Rev. CENIC Cienc. Quím.; vol. 51. (no.2): 325-368. Año. 2020. e-ISSN: 2221-2442.

BIBLIOGRAPHIC REWIEW

THE FAMOUS FINNISH CHEMIST JOHAN GADOLIN (1760-1852) IN THE LITERATURE BETWEEN THE 19TH AND 21TH CENTURIES

El famoso químico finlandés Johan Gadolin (1760-1852) en la literatura entre los siglos XIX y XXI

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Recibido: 19 de octubre de 2020. **Aceptado**: 10 de diciembre de 2020.

ABSTRACT

Johan Gadolin (1760-1852), considered the father of Finnish chemistry, was one of the leading chemists of the second half of the 18th century and the first half of the 19th century. His life and scientific achievements were described in the literature published between the 19th and 21st centuries. The purpose of this paper is to familiarize readers with the important events in the life of Gadolin and his research activities, in particular some of his research results, as well as his selected publications. In addition, the names of authors of biographical notes or biographies about Gadolin, published in 1839-2017 are presented.

Keywords: J. Gadolin; Analytical chemistry; Yttrium; Chemical elements; Finnland & Sverige – XVIII-XIX centuries

RESUMEN

Johan Gadolin (1760-1852), considerado el padre de la química finlandesa, fue uno de los principales químicos de la segunda mitad del siglo XVIII y la primera mitad del XIX. Su vida y sus logros científicos fueron descritos en la literatura publicada entre los siglos XIX y XXI. El propósito de este artículo es familiarizar a los lectores con los acontecimientos importantes en la vida de Gadolin y sus actividades de investigación, en particular algunos de sus resultados de investigación, así como sus publicaciones seleccionadas. Además, se presentan los nombres de los autores de notas biográficas o biografías sobre Gadolin, publicadas en 1839-2017.

Palabras clave: J. Gadolin; Química analítica; Itrio; Elementos químicos; Finlandia y Sverige - siglos XVIII-XIX

INTRODUCCIÓN

Gadolin became a specialist in analytical chemistry. It is in this field of chemistry,

he probably achieved the most significant successes on international scale. Lauri Niinistö (Niinistö, 2004, p. 138).

The important events in the Gadolin's life

Johan Gadolin (1760-1852) (Fig. 1) was born in Åbo (in Finnish Turku) on June, 5, 1760, and he was the son of Jacob Gadolin (1719-1802), a Professor of Physics and Theology at the Swedish National University of Åbo, also called the *Kunliga Akademin i Åbo* ("Building the Future", 2005), and Elisabeth (née Browallius) (1737-1793) (Tigerstedt, 1877, p. 97).

As a child, he showed great mathematical talent and studied at home with his father and home-teacher. At the age of 15, he began studying chemistry and physics at the University of Åbo. After four years of study, at the age of 19, he went to Uppsala in the summer of 1779 to continue his studies in chemistry under the direction of Torbern Bergman (1735-1784), one of the leading chemists of the time in Europe.

In Uppsala, in addition to chemistry, he studied mathematics, physics, philosophy, Latin, geology and mineralogy ("Suomen kemian historia", n.d.). In 1781, he published his first chemical study, the dissertation *De Analysi Ferri* ("Dissertatio Chemica De Analysi", 1871). A year later, on June 13, 1782, he received a Master's Degree in Philosophy after the publication of the mathematical treatise *De Problemate Catenario* ("Dissertatio Gradvalis De Problemate", 1782).

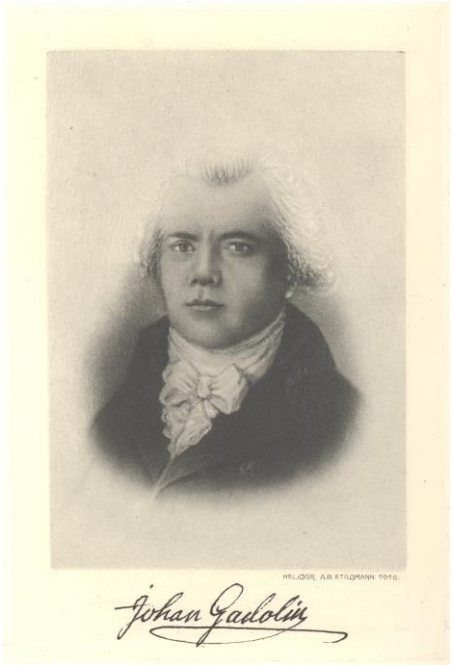

Fig. 1. Johan Gadolin (1760-1852) ("Johan Gadolin", 2008).

On July 2, 1785 he was appointed as an *E.O. Adjunct* (Pro Tempore Adjunct) at the Faculty of Philosophy as an award for his advances in physics and chemistry. In the same year, on August 8, he became a *E.O. Professor* (Pro Tempore Professor) at the University of Åbo (Renwall, 1869, p. 241; Tigerstedt, 1877, p. 101).

In the spring of 1786, Gadolin went on a two-years study trip to Europe. The anonymous author of an online article entitled *Suomen kemian historia. Johan Gadolin* (n.d.) wrote that he: "was able to write in Latin, German, Russian, English, French and Swedish. This made it possible to get acquainted with the greatest chemists of that time as well as to make fruitful connections with scientists" (p. 1). He traveled over Denmark to Germany, Holland, and England. He mainly stayed in Lüneburg, Helmstädt, the Harz region Mines, Göttingen, Amsterdam, London and Dublin (Hjelt & Tigerstedt,1910, p. IV). He met, among others, the German chemists Lorenz von Crell (1744-1816) and Johann Friedrich Gmelin (1748-1804) (Niinistö, 2014). In London, he worked with the Scots-Irish chemist Adair Crawford (1748-1795), who later discovered strontium (1790), and with the Irish chemist and natural philosopher Richard Kirwan (1733-1812) (Berry, 1915, p. 158). In addition, he attended the meetings of the Royal Society (Hjelt &Tigerstedt, 1910, p. IV-V; "Suomen kemian historia", n.d.; Dean & Dean, 1996, p. S166).

He was also in Dublin in Ireland. The physician and secretary of the Royal Society Sir Charles Blagden (1748-1820), informed about this the British naturalist Sir Joseph Banks (1743-1820), president of the Royal Society, in a brief mention in one of the letters of June 4, 1787. Bladgen (1958) wrote about it: "Gadolin is accompanying Kirwan to Ireland" (p. 70).

After returning from abroad, in a letter dated 5 August 1788, which Gadolin (1958) sent to Banks, he thanked him "for his kindness during his visit to England." He also informed him that "at Stockholm he repeated [Marc-Auguste] Pictet's [(1752-1825] experiments for reflecting heat from concave mirrors, with Prof. [Johan Carl] Wileke [Wilcke (1732-1796)] and others", and "hopes to remain at Åbo Univ. to conduct analyses of various minerals." In addition, in the letter he asked him "for samples of diamond spar", and provided information on sending "a paper on a method of analysing Iron to the Memoirs of Stockholm Academy" (pp. 350-351).

On January 3, 1789, he was appointed Ordinary Lecturer and shortly thereafter on May 6, he became an Extraordinary Professor of Chemistry (Tigerstedt, 1877, p. 102). He began to lecture, because the current head of the Department of Chemistry Pehr Adrian Gadd (1727-1797) was released from this duty. After Gadd's death, as a full Professor, he became his successor. He immediately took charge of the chemical laboratory and the mineralogical cabinet (Renvall, 1869, p. 241) and worked at the University of Åbo for twenty-five years, until 1822. In 1809, after the creation of the Grand Duchy of Finland, which was part of the Russian Empire, this University was renamed the *Imperial Academy of Åbo* ("Building the Future", 2005).

Gadolin was married twice. On September 30, 1794, he was married Hedvig Magdalena Tihleman (1776 - 1817), a daughter of a merchant. After her death, he remained alone for three years and on March 24, 1820, he remarried to Ebba Katarina Palander (1786-1857), the sister of Professor Gabriel Palander (1776-1821). He had nine children from his first marriage. Two of them died at a young age. In the second marriage he had no children (Tigerstedt, 1877, pp. 104, 217).

The great conflagration that destroyed Åbo in 1827 interruped Gadolin's scientific activity forever. The University buildings and collections were largely destroyed in flames. A year later, the University was transferred to Helsingfors and renamed the *Imperial Alexander University*. ("Building the Future", 2005).

After this tragic event, Gadolin lived for 25 years on his two county estates. The first was located in the *Parish Vichtis* (in Finnish Vihti), and the second in the *Parish Virmo* (in Finnish Mynämäki). He died on the second estate at the age of 92 on August 15, 1852 (Hjelt & Tigerstedt, 1910, p. VII).

Gadolin's works

The list of works published by Gadolin includes 59 papers published over forty-two years from 1781 to 1827 (Tigerstedt, 1877, pp. 220-224). His works include dissertations in Latin as well as articles presenting his research results. Most of them were published in *Kungliga Svenska Vetenskapsakademien,* and *Handlingar* and *Nova Acta Regiae Societatis Scientiarum Upsaliensis* in Sweden, as well as in *Chemische Annalen für die Freunde der Naturlehre, Arzneygelährtheit, Haushaltungskunst, und Manufacturen* (*Crells Chemische Annalen*) in Germany.

In France, he published his articles in *Annales De Chimie, Ou, Recueil De Mémoires Concernant La Chimie Et Les Arts Qui En Dépendent* (Gadolin, 1793) and *Observations Sur La Physique, Sur L'Histoire Naturelle Et Sur Les Arts* (Gadolin, 1789a).

Among them are his original articles deal with thermochemistry and inorganic chemistry. For instance, during last year in Uppsala (1783), he began his important thermal engineering research on specific heat, which he later continued in Åbo and published in 1784 (Gadolin, 1784). Partington (1962) wrote about this study as follows: "He made accurate determinations of the specific heat (0.5315) and latent heat of fussion (81.1) of ice (which he showed to be the same as that of snow)" (p. 235).

In 1788, he wrote an article under the title *Rön och Anmärkningar om Järnmalmers Proberande på våta vägen*, about analysis of iron ores by wet method (Gadolin 1788a). According to T[horpe] (1911), he gave in it "the first suggestion of a method of volumetric analysis" (p. 49). One year later, he wrote an article entitled *Undersökning huruvida Brunsten kan förvandlas i Kalkjord* (Gadolin, 1789b). Lennardson (2017) wrote that he described in it how he "found that the calcium compounds (lime) were contaminants in the sugar" (p. 26).

Other article written by Gadolin in Latin, under the title *Animadversiones in novam Nomenclaturæ Chemicæ Methodum* was also published in 1788 (Gadolin, 1788c). In this article he presents his comments on the changes in the new chemical nomenclature described in the book *Méthode De Nomenclature Chimique*, which jointly wrote by the French chemists Louis-

Bernard Guyton de Morveau (1737-1816), Antoine-Laurent Lavoisier (1743-1794), Claude-Louis Berthollet (1748-1822) and Antoine-François de Fourcroy (1755-1809) (de Morveau, Lavoisier, Bertholet, & de Fourcroy, 1787). This paper was also included in the original in the book written by Hjelt and Tigerstedt (Hjelt & Tigerstedt, 1910, pp. 62-72). In 1789, the French chemist Pierre-Auguste Adet (1763-1832) translated this article into French. In the final part of it, Gadolin cautiously talks about the anti-phlogistic (oxygen) theory. Adet (1789) wrote that he says that "although it seems to him that the anti-phlogistic theory has some semblance of truth, that phlogiston doesn't push him away, & that he believes that science is still too weak for us to think about creating a theory and chemical nomenclature" (p. 206).

In 1791, Gadolin described his new cooling device for brandy distilleries in one of his works written in Swedish entitled *Beskrifning på en förbättrad Afkylningsanstalt vid Bränvins-Brännerier* (Gadolin, 1791). The illustration of this distillation apparatus is included in a excerpt of this paper translated into German by the Finnish chemist and historian of chemistry Edvard Immanuel Hjelt (1855-1921) and the Finnish-Swedish Physician and Professor of Physiology Robert Tigerstedt (1853-1923) (Hjelt & Tigerstedt, 1910, p. 55).

His paper under the title *Om Kopparens förmåga at fälla Tenn utur dess Uplösning i Vinstens-Syra* (On the Ability of Copper to Precipitate Tin from its Solution in Tartaric Acid) was published in 1788 (Gadolin, 1788b). In this article he mentioning the two oxidation states of tin and their disproportionation reaction (Pyykkö & Orama, 1988, pp. 882-883).

He also sent twenty-two reports in the form of a letter to the German chemist Lorenz Florenz Friedrich von Crell (1744–1816), who then published these letters in Germany in the *Crells Chemische Annalen* and the *Annales de Chimie* in 1787-1798 (Hjelt & Tigerstedt, 1910, p. XCVII-XCVIII) and to Guyton de Morveau and Berthollet, who published them in *Annales De Chimie, Ou, Recueil De Mémoires Concernant La Chimie Et Les Arts Qui En Dépendent* (Guyton, 1791; Berthollet, 1790). Thus, the scientific community in Europe was able to gain access to his works very quickly (Niinistö, 2014).

The first textbook in Swedish under the title *Inledning Til Chemien*, in which Gadolin used the new anti-phlogistic chemistry was published in 1798 (Gadolin, 1798). This book was modeled on de Fourcroy *Philosophie Chimique* (Fourcroy, 1792). In a letter sent by him to Guyton de Morveau on January 19, 1797, Gadolin (1797) informed him of his intention to publish this book. He wrote about it:

Je me propose de publier bientôt une Philosophia chemica, d'après M. Fourcroy, ou plutôt une traduction en suédois de son ouvrage, qui me paroît, de tous les livres élémentaires dans la chimie, être le plus applicable aux leçons chimiques (I intend to publish soon a *Philosophia chemica*, according to M. Fourcroy, or rather a Swedish translation of his work, which seems to me, of all the elementary books in chemistry, to be the most applicable to chemical lessons) (p. 109).

One of his works concerns the chemical mineral system, that he created. In 1825, he published it in Berlin in his book, which he wrote in Latin (Gadolin, 1825). Hjelm and Tigerstedt (1910) wrote about this system as follow:

However, this work is no major importance and Gadolin's chemical mineral system has never been considered in mineralogy. However, in this branch of natural research, Johan

Gadolin's nephew, AXEL GADOLIN (General and Professor of the Artillery Academy in St. Petersburg, born in 1828, died in 1892), gained a famous name (p. VII).

In 1827, he wrote a book entitled *Commentatio De Gemmis Arte Procreandis* (Gadolin, 1827). Sinkankas (1996) wrote that in this 37-page book he discussed "some general principles of chemical combination, alumina in gemstones, its isolation by chemical means, and the compositions of alumina-bearing gemstones as corundum, chrysoberyl, spinel, beryl, euclase, topaz, and garnets" (p. 337).

Gadolin's most famous experimental achievement

Gadolin went down in the history as a discoverer of yttrium. It was the "unknown earth" discovered by him in 1794 in a small greenish black sample (Thomson, 1810, p. 88) of a mineral found by the chemist and amateur geologist, Captain Carl Axel Arrhenius (1757-1824) in a feldspar mine near the Swedish village of Ytterby on the island of Resarö in the Stockholm archipelago, who called it a *ytterbite.* Gadolin performed the first full analysis of the chemical composition of ytterbite. Its results showed that the sample contained 38% of its weight, the *okänd Jordat* (unknown earth). He published the results of his research in an article entitled *Undersökning av en Svart tung Stenart ifrån Ytterby Stenbrott i Roslagen* (Investigation of a Black Heavy Rock from Ytterby Quarry in Roslagen) (Gadolin, 1794, p. 146). This article was published two years later also in German in *Crells Chemischen Annalen* (Gadolin, 1796). The subsequent stages of mineral sample analysis were also described in detail by him. Professor Pekka Pyykkö (b. 1941) and Dr. Olli Orama (b. 1944) from the Department of Chemistry of the University of Helsinki, in their article, presented an English version of his procedure for the chemical analysis of a sample (Pyykkö & Orama, 1996, pp. 1-12).

The first confirmation of Gadolin's analysis was made by the Swedish chemist Anders Gustaf Ekeberg (1767-1813), the discoverer of tantalum in 1802. Adunka and Orna (2018) wrote that "he had obtained a larger sample of ytterbite which had been partially purified of feldspar" (p. 17). His analysis showed that the sample contained 47.5% of its weight, the "new earth", subsequently called *yttria*. He published the results of his analysis in an article under the title *Ytterligare undersökningar af den svarta Stenarten frön Ytterby och den dåri fundna egna jord* (Further Investigations of the Black Rock Species of Ytterby and the Earth Found In It) in 1797 (Ekeberg, 1797, p. 159; Pyykkö & Orama, 1996, p. 9).

In 1800, the French chemist Louis-Nicolas Vauquelin (1763-1829), who discovered of chromium (1797) and beryllium (1798), made the second confirmation of Gadolin's analysis. He showed that the sample of mineral from Ytterby contained 35% of its weight, the *terre nouvelle, ou yttria* (new earth, or yttria) (Vauquelin, 1800, p. 152).

The third confirmation of Gadolin's analysis was made by the German chemist Martin Heinrich Klaproth (1743-1817) in 1802. His analysis of the chemical composition of the sample of mineral from Ytterby showed that it contained 59.75% of its weight, the "unknown earth" (*Yttererde*) (Klaproth, 1802, p. 65).

Rabinovich (2010) wrote about the great achievement of Gadolin as follow:

Although Gadolin had actually isolated yttrium oxide (Y2O3), he is usually credited with the discovery of the element, which was subsequently obtained in fairly pure form by [the German chemist] Friedrich Wöhler (1800–1882), better known of course for his synthesis of urea from ammonium cyanate (p. 23).

Wöhler published the results of his research in an article entitled *Ueber das Beryllium und Yttrium* in 1828 (Wöhler, 1828). He made it made by reacting yttrium chloride with potassium ("Ytrrium", 2020).

Wöhler (1828) wrote about it:

Ich habe ihre Abscheidung auf dieselbe Weise, wie die des Aluminiums versucht, nämlich durch Reduction ihrer Chlorverbindungen vermittelst Kalium, und eben so leicht, wie bei jenem, ist es mir geglückt, diese Metalle in isolirtem Zustande zu erhalten (I tried their deposition [beryllium, yttrium] in the same way as that of aluminium, namely by reducing their chlorine compounds by means of potassium, and just as easily as with that one [aluminium], I succeeded in keeping these metals in an isolated state) (p. 577).

Biographical notes or biographies about Johan Gadolin published in 1839-2017

In 1839, Gadolin's biographical note was published in the *Biographiskt Lexicon Öfver Namnkunnige Svenska Män* (Biographical Lexicon of the Famous Swedish Men) written by an anonymous author ("Biographiskt Lexicon Öfver", 1839, pp.118-119).

Thirty years later, in 1869, the Finnish librarian Robert Alfred Renvall (1829-1895) wrote biographical note of Gadolin and published it in his *Biografiska Anteckningar Öfver Det Finska Universitets Lärare, Embets- och Tjenstemän*, *Från Dess Flyttning Till Helsingfors År 1828 Till Nuvarande Tid* (Biographical Notes About the Teacher of the University of Finland, Officials, from its Relocation to Helsinki in 1828 to the Present Time) (Renvall, 1869, pp. 241-243).

The Gadolin's first biography was written twenty-five years after his death by Tigerstedt in 1877. In the first part of his work, the author described his life and activities as an academic teacher and patriot. Then he described Gadolin's works in the field of thermochemistry, as well as in theoretical and practical chemistry. Finally, he discussed his scientific activity in the years 1805-1827 (Tigerstedt, 1877).

In the first half of the 20th century, some authors wrote about Gadolin in German and English. In 1910, Hjelt and Tigerstedt wrote about his life and works in their book. This publication is enriched by list and the content of Gadolin's correspondence with many scientists. In addition, it contains fragments of 31 reprints of his selected works (Hjelt & Tigerstedt, 1910).

In 1911, an article about him was appeared in *Nature*. Its author was the British chemist and historian of chemistry Sir Thomas Edward Thorpe (1845-1925) (T[horpe], 1911).

Professor Gustaf Komppa from Helsingfors wrote about him and other Finnish chemists in an article under the title *Über ältere finnische Chemiker*, which was published in 1927 (Komppa, 1927).

In the second half of the 20th century, several authors of Gadolin's bibliographic notes wrote them in English, Swedish, and Russian. The American chemist and historian of chemistry Mary Elvira Weeks (1892-1975) wrote about him in her book under the title *Discovery of the Elements* in 1956 (Weeks, 1956, p. 698-699), while the British chemist and historian of chemistry James Riddick Partington (1886 -1965) brought the reader closer to his life and work in his *History of Chemistry* published in 1962 (Partington, 1962, pp. 234-236).

In 1966, a book about him was published in Sweden. It was written by the Finnish-Swedish scientist Ragnar Granit (1900-1991), who received the Nobel Prize in Physiology or Medicine in 1967 (Granit, 1966).

Pyykkö and Orama wrote about him in an article published in 1988 (Pyykkö & Orama, 1988, p. 881-882), and Professor Emeritus Peter B. Dean and Kirsti I. Dean from the Department of Diagnostic Radiology at the University of Turku (Finland) described his early life and education as well as his career in the eighteenth century (Dean & Dean, 1996).

In 1991, the Russian historian of science Vladimir Akimovich Volkov (1936-2012), Evgeny Vladimirovich Vonsky, and Galina Ivanovna Kuznetsova briefly wrote about his life and scientific activity in their book under the title *Vydayushchiyesya khimiki mira. Biograficheskiy Spravochnik* (Outstanding Chemists of the World. Biographical Guide) (Volkov, Vonsky, & Kuznetsova, 1991, p. 656).

In the 21st century, Gadolin was not forgotten either. His biography in Russian was written by Lauri Niinistö (b. 1941), a Professor of Inorganic Chemistry at Helsinki University of Technology. He published it in the book *Sto zamechatel'nykh finnov. Kaleydoskop biografiy* (One hundred wonderful Finns. A Biographical Kaleidoscope) in 2004. An electronic version of this book is also available on the Internet (Niinistö, 2004, pp. 137-140).

Professor Emeritus James L. Marshall and M. Ed. Virginia R. Marshall (1945-2014) from Department of Chemistry at the University of North Texas in Denton (U.S.A.) in an article entitled *Rediscovery of the Elements*. *Yttrium and Johan Gadolin* briefly wrote about him and his important researches in 2008 (Marshall & Marshall, 2008).

Academician Enrique J. Baran, a full member of the *Academia Nacional de Ciencias Exactas, Físicas y Naturales* (National Academy of Exact, Physical and Natural Sciences) in Buenos Aires (Argentina), wrote about Gadolin in an article under the title *La Fascinante Historia Del Descubrimiento De Las Tierras Raras* (The Fascinating Story of the Rare Earth Discovery)(Baran, 2016).

In 2017, Professor Wolfhard Semmler from German Cancer Research Center in Heidelberg (Germany) wrote about Gadolin's life and work in an article entitled *Johan Gadolin – Namensgeber für das Element Gadolinium* (Semmler, 2017).

CONCLUSION

Johan Gadolin was one of the most distinguished chemists of his time. He is considered the father of Finnish chemistry. In the years 1788-1823, he was elected as a member of several academies of sciences and scientific associations. He became a member of the Royal Academy of Sciences in Dublin in 1788 (Tagerstedt, 1877, p. 110). On February 1790, the Royal Swedish Academy of Sciences in Stockholm elected him as a domestic member. In 1809, he became a foreign member of this Academy (Dahlgren, 1915, p. 131). He became a corresponding member of the Imperial Academy of Sciences in St. Petersburg on May 22, 1811 ("Gadolin Yukhan", 2017). On October 29, 1791, he became a member of the Scientific Society of Uppsala. The *Société de Medécine*, *Chirurgie et Pharmacie de Brussels* (Society of Medicine, Surgery and Pharmacy of Brussels) elected him a member in 1795. On November 25, 1804, he was elected a member of the Scientific Society in Göttingen. He became the member of the Naturalist Society of Moscow (April 24, 1814), the Physiographical Society in Lund (March 9, 1815), the Naturalist Society in Marburg (September 13, 1817), and the Mineralogical Society of St. Petersburg (March 29, 1819). On March 24, 1816, he was elected an honorary member of the Mineralogical Society of Jena. He became an honorary member of the Pharmaceutical Society of St. Petersburg on March 29, 1819, and the Finnish Scientific Society on April 3, 1823 (Tagerstedt, 1877, p. 111).

On March 15, 1825, he was honored the Order of Saint Anna, 2nd class, and on July 3, 1840, he was awarded the Order of Saint Vladimir, 3rd class (Renvall, 1869, p. 241).

In honor of Gadolin, a black mineral in which he discovered "unknown earth", Klaproth (1802) called *gadolinite*. He wrote about it: "So Mr. *Gadolin* has the merit, that he first discovered this new earth in the current fossil; therefore, also with a few naturalists, I prefer the name *Gadolinite* compared to the previous name *Ytterbite*" (p. 54).

Gadolinite is currently differentiated in Gadolinite-(Ce)[$(Ce,La,Nd,Y)_2Fe2+Be_2Si_2O_{10}$] ("Gadolinite-(Ce)", 2020), Gadolinite-(Y) [$Y_2Fe2+Be_2Si_2O_{10}$] ("Gadolinite-(Y)", 2020), and Gadolinite-(Nd) [$Nd_2Fe2+Be_2O_2(SiO_4)_2$] ("Gadolinite-(Nd)", 2020), according to the most commonly occurring rare earth elements in the mineral. Gadolinite - (Y) is the current name of the gadolinium mineral that was mined in Ytterby, while Gadolinite - (Nd) was found in the Malmkärra mine, near Norberg in Sweden. Gadolinite - (Ce) is mined in Buer, near Bjørkedalen in Norway.

The element 64 in the Periodic Table was named after Johan Gadolin (Weeks, 1956, p. 875; Adunka, 2018, p. 23; McLennan, 2018, p. 525; Childs, 1998, p. 42). The Swiss chemist Jean-Charles Galissard de Marignac (1817-1894) in a letter sent in 1886 to the French chemist Paul-Émile Lecoq de Boisbaudran (1838-1912), the discoverer of gallium in 1875, proposed the name *gadolinium* for the element Yα, which he identified spectroscopically in the mineral gadolinite in 1880. Marigniac also separated his oxide and is credited with its discovery. This metal was isolated by Lecoq de Boisbaudran in 1886 ("Gadolinium", n.d.).

Boisbaudran (1886) in a short note published in *Comptes Rendus de l'Académie des Sciences* under the title *Le Yα de M. de Marignac est définitivement nomme gadolinium* (Mr. de Marignac's Yα Is Definitely Named Gadolinium), wrote:

During a correspondence which I recently had the honor of maintaining with M. de Marignac, I took the liberty to draw the attention of the illustrious chemist to the advantage which there would be, for those who deal with rare earths, to see the Yα receivings interesting, has long been too well studied and its spectrum offers characteristics too clear for any doubt to exist as to its individuality. ... Mr. de Marignac kindly asked me to announce to the Academy that he had chosen the name of gadolinium (symbol Gd) for the metal of Yα (p. 902).

In the years 1784-1801, correspondence was conducted between Gadolin and scientists from various European countries, including Sweden. He received about 150 letters. Among the letter senders were, among others Guyton de Morveau and Armand Seguin (1767-1835) from France, and Kirwan, Crawford, and Banks from England. He also received letters from Crell and Gmelin from Germany. Most letter senders were from Sweden. He received them, among others from Ekeberg, Carl Wilhelm Scheele (1742-1786), Johan Gottlieb Gahn (1745-1818), Peter Jacob Hjelm (1746-1813), Sven Rinman (1720-1792), Johan Carl Wilcke (1732-1796) and Olof Peter Swartz (1760-1818) (Hjelt & Tigerstedt, 1910, p. LXVI).

After Gadolin, not only his papers and letters remained. In addition, since 1937, the *Suomalaisten Kemistien Seura* (Society of Finnish Chemists) has awarded outstanding chemists a gold medal of recognition, named the *Gadolin Medal*, in honor of this great chemist (Weeks, 1956, p. 694). This medal was made in 1936. Its author was Emil Wikström (1864-1942). On the obverse there is a Gadolin's image. The reverse side presents a group of chemists studying the rare earths obtained from the gadolinite mineral. This is a double-sided medal with a diameter of 60 mm.

On its front there is an inscription: JOHAN GADOLIN / 1760 / 1852 / PRO / EXIMII / MERITS [FOR EXCELLENT MERIT]. It has an embossed inscription around: RERVM / CHEMICARVM / ILLVSTRISSIMVS / IN / FENNIA / INVESTIGATOR [THINGS / CHEMICAL PROPERTIES / FAMOUS / IN / FINLAND / INVESTIGATOR]. On its reverse, on the upper part is written: GADOLINIT, and the lower one - /S / K / S / [SUOMALAISTEN KEMISTIEN SEURA]. The bronze Gadolin's medal for collectors' needs is available on the Internet ("Henkilömitali; mitali; muistomitali", n.d.).

Gadolin's death did not go unnoticed. In the nineteenth century, books with his biographical notes or biographies were written in Swedish. In the twentieth and twenty-first centuries, his life and work were described by authors of books and articles from U.S.A., Great Britain, Finland, Sweden, Russia, Argentina and Germany.

A British chemist and historians of chemistry, and a chemist from Finland have spoken very positive about Gadolin and his work. In their eyes, he was the most eminent Finnish scientist and an excellent experimenter. Below, these statements are quoted.

T[horpe] (1911) wrote about his place in the history of chemistry as follows:

JOHAN GADOLIN, one of the most distinguished of Finnish men of science, occupies a well-defined position in the history of chemistry. He was a pupil of Bergman, a friend of Scheele, and the forerunner of Berzelius. He served as a connecting link, as it were, in the new departure of the science as initiated by the workers at Upsala, and as so splendidly furthered by the secretary of the Stockholm Academy. Gadolin's scientific activity was, in

fact, concentrated within the two decades which elapsed between the death of Scheele and the coming of Berzelius, and his labours worthily upheld the traditions of the Scandinavian school (p. 48).

Niinistö (2014) wrote about him:

In a short time, Johan Gadolin raised the research in chemistry in Finland to international level. Of this, his many pioneering publications bear witness to lasting value; moreover, the fact that the University of Göttingen called him the holder of the chair of chemistry after the renowned J. F. Gmelin, an honor that Gadolin to the happiness of the Åbo Academy, declined. The subject of chemistry, as well as the natural sciences in general, lacked a wider foundation during this time and therefore depended on the efforts of individuals. Neither could Gadolin create his own scientific direction, but the analytical-mineralogical tradition continued through his student Per Adolf von Bonsdorff [(1791-1839)] when he succeeded Gadolin on the chemistry chair (p. 1).

There is also other evidence of recognition and respect for Gadolin. For instance, on June 4, 1960, a postage stamp dedicated to the 200th anniversary of Gadolin's birth was issued in Finland. His image on the stamp was based on his portrait (Fig.1), probably taken at the age of 19, around the time he left Åbo to continue his studies at Uppsala University (Rabinovich, 2010, p. 23). In autumn 2008, was opened *The ChemistryLab Gadolin* at the University of Helsinki. It was named after Gadolin. According to the founders of Chemistrylab Gadolin (2020) it is "an active learning environment that offers fascinating experiences for schools and educational institutions" (p. 1).

It is also worth emphasizing that Gadolin entered to the list of 100 Distinguished European Chemists from the Chemical Revolution to the 21st Century developed by the European Chemical Society ("100 Distinguished European", 2020).

BIBLIOGRAPHIC REFERENCES

100 Distinguished European Chemists from the Chemical Revolution to the 21st Century. (2020). Retrieved from European Chemical Society website: https://www.euchems.eu/policy-and-communication/publications/100-distinguished-european-chemists-2/

Adet, Extrait D' une Dissertation. Intitulée Animadversiones in novam Nomenclaturæ Chemicæ methodum. *Annales De Chimie Ou, Recueil De Mémoires Concernant La Chimie Et Les Arts Qui En Dépendent*, , *2*, 191-206. Retrieved from https://archive.org/details/s3id13207710/page/190/mode/2up?q

Adunka, R., & Orna, M.V. (2018). *Carl Auer von Welsbach*: *Chemist, Inventor, Entrepreneur*, Cham: Springer International Publishing AG.

Baran, E. J. (2016). La Fascinante Historia Del Descubrimiento De Las Tierras Raras. *Anales de la Academia Nacional de Ciencias Exactas, Físicas y Naturale*, *68*, 85-105. Retrieved from https://www.ancefn.org.ar/user/FILES/ANALES/TOMO_68/12.pdf

Berry, H. F. (1915). *A History of The Royal Dublin Society*, New York, Bombay, Calcutta, and Madras: Longmans, Green and Co. Retrieved from https://archive.org/details/historyofroyaldu00berrrich?q

Berthollet. (1790). Lettre De M. Gadolin A M. Berthollet. *Annales De Chimie Ou, Recueil De Mémoires Concernant La Chimie Et Les Arts Qui En Dépendent*, *4*, 16-18. Retrieved from https://archive.org/details/annalesdechimiee04pari/page/16/mode/2up

Biographiskt Lexicon Öfver Namnkunnige Svenska Män. (1839). Femte Bandet, Första Häftet. Upsala: Leffler och Sebell, pp.118-119. Retrieved from https://archive.org/details/biographisktlex00unkngoog/page/n142/mode/2up

Blagden, C. (1958). 161. [London 1787] June 4. In W. R. Dawson, (Ed.), *The Banks letters. A Calendar of the Manuscript correspondence of Sir Joseph Banks preserved in the British Museum, the British Museum (Natural History) and other collections in Great Britain*, London: Printed by Order of the Trustees of the British Musem, p. 70. Retrieved from https://archive.org/details/banksletterscale1958bank/page/70/mode/2up

Building The Future Since 1640. (2005). Retrieved from University of Helsinki website: http://www.helsinki.fi/yliopistonhistoria/english/index.htm

ChemistryLab Gadolin. (2020). Retrieved from Science Education at University of Helsinki website: https://www.helsinki.fi/en/science-education/chemistrylab-gadolin

Childs, P. E. (1998) From hydrogen to meitnerium: naming the chemical elements. In K. J. Thurlow (Ed.), *Chemical Nomenclature*, (p. 42). Dordrecht: Springer Science + Business Media.

Dahlgren, E. W. (1915). *Kungl. Svenska Vetenskapsakadmien*. *Personförteckningar, 1739-1915*, Stockholm: Almqvist & Wiksells Boktryckeri-A.-B. pp. 57, 131. Retrieved from https://archive.org/details/personfrteckni00svenuoft/page/56/mode/2up?q

Dean, P. B., & Dean, K. I. (1996). Sir Johan Gadolin of Turku: The Grandfather of Gadolinium. *Academic Radiology*, 3, pp. S166-S169. http://dx.doi.org/10.1016/S1076-6332(96)80523-X

de Morveau, Lavoisier, Bertholet, & de Fourcroy. (1787). *Méthode De Nomenclature Chimique.* On *Y A Joint Un nouveau Système de Caractères Chimiques, adaptés à cette Nomenclature, par M.M. Hassenfratz & Adet*, Paris: Cuchet. Retrieved from https://archive.org/details/b2803806x/page/n7.

Dissertatio Chemica De Analysi Ferri, Quam, Venia Ampliss. Facult. Philos., Præside Mag. Torb. Bergman, … Publice Ventilandam Sistit Johannes Gadolin, Aboa-Fenno. In Auditorio Gustaviano Majori d. 9 Jun. Anno. 1781, Apud Joh. Edman, Director. (1781). Upsaliæ: Et Reg. Acad. Typogr.

Retrieved from Uppsala University Publication website:

https://uu.diva-portal.org/smash/record.jsf?pid=diva2%3A1178413&dswid=1442

Dissertatio Gradvalis De Problemate Catenario, Qvam, Venia Ampl. Facvlt. Philos. Praeside Mag. Freder. Mallet,... Pvblico Examini Svbiicit Iohannes Gadolin, Aboa-Fenno. In Avdit. Gvst. Mai. D. XIII Ivn. MDCCLXXXII. Apvd Iohan. Edman, Director. (1782). Vpsaliæ: Et Reg.Acad. Typogr.

Retrieved from Uppsala University Publications website: https://uu.diva-portal.org/smash/record.jsf?aq=&c=1&af=%5B%5D&searchType=SIMPLE&query=de+problemate+catenario&language=en&pid=diva2%3A1358947&dswid=707.

Ekeberg, A.G. (1797). Ytterligare undersökningar af den svarta Stenarten frön Ytterby och den dåri fundna egna jord. *Kungl. Svenska Vetenskapsakademiens Handlingar*, *18*, 156-164. Retrieved from https://www.biodiversitylibrary.org/item/180070#page/172/mode/1up.

Fourcroy, A. F. (1792). *Philosopie Chimique*, *Ou Vérités Fondamentales De La Chimie Moderne.* Paris. Retrieved from https://gallica.bnf.fr/ark:/12148/bpt6k15100791/f7.image.

Gadolin, J. (1958). Gadolin Johan (1760-1852). Chemist and Mineralogist. In W. R. Dawson, (Ed.), *The Banks letters. A Calendar of the Manuscript correspondence of Sir Joseph Banks preserved in the British Museum, the British Museum (Natural History) and other collections in Great Britain*, London: Printed by Order of the Trustees of the British Musem, (pp. 350-351). Retrieved from https://archive.org/details/banksletterscale1958bank/page/350/mode/2up.

Gadolin, J. (1827). *Commentatio De Gemmis Arte Procreandis.* AboÆ: Ex Officina J. C. Frenckell. Retrieved from https://archive.org/details/CommentatioDeGemmisArteProcreandis/page/n1/mode/2up.

Gadolin, I. (1825). *Systema Fossilium Analysibus Chemicis Examinatorum Secundum partium Constitutivarum Rationes Ordinatorum*, Berolini: Apud Ge. Reimerum. Retrieved from Retrieved from Bayerische StaatsBibliothek digital website: https://reader.digitale-sammlungen.de//de/fs1/object/display/bsb10225983_00005.html.

Gadolin, J. (1798). *Inledning Til Chemien.* Åbo: Tryckt i Frænckellska Boktryckeriet. Retrieved from https://books.google.pl/books?hl=pl&lr=&id=Q8rPY_8sSogC&oi=fnd&pg=PA1&dq=

Gadolin. (1797). Extrait De Lettres Des Savans Étrangers. *Annales De Chimie Ou, Recueil De Mémoires Concernant La Chimie Et Les Arts Qui En Dépendent*, *22*, p. 109. Retrieved from https://gallica.bnf.fr/ark:/12148/bpt6k6569007r/f115.item.r.

Gadolin, J. (1796). Von einer Schvarzen Schweren Steinart aus Ytterby Steinbruch in Roslagen in Schweden. *Crells Chemischen Annalen*, *1*, 313-329. Retrieved from https://reader.digitale-sammlungen.de/de/fs1/object/display/bsb10072281_00321.html?contextType.

Gadolin, J. (1794). Undersökning av en Svart tung Stenart ifrån Ytterby Stenbrott i Roslagen. *Kungl. Svenska Vetenskapsakademiens Handlingar*, *15*, 137-155. Retrieved from https://www.biodiversitylibrary.org/item/180081#page/143/mode/1up.

Gadolin, J. (1793). Réflexions Générales Concernant l'effet de la Chaleur sur les attractions chimiques des corps. *Annales De Chimie Ou, Recueil De Mémoires Concernant La Chimie Et Les Arts Qui En Dépendent*, *17*, 101-112. Retrieved from https://archive.org/details/annalesdechimie109unkngoog/page/n105/mode/2up.

Gadolin, J. (1791).*Beskrifning på en förbättrad Afkylnings-Anstalt vid Bränvins-Bränner*ier. *Kungl. Svenska Vetenskapsakademiens Handlingar*, *12*, 193-213. Retrieved from https://www.biodiversitylibrary.org/item/180071#page/209/mode/1up.

Gadolin, J. (1789a). Suite Des Expériences Sur le Blanchir d'un Métal par l'Etain. *Observations Sur La Physique, Sur L'Histoire Naturelle Et Sur Les Arts*, *34*, 430-435. Retrieved from https://archive.org/details/observationsetm34pari/page/430/mode/2up.

Gadolin, J. (1789b). *Undersökning huruvida Brunsten kan förvandlas i Kalkjord. Kungl. Svenska Vetenskapsakademiens Handlingar*, *10*, 141-150. Retrieved from https://www.biodiversitylibrary.org/item/180258#page/151/mode/1up.

Gadolin, J. (1788a). Ròn och Anmarkningar om Jarnmalmers Proberante på vagen. *Kungl. Svenska Vetenskapsakademiens Handlingar*, *9*, 115-137. Retrieved from https://www.biodiversitylibrary.org/item/180072#page/127/mode/1up

Gadolin, J. (1788b). *Om Kopparens förmåga at fälla Tenn utur dess Uplösning i Vinstens-Syra, Kungl. Svenska Vetenskapsakademiens Handlingar*, *9*, 186-194. Retrieved from https://www.biodiversitylibrary.org/item/180072#page/198/mode/1up.

Gadolin, J. (1788c). *Animadversiones in novam Nomenclaturæ Chemicæ Methodum*, Retrieved from https://core.ac.uk/download/pdf/39930535.pdf.

Gadolin, J. (1784). Ròn och Anmarkningar om Kroppars absoluta Varme, *Kungl. Svenska Vetenskapsakademiens Handlingar*, *5*, 218-236. Retrieved from https://www.biodiversitylibrary.org/item/180234#page/230/mode/1up.

Gadolin Yukhan (Yogan)[Гадолин Юхан (Йоган)]. (2017). Retrieved from Arkhivy Rossiyskoy Akademii Nauk website: http://isaran.ru/?q=ru/person&guid=56C9F17A-62C6-91F4-DDF7-7CC7DEC28A4E&str.

Gadolinite-(Ce). (2020). Retrieved from Mindat.org and the Hudson Institute of Mineralogy website: https://www.mindat.org/min-1627.html.

Gadolinite-(Y). (2020). Retrieved from Mindat.org and the Hudson Institute of Mineralogy website: https://www.mindat.org/min-1628.html.

Gadolinite-(Nd). (2020). Retrieved from Mindat.org and the Hudson Institute of Mineralogy website: https://www.mindat.org/min-47913.html

Gadolinium. (n.d.). Retrieved from PuBChem website: https://pubchem.ncbi.nlm.nih.gov/compound/Gadolinium

Granit, R. (1966). *Johan Gadolin. Minnesteckning*, Stockholm: Almqvist & Wiksell. Retrieved from http://www.rgs.fi/pubs/1966-008.pdf.

Guyton. (1790). Extrait D'une Lettre écrite à M. Guyton (ci-devant De Morveau) Par M. Jean Gadolin. *Annales De Chimie Ou, Recueil De Mémoires Concernant La Chimie Et Les Arts Qui En Dépendent*, 1791, 26-29. Retrieved from https://archive.org/details/annalesdechimie14unkngoog/page/n33/mode/2up

Hjelt, E., & Tigerstedt, R. (1910). *Johan Gadolin 1760 - 1852 In Memoriam. Wissenschaftliche Abhandlungen Johan Gadolins In Auswahl*, Helsingfors: Druckerei Der Finnischen Literaturgesellschaft. Retrieved from https://archive.org/details/actasocietatissc39suom/page/n7/mode/2up?q

Johan Gadolin (1760 – 1852), the Finish chemist. (2008). Public Domain. File:Portrait j gadolin.jpg. Retrieved from Wikimedia Commons website: https://commons.wikimedia.org/wiki/File:Portrait_j_gadolin.jpg

Klaproth, M. H. (1802). LXXVI. Chemische Untersuchung des Gadolinits. *Klaproths Beiträge zur chemischen Kenntniss der Mineralkörper*, *3*, pp. 52-79. Retrieved from https://archive.org/details/beitrgezurchemi01klapgoog/page/n67/mode/2up.

Komppa, G. (1927). Über ältere finnische Chemiker. *Agnewandte Chemie*, *40*(48), 1431-1434. https://doi.org/10.1002/ange.19270404803.

Lennartson, A. (2017). *The Chemical Works of Carl Wilhelm Scheele*, Cham: Springer International Publishing AG.

Lecoq de Boisbaudran. (1886). Le Yα de M. de Marignac est définitivement nomme gadolinium. *Comptes Rendus Hebdomadaires Des Séances De L'Académie Des Sciences*, *102*, p. 902. Retrieved from https://gallica.bnf.fr/ark:/12148/bpt6k3058f/f900.item.r

Marshall, J. L., & Marshall,V. R. (2008). *The Hexagon*, *Spring*, 8-11. Retrieved from https://digital.library.unt.edu/ark:/67531/metadc111224/m/.

McLennan, S. M. (2018). Gadolinium. In W. M. White, W. H. Cassey, B. Marty, & H. Yurimoto (Eds.), *Encyclopedia of Geochemistry. A Comprehensive Reference Source of the Chenmistry of The Earth*, *(*p. 525). Cham: Springer International Publishing AG.

Henkilömitali; mitali; muistomitali; tunnustusmitali; Johan Gadolin 1760-1852. (n.d.). [in Finnish]. Retrieved from Finna.fi website: https://www.finna.fi/Record/musketti.M012:RK43009:1?lng=en-gb

Niinistö, L. (2014). *Gadolin, Johan (1760-1852), Profesor i kemi*. Biografiskt lexikon för Finland (in Swedish). Retrieved from http://www.blf.fi/artikel.php?id=2621

Niinistö, L. (2004). Yukhan Gadolin (1760–1852) professor khimii. In T. Vikhavaynen (Ed.),

Sto zamechatel'nykh finnov. Kaleydoskop biografiy (pp. 137-140), (I. M. Solomeshcha, Trans.). Khel'sinki: Obshchestvo Finskoy Literatury (in Russian). Retrieved from http://www.kansallisbiografia.fi/pdf/kb_ru.pdf

Partington, J. R. (1962). *A History of Chemistry*. Volume Three, London: Macmillan & Company.

Pyykkö, P., & Orama, O. (1996). What did Johan Gadolin Actually Do? In C. H. Evans (Ed.), *Episodes from the History of the Rare Earth Elements* (pp.1-12.). Dodrecht, Boston, London: Kluwer Academic Publishers.

Pyykkö, P., & Orama, O. (1988). Johan Gadolin's 1788 Paper Mentioning the Several Oxidation States of Tin and Their Disproportionation Reaction. *New Journal of Chemistry*, *12*, 881-883. Retrieved from http://www.chem.helsinki.fi/~pyykko/pekka/Gadolin_88_3.pdf

Rabinovich, D. (2010). Gadolin and the Cradle of the Rare Earths. *Chemistry International*, *32*(6), p. 23. Retrieved from http://publications.iupac.org/publications/ci/2010/3206/si.html

Renvall, R. A. (1869). *Biografiska Anteckningar Öfver Det Finska Universitets Lärare, Embets- och Tjenstemän*, (pp. 241-243). Helisngfors: Finska Litteratur-Sällskapets Tryckeri. (in Swedish). Retrieved from https://archive.org/details/biografiskaante00renvgoog/page/n1/mode/2up?q

Semmler, W. (2017). Johan Gadolin – Namensgeber für das Element Gadolinium. *Radiologe*, *57*, 470-472. http://dx.doi.org/10.1007/s00117-017-0259-2

Sinkankas, J. (1993). *Gemology*. *An Annotated Bibliography*, Volume 1, Metuchen, Nj. & London: The Scarecrow Press, Inc. Retrieved from https://archive.org/details/GemologyAnAnnotatedBibliography/page/n403/mode/2up

Suomen kemian historia. *Johan Gadolin* (n.d.). Retrieved from https://kemianhistoria.luma.fi/johan-gadolin/

Thomson, T. (1810). *System of Chemistry*, The Fourth Edition, Vol. II., Edinburgh: Printed for Bell & Bradfute. Retrieved from https://archive.org/details/in.ernet.dli.2015.162482/page/n93/mode/2up.

T[horpe], T. E. (1911). Johan Gadolin. *Nature*, *86*(2158), 48-49. https://doi.org/10.1038/086048a0.

Tigerstedt, R. (1877). Johan Gadolin. Ett bidrag till de induktiva vetenskapernas historia I Finland. In *Bidrag till Kännedom Av Finlands Natur Och Folk, utgifna af Finska Vetenskaps-Societeten*. *Tjugondesjette Häftet* (Contribution to Knowledge of Finland's Nature and People, Issued by Finnish Science Society. Twenty-sixth Booklet). (pp. 91-225). Helsingfors: Finska Litteratur-sällskapets tryckeri. Retrieved from https://archive.org/details/bidragtillkanned2618suom/page/n3/mode/2up?q.

Vauquelin. (1800). Manière dont se comporte la gadolinite avec les acides minéraux. *Annales De Chimie Ou, Recueil De Mémoires Concernant La Chimie Et Les Arts Qui En Dépendent*, *36*, pp. 148-160. Retrieved from IRIS (Bibliothèque Numérique En Histoire Des Sciences) website: https://iris.univ-lille.fr/handle/1908/1021.

Volkov, V. A., Vonskiy, Ye.V., & Kuznetsova, G. I. (1991). *Vydayushchiyesya khimiki mira. Biograficheskiy Spravochnik*, Moskva: Vysshaya Shkola (in Russian). Retrieved from http://publ.lib.ru/ARCHIVES/V/VOLKOV_Vladimir_Akimovich/Volkov_V.A..._Vydayuschiesya_himiki_mira.(1991).[djv-fax].zip

Wöhler, F. (1828). Ueber das Beryllium und Yttrium. *Annalen der Physik*, *89*(8), 577-582. https://doi.org/10.1002/andp.18280890805.

Yttrium. (2020). Retrieved from *Royal Society of Chemistry* website: https://www.rsc.org/periodic-table/element/39/yttrium%23history.