Estudios Geológicos 81(2)
julio-diciembre 2025, 1142
ISSN-L: 0367-0449
https://doi.org/10.3989/egeol.45758.1142

The Historical Collection of Feldspars in the Museo Nacional de Ciencias Naturales of Madrid. The case of "valencianite"

La Colección Histórica de Feldespatos en el Museo Nacional de Ciencias Naturales de Madrid. El caso de la "valencianita"

Luis Sánchez-Muñoz[1]*, Martín Fernández Hernán[2], Odulio J. M. de Moura[3]

[1] Dpt. Geología, José Gutiérrez Abascal 2, Museo Nacional de Ciencias Naturales, MNCN-CSIC, 28006 Madrid, Spain. ORCID: https://orcid.org/0000-0003-4264-4501
[2] Calle Goya 80, El Boalo, 28413 Madrid, Spain; martinfernandezh@gmail.com; ORCID: https://orcid.org/0009-0007-2539-3129
[3] MINAGEM, Governador Valadares, Minas Gerais, Brasil; odulio@gmail.com; ORCID: https://orcid.org/0009-0002-8586-124X
*Corresponding author: lsm@mncn.csic.es

ABSTRACT

The Historical Collection of Feldspars at the Museo Nacional de Ciencias Naturales (MNCN-CSIC) began its formation with the founding and development of the Real Gabinete de Historia Natural (RGHN) in the mid-18th century, in the context of the Age of Enlightenment, at the dawn of the development of feldspar mineralogy and terminology. The collection grew and was later improved during the 19th and early 20th centuries. It currently consists of 324 mineral specimens, with feldspars being the main mineral phase. Thanks to the handwritten documents available in the Archivo Histórico MNCN, we can trace the history of the collection's formation and its protagonists. Several historical specimens stand out in the collection, such as the Labrador Stone (labradorite), the adularia from the Alps, and the large potassium feldspar crystals and twins from Bustraviejo (Madrid). In addition, we document historical and mineralogical details of the "valencianite" specimens from the Valenciana mine, Guanajuato (Mexico), a mineral that has recently been proposed as a new mineral species in the group of potassium feldspars.

Keywords: Feldspars; Age of Enlightenment; labradorite; adularia; "valencianite".

RESUMEN

La Colección Histórica de Feldespatos del Museo Nacional de Ciencias Naturales (MNCN-CSIC) empezó a formarse con la fundación y el desarrollo de Real Gabinete de Historia Natural (RGHN) a mediados del siglo XVIII, en el contexto de la Ilustración, en los inicios del desarrollo de la mineralogía y la terminología de los feldespatos. La colección creció y mejoró más tarde durante el siglo XIX y principios del siglo XX, con diversos aportes. Actualmente, consta de 324 ejemplares minerales con los feldespatos como fase principal. Gracias a los documentos manuscritos, disponibles en el Archivo Histórico del MNCN, podemos trazar la historia de la formación de la colección, y sus protagonistas. En la colección destacan varios ejemplares históricos, como la Piedra de Labrador (labradorita), las adularias de los Alpes, y los grandes cristales y maclas de feldespato potásico de Bustraviejo (Madrid). Finalmente, se presentan detalles históricos y mineralógicos de los especímenes de "valencianita" de la mina Valenciana, Guanajuato (Méjico), mineral que ha sido propuesto, recientemente, como una nueva especie mineral en el grupo de los feldespatos potásicos.

Palabras clave: feldespatos, Ilustración, labradorita, adularia, "valencianita".

Recibido el 22 de abril de 2025; Aceptado el 12 de junio de 2025; Publicado online el 19 de diciembre de 2025.

Cómo citar: Sánchez-Muñoz, L., Fernández Hernán, M. & de Moura. O. J. M. (2025). The Historical Collection of Feldspars in the Museo Nacional de Ciencias Naturales of Madrid. The case of "valencianite". *Estudios Geológicos*, 81(2), 1142. https://doi.org/10.3989/egeol.45758.1142

Introduction: feldspars in the MNCN-CSIC

The MNCN currently has two collections of feldspar minerals. One is the Historical Collection, formed since the institution's creation in the 18th century as the Royal Cabinet of Natural History (RGHN) during the Age of Enlightenment in Spain. It was formed during the transition from natural philosophy to modern natural sciences. The other is the Scientific Collection, developed since the late 20th century and constantly growing. This work documents the development of the Historical Collection, when optical properties (color and iridescence), the crystal habit of euhedral crystals and the orientation of cleavage planes were the main classification criteria. In particular, the case of "valencianite" feldspar is developed in more detail, as it has recently been suggested as an additional mineral species in the group of potassium feldspars.

Feldspars in the Age of Enlightenment

At the beginning of the 18th century, natural history and mineralogy were closely focused on the deluge. There were no terms for feldspars, and granitic rocks (granite and porphyry) were still described using Pliny the Elder's terms, such as Syonite and Pyrrhopoecilus (Woodward, 1728), or as spars. However, with the advent of the Enlightenment and the revival of academic naturalism, a wide variety of terms proliferated. An international mineralogical community was formed at about the same time, and terms were introduced to refer to what we now call "feldspar" (*feldespatos* in Spanish), including the following: *Crystallisatum campestre; fåltspat, feldspathum; felt spat; feldspatha; Feldstein, feldspat; feld-spath; felsit; feltspat; glass spar; petunt-se; pseudo-spathum; quartzum rupestre; quartz-spath; quartzum spathosum; rhombic quartz; spar; spat; spath; spath fusible; spathum; spatum campestre; spatum compactum scintillans; spatum durum scintillans; spatum durum, lateribus nitidis, as chalyben scintillans; spath quartzeux, spatum fixum scintillans; spatum lateribus nitidus; spatum pyrimachum; spathum referens; spathum phomboidale opacum, spatum siliceum, spathi, vitreum album; saxum spatosum, silex spathum.*

From this list of terms, it is clear that at that time the distinction between feldspars, quartz, and calcite was not yet fully understood. It is also clear that each community had its own terms in their own language or in Latin.

Carl Linnaeus (1707–1778) was interested in a general classification of nature, that is, of the three natural kingdoms, and paid particular attention to the "regnum lapideum". In the first classification of his Systema Naturae of 1735, feldspars were included under the term "spatum lamellatun" (lamellar spar) in the group "petrae" (stones) and also under "spatosum rubrun" in the group "saxum" (rocks) (Linnaeus, 1735). A terminological innovation appeared in the expanded second edition in 1740, where a distinction was made between "Fels-Stein" for stones such as "petra" and "Feld-Steine" for rocks such as "saxa" and "lapides vulgarissimus" (Linnaeus, 1740). From 1738, Linnaeus was involved in the formation of the Royal Swedish Academy of Science in Stockholm (Sweden), and among other actions, he commissioned Daniel Tilas (1712-1772) in 1740 to collect "spars" thought to be calcareous (i.e., calcite) in Finland, owing to his interest in its possible relationship with metal mining. In his report, Tilas (1840) stated that he had not found "spars" but rather "felt spat", a mineral that he termed in the same work in four different ways, "felt spat", "feltspat", "spat", and also "feldspat". Perhaps, he did not know what to call them and did not remember how he had done it previously, because there was not yet a name accepted by the entire community. The relevant text is reproduced as Figure 1.

In the 1747 edition, Linnaeus introduced a new term for spars, "spatum compactum scintillans", a stone for which he did not yet have a term in his native language, unlike the other three types of spar. In his 1748 edition, however, the term "Fåltspat" already appears as a translation for this particular spar (Linnaeus, 1748). But, in the 1747 work Mineralogy by Johan G. Wallerius (1709-1785), the term "Felt-Spat" (Figure 2) had already been used, citing Tilas's work as the source, corresponding to other names, such as "spautum pyrimachum" or "spatum durum scintillans" by Linnaeus (Wallerius, 1747).

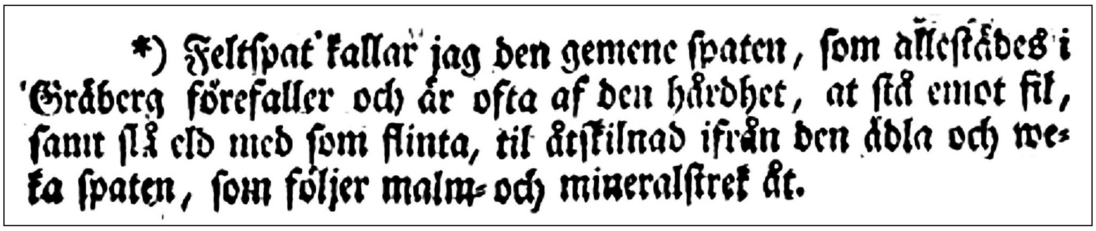
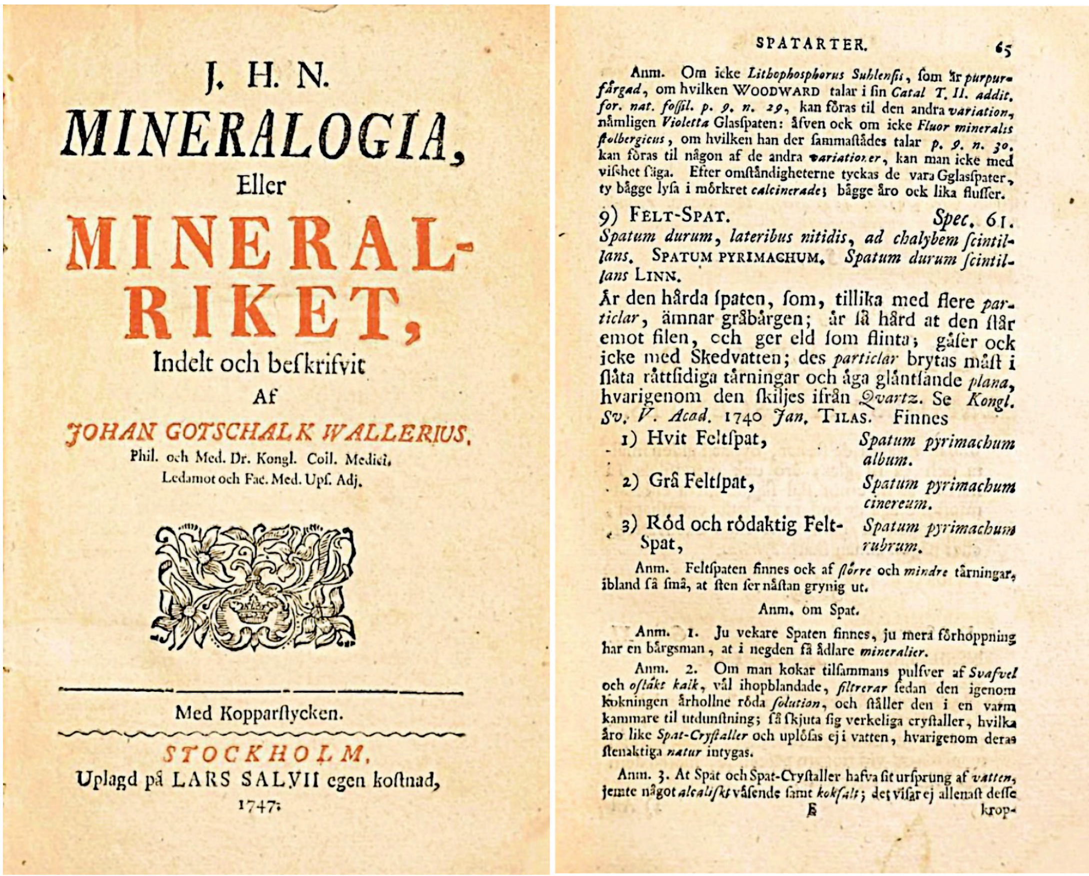

*) Feltſpat kallar jag den gemene ſpaten, ſom alleſtådes i Gråberg förefaller och år ofta af den hårdhet, at ſtå emot fil, ſamt ſlå eld med ſom flinta, til åtſkilnad ifrån den ådla och weka ſpaten, ſom följer malm- och mineralſtrek åt.

Figure 1.— ”Feltspar kallar jag den gemene spaten, fom alleftådes i Gråberg förefaller och år ofta den hårdhet, at ftå emot fil, samt flå eld med fom flinta, til åtftilnad ifrån ben ådla och meka spaten, fom följer malm-och minerastrek åt”. Translation: ”Feldtspat” I call the common spar found everywhere in Gråberg (granite, gneiss, etc.), and often of such a hardness as to resist the file and give fire as flint. This is done in order to distinguish it from the noble and soft spar accompanying streaks of ores and mineral”. From p. 191 in Tilas (1740), Zenzen (1925).


J. H. N.
MINERALOGIA,
Eller
MINERAL-
RIKET,
Indelt och beſkrifvit
Af
JOHAN GOTSCHALK WALLERIUS,
Phil. och Med. Dr. Kongl. Coll. Medici,
Ledamot och Fac. Med. Upſ. Adj.

Med Kopparſtycken.
STOCKHOLM,
Uplagd på LARS SALVII egen koſtnad,
1747.

SPATARTER. 65

Anm. Om icke *Lithophosphorus Sublenſis*, ſom är *purpurfårgad*, om hvilken WOODWARD talar i ſin *Catal T. II. addit. for. nat. foſſil. p. 9. n. 29*, kan föras til den andra *variation*, nämligen *Violetta* Glasſpaten: åfven ock om icke *Fluor mineralis ſtolbergicus*, om hvilken han der ſammaſtådes talar *p. 9. n. 30.* kan föras til någon af de andra *variationer*, kan man icke med viſshet ſäga. Efter omſtåndigheterne tyckas de vara Gglasſpater, ty bågge lyſa i mörkret *calcinerade*; bågge åro ock lika fluſſer.

9) FELT-SPAT. *Spec.* 61.

Spatum durum, lateribus nitidis, ad chalybem ſcintillans. SPATUM PYRIMACHUM. *Spatum durum ſcintillans* LINN.

År den hårda ſpaten, ſom, tillika med flere *particlar*, ämnar gråbärgen; år ſå hård at den ſlår emot filen, och ger eld ſom flinta; gåſer ock icke med Skedvatten; des *particlar* brytas måſt i ſmåta råttſidiga tårningar och åga glåntſande *plana*, hvarigenom den ſkiljes ifrån *Qvartz*. Se *Kongl. Sv. V. Acad.* 1740 *Jan.* TILAS. Finnes

1) Hvit Feltſpat, *Spatum pyrimachum album.*
2) Grå Feltſpat, *Spatum pyrimachum cinereum.*
3) Röd och rödaktig Felt-Spat, *Spatum pyrimachum rubrum.*

Anm. Feltſpaten finnes ock af *ſtörre* och *mindre* tårningar, ibland ſå ſmå, at ſten ſer nåſtan grynig ut.

Anm. om Spat.

Anm. 1. Ju vekare Spaten finnes, ju mera förhoppning har en bårgsman, at i negden få ådlare *mineralier.*

Anm. 2. Om man kokar tilſammans pulfver af *Svafvel* och *oſläkt kalk*, vål ihopblandade, *filtrerar* ſedan den igenom kokningen århollne röda *ſolution*, och ſtåller den i en varm kammare til utdunſtning; ſå ſkjuta ſig verkeliga cryſtaller, hvilka åro like *Spat-Cryſtaller* och uplöſas ej i vatten, hvarigenom deras ſtenaktiga *natur* intygas.

Anm. 3. At Spat och Spat-Cryſtaller hafva ſit urſprung af *vatten*, jemte något *alcaliſkt* våſende ſamt *kokſalt*; det viſar ej allenaſt deſſe

E krop-

Figure 2.— Cover and page 65 showing the mineral species number 61 corresponding to “Felt-Spat” in the first general work on Mineralogy, by Johan G. Wallerius (1747).

The German translation of Wallerius’s work by the mineralogist Johann Daniel Denso (1708–1795) in 1750 further popularized the term “feldspath” (Denso, 1750). The book by the Swedish mineralogist Axel Fredrik Cronstedt (1722–1765), entitled “Försök til mineralogie, eller mineral-rikets upställning” (An attempt at mineralogy or arrangement of the Mineral Kingdom), was, along with Wallerius’s book, an important source for the development of mineralogy textbooks in the rest of Europe. This author also used the term “Fåltspat” of Linnaeus and Tilas as an equivalent of “spatum scintillans” to refer to feldspars in rocks (Cronstedt, 1758). In Argenville’s 1755 work on Oryctologie the term “Pierres de Amazones” or “Lapis Amazonious”, i.e., amazonite variety, appears but is unrelated to the numerous varieties of “Spath”, although he did recognize also a green spar.

Pedro Franco Dávila (1711-1786) published a three-volume catalogue of natural objects in Paris in 1767. In the second volume on earths, minerals and stones, including "fusible spaths ou fluors", different varieties of fusible spaths, as well as "Feld-Spaths" or "Spath quartzeux" were distinguished. Dávila included "Swiss glass spar", i.e., the crystalline variety later called adularia; "compact spar" used in the fabrication of porcelain as a raw material; "red feld-spath" in granitic rocks with quartz and mica; "green feld-spath" or "Basalte spatheux" in rocks from Sweden, i.e., amazonite from pegmatites, as well as other white varieties, which were classified separately from the glassy (i.e., crystalline) spars crystallized in cubes (i.e., fluorite). Four years later, the RGHN named Dávila as its first director, a position he held until 1786, and acquired his collection. During that time, Dávila maintained contact with other European mineralogists and added to the RGHN's collection, as will be seen below.

The catalog of specimens from Dávila's collection, and also his collection, were used as sources for the early work of Jean-Baptiste Louis Romé de L'Isle (1736–1790). In his first publication on Cristallographie in 1772, Romé de L'Isle described the "pierreux cristaux", without clearly differentiating among feldspars. However, in the second edition in 1783, he recognized the diversity of feldspars based on their coloration, including white, red, gray, and green. Furthermore, de L'Isle developed a classification of crystal forms for "Feld-Spath" varieties, including "espèces de macles" (i.e., twins or twinned feldspars), already citing Pini, Saussure and Wallerius as sources (Romé de L'Isle, 1783). Using the catalogue of the mineralogist Jacob Forster (1739–1806) prepared in 1780 as a source, de L'Isle also described labradorite.

Forster had already described the origin of the iridescence in different colours, such as green, purple (red) and navy blue, of the "Pierre de Labrador" from the feldspath of Labrador (Canada). He attributed it to the extreme fineness of lamellae that it contained (Forster, 1780). The influence of this Prussian mineralogist was particularly important in the development of the MNCN collection. Thanks to the mediation of Christian Heuland, his nephew, with the Conde de Floridablanca, the RGHN acquired an important part of Forster's collection of between 2,000 and 3,000 items for the sum of 600,000 reales in 1787 (MNCN, 1787).

The Labrador stone had been described earlier, however, by missionaries when the first German and English branches of the Moravian Church settled in Nain in 1771. The German missionary Joachim Wolfes arrived in Labrador in 1772 (Hiller 1967), and later other missionaries familiar with the Inuit's mine on Paul Island (Bell, 1895, Waard, 1969). The first samples were brought to Europe by Bishop Leiriz of the Christian community of Labrador. The first description in Germany was made in 1775 by Johann Samuel Schröter (1724-1811). He referred to an angular stone from the Inuit country with a Schiller effect (Schröter, 1775), Paul Island being the place where it is most abundant. However, the first detailed description of Labrador stone as a "feldspat aus Labrador" was made in 1778 by Nathanael Gottfried Leske (1751–1786), a German natural scientist and professor of the University of Leipzig (Leske, 1778). Later, Labrador stone appeared in the work of Werner (1780), who listed three types of feldspars: common or gemeiner, Labrador Stone (Labradorstein), and moonstone or Mondstein. In Leske's descriptions and classification as a feldspar, the author explained the spathic character (scaly lamination) as an evident feature, according to the cleavage in thin and regular sheets, the original black to gray color, the opacity with an almost metallic micaceous luster, the reflections in diverse colors from intense red to sapphire sky blue or navy blue, passing through grass green and topaz yellow or gold, only in certain directions of the stone and viewed from a certain angle, with a hardness similar to the rest of the feldspars, and insolubility in acids. Numerous interpretations were given to explain the iridescence of the stone, but an explanation would not arrive until the 20th century with the advent of electron microscopy. The phenomenon arises as an interference color due to the pseudoperiodic spacing of two feldspar lamellae of different composition, as suggested by Forster.

Carlo Ermenegildo Pini (1739-1825) wrote a work in 1779 already entirely dedicated to the study of feldspars (Pini, 1779). There, he explained that "Fels-Spath" meant "*spars from rocks*", and many of the old terms were discussed, although the term feldspar had already been standardized at that time. Other new terms were included for this mineral group. Pini also described the famous feldspar crystals from Mont St. Gotthard in Switzerland, whose original name was Mount Adula, hence the name "adularia" that this author suggested; some of them occur as transparent crystals and with an iridescent effect like opal, and therefore coinciding with the Lunaria that came from the East (Ceylon, now Sri Lanka) and with the Labrador stone that came from North America (Pini, 1783).

In 1789, Francisco Campuzano, Commissioner of the Province of Marina and interested in the productions of the mineral kingdom in America, translated into Spanish the work of the Irish mineralogist Richard Kirwan (1733-1812), member of the Royal Society since 1780, which had been written in 1784 (Kirwan, 1784). The term "feld-espato" was used as a Spanish translation of "feltspar" from the original English, a mineral in granites with quartz, mica and schorl, in Rapakiwi (i.e., granites from Finland), in porphyries, and also in the "Moor-stone" or "Piedra de Moros" (perhaps in reference to what we now call "pegmatites"). Kirwan mainly used as a source "Voyages dans les Alpes" by Horace-Bénédict de Saussure (1740-1799), a foreign member of the Royal Society since 1788. In later editions, Kirwan used the term "felspar" considering that the origin of the term was "fels", i.e., a rock, and not "feld", i.e., "field", and also he used Pini to refer to adularia, Werner in relation to Labrador Stone, and Bindheim for the green feldspar (amazonite) of Siberia (Kirwan, 1794).

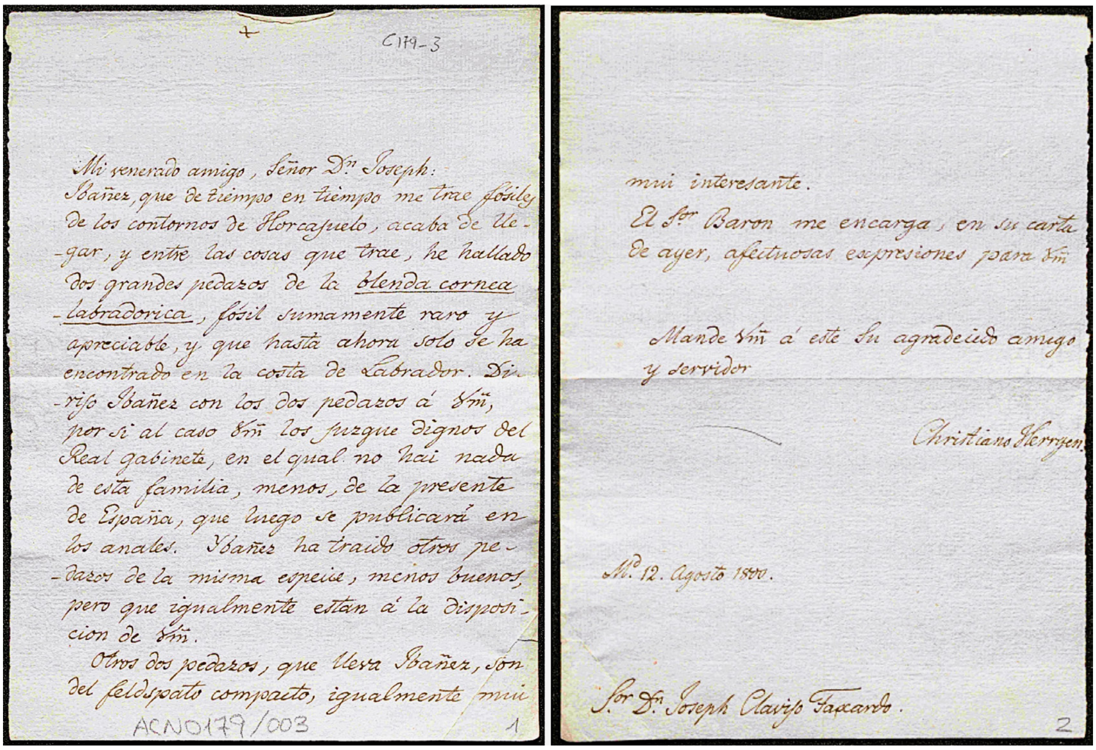
The term "feldspar" appeared later in 1795 in the work "Elementos de Orictognosia" by Madrid native Andrés Manuel del Río Fernández (1764-1849), published in Mexico for use in its Real Seminario de Minería (Río 1795). This work was based on the knowledge of "fossils" (minerals) according to the principles of Abraham Gottlob Werner (1749-1817), of whom del Río considered himself a disciple. Del Río distinguished several types of feldspar, including "common" in massive forms or prismatic crystals in gneisses and granites; "imperfect leafy" in reference to basal cleavage along the (001) plane; the "Piedra de Labrador" in which the optical effects of variable color were recognized; and "adularia" by Pini, which he related to the Ceylon Moonstone. As a second part of his first work, which was also published in Mexico (Río, 1805), feldspars were mentioned in the context of primitive rocks, in relation to "granite", "gneiss", "syenite", "porphyry" and "topaz rock" (referring to what we now call pegmatites). Feldspars were also mentioned in relation to porphyries, in Humboldt's appendix to this work on "geological passiography", in reference to rock stratifications and Geognosia or Geology.

At that time, in Spain, the first issue of the journal Anales de Historia Natural was published in October 1799, where an article appeared by Christiano Herrgen (1765-1816), one of the first four editors of the journal and also a disciple of Werner. He wrote on "Mineralogical Geography", using as a source the mineralogical system of the work by Johann Friedrich Wilhelm Widenmann (1764-1798) entitled "Handbuch des oryktognostischen Teils der Mineralogie", which had been published in Leipzig in 1794. In the third genus, called "siliceous", he distinguished 34 families, among them the family "XXIII Feldespatos", which included three species: common, adularia, and compact feldspar (Herrgen, 1799). Five years later, in 1804, Herrgen published in the same journal a translation of the mineralogical system of Josef Brunner, inspector of the Bavarian Mining Court in Leipzig, written in German in 1799. In that work, five terms were cited, which correlate with different feldspars: "espato cambiante" could refer to the iridescent alkali feldspars of the Norwegian syenites; "blenda cornea de Labrador" was described as a stone that could have various colors, including black, copper red, yellow or white, gray, and green. "Feldespato" was described as a laminar mineral, that is, referring to its double cleavage according to (001) and (010). "Labrador" was described as a play-of-color mineral, which thus repeated the description of the first stone. The fifth term is "adularia", in which the euhedral habit of the crystals was recognized, as well as the bluish white iridescence (Herrgen, 1804).

Thus, a transition took place throughout the 18th century, from the earliest Latin texts to a multitude of works written in different national languages, with an understanding of the feldspar group before the advent of high-precision chemical analysis in the first half of the 19th century. The American, Spanish, and European naturalists and mineralogists who founded the RGHN in Spain were in contact with their contemporaries, primarily with the German school of Werner.

The Historical Collection of Feldspars at the MNCN

The feldspar collection at the current MNCN dates back to the founding of the RGHN, from the Real Casa de la Geografía y Gabinete de Historia Natural in 1752. One of the earliest documents available regarding the feldspar collection is a letter dated February 27, 1780, addressed to Pedro Franco Dávila (1711–1786) and sent by Fernando López de Cárdenas (1719–1786), in which he expressed his interest in collecting quartz and "espaltos," that is, feldspars (MNCN, 1780a). Another early document is a letter from Joseph Clavijo (1726-1806) to the Duke of Alcudia, Manuel de Godoy Principe de la Paz (1767-1851), where he describes a sample from a quarry in Cordoba; Clavijo identified it as the stone that the ancients called "ophites", where he said that "the white spots with a greenish tinge are feldspar ("feld-espato") crystals, and the small blackish circles are transparent black quartz (MNCN, 1794). Another example of a historical document to consider is a letter dated August 12, 1800, from Christiano Herrgen to Joseph Clavijo Faxardo, in which he relates that Joseph Ibañez had brought several specimens of labradorite to the RGHN. The document (Figure 3) speaks of large pieces of "blenda cornea labradorica", as an extremely rare and valuable fossil, which until now has only been found on the coast of Labrador and compares them with other fragments of compact "feldspato" (MNCN, 1800a).


C179-3

Mi venerado amigo, Señor Dn. Joseph:
Ibañez, que de tiempo en tiempo me trae fósiles de los contornos de Horcajuelo, acaba de llegar, y entre las cosas que trae, he hallado dos grandes pedazos de la blenda cornea labradorica, fósil sumamente raro y apreciable, y que hasta ahora solo se ha encontrado en la costa de Labrador. Dirijo Ibañez con los dos pedazos á Vm, por si al caso Vm los juzgue dignos del Real gabinete, en el qual no hai nada de esta familia, menos, de la presente de España, que luego se publicará en los anales. Ibañez ha traido otros pedazos de la misma especie, menos buenos, pero que igualmente están á la disposicion de Vm.
Otros dos pedazos, que lleva Ibañez, son del feldspato compacto, igualmente mui

ACN0179/003 1

mui interesante.
El Sr Baron me encarga, en su carta de ayer, afectuosas expresiones para Vm
Mande Vm á este su agradecido amigo y servidor
Christiano Herrgen

Md. 12. Agosto 1800.

Sor Dn. Joseph Clavijo Faxardo.

2

Figure 3. Letter dated August 12, 1800, from Christiano Herrgen to Joseph Clavijo Faxardo regarding the sending of samples of "blenda cornea labradórica" to RGHN.

A large specimen of anorthosite mainly consisting of iridescent labradorite is still available in the Historical Collection of Feldspars of the MNCN, and it is shown in the permanent exhibition of the museum (Figure 4).

Since then, the feldspar collection has grown and currently consists of 324 specimens. Following the original identification of donors and collectors, the collection consists of the specimens shown in Table 1.

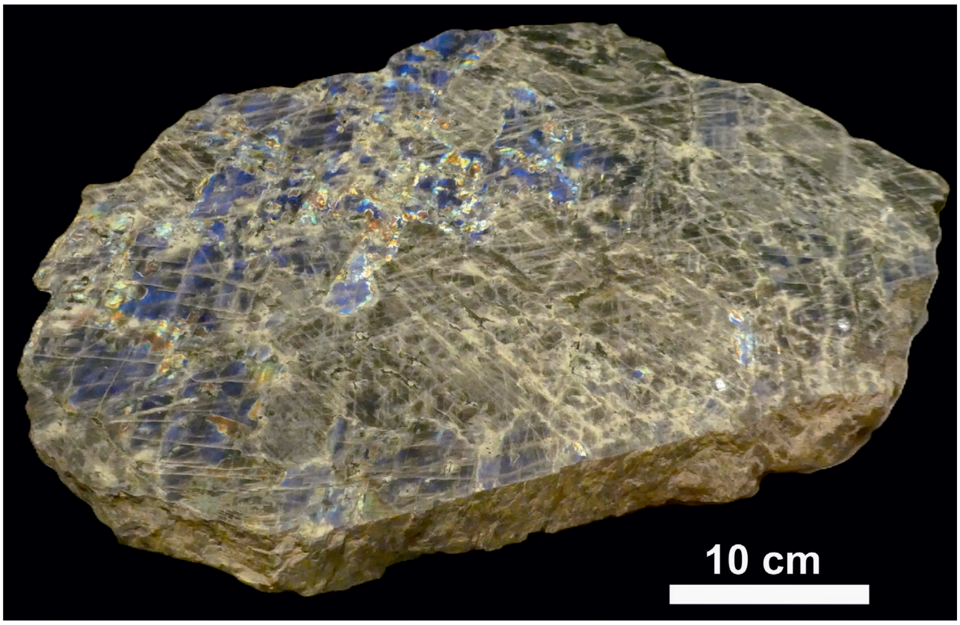


Figura 4. Specimen 13150 of labradorite (anorthosite) from the Labrador Coast, the largest available in the MNCN collection, measuring 60 x 38.4 cm and weighing 138 kg.

Table 1.— Feldspars in the Historical Collection of the MNCN.

Minerals	**Founds (Permanent Exhibion)**
Sanidine	13 (0)
Orthoclase (ortosa)	199 (1)
Microcline	42 (4)
Albite	31 (0)
Oligoclase	5 (0)
Andesine	7 (0)
Labradorite	5 (1)
Bytownite	0 (0)
Anorthite	22 (0)

Recorded donors include R. Altieri, D. C. Bouhard, T. Bravo, S. Calderón, R. Candel Vila, A. Charles de Mauroy, J. M. Fano, I. Fernández de Henestosa y Ortiz de Mioño (Marqués de Camarasa), P. Font i Quer, E. Hernández-Pacheco, J. M. Hueca, L. Fernández Navarro, J. Folch i Girona, J. Galván, A. Garralón Lafuente, F. Gómez Llueca, A. Lacroix, A. Lastre, J. Macpherson y Hemas, G. Martín Cardoso, Menchero, F. Novoa Álvarez, Pérez Garrido, Enrique Rioja, Regueral, I. Rodriguez Conde, J. Royo y Gómez, M. San Miguel, V. Sos Baynat, J.M. Tinas, J. Tuiro, J. Vilanova y Piera, and A. von Humboldt. Although he is not among the donors, Antonio de Pineda y Ramírez (1753-1792) should also be mentioned. He may have collected some of the valencianite samples in Mexico as part of the Malaspina Expedition (1789-1794). Odulio José Marensi de Moura and Martín Fernández Hernán, authors of this article, are also donors of feldspars to the collection of the MNCN.

The origin of sanidine specimens is primarily the Spanish volcanic rocks of Girona, Tenerife, and Almería, as well as Vesuvius in Italy.

The orthoclase specimens come primarily from the miarolitic pegmatites of the Hercynian granite of La Cabrera, near Bustraviejo (Madrid), also from the granitic porphyry of Zarzalejo (Madrid), as well as Carlsbad twins composed of two crystalline individuals with some degree of deformation from the well-known Ollo de Sapo gneiss formation. In all these cases, they are actually microcline, as the twin patterns can be seen by optical microscopy using thin sections. They were originally named "ortosa" due to their euhedral habit, forming Carlsbad-, Baveno-, and Manebach-type twins. In addition, some specimens were collected by Alexander von Humboldt (1769-1859) in the Sierra of Madrid, specimens that are recognizable because they have a very characteristic label, as shown in Figure 5.

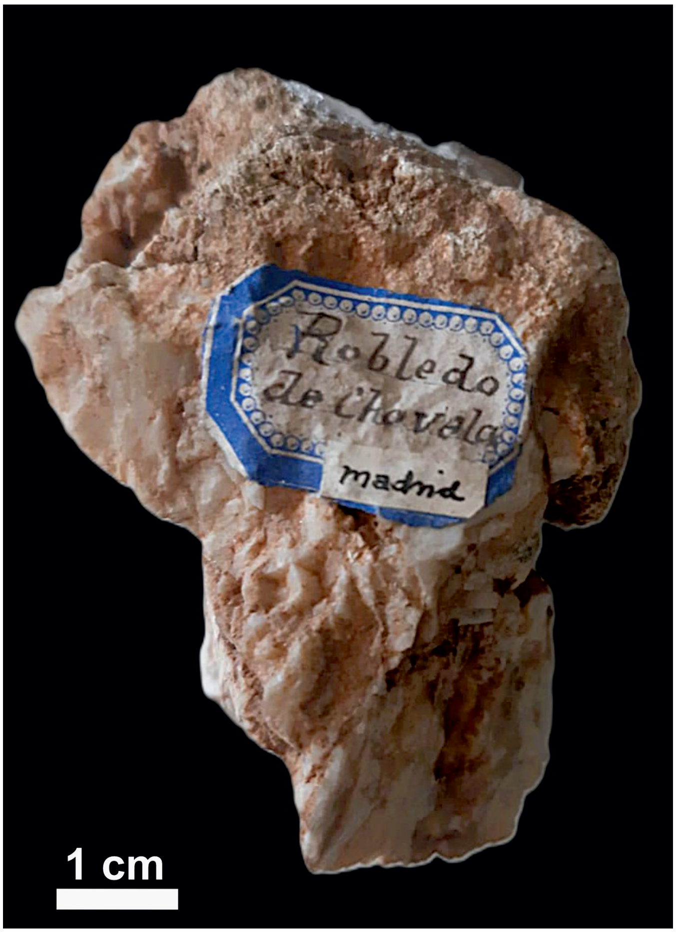


Figure 5.— Specimen 12972 of "ortosa" in the limestone quarries of Robledo de Chavela (Madrid), showing the typical label of the samples collected by Alexander von Humboldt.

Other samples catalogued as orthoclase are the adularia from the Alps, including the most famous localities in Switzerland, such as Saint Gotthard, and others from the Austrian Tyrol, such as Pfitschal or Salzburg. Many of the adularia specimens in the collection were acquired through an exchange with donation by Hermenegildo Pini (MNCN, 1787). Other samples possibly arrived at the museum in the first quarter of the last century, according to a pair of documents describing exchanges of fossils, minerals and rocks with Austria and Switzerland (MNCN, 1908; MNCN, 1925). Furthermore, we have a document that shows Franco Dávila's early interest in the "piedra de la luna" (moonstone), having commissioned Juan Bautista Paris to find a sample for the RGHN, according to letters dated January 4 and April 16, 1780. These letters mention that these stones resemble opal, but have a different brilliance, and that in candlelight they have a very pretty and strange appearance (MNCN, 1780b). Most of the adularia specimens in the collection are more or less transparent euhedral crystals, although there are some specimens with opalescent, whitish, and blue iridescences. A particularly interesting specimen of adularia is shown in Figure 6.

Figure 6.— Specimen 13011 of adularia from Salzburg (Austria), currently on display in the Minerals Room of the MNCN-CSIC.

Most of the microcline specimens are fragments of perthitic potassium feldspar from pegmatites in the province of Madrid, especially around El Escorial and Colmenar Viejo, as well as other Spanish pegmatites from Salamanca, Segovia, Pontevedra and Badajoz. Five amazonite specimens have been included in this group, including specimens from Pikes Peak (Colorado, USA) and the Ural Mountains (Russia), and specimen 13095 from Anjanabonoina, donated by the prestigious French geologist and mineralogist Alfred Lacroix (1863-1948), as a result of his close relationship with Lucas Fernández Navarro (1869-1930) since at least 1922 (MNCN, 1924). Thus, microcline was originally identified with the old term "compact feldspar", which had spar cleavage, but also a perthitic texture visible to the naked eye scale, or green colour.

The albite specimens are a heterogeneous group of samples, including those from Cerro de Piñuecar (Madrid) and La Cabrera (Madrid), crystals with a cleavelandite habit from Minas Gerais (Brazil), as well as small euhedral crystals classified as the "pericline" variety from the Alps of Switzerland and Austria. Notable among the donations is an albite from Antequera (Málaga), donated by José Macpherson y Hemas (1839-1902), and a pair of specimens donated by the Stockholm Museum in Sweden, related to the exchange of samples that took place between both museums, thanks to the collaboration between Ignacio Bolívar and Gregori Aminoff in 1930 (MNCN, 1930). There are also documents that attest to the donation and exchange of minerals with Adrien Charles, Marquis of Mauroy, one of them being an albite, in collaboration with Francisco Quiroga (MNCN, 1894).

Plagioclase is very poorly represented in the historical collection, and electron microprobe analysis has not been performed to verify the correct identification in any of these specimens. Of note are some confirmed oligoclase specimens from pegmatites in the Arendal region (Norway) and Iterby (Sweden), which were correctly identified by unknown donors or by chemical analysis in the first half of the 20th century. Also, the aforementioned labradorite from Labrador and andesine from Shinao (Japan) are important specimens. In addition, there are samples of anorthite from Vesuvius on Mount Somma in Naples (Italy), some of which have a label similar to that shown in Figure 5, and therefore correspond to donations from Alexander von Humboldt. No historical specimens of bytownite are available. Given the paucity of plagioclase in the MNCN's Historical Collection, a particular effort has been made to compile relevant specimens for the Scientific Collection.

The historical specimens of "valencianite"

Particularly important are the specimens of "valencianite" from the Valenciana silver mine in Guanajuato (Mexico). These specimens were originally classified as varieties of orthoclase together with adularia, i.e., as macroscopic crystals, in transparent to opaque masses, but having a habit with well-developed (curved!) faces. The historical collection has two samples of "valencianite", specimens 13043 and 13046, from the Valenciana mine. We also have a third non-historical sample (specimen 803). It was recently donated by Peter Modreski (U.S. Geological Survey of Denver, CO, USA), and acquired from Xtal-Dennis Beals Minerals, Greewood Village (Colorado, U.S.A.) from the same Mexican locality (Figure 7), but with different mineral features and also a distinctive X-ray diffraction pattern (Figure 8). Different samples of this mineral displays distinct values of the 2V angle, between 45º and 56º, and the optic plane practically parallel to (010), and thus, close to that of (volcanic) sanidine. In orthoclase and microcline, this plane is perpendicular to (010) (Chaisson, 1950; Laves 1950). Therefore, "valencianite" is a different polymorph from the three currently recognized mineral species of the potassium feldspar group by the International Mineralogical Association (IMA), i.e., sanidine, orthoclase and microline.

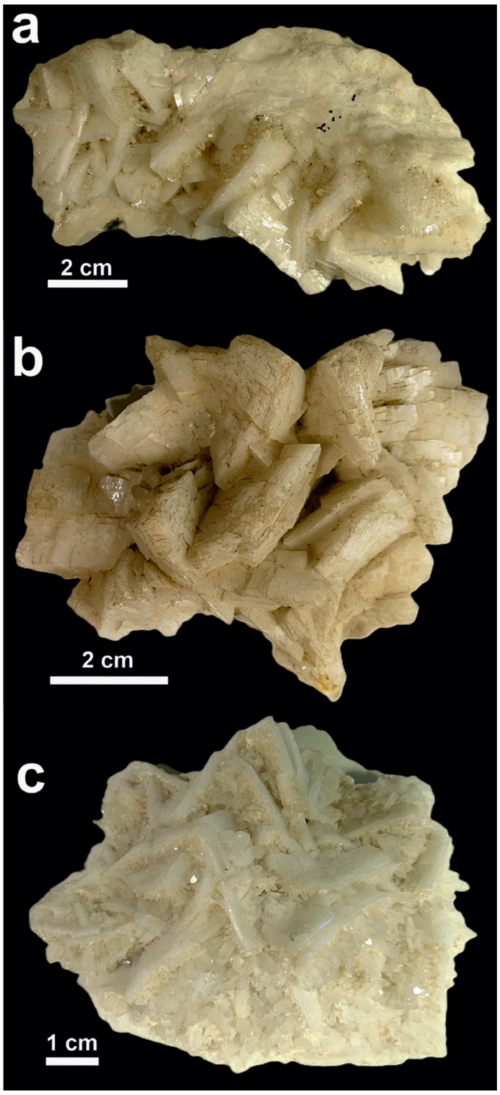


Figure 7.— The three specimens of "valencianite" from Valenciana mine, Guanajuato (Mexico), available in the MNCN-CSIC. a) Historical specimen 13043, 11 x 6 cm; b) Historical specimen 13046, 8 x 6 cm; and c) specimen 803, 7 x 6 cm, recently donated by Peter Modreski.

Specimen 13046 is the same specimen that was used previously (specimen AGM) for the identificacion and characterization of “valencianite” as a new *mineral species* in the group of potassium feldspars (Sánchez-Muñoz, et al. 2013, 2022). “Valencianite” has a chemical composition established from electron microprobe analysis to be very close to the ideal $KAlSi_3O_8$. It has the cell dimensions similar to that of disordered sanidine, but non-orthogonal α and γ cell angles with a low obliquity similar to triclinic microcline. Its nuclear magnetic resonace (NMR) spectra are consistent with Si and Al atoms having a modified Loewenstein’s distribution over four T tetrahedral sites, with additional strong constraints of charge dispersion, and K atoms in at least two M cavity half-sites. Their electron diffraction patterns lack diffuse streaks, owing to the lack of fine twinning or tweed microtexture at the mesoscale. Thus, it crystallized with triclinic symmetry at low (epithermal) temperatures. Recently, Prof. Javier Zúñiga, of the Dept. of Condensed Matter Physics of the Basque Country University (UPV/EHU) in Bilbao, performed single-crystal X-ray diffraction experiments. He obtained a $C\bar{1}$ triclinic lattice with the following cell parameters: a = 8.5918(9) Å; b = 13.021(1) Å; c = 7.1709(8) Å; α = 90.047(9)º, β = 116.128(8)º; γ = 89.735(9)º; V = 720.25(14) Å^3; and R = 3.64%. Unit-cell parameters using Rietveld refinement by using the whole-pattern decomposition (i.e., the profile-matching method) of powder X-ray diffraction patterns, are very similar to those from single-crystal experiments with specimen AGM: a = 8.594(1) Å; b = 13.024(1) Å; c = 7.177(1) Å; α = 90.06(1)º, β = 116.07(1)º; γ = 89.74(1)º.

Specimen 13043 is similar to specimen 13046, but the obliquity derived from peak splitting is lower owing to a smaller deviation from the orthogonality of the monoclinic structure.

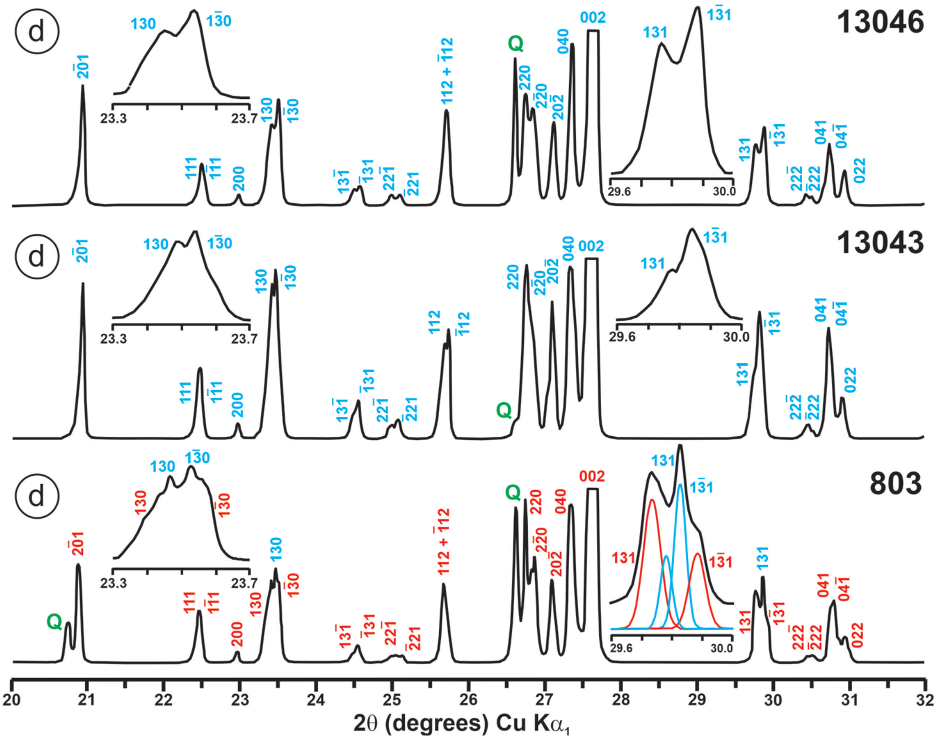


Figure 8.— Powder XRD patterns of the three specimens of K-feldspar in Figure 7 from Mina Valenciana, Guanajuato (Mexico), are shown with (hkl) values of the main Bragg diffraction peaks. Insets show the regions in which the (130)-(1$\bar{3}$0) peak splitting between 23.3 and 23.7º 2θ can appear, as well as the (1$\bar{3}$1)-(131) peak splitting between 29.6 and 30.0º 2θ. a) Specimen 13046 (idem specimen AGM) $Or_{97.3}Ab_{2.5}$ corresponds with “valencianite” with triclinicity Δ = 0.15, showing (hkl) peaks in blue. b) Specimen 13043 corresponds with “valencianite” with triclinicity Δ = 0.10, showing (hkl) peaks in blue. c) Specimen 803 is K-feldspar composed of two components. They can be interpreted as primary “valencianite” with triclinicity Δ ~ 0.06, (hkl) peaks in blue, at ~ 40 % wt, and a secondary triclinic K-feldspar with triclinicity Δ ~ 0.19, i.e., microcline, at 60% wt, with (hkl) peaks in red. The XRD patterns were obtained using a PANalytical X-Pert PRO theta-two theta instrument, with Cu Kα_1 radiation at 45 kV and 40 mA, and a primary germanium monocromator (Inc Beam 1xGe111Cu/Co), a X’Celerator RTMS-type detector. XRD patterns were recorded between 20 and 32º 2θ, with a step size of 0.004º and time constant of 4 s, in Servicio Interdepartamental de Investigación (SIdI) Universidad Autónoma de Madrid.The letter Q (green) marks peaks of quartz impurities in the samples.

Specimen 803 is different from true single-phase valencianite. The X-ray pattern is composed by a mixture of K-feldspars, and thus, it is similar to other samples from the same locality (Solé et al. 2021). Specimen 803 also has an adularia habit, but it shows some porosity, fine white clay mineral inclusions, and reddish iron oxide particles, indicating alteration from water circulation after crystallization, involving the transformation of primary "valencianite" into the well-known conventional K-feldspar of microcline. The coexistence of several K-feldspars has also been found in apparent single-crystals of "valencianite" at the Seikose mine, Japan (Akizuki and Sunagawa, 1978). In that specimen, true "valencianite" sectors coexist with others of microcline, as is also interpreted to be case in our specimen 803 (Figure 8). Hence, the two historical "valencianite" specimens from MNCN requires a particular explanation about their possible origin, and we have three different possibilities.

The first mention of the Valenciana mine in the MNCN arose because of the famous silver mineralization of Gauanajuato, from Antonio Pineda (1753–1792) in connection with the Malaspina scientific expedition, also called "the Scientific and Political Voyage around the World". The expedition took place between 1789 and 1794, and included Mexico and the western coasts of North and South America. Pineda was at the Valenciana mine on October 31, 1791 (MNCN, 1791a), and became interested in silver mining, describing the mineralization along with pyrite, in the form of golden flakes. Perhaps he was referring to "valencianite" when he described lamellar and other flake-shaped crystals covered in a white crust, as well as white euhedral quartz and a stone with the appearance of white resin (MNCN, 1791b). Despite the enormous volume of written documents left by Pineda relating to mineralogy and various objects of natural history as well as anthropology, the writing on the labels of the specimens of "valencianite" does not correspond to Pineda's handwriting. This enlightened naturalist died, exhausted after a scientific trip to the jungle, in Luzon (Philippine Islands) on July 6, 1792 (Madulid, 1982).

A second possible source for the two historical "valencianite" specimens in the MNCN is Alexander von Humboldt, whose trip to North and South America took place between 1799 and 1804. From late 1803 to early 1804, Humboldt visited Mexico, including the Real Seminario de Minería de Nueva España, and therefore, he visited Andrés Manuel del Río. There are several documents that attest to Humboldt's shipments of minerals and rocks to the RGHN (MNCN, 1800b; MNCN, 1801; MNCN, 1803; MNCN, 1818; MNCN, 1873). In his 1811 publication, Humboldt showed that he was particularly interested in the Valenciana silver mines, because he was aware of their economic importance. He estimated that the silver production of this mine had been far greater than that of the famous mines of Potosí (present-day Bolivia). He explained that the silver production of the Valenciana mine at that time had been almost double that of the Potosí mine. He cited the "crystallized feldspar" from the Guanajuato vein, a mineral that Mexican mineralogists (i.e., del Río and his assistants) called "rhomboidal quartz." To our knowledge, this is the first correct recognition of "valencianite" as a feldspar mineral.

Third, it is also possible that the samples we have at the MNCN may have been forwarded by Andrés Manuel del Río. In 1804, del Río described this mineral as "rhomboidal quartz," although in a footnote, he said that the lamellar crosses and crystallization indicated that it is a new "genus", i.e., what we call now a "mineral species". In 1819, del Río responded to Humboldt's criticism of 1811, regarding his identification of "valencianite" as a rhomboidal quartz, justifying his initial interpretation and report of 1804 published in a footnote to his translation of Karsten's Mineralogical Tables. He stated that he thought "valencianite" was, in fact, a new mineral species, but said that he knew at the time that the mineral had twice as much alumina as silica, due to an erroneous chemical analysis, and therefore thought it was not a feldspar. He suggested that this new genus be named "chovelia" in memory of the late Casimiro Chowell Jurado (1775-1810), close friend and manager of the La Valenciana mine, who was killed in 1810 during the Mexican insurgency at the beginning of the Mexican War of Independence. In spite of the identification of "valencianite" as feldspar by Humboldt, del Río criticized him for having taken so many pieces of that mineral from him without having yet performed any definitive chemical analysis (Río, 1819). In 1832, del Río still continued to defend the term "chovelia" for this mineral from the Valenciana mine, adding that in addition to silica and alumina, he had found "jargonia", that is, zirconium oxide (Río, 1832). In 1834 and 1835, del Río continued to insist on his proposal of "chovelia" as a “valencianite” feldspar from Mexico, comparing it with the Perikline species different from albite (Río, 1834, 1835).

From 1830 onward, Johann Friedrich August Breithaupt (1791-1873) was developing a detailed classification of feldspars on a crystallographic basis (Breithaupt, 1830a, 1830b), where he included a “genus” (i.e., a group) called “Felsit-Grammit” with another called “Normale Felsite oder Orthoklase”, i.e. the orthoclase group, which consisted of four species including “Valencianer” (valencianite), “Adularer” (adularia), “Glasiger” (sanidine) and “Pegmatischer” (twinned orthoclase-type feldspar from pegmatites). That same year, Breithaupt distinguished genera based on the angle formed by the two main cleavages of the feldspars, that is, along (001) and (010) orientations, which was orthogonal P∧M = 90° for “Orthoklastiche Felsite” and > 90° in “Gedrehte Felsite” or transformed felsites. In the second group, he included “Valencianer Felsit” or “Valencianit” where P∧M = 93°. Del Río had informed the German mineralogist previously that his chemical analysis indicated 52% by weight of silica, 38% alumina, and 13% by weight of a “problematic hydrochloride.” Unable to identify this problematic compound, del Río contacted Breithaupt to get an identification of it:

> “*This information concerning the chemistry of Valencian felsite came to me from the aforementioned esteemed mineralogist, through the kind mediation of Mr. F. de Mornay in London, to whom I also owe samples of the mineral. Later, I saw a whole geode of it at the home of Cabinet Counselor Heyer, from which I was also able to examine some fragments and found them identical to the original. I remember seeing such geodes in the Berlin Museum in 1818, which probably originated with Mr. von Humboldt, who also mentions this felsite in his works on Nueva España. Mr. del Río wanted to investigate the alkaline component more closely, when political circumstances arose that forced him, a native Spaniard, to leave Mexico*.” (Breithaupt; 1830a)

The second species in this group was a new term invented by Breithaupt, “Mikrokliner Felsit oder Mikroklin” or microcline, where he established a micro-inclination or deviation from the orthogonality of the angle P∧M of 90º 21′, while giving a chemical composition by weight of 65% silica, 20% alumina, 12.25% potash, 1.25% iron oxide and 0.5% water. And the third species in the group was “Hyposklerischer Felsit oder Hyposklerit” from Arendal (Norway), with P∧M = 93º 32′, although this term was not repeated into other publications; it was discovered that it is, actually, a mixture of several minerals (Rammelsberg, 1850). Interestingly, Breithaupt established a different classification in 1832 using only crystallographic data without chemical information, and so included 12 species in the genus “Felsit”, including “Valencianite” (P∧M = 93°) with “Petaline” (petalite), and other terms as “Perikliner” (P∧M = 93° 19′), “Pegmatischer”, “Mikrokliner”, “Amazoner”, “Adularer”, “Glasiger”, “Hyposklerischer”; “Tetartiner”, “Oligoklastischer”, “Porzellaner” and “Polychromatischer” (for labradorite) (Breithaupt, 1832). The controversy ended with the arrival of high-quality chemical data, and in 1841, the Swedish chemist Jöns Jacob Berzelius (1779-1848) identified “valencianite” as microcline on the basis of chemical analyses performed in Gustav Rose’s chemical laboratory (Berzelius, 1841).

In the mid-20th century, following the development of optical microscopy and X-ray diffraction techniques, Fritz Laves (1906–1978) became aware of euhedral adularia crystals with the Felsöbanya habit from Guanajuato, with a triclinic adularia geometry, and brought some samples to the University of Chicago, where they were studied by Ursula B. Marvin (1921–2018), Chaisson (1950). They displayed sanidine-like optical characteristics but microcline-like X-ray patterns with low triclinicity. This anomalous “triclinic adularia” was interpreted as a variety different from “monoclinic adularia”, i.e., distinct from the typical St. Gotthard adularia. This Alpine adularia has, in most cases, a monoclinic symmetry in powder X-ray patterns and diffuse streaks (instead of Bragg diffraction spots) in X-ray photographs, a value of angle 2V ~ 40º but oriented with the optical plane approximately perpendicular to (010), an average degree of order intermediate between sanidine and microcline (Laves, 1950; Laves and Goldsmith, 1961), as well as a “tweed” contrast in transmission electron microscopy images along the [001] zone (Sánchez-Muñoz et al., 2012). These features corresponds to the current name of IMA “orthoclase” as a mineral species, and can be explained by Mallard’s hypothesis, which is useless to explain “valencianite”.

Another study of a specimen of euhedral K-feldspar or adularia from Guanajuato showed a 2V an optic axial plane parallel to (010), as well a single monoclinic phase, consistent with the X-ray variant of high sanidine. However, an aliquot of this sample was studied by Hebert Kroll by using a Gunier photograph, showing many reflections doubled, features that were interpreted as "the presence of two monoclinic phases" (Černý and Chapman, 1986). As is clear in the powder X-ray diffraction patterns of "valencianite" in Figure 8a and 8b, the "doubled reflections" are, actually, consistent with a single phase but having a triclinic symmetry. Note that at that time, it was known that the (hkl), (hk0) and (0kl) reflections split in two signals, whereas the (h0l), (h00) (0k0) and (00l) reflections always remain single after the monoclinic $C2/m$ to triclinic $C\overline{1}$ transformation (Blasi, 1984).

Interpretation and implications

It is evident that Linnaeus was inspired by Aristotle's *scala naturae* when he developed his Systema Naturae into three kingdoms, with a well-defined hierarchical structure. Minerals were studied similarly to animals and plants using the concept of "species", a form of classification that has continued to the present day, and minerals are still classified as "mineral species". Before the development of precise chemical data and structural data by diffractometric techniques, species were distinguished only by using optical properties (color and iridescence), crystal geometry and structural symmetry from cleavage planes.

With the advent of chemical data, microtextural observations and optical and electron microscopy, a great diversity of feldspar *variants* was found. Once symmetry was analyzed by single-crystal X-ray diffraction, the "lattice" concept (i.e, the "lattice model") was improved and associated to mineral species. For K-feldspars, in 1934 the Norwegian mineralogist Thomas Fredrik Weiby Barth (1899-1971) suggested that: i) a similar cell has "variate atom equipoints" for Si and Al atoms, in other words, Si-Al order-disorder, and ii) K-feldspar is trimorphous, with sanidine, adularia and microcline, related by polymorphic changes, despite the fact that apparently monoclinic alkali feldpars are formed by submicroscopically twinned microcline, following Mallard's hypothesis. Later, adularia was identified with orthoclase, to give rise to the presently accepted mineral species by IMA (i.e., sanidine, orthoclase and microcline). The polymorphism of this compound was explained by a continuous linear transformation path of stable states, involving only a process of Si-Al chemical order-disorder along the K-feldspar series, with a monoclinic-triclinic transition at an intermediate point. "Valencianite" was considered to be an *unstable* structural state (Laves and Viswanathan, 1967). Since this idealized interpretation has been supported by most mineralogists to the present day, the term "valencianite" has been avoided and ignored, as it was not a necessary structure to make sense of such a simple idealized structural scheme.

Conclusion

The development of the MNCN-CSIC Historical Collection of Feldspars coincided with the development of mineralogy as an empirical science, in a historical context where the diversity of feldspars was progressively recognized. Some of the knowledge acquired up to 1840 on feldspars was partially lost with the legacy of the discoveries of different mineral species and was reinterpreted by modern experimental techniques, as was the case with "valencianite." Currently, we know that the mineral characteristics of this mineral phase (i.e., a completely disordered local structure with triclinic symmetry) are incompatible with a simple, idealized monoclinic-triclinic transition based on a transformation related only to Si-Al order-disorder chemical processes at tetrahedral sites. In the near future, "valencianite" could be accepted as a new mineral species by the Commission for New Minerals and Mineral Names (CNMMN) of the IMA. If this mineral structure of empirical origin were accepted, it could change the traditional view of the order-disorder transformation in potassium feldspars.

ACKNOWLEDGEMENTS

We thank to Prof. Javier Zúñiga (UPV/EHU) the single-crystal X-ray diffraction pattern and crystallographic data of specimen 13046 (specimen AGM), and the calculation of lattice parameters from it, as well as Noemí González Díaz (SIDI, UAM) for the powder XRD patterns of Figure 8 and Marta Furio (MNCN, CSIC) for the Rietveld refinement of the cell parameters. In addition, we thank Robert F. Martin and one anonymous reviewer for the suggestions and constructive comments.

DECLARATION OF COMPETING INTEREST

The authors of this article declare that they have no financial, professional or personal conflicts of interest that could have inappropriately influenced this work.

CRediT AUTHORSHIP

Luis Sánchez-Muñoz: Conceptualization, Data curation, Formal analysis, Resources, Supervision, Validation, Writing - original draft, Writing – review & editing. **Martín Fernández Hernán**: Data curation, Investigation, Visualization, Writing – review & editing. **Odulio J.M. de Moura**: Investigation, Supervision, Writing – review & editing.

References

Akizuki, M. & Sunagawa, I. (1978). Study of the sector structure in adularia by means of optical microscopy, infra-red absorption, and electron microscopy. *Mineralogical Magazine*, 42, 453-462. https://doi.org/10.1180/minmag.1978.042.324.07

Barth, T. F. W. (1934). Polymorphic phenomena and crystal structure. *American Journal of Science*, 227, 273-286. https://doi.org/10.2475/ajs.s5-27.160.273

Bell, R. (1895). The Labrador Peninsula. *Scottish Geographical Magazine*, 11(7), 335-361. https://doi.org/10.1080/00369229508732795

Berzelius, J. (1841). *Rapport Annuel sur les Progress des Sciences Physiques et Chimiques*. Présenté le 31 Mars 1840 a L'Academie Royale des Sciences de Stockholm, Paris, Fortin, Masson et Cie, Libraires-Éditeurs.

Blasi, A. (1984). The variation of 2θ angles in powder diffraction patterns of one- and two-step K-rich feldspars. *Bulletin de Minéralogie*, 107, 437-445. https://doi.org/10.3406/bulmi.1984.7773

Breithaupt, A. (1830a). Über die Felsite und einige neue Specien ihres Geschlechts. Schweigger's. *Journal of Chemical Physics*, 60, 316-330.

Breithaupt, A. (1830b). *Uibersicht des Mineral-System's*. J. G. Engelhardt, Freiberg.

Breithaupt, A. (1832). *Vollständige Charakteristik des Mineral - System's*. Arnoldische Bucggandlung, Lepizig.

Černý, P. & Chapman, R. (1986). Adularia from hydrothermal vein deposits: Extremes in structural state. *The Canadian Mineralogist*, 24, 717-728.

Chaisson, U. (1950). The optics of triclinic adularia. *Journal of Geology*, 58, 537-547. https://doi.org/10.1086/625761

Cronstedt, A. F. (1758). *Försök til Mineralogie, eller Mineral-Rickets Upställning*. N. von Oelreich, Stockholm.

D'Argenville, A. J. D. (1755). *L'Histoire naturelle eclaircie dans une de ses parties principales, l'Oryctologie qui traites des terres, des pierres, des métaus, des mineraux et autre fossiles*. Chez De Eure, Paris.

Dávila, F. (1767). *Catalogue systématique et raisonné des curiosités de la nature et de l'art. Tome Second*. Chez Briasson, Paris. https://doi.org/10.5962/bhl.title.154817

Denso, J. D. (1750). *Wallerius: Mineralogie, Oder Mineralreich*. Berlegts Christofph Gottlieb Nicolai, Berlin, 632 pp.

Forster, J. (1780). *Catalogue raisonné d'une collection de minéraux, cristallisations, pétrifications, coquilles, et autre object d'histoire naturelle*. Didot, Paris. https://doi.org/10.5962/bhl.title.69816

Herrgen, C. (1799). Materiales para la geografía mineralógica de España, y de sus posesiones de América. *Anales de Historia Natural*, 1, 5-16.

Herrgen, C. (1804). De un sistema nuevo de mineralogía, por D. Josef Brunner, primer inspector del tribunal del elector de Baviera, en Gottesgab del Fichtelberg: Leipzig, 1800. *Anales de Historia Natural*, 7(21), 219-342.

Hiller, J. (1967). *The foundation and the early years of the Moravian mission in Labrador, 1752-1805* [Master thesis dissertation, Memorial University of Newfoundland] http://research.library.mun.ca/id/eprint/6833

Humboldt, A. (1811). *Essai politique sur le Royaume de la Nouvelle-Espagne*. Schoell, Paris. https://doi.org/10.5962/bhl.title.38063

Kirwan, R. (1784). *Elements of Mineralogy*. P. Elmsly, London. https://doi.org/10.5962/bhl.title.23628

Kirwan, R. (1794). *Elements of Mineralogy* (Second Edition, Volume I. Earths and stones). J. Nichols, London.

Laves, F. (1950). The lattice and twinning of microcline and other potash feldspars. *Journal of Geology*, 58, 548-571. https://doi.org/10.1086/625762

Laves, F., Goldsmith, J. R. (1961). Polymorphism, order, disorder, diffusion and confusion in the feldspars. *Cursillos y Conferencias*, 8, 71-80.

Laves, F. & Viswanathan, K. (1967). Relations between the optic axial angle and triclinicity of potash feldspars, and their significance for the definition of "stable" and "unstable" states of alkali feldspars. *Schweizerische Mineralogische und Petrographische Mitteilungen*, 47, 147-162.

Leske, N. G (1778). Abhandlung von einigen fich mandelaben zum Feldspat gehdrigen Steinen aus Labrador. *Der Naturforscher*, 12, 145-163.

Linnaeus, C. (1735). *Systema naturae sive regna tria naturae systematice proposita per clases, ordines, genera, & species*. Lugduni Batavorum, Theodorum Haak. https://doi.org/10.5962/bhl.title.877

Linnaeus, C. (1740). S*ystema naturae sive regna tria naturae systematice proposita per clases, ordines, genera, & species*. Johann Joachim Langen, Salle.

Linnaeus, C. (1747). *Systema naturae in qvo natvrae regna tria, secvundvm clases, ordines, genera, species, systematice proponvntvr*. Editio Altera Avctior et Emendatior, Halae Magdebvrgicae.

Linnaeus, C. (1748). *Systema naturae sistens regna tria naturae in clases et ordines genera et species redacta tabulisque aeneis illustrata*. Impensis Godofr. Kiesewetteri, Lipsiae. https://doi.org/10.5962/bhl.title.36934

Madulid, D. A. (1982). The life and work of Antonio Pineda, naturalist of the Malaspina Expedition. *Archives of natural History*, 11(1), 43-59. https://doi.org/10.3366/anh.1982.11.1.43

MNCN (1787). *Oficio del Conde de Floridablanca a don Eugenio Izquierdo, le informa que don Christiano Heuland ha conseguido que su tío Jacobo Forster ceda, su gabinete de historia natural por 600.000 rs*. Documento ACN0090/041, Archivo MNCN-CSIC.

MNCN (1780a). C*arta de D. Fernando López de Cárdenas a D. Pedro Franco Dávila informándole que con la llegada de las dos remesas ha terminado su tarea del año que pasa*. Documento ACN0071/594, Archivo MNCN-CSIC.

MNCN (1780b). *Carta de D. Juan París a D. Pedro Franco Dávila contestando a la suya de 4 de septiembre último en la que le comunicaba que el Real Museo poseía la turquesa y sobre todo la venturina*. Documento ACN0071/592, Archivo MNCN-CSIC.

MNCN (1787). *Carta de don Hermenegildo Pini al señor Izquierdo, director del Gabinete de Historia Natural anunciándole el envío de dos cajones con minerales «chosis» en el navío «la Polacha», vía Alicante*. Documento ACN0090/044, Archivo MNCN-CSIC.

MNCN (1791a). *Vuelta desde Guanajuato para México. [Antonio Pineda]*. Documento ACN0033/616, Archivo MNCN-CSIC.

MNCN (1791b). *Apuntes y noticias sobre Guanajuato. [Antonio Pineda]*. Documento ACN0033/614, Archivo MNCN-CSIC.

MNCN (1794). *Carta de don Joseph Clavijo [al Duque de la Alcudia] presentándole la piedra tenida como la «Ophites de los Antiguos»*. Documento ACN0098/217, Archivo MNCN-CSIC.

MNCN (1800a). *Comunicación de Herrgen a Clavijo de unos fósiles traídos por Ibáñez y que hasta el momento sólo existían en la Costa del Labrador*. Documento ACN0179/003, Archivo MNCN-CSIC.

MNCN (1800b). *Oficio de don Mariano Luis de Urquijo a don Josef Clavijo, le informa que ha prevenido a los Directores de la Compañía de Filipinas para que le hagan llegar un cajón con minerales que conduce, de Caracas, el bergantín «San Ignacio de Loyola»*. Documento ACN0104/385, Archivo MNCN-CSIC.

MNCN (1801). *Carta del Barón de Humboldt a don Josef Clavijo, le habla de sus viajes y del envío que le dirige para el Real Gabinete*. Documento ACN0105/419, Archivo MNCN-CSIC.

MNCN (1803). *Oficio de don Pedro Cevallos a don Eugenio Izquierdo avisando la llegada, a la Aduana de Madrid, de cuatro cajones remitidos de América por el barón de Humboldt, para que se custodien en el Gabinete*. Documento ACN0106/449, Archivo MNCN-CSIC.

MNCN (1818). *Papeles referentes a la revisión de los cajones con minerales remitidos unos por Humboldt y otros por Gimbernat*. Documento ACN0124/086, Archivo MNCN-CSIC.

MNCN (1873). *Catálogo de la colección de rocas del Barón de Humboldt. José María Solano y Eulate*. Documento ACN0250/004, Archivo MNCN-CSIC.

MNCN (1894). *Propuesta del Marqués de Mauroy, Ingeniero Civil de Minas y Vicepresidente de la Société Française de Minéralogie, a Francisco Quiroga para el intercambio de meteoritos y otros minerales con el Museo de Ciencias de Madrid*. Documento ACN0261/019, Archivo MNCN-CSIC.

MNCN (1908). *Expediente sobre el envío de ejemplares geológicos y mineralógicos, que realiza el Museo, en concepto de cambio, al Museo de Viena, a la Cia. Grebel Vendler de Suiza y al Dr. Kaiser de la Univ. Giessen*. Documento ACN0274/026, Archivo MNCN-CSIC.

MNCN (1924). *Correspondencia entre los presidentes de las comisiones internacionales de vulcanología, señores Lacroix (Francia), Malladra (Italia) y Fernández Navarro (España), para optimizar los trabajos de investigación*. Documento ACN0305/019, Archivo MNCN-CSIC.

MNCN (1925). *José Royo Gómez dona al Museo de Ciencias Naturales más de tres mil ejemplares de fósiles, minerales y rocas pertenencientes a distintos especialistas de Francia, Suiza, Alemania y Bélgica*. Documento ACN0277/012, Archivo MNCN-CSIC.

MNCN (1930). *Expediente por el que Ignacio Bolívar, agradece al profesor Gregori Aminoff el envío al Museo de ejemplares de minerales como intercambio entre el Museo de Ciencias de Madrid y el Museo de Estocolmo*. Documento ACN0278/014, Archivo MNCN-CSIC.

Pini, H. (1779). *Memoire sur des nouvelles cristallisations de feldspath et autres singularités renfermeés dan les granites des environs de Baveno*. Joseph Marelli, Milan.

Pini, H. (1783). *Memoria mineralógica sulla montagna e sui contorni di S. Gottardo*. Giuseppe Maralli, Milan.

Rammelsberg, C. (1850). Ueber den Hyposklerit von Arendal. *Annalen der Physik*, 155(2), 305-307. https://doi.org/10.1002/andp.18501550211

Río, A. M. del (1795). *Elementos de orictognosia. Del conocimiento de los fósiles, dispuestos, según los principios de A. G. Wérner, para el uso del Real Seminario de Minería de México*. Mariano Joseph de Zúñiga y Ontiveros, México.

Río, A. M. del (1804). *Tablas Mineralógicas dispuestas según los descubrimientos más recientes e ilustradas con notas por D. L. G. Karsten*. Mariano Joseph de Zúñiga y Ontiveros, México.

Río, A. M. del (1805). *Elementos de orictognosia ó del conocimiento de los fósiles, dispuestos, según los principios de A. G. Wérner, para el uso del Real Seminario de Minería de México*. Mariano Joseph de Zúñiga y Ontiveros, México.

Río, A. M. del (1819). Carta dirigida al Sr. Barón de Humboldt por D. Andrés del Río, profesor de mineralogía del Real Seminario de Mineralogía de México, y socio corresponsal de algunas academias nacionales y extranjeras. *Mercurio de España*, 1, 169-176.

Río, A. M. del (1832). *Elementos de Orictognosia, o del conocimiento de los fosiles, según el sistema de Bercelio y según los principios de Abraham Gottlob Werner*. Juan F. Hurtel, Filadelfia.

Río, A. M. del (1834). Observations on the treatise of Mineralogy of Mr. C.U. Shepard, with the translation of "The characteristic of the Classes and Orders of Breithaupt". *Transactions of the Geological Society of Pennsylvania*, 1(1), 113-136.

Río, A. M. del (1835). Reply to "Observations on the Treatise of Mineralogy of Mr. C. U. Shepard". *The American Journal of Science and Arts*, 27, 312-325.

Romé Delisle, J.-B. L. (1772). *Essai de Cristallographie, ou description des figures géometriques*. Chez Didot jeune, and Knapen & Delaguette, Paris.

Romé de L'Isle, J.-B. L. (1783). *Cristallographie, ou description des formes propres a tous les corps du regne mineral, dan l'état du combinations saline, pierreuse ou métallique* (Second édition), De L'Imprimerie de Monsieur, Paris.

Sánchez-Muñoz, L., Sanz, J., Sobrados, I. & Gan, Z. (2013). Medium-range order in disordered K-feldspars by multinuclear NMR. *American Mineralogist*, 98(11-12), 2115-2131. https://doi.org/10.2138/am.2013.4448

Sánchez-Muñoz, L., García-Guinea, J., Zagorsky, V. Ye., Juwono, T., Modreski, P. J., Cremades, A., Van Tendeloo, G., de Moura, O. J. M. (2012). The evolution of twin patterns in perthitic k-feldspar from granitic pegmatites. *The Canadian Mineralogist*, 50, 989-1024. https://doi.org/10.3749/canmin.50.4.989

Sánchez-Muñoz, L., Florian, P., Gan, Z. & Muñoz, F. (2022). Order-Disorder diversity of the solid state by NMR: The role of electrical charges. *Minerals*, 12(11), 1375. https://doi.org/10.3390/min12111375

Schröter, J. S. (1775). Von dem Changeant oder Schieler unter den Steinen aus dem lande der Esquimaux, *Journal für die Liebhaber des Steinreichs und der Konchyliologie*, 2, 397-406.

Solé, J., Pi-Puig, T. & Ortega-Rivera, A. (2021). A mineralogical, geochemical, and geochronological study of 'valencianite'from La Valenciana mine, Guanajuato, Mexico. *Minerals*, 11(7), 741. https://doi.org/10.3390/min11070741

Tilas, D. (1740). Tanckar om Malmletande, i anledning af löse gråstenar. *Kongliga Swenska Wetenskaps Academiens Handlingar*, 1, 190-193.

Wallerius, J. G. (1747). *Mineralogia, Eller Mineral-ricket*. Med. Kopparstycken, Stockholm.

Waard, D. de (1969). Annotated bibliography of anorthosite petrogenesis. In Y. W. Isachsen (Ed.), *Origin of anorthosite and related rocks* (pp. 1-11), State University of New York College at Plattsburgh.

Werner, A. G. (1780). *Axel von Kronstedts Bersuch einer Mineralogie*. Bey Siegfried Lebrecht Crusius, Leipzig.

Woodward, J. (1728). Foss*ils of all kinds, digested into a method suitable to their mutual relation and affinity*. William-Innys, London.

Zenzén, N. (1925). On the first use of the term "Feldtspats" (= feldspar etc.) by Daniel Tilas in 1740. *Geologiska Föreningen i Stockholm Förhandlingar*, 47(4), 390-405. https://doi.org/10.1080/11035892509445614