MINERALS with a FRENCH CONNECTION

François Fontan and Robert F. Martin

The Canadian Mineralogist
Special Publication 13

Géosciences pour une Terre durable
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MUSÉUM
TOULOUSE

GÉOSCIENCES
ENVIRONNEMENT
TOULOUSE

TABLE OF CONTENTS

PRÉFACE

Il est grand temps de célébrer les contributions de savants qui ont fait de la France le berceau de la minéralogie et de la cristallographie. En 2004, j'ai proposé un tel projet à François Fontan. Encore impliqué à cette époque dans la recherche, il approchait néanmoins de la fin de sa carrière comme chercheur CNRS à l'Université Paul Sabatier à Toulouse, et tenait à redorer l'image de la minéralogie en France. Elève de François Permingeat, membre fondateur de l'Association minéralogique internationale, François connaissait très bien les rouages de l'Association, et a longtemps servi de délégué français à son comité de nomenclature des minéraux. Il était spécialiste de la systématique et, particulièrement, de la cristallochimie des minéraux phosphatés. Il accepta ma proposition, et entreprit cette grande aventure en 2005 avec enthousiasme. Quiconque le connaissait savait que l'histoire des sciences le passionnait, et il parlait de son héritage avec grande fierté. Son décès le 26 juillet 2007 m'a causé un grand choc. En deux années de travail, il avait quand même réussi à trouver les biographies essentielles, les portraits de savants, et une bibliographie de leurs articles originaux.

Dès 2007, j'ai décidé de prendre la relève afin de mener à terme ce projet ambitieux. Je me souviens très bien de m'être demandé comment procéder face aux nombreux défis qui se présentaient à moi. Je n'ai pu commencer ce travail que lentement compte tenu de mes fonctions dans les domaines de l'enseignement, de la recherche, et de la rédaction. Mon objectif était de décrire et d'illustrer tous les minéraux ayant une localité-type en France, y compris la Nouvelle-Calédonie, ainsi que ceux découverts ailleurs et nommés en l'honneur de citoyens français. François n'a pas contribué au choix des illustrations de minéraux. Autant que possible, j'ai pris le parti de publier au moins une photo de chaque minéral issu de sa localité-type. En cas d'impossibilité, je n'ai pas hésité à en choisir provenant d'autres localités afin de bien représenter chaque espèce. Dans un tel projet, on s'aperçoit que certaines informations sont déjà perdues; il est donc opportun de publier cet ouvrage dès maintenant. Malgré tous les défis, mes contacts avec les nombreux experts, tant professionnels qu'amateurs, se sont révélés assez aisés. Leur désir de m'aider dans mes démarches m'a vraiment impressionné. Il a ainsi été possible de réaliser, au cours de ces dix dernières années, un ouvrage faisant autorité et relativement encyclopédique qui représente bien l'héritage de François Fontan.

Dès le départ, il a toujours été question de réaliser ce livre en anglais plutôt que dans la langue de Molière. La raison en est très simple. L'impact des contributions des chercheurs et amateurs français au développement de la minéralogie et de la cristallographie mérite d'être présenté à un auditoire international. Les compilations "nationales" des espèces minérales découvertes en Belgique, au Brésil, au Groënland, en Italie, en Russie et en Suisse sont toutes publiées en anglais, et pour la même raison.

J'espère que ceux que la minéralogie passionne, qu'ils soient professionnels ou amateurs, trouveront ici une mine d'informations utiles à propos de chaque espèce minérale, de sa localité-type, de la personne mise à l'honneur ou bien de l'endroit qui a motivé le nom, ainsi que toute la littérature pertinente. Le livre démontre bien les rôles fondateurs des scientifiques français au développement de la minéralogie et de la cristallographie, et les activités des minéralogistes amateurs, qui assurent ces derniers temps la vitalité des recherches sur le terrain.

Robert F. Martin

INTRODUCTION

THE SCOPE AND CONTENTS OF THIS BOOK

Minerals have been attracting attention for well over two millenia because of their beauty, their utility, and their significance as products of natural processes. Theophrastus in 314 B.C. and Pliny the Elder in 77 A.D. wrote the first compendia of mineral lore. Since then, one has seen a steady progression in knowledge about minerals, as chronicled by Hazen (1984) and Sureda (2008), among others. Although all are by definition naturally occurring, and thus witnesses of natural processes, some minerals clearly have appeared relatively recently because of man's activities. Of the 5237 known and approved minerals on the International Mineralogical Association's latest tally (March 2017), roughly 4% have arisen as a direct result of mining activities in some way or other (Hazen *et al.* 2017). The nine arsenate minerals discovered at Sainte-Marie-aux-Mines are certainly a case in point.

The minerals featured in this book, a subset of the above, all have in common a French connection, either because they have a type locality in metropolitan France (*n* = 123) or New Caledonia (*n* = 4), or because they are named in honor of a French citizen (*n* = 128). A description of each mineral provides an opportunity to delve into the biography of professionals and amateurs who have contributed to the development of mineralogy and crystallography in France over the last three centuries. This compilation is a major contribution to the geoheritage of France, and to the national inventory being assembled (De Wever *et al.* 2015).

EARLY DISCOVERIES

In the early 1700s, only gold, silver, copper, iron, tin, lead, zinc, mercury and a handful of other elements were known. Between 1735 and 1860, minerals were intensively studied by analytical chemists in the search for new elements. Thirty-eight of the forty-three new elements discovered in that period were isolated during the analysis of minerals (Hazen 1984, Fig. 1). It is not uncommon to see an article by a mineralogist on a new species discovered in the 18th and 19th centuries followed soon thereafter by an article by a chemist like Nicolas-Louis Vauquelin (1763–1828) reporting the results of an analysis of the same mineral. Both chemistry and mineralogy made great strides in that period.

Fig. 1. The Muséum national d'Histoire naturelle at the Jardin des Plantes, Paris. The postcard was mailed in 1903. This and the five other figures shown in the Introduction are contributions from Vincent Dubost's collection of postcards.

AFMITE

$Al_3(OH)_4(H_2O)_3(PO_4)(PO_3OH){\bullet}H_2O$
Triclinic, $P\bar{1}$; a 7.386(3), b 7.716(3), c 11.345(4) Å, α 99.773(5), β 91.141(6), γ 115.58(5)°

Afmite from its type locality. Field of view: 0.3 mm. Collection and photo: Guy Bernadi.

Afmite from its type locality. Field of view: 0.3 mm. Collection and photo: Guy Bernadi.

TYPE LOCALITY

Afmite was discovered at Fumade, near the village of Castelnau-de-Brassac [43°39.5′ N, 2°29.97′ E], roughly 25 km northeast of Castres (Tarn), France.

OCCURRENCE

Phosphate-mineralized rocks are found in furrows in plowed fields. The phosphates are found in solution cavities and along fractures in shale and siltstone of Cambrian age, mildly affected by the emplacement of the Sidobre granite, of Late Carboniferous age (304 ± 8 Ma). The associated hydrothermal activity caused the oxidation of pyrite and the dissolution of phosphate nodules in the shale. Afmite, the dominant phosphate, is associated with the Al phosphates matulaite and variscite.

DESCRIPTION

The crystals are thin, colorless diamond-shaped tablets on {001}, with [010] elongation; their maximum dimension is 0.40 mm across. The tablets are commonly twinned on [010] with {010} and $\{1\bar{1}0\}$ composition planes, and form slightly concave or convex star-like sixlings. Cockscomb aggregates of tablets and sixlings attain 1 mm across. The structure consists of chains of AlO_6 octahedra parallel to [110] in which dimers of edge-sharing octahedra share corners with individual octahedra. Both PO_4 and (PO_3OH) tetrahedra link the chains into sheets parallel to {001}. The PO_4 tetrahedra further serve to link two sheets together to form a *T–O–T–O–T* sandwich; isolated H_2O groups located in the interlayer region provide intersheet linkage *via* hydrogen bonds.

NAME

The name is inspired by the acronym AFM, which stands for the Association Française de Microminéralogie. This association, founded in 1984, is very active in the area of micromount mineralogy. Members are responsible for the discovery of 21 new species, and have focused much attention on the phosphate assemblages of the Fumade locality.

TYPE SPECIMEN

The holotype specimen is deposited in the Natural History Museum of Los Angeles County, in Los Angeles, California, under catalogue number 55425.

COMMENTS

Lheur & Meisser (2010) have documented the suite of spectacular microcrystals of various phosphates known at Fumade prior to the discovery of afmite. The mineral is closely related to the turquoise group, and in particular to planerite.

The logo of the Association Française de Microminéralogie

IMA STATUS

Approved, IMA 2005-025a. Dana class: 42.9.3.6; Strunz class: 8.DD.15.

REFERENCES

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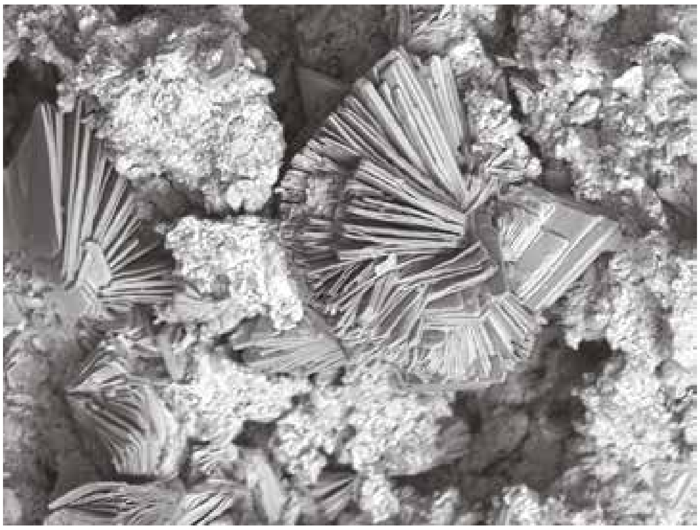
Favreau, G., Bernadi, G. & Gayraud, L. (2013): Fumade (Tarn) descriptions complémentaires des espèces minérales. *Le Cahier des Micromonteurs* **119**, 1-6.



Afmite from its type locality. Field of view: 2 mm. SEM photo: Georges Favreau and Bertrand Devouard.

Afmite tablets in cockscomb aggregates. Field of view: roughly 1 mm. Collection and photo: Georges Favreau. This is Figure 1 of Kampf *et al.* (2011).

ERYTHRITE

$Co_3(AsO_4)_2 \bullet 8H_2O$
Monoclinic, *C2/m*; *a* 10.273(2), *b* 13.4342(6), *c* 4.7543(9) Å, β 105.11(2)°

Erythrite from Beyrède-Jumet, Aure Valley, Hautes-Pyrénées, France. Field of view: 1.55 mm. Collection and photo: Pascal Chollet (specimen 6178).

Erythrite, doubly terminated crystal. Agoudal, Bou Azer district, Tazenakht, Ouarzazate Province, Souss-Massa-Draâ region, Morocco. Field of view: 5.1 mm. Collection and photo: Guy Bernadi.

TYPE LOCALITIES

Beudant (1832) presented information on erythrite from two localities: the Les Chalanches silver mine, near Allemont (Isère), Rhône-Alpes, France, and Riegelsdorf, Hesse, Germany.

OCCURRENCE

Erythrite is a secondary mineral found in the oxide zone of Co–Ni–As-bearing deposits. It is commonly associated with cobaltite, skutterudite, symplesite, roselite-β, scorodite, pharmacosiderite, adamite, morenosite, retgersite, annabergite, asbolane and malachite.

DESCRIPTION

Erythrite crystals are typically flattened on [010], and may be elongate and prismatic, attaining 10 cm, striated parallel to [001], in radiating or stellate groups. The crystals are crimson to pink, transparent to translucent, and their luster is subadamantine. They exhibit a perfect {010} cleavage. Some crystals are compositionally zoned. The structure consists $Co(1)O_2(H_2O)_4$ octahedra and $Co(2)_2O_6(H_2O)_4$ double-octahedron groups, which are linked *via* XO_4 tetrahedra to complex sheets oriented along (010), further interconnected by hydrogen bonds only. Any Fe^{2+} in the structure favors the Co(2) position.

NAME

Beudant (1832) named the mineral *erythrine*, from the Greek *erythros*, red.

TYPE SPECIMENS

There is no record of type specimens.

COMMENTS

The mineral was known before 1832 as cobalt arséniaté in France, and *arseniksaurer Kobalt* in Germany. The Les Chalanches mine is commonly considered to be one of the two type localities on the basis of Beudant's early mention of it. The mine was discovered in 1767–1768; although of small size, it became very well known for its silver mineralization. It is also the type locality of valentinite. Both erythrite and annabergite are present as coatings on mineralized samples. Erythrite exhibits solid solutions with annabergite, $Ni_3(AsO_4)_2 \bullet 8H_2O$, and hörnesite, $Mg_3(AsO_4)_2 \bullet 8H_2O$.

IMA STATUS

Grandfathered; Dana class: 40.3.6.3; Strunz class: 8.CE.40. A member of the *Vivianite* group.

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Martens, W.N., Kloprogge, J.T., Frost, R.L. & Rintoul, L. (2004): Single crystal Raman study of erythrite, $Co_3(AsO_4)_2 \bullet 8H_2O$. *Journal of Raman Spectroscopy* **35**, 208-216.

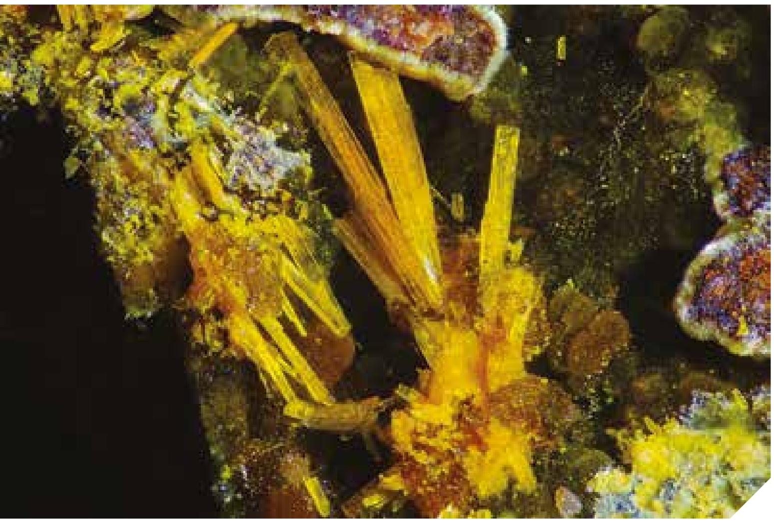
Capitelli, F., Elaatmani, M., Lalaoui, M.D. & Piniella, J.F. (2007): Crystal structure of a vivianite-type mineral: Mg-rich erythrite, $(Co_{2.16}Ni_{0.24}Mg_{0.60})(AsO_4)_2 \bullet 8H_2O$. *Zeitschrift für Kristallographie* **222**, 676-679.

Cook, R.B. (2007): Erythrite, Bou Azzer, Morocco. *Rocks & Minerals* **82**, 402-408.

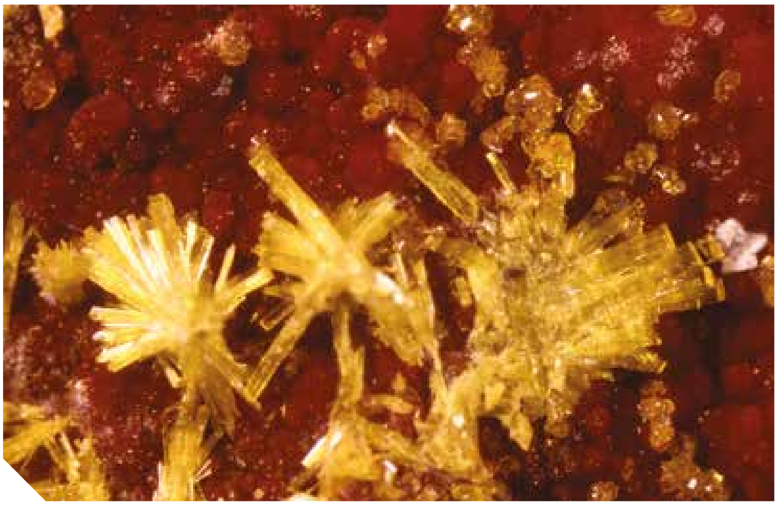
Erythrite, from the Saint-Jacques vein, Neuenberg, Sainte-Marie-des-Mines (Haut-Rhin), France. Field of view: 3 mm. Collection: Cédric Lheur. Photo: William Péraud.

FONTANITE

$Ca(UO_2)_3(CO_3)_2O_2 \bullet 6H_2O$
Monoclinic, $P2_1/n$; a 6.968(3), b 17.276(7), c 15.377(6) Å, β 90.064(6)°



Fontanite, the cotype specimen. Field of view: 1.5 mm. Collection: Institut royal des Sciences naturelles de Belgique, reference number RC 4216. Photo: Eddy Van Der Meersche.



Fontanite from its type locality. Field of view: 3.6 mm. Collection: F. Durand. Photo: Robert Vernet.

TYPE LOCALITY

The mineral was discovered at the Rabejac uranium deposit, 7 km south-southeast of Lodève (Hérault), France.

OCCURRENCE

The Lodève basin is Permian in age; its clastic sedimentary rocks are well known for their enrichment in uranium. Is the mineralization syngenetic, with the primary uraniferous minerals in detritus shed from the Massif Central to the north, or is it epigenetic, possibly related to coeval felsic magmatism and also to Tertiary volcanism? Caubel (1997) favored the syngenetic hypothesis, and pointed out that uranium is linked to horizons rich in organic matter. Signs of uranium mineralization, leading mostly to uraninite and coffinite, are found along fractures and bedding planes in pelitic redbeds.

DESCRIPTION

The bright yellow rectangular plates of fontanite define star-shaped aggregates up to 4 mm across. Individual (010) plates are elongate along **c** and attain 1 mm in length. Their luster is vitreous. They are associated with billietite and uranophane. Fontanite is the only uranyl carbonate with a sheet based upon the phosphuranylite anion-topology. This sheet contains uranyl pentagonal and hexagonal bipyramids, and the triangles of the anion topology are populated by carbonate triangles, such that the CO_3 group shares an edge with a hexagonal bipyramid of an adjacent chain. Calcium atoms and H_2O groups located in the interlayer provide linkages between the sheets.

NAME

The name honors François Fontan, born in Toulouse in 1942, systematic mineralogist who attended university in Toulouse, mostly, but he also was a visiting student at the Université de Liège (Belgium). He defended his Doctorat d'État in 1978, prepared under the guidance of François Permingeat: *Étude minéralogique et essais expérimentaux*

François Fontan

sur des phosphates de fer et de manganèse de pegmatites des Jebilet (*Maroc*) *et des Pyrénées* (*France*). He spent his career as a systematic mineralogist in a laboratory associated with the CNRS at the Université Paul Sabatier in Toulouse. He specialized in the study of Fe, Mn, Li, Na and Be phosphates in granitic pegmatites, in particular those enriched in rare elements (Nb, Ta, Zr, Hf, Sn). He was also involved in the classification of minerals and the internal evolution of granitic pegmatites. He contributed to the description of five new species (krautite, lulzacite, ferrorosemaryite, staněkite and joosteite), and served as the French delegate to the Commission on New Minerals and Mineral Names from 1978 to 1988. François also supervised doctoral theses on the nepheline syenite pegmatites of the Tamazeght alkaline complex in Morocco, and with Pierre Monchoux, investigated unusual corundum-bearing anatectic pegmatites in the Pyrénées. He was a major contributor to the *Atlas of Non-Silicate Minerals in Thin Section* (2011), and is the lead author of this book. He passed away in 2007, two years after undertaking this project.

TYPE SPECIMEN

The holotype specimen is deposited in the reference collection of the Institut royal des Sciences naturelles de Belgique in Brussels (specimen RC4216).

COMMENTS

At the time of his sudden death, François had laid the groundwork for this book.

IMA STATUS

Approved, IMA 1991-034. Dana class: 15.3.6.1; Strunz class: 5.EC.5.

REFERENCES

Deliens, M. & Piret, P. (1992): La fontanite, carbonate hydraté d'uranyle et de calcium, nouvelle espèce minérale de Rabejac, Hérault, France. *European Journal of Mineralogy* **4**, 1271-1274.

Caubel, A. (1997): Minéralogie du gisement d'uranium de Rabejac, Hérault. *Le Règne Minéral* **13**, 5-18.

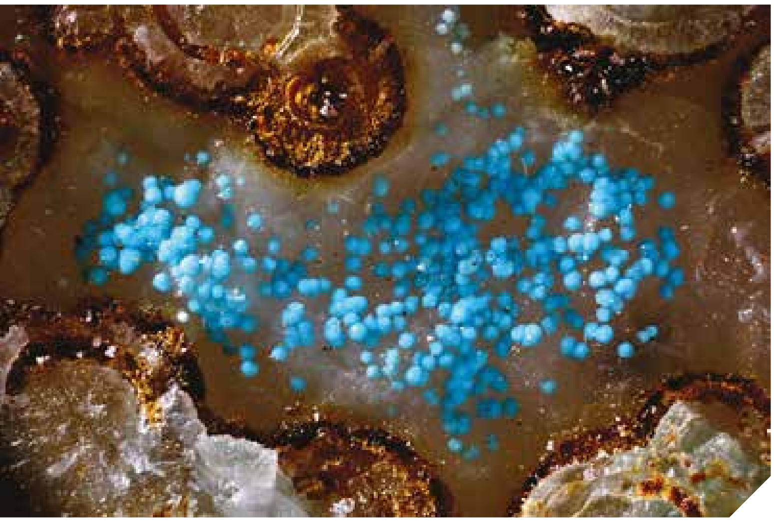
Hughes, K.-A. & Burns, P.C. (2003): A new uranyl carbonate sheet in the crystal structure of fontanite, $Ca[(UO_2)_3(CO_3)_2O_2](H_2O)_6$. *American Mineralogist* **88**, 962-966.

Burns, P.C. (2005): U^{6+} minerals and inorganic compounds: insights into an expanded structural hierarchy of crystal structures. *The Canadian Mineralogist* **43**, 1839-1894.

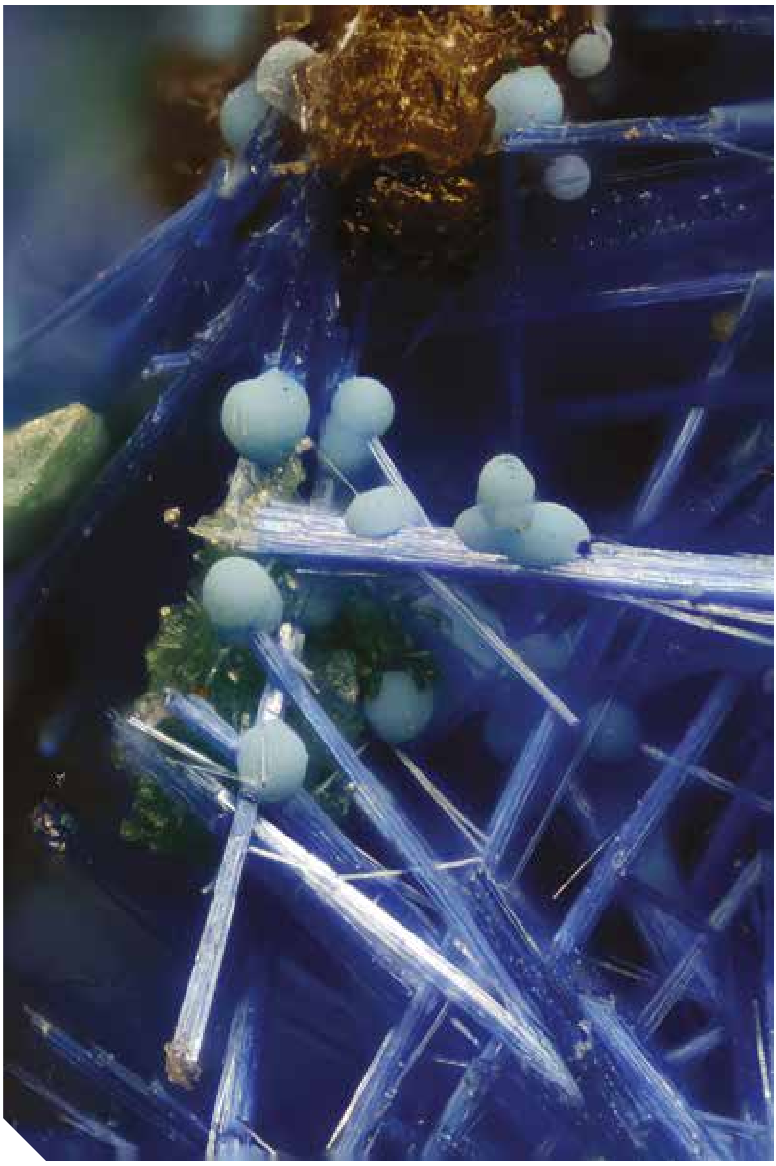
The site of the Rabejac mine, near Lodève (Hérault). Photo: courtesy of Robert Pecorini.

FORÊTITE

$Cu_2Al_2(AsO_4)(OH,O,H_2O)_6$
Triclinic, $P\bar{1}$; a 6.969(9), b 7.676(9), c 8.591(11) Å, α 82.01(9), β 71.68(8), γ 102.68(8)°



Forêtite from its type locality (Annex S), here associated with goethite on a quartz substrate. Field of view: 5 mm. Figure 2 of Mills *et al.* (2012). Collection: Pierre Rostan. Photo: Pierre Clolus.



Forêtite from its type locality, here with cyanotrichite. Field of view: 1.8 mm. Collection: Valérie Galéa-Clolus. Photo: Pierre Clolus.

TYPE LOCALITY

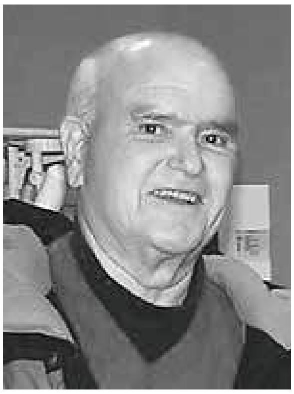
The mineral was found in the Cap Garonne Cu–Pb mine, Le Pradet (Var), France, in a chamber referred to as Annex S near the entrance of the south mine, and also at pillar 44b in the north mine.

OCCURRENCE

The mineralized horizon at Cap Garonne, located 12 km or so southeast of Toulon, is a Lower Triassic redbed sequence of fluviatile origin, which rests on similar rocks of Permian age intercalated with basaltic flows. The basal conglomerate of the Triassic sequence is mineralized over a maximum thickness of 0.2 to 1.2 meters, and was exploited by the “room and pillar” scheme between 1862 and 1917 for chalcocite, covellite, tennantite and galena. Numerous secondary minerals resulted from their oxidation. They formed repeatedly during uplift and Alpine deformation, and some appeared even since the closure of the mine. Forêtite is a secondary mineral associated with bariopharmacoalumite, chalcophyllite, cyanotrichite, parnauite and goethite.

DESCRIPTION

Forêtite is found as tiny spherical aggregates of crystals pale blue to aqua in color. Each sphere, measuring up to 0.1 mm across, consists of minute plates, each no more than 20 µm across; 10 µm is more typical. For this reason, efforts to characterize the new species had to rely on powder X-ray diffraction; both conventional and synchrotron approaches with single crystals failed.



Jean-Paul Forêt

NAME

The name honors Jean-Paul Forêt, born in Toulon (Var) in 1943, an Earth scientist who acquired his teaching credentials in Earth sciences at the Université de Marseille Saint Charles. He then taught for ten years in Hyères-les-Palmiers (Var), all the while preparing a Diplôme d'Études Approfondies (DEA) in physical oceanography and biology. He wrote a M.Sc. thesis in the biological sciences, then defended his doctoral thesis (1972). He was employed as geological engineer with a focus on the environment with the Direction départementale de l'équipement du Var, and was among the first in France to prioritize risk assessment in the face of natural disasters. In the context of his professional activities, he proposed the development of a mineralogical museum in the Cap Garonne mine at Le Pradet, and he has been its scientific advisor since 1977.

TYPE SPECIMENS

Seven cotype specimens of forêtite have been deposited. Five of these are in the collection of the Natural History Museum of Los Angeles County, catalogue numbers 63573, 63574, 63575, 63576 and 63577 (all from Annex S), one is in the collection of Museum Victoria, Melbourne, Australia, registration number M51746 (from Annex S), and one is in the collection of the Muséum national d'Histoire naturelle, Paris, catalogue number 211.58 (from pillar 44b).

COMMENTS

After the initial discovery of forêtite in the early 1980s, by Georges Favreau, the mineral was provisionally known as phase X2.

IMA STATUS

Approved, IMA 2011-100; Dana class: tba; Strunz class: tba.

REFERENCES

Mari, G. & Sarp, H. (2006): Cap Garonne (Var, France). *Le Cahier des Micromonteurs* **93**, 131-138.

Mills, S.J., Kampf, A.R., McDonald, A.M., Favreau, G. & Chiappero, P.-J. (2012): Forêtite, a new secondary arsenate mineral from the Cap Garonne mine, France. *Mineralogical Magazine* **76**, 769-775.

TRIMOUNSITE-(Y)

$Y_2Ti_2SiO_9$
Monoclinic, $P2_1/c$; a 12.293(2), b 11.124(2), c 4.8610(10) Å, β 95.69(3)°

Trimounsite-(Y) from its type locality.
Field of view: 4 mm.
Collection and photo: Guy Bernadi.

Trimounsite-(Y) from its type locality.
Field of view: 5 mm.
Collection and photo: Guy Bernadi.

TYPE LOCALITY

The mineral was discovered at the Trimouns talc deposit, near Luzenac (Ariège), France.

OCCURRENCE

The deposit arose by intense metasomatism of gneiss, migmatites and mica schists by Mg-rich hydrothermal fluids over the range 250°–300°C, to give a talc + clinochlore mixture. Trimounsite-(Y) is associated with allanite-(Ce), dolomite, bastnäsite-(Ce), dissakisite-(Ce) and aeschynite-(Y).

DESCRIPTION

The crystals occur in microcavities lined with dolomite crystals. Trimounsite-(Y) resembles allanite, with a prismatic habit elongate along (001). It is pale brown, with an adamantine luster and striated faces. Its cathodoluminescence is bright blue, and its Raman spectrum is very characteristic. Crystals up to 5 mm in length have been found. The dominant structural element is a spiral-like chain of edge-sharing strongly distorted TiO_6 octahedra aligned parallel to [001] and decorated by isolated SiO_4 tetrahedra in a staggered arrangement. Each TiO_6 octahedron shares four edges with other octahedra. Two non-equivalent (Y,REE) sites separate the chains along the **a** and **b** axes.

NAME

The name recalls the type locality, the Trimouns talc deposit. The word Trimouns means three peaks in Occitan.

TYPE SPECIMEN

Type material has been deposited in the Institut royal des sciences naturelles de Belgique in Brussels. The holotype bears sample number RC 3967.

COMMENTS

Pierre Gatel, amateur mineralogist, discovered the mineral, and wrote about the suite of minerals found in the Trimouns deposit. The long Ti–Ti distances and the degree of deformation of the octahedra reflect the strong cation–cation repulsive forces. In spite of the same stoichiometry, the synthetic compounds $La_2Ti_2SiO_9$ and $Ce_2Ti_2SiO_9$ adopt the space group *C*2/*m*, not *C*2/*c*.

The Luzenac talc mine at Trimouns. Photo: Philippe de Parseval.

IMA STATUS

Approved, IMA 1989-042; Dana class: 52.4.8.1; Strunz class: 9.AG.25.

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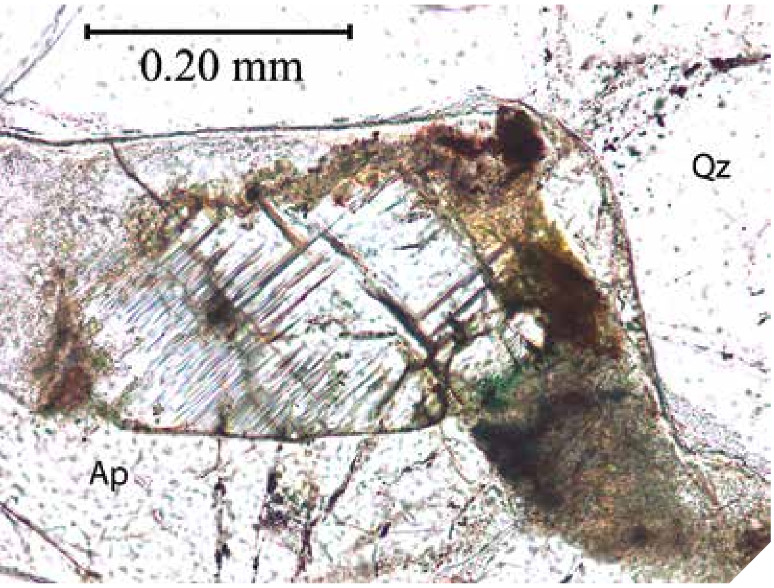
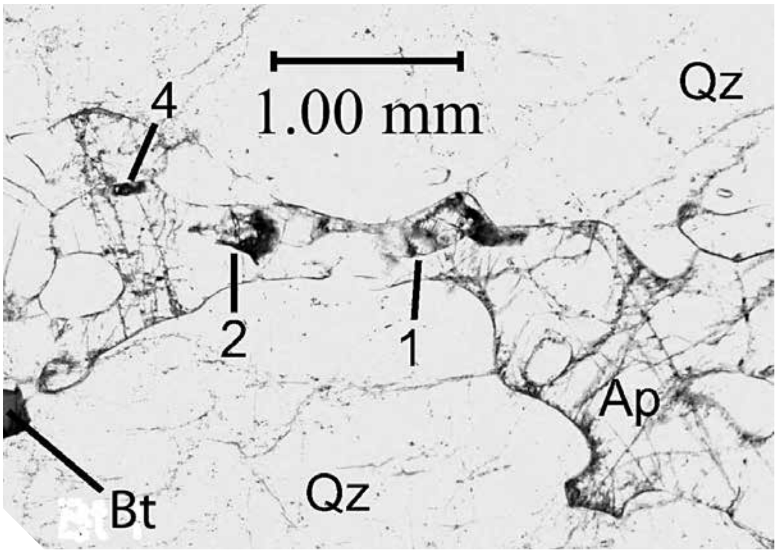
**Trimounsite-(Y) from its type locality,
here with clinochlore and dolomite. Field of view: 10 mm.
Collection and photo: Pascale and Daniel Journet.**

CHOPINITE

$Mg_3(PO_4)_2$
Monoclinic, $P2_1/c$; a 5.9305(7), b 4.7583(6), c 10.2566(10) Å, β 90.663(9)°



Chopinite from its type locality; it is the high-relief phase encased in fluorapatite (Ap). Adapted from Figure 4a of Grew *et al.* (2007). Photo: courtesy of Ed Grew.



Chopinite grains numbered 1 (the one illustrated to the left), 2 and 4, encased in fluorapatite (Ap). Adapted from Figure 3 of Grew *et al.* (2007). Photo: courtesy of Ed Grew.

TYPE LOCALITY

The mineral was discovered in paragneiss at Brattnevet Peninsula, Larsemann Hills, Prydz Bay, East Antarctica.

OCCURRENCE

At the type locality, chopinite occurs in a fluorapatite segregation in granulite-facies (800–860°C, 6–7 kbar) biotite – quartz – plagioclase paragneiss. The segregations are enclosed in quartz in a domain roughly 10 cm thick and 3 m long in the paragneiss. Prismatine and cordierite also are present. Wagnerite-*Ma5bc*, biotite, albite, pyrite, and monazite-(Ce) also are present in the chopinite-bearing section, but not in contact with chopinite. It is inferred to have formed as a result of high concentrations of P in an anatectic melt by reaction of biotite with that melt. The ratio P/Ca exceeded that buffered by apatite saturation owing to the very slow diffusion of P relative to Ca in the melt. Chopinite is also found in the meteorite Graves Nunataks (GRA) 95209, a transitional acapulcoite (primitive achondrite)

DESCRIPTION

Chopinite is colorless and transparent in thin section, and has two good cleavages, which could be {001} and {100}, by analogy with sarcopside, $Fe^{2+}{}_3(PO_4)_2$. Both chopinite and sarcopside adopt an olivine-type structure, but with ordered vacancies and strongly distorted octahedra due to the 5+ valence of phosphorus. This results in marked ordering of Mg at M2, whereas Fe^{2+} concentrates at M1, most likely because of its axial symmetry.

NAME

Christian Chopin

The name honors Christian Chopin (b. 1955), originally from Lyon, now Professor at the École Normale Supérieure, in Paris, France, in recognition of his major contributions to the mineralogy of phosphates. In particular, he was coauthor of an experimental investigation of the system $MgO–P_2O_5–H_2O$ (Brunet *et al.* 1998), which did deal with the field of stability of $Mg_3(PO_4)_2$-II (*i.e.*, chopinite). Before delving in these experimental studies, however, he had written his doctoral thesis under the guidance of Pierre Saliot on occurrences of Mg–Al-rich metamorphic rocks in the Gran Paradiso massif, one of the three internal metamorphic massifs of the Western Alps. It is in those rocks that he discovered the presence of coesite relics coexisting with pyrope, talc and clinochlore, described in a seminal article [*Contributions to Mineralogy and Petrology* **86**, 107-118 (1984)]. He concluded that these crustal rocks had undergone ultrahigh-pressure metamorphism as a result of subduction down to a depth of at least 100 km before being exhumed. In the area of public service, Christian is the managing editor of the *European Journal of Mineralogy*.

TYPE SPECIMENS

Holotype material (sample 121401E and thin section 121401E4) is deposited at the École nationale supérieure des Mines de Paris (reference number M 73096).

COMMENTS

Experimental studies had earlier established the stability field of $Mg_3(PO_4)_2$-II (chopinite), and shown that it is the high-pressure polymorph. The structure of farringtonite (also monoclinic, space group $P2_1/a$) is stable at a lower crustal pressure.

IMA STATUS

Approved, IMA 2006-004; Dana class: 38.3.1.3; Strunz class: 8.AB.15. A member of the *Sarcopside* group.

REFERENCES

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DESCLOIZITE

$^{[7]}\mathrm{PbZn(VO_4)(OH)}$
Orthorhombic, *Pnma*; a 7.610(2), b 6.047(2), c 9.453(2) Å

Descloizite from the Venus Pb–Zn deposit, El Guaico district, Sierra de Córdoba, Punilla Department, Argentina. Field of view: 4 mm. Collection and photo: Stephan Wolfsried.

Descloizite from Mapimí, Durango, Mexico. Field of view: 4.2 mm. Collection and photo: Henry Minot.

TYPE LOCALITY

The mineral was discovered in a collection brought back from an unspecified locality in the La Plata district, possibly the Venus Pb–Zn deposit, Sierra de Córdoba, Punilla Department, Córdoba, Argentina.

OCCURRENCE

Descloizite occurs as a secondary mineral in veins in vanadiferous lead ores, in association with pyromorphite, vanadinite, mottramite, pyromorphite and mimetite.

DESCRIPTION

Descloizite occurs as small prismatic or pyramidal crystals, usually forming drusy crusts and stalactitic aggregates, and also as fibrous encrusting masses with a mammillary surface. The crystals are deep cherry-red to brown or black, and transparent or translucent with a greasy luster. The structure consists of a three-dimensional assemblage of distorted $\mathrm{VO_4}$ tetrahedra, $\mathrm{ZnO_4(OH)_2}$ octahedra deformed owing to the Jahn–Teller effect, and $\mathrm{PbO_7(OH)}$ square antiprisms sharing corners and edges. The octahedra share edges and are strung out parallel to [001]. The tetrahedra link two such chains into a framework. Cavities host the Pb atoms.

NAME

The name honors Alfred Louis Olivier Legrand Des Cloizeaux, eminent mineralogist born in Beauvais (Oise) in 1817. He had the good fortune as a student to meet Armand Lévy (1794–1841), brilliant mathematician who had acquired experience in applications to mineralogy. Lévy taught him the principles of crystallography, the technique of drawing crystals, and encouraged him to attend the courses of Alexandre Brongniart at the Muséum, and of Armand Dufrénoy at the École des Mines. He met Jean-Baptiste

Alfred Louis Olivier Legrand Des Cloizeaux

Biot at the Collège de France, and later got to know Henri de Senarmont and of his investigations of optical properties. He traveled to Iceland to find cristals of transparent calcite for Biot's investigations. He also traveled throughout Europe to become familiar with the major collections. In 1853, he was named professor at the École normale supérieure des Mines. He later replaced Haüy as chair of mineralogy at the Muséum national d'Histoire naturelle in Paris. His main work consisted in the meticulous and systematic examination of crystals of numerous minerals, in particular quartz, to establish their optical properties and those of their synthetic equivalents. He documented the polarization of light by crystals, and established ways to distinguish the various feldspar-group minerals. He is credited with the discovery and naming of microcline, and he studied its conversion to orthoclase by heating. Alfred Lacroix was his star student. Des Cloizeaux was elected a member of the Académie des Sciences in 1869, and its president in 1889. He was awarded the Wollaston Medal by the Geological Society of London in 1886. His best-known textbooks are *Leçons de cristallographie* (1861) and *Manuel de minéralogie* (three volumes, 1862, 1874 and 1893). He died in Paris in 1897.

TYPE SPECIMEN

Type material is likely entered in the collection of École nationale supérieure des Mines de Paris, but is not listed in the catalog of type specimens.

COMMENTS

Descloizite forms a solid-solution series with mottramite, $PbCu(VO_4)(OH)$. A related species is arsendescloizite, $PbZn(AsO_4)(OH)$, described on page 280. There is limited solid-solution of descloizite toward arsendescloizite. Note that the name is not spelled Des Cloizeaux in the first of the two references below.

IMA STATUS

Grandfathered; Dana class: 41.5.2.1; Strunz class: 8.BH.40. A member of the *Adelite–Descloizite* group.

REFERENCES

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Vassilikou-Dova, A.B. & Eftaxias, K. (1992): Electron paramagnetic resonance of Cu^{2+} in descloizite mineral: an unusual electronic configuration. *Journal of Physics: Condensed Matter* **4**, 241-248.

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Đorđević, T., Kolitsch, U. & Nasadala (*sic*), L. (2016): A single-crystal X-ray and Raman spectroscopic study of hydrothermally synthesized arsenates and vanadates with the descloizite and adelite structure types. *American Mineralogist* **101**, 1135-1149.

HAÜYNE

$Na_3Ca(Si_3Al_3)O_{12}(SO_4)$
Cubic, $P\bar{4}3n$; a 9.1164(5) Å

Haüyne from its type locality, and specifically the San Vito quarry. Size of the crystal: 1.92 mm. Ex. G. Di Rosa collection. Collection: Museo civico di Storia Naturale, Milan. Photo: Matteo Chinellato.

Haüyne from Mendig, Laacher See volcanic district, Germany. Field of view: 0.5 mm. Collection and photo: Günter Blaß.

TYPE LOCALITIES

The mineral was discovered at Lago Nemi, in the Alban Hills, Lazio, and in the Somma–Vesuvio volcanic complex, Campania, Italy.

OCCURRENCE

Haüyne is a common rock-forming mineral in phonolite and related leucite- or nepheline-rich igneous rocks, and in metamorphic ejecta. At the type localities, it coexists with nepheline, leucite and sanidine.

DESCRIPTION

Haüyne may be colorless, pale gray, blue or green. It has a vitreous to greasy luster, and mostly is found as anhedral grains, although euhedral crystals do occur in cavities. The structure has four-membered rings of AlO_4 and SiO_4 tetrahedra that are parallel to {100}. These rings are further linked to form six-membered rings parallel to {111}. The overall linkage of these rings gives rise to cubo-octahedral cages, which contain $[Na_3Ca{\bullet}SO_4]^{3+}$ (75%) and $[K_2Ca{\bullet}OH]^{3+}$ (25%). The above formula is idealized.

NAME

The name honors René-Just Haüy, born in 1743 in Saint-Just-en-Chaussée (Oise) in a family of modest means. Friends of the family enabled him to attend college. He was ordained to the priesthood (1770), and taught at the Collège du Cardinal Lemoyne, his *alma mater.* He developed a strong interest in botany, but happened to drop a crystal of calcite accidentally one day, according to legend; this incident changed his life. Examination of the fragments led him to formulate a law of crystallization that bears his name. Given any crystal, he sought to determine the precise shape of its "constituent molecules", their mutual arrangements, and the laws that govern these. While assigned to teach humanities at the Université de Paris, he published *Essai d'une théorie*

René-Just Haüy

sur la structure des crystaux, appliquée à plusieurs genres de substances crystallisées (1784), and *De la structure considérée comme caractère distinctif des minéraux* (1793). He was jailed during the Revolution, and narrowly escaped execution. In 1795, he was named the first curator of collections at the École des Mines. His *Traité de Minéralogie* (five volumes) appeared in 1801. Under Napoléon, he was appointed to the Muséum national d'Histoire naturelle (1802), and founded its Musée de Minéralogie. He described several minerals while there, and wrote treatises on mineralogy and crystallography, among which *Traité de Cristallographie* (two volumes, 1822). Abbé Haüy was elected to the Académie des Sciences in 1783; he is considered, with Jean-Baptiste Romé de l'Isle, a founding father of geometrical crystallography. In 1821, he was elected a foreign member of the Royal Swedish Academy of Sciences. His name is one of the 72 names inscribed on the Eiffel Tower. He died in Paris in 1822.

TYPE SPECIMENS

Type material was deposited at the Muséum national d'Histoire naturelle (specimens 2395 and following, part of the Haüy collection).

COMMENTS

The mineral was initially discovered near Lago Nemi, in the Alban Hills of the Latium, near Rome, by Carlo Giuseppe Gismondi (1762–1824), Professor of mineralogy at La Sapienza, in Rome, who had called it "latialite". He presented his report orally to the Accademia dei Lincei in 1803, but he never published it. Bruun-Neergaard (1807) reasoned that as the mineral was recognized at Vesuvius, the label "latialite" was not quite appropriate. He thus proposed *haüyne*.

IMA STATUS

Grandfathered; Dana class: 76.2.3.3; Strunz class: 9.FB.10. A member of the *Cancrinite–Sodalite* group.

REFERENCES

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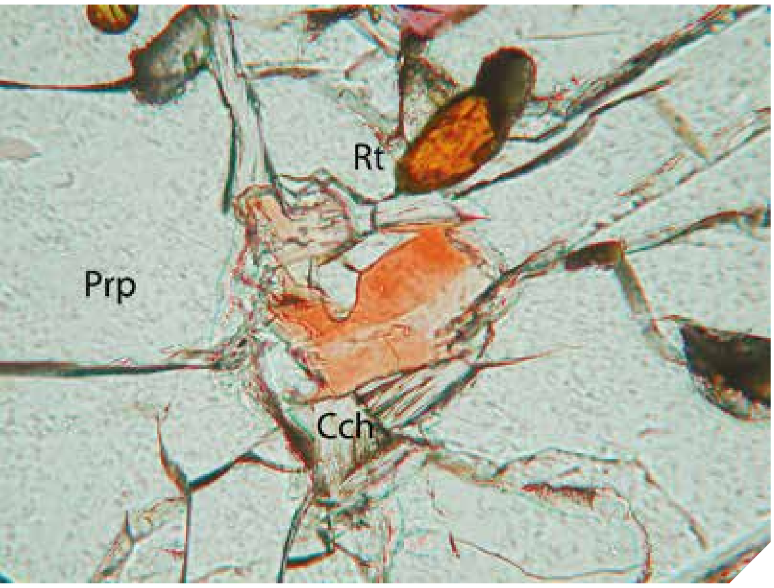
Ballirano, P. (2012): Haüyne: mutual cations/anionic groups arrangement and thermal expansion mechanism. *Physics and Chemistry of Minerals* **39**, 733-747.

MAGNESIODUMORTIERITE

$MgAl_6BSi_3O_{17}(OH)$
Orthorhombic, *Pmcn*; *a* 11.91(3), *b* 20.40(3), *c* 4.730(2) Å



Magnesiodumortierite (central grain, in plane-polarized light) from its type locality, along with ellenbergerite (top), clinochlore (Cch) and rutile (Rt), all enclosed in pyrope (Prp). Field of view: 0.45 mm. Collection and photo: Hans-Peter Schertl.

Magnesiodumortierite from its type locality, here with clinochlore (below the central grain), pyrope and kyanite (with the excellent cleavage). Field of view: 0.4 mm. Collection and photo: Hans-Peter Schertl.

TYPE LOCALITY

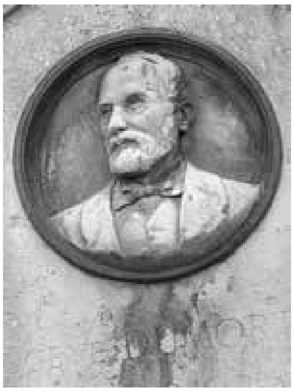
Magnesiodumortierite was found in the coesite-bearing whiteschists of the Dora-Maira massif, Piedmont, western Alps, Italy.

OCCURRENCE

Magnesiodumortierite was discovered as rare inclusions in pyrope megablasts of the quartz – phengite – kyanite (± talc) schist layers (so-called "pyrope quartzite" or "white-schists" that occur within the orthogneiss of the coesite-bearing terrane (Brossasco–Isasca unit) of the southern Dora-Maira massif, western Alps, Italy. The megablasts are up to 25 cm in diameter and include many phases, such as bearthite, ellenbergerite and magnesiostaurolite in addition to magnesiodumortierite. Other inclusions in the pyrope are kyanite, talc, rutile, zircon, monazite, dravite, minor wagnerite, all of which also occur in the matrix, plus clinochlore and minor ellenbergerite, orthopyroxene, gedrite, corundum, sapphirine, apatite, glaucophane and vermiculite, which occur only as inclusions.

DESCRIPTION

Magnesiodumortierite occurs as tiny anhedral grains (10 to 100 μm in maximum dimension) in polymineralic inclusions in pyrope, where they may be seen to overgrow kyanite or magnesiostaurolite, or to fill narrow cracks in pyrope. The mineral is transparent with a vitreous luster and pink to red color. One very poor cleavage plane, parallel to [001], is present. The main features of the structure are: a single [001] chain of *M*(l) octahedra, which share opposite faces; a double [001] chain containing two independent octahedra, *M*(2) and *M*(3), which share corners and edges; a second double [001] chain of $M(4)$ octahedra, which share edges and, within the (100) symmetry plane, one face. The double chains of $M(2)$ and $M(3)$ form (010) slabs by sharing their O(1) corners. The $M(4)$ chains link these slabs through O(6), and a three-dimensional framework of octahedra is established where two infinite [001] channels are filled with the $M(1)$ chain of octahedra and the BO_3 triangle, respectively. The BO_3 groups also link the (010) slab with the $M(4)$ chain; the Si and B polyhedra only share corners with octahedra.



Vincent-Eugène Dumortier

NAME

The name recalls the composition and relationship with dumortierite, whose name honors Vincent-Eugène Dumortier (1801–1876), renowned paleontologist (see page 76).

TYPE SPECIMEN

Type material has been deposited the Museo Regionale di Scienze Naturali in Torino (specimen 93005.1/2). Contrary to what was reported by Chopin *et al.* (1995) and Ferraris *et al.* (1995), a cotype specimen was not deposited at the Muséum national d'Histoire naturelle in Paris.

COMMENTS

There is no trace of Al at the $M(1)$ site, which is occupied by Al in dumortierite. The structure bears a strong resemblance to that of ellenbergerite, another high-pressure mineral found in the same assemblages. Textural evidence suggests that it formed together with ellenbergerite at conditions inferred to be about 25–30 kbar, 700°C.

IMA STATUS

Redefined, IMA 1992-050; Dana class: 54.1.2.2; Strunz class: 9.AJ.10. A member of the *Dumortierite* group.

REFERENCES

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Evans, R.J. & Groat, L.A. (2012): Structure and topology of dumortierite and dumortierite-like materials. *The Canadian Mineralogist* **50**, 1197-1231.

Pieczka, A., Evans, R.J., Grew, E.S., Groat, L.A., Ma Chi & Rossman, G.R. (2013): The dumortierite supergroup. I. A new nomenclature for the dumortierite and holtite groups. *Mineralogical Magazine* **77**, 2825-2839.

PARAPIERROTITE

$TlSb_5S_8$
Monoclinic, *Pn*; *a* 8.116(6), *b* 19.48(1), *c* 9.095(6) Å, β 91.95(2)°

Parapierrotite from its type locality, here with realgar. Field of view: 1.2 mm. Collection and photo: Stephan Wolfsried.

Parapierrotite from its type locality, here with realgar and orpiment. Field of view: 0.7 mm. Collection and photo: Vincent Bourgoin.

TYPE LOCALITY

Parapierrotite was discovered embedded in samples of realgar collected at the Crven Dol deposit, Allchar, Macedonia.

OCCURRENCE

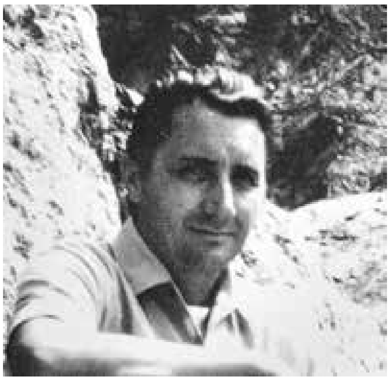
The Allchar deposit is a low-temperature hydrothermal gold – arsenic – antimony – thallium deposit in southern Macedonia. The Kozuf–Arid metallogenic zone of Pliocene mineralization extends along the Greek–Macedonian border. Volcanic structures and subvolcanic calc-alkaline intrusions are confined to northeasterly trending neotectonic faults. Igneous rocks are represented by calc-alkaline andesite and quartz latite. All subvolcanic intrusive bodies of the Kozuf district belong to the youngest phase, dated at 5.1–3.9 Ma. The Kozuf–Arid metallogenic zone is characterized by the development of complex Au–As–Sb–Tl mineralization.

DESCRIPTION

The prismatic crystals of parapierrotite are black, with a semimetallic luster. They are usually well developed, and located in small cavities in massive realgar. In general, the length of the crystals is less than one millimeter, but exceptionally, they attain 3 mm. The crystals are generally isolated and well terminated. Clusters are more unusual. The prism zone [001] is invariably well developed. Four variants are recognized, depending on the relative development of the forms {110}, {010} and {100}. The mineral is devoid of cleavage and twinning. In reflected light, it is clearly anisotropic and only slightly pleochroic. The structure consists of corrugated infinite Sb_5S_8 double layers parallel to (101); these exhibit a deformed NaCl-type structure between the *n*-glide planes. The two independent Tl atoms fit between the layers. They are coordinated by eight and nine S atoms, respectively, defining trigonal prisms with two or three additional S atoms located near the side faces. The Sb atoms are in an octahedral environment, but with three, four or five nearest neighbors.

NAME

The name is a combination of *para*, from the Latin for beside, and pierrotite, $Tl_2(Sb,As)_{10}S_{16}$ (orthorhombic). That mineral was named in honor of Roland Pierrot (1930–1998), director of the Laboratoire de Minéralogie, BRGM, Orléans-la-Source, France. In that capacity, he was a major contributor to the descriptive and regional mineralogy of France.



Roland Pierrot

TYPE SPECIMEN

The holotype specimen has been deposited at the École nationale supérieure des Mines de Paris (number 51117).

COMMENTS

Parapierrotite also occurs at the Jas Roux deposit, Mont Pelvoux (Hautes-Alpes), France, the type locality of pierrotite, but is extremely rare there. The name "Allchar" is derived from the names Allatini, the bank that owns the concession, and Charteau, a mining engineer who worked at the mine.

IMA STATUS

Approved, IMA 1974-059; Dana class: 3.8.14.1; Strunz class: 2.HC.05f. A member of the *Sartorite* homologous series in the family of *Sulfosalts*.

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Parapierrotite from its type locality, here with realgar. Field of view: 2 mm. Collection: Luigi Chiappino. Photo: Germano Fretti (deceased).

PHOSPHOELLENBERGERITE

$(Mg,\square)_2Mg_{12}(PO_4,PO_3OH)_6(PO_3OH,CO_3)_2(OH)_6$
Hexagonal, $P6_3mc$; a 12.467(2), c 5.0437(4) Å

Phosphoellenbergerite from its type locality. The specimen measures 2 × 2 × 1 cm. Collection and photo: Bruno Marello.

Phosphoellenbergerite from its type locality. The crystal is roughly 2 cm in length. Collection and photo: Bruno Marello.

TYPE LOCALITIES

Phosphoellenbergerite was discovered at Masueria, in the Brossasco–Isasca coesite-bearing unit, in the Dora-Maira massif, Val Varaita, province of Cuneo, western Alps, Italy.

OCCURRENCE

Phosphoellenbergerite is found included in fist-size pyrope megablasts in lenses of coesite-bearing pyrope – kyanite – phengite quartzite ("pyrope whiteschist") occurring in Val Varaita, southern Dora-Maira massif, western Alps. The primary, ultrahigh-pressure metamorphic assemblage formed near 725°C and 30 kbar; phosphoellenbergerite either overgrows P-bearing ellenbergerite or is associated with later phases like gedrite. These rocks were formed during Alpine times by unusually deep burial of continental crust along a low temperature-gradient.

DESCRIPTION

Phosphoellenbergerite is azure blue with a white streak. It is translucent to transparent and has a vitreous luster. At the type locality, the grains are prismatic, up to 6 mm in length, and untwinned. Fluorescence was not observed, nor is there cleavage or parting. The hardness is 6½. The structure consists of two main structural units: double chains (or ribbons) formed by pairs of face-sharing Mg octahedra ($M2$) linked by edges, and single chains of face-sharing Mg octahedra ($M1$). Both extend along the **c** direction. These chains of octahedra are linked by corner-sharing to the $P\phi_4$ tetrahedra (ϕ stands for O,OH). The P atoms are distributed over two tetrahedral sites; *T*1 is located on the three-fold axis, whereas *T*2 serves to connect the single chains to the double chains.

François Ellenberger

NAME

The name recalls the mineral's composition and its relationship with ellenbergerite. The name honors François Ellenberger (1915–2000), specialist of the internal metamorphic complexes of the western Alps, where the two minerals were discovered.

TYPE SPECIMENS

There is no mention of type specimens being deposited.

COMMENTS

For temperatures higher than 500°C, phosphoellenbergerite is stable only above 5.5 kbar (Brunet *et al.* 1998). Its field of stability is shifted to lower pressures compared with that of ellenbergerite. The azure blue crystals are intermediate members of the phosphoellenbergerite – ellenbergerite (see page 360) series.

IMA STATUS

Approved, IMA 1994-006; Dana class: 43.4.14.1; Strunz class: 8.BB.55.

Phosphoellenbergerite from its type locality. Field of view: 3 mm. Ex. Vincenzo Miletto collection. Collection and photo: Bruno Marello.

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RAGUINITE

$TlFeS_2$
Monoclinic, *C*2/*m*; *a* 11.636(28), *b* 5.304(2), *c* 6.799(27) Å, β 116.71(21)°

Raguinite, here with orpiment, from its type locality. Field of view: 1.2 mm. Collection and photo: Stephan Wolfsried.

Raguinite, here with realgar and orpiment, from its type locality. Field of view: 2 mm. Collection and photo: Stephan Wolfsried.

TYPE LOCALITY

Raguinite was discovered in the Crven Dol mine of the Allchar Au, As, Sb and Tl deposit, located 5 km from the village of Rožden, on Kožuf Mountain in southern Macedonia, close to the border with Greece.

OCCURRENCE

The host rocks of the low-temperature Allchar deposit are Paleozoic schists intercalated with dolomitized marble. Mineralization is related to a Pliocene calc-alkaline subvolcanic complex. Raguinite is most abundant in ores rich in lorándite, and may in fact be replaced by lorándite ($TlAsS_2$); it is closely associated with pyrite, in such a way that both raguinite and pyrite are considered products of the pseudomorphism of an unknown precursor. Other minerals in the ore are orpiment, realgar, vrbaite and picotpaulite.

DESCRIPTION

Raguinite forms pseudohexagonal tablets or truncated bipyramids. It also forms sheafs of brilliantly colored bronze fibers. These are fragile and split up into coalescent fine needles. They are quite strongly pleochroic, from creamy gray perpendicular to the fibers to pinkish parallel to them. The crystal structure contains infinite linear chains of edge-sharing FeS_4 tetrahedra aligned parallel to the **b** axis. The thallium atoms are strung out along the **a** axis, and coordinated to six sulfur atoms in a distorted trigonal prismatic arrangement.

NAME

The mineral is named in honor of Eugène Paul Antoine Jacques Raguin (1900–2001), a leading figure in petrology, mineralogy and ore deposits in France in the 20th century. Eugène Raguin graduated from the École Polytechnique (class of 1918), and entered the École des Mines de Paris in 1922 after his military service. An encounter with Pierre-Marie Termier (1859–1930) in 1921 motivated him to turn to geology rather than


Eugène Paul Antoine Jacques Raguin

to administrative responsibilities in the mining sector. He became Termier's assistant, working on geological mapping projects, then became associated in 1930 with Termier's successor, Louis de Launay. Eugène Raguin inherited de Launay's course in applied geology in 1935, remaining with that commitment until 1972, the year of his retirement. He considered teaching as his primary vocation rather than research. He is credited with a major reorganization of the curriculum for the applied geology option at the École nationale supérieure des Mines de Paris. He created a fourth year, which allowed directed studies (field and laboratory), followed by a final report and synthesis. In the footsteps of de Launay, many of these directed studies focused on ore deposits in France and abroad. He was a gifted teacher, yet a simple and modest man. The main foci of this interests were the basement complexes of the Massif Central and the Alps, as well as the Pyrénées. He published *Géologie appliquée* (1934, 1948), *Géologie des gîtes minéraux* (1940, 1961), and *Géologie du granite* (1946, 1957), among other textbooks. On granites, he believed in the powers of mineralizing fluids, and shunned the extreme "transformist" views of the Roubault school. He was awarded the Gosselet Prize by the Société géologique de France in 1951 in recognition of the breadth of his studies in applied geology.

TYPE SPECIMENS

The holotype specimen is deposited at the École nationale supérieure des Mines de Paris (specimen 50944). Portions of the same specimen were deposited at the Museum of Geology, Lausanne, Switzerland (numbers 79683, 79684).

COMMENTS

According to Johan *et al*. (1969), raguinite can be considered to have a deformed chalcopyrite-type structure. Raguinite was discovered in the Allchar deposit, whose name is inspired by the name of the bank that owned the concession, Allatini, and Charteau, a mining engineer who worked at the mine.

IMA STATUS

Approved, IMA 1968-022; Dana class: 2.9.9.1; Strunz class: 2.CB.60.

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APPENDIX 5.

MINERALS (n = 128) DISCOVERED ELSEWHERE THAN IN FRANCE AND NAMED AFTER FRENCH CITIZENS: CHRONOLOGICAL LISTING

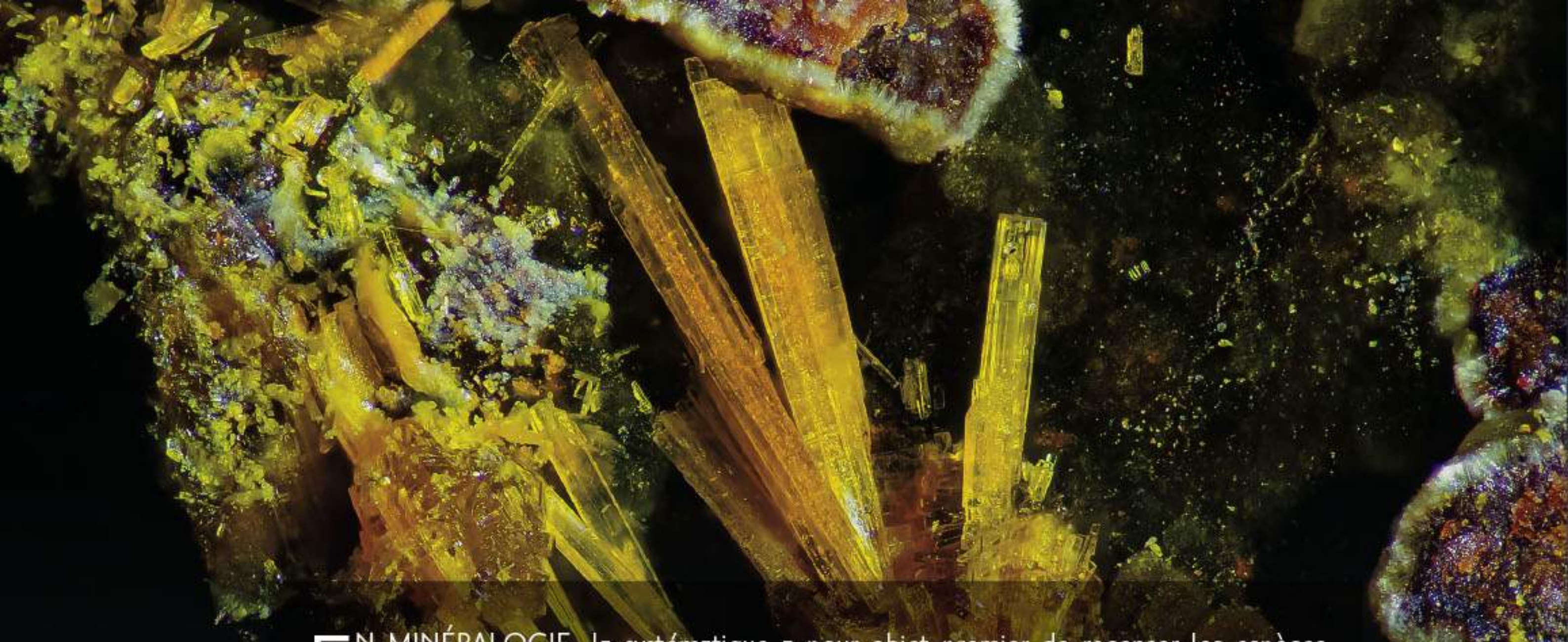
1791	dolomite
1801	cordierite
1801	chenevixite
1804	bournonite
1804	proustite
1807	haüyne
1814	dufrénite
1818	vauquelinite
1824	brochantite
1825	lévyne-Ca
1826	thénardite
1826	beudantite
1826	gaylussite
1841	oxycalcioroméite
1842	faujasite-Ca
1845	dufrénoysite
1847	delafossite
1851	senarmontite
1854	descloizite
1861	wurtzite
1864	boussingaultite
1864	devilline
1865	oxyplumboroméite
1866	adamite
1868	claudetite
1868	bobierrite
1876	daubréeite
1876	daubréelite
1879	mallardite
1893	cumengeite
1895	hydroxycalcioroméite
1899	carnotite
1902	grandidierite
1904	moissanite
1906	gorceixite
1908	villiaumite
1908	plancheite
1914	lacroixite
1915	fornacite
1921	curite
1922	becquerelite
1922	barroisite
1924	dussertite
1924	sklodowskite
1928	julienite
1931	serandite
1933	cuprosklodowskite
1938	ungemachite
1955	vésigniéite
1956	paradamite
1956	hibonite
1957	sphaerobertrandite
1959	wyartite
1960	béhierite
1963	chervetite
1964	gaudefroyite
1964	guérinite
1964	bariandite
1965	jouravskite
1965	guilleminite
1967	guettardite
1967	launayite
1968	despujolsite
1968	curienite
1969	agardite-(Y)
1969	henritermierite
1969	lemoynite
1969	raguinite
1970	schubnelite
1970	agardite-(Ce)
1970	lenoblite
1970	roubaultite
1970	picotpaulite
1971	fischesserite
1971	permingeatite
1972	lévyne-Na
1973	brassite
1974	cesbronite
1975	krautite
1975	parapierrotite
1976	nickelboussingaultite
1976	joliotite
1978	sabatierite
1978	liandratite
1979	agardite-(La)
1979	aubertite
1980	macquartite
1982	arsendescloizite
1982	neltnerite
1983	asselbornite
1983	molybdofornacite
1984	mantienneite
1986	ellenbergerite
1986	protasite
1988	rémondite-(Ce)
1988	magnesioaubertite
1988	cassedanneite
1989	cervelleite
1990	bussyite-(Ce)
1990	lévyclaudite
1990	natrolemoynite
1992	coquandite
1993	arsenogorceixite
1994	saliotite
1995	magnesiodumortierite
1996	phosphoellenbergerite
2000	rémondite-(La)
2002	moëloite
2004	jacquesdietrichite
2005	plumboagardite
2005	rouxelite
2007	chopinite
2009	bussyite-(Y)
2009	stibioclaudetite
2009	tazieffite
2010	meerschautite
2010	lecoqite-(Y)
2010	hibonite-(Fe)
2011	leguernite
2011	agardite-(Nd)
2013	fluorcalcioroméite
2013	lavoisierite
2014	favreauite
2014	fabrièsite
2016	metathénardite
2016	péligotite
2016	silicocarnotite
2017	argentodufrénoysite

The date reported here refers to the first description of a given mineral in the literature. The name of a few minerals was proposed after the initial discovery (Appendix 4).

ABOUT THE AUTHORS

François Fontan spent his career in research with the CNRS (Centre National de la Recherche Scientifique) at the Université Paul-Sabatier in Toulouse. He was particularly interested in the mineralogy and genesis of phosphate minerals, and in the internal evolution of granitic pegmatites. He passed away on July 26, 2007, two months shy of his official retirement, and two years after undertaking this major project.

Robert F. Martin, a graduate of the University of Ottawa, Pennsylvania State University and Stanford University, spent his career at McGill University, in Montreal, where he presently holds the title of Professor Emeritus. He is particular interested in the mineralogy, geochemistry and petrology of igneous rocks, and metasomatic interactions prior to anatexis of the crust and mantle. He served as fourth editor of The Canadian Mineralogist (1978–2012), and in 1997, he initiated a series of Special Publications of The Canadian Mineralogist, of which this is number 13. Errors, omissions and relevant new information should be reported to him at robert.martin@mcgill.ca.



EN MINÉRALOGIE, la systématique a pour objet premier de recenser les espèces cristallines, briques élémentaires constitutives du monde minéral. A ses débuts, sous les auspices des savants français Romé de l'Isle et de René-Just Haüy, la minéralogie a été essentiellement systématique des minéraux. Depuis lors, cette science a évolué et s'est développée dans de multiples directions. La systématique reste néanmoins un socle toujours plus robuste, qui s'enrichit de près d'une centaine d'espèces nouvelles par an. Cet ouvrage est l'occasion d'illustrer cette permanence de la systématique sous l'angle des espèces minérales ayant une connexion avec la France. Engagé par François Fontan (1942–2007), chercheur du CNRS à l'université Paul Sabatier, Toulouse (France), ce travail a été parachevé par Robert Martin, professeur émérite de géologie à l'université McGill de Montréal (Canada). Le lecteur découvrira ainsi toute la diversité des personnalités qui ont contribué au dynamisme de la minéralogie française, tout en parcourant la variété des espèces décrites, ainsi que leurs gisements d'origine.

SYSTEMATIC MINERALOGY has as its main goal a survey of crystalline species, the basic building blocks of all natural assemblages. As a nascent area of investigation under the guidance of such visionaries as Romé de l'Isle and René-Just Haüy, mineralogy consisted essentially of the systematic approach. Since then, the field has evolved and developed in multiple directions. Nevertheless, systematic mineralogy remains a solid core, enriched each year by discoveries of a hundred or so new species. This book offers an opportunity to illustrate this systematic approach in the context of mineral species with a French connection. François Fontan (1942–2007), research scientist (CNRS) at Université Paul Sabatier in Toulouse (France), undertook the project, and Robert Martin, Emeritus Professor of Geology at McGill University, Montreal (Canada), brought it to fruition. The profiles and discoveries of past and contemporary contributors to the vitality of mineralogy in France are highlighted, as is the geological context of the type localities.

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