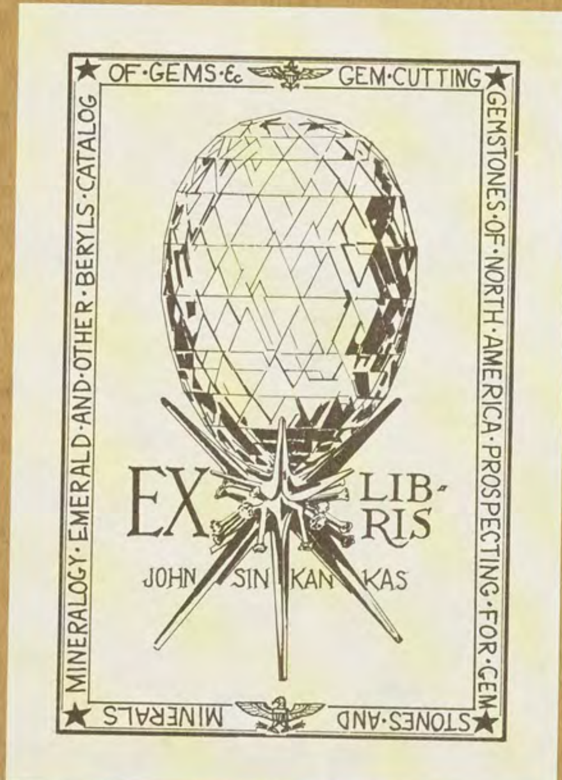
HAÜY

Festschrift

Amer. Mineral.
reprint.

CaT


MINERALOGY · EMERALD · AND · OTHER · BERYLS · CATALOG
OF · GEMS · &c
GEM · CUTTING
GEMSTONES · OF · NORTH · AMERICA · PROSPECTING · FOR · GEM
STONES · AND
MINERALS
EX LIB-RIS
JOHN SIN KAN KAS

Ko Krae Yedlie

Cat

BULLETIN OF THE NEW YORK MINERALOGICAL CLUB

VOL. 2, NO. 3

THE HAÜY CELEBRATION

CONTENTS

Reprinted from

THE AMERICAN MINERALOGIST, Vol. 3, No. 6, June, 1918

PRESS OF
THE NEW ERA PRINTING COMPANY
LANCASTER, PA.

PLATE 2.

Traduit du dessin de F. Massard. par R. D'Elvaux 1806

"Au Savant Auteur des Traités de Physique et de Minéralogie"

THE MASSARD-D'ELVAUX PORTRAIT OF HAÜY. From "Tableau Méthodique des Espèces Minérales," by J. A. H. Lucas. Paris, 1806.

[Reprinted from THE AMERICAN MINERALOGIST, Vol. 3, No. 6, June, 1918.]

THE ABBÉ RENÉ-JUST HAÜY CELEBRATION

THE Abbé Haüy Celebration, in honor of the 175th anniversary of the birth of this noted crystallographer, was held at the American Museum of Natural History on the evening of Thursday, February 28, 1918, under the auspices of the New York Mineralogical Club, jointly with the New York Academy of Sciences, Section E of the American Association for the Advancement of Science and other organizations. The chairman of the Committee, George F. Kunz, presided. Papers were presented by a number of the members of the Committee and one written for the Celebration by the late L. P. Gratacap was read in part. Addresses were made by R. A. A. Johnston, Alexander H. Phillips, J. Volney Lewis, Herbert P. Whitlock and others. An exhibition of books, portraits and other memorabilia was shown in two special cases in the Mineralogical Hall of the Museum [see list below]. A collection of books, prints and photographs was assembled in the Stuart Gallery of the New York Public Library, Fifth Avenue at 42d Street, and also at the New York State Library, Albany, N. Y.

Preceding the meeting there was a banquet, given by the members of the Committee, in the Aztec Restaurant of the American Museum of Natural History, at which were present: George E. Ashby, David J. Atkins, Sydney H. Ball, George F. Black, Mrs. Wilda L. Brown, Raymond B. Earle, Axel O. Ihlseng, Kenzo Ikeda, Robert A. A. Johnston, George F. Kunz, Wallace Goold Levison, J. Volney Lewis, Frederick A. Lucas, James H. Mackintosh, A. Operti, Alexander H. Phillips, J. F. Quinn, Miss Catherine Schroder, Miss May L. Schroder, Gilman S. Stanton, Herbert P. Whitlock, and J. E. Woodman.

The menu was as follows:

MENU

Grapefruit, Daubenton
Pea Soup à la Fouqué Filet de Sole, Fremy
Whale Steak, Abbé Haüy
Baked Potatoes, Dolomieu
Hearts of Lettuce Salad, Michel Levy
Pie and Ice Cream, Descloizeaux
Demi-Tasse, Du Bournon

COMMITTEE

Honorary Chairman

ALFRED LACROIX

Professeur de Minéralogie au Muséum d'Histoire Naturelle, Paris, France (occupying the Chair of Abbé Haüy)

*FRANK D. ADAMS, McGill University, Montreal, Canada.
*JEROME ALEXANDER, New York Section of the Society of Chemical Industry.
*GEORGE E. ASHBY, New York Microscopical Society.
*SYDNEY H. BALL, American Institute of Mining Engineers.
ERWIN H. BARBOUR, University of Nebraska, Lincoln, Neb.
CLARENCE S. BEMENT, Mineralogist.
*CHARLES P. BERKEY, American Association for the Advancement of Science (Section E).
*GEORGE F. BLACK, New York Public Library.
*FRANK W. CLARKE, U. S. Geological Survey.
*CHARLES A. COLTON, Newark Technical High School.
EDWARD S. DANA, Yale University, New Haven, Conn.
*MARY C. DICKERSON, American Museum of Natural History, N. Y.
ARTHUR S. EAKLE, University of California, Berkeley.
*R. B. EARLE, New York Academy of Sciences.
*OLIVER C. FARRINGTON, Field Museum of Natural History, Chicago.
*GEORGE I. FINLAY, New York Academy of Sciences.
WILLIAM E. FORD, Sheffield Scientific School, Yale University, New Haven, Conn.
*SAMUEL G. GORDON, Academy of Natural Sciences, Philadelphia, Pa.
*MCDOUGALL HAWKES, Museum of French Art, Institut Français aux Etats-Unis.
WILLIAM H. HOBBS, University of Michigan, Ann Arbor, Michigan.
W. O. HOTCHKISS, State Geologist, Wisconsin.
*EDMUND O. HOVEY, New York Academy of Sciences, American Association for the Advancement of Science (Section E).

*Official Appointment.

*Axel O. Ihlseng, American Institute of Mining Engineers.
*Kenzo Ikeda, Imperial University of Tokyo, Japan.
*Robert A. A. Johnston, Geological Survey of Canada, Ottawa, Canada.
*Edward H. Kraus, University of Michigan, Ann Arbor.
Henry B. Kümmel, State Geologist, New Jersey.
*George F. Kunz, New York Mineralogical Club, American Scenic and Historic Preservation Society, Museum of French Art, Institut Français aux Etats-Unis.
*Wallace Goold Levison, Brooklyn Institute of Arts and Sciences.
*J. Volney Lewis, State University of New Jersey, New Brunswick.
*Frederic A. Lucas, American Museum of Natural History.
Lea McI. Luquer, Columbia University, N. Y.
*James G. Manchester, New York Mineralogical Club.
Daniel S. Martin, Charleston Museum, Charleston, S. C.
*E. B. Mathews, Johns Hopkins University, Baltimore, Md.
George P. Merrill, U. S. National Museum, Washington, D. C.
*Benj. L. Miller, Lehigh University, South Bethlehem, Pa.
*Alfred J. Moses, Columbia University, New York.
Charles Palache, Harvard University, Cambridge, Mass.
Arthur L. Parsons, University of Toronto, Canada.
*Alexander H. Phillips, Princeton University, New Jersey.
Joseph E. Pogue, U. S. National Museum, Washington, D. C.
Washington A. Roebling, Mineralogist.
Austin F. Rogers, Leland Stanford Junior University, California.
*G. A. Roush, Lehigh University, South Bethlehem, Pa.
*Waldemar T. Schaller, U. S. Geological Survey.
*Joseph T. Singewald, Jr., Johns Hopkins University, Baltimore, Md.
*Gilman S. Stanton, New York Mineralogical Club.
*C. H. Swartz, Johns Hopkins University, Baltimore, Md.
*Arthur C. Terrill, University of Kansas, Lawrence, Kan.
*Ralph W. Tower, American Museum of Natural History.
*Alexander Vachon, Université Laval, Quebec.
Frank R. van Horn, Case School of Applied Science, Cleveland, O.
Henry S. Washington, Geophysical Laboratory, Washington, D. C.
Edgar T. Wherry, Bureau of Chemistry, U. S. Department of Agriculture, Washington, D. C.
*Joseph P. Wintringham, New York Mineralogical Club.
*J. Edmund Woodman, American Association for the Advancement of Science (Section E).
George F. Kunz, *Chairman,* 405 Fifth Avenue, New York City.
Herbert P. Whitlock, *Secretary,* The New York State Museum, Albany, N. Y.

*Official Appointment.

Editing Committee: George F. Kunz, Herbert P. Whitlock and Edgar T. Wherry.

Haüy Exhibition at the American Museum of Natural History

Mineral Specimens:

Varieties of amphibole:

Tremolite........................Canaan, Conn.
Actinolite........................Blanford, Mass.
Hornblende.......................Norway.

These were formerly considered separate species, but were united into a single group by Haüy.

Mineral species and varieties separated and described by Abbé Haüy:

Euclase................Villa Rica, Brazil.
Iolite (Dichroite).........Bodenmais, Bavaria.
Staurolite...............Mt. Campione, Switzerland.

Two specimens of azurite, with original presentation label, signed by Haüy. Loaned by Columbia University.

Specimen. Cleavage rhombohedron of calcite, similar to the one which suggested to Haüy his great discovery.

Cleavage fragments of calcite, showing the way in which this mineral breaks.

A crystal of calcite similar to the one accidentally broken by Haüy in the collection of Citoyen Defrance du Croisset.

A goniometer similar to that used by Haüy. Loaned by the New York State Museum.

Five specimens of haüynite:

1. From Vesuvius.
2. " Marion, Italy.
3. " Mt. Somma.
4. " Niedermendig, Germany.
5. " Vesuvius.

Haüynite: It is interesting to observe that a tribute has been paid to the genius of Haüy by Bruun-Neergard in 1807 in the naming of a silicate mineral in honor of this world-renowned scientist. The mineral named haüynite or haüyne, after Haüy, is a complex silicate of sodium, calcium and aluminum, belonging to the sodalite group. It occurs frequently in the lavas of Mt. Vesuvius and crystallizes in the isometric system. The hardness is from 5.5 to 6, and the specific gravity is about 2.45. The mineral is generally translucent, and the luster vitreous. The coloration varies in different examples, red and yellow being, however, rare, while specimens of blue or green hue are usual.

Portraits of Abbé Haüy: [Plates 2, 6, 7, 8, 9, 10, and 11.]

1. Sent by Prof. Alfred Lacroix. Copy of one in his possession.
2. By Ambroise Tardieu, French engraver, 1788–1841.
3. By Johann Anton Riedel, engraver, 1733–1816; after F. Massard. Print published about 1812.
4. By Félix Massard. Engraver, R. Delvaux. 1748–1823.
5. Abbé René-Just Haüy
6. The Haüy Freres

} From the George F. Kunz Collection at the Field Museum of Natural History, Chicago, Ill.

Portrait of Valentin Haüy, brother of Abbé Haüy, well known as the founder of the Institution of Jeunes-Aveugles, similar forms of which he established in Russia and Germany.

Autographs: [Plate 12.]

Photographic reproduction of the title-page of "Des Surfaces Vibrantes" given by Abbé Haüy to Dr. J. G. Cogswell, the first librarian of the Astor Library, now the New York Public Library (now in the possession of the Library), with photographic reproduction of the inscription, which reads:

A Monsieur Kogswell, hommage de la reconnaissance et du respectueux attachement de l'auteur. 1819.

(Signed) HAÜY.

Original letter of Abbé Haüy, written on the 4th of September, 1813, to one Monsieur Marron. Property of George F. Kunz.

Photographic reproduction of a letter in the possession of Professor Alfred Lacroix, with signature of Haüy.

Reproduction of a fac-simile letter from the "Isographie des Hommes Célèbres," assembled by T. Delarue. Paris, 1843.

Books:

1. "Exposition Raisonée de la Théorie de l'Électricité et du Magnétisme." Paris, 1787.

   An analytical explanation of the theory of electricity and of magnetism as propounded by M. Aepinus. Thus Abbé Haüy rendered an invaluable service to physics by reducing to simple formulæ a work little known, but of inestimable value.

2. "Traité Elémentaire de Physique" (Elementary treatise on Physics). Abbé Haüy. Paris, 1803.
   - Vol. I: Peculiar Qualities of Substance; Physics of Water, of Air, of Electricity.
   - Vol. II: Galvanic Electricity, Magnetism, Light.
3. "Traité de Minéralogie." Abbé Haüy. Paris, 1801.
   - Vol. I: Theory of Minerals; Theory and Structure of Minerals; Mineral Characteristics; Discussion of the Theory and the Laws of Mineralogy with Particular Reference to the Structure of Crystals.
   - Vol. II: Continuation of the Discussion in Vol. I; Exhaustive Treatment of Minerals of the 1st Group, *i. e.*, Acid Earthy Substances.
   - Vol. III: Continuation of Treatment of Minerals of the First Group. Minerals of the Second Group, *i. e.*, Non-metallic Combustible Substances; Treatment of the Third Group, *i. e.*, Metallic Substances.
   - Vol. IV: Continuation of the Third Group Discussion; Appendices including the Treatment of the Products of Volcanoes.
   - Vol. V: Tabulated Mineralogical Characteristics; A Methodical Distribution of Minerals; 86 Plates of Geometrical Figures.
4. "Tableau Comparatif des Résultats de la Cristallographie et de l'Analyse Chimique." Abbé Haüy. Paris, 1809. (2 copies shown.)

   The Introduction presents a comparative, classified list of results in the study of Crystallography.
5. "Traité des Caractères Physiques des Pierres Précieuses." Abbé Haüy. Paris, 1817. (2 copies.)

   The treatment of the physical qualities of precious stones to allow of their identification after cutting.
6. Italian Translation by Luigi Configliachi of "Traité des Caractères Physiques des Pierres Précieuses." Milano, 1819. (2 copies.)
7. "Mémoire Sur le Pyroxène Analogique." Abbé Haüy, Paris, 1819. Extrait des Annales des Mines.

   In which Abbé Haüy indicates the numerous forms of pyroxene and describes a new variation.

8. Copy of the Mémoires de l'Académie Royale des Sciences, showing articles written by Haüy—

   1st, "Observations on the Tourmaline." July 28, 1784, p. 270.

   2d, "Observations on the Structure of Crystals of Feldspar," p. 273.

9. Copy of the Mémoires de l'Académie Royale des Sciences, showing the Memorial Eulogy on Abbé Haüy delivered by Baron Cuvier, June 2, 1823.

10. A text book of the period just prior to the influence of Haüy, published in England in 1771. (Loaned by Herbert P. Whitlock.)

    A text book of Mineralogy published in 1823, one year after the death of Haüy. (Loaned by Herbert P. Whitlock.)

    Note the resemblance of the latter to a modern work, due to the influence of Haüy.

11. Catalog of Scientific Papers of the Royal Society of London. Vol. III, 1869. Opened at pages 230–231 showing the bibliography of Abbé Haüy.

Bibliography:

1. Photographic reproduction of bibliography (*Royal Society o London,* showing also pages 232 and 233.)
2. Photographic reproduction of pp. 1038, 1039, and 1040 of the "*Biographisch-Literarisches Handwörterbuch.*" J. C. Poggendorff, Leipzig, 1863. Vol. 1. (Giving bibliography of Abbé Haüy.)

The biographical notice of the honorary chairman of the celebration in the French annual *Qui êtes-vous* (Who's who) runs as follows:

Lacroix, Alfred. Born February 4, 1863, at Macon (Saône-et-Loire). Chevalier de la Légion d'Honneur. Membre de l'Institute (1904), professeur at the Muséum d'Histoire Naturelle (1893), director of the Laboratory of Mineralogy, of the École des Hautes Études.

Residence, Quai Henri IV, 8, Paris.

Educated at the Lycée of Mâcon, the Sorbonne and the Collège de France.

Married Mlle. Catherine Fouqué.

PLATE 3.

Institut de France
Académie des Sciences

Paris, le 25/1 1918

Mon cher ami,

Je vous ai fait expédier : 1° le portrait d'Haüy 2° la photographie d'un autographe relatif à lui, faisant partie de ma collection. 3° celle de 3 échantillons de sa collection. Vous donnant les dimensions de 3,5 pour l'échantillon de sa collection avec leur étiquette originale : les seules ont été faites postérieures à l'entrée de cette collection au Muséum.

A la mort d'Haüy, ses héritiers vendirent cette collection en Angleterre. En 1848 elle était en possession du duc de Buckingham. Elle fut achetée par une décision de l'Assemblée nationale au prix de 325 livres st. Cette acquisition fut faite sur l'initiative de Dufrénoy, alors professeur de minéralogie. Le nombre d'échantillons est voisin de 8000.

Cordialement à vous,

A. Lacroix

Pourriez vous me faire savoir s'il existe des autographes de Dolomieu dans les bibliothèques de New York et dans l'affirmative serait-il possible d'en obtenir copie.

LETTER FROM PROF. ALFRED LACROIX, TO DR. GEORGE F. KUNZ, concerning Haüy mementoes.

PLATE 4.

MUSÉUM
NATIONAL
D'HISTOIRE NATURELLE

MINÉRALOGIE

Paris, le 16/1 1918

Rue de Buffon, N° 61

Monsieur le Président et ami:

Je vous remercie de m'avoir mis en relations avec M. Graton dont les travaux ont un très grand intérêt pour moi. Je lui ai écrit.

Je suis heureux d'apprendre la commémoration de l'anniversaire d'Haüy que vous préparez et je serai très honoré de voir mon nom ajouté à celui de votre comité.

Par le prochain courrier je vous enverrai:

1°. La lithographie du buste d'Haüy que je possède dans mon [illegible].

2° Une belle photographie du portrait d'Haüy qui se trouve dans mon cabinet et qui est fort ressemblant: il a été fait d'après nature.

3° Une notice sur la collection d'Haüy et une photo [illegible] [illegible] [illegible] [illegible] de sa collection; elle ne se trouve pas dans le meuble original.

4° La photographie de [illegible] autographe d'Haüy que je possède.

Si vous m'aviez prévenu plus tôt, j'aurais pu vous fournir des documents plus complets.

Nous vous envoyons pour vous et les vôtres nos amitiés les plus cordiales

A. Lacroix

Je vous envoie pour vous et pour l'Académie de New York l'Annuaire historique de l'Académie des sciences pour 1918.

Je prépare pour la séance annuelle de l'Académie (en décembre) l'éloge de Dolomieu. J'ai trouvé dans ses archives de longues correspondances de lui, qui me permettront de mettre sa vie sous un jour nouveau. Il est possible que je fasse un volume pour publier ces documents, intéressants pour l'histoire de la Révolution française aussi bien que pour la minéralogie.

Savez-vous s'il existe des autographes de Dolomieu dans les collections de New York?

POST-CARD FROM PROF. ALFRED LACROIX, announcing the sending of Haüy souvenirs, and giving particulars as to Haüy's collection of minerals.

Docteur ès sciences. Préparateur au Collège de France (1887); head of the Mission Scientifique de la Martinique (1902–1903); many scientific missions (United States and Canada, Asia Minor, Greece, Italy, Germany, England; member of the Comite des Travaux Historiques et Scientifiques (1895), and of the Commission de la Carte Géologique de France (1906). Honorary or corresponding member of the mineralogical societies of London and St. Petersburg and the Geological Society of London.

Works: *Minéralogie de la France*, five volumes, 1893–1902. *Les Enclaves des roches volcaniques. La Montagne Pelée et ses eruptions*, 1904. (And numerous scientific papers.)

Lauréat de l'Institut (1892–1093) and of the Société de Géographie (1904). Sécretaire Perpétuel of the Section of Physics in the Académie des Sciences (from 1914).[1]

Prof. Lacroix occupies the curatorship of the mineralogical cabinet of the Muséum d'Histoire Naturelle. He was elected a member of the Académie des Sciences, section de mineralogie, in 1904.

The collection of the Muséum d'Histoire Naturelle[2] is the greatest in France and is of unusual interest because, dating from 1793, it has had as its administrators some of the greatest of France's mineralogists. Since its foundation in 1793, the collection has been under the following: Daubenton (1793–1800), Dolomieu (1800–1802), Haüy (1802–1822), Alex. Brongniart (1822–1847), Dufrenoy (1847–1857), Delafosse (1857–1876), Des Cloizeaux (1876–1893). Since 1893, Professor A. Lacroix (b. 1863), Secrétaire perpétuel de l'Académie des Sciences, has been the administrator of the collection.

The collection itself is made up of numerous important aggre-

[1] Since the reorganization of the Académie in 1803, under Napoleon as First Consul, there have been only seven secrétaires perpétuels for the division of Mathematical Sciences, namely:

1803.	Delambre	Astronomer.
1822.	Fourier	Philosopher and sociologist.
1830.	Arago	Astronomer.
1853.	Elie de Beaumont	Geologist.
1874.	Joseph Bertrand	Mathematician.
1900.	Darbaux	Mathematician.
1914.	Lacroix	Mineralogist.

[2] *Collection de Minéralogie, Guide du Visiteur*, par A. Lacroix, 3d ed., 132 pp., folding plan, Paris, 1915.

gates: Chantilly Collection (1793), Weiss Collection (1802), Brongniart Collection (1823), Sage Collection, Cabinet de la Monnaie (1825), Gillet de Laumont Collection, including the Romé de l'Isle Collection (1835), Bischoffsheim Collection (1890), Des Cloizeaux Collection (1904), Ch. Frossard Collection (1908), J. Pierpont Morgan Collection (1902–1913).

A portion of the collection of Des Cloizeaux comprehends types of his varied work and exists in the general collections. The Haüy Collection contains many of his original specimens, which he described from time to time.

The Muséum collections are arranged in 15 groups and are contained in 192 cases. The catalog contains 132 octavo pages and one folding plan of the arrangement of the collection. The alphabetical index of 41 pages is most excellent and greatly facilitates reference.

In the Haüy Collection, placed in the entrance hall, there are nearly 8,000 specimens, all the labels of which are in the handwriting of Abbé Haüy and displayed near the collection models. Two cases in the same hall with the Haüy specimens contain a series of crystallographic models made under the direction of Romé de l'Isle, in accordance with the figures in his *Traité de Cristallographie* published in 1783.

The following pages contain the papers contributed for the Haüy Celebration, and in part read at the meeting; they have been arranged and edited by Dr. Edgar T. Wherry.

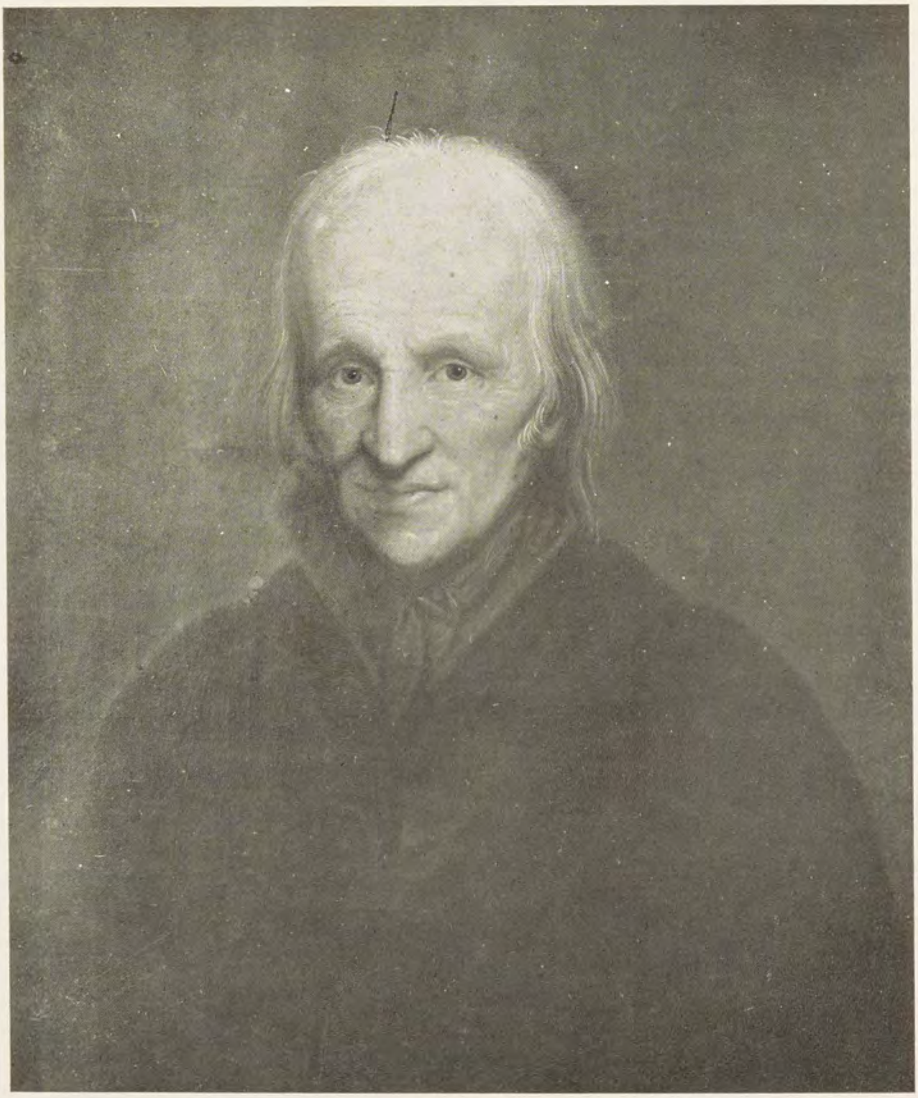
The publication of the Haüy proceedings and papers in this magazine has been made possible by the generous aid of Colonel William Boyce Thompson of New York City, whose interest in mineralogy and scientific research is well known.

PLATE 5.

OLD CHURCH AT ST. JUST EN-CHAUSSÉE, where Haüy was chorister in his childhood; from biography of Haüy in the series "Les Contemporains."

SPECIMENS FROM THE HAÜY COLLECTION IN THE MUSEUM D'HISTOIRE NATURELLE, PARIS, with Haüy's original labels in his own handwriting. Photographed in the Museum for Haüy celebration at the American Museum of Natural History, New York, February 28, 1918.

PLATE 6.



PORTRAIT OF HAÜY, in the possession of Prof. Alfred Lacroix, who occupies the chair of mineralogy in the Muséum d'Histoire Naturelle, formerly filled by Haüy, from 1802 to 1822.

THE LIFE AND WORK OF HAÜY

GEORGE F. KUNZ

Chairman, Haüy Celebration Committee

If a keen and observant mineralogist had not accidentally dropped a group of calcite crystals belonging to a French collector in such a manner that one crystal was broken; and if this crystal had not been presented to the mineralogist who broke it; and if he had not possessed the wonderful gift of thoughtful and conscientious observation that is characteristic of the people of France—even tho he was but the son of a weaver (indeed, this weaver probably possessed the same qualities); and if he had not interested himself in botany and had not casually listened to a lecture of the great Daubenton, professor of mineralogy and curator at the Muséum d'Histoire Naturelle at Paris; then modern crystallography would not have been founded on the scientific basis on which it now rests.

It is because of this event that we are here assembled, at the 175th anniversary of the birth of this mineralogist, to celebrate and do honor to him, and to the great institution with which he was later connected, and to urge, as an added inspiration to our young men, the importance of the study of mineralogy, especially of crystallography, as this would be of the greatest aid to the nation in times of war and in times of peace. So greatly has Haüy's work been appreciated that at this time of stress no difficulty was found in obtaining the coöperation of eminent scientists in nearly forty institutions in the United States and Canada, who have selected as their honorary chairman the present incumbent of the chair of mineralogy in the Muséum d'Histoire Naturelle, Professor Alfred Lacroix, who not only has so ably contributed to the science of mineralogy, but has been further honored with being called to the secretaryship of the Académie des Sciences, a post once occupied by the famous Georges Cuvier, who wrote the great eulogy of Abbé Haüy.

The life of Abbé Haüy, the founder of the science of crystallography, furnishes us with one of the many instances in which a great scientist has developed out of the simplest surroundings, and without having enjoyed any very exceptional advantages.

René-Just Haüy, the son of a poor weaver, Just Haüy, and of his wife Magdeleine Candelot, was born in the town of St. Just, Dept. Oise, France, on February 28, 1743.[1] In his childhood his religious bent found expression in frequent attendance at the simple services of the village church, whither he may perhaps have been attracted partly by his natural love of music. His assiduity was remarked by the prior of an abbey of Premonstrants near the village who, after having taken occasion to talk with him several times, became impressed with the liveliness of his intelligence, and had him given some lessons by certain of the monks. Believing that he would prove worthy of any assistance that might be afforded him to secure better educational advantages than he could hope for in his native village, the prior suggested to the boy's mother that she take him for a while to Paris, where, by means of letters of recommendation, Haüy could secure entrance to some educational institution, so as to develop his abilities.

The mother's means were very scant, barely sufficient to enable her to subsist for a few months in the great city, but her love for her son and her ambition for his success induced her to take the risk. At first, however, the boy could find no better position in Paris than that of chorister in a small church of the St. Antoine quarter, not an uncongenial occupation, it is true, for a lover of church music, but still one that offered no prospect of mental culture. However, the boy's patient and willing acceptance of this place was before long rewarded. One of the good prior's letters influenced a Parisian friend to secure for Haüy a scholarship in the College of Navarre, where his devotion to his studies and his general good conduct won for him the favor of those in charge of the institution, so that he was accorded the position of usher; and subsequently, in 1764, before he had attained his twenty-first year, an appointment as *régent* (master) of the fourth class. So deceptive are physical indications that when he was named for this position he heard one of his colleagues remark, "There is a young man who will not live out the year." At the end of a few years he was appointed *régent* of the second class in an associated educational establishment, the Cardinal Lemoine College.[2]

[1] At the date of Haüy's birth his native town formed part of the old province Ile de France, the department of the Oise not having yet been constituted.

[2] These two colleges formed part of the complex constituting the Université. The Collège de Navarre dated from 1304, when it was founded by Jeanne de

PLATE 7.

RENÉ JUST HAÜY.

PORTRAIT OF RENÉ JUST HAÜY. Drawn by Ambroise Tardieu (1788–1841).

While still in the Collège de Navarre, Haüy was attracted to the study of physics, and followed a course of lectures delivered there by Brisson. To these he listened with such lively interest, and watched the experiments performed by the lecturer so closely, that he was able to repeat many of them for his own instruction. However, altho he was thus laying a foundation for his later work, his knowledge of natural history was still very slight. His first earnest effort in this direction was due to his friendly relations with a fellow instructor, the Abbé Charles Lhomond (1727–1794), who composed a number of elementary educational books for the use of young people. With him Haüy frequently took long walks into the suburbs of Paris, during which Lhomond, an enthusiastic botanist, busied himself with collecting specimens of plant life. The young master soon began to feel regret that he could not intelligently share in the interest of his friend, and this moved him to take up the study by himself, saying nothing to Lhomond about it until he should have attained some degree of proficiency. A good opportunity presented itself during one of his vacations, which he passed in his native village, for he found there a monk who knew something of botany. Haüy profited by this chance so well that on his return to Paris he was able to give Lhomond a pleasant surprise by proving, on their next walking tour, that his own knowledge of botany was now almost on a level with that of his friend. Indeed, he published in the Mémoires of the Académie for 1785 (p. 210) a paper on the "Manière de faire des herbiers." In the preparation of his own herbarium he employed a special process for preserving the colors of flowers.

Thus, little by little, Haüy was moving forward along the path that was eventually to lead him to the discovery which has made him famous. It was but natural that his botanical studies should render him a frequent visitor to the Jardin du Roi, now the Jardin des Plantes, the establishment of which dates back to 1626.[1] On one of these visits he was led, almost by chance, to

Navarre, wife of Philippe le Bel; among its pupils had been the Duc d'Anjou (Henri III), Henri de Navarre (Henry IV), Armand Duplessis (later the famous Cardinal Richelieu) and Bossuet. The Collège du Cardinal Lemoine was of even earlier foundation, since it was established in 1297 by Cardinal Jean Lemoine.

[1] The first idea of the Jardin du Roi has been attributed to the physician of Marie de'Medici, Jean Rolin, who in his travels had visited the recently established botanical gardens in Germany and Italy.

assist at a lecture on mineralogy by Daubenton. His study of physics in general had been sufficiently thoro to enable him to grasp the general principles of mineralogical science, and his quick perceptions were impressed with the difference between the systematic classification of plant forms, and the comparative lack of system in the arrangement of mineral forms. He soon realized that this must be due to the fact that while it was comparatively easy to trace the relationship of the groups of plants by the constancy of even the most complicated forms, the classification of minerals presented much greater difficulty, since in many cases the external forms of those of identical chemical composition were widely diverse.

The train of thought suggested by these reflections was given a definite direction by what we may call a happy chance, altho the real value of such a fortuitous happening strictly depends upon the preparation of the mind to seize upon its real significance. Haüy himself relates this circumstance as follows in his "Traité":[1]

"The observation I have just noted is that which has served to develop my ideas on the structure of crystals. It presented itself in the case of a crystal that the citizen Defrance[2] was kind enough to give me just after it had broken off from a group this enlightened amateur was showing me, and which formed part of his mineralogical collection. The prism had a single fracture along one of the edges of the base, by which it had been attached to the rest of the group. Instead of placing it in the collection I was then forming, I tried to divide it in other directions, and I succeeded, after several attempts, in extracting its rhomboid nucleus. This at once surprised me, and gave me the hope that I could advance beyond this first step."

In his eulogy of Haüy, delivered before the Academy of Sciences June 2, 1823, the great Cuvier repeats this story with the slight variation that Haüy "by a fortunate awkwardness" had let the group fall so that the crystal broke off. It is a rather curious circumstance that some six or seven years before this time a young Swedish chemist named Gahn, later professor at Abo, Finland, in breaking a pyramidal calcite crystal had also remarked its rhomboid nucleus. He communicated his observation to his master Bergmann, of Upsala, but the latter failed to realize its

[1] *Traité de Minéralogie*, vol. I, pp. 23, 24, 1801.

[2] Defrance du Croisset, a financier (*mâitre de comptes*), who owned fine collections of shells and minerals, which he was always ready to show to savants.

PLATE 8.

1743 ✻ 1822

Publié par L. Curmer à Paris

Portrait of Haüy. Engraved from a medallion by A. Féart.

significance and, instead of carrying out experimental research on other crystals, lost himself in a maze of hypotheses.

Haüy, on the contrary, immediately proceeded to utilize this chance observation. On his return to his room he took a piece of spar of hexahedral form and, after breaking it carefully and skillfully, found the fragments of a rhomboid; the same proved true of lenticular spar. Pursuing his researches, he experimented with a great variety of crystals and found that the principle constantly held good. The variation, in most cases, of the exterior form from the primal form was due to the wearing away of superposed layers, either at the angles or along the edges, and to a special and peculiar arrangement of the elementary molecules, subordinated to the same structural laws.

In view of the fact that Romé de l'Isle's investigations and partial results in the domain of crystallography were so soon eclipsed by those of Haüy, we may perhaps forgive him for the satirical turn of certain of his criticisms of his rival. Thus Cuvier tells us that he is said to have found pleasure in calling Haüy a "cristalloclaste" because he was a breaker of crystals, just as in the Eastern Empire those who shattered the church images they considered as lures to idolatry were called "iconoclasts."[1]

Haüy now felt sufficient confidence in the value of his observations and the deductions he had made from them to speak of his results to Daubenton, and the latter communicated them to Laplace, who advised Haüy to present them to the Academy of Sciences.[2] It was not an easy matter to overcome his disinclination to do so, not from any want of confidence in the truth of his discovery but from an inborn lack of self-assurance. Finally, on January 10, 1781, he read before the Academy his first memoir, in which he treated of the crystallization of garnets and calcareous spars. In accordance with the rules of the Academy a communication made by a non-member was only published according to a report made by one or more members. In the present case this duty devolved upon Daubenton and Bezout, but their report, published in the following month, showed that they had failed to grasp the full importance of Haüy's communication. On January 22, however, the latter read a second me-

[1] Baron Georges Cuvier, "Éloges historiques," Paris, in "Éloge historique de René-Just Haüy," p. 261, 1860.

[2] L. Gratacap, Le Muséum d'Histoire Naturelle. Paris, 1854.

moir in which he confined himself strictly to the calcites. This time, in a report by the same members, the publication of which was delayed until the following December, the scope of the discovery was satisfactorily presented, and justice was done to its importance.

As an acknowledgment of the great service Haüy had rendered to the science of mineralogy, the Academy was eager to include him among its members, but there was at this time no vacancy either in the section of physics or in that of mineralogy. However, he was elected as *adjoint* in the class of botany, a vacancy caused by the promotion of the botanist Jussieu to the rank of *associé*. When it became necessary for him to appear as a candidate, a difficulty arose about his dress, since he was exceedingly loath to lay aside the strictly ecclesiastical garb prescribed by the old rules of the church, and it required the authoritative opinion of a doctor of the Sorbonne to remove his scruples. The date of his election was February 12, 1783, and five years later he became *associé* in the class of natural history and mineralogy.[1]

An unofficial recognition of Haüy's merit, one scarcely less impressive than his speedy election to the Academy, was the request made by such masters of science as Lagrange, Laplace, Fourcroy, Berthollet, and De Morveau, that the diffident master of the second class in the Cardinal Lemoine College should deliver a special course of lectures for them on his new theory. Indeed, this theory was so bound up with his personality, he was so exclusively the fountain-head whence all exact knowledge of it must flow, that the master minds in other fields were for the time being obliged to content themselves with the part of learners.

With the lapse of twenty years from the beginning of Haüy's service in the university, he became entitled to receive a pension as emeritus. This he hastened to ask for, as by adding it to the income from a small benefice, he would be provided with what was strictly necessary; he continued to lodge in the Cardinal Lemoine College. It remained, however, requisite that this small sum should be assured to him. Unfortunately, political events were about to dispose of things otherwise. One of the radical measures adopted by the Constituent Assembly was a law requiring the clergy to take an oath of adhesion to the new form of government, under penalty of being deprived of their

[1] In plate 9, as well as in the frontispiece, Haüy is shown wearing the jacket of the Academy.

PLATE 9.

Haüy

PORTRAITS OF HAÜY, in his uniform as member of the Académie des Sciences.

emoluments and of their places. Haüy's sensitive conscience opposed a bar to his taking this oath. He therefore became subject to the penalty imposed upon those who refused, and as a result he found himself stripped of his little income.

This punishment, however, fell far short of satisfying the anti-clerical partisans of the Revolution, and by another decree passed a few days after the assault on the Tuileries, August 10, 1792, and the imprisonment of the royal family, it was ordered that all priests who had failed to take the oath should be imprisoned. Haüy, in his retired life, solely devoted to scientific study, had but a rather vague sense of the rapid political changes transpiring in Paris, and he was therefore much startled when one day a party of rough men violently entered his modest retreat in the college. Their first question was whether he had any firearms with him. Haüy, who had quickly regained his wonted composure, answered, "I have none but this," at the same time drawing a spark from an electric machine. His quiet bearing and this half-humorous response served to quiet the men a little, but they soon began a hunt for compromising material of any kind. They seized his papers, covered with algebraic formulas, which they may have suspected to be mysterious and treasonable ciphers, and what was much more trying for him, tumbled about his precious minerals, his sole and only treasure. The search being completed, they bore him away to the nearby seminary of St. Formin, which had been turned into a prison. Here he found himself shut up with all the recalcitrant priests and masters of this quarter of Paris.

The change from his simple room in the college to a similar one in the seminary seemed a matter of comparative indifference, and the presence of many of his friends still further tranquilized him. He was also accorded the favor of having the drawers filled with his precious crystals brought to him, and was able to put them again into some sort of order. The very real risk from the passions of the bloodthirsty mob he was far from realizing. Fortunately he had friends outside who were better aware of the dangers of his position. Among them was his colleague of a later time, Geoffroy St. Hilaire, who left no stone unturned to secure the liberation of his friend. His appeal and their own affection and respect for Haüy induced members of the Academy and functionaries of the Jardin du Roi to subject themselves to the humiliation and rebuffs they were sure to encounter in asking any favor of the ferocious men then in control of Paris. There was, however, so little possible excuse for persecuting one so harmless as Haüy that their efforts were at last crowned with success, and an order of release was granted. Armed with this, Geoffroy St. Hilaire lost no time in hastening to the St. Formin seminary. On his arrival there, rather late in the day, he found Haüy perfectly unconcerned and quite disinclined to leave that same evening. When the morrow came it was still hard to persuade him of the imminent peril in which he was, and to induce him to leave the place. How important haste was in this matter was soon made evident by the dreadful prison massacres that took place a few days later, on September 2, 1792, when eighty priests who had shared his captivity at the St. Formin were done to death by the brutal mob.

This was the only serious danger to which Haüy was subjected during the Revolution, and his experience of the active side of the great political convulsion was limited to a single appearance at the review of the battalion to which he had been assigned. His obvious physical unfitness for military service procured him an immediate discharge. He was called on November 9, 1794, to the professorship of physics at the École Normale; on April 17, 1795, the Commission of Weights and Measures appointed him as secretary, and in the same year he was made Curator of the École des Mines. Here it was that he composed his great *Traité de Minéralogie*, originally published serially in the *Journal des Mines*, and later issued, in 1801, in four octavo volumes. This work was immediately recognized as the most important contribution yet offered by France to the science of mineralogy, one that placed the country in the very forefront of the European nations in this science. In it the author makes crystallography the basis of his determination of mineral species, relegating the data derived from chemical analysis to second rank. The mathematical precision with which the crystallographic facts could be presented provided an absolutely exact basis for mineralogy which it had lacked before that time, as the correctness of the crystallographic determinations could always be proved by rigid geometrical tests.

On Daubenton's death in 1800 Haüy seemed clearly indicated as his legitimate successor in the position of professor of mineralogy at the Muséum, but he himself earnestly solicited that

PLATE 10.

HAUY

D'APRÈS J. BOILLY

PORTRAIT OF HAÜY, engraved from drawing by J. Boilly.

Dolomieu should be chosen, altho the latter was at this time confined in a Sicilian prison, whence he was only able to communicate with his friends by means of a few lines written with lamp-black on slivers of wood, even this poor resource being obtained by bribing his jailor. He was nevertheless elected to the professorship, but only occupied the post for a brief time after his return from captivity, for his health had been undermined by his sufferings. He died in 1801, and in the following year Haüy was chosen to succeed him.

Haüy's entrance into this wider sphere of activity gave new life to the study of mineralogy in the Muséum, for the great reputation he had already acquired attracted students from all parts of Europe. His hearers were not only impressed by the lucidity of his expositions, but were also charmed by the unaffected simplicity and kindliness of his manner.

When public worship was restored in France during the Consulate, Haüy was given the title of honorary canon of Notre Dame, and on the institution of the Légion d'Honneur he was made chevalier in the new order. From the constitution of the Institute in 1795, he formed part of it, with the other members of the Academy of Sciences. Napoleon, the First Consul, who, as is well known, fully realized the great importance of the higher education for the upbuilding of a nation's fame and prosperity, commissioned Haüy to write a treatise on physics to be used in the *lycées* of France. On learning that he was to be given but six months' time for the completion of a work of this scope, the scientist hesitated to undertake it, but was at last persuaded to do so. He took up the task so zealously that at the expiration of four months he was able to offer the two volumes of his "Traité de Physique" to the First Consul.

While exiled on the island of Elba in 1814, Napoleon occupied some of his enforced leisure in reading this treatise, and on his triumphant return to Paris in the spring of 1815, he promoted Haüy to the rank of officer in the Légion d'Honneur,[1] a grade that was taken from him in the Restoration which followed soon.

When the allied sovereigns assembled in Paris on Napoleon's downfall Haüy's modest lodging was visited by the King of Prussia, the father of William I of Germany, by Alexander I of Russia, and by Archduke John of Austria. The Austrian archdukes are said to have tried to induce him to sell his collection

[1] In the frontispiece Haüy is shown wearing the medal indicating this rank.

by the tempting offer of 600,000 francs for it. However, he declared that he had resolved to bequeath it to France. His generous intention was left unfulfilled, and some years after his death his heirs were induced to sell it in England, where it remained until the overthrow of Louis Philip, in 1848; it was then in the possession of the Duke of Buckingham, and was bought from him for £325 or 8,125 francs by the Second Republic, and placed in the Muséum d'Histoire Naturelle, its natural resting place.

In spite of the high reputation he had gained as a scientist, Haüy suffered from straitened circumstances in the closing years of his life. With barely enough to provide for his own absolute needs, he was obliged to receive and care for his brother Valentin, who, after founding the "Institution des Jeunes Aveugles" in Paris, traveled to Germany and Russia and founded there similar institutions for the blind. From these wanderings he returned with broken health and without money, and thus imposed an added burden upon René-Just Haüy. Valentin died a few days before his illustrious brother, on March 19, 1822. However, the latter's simple habits and almost ascetic mode of living made him less sensitive to the inconveniences resulting from his lack of means than would have been the case with many others; indeed, he is said to have even been able to give a little aid now and then to those poorer than himself.

Altho never robust, he must have had an essentially sound constitution, for he had attained the age of seventy-nine years when he passed away on June 3, 1822. His death was the result of an accident, altho the fatal outcome was undoubtedly due to his physical condition. He fell, while walking across his room, and broke his thigh-bone. An abscess formed at the point of fracture and an acute fever which supervened put an end to his life in a few days. M. Brongniart, who had been his assistant in teaching for several years, was called to fill his place as professor in the Muséum.

The 8th of November, 1903, was a festival day in the little city of Saint-Just-en-Chaussée (dept. Oise), for it was on this day that a monument was dedicated there to the brothers Haüy, the scientist René-Just and the philanthropist Valentin. The title the latter possesses to the grateful remembrance of all who are interested in what makes life more bearable for those afflicted with blindness must not be forgotten in our admiration

PLATE 11.

LES FRERES HAÜY.

PORTRAITS OF THE BROTHERS HAÜY (RENÉ JUST AND VALENTIN) drawn by J. Boilly, engraved by Alphonse Boilly.

for the more famous discoverer of crystallography. Valentin Haüy's methods for enabling those born blind to share the power of reading with their more favored brothers and sisters merit a place alongside of the methods initiated by the celebrated Abbé de l'Épée to give the deaf-mutes the power to communicate with those enjoying the powers of hearing and speech.

One of the most illustrious continuers of Haüy's work, the mineralogist and geologist François Mallard[1] (1833–1894); has paid him the following just tribute:[2]

"The science of crystallography was entirely created by Haüy's genius, and his successors have had little to do except to perfect the details of his work. No other branch of human knowledge is in the same degree the work of one man alone."

It is but natural, in view of the surprising revelations as to the structural relationship of minerals due to Haüy's discoveries and researches, that mineralogy, properly so called, should have been for a time thrust into the background. However, during the first quarter of the nineteenth century the development of mineralogical chemistry greatly changed the aspect of things in this respect, and at the time of Haüy's death in 1822, a reaction of the mineralogical chemists against the exclusive pretensions of the crystallographers had already taken place.

The most illustrious predecessor of Haüy in the study of crystal forms was unquestionably Romé de l'Isle (1736–1790), who in 1772 published his *Essai de Cristallographie*, in which he foresaw the importance of crystalline symmetry and announced the constance of crystal faces. The views expressed here were presented in a fuller form in a second edition issued in 1783, in three volumes, and bearing the title *Cristallographie*. To this book Linnæus gives the following high praise: "Among the works produced in this century on mineralogy, it is certain that your *Cristallographie* takes the first place. It testifies to your penetrating intellect, to the immense number of observations you have made, to your wide reading, and, what is rare indeed, to your kindly attitude toward myself."

In this work Romé de l'Isle embodied the results he had been able to obtain by the help of Carangeot's recently contrived

[1] Author of *Traité de cristallographie géometrique et physique*, Paris, 1879–1884; 2 vols. and atlas.

[2] Cited in *La Science Française*, Exposition Universelle de San Francisco, vol. I, p. 170.

goniometer, for accurately measuring the angles of crystals; this instrument having been made from Carangeot's drawings by the mechanician Vinçard. There can be no doubt that crystallography owed much to the mechanical aid the goniometer afforded; indeed, it has frequently been the case that important discoveries in pure science have depended upon the invention of new mechanical apparatus. In 1809, Dr. Wollaston (1766–1829) invented a perfected instrument, the reflection goniometer, those of the Carangeot type subsequently being known as contact goniometers. For the proper measurement of small crystals the reflection goniometer is needed, but for the larger ones the more easily and quickly operated contact goniometer has been found useful.

The credit of publishing the first accurate observations on a type of crystal has been given to Nicholas Steno, a Danish physician, who later became Bishop of Titupolis. In a work published in 1669,[1] he treated of the characteristics of quartz crystals, carefully noting that whatever may be their apparent diversity of form the angles between similar pairs of faces are always the same. The theory of the upbuilding of a crystal about a definite and constant nucleus is also enunciated by him. The first book devoted to crystallography as a separate branch of mineralogy was the *Prodromus Crystallographiæ* of M. A. Capeller. This appeared in Lucerne in 1723, nearly fifty years before the publication of De l'Isle's *Essai*.

Of the immediate predecessors or contemporaries of Romé de l'Isle one of the most noted was the Swedish physicist Torbern Olaf Bergmann, whose essay on the crystal forms of calcspar was printed in 1773 in the Acta of the Royal Society of Sciences in Upsala. Had he followed out the indications supplied by his observations he might have occupied a much higher place than he does in the history of crystallography. A year later, in 1774, Abraham Gottlob Werner (1750–1817) in his writing *Von den äusserlichen Kennzeichen der Fossilien* treated of the various forms of crystals, and undertook a partial classification of them.

Of the special merits of Haüy's discovery and theory, Von Kobell has written as follows:[2]

[1] "De solido intra solidum naturaliter contento," Florence, 1669; Engl. transl. 1761; see also *American Mineralogist*, 2, 33, 1917.

[2] Franz von Kobell, *Geschichte der Mineralogie von 1650–1860*, pp. 188, 191, 1864.

"The laws governing crystallization as presented by Haüy not only indicated the form derivable from a given nucleus, but at the same time those which could not be derived therefrom, and showed that the dimensions given by calculation constituted the accurate definition of those approximately determinable by the goniometer. One of the most important results of Haüy's researches was the discovery of the law of symmetry, according to which when one form of crystallization is modified by its combination with other forms, all the similar parts, the edges, angles and faces, are always modified at the same time and in the same way. Haüy called the goniometer a kind of geometrical magnifier, which enabled the observer to perceive excessively slight differences, which could not be perceived ocularly. To him is due the credit of recognizing that the so-called Spanish chrysolite was apatite, long before Vauquelin reached the same result thru chemical analysis. He also recognized before Klaproth that the mineral from Norway called vesuvianite was in reality zircon. His crystallography first brought the beryl and the emerald into the same species, and showed that euclase constituted a peculiar species.

We have already alluded to the *Traité de Physique* written in 1803 at the instance of Napoleon Bonaparte, when First Consul. In his introduction to this work Haüy remarks that nothing was better calculated to stimulate his zeal than the hope of realizing the views of the "Hero of France," who wished to provide for the students enrolled in the higher schools a grade of instruction calculated to develop their judgment by the acquisition of a thoroly systematized learning, which would assure their success in whatever functions they might later be called upon to fulfill. In this connection, he insists upon the fact that any exposition becomes vague when it is strictly confined to its general outlines, and that details may fairly be called the touchstones of theories, for they either guarantee their value or reveal their weakness.

In 1809, eight years after the publication of his *Traité de Minéralogie*, wherein he states the essential principles of his discovery of the laws governing crystallization, Haüy issued a work entitled *Tableau Comparatif des Résultats de la Cristallographie, relativement à la Classification des Minéraux*.[1] He herein states that his principal object in publishing the book is his wish to

[1] Paris, 1809; 312 pp.; 4 plates.

give to those who had followed his course of lectures a full tabulation of his mineralogical methods, revised in accordance with the discoveries and observations with which science had been enriched since the publication of his *Traité de Minéralogie.* New minerals had been discovered by travellers, and a more thoro study of those already classified had shown many of them to be related to species with which no connection had been suspected.[1]

One of the peculiar merits of crystallography, in his opinion, was that it made use of what might not unjustly be termed a "palpable means" of verification, and that it depended upon the kind of anatomy of which crystals are susceptible, as well as upon modifications of a structure which, to a certain extent in the case of minerals, is what the organism is in regard to beings endowed with life. Thus mineralogy was made to share with zoölogy and botany the merit of making a direct appeal to the eye.[2]

That with all his single-minded devotion to the cause of pure science Haüy was not without a quick sense of the value of applying scientific knowledge to useful ends, is shown in one of his latest works, *Traité des Caractères Physiques des Pierres Précieuses.*[3] In his introduction, to emphasize the chemical importance of gem-stones, he alludes to the fact that thru the analysis of the jacinth and the beryl two new elements had been discovered, Klaproth having recognized zirconium in the former, while the presence of another new element, glucinum, had been found by Vauquelin in beryl. In the preparation of this treatise Haüy asserts that his aim is to present clearly the physical characteristics observable in precious stones that are cut as gems, and to arrange the data in the form of rules that may be used for the determination of these gems. He believes that such rules will prove of great value to the gem-cutters as well as to the dealers in gems, since they enable them to verify impressions received thru the eye.

However, the chief object of the work is to help those forming collections of gem-stones, as among the collectors of these objects, which, as Haüy writes, "form part of what we look upon as

[1] *Tableau Comparatif,* introduction, p. 1.

[2] *Op. cit.,* p. xvii.

[3] Paris, 1817; xvi, xxii and 253 pp., 3 plates.

our riches," there was but little positive knowledge of them. Of this he says:

"The idea that what has been offered them as an Oriental ruby is really one of those eagerly-sought stones which occupy the first rank after the diamond, is a satisfaction that they only enjoy on the bare word of the dealer. I have therefore thought that they would gladly assure themselves, by decisive tests, of the authenticity of an object which had cost them a sum proportionate to their appreciation of it, and learn whether the name under which they had acquired it was really that to which its characteristics entitled it."

It is interesting to learn that the completion of this treatise was hastened by the impression a perusal of the unfinished manuscript produced upon the great English banker and gem-collector, Henry Philip Hope, while he was on a visit to Paris. Haüy adds that as a testimony of his appreciation, Hope generously donated to the scientist's collection a number of rare specimens which were lacking, their place being but poorly supplied by analogous material not possessing all their characteristics. Hope also took occasion to supply himself with the mechanical instruments necessary to prove experimentally the existence of the several properties of the gem-stones.

One of the earliest records of Haüy's crystallographic investigations is the *Mémoire* on the structure of feldspar crystals, read by him before the Académie Royale des Sciences, June 26, 1784. In it he notes that M. Demarest, a member of the Académie, had brought back from his travels, in 1770, specimens of two very interesting varieties of feldspar, one of which he had found among the lavas of Auvergne and the other in the province of Limousin. He deposited in the Cabinet du Roi an especially fine specimen of the latter variety, which was a six-faced prism. The first variety was also of prismatic form, but with ten faces. Haüy describes these crystals exhaustively in his *Mémoire*, treating them as secondary forms of feldspar. Combined with the examples described by Padre Pini, professor of natural history in Milan, in a paper published in 1779, Haüy found that they constituted one of the most complete series of crystal forms that had yet been observed. He adds:

"Besides the fact that feldspar crystals already merit the attention of naturalists for the reason that they are forms of one of the most interesting substances in the mineral kingdom, I have also been incited to communicate my observations to the Académie, on account of the new proofs they appear to furnish me of the principles I enunciated in the outline of a theory regarding crystals, published toward the end of the year 1783. I have not yet seen feldspar in its simple primitive form, freed from all accidental faces. This form would be that of a quadrilateral prism."

The characteristic letters of Haüy here added give an excellent idea of his quality of mind, of the grace of his style and of his urbanity. The longer one is translated from a facsimile reproduction in *Isographie des Hommes Célèbres* (Paris, 1843), the material for which was assembled by T. Delarue.

Paris, September 8, 1807

Sir: It would be difficult for me to recall a visit which has given me greater cause to feel flattered at having received it, than that of Mr. Nass. It combined the advantage of becoming acquainted with a very distinguished savant and the lively satisfaction of receiving from you a very precious gift accompanied with an exceedingly kind letter. Your crystals of arsenical cobalt offer a variety lacking in my collection, of which they now form one of the finest ornaments. I finished, a few days ago, my public course of lectures on mineralogy, and I hasten to fulfill the promise I made you to send you an article for the second volume of your excellent manual. It is an epitome of what is new in my lectures relative to the science of which they treated. I add it to my letter, begging you, Sir, to make all the changes and modifications you may judge proper. I speak of myself in the third person, because I have thought it might perhaps be better that the article should be considered to have been communicated to you by one of those who assisted at my course. I could have written at greater length, had I not feared to exceed the limits. I will add here, for yourself alone, a résumé of the observations I have made on a letter written anonymously to M. Berthollet, and which you have doubtless read in the *Journal de Physique*, July, 1807, vol. VI. The writer seems to have failed to grasp the method I employ in the determination of mineral species. It is not only in the results of mechanical division, or of cleavage, that I make it consist, but also in the relations established by calculation between the dimensions of the primitive form indicated by the operations in question. Thus the cymophane, the apophillite (ichthyophthalmite), the peridot, the mésotype, etc., having been mechanically divided, give as the primitive form a rectangular parallelopiped. On the other hand the phosphate of lime, the sulfate of copper, etc., give hexagonal prisms, such as are determined by the laws of decrescence which produce their secondary forms, varying from one species to another; and it is above all this variation that, in my method, serves to trace the lines of demarcation which sharply separate the bodies I take as types of species. *A fortiori*, the same theory indicates the distinction of species whose primitive forms differ by the respective disposition of their faces. There results from this, in regard to each one of the species in question, a particular system of crystallization to which it is impossible, without violating nature, to bring the varieties comprised in another species. All the subordinate divisions that can be conceived in the sense of diagonals of primitive forms, or in other directions (and in this connection the anonymous writer establishes rules by supposing a multitude of cleavages I have never seen), all these divisions, I repeat, will not become recognizable from the divisions proven to be unrecognizable by calculation. The writer's objections come a little late, since my system is complete from beginning to end, and I can demonstrate to anyone the application of my principles to each one of the species which compose it. I have believed that I ought to communicate these observations to my students, several of whom have already made them on their own account. However, I have never made a printed reply to any objections which have been raised against me; when they seemed to me to be well founded, I accepted the correction. I recall that a famous savant, having composed an answer to an attack directed against him, read it to Daubenton, saying to him, "Is this not victorious?" "Without doubt," replied Daubenton, "but you are going to have a war on your hands, and what victory is comparable to peace?" Daubenton was my master in mineralogy;

I have also taken him as my master in morality. Will you pardon me, Sir, for having entered into all these details with you? I beg you at least to look upon them as a witness of how highly I prize your esteem.

Accept the expression of my lively gratitude and that of the great respect with which I have the honor to be, Sir,

Your Very Humble
and Very Obedient Servant,
HAÜY

If you see fit, Sir, to make any changes in my article, I ask indulgence as to what I write of the arsenical cobalt. I would be flattered to be able to send you some small specimens from among my duplicates; but I should wish to know those which you lack, especially of the minerals of France.

PLATE 12.

Paris, ce 4 Sept. 1813.

Monsieur.

Le plaisir que m'a causé la lecture des vers aussi élégans qu'harmonieux que vous avez eu la bonté de m'adresser, me prouve que l'étude de la minéralogie ne m'a point fait oublier les beautés de Virgile et d'Horace, que j'ai passé vingt années de ma vie à développer. La peinture que vous faites des résultats de mes travaux en Histoire Naturelle annonce de votre part cette indulgence qui est la compagne ordinaire d'un grand mérite. Mais, je me ferois tort à moi-même, si je désavouois l'idée avantageuse que vous me paroissez, Monsieur, avoir conçue de moi, sous le rapport des qualités morales, surtout dans un moment où je me sens sollicité si vivement par la reconnoissance. Agréez l'hommage de celle que je vous ai vouée à si juste titre, et permettez moi d'y joindre l'assurance de la considération très-distinguée avec laquelle j'ai l'honneur d'être,

Monsieur,

Votre très humble
et très obéissant
serviteur Haüy

à Monsieur Marron.

GEO. F. KUNZ OWNER

LETTER OF HAÜY TO MONSIEUR MARRON, AND NOTE TO DR. COGSWELL; reduced.

à Monsieur Kogswell,
hommage de la reconnoissance
et du respectueux attachement
de l'auteur.

PARIS, Sept. 4, 1813

Sir: The pleasure caused me by the reading of the verses, as elegant as they are harmonious, which you have the goodness to address to me, proves to me that the study of mineralogy has not made me forget the beauties of Virgil and of Horace, which I have passed twenty years of my life in cultivating. The picture that you draw of the results of my work in Natural History, testifies on your part to that indulgence which is the usual associate of great merit. But I would be doing myself a wrong if I should disavow the good opinion you seem to me, Sir, to have formed of me in the matter of moral qualities, above all at a time when I feel myself so powerfully moved by gratitude. Accept the homage of that which I have so justly dedicated to you, and permit me to join with it the assurance of the very distinguished regard with which I have the honor to be

Sir
Your Very Humble and
Very Obedient Servant

HAÜY

To Monsieur Marron.

A copy of one of Haüy's writings, now in the New York Public Library, an offprint of his memoir *Des surfaces vibrantes,* bears on the title leaf an autograph presentation by the author to "Monsieur Kogswell." This was Dr. Joseph G. Cogswell, the first Superintendent of the Astor Library, who visited Paris in 1819, during his three years' residence in Europe.[1]

[1] *Bull. N. Y. Public Library,* 22 (3), p. 204, March, 1918.

I have the honor, my dear sir, of sending you a synopsis for the *Journal Encyclopédique*, with a few words for the authors of this publication. I beg you to be so kind as to enclose these two papers in an envelope and to send them to the gentlemen in question, with a copy of the work. Would you also be so kind as to announce it in the *Gazette*, and on the public posters. I charge myself with the *Journal de Paris*, the *Mercure*, the *Année Littéraire*, the *Journal de Monsieur*, the *Annonces* of the Abbé de Fonsenai [?], the *Journal des Savans*, and the law journal of M. Buchoz. The binder whom I saw this morning has promised me, for Sunday, my eighty copies, from which I shall make my presentations.

I have the honor of being, sir,
With the highest regard,
Your very humble and
Obedient servant
HAÜY

December 9th
(Collection Berard)

j'ai l'honneur, Monsieur, de vous envoyer
une analyse pour le journal encyclopedique,
avec un petit mot pour messieurs les
auteurs de ce journal. je vous prie de
vouloir mettre ces deux papiers sous
enveloppe, et de les leur faire parvenir
avec un exemplaire de l'ouvrage.
voudriés vous bien aussi le faire annoncer
dans la gazette et dans les petites
affiches. je me charge du journal de
Paris, du mercure, de l'année litteraire,
du journal de monsieur, des annonces
de m. l'abbé de Fontenai, du journal
des savans et de la feuille periodique
de m Buchoz. Le Relieur que j'ai vû
ce matin m'a promis pour Dimanche
mes quatrevingt exemplaires, sur lesquels
je ferai mes liberalités

j'ai l'honneur d'etre avec la
plus parfaite consideration,

Monsieur

votre très humble
et très obeissant
serviteur
Haüy

ce 9 Dec.

à M. Barrois Libraire

Collon de Mr Béraud.

LETTER OF HAÜY, dated December 9, announcing that he sends a notice of his latest work for the "Journal Encyclopedique." To M. Barrois, Libraire.

Among the many titles and honors bestowed upon Haüy, the following is a list of the principal ones:

Member of the Institut National (Académie des Sciences); Honorary Canon of the Église Métropolitain de Paris (Notre Dame); Professor of Mineralogy at the Muséum d'Histoire Naturelle; Professor of Mineralogy in the Faculty of Sciences of the Université Royale; Member of the Académie Royale des Sciences of Berlin and of the Société des Scrutateurs de la Nature (Naturforscher) in the same place; Member of the Imperial Academy of Sciences of St. Petersburg; of the Royal Academies of Sciences of Lisbon and of Munich; of the Imperial University of Vilna; of the Geological Society of London; of the Mineralogical Society of Jena; of the Société Italienne des Sciences; of the Société des Sciences de Haarlem, etc. Officer of the Légion d'Honneur and Chevalier of the Order of St. Michael, of Bavaria.

Bibliography of Haüy's writings.

Essai d'un théorie sur la structure des cristaux, Paris, 1784.

Exposition raisonnée de la théorie de l'électricité et du magnétisme, d'après les principes d'Æpinus, Paris, 1787.

De la structure considérée comme caractère distinctif des minéraux, Paris, 1793.

Exposition de la théorie de la structure des cristaux, Paris, 1793.

Extrait d'un traité élémentaire de minéralogie, Paris, 1797.

Traité de minéralogie, 4 vols., Paris, 1801; 2d ed. in 1822.

Traité élémentaire de physique, 2 vols., Paris, 1803; 2d ed. in 1806; 3d in 1821.

Tableau comparatif des résultats de la cristallographie, et de l'analyse chimique relativement à la classification des minéraux, Paris, 1809.

Traité des pierres précieuses, Paris, 1817.

Traité de cristallographie, 2 vols., Paris, 1822.

Sur l'alumine fluatée (*Journ. phys.*, **49**, 1799).

Sur l'électricité de l'apatite (*Journ. Min.*, **2**, 1796).

Sur les services rendus a là science minéralogique de Romé de l'Isle (*Journ. Min.*, **4**, 1796).

Sur la forme des stalactites (*Journ. Min.*, **4**, 1796).

Distribution et nomenclature des substances dont l'étude est du ressort de la géologie (*Journ. Min.*, **6**, 1797).

Sur la mesure des angles des cristaux (*Ann. Min.* [1], **3**, 1818).

Sur le pyroxène analogique (*Ann. Min.* [1], **4**, 1819).

Sur la structure des cristaux de mercure sulfuré (*Ann chim. phys.*, **8**, 1818).

Sur l'électricité des minéraux (Ann. chim. phys., **8**, 1818).

[The following are not in Royal Society list.]

Obs. sur les schörl (*Mém. de la Académie royal des science*, 1784).

Sur la structure des cristaux de feldspath (*Mem. Par.*, 1785).

Sur la structure de diverses cristaux metalliques (*Mem. Par.*, 1785).
Sur la structure du cristal de roche (*Mem. Par.*, 1786).
Sur la structure des cristaux de schörl (*Mem. Par.*, 1787).
Mémoire où l'on expose les problèmes relatifs à la structure des cristaux (*Mem. Par.*, 1788).
Sur la double réfraction du spath d'islande (*Mem. Par.*, 1788).
Sur la manière de ramener à la théorie du parallélipipède celle de toutes les autres formes primitives des cristaux (*Mem. Par.*, 1789).
Sur la structure des cristaux de grenat (*Journ. phys.*, **19**, 1782).
Sur la structure des spaths calcaires (*Journ. phys.*, **20**, 1782).
Sur le spath adamantine (*Journ. phys.*, **30**, 1787).
De l'électricité du spath boracique (*Journ. phys.*, **38**, 1791).
Sur les aimants naturels (*Journ. phys.*, **45**, 1794).

Biographies of Haüy

Cuvier, Georges, baron. Éloge historique de M. Haüy, prononcé dans la séance publique de l'Académie royale des sciences, le 2 juin 1823. (*Académie royale des sciences de l'Institut de France*, **8**, pp. cxliv-clxxviii, Paris, 1829).
—— Biographical notice of Haüy. (*Am. J. Sci.* [1], **8**, 362–371. 1824). Translated and abridged by John Griscom.
—— Memoir of Haüy. Translated for the Smithsonian Institution by C. A. Alexander. (Smiths. Inst. Ann. Rept., **1860**, 376–392. 1861).
—— Éloge historique de René-Just Haüy. (In his: *Éloges historiques*, 247–283, Paris [1860]).
Delafosse et Durozoir. L'Abbé Réné-Just Haüy. (In: *Biographie universelle, ancienne et moderne.* Supplement, **66**, 551–563, Paris, 1839).

Portraits of Haüy

Biographie nouvelle des contemporains. Paris, 1823. **9**, pl. opp. p. 74. Bust port., with star of Legion of Honor. In outline.
Cap, Le Muséum d'Histoire Naturelle. Paris, 1854. Pl. opp. p. 71. Head, facing left. From medal. Engr. by A. Feart.
Lucas, Tableau methodique des espèces minérales. Part 1. Paris, 1806. Frontispiece. Facing left and partly front. Portrayed in the act of measuring the angle of a crystal of calcite. "Traduit du dessin de F. Massard."
Leonhard, Taschenbuch für die gesammte Mineralogie. **3**. Frankfurt am Main, 1809. Frontispiece. Evidently copied from the frontispiece in Lucas, without the crystal.
Société Montyon et Franklin. Portraits et histoire des hommes utiles. Paris, 1833–41. In v. **2**, pl. 47. [Not seen; not in New York Publ. Libr.]

AN OUTLINE OF THE LIFE OF RENÉ-JUST HAÜY

GEORGE F. BLACK
New York Public Library

René-Just Haüy, commonly known as the Abbé Haüy, from his having been an honorary canon of Notre Dame, was born at Saint-Just, a small market town in the department of the Oise, on the 28th of February, 1743. His parents were poor, his father being a humble weaver. The boy's love of singing and music was the means of drawing attention to him in his native town. On the advice of a Premonstratensian prior his mother took him to Paris, where the kindness of friends enabled young Haüy to secure the post of chorister in a church of the quarter Saint-Antoine. The interest of his patrons later secured for him a scholarship in the college of Navarre, where he studied simultaneously the ancient languages and the sciences, particularly physics. His industry and good conduct at the college gained him further notice, and he received the appointment of mastership of the fourth class in Latin in his twenty-first year. Some time later he was transferred to the college of Cardinal Lemoine in a similar but higher capacity.

At this college Haüy became the friend and companion of Charles François L'Homond or Lhomond, one of the regents and a distinguished botanist. This friendship led Haüy to take up the study of botany, in which he obtained considerable proficiency. The pursuit of this study necessitated frequent visits to the *Jardin du Roi* (now the *Jardin des Plantes.*) On one of these visits he was led to attend a lecture on mineralogy by Daubenton, where, as Cuvier says, "he unexpectedly found himself in the presence of a new object of study, more congenial to his first taste for physics than even that of plants."

Happening to let fall a beautiful specimen of calcite belonging to a friend, M. De France du Croisset, he was led by examination of the fragments to the geometrical law of crystallization associated with his name. The conformity of the superposed layers of crystalline matter with the planes of the central polyhedron had revealed to him the secret of their development, and caused him to cry out "*Tout est trouvé*" (all is found). He was the first to show that the structure of crystals is regulated by invariable laws, thus putting the study of crystallography on a scientific basis. "From the moment," says Sir John Herschel, "that the genius of Haüy discovered the general fact that they could be cloven or split in such directions as to lay bare their peculiar primitive or fundamental forms, from that moment mineralogy ceased to be an unmeaning list of names, a mere laborious cataloging of stones and rubbish."

The value of his discovery, the mathematical theory of which is given by Haüy in his *Traité de minéralogie*, was immediately recognized by Daubenton and Laplace, and on their advice it was communicated to the French Academy in November, 1783, and published in the following year under the title: *Essai d'un théorie sur la structure des cristaux, appliquée a plusieurs genres de substances crystallisées.*

Haüy also greatly increased our knowledge of pyro-electricity by his work on the "*Théorie de l'électricité et du magnétisme, d'apres les principes de M. Aepinus,*" published in 1787. When the Revolution broke out in 1792 Haüy was thrown into prison for refusing to take the required oath, and for a time his life was in danger. From this peril he was saved by the intercession of his friend and pupil Étienne Geoffroy Saint-Hilaire, and the remark of a citizen, that "it were better to spare a recusant priest, than to put to death a quiet man of letters."

In 1794 the Convention appointed him keeper of the cabinet of the School of Mines, and it was in this capacity that he prepared his principal work, *Traité de minéralogie,* published in four volumes in 1801. (An *Extrait* of this work had appeared in 1797.) In 1802, under Napoleon, he became professor of mineralogy in the Museum of Natural History, and in the following year, at the request of the government, he prepared his *Traité élémentaire de physique,* a work which passed thru three editions during the author's lifetime. Many honors were showered upon him by the rulers of different European states, but amidst all he preserved the modest simplicity which had distinguished his early life. By the government of the Restoration he was deprived of his appointments and pension, and his latter days were in consequence clouded by poverty. The strong courage and high moral qualities which had helped him in his youth did not desert him in his old age, and he lived cheerful and respected till his death in Paris, from the result of a fall, on June third, 1822.

RENÉ-JUST HAÜY AND HIS INFLUENCE

HERBERT P. WHITLOCK

New York State Museum

Reviewing the history of the modern sciences it appears to us remarkable that in so many instances the person of one individual assembles the scattered observations and deductions of his predecessors, unifies and crystallizes the thought of his epoch and gives to his special branch of learning that impetus which, kindling at the fire of his genius, lights his successors along the way to modern scientific attainment. Thus, we speak of Newton as the father of mechanical physics; of Cuvier as the originator of comparative zoölogy and of Linnæus as the founder of biological classification. The year 1743, to which we direct our attention on this, its 175th anniversary, was remarkable in that it saw the birth, in France, of two such intellectual giants—Lavoisier and Haüy.

It is not without significance that modern mineralogy, based as it is on chemistry and crystallography, should, by a mere coincidence, be heralded into existence by these twins of genius. It is not without significance that, caught in the whirlwind of the Revolution, they should have together endured imprisonment. To what heights the mind of Lavoisier would have attained had his life been spared, we of course have no means of estimating. Suffice it, however, that the Abbé Haüy emerged from that supreme experience as one of the most profound analytical thinkers of two centuries.

René-Just Haüy, honorary canon of Notre Dame, member of the French Academy, creator of the science of crystallography, was born on the 28th of February, 1743, in the village of St. Just, about 70 kilometers north of Paris and directly on that now historic line which marks the limit of the German drive of 1914. As a child Haüy early showed a marked taste for church music, which trait, coupled with his interest in religious ceremonies, attracted the attention of the prior of an abbey at Prémontres; perceiving his aptitude and intelligence, the latter arranged to have him instructed by some of the monks. His progress was such that his instructors prevailed upon his mother to spare enough from her meager livelihood to enable him to go to Paris in search of ampler educational advantages. In Paris, Haüy was forced to earn his living as a choir boy and became a good musician on the violin and harpsichord. "This employment," said he with some naïveté, "has at least this agreeable quality, that it does not permit me to bury my talent for music." Meanwhile his patrons were not idle, and before long Haüy received a scholarship in the College of Navarre which enabled him to pursue his education in the classics. At Navarre, application and intelligence advanced him from the rôle of student to that of instructor, the gift of teaching which so distinguished his career being thus early recognized and fostered. Here, under M. Brisson, he developed a taste for physical experiments, particularly those relating to electricity. Shortly after attaining his majority and with it his clerical degrees he entered a broader field of study and teaching at the College of Cardinal Lemoine in Paris.

Among his colleagues at Paris was numbered Lhomond, the grammarian, whose passion for botany gave to Haüy his first insight into the realm of natural science, and by directing his attention to the symmetries of plant life paved the way to those more intricate and beautiful symmetries of crystallization which were to render his name renowned. By a happy accident the Jardin du Roi adjoined the college and proved a favorite scene of the botanical walks of Haüy and his "chosen companion and director of conscience." Thence it was that, noticing on one occasion the crowd of students entering the class in mineralogy conducted by Daubenton, he entered with them and found the real goal of his scientific aspiration, the study to which he was to devote his life. Coming to this new world of inorganic shapes, complex and yet regular, fresh from the contemplation of the geometrical symmetry of the forms of plant life, Haüy was struck with the apparent lack of orderly arrangement where his scientific instinct had told him order must be. How, he reasoned, can the same stone, the same salt, reveal itself in cubes, in prisms, in points, without changing its composition to the extent of a single atom, while the rose has always the same petals, the acorn the same curve, the cedar the same relative height and the same development?

To what extent can we assume that the Abbé Haüy owed his great discovery to an accident? Such accidents are only the guiding threads held out by the hand of Opportunity. We know that in the house of his friend, M. Defrance, Haüy dropped the now historic group of prismatic crystals of calcite and gathered from the ruin of a fine specimen the cleavage pieces to him recognizable as of the same form as other crystals of calcite; it thus appears that he had inevitably thrust upon him the key to the mystery of the mathematical inter-relation of these forms. But without a mind prepared to interpret this chance occurrence, without the imagination reaching out to its interpretation, the incident would have meant no more to him than to his friend who stood beside him. Bergmann, altho unknown to Haüy, had had an almost identical incident called to his attention by his pupil Gahn, but had failed to fully realize its significance. Bergmann did not voice the cry, which on the lips of his illustrious successor has become historic, "*Tout est trouvé.*"

Returning to his cabinet, Haüy lost no time in verifying the principle which was thus revealed to him. Under his hammer were sacrificed successively a scalenohedral crystal of calcite of the form known as "dog tooth spar," and another of a low rhombohedral habit; in each case the primitive cleavage rhombohedron appeared among the fragments, as he expected that it would. With the idea of developing the "primitive form" from other species he ruthlessly attacked the other treasured specimens of his little collection and his sacrifice was fully justified by the results, for the cleavage fragments in many instances furnished him with the basis, significantly termed by him *le noyau*, upon which the complicatedly modified crystal combinations were, as it were, built up. He conceived the theory of modified forms, built up from the primitive by diminishing layers of crystal particles (*decroissements*), each successive layer having a definite relation to the preceding one and to the primitive nucleus.

But the Abbé Haüy had spent fifteen years of his life in teaching Latin and had, like so many of us, forgotten what little geometry he had acquired at the College of Navarre. He set himself assiduously but tranquilly to master enough mathematics to enable him to prove his law. In the introduction to his *Traité de Cristallographie* we find this illuminating paragraph which represents his experience during these days. He says:

"In the solution of analytical problems, the object of which is to represent the progress of nature, we are led by very rapid methods to results which are often overlooked and which now and then excite our surprise by the paradoxical form in which they are presented. But when, guided by simple reasoning, we return step by step over the course which was so quickly bridged by calculation, we end by perceiving the action of the principles which have given birth to these results."

The researches of the Abbé Haüy, communicated to his master in science, Daubenton, and thru him to Laplace, won for him in 1783 a place in the academy left vacant in the class of botany; and in 1788 he was ranked as associate in the class of natural history and mineralogy. Nor was it long before, armed with this new torch of truth, the science of mineralogy began at the hands of Haüy to undergo a rejuvenation; from the nebulous mineral group which up to that time had gone by the generic name of schorl, there emerged 14 well-defined species. The zeolites yielded 6 species, the garnets 4 and the zircons 5.

In 1784, having been in the service of the university twenty years, on the advice of his friend Lhomond, Haüy availed himself of the right to retire on a pension as emeritus professor and proceeded to devote himself to research.

A man of Spartan simplicity in his secular and religious life, it is said that he, thru ignorance of the formalities and etiquette of the Louvre, appeared at his first lecture before the court in a long ecclesiastical gown, doubtless grown shabby by much wear in his daily round of prayer and teaching.

The Revolution, by depriving him of his pension, further augmented the rigors of his life, but altho forced to earn his living, the placidity of his disposition and the simplicity of his tastes rendered him to an extent immune to the privations of this period of his life. Indeed so immersed was he in worship, labor and study, that it was with astonishment rather than fear that he received the delegation of citizens who came to arrest him. They demanded of him his firearms and he showed them the spark of an electric machine; they searched his papers and found only algebraic formulas. Nevertheless he was apprehended and lodged, together with all the other priests and regents of that part of Paris, in the Seminary of Saint Firmin, which had been turned into a prison. For Haüy it was but the exchange of an ecclesiastical for a secular cell. In the midst of his friends and brothers in religion he prevailed on his jailors to send for his cabinets of crystals and was soon again in the midst of his interrupted researches. And it was thus that his former pupil and colleague Geoffroy Saint Hilaire found him when, armed with the order for his release, he penetrated the prison, which had become in reality a retreat. Arriving late in the day, he was unable to persuade Haüy to exchange his tranquil incarceration for liberty until the following day, which was the 31st of August, just two days before that fatal 2d of September which, had it dawned upon the Abbé Haüy in prison, would have inevitably seen him mount the steps of the guillotine.

The unobtrusive and almost shrinking modesty which always characterized Haüy, together with his sober garb and peaceful bearing, must have preserved him from further outrage, for we do not hear of his being again molested; and later the Convention nominated him as one of the Commission of Weights and Measures (1793–1794). Under the Republic he was constituted Minister of Mines and prepared his great work, the *Traité de Minéralogie*, which was published in 1801. Of this Cuvier writes:

"He has made of mineralogy a science just as precise and just as methodical as astronomy. . . . In a word we may say that M. Haüy is to Werner and Romé de l'Isle what Newton was to Kepler and Copernicus."

One incident may be cited to illustrate his characteristic charity and lack of self-assertion. On the death of Daubenton in 1799, when, according to precedent, Dolomieu, his assistant, would have been named as a successor to the chair of mineralogy at the Museum of Natural History, it happened that Dolomieu had been arrested and held as a political prisoner in Sicily. Haüy, who was the obvious candidate for this honor, so urged the claims of his absent rival that thru sentiment rather than merit Dolomieu was given the chair; however, he never lived to fill it, his premature death in 1802 leaving the field free to his generous colleague, who was immediately elected to the professorship.

Haüy had never relinquished his studies in physics; indeed, he constantly drew upon his skill and knowledge as a physicist in his mineralogical researches. On being asked by the government, however, to prepare a treatise on Physics, to be used as a text book in the schools, he hesitated to undertake a task which would cause him to abandon even temporarily his chosen field. The Abbé Emery, the ancient superior of Saint Sulpice, advised him in these words:

"Do not hesitate; you would commit a grave mistake if you lost this occasion, in treating of nature, to speak of its Author."

"And do not forget," he added, "to take on the title page your title of Metropolitan Canon."

The Treatise on Physics, like everything else from the pen of Haüy, is a model of purity of thought and clarity of expression, to which sterling literary qualities his natural love of teaching has added a charm of interest calculated to inspire the young students with his own love of the natural sciences.

The closing years of his life were marked by another reversal of fortune, when under the Restoration he was deprived of his pension and honors. But no administration, no political reversal, could take from him the fame which he had earned or the satisfaction of a life well spent in the elevation of the science which he loved. Cuvier has given us a striking picture of the true greatness of the unassuming Abbé of Revolutionary France —sought out by every visitor of distinction who entered Paris, yet never inaccessible to the poorest and humblest student. He never changed the hours of his meager meals, of his rising and retiring, day by day he took the same exercise, he traversed the same streets, losing no opportunity to show the small kindnesses and courtesies which so distinguished him, directing strangers whom he found embarrassed by the intricacies of Paris, and distributing to them cards of admission to the collections. On his occasional visits to his native village none of his ancient neighbors could detect by his manner that he had in Paris become a person of distinction.

His death was hastened by a fall which fractured the crown of his thigh bone and resulted in a painful abscess. Despite his condition he labored to the end on a new edition of his *Traité de Minéralogie,* which appeared in 1823, a year after his death.

Such was the man whose name we honor today. As to his influence, no one of us who has dipped more than casually into the wonderful science of crystallography has failed to have felt it. Beginning with that admirable mineral species calcite, called by him the "Protheus" among minerals, from a meaningless chaos of unrelated forms he produced an ordered science. To any one who will consult the literature of mineralogy in the latter half of the eighteenth and the first half of the nineteenth centuries there will appear a well-marked line of distinction between the old and the new, between those who wrote before Haüy published his *Essai d'une théorie sur la structure des cristaux* and those who succeeded him and profited by his teachings.

William Phillips writing in 1823 says:

"The labors of the Abbé Haüy have shed over mineralogy a purely philosophical luster which indeed has been one of the chief causes of raising the study to the rank of a science; this he has done by showing the consonance of the laws of crystallization with rigid calculation: he has proved that in crystallization there is a *natural geometry.*"

It was as tho he took as his motto the inspired words of Guglielmini, uttered nearly a century before the publication of his *Traité de Minéralogie:*

"Crystallization is a curious and wonderful operation of Nature's geometry, and therefore worthy of being investigated with all the genius of man and with the whole energy of the mind, not because of the pleasure which always attends the knowledge of wonders, but because of its great usefulness in natural science; for Nature here as it were discloses herself, and having cast aside every veil, permits us to behold not merely the results of her operation, but the very processes themselves."

The century and three quarters since the birth of Haüy has been marked by many crystallographic milestones. Deep cut on the cornice of this Hall of Fame are the names of Weiss and Naumann, of Miller, Mohs and Zippe; of Haidinger, Dana, Vom Rath and Goldschmidt; high priests of the altar of mathematical crystallography, the fire of which was first kindled by that other priest whose name we honor today. And beside these names I read the names of those others no less illustrious, Bravais, Sohncke, Schönflies, Fedorov, Barlow, Tutton and last and greatest the elder and the younger Bragg.

Just as in the Mont Cenis tunnel the engineers of France and Italy could hear each other's blows from the other side of the barrier of rock, so today the advance guard of workers in organic and inorganic sciences seem to hear rumors from the other side of that wall of the unknown which hides the origin of life. Who can say but that when the future has yielded up that supreme secret, biologist and crystallographer may not reëcho the words of Haüy: "*Tout est trouvé.*"

PLATE 14.

TRAITÉ
DE
MINÉRALOGIE,

PAR LE C^{EN}. HAÜY,

Membre de l'Institut National des Sciences et Arts, et Conservateur des Collections minéralogiques de l'École des Mines.

PUBLIÉ PAR LE CONSEIL DES MINES.

En cinq volumes, dont un contient 86 planches.

TOME PREMIER.

DE L'IMPRIMERIE DE DELANCE.

A PARIS,

CHEZ LOUIS, LIBRAIRE, RUE DE SAVOYE, N°. 12.

(X) 1801.

TITLE PAGE OF THE FIRST EDITION (4 volumes) of the Traité de Minéralogie by Abbe Haüy.

HAÜY'S TRAITÉ DE MINÉRALOGIE

BY THE LATE LOUIS POPE GRATACAP

René-Just Haüy became a distinct intellectual phenomenon when he dropped botany and adopted mineralogy. It might perhaps be cynically suggested, by some, that Haüy's retreat from the ministry was the initial step in his intellectual promotion. The broken calcite crystal, which lay at his feet, revealed to a very keen mind an interpretation of mineral forms that embodied, if not exactly the deepest truth, such a very considerable portion of crystallographic precision, as to ensure mineralogy's development upon mathematical principles. A crystallized calcite fragment slipped from the observer's hand and was sundered into cleavage pieces, which were rhombohedrons. A moment's hesitating inspection, and soon the observer, now become an experimenter, was engaged in slicing the rhombohedrons into smaller ones. The process continued, under the excitement of an illuminating suspicion, and, as in the progressive subdivision, the endless rhombohedrons sprang repetitively into view, the suspicion became a conviction, and the formative theory of *molécules intégrantes*—irreducible nuclei—was born. And a structure of geometrical symmetry, built up by ultimate and equivalent particles, ushered in at once the conception of the "*law of equal numbers.*"

From this foundation, guided by an already well-stored memory, knowledge of contemporaneous research, and access to the cabinet of the École des Mines, Haüy industriously prosecuted his studies, arranged his facts, and offered to the scientific world a formulation of mineral science, which took the shape of the *Traité de Minéralogie*, a work in four volumes, with an Atlas of plates, published in 1801, and which far superseded any previous attempt to create a mineralogical system. It is a work of comprehensive insight, and much of it, written with literary fluency, repays to-day the casual curiosity of the antiquarian, while more appropriately enlisting the admiration and sympathy of the mineralogist.

It seems an adequate response to the expectations connected with this 175th anniversary of the great Abbé's birth, to turn over the pages of this masterpiece, and disclose to those, un-familiar with its contents, some phases or aspects of its method and its style. The treatment is rather diffuse, but all the more interesting from its detailed amplification, and the personal intimacy of its confessions and reflections. The work opens with a Preliminary Discourse which assumes the character of a literary dissertation, generally philosophic, frequently eloquent, and always dignified and learned. Our author first approaches his theme with some comparisons—rather deprecatingly drawn—between the obvious charms of zoology and botany, with their living subjects of study, and the "larger part of minerals, concealed in the recesses of the earth, emerging in a pile of debris, and carrying the marks of violence from the tools which drag them out of their beds, and seeming, to the ordinary man, dull masses, without expression, without language, and created solely to be appropriated to our needs."

The next paragraph cumulatively displays the profundities and mysteries of mineral science heaping up, as it were, in a phalanx of claims its various aspects of interest. "The polyhedral forms of which it might seem a directing hand had shaped the outlines and angles, with the assistance of a compass; the variations that these forms undergo in the same substance, without losing their regularity, and offering, by means of exact calculation, a revelation of the nature of the Proteus concealed beneath their metamorphoses; the confirmation of experiments, concurring with the features which appeal to the eye, to disclose properties otherwise unnoticed; the principles of Archimedes applied to the relations of weight and volume; the refractive power made use of to separate substances, thru which the image of an object appears single, and those which astonish our inspection by forming two; the application of heat, replacing friction, to develop electric poles, in a body whose crystal shape, by its special modifications, indicates beforehand the position of the same poles; the natural magnetism inhering in some minerals, revealing iron; the various chemical agents furnishing means to dispel the doubts that other tests have failed to allay; the resources secured by analysis for the further elaboration of chemical knowledge; all unite to make mineralogy a science worthy of reception among spirits naturally susceptible to the charm of precise research, inclined towards those studies which present the most intellectual problems, and show us a group of facts most inseparable thru their mutual unions." The modern treatise on mineralogy would hardly venture into these fields of embellishment; such a treatment belongs to ages of genial dogmatism.

Haüy notes the easy separation of natural substances into stones (*pierres*), salts, bitumens, and metals, the quick recognition of crystals, the artificial and purely empirical classification of minerals, by their external characters, combined with a few simple reactions, as the effervescing of carbonates, the later more scientific systems of Cronstedt, Bergmann, Born, Kirwan, etc., when analysis usurped the place of mere inspection. He emphasizes, as he proceeds, the importance of distinguishing varieties, as in calcite, a conviction inordinately incorporated in his description of that mineral. He illustrates the value of analysis in alluding to the mineral smithsonite (old style, calamine), which at first was regarded as a zeolite, later as heavy spar, and shown conclusively by the chemist to be a salt of zinc.

He concludes: "We see by what precedes, that chemistry and mineralogy concur necessarily in the construction of a method—whatever it may be—which has for its object the classification of inorganic substances; and that it is chemistry which lays the foundations of such a classification by its separation of species." But in geometry we procure direct assistance for the interpretation of those "pure jewels of nature" which are known as crystals. Haüy here touches the nucleal thought of his mineralogical speculations *les molécules intégrantes*, "of which the faces are to be regarded as natural joints, indicated by the mechanical division of these crystals, and of which the angles and the dimensions respectively are determined by calculation, aided by ocular inspection." These nucleal molecules, relative to different species, exhibit between themselves more or less well-marked differences, except in a few instances, where the regular character of the forms offer points of contact between certain species, or—as we would say to-day—distinguish minerals belonging to the same system.

Haüy then says: "It follows from all this, that the determination of the nucleal molecules must have a great influence upon the definition of species, and this consideration has led me—more than once—either to subdivide into many species a group, formerly united into one, or to bring together the scattered members of a single species, of which custom has made many distinct species." These distinctions he further says—and not without conscious elation—have been confirmed by chemical analysis, while he seems willing to believe that under the guidance of this principle of ultimate crystallographic reduction, species may be determined whose systemic relations would only remain to be fixed by chemical research. The purpose of his Treatise is then fully enunciated: "The principal purpose of the Treatise is the exposition and the development of a method founded upon certain principles, and which may serve as a frame to enclose all the facts offered by mineralogy, assisted by the different sciences which lend their hand to it, and advance with it on the same path. It is the gathering together of all the known minerals, under one point of view, to compare them with each other, to study their characters, and to question both experience and theory upon the different reactions (*phenomênes*) of which they are susceptible. All the information that can furnish to the student the double assistance of being guided and illuminated in his advance, will be employed; confirming the thought that a science is made up of all of those facts which are needed for the deepest penetration of its subject."

With reference to one modern method of classification, that of field association, our author's words, of course utterly unrelated to any criticism, are of interest, when he writes: "In such a treatise we have minerals brought together and arranged in a symmetrical order, whereas Nature leaping over, on all sides, these artificial limits, outlined by our method, separates what we unite, associates and confounds together what we have separated;" and this theme inspires our author to further enlargements, always in a vein of appropriate eloquence. He soon professes his adherence to the chemical method, and asks: "Where may we discover relations more intimate to bind together various mineral substances than those founded upon the existence of an identical principle (*constitution*), or discover differences between them more clearly cut than those which are conditioned upon the individual principles (*constitutions*) of each?" This comparison, he urges, "will then be the most exact and at the same time the most natural, and also the least arbitrary, if the means selected for its guidance is that which unveils for us the intimate composition and nature of each substance, which teaches us what it is in itself, rather than that which shows us only its associations, or, at most, its exterior features."

And then, restricting the compass of his work, he adds: "There are two problems to solve. The first consists in dividing and subdividing the totality of substances, reviewed in such a way that each may secure its correct position. This is classification. The second has for its object to furnish easy and adequate means of characterization, that the substance may be recognized wherever found, and its position in the system discovered." He then alludes to chemical research and what it has accomplished, instancing the chemical design to characterize genera of minerals by the acid element or radical within them, and species by the diversity of bases combined successively with the same acid. This method is discarded by Haüy and he selects the metallic base as a more significant datum of reference: "The metals have a character so remarkable, so speaking (*parlans*), that they have been chosen by common consent as the fixed points around which unite all the combinations of which they form a part." But, with an abbreviated recognition of the nature of a salt, he separates the combinations of the alkaline earths and of the alkalies, from the metallic compounds, and disposes of them in groups as salts, mentioning separately, however, metallic salts. These salts, thus arbitrarily restricted, comprise three orders, under the class title of Substances Acidiferous. The orders were: Substances Acidiferous Earthy; Substances Acidiferous Alkaline; Substances Acidiferous Alkaline-Earthy. A second class is formed of substances denominated Earthy which "have no acid in combination with the earths of which they are composed," and over the limitations and contents of this poorly defined section Haüy evidently is seriously disturbed. He hopes that mineral chemistry, as developed by Cronstedt, Bergmann, Klaproth, and Vauquelin, will continue to throw more and more desired light upon the minerals thus grouped together, albeit he feels constrained to observe that he has himself contributed to the improvement of this section in details, as "by a more exacting rearrangement of the substances constituting its species, and also by the care I have taken to call species only those minerals which really merit it, those having a type capable of a rigorous determination."

It is in this more or less ambiguously defined section that are found quartz, zircon, telésie (sapphire), cymophane (chrysoberyl), spinel, topaz, emerald, euclase, garnet, amphigene (leucite), the feldspars, the pyroxenes, the amphiboles, (schorl) and generally a confusion of silicates, with oxides and titanates, etc., whose elements were unquestionably by Haüy more carefully isolated and individualized, than had previously been the case. Their very technical separation under the more or less pedantic assumption of various silicic acids had not then, could not then, have been dreamed of. Haüy's third class was made up of combustible substances, as the diamond, sulfur, bitumens, and these again were composed of two orders, as *simple* and *compound* combustible substances.

The fourth class is made to embrace metallic compounds, with a metal as a generic symbol, and under it the species arranged consecutively as, first the native metal, and then its combinations "whether with another metal (as alloys), or with oxygen (oxides), or with combustibles (as sulfur), or with acids." And our author, in view of the consideration that he should present a distribution "conceived as to the essential nature of the things it concerns, at once symmetrical, and better fitted to appease our mentality and to impart order and a logical succession of ideas," reapportions the metals into orders, as they are fusible but not oxidizable by heat (gold, platinum); as oxidized upon heating but not at once fusible (lead, nickel) and those oxidized but not fused by heat (manganese, iron). The treatise closes with three appendices of which the first treats of "substances of which the nature is not yet sufficiently known to permit us to assign them a place in the system." Many of these our author explains are substances he has never possessed except in small amounts, but which, with scientific instinct, he asserts will yet take their proper place in the series. Others he insists demand prolonged chemical investigation. Here we encounter amianthus, aplome, aragonite, anhydrite, coccolite, diaspore, sepiolite, jade, koupholite (prehnite), lepidolite, tourmaline, the zeolites, and other familiar species, whose excellent descriptions as presented by Haüy afford to the modern reader, luxuriating in the affluence of present knowledge, most interesting diversion.

The second appendix is a contribution to lithology, with granite, schist, limestone, porphyry, argillite, serpentine, clay, breccia, conglomerate, oölite, and sandstone described, and introduced by an observation often repeated elsewhere, and always symptomatic of the striking philosophic tendency, in a scientific sense, of this master-mind toward precision: "A mineral system which pursues an ordered law, and submits to the control of fixed and ascertained principles, namely a true system, should only offer for our consideration substances which may be shaped into a series of unities distinctly detached from one another. I have attempted to construct such a series, starting from the idea that the nucleal molecules should be allowed the larger rôle in making specific distinctions. Yet this preconception is subordinated in practice to certain special considerations which, without doing violence to it, in a sense, constrain it to bend to the travail of nature."

Haüy mentions with undisguised admiration Werner's system of mineral identification, by means of a tabulation of minerals' physical qualities, alluding to it as a complete system, "where all the qualities of a mineral which affect our senses, all that there is in it, in such a way accessible to observation, is carefully discriminated; where all the indications which an attentive student can recognize are well formulated, forming in themselves a picture of each species." He inclines, however, to reject this, following a method of description wherein he establishes distinctive characters, those which are the most constant, the most closely linked with the constitution of the nucleal molecules (*molécules intégrantes*). And his reflections, as if part of a soliloquy, take this form: "The picture of a species should offer first a summation of its characters, by which it may be determined; second its varieties, and, the specific characters being fixed points from which we derive an impression of the species, I shall exclude colors, at least in connection with earthy or acidiferous substances, as variable, fugitive, and foreign to the specific type, which is the nucleal molecule.

"I will mention the specific gravity and the hardness of the mineral. I will not omit the property of double or single refraction, as that inheres in the very nature of the substance, altho not always easily observed. The luster shall be given, not as to its intensity, an attribute easily modified, but in relation to an aspect less easily altered, as such as are unctuous, nacreous, vitreous, etc. And according to conditions new characters shall be quoted associated with these, as electricity developed by heat, or phosphorescence by fire.

"I will above all aim to give precision to the character of a mineral's mechanical division, and in place of limiting myself to a general enumeration of its nature, if it occurs in several ways, I will add the value of the angles which the natural cleavages make between one another, and as these cleavages, being the first indices for the exact determination either of the primitive form or that of the nucleal molecule, it will be essential to indicate those forms the knowledge of which is so important to a correct conception of the species.

"Finally I will enumerate its reactions, with acids or with heat. It will then be necessary to consider its varieties, and at first those relative to *form*, as most important. Each shall have its name and description, and, if the form is the product of a regular crystallization, I will indicate it by symbols, composed of letters and exponents, indicating the laws of decrescence upon which it depends, and which, united to an exact figure, will furnish the best of all possible descriptions. I will add the respective inclinations of its faces determined by calculation, in which abides properly the imprint (*empreinte*) that a crystal carries of the species to which it belongs.

"Lastly the modifications of color, of transparency, will be included as the finishing shading (*nuances*) to the picture."

With these elements of identification fully drawn, Haüy unites in his system an enumeration of the principal localities of each species, an explanation of the different views held by authors as to its nature, with the addition of his own criticisms, and an elucidation of the manner by which its correct position was ascertained.

He also dwells upon any interesting physical property of the mineral, and, with a generosity of interest, scarcely permissible to-day, in the vastly more extended compass of mineral science, dwells upon the industrial uses of minerals, and even therapeutic values.

This outline of the method of the famous Traité reveals at once the scientific penetration of its author, and especially emphasizes his exacting attitude towards definition, and the rigor of an encompassing conception of the signs and essence of mineral specificity. It particularly too brings into view the province of crystallography with whose foundation Haüy is so clearly and closely associated, for at almost every angle of elucidation he reiterates the systemic force—the *vis fabricans*—of crystallographic constants. Let us now briefly inspect this fundamental hypothesis of his method.

Haüy seized upon the accidental hint revealed to him in a fractured calcite, that the ultimate components of crystals are irreducible initial formative nuclei (*molécules intégrantes*) whose addition upon each other in varying numbers constitute the mechanical constructive basis of a series of derivative crystals. He applies this hypothesis relentlessly to almost all of the mineral species described in his Traité, and may be said to most convincingly show its plausibility in the hexagonal and isometric systems, as illustrated in calcite, galena, pyrite, halite, fluorite, etc.

"Such then," he urges, "is the action of these laws [of attraction] upon the nucleal molecules (*molécules intégrantes*) that when uninterrupted the grouping of these compose plane surfaces, from which result the regular forms similar to those of geometrical solids. We possess frequent examples of this regularity in garnet, topaz, emerald, carbonate of lime, sulfate of baryta, etc., and in a great number of metallic substances.

"The contemplation of the polyhedrons always conjures surprise in those meeting them for the first time, and it is often necessary to show examples of these minerals covered with the native matrix to assure such that they are not artificial, and compel them to acknowledge the geometry of nature," a naïve allusion to the familiar incredulity, such as all collectors encounter in their uninformed mineralogical friends. Recalling his botanical studies, he speaks of a flower made up of elements, in each example equal in number, and similar in outline, with the parts always identically arranged, and with their variations limited to slight and fugitive shades, "so that we can say anyone who has seen one has seen the entire species."

"It is quite different," he continues, "with minerals. Frequently the crystals of the same substance assume very diverse forms, all equally sharply developed and outlined with equal precision. The carbonate of lime, for example, takes according to circumstances the form of a rhombohedron (*rhomboidé*), that of a regular hexagonal prism, that of a solid terminated by twelve scalenohedral triangles, that of a dodecahedron with pentagonal faces (rhombohedron and hexagonal prism), etc. The sulfide of iron or pyrite produces now cubes, now regular octahedrons, here dodecahedrons with pentagonal faces (pyritohedrons), there icosahedrons with triangular faces (pyritohedron and octahedron)."

Haüy indicates combinations of forms as phases of transition from one form to another, as a cube modified by octahedrons, while he calls the wondering attention of the student to "certain crystallographic forms which most remarkably conceal all indications of common elements and would indicate a complete metamorphosis of the mineral to which they belong. To illustrate with one example let one place by the side of a hexagonal prism of calcite the dodecahedron with scalene faces [scalenohedron], it would be difficult for any one to imagine how two polyhedrons, so contrasted at first inspection, should unite, and, so to speak, lose themselves, in the crystallization of the same mineral."

With this introduction he begins his Theory of the Structure of Crystals and, in a section of 115 pages, discusses in a manner quite unapproached at that time the crystallographic unity of series of faces, and the derivation of faces from each other; and he gathers within the voluminous and exacting scope of his inquiry the obedient services of mathematics.

His mechanical division of minerals enters the base of his system, and practically constitutes the platform of its superstructure. "This," he avers, "is the sole means of recognizing the true primitive form, and proves that this form is invariable in the same substance, however diversified, however contrasted may be the forms of the crystals belonging to that substance." Then he takes a hexagonal prism, and slicing alternate edges, above and below, develops an upper and lower rhombohedron, terminating a hexagonal prism (Haüy's "dodecahedron with pentagonal faces"). Continue removal of these cleavage plates, and the prism disappears, leaving a rhombohedron of which the vertical angle and its opposite is 101° 32′. This observation he properly maintains has developed his ideas on the structure of crystals, and has been the key to his theory. It was made upon a specimen shown to him by M. Defrance. A prism detached itself from the group with a fracture at its base by which it had adhered to the rest of the specimen. His exact language here may prove of interest: "instead of putting this specimen in my growing cabinet I determined to attempt its division differently, and, after some experiments, I succeeded in extracting the rhombohedral nucleus, which caused me much surprise, mingled with the hope of not being forced to stop at this first step."

His second example, illustrative of what might be descriptively called divisional crystallographic analysis, is the so-called *metastatique* crystal, or the scalenohedron, which Bergmann had already reduce to a nucleus. Slicing this on the equatorial edges as he describes (Plate I, Fig. 6) he obtained the primitive rhombohedron. He continues: "If it is remarkable to see this nucleus issue from varieties (of calcite) which are contrasted among themselves, by their configuration it might have been less anticipated to find it in crystals which are themselves rhombohedrons, but of different angles." He then instances five of these rhombohedrons, one more obtuse, and the rest more acute, than the nucleus, from all of which, however, he extracted the primitive crystal, with its angle of 101° 32′, and "thus," he triumphantly concludes, "the paradox born of the diversity of the angles is cleared up by the double employment of the rhombohedron, which here inserts itself in disguise, and conceals its fixed character under a variable exterior."

He attacks other minerals by his divisional analysis, and elicits from them formative nuclei, as the octahedron from fluorite, the rectangular prism with rhombic base from barite, a hexagonal prism from apatite, a cube from galena, " and each of these forms will be constant relatively to the entire species, in such a manner that the angles undergo no appreciable variation." And with respect to those crystals which cannot be subjected to such mechanical division, the theory, assisted by other indications developed by him further on, permits him to determine their primitive forms, at least with much probability. He thus achieves his definition: "the primitive form is a solid of a fixed outline, always involved symmetrically in all the crystals of the same species, and of which the faces follow the direction of the plates which compose the crystals."

He reduces his primitive forms to six, the parallelopipedon, the octahedron, the tetrahedron, the regular hexagonal prism, the dodecahedron with rhombic faces all equal and similar, and the dodecahedron with triangular faces, made up of two pyramids united at their bases.

The word *noyau* as used by Haüy is not necessarily the nucleal molecule, for which he designs the appellation *molécule intégrante*. It may be the last term of his mechanical subdivision, or it may not be. Thus he makes a tetrahedron the *molécule intégrante* of tourmaline, though the *noyau* might be a parallelopipedon. In apatite one may divide the crystal parallel to the side of a prism, but will finally reach a term which is a triangular prism, only, and that is the *molécule intégrante*. Refining his distinction he concludes that it is possible to reduce his *molécules intégrantes* to three, the tetrahedron or the most simple pyramid the trigonal prism or the most simple of all the prisms, and the parallelopipedon or the simplest of solids, with faces parallel to each other in pairs; in all a group of solids with four or five or six faces. "If these forms," he insists, "are not those of the real *molécules intégrantes* employed in nature, they deserve at least to take their places in our conception, as, with such a moderate expenditure of means we can establish a theory which includes so many contrasted cases."

Haüy yields to a rather elastic interpretation of his ultimate forms, giving them varying dimensions and angles, according as they subserve the purposes of one species or of another. The parallelopipedon could be oblique or rectangular; it could be the type of the calcite rhombohedron, or of the fluorite cube. All vary, according to the requirements made upon them, to form the crystal discussed. In building crystal forms, Haüy makes use of a regular decrescence or of a regular accrescence, from or to the primitive form, by the removal or addition in successive tiers of the *molécules intégrantes*, on all faces. Thus a nucleal cube concealed in the primitive form of a rhombic dodecahedron is revealed at once, by removing the six solid angles, and this can be easily conceived as practical by considering them built up of superimposed layers (*lames de superposition*), each layer consecutively widened, and made up of cubical *molécules intégrantes*, until by their successive removal the nucleal cube remains.

"Thus," he observes, denoting the enlarged figure of the regularly piled up small cubes, whose abstraction, in this orderly manner, reduces the rhombic dodecahedron to the cube, "if to this sort of rude masonry, appealing to the eye, we substitute in thought the infinitely delicate architecture of nature, we can conceive of the nucleus as being made up of an incomparably greater number of imperceptible cubes. The number of the superimposed layers will also be incomparably greater. As an inevitable result the furrows that these layers make, by the alternate prominence and retreat of their edges, will be imperceptible to our senses; thus takes place the growth of those polyhedrons which crystallization has leisurely elaborated, without being either hastened or disturbed in its progress."

Haüy then discusses at length processes of decrescence, as those in width and height, and visually, by means of figures, demonstrates the formation of the pyritohedron from the cube. The discussion here proceeds at some length, and cannot and need not be inserted here. The illustrations of the development of the calcite scalenohedron from the nucleal rhombohedron by diminishing additions of successional nuclei is clearly drawn. The argument becomes variously extended, and the diagrams of his Atlas accompanied by his commentary ingeniously adapts his fundamental thought by hypotheses as to the rate and manner of accretion, to explain the derivation of crystals of differing inclinations; and he establishes two processes of decrescence, that *sur les bords* (by edges) and *sur les angles* (by angles), and the latter serviceably meets the requirements of securing an octahedron with equilateral triangular faces from a cube. He observes "that the striations and furrows which roughen the faces of secondary crystals, where the process of nature has not attained the degree of finish and perfection of which it is susceptible, indicate frequently by their direction, those that follow the layers of superposition, and these accidents which, in mechanically divisible bodies, confirm the theory, permit us to interview the progress of crystallization, and the manner of superposition in those crystals which are incapable of such division, and thus assist us, by analogy, to divine the form and position of the nucleus, which escapes visual detection."

Haüy defines "mixed decrescences" and "intermediate decrescences," and distinguishes between simple secondary forms, or those developed by a single law of decrescence, and composite secondary forms, resulting from the action of many laws simultaneously effective. The theme assumes much complication, but is developed with skill under the guidance of geometrical premises. It must in this connection be fully understood that Haüy by decrescence did not necessarily mean a shrinkage in size, but a serial addition of *diminishing* superposition.

Finally, to complete this imperfect rendition of Haüy's voluminous treatment, it is important to call attention to his observations under the heading of "Difference between Structure and Accession." He here tells his readers that the steps of crystal development are not observed in nature, that the minutest crystal, having the same form, as perfectly developed as the largest, must be conceived of as enclosing already a minute nucleus, proportioned to its size, and enveloped in such a number of decrescent layers as are required for the growth of all of its faces. We never are permitted to see the intermediate steps of approach from the nucleus to its completed crystallographic end.

"It is necessary then," he concludes, "to conceive from the first instant a dodecahedral crystal, for instance, as a very small crystal, containing its cubic nucleus, appropriate to its minuteness, and that in the succeeding intervals this sort of embryo increases, without change of form, by new depositions around it, as *pari passu* the nucleus increases in its turn, always conserving an unchanged relation to the whole crystal." This singular hypothesis cannot readily be subjected to serious consideration. With painstaking assiduity the author demonstrates, at least pictorially, this barren supposition.

Haüy outlines his laws of crystallization; he summarizes for us, and very interestingly, his views of the process thru whose agency these iconic marvels have arisen. His language, always carefully adjusted to his purpose of definition, can be most acceptably quoted. "We conceive in general that the stony molecules or the metallic or others suspended in a liquid and disposed to unite in the formation of a crystal, are at the same time attracted towards each other and by the molecules even of the solution itself; and it is because their mutual affinity exceeds that of the solution that their combination operates. Now the attraction of the solution varies, and thus this variation, conjoined with the mutual attraction of the molecules, which remains constant, undergoes changes which exercise an influence upon the diversity of crystal forms. And furthermore if there are foreign substances dissolved, they will, in their turn, modify the action of the liquid upon the coalescing molecules. It would indeed appear as a proof of this, that in certain crystals of axinite, some are colored violet by manganese, and others green by chlorite. The former show additional faces not observed on the latter, which moreover is more regularly shaped, and has not a striated surface, as in the violet-tinted crystals.

"An excess of some of the essential principles would also have an influence upon the form of the crystal, in adding its particular value to that of the solution. For, we can scarcely doubt that there is a fixed proportion of elements in each mineral substance, which constitutes its true nature, so that what exceeds a given limit should be to that degree regarded as accidental and foreign." There are of course here intimations of many facts now clearly established in the retinue of phenomena accompanying crystallizing solutions.

In these introductory pages almost redundantly expanded and yet constantly stimulating, readable, and suggestive, a section describing twinned conditions in crystals is inserted. To one phase of these juxtapositions Haüy assigns the name of *hemi-trope*, and this in the body of his work he especially illustrates by spinel. He detects the twinned relation of staurolite crystals, and, with a noticeable *naïveté*, penetrated by the scientific insight of the philosopher, he remarks: "But altho in general the position of crystal groups may be infinitely varied, we find, upon a closer scrutiny, that they are subjected to certain laws analogous to structure, and that these crystals, in place of precipitating themselves tumultuously one upon the other, have, in a manner, prearranged their disposition." The intersection of crystals interests him, and the involution (*enfoncement*) of one crystal in another—"but which always have a plane of juncture, produced by decrescence, so that the two structures follow their regular development, each in its sphere, towards their common plane, which forms their respective limits."

Haüy advanced in all directions the technique of crystallography, and while his devices in applying signs to crystals have become quite obsolete, or are today unknown, his suggestions were animated by the true and abiding spirit of scientific inquiry and of systemic insight. The section of his work which is devoted to the Theory of the Laws which govern the structure of crystals, in its geometric discussion, displays the prestige of his mathematical accomplishments.

Under the heading of *La Crystallization Indeterminable*, he considers concretions, stalactites, incrustations, pseudomorphs, and thruout these pages the modern student will discover paragraphs of vivid description and attractive speculation. The section upon mineralogical methods might be aptly styled a mineralogical polemic. The discussion is profuse, the argumentation with analogies drawn from botany rather abstract, while the conclusions are neither pedantic nor futile, but practically operative to-day. His belligerency over feldspar in controverting the position taken by Kirwan has quite a modern asperity, and terminates in his definition of a mineral species, as "a collection of bodies of which the nucleal molecules are similar and composed of the same elements combined in the same proportions." Along by the side of many utterly obsolete distinctions, these pages evince the remarkable prescience of a strictly logical mind, imbued with an enthusiasm that increased with every added step its author takes into the profundities of his chosen field of investigation.

Take the section on Mineral Nomenclature; it readily excites admiration from the lucidity and reasonableness of its positions, and again distinguishes Haüy as a master systematist bringing order into the confusion of previous miscellaneous terminologies. In the Nomenclature of Crystals, again Haüy struggles to improve contemporaneous conditions, and his efforts throw an illuminating light upon the coördinating regulative efficacy of that later institution of the six systems, which, with the 32 classes of symmetry, at present receive the allegiance of mineralogists. We probably have done scant or imperfect justice to the variety of contents and the novelty of prediction and affirmation contained in the introductory chapters to the System itself of Haüy's great work, but under the limitations of space we could not have more generously embodied its results. It is certainly incumbent upon this *aperçu* to look further into some features, interesting to mineralogists, of the System itself.

Haüy's ardor for varietal separations on crystallographic grounds appears conspicuously in his treatment of calcite (*chaux carbonatée*), wherein he lists some fifty form varieties and names each one, all of them being simply different crystal forms and different combinations of crystal forms. These are well figured in his Atlas (Plates 23–28). Among these occurs naturally the *chaux carbonatée métastatique* which is a scalenohedron, *v* $(21\bar{3}1)$, denoted as a dodecahedron and which indicated to him a *métastase* or transposition of the angles between two faces of the nucleal rhombohedral molecule to the faces of the scalenohedron. The name survived a long time in mineralogical literature. Here are arranged the calcite *mixte*, the calcite *cuboïde*, calcite *unitaire*, calcite *binaire*, calcite *imitable*, calcite *contractée*. As an example of this tiresome partition take calcite *bibinaire*, which is a prism terminated by a scalenohedron and an obtuse rhombohedron. Haüy seems to revel in these form distinctions and met the nomenclatorial problem they created with consummate ease. The amorphous phases of calcite he also describes at some length and groups in this connection Saussure's dolomite, Kijnor's dolomite (*chaux carbonatée aluminifère*) of which the analysis records 1.40 per cent. of magnesia, de l'Isle's *mine de fer spathique* as *chaux carbonatée ferrifère* or siderite and which he is inclined to consider as a calcite into which has been accidentally drawn (*entrainé*) more or less iron in its crystallization.

Our "Fontainebleau limestone" is *chaux carbonatée quartzifère* and the real dolomite is *chaux carbonatée magnésifère.* His observations upon calcite are interesting and especially perhaps his reference to its protean character, its amazing aptitude for crystal diversity as well as its suggestiveness in the geometrical alignment of its various forms. His discussion of double refraction is very extended and a series of experiments (*observations*) illustrate Haüy's scientific profundity, but altho there is clearly distinguished the extraordinary ray (*rayon d'abérration*) and the ordinary ray (*rayon ordinaire*) the phenomenon of polarization was not recognized and Haüy's speculations were practically almost barren in results.

The second mineral considered by Haüy is the phosphate of calcium (*chaux phosphatée*), apatite. This mineral had been regarded by Romé de l'Isle as a variety of emerald, and pyramidal forms were named by him Oriental chrysolite. Klaproth, Proust, Bertrand, and Pelletier analyzed the phosphate of calcium and Vauquelin showed that Romé de l'Isle's chrysolite was the same substance. Haüy had already detected its spuriousness as a gem from its lack of hardness and its unresponsive surface.

Fluorite attracts Haüy from its perfect cleavage and the ease with which such a treatment develops the nucleal octahedron but in this case the *molécule intégrante* is a tetrahedron as a three-sided pyramid standing on a trigonal base. He has a passion for the geometrical resolution of solid forms and it is by pursuing this to its limit that he devises the "nucleal molecule." It is here that he speaks of his conception that the nucleal molecules must be similar; it seems to him probable that the structure is perforated by a multitude of vacuoles "filled either with the water of crystallization or with some other substance" (vol. II, p. 252). He makes in this species rhomboidal units formed from an octahedron and attached tetrahedrons, for to a central octahedron two terminal tetrahedrons can be conjoined and the resultant form is an inclined rhombic prism. In fluorite as in calcite our author separates varieties of crystal combinations and indicates them by geometric names. His allusion to chlorophane has some interest. He writes: "There is found in Siberia a violet substance which shows a strong resemblance to calcium fluoride, but whose phosphorescence is developed under peculiar circumstances. It has been given the name of chlorophane meaning a body emitting a green light. If a fragment is put upon hot coal it does not decrepitate, but soon diffuses an emerald glow, producing a very beautiful effect. The light slowly languishes, and disappears, at the end of a certain time; the stone has then become decolorized and limpid."

In his analysis of gypsum (*chaux sulfatée*) he makes an informing reference to La Hire, who in 1710 undertook to determine the structure of calcium sulfate and resolved it into triangles; this fallacy Haüy exposes and makes the molecule a parallelopipedon and, as he says, there is a much greater number of parts of contact between the lateral faces than between the base of the molecules; its perfect cleavage along the base is thus explained, and he reasserts in another place the feebleness of cohesion as relating to the surfaces of contact between the molecules.

Barite receives its crystallographic variations, with 13 distinctive names applied to them. He tells us that at the beginning of the eighteenth century one Carascialo, suspecting from the weight and luster of this mineral that it contained silver, subjected it to fire and was amazed to obtain only a red light shining in the dark. Such was the origin of the Bologna phosphorus (vol. II, p. 307).

It would interest the members of the New York Mineralogical Club to examine the excellent figures given by Haüy in his Atlas, and it forms a subject also of agreeable surprise, perhaps, to note the nucleal molecule invariably prefixed to these figures as their geometrical unit. In a discursive review of the system and for the illustrative purposes simply of our inspection I will only disengage those statements or assertions that either demonstrate his perspicuity or contain some detail of possible piquancy or interest to ourselves. For instance, remarking the chemical relationship of barium and strontium, he reiterates the crystallographic resemblances between minerals, as in barite and strontianite, saying "There is almost an identical crystal germ (*noyau*) in each and the secondary crystals furnish ocular resemblances, so that one may compare them to what botanists term a 'family resemblance' (*air de famille*)."

Haüy in 1791 received two crystals of the borate of magnesia, which were the first specimens of this mineral—early considered as a cubical quartz—that the Abbé had seen. Intent upon eliciting their physical properties he heated them, exposed them to an electric test and observed at once that the heat had electrified them. By comparison with known electrical dispositions in tourmaline where, however, there is but one axis (axis of symmetry) while in the case of the boracite there are four, each one of which passes thru two opposite solid angles, he deduces the existence of electric poles—two for each axis. He then recalls the contrasts in electric character of the opposite ends of the tourmaline crystal according as they are made up of solid angles or are facetted, and guided by analogy determines that resinous (positive) electricity resides in the completed angles, and the vitreous (negative) in the opposed facetted angles. It is impossible to restrain the impulse to quote the Abbé's reflections at this point: "I do not know whether, in the midst of the imposing apparatus of an artificial equipment and amid the density of phenomena that they afford, there is anything better calculated to excite the interest of physicists than these minute electric instruments, built up by crystallization, than this union of distinct and opposite reactions confined within the compass of a crystal which has not more than 2 mm. of thickness; and here is renewed the observation already often made, that the works of nature which seem most desirous to escape our scrutiny, are sometimes those which have the most to show us" (vol. II, pp. 343–344).

Hastening along many pages of instructive comment upon saltpeter, common salt, carbonate of soda, the alums, cryolite—which he informs us was brought by a missionary from Greenland and left in Copenhagen quite unnoticed until it attracted the attention of M. Abildgaard, who first identified hydrofluoric acid as one of its components—we encounter quartz in his Second Class of Earthy Substances (*Substances terreuses*). Haüy makes a rhombohedron the primitive form, but the nucleal molecule (*molécule intégrante*) is an irregular tetrahedron, into which he analyzes the primitive rhombohedron (rhomboïde). The varieties are quite exhaustively enumerated and distinctions based on form, texture, color, described with much particularity. Silex or flint, which had been regarded as a separate species, he unites with quartz, remarking, "what has above everything else confirmed me in this opinion is that reflecting upon the systematic disposition of minerals I have realized the advantage of a system when the species were restricted within their veritable limits, when the differences which defined these limits were made to reside in the intrinsic nature of the objects rather than in their exterior character. In examining the matter in this light no line of separation is discoverable between quartz and silex" (vol. II, p. 439).

His remarks on the occurrences of varieties of quartz are most interesting and ample. Opal is not distinguished by Haüy as anything else than a variety of quartz, and in the case of hydrophane he is at much pains to explain the translucency of the substance when water-soaked.

In the determination of his nucleal or building molecule (*molécule intégrante*), when the opportunities of nature deny him the easy cleavage of calcite, fluorite, or galena, Haüy resorts to his geometrical facility in a theoretical subdivision of the primitive form. Thus he takes the octahedron of zircon and splits it up into tetrahedrons, and, applying these to each other simultaneously in two series by their faces or by their edges, composes the crystals of that mineral. The hint drawn from his calcite leads him on by reason of his strong prepossession to impart to it the widest relevancy into speculative diversions that must be regarded as purely fanciful.

Télésie, or a perfect body (*corps parfait*) is the name applied to sapphire and ruby. The opening paragraph of Haüy's notes may seem deserving of quotation. "The most anciently known crystals of télésie have been brought from the royalties of Pegu and the island of Ceylon. It has been found, since, in Bohemia, between Meronitz and Bilin; and in France a league from the city of Puy, in the sand of a neighboring stream of the village of Expailly, where the specimens are mixed with garnets, zircons, and particles of iron. They have been called the "Sapphires of Puy" (vol. II, p. 485). He exhibits a scientific impatience at the confusion caused by making color a significant token of species, but indulges in a curious conceit of arranging the gems in the order of the spectrum, as red, ruby, red mixed with orange, vermeille red saturated with orange, hyacinth *la belle*, orange-red garnet, orange-hyacinth (zircon), yellow-topaz, yellow-green chrysolite, green-yellow peridot, green emerald, green-bluish aquamarine, blue sapphire, and dark sapphire (male sapphire of authors). Thruout the pages dealing with gems there is much interesting specification of their quality, and the current nomenclature of lapidaries in his day is detailed.

Cymophane (chrysoberyl) is briefly touched upon, but the twinned alexandrite was unknown to Haüy. He refers the species to Brazil as he has detected a large number acquired in Portugal mixed with Brazilian topaz. Spinel interests him from its hemitrope twinning, which he very lucidly explains and figures, suggesting that this combination depends upon a sort of polarity exercised upon the *molécules intégrantes.* He notes their previous confusion with sapphire (ruby) before their crystal shapes were fully separated.

The topaz is submitted to the crystallographic differentiation which Haüy applies to minerals, and we read of the topaz bioctahedral, the topaz *subtractive*, the topaz *monastique*, the topaz *soudouble*, the topaz *distique*, the topaz *dissimilaire*, the topaz *cylindrical.* He notes that topaz of the ancients was a green stone (chrysolite of Pliny?) which was found in an island of the same name in the Red Sea. The name was derived from a Greek word (τοπάζειν) meaning to hunt for something, to follow it by guessing, in allusion to the nebulous nature of the place which caused the navigators to search for it. The largest crystal seen by him was a topaz distique of a bluish-green, about 35 mm. in thickness and length, weighing a little over 100 grams. The topazes of Saxony and of Brazil had been separated and were regarded as different species, and Romé de l'Isle claimed an angular distinction, which Haüy correctly denies.

The primitive form of emerald is a hexagonal prism but the *molécule intégrante* is an equilateral trigonal prism. Here again the varietal forms receive names and are symbolized by letters and exponents. Romé de l'Isle and Haüy both were instrumental in identifying the beryl with emerald, and the latter (after experimental tests for the double refraction of the beryl) concludes: "Thus all of the physical and geometrical characters agree and invite a union of emerald and the aquamarine, for which I trust that chemistry may yet furnish justification" (vol. II, p. 528); this Vauquelin later supplied.

The mineral euclase derives its name from its easy cleavage, this being given it by Haüy himself. The crystallography of this mineral perplexes Haüy and his system of decrescence seems to fail to account for the terminal modifications of the euclase prism and even the secondary prismatic planes. A hypothesis helps him out, but he admits that "perhaps the actual thread by which to escape from this sort of labyrinth, may have escaped him" (vol. II, p. 538).

Haüy makes the rhombic dodecahedron the primitive form of garnet and the tetrahedral pyramid with isosceles triangular faces equal and similar the *molécule intégrante.* The figures in the Atlas of the usual forms and combinations are excellent. Klaproth's and Vauquelin's analyses are quoted. Leucite—changed by Haüy into amphigene—had only recently been separated from garnet. The variations in the analyses of garnet naturally disturb him, but the staying power of his reliance upon form led him to accept their specific identity. He says: "In a word, altho there can be no question that naturalists have too carelessly placed certain bodies under garnet, following the guide of exterior form, which is not decisive in the present case; it yet seems to me that our knowledge in this is not sufficiently advanced and that in attempting to rectify unions already made, we may flatter ourselves not to trace any false line of separation" (II, 555). Constantly straining his geometric invention, Haüy finds in the garnet rhombic dodecahedron an interesting suggestion. This form can be interpreted as a hexagonal prism with two summits each made up of three rhombs, but among an infinity of possible dodecahedrons, that of garnet, of which the planes and terminal faces are equal of similar rhombs, is the one which offers a minimum surface. He then considers the form of a bee's cell as identical, and finds thus in the labor of the bees a double economy of time and substance (II, 557). This moderate and pleasing tone seems characteristic of a speculative mind which turns eagerly into all paths of suggestive comparison or illustration. In Haüy's day the garnet called *syrian* was especially in favor; it is described as red mingled with violet (probably a pyrope); in almost equal esteem was a stone of corncockle-red. He writes: "The red of these last is so intense that if cut in facets they appear almost black. They are therefore rounded beneath, and hollowed somewhat, so that the reflections of the side tint may become disengaged and display themselves with a greater liberty" (vol. II, p. 559).

Amphigene as Haüy terms it—something with a double origin—leucite in our terminology, affords this zealous geometrician further material for complicated divisions. The ordinary tetragonal trisoctahedron he styles amphigene *trapezoïdal,* made up of twenty-four equal and similar trapezoids, and from these he extracts the rhombic dodecahedron and the cube, and combining the divisions parallel to the faces of the former with those parallel to the cube he reaches at last, after the dodecahedron has been split up in forty-eight tetrahedrons (always a three-sided pyramid on a triangular base) and the cube also reduces to twenty-four tetrahedrons, a *molécule intégrante* which is a tetrahedron and "is the same whether one considers the cube or the dodecahedron as the primitive form" (vol. II, p. 565).

Leucite's volcanic associations were fully understood by Haüy, but his review of contemporaneous opinions as to this are interesting, and his own comment deserves attention; the existence of potassium, recognized by Klaproth in amphigene, is worthy of note in his eyes as revealing a substance which in a free state unites a high degree of solubility, a distinctive taste and fusibility, but fading into the composition of a tasteless, insoluble and infusible substance; while, more important still, potassium is discovered in the mineral kingdom where until this chemical research it had escaped detection, and was regarded as belonging exclusively to the vegetable kingdom.

Idocrase, meaning confused or mixed form, is Haüy's substitute name for Werner's vesuvian. He notes its analogy with zircon, meionite, etc., and his name alludes to these perplexing resemblances. Dana has taken much exception to the nomenclatural innovations of Haüy and has recounted them with censure, remarking that "Haüy's own names are remarkable, in general, for their indefiniteness of signification, which makes them etymologically nearly as good for one mineral as another, and very bad for almost none." Perhaps in extenuation for Haüy's indifference or neglect of the Law of Priority it might be insisted that as names simply, his names have enough significance to keep them applicable, and have in addition an unmistakable euphonic dignity superior to the names they are intended to supersede, while they embody an inexpressible remonstrance against the monotony of the terminal *ite* which seems to make commonplace and trifling so many mineral terms. In his description of idocrase he asserts the fixity and regularity of crystallographic forms, and observes the nearness in angle between the rhomboid (rhombohedron) and a cube but points out the axial direction in the former as passing thru the solid angle. Meionite, a Haüyan name meaning less or inferior, alluding to a shortened vertical axis, had been confused by Romé de l'Isle with zircon. Haüy recognizes its specific isolation.

Corindon (corundum) separated from sapphire (*télésie*) by authors, is recognized by Haüy as closely related to sapphire and, tho he hesitates to decide this identity, he publishes his belief in support of the same attitude of Bournon.

Pleonaste is Haüy's name for Delamétherie's ceylonite, and he instances its close resemblance to spinel. "Spinel," he remarks, "compared to pleonaste furnishes an instance of a unity of character quite uncommon between two minerals of differing character. They both have the same primitive form and almost the same specific gravity; the difference in hardness is not great so that there remains for their distinction only characters less decisive as texture, fracture and color" (vol. III, p. 20). The name pleonaste, or superabundant, is intended to denote the excess of faces on the solid angles of the octahedron, which are absent in spinel.

Axinite, Haüy's substitution for yanolite of Delamétherie and certainly a better name, indicating the hatchet-shaped form of the crystals, receives from this undiscouraged analyzer of crystal forms this ingenuous tribute: "No substance has longer defied the application of the laws which govern the structure of crystals than axinite. The difficulty of understanding its natural joints, the numerous structures with which most forms are loaded, the slight deviations of which the clearest faces are rarely exempt, in fine, the nature of the primitive form that I can only deduce theoretically by assuming unequal edges of its basal planes, all concur in offering one of those complicated problems which often times revolved in a thousand ways does not leave the mind fully satisfied with the results" (vol. III, pp. 30–31). He refers to the polish of axinite and its agreeable colors but denies it a place among "stones which are material for the lapidary's art."

Tourmaline solicits Haüy's careful study and his descriptions—now over a hundred years old—of occurrences have yet a vivid reality. Its electrical properties particularly excite his curiosity and he gives the record of many experiments with considerable theorizing explanations. He does not seem to have examined rubellite, altho he alludes to the tourmaline of Madagascar.

Amphibole is another Haüyan name replacing the hornblende of earlier years and means equivocal, ambiguous; he rejects hornblende as too incorrect (*trop impropre*) to be retained. He regards it as abundant in primitive mountains but rarely in good crystals. The crystals found in granite are short, irregular lamellas, tho forming at times over two thirds of the rock. In steatitic, micaceous or chloritic rocks the amphibole is developed in long prisms but poorly terminated. It is met with rarely in the cavities of veins, wherein it might have more easily taken the regular forms peculiar to it. Volcanic masses furnish fine single crystals; not indeed does he think that they should be regarded as an immediate product of the volcano "but because having been incorporated in the rocks where they originated, previous to the action of the subterranean fires, they have been subsequently separated from their base, by the effects of scorification, to be thrown out at the moment of eruption with the lighter scoria, which envelop them" (vol. III, p. 66).

HAÜY'S CONTRIBUTION TO OUR KNOWLEDGE OF ISOMORPHISM

EDWARD H. KRAUS

University of Michigan

ALTHO the striking results of the first studies leading up to the establishment of the principle of isomorphism were not announced by Mitscherlich until 1819, only three years before Haüy's death, nevertheless, no historical account of the development and subsequent modifications of this important principle can be considered complete without referring in a comparatively large way to the earlier contributions of Abbé René-Just Haüy, in whose honor we have met. Probably next in importance for the advancement of crystallography to Haüy's discovery of the Law of the Rationality of Indices was the pronouncement by him that every solid substance with a definite chemical composition possesses a characteristic crystal form.

Haüy was early in life an ardent student of botany, and was impressed by the fact that there is a certain constancy to be observed in the forms of flowers and plants. This observation caused him to ponder extensively as to why there should not be a similar constancy among the minerals, which are so much simpler, chemically and geometrically. Thus, Haüy might have said: "How is it, that the same stone, the same salt, show themselves in cubes, in prisms, in needles, without the change of an atom in their composition; while the rose has always the same petals, the acorn the same curvature, the cedar the same height and the same development?" While this thought led primarily to the discovery of the Law of the Rationality of Indices, nevertheless, one cannot but feel that its influence undoubtedly extended further. It unquestionably played an important part, in connection with the constancy of angles, especially cleavage angles, in causing Haüy to make the pronouncement referred to above, which only a man of keen insight, unusual ability, and great intellectual boldness could have made.

It must be remembered that just at that time, namely, the last quarter of the eighteenth century, epoch-making discoveries in chemistry were being announced. Thus, in 1774, Priestly discovered oxygen, and, in 1783, Cavendish the compound nature of water. Lavoisier published his "Elements de Chimie" and "Reflexions sur le Phlogistique" in 1782 and 1783, respectively. To have dared to make such a generalization clearly indicates that Haüy was a close student of chemistry, and well acquainted with its recent advances.

As is well-known, immediately after discussing the results of his remarkable studies before the French Academy of Sciences in 1782 and the publication under the auspices of that Academy of his first book entitled "*Essai d'un Theorie sur la Structure des Cristaux*" in 1784, Haüy was universally recognized as having placed crystallography upon a sound and rational basis, and was accordingly heralded as the "father of crystallography." Haüy at once became the dominant figure of that period in crystallography.

His views on the relation of chemical composition to crystalline form were generally accepted, altho many facts were then known, which were not in accord with Haüy's pronouncement that "every chemical substance possesses a characteristic crystalline form, and that substances differing in chemical composition cannot occur in the same form." Thus, Romé de l'Isle knew, as early as 1772, that the sulfates of copper and iron crystallize together from a solution of both compounds. In 1784, Le Blanc showed that the chemical composition of these crystals varied, although the crystalline form remained the same. The observations of Beudant and von Fuchs, made a few years later, must also be mentioned. The former studied intensively the mixed crystallizations of the sulfates of zinc, iron, and copper, and obtained single crystals containing all three of these salts. These mixed crystals were obviously in direct opposition to Haüy's view.

To von Fuchs we owe the introduction of the term "vicarious constituents." He studied the composition of gehlenite in 1815 and observed the presence of iron, which he interpreted as replacing the calcium, and hence, not an essential but a "vicarious constituent." From further analytical data, it was soon evident that many minerals must be interpreted in this manner. In 1817 von Fuchs explained the similarity in the crystalline forms of the carbonates and the sulfates of calcium, strontium, and lead in this way.

One can readily see why Haüy could not be induced to change or modify his views, especially when we recall that by noting a marked difference in the size of the angles of specimens labelled sulfate of baryta, he concluded that they could not possibly have the same composition. Some were from Sicily, while the others were obtained from Derbyshire. Subsequent examination by Vauquelin showed clearly that those from Sicily consisted of sulfate of strontium, while the specimens from Derbyshire were sulfate of barium. The claim that two substances, chemically distinct and not crystallizing in the cubic system, could possess the same form, as indicated by the researches of Le Blanc, Beudant, and von Fuchs, was, hence, persistently opposed by Haüy. Small wonder then, that when the investigations of Beudant were submitted to the criticism of the French Academy of Sciences in 1819, they were discredited, judgment being passed by Haüy, Vauquelin, and Brochant. It was, however, postulated by this committee that one constitutent might determine the crystal form of a substance, even tho present in very small amounts, while the other constituents remained without influence in this respect.

It was at this stage of our knowledge of the relationship between chemical composition and crystal form, that Mitscherlich published the results of his studies on the phosphates and arsenates of potassium and ammonium. His observations were apparently in direct opposition to the theory held by Haüy, for there could be no question about the difference in the chemical composition of the salts, and the crystals were to all intents and purposes identical in form. Further investigations were carried on by Mitscherlich, and two years later, namely in 1821, he characterized this phenomenon of analogous chemical substances crystallizing in forms which appeared to be identical as the principle of isomorphism. Undoubtedly Mitscherlich had at this time absolute identity of form in mind. The fact that Berzelius was greatly interested in Mitscherlich, and that the latter had studied for nearly two years in Berzelius's laboratory in Stockholm, aided materially in gaining wide recognition for this new principle.

As was to be expected from the course of events up to this date, Haüy did not look with favor upon Mitscherlich's work. Haüy still believed in his pronouncement that the chemical composition does exert a large influence upon the crystal form. His experience in applying this idea had been so successful, and his faith in it so great, that he could not believe that these observations invalidated his theory. It must not be forgotten in this connection, that it was Haüy who showed that the crystal development of the emerald agreed with that of beryl, and accordingly he predicted that an analysis of emerald must show the presence of the element beryllium. This was subsequently confirmed by Vauquelin. Many other illustrations of this character might be cited. Hence, we can fully appreciate Haüy's feelings when he wrote to Brochant that "if Mitscherlich's theory is correct, mineralogy would be the most wretched of the sciences."

Haüy died in 1822 believing firmly in his theory, and undoubtedly with a strong conviction that it would eventually be fully confirmed. However, with the establishment of the principle of dimorphism by Mitscherlich in 1823 it appeared as tho the evidence was overwhelmingly opposed to the theory of Haüy. Mitscherlich had observed that the element sulfur could occur in distinctly different crystal forms, depending upon the conditions of formation. Dimorphism also cleared up the mystery of calcite and aragonite, the true nature of which had been under discussion for many years. It also showed that Haüy's pronouncement could not be applied as universally as he had originally thought.

Further investigations, however, caused Mitscherlich to doubt the absolute agreement of angles or crystals of isomorphous substances. The construction and use of a reflecting goniometer of greater accuracy than had previously been employed showed unmistakably that slight but distinctive differences exist in the angles of isomorphous substances crystallizing in systems other than the cubic. These differences Mitscherlich was, however, inclined to attribute to variations caused by changes in temperature.

On account of the apparent contradiction in the views of Haüy and Mitscherlich regarding the relationship between chemical composition and crystal form, investigations in this field have been uncommonly numerous. It was recognized rather early that the original idea of absolute identity of form, expressed by Mitscherlich, must be modified, absolute identity giving way to striking similarity of form. Many studies involving careful crystallographic measurements show conclusively that compounds, which are very closely related chemically, yield crystals which may appear to be identical in form. However, when they are measured with a modern goniometer, it is observed that the angles between similar faces are not absolutely of the same value, there being small but nevertheless characteristic differences. Perhaps the most extensive and painstaking researches in this special field of chemical crystallography are those carried out by Tutton. Many isomorphous series of artificial compounds of unusual purity were studied. Some of these compounds were comparatively simple in composition, while others were very complex. As a result of these investigations, extending over many years, Tutton and others have definitely demonstrated that crystal angles are functions of the chemical composition, as Haüy had in the main postulated.

There can be no question whatever, but that the bold pronouncement by Haüy, at a time when modern chemistry was in its infancy, chemical compositions being expressed in percentages and by formulas, did much to stimulate research not only in mineralogy, but in chemistry as well. In those days these two subjects were more closely allied than they unfortunately are today. The many attempts, during a period of nearly a century, to reconcile the conflicting views of the early part of the nineteenth century have been fruitful of discoveries of great importance in bringing chemistry and mineralogy up to our present advanced stage of knowledge. The debt we owe to Haüy in this regard is indeed great.

HAÜY, THE "FATHER OF CRYSTALLOGRAPHY"

FRANK D. ADAMS
McGill University

It is very fitting that the student in any branch of knowledge, and particularly in Natural Science, should pause, on occasion, to glance back at the history of the development of his subject. Nothing can be more instructive than to trace anew the progress that has been made thruout the centuries, from the very crudest beginnings, a progress as sure and irresistible as the oncoming tide, now gradual, and now, like the onrush of a seventh wave, going forward more rapidly, borne on by the stimulus of some exceptionally brilliant mind. To re-study the problems which have from time to time presented themselves, and to observe with what ingenuity they have been attacked and overcome must needs afford the greatest possible incentive and encouragement to the present-day student in dealing with the problems which still await solution.

Crystallography forms no exception to this generality, and altho comparatively few years have elapsed since its firm establishment as an exact science, the page of its history is emblazoned with the names of scores of eminent men, from the times of Nicolaus Steno and of Romé de l'Isle, who laid the first foundation, up to the present day. Unquestionably, however, the first solid pillar in the structure of the science was set up by the Abbé Haüy, professor of the humanities at the University of Paris, during the last decades of the eighteenth century. He it was who, by careful observation and research, followed by clear deductive reasoning, first brought order out of chaos and raised the study of crystals to the dignity of a science. In his own words, "*un coup d'oeil peu attentif, jété sur les cristaux, les fit appeler d'abord de purs* JEUX DE LA NATURE, *ce qui n'étoit qu'une manière plus élégante de faire l'aveu de son ignorance. Un examen réfléchi nous y découvre des lois d'arrangement, à l'aide desquelles le calcul représente et enchâine l'un à l'autre les résultats observés; lois si variables et en même temps si précises et si régulières; ordinairement très simples, sans rien perdre de leur fécondité!*" The fact that the theory of crystal structure elaborated by Haüy, and based on his discourses of these laws of symmetry, of rational intercepts, and of constancy of crystalline form, does not differ very materially, in its essential points, from the views now prevailing, is a remarkable tribute to his genius, and will forever render the name of Haüy famous as the "Father of Crystallography." This proud title is most appropriate and has been bestowed upon Haüy with reason. If any support were needed, it is only necessary to recall the testimony of Henry James Brooke, in his "Familiar Introduction to Crystallography," published in 1823 a few years after Haüy's death, to the effect that "The Abbey Haüy's works on crystallography are the only ones in which a truly scientific exposition of the theory of crystals is to be found." His work has afforded the key wherewith it has been possible for his successors to unlock many of the secrets of crystal structure, and the great strides which the science has made during the past century have all had, as their starting point, the discoveries and theories of Haüy. It is especially fitting that now, on the one hundred and seventy-fifth anniversary of his birth, crystallographers thruout the world should unite in paying homage to the memory of this distinguished scientist, and should be reminded afresh of the extent to which the science of crystallography is indebted to his brilliant pioneer work.

HAÜY'S LAW OF RATIONAL INTERCEPTS

ALFRED J. MOSES

Columbia University

ALTHO crystals had been observed for thousands of years they had been regarded as little more than freaks of nature without regularity in shape or constancy in angles until in 1669 Steno showed that in quartz or rock crystal the angles between corresponding faces were constant, no matter how much the crystals varied in shape; and Guglielmini in 1704 extended this by stating that every substance had its peculiar crystals, the angles of which were constant.

But crystals of the same substance are not always bounded by corresponding faces and both the numbers of faces and the values of the angles are often different on different crystals. That any intimate relation between such crystals existed was first shown by Romé de l'Isle, who with the newly invented goniometer measured all obtainable crystals, made models and drawings of them, and in 1783 described over four hundred forms; he showed that the different crystals of any one substance consituted a series the members of which could be derived by modifying one so-called primitive form by secondary planes, each geometrically similar part of the primitive form being replaced by the same number of planes in the same way. In other words, de l'Isle discovered the law of symmetry: "all crystals of any one substance are of the same grade of symmetry," and thereby placed all forms possible with crystals of the same substance in a definite series.

In de l'Isle's series, however, the secondary or modifying planes could be at any angles provided the symmetry was maintained, and theoretically, the number of possible forms was still infinite. Haüy's great service was the discovery of the limiting law.

Bergmann, in 1773, had shown that calcite could be cleaved into six-faced forms (rhombohedra) of constant angles and that these could be built again into the many crystal forms of calcite. Haüy assumed that this property of cleavage was common to all crystals and developed on this basis a theory of crystal structure in which the cleavage form was assumed to be the primitive form or nucleus and the secondary forms to result by the addition on each face of successive layers made up of rows of little "integrant molecules," polyhedra of shapes determined by the cleavage. Each successive layer was assumed to diminish regularly by the subtraction of one or more rows and each row by one or more molecules, *always by some simple rational number, never to his knowledge exceeding four;* and the planes tangent to the resultant step-like solids were at the angles actually observed in the crystals.

Haüy's theory of crystal structure has been abandoned, at least as to the exact details, but his discovery, that the faces of crystals of the same substance do not occupy arbitrary relative positions but must fulfill certain conditions which can be expressed by simple rational numbers, is the basis of the greatest law of crystallography, the law of rational intercepts.

MODERN EXTENSIONS OF HAÜY'S LAWS OF CRYSTALLOGRAPHY

EDGAR T. WHERRY

U. S. Bureau of Chemistry

It is perhaps not generally appreciated to what an extent modern work on crystal structure is based upon the fundamental principles enunciated by Haüy over 125 years ago. The terminology may be different, but the ideas remain the same. He spoke of "integral molecules," we say "crystal molecules," "unit cells of the space lattices," etc. He adopted as the shapes of these units the parallelopiped, octahedron, tetrahedron, hexagonal prism, rhombic dodecahedron, and hexagonal bipyramid. We still use some of these, altho certain changes in the list have been required as a result of subsequent investigations. His law of rational indices has held firm, and has furnished a starting point for many subsequent generalizations. The point-system or space-lattice theory of crystal structure is a direct extension of it. Professor Goldschmidt's recognition of harmony and complication in the symbols of zones of forms is another. And now that the use of X-rays has furnished, especially in the hands of the Braggs, a means of demonstrating the reality of space-lattices and the occupation of their nodes by atoms, rather than by chemical molecules, it is possible to go still further.

The Russian crystallographer, E. S. Fedorov, has been during the past few years carrying on extensive researches on what he terms "crystallo-chemistry," and, aided by the Braggs's working out of the structures of a number of simple salts, has recently formulated certain laws and principles extending Haüy's original law into this field.[1] Being written in Russian,[2] his papers are comparatively inaccessible to English-speaking scientists, but it has fortunately been possible to have very full and accurate abstracts of them published in *Chemical Abstracts*.[3]

[1] The fundamental law of crystallochemistry. *Bull. Russ. Acad. Sci.*, 1916, 435–454; The chemical side of crystalline structure, *ibid.*, 547–553; Note on the determination of the densities of atoms in crystal faces, *ibid.*, 1675–1688.

[2] As there is in the Russian alfabet no letter exactly equivalent to our "h," the name "Haüy" becomes "Gaui" when transliterated.

[3] Chem. Abstr., **12**, 8–13, 1918 (on 3d line for Bross read Bragg).

The principal points made by Professor Fedorov are: The space arrangement of atoms in three crystallographic directions, and the units to be used in the corresponding axes, may be expressed rationally, altho, because of our inability to determine the positions of the atoms with absolute exactness, only approximately rational relations are as a rule obtained. Planes determined by any three atoms are possible crystal faces, but the greater the density of a face the more important it is, crystallographically speaking, and the more likely to appear on the actual crystal. The importance of planes is increased by the presence in them of dissimilar atoms, capable of attracting one another, and due to similar chemical attractions the bond between parallel planes is made stronger. The nearest distance between unlike atoms in any space-lattice is in general inversely proportional to their chemical affinity, altho exceptions may occur when an atom of one kind holds two or more of another. Thruout these theorems the influence of Haüy's law of rational indices can be clearly traced.

An extension of the idea of arrangement of atoms in layers into the field of optical properties has recently been attempted by the writer. Thus far only tetragonal crystals have been studied, but in a number of substances which crystallize in this system there has been found to be a correlation between crystallographic axial ratio and refractive indices. Deriving from the indices, by the use of the Lorentz-Lorenz formula, the "refractions," the following inverse relationship has been found to hold in certain simple compounds:

$$\frac{\omega^2 - 1}{\omega^2 + 2} : \frac{\epsilon^2 - 1}{\epsilon^2 + 2} = c : a.$$

It is of course necessary that the true axial ratio, based on all the layers of atoms present, be used; and in many cases this is not the same as the standard axial ratio, which is obtained by taking the most prominent pyramid form to be (111). There are, furthermore, many disturbing factors, such as irregularity of the layers, asymmetric arrangements of atoms, which produce rotation of the plane of polarized light, and the presence of absorption bands and other color phenomena, such as pleochroism. Because of the presence of one or more of these features, the effects of which cannot as yet be evaluated, this rule fails to hold with complex compounds, but it does hold for enough simple ones to indicate that it is a fundamental relationship.

In a preliminary paper on this subject, recently published,[4] a few organic compounds were considered. Similar relations prove to hold with the minerals of the zircon group, the crystallographic features of which were first established by Haüy.

In cassiterite the refraction ratio is 0.945, the alternate axial ratio 0.951; in rutile the values are 0.926 and 0.911 respectively. The practical identity of the two ratios shows that in these minerals the space-lattice must have the same number of layers of atoms in the horizontal as in the vertical direction. In zircon and xenotime the refraction ratios are not equal to either axial ratio, but to 3/2 the standard one. This is interpreted to show that in the unit cells of these minerals there are three layers of atoms horizontally for every two vertically. It is accordingly possible to tell in this way something about the space-lattices of crystals, and when the refraction data are combined with the observed symmetry relations, to work out in detail probable arrangements of atoms for the substances. A few minerals in addition to those of the zircon group have also been studied in this way, but in most cases the presence of disturbing factors prevents the complete recognition of their structure. Further work is planned, however, to evaluate as far as possible the influence of these factors, as well as to apply this method of study to substances crystallizing in other systems than the tetragonal.

How slowly could such investigations progress had not Haüy blazed the way by his clear recognition of the significance of cleavage and the rationality of indices!

[4] *J. Wash. Acad. Sci.*, 8, 277–285, 319–327; 1918.