarum et lapidum historia* comes in two sections. The first part deals with the nature, origin and formation of gems and stones. The second part contains more detailed descriptions and discussions of the different stones, beginning with diamonds, the most translucent of stones, and ending with marbles and animal body stones. Remarkably, in the first part of the book after the description of the 'accidents' of the stones (the attributes or properties which do not affect the essence of stones in Aristotelian natural philosophy), De Boodt indicates that this is also very useful knowledge because it serves to distinguish real from counterfeit stones, a purpose of the book which was reflected in the titles of the later French translation of De Boodt in the 1640s as well as in the lapidary of the Cambridge scholar Thomas Nicols in English, which was a derivative of De Boodt's *Gemmarum et lapidum historia*.[37] According to De Boodt, it is sensory investigation of the 'accidents' which will allow the expert to make this distinction. What follows is a description of different ways to make stones look larger as well as how to change their colour by heating and dyeing, faceting and the application of metal foils. To be able to judge the difference between real and fake stones, it is helpful, according to De Boodt, to know how to counterfeit stones. De Boodt includes several recipes highlighting in particular two best-selling sixteenth century books of secrets as the source of his recipes: Giovanni Battista Della Porta's *Natural Magic* (for recipes to colour crystals to make them resemble emeralds and other stones), and *The Secrets of Alessio Piemontese* (for the fabrication of pastes for making imitation stones on the basis of grinding up real stones).[38] In contrast to Albertus Magnus' traditional lapidary, De Boodt was convinced that understanding counterfeit gemstones was not useful for understanding natural stones. Counterfeit gemstones were just glass imitations, which, De Boodt maintained, had nothing in common with the materials and processes by which natural stones were produced.[39]

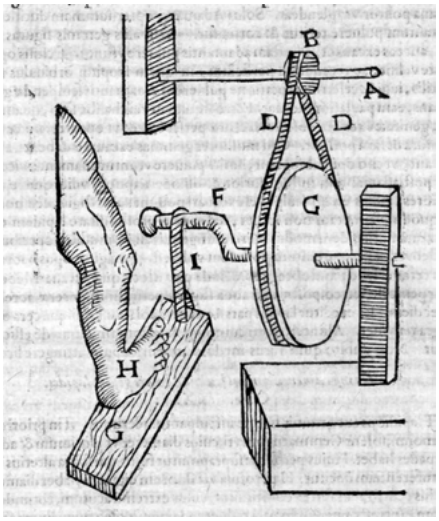
Nevertheless, the use of stones in art was an important element in De Boodt's determination of the scope of his natural history. It is for this reason that his description of lapis lazuli focused on how to grind the stone to make the pigment.[40] The use of pearls by gold-

37 Anselmus De Boodt: Gemmarum et lapidum historia, Hanau 1609, p. 29–33. On the title page: "[…] ou sont amplement descrites leur naissance, iuste prix, moyen de les cognoistre, & se garder des contrefaites", in: Anselm De Boodt: Le parfaict joaillier ou Histoire des pierreries, Lyon 1644; "With cautions for the undeceiving of all those that deal with Pretious Stones", in: Thomas Nicols: Lapidary or, the History of Pretious Stones, Cambridge 1652.

38 Compare Joanna Whalley: Smoke and Mirrors. The Enhancement and Simulation of Gemstones in Renaissance Europe, in: David Saunders, Marika Spring, and Andrew Meek (ed.): The Renaissance Workshop. The Materials and Techniques of Renaissance Art, London 2013, p. 79–89.

39 De Boodt 1609 (see n. 37), p. 17.

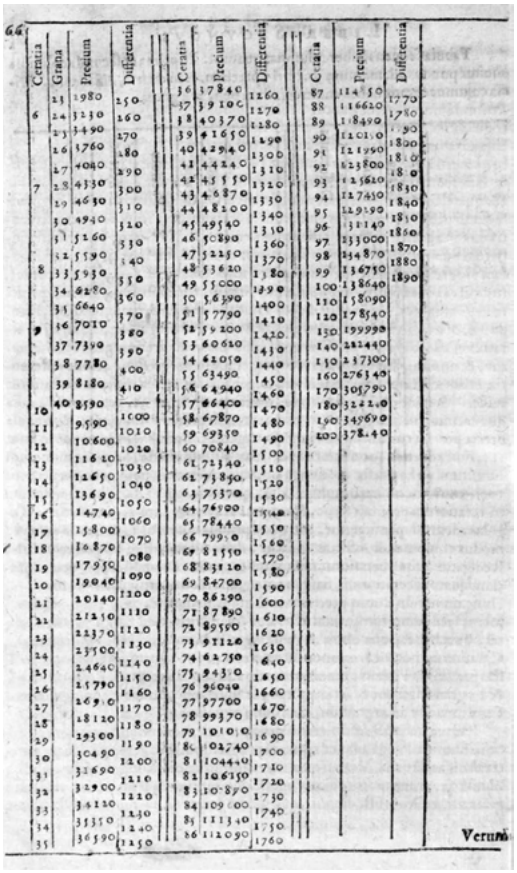
40 De Boodt 1609 (see n. 37), p. 140–146.



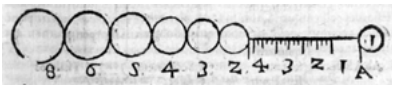
3 Anselmus De Boodt: Gemmarum et lapidum historia, Hanoviae 1609, p. 36

smiths and jewellers also made De Boodt decide to include pearls in his book, although, as he admitted, many would argue against including them as gemstones.[41] De Boodt also included significant information on artisanal practices of cutting, engraving and polishing of stones.[42] De Boodt identifies hardness as the main property of the stone in determining the use of different tools, instruments and abrasives. Diamond powder is to be used for cutting, while for softer stones the use of emery suffices. The iron or steel wheel cuts common stones such as marbles. De Boodt illustrates several machines for cutting stones. An example is a machine where the movement of "the foot of the sculptor" drives the wheel with a pin dipped in diamond powder (fig. 3). For cutting larger pieces of stone De Boodt recommended the use of the bow saw. Beside fostering the discernment of the consumer between real and false stones, the knowledge of the marketplace also entered De Boodt's natural history by the adoption of the discussion of price of precious as well as common stones like coral and amber. De Boodt offers his readers tables and diagrams to help them determine and negotiate the price of stones. He includes a table in which he sets carat and weight (grains) out against the price of diamonds (fig. 4).[43] When discussing the price of garnets he recommends the use of scaled drawings to measure the diameter of the garnet (fig. 5).[44] He suggests a similar paper tool to measure the size of an amethyst, again connecting it to the price of the stone (fig. 6).[45] The weight and the size of the stone are the

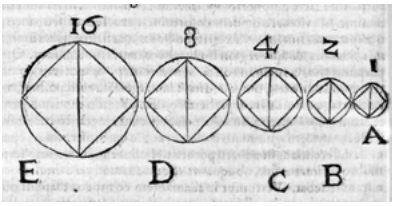
41 De Boodt 1609 (see n. 37), p. 83.
42 De Boodt 1609 (see n. 37), p. 35–42.
43 De Boodt 1609 (see n. 37), p. 65f.
44 De Boodt 1609 (see n. 37), p. 77.
45 De Boodt 1609 (see n. 37), p. 82.



4 Anselmus De Boodt: Gemmarum et lapidum historia, Hanoviae 1609, p. 66



5 Anselmus De Boodt: Gemmarum et lapidum historia, Hanoviae 1609, p. 77

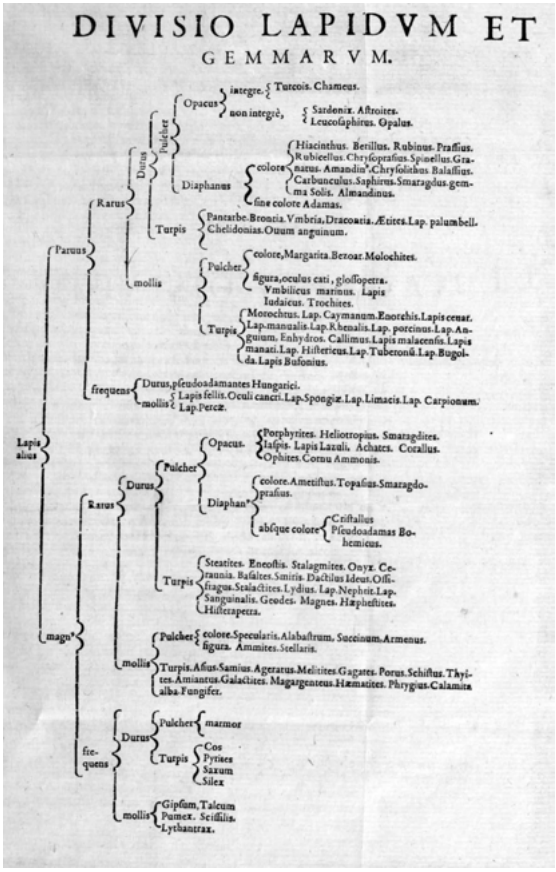


6 Anselmus De Boodt: Gemmarum et lapidum historia, Hanoviae 1609, p. 82

all-important qualities in determining its value. In contrast, the price of easily available stones, like agate, is dependent on its form, not on its composition.

The artisanal and mercantile knowledge of stones not only determined the scope of De Boodt's natural history, it also determined his definition and classification of stones. While earlier lapidaries typically only listed the different stones in alphabetical order, or following Pliny, loosely ordered precious stones only according to colour, De Boodt was one of the first to attempt a classification. Defining a stone as hardened earth and a solid body which cannot be liquefied in water, De Boodt uses four properties of stones to classify them: size, rarity, hardness and beauty (fig. 7).[46] The division between a large and a small stone is the size of a chicken egg, according to De Boodt. He defines rarity as found 'in few provinces' and in small numbers without giving an example of stone which is to be excluded from the category of preciousness on this condition. A stone is hard if it can only

46 De Boodt 1609 (see n. 37), p. 1–3.



7 Anselmus De Boodt: Gemmarum et lapidum historia, Hanoviae 1609, folding plate between p. 3 and p. 4

be cut by an iron or steel blade or wheel. De Boodt recognises three degrees of hardness depending upon the material needed to cut the stone: iron, emery, or diamond. Beauty is primarily defined in terms of translucency and colour. A stone is precious if it is small, rare, hard and beautiful. This definition excludes onyx, because it is not beautifully coloured, and topaz, rock crystal and jasper, because these stones come in large chunks. In conclusion, the properties of the stones which De Boodt used for his classification are those which mattered to artisans and merchants. It is the artisanal and mercantile knowledge of stones, focused on their physical qualities, such as the behaviour of the stone when it is cut, or the size as the most important element in determining the value of a stone in commercial exchange, which underlies De Boodt's classification of stones. Of all these properties it is hardness, determined by the materials used for working the stone by the artisan, which was the most important criterion for De Boodt, confirming the shift away from colour.

Conclusion

In conclusion, against the background of the continuity and the longevity of the learned inquiry of stones stretching back from the early modern period to Antiquity, I have argued that global trade and the use of stones in art transformed the science of stones circa 1600. At this time the kind of knowledge of stones that artisans and merchants valued became equally valued by scholars like De Boodt, who made the physical properties of stones valued by artisans and merchants the structuring force behind his classification of stones. However, in De Boodt's work the epistemic mapping of materials and processes in the art of glassmaking on the nature of stones, which had dominated the lapidary tradition since Albertus Magnus, also came to an end. For De Boodt, hardness replaced the optical qualities of stones (transparency and colour) as the most important criterion in ordering the stones. Ironically, De Boodt champions the property giving stones durability and incorruptibility which the advocates of the art of glassmaking, such as Biringuccio and Neri, singing the praises of the art imitating the transparency and colour of gemstones, put forward as the last and only quality of gemstones glassmakers failed to be able to imitate. While no longer a model for understanding the nature of gemstones, the art of glassmaking offered the new science of stones its most important classification principle.