

MINERALS *and their* LOCALITIES



*This book is respectfully dedicated to the memory
of Dr. John Sinkankas for his kind initiative
and support to publish this book in English version.*



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Jan H. Bernard and Jaroslav Hyršl

Edited by Vandall T. King



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*The photographed specimens are from the collections of both authors
as well as from many other collections.*

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their specimens for this book.*

Front cover photos:

Turquoise, polished, 55 mm, Zhilandy, Kazakhstan, G

Galena, 45 mm, Madan, Bulgaria, G

Sphalerite, xx 12 mm, Morococha, Peru, H

Gypsum, xx 40 mm, Las Salinas, Peru, H

Variscite, xx 5 mm, Itumbiara, Brazil, H

Rhodochrosite, polished, 50 mm, Capillitas, Argentina, H

Back cover photo:

Wolframite, 45 mm, Yaogangxian, China, H

Page 1: Muscovite, 45 mm, Linopolis, Brazil, H

Page 2: Vivianite, 100 mm, Huanzala, Bolivia, H

Page 3: Liddicoatite, polished, 70 mm, Anjanabonoina, Madagaskar, G

Page 5: Opal - fire, polished, 50 mm, Mezezo, Ethiopia, G

Page 12: Brazilianite, 35 mm, Linopolis, Brazil, H

Page 13: Gold, 35 mm, Eagle's Nest Mine, California, G

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PREFACE

This book reviews about 8,500 mineral localities from all over the world, for all valid mineral species (over 4,200), in the context of their geoenvironment. The contents are partly based on the Czech book "Encyclopedic Synopsis of Minerals", published by the Academia Publishing House in Prague and which received the Czech Literary Award for best book in the natural sciences for the year 1992. All 5,000 copies of the book were sold out in a few years.

The current progress in mineralogy, with countless new data in books and scientific as well as amateur journals, required considerable revision to the contents of the present book when compared with the 1992 edition. More than 4,200 minerals have now been described, compared with 3,350 minerals in the former edition. The mineral systematic classification is based on the updated classification according to Strunz (1996).

The principal orientation of this English edition was changed, however, with regard to the world's mineral localities and environment of mineral occurrences, as a result of the personal experience of both authors and a study of recent literature in the field of mineralogy. Current encyclopedic books mostly emphasize the properties of individual minerals, but in this book the mineral properties description is limited to the chemical formula, allegiance to a mineral group, symmetry and crystal structure as well as the strongest X-ray powder diffraction lines, and basic physical properties, including main optical data for transparent and opaque minerals. More attention is paid to crystal habit or aggregate development and their sizes, particularly for the most important localities, to the presence of typical mineral assemblages, and to the appearance of the mineral in magmatic rocks, pegmatites, ore veins or other types of ore deposits, including secondary minerals, in Alpine fissures, as well as in sedimentary and metamorphic rocks and in residual and alluvial deposits. Special attention was paid to localities of gemstones.

The authors hope that this book may be useful especially for mineral collectors. Museum curators and mineral dealers may perhaps also find here a source of information about appearance, localities, rarity and development of minerals. We hope the book may be of some use also for geologists, petrologists, and economic geologists who wish to find additional information.



INTRODUCTION

Several definitions of “mineral species” have been promulgated but most of them were not generally accepted. As useful we find the definition of Strunz and Nickel (2001) according to which a mineral substance is “a naturally occurring solid that has been formed by geochemical and geophysical processes, either on earth or in extraterrestrial bodies”. Besides minerals with definite three-dimensional atomic structure, the current definition also permits naturally amorphous phases. Among minerals we find mainly inorganic species - elements, alloys, carbides etc., sulfides and similar compounds, halides, oxides and similar compounds, oxidic compounds with complex anions, and a few organic species.

Mineral species

By far, the largest number of minerals described in our book are considered valid mineral species. They have been submitted to, and accepted by, the Commission on New Minerals and Mineral Names (CNMMN) of the International Mineralogical Association (IMA), or else existed before the CNMMN started its fruitful existence (1959). The principles of criteria for valid mineral species, with a list of discredited mineral names, were published by Nickel and Mandarino (1987). The description of valid species must contain chemical formula, structure (crystal system, space group, and unit cell dimensions), and at least some other physical data. A list of valid mineral species is presented in Fleischer’s “Glossary of Mineral Species”, most recently in the 9th edition by Mandarino and Back (2004). Somewhat broader is the list of mineral species in the “Strunz Mineralogical Tables” by Strunz and Nickel (2001). There is no problem with the validity of at least 95 % of minerals, thanks to the positive role of the CNMMN in limiting the number of newly described minerals.

The composition of most mineral specimens deviates, however, more or less from the theoretical chemical composition, characteristic for the “end-members” of mineral series. The critical species boundary between two minerals of identical structure and similar chemical formula, distinguished only by substitution of one of the components, is imposed at 50 % of atomic site occupancy. The Sb members of the tennantite group (2.G) will serve as a good example:

tetrahedrite

$\text{Cu}_{12}[\text{S}(\text{SbS}_3)_4]$

Ag-rich tetrahedrite

$[\text{Cu},\text{Ag}]_{12}[\text{S}(\text{SbS}_3)_4]$

Cu-rich freibergite

$(\text{Ag},\text{Cu})_{12}[\text{S}(\text{SbS}_3)_4]$

freibergite

$\text{Ag}_{12}[\text{S}(\text{SbS}_3)_4]$

Remark: both minerals always contain more or less Fe, Zn, and often Hg. Nearly pure freibergite is very rare.

The decision that a new mineral species is established when one of the cations or anions is changed for another one has unfortunate consequences in groups of minerals with very complicated compositions, e.g. the

amphibole, mica, tourmaline, labuntsovite, eudialyte, and several other groups: The number of new mineral species may grow as an avalanche, flooding the mineral population with tens or possibly hundreds of names, even when the amount of the substituting component may represent only 1-2 weight % of the whole composition.

Polytypes are, according to criteria of the CNMMN (Nickel and Mandarino, 1987, p. 1032), not regarded as individual mineral species. Exceptions are a few polytypes with different chemical formulae (e.g. baumhauerite, ferronigerite, etc.).

In this book we recognize three main groups of minerals (with distinguished graphic form):

a) **valid mineral species**: here we include all valid mineral species, which have been described up to first months of 2004. Nearly all valid mineral names were accepted by the CNMMN or appeared before 1959 and are present in Fleischer's Glossary. In addition to these we recognize as valid several minerals which for different reasons have not yet passed through the necessary procedure of the CNMMN: they are marked by a small asterisk after the name of the mineral. Other entries represent transitional members of mineral series, which are very common and which have practical usage. Here belong biotite (with end-members annite-phlogopite), lepidolite (trilithionite-polylithionite), olivine (forsterite-fayalite), and wolframite (ferberite-hübnerite). The members of the plagioclase series are also separately listed: andesine, oligoclase, labradorite, bytownite (series end-members albite and anorthite). These transitional members largely dominate over the end-members, being among the most important rock-forming minerals (eg: biotite, olivine), or among the important economic ore minerals (eg: lepidolite, wolframite). In many cases, minerals have an intermediate composition between theoretical end-members.

b) **other minerals**: mainly minerals inadequately described and several important mineral mixtures, (e.g. limonite and psilomelane) are included here to provide the reader with a comprehensive reference to the mineral name's usage.

c) **synonyms, varieties, a few rare mineral mixtures, etc.** Only the synonyms and varieties in general use are mentioned in this book. As already emphasized, valid mineral species in our book must occur in nature. For that reason the theoretical members of some groups, not yet found in nature, the knowledge of which resulted from systematic studies, are not registered in this book (e.g. in the amphibole group). For more detailed information see “Dana's System of Mineralogy” (1944, 1951, 1962), de Fourestier (1999) and Strunz and Nickel (2001).

Mineral names

The internationally used mineral names are mainly based on names of localities (e.g. freibergite) or persons (e.g. häüyne), they may have old Greek origins (e.g. epidote), less often Latin (e.g. lavendulan), rarely

Arabic or other languages; they may be named according to chemical composition (e.g. fluorite), to crystallographic terms (e.g. prismatine), to an organization (e.g., mgriite), to a journal (minrecordite), etc. Some names are of very old origin, often without known source, e.g. quartz or cinnabar. Current practice most often names minerals after localities and persons, recently with as exact form as possible, using even uncommon diacritical letters.

According to the principles published by Nickel and Mandarino (1987), the adjectival modifier in the form of a hyphenated prefix should be avoided, as for instance "Mn-siderite" instead of the correct "manganoan siderite". On the other hand, the use of a suffix was introduced to indicate the dominant rare-earth element (REE), e.g. monazite-(Ce), monazite-(Nd), etc. In a few cases a similar procedure has been used for minerals which contain different substituting elements in one or more structural sites, e.g. jahnsite-(CaMnMg), jahnsite-(CaMnMn), etc. Other examples are pumpellyite-(Fe²⁺), pumpellyite-(Mn²⁺), or numerous zeolites, e.g. gmelinite-Na, gmelinite-Ca, etc. For the formerly used prefixes such as Greek letters, it is recommended to write them as suffixes instead (e.g. "domeykite-beta" rather than " β -domeykite").

The mineral names originating in English, German, and other Germanic languages, French, and other Latin languages, and in the Polish, Czech, Greek, Hungarian, Finnish, and Swahili languages are written without any change, keeping the diacritical marks. Japanese and Korean names are written in the English transcription, Chinese names in the Pinyin transcription to English. The transcription of names of minerals written in the Cyrillic alphabet (Russian, Ukrainian, Serbian, Bulgarian) is more complicated. To make it clearer, a comparative table shows how to transliterate individual letters:

Russian letter	Latin letter	Example
ÿ, я, ю	y	yuksporite, belyankinitie
х	kh	talnakhite, khibinskite
ц	ts	labuntsovite
ж	zh	zhemchuzhnikovite
ш	sh	shafranovskite
ч	ch	charoite, chekhovichite
щ	shch	shcherbakovite

Detailed information about the origin of mineral names can be found especially in the books by Hey (1955), Clark (1993), and Blackburn and Dennen (1997).

Chemical formulae

The system of writing chemical formulae follows in our book that one used by H. Strunz since 1941 (Strunz and Nickel 2001): "Subsidiary anions (OH,F,O) are positioned before the complex anions, with both enclosed in square brackets, e.g. fluorapatite Ca[Fl(PO₄)₃] or euchroite Cu₂[OH|AsO₄]•3H₂O. This procedure was adopted for reasons of specified bonding strength, as all valence electrons of the subsidiary anions are used in bonding to the cations, whereas only a fraction of the valency electrons of the oxygens of the complex ions are involved in bonding to the cations". The ionic charge of elements is indicated in some cases, e.g. for cations by (+), for anions by (-).

Alphanumeric coding scheme encompassing mineral groups

The authors applied a simplified alphanumeric coding scheme, introduced by Strunz (1996). Thanks to the kind permission of Dr. E. Nägele from the E. Schweizerbart'sche Verlagsbuchhandlung in Stuttgart we were able to use the scheme in this book. Two characters are used, the first (numeric) represents the class, the second (alphabetic) a division. Often the names of generally used mineral groups are introduced too.

1. Elements

- 1.A Metals and intermetallic alloys
- 1.B Carbides etc.
- 1.C Metalloids and nonmetals

2. Sulfides and Sulfosalts

- Sulfides
 - 2.A Metal and metalloid alloys
 - 2.B Sulfides with M : S > 1:1
 - 2.C Sulfides with M : S = 1:1
 - 2.D Sulfides with M : S = 3:4 and 2:3
 - 2.E Sulfides with M : S < 1:2
 - 2.F Sulfides of As, alkalies, with halides, oxide, hydroxide, H₂O
- Sulfosalts
 - 2.G Sulfarsenites, sulfantimonites, sulfbismuthites
 - 2.H Sulfosalts of SnS archetype
 - 2.J Sulfosalts of PbS archetype
 - 2.K Sulfarsenates

3. Halides

- 3.A Simple halides without H₂O
- 3.B Simple halides with H₂O
- 3.C Complex halides
- 3.D Oxyhalides, hydroxyhalides, and related double halides

4. Oxides

- 4.A Oxides with M : O = 2:1 and 1:1
- 4.B Oxides with M : O = 3:4, etc.
- 4.C Oxides with M : O = 2:3, 3:5, etc.
- 4.D Oxides with M : O = 1:2, etc.
- 4.E Oxides with M : O < 1:2
- 4.F Hydroxides (without V or U)
- 4.G Uranyl hydroxides
- 4.H Vanadates
- 4.J Arsenites and similar compounds
- 4.K Iodates

5. Carbonates and Nitrates

- 5.A Carbonates without additional anions, without H₂O
- 5.B Carbonates with additional anions, without H₂O
- 5.C Carbonates without additional anions, with H₂O
- 5.D Carbonates with additional anions, with H₂O
- 5.E Uranyl carbonates
- 5.N Nitrates

6. Borates

- 6.A Monoborates
- 6.B Diborates
- 6.C Triborates
- 6.D Tetraborates
- 6.E Pentaborates
- 6.F Hexaborates
- 6.G Heptaborates and other megaborates

7. Sulfates

- 7.A Sulfates without additional anions, without H₂O
- 7.B Sulfates with additional anions, without H₂O
- 7.C Sulfates without additional anions, with H₂O
- 7.D Sulfates with additional anions, with H₂O
- 7.E Uranyl sulfates
- 7.F Chromates
- 7.G Molybdates and wolframates
- 7.H Uranium and uranyl molybdates and wolframates

8. Phosphates

- 8.A Phosphates without additional anions, without H₂O
- 8.B Phosphates with additional anions, without H₂O
- 8.C Phosphates without additional anions, with H₂O
- 8.D Phosphates with additional anions, with H₂O
- 8.E Uranyl phosphates
- 8.F Polyphosphates

9. Silicates

- 9.A Nesosilicates (island silicates)
- 9.B Sorosilicates (groups of islands silicates)
- 9.C Cyclosilicates (ring silicates)
- 9.D Inosilicates (chain silicates)
- 9.E Phyllosilicates (sheet silicates)
- 9.F Tectosilicates (framework silicates) without zeolitic H₂O
- 9.G Tectosilicates (framework silicates) with zeolitic H₂O

10. Organic compounds

- 10.A Salts of organic acids
- 10.B Hydrocarbons
- 10.C Miscellaneous organic minerals

The later alphanumeric coding scheme of Strunz and Nickel (2001) is much more detailed using five characters: for a class, a division, a subdivision, and two numeric digits at the end used for groups and individual minerals.

Crystal symmetry

All minerals (except amorphous ones) belong to one of seven crystal systems and to one of 230 space groups. Lattice constants or unit cell dimensions, expressing

directions and distances or regular internal arrangement, are characteristic for every mineral species. They are presented in Ångström units (Å), expressed differently according to the crystal system: only *a* for the cubic system, *a,c* for the hexagonal, trigonal, and tetragonal systems, *a,b,c* for the orthorhombic system, *a,b,c* and β for the monoclinic system, and *a,b,c* and α,β,γ for the triclinic system. The lattice constants may vary somewhat for the same mineral due to chemical composition variation, e.g. due to isomorphic replacement of elements. They are expressed to two decimals in our book. The number of *Z* is number of formula units per unit cell.

Strongest X-ray powder diffraction lines ("d-lines")

These lines are characteristic for each mineral species. Each line for any given mineral occurs at a specific angle and displays a specific intensity. The set of such lines characterizes the given mineral's structure and can be therefore used for mineral identification, most often by the X-ray powder diffraction method.

In this book, the strongest diffraction lines, most commonly between 3 and 7 lines, were excerpted mainly from the original papers and partly from the "Mineral Powder Diffraction File", published by the Joint Committees on Powder Diffraction Standards (JCPDS). In most cases the five most intense lines are listed. All lines were rounded off due to the precision measurement difference as follows: for numbers starting with 4 and more - to one decimal, for numbers starting with 3 or 2 - to two decimals, and for numbers starting with 1 or 0 - to three decimals (for instance 5.6, 4.8, 3.22, 2.78, 1.967, 0.895). The intensities of the "d-lines" are graded from 1 to 10. For those few papers using semi-quantitative "d-lines" intensities, we converted them as follows: VS (very strong) = 10, S (strong) = 8, MS (medium strong) = 6, etc.

Habit

Minerals build either crystals which reflect their internal arrangement on the exterior, or different types of aggregates, composed of numerous incompletely developed crystals. The "habit" means the general shape of crystals or aggregates. Crystals may be covered with one or more equivalent faces, which together compose a form. Many minerals display characteristic twinning, an intergrowth of two or more individual crystals of the same mineral along a certain crystallographic plane or axis. For specifying the orientation of the crystal faces in relation to the crystal axes, a set of three or four numbers called Miller indices are used. For instance, the symbol for an orthorhombic dipyramidal form is {111}, for a hexagonal prism form it is {1010}. A single face is indicated by Miller indices in parentheses (), the form is in braces {}, the crystallographic zone or direction is in square brackets []. Twins may also be precisely described using Miller indices.

Cleavage

Cleavage along crystallographically rational planes is a property important for mineral identification: it may be perfect, good, poor, distinct, or indistinct (the last

two are not usually mentioned in this book). Miller indices are also used to specify the orientation of cleavage planes. Parting is the breaking of a crystal along planes of weakness caused usually by external deformation, oriented mechanical inclusions, and rarely by twinning, but may also be described by Miller indices.

Fracture

Fracture is the way a mineral breaks without cleavage or parting. It may be hackly, conchoidal, irregular, etc.

Tenacity

We recognize many minerals which are brittle to various degrees, less common are malleable (e.g gold), ductile (e.g. copper), sectile (e.g. chalcocite), elastic (e.g. micas), or flexible (e.g. talc) minerals.

Color, transparency, luster, streak

Some minerals have a color as a characteristic property, others are colored or colorless when pure, but become differently colored by trace elements, by inclusions or when influenced by radiation. The mineral may be transparent, translucent, or opaque, with all possible intermediate gradations. Luster depends on light reflectance from the mineral surface. The common lusters include: metallic, semimetallic, adamantine, vitreous, resinous, greasy, pearly, earthy, and dull. The streak is a useful property for simple identification of minerals: the color of the powder is produced by rubbing the mineral on a flat piece of unglazed porcelain.

Hardness (H)

The Mohs' hardness, an empirical, not linear scale of ability of a mineral to scratch another one: 1 - talc, 2 - gypsum, 3 - calcite, 4 - fluorite, 5 - apatite, 6 - orthoclase, 7 - quartz, 8 - topaz, 9 - corundum, 10 - diamond.

Vickers microhardness (VHN)

The VHN is a quantitative hardness measurement using the shock effect on a mineral surface and its comparison with several standards, observed under a special microscope. It is expressed in kg/mm² and different weights are used (the weights are not mentioned in this book).

Density (D)

Density can be expressed as measured on a mineral - D, or calculated from the cell constants and chemical formula - D(calc.). It equals mass per unit volume of a mineral, given in grams per cubic centimeter. The basis for density comparison is water equaling 1 g/cm³.

Optical constants in transmitted light

They are valid for non-opaque minerals and are usually measured using a polarizing microscope. The technical definition of refractive index of a substance is the ratio of the velocity of light in vacuum to the velocity of light in a mineral, but the practical measurement is based on comparison of mineral's optical properties with standard liquids. Refractive index is labelled as N for isotropic minerals (those with the same optical

properties in all directions), as No and Ne for optically uniaxial minerals, and as Np, Nm, and Ng (minimal, middle, and maximal index) for optically biaxial minerals. 2V is the angle between the two optical axes in a biaxial mineral. Optic sign of biaxial minerals (+) and (-) expresses a quantitative relation among refractive indices, where, e.g. the sign $e < o$ is defined as negative and vice versa. Pleochroism is a property of certain minerals to absorb light of various wavelengths in different vibration directions, exhibiting variation of colors. It is observed under non-crossed nicols. The optical anisotropy is observed during rotation of the mineral under crossed nicols and may offer useful identification clues due to different colors.

Optical constants in reflected light

In crystal optics for reflected light, valid for opaque minerals, the general principles are the same as for transmitted light. Here, the following properties are observed: the color, the birefringence, and the reflection pleochroism, the optical anisotropy, the internal reflections as well as the reflectivity.

The color of most opaque minerals is white or gray in different hues, other colors are more rare but more useful for the mineral identification. The reflection pleochroism corresponds to pleochroism in transmitted light, and is an important identification property of opaque minerals; it varies with different directions and is expressed for uniaxial minerals in two colors and for biaxial minerals in three colors. Optical anisotropy for opaque minerals is commonly in pale colors, only a few minerals exhibit stronger colored anisotropy. Some minerals exhibit characteristic internal reflections. The reflectivity (R) is a property based on the relative ability of an opaque mineral to reflect the light beam on the polished mineral surface, expressed in percentage. The collected data on optics of opaque minerals may be found in books by Uyttenbogaardt and Burke (1971) and Picot and Johan (1982).

Fluorescence under ultraviolet light (UV)

Fluorescence is usually given under short-wave UV light (SW, 254 nm) and long-wave UV light (LW, 365 nm). Recently, a new wavelength of UV, called mid-wave (~300 nm) has been used to further characterize minerals, but there is a limited data base available to summarize here. When the wavelength is known, we include it, otherwise we use just the term UV light. A detailed review was published by Robbins (1994).

Other physical properties

Among other physical properties, only those useful for mineral identification are mentioned, e.g. magnetic properties or radioactivity.

Mineral localities

A well balanced selection of mineral localities was central to the authors' effort. We took into consideration famous old, often now exhausted localities, well-known in literature, because in the hands of museum curators, mineral dealers, and collectors fantastic, highly appreciated specimens from such old finds still circulate. However, most of our interest was focussed

on current localities which are promising to offer new discoveries. Getting to know those recently discovered localities requires not only following the mineralogical journals but also visiting regularly the world's principal mineral shows and if possible, even the localities themselves.

Individual localities mentioned in the text are listed in the enclosed List of mineral localities, which often presents more detailed information than is in the entries of the text. The localities are frequently accompanied by information not only about distance from a better known town in the area but also about the administrative regional units to which they belong. We consulted especially the third edition of the Merriam-Webster's Geographical Dictionary (1997) and various modern geographical atlases. The most common terms of administrative units are expressed in abbreviations: Rep. (republic), prov. (province), co. (county), munic. (municipio), pref. (prefecture), dépt. (département), dept. (departamento), dist. (district). Less common terms are not abbreviated, e.g. canton (Switzerland), vilayet (Turkey), region (Chile), kray and oblast (Russia). The country names are always included in text, except in the cases of the USA, UK, and the provinces Ontario and Québec in Canada, generally well known to readers. However, the names of countries are always referred to in the List of mineral localities. Other geographical abbreviations used are as follows: Mt. (mount or mountain), Mts. (mountains), R. (river), Is. (island), Volc. (volcano), Penin. (peninsula), St. (Saint), Ste. (Sainte).

Recent developments in many countries have brought numerous changes in geographical names and in the administrative divisions inside those countries, e.g. in Spain, UK, Russia, some African countries, etc. Several repeated changes of administrative divisions in central and eastern Europe during the last 60 years are the reason why the use of some historical names of regions is preferred here, e.g. Upper Silesia, Moravia and Transylvania. Some names of towns or even mountains were either changed or written in another manner, e.g. the famous locality Dzhezkazgan in Kazakhstan is now written as Zhezqazghan, Karatau Plat. as Qaratau Plat., Krivoy Rog in Ukraine is written now as Kryvyy Rih. In addition, for some important localities in Europe, where the old name were changed in connection with political events, the old names are mentioned alongside the new ones.

Especially significant problems have arisen with localities in Congo-Zaire: the country, named Democratic Republic of Congo since 1960, was changed to Zaire by dictator Mobutu in 1971, but returned to the original name after the revolution in 1997. Its mineral rich Katanga province was renamed Shaba by Mobutu, and is now the Katanga administrative region again. The former Kivu province is now divided to three regions:

Nord-Kivu, Sud-Kivu, and Maniema. There is also a country called Republic of Congo or simply Congo (capital Brazzaville).

Information about system of diacritical marks used for foreign locality names is in the paragraph on "Mineral Names".

The sequence of description of mineral occurrences, in entries with numerous localities and varied genetic types, is as follows. Localities are mostly first listed in order of genetic types of mineralization (i.e. products of magmatic, pegmatitic, and contact metasomatic processes, of hydrothermal processes, of Alpine fissures, of sedimentary, regional metamorphic, or weathering processes). Within each genetic class, localities are listed preferentially by continents, i.e. first are described localities of magmatic origin (in the sequence North and South America and Greenland, then Europe, Asia, Africa, Australia, and Antarctica), then those of pegmatitic origin in the same sequence: North and South America and Greenland, then Europe, etc. For some economically important minerals more detailed genetic data are presented.

Note that the generalized genetic types presented may be a matter of discussion for some localities, for which there is not enough space in this book. The first author (J.H.B.) occupied himself with genetic problems of ore deposits for some 40 years and participated in numerous symposia on this matter. The explanation of many genetic types of ore mineralizations changed during this period: for example, the genesis of Pb-Zn ore deposits or fluorite deposits of the central United States or of the Upper Silesian historical region in Poland, where the importance of ore-bearing brines prevailed over the former explanation by sedimentary processes. Another problem concerned genetic conditions in the gold-bearing "greenstone" in Abitibi province in northern Ontario and Québec. Some genetic problems still remain uncertain due to divergent opinions among scientists. Since some mineral occurrences of metamorphic character (e.g. skarns) may be formed by both contact and regional metamorphism, their origin may be problematic. We hope that the kind reader will be aware of problems with genetic classification of some mineralizations.

References

The present book normally provides one or more references to each entry, as far as possible in English, although in some cases the most recent papers are in another language. For common minerals with tens or even hundreds of existing references, the choice of the best references was often rather difficult.

Data on minerals and localities were collected from numerous books (a list of these references is at the end of the text) and from the most important both scientific and amateur mineralogical journals.



MINERAL SPECIES AND THEIR LOCALITIES



EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Bold types	valid mineral species
Bold italics types	for minerals inadequately described, for some transitional series members, or for several important minerals mixtures
<i>Italics</i>	synonyms, varieties, a few other mineral mixtures, more detailed information see page 7
*	valid mineral species in our opinion which for different reasons has not yet passed through necessary procedure of the CNMMN
*	mineral species which are in some cases used as a gemstone
x, xx	crystal, crystals

A letter at the end of picture description means the photographer:

H – Jaroslav Hyršl, G – Studio Granit, T – Jaromír Tvrď, Z – Petr Zajíček

FOR SOME JOURNALS THE FOLLOWING ABBREVIATIONS WERE USED:

AC – Acta Crystallographica, Sect. B, Structural Crystallography and Crystal Chemistry	MW – Mineralien-Welt (Haltern)
AM – American Mineralogist	MZh – Mineralogicheskiy Zhurnal
AMG – Arkiv Mineralogi och Geologi (Stockholm)	NJbMA – Neues Jahrbuch für Mineralogie, Abhandlungen
ASG – Archives de Science Genève	NJbMM – Neues Jahrbuch für Mineralogie, Monatshefte
BM – Bulletin de la Société française de minéralogie et de cristallographie	PDF – Powder Diffraction File (JCPDS)
CCM – Clays and Clay Minerals	PM – Periodico di Mineralogia
ChE – Chemie der Erde (Jena)	SchwMPM – Schweizerische mineralogische und petrographische Mitteilungen
CM – Canadian Mineralogist	TMPM – Tschermak's mineralogische und petrographische Mitteilungen
CMP – Contributions to Mineralogy and Petrology	USGSB – U.S. Geological Survey Bulletin
DAN SSSR, now DAN R – Doklady Akademii nauk SSSR, ser. geologiya, now Doklady Akademii nauk of Russia	WS – World of Stones (Moscow)
EJM – European Journal of Mineralogy	ZK – Zeitschrift für Kristallographie
EG – Economic Geology	ZVMO – Zapiski Vsesoyuznogo Mineralogicheskogo Obshchestva, now Zapiski Vserusskogo Mineralogicheskogo Obshchestva
GCA – Geochimica et Cosmochimica Acta	
JCGS – Journal of the Czech Geological Society (Prague)	
MA – Mineralogical Abstracts	
MJJ – Mineralogical Journal of Japan	
MM – Mineralogical Magazine	
MP – Mineralogy and Petrology	
MR – Mineralogical Record	

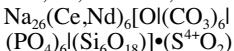
Other journals which often contain very important information are Lapis, extraLapis, extraLapis English, der Aufschluss, Gems & Gemology, Rocks and Minerals, Lithos, etc.

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Abelsonite

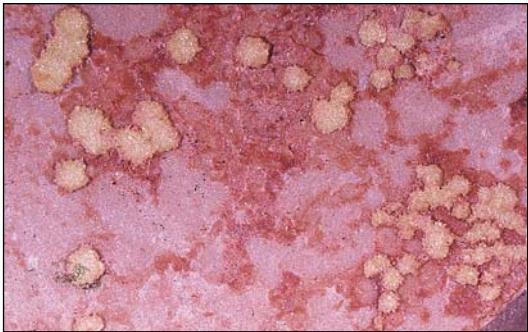
$C_{31}H_{32}N_4Ni$ (10.C, purine-porphyrine group), a nickel porphyrine. Triclinic, $a,b,c = 8.44, 11.12, 7.28$, $\alpha,\beta,\gamma = 90^\circ 53'$, $113^\circ 45'$, $79^\circ 34'$, $Z = 1$. d: $10.9(10) - 7.6(5) - 5.8(4) - 3.77(8) - 3.14(4)$. Tabular crystals in aggregates to 3 mm. Pink, red-brown, luster submetallic to adamantine, soft. Cleavage on {111}. H < 3. D = 1.45. With authigenic minerals in drill cores from oil shales of the Green River Formation in Uintah County, Utah, and in Rio Blanco County, Colorado. AM, 63, 930-937, 1978.

Abenakiite-(Ce)

(9.C), a $[\text{Si}_6\text{O}_{18}]$ cyclosilicate. Trigonal, $R\bar{3}$, $a,c = 16.02, 19.76$, $Z = 3$. d: $8.0(9) - 6.6(9) - 3.77(9) - 3.59(8) - 2.67(10)$. Single crystals to 2×1 mm. Pale brown, luster vitreous. H > 4. D = 3.21. $No,e = 1.586, 1.589$. With aegirine, manganneptunite, and sérandite, etc. at Mont St-Hilaire, Québec. CM 32, 843-854, 1994.

Abernathyite

$K_2[(\text{UO}_2)_2(\text{AsO}_4)_2] \bullet 6\text{H}_2\text{O}$ (8.E, sodium autunite group). Tetragonal, $P4/ncc$, $a,c = 7.18, 18.13$, $Z = 2$. d: $9.1(10) - 3.83(9) - 3.59(8) - 3.34(8)$. Crystals to 0.5 mm in aggregates, yellow, transparent, luster vitreous, streak pale yellow. Cleavage {001} perfect. H = 2.5. D = 3.74. $No,e = 1.597, 1.570$. Yellow-green fluorescence under SW and LW UV light. Rare with scorodite in U-bearing lignite in the Caves Hill and Slim Buttes areas, both Harding Co., South Dakota, and at the Fuemrole No.2 mine, Emery co., Utah. Also at Menzenschwand, Schwarzwald Mts., in the Saimauf quarry, Spessart Mts., Bavaria, both Germany, and from the Rabejac deposit, Hérault dépt., France. AM 49, 1578-1602, 1964.



Abernathyite, 12 mm, Rivieral, France, H

Abhurite

$\text{Sn}_{21}^{2+}\text{O}_6(\text{OH})_{14}\text{Cl}_{16}$ (3.D). Trigonal, $R\bar{3}2$, $a,c = 10.02, 44.01$, $Z = 3$. d: $4.1(5) - 3.40(5) - 2.89(7) - 2.82(5) - 2.53(10)$. Thin tabular crystals to 1.5 mm, cryptocrystalline crusts, colorless, transparent, luster adamantine. H = 2. D = 4.42. $No,e = 2.06, 2.11, (+)$. On surface of corroded tin ingots from a ship wrecked 100 years ago in Red Sea, Saudi Arabia. AM 78, 235-236, 1993.

Abswurmbachite

$\text{Cu}^{2+}\text{Mn}_6^{3+}[\text{O}_8](\text{SiO}_4)$ (9.A, braunite group). Tetragonal, $I4/acd$, $a,c = 9.41, 18.55$, $Z = 8$. d: $2.70(10) - 2.35(2) - 2.13(2) - 1.651(3)$. Fibrous to equant grains to 0.05 mm. Black, opaque, luster metallic, streak brownish black, brittle. D (synth., calc.) = 4.96. In refl. light gray, weakly

anisotropic. R(synth.) = 6-21 %. VHN(synth.) = 920. With quartz, rutile, piemontite, sursassite, ardennite, hollandite, and shattuckite, etc., in brownish red, low-grade high-pressure metamorphic Mn-rich quartzite on Mt. Ochi, near Karystos, Euboea, and near Apikia, Andros Is., both Greece. NJbMA 163, 117-143, 1991.

Acanthite

Ag_2S (2.B, acanthite group). Monoclinic, $C2/m$, $a,b,c = 4.23, 6.93, 7.86$, $\beta = 99^\circ 37'$, $Z = 4$. Stable by $< 173^\circ\text{C}$, all argentite specimens are actually acanthite paramorphs after argentite (see under argentite). Crystals of acanthite formed directly below 173°C are rare. d: $2.84(7) - 2.61(10) - 2.44(8) - 2.38(8) - 2.09(6)$. In spiny columnar crystals, iron black, opaque, luster metallic. Sectile. H = 2-2.5. D = 7.22. In refl. light gray with greenish tint. R = 35 %. VHN = 26-61. Rare at Georgetown, Clear Creek co., and at Rice, Dolores co., both Colorado, at the Questa mine, Taos co., New Mexico, at Kellogg, Shoshone co., Idaho, and at Som-



Acanthite, x 16 mm, Freiberg, Germany, H

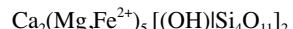
brerete, Zacatecas, Mexico. In small crystals at Jáchymov, Bohemia, Czech Rep., at Annaberg, and mainly in crystals to 5 cm at the Himmelsfürst mine, Freiberg, both Saxony, Germany. In the subtropical areas acanthite may occur on a limit zone between the oxidation and cementation zone. CM 12, 365, 1974.

Acetamide

(10.A, group of salts of organic acids). Trigonal, $R\bar{3}c$, $a,c = 11.44, 13.50$, $Z = 18$. d: $5.7(10) - 3.54(9) - 3.32(3) - 2.86(8)$. Crystals to 5 mm or granular aggregates that readily evaporate when warmed by sunlight. Colorless or gray due to inclusions. H = 1-1.5. D = 1.17. $No,e = 1.495, 1.460, (-)$. Taste strongly bitter. From burning coal dumps at Shamokin, Northumberland co., Pennsylvania, and at Chernovograd, Lviv-Volhynia basin, Ukraine. AM 61, 338, 1976.

Achavalite *

(2.C, nickeline group). Hexagonal, $P6_3/mmc$, $a,c = 3.64, 5.95$, $Z = 2$. d(synth.): $2.78(10) - 2.16(9) - 1.815(7) - 1.165(4)$. Dark gray, opaque, luster metallic. H = 2.5. Magnetic. Rare in the Cerro de Cacheuta dist., Mendoza prov., Argentina. NJbMM 279, 1972. Achroite → a colorless variety of elbaite or rossmanite. Actomite → aegirine.

Actinolite *

(9.D, tremolite group). Varieties: manganese actinolite, chromian actinolite *smaragdite*, massive actino-

lite *nephrite*, asbestosiform actinolite *byssolite*. Monoclinic, $C2/m$, $a,b,c = 9.89, 18.20, 5.31$, $\beta = 104^\circ 36'$, $Z = 2$. d: 8.4(10) – 3.13(8) – 2.71(10) – 1.564(6) – 1.084(7) – 1.052(9). Long-bladed, sometimes



Actinolite, 70 mm, Rila Mts., Bulgaria, G

coast of North America: Kobuk River Valley, Alaska, at Cassiar, 300 km E of Skagway, at Ogden Mt., on Fraser R., all British Columbia, in Granite Mts., Wyoming, as beach pebbles in Placer and Monterey



Actinolite - byssolite, 50 mm, Valle d'Aosta, Italy, G

short-columnar crystals, usually in granular, radiated, thin columnar, or fibrous aggregates, also massive. Green to blackish green, luster vitreous or dull. Twinning on {100} common. Cleavage {110} perfect, parting on {010} and {100}. H = 5-6. D = 3.05–3.25. $N_p,m,g = 1.615\text{--}1.643, 1.625\text{--}1.650, 1.635\text{--}1.665, 2V = 40\text{--}50^\circ$. Pleochroic: pale yellow, pale green, green. Actinolite sometimes originates during secondary uralitization of augite, vivid green Cr-variety smaragdite often accompanies chromite in ultrabasic rocks and chromite deposits, e.g. at the Soridag mine, Guleman dist., Elazig vilayet, Turkey. In dark green crystals and as byssolite in dolerite on Monte Redondo, 160 km N of Lisbon, Portugal. Columnar aggregates in ultrabasic rocks at Smrčina, near Sobotín, Moravia, Czech Rep., in skarn at the Sankt Christoph mine, near Breitenbrunn, Saxony, Germany, and many localities in the Alps, e.g. on Grossgreiner Mt., overlooking Zillertal Valley, Tirol, Austria, and at Passo di Vizze, Trentino-Alto Adige, Italy. Actinolite asbestos occurs mainly in the Alps between Monte Cenis and Mont Blanc, as well as in Val Malenco, Lombardy, Italy.

A component of some skarns and eclogites. With anthophyllite, talc, chromean spinel, and magnetite in desilicified pegmatites, mainly at the exocontact, e.g. at Drahonín, Smrček, and on Ždár hill, near Ruda nad Moravou, all Moravia, Czech Rep.

The most important occurrences are in metamorphic conditions: in basic rocks of the regional-metamorphic facies, in greenschists, or in contact metamorphic hornfelses, with epidote, chlorite, albite, titanite, etc. In rich masses at Pelham, Hampshire co., Massachusetts, in very broad blades with talc at Chester, Windsor co., Vermont, at Wrightwood, San Bernardino co., California, in fine crystals in talc near Wenatchee Lake, Chelan co., Washington, also at Sulzer, Prince of Wales Is., Alaska. A Zn-Mn-rich variety at Franklin, Sussex co., New Jersey. In groups of large crystals from Santa Margarita Is., munic. Mulehgé, Baja California, Mexico.

Nephrite is a massive actinolite variety, usually white or green. The biggest commercial deposits, both primary and alluvial, are in a long belt along the western

Counties, California, etc. At Jordanów Śląski, Lower Silesia, Poland. The oldest known deposits of white nephrite are in Kunlun Mts., near Hotan, Xinjiang Uygur Autonom. region, China, also at Fengtien, Taiwan. Green at Ospinskoye and Bartogolskoye, both eastern Sayan Mts., and at Kartashubinskoye, western Sayan Mts., white at Burumskoye, Vitim River Valley, all Siberia, Russia. In many localities in New Zealand. Deer et al., v. 2B, 137–231, 1997.

Acuminite $\text{Sr}[\text{AlF}_4(\text{OH})] \cdot \text{H}_2\text{O}$ (3.C). Monoclinic, $C2/c$ or Cc , $a,b,c = 13.22, 5.17, 14.25$, $\beta = 111^\circ 36'$, $Z = 8$. d: 4.8(10) – 4.7(10) – 3.50(10) – 3.35(10) – 2.07(9). Spear-like crystals in aggregates to 1 mm. Colorless, transparent, luster vitreous. Cleavage {001} perfect. H = 3.5. D = 3.30. $N_p,m,g = 1.450, 1.452, 1.463, 2V(\text{calc.}) = 49^\circ$, (+). Rare in cavities with celestine, fluorite, and jarlite in cryolite pegmatite at Ivigtut, Greenland. MR 24, 36, 1993.

Adamite $\text{Zn}_2[(\text{OH})_2(\text{AsO}_4)_2]$ (8.B, libethenite group), also in Al, Co, Ni and Cu varieties. Orthorhombic, $Pnnm$, $a,b,c = 8.30, 8.51, 6.04$, $Z = 4$. d: 4.9(9) – 2.97(9) – 2.70(8) – 2.45(10) – 1.608(8). Columnar, elongated along [010] or [001] or equant crystals, often joined together in crusts of radial aggregates. Yellow-green or light yellow, colorless, bright green (Cu variety), pink (Mn variety), sky blue (Al variety) or purple violet (Co variety), transparent



Adamite, 50 mm, Ojuela mine, Mexico, G

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to translucent, luster vitreous, streak white. Cleavage {101} good. H = 3.5. D = 4.32-4.48. $N_p, m, g = 1.722, 1.742, 1.763$ (Mapimi), $2V = 88^\circ$, (+ or -), visibly pleochroic. Some varieties (yellow from Mapimi) fluoresce yellow-green under SW and LW UV light.

Adamite formed by oxidation of sphalerite in presence of As. At Franklin, Sussex co., New Jersey, in the Gold Hill dist., Tooele co., at the Iron Blossom mine, Juab co., both Utah, on Cedar Mt., Mineral co., Nevada, and at the Grandview mine, Grand Canyon, Coconino co., Arizona. The most widely known locality is the Ojuela mine at Mapimi, Durango, Mexico, where it occurs as yellow columnar crystals to 4 cm (exceptionally to 12 cm) in druses, also in green to blue-green crystals to 2.5 cm and purple crystals to 6 cm, on characteristic rusty and earthy limonite with hemimorphite, less common as splendid purple violet crystals to 6 cm and green to sky blue crystals to 2.5. Its type locality is Chañarcillo, Atacama region, Chile. In Europe at Lavrion in blue or pale green globules and blue or yellow-green crystals, also on Thasos Is., both Greece, and at the Cap Garonne mine, Var dépt., France, here also as Cu and Co varieties. Found at Ain Achour, near Guelma, Constantine prov., Algeria, fine green crystals at Tsumeb, Namibia. In the Kintore open cut, Broken Hill, New South Wales, and at the Beltana mine, Puttapa, S of Leigh Creek, South Australia. AM 61, 979, 1976.

Adamsite-(Y)

$\text{NaY}[\text{CO}_3]_2 \cdot 6\text{H}_2\text{O}$ (5.C). Triclinic, $P\bar{1}$, $a, b, c = 6.26, 13.05, 13.22$, $\alpha, \beta, \gamma = 91^\circ 10', 103^\circ 42', 89^\circ 59'$, $Z = 4$. d: 12.8(10) – 6.5(7) – 4.4(6) – 4.3(6) – 2.57(6). In flat, acicular to fibrous crystals to 2.5 cm, elongated along [001], and spherical growths of crystals, colorless to white, also pale purple, transparent to translucent, luster vitreous to pearly. Cleavage {001} perfect, {100} and {010} good. H = 3. D = 2.27. $N_p, m, g = 1.480, 1.498, 1.571$, $2V = 53^\circ$, (+). It is a late-stage mineral in cavities of alkaline pegmatite dike at Mont St-Hilaire, Québec. CM 38, 1457-1466, 2000.

Adelite

$\text{CaMg}[(\text{OH})(\text{AsO}_4)]$ (8.D, adelite group). Orthorhombic, $P2_12_12$, $a, b, c = 7.52, 8.85, 5.85$, $Z = 4$. d: 4.1(7) – 3.16(10) – 2.59(7) – 2.33(7). Massive, rarely in crystals, colorless, gray, blue-gray, yellow, pale green, translucent, luster resinous, streak white. H = 5. D = 3.73. $N_p, m, g = 1.712, 1.721, 1.730$, $2V = 70-90^\circ$, (+). In Mn skarn at Långban, at Nordmark, and at Jakobsberg, all Värmland prov., Sweden, at Franklin, Sussex co., New Jersey, also at Sankt Andreasberg, Harz Mts., Germany. CM 18, 191, 1980.

Admontite

$\text{Mg}[\text{B}_6\text{O}_7(\text{OH})_6] \cdot 4.5\text{H}_2\text{O}$ (6.F). Monoclinic, $P2_1/c$, $a, b, c = 12.66, 10.09, 11.32$, $\beta = 109^\circ 36'$, $Z = 4$. d: 12.1(9) – 7.6(10B) – 5.3(7) – 3.93(8B) – 2.68(9). Imperfect tabular crystals. Colorless, translucent. H = 2.5. D = 1.82. $N_p, g = 1.442, 1.504$, $2V \sim 30^\circ$, (-). In the Schildmauer deposit, near Admont, Styria, Austria, together with gypsum, anhydrite, etc. TMPM 26, 73, 1979.

Adularia → a variety of orthoclase.

Aegirine

$(\text{Na}, \text{Ca})(\text{Fe}^{3+}, \text{Mg}, \text{Fe}^{2+})[\text{Si}_2\text{O}_6]$ (9.D, jadeite group), a pyroxene, an end $\text{Na}-\text{Fe}^{3+}$ -member also named acmite. Monoclinic, $C2/c$, $a, b, c =$

9.61-9.69, 8.78-8.84, 5.26-5.29, $\beta = 105^\circ-107^\circ 24'$, $Z = 4$. d: 6.4(10) – 4.4(2) – 2.98(3) – 2.91(6). Long prismatic to pointed, vertically striated crystals with blunt or acute termination, also radiating fibrous aggregates



Aegirine in charoite, xx 15 mm, Murun massif, Russia, G

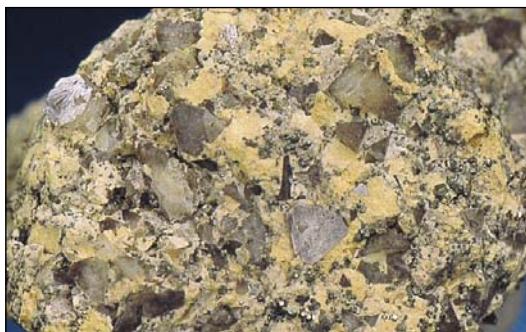
or grains. Commonly twinned on {100}. Green to black, brown-green or reddish brown, translucent to opaque, luster vitreous. Cleavage {110} perfect, parting on {100}. H = 6-6.5. D = 3.50-3.60. $N_p, m, g = 1.750-1.776, 1.780-1.820, 1.795-1.836$, $2V = 60-70^\circ$, (-), strongly pleochroic: green tints.

A typical mineral of alkaline igneous rocks and extrusive equivalents associated with Na amphiboles, astrophyllite, aenigmatite, analcime, etc. An accessory mineral of some phonolites or basalts, e.g. in Kaiserstuhl hills, Baden, Germany. Most common occurrences in alkaline rocks, e.g. in alkaline syenites, their pegmatites, and carbonatites. At Quincy, Norfolk co., Massachusetts, in very long crystals at Magnet Cove, Hot Spring co., Arkansas, in the Point of Rock quarry, Colfax co., New Mexico, and at Mont St-Hilaire, Québec. In numerous localities in the Khibiny massif and Lovozero massif, both Kola Penin., Russia, at Narssârssuk, Greenland, in the Sierra de Monchique, Faro, Portugal. In crystals to 10 cm from alkaline pegmatites at Langesundsfjord, e.g. on Låven Is., Vestfold, and at Eker, near Kongsberg, Buskerud, both Norway, abundant at Norra Kärr, Jönköping prov., Sweden. In splendid lustrous columns over 20 cm long growing on orthoclase and quartz on the Malosa Plateau, Zomba dist., Malawi. Dark brown Mn-rich aegirine in Mn skarn at Långban, Värmland prov., Sweden. Also in Na_2CO_3 -rich sediments in the Green



Aegirine, xx 20 mm, Malosa Plat., Malawi, G

clay-like, or massive. Colorless, gray, white, flesh red, transparent to translucent, luster vitreous. Cleavage {111} perfect. $H = 7$. $D = 2.88$. $N = 1.563 - 1.600$. A rather uncommon alteration product of feldspars. Its type locality is the Zuni mine, Zuni Gulch, near Silverton, San Juan co., also at the Charter Oak mine, Ouray co., both Colorado, found at Brumado, Bahia, Brazil. Clay-like dillnite with diasporite crystals and pyrite in hydrothermally altered Triassic limestones at Banská Belá, Slovakia. Abundant in a rock, from which it is mined as a raw material for production of small ornamental objects, at Azrou Melloul, near Afella, High Atlas Mts., Morocco, also at Beni-Embarek, Algeria. In exceptional tetrahedrons to 2 cm at the Big Bertha Extension mine, Quartzsite, La Paz co., Arizona, in the Tin-tic dist., Juab co., Utah, etc., and at Cerro de Pasco, Pasco dept., Peru. As transparent tetrahedrons at Kuni, Gümma pref., Japan. Common in Al-rich shales at Postmasburg, Griqualand West, Northern Cape prov., South Africa. AC, B 38, 390, 1982.



Zunyite, 30 mm, Zuni mine, Colorado, H

Zussmanite

$K(Fe^{2+},Mg,Mn^{2+})_{13^-}[(OH)_3|Si_3O_3|(Si,Al)_6O_{18}]_2$ (9.E), a modulated phyllosilicate. Trigonal, $R\bar{3}$, $a,c = 11.66, 28.69$, $Z = 3$. $d: 9.6(10) - 4.8(10) - 3.19(8)$. Minute tabular crystals, pale green, translucent, luster vitreous. Cleavage {0001} perfect. $D = 3.15$. $No,e = 1.643, 1.623$, (-). In metamorphosed shales, siliceous ironstones, and impure limestones of the Franciscan Formation in the Laytonville quarry, Laytonville, Mendocino co., California. In low-grade metamorphic rocks of Punta Nihue, Los Lagos region, Chile. MM 43, 605-614, 1980.

Zvyagintsevite

$(Pd,Pt,Au)_3(Pb,Sn)$ (1.A). Cubic, $Pm\bar{3}m$, $a = 4.03$, $Z = 1$. $d(synth.) = 2.32(10) - 2.01(8) - 1.423(7) - 1.215(9) - 0.923(6)$. In

cubes, irregular grains to 0.25 mm and veinlets to 0.12 mm long. Creamy white, luster metallic. $H = 5$. $D = 13.32$. In refl. light white. $R = 60-67\%$. $VHN = 279$.

With pyrrhotite in the Stillwater complex, Sweetwater co., Montana. With chalcopyrite, cubanite, pentlandite, and other minerals at Talmakh, near Noril'sk, Siberia, exceptional cubes to 7 mm occur in the Konder massif, near Nelkan, Khabarovsk kray, Russia. With vysotskite and Pd-Pb oxide in aggregates to 1 cm in the Kirakkajuppura Pt deposit, Penikat layered complex, Lappi prov., Finland. CM 37, 1507-1524, 1999.

Zwieselite

$(Fe^{2+},Mn^{2+})_2[Fl(PO_4)]$ (8.B, triplite group). Monoclinic, $I2/a$, $a,b,c = 12.05, 6.45, 9.89$, $\beta = 107^\circ 24'$, $Z = 8$. $d: 3.66(5) - 3.26(7) - 3.05(9) - 2.87(10)$. Usually massive, dark brown to black (when altered), translucent, luster vitreous to resinous, streak white to tan. Cleavage {001} good to perfect. $H = 5$. $D = 3.5-3.9$. $No,m,g = 1.696, 1.704, 1.713$, $2V = 87^\circ$, (+). A primary phosphate in some pegmatites, its type locality is Rabenstein, near Zwiesel, Bavaria, Germany. Also in the Sierra de Córdoba, Córdoba prov., Argentina, at Dolní Bory and Cyrilov, both Moravia, Czech Rep., at Kemiö, Turku ja Pori prov., Finland. Found in crystals to 1 cm near Freñeda, Salamanca prov., Spain. MM 31, 587, 1957. Acta Univ. Carol., Geol. (Prague) 97, 1964.

Zýkaite

$Fe_4^{3+}[(OH)(SO_4)|(AsO_4)_3] \bullet 15H_2O$ (8.D, sanjuanite-destinezite group). Orthorhombic, $a,b,c = 20.85, 7.03, 36.99$, $Z = 8$. $d: 10.6(7) - 10.4(10) - 6.9(4) - 5.6(4)$. Nodules to 3 cm, grayish white, pale yellow to pale green, luster dull, streak white. $H \sim 2$. $D = 2.5$. $No,g = 1.632, 1.646$, $2V = 60^\circ$. Water insoluble. With kaňkite, pitticite, gypsum, etc., in medieval dumps at Kaňk, near Kutná Hora, Bohemia, Czech Rep., at Munzig, near Meissen, and at Grossvoigtsberg, near Freiberg, both Saxony, Germany. AM 63, 1284, 1978.



Zýkaite, 20 mm, Kaňk, Czech Rep., G

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THE RICHEST TYPE LOCALITIES OF THE WORLD

Mineralogists, especially amateurs, are often interested in a number of type minerals and in a total number of minerals found on the most prominent world's mineral localities. Data of all found minerals for several localities had been already published several times, but often have become obsolete.

Such data are dependent on different sources: sometimes are included all mineral species, other times are omitted minerals of dissimilar origin, e.g. the rock-forming minerals on ore deposits, the mineral of slags, etc.

The comparison of localities is also dependent on their range: some localities are represented by a single rock or ore body, volcano, mine or quarry, some by a small massif, ore deposit or district. On the other hand, the largest "locality" may represent an extensive rock massif or complex of generally identical composition and origin.

In the attached table, mineral localities are listed according to declining number of type minerals, completed by data of all minerals found on the same locality to date. The data are accompanied by numbers expressing genetic type of each locality and by corresponding references; data without denotation were collected from the world's mineralogical literature. At the end of the table are mentioned several world's famous localities with a low number of type minerals but with a high number of all minerals found.

All mentioned mineral localities may be classified into several principal genetic types (denominated as 1-11):

1. minerals of ore deposits of magmatic origin
2. minerals of active volcanos
3. minerals of alkaline igneous rocks and their pegmatites
4. minerals of granite pegmatites
5. minerals of metasomatic ore deposits of a hydrothermal origin, with a rich oxidation zone
6. minerals of hydrothermal ore vein deposits, without a rich oxidation zone
7. minerals of hydrothermal ore vein deposits, with a rich oxidation zone
8. minerals of a sedimentary ore deposit, with a prominent subsequent cementation and oxidation
9. minerals of ore deposits of a highly metamorphic origin
10. minerals of an ore occurrence of metamorphic origin at Lengenbach.
11. minerals of contact metamorphic origin

An evident predominance among mentioned mineral localities display these ones which are connected with alkaline igneous massifs. A high number of type minerals is in this case, among others, influenced by presence of complex silicates with an abundant cation exchange in the mineral structures (e.g. minerals of the labuntsovite, eudialyte, and astrophyllite groups). Here belong alkaline igneous massifs of Khibiny (1,327 sq. km) and of Lovozero (650 sq. km), both on Kola Peninsula (Russia), an oval Ilmaussaq complex in

Greenland (17x8 km), a quarry at Mont St-Hilaire (Québec), a small massif at Dara-i-Pioz (Tajikistan), and a deposit on Karnasurt Mt. as the richest type locality of the Lovozero massif. An example of extremely rich body on mineral species is the Yubileynaya alkaline pegmatite lode on Karnasurt Mt., only of 26x1 m range, with 12 type minerals.

Uncommon are few ore deposits of a highly metamorphic origin, very rich in minerals: Långban (Sweden), Franklin and neighbouring Sterling Hill (New Jersey), and Broken Hill (Australia).

The metasomatic and vein ore deposits of hydrothermal origin with a rich oxidation zone display very rich mineral variability: at Tsumeb (Namibia) are besides a surface oxidation zone known other two deeper oxidation zones. Others include following ore localities: the U ore deposit Shinkolobwe (Katanga, Dem. Rep. of Congo), Schneeberg and the Clara mine (both Germany), Jáchymov (Czech Rep.), Moctezuma (Mexico), and Lavrion (Greece); Jáchymov displays the record number - 384 - of minerals known from one locality. On the contrary, at Bisbee (Arizona) only two type minerals were registered in spite of having been particularly prolific in number of found minerals. When compared with localities rich in oxidation products mentioned above, some famous ore deposits and districts without a rich oxidation zone are relatively poor on type minerals (e.g. Freiberg and Sankt Andreasberg, both Germany, or Příbram, Czech Rep.).

Fumaroles and contacts of some active volcanos are rich on type minerals, especially Vesuvius-Monte Somma (Italy), Tolbachik (Kamchatka Peninsula, Russia), and Bellerberg (Germany).

Surprisingly late in the sequence of our schedule are type localities of granite pegmatites, e.g. a very rich cryolite pegmatite Ivigtut (Greenland), a beryl-phosphate-rich Kobokobo quarry (Kivu-Sud, Dem. Rep. of Congo) and two phosphate-rich pegmatites at Hagedorf (Germany) and the Tip Top mine (South Dakota). An isolated genetic position have two registered mineral localities:

- a) Lengenbach, Binntal (Switzerland) with a leading association of Pb-As sulfosalts, rare Tl minerals, etc., which accumulated in Triassic metadolomite due to replacement during Alpine regional metamorphism.
- b) Taldnakh-Noril'sk (Siberia, Russia) as the richest representant of the Ni-Cu ore deposits with Pt and Pd minerals formed during magmatic segregation.

The poorest genetic type on mineral heterogeneity display mineralizations of sedimentary origin. Perhaps the richest localities in terms of known minerals, but with only one type mineral, are neighboring U ore deposits of Ronneburg (Thuringia, Germany) which formed due to weathering of U-bearing Ordovician black shales, and of Culmitzsch formed by weathering of Permian U ore veins, in both cases with a later cementation and oxidation. As a representant of the contact metamorphic mineralization let us name that one of the Crestmore quarry, California.

Horváth (2003) reports similar numbers of type minerals from the richest localities.

Locality	Genetic type	Type minerals	All found minerals	References
Lovozero massif	3	90	~320	I. Pekov, p.c., 2004
Karnasurt		41		I. Pekov, p.c., 2004
Alluayy		24		
Khibiny massif	3	80	~370	Lapis 25, 7/8, 13, 2000
Kukisvumchorr		22		
Yukspor		21		I. Pekov, p.c., 2004
Långban	9	72	~270	Holstam-Langhof, 1999
Tsumeb	5	59	241	G. Gebhard, 1991
Franklin-Sterling Hill	9	58	361	Miner. News 20, 10, 1, 2004
Vesuvius, incl. Monte Somma	2	56		
Mont St-Hilaire	3	43	357	Miner. News 20, 10, 1, 2004
Shinkolobwe	5	37	102	H. Goethels, p.c., 2004
Schneeberg, incl. Neustädtel	7	36	~250	Emser Hefte 4,1, 38, 1982
Ilímaussaq complex	3	31	182	MR 24, 2, 1-62, 1993
Talnakh-Noril'sk	1	29	~290	P. Kolesár, p.c., 2004
Tolbachik	2	26	120	Lapis 25, 1, 37-40, 2000
Jáchymov	7	25	384	JCGS 48, 3-4, 2003
Lengenbach	10	25	81	Stalder et al., 1998
Moctezuma	7	23	132	Lapis 26, 1, 11-40, 2001
Dara-i-Pioz	3	20		
Ivigtut	4	17	>90	MR 24, 2, 29-36, 1993
Lavrion	7	16	366	Lapis 25, 10, 45-46, 2000
Bellerberg	2	14	183	T.Wieland, p.c., 2004
Kobokobo	4	14		
Clara mine	7	13	>350	Lapis 29, 2, 18-23, 2004
Hagendorf	4	13	~160	Kastning-Schlüter, 1994
Broken Hill (Australia)	9	13	>200	Birch et al., 1999
Tip Top mine	4	12	85	Matrix 10, 3, 138-146, 2002
Freiberg	6	10	134	Flach, 1986
Crestmore quarry	11	10	> 200	MR 35, 325-330, 2004
Sankt Andreasberg	6	5	154	Lapis 14, 7/8, 23-67, 1989
Příbram	6	4	>200	Emser Hefte 13, 1, 1-59, 1992
Bisbee	7	2	285	MR 24, 421-436, 1993
Ronneburg-Culmitzsch	8	1	218	Lapis 23, 7/8, 24-77, 1998

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ALPHABETIC LIST OF MINERAL LOCALITIES

The present alphabetic list, comprising about 8,500 localities of minerals from the whole world, should not be considered as a real index of all geographical entries found in the chapter Mineral Species and their Localities. Included are names of each occurrence, mine, quarry, small mineral or ore district, small area, lake, small mountain group or mount, as well as terms for certain geological unit, zone or formation, in such case not taking into account their spacious dimension.

Omitted as entries are names of a country, state, province, region (Chile), kray and oblast (both Russia), and of similar administrative unites, names of a large mountain range, sea, ocean, etc. which do not signify a real mineral locality.

Let us remark that the Alphabetic List of Mineral Localities often contains more detailed information on geographical position of a mineral locality than brought in the chapter Mineral Species and their Localities.

For type minerals are used SMALL CAPITALS, for mixtures or inadequately defined minerals *italics*.

A

Aachen, Nordrhein-Westfalen (Germany) wurtzite
Aar massif, Bern canton (Switzerland) faujasite-Na
Abae R., Minas Gerais (Brazil) diamond, GORCEIXITE
Abakaliki, Anambra State (Nigeria) cerussite
Abee enstatite chondrite meteorite, Alberta (Canada) keilite, niningerite
Abenab mine, 30 km N of Grootfontein (Namibia) descloizite, vanadinite
Aberfoyle mine, Tasmania (Australia) cassiterite, matildite
Aberllyn mine, Llanrwst dist., Gwynedd, Wales (Great Britain) namuwite
Abertamy, Bohemia (Czech Rep.) annabergite, bismuth, erythrite, nickeline, silver, schultenite, stephanite, uraninite
Abitibi region, Ontario and Québec (Canada) gold
Abramovka R., on a hill nearby, Primorskiy kray (Russia) TANTALUM
Absaroka Range, northwestern Wyoming (USA) leucite
Abu Dabbab, Arabian desert (Egypt) wolframite
Abuja, Federal Territory (Nigeria) liddicoatite
Abundancia mine, El Guanaco, Atacama region (Chile) lammerite, LEMANSKIITE
Abu Suwagel (Egypt) platinum
Abydos, 100 km S of Port Hedland, Western Australia (Australia) tanteuxenite-(Y)
Acari, Campina Grande region, Pará State (Brazil) bismutotantalite
Acarí mine, near Nazca, Arequipa dept. (Peru) chrysocolla, diopside, opal (g)
Acfer, Sahara desert (Algeria) grossite
Achenbach, Siegerland (Germany) bottinoite, chalcoalumite, delafossite, glaukosphaerite, millerite, tučekite, ullmannite
Achsel Alm, Hollersbachtal Valley, Tirol (Austria) fluorite, wulfenite
Aci Castello, on slopes of Etna Volc., Catania, Sicily (Italy) chabazite-Na, faujasite-Na, gonnardite, PHILLIPSITE-K, PHILLIPSITE-Na
Aci Reale, on slopes of Etna Volc., Sicily (Italy) faujasite-Na

Explanations of abbreviations used in the Alphabetic List of Mineral Localities:

Rep. – Republic, prov. – province, pref. – prefecture, co. – county, dépt. – département, dept. – departamento, dist. – district, munic. – municipio, St. – Saint, Ste. – Sainte. Is. – island, Mt. – mount, mountain, Mts. – mountains, R. – river, Penin. – peninsula, Volc. – volcano, Plat. – platform.

Abbreviations used for specific gemmy varieties of minerals:

g – gemmy mineral	ku – kunzite (spodumene)
ag – agate (quartz)	mo – morganite (beryl)
al – alexandrite (chrysoberyl)	rb – rubellite (tourmaline)
am – amethyst (quartz)	ro – rock crystal (quartz)
cr – chrysoprase (quartz)	rs – rose quartz (quartz)
em – emerald (beryl)	ru – ruby (corundum)
he – heliodor, golden (beryl)	sa – sapphire (corundum)
hi – hiddenite (spodumene)	sm – smoky quartz (quartz)
in – indicolite (tourmaline)	ts – tsavorite (grossular)
ja – jasper (quartz)	ve – verdelite (tourmaline)

Aci Trezza, Sicily (Italy) CHABAZITE-Na, gonnardite
Acobambilla, near Huancavelica, Huancavelica dept. (Peru) orpiment
Acton, Montgomery co., Pennsylvania (USA) devilline
Acushnet, Bristol co., Massachusetts (USA) orthoclase
Adamello massif, Brescia prov., Lombardy (Italy) elbaite, lepidolite, stibiotatite, stibiomicrolite
Adams mine, Spruce Pine, North Carolina (USA) dravite
Addie quarry, Jackson co., North Carolina (USA) pokrovskite
Addy pegmatite, Fremont co., Colorado (USA) aeschynite-(Y)
Addis Abeba (Ethiopia) riebeckite
Aderville, Louron Valley, Haute-Pyrénées dépt. (France) FRIEDELITE
Adhi-Kot enstatite chondrite meteorite keilite
Adilabad, Satmala Hills, Andhra Pradesh (India) kutnohorite
Adirondack Mts., New York (USA) ferrosilite, hercynite, imogolite, labradorite
Adler mine, Eisern, Siegerland (Germany) tučekite
Adobe Creek, near Animas Station, Hidalgo co., New Mexico (USA) nitrocalcite
Adolfsglück mine, Hope, Lower Saxony (Germany) zirkelite
Adrar chondrite meteorite NIERITE
Adun-Cholon, Nerchinsk area, Chita oblast, Siberia (Russia) beryl (aq), jeremejevite, scorodite, topaz (g)
Aeginental Valley, Nufenenpass road, Valais canton (Switzerland) uricite
Afrikanda massif, 45 km SW of Apatity, Kola Penin. (Russia) CAFETITE, KASSITE, melilite, perovskite, schorlomite, ZIRCONOLITE
Afu granite complex, near Nasarawa, Plateau State (Nigeria) cassiterite, ferrocolumbite, fluocerite-(Ce)
Agadèz (central Niger) coffinite, uraninite
Agalyk, 15 km S of Samarkand, Kara-Tyube Mts. (Uzbekistan) kolovratite, VÉSIGNIÉITE, volborthite
Agate Beach, Lincoln co., Oregon (USA) clinoptilolite, erionite-Na

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- Aghbar mine**, formerly Arhbar, 9 km E of Bou Azzer (Morocco) ARHBARITE, cobaltaustinite, cobaltkoritnigite, cobaltlotharmeyerite, conichalcite, erythrite, skutterudite, wendwilsonite, zincroselite
- Aghios Philippos**, near Kirkí, Thrace (Greece) KIRKIITE, LÉVYCLAUDITE
- Aginskoye deposit**, ~ 350 km N of Petropavlovsk-Kamchatskiy, Kamchatka Penin. (Russia) balyakinite, BEZMERTNOVITE, BILIBINSKITE, BOGDANOVITE
- Agouim-Ifilt area**, along the highway Marrakech-Ouarzazate (Morocco) quartz (ag)
- Agoura Hills**, Los Angeles co., California (USA) clinoptilolite-K, dachiardite-Ca, ferrierite-Mg
- Agrigento area**, Sicily (Italy) MELANOPHLOGITE, sulfur
- Aguas Blancas**, Copiapo, Atacama region (Chile) eucairite
- Aguilas**, Sierra de Almenara, Murcia (Spain) FERBERITE
- Ahlen**, near Münster, Nordrhein-Westfalen (Germany) strontianite
- Ahmeek mine**, Keweenaw co., Michigan (USA) algodonite, calumetite, kamiokite, saponite
- Ahrbrück**, Eifel Mts. (Germany) veenite
- Ahumada mine**, Los Lamentos dist., Chihuahua (Mexico) vanadinite
- Aian**, Aldan Plat., Sakha, Siberia (Russia) qandilite
- Aidyrlin**, southern Ural Mts. (Russia) halloysite-7Å
- Aiken County**, South Carolina (USA) gorceixite
- Aikuaventchorr Mt.**, Yukspor Mt., Khibiny massif, Kola Penin. (Russia) chabasite-K
- Aïn Achour**, near Guelma, Constantine dépt. (Algeria) adamite
- Aïn Barbar**, Constantine dépt. (Algeria) brochantite
- Aïn Taïba**, 190 km S of Ouargla, Sahara desert (Algeria) ferrohögbonite-(2N2S)
- Aislaby**, North Yorkshire, England (Great Britain) boracite
- Aït Ahmame**, 30 km ESE of Bou Azzer (southern Morocco) alloclasite, erythrite, gersdorffite, heterogenite, löllingite, nickel-skutterudite, rammelsbergite, roselite-beta, skutterudite, szaibelyite, talmessite
- Ajmer dist.**, Rajputana (India) clarkeite, uraninite
- Ajo**, Pima co., Arizona (USA) anhydrite, bornite, chalcopyrite, connellite, PAPAGOITE, shattuckite
- Akagane mine**, Iwate pref. (Japan) AKAGANEITE, ferro-actinolite, tilleyite
- Akatani mine**, Fukui pref. (Japan) arsenic
- Akatore Creek**, eastern Otago, South Is. (New Zealand) AKATOREITE, tinzenite
- Akatuy**, Chita oblast, Siberia (Russia) CHVILEVAITE
- Akenobe mine**, Hyōgo pref. (Japan) cassiterite, emplectite, ferberite, hisingerite, mawsonite, roquésite, stannoidite, witichenite, wolframite
- Åker**, Gävle prov. (Sweden) spinel
- Akeshi mine**, Kagoshima pref. (Japan) luzonite
- Akhmatovskaya Kop'**, near Zlatoust, southern Ural Mts. (Russia) clinochlore, clintonite, diopside, perovskite
- Akhtaragda R.**, a tributary of Vilyuy R., Sakha, Siberia (Russia) akhtaragdite, WILUITE
- Akhtenskoye deposit**, near Zlatoust, southern Ural Mts. (Russia) AKHTENSHITE
- Akimoto mine**, Miyazaki pref. (Japan) manganaxinite
- Akita pref.** (Japan) réniérite
- Akjouit**, 250 km NE of Nouakchott (Mauretania) cobaltite, delaossite
- Aktash deposit**, Kosh-Agach dist., about 450 km SE of Barnaul, Gornyy Altay Mts., Siberia (Russia) AKTASHITE, wakabayashilite
- Aktyubinsk**, southern Ural Mts. (Kazakhstan) hauerite
- Alabashka**, near Murzinka, central Ural Mts. (Russia) beryl (aq, he), elbaite (rb, ve), foitite, muscovite, topaz (g)
- Alacran**, Pampa Larga, Antofagasta region (Chile) ALACRANITE, arsenolamprite, dimorphite
- Alakurtti pegmatite field**, northern Karelia (Russia) gahnite, YTTROBETAFITE-(Y), YTTROPYROCHLORE-(Y)
- Alamos**, 50 km E of Navojoa, Sonora (Mexico) ALAMOSITE, clinzoisoisite, erythrite
- Alaotra Lake**, 180 km NE of Antananarivo (Madagascar) chrysoberyl (g)
- Alaska Silver mine**, near Ouray, Silverton dist., San Juan co., Colorado (USA) benjaminite, CUPROPAVONITE, jordanite, MUMMETITE, pavonite
- Ala Valley**, Torino prov., Piedmont (Italy) ardennite, clinochlore, diopside, grossular, titanite, vesuvianite
- Alaverdi dist.**, 110 km N of Yerevan (Armenia) oldhamite, zinc
- Albany County**, Wyoming (USA) mirabilite
- Albareto meteorite** (Italy) TROILITE
- Albarradón**, near Mazapil, Zacatecas (Mexico) IODAR-GYRITE
- Albères massif**, Pyrénées-Orientales dépt. (France) magniotorplite, stančíkite
- Albero Bassi**, near Schio, Vicenza prov., Veneto (Italy) ferrierite-Mg, HEULANDITE-K
- Alberoda**, 366 mine, 3 km NE of Aue, Saxony (Germany) argentite, arsenic, fettelite, petrovicite, proustite, rösslerite, uraninite, whewellite
- Albertine mine**, near Harzgerode, Harz Mts. (Germany) ullmannite
- Albigna Glacier**, Val Bregaglia, Graubünden canton (Switzerland) beyerite, bismuthinite, friedrichite, gladite, krupkaite
- Albin palasite meteorite** stanfieldite
- Alcaparrosa**, Antofagasta region (Chile) botryogen, ferrinatrite, halotrichite, METAHOHMANNITE, quenstedtite, rhombo-clase, szomolnokite, voltaite
- Alcarán**, near Copiapo, Atacama region (Chile) metastibnite
- Alchichica**, munic. Tepeyahualco, Puebla (Mexico) alabandite
- Alchuri**, 30 km N of Skardu, Shigar Valley, Northern Areas (Pakistan) clinzoisoisite, corundum (sa), epidote, ferro-axinite, fluorapatite, phenakite, zoisite
- Aldama**, 28 km NE of Chihuahua, Chihuahua (Mexico) nováčekite
- Aldan Plat.**, southern Sakha, Siberia (Russia) arsenosulvanite, catapleite, manganese, phlogopite, richterite, sapphirine, serpentine, sinhalite, spinel, yafsoanite
- Aldear Is.**, Queen Charlotte Islands, Brit. Columbia (Canada) stibarsen
- Aleksandrov Log deposit**, Solov'eva Mt., near Nizhniy Tagil, central Ural Mts. (Russia) inaglyite, KASHINITE
- Aleksandrovskiy Golets**, Chara area, Udkan Range, Chita oblast, Siberia (Russia) IRIGINITE, MOLURANITE
- Alekseev mine**, Stanovoy Range, Sakha, Siberia (Russia) ALEKSITE
- Alekseevskiy mine**, Khakassia, ~ 200 km SW of Krasnoyarsk, Krasnoyarsk kray, Siberia (Russia) FERRIMOLYBDITE
- Alexo mine**, near Timmins, Ontario (Canada) oregonite
- Aley**, E of Williston Lake, Brit. Columbia (Canada) burbankite
- Alghero**, near Sassari, Sardinia (Italy) azurite, enargite
- Algodones mine**, near Coquimbo, Coquimbo region (Chile) ALGODONITE, DOMEYKITE
- Algoma mine**, Ontonagon co., Michigan (USA) paramelaconite, planchéite, tenorite
- Algoma**, 140 km W of Sudbury, Ontario (Canada) morenosite
- Aliabad**, Hunza Valley, Northern Areas (Pakistan) norbergite, pargasite, spinel
- Alianza mine**, Oficina Victoria, Tarapacá region (Chile) HECTORFLORESITE
- Alibag quarry**, 40 km S of Bombay, Maharashtra (India) epistilbite, goosecreekite, laumontite