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Structural-Chemical Systematics of Minerals

Third Edition

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The classification tables are complemented by the new mineral species, that were discoveried at 2007-2016 years [4], [50].The formulae of some mineral species were corrected and some mineral species were transfered to another taxons on account of the appearance of new data about the chemical composition or the crystal structures.

Structural-chemical systematic of minerals is representative of recent data on connection between chemical composition and crystal structures and properties of minerals, conditions of mineral formations, paragenesis. The chemical signs are the basis of structural-chemical systematic. The crystal structures of mineral consider on the middle and low-level taxons, but not on the high-level taxons, because the mineral structure is depend on chemical composition and physical-chemical parameters of mineralforming systems.

The classification tables are given, which include near by 5000 mineral species. This enables to use developed classification for scientific and practical purposes.

This book designed for the wide circle of mineralogists, petrographers, geochemists, students of geolodical institutions and colleges.

COVENTIONAL ABBREVIATIONS:
CN – coordinate number
HPC – hexagonal close-packed
CPC – cubic close-packed
CP – close-packed
FC – force characteristic (γ)

$\gamma_{orb} = F/r_{orb}$
$\gamma_{orb}^{n+} = I_n/r^{n+}$
$\gamma_i = I_n/r_i$

F – affinity of electron
I_n – ionization potential of n –th electron
r_{orb} – atom´s orbital radius
r_{orb}^{n+} – ion´s orbital radius
r_i – ionic radius

A.A. Godovikov introduced unnamed taxons. The names for these taxons was proposed by S.N.Nenasheva. These taxons marked by asterisk on the right from taxon. For example: quasitype*, quasisubtype*, overclass*.

The new taxons and new mineral species was introduced by S.N.Nenasheva, marked by asterisk on the left. For example: *3.2.5.3.6.3. Oxido-thiosulpfates,*museumite, *telyushenkoite.

Formulas of mineral species are given in modern reference books: [4], [42], [46], [50].

Introduction

Inspite of the existing opinions, especially of young scientists, that there is no sense to explore the systematic (in all forms) and that it is more important to get quite definite physical data, there are hundreds works which are dedicated to the mineral systematic. Some well-known scientists worked on them, such as M.Lomonosov, J. Bercelius, V. Severgin, J.D. Dan, V. Vernadskiy. H. Strunz, A. Povarennykh, I. Kostov and other ones, and dedicate their investigations to systematic of minerals.

This can be explained by the following reasons:

1) There is a necessity to systematize different and numerous information on individual minerals. Without this it is not possible to get slim and scientific description. The comprehension of it usually comes with the age of scientist and with spreading of the scientific range of interests.
2) There are a lot of mineral properties which are used in their descriptions. We need to know them not only for mineral diagnostics, but also for clarification of their searching features, forming conditions of their paragenetic associations, capabilities of mineral utilization by humans.
3) By belonging of minerals to the complete different chemical compound types; by differences and complexity of their composition.
4) Among minerals there are substances which were formed in completely, even in interexcluded physical-chemical conditions.

Any of mineral systematics appears to be multidimentioned, because it should consider all the multitude of different mineral features. The systematic which is expressed in most usual table appearance could mirror, on essence, only one of all possible sections of multidementioned area of mineral properties. The best of all modern systematic's appearances is systematic in computer databases on diskettes or on compact disks which are considered maximum number of different mineral properties. They allow to get different concrete sections of multidementioned area of mineral properties, to clarify all correlations and queries.

Historically earlier were those of mineral systematics which were based on chemical features. Unfortunately all these variants are based on highly limited number of general chemical features, on very general ideas about connection between properties of elements and their position in Periodic system. These ideas could not mirror in necessary measure all varieties and regularities of chemical compounds and features of minerals, real complexities of connection between electronic structure of elements and structure, properties of substances they forming. Big troubles of chemical systematics are determinated by unsatisfactory condition of nomenclature and classification of inorganic crystalline substances, including the majority of mineral species. All this brings to considerable drawbacks of these systematics, impossibility of their wide use. This is complicated by that usually authors of chemical systematics are not stopped on basing of their works, satisfying either on schemes of chemical features which were used in classification tables or on table of itself.

The next time group can be represented by crystallochemical, rather structural-geometrical, systematics which are widely spread. Appealing feature in all these systematics is that the concrete peculiarities of crystalline structures of minerals which can be obtained experimentally are in their basis. However, all similar systematics which can excellently demonstrate regularities of connections of mineral properties with geometrical peculiarities of their crystalline structures, be found practically weak in

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solution questions on mineral genesis and paragenesis. This is clear, because the structure of minerals appears to be the secondary feature on comparison with their chemical features, as long as the structure itself is determined by chemical composition of mineral, physical-chemical parameters of system in which it forms and stays in.

Inspite of widely spreading of such systematics, what is most likely the time tribute, they can not satisfy mineralogists, because of the shown reasons. This is most brightly expressed in whole series of works by I. Kostov, who has written in one of them: "In modern crystalline chemical classifications paragenetic connections between minerals are ignored, therefore we have formal, although slim in some cases distribution [39]. Unsatisfaction of mineralogists in this kind of systematics gives as a result the appearance of geochemical systematic of minerals by I. Kostov [40] in which by division of minerals in subclasses the element triads which characterize definite mineral associations set as a leading feature. Obviously, this cause the appearance of extremely unsuccessful and voluntary "chemical" systematic by E. Semenov [60] and very detailed, but without descriptive principles and often inconsequent systematic by A. Hoelzel [34] and A. Clark [12]. Speciesforming cations have the supreme position in class systematic in these works.

The luck of satisfying mineral systematic, obviously played its role in that the last time more and more reference books comes which have alphabetic mineral classification [16]; [2]; [57]; [17]; [51].

It is apparent that mineralogist will be satisfied, if systematic has on its basis chemical features which could enable to understand their connection with mineral structure and properties, mineralforming conditions and paragenesis. Features which are characterizing the structure of minerals should have not the highest taxon positions, but rather middle or even inferior taxon positions, because they are in straight dependence on chemical composition and physical-chemical parameters of mineralforming systems. It is important to aim for selecting in systematic such taxons which:

a) could unite possibly greater number of mineral species, this should ease their general characteristic and save mineralogy from numerous repetitions which appear in such cases, when mineralogy, because of the luck of really well-developed systematic, is stated as descriptive science;
b) could show gradual transformations from one taxons to other, their natural and numerous interconnections.

Maximally all these features could be represented in systematic which based on:

a) detaily developed ideas about the connection between properties of elements and their electronic structure, their position in Periodic table;
b) numerous chemical features which are often not considerated in necessary measure and from which the chemical properties of minerals, mineralforming conditions and paragenesis are dependent;
c) clarified regularities in connection between fundamental properties of elements and structure of chemical compound, their forming;
d) regularities in structure and mineral properties variance on dependence on physical-chemical parameters of systems in which they have formed and stated.

Developing any systematic of natural objects including minerals, two approaches which are contrary on essence should be considered. One of them, the simple one, brings us for putting all considerated objects in developed scheme, basing on "strong" logical requests. Inspite of bribing scientific vividness this way is impossible for natural objects and it could not bring to creation of their really natural systematic which considers all numerous natural connections a transformations among them. And exactly natural systematic is rather necessary and acquittal for them. This could explain that V. Vernadkiy [65], who complained on natural mineral systematic's absence, felt respect to it. The Mendeleev's success in creation of Periodic low and developing the table variant of Periodic system, could be explained simultaneously; when he instead of following the dependence of properties of elements on their atomic weights, proclaimed by himself, did three deviations, changing position in the following systems of element pairs: Co and Ni, Se and Br, Te and I which has been found its explanation later.

Such complexities which appeared on the simplest level of chemical objects - elements risen many times in conversion to their compounds, when atomic electronic structure, energy levels of electronic orbitals revealed not impurely, but rather through the chemical bond, crystalline structure of substance which extremely complicate the creation of natural systematic of minerals.

However, the situation is not completely lost and the exit could be found, if in systematic development consider not only the formal features, but also real mineral associations, their paragenesises, differences in physical chemical parameters of mineralforming systems, giving favor in mineral order in systematic exactly to the last features. This way could be vendicated by two reasons. First, it is necessary to consider that natural mineral associations, sequential transformations in mineralforming processes are not accidental, but appear to be the results of selecting, sometimes long and complex, of individual elements by their properties in natural associations in whole. Thus, this feature could be considered as criteria of naturality of mineral systematic. More than, its utilization allows to unseal deep connections in properties of individual elements, motives of their definite behavior in mineralforming processes. Second, coordination of systematic not only with properties of minerals, their structure, but also with mineralforming conditions, their paragenesis, transformation conditions from one taxon to other one either on the same level or by its consequent deepening and detailing, has to be the most important demand of the mineralogy. Without it the scientific understanding and statement and finally the creation of natural mineral systematic is impossible. The numerous examples of what was said are mentioned below.

Let's concentrate on selecting principles of highest taxon systematic, their sequence, connections; however, remember, that definitions of lower taxons - mineral species, subspecies, seria (genus), varieties, groups, families which were given earlier [22], [25] are not considered by us. To the highest taxons we refer all taxons up to classes, quasiclasses and subclasses inclusive, although not all authors give them special names, tracing their sequence by numbers (first of all roman, and then arabic) and letters (first of all capital, and then small ones) or by consequent rising numeric indexes. We use for this purpose only arabic numbers and primary small letters of alphabet.

Before we go to consideration of taxons themselves it is necessary to stop on precise definition of the number of basic terms and positions.

We should begin with systematic of elementary substances[1], compounds in dependence on prevalence of one or another definite type of chemical bond in them -

[1] In majority chemistry courses, especially primary ones, elementary substances which include substances, consisting of atoms of one sort called simple substances. Mineralogists, who however, did not pay attention that this term is completely identical to term which defines simple binary compounds in contrast to complex or binary compounds, have borrowed this term form them.

geochemical systematic of elements and cations which is used in developed natural mineral systematic.

Division of elementary substances on metals, semi-metals and nonmetals

Special atomic properties of individual elements are most visible in elementary substances, because they contain no other atoms, except the atoms of given element. But even in this case there is no simple connection between the fundamental properties of elements, for example values of their force characteristics, order numbers, and physical or chemical properties of elementary substances as far as this dependence is complicated by chemical bond between atoms, by its type, by crystalline structure of given elementary substance which is stable in definite intervals of temperature and pressure, by other physical chemical parameters[2].

Elementary substances at all times are divided on: 1) metals, 2) semimetals or metalloids and 3) nonmetals. In Russia, however, the tendency of refusal from terms “semimetals” and “metalloids” which are exclude from chemical reference books and textbooks [1], has been strongly become apparent. In USA in latest reference books on chemistry they are sometimes even selected in tables by special color [4], [60]. Unfortunately, there are no strong term definitions given, that is why different authors have completely different boundaries between these groups of substances.

For example, in P.W. Atkins’s and J.A. Beran’s book [2] we can find the following definitions:

“A **metal** is a substance that conducts electricity, has a metallic luster, and malleable and ductile” (p.43).

"A **nonmetal** is a substance that does not conduct electricity and is neither malleable nor ductile" (p.43).

"A **metalloid** has the physical appearance and properties of a metal but behaves chemically like a nonmetal" (p.44).

Inspite of their lapidarity and simplicity these definitions have insufficiency which brings to the different number of elementary substances, included in every group by different authors. First of all it is remarkable, that all used features are nonadequate. So, in definition of metal and nonmetal - it is electroconductivity, malleability, plasticity which are some of the physical properties. At the same time, there is no allusion about how these substances look (by the way it is not clear enough, what authors are consider by that - luster, color or something else), not rather about their chemical properties, but it is not clear which of them, although exactly some inconcrete physical magnitudes, including external look, and chemical properties are put in the term definition basis of “metalloid”. It is not amazing, that such situation brings to contradictions in relating some elementary substances to each of three stressed groups by different authors. Following that tables of comparing physical and chemical properties of metals and nonmetals from which, by incomprehensible reasons, the semimetals are completely excluded, are not improve the situation. Such situation is not confusing for majority of

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[2] The narrow connection between elements properties - their electronic structure, their position in Periodic table and properties of elementary substances clarifying clearly on curve, called “atomic volumes curve” of elements which was used for explaining of Periodic low by D.I. Mendeleev [48], J.L. Meyer [49] for basing of elements division on atmo-, litho, chalco- and siderophylic by V.M. Goldschmidt [32] and many of the followers. However, usually scientists forget that this curve shows the dependence of specific element volumes of elementary substances , not the elements, on ordinal (atomic) numbers or atomic masses of elements. This could be explained by intersubstitution of terms “element” and “elementary (simple) substance”, what is completely impossible as noted earlier [21]

authors and is in accordance with dialectic logic, when metalloids or semimetals are defined as substances which have to be found on boundary between metals and nonmetals and which have properties both of metals and nonmetals [67].

As a result K.W. Whitten and K.D Gailey [67] build boundary metals ↔ nonmetals strongly through diagonal B → Si → As → Te → At, and all mentioned elements are placed to the right from this boundary. They did not select semimetals concretely, although the indistinct definition for semimetals is included, and their selection is considered to be individual for every author. P.W. Atkins and J.A. Beran [3] as semimetals pick out Si, Ge, As, Sb, Te and Po, as far as Al, Ga, Sn and Bi are considered to be rather metals and B, C, P, Se, I and At are refered to nonmetals.

Considered definitions from native encyclopedic reference books are not more successful.

The most strong of them is definition of metals which is given in PED [54]. According to it, elementary substances which "have some typical properties: high electroconductivity and thermal conductivity, negative thermal electroconductivity coefficient[3], ability to reflect electromagnetic waves (luster and untransparency), plasticity[4] at usual conditions", considered as metals (p. 409).

Metallic conductivity type usually explained by presence of free electrons in metals which appear as a result of valent and conductivity zone overlapping, because the width of the forbidden zone in metals (DE_0) is 0.

Definitions of "semimetal" term which are given by chemists are completely unsuccessful. Thus, in CED [11] we can find: "**Semimetals** (semimetalic elements, "fragile metals") - elements, occupying places on boundary between metals and nonmetals (how this boundary comes - it is not mentioned, although by different authors it is completely different; meaning of "on boundary" is not clear enough - A.G.) in Periodic system of elements by Mendeleev (here is the evident mixing of terms "elementary substance" and "element" - A.G.). They characterize by covalent crystalline lattice (this is not right, because "lattices" of elementary As, Sb and Te which are practically refered to semimetals by all authors are quasimolecular - A.G.) along with metallic conductivity (As, Sb, Te have semiconductive type of conductivity - A.G.). To semimetals are refered Sb, Bi, Po, sometimes (when ? - A.G.) also Ge, As, Te, although they are conductors by conductivity type (not conductors, but semiconductors ! - A.G.), and by chemical properties (which of them ? - A.G.) - nonmetals, and Sn which has simiconductor modification" (p. 472). In addition to numerous rough mistakes in this definition it can be noted, that as basis of referring of element (as a matter of fact simple substance) to semimetals the existence of polymorphs with semiconductor properties (case of Sn which has lowtemperature modification - "gray tin" with diamond structure and semiconductor properties) have been chosen. This present to be absolutely impossible, because polymorphs, including those of them which have semiconductor properties are known for other elementary metallic substances and vice-versa, some nonmetals and semimetals have polymorphs with metallic conductivity (for example, polymorphs of Ge and Si which are stable at very high pressures).

More clear definition is given in PED [54], where we can find: "**semimetals" -** substances, occupying by electrical properties intermediate position between *metals* and

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[3] Metallic Al has unlike the other metals positive thermal electroconductivity coefficient.

[4] Not all of the metals are plastic and have low hardness. The most bright examples of fragile metals which differ by perfect cleavage and high hardness, are Cr and Os. The cleavage can be also found in monoctystalls of iron which has malleability properties in polycrystallic blanks, and other metals. As it was shown earlier [18], such properties of metals could be explained by peculiarities of theirs chemical bond, when the covalent component of chemical bond is appeared equally with its metallic component.

semiconductors; … from one side semimetals remain to be conductors up to absolute temperature naught, but from another side - with minor (comparing to metals) concentration of current carriers i. With temperature rising the number of carriers increased, electroconductivity raised too” (p. 563). Thus, semimetals characterized although by high conductivity, but of semiconductor type.

In connection with it, it is expedient to give both more strong definition of boundaries between metals, semimetals and nonmetals, and list of elementary substances, refered to each of these groups.

Earlier [21] was shown, that the boundary between metals from one side and nonmetals and semimetals from the other one in expanded variant of Periodic system comes among s-elements through H and He, refered to nonmetals and Li - Be, refered to metals. Further this boundary comes through p-elements as broken line B → Si → Ge → Sb → Bi. To the left from this boundary are the elements, forming only metallic elementary substances which completely suited for definition from PED [54], mentioned earlier. To the right of this boundary there are elements, forming elementary substances which have the properties of nonmetals and semimetals.

Indicated boundary is determinated by diagonal similarity in properties of element pairs B - Si and Ge - Sb; and belonging of pairs Si -Ge and Sb- Bi to shrink-analogies after *d* and *f* pressing respectively.

Comparing the values of forbidden zone width of elementary substances of p elements (DE_0,eV):

B	C(diamond)	N	O	F	Ne
1,5	5,2	-	-	-	-
Al	Si	P(bl.)	S	Cl	Ar
0	1,21	0,33	2,6	-	-
Ga	Ge	As	Se	Br	Kr
0	0,78	1,2	2,1	-	-
In	Sn	Sb	Te	I	Xe
0	0	0,12	0,32	1,35	-
Tl	Pb	Bi	Po	At	Rn
0	0	0	0	?	-

and the values of their specific resistancy (p, om·cm; at 20^0C): (see the next page),

B	C(diamond)	N	O	F	Ne
$4\cdot10^6$-10^7	$>10^{16}$	-	-	-	-
Al	Si	P(bl.)	S	Cl	Ar
$2,5\cdot10^{-6}$	$2,3\cdot10^5$	$3,1\cdot10^6$	$2,0\cdot10^{16}$	-	-
Ga	Ge	As	Se	Br	Kr
$1,4\cdot10^{-5}$	48-60	$3,5\cdot10^{-5}$	1,2.10	-	-
In	Sn	Sb	Te	I	Xe
$8,2\cdot10^{-6}$	1,0·10-5	$4,3\cdot10^{-5}$	3-$5\cdot10^{-1}$	$1,3\cdot10^9$	-
Tl	Pb	Bi	Po	At	Rn
$1,8\cdot10^{-5}$	$1,9\cdot10^{-5}$	$1,0\cdot10^{-4}$	42-$10\cdot10^{-3}$	?	-

we can see, that by the value of ΔE_0 not only elementary substances which could be found to the left of the boundary metal ↔ nonmetal - Al, Ga, In, Tl, Sn, Pb, but also Bi and Po which laying to the right of this boundary, should be refered to metals. By the value of specific resistancy the number of substances which could be refered to metals is even greater. Thus, besides mentioned ones, there are As, Sb and with small strain Te among them.

Another picture is drawn by comparing structures with physical properties, connected with them, of considered elementary substances. So, elementary Al, Ga, In, Tl, Sn and Pb which are found to the left from the boundary metal ↔ nonmetal, have specific for metals crystalline structures (except Ga) and malleability, plasticity. Quite another matter - elementary As, Sb, Bi and Te, found to the right from this boundary which characterized by quasimolecular crystalline structures, typical for nonmetals, and as an effect - perfect cleavage, high fragility, not usual for metals.

Such properties of elementary As, Sb, Bi and Te, satisfied both for metals and for nonmetals from the other side, give us opportunity to mark out these substances as semimetals.

Besides As, Sb, Bi and Te, rare radioactive Po and At should be refered to semimetals. Because of the rarity and small quantities in which these substances known, we can consider on properties on whole about their belonging to semimetals.

Thus, on definition of Po in SCE [59] we could find, that elementary Po slowly dissolves in HCl with formation of ion Po^{2+} which oxidize by radioactivity itself up to Po^{4+}. Hydrogen sulfide sediments sulfide PoS from solutions of Po salts. For Po the following substances are well known: oxides - PoO and PoO_2, halogenides PoX_4, sulfates $Po[SO_4]_2$ and $PoO[SO_4]$, halogensalts $M[PoX_6]$. By these and many other features Po - is typical metallic element. Considerably rarely Po reveals features of nonmetals, come forward with Po^{2-} in hydride H_2Po and in polonides.

In definition of At from CE [9] we could find: “For At it is typical to combine properties of both nonmetals (halogens) and metals (Po, Pb, and so on). Thus, analogically to iodine, At could be easily dissolved and extracted by organic solvents; by fugitiveness it gives way to I_2, but it could also be distilled away. By acting on At solution of hydrogen, gaseous HAt forming in reaction moment. Simultaneously to I_2, At in water solution is reducted by SO_2 and oxidized by Br_2. However, like metals, At could be sedimenated from hydrochloric acid solutions by hydrogen. In presence of oxidants in water acid solutions At exists in single charged cation which probably has the following structure: $[At(H_2O)_x]^+$, where x = 1 or 2" (p. 397).

Especially we should concentrate on elementary Si and Ge which are referred by some authors [3] to semimetals, although, according to mentioned earlier values of width of forbidden zone and their specific resistancy values, they should be refered to nonmetals. Their referring to semimetals most likely is a result of misunderstanding. This could be connected with that elementary Si and Ge in private life and trade received names “metallic” silicon and germanium respectively because of their strong not metallic, but rather semimetalic lustre which is a result of pretty high concentration of current bearers at normal temperature in these semiconductors with diamond type structure. In accordance with it, it is necessary to remember that simultaneous names are used for some other nonmetals, for example, “metallic selenium” and “metallic iodine” which are characterized in elementary state by semimetalic lustre too.

All that was said shows, that elementary substances should be divided on: metals, semimetals and nonmetals.

To the last ones the elementary B; C (different allotropes), Si, Ge, N, P (different allotropes), O_2 and so on allotropes of O, S_8 and other allotropes of S, Se_8 and other allotropes of Se; F_2, Cl_2, Br_2, I_2, and also H_2 and noble gases - He, Ne, Ar, Kr, Xe and Rn refered. Among them diamond and other allotropes of C, native Se, Ge, S (different allotropes), Se are known as minerals.

Boundaries between considered groups of elementary substances, in that way, could be presented by following:

B	**C**	**N**	**O**	**F**	**Ne**
Al	**Si**	**P**	**S**	**Cl**	**Ar**
Ga	**Ge**	*As*	**Se**	**Br**	**Kr**
In	Sn	*Sb*	*Te*	**I**	**Xe**
Tl	Pb	*Bi*	*Po*	*At*	**Rn**

Here is the boundary between metals which are typed in normal style, and nonmetals which are typed in semibold style, and semimetals, selected by italic and underlined, is shown by semibold broken line; thin broken line - boundary between semimetals and nonmetals.

Basic types of chemical substances, selected by primary type of chemical bond

The majority of elementary substances are refered to metals. Considerably less of them are semimetals. Nonmetals are not so numerous too. There are incomprehensibly more compounds of different elements with each other. The chemical bond type in them, their crystalline structures and properties are dependent on differences in electronegativeness between substanceforming elements (atoms, ions), their atomic (ordering) numbers. Changing of chemical bond type, properties of compounds in dependence on changing of fundamental properties of atoms, forming them, could be happened either consequently or sporadically. Earlier [18], [21], [27] it was mentioned, that chemical bond should be considered as metallic-covalent-ionic-residuum one in whole; its character in compound is defined not only by extent of covalency (ionicity), in general case by proportional difference in force characteristics (electronegativenesses), but also by extent of metallicity, determined by ordering number of element or by average ordering number of electropositive elements in compound. The extent of its “residuality” could in some cases be one more measurement of chemical bond which although could not be easily expressed through the mentioned fundamental properties of elements and atoms. Despite that the nature of chemical bond in all its demonstrations is the same, usually four extreme types of chemical bond are selected: metallic, covalent, ionic and residuum bond which are expressed in different compounds in different extent.

Metals which elements occupied left greatest part of extended variant of Periodic system, by interaction with each other are forming substances with typical metallic properties - first of all with high conductivity, strong metallic lustre, determined by metallic type of bond or simply by metallic bond. Such substances called metallides or intermetallides. Unfortunately these terms have lost the most part of their definition up today, so now it is necessary to concentrate on them.

Thus, in CED [11] we could find: “**Metallides** (intermetallides), chemical compounds of two or several metals. Compounds of transitive metals with more electropositive nonmetals (H, B, C, N and so on), characterized predominantly by metallic type of chemical bond, are also frequently refered to metallides (but may be in vain ! - A.G.)" (p. 325). We can see, that this "definition" of metallides which have been given by S.S. Kiparisov, not so much appears to be really definition, as noncritical exposition of different ways to it. When different authors are unrestricted in referring various compounds to metallides by their matter of taste, but not by the basis requests of their definition.

Definition of metallides, given in SCE [58] is not much better. "**Metallical compounds** (metallides, metalsimilar compounds, intermediate phases in alloys) - chemical compounds which have metallic properties (which of them ? - A.G.) The majority of metallical compounds are formed by interacting of several metals (intermetallic compounds), but they could also include (in which appearance, in which quantities ? - A.G.) C, N, B, Si, H and other nonmetals (which of them ? - A.G.). In accordance with it metalsimilar carbides, nitrides, borides, silicides, hydrides and so on are refered to metallical (?!! - A.G.) compounds" (p. 139). But where should we refer numerous nonmetalsimilar carbides, nitrides, borides, silicides with covalent (muassonite) or even ionic chemical bond, compounds with polyradicals as $Ca[C_2]$ and what means "metalsimilar" - is not clear. In this way, this definition, belonging to B.K. Wolf, can not sustain any criticism too.

More resent definition from CE [10] is not also clarify this situation. Where we can find: "**Metallical compounds** (metallides) have metallic properties, in particular electrical conductivity which caused by metallic character of chemical bond. To metallical compounds refer compounds of metals with each other - *intermetallides* and more other compounds of metals (in general of transitive ones) with nonmetals. Metallic properties are usually strongly clarifying in rich-metal compounds - lowest carbides, nitrides, sulfides, oxides and so on" (p. 42).

The wide treatment of notion "metallides" (intermetallides) to which refered not only compounds of metals with each other, but also compounds with semimetals, H (hydrides), light nonmetals with from 1 up to 3 p-electrons - B, C, Si, N and P (borides, carbides, silicides, nitrides, phosphides), accepted by W. Pearson [53], P.I. Kripyakevich [41]. And what is more, P.I. Kripyakevich as intermetallides considers some selenides, sulfides, sulfosalts and even oxides, especially those of them which are subcompounds or substances with cluster [5] structure.

At the same time, in reference book on chemical nomenclature by A.I. Busev and I.P.Efimov [8] we could find much more narrow treatment of these terms : "**Metallides** (intermetallic compounds) - chemical compounds of metals with each other. The metallic chemical bond is the prevalent one in such compounds. Metallides are not submitting by regularities of composition permanency and simple divisible ratios." (p. 109). The last statement is not, however, correct. Thus, among metals from one side there are compounds which are not submitting by simple divisible ratios, by usual valent states of elements - in composition of such compounds electropositive elements sharply predominate upon electronegative ones, and they called *subcompounds*. The electronic structure of such substances, their abilities of isomorphism are usually analyzed with consideration of so-called electronic concentration [33]. From the other side among metals there are a lot of compounds, in which elements have their usual valences and characterized by simple integer ratios. At the same time there are many compounds with variable in definite limits composition which are refered to metallides - bertollides, ordered alloies - Kurnakov's phases.

Considering all mentioned contradictions in terminology, we will limit term metalloids only by compounds of metals with each other, - elements which could be found to the left from mentioned earlier boundary metal $\leftrightarrow$ nonmetal in extended variant of Periodic system. Term “intermetallides” like all its synonyms, should be recognized as indefinite, obsoleted and should be excluded from usage. Metallic conductivity, frequently metallic lustre and malleability are typical for metallides. These properties are defined by metallic type of chemical bond which is typical for these substances.

Simultaneously to metallides it is expedient to select also *semimetallides* to which we could refer compounds of metals with semimetals - arsenides, antimonides, bismuthides and tellurides (polonides and astatides which are not known in mineral forms, could be refered to them also). Here are the substances with high conductivity, frequently of semiconductive type, with metallic lustre, fragile, in some cases with cleavage, up to perfect one (tetradimite mineral family). These minerals are characterized by chemical bond with predominance of its metallic component.

After that, the association of compounds of electropositive (metallical) and semimetallical elements with the rest of nonmetallical elements in *nonmetallides* is coming real by itself. Overwhelming number of compounds from chalcogen up to halogen with pretty various properties, defined by consequent decreasing of metallicity extent and covalency extent of chemical bond and increasing of its ionicity extent in mentioned direction, are refered to nonmetallides.

Among nonmetallides IVa-nonmetallides are distinguished by their properties, what is defined by special - “passing” - place of IVa-elements in Periodic system. This clarifies in what to the left to IVa group practically only metallic elements could be found, but to the right from it - rather nonmetallic and semimetallic. There is only one exception - B which is refered to nonmetallic elements, placed in IIIa-group; the last two elements of IVa group - An and Pb are refered to metallic elements too. Exactly the same peculiar placement of IVa elements in Periodic system brings E. Zintl and H. Kaiser [69] to confinement, that this group could be considered as boundary between metallides and nonmetallides. Later this boundary was called Zintl boundary, although it was unclear, but rather diffusual, what was stressed by T.V. Massalskyi [47] and what is presented to be natural, because of that was said.

By special placement of IVa group in Periodic system such specific properties of IVa-nonmetals as their ability to form entire variety of organic compounds, including hydrocarbons, siliciumhydrogens (silanes, silones and so on), germaniumorganic compounds which are more rare, but rather close by structure and properties to them, could be explained. At the same time carbides, silicides and germanides could be considered as derivatives of respective hydrogen compounds. Depending on electropositive element, they could have completely different type of chemical bond, including metallic, covalent, residual or ionic one. By this the variety in properties of such compounds, including differences in crystalline structure, difficulty of determining their place in total sequence of taxon changing in systematic, is defined. Thus, it was already mentioned, that some authors include them in “intermetallides”. However, it is uncomfortable not only because of the specific properties of these substances, but also therefore, that such their position splits natural connections and transforms in united series: metallides → semimetallides → chalcogen compounds → oxygen compunds → halogen compounds which is presented to be natural changing of chemical bond type: metallic → metallic-covalent → ionic-covalent → covalent-ionic → ionic bond.

Considering what was said, the most correct way is to select from total series of different compounds those substances which are formed by IVa-nonmetallic elements, excluding compounds like carbonates which should be considered with the rest of oxygen compounds by particularities of their composition and properties. Compounds of IVa-nonmetals, including native minerals, carbides, silicides and organic compounds, should be considered as concluding ones in the systematic. Such compounds of Va-nonmetals (N and P) as nitrides and phosphides which are close by their properties, structures, mineralforming conditions to carbides and silicides, and which have such common features with IVa-nonmetals, as for example that they belonging to the light (containing from 1 up to 3 p-electrons) typical p-elements (2 and 3 periods), are also refered here. It is important, that in this case organic compounds which are concluding the mineralogical systematic, are found their legal place.

Simple compounds, binary and more complex compounds, salts.

Such terms as simple compounds, binary and more complex compounds, salts, are very important in order to understand the basis of mineral systematic. Compounds of two elements which are consist of simple cations and anions are usually refered to *simple* substances[5]. For example of simple compounds we could mention sphalerite ZnS, chalcosine Cu_2S, antimonite Sb_2S_3, hematite Fe_2O_3, halite NaCl and so on minerals. By their properties they could be refered to bases, amphotericcompounds, anhydrydes. Some of them, for example, sphalerite ZnS, chalcosine Cu_2S, antimonite Sb_2S_3, halite NaCl are, at the same time, salts of nonoxygen acids, such as H_2S, HCl. Minerals which contain simple complex ions, for example, ammonium chloride NH_4Cl or simple complex anions, for example, pyrite $Fe[S_2]$, arsenopyrite Fe[AsS], scutterudite $Co_4\ [As_4]_3$ could be refered to simple compounds too.

To *binary* or more complex compounds referred minerals which contain more than one cation. For example chalcopyrite $CuFeS_2$, stannite $CuFeSnS_4$, perovskite $CaTiO_3$, ferberite $FeWO_4$, gagarinite $NaTRCaF_6$, carnallite $KMg(H_2O)_6\ Cl_3$.

Significantly more complex is term “salts”. Thus, in book by A.I. Busev and I. P. Efimov [8] we could find: “Salts - the class (what is class is not defined at all and in this case this term hasn’t any special taxonomic assignment - A.G.) of chemical compounds, ctrystalline substances which have ionic structure (not always! - A.G.). By dissociation in aqueous solutions salts give positive charging ions of metals and negative charging ions of acid residues (sometimes also ions of hydrogen or hydroxo-group)” (p. 419).

In CED [11] the following definition is given: “Salts - are the products of substitution of H atoms in acids instead of metal or of OH group in bases instead of acid residuum. By the complete substitution normal or average salts are forming, for example NaCl, K_2SO_4, $(C_{17}H_{35}COO)_3$ Al. Incomplete substitution of H atoms brings to acid salts (for example ammonium hydrosulfate NH_4HSO_4) incomplete substitution of OH groups - to basis salts, for example aluminum dihydroxostearate $(C_{17}H_{35}COO)Al(OH)_2$ ... Salts usually have ionic crystalline structure[6] and characterized by relatively high temperature values of melting and boiling points. Many salts are soluble in water[7], with complete dissociation on ions” (p. 533).

The most essential drawback of all these definitions is that they are limited by oxygen and often water-soluble compounds. Only in acid definition which is given in

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[5] Electropositive components of compound called cations without any dependence on chemical bond type. That is why cations in compounds with different type of chemical bond are playing different role, approaching to idealized positive charged particle by increasing of chemical bond ionic extent. Thus, cations in the majority of sulfates, nitrates, chlorides (except minerals of Ag), halogen salts are close to ideal cations. By this time, in compounds with preferred metallic and covalent chemical bond, so-called cations takes their part only as electropositive components of compound. We could say the same thing about anions, as electronegative components of compound.

[6] The chemical bond between cation and acid residuum in chalcophylic element salts, especially of weak acids, often is covalent.

[7] Silicium acid salts - silicates, the most numerous among minerals, in majority hardly soluble in water; low solubility of compounds is one of the most important conditions of their long preservation in form of minerals in nature.

CED, it is mentioned, that the substitution of O atoms instead of S atoms brings to formation of tioacids. At the same time, salts of tioacids - tiosalts[8] - are extremely numerous among minerals and have been considered since V.I. Vernadkiyi as products of reaction between tiobases (Na_2S, FeS, Cu_2S and etc.) and tioanhydrides (As_2S_3, Sb_2S_3, Bi_2S_3 and so on). The fact of existence of halogenanhydrides, halogen acids[9], halogenbases and product of their reacting - halogensalts[10] which are also numerous in nature [24] is practically ignored. Talking about bases, anhydrides, acids, salts, it is necessary, in this way, to distinguish chalco- oxy- and halogenbases, chalco- oxy- and halogenanhydrides, chalco-, oxy- and halogenacids, chalco-, oxy and halogensalts [26], [27].

Their forming could be presented by the following reactions:

a) for bases:
$2Na + H_2S \rightarrow H_2 + Na_2S$ (tiobase),
$2Na + H_2O \rightarrow H_2 + 2NaOH$ (hydroxybase),
$2Na + 2HCl \rightarrow H_2 + 2NaCl$ (halogenbase);
b) for acids:
$As_2S_5 + 3H_2S \rightarrow 2H_3AsS_4$ (tioacid),
$SO_3 + H_2O \rightarrow H_2SO_4$ (oxyacid),
$BF_3 + HF \rightarrow HBF_4$ (halogenacid);
c) for salts:
$3Na_2S + As_2S_5 \rightarrow 2Na_3AsS_4$ (tiosalt),
$Na_2O + SO_3 \rightarrow Na_2O_4$ (oxysalt),
$NaF + BF_3 \rightarrow NaBF_4$ (halogensalt).

Every of the enumerated groups of substances has special properties. Thus, typical bases are characterized by ionic cation-ligand bond, ionic homodesmic coordinate structure, and in limit, the most typical cases - good solubility in water and dissociation in solutions by the reactions like $Na_2S \rightarrow 2Na^+ + S^{2-}$, $NaOH \rightarrow Na^+ + OH^-$, $NaCl \rightarrow Na^+ + Cl^-$. Baseses are characterized by low valency (W) of cations, relatively high temperatures of melting point, low vapor resiliency. By increasing of covalent extent of bond cation-ligand, all mentioned properties become less definite.

Typical anhydrides, for example As_2S_5, As_2S_3, SO_3, P_2O_5, BF_3, SiF_4 are characterized by molecular (SO_3, P_2O_5, BF_3, SiF_4) or quasimolecular[11] (As_2S_5, As_2S_3)

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8 Tiosalts are referred to chalcosalts, including tio- and seleniumsalts; here and further we use prefix "chalco" not as uniting term, covering compounds of all IVa-elements - O, S, Se, Te, Po, what is unsuccessfully were recommended by "IUPAK chemical nomenclature rules " [52], but rather just as referring to compounds of S and Se one.

9 In CED [11] halogenacids are referred to so-called beyongacids (superacids, magical acids), defined as "complex nonwater (more correct - nonoxygen - A.G.) mineral acids, acidity of which is higher, then of 100% H_2SO_4" (p. 517); among their examples the products of reaction of halogenanhydrides (AsF_5, SbF_5, BF_3) with protoncontaining nonoxygen acids (HF and so on) are noted.

10 It should be noted, that chalcobases and halogenbases are at the same time the salts of nonoxygen acids such as sulfurhydrogen, hydrogen chloride and so on, differing by all usual for them properties, particularly by that they easily dissolve in water, dissociating on cations Na^+ and anions S^{2-} (in case of Na_2S) and Cl^- (in case of NaCl).

11 Term "quasimolecular structure", "quasimolecular crystall" are introduced for solid state substances, intermediate between lowmolecular or simply molecular (SO_3, P_2O_5, BF_3, SiF_4 - in their structures there are small discreet molecules which are connected with each other by residual bond) and polymeric highmolecular compounds. There are indefinite in one (chains and ribbons), two (layers) or even three dimensions (frameworks) in structure of quasimolecular compounds. Quasimoleculas are connected in structure by residuum, covalent-residual and so on bonds. From polymeric moleculas, quasimoleculas are

structure with covalent bond inside molecules (and quasimolecules) and residual bond between them. That is why the most typical of such substances are not dissolve in water or react with it intensively, they have low temperatures of melting points, high vapor resiliency. Highcovalent cations-anionformers (W usually 4, rare 3 like B) are extremely usual for them.

Chalco-, oxy- or halogensalts could be defined as products of reaction of chalco-, oxy- or halogenbases with chalco-, oxy- or halogenanhydrides which are in most typical cases have heterodesmical bond - ionic one between cations and acid residues and ionic-covalent one between anionformer and ligands. Such salts are good dissolving in water with formation of positive charged cations and negative charged complex anions, preserving in solutions the same form as in crystalline solids, although they are often hydrotated in one measure or another. Increasing of the covalent or metallicity extent of bond cation - acid residuum (anionic radical) brings to decreasing in salt solubility[12].

From the crystallochemical point if view the essential feature of salts is heterodesmicity of their structures for which both simple (Na^+, Ca^{2+} and so on) and complex ($[Mg(H_2O)_6]^{2+}$ and so on), including polymer ($[Na(H_2O)_4]^{3+}$ and so on) cations and in obligatory order complex, mono- or heteronuclear, mono- or polymeric, for example, $[SO_4]^{2-}$, $[SiO_4]^{4-}$, $[Si_2O_6]^{4-}$, $[AlSiO_4]^-$, $[B_2O_5]^{4-}$ and so on anions are typical.

Belonging of given substance to simple, binary compound or to salt is determined by fundamental properties of substanceforming atoms - their FC and Z, their ratios, by affiliation of substance to chalcogen, oxygen or halogen compounds. General regularity is that transformation: simple compound → binary compound → salt, has come by increasing of difference in FC of substanceforming cations, i.e. by increasing of ionic extent of chemical bond; as far as decreasing of their total or average Z, i.e. decreasing of metallicity extent of chemical bond could be favorable for transformation either to one or to another direction.

All what was said could be illustrated by transformation simple compound → binary substance → salt in sequence of oxygen compounds AO_2 (simple cation A oxide) → ABO_4 (complex cations A and B oxide) → $M[TO_4]$ (oxysalt of M^{n+} cation and tetrahedral anionic radical $[TO_4]^{n-}$ with anionformer T) with dependence on difference in FC between cations (A and B; M and T) and total value of Z, in which cations A(B) and M(T) respect to s- and d-cations (Fig. 1). On considered figure simple oxides AO_2 with rutile structure and binary oxides ABO_4 with dirutile structure placed in the left part with minimal values of differences in FC and with oscillating in wide limits values ΣZ (area I). To the right and upward from this area there is area II - complex oxides with ferberite structure $^{(6)}Fe^{(6)}WO_4$, changing with increasing of differences in FC by area III - oxysalts with scheelite structure $^{(8)}Ca[WO_4]$. Further increasing of differences in FC brings to increasing of cation CN in oxysalts $M[TO_4]$ (changing of areas IV → V → VI) along with preserving their oxysalt nature.

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differed by simple structure, saving of their forms in crystallic solid (in solid polymers macromoleculas laid in packages or globulas). Crystallic solids which include quasimoleculas, have not only near, but also far order, as far as in solid polymers far order is absent, that is why they have renthenoamorphic properties.

[12] To salts, as it was already said, referred also substances which could be considered as products of reaction between oxybases and nonoxygen acids like H_2S, HF and so on, for example, Na_2S, NaF and so on which in typical caseses have isodesmical structures, ionic bond, high solubility, dissociating on simple cations and anions and which are, at the same time, chalco- and halogenbases which should be considered, in order to avoid the confusion and because of the matives, mentioned earlier, as such, with distinguishing from other salts.

Analogical regularities were found for great number not only of other oxygen, but also of chalcogen and halogen compounds [26], [27].

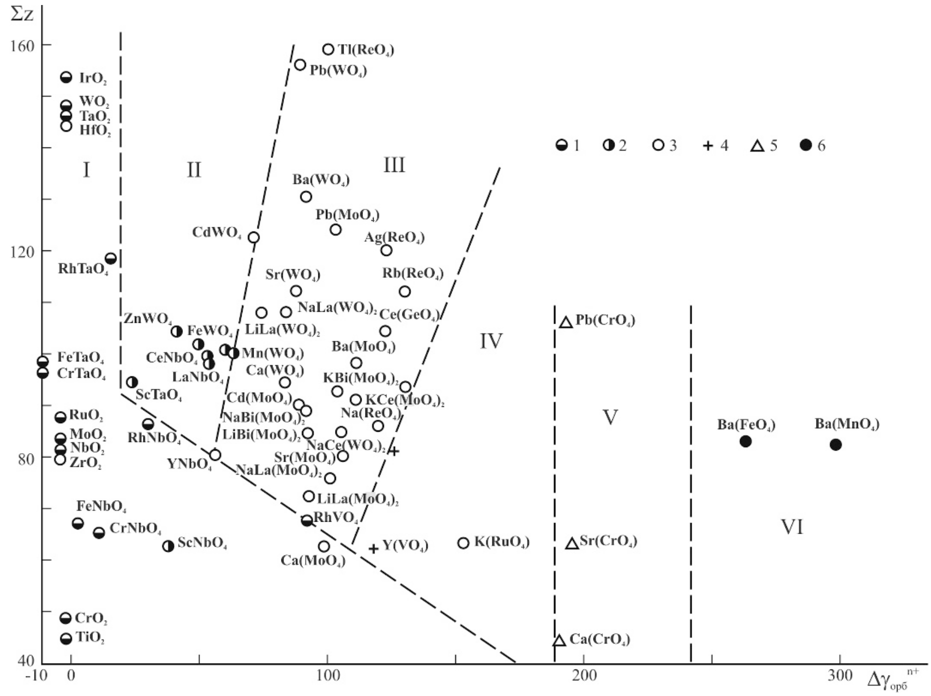

Fig.1 The dependence between the total value of atomic number (ΣZ) of atoms A(B), M(T), difference of their force characteristics ($\Delta\gamma_{opb.}^{n+}$) and the structure of compounds formed by them in sequence of oxygen compounds $2AO_2 \rightarrow ABO_4 \rightarrow M[TO_4]$.

(T)= ***d***- cations; I – area of crystals with rutile (TiO_2 and so on.) or dirutile ($FeNbO_4$ and so on) structures, II – area of crystals with structure of ferberite $FeWO_4$, III – of scheelite $Ca[WO_4]$ type, IV – of type of $Y[VO_4]$, V – of type of $Pb[CrO_4]$, VI – of type of $Ba[FeO_4]$; the type of structure: 1 – TiO_2, 2 – $FeWO_4$, 3 – $Ca[WO_4]$, 4 – $Y[VO_4]$, 5 – $Pb[CrO_4]$, 6 – $Ba[FeO_4]$.

All what was said tells not only about considerable differences in crystalline structures and properties of simple compounds, complex compounds, salts, but also about their natural change in mentioned order as long with changing of FC and Z, and creates the basis for classification of substances in limits of chalcogen, oxygen and halogen compounds.

Geochemical classification of elements and cations

The first highly successful geochemical systematic of elements which haven't lost its significance by now was element separating on geochemical (genetic) groups, offered 70 years ago by V.M. Goldschmidt [32]. This systematic he has based from one side on division of elements along with fusion of metals on metallic melt - sulfide melt, harden as matte and silicate melt, harden as slag, taking this process as a model of Earth substance differentiation in development process. From the other side he has paid the attention that elements which are typical for mentioned metallurgy products, have taken not accidental, but rather defined position in curve of dependence of atomic volumes of elementary substances upon atomic (ordered) element number[13] (Fig. 2).

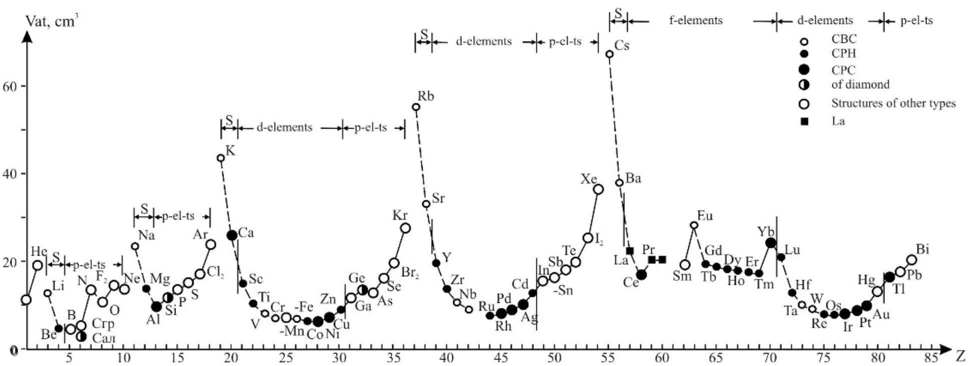

Fig. 2 The variation of atomic volume of elementary substances (V) by increasing of atomic number (Z) of corresponding elements.1 – cubic body-centered, 2 – close-packing hexagonal, 3 – close-packeing cubic, 4 – of diamond, 5 – ionic type structure, 6 – structures of La.

On this basis V.M. Goldschmidt has divided all elements on 4 groups:

1. *Siderophylic* elements, placed in minimal parts of curves of dependence of atomic volumes upon atomic number. To them he refered C, P, Fe, Co, Ni, Tc(Ma), Mo, Ru, Rh, Re, Os, Ir and Pt.
2. *Chalcophylic* elements, placed in ascending parts of curves of dependence of atomic volumes upon atomic number - S, Cu, Zn, Ga, Ge, As, Se, Pd (more correctly it should be refered to siderophylic elements), Ag, Cd, In, Sn, Sb, Te, Au, Hg, Tl, Pb, Bi и Po.
3. *Lithophylic* elements, placed in descending parts of curves of dependence of atomic volumes upon atomic number - Li, Be, B, Na, Al, Si, K, Ca, Sc, Ti, V, Cr, Mn, Rb, Sr, Y, Zr, Nb, Cs, Ba, Ln, Hf, Ta, W, Fr (it has not been placed yet on V.M.Goldschmidt's curve), Ra, Ac, Th, Pa, U; here he refered also O, F, Cl, Br, I, placed on ascending parts of considered curves, taking into account commonness of these elements in minerals of rocks and doing deviation from logical-formal in favor to natural element classification.

[13] This curve, firstly used by D.I. Mendeleev [48] and L. Mayer [49], usually because of substitution of terms element and elementary (simple) substance, incorrectly called "curve of atomic volumes of elements". Along with it, it is forgotten that in its basis have been put only one property of elements - their ordered numbers, as far as values of atomic volumes are referred to elementary substances, but not to elements and their utilization with clarifying of element properties is not correct enough, that was discussed in detail before [18], [19].

4. *Atmophylic* elements, placed in upward parts of curves of dependence of atomic volumes upon atomic number - He, N, Ne, Ar, Kr, Xe, Rn; here he refered H too.

Not disclaiming successfulness of offered by V.M. Goldschmidt terms which are correspond to objective existing regular connections of element structures and their behavior in natural processes, expressed, in particular, on mentioned figure, what was determined their vitality, it is necessary to stress, that such general conclusion of element properties inevitably brings us to disputable places of some of them, especially those ones which could be refered equally to different groups. We could note more contradictions which have roots in fact that curve of atomic volumes, used for systematic, was built with using only one element property - their order numbers. All other used values - atomic volumes - are refered not to elements - totality of atoms of one sort in free state, but rather to properties of elementary substances, depending upon their crystalline structure, physical-chemical parameters which are defined the stability of one or another concrete polymorphic modification.

Definite discrepancies of his systematic of elements to actual material V.M. Goldschmidt has felt himself soon. In accordance with it in 1928 year [33] he has already noted, that element comparing on atomic volumes is correct only if they are stated at the same valency condition and have the same CN. The same thing was noted by A.E. Fersman [14].

Definite limited nature of element classification offered by material V.M. Goldschmidt has been token into account by V.V. Shcherbina [61], who stressed the importance of magnetic properties of elementary substances, type of cations, formed by given element for classification of elements. In connection with it he wrote: "… being of certain element in one or another group (considering geochemical groups of elements by Goldschmidt - A.G.) not disturbs it to clarify its peculiarities which could be typical for other groups. Thus, for iron it could be said, that it possess both lithophylic and chalcophylic and siderophylic properties, but, taking in mind, that world consists of metallic iron, that iron has a lot of properties of siderophylic elements, it could be refered to siderophylic elements. Tin, owing to paramagnetic properties, could be found mainly in form of cassiterite in association with lithophylic elements in nature, but by several of its properties (atomic structure, formation of complex sulfides and so on) it could be refered to chalcophylic elements. Presence of small quantities of tin in many sulfide minerals confirms this point of view.

Arsenic, when it plays cation part, i.e. in form of As_2S_3 and its compounds, undoubtedly is chalcophylic. Vice versa, anionic arsenic in speryllite $PtAs_2$, smaltite $CoAs_2$ and so on characterize the siderophylic nature of these elements. Halloids, laid on ascending curve, refered to the typical lithopylic elements.

Palladium, owing to the sequence of its properties, is refered to chalcophylic elements by many authors, although, perhaps, more correctly to refer it to siderophylic group.

Molybdenum, inspite of its primary place in nature exclusively in form of sulfide - molybdenite[14] - nevertheless could not be refered to chalcophylic elements, because molybdenum is paramagnetic (this is about elementary substance, but not about element - A.G.), not forming ion with 18 outer-shell electrons, not forming complex sulfides like $R_2S \cdot MoS_2$ or $RS \cdot MoS_2$; molybdenite frequently occurs without escort of other chalcophylic elements in nature. At least, litho-, chalco- and siderophylic properties,

[14] V.V. Shcherbina failed to take in consideration the existence of different complex oxides of Mo and W, molybdates and tungstenates in nature. Along with it in some tungstenates, for example in scheelite, the quantity of isomorphous dashes of Mo achieves industrial significant values.

based on ionic structure, are periodical properties too. Lithophylic elements changed by siderophylic, and siderophylic - by chalcophylic, that is why element, placed between litho- and siderophylic elements, could be refered to chalcophylic elements hardly. As for its affinity with sulfur, it could be explained by nontypical placement of outer-shell electrons in molybdenum atom.” (p. 32-33).

Unsatisfaction in V.M. Goldschmidt’s systematic brings to development of personal geochemical systematics by several scientists. Particular interesting were those of them which were offered by A.E. Fersman [14] and A.N. Zavaritskyi [68].

In Fersman’s systematic we should stress the selection of typical elements (i.e. elements with cenosymmetrical outer-shell and subouter-shell electrons). This were done by separating of these elements from the rest by double horizontal line. In upward part of table there are all typical elements from first three periods, and elements from K up to Ni including too. By this the special properties of majority of elements, refered to first seria of d-elements which refered, as it has been established later [62], to cenosymmetricals too, were pointed out.

Geochemical classification by A.N. Zavaritskyi differs by the greatest consequence and detailness. It is based, from one side, on element properties which are reflected in extended variant of Periodic system, from the other side - on enormous personal experience of outstanding petrographier and petrologer. He selected in limits of Periodic system 11 element areas:

1. Hydrogen area - H, stressing its special role in minerals.
2. Noble gas area - He, Ne, Ar, Kr, Xr, Rn.
3. Rock elements area - Li, Na, K, Rb, Cs, Be, Mg, Ca, Al, Si.
4. Area of elements of magnetic emanations - B, C, N, O, P, S, F, Cl.
5. Iron group elements area - Ti, V, Cr, Mn, Fe, Co, Ni. Touching this group A.N.Zavaritskyi noted, that "geological processes of iron ore forming are much closer to processes of rock forming, then to processes of forming of other element ores. Such ores are magmatic iron ores and ores of sediment genesis" (p. 16).
6. Rare element area - Sc, Y, Ln, Zr, Hf, Nb, Ta, as that A.N.Zavaritskyi noted definite convention in uniting of elements in this group.
7. Radioactive elements area - Fr, Ra, Ac, Th, Pa, U.
8. Platinum group elements area - Ru, Rh, Pd, Os, Ir, Pt.
9. Metallic (colour) elements area - Cu, Ag, Au, Zn, Cd, Hg, Ga, In, Tl, Ge, Sn, Pb.
10. Metalloid metalogenic elements (elements "sulfoacids") area - As, Sb, Bi, Se, Te, Po.
11. Heavy halloids area - I, Br, At.

Mo, W, Tc and Re remained without selected areas in A.N. Zavaritskyi’s systematic.

Separately we need to note, that systematic by A.N. Zavaritskyi, as he noted himself, is by many features close to technical classification of elements by G.Berg, developed on the basis of exceptionally industrial (technical) features, what is consolidates the importance of both of them.

Our mineralogy-crystallochemical systematic of elements is prove to be close to considered earlier. This systematic developed with taking into account recent data on peculiarities of electronic structure of elements - studies about ceno- and noncenosymmetrical electrons, elements, different extents of closeness (analogy) in properties of elements as a dependence on their electronegativeness, expressed by force characteristics - FC and order number of element Z [5], [26], [31], although it has some essential differences. It is comfortable to combine selected in this systematic 13 areas of elements into more important groups, using terminology of V.M. Goldschmidt, changing, however, groups filling with considering of mentioned data. In this case we will have the following element systematic:

1. Hydrogen - H. Selecting H into separated group is corresponding to systematic by A.N. Zavaritskyi.
2. Lithophylic elements with low FC.
   - 2.1 Alkaline and alkaline-earth elements - Li, Na, K, Rb, Cs, Fr; Mg, Ca, Sr, Ba.
   - 2.2 Rare earth and radioactive elements - Sc, Y, Ln (La - Yb), Th, U.
   - 2.3 Amphoteric elements - Be, Al, (Ga)
   - 2.4 Cenosymmetrical d'-elements - Ti, V, Cr, Mn, Fe, Co, Ni - group of elements fully analogical to iron group of A.N. Zavaritskyi; Ti connected by diagonal similarity with Nb and Ta, refered to the next group 3.1. The isomorphism between them and commonness of Ti dashes in Nb and Ta minerals and vice versa could be explained by this.
3. Lithophylic elements with middle FC
   - 3.1 Noncenosymmetrical d'-complexformers - Zr, Hf, Nb, Ta.
   - 3.2 Mo and W.
4. Noble-metallic (siderophylic) elements - Ru, Rh, Pd, Ag, Os, Ir, Pt, Au; among them Ag and Au often are found in chalcophylic minerals and associations.
5. Chalcophylic elements.
   - 5.1 Chalcophylic elements with low FC - Cu, Zn, Cd, Hg, (Ga), In, Tl, Pb.
   - 5.2 Chalcophylic elements with middle FC - Ge, Sn, As, Sb, Bi, Se, Te. Groups 5.1 and 5.2 are close to groups 9 - metallic (colour) elements and 10 - metalloid metalogenic elements (elements "sulfoacids") of A.N. Zavaritskyi respectively, with the exception of Ge and Sn which he refered to group 9.
6. Light anionformers - B, C, Si, N, P, O, S, F, Cl - group of elements fully analogical to group of elements of magmatic emanations by A.N. Zavaritskyi, included in form of anionformers (B, C, Si, N, P, S) or anions (O, F, Cl) into lithophylic minerals, and only S plays, along with it, anion role in chalcophylic minerals.
7. Heavy anionformers - Br and I.
8. Noblegases elements - He, Ne, Ar, Kr, Xe, Rn.

This mentioned systematic, however, needs in additional specifications, because, as it was said earlier [26], [27], the majority of elements are amphoteric and their acid-basic properties are defined by properties of other elements, included in compound, their ratios, physical-chemical parameters of systems in which this mineral was formed or placed. It was shown, that the considerations about amphoterity in use for crtystallic substances, should be based on values of CN of cations. General regularity here is that increasing of cation's CN brings to strengthening of its basic properties, and decreasing of its CN, opposite, - to increasing of its acid properties. Thus, the cations of typical siderophylic elements could in crystallochemical relation be the analogies of typical lithophylic elements, and cations of typical chalcophylic elements could be the analogies of typical lithophylic elements. In this connection, we could point-out Mn^{2+}, Fe^{2+} , Co^{2+} , Ni^{2+} which along with CN = 6 are the crystallochemical analogies for Mg^{2+}, what is clarifying in wide isomorphism among them, formation not only isoformular, but also isostructural compound. Simultaneously, Pb^{2+} with CN 12 is crystallochemical analogue of Ba^{2+} , K^+ in minerals like hollandite, Ca^{2+} - in makedonite ($PbTiO_3$) which is close to perovskite structure ($CaTiO_3$); Tl^+ with CN = 12 is analogue of typical lithophylic alkaline K^+ in isostructural pair djerfisherite - thalfenisite. There are a lot of such examples, what is difficulties using of generalized systematic of elements (cations) like considered before.

Differences in acid-alkaline properties of cations with different CN is comfortable to express by set values of FC - their references to CN - FC/CN which along with the electronic type of cation (s-, f-, d-, p-), its order number allow to come to very important conclusions. Let's see it in detail in order, replying for transformation from s-, f- through d- to p-elements.

Elements of s- and f-type in majority give cations with so low values of FC/CN, that almost all of them could be refered to cations with alkaline or clear basic properties (Fig.3).

Particular place among s-cations occupies Li^+, for which with CN = 4 FC/CN = 7,1, Mg^{2+} which has FC/CN with CN = 6 equal to 10,2, and with CN = 4 - 15,3; and Be^{2+} which FC/CN with CN = 6 equal to 21,8, and with CN = 4 - 32,8. All mentioned peculiarities of these cations clarify in their special behavior in compounds. Thus, Li^+ is not isomorphous to other s-cations of Ia-group with lower FC/CN. At the same time, its compounds by their properties and mineralforming conditions are clearly differ even from isostructural minerals. For example, we could cite holmquistite, lepidolite and spodumene which are in this connection "rara avises" in families of amphiboles, micas and pyroxenes respectively.

The role of $^{(6)}Mg^{2+}$ in minerals is also original. In many of them it shows isomporphysm up to full one with cations like $^{(6)}Fe^{2+}$, $^{(6)}Mn^{2+}$, but not with other IIa-cations, in sequence of minerals (for example, in micas, chlorites) it is isomorphous in wide limits to $^{(6)}Al^{3+}$. But cations of $^{(4)}Mg^{2+}$ could be isomorphous even to cations like $^{(4)}Al^{3+}$ or they could play crystallochemical role, simultaneous to last ones which is appeared, for example, in oxyspinellides. By this way, in crystallochemical relation in Mg^{2+} the transformation to amphoteric cations is clarified.

The typical amphoteric s-cation is Be^{2+}, for which in minerals CN = 4 is usual (FC/CN = 32,8). The formation of minerals like beryllosilicates, characterized by that they contain heteronuclear beryllium-silicium radicals, beryllophosphates with mixed heteronuclear beryllum-phoshatoes radicals and so on minerals, is directly connected with this.

The U^{6+} for which more then 180 mineral species are known with U^{6+} in form of ion uranyl $(UO_2)^{2+}$, has special position among considering f-cations. Among them there are small number of respectively simple compounds, as far as the majority of them has properties of salts of weak acids, in which uranile ion is included in complex anion radicals. This has been established in uranates and in numerous salts of uranyl-acids. Because by now there is no precise values of FC of U^{6+}, in order to determine the FC/CN ratio we have to take two extreme values of FC. Along with it, it is important, that even with respectively high values of CN (8 = 2 + 6 and 6 = 2 + 4) they are noticeable higher then analogue values of almost all considered s- and f-cations, except $^{(4)}Be^{2+}$. Thus, all considered cations could be divided on two types 1)lithophylic s- and 2)lithophylic f-cations which are clearly isolated on mentioned Fig. 3.

As it was known, two d-elements - Sc and Y are close by their properties to lantanides. Their closeness is so great, that they are usually situated in the same minerals in form of isomorphous mixtures and they could be hardly separated by chemical ways from

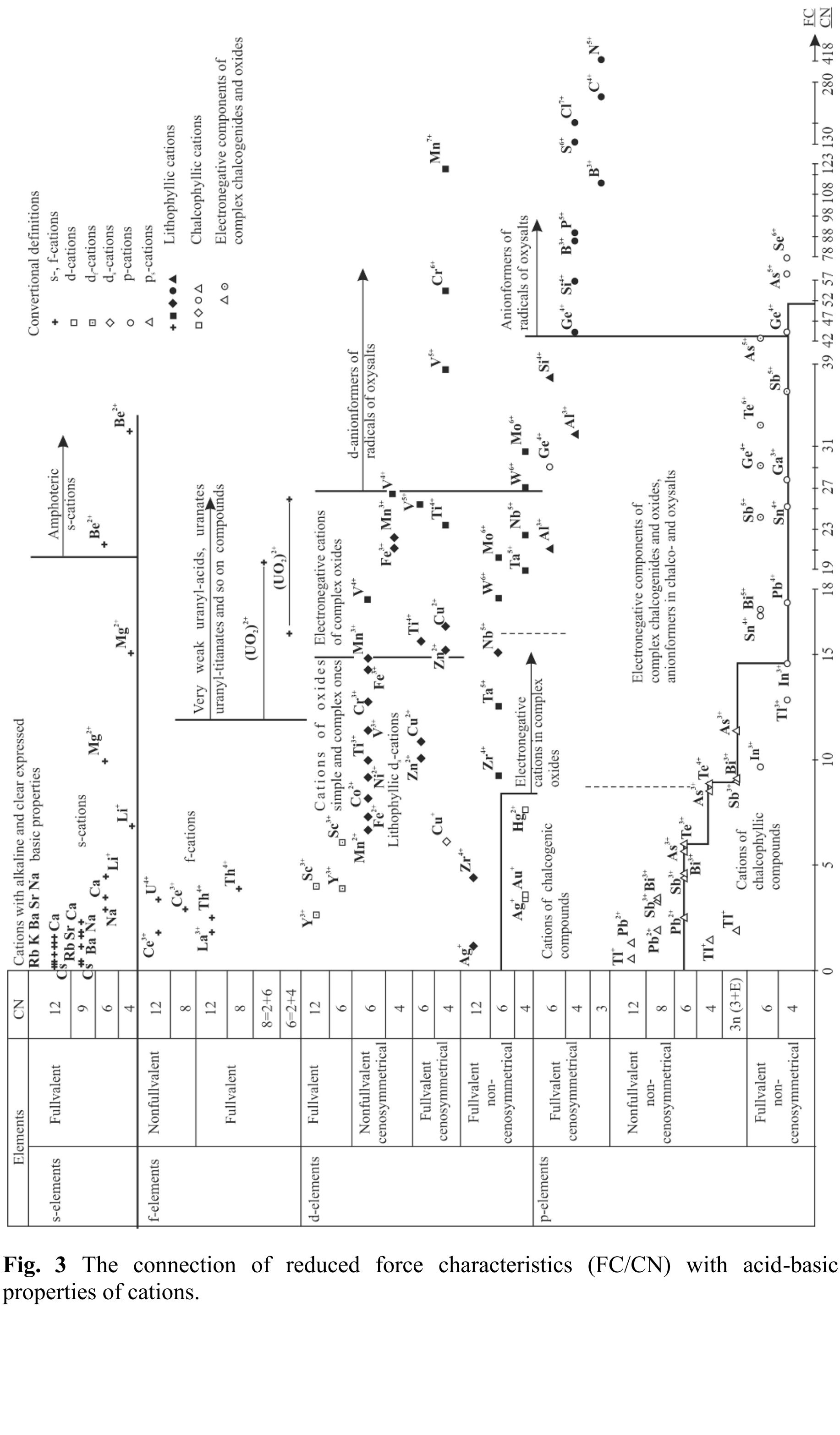

Fig. 3 The connection of reduced force characteristics (FC/CN) with acid-basic properties of cations.

each other. All this bring to association of all considered elements to rare-earth's group, for designation of which symbol TR was accepted. The comparison of values of FC/CN of Sc^{3+} and Y^{3+} with these values of lantanides cations which was done in the same Fig.3, shows their pretty beg closeness. Considering all that was said, these cations are designated as lithophylic d_f-cations. It shouldn't be forgotten, that maximal closeness with f-cations they have only with high CN, as long as with CN = 6, for example, Sc^{3+} could play crystallochemical role of $^{(6)}Al^{3+}$ which is presented in bazzite $(Sc,Al)_2\ Be_3\ [Si_6O_{18}]$ which is crystallochemical analogue of beryl $Al_2\ Be_3\ [Si_6O_{18}]$.

Significantly more complex are the connections of values of FC/CN with acid-basic properties in other d-cations (Fig.3) (platinoides are excepted from consideration, because of their original properties and differences in behavior in minerals from majority of other elements). This is determined either by great variety of their valences and CN or by their belonging not only to lithophylic, but also to chalcophylic elements (cations).

Here first of all let's stop on nonfullvalent cations of cenosymmetrical d-elements which have been associated before by A.N. Zavaritskyi to group of iron, and by us - to group of cenosymmetrical d'-elements. In Fig. 3 it is clear, that by valency and value of FC/CN such cations as $^{(6)}Mn^{2+}$ (6,7), $^{(6)}Fe^{2+}$ (7,4), $^{(6)}Co^{2+}$ (8,3), $^{(6)}Ni^{2+}$ (9,3) are close to $^{(6)}Mg^{2+}$ (10,2). This is presented in isomorphism up to full one between these cations in many of minerals. Close values of FC/CN have also threevalent $^{(6)}Ti^{3+}$ (10,1), $^{(6)}V^{3+}$ (11,5), $^{(6)}Cr^{3+}$ (12,9), $^{(6)}Fe^{3+}$ (14,4), $^{(6)}Mn^{3+}$ (14,9), for which wide isomorphism both with each other and with $^{(6)}Al^{3+}$ (21,4) (oxyspinellides, pyroxenes, garnets and so on) is also noticed. It should be pointed-out, that in many of minerals there is a wide isomorphism between considered two- and threevalent cations (especially in micas, chlorites) too.

By value of FC/CN threevalent $^{(6)}Ti^{3+}$, $^{(6)}V^{3+}$, $^{(6)}Cr^{3+}$, $^{(6)}Fe^{3+}$, $^{(6)}Mn^{3+}$ are also close to $^{(4)}Mg^{2+}$ (15,3), what is explaining their close crystallochemical role in minerals like oxyspinellides. $^{(6)}Ti^{4+}$ (15,8), $^{(6)}V^{4+}$ (17,8), $^{(4)}Fe^{3+}$ (21,6), $^{(4)}Mn^{3+}$ (22,4), $^{(4)}Ti^{4+}$ (23,7), $^{(6)}V^{5+}$ (25,6), $^{(4)}V^{4+}$ (26,7) are playing different crystallochemical role. They are presented in complex oxides, for example, as electronegative amphoteric cations with very weak acid properties, weak anionformers in minerals like ferrisilicates getting closer in this relation to $^{(4)}Be^{2+}$ (32,8) и $^{(4)}Al^{3+}$ (32,2).

Here we should note, that by value of FC/CN among cations of Ti even $^{(4)}Ti^{4+}$ (23,7) is far from typical anionformers. That is why the respective substances which have not been known as minerals yet should be considered as complex oxides. Use of accepted in chemistry name titanates, considering salts of titanium acids, is very probational.

Considering mentioned closeness of these cations with such s-cations as $^{(6)}Mg^{2+}$, $^{(4)}Mg^{2+}$, $^{(4)}Be^{2+}$ and belonging of respective elements to lithophylls, all of them are designated by us as d_s-cations.

To d_s-cations also refered $^{(6)}Zn^{2+}$ (10,2) and $^{(6)}Cu^{2+}$ (11,0) which are close by FC/CN to $^{(6)}Mg^{2+}$ (10,2) and $^{(4)}Mg^{2+}$ (15,3), by what their close crystallochemical role, for example in oxyspinellides, pyroxenes and some other minerals is explained.

Special position on Fig.3 have cations of elements, selected by us as noncenosymmetrical d'-complexformers - Zr, Hf, Nb and Ta. Inspite of low values of FC/CN, these cations rarely play role of cations of simple compounds in minerals, for example, in simple oxides, zircon and so on. The role of electronegative cations in complex compounds like zirkonates, tantaloniobates, where they, however, are not reaching the role of typical anionformers, are more characterizing for them. Their inclination for complexforming is clarifying in formation of mixed anionic radicals of zircono- and tantalosilicates. By these features Ti^{4+} is very close to them. It is also forming minerals like titanosilicates, in which isomorphous substitutions between Ti and Nb, Ta are presented, what is reverberation of diagonal similarity Ti with Nb and Ta which was mentioned before.

By this way, Ti is presented as element with dual crystallochemical peculiarities - from one side it is one of the cenosymmetrical d'-elements, from another one - it comes forward as equitable member of noncenosymmetrical d'-complexformers.

The role of electronegative cations in complex oxides, rushing for role of anionformers in oxysalts is more clearly presented in Mo^{6+} , W^{6+}, especially with CN = 4, responding to molybdates and tungstenates. At the same time it should be stressed, that anhydrides of respective acids are solid substances with high melting temperatures, they are hardly dissolve in water by what they are completely differ from anhydrides of typical oxyacids. They have considerable lower values of FC/CN (see Fig. 3). All this shows their natural connection with complex oxides and unnaturalness of their removing to principle different taxons, how it, for example, was done by A.S. Povarennykh [55], who considered minerals like tungstenates with CN of Mo^{6+} и W^{6} equal to 6 among complex oxides, and minerals like scheelite with CN of Mo^{6+} и W^{6+} equal to 4 among complete different place in systematic - among oxysalts which are close to sulfates, with which they have not any genetic connections. They are associated with them only by formal features - similarity in CN and valences of anionformers. The same thing we could say about dragging off the vanadates with CN V^{5+} = 4 from other closely connected with them minerals of V^{5+} in which it has CN = 5 or 6 and consideration of them in common or closely with minerals of phosphates class only by formal features - isoformularity of respective acids, same valency of anionformers, similarity of their CN.

Thus, cenosymmetrical $^{(6)}Ti^{4+}$, $^{(6)}V^{4+}$, $^{(4)}Fe^{3+}$, $^{(4)}Mn^{3+}$, $^{(4)}Ti^{4+}$, $^{(6)}V^{5+}$, $^{(4)}V^{4+}$ and noncenosymmetrical $^{(6)}Zr^{4+}$, $^{(6)}Ta^{5+}$, $^{(6)}Nb^{5+}$, $^{(6)}W^{6+}$, $^{(4)}Ta^{5+}$, $^{(6)}Mo^{6+}$, $^{(4)}Nb^{5+}$, $^{(4)}W^{6+}$, $^{(4)}Mo^{6+}$ are present the group of amphoteric cations with properties varying from weak basic ones with CN = 6 up to weak acid ones with CN = 4, ending on $^{(4)}V^{5+}$ which shows the most acid properties. At the same time, fullvalent $^{(4)}Cr^{6+}$ and $^{(4)}Mn^{7+}$ have strong enough acid properties, what is expressed in their role as anionformers of strong chromic and manganic acids and their salts.

Considering what was said, it is expedient to divide all mentioned d-cations on three groups by their crystallochemical role in minerals:

a) Lithophylic d-cations with low FC - $^{(4)}Fe^{3+}$, $^{(4)}Mn^{3+}$. It is convenient to unite them with s-cations, considering them as d_s-cations, because they are crystallochemically closely connected with other three- and bivalent d_s-cations, what is presented in paragenesis of respective minerals, placed in association or appropriately changing each other by changing of oxidizing potential Eh. At the same time it should not be forgotten about significant role of $^{(4)}Fe^{3+}$in chalcogen minerals.
b) Lithophylic d-cations with middle FC - $^{(6)}Ti^{4+}$, $^{(6)}V^{4+}$, $^{(4)}Ti^{4+}$, $^{(6)}V^{5+}$, $^{(4)}V^{4+}$, $^{(6)}Zr^{4+}$, $^{(6)}Ta^{5+}$, $^{(6)}Nb^{5+}$, $^{(6)}W^{6+}$, $^{(4)}Ta^{5+}$, $^{(6)}Mo^{6+}$, $^{(4)}Nb^{5+}$, $^{(4)}W^{6+}$, $^{(4)}Mo^{6+}$, $^{(4)}V^{5+}$. They form both simple and complex oxides which by their composition, sequence of properties and especially by their genesis are closely connected with oxysalts, ending this sequence. Dragging off the last ones by high constants of respective acids feature and consideration of these classes of minerals from this basis with oxysalts of p-anionformers (phosphates and sulfates), as it was usually done by logical-formal motives, is absolutely unnatural. Middle values of Eh, needed for formation of such minerals, their low solubility, character of paragenesis are in good agreement with it.

c) Lithophylic d-cations with high FC - $^{(4)}Cr^{6+}$ и $^{(4)}Mn^{7+}$ which are d-anionformers of strong acids, consideration of which should end the oxygen compounds of lithophylic d-cations.

In addition to what was said let's cite the sequence of considered classes of oxysalts by increasing of pKa of respective acids:

Class (4) - Vanadates (3,74; $H_3[VO_4]$)
Class (4) - Molybdates (2,54; $H_2[MoO_4]$)
Class (4) - Tungstenates (2,20; $H_2[WO_4]$)
Class (4) - Chromates (0,80; $H_2[CrO_4]$)

As d_s-cation in some minerals could be $^{(12)}Ag^+$ (1,2), playing, for example, in argentojarosite role of $^{(12)}K^+$ (0,61) , $^{(4)}Zn$ (15,3) и $^{(4)}Cu$ (16,5) which are usually typical chalcophylic cations and just sometimes play role of d_s-cations, for example, in oxyspinellides.

The rest of d-cations with CN = 4 and lower are typical chalcophylic.

The same features are in the basis of p-cations systematic (Fig. 3) which could be united by their role in minerals in 5 groups:

a) p_s-cations of lithophylic elements - $^{(6)}Al^{3+}$ и $^{(4)}Al^{3+}$ which are close crystallochemically, as it have already been pointed-out, to $^{(6)}Mg^{2+}$ and especially to $^{(4)}Mg^{2+}$ and $^{(4)}Be^{2+}$. Here by value of FC/CN we could refer $^{(6)}Ge^{4+}$ and $^{(6)}Si^{4+}$. However, $^{(6)}Si^{4+}$ is stable only at very high pressures (stishovite with structure of rutile) and it appears extremely rarely in composition of minerals, formed in Earth crust. From them we could point only on one certainly established mineral - thaumasite with formulae $Ca_3Si(OH)_6$ $[CO_3][SO_4]\cdot 12H_2O$. And if we take in consideration narrow genetical connection of minerals $^{(6)}Ge^{4+}$ and $^{(6)}Si^{4+}$ with minerals $^{(4)}Ge^{4+}$ и$^{(4)}Si^{4+}$, refered to very weak anhydrides of silicium and germanium acids and to their salts, it is expedient, because of the same purposes which were discussed previously, to consider the minerals of $^{(6)}Ge^{4+}$ и $^{(6)}Si^{4+}$ with minerals of $^{(4)}Ge^{4+}$ и $^{(4)}Si^{4+}$, separating them from those of $^{(6)}Al^{3+}$ и $^{(4)}Al^{3+}$. We should not forget about definite crystallochemical closeness of $^{(4)}Al^{3+}$ and $^{(4)}Si^{4+}$, presented in fact of existence of numerous alumosilicates with heteronuclear alumosilicium polymeric radicals.
b) Lithophylic anionformers of oxyacids, to which fullvalent cations of p-elements, separated previously as light anionformers - $^{(4)}Si^{4+}$, $^{(4)}B^{3+}$, $^{(4)}P^{5+}$, $^{(3)}B^{3+}$, $^{(4)}S^{6+}$, $^{(4)}Cl^{7+}$, $^{(4)}C^{4+}$, $^{(4)}N^{5+}$ are refered. Here especially should be noted difference in CN which could have B, owing to its properties as anionformer are considerably changing - $^{(4)}B^{3+}$ by these features is placed between $^{(4)}Si^{4+}$ и $^{(4)}P^{5+}$, as far as $^{(3)}B^{3+}$ - between $^{(4)}P^{5+}$, and $^{(4)}S^{6+}$. Besides that, there are many minerals, consisting of polymeric radicals with $^{(4)}B^{3+}$ and $^{(3)}B^{3+}$ at the same time and which are considerably differ by their properties and forming conditions, paragenesis from other borates. To the same group we could refer the salts of $^{(4)}S^{4+}$ - sulfites, because inspite of low value of FC/CN of this anionformer (17.8), sulfuric acid is refered to strong acids (pKa=1.85). And its salts could be considered in connection with sulfates, from which they differ first of all by lower value of Eh, needed for their formation.
c) p_s-cations of chalcophylic elements - $^{(12)}Tl^+$, $^{(12)}Pb^{2+}$, $^{(8)}Pb^{2+}$,$^{(8)}Sb^{3+}$ и $^{(8)}Bi^{3+}$. Among them $^{(12)}Tl^+$ is, as it have already been said, crystallochemical analogue of $^{(12)}K^+$ in pair djerfisherite - thalfenisite and so on minerals; $^{(12)}Pb^{2+}$- $^{(12)}Ca^{2+}$ in

macedonite; $^{(12)}Ba^{2+}$,$^{(12)}K^{+}$ - in minerals like hollandite; $^{(8)}Pb^{2+}$, $^{(8)}Sb^{3+}$ and $^{(8)}Bi^{3+}$ - $^{(8)}Ca^{2+}$, $^{(8)}TR^{3+}$ in minerals with structure of pyroclore. The same cations are included in composition of some other lithophylic minerals.

d) Chalcophylic p-cations with low FC, - $^{(4)}Tl^{+}$, $^{(3)}Tl^{+}$, $^{(6)}Pb^{2+}$, $^{(6)}Sb^{3+}$, $^{(6)}Bi^{3+}$, $^{(6)}As^{3+}$, $^{(6)}Te^{4+}$, $^{(4)}As^{3+}$, $^{(4)}Te^{4+}$, $^{(6)}In^{3+}$, $^{(4)}Tl^{3+}$, $^{(4)}In^{3+}$, $^{(6)}Sn^{4+}$, $^{(4)}Pb^{4+}$, $^{(4)}Sn^{4+}$, $^{(4)}Ga^{4+}$, coming forward as electropositive components in simple and complex chalcogen compounds, chalcosalts, in which CN of many cations is increasing, for example, for Pb^{2+} up to 7 and even 8, for Cu^{+} up to 6 an so on; and also in oxygen minerals, refered to arsenites, …, tellurites, tellurates.

e) Chalcophylic p-cations with middle FC - $^{(3+E)}Sb^{3+}$, $^{(3+E)}Bi^{3+}$, $^{(3+E)}As^{3+}$, $^{(6)}Bi^{5+}$, $^{(6)}Sb^{5+}$,$^{(6)}Te^{6+}$,$^{(4)}Sb^{5+}$,$^{(6)}As^{3+}$, coming forward as electronegative components in complex sulfides and oxides, anionformers of chalcosalts → oxysalts like arsenites, …, tellurites and tellurates. Along with it by their properties and conditions of formation the last minerals are rather close to respective complex compounds, then to typical oxysalts like phosphates and sulfates, among which they usually are considered without any sense and basis. In this relation they are resembling considered earlier tantaloniobates, molybdates, tungstenates, vanadates.

f) Chalcophylic anionformers of oxysalts radicals - $^{(4)}Ge^{4+}$,$^{(4)}As^{5+}$,$^{(4)}Se^{6+}$. Oxysalts, responding to such acids because of crystallochemical logical-formal similarity usually are refered in systematic just behind silicates, phosphates and sulfates respectively. Conditionally selenites are inserted here too which inspite of that anionformer $^{(4)}Se^{4+}$ has low value of FC/CN are the salts of strong enough acids, resembling in this relation sulfites with anionformer $^{(4)}S^{4+}$. However, taking in mind the conditions of formation of these minerals mainly because of oxidizing the chalcogen minerals, narrow their chemical and paragenetic connection with minerals, formed by elements of two previous groups, the most natural is to place this group at the end of our consideration of chalcophylic elements. Along with it, the following sequence of mineral classes depending on strength of their acids should be also contemplated:

Class (6) - Arsenites (9,23; H_3AsO_3)
Class (4) - Germanates (9,10; H_2 [GeO_4]) - are considered just behind silicates
Class (6) - Tellurates (7,61; H_6TeO_6 or $Te(OH)_6$)
Class (4) - Tellurites (2,57; H_2TeO_3)
Class - Selenites (2,75; H_2SeO_3)
Class (4) - Arsenates (2,25; H_3 [AsO_4])
Class (4) - Selenates (1,92; $H_2[SeO_4]$)

Resuming and taking into account some well-known facts, the systematic of the most important ions, including in minerals could be presented in the following form (the values of FC/CN are pointed-out in brackets):

1. Hydrogen and hydrogencontaining ions, neutral molecules - H^{+}, $(H_3O)^{+}$, NH^{+}_4; $(OH)^{-}$; H_2O.
2. Cations of lithophylic elements with low FC, including:
   a). s-Cations - $^{(12)}Cs^{+}$ (0,35), $^{(12)}Rb^{+}$ (0,47), $^{(9)}Cs^{+}$ (0,47), $^{(12)}K^{+}$ (0,61), $^{(9)}Rb^{+}$ (0,63), $^{(12)}Ba^{2+}$ (0,96), $^{(12)}Sr^{2+}$ (1,3), $^{(9)}Ba^{2+}$ (1,3), $^{(12)}Na^{+}$ (1,5), $^{(12)}Ca^{2+}$ (1,8), $^{(9)}Sr^{2+}$ (1,8), $^{(9)}Na^{+}$ (2,0), $^{(9)}Ca^{2+}$ (2,5), $^{(6)}Na^{+}$ (3,1), $^{(6)}Ca^{2+}$ (3,7), $^{(6)}Li^{+}$ (3,7), $^{(4)}Li^{+}$ (7,1), $^{(6)}Mg^{2+}$ (10,2), $^{(4)}Mg^{2+}$ (15,3), $^{(6)}Be^{2+}$ (21,8), $^{(4)}Be^{2+}$ (32,8).

b). f-Cations – $^{(12)}Ce^{3+}$ (2,0), $^{(12)}La^{3+}$ (2,0), $^{(12)}Th^{4+}$ (2,7), $^{(8)}Ce^{3+}$ (3,1), $^{(12)}U^{4+}$ (3,65), $^{(8)}Th^{4+}$ (4,1); special properties has U^{6+} which is found in minerals mostly in form of ion of uranile $(UO_2)^{2+}$, forming weak uranyl acids, uranates and numerous uranyl-oxysalts.

c). d_f-Cations - $^{(12)}Y^{3+}$ (2,7), $^{(6)}Y^{3+}$ (4,0), $^{(12)}Sc^{3+}$ (4,2), $^{(6)}Sc^{3+}$ (6,3).

d). d_s-Cations - $^{(12)}Ag^{+}$ (1,2), $^{(6)}Mn^{2+}$ (6,7), $^{(6)}Fe^{2+}$ (7,4), $^{(6)}Co^{2+}$ (8,3), $^{(6)}Ni^{2+}$ (9,3), $^{(6)}Ti^{3+}$ (10,10), $^{(6)}Zn^{2+}$ (10,2), $^{(6)}Cu^{2+}$ (11,0), $^{(6)}V^{3+}$ (11,5), $^{(6)}Cr^{3+}$ (12,9), $^{(6)}Fe^{3+}$ (14,4), $^{(6)}Mn^{3+}$ (14,9), $^{(4)}Fe^{3+}$ (21,6), $^{(4)}Mn^{3+}$ (22,4); partially the same role is played by $^{(4)}Zn^{2+}$ (15,3) and $^{(4)}Cu^{2+}$ (16,5) which are more characteric for chalcophylic minerals; cations $^{(6)}Mn^{2+}$ (6,7), $^{(6)}\mathbf{Fe}^{2+}$ (7,4), $^{(6)}Co^{2+}$ (8,3), $^{(6)}Ni^{2+}$ (9,3), $^{(6)}Cr^{3+}$ (12,9), $^{(6)}\mathbf{Fe}^{3+}$ (14,4), $^{(6)}Mn^{3+}$ (14,9), $^{(4)}\mathbf{Fe}^{3+}$ (21,6), $^{(4)}Mn^{3+}$ (22,4), especially those which are selected with bold, are coming forward also as chalcophylic cations with low FC (Group. 4.d).

e). p_s-Cations of lithophylic elements - $^{(6)}Al^{3+}$ (21,4), $^{(6)}Ge^{4+}$ (29,2), $^{(4)}Al^{3+}$ (32,2), $^{(6)}Si^{4+}$ (37,6).

f). p_s-Cations of chalcophylic elements - $^{(12)}Tl^{+}$ (0,48), $^{(12)}Pb^{2+}$ (1,3), $^{(8)}Pb^{2+}$ (1,9), $^{(8)}Sb^{3+}$ (3,3), $^{(8)}Bi^{3+}$ (3,4), $^{(6)}Pb^{2+}$ (2,5), $^{(6)}Sb^{3+}$ (4,4), $^{(6)}Bi^{3+}$ (4,6), $^{(6)}As^{3+}$ (5,7), $^{(6)}Te^{4+}$(6,0); cations $^{(6)}Pb^{2+}$ (2,5), $^{(6)}Sb^{3+}$ (4,4), $^{(6)}Bi^{3+}$ (4,6), $^{(6)}As^{3+}$ (5,7), $^{(6)}Te^{4+}$(6,0) are presented as cations also in some chalcosalts.

3. Cations - complexformers of lithopyllic elements with low - middle FC, including:

   a). Cations of noncenosymmetrical d'-complexformers with low - middle FC - $^{(12)}Zr^{4+}$ (4,5), $^{(6)}Zr^{4+}$ (9,4), $^{(6)}Ta^{5+}$ (12,7), $^{(6)}Nb^{5+}$ (15,2), $^{(6)}W^{6+}$ (17,8), $^{(4)}Ta^{5+}$ (19,1), $^{(6)}Mo^{6+}$ (20,6), $^{(4)}Nb^{5+}$ (22,7), $^{(4)}W^{6+}$ (26,8), $^{(4)}Mo^{6+}$ (30,9).

   b). Cations of cenosymmetrical d'-complexformers with middle FC - $^{(6)}Ti^{4+}$ (15,8), $^{(6)}V^{4+}$ (17,8), $^{(4)}Ti^{4+}$ (23,7), $^{(6)}V^{5+}$ (25,6), $^{(4)}V^{4+}$ (26,7), $^{(4)}V^{5+}$ (38,4), $^{(4)}Cr^{6+}$ (54,4), $^{(4)}Mn^{7+}$ (121,3)).

4. Chalcophylic cations with low FC, including:

   a). Cations of chalcophylic elements with low FC - $^{(4)}Tl^{+}$ (1,45), $^{(3)}Tl^{+}$ (1,9), $^{(6)}Pb^{2+}$ (2,5), $^{(4)}Ag^{+}$ (3,5), $^{(4)}Au^{+}$ (3,6), $^{(6)}Sb^{3+}$ (4,4), $^{(6)}Bi^{3+}$ (4,6), $^{(6)}As^{3+}$ (5,7), $^{(6)}Te^{4+}$ (6,0), $^{(4)}Cu^{+}$ (6,2), $^{(4)}Hg^{2+}$ (7,7), $^{(4)}As^{3+}$ (8,6), $^{(4)}Te^{4+}$ (8,9), $^{(3+E)}Sb^{3+}$ (8,9), $^{(3+E)}Bi^{3+}$ (9,1), $^{(6)}In^{3+}$ (9,7), $^{(6)}Zn^{2+}$ (10,2), $^{(6)}Cu^{2+}$ (11,0), $^{(3+E)}As^{3+}$ (11,4), $^{(4)}Tl^{3+}$ (12,8), $^{(4)}In^{3+}$ (14,6), $^{(4)}Zn^{2+}$ (15,3), $^{(4)}Cu^{2+}$ (16,5), $^{(6)}Sn^{4+}$ (16,9), $^{(4)}Pb^{4+}$ (17,5), $^{(4)}Sn^{4+}$ (25,3), $^{(4)}Ga^{3+}$ (37,8) and cations of the same elements with lower CN; cations $^{(6)}Pb^{2+}$ (2,5), $^{(6)}Sb^{3+}$ (4,4), $^{(6)}Bi^{3+}$ (4,6), $^{(6)}As^{3+}$ (5,7), $^{(6)}Te^{4+}$ (6,0) are coming forward as cations in some oxides too (see group. 2.f), $^{(6)}Sb^{3+}$ (4,4), $^{(6)}Bi^{3+}$ (4,6), $^{(6)}As^{3+}$ (5,7), $^{(6)}Te^{4+}$ (6,0), $^{(4)}As^{3+}$ (8,6), $^{(4)}Te^{4+}$ (8,9), $^{(3+E)}Sb^{3+}$ (8,9), $^{(3+E)}Bi^{3+}$ (9,1), $^{(3+E)}As^{3+}$ (11,4), $^{(6)}Sn^{4+}$ (16,9) - as complexformers in sequence of complex chalcogen and oxygen compounds (group 5).

   b). Some, firstly selected with bold, cations of cenosymmetrical d'-elements - $^{(6)}Mn^{2+}$ (6,7), $^{(6)}\mathbf{Fe}^{2+}$ (7,4), $^{(6)}Co^{2+}$ (8,3), $^{(6)}Ni^{2+}$ (9,3), $^{(6)}Cr^{3+}$ (12,9), $^{(6)}\mathbf{Fe}^{3+}$ (14,4), $^{(6)}Mn^{3+}$ (14,9), $^{(4)}\mathbf{Fe}^{3+}$ (21,6), $^{(4)}Mn^{3+}$ (22,4), widely known in minerals as d_s-cations (see group 2.f).

5. Chalcophylic cations-complexformers (in general cations of chalcophylic elements with middle FC) - $^{(6)}Sb^{3+}$ (4,4), $^{(6)}Bi^{3+}$ (4,6), $^{(6)}As^{3+}$ (5,7), $^{(6)}Te^{4+}$ (6,0), $^{(4)}As^{3+}$ (8,6), $^{(4)}Te^{4+}$ (8,9), $^{(3+E)}Sb^{3+}$ (8,9), $^{(3+E)}Bi^{3+}$ (9,1), $^{(3+E)}As^{3+}$ (11,4), $^{(6)}Sn^{4+}$ (16,9), $^{(6)}Bi^{5+}$ (17,2), $^{(6)}Sb^{5+}$ (24,3), $^{(6)}Ge^{4+}$ (29,2), $^{(6)}Te^{6+}$ (33,1), $^{(4)}Sb^{5+}$ (36,4), $^{(6)}As^{5+}$ (42,4), $^{(4)}Ge^{4+}$ (43,6), $^{(4)}As^{5+}$ (63,7), $^{(4)}Se^{6+}$ (78,0); cations $^{(6)}Sb^{3+}$ (4,4), $^{(6)}Bi^{3+}$ (4,6), $^{(6)}As^{3+}$ (5,7), $^{(6)}Te^{4+}$ (6,0), $^{(4)}As^{3+}$ (8,6), $^{(4)}Te^{4+}$ (8,9), $^{(3+E)}Sb^{3+}$ (8,9),

$^{(3+E)}Bi^{3+}$ (9,1), $^{(3+E)}As^{3+}$ (11,4), $^{(6)}Sn^{4+}$ (16,9) are coming forward similar to cations of chalcophylic elements with low FC (group 4.a).

6. p-Anionformers (cations of light and heavy anionformers) - $^{(4)}Si^{4+}$(56,4), $^{(4)}B^{3+}$ (86,2), $^{(4)}P^{5+}$(90,3), $^{(3)}B^{3+}$ (114,9), $^{(4)}S^{6+}$ (130,2), $^{(4)}Cl^{7+}$ (181,8), $^{(3)}C^{4+}$(238,8), $^{(3)}N^{5+}$ (418,3); $^{(4)}S^{4+}$ (17,8), $^{(3)}I^{5+}$ (23,7), $^{(3)}Br^{5+}$ (27,3).

The presented systematic of cations has been placed by us in the basis of subsequent mineral systematic, especially in limits of classes, selected by character of anions. At the same time it shows that the same cations could play cation role in minerals of different types, for example, in lithopylic and chalcophylic, come forward in some minerals as cations, presenting their basic properties, and in other ones - as anionformers, presenting their acid properties. The value of FC/CN predetermines the role of cations in compounds in total, but it could not be used as stricted formal criteria, because the properties of cations mostly depend also on delicacies in atomic structure, in particular on belonging to cenosymmetricals or noncenosymmetricals, on values of their Z. At the same time, in many cases it allows to consider not only the role of cation in compounds, but also about possibility of isomorphism between it and other cations, especially if they are close by other features.

Highest taxons of structural-chemical systematic of minerals, preceding classes

All what was said shows, that the principal type of chemical bond in compounds should be considered as major feature of the most important taxons of mineralogical systematic. By this feature all minerals could be united in five types:

1. Type: Minerals with principal metallic and metallic-covalent bond - native metals and semimetals, metallides and semimetallides.
2. Type: Minerals with principal metallic-covalent and ionic-covalent, rare van der Waals forces - chalcogen compounds and native VIa-nonmetals.
3. Type: Minerals with principal ionic-covalent and covalent-ionic - nonmetallides of light (typical, cenosymmetrical) VIa-element (O) - oxygen compounds.
4. Type: Minerals with principal covalent-ionic and ionic bond - halogen compounds.
5. Type: Carbon, its compounds (without carbonates) and related substances.

Touching the selected types, it should be noted, that type “elementary (simple) compounds” which is usually started the majority of well-known systematics is disappeared from their number. From our point of view this is not only justified, but also is necessary action because of the following purposes:

a). In type of elementary substances usually unite the substance with completely different types of chemical bond - metals, semimetals, nonmetals, semiconductors, molecular substances which have only one in common - every of these substances consists of atoms of one sort. At the same time the properties, formation conditions, paragenesis of elementary (native) substances with different type of chemical bond have nothing common with each other.

b). Because of what was said it is very difficult to build systematic of elementary substance so, that we could get natural transformation from them to minerals of the following taxon.

Considering what was pointed out and necessity of association of the most close to each other by properties, genesis and paragenesis minerals, in natural systematic of minerals, it is more expedient to specify native metals, metallides, semimetals, semimetallides from selected earlier type of "elementary (simple) substances" to independent type, what we have been done previously. Along with it native metals are removing in front of respective metallides, and semimetals - in front of respective semimetallides. Simultaneously, native nonmetals - S and Se, are considered in front of chalcogen compounds, at the expense of which they are often formed.

The considerable peculiarity of classification of minerals, as far as inorganic crystalline substances at all, is impossibility of utilizing the strict system approach in its development. This have been already clarified in special position of type V among all mentioned types, in specific place of native minerals in systematic, what was discussed above. The same thing should be token into account with selection of further taxons in every type, when in the basis of their selection we should put different features, determined by complexity of their composition, peculiarities of chemical bond, crystalline structures, properties and conditions of formation of respective substances.

Thus type 1 divided on two subtypes: 1.1 - metals and metallides, 1.2 - semimetals and semimetallides, reflecting the considerable differences in chemical bond, structures, properties of both these and those ones. The last one, in its turn is divided on 2 quasisubtypes*: 1.2.1 - semimetals and semimetallides of Va-semimetals, 1.2.2 - semimetals and semimetallides of VIa-semimetals.

Type 2 firstly is dividing on two quasitypes*, uniting completely different by type of chemical bond substances: 2a. - elementary (native) VIa-nonmetals which are characterized by residuum chemical bond, and 2b. - chalcogen compounds which have principal metallic-covalent and ionic-covalent chemical bond. Further quasitype* 2b. is dividing on two subtypes: 2b.1. - chalcogen substances of sidero- and chalcophylic cations, and 2b.2 - chalcogen compounds of lithophylic cations, reflecting considerable differences in composition, stability in natural conditions, properties, conditions of formation and paragenesis of minerals from every subtype. In this case the requirement of consequent transformation from one taxons to other ones, is observed, because some minerals of the last subtype are close by composition, properties, conditions of formation to minerals, beginning the next type 3. Subtype 2b.1 in its turn is divided on two quasisubtypes*: 2b.1a. - sulfides and sulfosalts of sidero- and chalcophylic cations, 2b.1b. - selenides and selenosalts of sidero- and chalcophylic cations, reverberating differences in properties, conditions of formation and paragenesis of natural chalcogen compounds of S and Se, although many of them are connected by continuous isomorphous transformations. It should be token in mind, that in minerals, refered to chalcogen compounds the consequent transformation from simple chalcogenides through complex ones to chalcosalts is often observed. Exactly by this it is expressed, that one authors consider all chalcosalts as complex chalcogenides, as far as other ones persistently isolate them in separate taxons as chalcosalts which are the natural end of sequences like simple chalcogenides → complex (binary and so on) chalcogenides → chalcosalts.

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* The titles of taxons, selected by "*", are suggested by S.N. Nenasheva for comparing convenience. A.A. Godovikov leave these taxons without any titles.

Type 3 is divided by belonging of minerals to iso- or anisodesmical compounds first of all on two subtypes: 3.1 - oxides and hydroxides (isodesmical), 3.2. - oxysalts (anisodesmical). In dependence on belonging of mineral cations of first of them to one or another type it is divided further on six consequently changing each other quasisubtypes*, what is responding for transformation from cations with low FC to cations with high FC, from lithophylic cations through chalcophylic ones to cations of nonmetallic elements with highest FC:

3.1a - oxides and hydroxides of lithophylic cations with low FC,
3.1b - oxides and hydroxides of lithophylic cations with middle FC,
3.1c - oxides and hydroxides of chalcophylic cations (except Va- and VIa-cations),
3.1d - oxides and hydroxides of Va-cations (As, Sb, Bi),
3.1e - oxides and hydroxides of VIa-cations (Te),
3.1f - oxides and hydroxides of nonmetallic (lithophylic) cations.

Subtype 3.2 is also divided further immediate on classes, what is considered below.

Type 4 initially is divided by the same features on two subtypes: 4.1 - halogenides (isodesmical) and 4.2 - halogensalts (anisodesmical). The last one by dependence on belonging of anionformers to d- or p-cations in its turn is divided on two quasisubtypes*: 4.2a. - halogensalts with d-anionformers and 4.2b. - halogensalts with p-anionformers. Here it is necessary to pay attention on, that the majority of authors, however, because of the tradition, taking roots in last century, by this time are considering halogensalts as complex halogenides. By this the fact of clear isolation of radical groups in their structures, for example, tetrahedral $[BF_4]^-$, $[BeF_4]^{2-}$, octahedral - $[SiF_6]^{2-}$, $[AlF_6]^{3-}$, polymeric - $[BeF_3]^-$, $[B_2F_7]^-$, $[Al_3F_{14}]^{2-}$ and other, many of which are stable in solutions, and high solubility of many of halogensalts, is completely ignored. Some halogenacids, for example, $H[BF_4]$, as it have been already noted, are so strong, that they have in chemistry name superacids or magical acids. All this monosemantically testifies about salt nature of halogensalts [24]. Misunderstanding of it carried on, for example H. Strunz [63] to consideration of halogensalts not only as complex halogenides, but also as isodesmical (!) compounds, to associating by this feature of all halogensalts with oxides. Rather exactly with this, the place, leading up to present time in mineralogical systematic to halogen compounds between chalcogen and oxygen compounds [51], [34], or between oxides and oxysalts [12], is connected. Although by chemical bond type, existence of halogensalts among halogen compounds, they should be considered behind oxygen compounds.

The sequence of types: chalcogen → oxygen → halogen compounds - responds, as it was stressed earlier, for regular changing in their representatives of principal chemical bond type in direction: metallic-covalent → ionic-covalent → covalent-ionic → ionic bond.

The systematic of type 5 is building significantly more difficulty because of purposes, showed before. Initially it is divided on two quasitypes*, completely different by number of representatives, first of which - 5a. associating inorganic compounds, including native IVa-nonmetals, second one - 5b. - organic compounds. First of them is further divided on two subtypes: 5a.1. - elementary (native) IVa-nonmetals, 5a.2. - minerals with principal covalent and metallic-covalent chemical bond - carbides, and compounds which are close to them - silicides, nitrides and phosphides. Organic compounds in which the most important role is played by residuum bond, are further divided on to three subtypes: 5b.1. - salts of organic acids, 5b.2. - hydrocarbons and related compounds, 5b.3. - natural mixtures of organic substances, including fossil resin.

Thus, we could obtain the following scheme of intersubordination of considered taxons:

1. Type: Minerals with principal metallic and metallic-covalent bond - native metals and semimetals, metallides and semimetallides.
   - 1.1. Subtype: Metals and metallides.
   - 1.2. Subtype: Semimetals and semimetallides (only of sidero- and chalcophylic cations)
   - 1.2.1 Quasisubtype*: Semimetals and semimetallides of Va-semimetals.
   - 1.2.2 Quasisubtype*: Semimetals and semimetallides of VIa-semimetals
2. Type: Minerals with principal metallic-covalent and ionic-covalent bond, rare van der Waals forces - chalcogen compounds and native VIa-nonmetals.
   - 2a. Quasitype*: Elementary (native) VIa-nonmetals (residuum bond).
   - 2b. Quasitype*: Chalcogenic compounds - compounds of d-schrink-analogues - S and Se (metallic-covalent and ionic-covalent bond, rare van der Waals forces) - simple chalcogen compounds (isodesmical) → complex chalcogen compounds → chalcosalts (anisodesmical).
   - 2b.1. Subtype: Chalcogenic compounds of sidero- and chalcophylic cations.
   - 2b.1a. Quasisubtype*: Sulfides and sulfosalts of sidero- and chalcophylic cations.
   - 2b.1b. Quasisubtype*: Selenides and selenosalts of sidero- and chalcophylic cations.
   - 2b.2. Subtype: Chalcogen compounds of lithophylic cations.
3. Type: Minerals with principal ionic-covalent and covalent-ionic bond - nonmetallides of light (typical, cenosymmetrical) IVa-element (O) - oxygen compounds.
   - 3.1. Subtype: Oxides and hydroxides (isodesmical).
   - 3.1a. Quasisubtype*: Oxides and hydroxides of lithophylic cations with low FC - Force Characteristics.
   - 3.1b. Quasisubtype*: Oxides and hydroxides of lithophylic cations with middle FC.
   - 3.1c. Quasisubtype*: Oxides and hydroxides of chalcophylic cations (except Va- and VIa- cations) - simple and complex → arsenites, …, tellurates.
   - 3.1d. Quasisubtype*:Oxides and hydroxides of Va-cations (As, Sb, Bi).
   - 3.1e. Quasisubtype*: Oxides and hydroxides of VIa-cations (Te).
   - 3.1f. Quasisubtype*: Oxides and hydroxides of nonmetallic (lithophylic) cations.
   - 3.2. Subtype: Oxysalts (anisodesmical).
4. Type: Minerals with principal covalent-ionic and ionic bond - halogen compounds.
   - 4.1. Subtype: Halogenides (isodesmical).
   - 4.2. Subtype: Halogensalts (anisodesmical)(with hexacyanoferrates and hexatiocyanates, rhodonides).
   - 4.2a. Quasisubtype*: Halogensalts with d-anionformers.
   - 4.2b. Quasisubtype*: Halogensalts with p-anionformers.
5. Type: Carbon, its compounds (without carbonates) and related substances.
   - 5a.Quasitype*: Inorganic compounds of carbon (without carbonates) and related substances.

5a.1. Subtype: Native minerals.
5a.2. Subtype: Minerals with principal covalent and metallic-covalent bond - carbides and related compounds - silicides, nitrides and phosphides.
5b. Quasitype*: Organic compounds.
5b.1. Subtype: Salts of organic acids.
5b.2. Subtype: Hydrocarbons and related compounds.
5b.3. Subtype: Mixtures of organic compounds, including fossil resines.

After development of scheme of highest taxons of mineralogical systematic, we could begin to separate classes and to base their sequence, their subdivision on quasi and subclasses.

Classes and their sequence

As it have been already known, the classes of compounds in chemistry, since it have been suggested at the beginning of last century by J.J. Berzelius, are selected by anions. The same approach is preserved in mineralogy. However, there two questions which are considerable from the systematic's point of view:

1) which part of compound's formulae in which basis should be considered as anion;
2) which one should be the sequence of consideration of separate classes which place in it should occupy the compounds with several anions - aresenido-sulfides, sulfido-halogenides, silicato-carbonates, silicato-fluorides, arsenato-sulfates and so on.

For compounds with simple anions like S^{2-} , O^{2-}, F^-, Cl^-, even with polynuclear one like $[S_2]^{2-}$, $[As_4]^{4-}$, and so on, the question of selection of anion is pretty obvious and it could be ignored. It is not more clear also for compounds with complex anions like $[SiO_4]^{4-}$, $[SO_4]^{2-}$, $[CO_3]^{2-}$, including polymeric $[Si_6O_{18}]^{1\,2-}$, $[Si_2O_5]^{2-}$ and so on, in which anionformers have the lowest of all possible values of coordination number, i.e. present their acid properties in maximal extent. However, situation for amorphous anionformers is getting even more difficult, when it is needed to make boundary between binary (complex) compounds and salts with complex anions, because anionformers could have different CN depending on acid-basic properties.

It was shown earlier, that as cations-anionformers (complexformers) could be considered:

1. Cations - complexformers of lithophylic elements with low-middle FC, including:
   a). Cations of noncenosymmetrical d'-complexformers with low-middle FC -${}^{(12)}Zr^{4+}$, ${}^{(6)}Zr^{4+}$, ${}^{(6)}Ta^{5+}$, ${}^{(6)}Nb^{5+}$, ${}^{(6)}W^{6+}$, ${}^{(4)}Ta^{5+}$, ${}^{(6)}Mo^{6+}$, ${}^{(6)}Nb^{5+}$, ${}^{(4)}W^{6+}$, ${}^{(4)}Mo^{6+}$.
   b). Cations of cenosymmetrical d-complexformers with middle FC - ${}^{(6)}Ti^{4+}$, ${}^{(6)}V^{4+}$, ${}^{(4)}Ti^{4+}$, ${}^{(6)}V^{5+}$, ${}^{(4)}V^{4+}$, ${}^{(4)}V^{5+}$, ${}^{(4)}Cr^{6+}$, ${}^{(4)}Mn^{7+}$.
2. Chalcophylic cations-complexformers (mainly cations of chalcophylic elements with middle FC) - ${}^{(6)}Sb^{3+}$, ${}^{(6)}Bi^{3+}$, ${}^{(6)}As^{3+}$, ${}^{(6)}Te^{4+}$, ${}^{(4)}As^{3+}$, ${}^{(4)}Te^{4+}$, ${}^{(3+E)}Sb^{3+}$, ${}^{(3+E)}Bi^{3+}$, ${}^{(3+E)}As^{3+}$, ${}^{(6)}Sn^{4+}$, ${}^{(6)}Bi^{5+}$, ${}^{(6)}Sb^{5+}$, ${}^{(6)}Ge^{4+}$, ${}^{(6)}Te^{6+}$, ${}^{(4)}Sb^{5+}$,

$^{(6)}As^{5+}$, $^{(4)}Ge^{4+}$, $^{(4)}As^{5+}$, $^{(4)}Se^{6+}$; cations $^{(6)}Sb^{3+}$, $^{(6)}Bi^{3+}$, $^{(6)}As^{3+}$, $^{(6)}Te^{4+}$, $^{(4)}As^{3+}$, $^{(4)}Te^{4+}$, $^{(3+E)}Sb^{3+}$, $^{(3+E)}Bi^{3+}$, $^{(3+E)}As^{3+}$, $^{(6)}Sn^{4+}$, are coming forward similar to cations of chalcophylic elements with low FC (group 4.a).

3. p-Anionformers (cations of light and heavy anionformers) - $^{(4)}Si^{4+}$, $^{(4)}B^{3+}$, $^{(4)}P^{5+}$, $^{(3)}B^{3+}$, $^{(4)}S^{6+}$, $^{(4)}Cl^{7+}$, $^{(3)}C^{4+}$, $^{(3)}N^{5+}$, $^{(4)}S^{4+}$, $^{(3)}I^{5+}$, $^{(3)}Br^{5+}$.

Every of these three groups is responding to minerals of definite paragenesis, planning its specific sequence of mineral changing depending on changing of acid-basis conditions, oxidizing potential. Thus, cations - complexformers of lithophylic elements with low-middle FC are included in composition of oxygen compounds - complex oxides and oxysalts, placed predominantly in igneous rocks, in connected with them pegmatite and hydrothermal veins, in products of their metamorphism and weathering. The transformation from complex oxides to oxysalts is responding to increasing of acidity of cation-complexformer, decreasing of its CN from 6 through 5 up to 4. By this way we could design narrow genetically connected sequences of minerals like: (6)-vanadates → (5)-vanadates → (4)-vanadates, in which first their members are refered to typical complex oxides, and the last ones - are typical oxysalts, including of rather strong acids, to which we could refere (4)-vanadates and all the more (4)-arsenates. (4)-chromates and (4)-permanganates which are oxyslats of very strong acids, are ending these saubstances. Many of considered cations-complexformers are included in composition of genetically coneccted with each other minerals, refered to common paragenesis, for example, titanates and tantaloniobates of alkaline and rare-metallic granitic pegnatites, but $^{(6)}Zr^{4+}$, $^{(6)}Ti^{4+}$,$^{(5)}Ti^{4+}$, $^{(6)}Ta^{5+}$, $^{(6)}Nb^{5+}$ and so on cations are typical for mixed anionic radicals like zircono-, titano-, niobo-, tantalosilicatous ones which are especially characteric for paragenesises of agpaitic rocks and their derivatives.

The cations of the second group are typical for paragenesises of two types. One of them is characterized by primary minerals in which as ligands coming S and Se. Mentioned cations-complexformers are included in composition of complex chalcogenides and chalcosalts of sulfide deposits of magmatogenic, volcanogenic and metamorphogenic genesis, different hydrothermal veins, genetically connected often with acid rocks. Another paragenesis which is typical for them, is forming in zone of oxidation of mentioned earlier primary paragenetic associations of minerals and for which both complex oxides and oxysalts up to salts of relatively strong oxyacids like arsenic acid, are characteric.

The anionformers of third group are typical for mineral paragenesises of magmatic and igneous rocks, theirs pegmatites (silicates, some phosphates, carbonates, borates), skarns (silicates, borates, carbonates), hydrothermal veins (especially carbonates and some sulfates), volcanic exhalations (sulfates, halogenides, halogensalts), crusts of weathering (silicates), marine sediments (halogenides, sulfates, carbonates, phosphates, borates), evaporites (borates, halogenides), zones of oxidation (carbonates, sulfates, nitrates and so on).

Thus, every of mentioned groups of cations-anionformers are included in composition of minerals of its own paragenesis, as if it is forming its own genetic branch.

Earlier [26], [27] it was shown, that:

a). The quantitative measure of acid-basic properties of elements (cations) is their force characteristic (FC) and the value of atomic number (Z): decreasing of FC with constant Z is responding to strengthening of basic properties of cations, and vice-versa increasing of (FC), - acidic ones. Typical cations have coordinate number (CN) by one order or by two times less, then amphoteric cations, and amphoteric cations on their own turn - by one order lower, then typical anionformers.

b). The values of FC and Z of cations allow to clarify regular changing of structures of compounds in sequences, responding to transformation from simple compounds with coordinate structure to salts, and to predict with more probability the structures of unknown compounds either in total form, or in some of their details (for example, conditions of transformations from cubical "perovskites" to tetrahonal, orthorombic and minoclinic), regularities of polymorphous transformations.

c). With constant in definite limits physical-chemical parameters, first of all temperature and pressure, straightening of acid properties of amphoteric cations is clarifying in increasing of their valency, and with permanent valency (with permanent in definite limits oxidizing potential) - in decreasing of theirs CN. On the contrary, increasing of their basic properties are responding to decreasing of valency, decreasing of theirs CN.

d). In compounds, containing only amphoteric cations, last ones play typical cation role; their basic properties are increasing by straightening of acid properties of ligands, including complex anions too.

e). For cations with basic properties low valences (lower or equal to 2), high CN (usually higher then 6) are typical. For cations with acid properties (anionformers) - high valency (equal or higher then 4) and low CN (usually lower then 6); amphoteric cations in this relations placed intermediate position.

f). The structures of simple compounds, containing cations with basic properties, are coordinate (PbS, MgO, NaCl, CaF_2 and so on); containing cations with acid properties - are molecular or quasimolecular (As_4S_4, As_2S_3, B_2O_3, CO_2, SO_3, B_2F_4 and so on). In agreement with it the first ones differ by their high melting temperatures, low vapor resiliency; and second ones - by low melting temperatures, high vapor resiliency.

g). Amphotherity from crystallochemical positions is clarifying initially in changing of coupling motive of cation polyhedres with amphoteric cations from typical cationic, when cation polyhedres are connecting by edges or even verges in compounds, not containing cations with very low FC (as it is, for example, in ilmenite) up to motives in which these polyhedres are connected with each other only by bridge ligands. Further decreasing of FC bring to change of CN by cation from CN > 6 to CN = 6, defined by difference in FC of elements - partners in compound, their average or summary atomic numbers, formation of complex anion. Visually this could be seen in sequences of compounds, containing, along with basic cations, cations with lower CN which are playing more distinct role of anionformers up to formation of complex anions, as it is, for example, in sequences: simple oxides → binary oxides → oxysalts like $2AO_2$ ($2TiO_2$) → ABO_4 ($FeWO_4$) → $M[TO_4]$ ($Ca[WO_4]$).

All this show us, that the boundary "complex compounds → salts" for compounds of different types is coming differently, defining first of all by fundamental properties of atoms, forming them, - their FC and Z.

At the same time, it is not correct to refer to compounds of definite type the substances only by their brutto-formulae which is not consider their structure. Thus by now, practically all authors refer oxygen compounds, containing Te^{6+}, to salts of telluric acid or to tellurates, considering them as analogues of sulfates in narrow connection with last ones. By the first view this is absolutely natural, especially, if base on primitive-straightforward ideas about analogies of properties of elements in limits of separate subgroups of Periodic system, for example, expressing in association of O, S, Se, Te and Po in "chalcogenes", as it is offered by "Nomenclature rules of IUPACK in chemistry" [52], and what is done by , for example G.B. Bokiy and N.A. Golubkova later [7]. They are not considered differences between ceno- and noncenosymmetrical elements [62], [20], [21], nonmetallic and semimetallic elements, elements shell- and shrink-analogues, their differences from nonshell- and nonshrink analogues [21], [31].

The similarity of brutto-formulaes of sulfur, selenic and so-called telluric acids - H_2SO_4, H_2SeO_4 and H_2TeO_4 respectively is pushing on this way. However, if first two compounds are fully respond to structural ideas about acids, because they contain separated tetrahedral complex radicals $[SO_4]^{2-}$ or $[SeO_4]^{2-}$ with CN S and Se, equal to 4, what gives us opportunity to write their structural formulaes as H_2 $[SO_4]$ and H_2 $[SeO_4]$, this could not bee said about "telluric acid". The investigation of this compound was not established in its structures the anionic groups $[TeO_4]^{2-}$ with CN of Te = 4. Instead of it, it was found that cations Te^{6+} have CN = 6, i.e. respond to CN of amphoteric or weak acid anionformers. The structure of this compound is to be consisting of chains of TeO_4 $(OH)_2$ - octahedrons, in two opposite edges of which OH-ions are placed, connected with each other by common O atoms of equatorial edges of octahedrons [66]. It is easy to see, that by separating of repetition period of such structure we get structural formulae in form of $Te(OH)_2O_2$. Thus, this compound is hydroxido-oxide of Te^{6+} with very weak acid properties, clearly differing it from sulfur and selenic acids. That is why it should be considered not among acids and their salts in subtype 3.2. - oxysalts, but rather in subtype 3.1. - oxides and hydroxides at the end of it as compound with intermediate properties from oxides and hydroxides to acids and salts. The existence of so-called telluric acid with formulae $Te(OH)_6$ or H_6TeO_6, for which the octahedral coordination of Te, different polymeric groups, established in it salts [66], close by this and other properties to complex oxides, is characteric, is not changing this conclusion.

In advantage to what was said clear differences in properties of SO_3, SeO_3, H_2SO_4, H_2SeO_4 from one side, and TeO_3, $Te(OH)_6$ or H_6TeO_6 - from another are evident.

Thus, SO_3 in normal conditions - gas (b.p. 44,8°C), lower 16,8°C - SO_3 - transparent icy mass; energically reacts with water, forming sulfur acid H_2 $[SO_4]$ which has pKa = 1,94;

SeO_3 - solid glassy or asbestic substance (m.p. 118,5°C; b.p. 185°C); energically reacts with water, forming selenic acid H_2 $[SeO_4]$ with pKa = 1,92;

TeO_3 - solid respectively inert substance, on which are not act neither cold water, nor diluted bases (m.p. - higher then 400°C); obtained by dehydrotation of H_6TeO_6 in oxygen atmosphere with presence of concentrated $H_2[SO_4]$; on the first stage of dehydrotation of H_6TeO_6 results TeO_2 $(OH)_2$; the compound H_6TeO_6 has properties of weak acid with pKa = 7,61.

All this considered to be natural, if take into account, that S and Se are connected by shrink-analogue, what is narrowing their properties, as far as Te differ from them, not being theirs shrink analogue. This responds also to systematic of cations which was given earlier, in accordance with which the typical in minerals for Te cation $^{(6)}Te^{6+}$ is refered to chalcophylic cations with middle FC, clearly differing in this aspect from $^{(4)}S^{6+}$ and $^{(4)}Se^{6+}$, for which CN = 6 has not been established in minerals. Shrink analogue of S and Se and not shrink-analogue with them of Te clarifying in elementary substance too, among which S and Se are nonmetals, as far as Te - semimetal[15]. By what

[15] Misunderstanding of different stages of analogues between elements of one group [21], [31] often brings to absolutely absurd associations of elements in limits of subgroups. Unfortunately, this could be found even in reference books and manuals, standing several editions. As example to what was said we could note the subdivision of VIa-elements by N.S. Achmetov [1] on O, after that S and, at last "elements of subgroup of Se" - Se, Te and Po, as far as in fact they should be divided on: 1) nonmetallic cenosymmetrical elements - O, 2) nonmetallic d-shrink analogues - S and Se, 3) semimetallic f-shrink

was said it is not amazing, that so-called salts of telluric acid and tellurates should be considered as complex oxides, containing $^{(6)}Te^{6+}$, what is confirmed by results of investigation of their crystalline structures. For example, we could mention mineral yafsoanite. The authors, who have discovered it [37], have opinion, that it is “refered to group (correct - to class - A.G.) of tellurates and it is complex salt of telluric acid” (p. 120) with formulae $(Zn_{1,38}\ Ca_{1,36}\ Pb_{0,26})_{\Sigma 3}\ TeO_6$. The investigation of its structure [36] shows, that the structural formulae of yafsoanite has form of $^{(8)}Ca_3\ ^{(6)}Te_2\ [^{(4)}ZnO_4]_3$ and it should be considered as complex oxide - zincate with structure, analogical to those of garnet in which the role Si is played by Zn, and Te is coming as typical cation - Al. In this relation yafsoanite is analogical to isostructural synthetic complex oxides, called incorrectly garnets, and more correct - garnatites - with common formulae $^{(8)}R^{3+}{}_3\,^{(6)}M^{3+}{}_2\ [^{(4)}X^{3+}O_4]_3$, where R^{3+}= Y, Ln; M^{3+}, X^{3+}= Fe, Al, Ga.

Analogical reasons force to consider the substances of Te^{4+}, often called tellurites, among complex oxides to which by the same purposes we refer also arsenites, antimonites and antimonates.

To complex oxides, considered at their end, we refer also compounds with d-oxoradicals, even with tetrahedral coordination of anionformer - vanadates, molybdates, tungstenates, because respective “acids” and “anhydrides” are not only solid substances with octahedral coordination of V^{5+} , Mo^{6+}, W^{6+}, but also have very wear acid properties, more weak, then those of silicium acid. Such position of considering substances is imagine to be even more well-grounded, because it reverberates the natural connections of them with complex oxides, in which CN of electronegative cations (including V^{5+}, Mo^{6+} , W^{6+}) is sequentially changing from 6 through 5 to 4. By this the considerable chemical differences in properties of d- and p-elements are clarifying, in particular as anionformers, forcing us to separate vanadates from class of phosphates and arsenates, and molybdates and tungstenates from class of sulfates and selenates in which they have been usually considered since last century by such common feature as group-analogue, and formal similarity of oxoradicals.

Among d-elements in this relation position only cenosymmetrical Cr and Mn in their highest oxidizing extent, oxygen compounds of which refered to strong anhydrides (acids), forming typical salts with heterodesmical bonds - chromates and permanganates. This allows to consider, for example, chromates exactly after sulfates.

The sequence of classes in most numerous by number of representatives subtype of oxysalts should be also considered in detail, because there is no common or somehow regular way, what is illustrated by respective parts of systematic by different authors:

E.S.Dana, [13]
VI.<u>Salts of oxygen acids</u>
VI.Oxygen salts (oxysalts)
 1.Carbonates
 2.Silicates
 3.Niobates, tantalates
 4.Phosphates, arsenates, vanadates, antimonates, antimonites, arsenites

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analogues - Te and Po. The same could be said about all other groups, on which we could unstop, however special attention attracts accepted by him division of VIIIb-elements. N.S. Achmetov divide them strongly by verticals, selecting 3 groups : 1) Fe, Ru, Os; 2) Co, Rh, Ir; 3) Ni, Pd, Pt. Along with it, it has not been token into account, that Fe, Co and Ni are cenosymmetricals. This bring to their high oxidizing, low normal electrode potentials, rareness in nature in native form. Other VIIIb elements - noncenosymmetrical f-shrink-analogues and they are not accidentally usually considered in common as platinoides. High normal electrode potentials, usualness of their native form in nature - are the common features for them [28].

Phosphates and so on with sulfate-anions and so on
Nitrates
5.Borates
Uranates
6.Sulfates, chromates
Tellurates; also tellurites, selenites
7.Tungstenates, molybdates

A.G. Betekhtin, [6]
VI.Oxygen salts (oxysalts)
1 class.Iodates
2 class.Nitrates
3 class.Carbonates
4 class.Sulfates, selenates, tellurates
5 class.Chromates
6 class.Molybdates and tungstenates
7 class.Phosphates, arsenates and vanadates
8 class.Arsenites
9 class.Borates
10 class.Silicates

A.S Povarennykh, [55]
Class III.Silicates, borosilicates, alumosilicates, beryllosilicates titanosilicates, zirconosilicates and uranosilicates
Class IV.Borates
Class V.Vanadates
Class VI.Arsenates
Class VII.Phosphates
Class VIII.Tellurites and selenites
Class IX.Tungstenates and molybdates
Class X.Chromates and selenates
Class XI.Sulfates
Class XII.Carbonates
Class XIII.Iodates
Class XIV.Nitrates

I.Kostov, [40]
Class V.Silicates
Class VI.Borates
Class VII.Phosphates, arsenates and vanadates
Class VIII.Tungstenates and molybdates
Class IX.Sulfates
A.Sulfates
B.Selenates, selenites, tellurates and tellurites
Class X.Chromates
Class XI.Carbonates
Class XII.Nitrates and iodates
A.Nitrates
B.Iodates

H.Strunz, [63]
V.Nitrates, carbonates, borates
Va.Nitrates
Vb.Carbonates
Vc.Borates
VI.Sulfates (chromates, molybdates, tungstenates)
A.- D.Sulfates
E.Chromates
F.Molybdates and tungstenates
VII.Phosphates, arsenates, vanadates
VIII.Silicates

A.A.Godovikov, [22]

Subtype II.Oxysalts
- Class 1.Silicates
- Class 2.Phosphates (arsenates)
- Class 3.Sulfates
- Class 4.Borates
  - Quasiclass 1.(4)-Borates
  - Quasiclass 2.(4)-(3)-Borates
  - Quasiclass 3.(3)-Borates
- Class 5. Carbonates
- Class 6. Nitrates

A.R.Hoelzel,[34]

5.Carbonates, nitrates, borates
6.Sulfates. chromates, molybdates, tungstenates
7.Phosphates, arsenates, vanadates
8.Silicates

A.M.Clark, [12]

9.Borates
10.Borates with other anions
11.Carbonates
12.Carbonates with other anions
13.Nitrates
14.Silicates, not containing Al
15.Silicates of Al
16.Silicates, containing Al and other metals
17.Silicates, containing also other anions
18.Niobates and tantalates
19.Phosphates
20.Arsenates (also arsenates with phosphate-ion, but without other anions)
21.Vanadates (and vanadates with arsenat- or phosphate-ions)
22.Phosphates, arsenates or vanadates with other cations
23.Arsenites
24.Antimonates and antimonites
25.Sulfates
26.Sulfates with halogenid-ions
27.Sulfites, chromates, molybdates and tungstenates
28.Selenites, selenates, tellurites and tellurates
29.Iodates
30.Tioceanates

It is easy to see big discord, presented in position of separated classes by different authors. The situation is aggravating also by, that, usually, the explanations of accepted sequence are not given in publications.

In accepted by us sequence of substances change, responding to decreasing in them of extent of metallicity of chemical bond by increasing of its covalent extent, and after that ionicity, up to appearing of ionic compounds; oxysalts begin to appear at the end of class of oxides and hydroxides. In this case right after complex oxides and hydroxides, ending with minerals of silica family, it is natural to place the class of silicates - oxysalts of the most weak oxyacids, beginning of it with alumosilicates, structures of many of which are derivatives of structures of different polymorphs of silica. The connection between properties and formation conditions of minerals of silica family and silicates is so significant, that some mineralogists placed silica family into one class with silicates, excluding it from oxides [40], [43].

The silicates are close to complex oxides not only because they are salts of very weak silicium acids, but also by such properties as low solubility, high temperatures of melting point, and many of them also because they contain in their structure polymeric radicals, what makes them close to many of titanates, tantalo-niobates and so on minerals.

Oxides and silicates of lithophylic elements, usually, are forming in endogenious, often in hightemperature, processes; for oxides and silicates of chalcophylic elements it is more usual to form in oxidation zone conditions.

Further sequence of placement of classes it is more convenient to subdue to changing sequence of salts, responding to decreasing of straight of acids, forming these salts. Such sequence replies in total for increasing of ionicity extent of chemical bond between cations and acid radicals, decreasing of polymeric radicals role in salts, increasing of their solubility, changing of formation conditions from hypogenic to more and more lowtemperature ones, up to surface ones, regular changing of many physical properties of respective minerals.

This sequence, however, is disturbed in class of borates, including minerals, in which CN of B in oxyradicals could be 4; 3; 4 and 3. In dependence from it have been suggested [22] to divide borates onto 3 quasiclasses: 1) (4)-borates, 2) (3)-borates, 3) (4)-(3)-borates, considering them in systematic in mentioned sequence. First of them are structurally close to silicates; radical groups of (4)-borates could polycondensate with silicium-oxygen radicals, forming common heteronuclear polymeric radicals of borosilicates. (4)-Borates are characteric for hypogenic conditions; high pressure and increased basicity are favorable for their formation. (3)-Borates are mainly hypogenic minerals too, as far as formation of (4)-(3)-borates is typical along with evaporation from marine and lacustrine water with formation of evaporates, in some crusts of weathering, rarely in lowtemperature hydrotermal veins.

In light of what was said we have accepted the following sequence of consideration of separate classes of oxysalts with lithophylic p-anionformers (in brackets the values of pKa and formulaes of acids, for which they are defined are given [44], for polybasic acids acid index is given of first stage of dissociation):

Class 1.Silicates	(9,9; H_4 [SiO_4])
Class 2.Borates	
Quasiclass a).(4)-Borates	
Quasiclass b).(3)-Borates	(9,15; H_3 [BO_3])
Quasiclass c).(4)-(3)-Borates	
Class 3.Carbonates	(3,25; H_2 [CO_3])
Class 4.Phosphates	(2,15; H_3 [PO_4])
Class 5.Sulfates	(1,94; H_2 [SO_4])
Class 6.Nitrates	(-1,64; H[NO_3]; from [9] p. 98)
Class 6a.Iodates	(0,77; H [IO_3])
Class 6b.Rodanates	(-1; H[CNS])

Referring of minerals to definite class of oxysalts is disputable, when in its composition there are several different anionic radicals, for example, $[SiO_4]^{4-}$ and $[PO_4]^{3-}$; $[CO_3]^{2-}$ and $[SO_4]^{2-}$; $[CO_3]^{2-}$ and F^-, i.e. when mineral is mixed salt [23]. Along with to mixed salts are not refered:

a) Inclusion compounds which have structure with big cavities, in which addition ions are placed, sometimes with cations (oxides of Mn with tunnel structures like hollandite, minerals of cancrinite-vishnevite seria, zeolites);
b) Minerals with hybrid structures in which separated layers are neutral or weakly charged packages, containing in their composition “heterogeneous” anion (tundrite, lomonosovite and so on minerals).

By now it have been suggested to refer such minerals to definite class by the most strong anion [22], [23], However, modeling of developed systematic in exposition of A.E. Fersman Mineralogical museum RAS showed, that from the paragenetic point of view it is more convenient to do vice versa, referring minerals - mixed salt to this or that class by anion of the most weak acid [25].

Analogical approach is used by us for many other minerals with several anions which are not refered to oxysalts, such as arsenido-tellurides, arsenido-sulfides, sulfido-halogenides and so on.

In subtype of halogenides two classes are separated: 1. Fluorides and 2. Chlorides, bromides, iodides. Here fluorides are separated in independent class as derivatives of cenosymmetrical F, considerably differing by its properties and genesis, paragenesis from all other halogenides. The rest of halogenides is associated in one class somewhat conditionally. In it chlorides and bromides, as derivatives of d-shrink-analogues - Cl and Br - have mach more similarities with each other, then with iodides. The last ones are refered to this class because they have few representatives among minerals. In systematic of inorganic crystalline substances they should be separated in independent class.

In subtype of halogensalts the separation of classes is executed on bases which were explained earlier [24], although they have different sequence. It, as in oxysalts case, respond to increasing of straight of respective halogenacids too.

The sequence of highest taxons in developed structural-chemical systematic of minerals

1. Type: Minerals with principal metallic and metallic-covalent bond - native metals and semimetals, metallides and semimetallides.

1.1. Subtype: Metals and metallides.

1.1.1. Class: Metals and metallides of sidero- and chalcophylic elements.

1.1.2. Class: Metals and metallides of lithophylic elements.

1.2. Subtype: Semimetals and semimetallides (of sidero and chalcophylic cations only).

1.2.1. Quasisubtype*: Semimetals and semimetallides of Va-semimetals.

1.2.1a. Class: Native Va-semimetals.

1.2.1b. Class: Va-Semimetallides - arsenides, antimonides, bismutides.

1.2.2. Quasisubtype*: Semimetals and semimetallides of VIa-semimetals.

1.2.2a. Class: Native VIa-semimetals.

1.2.2b. Class: VIa-semimetallides - tellurides.

2. Type: Minerals with principal metallic-covalent and ionic-covalent bond, rare van der Waals forces - native VIa-nonmetals, chalcogen compounds: - chalcogenides (isodesmical) → chalcosalts (anisodesmical).

2a. Quasitype*: Native VIa-nonmetals (van der Waals forces).

2b. Quasitype*: Chalcogenic compounds (metallic-covalent and ionic-covalent bond, rare van der Waals forces) - simple (isodesmical) → complex → chalcosalts (anisodesmical).

2b.1. Subtype: Chalcogenic compounds of sidero- and chalcophylic cations.

2b.1a. Quasisubtype*: Sulfides and sulfosalts of sidero- and chalcophylic cations.

2b.1a.1. Class: Sulfides of sidero- and chalcophylic cations.

2b.1a.2. Class: Sulfosalts of sidero and chalcophylic cations.

2b.1b. Quasisubtype*: Selenides and selenosalts of sidero- and chalcophylic cations.

2b.1b.1. Class: Selenides of sidero- and chalcophylic cations.

2b.1b.2. Class: Selenosalts of sidero- and chalcophylic cations.

2b.2. Subtype: Chalcophylic compounds of lithophylic cations.

2b.2.1. Class: Sulfides (and selenides) of lithophylic cations.

2b.2.2. Class: Sulfosalts of lithophylic cations.

3 Type: Minerals with principal ionic-covalent and covalent-ionic bond - nonmetallides of light (typical, cenosymmetrical) VIa-element (O) - oxygen compounds: Oxides and hydroxides (isodesmical → anisodesmical) → oxosalts (anisodesmical).

3.1. Subtype: Oxides and hydroxides (isodesmical).

3.1a. Quasisubtype*: Oxides and hydroxides of lithophylic cations with low FC - Force Characteristics.

3.1a.1. Class: Oxides and hydroxides of s-, d_s- and p_s-cations.

3.1a.2. Class: Oxides and hydroxides of f-cations with low FC - of 4-valent f-cations.

3.1a.3. Class: Oxides and hydroxides of f-cations with middle FC - of 6-valent f-cations (U^{6+}) → uranyl $(UO_2)^{2+}$ compounds- uranyl acids, uranates and their derivatives (uranium micas and related minerals).

3.1b. Quasisubtype*: Oxides and hydroxides of lithophylic cations with middle FC.

3.1b.1. Overclass*: Oxides of Zr .

3.1b.1a. Class: Simple oxides of Zr.

3.1b.1b. Class: Complex oxides of Zr → titanates of zirconium → zirconotitanates.

3.1b.2. Overclass*: Oxides of Sn^{4+} and Ti^{4+}.

3.1b.2a. Class: Simple oxides and hydroxides of Sn^{4+} and Ti^{4+}.

3.1b.2b. Class: Complex oxides of Ti^{4+} (Sn^{4+}) → titanates (stannates), ((6)-titanates, (6)-stannates only).

3.1b.3. Overclass*: Oxides and hydroxides of Nb^{5+} and Ta^{5+}.

3.1b.3a. Class: Simple oxides and hydroxides of Nb^{5+} and Ta^{5+}.

3.1b.3b. Class: Complex oxides of Nb^{5+} and Ta^{5+} ((6)-tantaloniobates → (4)-tantaloniobates).

3.1b.4. Overclass*: Oxides and hydroxides of Mo and W .

3.1b.4a. Class: Simple oxides and hydroxides of Mo and W .

3.1b.4b. Class: Complex oxides and hydroxides of Mo and W ((6)-molybdates and tungstenates → (4)-molybdates and tungstenates).

3.1b.5. Overclass*: Oxides and hydroxides of Mn^{4+}.

3.1b.5a. Class: Simple oxides and hydroxides of Mn^{4+}.

3.1b.5b. Class: Complex oxides and hydroxides of Mn^{4+}.

3.1b.6. Overclass*: Oxides and hydroxides of V^{4+}.
3.1b.6a. Class: Simple oxides and hydroxides of V^{4+}.
3.1b.6b. Class: Complex oxides and hydroxides of V^{4+}(vanadites).
3.1b.7. Overclass*: Oxides and hydroxides of V^{5+}.
3.1b.7a. Class: Simple oxides and hydroxides of V^{5+}.
3.1b.7b. Class: Complex oxides and hydroxides of V^{5+}((6)-vanadates → (5)-vanadates → (4)-vanadates).
3.1b.7b.1. Quasiclass: (6)-Vanadates.
3.1b.7b.2. Quasiclass: (5)-Vanadates.
3.1b.7b.3. Quasiclass: (4)-Vanadates.
3.1c. Quasisubtype*: Oxides and hydroxides of chalcophylic cations (except Va- and VIa-cations).
3.1c.1. Overclass*: Oxides and hydroxides of Ib-cations.
3.1c.2. Overclass*: Oxides and hydroxides of IIb-cations.
3.1c.3. Overclass*: Oxides and hydroxides of IIIa-cations.
3.1c.4. Overclass*: Oxides and hydroxides of IVa-cations.
3.1d. Quasisubtype*: Oxides and hydroxides of Va-cations.
3.1d.1. Overclass*: Oxides and hydroxides of As^{3+}, Sb^{3+}, Bi^{3+}.
3.1d.1a. Class: Simple oxides and hydroxides of As^{3+}, Sb^{3+}, Bi^{3+}.
3.1d.1b. Class: Complex oxides and hydroxides of As^{3+}, Sb^{3+}, Bi^{3+} →
(6)-Arsenites, antimonites, bismutites.
3.1d.2. Overclass : Oxides and hydroxides of As^{5+}, Sb^{5+}, Bi^{5+} (all are complex) → arsenates, antimonates and bismutates (only (6)-arsenates, (6)-antimonates and (6)-bismutates).
3.1e. Quasisubtype*: Oxides and hydroxides of VIa-cations (Te).
3.1e.1. Overclass*: Oxides and hydroxides of Te^{4+}.
3.1e.1a. Class: Simple oxides and hydroxides of Te^{4+}.
3.1e.1b. Class: Complex oxides and hydroxides of Te^{4+} → tellurites.
3.1e.2. Overclass: Oxides and hydroxides of Te^{6+} (all are complex) → tellurates (all (6)-tellurates).
3.1f. Quasisubtype*: Oxides and hydroxides of nonmetals (lithophylic) elements.
3.1f.1. Class: Oxides and hydroxides of Si and Ge (silicic and germanium anhydrides, silicic and germanium acids).
3.1f.2. Class: Oxides and hydroxides of B (boric anhydride and boric acids).
3.1f.3. Class: Oxides and hydroxides of Se (selenic anhydride).

3.2. Subtype: Oxosalts (anisodesmical).
3.2.1. Class: Silicates.
3.2.1a. Class: Germanates (zone of oxidization of Tsumeb and Franse).
3.2.2. Class: Borates.
3.2.2.1. Quasiclass: (4)-Borates.
3.2.2.2. Quasiclass: (3)-Borates.
3.2.2.3. Quasiclass: (4)-(3)-Borates.
3.2.3. Class: Carbonates.
3.2.4. Class: Phosphates
3.2.4.1. Quasiclass: Orthophosphates
3.2.4.2. Quasiclass: Pyrophosphates
3.2.4.3. Quasiclass: Triphosphates
3.2.4a.Class: Arsenates.
3.2.4a.1. Quasiclass: (6)-Arsenates.

3.2.4a.2. Quasiclass: (4)-Arsenates (orthoarsenates).
*3.2.4b. Class: Arsenites
3.2.5. Class: Sulfates.
3.2.6. Class: Sulfites.
3.2.6a. Class: Selenites.
3.2.7. Class: Chromates.
3.2.8. Class: Nitrates.
3.2.8a.Class: Iodates.
*3.2.8b.Class: Iodites
3.2.8c.Class: Rhodanates (tiocyanates).

4. Type: Minerals with principal covalent-ionic and ionic bond - halogen compounds.

4.1. Subtype: Halogenides (isodesmical).
4.1.1. Class: Fluorides.
4.1.2. Class: Chlorides, bromides.
4.1.2a. Class: Iodides.

4.2. Subtype: halogensalts (anisodesmical) (with hexacyanoferrates and hexatiocyanates, rhodonides).
4.2a. Quasisubtype*: Halogensalts with d-anionformers.
4.2a.1. Class: Cloroferrites and clorocuprites (of s-cations and NH^{+}_{4} only).
4.2a.2. Class: Hexachlorferrates and hexachlormanganates (of s-cations only).
4.2b. Quasisubtype*: Halogensalts with p-anionformers.
4.2b.1. Class: Fluoraluminates (of s-cations only).
4.2b.2. Class: Fluorborates (of s-cations only).
4.2b.3. Class: Fluorsilicates (of s-cations and NH^{+}_{4} only).
4.2b.4. Class: Chloraluminates (of s-cations only).

5. Type: Carbon, its compounds (without carbonates) and related substances.
5a. Quasitype*: Inorganic compounds (without carbonates) and related substances.
5a.1. Subtype: Native minerals.
5a.2. Subtype: Minerals with principal covalent or metallic-covalent bond - carbides and related compounds - silicides, nitrides and phosphides.
5a.2.1. Class: Carbides.
5a.2.1a. Class: Silicides.
5a.2.2. Class: Nitrides.
5a.2.2a. Class: Phosphides.
5b. Quasitype*: Organic carbon compounds (mineral with principal van der Waals forces bond).
5b.1. Subtype: Salts of organic acids.
5b.1.1. Class: Salts of benzopolycarbonic acids ($C_6H_{6-n}(COOH)_n$; $n = 6$).
5b.1.2. Class: Salts of citric acids (citrates).
5b.1.3. Class: Salts of acetic acids (acetates).
5b.1.4. Class: Salts of oxalic acids (oxalates).
*5b.1.5. Class: Salts of formic acids (formates).
5b.2. Subtype: Hydrocarbons and related compounds.
5b.2.1. Class: Hydrocarbons cyclic (by decreasing of $x = H : C$).
5b.2.2. Class: Hydrocarbons oxygenbearing (by increasing of $O : C$).

5b.2.3. Class: Nitrogenbearing organic compounds.

5b.3. Subtype: Mixtures of organic substances, including amber and related substances..

So, the principles of taxon separation in developed structural-chemical systematic of minerals are presented in table #1.

Table #1.General enumeration of the taxons of structural-chemical classification of minerals

Taxon	Feature	Examples
1	2	3
Type	It is principle type of chemical bond (but not a single type of chemical bond)	The five types are uniting all minerals species: 1.Type: Minerals with principal metallic and metallic-covalent bond - native metals and semimetals, metallides and semimetallides. 2.Type: Minerals with principal metallic-covalent and ionic-covalent bond, rare van der Waals forces - chalcogen compounds and native VIa nonmetals. 3.Type: Minerals with principal ionic-covalent and covalent-ionic bond - nonmetallides of light (typical, noncenosymmetrical) VIa element (O) - oxygen compounds. 4.Type: Minerals with principle covalent-ionic and ionic bond - halogen compounds. 5.Type: Carbon, its compounds (without carbonates) and related substances.
Quasi-type*	Type of chemical bond (this taxon is divided when more higher taxon unites the minerals with three or more types of chemical bond)	There are two quasitypes at the second type of minerals with principal metallic-covalent and ionic-covalent bond, rare van der Waals forces - chalcogen compound and native VIa nonmetals: 2a. Native VIa nonmetals (van der Waals forces); 2b. Chalcogenic compounds (metallic-covalent and ionic-covalent bond rare van der Waals forces) - simple (isodesmical) -> complex -> chalcosalts (anisodesmical)
Subtype	1.Type of chemical bond, (only single type of chemical bond) 2. Type of cation (siderophylic, chalcophylic or lithophylic) 3. Belonging of	There are two subtypes at the 1. taxon of minerals with principal metallic and metallic-covalent bond - native metals and semimetals, metallides and semimetallides: 1.1 Metals and metallides; 1.2 Semimetals and semimetallides. There are two subtypes at the 2b. quasitype of the second type: 2b.1. Chalcogenic compounds of sidero- and chalcophylic cations (metallic-covalent bond); 2b.2. Chalcogenic compounds of lithophylic cations (ionic-covalent bond). There are two subtypes at the 3 type of minerals with

	mineral to isodesmical and anisodesmical compounds	principal ionic-covalent and covalent-ionic bond - nonmetallides of light (typical, noncenosymmetrical) VIa-element (O) - oxygen compounds: 3.1. Oxides and hydroxides (isodesmical); 3.2. Oxysalts (anisodesmical) There are two subtypes at the 4 type of minerals with principle covalent-ionic and ionic bond - halogen compounds: 4.1. Halogenides (isodesmical); 4.2. Halogenosalts (anisodesmical) (with hexacyanoferrates and hexatiocyanates, rhodonides).
Quasi-subtype*	1.Anion 2. Type of cation and FC of cation	There are two quasitypes at the 2b.1. subtype chalcogen compounds of sidero- and chalcophylic cations (metallic-covalent bond): 2b.1a. Sulfides and sulfosalts of sidero- and chalcophylic cations; 2b.1b. Selenides and selenosalts of sidero- and chalcophylic cations. There are six consequently changing quasitypes at the 3.1 Subtype oxides and hydroxides (isodesmical), that are corresponding for transferal from the cations with low FC to the cations with high FC, from lithophylic cations to chalcophylic and to nonmetallic cations of the elements with mostly high FC: 3.1a - Oxides and hydroxides of lithophylic cations with low FC; 3.1b - Oxides and hydroxides of lithophylic cations with middle FC; 3.1c - Oxides and hydroxides of chalcophylic cations (without Va- and VIa- cations); 3.1d - Oxides and hydroxides Va- cations (As, Sb, Bi); 3.1e -Oxides and hydroxides VIa- cation (Te); 3.1f - Oxides and hydroxides of nonmetals (lithophylic) elements;
Over-class*	Cation	There are seven overclasses at the 3.1b. taxon - oxides and hydroxides of lithophylic cations with middle FC: 3.1b.1. Oxides Zr; 3.1b.2. Oxides Ti (Ti^{4+}); 3.1b.3. Oxides and hydroxides Nb^{5+} и Ta^{5+}; 3.1b.4. Oxides and hydroxides Mo и W; 3.1b.5. Oxides and hydroxides Mn^{4+} ; 3.1b.6. Oxides and hydroxides V^{4+} ; 3.1b.7. Oxides and hydroxides V^{5+}.

Class	Type of anion (simple, complex) or compound (simple, complex) 2. Anionforming, when minerals are anisodesmical compounds	There are two classes at the 2b.1a. quasitype- sulfides and sulfosalts of sidero- and chalcophylic cations: 2b.1a.1. Class: Sulfides of sidero- and chalcophylic cations; 2b.1a.2. Class: Sulfosalts of sidero- and chalcophylic cations; There are two classes at the 3b.1b.1. overclass - oxides Zr: 3.1b.1a. Class: Simple oxides of Zr; 3.1b.1b. Class: Complex oxides of Zr -> titanates of Zr -> zirconotitanates. There are eleven classes at the 3.2. subtype - Oxosalts (anisodesmical): 3.2.1. Class: Silicates; 3.2.2. Class: Borates; 3.2.3. Class: Carbonates; 3.2.4. Class: Phosphates; 3.2.4a. Class: Arsenates; 3.2.5. Class: Sulfates; 3.2.6. Class: Sulfites; 3.2.6a. Class: Selenites; 3.2.7. Class: Nitrates; 3.2.7a. Class: Iodates; 3.2.7б. Class: Rhodonates (tiocyanates).
Quasi class	Coordination number of the anionforming	There are three quasiclasses at the 3.1b.7b. class - complex oxides and hydroxides of V^{5+} ((6)-vanadates -> (5)-vanadates -> (4)-vanadates): 3.1b.7b.1. Qusiclass: (6)-vanadates; 3.1b.7b.2 Qusiclass: (5)-vanadates; 3.1b.7b.3 Qusiclass: (4)-vanadates; There are tree quasiclasses at the borates class: 1) (4)-borates; 2) (3)-borates; 3) (4)-(3)-borates: 3.2.2.1. Quasiclass: (4)-Borates; 3.2.2.2. Quasiclass: (3)-Borates; 3.2.2.3. Quasiclass: (4)-(3)-Borates;
Subclass	The size of FC	There are three subclasses at the class of silicates: 1) silicates with low FC; 2) silicates with middle FC; 3) silicates of chalcophylic elements.
Family	The minerals of one family have similar of equal compound, single	The family of zeolites unite the subfamilies: thomsonite, scolecite-natrolite, garronite, wairakite, gmelinite, stilbite, stellerite, mordenite. The micas family unite dioctahedral and trioctahedral micas

	genesis or paragenesis	and all polytypes.
Subfamily	Similar or equal compound and same type of structure	There are five subfamilies at the chalcopyrite family: talnakhite, actually chalcopyrite, germanite, briartite, morozeviczite. There are three subfamilies at the stannite family: stannoidite, actually stannite, rodostannite.
Series (genus)	Uninterrupted solid solutions between two or greater number of the extreme members	The forsterite genus and garnet genus among of the middle tetrasilicates
Group	The same type of the compound or structure	The dolomite group include dolomite, ankerite, kutnohorite, benstonite, eitelite. All its minerals have one type structure, but they have not the uninterrupted solid solutions between ones.
Mineral species	There is an individual chemical compound, extreme member of the solid solutions, middle member of the uninterrupted solid solutions.	a) There are three mineral species at the genus monticellite: monticellite, glaucochroite, kirnschsteinite. b) There are five mineral species at the forsterite genus: forsterite, fayalite, tephroite, liebenbergite, laihunite.

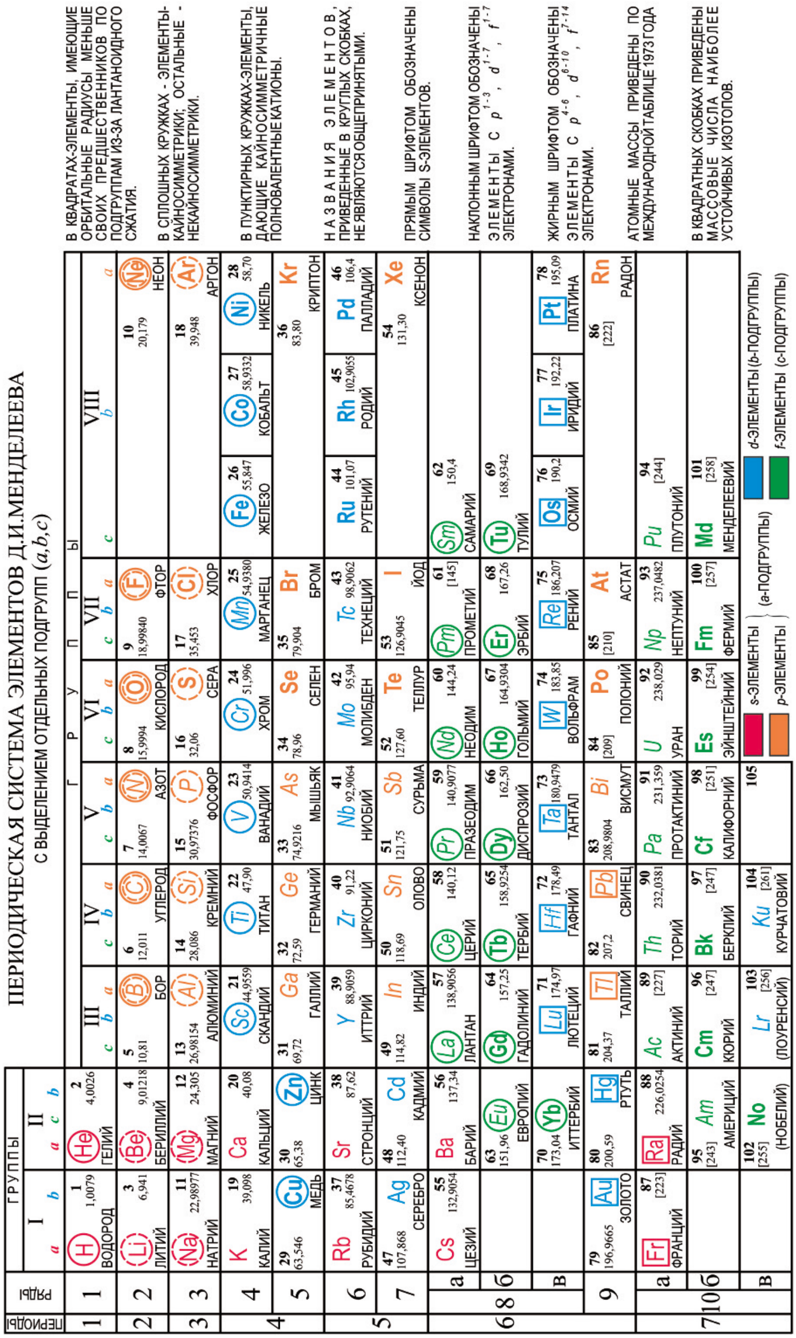

Fig. 4 Periodical table of elements D.I. Mendeleev′s with little Sub-Groups (a,b,c)

Structural-Chemical Systematic of Minerals

1.TYPE: MINERALS WITH PRINCIPAL METALLIC END METALLIC-COVALENT BOND – NATIVE METALS AND SEMIMETALS, METALLIDES AND SEMIMETALLIDES

1.1. SUBTIPE: METALS AND METALLIDES

1.1.1. ***Class***: Metals and metallides of sidero- and chalcophylic elements

1.1.1.1. <u>Minerals of heavy noncenosymmetrical *d*-elements (with 5 – 10 *d*-electrons)</u>

1.1.1.1.1. Minerals of **VIII***b*-elements (platinoides Pn)

1.1.1.1.1.1. Native metals

Platinum group	
Platinum	Pt
Iridium	Ir
Palladium	Pd
Rhodium	(Rh,Pt)
Osmium group	
Osmium	Os
Ruthenium	Ru
*Rutheniridosmin	(Ir,Os,Ru)

1.1.1.1.1.2. Metallides

	1.1.1.1.1.2.1. Only Pn
*Iridrhodruthenium	$Ru_{6,4}Rh_{1,7}Ir_{1,2}Pt_{0,7}Os_{0,04}$
	1.1.1.1.1.2.2. Ferreeds
Isoferroplatinum group	
Isoferroplatinum	Pt_3Fe
Unnamed 023	$Pt_2(Ir,Os)Fe$
*Chengdeite	$(Ir,Pt,Os,Ru)_3(Fe,Ni)$
*Unnamed	Pt_2Fe
Tetraferroplatinum group	
Unnamed 021	RhFe
Tetraferroplatinum	$Pt_{1+x}Fe$ $(0 \leq x \leq 1)$
Unnamed 022	Pt(Fe,Ni,Cu)
Ferronickelplatinum	Pt_2FeNi
Tulameenite	Pt_4Fe_2CuNi or Pt_2FeCu
Unnamed 305	Pt_3Cu_2Fe
Group $\mathbf{Pn_2(Fn,Cu)_3}$	
Unnamed 308	$(Os,Ir,Ru,Pt)_2Fe_3$
Unnamed 306	$(Ru,Os,Ir,Pt)_2(Fe,Ni,Cr)_3$
Unnamed 454	$Pt_2(Fe,Bi)_3$

A. A. Godovikov and S. N. Nenasheva, *Structural-Chemical Systematics of Minerals*, https://doi.org/10.1007/978-3-319-72877-3_2

Group **Pn(Fn,Cu)$_3$**		
Unnamed 304		$Pt(Ni,Cu,Fe)_3$
Unnamed 307		$(Pt,Ir,Os)(Fe,Ni,Cr,Cu)_3$
Unnamed 302		$PtCu_2Fe$
		1.1.1.1.1.2.3. Pn and Ag
Unnamed 498		$PdAg$
		1.1.1.1.1.2.4. Pn, Ag and Tl
Unnamed 455	2,(6)	$(Pd,Ag)_8Tl_3$
Unnamed 456	1,75	Pd_6AgTl_4
		1.1.1.1.1.2.5. Pn and Tl
Unnamed 453	2,5	$(Pd,Sn,Cu,Fe)_5(Tl,S)_2$
		1.1.1.1.1.2.6. Pn and Au
Unnamed 443		$PdAu_3$
		1.1.1.1.1.2.7. Mercureeds (amalgams)
Potarite		$PdHg$
		1.1.1.1.1.2.8. Cuprides
		1.1.1.1.1.2.8.1. Proper cuprides
Unnamed 514		Pt_3Cu
Unnamed 515		$(Pd,Pt,Au)_2Cu$
*Skaergaardite		$PdCu$
Hongshiite		$PtCu$
*Unnamed		$PtCu_{1-x}Sb_x$
Unnamed 433		Pt_2Cu_3
Unnamed 303		$PtCu_3$
*Nielsenite		$PdCu_3$
		*1.1.1.1.1.2.8.2. Cuprido-zincides
*Bortnikovite		Pd_4Cu_3Zn
		1.1.1.1.1.2.8.3. Cuprido-stanides
Cabriite family		
Unnamed 019		$Pd_6Cu_2(Sn,Sb)$
Cabriite		Pd_2CuSn
Unnamed 389		Rh_2CuSn
Stannopalladinite		$(Pd,Cu)_3Sn_2$
		1.1.1.1.1.2.9. Stanides
		1.1.1.1.1.2.9.1. Proper stanides
Unnamed 411		$(Pd,Pt)_7(Sn,Pb)_2$
Zvyagintsevite family		
Zvyagintsevite series		
Rustenburgite		Pt_3Sn
Atokite		Pd_3Sn
Zvyagintsevite		$Pd_3(Pb,Sn)$
Unnamed		Pd_3Pb
Maslenytskovite series		
Maslenytskovite-(Pt)		$Pt_{3-x}Pd_xSn_{1-y}\square_y$ $(0,6 \le x \le 1,5)$; $(0 \le y \le 0,1)$
Maslenytskovite-(Pd)		$Pd_{3-x}Pt_xSn_{1-y}\square_y$ $(0,6 \le x \le 1,5)$; $(0 \le y \le 0,1)$
Taimyrite		$(Pd,Cu,Pt)_3Sn$
*Tatyanaite		$(Pt,Pd,Cu)_9Cu_3Sn_4$

Paolovite family
Palarstanide $Pd_5(Sn,As)_2$
Unnamed 020 $(Pt,Pd)_5(Sn,Sb)_2$
Paolovite Pd_2Sn
Niggliite group
Niggliite $PtSn$
Unnamed 436 $(Ni,Pt)Sn$

1.1.1.1.1.2.9.2. Stanides-arsenides
Unnamed 233 Pd_6Sn_2As

1.1.1.1.1.2.10. Plumbides
1.1.1.1.1.2.10.1. Proper plumbides
Plumbopalladinite Pd_3Pb_2
*Norilskite $(Pd,Ag)_{2-x}Pb$ (0.08 <= x <= 0.11)

1.1.1.1.1.2.10.2. Plumbido-sulfides
*Shandite $Pb_2Ni_3S_2$
Rhodplumsite $Rh_3Pb_2S_2$
*Laflammeite $Pd_3Pb_2S_2$

1.1.1.1.2. Minerals of I*b*-elements
1.1.1.1.2.1. Minerals of Ag
1.1.1.1.2.1.1. Native metals
Silver family
Silver-*3C* Ag
Silver -*2H*
Silver -*4H*

1.1.1.1.2.1.2. Metallides
1.1.1.1.2.1.2.1. Ag, Au and Cu
Unnamed 005 $AuAgCu$

1.1.1.1.2.1.2.2. Mercureeds (amalgams)
*Amalgam (Ag,Hg)

1.1.1.1.2.1.2.2.1. Simple
Moschellandsbergite family
*Eugenite $Ag_{11}Hg_2$
Luanheite Ag_3Hg
Moschellandsbergite Ag_2Hg_3
Paraschachnerite $Ag_{1,2}Hg_{0,8}$
Schachnerite $Ag_{1,1}Hg_{0,9}$

1.1.1.1.2.1.2.2.2. Complex
1.1.1.1.2.1.2.2.2.1. Ag, Au and Hg
Unnamed 016 $Au_5Ag_{10}Hg$
Unnamed 015 $Au_{1.6}Ag_{7.4}Hg$

1.1.1.1.2.2. Minerals of Au
1.1.1.1.2.2.1. Native metals
Gold series
Gold Au
Electrum (Au,Ag)

1.1.1.1.2.2.2. Metallides
1.1.1.1.2.2.2.1. Mercureeds (amalgams)
Unnamed 3 $(Au,Ag)_3Hg$
Weishanite $(Au,Ag)_{1.2}Hg_{0.8}$

*Amalgam $(Au,Ag)_2Hg$
*Amalgam α-AuAgHg
*Amalgam (Au,Ag)Hg

1.1.1.1.2.2.2.2. Cuprides

Auricupride family
Unnamed 464 Au_3Cu
Auricupride $AuCu_3$
Tetra-auricupride AuCu

*1.1.1.1.2.2.2.3. Stannides

*Yuanjiangite AuSn
*Unnamed $AuSn_2$
*Nisnite Ni_3Sn

1.1.1.1.2.2.2.4. Plumbides

*Novodneprite $AuPb_3$
Anyuiite $AuPb_2$
*Hunchunite Au_2Pb

1.1.1.1.3. Minerals of **II***b*-elements
1.1.1.1.3.1. Native metals
Mercury Hg
1.1.1.1.3.2. Metallides 1.1.1.1.3.2.1. Cuprides
Kolymite Cu_7Hg_6
*Belendorffite Cu_7Hg_6 trig.,pseudo-cub.

1.1.1.1.3.2.2. Plumbides

Leadamalgam (altmarkite) $Hg_{0.3}Pb_{0.7}$

1.1.1.2. <u>Minerals of cenosymmetrical *d*-elements</u>
*1.1.1.2.1. Minerals of **VII***b*-elements
*1.1.1.2.1.1. Native metals
1.1.1.2.2. Minerals of **VIII***b*-elements (Fn)
1.1.1.2.2.1. Native metals
Iron family
Iron α-Fe
*Hexaferrum $(Fe_{0,65}Ir_{0,14}Os_{0,08}Ru_{0,08}Rh_{0,03}Ni_{0,01}Cu_{0,01})_{\Sigma 1,00}$
Nickel series
Nickel Ni
Taenite γ-(Ni,Fe)
Kamacite α- (Fe,Ni)
1.1.1.2.2.2. Metallides 1.1.1.2.2.2.1. Only Fn
Awaruite up $FeNi_2$ to $FeNi_3$
Tetrataenite group
Tetrataenite FeNi
Wairauite FeCo
Unnamed 014 Fe_2Co

1.1.1.2.2.2.2. Chromides

Ferchromide series
Ferchromide $Cr_{1.5}Fe_{0.2}$
Chromferide $Cr_{0,2}Fe_{1,5}$

1.1.1.2.2.2.3. Stanides

Unnamed 288 Ni_3Sn_2

	1.1.1.2.2.2.4. Plumbides
	1.1.1.2.2.2.4.1. Plumbido-sulfides
Shandite	$Ni_3Pb_2S_2$
	*1.1.1.2.2.2.5.Tantalido-niobides
*Jedwabite	$Fe_7(Ta,Nb)_3$
1.1.1.2.3. Minerals of **I***b*-elements (Cu)	
1.1.1.2.3.1. Native metals	
Copper	Cu
1.1.1.2.3.2. Metallides	1.1.1.2.3.2.1. Zincides
Brass family	
Unnamed 009	$Cu_{4.45}Zn$
Unnamed 008	Cu_3Zn
*Unnamed	$(Cu, Au,Ag)_4Zn$
*Unnamed	$Cu_{1,81}Zn_{1,2}Fe_{0,07}$
Brass	β-CuZn
Zhanghengite	CuZn
Danbaite	$CuZn_2$
	1.1.1.2.3.2.2. Stanides
Bronze family	
Unnamed 013	(Cu,Ni,Sn)
Unnamed 012	Cu_3Sn
Bronze-n	Cu_6Sn_5
Unnamed 007	Cu(Sn,Sb)
*Unnamed solid solution	$Cu_3AuHg_{0,4}Sn_{0,7}$-$Cu_3Au_{1,8}HgSn$
	1.1.1.2.3.2.3. Aluminides
Cupalite	(Cu,Zn)Al
Khatyrkite	$(Cu,Zn)Al_2$
1.1.1.2.4. Minerals of **II***b*-elements(Zn and Cd)	
1.1.1.2.4.1. Native metals	
Zinc group	
Zinc	Zn
Cadmium	Cd
1.1.1.2.4.2.Metallides	1.1.1.2.4.2.1. Aluminides
Unnamed 011	Zn_2Al
Unnamed 010	$ZnAl_2$
*1.1.1.2.5. Minerals of **VI***b*-elements	
*1.1.1.2.5.1. Native metals	
*Titanium	Ti
1.1.1.3. Minerals of noncenosymmetrical *p*-elements	
1.1.1.3.1. Minerals of **III***a*-elements	
1.1.1.3.1.1. Native metals	
Indium	In
1.1.1.3.2. Minerals of **IV***a*-elements	
1.1.1.3.2.1. Native metals	
Tin	Sn

Lead	Pb

1.1.2. ***Class***: Metalls and metallides of lithophylic elements

1.1.2.1. Minerals of light ***d***-elements (with 1 – 4 d-electrons)
1.1.2.1.1. Minerals of noncenosymmetrical *d*-elements
1.1.2.1.1.1. Minerals of **V***b*-elements
1.1.2.1.1.1.1. Native metals
*1.1.2.1.1.2. Minerals of **VI**b-elements
*1.1.2.1.1.2.1. Native metals

*Hexamolybdenum	(Mo,Ru,Fe)
*Tungsten	W

1.1.2.1.2. Minerals of cenosymmetrical *d*-elements
1.1.2.1.2.1.Minerals of **VI***b*-elements
1.1.2.1.2.1.1. Native metals

Chromium	Cr

1.1.2.2. Minerals of light *p*-elements
1.1.2.2.1. Minerals of light cenosymmetrical *p*-elements
1.1.2.2.1.1. Minerals of **III**a-elements
1.1.2.2.1.1.1. Native metals

Aluminium	Al

*1.1.2.2.1.1.2. Metallides

*Unnamed	$Al_{0.98}(Si,Cu,Ag)_{0,02}$
*Unnamed	$Al_{0.72}(Si,Cu,Ag,Mn,Fe)_{0,28}$
*Unnamed	$Al_{0.7}(Si,Mn,Fe)_{0,3}$
*Icosahedrite	$Al_{63}Cu_{24}Fe_{13}$

1.2. Subtype: Semimetals and semimetallides (ohly of sidero- and chalcophylic cations)

1.2.1.Quasisubtype*: Semimetals and semimetallides of V*a*-elements

1.2.1a. ***Class***: Native V*a*-semimetalls

Arsenic family
Arsenic group

Arsenic	As
*Pararsenolamprite	As
Stibarsen (allemontite)	SbAs
Antimony	Sb
Bismuth	Bi
Arsenolamprite	As
Paradocrasite	$Sb_2(Sb,As)_2$

1.2.1b. ***Class***: **V**a-Semimetals- arsenides, antimonides, bismuthides

1.2.1b.1. Minerals of heavy *d*-elements (with 5 – 10 *d*-electrons)
1.2.1b.1.1. Minerals of heavy noncenosymmetrical *d*-elements (with 5 – 10 *d*-electrons)
1.2.1b.1.1.1. Minerals of **VIII***b*-cations (Pn^{n+})
1.2.1b.1.1.1.1. Arsenides

1.2.1b.1.1.1.1.1. Polyanionic
1.2.1b.1.1.1.1.1.1. Pn^{2+}
1.2.1b.1.1.1.1.1.1.1. Proper polyarsenides with As : Pn = 2 - diarsenides (simple)

Sperrylite family 0,5	
Sperrylite	Pt[As_2]
Iridarsenite	Ir[As_2]
Omeiite group	
Omeiite	(Os,Ru)[As_2]
Anduoite	(Ru,Os)[As_2]
Unnamed 442	(Fe,Pt)[$(As,S)_2$]

1.2.1b.1.1.1.1.1.2. Pn^{3+}
1.2.1b.1.1.1.1.1.2.1. Polyarsenido-sulfides with (As+S) : Pn = 2 - diarsenido-sulfides (simple)

Hollingworthite series	
Platarsite 0,5	(Pt,Ph,Ru)[AsS]
Hollingworthite	(Rh,Pt,Pd)[AsS]
Osarsite group	
Osarsite 0,5	(Os,Ru)[AsS]
Irarsite 0,5	(Ir,Ru,Rh,Pt)[AsS]
Ruarsite 0,5	Ru[AsS]

1.2.1b.1.1.1.1.1.3. $Pn^{>3+}$ (?)
1.2.1b.1.1.1.1.1.3.1. Polyarsenides → subarsenides
1.2.1b. 1.1.1.1.1.3.1.1. Proper polyarsenides (simple)

Unnamed 400 0,2	$OsAs_5$
Unnamed 175 0,6	Pd_3As_5
Unnamed 176 0,(6)	Pd_2As_3

1.2.1b.1.1.1.1.1.3.2. Polyarsenido-sulfides
1.2.1b.1.1.1.1.1.3.2.1.Simple

Unnamed 463 0,1(6)	$PtAs_2S_4$
Unnamed 441 0,25	$PtAs_2S_2$
Unnamed 174 0,25	$Pt_2As_5S_3$

1.2.1b.1.1.1.1.1.3.2.2. Complex

Unnamed 163 0,1(6)	$PdCu(As,S)_6$
Unnamed 312 0,(3)	$Pd_2Cu_2As_5S_7$

1.2.1b.1.1.1.1.2. Subarsenides
1.2.1b.1.1.1.1.2.1. Proper subarsenides
1.2.1b.1.1.1.1.2.1.1. Simple

Unnamed 461 3,(3)	$Pd_{10}As_3$
Series **$(Pd,Ni)_3As$** 3	
Unnamed 410	$(Pd,Ni)_3As$
Unnamed 414	$(Pd,Pt,Pb)_3(As,Sb)$
*Unnamed	$(Pd,Pt)_3(Sb,Sn,As)$
*Vincentite	$(Pd,Pt,)_3(As,Sb,Te)$
Unnamed 388	$(Ru,Os,Fe,Rh,Ir,Ni)_3As$
Stillwaterite family	
Stillwaterite 2,(6)	Pd_8As_3
Arsenopalladinite	$Pd_8(As,Sb)_3$
Unnamed 224 2,5	Pd_5As_2

Unnamed 231 2,5 — $(Pd,Ni)_5As_2$

Palladoarsenide family 2

Palladoarsenide — Pd_2As

*Rhodarsenide — $(Rh,Pd)_2As$

*Palladodymite — $(Pd,Rh)_2As$

Palladobismutharsenide — $Pd_{10}(BiAs_4)_{\Sigma5}$

Unnamed — $Pd_8(BiAs_3)_{\Sigma4}$

*Unnamed — $Pd_3(Sb,As)$

*Polkanovite 1,7 — $Rh_{12}As_7$

1.2.1b.1.1.1.1.2.1.2. Complex

1.2.1b.1.1.1.1.2.1.2.1. Only Pn

Unnamed 403 2 — OsRuAs

1.2.1b.1.1.1.1.2.1.2.2. Pn and Fn

Unnamed 232 2,(6) — $Pd_2Ni_6As_3$

*Unnamed 2,5 — $Pd_5(As,Te,Sn)_2$

*Unnamed 2,5 — $(Pd,Pt)_5(Sn,As,Sb)_2$

Unnamed 223 2,(3) — $Pd_3Ni_4As_3$

Majakite group

Majakite — PdNiAs

Zaccariniite = Unnamed 387 — RhNiAs

Unnamed 381 1,7(3) — $Pd_{1.6}NiAs_{1.5}$

*Menshikovite — $Pd_3Ni_2As_3$

1.2.1b.1.1.1.1.2.1.2.3. Pn and Cu

Unnamed 434 8,(3) — $(Pt,Pd)_{17}Cu_8As_3$

Unnamed 221 3,5 — $(Pd,Cu)_7(As,Sb)_2$

1.2.1b.1.1.1.1.2.1.2.4. Pn and Hg

Atheneite 2 — $Pd_2(As_{0.75}Hg_{0.25})$

1.2.1b.1.1.1.1.2.1.2.5. Pn and Pb

Borishanskiite 2 — $Pd_{1+x}(As,Pb)_2$ (x=0-0.2)

1.2.1b.1.1.1.1.2.1.2.6. Pn and Sn

Group **Pd_6SnAs** 7

Unnamed 310 — Pd_6SnAs

Unnamed 311 — Pd_6SnSb

1.2.1b.1.1.1.2.2.2. Subantimonido-arsenides (simple)

Mertieite family

Mertieite-I 2,2 — $Pd_{5+x}(Sb,As)_{2-x}$ (x=0.1-0.2)

Isomertieite 2,2 — $Pd_{11}Sb_2As_2$

Mertieite-II 2,(6) — $Pd_8(Sb,As)_3$

1.2.1b.1.1.1.1.2.3. Subarsenido-sulfides

1.2.1b.1.1.1.1.1.2.3.1. Simple

Unnamed 229 2,(6) — Pd_8As_2S

1.2.1b.1.1.1.1.2.3.2. Complex

Daomanite 0,(6) — $CuPtAsS_2$

1.2.1b.1.1.1.1.3. Monoanionic

1.2.1b.1.1.1.1.3.1. Pn^{2+} and Pn^{3+} (complex)

1.2.1b.1.1.1.1.3.1.1. Proper arsenides

Unnamed 225 1,(3) — $Pd_4As_3 \rightarrow Pd^{2+}{}_3Pd^{3+}As_3$

1.2.1b.1.1.1.1.3.1.2. Arsenido- sulfides
Unnamed 401 1 $Os^{2+}Rh^{3+}AsS$

1.2.1b.1.1.1.1.3.2. Pn^{3+}
1.2.1b.1.1.1.1.3.2.1. Proper arsenides (simple)
Ruthenarsenite group 1
Cherepanovite RhAs
Ruthenarsenite (Ru,Ni)As
Unnamed 309 Pd(As,Te)

1.2.1b.1.1.1.1.3.2.2. Arsenido- sulfides (simple)
Unnamed 177 0,(8) $Pd^{3+}{}_8As_6S_3$
*1.2.1б.1.1.1.1.3.2.3. Arsenido -tellurides
*Törnroosite $Pd_{11}As_2Te_2$
1.2.1b.1.1.1.2. Antimonides
1.2.1b.1.1.1.2.1. Polyantimonides
1.2.1b.1.1.1.2.1.1. Pn^{2+}
1.2.1b.1.1.1.2.1.1.1. Proper Polyantimonides (simple)
Geversite group (?)
Geversite $Pt[Sb_2]$
Unnamed 161 0,5 $Pd[Sb_2]$ (?)

1.2.1b.1.1.1.2.1.1.2. Polybismuthido-anthimonido-tellurides (simple)
1.2.1b.1.1.1.2.1.2. Pn^{3+}
1.2.1b.1.1.1.2.1.2.1. Polyantimonido -sulfides (simple)
Tolovkite group (?)
Tolovkite Ir[SbS]
*Changchengite Ir[BiS]
Unnamed 158 0,5 Rh[SbS]
1.2.1b.1.1.1.2.2. Subantimonides (simple)
Unnamed 472 4 Pd_4Sb
Unnamed 429 3 $(Pd,Cu)_3Sb$
*Naldrettite Pd_2Sb
Stibiopalladinite 2,5 Pd_5Sb_2
Unnamed 234 2 $(Pd,Pt,Ni)_2(Sb,Sn)$
Genkinite series (?)
Genkinite 1,(3) $(Pt,Pd,Rh,Ni)_4Sb_3$
Unnamed 493 1,(3) $(Pd,Pt)_4Sb_3$
*Ungavaite Pd_4Sb_3

1.2.1b.1.1.1.2.3. Monoanionic
1.2.1b.1.1.1.2.3.1. Pn^{2+}
1.2.1b.1.1.1.2.3.1.1. Proper antimonides (simple)
Unnamed 445 1,5 $(Pt,Pd)_3Sb_2 \rightarrow (Pt,Pd)^{2+}{}_3Sb_2$
1.2.1b.1.1.1.2.3.2. Minerals Pn^{3+}
1.2.1b.1.1.1.2.3.2.1. Proper antimonides
1.2.1b.1.1.1.2.3.2.1.1. Simple
Sudburyite group
Unnamed 142 1 RhSb
Sudburyite 1 PdSb

Unnamed 471 1 — $Pd(Sb,Te,Bi)$
Stumpflite 1 — $PtSb$

1.2.1b.1.1.1.2.3.2.1.2. Simple→ Complex
Unnamed 179 0,(6) — $Pd_2(Sb,Te)_3$

1.2.1b.1.1.1.3. Bismuthides
1.2.1b.1.1.1.3.1. Polybismuthides
1.2.1b.1.1.1.3.1.1. Pn^{2+}
1.2.1b.1.1.1.3.1.1.1. Polybismuthides with Bi : Pn = 2 - dibismuthides (simple)
Froodite group
Insizwaite 0,5 — $Pt[(Bi,Sb)_2]$
Froodite — $Pd[Bi_2]$

1.2.1b.1.1.1.3.1.2. $Pn^{>3+}$ (?)
1.2.1b.1.1.1.3.1.2.1. Polybismuthides → subbismuthides (?) with Bi : Pn = 0,(3) (simple)
Unnamed 230 0,(3) — $PdBi_3$
1.2.1b.1.1.1.3.2. Subbismuthides (complex)
Unnamed 018 6 — Pd_3Pb_3Bi
Unnamed 228 4 — $(Pd,Rh,Pt)_3Pb(Bi,Te)$

1.2.1b.1.1.1.3.3. Monoanionic
1.2.1b.1.1.1.3.3.1. Pn^{3+}
1.2.1b.1.1.1.3.3.1.1. Proper bismuthides (simple)
Series **(Pt,Pd)(Bi,Sb)**
Unnamed 446 1 — $(Pt,Pd)(Bi,Sb)$
Unnamed 143 1 — $(Pt,Pd)(Bi,Sb)$
Polarite — $Pd(Bi,Pb)$

1.2.1b.1.1.1.3.3.1.2. Pn^{2+} and Pn^{4+}
1.2.1b.1.1.1.3.3.1.2.1. Proper bismuthides (complex)
Urvantsevite — $Pd(Bi,Pb)_2$

1.2.1b.1.1.2. Minerals of **I**b-cations
1.2.1b.1.2.1. Minerals of Ag
1.2.1b.1.1.2.1.1. Arsenides
1.2.1b.1.1.2.1.1.1. Polyarsenido (?)-sulfides (simple)
Dervillite 0,(6) — Ag_2AsS_2
1.2.1b.1.1.2.1.1.2. Monoanionic (complex)
Kutinaite — $(Ag_6Cu_{14})_{\Sigma 20}As_7 \rightarrow (Ag_6Cu_{13})^{+}_{\Sigma 19}Cu^{2+}As_7$

1.2.1b.1.1.2.1.2. Antimonides
1.2.1b.1.1.2.1.2.1. Polyantimonides (?) (simple)
Allargentum — $Ag_{1-x}Sb$ (0,09 < x < 0,16)
1.2.1b.1.1.2.1.2.2. Monoanionic (simple)
Dyscrasite — Ag_3Sb
1.2.1b.1.1.2.2. Minerals of Au
1.2.1b.1.1.2.2.1. Antimonides
1.2.1b.1.1.2.2.1.1. Polyantimonides (?) (simple – Au^{2+})
Aurostibite 0,5 — $Au[Sb_2]$

1.2.1b.1.1.2.2.1.2. Monoanionic
1.2.1b.1.1.2.2.1.2.1. Au^{+}
1.2.1b.1.1.2.2.1.2.1.1. Antimonido-sulfides (complex)

Criddleite	$TlAu_3Ag_2Sb^{3+}{}_{10}$

1.2.1b.1.1.2.2.2. Bismutides
1.2.1b.1.1.2.2.2.1. Subbismutides (simple)

Maldonite	Au_2Bi

1.2.1b.1.1.3. Minerals of **II***b*-cations (Hg)
1.2.1b.1.1.3.1. Antimonides
1.2.1b.1.1.3.1.1. Monoanionic
1.2.1b.1.2.3.1.1.1. Antimonido-sulfides (complex)

Tvalchrelidzeite	Hg_3SbAsS_3

1.2.1b.1.2. <u>Minerals of cenosymmetrical *d*-cations</u>
1.2.1b.1.2.1. Minerals of **VIII***b*-cations (Fn^{n+})
1.2.1b.1.2.1.1. Arsenides
1.2.1b.1.2.1.1.1. Polyanionic
1.2.1b.1.2.1.1.1.1. Fn^{2+} (seldom Fn^{4+} ?)
1.2.1b.1.2.1.1.1.1.1. Proper arsenides with As : Fn = 2 – diarsenides (simple)

Löllingite family	
Krutovite	$Ni[As_2]$
Pararammelsbergite	$Ni[As_2]$
Löllingite group (compare with marcasite (group); ullmannite (series))	
Rammelsbergite	$Ni[As_2]$
Safflorite	$Co[As_2]$
Löllingite	$Fe[As_2]$
Clinosafflorite	$Co[As_2]$

1.2.1b.1.2.1.1.1.1.2. Minerals of Fn^{3+}
1.2.1b.1.2.1.1.1.1.2.1. Proper arsenides with As : Fn = 3 – Triarsenides (simple)

Skutterudite series	
Nickelskutterudite (chloanthite)	$(Ni,Co,Fe)As_3$
Skutterudite	$CoAs_3$
*Ferroskutterudite	$(Fe,Co)As_3$

1.2.1b.1.2.1.1.1.1.2.2. Arsenido-sulfides with (As+S) : Fn = 2 – diarsenido-sulfides (simple)

Gersdorffite series (?) (compare with pyrite (group))	
Gersdorffite	Ni[AsS]
Unnamed 450	(Ni,Fe,Co)[AsS]
Arsenopyrite family (compare with marcasite (group); ullmannite (series))	
Cobaltite	Co[AsS]
Glaucodote	(Co,Fe)[AsS]
Alloclasite	(Co,Fe)[AsS]
Arsenopyrite	Fe[AsS]
Seinäjokite	$(Fe,Ni)[(Sb,As)_2]$
*Unnamed	(Fe,Ni)SbAs
*Oenite	CoSbAs

1.2.1b.1.2.1.1.1.1.2.3. Arsenido-selenides with (As+Se) : Fn = 2 – diarsenido-selenides
Unnamed 479 Co[AsSe](?)
*Jolliffeite NiAsSe

1.2.1b.1.2.1.1.2. Subarsenides
1.2.1b.1.2.1.1.2.1. Proper arsenides (simple)
Maucherite family
Dienerite = nickelskutterudite $(Ni,Co,Fe)As_3$
Orcelite 2,5 $Ni_{5-x}As_2$
Unnamed 385 2,(3) $(Ni,Fe)_7(As,Sb)_3$
Maucherite 1,375 $Ni_{11}As_8$

1.2.1b.1.2.1.1.2.2. Subarsenido-antimonido-sulfides (simple)
Vozhminite $(Ni,Co)_4(As,Sb)S_2$

1.2.1b.1.2.1.1.3. Monoanionic
1.2.1b.1.2.1.1.3.1. Fn^{2+}
1.2.1b.1.2.1.1.3.1.1. Proper arsenides (simple)
Oregonite $FeNi_2As_2$

1.2.1b.1.2.1.1.3.2. Fn^{3+}
1.2.1b.1.2.1.1.3.2.1. Proper arsenides (simple)
Nickeline family
Nickeline series
Nickeline NiAs
Langisite CoAs
Breithauptite NiSb
Modderite group
Modderite orth. CoAs
Westerveldite orth. (Fe,Ni)As

1.2.1b.1.2.1.1.3.3. Fn^{3+} and Fn^{4+}
1.2.1b.1.2.1.1.3.3.1. Arsenido-sulfides (complex)
Unnamed 157 $(Co,Ni)_2AsS_2 \rightarrow Fn^{3+}Fn^{4+}AsS_2$
1.2.1b.1.2.1.1.3.4. Fn^{4+}
1.2.1b.1.2.1.1.3.4.1. Proper arsenides (simple)
Unnamed 162 $(Ni,Pd)_3As_4$

1.2.1b.1.2.1.2. Antimonides
1.2.1b.1.2.1.2.1. Polyanionic
1.2.1b.1.2.1.2.1.1. Fn^{2+}
1.2.1b.1.2.1.2.1.1.1. Proper polyantimonides with Sb : Fn = 2 - diantimonides (simple)
Nisbite group (?) (compare with pyrite (series))
Nisbite $Ni[Sb_2]$
Unnamed 159 $Co[Sb_2]$
*1.2.1б.1.2.1.2.1.1.2. Proper polyantimonides with Sb : Fn = 3 – триантимониды
*Kieftite $CoSb_3$

1.2.1b.1.2.1.2.1.2. Fn^{3+}

1.2.1b.1.2.1.2.1.2.1. Polyantimonido-sulfides with (Sb+S) : Fn = 2 - diantimonides-sulfides (simple)

Ullmannite family (compare with marcasite (droup.); arsenopyrite (series))

Ullmannite	Ni[SbS]
Willyamite	(Co,Ni)[SbS]
Costibite	Co[SbS]
Paracostibite	Co[SbS]
Gudmundite	Fe[SbS]

1.2.1b.1.2.1.2.2. Subantimonides (simple)

Unnamed 384 3	Ni_3Sb
Unnamed 383 2	$(Ni,Cu)_2Sb$

1.2.1b.1.2.1.2.3. Monoanionic

1.2.1b.1.2.1.2.3.1. Fn^{2+}

1.2.1b.1.2.1.2.3.1.1. Bismuthido-sulfides (complex – Ni^{2+} and Pb^{2+})

Parkerite (an. 3)	$Ni_3(Bi,Pb)_2S_2$

1.2.1b.1.2.1.2.3.2. Fn^{2+} and Fn^{3+}

1.2.1b.1.2.1.2.3.2.1. Antimonido-sulfides → bismuthido-tellurido-sulfides → Bismuthido-sulfides (complex – Ni^{2+} and Ni^{3+}))

Hauchecornite family ($Ni^{2+}{}_5Ni^{3+}{}_4X_2S_8$, X = As^{3-}, Sb^{3-}, Bi^{3-}, Te^{2-})

Arsenohauchecornite	$Ni^{2+}{}_{10}Ni^{3+}{}_8Bi_3AsS_{16}$
Hauchecornite group	
Tučekite	$Ni^{2+}{}_5Ni^{3+}{}_4Sb_2S_8$
Hauchecornite	$Ni^{2+}{}_5Ni^{3+}{}_4Bi(Sb,Bi)S_8$
Bismutohauchecornite	$Ni^{2+}{}_5Ni^{3+}{}_4Bi_2S_8$
Tellurohauchecornite	$Ni^{2+}{}_6Ni^{3+}{}_3BiTeS_8$

1.2.1b.1.2.1.2.3.3. Fn^{3+} and Fn^{4+}

1.2.1b.1.2.1.2.3.3.1. Bismuthido-sulfides (complex- Ni^{3+} and Ni^{4+})

Parkerite (an. 1 and 2)	$Ni^{3+}{}_2Ni^{4+}Bi_2S_2$

1.2.1b.1.2.2. Minerals of **I***b*-cations

1.2.1b.1.2.2.1. Arsenides

1.2.1b.1.2.2.1.1. Polyanionic (only Cu^{2+})

1.2.1b.1.2.2.1.1.1. Poper arsenides (simple)

Paxite	$Cu[As_2]$

1.2.1b.1.2.2.1.1.2. Arsenido-sulfides (simple)

Lautite	$Cu[AsS]^{\infty}$

1.2.1b.1.2.2.1.2. Subarsenides (simple)

Algodonite	$Cu_{17}As_3$

1.2.1b.1.2.2.1.3. Monoanionic

1.2.1b.1.2.2.1.3.1. Cu^+

1.2.1b.1.2.2.1.3.1.1. Poper arsenides (simple)

Domeykite family

Domeykite	α-Cu_3As

Metadomeykite β-Cu_3As

1.2.1b.1.2.2.1.3.2. Cu^+ and Cu^{2+}
1.2.1b.1.2.2.1.3.2.1. Poper arsenides (complex)
Koutekite family
Koutekite $Cu_5As_2 \rightarrow Cu^+{}_4Cu^{2+}As_2$
Novakite $(Cu,Ag)_{21}As_{10} \rightarrow (Cu,Ag)^+{}_{12}Cu^{2+}{}_9As_{10}$
Unnamed 220 $Cu_2As \rightarrow Cu^+Cu^{2+}As$

1.2.1b.1.2.2.2. Antimonides
1.2.1b.1.2.2.2.1. Subantimonides (simple)
1.2.1b.1.2.2.2.2. Monoanionic
1.2.1b.1.2.2.2.2.1. Cu^+ and Cu^{2+}
1.2.1b.1.2.2.2.2.1.1. Proper antimonides (complex)
Cuprostibite $Cu_2Sb \rightarrow Cu^+Cu^{2+}(Sb,Tl)$
*Zlatogorite $CuNiSb_2$
*Sorosite Cu(Sn,Sb)

1.2.1b.1.2.2.2.2.1.2. Antiminido-sulfides (complex)
1.2.1b.1.2.2.2.2.1.2.1.1. Cu^+, $Cu^{2+}$and Tl^+
Rohaite $TlCu_5SbS_2 \rightarrow Tl^+Cu^+{}_4Cu^{2+}SbS_2$
1.2.1b.1.2.2.2.2.1.2.1.2. Cu^+, Cu^{2+},Tl^+ andFe^{2+}
Chalcothallite 3 $Tl_2(Cu,Fe)_6SbS_4 \rightarrow Tl^+{}_6(Cu,Ag)^+{}_9(Cu,Fe)^{2+}{}_9Sb_3S_{12}$

1.2.1b.2. Minerals of noncenosymmetrical *p*-cations
1.2.1b.2.1. Minerals of **IV***a*-cations
1.2.1b.2.1.1. Minerals of Sn^{2+} (?)
1.2.1b.2.1.1.1. Antimonides
1.2.1b.2.1.1.1.1. Polyanionic(?) antimonido-arsenides (simple)
Unnamed 181 0,25 $Sn[(Sb,As)_2]_2$

1.2.1b.2.1.1.1.1.Моноанионные (сложные - Sn^{2+} and Sn^{4+})
Stistaite $2SnSb \rightarrow Sn^{2+}Sn^{4+}Sb_2$

1.2.2. Quasisubtype*: Semimetals and semimetallidess of **V**a-semimetals

1.2.2a. **Class:** Native **VI**a-semimetals
Tellurium Te

1.2.2b. ***Class***: **VI**a-semimetalls -tellurides
1.2.2b.1. Minerals of heavy *d*-cations (with 5 – 10 *d*-electrons)
1.2.2b.1.1. Minerals of noncenosymmetrical *d*-cations
1.2.2b.1.1.1. Minerals of **VIII***b*-cations (Pn^{n+})
1.2.2b.1.1.1.1. Polytellurides (?)
1.2.2b.1.1.1.1.1. Proper polytellurides (simple)
*Unnamed (Pd теллурид) Pd_2Te
Unnamed 180 0,(3) $PdTe_3$
*Merenskyite $Pd_{1-x}Pt_xBi_yTe_{2-y}$ $(0 \le x \le 0,5)$; $(0 \le y \le 0,(6))$ или $PdTe_2$
*Gaotaiite 0,375 Ir_3Te_8

*Shuangfengite 0,5	$(Ir,Pt)Te_2$
*1.2.2б.1.1.1.1.1.1. Complex	
*Pašavaite	$Pd_3Pb_2Te_2$
1.2.2b.1.1.1.1.2. Polytellurido-bismuthides (simple)	
Michenerite series (?) (Pn^{3+})	
Maslovite 0,5	Pt[BiTe]
Michenerite	Pd[BiTe]
1.2.2b.1.1.1.2. Subtellurides	
1.2.2b.1.1.1.2.1. Proper subtellurides	
1.2.2b.1.1.1.2.1.1. Simple	
Unnamed 459 8	$(Pd,Au)_8(Te,As)$
Unnamed 343 8	$(Pd,Au)_8(Te,As)$
Keithconnite family	
Keithconnite group (?) 3	
Unnamed 516	$(Rh,Pd)_3Te$
Keithconnite	$Pd_{20}Te_7$
Unnamed 115 2,(6)	Pd_8Te_3
Group. (?) 2.5	
Unnamed 117	$Pd_5(Te,Bi,Sb)_2$
Unnamed 116	$(Pd,Cu,Sn)_5(Te,S)_2$
Telluropalladinite 2,25	Pd_9Te_4
*Unnamed 2	Pd_2Te
Unnamed 118 1,5	$(Pd,Ni)_3(Te,Sb,Bi)_2$
*Oulankaite 1,5	$(Pd,Pt)_5(Cu,Fe,Ag)_4SnTe_2S_2$
*Oulankaite-Ag	$(Pd,Pt)_{5+x}(Ag,Cu,Fe)_{4-x}SnTe_2S_2$
*Unnamed	$(Pd,Ni)_2Te_2Sb$
1.2.2b.1.1.1.2.1.2. Complex	
1.2.2b.1.1.1.2.1.2.1. Pn and Ag	
Sopcheite group 1,75	
Unnamed 440	Pd_6AgTe_4
Sopcheite	$Pd_3Ag_4Te_4$
*Lukkulaisvaaraite	$Pd_{14}Ag_2Te_9$
	1.2.2b.1.1.1.2.1.2.2. Pn and Ag, Pb(Bi)
Telargpalite	$PdAg_3Te$
*Telargpalite-Bi	$(Pd,Ag)_3(Bi_{0,51}Te_{0,43}Pb_{0,02})_{0.96}$
	1.2.2b.1.1.1.2.1.2.3. Pn and Hg
Temagamite	Pd_3HgTe_3
	1.2.2b.1.1.1.2.1.2.4. Pn and Bi
Unnamed 438 0,(3)	$PdBiTe_2$
1.2.2b.1.1.1.2.2. Subtellurido-arsenides (simple)	
Unnamed 341 4	$Pd_8(As,Te)_2$
Unnamed 460 4	Pd_8AsTe
Unnamed 342 3,(3)	$Pd_{10}(As,Te)_3$
Unnamed 524 3	$(Pt,Pd)_3(Te,As)$
Unnamed 476 3	$Pd_3(Te,As)$
Unnamed 477 2,45	$(Rh,Pd)_{4.9}(As,Te)_2$

Unnamed 119 2 $Pd_2(Te,As)$
*Unnamed $Pd_{11}Te_2As_2$

1.2.2b.1.1.1.2.3. Subtellurido-sulfides (complex)
Unnamed 116 2,5 $(Pd,Cu,Sn)_5(Te,S)_2$
Vasilite 2,3 $(Pd,Cu)_{16}(S,Te)_7$
1.2.2b.1.1.1.3. Monoanionic
1.2.2b.1.1.1.3.1. Pn^{2+} and Pn^{3+} (complex)
1.2.2b.1.1.1.3.1.1. Proper tellurides
Unnamed 439 0,75 $(Pt,Pd,Ni)_3Te_4 \rightarrow (Pt,Pd,Ni)^{2+}(Pt,Pd,Ni)^{3+}{}_2Te_4$
1.2.2b.1.1.1.3.1.2. Tellurido-antimonides
1.2.2b.1.1.1.3.1.3. Tellurido-bismuthides (antimonides).
Unnamed 226 0,875 $Pd_7(Bi,Te)_8 \rightarrow Pd^{2+}{}_5Pd^{3+}{}_2(Bi,Te)_8$
Unnamed 173 0,8(3) $Pd_5(Bi,Sb)_2Te_4 \rightarrow Pd^{2+}Pd^{3+}{}_4(Bi,Sb)_2Te_4$
1.2.2b.1.1.1.3.2. Pn^{3+} (simple)
Kotulskite series
Kotulskite $Pd(Te,Bi)_{2-x}$ (x~0.4)
Sobolevskite PdBi
Unnamed 444 0,(8) $Pd^{3+}{}_8Bi_6Te_3$
1.2.2b.1.1.1.3.3. Pn^{3+} and Pn^{4+} (complex)
1.2.2b.1.1.1.3.3.1. Proper tellurides
Unnamed 171 0,625 $(Ni,Pd)_5(Te,Bi)_8 \rightarrow (Ni,Pd)^{3+}{}_4(Ni,Pd)^{4+}(Te,Bi)_8$
1.2.2b.1.1.1.3.3.2. Tellurido-antimonides
Borovskite 0,6 $Pd_3SbTe_4 \rightarrow Pd^{3+}Pd^{4+}{}_2SbTe_4$
1.2.2b.1.1.1.3.4. Pn^{4+} (simple)
Moncheite $PtTe_2$
Merenskyite $PdTe_2$
(Kotulskite) see. Sobolevskite series
*Mayingite IrBiTe
*Telluromayingite $Ir(Te,Bi)_2$

1.2.2b.1.1.2. Tellurides of **I***b*-cations
1.2.2b.1.1.2.1.Tellurides of Ag^+
1.2.2b.1.1.2.1.1. Polyanionic (?)
1.2.2b.1.1.2.1.1.1. Simple
Unnamed 155 0,25 $(Au,Ag)(Te,Pb)_4$
1.2.2b.1.1.2.1.1.2. Complex (Ag^+, Cu^+ nad Cu^{2+})
Cameronite 0,8 $AgCu_7Te_{10} \rightarrow Ag^+Cu^+{}_5Cu^{2+}{}_2[Te_2]_5$

1.2.2b.1.1.2.1.2. Subtellurides
1.2.2b.1.1.2.1.2.1. Simple
Unnamed 109 3,5 Ag_7Te_2
Empressite family
Stützite 1,(6) $Ag_{5-x}Te_3$
Unnamed 382 1,5 Ag_3Te_2
Empressite 1 AgTe
1.2.2b.1.1.2.1.2.2. Complex (Ag и Bi)
Unnamed 185 2 Ag_3BiTe_2
Unnamed 398 1,57 $Ag_8Bi_3Te_7$
Unnamed 237 0,75 $AgBi_2Te_4$

1.2.2b.1.1.2.1.3. Monoanionic
1.2.2b.1.1.2.1.3.1. Proper tellurides
1.2.2b.1.1.2.1.3.1.1. Simple
Hessite 2 Ag_2Te
1.2.2b.1.1.2.1.3.1.2. Complex 1.2.2b.1.1.2.1.3.1.2.1. Ag^+ and Au^+
Petzite family 2
Muthmannite (Ag,Au) Te
Petzite $AuAg_3Te_2$
1.2.2b.1.1.2.1.3.1.2.2. Ag^+ and Au^{3+}
Sylvanite $AuAgTe_4$
1.2.2b.1.1.2.1.3.1.2.3. Ag^+, Cu^+ and Cu^{2+}
Henryite $Ag_3Cu_4Te_4 \rightarrow Ag^+{}_3Cu^+{}_3Cu^{2+}Te_4$

1.2.2b.1.1.2.1.3.1.2.4. Ag^+ and $Sb^{3+}\rightarrow$ telluroantiminites
Unnamed 186 1 $Ag^+Sb^{3+}Te_2$
*Mazzettiite $Ag_3Hg^{2+}PbSb^{3+}Te_5$

1.2.2b.1.1.2.1.3.1.2.5. Ag^+ and $Bi^{3+}\rightarrow$ tellubismuthites Ag
Volynskite $Ag^+Bi^{3+}Te_2$

1.2.2b.1.1.2.1.3.2. Tellurido-sulfides
1.2.2b.1.1.2.1.3.2.1.Simple
Cervelleite family (?) 2
Unnamed 110 $(Ag,Cu,Bi)^+{}_6Te_2S$
Cervelleite $Ag^+{}_4TeS$
*Unnamed Ag_2Cu_2TeS
1.2.2b.1.1.2.1.3.2.2. Complex
1.2.2b.1.1.2.1.3.2.2.1. Ag^+ and Cu^+
Unnamed 111 2 $Ag^+{}_5Cu^+TeS_2$
1.2.2b.1.1.2.1.3.2.2.2. Ag^+ and Fe^{2+}
Unnamed 317 1,8 $Ag^+{}_{10}Fe^{2+}Te_2S_4$
1.2.2b.1.1.2.1.3.2.2.3. Ag^+ and Pb^{2+}
Unnamed 397 1,28 Ag_4PbTe_2S
1.2.2b.1.1.2.1.3.2.2.4. Ag^+ and 3-valence Va-cations$\rightarrow$tellurosulfoantimonites of Ag^+
Benleonardite family (?)
Unnamed 316 $Ag_9SbTe_2S_4$
Benleonardite $Ag_{15}Cu(Sb,As)_2S_7Te_4$
1.2.2b.1.1.2.1.3.2.2.5. Ag^+, $Cu^{2+}$and 3-valence Va-cations $\rightarrow$ tellurosulfobismuthites of Ag^+ and Cu^{2+}
Unnamed 154 0,8 $Ag_3Cu^{2+}Bi^{3+}Te_2S_2$

*1.2.2б.1.1.2.1.3.3. Tellurido-selenides
*Kurilite Ag_8Te_3Se

1.2.2b.1.1.2.2. Tellurides of Au
1.2.2b.1.1.2.2.1. Polytellurides (?) (simple $\rightarrow$ complex)
Calaverite family 0,5 (x = 2)
Calaverite $AuTe_2$
Krennerite $(Au,Ag)Te_2$

Kostovite $AuCuTe_4$

1.2.2b.1.1.2.2.2. Subtellurides (complex)
Bezsmertnovite 11 Au_8Cu_2PbTe or, more precisely $Au_{8-x}Ag_xCu_{2-y}Fe_yPb_{1-z}Te_{1+z}$
$(0 \leq x \leq 0,7)$; $(0,16 \leq y \leq 0,36)$; $(0 \leq z \leq 0,28)$
Bogdanovite group (?) 8
Unnamed 131 $Au_5Cu_3(Te,Pb)$
Bogdanovite $(Au,Te,Pb)_3(Cu,Fe)$
Bilibinskite group (?) 3
Unnamed 130 $Au_5Cu(Te,Pb)_2$
Bilibinskite $Au_3Cu_2Pb \cdot nTeO_2$
Group. (?) 2
Unnamed 128 $Au(Fe,Cu)(Te,Pb)$
Unnamed 129 $Au_3(Fe,Cu)(Te,Pb)_2$
*Honeaite Au_3TlTe_2

1.2.2b.1.1.2.2.3. Monoanionic
1.2.2b.1.1.2.2.3.1. Tellurides of Au^+
1.2.2b.1.1.2.2.3.1.1. Telluride-sulfides (complex of Au^+, Pb^{2+} , Sb^3, Te^{4+}) → telluro-sulfoantimonites of Au^+ and Pb^{2+} to tellurosulfoantimonites of Ag^+, Pb^{2+} and Te^{4+}
*Museumite $[Pb_2(Pb,Sb)_2S_8][(Te,Au)_2]$
Nagyagite series
Nagyágite $[Pb(Pb,Sb)S_2][(Au,Te)]$
*Buckhornite $[Pb_2BiS_3][AuTe_2]$

1.2.2b.1.1.2.2.3.2. Tellurides of Au^{3+} (?)
1.2.2b.1.1.2.2.3.2.1. Proper tellurides (simple)
Montbrayite 1,5 $Au^{3+}{}_2Te_3$

1.2.2b.1.1.2.2.3.2.2. Tellurido-arsenides (complex of - Au^{3+}, Ag^+ и Pb^{2+})
Unnamed 313 1 $Au^{3+}{}_3Ag^+Pb^{2+}As_2Te_3$
1.2.2b.1.1.2.2.3.2.3. Tellurido-arsenides (complex of - Au^{3+}, Pb^{2+} и Bi^{3+})
Unnamed 474 0,5 $Au^{3+}Pb^{2+}{}_2Bi^{3+}Te_2S_3$

1.2.2b.1.1.3. Tellurides of **II***b*-cations (only Hg^{2+})
1.2.2b.1.1.3.1. Monoanionic (simple)
Coloradoite HgTe

1.2.2b.1.2. Minerals of cenosymmetrical *d*-cations
1.2.2b.1.2.1. Minerals of **VIII***b*-cations (Fn^{n+})
1.2.2b.1.2.1.1. Polyanionic
1.2.2b.1.2.1.1.1. Fn^{2+}
1.2.2b.1.2.1.1.1.1. Proper polytellurides with Te : Fn = 2 ditellurides (simple)
Frohbergite series
Mattagamite $Co[Te_2]$
Frohbergite $Fe[Te_2]$
1.2.2b.1.2.1.1.1.2. Polytellurido-selenides with (Te + Se) : Fn = 2 ditellurido-selenides (simple)
Kitkaite Ni[TeSe]
1.2.2b.1.2.1.2. Monoanionic

*Imgreite NiTe

1.2.2b.1.2.1.2.1. Fn^{3+} and Fn^{4+}
1.2.2b.1.2.1.2.1.1. Tellurido-antiminides (complex)
Vavřinite 0,(6) $Ni_2SbTe_2 \rightarrow Ni^{3+}Ni^{4+}SbTe_2$
1.2.2b.1.2.1.2.2. Fn^{4+}
1.2.2b.1.2.1.2.2.1. Proper tellurides (simple)
Melonite $NiTe_2$

1.2.2b.1.2.2. Tellurides of **I***b*-cations
1.2.2b.1.2.2.1. Monoanionic
1.2.2b.1.2.2.1.1. Cu^{+} и Cu^{2+} (complex)
Ricardite family
Rickardite $Cu_{3-x}Te_2$
Weissite $Cu_{2-x}Te$
1.2.2b.1.2.2.1.2. Cu^{2+} (simple)
Vulcanite CuTe

1.2.2b.2. <u>Minerals of *p*-cations</u>
1.2.2b.2.1. Tellurides of **IV***a*-cations (Pb^{n+})
1.2.2b.2.1.1. Subtellurido-sulfides (complex)
*Saddlebackite $Pb_2Bi_2Te_2S_3$
Unnamed 208 1,(3) $PbBi_3TeS_2$
1.2.2b.2.1.2. Monoanionic
1.2.2b.2.1.2.1. Pb^{2+}
1.2.2b.2.1.2.1.1. Proper tellurides
1.2.2b.2.1.2.1.1.1. Simple
Altaite PbTe
1.2.2b.2.1.2.1.1.2. Complex (Pb^{2+} and Bi^{3+})
Rucklidgeite group (x=1(3))
Rucklidgeite $(Pb,Ag,Bi)Bi_2Te_4$
Aleksite $PbBi_2(Te_2S_2)_{\Sigma 4}$
Kochkarite 1,4 $PbBi_4Te_7$
1.2.2b.2.1.2.1.2. Tellurido-sulfides (simple)
Unnamed 236 1 Pb_2TeS
1.2.2b.2.1.2.1.3. Tellurido-chlorides (complex of - Pb^{2+} and Te^{4+})
Radhakrishnaite $PbTe_3(Cl,S)_2$
1.2.2b.2.1.2.2. Pb^{2+} and Pb^{4+}
1.2.2b.2.1.2.2.1. Proper tellurides (complex)
Unnamed 238 $Pb_2Te_3 \rightarrow Pb^{2+}Pb^{4+}Te_3$
1.2.2b.2.1.2.3. Pb^{4+}
1.2.2b.2.1.2.3.1. Proper tellurides (simple)
Unnamed 239 0,5 $PbTe_2$
1.2.2b.2.1.2.3.2. Tellurido-chlorides (simple)
Kolarite $PbTeCl_2$

1.2.2b.2.2. Tellurides of **V**a-cations
1.2.2b.2.2.1. Subtellurides
1.2.2b.2.2.1.1. Proper tellurides (simple)
Hedleyite 2,(3) Bi_7Te_3

Unnamed 396 2,25	Bi_9Te_4
Unnamed 125 1,5	Bi_3Te_2
Pilsenite 1,(3)	Bi_4Te_3
Tsumoite 1	BiTe
Unnamed 412 0,75	Bi_3Te_4

1.2.2b.2.2.1.2. Subtellurido-sulfides (simple)

Unnamed 121 3	$Bi_{15}TeS_4$
Unnamed 122 2,25	$Bi_9Te_2S_2$
Series (?)	
"Mineral K" 1,5	$Bi_9(Te_2S)_2$
"Mineral L" 1,5	Bi_3TeS
Unnamed 418 1,5	Bi_6TeS_3
"Mineral P" 1,5	$Bi_{15}(TeS_4)_2$
Joseite series 1,(3)	
Joseite-B	Bi_4Te_2S
Joseite-A	Bi_4TeS_2
***Baksanite** series	
*Baksanite	$Bi_6(Te_2S_3)$
Ingodite series 1	
Sulphotsumoite	Bi_3Te_2S
Ingodite	Bi_2TeS
Unnamed 147	Bi_2TeS
"Mineral M"	$(Bi,Pb)_2TeS$
Unnamed 153	Bi_4TeSe_3
Unnamed 148	Bi(S,Te)
Series (?) 0,75	
Unnamed 126	$Bi_3(Te,Se)_3S$
Unnamed 123	$Bi_3Te_2S_2$

1.2.2b.2.2.2. Monoanionic

1.2.2b.2.2.2.1. Sb^{3+} and Bi^{3+}

1.2.2b.2.2.2.1.1. Proper tellurides (simple)

Tellurobismuthite group 0,(6)	
Telluroantimony	Sb_2Te_2Te
Tellurobismuthite	Bi_2Te_2Te
*Unnamed	Bi_2Te

*1.2.2б.2.2.2.1.2. Complex

*Unnamed	$Sb(Ni,Fe,Pd)_2Te_2$
*Unnamed	$(Sb,Bi)Pd(Ni,Fe)Te_2$

1.2.2b.2.2.2.1.2.1. Tellurido-sulfides (simple)

Tetradymite family 0,(6)	
Tetradymite	Bi_2Te_2S
Kawazulite	Bi_2Te_2Se
*Vihorlatite	$Bi_{24}Te_4Se_{17}$
*Unnamed	Bi_4Te_2Se
*Unnamed	$Bi_6(Te,Se)_3$

1.2.2b.2.2.2.2. Bi^{3+} and Bi^{5+} (?) (polytellurides (?) (simple)

Unnamed 152 0,6	$Bi^{3+}Bi^{5+}{}_3Te_5$ (?)
Unnamed 151 0,4	$Bi^{5+}{}_2Te_5$ (?)

2. TYPE: MINERALS WITH PRINCIPAL METALLIC-COVALENT AND IONIC- COVALENT BOND , RARE VAN DER WAALS FORSES (NATIVE VIA-NONMETALS) – CHALCOGENIC COMPOUNDS: CHALCOGENIDES (ISODESMICAL) →CHALCOSALTS (ANISODESMICAL)

2a. Quasitype*: Native VI*a*-nonmetals (van der Waals forses)

Sulfur family

α-Sulfur	S
β-Sulfur	S
Rosickyite	S
*Sulfurite amorphous	S_8
Selenium	Se

2b. Quasitype*: Chalcogenic compounds (metallic-covalent and ionic-covalent bond , rare van der Waals forses)-simple (isodesmical) → complex → chalcosalts (anisodesmical**).**

2b.1. Subtype: Chalcogenic compounds of sidero- and chalcophylic cations

2b.1a. Quasisubtype*: Sulfides and sulfosalts of sidero- and chalcophylic cations

2b.1a.1. ***Class:*** Sulfides of sidero- and chalcophylic cations

2b.1a.1.1.Minerals of heavy ***d***-cations (with 5 – 10 ***d***-electrons) and their crystallochemical analogues.

2b.1a.1.1.1. Minerals of cenosymmetrical ***d***-cations

2b.1a.1.1.1.1. Minerals of **VII***b* – **VIII***b*-cations (Mn, Fe, Co, Ni) and their crystallochemical analogues (Cr^{3+}, V^{3+}, V^{4+}, Ti^{3+}) – cations of wide iron family – Fn'^{n+}

2b.1a.1.1.1.1.1. Polyanionic

2b.1a.1.1.1.1.1.1. Minerals of M^{2+}

2b.1a.1.1.1.1.1.1.1. Simple→ complex

Pyrite group

Vaesite	$Ni[S_2]$
Cattierite	$Co[S_2]$
Pyrite	$Fe[S_2]$
Villamaninite	$Cu(Ni,Co,Fe)[S_2]_2$
Fukuchilite	$(Cu,Fe)[S_2]$
Hauerite	$Mn[S_2]$

Marcasite group (compare with arsenopyrite (series.))

Marcasite	$Fe[S_2]$

2b.1a.1.1.1.1.2. Subsulfides

2b.1a.1.1.1.1.2.1. Simple

Heazlewoodite 1,5	Ni_3S_2

2b.1a.1.1.1.1.2.2. Complex

2b.1a.1.1.1.1.2.2.1. Only Fn'

Pentlandite family

Pentlandite group 1,125

Pentlandite	$(Co,Ni,Fe)_{<1}Fe_4Ni_4S_8$
Cobaltpentlandite	Co_9S_8
Mackinawite	$(Fe,Ni)_9S_8$
Godlevskite	$(Ni,Fe)_9S_8$
Smythite	$(Fe,Ni)_9S_{11}$

2b.1a.1.1.1.1.2.2.2. Fn', Pt, Cu and Pb

Kharaelakhite $(Cu,Pt,Pb,Fe,Ni)_9S_8$
*Sugakiite $Cu(Fe,Ni)_8S_8$
*Tarkianite $(Cu,Fe)(Re,Mo)_4S_8$

2b.1a.1.1.1.1.2.2.3. Fn', Cu, Cd and Pb

Shadlunite series
Manganese-shadlunite $(Mn,Pb,Cd)Cu_4Fe_4S_8$
Shadlunite $(Pb,Cd)Cu_4Fe_4S_8$

2b.1a.1.1.1.1.2.2.4. Fn' and Ag

Argentopentlandite $Ag(Fe,Ni)_8S_8$

2b.1a.1.1.1.1.2.2.5. Fn' and Hg

Donharrisite $Ni_8Hg_3S_9$

*2б.1а.1.1.1.1.2.2.6. Fn' и Nb

*Edgarite $FeNb_3S_6$

2b.1a.1.1.1.1.3. Monoanionic
2b.1a.1.1.1.1.3.1. M^{2+} (simple)

Troilite family 1
Troilite group
Millerite NiS
Jaipurite γ-CoS
Troilite FeS
Unnamed 139 (Fe,Ni,Ir)S
Unnamed 386 (Ni,Fe,Ir,Cu,Rh,Pt)S
Alabandite MnS
Unnamed 138 β-MnS
*Rambergite γ- MnS
Unnamed 141 CrS

2b.1a.1.1.1.1.3.2. Fe^{2+} and Fe^{3+} (complex)

2b.1a.1.1.1.1.3.2.1. Only Fn
2b.1a.1.1.1.1.3.2.1.1. $Fe^{2+} >> Fe^{3+}$

Pyrrhotite family
Hexapyrrhotite series (?) $Fn_{1-x}S$ (x = от 0 до 0,17)
Pyrrhotite-*1C* $Fe_{1-x}S$
Unnamed 331 $(Fe,Ni)_{1-x}S$
Unnamed 140 $(Fe,Ag)_xS$
Polysomatic series of **clino(mono)pyrrhotites** $nFeS\cdot Fe_2S_3$ or $Fe^{2+}{}_nFe^{3+}{}_2S_{3+n}$
Pyrrhotite-*6C* (n = 9) $Fe_{11}S_{12} \rightarrow Fe^{2+}{}_9Fe^{3+}{}_2S_{12}$
Pyrrhotite-*11C* (n = 8) $Fe_{10}S_{11} \rightarrow Fe^{2+}{}_8Fe^{3+}{}_2S_{11}$
Pyrrhotite-*5C* (n = 7) $Fe_9S_{10} \rightarrow Fe^{2+}{}_7Fe^{3+}{}_2S_{10}$
Pyrrhotite-*4C* (n = 5) $Fe_7S_8 \rightarrow Fe^{2+}{}_5Fe^{3+}{}_2S_8$

2b.1a.1.1.1.1.3.2.1.2. $M^{2+}: M^{3+}= 1,5$

Smythite $Fe_5S_6 \rightarrow Fe^{2+}{}_3Fe^{3+}{}_2S_6$
*Murchisite Cr_5S_6

2b.1a.1.1.1.1.3.2.1.3. $M^{2+}: M^{3+} = 0.5$;

Sulfospinelides family Fn; $M^{2+} = Fn^{2+}, Cu^{2+}, Zn^{2+}$; $M^{3+} = Fn'^{3+}$; In^{3+}(compare with sulfospinelides of Pn (series.); selenospinelides (series.); oxospinelides (series.))
Linnaeite series - only of Fn^{2+} и Fn^{3+}

Polydymite $Ni^{2+}Ni^{3+}{}_2S_4$
Siegenite $Co^{2+}(Ni,Co)^{3+}{}_2S_4$
Nickel Linnaeite = polydymite $Ni^{2+}Ni^{3+}{}_2S_4$
Linnaeite $Co_3S_4 \rightarrow Co^{2+}Co^{3+}{}_2S_4$
Violarite $Fe^{2+}Ni^{3+}{}_2S_4$
Greigite $Fe_3S_4 \rightarrow Fe^{2+}Fe^{3+}{}_2S_4$
Carrollite series - $M^{2+} = Cu^{2+}$; $M^{3+} = Fn^{3+}$
Fletcherite $Cu(Ni,Co)_2S_4$
Carrollite $Cu(Co,Ni)_2S_4$
Daubreelite group - $M^{2+} = Fe^{2+}$; $M^{3+} = Cr^{3+}$
Daubreelite $Fe^{2+}Cr^{3+}{}_2S_4$
Brezinaite group - $M^{2+} = Fe^{2+}, Cr^{2+}$; $M^{3+} = Cr^{3+}, Ti^{3+}$
Brezinaite $Cr_3S_4 \rightarrow Cr^{2+}Cr^{3+}{}_2S_4$
Heideite $(Fe,Cr)^{2+}{}_{1+x}(Ti^{3+},Fe^{2+})_2S_4$
Kalininite group - $M^{2+} = Cu^{2+}, Zn^{2+}$; $M^{3+} = Cr^{3+}, Sb^{3+}$
Florensovite $Cu(Cr_{1,5}Sb_{0,5})_{\Sigma 2}S_4$
Kalininite $ZnCr_2S_4$
*Kuprokalininite $CuCr_2S_4$
Indite $FeIn_2S_4 \rightarrow Fe^{2+}{}_{1-3x}Fe^{3+}{}_{2x}In_2S_4$ $(0 \le x \le 0,33)$
*Cadmoindite $CdIn_2S_4$
*Jichengite $Cu^{+}{}_2Ir^{3+}{}_6(Ni,Fe)^{2+}{}_{10}S_{20}$

2b.1a.1.1.1.1.3.2.1.4. $2M^{3+} \rightarrow M^{+}M^{2+}M^{3+}$

Cubanite family - $M^{+} = Cu^{+}, Ag^{+}$; $M^{2+} = Fe^{2+}$; $M^{3+} = Fe^{3+}$
Isocubanite $CuFe_2S_3 \rightarrow Cu^{+}Fe^{2+}Fe^{3+}S_3$
Cubanite $CuFe_2S_3 \rightarrow Cu^{+}Fe^{2+}Fe^{3+}S_3$
Argentopyrite $AgFe_2S_3 \rightarrow AgFe^{2+}Fe^{3+}S_3$
Sternbergite $AgFe_2S_3 \rightarrow AgFe^{2+}Fe^{3+}S_3$
*Unnamed $(Cu,Ag,Fe)_6S_4 \rightarrow Cu_3Ag_2FeS_4$

2b.1a.1.1.1.2. Minerals of I*b*-cations
2b.1a.1.1.1.2.1. Polyanionic (simple)
Unnamed $Cu[S_2]$
2b.1a.1.1.1.2.2. Mono-polyanionic (complex)
Covellite $3CuS \rightarrow Cu^{+}{}_2S \cdot Cu^{2+}[S_2]$
2b.1a.1.1.1.2.3. Monoanionic
2b.1a.1.1.1.2.3.1. $M^{+} \rightarrow M^{+}$ and M^{2+} (simple→ complex)

2b.1a.1.1.1.2.3.1.1. Only Cu

Polysomatic (?) series of **chalcocite** $mCu_2S \cdot nCuS$ или $Cu^{+}{}_{2m}Cu^{2+}{}_nS_{m+n}$

Chalcocite	(m= 1 ; n= 0)	Cu_2S
Tetrachalcocite	(m=24 ; n= 1)	$Cu_{49}S_{25} \rightarrow Cu^{+}{}_{48}Cu^{2+}S_{25}$
Djurleite	(m=15 ; n= 1)	$Cu_{31}S_{16} \rightarrow Cu^{+}{}_{30}Cu^{2+}S_{16}$
Digenite	(m= 4 ; n= 1)	$Cu_9S_5 \rightarrow Cu^{+}{}_8Cu^{2+}S_5$
Roxbyite	(m= 4 ; n= 1)	$Cu_9S_5 \rightarrow Cu^{+}{}_8Cu^{2+}S_5$
Anilite	(m= 3 ; n= 1)	$Cu_7S_4 \rightarrow Cu^{+}{}_6Cu^{2+}S_4$
Geerite	(m= 3 ; n= 2)	$Cu_8S_5 \rightarrow Cu^{+}{}_6Cu^{2+}{}_2S_5$
Spionkopite	(m=11 ; n=17)	$Cu_{39}S_{28} \rightarrow Cu^{+}{}_{22}Cu^{2+}{}_{17}S_{28}$
Yarrowite	(m= 1 ; n= 7)	$Cu_9S_8 \rightarrow Cu^{+}{}_2Cu^{2+}{}_7S_8$

2b.1a.1.1.1.2.3.1.2. Cu^{+} and Hg^{2+}

Gortdrumite $Cu^{+}_6Hg^{2+}_2S_5$

2b.1a.1.1.1.2.3.1.3. Cu^+ and Pb^{2+}

Betekhtinite $(Cu,Fe)_{21}Pb_2S_{15}$

2b.1a.1.1.1.2.3.2. M^+ and $2M^{2+} \rightarrow M^+M^{3+}$ (complex)

2b.1a.1.1.1.2.3.2.1. $M^+ : M^{2+} \cong 2$; Cu : Fe $\cong 5$

Bornite series

Bornite (orange) $Cu_{5-x}FeS_{4+x}$

Bornite (brown- usual) $Cu^+_5Fe^{3+}S_4$

Bornite (pink) $Cu_{5+x}FeS_{4-x}$

2b.1a.1.1.1.2.3.2.2. Cu : Fe = 3

*Wilhelmramsayite $Cu_3FeS_3{\cdot}2H_2O$

Idaite $Cu_3FeS_4 \rightarrow Cu^+Cu^{2+}_2Fe^{3+}S_4$

*Unnamed $Cu_4FeS_4 \rightarrow Cu^+_2Cu^{2+}_2Fe^{2+}S_4$

*Unnamed $(Cu_{0,96}K_{0,04})(Fe_{0,6}Cu_{0,4})(S_{1,98}O_{0,02})$

2b.1a.1.1.1.2.3.2.3. $2M^{2+} \rightarrow M^+M^{3+}$ when $M^+ \cong M^{3+}$

Chalcopyrite family (x = number of additional cations or vacancies to 1 $CuFeS_2$)

*Horomanite $Fe_6Ni_3S_8$

*Samaniite $Cu_2Fe_5Ni_2S_8$

Talnakhite subfamily (x > 0; Cu $\cong$ Fn)

Mooihoekite (x = 1/2) $Cu_9Fe_9S_{16} \rightarrow Cu^+_9Fe^{2+}_4Fe^{3+}_5S_{16}$ $(2\square 3Fn^{3+} \rightarrow Cu^+4Fn^{2+})$

Putoranite (x = 1/4) $Cu_9Fe_9S_{16} \rightarrow Cu^+_9Fe^{2+}_4Fe^{3+}_5S_{16}$ $(2\square 3Fe^{3+} \rightarrow Cu^+4Fe^{2+})$

Haycockite (x = 1/4) $Cu_8Fe_{10}S_{16} \rightarrow Cu^+_8Fe^{2+}_6Fe^{3+}_4S_{16}$ $(2\square 4Fn^{3+} \rightarrow 6Fn^{2+})$

Talnakhite (x = 1/8) $Cu_9(Fe,Ni)_8S_{16} \rightarrow Cu^+_9Fe^{2+}Fe^{3+}_7S_{16}$ $(\square Fn^{3+} \rightarrow Cu^+Fn^{2+})$

Proper chalcopyrite subfamily (x = 0; $Cu^+ = Fe^{3+}(Ga^{3+},In^{3+})$)

Isochalcopyrite $CuFe_2S_3$

Chalcopyrite group

Chalcopyrite $CuFeS_2$

Gallite $CuGaS_2$

Roquesite $CuInS_2$

Germanite subfamily ($2Fe^{3+} \rightarrow M^{2+}M^{4+}$; $M^{4+} = Ge^{4+}$)

Proper germanite subfamily(x > 0; $M^+ = Cu^+$; $M^{2+} = Cu^{2+}, Zn^{2+}$)

Germanite series (x = 1/8)

Germanite $Cu^+_8Cu^{2+}_5Fe_2Ge_2S_{16}$

*Maikainite $Cu_{20}(Fe,Cu)_6Mo_2Ge_6S_{32} \rightarrow Cu^+_{20}(Fe,Cu)^{2+}_6Mo^{4+}_2Ge^{4+}_6S_{32}$

*Ovamboite $Cu_{20}(Fe,Cu,Zn)_6W_2Ge_6S_{32} \rightarrow Cu^+_{20}(Fe,Cu,Zn)^{2+}_6W^{4+}_2Ge^{4+}_6S_{32}$

*Calvertite $Cu_{10}GeS_8$ $Cu^+_8Cu^{2+}_2Ge^{4+}S_8$

Renierite $Cu^+_{10}(Zn,Cu)^{2+}Fe^{3+}_4Ge^{4+}_2S_{16}$

Briartite subfamily (x = 0; $M^+ = Cu^+$; $M^{2+} = Fe^{2+}, Zn^{2+}$)

Briartite $Cu^+_8(Fe,Zn)^{2+}_4Ge_4S_{16}$

*Barquillite $Cu^+_2(Cd,Fe)^{2+}GeS_4$

Morozeviczite subfamily (x < 0; $M^+ = Cu^+$; $M^{2+} = Pb^{2+}, Cu^{2+}, Ge^{2+}$; $M^{3+} = Fe^{3+}, As^{3+}$)

Morozeviczite $Pb_3Ge_{1-x}S_4$

Polkovicite (x = 0,625) $(Fe,Pb)_3(Ge,Fe)_{1-x}S_4$

Stannite family ($2Fe^{3+} \rightarrow M^{2+}M^{4+}$; $M^{4+} = Sn^{4+}$; Mo^{4+}, W^{4+})

Stannoidite subfamily (x > 0; $M^+ = Cu+$; $M^{2+} = Fe^{2+}$, Cu^{2+}; $M^{3+} = Fe^{3+}$, V^{3+})

Mawsonite group (x = 1/4)

Mawsonite $Cu^+_6Fe^{3+}_2Sn^{4+}S_8$ ($\square 2Fe^{3+} \rightarrow 2Cu^+Sn^{4+}$)

Chatkalite $Cu^+_6Fe^{2+}Sn^{4+}_2S_8$ ($\square 4Fe^{3+} \rightarrow 2Cu^+Fe^{2+}2Sn^{4+}$)

Stannoidite series (x = 1/6)

Stannoidite $Cu^+_8(Fe,Zn)^{2+}Fe^{3+}_2Sn^{4+}_2S_{12}$ $\square 4Fe^{3+} \rightarrow 2Cu^+Fe^{2+}2Sn^{4+}$)

Cuprostannoidite $Cu^+_8Cu^{2+}Fe^{3+}_2Sn^{4+}_2S_{12}$ ($\square 4Fe^{3+} \rightarrow 2Cu^+Cu^{2+}2Sn^{4+}$)

Nekrasovite series (x = 1/8)

Nekrasovite $Cu_{26}V_2Sn_6S_{32} \rightarrow Cu_{18}Cu^{2+}_8V^{3+}_2Sn^{4+}_6S_{32}$ ($2\square 16Fe^{3+} \rightarrow 2Cu^+8Cu^{2+}2V^{3+}6Sn^{4+}$)

Proper stannite subfamily (x = 0; $M^+ = Cu^+$, Ag^+; $M^{2+} = Fe^{2+}$, Zn^{2+}, Cu^{2+}, Cd^{2+}, Hg^{2+}; $M^{3+}= Fe^{3+}$, In^{3+}; $M^{4+} = Sn^{4+}$, Mo^{4+}, W^{4+})

Sakuraiite (Cu,Zn,Fe,In,Sn)S

Stannite series

Stannite Cu_2FeSnS_4

Kuramite Cu_2CuSnS_4

Cernyite Cu_2CdSnS_4

Velikite Cu_2HgSnS_4

Hocartite Ag_2FeSnS_4

Pirquitasite Ag_2ZnSnS_4

Kësterite series

Ferrokësterite $Cu_2(Fe,Zn)SnS_4$

Kësterite $Cu_2(Zn,Fe)SnS_4$

Petrukite $Cu_2(Fe,Zn)SnS_4$

Hemusite group ($M^{2+}=Cu^{2+}$; $M^{4+} = Sn^{4+}$, Mo^{4+}, W^{4+})

*Catamarcaite Cu_6GeWS_8

Hemusite $Cu_6MoSnS_8 \rightarrow Cu_4Cu^{2+}_2Mo^{4+}Sn^{4+}S_8$ ($4Fe^{3+} \rightarrow \square 2Mo^{4+}Sn^{4+}$)

Kiddcreekite $Cu_6WSnS_8 \rightarrow Cu_4Cu^{2+}_2W^{4+}Sn^{4+}S_8$ ($4Fe^{3+} \rightarrow \square 2W^{4+}Sn^{4+}$)

Vinciennite ($M^{2+} = Cu^{2+}$; $M^{3+} = Fe^{3+}$, As^{3+}; $M^{4+} = Sn^{4+}$)
$Cu_{10}Fe_4SnAsS_{16} \rightarrow Cu^+_7Cu^{2+}_3Fe^{3+}_4Sn^{4+}AsS_{16}$ ($4Cu^+Fe^{3+} \rightarrow 3\square Sn^{4+}As^{3+}$)

Mohite ($M^{2+} = 0$; $M^{4+} = Sn^{4+}$) $Cu^+_4Sn^{4+}_2S_6$ ($3Fe^{3+} \rightarrow Cu^+2Sn^{4+}$)

Rhodostannite subfamily (x < 0, $M^+ = Cu^+$; $M^{2+} = Fe^{2+}$; $M^{4+} = Sn^{4+}$)

Rhodostannite (x = 1/2) $Cu^+_2Fe^{2+}Sn^{4+}_3S_8$ ($2Cu^+4Fe^{3+} \rightarrow 2\square Fe^{2+}3Sn^{4+}$)

*Toyohaite $Ag^+_2Fe^{2+}Sn^{4+}_3S_8$

2b.1a.1.1.1.2.3.2.4. $M^{2+}= Cu^{2+}$, Fe^{2+}; Cu : Fe = 5

Nukundamite $Cu_{3.4}Fe_{0.6}S_4$

2b.1a.1.1.1.3. Minerals of **II**b-cations - Zn^{2+} (and Cd^{2+})
2b.1a.1.1.1.3.1. Monoanionic (simple)
Sphalerite family
Sphalerite-*3C* ZnS
Sphalerite-*2H* (wurtzite)
*Wurtzite-*2H*, -*15R*, -*18R*, *21R*, *4H*, *8H* polytypes
Sphalerite-*3R* (matraite)
*Buseckite (Fe,Zn,Mn)S
*Rudaschevskite (Fe,Zn)S
Hawleyite-*3C* CdS
Hawleyite -*2H* (greenockite)
*2б.1a.1.1.1.3.2. Complex
*Unnamed $Zn_2(Fe,Cu)S_3$

2b.1a.1.1.2. <u>Minerals of heavy noncenosymmetrycal *d*-cations</u>
2b.1a.1.1.2.1. Minerals of **VIII**b-cations (platinoides-Pn^{n+})
2b.1a.1.1.2.1.1. Polyanionic (simple)
Laurite group
Erlichmanite $Os[S_2]$
Laurite $Ru[S_2]$
2b.1a.1.1.2.1.2. Subcompound
2b.1a.1.1.2.1.2.1. Simple
*Miassite $Rh_{17}S_{15}$
*Kingstonite $(Rd,Ir,Pt)_3S_4$
2b.1a.1.1.2.1.2.2. Complex
Rhodplumsite $Rh_3Pb_2S_2$
2b.1a.1.1.2.1.3. Monoanionic
2b.1a.1.1.2.1.3.1. Pn^{2+}
2b.1a.1.1.2.1.3.1.1. Simple
Cooperite family
Cooperite PtS
Vysotskite (Pd,Ni,Pt)S
*Unnamed $(Pt,Pd)_3S_2$
2b.1a.1.1.2.1.3.1.2. Complex
Braggite (Pt,Pd,Ni)S
*Unnamed PtSnS

2b.1a.1.1.2.1.3.2. M^{2+} and M^{3+} (complex)
Sulfospinelides family Pn^{n+} (compare with sulfospinelides Fn^{n+} (series))
2b.1a.1.1.2.1.3.2.1. Cu^{2+}, Fe^{2+} and Pn^{3+}
*Lisiguangite $CuPtBiS_3$
*Malyshevite $PdBiCuS_3$
Malanite group
Malanite $(Cu,Fe)^{2+}Pt^{3+}(Ir,Co,Pd)^{3+}S_4$
Cuproiridsite $Cu^{2+}Ir^{3+}{}_2S_4$
Cuprorhodsite $(Cu,Fe)^{2+}Rh^{3+}{}_2S_4$
*Ferrorhodsite $(Fe,Cu)(Rh,Ir,Pt)_2S_4$
2b.1a.1.1.2.1.3.2.2. Cu^{2+}, Pb^{2+} and Pn^{3+}
Inaglyite subfamily
Xingzhongite $PbCuFe^{3+}{}_{0,67}\bullet{}_{0,33}(Ir,Rh,Pt)_2S_4$

Inaglyite group
Inaglyite $Pb^{2+}Cu^{2+}_3(Ir,Pt)^{3+}_8S_{16}$
Konderite $Pb^{2+}Cu^{2+}_3(Rh,Pt,Ir)^{3+}_8S_{16}$
*Konderite-Fe $(Fe,Pb)^{2+}Cu^{2+}_3(Rh,Ir,Pd,Pt)^{3+}_8S_{16}$
2b.1a.1.1.2.1.3.3. Pn^{3+} (simple)
Bowieite group
Kashinite $(Ir,Rh)_2S_3$
Bowieite $(Rh,IrPt)_2S_3$
2b.1a.1.1.2.1.3.4. Pn^{4+} и Pn^{6+} (complex)
Beta-iridisite $4Ir_{0,75}S_2 \rightarrow Ir^{4+}Ir^{6+}_2S_8$ (?)

2b.1a.1.1.2.2. Minerals of **I***b*-cations and Tl^+ (CN ≤ 4)
2b.1a.1.1.2.2.1. Minerals of Tl^+ (CN ≤ 4)
2b.1a.1.1.2.2.1.1. Monoanionic
2b.1a.1.1.2.2.1.1.1. Simple
Carlinite Tl_2S
2b.1a.1.1.2.2.1.1.2. Complex
Raguinite $TlFe^{3+}S_2$
*Unnamed $Tl_2(Cu,Fe)_6S_5$

2b.1a.1.1.2.2.2. Minerals of Ag^+ and Au^+
2b.1a.1.1.2.2.2.1. Monoanionic
2b.1a.1.1.2.2.2.1.1. Proper sulfides 2b.1a.1.1.2.2.2.1.1.1. Simple
*Unnamed AuS
Acanthite family
Acanthite Ag_2S
Argentite Ag_2S
2b.1a.1.1.2.2.2.1.1.2. Complex 2b.1a.1.1.2.2.2.1.1.2.1. Ag^+ and Fe^{3+}, In^{3+}
*Lenaite $AgFeS_2$
*Laforêtite $AgInS_2$
2b.1a.1.1.2.2.2.1.1.2.2. Ag^+ and Cu^+
Stromeyerite family
Jalpaite Ag_3CuS_2
Mckinstryite $Ag_5Cu_3S_4$
Stromeyerite AgCuS
2b.1a.1.1.2.2.2.1.1.2.2. Ag^+ and Au^+
Uytenbogaardtite family
Uytenbogaardtite $AuAg_3S_2$
Petrovskaite AuAg(S,Se)
2b.1a.1.1.2.2.2.1.1.2.3. $Ag^+(Cu^+)$ and Hg^{2+}
Balkanite family
Danielsite $(Cu,Ag)_{14}Hg^{2+}S_8$
Balkanite group
Balkanite $Ag_5Cu_9Hg^{2+}S_8$
Imiterite Ag_2HgS_2
2b.1a.1.1.2.2.2.1.1.2.4. $Ag^+(Cu^+)$ and Pb^{2+}
Furutobeite $AgCu_5PbS_4$
2b.1a.1.1.2.2.2.1.1.2.5. Ag and $Sn^{4+}(Ge^{4+})$
Canfieldite group
Canfieldite Ag_8SnS_6

Argyrodite Ag_8GeS_6
*Putzite $(Cu_{4,7}Ag_{3,3})_8GeS_6$
*Calvertite $Cu_{10}GeS_8 \rightarrow Cu^{+}_8Cu^{2+}_2Ge^{4+}S_8$
*Alburnite $Ag_8GeTe_2S_4$

2b.1a.1.1.2.2.2.2. Sulfido-halogenides (complex)
*Iltisite $AgHgS(Cl,Br)$
Perroudite $Ag^{+}_4Hg^{2+}_5S_5(I,Br)_2Cl_2$
*Capgaronnite $AgHgS(Cl,Br,I,)$

2b.1a.1.1.2.3. Minerals of **II***b*-cations – Hg^{2+}
2b.1a.1.1.2.3.1. Monoanionic
2b.1a.1.1.2.3.1.1. Proper sulfides (simple)
Cinnabar family
Cinnabar HgS
Metacinnabar HgS
Hypercinnabar HgS
Polhemusite $(Zn,Hg)S$

2b.1a.1.1.2.3.1.2. Sulfido-halogenides (simple)
Corderoite family
*Kenshuite $Hg_3S_2Cl_2$
Corderoite $Hg_3S_2Cl_2$
Lavrentievite $Hg_3S_2(Cl,Br)_2$
*Radtkeite Hg_3S_2ClI
Arzakite $Hg_3^{2+}S_2(Br,Cl)_2$
Grechishchevite $Hg_3S_2(Br,Cl,I)_2$

2b.1a.1.2. Minerals of noncenosymmetrical ***p***-cations
2b.1a.1.2.1. Minerals of **IV***a*-cations (all monoanionic)
2b.1a.1.2.1.1. Minerals of Sn
2b.1a.1.2.1.1.1. Minerals of Sn^{2+}
2b.1a.1.2.1.1.1.1. Simple
Herzenbergite SnS
2b.1a.1.2.1.1.1.2. Complex
*Unnamed $SnGeS_3$
Teallite $PbSnS_2$
*Suredaite $PbSnS_3$
2b.1a.1.2.1.1.2. Minerals of Sn^{2+} and Sn^{4+} (complex)
Ottemannite $Sn^{2+}Sn^{4+}S_3$
2b.1a.1.2.1.1.3. Minerals of Sn^{4+} (simple)
Berndtite-*2T* SnS_2
Berndtite-*4H*

2b.1a.1.2.1.2. Minerals of Pb
2b.1a.1.2.1.2.1. Minerals of Pb^{2+} (simple)
Galena-clausthalite series
Galena PbS
Clausthalite $PbSe$ see selenides

2b.1a.1.2.2. Minerals of V*a*-cations
2b.1a.1.2.2.1. Subsulfides (simple and complex)

Realgar family	
Duranusite	As_4S
Pääkkönenite	Sb_2AsS_2
Dimorphite	As_4S_3
Realgar	$4AsS \rightarrow As_4S_4$
Pararealgar	AsS
Alacranite	As_8S_9
Uzonite	As_4S_5

2b.1a.1.2.2.2. Monoanionic (only As^{3+},Sb^{3+},Bi^{3+})
2b.1a.1.2.2.2.1. Proper sulfides (simple and complex)

Orpiment family	
Orpiment group	
Orpiment	$[As_2S_3]^{\infty 2}$
*Anorpiment	$[As_2S_3]$
Getchellite	$[SbAsS_3]^{\infty 2}$
Stibnite group	
Stibnite	Sb_2S_3
Bismuthinite	Bi_2S_3
Metastibnite	Sb_2S_3
Wakabayashillite	$(As,Sb)_6As_4S_{14}$

2b.1a.1.2.2.2.2. Sulfido-oxides (simple)

Kermesite	Sb_2S_2O

*2б.1a.1.2.2.2.3. Sulfido-halogenidesы

*Demecheleite-(Br)	BiSBr
*Demecheleite-(Cl)	BiSCl

2b.1a.2. ***Class:*** Sulfosalts of sidero- and chalcophylic cations
2b.1a.2.1. Sulfosalts of heavy *d*-cations
2b.1a.2.1.1. Minerals of cenosymmetrical *d*-cations
2b.1a.2.1.1.1. Minerals of **VII***b*- and **VIII***b*-cations - the family of Fn'
2b.1a.2.1.1.1.1. Sulfoantimonites and sulfobismuthites
2b.1a.2.1.1.1.1.1. Fn'^{2+}
2b.1a.2.1.1.1.1.1.1. Simple

Berthierite group	
Berthierite	$FeSb_2S_4$
*Clerite	$MnSb_2S_4$
Garavellite	$FeBiSbS_4$
*Grațianite	$MnBi_2S_4$

2b.1a.2.1.1.1.1.1.2. Complex
2b.1a.2.1.1.1.1.1.2.1. Fn'^{2+} and Cu^+

Lapieite group	
Lapieite	$Cu^+Ni^{2+}SbS_3$
Mückeite	$Cu^+Ni^{2+}BiS_3$

2b.1a.2.1.1.1.1.1.2.2. Fn'^{2+} and Ag^+

Samsonite $Ag_4Mn^{2+}Sb_2S_6$

2b.1a.2.1.1.1.1.2. Fn^{3+} (complex - Fn^{3+}, Cu^+, and Pb^{2+})
Miharaite $Cu^+_4Pb^{2+}Fe^{3+}BiS_6$

2b.1a.2.1.1.2. Minerals of II*b*-cations
2b.1a.2.1.1.2.1. Sulfoarsenites
2b.1a.2.1.1.2.1.1. Cu^+ (simple)
Sinnerite $Cu_6As_4S_9$
*Watanabeite $Cu_4(As,Sb)_2S_5$

2b.1a.2.1.1.2.1.2. Cu^+ and Cu^{2+} (all complex)
Enargite family ($M^+= Cu^+$; $M^{2+}= Cu^{2+}$; M^+: $M^{2+}< 1$; $Y^{3+}= As^{3+}$, V^{3+})
Colusite subfamily ($M^+ : M^{2+} \cong 0,86$)
Colusite $Cu_{13}VAs_3S_{16} \rightarrow Cu^+_6Cu^{2+}_7VAs_3S_{16}$
*Stibiocolusite $Cu_{26}V_2(Sb,Sn,As)_6S_{32}$
*Germanocolusite $Cu_{26}V_2(Ge,As)_6S_{32}$
Proper enargite subfamily ($M^+ : M^{2+} = 0,5$)
Enargite $Cu_3AsS_4 \rightarrow Cu^+Cu^{2+}_2AsS_4$
*Unnamed Cu_3AsS_4
Luzonite series
Luzonite $Cu_3AsS_4 \rightarrow Cu^+Cu^{2+}_2AsS_4$
Famatinite $Cu_3SbS_4 \rightarrow Cu^+Cu^{2+}_2SbS_4$
Sulvanite series (?)
Arsenosulvanite $Cu_3(As,V)S_4 \rightarrow Cu^+Cu^{2+}_2(As,V)S_4$
Sulvanite $Cu_3VS_4 \rightarrow Cu^+Cu^{2+}_2VS_4$

2b.1a.2.1.1.2.2. Sulfoarsenito-sulfoantimonites
2b.1a.2.1.1.2.2.1. M^+ and M^{2+} (complex)
Fahlores family ($M^+ = Cu^+$, Ag^+; $M^{2+} = Cu^{2+}$, Fe^{2+}, Zn^{2+}, Cd^{2+}, Hg^{2+})
Proper fahlores subfamily ($M^+ : M^{2+} = 5$)
Fahlores series - tennantite - tetrahedrite (compare with giraudite (group))
Ferrotennantite $Cu^+_{10}Fe^{2+}_2As_4S_{13}$
Coppite $Cu_{10}Fe_2Sb_4S_{13}$
Freibergite $Ag_6Cu_4Fe_2Sb_4S_{13}$
Tennantite (cuprotennantite) $Cu_{10}Cu_2As_4S_{13}$
Tetrahedrite (cuprotetrahedrite) $Cu_{10}Cu_2Sb_4S_{13}$
Miedziankite $Cu_{10}Zn_2As_4S_{13}$
Argentotennantite $(Ag,Cu)_{10}(Zn,Fe)_2(As,Sb)_4S_{13}$
Sandbergerite $Cu_{10}Zn_2Sb_4S_{13}$
Zincsandbergerite $Ag_6Cu_4Zn_2Sb_4S_{13}$
Cadmian tetrahedrite $Cu_{10}Cd_2Sb_4S_{13}$
Mercurian tennantite $Cu_{10}Hg_2As_4S_{13}$
Schwazite (mercurian tetrahedrite) $Cu_{10}Hg_2Sb_4S_{13}$
Goldfieldite series
Goldfieldite $Cu_{10}Te_4S_{13}$
Nowackiite subfamily (M^+: $M^{2+} = 2$)
Nowackiite $Cu_6Zn_3As_4S_{12}$
Aktashite $Cu_6Hg_3As_4S_{12}$
Gruzdevite $Cu_6Hg_3Sb_4S_{12}$

2b.1a.2.1.1.2.3. Sulfoantimonites
2б.1a.2.1.1.2.3.1. Cu^{+} (simple)
Skinnerite Cu_3SbS_3
*Unnamed $(Cu,Zn)_3(Sb,As)S_3$
Chalcostibite $CuSbS_2$
2b.1a.2.1.1.2.4. Sulfobismuthites
2b.1a.2.1.1.2.4.1. Cu^{+}
2b.1a.2.1.1.2.4.1.1. Simple
Wittichenite family
Wittichenite Cu_3BiS_3
Emplectite $CuBiS_2$
Cuprobismutite $Cu_8AgBi_{13}S_{24}$
Hodrušhite $Cu_4Bi_6S_{11}$
2б.1a.2.1.1.2.4.1.2. Complex (Cu^{+}, Ag^{+}, Pb^{2+})
Larosite $(Cu,Ag)_{21}PbBiS_{13}$
*Kupčikite $Cu_{3,4}Fe_{0,6}Bi_5S_{10}$
*Pizgrischite $Cu_{17}PbBi_{17}S_{35}$

2b.1a.2.1.2. <u>Sulfosalts of noncenosymmetrical ***d***-cations and ***p_d***-cations</u>
2b.1a.2.1.2.1. Minerals of **I***b*-cations and Tl^{+}
2b.1a.2.1.2.1.1. Tl^{+}
2b.1a.2.1.2.1.1.1. Sulfoarsenites
2b.1a.2.1.2.1.1.1.1. Proper sulfoarsenites
2b.1a.2.1.2.1.1.1.1.1. Simple
Ellisite Tl_3AsS_3
Lorandite $TlAsS_2$
*Fangite Tl_3AsS_4
*Bernardite $Tl(As,Sb)_5S_8$
*Gillulyite $Tl_2As_{7.5}Sb_{0.3}S_{13}$
2b.1a.2.1.2.1.1.1.1.2. Complex
2b.1a.2.1.2.1.1.1.1.2.1. Tl^{+} $(Cu,Ag)^{+}$ and Hg^{2+}
Routhierite $Tl(Cu,Ag)(Hg,Zn)_2(As,Sb)_2S_6$
*Arsiccioite $TlAgHg_2(As,Sb)_2S_6$
*Sb-routhierite $TlCuHg_2(Sb,As)_2S_6$
*Stalderite $TlCu(Zn,Fe,Hg)_2As_2S_6$
*Gabrielite $Tl_2AgCu_2As_3S_7$
*Erniggliite $Tl_2SnAs_2S_6$
*Sicherite $TlAg_2(As_2Sb)_{\sum 3}S_6$
*Raberite $Tl_5Ag_4As_6SbS_{15}$
2b.1a.2.1.2.1.1.1.1.2.2. Tl^{+} and Hg^{2+}
Christite $TlHgAsS_3$
Simonite $TlHgAs_3S_6$
2b.1a.2.1.2.1.1.1.1.2.3. Tl^{+}, (Cu^{+},Ag^{+}) and Pb^{2+}
Wallisite group
Wallisite $TlCuPbAs_2S_5$
Hatchite $TlAgPbAs_2S_5$
*Dalnegroite $Tl_{5-x}Pb_{2x}(As,Sb)_{21-x}S_{34}$
*Unnamed $(Tl,Ag)_2Pb_6(As,Sb)_{16}S_{31}$
2b.1a.2.1.2.1.1.1.1.2.4. Tl^{+} and Pb^{2+}

Hutchinsonit $TlPbAs_5S_9$
*Edenharterite $TlPbAs_3S_6$
*Jentschite $TlPbAs_2SbS_6$
*Boscardinite $TlPb_4(Sb_7As_2)_{\Sigma 9}S_{18}$

2b.1a.2.1.2.1.1.1.2. Sulfoarsenito-sulfoarsenates (complex)
Imhofite $Tl_{5.8}As_{15.4}S_{26}$
2b.1a.2.1.2.1.1.2. Sulfoantimonites
2b.1a.2.1.2.1.1.2.1. Simple
Weissbergite $TlSbS_2$
*Jankovicite $Tl_5Sb^{3+}{}_9(As,Sb)^{3+}{}_4S_{22}$
Pierrotite family
Pierrotite $Tl_2(Sb_6As_4)_{\Sigma 10}S_{16}$
Parapierrotite $Tl_2(Sb_9As)_{\Sigma 10}S_{16}$
*Protochabournéite $Tl_{5-x}Pb_{2x}(Sb,As)_{21-x}S_{34}$ (x~1.2-1.5)
Chabourneite $Tl_{10}(Sb_{22,5}As_{19,5})_{42}S_{68}$
2b.1a.2.1.2.1.1.2.2. Complex 2b.1a.2.1.2.1.1.2.2.1. Tl^+ and Hg^+
Vaughanite $Tl^+Hg^+Sb^{3+}{}_4S_7$
2b.1a.2.1.2.1.1.2.2.2. Tl^+ and Hg^{2+}
Vrbaite $Tl_4Hg_3(Sb_2As_8)_{\Sigma 10}S_{20}$

2b.1a.2.1.2.1.2. Minerals of Ag
2b.1a.2.1.2.1.2.1. Sulfoarsenites
2b.1a.2.1.2.1.2.1.1.Simple
Pearceite series
Pearceite $(Ag,Cu)_{16}As_2S_{11}$
*Pearceite Tac $(Ag,Cu)_{16}As_2S_{11}$
*Cupropearceite $(Ag_9Cu_7)_{16}As_2S_{11}$
*Antimonpearceite $(Ag,Cu)_{16}(Sb,As)_2S_{11}$
Polybasite $(Ag,Cu)_{16}Sb_2S_{11}$
*Arsenpolybasite $(Ag,Cu)_{16}(As,Sb)_2S_{11}$
*Selenopolybasite $Ag_{15}CuSb_2S_9Se_2$
Proustite family
Proustite series
Proustite Ag_3AsS_3
Pyrargyrite Ag_3SbS_3
Xanthoconite group
Xanthoconite Ag_3AsS_3
Pyrostilpnite Ag_3SbS_3
Smithite family
Smithite $AgAsS_2$
Trechmannite $AgAsS_2$
2b.1a.2.1.2.1.2.1.2. Complex (Ag^+ and Hg^{2+})
Laffittite $AgHgAsS_3$
*Fettelite $[Ag_6As_2S_7][Ag_{10}HgAs_2S_8]$
*Debattistiite $Ag_9Hg_{0.5}As_6S_{12}Te_2$
*2б.1a.2.1.2.1.2.1.3. Complex (Ag^+, Cd^{2+}, Pb)
*Quadratite $Ag(Cd,Pb)(As,Sb)S_3$
*Manganoquadratite $AgMnAsS_3$

2b.1a.2.1.2.1.2.2. Sulfoarsenites (simple)
Billingsleyite $Ag_7(As,Sb)S_6$
*2б.1a.2.1.2.1.2.2.1. Sulfoarsenito-halogenides
*Mutnovskite $Pb_2AsS_3(I,Cl,Br)$

2b.1a.2.1.2.1.2.3. Sulfoantimonites
2b.1a.2.1.2.1.2.3.1. Simple
Stephanite family (compare with selenostephanite)
Stephanite Ag_5SbS_4
Miargyrite subfamily
Miargyrite $AgSbS_2$
*Cubargyrite $AgSbS_2$
*Baumstarkite $AgSbS_2$
Aramayoite $Ag(Sb,Bi)S_2$
*Ferdowsiite $Ag_8(Sb_5As_3)_{\sum 8}S_{16}$

2b.1a.2.1.2.1.2.3.2. Complex (Ag^+ and Pb^{2+})
Brongniardite = diaphorite $Ag_3Pb_2Sb_3S_8$
Roshchinite $Ag_{19}Pb_{10}Sb_{51}S_{96}$
Diaphorite $Ag_3Pb_2Sb_3S_8$
*Tubulite $Ag_2Pb_{22}Sb_{20}S_{53}$
*Unnamed $Ag_3Pb_6(Sb,Bi)_{11}S_{24}$

2b.1a.2.1.2.1.2.4. Sulfobismuthites
2b.1a.2.1.2.1.2.4.1. Simple→ complex
Matildite $AgBiS_2$
*Schapbachite $AgBiS_2$
*Unnamed cub. $AgBiS_2$
Benjaminite $Ag_3Bi_7S_{12}$
Pavonite series
Pavonite $AgBi_3S_5$
Cupropavonite $AgCu_2PbBi_5S_{10}$
*Cupromakopavonite N = 4,5 $Ag_3Cu_8Pb_4Bi_{19}S_{38}$
*Cupromakovickyite N = 4 $Ag_2Cu_8Pb_4Bi_{18}S_{36}$
*Makovickyite $Ag_{1,5}Bi_{5,5}S_9$
*Dantopaite $Ag_5Bi_{13}S_{22}$
*Cu-Pb-benjaminite N = 7.86
*Cu-Pb-mummeite N = 8
*Unnamed $Ag_5CuPbBi_4(S,Se)_{10}$
*Borodaevite $[Ag_5(Fe,Pb)Bi_7]_{\Sigma 13}(Sb,Bi)_2S_{17}$

2b.1a.2.1.2.1.2.4.2. Complex
2b.1a.2.1.2.1.2.4.2.1. Ag^+ and Cu^+
Arcubisite Ag_6CuBiS_4
2b.1a.2.1.2.1.2.4.2.2. $Ag^+(Cu^+)$ and Pb^{2+}
Padéraite $Cu_7(Cu,Ag)_{0.33}Pb_{1.33}Bi_{11.33}S_{22}$
Mummeite $Cu_{0.58}Ag_{3.11}Pb_{1.10}Bi_{6.65}S_{13}$
Berryite series
Berryite-(Cu) $(Cu,Ag)_5Pb_3Bi_7S_{16}$
Berryite-(Ag) $(Ag,Cu)_5Pb_3Bi_7S_{16}$

p-Ourayite $Ag_{3,6}Pb_{2,8}Bi_{5,6}S_{13}$
Treasurite $Ag_7Pb_6Bi_{15}S_{32}$
Gustavite $AgPbBi_3S_6$
Ourayite $Ag_3Pb_4Bi_5S_{13}$
*Terrywallaceite $AgPb(Sb,Bi)_3S_6$

*2б.1a.2.1.2.1.2.5. Sulfoarsenantimonites
*Unnamed Ag_2SbAsS_4

2b.1a.2.1.2.2. Minerals of **II***b*-cations (Hg^{2+})
2b.1a.2.1.2.2.1. Sulfoarsenites (complex)
Galkhaite $(Hg_5Cu)CsAs_4S_{12}$

2b.1a.2.1.2.2.2. Sulfoantimonites (mono-polyanionic) (simple)
Livingstonite $HgSb_4S_8 \rightarrow Hg^{2+}Sb^{3+}{}_4S_6[S_2]$

*2б.1a.2.1.2.2.3. Sulfobismuthites (complex)
*Grumiplucite $HgBi_2S_4$

2b.1a.2.2. Sulfosalts of noncenosymmetrical *p*-cations
2b.1a.2.2.1. Minerals of **IV***a*-cations (only Pb^{2+})
2b.1a.2.2.1.1. Sulfoarsenites
2b.1a.2.2.1.1.1. Simple
Jordanite series
Jordanite $Pb_{14}(As,Sb)_6S_{23}$
Geocronite $Pb_{14}(Sb,As)_6S_{23}$
*Marumoite $Pb_8As_{10}S_{23}$
Gratonite $Pb_9As_4S_{15}$
*Tsugaruite $Pb_4As_2S_7$
Kirkiite $Pb_{10}(As_3Bi_3)_{\Sigma 6}S_{19}$
Dufrénoysite $Pb_2As_2S_5$
Baumhauerite $Pb_3As_4S_9$ or $Pb_{12}As_{16}S_{36}$
*Argentobaumhauerite = baumhauerite 2a $Ag_{1.5}Pb_{22}As_{33.5}S_{72}$
Liveingite $Pb_{18.5}As_{25}S_{56}$
Sartorite $PbAs_2S_4$
2b.1a.2.2.1.1.2. Complex
2b.1a.2.2.1.1.2.1. Pb^{2+} and Cu^+
Seligmannite (y = MS : M_2S = 2) $CuPbAsS_3$
2b.1a.2.2.1.1.2.2. Pb^{2+} and $Ag^+(Cu^+)$
Marrite $AgPbAsS_3$
Lengenbachite (y = ≤ 6) $(Ag,Cu)_2Pb_6As_4S_{13}$
*2б.1a.2.2.1.1.3. Pb^{2+},Cd
*Tazievite $Pb_{20}Cd_2(As,Bi)_{22}S_{50}Cl_{10}$
*2б.1a.2.2.1.1.3. Pb^{2+}, Hg
*Daliranite $PbHgAs_2S_6$

2b.1a.2.2.1.2. Sulfoantimonites
2b.1a.2.2.1.2.1. Proper sulfoantimonites
2b.1a.2.2.1.2.1.1. Simplee
Falkmanite $Pb_{5,4}Sb_{3,6}S_{11} \sim Pb_3Sb_2S_6$

Boulangerite	$Pb_5Sb_4S_{11}$
*Moëloite	$Pb_6Sb_6S_{17}$ or $Pb_6Sb_6S_{14}(S_3)$
Semseyite	$Pb_9Sb_8S_{21}$
Madocite	$Pb_{19}(Sb,As)_{16}S_{43}$
Veenite	$Pb_2(Sb,As)_2S_5$
Sorbyite	$Pb_9Cu(Sb,As)_{11}S_{26}$
Heteromorphite	$Pb_7Sb_8S_{19}$
Launayite	$Pb_{10}Cu(Sb,As)_{13}S_{30}$
Robinsonite	$Pb_4Sb_6S_{13}$
Plagionite	$Pb_5Sb_8S_{17}$
Twinnite series (?)	
Guettardite	$Pb(Sb,As)_2S_4$
Twinnite	$Pb(SbAs)_{\Sigma 2}S_4$
Rathite	$Pb_{12-x}Ag_2Tl_{x/2}As_{18+x/2}S_{40}$
Zinkenite	$Pb_9Sb_{22}S_{42}$
Fülöppite	$Pb_3Sb_8S_{15}$
Playfairite	$Pb_{16}(Sb,As)_{19}S_{44}Cl$
2b.1a.2.2.1.2.1.2. Complex	2b.1a.2.2.1.2.1.2.1. Pb^{2+} and Fn'^{2+}
Jamesonite family	
Jamesonite series (?)	
Jamesonite	$Pb_4FeSb_6S_{14}$
Benavidesite	$Pb_4(Mn,Fe)Sb_6S_{14}$
*Marrucciite	$Hg_3Pb_{16}Sb_{18}S_{46}$
	2b.1a.2.2.1.2.1.2.2. Pb^{2+} and Cu^{+}
Bournonite (y = 2)	$CuPbSbS_3$
Tintinaite series (y = 11)	
Tintinaite-(Sb)	$Pb_{10}Cu_2Sb_{16}S_{35}$
Tintinaite-(Bi)	$Pb_{10}Cu_2(Bi,Sb)_{16}S_{35}$
Meneghinite series (y=26-20)	
Meneghinite	$CuPb_{13}Sb_7S_{24}$
Jaskolskiite	$Cu_xPb_{2+x}(Sb,Bi)_{2-x}S_5$ (x = 0,2)
*Rouxelite	$Cu_2HgPb_{22}Sb_{28}S_{64}(O,S)_2$
*Izoklakeite	$(Cu,Fe)_2Pb_{27}(Sb,Bi)_{19}S_{57}$
*Unnamed	$Cu_5Fe_6Pb_6Bi_2S_{21}$ (?)
	2b.1a.2.2.1.2.1.2.3. Pb^{2+} and Tl^{+}, Ag^{+}
Rayite	$TlAg_3Pb_{16}Sb_{16}S_{42}$
	2b.1a.2.2.1.2.1.2.4. Pb^{2+} and $Ag^{+}(Cu^{+})$
Andorite family (y=2)	
Andorite group	
Freieslebenite	$AgPbSbS_3$
Andorite	$AgPbSb_3S_6$
Senandorite	$AgPbSb_3S_6$
Ramdohrite (y = 4)	$Ag_3Pb_6Sb_{11}S_{24}$
Fizelyite (y = 5,6)	$Ag_5Pb_{14}Sb_{21}S_{48}$
Owyheeite family (y = 8)	
Owyheeite	$Ag_{3+x}Pb_{10-2x}Sb_{11+x}S_{28}$ ($-0,13 \le x \le 0,2$)
Zoubekite	$AgPb_4Sb_4S_{10}$
*Parasterryite	$Ag_4Pb_{20}(Sb_{14.5}As_{9.5})_{24}S_{58}$
Sterryite	$(Ag,Cu)_2Pb_{10}(Sb,As)_{12}S_{29}$

2b.1a.2.2.1.2.1.2.5. Pb^{2+}, Fn'^{2+} and Ag^{+}

Uchucchacuaite	$AgPb_3Mn^{2+}Sb_5S_{12}$
*Menchettite	$AgPb_{2.40}Mn^{2+}_{1.60}Sb_3As_2S_{12}$
*Unnamed	$AgPb_9(Sb,As)_{13}S_{29}$

2b.1a.2.2.1.2.1.2.6. Pb^{2+}, Fn^{2+}, Sn^{2+} and Sn^{4+}

Franckeite series

Franckeite	$Pb_5Fe^{2+}Sn^{2+}Sn^{4+}_2Sb_2S_{14}$
Cylindrite	$Pb_3Fe^{2+}Sn^{2+}Sn^{4+}_3Sb_2S_{14}$

2b.1a.2.2.1.2.2. Sulfoantimonito-halogenides (simple)

Dadsonite	$Pb_{23}Sb_{25}S_{60}Cl$
Ardaite	$Pb_{19}Sb_{13}S_{35}Cl_7$

*2б.1a.2.2.1.2.3. Sulfoantimonito-chlorido-oxides (simple)

*Pillaite	$Pb_9Sb_{10}S_{23}ClO_{0,5}$
*Pellouxite	$(Cu,Ag)_2Pb_{21}Sb_{23}S_{55}ClO$

*2б.1a.2.2.1.2.4. Sulfoantimonito-oxides (simple)

*Scainiite	$Pb_{14}Sb_{30}S_{54}O_5$
*Chovanite	$Pb_{15-2x}Sb_{14+2x}S_{36}O_x$

2b.1a.2.2.1.3. Sulfobismuthites

2b.1a.2.2.1.3.1. Proper sulfobismuthites

2b.1a.2.2.1.3.1.1. Simple

Aschamalmite	$Pb_6Bi_2S_9$

Lillianite family

Lillianite	$Pb_{3-2x}Ag_xBi_{2+x}S_6$
Xilingolite	$Pb_3Bi_2S_6$
Cosalite	$Pb_2Bi_2S_5$
Cannizzarite	$Pb_8Bi_{10}S_{23}$
Galenobismutite	$PbBi_2S_4$
*Kudriavite	$(Cd,Pb)Bi_2S_4$
Sakharovaite	$(Pb,Fe)_5(Bi,Sb)_6S_{14}$ (?)
*Mozgovaite	$PbBi_4(S,Se)_7$
Ustarasite	$Pb(Bi,Sb)_6S_{10}$
*Crerarite	$(Pb,Pt)Bi_3(S,Se)_{4-x}$ $(x \sim 0.7)$

2b.1a.2.2.1.3.1.2. Complex

2b.1a.2.2.1.3.1.2.1. Pb^{2+} and Cu^{+}

*Pizgrischite	$Cu_{17}PbBi_{17}S_{35}$

Aikinite homologous series – $Cu_{1-x}Pb_{1-x}Bi_{1+x}S_3$

Aikinite	$(0 < x < 0,11)$	$CuPbBiS_3$
Friedrichite	$(0,13 < x < 0,20)$	$Cu_5Pb_5Bi_7S_{18}$
*Felbertalite	$(x = 0,26)$	$Cu_2Pb_6Bi_8S_{19}$
Hammarite	$(0,32 < x < 0,38)$	$Cu_2Pb_2Bi_4S_9$
*Emilite	$(x = 0,32)$	$Cu_{10,7}Pb_{10,7}Bi_{21,3}S_{48}$
Lindströmite	$(x = 0,4)$	$Cu_3Pb_3Bi_7S_{15}$
Krupkaite	$(0,41 < x < 0,48)$	$CuPbBi_3S_6$
*Paarite	$(x = 0,58)$	$Cu_{1,7}Pb_{1,7}Bi_{6,3}S_{12}$
*Zalzburgite	$(x = 0,6)$	$Cu_{1,6}Pb_{1,6}Bi_{6,4}S_{12}$
Gladite	$(0,62 < x < 0,77)$	$CuPbBi_5S_9$
*Unnamed	$(x = 0,75)$	$CuPbBi_7S_{12}$
*Pekoite	$(x = 0,83)$	$CuPbBi_{11}(S,Se)_{18}$

*Unnamed (x = 0,92) $CuPbBi_{23}S_{36}$
Nuffildite $Cu_{1.4}Pb_{2.4}Bi_{2.4}Sb_{0.2}S_7$
*Angelaite $Cu_2AgPbBiS_4$
Neyite $(Cu,Ag)_2Pb_7Bi_6S_{17}$ or $Ag_2Cu_6Pb_{25}Bi_{26}S_{68}$
*Cuproneyite $Cu_7Pb_{27}Bi_{25}S_{68}$
Kobellite $Pb_{11}(Cu,Fe)_2(Bi,Sb)_{15}S_{35}$
Eclarite $(Cu,Fe)Pb_9Bi_{12}S_{28}$
Giessenit $(Cu,Fe)_2Pb_{26.4}(Bi,Sb)_{19.6}S_{57}$

2b.1a.2.2.1.3.1.2.2. Pb^{2+} and Ag^+, Au^+

Heyrovskyite $Pb_6Bi_2S_9$
Vikingite family
Vikingite $Ag_5Pb_8Bi_{13}S_{30}$
Eskimoite $Ag_7Pb_{10}Bi_{15}S_{36}$
Ourayite $Ag_3Pb_4Bi_5S_{13}$
*Jonassonite Au(Bi,Pb)$_5$S$_4$ $Au(Bi,Pb)_5S_4$

2b.1a.2.2.1.3.1.2.3. Pb^{2+}, Cu^+ and Sn^{4+}

Levyclaudite $Cu^+_3Pb_8Sn^{4+}_7(Bi,Sb)_3S_{28}$
*Coiraite $(Pb,Sn)_{12.5}Sn^{4+}_5Fe^{2+}As_3S_{28}$

*2б.1a.2.2.1.3.1.2.4. Pb^{2+}, In^{3+}, Sn^{4+}
*Znamenskyite $Pb_4In_2Bi_4S_{13}$
*Abramovite $Pb_2InSnBiS_7$

2б.1a.2.2.1.3.2. Sulfobismuthito-halogenides
*2б.1a.2.2.1.3.2.1. Simple
*2б.1a.2.2.1.3.2.2. Complex

*2б.1a.2.2.1.3.2.2.1. Pb, Sn^{4+}

*Vurroite $Pb_{20}Sn_2(Bi,As)_{22}S_{54}Cl_6$

*2б.1a.2.2.1.4. Sulfoselenobismuthites
*2б.1a.2.2.1.4.1. Simple
*Babkinite $Pb_2Bi_2(S,Se)_3$

*2б.1a.2.2.1.5. Sulfoselenotelluroantimonites
*Tsnigriite $Ag_9SbTe_3(S,Se)_3$

2b.1b. Quasisubtype*: Selenides and selenosalts of sidero- and chalcophilic cations
2b.1b.1**.** ***Class*****:** Selenides sidero- and chalcophilic cations
2b.1b.1.1. Minerals of heavy *d*-elements and their crystallochemical analogues.
2b.1b.1.1.1. Minerals of cenosymmetrical *d*-cations
2b.1b.1.1.1.1. Minerals of **VIII***b*-cations - families of Fn^{n+}
2b.1b.1.1.1.1.1. Polyanionic
2b.1b.1.1.1.1.1.1. Fn^{2+} (simple)
Trogtalite family
Trogtalite group
Penroseite $(Ni,Co,Cu)[Se_2]$
Trogtalite $Co[Se_2]$
Kullerudite group
Kullerudite $Ni[Se_2]$
Ferroselite $Fe[Se_2]$

*Dzharkenite $Fe[Se_2]$
2b.1b.1.1.1.1.2. Monoanionic
2b.1b.1.1.1.1.2.1. Fn^{2+} (simple)
Sederoholmite family
Sederoholmite group
Sederoholmite β-NiSe
Freboldite CoSe
Mäkinenite γ-NiSe

2b.1b.1.1.1.1.2.2. Minerals of M^{2+} and M^{3+} (complex)
Selenospinelides family ($M^{2+} : M^{3+} = 0,5$; compare with sulfospinelides of Fn (family); sulfospinelides of Pn (family))
Bornhardtite family (M^{2+} and M^{3+} only Fn)
Wilkmanite $Ni_3Se_4 \rightarrow Ni^{2+}Ni^{3+}_2Se_4$
Bornhardtite group
Trüstedtite Ni_3Se_4
Bornhardtite $Co_3Se_4 \rightarrow Co^{2+}Co^{3+}_2Se_4$
Tyrrellite series ($M^{2+} = Cu^{2+}$, $M^{3+}= Fn^{3+}$)
Tyrrellite-(Ni) (an.1) $Cu(Ni,Co)_2Se_4$
Tyrrellite-(Co) (an.2) $Cu(Co,Ni)_2Se_4$

2b.1b.1.1.1.2. Minerals of I*b*-elements – Cu (and Tl^+ with CN ≤ 4)
2b.1b.1.1.1.2.1. Polyanionic (simple)
Krutaite family
Krutaite $Cu[Se]_2$
Bambollaite $Cu[(Se,Te)_2]$

2b.1b.1.1.1.2.2. Mono polyanionic (complex)
Klockmannite (compare with covellite) $3CuSe \rightarrow Cu_2Se \cdot Cu[Se_2]$

2b.1b.1.1.1.2.3. Monoanionic
2b.1b.1.1.1.2.3.1. Cu^+
2b.1b.1.1.1.2.3.1.1. Simple
Berzelianite family
Berzelianite Cu_2Se
Bellidoite Cu_2Se

2b.1b.1.1.1.2.3.1.2. Complex 2b.1b.1.1.1.2.3.1.2.1. Cu^+ and Tl^+
Crookesite $TlCu_7Se_4$
2b.1b.1.1.1.2.3.2. Cu^+ and Cu^{2+} (complex)
2b.1b.1.1.1.2.3.2.1. Cu^+, Tl^+ and Cu^{2+} and Cu^{2+} (Fe^{3+});
Sabatierite family $M^+ : M^{2+}$ = up 6 (sabatierite) to 2 (when $2M^{2+} \leftarrow M^+M^{3+}$) (bukovite)
Sabatierite $Tl^+Cu^+_5Cu^{2+}Se_4$
Bukovite $Tl^+_2Cu^+_{3+x}Fe^{3+}Se_{4-x}$
2b.1b.1.1.1.2.3.2.2. $Cu^+ : Cu^{2+} = 2$
Umangite $Cu_3Se_2 \rightarrow Cu^+_2Cu^{2+}Se_2$
2b.1b.1.1.1.2.3.2.3. $Cu^+ : Cu^{2+}= 0,(6)$
Athabascaite $Cu_5Se_4 \rightarrow Cu+_2Cu^{2+}_3Se_4$

2b.1b.1.1.1.2.3.2.4. $M^+ : M^{2+} = 0,2$

Geffroyite $(Cu,Fe,Ag)_9Se_8$

2b.1b.1.1.1.2.3.3. M^{2+}

2b.1b.1.1.1.2.3.3.1. Complex

2b.1b.1.1.1.2.3.3.1.1. $2M^{2+} \rightarrow Cu^+M^{3+}(Fe^{3+})$

Eskebornite (comp. chalcopyrite (subfam.)) $Cu^+Fe^{3+}Se_2$

2b.1b.1.1.1.2.3.3.1.2. $3M^{2+} \rightarrow 2M^+(Cu^+)M^{4+}(Sn^{4+})$

Selenocernyite (comp.stannite (series)) $Cu^+_2Cd^{2+}Sn^{4+}Se_4$

2b.1b.1.1.1.3. Minerals of **II***b*-cations - Zn^{2+} (and Cd^{2+})

2b.1b.1.1.1.3.1. Monoanionic (simple)

Stilleite family (compare with sphalerite (family))

Stilleite	ZnSe
Cadmoselite	CdSe

2b.1b.1.1.2. Minerals of heavy noncenosymmetrical *d*-cations

2b.1b.1.1.2.1. Minerals of **VIII***b*-cations (Pn^{n+})

2b.1b.1.1.2.1.1. Subselenides

2b.1b.1.1.2.1.1.1. Simple

*Sudovikovite	$PtSe_2$
*Verbeekite	$PdSe_2$
Palladseite	$Pd_{17}Se_{15}$
*Luberoite	Pt_5Se_4

2b.1b.1.1.2.1.1.2. Complex

*Jagueite	$Pd_3Cu_2Se_4$
*Unnamed	$Pd_3Cu_2Se_4$
Oosterboschite	$(Pd,Cu)_7Se_5$
*Miessiite	$Pd_{11}Te_2Se_2$
*Chrisstanleyite	$Pd_3Ag_2Se_4$
*Padmaite	PdBiSe
*Jacutingaite	Pt_2HgSe_3
*Tischendorfite	$Pd_8Hg_3Se_9$
*Unnamed	$(Pb,Cu,Hg)_{1,16}Se$

2b.1b.1.1.2.2. Minerals of **I***b*-cations

2b.1b.1.1.2.2.1. Monoanionic

2b.1b.1.1.2.2.1.1. Ag^+

2b.1b.1.1.2.2.1.1.1. Proper selenides

2b.1b.1.1.2.2.1.1.1.1. Simple

Naumannite Ag_2Se

2b.1b.1.1.2.2.1.1.1.2. Complex

2b.1b.1.1.2.2.1.1.1.2.1. Cu^+ and Ag^+

Eucairite	AgCuSe
*Selenojalpaite	Ag_3CuSe_2
*Unnamed	$(Ag,Cu)_{14}S_6Se_3$

2b.1b.1.1.2.2.1.1.1.2.2. Ag and Au^+

Fischesserite $AuAg_3Se_2$

2b.1b.1.1.2.2.1.1.1.2. Selenido-sulfides

2b.1b.1.1.2.2.1.1.1.2.1. Simple
Aguilarite Ag_4SeS
2b.1b.1.1.1.2.2.1.1.2.2. Complex
Penzhinite $Au^+Ag^+(Ag_{2,65}Cu_{0,35})^{2+}{}_{\Sigma3}(S_{3,31}Se_{0,69})_{\Sigma4}$

2b.1b.1.1.2.3. Minerals of **II**b-cations (Hg^{2+})
2b.1b.1.1.2.3.1. Monoanionic (simple)
Tiemannite HgSe
*2б.1б.1.1.2.3.2.Complex
*Brodtkorbite Cu_2HgSe_2

2b.1b.1.2. <u>Minerals of noncenosymmetrical *p*-cations</u>
2b.1b.1.2.1. Minerals of **IV***a*-cations
2b.1b.1.2.1.1. Minerals of Pb
2b.1b.1.2.1.1.1. Monoanionic (simple)
2b.1b.1.2.1.1.1.1. Pb^{2+}
Clausthalite (comp.galena – clausthalite (series)) PbSe
2b.1b.1.2.2. Minerals of **V***a*-cations
2b.1b.1.2.2.1. Subselenido-sulfides (simple)
*Antimonselite Sb_2Se_3
Laitakarite family
Laitakarite series
Ikunolite $Bi_4(S,Se)_3$
Laitakarite $Bi_4(Se,S)_3 \rightarrow Bi_4Se_2S$
Nevskite (Bi,Pb)(Se,S)
Laphamite As_2Se_3
2b.1b.1.2.2.2. Monoanionic
2b.1b.1.2.2.2.1. Selenido-sulfides (at that number selenido-tellurides) (simple)
Guanajuatite family
Paraguanajuatite group
Paraguanajuatite Bi_2Se_3
Skippenite $Bi_2(Se_2Te)_{\Sigma3}$
Guanajuatite Bi_2Se_3
*Telluronevskite Bi_3TeSe_2
*Vihorlatite $Bi_{24}Se_{17}Te_4$

2b.1b.2. ***Class***: Selenosalts of sidero- and chalcophylic cations
2b.1b.2.1. Selenosalts of heavy *d*- cations
2b.1b.2.1.1. <u>Minerals of cenosymmetrical *d*-cations</u>
2b.1b.2.1.1.1. Minerals of **I***b*-cations
2b.1b.2.1.1.1.1. Cu^+
2b.1b.2.1.1.1.1.1. Selenoarsenites (simple)
Mgriite Cu_3AsSe_3

2b.1b.2.1.1.1.2. Cu^+ and Cu^{2+}(Fe^{2+}, Zn^{2+}, Hg^{2+}, Pb^{2+}) (complex)
2b.1b.2.1.1.1.2.1. Selenoarsenites
Chameanite $Cu^+{}_3(Cu,Fe)^{2+}As(Se,S)_4$
*Unnamed $(Cu,Co,Ni)_7As_3Se_6$

2b.1b.2.1.1.1.2.2. Selenoarsenito-selenoantimonites

Giraudite series (compare with fahlores (series))
Giraudite (Se-sandbergerite) $Cu_6[Cu_4(Fe,Zn)_2]As_4Se_{13}$
Hakite (Se-schwazite) $Cu_{10}Hg_2Sb_4(Se,S)_{13}$

2b.1b.2.1.1.1.2.3. Selenoantimonites
Permingeatite (comp. enargite (family)) $Cu_3SbSe_4 \rightarrow Cu^{+}Cu^{2+}{}_2SbSe_4$

2b.1b.2.1.1.1.2.4. Selenobismuthites and seleno-sulfobismutites
*2б.1б.2.1.1.1.2.4.1. Cu^{+}
*Eldragonite $Cu^{+}{}_6BiSe^{2-}{}_4(Se_2)^{2-}$
2b.1b.2.1.1.1.2.4.2. Cu^{+}, Hg^{2+} and Pb^{2+}
Petrovicite $Cu_3HgPbBiSe_5$
2b.1b.2.1.1.1.2.4.3. Cu^{+} and Pb^{2+}
*Schlemaite $(Cu,\square)_6(Pb,Bi)Se_4$
Součekite (compare with aikinite (series)) $CuPbBi(SeS_2)_{\Sigma 3}$
*Součekite-like mineral $Cu_{2,1-2,6}Ag_{0,7}Pb_{0,3}Bi_{0,2}Se_3$ (?)
Proudite $Pb_8Bi_{10}S_{23}$
Watkinsonite $PbCu_2Bi_4Se_8$
Nordströmite $CuPb_3Bi_7(S,Se)_{14}$ S : Se = 2,4
Junoite $Cu_2Pb_3Bi_8(S,Se)_{16}$ S : Se = 1,7 - 4,8
Pekoite $CuPbBi_{11}(S,Se)_{18}$ S : Se = 5,2

2b.1b.2.1.2. <u>Selenosalts of noncenosymmetrical *d*-cations</u>
*2b.1b.2.1.2.1. Minerals of **VIII***b*-cations
*Kalungaite PdAsSe
*Milotaite PdSbSe

2b.1b.2.1.2.2. Minerals of **I***b*-elements
2b.1b.2.1.2.2.1. Minerals of Ag
2b.1b.2.1.2.2.1.1. Selenoantimonites (simple)
Selenostephanite (comp. stephanite (group.)) $Ag_5Sb(Se,S)_4$
*Selenopolybasite $Ag_{15}CuSb_2S_9Se_2$

2b.1b.2.1.2.2.1.2. Selenobismutites (simple)
Bohdanowiczite $AgBiSe_2$
*Litochlebite $Ag_2PbBi_4Se_8$

2b.1b.2.2. <u>Selenosalts of noncenosymmetrical *p*-cations</u>
2b.1b.2.2.1. Minerals of **IV***a*-cations (Pb^{2+})
2b.1b.2.2.1.1. Seleno-sulfobismutites (at that number telluro-selenosulfobismutit) (simple)
Weibullite family
Weibullite $Ag_{0.3}Pb_{5.3}Bi_{8.3}(S,Se)_{18}$
Wittite $Pb_8Bi_{10}(S,Se)_{23}Se$
Poubaite (Te,Se-galenobismutite) $PbBi_2(Se,Te,S)_4$

2b.2. Subtype: Chalcogenic compounds of lithophylic cations
2b.2.1. ***Class***: Sulfides (and selenides) of lithophylic cations
2b.2.1.1. Minerals of light *d*-elements (with 1 – 4 *d*-electrons)
2b.2.1.1.1. <u>Minerals of cenosymmetrical *d*-elements</u>

*2б.2.1.1.1.1. Minerals of **IV***b*-elements
*Wassonite TiS

2b.2.1.1.1.1. Minerals of **V***b*-elements
2b.2.1.1.1.1.1. Minerals of M^{5+} 2b.2.1.1.1.1.1.1. Simple
Patronite $V[S_2]_2$
*Colimaite K_3VS_4

2b.2.1.1.2. Minerals of noncenosymmetrical *d*-elements
2b.2.1.1.2.1.Minerals of **VI***b*-elements
2b.2.1.1.2.1.1. Monoanionic
2b.2.1.1.2.1.1.1. Minerals of M^{4+} 2b.2.1.1.2.1.1.1.1. Simple

Molybdenite family

Molybdenite group

Molybdenite -*2H*	MoS_2
Molybdenite -3R	
Tungstenite-*2H*	WS_2
*Tungstenite-*3R*	WS_2
Drysdallite	$MoSe_2$
Jordisite	MoS_2
*Rheniite	ReS_2

*2б.2.1.1.2.2. Minerals of VI*b*-элементов and VII*b*-elements

*Tarkianite	$(Re,Mo)_4(Cu,Fe)S_8$
*Buseckite	(Fe,Zn,Mn)S

2b.2.1.2. Sulfides of *s*-elements
2b.2.1.2.1. Sulfides of **I***a*-cations and Tl^+ (with CN=8-12) (all monoanionic)
2b.2.1.2.1.1. Sulfides of Tl^+(K)
2b.2.1.2.1.1.1. Proper sulfides 2b.2.1.2.1.1.1.1.Complex
2b.2.1.2.1.1.1.1.1. $M^+(K^+,Tl^+,Cu^+)$ and $M^{3+}(Fe^{3+})$

Murunskite group

Thalcusite	$Tl_2Cu^+{}_3Fe^{3+}S_4$
Murunskite	$K_2Cu^+{}_3Fe^{3+}S_4$

2b.2.1.2.1.1.1.1.2. $M^+(K^+,Tl^+)$, $M^{2+}(Fe^{2+})$ and $M^{3+}(Fe^{3+})$

Rasvumite group

Picotpaulite	$TlFe^{2+}Fe^{3+}S_3$
Rasvumite	$KFe^{2+}Fe^{3+}S_3$

2b.2.1.2.1.1.1.1.3. $M^+(K^+)$,$M^{2+}(Fe^{2+})$ and $M^{3+}(Fe^{3+})$

*Owensite	$(Ba,Pb)_6(Cu^{1+},Fe,Ni)_{25}S_{27}$
Bartonite	$K_6(Fe,Cu)_{20}S_{26}S$
*Chlorbartonite	$K_6(Fe,Cu)_{24}S_{26}(Cl,S)$

2b.2.1.2.1.1.2. Sulfido-chlorides 2b.2.1.2.1.1.2.1. Complex

Djerfisherite group

Thalfenisite	$Tl_6(Fe,Ni,Cu)_{25}S_{26}Cl$
Djerfisherite	$K_6(Fe,Cu,Ni)_{25}S_{26}Cl$

2b.2.1.2.1.2. Sulfides of Na

2b.2.1.2.1.2.1. Complex	2b.2.1.2.1.2.1.1. Anhydrous
	2b.2.1.2.1.2.1.1.1. $M^+(Na^+)$ and $M^{2+}(Fe^{2+},Cu^{2+},Zn^{2+})$
Chvilevaite	$Na^+_2Cu^+_2(Fe,Cu,Zn)^{2+}_2S_4$
	2b.2.1.2.1.2.1.1.2. $M^+(Na^+)$ and $M^{3+}(Cr^{3+})$
Caswellsilverite	$NaCr^{3+}S_2$
	2b.2.1.2.1.2.1.2. Hydrous
	2b.2.1.2.1.2.1.2.1. $M^+(Na^+)$ and $M^{3+}(Fe^{3+})$
Erdite	$Na^+Fe^{3+}S_2 \cdot 2H_2O$
Coyoteite	$Na^+Fe^{3+}_3S_5 \cdot 2H_2O$
	2b.2.1.2.1.2.1.2.2. $M^+(Na^+,K^+, Cu^+)$, $M^{2+}(Fe^{2+})$ and $M^{3+}(Fe^{3+})$
Orickite	$CuFeS_2 \cdot nH_2O$
	2b.2.1.2.1.2.1.2.3. $M^+(Na^+)$, $M^{3+}(Cr^{3+})$ and $M^{6+}(Cr^{6+})$
Schöllhornite	$Na_{0.3}CrS_2 \cdot H_2O$
*Pautovite	$CsFe_2S_3$

2b.2.1.2.2.Sulfides of **II*a***-cations and their crystallochemical analogues (all monoanionic)

2b.2.1.2.2.1. Proper sulfides	2b.2.1.2.2.1.1. Simple
Niningerite family	
Oldhamite	CaS
Niningerite series	
Niningerite -(Mg)	(Mg,Fe,Mn)S
Niningerite -(Fe)	(Fe,Mg,Mn)S
*Keilite	(Fe,Mg)S
*2б.2.1.2.2.1.2. Complex	
*2б.2.1.2.2.1.2.1.Hydrates	
*Cronusite	$Ca_{0,2}(H_2O)_2CrS_2$

2b.2.1.2.2.2. Sulfido-oxides	2b.2.1.2.2.2.1. Complexe
Sarabauite	$CaSb^{3+}_{10}S_6O_{10}$
*Apuanite	$Fe^{2+}Fe^{3+}_4Sb^{3+}_4O_{12}S$

*2б.2.1.2.2.3. Sulfido-oxido-carbonates	*2б.2.1.2.2.3.1. Hydrates
*Ignicolorite	$FeS_2 \cdot 0.7CaCO_3 \cdot 2.8\ H_2O$

2b.2.1.2.2.3. Sulfido-hydroxides	2b.2.1.2.2.3.1. Complex
Valleriite family	
Valleriite	$(Mg,Al)_3(Fe,Cu)_4(OH)_6S_4 \rightarrow 4\ (Fe,Cu)S \cdot 3\ (Mg,Al)(OH)_2$
*Ferrovalleriite	$2(Fe,Cu)S\ 1.53[(Fe,Al,Mg)(OH)_2]$
Haapalaite	$(Mg,Fe^{2+})_3(Fe,Ni)^{2+}_4(OH)_6S_4 \rightarrow 4\ (Fe,Ni)S \cdot 3\ (Mg,Fe^{2+})(OH)_2$
Tochilinite	$(Mg,Fe)_5Fe_6(OH)_{10}S_6 \rightarrow 6FeS \cdot 5\ (Mg,Fe^{2+})(OH)_2$
*Ferrotochilinite	$FeS\ 0.85[Fe(OH)_2]$
Yushkinite	$(Mg,Al)(OH)_2 \cdot VS_2$
*Vyalsovite	$FeS \cdot Ca(OH)_2 \cdot Al(OH)_3$
*Ekplexite	$(Mg_{1-x}Al_x)(Nb,Mo,W)(OH)_{2+x}S_2$
*Kaskasite	$Mg_{1-x}Al_x(OH)_{2+x}(Mo,Nb)S_2$

*Manganokaskasite $Mn_{1-x}Al_x(OH)_{2+x}(Mo,Nb)S_2$

2b.2.1.2.2.4. Sulfido-tiosulfates
2b.2.1.2.2.4.1. Hydrate
2b.2.1.2.2.4.1.1. Basic
Bazhenovite $Ca_8(OH)_2S_5[S_2O_3]\cdot 20H_2O$

2b.2.2. ***Class:*** Sulfosalts of lithophylic cations
2b.2.2.1. Minerals of **I***a*-elements and Tl^+ (with CN = 8-12)
2b.2.2.1.1. Sulfoantimonites
2b.2.2.1.1.1. Proper sulfoantimonites
2b.2.2.1.1.1.1. Simple
2b.2.2.1.1.1.1.1. Crystalline hydrate (middle)
Gerstleyite $Na_2(Sb,As)_8S_{13}\cdot 2H_2O$
*Ambrinoite $(K,NH_4)_2(As,Sb)_8S_{13}\cdot H_2O$
2b.2.2.1.1.2. Sulfoantimonito-antimonites
2b.2.2.1.1.2.1. Hydrate (basic)
Cetineite $NaK_5Sb_{14}S_6O_{18} \cdot 6H_2O$
*Ottensite $Na_3(Sb_2O_3)_3(SbS_3) \cdot 3H_2O$

3. TYPE: MINERALS WITH PRINCIPAL IONIC-COVALENT AND COVALENT- IONIC BOND – NONMETALLIDES OF LIGTH (TYPICAL NONCENOSYMMETRICAL) VIa-ELEMENT (O) – OXIGEN COMPOUNDS: OXIDES AND HYDROXIDES (ISODESMICAL → ANISODESMICAL) → OXOCALTS (ANISODESMICAL)

3.1. SUBTIPE: OXIDES AND HYDROXIDES (ISODESMICAL)
3.1a. *QUASISUBTIPE: OXIDES AND HYDROXIDES OF LITHOPFYLLIC CATIONS WITH LOW FC*
3.1a.1. ***Class:*** Oxides and hydroxides of ***s***-, ***d_s***- and ***p_s***-cations
3.1a.1.1. Oxides and hydroxides of ***s***-, $\boldsymbol{d_s}$- and $\boldsymbol{p_s}$-cations without Li^+, Be^{2+}
3.1a.1.1.1. Monoanionic
3.1a.1.1.1.1. Proper oxides
3.1a.1.1.1.1.1. M^{2+}
3.1a.1.1.1.1.1.1. Simple
Periclase group
Periclase MgO
Hongquiite дискредитирован TiO
Manganosite MnO
Wüstite FeO
Bunsenite NiO
Lime CaO

3.1a.1.1.1.1.1.2. M^+,M^{2+} and M^{3+}
3.1a.1.1.1.1.1.2.1. Complex CN M(A,B) = 4 – 6
Diaoyudaoite $NaAl_{11}O_{17}$
Oxsospinelides family - AB_2O_4; $A(M^{2+}) : B(M^{3+}) = 2$
Spinel subfamily A = Mg^{2+}, Fe^{2+}, Mn^{2+}, Ni^{2+}, Co^{2+}; B = Al^{3+}, V^{3+}, Cr^{3+}, Mn^{3+}, Fe^{3+}, Co^{3+}, Ni^{3+}, Mg^{2+}
Magnetite series $^{(6)}A^{(6)}B|^{(4)}B'O_4|$; A = Mg^{2+}, Fe^{2+}, Ni^{2+}, Mn^{2+}; B = Fe^{3+}, Mn^{3+}; B' = Fe^{3+}

*Cuprospinel	$(Cu,Mg)Fe_2O_4$
Magnesioferrite	$MgFe_2O_4$
Trevorite	$NiFe_2O_4$
Magnetite	$Fe_3O_4 \rightarrow {}^{(6)}Fe^{2+(6)}Fe\|^{(4)}FeO_4$
Jacobsite	$Mn^{2+}Fe_2^{3+}O_4$
Chromite series $^{(4)}A^{(6)}B_2O_4$; $A = Mg^{2+}, Fe^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}$; $B = Mg, Cr^{3+}, Al^{3+}, V^{3+}$	
Magnesiochromite	$MgCr_2^{3+}O_4$
Cochromite	$CoCr_2O_4$
Chromite	$FeCr_2O_4$
Manganochromite	$Mn^{2+}Cr_2O_4$
*Xieite orth.	$FeCr_2O_4$
Spinel series $^{(4)}A^{(6)}B_2O_4$; $A = Mg^{2+}, Mn^{2+}, Fe^{2+}$; $B = Al^{3+}, Fe^{3+}$	
Spinel	$MgAl_2O_4$
*Krotite	$CaAl_2O_4$
Hercynite	$Fe^{2+}Al_2O_4$
Galaxite	$Mn^{2+}Al_2O_4$
*Brunogeierite	$GeFe_2O_4 \rightarrow (Ge^{2+},Fe^{2+})Fe^{3+}{}_2O_4$
Coulsonite series $^{(4)}A^{(6)}B_2O_4$; $A = Mn^{2+}, Fe^{2+}$; $B = V^{3+}, Cr^{3+}$	
Vuorelainenite	$Mn^{2+}V_2^{3+}O_4$
*Magnesiocoulsonite	$Mg\ V_2^{3+}O_4$
Coulsonite	FeV_2O_4
*Unnamed	$Mn_2La_2O_5$
Hausmannite group $^{(4)}A^{(6)}B_2O_4$; $A = Fe^{2+}, Mg^{2+}, Mn^{2+}$; $B = Cr^{3+}, Fe^{3+}, Mn^{3+}$	
Iwakiite	$Mn^{2+}Fe_2^{3+}O_4$
Hausmannite	$MnMn_2O_4$
	CN $M^2+ = 8$
Marokite	$^{(8)}Ca^{(6)}Mn_2O_4$

3.1a.1.1.1.1.2. M^{2+}, M^{3+} — $M^{2+} : M^{3+} = \geq 1$

Muskoxite	$Mg_7Fe_4^{3+}(OH)_{26} \cdot H_2O$
Brownmillerite family	
Brownmillerite	$Ca_2(Al,Fe)_2O_5 \cong$ $\cong {}^{(\leq 9)}Ca_2{}^{(6)}(Fe,Al)O^{(4)}(Al,Fe)O_4$
Srebrodolskite	$Ca_2Fe_2O_5 \rightarrow {}^{(<9)}Ca_2{}^{(6)}FeO^{(4)}FeO_4$
*Tululite	$Ca_{14}(Fe^{3+},Al)(Al,Zn,Fe^{3+},Si,P,Mn,Mg)_{15}O_{36}$
	$M^{2+} : M^{3+} = < 1$
*Aciculite	$CaFe_2O_4$
*Harmunite	$CaFe_2O_4$
Mayenite	$^{(8)}Ca_{12}{}^{(5;4)}Al_{14}O_{33}$
*Dmitryivanovite	$CaAl_2O_4$
*Grossite	$CaAl_4O_7$
*Barioferrite	$BaFe^{3+}{}_{12}O_{19}$

3.1a.1.1.1.1.3. M^{3+}

3.1a.1.1.1.1.3.1. Simple

Corundum family	
*Deltalumite	Al_2O
Corundum group	
Corundum	Al_2O_3
*Tistarite	Ti_2O_3

Hematite Fe_2O_3
Unnamed $(Ru,Fe)_2O_3$
Eskolaite Cr_2O_3
Karelianite V_2O_3
Maghemite series
Maghemite $\gamma\text{-}Fe_2O_3 \rightarrow Fe_{2,67}O_4 \rightarrow {}^{(6)}Fe^{3+}{}_{0,67}\square_{0,33}{}^{(6)}Fe^{3+}|{}^{(4)}Fe^{3+}O_4|$
Titanomaghemite $Fe(Fe,Ti)_2O_4$
Luogufengite $\varepsilon\text{-}Fe_2O_3$
*Ittriaite-(Y) Y_2O_3
Bixbyite $Mn_2{}^{3+}O_3$

3.1a.1.1.1.1.3.1. Hydrates

Akdalaite $(Al_2O_3)_5 \cdot H_2O$

*3.1a.1.1.1.1.4. M^{2+}, M^{3+}, M^{4+}, M^{5+}
*Wernerkrauseite $CaFe^{3+}{}_2Mn^{4+}O_6$
*Bitikleite (SnAl) $Ca_3SnSb[AlO_4]_3$
*Dzhuluite – new name of bitikleite-(SnFe) $Ca_3SbSn[FeO_4]_3$
*Usturite - new name of bitikleite-(ZrFe). $Ca_3SbZr[FeO_4]_3$

3.1a.1.1.1.2. Hydroxido-oxides
3.1a.1.1.1.2.1. Proper hydroxido-oxides M^{3+} 3.1a.1.1.1.2.1.1. Simple
Diaspore family
Diaspore group
Diaspore $\alpha\text{-}Al(OH)O$
Montroseite $\alpha\text{-}(V,Fe)(OH)O$
Bracewellite $\alpha\text{-}Cr(OH)O$
Groutite $\alpha\text{-}Mn(OH)O$
Goethite $\alpha\text{-}Fe(OH)O$
Grimaldiite $(Cr,Al)(OH)O$
Guyanaite $(Cr,Fe,Al)(OH)O$
Feroxyhyte $\delta\text{-}Fe(OH)O$
Akaganeite group
Akaganeite $\beta\text{-}Fe(OH,Cl)O$
Feitknechtite $Mn(OH)O$
Böhmite group
Böhmite $\gamma\text{-}Al(OH)O$
Lepidocrocite $\gamma\text{-}Fe(OH)O$
*Tsumgallite $Ga(OH)O$

3.1a.1.1.1.3. Hydroxides
3.1a.1.1.1.3.1. M^{2+} 3.1a.1.1.1.3.1.1. Simple
Brucite family
Brucite $Mg(OH)_2$
Amakinite $(Fe,Mg)(OH)_2$
Pyrochroite group
Pyrochroite $Mn(OH)_2$
Theophrastite $Ni(OH)_2$
Portlandite $Ca(OH)_2$

3.1a.1.1.1.3.2. M^{3+}
Gibbsite family

Gibbsite	$Al(OH)_3$
Bayerite	$Al(OH)_3$
Nordstrandite	$Al(OH)_3$
Doyleite	$Al(OH)_3$
Söhngeite	$Ga(OH)_3$
*Bernalite	$Fe(OH)_3$

3.1a.1.1.1.3.3. M^{2+}, M^{3+}	3.1a.1.1.1.3.3.1. Complex
*Taschelgite	$CaMgFe^{2+}Al_9O_{16}(OH)$
	3.1a.1.1.1.3.3.1.1. Hydrates
Meixnerite	$Mg_6Al_2(OH)_{18}\cdot 4H_2O$
*Fougerite	$Fe^{2+}{}_6Fe^{3+}{}_2(OH)_{18}\cdot 4H_2O$

3.1a.1.1.2. Polyanionic
3.1a.1.1.2.1. Proper oxides

3.1a.1.1.2.2. Oxido-silicates	3.1a.1.1.2.2.1. Complex
Braunite family	
Braunite II	$Ca^{2+}Mn^{3+}{}_{14}O_{20}[SiO_4]$
Braunite	$Mn^{2+}Mn^{3+}{}_6O_8[SiO_4]$
*Gatedalite	$Mn^{2+}{}_2Mn^{3+}{}_4ZrO_8[SiO_4]$
Neltnerite	$CaMn^{3+}{}_6O_8[SiO_4]$
*Abswurmbachite	$Cu^{2+}Mn^{3+}{}_6O_8[SiO_4]$
Dorrite	$Ca_4(Mg_3Fe^{3+}{}_9)O_4[Si_3Al_8Fe^{3+}O_{36}]$
Sapphirine family	
Sapphirine	$Mg_4(Mg_3Al_9)O_4[Si_3Al_9O_{36}]$
Sapphirine-1TC, -2M, -4M polytipes	$(Mg,Al,Fe^{2+})_8[(Al,Si,Fe^{3+})_6O_{18}]O_2$
Surinamite	$Mg_3Al_3O[Si_3BeAlO_{15}]$
	*3.1a.1.1.1.2.1. Hydrates

3.1a.1.1.2.3. Oxido-halogenides	
*Brearleyite	$Ca_{12}Al_{14}O_{32}Cl_2$
	3.1a.1.1.2.3.1. Hydrates
*Kyuygenite = Chlorkyuygenite	$Ca_{12}Al_{14}O_{32}[(H_2O)_4Cl_2]$
*Fluorkyuygenite	$Ca_{12}Al_{14}O_{32}[(H_2O)_4F_2]$

3.1a.1.1.2.4. Hydroxido-oxides	3.1a.1.1.2.4.1. Simple
Ferrihydrite	$Fe_{10}{}^{3+}O_{14}(OH)_2$
Manganite family	
Manganite	Mn[OHO]
Heterogenite-*3R*	Co[OHO]
Heterogenite-2H	

3.1a.1.1.2.5. Hydroxido-oxido-silicates

*Macaulayite	$Fe_{24}O_{43}Si_4(OH)_2$

*3.1a.1.1.2.6. Hydroxido-oxido-carboates

*3.1a.1.1.2.6.1. Simple	*3.1a.1.1.2.6.1.1. Hydrates
*Mössbauerite	$Fe^{3+}{}_3O_2(OH)_4(CO_3)_{0.5}\cdot 1.5H_2O$
*3.1a.1.1.2.6.2. Complex	*3.1a.1.1.2.6.2.1. Hydrates

*Trébeurdenite $Fe^{2+}{}_2Fe^{3+}{}_4O_2(OH)_{10}(CO_3) \cdot 3H_2O$

*3.1a.1.1.2.7. Hydroxido-carbonates
*Karchevskyite $Mg_{18}Al_9(OH)_{54}Sr_2[CO_3]_9(H_2O)_6(H_3O)_5$

*3.1a.1.1.2.8. Hydroxido-oxido-sulfates
*3.1a.1.1. 2.8.1. Simple *3.1a.1.1. 2.8.1.1. Hydrates
*Schwertmannite $Fe_{16}O_{16}(OH)_{9,6}(SO_4)_{3,2}\cdot 10H_2O$ or→ $Fe_{16}O_{16}(OH)_y(SO_4)_z\cdot nH_2O$, где 2≤ z ≤3,5; 16-y = 2z
3.1a.1.1.2.9. Hydroxido-oxido-halogenides 3.1a.1.1.2.9.1. Simple
Zharchikhite $Al(OH)_2F$
*3.1a.1.1. 2.9.1.1. Hydrates
*Lesukite $Al_2(OH)_5Cl\cdot 2H_2O$

3.1a.1.1.2.9.2. M^{2+}, M^{3+}
3.1a.1.1.2.9.2.1. Complex *3.1a.1.1. 2.9.2.1. Hydrates
Iowaite $Mg_6Fe_2^{3+}(OH)_{16}Cl_2 \cdot 4H_2O$
*Droninoite $Ni_3Fe^{3+}(OH)_8Cl\cdot 2H_2O$

3.1a.1.2. Oxides and hydroxides Be^{2+} (all monoanionic)
3.1a.1.2.1. Proper oxides
3.1a.1.2.1.1. Simple
Bromellite BeO
3.1a.1.2.1.2. Complex
*Rhodizite $KBe_4Al_4(B_{11}Be)O_{28}$
*Londonite $CsBe_5Al_4B_{11}O_{28}$
*Byrudite (Be,□)$(V^{3+},Ti^{4+})_3O_6$

Taaffeite family
Taaffeite $Mg_3Al_8BeO_{16}$
*Magnesiotaaffeite-2N´2S гексаг. $Mg_3Al_8BeO_{16}$
*Magnesiotaaffeite-6N´3S тригон. $Mg_2BeAl_6O_{12}$
*Ferrotaaффеит-2N´2S $(Fe^{2+},Mg,Zn)_3Al_8BeO_{16}$
*Ferrotaaффеит-6N´3S $BeFe_2^{2+}Al_6O_{12}$
Pehrmanite synonym of *Ferrotaaффеит-6N´3S
Chrysoberyl Al_2BeO_4
*Maryinskite $Be(Cr,Al)_2O_4$

3.1a.1.2.2. Hydroxides
3.1a.1.2.2.1. Simple
Behoite family
Behoite β-$Be(OH)_2$
Clinobehoite $Be(OH)_2$

3.1a.1.3. **Oxides and hydroxides of Zn^{2+}, Pb^{2+}, As^{3+}, Sb^{3+} and Sb^{5+} lithophylic paragenetic association of Franclin and Sterling Hill, New Jersey, USA, Langban and Jacobsberg, Sweden.**
3.1a.1.3.1. Minerals of Zn^{2+}
3.1a.1.3.1.1. Simple
3.1a.1.3.1.1.1. Neutral

Zincite (Zn,Mn)O
3.1a.1.3.1.2. Complex
3.1a.1.3.1.2.1. Neutral

Franklinite group $^{(4)}A^{(6)}B_2O_4$; $A = Zn^{2+}, Mn^{2+}, Fe^{2+}$; $B = Al^{3+}, Fe^{3+}, Mn^{3+}$ (compare with oxospinelides (family))

Gahnite $ZnAl_2O_4$
Franklinite $(Zn,Mn,Fe)(Fe,Mn)_2O_4$

Hetaerolite family (?) $^{(4)}A^{(6)}B_2O_4 \rightarrow H_{3x}AB_{2-x}O_4$; $A = Zn^{2+}$; $B^{3+} = Mn^{3+}$

Hetaerolite $^{(4)}ZnMn_2O_4$
Hydrohetaerolite $HZnMn^{3+}_{5/3}O_4$
*Cianciulliite $Mn(Mg,Mn)Zn_2(OH)_{10}{\cdot}2\text{-}4H_2O$

3.1a.1.3.2. Minerals of Pb^{2+}
3.1a.1.3.2.1. Complex
3.1a.1.3.2.1.1. Neutral

Plumboferrite $Pb_2(Fe^{3+},Mn^{2+},Mg)_{11}O_{19}$
Magnetoplumbite $PbFe_{12}{}^{3+}O_{19}$
(compare with hibonite (group))
*Ferricoronadite $Pb[Mn^{4+}{}_6(Fe^{3+},Mn^{3+})_2]O_{16}$
*Nežilovite $PbZn_2(Mn^{4+},Ti^{4+})_2Fe^{3+}{}_8O_{19}$

3.1a.1.3.2.1.2. Oxido-hydroxides

Quenselite $PbMn^{3+}(OH)O_2$
Hematophanite $Pb_4Fe^{3+}{}_3(OH,Cl)O_8$

3.1a.1.3.3. Minerals of As^{3+} and Sb^{3+}
3.1a.1.3.3. Complex 3.1a.1.3.3.1. Neutral

Stenhuggari**te** $CaFe^{3+}Sb^{3+}As^{3+}{}_2O_7$
Filipstadite $(Mn,Mg)_4Fe^{3+}Sb^{5+}O_8$
(compare with oxospinelides (family.); $_4$

3.1a.1.3.4. Minerals of Sb^{5+}
3.1a.1.3.4.1. Proper oxides
3.1a.1.3.4.1.1. Complex 3.1a.1.3.4.1.1.1. Neutral

Monimolite $(Pb,Ca)_3Sb^{5+}{}_2O_8$ (?)
Melanostibite $Mn^{2+}{}_2Fe^{3+}Sb^{5+}O_6$
Ingersonite $Ca_3MnSb^{5+}{}_4O_{14}$
Swedenborgite $NaBe_4Sb^{5+}O_7 \rightarrow {}^{(12)}Na[{}^{(4)}Be_4O({}^{(6)}Sb^{5+}O_6)]^{\infty 3}$
*Rinmanite $Zn^{2+}{}_2Sb^{5+}{}_2Mg_2Fe^{3+}{}_4O_{14}(OH)_2$

3.1a.1.3.4.2. Oxido-silicates
3.1a.1.3.4.2.1. Complex 3.1a.1.3.4.2.1.1. Neutral

Katoptrite series

Katoptrite $^{(6)}(Mn^{2+}{}_5Sb^{5+}{}_2)_{\Sigma 7}{}^{(4)}(Mn^{2+}{}_8Al_4Si_2)_{\Sigma 14}O_{28}|^{\infty 2}$
Yeatmanite $^{(6)}(Mn^{2+}{}_5Sb^{5+}{}_2)_{\Sigma 7}{}^{(4)}(Mn^{2+}{}_2Zn_8Si_4)_{\Sigma 14}O_{28}|^{\infty 2}$
*Örebroite $Mn_6{}^{2+}(Fe^{3+},Sb^{5+})_2(SiO_4)_2(O,OH)_6$

3.1a.2.***Class:*** Oxides and hydroxides of ***f***-cations low FC of 4-valence ***f***-cations
3.1a.2.1.1. Proper oxides
3.1a.2.1.1.1. Monoanionic
3.1a.2.1.1.1.1. Neutral

Uraninite group

Uraninite	UO_2
Thorianite	ThO_2
Cerianite-(Ce)	$(Ce,Th)O_2$

3.1a.2.1.1.2. Polyanionic oxides (peroxides)

3.1a.2.1.1.2.1. Hydrates

Studtite family

Studtite	$UO_4{\cdot}2H_2O \rightarrow U[O_2]_2{\cdot}2H_2O$
Metastudtite	$UO_4{\cdot}2H_2O \rightarrow U[O_2]_2{\cdot}2H_2O$

3.1a.3.***Class***: Oxides and hydroxides of ***f***-cations with middle FC – 6-valence ***f***-cations (U^{6+}) → compounds uranyl $(UO_2)^{2+}$ – k. uranil asids, uranates and their derivates (uranium micas and related minerals)

3.1a.3.1. Uranil acids and uranates

3.1a.3.1.1. Uranil acids (hydrates of uranyl hydroxides)

*Paulscherrerite	$UO_2(OH)_2$
Paraschoepite	$UO_3{\cdot}2H_2O$
Schoepite family	
Schoepite	$[(UO_2)_8O_2(OH)_{12}]^{\infty 2}{\cdot}(H_2O)_{12}$
Metaschoepite	$[(UO_2)_8O_2(OH)_{12}]^{\infty 2}{\cdot}(H_2O)_{10}$

3.1a.3.1.2. Uranates

3.1a.3.1.2.1. Basic

*Vorlanite	$CaU^{6+}O_4$
Metacalciouranoite	$[(UO_2)_2O_2(OH)_2]^{\infty 2}(Ca,Na_2,Ba)$

3.1a.3.1.2.2. Hydrates

3.1a.3.1.2.2.1. Oxides-hydroxides

Ianthinite	$[(UO_2)_4O_6(OH)_4]^{\infty 2}U^{4+}{}_2{\cdot}9H_2O$
Vandendrisscheite family (y =7)	$y = UO_2 : Me^{2+}$
Vandendriesscheite	$[(UO_2)_{10}O_6(OH)_{11}]Pb_{1.5}{\cdot}11H_2O$
Metavandendriesscheite	$[(UO_2)_7O_2(OH)_{12}]^{\infty 2}Pb{\cdot}nH_2O$
Becquerelite family (y = 6) $Ba(UO_2)_6O_4(OH)_6 \cdot 8H_2O$	
Vandenbrandeite	$[(UO_2)_2(OH)_8]^{\infty 2}Cu_2$
Becquerelite	$[(UO_2)_6O_4(OH)_6]^{\infty 2}Ca(H_2O)_4{\cdot}4H_2O$
Billietite	$[(UO_2)_6O_4(OH)_6]^{\infty 2}Ba(H_2O){\cdot}7H_2O$
Compreignacite	$[(UO_2)_6O_4(OH)_6]^{\infty 2}K_2{\cdot}7H_2O$
Fourmarierite family (y = 4) $PbO\ (UO_2)_4(OH)_{4+2x} \cdot 4H_2O$	
Fourmarierite	$[(UO_2)_4O_{3-2x}(OH)_{4+2x}]^{\infty 2}Pb_{1-x}{\cdot}4H_2O$ or $[(UO_2)_4O_3(OH)_4]^{\infty 2}Pb{\cdot}4H_2O$
Richetite	$[(UO_2)_{36}O_{36}(OH)_{24}]^{\infty 2}(Fe^{3+},Mg)_xPb^{2+}{}_{8.6}{\cdot}41H_2O$
Agrinierite family	
Agrinierite (y = 3)	$[(UO_2)_3O_3(OH)_2](K_2,Ca,Sr){\cdot}H_2O$
Protasit (y = 3)	$[(UO_2)_3O_3(OH)_2]^{\infty 2}\ Ba(H_2O)_3$
Rameauite (y=1.5)	$[(UO_2)_3O_3(OH)_2]^{\infty 2}{}_2K_2Ca{\cdot}6H_2O$
Curite family	
Curite (y = 2.(6))	$[(UO_2)_4O_{4+x}(OH)_{3-x}]^{\infty 2}{}_2Pb_{3+x}(H_2O)_2$
Sayrite (y = 2.5)	$[(UO_2)_5O_6(OH)_2]^{\infty 2}Pb_2{\cdot}4H_2O$
*Spriggite (y = 2)	$[(UO_2)_6O_8(OH)_2]^{\infty 2}Pb_3{\cdot}3H_2O$
Masuyite (y=1.75)	$[(UO_2)_3O_3(OH)_2]^{\infty 2}Pb(H_2O)_3$

Clarkeite family (y = 2)
Wölsendorfite $[(UO_2)_{14}O_{19}(OH)_4]^{\infty 2}$ $Pb_7{\cdot}12H_2O$
Calciouranoite $[(UO_2)_2O_2(OH)_2]^{\infty 2}(Ca,Ba,Pb,K,Na){\cdot}4H_2O$ [1*]
Bauranoite $[(UO_2)_2O_2(OH)_2]^{\infty 2}Ba{\cdot}4H_2O$
Clarkeite $[(UO_2)_2O_2(OH)_2]^{\infty 2}$ $(Na,K,Ca,Pb){\cdot}nH_2O$
Uranosphaerite (y = 0.(6)) $[(UO_2)O_2(OH)]^{\infty 2}Bi$

3.1a.3.2. Uranilo-titanates
3.1a.3.2.1. Basic
Orthobrannerite $U^{+6}U^{+4}Ti_4O_{12}(OH)_2$ [2*] or $[(UO_2)_2(TiO_3)_4(OH)_2]^{\infty 2}U^{4+}$
*Cleusonite $Pb(U^{4+},U^{6+})(Ti,Fe^{2+},Fe^{3+})_{20}(O,OH)_{38}$
*Holfertite $U^{6+}_{2-x}Ti(O_{8-4x}OH_{4x})_{\Sigma 8}[(H_2O)_3Ca_x]$ →or $[(UO_2)_{2-x}TiO_{4-2x}(OH)_{4x}][(H_2O)_3Ca_x]$

3.1a.3.3a. Uranilo-molybdenic acids (hydrates)
Umohoite $[(UO_2)(MoO_4)(H_2O)_2]^{\infty 2}{\cdot}H_2O$ [3]
Iriginite $[(UO_2)(^{[6]}Mo_2O_7)(H_2O)_2]^{\infty 2}{\cdot}H_2O$
3.1a.3.3b. Uranilo-molybdates
3.1a.3.3b.1. Basic → acid
Deloryite group (x = 0.5; y = 0.25, where x=UO_2:MoO_4, y= UO_2:Me^{2+})
Deloryite $[(UO_2)(MoO_4)_2(OH)_6]^{\infty 2}{\cdot}Cu_4$
3.1a.3.3b.1.1. Hydrates
3.1a.3.3b.1.1.1. Basic → acid
Moluranite group (x = 0.43; y = 1,5)
Moluranite $H_4U^{4+}(UO_2)_3(MoO_4)_7 18H_2O$ [4*]
Urmolite family (x= (UO_2) : (MoO_4) = 1; y = (UO_2) : M^{2+}; 2 ≤ y ≤ 5)
Cousinite (y = 2) $[(UO_2)_2(MoO_4)_2(OH)_2]^{\infty 2}Mg{\cdot}5H_2O$
Calcurmolite (y = 3) $[(UO_2)_3(MoO_4)_2(OH)_{6-x}]^{\infty 2}(Ca_{1-x}Na_x)_2{\cdot}nH_2O$
* Unnamed 1 (y = 4) $[(UO_2)_4(MoO_4)_4(OH)_2]^{\infty 2}Ca_{1-x}Na_x{\cdot}10\text{-}14H_2O$
Unnamed 2 (y = 4) $[(UO_2)_4(MoO_4)_4(OH)_2]^{\infty 2}Na_2{\cdot}12H_2O$
Natrurmolite [4**] (y = 5) $[(UO_2)_5(MoO_4)_5(OH)_2]^{\infty 2}Na_2{\cdot}8H_2O$
Uranotungstite group (x = 2; y = 2)
Uranotungstite $[(UO_2)_2(WO_4)(OH)_4]^{\infty 2}Fe{\cdot}12H_2O$
3.1a.3.3b.1.1.2. Neutral
Tengchongite group (x = 3; y = 6)
Tengchongite $[(UO_2)_6(MoO_4)_2O_5]^{\infty 2}Ca{\cdot}12H_2O$

3.1a.3.4a. Uranylo-vanadic acids (hydrates)
Ferganite $[(UO_2)_3(V_2O_8)]^{\infty 2}{\cdot}6H_2O$
Uvanite $[(UO_2)_2(V_6O_{17})]^{\infty 2}{\cdot}15H_2O$
3.1a.3.4b. Uranyl-polyvanadates
3.1a.3.4b.1. Hydrates
3.1a.3.4b.1.1. Neutral

[1*] The structure formula is given by anlogy with bauranoite.
[2*] Metamict; the crystal structure formula is assigned from morfology and crystallochemical consideration .
[3*] Initial formula has been changed by putting out the $(MoO_4)^{2-}$ radical.
[4*] The name does not aprooved by the CNMMN IMA and is used after G. A. Sidorenko.

Rauvite group (x = 0.2; y = 2)
Rauvite $[(UO_2)_2(V_{10}O_{28})]^{\infty 2}Ca\cdot 16H_2O$
3.1a.3.4c. Uranylo-(5)-vanadates
3.1a.3.4c.1. Hydrates
3.1a.3.4c.1.1. Basic
Vanuralite family (x = 1; y = 1,(3))
Vanuralite $[(UO_2)_2(V_2O_8)(OH)]^{\infty 2}Al\cdot 11H_2O$
Metavanuralite $[(UO_2)_2(V_2O_8)(OH)]^{\infty 2}Al\cdot 8H_2O$
Tyuyamunite family
Tyuyamunite $[(UO_2)_2(V_2O_8)]^{\infty 2}Ca\cdot 5\text{-}8H_2O$
Metatyuyamunite $[(UO_2)_2(V_2O_8)]^{\infty 2}Ca\cdot 3\text{-}5H_2O$
Carnotite family (x = 1; y = 2)
Sengierite $[(UO_2)_2(V_2O_8)]^{\infty 2}Cu_2(OH)_2\cdot 6H_2O$
Strelkinite $[(UO_2)_2(V_2O_8)]^{\infty 2}Na_2\cdot 6H_2O$
Carnotite $[(UO_2)_2(V_2O_8)]^{\infty 2}K_2\cdot 3H_2O$
Margaritasite $[(UO_2)_2(V_2O_8)]^{\infty 2}$ $(Cs, H_3O, K)_2\cdot nH_2O$, где n=1
Curienite family (x = 1; y = 2)
Curienite $[(UO_2)_2(V_2O_8)]^{\infty 2\cdot}Pb(H_2O)_4\cdot H_2O$
Francevillite $[(UO_2)_2(V_2O_8)]^{\infty 2\cdot}(Ba,Pb)(H_2O)_4\cdot H_2O$

3.1a.3.4d. Uranylo-(4)-vanadates
3.1a.3.4d.1. Hydrates
3.1a.3.4d.1.1. Neutral
Fritzscheite (x=1; y=2) $[(UO_2)_2(VO_4,PO_4)_2]^{\infty 2}Mn^{2+}\cdot 4H_2O$ [5*]
*Mathesiusite $[(UO_2)_4(VO_5)(SO_4)_4]K_5(H_2O)_4$

3.1a.3.5a Uranylo-telluric acids (anhydrous)
Schmitterite $[(UO_2)_2(Te_2O_6)^{\infty 1}]^{\infty 2}$
Cliffordite $\{(UO_2)[Te_3O_7]^{\infty 3}\}^{\infty 3}$

3.1a.3.5b. Uranylo-tellurites
3.1a.3.5b.1. Neutral
Moctezumite $[(UO_2)Pb]^{\infty 2}(TeO_3)_2$
*Markcooperite $[(UO_2)(TeO_6)Pb_2]$

3.1a.3.6a. Uranylo-silica acids (hydrates)
*Uranosilite $[(UO_2)(Si_7O_{15})]$
Soddyite $[(UO_2)_2(H_2O)_2(SiO_4)]^{\infty 3.}$
3.1a.3.6b. Uranylo-silicates
3.1a.3.6b.1. Uranylo-mono-disilicates (κ = 1.2)
3.1a.3.6b.1.1. Hydrates
3.1a.3.6b.1.1.1. Basic
Magursilite group (x = 0.8; y=1)
Magursilite [4*] $[(UO_2)_4(Si_5O_{13})^{\infty 2}{}_2]^{\infty 3}Mg_4(OH)_4\cdot 15H_2O$[6*]

[5*] The structure formula is assigned from morphology and crystallochemical consideration of synthetic phase. There is no chemical analyses for original mineral.
[6*] The structure formula is assigned by A. A. Godovikov from physical properties, initial chemical analysis and crystallochemical consideration.

Ursilite (Calciumursilite)[7*] $[(UO_2)_4(Si_5O_{13})^{\infty 2}{}_2]^{\infty 3}Ca_4(OH)_4\cdot 15H_2O$ [6*]
Calcioursilite $[(UO_2)_4(Si_2O_5)_5]Ca_4(OH)_6\cdot 15H_2O$
3.1a.3.6b.1.1.2. Neutral
Weeksite family (x = 0.8; y = 2)
Haiweeite group
Metahaiweeite $[(UO_2)_2(Si_5O_{13})^{\infty 2}]^{\infty 3}Ca\cdot nH_2O$ [8*]
Haiweeite $[(UO_2)_2Si_5O_{12}(OH)_2]Ca\cdot 6H_2O$
Weeksite $[(UO_2)_2(Si_5O_{13})^{\infty 2}]^{\infty 3}(K,Na)_2(H_2O)_4$
*Coutinhoite $[(UO_2)_2(Si_5O_{13})]Th_xBa_{1-2x}\cdot 3H_2O$
*3.1a.3.6б.2. Uranylo-disilicates
*3.1a.3.6б.2.1. Hydrates
*Carlosbarbosaite $[(UO_2)_2(Nb^{5+}Si)O_6(OH)_2]Ca_{0.5}\square_{0.5}\cdot 2H_2O$

3.1a.3.6b.2. Uranylo-tetrasilicates
3.1a.3.6b.2.1. Hydrates
3.1a.3.6b.2.1.1. Neutral
Kasolite group (x = 1; y = 1)
Oursinite $(UO_2)_2(SiO_3OH)_2]^{\infty 2}(Co,Mg)\cdot 6H_2O$
Kasolite $[(UO_2)(SiO_4)]^{\infty 2}Pb(H_2O)$
3.1a.3.6b.2.1.2. Acid
Swamböite group (x = 1; y = 2)
Swamböite $[(UO_2)_6(SiO_3OH)_6]^{\infty 2}{}_3U^{6+}\cdot 30H_2O$
Sklodowskite family (x = 1; y = 2)
Sklodowskite $[(UO_2)_2(SiO_4H)_2]^{\infty 2}Mg\cdot(H_2O)_4\cdot 2H_2O$
Cuprosklodowskite $[(UO_2)_2(SiO_3OH)_2]^{\infty 2}Cu(H_2O)_4\cdot 2H_2O$
Uranophane $[(UO_2)_2(SiO_3OH)_2]^{\infty 2}Ca(H_2O)_4\cdot H_2O$
Beta-uranophane $[(UO_2)_2(SiO_3OH)_2]^{\infty 2}Ca(H_2O)_4\cdot H_2O$
*Uranophane mon. $[(UO_2)_2(SiO_3OH)_2]^{\infty 2}Ca(H_2O)_4\cdot H_2O$
Sodium boltwoodite $[(UO_2)(SiO_3OH)]^{\infty 2}(Na,K)(H_2O)$
Boltwoodite $[(UO_2)(SiO_3OH)]^{\infty 2}K(H_2O)$

3.1a.3.7a. Uranylo-phosphoric acids (hydrates)
Vanmeersscheite family (x = 1.5; y = 1.5)
Vanmeersscheite $[(UO_2)_3(PO_4)_2]U(OH)_6\cdot 4H_2O$
Metavanmeersscheite $[(UO_2)_3(PO_4)_2]U(OH)_6\cdot 2H_2O$

3.1a.3.7b. Uranylo-phosphates
3.1a.3.7b.1. Uranylo-phosphates f-cations
3.1a.3.7b.1.1. Basic
Althupite (x = 1.75; y = 2) $[(UO_2)_7O_2(OH)_5(PO_4)_4]AlTh\cdot 15H_2O$

3.1a.3.7b.1.2. Hydrates
3.1a.3.7b.1.2.1. Basic (x = 1.5; y = 2)
Francoisite-(Nd) $[(UO_2)_3O(OH)(PO_4)_2]^{\infty 2}\cdot Nd\cdot 6H_2O$
*Francoisite-(Ce) $[(UO_2)_3O(OH)(PO_4)_2]^{\infty 2}Ce\cdot 6H_2O$

[7*] The name does not aprooved by the CNMMN IMA and is used after A. A. Chernikov.
[8*] The structure formula is assigned from morphology which is close to morphology of weeksite, initial chemical analysis and crystallochemical consideration.

3.1a.3.7b.2. Uranylo-phosphates ***s***-, ***d_s***- и ***p_s***-cations
3.1a.3.7b.2.1. Actually uranylo-phosphates ($x = UO_2 : PO_4$, $y = UO_2 : Me^{2+}$)
3.1a.3.7b.2.1.1. Hydrates
3.1a.3.7b.2.1.1.1. Basic

Kamitugaite (x = 2.5; y = 2)	$[(UO_2)_5((P,As)O_4)_2(OH)_9]^{\infty 2}PbAl\cdot 9,5H_2O$
Renardite (x = 2; y = 2)	$[(UO_2)_2(PO_4)(OH)_2]_2^{\infty 2}Pb\cdot 7H_2O$
Mundite family	
Mundite (x = 1.5; y = 2)	$[(UO_2)_3O(OH)(PO_4)_2]^{\infty 2}Al\cdot 6,5H_2O$
Upalite (x = 1.5; y = 2)	$[(UO_2)_3O(OH)(PO_4)_2]^{\infty 2}Al(H_2O)_5\cdot 2H_2O$
Dumontite family	
Dumontite group (x = 1.5; y = 1.5)	
Phurcalite	$[(UO_2)_3O_2(PO_4)_2]^{\infty 2}Ca_2(H_2O)_7$
Dumontite	$[(UO_2)_3O_2(PO_4)_2]^{\infty 2}Pb_2(H_2O)_5$
Bergenite	$[(UO_2)_3O_2(PO_4)_2]^{\infty 2}(Ba_{1.33}Ca_{0.67})_2\cdot 16H_2O$ (Ba: Ca=2)
Dewindtite group (x = 1.5; y = 1)	
Dewindite	$[H(UO_2)_3(PO_4)_2O_2)]^{\infty 2}{}_2Pb_3(H_2O)_9\cdot 3H_2O$
Phosphuranylite family	
Phosphuranylite (x = 1.75; y = 2.(3))	$\{[(UO_2)_3(PO_4)_2O_2]^{\infty 2}{}_2(UO_2)\}^{\infty 3}(H_3O)_3KCa(H_2O)_8$
Yingjiangite (x = 1.75; y = 3.5)	$[(UO_2)_7(PO_4)_4(OH)_6]K_2Ca\cdot 6H_2O$
Threadgoldite (x=1; y = 1.(3))	$[UO_2)_2(PO_4)_2]^{\infty 2}Al(OH)(H_2O)_4\cdot 4H_2O$
Phuralumite (x = 1.5; y = 1)	$[(UO_2)_3O(OH)(PO_4)_2]^{\infty 2}Al_2(OH)_3\cdot 11H_2O$
Triangulite (x = 1; y = 0.(8))	$[(UO_2)_4(PO_4)_4(OH)_5]^{\infty 2}Al_3\cdot 5H_2O$
Vochtenite (x = 1; y = 1.6)	$[(UO_2)_4(PO_4)_4(OH)]^{\infty 2}(Fe,Mg)Fe^{3+}\cdot(12\text{-}13)H_2O$
*Lakebogaite (x = 0.5; y = 0.4)	$[(UO_2)_2(PO_4)_4(OH)_2]CaNaFe^{3+}{}_2H\cdot 8H_2O$
Moreauite (x = 0.(3); y = 0.(2))	$[(UO_2)(PO_4)_2]^{\infty 2}Al_3(PO_4)(OH)_2\cdot 13H_2O$
Ranunculite (x = 1; y = 0.5)	$[(UO_2)(PO_4)]^{\infty 2}HAl(OH)_3\cdot 4H_2O$
Furongite (x = 1; y = 0.(3))	$[(UO_2)_7(PO_4)_{13}]^{\infty 2}Al_{13}(OH)_{14}\cdot 58H_2O$

3.1a.3.7b.2.1.1.2. Neutral

Torbernite family (y = 2)	
Torbernite group	
α-Torbernite (tetrag.)	$[(UO_2)_2(PO_4)_2]^{\infty 2}Cu(H_2O)_4\cdot 8H_2O$
β-Torbernite (tricl.)	$[(UO_2)_2(PO_4)_2]^{\infty 2}Cu(H_2O)_4\cdot 8H_2O$
*Metasaleeite	$[(UO_2)_2(PO_4)_2]Mg\cdot 8H_2O$
Saleeite	$[(UO_2)_2(PO_4)_2]^{\infty 2}Mg(H_2O)_4\cdot 6H_2O$
Autunite	$[(UO_2)_2(PO_4)_2]^{\infty 2}Ca\ 11H_2O$
*Uranospatite	$[(UO_2)(PO_4)]_2Al_{1-x}\square_x(H_2O)_{20+3x}F_{1-x}$, 0< x <0,33
Metatorbernite group	
Metatorbernite	$[(UO_2)_2(PO_4)_2]^{\infty 2}Cu(H_2O)_8$
Przhevalskite group	
Przhevalskite	$[(UO_2)(PO_4)]^{\infty 2}{}_2Pb\cdot 4H_2O$
Sabugalite family (y = 2)	
Sabugalite	$[(UO_2)_4(PO_4)_4]^{\infty 2}HAl(H_2O)_4\cdot 8H_2O$
Bassetite	$[(UO_2)_2(PO_4)_2]^{\infty 2}Fe^{2+}(H_2O)_4\ (H_2O)_4$
Lehnerite	$[(UO_2)_2(PO_4)_2]^{\infty 2}Mn^{2+}(H_2O)_4(H_2O)_4$
Meta-uranocircite I	$[(UO_2)_2(PO_4)_2]^{\infty 2}Ba(H_2O)_8$
Meta-uranocircite II	$[(UO_2)_2(PO_4)_2]^{\infty 2}Ba(H_2O)_6$

(synthetic phase)
Uranocircite group
Uranocircite $[(UO_2)_2(PO_4)_2]^{\infty 2}Ba\cdot 10H_2O$
Meta-autunite group
Meta-autunite $[(UO_2)_2(PO_4)_2]^{\infty 2}Ca(H_2O)_{6-8}$
*Metanatroautunite = natroautunite $[(UO_2)_2(PO_4)_2]Na_2\cdot 7H_2O$
Meta-ankoleite $[(UO_2)(PO_4)]^{\infty 2}K(H_2O)_3$
Uramphite $[(UO_2)(PO_4)]^{\infty 2}(NH_4)(H_2O)_3$
*Metauramphite $[(UO_2)_2(PO_4)_2](NH_4)_2\cdot 6H_2O$
Chernikovite $[(UO_2)(PO_4)]^{\infty 2}(H_3O)(H_2O)_3$
Parsonsite family (y = 0.5)
Ulrichite $[(UO_2)(PO_4)_2]^{\infty 2}CaCu(H_2O)_4$
Parsonsite $[(UO_2)(PO_4)_2]^{\infty 2}Pb_2(H_2O)$

3.1a.3.7b.2.2. Uranylo-phosphato-sulfates
3.1a.3.7b.2.2.1. Hydrates
3.1a.3.7b.2.2.1.1. Basic
Xiangjiangite (y = 2.(6)) $[(UO_2)_4(PO_4)_2(SO_4)_2(OH)]^{\infty 2}(Fe^{3+},Al)\cdot 22H_2O$
Coconinoite (y=0.(3)) $[(UO_2)_2(PO_4)_4(SO_4)](Al,Fe^{3+})_4(OH)_2\cdot 18\text{-}20H_2O$

*3.1a.3.7c Uranylo-bismuthilo-phosphates
*Phosphowalpurgite $[(UO_2)(BiO)_4(PO_4)_2]\cdot 2H_2O$
*Šreinite $[(UO_2)_4(BiO)_3(PO_4)_2]Pb(OH)_7\cdot 4H_2O$

3.1a.3.8a. Uranylo-arsenic acids
Trögerite $[(UO_2)(AsO_4)](H_3O)\cdot 3H_2O$

3.1a.3.8b. Uranylo-arsenates
3.1a.3.8b.1. Neutral
*Chistyakovaite (y=1.3) $[(UO_2)_2(AsO_4)_2(F,OH)]Al\cdot 6H_2O$
Hallimondite (y=0.5) $[(UO_2)(AsO_4)_2]^{\infty 2}Pb_2$
3.1a.3.8b.2. Hydrates
3.1a.3.8b.2.1.Basic
Arsenuranylite (y=4) $[(UO_2)_4(AsO_4)_2]Ca(OH)\cdot 6H_2O$
Hüegelite (y=1.5) $[(UO_2)_3O_2(AsO_4)_2]^{\infty 2}Pb_2(H_2O)_5$[9*]
3.1a.3.8b.2.2. Neutral
*Uramarsite $[(UO_2)(AsO_4)]NH_4\cdot 3H_2O$
Uranospinite family (y = 2;)
Novacekite group
Novacekite-II $[(UO_2)_2(AsO_4)_2]^{\infty 2}Mg\cdot 10H_2O$
Uranospinite $[(UO_2)_2(AsO_4)_2]^{\infty 2}Ca(H_2O)_4\cdot 6H_2O$
Heinrichite $[(UO_2)_2(AsO_4)_2]^{\infty 2}Ba(H_2O)_8\cdot(2\text{-}4)H_2O$
Zeunerite family(y=2)
Zeunerite $[(UO_2)_2(AsO_4)_2]^{\infty 2}Cu(H_2O)_4\cdot 8H_2O$
Kirchheimerite $[(UO_2)_2(AsO_4)_2]^{\infty 2}Cu(H_2O)_4\cdot 8H_2O$
Meta-uranospinite $[(UO_2)_2(AsO_4)_2]^{\infty 2}Ca(H_2O)_4\cdot 4H_2O$
Meta-Na-uranospinite $[(UO_2)_2(AsO_4)_2]^{\infty 2}Na_2\cdot 5H_2O$

[9*] The structure formula is assigned on the analogy of dumontite.

Metalodevite	$[(UO_2)_2(AsO_4)_2]^{\infty2}Zn(H_2O)_4{\cdot}6H_2O$
Metaheinrichite	$[(UO_2)_2(AsO_4)_2]^{\infty2}Ba(H_2O)_8$
Metazeunerite family (y=2)	
Metazeunerite	$[(UO_2)_2(AsO_4)_2]^{\infty2}Cu(H_2O)_4{\cdot}4H_2O$ or $[(UO_2)(AsO_4)]^{\infty2}{}_2Cu\ (H_2O)_8$
Novacekite-I	$[(UO_2)_2(AsO_4)_2]^{\infty2}Mg(H_2O)_4{\cdot}8H_2O$
Metanováčekite	$[(UO_2)_2(AsO_4)_2]^{\infty2}Mg(H_2O)_4{\cdot}2\text{-}4H_2O$
Kahlerite	$[(UO_2)_2(AsO_4)_2]^{\infty2}Fe^{2+}(H_2O)_4{\cdot}8H_2O$
*Metarauchite	$[(UO_2)_2(AsO_4)_2]Ni{\cdot}8H_2O$
*Rauchite	$[(UO_2)_2(AsO_4)_2]Ni{\cdot}10H_2O$
Arsenuranospathite	$[(UO_2)_2(AsO_4)_2]AlF{\cdot}20H_2O$
Abernathyite family (y=2)	
Metakirchheimerite	$[(UO_2)_2(AsO_4)_2]^{\infty2}Co(H_2O)_4{\cdot}4H_2O$
Metakahlerite	$[(UO_2)_2(AsO_4)_2]^{\infty2}Fe^{2+}(H_2O)_4{\cdot}4H_2O$
Sodium uranospinite	$[(UO_2)_2(AsO_4)_2]^{\infty2}(Na_2,Ca)(H_2O)_4{\cdot}6H_2O$
Abernathyite	$[(UO_2)(AsO_4)]^{\infty2}K(H_2O)_3$
*Nielsbohrite	$[(UO_2)_3(AsO_4)]K(OH)_4{\cdot}H_2O$
H-metauranospinite	$[(UO_2)(AsO_4)]^{\infty2}(H_3O)(H_2O)_3$

*3.1a.3.8в. Uranylo-arsenato-arsenites
*3.1a.3.8в.1. Hydrates

*Seelite	$[(UO_2)(AsO_3)_x(AsO_4)_{1-x}]^{\infty2}{}_2Mg{\cdot}7H_2O$ (x = ~ 0,7)

*3.1a.3.8г. Uranylo-arsenous acids

*Chadwikite	$(UO_2)H(AsO_3)$

*3.1a.3.8г.1. Hydrates

*Mineral D	$(UO_2)H(AsO_3){\cdot}H_2O$
*Štěpite	$(UO_2)H_2(AsO_3)_2{\cdot}4H_2O$

*3.1a.3.8д. Uranylo-arsenites
*3.1a.3.8д.1. Hydrates

*Dymkovite	$[(UO_2)_2(As^{3+}O_3)_2]Ni{\cdot}7H_2O$

3.1a.3.9a. Uranylo-bismuthilo-arsenic acids (hydrates)

Walpurgite	$[(UO_2)(BiO)_4(AsO_4)_2]^{\infty2}{\cdot}2H_2O$

3.1a.3.9b. Uranylo-bismuthilo-arsenates
3.1a.3.9b.1. Hydrates
3.1a.3.9b.1.1. Basic

Asselbornite (y=4)	$[(UO_2)_4(BiO)_3(AsO_4)_2]Pb(OH)_7{\cdot}4H_2O$

3.1a.3.10a. Uranylo-carbonic acids

Rutherfordine family	
Rutherfordine	$[(UO_2)(CO_3)]^{\infty2}$
*Blatonite	$[(UO_2)(CO_3)]^{\infty2}{\cdot}H_2O$
Joliotite	$[(UO_2)(CO_3)]^{\infty2}{\cdot}1{,}5\text{-}2H_2O$
*Oswaldpeetersite	$(UO_2)_2(CO_3)(OH)_2{\cdot}4H_2O$

3.1a.3.10 b. Uranylo-carbonates

3.1a.3.10 b.1. Uranylo-carbonates **f**-cations

3.1a.3.10 b.1.1. Hydrates

3.1a.3.10 b.1.1.1. Oxido-uranylo-carbonates

Kamotoite-(Y) (y=1.(3)) $[(UO_2)_4O_4(CO_3)_3]^{\infty 2}(Y,REE)_2\cdot 14H_2O$

3.1a.3.10 b.1.1.2. Basic

Bijvoetite -(Y) (y=0.(6)) $[(UO_2)_{16}(OH)_8O_8(CO_3)_{16}(H_2O)_{25}(Y,REE)_8](H_2O)_{14}$

Wyartite (y=2.(3)) $[(UO_2)_2O_4(OH)(CO_3)]^{\infty 2}CaU^{5+}\cdot 7H_2O$

Astrocyanite-(Ce) (y=0.2) $[(UO_2)(CO_3)_3]^{\infty 2}Cu_2Ce_2(CO_3)_2(OH)_2\cdot 1,5H_2O$

Shabaite -(Nd) (y=0.25) $[(UO_2)(CO_3)_3]^{\infty 2}CaNd_2(CO_3)(OH)_2\cdot 6H_2O$

*3.1a.3.10б.1.1.3. Silicato-uranilo-carbonates

*Lepersonnite-(Gd) $[(UO_2)_{24}(CO_3)_8(Si_4O_{28})]CaGd_2\cdot 60H_2O$

3.1a.3.10 b.2. Uranylo-carbonates ***s***-, $\boldsymbol{d_s}$- и $\boldsymbol{p_s}$-cations

3.1a.3.10 b.2.1. Actually uranilo-carbonates

3.1a.3.10 b.2.1.1. Neutral

Widenmannite (y=0.5) $[(UO_2)(OH)_2(CO_3)_3]Pb_2$

*Čejkaite (y = 0,5) $[(UO_2)(CO_3)_3]Na_4$

*Agricolaite $[(UO_2)(CO_3)_3]K_4$

3.1a.3.10 b.2.1.2. Hydrates

3.1a.3.10 b.2.1.2.1. Basic

Sharpite (y=6) $[(UO_2)_6(OH)_4(CO_3)_5]Ca\cdot 6H_2O$

Urancalcarite (y=3) $[(UO_2)_3(OH)_6(CO_3)]^{\infty 3}Ca(H_2O)_3$

Roubaultite (y=1.5) $[(UO_2)_3O_2(OH)_2(CO_3)_2]^{\infty 2}Cu_2(H_2O)_4$

3.1a.3.10 b.2.1.2.2. Neutral

Zellerite family (y = 1)

Fontanite $[(UO_2)_3O_2(CO_3)_2]Ca\ (H_2O)_6$

Zellerite $[(UO_2)(CO_3)_2]^{\infty}Ca(H_2O)_3\cdot 2H_2O$

Metazellerite $[(UO_2)(CO_3)_2]^{\infty}Ca(H_2O)_3$

Liebigite family (y = 0.5)

Bayleyite $[(UO_2)(CO_3)_3](Mg(H_2O)_6)_2\cdot 6H_2O$

Swartzite $[(UO_2)(CO_3)_3]\ {}^{[8]}Ca(H_2O)_6\cdot {}^{[6]}Mg(H_2O)_6$

Liebigite $[(UO_2)(CO_3)_3]Ca_2(H_2O)_8\cdot 3H_2O$

Andersonite $[(UO_2)(CO_3)_3]Na_2Ca(H_2O)_5\cdot H_2O$

Grimselite $[(UO_2)(CO_3)_3]K_3Na\cdot H_2O$

*Synthetical $[(UO_2)(CO_3)_3]K_2Ca(H_2O)_6$

*Braunerite $[(UO_2)(CO_3)_3]K_2Ca\cdot 6H_2O$

*Linekite $[(UO_2)(CO_3)_3]_2K_2Ca_3\cdot 7H_2O$

Voglite (y = 0.(3)) $[(UO_2)(CO_3)_4]Ca_2Cu(H_2O)_6$

Rabbittite family

Albrechtschraufite (y = 0.4) $[(UO_2)(CO_3)_3]_2Ca_4MgF_2(H_2O)_{13}\cdot 17H_2O$

Rabbittite (y = 0.(3)) $[(UO_2)_2(CO_3)_6]^{\infty 2}Ca_3Mg_3(OH)_4\cdot 18H_2O$

Znucalite (y=0.08) $[(UO_2)(CO_3)_3]^{\infty 2}CaZn_{11}(OH)_{20}(H_2O)_4$

*3.1a.3.10б.2.2. Uranylo-carbonato-sulfates

*3.1a.3.10б.2.2.1. Hydrates

*Ježekite $[(UO_2)(CO_3)_3](SO_4)_2Na_8(H_2O)_4$

3.1a.3.10 b.2.3. Uranylo-carbonato + sulfato-fluorides

3.1a.3.10 b.2.3.1. Neutral

Schröckingerite (y=0.3) $\{[(UO_2)(CO_3)_3]\ {}^{[6]}Na(H_2O)_3{}^{[8]}Ca_3(SO_4)F(H_2O)_3\}^{\infty 2}\cdot 4H_2O$

3.1a.3.11. Uranylo-selenites
3.1a.3.11.1. Hydrates
3.1a.3.11.1.1. Basic
Marthozite (y =3) $[(UO_2)_3O_2(Se^{4+}O_3)_2]^{\infty 2}Cu^{2+}(H_2O)_8$
Guilleminite (y = 3)* $[(UO_2)_3O_2(SeO_3)_2]^{\infty 2}Ba\cdot 3H_2O$
*Larisaite $[(UO_2)_3O_2(Se^{4+}O_3)_2]^{\infty 2}Na(H_3O)\cdot 4H_2O$
3.1a.3.11.1.2. Basic
*Piretite (y = 3) $[(UO_2)_3(Se^{4+}O_3)_2(OH)_4]^{\infty 2}Ca\cdot 4H_2O$
Demesmaekerite (y = 0.28) $[(UO_2)_2(SeO_3)_6]^{\infty 1}[Cu_5(OH)_6(H_2O)_2Pb_2]^{\infty 2}$
Derriksite (y = 0.25) $[(UO_2)(SeO_3)_2]^{\infty 1}[Cu_4(OH)_6]^{\infty 2.}$
Haynesite $[(UO_2)_3(OH)_2(SeO_3)_2]^{\infty 2}\cdot 5H_2O$ [1]*

*3.1a.3.12a. Uranylo-sulfuric acids (hydrates) *3.1a.3.12a.1. Neutral
*Shumwayite $[(UO_2)_2(SO_4)_2]\cdot 5H_2O$
*3.1a.3.12a.2. Basic
*Jachymovite $[(UO_2)_8(SO_4)(OH)_{14}]^{\infty 2}\cdot 13H_2O$

*3.1a.3.12б. Uranylo-sulfates
*3.1a.3.12б.1. Uranylo-sulfates ***s-, d_s-, u p_s***-cations
*3.1a.3.12б.1.1. Neutral *3.1a.3.12б.1.1.1. Hydrates
*Beshtauite $[(UO_2)(SO_4)_2](NH_4)_2\cdot 2H_2O$
*Geschieberite $[(UO_2)(SO_4)_2]K_2\cdot 2H_2O$
*Klaprothite monoclinic $[(UO_2)(SO_4)_4]Na_6\cdot 4H_2O$
*Peligotite triclinic $[(UO_2)(SO_4)_4]Na_6\cdot 4H_2O$
*Ottohahnite $[(UO_2)_2(SO_4)_5]Na_6(H_2O)_7\cdot 1.5H_2O$
*Bobcookite $[(UO_2)_2(SO_4)_4]NaAl\cdot 18H_2O$
*Wetherillite $[(UO_2)_2(SO_4)_4]Na_2Mg\cdot 18H_2O$
*Svornostite $[(UO_2)(SO_4)_2]_2K_2Mg\cdot 8H_2O$
*Oppenheimerite $[(UO_2)(SO_4)_2]\ Na_2\cdot 3H_2O$
*Fermiite $[(UO_2)(SO_4)_3]Na_4\cdot 3H_2O$
*3.1a.3.12б.1.1.1.1. Basic
*Adolfpateraite (y = 2) $[(UO_2)(SO_4)(OH)]K\cdot H_2O$
*3.1a.3.12б.1.1.1.1.1. Hydrates
Metauranopilite
*Plašilite $[(UO_2)_2(SO_4)(OH)]Na\cdot 2H_2O$
Rabejacite (y = 2) $[(UO_2)_4O_4(SO_4)_2]^{\infty 2}Ca_2\cdot 8H_2O$
Meta-uranopilite $[(UO_2)_6(SO_4)(OH)_{10}]^{\infty 2}\cdot 5H_2O$
Nickel-zippeite group (y = 3)
Zinczippeite $[(UO_2)_2O_2(SO_4)]^{\infty 2}Zn\cdot 3.5H_2O$
Magnesiozippeite $[(UO_2)_6(SO_4)_3(OH)_{10}]^{\infty 2}Mg_2\cdot 16H_2O$
Nickelzippeite $[(UO_2)_6(SO_4)_3(OH)_{10}]^{\infty 2}Ni_2\cdot 16H_2O$
Deliensite $[(UO_2)_2(SO_4)_2(OH)_2]^{\infty 2}Fe\cdot 7H_2O$
Johannite $[(UO_2)_2(OH)_2(SO_4)_2]^{\infty 2}Cu(H_2O)_4\cdot 4H_2O$ (y = 2)

*3.1a.3.12б.2. Oxido-uranylo-sulfates ***s-, d_s-, u p_s***-cations
*3.1a.3.12б.2.1. Hydrates
Zippeite group

Sodium zippeite (y = 1,5)	$[(UO_2)_8O_5(SO_4)_4]Na_5(OH)_3 \cdot 12H_2O$
Zippeite (y = 1,5)	$[(UO_2)_4O_3(SO_4)_2]K_3(OH) \cdot 3H_2O$
Cobaltzippeite	$[(UO_2)_2O_2(SO_4)]Co\ 3.5H_2O$
*Plavnoite	$[(UO_2)_2O_2(SO_4)]K_{0.8}Mn_{0.6} \cdot 3.5H_2O$
*Pseudojohannite (y = 1,2)	$[(UO_2)_4O_4(SO_4)_2(OH)_2]Cu_3 \cdot 12H_2O$
Uranopilite	$[(UO_2)_6(SO_4)O_2(OH)_6(H_2O)_6]^{\infty 2}\ (H_2O)_8$
*Marécottite	$[(UO_2)_8O_6(SO_4)_4]Mg_3(OH)_2 \cdot 28H_2O$

*3.1a.3.12б.3. Uranylo-sulfato-sulfites

*3.1a.3.12б.3.1. Basic *3.1a.3.12б.3.1.1. Hydrates

*Meisserite	$[(UO_2)(SO_4)_3(SO_3OH)]Na_5(H_2O)$
*Belakovskiite	$[(UO_2)(SO_4)_4(SO_3OH)]Na_7(H_2O)_3$

*3.1a.3.12б.4. Uranylo-sulfato-chlorides *3.1a.3.12б.4. 1. Hydrates

*Bluelizardite	$[(UO_2)(SO_4)_4]Na_7Cl(H_2O)_2$

*3.1a.3.12б.3. Uranylo-sulfates ***f***-cations

*3.1a.3.12.1.3. Basic *3.1a.3.12.1.3.1. Hydrates

*Sejkoraite-(Y)	$[(UO_2)_8O_6(SO_4)_4(OH)_2]Y_2 \cdot 26H_2O$

3.1b. QUASISUBTIPE AND HYDROXIDES LITHOPHYLIC CATION WITH MIDDLE FC

3.1б.1. **Overclass***: Oxides of Zr

3.1b.1a. ***Class***: Simple oxides of Zr

3.1b.1a.1. Neutral

Baddeleyite family

Baddeleyite	ZrO_2

3.1b.1b. ***Class:*** Complex oxides of Zr^{4+} →titanates of Zr^{4+} → zirconotitanates

3.1b.1b.1. Neutral

*Lakargiite	$Ca(Zr,Ti,Sn)O_3$ или $CaZrO_3$
Srilankite	$ZrTi_2O_6$
*Zirconolite-2M	$CaZrTi_2O_7$
*Zirconolite-3O	$CaZrTi_2O_7$
*Zirconolite-3T	$CaZrTi_2O_7$
Tazheranite	$Ca_2Zr_5Ti_2O_{16}$
Calzirtite	$Ca_2Zr_5Ti_2O_{16} \rightarrow {}^{(8)}Ca^{(8)}(CaZr)_{\Sigma 2}{}^{(7)}Zr_4{}^{(6)}Ti_2O_{16}$
*Calzirtite orth.	$Ca_2Zr_5Ti_2O_{16}$
*Hiärneite	$(Ca,Mn^{2+},Na)_2(Zr,Mn^{3+})_5(Sb^{5+},Ti,Fe^{3+})_2O_{16}$
Zirkelite	$(Ti,Ca,Zr)O_{2-x}$
*Laachite	$(Ca,Mn)_2Zr_2Nb_2TiFeO_{14}$
*Elbrusite-(Zr)	$Ca_3(Zr_{1.5}U^{6+}{}_{0.5})Fe_3{}^{3+}O_{12}$
*Polymignite	$(Ca,Fe,Y,Th)(Nb,Ti,Ta,Zr)O_4$
*Unnamed	$(Gd,Ce,Ca,La,U)_4ZrTi_2O_{12}$

*3.1б.1б.1.1. Hydrates

*Menesezite	$Ba_2MgZr_4(BaNb_{12}O_{42}) \cdot 12H_2O$
*Allendeite	$Sc_4Zr_3O_{12}$

3.1b.2. **Overclass***: Oxides of Sn^{4+} and Ti^{4+}

3.1b.2a. ***Class:*** Simple oxides and hydroxides of Sn^{4+} and Ti^{4+}

3.1b.2a.1. Oxides of Sn^{4+} 3.1b.2a.1.1. Neutral

Cassiterite	SnO_2

3.1b.2a.2. Hydroxides of Sn^{4+}

3.1b.2a.2.1. Simple — 3.1b.2a.2.1.1. Oxido-hydroxides

Varlamoffite	$(Sn,Fe)^{2+}(O,OH)_2$

3.1b.2a.2.2. Complex (hydrostannates)

3.1b.2a.2.2.1. Neutral

Schoenfliesite	$Mg[Sn^{4+}(OH)_6]$
Stottite group	
Jeanbandyite	$(Fe^{3+},Mn^{2+})[Sn^{4+}(OH,O)_6]$
Tetrawickmanite	$Mn^{2+}[Sn^{4+}(OH)_6]$
Stottite	$Fe^{2+}[Ge^{4+}(OH)_6]$
Wickmanite group	
Vismirnovite	$Zn[Sn^{4+}(OH)_6]$
Mushistonite	$(Cu,Zn,Fe)[Sn^{4+}(OH)_6]$
Natanite	$Fe^{2+}[Sn^{4+}(OH)_6]$
Wickmanite	$(Mn,Ca)[Sn^{4+}(OH)_6]$
Burtite	$Ca[Sn^{4+}(OH)_6]$

3.1b.2a.3. Simple oxides of Ti^{4+} — 3.1b.2a.3.1. Neutral

Rutile family	
Rutile	TiO_2
Brookite	TiO_2
Anatase	TiO_2
*Monoclinic	TiO_2
*Orthorhombic. TiO_2 with structure α-PbO_2	TiO_2
*Akaogiite	TiO_2
Ilmenorutile series	
Ilmenorutile	$Fe_x(Nb,Ta)_{2x}$ $4Ti_{1-x}O_2$
Strüverite	$(Ti,Ta,Fe^{3+})O_2$

*3.1б.2a.3.1.2. Basic $(Ti,Cr,Fe)(O,OH)_2$

*Carmaichaelite	$(Ti,Cr,Fe)(O,OH)_2$

3.1b.2b. ***Class***: Complex oxides of Ti^{4+} (Sn^{4+}) → titanates (stannates) (only (6)-titanates, (6)- stannates)

3.1b.2b.1. Titanates of ***s***-, ***d$_s$***- and ***p$_s$***-cations

3.1b.2b.1.1. M^{3+}(Fe^{3+}, Cr^{3+}, V^{3+}, Al^{3+})

3.1b.2b.1.1.1. Neutral

Pseudorutile family	
Pseudorutile	$Fe^{3+}{}_2Ti_3O_9$
Schreyerite	$V^{3+}{}_2Ti_3O_9$
Kyzylkumite	$V^{3+}{}_2Ti_3O_9$
*Olkhonskite	$(Cr,V)_2Ti_3O_9$
*Unnamed	$(Cr,V)_2Ti_4O_{11}$
*Unnamed	$(Cr,V)_2Ti_2O_7$
Pseudobrookite family	
Pseudobrookite	$Fe^{3+}{}_2TiO_5$
*Panguite	$(Ti,Sc,Al,Mg,Zr,Ca)_{1.8}O_3$ or $(Ti,Sc,Al,Mg,Zr,Ca)_3O_5$
*Kangite	$(Sc,Ti,Al,Zr,Mg,Ca,□)_2O_3$

Berdesinskiite $V^{3+}{}_2TiO_5$
*Oxyvanite $V^{3+}{}_2V^{4+}O_5$
Priderite family (compare with cryptomelane (group))
Priderite $K(Ti_7{}^{4+}Fe^{3+})O_{16}$
*Batiferrite $(Ti_2Fe^{3+}{}_8Fe^{2+}{}_2)O_{19}\cdot Ba$
*Haggertyite $[(Ti^{4+}{}_5Fe^{2+}{}_4Fe^{3+}{}_2Mg)O_{19}]Ba$
*Henrymeyerite $(Ti_7Fe)O_{16}\cdot Ba$
*Ankangite (discredited) $(Ti,V^{3+},Cr^{3+})_8O_{16}Ba$
Mannardite group
Mannardite $|V^{3+}{}_2Ti_6O_{16}|^{\infty 3}Ba$
Redledgeite $|Cr^{3+}{}_2Ti_6O_{16}|^{\infty 3}Ba$ or $Ba_x[(Cr,Fe,V)^{3+}{}_{2x}Ti_{8-2x}]O_{16}$

3.1b.2b.1.1.2. Basic

Tivanite $V^{3+}Ti(OH)O_3$

3.1b.2b.1.2. M^{3+} and M^{2+}

3.1b.2b.1.2.1. Neutral

Senaite series (compare with crichtonite (series))
Landauite $(Na,Pb)(Mn^{2+},Y)(Zn,Fe)_2(Ti,Fe^{3+},Nb)_{18}(O,OH,F)O_{38}$ → or $^{(12)}Na\{^{(6)}(Ti^{4+}{}_{15}Fe^{3+}{}_3Mn^{2+})_{\Sigma 19}(O,OH,F)O_{30}|^{(4)}ZnO_4|_2\}^{\infty 3}$
Senaite $Pb(Mn,Y,U)(Fe,Zn)_2(Ti,Fe,Cr,V)_{18}O_{38}$ → or $Pb\{(Ti,Fe,Mn)_{19}O_{30}|^{(4)}(Fe,Mn)O_4|_2\}^{\infty 3}$
Lindsleyite $(Ba,Sr)(Zr,Ca)(Fe,Mg)_2(Ti,Cr,Fe)_{18}O_{38}$
Mathiasite $(K,Ba)(Zr,Ca)(Fe,Mg)_2)(Ti,Cr)_{18}O_{38}$ → or $(K,Ba)\{^{(6)}(Ti,Cr)_{18}O_{30}|^{(4)}(Fe,Mg)O_4|_2\}^{\infty 3}$
Hibonite group (compare with magnetoplumbite (group))
Hibonite $(Ca,TR)(Al,Mg,Ti)_{12}O_{19}$
*Hibonite-(Fe) $(Fe,Mg)Al_{12}O_{19}$
Hawthorneite $Ba(MgCr^{3+}{}_4Fe^{2+}{}_2Fe^{3+}{}_2Ti^{4+}{}_3)_{\Sigma 12}O_{19}$
Yimengite $K(Cr,Ti,Fe,Mg)_{12}O_{19}$
*Shulamitite $Ca_3TiFe^{3+}AlO_8$
Uhligite $Ca_3(Ti,Al,Zr)_9O_{20}$ (?)
Jeppeite $(K,Ba)_2(Ti,Fe^{3+})_6O_{13}$
Kennedyite $MgFe^{3+}{}_2Ti_3O_{10}$

*3.1б.2б.1.2.2. Oxido-hydroxides

*Almeidaite $PbZn_2(Mn,Y)(Ti,Fe^{3+})_{18}O_{36}(OH,O)_2$
Polysomatic series of **magnesiohögbomite**
*Magnesiohögbomite-2N2S $Mg_6(Al_{14}Ti_2)O_{30}(OH)_2$
*Magnesiohögbomite-2N3S $Mg_8(Al_{18}Ti_2)O_{38}(OH)_2$
*Magnesiohögbomite-6N6S $Mg_{18}(Al_{42}Ti_6)O_{90}(OH)_6$
Högbomit series
Högbomit-10T= *magnesiohögbomite-2N2S
Högbomit-15R = *magnesiohögbomite-6N6S
Högbomit-18R= *magnesiohögbomite-6N6S
* *Högbomit-24R*= *magnesiohögbomite6N6S
*Zincohögbomit-2N2S $Zn_6(Al_{14}Ti_2)_{\Sigma 16}O_{30}(OH)_2$
* Zincohögbomi-2N6S $Zn_{14}(Al_{30}Ti_2)_{\Sigma 32}O_{62}(OH)_2$

* Ferrohögbomit-2N2S	$(Fe^{2+}{}_3ZnMgAl)_{\Sigma 6}(Al_{14}Fe^{3+}Ti^{4+})_{\Sigma 16}O_{30}(OH)_2$

3.1b.2b.1.2.2. Basic

Nigerite family

*Magnesionigerite-2N1S = пенчжичжуанит	$Mg_4(Al_{10}Sn_2)_{\Sigma 12}O_{22}(OH)_2$
*Magnesionigerite-6N6S	$Mg_{18}(Al_{42}Sn_6)_{\Sigma 48}O_{90}(OH)_6$
Ferronigerite-2N1S	$(Fe,Mg)_4(Al_{10}Sn_2)_{\Sigma 12}O_{22}(OH)_2$
*Ferronigerite-6N6S	$Fe_8(Al_{42}Sn_6)O_{90}(OH)_6$
*Pengzhizhongite = Magnesionigerite-2N1S	$Mg_4(Al_{10}Sn_2)_{\Sigma 12}O_{22}(OH)_2$

3.1b.2b.1.2.3. Hydrates

Cafetite	$Ca(Fe^{3+},Al)_2Ti_4O_{12}\cdot 4H_2O$ or $Ca[Ti_2O_5](H_2O)$

3.1b.2b.1.3. M^{2+} ($2\ M^{2+} \rightarrow M^{+}M^{3+}$)

3.1b.2b.1.3.1. Neutral

Armalcolite	$(Mg,Fe^{2+})Ti^{4+}{}_2O_5$

Ilmenite series

Geikielite	$MgTiO_3$
Ecandrewsite	$(Zn,Fe,Mn)TiO_3$
Ilmenite	$Fe^{2+}TiO_3$
Pyrophanite	$MnTiO_3$

Perovskite family (compare with latrappite)

Perovskite	$CaTiO_3$
*Barioperovskite	$BaTiO_3$
*Megoite	$CaSnO_3$
Loparite-(Ce)	$(Na,Ce,Sr)(Ce,Th)(Ti,Nb)_2O_6$
Tausonite	$SrTiO_3$
*K-Sr-loparite	$(Sr,La,K,Ce,Ca,Th,Na)(Ti,Cr,Nb)O_3$
Macedonite	$PbTiO_3$

Ulvöspinel series (compare with oxispinelides (series); sulfospinelides (series); selenospinelides (series)

Qandilite	$MgTi^{4+}[MgO_4] \rightarrow Mg_2TiO_4$
Ulvöspinel (ulvite)	$Fe^{2+}Ti^{4+}[Fe^{2+}O_4] \rightarrow Fe^{2+}{}_2TiO_4$

3.1b.2b.1.3.2. Basic

Kassite	$CaTi_2(OH)_2O_4$

3.1b.2b.1.4. Titanates of M^{3+} and M^{+}

3.1b.2b.1.4.1. Basic → acids

Freudenbergite	$Na\vert Fe^{3+}Ti_3O_8\vert^{\infty 3} \rightarrow {}^{(12)}Na_{1-y}\vert Fe^{3+}{}_{1-x}Ti_{3-x}Si_xO_8H_{3x+y}\vert^{\infty 3}$

3.1b.2b.2. Titanates of ***s***-, ***d****s*- and ***p****s*-cations with unknown structure and questionable

Kleberite	$FeTi_6O_{11}\cdot(OH)_5$
Manganbelyankinite	$(Mn,Ca)(Ti,Nb)_5O_{12}\cdot 9H_2O$
Belyankinite	$Ca(Ti,Zr,Nb)_6O_{13}\cdot 14H_2O$ (?)

3.1.3.2.2.2. Titanates of ***f***-cationsa

3.1.3.2.2.2.1. Neutral→ Basic

Crichtonite series (compare with senaite (series))

*Davidite-(Ce) $Ce(Y,U)Fe_2(Ti,Fe,Cr,V)_{18}(O,OH,F)_{38}$
Davidite-(La) $La(Y,U)Fe_2(Ti,Fe,Cr,V)_{18}(O,OH,F)_{38}$
*Unnamed $(Ca,Ce)Sc(Ti,Fe,Al)_{20}(O,OH)_{38}$
Loveringite $(Ca,Ce,La)(Zr,Fe)(Mg,Fe)_2(Ti,Fe,Cr,Al)_{18}O_{38}$
*Dessauite-(Y) $SrYFe^{3+}{}_2(Ti_{11}Fe_7)_{\Sigma 18}O_{38}$
Crichtonite $(Sr,La,Ce,Y)|(Ti,Fe^{3+},Mn)_{21}O_{38}|^{\infty 3}$
*Gramaccioliite – (Y) $(Pb,Sr)(Y,Mn)(Ti,Fe^{3+})_{18}Fe^{3+}{}_2O_{38}$

Brannerite family

Brannerite group

Lucasite-(Ce) $(Ce,La)Ti_2(O,OH)_6$
Brannerite $(U,Ca,Ce)(Ti,Fe^{3+})_2O_6$
Thorutite $(Th,U,Ca)Ti_2(O,OH)_6$
Yttrocrasite-(Y) $(Y,Th,Ca,U)(Ti,Fe^{3+})_2(O,OH)_6$

3.1b.3. **<u>Overclass</u>***: Oxides and hydroxides of Nb^{5+} and Ta^{5+}

3.1b.3a. ***Class:*** Simple oxides and hydroxides of Nb^{5+} and Ta^{5+}

3.1b.3a.1. Neutral

Tantite $(Ta,Nb)_2O_5$

Ixiolite family

Ixiolite group

Ixiolite $(Ta,Fe,Sn,Nb,Mn)_4O_8$
*Unnamed $(Sc,Fe^{3+})(Nb,Ta)O_4$

Wodginite group

*Titanowodginite $Mn^{2+}TiTa_2O_8$
*Ferrowodginite $Fe^{2+}SnTa_2O_8$
*Fe^{2+}-Ti-wodginite $(Fe,Mn)_4(Ti,Sn,Ta)_4(Ta,Nb,W)_8O_{32}$
*Tantalowodginite $(Mn_2,\square)_4Ta_4Ta_8O_{32}$
*Wodginite $MnSnTa_2O_8$

3.1b.3a.2.Hydroxides

Kimrobinsonite $Ta(OH)_3(O,CO_3)$

3.1b.3b. ***Class***: Complex oxides of Nb^{5+} and Ta^{5+} ((6)-tantaloniobates→ (4)-tantaloniobates)

3.1b.3b.1. Tantaloniobates of ***s***-, $\boldsymbol{d_s}$- and $\boldsymbol{p_s}$-cations

3.1b.3b.1.1. Tantaloniobates of ***s***-, $\boldsymbol{d_s}$- and $\boldsymbol{p_s}$-cations (without Li and Be)

3.1b.3b.1.1.1. Proper tantaloniobates

3.1b.3b.1.1.1.1. $M^{4+} = Sn^{4+}(Ti^{4+})$

3.1b.3b.1.1.1.1.1. Neutral

3.1b.3b.1.1.1.2. $M^{3+} = Al^{3+}$

3.1b.3b.1.1.1.2.1. Neutral

Alumotantite $AlTaO_4$
*Heftetjernite $ScTaO_4$

3.1b.3b.1.1.1.2.2. Basic

Simpsonite $Al_4(Ta,Nb)_3O_{13}(OH,F)$

3.1b.3b.1.1.1.3. M^{2+} (Sn^{2+}, Mg, Fe^{2+}, Mn^{2+}, Ca^{2+})

3.1b.3b.1.1.1.3.1. Neutral → acids → basic

Thoreaulite series

Foordite $Sn|Nb_2O_6|^{\infty 2}$
Thoreaulite $Sn|Ta_2O_6|^{\infty 2}$

Tapiolite series

Tapiolite-Fe $FeTa_2O_6$
Tapiolite-Mn $MnTa_2O_6$
Columbite series
Columbite-(Mg) = Magnocolumbite $(Mg,Fe,Mn)(Nb,Ta)_2O_6$
Columbite-(Fe) = Ferrocolumbite $FeNb_2O_6$
Columbite-(Mn) = Manganocolumbite $(Mn,Fe)(Nb,Ta)_2O_6$
Ferrotantalite = tantalite-(Fe)_ $FeTa_2O_6$
Manganotantalite = tantalite(Mn)- $MnTa_2O_6$
*Magnesiotantalite = tantalite-(Mg) $MgTa_2O_6$
Calciotantite $CaTa_4O_{11}$
Rynersonite family
Rynersonite $Ca(Ta,Nb)_2O_6$
Changbaiite $PbNb_2O_6$

Microlite family (compare with pyrochlore (series))
Microlite series
Bariopyrochlore $Ba_2Nb_2O_7$
*Hydropyrochlore $(H_2O\square)_2Nb_2(O,OH)_6\cdot H_2O$
*Hydroxycalciopyrochlore $(Ca,Na,U,\square)_2(Nb,Ti)_2O_6(OH)$
*Aspedamite $\square_{12}(Fe^{3+},Fe^{2+})_3Nb_4[Th(Nb,Fe^{3+})_{12}O_{42}](H_2O,OH)_{12}$
*Oxystibiomicrolite $(Sb,Ca)_2Ta_2O_6O$
*Fluorcalciomicrolite $(Ca,Na,\square)_2Ta_2O_6F$
Bariomicrolite = *hydrokenomicrolite $(\square,H_2O)_2Ta_2(O,OH)_6(H_2O)$
Parabariomicrolite $BaTa_4O_{10}(OH)_2\cdot 2H_2O$
*Hydrokenomicrolite $(\square,H_2O)_2Ta_2(O,OH)_6(H_2O)$
Bismutomicrolite series
*Hydroxykenomicrolite $(\square,Na,Sb^{3+})_2|Ta_2O_6(OH)$
*Fluorsodicmicrolite $(Na,Ca)Ta_2O_6F$
Stibiobetafite = oxycalciopyrochlore $Ca_2Nb_2O_6O$
Stannomicrolite = oxystannomicrolite $Sn_2Ta_2O_6O$
Cesplumtantite $(Cs,Na)_2(Pb, Sb^{3+}\cdot Sn^{2+})_3Ta_8O_{24}$

3.1b.3b.1.1.1.3.2. Hydrates
Gerasimovskite $(Mn,Ca)(Nb,Ti)_{5\text{-}6}O_{12\text{-}16}\cdot 8\text{-}9H_2O$ (?)
Franconite $(Na,Ca)_2(Nb,Ti)_4O_{11}\cdot 9H_2O$
*Hochelagaite $(Ca,Na,Sr)Nb_4O_{11}\cdot 8H_2O$
*Ternovite $(Mg,Ca)Nb_4O_{11}\cdot 10H_2O$
*Peterandresenite $Mn_4Nb_6O_{19}\cdot 14H_2O$

3.1b.3b.1.1.1.4. M^{3+} and M^{+}
3.1b.3b.1.1.1.4.1. Neutral
Sosedkoite $(K,Na)_5Al_2(Ta,Nb,Sb)_{22}O_{60}$
3.1b.3b.1.1.1.5. M^{+}
3.1b.3b.1.1.1.5.1. Neutral → basic
Rankamaite $(Na,K,Pb)(Ta,Nb,Al)_4(O,OH)_{10}$
Natrotantite $Na_2Ta_4O_{11}$
Irtyshite $Na_2(Ta,Nb)_4O_{11}$
Latrappite $(Ca,Na)(Nb,Ti,Fe)O_3$ (compare perovskite (series); loparite (group)) macedonite (group));
Lueshite family

Lueshite	$NaNbO_3$
*Isolueshite	(Na,La,Ca,)(Nb,Ti)O_3

3.1b.3b.1.1.2. Tantaloniobato-tungstenates of Mg, Fe^{2+}, Mn^{2+}

3.1b.3b.1.1.2.1. Neutral

Qitianlingite	$(Fe,Mn)^{2+}{}_2(Nb,Ta)_2W^{6+}O_{10}$
*Koragoite	$Mn_2{}^{2+}Mn^{3+}Nb_2(Nb,Ta)_3W_2O_{20}$

3.1b.3b.1.2. Tantaloniobates of Li 3.1b.3b.1.2.1. Neutral

Lithiotantite family

Lithiotantite	$Li(Ta,Nb)_3O_8$
Lithiowodginite	$Li(Ta,Nb)_3O_8$

3.1b.3b.2. Tantaloniobates of ***f***-elements

3.1b.3b.2.1. Tantaloniobates of U

3.1b.3b.2.1.1. Neutral

Liandratite	$U^{6+}(Nb,Ta)_2O_8$
Petscheckite	$U^{4+}Fe^{2+}(Nb,Ta)_2O_8$

3.1b.3b.2.2. Tantaloniobates of TR

3.1b.3b.2.2.1. Neutral → basic

Euxenite series	
Euxenite-(Y)	$(Y,Ca,Ce,U,Th)|(Nb,Ta,Ti)_2O_6|^{\infty 3}$
Vigezzite	$(Ca,Ce)|(Nb,Ta,Ti)_2O_6|^{\infty 3}$
*Titanvigezzite	$(Ca,Ce)|(Ti,Nb,Si,Ta)_2O_6|^{\infty 3}$
Fersmite	$(Ca,Ce,Na)|(Nb,Ti,Fe,Al)_2(O,OH,F)_6|^{\infty 3}$
Tanteuxenite-(Y)	$(Y,Ca,Ce)|(Ta,Nb,Ti)_2(O,OH)_6|^{\infty 3}$
Aeschynite series	
Niobo-aeschynite-(Ce)	$(Ce,Ca,Th)|(Nb,Ti)_2(O,OH)_6|^{\infty 3}$
*Niobo-aeschynite-(Nd)	$(Nd,Ce)|(Nb,Ti)_2(O,OH)_6|^{\infty 3}$
*Niobo-aeschynite-(Y)	$(Y,Ca,Ce,Nd,Th)(Nb,Ta,Ti,Fe)_2(O,OH)_6$
*Yttroniobo-aeschynite-(Ce)	$(Ce,Y,Ca,Th)|(Nb,Ti,Ta)_2O_6$
Tantal-aeschynite-(Y)	$(Y,Ce,Ca)|(Ta,Ti,Nb)_2O_6|^{\infty 3}$
Aeschynite-(Nd)	$(Nd,Ce,Ca,Th)|(Ti,Nb)_2(O,OH)_6|^{\infty 3}$
Aeschynite-(Ce)	$(Ce,Ca,Fe,Th)|(Ti,Nb)_2(O,OH)_6|^{\infty 3}$
Aeschynite-(Y)	$(Y,Ca,Fe,Th)|(Ti,Nb)_2(O,OH)_6|^{\infty 3}$
Polycrase series	
Polycrase-(Y)	$(Y,Ca,Ce,U,Th)|(Ti,Nb,Ta)_2O_6|^{\infty 3}$
*Uranopolycrase	$(U,Y)(Ti,Nb)_2O_6$
Kobeite-(Y)	$(Y,U)(Ti,Nb)_2(O,OH)$
Loranskite-(Y)	$(Y,Ce,Ca)ZrTaO_6$
Samarskite series	
*Calciosamarskite	$(Ca,Fe,Y)(Nb,Ta,Ti)O_4$
Samarskite-(Y)	$(Y,Ce,U,Fe^{3+})_3(Nb,Ta,Ti)_5O_{16}$
*Samarskite-(Yb)	$(Yb,Y,REE,U,Th,Ca,Fe^{2+})(Nb,Ta,Ti)O_4$
Pyrochlore series	(compare with microlite (series))
Yttropyrochlore-(Y) discredited	
Yttrobetafite-(Y) discredited	
Betafite	$Ca_2(Ti,Nb)O_6(OH)$

Uranpyrochlore discredited
Ceriopyrochlore-(Ce) $Ce_2Nb_2O_6(OH)$
Plumbopyrochlore $Pb_2Nb_2O_7$
Pyrochlore $NaCaNb_2O_6F$
*Fluornatropyrochlore $(Na,Pb,Ca,REE,U)_2Nb_2O_6F$
*Hydroxymanganopyrochlore $(Mn,Th,Na,Ca,REE)_2(Nb,Ti)_2O_6(OH)$
Uranmicrolite $(U_{0.5}Ca_{0.5})Ta_2O_6(OH)$
Calciobetafite $Ca_2(NbTi)O_6(OH)$
*Bismutopyrochlore discredited
Murataite-(Y) $((Y,Na)_6Zn(Zn,Fe^{3+})_4(Ti,Nb,Na)_{12}O_{29}(O,F,OH)_{10}F_4$
Beta-fergusonite series
Beta-fergusonite-(Ce) $(Ce,La,Nd)[NbO_4]$
Beta-fergusonite-(Nd) $(Nd,Ce)[NbO_4]$
Beta-fergusonite-(Y) $Y[NbO_4]$
Ishikawaite $(U,Fe,Y)NbO_4$
Fergusonite series
*Iwashiroite-(Y) $YTaO_4$
*Fergusonite-(Ce) $CeNbO_4·0.3H_2O$
Fergusonite-(Y) $(Y,Er,Ce,Fe)[(Nb,Ta,Ti)O_4]$
Formanite-(Y) $Y[(Ta,Nb)O_4]$
Yttrotantalite-(Y) $(Y,U,Fe^{2+})[(Ta,Nb)O_4]$

3.1b.3b.2.3. Tantaloniobates of Sb^{3+} and Bi^{3+} 3.1b.3b.2.3.1. Neutral
Stibiotantalite family
Stibiotantalite group
Stibiotantalite $Sb|(Ta,Nb)O_4|^{\infty 2}$
Stibiocolumbite $Sb|NbO_4|^{\infty 2}$
Bismutocolumbite $Bi|NbO_4|^{\infty 2}$
*Yttrocolumbite-(Y) $YNbO_4$
Bismutotantalite $Bi|(Ta,Nb)O_4|^{\infty 2}$
Zimbabweite $^{(8)}Na\{^{(6)}(PbNa_{0,5}K_{0,5})_{\Sigma 2}As^{3+}{}_4|^{(6)}(Ta_3Nb_{0,5}Ti_{0,5})_{\Sigma 4}O_{18}|^{\infty 2}\}^{\infty 2}$
*Unnamed $Mn^{2+}{}_3U^{4+}As^{3+}{}_2Sb^{3+}{}_2Ta^{5+}{}_2Ti^{4+}{}_2O_{20}$

*3.1б.3b.2.3.4. Tantaloniobato-tungstenates Sb^{3+} и Bi^{3+}
*Billwiseite $Sb^{3+}{}_5(Nb,Ta)_3WO_{18}$

3.1b.4. __**Overclass**__*: Oxides and hydroxides of Mo and W
3.1b.4a. ***Class:*** Simple oxides and hydroxides of Mo and W
3.1b.4a.1.Neutral
Tugarinivite MoO_2
Molybdite MoO_3
*Cupromolybdite $Cu^{2+}{}_3Mo^{6+}{}_2O_9$
3.1b.4a.2. Oxido-hydroxides
Tungstite $WO_3·H_2O \rightarrow H_2WO_4 \rightarrow W(OH)_2O_2$
Alumotungstite series
Alumotungstite $\square_2W_2O_6(H_2O)$
Ferritungstite = hydrokenoelsmoreite $\square_2W_2O_6(H_2O)$
3.1b.4a.3. Hydrates (molybdenum and tungsten acids)
Hydrotungstite family

Sidwellite	$MoO_3 \cdot 2H_2O \rightarrow H_2MoO_4 \cdot H_2O \rightarrow Mo(OH)_2O_2 \cdot H_2O$
Hydrotungstite	$WO_3 \cdot 2H_2O \rightarrow H_2WO_4 \cdot H_2O \rightarrow W(OH)_2O_2 \cdot H_2O$
Meymacite	$WO_3 \cdot 2H_2O \rightarrow H_2WO_4 \cdot H_2O \rightarrow W(OH)_2O_2 \cdot H_2O$
*Elsmoreite	$WO_3 \cdot 5H_2O$

3.1b.4b.***Class:*** Complex oxides and hydroxides of Mo and W ((6)-molybdates and tungstenates → (4)-molybdates and tungstenates)

3.1b.4b.1. Molybdates and tungstenates of ***s***-, $\boldsymbol{d_s}$- and $\boldsymbol{p_s}$-cations

3.1b.4b.1.1. Proper molybdates and tungstenates

3.1b.4b.1.1.1. $M^{3+}(Al^{3+},Fe^{3+})$ 3.1b.4b.1.1.1.1. Oxido-hydroxides → → hydroxides → hydrates

Anthoinite family	
Anthoinite	$AlWO_3(OH)_3$
Mpororoite	$AlWO_3(OH)_3 \cdot H_2O$
*Bamfordite	$Fe^{3+}Mo_2(OH)_3O_6 \cdot H_2O$
*Ferrimolybdite	$Fe^{3+}_2[MoO_4]_3 \cdot 8H_2O$ (?)
*Ophirite	$Ca_2Mn_4[Zn_2Mn^{3+}_2(H_2O)_2(Fe^{3+}W_9O_{34})_2] \cdot 46H_2O$

3.1b.4b.1.1.2. $M^{3+}$and M^{2+} 3.1b.4b.1.1.2.1. Oxido-hydroxides

Jixianite	$Pb(W,Fe^{3+})_2(O,OH)_7$

3.1b.4b.1.1.3. M^{3+}, M^{2+} and M^{+} 3.1b.4b.1.1.3.1. Hydrates

Phyllotugstite	$HCaFe^{3+}_3[WO_4]_6 \cdot 10H_2O$
*Pittongite	$(Na,\cdot H_2O)_{0.7}(W,Fe^{3+})(O,OH)_3$

3.1b.4b.1.1.4. M^{2+} 3.1b.4b.1.1.4.1. Neutral

Wolframite series	
*Huanzalaite	$MgWO_4$
Ferberite	$FeWO_4$
Huebnerite	$MnWO_4$
Sanmartinite	$(Zn,Fe,Ca,Mn)WO_4$
Scheelite series	
Powellite	$Ca[MoO_4]$
Scheelite	$Ca[WO_4]$

* 3.1б.4б.1.1.5 M^{2+} и Mo^{4+}

*Kamiokite	$Fe^{2+}_2Mo^{4+}_3O_8 \rightarrow Fe^{2+}_2Mo^{4+}[MoO_4]_2$

3.1b.4b.1.2. Molybdato (tungstenato)-vanadates

3.1b.4b.1.2.1. Hydrates

Rankachite	$Ca_{0.5}(V^{4+},V^{5+})(W^{6+},Fe^{3+})_2O_8(OH) \cdot 2H_2O$

3.1b.4b.1.3. Molybdato (tungstenato)-phosphates

3.1b.4b.1.3.1. Hydrates

Melkovite	$[Ca_2(H_2O)_{15}Ca(H_2O)_6][Mo_8^{6+}P_2Fe_3^{3+}O_{36}(OH)]$

3.1b.4b.1.4. Phospho- molybdato- phosphates

3.1b.4b.1.4.1. Hydrates

Mendozavilite family	
Paramendozavilite	$NaAl_4Fe^{3+}_7(OH)_{16}[PMo_{12}O_{40}][PO_4]_5 \cdot 56H_2O$

Mendozavilite-NaFe $[Na_2(H_2O)_{15}Fe^{3+}(H_2O)_6][Mo_8{}^{6+}P_2Fe_3{}^{3+}O_{35}(OH)_2]$
*Mendozavilite-NaCu $[Na_2(H_2O)_{15}Cu(H_2O)_6][Mo^{6+}{}_8P_2Fe^{3+}{}_3O_{34}(OH)_3]$
*Mendozavilite-KCa $[K_2(H_2O)_{15}Ca(H_2O)_6][Mo^{6+}{}_8P_2Fe^{3+}{}_3O_{34}(OH)_3]$

*3.1b.4b.1.5. Molybdato (tungstenato)-arsenates
*3.1b.4b.1.5.1. Hydrates
*Betpakdalite group
*Betpakdalite-CaCa $[Ca_2(H_2O)_{17}Ca(H_2O)_6][Mo^{6+}{}_8As^{5+}{}_2Fe^{3+}{}_3O_{36}(OH)]$
*Betpakdalite-CaMg $[Ca_2(H_2O)_{17}Mg(H_2O)_6][Mo^{6+}{}_8As^{5+}{}_2Fe^{3+}{}_3O_{36}(OH)]$
*Betpakdalite-NaCa $[Na_2(H_2O)_{17}Ca(H_2O)_6][Mo^{6+}{}_8As^{5+}{}_2Fe^{3+}{}_3O_{34}(OH)_3]$
*Betpakdalite-NaNa $[Na_2(H_2O)_{16}Na(H_2O)_6][Mo^{6+}{}_8As^{5+}{}_2Fe^{3+}{}_3O_{33}(OH)_4]$
*Obradovičite-KCu $[K_2(H_2O)_{17}Cu^{2+}(H_2O)_6][Mo_8{}^{6+}As_2Fe^{3+}{}_3O_{34}(OH)_3]$
*Obradovičite-NaCu $[Na_2(H_2O)_{17}Cu^{2+}(H_2O)_6][Mo_8{}^{6+}As_2Fe^{3+}{}_3O_{34}(OH)_3]$
*Obradovičite-NaNa $[Na_2(H_2O)_{16}Na(H_2O)_6][Mo_8{}^{6+}As_2Fe_3{}^{3+}O_{33}(OH)_4]$

3.1b.4b.2. Molybdates and tungstenates of ***f***-elements
*3.1б.4б.2.1. Proper molybdates and tungstenates
3.1b.4b.2.1.1. Neutral
Sedovite $U^{4+}[MoO_4]_2$
3.1b.3.4b.2.2. Basic
Mourite $U^{4+}Mo_5(OH)_{10}O_{12}$
Yttrotungstite -(Y) series
Cerotungstite-(Ce) $(Ce,Nd)W_2(OH)_3O_6$
*Yttrotungstite-(Ce) $(Ce,REE)W_2(OH)_3O_6$
Yttrotungstite-(Y) $(Y,REE)W_2(OH)_3O_6$

*3.1b.4b.2.2. Molybdato- and tungstenato - arsenates
*3.1b.4b.2.2.1. Neutral
*Paraniite-(Y) $Ca_2(Y,REE)(AsO_4)(WO_4)_2$

3.1b.4b.3. Molybdates and tungstenates of ***d***-cations
3.1b.4b.3.1. Molybdates of Mo^{4+}
3.1b.4b.3.1.1. Hydrates
Ilsemannite $(Mo^{6+}{}_2Mo^{4+})O_8{\cdot}H_2O \rightarrow MoMo_2O_8{\cdot}H_2O \rightarrow Mo^{4+}[MoO_4]_2{\cdot}H_2O$ (?)

3.1b.4b.3.2. Molybdates and tungstenates of **I***b*-cations - Cu^{2+}
3.1b.4b.3.2.1. Proper molybdates and tungstenates 3.1b.4b.3.2.1.1. Basic
Lindgrenite family
Lindgrenite $Cu^{2+}{}_3(OH)_2[MoO_4]_2$
*Markascherite $Cu^{2+}{}_3(OH)_4[MoO_4]$
*Szenicsite $Cu^{2+}{}_3(OH)_4[MoO_4]$
Cuprotungstite $Cu^{2+}{}_3(OH)_2[WO_4]_2$

*3.1b.4b.3.2.2. Oxido-molybdato (tungstenato)-sulfates
*Vergasovaite $Cu^{2+}{}_3O[MoO_4][SO_4]$

3.1b.4b.4. Molybdates and tungstenates of ***p***-metals
3.1b.4b.4.1. Molybdates and tungstenates of IV*a*-cations – Pb^{2+}
3.1b.4b.4.1.1. Proper molybdates and tungstenates

3.1b.4b.4.1.1.1. Neutral

Wulfenite family

Wulfenite group

Wulfenite $Pb[MoO_4]$

Stolzite $Pb[WO_4]$

Raspite $Pb[WO_4]$

*Raspite, beneficiate Te $Pb[(W_{0.56}Te_{0.44})O_4]$

3.1b.4b.4.1.1.2. Oxido-molybdato-halogenides

Pinalite $Pb_3O[WO_4]Cl_2$

*Parkinsonite $Pb_7MoO_9Cl_2$

3.1b.4b.5. Molybdates and tungstenates of semimetals

3.1b.4b.5.1. Molybdates and tungstenates of Bi^{3+}

3.1b.4b.5.1.1. Proper molybdates and tungstenates

3.1b.4b.5.1.1.1. Oxido-molybdates (tungstenates)

*Biehlite $(Sb,As)^{3+}{}_2Mo^{6+}O_6$

Koechlinite group

Koechlinite $Bi_2MoO_6 \rightarrow [Bi_2O_2]^{\infty 2}[MoO_4]^{\infty 2}$

Russellite $Bi_2WO_6 \rightarrow [Bi_2O_2]^{\infty 2}[WO_4]^{\infty 2}$

*3.1б.4б.5.1.1.1.1 Oxido-hydroxido-molybdates (hydrates)

*Gelosaite $BiMo^{6+}{}_{2-5x}Mo^{5+}{}_{6x}O_7(OH)\cdot H_2O$ $(0 \le x \le 0.4)$ or $Bi^{3+}Mo^{6+}{}_{2+x}O_7(OH)\cdot H_2O$

*3.1б.4б.5.1.1.2. Oxido –molybdato-arsenates

*Schlegelite $Bi_7O_4[MoO_4]_2[AsO_4]_3$

*3.1б.4б.5.1.1.1.1. Hydrates

*Vajdakite $[(Mo^{6+}O_2)_2(H_2O)_2As^{3+}{}_2O_5]\cdot H_2O$

3.1b.4b.5.1.2. Molybdato-tellurates of Bi^{3+}

3.1b.4b.5.1.2.1. Neutral

Chiluite $Bi_6Mo_2Te_2O_{21}$

3.1b.5. Overclass*: Oxides and hydroxides of Mn^{4+}

3.1b.5a. ***Class:*** Simple oxides and hydroxides of $Mn^{4+} \rightarrow$ complex oxides and hydroxides of Mn^{4+}

3.1b.5a.1. Neutral oxido-hydroxides

Pyrolusite family (compare with rutile (family); cassiterite (group))

Pyrolusite β -MnO_2

Ramsdellite γ-MnO_2

*Akhtenskite ε-MnO_2

Nsutite $Mn^{2+}{}_xMn^{4+}{}_{1-x}(OH)_{2x}O_{2-2x}$

3.1b.5b. ***Class:*** Complex oxides and hydroxides of Mn^{4+}

*3.1б.5б.1. Neutral

*Strontiomelane $SrMn^{4+}{}_6Mn^{3+}{}_2O_{16}$

*Zenzénite $Pb_3(Fe^{3+},Mn^{3+})_4Mn^{4+}{}_3O_{15}$

3.1b.5b.1. Oxido-hydroxodes $\rightarrow$ hydrates

Cryptomelane family (compare with priderite (family))

Coronadite group

Manjiroite	$Na(Mn_7^{4+}Mn^{3+})O_{16}$
Coronadite	$Pb(Mn^{4+}{}_6Mn^{3+}{}_2)O_{16}$
Cryptomelane group	
Hollandite	$Ba(Mn^{4+}{}_6Mn^{3+}{}_2)O_{16}$
Cryptomelane	$K(Mn^{4+}{}_7Mn^{3+})_8O_{16}$
Romanèshite	$(Ba,\cdot H_2O)_2(Mn^{4+},Mn^{3+})_5O_{10}$
Todorokite family	
*Jianshuiite	$MgMnO_7{\cdot}3H_2O$
Todorokite	$(Na,Ca,K,Ba,Sr)_{1-x}(Mn,Mg,Al)_6O_{12}\cdot 3\text{-}4H_2O$
Woodruffite	$Zn_2Mn_5^{4+}O_{12}\cdot 4H_2O$
Rancieite series	
Takanelite	$(Mn^{2+},Ca)_{2x}Mn^{4+}{}_{1-x}O_2\cdot 0.7H_2O$
Rancieite	$(Ca,Mn^{2+})_{0.2}(Mn^{4+},Mn^{3+})O_2\cdot 0.6H_2O$
Chalcophanite series	
Chalcophanite	$(Zn,Fe^{2+},Mn^{2+})\|Mn^{4+}{}_3O_7\|^{\infty 2}{\cdot}3H_2O$
*Ni-chalcophanite	$(Ni,Cu,Co^{3+})\|Mn^{4+}{}_3O_7\|^{\infty 2}{\cdot}5H_2O$
*Ernienickelite	$Ni\|Mn^{4+}{}_3O_7\|^{\infty 2}{\cdot}3H_2O$
Aurorite	$(Mn,Ag,Ca)\|Mn^{4+}{}_3O_7\|^{\infty 2}{\cdot}3H_2O$
*Jianshuiite	$(Mg,Mn)^{2+}\|Mn^{4+}{}_3O_7\|^{\infty 2}{\cdot}7H_2O$
Cesarolite	$Pb(OH)\|Mn^{4+}{}_3O_6(OH)\|^{\infty 2}$
Lithiophorite family	
Lithiophorite group	
Lithiophorite	$\|(Al,Li)(OH)_2\|^{\infty 2}\|MnO_2\|^{\infty 2}$
Mn^{2+}-lithiophorite	$\|(Al,Mn^{2+},Li)(OH)_2\|^{\infty 2}\|MnO_2\|^{\infty 2}$
Janggunite	$\|(Mn^{2+},Fe^{3+})_{1+x}(OH)_4\|^{\infty 2}\|Mn^{4+}{}_{5-x}(OH)_2O_8\|^{\infty 2}$
Birnessite series	$R_{2x}(OH,\cdot H_2O)_{6x}\|(Mn^{4+},Mn^{3+},Mg,Ca)_{1-x}(OH)_2O\|^{\infty 2}$; R = Na, K; 1/2Ca, 1/2Mg; 1/3Mn^{3+}
Mn-Birnessite	
Mg-Birnessite	
Ca-Birnessite (or simple birnessite)	
Na-Birnessite	
*Clinobirnessite	
Asbolane series	$M_{1-y}(OH)_{2-2y+x}Mn^{4+}{}_2(OH)_{2x}O_{4-2x}$; M = Al, Fe^{3+}; Ni^{2+}, Co^{2+}, Fe^{2+}, Ca
Al-Asbolane	
Ni-Asbolane	
Co-Asbolane	
Vernadite	$MnO_2{\cdot}nH_2O$

3.1b.6. **<u>Overclass</u>***: Oxides and hydroxides of V^{4+}

3.1b.6a. ***Class:*** Simple oxides and hydroxides of V^{4+}

3.1b.6a.1. Neutral

Paramontroseite	VO_2

3.1b.6a.2. Oxido-hydroxides (hydrates ?)

Doloresite	$6VO_2{\cdot}4H_2O \rightarrow V^{4+}{}_6(OH)_4O_4$
Duttonite family	
Duttonite	$VO_2{\cdot}H_2O \rightarrow V^{4+}(OH)_2O$
Lenoblite	$VO_2{\cdot}H_2O \rightarrow V^{4+}(OH)_2O$

3.1b.6b.**Class:** Complex oxides and hydroxides of V^{4+} → vanadites
3.1b.6b.1. Oxides of ***s***-cations and V^{4+}
*3.1б.6б.1.1. Neutral

*Cavoite	$CaV^{4+}_3O_7$
	3.1b.6b.1.2. Hydrates
*Bassoite	$SrV^{4+}_3O_7·4H_2O$
Simplotite	$CaV^{4+}_4O_9·5H_2O$

3.1b.6b.2. Oxides of *d*-cations and V^{4+}

	3.1b.6b.2.1. Neutral
Nolanite	$(^{(6;4)}Fe^{2+}_6V^{3+}_4)_{\Sigma 10}V^{4+}_{13}O_{38}$
	3.1b.6b.2.2. Oxido-hydroxides
Häggite	$V_2(OH)_3O_2 \rightarrow V^{3+}V^{4+}(OH)_3O_2$

3.1b.6b.3. Oxides of *p*-cations and V^{4+}

	3.1b.6b.3.1. Neutral
Stibivanite	$Sb^{3+}_2VO_5$

3.1b.7. **<u>Overclass</u>***: Oxides and hydroxides of V^{5+}
3.1b.7a. ***Class:*** Simple oxides and hydroxides of V^{5+}

	3.1b.7a.1. Neutral
Shcherbinaite family	
Shcherbinaite	$^{(5)}V_2O_5$
Bannermanite	$(Na,K)_xV^{4+}_xV^{5+}_{6-x}O_{15}$ (при $x = 0 \rightarrow 3V_2O_5$)
	3.1b.7a.2. Hydrates
Homologous series of **navajoite** -	
Navajoite	$(V^{5+},Fe^{3+})_{10}O_{24}·12H_2O$
Bariandite	$Al_{0.6}(V^{4+}V^{5+})_8O_{20}·9H_2O$
Vanoxite	$V^{4+}_4V^{5+}_2O_{13}·8H_2O$ (?)

3.1b.7b. ***Class:*** Complex oxides and hydroxides of V^{5+} → (6)-vanadates → (5)-vanadates → (4)-vanadates
3.1b.7b.1. Quasiclass: (6)-Vanadates
3.1b.7b.1.1. (6)- Vanadates of ***s***-, $\boldsymbol{d_s}$- and $\boldsymbol{p_s}$-cations

	3.1b.7b.1.1.1. Hydrates
Pascoite family	
Pascoite	$Ca_3(H_2O)_{17}[V_{10}O_{28}]^{\infty}$
*Magnesiopascoite	$Ca_2Mg[V_{10}O_{28}]·16H_2O$
*Rakovanite	$Na_3(H_2O)_{15}H_3[V_{10}O_{28}]$
*Kokinosite	$Na_2Ca_2(H_2O)_{24}[V_{10}O_{28}]$
*Gunterite	$(Na_{4-x}Ca_x)_{\Sigma 4}(H_2O)_{16}(H_{2-x}V_{10}O_{28}]·6H_2O$
Hummerite	$K_2Mg_2(H_2O)_{16}[V_{10}O_{28}]^{\infty}$
Huemulite	$Na_4Mg(H_2O)_{24}[V_{10}O_{28}]^{\infty}$
*Lasalite	$Na_2Mg_2(H_2O)_{20}[V_{10}O_{28}]^{\infty}$
*Hughesite	$Na_3Al(H_2O)_{22}[V_{10}O_{28}]^{\infty}$
*Postite	$Mg(H_2O)_6Al_2(OH)_2(H_2O)_8[V_{10}O_{20}]·13H_2O$
*Wernerbaurite	$\{(NH_4)_2[Ca_2(H_2O)_{14}](H_2O)_2\}[V_{10}O_{28}]\}$
*Schindlerite	$(NH_4)_4Na_2(H_2O)_{10}[V_{10}O_{28}]$

3.1b.7b.1.2. (6)-Vanadates of ***d***-cations
3.1b.7b.1.2.1. (6)-Vanadates of V^{4+}

3.1b.7b.2.1.1. Hydrates

Corvusite series
Corvusite $(Na,Ca,K)_x(V^{5+},V^{4+},Fe^{2+})_8O_{20}\cdot 4H_2O$ x = 0.8-1.2
Grantsite $(Na,Ca)_x(V^{5+},V^{4+})_6O_{16}\cdot 4H_2O$ x = □ 2,5
Straczekite $(Ca,K,Ba)(V^{5+}V^{4+})_8O_{20}\cdot 3H_2O$
*Nashite $Na_3Ca_2[(V^{5+}{}_9V^{4+})O_{28}]\cdot 24H_2O$

3.1b.7b.1.2.2. (6)-Vanadates of ***p***-cations

3.1b.7b.1.2.2.1. Neutral

Dreyerite family (compare with pucherite)
Dreyerite $Bi[^{(6)}VO_4]^{\infty}$
Clinobisvanite $Bi[^{(6)}VO_4]^{\infty}$

3.1b.7b.2. Quasiclass: (5)-Vanadates
3.1b.7b.2.1. (5)-Vanadates of ***s***-, ***d****s*- and ***p****s*-cations
3.1b.7b.2.1.1. Proper (5)-vanadates
3.1b.7b.2.1.1.1. (5)-Vanadates with $[^{(5)}V_6O_{16}]^{\infty}$- radicals

3.1b.7b.2.1.1.1.1. Hydrates (neutral)

Hewettite family
Hewettite group
Hewettite $Ca(H_2O)_9[V_6O_{16}]^{\infty}$
Barnesite $Na_2(H_2O)_3[V_6O_{16}]^{\infty}$
Metahewettite $Ca(H_2O)_3[V_6O_{16}]^{\infty}$
*Phosphovanadylite-Ba $Ba[V^{4+}{}_4P_2O_{12}(OH)_4]\cdot 12H_2O$
*Phosphovanadylite-Ca $Ca[V^{4+}{}_4P_2O_{12}(OH)_4]\cdot 12H_2O$

3.1b.7b.2.1.1.2. (5)-Vanadates with $[^{(5)}V_2O_6]^{\infty}$- radicals

3.1b.7b.2.1.1.2.1. Basic → hydrates (basic)

Delrioite family
Metadelrioite $SrCa(OH)_2[V_2O_6]^{\infty}$
Delrioite $Sr[V^{5+}{}_2O_6]\cdot 4H_2O$
*Calciodelrioite $Ca[V_2O_6]^{\infty}\cdot 4H_2O$

3.1b.7b.2.1.1.2.2. Hydrates (neutral)

Rossite family
Metarossite $Ca(H_2O)_2[V_2O_6]^{\infty}$
Rossite $Ca(H_2O)_4[V_2O_6]^{\infty}$
*Ansermetite $Mn[V_2O_6]\cdot 4H_2O$

3.1b.7b.2.1.2. (5)-Vanadates-(4)-vanadates

3.1b.7b.2.1.2.1. Hydrates (basic)

Vanalite $NaAl_8V_{10}O_{38}\cdot 30H_2O \rightarrow$
$NaAl_8(H_2O)_{25}(OH)_{11}[V^{5+}{}_6O_{16}]^{\infty}[VO_4]_4$

3.1b.7b.2.2. (5)-Vanadates of ***d***-cations
3.1b.7b.2.2.1. (5)-Vanadates of V^{4+}

3.1b.7b.2.2.1.1. Proper (5)-vanadates

3.1b.7b.2.2.1.1.1. Hydrates

Sherwoodite $Ca_9Al_2V^{4+}{}_4V^{5+}{}_{24}O_{80}\cdot 56H_2O$

Satpaevite $Al_{12}V^{4+}{}_2V^{5+}{}_6O_{37}\cdot 30H_2O \rightarrow$

$Al_{12}V^{4+}{}_2(OH)_{42}[V^{5+}{}_6O_{16}]^{\infty}\cdot 9H_2O$

Melanovanadite $Ca(V^{4+}{}_2V^{5+}{}_2)O_{10}\cdot 5H_2O$

3.1b.7b.2.2.1.2. (5)-Vanadates-(4)-vanadates

3.1b.7b.2.2.1.2.1. Hydrates

Hendersonite $Ca_3(V^{4+},V^{5+})_{12}O_{32}\cdot 12H_2O$

Bokite $KAl_3Fe^{3+}{}_6V^{4+}{}_6V^{5+}{}_{20}O_{76}\cdot 15H_2O$

*3.1б.7б.2.2.1.3. (5)-Vanadato-(4)-vanadao-arsenito-arsenstes

*3.1б.7б.2.2.1.3.1. Hydrates

*Vanarsite $NaCa_{12}(As^{3+}V^{5+}{}_{8.5}V^{4+}{}_{3.5}As^{5+}{}_6O_{51})_2\cdot 78H_2O$

*Morrisonite $Ca_{11}(As^{3+}V^{5+}{}_{10}V^{4+}{}_2As^{5+}{}_6O_{51})_2\cdot 78H_2O$

*Gatewayite $Ca_6(As^{3+}V^{5+}{}_9V^{4+}{}_3As^{5+}{}_6O_{51})\cdot 31H_2O$

3.1b.7b.3. Quasiclass: (4)-Vanadates

3.1b.7b.3.1. (4)-Vanadates of ***s***-, ***d$_s$***- and ***p$_s$***- cations

3.1b.7b.3.1.1. Divanadates

*3.1b.7b.3.1.1.1. Neutral

*Metamunirite β-$NaV^{5+}O_3$

*Ronneburgite $K_2Mn^{2+}V^{5+}{}_4O_{12}$

3.1b.7b.3.1.1.2. Hydrates

Munirite $Na_2[V_2O_6]^{\infty}\cdot 4H_2O$

*Dickthomssenite $Mg[V_2O_6[\cdot 7H_2O$

Alvanite $(Zn,Ni)Al_4[V_2O_6](OH)_{12}\cdot 2H_2O$

*Ankinovichite $(Ni,Zn)Al_4[V_2O_6](OH)_{12}\cdot(H_2O)_2$

3.1b.7b.3.1.2. Trivanadates

3.1b.7b.3.1.2.1. Hydrates

Pintadoite $Ca_2[V_2O_7]\cdot 9H_2O$

3.1b.7b.3.1.3. Tetravanadates

3.1b.7b.3.1.3.1. $M^{3+} = Al^{3+}, Fe^{3+}$ $(2M^{3+}\rightarrow M^{2+}M^{4+})$

3.1b.7b.3.1.3.1.1. Proper tetravanadates

*3.1b.7b.3.1.3.1.1.1. Neutral

*Ziminaite $(Fe^{3+},Al)_6[V^{5+}O_4]_6$

*Koksharovite $CaMg_2Fe_4{}^{3+}[V^{5+}O_4]_6$

*Reppiaite $Mn^{2+}{}_5(OH)_4[V^{5+}O_4]_2$

*Argandite $Mn^{2+}{}_7(OH)_8[VO_4]_2$

3.1b.7b.3.1.3.1.1.3. Hydrates

3.1b.7b.3.1.3.1.1.3.1. Basic

Santafeite $(Ca,Sr,Na)_3(Mn^{2+},Fe^{3+})_2Mn_2{}^{4+}(VO_4)_4(OH,O)_5\cdot 2H_2O$

3.1b.7b.3.1.3.1.1.3.2. Neutral

Schubnelite family

Steigerite $Al[VO_4]\cdot 3H_2O$

Fervanite $Fe_4[VO_4]_4\cdot 5H_2O$

Schubnelite $Fe[VO_4]\cdot H_2O$

Rusakovite $(Fe^{3+},Al)_5(OH)_9[(VO_4),(PO_4)]_2 \cdot 3H_2O$
*Kolovratite $(Ni,Zn)_xVO_4 \cdot nH_2O$

3.1b.7b.3.1.3.1.2. Vanadato-phosphates
3.1b.7b.3.1.3.1.2.1. Hydrates
Schoderite family
Schoderite $Al_2[VO_4][PO_4] \cdot 8H_2O$
Metaschoderite $Al_2[VO_4][PO_4] \cdot 6H_2O$

*3.1б.7б.3.1.3.1.3. Vanadato-arsenates
*Gottlobite $CaMg(OH)[(VO_4),(AsO_4)]$
*Nabiasite $BaMn_9(OH)_2[(V,As)O_4]_6$
*Fianelite $Mn^{2+}{}_2V^{5+}(V^{5+},As^{5+})O_7 \cdot 2H_2O$

3.1b.7b.3.1.3.2. M^{3+} and M^{2+} 3.1b.7b.3.1.3.2.1. Neutral
Lyonsite $Cu^{2+}{}_3Fe^{3+}{}_4[VO_4]_6$
*Grigorievite $Cu^{2+}{}_3Fe^{3+}{}_2Al_2[VO_4]_6$
3.1b.7b.3.1.3.2.2. Basic
Mounanaite $PbFe^{3+}{}_2(OH)_2[VO_4]_2$
*Krettnichite $PbMn^{3+}{}_2(OH)_2[VO_4]_2$
*Tokyoite $Ba_2Mn^{3+}(OH)[VO_4]_2$

3.1b.7b.3.1.3.3. M^{3+}, M^{2+} and M^{+}
3.1b.7b.3.1.3.3.1. Neutral
Howardevansite $Na_2Cu^{2+}{}_2Fe^{3+}{}_4[VO_4]_6$

3.1b.7b.3.1.3.4. M^{2+} 3.1b.7b.3.1.3.4.1. Oxido-tetravanadates and tetravanadato-chlorides
Heyite $Pb_5Fe^{2+}{}_2O_4[VO_4]_2$
3.1b.7b.3.1.3.4.2. Basic
Descloizite family
Calciovolborthite group
Calciovolborthite $CaCu(OH)[VO_4]$
Calcium mottramite $Pb_2CaCu_3(OH)_3[VO_4]_3$
Descloizite group
Descloizite $Pb(Zn,Cu)(OH)[VO_4]$
Mottramite $PbCu(OH)[VO_4]$
Čechite $Pb(Fe^{2+},Mn)(OH)[VO_4]$
Pyrobelonite $PbMn(OH)[VO_4]$
Vesignieite $BaCu_3(OH)_2[VO_4]_2$
Leningradite $PbCu_3Cl_2[VO_4]_2$
Brackebuschite series
Gamagarite $Ba_2(Fe,Mn)^{3+}(OH)[VO_4]_2$
Brackebuschite $Pb_2(Mn,Fe)^{3+}(OH)[VO_4]_2$
*Calderonite $Pb_2Fe^{3+}(OH)[VO_4]_2$
*Fe-brackebuschite $(Pb_{1,8}Zn_{0,2})(Fe^{3+}{}_{0,75}Mn^{3+}{}_{0,15}Al_{0,1})(OH)[VO_4]_2$

3.1b.7b.3.1.3.5. Vanadates of M^{2+} and M^{+}
3.1b.7b.3.1.3.5.1. Polyvanadates
3.1b.7b.3.1.3.5.1.1. Hydrates

Huemulite $Na_4Mg(H_2O)_{24}[V_{10}O_{28}]^{\infty}$

3.1b.7b.3.1.3.5.2. Tetravanadates

3.1b.7b.3.1.3.5.2.1. Neutral

Palenzonaite $NaCa_2Mn^{2+}{}_2[VO_4]_3$

*Schäferite $NaCa_2Mg^{2+}{}_2[VO_4]_3$

3.1b.7b.3.1.3.5.3. Vanadates with unknown structure

3.1b.7b.3.1.3.5.3.1. Hydrates

Kazakhstanite $Fe^{3+}{}_5(OH)_9V^{4+}{}_3V^{5+}{}_{12}O_{39}\cdot 9H_2O$

3.1b.7b.3.2. (4)-Vanadates of ***f***-cations

3.1b.7b.3.2.1. Tetravanadates 3.1b.7b.3.2.1.1. Neutral

Wakefieldite series

Wakefieldite-(Ce) $Ce[VO_4]$

Wakefieldite-(Y) $Y[VO_4]$

*Wakefieldite-(La) $La[VO_4]$

*Wakefieldite-(Nd) $Nd[VO_4]$

3.1b.7b.3.3. (4)-Vanadates of ***d***-cations

3.1b.7b.3.3.1. Vanadates of **I*b***-cations

3.1b.7b.3.3.1.1. Cu^{2+}

3.1b.7b.3.3.1.1.1. Trivanadates 3.1b.7b.3.3.1.1.1.1. Neutral

Ziesite family

Ziesite β-$Cu_2[V_2O_7]$

Blossite α-$Cu_2[V_2O_7]$

3.1b.7b.3.3.1.1.1.2. Hydrates (basic)

Volborthite $Cu_3(OH)_2(H_2O)_2[V_2O_7]$

*Karpenkoite $(Co,Zn)_3(OH)_2(H_2O)_2[V_2O_7]$

3.1б.7б.3.3.1.1.1.3. Оксидо-триванадато-хлориды

3.1б.7б.3.3.1.1.1.3.1. Кристаллогидраты (основные)

*Engelhauptite $KCu_3(OH)_2[V_2O_7]Cl$

*3.1б.7б.3.3.1.1.2. Триванадато-тетраванадаты

*3.1б.7б.3.3.1.1.2.1. Оксидо-триванадато-тетраванадаты

*Kainotropite $Cu_4Fe^{3+}O_2[V_2O_7][VO_4]$

3.1b.7b.3.3.1.1.3. Tetravanadates 3.1b.7b.3.3.1.1.3.1. Neutral

Mcbirneyite $Cu_3[VO_4]_2$

*Pseudolyonsite $Cu_3[VO_4]_2$

*Borisenkoite $Cu_3[(V,As)O_4]_2$

3.1b.7b.3.3.1.1.3.2. Oxido-tetravanadates

Stoiberite family

Stoiberite $Cu_5O_2[VO_4]_2$

*Starovaite $KCu_5O[VO_4]_3$

Fingerite $Cu_{11}O_2[VO_4]_6$

*3.1б.7б.3.3.1.1.3.3. Oxido-tetravanadato-chlorides

*Averievite $Cu_5O_2[VO_4]_2\cdot CuCl_2\cdot MCl$, M=Cs,K,Rb

*Yaroshevskite $Cu_9O_2[VO_4]_4Cl_2$

3.1b.7b.3.3.1.1.3.4. Hydroxides

Turanite $Cu_5(OH)_4[VO_4]_2$

*3.1б.7б.3.3.1.2. M^+ и M^{2+}

*3.1б.7б.3.3.1.2.1. Ag^+, Hg^{2+}

*Tillmannsite $(Ag_3Hg)(V,As)O_4$

3.1b.7b.3.3.1.3. Cu^{2+}, Pb^{2+} and Bi^{3+}

3.1b.7b.3.3.1.3.1. Tetravanadates

3.1b.7b.3.3.1.3.1.1. Hydrates (basic)

Duhamelite $Pb_2Cu_4Bi(OH)_3[VO_4]_4 \cdot 8H_2O$

*3.1б.7б.3.3.2. Vanadates of II*b*-cations

*3.1б.7б.3.3.2.1. Zn^{2+}

*3.1б.7б.3.3.2.1.1. Trivanadates

*3.1б.7б.3.3.2.1.1.1. Hydrates

*Martyite $Zn_3(OH)_2[V_2O_7] \cdot 2H_2O$

3.1b.7b.3.4. (4)-Vanadates of ***p***-cations

3.1b.7b.3.4.1. Vanadates of **IV***a*-cations

3.1b.7b.3.4.1.1. Pb^{2+}

3.1b.7b.3.4.1.1.1. Trivanadates 3.1b.7b.3.4.1.1.1.1. Neutral

Chervetite $Pb_2[V_2O_7]$

3.1b.7b.3.4.1.1.2. Tetravanadates

3.1b.7b.3.4.1.1.2.1. Tetravanadato-chlorides

3.1b.7b.3.4.1.1.2.1.1. Oxido-chlorido-vanadates

Kombatite $Pb_{14}O_9[VO_4]_2Cl_4$

3.1b.7b.3.4.1.1.2.1.2. Neutral

Vanadinite $Pb_5[VO_4]_3Cl$ (compare with apatite (family); pyromorphite (group))

3.1b.7b.3.4.1.1.2.2. Tetravanadato-chromates

3.1b.7b.3.4.1.1.2.2.1. Hydrates

Cassedanneite $Pb_5(VO_4)_2(CrO_4)_2 \cdot H_2O$

3.1b.7b.3.4.1.2. $Pb^{2+}$and Bi^{3+}

3.1b.7b.3.4.1.2.1.Hydrovanadato-tetravanadates

3.1b.7b.3.4.1.2.1.1. Hydrates

Pottsite $PbBi[VO_3OH][VO_4] \cdot 2H_2O$

3.1b.7b.3.4.2. Vanadates of **V**a-cations

3.1b.7b.3.4.2.1. Tetravanadates (orthovanadates)

3.1b.7b.3.4.2.1.1. Neutral

Pucherite $Bi[^{(4)}VO_4]^{\infty}$ (compare with dreyerite (family))

3.1b.7b.3.4.2.1.2. Oxido-hydroxides

Schumacherite $Bi^{3+}{}_3(OH)O[VO_4]_2$

*Hechtsbergite $Bi_2O(OH)[VO_4]$

3.1c. **Quasisubtype***: Oxides and hydroxides of chalcophylic cations (without **V**a- and **VI**a- cations)
3.1c.1. **Overclass***: oxides and hydroxides of **I*b***-cations
3.1c.1.1. Cu^{+}
3.1c.1.1.1. Simple

Cuprite	Cu_2O

3.1c.1.2. Cu^{+} and Fe^{3+} (Cu^{2+})
3.1c.1.2.1. Complex

Delafossite family	
Delafossite group	
Delafossite	$Cu^{+}Fe^{3+}O_2$
Mcconnellite	$Cu^{+}Cr^{3+}O_2$
Crednerite	$CuMnO_2$
Paramelaconite	$Cu^{+}_2Cu^{2+}_2O_3$

3.1c.1.3. Cu^{2+}
3.1c.1.3.1. Proper oxides
3.1c.1.3.1.1. Simple

Tenorite	CuO

3.1c.1.3.2. Oxido-halogenides
3.1c.1.3.2.1. Simple

Melanothallite	Cu_2OCl_2

3.1c.1.3.2.2.Complex

Murdochite	$Pb^{4+}_2Cu^{2+}_{12}O_{15}(Cl,Br)_2$

3.1c.1.3.3. Hydroxides and hydroxido-halogenides
3.1c.1.3.3.1. Simple

Spertiniite	$Cu(OH)_2$

3.1c.1.3.3.2. Hydrates

Calumetite family	
Calumetite	$Cu(OH,Cl)_2 \cdot 2H_2O$
Anthonyite	$Cu(OH,Cl)_2 \cdot 3H_2O$

3.1c.2. **Overclass***: Oxides and hydroxides of **II*b***-cations
3.1c.2.1. Oxides and hydroxides of Hg
3.1c.2.1.1. Hg^{+}
3.1c.2.1.1.1. Oxido-halogenides
3.1c.2.1.1.1.1. Simple

Poyarkovite family	
Poyarkovite	Hg_3OCl
Kadyrelite	$Hg_6^{1+}Br_3O_{1.5}$

3.1c.2.1.1.2. Hydroxido-oxido-halogenides
3.1c.2.1.1.2.1. Simple

Eglestonite	$Hg^{+}_6(OH)OCl_3$

3.1c.2.1.2. Hg^{+} and Hg^{2+}
3.1c.2.1.2.1. Oxido-halogenides
3.1c.2.1.2.1.1. Complex

Terlinguaite $Hg_2OCl \rightarrow Hg^{+}Hg^{2+}OCl$
*Aurivilliusite $Hg^{+}Hg^{2+}OI$
*Tedhadleyite $Hg^{+}_{10}Hg^{2+}O_4I_2(Cl,Br)_2$

*3.1c.2.1.2.2. Oxido-sulfides
*Deanesmithite $Hg^{+}_2Hg^{2+}_3Cr^{6+}O_5S_2$

3.1c.2.1.3. Hg^{2+}
3.1c.2.1.3.1. Proper oxides
3.1c.2.1.3.1.1. Simple
Montroydite HgO

3.1c.2.1.3.2. Oxido-halogenides
3.1c.2.1.3.2.1. Simple
Comancheite family
Pinchite $Hg_5O_4Cl_2$
*Terkinguacreekite $Hg^{2+}_3O_2Cl_2$
Comancheite $Hg_{13}O_9(Cl,Br)_8$

*3.1c.2.1.3.3. Oxido-halogenido-carbonates
*Vasilyevite $Hg^{2+}_{10}O_6I_3(Br,Cl)_3(CO_3)$

3.1c.2.2. Oxides and hydroxides of Zn^{2+} and Cd^{2+}
3.1c.2.2.1. Simple oxides and hydroxides
3.1c.2.2.1.1. Proper oxides
3.1c.2.2.1.1.1. Simple
Zincite ZnO (compare with bromellite (group))
Monteponite CdO (compare with periclase (series)

3.1c.2.2.1.2. Hydroxides
3.1c.2.2.1.2.1. Simple
Sweetite family
Sweetite $Zn(OH)_2$
Ashoverite $Zn(OH)_2$
Wülfingite $Zn(OH)_2$

3.1c.3.**<u>Overclass</u>***: Oxides and hydroxides of **III*a***-cations
3.1c.3.1. Proper oxides
3.1c.3.1.1. Simple
Avicennite Tl_2O_3

3.1c.3.2. Hydroxides
3.1c.3.2.1. Simple
Dzhalindite $In(OH)_3$

3.1c.4. **<u>Overclass</u>***: Oxides and hydroxides of **IV*a***-cations
3.1c.4.1. Oxides and hydroxides of Pb
3.1c.4.1.1. Oxides and hydroxides of Pb^{2+}
3.1c.4.1.1.1. Proper oxides
3.1c.4.1.1.1.1. Simple

Litharge family

Litharge	PbO
Massicot	β-PbO
*Unnamed	α-PbO

3.1c.4.1.1.2. Oxido-halogenides
3.1c.4.1.1.2.1. Simple

Mendipite	$Pb_3O_2Cl_2$
*Damaraite	$Pb_3O_2(OH)Cl$

3.1c.4.1.1.3. Oxido-silicato-chlorides
3.1c.4.1.1.3.1. Simple

Asisite	$Pb_7SiO_8Cl_2 \rightarrow Pb_7O_4[SiO_4]Cl_2$

3.1в.4.1.1.4. Oxido-borato-carbonato- chlorides
3.1в.4.1.1.4.1. Simple

*Mereheadite	$Pb_{47}O_{24}(OH)_{13}Cl_{25}(BO_3)_2(CO_3)$

3.1c.4.1.2. Oxides and hydroxides of Pb^{2+} andPb^{4+}
3.1c.4.1.2.1. Proper oxides
3.1c.4.1.2.1.1. Complex

Minium	$Pb_3O_4 \rightarrow Pb^{2+}{}_2Pb^{4+}O_4$

3.1c.4.1.3. Oxides and hydroxides of Pb^{4+}
3.1c.4.1.3.1. Proper oxides
3.1c.4.1.3.1.1. Simple

Plattnerite family

Plattnerite	PbO_2
Scrutinyite	α-PbO_2

*3.1в.4.1.3.1.1. Complex

*Lindqvistite	$Pb^{2+}{}_2Mn^{2+}Fe^{3+}{}_{16}O_{27}$

3.1c.4.2 Oxides and hydroxides of Ge и Sn
3.1c.4.2.1. Oxides and hydroxides of Sn^{2+}
3.1c.4.2.1.1. Proper oxides
3.1c.4.2.1.1.1. Simple

Romarchite	SnO

3.1c.4.2.1.2. Oxido-hydroxides and oxido-hydroxido-halogenides
3.1c.4.2.1.2.1. Simple

Hydroromarchite family

Hydroromarchite	$Sn_3(OH)_2O_2$
Abhurite	$Sn_3(OH)_2OCl_2$
*Unnamed	$Sn_4O(OH,F)_6$

*3.1c.4.2.1.2.2. Complex

*Eyselite	$Fe^{3+}Ge^{4+}{}_3O_7(OH)$

*3.1в.4.2.1.2.2. Oxides and hydroxides of Ge^{4+}

*Krieselite	$(Al,Ga)_2(Ge,C)O_4(OH)_2$

3.1d. Quasisubtype*: Oxides and hydroxides of **Va**-катионов
3.1d.1. Overclass*: Oxides and hydroxides of As^{3+},Sb^{3+},Bi^{3+}
3.1d.1a. Class: Simple oxides and hydroxides of As^{3+}, Sb^{3+}, Bi^{3+}
3.1d.1a.1. Proper oxides

Arsenolite family	
Arsenolite group	
Arsenolite	$2As_2O_3 \rightarrow As_4O_6$
Senarmontite	$2Sb_2O_3 \rightarrow Sb_4O_6$
Valentinite	$\|Sb_2O_3\|^{\infty}$
Claudetite	$\|As_2O_3\|^{\infty2}$
*Stibioclaudetite	$AsSbO_3$
Bismite	α-$\|Bi_2O_3\|^{\infty3}$
*Sphaerobismoite	$Bi_2O_3\|$

3.1d.1a.2. Oxido (hydroxido)-halogenides

Bismoclite group	
Zavaritskite	BiOF
Daubreeite	BiO(OH,Cl)
Bismoclite	BiOCl
Onoratoite	$Sb_8O_{11}Cl_2$
*Torrecillasite	$Na(As,Sb)^{3+}{}_4O_6Cl$

3.1d.1a.3. Oxido-silicates

Sillenite	γ-$Bi_{12}SiO_{20} \rightarrow \gamma$- $Bi_{12}O_{16}[SiO_4]$

3.1d.1b. ***Class***: Complex oxides and hydroxides of As^{3+}, Sb^{3+}, Bi^{3+} $\rightarrow$ (6)-arsenites, antiminites, bismuthites
3.1d.1b.1. Arsenites of ***s***-, ***d_s***- and ***p_s***- cations
3.1d.1b.1.1. Arsenites of M^{3+}

	3.1d.1b.1.1.1. Oxides and hydroxides
Karibibite	$Fe^{3+}{}_2As_4(O,OH)_9$

3.1d.1b.1.2. M^{3+} and M^{2+}
3.1d.1b.1.2.1. Proper arsenites

	3.1d.1b.1.2.1.1. Neutral
Schneiderhöhnite	$Fe^{2+}Fe^{3+}{}_3As_5O_{13}$
Stenhuggarite	$CaFe^{3+}SbAs_2O_7$
	*3.1d.1b.1.2.1.2. Basic
*Graeserite	$Fe^{3+}{}_4Ti_3AsO_{13}(OH)$
*Fetiasite	$Fe^{2+}Fe^{3+}{}_2[As^{3+}{}_2O_5]O_2$
	3.1d.1b.1.2.1.3. Hydrates
Lazarenkoite	$(Ca,Fe^{2+})Fe^{3+}As_3O_7 \cdot 3H_2O$
Cafarsite	$Ca_8(Ti,Fe^{2+},Fe^{3+},Mn)_{6-7}As_{12}O_{36} \cdot 4H_2O$

3.1d.1b.1.2.2. Arsenito-sulfides
3.1d.1b.1.2.2.1. Neutral

Versiliaite	$(Fe^{2+},Fe^{3+},Zn)_8(Sb^{3+},Fe^{3+},As)_{16}O_{32}S_{1.3}$

3.1d.1b.1.3. Arsenites of M^{2+}
3.1d.1b.1.3.1. Proper arsenites
3.1d.1b.1.3.1.1. Neutral
Schafarzikite $FeSb_2O_4$
3.1d.1b.1.3.1.2. Basic
Manganarsite family
Manganarsite $Mn_3(OH)_4As_2O_4$
Magnussonite $Mn_5(OH,Cl)As_3O_9$
3.1d.1b.1.3.1.3. Acid
Trigonite $Pb_3Mn(AsO_3)_2(AsO_2OH)$
3.1d.1b.1.3.1.4. Hydrates
Rouseite $Pb_2Mn(AsO_3)_2{\cdot}2H_2O$

3.1d.1b.1.3.2. Arsenito-halogenides 3.1d.1b.1.3.2.1. Neutral
Nanlingite $NaCa_5LiMg_{12}(AsO_3)_2[Fe^{2+}(AsO_3)_6]F_{14}$
*Lucabindiite $(K,NH_4)(As_4O_6)(Cl,Br)$

3.1d.1b.2. Arsenites of ***d***- cations
3.1d.1b.2.1. Arsenites of Ti^{4+}, V^{4+} 3.1d.1b.2.1.1. Basic
Tomichite family
Tomichite group
Tomichite $(V,Fe)^{3+}{}_4Ti_3(OH)AsO_{13}$
Derbylite $Fe^{3+}{}_4Ti_3(OH)SbO_{13}$
Hemloite $(Ti,V^{3+},Fe^{2+},Fe^{3+})_{12}(OH)(As,Sb)^{3+}{}_2O_{23}$
*3.1г.1б.2.1.2. Hydrates
*Dukeite $Bi^{3+}{}_{24}Cr^{6+}{}_8O_{57}(OH)_6(H_2O)_3$

3.1d.1b.2.2. Arsenites of **I***b*-cations
3.1d.1b.2.2.1. Arsenites of Au (only Au^+)
3.1d.1b.2.2.1.1. Antimonito- antimonates
3.1d.1b.2.2.1.1.1. Neutral
*3.1d.1б.2.2.1.2. Antimonites
*Unnamed $Au_2Sb^{3+}O_2(OH)$

3.1d.1b.2.2.2. Arsenites of Cu (only Cu^{2+})
3.1d.1b.2.2.2.1. Neutral
Trippkeite $CuAs_2O_4$

*3.1d.1б.2.2.3. Bismuthites Cu (only Cu^{2+}) и M^{3+}
*Kusachiite $CuBi_2O_4$

*3.1г.1б.2.2.3.1. Bismuthito-oxido-sulfato-halogenides
*Atlasovite $Cu^{2+}{}_6Fe^{3+}Bi^{3+}O_4[SO_4]_5{\cdot}KCl$

3.1d.1b.2.3. Arsenites of **II***b*-cations
3.1d.1b.2.3.1. Arsenites of Hg
3.1d.1b.2.3.1.1. Oxido-halogenides
Kelyanite $Hg_{12}SbO_6BrCl_2$

3.1d.1b.2.3.2. Arsenites of Zn
3.1d.1b.2.3.2.1. Neutral
Leiteite family
Leiteite $ZnAs_2O_4$
Reinerite $Zn_3As_2O_6$

3.1d.1b.3. Arsenites of ***p***-cations
3.1d.1b.3.1. Arsenites of **IV*a***-cations (Pb^{2+})
3.1d.1b.3.1.1. Proper arsenites
3.1d.1b.3.1.1.1. Neutral
Paulmooreite $Pb_2As_2O_5$

3.1d.1b.3.1.2. Arsenito-halogenites 3.1d.1b.3.1.2.1. Neutral →basic
Nadorite group
Nadorite $PbSbO_2Cl$
Perite $PbBiO_2Cl$
Finnemanite $Pb_5As_3O_9Cl$
Gebhardite $Pb_8As_4O_{11}Cl_6$
Freedite $Pb_8Cu^+(As^{3+}O_3)_2O_3Cl_5$
Ecdemite family
Ecdemite group
Ecdemite $Pb_6As_2O_7Cl_4$
Thorikosite $Pb_3(OH)(Sb_{0.6}As_{0,4})O_3Cl_2$
Heliophyllite $Pb_6As_2O_7Cl_4$

3.1d.2. **<u>Overclass</u>*:*** Oxides and hydroxides of As^{5+}, Sb^{5+}, Bi^{5+} (all complex) → arsenates, antimonates and bismuthates (only (6)-arsenates, (6)-antimonates and (6)-bismuthates)
3.1d.2.1. Quasiclass: (6)-arsenates, (6)-antimonates and (6)-bismuthates
3.1d.2.1.1. (6)-Arsenates, (6)-antimonates and (6)-bismuthates of - ***s***-, $\boldsymbol{d_s}$- and $\boldsymbol{p_s}$- cations
3.1d.2.1.1.1. ((6) - Arsenates, (6) - antimonates and (6) - bismuthates of ***s***-, $\boldsymbol{d_s}$- and $\boldsymbol{p_s}$- cations (without Li and Be)
3.1d.2.1.1.1.1. (6)-Arsenates, (6)-antimonates and (6)-bismuthates of M^{3+}
3.1d.2.1.1.1.1.1. Proper (6)-Arsenates, (6)-antimonates and (6)-bismuthates
3.1d.2.1.1.1.1.1.1. Basic
Bahianite $Al_5(OH)_2Sb_3O_{14} \rightarrow \{Al_5(OH)_2|Sb_3O_{14}|^{\infty}\}^{\infty 3}$
3.1d.2.1.1.1.2. (6)-Antimonates of M^{3+} and M^{2+}
3.1d.2.1.1.1.2.1. Neutral
Melanostibite $Mn^{2+}{}_2Fe^{3+}SbO_6$
*Paganoite $NiBi^{3+}As^{5+}O_5$
Cualstibite $Cu_2AlSb^{5+}(OH)_{12}$
*Zincalstibite $(Zn,Cu)_2Al(OH)_6[Sb(OH)_6]$ или $Zn_2AlSb(OH)_{12}$
*Omsite $(Ni,Cu)_2Fe^{3+}(OH)_6[Sb(OH)_6]$

3.1d.2.1.1.1.2.2. (6)-Antimonates-sulfato-hlorides
3.1d.2.1.1.1.2.3.1. Basic
Mammothite $Pb_6Cu_4Al(OH)_{16}SbO_2[SO_4]_2Cl_4$

3.1d.2.1.1.1.3. (6)- antimonates M^{2+}
3.1d.2.1.1.1.3.1. Neutral
Byströmite group (compare with tapiolite (group)) $MgSb_2{}^{5+}O_6$

Byströmite $MgSb^{5+}{}_2O_6$
Tripuhyite $Fe^{2+}Sb^{5+}{}_2O_6$ or FeSbO

*3.1г.2.1.1.1.3.2. Basic

*Bottinoite $Ni[Sb^{5+}(OH)_6]_2{\cdot}6H_2O$

3.1d.2.1.1.1.3.3. Oxido-antimonates

Ingersonite $Ca_3MnSb^{5+}{}_4O_{14}$

3.1d.2.1.1.1.3.3.1. Hydrates

Brandholzite $Mg(H_2O)_6[Sb(OH)_6]_2$

3.1d.2.1.1.1.4. (6)-Antimonates M^{2+} and M^+

3.1d.2.1.1.1.4.1. Basic

Roméite series (compare with pyrochlore (series); partzite (series))
*Fluorcalcioroméite $[Sb^{5+}{}_2O_6]^{\infty 3}(Ca,Na)_2F$
*Oxycalcioroméite $Ca_2Sb_2O_7$
*Oxyplumboroméite $Pb_2Sb_2O_7$
Na-romeite $[Sb_2O_6]^{\infty 3}(Na,Ca,Mn)_2(OH,F)$
Lewisite $[(Sb,Ti)_2(O,OH)_6|^{\infty 3\cdot}(Ca,Fe,Na)_2(O,OH)$

3.1d.2.1.1.1.5. (6)-Antiminates of M^+ 3.1d.2.1.1.1.5.1. Acid

Mopungite $Na[Sb(OH)_6]$

*3.1d.2.1.1.1.5.2. Neutral

*Brizziite $NaSb^{5+}O_3$

3.1d.2.1.1.2. (6) - Antimonates of Be→ beryllo-antimonates

3.1e.2.1.1.2.1. Neutral

Swedenborgite $NaBe_4SbO_7 \rightarrow$
$^{(12)}Na[^{(4)}Be_4O(^{(6)}SbO_6)]^{\infty 3}$

3.1d.2.1.2. (6)-Arsenates, (6)-antimonates of ***d***-cations
3.1d.2.1.2.1. (6)-Arsenates, (6)-antimonates of I*b*-elements
3.1d.2.1.2.1.1. (6)-Arsenates, (6)-antimonates of Cu^{2+}

3.1e.2.1.2.1.1.1. Basic

Namibite $Cu(BiO)_2[VO_4](OH)$

3.1d.2.1.2.1.2. (6) Antimonates of Cu^+

3 .1e.2.1.2.1.2.1. Acid-basic

Partzite group (compare with pyrochlore (series); romeite (series)
Partzite $Cu_2Sb_2O_5(OH)_2$ (?)→
$|Sb_2O_5|^{\infty 3\cdot}Cu_2(OH)_2$ (?)
Stetefeldtite $Ag_2Sb_2(O,OH)_7 \rightarrow$
$|Sb_2(O,OH)_6|^{\infty 3\cdot}Ag_2(O,OH)$
*Auriacusite $Fe^{3+}Cu^{2+}[(As,Sb)O_4]O$

3.1d.2.1.2.2. (6)-Arsenates and (6)-antimonates of **II***b*-elements
3.1d.2.1.2.2.1. (6)-Arsenates and (6)-antimonates of Hg

3.1d.2.1.2.2.1.1. Basic (acid ?)

*Shanovite $Hg^{2+}{}_8Sb^{5+}{}_2O_{13}$
Shakhovite $Hg^{+}{}_4(OH)_3Sb^{5+}O_3$

3.1d.2.1.2.2.2. (6)-Arsenates and (6)-Antimonates of Zn

3.1d.2.1.2.2.2.1. Neutral

Ordoñezite $ZnSb_2O_6$ (compare with tapiolite (group); byströmimite (group)

*3.1d.2.1.2.2.2.2. Basic

*Sabelliite $(Cu,Zn)_2Zn[(As,Sb)O_4](OH)_3$

3.1d.2.1.3. (6) - Arsenates and and (6) - Antimonates of ***p***-metals

3.1d.2.1.3.1. (6)- Arsenates and (6) - antimonates of **IVa**-elements (Pb^{2+})

*Rosiaite $PbSb_2O_6$

3.1d.2.1.3.1.1. Neutral

Monimolite $(Pb,Ca)_3Sb_2O_8$

3.1d.2.1.3.1.2. Basic (acid)

Bindheimite $Pb_2Sb_2O_7$

3.1d.2.1.3.2. (6)-Arsenates, (6)-antimonates of **V**a-elements

3.1d.2.1.3.2.1. (6)-Arsenates, (6)-antimonates of Sb^{3+} and Bi^{3+}

3.1d.2.1.3.2.1.1. Neutral → basic (acid)

Cervantite (compare with stibiotantalite (group)) $Sb_2O_4 \rightarrow {}^{(4)}Sb^{3+}|{}^{(6)}Sb^{5+}O_4|^{\infty 2}$

*Clinocervantite $\beta\text{-}Sb_2O_4$

Stibiconite group (compare with romeite (series); partzite (group); bindheimite)

Stibiconite questionable $Sb_3O_6(OH) \rightarrow |Sb^{5+}{}_2O_6|^{\infty 3} \cdot Sb^{3+}(OH)$

Bismutostibiconite questionable $Bi(Sb,Fe)_2O_7 \rightarrow |(Sb,Fe)_2O_6|^{\infty 3} \cdot BiO$

3.1e. Quasisubtype*: Oxides and hydroxides of VIa-cations (Te)

3.1e.1. Overclass*: Oxides and hydroxides of Te^{4+}

3.1e.1a. Class: Simple oxides and hydroxides of Te^{4+}

Tellurite family

Tellurite TeO_2

Paratellurite TeO_2

3.1e.1b. ***Class:*** Complex oxides and hydroxides Te^{4+} → Tellurites

3.1e.1b.1. Tellurites of **s**- and ***d$_s$***-ations

3.1e.1b.1.1. Tellurites M^{3+}

3.1e.1b.1.1.1. Tellurites Fe^{3+}

3.1e.1b.1.1.1.1. Proper tellurites

3.1e.1b.1.1.1.1.1. Neutral

Blakeite questionable $Fe^{3+}{}_2Te_3O_9$

3.1e.1b.1.1.1.1.2. Basic and hydroxido-chlorides

Mackayite $Fe^{3+}Te_2(OH)O_5$

Rodalquilarite $H_3Fe^{3+}{}_2Te_4O_{12}Cl \rightarrow Fe^{3+}{}_2Te_4(OH)_3O_9Cl$

3.1e.1b.1.1.1.1.3. Hydrates

Emmonsite $Fe^{3+}{}_2Te_3O_9 \cdot 2H_2O$

Sonoraite $Fe^{3+}Te(OH)O_3 \cdot H_2O$

3.1e.1b.1.1.1.2. Tellurito-sulfates 3.1e.1b.1.1.1.2.1. Hydrates

Poughite $Fe^{3+}{}_2Te_2O_6[SO_4] \cdot 3H_2O$

3.1e.1b.1.1.2. Tellurites of Fe^{3+} and Bi^{3+}

3.1e.1b.1.1.2.1. Tellurito-tellurates 3.1e.1b.1.1.2.1.1. Hydrates

Yecoraite $Fe_3{}^{3+}Bi_5O_9(Te^{4+}O_3)(Te^{6+}O_4)_2 \cdot 9H_2O$

*Pingguite $Bi_6Te^{4+}{}_2O_{13}$

3.1e.1b.1.1.3. Tellurites of M^{3+} and M^{2+}
3.1e.1b.1.1.3.1. Proper tellurites
3.1e.1b.1.1.3.1.1. Hydrates (basic)
Eztlite $Pb_3Fe^{3+}{}_6Te^{4+}{}_3Te^{6+}(OH)_{10}O_{15}·8H_2O$

3.1e.1b.1.1.3.2. Tellurito-monoalu-monosilicates
3.1e.1b.1.1.3.2.1. Hydrates (basic)
Burckhardtite $Pb_2(Fe^{3+}Te^{6+})[AlSi_3O_8]O_6$

3.1e.1b.1.1.4. Tellurites of M^{2+}
3.1e.1b.1.1.4.1. Proper tellurites
3.1e.1b.1.1.4.1.1. Neutral
Spiroffite $(Mn,Zn)_2Te_3O_8$
*Zincospiroffite $Zn_2Te_3O_8$
Denningite $(Mn,Ca)Te^{4+}{}_4O_{10}$
3.1e.1b.1.1.4.1.2. Neutral→ Hydrates (compounds inclusions)
Zemannite family
Kinichilite $Mg_{0.5}Mn^{2+}Fe^{3+}(Te^{4+}O_3)_3$ $4.5H_2O$
Zemannite $Mg_{0.5}ZnFe^{3+}(Te^{4+}O_3)_3$ $4.5H_2O$
*Ilirneyite $Mg_{0.5}\{ZnMn^{3+}(TeO_3)_3\}^{\infty 3}·4.5H_2O$

3.1e.1b.1.1.4.2. Tellurito-tellurates
3.1e.1b.1.1.4.2.1. Neutral
Carlfriesite $CaTe^{4+}{}_2Te^{6+}O_8$
*Walfordite $(Fe^{3+}Te^{6+})Te^{4+}{}_3O_8$

3.1e.1b.1.1.4.3. Tellurito-carbonates
3.1e.1b.1.1.4.3.1. Neutral
Mroseite $CaTeO_2[CO_3]$

3.1e.1b.1.1.5. Tellurites of M^{2+} and M^{+}
3.1e.1b.1.1.5.1. Proper tellurites
3.1e.1b.1.1.5.1.1. Hydrates
Keystoneite $Mg_{0,5}(Ni^{2+}Fe^{3+})_{\sum 2}(TeO_3)_3·4.5H_2O$

3.1e.1b.1.1.5.2. Tellurito-sulfato-halogenides
3.1e.1b.1.1.5.2.1. Oxido-tellurito-sulfato-halogenides
Nabokoite $KCu^{2+}{}_7Te^{4+}O_4[SO_4]_5Cl$

3.1e.1b.2. Tellurites of *d*-cations
3.1e.1b.2.1. Tellurites of **IV***b*-cations (Ti^{4+})
3.1e.1b.2.1.1. Neutral
Winstanleyite $TiTe_3O_8$

3.1e.1b.2.2. Tellurites of **I***b*-cations·
3.1e.1b.2.2.1. Tellurites of Cu^{2+}
*3.1e.1б.2.2.1. Proper tellurites
3.1e.1b.2.2.1.1.1. Neutral
Rajite $CuTe_2O_5$
Balyakinite $CuTeO_3$

3.1e.1b.2.2.1.1.2. Hydrates
3.1e.1b.2.2.1.2.1.1. Basic

Cesbronite $Cu_5Te_2O_6(OH)_6{\cdot}2H_2O$
*Brumadoite $Cu_3(Te^{6+}O_4)(OH)_4{\cdot}5H_2O$

3.1e.1b.2.2.1.1.2.2. Neutral

Graemite family
Graemite $CuTeO_3{\cdot}H_2O$
Teineite $Cu(Te,S)O_3{\cdot}2H_2O$

*3.1e.1b.2.2.1.2. Tellurito-arsenates
*Juabite $CaCu^{2+}_{10}(TeO_3)_4[AsO_4]_4(OH)_2(H_2O)_4$

*3.1e.1b.2.2.1.3. Tellurito-halogenides
*3.1e.1b.2.2.1.3.1. Basic
*Mojaveite $Cu^{2+}_6[T^{6+}O_4(OH)_2](OH)_7Cl$

3.1e.1b.2.2.2. Tellurites of Cu^{2+} and Zn
3.1e.1b.2.2.2.1. Proper tellurites
3.1e.1b.2.2.2.1.1. Basic
Quetzalcoatlite $Cu^{2+}_3Zn_6Te^{6+}_2O_{12}(OH)_6\cdot Ag_xPb_yCl_{x+2y}$

*3.1e.1б.2.2.3. Tellurito-arsenato-halogenides
*3.1e.1b.2.2.3.1.Hydrates
*Eurekadumpite $(Cu,Zn)_{16}(TeO_3)_2(AsO_4)_3Cl(OH)_{18}{\cdot}7H_2O$

3.1e.1b.2.2.2.2. Tellurito-tellurato-halogenides
3.1e.1b.2.2.2.2.1. Hydrates
3.1e.1b.2.2.2.2.1.1. Basic
Tlalocite $Cu_{10}Zn_6Te^{4+}Te^{6+}_2(OH)_{25}O_{11}Cl{\cdot}27H_2O$

3.1e.1b.2.2.2.3. Tellurito-tellurato-sulfates
3.1e.1b.2.2.2.3.1. Neutral
Tlapallite $H_6Ca_2Cu_3Te^{4+}_4Te^{6+}O_{18}[SO_4]$

3.1e.1b.2.2.3. Tellurites of Cu^{2+} and Pb
Choloalite $(Pb,Ca)_3(Cu,Sb)_3Te_6O_{18}Cl$

3.1e.1b.2.3. Tellurites of **II***b*-elements
3.1e.1b.2.3.1. Tellurites of Hg^+
3.1e.1b.2.3.1.1. Neutral
Magnolite $Hg^+_2TeO_3$

3.1e.1b.3. Tellurites of ***p***-cations (Pb^{2+})
3.1e.1b.3.1. Proper tellurites
3.1e.1b.3.1.1. Neutral

Plumbotellurite family
Plumbotellurite α-$PbTeO_3$
Fairbankite $PbTeO_3$

*3.1e.1б.3.2. Tellurato-halogenides

*Telluroperite $Pb_3Te^{4+}O_4Cl_2$

3.1e.1b.3.2. Tellurito-tellurates
3.1e.1b.3.2.1. Acid
3.1e.1b.3.2.2. Hydrates
Oboyerite $H_6Pb_6Te^{4+}{}_3Te^{6+}{}_2O_{21}\cdot 2H_2O$

3.1e.1b.4. Tellurites of semimetals
3.1e.1b.4.1. Tellurites of Bi^{3+}
3.1e.1b.4.1.1. Neutral
Smirnite Bi_2TeO_5
Chekhovichite $Bi_2Te_4O_{11}$

3.1e.2. **Overclass:** Oxides and hydroxides of Te^{6+} (all complex) → tellurates (all (6)-tellurates)
3.1e.2.1. Tellurites of ***s***- and ***d**s*- cations (M^{2+})
3.1e.2.1.1. Neutral
Yafsoanite $Ca_3Zn_3[TeO_6]_2$ → $Ca_3Te_2|ZnO_4|_3$
3.1e.2.1.2. Hydrates
Cuzticite $Fe_2TeO_6\cdot 3H_2O$

3.1e.2.2. Tellurates of ***d***-cations
3.1e.2.2.1. Tellurates of Mn^{4+}
3.1e.2.2.1.1. Tellurates of Mn^{4+} and Pb
3.1e.2.2.1.1.1. Neutral
Kuranakhite $PbMn^{4+}TeO_6$
*3.1д.2.2.1.1.2. Hydrates
*Xocolatlite $Ca_2Mn^{4+}{}_2Te^{6+}{}_2O_{12}\cdot H_2O$

3.1e.2.2.2. Tellurates of **I***b*-cations
3.1e.2.2.2.1. Tellurates of Cu^{2+}
3.1e.2.2.2.1.1. Basic
Xocomecatlite $Cu_3Te^{6+}O_4(OH)_4$
*Frankhawthorneite $Cu_2Te^{6+}O_4(OH)_2$
*Mcalpineite $Cu^{2+}{}_3Te^{6+}O_6$
*3.1д.2.2.2.1.1.1. Hydrates
*Raisaite $Cu^{2+}Mg[Te^{6+}O_4(OH)_2]\cdot 6H_2O$
*Utahite $Cu^{2+}{}_5Zn_3(Te^{6+}O_4)_4(OH)_8\cdot 7H_2O$
*Leisingite $Cu^{2+}(Mg,Cu,FeZn)_2Te^{6+}O_6\cdot 6H_2O$

3.1e.2.2.2.2. Tellurates of Cu^{2+} and Pb
3.1e.2.2.2.2.1. Basic
Khinite family
Khinite $PbCu_3Te^{6+}(OH)_2O_6$
Parakhinite = khinit-3T $PbCu_3Te^{6+}(OH)_2O_6$
*Housleyite $Pb_6Cu^{2+}Te^{6+}{}_4(OH)_2O_{18}$
*Timroseite $Pb_2Cu^{2+}{}_5(Te^{6+}O_6)_2(OH)_2$
*Paratimroseite $Pb_2Cu^{2+}{}_4(Te^{6+}O_6)_2(H_2O)_2$
*Andycristiite $PbCu^{2+}(Te^{6+}O_5)(H_2O)$
*Eckhardite $(Ca,Pb)Cu^{2+}Te^{6+}O_5(H_2O)_2$

*3.1e.2.2.2.2.3. Tellurato-carbonates
*3.1e.2.2.2.2.3.1. Basic
*Agaite $Pb_3Cu^{2+}Te^{6+}O_5(OH)_2[CO_3]$

*3.1e.2.2.2.2.4. Tellurato-sulfates
*3.1e.2.2.2.2.4.1. Basic
*3.1e.2.2.2.2.4.1.1.Hydrates
*Bairdite $Pb_2Cu^{2+}{}_4(Te^{6+}O_5)_2(OH)_2[SO_4](H_2O)$

3.1e.2.2.2.3. Tellurates of **II***b*-cations
3.1e.2.2.3.1. Tellurates of Zn
3.1e.2.2.3.1.1. Tellurates of Zn and Pb
3.1e.2.2.3.1.1.1. Tellurato-arsenates 3.1e.2.2.3.1.1.1.1. Basic
Dugganite $Pb_3Zn_3Te^{6+}O_6[AsO_4]_2$
*Joëlbruggerite $Pb_3Zn_3(Sb^{5+},Te^{6+})O_5[AsO_4]_2(OH,O)$

*3.1e.2.2.3.1.1.2. Tellurato-phosphates
*3.1e.2.2.3.1.1.2.1.Basic
*Kuksite $Pb_3Zn_3Te^{6+}O_6[PO_4]_2$

*3.1e.2.2.3.1.1.2. Tellurato -vanadates
*3.1e.2.2.3.1.1.2.1.Basic
*Cheremnykhite $Pb_3Zn_3Te^{6+}O_6[VO_4]_2$

3.1e.2.3. Tellurates of ***p***-metals
3.1e.2.3.1. Tellurates of **IV***a*-metals 3.1e.2.3.1.1. Hydrates
*Ottoite $Pb_2Te^{6+}O_5$
Schieffelinite $Pb_{10}Te_6O_{20}(OH)_{14}[SO_4]\cdot 5H_2O$
*Chromschieffelinite $Pb_{10}Te_6O_{20}(OH)_{14}[CrO_4]\cdot(H_2O)_5$
*Thorneite $Pb_6[Te^{6+}{}_2O_{10}][CO_3]Cl_2(H_2O)$

3.1e.2.4. Tellurates of semimetals (Bi^{3+}) 3.1e.2.4.1. Hydrates
Montanite $Bi_2TeO_6\cdot 2H_2O$

3.1f. Quasisubtype*: Oxides and hydroxides of nonmetals (lithophylic) elements
3.1f.1. ***Class:*** Oxides and hydroxides of Si and Ge (silicic and germanium anhydrides, silicic and germanium asids)
3.1f.1.1. Ionic-covalent crystalls 3.1f.1.1.1. Neutral

Stishovite group (compare with rutile, cassiterite)
Stishovite $^{(6)}SiO_2$
*Mon. (mineral high pressure) SiO_2
Argutite $^{(6)}GeO_2$

Silice family
Coesite $\{SiO_2\}^{\infty 3}$
β-Tridymite $\{SiO_2\}^{\infty 3}$
α-Tridymite $\{SiO_2\}^{\infty 3}$
*Orthorhombic SiO_2
*Seifertite orth. SiO_2
Cristobalite $\{SiO_2\}^{\infty 3}$
β-Quartz $\{SiO_2\}^{\infty 3}$

α-Quartz $\{SiO_2\}^{\infty 3}$
Lutecine $\{SiO_2\}^{\infty 3}$

3.1f.1.2. Globular crystalls 3.1f.1.2.1. Hydrates
Opal family
Opal $SiO_2 \cdot nH_2O$
Silhydrite $3SiO_2 \cdot H_2O$

3.1f.1.3. Silico-organic substances
Melanophlogite $Si_{46}O_{92}\ C_2H_{17}O_5$
*Chibaite $SiO_2 \cdot n(CH_4,C_2H_6,C_3H_8,C_4H_{10})$; ($n_{max}$ = 3/17)

3.1f.2. ***Class:*** Oxides and hedroxides of B (boric anhydride and boric asids)
Sassolite family
Metaborite HBO_2
*Clinometaborite β-HBO_2
Sassolite $B(OH)_3 \rightarrow H_3BO_3$

3.1f.3 ***Class:*** Oxides and hedroxides of Se (selenium anhydrite)
Downeyite SeO_2

3.2. Subtype: Oxosalts (anisodesmical)
3.2.1. ***Class:*** Silicates
Subclass: Silicates of cations with low FC
Silicates and alumosilicates of ***s***-, $\boldsymbol{d_s}$- and $\boldsymbol{p_s}$-cations
Silicates and alumosilicates of ***s***-, $\boldsymbol{d_s}$- and $\boldsymbol{p_s}$-cations (without Li^+ and Be^{2+})
Proper silicates and alumosilicates
Zero-alumosilicates (K = 0 Neutral, with compounds inclusions which contain H_2O
Cordierite family
Cordierite series
Cordierite $Mg_2\{Al_3[(Si_5Al)_{\Sigma 6}O_{18}]\}^{\infty 3}$
Sekaninaite $Fe^{2+}{}_2\{Al_3[(Si_5Al)_{\Sigma 6}O_{18}]\}^{\infty 3}$
Indialite $(Mg,Fe)_2\{Al_3[(Si_5Al)_{\Sigma 6}O_{18}]\}^{\infty 3}$
*Ferroindialite $(Fe,Mg)_2\{Al_3[(Si_5Al)_{\Sigma 6}O_{18}]\}^{\infty 3}$
Feldspar family
Plagioclase subfamily (**Ca-Na-feldspar**)
Anorthite $Ca[Al_2Si_2O_8]^{\infty 3}$ (An); An_{90-100}
*Dmisteinbergite $Ca[Al_2Si_2O_8]$
*Svyatoslavite $Ca[Al_2Si_2O_8]$
*Lisetite $Na_2Ca[Al_2Si_2O_8]_2$
Bytownite An_{70-90}
*Maskelynite – it is a glass whis bytownite composition
Labradorite An_{50-70}
Andesine An_{30-50}
Oligoclase An_{10-30}
*Lingunite $Na[AlSi_3O_8]$
Na-K-feldspar subfamily
Albite $Na[AlSi_3O_8]$ (Ab); An_{0-10}
*Albite tetragonal $Na[AlSi_3O_8]$
*Kumdykolite $Na[AlSi_3O_8]$

Anorthoclase	$(Na,K)[AlSi_3O_8]^{\infty 3}$
Sanidine	$(K,Na)[AlSi_3O_8]^{\infty 3}$
Microcline	$K[AlSi_3O_8]^{\infty 3}$
*Rubicline	$Rb[AlSi_3O_8]^{\infty 3}$
Orthoclase	$K[AlSi_3O_8]^{\infty 3}$
*Mineral mon., pseudotet. whis hollandite structure.	$K[AlSi_3O_8]$
*Kokchetavite	$K[AlSi_3O_8]$
К-Ba-feldspar subfamily	
Hyalophane	$(K,Ba)[(Si,Al)Si_3O_8]^{\infty 3}$
Celsian	$Ba[Al_2Si_2O_8]^{\infty 3}$
Paracelsian	$Ba[Al_2Si_2O_8]^{\infty 3}$
*Filatovite	$K[(Al,Zn)_2(As,Si)_2O_8]^{\infty 3}$
Slawsonite	$(Sr,Ca)[Al_2Si_2O_8]^{\infty 3}$
Banalsite	$BaNa_2[Al_2Si_2O_8]^{\infty 3}{}_2$
Buddingtonite	$NH_4[AlSi_3O_8$
Feldspathoid family	
Nepheline subfamily	
Stronalsite	$Na_2Sr[AlSiO_4]^{\infty 3}{}_4$
Nepheline	$4(Na,K)[AlSiO_4]^{\infty 3} \rightarrow KNa_3[AlSiO_4]^{\infty 3}{}_4$
Trikalsilite	$(K_{0.67}Na_{0.33})[AlSiO_4]^{\infty 3}$
Panunzite	$(K_{0.7}Na_{0.3})[AlSiO_4]^{\infty 3}$
Kalsilite	$K[AlSiO_4]^{\infty 3}$
*Megakalsilite	$K[AlSiO_4]$
Kaliophilite	$K[AlSiO_4]^{\infty 3}$
Leucite subfamily	
Leucite	$K[AlSi_2O_6]^{\infty 3}$
Ammonioleucite	$NH_4[AlSi_2O_6]^{\infty 3}$
Pollucite	$(Cs,Na)[AlSi_2O_6]^{\infty 3} \cdot nH_2O$
Scapolite series $(Ca,Na)_4(Si,Al)_{12}O_{24}(CO_3,SO_4,Cl)$	
*Silvialite	$[Al_6Si_6O_{24}]$ $Ca_4(SO_4)$ or $[Al_2Si_2O_8]^{\infty 3}{}_3$ $Ca_4(SO_4)$
Meionite	$[(Si,Al)_4O_8]_3(Ca,Na)_4(CO_3,SO_4,Cl)$, Me_{75-100}
Mizzonite	Me_{50-75}
Dipyre	Me_{25-50}
Marialite	$[AlSi_3O_8]^{\infty 3}{}_3Na_4Cl$; Me_{0-25}
Cancrinite series	
*Balliranoite	$[Al_6Si_6O_{24}][(Na,K)_6(CO_3)_2][Ca_2Cl_2]$
Cancrinite	$[Al_6Si_6O_{24}][(Na,K)_6(CO_3)_2][Ca_2(H_2O)_2]$
Cancrisilite	$[Al_5Si_7O_{24}][Na_5CO_3(H_2O)][Na_2(H_2O)_2]$
Davyne	$[Al_6Si_6O_{24}][(Na,K)_6(SO_4)_{0.5}Cl][Ca_2Cl_2]$
*Depmeierite	$[Al_6Si_6O_{24}][Na_6(PO_4),(CO_3)]_{0.5-1}(H_2O)][Na_2(H_2O)_2]$
*Hydroxicancrinite	$[Al_6Si_6O_{24}][Na_6(OH)(CO_3)][Na_2(H_2O)_2]$
*Kyanoxalite	$[Al_{5-6}Si_{6-7}O_{24}][Na_6(C_2O_4)(H_2O)_3](OH)][Na_2(H_2O)_2]$
Microsommite	$[Al_6Si_6O_{24}][(Na,K)_6(SO_4)][Ca_2Cl_2]$
*Pitiglianoite	$[Al_6Si_6O_{24}][Na_4K_2(SO_4)][Na_2(H_2O)_2]$
*Qudridavyne	$[Al_6Si_6O_{24}][(Na,K)_6Cl_2)][Ca_2Cl_2]$
*Carbobystrite	$[Al_6Si_6O_{24}]Na_8(CO_3)\cdot 4H_2O$
*Farneseite	$[Al_6Si_6O_{24}]_7Na_{46}Ca_{10}(SO_4)_{12}\cdot 6H_2O$
*Alloriite	$[Al_6Si_6O_{24}][Na_5K_{1.5}Ca](SO_4)(OH)_{0.5}\cdot H_2O$

*Biachellaite	$[Al_6Si_6O_{24}](Na,Ca,K)_8(OH)_{0.5}(SO_4)_2 \cdot H_2O$
*Kircherite	$[Al_{12}Si_{12}O_{48}](Na_{10}Ca_4K_2)(SO_4)_4 \cdot 2/3H_2O$
*Tounkite	$[Al_6Si_6O_{24}](Na,Ca,K)_8(SO_4)_2Cl \cdot 0.5H_2O$
Afghanite	$[Al_{24}Si_{24}O_{96}][(Na,K)_{22}Ca_{10}](SO_4)_6Cl_6$
Giuseppettite	$[Si_{48}Al_{48}O_{192}]Na_{42}K_{16}Ca_6](SO_4)_{10}Cl_2 \cdot 5H_2O$
*Marinellite	$[Al_{36}Si_{36}O_{144}]Na_{42}Ca_6(SO_4)_8Cl_2 \cdot 6H_2O$
Franzinite	$[Si_{30}Al_{30}O_{120}](Na,K)_{30}Ca_{10}(SO_4)_{10} \cdot 2H_2O$ or
	$[SiAlO_4]_{30}(Na,K)_{30}Ca_{10}(SO_4)_{10} \cdot 2H_2O$
*Fantappieite	$[Al_{99}Si_{99}O_{396}]Na_{82.5}Ca_{33}K_{16.5}(SO_4)_{33} \cdot 6H_2O$
*Bystrite	$[Al_6Si_6O_{24}]Ca(Na,K)_7(S_3)_{1,5} \cdot H_2O$
Vishnevite series	
Wenkite	$[(Si,Al)_{20}O_{41}]Ba_4Ca_6(OH)_2(SO_4)_3 \cdot H_2O$
Liottite	$[Si_{18}Al_{18}O_{72}]Na_{16}Ca_8(SO_4)_5Cl_4$
Sacrofanite	$[(Si,Al)_{12}O_{24}](Na,Ca)_9(OH,SO_4,CO_3,Cl)_4 \cdot nH_2O$
Vishnevite	$[(Al_6Si_6)O_{24}]Na_8(SO_4) \cdot 2H_2O$
Sodalite series	
Sodalite	$[AlSiO_4]^{\infty 3}_6 \cdot Na_8Cl_2$
Haüyne	$[(Si_3Al_3)O_{12}]Na_3Ca(SO_4)$
*Vladimirivanovite	$[Al_6Si_6O_{24}]Na_6Ca_2[SO_4,S_3,S_2,Cl]_2 \cdot H_2O$
Lazurite series	
Lazurite	$[(Al_6Si_6O_{24})]Na_6Ca_2(SO_4,S,S_2,S_3,Cl,OH)_2$
Nosean	$[(Si_6Al_6)O_{24}]Na_8(SO_4) \cdot H_2O$
Zeolites family Low-silicic zeolites (Si : Al up 1 to 1,(6))	
Parthéite	$[(Si_4Al_4O_{15}]Ca_2(OH)_2 \cdot 4H_2O$
Thomsonite subfamily(Si : Al = 1)	
Gismondine	$[AlSiO_4]^{\infty 3}_2Ca(H_2O)_4$
Thomsonite-Ca	$[AlSiO_4]^{\infty 3}_5NaCa_2(H_2O)_6$
*Thomsonite-Sr	$[AlSiO_4]^{\infty 3}_5(Sr,Ca)_2Na \cdot 6\text{-}7H_2O$
Willhendersonite	$[AlSiO_4]^{\infty 3}_3KCa(H_2O)_5$
*Willhendersonite-Ca	$[AlSiO_4]^{\infty 3}_3CaK(H_2O)_5$
Amicite	$[AlSiO_4]^{\infty 3}_4 \cdot K_2Na_2(H_2O)_5$
*Flörkeite	$[AlSiO_4]_8\ K_3Ca_2Na \cdot 12H_2O$
*Bellbergite	$[AlSiO_4]^{\infty 3}_{18}\ (K,Ba,Sr)_2Sr_2Ca_2(Ca,Na)_4 \cdot 30(H_2O)$
*Tschörtnerite	$[AlSiO_4]^{\infty 3}_{12}\ Ca_4(K,Ca,Sr,Ba)_3Cu_3(OH)_8 \cdot nH_2O$ $n \approx 20$
Scolecite-natrolite subfamily (Si : Al = 1,5)	
Scolecite	$[Al_2Si_3O_{10}]^{\infty 3} \cdot Ca(H_2O)_3$
Cowlesite	$[Al_2Si_3O_{10}]^{\infty 3} \cdot Ca(H_2O)_{5\text{-}6}$
Edingtonite	$[Al_2Si_3O_{10}]^{\infty 3} \cdot Ba(H_2O)_4$
Mesolite	$[Al_2Si_3O_{10}]^{\infty 3}_3 \cdot Na_2Ca_2(H_2O)_8$
Gonnardite	$[(Si,Al)_5O_{10}](Na,Ca)_2 \cdot 3H_2O$
Natrolite	$[Al_2Si_3O_{10}]^{\infty 3} \cdot Na_2(H_2O)_2$
Paranatrolite	$[Al_2Si_3O_{10}]^{\infty 3}Na_2(H_2O)_3$
Garronite subfamily (Si:Al = 1,(6))	
Garronite-Ca	$[Al_3Si_5O_{16}]^{\infty 3}_2 \cdot NaCa_{2.5}(H_2O)_{14}$
Garronite-Na	$[Al_3Si_3O_{16}]^{\infty 3}_2 \cdot Na_6 \cdot 8.5H_2O$
Phillipsite-Ca	$[(Si_{10}Al_6)O_{32}]Ca_3 \cdot 12H_2O$
*Phillipsite-K	$[(Si_{10}Al_6)O_{32}]K_6 \cdot 12H_2O$
*Phillipsite-Na	$[(Si_{10}Al_6)O_{32}]Na_6 \cdot 12H_2O$
*Unnamed (Si:Al = 1,9)	$[Al_{11}Si_{21}O_{64}]Ca_5K_2 \cdot 18.4H_2O$

Middle-silicic zeolites (Si : Al up 2 to 2,2)	
Gobbinsite (Si:Al =2.2)	$[(Si_{11}Al_5)O_{32}]Na_5\cdot 11H_2O$
Wairakite subfamily (Si : Al = 2)	
Wairakite	$[AlSi_2O_6]^{\infty3}_{2}\cdot Ca(H_2O)_2$
Laumontite	$[AlSi_2O_6]^{\infty3}_{2}\cdot Ca(H_2O)_4$
Chabazite series	
*Chabazite-Ca	$[AlSi_2O_6]^{\infty3}_{4}Ca_2\cdot 13H_2O$
*Chabazite-K	$[AlSi_2O_6]^{\infty3}_{4}K_2NaCa_{0,5}\cdot 11H_2O$
*Chabazite-Na	$[Al_4Si_8O_{24}](Na_3K)\cdot 11H_2O$
*Chabazite-Mg	$[Al_3Si_9O_{24}]^{\infty3}Mg_{0.7}K_{0.5}Ca_{0,5}Na_{0.1}\cdot 10H_2O$
*Chabazite-Sr	$[Al_4Si_8O_{24}](Sr,Ca)_2\cdot 11H_2O$
Lévyne-Ca	$[AlSi_2O_6]^{\infty3}_{6}Ca_3\cdot 18H_2O$
*Lévyne-Na	$[AlSi_2O_6]^{\infty3}_{6}Na_6\cdot 18H_2O$
Herschelite	$[Al_2Si_4O_{12}]_2(Na_2,K_2,Ca,Sr,Mg)_2\cdot 12H_2O$
Gmelinite subfamily (Al : Si = 2)	
Gmelinite-Ca	$[AlSi_2O_6]^{\infty3}_{4}Ca_2(H_2O)_{11}$
*Gmelinite-Na	$[AlSi_2O_6]^{\infty3}_{4}Na_4(H_2O)_{11}$
*Gmelinite-K	$[AlSi_2O_6]^{\infty3}_{4}K_4\cdot 22H_2O$
Faujasite	$[AlSi_2O_6]^{\infty3}_{4}Na_2Ca(H_2O)_{16}$
α-Leongardite	$[AlSi_2O_6]^{\infty3}_{4}(K,Na)_2Ca(H_2O)_7$
Analcime	$[AlSi_2O_6]^{\infty3}Na(H_2O)$
Perlialite	$[AlSi_2O_6]^{\infty3}_{12}\cdot K_9Na(Ca,Sr)(H_2O)_{15}$
Harmotome	$[Si_{12}Al_4O_{32}]Ba_2(H_2O)_{12}$

*Meierite $Ba_{44}Si_{66}Al_{30}O_{192}Cl_{25}(OH)_{33}$ or $[AlSi_{2.2}O_{6.4}]\ Ba_{1.5}Cl_{0.8}(OH)_{1.1}$

High-silicic zeolites (Si : Al up 2,5 to 3,5)	
Merlinoite (Si : Al = 2,(5))	$[Al_9Si_{23}O_{64}]^{\infty3}K_5Ca_2(H_2O)_{24}$
*Montesommaite	$[Al_9Si_{23}O_{64}]^{\infty3}K_9\cdot 10H_2O$
Offretite (Si : Al = 2,6)	$[Al_5Si_{13}O_{36}]^{\infty3}\cdot KCaMg(H_2O)_{15}$
Erionite-Ca	$[Al_{10}Si_{26}O_{72}]Ca_5\cdot 30H_2O$
*Erionite-K	$[(Al_{10}Si_{26}O_{72})]K_{10}\cdot 30H_2O$
*Erionite-Na	$[(Al_{10}Si_{26}O_{72})]Na_{10}\cdot 30H_2O$
Stilbite subfamily (Si : Al = 3)	
Yugawaralite	$[AlSi_3O_8]^{\infty3}_{2}\cdot Ca(H_2O)_4$
Epistilbite	$[AlSi_3O_8]^{\infty3}_{6}\cdot Ca_3(H_2O)_{16}$
*Tschernichite	$[AlSi_3O_8]^{\infty3}_{2}Ca\cdot 8H_2O$
*Brewsterite-Ba	$[AlSi_3O_8]^{\infty3}_{4}Ba_2\cdot 10H_2O$
Brewsterite-Sr	$[AlSi_3O_8]^{\infty3}_{4}Sr_2\cdot 10H_2O$
Wellsite	$[AlSi_3O_8]^{\infty3}_{2}\cdot(Ba,Ca,K_2)(H_2O)_6$
*Heulandite-Ba	$[Al_9Si_{27}O_{72}](Ba,Ca,Sr,K,Na)_5\cdot 22H_2O$
*Heulandite-Ca	$[Al_9Si_{27}O_{72}](Ca,Na,K)_5\cdot 26H_2O$
*Heulandite-K	$[Al_9Si_{27}O_{72}](K,Ca,Na,)_5\cdot 26H_2O$
*Heulandite-Na	$[Al_9Si_{27}O_{72}](Na,Ca,K)_6\cdot 22H_2O$
*Heulandite-Sr	$[Al_9Si_{27}O_{72}](Sr,Ca,Na)_5\cdot 24H_2O$
Mazzite-Mg	$[Al_{10}Si_{26}O_{72}]^{\infty3}\ Mg_5\cdot 30H_2O$
*Mazzite-Na	$[Al_8Si_{28}O_{72}]^{\infty3}\ Na_8\cdot 30H_2O$
*Stilbite-Ca	$[(Al_9Si_{27})O_{72}]NaCa_4\cdot 28H_2O$

*Stilbite-Na	$[Al_9Si_{27}O_{72}]Na_9 \cdot 28H_2O$
Goosecreekite	$[AlSi_3O_8]^{\infty 3}{}_2Ca(H_2O)_5$
*Maricopaite	$[Al_{12}Si_{36}O_{99}]Ca_2Pb_7$ n(H_2O,OH)
Paulingite-Ca (Si : Al = 3,2)	$[Al_5Si_{16}O_{42}]^{\infty 3}{}_2(Ca,K,Na,Ba,\square)_{10} \cdot 34H_2O$
*Paulingite-Na	$[Al_{10}Si_{35}O_{90}](Na_2,K_2,Ca,Ba)_5 \cdot 45H_2O$
*Paulingite-K	$[(Si,Al)_{42}O_{84}](K,Ca,Na,Ba,\square)_{10} \cdot 34H_2O$
Stellerite subfamily (Si : Al = 3,5)	
Stellerite	$[Al_2Si_7O_{18}]^{\infty 3}{}_4\ Ca_4 \cdot 28H_2O$
Barrerite	$[Al_2Si_7O_{18}]^{\infty 3}Na_2 \cdot 6H_2O$
*Direnzoite (Si : Al = 3,6)	$[Al_{13}Si_{47}O_{120}]NaK_6MgCa_2 \cdot 36H_2O$
Ultra-high-silicic zeolites (Si : Al up 3,8 to 6 and above)	
Svetlozarite (Si : Al = 3.8)	$[Al_{10}Si_{38}O_{96}](Na_2,Ca,K_2)_5 \cdot 25H_2O$
*Boggsite (Si : Al = 4,2)	$[(Al_{18}Si_{77})_{\Sigma 96}O_{192}]Na_3Ca_8 \cdot 70H_2O$
Dachiardite series (Si : Al = 5)	
Sodium dachiardite	$[Al_8Si_{40}O_{96}](Na_2,Ca,K_2)_{4\text{-}5} \cdot 26H_2O$
Dachiardite-Ca	$[Al_4Si_{20})O_{48}]Ca_2 \cdot 13H_2O$
Dachiardite-K	$[Al_4Si_{20}O_{48}]K_4 \cdot 13H_2O$
***Clinoptilolite** subfamily (Si : Al = 5)	
*Clinoptilolite-Ca	$[Al_6Si_{30}O_{72}]Ca_3 \cdot 20H_2O$
*Clinoptilolite-K	$[Al_6Si_{30}O_{72}]K_6 \cdot 20H_2O$
*Clinoptilolite-Na	$[Al_6Si_{30}O_{72}]Na_6 \cdot 20H_2O$
Tsaregorodtsevite (Si : Al = 5)	$[Si_4(SiAl)O_{12}]N(CH_3)_4$
Mordenite subfamily (Si : Al = 5)	
Mordenite	$[AlSi_5O_{12}]^{\infty 3}{}_8 \cdot (Na_2,Ca,K_2)_4 \cdot 28H_2O$
*Terranovaite	$[Si_{68}Al_{12}O_{160}](Na,Ca)_8 \cdot 29H_2O$
*Gottardite (Si : Al = 6,2)	$[Si_{117}Al_{19}O_{272}]Na_3Mg_3Ca_5 \cdot 93H_2O$
***Ferrierite** subfamily (Si : Al = 6,2)	
*Ferrierite-K	$[Al_5Si_{31}O_{72}]K_2NaMg \cdot 18H_2O$
*Ferrierite-Na	$[Al_5Si_{31}O_{72}]Na_3KMg_{0,5} \cdot 18H_2O$
*Ferrierite-Mg	$[Al_7Si_{29}O_{72}]Mg_{2,5}K_{0,5}Na_{0,5}Ca_{0,5} \cdot 18nH_2O$
*Mutinaite (Si : Al = 7,7)	$[Al_{11}Si_{85}O_{192}]Na_3Ca_4 \cdot 60H_2O$
	Basic zero-alumosilicates
Bicchulite family	
Bicchulite	$Ca_2(OH)_2[Al_2SiO_6]^{\infty 3}$
Kamaishilite	$Ca_2(OH)_2[Al_2SiO_6]^{\infty 3}$
	Hydrates; neutral
Cymrite	$Ba[AlSiO_4]^{\infty 2}{}_2 \cdot nH_2O$ (n = 0.5-1)
Zeroalumosilicato-carbonato-chlorides	*Hydrates
*Kampfite	$Ba_{12}[(Si_{11}Al_5)O_{31}](CO_3)_8Cl_5$
Zerosilicates	*Hydrates
*Afwillite	$Ca_3[SiO_4][SiO_2(OH)_2] \cdot 2H_2O$
	*Hydrates basic
*Makatite	$Na_2[Si_4O_8](OH)_2 \cdot 4H_2O$
*Yegorovite	$Na_4[Si_4O_8(OH)_4] \cdot 7H_2O$
*Megaciclite	$Na_8K[Si_9O_{18}](OH)_9 \cdot 19H_2O$

Zero-monoalumo- and zero-monosilicates (0 < K < 1)
*Ellingsenite $Na_5Ca_6[Si_{18}O_{38}](OH)_{13}\cdot 6H_2O$

Zero-monoalumosilicates c K_Σ = 0,3 and 0,(3)
Neutral
Naujakasite $Na_6\{Fe^{2+}[Al_4Si_8O_{26}]^{\infty 2}$
*Manganonaujakasite $Na_6(Mn,Fe)^{2+}[Al_4Si_8O_{26}]^{\infty 2}$
Acid
Lithosite $K_3[HAl_2Si_4O_{13}]^{\infty 3}$

*Zero-monosilicates with K = 0,3 *Basic → Hydrates
*Esquireite $Ba[Si_6O_{13}]\cdot 7H_2O$

Zero-monoalumosilicates with K_Σ = 0,4 Neutral → Hydrates
Latiumite family
Tuscanite $[(Si,Al)_5O_{11}]^{\infty 2}{}_2KCa_6(SO_4,CO_3)_2(OH)\cdot H_2O$
Latiumite $[(Si,Al)_5O_{11}]^{\infty 2\cdot}(Ca,K)_4(SO_4,CO_3)$

Zero-monoalumosilicates with K_Σ = 0,45
*Kenyaite $Na_2[Si_{22}O_{41}(OH)_8]\cdot 6H_2O$
*Günterblassite $(K,Ca,Ba,Na,\square)_3Fe[(Si,Al)_{13}O_{25}(OH,O)_4]\cdot 7H_2O$
*Hillesheimite $(K,Ca,Ba,\square)_2(Mg,Fe,Ca,\square)_2[(Si,Al)_{13}O_{23}(OH)_6](OH)\cdot 8H_2O$

*Zero-monoalumosilicato-halogenides
*Umbrianite $K_7Na_2Ca_2[Al_3Si_{10}O_{29}]F_2Cl_2$

*Zero-monoalumosilicates and zero-monosilicates c K_Σ = 0,5
*Ertixiite $Na_2[Si_4O_9]$
*Tosudite $Na(Al_4Mg_2)[AlSi_7O_{18}](OH)_{12}\cdot 5H_2O$

Zero-monoalumosilicates with K_Σ = 0,5
Acid zero-monoalumosilicates
Ussingite $[AlSi_3O_8(OH)]^{\infty 3\cdot}Na_2$
*Hydrates
*Franklinphillite $K_4Mn^{2+}{}_{48}[Al_9Si_{63}O_{163}](OH)_{53}\cdot 6H_2O$

*Zero-monoalumosilicates with K_Σ = 0,57 *Neutral
*Wadalite $Ca_6(Al,Si,Mg,Fe)_7O_{16}Cl_3$ (?)
*Hydrates
*Magadiite $[Si_7O_{13}(OH)_3]Na\cdot 4H_2O$

Zero-monoalumosilicates and zero-monosilicates with K_Σ = 0,6
Neutral → basic→hydrates
*Parsettensite $(K,Na,Ca)_{7.5}(Mn,Mg)_{49}Si_{72}O_{168}(OH)_{50}\cdot nH_2O$
Zussmanite $[AlSi_{17}O_{42}]^{\infty 2\cdot}(K,Na)(Fe,Mg,Mn,Al)_{13}(OH)_{14}$
*Coombsite $[Al_{1,5}Si_{16,5}O_{42}]^{\infty 2}(K,Na)(Mn,Fe,Mg)_{13}(OH)_{14}$
Stilpnomelane series
Calciumferristilpnomelane $[Al_2Si_{16}O_{42}]^{\infty 2\cdot}Ca_{0,5}(Fe^{3+},Fe^{2+})_{12}(O,OH)_{12}(H_2O)_{6-8}$

Kaliferristilpnomelane
$[Al_2Si_{16}O_{42}]^{\infty 2}\cdot K_2(Fe^{3+},Fe^{2+})_{12}(O,OH)_{12}(H_2O)_{6-8}$
Calciumferrostilpnomelane $[Al_2Si_{16}O_{42}]^{\infty 2}\cdot Ca_{0,5}(Fe^{2+},Fe^{3+})_{12}(O,OH)_{12}(H_2O)_{6-8}$
Stilpnomelane (kaliferrostilpnomelane)
$[Al_2Si_{16}O_{42}]^{\infty 2}\cdot K(Fe^{2+},Fe^{3+},Mg)_{12}(O,OH)_{12}(H_2O)_{6-8}$
*Lennilenapeite $[(Si,Al)_{18}(O,OH)_{42}]\ K_{1,5-1,75}(Mg,Mn^{2+},Fe^{2+},Zn)_{12}(O,OH)_{12}\cdot 4H_2O$
Ganophyllite (manganstilpnomelane))
$[Al_2Si_{16}O_{42}]^{\infty 2}\cdot K(Mn^{2+},Fe^{2+},Fe^{3+})_{12}(O,OH)_{12}(H_2O)_{6-8}$
*Tamaite $(Ca,K,Ba,Na)_{3-4}Mn_{24}(Si,Al)_{40}(O,OH)_{112}\cdot 21H_2O$
*Carlosturanite $[(Si,Al)_{12}O_{28}](Mg,Fe,Ti)_{21}(OH)_{34}\cdot H_2O$
*Kvanfieldite $[Si_6O_{14}]Na_4(Ca,Mn)(OH)_2$

Zero-monoalumosilicates and zero-monosilicates with $K_\Sigma = 0,75$
Neutral → basic→hydrates
Delhayelite family
Fedorite $[Si_8O_{19}]^{\infty 2}(K,Na)_{2-3}(Ca,Na)_7(OH,F)_2\cdot nH_2O)$
Delhayelite $[AlSi_7O_{19}]^{\infty 2}{}_2K_7Ca_5Na_3F_4Cl_2$
*Fivegite $[AlSi_7O_{17}(O_{2-x}OH_x)]K_4Ca_2[(H_2O)_{2-x}OH_x]Cl$
*Hydrodelhayelite $[AlSi_7O_{17}(OH)_2]KCa_2\cdot 6H_2O$
Macdonaldite $[Si_8O_{18}(OH)]^{\infty 2}{}_2BaCa_4\cdot 10H_2O$
Mountainite $[Si_8O_{19}(OH)]^{\infty 2}{}_2KNa_2Ca_2\cdot 6H_2O$
Rhodesite $[Si_8O_{19}]^{\infty 2}KHCa_2\cdot 5H_2O$
*Lalondeite $[Si_8O_{19}]_2(Na,Ca)_6(Ca,Na)_3(F,OH)_2\cdot 3H_2O$

*Zero-monoalumosilicates and zero-monosilicates with $K_\Sigma = 0,8$ O Hydrates
*Sarcolite $Na_4Ca_{12}[Al_8Si_{12}O_{46}][SiO_4,PO_4](OH,H_2O)_4(CO_3,Cl)$
Zeophyllite $Ca_{13}(OH)_2F_8[Si_{10}O_{28}]\cdot 6H_2O$
*Zakharovite $Na_4Mn^{2+}{}_5[Si_{10}O_{24}](OH)_6\cdot 6H_2O$
*Akatoreite $Mn^{2+}{}_9[Al_2Si_8O_{24}](OH)_8$

Zero-monoalumosilicates and zero-monosilicates with $K_\Sigma = 0,83$
Hydrates (basic and neutral)
Truscottite family
Truscottite $(Ca,Mn)_{14}(OH)_8[Si_{24}O_{58}]\cdot 2H_2O$
Reyerite $(Na,K)_2Ca_{14}[Al_2Si_{22}O_{58}](OH)_8\cdot 6H_2O$
*Eggletonite $(Na,K,Ca)_2(Mn,Fe)_8(OH)_7[(Si,Al)_{12}O_{29}]\cdot 11H_2O$

*Zero-monoalumosilicates and zero-monosilicates with $K_\Sigma = 0,88$
*Armbrusterite $K_5Na_6Mn^{3+}Mn^{2+}{}_{14}[Si_9O_{22}]_4(OH)_{10}\cdot 4H_2O$

Monoalumosilicates and monosilicates (K = 1)
Monoalumosilicates Neutral
Sillimanite family
Sillimanite $Al[AlSiO_5]^\infty$
Mullite $Al_2[(Al_{2+2x}Si_{2-2x})O_{10-x}]^\infty$
Basic alumosilicates hydrates
*Allofan $Al_2SiO_5\cdot H_2O$
Prehnite $Ca_2Al(OH)_2[AlSi_3O_{10}]^{\infty 2}$
Mica family

Fragile mica subfamily – $^{(4)}(Al,Fe^{3+})$: Si up 3 : 1 to 1 : 1	
Clintonite	$Ca\{(Mg_2Al)(OH)_2[Al_3SiO_{10}]^{\infty 2}\}^{\infty 2}$
Margarite	$Ca\{Al_2\square(OH)_2[Al_2Si_2O_{10}]^{\infty 2}\}^{\infty 2}$
Chernykhite	$BaV^{3+}{}_2\square(OH)_2[Al_2Si_2O_{10}]^{\infty 2}\}^{\infty 2}$
Siderophyllite subfamily	
Preiswerkite	$Na\{Mg_2Al(OH)_2[Al_2Si_2O_{10}]^{\infty 2}\}^{\infty 2}$
Siderophyllite	$K\{Fe^{2+}{}_2Al(OH)_2[Al_2Si_2O_{10}]^{\infty 2}\}^{\infty 2}$
Anandite subfamily	
Kinoshitalite	$(Ba,K)\{(Mg,Mn)_3(OH)_2[Al_2Si_2O_{10}]^{\infty 2}\}^{\infty 2}$
*Ferrokinoshitalite	$BaFe^{2+}{}_3(OH)_2[Al_2Si_2O_{10}]^{\infty 2}\}^{\infty 2}$
Anandite	$BaFe^{2+}{}_3(OH)[(Si_3Fe^{3+})O_{10}]S$
*Oxykinoshitalite	$BaMg_2Ti^{4+}O_2[(Si_2Al_2)O_{10}]$
Usual mica subfamily – $^{(4)}(Al,Fe)^{3+}$: Si ~ 1 : 3	
Paragonite	$Na\{Al_2\square(OH)_2[AlSi_3O_{10}]^{\infty 2}\}^{\infty 2}$
*Na-Sr mica	$Na_{0,50}Sr_{0,25}Al_2(Na_{0,25}\square_{0,75})(OH)_2[Al_{1,25}Si_{2,75}O_{10}]$
Muscovite series	
Muscovite	$K\{Al_2\square(OH)_2[AlSi_3O_{10}]^{\infty 2}\}^{\infty 2}$
*Ganterite	$Ba_{0,5}(Na,K)_{0,5}\{Al_2(OH)_2[Al_{1,5}Si_{2,5}O_{10}]^{\infty 2}\}^{\infty 2}$
*Chromphyllite	$K\{Cr_2\square(OH,F)_2[AlSi_3O_{10}]^{\infty 2}\}^{\infty 2}$
Roscoelite	$K\{V_2(OH)_2[AlSi_3O_{10}]^{\infty 2}\}^{\infty 2}$
*Nanpingite	$Cs\{Al_2(OH,F)_2[AlSi_3O_{10}]^{\infty 2}\}^{\infty 2}$
Tobelite	$NH_4\{Al_2(OH)_2[AlSi_3O_{10}]^{\infty 2}\}^{\infty 2}$
Phlogopite subfamily	
Wonesite	$(Na,K,\square)(Mg,Fe,Al)_6(OH,F)_4[(Si,Al)_8O_{20}]^{\infty 2}\}^{\infty 2}$
Sodium phlogopite	$Na\{Mg_3(OH)_2[AlSi_3O_{10}]^{\infty 2}\}^{\infty 2}$
Hydroxyl-phlogopite	$K\{Mg_3(OH)_2[AlSi_3O_{10}]^{\infty 2}\}^{\infty 2}$
Tetraferriphlogopite	$K\{Mg_3(OH)_2[(Fe^{3+}Si_3O_{10}]^{\infty 2}\}^{\infty 2}$
Fluorophlogopite	$K\{Mg_3(F,OH)_2[AlSi_3O_{10}]^{\infty 2}\}^{\infty 2}$
*Oxyphlogopite	$K(Mg,Ti,Fe)_3(O,F)_2[(Si,Al)_4O_{10}]$
*Aspidolite	$NaMg_3(OH)_2[AlSi_3O_{10}]$
Manganophyllite	$K(Mn,Mg,Al)_{2\text{-}3}(OH)_2[(Al,Si)_4O_{10}]$
*Schirozulite	$KMn^{2+}{}_3(OH)_2[AlSi_3O_{10}]$
Annite	$KFe^{2+}{}_3(OH)_2[(Fe^{3+}Si_3O_{10}]$
Tetraferriannite	$K\{(Fe^{2+},Mg)_3(OH)_2[(Fe^{3+},Al)Si_3O_{10}]^{\infty 2}\}^{\infty 2}$
Fluorannite	$KFe^{2+}{}_3F_2[AlSi_3O_{10}]$
*Montdorite	$KFe^{2+}{}_{1,5}Mn^{2+}{}_{0,5}Mg_{0,5}\square_{0,5}F_2[Si_4O_{10}]$
*Yangzhumingite	$KMg_{2.5}F_2[Si_4O_{10}]^{\infty}$

Biotite – micas between, or close to, the annite-phlogopite and siderophellite - eastonite joins; dark micas without lithium

Chlorite family	
Diseptochlorite subfamily	
Sudoite	$Mg_2Al_3(OH)_8[AlSi_3O_{10}]$
*Glagolevite	$NaMg_6(OH,O)_8[AlSi_3O_{10}]\cdot H_2O$
Clinochlore series	
Corundophilite = Fe-clinochlor	$(Mg,Fe)_3\{(Mg,Al)_3(OH)_8[AlSi_3O_{10}]$
Leuchtenbergite = clinochlor	$(Mg,Al)_6(OH)_8[AlSi_3O_{10}]$
Clinochlore	$(Mg_5Al(OH)_8[AlSi_3O_{10}]$
Ripidolite	$(Mg,Fe,Al)_6(OH)_8[AlSi_3O_{10}]$
Prochlorite	$Mg_5Al(OH)_8[AlSi_3O_{10}]$

Chamosite $(Fe,Al,Mg)_6(OH)_8[AlSi_3O_{10}]$
Orthochamosite $(Fe^{2+},Mg,Fe^{3+})_5Al(OH,O)_8[AlSi_3O_{10}]$
Gonyerite $Mn^{2+}{}_5Fe^{3+}(OH)_8[Fe^{3+}Si_3O_{10}]$
Pennantite $Mn^{2+}{}_5Al(OH)_8[AlSi_3O_{10}]$
Nimite $(Ni,Mg,Al)_6(OH)_8[AlSi_3O_{10}]$
Septechlorites subfamily
Odinite (mon.) $(Fe^{3+},Mg,Al,Fe^{2+})_{2.5}(OH)_4[(Si,Al)_2O_5]$
Amesite series
Amesite $Mg_2Al(OH)_4[AlSiO_5]$
Brindleyite (nimesite) $(Ni,Al)_3(OH)_4[(Si,Al)_2O_5]$
Fraipontite $(Zn,Al)_3(OH)_4[(Si,Al)_2O_5]$
Cronstedtite series
Berthierine $(Fe^{2+},Fe^{3+},Al)_3(OH)_4[(Si,Al)_2O_5]$
Cronstedtite $(Fe^{2+}Fe^{3+})_3(OH)_4[(Si,Fe^{3+})_2O_5]$
*Guidottiite $(Mn_2Fe^{3+})(OH)_4[(Si,Fe^{3+})O_5]$
Hydromica family
Vermiculite subfamily
Vermiculite $Mg_{0.7}(Mg,Fe^{3+},Al)_6(OH)_4[(Si,Al)_8O_{20}]\cdot 8H_2O$
Brammallite $(Na,H_3O)(Al,Mg,Fe)_2(OH)_2[Si,Al)_4O_{10}]$
Illite $K_{0.65}Al_{2.0}(OH)_2[Al_{0.65}Si_{3.35}O_{10}]$
Hydrobiotite $K(Mg,Fe^{2+})_6(OH)_4[(Si,Al)_8O_{20}]\cdot nH_2O$
*Rudenkoite $Sr_3(OH,O)_8Cl_2[(Si_{3.5}Al_{3.5})O_{10}]\cdot H_2O$
Celadonite series
Celadonite $KFe^{3+}(Mg,Fe^{2+})[\square Si_4O_{10}](OH)_2$
*Alumoceladonite $KAl(Mg,Fe^{2+})[\square Si_4O_{10}](OH)_2$
*Ferroalumoceladonite $KFe^{2+}Al[\square Si_4O_{10}](OH)_2$
*Ferroceladonite $KFe^{3+}(Fe^{2+},Mg)[\square Si_4O_{10}](OH)_2$
*Chromceladonite $KCr^{3+}(Mg,Fe^{2+})[\square Si_4O_{10}](OH)_2$
*Manganiceladonite $KMgMn^{3+}[Si_4O_{10}](OH)_2$
Glauconite $(K,Na)(Mg,Fe^{2+},Fe^{3+})(Fe^{3+},Al)[Si,Al)_4O_{10}](OH)_2$
*Corrensite orth., regular interstratification of trioctahedral **chlorite** with either trioctahedral **vermiculite** or trioctahedral **smectite**.
Smectite family
Montmorillonite subfamily
Swinefordite $Ca_{0.2}(Li,Al,Mg,Fe)_3(OH,F)_2[(Si,Al)_2O_5]_2\cdot nH_2O_2$
Montmorillonite $(Na,Ca)_{0.3}(Al,Mg)_2(OH)_2[Si_2O_5]_2\cdot nH_2O$
*Montmorillonite-Fe $(Na,Ca)_{0.3}(Fe,Mg)_2(OH)_2[Si_2O_5]_2\cdot nH_2O$
*Brinrobertsite $(Na,K,Ca)_{0.3}(Al,Fe,Mg)_4(OH)_4[(Si,Al)_8O_{20}]\cdot 3,5H_2O$
Volkonskoite $(Na,K,Ca)_{0.3}(Al,Mg,Fe)_4(OH)_4[(Si,Al)_8O_{20}]\cdot 3,5H_2O$
Beidellite $(Na,Ca)_{0.3}Al_2(OH)_2[(Si,Al)_4O_{10}]\cdot nH_2O$
Nontronite $Na_{0.3}Fe_2^{3+}(OH)_2[(Si,Al)_4O_{10}]\cdot nH_2O$
*Rectorite $(Na,Ca)Al_4(OH)_4[(Si,Al)_8O_{20}]\cdot 2H_2O$
*Yakhontovite $CaCu^{2+}{}_2(OH)_2[Si_4O_{10}]\cdot 3H_2O$
Saponite subfamily
Sobotkite $(K,Ca_{0.5})_{0.33}(Mg_{0.66}Al_{0.33})_3(OH)_2[(Si_3Al)O_{10}]\cdot 1\text{-}5H_2O$
Saponite $(Ca,Na)_{0.3}(Mg,Fe^{2+})_3(OH)_2[(Si,Al)_4O_{10}]\cdot 4H_2O$
Ferrisaponite $Ca_{0,3}(Fe^{3+}Mg,Fe^{2+})_3(OH)_2[(Si,Al)_4O_{10}]\cdot 4H_2O$
*Ferrosaponite $Ca_{0.3}(Fe^{2+},Mg,Fe^{3+})_3(OH)_2[(Si,Al)_4O_{10}]\cdot 4H_2O$
Palygorskite-sepiolite family (alumosilicates $\rightarrow$ silicates)
Palygorskite subfamily

Palygorskite $(Mg,Al)_2(OH)[Si_4O_{10}]\cdot 4H_2O$
Yofortierite $(Mn^{2+},Mg,Fe^{3+})_5(OH,H_2O)_2[Si_8O_{20}]\cdot 7H_2O$
Tuperssuatsiaite $Na_2(Fe^{3+},Mn^{2+})_3(OH)_2[Si_8O_{20}]\cdot 4H_2O$
*Raite $Na_3Mn^{2+}{}_3Ti^{4+}{}_{0,25}(OH)_2[Si_8O_{20}]\cdot 10H_2O$
*Windhoekite $Ca_2Fe^{3+}{}_{2.67}(OH)_4[(Si,Al)_8O_{20}]\cdot 10H_2O$
Sepiolite subfamily
Sepiolite $Mg_4(OH)_2[Si_6O_{15}]\cdot 6H_2O$
*Ferrisepiolite $(Fe^{3+},Fe^{2+},Mg)_4(O,OH)_2[(Si,Fe^{3+})_6O_{15}]\cdot 6H_2O$
Falcondoite $Ni_4(OH)_2[Si_6O_{15}]\cdot 6H_2O$
Loughlinite $Na_2Mg_3[Si_6O_{16}]\cdot 8H_2O$
Osumilite family
Armenite $BaCa_2Al_3[Al_3Si_9O_{30}]\cdot 2H_2O$
Osumilite series
Yagiite $(Na,K)_3Mg_4Al_6[(Si,Al)_{12}O_{30}]_2$
Osumilite-(Mg) $(K,Na)(Mg,Fe^{2+})_2(Al,Fe^{3+})_3[(Si,Al)_{12}O_{30}]$
Osumilite $(K,Na)(Fe,Mg,Mn)^{2+}{}_2(Al,Fe^{3+})_3[(Si,Al)_{12}O_{30}]$
*Trattnerite $(Mg,Fe^{2+})_3Fe^{3+}{}_2[Si_{12}O_{30}]$
Chayesite $K(Mg,Fe^{2+})_2(Mg,Fe^{2+})_2Fe^{3+}[Si_{12}O_{30}]$
*Unnamed $Fe^{2+}{}_5Mg^{2+}{}_5[(Al,Si)_{12,5}O_{30}]_2$

Monosilicates
Proper monosilicates Neutral
Gillespite family
Gillespite $BaFe^{2+}[Si_4O_{10}]^{\infty 2}$
Sanbornite $Ba[Si_2O_5]^{\infty 2}$
*Bigcreekite $Ba[Si_2O_5]\cdot 4H_2O$
Natrosilite $Na_2[Si_2O_5]^{\infty 2}$
Fenaksite $K_2Na_2Fe^{2+}{}_2[Si_8O_{20}]^{\infty}$
*Manaksite $NaKMn[Si_4O_{10}]$
*Tuhualite $(Na,K)Fe^{2+}Fe^{3+}[Si_6O_{15}]$
*Kalifersite $(K,Na)_5Fe^{3+}{}_7[Si_{20}O_{50}](OH)_6\cdot 12H_2O$
Roedderite series
Roedderite $KNa(Mg,Fe)_5[Si_{12}O_{30}]^{\infty}$
Merrihueite $KNa(Fe,Mg,)_5[Si_{12}O_{30}]^{\infty}$
Eifelite $KNa_3Mg_4[Si_{12}O_{30}]^{\infty}$
*Shibkovite $K(Ca,Mn,Na)_2(K_{2-x}\square_x)Zn_3[Si_{12}O_{30}]$
*Shirokshinite $KNaMg_2[Si_4O_{10}]F_2$
Agrellite $NaCa_2F[Si_4O_{10}]^{\infty}$
*Friedrichbeckeite $K(\square_{0.5}Na_{0.5})_2Mg_2(MgBe_2)[Si_{12}O_{30}]\square$
Hydrates (basic)
*Cairncrossite (M^{2+} : OH = 4.5) $Sr_2Ca_{7-x}Na_{2x}(OH)_2[Si_4O_{10}]_4\,(H_2O)_{15-x}$ $(0 \le x \le 1)$
*Calcinaksite $KNaCa[Si_4O_{10}]\cdot H_2O$
Canasite (M^{2+} : OH = 2) $K_3Na_3Ca_5(O,OH,F)_4[Si_{12}O_{30}]^{\infty}$
*Fluorcanasite $K_3Na_3Ca_5(F,OH)_4[Si_{12}O_{30}]\cdot H_2O$
*Frankamenite $K_3Na_3Ca_5(OH)F_3[Si_{12}O_{30}]\cdot H_2O$
Talc-pyrophyllite family (M^{2+} : OH = 1,5)
*Erlianite $Fe^{2+}{}_4Fe^{3+}{}_2(OH)_8[Si_2O_5]_3$
Pyrophyllite series
Pyrophyllite $\{Al_2(OH)_2[Si_2O_5]^{\infty 2}{}_2\}^{\infty 2}$

Ferripyrophyllite $\{Fe^{3+}{}_2(OH)_2[Si_2O_5]^{\infty 2}{}_2\}^{\infty 2}$
Talc series
Talc $\{Mg_3(OH)_2[Si_2O_5]^{\infty 2}{}_2\}^{\infty 2}$
*Stevensite $Mg_3(OH)_2[Si_4O_{10}]$
Minnesotaite $\{(Fe,Mg)_3(OH)_2[Si_2O_5]^{\infty 2}{}_2\}^{\infty 2}$
Willemseite = nickel-kerolite $\{(Ni,Mg)_3(OH)_2[Si_2O_5]^{\infty 2}{}_2\}^{\infty 2}$
Kerolite series
Kerolite $\{Mg_3(OH)_2[Si_2O_5]^{\infty 2}{}_2\}^{\infty 2}\cdot H_2O$
*****Tungusite** family (M^{2+} : OH = 1)
*Tungusite $Ca_{14}Fe^{2+}{}_9(OH)_{22}[Si_6O_{15}]_4$
Pyrosmalite family (M^{2+} : OH = 0,8)
Pyrosmalite series
Pyrosmalite-(Fe) $(Fe^{2+},Mn)_8(OH,Cl)_{10}[Si_6O_{15}]^{\infty 2}$
Pyrosmalite-(Mn) $(Mn^{2+},Fe)_8(OH,Cl)_{10}[Si_6O_{15}]^{\infty 2}$
Brokenhillite $(Mn,Fe)_8(OH,Cl)_{10}[Si_6O_{15}]^{\infty 2}$
Mcgillite $(Mn,Fe)_8(OH)_8Cl_2[Si_6O_{15}]^{\infty 2}$
Friedelite $Mn_8(OH,Cl)_{10}[Si_6O_{15}]^{\infty 2}$
Bementite $Mn_7(OH)_8[Si_6O_{15}]^{\infty 2}$
*Innsbruckite $Mn_{33}(OH)_{38}[Si_2O_5]_{14}$
Serpentine family (M^{2+} : OH = 0,75)
Antigorite $\{Mg_6(OH)_8[Si_4O_{10}]^{\infty 2}\}^{\infty 2}$
Caryopilite $\{Mn_6(OH)_8[Si_4O_{10}]^{\infty 2}\}^{\infty 2}$
Clinochrysotile $\{Mg_3(OH)_4[Si_2O_5]^{\infty 2}\}^{\infty 2}$
Lizardite $\{Mg_3(OH)_4[Si_2O_5]^{\infty 2}\}^{\infty 2}$
Orthochrysotile $\{Mg_3(OH)_4[Si_2O_5]^{\infty 2}\}^{\infty 2}$
Greenalite $\{(Fe^{2+},Fe^{3+})_{2\text{-}3}(OH)_4[Si_2O_5]^{\infty 2}\}^{\infty 2}$
Karpinskite $\{(Mg,Ni)_2(OH)_2[Si_2O_5]^{\infty 2}\}^{\infty 2}$
*Willemseite $\{(Ni,Mg)_3(OH)_2[Si_2O_5]_2$
Nepouite $\{Ni_3(OH)_4[Si_2O_5]^{\infty 2}\}^{\infty 2}$
Pecoraite $\{Ni_3(OH)_4[Si_2O_5]^{\infty 2}\}^{\infty 2}$
Kaolinite-halloysite family (M^{2+} : OH = 0,75)
Kaolinite subfamily
Kaolinite $\{Al_2(OH)_4[Si_2O_5]^{\infty 2}\}^{\infty 2}$
Dickite $\{Al_2(OH)_4[Si_2O_5]^{\infty 2}\}^{\infty 2}$
Nacrite $\{Al_2(OH)_4[Si_2O_5]^{\infty 2}\}^{\infty 2}$
*Kellyite $(Mn^{2+},Mg,Al)_3(OH)_4[(Si,Al)_2O_5]$
Halloysite subfamily
Halloysite-10Å. $\{Al_2(OH)_4[Si_2O_5]^{\infty 2}\}^{\infty 2}\cdot(H_2O)_2$
*Halloysite-7Å $\{Al_2(OH)_4[Si_2O_5]^{\infty 2}\}^{\infty 2}$
Endellite = halloysite-10Å $\{Al_2(OH)_4[Si_2O_5]^{\infty 2}\}^{\infty 2}\cdot(H_2O)_2$
Hisingerite $\{Fe^{3+}{}_2(OH)_4[Si_2O_5]^{\infty 2}\}^{\infty 2}\cdot(H_2O)_2$
Grumantite $Na[Si_2O_4(OH)]^{\infty 2}\cdot H_2O$
Kanemite $Na[Si_2O_4(OH)]\cdot 3H_2O$

Basic → silicato-fluorides → Hydrates

Apophyllite family
Apophyllite series
Natrofluorapophyllite = apophyllite-(NaF) $NaCa_4F[Si_4O_{10}]^{\infty 2}{}_2\cdot 8H_2O$
Hydroxyapophyllite = apophyllite-(KOH) $KCa_4F[Si_4O_{10}]^{\infty 2}{}_2\cdot 8H_2O$

Fluorapophyllite = apophyllite-(KF) $KCa_4(F,OH)[Si_4O_{10}]^{\infty 2}{}_2 \cdot 8H_2O$
Bannisterite $(Ca,K,Na,)(Mn^{2+},Fe^{2+})_{10}(OH)_8[(Si,Al)_{16}O_{38}]^{\infty 2} \cdot nH_2O$
*Gyrolite $(NaCa_2)Ca_{14}(OH)_8[(Si_{23}Al)O_{60}] \cdot (14+x)H_2O$
*Orlymanite $Ca_4Mn^{2+}{}_3(OH)_6[Si_8O_{20}] \cdot 2H_2O$
*Cryptophyllite $K_2Ca[Si_4O_{10}] \cdot 5H_2O$
*Shlykovite $KCa[Si_4O_9(OH)] \cdot 3H_2O$
*Aklimaite $Ca_4[Si_2O_5(OH)_2](OH)_4 \cdot 5H_2O$
Suolunite $Ca_2[Si_2O_5(OH)_2] \cdot H_2O$
Revdite $Na_{16}[Si_{16}O_{27}(OH)_{26}] \cdot 28H_2O$

Neutral

Nekoite $Ca_3[Si_6O_{15}]^{\infty 2} \cdot 7H_2O$

Mono-mono-disilicates with mixed silicooxygens radical

Basic

Charoite $(K,Na)_5(Ca,Ba,Sr)_8(OH,F)[Si_6O_{15}]^{\infty 2}{}_2\,[Si_6O_{16}] \cdot (H_2O)_n$
Okenite $\{Ca_8(H_2O)_6[Si_6O_{15}]^{\infty}{}_2[Si_6O_{16}]^{\infty}\}^{\infty 2} \cdot Ca_2(H_2O)_{12}$

Mono-disilicates (including isomorphic alumosilicates)
Mono-disilicates with К = 1,1(6)

Hydrates (basic)

Riversideite family
Tacharanite $Ca_8Al_{1,33}(H_2O)_9(OH)_6[Si_{12}O_{31}]^{\infty 2}$ (?)
Riversideite $Ca_{10}(H_2O)_3(OH)_6[Si_{12}O_{31}]^{\infty 2}$
Plombierite $Ca_{10}(H_2O)_{18}(OH)_6[Si_{12}O_{31}]^{\infty 2}$

Mono-disilicates with К = 1,(3)

Basic

*Denisovite $(K,Na)Ca_2(F,OH)[Si_3O_8]$
*Marshallsussmanite $NaCaMn(OH)[Si_3O_8]$
Jimthompsonite family
Jimthompsonite $(Mg,Fe^{2+})_5(OH)_2[Si_6O_{16}]^{\infty}$
Clinojimthompsonite $(Mg,Fe^{2+})_5(OH)_2[Si_6O_{16}]^{\infty}$
*Ca-jimthompsonite $Ca_2(Mg,Fe)_8(OH)_4[Si_6O_{16}]_2$

*Hydrates (neutral)

*Shafranovskite $(Na,K)_6(Mn,Fe)^{2+}{}_3[Si_9O_{24}] \cdot 6H_2O$

Mono-disilicates with К = 1,(3) + 1,5

Basic

Chesterite $(Fe,Mg)_{17}(OH)_6[Si_6O_{16}]^{\infty 2}{}_2[Si_4O_{11}]^{\infty 2}{}_2$

Mono-disilicates with К=1,4

Acid

Tokkoite $K_2|Ca_4(F,OH)[Si_7O_{18}(OH)]^{\infty}|^{\infty 2}$
(it as isostructural with tinaksite during isomorphism: $\square 2Ca^{2+}(F,OH)^- \rightarrow Na^+Ti^{4+}O^{2-}$)

Mono-disilicates with К = 1,5

Basic

Amphiboles family
Mg,Fe^{2+}- amphiboles subfamily

Gedrite series
Magnesiogedrite = gedrite
Gedrite $\square Mg_2(Mg_3Al_2)(OH)_2[(Al_2Si_6)O_{22}]^{\infty}$
Ferrogedrite $(Fe^{2+},Mg)_5Al_2(OH)_2[AlSi_3O_{11}]_2$
Sodicgedrite $Na(Mg,Fe^{2+})_6Al(OH)_2[AlSi_3O_{11}]^{\infty}_2$
*Sodic-ferrogedrite $NaFe_2(Fe_4Al)(OH)_2[AlSi_3O_{11}]^{\infty}_2$
Anthophyllite series
Magnesio-anthophyllite = anthophyllite
Anthophyllite $\square Mg_2Mg_5(OH)_2[Si_4O_{11}]^{\infty}_2$
*Proto-anthophyllite $(Mg,Fe^{2+})_7(OH)_2[Si_4O_{11}]^{\infty}_2$
Ferro-anthophyllite $Fe^{2+}_2Fe^{2+}_5(OH)_2[Si_4O_{11}]^{\infty}_2$
Proto-ferro-anthophyllite $\square\{Fe_2^{2+}\}\{Fe_5^{2+}\}(OH)_2[Si_4O_{11}]_2$
*Protomangano-ferro-anthophyllite $\square Mn^{2+}_2Fe^2_5(OH)_2[Si_4O_{11}]^{\infty}_2$
*Sodicanthophyllite $NaMg_7(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}_2$
Protomangan-anthophyllite $(Fe,Mn)_7(OH)_2[Si_4O_{11}]^{\infty}_2$
Cummingtonite series
Magnesio-cummingtonite = cummingtonite
Cummingtonite $\square Mg_2Mg_5(OH)_2[Si_4O_{11}]^{\infty}_2$
Grunerite $\square Fe^{2+}Fe^{2+}_7(OH)_2[Si_4O_{11}]^{\infty}_2$
*Manganogrunerite $(Mn,Fe^{2+})_7(OH)_2[Si_4O_{11}]^{\infty}_2$
*Permanganogrunerite $Mn^{2+}_4Fe^{2+}_3(OH)_2[Si_4O_{11}]^{\infty}_2$
*Manganocummingtonite = tirodite $\square Mn_2Mg_5(OH)_2[Si_4O_{11}]^{\infty}_2$

Mn-amphiboles subfamily
Basic
Dannemorite = manganogrunerite

***Mg,Fe,Ca-amphiboles** subfamily
Ca-amphiboles subfamily
Hornblende series
Tschermakite subseries
Tschermakite $Ca_2Mg_3Al_2(OH)_2[AlSi_3O_{11}]^{\infty}_2$
Aluminotschermakite $Ca_2Mg_3Al_2(OH)_2[AlSi_3O_{11}]^{\infty}_2$
Ferro-tschermakite $\square Ca_2(Fe_3^{2+}Al_2\}(OH)_2[AlSi_3O_{11}]^{\infty}_2$
*Alumino-ferrotschermakite $\square Ca_2(Fe^{2+}_3Al_2)(OH)_2[AlSi_3O_{11}]^{\infty}_2$
Ferro-ferri-tschermakite $\square Ca_2(Fe^{2+}_3Fe^{3+}_2)(OH)_2[AlSi_3O_{11}]^{\infty}_2$
Ferritschermakite $\square Ca_2Mg_3Fe^{3+}_2(OH)_2[AlSi_3O_{11}]^{\infty}_2$
*Ferri-ferro-tschermakite $\square Ca_2(Fe_3^{2+}Fe_2^{3+})(OH)_2[(AlSi_3O_{11}]^{\infty}_2$
Hornblende subseries
Magnesio-hornblende $\square Ca_2Mg_4Al(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}_2$
*Magnesio-ferri-fluoro-hornblende $\square Ca_2(Mg_4Fe^{3+})F_2[Al_{0.5}Si_{3.5}O_{11}]_2$
*Ferrimagnesiohornblendite $Ca_2[Mg_4(Fe,Al)](OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}_2$
Ferro-hornblende $\square Ca_2Fe^{2+}_4Al(OH,F)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}_2$
*Ferro-ferri-hornblende $\square Ca_2(Fe^{2+}_4Fe^{3+})(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}_2$
Tremolite subseries (Na+K) в A < 0,5; Ti < 0,5
Tremolite $\square Ca_2Mg_5(OH)_2[Si_4O_{11}]^{\infty}_2$
Actinolite $\square Ca_2Mg_{<4.5}Fe^{2+}_{>0.5}(OH)_2[Si_4O_{11}]^{\infty}_2$
Ferro-actinolite $\square Ca_2Mg_{<2.5}Fe^{2+}_{>2.5}(OH)_2[Si_4O_{11}]^{\infty}_2$

*Parvo-manganotremolite $\square CaMnMg_5(OH)_2[Si_4O_{11}]^{\infty}{}_2$

Ti-amphiboles subfamily (Na : Ca = 1 : 2)
*Obertiite $NaNa_2(Mg_3Fe^{3+}Ti)O_2[Si_4O_{11}]$
*Dellaventuraite $NaNa_2(MgMn^{3+}{}_2Ti^{4+}Li)O_2[Si_4O_{11}]_2$
*Ferroobertiite $NaNa_2(Fe^{2+}{}_3Fe^{3+}Ti^{4+})O_2[Si_4O_{11}]_2$

Kaersutite series
Kaersutite $NaCa_2(Mg_3Ti^{4+}Al)O_2[AlSi_3O_{11}]^{\infty}{}_2$
Ferro-kaersutite $NaCa_2(Fe^{2+}{}_3Ti^{4+}Al)O_2[AlSi_3O_{11}]^{\infty}{}_2$
Magnesiosadanagaite $NaCa_2(Mg_3Al_2)(Al_3Si_5O_{22})(OH)_2[(Al_{1.5}Si_{2.5}O_{11}]^{\infty}{}_2$
Sadanagaite $NaCa_2(Mg_3Al_2)(OH)_2[(Al_{1.5}Si_{2.5}O_{11}]^{\infty}{}_2$
*Potassic-aluminosadanagaite $KCa_2[Fe^{2+}{}_3(Al,Fe^{3+})_2](OH)_2[Al_3Si_5O_{22}]$
*Potassic-sadanagaite $KCa_2(Mg_3Al_2)(OH)_2[Al_3Si_5O_{22}]$
*Potassic-magnesio-sadanagaite $KCa_2(Mg_3Fe^{3+}{}_2)(OH)_2[Al_3Si_5O_{22}]$
*Potassic-ferri-sadanagaite $KCa_2(Mg^{2+}{}_3Fe^{3+}{}_2)(OH)_2[Al_3Si_5O_{22}]$
*Cannilloite $CaCa_2(Mg_4Al)(OH,F)_2[Al_3Si_5O_{22}]$
*Fluorocannilloite $CaCa_2(Mg_4Al)F_2[Al_3Si_5O_{22}]$

Pargasite subfamily (Na : Ca = 1 : 2)
*Fluoro-potassic-pargasite $KCa_2(Mg_4Al)Al_2F_2[AlSi_3O_{11}]_2$

Pargasite series
Pargasite $NaCa_2Mg_4Al(OH)_2[AlSi_3O_{11}]^{\infty}{}_2$
Potassic-pargasite $KCa_2Mg_5(OH,F)_2[(Si,Al)_4O_{11}]^{\infty}{}_2$
*Potassic-fluoro -pargasite $KCa_2(Mg_4Al)Al_2F_2[AlSi_3O_{11}]_2$
*Chloro-potassic-pargasite $(K,Na)Ca_2(Fe^{2+},Mg)_4Fe^{3+}Cl_2[AlSi_3O_{11}]_2$
Ferrohydroxylpargasite $NaCa_2(Fe^{2+},Mg)_4Al(OH,F)_2[AlSi_3O_{11}]^{\infty}{}_2$
*Ferro-pargasite $NaCa_2(Fe^{2+},Mg)_4Al(OH)_2[Si_6Al_2O_{22}]$
*Chromio-pargasite $NaCa_2Mg_4Cr^{3+}(OH)_2[Si_6Al_2O_{22}]$
Fluorpargasite $NaCa_2(Mg,Fe^{2+})_4AlF_2[AlSi_3O_{11}]^{\infty}{}_2$

Hastingsite series
Magnesio-hastingsite $NaCa_2(Mg,Fe^{2+})_4Fe^{3+}(OH)_2[AlSi_3O_{11}]^{\infty}{}_2$
*Fluoro-magnesiohastingsite $NaCa_2(Mg,Fe^{2+})_4Fe^{3+}F_2[AlSi_3O_{11}]^{\infty}{}_2$
Hastingsite $NaCa_2(Fe^{2+},Mg)_4Fe^{3+}(OH)_2[AlSi_3O_{11}]^{\infty}{}_2$
*Fluoro-potassichastingsite $(K,Na)Ca_2(Fe^{2+}{}_4 Fe^{3+})F_2[Si_6Al_2O_{22}]$
*Chloro-potassic-hastingsite $(K,Na)Ca_2(Fe^{2+}{}_4 Fe^{3+}) Cl_2[Si_6Al_2O_{22}]$
*Potassic-magnesio-hastingsite $KCa_2(Mg_4Fe^{3+})(OH)_2[Si_6Al_2O_{22}]$
*Potassic-hastingsite $KCa_2(Fe^{2+}{}_4Fe^{3+})(OH)_2[Si_6Al_2O_{22}]$
*Oxo-magnesio-hastingsite $NaCa_2(Mg_2Fe^{3+}{}_3)O_2[Si_6Al_2O_{22}]$

Edenite series
Edenite $NaCa_2Mg_5(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}{}_2$
*Fluoro-edenite $NaCa_2Mg_5F_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}{}_2$
Ferro-edenite $NaCa_2Fe^{2}{}_5(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}{}_2$
*Parvo-manganoedenite $NaCaMnMg_5(OH)_2[Al_{0,5}Si_{3,5}O_{11}]_2$

Winchite subfamily (Na : Ca = 1 : 1)

Winchite series
Winchite $\square NaCa(Mg_4Al)(OH)_2[Si_4O_{11}]^{\infty}{}_2$
*Parvowinchite $(NaMn^{2+})(Mg_4Al)(OH)_2[Si_4O_{11}]_2$
Ferro-winchite $\square NaCaFe^{2+}{}_4Al(OH)_2[Si_4O_{11}]^{\infty}{}_2$
*Ferri-winchite $\square (NaCa)Mg_4Fe^{3+}(OH)_2[Si_4O_{11}]^{\infty}{}_2$

Barroisite □$NaCa(Mg,Fe^{2+})_3Al_2(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}{}_2$
Ferro-barroisite □$(NaCa)Fe^{2+}{}_3Al_2(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}{}_2$
Ferri-barroisite □$(NaCa)(Mg_3Fe^{3+}{}_2)(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}{}_2$
Ferro-ferri-barroisite □$(NaCa)(Fe^{2+}{}_3Fe^{3+}{}_2)(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}{}_2$

Glaucophane subfamily (Na_2)

Glaucophane series
Glaucophane □$Na_2(Mg,Fe^{2+})_3Al_2(OH)_2[Si_4O_{11}]^{\infty}{}_2$
Ferro-glaucophane □$Na_2(Fe^{2+},Mg)_3Al_2(OH)_2[Si_4O_{11}]^{\infty}{}_2$

Crossite series
Crossite $Na_2(Mg,Fe^{2+})_3(Al,Fe^{3+})_2(OH)_2[Si_4O_{11}]^{\infty}{}_2$

Ribeckite series
Hydroxylmagnesioribeckite=magnesioriebeckite $Na_2(Mg,Fe^{2+})_3Fe^{3+}{}_2(OH)_2[Si_4O_{11}]^{\infty}{}_2$
Hydroxylribeckite = riebeckite $Na_2(Fe^{2+}{}_3Fe^{3+}{}_2(OH,F)_2[Si_4O_{11}]^{\infty}{}_2$
Fluororibeckite □$Na_2(Fe^{2+}{}_3Fe^{3+}{}_2)F_2[Si_4O_{11}]^{\infty}{}_2$
*Magnesioribeckite □$Na_2(Mg,Fe^{2+})_3Fe^{3+}{}_2(OH)_2[Si_4O_{11}]^{\infty}{}_2$

Taramite series
*Aluminomagnesiotaramite $Na(Ca,Na)(Mg_3Al_2)(OH)_2[AlSi_3O_{11}]^{\infty}{}_2$
*Fluoro-alumino-magnesiotaramite $Na(Ca,Na)(Mg_3Al_2)F_2[AlSi_3O_{11}]^{\infty}{}_2$
Magnesiotaramite $Na_2Ca(Mg_3\ AlFe^{3+}(OH)_2[AlSi_3O_{11}]^{\infty}{}_2$
Taramite $Na(NaCa)\ (Mg_3Al_2)(OH)_2[AlSi_3O_{11}]^{\infty}{}_2$
*Aluminotaramite $Na(Ca,Na)(Fe^{2+}{}_3Al_2)(OH)_2[AlSi_3O_{11}]_2$
*Ferrimagnesiotaramite $Na(Ca,Na)(Mg_3Fe^{3+}{}_2)(OH)_2[AlSi_3O_{11}]^{\infty}{}_2$
Ferri-taramite $Na(CaNa)(Mg_3Fe^{3+}{}_2)(OH)_2[AlSi_3O_{11}]_2$
*Ferro-ferri-taramite $Na(CaNa)(Fe_3{}^{2+}Fe_2{}^{3+})(OH)_2[AlSi_3O_{11}]_2$
*Chloro-potassic-ferri-magnesiotaramite $K(Ca,Na)(Mg_3Fe^{3+}{}_2)Cl_2[AlSi_3O_{11}]^{\infty}{}_2$

Richterite series
Richterite $Na_2Ca(Mg,Fe^{2+})_5(OH)_2[Si_4O_{11}]^{\infty}{}_2$
*Potassic-richterite $K(Na,Ca)Mg_5(OH)_2[Si_4O_{11}]^{\infty}{}_2$
Fluoro-richterite $Na(NaCa)Mg_5F_2[Si_4O_{11}]^{\infty}{}_2$
Fluoro-potassicrichterite $KNaCaMg_5F_2[Si_4O_{11}]^{\infty}{}_2$
Ferror-richterite $Na(NaCa)Fe^{2+}{}_5(OH)_2[Si_4O_{11}]^{\infty}{}_2$
*Richterite-MgSrK $(K,Na)(Ca,Sr,Mg,Na)Na(Mg,Na)_5(OH)_2[Si_4O_{11}]_2$

Katophorite series
*Magnesiokatophorite $Na(CaNa)(Mg_4Al)(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}{}_2$
*Ferrikatophorite $Na(NaCa)(Fe^{2+}{}_4Fe^{3+})(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}{}_2$
Aluminokatophorite *$Na_2Ca(Fe^{2+}{}_4Al)(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}{}_2$
Katophorite *$Na(NaCa)(Mg^{2+}{}_4Al)(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}{}_2$

Arfvedsonite subfamily
Nybøite $NaNa_2Mg_3Al_2(OH)_2[Al_{0,5}Si_{3,5}O_{11}]^{\infty}{}_2$
*Ferri-nybøite $NaNa_2(Mg_3Fe^{3+}{}_2)(OH)_2[Al_{0.5}Si_{3.5}O_{11}]_2$
*Ferro-ferri-nybøite $NaNa_2(Fe^{2+}{}_3Fe^{3+}{}_2)(OH)_2[Al_{0.5}Si_{3.5}O_{11}]_2$
*Ferro-nybøite $NaNa_2(Fe^{2+}{}_3Al_2)(OH)_2[Al_{0.5}Si_{3.5}O_{11}]_2$
*Fluoronybøite $NaNa_2(Mg_3Al_2)F_2[Al_{0.5}Si_{3.5}O_{11}]_2$

Eckermannite series
Eckermannite *$NaNa_2(Mg_4Al(OH)_2[Si_4O_{11}]^{\infty}{}_2$
*Ferroeckermannite $NaNa_2(Fe^{2+}{}_4Al)(OH)_2[Si_4O_{11}]^{\infty}{}_2$

Fluoreckermannite $Na_3(Mg,Fe^{2+})_4(Al,Fe^{3+})(F,OH)_2[Si_4O_{11}]^{\infty}{}_2$
Arfvedsonite series
*Arfvedsonite $NaNa_2(Fe^{2+}{}_4Fe^{3+})(OH)_2[Si_4O_{11}]^{\infty}{}_2$
Magnesioarfvedsonite $NaNa_2(Mg_4Fe^{3+})(OH)_2[Si_4O_{11}]^{\infty}{}_2$
*Potassic-arfvedsonite $KNa_2(Fe^{2+}{}_4Fe^{3+})(OH)_2[Si_4O_{11}]^{\infty}{}_2$
*Potassic-magnesio-arfvedsonite $KNa_2(Mg,Fe^{2+})_4Fe^{3+}(OH,F)_2[Si_4O_{11}]^{\infty}{}_2$
*Fluoro-magnesio-arfvedsonite $NaNa_2(Mg_4Fe^{3+})F_2[Si_4O_{11}]^{\infty}{}_2$
Hydroxylarfvedsonite = arfvedsonite $Na_3(Fe^{2+}, Fe^{3+})_4(OH)_2[Si_4O_{11}]^{\infty}{}_2$
Fluorarfvedsonite $Na_3(Fe^{2+},Mg)_4Fe^{3+}F_2[Si_4O_{11}]^{\infty}{}_2$
Kalifluorarfvedsonite $KNa_2(Fe^{2+}{}_4Fe^{3+})_2F_2[Si_4O_{11}]^{\infty}{}_2$
Kozulite = mangano-ferri-eckermanite $NaNa_2(Mn^{2+}{}_4Fe^{3+})(OH_2[Si_4O_{11}]^{\infty}{}_2$

Mono-disilicato-oxides with К = 1,5 Neutral
*Mangano-mangani-ungarettiite $NaNa_2(Mn^{2+}{}_2Mn^{3+}{}_3)O_2[Si_4O_{11}]^{\infty}{}_2$

Mono-disilicates with К = 1,(6) Neutral
Pellyite $Ba_4Ca_2Fe_4[Si_{12}O_{34}]^{\infty}$
Basic and hydrates
Xonotlite family
Xonotlite $Ca_6(OH)_2[Si_6O_{17}]^{\infty}$
Inesite $Ca_2Mn_7(OH)_2(H_2O)_5[Si_{10}O_{28}]^{\infty}$

Mono-disilicato-oxides with К = 1,6
Basic
Hillebrandite $Ca_2(OH)_2[SiO_3]^{\infty}$
Deerite $Fe^{2+}{}_6Fe^{3+}{}_3(OH)_5[Si_6O_{20}]^{\infty}$
Howieite series
Taneyamalite $Na(Mn^{2+}, Mg, Fe^{3+},Al)_{12}[Si_6O_{17}]_2(O,OH)_{10}$
Howieite $Na(Fe^{2+},Fe^{3+},Mn,Al,Mg)_{12}(O,OH)_{10}[Si_6O_{17}]^{\infty}{}_2$

*Mono-disilicato carbonato-chlorides with К = 1,75
*Hydrates
*Fencooperite $Ba_6Fe^{3+}{}_3[Si_8O_{23}][CO_3]_2Cl_3{\cdot}H_2O$

Disilicates (К = 2)
Neutral
Imandrite $Na_{12}Ca_3Fe^{3+}{}_2[Si_6O_{18}]_2$
*Unnamed $(Na_{0.06}Ca_{0.02}Mg_{0.71}Fe_{0.20}Al_{0.11})_{\Sigma 1.1}[Si_{0.94}O_3]$
Pyroxenes family
Mg-Fe(Mn)- pyroxenes subfamily
*Akimotoite $(Mg,Fe)[SiO_3]$
Enstatite series (orthopyroxenes)
Enstatite $Mg_2[Si_2O_6]^{\infty}$
Hypersthene = Fe-энстатин $(Mg,Fe,Al)_2[(Si,Al)_2O_6]^{\infty}$
Donpeacorite $Mg(Mn,Mg)[Si_2O_6]^{\infty}$
Clinoenstatite series
Clinoenstatite $Mg_2[Si_2O_6]^{\infty}$
Pigeonite $(Mg,Fe,Ca)(Mg,Fe)[Si_2O_6]^{\infty}$
Kanoite $(Mn^{2+},Mg)_2[Si_2O_6]^{\infty}$

Clinoferrosilite	$(Fe,Mg)_2[Si_2O_6]^\infty$
*Ferrosilite	$(Fe^{2+}Mg)_2[Si_2O_6]^\infty$
Ca-Na-pyroxenes subfamily	
Augite series	
*Kushiroite	$CaAl[AlSiO_6]^\infty$
Esseneite	$CaFe^{3+}[AlSiO_6]^\infty$
*Davisite	$CaSc[AlSiO_6]$
*Grossmanite	$CaTi^{3+}[AlSiO_6]$
Augite	$(Ca,Na)(Mg,Fe,Al)[(Si,Al)_2O_6]^\infty$
Omphacite	$(Ca,Na)(Mg,Fe^{2+},Fe^{3+},Al)[(Si,Al)_2O_6]^\infty$
Diopside series	
Diopside	$CaMg[Si_2O_6]^\infty$
Hedenbergite	$CaFe^{2+}[Si_2O_6]^\infty$
Johannsenite	$Ca(Mn,Fe)^{2+}[Si_2O_6]^\infty$
Jervisite	$(Na,Ca,Fe^{2+})(Sc,Mg,Fe^{2+})[Si_2O_6]^\infty$
*Na-Mg pyroxene	$(Na,Mg,Ca,Mn)(Mg,Al,Cr,Fe)[Si_2O_6]^\infty$
Aegirine series	
Natalyite	$NaV[Si_2O_6]^\infty$
Kosmochlor	$NaCr[Si_2O_6]^\infty$
Aegirine	$NaFe^{3+}[Si_2O_6]^\infty$
Jadeite	$Na(Al,Fe^{3+})[Si_2O_6]^\infty$
*Namansilite	$NaMn^{3+}[Si_2O_6]$
*Vladykinite	$Na_3Sr_4(Fe^{2+}Fe^{3+})[Si_2O_6]_4$
Pyroxenoids family	
	Neutral
Rhodonite subfamily	
***Pyroxmangite** series	
Pyroxmangite	$Mn^{2+}[SiO_3]^\infty$
*Pyroxferroite	$Fe_7[Si_7O_{21}]^\infty$
Rhodonite	$Mn_5[Si_5O_{15}]^\infty$
Bustamite	$CaMn^{2+}[Si_2O_6]^\infty$
*Mendigite	$Mn_2Mn_2MnCa[Si_3O_9]_2$
Ferrobustamite	$Ca_3(Fe^{2+},Ca)_3[Si_3O_9]^\infty{}_2$
Wollastonite subfamily	
Wollastonite-1T	$Ca_3[Si_3O_9]^\infty$
Parawollastonite or wollastonite-2M	$Ca_3[Si_3O_9]^\infty$
*Manganoparawollastonite	$Ca[SiO_3]$
Wollastonite-7T	$Ca_3[Si_3O_9]^\infty$
Pseudowollastonite (synthetic)	$3\beta s\text{-}CaSiO_3 \rightarrow Ca_3[Si_3O_9]$
Walstromite	$BaCa_2[Si_3O_9]$
Combeite	$Na_4Ca_4[Si_6O_{18}]$
*Unnamed (synthetic)	$K_{2.9}Rb_{0.1}Er[Si_3O_9]$
	Acid pyroxenoids → hydrates
*Neotocite	$(Mn^{2+},Fe^{2+})[SiO_3]\cdot H_2O$
*Nchwaningite	$Mn^{2+}{}_2(OH)_2[SiO_3]\cdot H_2O$
*Imogolite	$Al_2(OH)_4[SiO_3]$
Babingtonite series	
Babingtonite	$Ca_2Fe^{2+}Fe^{3+}[Si_5O_{14}(OH)]^\infty$

*Scandiobabingtonite	$Ca_2(Fe,Mn)Sc[Si_5O_{14}(OH)]^{\infty}$
Manganbabingtonite	$Ca_2(Mn,Fe)^{2+}Fe^{3+}[Si_5O_{14}(OH)]^{\infty}$
Marsturite	$NaCaMn^{2+}{}_3[Si_5O_{14}(OH)]^{\infty}$
*Ruizite	$Ca_2Mn^{3+}{}_2[Si_4O_{11}(OH)_4]\cdot 2H_2O$
Cascandite	$CaSc[Si_3O_8(OH)]^{\infty}$
Rosenhahnite	$Ca_3[Si_3O_8(OH)_2]$
*Trabzonite	$Ca_4[Si_3O_9(OH)_2]$
Tobermorite family	
Tobermorite-9A	$Ca_5[HSi_3O_9]^{\infty}{}_2\cdot 2H_2O$
Tobermorite-11A = Clinotobermorite	$Ca_5[Si_6O_{17}]\cdot 5H_2O$
Tobermorite-14A	$\{Ca_4[Si_3O_8(OH)]_2\cdot 2H_2O\}\cdot(Ca\cdot 5H_2O)$
*Clinotobermorite	$Ca_5[Si_6O_{17}]\cdot 5H_2O$
Pectolite series	
Serandite	$NaMn^{2+}{}_2[Si_3O_8(OH)]^{\infty}$
Pectolite	$NaCa_2[Si_3O_8(OH)]^{\infty}$
*Pectolite M2abc	$Na(Ca,Mn^{2+})_2[Si_3O_8(OH)]^{\infty}$
	Oxido-disilicates
Krinovite series	
Dorrite	$Ca_4(Mg_3Fe^{3+}{}_9)O_4[Si_3Al_8Fe^{3+}O_{36}]$
Wilkinsonite	$Na_4(Fe^{2+}{}_8Fe^{3+}{}_4)O_4[Si_6O_{18}]_2$
Krinovite	$Na_4(Mg_8Cr^{3+}{}_4O_4)[Si_6O_{18}]_2$
	Basic disilicates $\rightarrow$hydrates
*Bunnoite	$Mn^{2+}{}_6Al(OH)_3[Si_6O_{18}]$
Carpholite series	
Magnesiocarpholite	$MgAl_2(OH)_4[Si_2O_6]^{\infty}$
Ferrocarpholite	$(Fe,Mg)Al_2(OH)_4[Si_2O_6]^{\infty}$
Carpholite	$Mn^{2+}Al_2(OH)_4[Si_2O_6]^{\infty}$
*Potassiccarpholite	$(K,\square)(Mn^{2+},Li)_2Al_4(OH,F)_8[Si_2O_6]_2$
*Vanadiocarpholite	$Mn^{2+}V^{3+}Al(OH)_4[Si_2O_6]^{\infty}$
Gageite series	
Balangeroite	$Mg_{21}O_3(OH)_{20}[Si_2O_6]^{\infty}{}_4$
Gageite-*1Tc*	$Mn^{2+}{}_{21}O_3(OH)_{20}[Si_2O_6]^{\infty}{}_4$
Gagei -*2M*	$Mn^{2+}{}_{21}O_3(OH)_{20}[Si_2O_6]^{\infty}{}_4$
Foshagite	$Ca_4(OH)_2[Si_3O_9]^{\infty}$
Saneroite	$Na_{1,15}(H,Mn^{2+},Mn^{3+})_5(OH)[Si_{5,5}V_{0,5})_{\Sigma 6}O_{18}]$
*Braccoite	$NaMn^{2+}{}_5(OH)[Si_5As^{5+}O_{17}(OH)]$
*Cerchiaraite-(Al)	$Ba_4Al_4O_3(OH)_3[Si_4O_{12}][Si_2O_3(OH)_4]Cl$
*Cerchiaraite-(Fe)	$Ba_4Fe^{3+}{}_4O_3(OH)_3[Si_4O_{12}][Si_2O_3(OH)_4]Cl$
*Cerchiaraite-(Mn)	$Ba_4Mn^{3+}{}_4O_2(OH)_4{}^{+}[Si_4O_{12}][Si_2O_3(OH)_4]Cl_2$
Verplanckite family	
Verplanckite	$\vert(Mn^{3+},Ti,Fe^{3+})_6(OH,O)_2[Si_4O_{12}]_3\vert^{\infty 3}\cdot Ba_{12}(OH,H_2O)_7Cl_9$
Muirite	$Ba_{10}Ca_2Mn^{2+}TiSi_{10}O_{30}(OH,Cl,F)_{10}$
*Hubeite	$Ca_2Mn^{2+}Fe^{3+}[Si_4O_{12}(OH)]\cdot(H_2O)_2$
*Bavsiite	$Ba_2V_2O_2[Si_4O_{12}]$
	Hydrates; acid; acid-basic
Santaclaraite	$CaMn_4(H_2O)(OH)[Si_5O_{14}(OH)]^{\infty}$
*Middendorfite	$K_3Na_2Mn_5[Si_{12}(O,OH)_{36}]\cdot 2H_2O$
Krauskopfite	$Ba_2(H_2O)_4[Si_4O_8(OH)_4]^{\infty}$
*Jennite	$Ca_9(OH)_6[Si_6O_{18}]\cdot 8H_2O$

*Oxido-phosphato-carbonato-disilicates

Hydrates

*Devitoite $[Ba_6(PO_4)_2(CO_3)]\{Fe^{2+}{}_7Fe^{3+}{}_2O_2[Si_4O_{12}]_2(OH)_4\}$

*Disilicato-Trisilicates

*Strakhovite $NaBa_3(Mn^{2+},Mn^{3+})_4[Si_4O_{10}(OH)_2][Si_2O_7]O_2(F,OH)\cdot H_2O$

*Varennesite $Na_8Mn^{2+}{}_2(OH,Cl)_2Si_{10}O_{25}\cdot 12H_2O$

Trisilicates (K = 3)

Proper trisilicates

Neutral

Melilite group

Gehlenite $Ca_2Al[AlSiO_7]$

Melilite $(Ca,Na)_2(Al,Mg)[(Si,Al)_2O_7]$

Akermanite $Ca_2Mg[Si_2O_7]$

*Alumoakermanite $(Ca,Na)_2(Al,Mg,Fe^{2+})[Si_2O_7]$

Hardystonite $Ca_2Zn[Si_2O_7]$

Rankinite family

Rankinite $Ca_3[Si_2O_7]$

Kilchoanite $Ca_3[Si_2O_7]$

Andremeyerite $BaFe^{2+}{}_2[Si_2O_7]$

Taikanite $(Sr,Ba)_4Mn_2[Si_2O_7]_2$

Basic

Ilvaite family

Ilvaite $CaFe^{2+}{}_2Fe^{3+}O(OH)[Si_2O_7]$

*Manganilvaite $CaFe^{2+}Mn^{2+}Fe^{3+}O(OH)[Si_2O_7]$

Orthoericssonite $BaMn_2Fe^{3+}O(OH)[Si_2O_7]$

Ericssonite $BaMn_2Fe^{3+}O(OH)[Si_2O_7]$

*Ferroericssonite $BaFe^{2+}{}_2Fe^{3+}O(OH)[Si_2O_7]$

Cuspidine family

Cuspidine $Ca_4(F,OH)_2[Si_2O_7]$

Jaffeite $Ca_6(OH)_6[Si_2O_7]$

Hydrates

Basic

Lawsonite family

Lawsonite $CaAl_2(OH)_2[Si_2O_7]\cdot H_2O$

*Cortesognoite $CaV_2(OH)_2[Si_2O_7]\cdot H_2O$

*Itoigawaite $SrAl_2(OH)_2[Si_2O_7]\cdot H_2O$

*Hennomartinite $SrMn^{3+}{}_2(OH)_2[Si_2O_7]\cdot H_2O$

*Noélbelsonite $BaMn^{3+}{}_2(OH)_2[Si_2O_7]\cdot H_2O$

Neutral

Killalaite $Ca_3[Si_2O_7]\cdot H_2O$

*Trisilicato-chlorides

*Rusinovite $Ca_{10}[Si_2O_7]_3Cl_2$

Trisilicato-tetrasilicates

*Trisilicato-tetrasilicates whis K=3,2

*Medaite $(Mn^{2+},Ca)_6(V,As)^{5+}[Si_5O_{18}(OH)]$

*Pavlovskiite $Ca_8[Si_3O_{10}][SiO_4]_2$

Trisilicato-tetrasilicates with $Si_2O_7 : SiO_4 = 2 : 1$

Hydroxido-silicato-chlorides

Rustumite $Ca_{10}(OH)_2Cl_2[Si_2O_7]_2[SiO_4]$

Trisilicato-tetrasilicates with $Si_2O_7 : SiO_4 = 1 : 1$ Basic

Epidote family (compare with allanite (series)

Zoisite $Ca_2Al_3O(OH)[Si_2O_7][SiO_4]$

Epidote series

Clinozoisite $Ca_2Al_3O(OH)[Si_2O_7][SiO_4]$

*Niigataite $CaSrAl_3O(OH)[Si_2O_7][SiO_4]$

Epidote $Ca_2Fe^{3+}Al_2O(OH)[Si_2O_7][SiO_4]$

*Epidote-(Pb) $(Ca,Pb)(Al_2Fe^{3+})O(OH)[Si_2O_7][SiO_4]$

*Epidote-(Sr) $CaSrFe^{3+}Al_2O(OH)[Si_2O_7][SiO]$

Piemontite $Ca_2Mn^{3+}Al_2O(OH)[Si_2O_7][SiO_4]]$

*Piemontite-(Pb) $CaPbMn^{3+}Al_2O(OH)[Si_2O_7][SiO_4]$

*Piemontite-(Sr) $SrCaMn^{3+}Al_2O(OH)[Si_2O_7][SiO_4]$

*Manganiпьемонтит-(Sr) = *Tweddillite

$CaSrMn^{3+}{}_2AlO(OH)[Si_2O_7][SiO_4]$

Mukhinite $Ca_2V^{3+}Al_2O(OH)[Si_2O_7][SiO_4]$

*Cassagnaite $Ca_4Fe_4{}^{3+}V_2{}^{3+}(OH)_6O_2[Si_3O_{10}][SiO_4]_2$

*Uedaite-(Ce) $(Mn^{2+}Ce)Al_2Fe^{2+}O(OH)[Si_2O_7][SiO_4]$

Sursassite series

Sursassite $Mn_2Al_3(OH)_3[Si_2O_7][SiO_4]$

Macfallite $Ca_2Mn^{3+}{}_3(OH)_3[Si_2O_7][SiO_4]$

Cebollite $Ca_4Al_2O(OH)_2[Si_2O_7][SiO_4]$ (?)

Dellaite $Ca_6(OH)_2[Si_2O_7][SiO_4]$

Hydrates

Pumpellyite series

*Pumpellyite-(Al) $Ca_2AlAl_2O(OH)[Si_2O_7][SiO_4]{\cdot}H_2O$

Pumpellyite-(Fe^{2+}) $Ca_2Fe^{2+}Al_2(OH)_2[Si_2O_7][SiO_4]{\cdot}H_2O$

*Pumpellyite-(Fe^{3+}) $Ca_2Fe^{3+}Al_2O(OH)[Si_2O_7][SiO_4]{\cdot}H_2O$

*Pumpellyite-(Mg) $Ca_2MgAl_2(OH)_2[Si_2O_7][SiO_4]{\cdot}H_2O$

Pumpellyite-(Mn) $Ca_2MnAl_2(OH)_2[Si_2O_7][SiO_4]{\cdot}H_2O$

Shuiskite $Ca_2(Mg,Al,Fe)(Cr,Al)_2(OH)_2[Si_2O_7][(Si,Al)O_4]{\cdot}H_2O$

Julgoldite-(Fe^{2+}) $Ca_2Fe^{2+}(Fe^{3+},Al)_2(OH)_2[Si_2O_7][SiO_4]{\cdot}H_2O$

*Julgoldite-(Fe^{3+}) $Ca_2Fe^{3+}(Fe^{3+})_2O(OH)[Si_2O_7][SiO_4]{\cdot}H_2O$

*Julgoldite-(Mg) $Ca_2Mg(Fe^{3+})_2(OH)_2[Si_2O_7][SiO_4]{\cdot}H_2O$

*Poppiite $Ca_2V^{3+}V^{3+}{}_2O(OH)[Si_2O_7][SiO_4]{\cdot}H_2O$

*Okhotskite $Ca_2(Mn^{2+},Mg,Mn^{3+},Al,Fe^{3+})_3(O,OH)_3[Si_2O_7][SiO_4]$

Trisilicato-tetrasilicates with К=3,4 *Hydrates

*Vertumnite $Ca_8[Al_4Al_4Si_5O_{12}(OH)_{36}]{\cdot}10H_2O$

*Strätlingite $Ca_8[Al_4Al_4Si_4O_8(OH)_{40}]{\cdot}10H_2O$

*Aerinite $(Ca_{5,1}Na_{0,5})(Fe^{3+}AlFe^{2+}{}_{1,7}Mg_{0,3})(Al_{5,1}Mg_{0,7})[Si_{12}O_{36}(OH)_{12}H][(H_2O)_{12}(CO_3)_{1,2}]$ or

*$Ca_4Al_{10}[Si_{12}O_{36}(OH)_{12}][CO_3](H_2O)$ [Krivovochev, 2008]

Trisilicato-tetrasilicates with $Si_2O_7 : SiO_4 = 0,4 : 1$ Basic

Vesuvianite $(Ca,Na)_{19}(Al,Mg,Fe)_{13}(OH,F,O)_{10}[SiO_4]_{10}[Si_2O_7]$

*Alumovesuvianite	$Ca_{19}Al(Al_{10}Mg_2)O(OH)_9[Si_2O_7]_4[SiO_4]_{10}$
*Fluorvesuvianite	$Ca_{19}(Al,Mg)_{13}O(F,OH)_9[Si_2O_7]_4[SiO_4]_{10}$
*Manganovesuvianite	$(Ca,Na,\square)_{19}(Al,Mg,Fe^{3+})_{13}(\square,B,Al,Fe^{3+})_5(OH,F,O)_{10}[Si_2O_7]_4[SiO_4]_{10}$
*Wiluite	$Ca_{19}(Al,Mg,Fe,Ti)_{13}(B,Al,\square)_5(O,OH)_{10}[Si_2O_7]_4[SiO_4]_{10}$

*Трисиликато-тетрасиликато-фосфаты (К = 3,(3))

*Lavoisierite	$Mn^{2+}{}_8[Al_{10}(Mn^{3+}Mg)](OH)_{12}[(Si_{11}P)O_{44}]$

Tetrasilicates (orthosilicates) (К = 4) Neutral

Garnet series	
Knorringite	$Mg_3Cr_2[SiO_4]_3$
Pyrope	$Mg_3Al_2[SiO_4]_3$
*Menzerite-(Y)	$CaY_2Mg_2[SiO_4]_3$
Almandine	$Fe^{2+}{}_3Al_2[SiO_4]_3$
Spessartine	$Mn^{2+}{}_3Al_2[SiO_4]_3$
Majorite	$Mg_3(MgSi)[SiO_4]_3$
*Eringaite	$Ca_3Sc_2[SiO_4]_3$
Grossular	$Ca_3Al_2[SiO_4]_3$
*Irinarassite	$Ca_3Sn_2Al_2SiO_{12}$ или $Ca_3[Al_{2/3}Sn_{2/3}Si_{1/3}O_4]_3$
Calderite	$(Mn^{2+},Ca)_3(Fe^{3+},Al)_2[SiO_4]_3$
Andradite	$Ca_3Fe^{3+}{}_2[SiO_4]_3$
*Ti-andradite	$Ca_3Ti^{4+}{}_2[(Fe^{3+}{}_{0.66}Si_{0.33})O_4]_3$
Schorlomite	$Ca_3Ti^{4+}{}_2[(Fe^{3+}{}_2Si)O_{123}$
*Morimotoite	$Ca_3TiFe^{2+}[SiO_4]_3$
*Hutcheonite	$Ca_3Ti^{4+}{}_2[(Si_{0.33}Al_{0.66})O_4]_3$
Kimzeyite	$Ca_3Zr_2[Al_2Si)O_{12}]$
*Kerimasite	$Ca_3Zr_2[(Fe^{3+}{}_2Si)O_{12}]$
Uvarovite	$Ca_3Cr_2[SiO_4]_3$
Goldmanite	$Ca_3(V,Al,Fe)^{3+}{}_2[SiO_4]_3$
*Momoite	$Mn^{2+}{}_3V^{3+}{}_2[SiO_4]_3$
Yamatoite	$(Mn^{2+},Ca)_3(V^{3+},Al)_2[SiO_4]_3$
*Toturite	$Ca_3Sn_2[(Fe^{3+}{}_2Si)O_{12}]$
Hydrogarnet family	
Hydrougrandite	$(Ca,Mg,Fe^{2+})_3(Fe^{3+},Al)_2[SiO_4]_2(OH)_4$
*Henritermierite	$Ca_3(Mn^{3+},Al)_2[SiO_4]_2(OH)_4$
*Holstamite	$Ca_3Al_2[SiO_4]_2(OH)_4$
Hibschite (plazolite)	$Ca_3Al_2[SiO_4]_{3-x}(OH)_{4x}$ $(0,2 \le x \le 1,5)$
Katoite	$Ca_3Al_2[SiO_4]_{3-x}(OH)_{4x}$ $(1,5 < x \le 3)$
Olivine family	
*Calcio-olivine	$Ca_2[SiO_4]$
Wadsleyite	β-$(Mg,Fe^{2+})_2[SiO_4]$
*Wadsleyite II	$(Mg,Fe)_{11}[(Al,Si)_6(OH)_2O_{22}]$
Ringwoodite	$(Mg,Fe^{2+})_2[SiO_4]$
Forsterite series	
Forsterite	$Mg_2[SiO_4]$
Fayalite	$Fe^{2+}{}_2[SiO_4]$
Tephroite	$Mn^{2+}{}_2[SiO_4]$
Liebenbergite	$Ni^{2+}[SiO_4]$
Laihunite	$Fe^{2+}Fe^{3+}{}_2[SiO_4]_2$

*Unnamed $(Na_{0.08}Ca_{0.03}Mg_{0.95}Fe_{0.26}Al_{0.15}Si_{0.25}\square_{0.28})_2[SiO_4]$
Monticellite family
Monticellite $CaMg[SiO_4]$
Kirschsteinite $CaFe^{2+}[SiO_4]$
Glaucochroite $CaMn^{2+}[SiO_4]$
Merwinite $Ca_3Mg[SiO_4]_2$
Bredigite $(Ca,Ba)Ca_{13}Mg_2[SiO_4]_8$
Larnite β-$Ca_2[SiO_4]$

Oxido-tetrasilicates (at that number sulfido-oxido tetrasilicates)
*Hatrurite $Ca_3O[SiO_4]$
Kyanite family
(Sillimanite) see monoalumosilicates, sillimanite (family)
Andalusite $^{(6)}Al^{(5)}AlO[SiO_4]$
Kanonaite $^{(6)}(Mn^{3+},Al)^{(5)}AlO[SiO_4]$
Kyanite $^{(6)}Al_2O[SiO_4]$
Staurolite family
Yoderite $Mg_2Al_6O_2(OH)_2[SiO_4]_4$
Staurolite $Fe_2^{2+}Al_9Si_4O_{23}(OH)$
*Magnesiostaurolite $\square_4Mg_4Al_{16}(Al_2\square_2)Si_8O_{40}[O_6(OH)_2]$
*Zincostaurolite $\square_4Zn_4Al_{16}(Al_2\square_2)Si_8O_{40}[O_6(OH)_2]$
Jasmundite $Ca_{11}SO_2[SiO_4]_4$

Basic oxido-tetrasilicates

Davreuxite $Mn^{2+}Al_6(OH)_2O[SiO_4]_4$
Chloritoid family
Chloritoid series
Magnesiochloritoid $\{Mg_2Al(OH)_4Al_3O_2[SiO_4]_2\}^{\infty 2}$
Chloritoid $\{(Fe^{2+},Mg)_2Al(OH)_4Al_3O_2[SiO_4]_2\}^{\infty 2}$
Ottrelite $\{(Mn^{2+},Fe^{2+},Mg)_2Al(OH)_4Al_3O_2[SiO_4]_2\}^{\infty 2}$
Humite polysomatic series $M_{3+n}X_2[SiO_4]_{1+0,5n}$, where $M^{2+} = Mg^{2+}, Fe^{2+}, Mn^{2+}$; $X = F^-, OH^-$; n = 0 ; 2; 4; 6
Norbergite $Mg_3(F,OH)_2[SiO_4]$ (n = 0)
Chondrodite group
Chondrodite $Mg_5(F,OH)_2[SiO_4]_2$ (n = 2)
*Hydroxychondrodite $Mg_5(OH)_2[SiO_4]_2$
*Kumtyubeite $Ca_5F_2[SiO_4]_2$
Alleghanyite $Mn^{2+}{}_5(OH)_2[SiO_4]_2$ (n = 2)
Reinhardbraunsite $Ca_5(OH,F)_2[SiO_4]_2$
Ribbeite $Mn^{2+}{}_5(OH)_2[SiO_4]_2$ (n = 2)
Humite series
Humite $(Mg,Fe^{2+})_7(F,OH)_2[SiO_4]_3$ (n = 4)
Manganhumite $(Mn^{2+},Mg)_7(OH)_2[SiO_4]_3$ (n = 4)
*Chegemite $Ca_7(OH)_2[SiO_4]_3$
*Fluorchegemite $Ca_7F_2[SiO_4]_3$
Leucophoenicite $Mn^{2+}{}_7(OH)_2[SiO_4]_3$ (n = 4)
Clinohumite series
Titanclinohumite $(Mg,Fe,Ti)_9F_2[SiO_4]_4$ (n = 6)
Clinohumite $(Mg,Fe^{2+})_9(F,OH)_2[SiO_4]_4$ (n = 6)
*Hydroxylclinohumite $Mg_9(OH,F)_2[SiO_4]_4$ (n = 6)
Jerrygibbsite $Mn^{2+}{}_9(OH)_2[SiO_4]_4$ (n = 6)

Sonolite $Mn^{2+}_9(OH)_2[SiO_4]_4$ (n = 6)
*Poldervaartite $Ca(Ca_{0,5}Mn_{0,5})(OH)[SiO_3OH]$
*Olmiite $CaMn[SiO_3(OH)](OH)$
Welinite family
Welinite $Mn^{2+}_3(Mn^{4+},W)(O,OH)_3[SiO_4]$
Franciscanite $Mn_3(V^{5+}_x,\square_{1-x})(O,OH)_3[SiO_4]$ (x ~ 0.5)
*Vuagnatite $CaAl(OH)[SiO_4]$
*Mozartite $CaMn^{3+}(OH)[SiO_4]$
Chantalite $CaAl_2(OH)_4[SiO_4]$

Hydrates (basic)

*Spadaite $Mg[SiO_2(OH)_2]\cdot H_2O]$
*Chesnokovite $Na_2[SiO_2(OH)_2]\cdot 8H_2O$
Kittatinnyite(compare with wallkilldellite (gr.)) $Ca_4Mn^{2+}_2Mn^{3+}_4(OH)_8[SiO_4]_4\cdot 18H_2O$
*Orientite $Ca_8Mn^{3+}_{10}(OH)_{10}[Si_3O_{10}]_3[SiO_4]_3\cdot 4H_2O$

*Oxido-tetrasilicato-halogenides
*Wadalite $Ca_6Al_5O_8[SiO_4]_2Cl_3$
*Eltyubyuite $Ca_{12}Fe^{3+}_{10}Si_4O_{32}Cl_6$ or $Ca_{12}Fe^{3+}_6[(Fe^{3+}_4Si_4)O_{32}]Cl_6$

Acid →tetrasilicato-fluorides

Bultfonteinite $Ca_4[SiO_3(OH)]_2F_2\cdot 2H_2O$

*Tetrasilicato-phosphates
*Harrisonite $Ca(Fe,Mg)_6[SiO_4]_2[PO_4]_2$

Silicato-halogenides
Di-trisilicato-halogenides

Basic

Zunyite (K = 2,4) $Al_{12}(OH)_{14}\{[AlO_4][Si_5O_{16}]\}F_4Cl$
Magbasite (K = 2,(6)) $KBa(Al,Sc)(Mg,Fe^{2+})_6[Si_6O_{20}]F_2$
*Jagoite (K = 2,(6)) $Pb_{18}Fe_4^{3+}[Si_4(Si,Fe^{3+})_6][Pb_4Si_{16}(Si,Fe)_4]O_{82}Cl_6$

Tetrasilicato-halogenides Basic
Topaz $Al_2[SiO_4](F,OH)_2$
*Topaz-(OH) $Al_2[SiO_4](OH,F)_2$
*Podnoginite $Ca_2[SiO_4]CaF_2$
*Rondorfite $Ca_8Mg[SiO_4]_4Cl_2$
*Edgrewite $Ca_9[SiO_4]_4F_{1.2}(OH)_{0.8}$
*Hydroxyledgrewite $Ca_9[SiO_4]_4(OH)_2$

*Tetrasilicato-oxido-sulphates
*Gazeevite $BaCa_6[SiO_4]_2[SO_4]_2O$
*Nabimusaite $KCa_{12}[SiO_4]_4[SO_4]_2O_2F$

Silicato-borates
Borosilicates
Zero-borosilicates ($K_\Sigma = 0$) Neutral
Danburite $Ca[Si_2B_2O_8]^{\infty 3} \rightarrow Ca[(Si_2O_7)B_2O]^{\infty 3}$
*Maleevite $Ba[Si_2B_2O_8]$
*Pekovite $Sr[Si_2B_2O_8]$

Reedmergnerite $Na[Si_3BO_8]^{\infty 3} \rightarrow Na[SiO_3BO_5]^{\infty 3}$
*Malinkoite $Na[SiBO_4]$
*Pudrettite $KNa_2[Si_{12}B_3O_{30}]$
*Jadarite $LiNa[SiB_3O_7(OH)]$
*Lisitsynite $K[Si_2BO_6]$
*Kirchhoffite $Cs[Si_2BO_6]$

*Zero-monoborosilicates (K_Σ = 0,32) Acid
*Martinite $(Na,\square,Ca)_{12}Ca_4[(Si,S,B)_{14}B_2O_{38}](OH,Cl)_2F_2{\cdot}4H_2O$

*Zero-monoborosilicates (K = 0.5) Basic (hydrates)
*Steedeite $NaMn_2[BSi_3O_9](OH)_2$
*Nolzeite $NaMn_2[Si_3BO_9](OH)_2{\cdot}2H_2O$

Zero-monoborosilicates (K_Σ = 0,(6) Acid
Searlesite $Na[(Si_2O_5B(OH)_2]^{\infty 2}$
*Okayamalite $Ca_2[B_2SiO_7]$
*Itsiite $Ba_2Ca[BSi_2O_7]_2$

*Zero-monoborosilicates (K = 0.75) Basic
*Odigitriaite $CsNa_5Ca_5[Si_{14}B_2O_{38}]F_2$

*Zero-monoborosilicates (K_Σ = 0,9) Basic (hydrates)
*Kasatkinite $Ba_2Ca_8[B_5Si_8O_{32}](OH)_3{\cdot}6H_2O$

Monoborosilicates (K_Σ = 1) Neutral
Homilite $Ca_2Fe^{2+}[Si_2B_2O_{10}]^{\infty 2} \rightarrow Ca_2Fe^{2+}[(SiO_4)_2B_2O_2]^{\infty 2}$
*Boromullite $Al_8O_9[AlBSi_2O_{10}]$

Acid

Datolite family
Datolite $Ca[(SiO_4)BOH]^{\infty 2}$
Bakerite $Ca_4[Si_3B_5O_{15}(OH)_5]^{\infty 2} \rightarrow Ca_4[(SiO_4)_3(BO_3OH)(BOH)_4]^{\infty 2}$

*Zero-monoborosilicat-fluorides
*Kapitsaite-(Y) $(Ba,Pb)_4(Y,Ca)_2[Si_8B_4O_{28}]F$
*Khvorovite $Pb^{2+}{}_4Ca_2[Si_8B_2(S,B)O_{28}]F$

*Mono-diborosilicates (K_Σ = 1,7)
*Piergorite-(Ce) $Ca_8Ce_2(Al_{0.5}Fe^{3+}{}_{0,5})(\square Li,Be)_2[Si_6B_8O_{36}](OH)_2$
*Vistepite $Mn^{2+}{}_5Sn^{4+}[B_2Si_5O_{20}]$

*Mono-diborosilicates (K = 1,8) Hydrates
*Oyelite $Ca_{10}[B_2Si_8O_{29}]{\cdot}12H_2O$

Diborosilicates (K_Σ = 2) Oxido-diborosilicates
Serendibite $Ca_4(Mg_6Al_6)O_4[Si_6B_3Al_3O_{36}]$
(compare with aenigmatite (family))

Basic diborosilicates

Axinite series

*Axinite-(Mg) = magnesioaxinite $\{Ca_2MgAl_2(OH)[(Si_2O_7)_2BO]\}^{\infty 2}$
*Axinite-(Fe) $\{Ca_2FeAl_2(OH)[(Si_2O_7)_2BO]\}^{\infty 2}$
*Axinite-(Mn) $\{Ca_2(Mn,Fe)Al_2(OH)[(Si_2O_7)_2BO]\}^{\infty 2}$
Tinzenite *$CaMn^{2+}{}_4Al_4(OH)_2[(Si_2O_7)_4B_2O_2]$

Neutral→ acid diborosilicato-chlorides

Taramellite family
Taramellite $Ba_4(Fe^{3+},Ti,Fe^{2+},Mg,V^{3+})_4[(Si_8B_2O_{27})O_2Cl_x]$
Nagashimalite $Ba_4(V^{3+},Ti)_4[(Si_8B_2O_{27})(O,OH)_2Cl]$
Titantaramellite $Ba_4(,Ti,Fe^{3+},Fe^{2+},Mg)_4[(Si_8B_2O_{27})O_2Cl_{0-1}]$

Di-tri-borosilicates ($2 < K_\Sigma < 3$) Basic
Kornerupine $Mg_3Al_6(OH)O_4[(Al,Si)_2(Si,B)O_{10}][Si_2O_7]$
*Prismatine $Mg_3Al_6(OH)BO_7[Si_2O_7]_2$

Silicato-(4)-borate
Zero-silicato-(4)-borates Acid zero-silicato-(4)-borato-chlorides
Kalborsite $[Al_2Si_3O_{10}]^{\infty 3}{}_2[B(OH)_4]\cdot K_6Cl$

Silicato-(3)-borates
Disilicato-(3)-borates
Disilicato-(3)-borates ($K_{Si} = 2$) Basic

Tourmaline series (compare with elbaite (series))
Olenite $NaAl_3Al_6O_3F[Si_6O_{18}][BO_3]_3$
*Luinaite-(OH) $(Na,\square)(Fe^{3+},Mg)_3Al_6(OH)_3(OH)[Si_6O_{18}][BO_3]_3$
Buergerite = fluor-buergerite $NaFe^{3+}{}_3Al_6O_3F[Si_6O_{18}][BO_3]_3$
*Povondraite $NaFe^{3+}{}_3Fe^{3+}{}_6O(OH)_3[Si_6O_{18}][BO_3]_3$
*Chromo-alumino-povondraite $NaCr_3(Al_4Mg_2)O(OH)_3[Si_6O_{18}][BO_3]_3$
Dravite $NaMg_3Al_6(OH)_3(OH)[Si_6O_{18}][BO_3]_3$
*Oxy-dravite $Na(Al_2Mg)(Al_5Mg)O(OH)_3[Si_6O_{18}][BO_3]_3$
*Fluor-dravite $NaMg_3Al_6(OH,F)_{3+1}[Si_6O_{18}][BO_3]_3$
*Vanadiodravite $NaMg_3V_6(OH,F)_{3+1}[Si_6O_{18}][BO_3]_3$
*Vanadio-oxy-dravite $NaV_3(V_4Mg_2)(OH)_3O[Si_6O_{18}][BO_3]_3$
*Oxy-vanadium-dravite $NaV_3(V_4Mg_2)(OH)_3O[Si_6O_{18}][BO_3]_3$
*Vanadio-oxy-chromium dravite $NaV_3(Cr_4Mg_2)(OH)_3O[Si_6O_{18}][BO_3]_3$
Chromdravite $NaMg_3Cr_6(OH)_3(OH)[Si_6O_{18}][BO_3]_3$
*Oxy-chromium-dravite $NaCr_3(Cr_4Mg_2)O(OH)_3[Si_6O_{18}][BO_3]_3$
Schorl $NaFe^{2+}{}_3Al_6(OH)_3(OH)[Si_6O_{18}][BO_3]_3$
*Fluor-schorl $NaFe^{2+}{}_3Al_6(OH)_3F[Si_6O_{18}][BO_3]_3$
*Oxy-schorl $NaFe^{2+}{}_3Al_6(OH)_3O[Si_6O_{18}][BO_3]_3$
*Bosiite $NaFe^{3+}{}_3(Al_4Mg_2)(OH)_3O[Si_6O_{18}][BO_3]_3$
Ferridravite $NaFe_3{}^{3+}(Mg_2Fe_4{}^{3+})(OH)_3O[Si_6O_{18}][BO_3]_3$
*K-and O-dominate dravite $KFe^{3+}{}_3(Mg_2Fe^{3+}{}_4)O(OH)_3[Si_6O_{18}][BO_3]_3$
*Tsilaisite $Na(Mn^{2+})_3Al_6(OH)_3(OH)[Si_6O_{18}][BO_3]_3$
Uvite $Ca(Mg,Fe^{2+})_3Al_5Mg(OH)_3(OH)[Si_6O_{18}][BO_3]_3$
*Lucchesiite $CaFe^{2+}{}_3Al_6O(OH)_3[Si_6O_{18}][BO_3]_3$
*Feruvite $Ca(Fe,Mg)_3Al_6(OH)_3(OH)[Si_6O_{18}][BO_3]_3$
*Adachiite $CaFe^{2+}{}_3Al_6(OH)_3(OH)[Si_5AlO_{18}][BO_3]_3$
*Foitite $(\square,Na)(Fe_2{}^{2+}Al)Al_6(OH)_3(OH)[Si_6O_{18}][BO_3]_3$
*Magnesio-foitite $\square(Mg_2Al)Al_6(OH)_4[Si_6O_{18}][BO_3]_3$
*Capranicaite $(K,\square)CaNaAl_4[Si_2O_6][BO_3]_4$

Di-tri-alumosilicatj-(3)-borato-carbonates Asid
*Harkerite $Ca_{12}Mg_4Al[SiO_4]_4[BO_3]_3[CO_3]_5\cdot H_2O$

Tetrasilicato-(3)-borates
Oxido-tetrasilicato-(3)-borates
Dumortierite $Al_7O_3[SiO_4]_3[BO_3]$
*Magnesiodumortierite $MgAl_6O_3[SiO_4]_3[BO_3]$
*Werdingite $(Mg,Fe^{2+})_2Al_{14}B_4Si_4O_{37} = (Mg,Fe^{2+})_2Al_{14}O_9[SiO_4]_4[BO_3]_4$
*Fe analog werdingite $(Fe^{2+},Mg)_2Al_{14}O_9[SiO_4]_4[BO_3]_4$
*Boralsilite $Al_{16}B_6Si_2O_{37} = Al_{16}O_{11}[SiO_4]_2[BO_3]_6$
*Holtite $(Ta,\square)Al_6O_3[SiO_4]_3[BO_3]$
*Nioboholtite $(Nb_{0.6}\square_{0.4})Al_6O_3[SiO_4]_3[BO_3]$
*Titanoholtite $(Ti_{0.75}\square_{0.25})Al_6O_3[SiO_4]_3[BO_3]$
Grandidierite $^{(5)}Mg^{(6)}Al_2{}^{(5)}AlO_2[SiO_4][BO_3]$
*Ominelite $(Fe,Mg)Al_2AlO_2[SiO_4][BO_3]$

Borosilicato-(4)-(3)-borates Acid
Howlite $Ca_2(OH)_5SiB_5O_9 \rightarrow Ca_2\{[SiB_2O_5(OH)_3]^{\infty}B_3O_4(OH)_3\}^{\infty 3}$
Garrelsite $NaBa_3(OH)_4Si_2B_7O_{16} \rightarrow CaBa_3(OH)_2[(SiO_4)_2{}^{(4)}B_2O_2OH_2]^{\infty}B_5O_6\}^{\infty 2}$
*Hundholmenite-(Y) $Y_{15}AlCa_x(As^{3+})_{1-x}(Si,As^{5+})Si_6B_3(O,F)_{48}$

Silicato-phosphates
Disilicato-phosphates Neutral
Phosinaite family
Clinophosinaite $Na_3Ca[SiO_3][PO_4]$
Phosinaite-(Ce) $Na_{13}Ca_2Ce[SiO_3]_4[PO_4]_4$

Tetrasilicato-phosphates NeutralCa$_3$Al$_{7.7}$Si$_3$P$_4$O$_{23.5}$(OH)$_{14.1}\cdot$8H$_2$O
Nagelschmidtite $Ca_7[SiO_4]_2[PO_4]_2$
*Silicocarnotite $Ca_5[(SiO_4)(PO_4)][PO_4]$
*Flamite $(Ca,Na,K)_2[(Si,P)O_4]$
Hydrates
Perhamite $Ca_3Al_{7.7}Si_3P_4O_{23.5}(OH)_{14.1}\cdot 8H_2O$
*Krásnoite $Ca_3Al_{7.7}Si_3P_4O_{23.5}(OH)_{12.1}F_2\cdot 8H_2O$

*Tetrasilicato-phosphato-halogenides
*Zadovite $BaCa_6[(SiO_4)(PO_4)][PO_4]_2F$

*Silicato-arsenates
*Mono-disilicato-arsenates (K=1,(6))
*Basic
*Johninnesite $Na_2Mn^{2+}{}_9(Mg,Mn^{2+})_7(OH)_8[Si_6O_{17}]_2[AsO_4]_2$

*Disilicato-arsenates *Hydrates
*Tiragalloite $Mn^{2+}{}_4[Si_3O_8(OH)][AsO_4]$

Zero-monosilicato-carbonates Hydrates
Carletonite $KNa_4Ca_4(F,OH)(H_2O)[Si_8O_{18}]^{\infty 2}[CO_3]_4$

*Monosilicato-carbonates *Hydrates
*Niksergievite $Ba_2Al_3[(Si,Al)_4O_{10}][CO_3](OH)_6 \cdot nH_2O$

*Monosilicato-carbonato-halogenides
*Основные
*Hanjiangite $Ba_2Ca(V^{3+}Al)(OH)_2[Si_3AlO_{10}]F[CO_3]_2$

Disilicato-carbonates Basic
Fukalite $Ca_4(OH,F)_2[Si_2O_6]^{\infty}[CO_3]$
Hydrates
Scawtite $Ca_7(H_2O)_2[Si_6O_{18}][CO_3]$

Trisilicato-carbonates Neutral
Tilleyite $Ca_5[Si_2O_7][CO_3]_2$

Tetrasilicato-carbonates Neutral
Spurrite family
Spurrite $Ca_5[SiO_4]_2[CO_3]$
*Galuskinite $Ca_7[SiO_4]_3[CO_3]$

Silicato-sulfates
Tetrasilicato-sulfates Neutral
*Ternesite $Ca_5[SiO_4]_2[SO_4]$
Basic
Ellestadite series (compare with apatite (family))
Ellestadite-(OH) $Ca_{10}(OH)_2[SiO_4]_3[SO_4]_3$
Ellestadite-(F) $Ca_{10}F_2[SiO_4]_3[SO_4]_3$
*Ellestadite-(Cl) $Ca_2Cl_2[SiO_4]_3[SO_4]_3$
Hydrates
Chessexite $(Na,K)_4Ca_2(Mg,Zn)_3Al_8(OH)_{10}[SiO_4]_2[SO_4]_{10} \cdot 40H_2O$

Silicates of Li
Proper silicates of Li
Zeroalumosilicates (K = 0) Neutral
Eucryptite $^{(4)}Li[AlSiO_4]^{\infty3}$
Petalite $^{(4)}Li[AlSi_4O_{10}]^{\infty3}$
Virgilite $Li[AlSi_2O_6]^{\infty3}$
Bikitaite $Li[AlSi_2O_6]^{\infty3} \cdot H_2O$

Monoalumo-and monosilicates (K = 1)
Neutral *and hydrates
Emeleusite family (compare with osumilite (family))
Emeleusite $Na_4Li_2Fe^{3+}{}_2[Si_{12}O_{30}]^{\infty}$
Sugilite $KNa_2(Fe^{3+},Mn^{2+},Al)_2Li_3[Si_{12}O_{30}]^{\infty}$
*Silinaite $NaLi[Si_2O_5] \cdot 2H_2O$
Basic
Lithium mica family
Fragile lithium mica subfamily
Ephesite $Na\{LiAl_2(OH)_2[AlSiO_5]^{\infty2}{}_2\}^{\infty2}$

Usual lithium mica subfamily

Lepidolite series

Hydroxyllepidolite, Fluorlepidolite a Li-rich micas in, or close to, the so-called Polylithionite-Trilithionite join.

*Voloshinite $Rb(LiAl_{1.5}\square_{1.5})[Al_{0.5}Si_{3.5}]O_{10}F_2$

*Zinnwaldite is series by Fleischer's, 2014.

*Zinnwaldite 1M, 2M, 3T polytyps

Masutomilite $K\{LiMn^{2+}AlF_2[AlSi_3O_{10}]^{\infty 2}\}^{\infty 2}$

Polylithionite $K\{Li_2AlF_2[Si_2O_5]^{\infty 2}{}_2\}^{\infty 2}$

*Orlovite $KLi_2TiF[Si_4O_{11}]$

*Cs-polylithionite

$(Cs_{0,75}K_{0,23}Rb_{0,02})_{1,00}(Al_{1,33}Li_{1,27}Mn_{0,01})_{2,61}[(Si_{3,72}Al_{0,28})_{4,00}O_{10}]F_{1,46}(OH)_{0,54}$

*Sokolovaite $CsLi_2AlF_2[Si_4O_{10}]$

*Trilylithionite $KLi_{1,5}Al_{1,5}F_2[AlSi_3O_{10}]$

Tainiolite $K\{LiMg_2F_2[Si_2O_5]^{\infty 2}{}_2\}^{\infty 2}$

Norrishite $K\{LiMn^{3+}{}_2O_2[Si_2O_5]^{\infty 2}{}_2\}^{\infty 2}$

*__Saliotite__ family

*Saliotite $Li_{0,5}Na_{0,5}Al_3(OH)_2[AlSi_3O_{10}]$

Lithium chlorite family (in what numbers borosilicate of Li)

Cookeite $LiAl_2(OH)_6\{Al_2(OH)_2[(Si,Al)_2O_5]^{\infty 2}{}_2\}^{\infty 2}$

*Borocookeite $LiAl_4(OH)_8[BSi_3O_{10}] = LiAl_2(OH)_6Al_2(OH)_2[BSi_3O_{10}]$

Manandonite $Li_2Al_2(OH)_6\{Al_2(OH)_2[Si_2AlBO_{10}]^{\infty 2}\}^{\infty 2}$

Lithium smectite family

Hectorite $Na_{0.3}\{(Mg,Li)_3(F,OH)_2[Si_2O_5]^{\infty 2}{}_2\}^{\infty 2}\cdot nH_2O$

Mono-dialumosilicates (1 < К < 2) Basic

Lithium amphibole family

Holmquistite series

Magnesioclinoholmquistite $\square Li_2(Mg,Fe^{2+})_3Al_2(OH)_2[Si_4O_{11}]^{\infty}{}_2$

Ferroclinoholmquistite $\square Li_2(Fe^{2+},Mg)_3Al_2(OH)_2[Si_4O_{11}]^{\infty}{}_2$

Clino-holmquistite series

Magnesioclinoholmquistite $\square Li_2(Mg,Fe^{2+})_3Al_2(OH)_2[Si_4O_{11}]^{\infty}{}_2$

Clino-holmquistite $\square Li_2(Mg,Fe^{2+})_3Al_2(OH)_2[Si_4O_{11}]^{\infty}{}_2$

Ferroclinoholmquistite $\square Li_2(Fe^{2+},Mg)_3Al_2(OH)_2[Si_4O_{11}]^{\infty}{}_2$

*Ferriclinoferroholmquistite $\square Li_2(Fe^{2+}{}_3Fe^{3+}{}_2)(OH)_2[Si_4O_{11}]^{\infty}{}_2$

*Kornite $(Na,K)Na_2(Mg_2Mn^{3+}{}_2Li)(OH)_2[Si_4O_{11}]_2$

*Ottoliniite $(Na,Li)(Mg_3Fe^{3+}Al)(OH)_2[Si_4O_{11}]$

*Ferri-ottolinite $(Na,Li)_2(Mg_3Fe^{3+}{}_2)(OH)_2[Si_4O_{11}]_2$

*Ferriwhittakerite $Na(Na_{1+x}Li_{1-x})(Mg_2Fe^{3+}{}_2Li)(OH)_2[Si_4O_{11}]_2$

*Sodic-ferripedrizite $NaLi_2(Fe^{3+}{}_2Mg_2Li)(OH)_2[Si_4O_{11}]_2$

*Sodic-ferri-ferropedrizite $NaLi_2(Fe^{3+}{}_2Fe_2Li)(OH)_2[Si_4O_{11}]_2$

*Ferropedrizite $NaLi_2(Fe^{2+}{}_2Al_2Li)(OH)_2[Si_4O_{11}]_2$

*Fluoro-sodic-ferropedrizite $NaLi_2(Fe^{2+}{}_2Al_2Li)F_2[Si_4O_{11}]_2$

*Fluoro-sodic-pedrizite $NaLi_2(Mg_2Al_2Li)F_2[Si_4O_{11}]_2$

*Leakeite $NaNa_2(Mg_2Al_2Li)(OH)_2[Si_4O_{11}]_2$

*Ferroleakeite $NaNa_2(Fe_2Al_2Li)(OH)_2[Si_4O_{11}]_2$
*Potassic-leakeite $KNa_2(Mg_2Al_2Li)(OH)_2[Si_4O_{11}]_2$
*Fluoroleakeite $NaNa_2(Mg_2Al_2Li)F_2[Si_4O_{11}]_2$
*Fluoro-aluminoleakeite $NaNa_2(Mg_2Al_2Li)F_2[Si_4O_{11}]_2$
*Oxo-mangani-leakeite $NaNa_2(Mn^{3+}{}_4Li)O_2[Si_4O_{11}]_2$
*Lunijianlaite $Li(OH)_{10}[Al_{3.5}Si_{3.5}O_{20}]$

Disilicates (K = 2) Neutral
Spodumene (compare with pyroxene (family)) $LiAl[Si_2O_6]^{\infty}$
*Watatsumiite $KNa_2LiMn_2V^{4+}{}_2[Si_2O_6]_4$
*Balestraite $KLi_2V^{5+}[Si_2O_6]_2$
Acid
Nambulite series (compare with marsturite (group); pyroxenoids (family))
Nambulite $NaLiMn_8[Si_5O_{14}(OH)]^{\infty}{}_2$
Natronambulite $(Na,Li)(Mn,Ca)_4[Si_5O_{14}(OH)]^{\infty}$
*Tanohataite $LiMn_2[Si_3O_8(OH)]$
Lithiomarsturite $LiCa_2Mn_2[Si_5O_{14}(OH)]^{\infty}$
Basic
Balipholite $LiBaMg_2Al_3(OH)_4F_4[Si_2O_6]_2$
*Katayamalite $KLi_3Ca_7Ti_2(OH)_2[Si_6O_{18}]_2$
*Aleksandrovite $KLi_3Ca_7Sn_2F_2[Si_6O_{18}]_2$

Silicato-borates
Borosilicates
Monoborosilicates $K_{\Sigma} = 1$ Basic
Manandonite $Li_2Al_2(OH)_6\{Al_2(OH)_2[Si_2AlBO_{10}]^{\infty 2}\}^{\infty 2}$

Silicato-(3)-borates
Disilicato-(3)-borates Basic
Elbaite series (compare with tourmaline (series))
Liddicoatite = fluor-liddicoatite
*Fluor-liddicoatite $Ca(Li_3Al)Al_6(OH)_3F[Si_6O_{18}][BO_3]_3$
Elbaite $Na(Li_{1.5}Al_{1.5})Al_6(OH)_3(OH)[Si_6O_{18}][BO_3]_3$
*Fluorelbaite $Na(Li_{1.5}Al_{1.5})_{\Sigma 3}Al_6(OH)_3F[Si_6O_{18}][BO_3]_3$
*Rossmanite $\square(LiAl_2)Al_6(OH)_3(OH)[Si_6O_{18}][BO_3]_3$
*Oxyrossmanite $\square(Li_{0.5}Al_{2.5})Al_6O(OH)_3[Si_6O_{18}][BO_3]_3$
*Darrellhenryite $Na(LiAl_2)Al_6O(OH)_3[Si_6O_{18}][BO_3]_3$

Beryllium silicates
Proper beryllium silicates Hydrates
Beryllite $Be_3(OH)_2[SiO_4]\cdot H_2O$

Beryllosilicates
Zero-beryllosilicates ($K_{\Sigma} = 0$)
Zero-beryllosilicates with Be_{Σ} : Si > 1
Neutral
Phenakite $Be[BeSiO_4]^{\infty 3}$
Acid
Bertrandite $Be_3[Be_5(OH)_4(Si_2O_7)_2]^{\infty 3}$

*Sphaerobertrandite $Be_3[Be_5(OH)_4(Si_2O_7)_2]^{\infty3}$

Zero-beryllosilicates with (Be,Al) : Si = 1 Neutral

Trimerite $CaMn^{2+}{}_2[BeSiO_4]_3$

Liberite $Li_2Be[SiO_4]$

Helvine series

Danalite $[BeSiO_4]_6\ Fe_8S_2$

Helvine $[BeSiO_4]_6\ Mn_8S_2$

Genthelvite $[BeSiO_4]_6\ Zn_8S_2$

*Zero-beryllosilicates with (Be,Al) : Si = 0,75 Hydrates

*Alflarsenite $NaCa_2[Be_3Si_4O_{13}(OH)]\cdot2H_2O$

Zero-beryllosilicates with (Be,Al) : Si = 0,5

Neutral

Beryl series

Beryl $Al_2[Be_3(Si_6O_{18})]^{\infty3}$

*Pezzottaite $CsAl_2[(Be_2Li)(Si_6O_{18})]$

Bazzite $(Sc,Al)_2[Be_3(Si_6O_{18})]^{\infty3}$

Chkalovite $Na_2[Be(Si_2O_6)]^{\infty3}$

Tugtupite $[BeAlSi_4O_{12}]^{\infty3}\cdot Na_4Cl$

*Hydrates

*Stoppanite $Fe^{3+}{}_3(Fe^{2+},Mg)Na[Be_3(Si_6O_{18})]^{\infty3}{}_2(H_2O)_2$

Zero-beryllosilicato-fluorides with (Be,Al) : Si = 0,7

Meliphanite family

Meliphanite $(Na,Ca,)_4Ca_4(F,O)_4[Be_4AlSi_7O_{24}]$

Zero-beryllosilicato-fluorides with (Be,Al) : Si = 0,5

Leucophanite $Ca_4Na_4F_4[Be_4Si_8O_{24}]$

Zero-beryllosilicates with (Be,Al) : Si < 0,5

Neutral

*Oftedalite $K(Cs,Ca,Mn^{2+})_2[Be_3AlSi_{11}O_{30}]$

*Agakhanovite-(Y) $YCa\square_2K[Be_3Si_{12}O_{30}]$

Zero-beryllosilicates with (Be,Al) : Si < 0,5 Neutral → hydrates

Epididymite family

Epididymite $Be[Be_3(Si_6O_{15})_2]^{\infty3}\cdot Na_4(H_2O)_2$

Eudidymite $Be[Be_3(Si_6O_{15})_2]^{\infty3}\cdot Na_4(H_2O)_2$

Milarite $KCa_2[Be_2Al(Si_{12}O_{30})]^{\infty3}\cdot(H_2O)_{0,5}$

*Almarudite $K(\square,Na)_2(Mn,Fe,Mg)_2[(Be,Al)_3(Si_{12}O_{30})]$

*Eirikite $KNa_6[Be_2(Al_3Si_{15})O_{39}F_2]$

Lovdarite $K_4Na_{12}[Be_8Si_{28}O_{72}]\cdot18H_2O$

*Nabesite $Na_2[BeSi_4O_{10}]\cdot4H_2O$

Zero-monoberyllosilicates ($0 < K_\Sigma < 1$)

Zero-monoberyllosilicates with $K_\Sigma = 0,1$

*Neutral

*Telyushenkoite $CsNa_6[Be_2(Al_3Si_{15})O_{39}F_2]$
Leifite $NaNa_6[Be_2Al_3Si_{15}O_{39}F_2]$

Zero-monoberyllosilicates with $K_\Sigma = 0,3$
Bavenite $Ca_4[Be_2(OH)_2Al_2(Si_3O_{10})(Si_6O_{16})^{\infty}]^{\infty 3}$
Hydrates (acid)
Chiavennite $CaMn[Be_2Si_5O_{13}(OH)_2]\cdot 2H_2O$
*Ferrochiavennite $Ca_{1-2}Fe[Be_2Si_5O_{13}(OH)_2]\cdot 2H_2O$
*Roggianite $Ca_2[BeAl_2Si_4O_{13}(OH)_2]\cdot 2,5H_2O$

Zero-monoberyllosilicates with $K_\Sigma = 0,(6)$ Neutral
Gugiaite family
Gugiaite $Ca_2[Be(Si_2O_7)]^{\infty 2}$
Jeffreyite $(Ca,Na)_2[(Be,Al)Si_2(O,OH)_7]^{\infty 2}$
Barylite $Ba[Be_2(Si_2O_7)]^{\infty 3.}$
*Clinobarylite $Ba[Be_2Si_2O_7)]$

Zero-monoberyllosilicates with $K_\Sigma = 0,8$
Acid
Aminoffite family
Harstigite $Ca_6Mn[Be_2(OH)Si_3O_{11}]^{\infty 2}{}_2$
Aminoffite $Ca_3[Be_2(OH)_2Si_3O_{10}]$

Monoberyllosilicates ($K_\Sigma = 1$) Acid
Euclase $Al[Be(OH)(SiO_4)]^{\infty}$
Bityite $Ca\{LiAl_2(OH)_2[(BeAl)Si_2O_{10}]^{\infty 2}\}^{\infty 2}$

Diberyllosilicates ($K_\Sigma = 2$) Beryllosilicato-fluorides
Hsianghualite $Ca_3Li_2[Be_3Si_3O_{12}]^{\infty 3}F_2$
*Khmaralite $Mg_4(Mg_3Al_9)O_4[Si_5Be_2Al_5O_{36}]$

*Di-triberillosilicates

Silicates and alumosilicates of Sn^{4+}
Proper silicates and alumosilicates
*Zero-monoberyllosilicates (K = 1,25)
*Eakerite $Ca_2Sn^{4+}[Al_2Si_6O_{18}](OH)_2\cdot 2H_2O$

Monosilicates (K = 1) Neutral
Brannockite (compare with osumilite (family)) $KLi_3Sn^{4+}{}_2[Si_{12}O_{30}]^{\infty}$

Disilicates (K = 2) Neutral
Pabstite (compare with benitoite (group) $Ba(Sn,Ti)^{4+}[Si_3O_9]$
Hydrates
Stokesite $2CaSnSi_3O_9\cdot 2H_2O \rightarrow Ca_2Sn^{4+}{}_2[Si_6O_{18}]^{\infty}\cdot 4H_2O$

*Trisilicates (K = 3)
*Kristiansenite $Ca_2ScSn[Si_2O_7][Si_2O_6OH]$

Tetrasilicates (К = 4) Oxido-tetrasilicates
Malayaite (compare with titanite (group)) $Ca|Sn^{4+}O[SiO_4]|^{\infty 2}$

Beryllosilicates of Sn
Zero-monoberyllosilicates (K_Σ = 0,25)
Hydrates
Sorensenite $Na_4Sn^{4+}[Be_2(Si_3O_9)_2]^{\infty 3}\cdot 2H_2O$

Mono-diberyllosilicates (K_Σ = 1,2) Acid
Sverigeite $NaMn^{2+}{}_2Sn^{4+}[Be_2Si_3O_{12}(OH)]$

Silicates of Zn^{2+}, Pb^{2+}, As^{3+}, Sb^{3+} и Sb^{5+} paragenetic association of Franclin and Sterling Hill, New Jersey, USA, Langban and Jacobsberg, Sweden.

Minerals of Zn
Zero-mono(zinc)alumosilicates Acid-neutral
Minehillite $(K,Na)_{2-3}Ca_{28}(OH)_{12}[(Zn_5Al_4Si_{40})O_{112}(OH)_4]$
(compare with reyerite, truscottite)

*Mono-disilicates *Hydrates
*Gaultite $Na_4Zn_2[Si_7O_{18}]\cdot 5H_2O$

Disilicates Neutral
Petedunnite $CaZn[Si_2O_6]^{\infty}$

Trisilicates Neutral
Hardystonite (compare with melilite) $Ca_2|^{(4)}Zn[Si_2O_7]|^{\infty 2}$

*Tri-tetrasilicates
*Scheuchzerite (К = 3.8) $Na(Mn,Mg,Zn)_9[VSi_9O_{28}(OH)](OH)_3$

Tetrasilicates
Proper tetrasilicates Neutral
Willemite $\{^{(4)}Zn_2[SiO_4]\}^{\infty 3}$
*Xingsaoite = Co-willemite) $(Zn,Co)_2[SiO_4]$
Larsenite group (CN Zn^{2+} = 6)
Esperite $Ca_2PbZn_3[SiO_4]_3$
Larsenite $PbZn[SiO_4]$
Basic
Hodgkinsonite family
Gerstmannite $(Mn,Mg)(OH)_2\{^{(4)}Mg^{(4)}Zn[SiO_4]\}^{\infty 2}$
Hodgkinsonite $Mn(OH)_2\{^{(4)}Zn_2[SiO_4]\}^{\infty 2}$
*Franklinfurnaceite $Ca_2Fe^{3+}Mn^{3+}Mn^{2+}{}_3[Zn_2Si_2O_{10}](OH)_8$
Hydrates
Clinohedrite $Ca\{^{(4)}Zn(H_2O)[SiO_4]\}^{\infty 2}$

Tetrasilicato-arsenates Basic
Holdenite family
Holdenite $(Mn,Mg)_6Zn_3(OH)_8[SiO_4][AsO_4]_2$

Kolicite $Mn_7Zn_4(OH)_8[SiO_4]_2[AsO_4]_2$

*Tetrasilicato -arsenito- arsenates Основные
*Mcgovernite $Zn_3(Mn^{2+},Mg)_{42}(OH)_{40}[SiO_4]_8[As^{3+}O_3]_2[As^{5+}O_4]_4$

Minerals of Pb
*Zerosilucates с К = 0
*Plumbotsumite $Pb_5[Si_4O_8](OH)_{10}$

*Zero-monosilicates with К = 0,9
*Wickenburgite $Pb_3CaAl[AlSi_{10}O_{27}]\cdot(H_2O)_4$

*Monosilicates with К = 1 Hydrates
*Plumbophyllite $Pb_2[Si_4O_{10}]\cdot H_2O$

*Mono-disilicates with К = 1,6 Hydrates
*Luddenite $Pb_2Cu^{2+}{}_2[Si_5O_{14}]\cdot 14H_2O$

*Mono-disilicato-(3)-borato-oxido-carbonates К = 1,6
*Britvinite $Pb_{14}Mg_9[Si_{10}O_{28}][BO_3]_4[CO_3]_2F_2(OH)_{12}$

Disilicates
Proter disilicates Neutral
Margarosanite $Pb(Ca,Mn)_2[Si_3O_9]$

Disilicato-sulfates Hydrates
Roeblingite $Pb_2Ca_6Mn(H_2O)_4(OH)_2[Si_3O_9]_2[SO_4]_2$

Trisilicates Neutral
Barysilite $MnPb_8[Si_2O_7]_3$

Oxido-trisilicates
Melanotekite series
Melanotekite $Pb_2Fe^{3+}{}_2O_2[Si_2O_7]$
Kentrolite $Pb_2Mn^{3+}{}_2O_2[Si_2O_7]$

*Trisilicato-halogenides
*Nasonite $Pb_6Ca_4[Si_2O_7]_3Cl_2$

Tri-tetrasilicates Basic
Hancockite $CaPbFe^{3+}Al_2O(OH)[Si_2O_7][SiO_4]$
(compare with epidote (family))

*Tri-tetrasilicato-oxido-carbonates Hydrates
Molybdophyllite (K = 3.6) $Pb_8Mg_9[Si_{10}O_{30}(OH)_8][CO_3]_3\cdot H_2O$

Beryllosilicates
Mono-diberyllosilicates (K_Σ = 1,5) Basic
Joesmithite (structure of amphibole) $PbCa_2(Mg_3Fe_2{}^{3+}(OH)_2[BeSi_3O_{11}]^{\infty}{}_2$

*Tri-tetrasilites (К = 3,4) $Si_2O_7 : SiO_4 = 2 : 3$ *Основные
*Samfowlerite $Ca_{28}Mn_6Zn_4(Zn_{1,5}Be_{2,5})_{\Sigma 4}Be_{12}[SiO_4]_{12}[Si_2O_7]_8(OH)_{12}$

Berylloborosilicates
Zero-monoberylloborosilicates ($0 < K_\Sigma < 1$) Neutral
Zero-monoberylloborosilicato-fluorides
Hyalotekite $Pb_2Ba_2Ca_2[(Be_{0,5}Si_{9,5})_{\Sigma 10}B_2O_{28}]^{\infty 3}F$

*Zero-monoberylloborosilicato-halogenides Basic
*Wawayandaite $Ca_6Mn_2Be_5[BBe_4Si_6O_{23}](OH,Cl)_{15}$

Minerals of As and Sb
Proper silicates
Disilicates Basic
Schallerite family
Schallerite $(Mn,Fe)_{16}As^{3+}_3(OH)_{17}[Si_{12}O_{36}]$
Nelenite $(Mn,Fe)_{16}As^{3+}_3(OH)_{17}[Si_{12}O_{36}]$
*Långbanite $Mn^{2+}_4Mn^{3+}_9Sb^{5+}[Si_2O_{24}]$

*Di-triberyllosilicates ($K_\Sigma = 2.2$) *Oxido-di-triberyllosilicates
Welshite $Ca_4(Mg_9Sb^{5+}_3)O_4[Be_3Si_6AlO_{36}]$

Silicato-arsenates
*Tri-tetrasilicato-arsenates
*Ardennite-(As) $Mn^{2+}_4(Al,Fe^{3+})_5Mg[SiO_4]_2[Si_3O_{10}][(As,V)O_4](OH)_6$
*Ardennite-(V) $Mn^{2+}_4(Al,Fe^{3+})_5Mg[SiO_4]_2[Si_3O_{10}][(V,Si,As)O_4](OH)_6$

Tetrasilicato-arsenates Basic
Dixenite family
Dixenite $CuMn^{2+}_{14}Fe^{3+}(As^{3+}O_3)_5(OH)_6[SiO_4]_2[As^{5+}O_4]$
Kraisslite $Zn_3(Mn,Mg)_{25}(Fe^{3+},Al)(As^{3+}O_3)_2(OH)_{16}[(Si,As^{5+})O_4]_{10}$
Oxido-tetrasilicato-arsenates
Parwelite $Mn^{2+}_{10}(Sb^{5+}O_4)_2[SiO_4]_2[AsO_4]_2$

*Tetrasilicato-antimonates
*Tegengrenite $(Mg,Mn)_4(Sb^{5+}O_4)[(Mn^{3+},Si,Ti)O_4]$

Silicates of ***f***-elements
Proper silicates
*Zero-monosilicates with К = 0,(6)
*Chiappinoite-(Y) $Y_2Mn[Si_3O_7]_4$

*Zero-monosilicates with К = 0,75 Hydrates
*Thornasite $Na_{12}Th_3[Si_8O_{19}]_4\cdot 18H_2O$
*Monteregianite –(Y) $Na_4K_2Y_2[Si_{16}O_{38}]\cdot 10H_2O$

Monosilicates (К = 1) Neutral
Ekanite family
Ekanite $Ca_2Th[Si_4O_{10}]^{\infty 2}_2$

Iraqite-(La) $(K_{1-x}\square_x)Ca_2(La,Ce,Th)[Si_4O_{10}]^{\infty 2}{}_2$
Steacyite $(K_{1-x}\square_x)(Na,Ca)_2Th[Si_4O_{10}]^{\infty 2}{}_2$ (x = 0,1-0,4)
*Moskvinite-(Y) $Na_2K(Y,REE)[Si_6O_{15}]$

Hydrates

*Mendeleevite-(Ce) $Cs_6(Ce_{22}Ca_6)[Si_{70}O_{175}](OH,F)_{14}(H_2O)_{21}$
*Mendeleevite-(Nd) $Cs_6(Nd,REE)_{23}Ca_7[Si_{70}O_{175}](OH,F)_{19}(H_2O)_{16}$
*K-mendeleevite-(Ce) $K_6Cs_6(REE_{22}Ca_6)[Si_{70}O_{175}](OH,F)_{20}(H_2O)$
*Yakovenchukite-(Y) $K_3NaCaY_2[Si_{12}O_{30}](H_2O)_4$
*Turkestanite $(K_{1-x},\square_x)(Ca,Na)_2Th[Si_8O_{20}]\cdot nH_2O$
*Arapovite $(K_{1-x},\square_x)(Ca,Na)_2(U,Th)[Si_8O_{20}]\cdot H_2O$ (x~0.5)
Sazhinite-(Ce) $Na_3Ce[Si_6O_{15}]^{\infty 2}\cdot 6H_2O$
*Sazhinite-(La) $Na_3La[Si_6O_{15}](H_2O)_2$
Ashcroftine-(Y) $K_{10}Na_{10}(Y,Ca)_{24}(OH)_4(CO_3)_{16}[Si_{56}O_{140}]\cdot 16H_2O$

Monosilicato-trisilicates (mixed) Basic
Miserite-(Y) $K_2Ca_{10}Y_2(OH)_2F_2[Si_{12}O_{30}]^{\infty}[Si_2O_7]_2$
Miserite $K_2(Ca,Ce)_{12}(OH,F)_4[Si_{12}O_{30}]^{\infty}[Si_2O_7]_2$

Mono-disilicates (1 < K < 2) Neutral
Nordite-(La) $Na_6(Sr,Ca)_2(La,Ce)_2(Mn,Zn,Mg)_2[Si_{12}O_{34}]^{\infty}$
*Nordite-(Ce) $Na_6(Sr,Ca)_2(Ce,La)_2(Mn,Zn,Mg)_2[Si_{12}O_{34}]^{\infty}$
*Manganonordite-(Ce) $Na_6(Sr,Ba)_2(Ce,La)_2(Mn,Zn,Fe,Mg)_2[Si_{12}O_{34}]^{\infty}$
*Ferronordite-(La) $Na_3Sr(La,Ce)Fe^{2+}[Si_6O_{17}]^{\infty}$
*Ferronordite-(Ce) $Na_3SrCeFe^{2+}[Si_6O_{17}]^{\infty}$

Basic

*Atelisite-(Y) $Y_4(OH)_8[Si_3O_8]$

Disilicates (K = 2) Hydrates
*Gerenite-(Y) $(Ca,Na)_2(Y,Th)_3[Si_6O_{18}]^{\infty}\cdot 2H_2O$

*Asid

Thorosteenstrupine $CaThMn^{2+}[Si_4O_{11}(O,F)]\cdot 6H_2O$

Disilicato-trisilicates (K = 2,(6)) Basic
Thalénite-(Y) $Y_3(OH)[Si_3O_{10}]$
*Fluorthalénite-(Y) $Y_3F[Si_3O_{10}]$

Trisilicates (K = 3)
Proper trisilicates Neutral

Thortveitite family

Thortveitite group

Keiviite-(Yb) $Yb_2[Si_2O_7]$
*Keiviite-(Y) $(Y,Yb)_2[Si_2O_7]$
Thortveitite-(Sc) $(Sc,Y)_2[Si_2O_7]$
Yttrialite-(Y) $Y_2[Si_2O_7]$
*Percleveite-(Ce) $(Ce,La,Nd)_2[Si_2O_7]$

Oxido-trisilicates

Perrierite family

Perrierite-(Ce) $(Ce,La,Ca,Sr)_4(Fe^{2+},Mg,Mn^{2+})(Ti^{4+},Fe^{3+})_4O_8[Si_2O_7]_2$
*Perrierite-(La) $(La,Ce,Ca)_4Fe^{2+}(Ti^{4+},Fe^{3+})_4O_8[Si_2O_7]_2$
*Matsubaraite $Sr_4Ti_5O_8[Si_2O_7]_2$

Chevkinite-(Ce)	$(REE,Ca)_4Fe^{2+}{}_2(Ti^{3+},Fe^{3+})_3O_8[Si_2O_7]_2$
*Dingdaohengite-(Ce)	$(Ce,La)_4Fe^{2+}(Ti,Fe^{2+},Mg,Fe^{3+})_2Ti_2O_8[Si_2O_7]_2$
*Maoniupingite-(Ce)	$(Ca,Ce)_4(Fe^{3+}TiFe^{2+}\square)(TiFe^{3+}Nb)_4O_8[Si_2O_7]_2$
*Cr-chevkinite	$(Ce,La,Nd,Pr,Th)_4(Mg,Fe,Ca)_2Cr^{3+}{}_2(Ti,Al,Nb)_2O_8[Si_2O_7]_2$
*Polyakovite-(Ce)	$(REE,Ca)_4(Mg,Fe^{2+})(Cr,Fe^{3+})_2(Ti,Nb)_2O_8[Si_2O_7]_2$
Strontiochevkinite	$(Sr,La,Ce,Ca)_4(Fe^{2+},Fe^{3+})(Ti^{3+},Zr)_4O_8[Si_2O_7]_2$
*Christofschäferite-(Ce)	$(Ce,La,Ca)_4Mn(Ti,Fe)_3(Fe,Ti)O_8[Si_2O_7]_2$
*Fogoite-(Y)	$Na_3Ca_2Y_2TiOF_3[Si_2O_7]_2$
*Stavelotite-(La)	$La_3Mn^{2+}{}_3Cu(Mn^{3+}{}_{24}Fe^{3+}Mn^{4+})O_{30}[Si_2O_7]_6$
	Trisilicato-fluorides
Rowlandite-(Y)	$Fe^{2+}Y_4[Si_2O_7]_2F_2$
Trisilicato-tetrasilicates	Neutral
*Perböite-(Ce)	$(CaCe_3)(Al_3Fe^{2+})O(OH)_2[Si_2O_7][SiO_4]_3$
*Alnaperböite-(Ce)	$(CaCe_{2.5}Na_{0.5})Al_4O(OH)_2[Si_2O_7][SiO_4]_3$
Oxido(fluorido)-hydroxido-trisilicato-tetrasilicates	
Allanite series (compare with epidote (family))(K = 3,3)	
*Allanite-(La)	$LaCaAl_2Fe^{2+}{}_3O(OH)[Si_2O_7][SiO_4]$
Allanite-(Ce) (orthite)	$CaCeAl_2Fe^{2+}O(OH)[Si_2O_7][SiO_4]$
*Allanite-(Nd)	$CaNdAl_2Fe^{2+}O(OH)[Si_2O_7][SiO_4]$
Allanite-(Y) (yttriumorthite)	$CaYAl_2Fe^{2+}O(OH)[Si_2O_7][SiO_4]$
*Ferriallanite-(Ce)	$CaCeFe^{3+}AlFe^{2+}O(OH)[Si_2O_7][SiO_4]$
*Uedaite-(Ce)	$(Mn^{2+}Ce)(Al_2Fe^{2+})O(OH)[Si_2O_7][SiO_4]$
*Dissakisite-(Ce)	$Ca(Ce,La)MgAl_2O(OH)[Si_2O_7][SiO_4]$
*Androsite-(La)	$Mn^{2+}LaMn^{2+}Mn^{3+}AlO(OH)[Si_2O_7][SiO_4]$
*Manganiandrosite-(Ce)	$Mn^{2+}CeMn^{3+}AlMn^{2+}O(OH)[Si_2O_7][SiO_4]$
*Vanadoandrosite-(Ce)	$Mn^{2+}CeV^{3+}AlMn^{2+}O(OH)[Si_2O_7][SiO_4]$
*Åskagenite-(Nd)	$Mn^{2+}NdAl_2Fe^{3+}O_2[Si_2O_7][SiO_4]$
Dollaseite-(Ce)	$Ca(Ce,La,Nd)Mg_2AlF(OH)[Si_2O_7][SiO_4]$
*Västmanlandite-(Ce)	$(Ce,La)_3CaAl_2Mg_2F(OH)_2[Si_2O_7][SiO_4]_3$
*Khristovite-(Ce)	$CaCeMgMn^{2+}AlF(OH)[Si_2O_7][SiO_4]$
*Gatelite-(Ce)	$(CaCe_3)(Al_3Mg)O(OH)_2[Si_2O_7][SiO_4]_3$
Tetrasilicates (K = 4)	Neutral→ acid
*Unnamed	$CaCe_2[SiO_4]_2$
Thorite family	
Thorite	$Th[SiO_4]$
*Stetindite-(Ce)	$Ce^{4+}[SiO_4]$
Thorogummite	$Th[(SiO_4)_{1-x}(OH)_{4x}]$
Coffinite	$U[SiO_4]\cdot nH_2O$
Huttonite	$Th[SiO_4]$
Tombarthite-(Y)	$Y_4(Si,H_4)_4O_{12-x}(OH)_{4+2x}$
Vyuntspakhkite-(Y)	$Y(Al,Si)[SiO_4](OH,O)_2$
	Acid-basic
Törnebohmite-(Ce)	$(Ce,La)_2Al(OH)[SiO_4]_2$
*Törnebohmite-(La)	$(La,Ce)_2Al(OH)[SiO_4]_2$
Cerite-(Ce)	$(Ce,La,Ca)_9(Mg,Fe^{3+})(OH)_3[SiO_4]_3[SiO_3(OH)]_4$
*Aluminocerite-(Ce)	$(Ce,La)_9(Al,Fe^{3+})(OH)_3[SiO_4]_3[SiO_3(OH)]_4$
*Cerite-(La)	$(La,Ce,Ca)_9(Fe^{3+},Ca,Mg)(OH)_3[SiO_4]_3[SiO_3(OH)]$

Britholite series
Britholite-(Ce) $(Ce,Ca)_5(OH)[SiO_4]_3$
Britholite-(Y) $(Y,Ca)_5(OH)[SiO_4]_3$
Tetrasilicato-halogenides
*Fluorbritholite-(Ce) $(Ce,Ca)_5F[SiO_4]_3$
Fluorbritholite-(Y) $(Y,Ca)_5F[SiO_4)]_3$
*Fluorcalciobritholite $(Ca,REE)_5F[(Si,P)O_4]_3$
Basic
Kuliokite-(Y) $(Y,Yb)_4Al(OH)_2[SiO_4]_2F_5$

Silicates of ***f***-cations with unknown structure
Umbozerite $Na_3Sr_4Th[Si_8O_{23}OH]$

Beryllosilicates
*Zero-monoberyylosilicates (K_Σ = 0,3)
*Bussyite-(Ce) $(Ce,REE)_3(Na,H_2O)_6Mn[Be_5Si_9(O,OH)_{30}]F_4$

Zero-monoberyylosilicates (K_Σ = 0,8) Acid
Semenovite-(Ce) $Na_8Ca_2Ce_2Fe^{2+}[Be_6Si_{14}O_{40}]F_4(OH)_4$

Monoberillosilicates Neutral →Acid
Gadolinite series
Gadolinite-(Ce) $Ce_2Fe^{2+}[BeO(SiO_4)]^{\infty 2}{}_2$
Gadolinite-(Y) $Y_2Fe^{2+}[BeO(SiO_4)]^{\infty 2}{}_2$
Minasgeraisite-(Y) $CaY_2[BeO(SiO_4)]^{\infty 2}{}_2$
Hingganite-(Ce) $(Ce,Y,Yb)[Be(OH)(SiO_4)]^{\infty 2}$
Hingganite-(Y) $(Y,Yb,Er)[Be(OH)(SiO_4)]^{\infty 2}$
Hingganite-(Yb) $(Yb,Y)[Be(OH)(SiO_4)]^{\infty 2}$
*Calcybeborosilite-(Y) $(Y,Ca)_2(\square,Fe^{2+})[(B,Be)_2(OH,O)(SiO_{4)}]_2$

*Tetraberillosilicatesr (К = 4)
*Makarochkinite $Ca_2Fe^{2+}{}_4Fe^{3+}TiO_2[BeAlSi_4O_{18}]$

Borosilicates
Zero-borosilicates Basic
Tritomite-(Ce) $Ce_5(OH,O)[(SiO_4,BO_4)_3]$
Tritomite-(Y) $Y_5(OH,O,F)[(SiO_4,BO_4)_3]$

*Zero-monoborosilicates (K = 0.8)
*Perettiite-(Y) $Y^{3+}{}_2Mn^{2+}{}_4Fe^{2+}[Si_2B_8O_{24}]$

Monoborosilicates Neutral
Stillwellite-(Ce) $(Ce,La,Ca)BSiO_5 \rightarrow (Ce,La,Ca)_3[(SiO_3)_3(B_3O_6)^{\infty}]^{\infty}$

Mono-diborosilicates Basic
Tadzhikite-(Ce) $Ca_2(Ca,Y)_2(Ti,Al,Fe^{3+})(Ce,Y,\square)(OH)_2[Si_4B_4O_{16}(O,OH)_6]$
Tadzhikite-(Y) $(Ca,Ce)_4(Ti^{4+},Fe^{3+},Al)(Y,Ce)_2(OH)_2[B_4Si_4O_{22}]$
Acid
*Hellandite-(Ce) $(Ca,REE)_4Ce_2Al\square_2(OH)_2[Si_2B_2O_{11}]_2$

Hellandite-(Y) $(Ca,REE)_4Y_2Al\square_2(OH)_2[B_2Si_2O_{11}]_2$
*Mottanaite-(Ce) $Ca_4(Ce,Ca)_2AlBe_2O_2[Si_2B_2O_{11}]_2$
*Ciprianite $Ca_4[(Th,U)REE]_2Al\square_2(OH)_2[Si_2B_2O_{11}]_2$

*Tri-tetraborosilicates К = 3,(1)
*Proshchenkoite-(Y) $Ca(Y,REE,CaNa,Mn)_{15}(Fe^{2+},Mn)(P,Si)[Si_6B_3O_{34}]F_{14}$

*Tri-tetraborosilicates К = 3,(1)
*Laptevite-(Ce) $NaFe^{2+}(REE_7Ca_5Y_3)[SiO_4]_4[Si_3B_2PO_{18}][BO_3]F_{11}$

*Tri-tetraborosilicates K = 3,6
Okanoganite-(Y) $(Ca,Na,REE,Th)_{16}Fe^{3+}[Si_7B_3O_{34}(OH)_4]F_{10}$

*Tetraborosilicates
*Vicanite-(Ce) $(Ca,REE,Th)_{15}As^{5+}(As^{3+}_{0,5},Na_{0,5})Fe^{3+}[Si_6B_4O_{40}]F_7$

Borosilicates of ***f***-cations with unknown structure
Melanocerite-(Ce) $Ce_5(OH,O)[(SiO_4,BO_4)]_3$
Cappelenite-(Y) $Ba(Y,Ce)_6[Si_3B_6O_{24}]F_2$

Silicato-phosphates
Disilicato-phosphates Neutral
Phosinaite-(Ce) $Na_{13}Ca_2Ce[SiO_3]_4[PO_4]_4$

Tetrasilicato-phosphates-sulfates Hydrates
Saryarkite-(Y) $Ca(Y,Th)Al_5(OH)_7[SiO_4]_2[PO_4][SO_4]\cdot 6H_2O$

*Silicato-phosphato-carbonates
*Abenakiite-(Ce) $Na_{26}REE_6[SiO_3]_6[PO_4]_6[CO_3]_6(S^{4+}O_2)O$

Silicato-carbonates
Monosilicato-carbonates Hydrates
Caysichite-(Y) $Y_4Ca_3Gd(OH)[Si_8O_{20}][CO_3]_6\cdot 7H_2O$

Disilicato-carbonates Hydrates
Kainosite-(Y) $Ca_2(Y,Ce)_2[SiO_3]_4[CO_3]\cdot H_2O$

*Trisilicato-carbonates Средние
*Biraite-(Ce) $Ce_2Fe^{2+}[Si_2O_7][CO_3]$

Tetrasilicato-carbonates Neutral
Iimoriite-(Y) $Y_2[SiO_4][CO_3]$

Subclass: Silicates of cations with middle FC
Silicates of V^{4+}
Monosilicates Hydrates
Cavansite family
Cavansite $Ca(V^{4+}O)[Si_4O_{10}]^{\infty 2}\cdot 4H_2O$
Pentagonite $Ca(V^{4+}O)[Si_4O_{10}]^{\infty 2}\cdot 4H_2O$

Trisilicates Neutral $BaV^{4+}Si_2O_7$

Haradaite group

Haradaite $SrV^{4+}[Si_2O_7]$

Suzukiite $BaV^{4+}[Si_2O_7]$

*Tetrasilicates

*Oxido-tetrasilicates

*Vanadomalayaite $Ca\{V^{4+}O[SiO_4]\}^{\infty 2}$

Silicates of Zr → zirconium silicates

Zirconium silicates of ***s***-, ***d_s***- and ***p_s***-cations

Zirconium silicates of ***s***-, ***d_s***- and ***p_s***-cations without Li^+ and Be^{2+}

Proper zirconium silicates

Zirconomonosilicates (K = 1) Neutral

Dalyite $K_2|Zr[Si_6O_{15}]^{\infty 2}|^{\infty 3}$

Hydrates

Elpidite family

Armstrongite $Ca|Zr[Si_6O_{15}]^{\infty 2}|^{\infty 3}(H_2O)_3$

Elpidite $Na_2|Zr[Si_6O_{15}]^{\infty 2}|^{\infty 3}(H_2O)_3$

*Yusupovite $Na_2Zr[Si_6O_{15}]\cdot 2.5H_2O$

*Zeravshanite $Cs_4Na_2Zr_3[Si_6O_{15}]_3(H_2O)_2$

Zirconomono-disilicates (1 < K < 2)

Zirconomono-disilicates with K = 1,2 Neutral

Lemoynite $|CaZr_2[Si_{10}O_{26}]^{\infty 2}|^{\infty 3}(Na,K)_2(H_2O)_{5-6}$

*Natrolemoynite $|Na_4Zr_2[Si_{10}O_{26}]^{\infty 2}|^{\infty 3}\cdot 9H_2O$

Zirconomono-disilicates with K = 1,(3) Hydrates

*Kapustinite $Na_{5,5}Mn_{0,25}Zr[Si_6O_{16}](OH)_2$

Terskite $Na_4Zr[Si_6O_{16}]\cdot 2H_2O$

*Hydroterskite $Na_2Zr[Si_6O_{12}(OH)_4](OH)_2$

Zirconomono-disilicates with K = 1,5 Neutral

Vlasovite $Na_2|Zr[Si_4O_{11}]^{\infty}|^{\infty 3}$

*Hydrates

*Tumchaite $Na_2(Zr,Sn)[Si_4O_{11}]\cdot 2H_2O$

*Zirconomono-disilicates with K = 1,54

*Rastsvetaevaite $Na_{27}K_8Ca_{12}Fe_3Zr_6[Si_{52}O_{144}](O,OH)_6Cl_2$

*Zirconomono-disilicates with K = 1,77

*Aqualite $(H_3O)_8(Na,R,Sr)_5Ca_6Zr_3[Si_{26}O_{66}(OH)_9]Cl$

Zirconomono-disilicates with K = 1,84

Neutral

*Khomyakovite $Na_{12}Sr_3Ca_6Fe_3WZr_3[Si_{25}O_{73}](O,OH,\cdot H_2O)_3(Cl,OH)_2$

*Manganokhomyakovite $Na_{12}Sr_3Ca_6Mn_3WZr_3[Si_{25}O_{73}](O,OH,\cdot H_2O)_3(Cl,OH)_2$

*Raslakite $Na_{15}Ca_3Fe_3(Na,Zr)_3Zr_3(Si,Nb)[Si_{25}O_{73}](OH,\cdot H_2O)_3(Cl,OH)_2$

*Mn analog raslakite $[Na,H_3O]_{15}[Ca_3Mn]_3Na_3Zr_3(Si,Ti)[Si_{25}O_{72}OH](OH)_2\cdot 2H_2O$

Zirconodisilicates with (K = 2) Neutral

Wadeite family

Bazirite $Ba|Zr[Si_3O_9]|^{\infty 3}$

Wadeite $K_2|Zr[Si_3O_9]|^{\infty 3}$

Neutral → acid → hydrates

***Eudialyte**

Eudialyte $Na_{15}Ca_7Fe^{2+}{}_3Zr_3SiO[Si_3O_9]_2[Si_9O_{27}]_2\}^{\infty 3}$ $(OH)_2Cl$

*Davinciite $Na_{12}K_3Ca_6Fe^{2+}{}_3Zr_3[Si_{26}O_{72}](O,OH)_2Cl_2$

*Ikranite $Na_{15}Ca_6Fe^{3+}{}_2Zr_3(\square,Zr)(\square,Si)[Si_{24}O_{66}(O,OH)]\cdot nH_2O$

*Georgbarsanovite $Na_{12}(Mn,Sr,REE)_3Ca_6Fe^{2+}{}_3Zr_3Nb[Si_{25}O_{76}]Cl_2\cdot H_2O$

*Zirsilite-(Ce) $(Na,\square)_{12}(Ce,Na)_3Ca_6Mn_3Zr_3Nb[Si_{25}O_{73}](OH)_3(CO_3)\cdot H_2O$

*Kentbrooksite $(Na,REE)_{15}(Ca,REE)_6Mn^{2+}{}_3Zr_3Nb[Si_{25}O_{74}]F_2\cdot 2H_2O$

*Carbokentbrooksite $(Na,\square)_{12}(Na,Ce)_3Ca_6Mn_3Zr_3Nb[Si_{25}O_{73}](OH)_3(CO_3)\cdot H_2O$

*Ferrokentbrooksite $Na_{15}Ca_6Fe_3Zr_3Nb[Si_{25}O_{73}](O,OH,\cdot H_2O)_3(F,Cl)_2$

*Andrianovite $Na_{12}(Ca,Sr,Ce)_3Ca_6Mn_3Zr_3Nb[Si_{25}O_{73}](O,OH,\cdot H_2O)_5$

*Voronkovite $Na_{15}(Na,Ca,Ce)_3(Mn,Ca)_3Fe_3Zr_3[Si_{26}O_{72}](OH,O)_4Cl\cdot H_2O$

*Manganoeudialyte $Na_{14}Ca_6Mn_3Zr_3[Si_{26}O_{72}(OH)_2]Cl_2\cdot 4H_2O$

*Ilyukhinite $(H_3O,Na)_{14}Ca_6Mn_2Zr_3[Si_{26}O_{72}(OH)_2]\cdot 3H_2O$

*Golyshevite $(Na,Ca)_{10}Ca_9(Fe^{3+},Fe^{2+})_2Zr_3Nb[Si_{25}O_{72}](OH)_3(CO_3)\cdot H_2O$

*Mogovidite $Na_9(Ca,Na)_6Ca_6(Fe^{3+},Fe^{2+})_2Zr_3\square[Si_{25}O_{72}](CO_3)(OH,\cdot H_2O)_4$

*Taseqite $Na_{12}Sr_3Ca_6Fe_3Zr_3Nb[Si_{25}O_{73}](O,OH,\cdot H_2O)_3Cl_2$

*Johnsenite-(Ce) $Na_{12}(Ce,La,Sr,Ca,\square)_3Ca_6Mn_3Zr_3W[Si_{25}O_{73}][CO_3](OH,Cl)_2$

*Oneillite $Na_{15}Ca_3Mn_3Fe_3Zr_3Nb[Si_{25}O_{73}](O,OH,\cdot H_2O)_3(OH)_2$

*Feklichevite $Na_{11}Ca_9(Fe^{3+},Fe^{2+})_2Zr_3Nb[Si_{25}O_{73}](OH,\cdot H_2O,Cl,O)_5$

*Bobtreilite $(Na,Ca)_{13}Sr_{11}(Zr,Y,Nb)_{14}[Si_{42}B_6O_{132}(OH)_{12}]\cdot 12H_2O$

*Labyrinthite $(Na,K,Sr)_{35}Ca_{12}Fe_3Zr_6Ti[Si_{51}O_{144}(O,OH,\cdot H_2O)_9]Cl_3$

*Dualite

$Na_{30}(Ca,Na,Ce,Sr)_{12}(Na,Mn,Fe,Ti)_6Zr_3Ti_3Mn[Si_{51}O_{144}](OH,\cdot H_2O,Cl)_9$

Lovozerite family

*Townendite $Na_8Zr[Si_6O_{18}]$

Koashvite $Na_6Ca)|Ti^{4+}[Si_6O_{18}]|^{\infty 3}$

Zirsinalite $Na_6(Ca,Mn,Fe^{2+})|Zr[Si_6O_{18}]|^{\infty 3}$

Lovozerite $Na_3Ca\,|\,Zr[Si_6O_{15}(OH,O)_3]\,|^{\infty}$

Petarasite $Na_5Zr\,|\,Zr[Si_6O_{18}]\,|^{\infty 3}(Cl,OH)\cdot 2H_2O$

*Litvinskite $Na_3Zr[Si_6O_{13},(OH)_5]^{\infty 3}$

Catapleiite family

Catapleiite series

Catapleiite $|Zr[Si_3O_9]|^{\infty 3}Na_2\cdot 2H_2O$

Gaidonnayite $Zr[Si_3O_9]|^{\infty 3}Na_2(H_2O)_2$

*Calcigaidonnayite $|\,Zr[Si_3O_9]\,|^{\infty 3}(Ca,Na,K)_{2-x}\cdot n(H_2O)$

Georgechaoite $|Zr[Si_3O_9]|^{\infty}NaK(H_2O)_2$

Calciohilairite $|Zr[Si_3O_9]|^{\infty}Ca(H_2O)_3$

Komkovite $|Zr[Si_3O_9]|^{\infty 3}Ba(H_2O)_3$

*Rogermitchellite $Na_6(Sr,Na)_{12}Ba_2Zr_{13}[Si_{39}(B,Si)_6O_{123}](OH)_{12}\cdot 9H_2O$

Hilairite $|Zr[Si_3O_9]|^{\infty 3}Na_2(H_2O)_3$

*REE analog hilairite $Na_{4,34}K_{0,57}(Y_{0,69}REE_{0,17})(Zr_{0,65}Ti_{0,20}Nb_{0,11})[Si_6O_{18}]\cdot 6H_2O$

Kostylevite family

Kostylevite $|Zr[Si_3O_9]|^{\infty 3}K_2(H_2O)$

Umbite $|Zr[Si_3O_9]|^{\infty 3}K_2(H_2O)$

Paraumbite $|Zr_2[Si_3O_9]|^{\infty 3}{}_2K_3H\cdot 3H_2O$

Zirconotrisilicates (K = 3)

Neutral

Keldyshite family

Gittinsite $Ca|Zr[Si_2O_7]|^{\infty 3}$

Parakeldyshite $Na_2|Zr[Si_2O_7]|^{\infty 3}$

Keldyshite $Na_{2-x}H_x|Zr[Si_2O_7]|^{\infty 3}(H_2O)_n$

Khibinskite $K_2|Zr[Si_2O_7]|^{\infty 3}$

Basic

*Dovyrenite $Ca_6|Zr[Si_2O_7]_2(OH)_4$

Oxido-hydroxido-zirconotrisilicato-fluorides $(Na,Ca)_2Ca_4Zr(Mn,Ti,Fe)(F,O)_4[Si_2O_7]_2$

Baghdadite family

Baghdadite $Ca_3|ZrO_2[Si_2O_7]|$

Burpalite $Na_2Ca|ZrF_2[Si_2O_7]|$

Hiortdahlite $(Na,Ca)_2Ca_4Zr(Mn,Ti,Fe)(F,O)_4[Si_2O_7]_2$

*Rengeite $Sr_4ZrTi_4[Si_4O_{22}] \rightarrow Sr_4ZrTiTi_3O_8[Si_2O_7]_2$

Tetrasilicates of Zr Neutral

Zircon series

Zircon $Zr[SiO_4]$

*Reidite $Zr[SiO_4]$

Hafnon $(Hf,Zr)[SiO_4]$

Kimzeyite (compare with garnet (series)) $Ca_3Zr_2[(SiAl_2)O_{12}]$

Zirconosilicates with unknown structure

Loudounite $NaCa_5Zr_4Si_{16}O_{40}(OH)_{11}\cdot 8H_2O$

Zirconodisilicato-phosphates Hydrates

Steenstrupine-(Ce) $Na_{14}|Ce^{3+}{}_6Mn^{2+}Mn^{3+}Fe^{2+}{}_2(Zr,Th)[Si_6O_{18}]_2[PO_4]_7|^{\infty 2}\cdot 3H_2O$

Zirconosilicates of Li

Zirconomonosilicates (K = 1) Neutral

Sogdianite family (compare with osumilite (family))

Sogdianite $KNa|Li_2Zr_2[Si_{12}O_{30}]|^{\infty 3}$

Darapiosite $KNa_2(Mn, Zr)_2|Li_2 Zn[Si_{12}O_{30}]|^{\infty 3}$

Zektzerite $Na_2|Li_2ZrZr[Si_{12}O_{30}]|^{\infty 3}$

*Dusmatovite $K(K,Na,\square)(Zn,Li)_3(Mn^{2+},Y,Zr)_2[Si_{12}O_{30}]$

Zirconosilicates of ***f***-cations

Tranquillityite $Fe_8(Zr,Y)_2Ti_3Si_3O_{24}$

*Sazykinaite-(Y) $Na_5YZr[Si_6O_{18}]\cdot 6H_2O$

Titanosilicates (with niobo- and tantalosilicates)

Titanosilicates of s-, d_s- and p_s-cations

Titanosilicates of s-, d_s- and p_s-cations without Li^+ and Be^{2+}

Proper titanosilicates

*Titano-zero-monosilicates

*Lourenswalsite (K = 0.66) $(K,Ba)_2Ti_4[(Si,Al,Fe)_6O_{14}](OH)_{12}$

*Oxido-titano-zero-monosilicates (К = 0,86)
*Hydrates
*Nafertisite $Na_3Fe^{2+}{}_{10}O_2(OH)_6[Ti_2Si_{12}O_{34}]F\cdot 2H_2O$

Titano-monosilicates (К = 1) Neutral
Davanite $K_2|Ti[Si_6O_{15}]^{\infty 2}|^{\infty 3}$
*Hydrates
*Ershovite $Na_4K_3(Fe^{2+},Mn^{2+},Ti)_2(OH)_4[Si_8O_{20}]\cdot 4H_2O$
*Paraershovite $Na_3K_3Fe^{3+}{}_2(OH)_2[Si_8O_{20}(OH)_2]\cdot(H_2O)_4$

Oxido-titanosilicates → Hydrates
Narsarsukite family
Narsarsukite $Na_2|TiO[Si_4O_{10}]^{\infty}|^{\infty 3}$
Penkvilksite $Na_2|TiO[Si_4O_{10}]^{\infty}|^{\infty 3}\cdot 2H_2O$
*Intersilite $Na_6Mn^{2+}Ti[Si_{10}O_{24}(OH)](OH)_3\cdot 4H_2O$

Titanomono-disilicates with mixed silicooxygen anions Hydrates
Vinogradovite $Na_4|(TiO)_4[Si_4O_{10}]^{\infty}[Si_2O_6]^{\infty}{}_2|^{\infty 3}\cdot(H_2O,Na,K)_3$
*Paravinogradovite $(Na,\square)_2(Ti^{4+},Fe^{3+})_4[Si_3AlO_{10}][Si_2O_6]_2(OH)_4\cdot H_2O$

*Titanomono-disilicates with К = 1.14 Basic
*Senkevichite $CsNaKCa_2TiO[Si_7O_{18}](OH)$

*Titanomono-disilicates with К = 1.28
*Caryochroite $(Na,Sr)_3(Fe^{3+},Mg)_{10}[Ti_2Si_{12}O_{37}](O,OH)_9\cdot 8H_2O$

Titanomono-disilicates (К = 1,4) Basic
Tinaksite $NaK_2Ca_2|Ti(OH)[Si_7O_{19}]^{\infty}|^{\infty 2}$

*Titano(niobo)mono-disilicates *Hydrates
*Haineaultite (K = 1,(6)) $(Na,Ca)_5Ca(Ti,Nb)_5[(Si,S)_{12}O_{34}](OH,F)_8\cdot 5H_2O$
*Chivruaiite $Ca_4(Ti,Nb)_5[Si_6O_{17}]_2(OH,O)_5\cdot 13\text{-}14H_2O$

Титано(ниобо)моно-дисиликато-хлориды (K = 1,7)
∗Alluaivite $Na_{19}(Ca,Mn^{2+})_6(Ti,Nb)_3[Si_{26}O_{74}]Cl\cdot 2H_2O$

Titanodisilicates (K = 2) Neutral
Benitoite $Ba|Ti[Si_3O_9]|^{\infty 3}$
*Hydrates
∗Zorite $Na_6Ti_5[Si_{12}O_{36}](O,OH)_3\cdot 11H_2O$

Oxido-titanodisilicates
Baotite $Ba_4Ti_4(Ti,Nb,Fe)_4O_{16}[Si_4O_{12}]Cl$
*Niobobaotite $Ba_4(Nb,Ti,Fe)_8O_{16}[Si_4O_{12}]Cl$
Lorenzenite $|Na_2Ti_2O_3[Si_2O_6]^{\infty}|^{\infty 2}$
Shcherbakovite $K_2NaTi_2{}^{4+}[Si_4O_{12}]O(OH)$
Batisite family
Batisite $Na_2BaO_2|Ti_2[Si_4O_{12}]|^{\infty 3}$

*Noonkanbahite $KNaBaO_2Ti_2[Si_4O_{12}]$

Aenigmatite series (compare with krinovite (series))

Rhönite $|Ca_4,Mg_8Ti_2O_4[(SiAl)_6O_{36}]^{\infty}|^{\infty 2}$

Aenigmatite $|Na_2Fe^{2+}{}_5TiO_2[Si_6O_{18}]^{\infty}|^{\infty 2}$

*Høgtuvaite $Ca_4(Fe_6{}^{2+}Fe_6{}^{3+})O_4[Si_8Be_2Al_2O_{36}]$

*Hydrates

Kukisvumite $Na_6ZnO_4|Ti_2[Si_4O_{12}]|^{\infty 3}{}_2\cdot 4H_2O$

*Manganokukisvumite $Na_6MnO_4|Ti_2[Si_4O_{12}]|^{\infty 3}{}_2\cdot 4H_2O$

Titanodisilicato-fluorides Basic

Yuksporite

$K_4(Ca,Na)_{14}(Sr,Ba)_2(\square,Mn,Fe)(Ti,Nb)_4(O,OH)_4[Si_6O_{17}]_2[Si_2O_7]_3(H_2O,OH)_3$

*Eveslogite $(Ca_{25}K_{24})Ti_{12}[Si_4O_{12}]_{12}(OH)_{12}F_{14}$

Labuntsovite family

Nenadkevichite group

Nenadkevichite $Na_{8-x}Nb_4[Si_4O_{12}]_2(O,OH)_4\cdot 8H_2O$

*Korobitsynite $Na_{8-x}Ti_4[Si_4O_{12}]_2(O,OH)_4\cdot 8H_2O$

Vuoriyarvite group

*Vuoriyarvite-K $(K,Na,\square)_{12}Nb_8[Si_4O_{12}]_4O_8\cdot 12\text{-}16H_2O$

*Tsepinite-Ca $(Ca,K,Na)_{2-x}(Ti,Nb)_2[Si_4O_{12}](OH,O)_2\cdot 4H_2O$

*Tsepinite-K $(K,Ba,Na)_2(Ti,Nb)_2[Si_4O_{12}](OH,O)_2\cdot 3H_2O$

*Tsepinite-Na $(Na,H_3O,K,Sr,Ba,\square)_{12}Ti_8[Si_4O_{12}]_4(OH,O)_8\cdot 12\text{-}16H_2O$

*Tsepinite-Sr $(Sr,Ba,K)(Ti,Nb)_2[Si_4O_{12}](OH,O)_2\cdot 3H_2O$

Paratsepinite group

*Paratsepinite-Ba $(Ba,Na,K)_{2-x}(Ti,Nb)_2[Si_4O_{12}](OH,O)_2\cdot 4H_2O$

*Paratsepinite-Na $(Na,Sr,K,Ca)_2(Ti,Nb)_2[Si_4O_{12}](O,OH)_2\cdot 4H_2O$

Kuzmenkoite group

*Kuzmenkoite-Mn $K_4Mn_2Ti_8[Si_4O_{12}]_4(OH,O)_8\cdot 10\text{-}12H_2O$

*Kuzmenkoite-Zn $K_2ZnTi_4[Si_4O_{12}]_2(OH)_4\cdot 6\text{-}8H_2O$

*Burovaite-Ca $(Na,K)_4Ca_2(Ti,Nb)_8[Si_4O_{12}]_4(OH,O)_8\cdot 12H_2O$

*Lepkhenelmite-Zn $Ba_2Zn(Ti,Nb)_4[Si_4O_{12}]_2(OH,O)_4\cdot 7H_2O$

*Gjerdingenite-Ca $K_2Ca(Nb,Ti)_4[Si_4O_{12}]_2(O,OH)_4\cdot 6H_2O$

*Gjerdingenite-Fe $K_2Fe(Nb,Ti)_4[Si_4O_{12}]_2(O,OH)_4\cdot 6H_2O$

*Gjerdingenite-Mn $K_2Mn(Nb,Ti)_4[Si_4O_{12}]_2(O,OH)_4\cdot 6H_2O$

*Gjerdingenite-Na $(K,Na)_2Na(Nb,Ti)_4[Si_4O_{12}]_2(OH,O)_4\cdot 5H_2O$

*Karupmøllerite-Ca $(Na,Ca,K)_2Ca(Nb,Ti)_4[Si_4O_{12}]_2(O,OH)_4\cdot 7H_2O$

Lemmleinite group

*Lemmleinite-K $Na_4K_8Ti_8[Si_4O_{12}]_4(O,OH)_8\cdot 8H_2O$

*Lemmleinite-Ba $Na_4K_4Ba_{2+x}Ti_8[Si_4O_{12}]_4(O,OH)_8\cdot 8H_2O$

Labuntsovite group

*Labuntsovite-Fe $Na_4K_4Fe_2{}^{2+}Ti_8[Si_4O_{12}]_4(O,OH)_8\cdot 10\text{-}12H_2O$

*Labuntsovite-Mg $Na_4K_4Mg_2Ti_8O_4[Si_4O_{12}](OH)_4\cdot 10\text{-}12H_2O$

*Labuntsovite-Mn $Na_4K_4Mn_2{}^{2+}Ti_8O_4[Si_4O_{12}]_4(OH)_4\cdot 10\text{-}12H_2O$

Paralabuntsovite group

*Paralabuntsovite-Mg $Na_8K_8Mg_4Ti_{16}[Si_4O_{12}](O,OH)_{16}\cdot 20\text{-}24H_2O$

Organovaite droup

*Organovaite-Mn $K_2MnNb_4[Si_4O_{12}]_2O_4\cdot 5\text{-}7H_2O$

*Organovaite-Zn $K_2Zn(Nb,Ti)_4[Si_4O_{12}]_2(O,OH)_4\cdot 6H_2O$

*Parakuzmenkoite-Fe $(K,Ba)_8Fe_4Ti_{16}[Si_4O_{12}]_8(OH,O)_{16}\cdot 20\text{-}28H_2O$

Gutkovaite group

*Gutkovaite-Mn $CaK_2Mn(Ti,Nb)_4[Si_4O_{12}]_2(O,OH)_4 \cdot 5H_2O$
*Alsakharovite-Zn $NaSrKZn(Ti,Nb)_4[Si_4O_{12}]_2(O,OH)_4 \cdot 7H_2O$
*Neskevaraite-Fe $NaKK_2Fe(Ti,Nb)_4[Si_4O_{12}]_2(O,OH)_4 \cdot 6H_2O$

Astrophyllite family (that is "titanosilicates micas " by N.V.Belov's opinion)
Niobophyllite *$K_2NaFe_7^{2+}(Nb,Ti)O_2[Si_4O_{12}]_2(OH)_4(O,F)$
Kupletskite $K_2NaMn^{2+}{}_7Ti_2(OH)_4O_2[Si_4O_{12}]_2F_4$
Astrophyllite $K_2NaFe_7^{2+}Ti_2(OH)_4O_2[Si_4O_{12}]_2F$
Magnesioastrophyllite = *Lobanovite
*Lobanovite $K_2Na(Fe_4^{2+}Mg_2Na)Ti_2(OH)_4O_2[Si_4O_{12}]_2$
*Tarbagataite $(K\square)Ca(Fe^{2+},Mn)_7Ti_2(OH)_5O_2[Si_4O_{12}]_2$
*Sveinbergeite $Ca(Fe^{2+}{}_6Fe^{3+})Ti_2(OH)_5O_2[Si_4O_{12}]_2\ (H_2O)_4$
Kupletskite-(Cs) $Cs_2NaMn^{2+}{}_7Ti_2O_2[Si_4O_{12}]_2(OH)_4F$
Zircophyllite $K_2NaMn^{2+}{}_7Zr_2O_2[Si_4O_{12}]_2(OH)_4F$
*Ferrozircophyllite $K_2Na(Fe^{2+},Mn)_7Zr_2O_2[Si_4O_{12}]_2(OH)_4F$
*Niobokupletskite $K_2NaMn_7^{2+}(Nb,Zr,Ti)O_2[Si_4O_{12}]_2(OH)_4(O,F)$
Acid → Hydrates

Kazakovite family
Kazakovite $Na_6Mn|Ti[Si_6O_{18}]|^{\infty 3}$
Tisinalite $Na_3Mn^{2+}Ti[Si_6O_{15}OH)_3]$
Ohmilite $Sr_3|(Ti,Fe^{3+})(O,OH)[Si_4O_{12}]^{\infty}|^{\infty} \cdot (H_2O)_{2-3}$

Strontio-orthojoaquinite series (compare with joaquinite (family))
Strontio-orthojoaquinite $Sr_2Ba_2(Na,Fe^{2+})_2|Ti(O,OH)[Si_4O_{12}]|^{\infty 2}{}_2 \cdot H_2O$
*Bario-orthojoaquinite $(Ba,Sr)_4Fe^{2+}{}_2Ti_2[Si_8O_{26}] \cdot H_2O$
*Strontiojoaquinite mon. $Sr_2Ba_2(Na,Fe^{2+})_2|Ti(O,OH)[Si_4O_{12}]|^{\infty 2}{}_2 \cdot H_2O$

*Titanodi-trisilicates (K = 2.5)
Traskite $Ba_{21}Ca(Fe^{2+},Mn,Ti)_4(Ti,Fe,Mg)_{12}[Si_{12}O_{36}][Si_2O_7]_6(O,OH)_{30}Cl_6$

Titanotrisilicates (K = 3)
Oxido-titanotrisilicates
Belkovite $Ba_3|[NbO_2]_6[Si_2O_7]_2|^{\infty 3}$
Fresnoite $Ba_2|(^{(5)}TiO)[Si_2O_7]|^{\infty 2}$
*Unnamed $(Ca,Fe)_3TiO_2[Si_2O_7]$
*Batisivite $BaV^{3+}{}_8Ti_6O_{22}[Si_2O_7]$
*Greenwoodite $Ba_{2-x}\ (V^{3+}OH)_xV^{3+}{}_9(Fe^{3+},Fe^{2+})_2O_{15}[Si_2O_7]$
*Kolskyite $(Ca,\square)Na_2Ti_4O_4[Si_2O_7]_2 \cdot 7H_2O$
*Laurentianite $[Na(H_2O)_2]_3[NbO(H_2O)]_3[Si_2O_7]_2$
*Kazanskyite $BaNa_3Ti_2NbO_2(OH)_2[Si_2O_7]_2(H_2O)_4$

*Titanosilicato-halogenides (fluorides)
*Altisite $K_6Na_3Al_2Ti_2Si_8O_{26}Cl_3$
Hydrates
*Bulgakite $Li_2(Ca,Na)Fe^{2+}{}_7Ti_2[Si_8O_{24}]O_2(OH)_4(F,O)(H_2O)_2$
*Nalivkinite $Li_2NaFe^{2+}{}_7Ti_2[Si_8O_{24}]O_2(OH)_4F(H_2O)_2$

*Titano-trisilicato-fluorides (K = 3)
*Roumaite $(Ca,Na,Ce,\square)_7(Nb,Ti)[Si_2O_7]_2(OH)F_3$
Hydrates
*Saamite $Ba\square Na_3Ti_2NbO_2(OH)_2[Si_2O_7]_2(H_2O)_2$

Oxido-titano (niobo) trisilicato-fluorides
Nacareniobsite-(Ce) $Na_3Ca_3(Ce,La)NbO[Si_2O_7]_2F_3$
*Lileyite $Ba_2(Na,Fe,Ca)_3MgTi_2O_2[Si_2O_7]_2F$

Oxido-hydroxido (fluorido)-titanosilicates
Rosenbuschite $Ca_6Zr_2Na_6ZrTi[Si_2O_7]_4(OF)_2F_4$
*Hainite $Na_2Ca_4(Y,REE)TiO[Si_2O_7]_2F_3$
*Kochite $Ca_2MnZrNa_3Ti[Si_2O_7]_2(OF)F_2$
Lamprophyllite family
Janhaugite $Na_3Mn_3|(Ti,Zr,Nb)O(OH,F)[Si_2O_7]|^{\infty 2}_2$
Låvenite $Na_2Ca_2Mn_2|(Zr,Ti)O(F,OH)[Si_2O_7]|^{\infty 2}_2$
*Normandite $NaCa(Mn^{2+},Fe^{2+})|(Ti,Nb,Zr)OF[Si_2O_7]|^{\infty 2}$
*Perraultite $(Na,Ca)_2(Ba,K)_2(Mn,Fe)_8(Ti,Nb)_4O_4[Si_2O_7]_4(OH)_2(OH,F)_4$
*Jinshajiangite $NaBaFe_4^{2+}Ti_2O_2[Si_2O_7]_2(OH)_2F$
Seidozerite $(Na,Ca)_4Mn_2|Zr_{0,5}Ti_{0,5}O(F,OH)[Si_2O_7]|^{\infty 2}_2$
*Grenmarit $(Na,Ca)_4(Mn,Na)(Zr,Mn)_2(Zr,Ti)(O,F)_4[Si_2O_7]_2$
Wöhlerite $Na_2Ca_4|Zr_{0,5}(Nb,Ti)_{0,5}(O,F)_2[Si_2O_7]|^{\infty 2}_2$
*Marianoite $Na_2Ca_4(Nb,Zr)_2(O,F)_4[Si_2O_7]_2$
*Schüllerite $Na_2Ba_2Mg_2Ti_2O_2F_2[Si_2O_7]_2$
*Surkhobite $KBa_3Ca_2Na_2Mn_{16}Ti_8O_8[Si_2O_7]_8(OH)_4(F,O,OH)_8$
Bafertisite *$Ba_2Fe^{2}_4Ti_2O_2(OH)_2F_2[Si_2O_7]_2$
*Camaraite $Ba_3Na(Fe^{2+},Mn)_8(OH,F)_7Ti_4O_4[Si_2O_7]_4$
*Ba-Mn titanosilicate $Ba[Mn^{2+}_2(OH)]\{TiO(OH)[Si_2O_7]\}$
*Hejtmanite $Ba(Mn^{2+},Fe^{2+})_2\{TiO(OH,F)_2[Si_2O_7]\}$
*Vigrishinite $Zn_2Ti_{4-x}O_2(OH,F,O)_2[Si_2O_7]_2(H_2O,OH,\square)_4$ (x<1)
Lamprophyllite series
Lamprophyllite $(SrNa)Ti_2Na_3TiO_2[Si_2O_7]_2(OH)_2$
*Fluorlamprophyllite $Na_3(SrNa)Ti_3O_2F_2[Si_2O_7]_2$
Barytolamprophyllite $(BaK)Ti_2Na_3TiO_2[Si_2O_7]_2(OH)_2$
*Emmerichite $Ba_2Na(Na,Fe^{2+})_2(Fe^{3+},Mg)Ti_2O_2F_2[Si_2O_7]_2$
*Nabalamprophyllite $(BaNa)Ti_2Na_3TiO_2[Si_2O_7]_2(OH)_2$
*Lamprophyllite orth. $(SrNa)Ti_2Na_3TiO_2[Si_2O_7]_2(OH)_2$
Götzenite group
Götzenite $Ca_4NaCa_2Ti[Si_2O_7]_2(OF)F_2$
Niocalite $Ca_7|Nb[Si_2O_7]_2O_3F$
*Fersmanite $Ca_5Na_3Ti_3Nb[Si_2O_7]_2O_8F_2$ or $Ca_4(Na,Ca)_4(Ti,Nb)_4[Si_2O_7]_2O_8F_3$
Hydrates
*Delindeite $Ba_2Ti_2(Na_2\square)Ti[Si_2O_7]_2(OH)_2(H_2O)_2O_2$
*Chirvinskyite $(Na,Ca)_{13}(Fe,Mn,\square)_2(Ti,Zr)_5(OH,O)_{12}[Si_2O_7]_4\cdot 2H_2O$

*Oxido-fluorido-phosphato-titanosilicates
*Sobolevite $Na_6(Na_2Ca)(NaCaMn)Na_2Ti_2Na_2(TiMn)[Si_2O_7]_2[PO_4]_4O_2(OF)F_2$
*Polyphite $Na_6(Na_4Ca_2)_2Na_2Ti_2Na_2Ti_2[Si_2O_7]_2[PO_4]_6O_4F_4$
*Quadruphite $Na_{14}Ca_2Ti_4O_4F_2[Si_2O_7]_2[PO_4]_4$
*Hydroxido (fluorido) Hydrates
*Shkatulkalite $Na_{10}MnTi_3Nb_3(OH)_2F[Si_2O_7]_6\cdot 12H_2O$
Komarovite series
Komarovite $(Ca,Mn,H)_2|Nb_2O_3(OH,F)_2[Si_2O_7]|^{\infty 3}(H_2O)_{3,5}$
Na-komarovite $(Na,Ca,H)_2|Nb_2O_3(OH,F)_2[Si_2O_7]|^{\infty 3}\cdot H_2O$ or

$Na_6CaNb_6O_{14}[Si_4O_{12}]\cdot4H_2O$

Epistolite $Na_2(Nb,Ti)_2O_2[Si_2O_7]\cdot nH_2O$

*Zvyaginite $(Na\square)Nb_2Zn\square_2Ti[O(OH)][Si_2O_7]_2O_2[(OH)F](H_2O)_5$

Murmanite-lomonosovite family

Murmanite $Na_2Ti_2Na_2Ti_2[Si_2O_7]_2O_4(H_2O)_4$

*Calciomurmanite $(Na,\square)_2Ca(Ti,Mg,Nb)_4O_2(OH,O)_2[Si_2O_7]_2(H_2O)_4$

*Bykovaite $(Ba,Na,K)_2(Na,Ti,Mn)_4(Ti,Nb)_2O_2[Si_2O_7]_2(H_2O,F,OH)_2\cdot3.5H_2O$

*Nechelustovite $(Ba,Sr,K)_2(Na,Ti,Mn)_4(Ti,Nb)_2O_2[Si_2O_7]_2(O,H_2O,F)_2\cdot4.5H_2O$

Bornemanite $Na_6BaTi_2NbO_2[Si_2O_7]_2[PO_4](OH)F$

Vuonnemite $Na_6Na_2Nb_2Na_3Ti[Si_2O_7]_2[PO_4]_2O_2(OF)$

Lomonosovite $Na_6Na_2Ti_2Na_2Ti_2[Si_2O_7]_2[PO_4]_2O_4$

Betalomonosovite $Na_2\square_4Na_2Ti_2Na_2Ti_2[Si_2O_7]_2[PO_3(OH)][(PO_2(OH)_2]O_2(OF)$

Yoshimuraite $Ba_2Mn_2TiO[Si_2O_7][PO_4](OH)$

Innelite and polytypes 1T and 2M

$Ba_4Ti_2Na(NaCa)Ti[O(OH)][Si_2O_7]_2[(SO_4)(PO_4)]O_2$

*Phosphoinnelite $Na_3Ba_4Ti_3[Si_2O_7]_2[PO_4]_2O_2F$

Basic

Ellenbergerite $Mg_6Al_6Ti(OH)_{10}[Si_2O_7]_4$

* Titanotri-tetrasilicates (K = 3,2) *Hydrates

*Hogarthite $(Na,K)_2CaTi_2[Si_{10}O_{26}]\cdot8H_2O$

*Titanotri-tetrasilicates (K = 3,4) *Hydrates

*Tiettaite $(Na,K)_{17}FeTiSi_{16}O_{29}(OH)_{30}\cdot2H_2O$

Titanotetrasilicates (K = 4)

Oxido-titanotetrasilicates

Titanite $Ca|TiO[SiO_4]|^{\infty2}$

*Natrotitanite $(Na_{0.5}Y_{0.5})|TiO[SiO_4]|^{\infty2}$

Natisite $Na_2|(^{(5)}TiO)[SiO_4]|^{\infty2}$

*Paranatisite $Na_2\{TiO[SiO_4]\}$

*Sitinakite $Na_2\{Ti_4O_5(OH)[SiO_4]_2\}K\cdot4H_2O$

Hydrates

Mongolite $Ca_4(OH)_8|Nb_6O_4(OH)_2[SiO_4]_5|^{\infty2}\cdot5\text{-}6H_2O$

*Ivanyukite-Na $Na_2\{Ti_4O_2(OH)_2[SiO_4]_3\}\cdot6H_2O$

*Ivanyukite-K $K_2\{Ti_4O_2(OH)_2[SiO_4]_3\}\cdot9H_2O$

*Ivanyukite-Cu $Cu\{Ti_4O_2(OH)_2[SiO_4]_3\}\cdot7H_2O$

Titanoborosilicates

Oxido-and oxido-hydroxido-titanoborosilicates

Leucosphenite (K_Σ = 0,(6)) $Ba|Na_4Ti_2O_2[Si_{10}B_2O_{28}]^{\infty2}|^{\infty2}$

Tienshanite (K_Σ = 1,2) $KNa_9Ba_6Ca_2|(Mn,Fe)_6(Ti,Nb,Ta)_6(O,OH,F)_{11}[Si_{36}B_{12}O_{114}]^{\infty2}|^{\infty2}$

*Titanoborosilicato-phosphates Hydrates

*Byzantievite

$Ba_5(Ca,REE,Y)_{22}(Ti,Nb)_{18}(SiO_4)_4(PO_4,SiO_4)_4(BO_3)_9O_{22}[(OH),F]_{43}\cdot1.5H_2O$

Titanosilicates of Li Neutral

*Titanomonosilicates (K = 1)

*Berezanskite $KLi_3Ti_2[Si_{12}O_{30}]$

*Unnamed $KLi_3Zn_2[Si_{12}O_{30}]$

*Titanomono-disilicates (К = 1,4) Hydrates
*Punkaruaivite $Li\{Ti_2(OH)_2[Si_4O_{11}(OH)]\}\cdot 2H_2O$

Oxido-titanomono-disilicates
Titanomono-disilicates (K = 1,5)
Neptunite series
Neptunite $KNa_2|Li(Fe^{2+},Mn)_2Ti_2O_2[Si_4O_{11}]^{\infty 3}{}_2|^{\infty 3}$
Manganneptunite $KNa_2|Li(Mn,Fe^{2+})_2Ti_2O_2[Si_4O_{11}]^{\infty 3}{}_2|^{\infty 3}$
*Magnesioneptunite $KNa_2|Li(Mg,Fe^{2+})_2Ti_2O_2[Si_4O_{11}]^{\infty 3}{}_2|^{\infty 3}$

*Titanomono-disilicato-fluorides
*Faizievite $K_2Na(Ca_6Na)Ti_4Li_6F_2[Si_4O_{11}]_6$

Titanodisilicates (К = 2) Basic
Baratovite $(K,Na)Ca_7Li_3Ti_2F_2[SiO_3]_{12}$
*Katayamalite $KLi_3Ca_7Ti_2(OH)_2[Si_6O_{18}]_2$

Oxido-titanodisilicates *Hydrates
*Lintisite $Na_3LiTi_2O_2[Si_4O_{12}]\cdot 2H_2O$

*Titanotrisilicates (К = 3) *Hydrates
*Eliseevite $Na_{1.5}Li[Ti_2Si_4O_{12.5}(OH)_{1.5}]\cdot 2H_2O$

*Titanotrisilicato-carbonates -halogenides
*Bussenite $Ba_4(Na,\square)_2(Fe^{2+},Na)_2Ti_2[Si_2O_7]_2(CO_3)_2O_2(OH)_2(H_2O)_2F_2$

*Titanotrisilicates Be
*Odintsovite $K_2Na_4Ca_3Ti_2Be_4[Si_{12}O_{38}]$

Titanosilicates of ***f***- elements
Proper titanosilicates
*Titanomono-disilicates (K = 1,5) *Hydrates
*Seidite-(Ce) $Na_4SrCeTi[Si_8O_{22}]F\cdot 5H_2O$

Titanodisilicates (К = 2)
Oxido-hydroxido-titanodsilicates Hydrates
Joaquinite family (ср. стронциоджоакинита (с.))
Byelorussite group
Orthojoaquinite-(Ce) $Ba_2NaFe^{2+}Ce_2(OH,F)Ti_2O_2[Si_4O_{12}]_2\cdot H_2O$
*Orthojoaquinite-(La) $Ba_2NaFe^{2+}La_2(O,OH)Ti_2O_2[Si_4O_{12}]_2\cdot H_2O$
Byelorussite-(Ce) $Ba_2NaMnCe_2(F,OH)Ti_2O_2[Si_4O_{12}]_2\cdot H_2O$
Joaquinite-(Ce) $Ba_2NaFe^{2+}Ce_2(OH)Ti_2O_2[Si_4O_{12}]_2\cdot H_2O$
*K-Ti analog ilímaussite-(Ce)
$(Ba,Na,K,Ca)_{11-12}(REE,Fe,Th)_4(Ti,Nb)_6[Si_6O_{18}]_4(OH)_{12}\cdot 4,5H_2O$
*Pyatenkoite-(Y) $Na_5(Y,Dy,Gd)Ti[Si_6O_{18}]\cdot 6H_2O$

*Titanodo-trisilicates with mixed silicooxygenous anions
*Diversilite-(Ce) (K = 2,5)

$Na_2(Ba,K)_6Ce_2Fe^{2+}Ti_3[Si_3O_9]_3[SiO_3OH]_3(OH)_7 \cdot nH_2O$

Titanitrisilicates (K = 3) Basic

Rinkite family (compare götzenite)

Rinkite $(Ca_3REE)Na(Na,Ca)Ti[Si_2O_7]_2(O,F)F_2$

*Mosandrite = Lovchorrite $NaCaCeTi[Si_2O_7]O_2$ (?)

Hydrates

*Batievaite-(Y) $Y_2Ca_2Ti(OH)_2[Si_2O_7]_2(H_2O)_4$

*Titanitrisilicato-oxido-arsenates

*Cervandonite-(Ce) $(Ce,Nd,La)(Fe^{3+}, Fe^{2+},Ti^{4+},Al)_3O_2[Si_2O_7]_{1-x+y}[AsO_3]_{1+x-y}(OH)_{3x-3y}$, $x = 0{,}47$, $y = 0{,}31$

*Titanotri-tetrasilicates with mixed silicooxygenous anions

*Oxido-titanotri-tetrasikicates *Basic

Ilimaussite-(Ce) (K = 3,4) $(Ba,Na)_{10}K_3Na_{4,5}Ce_5(Nb,Ti)_6[Si_{12}O_{36}][Si_9O_{18}(O,OH)_{24}]O_6$

Titanotetrasilicates (K = 4)

Oxido-titanotetrasilicates

Trimounsite-(Y) $Y_2|Ti_2O_5[SiO_4]|^{\infty 3}$

Titanosilicates with unknown structure

Ilmajokite $(Na,Ce,Ba)_{10}Ti_5Si_{14}O_{22}(OH)_{44} \cdot nH_2O$

Titanosilicato-phosphates with unknown structure

Laplandite-(Ce) $Na_4CeTiSi_7O_{18}(PO_4) \cdot 5H_2O$

*Karnasurtite-(Ce) $(Ce,La,Th)(Ti,Nb)(Al,Fe^{3+})[(Si,P)_2O_7](OH)_4 \cdot 3H_2O$

Titanosilicato-carbonates

Titanotetrasilicato-carbonates Hydrates

Tundrite series

Tundrite-(Ce) $Na_2Ce_2TiO_2[SiO_4][CO_3]_2$

Tundrite-(Nd) $Na_2Nd_2TiO_2[SiO_4][CO_3]_2$

*Titanotetrasilicato-hydrocarbonates *Hydrates

*Kihlmanite-(Ce) $Ce_2TiO_2[SiO_4][HCO_3]_2(H_2O)$

Subclass: Silicates of chalcophylic elements

Silicates of **I***b*-cations (Cu^{2+})

*Zero-monoalumosilicates (K = 0,(6))

*Kurumsakite $(Zn,Ni,Cu^{2+})_8Al_8V^{5+}{}_2[Si_5O_{35}] \cdot 27(H_2O)$

*Zero-monoalumosilicates (K = 0,75) *Hydrates

*Ajoite $(K,Na)_3Cu_{20}[Al_3Si_{29}O_{76}](OH)_{16} \cdot 8H_2O$

Monosilicates (K = 1) Neutral

Cuprorivaite family

Cuprorivaite $CaCu^{2+}[Si_4O_{10}]^{\infty 2}$

*Effenbergerite $BaCu^{2+}[Si_4O_{10}]$

*Wesselsite $SrCu^{2+}[Si_4O_{10}]$

Litidionite $KNaCu^{2+}[Si_4O_{10}]^{\infty2}$

Acid-basic

Chrysocolla $\{Cu^{2+}{}_2H_2(OH)_4[Si_2O_5]^{\infty2}\}^{\infty2}$

with $(Al,Fe)^{3+}$ in place of $Cu^{2+}H^+$: $\{Cu_{2-x}H_{2-x}(Al,Fe)_x(OH)_4[Si_2O_5]^{\infty2}\}^{\infty2}$

if x = 2 $(Al,Fe)_2(OH)_4[Si_2O_5]^{\infty2}\}^{\infty2}$ (kaolinite)

Mono-disilicates *Neutral

*Lavinskyite (K = 1,5) $K(LiCu)Cu^{2+}{}_6[Si_4O_{11}]_2(OH)_4$

*Liebauite (K = 1,8) $Ca_3Cu_5[Si_9O_{26}]$

Hydrates

Plancheite (K = 1,5) $Cu^{2+}{}_8(OH)_4[Si_4O_{11}]^{\infty2}{}_2{\cdot}H_2O$

*Gilalite (K = 1,6) $Cu^{2+}{}_5[Si_6O_{17}]{\cdot}7H_2O$

*Apachite (K = 1,8) $Cu^{2+}{}_9[Si_{10}O_{29}]{\cdot}11H_2O$

Disilicates (K = 2) Basic

Papagoite $Ca_2Cu^{2+}{}_2Al_2(OH)_6[Si_4O_{12}]$

Shattuckite $Cu^{2+}{}_5(OH)_2[Si_2O_6]^{\infty2}{}_2$

Hydrates

Dioptase $Cu_6[Si_6O_{18}](H_2O)_6$

Di-trisilicates (K = 2,(6)) Hydrates

Kinoite $Ca_2\{Cu^{2+}{}_2(H_2O)_2[Si_3O_{10}]\}^{\infty3}$

*Trisilicates

*Scottyite $BaCu_2[Si_2O_7]$

*Tetrasilicates *Hydrates

*Stringhamite $CaCu^{2+}[SiO_4]{\cdot}H_2O$

*Unnamed $Cu^{2+}{}_8(OH)_{12}[SiO_4]{\cdot}8H_2O$

*Silicato-carbonates

*Disilicato-carbonates (K = 2)

*Whelanite $Cu^{2+}{}_2Ca_6[Si_6O_{17}(OH)][CO_3](OH)_3(H_2O)_2$

*Silicato-hydrocarbonaro-chlorides *Basic

*Ashburtonite $HPb_4Cu^{2+}{}_4[Si_4O_{12}](HCO_3)_4(OH)_4Cl$

Silicates of **II***b*-cations

Silcates of Hg^+

Trisilicates Neutral

Edgarbaileyite $Hg^+{}_6[Si_2O_7]$

Silicates of Zn → zincosilicates

Alumosilicates and proper silicates

Zero-monozincoalumosilicates (K = 0,8) Acid-basic

Minehillite $(K,Na)_2Ca_{28}(OH)_{12}[(Zn_5Al_4Si_{40})O_{112}(OH)_4]$

(compare with reyerite and truscottite)

Monoalumosilicates (K = 1) Basic

Hendricksite $K\{(Zn,Mg,Mn)_3(OH)_2[AlSi_3O_{10}]^{\infty2}$
(compare with subfamily of common mica)
Baileychlore $(Fe^{2+},Mg)_3(OH)_6\{(Zn,Al)_3(OH)_2[AlSi_3O_{10}]^{\infty2}\}^{\infty2}$
(compare with chlorites (family))
Fraipontite = zinalsite $\{(Zn,Al)_3(OH)_4[(Si,Al)_2O_5]^{\infty2}{}_2\}^{\infty2}$
(compare with kaolinite (family))
*Klöchite $KNaFe^{2+}{}_2Zn_3[Si_{12}O_{30}]$
Sauconite series (compare with smectite (family))
Sauconite $Na_{0,33}\{Zn_3(OH)_2[(Si,Al)_4O_{10}]^{\infty2}\}^{\infty2}(H_2O)_4$
Zincsilite $Zn_3(OH)_2[Si_4O_{10}]\cdot4H_2O$
Trisilicates (K = 3) Hydrates
Hemimorphite $\{^{(4)}Zn_4(OH)_2[Si_2O_7]\}^{\infty3}\cdot H_2O$
Junitoite $CaZn_2[Si_2O_7]\cdot H_2O$

Silicates of Zn with unknown structure Hydrates
Silicates of **IV***a*-cations
Silicates of Pb^{2+}
Proper silicates
*Zero-monoalumosilicates (K = 0,4)
*Rongibbsite $Pb_2[(AlSi_4)O_{11}](OH)$

*Zero-monoalumosilicates (K = 0,9)
*Wickenburgite $Pb_3CaAl[AlSi_{10}O_{27}](H_2O)_3$

*Mono-disilicates (K = 1,3) Hydrates
*Yangite $PbMn[Si_3O_8]\cdot H_2O$

*Mono-disilicates (K = 1,5) Hydrates
*Mathewrogersite $Pb_7Fe^{2+}GeAl_3[Si_3O_9]_4(OH)_4\cdot2H_2O$

Disilicates (K = 2) Neutral
Plumalsite $Pb_4Al_2[SiO_3]_7$
Alamosite $PbSiO_3 \rightarrow Pb_{12}[Si_{12}O_{36}]$

*Disilicato-halogenides Hydrates
*Hyttsjöite $Pb_{18}Ba_2Ca_5Mn^{2+}{}_2Fe^{3+}{}_2[Si_{30}O_{90}]Cl\cdot H_2O$

*Disilicato-trisilicates (K = 2,8) *Hydrates
*Creaseyite $Pb_2Cu^{2+}{}_2Fe^{3+}{}_2[Si_5O_{17}]\cdot6H_2O$

*Trisilicato-tetrasilicares (K = 3,(3))
*Ganomalite $Pb_9Ca_5Mn[Si_9O_{33}]$

*Silicato-carbonates
*Mono-silicatocarbonates Basic
*Surite $(Pb,Ca)_3Al_2(OH)_3[(Si,Al)_4O_{10}][CO_3]_2\cdot0.3H_2O$
*Hydrates
*Ferrisurite $(Pb,Ca)_{2.4}Fe^{3+}{}_2(OH)_3[Si_4O_{10}][CO_3]_{1.7}\cdot nH_2O$

Silicato-sulfates

Trisilicato-tetrasilicato-sulfates Neutral
Queitite $Pb_4Zn_2[Si_2O_7][SiO_4][SO_4]$

*Silicato-sulfato-carbonates *Basic
*Kegelite $Pb_8Al_4[Si_4O_{10}]_2[SO_4]_2[CO_3]_4(OH)_8$

Silicato-chromates
Tetrasilicato-chromates and tetrasilicato-chromato-fluorides
Neutral
Hemihedrite series
Iranite $CuPb_{10}(OH)_2[SiO_4]_2[CrO_4]_6$
Hemihedrite $ZnPb_{10}F_2[SiO_4]_2[CrO_4]_6$

Silicato-sulfato-chlorides Neutral
Mattheddleite $Pb_{10}[SiO_4]_3[SO_4]_3Cl_2$
(compare with wulfenite (series); ellestadite (group); apatite (group))

Silicates of **V*a***-elements
Silicates of nonfull-valence **Va**-cations (As^{3+}, Sb^{3+} and Bi^{3+})
Proper silicates
Monosilicates
Basic
Chapmanite $Sb^{3+}\{Fe^{3+}{}_2(OH)O_3[Si_2O_5]^{\infty 2}\}^{\infty 2}$

Tetrasilicates Neutral
Eulytine $Bi_4[SiO_4]_3$
Bismutoferrite $Fe^{3+}{}_2Bi[SiO_4]_2(OH)$

Titanoberyllosilicates
Titanotriberyllosilicates ($K_\Sigma = 3$)
Oxido-titanotriberyllosilicates
Asbecasite $Ca_3(Ti,Sn)As^{3+}{}_6O_6[BeSiO_7]_2$

3.2.1a. ***Class:*** Germanates (zone of oxidization of Tsumeb and at France ?)
Tetragermanates (orthogermanates) Basic
Carboirite (compare with chloritoid (family)
$$2[Fe^{2+}Al_2GeO_5(OH)_2] \rightarrow \{Fe^{2+}{}_2Al(OH)_4Al_3O_2[GeO_4]_2\}^{\infty 2}$$

Germanates (?) with unknown structure
Bartelkeite $PbFeGe[Ge_2O_7](OH)_2 \cdot H_2O$
Otjisumeite $PbGe_4O_9$
(see also sulfates of Ge – itoite, schaurteite, fleischerite)

3.2.2. ***Class:*** Borates
3.2.2.1. Quasiclass: (4)-Borates of cations with low FC
(4)-Borates of ***s*-, *d*$_s$- and *p*$_s$-** cations
(4)-Borates of ***s*-, *d*$_s$-** and ***p*$_s$-** cations without Li and Be
Proper (4)-Borates
*Zero-monoborates (K = 0,28)
Asid

*Jarandolite (Serbianite)		$Ca[B_3O_4(OH)_3]$
Zero-monoborates (К = 0,(6))		
	Neutral	
Johachidolite		$Ca\{^{(6)}Al[B_3O_7]^{\infty 2}\}^{\infty 3}$
Monoborates (К = 1)	Acid	
*Shimazakiite		$Ca_2B_2O_5$
Korzhinskite		$CaB_2O_4 \cdot 0.5H_2O$
Diborates (К = 2)	Acid	
Vimsite family		
Vimsite		$Ca[B_2O_2(OH)_4]^{\infty}$
Uralborite		$Ca[B_2O_2(OH)_4]^{\infty}$
Triborates (К = 3)	Acid	
Pinnoite		$Mg[B_2O(OH)_6]$
	Hydrates	
Pentahydroborite		$\{Ca[B_2O(OH)_6]\}^{\infty 2} \cdot 2H_2O)_2$
Tetraborates (К = 4)	Neutral	
Sinhalite		$MgAl[BO_4]$
	Acid	
*Pseudosinhalite		$(Mg,Fe)_2Al_3B_2O_9(OH)$
Frolovite		$\{Ca[B(OH)_4]_2\}^{\infty 2}$
	Hydrates	
Hexahydroborite		$Ca(H_2O)_2[B(OH)_4]_2$
Tetraborates and tetraborato-halogenides	Basic- acid	
Teepleite		$Na_2Cl[B(OH)_4]$
(4)-Borato-phosphates	Basic-acid	
Seamanite		$Mn_3(OH)_2[B(OH)_4][PO_4]$
(4)-Borato-arsenates	Acid	
Cahnite		$Ca_2[B(OH)_4][AsO_4]$
(4)-Borato-carbonates	Hydrates	
Carboborite		$Ca_2Mg(H_2O)_4[B(OH)_4]_2[CO_3]_2$
*Imayoshiite		$Ca_3Al(OH)_6[B(OH)_4][CO_3] \cdot 12H_2O$
(4)-Borato-sulfates	Basic-acid	
Sulfoborite		$Mg_3(OH,F)_2[B(OH)_4]_2[SO_4]$
	Hydrates	
Charlesite family		
Charlesite		$Ca_6(Al,Si)_2(OH,O)_{12}[B(OH)_4][SO_4]_2 \cdot 26H_2O$
Sturmanite		$Ca_6Fe^{3+}{}_2(OH)_{12}[B(OH)_4][SO_4]_{2.5} \cdot 25H_2O$
*Buryatite		$Ca_3(Si,Fe^{3+},Al)(OH)_5O[B(OH)_4][SO_4] \cdot 12H_2O$

(4)-Borates Be → beryllo borates

Zero-monoberyllo-(4)-borates (K = 0,5)
Acid
Rhodizite $KBe_4Al_4(B_{11}Be)O_{28}$

*Zero-monoberyllo-(4)-borates (K = 0,6(6))
*Londonite $CsBe_5Al_4B_{11}O_{28}$

(4)-Borates of ***f***-cations
(4)-Borato-carbonates Acid
Moydite-(Y) $Y[B(OH)_4][CO_3]$

(4)-Borates of cations with middle FC
(4)-Borates of Nb and Ta Neutral
Behierite $Ta[BO_4]$
*Schiavinatoite $(Nb_{0,52}Ta_{0,48})[BO_4]$

(4)-Borates of chalcophylic elements
(4)-Borates of Cu
(4)-Borates and (4)-borato-halogenides Acid
Henmilite $Ca_2Cu^{2+}[B(OH)_4]_2(OH)_4$
Bandylite $CuCl[B(OH)_4]$
*Jacquesdietrichite $Cu_2[BO(OH)_2](OH)_3$

3.2.2.2. Quasiclass: (3)-Borates
(3)-Borates of cations with low FC
(3)-Borates of ***s***-, ***d$_s$***- and ***p$_s$***-cations
(3)- Borates of ***s***-, ***d$_s$***- and ***p$_s$***-cations without Li and Be
Proper (3)-Borates
(3)-Diborates Neutral
Suanite family
Suanite $Mg_2[B_2O_5]$
Kurchatovite $CaMg[B_2O_5]$
Clinokurchatovite $CaMg[B_2O_5]$
Basic
Wiserite $(Mn,Mg)_{14}(OH)_8(Si,Mg)(O,OH)_4Cl[B_2O_5]_4$
Acid
Szaibelyite family
Szaibelyite $Mg_2(OH)[B_2O_4(OH)]$
Sussexite $Mn_2(OH)[B_2O_4(OH)]$
Hydrates
Satimolite $KNa_2Al_4Cl_3[B_2O_5]_3\cdot 13H_2O$

(3)-Monoborates Neutral
Kotoite family
*Takedaite $Ca_3[BO_3]_2$
Kotoite $Mg_3[BO_3]_2$
Jimboite $Mn_3[BO_3]_2$
Oxido-(3)-monoborates
Warwickite $Mg(Ti,Fe,Al)_2O[BO_3]$
*Yuanfuliite $Mg(Fe^{3+},Al)O[BO_3]$

Ludwigite series
Azoproite $(Mg,Fe^{2+})_2(Fe^{3+},Ti,Mg)O_2[BO_3]$
Ludwigite $(Mg,Fe^{2+})_2Fe^{3+}O_2[BO_3]$
Bonaccordite $Ni_2Fe^{3+}O_2[BO_3]$
Vonsenite $(Fe^{2+},Mg)_2Fe^{3+}O_2[BO_3]$
Fredrikssonite $Mg_2Mn^{3+}O_2[BO_3]$
Orthopinakiolite series
Chestermanite $Mg_2(Fe^{3+},Mg,Al,Sb^{5+})O_2[BO_3]$
Takeuchiite $(Mg,Mn^{2+})_2(Mn,Fe)^{3+}O_2[BO_3]$
Orthopinakiolite $(Mg,Mn^{2+})_2Mn^{3+}O_2[BO_3]$
Pinakiolite $Mg_2Mn^{3+}O_2[BO_3]$
(compare with hulsite (group)) Basic
Jeremejevite $Al_6F_3[BO_3]_5$
Fluoborite (nocerite) $Mg_3(F,OH)_3[BO_3]$
*Pertsevite-(F) $Mg_2F[BO_3]$
*Pertsevite-(OH) $Mg_2(OH)[BO_3]$
Karlite $(Mg,Al_x)_7(OH)_4Cl_{1-x}[BO_3]_3$
Acid
Sibirskite $CaH[BO_3]$
Hydrates
*Parasibirskite $Ca_2B_2O_5{\cdot}H_2O$
Wightmanite family
Wightmanite $Mg_5(OH)_5O[BO_3]{\cdot}2H_2O$
Shabynite $Mg_5(OH)_5(Cl,OH)_2[BO_3]{\cdot}4H_2O$
Nifontovite $Ca_3[BO(OH)_2]_6{\cdot}2H_2O$
Olshanskyite $Ca_2(OH)[BO(OH)_2]_3{\cdot}3H_2O$

*(3)-Borato-halogenides
*Hydroxylborite $Mg_3[BO_3(OH)_2]F$

(3)-Borato-carbonates
(3)-Monoborato-carbonates
(3)- Monoborato-carbonates with $BO_3 : CO_3 = 3 : 1$
Basic
Gaudefroyite $Ca_4Mn^{3+}{}_3O_3[BO_3]_3[CO_3]$

(3)-Monoborato-carbonates with $BO_3 : CO_3 = 2 : 1$
Hydrates (neutral)
Sakhaite $Ca_{48}Mg_{16}Al[SiO_3OH]_4[CO_3]_{16}[BO_3]_{28}(H_2O)_3(HCl)_3$

(3)- Monoborato-carbonates with $BO_3 : CO_3 = 1 : 1$
Hydrates (acid)
Canavesite $Mg_2[BO_2(OH)][CO_3]{\cdot}5H_2O$

(3)-Borato-phosphates
(3)- Monoborato-phosphates Hydrates
Lüneburgite $Mg_3[B(OH)_3]_2[PO_4]_2{\cdot}6H_2O$

(3)-Borates of Be
(3)-Monoborates of Be Basic

Hambergite $Be_2(OH)[BO_3]$

Hydrates

Berborite $Be_2(OH,F)[BO_3]\cdot H_2O$

*(3)-Borates ***f***-cations

*Peprossite-(Ce) $(Ce,La)(Al_3O)_{2/3}[B_4O_{10}]$

(3)-Borates of cations with middle FC

(3)-Monoborates of Zr

Oxido-(3)-monoborates

Painite *$CaZrAl_9O_{15}[BO_3]$

(3)-Borates of chalcophylic ***p***-elements

(3)-Monoborates of Sn^{4+} Neutral

Nordenskiöldine family

Tusionite $MnSn[BO_3]_2$

Nordenskiöldine $CaSn[BO_3]_2$

Oxido-(3)-monoborates

Hulsite series (compare with pinakiolite (group))

Magnesiohulsite $(Mg,Fe)_2(Fe,Sn,Mg)O_2[BO_3]$

Hulsite (paigeite) $(Fe^{2+},Mg)_2(Fe^{3+},Sn)O_2[BO_3]$

*Aluminomagnesiohulsite $Mg_2(Al_{1-2x}Mg_xSn_x)O_2[BO_3]$ x = 0,18

(3)-Monoborates of Sb^{5+}

Oxido-(3)-monoborates

Blatterite $Sb^{5+}{}_3(Mn^{3+},Fe^{3+})_9(Mn^{2+},Mg)_{35}O_{32}[BO_3]_{16}$

(compare with ludwigite (family))

3.2.2.3. Quasiclass: (4)-(3)-Borates

(4)-(3)-Borates of ***s***-, d_s- and p_s- cations

(4)-(3)- Borates of ***s***-, d_s- and p_s- cations without Li and Be

Proper (4)-(3)-borates (x =MO : B_2O_3)

(4)-(3)-Borates with x = 1 Neutral

Calciborite $Ca[B_2O_4]^{\infty}$

Acid

Fedorovskite series

Fedorovskite $Ca_2Mg_2(OH)_4[B_4O_7(OH)_2]$

Roweit $Ca_2Mn^{2+}{}_2(OH)_4[B_4O_7(OH)_2]$

*Mg-roweit $Ca_2(Mn^{2+},Mg)_2(OH)_4[B_4O_7(OH)_2]$

(4)-(3)-Borates with x = 0,8

Priceite family

Priceite (pandermite) $Ca_2(H_2O)[B_5O_7(OH)_5]$

Tertschite $Ca_2(H_2O)_7[B_5O_6(OH)_7]$ (?)

(4)-(3)-Borates with x = 0,(6) Acid

Fabianite $Ca[B_3O_5(OH)]^{\infty 2}$

Hydrates

Hydroboracite family

Colemanite $Ca[B_3O_4(OH)_3]^{\infty}\cdot H_2O$
Meyerhofferite $Ca_2[B_3O_4(OH)_3]^{\infty}_2\cdot 2H_2O$
Hydroboracite $CaMg[B_3O_4(OH)_3]^{\infty}_2\cdot 3H_2O$
Inderborite $CaMg[B_3O_3(OH)_5]^{\infty}_2\cdot 6H_2O$
Inyoite family
Inyoite $Ca[B_3O_3(OH)_5]\cdot 4H_2O$
Inderite $Mg[B_3O_3(OH)_5]\cdot 5H_2O$
Kurnakovite $Mg[B_3O_3(OH)_5]\cdot 5H_2O$
Veatchite family
Veatchite $Sr_2[B_5O_8(OH)]^{\infty}_2[B(OH)_3]\cdot H_2O$
Veatchite-A $Sr_2[B_5O_8(OH)]^{\infty}_2[B(OH)_3]\cdot H_2O$
Veatchite-P $Sr_2[B_5O_8(OH)]^{\infty}_2[B(OH)_3]\cdot H_2O]$
Ulexite family
*Tuzlaite $NaCa_2[B_5O_8(OH)_2]^{\infty}\cdot 3H_2O]$
Probertite $NaCa_2[B_5O_7(OH)_4]^{\infty}\cdot 3H_2O]$
Ulexite $NaCa[B_5O_6(OH)_6]^{\infty}\cdot 5H_2O]$

*(4)-(3)-Borates with x = 0,56
*Studenitsite $NaCa_2[B_9O_{14}(OH)_4]^{\infty}\cdot 2H_2O$

(4)-(3)-Borates with x = 0,54 Acid
Preobrazhenskite $Mg_3[B_{11}O_{15}(OH)_9]^{\infty 2}$

(4)-(3)-Borates with x = 0,5 Hydrates
Halurgite family
Halurgite $Mg_2(H_2O)[B_4O_5(OH)_4]_2$
*Hungchaoite $Mg(H_2O)_5[B_4O_5(OH)_4]\cdot 2H_2O$
Wardsmithite $Ca_5Mg[B_4O_5(OH)_4]_6\cdot 18H_2O$
Borax family
Kernite $Na_2(H_2O)_3[B_4O_6(OH)_2]$
Tincalconite $Na_2(H_2O)_3[B_4O_5(OH)_4]$
Borax $Na_2B_4O_5(OH)_4\cdot 8H_2O \rightarrow [Na(H_2O)_4]^{\infty 2}[B_4O_5(OH)_4]$
Aristarainite $Na_2(H_2O)_2\{Mg(H_2O)_2[B_6O_8(OH)_4]^{\infty}_2\}^{\infty 2}$
Kaliborite (paternoite) $HKMg_2(H_2O)_4[B_6O_8(OH)_5]^{\infty}_2$
*Alfredstelznerite $Ca_4(H_2O)_4[B_4O_4(OH)_6]_4\cdot(H_2O)_{15}$

(4)-(3)-Borates with x = 0,4 Hydrates
Biringuccite family
Biringuccite $Na_2(H_2O)[B_5O_8(OH)]^{\infty 2}$
Nasinite $Na_2(H_2O)_2[B_5O_8(OH)]^{\infty 2}$
Ezcurrite $Na_2(H_2O)_2[B_5O_7(OH)_3]$

(4)-(3)-Borates with x = 0,(3) Acid
Ameghinite $Na[B_3O_3(OH)_4]$
Hydrates
Tunellite family
Nobleite $Ca(H_2O)_3[B_6O_9(OH)_2]^{\infty 2}$
Tunellite $Sr(H_2O)_3[B_6O_9(OH)_2]^{\infty 2}$
Gowerite $Ca(H_2O)_3[B_5O_8(OH)B(OH)_3]^{\infty 2} \rightarrow Ca(H_2O)[B_6O_8(OH)_4]^{\infty 2}\cdot 3H_2O$

Aksaite family
Aksaite $Mg(H_2O)_2[B_6O_7(OH)_6]$
Mcallisterite $Mg_2(H_2O)_3[B_6O_7(OH)_6]_2 \cdot 6H_2O$
Admontite $Mg_2(H_2O)_3[B_6O_7(OH)_6]_2 \cdot 1.5H_2O$
Rivadavite $Na_6Mg[B_6O_7(OH)_6]_4 \cdot 10H_2O$

(4)-(3)-Borates with x = 0,28 Hydrates
Ginorite family
Ginorite $Ca_2[B_{14}O_{20}(OH)_6]^{\infty 2} \cdot 5H_2O$
Strontioginorite $SrCa[B_{14}O_{20}(OH)_6]^{\infty 2} \cdot 5H_2O$

(4)-(3)-Borates with x = 0,25 Acid
Strontioborite $Sr[B_8O_{11}(OH)_4]^{\infty 2}$

(4)-(3)-Borates with x = 0,2 Hydrates
Sborgite family
Sborgite $Na(H_2O)_3[B_5O_6(OH)_4]$
Santite $K(H_2O)_2[B_5O_6(OH)_4]$
*Ramanite-(Cs) $Cs(H_2O)_3[B_5O_6(OH)_4]$
*Ramanite-(Rb) $Rb(H_2O)_3[B_5O_6(OH)_4]$
Larderellite $NH_4(H_2O)[B_5O_7(OH)_2]$
Ammonioborite $(NH_4)_3(H_2O)_4[B_{15}O_{20}(OH)_8]$

(4)-(3)-Borato-arsenates Hydrates
Teruggite $Ca_4Mg[B_6O_7(OH)_6]_2[AsO_4]_2 \cdot 12H_2O$

(4)-(3)-Borato-carbonates Acid
Borcarite $Ca_4Mg[B_4O_6(OH)_6][CO_3]_2$
*Numanoite $Ca_4Cu[B_4O_6(OH)_6][CO_3]_2$

*(4)-(3)-Borato-hydrocarbonates Hydrates
*Qilianshanite $NaH_4[BO_3][CO_3]\ 2H_2O$

(4)-(3)-Borato-sulfates
*Vitimite $Ca_6[B_{14}O_{19}(OH)_{14}][SO_4] \cdot 5H_2O$

(4)-(3)- Borato-sulfato-chlorides
Heidornite $Ca_3Na_2Cl[B_5O_8(OH)_2][SO_4]_2$

(4)-(3)-Borato-chlorides
*(4)-(3)- Borato-chlorides x = 2 Hydrates
*Chelkarite $CaMg[B_2O_4]Cl_2 \cdot 7\ H_2O$

(4)-(3)-Borato-chlorides with x = 1,(3) Acid
Solongoite $Ca_2[B_3O_4(OH)_4]Cl$

*(4)-(3)-Borato-chlorides with x = 1,2
*Brianroulstonite $Ca_3[B_5O_6(OH)_6](OH)Cl_2 \cdot 8H_2O$

(4)-(3)-Borato-chlorides with x = 1 Hydrates (acid)

Ekaterinite $Ca_2[B_4O_7(Cl,OH)_2]{\cdot}2H_2O$
Hydrochlorborite $Ca_2[B_4O_4(OH)_7]Cl{\cdot}7H_2O$

(4)-(3)-Borato-chlorides with c x = 0,86 Neutral
Boracite family
Boracite $Mg_3[B_7O_{13}]Cl \rightarrow [B_7O_{12}]^{\infty 3}{\cdot}Mg_3OCl$
*Trembathite $Mg_3[B_7O_{13}]Cl \rightarrow [B_7O_{12}]^{\infty 3}{\cdot}Mg_3OCl$
Chambersite $Mn_3[B_7O_{13}]Cl \rightarrow [B_7O_{12}]^{\infty 3}{\cdot}Mn_3OCl$
Ericaite $(Fe,Mg,Mn)_3[B_7O_{13}]Cl \rightarrow [B_7O_{12}]^{\infty 3}$ $(Fe,Mg,Mn)_3OCl$
Congolite $(Fe,Mg,Mn)_3[B_7O_{13}]Cl \rightarrow [B_7O_{12}]^{\infty 3}$ $(Fe,Mg,Mn)_3OCl$

(4)-(3)-Borato-chlorides with x = 0,8 Acid
Hilgardite family
Hilgardite $Ca_2[B_5O_8(OH)_2]Cl$
*Hilgardite-1TC $Ca_2[B_5O_8(OH)_2]Cl$
Parahilgardite $Ca_2[B_5O_8(OH)_2]Cl$
Cl-tyretskite $(Ca,Sr)_2[B_5O_8(OH)_2]Cl$
Tyretskite-1Tc $(Ca,Sr)_2[B_5O_9(OH)]{\cdot}H_2O$
*Hydrates
*Kurgantaite $CaSr[B_5O_9]Cl{\cdot}H_2O$

*(4)-(3)-Borato-chlorides with x = 0,7
*Pringleite $Ca_9B_{26}O_{34}(OH)_{24}Cl_4{\cdot}13H_2O$ (tric.)
*Ruitenbergite $Ca_9B_{26}O_{34}(OH)_{24}Cl_4{\cdot}13H_2O$ (mon.)
*Walkerite $Ca_{16}(Mg,Li,\square)_2[B_{13}O_{17}(OH)_{12}]_4Cl_6{\cdot}28H_2O$

*(4)-(3)-Borato-chlorides with x = 0,4 *Hydrates
Volkovskite $KCa_4[B_5O_8(OH)]_4[B(OH)_3]_2Cl{\cdot}4H_2O$

*(4)-(3)Borato-chlorides with x = 0,2 *Hydrates
*Penobsquisite $Ca_2FeCl[B_9O_{13}(OH)_6]{\cdot}4H_2O$

*(4)-(3)-Borato-chromates
*Iquiqueite $K_3Na_4Mg[B_{24}O_{39}(OH)][CrO_4]{\cdot}12H_2O$

*(4)-(3)-Borato-chlorides of ***f*** - cations
*(4)-(3)-Borato-chlorides with x = 1 *Hydrates
*Braitschite-(Ce) $Ca_6NaCe_2[B_6O_7(OH)_3(O,OH)_3]_4{\cdot}H_2O$

*(4)-(3)-Borates chalcophylic elements
*(4)-(3)-Borates Cu
*Santarosaite CuB_2O_4

*(4)-(3)-Borates Zn
*(4)-(3)-Borato-chlorides Zn
*Chubarovite $KZn_2[BO_3]Cl_2$

*(4)-(3)-Borates Pb Hydrates
*Leucostaurite $Pb^{2+}{}_2[B_5O_9]Cl{\cdot}0.5H_2O$

3.2.3. ***Class:*** Carbonates
3.2.3.1. Subclass: Carbonates of cations with low FC
3.2.3.1.1. Carbonates of ***s-, d$_s$***- and ***p$_s$***- cations
3.2.3.1.1.1 Carbonates of ***s-, d$_s$***- and ***p$_s$***- cations without Li^+ and Be^{2+}
3.2.3.1.1.1.1. Proper carbonates x = $M^{2+}/[CO_3]$
3.2.3.1.1.1.1.1. Neutral (x = 1)

Calcite group (compare with smithsonite (group))

Magnesite	$Mg[CO_3]$
Gaspeite	$(Ni,Mg,Fe)[CO_3]$
Sphaerocobaltite	$Co[CO_3]$
Siderite	$Fe[CO_3]$
Rhodochrosite	$Mn[CO_3]$
Calcite	$Ca[CO_3]$

Aragonite group (compare with cerussite (group))

Aragonite	$Ca[CO_3]$
Strontianite	$Sr[CO_3]$
Witherite	$Ba[CO_3]$
*Unnamed mon.	$Ca[CO_3]$

Dolomite group (compare with minrecordite (group))

Dolomite	$CaMg[CO_3]_2$
Ankerite	$Ca(Fe,Mg)[CO_3]_2$
Kutnohorite	$Ca(Mn,Mg,Fe)[CO_3]_2$
Benstonite	$(Ba,Sr)_6Ca_6Mg[CO_3]_{13}$
Eitelite	$Na_2Mg[CO_3]_2$

Huntite group

Huntite	$CaMg_3[CO_3]_4$
Norsethite	$BaMg[CO_3]_2$

Fairchildite group

Vaterite	$Ca[CO_3]$
Fairchildite	$K_2Ca[CO_3]_2$
Gregoryite	$Na_2[CO_3]$

Alstonite family

Paralstonite	$(Ba,Sr)Ca[CO_3]_2$
*Olekminskite	$Sr(Sr,Ca,Ba)[CO_3]_2$
Barytocalcite	$BaCa[CO_3]_2$
Alstonite	$BaCa[CO_3]_2$

Shortite family

Shortite	$Na_2Ca_2[CO_3]_3$
Nyerereite	$Na_2Ca[CO_3]_2$
Natrofairchildite	$Na_2Ca[CO_3]_2$
Zemkorite	$(Na,K)_2Ca[CO_3]_2$
Bütschliite	$K_2Ca[CO_3]_2$

Natrite	$Na_2[CO_3]$

3.2.3.1.1.1.1.2. Basic and carbonato-halogenides

Rouvilleite (M8) (x = 1,1(6))	$Na_3Ca(Mn,Ca)F[CO_3]_3$
Northupite (x = 1,25)	$Na_3MgCl[CO_3]_2$
Dawsonite (x = 2)	$NaAl(OH)_2[CO_3]$
Nullaginite (x = 2)	$Ni_2(OH)_2[CO_3]$
Brenkite (x = 2)	$Ca_2F_2[CO_3]$
Tunisite (x = 2,125)	$NaCa_2Al_4(OH)_8Cl[CO_3]_4$

Holdawayite (x = 3) $Mn_6(OH)_7(Cl,OH)[CO_3]_2$

3.2.3.1.1.1.1.3. Hydrates

*Alexkhomyakovite $K_6(Ca_2Na)Cl[CO_3]_5 \cdot 6H_2O$
Kambaldaite (x = 1,1(6)) $NaNi_4(OH)_3[CO_3]_3 \cdot 3H_2O$

Hydromagnesite family (x = 1,25)
Hydromagnesite $Mg_5(OH)_2[CO_3]_4 \cdot 4H_2O$
Dypingite $Mg_5(OH)_2[CO_3]_4 \cdot 5H_2O$
Giorgiosite $Mg_5(OH)_2[CO_3]_4 \cdot 5H_2O$
Indigirite $Mg_2Al_2(OH)_2[CO_3]_4 \cdot 15H_2O$
*Widgiemoolthalite $(Ni,Mg)_5(OH)_2[CO_3]_4 \cdot 4\text{-}5H_2O$

Dresserite family (x = 2)
Strontiodresserite $(Sr,Ca)Al_2(OH)_4[CO_3]_2 \cdot H_2O$
Dresserite $BaAl_2(OH)_4[CO_3]_2 \cdot H_2O$
Hydrodresserite $BaAl_2(OH)_4[CO_3]_2 \cdot 3H_2O$

Alumohydrocalcite family (x = 2)
Alumohydrocalcite $CaAl_2(OH)_4[CO_3]_2 \cdot 3H_2O$
Para-alumohydrocalcite $CaAl_2(OH)_4[CO_3]_2 \cdot 6H_2O$
*Kochsandorite $CaAl_2(OH)_4[CO_3]_2 \cdot H_2O$

Artinite family (x = 2)
Pokrovskite $Mg_2(OH)_2[CO_3]$
Artinite $Mg_2(OH)_2[CO_3] \cdot 3H_2O$
*Chlorartinite $Mg_2(OH)Cl[CO_3] \cdot 3H_2O$
Otwayite $(Ni,Mg)_2(OH)_2[CO_3] \cdot H_2O$

Zaratite family (x = 3)
Zaratite $Ni_3(OH)_4[CO_3] \cdot 4H_2O$
Defernite $Ca_6(OH)_7(Cl,OH)_{1-2x}[CO_3]_{2-x}[SiO_4]_x$, where $x \leq 0,5$

Brugnatellite family (x = 7-7,5)
Hydroscarbroite $Al_{14}(OH)_{36}[CO_3]_3 \cdot nH_2O$
Scarbroite $Al_5(OH)_{13}[CO_3] \cdot 5H_2O$
Brugnatellite $Fe^{3+}Mg_6(OH)_{13}[CO_3] \cdot 4H_2O$
*Quintinite-3T $Mg_4Al_2(OH)_{12}[CO_3] \cdot 4H_2O$
*Quintinite $Mg_4Al_2(OH)_{12}[CO_3] \cdot 3H_2O$

Hydrotalcite family(x = 9)
*Caresite-3T $Fe_4Al_2(OH)_{12}[CO_3] \cdot 3H_2O$
Hydrotalcite $Mg_6Al_2(OH)_{16}[CO_3] \cdot 4H_2O$
*Charmarite-3T $Mn_4Al_2(OH)_{12}[CO_3] \cdot 3H_2O$
Pyroaurite $Mg_6Fe^{3+}{}_2(OH)_{16}[CO_3] \cdot 4H_2O$
Desautelsite $Mg_6Mn^{3+}{}_2(OH)_{16}[CO_3] \cdot 4H_2O$
Stichtite-3R $Mg_6Cr^{3+}{}_2(OH)_{16}[CO_3] \cdot 4H_2O$
*Stichtite-2H = Barbertonite $Mg_6Cr^{3+}{}_2(OH)_{16}[CO_3] \cdot 4H_2O$
Takovite $Ni_6Al_2(OH)_{16}[CO_3] \cdot 4H_2O$
Reevesite $Ni_6Fe^{3+}{}_2(OH)_{16}[CO_3] \cdot 4H_2O$
*Fe-reevesite $Fe^{2+}{}_4Ni_2(Fe^{3+}{}_{1,96}Al_{0,03}Cr_{0,01})_2(OH)_{16}[CO_3] \cdot 4H_2O$
Comblainite $Ni^{2+}{}_4Co^{3+}{}_2(OH)_{12}[CO_3] \cdot 3H_2O$

Manasseite group (x = 9)
Manasseite = hydrotalcite $Mg_6Al_2(OH)_{16}[CO_3] \cdot 4H_2O$
Sjögrenite = pyroaurite $Mg_6Fe^{3+}{}_2(OH)_{16}[CO_3] \cdot 4H_2O$

Coalingite (x = 13) $Mg_{10}Fe^{3+}{}_2(OH)_{24}[CO_3] \cdot H_2O$

3.2.3.1.1.1.1.3.2. Neutral (x = 1)

Lansfordite family

Lansfordite $Mg[CO_3]\cdot5H_2O$
Baylissite $K_2Mg[CO_3]_2\cdot4H_2O$
Monohydrocalcite $Ca[CO_3]\cdot H_2O$
Gaylussite family
Pirssonite $Na_2Ca[CO_3]_2\cdot2H_2O$
Gaylussite $Na_2Ca[CO_3]_2\cdot5H_2O$
Ikaite group
Hellyerite $Ni[CO_3]\cdot6H_2O$
Ikaite $Ca[CO_3]\cdot6H_2O$
Natron family
Thermonatrite $Na_2[CO_3]\cdot H_2O$
Natron $Na_2[CO_3]\cdot10H_2O$

*3.2.3.1.1.1.2. Carbonato-borates *3.2.3.1.1.1.2.1. Hydrates (asid)
*Qilianshanite $NaH_4[CO_3][BO_3]\cdot2H_2O$

3.2.3.1.1.1.3. Carbonato-phosphates
*3.2.3.1.1.1.3.2. Carbonato-phosphates with $CO_3 : PO_4 \sim 18$
*3.2.3.1.1.1.3.2.1. Hydrates
*Karchevskyite $Mg_{18}Al_9(OH)_{54}Sr_2[CO_3]_9(H_2O)_6(H_3O)_5$

3.2.3.1.1.1.2.1. Carbonato-phosphates with $CO_3 : PO_4 = 1$
3.2.3.1.1.1.2.1.1. Neutral
Bradleyite group
Bradleyite $Na_3Mg[CO_3][PO_4]$
*Crawfordite $Na_3Sr[CO_3][PO_4]$
Bonshtedtite $Na_3Fe^{2+}[CO_3][PO_4]$
Sidorenkite $Na_3Mn^{2+}[CO_3][PO_4]$

3.2.3.1.1.1.2.2. Carbonato-phosphates with $CO_3 : PO_4 = 0,(3)$
Heneuite $CaMg_5(OH)[CO_3][PO_4]$

3.2.3.1.1.1.4. Carbonato-dihydrophosphato-phosphates
3.2.3.1.1.1.4.1. Hydrates (basic)
Girvasite $NaCa_2Mg_3(OH)_2[CO_3][PO_2(OH)_2][PO_4]_2\cdot4H_2O$

3.2.3.1.1.1.5. Carbonato-sulfates
*3.2.3.1.1.1.5.1. Carbonato-sulfates with $CO_3 : SO_4 = 8$
*3.2.3.1.1.1.5.1.1. Hydrates
*3.2.3.1.1.1.5.1.1.1. Basic
*Putnisite $SrCa_4Cr^{3+}{}_8[CO_3]_8[SO_4](OH)_{16}\cdot23H_2O$

3.2.3.1.1.1.5.1. Carbonato-sulfates with $CO_3 : SO_4 = 4$
3.2.3.1.1.1.5.1.1. Neutral
Tychite group (x = 1)
Tychite $Na_6Mg_2[CO_3]_4[SO_4]$
Ferrotychite $Na_6Fe^{2+}{}_2[CO_3]_4[SO_4]$
*Manganotychite $Na_6Mn^{2+}{}_2[CO_3]_4[SO_4]$

3.2.3.1.1.1.5.2. Carbonato-sulfates with $CO_3 : SO_4 = 1$

3.2.3.1.1.1.5.2.1. Hydrates

3.2.3.1.1.1.5.2.1.1. Basic

Tatarskite (x = 2) $Ca_6Mg_2[CO_3]_2(SO_4)_2(OH)_4Cl_4 \cdot 7H_2O$

3.2.3.1.1.1.5.3. Carbonato-sulfates with $CO_3 : SO_4 = 1$

3.2.3.1.1.1.5.3.1. Neutral

Burkeite (x = 1) $Na_6[CO_3][SO_4]_2$

3.2.3.1.1.1.5.3.2. Hydrates

Rapidcreekite $Ca_2[CO_3][SO_4] \cdot 4H_2O$

3.2.3.1.1.1.5.4. Carbonato-sulfates with variable ratio $CO_3 : SO_4$ with the proviso that $CO_3 < SO_4$

3.2.3.1.1.1.5.4.1. Basic

Paraotwayite (x = 3) $Ni(OH)_{2-x}[(SO_4)(CO_3)]_{0.5x}$

3.2.3.1.1.1.5. Carbonato-sulfates with $CO_3 : SO_4 = 1$

3.2.3.1.1.1.5.1. Carbonato-sulfato-chlorides

Hanksite (x = 1,04) $KNa_{22}[CO_3]_2[SO_4]_9Cl$

*3.2.3.1.1.1.6. Carbonato-fluorides

*Podlesnoite $BaCa_2[CO_3]_2F_2$

*3.2.3.1.1.1.6.1. Hydrates

*Sheldrikite $NaCa_3[CO_3]_2F_3 \cdot H_2O$

3.2.3.1.1.1.7. Carbonato-fluoraluminates

3.2.3.1.1.1.7.1. Neutral

Stenonite $Sr_2AlF_5[CO_3] \rightarrow Sr_2[CO_3][AlF_5]^{\infty}$

3.2.3.1.1.1.7.2. Hydrates

Montroyalite $Sr_4Al_8(OH,F)_{26}[CO_3]_3 \cdot 10H_2O \rightarrow Sr_4[CO_3]_3[Al_4(OH,F)_{13}]_2 \cdot 10H_2O$

3.2.3.1.1.1.8. Carbonato-fluoraluminato-hydrocarbonates

3.2.3.1.1.1.8.1. Neutral

Barentsite $Na_7AlF_4[HCO_3]_2[CO_3]_2 \rightarrow Na_7[HCO_3]_2[CO_3]_2[AlF_4]^{\infty}$

3.2.3.1.1.1.9. Hydrocarbonato-carbonates

3.2.3.1.1.1.9.1. Hydrocarbonato-carbonates with $HCO_3 : CO_3 = 0,(4)$

3.2.3.1.1.1.9.1.1. Hydrates (basic)

Sergeevite (x = 1) $Ca_2Mg_{11}(OH)_4[HCO_3]_4[CO_3]_9 \cdot 6H_2O$

3.2.3.1.1.1.9.2. Hydrocarbonato-carbonates with $HCO_3 : CO_3 = 1$

3.2.3.1.1.1.9.2.1. Hydrates (neutral)

Trona (x = 0,75) $Na_3[HCO_3][CO_3] \cdot 2H_2O$

3.2.3.1.1.1.9.3. Hydrocarbonato-carbonates with $HCO_3 : CO_3 = 3$

3.2.3.1.1.1.9.3.1. Neutral

Wegscheiderite (x = 0,625) $Na_5[HCO_3]_3[CO_3]$

3.2.3.1.1.1.10. Hydrocarbonates

3.2.3.1.1.1.10.1. Neutral

Nahcolite family (x = 0,5)

Nahcolite $Na[HCO_3]$

Kalicinite $K[HCO_3]$

Teschemacherite $NH_4[HCO_3]$

3.2.3.1.1.1.9.2. Hydrates (basic)

Nesquehonite (x = 1) $MgOH[HCO_3]·2H_2O$

3.2.3.1.1.2. Carbonates of Li

3.2.3.1.1.2.1. Neutral

Zabuyelite $Li_2[CO_3]$

*3.2.3.1.1.3. Carbonates of Be

*Niveolanite $NaBe[CO_3](OH)·2H_2O$

3.2.3.1.2. Carbonates of ***f***-elements

3.2.3.1.2.1. Neutral

Burbankite family (x = 1)

Sahamalite-(Ce) $(Mg,Fe^{2+})Ce_2[CO_3]_4$

Carbocernaite $(Ca,Na)(Sr,Ce,Ba)[CO_3]_2$

Khanneshite $(Na,Ca)_3(Ba,Sr,Ce,Ca)_3[CO_3]_5$

Ewaldite $Ba(Ca,Y,Na,K)[CO_3]_2·2.6H_2O$

Burbankite $(Na,Ca)_3(Sr,Ba,Ce)_3[CO_3]_5$

*Calcioburbankite $Na_3(Ca,REE,Sr)_3[CO_3]_5$

Remondite-(Ce) $Na_3(Ce,La,Ca,Na,Sr)_3[CO_3]_5$

*Remondite-(La) $Na_3(La,Ce,Ca)_3[CO_3]_5$

*Petersenite-(Ce) $Na_4REE_2[CO_3]_5$

*Paratooite-(La) $(La,REE,Ca,Na,Sr)_6Cu^{2+}[CO_3]_8$

*3.2.3.1.2.1.1. Hydrates

*Shomiokite-(Y) $Na_3Y[CO_3]_3·3H_2O$

*Lecoqite-(Y) $Na_3Y[CO_3]_3·6H_2O$

3.2.3.1.2.2. Carbonato-fluorides and basic carbonares

Baiyuneboite-(Ce) $NaBaCe_2F[CO_3]_4$

Polysomatic series of bastnäsite $mM^{2+}[CO_3]·nTR(F,OH)[CO_3]·pH_2O$ or $M_{2+m}TR_n(F,OH)_n[CO_3]_{m+n}·pH_2O$, where M^{2+} = Ca, Sr, Ba; TR = Ce, La, Nd, Y...Th with the proviso that $0 < p < 3$ (ratio m:n is reported at the name of groups, series, famileis ib round brackets)

Parisite subseries (m : n = 2)

*Kukharenkoite-(Ce) = Zhonghuacerite-(Ce) (x = 1,1(6)) $Ba_2(Ce,REE)F[CO_3]_3$

*Kukharenkoite-(La) $Ba_2(La,REE)F[CO_3]_3$

Cebaite group (x=1,2) (m : n = 1,5)

Cebaite-(Ce) $Ba_3Ce_2F_2[CO_3]_5$

Synchysite family (x = 1,25) (m : n = 1)

Synchysite-(Nd) $CaNdF[CO_3]_2$

Synchysite-(Ce) $CaCeF[CO_3]_2$

*Synchysite-(Ce) tet $CaCeF[CO_3]_2$

*Synchysite-(Ce) trig $CaCeF[CO_3]_2$

Synchysite-(Y) $CaYF[CO_3]_2$

Huanghoite-(Ce) $BaCeF[CO_3]_2$
*Qaqarssukite-(Ce) $BaCeF[CO_3]_2$
*Horvathite-(Y) $NaYF_2[CO_3]$
Röntgenite-(Ce) (x = 1,3) $Ca_2Ce_3F_3[CO_3]_5$ (m : n = 0,(6))
Parisite family (x = 1,(3)) (m : n = 0,5)
Parisite-(Ce)* $CaCe_2F_2[CO_3]_3$
*Lukechangite-(Ce) $Na_3Ce_2F[CO_3]_4$
Parisite-(Nd) $CaNd_2F_2[CO_3]_3$
Cordylite-(Ce) $NaBaCe_2F_2[CO_3]_4$
*Cordylite-(La) $NaCaBa_2La_3SrF_2[CO_3]_8$
Bastnäsite group (x = 1,5) (only n)
Bastnäsite-(Ce) $(Ce,La)F[CO_3]$
Bastnäsite-(Y) $(Y,REE)F[CO_3]$
*Bastnäsite-(La) $(La,Ce)F[CO_3]$
Hydroxylbastnäsite-(Ce) $(Ce,La,Nd)(OH,F)[CO_3]$
*Hydroxylbastnäsite-(La) $(La,Nd)(OH,F)[CO_3]$
*Hydroxylbastnäsite-(Nd) $(Nd,La)(OH,F)[CO_3]$
Ancylite subseries (hydrates basic)
Ancylite group
Calcio-ancylite-(Ce) (x = 1,25) $(Ca,Sr)Ce(OH)[CO_3]_2 \cdot H_2O$ (m : n = 1)
*Calcio-ancylite-(Nd) $Ca(Nd,Ce,Gd,Y)_3(OH)_3[CO_3]_4 \cdot H_2O$
Ancylite-(Ce) $SrCe(OH)[CO_3]_2 \cdot H_2O$
*Ancylite-(La) $SrLa(OH)[CO_3]_2 \cdot H_2O$
*Unnamed-(Nd) $Nd[CO_3][(OH),\cdot H_2O]$
*Kamphagite-(Y) $Ca_2(Y,REE)_2(OH)_2[CO_3]_4 \cdot 3H_2O$
*Unnamed (x = 1,42) $(Ca,Sr)((Nd,La,Pr,Sm)_5(OH)_5[CO_3]_6 \cdot H_2O$ (m:n = 0,2)
*Kozoite-(La) $(La,Nd,Ca)(OH)[CO_3]$
*Kozoite-(Nd) (x = 1,5) $(Nd,La,Ca)(OH)[CO_3]$
*Decrespignyite-(Y) (x = 1,75) (m:n = 0,17) $(Y,REE)^{3+}{}_4Cu^{2+}[CO_3]_4Cl(OH)_5 \cdot 2H_2O$
*Arisite-(Ce) (x = 1.75) (m:n = 0,33) $NaCe_2F[CO_3]_2[F_{2x}(CO_3)_{1-x}]$
*Arisite-(La) $NaLa_2F[CO_3]_2[F_{2x}(CO_3)_{1-x}]$
Thorbastnäsite-(Ce) (x = 1,5) $ThCeF_2[CO_3]_2 \cdot 3H_2O$
*Lusernaite-(Y) $Y_4Al[CO_3]_2(OH)_{10}F \cdot 6H_2O$
3.2.3.1.2.2.1. Hydrates

3.2.3.1.2.2.1.1. Neutral

Lanthanite family (x = 1)
Calkinsite-(Ce) $(Ce,La)_2[CO_3]_3 \cdot 4H_2O$
Lanthanite-(Ce) $(Ce,La,Nd)_2[CO_3]_3 \cdot 8H_2O$
Lanthanite-(La) $(La,Nd)_2[CO_3]_3 \cdot 8H_2O$
Lanthanite-(Nd) $(Nd,La)_2[CO_3]_3 \cdot 8H_2O$
Tengerite-(Y) $Y_2[CO_3]_3 \cdot 2\text{-}3H_2O$
Lokkaite family
Lokkaite-(Y) $CaY_4[CO_3]_7 \cdot 9H_2O$
Kimuraite-(Y) $CaY_2[CO_3]_4 \cdot 6H_2O$
*Adamsite-(Y) $NaY[CO_3]_2 \cdot 6H_2O$
Mckelveyite family

* According to Can. Min., 2001, v. 39, p.1713 the polytypes of parisite-(Ce): 4H, 8H, 10H, 14H, 16H, $6R_1$, $6R_2$, 18R, 25R, 30R, 36R, 42R be exist.

*Galgenbergite-(Ce) $Ca(Ce,REE)_2[CO_3]_4 \cdot H_2O$
Donnayite-(Y) $NaCaSr_3Y[CO_3]_6 \cdot 3H_2O$
Donnayite-(Y) trig. $NaCaSr_3Y[CO_3]_6 \cdot 3H_2O$
Mckelveyite-(Y) $Ba_3Na(Ca,U)Y[CO_3]_6 \cdot 3H_2O$
Tuliokite $BaNa_6Th[CO_3]_6 \cdot 6H_2O$

*3.2.3.1.2.3. Carbonato -sulfato-halogenides
*Reederite-(Y) $(Na,Mn)_{15}Y_2[CO_3]_9[SO_3F]Cl$

*3.2.3.1.2.4. Carbonato-hydrocarbonato-sulfato-halogenides
*3.2.3.1.2.4.1. Basic
*Mineevite-(Y) $Na_{25}Ba(Y,Gd,Dy)_2[CO_3]_{11}(HCO_3)_4(SO_4)_2F_2Cl$

3.2.3.1.2.5. Carbonato-phosphates 3.2.3.1.2.5.1. Basic
Daqingshanite-(Ce) $Sr_3Ce[CO_3]_3[PO_4]$

*3.2.3.1.2.6. Carbonato-hydrophosphates *3.2.3.1.2.6.1. Hydrates
*Micheelsenite $(Ca,Y)_3Al[HPO_4,CO_3][CO_3](OH)_6 \cdot 12H_2O$
*Micheelsenite-(Y) $Ca_4Y_2(Al,Y,Dy)_2[(P,Al)O_4]_2[CO_3](OH)_{12} \cdot 25H_2O$

*3.2.3.1.2.7. Hydrocarbonates *3.2.3.1.2.7.1. Basic
*Tomasclarkeite-(Y) $Na(Y,REE)(HCO_3)(OH)_3 \cdot 4H_2O$

3.2.3.2. Subclass: Carbonates of cations with middle FC
3.2.3.2.1. Carbonates of Zr 3.2.3.2.1.1. Hydrates (neutral)
Weloganite (x = 1) $Sr_3Na_2Zr[CO_3]_6 \cdot 3H_2O$
(compare with mckelveyite)

3.2.3.2.2. Carbonates of Ti 3.2.3.2.2.1. Oxido-carbonates
Sabinaite (x= 2) $Na_4Zr_2TiO_4[CO_3]_4$

3.2.3.2.3. Carbonates of Mn^{4+} 3.2.3.2.3.1. Hydrates (neutral)
Jouravskite $Ca_3Mn^{4+}[CO_3][SO_4](OH)_6 \cdot 12H_2O$

3.2.3.3. Subklass: Carbonates of chalcophylic cations
*3.2.3.3a. Carbonates VIIб – VIIIб cations Основные
*Chukanovite $Fe^{2+}_2(OH)_2[CO_3]$

3.2.3.3.1. Carbonates of Cu^{2+}
3.2.3.3.1.1. Proper carbonates 3.2.3.3.1.1.1. Basic
Azurite (x= 1,5) $Cu_3(OH)_2[CO_3]_2$
Malachite family (x = 2)
Mcguinnessite $(Mg,Cu)_2(OH)_2[CO_3]$
Kolwezite $CuCo(OH)_2[CO_3]$
Glaukosphaerite $(Cu,Ni)_2(OH)_2[CO_3]$
Malachite $Cu_2(OH)_2[CO_3]$
*Huangodoyite $Na_2Cu[CO_3]_2$
Georgeite (x = 1,(6)) $Cu_2(OH)_2[CO_3]$
3.2.3.3.1.1.2. Hydrates
3.2.3.3.1.1.2.1. Basic

Callaghanite (x = 4) $Cu_2Mg_2(OH)_6[CO_3]\cdot 2H_2O$

3.2.3.3.1.1.2.2. Neutral

Chalconatronite (x = 1) $Na_2Cu[CO_3]_2\cdot 3H_2O$

3.2.3.3.1.2. Carbonato-sulfates (0,25:1) Cu^{2+}

3.2.3.3.1.2.1. Hydrates (basic)

Nakauriite (x = 1,6) $Cu_8(OH)_6[CO_3][SO_4]_4\cdot 48H_2O$

3.2.3.3.2. Carbonates of Hg^+

3.2.3.3.3.2.1. Hydrates (basic)

Szymańskiite (x = 1,5) $(H_3O)_8Hg^+_{16}(Ni,Mg)_6(OH)_{12}[CO_3]_{12}\cdot 3H_2O$

*Clearcreekite mon. $Hg^+_3[CO_3](OH)\cdot 2H_2O$

*Peterbaylissite orth., pseudohex. $Hg^+_3[CO_3](OH)\cdot 2H_2O$

3.2.3.3.3. Carbonates of Zn and Cd

3.2.3.3.3.1. Proper carbonates

3.2.3.3.3.1.1. Neutral

Smithsonite group (compare with calcite (group))

Smithsonite (x = 1) $Zn[CO_3]$

Otavite $Cd[CO_3]$

Minrecordite (x = 1) $CaZn[CO_3]_2$

(compare with dolomite (group)

3.2.3.3.3.1.2. Basic

Rosasite group (x = 2)

Rosasite $(Cu,Zn)_2(OH)_2[CO_3]$

Zincrosasite $(Zn,Cu)_2(OH)_2[CO_3]$

Hydrozincite family (x = 2,5)

Hydrozincite $Zn_5(OH)_6[CO_3]_2$

*Parádsasvárite $Zn_2(OH)_2[CO_3]$

Aurichalcite $(Zn,Cu)_5(OH)_6[CO_3]_2$

Loseyite group (x = 3,5)

Sclarite $(Zn,Mg,Mn)_4Zn_3(OH)_{10}[CO_3]_2$

Loseyite $(Mn,Zn)_7(OH)_{10}[CO_3]_2$

3.2.3.3.3.1.3. Hydrates (basic)

Claraite(x = 3) $(Cu,Zn)_3(OH)_4[CO_3]\cdot 4H_2O$

*Zaccagnaite $Zn_4Al_2(OH)_{12}[CO_3]\cdot 3H_2O$

3.2.3.3.3.2. Sulfato-carbonates (0,5:1)

3.2.3.3.3.2.1. Basic

*Brianyoungite $Zn_{12}[CO_3]_3[SO_4](OH)_{16}$

Hauckite (x = 8) $(Mg,Mn)_{24}Zn_{18}Fe^{3+}_3(OH)_{81}[CO_3]_2[SO_4]_4$

3.2.3.3.4. Carbonates of Pb^{2+}

3.2.3.3.4.1. Proper carbonates

3.2.3.3.4.1.1. Neutral

Cerussite (x = 1) $Pb[CO_3]$

(compare with aragonite (group))

*Sanromanite $Na_2CaPb_3[CO_3]_5$

3.2.3.3.4.1.2. Basic and carbonato-chlorides

Hydrocerussite (x = 1,5) $Pb_5O(OH)_2[CO_3]_3$

Plumbonacrite (x = 1,(6)) $Pb_5(OH)_2O[CO_3]_3$

Phosgenite (x = 2) $Pb_2Cl_2[CO_3]$
*Barstowite (x = 4) $Pb_4Cl_6[CO_3]\cdot H_2O$
Schuilingite-(Nd) (x = 1,1(6)) $PbCuNd(OH)[CO_3]_3\cdot H_2O$
Gysinite-(Nd) (x = 1,25) $PbNd(OH)[CO_3]_2\cdot H_2O$
Dundasite (x = 2) $PbAl_2(OH)_4[CO_3]_2\cdot H_2O$
*Petterdite (x = 2) $PbCr_2(OH)_4[CO_3]_2\cdot H_2O$

*3.2.3.3.4.1.3.Oxido-carbonates
*Shannonite $Pb_2O[CO_3]$

3.2.3.3.4.2. Carbonato-sulfates
3.2.3.3.4.2.1. Carbonato-sulfates with $CO_3 : SO_4 = 4$
3.2.3.3.4.2.1.1. Oxido-hydrates
Nasledovite (x = 2) $PbMn_3Al_4O_5[CO_3]_4[SO_4]\cdot 5H_2O$

3.2.3.3.4.2.2. Carbonato-sulfates with $CO_3 : SO_4 = 2$
3.2.3.3.4.2.2.1. Basic
Leadhillite family(x = 1,(3))
Susannite $Pb_4(OH)_2[CO_3]_2[SO_4]$
Macphersonite $Pb_4(OH)_2[CO_3]_2[SO_4]$
Leadhillite $Pb_4(OH)_2[CO_3]_2[SO_4]$

3.2.3.3.4.2.3. Carbonato-sulfates with $CO_3 : SO_4 = 0,(3)$
3.2.3.3.4.2.3.1. Basic
Caledonite (x = 1,75) $Pb_5Cu_2(OH)_6[CO_3][SO_4]_3$

*3.2.3.3.4.2.4. Oxido-carbonato-sulfato-chlorides $CO_3 : SO_4 : Cl = 1: 4: 4$
*3.2.3.3.4.2.4.1. Basic
*Philolithite $Pb_{12}O_6Mn(Mg,Mn)_2(Mn,Mg)_4[CO_3]_4[SO_4]Cl_4(OH)_{12}$

*3.2.3.3.4.2.5. Carbonato-tiosulfates
*Fassinaite $Pb_2[S^{2+}{}_2O_3][CO_3]$

3.2.3.3.5. Carbonates of As^{3+}, Sb^{3+} and Bi^{3+}
3.2.3.3.5.1. Oxido- and oxido-carbonato-fluorides
Beyerite (x = 2) $(Ca,Pb)Bi_2O_2[CO_3]_2$
Kettnerite (x = 2,5) $CaBiOF[CO_3]$
Bismutite (x = 3) $CaBiOF[CO_3]$

3.2.3.3.5.2. Oxido-hydroxido-carbonates
Armangite (x = 53) $Mn^{2+}{}_{26}As^{3+}{}_{18}(OH)_4O_{50}[CO_3]$
(rather arsenito-carbonate !!)

3.2.3.4. Subclass: Carbonates of light p-anionformers (only Si^{4+})
3.2.3.4.1. Carbonato-sulfates (1:1)
3.2.3.4.1.1. Hydrates (basic)
Thaumasite (x = 2,5) $Ca_3Si(OH)_6[CO_3][SO_4]\cdot 12H_2O$

3.2.4. ***Class:*** Phosphates

3.2.4.1.Quasiclass: Orthophosphates

3.2.4.1.1. Subclass: Orthophosphates of cations with low FC
3.2.4.1.1.1. Orthophosphates of ***s*-, *d*$_s$-** and ***p*$_s$**-cations
3.2.4.1.1.1.1. Orthophosphates of ***s*-, *d*$_s$**- and ***p*$_s$**-cations without Li and Be
3.2.4.1.1.1.1.1. Proper orthophosphates 3.2.4.1.1.1.1.1.1. Neutral

Alluaudite family ($x = MO : PO_4 = 1,(3)$)
(compare with berzeliite (family); garnet (series))

Alluaudite	$Na\square Mn^{2+}Fe^{3+}_2[PO_4]_3$
Ferro-alluaudite	$Na\square(Fe^{2+},Mn^{2+})Fe^{3+}_2[PO_4]_3$
Maghagendorfite	$NaMgMn^{2+}(Fe^{2+},Fe^{3+})_2[PO_4]_3$
Hagendorfite	$NaCaMn^{2+}(Fe,Mn)^{2+}_2[PO_4]_3$
Varulite	$NaCaMnMn^{2+}_2[PO_4]_3$
Berlinite (x = 1,5)	$\{Al[PO_4]\}^{\infty 3}$
*Pretulite	$Sc[PO_4]$
*Rodolicoite	$Fe[PO_4]$
*Grattarolaite	$Fe_3^{3+}O_3[PO_4]$
Purpurite series (x = 1,5)	
Heterosite	$(Fe,Mn)^{3+}[PO_4]$
Purpurite	$(Mn,Fe)^{3+}[PO_4]$
Graftonite series (x = 1,5)	
Farringtonite	$Mg_3[PO_4]_2$
Sarcopside	$Fe^{2+}_3[PO_4]_2$
*Zavaliaite	$(Mn^{2+},Fe^{2+}, Mg)_3[PO_4]_2$
*Chopinite	$Mg_3[PO_4]_2$
Graftonite	$(Fe^{2+},Mn^{2+},Ca)_3[PO_4]_2$
Beusite	$(Mn,Fe,Ca,Mg)_3[PO_4]_2$
*Tuite polymorph of high pressure	γ-$Ca_3[PO_4]_2$
*Merrillite	$Ca_9Na(Mg,Fe^{2+})[PO_4]_7$
*Ferromerrillite	$Ca_9NaFe^{2+}[PO_4]_7$
Stanfieldite (x = 1,5)	$Ca_4(Mg,Fe,Mn)_5[PO_4]_6$
Bobfergusonite (x = 1,5)	$Na_2Mn_5Fe^{3+}Al[PO_4]_6$
*Manitobaite	$Na_{16}Mn_{15}Al_8[PO_4]_{30}$
Johnsomervilleite (x = 1,5)	$Na_{10}Ca_6Mg_{18}(Fe,Mn)_{25}[PO_4]_{36}$
Brianite family(x = 1,5)	
Panethite	$(Na,Ca,K)_2(Mg,Fe,Mn)_2[PO_4]_2$
Brianite	$Na_2CaMg[PO_4]_2$
Natrophilite family (x = 1,5)	
Marićite	$NaFe[PO_4]$
*Karenwebberite	$Na(Fe,Mn)^{2+}[PO_4]$
Natrophilite	$NaMn[PO_4]$
Buchwaldite	$NaCa[PO_4]$
Fillowite family (x = 1,5)	
Fillowite	$Na_2Ca(Mn,Fe)^{2+}_7[PO_4]_6$
*Chladniite	$Na_2CaMg_7[PO_4]_6$
*Galileiite	$(Na,K)_2(Fe,Mn,Cr)^{2+}_8[PO_4]_6$
*Unnamed	$(K,Na)_2(Fe,Mn,Cr)^{2+}_8[PO_4]_6$
Olgite	$(Ba,Sr)(Na,Sr,TR)_2Na[PO_4]_2$
*Bario-olgite	$Na(BaSr)Na[PO_4]_2$
Olympite (x = 1,5)	$LiNa_5[PO_4]_2$
Wyllieite group (x = 1,(6))	
Rosemaryite	$NaMn^{2+}Fe^{3+}Al[PO_4]_3$

*Ferrorosemaryite $\square NaFe^{2+}Fe^{3+}Al[PO_4]_3$
Wyllieite $Na_2Mn^{2+}Fe^{2+}Al[PO_4]_3$
Ferrowyllieite $Na_2(Fe^{2+},Mg)_2Al[PO_4]_3$
Qingheiite $Na_2Mn^{2+}Mg(Al,Fe^{3+})[PO_4]_3$
*Qingheiite-(Fe^{2+}) $Na_2MgFe^{2+}Al[PO_4]_3$

*3.2.4.1.1.1.1.1.2. Oxido-and phosphato-halogenides

*3.2.4.1.1.1.1.1.2.1. Neutral

*Moraskoite $Na_2MgF[PO_4]$

3.2.4.1.1.1.1.1.2.2. Basic

Melonjosephite (x = 1,5) $CaFe^{2+}Fe^{3+}(OH)[PO_4]_2$

Arrojadite group (x = 1,58)
Dickinsonite-(K,Mn,Na) $K(Na,Mn)Na_3CaAlMn_{13}[PO_4]_{12}(OH)_2$
Arrojadite-(BaFe) $BaFe(CaNa_2)Fe^{2+}{}_{13}Al[PO_4]_{11}[PO_3(OH)](OH)_2$
*Arrojadite-(BaNa) $BaNa_2(CaNa_2)Fe^{2+}{}_{13}Al[PO_4]_{11}[PO_3(OH)](OH)_2$
*Arrojadite-(KFe) $(KNa)Fe^{2+}(CaNa_2)Fe^{2+}{}_{13}Al[PO_4]_{11}[PO_3(OH)](OH)_2$
*Arrojadite-(KNa) $KNa_5CaFe^{2+}{}_{13}Al[PO_4]_{11}[PO_3(OH)](OH)_2$
*Arrojadite-(NaFe) $Na_2Fe^{2+}(CaNa_2)Fe^{2+}{}_{13}Al[PO_4]_{11}[PO_3(OH)](OH)_2$
*Arrojadite-(PbFe) $PbFe^{2+}(CaNa_2)Fe^{2+}{}_{13}Al[PO_4]_{11}[PO_3(OH)](OH)_2$
*Arrojadite-(SrFe) $SrFe^{2+}(CaNa_2)Fe^{2+}{}_{13}Al[PO_4]_{11}[PO_3(OH)](OH)_2$
*Arrojadite-(SrNa) $SrNa_2(CaNa_2)Fe^{2+}{}_{13}Al[PO_4]_{11}[PO_3(OH)](OH)_2$
*Fluorarrojadite-(BaFe) $Na_2CaBaFe^{2+}Fe^{2+}{}_{13}Al[PO_4]_{11}[PO_3(OH)]F_2$
*Fluorarrojadite-(BaNa) $BaNa_2(CaNa_2)Fe^{2+}{}_{13}Al[PO_4]_{11}[PO_3(OH)]F_2$
*Fluorarrojadite-(KNa) $KNa_3CaNa_2Fe^{2+}{}_{13}Al[PO_4]_{11}[PO_3(OH)]F_2$
*Fluorarrojadite-(NaFe) $Na_2Fe^{2+}(CaNa_2)Fe^{2+}{}_{13}Al[PO_4]_{11}[PO_3(OH)]F_2$

Samuelsonite (x = 1,6) $(Ca,Ba)Fe^{2+}{}_2Mn^{2+}{}_2Ca_8Al_2(OH)_2[PO_4]_{10}$
Nefedovite (x = 1,625) $Na_5Ca_4F[PO_4]_4$

Apatite family (x = 1,(6))
Oxyapatite hipothet. minal of apatite series $Ca_{10}O[PO_4]_6$
Fluorapatite $Ca_5F[PO_4]_3$
Carbonate-fluorapatite $Ca_5(F,OH)[(PO_4),(CO_3)]_3$
Hydroxylapatite $Ca_5(OH)[PO_4]_3$
Carbonate-hydroxylapatite $Ca_5(OH,F)[(PO_4),(CO_3)]_3$
Chlorapatite $Ca_5Cl[PO_4]_3$
*Clinohydroxylapatite = apatite-(CaOH)-M $Ca_5OH[PO_4]_3$
*Stronadelphite $Sr_5F[PO_4]_3$
*Miyahisaite $(Sr,Ca)_2Ba_3F[PO_4]_3$
*Alforsite $Ba_5Cl[PO_4]_3$

Belovite series
*Belovite-(Ce) $NaCe\,Sr_3F[PO_4]_3$
*Belovite-(La) $NaLaSr_3F[PO_4]_3$
*Fluorcaphite $SrCaCa_3F[PO_4]_3$
Apatite-(SrOH) $Sr_5OH[PO_4]_3$
Kuannersuite-(Ce) $Ba_6Na_2Ce_2FCl[PO_4]_6$

Goedkenite (x = 1,75) $(Sr,Ca)_2Al(OH)[PO_4]_2$
(comp. with brackebuschite gr.)
Arctite $Na_5Ca_7BaF_3[PO_4]_6$
*Bearthite $Ca_2Al(OH)[PO_4]_2$
Trolleite (x = 2) $Al_4(OH)_3[PO_4]_3$

Lazulite group (x = 2)

Lazulite	$(Mg,Fe^{2+})Al_2(OH)_2[PO_4]_2$
Scorzalite	$(Fe^{2+},Mg)Al_2(OH)_2[PO_4]_2$
Barbosalite	$Fe^{2+}Fe^{3+}{}_2(OH)_2[PO_4]_2$
Lipscombite (x = 2)	$(Fe,Mn)^{2+}Fe^{3+}{}_2(OH)_2[PO_4]_2$
*Staněkite	$Fe^{3+}(Mn,Fe^{2+},Mg)O[PO_4]$
*Lulzacite	$Sr_2Fe^{2+}(Fe^{2+},Mg)_2Al_4(OH)_{10}[PO_4]_4$
Penikisite group (x = 2)	
Penikisite	$Ba(Mg,Fe^{2+})_2Al_2(OH)_3[PO_4]_3$
Kulanite	$BaFe^{2+}{}_2Al_2(OH)_3[PO_4]_3$
Bjarebyite group (x = 2)	
Bjarebyite	$BaMn_2Al_2(OH)_3[PO_4]_3$
Perloffite	$BaMn_2Fe^{3+}{}_2(OH)_3[PO_4]_3$
*Johntomaite	$BaFe^{2+}{}_2Fe^{3+}{}_2(OH)_3[PO_4]_3$
Cirrolite (x = 2)	$Ca_3Al_2(OH)_3[PO_4]_3$
Satterlyite group (x = 2)	
Holtedahlite	$Mg_{12}(OH,O)_6(PO_3,OH,CO_3)[PO_4]_5$
Satterlyite	$(Fe,Mg)_{12}(OH,O)_6(PO_3,OH)[PO_4]_5$
Althausite group (x = 2)	
Althausite	$Mg_4(OH,O)(F,\square)[PO_4]_2$
Thadeuite	$CaMg_3(OH,F)_2[PO_4]_2$
Triplite group (x = 2)	
Zwieselite	$Fe^{2+}{}_2F[PO_4]$
Triplite	$Mn^{2+}{}_2F[PO_4]$
Wagnerite group (x = 2)	
Magniotriplite	$(Mg,Fe,Mn)_2F[PO_4]$
Wagnerite	$(Mg,Fe^{2+})_2F[PO_4]$
*Wagnerite Ma5bc polytype	$Mg_2(F,OH)[PO_4]$
*Hydroxylwagnerite	$Mg_2(OH)[PO_4]$
Wolfeite	$(Fe,Mn)^{2+}{}_2(OH)[PO_4]$
Triploidite	$(Mn,Fe)^{2+}{}_2(OH)[PO_4]$
Panasqueiraite family (x = 2)	
*Isokite	$CaMgF[PO_4]$
Panasqueiraite	$CaMg(OH,F)[PO_4]$
Lacroixite	$NaAl(F,OH)[PO_4]$
Nacaphite (x = 2)	$Na_2CaF[PO_4]$
Richellite (x = 2)	$CaFe^{3+}{}_2(OH,F)_2[PO_4]_2$
*Jagowerite (x = 2)	$BaAl_2(OH)_2[PO_4]_2$
Rockbridgeite series (x = 2,(3))	
Rockbridgeite	$(Fe,Mn)^{2+}Fe^{3+}{}_4(OH)_5[PO_4]_3$
Frondelite	$(Mn,Fe)^{2+}Fe^{3+}{}_4(OH)_5[PO_4]_3$
Brazilianite (x = 2,5)	$NaAl_3(OH)_4[PO_4]_2$
*Getehouseite (x = 2,5)	$Mn_5(OH)_4[PO_4]_2$
Augelite (x = 3)	$Al_2(OH)_3[PO_4]$
Laubmannite (x = 3)	$Fe^{2+}{}_3Fe^{3+}{}_6(OH)_{12}[PO_4]_4$
Viitaniemiite (x = 3)	$Na(Ca,Mn)Al(F,OH)_3[PO_4]$
*Raadeite (x = 3,5)	$Mg_7(OH)_8[PO_4]_2$
*Waterhauseite	$Mn_7(OH)_8[PO_4]_2$
*Unnamed	$(Fe,Mn)_3Al(OH)_6[PO_4]$

3.2.4.1.1.1.1.1.3.1. Basic, oxido-phosphato-fluorides

3.2.4.1.1.1.1.1.2.1.1. Hydrates

*Bederite (x = 1,(3))	□$Ca_2Mn^{2+}{}_2Fe^{3+}{}_2Mn^{2+}{}_2[PO_4]_6\cdot(H_2O)_2$
Senegalite	$Al_2(OH)_3[PO_4]\cdot H_2O$
Englishite (x = 1,(6))	$K_3Na_2Ca_{10}Al_{15}(OH)_7[PO_4]_{21}\cdot 26H_2O$
Landesite (x = 1,69)	$Mn_9Fe^{3+}{}_3(OH)_3[PO_4]_8\cdot 9H_2O$
Giniite (x = 1,75)	$Fe^{2+}Fe^{3+}{}_4(OH)_2[PO_4]_4\cdot 2H_2O$
Xanthoxenite (x = 1,75)	$Ca_4Fe^{3+}{}_2(OH)_2[PO_4]_4\cdot 3H_2O$
Overite group (x = 1,75)	
Overite	$CaMgAl(OH)[PO_4]_2\cdot 4H_2O$
*Juonniite	$CaMgSc(OH)[PO_4]_2\cdot 4H_2O$
Segelerite	$CaMgFe^{3+}(OH)[PO_4]_2\cdot 4H_2O$
*Manganosegelerite	$(Mn^{2+},Ca)(Mn^{2+},Fe^{2+},Mg)Fe^{3+}(OH)[PO_4]_2\cdot 4H_2O$
*Falsterite	$Ca_2MgMn^{2+}{}_2Fe^{2+}{}_2Fe^{3+}{}_2Zn_4(OH)_4[PO_4]_8\cdot 4H_2O$
*Ferraioloite (x = 1,75)	$MgMn^{2+}{}_4(Fe^{2+}{}_{0.5}Al_{0.5})_4Zn_4[PO_4]_8(OH)_4(H_2O)_{20}$
Lun'okite group (x = 1,75)	
Lun'okite	$MgMnAl(OH)[PO_4]_2\cdot 4H_2O$
Wilhelmvierlingite	$(Ca,Zn)Mn^{2+}Fe^{3+}(OH)[PO_4]_2\cdot 4H_2O$
Whiteite series (x = 1,75)	
Whiteite-(CaFeMg)	$Ca(Fe,Mn)^{2+}Mg_2Al_2(OH)_2[PO_4]_4\cdot 8H_2O$
Whiteite-(CaMnMg)	$CaMn^{2+}Mg_2Al_2(OH)_2[PO_4]_4\cdot 8H_2O$
Whiteite-(CaMnMn)	$CaMn^{2+}Mn_2Al_2(OH)_2[PO_4]_4\cdot 8H_2O$
Whiteite-(MnFeMg)	$(Mn^{2+},Ca)(Fe,Mn)^{2+}Mg_2Al_2(OH)_2[PO_4]_4\cdot 8H_2O$
Jahnsite series (x = 1,75)	
*Jahnsite-(CaMgMg)	$\{Ca\}\{Mg\}\{Mg_2\}\{Fe_2{}^{3+}\}(OH)_2[PO_4]_4\cdot 8H_2O$
*Jahnsite-(CaFeFe)	$\{Ca\}\{Fe^{2+}\}\{Fe_2{}^{2+}\}\{Fe_2{}^{3+}\}(OH)_2[PO_4]_4\cdot 8H_2O$
Jahnsite-(MnMnFe) (Rittmannite)	$MnMnFe^{2+}{}_2Fe^{3+}{}_2(OH)_2[PO_4]_4\cdot 8H_2O$
Jahnsite-(MnMnMn)	$Mn^{2+}Mn^{2+}Mn_2{}^{2+}Fe_2{}^{3+}(OH)_2[PO_4]_4\cdot 8H_2O$
Jahnsite-(CaMnMg)	$CaMn^{2+}Mg_2Fe_2{}^{3+}(OH)_2[PO_4]_4\cdot 8H_2O$
Jahnsite-(CaMnFe)	$CaMn^{2+}Fe_2{}^{2+}Fe_2{}^{3+}(OH)_2[PO_4]_4\cdot 8H_2O$
Jahnsite-(CaMnMn)	$CaMn^{2+}Mn_2{}^{2+}Fe_2{}^{3+}(OH)_2[PO_4]_4\cdot 8H_2O$
*Jahnsite-(NaFeMg)	$NaFe^{3+}Mg_2Fe^{3+}{}_2(OH)_2[PO_4]_4\cdot 8H_2O$
*Gladiusite	$(Fe^{2+},Mg)_4Fe^{3+}{}_2(OH)_{11}[PO_4]\cdot H_2O$
Leucophosphite series (x = 1,75)	
Tinsleyite	$KAl_2(OH)[PO_4]_2\cdot 2H_2O$
*Potassium-rich tinsleyite	$\vert K_{1.5}(H_2O)_{0.5}\vert[Al_2(OH)\{(OH)_{0.5}(H_2O)_{0.5}\}[PO_4]_2]$
Leucophosphite	$KFe^{3+}{}_2(OH)[PO_4]_2\cdot 2H_2O$
Spheniscidite	$(NH_4,K)(Fe^{3+},Al)_2(OH)[PO_4]_2\cdot 2H_2O$
Minyulite (x = 1,75)	$KAl_2(OH,F)[PO_4]_2\cdot 4H_2O$
Natrophosphate (x = 1,75)	$Na_7F[PO_4]_2\cdot 19H_2O$
Vashegyite (x = 1,8)	$Al_{11}(OH)_6[PO_4]_9\cdot 38H_2O$
Calcioferrite family (x = 1,8(3))	
Montgomeryite	$Ca_4MgAl_4(OH)_4[PO_4]_6\cdot 12H_2O$
Kingsmountite	$(Ca,Mn)_4(Fe,Mn)^{2+}Al_4(OH)_4[PO_4]_6\cdot 12H_2O$
Zodacite	$Ca_4MnFe^{3+}{}_4(OH)_4[PO_4]_6\cdot 12H_2O$
Keckite (x = 1,6)	$CaMn^{2+}(Fe^{3+}Mn^{2+})Fe_2{}^{3+}(OH)_3[PO_4]_4\cdot 7H_2O$
*Kapundaite	$NaCaFe^{3+}{}_4(OH)_3[PO_4]_4\cdot 5H_2O$
Vantasselite (x = 2)	$Al_4(OH)_3[PO_4]_3\cdot 9H_2O$
Cacoxenite (x = 2)	$AlFe^{3+}{}_{24}(OH)_{12}O_6[PO_4]_{17}\sim 75H_2O$
Kryzhanovskite group (x = 2)	
Kryzhanovskite	$MnFe^{3+}{}_2(OH)_2[PO_4]_2\cdot H_2O$
Garyansellite	$(Mg,Fe^{3+})_3(OH)[PO_4]_2\cdot 2H_2O$

*Angarfite (x = 2) $NaFe^{3+}_5(OH)_4[PO_4]_4 \cdot 4H_2O$
Gatumbaite (x = 2) $CaAl_2(OH)_2[PO_4]_2 \cdot H_2O$
Isoclasite (x = 2) $Ca_2(OH)[PO_4] \cdot 2H_2O$
Whitmoreite group (x = 2) (compare with arhurite (group))
Whitmoreite $Fe^{2+}Fe^{3+}_2(OH)_2[PO_4]_2 \cdot 4H_2O$
Earlshannonite $Mn^{2+}Fe^{3+}_2(OH)_2[PO_4]_2 \cdot 4H_2O$
Bermanite (x = 2) $Mn^{2+}Mn^{3+}_2(OH)_2[PO_4]_2 \cdot 4H_2O$
*Ercitite(x = 2) $NaMn^{3+}(OH)[PO_4] \cdot 2H_2O$
Sigloite (x = 2) $Fe^{3+}Al_2(OH)_3[PO_4]_2 \cdot 7H_2O$
Vauxite group (x = 2)
Vauxite $Fe^{2+}Al_2(OH)_2[PO_4]_2 \cdot 6H_2O$
*Ferrivauxite $Fe^{3+}Al_2(OH)_3[PO_4]_2 \cdot 5H_2O$
*Ferristrunzite $Fe^{3+}Fe^{3+}_2(OH)_3[PO_4]_2 \cdot 5H_2O$
*Ferrostrunzite $Fe^{2+}Fe^{3+}_2(OH)_2[PO_4]_2 \cdot 6H_2O$
Strunzite $Mn^{2+}Fe^{3+}_2(OH)_2[PO_4]_2 \cdot 6H_2O$
Metavauxite group (x = 2)
Metavauxite $Fe^{2+}Al_2(OH)_2[PO_4]_2 \cdot 8H_2O$
Pseudolaueite $Mn^{2+}Fe^{3+}_2(OH)_2[PO_4]_2 \cdot 8H_2O$
Paravauxite group (x = 2)
Gordonite $MgAl_2(OH)_2[PO_4]_2 \cdot 8H_2O$
*Mangangordonite $Mn^{2+}Al_2(OH)_2[PO_4]_2 \cdot 8H_2O$
*Kastningite $(Mn,Fe,Mg)Al_2(OH)_2[PO_4]_2 \cdot 8H_2O$
*Nordgauite $MnAl_2(F,OH)_2[PO_4]_2 \cdot 5H_2O$
*Kayrobertsonite $MnAl_2(OH)_2[PO_4]_2 \cdot 6H_2O$
Paravauxite $Fe^{2+}Al_2(OH)_2[PO_4]_2 \cdot 8H_2O$
Ushkovite $MgFe^{3+}_2(OH)_2[PO_4]_2 \cdot 8H_2O$
Laueite $Mn^{2+}Fe^{3+}_2(OH)_2[PO_4]_2 \cdot 8H_2O$
*Kummerite $Mn^{2+}Fe^{3+}Al(OH)_2[PO_4]_2 \cdot 8H_2O$
*Ferrolaueite $Fe^{2+}Fe^{3+}_2(OH)_2[PO_4]_2 \cdot 8H_2O$
Stewartite (x = 2) $Mn^{2+}Fe^{3+}_2(OH)_2[PO_4]_2 \cdot 8H_2O$
Kovdorskite (x = 2) $Mg_2(OH)[PO_4] \cdot 3H_2O$
Beraunite (x = 2, 2) $Fe^{2+}Fe^{3+}_5(OH)_5[PO_4]_4 \cdot 4H_2O$
Pararobertsite (x = 2,1(6)) $Ca_2Mn^{3+}_3O_2[PO_4]_3 \cdot 3H_2O$
Wavellite family (x = 2,25)
*Kobokoboite $Al_6(OH)_6[PO_4]_4 \cdot 11H_2O$
Wavellite $Al_3(OH,F)_3[PO_4]_2 \cdot 5H_2O$
Kingite $Al_3(OH,F)_3[PO_4]_2 \cdot 8H_2O$
Tinticite $Fe^{3+}_3(OH)_3[PO_4]_2 \cdot 3H_2O$
*Allanpringite $Fe^{3+}_3(OH)_3[PO_4]_2 \cdot 5H_2O$
Gormanite group (x = 2,25)
Gormanite $Fe^{2+}_3Al_4(OH)_6[PO_4]_4 \cdot 2H_2O$
*Eleonorite $Fe^{3+}_6O(OH)_4[PO_4]_4 \cdot 6H_2O$
Souzalite $Mg_3Al_4(OH)_6[PO_4]_4 \cdot 2H_2O$
Mitridatite group (x = 2,17)
Mitridatite $Ca_2Fe^{3+}_3O_2[PO_4]_3 \cdot 3H_2O$
Robertsite $Ca_2Mn^{3+}_3O_2[PO_4]_3 \cdot 3H_2O$
Natrodufrenite (x = 2,25) $(Na,\square)(Fe^{3+},Fe^{2+})(Fe^{3+},Al)_5(OH)_6[PO_4]_4 \cdot 2H_2O$
Dufrenite $Ca_{0.5}Fe^{2+}Fe^{3+}_5(OH)_6[PO_4]_4 \cdot 2H_2O$
Burangaite $(Na,Ca)(Fe^{2+},Mg)Al_5(OH,O)_6[PO_4]_4 \cdot 2H_2O$
*Matioliite $Na_2Mg_2Al_{10}(OH)_{12}[PO_4]_8 \cdot 4H_2O$

Kidwellite (x = 2,3)	$NaFe^{3+}_9(OH)_{11}[PO_4]_6 \cdot 3H_2O$
*Meurigite	$KFe^{3+}_7(OH)_7[PO_4]_5 \cdot 8H_2O$
*Meurigite-(Na)	$[Na(H_2O)_{2.5}][Fe^{3+}_8(OH)_7[PO_4]_6 \cdot (H_2O)_4$
Phosphofibrite	$(K_{0.5}(H_2O)_3)Fe_8^{3+}[PO_4]_6(OH)_{6.5} \cdot 6.5H_2O$
Eosphorite series (x = 2,5)	
Childrenite	$(Fe,Mn)^{2+}Al(OH)_2[PO_4] \cdot H_2O$
Ernstite	$(Mn^{2+},Fe^{3+})Al(OH)_2[PO_4] \cdot H_2O$
Eosphorite	$(Mn,Fe)^{2+}Al(OH)_2[PO_4] \cdot H_2O$
Foggite (x = 2,5)	$CaAl(OH)_2[PO_4] \cdot H_2O$
Wardite family (x = 2,5) (compare with turquoise (series); faustite (series))	
Aheylite	$(Fe,Zn)Al_6(OH)_8[PO_4]_4 \cdot 4H_2O$
Wardite	$NaAl_3(OH)_4[PO_4]_2 \cdot 2H_2O$
Cyrilovite	$NaFe^{3+}_3(OH)_4[PO_4]_2 \cdot 2H_2O$
*Angastonite	$CaMgAl_2(OH)_4[PO_4]_2 \cdot 7H_2O$
Millisite (x = 2,625)	$(Na,K)CaAl_6(OH)_9[PO_4]_4 \cdot 3H_2O$
Attakolite (x = 2,6(6))	$(Ca,Sr)Mn(Al,Fe^{3+})_4[PO_4]_3[HSiO_4](OH)_4$
Goyazite (x = 2,75)	$SrAl_3(OH)_5[PO_4]_2 \cdot H_2O$
*Springcreekite	$BaV^{3+}_3[(OH)_5(H_2O)]_{\Sigma 6}[PO_4]_2$
Delvauxite (x = 2,75)	$(Ca,Mg)(Fe^{3+},Al)_4(OH)_8[(PO_4),(SO_4),(CO_3)]_2 \cdot (4\text{-}6)H_2O$
Morinite (x = 2,75)	$NaCa_2Al_2(F,OH)_5[PO_4]_2 \cdot 2H_2O$
Aldermanite (x = 2,875)|	$Mg_5Al_{12}(OH)_{22}[PO_4]_8 \cdot 32H_2O$
Fluellite family (x = 3)	
Fluellite	$Al_2(OH)F_2[PO_4] \cdot 7H_2O$
Bolivarite	$Al_2(OH)_3[PO_4] \cdot (4\text{-}5)H_2O$
Evansite(x = 4,5)	$Al_3(OH)_6[PO_4] \cdot 8H_2O$

3.2.4.1.1.1.1.1.2.2. Neutral

Variscite family (x = 1,5)	
Variscite	$Al[PO_4] \cdot 2H_2O$
*Serrabrancaite	$Mn[PO_4] \cdot H_2O$
Strengite	$Fe^{3+}[PO_4] \cdot 2H_2O$
Metavariscite	$Al[PO_4] \cdot 2H_2O$
Phosphosiderite	$Fe^{3+}[PO_4] \cdot 2H_2O$
Kolbeckite	$Sc[PO_4] \cdot 2H_2O$
Koninckite (x = 1,5)	$Fe[PO_4] \cdot 3H_2O$
*Santabarbaraite	$Fe^{3+}_3(OH)_3[PO_4]_2 \cdot 5H_2O$
*Pakhomovskyite	$Co^{2+}_3[PO_4]_2 \cdot 8H_2O$
Fairfieldite group (x = 1,5)	
Cassidyite	$Ca_2Ni^{2+}[PO_4]_2 \cdot 2H_2O$
Collinsite	$Ca_2Mg[PO_4]_2 \cdot 2H_2O$
Messelite	$Ca_2(Fe,Mn)^{2+}[PO_4]_2 \cdot 2H_2O$
Fairfieldite	$Ca_2(Mn,Fe)^{2+}[PO_4]_2 \cdot 2H_2O$
*Hillite	$Ca_2Zn[PO_4]_2 \cdot 2H_2O$
Phosphoferrite group (x = 1,5)	
Phosphoferrite	$Fe^{2+}Fe^{2+}_2[PO_4]_2 \cdot 3H_2O$
*Correianevesite	$Fe^{2+}Mn^{2+}_2[PO_4]_2 \cdot 3H_2O$
Reddingite	$Mn^{2+}Mn^{2+}_2[PO_4]_2 \cdot 3H_2O$
Ludlamite group (x = 1,5)	
Ludlamite	$Fe^{2+}_3[PO_4]_2 \cdot 4H_2O$
Metaswitzerite	$(Mn^{2+},Fe^{2+})_3[PO_4]_2 \cdot 4H_2O$
Switzerite (x = 1,5)	$(Mn,Fe)^{2+}_3[PO_4]_2 \cdot 7H_2O$

Anapaite (x = 1,5) $Ca_2Fe^{2+}[PO_4]_2{\cdot}4H_2O$
Vivianite family (x = 1,5)
Bobierrite $Mg_3[PO_4]_2{\cdot}8H_2O$
*Cattiite $Mg_3[PO_4]_2{\cdot}22H_2O$
*Rimkorolgite $BaMg_5[PO_4]_4{\cdot}8H_2O$
Vivianite group
Barićite $(Mg,Fe^{2+})_3[PO_4]_2{\cdot}8H_2O$
Vivianite $Fe^{2+}{}_3[PO_4]_2{\cdot}8H_2O$
*Arupite $Ni_3[PO_4]_2{\cdot}8H_2O$
Metavivianite $Fe^{2+}Fe_2{}^{3+}(OH)_2[PO_4]_2{\cdot}6H_2O$
Wicksite (x = 1,5) $NaCa_2(Fe,Mn)^{2+}{}_4MgFe^{3+}[PO_4]_6{\cdot}2H_2O$
*Phase like to wicksite $(Ca,Na)_2(Mn,Fe,Mg)_4(Fe,Al)_2[PO_4]_6{\cdot}4H_2O$
*Tassieite $(Na,\square)Ca_2(Mg,Fe^{2+},Fe^{3+})_2(Fe^{3+},Mg)_2(,Fe^{2+},Mg)_2[PO_4]_6{\cdot}2H_2O$ or $NaCa_2Mg_3Fe^{2+}{}_2Fe^{3+}[PO_4]_6{\cdot}2H_2O$
Nastrophite group (x = 1,5)
Nastrophite $Na(Sr,Ba)[PO_4]{\cdot}9H_2O$
Nabaphite $NaBa[PO_4]{\cdot}9H_2O$
Dittmarite family (x = 1,5)
Dittmarite $(NH_4)Mg[PO_4]{\cdot}H_2O$
Niahite $(NH_4)Mn[PO_4]{\cdot}H_2O$
*Struvite group (x = 1,5)
Struvite $(NH_4)Mg[PO_4]{\cdot}6H_2O$
*Struvite-(K) $KMg[PO_4]{\cdot}6H_2O$
*Hazenite $KNaMg_2[PO_4]_2{\cdot}14H_2O$
*Bakhchisaraitsevite $Na_2Mg_5[PO_4]_4{\cdot}7H_2O$
*Apexite $NaMg[PO_4]{\cdot}9H_2O$

*3.2.4.1.1.1.1.1.3. Orthophosphato-carbonates *3.2.4.1.1.1.1.1.3.1. Hydrates
*Krasnovite $Ba(Al,Mg)[(PO_4),(CO_3)](OH)_2{\cdot}H_2O$
*Parwanite $(Na,K)(Mg,Ca)_4Al_8(OH)_7[PO_4]_8[CO_3]{\cdot}30H_2O$

3.2.4.1.1.1.1.1.4. Orthophosphato-sulfates
3.2.4.1.1.1.1.1.4.1. Orthophosphato-sulfates with $PO_4 : SO_4 = 11$
3.2.4.1.1.1.1.1.4.1.1. Hydrates (basic)
Sasaite $Al_6(OH)_3[PO_4]_5{\cdot}36H_2O$

3.2.4.1.1.1.1.1.4.2. Orthophosphato-sulfates with $PO_4 : SO_4 = 5$
3.2.4.1.1.1.1.1.4.2.1. Hydrates (basic)
Peisleyite $Na_2Al_9(OH)_6[(P,S)O_4]_8{\cdot}28H_2O$

3.2.4.1.1.1.1.1.4.3. Orthophosphato-sulfates with $PO_4 : SO_4 = 3$
3.2.4.1.1.1.1.1.4.3.1. Hydrates (basic)
Kribergite $Al_5(OH)_4[PO_4]_3[SO_4]{\cdot}4H_2O$

3.2.4.1.1.1.1.1.4.4. Orthophosphato-sulfates with $PO_4 : SO_4 = 1$ (basic)
Svanbergite $SrAl_3(OH)_6[PO_4][SO_4]$
*Woodhouseite $CaAl_3(OH)_6[PO_4][SO_4]$
*Unnamed $(Ba,Ca,K,Na,REE,Sr)(Al,Fe)_3(OH,F)_6[PO_4][SO_4]$
3.2.4.1.1.1.1.1.4.4.1. Hydrates (basic)
Diadochite family

Sanjuanite $Al_2(OH)[PO_4][SO_4]\cdot 9H_2O$
Diadochite $Fe^{3+}{}_2(OH)[PO_4][SO_4]\cdot 6H_2O$
*Destinezite $Fe^{3+}{}_2(OH)[PO_4][SO_4]\cdot 5H_2O$

3.2.4.1.1.1.1.1.4.5. Orthophosphato-sulfates with $PO_4 : SO_4$ = 0,(6)
3.2.4.1.1.1.1.1.4.5.1. Hydrates (basic)
Hotsonite $Al_5(OH)_{10}[PO_4][SO_4]\cdot 8H_2O$

*3.2.4.1.1.1.1.1.4.6. Orthophosphato-sulfates with $PO_4 : SO_4$ = 0,5
*Rossiantonite $Al_3(OH)_2[PO_4][SO_4]_2(H_2O)_{10}\cdot 4H_2O$

3.2.4.1.1.1.1.1.5. Orthophosphato-fluoraluminates
3.2.3.1.1.1.1.1.5.1. Neutral
Boggildite $Na_2Sr_2[PO_4][Al_2F_9]$

*3.2.4.1.1.1.1.1.5.2. Orthophosphato-sulfato- fluoraluminates
*3.2.4.1.1.1.1.1.5.2.1. Hydrates
Mitryaevaite $Al_4[PO_4]_2[(P,S)O_3(OH,O)]_2AlF_2(OH)_2\cdot 14.5H_2O$

*3.2.4.1.1.1.1.1.6. Hydro-orthophosphates
*3.2.4.1.1.1.1.1.6.1. Hydro-orthophosphates with $[HPO_4] : [PO_4]$ = 0,1(6)
*3.2.4.1.1.1.1.1.6.1.1. Neutral
Whitlockite $Ca_9(Mg,Fe^{2+})[PO_3OH][PO_4]_6$
*Strontiowhitlockite $Sr_9Mg[PO_3OH][PO_4]_6$
*Hedegaardiite $(Ca,Na)_9(Ca,Na)Mg[PO_3OH][PO_4]_6$
*Bobdownsite $Ca_9Mg[PO_3F][PO_4]_6$

3.2.4.1.1.1.1.1.6.2. Hydro-orthophosphat- halogenides with $[HPO_4] : [PO_4]$ = 0,(3)
3.2.4.1.1.1.1.1.6.2.1. Hydrates
3.2.4.1.1.1.1.1.6.2.1.1. Neutral (fluorides)
Mcauslanite $Fe^{2+}{}_3Al_2F[HPO_4][PO_4]_3\cdot 18H_2O$

*3.2.4.1.1.1.1.1.6.3. Hydro-orthophosphates with $[HPO_4] : [PO_4]$ = 0.5
*3.2.4.1.1.1.1.1.6.3.1. Hydrates (basic)
*Matulaite (x = 2) $Fe^{3+}Al_7(OH)_8[PO_3OH]_2[PO_4]_4\ (H_2O)_8\cdot 8H_2O$

3.2.4.1.1.1.1.1.6.4. Hydro-orthophosphates with $[PO_3(OH)] : [PO_4]$ = 1
3.2.4.1.1.1.1.1.6.4.1. Basic
Crandallite group(x = 2,25)
Crandallite $CaAl_3(OH)_6[PO_3(OH)][PO_4]$
*Benauite $SrFe^{3+}{}_3(OH)_6[PO_3(OH)][PO_4]$
Lusungite $SrAl_3(OH)_6[PO_3(OH)][PO_4]$
Gorceixite $BaAl_3(OH)_6[PO_3(OH)][PO_4]$
3.2.4.1.1.1.1.1.6.4.2. Hydrates
*Mejillonesite $NaMg_2(OH)_4[PO_3(OH)][PO_4]\cdot H_2O$
*Afmite $Al_3(OH)_4[PO_3(OH)][PO_4](H_2O)_3\cdot 8H_2O$
*Planerite $Al_6(OH)_8[PO_3(OH)]_2[PO_4]_2\cdot 4H_2O$
*Iangreyite $Ca_2Al_7(OH,F)_{15}[PO_3(OH)]_2[PO_4]_2\cdot 8H_2O$
Hureaulite $Mn_5[PO_3(OH)]_2[PO_4]_2\cdot 4H_2O$

*3.2.4.1.1.1.1.1.6.5. *Hydro-orthophosphates with [HPO_4] : [PO_4] = 1,(3)
*Wopmayite $Ca_6Na_3\square Mn[HPO_4]_4[PO_4]_3$

*3.2.4.1.1.1.1.1.6.6. Hydro-orthophosphates with [HPO_4] : [PO_4] = 2
*Groatite $NaCaMn^{2+}_2[PO_3(OH)]_2[PO_4]$

3.2.4.1.1.1.1.1.6.7. Hydro-orthophosphates with [HPO_4]:[PO_4] = 3
3.2.4.1.1.1.1.1.6.7.1. Hydrates
Francoanellite $K_3Al_5[HPO_4]_6[PO_4]_2\cdot 12H_2O$
Taranakite $K_3Al_5[HPO_4]_6[PO_4]_2\cdot 18H_2O$

*3.2.4.1.1.1.1.1.6.8. Hydro-orthophosphato-carbonates with [HPO_4] : [PO_4] = 0,(3)
*Phosphoellenbergerite $Mg_{14}[PO_4]_6[(HPO_4),(CO_3)]_2(OH)_6$

3.2.4.1.1.1.1.1.7. Hydrophosphates
3.2.4.1.1.1.1.1.7.1. Neutral (all with MO : HPO_4 = 1)
Monetite family
Monetite $Ca[HPO_4]$
Nahpoite $Na_2[HPO_4]$
Phosphammite $(NH_4)_2[HPO_4]$
3.2.4.1.1.1.1.1.7.2. Hydrates
3.2.4.1.1.1.1.1.7.2.1. Basic
Sinkankasite $MnAl(OH)[HPO_4]_2\cdot 6H_2O$
3.2.4.1.1.1.1.1.7.2.2. Neutral
Newberyite family
Newberyite $Mg[HPO_4]\cdot 3H_2O$
Phosphorrösslerite $Mg[HPO_4]\cdot 7H_2O$
Brushite $Ca[HPO_4]\cdot 2H_2O$
Dorfmanite $Na_2[HPO_4]\cdot 2H_2O$
*Catalanoite $Na_2[HPO_4]\cdot 8H_2O$
Hannayite family
Hannayite $(NH_4)_2Mg_3[HPO_4]_4\cdot 8H_2O$
Schertelite $(NH_4)_2Mg[HPO_4]_2\cdot 4H_2O$
Mundrabillaite $(NH_4)_2Ca[HPO_4]_2\cdot H_2O$
*Swaknoite $(NH_4)_2Ca[HPO_4]_2\cdot H_2O$
Stercorite $(NH_4)Na[HPO_4]\cdot 4H_2O$

3.2.4.1.1.1.1.1.8. Hydrophosphsto-sulfates
3.2.4.1.1.1.1.1.8.1. Hydrates
Ardealite $Ca_2[HPO_4][SO_4]\cdot 4H_2O$
*Camaronesite $[Fe^{3+}(H_2O)_2(PO_3OH)]_2[SO_4]\cdot 1\text{-}2H_2O$

*3.2.4.1.1.1.1.1.9. Hydro-dihydrophosphates *3.2.4.1.1.1.1.1.9.1. Hydrates

*Haigerachite $KFe^{3+}_3[H_2PO_4]_6[HPO_4]_2\cdot 4H_2O$
*Unnamed $KFe^{3+}_3[H_2PO_4]_2[HPO_4]_4\cdot 6H_2O$

3.2.4.1.1.1.1.1.10. Dihydrophosphstes 3.2.4.1.1.1.1.1.10.1. Neutral
Biphosphammite group
Archerite $(K,NH_4)[H_2PO_4]$

Biphosphammite $(NH_4,K)[H_2PO_4]$

3.2.4.1.1.1.2. Orthophosphates of Li
3.2.4.1.1.1.2.1. Proper orthophosphates 3.2.4.1.1.1.2.1.1. Neutral (x = 1,5)

Sicklerite series
Ferrisicklerite $Li_{1-x}(Fe,Mn)[PO_4]$
Sicklerite $Li_{1-x}(Mn,Fe)[PO_4]$

Triphylite series
Triphylite $LiFe^{2+}[PO_4]$
Lithiophilite $LiMn^{2+}[PO_4]$
*Simferite $Li(MgMn^{3+}_{0,4}Fe^{3+}_{0,6})_{\sum 2}[PO_4]_2$
Lithiophosphate $Li_3[PO_4]$
*Nalipoite $Li_2Na[PO_4]$

3.2.4.1.1.1.2.1.2. Basic

Griphite (x = 1,(6)) $Ca(Mn^{2+},Na,Li)_6Fe^{2+}Al_2(F,OH)_2[PO_4]_6$

Palermoite series (x = 2)
Bertossaite $(Li,Na)_2CaAl_4(OH,F)_4[PO_4]_4$
Palermoite $(Li,Na)_2(Sr,Ca)Al_4(OH)_4[PO_4]_4$

Amblygonite family (x = 2)

Amblygonite series
Amblygonite $(Li,Na)Al(F,OH)[PO_4]$
Montebrasite $LiAl(OH)[PO_4]$
Tavorite $LiFe^{3+}(OH)[PO_4]$

3.2.4.1.1.1.2.2. Hydrophosphato-phosphates Li

3.2.4.1.1.1.2.2.1. Basic

Tancoite $Na_2LiAl(OH)[HPO_4][PO_4]$

*3.2.4.1.1.1.2.3. Phosphato-carbonates
*3.2.4.1.1.1.2.3.1. Basic

*Peatite-(Y) $LiNa_3(Y,Na,Ca,HREE)_3[PO_4]_3[CO_3](F,OH)_2$
*Ramikite-(Y) $Li_2Na_6(Y,Ca,REE)_3Zr_3[PO_4]_6[CO_3]_2O_2(OH,F)_2$

3.2.4.1.1.1.3. Phosphates of Be → beryllophosphates
3.2.4.1.1.1.3.1. Proper phosphates → beryllophosphates

3.2.4.1.1.1.3.1.1. Neutral (x = 1,5)

Beryllonite $Na[Be(PO_4)]^{\infty}$
Hurlbutite $CaBe_2[PO_4]_2 \rightarrow Ca[Be_2O(P_2O_7)]^{\infty 3}$
*Stronriohurlbutite $SrBe_2[PO_4]_2$
Pahasapaite $(Ca_{5,5}Li_{3,6}K_{1,2}Na_{0,2}\square_{13,5})\{Li_8[Be_{24}(PO_4)_{24}]^{\infty 3}\}^{\infty 3}\cdot(H_2O)_{38}$

3.2.4.1.1.1.3.1.2. Basic (x = 2)

Babefphite $Ba(O,F)[Be(PO_4)]^{\infty 3}$

3.2.4.1.1.1.3.1.3. Acid (x = 2)

Herderite series
Väyrynenite $Mn[Be(OH)(PO_4)]^{\infty 2}$
Hydroxyl-herderite $Ca[Be(OH)(PO_4)]^{\infty 2}$
Fluorherderite $Ca[Be(F,OH)(PO_4)]^{\infty 2}$
*Herderite $CaBeF[PO_4]$

3.2.4.1.1.1.3.1.4. Hydrates

*Faheyite $MnFe^{3+}{}_2Be_2[PO_4]_4 \cdot 6H_2O$

3.2.4.1.1.1.3.1.4.1. Hydrates (acid)

Moraesite family

Moraesite $Be_2(OH)[PO_4] \cdot 4H_2O \rightarrow$

$\rightarrow Be(H_2O)_4[Be(OH)(PO_4)]$

*Weinebeneite $CaBe_3(OH)_2[PO_4]_2 \cdot 4H_2O \rightarrow$

$\rightarrow CaBe(H_2O)_4[Be(OH)(PO_4)\}^{\infty}{}_2$

Uralolite $Ca_2Be_4(OH)_3[PO_4]_3 \cdot 5H_2O$

Roscherite family

Zanazziite (x = 1,8(3)) $Ca_2(Mg,Fe^{2+})(Mg,Fe^{2+},Al)_4(OH)_4Be_4[PO_4]_6 \cdot 6H_2O$

*Atencioite $Ca_2Fe^{2+}\square Mg_2Fe^{2+}{}_2(OH)_4Be_4[PO_4]_6 \cdot 6H_2O$

*Footemineite $Ca_2Mn^{2+}\square Mn^{2+}{}_2Mn^{2+}{}_2 (OH)_4Be_4[PO_4]_6 \cdot 6H_2O$

*Greifensteinite $Ca_2(Fe^{2+},Mn^{2+})_5(OH)_4Be_4[PO_4]_6 \cdot 6H_2O$

Roscherite (x = 2) $Ca_2Mn_5{}^{2+}Be_4(OH)_4[PO_4]_6 \cdot 6H_2O$

*Ruifrancoite $Ca_2\square_2(Fe^{3+},Mn^{2+},Mg)_4(OH)_4(OH,H_2O)_2Be_4[PO_4]_6 \cdot 4H_2O$

*Gimaräesite $Ca_2(Zn,Mg,Fe)_5(OH)_4Be_4[PO_4]_6 \cdot 6H_2O$

3.2.4.1.1.1.3.2. Hydrophosphato-orthophosphates→beryllophosphato-hydrophosphates (?)

3.2.4.1.1.1.3.2.1. Hydrates

Fransoletite family

Fransoletite $Ca_3Be_2[HPO_4]_2[PO_4]_2 \cdot 4H_2O \rightarrow Ca_3[HPO_4]_2[BePO_4]_2 \cdot 4H_2O$

*Parafransoletite $Ca_3Be_2[PO_3(OH)]_2[PO_4]_2 \cdot 4H_2O$

Ehrleite $Ca_2ZnBe[PO_3OH][PO_4]_2 \cdot 4H_2O$

3.2.4.1.1.3.3. Beryllophosphates with unknown structure

3.2.4.1.1.1.3.3.1. Hydrates

Tiptopite (x = 2) *$K_2Na_3Li_3(OH)_2Be_6[PO_4]_6 \cdot H_2O$

Glucine (x = 2,5) $Ca(OH)_4Be_4[PO_4]_2 \cdot 0{,}5H_2O$

3.2.4.1.1.2.Phosphates of ***f***-elements

3.2.4.1.1.2.1. Proper phosphates

3.2.4.1.1.2.1.1. Neutral (x = 1,5)

Monazite family

Monazite series

Monazite-(Ce) $Ce[PO_4]$

Monazite-(La) $La[PO_4]$

Monazite-(Nd) $Nd[PO_4]$

*Монацит-(Sm) $Sm[PO_4]$

Cheralite $CaTh[PO_4]_2$

Xenotime-(Y) $Y[PO_4]$

*Xenotime-(Yb) $Yb[PO_4]$

Vitusite-(Ce) $Na_3Ce[PO_4]_2$

*Stornesite-(Y) $Y\square_2Na_6(Ca_5Na_3)(Mg,Fe)_{43}[PO_4]_{36}$

*Deloneite-(Ce) $(Na_{0.5}REE_{0.25}Ca_{0.25})(Ca_{0.75}REE_{0.25})Sr_{1.5}(CaNa_{0.25}REE_{0.25})[PO_4]_{30.5}(F, OH)$

*Karlgizekite-(Nd) $NaNdCa_3[PO_4]_3F$

Florencite group

3.2.4.1.1.2.1.2. Basic (x = 1,5)

Florencite-(Ce) $CeAl_3(OH)_6[PO_4]_2$

Florencite-(La) $LaAl_3(OH)_6[PO_4]_2$

Florencite-(Nd) $NdAl_3(OH)_6[PO_4]_2$

*Florencite-(Sm) $(Sm,Nd)Al_3(OH)_6[PO_4]_2$

Eylettersite $Th_{0.75}Al_3(OH)_6[PO_4]_2$

3.2.4.1.1.2.1.3. Hydrates(basic)

Vyacheslavite family (x = 2)

Vyacheslavite $U^{4+}(OH)[PO_4]\cdot nH_2O$

Lermontovite $U^{4+}(OH)[PO_4]\cdot H_2O$

3.2.4.1.1.2.1.3.2. Neutral

Rhabdophane group (x = 1,5)

Rhabdophane -(Ce)` $Ce[PO_4]\cdot H_2O$

Rhabdophane -(La) $La[PO_4]\cdot H_2O$

Rhabdophane -(Nd) $Nd[PO_4]\cdot H_2O$

Rhabdophane-(Y) $Y[PO_4]\cdot H_2O$

Grayite $(Th,Pb,Ca)[PO_4]\cdot H_2O$

Brockite $(Ca,Th,Ce^{3+})[PO_4]\cdot H_2O$

Tristramite $(Ca,U^{4+},Fe^{3+})[(PO_4),(SO_4)]\cdot 2H_2O$

Ningyoite $(U^{4+},Ca_2[PO_4]_2\cdot 1\text{-}2H_2O$

Churchite-(Y) $Y[PO_4]\cdot 2H_2O$

Churchite-(Nd) $Nd[PO_4]\cdot 2H_2O$

3.2.4.1.2. Subclass: Phosphates of cations with middle FC

3.2.4.1.2.1.Phosphates of Zr

3.2.4.1.2.1.1. Proper phosphates 3.2.4.1.2.1.1.1. Neutral (x = 1,5)

*Kosnarite $KZr_2[PO_4]_3$

*3.2.4.1.2.1.1.1.1. Hydrates

Gainesite $Na_2Zr_2Be[PO_4]_4\cdot 1{,}5H_2O$

*Zigrasite $MgZr[PO_4]_2(H_2O)_4$

*Mahlmoodite $FeZr[PO_4]_2\cdot 4H_2O$

*Mccrillisite $NaCsZr_2(Be,Li)[PO_4]_4\cdot 1\text{-}2H_2O$

*Selwynite $NaKZr_2(Be,Al)[PO_4]_4\cdot 2H_2O$

*3.2.4.1.2.1.1.1.2. Hydrates (basic)

*Wycheproofite $NaAlZr(OH)_2[PO_4]_2\cdot H_2O$

3.2.4.1.2.1.2. Phosphato-carbonates 3.2.4.1.2.1.2.1. Hydrates (basic)

Voggite $Na_2Zr(OH)[PO_4][CO_3]\cdot 2H_2O$

3.2.4.1.2.3. Phosphates of Ti 3.2.4.1.2.3.1. Basic

Curetonite $Ba_4Al_3Ti(O,OH)_4F[PO_4]_4$

3.2.4.1.2.3.1.1. Hydrates (basic)

Mantienneite group

Mantienneite $KMg_2Al_2Ti^{4+}(OH)_3[PO_4]_4\cdot 15H_2O$

Paulkerrite $K(Mg,Mn)_2(Fe^{3+},Al)_2Ti^{4+}(OH)_3[PO_4]_4\cdot 15H_2O$

*Benyacarite $(H_2O,K)_2Ti(Mn,Fe)^{2+}{}_2(Fe^{3+},Ti)_2[PO_4]_4(O,F)_2\cdot 14H_2O$

*3.2.4.1.2.3.2. Titano-(niobo)-oxido-dihydrophosphates

*Tazzoliite $Ba_{4-x}Na_xTi_2Nb_3SiO_{17}[PO_2(OH)_2]_x(OH)_{1-2x}$; $(0\leq x\leq 0.5)$

3.2.4.1.2.4. Phosphates of Nb and Ta 3.2.4.1.2.4.1. Oxido-hydrates

Olmsteadite group

Olmsteadite $KFe^{2+}{}_2(Nb,Ta)O_2[PO_4]_2\cdot 2H_2O$

Johnwalkite $K(Mn,Fe^{3+})_2(Nb,Ta)O_2[PO_4]_2\cdot 2(H_2O,OH)$

3.2.4.1.2.5. Phosphates of V^{4+} 3.2.4.1.2.5.1 Oxido-hydrates
Sincosite $Ca(V^{4+}O)_2[PO_4]_2 \cdot 5H_2O$
*Bariosincosite $Ba(V^{4+}O)_2[PO_4]_2 \cdot 4H_2O$
*Cloncurryite $Cu^{2+}V^{4+}Al_4OF_4[PO_4]_4 \cdot 10H_2O$

3.2.4.1.3. Subclass: Orthophosphates of chalcophylic elements
3.2.4.1.3.1.Orthophosphates of Cu
3.2.4.1.3.1.1. M^{2+}
3.2.4.1.3.1.1.1.Proper phosphates 3.2.4.1.3.1.1.1.1. Hydrates (basic and phosphato-halogenides)
Nissonite (x=2) $Cu_2Mg_2(OH)_2[PO_4]_2 \cdot 5H_2O$

3.2.4.1.3.1.2. M^{2+} and M^{3+}
3.2.4.1.3.1.2.1. Proper phosphates 3.2.4.1.3.1.2.1.1. Основные
Hentschelite (x=1,5) (comp. with lazulite (gr.) $Cu^{2+}Fe^{3+}{}_2(OH)_2[PO_4]_2$
*Zincolibethenite $CuZn(OH)[PO_4]$
Libethenite $Cu_2(OH)[PO_4]$
Pseudomalachite $Cu_5(OH)_4[PO_4]_2$
Reichenbachite $Cu_5(OH)_4[PO_4]_2$
Ludjibaite $Cu_5(OH)_4[PO_4]_2$
Cornetite $Cu_3(OH)_3[PO_4]$
3.2.4.1.3.1.2.1.2. Hydrates (basic)
*Kunatite $Cu^{2+}Fe^{3+}{}_2(OH)_2[PO_4]_2 \cdot 4H_2O$
Petersite-(Y) (x=2,5) (comp. with mixite (gr.)) $Cu^{2+}{}_6(Y,Ce,Nd,Ca)(OH)_6[PO_4]_3 \cdot 3H_2O$
Turquoise series (x=2,5) (compare with wardire (family); faustite (series)
Coeruleolactite $(Ca,Cu)Al_6(OH)_8[PO_4]_4$ $(4\text{-}5)H_2O$
Turquoise $CuAl_6(OH)_8[PO_4]_4 \cdot 4H_2O$
Chalcosiderite $CuFe^{3+}{}_6(OH)_8[PO_4]_4 \cdot 4H_2O$
*Bleasdaleite $(Ca,Fe^{3+})_2Cu_5(Bi,Cu)[PO_4]_4(H_2O,OH,Cl)_{13}$
Zapatalite (x=3) $Cu_3Al_4(OH)_9[PO_4]_3 \cdot 4H_2O$
Sieleckiite (x=4,5) $Cu_3Al_4(OH)_{12}[PO_4]_2 \cdot 2H_2O$

*3.2.4.1.3.1.2. Hydro-orthophosphates
*Calciopetersite $CaCu^{2+}{}_6(OH)_6[PO_3OH][(PO_4]_2 \cdot 3H_2O$

*3.2.4.1.3.1.2.3. Phosphato-oxides *3.2.4.1.3.1.2.3.1. Hydrates
*Mrázekite $Cu^{2+}{}_3Bi^{3+}{}_2(OH)_2O_2[PO_4]_2 \cdot 2H_2O$

3.2.4.1.3.1.2.4. Phosphato-sulfates
*Birchite $Cd_2Cu_2[PO_4]_2[SO_4] \cdot 2H_2O$

*3.2.4.1.3.1.2.5. Phosphato -halogenides *3.2.4.1.3.1.2.5.1. Hydrates
*Goldquarryite $(Cu^{2+},\square)(Cd,Ca)_2Al_3[PO_4]_4F_2(H_2O)_{10}\{(H_2O),F\}_2$
*Nevadaite $(Cu^{2+}\square AlV^{3+})_{\Sigma 6}\{Al_8[PO_4]_8F_8\}(OH)_2(H_2O)_{22}$

3.2.4.1.3.1.3. M^{+} and M^{2+}
3.2.4.1.3.1.3.1. Phosphato-halogenides 3.2.4.1.3.1.3.1.1. Hydrates (basic)

Sampleite (x = 1,625) $NaCaCu_5Cl[PO_4]_4 \cdot 5H_2O$

3.2.4.1.3.2. Orthophosphates of Zn^{2+}
3.2.4.1.3.2.1. Proper phosphates 3.2.4.1.3.2.1.1. Basic
Tarbuttite (x = 2) $Zn_2(OH)[PO_4]$
3.2.4.1.3.2.1.2. Hydrates 3.2.4.1.3.2.1.2.1. Basic
Spencerite (x = 2) $Zn_4(OH)_2[PO_4]_2·3H_2O$
Kipushite family (x = 3)
Kipushite $(Zn,Cu)_6(OH)_6[PO_4]_2·H_2O$
Veszelyite $(Zn,Cu)_3(OH)_3[PO_4]·2H_2O$
3.2.4.1.3.2.1.2. Neutral
3.2.4.1.3.2.1.2.1. Hydrates
Hopeite family (x = 1,5)
Phosphophyllite $Zn_2(Fe,Mn)^{2+}[PO_4]_2·4H_2O$
Hopeite $Zn_3[PO_4]_2·4H_2O$
Parahopeite $Zn_3[PO_4]_2·4H_2O$
*Nizamoffite $Mn^{2+}Zn_2[PO_4]_2(H_2O)_4$
Scholzite $CaZn_2[PO_4]_2·2H_2O$
Parascholzite $CaZn_2[PO_4]_2·2H_2O$

3.2.4.1.3.2a. M^{2+} and M^{3+}
3.2.4.1.3.2a.1. Proper phosphates
3.2.4.1.3.2a.1.1. Basic
*Plimerite (x = 2.3) $ZnFe^{3+}{}_4(OH)_5[PO_4]_3$
*Zinclipscombite (x = 2) $ZnFe^{3+}{}_2(OH)_2[PO_4]_2$
3.2.4.1.3.2a.1.1.1. Hydrates
*Zincoberaunite(x = 2.125) $ZnFe^{3+}{}_5(OH)_5[PO_4]_4·6H_2O$
Kleemanite family (x = 2)
Kehoeite $(Zn, Ca)Al_2(OH)_2[PO_4]_2·5H_2O$ (?)
Kleemanite $ZnAl_2(OH)_2[PO_4]_2·3H_2O$
Jungite (x=2) $Ca_2Zn_4Fe^{3+}{}_8(OH)_9[PO_4]_9·16H_2O$
Schoonerite (x = 1,8(3)) $ZnMn^{2+}Fe^{2+}{}_2Fe^{3+}(OH)_2[PO_4]_3·9H_2O$
*Flurlite (x = 1,8(3)) $Zn_3Mn^{2+}Fe^{3+}(OH)_2[PO_4]_3·9H_2O$
*Ferraioloite (x = 1,75) $MgMn^{2+}{}_4(Fe^2+_{0.5}Al_{0.5})_4Zn_4(OH)_4[PO_4]_8·20H_2O$
Faustite series (x = 2,5) (compare with turquoise (series))
Aheylite $(Fe,Zn)Al_6(OH)_8[PO_4]_4·4H_2O$
Faustite $(Zn,Cu)Al_6(OH)_8[PO_4]_4·4H_2O$

*3.2.4.1.3.2a.2. Phosphato-carbonates *3.2.4.1.3.2a.2.1. Hydrates(basic)
*Scorpionite $Ca_3Zn_2(OH)_2[PO_4]_2[CO_3]·H_2O$

3.2.4.1.3.3. Phosphstes of Pb
3.2.4.1.3.3.1. Proper phosphates and phosphato-halogenides
3.2.4.1.3.3.1.1. Basic and phosphato-halogenides
Pyromorphite series (x = 1,(6)) (compare with apatite (family); mimetite (group))
Pyromorphite $Pb_5Cl[PO_4]_3$
Hydroxylpyromorphite $Pb_5(OH)[PO_4]_3$
*Phosphohedyphane $Ca_2Pb_3[PO_4]_3Cl$
*Fluorphosphohedyphane $Ca_2Pb_3[PO_4]_3F$
*3.2.4.1.3.3.1.2. Hydrates (basic)
*Phosphogartrellite(x = 1,5) $PbCuFe[PO_4]_2(OH)·H_2O$
*Kintoreite (x = 2) $PbFe_3[PO_4][PO_3 OH] (OH)_6$

*Pattersonite $PbFe_3[PO_4]_2(OH)_5{\cdot}H_2O$

3.2.4.1.3.3.2. Hydrophoshato-phosphates

3.2.4.1.3.3.2.1. Basic

Drugmanite (x=1,75) $Pb_2(Fe^{3+},Al)(OH)_2[PO_3(OH)][PO_4]$
Plumbogummite (x=2,75) $PbAl_3(OH)_6[PO_3(OH)][PO_4]$

3.2.4.1.3.3.3. Hydrophoshato-phosphato-sulfates

3.2.4.1.3.3.3.1. Hydrates (basic)

Orpheite (x=2,35) discredited

3.2.4.1.3.3.4. Phosphato-sulfates 3.2.4.1.3.3.4.1. Basic

Tsumebite (x=1,5) $Pb_2Cu(OH)[PO_4][SO_4]$
Hinsdalite group (x=2,75) (compare with beudantite (group)
Hinsdalite $(Pb,Sr)Al_3(OH)_6[PO_4][SO_4]$
Corkite $PbFe^{3+}{}_3(OH)_6[PO_4][SO_4]$

3.2.4.1.3.3.5. Phosphato-chromates 3.2.4.1.3.3.5.1. Basic

Vauquelinite (x=1,25) $Pb_2Cu(OH)[PO_4][CrO_4]$
Embreyite (x=1,25) $Pb_5[PO_4]_2[CrO_4]_2{\cdot}H_2O$

*3.2.4.1.3.3.6. Phosphato-vanadates *3.2.4.1.3.3.6.1. Basic

*Bushmakinite $Pb_2Al(OH)[PO_4][VO_4]$
*Ferribushmakinite $Pb_2Fe^{3+}(OH)[PO_4][VO_4]$

*3.2.4.1.3.4. Phosphates of Hg

*3.2.4.1.3.4.1. Proper phosphates

3.2.4.1.3.4.1.1.Basic

*Artsmithite $Hg_4Al(OH)_{1+3x}[PO_4]_{2-x}$ x = 0,26

3.2.4.1.3.5. Phosphates of Va-cations (Bi^{3+})

3.2.4.1.3.5.1. Neutral

Ximengite (x=1,5) $BiPO_4$

3.2.4.1.3.4.2. Oxido-hydroxido-phosphates

3.2.4.1.3.5.2.1. Basic

Paulkellerite (x=4,5) $Bi_2Fe^{3+}(OH)_2O_2[PO_4]$
*Brendelite $(Bi,Pb)_2Fe^{3+}(OH)O_2[PO_4]$
*Petitjeanite $Bi^{3+}{}_3O(OH)[PO_4]_2$
*Smrkovecite $Bi_2O(OH)[PO_4]$
Waylandite family (x=3)
Zaïrite $BiFe^{3+}{}_3(OH)_6[PO_4]_2$
Waylandite $BiAl_3(OH)_6[PO_4]_2$
Hydroxylphosphabismite $Bi_2(OH)_3[PO_4]$

*3.2.4.1.3.4.2.2. Hydrates

*Mrázekite $Bi_2Cu^{2+}{}_3(OH)_2O_2[PO_4]_2{\cdot}2H_2O$

*3.2.4.2. Quasiclass: Pyrophosphates

*3.2.4.2.1. Subclass: Pyrophosphates of ***s*-, *d_s***- and ***p_s*** - cations

*3.2.4.2.1.1. Pyrophosphates of ***s-, d_s***- and ***p_s*** - cations without Li and Be
*3.2.4.2.1.1.1. Proper pyrophosphates
*Pyrocoproite $Mg(K,Na)_2[P_2O_7]$
*3.2.4.2.1.1.1.1. Hydrates
Canaphite $Na_2Ca[P_2O_7]\cdot 4H_2O$
*Arnhemite $(K,Na)_4Mg_2[P_2O_7]_2\cdot 5H_2O$

*3.2.4.2.2. Subclass: Pyrophosphates of chalcophylic elements
*3.2.4.2.2.1. Pyrophosphates of Cu
*3.2.4.2.2.1.1. M^+ и M^{2+}
*3.2.4.2.2.1.1.1. Proper pyrophosphates
*3.2.4.2.2.1.1.1.1. Hydrates
*Wooldridgeite $Na_2CaCu^{2+}{}_2[P_2O_7]_2(H_2O)_{10}$

*3.2.4.3. Quasiclass: Triphosphates
*3.2.4.3.1. Subclass: Triphosphates of cations with low FC
*3.2.4.3.1.1. Triphosphates ***s-, d_s***- and ***p_s*** - cations
*3.2.4.3.1.1. Triphosphates ***s-, d_s***- and ***p_s*** - cations without Li and Be
*3.2.4.3.1.1.1. Proper triphosphates *3.2.4.3.1.1.1.1. Hydrates
*Kanonerovite $MnNa_3P_3O_{10}\cdot 12H_2O$

3.2.4a. Class: Arsenates
3.2.4a.1. Quasiclass: (6)-Arsenates
3.2.4a.1.1. (6)-Arsenates of ***d-*** cations
3.2.4a.1.1.1. (6)-Arsenates of Cu^{2+}
3.2.4a.1.1.1.1. Oxido-(6)-arsenates x = MO/$[AsO_4]$
3.2.4a.1.1.1.1.1. Hydrates
Geminite $Cu[AsO_3OH]\cdot H_2O$

3.2.4a.1.2. (6)-Arsenates of ***p-***cations
3.2.4a.1.2.1. (6)-Arsenates of Pb^{2+} 3.2.4a.1.2.1.1. Neutral
Ludlockite $PbFe_4{}^{3+}As_{10}{}^{3+}O_{22}$

3.2.4a.2. Quasiclass: (4)-Arsenates (orthoarsenates)
3.2.4a.2.1. Orthoarsenates of cations with low FC
3.2.4a.2.1.1. Orthoarsenates of ***s-, d_s***- and ***p_s***- cations
3.2.4a.2.1.1.1. Orthoarsenates of ***s-, d_s***- and ***p_s***- cations without Li and Be
3.2.4a.2.1.1.1.1. Proper orthoarsenates 3.2.4a.2.1.1.1.1.1. Neutral
*Alarsite $Al[AsO_4]$
Xanthiosite $Ni_3[AsO_4]_2$
Berzeliite family
Berzeliite series (compare with garnet (series)) (x = 1.5)
Manganberzeliite $Ca_2NaMn_2[AsO_4]_3$
Berzeliite $NaCa_2Mg_2[AsO_4]_3$
Caryinite (x = 1.5) $NaCaCa(Mn,Mg)_2[AsO_4]_3$
(compare with alluaudite (family))
*Arsenioplеite (x = 1.5) $CaNaMn^{2+}Mn^{2+}{}_2[AsO_4]_3$
*Ozerovaite (x = 1.5) $Na_2KAl_3[AsO_4]_4$
*Calciojohillerite (x = 1.5) $NaCaMg_3[AsO_4]_3$

*Badalovite (x = 1.5) $Na_2Mg_2Fe^{3+}[AsO_4]_3$
*Yurmarinite (x = 1.6) $Na_7(Fe^{3+},Mg,Cu)_4[AsO_4]_6$
*Anatolyite (x = 2) $Na_6(Ca,Na)(Mg,Fe^{3+})_3Al[AsO_4]_6$
*Magnesiohatertite (x = 2.2) $(Na,Ca)_2Ca(Mg,Fe^{3+})_2[AsO_4]_3$

3.2.4a.2.1.1.1.1.1.1. Hydrates

Scorodite series
Mansfieldite $Al[AsO_4]\cdot 2H_2O$
Scorodite $Fe^{3+}[AsO_4]\cdot 2H_2O$
Kankite $Fe^{3+}[AsO_4]\cdot 3,5H_2O$
Grischunite $NaCa_2Mn^{2+}{}_5Fe^{3+}[AsO_4]_6\cdot 2H_2O$
Sterlinghillite $Mn_3[AsO_4]_2\cdot 3H_2O$
*Parascorodite $Fe^{3+}[AsO_4]\cdot 2H_2O$
*Yazganite $NaFe^{3+}{}_2Mg[AsO_4]_3\cdot H_2O$

Erythrite family
Erythrite series (compare with vivianite (group))
Hörnesite $Mg_3[AsO_4]_2\cdot 8H_2O$
Annabergite $Ni_3[AsO_4]_2\cdot 8H_2O$
Erythrite $Co_3[AsO_4]_2\cdot 8H_2O$
Manganese-hörnesite $(Mn,Mg)_3[AsO_4]_2\cdot 8H_2O$
*Castellaroite $Mn^{2+}{}_3[AsO_4]_2\cdot 4.5H_2O$
Parasymplesite $Fe^{2+}{}_3[AsO_4]_2\cdot 8H_2O$
Symplesite $Fe^{2+}{}_3[AsO_4]_2\cdot 8H_2O$
Rauenthalite $Ca_3[AsO_4]_2\cdot 10H_2O$
Phaunouxite $Ca_3[AsO_4]_2\cdot 11H_2O$

Roselite family
Roselite series
Wendwilsonite $Ca_2Mg[AsO_4]_2\cdot 2H_2O$
Roselite $Ca_2Co[AsO_4]_2\cdot 2H_2O$
Zincroselite $Ca_2Zn[AsO_4]_2\cdot 2H_2O$
Gaitite $Ca_2Zn[AsO_4]_2\cdot 2H_2O$
Brandtite $Ca_2Mn[AsO_4]_2\cdot 2H_2O$
Parabrandtite $Ca_2Mn[AsO_4]_2\cdot 2H_2O$
Talmessite series
Talmessite $Ca_2Mg[AsO_4]_2\cdot 2H_2O$
*Nickeltalmessite $Ca_2Ni[AsO_4]_2\cdot 2H_2O$
Roselite-вета = betaroselite $Ca_2Co[AsO_4]_2\cdot 2H_2O$
Smolianinovite (x = 1,5) $(Co,Ni,Mg,Ca)_3(Fe^{3+},Al)_2[AsO_4]_4\cdot 11H_2O$

3.2.4a.2.1.1.1.1.1. Basic

Johnbaumite $Ca_5(OH)[AsO_4]_3$
Fermorite $Ca_5(OH)[AsO_4]_3$
*Grandaite (x = 1.75) $Sr_2Al(OH)[AsO_4]_2$
Eveite (x = 2) (comp. with adamite (gr.)) $Mn_2(OH)[AsO_4]$

Adelite family (x = 2) (compare with conichalcite (group); austinite (group)
Adelite (x = 2) $CaMg(OH)[AsO_4]$
Nickelaustinite $Ca(Ni,Zn)(OH)[AsO_4]$
*Sewardite $CaFe^{3+}{}_2(OH)_2[AsO_4]_2$
Sarkinite $Mn^{2+}{}_2(OH)[AsO_4]$
Arsenoclasite (x = 2,5) $Mn^{2+}{}_5(OH)_4[AsO_4]_2$
Flinkite (x = 3,5) $Mn^{2+}{}_2Mn^{3+}(OH)_4[AsO_4]$
Allactite (x = 3,5) $Mn^{2+}{}_7(OH)_8[AsO_4]_2$

Jarosewichite (x = 4,5) $Mn^{2+}{}_3Mn^{3+}(OH)_6[AsO_4]$
*Canosioite $Ba_2Fe^{3+}(OH)[AsO_4]_2$

3.2.4a.2.1.1.1.1.2.1. Hydrates

*Cabalzarite $Ca(Mg,Al,Fe)_2[AsO_4]_2(H_2O,OH)_2$
*Cobaltlotharmeyerite (x = 1,5) $Ca(Co,Fe^{3+},Ni)_2[AsO_4]_2(OH,H_2O)_2$
*Nickellotharmeyerite (x = 1,5) $Ca(Ni,Fe^{3+})_2[AsO_4]_2(H_2O,OH)_2$
*Barahonite-(Al) (x = 1,88) $Ca_{12}Al_2(OH)_6[AsO_4]_8{\cdot}6H_2O$
*Barahonite-(Fe) $Ca_{12}Fe^{3+}{}_2(OH)_6[AsO_4]_8{\cdot}6H_2O$
*Cobaltarthurite (x = 2) $Co^{2+}Fe^{3+}{}_2(OH)_2[AsO_4]_2{\cdot}4H_2O$
*Maghrebite $MgAl_2(OH)_2[AsO_4]_2{\cdot}8H_2O$
*Bendadaite $Fe^{2+}Fe^{3+}{}_2(OH)_2[AsO_4]_2{\cdot}4H_2O$
*Césarferreiraite $Fe^{2+}Fe^{3+}{}_2(OH)_2[AsO_4]_2{\cdot}8H_2O$
Camgasite (x = 2) $CaMg(OH)[AsO_4]{\cdot}5H_2O$
*Coralloite (x = 2) $Mn^{2+}Mn^{3+}{}_2(OH)_2[AsO_4]_2{\cdot}4H_2O$
*Tapiaite $Ca_5Al_2(OH)_4[AsO_4]_4{\cdot}12H_2O$

Alumopharmacosiderite family (x = 2,1(6))
Alumopharmacosiderite $KAl_4(OH)_4[AsO_4]_3{\cdot}6,5H_2O$
Pharmacosiderite $KFe^{3+}{}_4(OH)_4[AsO_4]_3{\cdot}(6\text{-}7)H_2O$
*Bariuopharmacosiderite $BaFe^{3+}{}_8(OH)_8[AsO_4]_6{\cdot}10H_2O$
*Hydroniumpharmacosiderite $(H_3O)\ Fe^{3+}{}_4(OH)_4[AsO_4]_3{\cdot}4H_2O$
*Hydroniumpharmacoalumite $(H_3O)Al_4(OH)_4[AsO_4]_3{\cdot}4H_2O$
*Cesiumpharmacosiderite $CsFe^{3+}{}_4(OH)_4[AsO_4]_3{\cdot}4H_2O$
Talliumpharmacosiderite $TlFe_4[AsO_4]_3{\cdot}4H_2O$
*Bariopharmacoalumite $Ba_{0.5}Al_4(OH)_4[AsO_4]_3{\cdot}4H_2O$
*Natropharmacoalumite $NaAl_4(OH)_4[AsO_4]_3{\cdot}4H_2O$

Ferrisymplesite (x = 2,25) $Fe^{3+}{}_3(OH)_3[AsO_4]_2{\cdot}5H_2O$
*Kamaricaite(x = 2,25 $Fe^{3+}{}_3(OH)_3[AsO_4]_2{\cdot}3H_2O$
*Natropharmacosiderite (x = 2,(3)) $Na_2Fe^{3+}{}_4(OH)_5[AsO_4]_3{\cdot}7H_2O$
Calcium-pharmacosiderite (x = 2,(3)) $CaFe^{3+}{}_4(OH)_5[AsO_4]_3{\cdot}5H_2O$
*Ba-Zn-alumofarmacosiderite (x = 2,(3))
$(Ba,K)_{0,5}(Zn,Cu)_{0,5}(Al,Fe)_4(OH)_5[AsO_4]_3{\cdot}5H_2O$
Yukonite (x = 2,375) $Ca_2Fe^{3+}{}_5(OH)_7[AsO_4]_4{\cdot}7H_2O$

Akrochordite family (x = 2,5)
Akrochordite $MgMn^{2+}{}_4(OH)_4[AsO_4]_2{\cdot}4H_2O$
Wallkilldellite-Mn $Ca_2Mn^{2+}{}_3(OH)_4[AsO_4]_2{\cdot}9H_2O$
*Wallkilldellite-Fe $(Ca,Cu)_4Fe_6(OH)_8[(As,Si)O_4]_4{\cdot}18H_2O$

Ogdensburgite (x = 2,6) $(Ca,Zn,Mn)_4Fe^{3+}{}_6(OH)_{11}[AsO_4]_5{\cdot}5H_2O$
*Esperansaite (x = 2,75) $NaCa_2Al_2(OH)F_4[AsO_4]_2{\cdot}2H_2O$
Bulachite (x = 3) $Al_2(OH)_3[AsO_4]{\cdot}3H_2O$
*Bettertonite $Al_6(OH)_9[AsO_4]_3{\cdot}16H_2O$
*Penberthycroftite $Al_6(OH)_9(H_2O)_5[AsO_4]_3{\cdot}8H_2O$
Liskeardite (x = 4,5) $(Al,Fe)_3(OH)_6[AsO_4]{\cdot}5H_2O$

3.2.4a.2.1.1.1.2. Oxido-orthoarsenates (neutral)

*Wrightite (x = 2) $K_2Al_2O[AsO_4]_2$
*Katiarsite (x = 2.5) $KTiO[AsO_4]$
*Arsenatrotitanite(x = 2.5) $NaTiO[AsO_4]$
Angelellite (x = 3) $Fe^{3+}{}_4O_3[AsO_4]_2$

3.2.4a.2.1.1.1.2.1. Hydrates

Arseniosiderite family (x = 2,1(6))

Kolfanite $Ca_2Fe^{3+}{}_3O_2[AsO_4]_3 \cdot 2H_2O$
Arseniosiderite $Ca_2Fe^{3+}{}_3O_2[AsO_4]_3 \cdot 3H_2O$

3.2.4a.2.1.1.1.2.1.1 Oxido-orthoarsenato-arsenito-silicates (basic)
*Turtmannite $(Mn,Mg)_{22,5}Mg_{3-3x}O_{5-5x}(OH)_{20+x}[(V,As)O_4]_3[AsO_3]_x[SiO_4]_3$

*3.2.4a.2.1.1.1.2.1.2. Oxido-orthoarsenato-carbonates
*Sailaufite $(Ca,Na,\square)_2Mn^{3+}{}_3O_2[AsO_4]_2[CO_3] \cdot 3H_2O$

3.2.4a.2.1.1.1.3. Orthoarsenato-halogenides 3.2.4a.2.1.1.1.3.1. Neutral
Svabite series (x = 1,(6)) (compare with apatite (series))
Turneaureite $Ca_5Cl[AsO_4]_3$
Svabite $Ca_5F[AsO_4]_3$
Morelandite $Ca_2Ba_3[AsO_4]_3Cl$
Durangite family (x = 2)
Tilasite $CaMgF[AsO_4]$
*Arsenowagnerite $Mg_2F[AsO_4]$
*Maxwellite $NaFe^{3+}F[AsO_4]$
Durangite $NaAlF[AsO_4]$

3.2.4a.2.1.1.1.4. Arsenato-sulfates 3.2.4a.2.1.1.1.4.1. Basic
Weilerite family (x = 2,75)
Kemmlitzite $SrAl_3(OH)_6[AsO_4][SO_4]$
Weilerite $BaAl_3(OH)_6[AsO_4][SO_4]$
3.2.4a.2.1.1.1.4.1.1. Hydrates
3.2.4a.2.1.1.1.4.1.1.1. As : S = 3
Zykaite (x=1,5)(x = 1,5) $Fe^{3+}{}_4(OH)[AsO_4]_3[SO_4] \cdot 15H_2O$
3.2.4a.2.1.1.1.4.1.1.2. As : S = 1
Pitticite family (x=1,5)
Sarmientite $Fe^{3+}{}_2(OH)[AsO_4][SO_4] \cdot 5H_2O$
*Hilarionite $Fe^{3+}{}_2(OH)[AsO_4][SO_4] \cdot 6H_2O$
Bukovskyite $Fe^{3+}{}_2(OH)[AsO_4][SO_4] \cdot 7H_2O$
Pitticite $Fe^{3+}{}_2(OH)[AsO_4][SO_4] \cdot nH_2O$ (?)

3.2.4a.2.1.1.1.5. Гидроарсенато-арсенаты
*3.2.4a.2.1.1.1.5.1. Гидроарсенато-арсенаты с $AsO_3OH : AsO_4 = 1 : 2$
*Magnesiocanutite $NaMnMg_2[AsO_2(OH)_2][AsO_4]_2$
*3.2.4a.2.1.1.1.5.1.1. Кристаллогидраты
*Vladimirite (x = 2) $Ca_4[AsO_3(OH)][AsO_4]_2 \cdot 4H_2O$
*Chongite (x = 2.5) $Mg_2Ca_3[AsO_3(OH)][AsO_4]_2 \cdot 4H_2O$ *

3.2.4a.2.1.1.1.5.2. Hydroarsenato-arsenates with $AsO_3OH : AsO_4 = 1 : 1$
3.2.4a.2.1.1.1.5.2.1. Basic
Dussertite group (x = 2,75)
Arsenocrandallite $(Ca,Sr)Al_3(OH)_6[AsO_3(OH)][AsO_4]$
Arsenogoyazite $(Sr,Ca,Ba)Al_3(OH)_6[AsO_3(OH)][AsO_4]$
*Arsenogorceixite $BaAl_3(OH)_6[AsO_3(OH)][AsO_4]$
Dussertite $BaFe^{3+}{}_3(OH)_6[AsO_3(OH)][AsO_4]$
3.2.4a.2.1.1.1.5.2.1.1. Hydrates
Sainfeldite group (x = 1,25)

Villyaellenite $(Mn,Ca)Mn_2Ca_2[AsO_3(OH)]_2[AsO_4]_2 \cdot 4H_2O$
Irhtemite $Ca_4Mg[AsO_3(OH)]_2[AsO_4]_2 \cdot 4H_2O$
Sainfeldite $Ca_5[AsO_3(OH)]_2[AsO_4]_2 \cdot 4H_2O$
Picropharmacolite family
Guérinite $Ca_5[AsO_3(OH)]_2[AsO_4]_2 \cdot 9H_2O$
Picropharmacolite $Ca_4Mg[AsO_3(OH)]_2[AsO_4]_2 \cdot 11H_2O$
Chudobaite group
Chudobaite $(Mg,Zn)_5[AsO_3(OH)]_2[AsO_4]_2 \cdot 10H_2O$
Geigerite $Mn_5[AsO_3(OH)]_2[AsO_4]_2 \cdot 10H_2O$
*Miguelromeroite $MnMn_2Mn_2[AsO_3(OH)]_2[AsO_4]_2 \cdot 4H_2O$
Ferrarisite $Ca_5(H_2O)_8[AsO_3(OH)]_2[AsO_4]_2 \cdot H_2O$

*3.2.4a.2.1.1.1.5.3. Hydroarsenato-arsenates with $AsO_3OH : AsO_4 = 2 : 1$
*Canutite $NaMn_3[AsO_3(OH)]_2[AsO_4]$
*3.2.4a.2.1.1.1.5.3.1. Hydrates
*Joteite $Ca_2CuAl(OH)_2[AsO_3(OH)]_2[AsO_4](H_2O)_5$

3.2.4a.2.1.1.1.5.4. Hydroarsenato-arsenates with $AsO_3OH : AsO_4 = 4 : 1$
3.2.4a.2.1.1.1.5.4.1. Hydrates (neutral)
Mcnearite (x = 1.1) $NaCa_5[AsO_3(OH)]_4[AsO_4] \cdot 4H_2O$

3.2.4a.2.1.1.1.6. Hydroarsenato-arsenato-phosphates
3.2.4a.2.1.1.1.6.1. Hydrates with $AsO_3OH : AsO_4 : PO_4 = 2 : 3 : 3$ (neutral)
Walentaite (x = 1.375) $Ca_4Fe^{3+}{}_{12}[AsO_3(OH)]_4[AsO_4]_6[PO_4]_6 \cdot 28H_2O$

3.2.4a.2.1.1.1.6.2. Hydrates with $AsO_3OH : AsO_4 : PO_4 = 3 : 1 : 1$ (neutral)
Machatschkiite (x = 1,2) $Ca_6[AsO_3(OH)]_3[AsO_4][PO_4] \cdot 15H_2O$

3.2.4a.2.1.1.1.7. Hydroarsenates 3.2.4a.2.1.1.1.7.1. Basic
Weilite (x = 2) $Ca[AsO_3(OH)]$
*Švenekite $Ca[AsO_2(OH)_2]_2$
3.2.4a.2.1.1.1.7.2. Hydrates (neutral) (x=1)
Haidingerite family
Cobaltkoritnigite $(Co,Zn)[AsO_3(OH)] \cdot H_2O$
*Burgessite $Co_2(H_2O)_4[AsO_3(OH)]_2 \cdot H_2O$
Krautite $Mn[AsO_3(OH)] \cdot H_2O$
Fluckite $CaMn[AsO_3(OH)]_2 \cdot 2H_2O$
Haidingerite $Ca[AsO_3(OH)] \cdot H_2O$
Pharmacolite family
Pharmacolite $Ca[AsO_3(OH)] \cdot 2H_2O$
*Magnesiokoritnigite $Mg[AsO_3(OH)] \cdot H_2O$
Brassite $Mg[AsO_3(OH)] \cdot 4H_2O$
Rösslerite $Mg[AsO_3(OH)] \cdot 7H_2O$

3.2.4a.2.1.1.1.6. Dihydroarsenates 3.2.4a.2.1.1.1.6.1.
Hydrates (neutral) (x = 0,(3))
Kaatialaite $Fe[H_2AsO_4]_3 \cdot 5H_2O$

3.2.4a.2.1.1.2. Orthoarsenates of Be → berylloarsenates 3.2.4a.2.1.1.2.1. Acid
Bergslagite $Ca[Be(OH)AsO_4]^{\infty 2}$

3.2.4a.2.1.1.2.2. Hydrates

Bearsite $Be[Be(OH)AsO_4]\cdot 4H_2O$

*Okruschite $Ca_2Mn^{2+}{}_5Be_4(OH)_4[AsO_4]_6\cdot 6H_2O$

3.2.4a.2.1.2. Orthoarsenates of ***f***-cations

3.2.4a.2.1.2.1. Neutral (x = 1,5)

Chernovite-(Y) (compare with xenotime (group)) $Y[AsO_4]$

*Gasparite-(Ce) $(Ce,La,Nd)[AsO_4]$

3.2.4a.2.1.2.2. Basic

Arsenoflorencite-(Ce) $CeAl_3(OH)_6[AsO_4]_2$

*Arsenoflorencite-(La) $LaAl_3(OH)_6[AsO_4]_2$

*Graulichite-(Ce) $CeFe^{3+}{}_3(OH)_6[AsO_4]_2$

Retzian family

Retzian -(Ce) $Mn_2Ce(OH)_4[AsO_4]$

Retzian -(La) $Mn_2La(OH)_4[AsO_4]$

3.2.4a.2.1.2.2.1. Hydrates

*Goudeyite (x = 2,5) $(Al,Y)Cu^{2+}{}_6(OH)_6[AsO_4]_3\cdot 3H_2O$

*Agardite-(Ce) $(Ce,Ca)Cu^{2+}{}_6(OH)_6[AsO_4]_3\cdot 3H_2O$

*Agardite-(La) $(La,Ca)Cu^{2+}{}_6(OH)_6[AsO_4]_3\cdot 3H_2O$

*Agardite-(Y) $(Y,Ca)Cu^{2+}{}_6(OH)_6[AsO_4]_3\cdot 3H_2O$

*Agardite-(Nd) $NdCu^{2+}{}_6(OH)_6[AsO_4]_3\cdot 3H_2O$

*3.2.4a.2.1.2.2.1.1. Hydroarsenato-orthoarsenates

*Plumboagardite $(Pb,REE,Ca)Cu^{2+}{}_6(OH)_6[HAsO_4][AsO_4]_3\cdot 3H_2O$

*3.2.4a.2.1.2.2.1.2. Dihydroarsenates

*Vysokyite $U^{4+}[AsO_2(OH)_2]_4\cdot H_2O$

3.2.4a.2.2. Subclass: Orthoarsenates of chalcophylic elements

3.2.4a.2.2.1. Orthoarsenates of Ag, Cu

3.2.4a.2.2.1.1. M^+ and M^{2+}

3.2.4a.2.2.1.1.1. Proper orthoarsenates

3.2.4a.2.2.1.1.1.1. Neutral

*Bradaczekite(x = 1,5) $NaCu_4[AsO_4]_3$

*Zincobradazekite $NaZn_2Cu_2[AsO_4]_3$

Johillerite (x=1,5) $NaCu(Mg,Zn)_3[AsO_4]_3$

*Nickenichite $Na_{0,8}Ca_{0,4}Cu_{0,4}(Mg,Fe^{3+})_3[AsO_4]_3$

*Hatertite $Na_2(Ca,Na)(Fe^{3+},Cu)_2[AsO_4]_3$

3.2.4a.2.2.1.1.1.1.1.1. Hydrates

Keyite (x = 1,5) $Cu^{2+}{}_3(Zn,Cu^{2+})_4Cd_2[(AsO_4]_6(H_2O)_2$

*Erikapohlite $Cu^{2+}{}_3(Zn,Cu^{2+},Mg)_4Ca_2[(AsO_4]_6\cdot 2H_2O$

3.2.4a.2.2.1.1.1.2. Basic

Olivenite series (x=2)

Olivenite $Cu_2(OH)[AsO_4]$

*Zinkolivenite $CuZn(OH)[AsO_4]$

Conichalcite $CuCa(OH)[AsO_4]$

Cornwallite family (x=2,5)

Cornwallite $Cu_5(OH)_4[AsO_4]_2$

Cornubite $Cu_5(OH)_4[AsO_4]_2$

Clinoclase family (x=3)

Clinoclase (x=3) $Cu_3(OH)_3[AsO_4]$
*Gilmarite $Cu_3(OH)_3[AsO_4]$
Arhbarite $Cu_2Mg(OH)_3[AsO_4]$

3.2.4a.2.2.1.1.1.2.1. Hydrates (basic)

*Rollandite (x = 1,5) $Cu_3[AsO_4]_2{\cdot}4H_2O$
*Rruffite $Ca_2Cu^{2+}[AsO_4]_2{\cdot}2H_2O$
*Lukrahnite (x = 1,75) $Ca(Cu^{2+},Zn)(Fe^{3+},Zn)[AsO_4]_2(OH,{\cdot}H_2O)_2$
Euchroite family (x=2)
Strashimirite $Cu^{2+}{}_8(OH)_4[AsO_4]_4{\cdot}5H_2O$
Euchroite $Cu_2(OH)[AsO_4]{\cdot}3H_2O$
*Guanacoite (x = 2,5) $Cu_2Mg_2(Mg_{0.5}Cu_{0.5})(OH)_4[AsO_4]_2(H_2O)_4$
Philipsburgite (x=3) $(Cu,Zn)_6(OH)_6[(AsO_4),(PO_4)]_2{\cdot}H_2O$
(compare with kipushite (group))
*Forêtite (x = 5) $Cu_2Al_2(OH,O,{\cdot}H_2O)_6[AsO_4]$

*3.2.4a.2.2.1.1.2. Orthoarsenato-oxides
*Ericlaxmanite $Cu_4O[AsO_4]_2$
*Kozyrevskite $Cu_4O[AsO_4]_2$
*Popovite $Cu_5O_2[AsO_4]_2$
*Shchurovskyite $Cu_6K_2CaO_2[AsO_4]_4$
*Dmisokolovite $Cu_5K_3AlO_2[AsO_4]_4$
*Urusovite $Cu^{2+}AlO[AsO_4]$
*Edtollite $Cu_5K_2NaFe^{3+}O_2[AsO_4]_4$
*Melanarsite $Cu_7K_3Fe^{3+}O_4[AsO_4]_4$

3.2.4a.2.2.1.1.3. Orthoarsenato-carbonates ($AsO_4 : CO_3 = 2 : 1$)

3.2.4a.2.2.1.1.3.1. Hydrates (basic)

Tyrolite (x=2) $Ca_2Cu_9(OH)_8[AsO_4]_4[CO_3]{\cdot}11H_2O$

*3.2.4a.2.2.1.1.4. Orthoarsenato-phosphates ($AsO_4 : PO_4 = 1 : 1$)
*Hermannroseite $CaCu(OH)[(AsO_4),(PO_4)]$

3.2.4a.2.2.1.1.5. Orthoarsenato-sulfates
*3.2.4a.2.2.1.1.5.1. Orthoarsenato-sulfates with $AsO_4 : SO_4 = 1$
*3.2.4a.2.2.1.1.5.1.1. Orthoarsenato-oxido-sulfates with $AsO_4 : SO_4 = 1$
*Vasilseverginite $Cu_9O_4[AsO_4]_2[SO_4]_2$

3.2.4a.2.2.1.1.5.2. Orthoarsenato-sulfates with $AsO_4 : SO_4 = 2$

3.2.4a.2.2.1.1.5.2.1. Hydrates (basic)

Parnauite (x=3) $Cu_9(OH)_{10}[AsO_4]_2[SO_4]{\cdot}7H_2O$

*3.2.4a.2.2.1.1.5.3. Orthoarsenato-sulfates with $AsO_4 : SO_4 = 4$

*3.2.4a.2.2.1.1.5.3.1. Hydrates

Leogangite $Cu^{2+}{}_{10}(OH)_6[AsO_4]_4[SO_4]{\cdot}8H_2O$

3.2.4a.2.2.1.1.6. Orthoarsenato-chlorides 3.2.4a.2.2.1.1.6.1. Hydrates

*3.2.4a.2.2.1.1.6.1.1. Neutral

*Lemanskiite $NaCaCu^{2+}{}_5Cl[AsO_4]_4{\cdot}5H_2O$
*Mahnertite $(Na,Ca)Cu^{2+}{}_3Cl[AsO_4]_2{\cdot}5H_2O$
*Zdenekite (x = 6,5) $NaPbCu_5Cl[AsO_4]_4{\cdot}5H_2O$

3.2.4a.2.2.1.1.6.1.2. Basic

Shubnikovite (x=1,(6)) $Ca_2Cu_8(OH)Cl[AsO_4]_6 \cdot 7H_2O$ (?)

*3.2.4a.2.2.1.1.6.2. Oxido-orthoarsenato-chlorides

*Coparsite (x = 4) $Cu_4O_2[(As,V)O_4]Cl$

*Arsmirandite $Na_{18}Cu_{12}Fe^{3+}O_8[AsO_4]_8Cl_5$

3.2.4a.2.2.1.1.7. Hydroarsenato-orthoarsenates

3.2.4a.2.2.1.1.7.1. Hydrates (neutral)

*Pradeite $CoCu_4[AsO_3(OH)]_2[AsO_4]_2 \cdot 9H_2O$

Lindackerite (x=1) $Cu_5[AsO_3(OH)]_2[AsO_4]_2 \cdot 9H_2O$

*Hloušekite $(Ni,Co)Cu_4[AsO_3(OH)]_2[AsO_4]_2 \cdot 9H_2O$

*Ondrušite $CaCu_4[AsO_3(OH)]_2[AsO_4]_2 \cdot 10H_2O$

*Klajite $MnCu_4[AsO_3(OH)]_2[AsO_4]_2 \cdot 9\text{-}10H_2O$

*Zálesíite (x = 1) $CaCu_6\{[AsO_3(OH)][AsO_4]_2(OH)_6\} \cdot 3H_2O$

*Domerockite $Cu_4[AsO_3(OH)][AsO_4](OH)_3 \cdot H_2O$

3.2.4a.2.2.1.1.8.1.1. Hydroarsenato-orthoarsenato-oxides

*Braithwaiteite $NaCu^{2+}_5(Sb^{5+},Ti^{4+})[AsO_3(OH)]_2O_2[AsO_4]_4(H_2O)_8$

*3.2.4a.2.2.1.1.9. Hydroarsenates *3.2.4a.2.2.1.1.9.1. Hydrates

*Pushcharovskite $Cu[AsO_3OH] \cdot 1,5H_2O$

*Yvonite $Cu[AsO_3OH] \cdot 2H_2O$

*3.2.4a.2.2.1.1.9.1. Hydroarsenato-oxides

*Lapeyreite $Cu^{2+}_3O[AsO_3(OH)]_2 \cdot 0.75H_2O$

3.2.4a.2.2.1.2. M^{2+} and M^3

*3.2.4a.2.2.1.2.1. Proper orthoarsenares *3.2.4a.2.2.1.2.1.1. Basic

3.2.4a.2.2.1.2.1.1.1. Hydrates

Arthurite (x=2) $CuFe^{3+}_2(OH)_2[AsO_4]_2 \cdot 4H_2O$

*Attikaite (x=2) $Ca_3Cu^{2+}_2Al_2(OH)_4[AsO_4]_4 \cdot 2H_2O$

Chenevixite group (x=2,5)

Luetheite $Cu_2Al_2(OH)_4[AsO_4]_2 \cdot H_2O$

Chenevixite $Cu_2Fe^{3+}_2(OH)_4[AsO_4]_2 \cdot H_2O$

Ceruleite (x = 3,125) $Cu_2Al_7(OH)_{13}[AsO_4]_4 \cdot 11.5H_2O$

*Liroconite (x = 3,5) $Cu_2Al(OH)_4[AsO_4] \cdot 4H_2O$

*3.2.4a.2.2.1.2.1.1.1.1. Hydroarsenato-orthoarsenates

*Radovanite $Cu^{2+}_2Fe^{3+}[As^{5+}O_4][As^{3+}O_2OH]_2 \cdot H_2O$

*Segerstromite $Ca_3[As^{3+}(OH)_3]_2[As^{5+}O_4]_2$

3.2.4a.2.2.1.3. M^{2+}

3.2.4a.2.2.1.3.1. Proper orthoarsenato-phosphates

3.2.4a.2.2.1.3.1.1. Neutral

Lammerite(x=1,5) $Cu_3[AsO_4]_2$

*Lammerite-β $Cu_3[AsO_4]_2$

3.2.4a.2.2.1.3.2. Orthoarsenato-sulfates with $AsO_4 : SO_4 = 1,(3)$

3.2.4a.2.2.1.3.2.1. Hydrates (basic)

Chalcophyllite (x=3) $Cu_{18}Al_2(OH)_{24}[AsO_4]_4[SO_4]_3·36H_2O$

3.2.4a.2.2.1.3.3. Orthoarsenato-chlorides

3.2.4a.2.2.1.3.3.1. Hydrates

Lavendulan series (x=1,625)

Lavendulan $NaCaCu_5Cl[AsO_4]_4·5H_2O$

Zinclavendulan $NaCa(Zn,Cu)_5Cl[AsO_4]_4·(4\text{-}5)·H_2O$

*3.2.4a.2.2.1.3.4. Dihydroarsenato-orthoarsenates

*3.2.4a.2.2.1.3.4.1. Hydrates (neutral)

*Andyrobertsite (x = 1,3) $KCdCu^{2+}{}_5[As(OH)_2O_2][AsO_4]_4(H_2O)_2$

*Calcioandyrobertsite $KCaCu^{2+}{}_5[As(OH)_2O_2][AsO_4]_4(H_2O)_2$

3.2.4a.2.2.2. Orthoarsetates of Zn

3.2.4a.2.2.2.1. M^{2+}

3.2.4a.2.2.2.1.1. Proper orthoarsenates

3.2.4a.2.2.2.1.1.1. Neutral

Stranskiite (x=1,5) $Zn_2Cu[AsO_4]_2$

3.2.4a.2.2.2.1.1.2. Basic

Adamite family (x=2)

Paradamite $Zn_2(OH)[AsO_4]$

Adamite $Zn_2(OH)[AsO_4]$

Cuproadamite $(Cu,Zn)_2(OH)[AsO_4]$

Austinite $CaZn(OH)[AsO_4]$

Nickelaustinite $Ca(Ni,Zn)(OH)[AsO_4]$

Cobaltaustinite $Ca(Co,Zn)(OH)[AsO_4$

*Pharmazincite $KZn[AsO_4]$

Chlorophoenicite family (x=5)

Magnesiochlorophoenicite $(Mg,Mn)_3Zn_2(OH,O)_6[AsO_4]$

Chlorophoenicite $(Mn,Mg)_3Zn_2(OH,O)_6[AsO_4]$

Theisite (x=5) $Cu_5Zn_5(OH)_{14}[AsO_4]_2$

3.2.4a.2.2.2.1.1.3. Hydrates

3.2.4a.2.2.2.1.1.3.1. Basic

Legrandite $Zn_2(OH)[AsO_4]·H_2O$

*Ianbruceite $Zn_2(OH)(H_2O)[AsO_4](H_2O)_2$

Lotharmeyerite family (x=1,5)

Lotharmeyerite $Ca(Zn,Mn^{3+})_2[AsO_4]_2·2H_2O$

*Manganlotharmeyerite *$Ca(Mn^{3+},Zn)_2[AsO_4]_2(OH)_2$

*Ferrilotharmeyerite *$CaFe^{3+}Zn[AsO_4]_2(OH)·H_2O$

3.2.4a.2.2.2.1.1.3.2. Neutral

Köttigite family(x=1,5)

Warikahnite $Zn_3[AsO_4]_2·H_2O$

Metaköttigite $(Zn,Fe)_3[AsO_4]_2·8(H_2O,OH)$

Köttigite $Zn_3[AsO_4]_2·8H_2O$

Prosperite $CaZn_2[AsO_4]_2·H_2O$

*Arsenohopeite (ortho.) $Zn_3[AsO_4]_2·H_2O$

*Davideloydite (tricl.) $Zn_3[AsO_4]_2·H_2O$

3.2.4a.2.2.2.1.2. Hydroarsenates 3.2.4a.2.2.2.1.2.1. Basic

3.2.4a.2.2.2.1.2.2. Hydrates (basic)

Koritnigite (x=1) $Zn[AsO_3(OH)]·H_2O$

*3.2.4a.2.2.2.1.3. Hydroarsenato-orthoarsenates

*3.2.4a.2.2.2.1.3.1. Hydrates

*Nyholmite (x = 1) $Cd_3Zn_2[AsO_3(OH)]_2[AsO_4]_2·H_2O$

3.2.4a.2.2.2.2. $M^{2+}$and M^{3+}

3.2.4a.2.2.2.2.1. Proper orthoarsenates

3.2.4a.2.2.2.2.1.1. Basic

*Wilhelmkleinite (x = 2) $ZnFe^{3+}{}_2(OH)_2[AsO_4]_2$

Gerdtremmelite (x=4) $ZnAl_2(OH)_5[AsO_4]$

3.2.4a.2.2.2.2.1.2. Hydrates

3.2.4a.2.2.2.2.1.2.1. Basic

Ojuelaite (x=2) $ZnFe^{3+}{}_2(OH)_2[AsO_4]_2·4H_2O$

Mapimite (x=2,1(6)) $Zn_2Fe^{3+}{}_3(OH)_4[AsO_4]_3·10H_2O$

3.2.4a.2.2.2.2.1.2.2. Neutral

Fahleite (x=1,5) $CaZn_5Fe^{3+}{}_2[AsO_4]_6·14H_2O$

3.2.4a.2.2.2.3. M^+ and M^{2+}

3.2.4a.2.2.2.3.1. Hydroarsenato-arsenatrs

3.2.4a.2.2.2.3.1.1. Neutral

O'Danielite (x=1,75) $Na(Zn,Mg)_3[HAsO_4]_2[AsO_4]$

3.2.4a.2.2.3. Orthoarsenates of Hg^+

3.2.4a.2.2.3.1. Proper orthoarsenates 3.2.4a.2.2.3.1.1. Neutral

Chursinite (x=1,5) $Hg^+Hg^{2+}[AsO_4]$

*3.2.4a.2.2.3.2. Orthoarsenato-chlorides

*3.2.4a.2.2.3.2.1. Neutral

*Kuznetsovite $Hg^+{}_2Hg^{2+}Cl[AsO_4]$

*3.2.4a.2.2.4 Orthoarsenates of In

*3.2.4a.2.2.4.1. Proper orthoarsenates

*3.2.4a.2.2.4.1.1. Hydrates

*Yanomamite $In[AsO_4]·2H_2O$

3.2.4a.2.2.5. Orthoarsenates of Pb

3.2.4a.2.2.5.1. M^{2+}

3.2.4a.2.2.5.1.1. Proper orthoarsenates

3.2.4a.2.2.5.1.1.1. Oxido-orthoarsenates

Jamesite (x=2,85) $Pb_2ZnFe^{3+}{}_2(Fe^{3+}{}_{2,8}Zn_{1,2})(OH)_8[(OH)_{1,2}O_{0,8}][AsO_4]_4$

3.2.4a.2.2.5.1.1.2. Basic

Tsumcorite family(x=1,5)

Tsumcorite $Pb(Zn,Fe)_2(OH,·H_2O)_2[AsO_4]_2$

*Cobalttsumcorite $Pb(Co,Fe^{3+})_2(H_2O,OH)_2[AsO_4]_2$

*Nickeltsumcorite $Pb(Ni,Fe^{3+})_2(H_2O,OH)_2[AsO_4]_2$

Gartrellite $PbCuFe^{3+}(OH)[AsO_4]_2·H_2O$

*Zincgartrellite $Pb(Zn,Cu,Fe)_2(H_2O,OH)_2[AsO_4]_2$

Arsendecloizite family (x=2) (compare with decloizite (family))

Duftite $PbCu(OH)[AsO_4]$

Arsendecloizite $PbZn(OH)[AsO_4]$
Gabrielsonite $PbFe^{2+}(OH)[AsO_4]$
Carminite $PbFe^{3+}_2(OH)_2[AsO_4]_2$
Bayldonite (x = 2) $PbCu_3(OH)_2[AsO_4]_2$
*Segnitite (x = 2,75) $PbFe^{3+}_3H(OH)_6[AsO_4]_2$

3.2.4a.2.2.5.1.1.3. Hydrates
3.2.4a.2.2.5.1.1.3.1. Basic

Mawbyite (x=1,5) $Pb(Fe^{3+},Zn)_2[AsO_4]_2(OH,H_2O)_2$
*Longbanshuttanite $Pb_2Mn_2Mg(OH)_4[AsO_4]_2 \cdot 6H_2O$

3.2.4a.2.2.5.1.1.3.2. Neutral

Arsenbrackebuschite family
Arsenbrackebuschite (x=1,5) $Pb_2(Fe,Zn)[AsO_4]_2 \cdot H_2O$
*Feinglosite $Pb_2(Zn,Fe)[(As,S)O_4]_2 \cdot H_2O$
Thometzekite $Pb(Cu,Zn)_2[AsO_4]_2 \cdot 2H_2O$
Helmutwinklerite $PbZn_2[AsO_4]_2 \cdot 2H_2O$
*Rappoldite $Pb(Co,Ni)_2[AsO_4]_2 \cdot 2H_2O$

3.2.4a.2.2.5.1.2. Orthoarsenato-sulfates ($AsO_4 : SO_4 = 1$)
3.2.4a.2.2.5.1.2.1. Basic

Arsentsumebite (x=1,5) $CuPb_2(OH)[AsO_4][SO_4]$
(compare with brackebuschite (group))

3.2.4a.2.2.5.1.3. Orthoarsenato-chromates ($AsO_4 : CrO_4 = 1$)
3.2.4a.2.2.5.1.3.1. Basic

Fornacite (x=1,5) $Cu^{2+}Pb^{2+}_2(OH)[AsO_4][CrO_4]$
*Molybdofornacite $CuPb_2(OH) [AsO_4][MoO_4]$

3.2.4a.2.2.5.1.4. Orthoarsenato-chlorides 3.2.4a.2.2.5.1.4.1. Neutral

Mimetite family (x = 1,(6)) (compare with apatite (gr.); pyromorphite (gr.); vanadinite (gr.))
Hedyphane $Pb_3Ca_2Cl[AsO_4]_3$
Mimetite $Pb_5Cl[AsO_4]_3$
*Clinomimetite synonym of Mimetite-M $Pb_5Cl[AsO_4]_3$
*Vanackerite $Pb_4CdCl[AsO_4]_3$
Nealite (x=2,5) $Pb_4Fe^{2+}Cl_4[AsO_4]_2 \cdot 2H_2O$

3.2.4a.2.2.5.1.5. Oxido-orthoarsenato-chlorides

Sahlinite (x = 2,3) $Pb_{14}O_9Cl_4[AsO_4]_2$

3.2.4a.2.2.5.1.6. Hydroarsenates 3.2.4a.2.2.5.1.6.1. Neutral

Schultenite (x = 1) $Pb[AsO_3(OH)]$

3.2.4a.2.2.5.2. M^{2+} and M^{3+}
3.2.4a.2.2.5.2.1. Proper oprthoarsenates
3.2.4a.2.2.5.2.1.1. Oxido-orthoarsenates
3.2.4a.2.2.5.2.1.2. Orthoarsenato-sulfates ($AsO_4 : SO_4 = 1$)
3.2.4a.2.2.5.2.1.2.1. Basic

Beudantite group (x=2,75)
Hidalgoite $PbAl_3(OH)_6[AsO_4][SO_4]$
Beudantite $PbFe^{3+}_3(OH)_6[AsO_4][SO_4]$

*Gallobeudantite $PbGa^{3+}_3(OH)_6[AsO_4][SO_4]$

3.2.4a.2.2.5.2.1.3. Hydroarsenato-arsenates 3.2.4a.2.2.5.2.1.3.1. Basic
Philipsbornite (x=2.75) $PbAl_3(OH)_6[AsO_3(OH)][AsO_4]$

3.2.4a.2.2.6. Orthoarsenates of Va cations
3.2.4a.2.2.6.1. Orthoarsenates of Bi^{3+} 3.2.4a.2.2.6.1.1. Neutral
Rooseveltite (x=1,5) α-$Bi[AsO_4]$
*Tetrarooseveltite β-$Bi[AsO_4]$

3.2.4a.2.2.6.2. Hydroxido-oxido-arsenates
Preisingerite (x=2,25) (compare with schumacherite (gr.)) $Bi_3(OH)O[AsO_4]_2$
Atelestite (x=3) $Bi_2(OH)O[AsO_4]$
*Arsenowaylandite (x = 3) $BiAl_3(OH)_6[AsO_4]_2$
3.2.4a.2.2.6.1.2.1. Basic
Arsenobismite (x = 3) $Bi_2(OH)_3[AsO_4]$
*Neustädtelite (x = 3) $Bi_2Fe^{3+}Fe^{3+}O_2(OH)_2[AsO_4]_2$
*Cobaltneustädtelite $Bi_2Fe^{3+}Co^{2+}O(OH)_3[AsO_4]_2$
*Medenbachite $Bi_2Fe^{3+}Cu^{2+}O(OH)_3[AsO_4]_2$
3.2.4a.2.2.6.1.2.2. Hydrates (basic)
Mixite (x=2,5) (compare with agardite (group) $Cu_6Bi(OH)_6[AsO_4]_3{\cdot}3H_2O$
Juanitaite $(Cu,Ca,Fe)_{10}Bi(OH)_{11}[AsO_4]_4{\cdot}2H_2O$
Schneebergite $BiCo_2(OH)[AsO_4]_2{\cdot}H_2O_2$
Nickelschneebergite $BiNi_2(OH)[AsO_4]_2{\cdot}H_2O_2$
*Bouazzerite $Bi_6(Mg,Co)_{11}Fe^{3+}_{14}O_{12}(OH)_4[AsO_4]_{18}{\cdot}86H_2O$

3.2.4a.2.2.6.2. Orthoarsenates of Sb^{3+}
*3.2.4a.2.2.6.2.1. Proper orthoarsenates *3.2.4a.2.2.6.2.1.1. Hydrates
*Whitecapsite $H_{16}Fe^{2+}_5Fe^{3+}_{14}Sb^{3+}_6O_{16}[AsO_4]_{18}{\cdot}120H_2O$

3.2.4a.2.2.6.2.2. Oxido-arsenates
Manganostibite (x=3,5) $Mn_7Sb(As,Si)O_{12} \rightarrow |^{(6)}(Mn_5Sb)_{\Sigma 6}O_2||^{(4)}[Mn_2(As,Si)]_{\Sigma 3}O_{10}|$

3.2.4a.2.2.6.3. Orthoarsenates of As^{3+}
3.2.4a.2.2.6.3.1 Proper orthoarsenates 3.2.4a.2.2.6.3.1.1. Oxido-arsenates
Aerugite (x=3,9) $Ni^{2+}_{18}As^{3+}O_{12}[AsO_4]_5$
Hematolite (x=8,25) $(Mn,Mg,Al)_{15}(As^{3+}O_3)(OH)_{23}[AsO_4]_2$
*Arakiite $(Zn,Mn^{2+})(Mn^{2+},Mg)_{12}(Fe,Al)_2(As^{3+}O_3)(OH)_{23}[AsO_4]_2$
3.2.4a.2.2.6.3.1.2. Hydrates (basic)
Synadelphite (x=5,25) $(Mn,Mg,Ca,Pb)_9(As^{3+}O_3)(OH)_9[AsO_4]_2{\cdot}2H_2O$

3.2.4a.2.2.6.3.3. Orthoarsenato-chlorides 3.2.4a.2.2.6.3.2.1. Hydrates (basic)
Richelsdorfite (x=2,125) $Ca_2Cu^{2+}_5Sb^{5+}(OH)_6Cl[AsO_4]_4{\cdot}6H_2O$

*3.2.4a.3. Quasiclass: Pyroarsenates
*Petewilliamsite $(Ni,Co)_{30}[As_2O_7]_{15}$
*3.2.4a.3.1.1. Basic
*Theoparacelsite $Cu^{2+}_3(OH)_2[As_2O_7]$

*3.2.4a.4. Quasiclass: Orthoarsenato-arsenites (basic)

*Carlfrancisite
$Mn^{2+}_3(Mn^{2+},Mg,Fe^{3+},Al)_{42}(OH)_{42}[As^{5+}O_4]_4[(Si,As^{5+})O_4]_6[(As^{5+},Si)O_4]_2[As^{3+}O_3)]_2$

*3.2.4б. ***Class:*** Arsenites
*3.2.4б.1. Subclass: Arsenites of cations with low FC
*3.2.4б.1.1. Arsenites of ***s-**, **d_s*-** and ***p_s***- cations
*3.2.4б.1.1.1. Arsenito-oxides

*Fetiasite	$Fe^{2+}Fe^{3+}_2O_2[As^{3+}_2O_5]$

3.2.4б.1.1.2.Arsenito-silicates 3.2.4б.1.1.2.1. Basic

*Ekatite	$(Fe^{3+},Fe^{2+},Zn)_{12}(OH)_6[As^{3+}O_3]_6[(As^{3+}O_3),HO(SiO_3)]_2$

*3.2.4б.1.1.3. Арсенито-бораты (основные)

*Szklaryite	$\square Al_6BAs^{3+}_3O_{15}$

*3.2.4б.1.1.4. Arsenito-sulfates

*Tooeltite	$Fe_6^{3+}(OH)_4[AsO_3]_4[SO_4]\cdot 4H_2O$

*3.2.4б.1.1.5. Arsenito-halogenides *3.2.4б.1.1.5.1. Basic

*Georgiadesite (x = 4)	$Pb_4(OH)Cl_4[As^{3+}O_3]$
*Unnamed	$Pb_5Cl_7[As^{3+}O_3]$

3.2.5. ***Class:*** Sulfates
3.2.5.1.Subclass: Sulfates of cations with low FC
3.2.5.1.1. Sulfates of ***s-**, **d_s***- and ***p_s***- cations
3.2.5.1.1.1. Proper sulfates 3.2.5.1.1.1.1. Neutral

Millosevichite	$(Al,Fe^{3+})_2[SO_4]_3$
*Mikasaite	$(Fe^{3+},Al)_2[SO_4]_3$
*Perkovaite	$Mg_3Ca_2[SO_4]_5$
Anhydrite	$Ca[SO_4]$
Barite group (compare with anglesite (group); hashemite (group))	
Celestite	$Sr[SO_4]$
Barite	$Ba[SO_4]$
*Eldfellite	$NaFe^{3+}[SO_4]_2$
*Steklite	$KAl[SO_4]_2$
Yavapaiite	$KFe^{3+}[SO_4]_2$
Langbeinite group	
Langbeinite	$K_2Mg_2[SO_4]_3$
*Calciolangbeinite	$K_2Ca_2[SO_4]_3$
Manganolangbeinite	$K_2Mn_2[SO_4]_3$
Efremovite	$(NH_4)_2Mg_2[SO_4]_3$
Glauberite	$Na_2Ca[SO_4]_2$
Vanthoffite	$Na_6Mg[SO_4]_4$
Thenardite	$Na_2[SO_4]$
*Metathenardite	$Na_2[SO_4]$
Kalistrontite group	
Aphthitalite	$(K,Na)_3Na[SO_4]_2$
Kalistrontite	$K_2Sr[SO_4]_2$
Möhnite	$(NH_4)K_2Na[SO_4]_2$
Arcanite	$K_2[SO_4]$
Godovikovite group	

Godovikovite $NH_4Al[SO_4]_2$
*Pyracmonite $(NH_4)_3Fe^{3+}[SO_4]_3$
*Aluminopyracmonite $(NH_4)_3Al[SO_4]_3$
Sabieite $NH_4Fe^{3+}[SO_4]_2$
Mascagnite $(NH_4)_2[SO_4]$
*Bubnovaite $K_2Na_8Ca[SO_4]_6$

*3.2.1.1.1.1. Acids

*Ivsite $Na_3H[SO_4]_2$

3.2.5.1.1.1.2. Oxido-sulfates

Ye'elimite (x = 13) $Ca_4Al_6O_{12}[SO_4]$

3.2.5.1.1.1.3. Basic and sulfato-halogenides

D'Ansite group (x = 1,15)
D'Ansite $Na_{21}MgCl_3[SO_4]_{10}$
*D'Ansite-(Fe) $Na_{21}FeCl_3[SO_4]_{10}$
*D'Ansite-(Mn) $Na_{21}MnCl_3[SO_4]_{10}$
Cesanite (x = 1,1(6)) $Na_3Ca_2(OH)[SO_4]_3$
*Shuvalovite $K_2NaCa_2F[SO_4]_3$
*Krasheninnikovite $KNa_2CaMgF[SO_4]_3$
*Aiolosite $Na_2(Na_2Bi)Cl[SO_4]_3$
*Kononovite $NaMgF[SO_4]$
Alunite group (x = 1,25) (compare with argentojarosite; plumbojarosite)
Natroalunite $NaAl_3(OH)_6[SO_4]_2$
Minamiite $(Na,Ca,\square)Al_3(OH)_6[SO_4]_2$
*Huangite $Ca_{0.5}Al_3(OH)_6[SO_4]_2$
Alunite $KAl_3(OH)_6[SO_4]_2$
*Termessaite $K_2AlF_3[SO_4]$
*Termessaite-(NH4) $(NH_4)_2AlF_3[SO_4]$
*Walhierite $BaAl_6(OH)_{12}[SO_4]_4$
*Ammonioalunite $(NH_4)Al_3(OH)_6[SO_4]_2$
*Adranosite-(Al) $(NH_4)_4NaAl_2Cl(OH)_2[SO_4]_4$
*Adranosite-(Fe) $(NH_4)_4NaFe_2Cl(OH)_2[SO_4]_4$
Schlossmacherite $(H_3O)Al_3(OH)_6[SO_4]_2$
Natrojarosite $NaFe^{3+}_3(OH)_6[SO_4]_2$
Jarosite $KFe^{3+}_3(OH)_6[SO_4]_2$
Ammoniojarosite $NH_4Fe^{3+}_3(OH)_6[SO_4]_2$
Hydronium-jarosite $(H_3O)Fe^{3+}_3(OH)_6[SO_4]_2$
*Dorallcharite $Tl_{0,8}K_{0,2}Fe^{3+}_3(OH)_6[SO_4]_2$
Sulphohalite polysomatic series $n(Na_3X[SO_4])$ with the proviso that X = Cl, F
Kogarkoite $Na_3F[SO_4]$ (n=1)
Sulphohalite $Na_6ClF[SO_4]_2$ (n=2)
Galeite $Na_{15}ClF_4[SO_4]_5$ (n=5)
Schairerite $Na_{21}ClF_6[SO_4]_7$ (n=7)

3.2.5.1.1.1.4. Hydrates

3.2.5.1.1.1.4.1. Basic (in that number oxido-sulfates

Metavoltine (x = 1,1(6)) $K_2Na_6Fe^{2+}Fe^{3+}_6O_2[SO_4]_{12}\cdot 18H_2O$
*Alcaparrosaite (x = 1,25) $K_3Ti^{4+}Fe^{3+}O[SO_4]_4\cdot 2H_2O$
Copiapite group (x = 1,25)
Aluminocopiapite $Fe^{3+}_4Al(OH)O[SO_4]_6\cdot 20H_2O$
Ferricopiapite $Fe^{3+}_4(Fe^{3+}_{2/3}\square_{1/3})(OH)_2[SO_4]_6\cdot 20H_2O$
Magnesiocopiapite $MgFe^{3+}_4(OH)_2[SO_4]_6\cdot 20H_2O$

*Botryogen	$MgFe^{3+}(OH)[SO_4]_2\cdot 7H_2O$
Copiapite	$(Fe^{2+},Mg)Fe^{3+}{}_4(OH)_2[SO_4]_6\cdot 19H_2O$
Calciocopiapite	$CaFe^{3+}{}_4(OH)_2[SO_4]_6\cdot 19H_2O$
*Volaschioite	$Fe^{3+}{}_4O_2(OH)_6[SO_4]\cdot 2H_2O$
Sideronatrite family (x = 1,25)	
Metasideronatrite	$Na_2Fe^{3+}(OH)[SO_4]_2\cdot H_2O$
Sideronatrite	$Na_2Fe^{3+}(OH)[SO_4]_2\cdot 3H_2O$
Clinoungemachite (x= 1,25)	$K_3Na_9Fe^{3+}(OH)_3[SO_4]_6\cdot 9H_2O$
Clairite (x = 1,375)	$(NH_4)_2Fe^{3+}{}_3(OH)_3[SO_4]_4\cdot 3H_2O$
*Caminite	$Mg_7(OH)_4[SO_4]_5\cdot H_2O$
Hohmannite family (x = 1,5)	
Metahohmannite	$Fe^{3+}(OH)[SO_4]\cdot 1,5H_2O$
Butlerite	$Fe^{3+}(OH)[SO_4]\cdot 2H_2O$
Parabutlerite	$Fe^{3+}(OH)[SO_4]\cdot 2H_2O$
Amarantite	$Fe^{3+}(OH)[SO_4]\cdot 3H_2O$
Hohmannite	$Fe^{3+}(OH)[SO_4]\cdot 3,5H_2O$
Fibroferrite family (x = 1,5)	
*Riotintoite	$Al(OH)[SO_4]\cdot 3H_2O$
Jurbanite	$Al(OH)[SO_4]\cdot 5H_2O$
Rostite	$Al(OH,F)[SO_4]\cdot 5H_2O$
Fibroferrite	$Fe^{3+}(OH)[SO_4]\cdot 5H_2O$
Slavikite (x = 1,36)	$(H_3O)_3Mg_6Fe^{3+}{}_{15}(OH)_{18}[SO_4]_{21}\cdot 98H_2O$
Svyazhinite (x = 1,25)	$(Mg,Mn)(Al,Fe^{3+})F[SO_4]_2\cdot 14H_2O$
Uklonskovite (x = 2,5)	$NaMg(OH,F)[SO_4]\cdot 2H_2O$
*Kottenheimite	$Ca_6Si_2(OH)_{12}[SO_4]_4\cdot 24H_2O$
*Kottenheimite hexag.	$Ca_3Si(OH)_6[SO_4]_2\cdot 12H_2O$
*Laaherite mon.	$Ca_3Si(OH)_6[SO_4]_2\cdot 12H_2O$
Aluminite family (x = 3)	
*Mangazeite	$Al_2(OH)_4[SO_4]\cdot 3H_2O$
Meta-aluminite	$Al_2(OH)_4[SO_4]\cdot 5H_2O$
Aluminite	$Al_2(OH)_4[SO_4]\cdot 7H_2O$
Ettringite family (x = 3)	
Ettringite	$Ca_6Al_2(OH)_{12}[SO_4]_3\cdot 26H_2O$
Bentorite	$Ca_6(Cr,Al)_2(OH)_{12}[SO_4]_3\cdot 26H_2O$
Zaherite (x = 3,6)	$Al_{12}(OH)_{26}[SO_4]_5\cdot 20H_2O$
Wermlandite family (x = 4.0-5.5)	
Mountkeithite (x = 4)	$Mg_{11}Fe_3{}^{3+}[SO_4]_{3.5}(OH)_{24}\cdot 11H_2O$
Wermlandite	$Mg_8Al_2(OH)_{18}[SO_4]_2\cdot 12H_2O$
Motukoreaite	$NaMg_6Al_3(OH)_{18}[SO_4]_2\cdot 7H_2O$
Basaluminite family (x = 5-5.5)	
Basaluminite	$Al_4(OH)_{10}[SO_4]\cdot 4H_2O$
Felsöbányaite	$Al_4(OH)_{10}[SO_4]\cdot 4H_2O$
Hydrobasaluminite	$Al_4(OH)_{10}[SO_4]\cdot 9H_2O$
*Nikischerite(x = 5,5)	$Fe^{2+}{}_6Al_3(OH)_{18}[Na(H_2O)_6][SO_4]_2\cdot 6H_2O$
Shigaite (x = 5,5)	*$Mn^{2+}{}_6Al_3(OH)_{18}[Na(H_2O)_6][SO_4]_2\cdot 6H_2O$
Carrboydite (x = 6)	$(Ni_{1-x}Al_x)[SO_4]_{x/2}(OH)_2\cdot nH_2O$ ($x<0.5$, $n>3x/2$)
*Kuzelite (x = 7)	$Ca_4Al_2(OH)_{12}[SO_4]\cdot 6H_2O$
Jamborite family (x = 9)	
Jamborite	$Ni^{2+}{}_{1-x}Co_x{}^{3+}(OH)_{2-x}[SO_4]_x\cdot nH_2O$ where [$x\leq 1/3$; $n\leq(1-x)$]
Honessite	$(Ni_{1-x}Fe_x{}^{3+})(OH)_2[SO_4]_{x/2}\cdot nH_2O$ ($x < 0.5$, $n < 3x/2$)

Hydrohonessite $(Ni_{1-x}Fe_x^{3+})(OH)_2)[SO_4]_{x/2}\cdot nH_2O$ (x < 0.5, n > 3x/2)
Copper-aluminium analog of honessite
Copper-aluminium analog of hydrohonessite

3.2.5.1.1.1.4.2. Neutral (x = 1)

Alunogen family
Meta-alunogen $Al_4[SO_4]_6\cdot 27H_2O$
Alunogen $Al_2[SO_4]_3\cdot 17H_2O$
Coquimbite family
Lausenite $Fe^{3+}_2[SO_4]_3\cdot 6H_2O$
Kornelite $Fe^{3+}_2[SO_4]_3\cdot 7H_2O$
Paracoquimbite $Fe^{3+}_2[SO_4]_3\cdot 9H_2O$
Coquimbite $Fe^{3+}_2[SO_4]_3\cdot 9H_2O$
Quenstedtite $Fe^{3+}_2[SO_4]_3\cdot 10H_2O$
*Aluminocoquimbite $AlFe^{3+}[SO_4]_3\cdot 9H_2O$
Römerite $Fe^{2+}Fe^{3+}_2[SO_4]_4\cdot 14H_2O$
Halotrichite group
Pickeringite $MgAl_2[SO_4]_4\cdot 22H_2O$
*Wupatkiite $(Co,Mg,Ni)Al_2[SO_4]_4\cdot 22H_2O$
Halotrichite $Fe^{2+}Al_2[SO_4]_4\cdot 22H_2O$
Apjohnite $Mn^{2+}Al_2[SO_4]_4\cdot 22H_2O$
Bilinite $Fe^{2+}Fe^{3+}_2[SO_4]_4\cdot 22H_2O$
Redingtonite $(Fe,Mg,Ni)(Cr,Al)_2[SO_4]_4\cdot 22H_2O$
*Caichengyunite $Fe^{2+}_3Al_2[SO_4]_6\cdot 30H_2O$
*Lanmuchangite $TlAl[SO_4]_2\cdot 12H_2O$
Goldichite family
Krausite $KFe^{3+}[SO_4]_2\cdot H_2O$
Goldichite $KFe^{3+}[SO_4]_2\cdot 4H_2O$
Tamarugite family
Tamarugite $NaAl[SO_4]_2\cdot 6H_2O$
Amarillite $NaFe^{3+}[SO_4]_2\cdot 6H_2O$
Mendozite group
Mendozite $NaAl[SO_4]_2\cdot 11H_2O$
Kalinite $KAl[SO_4]_2\cdot 11H_2O$
Alum group
Sodium alum $NaAl[SO_4]_2\cdot 12H_2O$
Potassium alum $KAl[SO_4]_2\cdot 12H_2O$
Tschermigite $NH_4Al[SO_4]_2\cdot 12H_2O$
Lonecreekite $NH_4Fe^{3+}[SO_4]_2\cdot 12H_2O$
Voltaite $K_2Fe^{2+}_5Fe^{3+}_4[SO_4]_{12}\cdot 18H_2O$
*Ammoniovoltaite $(NH_4)_2Fe^{2+}_5Fe^{3+}_4[SO_4]_{12}\cdot 8H_2O$
*Ammoniomagnesiovoltaite $(NH_4)_2Mg_5Fe^{3+}_3Al[SO_4]_{12}\cdot 18H_2O$
*Zincovoltaite $K_2Zn_5Fe^{3+}_3Al[SO_4]_{12}\cdot 18H_2O$
*Pertlikite $K_2(Fe^{2+},Mg)_2(Mg,Fe^{3+})_4Fe^{3+}_2Al[SO_4]_{12}\cdot 18H_2O$
Ferrinatrite $Na_3Fe^{3+}[SO_4]_3\cdot 3H_2O$
Gypsum family
Bassanite $Ca[SO_4]\cdot 0,5H_2O$
Gypsum $Ca[SO_4]\cdot 2H_2O$
*Omongwaite $Na_2Ca_5[SO_4]_6\cdot 3H_2O$
Kieserite family (compare with gunningite (series))
Kieserite $Mg[SO_4]\cdot H_2O$

*Cobaltkieserite	$Co[SO_4]\cdot H_2O$
Dwornikite	$Ni[SO_4]\cdot H_2O$
Szomolnokite	$Fe[SO_4]\cdot H_2O$
Szmikite	$Mn[SO_4]\cdot H_2O$
Sanderite	$Mg[SO_4]\cdot 2H_2O$
Rozenite family (compare with boyleite (family))	
Starkeyite	$Mg[SO_4]\cdot 4H_2O$
*β-starkeyite	$Mg[SO_4]\cdot 4H_2O$
*Cranswickite	$Mg[SO_4]\cdot 4H_2O$
Aplowite	$Co[SO_4]\cdot 4H_2O$
Rozenite	$Fe[SO_4]\cdot 4H_2O$
Pentahydrite group (compare with chalcanthite (group))	
Pentahydrite	$Mg[SO_4]\cdot 5H_2O$
Siderotil	$Fe[SO_4]\cdot 5H_2O$
Jokokuite	$Mn[SO_4]\cdot 5H_2O$
*Chvaleticeite	$Mn[SO_4]\cdot 6H_2O$
Hexahydrite family(ср.вианкита (гр.))	
Hexahydrite group	
Hexahydrite	$Mg[SO_4]\cdot 6H_2O$
Retgersite	$Ni[SO_4]\cdot 6H_2O$
Moorhouseite group	
Nickelhexahydrite	$Ni[SO_4]\cdot 6H_2O$
Moorhouseite	$Co[SO_4]\cdot 6H_2O$
Ferrohexahydrite	$Fe[SO_4]\cdot 6H_2O$
Epsomite group	
Epsomite	$Mg[SO_4]\cdot 7H_2O$
Morenosite	$Ni[SO_4]\cdot 7H_2O$
Tauriscite	$Fe[SO_4]\cdot 7H_2O$
Melanterite group	
Bieberite	$Co[SO_4]\cdot 7H_2O$
Melanterite	$(Fe,Mg)[SO_4]\cdot 7H_2O$
Mallardite	$Mn[SO_4]\cdot 7H_2O$
Polyhalite family	
Görgeyite	$K_2Ca_5[SO_4]_6\cdot H_2O$
Polyhalite	$K_2MgCa_2[SO_4]_4\cdot 2H_2O$
Syngenite	$K_2Ca[SO_4]_2\cdot H_2O$
Eugsterite family	
Eugsterite	$Na_4Ca[SO_4]_3\cdot 2H_2O$
Hydroglauberite	$Na_{10}Ca_3[SO_4]_8\cdot 6H_2O$
Blödite family	
Blödite	$Na_2Mg[SO_4]_2\cdot 4H_2O$
*Cobaltoblödite	$Na_2Co[SO_4]_2\cdot 4H_2O$
*Manganoblödite	$Na_2Mn[SO_4]_2\cdot 4H_2O$
Nickelblödite	$Na_2(Ni,Mg)[SO_4]_2\cdot 4H_2O$
Wattevillite	$Na_2Ca[SO_4]_2\cdot 4H_2O$ (?)
Leonite	$K_2Mg[SO_4]_2\cdot 4H_2O$
Löweite	$Na_{12}Mg_7[SO_4]_{13}\cdot 15H_2O$
Konyaite	$Na_2Mg[SO_4]_2\cdot 5H_2O$
Picromerite group	
Picromerite	$K_2Mg[SO_4]_2\cdot 6H_2O$

*Nickelpicromerite $K_2Ni[SO_4]_2·6H_2O$
Boussingaultite $(NH_4)_2Mg[SO_4]_2·6H_2O$
Nickelboussingaultite $(NH_4)_2(Ni,Mg)[SO_4]_2·6H_2O$
Mohrite $(NH_4)_2Fe^{2+}[SO_4]_2·6H_2O$
*Mereiterite $K_2Fe^{2+}[SO_4]_2·4H_2O$
Mirabilite $Na_2[SO_4]·10H_2O$
Koktaite $(NH_4)_2Ca[SO_4]_2·H_2O$
Lecontite $Na(NH_4,K)[SO_4]·2H_2O$

*3.2.5.1.1.2. Sulfato-borates
*Tatarinovite $Ca_3Al[SO_4](OH)_6[B(OH)_4]·12H_2O$

*3.2.5.1.1.3. Sulfato-orthophosphato-halogenides
*3.2.5.1.1.3.1. Hydrates
*Arangasite $Al_2[SO_4][PO_4]F$

3.2.5.1.1.4. Sulfato-nitrates
3.2.5.1.1.4.1. Sulfato-nitrates with $SO_4 : NO_3 = 3$
3.2.5.1.1.41.1. Hydrates (acid)
Ungemachite group
Ungemachite $K_3Na_8Fe^{3+}[SO_4]_6[NO_3]_2·6H_2O$
Humberstonite $K_3Na_7Mg_2[SO_4]_6[NO_3]_2·6H_2O$

*3.2.5.1.1.4.2. Sulfato-nitrates with $SO_4 : NO_3 = 2$
3.2.5.1.1.4.2.1. Hydrates
*Witzkeite $Na_4K_4Ca[SO_4]_4[NO_3]_2·2H_2O$

3.2.5.1.1.4.3. Sulfato-nitrates with $SO_4 : NO_3 = 1$
3.2.5.1.1.4.3.1. Hydrates (basic)
Darapskite $Na_3[SO_4][NO_3]·H_2O$

3.2.5.1.1.4.4. Sulfato-nitrates with $SO_4 : NO_3 = 0,1(6)$
3.2.5.1.1.4.4.1. Hydrates (basic)
Mbobomkulite $(Ni,Cu^{2+})Al_4(OH)_{12}[NO_3,SO_4]_2·3H_2O$

*3.2.5.1.1.5. Sulfato-halogenides *3.2.5.1.1.5.1. Hydrates
*Khademite $Al[SO_4]F·5H_2O$
*Vlodavetsite $Ca_2Al[SO_4]_2F_2Cl·4H_2O$
*Vendidaite $Al_2[SO_4](OH)_3Cl·6H_2O$
*Wilcoxite $MgAl[SO_4]_2F·18H_2O$
Xitieshanite (x = 1,5) $Fe^{3+}[SO_4]Cl·6H_2O$
Kainite (x = 1,5) $KMg[SO_4]Cl·3H_2O$

3.2.5.1.1.6. Sulfato-iodates 3.2.5.1.1.6.1. Neutral
Hectorfloresite $Na_9[SO_4][IO_3]$
*3.2.5.1.1.6.1.1. Hydrates
*Fuenzalidaite $K_6Na_4Na_6Mg_{10}[SO_4]_{12}[IO_3]_{12}·12H_2O$

3.2.5.1.1.7. Sulfato-fluoraluminates 3.2.5.1.1.7.1. Hydrates (acid)
*Meniaulovite $Ca_4AlSi[SO_4]F_{13}·12H_2O$

Creedite $Ca_3[SO_4][Al_2F_8(OH)_2]·2H_2O$

3.2.5.1.1.8. Acid sulfates (hydrosulfates)
3.2.5.1.1.8.1. Proper hydrosulfates 3.2.5.1.1.8.1.1. Neutral
Mercallite family
Mercallite $K[HSO_4]$
Misenite $K_8H_6[SO_4]_7$
3.2.5.1.1.8.1.2. Hydrates
Matteuccite $Na[HSO_4]·H_2O$

3.2.5.1.1.8.2. Hydrosulfato-sulfates 3.2.5.1.1.8.2.1. Neutral
Letovicite $(NH_4)_3[HSO_4][SO_4]$
3.2.5.1.1.8.2.2. Hydrates
Rhomboclase $(H_3O)Fe^{3+}[SO_4]_2·3H_2O$
*Cossaite $(Mg_{0,5}□)Al_6[HSO_4][SO_4]_6F_6·36H_2O$

3.2.5.1.1.9. Sulfates with unknown structure (sulfato-fluoraluminates ?)
Lannonite $HCa_4Mg_2Al_4[SO_4]_8F_9·32H_2O$

3.2.5.1.2. Sulfates of ***f***-elements *3.2.5.1.2.1. Hydrates
*Běhounekite $U[SO_4]_2(H_2O)_4$

3.2.5.1.2.2. Sulfato-fluoraluminates (0,5:1) 3.2.5.1.2.2.1. Hydrates (basic)
Chukhrovite group
*Chukhrovite-(Ca) $Ca_3Ca_{1.5}Al_2[SO_4]F_{13}·12H_2O$
Chukhrovite-(Ce) $Ca_3CeF(H_2O)_{10}[SO_4][AlF_6]_2$
*Chukhrovite-(Nd) $Ca_3NdF(H_2O)_{12}[SO_4][AlF_6]_2$
Chukhrovite-(Y) $Ca_3YF(H_2O)_{10}[SO_4][AlF_6]_2$

*3.2.5.1.2.3. Sulfato-oxalates
*Levinsonite-(Y) $(Y,Nd,Ce)Al[SO_4]_2(C_2O_4)·12H_2O$
*Zugshunstite–(Ce) $(Ce,Nd,La)Al[SO_4]_2(C_2O_4)·12H_2O$

3.2.5.2. Subclass: Sulfates of cations with middle FC
3.2.5.2.1. Sulfates of Zr 3.2.5.2.1.1. Hydrates (neutral)
Zircosulfate $Zr[SO_4]_2·4H_2O$

*3.2.5.2.2. Sulfates of Sn *3.2.5.2.2.1. Hydrates (basic)
*Genplesite $Ca_3Sn(OH)_6[SO_4]_2·3H_2O$

3.2.5.2.3. Sulfates of Mn^{4+} 3.2.5.2.3.1. Hydrates (basic)
Despujolsite $Ca_3Mn^{4+}(OH)_6[SO_4]_2·3H_2O$

3.2.5.2.4. Sulfates of V^{4+} 3.2.5.2.4.1.Средние
*Pauflerite β-$VO[SO_4]$
3.2.5.2.4.1.1. Hydrates (oxido)
Minasragrite family
Minasragrite $VO[SO_4]·5H_2O$
*Orthominasragrite $VO[SO_4]·5H_2O$
*Anorthominasragrite $VO[SO_4]·5H_2O$

Stanleyite $VO[SO_4]\cdot 6H_2O$
*Bobjonesite $VO[SO_4] (H_2O)_3$
*Karpovite $Tl_2VO[SO_4]_2 (H_2O)$
*Evdokimovite $Tl_4[VO]_3[SO_4]_5(H_2O)_5$

3.2.5.3. Sulfates of chalcophylic elements
3.2.5.3.1. Sulfates of Ag^+ 3.2.5.3.1.1. Basic
Argentojarosite (comp. with alunite (gr.) $AgFe^{3+}_3(OH)_6[SO_4]_2$

3.2.5.3.2. Sulfates of Cu 3.2.5.3.2.1. Neutral
Chalcocyanite (x = 1) $Cu[SO_4]$
*Dravertite (x = 1) $CuMg[SO_4]_2$
*Saranchinaite $NaCu[SO_4]_2$
3.2.5.3.2.2. Oxido-sulfates
*Cryptochalcite (x = 1,2) $K_2Cu_5O[SO_4]_5$
*Cesiodimite (x = 1,2) $CsKCu_5O[SO_4]_5$
*Fedotovite (x = 1,(3)) $K_2Cu_3O[SO_4]_3$
*Wulffite (x = 1,5) $K_3NaCu_4O_2[SO_4]_4$
*Parawulffite (x = 1,5) $K_5Na_3Cu_8O_4[SO_4]_8$
Klyuchevskite (x = 1,5) $K_3Cu_3Fe^{3+}O_2[SO_4]_4$
*Alumoklyuchevskite (x = 1,5) $K_3Cu_3AlO_2[SO_4]_4$
*Eleomelanit(x = 1,5) $(K_2Pb)Cu_4O_2[SO_4]_4$
Dolerophanite (x = 2) $Cu_2O[SO_4]$
3.2.5.3.2.3. Basic and sulfato-halogenides
Piypite (x = 1,08) $K_4(Na,Cu)Cu_4O_2Cl[SO_4]_4$
Kamchatkite (x = 1,75) $KCu_3OCl[SO_4]_2$
Chlorothionite (x = 2) $K_2CuCl_2[SO_4]$
Antlerite (x = 3) $Cu_3(OH)_4[SO_4]$
Brochantite (x = 4) $Cu_4(OH)_6[SO_4]$
*Grandviewite (x = 8.25)) $Cu_3Al_9(OH)_{29}[SO_4]_2$
3.2.5.3.2.4. Hydrates
Cuprocopiapite group
Cuprocopiapite (x = 1,1(6)) $Cu^{2+}Fe^{3+}_4(OH)_2[SO_4]_6\cdot 20H_2O$
(compare with copiapite (group))
Aubertite family (x = 1,25)
Magnesioaubertite $(Mg,Cu)AlCl[SO_4]_2\cdot 14H_2O$
Aubertite $Cu^{2+}AlCl[SO_4]_2\cdot 14H_2O$
Guildite $Cu^{2+}Fe^{3+}(OH)[SO_4]_2\cdot 4H_2O$
Natrochalcite (x = 1,25) $NaCu^{2+}_2(OH)[SO_4]_2\cdot H_2O$
*Kaliochalcite $KCu_2(OH)[SO_4]_2(H_2O)$
Devilline family (x = 2,5)
Devilline $CaCu^{2+}_4(OH)_6[SO_4]_2\cdot 3H_2O$
*Vonbezingite $Ca_6Cu^{2+}_3(OH)_{12}[SO_4]_3\cdot 2H_2O$
*Lautenthalite $Cu^{2+}_4Pb(OH)_6[SO_4]_2\cdot 3H_2O$
Campigliaite $Cu^{2+}_4Mn^{2+}(OH)_6[SO_4]_2\cdot 4H_2O$
*Niedermayrite $Cu^{2+}_4Cd^{2+}(OH)_6[SO_4]_2\cdot 4H_2O$
*Edwardsite $Cu^{2+}_3Cd^{2+}_2(OH)_6[SO_4]_2\cdot 4H_2O$
Langite family (x = 4)
Posnjakite $Cu_4(OH)_6[SO_4]\cdot H_2O$
Langite $Cu_4(OH)_6[SO_4]\cdot 2H_2O$

Wroewolfeite $Cu_4(OH)_6[SO_4]\cdot 2H_2O$
*Kobyashevite $Cu^{2+}{}_5(OH)_6[SO_4]_2\cdot 2H_2O$
*Redgillite $Cu^{2+}{}_6(OH)_{10}[SO_4]\cdot H_2O$
*Montetrisaite $Cu^{2+}{}_6(OH)_{10}[SO_4]\cdot H_2O$
Chalcoalumite (x = 7) $CuAl_4(OH)_{12}[SO_4]\cdot 3H_2O$
Cyanotrichite group (x = 7)
Cyanotrichite $Cu^{2+}{}_4Al_2(OH)_{12}[SO_4]\cdot 2H_2O$
Carbonate-cyanotrichite $Cu^{2+}{}_4Al_2(OH)_{12}[(CO_3),(SO_4)]\cdot 2H_2O$
Woodwardite $(Cu^{2+},Al)_9(OH)_{18}[SO_4]_2\cdot nH_2O$
*Hydrowoodwardite $[Cu^{2+}{}_{1-x}Al_x(OH)_2][(SO_4)_{x/2}(H_2O)_n]$ x<0.5, n>3x/2n
*Camerolaite $Cu_6Al_3(OH)_{18}(H_2O)_2[SO_4][Sb(OH)_6]$
Spangolite (x = 7,5) $Cu^{2+}{}_6Al(OH)_{12}Cl[SO_4]\cdot 3H_2O$
Connellite (x = 19) $Cu^{2+}{}_{19}(OH)_{32}Cl_4[SO_4]\cdot 3H_2O$

3.2.5.3.2.4.2. Neutral

Ransomite (x = 1) $Cu^{2+}Fe^{3+}{}_2[SO_4]_4\cdot 6H_2O$
Chalcanthite family (x = 1) (compare with pentahydrite; melanterite (group))
Bonattite $Cu[SO_4]\cdot 3H_2O$
Chalcanthite $Cu[SO_4]\cdot 5H_2O$
Boothite $Cu[SO_4]\cdot 7H_2O$
Kröhnkite (x = 1) $Na_2Cu[SO_4]_2\cdot 2H_2O$
Leightonite (x = 1) $K_2Ca_2Cu[SO_4]_4\cdot 2H_2O$
Cyanochroite (x = 2) $K_2Cu[SO_4]_2\cdot 6H_2O$
(compare with picromerite (group))
*Alpersite $(Mg,Cu)[SO_4]\cdot 7H_2O$

3.2.5.3.3. Sulfates of Hg^{2+} 3.2.5.3.3.1. Oxido (nitrido)-sulfates

Schuetteite family
Schuetteite $Hg^{2+}{}_3O_2[SO_4]$
Gianellaite $Hg^{2+}{}_4N_2[SO_4](H_2O)_x$

3.2.5.3.4. Sulfates of Zn

*3.2.5.3.4.1. Proper sulfates *3.2.5.3.4.1.1. Neutral

Zincosite $Zn[SO_4]$

3.2.5.3.4.1.2. Hydrates

Gunningite family (comp. with kieserite (family))
Gunningite $Zn[SO_4]\cdot H_2O$
Poitevinite $(Cu,Fe,Zn)[SO_4]\cdot H_2O$
Boyleite family (comp. with rozenite (gr.))
Boyleite $Zn[SO_4]\cdot 4H_2O$
Ilesite $(Mn,Zn)[SO_4]\cdot 4H_2O$
Bianchite $Zn[SO_4]\cdot 6H_2O$
Goslarite family
Goslarite $Zn[SO_4]\cdot 7H_2O$
Zinc-melanterite $(Zn,Cu,Fe^{2+})[SO_4]\cdot 7H_2O$
*Changoite (x = 1) $Na_2Zn[SO_4]_2\cdot 4H_2O$
*Lishizhenite (x = 1) $ZnFe^{3+}{}_2[SO_4]_4\cdot 14H_2O$
Dietrichite (x = 1) $ZnAl_2[SO_4]_4\cdot 22H_2O$

3.2.5.3.4.1.3. Basic 3.2.5.3.4.1.3.1. Hedrates

Zincocopiapite (x = 1,1(6)) $ZnFe^{3+}{}_4(OH)_2[SO_4]_6\cdot 18H_2O$
*Chaidamuite (x = 1,25) $ZnFe^{3+}(OH)[SO_4]_2\cdot 4H_2O$

Ktenasite family
Serpierite $Ca(Cu,Zn)_4(OH)_6[SO_4]_2{\cdot}3H_2O$
*Orthoserpierite $Ca(Cu,Zn)_4(OH)_6[SO_4]_2{\cdot}3H_2O$
Ktenasite $(Cu,Zn)_5(OH)_6[SO_4]_2{\cdot}6H_2O$
*Christelite $Zn_3Cu_2(OH)_6[SO_4]_2{\cdot}4H_2O$
Schulenbergite family
Schulenbergite (x = 3,5) $(Cu,Zn)_7(OH)_{10}[(SO_4),(CO_3)]_2{\cdot}3H_2O$
Ramsbeckite (x = 3,75) $(Cu,Zn)_{15}(OH)_{22}[SO_4]_4{\cdot}6H_2O$
*Osakaite $Zn_4(OH)_6[SO_4]{\cdot}5H_2O$
*Lanshtainite(x = 4) $Zn_4(OH)_6[SO_4]{\cdot}3H_2O$
Namuwite (x = 4) $(Zn,Cu)_4(OH)_6[SO_4]{\cdot}4H_2O$
Zincaluminite (x = 5,5) $(Zn,Al)_9(OH)_{18}[SO_4]_2{\cdot}nH_2O$
Glaucocerinite (x = 6,(3)) $Zn_{1-x}Al_x(OH)_2[SO_4]_{x/2}{\cdot}nH_2O$ ($x<0.5$, $n>3x/2$)
*Natroglaucocerinite $[Zn_{8-x}Al_x(OH)_{16}][(SO_4)_{x/2+y/2}Na_y(H_2O)_6]$
*Zincowoodvardite $[Zn_{1-x}Al_x(OH)_2][(SO_4)_{x/2}(H_2O)_n]$ ($x<0.5$, $n>3x/2$)
*Kyrgyzstanite(x = 7.0) $ZnAl_4(OH)_{12}[SO_4]{\cdot}3H_2O$
Torreyite family (x = 6,5)
Torreyite $(Mg,Mn)_9Zn_4(OH)_{22}[SO_4]_2{\cdot}8H_2O$
Lawsonbauerite $(Mn,Mg)_9Zn_4(OH)_{22}[SO_4]_2{\cdot}8H_2O$
Mooreite family (x = 7,5)
Mooreite $Mg_9Zn_4Mn_2(OH)_{26}[SO_4]_2{\cdot}8H_2O$
*3.2.5.3.4.2. Sulfato-halogenides *3.2.5.3.4.2.1. Neutral
*Belousovite (x = 1) $KZnCl[SO_4]$
*3.2.5.3.4.2.2. Basic
*Gordaite (x = 4,5) $NaZn_4(OH)_6Cl[SO_4]{\cdot}6H_2O$
*Thèrésemagnanite (x = 4,5) $NaCo_4(OH)_6Cl[SO_4]{\cdot}6H_2O$
*Guarinoite (x = 6) $(Zn,Co,Ni)_6(OH,Cl)_{10}[SO_4]{\cdot}5H_2O$

*3.2.5.3.5. Sulfates of Tl^+
*Markhininite $Tl^+Bi^{3+}[SO_4]_2$

3.2.5.3.6. Sulfates of Tl^{3+} 3.2.5.3.6.1. Hydrates (neutral)
Monsmedite = voltaite with Tl

3.2.5.3.7. Sulfates of Pb^{2+} 3.2.5.3.7.1. Neutral
Anglesite (comp. with barite (gr.)) $Pb[SO_4]$
Palmierite $(K,Na)_2Pb[SO_4]_2$

3.2.5.3.7.2. Basic and oxido-sulfates, sulfato-halogenides
Caracolite (x = 1,1(6)) $Na_3Pb_2Cl[SO_4]_3$
Wherryite (x = 1,5) $Pb_7Cu_2(OH)_2[SO_4]_4[SiO_4]_2$
Linarite family (x = 2)
Lanarkite $Pb_2O[SO_4]$
Grandreefite $Pb_2F_2[SO_4]$
Linarite $PbCu^{2+}(OH)_2[SO_4]$
Plumbojarosite (x = 2,5) $PbFe^{3+}_6(OH)_{12}[SO_4]_4$
Osarizawaite (x = 2,5) $PbCuAl_2(OH)_6[SO_4]_2$
Chenite (x = 2,5) $Pb_4Cu(OH)_6[SO_4]_2$
*Beaverite-(Zn) (x = 2,5) $PbFe^{3+}_2Zn(OH)_6[SO_4]_2$
Beaverite (x = 2,75) $Pb(Fe,Cu,Al)_3(OH,{\cdot}H_2O)_6[SO_4]_2$

*Krivovichevite (x = 4,5)	$Pb_3AlOH)_7[SO_4]$
Elyite (x=5)	$Pb_4Cu(OH)_8[SO_4]$
Pseudograndreefite (x = 6)	$Pb_6F_{10}[SO_4]$
Sundiusite (x = 10)	$Pb_{10}O_8Cl_2[SO_4]$
	*3.2.5.3.6.2.1. Hydrates
*Symesite	$Pb_{10}O_7Cl_4[SO_4]\cdot H_2O$
*3.2.5.3.7.3. Oxido-thiosulphates	*3.2.5.3.7.3.1. Basic
*Sidpietersite	$Pb^{2+}{}_4(S^{6+}O_3S^{2-})O_2(OH)_2$
	*3.2.5.3.7.3.2. Hydrates
*Steverustite	$Pb^{2+}{}_5Cu^{+}(S^{6+}O_3S^{2-})_3(OH)_5\cdot 2H_2O$
*3.2.5.3.7.4. Sulfato-arsenates	*3.2.5.3.7.4.1. Hydrates (basic)
*Mallestigite (x = 2,75)	$Pb_3Sb(OH)_6[(SO_4),(AsO_4)]\cdot 3H_2O$
3.2.5.3.8.Sulfates of Ge^{4+}	3.2.5.3.8.1. Basic
Itoite (x = 2,5)	$Pb_3{}^{(6)}Ge^{4+}(OH)_2O_2[SO_4]_2$
	3.2.5.3.8.2. Hydrates (basic)
Fleischerite family (x= 2,5)	
Schaurteite	$Ca_3{}^{(6)}Ge^{4+}(OH)_6[SO_4]_2\cdot 3H_2O$
Fleischerite	$Pb_3Ge^{4+}(OH)_6[SO_4]_2\cdot 3H_2O$
*3.2.5.3.8.2.1. Sulfato-carbonates	
*Carraraite	$Ca_3Ge(OH)_6[SO_4][CO_3]\cdot 12H_2O$
3.2.5.3.9. Sulfates of As^{3+}, Sb^{3+}, Bi^{3+}	*3.2.5.9.1. Neutral
*Markhininite	$Tl^{+}Bi^{3+}[SO_4]_2$
	*3.2.5.3.9.2. Basic and hydrates
*Riomarinaite (x = 1.5)	$Bi^{3+}(OH)[SO_4]\cdot H_2O$
*3.2.5.3.9.3. Oxido-sulfates	*3.2.5.3.9.3.1. Neutral
*Coquandite	$Sb^{3+}{}_6O_8[SO_4]\cdot H_2O$
	*3.2.5.3.9.3.1. Basic and hydrates
Klebelsbergite (x = 6)	$Sb^{3+}{}_4O_4(OH)_2[SO_4]$
*Tavagnascoite	$Bi_4O_4(OH)_2[SO_4]$
*Cannonite	$Bi^{3+}{}_2O(OH)_2[SO_4]$
Peretaite (x = 3,5)	$CaSb^{3+}{}_4O_4(OH)_2[SO_4]_2\cdot 2H_2O$

3.2.6. ***Class:*** Sulfites

3.2.6.1. Subclass: Sulfites of cations with low FC

3.2.6.1.1. Sulfites of ***s*-, *d***

	3.2.6.1.1.1. Hydrates (neutral)
Hannebachite	$Ca[SO_3]\cdot 0{,}5H_2O$
*Gravegliaite	$Mn^{2+}[SO_3]\cdot 3H_2O$
*3.2.6.1.2. Sulfito-sulfates	*3.2.6.1.2.1. Hydrates
*Orschallite	$Ca_3[SO_3]_2[SO_4]\cdot 12H_2O$
*Hielscherite	$Ca_3Si(OH)_6[SO_3][SO_4]\cdot 11H_2O$

3.2.6.2. Subclass: Sulfites of chalcophylic cations 3.2.6.2.1. Neutral

Scotlandite $Pb[SO_3]$

3.2.6a. ***Class:*** Selenates
3.2.6a.1. Subclass: Selenates of chalcophylic cations (Pb^{2+})
3.2.6a.1.1. Proper selenates
3.2.6a.1.1.1. Neutral
Kerstenite $Pb[SeO_4]$ (?)
3.2.6a.1.2. Selnato-sulfates (1 : 1) 3.2.6a.1.2.1. Neutral
Olsacherite $Pb_2[SeO_4][SO_4]$

*3.2.6a.1.3. Selenato-iodates 3.2.6a.1.3.1. Proper
*3.2.6a.1.3.1.1. Complex 3.2.6a.1.3.1.1.1. Hydrates
*Carlosruizite $K_6Na_{10}Mg_{10}[IO_3]_{12}[SeO_4]_{12}\cdot 12H_2O$

3.2.6b. ***Class:*** Selenites
3.2.6b.1. Subclass: Selenites of catiobs with low FC
3.2.6b.1.1. Selenites of ***s-, d_s-*** and ***p_s***- cations 3.2.6b.1.1.1. Hydrates (neutral)
*Nestolaite $Ca[SeO_3]\cdot H_2O$
Mandarinoite $Fe^{3+}{}_2[Se^{4+}O_3]_3\cdot 6H_2O$
*Alfredopetrovite $Al^{3+}{}_2[Se^{4+}O_3]_3\cdot 6H_2O$
Ahlfeldite group
Ahlfeldite $Ni[Se^{4+}O_3]\cdot 2H_2O$
Cobaltomenite $Co[Se^{4+}O_3]\cdot 2H_2O$

3.2.6b.2. Subclass : Selenites of chalcophylic elements
3.2.6b.2.1. Selenites of Cu^{2+} 3.2.6b.2.1.1. Hydrates (neutral)
Chalcomenite family
Chalcomenite $Cu[Se^{4+}O_3]\cdot 2H_2O$

*3.2.6б.2.1.2. Selenito-oxides *3.2.6б.2.1.2.1. Basic and hydrates
*Favreauite $PbBiCu_6O_4(OH)[Se^{4+}O_3]_4\cdot H_2O$

*3.2.6б.2.1.3. Selenito-sulfates *3.2.6б.2.1.3.1. Basic and hydrates
*Pauladamsite $Cu_4(OH)_4[SeO_3][SO_4]\cdot 2H_2O$

*3.2.6б.2.1.4. Selenito-oxido-halogenides
*Ilinskite $NaCu_5O_2[Se^{4+}O_3]_2Cl_3$
*Georgbokiite $Cu_5O_2[SeO_3]_2Cl_2$
*Parageorgbokiite β-$Cu_5O_2[SeO_3]_2Cl_2$
*Nicksobolevite $Cu_7O_2[SeO_3]_2Cl_6$
*Burnsite $KCdCu_7O_2[SeO_3]_2Cl_9$
*Allochalcoselite $Cu^{+}Cu^{2+}{}_5PbO_2[SeO_3]_2Cl_5$
*Francisite $Cu^{2+}{}_3BiO_2[SeO_3]_2Cl$

3.2.6b.2.2. Selenites of Zn
*Zincomenite $Zn[SeO_3]$
3.2.6b.2.2.1. Basic selenites and selenito-halogenides
Sophiite = sofiite $Zn_2Cl_2[Se^{4+}O_3]$

*3.2.6б.2.2.2. Oxido-selenito-halogenides

*Chloromenite $Cu_9O_2[Se^{4+}O_3]_4Cl_6$
*Prewittite $KPb_{1,5}ZnCu^{2+}{}_6O_2[Se^{4+}O_3]_2Cl_{10}$

3.2.6b.2.3. Selenites of Pb^{2+}
3.2.6b.2.3.1. Proper selenites 3.2.6b.3.2.3.1.1. Neutral
Molybdomenite $Pb[Se^{4+}O_3]$

*3.2.6б.2.3.2. Oxido-selenites
*Plumboselite $Pb_3O_2[Se^{4+}O_3]$
3.2.6b.2.3.3. Selenito-selenates (1 :1)
3.2.6b.2.3.2.1. Basic
Schmiederite $Pb_2Cu^{2+}{}_2(OH)_4[Se^{4+}O_3][Se^{6+}O_4]$

*3.2.6б.2.3.4. Selenito-sulfates (1:1) *3.2.6б.2.3.4.1. Основные
*Munakataite $Pb_2Cu^{2+}{}_2(OH)_4[Se^{4+}O_3][S^{6+}O_4]$

*3.2.6б.2.3.5. Selenito-chlorides *3.2.6б.2.3.5.1. Средние
*Sarrabusite $Pb_5Cu^{2+}Cl_4[Se^{4+}O_3]_4$
*3.2.6b.2.3.5.2. Basic
*Unnamed $Pb_4Cu^{2+}Cl_3[Se^{4+}O_3]_3(OH)$
*3.2.6б.2.3.5.3. Hydrates
*Orlandite $Pb_3Cl_4[Se^{4+}O_3]\cdot H_2O$

3.2. 7. ***Class:*** Chromates
3.2.7.1. Subclass: Chromates of cations with low FC
3.2.7.1.1. Chromates of ***s-, d_s-*** and ***p_s***- cations
3.2.7.1.1.1. Proper chromates
3.2.7.1.1.1.1. Trichromates (bichromates) 3.2.7.1.1.1.1.1. Neutral
Lopezite $K_2[Cr_2O_7]$

3.2.7.1.1.1.2. Tetrachromates 3.2.7.1.1.2.1. Neutral
Chromatite $Ca[CrO_4]$
Hashemite (compare with barite (group)) $Ba[(Cr,S)O_4]$
Tarapacáite $K_2[CrO_4]$
*3.2.7.1.1.1.2.1.1. Hydrates
*Unnamed $Ca[CrO_4]\cdot 2H_2O$

3.2.7.1.1.2. Tetrachromato-iodates (0,5:1) 3.2.7.1.1.2.1. Neutral hydrates
Dietzeite $Ca_2[CrO_4][IO_3]_2\cdot H_2O$

3.2.7.2. Subclass: Chromates of chalcophylic elements
3.2.7.2.1. Tetrachromates of Pb^{2+} 3.2.7.2.1.1. Neutral
Crocoite $Pb[CrO_4]$

*3.2.7.2.1.2. Oxido-tetrachromates
*Reynoldsite $Pb^{2+}{}_2Mn^{4+}{}_2O_5[CrO_4]$

*3.2.7.2.1.3. Tetrachromato-silicates *3.2.7.2.1.3.1. Basic hydrates
*Maquartite $Pb^{2+}{}_3Cu^{2+}(OH)_4[CrO_4][SiO_3]\cdot 2H_2O$

*3.2.7.2.1.4. Тетрахроматы-галогениды
*Georgerobinsonite $Pb^{2+}_4(OH)_2FCl[CrO_4]_2$

3.2.7.2.2. Tetrachromates Pb^{4+} 3.2.7.2.2.1. Oxido-and tetrachromato-halogenides
Phoenicochroite (x = 4) $Pb_2O[CrO_4]$
Santanaite (x = 13) $Pb^{2+}_9Pb^{4+}_2O_{12}[CrO_4]$
Yedlinite $Pb^{2+}_2 Pb^{4+}_4(OH)_8O_2Cl_6[Cr^{6+}O_4]$

*3.2.7.2.3. Tetrachromates Hg^{2+}
*Edoylerite $Hg^{2+}_3[Cr^{6+}O_4]S_2$

*3.2.7.2.4. Tetrachromates Hg^+ и Hg^{2+} *3.2.7.2.4.1. Oxido-tetrachromates
*Wattersite $Hg^+_4Hg^{2+}Cr^{6+}O_6 \rightarrow Hg^+_4Hg^{2+}O_2[CrO_4]$

*3.2.7.2.5. Tetrachromates Bi^{3+}
*3.2.7.2.5.1. Oxido-tetrachromates
*Chrombismite $Bi^{3+}_{16}O_{23}[Cr^{6+}O_4]$

3.2.8. Class: Nitrates
3.2.8.1. Subclass: Nitrates of cations with low FC
3.2.8.1.1. Nitrates of ***s*-, *d*$_s$-** and ***p*$_s$**-cations
3.2.8.1.1.1. Neutral
Nitratine $Na[NO_3]$
Nitrobarite $Ba[NO_3]_2$
Niter (saltpeter) $K[NO_3]$
*Nitrammite $(NH_4)[NO_3]$
*Gwihabaite $(NH_4,K)[NO_3]$
3.2.8.1.1.2. Basic hydrates
Sveite $KAl_7(OH)_{16}Cl_2[NO_3]_4 \cdot 8H_2O$
3.2.8.1.1.2.1.1. Neutral
Nitromagnesite $Mg[NO_3]_2 \cdot 6H_2O$
Nitrocalcite $Ca[NO_3]_2 \cdot 4H_2O$

3.2.8.2. Subclass: Nitrates of chalcophylic elements
3.2.8.2.1. Nitrates of Cu^{2+}
3.2.8.2.1.1. Neutral
*Shilovite $Cu(NH_3)_4[NO_3]_2$
3.2.8.2.1.2. Basic
3.2.8.2.1.1. Basic
Gerhardtite $Cu_2(OH)_3[NO_3]$
*Rouaite $Cu_2(OH)_3[NO_3]$
3.2.8.2.1.3. Hydrates (basic)
Buttgenbachite $Cu_{19}(OH)_{32}Cl_4[NO_3]_2 \cdot 2H_2O$
Likasite $Cu_3(OH)_5 [NO_3] \cdot 2H_2O$

3.2.8a. ***Class:*** Iodates
3.2.8a.1. Subclass: Iodates of cations with low FC
3.2.8a.1.1. Iodates of ***s*-, *d*$_s$**- and ***p*$_s$**- cations
3.2.8a.1.1.1. Neutral
Lautarite $Ca[IO_3]_2$

3.2.8a.1.1.2. Hydrates (neutral)
Brüggenite $Ca[IO_3]_2 \cdot H_2O$

*3.2.8a.1.2. Iodato-chromates *3.2.8a.1.2.1. Hydrates
*Georgeericksenite $Na_6CaMg[IO_3]_6[CrO_4]_2 \cdot (H_2O)_{12}$

3.2.8a.2. Subclass: Iodates of chalcophylic elements
3.2.8a.2.1. Iodates of Cu^{2+} 3.2.8a.2.1.1. Basic
Salesite $Cu(OH)[IO_3]$
3.2.8a.2.1.2. Hydrates
Bellingerite $Cu_3[IO_3]_6 \cdot 2H_2O$

3.2.8a.2.2. Iodates of Pb^{2+} 3.2.8a.2.2.1. Iodato-halogenides
Seeligerite $Pb_3OCl_3[IO_3]$

*3.2.8b. ***Class:*** Iodites
*3.2.8b.1. Subclass: Iodites of chalcophylic elements
*3.2.8b.1.1. Iodites Pb^{2+}
*3.2.8b.1.1.1. Hydroxido-oxido-iodito-chalogenides
Schwartzembergite $Pb^{2+}{}_5I^{3+}O_6H_2Cl_3 \rightarrow Pb^{2+}{}_5(OH)_2O_2Cl^{+}{}_3[I^{3+}O_2]$

3.2.8c. ***Class:*** Rhodonates (tiocyanates)

4. TYPE: MINERALS WITH PRINCIPAL COVALENT-IONIC AND IONIC BOND – HALOGEN COMPAUNDS: HALOGENIDES (ISODESMICAL) → HALOGENSALTS (ANISODESMICAL)

4.1. SUBTYPE: HALOGENIDES (ISODESMICAL)

4.1.1.***Class***: Fluorides
4.1.1.1. Fluorides of ***s-***, d_s- and p_s- cations
4.1.1.1.1. Fluorides of ***s-***, d_s- and p_s- cations without Li and Be
4.1.1.1.1.1. Proper fluorides
4.1.1.1.1.1.1. Simple 4.1.1.1.1.1.1.1. Neutral
Sellaite MgF_2
Fluorite group
Fluorite CaF_2
Frankdicksonite BaF_2
*Strontiofluorite SrF_2
Villiaumite group
Villiaumite NaF
Carobbiite KF
*Oskarssonite AlF_3
*4.1.1.1.1.1.1.2. Hydrates
*Rosenbergite $AlF[F_{0,5}(H_2O)_{0,5}]_4 \cdot H_2O$
4.1.1.1.1.1.2. Complex 4.1.1.1.1.1.2.1. Neutral
Neighborite $NaMgF_3$
*Yakobssonite $CaAlF_5$
*Karasugite $SrCa[Al(F,OH)_7]$
*Calcioaravaipaite $PbCa_2AlF_9$

4.1.1.1.1.2. Fluorido-hexafluoraluminates 4.1.1.1.1.2.1. Neutral

Weberite family
Weberite $Na_2MgAlF_7 \rightarrow Na_2\{MgF[AlF_6]\}^{\infty3}$
Usovite $Ba_2CaMgAl_2F_{14} \rightarrow Ba_2\{CaMgF_2[AlF_6]_2\}^{\infty3}$
*Bøgvadite $Na_2SrBa_2Al_4F_{20} \rightarrow Na_2\{SrBa_2AlF_2[AlF_6]_3\}$
*Coulsellite $CaNa_3Mg_3AlF_{14} \rightarrow Na_3\{CaMg_3F_8[AlF_6]\}$
4.1.1.1.1.2.2. Hydrates
Carlhintzeite $Ca_2AlF_7{\cdot}H_2O \rightarrow Ca\{CaF[AlF_6]\}^{\infty3}{\cdot}H_2O$
*Leonardsenite $MgAlF_5{\cdot}2H_2O$

*4.1.1.1.1.3. Fluorido-chlorides
*Rorisite CaFCl
*Zhangpeishanite BaFCl

4.1.1.1.2. Fluorides of Li
4.1.1.1.2.1. Simple 4.1.1.1.2.1.1. Neutral
Griceite LiF

*4.1.1.1.2.2. Fluorido-hexafluoraluminates Li
*4.1.1.1.2.2.1. Complex *4.1.1.1.2.2.1.1. Neutral
*Simmonsite $Na_2Li[AlF_6]$

4.1.1.2. Fluorides of ***f***- cations
4.1.1.2.1. Simple 4.1.1.2.1.1. Neutral
Fluocerite series
Fluocerite-(Ce) CeF_3
Fluocerite-(La) LaF_3
*Waimirite-(Y) YF_3
4.1.1.2.2. Complex 4.1.1.2.2.1. Neutral
Tveitite-(Y) $(Y,Na)_6(Ca,Na,REE)_{12}(Ca,Na)F_{42}$
*Zajacite-(Ce) = gagarinite-(Ce) $NaCaCeF_6$
Gagarinite-(Y) $NaCaYF_6$
*Polezhaevaite-(Ce) $NaSrCeF_6$

*4.1.1.2.3.Oxido-fluorides
*Håleniusite-(La) (La,Ce)OF

*4.1.1.3. Fluorides of chalcophilic cations
*4.1.1.3.1. Fluorides of **I***b*-elements
*4.1.1.3.1.1. Fluorides of Cu^{2+}
*Khaidarkanite $Cu_4Al_3(OH)_{14}F_3{\cdot}2H_2O$

*4.1.1.3 2. Fluorides of IVa-elements
*4.1.1.3.2.1. Fluorides Pb^{2+}
*4.1.1.3.2.1.1. Simple
*Fluorocronite PbF_2
*4.1.1.3.2.1.1.1. Основные
*Artroeite $PbAl(OH)_2F_3$

*4.1.1.3.2.1.2. Fluorido-chlorides
*Laurelite $Pb_7F_{12}Cl_2$

*4.1.1.3.2.1.2.1. Fluorido-oxido-chlorides

*Rumseyite	$[Pb_2OF]Cl$

4.1.2. ***Class:*** Chlorides and bromides
4.1.2.1. Chlorides of cations with low FC
4.1.2.1.1. Chlorides of ***s-, d_s-*** and ***p_s***- cations
4.1.2.1.1.1. Simple

	4.1.2.1.1.1.1. Neutral
Molysite	$FeCl_3$
Lawrencite	$FeCl_2$
Scacchite	$MnCl_2$
*Chloromagnesite (disputable)	$MgCl_2$
*Chlorocalcite	$KCaCl_3$
Halite group	
Halite	$NaCl$
Sylvite	KCl
Salammoniac	NH_4Cl
	4.1.2.1.1.1.2. Basic
Kempite	$Mn_2(OH)_3Cl$
*Hibbingite	$\gamma\text{-}Fe^{2+}{}_2(OH)_3Cl$
	4.1.2.1.1.1.3. Hydrates
Hydrophilite = antarcticite or sinjarite	$CaCl_2{\cdot}6H_2O$
*Ghiaraite	$CaCl_2{\cdot}4H_2O$
	4.1.2.1.1.1.3.1. Basic
Cadwaladerite (x = 1,5)	$Al(OH)_2Cl{\cdot}4H_2O$
Korshunovskite (x = 2)	$Mg_2(OH)_3Cl{\cdot}3,5\text{-}4H_2O$
*Nepskoeite (x = 4)	$Mg_4(OH)_7Cl{\cdot}6H_2O$
Chloraluminite family	
Chloraluminite	$AlCl_3{\cdot}6H_2O \rightarrow [Al(H_2O)_6]Cl_3$
Rokühnite	$FeCl_2{\cdot}2H_2O \rightarrow [{}^{(6)}FeCl_2(H_2O)_2]^{\infty}$
Bischofite group	
Bischofite	$MgCl_2{\cdot}6H_2O \rightarrow [Mg(H_2O)_6]Cl_2$
Nickelbischofite	$NiCl_2{\cdot}6H_2O \rightarrow [Ni(H_2O)_6]Cl_2$
Sinjarite	$CaCl_2{\cdot}2H_2O \rightarrow [Ca(H_2O)_2Cl_2]^{\infty 2}$
Hydrohalite	$NaCl{\cdot}2H_2O$

4.1.2.1.1.2. Complex	4.1.2.1.1.2.1.Basic
*Koenenite	$Na_4Mg_9Al_4(OH)_{22}Cl_{12}$
*Kuliginite (x = 2)	$Fe^{2+}{}_3Mg(OH)_6Cl_2$
Chlormagaluminite group	4.1.2.1.1.2.1.1. Hydrates
Chlormagaluminite	$(Mg,Fe^{2+})_4Al_2(OH)_{12}Cl_2{\cdot}2H_2O$
Hydrocalumite	$Ca_2Al(OH)_6(Cl,CO_3,OH){\cdot}2H_2O$
*Iowaite (x = 4)	$Mg_6Fe^{3+}{}_2(OH)_{16}Cl_2{\cdot}4H_2O$
*Woodallite (x = 4)	$Mg_6Cr_2(OH)_{16}Cl_2{\cdot}4H_2O$
*Kopeyskite	$(NH_4)_2(Fe,Al,Ca,Mg)(Cl,OH)_5{\cdot}H_2O$
	4.1.2.1.1.2.1.1.1. Neutral
Tachyhydrite	$CaMg_2Cl_6{\cdot}12H_2O$
Carnallite	$KMgCl_3{\cdot}6H_2O \rightarrow K[Mg(H_2O)_6]Cl_3$

4.1.2.2. Chlorides, bromides, iodides of chalcophylic elements
4.1.2.2.1. Chlorides, bromides, iodides of **I*b***-elements
4.1.2.2.1.1. Chlorides, bromides, iodides of Cu^+, Ag^+, Hg^+
4.1.2.2.1.1.1. Simple 4.1.2.2.1.1.1.1. Neutral

Nantokite group
Nantokite $CuCl$
Chlorargyrite group
Chlorargyrite $AgCl$
Bromargyrite $AgBr$
Calomel $HgCl$
*Kuzminite $Hg_2(Br,Cl)_2$

4.1.2.2.1.1.2. Complex 4.1.2.2.1.1.2.1. Basic

Bideauxite (x = 1) $Pb_2Ag^+(F,OH)_2Cl_3$

4.1.2.2.1.2. Chlorides of Cu^{2+}
4.1.2.2.1.2.1. Simple

4.1.2.2.1.2.2. Neutral

Tolbachite $CuCl_2$
*Sanguite $KCuCl_3$

4.1.2.2.1.2.1.2. Basic

*Belloite $Cu(OH)Cl$
Atacamite family
Atacamite $Cu_2(OH)_3Cl$
*Clinoatacamite $Cu_2(OH)_3Cl$
Botallackite $Cu_2(OH)_3Cl$
*Fejerite $Cu_4(OH)_6ClF$
Claringbullite $Cu_4(OH)_6ClF$

4.1.2.2.1.2.1.3. Hydrates
4.1.2.2.1.2.1.3.1. Basic

*Bobkingite $Cu_5(OH)_8Cl_2(H_2O)_2$

4.1.2.2.1.2.1.3.1. Neutral

Eriochalcite $CuCl_2{\cdot}2H_2O \rightarrow [CuCl_2(H_2O)_2]$

4.1.2.2.1.1.2. Complex *4.1.2.2.1.1.2.1. Neutral

*Ammineite $[Cu(NH_3)_2]Cl_2$
*Romanorlovite $K_8Cu_6(OH)_3Cl_{17}$

4.1.2.2.1.1.2.2. Основные

Сем. **паратакамита**(x = 2)
Paratacamite $Cu_3(Cu,Zn)(OH)_6Cl_2$
*Paraатакамит-(Mg) $Cu_3(Mg,Cu)(OH)_6Cl_2$
*Paraатакамит-(Ni) $Cu_3(Ni,Cu)(OH)_6Cl_2$
*Haydeeite $Cu_3Mg(OH)_6Cl_2$
*Tondiite $Cu_3Mg(OH)_6Cl_2$
*Gerbertsmithite $Cu_3Zn(OH)_6Cl_2$
*Kapellasite $Cu_3Zn(OH)_6Cl_2$
*Gillardite $Cu_3Ni(OH)_6Cl_2$
*Leverettite $Cu_3Co(OH)_6Cl_2$
Boleite family
Boleite (x = 0,9) $KPb^{2+}_{26}Ag^+_9Cu^{2+}_{24}(OH)_{48}Cl_{62}$

Pseudoboleite $Pb_{31}Cu^{2+}{}_{24}(OH)_{48}Cl_{62}$
Percylite = boleite + psevdoboleite (?) $PbCu(OH)_2Cl_2$ (?)
Diaboleite (x = 1,5) $\{Pb_2Cu(OH)_4Cl_2\}^{\infty 2}$

*4.1.2.2.1.1.2.2.1. Hydrates

Cumengite (x = 1) $Pb_{21}Cu_{20}(OH)_{40}Cl_{42}\cdot 6H_2O$
*Feodosiyite $Cu_{11}Mg_2(OH)_8Cl_{18}\cdot 16H_2O$
*Centennialite $CaCu_3(OH)_6Cl_2\cdot nH_2O$ (n = 0.7)
*Avdoninite $K_2Cu_5(OH)_4Cl_8\cdot 2H_2O$
*Dioskouriite $CaCu_4(OH)_4Cl_6\cdot 4H_2O$
*Chrysothallite $K_6Cu_6Tl^{3+}(OH)_4Cl_{17}\cdot H_2O$
*Chanabayaite $Cu(N_3C_2H_2)(NH_3)Cl\cdot 0.25H_2O$

*4.1.2.2.1.1.3. Oxido-chlorides
*4.1.2.2.1.1.3.1. Basic
Chloroxiphite (x = 2) $Pb_3Cu(OH)_2O_2Cl_2$
*Fuettererite $Pb_3Cu^{2+}{}_6Te^{6+}O_6(OH)_7Cl_5$

4.1.2.2.2. Chlorides of **II*b***-elements
4.1.2.2.2.1. Chlorides of Zn

*4.1.2.2.2.1.1. Средние

*Flinteite K_2ZnCl_4
*Mellizinkalite $K_3Zn_2Cl_7$
*Amminite $[Zn(NH_3)_2]Cl_2$

4.1.2.2.2.1.2. Hydrates (basic)

*Cryobostryxite $ZnKCl_3\cdot 2H_2O$
Simonkolleite $Zn_5(OH)_8Cl_2\cdot H_2O\rightarrow[^{(4;6)}Zn_5(OH)_8]^{\infty 2}Cl_2\}^{\infty 2}\cdot H_2O$

*4.1.2.2.2.2. Chlorides of Hg
*4.1.2.2.2.2.1. Oxido-chlorides of Hg
*Hanawaltite $Hg^{+}{}_6Hg^{2+}Cl_2O_3$

*4.1.2.2.3. Хлориды **III*a***-элементов
*4.1.2.2.3.1. Хлориды Tl

*4.1.2.2.3.1.1. Neutral
*4.1.2.2.3.1.1.1. Simple

*Lafossaite TlCl

*4.1.2.2.3.1.1.2. Complex

*Steropesite Tl_3BiCl_6
*Hephaistosite $TlPb_2Cl_5$

4.1.2.2.4. Chlorides of **IV*a***-elements
4.1.2.2.4.1. Chlorides of Pb^{2+}
4.1.2.2.4.1.1. Simple

4.1.2.2.4.1.1.1. Neutral

Cotunnite family
Matlokite PbClF
Cotunnite $PbCl_2$

4.1.2.2.4.1.1.2. Basic and hydrates

Penfieldite (x = 0,(6)) $Pb_2(OH)Cl_3$
Fiedlerite (x = 0,75) $Pb_3F(OH)Cl_4\cdot H_2O$
Laurionite family (x = 1)
Laurionite Pb(OH)Cl

Paralaurionite $Pb(OH)Cl$

4.1.2.2.3.1.2. Complex 4.1.2.2.3.1.2.1. Neutral
*Challacolloite KPb_2Cl_5
Pseudocotunnite K_2PbCl_4 (?)
*Brontesite $(NH_4)_3PbCl_5$
*4.1.2.2.4.1.2.2. Basic
*4.1.2.2.5. Oxido-chlorides Pb
*4.1.2.2.5.1. Simple *4.1.2.2.5.1.1. Basic
*Blixite (x = 2) *$Pb_8O_5(OH)_2Cl_4$

*4.1.2.2.5.2. Complex *4.1.2.2.5.2.1. Basic
*Rickturneite $Pb_7O_4[Mg(OH)_4](OH)Cl_3$
*Hereroite $[Pb_{32}(O,\square)_{21}][AsO_4]_2[(Si,As,V,Mo)O_4]_2Cl_{10}$
*4.1.2.2.5.2.1.1. Hydrates
*Vladkrivovichevite $[Pb_{32}O_{18}][Pb_4Mn_2O][BO_3]_8Cl_{14}\cdot 2H_2O$

*4.1.2.2.6. Fluorides, chlorides **IV***a*-elements
*4.1.2.2.6.1. Fluorides, chlorides Bi^{3+}
*4.1.2.2.6.1.1. Simple
*4.1.2.2.6.1.2. Comhlex
*Argesite $(NH_4)_7Bi^{3+}{}_3Cl_{16}$

4.1.2a. ***Class***: Iodides
*Unnamed RhI_3
Marshite series
Marshite CuI
*Marshite cuprous CuI
Miersite $(Ag,Cu)I$
Iodargyrite AgI
*Iodargyrite 2H AgI
Tocornalite $(Ag,Hg)I$
*Coccinite HgI_2
*Moschelite Hg_2I_2

4.2. SUBTYPE: HALOGENOSALTS (ANISODESMICAL) (WITH HEXACYANOFERRATES AND HEXATIOCYANATES, RHODONIDES)
*4.2a. QUASISUBTYPE*HALOGENOSALTS WITH **d**-CATION-COMPLEXFORMERS*
4.2a.1. ***Class***: Chloroferrites and chlorocuprites (only ***s***- cations and $NH^+{}_4$)
4.2a.1.1. Chlorooxidopolycuprites 4.2a.1.1.1. Neutral
Ponomarevite $K_4[Cu^{2+}{}_4OCl_{10}]$

4.2a.1.2. Hexachlorocuprites 4.2a.1.2.1. Neutral chloroaquacuprites*
Mitscherlichite $K_2[Cu^{2+}Cl_4(H_2O)_2]$

4.2a.1.3. Rhodanidocobaltites
4.2a.1.3.1. Tetrarhodanidocobaltites II

* Partical "aqua" in complex anion´s name of halogenosalt means, that at least one of its ligands is $\cdot H_2O$; particles "oxo" and "hydroxo" means, that as ligands with halogen-ions appear O^{2-} - or OH^- -ions respectively.

4.2a.1.3.1.1. Hydrates (neutral)

Julienite $Na_2[Co(SCN)_4]\cdot 8H_2O$

4.2a.2. ***Class***: Hexachloroferrates and hexachloromanganates (only ***s***- cations)

4.2a.2.1. Hexachloroferrates II and hexachloromanganates II

4.2a.2.1.1. Neutral

Rinneite group

Rinneite $K_3Na[Fe^{2+}Cl_6]$

*Saltonseaite $K_3Na[Mn^{2+}Cl_6]$

Chlormanganokalite $K_4[Mn^{2+}Cl_6]$

Douglasite $K_2[Fe^{2+}Cl_4(H_2O)_2]$

4.2a.2.2. Hexachloroferrates III

4.2a.2.2.1. Chloroaquaferrates III (neutral)

Kremersite group

Erythrosiderite $K_2[Fe^{3+}Cl_5(H_2O)]$

Kremersite $(NH_4,K)_2[Fe^{3+}Cl_5(H_2O)]$

4.2b. Quasisubtype*: Halogenosalts with ***p***- anion-complexformers

4.2b.1. ***Class:*** Fluoroaluminates (only ***s***- cations)

4.2b.1.1. Hexafluoropolyaluminates 4.2b.1.1.1. Neutral (***s***-cations)

Chiolite $Na_5[Al_3F_{14}]^{\infty 2}$

*Ralstonite $NaMg[Al_3F_8(OH)_4]\cdot H_2O$

Prosopite $Ca[Al_2F_4(OH)_4]$

Jarlite group

Calcjarlite $Na_2(Ca,Sr,Na,\square)_{14}Al_{12}Mg_2(F,OH)_{64}(OH)_4$

Jarlite $Na_2(Sr,Na)_{14}Mg_2Al_{12}F_{64}(OH,\cdot H_2O)_4$

*Jørgensenite $Na_2(Sr,Ba)_{14}Na_2Al_{12}F_{64}(OH,F)_4$

4.2b.1.2. Hexafluoroaluminates

4.2b.1.2.1. Hexafluoroaluminates of ***s-, d$_s$-*** and ***p$_s$***-ations

4.2b.1.2.1.1. Hexafluoroaluminates of ***s-, d$_s$-*** and ***p$_s$***-ations without Li and Be

4.2b.1.2.1.1.1. Proper hexafluoroaluminates

4.2b.1.2.1.1.1.1. Neutral

Cryolite family

Cryolite $Na_3[AlF_6]$

Elpasolite $K_2Na[AlF_6]$

4.2b.1.2.1.1.1.2. Hydrates

Thomsenolite family

Thomsenolite $NaCa[AlF_6]\cdot H_2O$

Pachnolite $NaCa[AlF_6]\cdot H_2O$

4.2b.1.2.1.1.2. Fluorohydroxyaluminates 4.2b.1.2.1.1.2.1. Hydrates

Yaroslavite $Ca_3[AlF_5(OH)]_2\cdot H_2O$

*Ralstonite-like $Na_3CaMg_3\{AlF_{12}[(OH),O,F)]_2\}$

4.2b.1.2.1.1.3. Fluorohydroxaquaaluminates 4.2b.1.2.1.1.3.1. Neutral

Gearksutite family

Gearksutite $Ca[AlF_4(OH)(H_2O)]^{\infty 2}$

Tikhonenkovite $Sr[AlF_4(OH)(H_2O)]^{\infty 2}$
Acuminite $Sr[AlF_4(OH)(H_2O)]^{\infty 2}$

4.2b.1.2.1.2. Hexafluoroaluminates of Li 4.2b.1.2.1.2. Neutral
Cryolithionite family
Colquiriite $CaLi[AlF_6]$
Cryolithionite $Na_3Li_3[AlF_6]_2$

4.2b.2. ***Class:*** Fluoroborates (only ***s***- cations)
4.2b.2.1. Neutral
Ferruccite family
Ferruccite $Na[BF_4]$
Avogadrite $(K,Cs)[BF_4]$
*Barberiite $(NH_4)[BF_4]$

4.2b.3. ***Class***: Fluorosilicates (only ***s***- cations and NH^+_4)
4.2b.3.1. Neutral
Malladrite family
Malladrite $Na_2[SiF_6]$
Hieratite group
Hieratite $K_2[SiF_6]$
Cryptohalite $(NH_4)_2[SiF_6]$
Bararite $(NH_4)_2[SiF_6]$
*Demartinite $K_2[SiF_6]$
*Heklaite $KNa[SiF_6]$
*Knasibfite $K_3Na_4[SiF_6]_3[BF_4]$

4.2b.4. ***Class:*** Chloroaluminates (only ***s***- cations)
*4.2б.5. ***Класс***: Hexachlorostannates
*Panichiite $(NH_4)_2[SnCl_6]$

5. TYPE: CARBON, ITS COMPOUNDS (WITHOUT CARBONATES) AND RELATED SUBSTENCES

5a. **Quasitype*: Inorganic compaunds (withaut carbonates) and related substances**
5a.1. SUBTYPE: NATIVE MINERALS
Native carbon family
Graphite C
Lonsdaleite C
Chaoite C
Diamond C
*Carbon cubic C
Schungite C
Silicium group
Silicium Si
Germanium Ge

5a.2. SUBTYPE: MINERALS WITH PRICIPAL COVALENT AND METALLIC-COVALENT BOND - CARBIDES AND RELATED SUBSTANCES - SILICIDES, NITRIDES AND PHOSPHIDES
5a.2.1. ***Class:*** Carbides

5a.2.1.1. Carbides of **IV*a***-elements

Moissanite-*6H*	SiC
Moissanite -5H	
Moissanite -15R	
Moissanite -33R	
Moissanite –beta	

5a.2.1.2. Carbides of cenosymmetrical ***d***- elements

5a.2.1.2.1. Carbides of **VIII*b***- elements Simple

Haxonite	$(Fe,Ni)_{23}C_6$
Cohenite group (?)	
Cohenite	$(Fe,Ni,Co)_3C$
Unnamed 448	$(Mn,Fe)_3(C,Si)$
Chalypite	Fe_2C

*5a.2.1.2.2. Carbides of **VIII*b*** и **VI*b***- elements

*Isovite	$(Cr,Fe)_{23}C_6$

5a.2.1.2.2. Carbides of **VI*b***-elements Simple

Unnamed 241	Cr_2C
Tongbaite	Cr_3C_2

5a.2.1.2.3. Carbides of **IV*b***- elements Simple

Khamrabaevite series (?)	
Khamrabaevite	(Ti,V,Fe)C
Unnamed 330	(V,Ti)C

5a.2.1.3. Carbides of noncenosymmetrical ***d***- elements

*5a.2.1.3.1. Carbides of **VII*b***- elements

*Carbide Mn	Mn_3C

5a.2.1.3.2. Carbides of **VIII*b***-elements Complex

5a.2.1.3.3. Carbides of **VI*b***-elements Simple

Unnamed 290	WC

5a.2.1.3.4. Carbides of **V*b***-elements Simple

Tantalcarbi	(Ta,Nb)C
*Niobocarbide	(Nb,Ta)C

5a.2.1a. ***Class:*** Silicides

5a.2.1a.1. Silicides of noncenosymmetrical ***d***- elements

5a.2.1a.1.1. Silicides of **VIII*b***-elements Simple

*Palladosilicide	Pd_2Si
Unnamed 449	(Mn,Si,Fe)
Suessite family (x = M : X = 3)	
Suessite	$(Fe,Ni)_3Si$
Gupeiite	Fe_3Si
Unnamed 025	$(Cr,Fe)_3Si$
Perryite (x = 2.(6))	$(Ni,Fe)_8(Si,P)_3$

*Unnamed	Fe_2Si
*Hapkeite	Fe_2Si
*Mavlyanovite(x = 1.(6))	$(Mn,Fe)_5Si_3$
Xifengite (x = 1.(6))	Fe_5Si_3
*Naquite (tetr.) (x = 1)	FeSi
*Linzhiite	$FeSi_2$
Unnamed 424 (x = 0.43)	$FeSi_{2,3}$
*Luobusaite (x = 0.42)	$Fe_{0,84}Si_2$
	Complex
Unnamed 028 (x = 1)	$FeTiSi_2$
*Zangboite	$FeTiSi_2$

5a.2.1a.2. Silicides of ***s***- elements

5a.2.1a.3 Silicides of **II*a***- elements — Simple

Unnamed 024	Mg_2Si

5a.2.2. **Class**: Nitrides

*5a.2.2.1. Nitrides ***p***- elements

*Qingsongite	BN

5a.2.2.2. Nitrides (nitrido-oxides) **IV*a***- elements

Simple

Sinoite	Si_2N_2O
*Nierite	Si_3N_4

5a.2.2.2.1. Nitrides of cenosymmetrical *d*- elements

5a.2.2.2.1.1. Nitrides of **VIII*b***- elements — Simple

Roaldite	Fe_4N
Siderazot	Fe_5N_2

5a.2.2.2.1.2. Nitrides of **VI*b***- elements — Simple

Carlsbergite	CrN

5a.2.2.2.1.3. Nitrides of **IV*b***- elements — Simple

Osbornite	TiN

5a.2.2.2.2. Nitrides of noncenosymmetrical ***d***- elements

5a.2.2.2.2.1. Nitrides of **II*b***- elements — Compounds inclusions

Mosesite family

Mosesite	$\vert Hg_2N\vert^{\infty 3}\cdot(Cl,SO_4,MoO_4,CO_3)\cdot H_2O$
Kleinite	$\vert Hg_2N\vert^{\infty 3}\cdot(Cl,SO_4)\cdot(H_2O)_n$

5a.2.2a. ***Class:*** Phosphides

5a.2.2a.1. Phosphides of cenosymmetrical ***d***- elements

5a.2.2a.1.1. Phosphides of **VIII*b***- elements — Simple

*Melliniite	$(Ni,Fe)_4P$
*Murashkoite	FeP
*Zuktamrurite	FeP_2

Schreibersite series

Rhabdite	Ni_3P

Schreibersite $(Fe,Ni)_3P$
*Nickelphosthide $(Ni,Fe)_3P$
Barringerite $(Fe,Ni)_2P$
*Allabogdanite $(Ni,Fe)_2P$
*Transjordanite Ni_2P

5a.2.2a.1.2. Phosphides of **IV*b***-elements. Simple
Unnamed 027 TiP
*Complex
*Florenskyite FeTiP
*Andreyivanovite Fe(Cr,Fe,V,Ti)P

*5a.2.2a.1.3. Phosphides of **VI*b***- elements Complex
*Monipite MoNiP

5b. **Quasitype*: Organic carbon compounds (minerals with principal van der Waals forces bond)**
5b.1. SUBTYPE: SALTS OF ORGANIC ASIDS
5b.1.1. ***Class:*** Salts of benzopolycarbonic acids ($C_6H_{6-n}(COOH)_n$; n=6)
5b.1.1.1. Hydrates (neutral)
Mellite $Al_2[C_6(COO)_6]\cdot16H_2O$

5b.1.2***. Class:*** Salts of citric acid (citrates)
5b.1.2.2.1. Hydrates
5b.1.2.2.1.1. Oxido-citrates
Pigotite $Al_4O_3[C_6H_5O_7]\cdot13H_2O$
5b.1.2.2.1.2. Neutral
Earlandite $Ca_3[C_6H_5O_7]_2\cdot4H_2O$

5b.1.3. ***Class:*** Salts of acetic acid (acetates)
*Ca-acetic $Ca[CH_3COO]\cdot H_2O$
*Hoganite $C_4H_8O_5Cu \rightarrow Cu[CH_3COO]_2\cdot H_2O$
*Paceite $C_8H_{24}O_{14}CaCu \rightarrow CaCu[CH_3COO]_4\cdot6H_2O$

5b.1.3.1. Acetato-chlorides 5b.1.3.1.1. Hydrates (neutral)
Calclacite $CaCl[CH_3COO]\cdot5H_2O$

5b.1.4. ***Class:*** Salts of oxalic acid (oxalates)
5b.1.4.1. Salts of oxalic acid (oxalates) ***s-, d_s-, ps***-cations
*5b.1.4.1.1. Neutral
*Natroxalate $Na_2[C_2O_4]$
*Antipinite $KNa_3Cu_2[C_2O_4]_4$
5b.1.4.1.2. Hydrates (neutral)
Zhemchuzhnikovite series
Zhemchuzhnikovite $NaMg(Al,Fe^{3+})[C_2O_4]_3\cdot(8\text{-}9)H_2O$
Stepanovite $NaMgFe^{3+}[C_2O_4]_3\cdot(8\text{-}9)H_2O$
Minguzzite $K_3Fe^{3+}[C_2O_4]_3\cdot3H_2O$
Weddellite family
Glushinskite $Mg[C_2O_4]\cdot2H_2O$
Humboldtine $Fe^{2+}[C_2O_4]\cdot2H_2O$

Weddellite $Ca[C_2O_4]·2H_2O$
*Caoxite $Ca[C_2O_4]·3H_2O$
Whewellite $Ca[C_2O_4]·H_2O$
Oxammite $(NH_4)_2[C_2O_4]·H_2O$

*5б.1.4.2. Salts of oxalic acid (oxalates) ***f***- elements
*5б.1.4.2.1. Hydrates
*Deveroite-(Ce) $Ce_2[C_2O_4]_3·10H_2O$

5b.1.4.3. Salts of chalcophylic elements (Cu^{2+}) 5b.1.4.1.1.1. Hydrates (neutral)
Moolooite $Cu[C_2O_4]·nH_2O$
Wheatleyite $Na_2Cu^{2+}[C_2O_4]_2·2H_2O$
*Lindbergite $Mn^{2+}[C_2O_4]·2H_2O$

*5b.1.4.3. Oxalato-chlorides
*Novgorodovaite $Ca_2[C_2O_4]Cl_2·2H_2O$

*5b.1.4.4. Oxalato-sulfates
*Coskrenite-(Ce) $(Ce,Nd,La)_2[SO_4]_2[C_2O_4]·8H_2O$

*5b.1.5. Salts of formic asids (formates)
*Formicaite $Ca[COOH]_2$
*Dashkovaite $Mg[COOH]_2·2H_2O$

*5б.1.6. Salts of methylsulfonic acid CH_3SO_3H (methylsulfonates)
*Ernstburkeite $Mg(CH_3SO_3)_2·12H_2O$

5b.2. SUBTYPE: HYDROCARBONS AND RELATED COMPAUNDS
5b.2.1. ***Class:*** Hydrocarbons cyclic (in the order of decreasing x = H : C)
Evenkite family
Evenkite (n-tetracosene) $C_{24}H_{48}$ (x = 2)
Fichtelite $C_{19}H_{34}$ (x = 1,(8))
*Dinite $C_{20}H_{36}$ (x = 1,8)
Hartite $C_{20}H_{34}$ (x = 1,7)
Simonellite $C_{19}H_{24}$ (x = 1,26)
(1,1-dimethyl-7-isopropyl-1,2,3,4-tetrahydrophenanthrene)
Phylloretine $C_{18}H_{18}$ (x = 1)
Kratochvilite $C_{13}H_{10}$ (x = 0,77)
*Ravatite $C_{14}H_{10}$ (x = 0,7)
Idrialite (dimethylbenzphenanthrene) $C_{22}H_{14}$ (x = 0,64)
Karpatite = Carpathite $C_{24}H_{12}$ (x = 0,5)

5b.2.2. ***Class:*** Hydrocarbons oxygenbearing (in the order of increasing O : C)
*Lidinite $C_{27}H_{46}O$
Hoelite family
Refikite (δ-13-dihydro-d-pimaric acid) $C_{20}H_{32}O_2$
Hoelite (anthraquinone) $C_{14}H_8O_2$
Flagstaffite (cis-terpin hydrate) $C_{10}H_{18}(OH)_2·H_2O \rightarrow C_{10}H_{22}O_3$
Sapperit (cellulose) $C_6H_{10}O_5·mH_2O$

5b.2.3. ***Class:*** Nitrogenbearing organic compounds

Abelsonite family	
Abelsonite (nickel porphyrine)	$C_{31}H_{32}N_4Ni$
Kladnoite (phthalimide)	$C_6H_4(CO_2)NH$
Acetamide	CH_3CONH_2
Guanine	$C_5H_3(NH_2)N_4O$
Uricite (2,6,8-trihydroxypurine)	$C_5H_4N_4O_3$
*Tinnunculite	$C_5H_4N_4O_3 \cdot 2H_2O$
Urea	$CO(NH_2)_2$

5b.3. SUBTYPE: MIXTURES OF ORGANIC SUBSTANCES INCLUDING AMBER AND RELATED SUBSTANCES

Kerite
Asphalt
Ozokerite
Amber

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Symbols

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