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The Hand of the Connoisseur: Gems and Hardness in Enlightenment Mineralogy

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> Touch can distinguish transparent corundum or an Oriental stone from bodies that are less hard and less precious. Before looking at the gem, I allow it to slide through my fingers, and I make an initial judgment based on the way in which these stones, though not greasy, try to slip through…I once established by touch alone that a supposed Oriental stone, whose brilliance had seduced a jeweller, was in fact an inferior stone. It is well known that touch can work wonders in the discrimination of objects.[1]

The author of this passage, Antoine Caire-Morant (b. 1747), was a gem connoisseur in all but name. He made frequent use of the word *connaisseur* in his sole surviving publication, the *Science des pierres précieuses appliquées aux arts*, a work compiled in the eighteenth century and published posthumously in 1826. For Caire-Morant, a connoisseur of precious stones was someone who made sound judgments about their beauty, rank, merit, value, or price. Only a true connoisseur could appreciate the rarity of large rubies, to use one of his

[1] Antoine Caire-Morant, *La science des pierres précieuses, appliquées aux arts* (Paris, 1826), 26-7.

examples. All connoisseurs were captivated by the harmonious geometry of rose-cut diamonds, to use another.[2]

Caire-Morant's use of the word *connaisseur* will come as no surprise to present-day users of the French and English languages. His gem connoisseurs had the qualities that we now associate with connoisseurship in the fine arts. What *is* surprising about Caire-Morant is the way he made his judgments. He distinguished one gem from another by running them through his fingers, tipping them from one sack into another, or pressing them against the cutting wheel and feeling their resistance against his hand. His judgments were tactile, not just visual. After all, a skilled hand was crucial in his trade. He was a gem-cutter, a goldsmith's son who was apprenticed to a gem engraver in Turin and who spent much of his adult life establishing a workshop for cutting and polishing rock crystal in his home town of Briançon. Caire-Morant therefore exemplifies an overlooked feature of early modern science, namely the role of the hand of the artisan in making judgments about the qualities of materials. The notion that the hand of the artisan mattered for early modern science is, of course, a familiar one.[3] The notion that science and connoisseurship overlapped has also

[2] On Caire-Morant's life, see P. Guillaume, "Autobiographie de Caire-Morand, fondateur de la manufacture de cristal de roche de Briançon, en 1778," *Bulletin de la Société d'études des Hautes-Alpes*, 2 (1883): 142-170. A. Chabrand, *Antoine Cayre-Morand: Fondateur de la Manufacture de Cristal de Roche de Briançon* (Grenoble, 1874). Caire-Morant, *La science des pierres précieuses*, *passim* (usage of *connaisseur*).

[3] Representative works are Lissa Roberts, Simon Schaffer, Peter Dear, eds., *The Mindful Hand: Inquiry and Invention from the Late Renaissance to Early Industrialisation* (Amsterdam: Koninkliijke Nederlandse Akademie van Wetenschappen, 2007); Pamela Smith,

been explored in some detail, especially with respect to natural history in the Enlightenment.[4] But these two themes have not yet made contact. There are several studies of the manual side of early modern collections, but these focus on the preparation, maintenance and circulation of specimens rather than the evaluation of those specimens.[5] Studies of the relationship between natural history and connoisseurship focus on what Daniela Bleichmar has called "visual expertise."[6] Historians of science have imported the

The Body of the Artisan: Art and Experience in the Scientific Revolution (University of Chicago Press, 2004); Pamela Long, *Artisan/Practitioners and the Rise of the New Science, 1400-1600* (Oregon State University Press, 2011); and Paola Bertucci, *Artisanal Enlightenment: Science and the Mechanical Arts in Old Regime France* (Yale University Press, 2017).

[4] On connoisseurship and natural history in the Enlightenment, see section 3 of the introduction to this special issue.

[5] Representative works on this theme are: Harold J. Cook, "Time's Bodies: Crafting the Preparation and Preservation of Naturalia," in *Merchants and Marvels: Commerce, Science, and Art in Early Modern Europe*, ed. Pamela H. Smith and Paula Findlen (London: Routledge, 2002), 243–227; Dániel Margócsy, *Commercial Visions: Science, Trade, and Visual Culture in the Dutch Golden Age* (Chicago University Press, 2014), chap. 2; and Daniel Bert van de Roemer, "Art Opens the Book of Nature: Skilfulness and Knowledge in Dutch Curiosity Cabinets around 1700," in *Menagerie: Otto Marseus van Schrieck and the Scholars*, ed. Gero Seelig (Munich: Schwerin, 2017), 128–39.

[6] Daniela Bleichmar, "Learning to Look: Visual Expertise across Art and Science in Eighteenth-Century France," *Eighteenth-Century Studies* 46, no. 1 (2012): 85-111.

notion of the "eye of the connoisseur" from art history.[7] Yet the hand of the connoisseur, as much as the eye, is the focus of the most recent studies of painting and drawing in the Enlightenment.[8] Connoisseurship in the arts meant learning to touch, as well as learning to look.[9] The same applied to connoisseurship in the sciences. In particular, as I shall argue in this paper, it applied to the science of mineralogy.

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[7] Carol Gibson-Wood equates connoisseurship with "the authority of the eye" in her important *Studies in the Theory of Connoisseurship from Vasari to Morelli* (London: Garland Publishing, 1988), 6. Note also the titles of Anna Tummers, *The Eye of the Connoisseur: Authenticating Paintings by Rembrandt and his Contemporaries* (Amsterdam University Press, 2011); Pascal Griener, *La république de l'oeil: l'expérience de l'art au siècle des lumières* (Paris: Odile Jacob, 2010); Valérie Kobi, *Dans l'oeil du connaisseur: Pierre-Jean Mariette (1694-1774) et la construction des savoirs en histoire de l'art* (Presses universitaire Rennes, 2017).

[8] Kristel Smentek, "The Collector's Cut: Why Pierre-Jean Mariette Tore up His Drawings and Put Them Back Together Again," *Master Drawings* 46, no. 1 (2008): 36-60; and Joachim Rees, "Les Mains de Michel-Ange," *Revue de Synthèse* 132, no. 1 (2011): 53-74. The material side of eighteenth-century painting is explored in Ewa Lajer-Burcharth, *The Painter's Touch: Boucher, Chardin, Fragonard* (Princeton University Press, 2008).

[9] Here I paraphrase Mary Terrall: "If the connoisseur had to learn to look, visitors to collections of naturalia...also had to learn to handle and examine specimens." Terrall, "Handling Objects in Natural History Collections," in *The Material Cultures of Enlightenment Arts and Sciences*, ed. Adriana Carciun and Simon Schaffer (London: Palgrave Macmillan, 2016), 15-33, on 17. I would add that the "visitors to collections" included artisans, and that

This discipline came of age in the eighteenth century.[10] New treatises on minerals appeared in rapid succession across Europe. Many of these were dedicated to the classification of minerals of all kinds, as opposed to the classification of this or that kind of mineral or to the explanation of the origin of minerals.[11] Mineral collecting flourished;[12] the

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handling things and being a connoisseur were often the same thing. Terrall's example of bezoar stone (21-22) illustrates the latter point.

[10] There were, of course, important earlier traditions in the study of minerals, such as medieval lapidaries and Renaissance natural histories of minerals. These traditions are surveyed in Frank Adams, *The Birth and Development of the Geological Sciences* (Baltimore, MD: Williams & Wilkins, 1938), chaps. 4, 5, and 6. My point is that only in the eighteenth century was there something that we can call "mineralogy" without anachronism.

[11] Charles Spencer St. Clair, "The Classification Of Minerals: Some Representative Mineral Schemes From Agricola To Werner," unpublished PhD dissertation (University of Oklahoma, 1966), esp. the summary on 176-80. St. Clair starts with the work of Georg Agricola in the sixteenth century, but the great majority of the schemes he considers are from the eighteenth century. The same goes for the schemes summarised in Rachel Laudan, *From Mineralogy to Geology: the Foundations of a Science, 1650-1830* (University of Chicago Press, 1987), chap. 2, table 1.

[12] Wendell E. Wilson, *The History of Mineral Collecting, 1530-1799* (Tucson, Arizona: Mineralogical Record, 1994), 43-150. Jonathan Simon, "Mineralogy and Mineral Collections in 18th-Century France," *Endeavour* 26, no. 4 (2002): 132-136. *Idem*, "Taste, Order and Aesthetics in Eighteenth-Century Mineral Collections," in *From Private to Public: Natural Collections and Museums*, ed. Marco Beretta (Sagamore Beach, MA: Science History

words *mineralogy* and *minéralogie* appeared for the first time in the titles of French and English books[13]; the history of these books was written as the history of classification schemes.[14] These schemes gave increasing weight to chemistry and crystallography, the two pillars of modern mineralogy. Chemical mineralogy emerged from the mining industries of Sweden and Germany, where university-trained chemists worked alongside miners and assayers in state-sponsored institutions such as the Swedish Bureau of Mines and the Freiburg Mining Academy.[15] These institutions were joined by medical schools such as the

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Publications, 2005), 97-112. *Idem*, "The Values of the Mineral Kingdom and the French Republic," in *Ordering the World in the Eighteenth Century*, ed. Donald Diana and Frank O'Gorman (Basingstoke: Palgrave Macmillan, 2006), 163-189.

[13] According to the online catalogue of the British Library, the first book in English with the word "mineralogy" in the title was Johann Reinhold Forster, *An Introduction to Mineralogy* (London, 1768). The equivalent work in France was Jacques-Christophe Valmont de Bomare, *Minéralogie, ou Nouvelle exposition du règne minéral* (Paris, 1762). The Bibliothèque Nationale de France lists two earlier books with the word *minéralogie* in the title, from 1752 and 1753; these were both translations, unlike Bomare's book.

[14] Two key surveys in French were Torbern Bergman, trans. Jean-André Mongez, *Manuel du minéralogiste, ou Sciagraphie du règne minéral distribué d'après l'analyse chimique* (Paris, 1784), xiii-lxxix; and Romé de l'Isle, *Des caractères extérieurs des minéraux* (Paris, 1784), 57-82. The earliest scheme listed in these surveys appeared in a work by Torbern Bergman published in 1730.

[15] David Oldroyd, *Sciences of the Earth: Studies in the History of Mineralogy and Geology* (Brookfield, VT: Ashgate, 1998). Theodore Porter, "The Promotion of Mining and the

one at the University of Edinburgh.[16] Crystallography became a distinct discipline in the last two decades of the century, largely through the efforts of the Swede Torbern Bergman and the Frenchmen Jean-Baptiste Louis Romé de l'Isle and René-Just Haüy.[17] These ideas were synthesised in major works published near the end of the century, such as Haüy's *Traité de minéralogie* of 1801. In short, mineralogy was a characteristic science of the Enlightenment—taxonomic, utilitarian, and embedded in universities, state institutions and the culture of collecting.

Central to this science were gems, hardness, and cutters, topics that have slipped through the cracks of the secondary literature on Enlightenment mineralogy, and on the history of science more generally. Hardness is usually lumped together with other readily observable properties of minerals, such as color and transparency. Yet hardness played a distinctive role in eighteenth-century mineralogy. It cut across the distinction, standard in

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Advancement of Science: the Chemical Revolution of Mineralogy," *Annals of Science* 38, no. 5 (1981): 543-70. Hjalmar Fors, "Elements in the Melting Pot: Merging Chemistry, Assaying and Natural History, c. 1730-1760," *Osiris* 29 (2014): 230-44. *Idem*, *The Limits of Matter* (University of Chicago Press, 2015), chap. 5. Charlotte A. Abney Salomon, "The Pocket Laboratory: The Blowpipe in Eighteenth-Century Swedish Chemistry," *Ambix* 66, no. 1 (2019): 1-22.

[16] Matthew Eddy, *The Language of Mineralogy: John Walker, Chemistry and the Edinburgh Medical School, 1750-1800* (London: Routledge, 2016).

[17] Hélène Metzger, *La genèse de la science des cristaux* (Paris: Albert Blanchard, 1918). John G. Burke, *Origins of the Science of Crystals* (University of California Press, 1966). Laudan, *From Mineralogy to Geology*, chap. 4.

the period, between "external" properties such as color and transparency and "internal" ones such as chemical composition.[18] At the end of the century, hardness supplemented chemical and crystallographic criteria rather than being replaced by them. Hardness was one of the characters that Haüy recommended for easily determining the species to which a mineral belongs, a recommendation he made for density and double refraction but not for color.[19]

Discussions of hardness were often connected to gems, an unusually hard class of mineral. Gems were seen as a genuine class of mineral in this period, a category as natural as salts, metals or volcanic rocks. They were a staple of mineralogical treatises for most of the eighteenth century. Only in the last two decades of the century—between Romé de l'Isle's *Cristallographie* of 1783 and Haüy's *Traité de minéralogie* of 1801—did they come to be regarded as a commercial and aesthetic category rather than a natural one.[20] In the

[18] The distinction is the basis for the survey by Mongez noted above. See Bergman, trans. Jean-André Mongez, *Manuel du minéralogiste,* x-xii. On the distinction, see Simon, "Mineralogy and Mineral Collections," 134-5. The ambiguous place of hardness in this distinction can be seen by comparing Bergman, trans. Mongez, *Manuel du minéralogiste*, lx, 12-14; and Torbern Bergman, "La terre des gemmes," in *Opuscules chimiques et physiques*, trans. Louis-Bernard Guyton, Baron de Morveau, vol. 2 (Dijon, 1785), 78-124, on 80-81, 83, 110-11.

[19] René-Just Haüy, *Traité de minéralogie*, vol. 1 (Paris, 1801), xl-xli.

[20] Jean-Baptiste Louis de Romé de l'Isle, *Cristallographie, ou Description des formes propres a tous les corps du regne minéral* (Paris, 1783), vol. 2, 170. There is no category named *gemmes*, *pierres précieuses*, or similar in Haüy's *Traité de minéralogie*. The decline of the

meantime, they were central to several branches of mineralogy, as historians of collecting and chemistry have shown in recent years. Diamond, agate, beryl and corundum have received particular attention from historians.[21] In this paper I focus, not on this or that species of gem, but on the category of gems as a whole. Hardness was crucial to the classification of gems, and touch was crucial to judgments of hardness. The people who made these judgments were usually gem-cutters, a group that has long been overshadowed by goldsmiths. In Paris, as in other European cities, the guild of goldsmiths (*orfèvres*) was older, richer, and better documented than the guild of gem-cutters (*lapidaries*).[22] Historians of early modern science have paid far more attention to goldsmiths than they have to gem-

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category is noted at Antoine-François Fourcroy, *Encyclopédie méthodique: Chymie, pharmacie et métallurgie*, vol. 5 (Paris, 1808), 618-619.

[21] Michel Spiesser, "Nicolas Louis Vauquelin - La découverte de deux nouveaux éléments: le chrome (1797) et le glucinium (béryllium 1798)," *Bulletin de l'Union des physiciens* 10, no. 807 (1998): 1403-1416. Christine Lehman, "What is the 'True' Nature of Diamond?" *Nuncius* 31 (2016): 361-407. Stephen T. Irish, "The Corundum Stone and Crystallographic Chemistry," *Ambix* 64, no. 4 (2017): 301-325. Simon, "The Values of the Mineral Kingdom," 174-6.

[22] On early modern lapidary guilds in general, see Michael Bycroft and Sven Dupré, "Introduction," in *Gems in the Early Modern World: Materials, Knowledge and Global Trade*, ed. Bycroft and Dupré (Palgrave Macmillan, 2019), 1-32, on 10. On the Paris guild, see René de Lespinasse, *Les métiers et corporations de la ville de Paris: XIVe-XVIIIe siècles,* vol. 2 (Paris, 1892), 81-95. On the Paris goldsmiths, see Madeleine Bimbenet-Privat, *Les orfèvres et l'orfèvrerie de Paris au XVIIe siècle* (Paris: Commission des travaux historiques de la ville de Paris, 2002).

cutters.[23] The writings of naturalists and natural philosophers help to bring this humble but important class of artisan to light. France is a good place to look for cutters, since there was a strong French tradition of grounding mineralogy in gems and gem collections, as we shall see.[24]

To sum up, I shall use the case of gem hardness to show that connoisseurship in mineralogy often meant learning to touch, as well as learning to look. The argument proceeds in stages. Firstly, I show that the study of gems was linked to connoisseurship in the fine arts. Dictionaries in eighteenth-century France placed the *connoissance* of gems alongside the *connoissance* of paintings. Seventeenth-century books on precious stones echoed this usage; the genre evolved in parallel with books on the appraisal of paintings (section 1). Next, I argue that these books on precious stones were important precursors to the new mineralogical treatises that emerged in the middle of the eighteenth century. These treatises formalised a distinction between "Oriental" and "Occidental" gems that was also a distinction between hard and soft gems (section 2). The most skilled judges of gem hardness were gem-cutters, who continued to associate with mineralogists in the eighteenth century, especially through the culture of collecting (section 3). These cutters played a role in the quantification of hardness, especially in the development of hardness

[23] As an indication, there are nearly 50 unambiguous references to goldsmiths, and only one unambiguous reference to gem-cutting, in Pamela Long's thorough survey of early modern crafts and science: *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance* (Johns Hopkins University Press, 2001).

[24] By contrast, studies of German and Swedish mineralogy have focused on metallic mining: see the works cited in note 12 above.

scales but also in the invention of instruments for measuring hardness. All this suggests an enlarged view of connoisseurship in the Enlightenment arts and sciences (section 4).

Connoissance as connoisseurship

"An introduction to mineralogy, or to the *connoissances* that are needed to distinguish different species of fossils."[25] So began an influential book on the natural history of minerals, published in Paris in 1762. At first sight, *connoissance* is a false friend, a word that bears only a superficial resemblance to the English word "connoisseurship."[26] In the eighteenth century, however, *connoissance* often referred to the capacity to make fine judgments about the quality of material things—in other words, to what modern English speakers mean by "connoisseurship."[27] Moreover, *connoissance* had two other connotations that made it an appropriate term to use in a mineralogical context. One is the association between the *connoissance* of objects and physical interaction with them. The fourth edition of the dictionary of the Académie française, published in 1762, hinted at this association in its definition of *connoître*. One of the senses of the word listed there was *sentir* or *éprouver*, perhaps best translated as "feeling" or "trying out." The authors

[25] Jacques-Christophe Valmont de Bomare, *Minéralogie, ou Nouvelle exposition du règne minéral* (Paris, 1762), 1.

[26] This view is implied at Steven Shapin, "The Sciences of Subjectivity," *Social Studies of Science* 42, no. 2 (2012): 170-184, on 177-8.

[27] As argued in section 3 of the introduction to this special issue.

explained that this is the sort of knowledge one has of winter or headaches by virtue of having lived through a winter or had a headache—not merely by seeing a winter or seeing a person with a headache. The second constant in the early editions of the same dictionary was the association between connoisseurship and precious stones. The latter were mentioned as often as paintings to illustrate the meaning of the words *connoissance* and *connoisseur*. They were mentioned more often than books, poems and horses.[28]

It is no surprise, then, that books on precious stones in seventeenth- and eighteenth-century France were couched in the language of *connoissance*. Three of these "lapidaries," as the genre was sometimes called, were held in high regard in the eighteenth century.[29] The earliest of these, *Le parfaict joailler*, was a translation into French of a work first published in Latin in 1609 and written by the Prague physician Anselmus Boethius de Boodt. This translation, published in 1644, helps to explain the appearance of two more French lapidaries in 1661 and 1667, this time by two Parisian goldsmiths, Robert de Berquen and Pierre de Rosnel. The nearest eighteenth-century equivalent to these books was *Des pierres précieuses et des pierres fines*, written by the Anglo-French diplomat Louis Dutens and quickly translated into German and Italian after its initial publication in French in 1776. The subtitles of these works are suggestive:

[28] Based on a study of the first, fourth and fifth editions of the *Dictionnaire de l'Académie française*, available at "Dictionnaires d'autrefois," https://artfl-project.uchicago.edu/content/dictionnaires-dautrefois, accessed January 2021.

[29] For example, these three are singled out as examples of lapidaries in *Dictionnaire universel français et latin* [known as the *Dictionnaire de Trévoux*] (1721), vol. 3, 1301-2.

> Historie des pierreries, ou sont amplement descrites leur naissance, juste prix, moyen de les *cognoistre*, & se garder des contrefaites, facultez medicinales, & proprietz curieueses (Boodt).
>
> Nouveau traitté des pierres précieuses & perles, contenant leur vraye nature, dureté, couleurs & vertues: Chacune placée selon son ordre & degré, suivant la *cognoissance* des marchands orphevres (Berquen).
>
> Des pierres précieuses et des pierres fines, avec les moyens de les *connoître* & de les évaluer (Dutens).[30]

The point is not just that the words *connoître* and *connoissance* occur in these titles, but also that these words are used to denote connoisseurship, or something very much like it. Consider Boodt's title. *Cognoistre* cannot here refer to understanding in general, or knowledge-by-acquaintance, since this would include knowledge of the origin, medical

[30] Anselmus Boethius de Boodt, trans. Jean Bachou, ed. André Toll, *Le parfaict joaillier* (Lyon, 1644), based on Boodt's *Gemmarum et lapidum historia* (Hanover, 1609). Robert de Berquen, *Les merveilles des Indes Orientales et Occidentales* (Paris, 1661). Pierre de Rosnel, *Le Mercure Indien* (Paris, 1667), vol. 2. Louis Dutens, *Des pierres précieuses et des pierres fines* (Paris, 1776); I consulted the second edition of this work, published in Florence in 1783. Bibliographic details on these works are in John Sinkankas, *Gemology: an Annotated Bibliography* (Metuchen, NJ: Scarecrow Press, 1993), vol. 1, 97-8, 127-130, 291-292; vol. 2, 878-879.

virtues, and curious properties of gems, things that Boodt mentions in his subtitle but which he does not associate with the term *cognoistre*. Instead he uses that term in the phrase *moyen de les cognoistre*, implying that he is referring to a set of techniques for knowing gems and not to a set of propositions about them. Also, the phrases on either side of this one (*juste prix*, *se garder des contrefaites*) suggest that the techniques are to do with determining the value and authenticity of gems. Berquen's title is more explicit about the normative dimension of *connoissance*, since he says he will use the *connoissance* of the goldsmith to place gems in the correct order and rank (*ordre & degré*). Dutens' title shows the persistence of this usage in the eighteenth century.

The contents of these works corroborate their titles. They contain extensive advice on how to tell one gem from another with a view to telling good ones from bad. At the very start of Boodt's description of gemstones, we read that the value of diamonds lies in their transparency and lack of color, and that true diamonds can be identified by a test that Boodt describes in detail—upon the application of a certain dye to the surface of the stone, true diamonds become more brilliant whereas all other stones become less so. The French text refers to this is a *marque de cognoistre*, a translation of the Latin *notas dignoscendi*, a phrase that is perhaps best translated into English as "distinguishing mark." Similar tests are scattered through Boodt's descriptions of other stones—rock crystal can be distinguished from diamond by its hardness, amber from a variety of hyacinth by its ability to attract straw, and so on. The same kind of information abounds in the books by Berquen and Rosnel. As Rosnel put it:

> …I thought it appropriate to give a separate chapter to each species of precious stones, in the belief that this will show more clearly [*connoistre plus distinctement*]

> what each species has that is singular and commendable, and also to distinguish [*faire le discernment*] a costly stone from another, in order to disabuse [those] who have confused the names of precious stones and passed off a common stone for a valuable one.[31]

These books on the *connoissance* of gems developed in parallel with books on the *connoissance* of paintings. Consider Rosnel's *Mercure Indien* of 1667 and Piles' *De la connoissance des tableaux* of 1699. Both involved making fine judgments about the quality of valuable materials. Both were published in France in the second half of the seventeenth century. Both were new, in the sense that they helped to inaugurate a continuous French tradition of writing about the *connoissance* of their respective materials. There were German and Italian precedents for the lapidaries of Berquen and Rosnel, just as there were Italian precedents for Piles' book on connoisseurship, but the homegrown varieties of both genres can be dated to the middle of the seventeenth century.[32] The emergence of both

[31] Boodt, *Parfaict joaillier*, 144 (diamond), 201 (amber and hyacinth), 277 (diamond and rock crystal), cf. Boodt, *Gemmarum et lapidum*, 57 (*dignoscere*). Rosnel, *Mercure Indien*, vol. 2, 10. On Rosnel, see Michael Bycroft, "Regulation and Intellectual Change at the Paris Goldsmiths' Guild, 1660-1740," *Journal of Early Modern History* 22 (2018): 500-527, on 524-6.

[32] On Piles and his predecessors, in France and elsewhere, see Gibson-Wood, *Theories of Connoisseurship*, chaps. 2, 3, 4 and 5, esp. p. 42. Boodt's book and its Italian precursors are summarised in Annibale Mottana, "Italian Gemology During the Renaissance: A Step Towards Modern Mineralogy," in *The Origins of Geology in Italy*, ed. Gian Battista Vai and

genres was tied to the growing confidence of artisans in their relationship with learned writers. Rosnel and Berquen both played up the *connoissance* of the goldsmith, which they compared favourably with that of philosophers and naturalists such as Boodt.[33] The same spirit ran through the writings of Abraham Bosse, an engraver whose book on the theory of painting, published in 1649, was the prototype of Piles' books on the topic. Bosse hoped to raise the status of his art by presenting it to a learned audience in the form of a printed book. At the same time, he believed that painters and engravers were particularly well-placed to make judgments about the quality of paintings and engravings.[34] The word *connoissance*, then, had a similar meaning when applied to paintings as when applied to gems. If we translate it as "connoisseurship" in the former case, we should do the same in the latter case. The books on gems by Boodt, Berquen and Rosnel were a form of connoisseurship in the sense that mattered in France in the decades around 1700.

W. G. E. Caldwell (Geological Society of America, 2006), 1-21. There was an earlier tradition of French writing on gems, as described in Evelien Chayes, *L'éloquence des pierres précieuses: de Marbode de Rennes à Alard d'Amsterdam et Remy Belleau: sur quelques lapidaires du XVIe siècle* (Champion, 2010). Yet the starting-point for Berquen and Rosnel was Boodt, not earlier French authors.

[33] Berquen, *Merveilles des Indes*, 4, 6. Rosnel, *Mercure Indien*, vol. 1, "Au lecteur" and "Dedication" (both unpaginated).

[34] Gibson-Wood, *Theories of Connoisseurship*, chap. 4. Stefan Germer, trans. Aude Virey-Wallon, *Art-pouvoir-discours: la carrière intellectuelle d'André Félibien dans la France de Louis XIV* (Paris: Fondation Maison des sciences de l'homme, 2016), 99-105.

From lapidaries to mineralogies

But what did these books on gems have to do with mineralogy? Rather a lot. The continuity between lapidaries and mineralogies can be seen in the work of Antoine-Joseph Dezallier d'Argenville, a major figure in Enlightenment natural history from the 1720s to his death in 1765.[35] Argenville was a student of Piles who carried on his teacher's project of codifying the art of judging paintings.[36] Argenville's interest in painting and drawing is well known, as is the connection between these pursuits and his natural history of shells.[37] Yet Argenville wrote on minerals as well as shells, and in this respect he was a heir to Berquen and Rosnel. It is true that Argenville downplayed his debt to lapidaries, both the literary genre of that name and the class of artisans. "Rather than the research that a naturalist would have done," he wrote of Berquen and Rosnel, "they assembled all the usual fables on the virtues of stones." He explained that these authors "were concerned only with the rarity and price of fine stones, did not probe their nature, and wrote only as jewellers." Worse, they used the term *pierres précieuses*, which Argenville considered "vulgar." He considered this term

[35] See Bleichmar, "Learning to Look," and references therein.

[36] Gibson-Wood, *Theories of Connoisseurship*, chap. 6, esp. 71.

[37] Ibid, 89-94. Cf. Charlotte Guichard, "Taste Communities: The Rise of the 'Amateur' in Eighteenth-Century Paris," *Eighteenth-Century Studies* 45, no. 4 (2012): 519-547, and references therein.

to be out of place in a treatise on natural history, a discipline that he defined as the study of the "genera, varieties, relations and properties" of natural bodies.[38]

But a close look at Argenville's writings on minerals shows that his distinction between impressionable goldsmiths and sober naturalists was overdrawn. Argenville's preferred term was *pierres fines*, which is hardly less judgmental than *pierres précieuses*. And *pierres fines* dominated the classification of minerals that he sketched out in his 1742 book on the natural history of stones and shells. This was a classification of stones only, not of all minerals—a *lithologie* rather than a *minéralogie*, to use a term in book's title. The classification was a simple one, dividing all stones into crystalline stones, opaque stones, figured stones, and common stones. The first category was further divided into transparent and semi-transparent crystallised stones, and the second into stones that can and cannot be polished. The upshot was that one and a half of these four categories was dedicated to gems. The name of the fourth category, "common stones," implies a contrast to precious stones, a distinction that Argenville probably borrowed from Boodt. It is only a slight exaggeration to say that the *Lithologie* was a lapidary in disguise.[39]

The same goes for Argenville's *Oryctologie*, a much longer book, on the entire mineral kingdom, that appeared in 1755. The phrase "common stones" was gone, but the

[38] Antoine-Joseph Dezallier d'Argenville, *L'Histoire naturelle éclaircie dans deux de ses parties principales: la lithologie et la conchyliologie*, 18 and 35 (Berquen and Rosnel), 42 ("vulgar"). *Idem*, *L'Histoire naturelle éclaircie dans une de ses parties principales, l'oryctologie* (Paris, 1755), vi ("genera").

[39] Argenville, *Lithologie et conchyliologie*, 43-75 (descriptions of stones). Boodt, *Parfaict joaillier*, 1-2 ("pierres communes et précieuses").

division between crystalline stones (transparent and semi-transparent) and opaque stones (polishable and not polishable) remained. Argenville gave as many pages to the class of stones as he did to his two other classes combined. Within the class of stones, he dedicated considerably more pages to precious and semi-precious stones than he did to all the other stones combined. Gems were equally prominent in the influential *Minéralogie* of Jacques-Christoph Valmont de Bomare, the first French book with the word *minéralogie* in the title. Bomare gave nearly as much space to gems—he called them *pierres précieuses*, *crystaux*, and *agates*--as he did to the entire class of salts.[40]

The lapidary tradition survived even in the fine structure of these taxonomies. Transparency and polish were Argenville's two main criteria for grouping gems; both had been prized by goldsmiths such as Rosnel. The three-fold distinction between transparent, semi-transparent and opaque gems was already present in the book published by Boodt at the start of the sixteenth century. Some of the old criteria became even more pronounced in the eighteenth century, as naturalists looked for clear-cut criteria for dividing gems into varieties and grouping them into classes. The most important of these was the distinction between "Oriental" stones and "Occidental" ones. This distinction was already present in

[40] Page-counts based on Argenville's descriptions in *Oryctologie*, "Seconde partie," 115-316. Types of mineral: stones (93 pages), earths (61), salts, sulphurs and metals (37). Types of stone: precious stones, ie. all the pierres très-durs except those that cannot be polished (41), and all other stones (31). Bomare, *Minéralogie,* 109-287 (class of stones, including precious ones). Cf. *idem*, *Dictionnaire raisonné universel d'histoire naturelle*, 2nd ed. (Paris, 1775), vol. 6, 684-7.

Boodt's book, but it became explicit and widespread in the eighteenth century.[41] It was more prominent in Bomare's book, for example, that it had been in those of Berquen and Rosnel. Whereas Rosnel mentioned Oriental topaz, Indian topaz, and German topaz, Bomare enumerated two varieties, Oriental topaz and Occidental topaz. Garnet is another instructive case. Rosnel mentioned two "sorts" of garnet, Oriental and Occidental, before going on to describe three other "sorts" of garnet. By contrast, Bomare's systematic approach forced him to clear up the ambiguity, and he did so in favour of the Oriental/Occidental distinction. Of the eleven precious stones he described, all but three were divided into Oriental and Occidental varieties. [Sentences deleted] The distinction circulated widely—in dictionaries, encyclopaedias, academic articles, popular books on gems, and even a technical treatise on the specific weight of mineral substances. The distinction was commercially significant, as Rosnel's detailed account of gem prices shows. To give one example, four carats of "Oriental" amethyst cost at least ten times as much as four carats of the "Occidental" varieties of the same stone.[42] Argenville was wrong: the study of the "nature" of gems went hand-in-hand with knowledge of their "rarity and price."

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[41] Michael Bycroft, "Boethius de Boodt and the Emergence of the Oriental/Occidental Distinction in European Mineralogy," in *Gems in the Early Modern World*, ed. Bycroft and Dupré, 149-72.

[42] Boodt, *Parfaict joaillier*, "Avertissement" (three-fold distinction). Bomare, *Minéralogie*, vol. 1, 239-65 (descriptions of precious stones). The Oriental/Occidental distinction elsewhere: Argenville, *Lithologie et conchyliologie*, 53; Argenville, *Oryctologie*, 180; Louis-Jean-Marie Daubenton, "Connoissance des pierres précieuses," *Mémoires de l'Académie Royale des Sciences, année 1750* (1754): 28-38, on 35-36; Mathurin-Jacques Brisson,

Cutters and collectors

What does this have to do with hardness? A great deal, because the terms "Oriental" and "Occidental" did not refer to geography alone. As Argenville and Bomare explained, "Oriental" was the jeweller's term for a hard stone, "Occidental" their term for a soft stone.[43] Ultimately, it was gem-cutters who decided whether a stone was "Oriental" or "Occidental." They were, as one author put it, "the most reliable judges of hardness."[44] To investigate hardness, then, we need to know more about the link between cutters and mineralogists. One way to do so is through the culture of collecting.

Mineral collections were probably the most important site for French mineralogy until the end of the eighteenth century, when mining schools and chemical laboratories

Pesanteur spécifique des corps (Paris, 1787), vi-vii, xvi-xviii; Bomare, *Dictionnaire raisonné*, vol. 6, 685; Denis Diderot and Jean le Rond d'Alembert, *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers*, vol. 12 (1765), 593-5, on 594; vol. 11 (1765), 644; Louis Dutens, *Des pierres précieuses et des pierres fines* 2nd ed. (Florence, 1783), 19-20 and *passim*. On amethyst prices, see Pierre Rosnel, "De l'estimation des pierres precieuses et des perles, ensemble des autres pierres moins precieuses," in Rosnel, *Mercure Indien*, vol. 2, 9.

[43] Argenville, *Oryctologie*, 180. Bomare, *Dictionnaire raisonné*, vol. 6, 685.
[44] Dutens, *Pierres précieuses*, 19-20.

began to feature prominently in the discipline.[45] Collections were important for all branches of natural history, of course, but they were especially important for precious stones due to the difficulty of representing their characteristic properties in words and images, at least before the emergence of crystallography at the end of the century. Even then, collections were indispensable. As one collector asked, who could depict the play of light in an iris or the iridescence of an opal? The difference between a colorless diamond and a colorless sapphire was "far easier to perceive than to describe," in the words of another collector.[46] Argenville's major work on minerals was lavishly illustrated and included images of rock

[45] Wilson, *Mineral Collecting*, 48-63, is a fine survey of eighteenth-century mineral collections in France, especially when read alongside the census of mineral collectors (157-99) and bibliography of collection catalogs (201-228) in the same work. A broader census, covering all natural history collections, not just minerals, is in Laissus, "Cabinets d'histoire naturelle," 671-712. The following two paragraphs expand on these surveys by focusing on gems and by considering some new sources. This is not intended, however, as a systematic survey of French gem collections in the period. Mining schools in Arthur Birembaut, "L'Enseignement de la minéralogie et des techniques minères," in *Enseignement et diffusion des sciences en France au dix-huitième siècle*, ed. René Taton and Yves Laissus (Paris: Hermann, 1986), 366-418. On French mineral collections, see also the works by Jonathan Simon cited in note 11 above. Note especially the references to agates and dendrites in Simon, "The Values of the Mineral Kingdom and the French Republic."

[46] Jean-Baptiste Pujoulx, *Minéralogie à l'usage des gens du monde* (Paris, 1813), 22 (iris and opal). Etienne-Gilbert, Marquis de Drée, *Catalogue des huit collections qui composent le musée minéralogique de Et. de Drée* (Paris, 1811), 84 ("easier to perceive").

crystal, jasper and agate, but none of sapphire or topaz. The downside of gems for collectors was their expense, but this was balanced by two features that made them a good candidate for mineral collections. They were stores of value, meaning that they were accumulated by the wealthy as a matter of course, quite apart from any interest in mineralogy. And they were associated with engraved gems: semi-precious stones carved with text or images. Engraved gems were made of natural objects but had a long history in antiquarian collections. They therefore bridged the divide between medals and shells--between traditional collections centred on antiquities and the newer natural history collections that flourished in Paris from the 1730s onwards.[47]

Gem collections came in several kinds. A few wealthy individuals amassed large collections of diamonds and *pierres de couleur*, a phrase that referred primarily to rubies, sapphires, topaz, and emeralds. Examples are the writer Antoine de la Roque, whose dazzling collection of colored gems was described in an auction catalogue in 1749; and the tax farmer Alexandre Estienne d'Augny, whose equally grand collection was auctioned in

[47] The earlier history of engraved gems is dealt with in Antoine Schnapper, *Le Géant, la licorne et la tulipe: histoire et histoire naturelle* (Paris: Flammarion, 1988); and *idem*, *Curieux du Grand Siècle: collections et collectionneurs dans la France du XVIIe siècle: oeuvres d'art* (Paris: Flammarion, 1994), *passim*. The growth of natural history collections in Paris is covered in Krzysztof Pomian, "Medals/Shells = Erudition/Philosophy," in *Collectors and Curiosities: Paris and Venice 1500-1800* (Cambridge, UK: Polity Press, 1990); Yves Laissus, "Les cabinets d'histoire naturelle," in *Enseignement et diffusion*, ed. Taton and Laissus, 659-713.

1798.[48] These two collections overlapped with the wider culture of natural history. Both were linked to Dutens, who dedicated his book on precious stones to Augny and who treated the catalogue of Roque's collection as a work of natural history, not just as a list of specimens.[49] The catalogue was drawn up by Edme-François Gersaint, the preeminent trader of curiosities in Paris at the time; Gersaint's text included learned descriptions of each of the species of gem represented in Roque's collection.[50] Even the crown jewels were brought to bear on natural history. Charles Dufay, a member of the Royal Academy of Sciences, examined at least one of these jewels in experiments on the electricity and luminosity of diamonds in the 1730s.[51] Mathurin-Jacques Brisson, another academician, worked with royal jewellers to measure the specific weight of diamonds in the 1780s,

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[48] Edme-François Gersaint, *Catalogue raisonné des différens effets curieux & rares contenus dans le cabinet de feu M. le Chevalier de La Roque* (Paris, 1749). Anon., *Catalogue des diamans, pierres de couleurs, pierres précieuses et boîtes, composant la superbe collection du Citoyen Daugny* (Paris, 1798).

[49] Dutens, *Traité des pierres précieuses*, 3-4, 6-7. Note also the praise for Augny's collection on 113-14 and references to Augny's specimens at 60, 68, 117, 119, 128. Augny's specimens are also mentioned at Caire-Morant, *Pierres précieuses*, 30, 92, 129, 201, 213.

[50] Gersaint, *Catalogue raisonné du cabinet de la Roque,* 112-35, 139-40, 142-3.

[51] Georges Buffon, *Histoire naturelle des minéraux*, vol. 4 (Paris, 1786), 267. On Dufay's collection, see Michael Bycroft, *"*Style and Substance in Rococo Science," *Journal of Interdisciplinary History* 48, no. 3 (2018): 359-384, on 379-81; *idem*, "Physics and Natural History in the Eighteenth Century: the Case of Charles Dufay," unpublished PhD dissertation (University of Cambridge, 2013), chap. 3.

including the weight of two of the most prestigious stones in the crown jewels, the Regent's diamond and the French blue.[52] A handful of jewellers appeared in contemporary lists of cabinets of natural history, some with notable suites of precious stones. One such jeweller, Louis George Gabriel Gallois, owned a piece of tourmaline that he kept unmounted for the purpose of "doing experiments," probably a reference to the much-discussed phenomenon of pyroelectricity.[53] Royal scientific institutions were another site of gem collections,

[52] Brisson, *Pesanteur spécifique des corps*, 62-4. On these two diamonds, see François Farges, Scott Sucher, Herbert Horovitz, and Jean-Marc Fourcault, "The French Blue and the Hope: New Data from the Discovery of a Historical Lead Cast," *Gems and Gemology* 45, no. 1 (2009): 4–19; and François Farges, "Les Grands Diamants de La Couronne de François I à Louis XVI," *Versalia*, no. 16 (2014): 55–79, 64-6, 69-71.

[53] Romé de l'Isle, *Catalogue raisonné des minéraux, pierres fines et cristallisées, pétrifications, coquilles, madrépores, et autres curiosités de la nature et de l'art: qui composent le cabinet de M. Galois* (Paris, 1780), v, 97 (tourmaline), 97-109. Cf. Wilson, *Mineral Collecting*, 171; Laissus, "Cabinets d'histoire naturelle," 687. On the pyroelectricity of tourmaline, see Roderick Weir Home, "Aepinus, the Tourmaline Crystal, and the Theory of Electricity and Magnetism," *Isis* 67, no. 1 (1976): 21-30. The jeweller Pierre André Jacqmin had a collection in which "the suite of precious stones is very considerable": Argenville, *Conchyliologie nouvelle et portative* (Paris, 1767), 316. Cf. Wilson, *Mineral Collecting*, 177; Laissus, "Cabinets d'histoire naturelle," 688. The jeweller Fagnier had "a considerable number of fine and precious stones" in a collection noted in Argenville, *La conchyliologie, ou histoire naturelle des coquilles*, 3rd edn. (Paris, 1780), vol. 1, 265. Cf. Laissus, "Cabinets

especially the Jardin du roi and the École des mines. Dufay bequeathed his gem collection to the Garden upon his death in 1739; the École des mines incorporated a mineralogical collection and an ornamental collection after its establishment in 1783, with precious stones appearing in both.[54] These institutional collections—along with several private collections—were bound up with the crystallographic theories developed by Jean-Baptiste Louis Romé de l'Isle and René-Just Haüy in the last third of the century.[55] Romé de l'Isle's first book on crystallography drew heavily on gems owned by the Peruvian collector Pedro Franco Dàvila, specimens that the Romé de l'Isle had already described in an auction catalogue published

d'histoire naturelle," 686. Another jeweller, named Fouché, had some agates and jaspers but apparently no precious stones: Argenville, *Conchyliologie*, 3rd edn., 686. Cf. Laissus, 686.

[54] Dufay's bequest noted at Bernard le Bovier de Fontenelle, "Eloge de M. Du Fay," *Histoire de l'Académie Royale des sciences, année 1739* (1741): 73-83, on 81-2. Cf. Franck Bourdier, "Origines et transformations du cabinet du Jardin Royal des Plantes," *Revue générale des sciences pures et appliquées*, 18 (1962): 36-50, on 40; and Daubenton, "De la connoissance des pierres précieuses," 30. The École des mines gems are listed in Balthasar-Georges Sage, *Description méthodique du Cabinet de l'Ecole royale des Mines* (Paris, 1784), 57-79; and *idem*, *Description des objets d'art de la collection de B.G. Sage de l'Institut de France* (Paris, 1807), 55-67. On these collections, see Maddalena Napolitani, "'Born With the Taste for Science and the Arts': The Science and the Aesthetics of Balthazar-Georges Sage's Mineralogy Collections, 1783–1825," *Centaurus* 60, no. 4 (2018): 238-256.

[55] On the theories themselves, see the works cited in note 17, above.

in 1767.[56] Soon afterwards, René-Just Haüy developed his theory of crystals using specimens of garnet, topaz and rock crystal, among other minerals.[57] Haüy was coy about the location of his specimens, but a study of his publications shows that he personally acquired a range of gems, from hyacinth to diamond, in the course of the 1780s and 1790s.[58] By the time of

[56] Jean-Baptiste Louis Romé de l'Isle and Abbé Dugaut, *Catalogue systematique et raisonné des curiosités de la nature et de l'art, qui composent le cabinet de Mr. Davila* (Paris, 1767). Jean-Baptiste Louis Romé de l'Isle, *Essai de cristallographie* (Paris, 1772), esp. the numerous references to Dàvila's gem specimens at 194-243. Dàvila's mineral collection is described at Wilson, *Mineral Collecting*, 137-40. See also Juan Pimentel, "Across Nations and Ages: The Creole Collector and the Many Lives of the Megatherium," in *The Brokered World: Go-Betweens and Global Intelligence, 1770–1820*, ed. Simon Schaffer, Lissa Roberts, Kapil Raj, and James Delbourgo (Sagamore Beach, MA: Science History Publications, 2009), 321–54.

[57] See the following works by Haüy. *Essai d'une théorie sur la structure des crystaux* (Paris, 1784), 169-204. "Extrait d'un mémoire sur la structure des crystaux de grenat," *Journal de physique* 19 (1782): 366-70. "Mémoire sur la structure du cristal de roche," *Mémoires de l'Académie Royale des Sciences, année 1786* (1788), 78-93.

[58] See the following works by Haüy. "Structure du cristal de roche," 91. "Sur le diamant," *Journal d'histoire naturelle* (1792): 377-84, on 382. "Description de la Cymophane avec quelques réflexions sur les couleurs de gemmes," *Journal des mines* 4 (1796): 5-16, on 13. "Sur les pierres appelées jusqu'ici Hyacinthe et Jargon de Ceylon, leurs différences, leurs caractères physiques et géométriques," *Journal des mines* 5 (1796-1797): 83-96, on 93, 94. "Observations sur des cristaux trouvés parmi des pierres de Ceylon et qui paroissent appartenir à l'espèce de Corindon vulgairement spath adamantin," *Memoires de la Société*

his death in 1822, Haüy owned a full suite of precious stones, each of them cut and mounted in a gold setting.[59] Jacques Louis de Bournon is less well-known as a crystallographer, but he was close to Haüy and Romé de l'Isle before fleeing to England at the start of the French Revolution.[60] While in France, he found what he believed to be deposits of emerald and hyacinth; he lent specimens of rock crystal and chrysolite to Romé de l'Isle in the same period.[61] In England, Bournon built a series of collections that were very rich in diamond, ruby, sapphire and topaz.[62]

Cutters contributed to these collections in several ways, and not simply by cutting and polishing many of the specimens that appeared in them. One of their roles is illustrated by Argenville's *Oryctologie*, which included detailed and original accounts of the art of gem-

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d'histoire naturelle de Paris (1799): 55-8, on 55, 56, 58. *Traité de minéralogie*, vol. 2, 471; vol. 3, 7, 38, 43, 205; vol. 4, 361.

[59] A. Lacroix, "La vie et l'oeuvre de l'abbé René-Just Haüy," *Bulletin de la Société française de minéralogie* 67 (1944): 15-226, on 94.

[60] On Bournon's mineral collection, see Wilson, *Mineral Collecting*, 56-7.

[61] Jacques Louis de Bournon, "Sur le spath adamantin et l'adulaire," *Observations sur la physique, sur l'histoire naturelle, et sur les arts* 34 (1789): 451-7, on 453-4. Romé de l'Isle, *Cristallographie, ou Description des formes propres a tous les corps du regne minéral* (Paris, 1783), 93, 270 n. 168. Bournon's contribution to knowledge of corundum is analysed in Irish, "The Corundum Stone."

[62] Jacques Louis de Bournon, *Catalogue de la collection minéralogique du Comte de Bournon* (London, 1813), xiii-ix. Idem, *Catalogue raisonné des diamants dans le cabinet de Sir Abraham Hume* (London, 1815).

cutting. Here, Argenville was carrying on a tradition that Félibien had begun and that would be continued in the *Encyclopédie* of Diderot and d'Alembert.[63] Yet Argenville's descriptions of cutting were independent of both those sources. Argenville included many details that were absent in earlier sources, including the lapidaries by Boodt, Berquen and Rosnel.[64] He noted, for example, that small diamonds are cut by scoring them with another diamond, pushing a steel blade into the score, and hitting the blade once with a hammer, and that this requires a "skilful hand" to avoid breakages. Jewellery and gem-cutting are prominent in the glossary of natural historical terms that Argenville appended to his *Oryctologie*. Nearly a quarter of these terms (71 out of 304) were related to those two crafts. Several of these terms were obscure enough that they appeared neither in the *Encyclopédie* nor in a similar glossary given by Félibien. A *labora*, Argenville explained, was a diamond cut in India; a *grasse* diamond was one that by its very nature could not be polished. Argenville's diagram of gem cuts, showing the technical terms for different elements of each cut, also appears to be original to him—no comparable diagram appeared in earlier French books on gems. Argenville evidently felt that knowledge of gem-cutting was part and parcel of knowledge of the natural history of minerals. He gave no explicit rationale for this interest, but it is consistent with his view on connoisseurship in the fine arts. He not only collected

[63] On these two sources, and the relationship between them, see Michael Bycroft, "Dossier critique de l'article LAPIDAIRE, (Arts méchaniq.)," *Encyclopédie*, vol. 9, p. 282–283, *Édition numérique collaborative et critique de l'*Encyclopédie, accessed 5 mars 2021, permalink: 11280/338a6b40.

[64] Boodt, *Parfait joaillier*, 90-103, 173-5. Berquen, *Merveilles des Indes*, 12-15. Rosnel, *Mercure Indien*, vol. 2, 12.

engravings but also made engravings himself, and he maintained that the latter served the former. In other words, he believed that judgments about paintings and drawings were best made by people who had some acquaintance with the physical act of painting and drawing.[65] There are hints of the same principle in his account of gem-cutting. The purpose of the diagram of gem cuts, for example, was not just to illustrate key terms but also to show the ideal proportions of a brilliant cut. One role for cutters, then, was as an aid to connoisseurship.[66]

Another role was as experimenters. Cutters were called upon to perform specific acts that were thought to shed light on the natural history or natural philosophy of gems. Examples are scattered through the articles and treatises of eighteenth-century naturalists. Dufay consulted a diamond-cutter (*diamantaire*) in the hope of understanding the cause of the luminosity of diamonds.[67] Louis-Jean-Marie Daubenton, the curator of the Cabinet of Natural History at the Jardin du roi from 1745, made precise notes on the polishing process that strongly suggest interaction with polishers. He noted, for example, that diamonds grow

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[65] Guichard, "Taste Communities," 537-41, esp. 537. Note also the role of the hand of the artist, as well as the mind, in Argenville's concept of style: Gibson-Wood, *Theories of Connoisseurship*, 72-77.

[66] Antoine-Joseph Dezallier d'Argenville, *L'Histoire naturelle eclaircie dans une de ses parties principales, l'oryctologie* (Paris, 1755), 95-112 (glossary), 172-82 (lapidary arts), esp. 177-8 (scoring). Cf. Félibien, *Principes de l'architecture*, 459-780 (glossary).

[67] Charles-François de Cisternay Dufay, "Recherches sur la lumiere des diamants et de plusieurs autres matières," *Mémoires de l'Académie Royale des Sciences, année 1735* (1738): 347-72, on 362-5.

hot when polished against the grain; and that the grain on the triangular face of a diamond is always parallel to the base of the triangle. Daubenton used these observations to support a new theory about the crystal structure of diamonds.[68] Buffon, in his work on the cooling of spherical bodies, had a wide range of materials shaped into spheres of equal dimensions, including rock crystal, agate, jasper and jade. After the experiments, which took place between 1768 and 1774, Buffon had these spheres displayed at the cabinet of natural history.[69] Around this time, the cabinet acquired another specimen that was also tied to gem-cutters. This was a "great needle whose extremities are terminated by two hexagonal pyramids," donated by the astronomer Alexis-Marie de Rochon. In the words of a

[68] Louis-Jean-Marie Daubenton, "Diamant," *Encyclopédie*, vol. 4, 938-41, on 940. Georges Buffon, *Histoire naturelle des minéraux*, vol. 4, 268-9, notes e and f. Earlier references to the "grain" of gems include Robert Boyle, *An Essay about the Origin and Virtues of Gems* (1672), in *The Works of Robert Boyle*, ed. Michael Hunter and Edward B. Davis (London: Pickering & Chatto, 1999–2000), vol. 5, 3–72, on 19; and Giambatista Beccaria, "Observations sur la double réfraction du crystal de roche," *Journal d'observations sur la physique, sur l'histoire naturelle, et sur les arts*, vol. 2, 504-10, on 509. The details of these accounts differ significantly from Daubenton's.

[69] Georges Buffon, "Second mémoire: Suite des expériences sur le progrès de la chaleur dans les différentes substances minérales," *Histoire naturelle, générale et particulière: Supplément*, vol. 1 (Paris, 1774): 173-300, on 173-4, 299-300. The experiments on the age of the earth were done with iron spheres only: Lucien Leclaire, "*L'histoire naturelle des minéraux* ou Buffon géologue universaliste," in *Buffon 88: actes du colloque international pour le bicentenaire de la mort de Buffon, ed.* Jean Gayon (Paris: Vrin, 1992), 352-69.

contemporary, Rochon had acquired a "great knowledge" of rock crystal, and "a talent for mounting it (*mettre en oeuvre*)," during a visit to Madagascar. He used carefully worked pieces of rock crystal in the instrument that made his name, the prismatic micrometre.[70] Soon afterwards, Haüy placed gem-cutting at the centre of the new science of crystallography. He not only used cutters to determine the hardness and birefringence of gems, but also made the physical division of gems the key to the study of crystals.[71] Haüy usually called this procedure mechanical division (*division mécanique*), but when he wrote for artisans he explained that his procedure was identical to the operation that cutters knew as cleaving (*cliver*). The crystallographer was himself a cutter.[72]

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[70] On Rochon and his micrometre, see Danielle Fauque, "Alexis-Marie Rochon (1741–1817), savant astronome et opticien," *Revue d'histoire des sciences* 38, no. 1 (1985): 3-36, esp. 25-8. Alexis Rochon, *Voyages à Madagascar, à Maroc, et aux Indes Orientales* (Paris, 1801), vol. 2, 191 ("great needle"). Jean-Daniel Dumas to Glemet, 30 Aug 1768, cited in Jean-Paul Morel, "Mission scientifique de l'abbé Rochon à Madagascar." http://www.pierre-poivre.fr/, accessed June 2020, p. 2.

[71] Haüy, "Sur les pierres appelées hyacinthe," 88, 90. Cf. idem, *Traité des caractères physiques des pierres précieuses* (Paris, 1817), ix-xx. Note also Brisson's use of a cutter ("M. de la Croix, excellent lapidaire") to determine the hardness of gems at *Pesanteur spécifique*, 71, 73; and the "excellent lapidaire De La Croix" consulted by Caire-Morant, as mentioned in his *Traité des pierres précieuses*, 100, 151, 163.

[72] Haüy, *Traité des caractères physiques*, 3. For a description of the cleaving process, see Anon., "Cliver," in Diderot and d'Alembert, *Encyclopédie*, vol. 3 (1753): 538.

A final link between cutters and collections is suggested by a passage from Antoine Caire-Morant's treatise on precious stones. The nineteenth-century editor of this work looked back nostalgically to the previous century:

> The last century gave us the distinguished *amateur* Daugny: he had studied colored stones with such taste and intelligence that diamond-cutters and lapidaries went to him for models of perfection in the art, and they recognised him as a master capable of advising them on how to enhance diamonds by cutting them.[73]

The "Daugny" in this passage was Alexandre Estienne d'Augny, whose impressive collection of colored gems was noted above. This collection existed as early as 1776, when Dutens mentioned it in his book on precious stones; it was in Augny's hands until his death in 1798.[74] Caire-Morant was in Paris intermittently during this period, and he may have visited the collection himself, although there is no direct evidence that he did so.[75] In any case, his treatise gives examples of the sorts of "perfection in the art" that French cutters were considering in the latter decades of the century. Caire-Morant described a new diamond cut of his own invention. He explained how to use a goniometer, a device for measuring the angle between two faces of a crystal, when cutting the facets of brilliant diamonds.[76] And

[73] Caire-Morant, *Pierres précieuses*, iv.

[74] See notes 38 and 39 above.

[75] Caire-Morant's presence in Paris in this period is implied at his *Pierres précieuses*, 59-60, 363. Cf. Guillaume, "Autobiographie de Caire-Morand," 150-1.

[76] Caire-Morant, *Pierres précieuses*, 33 (diamond color), 64 (goniometer), 71-2 (new cut).

he compared the abrasive powers of "adamantine spar," a very hard stone recently imported from Canton, with that of its European equivalent, emery. This comparison was a collaboration between Caire-Morant, another cutter, and Barthélemy Faujas de Saint-Fond, a Parisian collector who supplied samples of adamantine spar for the two cutters to work on. Innovation—like connoisseurship, experiment, and crystallography—drew cutters and collectors together.[77]

Ranking and scratching

These connections between cutters and mineralogists help to explain the quantification of hardness in the last third of the eighteenth century. The quantification of hardness is usually traced to Friedrich Mohs, the German mineralogist who described a ten-point scale of hardness in a work published in 1812.[78] Soon afterwards, the German crystallographer

[77] Ibid, 363-4. Faujas' collection is noted at Wilson, *Mineral Collecting*, 83.

[78] Friedrich Mohs, trans. William Haidinger, *Treatise on Mineralogy: Or, The Natural History of the Mineral Kingdom* (Edinburgh, 1825), vol. 1, 300-7. Mohs first described the scale in his *Versuch einer Elementar-Methode zur naturhistorischen Bestimmung und Erkennung der Foßilien* (Vienna, 1812). The history of hardness scales is covered in Isaac Todhunter, *A History of the Theory of Elasticity and of the Strength of Materials: From Galilei to the Present Time* (Cambridge, UK, 1893), vol. 2, 582-92; Curtis P. Schuh, *Mineralogy & Crystallography: On the History of These Sciences From Beginnings Through 1919* (Tucson,

Seebeck described an elaborate instrument for measuring the hardness of any solid material, a device that came to be known as the scratch sclerometer.[79] Precursors to Mohs' scale have been found in a range of early modern mineralogical texts, but the role of precious stones in this history has been overlooked. All existing accounts omit Berquen, Rosnel, Dutens, and Caire-Morant, and most omit Boodt. The problem is not just that these contributions to the hardness scale have gone unacknowledged but also that the notion of a *scale* has been projected onto early mineralogy when the notion of a *ranking* was just as important. "Diamond is the hardest of all precious stones, and after that the Oriental topaz, sapphire, garnet and hyacinth." So wrote Boodt in 1609. He was not describing a scale. That is, he was not listing a subset of gems whose hardness could be used to the determine the hardness of any other gem within the same range of hardness. He was listing *all* the gems he knew within a range, and he implied that the hardness of these gems was a measure of their *quality*—which explains why the range he chose included the hardest gems of all. The logical extension of this concern for ranking was to organise an entire treatise of gems around the idea that the hardest gems are the best ones and therefore should be dealt with first. This is precisely what

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Arizona, 2007), 105-9; Sally Newcomb, *The World in a Crucible: Laboratory Practice and Geological Theory at the Beginning of Geology* (Geological Society of America, 2009), 12-17; S. M. Walley, "Historical Origins of Indentation Hardness Testing," *Materials Science and Technology* 28, no. 9-10 (2012): 1028-1044.

[79] Urlich Burchard, "The Sclerometer and the Determination of the Hardness of Minerals," *The Mineralogical Record* 35 (2004): 109-20, citing A. Seebeck, *Über Härteprüfung an Krystallen* (Berlin, 1833). Cf. Todhunter, *Elasticity and Strength of Materials*, vol. 2, 586-7; Schuh, *History of Mineralogy and Crystallography*, 392-3.

we find in Berquen's treatise, where hardness is valorised above other qualities. [sentences deleted] Berquen, a gem-cutter as well as a goldsmith, wrote that one must "order precious stones according to their degree of perfection, and principally to that of their hardness, from which derives all their visible lustre and beauty."[80] These precursors to Mohs' scale were a form of *connoissance*—they were an effort make fine judgments about the relative value of different species of gem.

The practice of ranking gems by hardness was carried over into the new mineralogical books of the eighteenth century, both in France and elsewhere. Bomare's influential treatise, published in 1762, was characteristic. He described gem species in the order of their hardness, with few exceptions, and he thought of this order as a ranking. "It takes a high polish," he wrote of amethyst, "and holds the seventh rank [*rang*] among stones (counting from diamond) with regards to hardness." Bomare borrowed most of his data on hardness from the Swedish writer Johan Gottschalk Wallerius, who had followed the order of hardness even more rigorously than Bomare in his mineralogical treatise first published in 1747. Another Swedish writer, Bengt Andersson Quist, was influential in France in the last quarter of the century. Quist compiled a list of minerals based on their ability to scratch eachother. On this list, published in 1768, each item could scratch the items below it but not those above it. This was a genuine innovation, but it had much in common with earlier rankings of gems. Quist's list was dominated by gems—the only exceptions were the categories *quarts* and *zëolit*, and even these contained varieties of opal. The list was meant to be comprehensive rather than

[80] Boodt, *Parfaict joaillier*, 67-8. Berquen, *Merveilles des Indes*, 29, cf. 19, 36. On Berquen, see Bycroft, "Regulation and Intellectual Change," 518, 522-524. See also the ranking by hardness in Dutens, *Pierres précieuses*, 19-20.

representative, with data on 108 specimens. And it was structured like a natural history of precious stones, with each specimen treated as a variety of one of the thirteen species listed in the table. The nature of Quist's table was apparent to the English, French and Scottish writers who adopted it in the 1780s and 1790s, and who called it a "table" or a "catalogue" rather than a "scale". Granted, these tables look very different from the scattered remarks on hardness in Berquen's book or the prose list in Dutens' book. But the difference was largely a matter of presentation—putting the well-known rankings in a table and giving each item a number. Even the number was not entirely new, since earlier writers had specified that ruby was the "first" stone for hardness, after diamond, sapphire the "second" stone, and so on. Quist was part of a tradition of ranking gems by hardness that stretched across the seventeenth and eighteenth centuries, and across artisans and naturalists (fig. 1).[81]

[81] Bomare, *Minéralogie*, 254 (amethyst). Jean Gotschalk Wallerius, trad. Baron d'Holbach, *Minéralogie, ou Description générale des substances du règne minéral* (Paris, 1753), 211-27. Bengt Andersson Quist, "Försök på en del kiesel-arter, och i synnerhet de härdare sä kallade äkta stenar," *Svenska Wetenskaps Academiens Handlingar* 39 (1768): 55-76, on 70-76. Adopted in Richard Kirwan, *Elements of Mineralogy* (London, 1785), 171-3; Axel Fredrik Cronstedt, trans. Gustav von Engestrom, *An Essay Towards a System of Mineralogy* (London, 1788), vol. 1, 225; Torbern Bergman, trans. J. C. Delamétherie, *Manuel du minéralogiste, ou Sciagraphie du règne minéral* (Paris, 1792), vol. 2, 340-45; Matthew Guthrie, "A Table of Gems, of the First and Second Orders," *The Bee* 13 (1793): in instalments through pages 41-215. On the latter see Jessie M. Sweet, "Matthew Guthrie (1743–1807): An Eighteenth-century Gemmologist," *Annals of Science* 20, no. 4 (1964): 245-302.

This tradition went hand-in-hand with practices for determining the hardness of particular specimens. Cutters and polishers had long known that there is no single material that is suitable for working all species of gems. Different gems required different materials. As early as the twelfth century, European craftsmen distinguished three groups of gem based on the materials used to polish them.[82] André Félibien distinguished four groups of gem on the same basis in a work published in 1676; the relevant text of Félibien's work was reproduced in a volume of the *Encylopédie* in 1765.[83] Just as important as the materials used to work gems was the ease with which they were worked by any given material. According to one mineralogist, writing in 1813, cutters sometimes judged the hardness of gems by the ease with which they were scratched by a point or blade made of iron or steel.[84] Caire-Morant, himself a cutter, noted that the hardness of gems could be judged by the resistance they showed during the process of cutting or polishing: "the pressure on the hand measures the resistance," he wrote. The problem, he observed, was that this required "a very delicate touch and infinite practice." He tried to quantify the procedure by substituting the hand of the cutter with a variable load. His idea was to use the weight of the load required to work a gem to measure the hardness of the gem. The greater the weight, the harder the gem. The idea of loading the wheel with a weight probably came

[82] Marjolijn Bol, "Polito et Claro: The Art and Knowledge of Polishing, 1100–1500," in *Gems in the Early Modern World*, ed. Bycroft and Dupré, 223-57, on 226.

[83] Félibien, *Principes de l'architecture*, 359-61. Anon., "Lapidaire," in Diderot and d'Alembert, *Encyclopédie*, vol. 9 (1765), 282–283.

[84] Pujoulx, *Minéralogie*, 70.

from diamond mills, some of which were equipped with lead blocks to speed up the faceting process (fig. 2).[85]

These procedures anticipated Mohs' scale of hardness and Seebeck's sclerometer. Mohs used a standard set of materials to divide minerals into groups based on their hardness, just as cutters did. Mohs' method also involved scratching minerals with a file. To locate a specimen on the scale, he advised, one must scratch the specimen with a file and scratch the minerals on the scale with the same file. For example, if the file scratches the specimen in the same way as a topaz, the substance has a hardness of 8, since topaz is the eighth mineral on the scale. The sameness of two scratches was to be judged, as Mohs put it, "from the resistance these bodies oppose to the file, and from the noise occasioned by their passing over it." These judgments required training the senses, or what Mohs called "short practice…for rendering these perceptions more delicate and perfect." Seebeck's instrument was an attempt to standardise judgments of resistance, just as Caire-Morant's had been. Both men used the weight of the load required to scratch a material as a measure of the hardness of the material.[86] It does not follow, of course, that Seebeck or Mohs derived their methods from gem cutters. But it does follow that mineralogical tests of hardness had more in common with the methods of cutters than meets the eye. They both involved the sensitive handling of materials with a view to making fine distinctions between them. Scratching was continuous with cutting and polishing, just as scales were continuous with rankings.

[85] Caire-Morant, *Pierres précieuses*, 24-6, esp. 24 ("pressure of the hand").

[86] Mohs, *Treatise on Mineralogy*, vol. 1, 300-7, esp. 304-5. Burchard, "The Sclerometer."

From connoisseurship to *connoissance*

Pierre-Jean Mariette has been called "the most brilliant connoisseur of the Enlightenment."[87] He was also good with his hands, as the art historian Kristel Smentek has shown. He did not simply look at the prints in the royal collection that he curated from 1750 onwards. He mounted them, enlarged them, cut them into sections, and even split double-sided drawings into two separate sheets.[88] The same goes for connoisseurs who dealt with gems. They used their hands as much as their eyes, running gems through their fingers, scratching them with files, and pressing them against the wheels of diamond mills. The aim of these gestures was, very often, to determine the quality of the gems in question. The active sense was touch, as much as sight. Sensitive gestures allowed the cutter or jeweller to tell the difference between hard and soft, slippery and static, heavy and light.[89] The hand usually worked in tandem with the eye, but the hand was indispensable. Manual skill did not always aim at connoisseurship, but it could easily be adapted to that purpose, as when Haüy had his gems cut to reveal their refractive qualities. Touch was often facilitated by instruments, such as files and wheels, but it was touch nonetheless: "the pressure on the

[87] Pascal Griener, "Préface," in Valérie Kobi, *Dans l'oeil du connaisseur: Pierre-Jean Mariette (1694-1774) et la construction des savoirs en histoire de l'art* (Presses universitaire Rennes, 2017).

[88] Smentek, "The Collector's Cut."

[89] Weighing gems by hand was common in the period: Pujoulx, *Minéralogie*, 82.

hand measures the resistance." Caire-Morant, like Mariette, made good judgments because he had good hands.

There are other ways in which the history of gem hardness enlarges the received view about connoisseurship in the Enlightenment. Connoisseurship is usually associated with the social élite, an idea encapsulated in the notion of an *amateur*. Yet some of the most important judgments about gems were made by cutters, one of the less prestigious classes of artisan in early modern France. As we have seen, cutters were in the best possible position to determine the hardness of gems. And hardness was the basis for the all-important distinction between Oriental and Occidental gems. As well as social diversity, there was a methodological diversity in the study of gems that goes beyond the familiar association between connoisseurship, collecting and classification. Collecting and classification were mixed up with instruments, experiments and quantification: the hardness detector invented by Caire-Morant, the experiments on double refraction done by Haüy and Pichenot, the rankings of gems that changed imperceptibly into hardness scales. These aspects of Enlightenment science, like touch, are not usually associated with connoisseurship. Yet they were all forms of *connoissance*, the peculiar, hybrid form of knowledge that involved making fine judgments about the quality of everything from wood to horses.[90] Historians have moved from the eye of the connoisseur to the hand of the connoisseur; perhaps the next step is to move from connoisseurship to *connoissance*.

[90] On the scope of *connoissance*, see section 3 of the introduction to this special issue.