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A BRIEF HISTORY OF MINERALOGY IN BRAZIL

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ABSTRACT

This article presents a brief history of mineralogy in Brazil. Special attention is given to the contribution of José Bonifácio de Andrada e Silva and also to the minerals that were first described in Brazil, the so-called "type –minerals" of Brazil.

KEYWORDS: Mineralogy in Brazil, José Bonifácio de Andrada e Silva, Type Minerals of Brazil

RESUMO

Este artigo apresenta um breve histórico sobre a mineralogia no Brasil. A contribuição de José Bonifácio de Andrada e Silva e os minerais que foram descritos pela primeira vez no Brasil, os chamados "minerais-tipo" brasileiros são tratados em detalhe.

PALAVRAS CHAVE: Mineralogia no Brasil, José Bonifácio de Andrada e Silva, Minerais-tipo brasileiros

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INTRODUCTION

Brazil possesses a very wide mineralogical diversity. About 16% of the mineralogical species known world wide are present in Brazil and about 60 species are type minerals of Brazil. [1-14]

The use of minerals was relatively wide spread among the native Indian population before the discovery of our country by the Portuguese in 1500, as can be documented by the excellent cave paintings of Serra da Capivara , São Raimundo Nonato, Piauí and the large number of stone utensils made from minerals and their variety of rocks. In addition, minerals and rocks were widely used for adornment, religious objects and rituals. [15] Some of the minerals used included amazonite (a variety of microcline ($KAlSi_3O_8$), graphite (C), hematite (Fe_2O_3), jadeite ($NaAlSi_2O_6$), malachite ($Cu_2(CO_3)(OH)_2$), nephrite (a variety of actinolite, $Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$), opal ($SiO_2$.nH2O), quartz ($SiO_2$) and its varieties, chalcedony, aventurite, hyaline, silex and jasper, sillimanite (Al_2SiO_5), amphibolite, basalt, diabase, diorite, steatite, phyllite, gabbro, gneiss, granite, quartzite schist and copal [15-16].

The oldest historical mineralogical record in Brazil is due to the Spaniard, Felipe de Guillén (born in Sevilla, 1487, died in Porto Seguro, 1571 ?) who suggested the occurrence of emerald (a variety of beryl. $Be_3Al_2Si_6O_{18}$) in the so-called Serra Resplandescente (Glowing Mountain) , a place full of emeralds. This was really a legendary geological formation, result of popular imagination, a place that was looked for by many explorers , but was never found or discovered. [16]

The first historian to describe expeditions in the Brazilian Highlands (Sertão) was the Portuguese Pêro de Magalhães Gândavo (born in Braga. 1540, died in Braga 1580). He talked about the occurrence of gold in the region corresponding to the present state of Minas Gerais.

Pêro de Magalhães Gândavo (1540-1580)

As mentioned by Cornejo and Bartorelli [16] the history and development of Brazilian mineralogy depended on a large number of factors and events. Some of them are the use of these substances for personal adornment, artifacts used in daily life and in rituals , the search for noble metals by the Portuguese Crown and by the scouts and explorers (bandeirantes), the discovery of large quantities of gold and diamond in Minas Gerais during the Colonial Period and the great scientific expeditions by European naturalists and travelers.

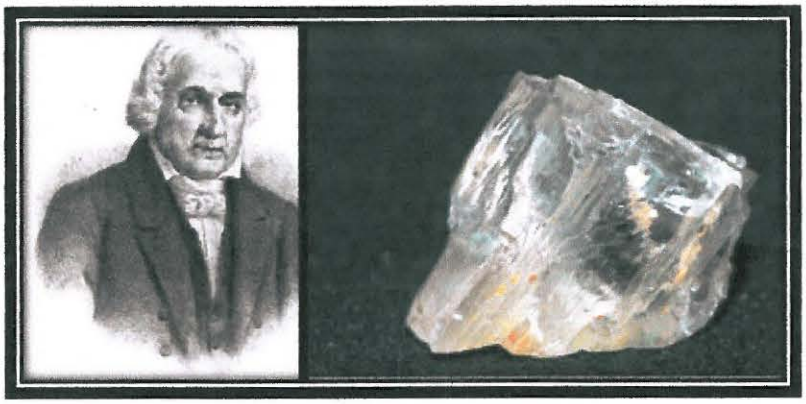
Other factors and events include the escape of the Portuguese Royal Family to Brazil , that eventually led to the founding of the Museu Nacional (National Museum) in Rio de Janeiro and the establishment of the Escola de Minas (School of Mines) in Ouro Preto , Minas Gerais.

The Portuguese Gabriel Soares de Souza (born in Portugal, 1540 and died in Bahia, 1591), in his work *"Tratado Descritivo do Brasil"*, published in 1587 made the first reports of the possible occurrence of gold, copper, iron, amethyst and garnet in the Sertão and in regions that correspond to the present State of Minas Gerais.

Father and son, both with the same name and residents of Santos (Afonso Sardinha "o Velho" , unknown date of birth and who died in 1616 and the son, called "o Moço", unknown date of birth and who died in 1604), who were experienced in mining discovered in 1589 the magnetite iron deposits in Morro de Araçoiaba, Ipanema (near present day Sorocaba in the State of São Paulo). They were also responsible for the first establishment of the first metallurgy plant in Brazil. The house of the "Sardinhas" is still preserved today and can be visited in the Parque Estadual do Pico do Jaraguá, São Paulo, a place known for gold prospecting[17].

JOSÉ BONIFÁCIO DE ANDRADA E SILVA

He is considered the "father of Brazilian mineralogy" and was born in Santos on July 13, 1763 and passed away on April 6, 1838 in Niteroi. He was the first Brazilian to describe a mineral species, petalite ($LiAlSi_4O_{10}$) while in Sweden.



José Bonifácio de Andrada e Silva (1763-1838) and a crystal of petalite

Besides being known as a notable statesman and industrial chemist he is also famous for describing three other minerals: spodumene, cryolite and scapolite . They form a group of minerals that constitute a solid solution series between marialite and meionite and were also described in Sweden.

The mineral andradite (nesosilicate) was named in his honor by the American mineralogist James Dwight Dana in 1868.

José Bonifácio, who originally studied at the University of Coimbra, Portugal, performed most of his scientific work in Europe. Upon his return to Brazil, he was mainly concerned with the governing of the country.

During his stay in Europe, he traveled widely and collaborated , worked and studied with many well known and renown scientists of the time. Among them we shall name Domenico Vandelli, Antoine François de Fourcroy, Jean-Pierre François Guillot Duhamel, René Just Haüy, Abraham Gottlob Werner, Friedrich Mohs, Friedrich Heinrich Alexander (Baron von Humboldt). Andrés Manuel Del Rio, Christian Leopold von Buch, Alessandro Volta, Peter Jacob Hjielm, Johann Gottlieb Gahn, Carl Axel Arrhenius, Peter Christian Abilgaard and Wilhelm von Eschwege. He consolidated his knwoldege in natural sciences and especially in mineralogy.[16] According to Figuerôa [18], José Bonifácio de Andrada may have not collaborated with F.H. Alexander and W. von Eschwege, for they may have not been present in Freiberg when he was there.

CONTEMPORARIES OF JOSÉ BONIFÁCIO

In 1789, the German geologists Abraham Gottlob Werner (born in Ozieczinica in 1749, died in Dresden in 1817) and Dietrich Ludwig Karsten (born in Bützow in 1768, died in Berlin in 1810) determined the first type mineral of Brazil, chrysoberyl ($BeAl_2O_4$), collected in alluvions of the region of Araçuai in Minas Gerais.

José Vieira Couto from Minas Gerais (born and died in Diamantina in 1752 and 1827, respectively) in 1798 indicated the possible occurrence of native lead, tin, diamond, copper, gold and platinum in Serro Frio, Abaeté, Diamantina (Arraial do Tijuco), Conceição do Mato Dentro and Ouro Preto (Vila Rica), all in Minas Gerais.

José de Sá Bettencourt Accioly (born in Caeté in 1754 or 1755 and died in Caeté in 1828) mentioned in 1822 the occurrence of niter (KNO_3) , specularite (a variety of hematite) and crocoite ($PbCrO_4$) in the region of Catas Altas in Minas Gerais.

The German naturalists Karl Friedrich Philipp von Martius (born in Erlangen in 1794 and died in Münich in 1868) and Johann Baptiste Ritter von Spix (born in Höchstadt an der Aisch in 1781 and died in München in 1826) related the presence of a variety of imperial topaz, ($Al_2SiO_4(F,OH)_2$)) in Vila Rica (actually Ouro Preto) in Minas Gerais and were the first scientists to visit the siderite meteorite (octahedrite I) Bendegó found in 1784 in Monte Santo, Sertão of Bahia and presently part of the municipality of Uauá. The voyage of the naturalists to Brazil was supported by the Academy of Sciences of Bavaria and had the purpose to establish botanical, zoological and mineralogical collections of the most important Mineralogical Provinces of our country. Their party was also present at the wedding of the Grand Duchess Leopoldina, who was also a very important amateur collector of minerals at the time.[19]

PERIOD AFTER JOSÉ BONIFÁCIO

Augustin Alexis Damour (born in Paris in 1808 and died also in Paris , probably in 1902) was a French mineralogist and described the second type mineral of Brazil, goyazite ($SrAl_3(PO_4)_2(OH,H_2O)_6$), found in 1894 in Lavra Ribeirão do Inferno, near Diamantina.

The Austrian petrologist, Eugen Hussak (born in Austria in 1856 and died in Caldas in 1911) with the English mineralogist George Thurland Prior (born in Oxford in 1862 and died in 1936) described in 1895 the type minerals derbylite ($Fe^{3+}Ti_3Sb^{3+}O_{13}(OH)$), tripuhyite ($Fe^{3+}Sb^{5+}O_4$), and florencite ($CeAl_3(PO_4)_2OH,H_2O)_6$), found in Tripui, Ouro Preto, Minas Gerais and senaite ($Pb(Ti,Fe,Mn)_{21}O_{38}$ found in Datas, Minas Gerais.

In 1906, E. Hussak described the type mineral of Brazil gorceixite, ($BaAl_3[PO_3(O,OH)]_2(OH)_6$), in honor of the French geologist Claude-Henri Gorceix (born and died in Saint Denis des Murs , 1842 and 1919, respectively) founder of the School of Mines and metallurgy in Ouro Preto, Minas Gerais. Besides being the first director, Gorceix also taught geology, mineralogy, chemistry and physics. His mortal remains were brought from France in 1973 and are resting in the yard of the Gorceix Museum of the Escola de Minas de Ouro Preto.

The first Brazilian to formulate a type mineral of Brazil was Professor Djalma Guimarães (born in Santa Luzia das Velhas in 1894 and died in Belo Horizonte in 1973) , who determined the mineral arrojadite in 1925, now arrojadite(KFe) ($(KNa)Fe^{2+}(Ca,Na_2)Fe^{2+})_{13}Al(PO_4)_{11}(PO_3OH)(OH)_2$), named in honor of Miguel Arrojado Ribeiro Lisboa (born in Rio de Janeiro in 1872 and died in the same city in 1932). He studied mining engineering and geology at the Escola de Minas de Ouro Preto , was General Inspector of Public Works against Drought (Inspetoria de Obras Contra as Secas-IOCS) established in 1909, studied the geology of North-Eastern Brazil as well as the geology of Western São Paulo and Eastern Mato Grosso and played an important role in the mining industry of Brazil.

During the last ten years (2003 to 2013), twenty three (23) type minerals from Brazil were approved by the *Commission on New Minerals, Nomenclature and Classification (CNMNC)* of the *International Mineralogical Association (IMA).* This corresponds to 2,2 minerals per year. From 1959 to 2002, seventeen (17) new minerals were approved, corresponding to 0,33 minerals per year. (See Table I).

The 23 new minerals are coutinhoite[20], lindbergite[21], atencioite[6], oxykinoshitalite[22], arrojadite (PbFe)[25], ruifrancoite[2], matioliite[24], menezesite[3], guimarãesite[26], brumadoite[4], qingheiite-(Fe^{2+})[9], bendadaite[7], manganoeudialyte[8], hidroxycalcioromeite[5], jacutingaite[11], uvite[10], carlosbarbosaite[27], fluor-elbaite[12], hydrokenomicrolite[13], fluorcalciomicrolite[14], pauloabibite[42] and almeidaite[42], besides fluoronatromicrolite [28] that was approved in 1998, but published only in 2011.

Other factors and events related to new minerals in Brazil happened during this period. In 2003 two new names for Brazilian minerals (waimirite and atroarite) were introduced in the literature without the approval of IMA[29]. The type mineral of Brazil arrojadite became a group of minerals in 2005[25].

The minerals giannettite and lewisite were officially discredited as being identical to hainite and romeite with Ti, respectively[30]. Recently, with the approval of IMA a new system of nomenclature was published for the super group of pyrochlore . Many species pertaining to this supergroup are presently under study[5].

Acoording to Smith[31], there are only three compilations about Brazilian minerals (Ferraz[32],Fróes Abreu[33] and Franco et al.[34]) and one about minerals from the State of São Paulo (Knecht)[35]. None of these has been updated.

TABLE I. LIST OF TYPE MINERALS FROM BRAZIL (1789-2013).

Year	Mineral	Author(s)
1789	Chrysoberyl	D. L. G. Karsten
1792	Euclase	R. J. Haüy
1803	Palladium	W. H. Wollaston
1853	Joseite	A. Kengott
1884	Goyazite	A. Damour
1895	Derbylite	E. Hussak; G. T. Prior
1897	Tripuhyite	E. Hussak; G. T. Prior
1898	Senaite	E. Hussak; G. T. Prior
1899	Florencite-(Ce)	E. Hussak; G. T. Prior
1906	Gorceixite	E. Hussak
1945	Brazilianite	F. H. Pough; E. P. Henderson
1947	Souzalite	W. T. Pecora; J. J. Fahey
1947	Scorzalite	W. T. Pecora; J. J. Fahey
1949	Frondelite	M. L. Lindberg
1953	Faheyite	M. L. Lindberg; K. J. Murata
1953	Moraesite	M. L. Lindberg; W. T. Pecora; A. L. Barbosa
1954	Barbosalite	M. L. Lindberg; W. T. Pecora
1954	Tavorite	M. L. Lindberg; W. T. Pecora
1955	Arsenopalladinite	F. A. Bannister; G. F. Claringbull; M. H. Hey
1974	Tantalaeschynite-(Y)	M. S. Adusumilli; C. Kieft; E. A. J. Burke
1974	Atheneite	A. M. Clark; A. J. Criddle; E. E. Fejer
1974	Isomertieite	A. M. Clark; A. J. Criddle; E. E. Fejer
1976	Bahianite	P. B. Moore; T. Iraki
1977	Palladseite	R. J. Davis; A. M. Clark; A. J. Criddle
1978	Whiteite-(CaFeMg)	P. B. Moore; J. Ito
1978	Whiteite-(MnFeMg)	P. B. Moore; J. Ito
1980	Lantanite-(Nd)	A. C. Roberts; G. Y. Chao; F. Cesbron
1986	Minasgeraisite-(Y)	E. E. Foord; R. V. Gaines; J. G. Crock; W. B. Simmons Jr.; C. P. Barbosa
1986	Parabariomicrolite	T. S. Ercit; F. C. Hawthorne; P. Cerny
1988	Lantanite-(La)	E. H. Nickel; J. A. Mandarino
1990	Arupite	V. F. Buchwald
1990	Zanazziite	P. B. Leavens; J. S. White; J. A. Nelen
1994	Yanomamite	N. F. Botelho; G. Roger; F.d'Yvoire; Y. Moëlo; M. Volfinger

1997	Quintinite	G. Y. Chao; R. A. Gault
2000	Dukeite	J. A. R. Stirling; A. C. Roberts; P. C. Burns; A. J. Criddle; M. N. Feinglos
2000	Serrabrancaite	Th. Witzke; R. Wegner; Th. Doering; H. Pöllmann; W. Schukmann
2004	Coutinhoite	D. Atencio; F. M. S. Carvalho; P. A. Matioli
2004	Lindbergite	D. Atencio; J. M. V. Coutinho; S. Graeser; P. A. Matioli; L. A. D. Menezes Filho
2005	Oxykinoshitalite	L. N. Kogarko; Yu. A. Uvarova; E. Sokolova; F. C. Hawthorne; L. Ottolini; J. D. Grice
2006	Atencioite	N. V. Chukanov; R. K. Rastsvetaeva; St. Möckel; A. E. Zadov; L. A. Levitskaya
2006	Kalungaite	N. F. Botelho; M. A. Moura; R. C. Peterson; C. J. Stanley; D. V. G. Silva
2006	Matioliite	D. Atencio; J. M. V. Coutinho; Y. P. Mascarenhas; J. A. Ellena
2006	Arrojadite-(PbFe)	C. Chopin; R. Oberti; F. Cámara.
2007	Guimarãesite	N. Chukanov; D. Atencio; A. E. Zadov; L. A. D. Menezes Filho; J. M. V. Coutinho
2007	Ruifrancoite	D. Atencio; N. V. Chukanov; J. M. V. Coutinho; L. A. D. Menezes Filho; V. T. Dubinchuk; St. Möckel
2008	Menezesite	D. Atencio; J. M. V. Coutinho; A. C. Doriguetto; Y. P. Mascarenhas; J. A. Ellena; V. C. Ferrari
2008	Brumadoite	D. Atencio; A. C. Roberts; P. A. Matioli; J. A. R. Stirling; K. E. Venance; W. Doherty; C. J. Stanley; R. Rowe; G. J. C. Carpenter; J. M. V. Coutinho
2010	Qingheite-(Fe^{2+})	F. Hatert; M. Baijot; S. Philippo; J. Wouters
2010	Bendadaite	U. Kolitsch; D. Atencio; N. V. Chukanov; N. V. Zubkova; L. A. D. Menezes Filho; J. M. V. Coutinho; W. D. Birch; J. Schlüter; D. Pohl; A. R. Kampf; I. M. Steele; G. Favreau; L. Nasdala; G. Giester; D. Yu. Pucharovsky

2010	Manganoeudialyte	S. F. Nomura; D. Atencio; N. V. Chukanov; R. K. Rastsvetaeva; J. M. V. Coutinho; T. K. Karipidis
2010	Uvite	C. M. Clark; F. C. Hawthorne; J. D. Grice
2010	Hydroxicalcioromeite	D. Atencio; M. B. Andrade; A. G. Christy; R. Gieré; P. M. Katarshov
2011	Carlos barbosalite	D. Atencio; A. C. Roberts; M. A. Cooper; L. A. de Menezes Filho; J. M. V. Coutinho; J. A. R. Stirling; N. A. Ball; E. Moffatt; M. L. S. C. Chaves; P. R. G. Brandão; A. W. Romano
2011	Jacutingaite	A. Vylamazová; F. Laufek; M. Drábek; A. R. Cabral; J. Haloda; T. Sidorinová; B. Lehmann; H. F. Galbiatti; J. Drahokoupil
2011	Fluornatromicrolite	Th. Witzke; M. Steins; T. Doering; W. Schukmann; R. Wegner; H. Pöllmann
2011	Fluorelbaite	F. Bosi; G. B. Andreozzi; H. Skogby; A. Lussier; N. A. Ball; F. C. Hawthorne
2012	Hydrokenomicrolite	F. C. Hawthorne
2012	Fluorcalciomicrolite	M. B. Andrade, D. Atencio, N. V. Chukanov, J. Ellena
2013	Pauloabibite	M. B. Andrade; D. Atencio; H. Yang; T. Downs; A. I. C Persiano; J. Ellena
2013	Almeidaite	D. Atencio

One can add some articles : Oliveira[36], Leonardos[1c] and Franco[14].

The book by Atencio represents an update of the subject[2a].

Before the establishment of the Commission for New Minerals and Names of Minerals (today CNMNC) of the International Mineralogical Association (IMA) in 1958, more than eighty names of new minerals were attributed to species from Brazil. Only nineteen (19) can really be considered type minerals from Brazil valid today, namely arsenopalladinite, barbosalite, brazilianite,

chrysoberyl, derbylite, euclase, faheyite, florencite-(Ce), frondelite, gorceixite, goyazite, joseite, moraesite, palladium, scorzalite, senaite, souzalite, tavorite and tripuhyite.

After the establishment of CNMMN-IMA , the description of staringite, tantalaeschynite-(Y), atheneite, isomertieite, bahianite, palladseite, whiteite-(CaFeMg), whiteite-(MnFeMg), lantanite-(Nd), minasgeraisite-(Y), parabariomicrolite, zanazziite, arupite, yanomamite, quintinite, dukeite, serrabrancaite, fluornatromicrolite, coutinhoite, lindbergite, oxykinoshitalite, atencioite, kalungaite, matioliite. menezesite, arrojadite-(PbFe), ruifrancoite guimarãesite (new definition), bendadaite, qingheiite-(Fe^{2+}), brumadoite, manganoeudialyte, hydroxicalciormeite, carlosbarbosaite, uvite, jacutingaite, fluorelbaite, hydrokenomicrolite and fluorcalciomicrolite were approved by the CNMMN-IMA. A redefinition of arsenopalladinite was published in 1974 With the approval of CNMMN-IMA, the mineral staringite was officially discredited in 1992.

The name lipscombite was first used for a synthetic material. The mineral, "lipscombite with Mn", described by Lindberg[37] in the Sapucaia pegmatite from Galileia, Minas Gerais and considered a type species, appears to be a different species with Mn or Fe^{3+} predominating over Fe^{2+}. X-ray diffraction patterns are practically identical, but the chemical results are very poor and an adequate formula can not be obtained. Today a lipscombite type is considered to be a material from the Otov pegmatite, near Domazlice, Bohemia, Czech Republic, described by Czech et al[38].

The name pseudorutile (1966) was introduced without official approval for a mineral that occurs in many places, including Brazil , was disaccredited and eventually officially revalidated in 1994 for a species from South Australia.

There is a large number of mineral species from Brazil that were introduced without official justification and include a wide variety of minerals such as tantalaeschynite-(Ce) (1968), ferrohalotrichite (1969), trautite (1971) ibitiarite (1975), coutinhite (1981), neodymite (1981) and heitorite (1991).

Another example are the minerals of the pyrochlore group rijkeboerite (1963) and djalmaite (1939) that were scrutinized by Atencio et al[5].

The important minerals investigated and studied in Brazil are the type minerals listed in Table I. An important work "*Enciclopédia dos Minerais do Brasil*" by P.C.P. das Neves and D. Atencio was launched in 2013 (Reference 1f) and is highly recommended for those interested in Brazilian Mineralogy.

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