## Alphabetical listing of minerals.

For convenience, this alphabetical listing is broken up into AB, CD, EF, GH, IJKL, MN, OPQR, ST and UVWXYZ sections. Readers may wish to merge them into one listing that can be searched at one time. Note that the brackets are omitted in chemical modifiers. Thus **abenakiite-Ce should be abenakiite-(Ce) in approved mineral names.**

## AB

**abelsonite** Nickel porphyrin; should match synthetic.
Occurrence: **C Milton & 5 others** 1978 AM 63 930-7.
MM 40 903.

**abenakiite-Ce** $Na_{26}(Ce,REE)_6(SiO_3)_6(PO_4)_6(CO_3)_6(SO_2)O$.
Structure: **AM McDonald GY Chao JD Grice** 1994 CM 32 843-54.

**abernathyite** $KUO_2AsO_4.4aq$. *Meta-autunite* structure type.
Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
Structure: **M Ross HT Evans Jr** 1964 AM 49 1578-602; also $NH_4$ & K analogs.
*Synthetic* Li analog: MA 82M/3942.

**abhurite** $Sn_{21}Cl_{16}(OH)_{14}O_6$.
*Synthetic*: **HG Von Schnering R Nesper H Pelshenko** 1981 ZN 36b 1557-60.
Identity of natural & *synthetic*: **R Edwards RD Gillard PA Williams** 1992 MM 56 221-6.
Occurrence: MM 50 741-61.

**abswurmbachite** $Cu^{2+}Mn^{3+}{}_6SiO_{12}$ - endmember. *Braunite* structure group.
Occurrence: SC&PXRD: **T Reinecke E Tillmans H-J Bernhardt** 1991 NJMA 163 117-43 (R567).

**abukumalite** $CaY_2(Si,P)_2O_8$. Probable analog of *britholite* in *apatite* group.
Occurrence: MM 25 621.

**acanthite** $Ag_2S$ - phase III.
Dimorphic with high-T cubic phase I *argentite*: (alpha- type): structure, **P Rahlfs** 1936 ZPC B31 157-94.
Essentially isostructural with low-temperature phase II Se analog *naumannite*.
Structure: **AJ Frueh** 1958 ZK 110 136-44;
**R Sadanaga S Sueno** 1967 MJJ 5 124-43, also alpha-beta transition.

**acetamide** $CH_3CONH_2$. XRPD matches *synthetic*.
Occurrence: **BI Srebrodol'skii** 1975 ZVMO 104 326-8 = AM 61 338 1976.

**achavalite** FeSe. Uncertain species.
Cell data consistent with *synthetic* delta-$Fe_7S_8$ with *niccolite* structure type, **Ö Ancoff T Ericsson A Gismelseed** 1994 ZK 209 197-205 (A551).
Occurrence: MM 28 722.
Note many complexities in synthetic system as Fe defects are introduced & T is changed.

[**achtarandite** pseudomorph after unknown mineral; epitaxial coat on *grossular*.
Occurrence: Siberia, **PA Pletnev MS Alferova EM Spiridonov** 2001 ZVMO 74 (7819).]

**actinolite** $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$. *Amphibole* structure group, monoclinic subgroup.
Fe-Mg order-disorder, *tremolite*-actinolite-*ferroactinolite*, ambient & high T: **BW Evans H Yang** 1998 AM 83 458-75.
*Synthetic* low-Ca: caution ordering, **J Driscall & 3 others** 2005 AM 90 900-11.

**acuminite** $SrAlF_4OH.aq$. Dimorphic with *tikhonenkovite*. Compare *artroite* $PbAlF_3(OH)_2$.
Structure: **E Krogh Andersen G Plough-Sørensen E Leonardsen** 1991 ZK 194 221-7 (K612).
Occurrence: MM 52 721.

**ADAMITE STRUCTURE GROUP OF ARSENATES**. Includes:

| | |
|---|---|
| *adamite* (orthorhombic) | $Zn_2AsO_4OH$ |
| "*cuproadamite*" | = orthorhombic Cu-substituted *adamite* |

*olivenite* (monoclinic) $Cu_2(AsO_4)OH$
*eveite* (orthorhombic) $Mn_2(AsO_4)OH$

*Andalusite* structure topology.
Isostructural with *libethenite* $Cu_2(PO_4)OH$.
*Synthetic* $(Co/Zn)_2PO_4OH$ analog of *libethinite*: **WTA Harrison & 5 others** 1995 JSSC 14 151-8 (H940).
Isostructural with alpha-$Mg_2PO_4OH$: **G Raade C Rømming** 1986 ZK 177 1-13.
*Synthetic* CoAs-analog: **H Riffel F Zettler H Hess** 1975 NJMM 514-7.
See *tarbuttite* for *synthetic* polymorph which may be P analog (K723).
*Synthetic* $(Mg,Ni)_2AsO_4OH$, XRPD & IR: **JM Rojo & 5 others** 1997 JSSC 132 107-12 (R735).

**adamite** $Zn_2AsO_4OH$. *Adamite* structure group.
Structure: **RJ Hill** 1976 AM 61 979-86;
**FC Hawthorne** 1976 CM 14 143-8 (H727);
**T Kato Y Miura** 1977 MJJ 8 320-8.

**adamsite-Y** $NaY_3(CO)_2.6aq$.
Occurrence & SC-XRD structure: **JD Grice & 3 others** 2000 CM 38 1457-66.

**ADELITE MINERAL GROUP OF CALCIUM & LEAD ARSENATES**

Conichalcite/descloizite structure type. Includes:

| | |
|---|---|
| *adelite* | $CaMgAsO_4OH$ |
| *arsendescloizite* | $PbZnAsO_4OH$ |
| *austinite* | $CaZnAsO_4OH$ |
| *cobaltaustinite* | $CaCoAsO_4OH$ |
| *conichalcite* | $CaCuAsO_4OH$ |
| *duftite* | $PbCuAsO_4OH$ |
| *gabrielsonite* | $PbFeAsO_4OH$ |
| *gottlobite* | $CaMg([V,As]O_4)(OH)$ |
| *nickel austinite* | $Ca(Ni,Zn)AsO_4OH$ |

See **DESCLOIZITE** for the isostructural vanadates.
There are two isostructural silicates:

| | |
|---|---|
| *mozartite* | $CaMnSiO_4(OH)$ |
| *vuagnatite* | $CaAlSiO_4(OH)$. |

Check relation between *calciovolborthite* & *tangeite*: **R Basso L Zefiro** 1994 NJMM 205-8.

**adelite** $CaMgAsO_4OH$. *Conichalcite/decloizite* structure type from cell data.
Adelite mineral group.
Structure determination not found.

**admontite** $MgB_6O_{10}.7aq$. Dimorph of m*callisterite*.
Occurrence: **K Walenta** 1979 TMPM 36 69-77 (W689) = AM 65 205.
Structure determination not found.

**aegirine** $NaFeSi_2O_6$. Renamed from *acmite*. Pyroxene structure family, monoclinic type.
Structure: **JR Clark DE Appleman JJ Papike** 1969 Mineral Soc Am Spec Paper 2 31-50;
high-T, **M Cameron S Sueno CT Prewitt JJ Papike** 1973 AM 58 594-618.
Mössbauer: **E de Grave A Van Alboom SG Eekhout** 1998 PCM 25 378-88 (D726).
Magnetic order: **O Ballet & 5 others** 1989 PCM 16 672-7.
Magnetic properties: **E Baum & 4 others** 1988 ZK 183273-84;
**E Baum W Treutmann W Lottermoser G Amthauer** 1997 PCM 24 294-300 (B1640).
Electrical conductivity/thermopower/ Mössbauer: **E Schmidbauer Th Kunzmann** 2004 PCM 31 102-14 (10122).
Crystal chemistry: **PC Piilonen AW McDonald AE Lalonde** 1998 CM 36 779-91.
Hydrothermal *synthesis*: **A Decarreau & 3 others** 2004 EJM 16 85-90 (10130).
*Synthetic* $NaInSi_2O_6$ analog: **J Ito** 1968 AM 53 1663-73.
*Synthetic* Li, NPD & Mössbauer SC, phase change: **W Lottermoser & 6 others** 1998 ZK 213 101-7 (L938);
NPD structure, phase change, **GJ Redhammer & 7 others** 2001 PCM 28 337-46 (2911).
*Synthetic* (Na,Li) series 80 & 298 K, SC-XRD structure: **GJ Redhammer G Roth** 2002 ZK 217 63-72 (7021);
IR, 20-300 K, **M Zhang & 3 others** 2002 PCM 29 609-16 (8452).

**AENIGMATITE STRUCTURE GROUP** Includes:

*aenigmatite* $Na_2Fe_5TiSi_6O_{20}$

(*baykovite / baikovite*, *synthetic* in silicate slag, close to *rhönite*, $[Ca_{1.1}Mg_{0.6}Ti_{0.3}(Al_{0.5}Si_{0.5})_2O_6][Al(Mg_{0.8}Ti_{1.2}Al_{0.1})_2O_4]$)

*dorrite* $Ca_2(Mg_2Fe_4)(Al_4Si_2)O_{20}$

*høgtuvaite* $(Ca,Na)_2$ (Fe,etc.)$_6(Si,Be,Al)_6O_{20}$

*krinovite* $NaMg_2CrSi_3O_{10}$

*makarochkinite* $Ca_2Fe^{2+}{}_4Fe^{3+}TiSi_4BeAlO_{20}$

*rhönite* $Ca_2(Fe,Mg,Ti)_6(Si,Al)_6O_{20}$

*serendibite* $Ca_2(Mg,Al)6$ $(Si,Al,B)_6O_{20}$

[SFCA *silicate-ferrite* in lime-fluxed iron ore sinter $Ca_{2.3}Mg_{0.8}Al_{1.5}Si_{1.1}Fe_{8.3}O_{20}$, structure: **WG Mumme** 1988 NJMM (8) 359-66 (M1271)]

[SFCA-1 matrix binder of low-alumina industrial iron ore sinter, $Ca_{3.2}Fe^{3+}{}_{14.7}Al_{1.3}Fe^{2+}{}_{0.8}O_{28}$, struct: **WG Mumme JMF Clout RW Gable** 1998 NJMA 173 93-117 (M1626)]

[SVCA *calcium vanadium oxide-silicate* in slag, $Ca_4Al_{15.4}V_{5.2}Mg_{1.0}Fe_{0.13}Si_{2.4}O_{40}$, **IT Ivanov** 1995 EJM 7 183-6.]

*welshite* ~$Ca_2Mg_{3.8}Mn_{0.6}Fe_{0.7}Sb_{1.5}Si_{2.8}Al_{0.7}Be_{1.7}As_{0.2}O_{20}$

*wilkinsonite* $Na_2Fe^{2+}{}_4Fe^{3+}2Si_6O_{20}$

Review: **DM Burt** 1994 CM 32 449-57;
**T Kunzmann** 1999 EJM 11 743-56 (K1182).

Literature review of *synthetic* phases, including ones above and Mg-free SFCA and beta-CFF:
**WG Mumme JMF Clout RW Gable** 1998 NJMA 173 93-117 (M1626)]

Occurrence of *malakhovite, dorrite, rhönite* & *leucorhönite* in waste combustion products of coal mines: **BV Chesnokov** 1997 DES 356 1064-5 (C965).

Solid solution: **BB Jensen** 1996 MM 60 982-6.

*Synthetic* $Na_2(Mg,Fe)_6(Ge,Fe)_6O_{18}O_2$, structure: **J Barbier** 1995 ZK 210 19-23.

*Synthetic* $Na_2Mg_{4+x}Fe_{2-2x}Si_{6+x}O_{18}O_2$, structure: **T Gasparik & 4 others** 1999 AM 84 257-66.

*Synthetic* $Na_2Mg_6Si_6O_{18}O_2$, SC-XRD structure: **H Yang J Konzett** 2000 AM 85 259-62.

**aenigmatite** $Na_2Fe_5TiSi_6O_{20}$. Aenigmanite structure type.

Structure: **S Merlino** 1970 JCSCC 1288-9 (M346);
**E Cannillo & 4 others** 1971 AM 56 427-46 (C260).

Occurrence: Kaidun meteorite, **AV Ivanov & 4 others** 2002 GI 40 694-7 (7946).

**aerinite** ~$(Na_{0.5}Ca_{5.1})(FeAl)(Fe_{1.7}Mg_{0.3})(Al_{5.1}Mg_{0.3})[Si_{12}O_{36}(OH)_{12}H](CO_3)_{1.2}.12aq$.

Reinstated: AM 73 1498-9.

Blue pigment used in Catalan romanic paintings XI-XV centuries.

Structure: preliminary, XRPD, AM 84 1467;
XRPD & Mössbauer, **J Rius E Elkaim X Torelles** 2004 EJM 16 127-34 (10134).

*Synthetic* $Na_2(Mg,Fe)_6[(Ge,Fe)_6O_{18}]O_2$: **J Barbier** 1995 ZK 210 19-23.

**aerugite** $Ni_{8.5}As_3O_{16}$.

Polysomatic series of *olivine/halite* layers with *xanthiosite* $Ni_3(AsO_4)_2$; Ge-varieties.

*Synthetic*: **ME Fleet J Barbier** 1989 AC B45 201-5 (F437).

*Synthetic* Co- & Mg-isotypes: **JB Taylor RD Heyding** 1958 Canad J Chem 36 597-606.

**AESCHYNITE STRUCTURE GROUP**. Includes:

*aeschynite-Ce* $(Ce,Ca,Fe,Th)(Ti,Nb)_2(O,OH)_6$

*aeschynite -Nd* $(Nd,Ce,Ca,Th)(Ti,Nb)_2(O,OH)_6$

*aeschynite -Y* $(Y,Ca,Fe,Th)(Ti,Nb)_2(O,OH)_6$

*nioboaeschynite* $(Ce,Ca,Th)(Nb,Ti)_2(O,OH)_6$

*rynersonite* $Ca(Ta,Nb)_2O_6$

*vigezzite* $(Ca,Ce)(Nb,Ta,Ti)_2O_6$

Compare *aeschynite* in Pnma with *euxenite* series in Pbcn.

New compositions, including *titano-vigezzite*, Baveno granite, Italy: **C Aurisicchio & 3 others** 2001 CM 65 509-22.

Composition variation, Mongolia: **Z Yang & 5 others** 2001 EJM 13 1207-14 (3808).
**aeschynite-Ce** $(Ce,Ca,Fe,Th)(Ti,Nb)_2(O,OH)_2$. *Aeschynite* structure type.
Structure: **VB Aleksandrov** 1964 DAN ES.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**aeschynite-Nd** $(Nd,Ce,Ca,Th)(Ti,Nb)_2(O,OH)_6$. *Aeschynite* structure type.
No structure determination found. MM 50 741.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**aeschynite-Y** $(Y,Ca,Fe,Th)(Ti,Nb)_2(O,OH)_6$. *Aeschynite* structure type.
Structure: 5 non-metamict, SC-XRD, **P Bonazzi S Menchetti** 1999 EJM 11 1043-9 (B1983).
Cell dimensions known for *synthetic* phase.
Metamict, heat-induced recrystallization & dehydrogenation: **P Bonazzi M Zoppi L Dei** 2002 EJM 14 141-50 (6142).
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
[**afanasyevaite** $Ca_8[Si_2O_7]_2.Cl_2O$. Not allowed as mineral name because occurs in burnt coal waste: AM 82 1038-41.]
**afghanite** $(Na,etc)_8(Si,Al)_{12}O_{24}(Cl,etc)_{3-4}.aq$. ABC-6 family of feldspathoid/zeolites,
ABCBCBAB stacking: **JV Smith JM Bennett** 1981 AM 66 777-88.
Review: Sabelli, p. 40.
Occurrence & crystallography: **P Bariand F Cesbron R Giraud** 1968 BSFMC 91 34-42 (B1437);
**GC Parodi P Ballirano A Maras** 1996 MR 27 109-14.
Structure: **EA Pobedimskaya & 3 others** SPD 36 663-5 (P459);
**R Rinaldi H-R Wenk** 1979 AC A35 825-8;
**RK Rastsvetaeva & 3 others** 1993 CrR 38 (2) 185-9 (R463);
improved XRPD, **P Ballirano & 4 others** 1994 PD 9 68-73;
crystal structure in P31c with Si/Al order, P **Ballirano & 3 others** 1997 EJM 9 21-30.
**afwillite** $Ca_3Si_2O_4(OH)_6$.
Structure: **HD Megaw** 1952 AC 5 477-91 (M56);
**KMA Malik JW Jeffery** 1976 AC B32 47-56.
**agardite-Ce** $Cu_6(Ce,Ca)(AsO_4)_3(OH)_6.3aq$. *Mixite* structure group.
Occurrence: & XRPD, **K Walenta T Theye** 2004 Aufschluss 55 17-23 = AM 89 1574.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.]
**agardite-La** $Cu_6(La,Ca)(AsO_4)_3(OH)_6.3aq$. *Mixite* structure group. Approved by IMA, but no details. Description: MM 50 741-61.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**agardite-Y** $Cu_6(Y,Ca)(AsO_4)_3(OH)_6.3aq$. *Mixite* structure group: review (E289).
Incomplete framework with 12-ring tunnel: Consortium for Theoretical Frameworks net 1207.
Structure: **H Hess** 1983 NJMM 385-92 (H874);
Ca-rich, **A Aruga I Nakai** 1985 AC C41 161-3 (A542).
Occurrence: MM 37 954.
Approved by IMA, but no details.
Description: MM 50 741-61.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**agrellite** $Na(Ca,RE,Sr)_2Si_4O_{10}F$. Tunnel-ribbon type.
C & I polytypes: **IV Rozhdestvenskaya LV Nishikova KA Lazebnik** 1998 ZVMO 127 89-94.
Structure: **S Ghose C Wan** 1979 AM 64 563-72.
*Strontium agrellite* $Na(Ca,Sr)_2Si_4O_{10}F$, Yakutia charoitite, SC-XRD structure: **IV Rozhdestvenskaya LV Nikishova** 1998 CrR 43 589-97 (R841).
Ocurrence: MM 40 903.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).
**agrinierite** $K_2(Ca,Sr)(UO_2)_3(OH)_2.2.4aq$.
Structure: SC-XRD, **CL Cahill PC Burns** 1999 AM 85 1294-7.
Sr content might be useful for encapsulation of radioactive waste.
Occurrence: **F Cesbron et al**. 1972 MM 39 781-9.
[**aguilarite** $Ag_4SeS$-beta. *Argentite* structure group. Structure determination not found.

Redefinition pending: MR 30 174.]
**aheylite** $FeAl_6(PO_4)_4(OH)_8.4aq$. Ferroan analog of *turquoise*.
New: MM 60 523;
description, **EE Foord JE Taggart Jr** 1998 MM 62 93-111.
**ahlfeldite** $(Ni/Co)SeO_3.2aq$. Isostructural with *cobaltomenite* & *clinochalcomenite*.
Structure: **M Wilder** 1990 NJMM 353-62 (W693).
*Synthetic* $(Mg/Zn)SeO_3.2aq$: **VF Gladkova YD Kondrashev** 1964 SPC 9 149-53.
[*Synthetic* sulphite dihydrates of Mn, Fe, Co, Ni & Zn: SR 57A 290-1.]
**aikinite** $PbCuBiS_3$. *Stibnite* structure group.
Complex series with *bismuthinite (B)* & *krupkaite (K)*, with *gladite (2B + 2K)*, *hammarite (4K + 2A)*, *lindstromite (8K + 2A), freidrichite (2K + 4A)* and *pekoite (4B + 2K)* as intermediates:
**C Danti & 4 others** 2001 NJMM 221-34 (1994);
**D Topa E Makovicky WH Paar** 2002 CM 849-69.
Structure review: **WG Mumme E Welin BJ Wuensch** 1976 AM 61 15-20.
Classification: **PB Moore** 1967 AM 52 1874-6.
Structure: **FE Wickman** 1954 Ark Min Geol 1 501-7 1953 = MA 12-432;
**M Ohmasa W Nowacki** 1970a ZK 132 71-86 (O88); 1970b NJMM (4) 158-62 (O82);
**I Kohatsu BJ Wuensch** 1971 AC B27 1245-52;
disorder, **A Pring** 1989 AM 74 250-5.
New 45 Å member of series from Felbertal, Austria, $Cu_{1.6}Pb_{1.6}Bi_{6.4}S_{12}$, SC-XRD structure: **D Topa T Balic-Zunic E Makovicky** 2000 CM 38 611-6.
**ajoite** $(K,Na)Cu_7AlSi_9O_{24}(OH)_6.3aq$.
Octahedral-tetrahedral structure: molecular sieve.
Compare with *bannisterite* $Ca(K,Na)(Mn,Fe)_{21}(Si,Al)_{32}O_{76}(OH)_{16}.12aq$ & *ganophyllite*.
Structure: SC-XRD, **JJ Pluth JV Smith** 2002 PNAS 99 11002-5.
Occurrence: **WT Schaller AC Vlisidis** 1958 AM 43 1107-11;
cell dimensions & chemical analysis, **GY Chao** 1981 AM 66 201-3.
**akaganéite** $Fe_8(OH,O)_{16}Cl_{1.25}$-beta. *Hollandite* structure type. Compare with *schwertmannite*.
Structure: natural: **JE Post VF Buchwald** 1991 AM 76 272-7;
ND & XRPD at 299-1073 K, transformation to *hematite* 563-683, **JE Post PJ Heaney RB Von Dreele JC Hanson** 2003 AM 88 782-8.
Occurrence: MM 33-1125.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
*Synthetic*: **AL Mackay** 1960 MM 32 545-57;
**A Szytula M Balanda A Dimitrijevic** 1970 Phys stat sol 3 1033-7;
FTIR, **E Murad JL Bishop** 2000 AM 85 716-21.
*Synthetic* FeOCl & alkoxy complexes, XAS: **J Choy & 3 others** 1995 IC 34 6524-31 (C803).
*Synthetic* $FeO(OH)_{1-x}(NO_3)_x$: **U Schwertmann J Friedl G Pfab** 1996 JSSC 126 336 (S1657).
*Synthetic* nanoparticles: **T Ryu S Wada** 1999 CIS 10 497-502 = MA 00M/2360.
Intercalated organic derivatives: may become components of electrical batteries.
Amorphous black ferric oxyhydroxide, adsorption of arsenate, chromate, phosphate, Pb and Zn, XPS: **M Ding & 3 others** 2000 GCA 64 1209-19 (D797).
*Synthetic* nanocrystals, high-T to *hematite*: **EA Deliyanni & 4 others** 2000 MMM 42 49-57 (785).
*Synthesis* and anion exchange: **J Cai & 4 others** 2001 ChM 13 4595-602 (3876).
*Synthetic* molybdate-substituted: **WR Richmond & 3 others** 2004 ChM 16 32s03-5 (10579).
**akatoreite** $Mn_9(Si,Al)_{10}O_{23}(OH)_9$.
Structure: **PC Burns FC Hawthorne** 1993 CM 31 321-9 (B1609).
Description: MM 38 987.
[**akdalaite** See **tohdite**]
**åkermanite** $Ca_2MgSi_2O_7$. *Melilite* structure type; phase transitions & modulated sub-types.
Structure: **M Kimata N Ii** 1981 NJMM 1-10 1981;
**IP Swainson MT Dove WW Schmahl A Putnis** 1992 PCM 19 185-95;
circular diffuse scattering, **K Iishi K Hagiya M Ohmasa** 1994 PCM 21 6-11;

phase change high P, **H Yang & 3 others** 1997 PCM 24 510-9 (Y225);
*Synthetic* Fe-; also present in slags: MM 29 985; incommensurate structure ($Mg_{0.55}Fe_{0.45}$): **K Kusaka & 4 others** 1998 MJJ 20 47-58 (K1103).
*Synthetic* Co-: **M Kimata** 1983 NJMM 221-41 (K750);
modulation, **K Hagiya M Ohmasa K Ishii** 1992 Proc Japan Acad 68B 25-9;
$(Ca_{1-x}Sr_x)_2CoSi_2O_7$, modulation: **K Ishi F Fujino Y Furukawa** 1990 PCM 17 467-71;
modulated structure, **K Hagiya M Ohmasa K Iishi** 1993 AC B49 172-9;
$Ca_2CoSi_2O_7$, incommensurate: **NE Brown CR Ross II SL Webb** 1994 PCM 21 469-80;
phase transitions, **M Riester H Böhm** 1997 ZK 212 506-9 (R745);
XRD structure of commensurate modulation, **M Riester H Boehm V Petricek** 2000 ZK 215 102-9 (R936).
*Synthetic* Sr-: **M Kimata** 1983 ZK 163 295-304.
*Synthetic* $(Ca_{1-x}Sr_x)_2$ $MgSi_2O_7$, modulation: **JC Jiang & 3 others** 1998 PCM 26 128-34 (J327);
**M Schosnig & 4 others** 2000 ZK 215 495-98;
incommensurate modulation, XRD, **J Kusz H Boehm** 2001 ZK 216 509-12 (3461).
*Synthetic*, doped with Cr, structure: **GM Kuz'micheva EV Zharikov AL Denisov** 1995 Zh Neorg Khim 40 1422-8;
**YuA Malinovskii ZV Panina** 1997 CrR 42 946-50 (M1610).
*Synthetic* $Ba_2CoSi_2O_7$ & $BaCo_2Si_2O_7$, not *åkermanite* structure: **RD Adams & 3 others** 1996 IC 35 3492-7 (A701).
[**akhtenskite** $MnO_2$-epsilon. *Synthetic*. Structure: **J Visser** 1979 PDF 38-820 = MM 52 72.]
**akimotoite** $(Mg,Fe)SiO_3$. *Ilmenite* structure group.
OH substitution, *synthetic*, IR: **N Bolfan-Casanova H Keppler DC Rubie** 2002 AM 87 603-8.
Occurrence: shocked Tenham chondrite & EM, **N Tomioka K Fujino** 1999 AM 84 267-71.
**akrochordite** $(Mn,Mg)_5(AsO_4)_2(OH)_4.4aq$.
Octahedral edge-shared triple bands connected by As tetrahedra.
Structure: **PB Moore PK Sen Gupta EO Schlemper** 1989 AM 74 256-62.
**aksaite** $MgB_6O_7(OH)_6.2aq$. Polyanion structure.
Matches *synthetic*: MM 33 1125-6.
Structure: **A Dal Negro L Ungaretti C Sabelli** 1971 AM 56 1553-66 (D171); MA 75-1853.
**aktashite** $Cu_6Hg_3As_4S_{12}$. Isostructural with *nowackiite* & *gruzdevite*.
Structure: **LN Kaplunnik EA Pobedimskaya NV Belov** 1980 SPD 25 141-2 (K625);
**W Nowacki** 1982 SPD 27 26-30 (N349).
Occurrence: MM 37 954.
**alabandite** MnS. *Galena/halite* structure type.
Isostructural with *altaite, clausthalite, galena, niningerite & oldhamite*.
Structure: **RWG Wyckoff** 1921 AJS 2 239-49;
**H Schnaase** 1933 = MA 6-169.
Hexagonal polymorph: IMA 95-028.
*Sphalerite-alabandite* solid solution $Cu_2SnS_3$-ZnS-MnS 1093 & 973 K: **EG Osadchii** 1996 NJMM 201-11 (O320).
Compressibility & conversion to hexagonal phase at 26 GPa: **JS Sweeney DL Heinz** 1993 PCM 22 63-8 (S1774).
Electronic structure in Fe-substituted, sulfur XANES: **SP Farrell & 5 others** 2002 AM 87 1321-32.
Occurrence: Peru, **GR Olivo K Gibbs** 2003 MM 67 95-102.
Ferroan- in meteorites: **AE Rubin** 1997 MPS 32 231-47.
**alacranite** $As_8S_9$.
Structure: SC-XRD, **PC Burns JD Percival** 2001 CM 39 809-18;
non-stoichiometric, **P Bonazzi & 3 others** 2003 EJM 15 283-8
SC-XRD, **P Bonazzi & 4 others** 2003 AM 88 1796-800.
Occurrence & crystallography: **VI Popova & 4 others** 1986 ZVMO 115 360-8 = AM 73 189.
XRPD matches AsS-alpha.
*Synthetic* AsS grown at 500 K, SC-XRD may be high-T polymorph of alacranite: **F Pertlik 1995** **Ost Akad Wiss Math-natur Kl Anz** 131 3-5 = MA 96M/1564.
**alamosite** $PbSiO_3$.
Structure: **ML Boucher DR Peacor** 1968 ZK 126 98-111 (B359).
*Synthetic* SC-XRD structure, **SV Krivovichev PC Burns** 2004 ZVMO 70-5.
**alarsite** $AlAsO_4$. Structural analog of *berlinite* $AlPO_4$, *rodolicolite* $FePO_4$ & *quartz* $SiO_2$.
New mineral: **TF Semenova & 3 others** 1994 DAN 338 501-5 (S1589).

**albite** $NaAlSi_3O_8$. *Feldspar* structure type: high/low phase transition.
Ga & Ge structural analogs. See *Feldspar* database.
High-P hollandite-structure polymorph in maskelynite glass of Sixiangkou L6 chondrite: **P Gillet M Chen L Dubrovinsky A El Goresy** 2000 S 287 1633-6, Perspectives, 1602-3 (G1185).
Fusion curve: **RA Lange** 2003 AM 88 109-20.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**albrechtschraufite** $Ca_4MgF_2(UO_2)_2(CO_3)_2$.
**K Mereiter** 1984 AC A40 Suppl C-247. No other information found.
**albrittonite** $CoCl_2.6aq$. Isostructural with *nickelbischofite*, and probably *bischofite*, but check details.
Structure: *synthetic*, **1961 JPSJ 16 1574**.
Occurrence: **WW Crook III L-A Marcotty** AM 65 207.
**aldermanite** $Mg_5Al_{12}(PO_4)_8(OH)_{22}.\sim32aq$.
Occurrence: **IR Harrowfield ER Segnit JA Watts** 1981 MM 44 59-62.
Structure determination not found.
**aldzhanite** $CaMgB_2O_4Cl.7aq$?
Occurrence: **NP Avrova et al.** 1971 AM 56 1122.
Structure determination not found.
**aleksite** $PbBi_2Te_2S_2$.
*Tetradymite* mineral/structure group; *aleksite* subgroup: **P Bayliss** 1991 AM 76 257-65.
Structure determination not found.
Occurrence: **AG Lipovetskii YS Borodaev EN Zav'yalov** 1979 AM 64 652.
**alforsite** $Ba_5(PO_4)_3Cl$. *Apatite* structure type.
Occurrence: MM 46 515.
Synthetic: **M Hata F Marumo S Iwai H Aoki** 1979 AC B35 2382-4.
**algodonite** $\sim As_{0.3}Cu_{1.7}$. *Allargentum* hP2 type.
Structure: **P Bayliss** 1990 CM 28 751-5.
**aliettite** 1:1 regular interstratified *talc*/trioctahedral *smectite*.
Description: **A Alietti J Mejsner** 1980 ClClM 28 388-90.
**alinite** $Ca_{21}Mg(Si_{0.8}Al_{0.2})_8O_{36}Cl_2$. Definition: MM 46 515.
Compare *jasmundite*, Cl for S.
Structure: **VV Ilyukhin & 4 others** 1977 SPD 22 697-8 (I106);
**AM Il'nets & 3 others** 1989 SPC 34 40-3 (I94).
*Synthesis* & hydration of *alinite* cement: **Y Kim S Hong H Kim** 2002 JACeS 85 1941-6 (7824).
[**alite** *Synthetic* monoclinic $Ca_3SiO_5$. Equals mineral *hatrurite*.
Structure: **H O'Daniel E Hellner** 1950 NJMM 108-11;
**JW Jeffrey**1952 AC 5 26-35;
**WG Mumme** 1995 NJMM (4) 145-60 (M1238).
May be 7 polymorphs with 4 basic structure types: triclinic, **R Golovastikov R Matveeve NV Belov** 1975 SPC 20 441-5;
rhombohedral, **AM Il'inets Y Malinowskii NN Nevskii** 1985 SPD 30 191-2;
XRPD profile refinement, **JC Taylor LP Aldridge** 1993 PD 8 138-44.
$^{29}Si$ NMR in Portland cement: **J Skibsted HJ Jakobsen C** Hall 1995 JCSF 91 4423-30 (S1578).
*Synthetic* Zn-, 3 monoclinic types, HRTEM: **K Urabe H Nakano H Morita** 2002 JACeS 85 423-9 (6704).
AFM of growth: **S Gauffinet & 3 others** 1998 CRASP 327 231-6 (G1124).
XRPD of Portland cement clinker: **JC Taylor I Hinczak CE Matulis** 2000 PD 15 7-19 (T636.]
**allabogdanite** $(Fe,Ni)_2P$. Dimorphic with *barringerite*.
Occurrence: Onello meteorite**, SN Britvin & 4 others** 2002 AM 87 1245-9.
**allactite** $Mn_7(AsO_4)_2(OH)_8$. *Pyrochroite* building block.
Structure: **PB Moore** 1968 AM 53 733-41.
[$Mg_7(PO_4)_2(OH)_8$. IMA 96-034. Analog of allactite.]
**ALLANITE MINERAL GROUP**
Nomenclature is confused: **TS Ercit** 2002 CM 40 1411-9.

*allanite-Ce* $(Ce,Ca,Y)_2(Al,Fe)_3Si_3O_{12}(OH)$
*allanite-La* $(La,Ce,Ca)_2(Al,Fe)_3Si_3O_{12}(OH)$
*allanite-Y* $(Y,Ce,Ca)_2(Al,Fe)_3Si_3O_{12}(OH)$.
Thorium/light rare-earth carrier in subducted crust: **J Hermann** 2002 CG 192 289-306 (8443).
Occurrence & SC-XRD structure, Yamanashi, Japan: **M Hoshino & 5 others 2005** MM 69 403-24.
**allanite-Ce** $(Ce,La,Ca)_2(Al,Fe)_3Si_3O_{12}(OH)$. *Epidote* type. See *dollaseite*-Ce.
Structure: **IM Rumanova IM Nikolaeva** 1960 SPC 4 789-95 (R505);
**ZV Pudovkina YuA Pyatenko** 1965 DES 153 146-9 = MA 18-243;
**WA Dollase** 1971 AM 56 447-64.
Vanadian-La & -Ce: MM 56 497-507;
heated, **P Bonazzi S Menchetti** 1994 AM 79 1176-84.
RE in I-type granitoid: **I Petrik & 3 others** 1995 Geologica Carpathica 46 79-94 = MA 96M/0882.
Occurrence in talc-chlorite, Trimouns, French Pyrenees: **P de Parseval F Fontan T Aigouy** 1997 CRASP 324 IIa 625-30 (D639).
Hydrothermal alteration, significant for nuclear waste: **SA Wood A Ricketts** 2000 CM 38 81-100.
Occurrence: 22 samples, Japanese granitic, REE & Mn enrichment, **M Hoshino & 4 others** 2006 CM 44 45-62.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**allanite-La** $(La,Ce,Ca)_2(Al,Fe)_3Si_3O_{12}(OH)$. *Epidote* type.
Occurrence: Bucca Della Vena mine, Italy, **P Orlandi M Pasero** 2006 CM 44 63-8.
**allanite-Y** $(Y,Ce,Ca)_2(Al,Fe)_3Si_3O_{12}(OH)$. *Epidote* type.
Structure determination not found.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
[**allemontite** SbAs. jvs: merely solid solution between *arsenic* & *antimony*?]
**allargentum** $Ag_{1-x}Sb_x$-hexagonal-epsilon.
Isostructural with *algodonite* & ?disordered *dyscrasite*.
Occurrence: MM 29 974.
Structure: **W Petruk et al** 1970 CM 10 163-72.
Composition ranges of natural specimens in Ag-Sb system: **C Cipriani M Corazza G Mazzetti** 1996 EJM 8 1347-50 (C882).
**alleghanyite** $Mn_5Si_2O_8(OH)_2$. *Humite* structure group.
Structure: **PJ Rentzeperis** 1970 ZK 132 1-18.
Mg- : **CA Francis** 1985 AM 70 182-5.
Occurrence: MM 23 624; ZVMO 125 96-102 = MA 96M/4510; 2002 ZVMO 98-111.
**allevardite** = *rectorite*. 1:1 dioctahedral *mica/smectite* interlayer.
Structure: **YuM Korolev** 1961 SPC 5 848-52 = MA 15-420;
**YuM Korolev** 1965 DES 162 143-6 = MA 19-179.
[potassium allevardite : MM 39 924.]
**allochalcoselite** $Cu^{+}Cu^{2+s}{}_5PbO_2(SeO_3)_2Cl_5$.
Occurrence & SC-XRD structure: **VP Vergasova & 5 others** AM 91 12201.
**alloclasite** (Co,Fe)AsS. *Arsenopyrite* chemical group.
Dimorphic with *glaucodot*: **JD Scott W Nowacki** 1976 CM 14 561-6.
**allophane** $Al_2SiO_5$.n aq. Distinct from *imogolite*.
Structure: **K Wada N Yoshinaga** 1969 AM 54 50-71.
ESCA & NMR: **H He TL Barr J Klinowski** 1995 ClM 30 201-9.
NMR, 5-coordinate Al: **CW Childs S Hayashi RH Newman** 1999 ClClM 47 64-9 (C1099).
*Synthetic*, nanoengineering: **F Ohashi & 4 others** 2002 ClM 37 451-6.
Adsorption & discrimination of alanine & alanyl-alanyl enantiomers: **H Hashizume BKG Theng A Yamagishi** 2002 ClM 37 551-8.
Interaction with Cu/Zn in Andosol: **C Latrille & 2 others** 2003 European J Soil Sci 54 357-64.
Weathering of volcanic glass: **S Hiradata S Wada** 2005 CLClM 53 401-8.
**ALLUAUDITE STRUCTURE GROUP** Includes:
*alluaudite* (Na, Ca)Fe(Mn,etc.)$_2(PO_4)_3$
*bradaczekite* $NaCu(AsO_4)_3$
*caryinite* $Na(Ca,Pb)(Ca,Mn)_2(AsO_4)_3$

*ferro-alluardite* $(Na,Ca)Fe^{2+}(Fe^{2+},Mn,Fe^{3+},Mg)_2(PO_4)_3$

*hagendorfite* $(Na,Ca)Mn(Fe,Mg)_2(PO_4)_3$

*varulite* $(Na,Ca)Mn(Mn,Fe)_2(PO_4)_3$

[*arseniopleite* Not equal to *caryinite*: **TS Ercit** 1993 MM 57 726-7.]

Almost dimorphic with *garnet*: **K Böstrom** 1957 Ark Mineral Geol 4 333.

*Synthetic* $NaCdIn_2(PO_4)_3$: **D Antenucci & 4 others** 1993 EJM 5 207-13 (A525).

*Synthetic* $NaFe_3(PO_4)_3$: **OV Yakubovich & 3 others** 1977 SPD 22 550-2 (Y130);
**DR Corbin & 5 others** 1986 IC 25 2279-84.

*Synthetic* $Cu_{1.35}Fe_3(PO_4)_3$: **TE Warner W Milius J Maier** 1993 JSSC 106 301-6.

*Synthetic* $AgMn_3(PO_4)(HPO_4)_2$: **F Leroux & 3 others** 1995 JSSC 117 206-12 (L646).

*Synthetic* $NaMn_3(PO_4)(HPO_4)_2$: **F Leroux & 5 others** 1995 JSSC 115 240-6 (L633) [jvs: near *varulite*].

*Synthetic* high-T polymorph of $NaCa_2(Mg/Ni/Co)_2(AsO_4)_3$: **S Khorari & 3 others** 1995 JSSC 118 267-73 (K782).

*Synthetic* $NaCaCdMg_2(PO_4)_3$: structure, **D Antenucci & 3 others** 1995 EJM 7 175-81;
reversible polymorphism with *fillowite*, **D Antenucci P Tarte A Fransolet** 1996 NJMM 289-96 (A724).

*Synthetic* $NaCaCdMg_2(AsO_4)_3$: structure, **S Khorari & 5 others** 1997 JSSC 131 298-304(K940).

*Synthetic* $NaCa_2(Mg/Ni/Co)_2(AsO_4)_3$: structure, **S Khorari A Rulmont P Tarte**1997 JSSC 131 290-7 (K941).

*Synthetic* $Na_3In_2([As/P]O_4)_3$: **K Lii J He** 1997 JSSC 131 131-7 (L850).

*Synthetic* $NaFe_{3.67}(PO_4)_3$, SC-XRD, IR, Mössbauer: **MB Korzenski & 3 others** 1998 JSSC 139 152-60 (K1095).

*Synthetic* $Ag_2FeMn_2(PO_4)_3$: N & XRD structure, magnetics, **N Chouaibi & 4 others** 2001 JSSC 159 46-50.

*Synthetic* $Tl_2Mn_3(As_2O_7)_2.3aq$, $CsMn_3(AsO_4)(HAsO_4)_3.3aq$ & $(Na/K)Mn_3(AsO_4)(HAsO_4)_2$: **N Stock GD Stucky AK Cheetham** 2001 JPCS 62 1457-67 (2912).

*Synthetic* $(Na_{1-x}Li_x)CdI_2(PO_4)_3$, x = 0 to 1, XRPD structure: **F Hatert & 3 others** 2002 JSSC 163 184-201 (5913).

*Synthetic* $Na_{1.72}Mn_{3.28}(AsO_4)_3$ review of other structures: **B Ayed M Krifa A Haddad** 2002 AC C58 i98-100 (7696).

*Synthetic* $NaMn(Fe,In)_2(PO_4)_3$, XRPD structure, IR, Mössbauer: **F Hatert & 4 others** 2000 AM 88 211-22.

*Synthetic* $Na_4CaFe_4(PO_4)_6$, structure, Mössbauer: **M Hidouri & 5 others** 2004 JSSC 177 55-60 (9808).

*Synthetic* $(Na_{1-x}Li_x)_{1.5}Mn_{1.5}\ Fe_{1.5}(PO_4)_3$, x = 0 to 1, XRPD structure: **F Hatert** 2004 MP 81 205-17 (10554).

*Synthetic* $Na_2(Mn_{1-x}Fe_x)Fe(PO_4)_3$, XRPD structure: **F Hatert & 5 others** 2005 CM AM 653-62.

**alluaudite** $(Na,Ca)Fe(Mn,etc.)_2(PO_4)_3$. Alluaudite structure group. Derivative of *wyllieite*.

Structure: **PB Moore** 1971 AM 56 1955-75 (M1156);
**PB Moore J Molin-Case** 1974 AM 59 280-90.

**alluaivite** $Na_{19}(Ca,Mn)_6(Ti,Nb)_3Si_{26}O_{74}Cl.2aq$. *Eudialyte* structure type.

Structure: **RK Rastsvetaeva AP & 3 others** 1990 SPD 35 492-5 (R498).

Occurrence: hyperagpaitic alkaline rocks, **Khomyakov** (1995).

**almandine** $Fe_3Al_2Si_3O_{12}$. *Garnet* structure type.

Structure: **GA Novak GV Gibbs** 1971 AM 56 791-825;
**W Prandl** 1971 ZK 134 333-43;
**CA Geiger & 5 others** 1992 PCM 19 121-6;
**T Armbruster CA Geiger GA Lager** 1992 AM 77 512-21.

Fe XAFS at 20-473 K, Debye-Waller factor: **S Quartieri & 3 others** 1997 PCM 24 200-5 (Q17).

SC-XRD, hydrostatic compression to 21 GPa: **L Zhang & 3 others** 1999 PCM 27 52-8 (Z217).

"Tetragonal almandine-pyrope phase" inclusion in *diamond*s from Brazil, SC-XRD structure: **LW Finger PG Conrad** 2000 AM 85 1804-7.

Occurrence in meteorites: **AE Rubin** 1997 MPS 32 231-47.

**almarudite** $K(void,Na)_2(Mn,Fe,Mg)_2(Be,Al)_3Si_{12}O_{60}$. Analog of *milarite*.

Occurrence: **T Mihajlović & 4 others** 2004 NJMA 179 265-94 (10060).

**alsakharovite-Zn** $NaSrKZn(Ti,Nb_4)\{Si_4O_{12})_2(O,OH)_4.7aq$. *Labuntsovite* mineral group.

Structure: **KA Rozenberg & 3 others** 2002 Dokl Chem 383 110-3.

Occurrence: **IV Pekov & 4 others** 2003 ZVMO 132 52-8.

**alstonite** $BaCa(CO_3)_2$. Dimorphic with *barytocalcite*.

Occurrence: **F Sartori** 1975 Li 8 199-207; MM 54 515-6.

Structure determination not found.

**altaite** PbTe. *Galena/halite* structure type.

Structure: **Y Noda S Okba S Sato Y Saito** 1983 AC B39 312-7;

thermal parameters 120-298K, **Y Noda & 5 others** 1987 AC C43 1443-5 (N386).
Occurrence: MA 96M/4577.

**althausite** $Mg_2PO_4OH$-delta. Dimorph of *holtedahlite*.

Phase relations between *synthetic* polymorphs *alpha* (low P & T: *adamite* structure group), *beta* (OH analog of *wagnerite*-F), *gamma* (*holtedahlite*), *delta* (*althausite*) & *epsilon* (**G Raade C Rømming** 1986 ZK 177 1-13): **G Raade** 1990 NJMM (7) 289-300 (R563).
Structure: **C Rømming G Raade** 1980 AM 65 488-98.
Occurrence: MM 40 903.

**althupite** $ThAl(UO_2)[(UO_2)_3O(OH)(PO_4)_2]_2.15aq$.

*Phosphuranylite* mineral group; geometrical isomer uudduuO; beware of problems.
Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
Structure: **P Piret M Deliens** 1987 BM 110 65-72.

**altisite** $K_6Na_3Ti_2[Al_2Si_8O_{26}]Cl_3$. Octahedral-tetrahedral framework as in *lemoynite*.

Consortium for Theoretical Frameworks net 1089.
Structure: **G Ferraris G Ivaldi AP Khomyakov** 1995 EJM 7 537-46 (F427).
Occurrence: **AP Khomyakov & 3 others** 1994 ZVMO 123(6) 81-5.
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).

**altmarkite** $HgPb_2$. Metallic deposit in natural gas plant.

XRPD matches synthetic tetragonal, a 2.5, c 4.5Å: **T Kaemmel & 5 others** 1977 Z Angew Geol 23 535-6 = AM 64 652.
[Also unnamed cubic Hg-Pb amalgam. Compare *leadamalgam* with tetragonal cell, a = 3.5, c = 4.5Å [ jvs: 2.5 x √2 = 3.5]
Unless proven otherwise, one might consider that altmarkite may equal *leadamalgam*.]

**ALUM STRUCTURE GROUP** Family name for hydrous alkali aluminum sulfates. Includes:

| | |
|---|---|
| *lanmuchangite* | $TlAl(SO_4)_2.12aq$ |
| *lonecreekite* | $(NH_4)Fe(SO_4)_2.12aq$ |
| *potassium alum* | $KAl(SO_4)_2.12aq$ |
| *sodium alum* | $NaAl(SO_4)_2.12aq$ |
| *tschermigite* | $(NH_4)Al(SO_4)_2.12aq$ |

Occurrence, steam condensate, Taupo, New Zealand: **KA Rodgers & 4 others** 2000 MM 64 125-42.
*Synthetic* γ-$NaAl(SO_4)_2.12aq$: **DT Cromer MI Kay AC Larson** 1967 AC 22 182-7; 1978 AC B34 182-7.
*Synthetic* $K/Rb/Cs(SO_4)_2.12aq$: **JK Beattie & 5 others** 1996 JChSD 1481-6 (B1488).
*Synthetic,* many compositions, XRD 296 & 173 K: **SC Nyburg & 3 others** 2000 AC B56 204-9 (N527).
*Synthetic potassium alum-tschermigite*, anomalous birefringence & dissymetrization: **AG Shtukenberg & 5 others** 2000 CrR 45 919-25 (1722)

**ALUMINA POLYMORPHS** **WARNING: chemical substitutions may occur**

| | |
|---|---|
| *alumina-alpha* | See *corundum* |
| *alumina-beta*, etc | See *beta-alumina* |
| *alumina-delta* | *Synthetic* |
| *alumina-epsilon* | *Synthetic* with defect *spinel* structure. Structure: **W Guse H Saalfeld** 1990 NJMM (5) 217-26. |
| *alumina-gamma* | *Synthetic*. Surface reactivity: **A Ionescu & 4 others** 2002 JPCB 106 9237-44 (7963). |
| *alumina-gamma'* | Triple cell of *–gamma*: **G Paglia & 7 others** 2004 ChM 16 220-36 (9905). |
| *alumina-chi* | Occurs, lateritic pisolite: **B Singh RJ Gilkes** 1995 ClM 30 39-44. |
| *alumina-eta* | Natural occurrence in bauxite: **DB Tilley RA Eggleton** 1996 ClClM 44 658-64 (T499). See *akdalaite*. |
| *alumina-kappa* | Pseudo-close-packed ABAC oxygen stacking with 3 octahedral & 1 tetrahedral Al. Structure: **B Ollivier R Retoux P Lacorre D Massiot G Férey** 1997 JMC 7 1049-56 (O335); XRPD profile refinement, **L Smrcok V Langer M Halvarsson S Ruppi** 2001 ZK 216 409-12 (2917). |
| *alumina-nu* | *Synthetic* |
| *alumina-theta* | *Synthetic* |

Special Topic: Alumina: 23 articles in 2003 JACeS 86 533-700.

**aluminite** $Al_2SO_4(OH)_4.7aq$. Review: Sabelli, p.18.

Structure: **C Sabelli R Trosti-Ferroni** 1978 AC B34 2407-12. See *meta-aluminite*.
**alumino-barroisite** *Amphibole*. Definition: MM 42 521.
**aluminocopiapite** $AlFe_4(SO_4)_6O(OH).20aq$. *Copiapite* structure type.
Review: Sabelli, p. 20.
Description: **JH Jolly HL Foster** 1967 AM 52 1220-3, just cell dimensions.
[**alumino-deerite** $\sim Fe_6Al_3Si_6O_{20}(OH)_5$. *Synthetic* endmember. MM 43 1057.]
**alumino-katophorite** $Na_2Ca(Fe,Mg)_4AlSi_7AlO_{22}(OH)_2$. *Amphibole* group.
Definition: **BE Leake** 1978 AM 63 1023-52; MM 42 521.
**alumino-magnesiohulsite** $Mg_2(Al_{1-2x}Mg_xSn_x)O_2(BO_3)$. *Hulsite* group.
Occurrence & SC-XRD structure: **N Pertsev & 4 others** 2004 EJM 16 151-61 (10177).
**alumino-taramite** *Amphibole*. Definition: MM 42 521.
**alumino-tschermakite** *Amphibole*. Definition: MM 42 521.
**alumino-winchite** *Amphibole*. Definition: MM 42 521.
**aluminum / aluminium** Al. *Copper* structure group. Cubic closest packed structure type.
Occurrence: Siberian traps, both F- & P- cubic, MM 43 1057; MM 48 59;
volcanic sublimate: **MA Korzhinsky & 3 others** 1995 N 375 544 (K738);
native, Si-, Fe- & Zn-, **SF Glavatskikh** 2000 DES 370 106-9;
authigenic minerals of Dukat silver orefield: MA 96M/4552;
metasomatized sediments, Pacific: **MP Davydov Pa Aleksandsov** 2001 DES 379 567-70 (2898).
**alumobritholite** $(Ca,Ce,Y)_3(Al,Fe)_2(Si,Al,PO_4)_3(F,O)$. *Britholite* type.
Occurrence: MM 33 1126.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**alumohydrocalcite** $CaAl_2(CO_3)_2(OH)_4.3aq$.
Structure determination not found.
Occurrence: MM 21 557.
**alumoklyuchevskite** $K_3Cu_3AlO_2(SO_4)_4$.
Occurrence: **MG Gorskaya & 4 others** 1995 ZVMO 124 95-100 = AM 81 249.
**alumopharmacosiderite** $KAl_4(AsO_4)_3(OH)_4.6.5aq$. *Pharmacosiderite* structure type.
Structure: **W Horn H Bank** NJMM 97-102 1981.
Occurrence: MM 24 602
[Review of As minerals in Black Forest: **K Walenta** 1966 TMPM 11 121-64.]
**alumotantite** $AlTaO_4$. Topotactic with *simpsonite*.
Structure: **TS Ercit FC Hawthorne** 1992 CM 30 653-62. Definition: MM 46 515.
**alumotungstite** $(W,Al)(O,OH)_3$? Compare with *cerotungstite* & *yttrotungstite*.
Occurrence: **ThG Sahama** 1981 MR 12 81-7. MM 39 905.
Structure determination not found.
**ALUNITE GROUP** Includes:
note: check for more members and superstructures

| | |
|---|---|
| *alunite* | $KAl_3(SO_4)_2(OH)_6$ |
| *ammonioalunite* | $NH_4Al_3(SO_4)_2(OH)_6$ |
| *ammoniojarosite* | $NH_4Fe_3(SO_4)_2(OH)_6$ |
| *argentojarosite* | $AgAl_3(SO_4)_2(OH)_6$ |
| *beaverite* | $Pb(Cu,etc.)_3(SO_4)_2(OH)_6$ |
| *carphosiderite* | hydronium-jarosite |
| *dorallcharite* | $Tl_{0.8}K_{0.2}Fe_3(SO_4)_2(OH)_6$ |
| *huangite* | $Ca_{0.5}Al_3(SO_4)_2(OH)_6$ |
| *hydronium-jarosite* | $(H_3O)Fe_3(SO_4)_2(OH)_6$ |
| *jarosite* | $KFe_3(SO_4)_2(OH)_6$ |
| *kintoreite* | $PbFe_3(SO_4)_2(OH,aq)_6$ |
| *minamiite* | $(Na,etc.)Al_3(SO_4)_2(OH)_6$ |
| *natroalunite* | $NaAl_3(SO_4)_2(OH)_6$ |
| *natrojarosite* | $KFe_3(SO_4)_2(OH)_6$ |

*osarizawaite* $PbCuAl_2(SO_4)_2(OH)_6$
[*oxonio-alunite* $(H_3O)Al_3(SO_4)_2(OH)_6$ endmember: MM 37 962]
[*plumboalunite* $PbAl_6(SO_4)_4(OH)_{12}$ endmember: MM 37 963]
*plumbojarosite* $PbFe_6(SO_4)_4(OH)_{12}$ (& unnamed phosphate analog)
*schlossmacherite* $(H_3O,Ca)Al_3(S/AsO_4)_2(OH)_6$
*segnitite* $PbFe_3H(AsO_4)_2(OH)_6$
*walthierite* $Ba_{0.5}void_{0.5}Al_3(SO_4)_2(OH)_6$

Nomenclature of alunite supergroup that includes alunite, *beudantite* and *crandallite* groups: **JL Jambor** 1999 CM 37 1323-42; discussion, **KM Scott** 38 1295-7; reply 1298-303.

Compilation of 42 natural & 19 *synthetic* members of alunite structure group: **CL Lengauer G Giester E Irran** 1994 PD 9 265-71.

*Synthetic* $PbAl_2(OH)_4(SO_4)_2.2aq$: MM 29 986.

*Synthetic* $KCr_3(SO_4)_2(OH)_6$: **CL Lengauer G Giester E Irran** 1994 PD 9 265-71.

Alunite-*jarosite* series, nomenclature: AM 80 633-4.

Relation to *pyrochlore* & hexagonal tungsten bronze: **M Goreaud B Raveau** 1980 AM 65 953-6.

Pb-dominant types, Broken Hill: **KJ Rattray & 3 others** 1996 MM 60 779-85.

*Alunite-jarosite*, Goldfield Nevada: analog for Mars, **JJ Papike & 3 others** 2006 AM 91 1197-200.

*Synthetic* K-hydroxonium *alunites*, inelastic neutron scattering: **GA Lager & 5 others** 2001 CM 39 1131-8.

*Synthetic* (Na/K/Rb/Tl/ammonium)- V(III)-*jarosites*, SC-XRD structure & IR: **D Grohol DG Nocera** 2002 JAChS 124 2640-3 (6781).

*Synthetic* $V^{3+}$ analogs of *ammoniojarosite, argentojarosite, dorallcharite, hydronium jarosite & jarosite*: **JE Dutrizac TT Chen** 2003 CM 41 479-88.

*Synthetic* K-oxonium, etc: thermal/XRD: **WW Rudoph R Mason P Schmidt** 2003 EJM 913-24.

**alunite** $KAl_3(SO_4)_2(OH)_6$. Alunite structure type. Review: Sabelli p. 24.

Structure: **SB Hendricks** 1937 AM 22 773-84;
**R Wang WF Bradley H Steinfink** 1965 AC 18 249-52 (W717);
**S Menchetti C Sabelli** 1976 NJMM 9 406-17;
**M Goreaud B Raveau** 1980 AM 65 953-6.

Visible & IR spectra: **JL Bishop E Murad** 2005 AM 90 1100-7.

Occurrence: steam condensate, Taupo, New Zealand, **KA Rodgers & 4 others** 2000 MM 64 125-42.

**alunogen** $Al_2(SO_4)_3.17aq$.

Structure: **S Menchetti C Sabelli** 1974 TMPM 21 164-78;
**JH Fang PD Robinson** 1976 AM 61 311-7.

Occurrence: with meta-alunogen, MM 63 413-9;
steam condensate, Taupo, New Zealand, **KA Rodgers & 4 others** 2000 MM 64 125-42.

**alushtite** Approximately = *montmorillonite/chlorite*.

Occurrence: **YuM Korolev** 1966 DES 165 140-3 = MA 19-268.

**alvanite** $(Zn,Ni)Al_4(VO_3)_2(OH)_{12}.2aq$. Unbranched 2-repeat chain.

Ni analog is *ankinovichite*.

Structure: **F Pertlik** 1990 NJMM 385-92 (P550).

Occurrence: MM 32 942.

**amakinite** $(Fe,Mg)(OH)_2$. *Brucite* structure group.

Occurrence: **IT Kozlov PP Levshov** 1962 ZVMO 91 72-7;
in meteorites: **AE Rubin** 1997 MPS 32 231-47.

**amarantite** $Fe(SO_4)OH.3aq$.

Related to *hohmannite* & *metahohmannite* $Fe_2[O(SO_4)_2].4aq$. Review: **Sabelli**, p. 20.

$[Fe_2(SO_4)_2.0.7aq$: **P Süsse** 1968 ZK 127 261-75;
**C Giovazzo S Menchetti** 1968 PM 37 727-31;
**F Scordari** 1978 MM 42 144-6.]

**amarillite** $NaFe(SO_4)_2.6aq$. Review: **Sabelli**, p. 19.

Structure: **J Li J Zhou W Dong** 1990 Chinese Science Bull 35 2073-5 = AM 77 212.

Occurrence: MM 23 624.

[**ambatoarinite** $Sr_5(La,Ce)(CO_3)_{17}O_3$.

Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.]

**AMBLYGONITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *amblygonite* | $(Li,Na)AlPO_4(F,OH)$ |
| *montebrasite* | $(Li,Na)AlPO_4(OH,F)$ |
| *natroamblygonite* | $(Na,Li)AlPO_4(OH,F)$ |
| *tavorite* | $LiFePO_4OH$ |

Amblygonite-montebrasite solid solution, SC-ND structure, $^6$Li-MAS, CP-MAS, REDOR NMR: **LA Groat & 6 others** 2003 AM 88 195-210.

**amblygonite** $(Li,Na)AlPO_4(F,OH)$. Amblygonite structure type.

Structure: **WH Baur** 1959 AC 12 988-94;
**IA Kondratieva SK Filatov IV Rozhdestvenskaya** 1989 ZVMO 118 47-54;
**LA Groat & 5 others** 1990 AM 75 992-1008.

F/OH exchange with *montebrasit*e, F monitor for granite & pegmatite: **D London GB Morgan VI MB Wolf** 2001 AM 86 225-33.

**ameghinite** $NaB_3O_3(OH)_4$. Isolated 3-ring two-triangle-one-tetrahedron borate.

Structure: **A Del Negro JM Martin Pozas L Ungaretti** 1975 AM 60 879-83 (D252).

Occurrence: MM 36 1147.

[**ameletite** $\sim Na_{18.5}Al_{12}Si_{12}O_{51}Cl_{0.5}$. jvs: minute hexagonal crystals suggest *cancrinite* family. Definition: MM 22 615.]

**amesite** $Mg_2Al(Si,Al)O_5(OH)_4$. *Kaolinite-serpentine* group.

$2H_2$ polytype: **SH Hall SW Bailey** 1979 ClClM 27 241-7 (H507);
**A Wiewióra JA Raussel-Colom T Garcia-González** 1991 AM 76 647-52.

$2H_1$ polytype, SC-XRD structure: **H Zheng SW Bailey** 1997 ClClM 45 301-10 (Z149).

Also: MA 12-99; MA 14-24; MA 16-249; MA 81-0219; MA 93M/0188.

Polarized optical absorption $Cr^{3+}$: **AN Platonov K Langer A Wieviora M Andrut** 1995 EJM 7 961-5.

[*nimesite* Ni analog of amesite. Occurrence: MM 39 922.]

**amicite** $K_2Na_2Al_4Si_4O_{16}.5aq$.

Zeolite family: *gismondine* structure type, IZA-SC code GIS; CTF net 23.

Structure: **A Alberti G Vezzalini** 1979 AC B35 2866-9 1979.

Occurrence: **AP Khomyakov & 3 others** 1984 DES 263 135-7.

Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).

**aminoffite** $Ca_3Be_2Si_3O_{10}(OH)_2$.

Structure: **A Coda G Rossi L Ungaretti** 1967 Accad Naz Lincei 43 225-32 (C151) = MA 70-219;
**DMC Huminicki FC Hawthorne** 2002 CM 40 915-22.

Occurrence: MM 25 622.

**ammonioalunite** $NH_4Al_3(SO_4)_2(OH)_6$. *Alunite* structure type.

Structure: **SP Altaner et al**. 1988 AM 145-52.

**ammonioborite** $(NH_4)_8B_{15}O_{20}(OH)_8.4aq$.

Structure: **S Merlino F Sartori** 1971 S 171 377-9.

Equals *synthetic*; compare with *larderellite* $(NH_4)B_5O_7(OH)_2$ & *synthetic* K-: AM 44 1150-8.

Occurrence: MM 22 615.

**ammoniojarosite** $(NH_4)Fe(SO_4)_2(OH)_6$. *Jarosite* structure type. *Alunite* family.

Review: **Sabelli** p. 25.

Structure: **WL Smith JE Lampert** 1973 JACr 6 490-2;
Raman: **K Sasaki O Tanaike H Konno** 1998 CM 36 1225-35.

Occurrence: MM 21 557.

**ammonioleucite** $(NH_4)AlSi_2O_6$. *Leucite* structure type.

Structure: cell data, **H Hori & 4 others** 1986 AM 71 1022-7;
XRPD, **M Yamada & 4 others** 1998 MJ 20 105-12 (Y243);
H & D *synthetics*, IR/XRPD, **M Andrut DE Harlov J Najorka** 2004 MM 68 177-89.

**ammonium illite** Listed MM 46 515.

**ammonium taranakite** $Al_5(NH_4)_3H_6(PO_4)_4.18aq$.

Occurrence: **JR Lehr & 4 others** 1966 Crystallographic Properties of Fertilizer Compounds, Tenn Valley Auth Chem Eng Bull 6, 163p (L758).

**AMPHIBOLE STRUCTURE GROUP** Includes monoclinic & orthorhombic subgroups.

The following names include traditional composition ranges used by petrologists and ideal endmembers, as selected by IMA Committee.

| | |
|---|---|
| *actinolite* | $Ca_2Mg_5Si_8O_{22}(OH)_2$ |
| *aluminobarroisite* | $CaNaMg_3Al_2Si_7AlO_{22}(OH)_2$ |
| *alumino-ferrobarroisite* | $CaNaFe_3Al_2Si_7AlO_{22}(OH)_2$ |
| *alumino-ferrotschermakite* | $Ca_2Fe_3Al_2Si_6Al_2O_{22}(OH)_2$ |
| *aluminokataphorite* | $Na_2Ca(Fe,Mg)_4AlSi_7AlO_{22}(OH)_2$ |
| *alumino-magnesiotaramite* | $NaCaNaMg_3Al_2Si_6Al_2O_{22}(OH)_2$ |
| *aluminotschermakite* | $Ca_2Mg_3Al_2Si_6Al_2O_{22}(OH)_2$ |
| *aluminotaramite* | $NaCaNaFe^{2+}{}_3Al_2Si_6Al_2O_{22}(OH)_2$ |
| *anthophyllite* | $Mg_7Si_8O_{22}(OH)_2$ |
| *arfvedsonite* | $NaNa_2Fe^{2+}{}_4Fe^{3+}Si_8O_{22}(OH)_2$ |
| *barroisite* | $CaNaMg_3AlFe^{3+}Si_7AlO_{22}(OH)_2$ |
| *canilloite* | $CaCa_2Mg_4AlSi_5Al_3O_{22}(OH)_2$ |
| *clinoferroholmquistite* | $Li_2Fe_3Al_2Si_8O_{22}(OH)_2$ |
| [discredited *clinoholmquistite* | $Li_2Mg_3Al_2Si_8O_{22}(OH)_2$] |
| crossite = | various glaucophanes & riebeckites |
| *cummingtonite* | $Mg_7Si_8O_{22}(OH)_2$ |
| dannemorite | = manganogrunerite |

*dashkesanite*

$K_{0.6}Na_{0.4}(Ca_{1.95}Mn_{0.05})(Fe_{0.8}^{2+}Mg_{0.8})_2(Fe_{0.35}^{3+}Fe_{0.5}^{2+}Mg_{0.15})_2Fe^{2+}(Si_{2.9}Al_{1.1})(Si_{3.4}Al_{0.6})O_{22}Cl_{1.4}(OH,F)_{0.6}$

| | |
|---|---|
| *dellaventuraite* | $NaNa_2(MgMn_2TiLi)Si_8O_{22}O_2$ |
| *eckermannite* | $NaNa_2Mg_4AlSi_8O_{22}(OH)_2$ |
| *edenite* | $NaCa_2Mg_5Si_7AlO_{22}(OH)_2$ |
| *ferribarroisite* | $CaNaMg_3Fe^{3+}{}_2Si_7AlO_{22}(OH)_2$ |
| *ferric-ferronyböite* | $NaNa_2Fe^{2+}{}_3Fe^{3+}{}_2Si_7AlO_{22}(OH)_2$ |
| *ferri-clinoholmquistite* | $Li_2(Fe^{2+},Mg)_3\ Fe^{3+}{}_2Si_8O_{22}(OH)_2$ |
| *ferri-clinoferroholmquistite* | $Li_2Fe^{2+}{}_3Fe^{3+}{}_2Si_8O_{22}(OH)_2$ |
| *ferric-nyböite* | $NaNa_2Mg_3Fe^{3+}{}_2Si_7AlO_{22}(OH)_2$ |
| *ferri-ferrobarroisite* | $CaNaFe^{2+}{}_3Fe^{3+}{}_2Si_7AlO_{22}(OH)_2$ |
| *ferri-ferrotschermakite* | $Ca_2Fe^{2+}{}_3Fe^{3+}{}_2Si_6Al_2O_{22}(OH)_2$ |
| *ferrikatophorite* | $Na_2Ca(Mg,Fe)_4FeSi_7AlO_{22}(OH)_2$ |
| *ferri-magnesiotaramite* | $NaCaNaMg_3Fe^{3+}{}_2Si_6Al_2O_{22}(OH)_2$ |
| *ferri-ottoliniite* | $NaLi(Mg_3Fe_2)Si_8O_{22}(OH)_2$ |
| *ferri-whittakerite* | $Na(NaLi)(Mg_2Fe_2Li)Si_8O_{22}(OH)_2$ |
| *ferritaramite* | $NaCaNaFe^{2+}{}_3Fe^{3+}{}_2Si_6Al_2O_{22}(OH)_2$ |
| *ferritschermakite* | $Ca_2Mg_3Fe^{3+}{}_2Si_6Al_2O_{22}(OH)_2$ |
| *ferro-actinolite* | $Ca_2Fe_5Si_8O_{22}(OH)_2$ |
| *ferro-anthophyllite* | $Fe_7Si_8O_{22}(OH)_2$ |
| *ferrobarroisite* | $CaNaFe^{2+}{}_3AlFe^{3+}Si_7AlO_{22}(OH)_2$ |
| *ferro-eckermannite* | $NaNa_2Fe^{2+}{}_4AlSi_8O_{22}(OH)_2$ |

| | |
|---|---|
| *ferro-edenite* | $NaCa_2Fe_5Si_7AlO_{22}(OH)_2$ |
| *ferrogedrite* | $Fe_5Al_2Si_6Al_2O_{22}(OH)_2$ |
| *ferroglaucophane* | $Na_2Fe_3Al_2Si_8O_{22}(OH)_2$ |
| *ferroholmquistite* | $Li_2Fe_3Al_2Si_8O_{22}(OH)_2$ |
| *ferrohornblende* | $Ca_2Fe^{2+}_4(Al,Fe^{3+})_2Si_7AlO_{22}(OH)_2$ |
| *ferrokaersutite* | $NaCa_2Fe^{2+}_4TiSi_6Al_2O_{23}OH$ |
| *ferroleakeite* | $NaNa_2Fe^{2+}_2Fe^{3+}_2LiSi_8O_{22}(OH)_2$ |
| *ferronyböite* | $NaNa_2Fe_3Al_2Si_7AlO_{22}(OH)_2$ |
| **"***ferro-ottoliniite"* | $(NaLi)(Fe_3^{2+}Fe^{3+}Al)Si_8O_{22}(OH)_2$ |
| *ferropargasite* | $NaCa_2Fe_4AlSi_6Al_2O_{22}(OH)_2$ |
| *ferripedrizite* | $NaLi_2(Fe_2Mg_2Li)Si_8O_{22}(OH)_2$ |
| *ferriwinchite* | $NaCaMg_4FeSi_8O_{22}(OH,F)_2$ |
| *ferrorichterite* | $NaCaNaFe_5Si_8O_{22}(OH)_2$ |
| *ferrotschermakite* | $Ca_2Fe^{2+}_3AlFe^{3+}Si_6Al_2O_{22}(OH)_2$ |
| *ferrowhittakerite* | $Na(NaLi)(Li\ Fe^{2+}_2Fe^{3+}Al)Si_8O_{22}O_2$ |
| *ferrowinchite* | $CaNaFe^{2+}_4(Al,Fe^{3+})Si_8O_{22}(OH)_2$ |
| *fluoro-arfvedsonite* | $NaNa_2(Fe^{2+}_4Fe^{3+})Si_8O_{22}F_2$ |
| *fluoro-cannilloite* | $CaCa_2(Mg_4Al)(Si_5Al_3)O_{22}F_2$ |
| *fluoro-edenite* | $NaCa_2Mg_5Si_7AlO_{22}F_2$ |
| *fluoro-ferro-leakite* | $NaNa_2(Fe^{2+}_2Fe^{3+}_2Li)Si_8O_{22}F_2$ |
| *fluoro-magnesio-arfvedsonite* | $NaNa_2(Mg,Fe)_4FeSi_8O_{22}(F,OH)_2$ |
| *fluoropargasite* | $NaCa_2Mg_4AlSi_6Al_2O_{22}F_2$ |
| *fluoro-potassic-magnesio-arfvedsonite* | $KNa_2Mg_5Si_8O_{22}F_2$ |
| *fluoro-sodic-pedrizite* | $NaLi_2Mg_2Al_2LiSi_8O_2F_2$ |
| *fluornyböite* | $NaNa_2(Al_2Mg_3)(Si_7Al)O_{22}F_2$. |
| *gedrite* | $Mg_5Al_2Si_6Al_2O_{22}(OH)_2$ |
| *glaucophane* | $Na_2Mg_3Al_2Si_8O_{22}(OH)_2$ |
| *grunerite* | $Fe_7Si_8O_{22}(OH)_2$ |
| *hastingsite* | $NaCa_2Fe^{2+}_4Fe^{3+}Si_6Al_2O_{22}(OH)_2$ |
| *holmquistite* | $Li_2Mg_3Al_2Si_8O_{22}(OH)_2$ |
| *hornblende* | petrologic term |
| *kaersutite* | $NaCa_2Mg_4TiSi_6Al_2O_{23}OH$ |
| *katophorite* | $NaCaNaFe^{2+}_4(Al,Fe^{3+})Si_7AlO_{22}(OH)_2$ |
| *kornite* | $(Na,K)Na_2Mg_2Mn^{3+}_2LiSi_8O_{22}(OH)_2$ |
| *kozulite* | $NaNa_2Mn^{2+}_4(Fe^{3+},Al)Si_8O_{22}(OH)_2$ |
| *leakeite* | $NaNa_2Mg_2Fe^{3+}_2LiSi_8O_{22}(OH)_2$ |
| *magnesio-aluminokatophorite* | |
| *magnesio-anthophyllite* | |
| *magnesio-arfvedsonite* | $NaNa_2Mg_4Fe^{3+}Si_8O_{22}(OH)_2$ |
| *magnesioclino-holmquistite* | $Li_2(Mg,Fe)_3Al_2Si_8O_{22}(OH)_2$ |
| *magnesiocummingtonite* | |
| *magnesioferri-katophorite* | $Na_2Ca(Mg,Fe)_4Fe(Si_7Al)O_{22}(OH)_2$ |
| *magnesiogedrite* | |
| *magnesiohastingsite* | $NaCa_2Mg_4Fe^{3+}Si_6Al_2O_{22}(OH)_2$ |
| *magnesio-holmquistite* | |

| | |
|---|---|
| *magnesiohornblende* | $Ca_2Mg_4(Al,Fe^{3+})Si_7AlO_{22}(OH)_2$ |
| *magnesiokataphorite* | $NaCaNaMg_4(Al,Fe^{3+})Si_7AlO_{22}(OH)_2$ |
| *magnesioriebeckite* | $Na_2Mg_3Fe^{3+}{}_2Si_8O_{22}(OH)_2$ |
| *magnesiosadanagaite* | $NaCa_2[Mg_3(Al,Fe^{3+})_2]Si_5Al_3O_{22}(OH)_2$ |
| *magnesiotaramite* | $NaCaNaMg_3AlFe^{3+}Si_6Al_2O_{22}(OH)_2$ |
| *manganocummingtonite* | $Mn_2Mg_5Si_8O_{22}(OH)_2$ |
| *manganogrunerite* | $Mn_2Fe_5Si_8O_{22}(OH)_2$ |
| *obertiite* | $NaNa_2Mg_3FeTiSi_8O_{22}O_2$ |
| *ottoliniite* | $NaLi\ Mg_3FeAlSi_8O_{22}O_2$ |
| *nyböite* | $NaNa_2Mg_3Al_2Si_7AlO_{22}(OH)_2$ |
| *papikeite* | $(Mn_{0.7}Fe_{0.3})_2(Fe_{0.8}Mg_{0.2})_5Si_4O_{11}(OH)_2$ |
| *pargasite* | $NaCa_2Mg_4AlSi_6Al_2O_{22}(OH)_2$ |
| *parvo-mangano-edenite* | $Na(CaMn)Mg_5Si_7AlO_{22}(OH)_2$ |
| *parvo-mangano-tremolite* | $(CaMn)Mg_5Si_8O_{22}(OH)_2$ |
| *permanganogrunerite* | $Mn_4Fe_3Si_8O_{22}(OH)_2$ |
| *potassicarfvedsonite* | $KNaFe_4FeSi_8O_{22}(OH)_2$ |
| *potassic-chloropargasite* | $(K,Na)Ca_2(Mg,Fe,Al)_5(Si,Al)_8O_{22}Cl(OH).$ |
| *potassicpargasite* | $(K,Na)Ca_2(Mg,Fe,Al)_5(Si,Al)_8O_{22}(OH,F)$ |
| *prewittite* | $(Fe_{0.8}Mn_{0.2})_2(Fe_{0.98}Mg_{0.02})_5Si_4O_{11}(OH)_2$ |
| *protoanthophyllite* | $(Mg,Fe)_7(Si_4O_{11})_2(OH)_2$ |
| *richterite* | $NaCaNaMg_5Si_8O_{22}(OH)_2$ |
| *riebeckite* | $Na_2Fe^{2+}{}_3Fe^{3+}{}_2Si_8O_{22}(OH)_2$ |
| *sadanagaite* | $NaCa_2Fe^{2+}{}_3(Fe^{3+},Al)_2Si_5Al_3O_{22}(OH)_2$ |
| *sodicanthophyllite* | $NaMg_7Si_7AlO_{22}(OH)_2$ |
| *sodic-ferripedrizite* | $NaLiNaFe_2Mg_2LiSi_8O_{22}(OH)_2$ |
| *sodic-ferri-ferropedrizite* | $NaLi_2Fe_2Fe_2LiSi_8O_{22}(OH)_2$ |
| *sodic-ferro-anthophyllite* | $NaFe_7Si_7AlO_{22}(OH)_2$ |
| *sodic-ferrogedrite* | $NaFe_6AlSi_6Al_2O_{22}(OH)_2$ |
| *sodicgedrite* | $NaMg_6AlSi_6Al_2O_{22}(OH)_2$ |
| *taramite* | $NaCaNaFe^{2+}{}_3AlFe^{3+}Si_6Al_2O_{22}(OH)_2$ |
| tirodite | = manganocummingtonite |
| *tremolite* | $Ca_2Mg_5Si_8O_{22}(OH)_2$ |
| *tschermakite* | $Ca_2Mg_3AlFe^{3+}Si_6Al_2O_{22}(OH)_2$ |
| *ungarettiite* | $NaNa_2(Mn^{2+}{}_2Mn^{3+}{}_3)Si_8O_{22}O_2$ |
| *[villiersite* | $(Ni,Mg,Fe,Co)_7Si_8O_{22}(OH)_2$ jvs:?] |
| *whittakerite* | $Na(NaLi)(Li\ Mg_2FeAl)Si_8O_{22}O_2$ |
| *winchite* | $CaNaMg_4(Al,Fe^{3+})Si_8O_{22}(OH)_2$ |

*ferrikaersutite* Mössbauer of upper mantle macrocrysts: **S Nasur AD Al-Rawan** 2006 AM 91 1163-9.

Nomenclature, IMA report: **BE Leake & 21 others** 1997 CM 35 219-46;
additions & revisions, **BE Leake & 12 others** 2003 CM 41 1355-62; MM 68 209-15; AM 89 883-7;
AMPH-IMA-04, revised Hypercard, **A Mogessie K Ettinger BE Leake** 2004 MM 68 825-30
sequence of prefixes, **EAJ Burke BE Leake 2**005 AM 90 516-7
new suggested chemical-based, **FC Hawthorne R Oberti** 2006 CM 44 1-21.
Additions and corrections: **JA Mandarino** 1998 MR 29 169-74. Further changes added by jvs.
K-dominant: diversity & occurrence, **FK Mazdab** 2003 CM 41 1329-44..
Review: **FS Hawthorne** 1978 CM 16 37-52;

**M Cameron JJ Papike** 1979 FM 57 28-67 = MA 80-0135, -2853;
**FC Hawthorne** 1983 CM 21 173-480;
**G Della Ventura & 4 others** 1993 AM 78 980-7.

Subsilicic *hastingsite*: MA 77-2664.

26 blue amphiboles: MA 82M/2427.

Sodium at A site in clinoamphiboles: **FC Hawthorne R Oberti N Sardone** 1996 CM 34 577-93.

Triclinic: MA 92M/1399.

Li-bearing alkali amphiboles: **FC Hawthorne & 4 others** 1994 AM 79 443-51.

Li substitution, substitutional mechanisms: **R Oberti & 3 others** 2003 EJM 15 309-20.

Five calcic hornblendes: **K Makino K Tomita** 1989 AM 74 1097-1105.

Eight calcic amphiboles: **R Oberti & 4 others** 1995 EJM 7 1049-63 (O292).

Entropy-driven disorder in endmembers: **FC Hawthorne** 1995 CM 33 1189-204.

Immiscibility in calcic: **AJ Zingg** 1996 JP 37 471-96.

Short-range order, bond-valence model: **FC Hawthorne** 1997 CM 35 201-16.

Si MAS-NMR of Ca & NaCa: **MD Welch S Liu J Klinowski** 1998 AM 83 85-96.

Role of Ti in H-deficient Na-Ca & Na: **FC Hawthorne & 3 others** 1998 CM 36 1253-65.

Site preferences for heavy/light REE: **P Bottazzi & 6 others** 1999 CMP 137 36-45 (B1965).

Asbestos regulation by EPA, natural *tremolite-actinolite-ferro-actinolite* series, chemistry, XRPD, optics: **JR Verkouteren AG Wylie** 2000 AM 85 1239-54.

OH stretching bands, IR of *manganoan magnesio-arfvedsonite* & *richterite*: **K Ishida FC Hawthorne** 2001 AM 86 965-72.

Thermodynamics of Ca-Mg-Fe(II) quadrilateral: **MS Ghiorso BW Evans** 2002 AM 87 79-98.

Cl-rich from Sudbury: CM 37 1385-403.

Intergrown *ferroanthophyllite* in *grunerite*, TEM: **KN Bozhilov BW Evans** 2001 AM 86 1252-60.

Heated *tremolite-ferro-actinolite*, IR: **K Ishida FC Hawthorne Y Ando** 2002 AM 87 891-8.

*Synthetic* $Ca_2Mg_5Si_8O_{22}F_2$-$NaCa_2Mg_4Ga_3Si_6O_{22}F_2$, XRPD refinement: **DM Jenkins FC Hawthorne** 1995 CM 33 13-24.

*Synthetic* fluorpargasite: **R Oberti & 4 others** 1995 CM 33 25-31.

*Synthetic* $Na_3Mg_5Si_8O_{21}(OH)_3$, MAS-NMR of monoclinic/triclinic phase transition at ~ 400K: **S Liu & 3 others** 1996 EJM 8 223-9 (L753).

*Synthetic potassium-richterite/tremolite* series, XRPD & IR: **FC Hawthorne & 5 others** 1997 AM 82 708-16.

*Synthetic* sodic 2-3 GPa 973-1073 K, compositional variation: **P Tropper & 3 others** 2000 CMP 139 146-62 (T647).

*Synthetic cummingtonite-grunerite*, C-P phase transition vs P, SC-XRD: **TB Ballaran RJ Angel MA Carpenter** 2000 EJM 12 1195-213 (298).

*Synthetic* sodic, Fe redox, Mössbauer, theory: **M Enders & 3 others** 2000 CMP 140 135-47.

*Anthophyllite-ferroanthophyllite*, natural/heated, thermodynam: **BW Evans & 3 others** 2001 AM 86 640-51.

*Cummingtonite-grunerite*, natural/heated, phase transition & mixing: **T Boffa Ballaran MA Carpenter MC Domeneghetti** 2001 PCM 28 87-101 (1640).

*Manganogrunerites*, SC-XRD struct, Fe/Mn order vs T: **JJ Reece & 4 others** 2002 PCM 29 562-70 (8213).

*Synthetic* Al-, F/OH constraints: **G Della Ventura & 4 others** 2001 EJM 13 841-7 (3411).

*Synthetic potassic-ferri-ferrorichterite*, SC-XRD structure/Mössbauer: **GJ Redhammer G Roth** 2002 EJM 14 105-14 (6138).

*Synthetic* Ga-*tremolite/aluminotschermakite*, XRPD structure: **DM Jenkins & 3 others** 2002 PCM 29 87-97 (7290).

*Synthetic tremolite-pargasite*: IR, **G Della Ventura & 3 others** 2003 EJM 15 341-8;
IR & TEM, **DM Jenkins KN Bozhilov K Ishida** 2003 AM 88 1104-14.

*Synthetic ferri-clinoferroholmquistite-riebeckite*: ordering, **G Iezzi & 4 others** 2003 AM 88 955-61.

*Synthetic* Ga,F-*tremolite-glaucophane*: cation substitutions, **MS Pavlovich Jr DM Jenkins** 2003 AM 88 1486-95.

Holmquistite & anthophyllite-gedrite, IR, OH bands: **K Ishida FC Hawthorne** 2003 PCM 30 330-6 (9240).

*Synthetic* $Na(NaMg)Mg_5Si_8O_{22}(OH)_2$, SC-XRD structure: **G Iezzi & 4 others** 2004 AM 89 640-6.;
low-T NPD & synchrotron IR, **G Iezzi & 6 others** 2005 AM 90 695-700.

*Synthetic* $NaNa_2Mg_5Si_8O_{21}(OH)_3$, SC-XRD structure: **F Camaro & 4 others** 2004 AM 89 1464-7.

*Synthetic magnesioriebeckite-ferriclinoholmquistite*: FTIR/Mössbauer, **G Della Ventura & 5 others** 2005 PCM 32 103-13.

*Synthetic magnesioriebeckite*: vs redox, **G Della Ventura & 5 others** 2005 AM 90 1375-83.

*Synthetic* (In/Sc)F-*eckermannite* & ScF-*nyboite*: MA 88M/1799.

Occurrence of *richterite-magnesioarfvedsonite-magnesioriebeckite* in Siberian carbonatites: **VS Samoilov** 2002 NJMA 177 199-211 (7270).

Oxy-amphibole equilibria in Ti-Ca-amphiboles: 2, 5,10 kbar: **RK Popp & 2 0thers** 2006 AM 91 54-66.
Growth & composition , calc-alkaline magmas, Romania **O Féménias & 6 others** 2006 AM 91 73-81.
OH-stretch IR bands, Ca amphiboles, assigned by deuteration & heating: **K Ishida FC Hawthorne** 2006 AM 91 871-9.

**amstallite** $CaAl_2Si_3O_8(OH)_4.aq$. Layer silicate.

Description: **R Quint** 1987 NJMM 253-62 (Q3).

**ANALCIME-LEUCITE STRUCTURE GROUP**. Zeolite/feldspathoid family.
IZA-SC code ANA. Consortium for Theoretical Frameworks net 583. Various symmetry types.

| Includes: | | |
|---|---|---|
| | *ammonioleucite* | $NH_4AlSi_2O_6$ |
| | *analcime* | $NaAlSi_2O_6.aq$ |
| | *hsianghualite* | $Ca_3Li_2Be_3(SiO_4)_3F_2$ |
| | *leucite* | $KAlSi_2O_6$ |
| | *pollucite* | $CsAlSi_2O_6$ |
| | *wairakite* | $CaAl_2Si_4O_{12}.2aq$ |
| | *viséite* | is doubtful species, and may be mixture. |

Analcime-pollucite series: high-T XRD, IR & thermal analysis of several types of water,
**OV Frank-Kamenetskaya & 4 others** 1997 ZVMO 126 62-71.
*Synthetic* analcime to Rb/Cs-leucite series, cell dimensions & thermodynamics: **GL Hovis J Roux E Rodrigues** 2002 AM 87 523-32.
*Synthetic* $Li_2Ca_3F_2[BeSiO_4]_3$: (R492).
*Synthetic* CsTiSiO, XRPD: **DE McCready ML Balmer KD Keefer** 1999 PD 12 40-6 (M1771).
*Synthetic* Tl-, discussion: **A Dyer** 2000 MM 64 9-10.
*Synthetic* conversion to leucite at 298-363, model use of cement & concrete for waste containment: **D Savage & 6 others** 2001 MM 65 571-87.
*Synthetic* $Cs_{12}Li_{13}Li_3Zn_8Si_{37}O_{96}.4aq$, XR & NPD structure: **S Park & 3 others** 2002 ChM 14 3187-96 (7714).

**analcime** $NaAlSi_2O_6.aq$. Analcime structure type.

Various symmetry types: **D Coombs** 1955 MM 30 699-707;
**F Mazzi E Galli** 1978 AM 63 448-60;
**W Nakajima M Akai C Kinoshita** 1984 Bull Fac Education, Kobe Univ, 72 105-21.
Structure: **WH Taylor** 1930 ZK 74 1-19;
**WH Taylor** 1938 ZK 99 283-90;
**IR Beattie** 1954 AC 7 357-9 (B1175);
**M Calleri G Ferraris** 1964 Atti Acad Sci Torino 98 821-46;
**CR Knowles FF Rinaldi JV Smith** 1965 Indian Mineral 6 127-40;
**G Ferraris DW Jones J Yerkess** 1972 ZK 135 240-52 (F158);
**F Mazzi** 1978 AM 63 448-60;
**Y Yokomori S Idaka** 1998 MMM 21 365-70 (Y236).
High-P, **RM Hazen LW Finger** 1979 Phase Transitions 1 1-22;
elasticity, structural evolution, **GD Gatta & 2 others** 2006 AM 91 568-78
Orthorhombic: **F Pechar** 1988 Z 8 247-9.
Monoclinic: **F Pechar** 1988 ZK 184 63-9.
Si-rich: **A Straub & 4 others** 1988 ZK 181 254-6.
Incoherent neutron scattering: **CMB Line B Winkler MT Dove** 1994 PCM 21 451-9.
NMR, **BL Phillips RJ Kirkpatrick** 1994 AM 79 1025-31.
Neutron PD, 30-300 K: **CBM Line & 3 others** 1996 MM 60 499-507.
Two types of water, high-T XRD, IR & DTA, **OV Frank-Kamenetskaya & 4 others** 1997 ZVMO 126 62-71.
High-T multi-nuclear NMR: **Y Kim RJ Kirkpatrick** 1998 AM 83 339-47.
NMR of O site exchange & Al-O-Al sites: **X Cheng P Zhao JF Stebbins** 2000 AM 85 1030-7.
Ion mobility & dynamic disordering of water, **NK Moroz & 3 others** 1998 PCM 25 282-7 (M1622).
Dehydrated, **VV Bakakin & 5 others** 1994 DES 339 520-4 (B1503).
High-P phase transitions to 3 GPa in dehydrated-, Raman: **YuM Miroshnichenko V Goryainov** 2000 MM 64 301-9.
Al,Si distribution, Monte Carlo analysis of NMR of cubic: **MT Dove V Heine** 1996 AM 81 39-44.
Al ordering, theory & observations: **T Takaishi** 1998 J Chem Soc Faraday 94 1507-18 (T575).
Solubility and stability in aqueous solution: **RT Wilkin HL Barnes** 1998 AM 83 746-61.
Dehydration dynamics, in situ synchrotron XRPD: **G Cruciani A Gualtieri** 1999 AM 84 112-9.

Thermodynamics of solid solutions: **PS Neuhoff & 3 others** 2004 AJS 21-66 (10071).
Occurrence: volcanic, Alberta, Canada, XRPD vs symmetry & origin, **RW Luth M Bowerman** 2004 CM 42 897-903;
Serbia, from *leucite*, **D Prelević & 3 others** 2004 MM 68 633-48.
From teschenite sills, Poland: **J Kapusta R Wlodyka** 1997 NJMM 241-55.
*Synthetic* Ge-: MM 32 958.
*Synthetic* $Na_{13}Al_{24}Si_{13}P_{11}O_{96}$: **G Artioli JJ Pluth JV Smith** 1984 AC C40 214-7 (A620).
*Synthetic* $NaGaSi_2O_6$.aq: **YuA Malinovskii & 4 others** 1991 Kristallografiya 36 571-6.
*Synthetic* Na-Cs gallosilicates: **WB Yelon D Xie JM Newsam J Dunn** 1990 Z 10 553-8.
Nucleation/growth in clear Al-silicate solution: **GS Wiersema RW Thompson** 1996 JMC 6 1693-9 (W773).
*Synthesis* in glycerol: **S Yang AG Vlessidis NP Evmiridis** 1997 Microporous Mater 9 273-86.
*Synthetic* $Cs_2AlCo_2P_3O_{12}$, structure: **P Feng X Bu GD Stucky** 1997 N 388 735-40 (F556).
Ammonium-exchanged: **NK Moroz & 3 others** 1998 J Struct Chem 39 281-83;
IR, **AYu Likhacheva & 3 others** 2002 PCM 29 617-23 (8453);
thermal decomposition, IR/XRD, **AYu Likhacheva & 2 others** 2004 PCM 31 306-12 (10543).
Nucleation & growth kinetics from Na-clinoptilolite: **RT Wilkin HL Barnes** 2000 AM 85 1329-41.
Cs/Sr sorption: **AF Redkin JJ Hemley** 2000 EJM 12 999-1014 (238).
*Synthetic* ammonium-ZnCa phosphates, analogs of analcime & *paracelsian*, SC-XRD structure:
**NZ Logar M Mrak V Kaucic** 2001 JSSC 156 480-6 (1320).
Ag-exchanged, SC-XRD: **YuV Seryotkin & 3 others** 2000 MMM 39 265-73 (3696).
*Synthetic* $(K/Na/NH_4)BeBP_2O_8$, SC-XRD structure of K: **H Zhang & 4 others** 2003 MMM 57 309-16 (8578).
*Synthetic* Li-, SC-XRD structure: **YuV Seryotkin & 4 others** 2000 J Struct Chem 41 1021-7 (7789).
Exchange diffusion of divalent Cu/Ni/Pb/Zn: **A Dyer & 2 others** 2004 MMM 75 273-9 (10783).

**anandite** $(Ba,K)(Fe,Mg)_3(Si,Al,Fe)_4O_{10}(O,OH)S$. Mica structure type.

Structure: **G Giuseppetti C Tadini** 1972 TMPM 18 169-84 (G282) = MA 74-141;
**MA Filut AC Rule SW Bailey** 1985 AM 70 1298-308 (F25.
Occurrence: MM 36 1147.

**anapaite** $Ca_2Fe(PO_4)_2.4aq$.

Structure: **IM Rumanova MN Znamenskaya** 1961SPC 5 650-8 1961;
**M Catti G Ferraris G Ivaldi** 1979 BM 102 314-8 1979;
Mössbauer before/after oxidation, **SG Eeckhout & 2 other** 1999 PCM 26 506-12 (E461).

**anatase** $TiO_2$. Trimorphic with *brookite* & *rutile*.

Used as white pigment in paint, plastic and paper.
Cu supported on anatase is used for selective oxidation of *o*-xylene to phthalic anhydride, CO oxidation, steam reforming & methanol dehydrogenation, etc.
Research on photocatalytic properties may lead to use in optoelectronic devices.
Structure: **L Vegard** 1916 Phil Mag 32 505-18 (C1114);
**DT Cromer K Harrington** 1955 JACS 77 4708-9;
SC-XRD to 1073K, **M Horn & 2 others** 1972 ZK 136 273-81 (H1422);
NPD, 15 & 295 K, **JK Burdett & 4 others** 1987 JAChS 109 3639-46;
NPD, **CJ Howard TM Sabine F Dickson** 1992 AC B47 462-8 (H989);
electron PD of nanocrystalline: **TE Weirich & 3 others** 2002 AC A58 303-15 (7658);
Raman/XRD, in fired kaolin, **E Murad** 2003 ClClM 51 689-92.
P-T of anatase, *brookite & rutile*, & $TiO_2$-II (alpha-$PbO_2$ type): **F Dachille PY Simons R Roy** 1968 AM 53 1929 (D784).
Equation of state, quantum-mechanical: **M Catayud & 6 others** 2001 PRB 64 184113(9) (3592).
Atomic model of surface: **PM Oliver & 3 others** 1997 JMC 7 563-8 (O330).
Anatase/rutile stability as function of grain size: **AA Gribb JF Banfield** 1997 AM 82 717-28.
Ru complex sensitizer in nanopowder: **V Shklover & 8 others** 1997 JSSC 132 60-72 (S1739).
Rutile nuclei at anatase {112} twin interfaces: **RL Penn JF Banfield** 1999 AM 84 871-6.
(101) & (001) surfaces, SEM & LEED; **R Hengerer & 3 others** 2000 SuS 460 162-9 (H1478).
(100) surface STM: **N Ruzycki & 3 others** 2003 SuS 529 L239-44.
Methanol adsorption on clean & hydroxylated (101) surface: **A Tilocca A Selloni** 2004 JPCB 108 19314-9 (10956).
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
*Synthetic* V-substituted anatase catalysts, V/Ti 0.14 - 7.99: **LE Briand & 3 others** 1995 JMC 5 1443-9.

Fe substitution in soil & synthetic: **U Schwertmann & 3 others** 1995 ClClM 43 599-606.
Equation of state, transition to alpha-$PbO_2$ *columbite* structure at 4.5 GPa: **T Arlt & 6 others** 2000 PRB 61 14414-9 (A928).
Precipitation from seeded titanyl sulfate solution, relation to production of white pigment: **S Sathyamoorthy GD Moggridge MJ Hounslow** 2001 CrGD 1 123-9 (1419).
Anatase-to-*rutile* in titania powder 1273 K: **PI Gouma MJ Mills** 2001 JACeS 84 619-22 (1328).
Anatase-to-*rutile* during calcination of amorphous titania with halide contaminant: **J Ovenstone K Chan** 2001 EJIC 1339-42 (2055).
Anatase-to-*rutile* transition, effect of silica: **K Okada & 3 others** 2001 JACeS 84 1591-6 (2058).
Li intercalation: **V Luca B Hunter B Moubaraki KS Murray** 2001 ChM 13 796-801 (1721);
**M Wagemaker APM Kentgens FM Mulder** 2002 N 418 397-9 (7845);
Raman/lattice dynamics, **M Smirnov R Baddour-Hadjean** 2003 JCP 121 2348-55 (10497)..
Nanophase, preparation, characterization & spectra: **KM Reddy CVG Reddy SV Manorama** 2001 JSSC 158 180-6 (2054).
Inhibition of anatase to *rutile* by addition of ceria, Raman, XRD: **MSP Francisco VR Mastelaro** 2002 ChM 14 2514-8 (7717).
Ge substitution & anatase/*rutile* transition: **K Okada & 3 others** 2002 JACeS 85 2078-82 (7826).
*Synthetic* Fe(III)-, XRD/TEM/Mössbauer: **M Hirano & 3 others** 2004 JACeS 87 35-41 (9916).

**ANCYLITE MINERAL/STRUCTURE GROUP** Includes:

| | |
|---|---|
| *ancylite-Ce* | $SrCe(CO_3)_2(OH).aq$ |
| *ancylite-La* | $SrLa(CO_3)_2(OH).aq$ |
| *calcio-ancylite-Ce* | $CaCe(CO_3)_2(OH).aq$ |
| *calcio-ancylite-Nd* | $CaNd(CO_3)_2(OH).aq$ |
| *gysinite* | $Pb(Nd,La)(CO_3)_2(OH).aq$ |
| *kozoite-Nd* | $Nd(CO_3)(OH)$ |

Based on topology of *aragonite* with addition of OH.
*Synthetic* DyOHCO, structure: **T Doert O Rademacher J Getzschmann** 1999 ZK 214 11-2 (D771).

**ancylite-Ce** $SrCe(CO_3)_2(OH).aq$.
Structure: **A Dal Negro G Rossi V Tazzoli** 1975 AM 60 280-4;
SC-XRD, **YuV Belovitskaya & 6 others** 2002 CrR 47 223-8 (7084).
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
In Khibina carbonatite: **AN Zaitsev et al**. 1998 MM 62 225-50.
In Ilimaussaq alkaline complex: **OV Petersen & 5 others** 2001 NJMM 493-504 (3590).

**ancylite-La** $Sr(La,Ce)(CO_3)_2(OH).aq$.
Description, Khibiny massif: **VN Yakovenchuk & 3 others** 1997 ZVMO 96-108 (Y227).

**ancylite-Nd** = IMA 90-063: CM 38 250.

**andalusite** $Al_2SiO_5$. Isostructural with *adamite-olivenite* group and related to *libethenite*.
Polymorphic with *kyanite & sillimanite*.
Structure: **CW Burnham MJ Buerger** 1961 ZK 115 269-90 (B47);
ND, **LW Finger E Prince** 1972 CIWYB 71 496-500 = MA 79-145;
**JK Winter S Ghose** 1979 AM 64 573-86;
high-P, **RL Ralph & 3 others** 1984 AM 69 513-9.
HRTEM: MA 89M/1612.
Cr substitution & interpretation of spectroscopy: MA 96M/1531.
Lattice-dynamics model: **T Pilati F Demartin CM Gramaccioli** 1997 AC B53 82-94 (P662).
XR photoelectron/electron energy-loss spectros *andalusite/kyanite/sllimanite*: **FS Ohuchi & 2 others** 2006 AM 91 740-6.
Crystallization kinetics for transitions with *kyanite* & *sillimanite*: **GT Ostapenko** 2004 GI 42 921-37 (10949).
High-P polymorph, probably of $V_3O_5$ structure type, synthesized from *anorthite, grossular & pyrope* in diamond cell: **I Ahmed-Zaïd M Madon** 1991N 353 426-8 (A778).
High-T transformation to *mullite* & silica: **A Hulsmans & 3 others** 2000 AM 85 980-6, 987-92.
Spinel-cordierite symplectites after, Bushveld Complex, S. Africa: **T Johnson & 3 others** 2004 JMG 22 529-45 (10577).
Nelson batholith, aureole, British Columbia: **DRM Pattison JJ Vogl** 2005 CM 43 51-88.

[**anderbergite** Hydrous silicate of Zr, Ca & REE.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.]

**andersonite** $Na_2Ca[UO_2(CO_3)_3].\sim 5.6aq.$

Crystallography: **K Mereiter** 1986 Anz Oester Akad Wiss Math-Naturwiss Kl 3 39-41.
Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80. Compare with liebigite.
Enthalpy of formation: **K Kubatko & 3 others** 2005 AM 90 1284-90.
Natural, infrared: **J Celka Z Urbanec J Cejka Jr** 1987 NJMM 488-501 (U38).
*Synthetic*: **A Coda A Della Giusta V Tazzoli** 1981 AC B37 1496-500 (C763A).
*Synthesis*: **R Vochten L Van Haverbeke K Van Springel** 1993 CM 31 167-71.
*Synthetic* $Ca_{1.5}Na_{0.6}[UO_2(CO_3)_3].5aq$, not isostr: **R Vochten & 4 others** 1994 CM 32 553-61.

**andesine** *Feldspar* family. Plagioclase subgroup; order-disorder. See Feldspar database

**andorite** $AgPbSb_3S_6$. *Lillianite* homologous series, subtype 4,4. Several variants; andorite IV is *quatrandorite*; andorite VI is *senandorite*.
General: **E Makovicky WG Mumme** 1979 NJMM 147 58-79.
*Synthetic* 24-layer repeat: **NI Organova & 3 others** 1983 DES 268 169-71 (O254).
*Synthetic* $Ag_{1.2}Sn_{0.9}Sb_3S_6$: MM 51 741-3.
*Synthetic* $Ag_2Mn_2Sb_6S_{12}$: **H Liu LLY Chang CR Knowles** 1994 CM 32 185-8.

**andradite** $Ca_3Fe_2Si_3O_{12}$. *Garnet* structure type.

Structure: **GA Novak GV Gibbs** 1971 AM 56 791-825;
**RM Hazen LW Finger** 1989 AM 74 352-9;
Ti-bearing, neutron powder, **GA Lager & 3 others** 1989 AM 74 840-51;
**KJ Kingma JW Downs** 1989 AM 74 1307-16;
hydrous, SC-XRD, **T Armbruster** 1995 EJM 7 1221-5 (A665);
hydrous, FTIR, **G Amthauer GR Rossman** 1998 AM 83 835-40.
Electronic adsorption ferric 300-750 K <10 GPa: **MN Taran K Langer** 2000 EJM 12 7-15 (T645).
SC-XRD, hydrostatic compression to 15 GPa: **L Zhang & 3 others** 1999 PCM 27 52-8 (Z217).
Sector zoning of titanian: **G Agrosi & 4 others** 2002 EJM 14 785-94.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**andremeyerite** $BaFe_2Si_2O_7$.

Structure: **E Cannillo F Mazzi G Rossi** 1988 AM 73 608-12. MM 39 905.

**androsite-La** $(Mn,Ca)(La,Ce,Ca,Nd)AlMn^{3+}Mn^{2+}(SiO_4)(Si_2O_7)OOH$.

*Epidote* structure group.
Structure, solid solution with *piemontite*: **P Bonazzi S Menchetti T Reinecke** 1996 AM 81 735-42.

**anduoite** $(Ru,Os)As_2$. *Marcasite* structure supergroup; *löllingite* subgroup.

Occurrence: MM 43 1057;
CM 39 591-606.
*Synthetic* $Ru/OsAs_2$: **RD Heyding LDCalvert** 1961Can J Chem 39 955-7 (H1041).

**andyrobertsite** $KCdCu_5(AsO_4)_4[As(OH)_2O_2]2aq.$

Lamellar intergrowth with *calcioandyrobertsite-1M & -2O* $KCaCu_5(AsO_4)_4[As(OH)_2O_2]2aq.$
Structure: SC-XRD, **MA Cooper FC Hawthorne** 2000 CM 38 817-30.
Occurrence & XRPD: **MA Cooper & 3 others** 1999 MR 30 181-6.

**angelellite** $Fe_4(AsO_4)_2O_3$.

Structure: **PB Moore T Araki** 1978 NJMA 132 91-100; MM 32 943.
*Synthetic*, partial frustration of magnetic order: **JP Wright AC McLaughlin JP Attfield** 2000 JCS 3663-8 (816).

**anglesite** $PbSO_4$. *Barite* structure type. Review: Sabelli p. 28.

Structure: **K Sahl** 1963 Beitr Mineral Petrol 9 111-32 = MA 69-1075;
**M Miyake & 3 others** 1978 AM 63 506-10;
rigid-body character, **SD Jacobsen & 3 others** 1998 CM 36 1053-60.
High-T oxide-melt/differential scanning calorimetry: **J Majzlan A Navrotsky JM Neil** 2002 GCA 66 1839-50 (7338).
XRD: *olsacherite* $Pb_2(SO_4)(SeO_4)$ has same topology as anglesite, but lower space group.

**anhydrite** $CaSO_4$. Isostructural with *ferruccite*.

Review: Sabelli p.33.
Crystallographic twin operations relate anhydrite to *zircon, scheelite*, etc.: (N373).
Structure: **E Höhne** 1963 SPC 7 359-69 (H892);
**FC Hawthorne RB Ferguson** 1975 CM 13 289-92;

**H Morikawa I Minato T Tomita S Iwai** 1975 AC B31 2164-5;
**A Kirfel G Will** 1980 AC B36 2881-90;
**A Kirfel G Will** 1981 AC B37 525-32;
**P Hartmann** 1989 EJM 1 721-2.
High-T oxide-melt/differential scan calorimetry: **J Majzlan A Navrotsky JM Neil** 2002 GCA 66 1839-50 (7338).
High-P,T transitions to *monazite/barite & distorted barite*, XRPD structures: **WA Crichton & 3 other s** 2005 AM 90 22-7.
Surface structure imaged by AFM: **H Shindo H Nozoye** 1992 JCSFaraday 88 711-4 (S1201).
Magma vapor deposition prior to 1991 Pinatuobo eruption: **RT Jakubowski & 4 others** 2002 AM 87 1029-45.
Precipitation in sediments of Grimsey hydrothermal field, Iceland: **T Kuhn & 4 others** 2003 ChG 202 5-21 (9884).
In meteorites: **AE Rubin** 1997 MPS 32 231-47;
naklites, **JC Bridges MM Grady** 2000 EPSL 176 267-79 (B2001).
Cathodoluminescence Eu-doped *synthetic*: **F Cesbron & 3 others** 1997 CRASP 324 IIa 353-60 (C900).
[**soluble anhydrite** (gamma-$Ca_2SO_4$)
*Synthetic*: **C Bezou & 4 others** 1995 JSSC 117 165-76 (B1329)]

**anilite** $Cu_7S_4$.

Structure: **K Koto N Morimoto** 1970 AC B26 915-24 (K204);
**HT Evans Jr** 1981 AM 66 807-18.
Occurrence: MM 37 954-5.

**ankangite** $Ba(Ti,V,Cr)_8O_{16}$. *Hollandite* structure type.

Incommensurate modulation, ED: **XJ Wu FH Li H Hashimoto** 1990 AC B46 11-7.

**ankerite** $Ca(Fe,Mg,Mn)(CO_3)_2$. *Dolomite* structure type.

Structure: **A Beran J Zemann** 1977 TMPM 24 279-86 (B1348) = MA 78-1516;
**D Jarosch** Osterr Akad Wiss Math-Nat Klasse Anz 122 61-2 = MA 88M/0280;
dolomite-ankerite, **RJ Reeder WA Dollase** 1989 AM 74 1159-67;
**K Reksten** 1990 AM 75 495-500;
superstructure, **HR Wenk & 3 others** 1991 PCM 17 527-39;
high-P, **NL Ross RJ Reeder** 1992 AM 77 412-21;
magnetics low-T, vs *siderite*, **G Hilscher & 3 others** 2005 EJM 17 103-5 (11024).
-dolomite, *synthesis*, characterization/energetics: **L Chai A Navrotsky** 1996 AM 81 1141-7.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**ankinovichite** $(Ni,Zn)Al_4(VO_3)_2(OH)_{12}.2aq$. Unbranched 2-repeat chain.

Zn analog is *alvanite*.
Occurrence & structure: **VY Karpenko & 6 others** 2004 ZVMO 133 59-63 (10869).

**annabergite** $Ni_3(AsO_4)_2.8aq$. *Vivianite* structure type.

Structure: **M Wildner & 3 others** 1996 EJM 8 187-93;
*cabrerite*, (Ni,Mg) variety, **G Giuseppetti C Tadini** 1982 BM 105 333-7.
-*erythrite-hörnesite synthetic* system: **JL Jambor JE Dutrizac** 1995 CM 33 1063-71.
-*erythrite* solid solution: site occupancy of Co & Ni from XRD/Raman/IR: **WM Martens & 3 others** 2005 CM 43 1065-75.

**annite** $KFe_3AlSi_3O_{10}(OH,F)_2$. *Mica* structure type.

Structure: **RM Hazen CW Burnham** 1973 AM 58 889-900.
Mössbauer: AM 79 51-62 1994.
XRPD/Mössbauer, -*phlogopite* join: **GJ Redhammer E Dachs G Amthauer** 1995 PCM 22 282-94 (R585).
IR: **B Boukili & 4 others** 2003 SMPM 83 33-46 (10934).
*Synthetic* Cs-ferriannite, crystal structure, possible repository radioactive Cs:
**M Mellini & 3 others** 1996 EJM 8 1265-71(M1455);
high P,T behavior, **P Comodi & 4 others** 1999 AM 84 325-32.
Oxidation mechanisms & chemistry: **DG Rancourt & 6 others** 2001 ClClM 49 455-91 (4007).
F-analog = IMA 99-048: CM 38 249.

**anorthite** *Feldspar* structure type. Plagioclase subtype. See Feldspar database.

Framework distortion with T & P, and order-disorder of Al/Si cause complex structural changes.
Polymorphic with hexagonal (*dmisteinbergite*) & orthorhombic (*svyatoslavite*) (actually, lower symmetry than ideal).
Breakdown of Ca-exchanged synthetic *faujasite*, Si/Al 1.26 to amorphous intermediate, 1073-1173K, & recrystallization to partly disordered anorthite, **R Dimitrijevic V Dondur A Kremenovic** 1996 Z 16 294-300 (D586).
Fe-rich coating vs dissolution at pH 2.6: **ME Hodson** 2003 GCA 67 3355-63 (9350).
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
*Synthetic* $MnAl_2Si_2O_8$: **RB Snow** 1943 JACeS 26 11-20;

**JR Rait HW Pinder** 1947 J Iron Steel Inst 154 371-98P.

**anorthoclase** *Feldspar* structure type. See Feldspar database.
Ternary composition bridging plagioclase & alkali feldspar subgroups. Triclinic to monoclinic transition with increasing T and decreasing P.

**anorthominasragrite** $VO(SO_4).5aq$. Triclinic polymorph of *orthominasragrite & minasragrite*.
Occurrence & SC-XRD structure: **MA Cooper & 3 others** 2003 CM 41 959-79.

[**anosovite** Synthetic $Ti_3O_5$ in slag. = *armalcolite*.
Structure: **AA Rusakov GS Zhdanov** 1951 DAN SSSR 77 411-4 Russian;
Rietveld XRPD, **IE Grey C Li IC Madsen** 1994 JSSC 113 62-73.]

**ansermetite** $MnV_2O_6.4aq$.
Occurrence & SC-XRD structure: **J Brugger & 3 others** CM 41 1423-31.
*Synthetic*: structure, **JH Liao & 4 others** 1996 Eur J Solid State Inorg Chem 33 411-27;
Co- analog, **NV Avtamonova & 2 others** 1990 Izv Akad Nauk SSSR Neorg Mater 26 346-9.

**antarcticite** $CaCl_2 .6aq$.
Structure: *synthetic*, A **Leclaire M-M Borel** 1977 AC B33 2938-90.
Br & Sr analogs; **PA Agron WR Busing** 1986 AC C42 141-3.
Occurrence: MM 33 1127.

**anthoinite** $WAlO_3(OH)_3$.
Occurrence: **ThG Sahama et al.** 1970 Bull Geol Soc Finlande 42 95-9;
1957 NJMA 91 35-40 = AM 43 384.
Structure determination not found.

**anthonyite** $Cu(OH,Cl)_2.3aq$. Occurrence: **SA Williams** 1963 AM 48 614-9.
Structure determination not found.

**anthophyllite** $(Mg,Fe)_7Si_8O_{22}(OH)_2$. *Amphibole* structure type.
Structure: **LW Finger** 1970 CIWYB 68 283-8;
**EM Walitzi F Walter K Ettinger** 1989 ZK 188 237-44.
Biopyribole polysomes: **BH Grobéty** 1996 AM 81 404-17.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
Replacement by *jimthompsonite*: **BH Grobéty** 1997 CMP 127 2337-47 (G908).

**antigorite** $Mg_3Si_2O_5(OH)_4$. *Kaolinite-serpentine* group.
Structure: **E Aruja** 1945 MM 27 65-74;
**J Zussman** 1954 MM 30 498-512;
**G Kunze** 1956 ZK 108 82-107; 1958 ZK 110 282-320;
TEM of polysomatism & stacking defects, **MT Otten** 1993 AM 78 75-84;
TEM & XRD, **S Uehara** 1998 CM 36 1595-605;
optical absorption of Fe & Mn, **SN Reddy & 4 others** 2001 NJMM 261-70 (2913);
FTIR & Mossbauer, **M Mellini & 4 others** 2002 EJM 14 97-104;
revised models, HRTEM, **I Dodony M Posfai PR Buseck** 2002 AM 87 1443-57;
polytypes & higher-order structures, TEM, **B Grobéty** 2003 AM 88 27-36;
m = 17 polysome, SC-XRD, **G Capitani M Mellini** 2004 AM 89 147-58;
HRTEM of 8-reversals in m = 17 polysome, **G Capitani M Mellini** 2005 AM 90 991-9.
P,T vs polysomatism & water: **B Wunder R Wirth M Gottschalk** 2001 EJM 13 485-95 (2070).
Vein from Elba Island, Italy, polysomatic faults, twinning, association with polygonal *serpentine* & *chrysotile*, XRD/IR/NMR & thermal analysis: **C Viti M Mellini** 1996 EJM 8 423-34 (V253).
High-P stability & transformation to phase A in cold oceanic slab:
**K Bose J Ganguly** 1995 EPSL 136 109-21 (B1449);
**B Wunder W Schreyer** 1997 Li 41 213-27.
High-P phase changes, *lizardite* & antigorite, room-T stability quenched phases E/ superhydrous B & D, in situ XRPD: **SR Shieh & 3 others** 2000 EPSL 177 69-80 (S2169).
High-P stability MSH & MASH systems, Al(III) substitution: **GD Bromiley AR Pawley** 2003 AM 88 99-108.
Acid treatment yielding microporous material: **K Kosuge K Shimada A Tsunashima** 1995 ChM 7 2241-6 (K828).
*Synthesis* without seeds, TEM: **B Wunder A Baronnet W Schreyer** 1997 AM 82 760-4.

**antimonpearceite** $(Ag,Cu)_{16}(Sb,As)_2S_{11}$. Isostructural with As analog *pearceite* from cell dimensions. Dimorphic with *polybasite*.
Occurrence: **C Frondel** 1963 AM 48 565-72.

*Synthesis*: **HT Hall** 1967 AM 52 1311-21.

**antimonselite** ~$Sb_2Se_3$. Analog of *stibnite*.

Occurrence: **L Chen Q Zhang D Li G Wang** 1993 Acta Miner Sinica 13 7 = 1994 AM 79 387;
**M Min D Li N Shi Q Liu Y Cao** 1995 Acta Miner Sinica 15 303-4 = AM 81 1017.

Stibnite-series: 1999 IGR 41 1042-50 (J361).

**antimony** Sb. *Tetradymite* mineral/structure group; *arsenic* subgroup: **P Bayliss** 1991 AM 76 257-65.

High-pressure: **D Schiferl DT Gomer JC Jamieson** 1981 AC B37 807-10;
review & new refinements, **H Iwasaki T Kikegawa** 1997 AC B53 353-7 (I201).

*Gudmundite*-antimony mineralization, Quebec ophiolite: **C Normand M Gauthier M Jebrak** 1996 EcG 91 149-63 (N408).

[**antitaenite** Proposed low-spin phase with ~25-30% Ni. Not submitted to CNMN.

Description: **DG Rancourt RB Scorzelli** 1995 J Magnetism Magnetic Materials 150 30-6 = AM 81 766.]

[**antofagastite** $CuCl_2.2aq$. Occurrence: MM 25 622.]

**antlerite** $Cu_3SO_4(OH)_4$. Close relation with *szenicsite* $Cu_3SO_4(OH)_4$.

Review: Sabelli p.19.

Structure: **T Araki** 1961 MJJ 3 223-35 (A32) = MA 16-27;
**FF Finney T Araki** 1963 N 197 70 = MA 16-250;
**FC Hawthorne LA Groat RK Eby** 1989 CM 27 205-9.

Raman vs OH: **RL Frost & 4 others** 2004 AM 89 1130-7.

*Synthesis*: **AM Pollard RG Thomas PA Williams** 1992 MM 58 359-65.

**anyuiite** $AuPb_2$.

Occurrence: **LV Razin GA Sidorenko** 1989 Min Zhur 11 88 = 1991 AM 76 299.

*Synthetic* has different XRD.

Sb-bearing variety also.

**apachite** $?(Cu,Mg,Ca)_9Si_{10}O_{29}.11aq$.

Occurrence: MM 43 1057.

**APATITE STRUCTURE GROUP OF PHOSPHATES, ARSENATES, SILICATES & SULFATES** Includes at least 19 minerals plus other synthetic analogs:

| | |
|---|---|
| [*abukumalite* | $CaY_2(Si,P)_2O_8$] |
| *alforsite* | $Ba_5(PO_4)_3Cl$ |
| *alumobritholite* | $(Ca,Ce,Y)_3(Al,Fe)_2(Si,Al,P)O_3(F,O)$ |
| *apatite* | $Ca_5(PO_4)_3F$ |
| *belovite* | $(Sr,etc)_5(PO_4)_3O$ |
| jvs: ? composition range & relation to -Ce & -La | |
| *belovite-Ce* | $NaSr_3(Ce,La)_5(PO_4)_3(F,OH)$ |
| *belovite-La* | $NaSr_3(La,Ce)_5(PO_4)_3(F,OH)$ |
| *britholite-Ce* | $Ca_2Ce_3(SiO_4)_3OH$ |
| *britholite-Y* | $Ca_2Y_3(SiO_4)_3OH$ |
| *caracolite [carocolite?]* | $Na_3Pb_2(SO_4)_3Cl$ |
| *carbonate-fluorapatite* | $Ca_5(PO_4,CO_3)_3F$ |
| *carbonate-hydroxylapatite* | $Ca_5(PO_4,CO_3)_3(OH,F)$ |
| *cesanite* | $Na_3Ca_2(SO_4)_3OH$ |
| *chlorapatite* | $(Ca,Sr)_5(AsO_4,PO_4)_3OH$ |
| *chlorellestadite* | |
| *deloneite* | $NaCa_3Ce(PO_4)_3F$ |
| *fermorite* | $(Ca,Sr)_5(As/PO_4)_3(OH)$ |
| *fluorapatite* | $Ca_5(PO_4)_3F$ |
| *fluorbritholite-Ce* | $Ca_2Ce_3(SiO_4)_3F$ |
| *fluorbritholite-Y* | $Ca_2Y_3(SiO_4)_3F$ |
| *fluorcaphite* | $Ca(Sr,Na,Ca)(Ca,Sr,Ce)_3(PO_4)_3F$ |
| *fluorellestadite* | |

*hedyphane* $Pb_3Ca_2(AsO_4)_3Cl$
*hydroxylapatite* $Ca_5(PO_4)_3OH$
*hydroxyellestadite*
*johnbaumite* $Ca_5(AsO_4)_3OH$
*kuannersuite-Ce* $Ba_6Na_2REE_2(PO_4)_6FCl$.
*mattheddleite*
*melanocerite* $?(Ce,Ca)_5(Si,B)_3O_{12}(OH,F)$.naq
*mimetite* $Pb_5(AsO_4)_3Cl$
*morelandite* $(Ba,Pb,Ca)_5[(As,P)O_4]_3Cl$
*pyromorphite* $Pb_5(PO_4)_3Cl$
[*R-apatite* $Na_{0.3}Ca_{3.2}Sr_{1.2}Ce_{0.3}(PO_4)_3F$
Submitted to CNMN for validation.]
*strontiapatite* $(Sr,Ca)_5(PO_4)_3(OH,F)$ jvs: choose!
*strontium-apatite* $Sr_5(PO_4)_3F$ jvs: choose!
*svabite* $Ca_5(AsO_4)_3(F,Cl,OH)$
*tritomite* $(Ce,La,Y,Th)_5(Si,B)_3(O,OH,F)_{13}$
*tritomite-Y* $(Y,Ca,La,Fe)_5(Si,B,Al)_3(O,OH,F)_{13}$
*turneaureite* $Ca_5[(As,P)O_4]_3Cl$
*vanadinite* $Pb_5(VO_4)_3Cl$
Mineral X $Ca_2Na(La,Ce)(SiO_4)_6(OH,F)_2$: ZK 191 249-63.
[$(Ca,Sr,Na,REE)_5(PO_4)_3F$. IMA 96-022 = MR 28 398. Apatite.]

Apatite occurs in teeth and bones, and the chemical substitutions of OH, F, carbonate, and various other elements, some toxic including Pb, are important for health.
Mn/REE-substituted apatite is luminescent, and useful as a phosphor and laser.
Apatite occurs in fossils and stromatolites.
Structure of apatite compounds, review of 77 structures, derivation & crystal chemistry: **TJ White D Zhiti** 2003 ACB 59 1-16 (8758).
Structure of R-apatite and relation to *deloneite, belovite, britholite, apatite, strontium-apatite*: **RK Rastsvetaeva AP Khomyakov** 1996 CrR 41 789-92 (R679); also 1996 AC A52 Suppl C-337.
Structure, natural & synthetic, NPD: **T Leventouri BC Chakooumakos N Papanearchou V Perdikatsis** 2001 JMR 16 2600-4 (3008).
High-P: A-B carbonate-, location of B carbonate ion, SC-XRD/FTIR, **ME Fleet X Liu** 2004 JSSC 177 3174-82 (10641); compressibility to 7 GPa, XRPD, **KN Matsukage & 3 others** 2004 PCM 31 580-4 (10891).
*Synthetic* carbonate-: 2-4 GPa, FTIR & SC-XRD structure: **ME Fleet X Liu PL King** 2004 AM 89 1422-32.
IR & Raman, F, OH & Cl apatites: **Y Liu P Comodi P Sassi** 1998 NJMA 174 211-22 (L964).
Diffusion of REE: **DJ Cherniak** 2000 GCA 64 3671-85 (104).
Cathodoluminescence: **J Barbarand M Pagel** 2001 AM 86 473-84.
Siliceous carbonate rocks, contact metamorphism, vs fluids:**SC Penniston-Dorland M Ferry** 2005 AM 90 16006-18.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
Near endmember natural $(Ca_5(PO_4)_3(F/OH/Cl)$: **M Hughes M Cameron KD Crowley** 1989 AM 74 870-6.
Natural ternary $Ca_5(PO_4)_3(F_{0.4}Cl_{0.3}OH_{0.3})$: **do** 1990 AM 75 -304.
Natural $Sr_{0.6,0.3}$ & $Mn_{1.2,0.4}$-fluorapatite: **do** 1991 AM 76 1857-62.
Natural REE apatites: **JM Hughes M Cameron AN Mariano** 1991AM 76 1165-73.
24 natural apatites, carbonatite & alkaline rocks: **Y Liu P Comodi** 1993 MM 57 709-19.
Natural carbonate fluorapatite called *francolite*, but polemic on its nature: AM 81 513-5.
Human dental enamel, 12 XRPD structures: **RM Wilson JC Elliott SEP Dowker** 1999 AM 84 1406-14.
Apatite rich in Si, Sr, REE, SC-XRD structure, IR, Raman: **P Comodi & 3 others** 1999 MM 63 661-72.
Strontian fluorapatite & belovite-Ce, SC-XRD structure: **JF Rakovan JM Hughes** 2000 AM 85 839-45.
Carbonate substitution in Uganda apatite, IR, Raman, SC-XRD: **P Comodi Y Liu** 2000 EJM 12 965-74 (237.
Weathering & Phanerozoic P cycle of marine life: **MW Guidry FT Mackenzie** 2000 G 28 631-4 (1049).
Francolite in Jurassic phosphatic stromatolites, bacteria-mediated precipitation of amorphous phosphate: **A Sanchez-Navas A Martin-Algarra** 2001 EJM 13 361-76 (2061).
P dependence of fission track annealing: **AS Wendt O Vidal LT Chadderton** 2002 EPSL 201 593-607.

Dissolution of igneous & sedimentary: **MW Guidry FT Mackenzie** 2003 GCA 67 2949-63 (9562).
Igneous, OH ordering, FTIR: **RC Tacker** 2004 AM 89 1411-21.
Occurrence: Tapira carbonatite complex, Brazil, IR, EMPA, ion microprobe, SC-XRD structure, **MG Brigatti & 4 others** 2004 EJM 16 677-85 (10615);
Catalão alkaline-carbonatite complex, brazil, IR, Raman, **MCM de Toledo & 5 others** 2004 CM 42 1139-58.
Occurrence in fertilizers: **JR Lehr and 4 others** 1966 Crystallographic Properties of Fertilizer Compounds, Tenn Valley Auth Chem Eng Bull 6, 163p (L758).
*Synthetic* $Ba_{10}(PO_4)_6CO_3$: MM 32 945.
*Synthetic* $Pb_5(AsO_4)_3I$: **H Wondratschek** 1963 NJMA 99 125.
*Synthetic* $Pb_5(VO_4)_3I$: **H Wondratschek** 1963 NJMA 99 125.
*Synthetic* Nd-doped $Sr_5(PO_4)_3F$ & $Sr_5(VO_4)_3F$: **DL Dorjer & 3 others** 1995 C51 549-51 (C758).
*Synthetic* $Sr_5(PO_4)_3Cl$: MA 75-179.
*Synthetic* $Ca_8H_2(PO_4)_6.5aq$: alternating apatite & water layers, **WE Brown & 3 others** 1962 N 196 1048-55.
*Synthetic* Mn-: **PR Suitch & 3 others** 1985 AC B41 173-9;
color, **K Dardenne D Vivien D Huguenin** 1999 JSSC 146 464-72 (D788).
*Synthetic* $Ca_2La_8Si_6O_{20}$-$Ca_8La_2P_6O_{26}$, $Pb_8Y_2Si_6O_{26}$-$Pb_2Y_8Si_6O_{26}$, $Mg_2Y_8Si_6O_{26}$-$Y_{10}Si_4B_2O_{26}$, $Ca_2Y_8Si_6O_{26}$-$Y_{10}Si_4B_2O_{26}$, $NaLa_9Si_4B_2O_{26}$ & $Na_2Ln_8Si_6O_{26}F_2$, $Ca_2Y_8(Si/P)_8O_{26}$: **J Ito** 1968 AM 53 890-907.
*Synthetic* $Pb_9(PO_4)_6$: MA 81-0261.
*Synthetic* CaVOH: MA 75-178.
MnSr: MA 92M/2641.
REE-apatites: MA 91M/2638.
(Cd,M): MA 86M/1444.
$KNd_9(SiO_4)_6O_2$: MA 80-0127.
*Synthetic* CaPBr: **JC Elliott E Dykes PE Mackie** 1981 AC B37 435-8.
MnCl-apatite: MA 73-2431 & 76-1446.
*Synthetic* $Ba_5(ReO_5)_3Cl$-apatite: **J-P Besse & 3 others** 1979 AC B35 1756-9.
F,Cl,OH-apatites: MA 79-3422.
Cd-apatite: MA 79-211 & 212.
Deviant SrNaPBr-apatite: MA 76-246.
F: MA 73-2427.
*Synthetic* OH/F-apatites: IR, 16 hydrothermal specimens, **A Baumer M Ganteaume WE Klee** 1985 BM 108 145-52.
*Synthetic* $Pb_5GeV_2O_{12}$: 1989 SPC 34 493-6; 1990 Z Struct Khim 31 80-4.
*Synthetic* $(Ca,Pb)_5(PO_4)_3(OH)$: 1989 AC B45 247-51.
*Synthetic* $La_3Nd_{11}(SiO_4)_9O_3$: 1990 SPC 35 184-5 = SR 57A 307.
*Synthetic* $Sr_5(CrO_4)F$: •E Herdtweck 1991 AC C47 1711-2 (H998).
*Synthetic* $Pb_3(La/Bi/Y)_2(SiO_4)_3$ & $Pb_2Y_3(SiO_4)_3O_{0.5}$: **G Engel K Cee** 1995 ZaaC 621 1803-7.
*Synthetic* $MnNd_4(SiO_4)_3O$: **E Klüver H Müller-Buschbaum** 1995 ZN 50b 61-5 (K800);
**L Chi & 3 others** 1996 Jiehou Huaxue 15 113-6 = CA 124:330589a.
*Synthetic* $Ba_5(OsO_5)_3Cl$, isomorphic $Ba_5(ReO_5)_3Cl$ : **JR Plaisir RAG de Graaff DJW IJdo** 1995 MRB 30 1249-52.
*Synthetic* silico-sulfate-chloride-: **J Neubauer H Pöllman** 1995 NJMA 168 237-58.
*Synthetic* apatite/CaO crystallites, HREM: **A Larsson A Landa** 1996 AC A52 Suppl C-317.
*Synthetic* $Ba_{10}(MnFeF_{11-x}Cl_x)_3F_xCl_{2-x}$: **J Darriet V Nazabel J Fompeyrine** 1996 JMC 6 1781-4 (D613).
Spiral growth & REE, cathodoluminescence & synchrotron XRF: **J Rakovan RJ Reeder** 1996 GCA 60 4435-45 (R732).
*Synthetic* $NaPr_9(SiO_4)_6S_2$: **C Sieke T Scheid** 1997 ZaaC 623 1345-6 (S1734).
Bioceramic coatings: state-of-the-art development trends: **RB Heimann TA Vu ML Wayman** 1997 EJM 9 597-615 (H1178), [Techniques for coating titanium alloy with 50 µm hydroxylapatite using powder sintering, powder adhesion by gluing & plasma spraying.]
Comparison of hydroxyapatite/$Ca_3(PO_4)_2$, Raman, use as prosthetic implant: **PN de Aza & 5 others** 1997 ChM 9 912-5 (D632); 916-22 (D633).
Electron-irradiation-induced phase segregation in crystalline & amorphous apatite, implication for nuclear waste: **A Meldrum LM Wang RC Ewing** 1997 AM 82 858-69.
Decomposition of hydroxylapatite/fluorapatite >12 GPa to $Ca_3(PO_4)_2$: **JK Murayama& 3 others** 1986 PEPI 44 293-303.
*Synthetic* Ca-Pb hydroxyapatite, thermal properties, EXAFS & oxidation of methane: **S Sugiyama & 4 others** 1998 JSSC 135 86-95 (S1897).

*Synthetic* Pb-hydroxyapatite: **S Sugiyama & 6 others** 1999 JSSC 143 296-302 (S2029).
*Synthetic* oxyapatite, TEM product of hydroxyapatite: **PA Henning & 3 others** 1999 AC B55 170-6 (H1405).
*Synthetic* iodo-oxyapatite, SC-XRD structure: **PA Henning S Lidin V Petricek** 1999 AC B55 165-9.
Nucleation at silica bioceramic surface, molecular orbital study: **N Sahai JA Tossell** 2000 JPCB 104 4322-41 (S2157).
Growth from aqueous solution, effect of Ni: JSSC 151 163-9 (G1190)
Pb uptake by Cl/F/OH apatites to generate *pyromorphite*, review of Pb immobilization in soils: **M Manecki PA Maurice SJ Traina** 2000 AM 85 923-42;
kinetics, **do** 2000 SoS 165 920-33 (740).
*Synthetic* $(Ca/Sr/Ba)_{10}(PO_4)_6S/Ca_{10}(PO_4)_6Se$, XRPD structure: **PA Henning et al** 2000 ZK 215 226-30 (H1472).
*Synthetic* $NaPb_4(PO_4)_3$: SC-XRD structure, **M El Koumiri & 4 others** 2000 MRB 35 503-13 (E471).
*Synthetic* Ca (P,V)OH-apatite, XRD/XPS/NMR/FTIR/UV: **CB Boechat & 4 others** 2000 PCCP 2 4225-30 (B2053).
*Synthetic* $La_5Si_2BO_{13}$,NPD structure: **D Mazza M Trimaudino A Delmastro B Lebech** 2000 JSSC 155 389-93 (804).
*Synthetic* A-type carbonate-, SC-XRD structure: **Y Suetsugu & 3 others** 2000 JSSC 155 292-7 (800).
Kinetics of aqueous Pb reaction with apatite, waste management: **M Manecki PA Maurice SJ Traina** 2000 SoS 165 920-3 (740).
Eu di-/ tri-valent in zoned apatite, wavelength-dispersive XANES: **J Rakovan M Newville S Sutton** 2001 AM 86 697-700.
*Synthetic* mono-silicate fluor-britholite, stability: **J Carpena & 4 others** 2001 CRASP STP 333 373-9 (3124).
Adsorption amino acids *synthetic* hydroxyapatite: **GMS El Shafei NA Moussa** 2001 JCIS 238 160-6 (2053).
*Synthetic* Ba hydroxyapatite, enhanced Pb adsorption: **S Sugiyama & 4 others** JCIS 238 183-7 (2052).
*Synthetic* Fe/Mn/Cu-hydroxyapatites, $^{31}P$ NAS-NMR: **B Sutter & 3 others** 2002 SSSAJ 66 455-63 (6627).
*Synthetic* $Eu_5(SiO_4)_3F/Yb_5(SiO_4)_3S$, structure: **C Wickleder & 3 others** 2002 ZaaC 628 1602-6.
*Synthetic* Sr phosphate-, oxocuprate ions in hexagonal channels, IR, NMR, XRPD structure: **PE Kazin & 4 others** 2003 ZaaC 629 344-52 (8756).
Light rare earth diffusion: **A Iqdari & 4 others** 2003 CRG 335 381-90 (9263).
*Synthetic* $Ca_5(PO_4)_3(CO_3)_x(OH)_{1-x}$, x >0.25, 2 GPa, ~1720 K: SC-XRD/FTIR structure, **ME Fleet X Liu** 2003 JSSC 174 412-7 (9328).
*Synthetic* $LiY_9(SiO_4)_6O_2$ & $Na_9(SiO_4)_6O_2$: SC-XRD structure, **GR Redhammer G Roth** 2003 ACC 59 i20-4.
Sr/Ba apatite/water distribution, potential thermometer, 278-333 K: **V Balter C Lécuyer** 2004 GCA 68 423-32 (9895).
*Synthetic* CaPbF-vanadinites: equilibrium & dis- structures: **Z Dong TJ White** 2004 ACB 60 138-45, 146-54 (10207).
S partition with melt: **F Parat F Holtz** 2004 CMP 147 201-12.
*Synthetic* K-doped carbonated hydroxyl-: XRPD structure, **TI Ivanova & 2 others** 2004 ZK 219 479-86 (10696).
*Synthetic* Cd-As-Cl-OH-, As/Cd clean-up: **CD Johnson & 4 others** 2004 DT (A1830).
*Synthetic* $La_{9.33+x}(Si,Ge)_6O_{26+3x/2}$, ionic conductors: **A Najib & 4 others** 2004 DT 3106-9 (10854).
*Synthetic* $(Nd/Sm)_{4.67}(O/S)(SiO_4)_3$: structure, **I Hartenbach T Schleid** 2005 ZK 220 206-10 (11036).

**APHTHITALITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *aphthitalite* | $(K,Na)_3Na(SO_4)_2$ |
| *bario-olgite* | $Ba(Na,Sr,REE)_2Na(PO_4)_2$ |
| *olgite* | $Na(Sr,Ba)PO_4$ |
| *vitusite* | $Na_3(Ce,La)(PO_4)_2$ |

Glaserite structure type.
*Synthetic* $Ca_7Mg_9(Ca,Mg)_2(PO_4)_2$: **B Dickens WE Brown** 1971 TMPM 16 79-104 (D533).
*Synthetic* $NaK_3(PO_3F)_2$: **J Durand W Granier L Cot JL Galigné** 1975 AC B31 1533-5.
*Synthetic* $CaK_3H(PO_4)_2$: **S Takagi M Mathew WE Brown** 1983 AC C39 166-9.
Need to check in detail for other structural analogs.
**aphthitalite** $(K,Na)_3Na(SO_4)_2$. Glaserite structure type.
Structure: **A Bellanca** 1943 PMR 14 67-98 = MA 9-230;
**A Saalfeld** 1973 NJMM 75-8;
**PB Moore** 1976 NJMA 127 187-96 (M567);
**K Okada J Ossaka** 1980 AC B36 919-21;
**PB Moore** 1981BM 104 536-47 (M695).
**apjohnite** $MnAl_2(SO_4)_4.22aq$. *Halotrichite* structure type. Review: **Sabelli** p. 10.
Structure: **S Menchetti C Sabelli** 1976 MM 40 599-608.
**aplowite** $(Co,Mn,Ni)SO_4.4aq$. Review: **Sabelli** p. 12.
*Rozenite* structure type from cell dimensions, no structure determination: **JL Jambor RN Boyle** 1965 CM 8 166-71.
Occurrence: MM 35 1127.
*Synthetic* $CoSO_4.4aq$: **T Kellersohn** 1992 AC C48 776-9 (K751).

**APOPHYLLITE STRUCTURE GROUP** Includes fluor-, hydroxyl- & natroapophyllite.
Nomenclature: AM 63 196-9.
Structure: **E Prince** 1971 AM 56 1243-5 (P149);
**H Bartl G Pfeifer** 1976 NJMM 58-65 (B768).
Surface alteration, AFM, vs ions, T & pH: **K Aldushin & 4 others** 2004 GCA 68 217-26 (9791).
Alteration, aqueous solution, AFM/XPS/MAS-NMR: **K Aldushin & 5 others** 2004 ClCIM 52 432-42.
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).

**apuanite** $Fe^{2+}Fe^{3+}_4SbO_{12}S$.

Compare with *schafarzikite* & *versilianite*: ?polysomatic series.
Structure: **M Mellini S Merlino** 1979 AM 64 1235-42 1979;
**M Mellini & 3 others** 1981 AM 66 1073-9.

**[aquacreptite** ?composition Similar to *attapulgite*-alpha.
Description: **S Shimoda** 1965 Clay Science 2 138-46.]

**aqualite** $(H_3O)_8(Na,K,Sr)_5Ca_6Zr_3Si_{26}O_{66}(OH)_9Cl$. Eudialyte group.

Occurrence: in progress.

**ARAGONITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *aragonite* | $CaCO_3$ |
| *cerussite* | $PbCO_3$ |
| *niter* | $KNO_3$ |
| *strontianite* | $SrCO_3$ |
| *witherite* | $BaCO_3$ |

High-P phase transformations to $P2_122$ phase: **C Lin L Liu** 1997 PCM 24 149-57 (L862).

**aragonite** $CaCO_3$. Aragonite structure type. High-P product of *calcite*.

Structure: **WL Bragg** 1924 Proc Roy Soc London A105 16-37;
**JPR de Villiers** 1971 AM 56 768-72 (D170);
**A Dal Negro L Ungaretti** 1971 AM 56 768-72;
**B Dickens JS Bowen** 1971 J Res Nat Bur Standards Phys Chem 75A 27-32;
**H Effenberger A Kirfel G Will** 1983 TMPM 31 151-64;
neutron, **D Jarosch G Heger** TMPM 35 127-31 1986 (J250);
non-Pnma, **DJM Bevan & 5 others** 2002 AC B58 448-56 (7454)
XRPD, orthorhombic, **EN Caspi & 3 others** 2005 ACB 61 129-32.
Anisotropic thermal expansion to 1 GPa & 763 K: **T Wu & 4 others** 1995 AM 80 941-6.
High-P: to *calcite*, transformation kinetics, **W Huang** 2003 MP 79 243-58;
to 50 GPa, transition to trigonal phase, **J Santillan Q Williams** 2004 AM 89 1348-52;
40 GPa, orthorhombic phase, **S Ono & 3 others** 2005 AM 90 667-71;
elasticity, SC-Brillouin spectroscopy, **L Liu C Chen C Lin Y Yang** 2005 PCM 32 97-102.
From *synthetic* Mg/Fe/Sr-*calcite*, high-P transformation: **S Lin Huang** 2004 CMP 147 604-14 (10550).
Raman spectroscopy to 30 GPa, **G Biellmann P Gillet** 1992 EJM 4 389-93.
XRPD of aragonite & *dolomite* at high P,T, **I Martinez J Zhang RJ Reeder** 1996 AM 81 611-24.
Surface structure & morphology: **NH de Leuw SC Parker** 1998 JPC B102 2914-22.
*Synthesis*: of hollow porous shells, **D Walsh S Mann** 1995 N 377 320-3 (M1782);
by carbonation, **J Ahn & 3 others** 2004 JACeS 87 286-8 (10025).
Sr heterogeneity & speciation in coral: **N Allison & 3 others** 2001 GCA 65 2669-76 (3151);
EXAFS, **AAF NA SRS MN** 2003 GCA 67 1189-94.
Iridescence of nacre in pearls, TEM: **MR Snow & 4 others** 2004 AM 89 1353-8.
Occurrence, sodic Lake Van, Turkey, analog for Martian meteorite: **J Kazmierczak S Kempe** 2003 Nw 90 167-72.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**arakiite** $ZnMn_{12}Fe_2(AsO_3)(AsO_4)_2(OH)_{23}$.

Close-packed layers with four out of five matching *hematolite*.
Structure: **MA Cooper FC Hawthorne** 1999 CM 37 1471-82.
Occurrence: **AC Roberts & 4 others** 2000 MR 31 253-6.

**aramayoite** $Ag_3Sb_2(Sb,Bi)S_6$. Distorted *halite* superstructure type.

Isotypic with *baumstarkite* $Ag_3Sb_2(Bi,Sb)S_6$.

Structure: **DJE Mullen W Nowacki** 1974 ZK 139 54-69 (M446);

SC-XRD structure: **H Effenberger & 4 others** 2002 AM 87 753-64..
Occurrence: MM 21 557.
[**arandisite** $3SnSiO_4.2SnO_2.4aq$. Occurrence: MM 22 615.]
**arapovite** $U(Ca,Na)_2(K_{1-x}void_x)[Si_8O_{20}]$,x ~ 0.5. *Steacyite* group.
Occurrence & SC-XRD structure: **YA Uvarova & 4 others** 2004 CM 42 1005-11 = AM 91 216.
**aravaipaite** $Pb_3AlF_9.aq$. Relation to layer in beta-$PbF_2$.
Structure: **AR Kampf** 2001 AM 86 927-31.
Occurrence: **AR Kampf PJ Dunn EE Foord** 1989 AM 74 927-33.
*Calcioaravaipaite* $PbCa_2Al(F,OH)_9$ has different connectivity.
**arcanite** $K_2SO_4$-low-beta. Review: **Sabelli**, p. 32.
Transition ~850 K low-beta (orthorhombic) to high-alpha (hexagonal): **H Arnold & 3 others** 1981 AC B37 1643-51.
Low: **JA MacGinnety** 1972 AC B28 2845-52;
296-15 K, **K OJima Y Nishihata A Sawada** 1995 AC B51 287-93.
High: **M Miyake H Monkawa S Iwai** 1980 AC B36 532-6; also MA 80-0178.
[*Taylorite* $K_5(NH_4)_1(SO_4)_3$ & *ooguanolite* $K(NH_4)SO_4$ may be solid solutions, but ordering should be tested: occurrence, MM 29 991.]
Occurrence in fertilizers: **JR Lehr & 4 others** 1966 Crystallographic Properties of Fertilizer Compounds, Tenn Valley Auth Chem Eng Bull 6, 163p (L758).
**archerite** $(K,NH_4)H_2PO_4$. Structure for *synthetic* may have been done.
Occurrence: **PJ Bridge** 1977 MM 41 33-5 = AM 62 1057.
**arctite** $Na_2Ca_4(PO_4)_3F$.
Structure: **EV Sokolova & 3 others** 1984 SPD 29 5-9 (S1279).
Definition: MM 46 515.
**arcubisite** $Ag_6CuBiS_4$.
Inadequate description: **S Karup-Møller** 1976 Li 9 253-7.
Check for structure of synthetic.
**ardaite** $Pb_{20}Sb_{12}S_{34}Cl_8$. Has *synthetic* equivalent.
Occurrence: **VV Breskovska & 4 others** 1982 MM 46 357-61.
Structure determination not found.
Compare *dadsonite*, *playfairite* and unnamed minerals: **VV Kostov J Macicek** 1995 EJM 7 1007-18 (K788).
*Synthesis* of chlorine sulfosalts: **V Kostov** 1993 C R Acad Bulgare Sciences 46 61-4 = MA 95M/4302.
**ardealite** $Ca_2HPO_4.4aq$. Review: **Sabelli** p.29.
Occurrence: Romania guano & cell dimensions: **S Marincea & 3 others** 2004 NJMA 464-8 (10913).
Synthetic: **T Sakae H Nagata T Sudo** 1978 AM 63 520-7.
Natural: **F Balenzano L Dell'Anna M Di Piero** 1984 NJMM 461-7.
Occurrence: MM 23 625.
**ardennite** $Mn_4(Al,Mg)_6(SiO_4)_2(Si_3O_{10})[(As,V)O_4](OH)_6$.
Structure: **G Donnay R Allmann** 1968 AC B24 845-55 (D78);
**R Allmann G Donnay** 1971 AC B27 1871-5 1971;
**M Pasero T Reinecke** 1991 EJM 3 819-35;
**M Pasero T Reinecke AM Fransolet** 1994 NJMA 2 137-67 (P450).
Crystal chemistry: **T Reinecke K Hatzipanagiotou** 1987 NJMA 158(1) 89-104.
Occurrence of two specimens in Japan with V>As: MA 97M/1931.
**arfvedsonite** $Na_3(Fe,Mg)_4FeSi_8O_{22}(OH)_2$. *Amphibole* structure type.
Structure: two Li-F-, **FC Hawthorne & 3 others** 1996 CM 34 1015-9;
seven Li-, **FC Hawthorne & 5 others** 2001 CM 39 1161-70.
**argentite** $Ag_2S$-beta-high. Dimorphic with *acanthite*.
Phase transition to *acanthite*-alpha-low: **R Sadanaga** 1967 MJJ 5 124-43 = MA 19-269.
Body-centered relative of *acanthite*: **Bragg & Claringbull**, 49.
**argentojarosite** $AgFe_3(SO_4)_2(OH)_6$. *Alunite* structure type. Review: **Sabelli** p.25.
Structure: **A May JJ Sjoberg EG Baglin** 1973 AM 58 936-41;
Raman spectrum, **K Sasaki O Tanaike H Konno** 1998 CM 36 1225-35;
SC-XRD, **LA Groat JL Jambor BC Pemberton** 2003 CM 41 921-8.
*Synthesis*: **K Sasaki M Tsunekawa H Konno** 1995 CM 33 1311-9.

**argentopentlandite** $Ag(Fe,Ni)_8S_8$. *Pentlandite* structure type.
Structure: **SR Hall JM Stewart** 1973 CM 12 169-77 (H387).
Occurrence: MM 43 1058;
-*mackinawite* inclusions in *chalcopyrite*, MA 02M/2580.
Argentian pentlandite: AM 57 132-45.
µm rims on pentlandite: MA 94M/4766.
**argentopyrite** $AgFe_2S_3$. Dimorphic with *sternbergite*. Structure determination not found.
Occurrence: **J Murdoch LG Berry** 1954 AM 39 475-85;
**GK Czamanske RR Larson** 1969 AM 54 1198-201.
**argentotennantite** $(Ag,Cu)_{10}(Zn,Fe)_2(As,Sb)_4S_{13}$. *Tetrahedrite* structure group.
Occurrence: **EM Spiridonov & 8 others** 1986 DAN SSSR 290 206 = MM 52 721.
**argutite** $GeO_2$. *Rutile* structure type from cell data.
Occurrence: **Z Johan E Oudin P Picot** 1984 AM 69 406.
T dependence of Raman & earlier literature: **TP Mernagh L Liu** 1997 PCM 24 7-16 (M1456)
**argyrodite** $Ag_8GeS_6$. Similar cell dimensions to *canfieldite*. Related to *putzite.*
No structure determination: **N Wang** 1978 NJMM 269-72.
Big range of *synthetics* (Ag/Cu/Cd, etc)(Ga/Si/Ge/P, etc) (S/Se/Te)(Cl/Br/I).
*Synthetic* $Ag_7GeSe_5I$, ordered Ag 173 K disordered 290 K: 1989 Eur J Solid State Chem 25 541 = SR 56A 270.
*Synthetic* $Ag_7PSe_6$, structure at 473 & 293 K: **M Evain & 4 others** 1998 AC B54 376-83 (L447).
*Synthetic* beta & gamma $Cu_7PSe_6$, SC-XRD structure**: E Gaudin & 4 others** 2000 AC B56 402-8 (G1204);
alpha, **E Gaudin & 3 others** 2000 AC B56 972-9 (909).
*Synthetic* γ-$Ag_7AlSe_6$, cubic, SC-XRD structure 293 K: **E Gaudin HJ Deiseroth T Zaiss** 2001 ZK 216 39-44 (A1268).
**arhbarite** $Cu_2AsO_4OH.6aq$. Structure determination not found.
Occurrence: **K Schmetzer G Tremmel O Medenbach** 1982 NJMM 529 = AM 68 1038.
**aristarainite** $Na_2Mg(B_6O_8(OH)_4)_2.4aq$. Sheet structure with chains.
Structure: **S Ghose C Wan** 1977 AM 62 979-89. MM 40 904.
**armalcolite** $(Mg,Fe)Ti_2O_5$ (ideal). *Pseudobrookite* structure type.
Description: **MD Lind RM Housley** S175 521-3 1971 (L300 & 594).
Redefined: MR 30 175.
Occurrence: MM 38 988.
In meteorites: **AE Rubin** 1997 MPS 32 231-47: see *Ca-armalcolite*.
*Synthetic* $Mg_{0.5}Fe_{0.5}$, random, **BA Wechsler CT Prewitt JJ Papike** 1976 EPSL 29 91-103;
**BA Wechsler** 1977 AM 62 913-20 1977.
*Synthetic* $MgTi_2O_5$: neutron powder, **BA Wechsler RB Von Dreele** 1989 AC 542-9 (W698);
XRPD, **IE Grey C Li IC Madsen** 1994 JSSC 113 62-73.
*Synthetic* $FeTi_2O_5$ & $(Fe,Mg)TiO_5$: N&XRPD <1273K: **RG Teller** 1990 JSSC 88 334-50 & 351-67 (T361).
*Synthetic* from Ti-doped basalt: **AYa Medvedev** 1996 MM 60 347-53.
**armangite** $Mn^{2+}_{26}As_{18}O_{50}(OH)_4\ CO_3$. *Fluorite* anion-deficient defect derivative.
Structure: **PB Moore T Araki** 1979 AM 64 748-57.
**armenite** $BaCa_2Al_6\ Si_9O_{30}.2aq$. *Osumilite* structure group.
Structure: **VV Bakakin VP Balko LP Solov'eva** 1975 SPC 19 460-2 (B1140);
**T Armbruster** 1991 SMPM 71 301-4 (A505);
ordering of water & superstructures, **T Armbruster M Czank** 1992 AM 77 422-30;
SC-XRD & Si MAS-NMR, **T Armbruster** 1999 AM 84 92-101.
Occurrence: MM 25 622.
**armstrongite** $CaZrSi_6O_{15}.3aq$. Consortium for Theoretical Frameworks net 1122.
Compare with *dalyite* & *sazhinite*.
Structure: **AA Kashaev AN Sapozhnikov** 1978 SPC 23 539-49 (K505);
XRPD, **YK Kabalov & 4 others** 2000 ZK 215 757-61 (990).
Occurrence: MM 39 905.
**arrojadite** $KNa_4CaMn_4Fe_{10}Al(PO_4)_{12}(OH,F)_2$. 2,3-connected octa-tetra net.
Isostructural with *dickinsonite-(KMnNa)* & *sigismundite*
$Na_3(Ba,K,Pb)(Ca,Sr)(Fe,Mg,Mn)_{14}Al(PO_4)_{12}(OH)_2$.

New research on 3 crystal structures & old specimens splits into **arrojadite-(BaFe); -(BaNa) ; -(PbFe); -(SrNa); -(SrFe) & fluorarrojadite-(BaFe); -(BaNa); -(KNa): F Camara & 3 others** 2006 AM 91 1249-59; **F Chopin & 2 others** 1260-70.
Possible relation with *panethite*.
Structure: **VM Krutik & 3 others** 1979 SPC 24 425-9 (K648);
**S Merlino M Mellini PF Zanazzi** 1981 AC B37 1733-6 (M698);
**PB Moore & 4 others** 1981 AM 66 1034-49 1981 (M698);
Mössbauer: **I Shinno Z Li** 1998 AM 83 1316-22.
Occurrence: MM 21 558.

**arsenbrackebuschite** $Pb_2(Fe,Zn)(AsO_4)_2(OH,aq)$. *Brackebuschite* structure type.
Structure: **W Hofmeister E Tillmanns** 1978 TMPM 25 153-63 (H972).
MM 42 521.

**arsendescloizite** $PbZnAsO_4OH$. *Conichalcite/descloizite* structure type.
*Adelite* mineral group.
Structure: SC-XRD, **P Keller F Lissner T Schleid** 2003 NJMM 374-84 (9352).
Occurrence: **P Keller PJ Dunn** 1982 MR 13 155-7 = MM 48 569.

**ARSENIC STRUCTURE GROUP** Includes:

| | |
|---|---|
| *antimony* | Sb |
| *arsenic* | As |
| *bismuth* | Bi |
| *stibarsen* | SbAs |

Subgroup of *tetradymite* mineral/structure group; **P Bayliss** 1991 AM 76 257-65.
High-P transitions in As, Bi, Sb and P: **H Iwasaki T Kikegawa** 1996 AC A52 Suppl C-529.

**arsenic** As. Arsenic structure type.
Structure: **P Bayliss** 1991 AM 76 257-65.
High-P, review: **H Iwasaki T Kikegawa** 1997 AC B53 353-7 (I201).
Polymorphic with *arsenolamprite & pararsenolamprite*.

**arseniopleite** $(Ca,Na)(Na,Pb)Mn(Mn,Mg,Fe)_2As_3O_{12}$
Not equal to *caryinite* which has Ca in third position: **TS Ercit** 1993 MM 57 726-7.
Structure & validation as species: **KT Tait FC Hawthorne** 2002 CM 41 71-7.

**arseniosiderite** $Ca_3Fe_4(AsO_4)_4(OH)_6.3aq$. *Mitridatite* structure group.
Structure: **PB Moore** 1974 AM 59 48-59.
*Kolfanite* has similar cell data and similar but different composition: is it just a variety?
[**arsenobismite** Discredited: **U Kolitsch** 1999 NJMM 322-6.]

**arsenoclasite / arsenoklasite** $Mn_5(AsO_4)_2(OH)_4$. Isostructural **with gatehousite**.
Layer structure. Compare with *cornubite, ludjibaite, pseudomalachite, reichenbachite & reppiaite*.
Structure review: **J Barbier** 1996 EJM 8 77-84.
Structure: **PB Moore JA Molin-Case** 1971 AM 56 1539-52 (M1155), errata 57 593.
Occurrence: MM 22 615.
*Synthetic* Co & Mn: **FA Ruszala JB Anderson E Kostiner** 1977 IC 16 2417-22.

**arsenocrandallite** $(Ca,Sr)Al_3[(As,P)O_4]_2(OH)_5.aq$. *Crandallite* structure type.
Occurrence: **K Walenta** 1982 AM 67 854 = MM 48 569.
Structure determination not found.

**arsenoflorencite-Ce** $(Ce,La)Al_3(As,PO_4)_2(OH)_6$. *Crandallite* structure type. Multiple domains.
Occurrence: **EH Nickel JE Temperly** 1987 MM 51 605-9.
Structure determination not found.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**arsenoflorencite-La** $LaAl_3(AsO_4)_2(OH)_6$. *Crandallite* structure type.
Occurrence: **B Scharm & 3 others** 1991 Casop Mineral Geol 36 103 = AM 78 672-8.
Structure determination not found.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**arsenoflorencite-Nd** $NdAl_3(AsO_4)_2(OH)_6$. *Crandallite* structure type.
Occurrence: **B Scharm & 3 others** 1991 Casop Mineral Geol 36 103 = AM 78 672-8.

Structure determination not found.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**arsenogorceixite** $BaAl_3H(AsO_4)_2(OH)_6$. Ideal endmember.
Occurrence: **K Walenta PJ Dunn** 1993 Aufschluss 44 250-4 = AM 81 249-54.
**arsenogoyazite** $SrAl_3(AsO_4)_2(OH)_5.aq$. *Crandallite* structure type.
Structure determination not found.
Description: MM 50 741.
**arsenohauchecornite** $Ni_{18}Bi_3As_{16}$. *Hauchecornite* structure group, superstructure.
Structure: **JD Grice RB Ferguson** 1989 CM 27 137-42.
Occurrence: MM 43 1058.
**arsenolamprite** As. Possibly isostructural with *black phosphorus*.
Description: **Z Johan** 1959 Chem Erde 20 71-80 = AM 45 479-80 1960.
**arsenolite** $As_2O_3$. Dimorph of *claudetite*.
Structure: **F Pertlik** 1978 Czech J Phys B28 170-6;
refinement, XRPD: **P Ballirano A Maras** 2002 ZK NCS 217 177-8 (7650)
Raman, **SJ Gilliam & 5 others** JSSC 193 54-8 (5071).
**arsenopalladinite** $Pd_8(As,Sb)_3$.
Occurrence: MM 31 953;
**LJ Cabri AM Clark TT Chen** 1977 CM 15 70-3;
MM 39 528-43 = AM 59 1332;
**GR Olivo M Gauthier** 1995 MM 59 455-63. [jvs: note change of composition.]

**ARSENOPYRITE CHEMICAL GROUP** Includes:

| | |
|---|---|
| *alloclasite* | (Co,Fe)AsS |
| *arsenopyrite* | FeAsS |
| *glaucodot* | (Co,Fe)AsS |
| *gudmundite* | FeSbS |
| *osarsite* | OsAsS |
| *ruarsite* | RuAsS |

Arsenopyrite is an ore for gold that is released by roasting in air.
**arsenopyrite** FeAsS. Isostructural with *osarsite* & *ruarsite*. Dimorphic with *glaucodot*.
Structure: **MJ Buerger** 1936 ZK 95 83-113;
**N Morimoto LA Clark** 1961 AM 46 1448-69 (M49);
**H Fuess T Kratz JJ Töpel-Schadt G Miehe** 1987 ZK 179 335-46.
Oxidized surface, XPS, AES & spectral reflectance: **S Richardson DJ Vaughan** 1989 MM 53 223-9 (R420).
Sector zoning: **I Vesselinov T Krestedjian** 1995 MP 52 85-106.
Oxidation in air & water, XPS & Auger: **HW Nesbitt IJ Muir AR Pratt** 1995 GCA 59 1773-86 (N477).
Secondary products on pyrite & arsenopyrite reacted with mine water and air: **HW Nesbitt IJ Muir** 1998 MP 62 123-44.
Fracture surface, reactivity with oxygen, synchrotron XPS: **AG Schaufuss & 5 others** 2000 AM 85 1754-66.
Reaction with sulfur dioxide, XRPD & SEM: **MG Aylmore FJ Lincoln** 2000 JAlCo 309 61-74.
Au substitution, as metal & chemical-bonded, XAS: **LJ Cabri & 6 others** 2000 CM 38 1265-81.
Au-bearing, Fe position from Mössbauer: **VV Murzin & 5 others** 2001 DES 378 460-3 (2065).
Alteration to *westerveldite* during grinding in $CO_2$: **MG Aylmore FJ Lincoln** 2001 JAC 314 103-13 (1005).
Stability/solubility in crustal fluids: **GS Pokrovski S Kara J Roux** 2002 GCA 66 2361-78 (7762).
Stability: vs pH, **D Craw D Falconer JH Youngson** 2003 ChG 199 71-82 (9070);
vs As(III) in low-T acid solution, **Y Yu Y Zhu Z Gao** 2004 SCD 47 427-36 (10649);
< 573 K, **EE Tyukova SV Voroshin** 2004 DES 399A 1240-4 (10892).
Au-bearing: Mössbauer evidence for non-equivalent Fe, **VV Murzin & 5 others** 2003 GI 41 812-20 (9327).
**arsenosulvanite** $Cu_3(As,V)S_4$. *Sphalerite* structure type.
Structure: **VI Mikheev** 1941 ZVMO 70 165-84 = AM 40 368;
SC-XRD, **OV Frank-Kamenetskaya & 2 others** 2002 J Struct Chem 43 89-100 (7694).
Isostructural with *sulvanite*: AM 79 750-62.
Occurrence: MM 30 728.
*Lazarevicite* $Cu_3AsS_4$ was independently defined as endmember.
**arsenouranospathite [arsenuranospathite]**
Occurrence: **K Walenta** 1978 MM 42 117-28 = AM 64 465.

[**arsenowaylandite** $BiAl_3(AsO_4)_2(OH)_6$. As analog of *waylandite*.
Approval for mineral name not requested from CNMN.
Occurrence: **B Scharm M Scharmova M Kundrat** 1994 AM 84 184.]
**arsenpolybasite** $(Ag,Cu)_{16}(As,Sb)_2S_{11}$. Isostructural with Sb analog *polybasite*.
Dimorphic with *pearceite*.
Structure determination not found.
Occurrence: MM 33 1127.
Synthetic: **HT Hall** 1957 AM 52 1311-21.
**arsentsumebite** $Pb_2Cu(AsO_4)(SO_4)(OH)$. *Brackebuschite* structure type.
Structure: **NV Zubkova & 5 others** 2002 MP 75 79-88 (7279).
Review: **Sabelli** p. 35; (E289).
Description: MM 39 905-6.
**arsenuranospathite** $HAl(UO_2)_4(AsO_4)_4.40aq$. Isostructural with *uranospathite*.
Structure determination not found.
Occurrence: **K Walenta** 1978 MM 42 117-28 = AM 64 465.
**arsenuranylite** $Ca(UO_2)_4(AsO_4)_2(OH)_4.6aq$.
*Phosphuranylite* structure group in reference, but no structure determination.
Occurrence: MM 32 944.
**ARTHURITE STRUCTURE GROUP**. Includes:

| | |
|---|---|
| *arthurite* | $CuFe_2[(As,P,S)O_4](O,OH)_2.4aq$ |
| *cobaltarthurite* | $CoFe_2(AsO_4)_2(OH)_2.4aq$. |
| *earlshannonite* | $MnFe_2(PO_4)_2(OH)_2.4aq$ |
| *ojuelaite* | $ZnFe_2(AsO_4)_2(OH)_2.4aq$ |
| *whitmoreite* | $FeFe_2(PO_4)_2(OH)_2.4aq$ |

Raman of arthurite & whitmoreite: **RL Frost L Duong W Martens** 2003 NJMM 223-40.
**arthurite** $CuFe_2[(As,P,S)O_4](O,OH)_2.4aq$. *Arthurite* structure type.
Review: *Sabelli* p. 40; (E289).
Structure: **RJ Davis MH Hey** 1964 MM 33 937;
**P Keller H Hess** 1978 NJMA 133 291-302.
Occurrence: MM 33 1127.
**artinite** $Mg_2CO_3(OH)_2.3aq$. *Lansfordite* mineral group of hydrated Mg carbonates.
Structure: **H Jagodzinski** 1965 TMPM ser 3 10 297-330;
**M Akao S Iwai** 1977 AC B33 3951-3.
Compare with *cuproartinite* $(Cu,Mg)_2CO_3(OH)_2.3aq$ & ***chlorartsinite*** $Mg_2(CO_3)Cl(OH).3aq$.
**artroeite** $PbAlF_3(OH)_2$. Edge-sharing $AlF_3(OH)_3$ dimers, 9-coordinated Pb.
Compare with *acuminite* & *tikhonenkovite*, dimorphs of $SrAlF_4OH.aq$.
Structure: **A R Kampf EE Foord** 1995 AM 80 179-83.
**artsmithite** $Hg_4Al(PO_4)_{2-x}(OH)_{1+3x}$, x = 0.26.
Structure: in prep
Occurrence, IR, SC&P-XRD: **AC Roberts & 5 others** 2003 CM 41 721-5.
**arupite** $Ni_3(PO_4)_2.8aq$. Ni analog of *vivianite*.
*Synthetic*, XRPD, structure: **VF Buchwald** 1990 NJMM (2) 76-80 (B1355) = MM 54 661.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**arzakite** $Hg_3S_2(Br,Cl)_2$. Isostructural series with Cl analog *lavrentievite* $Hg_3S_2(Cl,Br)_2$.
Occurrence: **VI Vasil'ev et al** 1985 AM 70 873-4.
Structure determination not found.
*Grechishchevite* may be the tetragonal polymorph of arzakite.
**asbecasite** $Ca_3(Ti,Sn)As_6Si_2Be_2O_{20}$. 2,3-connected octa-tetra net.
Structure: **E Cannillo G Guiseppetti C Tadini** 1969 Accad Naz Linzei 46 457-67(C202) = AM 55 1818;
**M Sacerdoti & 4 others** 1993 MM 57 315-22 (S1268).
Occurrence: MM 36 1147.
**asbolane** $(Co,Ni)_{1-y}MnO_2)_{2-x}(OH)_{2-2y+2x}.naq$.

Occurrence: **FV Chukrov et al**. 1982 AM 67 417-8;
**RG Burns VM Barnes HW Stockman** 1985 AM 70 205-8.
Detailed structure determination not found, but essential features known.
Asbolane & *lithiophorite* from laterite weathering of ultrabasite, XAS Co & Ni: **A Manceau S Llorca G Calas** 1987 GCA 51 103-13 (M966).
Mg-dominant, electron diffraction shows two sublattices and gradation to *buserite*: **Al Gorshkov YuA Bogdanov AV Mokhov** 1995 DAN 342 781-4 = AM 81 766.
Mg-Al-Ni variety from manganese nodule: **Al Gorshkov & 3 others** 1996 Trans Russ Acad Sci Earth Sci 230-4 (G873).

**aschamalmite** $Pb_6Bi_2S_9$. ?monoclinic relative of *heyrovskite*.
Phase equilibria: **H Liu LLY Chang** 1994 AM 79 1159-66.
Occurrence: **WG Mumme & 3 others** 1983 NJMM 433 = AM 69 810.

[ashanite discredited: AM 84 688.
Occurrence: **Z Rubo et al.** 1981 AM 66 217.]

**ashburtonite** $HPb_4Cu_4Si_4)_{12}(HCO_3)_4(OH)_4Cl$.
Structure: **JD Grice EH Nickel RA Gault** 1991 AM 76 1701-7.

**ashcroftine-Y** $KNaCaY_2Si_6O_{12}(OH)_{10}.4aq$.
Structure: **PB Moore & 3 others** 1972 AM 72 1176-89 (M1044).
Occurrence: MM 23 625.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**ashoverite** $Zn(OH)_2$.
Second tetragonal phase along with *sweetite*; also orthorhombic *wülfingite*.
Synthetic analog not known.
Occurrence: **AM Clark & 3 others** 1988 MM 52 699-702.
Structure determination not found.

**asisite** $Pb_7SiO_8Cl_2$. Layer structure, Si not located.
Structure: **RC Rouse & 5 others** 1988 AM 73 643-50;
ED, superstructure, **MD Welch** 2004 MM 68 147-54.

**aspidolite** $NaMg_3AlSi_3O_{10}(OH)_2$. Na end-member of series with *phlogopite mica*.
Nomenclature: **M Rieder & 14 others** 1998 AM 83 1366.
Magmatic: **F Costa MA Dungan BS Singer** 2000 AM 86 29-35.
Occurrence & structure: **Y Banno & 5 others** 2005 MM 69 1947-57 = AM 91 1207-8.

**asselbornite** $(Pb,Ba)(UO_2)_6(BiO_4)[(As,P)O_4]_2(OH)_{12}.3aq$.
Occurrence: **H Sarp J Bertrand J Deferne** 1983 NJMM 417-23.
Structure determination not found.

**astrocyanite-Ce** $Cu_2(Ce,Nd)_2(UO_2)(CO_3)_5(OH)_2.1.5aq$.
Occurrence: **M Deliens P Piret** 1990 EJM 2 407.
Structure determination not found.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**ASTROPHYLLITE GROUP** Includes:

| | |
|---|---|
| *astrophyllite* | $K_2Na(Fe,Mn)_7Ti_2Si_8O_{26}(OH)_4F$ |
| *cesium kupletskite* | $(Cs,K)_2Na(Mn,Fe,Li)_7(Ti,Nb)_2Si_8O_{26}(OH)_4F$ |
| *hydroastrophyllite* | $(H_3O,K)_2Ca(Fe,Mn)_{5-6}Ti_2Si_8O_{26}(OH)_4F$ |
| *kupletskite* | $K_2Na(Mn,Fe)_7(Ti,Nb)_2Si_8O_{26}(OH)_4F$ |
| *magnesium astrophyllite* | $K_2Na[Na(Fe,Mn)_4Mg_2]Ti_2Si_8O_{26}(OH)_4$void |
| *niobokupletskite* | $K_2Na(Mn,Zn,Fe)_7(Nb,Zr,Ti)_2Si_8O_{26}(OH)_4(O,F)$ |
| *niobophyllite* | $K_2Na(Fe,Mn)_7(Nb,Ti)_2Si_8O_{26}(OH)_4(F,O)$ |
| *zircophyllite* | $K_2(Na,Ca)(Mn,Fe)_7(Zr,Nb)_2Si_8O_{27}(OH)_4F$ |
| *Fe-dominant zircophyllite* | $K_2(Na,Ca)(Fe,Mn)_7(Zr,Nb)_2Si_8O_{27}(OH)_4F$ |

General: 87M/0281.
Nomenclature, revised composition: **PC Pilonen & 4 others** 2003 CM 41 1-26.
Crystal chemistry: 7 astrophyllites, 11 kupletskites, 1 niobokupletskite, SC-XRD structure & EPMA, **PC Pilonen AM McDonald AE Lalonde** 2003 CM 41 27-54.

Polysomatic relation to *bafertisite* & *nafertisite*: **G Ferraris et al.** IMA Mtg Pisa p. 117.

**astrophyllite** $K_2Na(Fe,Mn)_7Ti_2Si_8O_{26}(OH)_4F$. Astrophyllite structure group.

Structure: **IM Rumanova GI Malitskaya** 1960 SPC 4 481-95;
**PJ Woodrow** 1967 AC 22 673-8;
**BB Zvyagin ZV Vrublevskaya** 1976 SPC 21 542-5 = MA 78-213;
**ZV Vrublevskaya BB Zvyagin** 1976 SPC 21 546-9 1976 = MA 78-214;
**CC Peng C-S Ma** 1963 Scientia Sinica 12 272-6 = MA 16-611;
monoclinic, **N Shi & 4 others** 1998 AC B54 109-14 (S1904)
` Fe-rich triclinic, **NA Yamnova & 3 others** 2000 CrR 45 585-90 (1723);
Fe-rich triclinic, **MA Zhesheng & 5 others** 2001 Science in China D 44 508-16 (3594);
Mössbauer, **Z Li & 5 others** 2003 EJM 15 707-10 (9326).

**atacamite** $Cu_2Cl(OH)_3$. Trimorphic with *clinoatacamite* & *botallackite*.

Isostructural with *kempite* & *hibbingite*. Review: MA 71-98 (E289).

Structure: **H Brasseur J Toussaint** 1942 Bull Soc Roy Sci Liege 11 555-66 = MA 9-225;
**AF Wells** 1949 AC2 175-80;
**JB Parise BG Hyde** 1986 AC C42 1277-80 (P568).

*Synthetic* $Mg_2(OH)_3Cl$: MA 12-207.

*Synthetic* $Cd_2Cl(OH)_3$-beta: **Y Cudennec Y Gerault A Lecerf** 1997 CRASP 324 IIb 457-66 (C895).

Occurrence: in worm jaws, **HC Lichtenegger et al.** 2002 S 298 389;
in printed electronic wiring boards, **SR Stock LJ Turbini** 2002 S 298 (8477).

**atelestite** $Bi_2(AsO_4)O(OH)$. Cell data match *smrkovecite* $Bi_2O(OH)(PO_4)$.

Occurrence: **K Mereiter A Preisinger** 1986 Österr Akad Wiss Math-nat Kl Anz 123 79-81.
Structure determination not found.
Vanadium analog $Bi_2O(OH)VO_4$: IMA 95-050.

**athabascaite** $Cu_5Se_4$.

Occurrence: **DC Harris LJ Cabri S Kaiman** 1970 CM 10 207-15.
Structure determination not found.

**atheneite** $(Pd,Hg)_3As$.

Occurrence: **AM Clark AJ Criddle EE Fejer** 1974 MM 39 528-43. MM 39 906.
Structure determination not found.

**atlasovite** $Cu_6FeBiO_4(SO_4)_5KCl$. Isotypic series with *nabokoite*.

Occurrence: **VI Popova & 5 others** 1987 ZVMO 116 358 = AM 73 927 (P537).

**atokite** $(Pd,Pt)_3Sn$.

Isostructural with *rustenbergite* & *zvyagintsevite* $(Pd,Pt,Au)_3(Pb,Sn)$.

*Synthetic* has Pm3m, not Fm3m.
Structure: **P Mihalik SA Hiemstra JPR deVilliers** 1975 CM 13 146-50.
Occurrence: **JG Arnason DK Bird** 1995 Eos Suppl 11/7 F641.

**atopite** $?Ca_2Sb_2O_7$ or $CaSb_2O_6.0.5CaO$? MA 8-12; MA 11-209.

**attakolite** $(Ca,Sr)Mn(Al,Fe)_4(HSiO_4)(PO_4)_3(OH)_4$.

Structure: **JD Grice PJ Dunn** 1992 AM 77 1285-91.
Dimorph: AM 54 990.

**aubertite** $CuAl(SO_4)_2Cl.14aq$.

Isostructural *magnesioaubertite* $(Mg,Cu)Al(SO_4)_2Cl.14aq$;
intermediate composition, XRPD: **S Da Pelo F Frau** 2000 NJMM 279-88 (D807) .
Structure: **D Ginderow F Cesbron** 1979 AC B35 2499-502;
**F Cesbron & 3 others** 1979 BM 102 348;
*Svyazhinite* $(Mg,Mn,Ca)(Al,Fe)(SO_4)_2$ F.14aq has similar cell.

**augelite** $Al_2PO_4$. Structure: **T Araki JJ Finney T Zoltai** 1968 AM 53 1096-103.

**augite** $(Ca,Na)(Mg,Fe,Al)(Si,Al)_2O_6$. *Pyroxene* structure type.

Monoclinic, occurring in rocks with wide range of major, minor and trace elements.
End-member compositions: **AG Bulakh AN Zolotarev** 2004 NJMM 361-72 (10647).
*Augite-jadeite*, cation ordering: **TB Ballaran & 3 others** 1998 AM 83 419-33, 434-43.

Mg/Fe exchange, 973 to 1373 K in 3 crystals: **E Brizi G Molin PF Zanazzi** 2000 AM 85 1375-82.
Mg/Fe ordering kinetics, 973-1223 K, SC-XRD structure: **E Brizi & 3 others** 2001 AM 86 271-8.
*Clinoamphibole* lamellae (010) sheared augite, Ivrea Zone, TEM: **W Skrotzki** 2001 EJM 13 245-52 (2062).
Composition vs rock type, Skaergaard: **AG Bulakh AA Zolotarev** 2003 132-5 107-17.
Occurrence: Kiglapait, chemistry, *spinel* exsolution, **SA Morse M Ross** 2004 AM 89 1380-95.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**aurichalcite** $(Cu_{1-x}Zn_x)_5(CO_3)_2(OH)_6$. Compare with *hydrozincite*.

Structure: **MM Harding & 3 others** 1994 AC B50 673-6 (H918);
XAS of Cu and Zn ordering, **JM Charnock & 4 others** 1996 MM 60 887-96;
FTIR/EPR/optical absorption, **BJ Reddy F Nieto AS Navas** 2004 NJMM 302-16 (10659).
*Synthetic* material is a catalyst precursor for hydrogenation.
Conversion to copper catalyst <723 K, XRPD/XAS: **JW Couves and 6 others** 1991 N 354 465-70 (C731).
*Synthesis* for hydrogenation catalysis (cf. *tenorite*): **GJ de AA Soler-Illia & 3 others** 1997 ChM 9 184-91 (S1658).

**auricupride** $AuCu_3$. Superstructure of cubic-closest packing.

Domains in partially ordered variety: **SH Rahman** 1993 AC A49 68-79.
[jvs:*svyagintsevite* $(Pd,Pt)_3(Pb,Sn)$ may be isostructural.]

**aurivilliusite** HgHgOI.

Occurrence & XRD matching *synthetic*: **AC Roberts & 4 others** 2004 MM 68 241-3.
*Synthetic*: structure, **C Stålhandske & 2 others** 1985 ACC 41 167-8.

**aurorite** $(Mn,Ag,Ca)Mn_3O_7.3aq$. *Chalcophanite* structure type from XRPD.

See *ernienickelite*.
Occurrence: **AS Radtke CM Taylor DF Hewett** 1967 EG 62 186-206 = AM 52 1581.

**[?aurosiridium** Dana 1944 1 111 = MM 27 266.]

**aurostibite** $AuSb_2$. *Pyrite* structure type.

Description: **AR Graham S Kaiman** 1952 AM 37 461-9.
Hydrothermal alter to amorphous ~$Au_2SbO_2(OH)$: **Z Johan V Srein** 1998 CRASP Sci terre planetes 326 533-8 (J314).
Hydrothermal synthesis & characterization: **VI Tikhomirova AV Chichagov** 2000 DES 373A 974-6 (180).

[**austenite** $Fe_xC$.

Structure: **NJ Petch** 1942 J Iron Steel Inst 145 111-?;
**KH Jack** 1951 The iron-nitrogen system: the preparation and the crystal structure of nitrogen-austenite (?) and nitrogen-martensite (?) PRSL A208 200-15 = MA 11-367.
*Synthetic*: MA 11-367.]

**austinite** $CaZnAsO_4OH$. *Conichalcite/descloizite* structure type. *Adelite* mineral group.

Structure: **G Giuseppetti C Tadini** 1988 NJMM 159-66 (G768);
monoclinic, **LA Clark & 4 others** 1997 MM 61 677-83.
Occurrence: MM 24 602.

**AUTUNITE STRUCTURE GROUP** Includes (plus others):

| | |
|---|---|
| *autunite* | $Ca(UO_2)_2(PO_4)_2.10\text{-}12aq$ |
| *chernikovite* | $(H_3O)_2(UO_2)_2(PO_4)_2.6aq$ |
| *fritzscheite* | $Mn(UO_2)_2[(P,V)O_4]_2.4aq$ |
| *heinrichite* | $Ba(UO_2)_2(AsO_4)_2.10\text{-}12aq$ |
| *kahlerite* | $Fe(UO_2)_2(AsO_4)_2.10\text{-}12aq$ |
| *novacekite* | $Mg(UO_2)_2(AsO_4)_2.12aq$ |
| *sabugalite* | $HAl(UO_2)_4(PO_4)_4.16aq$ |
| *saléeite* | $Mg(UO_2)(PO_4)_2.10aq$ |
| *sodium-autunite* | $Na(UO_2)(PO_4).4aq$ |
| *torbernite* | $Cu(UO_2)_2(PO_4)_2.8\text{-}12aq$ |
| *trögerite* | $(UO_2)_3(AsO_4)_2.12aq$ |
| *uranocircite* | $Ba(UO_2)_2(PO_4)_2.12aq$ |
| *uranospathite* | $Al_{1-x}{}^{[]}{}_x(UO_2)_2(PO_4)_2aq_{20+3x}F_{1-3x}$ |
| *uranospinite* | $Ca(UO_2)_4(AsO_4)_4.10aq$ |
| *zeunerite* | $Cu(UO_2)_2(AsO_4)_2.10\text{-}16aq$ |

Review of structures containing*autunite*-type sheet & SCXRD structures of *synthetics*

with Mg/Mn/Fe/Co/Ni: **AJ Locock PC Burns TM Flynn** 2004 CM 42 1699-718.
Review of *torbernite*-related minerals: **M Ross HT Evans Jr** 1965 AM 50 1-12.
[jvs: compare *meta-autunite* group; may be complex transitional phases related by variable humidity.]
IR of P-members: **RL Frost** 2004 NJMM 145-62 (10287).
Sr- & Ba-dominant compounds with autunite sheet: **AJ Locock PC Burns TM Flynn** 2005 CM 43 721-33.
*Synthetic* Ca-autunite & Na/K/Ba/Mn/Cu/Ni/Co/Ni derivatives: MM 29 977.
*Synthetic* H-autunite, probably = *chernikovite*: **C Frondel** 1950 AM 35 762;
**V Ross** 1955 AM 40 917-9;
MM 31 962;
**RF Vochten et al.** 1992 MM 56 367-73.
*Synthetic* Cu-dominant *metatorbernite, metazeunerite, torbernite & zeunerite*: SC-XRD structure,
**AJ Locock PC Burns** 2003 CM 41 489-502.
**autunite** $Ca(UO_2)_2(PO_4)_2.11aq$. Autunite structure group.
Dehydrates to *meta-autunite* with 7 aq.
Structure: *synthetic*, SC-XRD, **AJ Locock PC Burns** 2003 AM 88 240-4.
Occurrence: **Y Takano** 1961 AM 46 812-22.
**avelinoite** $NaFe(PO_4)_2(OH)_2$.
Occurrence: **ML Lindberg WT Pecora** 1954 S 120 1074 = MM 30 728.
**averievite** $Cu_5O_2(VO_4)_2.nMX$.
Structure: **GL Starova & 3 others** 1997 MM 61 441-6.
Occurrence: **LP Vergasova & 3 others** 1998 DES 359A 450-3 (V342).
**avicennit**e $Tl_2O_3$ Isostructural with *bixbyite*.
Structure: **P Papamantellos** 1968 ZK 126 143-6.
Occurrence: MM 32 944.
**avogadrite** $(K,Cs)BF_4$. Isostructural with *barite*.
Structure: **A Bellanca F Sgarlata** 1951 ??: MA 11-535.
Occurrence: MM 21 558.
**awaruite** $FeNi_3$. Isostructural with *isoferroplatinum* & *chengdeite* Ir,Fe.
Structure **P Bayliss** 1990 CM 28 751-5. [jvs: possible superstructure & phase inversion.]
In meteorites: **AE Rubin** 1997 MPS 32 231-47;
**C Yang DB Williams JI Goldstein** 1997 GCA 61 2943-56 (Y204).

| **AXINITE STRUCTURE GROUP** | Includes: |
|---|---|
| *ferroaxinite* | $Ca_2FeAl_2BSi_4O_{15}(OH)$ |
| *magnesioaxinite* | $Ca_2MgAl_2BSi_4O_{15}(OH)$ |
| *manganaxinite* | $Ca_2(Mn,Fe)Al_2BSi_4O_{15}(OH)$ |
| *tinzenite* | $(Ca,Mn,Fe)_3Al_2BSi_4O_{15}(OH)$ |

Nomenclature: **E Sanero G Gottardi** 1968 AM 53 1407-11.
New crystal-chemical formula, **GB Andreozzi & 3 others** 2004 AM 89 1763-71.
Crystal chemistry: **GB Andreozzi & 4 others** 2000 AM 85 698-706.
[jvs: All crystal structures listed under *axinite*, the general mineral name.]
**axinite** $Ca_2(Fe,Mn)Al_2BO_3Si_4O_{12}OH$.
Structure: **T Ito Y Takéuchi** 1952 AC 5 202-8;
**T Ito & 5 others** 1969 Proc Japan Acad 45 490-4;
**Y Takéuchi & 5 others** 1974 ZK 140 289-312 (T374);
**Y Takéuchi** 1975 ZK 141 471-2;
low-Mn *tinzenite* = *severgenite*, **JS Swinnea & 3 others** 1981 AM 66 428-31;
high-Mn *tinzenite*, SC-XRD, **EL Belokoneva & 3 others** 2001 CR 46 30-2 (1349)
SC-XRD, Mossbauer, **GB Andreozzi & 4 others** 2000 AM 85 698-706.
Natural $Fe^{2+}$-: **A Pieczka J Kraczka** 1994 Mineralogica Polonica 25 43-8 = MA 95M/4643.
**azoproite** $(Mg,Fe)_2(Fe,Ti,Mg)BO_5$. 3 Å Zigzag Borate:
Structure: **MA Cooper FC Hawthorne** 1998 CM 36 1171-93.
Occurrence: **AA Konev & 3 others** 1970 ZVMO 99 225-31 = MM 37 955.
**azurite** $Cu_3(CO_3)_2(OH)_2$. Review: (E289).
Structure: **G Gattow J Zemann** 1958 AC 11 866-72 1958 (G6);

**F Zigan HD Schuster** 1972 ZK 135 416-36;
**PH Ribbe SC Eriksson** 1991 MR 22 65-6.
Charge density/antiferromagnetism: **EL Belokoneva YK Gubina JB Forsyth** 2001 PCM 26 498-507 (2914).

**babefphite** $BaBe(PO_4)(O,F)$. 1,2-vertex-connected tetrahedral net.
Structure: **DP Shaskin MA Simonov** 1968 DAN SSSR ES 176 152-5 = MA 70-2143;
**MA Simonov YuK Egorov-Tismenko NV Belov** 1980 SPC 25 28-30 (S1331).
Occurrence MM 36 1147-8.

**babingtonite** $Ca_2Fe^{2+}Fe^{3+}Si_5O_{14}(OH)$. Pyroxenoid. Series with *manganbabingtonite*.
Isostructural with *scandiobabingtonite*.
Structure: **T Araki T Zoltai** 1972 ZK 135 355-75 (A177);
**AL Kosoi** 1976 SPC 20 446-51 (K653);
faults, HREM, **M Czank** 1981 AC A37 617-20;
**T Tagai W Joswig H Fuess** 1990 MJJ 15 8-18 = MA 91M/3901;
Mg,Mn distribution, SC-XRD, **T Armbruster** 2000 SMPM 80 279-84 (774).
Occurrence: skarn, Spain, **A Cepedal & 4 others** 2003 EJM 15 1069-77 (10072).

**babkinite** $Pb_2Bi_2(S,Se)_3$.
Occurrence & crystallography: **IA Bryzgalov & 3 others** 1996 DAN 346 656-9 = AM 81 1513.

**baddeleyite** $ZrO_2$.
Structure: **JD McCullough KN Trueblood** 1959 AC 12 507-11;
**G Teufer** 1962 AC 15 1187 (tetragonal);
**DK Smith HW Newkirk** 1965 AC 18 983-91;
ND, 3 polymorphs with stabilizers, **CJ Howard RJ Hill BE Reichert** 1988 AC B44 116-20 (H987);
orthorhombic, **O Ohtaka & 5 others** 1990 Proc Japan Acad B 66 193-96;
monoclinic to tetragonal, undoped powder, ND, **F Frey H Boysen T Vogt** 1990 AC B46 724-30;
metastable *synthetic* monoclinic, XRPD, **J Malek L Benes T Mitsuhashi** 1997 PD 12 96-8 (M1769).
Stabilization of tetragonal against orthorhombic distortion, doping with Ce/Ge/Y/Nb, etc., XRPD:
**P Li I Chen JE Penner-Hahn** 1994 JACeS 77 1277-80, 1281-88, 1289-95 (L612).
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
*Synthetic* $Zr_{0.85}Ca_{0.15}O_{1.85}$, 290 & 1550 K, **RB Neder F Frey H Schulz** 1990 AC A46 799-809.
New occurrence: MA 95M/3324.
High-T phase transformations: MA 92M/1407;
**H Boysen F Frey T Vogt** 1991 AC B47 881-6.
Macrocrysts, Mbuji Mayi kimberlite, TEM: **L Kerschhofer U Scharer A Deutsch** 2000 EPSL 179 219-25 (K1247).
*Synthetic* (Tm/Yb/Lu)OF isostructural analogs: **A Taoudi JP Lovat B Frit** 1994 MRB 29 1137-47 (T403).
High-P transformation to *cotunnite* structure type: MA 80-1609.
*Synthetic* orthorhombic (jvs ?) $HfO_2$ (O267);
cubic, stabilized by $Y_2O_3$: **A Lakhlifi & 5 others** 1995 1995 JSSC 119 289-98.
High-P polymorph of $TiO_2$: **H Sato & 5 others** 1991 S 251 786-8 (S1802).
High-P polymorph of *portlandite*-$Ca(OH)_2$: **M Kunz & 8 others** 1996 High Pressure Res 14 311-9 (K852).
*Rutile*, high-P transformation to *baddeleyite* & *scrutinyite* types: **L Gerward JS Olsen** 1997 JACr 30 259-64 (G914).
High-P polymorph $SiO_2$, shock lamellae *quartz*, Shergotty meteorite: **A El Goresy & 4 others** 2000 S 288 1632-4 (E469).
*Synthetic* Y-stabilized, $Zr(Y)O_{1.86}$, *fluorite* structure type: AC B40 367-72 1984.
*Synthetic* Ca-stabilized fluorite structure type:
N&XRD 1500K, **T Proffen & 4 others** 1996 AC B52 66-71(P593);
N&XR diffuse scattering, **T Proffen RB Neder F Frey** 1966 AC B52 59-65 (P594).

**bafertisite** $Ba(Fe,Mn)_2TiSi_2O_7(O,OH)_2$.
Tetrahedral sheet topologically different from those in *batisite* & $Na_2Zn_3[SiO_4]_2$ (E292).
Polysomatic relation with *astrophyllite* & *nafertisite*.
Mn analog is *hejtmanite*.
Structure: **C Peng C Shen** 1963 Sci Sinica Iz 12 278-80 (P420);
**Y Kuan VI Simonov NV Belov** 1965 DAN SSSR ES 149 123-6;
2 structures, **RK Rastvetaeva & 3 others** 1991 SPC 36 186-9 (R476);
Cm spacegroup, **Z Yang G Cressey M Welch** 1999 PD14 22-4 (Y214).
Occurrence: MM 32 944.

Occurrence of bafertisite-like mineral: AM 82 433.
**baghdadite** $Ca_3ZrSi_2O_9$. *Wöhlerite/låvenite* supergroup, *wöhlerite* structure group from cell data, but no structure determination.
Occurrence: **HM Al-Hermezi D McKie AJ Hall** 1986 MM 50 119-23;
**S Matsubara R Miyawaki** 1999 MA 01M/4311.
**bahianite** $Al_5Sb_3O_{14}(OH)_2$.
Structure: **PB Moore T Araki** 1976 NJMA 126 113-25 (M552). MM 42 522.
**baileychlore** $[Zn_{2.5}Fe_{1.2}Al_{1.2}Mg_{0.8}](Si_{3.55}Al_{0.45})O_{10}(OH)_8$.
Zn endmember of trioctahedral *chlorite*s.
Occurrence: **AC Rule F Radke** 1988 AM 73 135-9.
[**baiyuneboite-Ce** $?NaBaCe_2(CO_3)_4F_2$. *Parisite* structure group.
May actually *be cordylite-Ce* because of revised composition: AM 75 240-6.
Structure: **P Fu Y Gong M Shao J Qian** 1987 Acta Mineral Sinica 7 298-304.]
**baksanite** $Bi_6(Te_2S_3)$.
Occurrence & XRPD: **IV Pekov & 5 others** 1996 Dokl Acad Sci 347 787-91 = MR 28 483.
**bakerite** $Ca_4B_5Si_3O_{15}(OH)_5$. *Gadolinite* group.
Structure: **N Perchiazzi & 3 others** 2004 AM 89 767-76.
Description: **J Murdoch** 1962 AM 47 919-23.
Similar cell, Japanese specimen: **I Kusachi C Henmi S Kobayashi** 1994 MJJ 17 111-7 (K722).
**bakhchisaraitsevite** $Na_2Mg_5[PO_4]_4.7aq$. Close to *rimkorolgite*.
Structure, SC-XRD: **OV Yakubovich & 3 others** 2000 CM 38 831-8.
Occurrence, XRPD & IR: **RP Liferovich & 7 others** 2000 NJMM 402-18 (120); AM 86 767.
**baksanite** $Bi_6Te_2S_3$. *Tetradymite* group.
Occurrence & XRPD: Tyrnyauz, **IV Pekov & 5 others** 1996 DAN 347 787-91;
Pb-rich, do, **L Bindi C Ciprinai** 2003 CM 41 1475-9.
**balangeroite** $(Mg,Fe^{2+},Fe^{3+},Mn)_{42}Si_{16}O_{54}(OH)_{40}$. Isostructural with *gageite*.
Structure: **G Ferraris M Mellini S Merlino** 1987 AM 72 382-91.
Fe Mössbauer: **A Deriu G Ferraris E Belluso** 1994 PCM 21 222-7.
**balavinskite** $Sr_2B_6O_{11}.4aq$. Inadequate description. AM 54 575 = MM 37 955.
**balipholite** $BaMg_2LiAl_3Si_4O_{12}(OH,F)_8$. *Carpholite* structure group.
Description: **Z Peng Z Ma S Han** 1987 Sci Sinica B30 779-84 = MA 88M/1796. MM 40 904.
**balkanite** $Cu_9Ag_5HgS_8$. *Danielsite* may have a superstructure of balkanite type.
Occurrence: **VA Atanassov GN Kirov** AM 58 11-5.
Structure determination not found.
**balyakinite** $CuTeO_3$.
Occurrence: **EM Spirodanov** 1980 DAN SSSR 253 1448 = MM 46 515.
*Synthetic*: **O Lindqvist** 1972 Acta Chem Scand 26 no. 4.
**bambollaite** $Cu(Se,Te)_2$.
Occurrence: **DC Harris EW Nuffield** 1972 CM 11 738-42.
Structure determination not found: check synthetic.
**bamfordite** $Fe^{3+}Mo_2O_6(OH)_3.aq$.
Occurrence & crystal structure: **WD Birch & 4 others** 1998 AM 83 172-7.
**banalsite** $BaNa_2Al_4Si_4O_{16}$. Isostructural with *stronalsite*.
Structure: **N Haga** 1973 MJJ 7 262-81 = MA 76-2354.
Occurrence: MM 27 266; MA 96M/4544.
**bandylite** $CuB(OH)_4Cl$. $B(OH)_4$ tetrahedra vertex-linked with Cu polyhedron.
Consortium for Theoretical Frameworks net 1128.
Structure: **M Fornaseri** 1950 PM 19 157-79 = MA 11-319;
**RL Collin** 1951 AC 4 204-9 (C700);
review (E289); MA 14-393;
SC-XRD refinement, **Y Li PC Burns** 2000 CM 38 713-5.
Occurrence: MM 25 623.

**bannermanite** $(Na,K)_xV^{4+}_xV^{5+}_{6-x}O_{15}$. *Vanadium bronze* structure group; *other* subgroup.
Beta-$NaV_6O_{16}$ structure type.
Structure: **JM Hughes LW Finney** 1983 AM 68 634-41.
**bannisterite** $Ca(K,Na)(Mn,Fe)_{21}(Si,Al)_{32}O_{76}(OH)_{16}.12aq$.
Layer structure: compare *ekmanite* & *ganophyllite*.
Compare with *ajoite* $(K,Na)Cu_7AlSi_9O_{24}(OH)_6.3aq$, octahedral-tetrahedral molecular sieve.
Structure: **PJ Heaney JE Post HT Evans Jr** 1992 ClClM 40 129-44;
barian-, MM 53 85-7;
Mossbauer, **EA Ferrow** 2006 MM 70 187-99..
Occurrence: MM 36 1148.
**baotite** $Ba_4(Ti,Nb)_8Si_4O_{28}Cl$.
Structure: **VI Simonov** 1961 SPC 5 523-5;
**C Peng K Chang** 1963 Sci Sinica 12 101-19 = MA 16-610;
**YuV Nekrasov & 3 others** 1970 SPC 14 508-14 (N315).
Occurrence & composition: MM 32 945;
**D Nemec D Ackermand** 1987 NJMM 31-42 (N382).
Nb-rich: **AF Cooper** 1996 MM 60 473-82.
**Ba-priderite** Listed MM 46 515.
**bararite** $(NH_4)_2SiF_6$. Occurrence: **Dana**.
Structure determination not found, but may be done for synthetic.
**baratovite** $KLi_3Ca_7(Ti,Zr)_2Si_{12}O_{36}F_2$.
Sheet structure, isostructural with *katayamalite.*
Structure: **S Menchetti C Sabelli** 1979 AM 64 383-9;
**NA Sandomirskii MA Simonov NV Belov** 1976 SPD 21 618-20 (S1267);
**WH Baur D Kassner** 1992 EJM 4 839-41 1992.
Description: MM 40 904.
**barberiite** $NH_4BF_4$.
*Synthetic*: **AP Caron JL Ragle** 1971 AC B27 1102-7.
Occurrence: **A Garavelli F Vurro** 1994 AM 79 381-4.
**barbertonite** $Mg_6Cr_2CO_3(OH)_{16}.4aq$. *Manasseite* structure type from cell dimensions.
Structure proposal: **HFW Taylor** 1973 MM 39 377-89 (T186).
Occurrence: MM 26 334.
**barbosalite** $Fe^{2+}Fe^{3+}(PO_4)_2(OH)_2$. *Lazulite* structure group.
Structure **ML Lindberg CL Christ** 1959 AC 12 695;
SC-XRD structure & Mössbauer from 80 to 300 K, **GJ Redhammer & 4 others** 2000 PCM 27 419-29 (R944).
Occurrence: MM 30 728.
*Synthetic* "iron lazulite": **L Katz WN Lipscomb** 1951 AC 4 345-8 (K45).
Thermal dehydration: **D Rouzies J Varloud JMM Millet** 1994 JCSF 90 3335-9 (R523).
**barentsite** $Na_7AlH_2(CO_3)_4F_4$.
Structure: **T LeThu & 4 others** 1983 DAN USSR ES 273 122-6 1983 (L596).
Description: MM 48 570.
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).
**bariandite** $V_2O_4.4V_2O_5.12aq$. *Vanadium bronze* structure type, *straczekite* subtype.
Review: **HT Evans Jr JM Hughes** 1990 AM 75 508-21.
Occurrence: MM 38 988.
**baricite** $(Mg,Fe)_3(PO_4)_2.8aq$. *Vivianite* structure type.
Structure: SC-XRD, **OV Yakubovich & 3 others** 2001 CM 39 1317-24;
IR & Raman, **RL Frost & 3 others** 2002 MM 66 1063-72.
Occurrence: **BD Sturman JA Mandarino** 1976 AM 61 1053.
**bariomicrolite** $Ba(Ta,Nb)_2(O,OH)_7$. *Pyrochlore* structure type.
Structure determination not found.
Occurrence: **AH Van der Veen** AM 48 1415.
Review: **DD Hogarth** 1977 AM 62 403-10.

Description: MM 42 522.

**bario-olgite** $Ba(Na,Sr,REE)_2Na(PO_4)_2$. Isostructural with *olgite.*

*Glaserite* (*aphthitalite*) structure group.

Occurrence & structure: **IV Pekov & 6 others** 2004 ZVMO 163 41-9 (10870).

**bario-orthojoaquinite** $(Ba,Sr)_4Fe_2Ti_2Si_8O_{26}$.aq.

*Joaquinite* structure group; *orthorhombic* subtype from crystallography.

Dimorphic with *joaquinite*. Perhaps a double-cell polytype of *joaquinite* structure.

Occurrence & review: **WS Wise** 1982 AM 67 809-16.

**bariopyrochlore** $(Ba,Sr)_2(Nb,Ti)_2(O,OH)_7$. Pyrochlore structure type.

Replaces *pandaite*.

Occurrence: **E Jager E Niggli AH Van der Veen** 1959 MM 32 10-25.

Review: **DD Hogarth** 1977 AM 62 403-10.

Description: MM 42 522.

**bariosincosite** $(Ba,Sr,Ca)[(V,Al,Fe)O(PO_4)]_2.4aq$. Ba analog of *sincosite.*

Occurrence & XRPD, literature review of *synthetic* analogs, speculation on symmetry: **A Pring & 6 others** 1999 MM 63 735-41 = AM 85 873.

*Synthetic* $Ba(VO(PO_4)_2.4aq$, structure: **M Roca & 5 others** 1997 IC 36 3414-21.

**BARITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *anglesite* | $PbSO_4$ |
| *avogadrite* | $(K,Cs)BF_4$ |
| *barite* | $BaSO_4$ |
| *celestine* | $SrSO_4$ |
| *hashemite* | $Ba(Cr,S)O_4$ |

*Synthetic* $TlBrO_4$: 1989 AC C45 701-4 = SR 56A 247-8.

*Synthetic* $BaBeF_4$: AM 52 1542-4.

*Synthetic* $KDy(SeO_4)_2$: 1990 SPC 35 646-9 = SR 57A 293.

*Synthetic* $(Ba,Sr)SO_4$: nucleation from aqueous solution, **A Putnis & 4 others** 2003 Phil Trans Roy Soc London A361 615-32.

**barite** $BaSO_4$. Barite structure type. Review: Sabelli p. 28.

Structure: **K Sahl** 1963 MA 69-1075;
**A Colville K Staudhammer** 1967 AM 52 1877-80;
**RJ Hill** 1977 CM 15 522-6;
**M Miyake & 3 others** 1978 AM 63 506-10;
high-T, **H Sawada Y Takéuchi** 1990 ZK 191 161-71;
rigid-body character, **SD Jacobsen & 3 others** 1998 CM 36 1053-60.

Surface structure, (001)/(210)-aq interface, XRD & AFM: **P Fenter & 4 others** 2001 JPC B 105 8112-9 (2915).

High-T oxide-melt/differential scanning calorimetry: **J Majzlan A Navrotsky JM Neil** 2002 GCA 66 1839-50 (7338).

Oscillatory zoning in Ba/Sr, growth in water: **I L-Heureux B Jamtveit** 2002 GCA 66 417-29 (5905).

Sr-barite droplets at sulfide blebs in *clinopyroxene* macrocrysts, Hungary: **K Torok & 3 others** 2003 Li 66 275-89 (8761).

In meteorites: **AE Rubin** 1997 MPS 32 231-47.

*Synthetic*, atomic force microscopy: **DD Archibald et al.** 1997 J CrGr 172 231-8 (A735).

*Synthesis* of solid-solution series with *anglesite*: **H Wang J Lee S Yu** 2002 ZK 217 145-8 (7378).

*Synthetic* $BaSeO_4$: SC-XRD structure, **A Andari & 4 others** 2005 ZK 220 5-6.

**barium-alumopharmacosiderite** $Ba(Al,Fe)_4(AsO_4)_3O_2(OH)_5.5aq$.

*Pharmacosiderite* structure group from cell data.

Structure determination not found.

Occurrence: **K Walenta** 1966 TMPM 11 121-64 = AM 52 1585.

**barium pharmacosiderite** $BaFe_4(AsO_4)_3O_2(OH)_5.5aq$.

*Pharmacosiderite* structure group from cell data.

Structure determination not found.

Occurrence: **K Walenta** 1966 TMPM 11 121-64 = AM 52 1585;
**DR Peacor PJ Dunn** 1985 MR 16 121-4;
**K Walenta** 1994 Aufschluss 45 73-81 = MA 95M/3344.

See group references for *synthetic* Ba pharmacosiderite.
[**barium uranophane** Incomplete description: MM 32 945.]
[**barium-zinc alumopharmacosiderite** $(Ba,K)_{0.5}(Zn,Cu)_{0.5}(Al,Fe)_4(AsO_4)_3.5aq$.
Not submitted to CNMN.
Description: **H Sarp PJ Chiappero G Favreau** 1994 Arch Sci Geneve 47 45 = MM 60 524.]
**barnesite** $(Na,Ca)V_6O_{16}.6aq$. *Vanadium bronze* structure group; *hewettite* subgroup.
Review: **HT Evans JM Hughes** 1990 AM 75 508-21. Matches *synthetic*.
Structure determination not found.
Occurrence: **M Ross** 1959 AM 44 322.
**barquillite** $Cu(Cd,Fe)GeS$. *Stannite* structure type.
Description & XRPD: **A Murciego & 5 others** 1999 EJM 11 111-7 (M1714).
**barrerite** $(Na,K,Ca)_2Al_2Si_7O_{18}.7aq$. *Zeolite* mineral group.
*Stilbite* structure type; IZA-SC code STI.
Structure: **E Galli A Alberti** 1975 BSFMC 98 331-40;
SC-XRD, 2 Alaska specimens, **M Sacerdoti A Sani G Vezzalini** 1999 MMM 30 103-9 (S2064).
Ca-exchanged = *stellerite*: AM 61 1053-6.
$NH_4$-exchanged, SCND deuterium form: **E Meneghinello & 6 others** 2000 EJM 12 1123-9 (303).
Description: MM 40 904.
**barringerite** $(Fe,Ni)_2P$.
Matches *synthetic* $Fe_2P$ & $Ni_2P$; look for structure determination.
Occurrence: **PR Buseck** 1969 S 165 169-71 = AM 55 317.
$Fe_2P$: AM 69 407.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**barringtonite** $MgCO_3.2aq$. *Lansfordite* mineral group of hydrous carbonates.
Occurrence: **B Mashar** 1965 MM 34 370-2.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**barroisite** $NaCa(Mg,Fe)_3Al_2(Si_7Al)O_{22}(OH)_2$. *Amphibole* group, monoclinic subgroup.
Review: **BE Leake** AM 63 1023-52 1978.
**barsanovite** $(Ca,Na)_9(Fe,Mn)_2(Zr,Nb)_2Si_{12}(O,Cl)_{37}$. *Eudialyte* structure type; piezoelectric.
Occurrence: **MD Dorfman VV Ilyukhin TA Burova** 1963 DAN 153 1164-7 = AM 49 1153.
Structure: ZVMO 119 65-72 1990 = MA 91M/0179.
**barstowite** $Pb_4Cl_6CO_3.aq$.
Structure, SC-XRD: **IM Steele JJ Pluth CJ Stanley** 1999 MM 63 901-7;
**H Kutzke & 5 others** 2000 ZK 215 110-3 (K1228).
Occurrence: **CJ Stanley & 4 others** 1991 MM 55 121-5;
Laurion, Greece, **N Perchiazzi C Rewitzer** 1995 Lapis 20 30-1 = MA 95M/4999.
**bartelkeite** $PbFeGe_3O_8$. Structure determination not found.
Occurrence: **P Keller et al** 1982 AM 67 413.
**bartonite** $K_6Fe_{24}S_{26}(S,Cl)$. Cluster structure related to *pentlandite* & *djerfisherite*.
Analog of *chlorbartonite* $K_6Fe_{24}S_{26}(Cl,S)$.
Structure: **HT Evans Jr JR Clark** 1981 AM 66 376-84.
Occurrence: MM 46 515-6.
**barylite** $BaBe_2Si_2O_7$. 2,3-vertex-connected-tetrahedral net. See *clinobarylite*.
Structure: **KK Abrashev VV Ilyukhin NV Belov** 1964 DES 144 137-9 = MA 17-257;
**do** 1965 SPC 9 691-9 (A556;
**E Cannillo A Dal Nagro G Rossi** 1970 RSIMP 26 53-62 (C209);
**PD Robinson JH Fang** 1977 AM 62 167-9.
*Synthesis*, also Sr- & Pb-: **J Ito C Frondel** 1966 Ark Mineral Geol 4 391-4.
*Synthetic* $Na/K/Rb/CsP_4N_7$, aristotype of barylite: **K Landskron E Irran W Schnick** 1999 CEJ 5 2548-53 (L1017).
**barysilite** $MnPb_8(Si_2O_7)_3$.
Structure: **J Lajzérowicz** 1964 CRASP 259 4248-50 = MA 18-244;
AC 20 357-63 1965;
**J Lajzérowicz** 1965 AC 357-63;

structural chemistry, **AB Harnick** 1972 AM 57 277-8.
Synthesis: **J Ito** 1968 AM 53 231-40.
Occurrence & SC-XRD refinement, **U Kolitsch D Holtsham** 2002 MM 66 353-63..
*Synthetic* $Pb_3Si_2O_7$: **W Petter AB Harnik U Keppler** 1969 AM 54 510-21 (P534);
**W Petter AB Harnick U Keppler** 1971 ZK 123 445; also Ba/Ca/Mg/Mn/Sr *synthetics*.
*Synthetic* Ca/Cd/Co/Fe/Mg/Mn/Ni/Zn: **J Ito C Frondel** 1967 AM 52 1077-84.
**barytocalcite** $BaCa(CO_3)_2$. Dimorphic with *alstonite*.
Structure: **K-F Alm** 1958 Ark Mineral Geol Stockholm 2 399-410 = MA 14-471.
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).
**barytolamprophyllite** $\sim(Na,K)_6(Ba,Ca,Sr)_3FeTiSi_8O_{34}F_2$.
*Lamprophyllite* structure type. *Seidozerite* structure group.
Occurrence: MM 36 1148.
Lamprophyllite has 2O & 2M polytypes, barytolamprophyllite is 2M: **O Johnsen** 1996 NJMM 407-17 (J148).
K,Ba,Mn-rich, probably unnamed M54: **RK Rastvetsaeva VG Evsynin AA Konev** 1995 CrR 40 472-4 (R557) = AM 81 766; new mineral name not submitted to CNMN.
Ba,Sr-type: **RK Rastsvetaeva MD Dorfman** 1995 CrR 40 951-4 (R612).
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).
[**basaluminite** $Al_4SO_4(OH)_{10}.4aq$.
Structure = microcrystalline *felsöbányaite*: **L Farkas F Pertlik** 1997 AM 83 1350.
Occurrence: MM 28 724; **P-L Tien** 1968 AM 53 722-32;
**T Clayton** 1980 MM 43 931-7.]
[**basinite** Calcium bilirubinate in human secretion. Not submitted to IMA.
Description: **NP Tschirvinsky L Savina ES Golovanova** 1990 Mineral Sbornik Lvov 44 84 = MM 60 524.]
**bassanite** $CaSO_4.0.5aq$. **Sabelli** p. 32.
Structure: monoclinic, **P Ballirano & 3 others** 2001 EJM 13 985-93 (3415).
Crystallography: **P Gay** 1966 MM 35 354-62.
Inelastic neutron scattering, dynamics of molecular water: **B Winkler B Hennion** 1994 PCM 21 539-45.
Crystal structure of *synthetic* with cell data matching bassanite: **C Bezou & 4 others** 1995 JSSC 117 165-76 (B1329); also extensive literature on other work.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
Cathodoluminescence, Eu-doped synthetic: **F Cesbron & 3 others** 1997 CRASP 324 IIa 353-60 (C900).
*Miltonite* (*synthetic* & natural) may match: MM 29 989-90; MA 11 366.
Compare with *natrium polyhalite* & gamma-$CaSO_4$:MA 83M/1240.
Occurrence in fertilizers: **JR Lehr & 4 others** 1966 Crystallographic Properties of Fertilizer Compounds, Tenn Valley Auth Chem Eng Bull 6, 163p (L758).
*Synthetic* $CaSO_4.0.5aq$: **L Schröper** 1973 ZaaC 401 1-14.
*Synthetic* $CaSO_4.0.5aq$ & 0.6aq: **C Bezou & 4 others** 1995 JSSC 117 165-76 (B1329).
**bassetite** $Fe(UO_2)_2(PO_4)_2.8aq$. *Meta-autunite* structure group.
Structure: **R Vochten E de Grave J Pelsmaekers** 1984 AM 69 967-78.
**bastinite** Li,Fe,Mn-phosphate.
Description: **DJ Fisher** 1946 AM 31 193.
Structure determination not found.
**bastite** $Ba(Ti,Nb,Fe)_2SiO_7$.
Occurrence: **C Peng G Chuan** 1963 Sci Scientia 12 101-19.
Structure determination not found.
**bastnäsite-Ce / bastnaesite-Ce** $(Ce,La)(CO_3)F$.
Essentially isostructural with *hydroxylbastnäsite* & *thorbastnäsite*.
Belongs to *parisite-rontgenite-synchisite* polysomatic group.
Structure: **I Oftedal** 1931 ZK 78 462-9;
**G Donnay JDH Donnay** 1953 AM 38 932-63;
**Y Ni JM Hughes AN Mariano 1993** AM 78 415-8;
*synthetic*, AM 44 180-1.
TEM of 3 new compounds in *bastnaesite-synchisite* series, MA 76-240.
TEM, new regular stacking, **G Yang Z Pan X Wu** 1994 Sci Geol Sinica 29 393-8 = MA 95M/2712.

Mixed-layer *bastnaesite-synchysite* 6R/2$H_2$/4H/12H polytypes, Sichuan Province: XRD/HRTEM, **D Meng & 3 others 2002** EPSL 203 817-28 (8026).

Bastnaesite-*vaterite*, symmetry change across polysomatic series: **Z Yang K Tao P Zhang** 1998 NJMM 1-12 (Y228).

Occurrence: talc-chlorite, Trimouns, French Pyrenees: **P de Parseval F Fontan T Aigouy** 1997 CRASP 324 IIa 625-30 (D639);
Khibina carbonatite, **AN Zaitsev et al.** 1998 MM 62 225-50;
Maoniuping REE deposit, China, **Z Yang & 5 others** 2000 NJMM 468-80 (119) .

Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

Major source of rare earths; separation is very complex: **DJ Fray** 2000 N 289 2295-6 (F703).

[**bastnäsite-Nd** (Nd,etc.)($CO_3$)F. See *neodymium bastnäsite* (Nd,Y,La,Ca)($CO_3$)(OH,F).naq.

Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.]

**bastnäsite-Y** (Y,Ce)($CO_3$)F.

Occurrence: **DA Mineev TI Lavrishcheva AV Bychova** 1972 ZVMO 99 328-32 = AM 57 594.

Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**batiferrite** $BaTi_2Fe_{10}O_{19}$. *Magnetoplumbite* type.

Occurrence, SC-XRD structure: **CL Lengauer E Tillmanns G Hentschel** 2001 MP 71 1-19 (1422).

**batisite** $Na_2BaTi_2(Si_2O_7)_2$. Isostructural with *noonkanbahite* ~$KNaBaTi_2Si_4O_{14}$ & *shcherbakovite* $Na(K,Ba)_2(Ti,Nb)_2(Si_2O_7)_2$.

Tetrahedral sheet topologically different from those in *bafertisite* & $Na_2Zn_3[SiO_4]_2$ (E292).

Structure: **AN Nikitin NV Belov** 1964 DAN USSR ES 146 142-3 (N322) = MA 17-359;
**WW Schmahl E Tillmanns** 1987 NJMM 107-18 (S1436).

Occurrence: MM 32 945-6.

**baumhauerite** $Pb_3As_4S_9$. *Sartorite* group.

Structure: **M Th Le Bihan** 1961 AC 14 1210-1;
**P Engel W Nowacki** 1969 ZK 129 178-202 (E91);
polytype-2a, **A Pring & 5 others** AM 1990 75 915-22;
polytypes, **A Pring S Graeser** 1994 AM 79 302-7.

*Synthetic* -II: MM 39 906.]

[**baumite** (discredited = impure *serpentine*, MR 30 174) $(Mg_{9.0}Al_{1.3}Mn_{0.9}Zn_{0.7}Fe_{0.1})(Al_{1.7}Si_{6.3})O_{20}(OH)_{16}$. *Septechlorite.*

Occurrence: **C Frondel J Ito** 1975 NJMA 123 111 = MA 40 904.]

**baumstarkite** $Ag_3Sb_2(Bi,Sb)S_6$. Isotypic with *aramayoite*.

Occurrence & SC-XRD structure: **H Effenberger & 4 others** 2002 AM 87 753-64.

**bauranoite** $BaU_2O_7$.4-5aq. Inadequate description.

Compare with *wölsendorfite* (Pb,Ca)$U_2O_7$.2aq & *metacalciouranoite / metacaltsuranoite* (Ca,Na,Ba)$U_2O_7$.1.7aq that may be structurally related & justify membership in proposed wölsendorfite group: AM 75 246.

Occurrence: **VP Rogova & 3 others** 1973 ZVMO 102 75-81 = AM 58 1111.

**bavenite** $Ca_4Be_2Al_2Si_9O_{26}(OH)_2$. Consortium for Theoretical Frameworks net 977.

Structure: **E Cannillo A Coda G Fagnani** 1966 AC 20 301-9 1966.

Occurrence: Greenland, IR, **OV Petersen HI Micheelsen ES Leonardsen** 1995 NJMM 321-35;
Shap, MA 96M/4916.

Is *duplexite* a Be-rich variety?: MM 28 728.

**bayankhanite** $Cu_xHg_yS$. Inadequate description: **VI Vasil'ev** 1986 AM 71 1543.

**bayerite** $Al(OH)_3$. Polymorphic with *doyleite*, *gibbsite* & *nordstrandite*.

Structure: **R Rothbauer F Zigan H O'Daniel** 1967 ZK 125 317-31;
NPD 4 K, **F Zigan W Joswig N Burger** 1978 ZK 148 255-73 (Z101).

Quantum-mechanical study: **JD Gale & 3 others** 2001 JPC B105 10236-42 (3428).

Occurrence: MM 22 616.

Cation array, Al oxides, hydroxides & oxyhydroxides: **A Ramos-Gallardo A Vegas** 1996 ZK 211 299-303 (R665).

*Synthetic* intercalated phenylphosphonate: **L Raki C Detellier** 1996 ChC 2475-6 (R805).

**baykovite** $Ca_{1.1}Mg_{0.6}Ti_{0.3}(Al_{0.5}Si_{0.5})_2O_6[Al(Mg_{0.8}Ti_{1.2}Al_{0.1})_2O_4]$.

"Brown mineral in blast-furnace slag": similar to natural *rhönite*. *Aenigmatite* structure type.

Structure: **AV Arakcheeva** 1995 CrR 40 (2) 220-7 (A590).

**bayldonite** $Cu_3PbH(AsO_4)_2O_2(OH)_2$. Approximately isostructural with *vésignéite*.

Occurrence: **VS de Portilla MP Quevedo VI Stepanov** 1981 AM 66 148-53.

Structure: **S Ghose C Wan** 1979 AC B35 819-23. Review: (E289).

**bayleyite** $Mg_2[UO_2(CO_3)_3].18aq$. Island structure in contrast to layer structure of *liebigite* $Ca_2[UO_2(CO_3)_3].11aq$ & framework structure of *synthetic* $Sr_2[UO_2(CO_3)_3].8aq$.

Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.

Structure: **Z Zhang K Luo Z Chen** Sci Sinica B28 344-50 1985 = MA 87M/2144;
*synthetic*, **K Mayer K Mereiter** 1986 TMPM 35 133-46 (M1252).

Occurrence: MM 28 724.

**baylissite** $K_2Mg(CO_3)_2.4aq$.

Structure: *synthetic*, **RB Bucat & 3 others** 1977 Australian J Chem 30 1379-82 (B1445).

Occurrence: MA 28-208. MM 42 522.

*Synthetic* $Rb_2Mg(CO_3)_2.4aq$: **QZ Yue A Adam** 1994 ZN 49b 1368-72 (Z100).

**?bazhenovite** $?CaS_5.CaS_2O_3.6Ca(OH)_2.20aq?$. Layer structure. Matches PDF 22-154.

Occurrence: **BV Chesnokov VO Polyakov AF Bushmakin** 1987 ZVMO 116 737-43;
**T Witke** 1997 EJM Suppl 9-1 391 (W822).

No thiosulfate detected using FTIR & SC-XRD: **LBindi & 3 others** 2005 AM 90 1556-62.

**bazirite** $BaZrSi_3O_9$. *Benitoit*e structure type.

Structure: **FC Hawthorne** 1987 NJMM 16-30 (H816).

Description: MM 40 904.

**bazzite** $Be_3(Sc,Al)_2Si_6O_{18}$. *Beryl* structure type.

Structure: **G Bergerhoff W Nowacki** 1955 SMPM 35 410-21 (B3);
**G Peyronel** 1956 AC 9 181-6;
**T Armbruster & 8 others** 1995 MP 52 113-26 (A587);
heavy-alkali rich, SC-XRD, **F Demartin CM Gramaccioli T Pilati** 2001 CM 38 1419-24.

*Synthesis*: AM 53 943-53.

Occurrence: cesian, Varese, Italy, CM 38 1409-18.

**bearsite** $Be_2(AsO_4)(OH).4aq$. As analog of *moraesite* from XRPD.

Description: **EV Kopchenova GA Sidorenko** 1962 ZVMO 91 442-6 = AM 48 210-1.

Structure determination not found.

**bearthite** $Ca_2Al[PO_4]_2(OH)$. *Brackebushite* structure type.

Structure: **C Chopin & 4 others** 1993 SMPM 73 1-9 (C662) = AM 75 1314.

Synthesis & thermodynamics: **F Brunet C Chopin** 1995 CMP 121 258-66.

**beaverite** $Pb(Cu,Fe,Al)_3(SO_4)_2(OH)_6$. *Alunite* structure type. Review: **Sabelli** p. 25.

Structure: **JL Jambor JE Dutrizac** 1983 CM 21 101-13;
**B Breidenstein J Schlüter G Gebhard** 1992 NJMM (5) 213-20 (B1357).

Synthesis: CM 23 47-51.

Occurrence: Chala, Bulgaria, **A Kunov P Petkov** 2001 MA 02M/3315.

**bechererite** $Zn_7Cu(OH)_{13}[SiO(OH)_3SO_4]$.

Occurrence & approximate structure: **G Giester B Rieck** 1996 AM 81 244-8.

Revised structure in P3, SCXRD: **C Hoffman T Armbruster G Giester** 1997 AM 82 1014-8.

**beckelite** $Ca_3(Ce,La,Y)_4(Si,Zr)_3O_{15}$.

Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

In meteorites, $(Ce,Ca)_5(SiO_4)_3(OH,F)$: **AE Rubin** 1997 MPS 32 231-47.

**BECQUERELITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *becquerelite* | $Ca(UO_2)_6O_4(OH)_6.8aq$ |
| *billietite* | $Ba(UO_2)_6O_4(OH)_6.8aq$ |
| *compreignaite* | $K_2(UO_2)_6O_4(OH)_6.8aq$ |

Review: **V Baran M Unzeitig** 1991 NJMM 63-75 (B1358);
**PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.

Transformation of *schoepite* into *becquerelite*, *billietite* & *wölsendorfite*: **R Vochten L Van Haverbeke** 1990 MP 43 65-72 (V225).

*Synthetic* $Ca_{1.5}U_6(OH)_7O_{16}.7aq$ & $Ca_2(UO_2)_2(Si_2O_6)_3.10aq$: **JM Skakle LP Moroni FP Glasser** 1997 PD 12 81-6 (S2108).
Dehydration of *metaschoepite*, & alteration to becquerelite: **AG Sowder SB Clark RA Field** 1999 EST 33 3552-7 (S2100).

**becquerelite** $Ca(UO_2)_6O_4(OH)_6.8aq$.

Structure: **J Meunier-Piret P Piret** 1982 BM 105 606-10;
**MK Papagoaga DE Appleman JM Steward** 1987 AM 72 1230-8;
**PC Burns Y Li** 2002 AM 87 550-7;
*synthetic,* FTIR, **S Amayri & 4 others** 2004 CM 42 953-62.
Crystal chemistry: NJMA 174 159-80 (C1076).
*Sr-exchanged*, structure: **PC Burns Y Li** 2001 AM submitted.

**bederite** $Ca_2Mn_2Fe_2Mn_2(PO_4)_6.2aq$.

Isostructural with *wicksite*, *grischunite*, & unnamed phase.
Structure, SC-XRD: **MA Galliski MA Cooper FC Hawthorne** 1999 AM 84 1674-9.

**behierite** $(Ta,Nb)BO_4$. *Zircon* structure type from XRPD.

Occurrence: MM 32 946;
**ME Mrose HJ Rose** 1961 AM 48 414.
Nb-analog = IMA 99-051: CM 38 249/

**behoite** $Be(OH)_2$-beta. Isostructural with epsilon-$Zn(OH)_2$.

Occurrence: MM 37 955.
Structure: **IJ Bear GM Lukasrewski AG Turnbull** 1965 Australian J Chem 18 1317-?.
*Synthetic*: **VA Seitz U Rosler K Schubert** 1950 ZaaC 261 94-105 1950.
Also metastable alpha-3-layer structure: SPD 34 187-9.
[*Clinobehoite* is monoclinic polymorph of behoite.]

**beidellite** $\sim(Na)_{0.3}Al_2(Al,Si)_4O_{10}(OH)_2.naq$. *Smectite* group.

Occurrence: **AH Weir R Greene-Kelly** 1962 AM 47 137-46.
Molecular dynamics modeling: **BJ Teppen & 4 others** 1997 JPC B 101 1579-87 (T504).
*Synthetic*, IR: **JT Kloprogge RL Frost L Hickey** 1999 JMSL 18 1921-3 (K1207).
*Synthesis* of ammonium-: **JT Kloprogge R Vogels** ClClM 43 135-7.
*Synthetic* & natural, pillared with Keggin compound: **J Miehe & 3 others** 1997 CI 69 523-36.
*Synthesis* & properties, *margarite*/beidellite 34Å phase: **T Matsuda M Kurosaki** 1998 CM 36 1569-76.
*Synthetic* Al-pillared, IR: **T Kloprogge RL Frost** 1999 Appl Clay Sci 15 431-45 = MA 00M/2367.

**belendorffite** $Hg_6Cu_7$.

*Beta-brass* structure type: ordered superstructure of $Cu_5Cd_8$ structure type.
No structure determination, but matches *synthetic*: **H-J Bernhardt K Schmetzer** 1992 NJMM 21-8 (B1356).
*Synthetic*, structure: **F Schoszberger** 1935 ZPC B29 65-78;
**T Lindahl S Westman** 1969 Acta Chem Scand 23 1181-90.
Contrast rhombohedral cell with cubic cell of *goldamalgam*, *kolymite*, & *moschellandsbergite*.

[**belite** $Ca_2SiO_4$. Occurs in Portland cement. See *alite*.

$^{29}Si$ NMR in Portland cement: **J Skibsted HJ Jakobsen C Hall** 1995 JCSF 91 4423-30 (S1578).
XRPD full-profile quantification of Portland cement clinker: **JC Taylor I Hinczak CE Matulis** 2000 PD 15 7-19 (T636.]

**belkovite** $Ba_3(Nb,Ti)_6(Si_2O_7)_2O_{12}$.

Structure: **AV Voloshin & 5 others** 1991 NJMM (1) 23-31 (V229).
*Synthetic* $Ba_3Si_4Nb_6O_{26}$: **J Shannon L Katz** 1970 AC B26 105-9.

*Synthetic* $Ba_3Si_4Ta_6O_{23}$ & $Ba_3Si_4Ta_6O_{26}$: **J Shannon L Katz** 1970 JSSC 1 399-408.

Occurrence: AM 77 1305.

**bellbergite** $(K,Ba,Sr)_2Sr_2Ca_2(Ca,Na)_4Al_{18}Si_{18}O_{72}.30aq$. *Zeolite* mineral group.

IZA-SC code EAB. Consortium for Theoretical Frameworks net 118.
Isostructural *synthetic* EAB zeolite: **R Rüdinger E Tillmanns G Hentschel** 1993 MP 48 147-52 (R460).

**bellidoite** $Cu_2Se$-beta. Matches *synthetic*. Occurrence: MM 40 904.

**bellingerite** $Cu_3(IO_3)_6.2aq$.

Structure: **S Ghose C Wan** 1974 AC B30 965-74; review (E289).
Occurrence: MM 26 334.

[**bellite** $Pb_5(Cr/SiO_4)_3Cl$. Discredited: MM 57 538-40.
Synthetic has *mimetite* structure type.]
**belloite** CuOHCl.
Occurrence, matches *synthetic*: **J Schluter K Klaska G Gebhard** 2000 NJMM 67-73 (S2163).
Structure: *synthetic*, **H Effenberger** 1984 Mh Chemie 115 725-30.
**belorussite-Ce** $NaBa_2Ce_2MnTi_2Si_8O_{26}(F,OH).aq$.
*Joaquinite* structure group, *orthorhombic* subtype from crystallography.
Occurrence: **EP Shpanov & 3 others** 1989 ZVMO 100-7 (S1352).
**belovite** $(Sr,etc.)_5(PO_4)_3OH$. *Apatite* structure type.
Occurrence: **LS Borodin ME Kazakova** 1955 AM 40 367-8. SR 29 374.
*Synthetic* $Sr_5(PO_4)_3Cl$: **K Sudarsanan RA Young** 1974 AC B30 1381-6.
**belovite-Ce** $NaSr_3(Ce,La)[PO_4]_3(F,OH)$. *Apatite* structure type.
*Strontian fluorapatite* & belovite-Ce, SC-XRD structure: **JF Rakovan JM Hughes** 2000 AM 85 839-45.
Occurrence: **IV Pekov & 4 others** 1995 ZVMO 124 98-110 = AM 81 1285.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**belovite-La** $NaSr_3(La,Ce)[PO_4]_3(F,OH)$. *Apatite* structure type.
Occurrence: **IV Pekov & 6 others** 1996 ZVMO 125 101-9 (P658) = AM 82 620.
**belyankinite** $Ca_2Ti_{12}NbZrSiO_{35}.28aq$. Occurrence: MM 29 976.
**belyankite** $Ca_3Al_2F_{12}.4aq$. Occurrence: MM 29 976.
**bementite** $Mn_8Si_6O_{15}(OH)_{10}$.
Structure: **AR Heinrich RA Eggleton S Guggenheim** 1994 AM 79 91-106.
[tosalite Fe-rich relative of *bementite*.
Incomplete description: **T Yoshimura** 1967 Sci Rept Fac Sci Kyushu Univ D 9 1-485 = AM 55 1070.]
[**bemmelenite** Colloidal ferrous carbonate. Occurrence: MM 26 334.]
**benauite** $HSrFe_3(PO_4)_2(OH)_6$. *Crandallite* type.
Crystallography, occurrence: **K Walenta WD Birch PJ Dunn** 1996 CEr 56 171-6 = AM 82 430-3.
**benavidesite** $Pb_4(Mn,Fe)Sb_6S_{14}$.
Isostructural with *jamesonite* from cell data, but no detailed analysis found.
Occurrence: **E Oudin et al.** AM 68 280.

**BENITOITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *bazirite* | $BaZrSi_3O_9$ |
| *benitoite* | $BaTiSi_3O_9$ |
| [*otjisumeite* | $PbGe_4O_9$] |
| *pabstite*. | $Ba(Sn,Ti)Si_3O_9$ |

Consortium for Theoretical Frameworks octa-tetra net 1112.
*Catapleiite* & *wadeite* have net topology CTF 1146 with different rotation.
Review: **FC Hawthorne** NJMM (1) 16-30 1987 (H1008).
*Otjisumeite* may have triclinic superstructure based on benitoite structure (K729).
*Synthetic* hexagonal $PbGe_4O_9$ isostructural with benitoite, **CR Robbins EM Levin** 1961 J Research 65A 127-31.
*Synthetic* $KZr(BeF_3)_3$: MA 18-161.
*Synthetic* $BaSi_4O_9$ 4 GPa 1273K, followed by grinding, benitoite type: **LW Finger RM Hazen B Fursenko** 1995 JPCS 56 1389-93.
*Synthetic* trigonal $BaSi_4O_9$, 1273K, before grinding, not benitote structure but related: **RM Hazen & 3 others** 1999 AM 84 987-9.
**benitoite** $BaTiSi_3O_9$.
Structure: **WH Zachariasen** 1930 ZK 74 139-46;
**K Fischer 1969** ZK 129 222-43 (F114).
MAS-NMR, $^{29}$Si: **ML Balmer & 4 others** 1997 JPCB 101 9170-9 (B1738);
**A Labouriau TG Higley WL Earl** 1998 JPCB 102 2897-904.
**benjaminite** $(Ag,Cu)_3(Bi,Pb)_7S_{12}$. *Pavonite* homologous series (K689): type $^7$P.
Structure: **E Makovicky WG Mumme** 1979 CM 17 607-18;

**HK Herbert WG Mumme** 1981 NJMM 69-80 = MA 81-3820.
AM 38 550-2.
Relation to *pavonite*: (K689).
**benleonardite** $Ag_8(Sb,As)Te_2S_3$.
Occurrence & XRPD: **CJ Stanley AJ Criddle JE Chisholm** 1986 MM 50 681-6.
Structure determination not found.
Occurrence, Montana: **PG Spry SE Thieben** 1996 MM 60 871-6.
**benstonite** $(Ba,Sr)_6Ca_6Mg(CO_3)_{13}$.
Structure: **H Effenberger** 1979 NJMA 136 326-37.
Occurrence: MM 32 989.
Sr-Ba-Ca-carbonates from 3 carbonatites actually consist of several phases, including benstonite proper and Mg-free analog probably resulting from high-T disordered Ca analog: **SV Sokolov & 3 others** 2001 GI 39 1218-29 (3899).
**bentorite** $Ca_6(Cr,Al)_2(SO_4)_3(OH)_{12}.26aq$. *Ettringite* structure type from cell data.
Review: Sabelli p. 18.
Structure determination not found.
Occurrence: **S Gross** 1980 Israel J Earth Sci 29 81-4 = AM 66 637.
[**benyacarite** $(aq,K)_2(Mn,Fe)_2(Fe,Ti,Al)_2Ti(PO_4)_4(O,F)_2.14aq$.
Essentially isostructural with *mantiennite* $KMg_2Al_2Ti(PO_4)_4(OH)_3.15aq$ & *paulkerrite* $K(Mg,Mn)_2(Fe,Al,Ti,Mg)_2(PO_4)_4(OH)_3.1aq$.
Structure: **F Demartin & 3 others** 1993 ZK 208 57-71 (D459).
Not yet approved by IMA.]
**beraunite** $Fe^{2+}Fe^{3+}_5(PO_4)_4(OH)_5.4aq$.
Structure: **L Fanfani PF Zanazzi** 1967 AC 22 173-81;
**PB Moore AR Kampf** 1992 ZK 201 263-81 (M1049).
Mn-, structure: **YMF di Cossato P Orlandi M Pasero** 1989 CM 27 441-6.
**berborite** $Be_2(BO_3)(OH,F).aq$.
Structures: polytypes 1T, 2T & 2H: **G Giuseppetti & 5 others** 1990 NJMA 162 101-16 (G673).
Occurrence: MM 36 1148.
**berdesinskiite** $V_2TiO_5$. XRPD indexes on $CrFeTiO_5$ unit cell.
Structure determination not found.
Occurrence: **H-J Bernhardt K Schmetzer O Medenbach** 1983 NJMM 110-8;
AM 67 1074; AM 68 1038; MM 48 570; CM 41 561-79.
**berezanskite** $KLi_3Ti_2Si_{12}O_{30}$. ?Isostructural with *brannockite* $KLi_3Sn_2Si_{12}O_{30}$.
? *osumilite* group.
Occurrence, XRPD & IR: **LA Pautov AA Agakhanov** 1997 ZVMO 4 75-80 (P770).
**bergenite** $Ba_4Ca_2[(UO_2)_3(PO_4)_2O_2)_3.16aq$.
*Phosphuranylite* structure type: uuduudSSO geometrical isomer.
Structure: **AJ Locock PC Burns** 2003 CM 41 91-101 .
Occurrence: **HW Bültemann GH Moh** 1959 NJMM 232-3 = AM 45 909;
**P Piret M Deliens** 1981 AM 66 102.
*Synthetic*: $Ba(UO_2)_4(PO_4)_2(OH)_4.8aq$: **V Ross** 1956 AM 41 818-920.
**bergslagite** $CaBeAsO_4(OH)$. Isostructural with *datolite*: *gadolinite* structural group.
Structure: **S Hansen L Fälth O Johnsen** 1984 ZK 166 73-80 (H890).
**berlinite** $AlPO_4$. *Quartz* structure type with Al/P alternation. Structural analog of *alarsite* $AlAsO_4$, *rodolicoite*, $FePO_4$ & *quartz* $SiO_2$. High-low transition.
[Also synthetic analogs of *cristobalite* & *tridymite*: **OW Flörke** 1967 ZK 125 134-46 (F273).]
Structure: **B Sharan BN Dutta** 1964 AC 17 82-5 (S138);
**D Schwarzenbach** 1966 ZK 123 161-85 (1193);
alpha-beta transition, **HN Ng C Calvo** 1976 Can J Phys 54 638-47 (1395);
charge density, **N Thong D Schwarzenbach** 1979 AC A35 658-64(1394);
synchrotron Laue, **IG Wood P Thompson JC Matthewman** 1983 AC B39 543-7 (W670);
calorimetry & neutron scattering of incommensurate phase, **JP Bachheimer B Berge G**

**Dolino** 1984 Solid State Comm 51-1 55-8.
-*quartz* solid solution from granite melt: **IV Vekser R Thomas R Wirth** 2003 AM 88 1724-30.
High pressure, **H Sowa J Macavei H Schulz** 1990 ZK 192 119-36 (S1048);
1990 JAC 23 397-400 = SR 57A 254-5;
TEM, **P Cordier JC Donkham J Peyronneau** 1993 PCM 20 176-89;
first-principles calculations, **DM Christie JR Chelikowsky** 1998 PCM 222-6 (C1029)
transformation to Cmcm phase >13 GPa, **SM Sharma N Garg SK Sikka** 2000 PRB 8824-7 (249).
Occurrence: **JR Lehr & 4 others** 1966 Crystallographic Properties of Fertilizer Compounds, Tenn Valley Auth Chem Eng Bull 6, 163p (L758).
*Synthetic* $FePO_4$: MM 30 735.

**bermanite** $Mn^{2+}Mn^{3+}_2(PO_4)_2(OH)_2.4aq$.

Octahedral-tetrahedral $Mn^{3+}P$ sheet crosslinked by $Mn^{2+}O_2aq_4$ layer.

Structure: **AR Kampf PB Moore** 1976 AM 61 1241-8 (K601);
polytypes, **P Bayliss** 1990 MM 54 137.
Occurrence: MM 25 603.

**bernalite** $Fe(OH)_3$. Distorted $ReO_3$ structure. *Schoenfliesite/stottite* structural group.

Structure: Immm, **WD Birch & 3 others** 1993 AM 78 827-34;
magnetic, **CA McCammon E De Grave A Pring** 1996 J Magnet Magnet Mater 152 33-9.
Mössbauer/optical spectroscopy/TEM: **CA McCammon & 3 others** 1995
XRPD structure to 9 GPa, revised space group to Pmmn: **MD Welch WA Crichton NL Ross** 2005 MM 69 309-15.

**bernardite** $Tl(As,Sb)_5S_8$.

Structure: **J Pasara & 3 others** 1989 MM 53 531-8.

**berndtite** $SnS_2$. *Melonite* structure type: $CdI_2$ (~ = *brucite*) topology.

Many polytypes: MA 86M/ 1435 & 4297.
6C & 27C polytypes, **AH Clark** 1972 Nw 59 361.
2H, 4H & 18R, **B Palosz W Steurer H Schulz** 1990 AC B46 449-55.
Occurrence: MM 35 1128.
High-P: **RM Hazen LW Finger** 1978 AM 63 289-92.

**berryite** $Pb_3(Cu,Ag)_5Bi_7S_{16}$.

Structure determination not found.
Occurrence: **EW Nuffield DC Harris** 1966 CM 8 407-13;
**SR Karup-Møller** 1966 CM 8 414-23.

**berthierine** $(Fe,Mg)_{2-3}(Si,Al)_2O_5(OH)_4$. *Kaolinite-serpentine* group.

Structure determination not found. 1M & 1H polytypes.
*Chlorite*-berthierine microstructures, TEM: **H Xu DR Veblen** 1996 CMP 124 291-301 (X18).
Diffuse reflectance: **WM Calvin TVV King** 1997 MPS 32 693-701.
Heat capacity: **C Bertoldi & 5 others** 2005 ClClM 53 380-8.
Occurrence: MA 96M/4535;
Minnesota Cretaceous laterite, **JA Toth SJ Fritz** 1997 ClClM 45 564-79, **SJ Fritz JA Toth** 580-6;
-chamosite intergrowth from Wyoming, **PC Ryan S Hillier** 2002 AM 87 1607-15.
Manganoan, New Zealand: **DS Coombs G Zhao DR Peacor** 2000 MM 64 1037-46.

**berthierite** $FeSb_2S_4$. *Clerite* is Mn analog.

Structure: **MJ Buerger T Hahn** 1955 AM 40 226-38 (B87);
**P Lemoine D Carré F Robert** 1991 AC C47 938-40 (L676).
Occurrence: H4/5 chondrite, Thuathe, Lesotho, **H de Bruijn & 2 others** 2004 NJMM 357-60 (10646).

**bertossaite** $(Li,Na)_2(Ca,Fe,Mn)Al_4(PO_4)_4(OH,F)_4$.

Analog of *palermoite* $(Li,Na)_2(Sr,Ca)Al_4(PO_4)_4(OH)_4$ from cell data.

Structure determination not found.
Occurrence: **O Von Knorring ME Mrose** AM 52 1583.

**bertrandite** $Be_4Si_2O_7(OH)_2$. Complex 3-connected net with OH dangle.

Structure: **T Ito J West** 1932 ZK 83 334-93;
**LP Solov'eva NV Belov** 1963 DES 140 1086-9 (S1501) = MA 16-420;
**do** SPC 9 458-60 (S1311) = MA 17-359;
**MA Simonov NV Belov** 1976 SPD 21 607-8 (S1269) = MA 78-2698;

high-P, **RM Hazen AY Ai** 1986 PCM 13 69-78 1986 (H621);
ND, **JW Downs FK Ross** 1987 AM 72 979-83;
**G Giuseppetti C Tadini V Mattioli** 1992 NJMM 13-9 (G774).

**beryl** $Be_3Al_2Si_6O_{18}$.

Isostructural with *bazzite, pezzottaite* $Cs(Be_2Li)Al_2Si_6O_{18}$ *& stoppaniite* $(Fe,Al,Mg)_4[Be_6Si_{12}O_{36}].(Na,void)_2.2$ aq.

*Cordierite* has same connectivity but different cation placement.

Structure: alkali position, **A Vorma TG Sahama I Haapala** 1965 Bull Comm geol Finlande 218 119-29;
**GV Gibbs DW Breck EP Meagher** 1968 Li 1 275-85 (G161);
IR & inelastic neutron scattering, **GJ Safford AW Naumann AL Hallowell** 1968 J Chem Phys 48 5503-8;
**B Morosin** 1972 AC B28 1899-903;
alkali positions in Cs-Li-, **FC Hawthorne P Cerny** 1977 CM 15 414-21 (H468);
thermal expansion of beryl & emerald, **JL Schlenker & 4 others** 1977 PCM 1 243-55;
Fe electronic absorption spectra, **DS Goldman GR Rossman KM Parkin** 1978 PCM 3 225-35;
polarized near-IR spectroscopy, **LV Nikol'skaya MI Samoilovich** 1980 SPC 24 604-8;
IR of molecular water & $CO_2$, **RD Aines GR Rossman** 1984 AM 69 319-27;
**MF Hochella GE Brown Jr** 1986 JACeS 69 13-8 (H689);
**RM Hazen AY Ai LW Finger** 1986 AM 71 977-84;
**C Aurisicchio & 3 others** 1988 AM 73 826-37;
alkali metals, XRD & NMR, **BL Sherriff & 4 others** 1991 CM 29 271-85;
ND, **G Artioli & 3 others** 1993 AM 78 762-8;
highest aq & Na, ND, **G Artioli & 3 others** 1995 AC B51 733-7;
channel occupancy low--alkali, FTIR/Raman/MAS NMR, **B Charoy & 3 others** 1996 AM 81 395-403;
SC-N&XRD, most hydrous, blue sodic, Ireland, **G Artioli & 3 others** 1995 AC B51 733-7 (A663);
Cr-doped *synthetic* emerald, **J Lee P Lee S Yu** 1995 J Geol Soc China (Taiwan) 38 273-85;
IR & Raman spectra, **T Pilati F Demartin CM Gramaccioli** 1997 AM 82 1054-62;
Raman, orientation & vibration of aq, *synthetic* alkali-free, **BA Kolesov CA Geiger** 2000 PCM 27 557-64ß;
optical spectra, **MN Taran GR Rossman** 2001 AM 86 973-80;
Mössbauer of aquamarine, **RR Viana & 4 others** 2002 PCM 29 78-86 (7289);
IR, UV-visible, XRPD of aquamarine, **RR Viana & 3 others** 2002 PCM 29 668-79 (8582);
charge-density Hartree-Fock analysis, **M Prencipe** 2002 PCM 29 552-62;
ND/polarized IR, water orientation, **G Diego Gatta & 3 others** 2006 AM 91 29-34.

*-cordierite-beryllium indialite*: symmetry/order: **SG Pecherskaya & 4 others** 2003 CrR 48 363-9 (9072).

Na-rich: MA 86M/0186.

Li-: MA 75-861.

*Synthetic* V/Mn/Co/Ni-substituted: **EN Emel'yanov & 3 others** 1965 SPC 10 46-9.

*Synthetic* $Be_3Sc_2Si_6O_{18}$: **C Frondel J Ito** 1968 AM 53 943-53.

Natural red: **K Nassau DL Wood** 1968 AM 53 801-6;
Gem, Utah, **JE Shigley & 2 others** 2003 GG 39 302-13**.**

Emerald: fluid inclusions in Madagascar, metasomatism, **Ye Vapnik & 3 others** 2006 MM 70 141-58;
do in Kazakstan, **EV Gavrilenko & 4 others** 2006 MM 70 159--74.

17 *synthetic* & 62 natural: optical & IR polarized, **DL Wood K Nassau** 1968 AM 53 777-800.

*Synthetic* emeralds: **EM Flanigen & 3 others** 1967 AM 52 744-72.

*Synthetic* $Be_3In_2Si_6O_{18}$: AM 53 1663-73.

*Synthetic* $(Be,Co)_3(Al,Co)_2Si_6O_{18}$ & $(Be,Cu)_3Al_2Si_6O_{18}.0.2aq$: 1989 SPC 34 430-4.

*Synthetic* Co-: polarized optical absorption, **MN Taran GR Rossman** 2001 AM 86 889-95;
valence & coordination of Co, **VP Solntsev & 3 others** 2004 PCM 31 1-11 (10014).

*Synthetic* ammonium, IR & EPR: **RI Mashkovtsev VP Solnitsev** 2002 PCM 29 65-71 (7287).

*Synthetic* Li/V/Ti/Cr/Mn/Rb/Cs, symmetry vs chemistry: **TV Demina & 2 others** 2003 ZVMO 132-5 1 (10513).

**beryllite** $Be_3SiO_4(OH)_2.aq$. Structure determination not found.

Occurrence: **MV Kuzmenko** 1954 DAN SSSR 99 451-4 = AM 40 787-8.

[**metaberyllite** $Be_3SiO_5.2aq$. Lower hydrate of *beryllite*.

Occurrence: **EI Semenov** 1972 ZVMO 102 75 = MM 39 920.] [jvs: check hydration levels!]

**beryllonite** $NaBePO_4$. Consortium for Theoretical Frameworks net 9 = BNT.

Structure: **NI Golovastikov** 1962 SPC 6 733-9 (G696);
**NI Golovastikov** 1962 SPD 7 102-5 (G699);

**G Giuseppetti C Tadini** 1973 TMPM 20 1-12 (G353).

*Synthetic* $Na(Zn_{0.8}Fe_{0.2})[PO_4]$, SPC 23 397-400 1978 (P481) = MA 16-133.

*Synthetic* $Na(Al,Ga)SiO_4$, phase relations: (C721).

*Synthetic* $NaZnP/AsO_4$: **M Andratschke A Feltz** 1990 ZaaC 582 179-89 (A675).

*Synthetic* Ag(Be/Zn)PO, structures **R Hammond J Barbier C Gallardo** 1998 JSSC 141 177-85 (H1378)

*Synthetic* $NaBSiO_4$: SC-XRD structure, **HA Graetsch W Schreyer** 2005 CM 43 759-67.

**beryllosodalite** ~$Na_4BeAlSi_4O_{12}Cl$. *Sodalite* structure type.

Occurrence: MM 32 946.

**berzelianite** $Cu_2Se$-alpha-high.

Structure: **W Borchert** 1945 ZK 106 5-24.

Cubic-alpha-high/tetragonal-beta-low transition at 473K: **P Rahlf** 1936 ?.

**berzeliite** $(Ca,Na)_3(Mg,Mn)_2As_3O_{12}$. *Garnet* structure type.

Structure: **FC Hawthorne** 1976 AC B32 1581-3.

Synthesis of Mg & Mn endmembers: **J Ito** 1968 AM 53 316-9.

**bessmertnovite** $Au_4Cu(Te,Pb)$.

Structure determination not found.

Occurrence: **EM Spiridonov TN Chvilera** 1981 AM 66 878.

**beta-alumina** Synthetic alumina-rich materials with *magnetoplumbite* structure type, related to *hibonite*, *magnetoplumbite* & *yimengite*. Illustrative composition is $CaAl_{12}O_{19}$.

The mineral *diaoyudaoite* is a sodium beta-alumina.

*Synthetic* $CaAl_{12}O_{19}$: A Utsunomiya & 4 others 1988 JSSC 75 197-200.

*Synthetic* $Na_{1+x}Al_{11}O_{17+x/2}$: **K Edström JO Thomas GC Farrington** 1991 AC B47 210-6.

*Synthetic* $AgAl_{12}O_{17}$: neutron powder, J Phys Condensed Matter 2 2335-44.

*Synthetic* $(Ba,Sr)CuAl_{10}O_{17}$: ZaaC 582 21-4.

*Synthetic* $Ag_{1.22-y}Cd_{y/2}Al_{11}O_{17.11}$: **K Edström JO Thomas GC Farrington** 1991 AC B47 643-6 (E346).

*Synthetic* $Li_{0.75}Na_{0.47}Al_{11}O_{17.11}$, SC-N&XRD: **K Edstrom & 3 others** 1997 AC B53 631-8.

Cation array in Al oxides/hydroxides/oxyhydroxides: **A Ramos-Gallardo A Vegas** 1996 ZK 211 299-303 (R665).

*Synthetic* BaMgAlSiO, structure = Na'''-beta-alumina: **N Iyi M Göbbels S Kimura** 1998 JSSC 136 258-62 (I233).

*Synthetic* Li & Rb-exchanged Na-, XANES: **A Marcelli A Mottana G Cibin** JACr 33 234-42 (M1811).

**beta"-alumina** Synthetic alumina-rich materials. Illustrative composition is $MAl_{11}O_{17}$.

*Synthetic* Ba-: **JO Thomas & 3 others** 1984 AC B40 208-13.

*Synthetic* $Na_{1.5}(H_3O)_{0.5}Fe_{10}ZnO_{17}.0.3aq$: 1990 JSSC 87 298-3072 = SR 57A 200-1.

*Synthetic* $K_{1.33}Fe_{10.27}Cd_{0.73}O_{16.87}$: 1990 Solid State Ionics 40-41 95-8 = SR 47A 203.

*Synthetic* $Na_2Ga_{11}O_{17}$: 1989 Solid State Ionics 35 223-7 = SR 56A 121.

*Synthetic* $Na_{1.3}K_{0.6}Fe_{10.1}Zn_{0.9}O_{17}$: 1989 JSSC 81 181-91 = SR 56A 160.

*Synthetic* $Ca_xMg_{2x-1}Al_{12-2x}O_{17}$: **M Alden JO Thomas GC Farrington** 1984 AC C40 1763-6 (A624).

*Synthetic* $Na_{1+x}Ga_{11-x/3}O_{17}$: **Y Michiue M Watanabe Y Fujiki** 1991 AC C47 495-8 (M1290).

*Synthetic* $Sr_xMg_{2x-1}Al_{12-2x}O_{17}$: **M Alden JO Thomas GC Farrington** 1985 AC C41 1700-3 (A626).

*Synthetic* ion-deficient Na,Mg-doped, structure: **PW Haycock & 4 others** 1995 Solid State Ionics 80 53-8.

[**beta-brass** Structure type, not a specific mineral. Includes:

| | |
|---|---|
| *belendorffite* | $Cu_7Hg_6$ |
| *goldamalgam* | (Au,Ag)Hg |
| *kolymite* | $Cu_7Hg_6$ |
| *moschellandsbergite* | $Ag_2Hg_3$ |

Structure of *synthetic* beta-brass: **F Schoszberger** 1935 Z phys Chem 29 1-3.

Contrast rhombohedral cell of belendorffite with cubic cell of goldamalgam, kolymite, & moschellandsbergite.

jvs: problem of superstructure and geometrical distortion that might depend on atomic ratio.]

**betafite** $(Ca,Na,U)_2(Ti,Nb,Ta)_2O_6(OH)$. *Pyrochlore* group, *betafite* subgroup.

Metamict: structure determination not found.

Occurrence: **DD Hogarth** 1977 AM 62 403-10.

Geochemical alteration: **GR Lumpkin RC Ewing** 1996 AM 81 1237-48.

Important because of relevance to encapsulation of high-level nuclear waste.

**betalomonosovite** $Na_7Ti_4Si_4P_2O_{23}(OH)_3$. *Murmanite-lomonosovite* mineral group.

General description of *betalomonosovite*, but no coordinates: **AD Khalikov YeS Makarov KhS Mamedov LYa P'yanzina** 1965 DES 162 138-40 (K774) = MA 19-182.

Structure: **RK Rastsvetaeva MI Sirota NV Belov** 1975 SPC 20 158-60 (R513); **RK Rastsvetaeva** 1986 SPC 31 633-6.

Disordered: **RK Rastsvetsaeva** 1988 ZVMO 117 696-705.

[**beta-roselite / roselite-beta** $Ca_2(Co,Mg)(AsO_4)_2.2aq$. *Fairfieldite* structure group.

Dimorphic with *roselite-alpha* in *roselite* group.

Occurrence: **C Frondel** 1955 AM 40 828.]

[**beta-uranophane / uranophane-beta** $Ca(UO_2)_2(SiO_3OH)_2.5aq$.]

**betekhinite** $Cu_{10}(Fe,Pb)S_6$.

Structure: **K Dornberger-Schiff E Höhne** 1959 AC 12 646-51.

Occurrence: MM 31 953; MR 26 143, 152 & 175.

**betpakdalite** $[Mg.aq_6]Ca_2aq_{13}[Mo_8As_2Fe_3O_{36}(OH).4aq$.

Structure: incorrect composition, **K Schmetzer B Nuber** 1984 NJMM 393-54 (S1205); analysis, **PB Moore** 1992 Australian J Chem 45 1335-54 (M1054); revised structure and composition, **MA Cooper FC Hawthorne** 37 61-6.

XRPD of *mendozavilite* $(Ca,Mg)_2[Fe_6(PO_4)_2(PMo_{11}O_{39})(OH,Cl)_{10}].33aq$ matches.

Occurrence: MM 32 989.

**BEUDANTITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *beudantite* | $PbFe_3(AsO_4(SO_4)(OH)_6$ |
| *corkite* | $PbFe_3(PO_4(SO_4)(OH)_6$ |
| *gallobeudantite* | $PbGa_3[(As/S)O_4]_2(OH)_6$ |
| *hidalgoite* | $PbAl_3(AsO_4(SO_4)(OH)_6$ |
| *hinsdalite* | $(Pb,Sr)Al_3(PO_4(SO_4)(OH)_6$ |
| *kemmlitzite* | $(Sr,Ce)Al_3(AsO_4(SO_4)(OH)_6$ |
| *schlossmacherite* | $(H_3O,Ca)Al_3(S/AsO_4)_2(OH)_6$ |
| *segnitite* | $PbFe_3H(AsO_4)_2(OH)_6$ |
| *svanbergite* | $SrAl_3(PO_4(SO_4)(OH)_6$ |
| *weilerite* | $BaAl_3(AsO_4(SO_4)(OH)_6$? |
| *woodhouseite* | $CaAl_3(PO_4(SO_4)(OH)_6$ |
| *germanium-rich beudantite* | $\sim PbFe_3[(As/Ge)O_4]_2(OH)_6$: occurrence at Tsumeb, Namibia, **J Gutzmer B Cairncross** 2001 MR 32 305-7. |

See *alunite-jarosite*.

Nomenclature of *alunite* supergroup comprising *alunite*, *beudantite* & *crandallite* groups: **JL Jambor** 1999 CM 37 1323-42; *jvs: confusing nomenclature, read in detail!*

Reviiew: nomenclature & composition boundaries, **JL Jambor & 3 others** 1996 CM 34 1305-15.

**beudantite** $PbFe_3(SO_4)(AsO_4)(OH)_6$. Beudantite structure type. Review: **Sabelli** p. 25.

Structure: **K Walenta** 1966 TMPM 11 121-64; **J Szymanski** 1988 CM 26 923-32; **G Giuseppetti C Tadini** 1989 NJMM 27-33 (G770).

**beusite** $(Mn,Fe,Ca,Mg)_3(PO_4)_2$. *Graftonite* structure type.

Occurrence: MM 37 955.

Ca-free: **IM Steele & 3 others** 1991 AM 76 1985-9.

Ca-rich: **MA Wise FC Hawthorne P Cerny** 1990 CM 28 141-6.

In meteorites: **AE Rubin** 1997 MPS 32 231-47.

*Synthetic* $Mn_3(PO_4)_2$: **JS Stephens** 1967 Dissertation McMaster Univ, Hamilton, Canada.

**beyerite** $CaBi_2(CO_3)_2O_2$.

Structure: **A Lagercrantz LA Sillen** 1948 Arkiv Kemi Mineral Geol 25A no. 20 1-21 = MA 11-256; SC-XRD, **JD Grice** 2002 CM 40 693-8.

Occurrence: **C Frondel** 1943 AM 28 532;

**EW Heinrich** 1946 AM 31 198;
(Ca,Pb)-, Cumbria, **RSW Braithwaite G Ryback** 1995 J Russell Soc 6 51-2 = MA 96M/4915.

**bianchite** $(Zn,Fe)SO_4.6aq$. *Hexahydrite* structure group. Review: **Sabelli** p. 9.

Occurrence: MM 22 616.

**bicchulite** $Ca_2[Al_2SiO_6](OH)_2$. *Sodalite* structure type. Dimorphic with *kamaishilite*.

Structure: **K Sahl ND Chatterjee** 1977 ZK 146 35-41;
**K Sahl** 1980 ZK 152 13-21 1980;
MAS-NMR & neutron PD, **SE Dann PJ Mead MT Weller** 1996 IC 35 1427-8 (D581).

*Synthetic* gallo-, structure : **SE Dann PJ Mead MT Weller** 1995 AnCh 34 2414-6 (D562);
EXAFS/neutron PD, **N Binsted & 3 others** 1998 AC B54 558-63 (B1861);
synthesis, **MT Weller & 3 others** 1999 JMC 9 283-7 (W947).

**bideauxite** $Pb_3AgCl_3(F,OH)_2$.

Structure: **MA Cooper & 4 others** 1999 CM 37 915-21.

Occurrence: **SA Williams** 1970 MM 37 637-40.

**bieberite** $CoSO_4.7aq$. *Melanterite* structure type.

Structure determination not found, but probably done for *synthetic*.

*-mooorhouseite* equilibria at 0.1 MMa: **I Chou RR Seal II** 2005 AM 90 912-7.

Review: **Sabelli** p.9.

**biehlite** $(Sb,As)_2MoO_6$.

Structure: **G Adiwidjaja & 4 others** 2000 ZK 215 529-35 (A942).

Occurrence & structure description, monoclinic: **J Schluter & 4 others** 2000 NJMM 234-40 (S2179) = AM 86 197.

*Synthetic* triclinic $Sb_2MoO_6$, SC-XRD: **A Laarif F Theobald H Vivier** 1984 ZK 167 117-24.

**bigcreekite** $Ba_2Si_2O_5.2aq$. Double-chain 2-repeat silicate.

Occurrence & SC-XRD structure: **LC Basciano & 5 others** 2001 CM 39 761-8.

**bijvoetite-Y** $(Y,Dy)_2(UO_2)_4(CO_3)_4(OH)_6.11aq$.

Structure: SC-XRD, **Y Li PC Burns RA Gault** 2000 CM 38 153-62.

Occurrence: **M Deliens P Pieret** 1982 CM 20 231-8.

Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**bikitaite** $LiAlSi_2O_6.aq$. Zeolite family. IZA-SC code BIK.

Consortium for Theoretical Frameworks tetrahedral net 98.

Structure: **V Kocman RI Gait J Rucklidge** 1974 AM 59 71-8;
**G Bissert F Liebau 1986** NJMM no. 6 241-52; 1989 Z 9 303-11;
SC-XRD, IR, molecular dynamics, **S Quartieri & 6 others** 1999 MMM 30 77-87 (Q24);
XRPD to 9 GPa & molecular dynamics: **O Ferro & 5 others** 2002 AM 87 1415-25;
Raman 5 to 625 K, **BA Kolesov CA Geiger** 2002 AM 87 1426-31;
effect of P, **P Comodi GD Gatta PF Zanazzi** 2003 EJM 15 247-56;
dehydration, XRPD, **O Ferro & 6 others** 2004 AM 89 94-101, molecul dynamics, **C Ceriani & 6 others** 102-9.

Occurrence: MM 31 954.

[**bilibinite** Hydrated silicate of U, Pb and REE.

Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.]

**bilibinskite** $?Au_3Cu_2PbTe_2$. Compare with *rickardite* & *moschellandsbergite*.

Structure determination not found.

Occurrence: **EM Spiridonov et al.** AM 64 652.

**bilinite** $Fe^{2+}Fe^{3+}(SO_4)_4.22aq$. *Halotrichite* structure group? Review: **Sabelli** p.11.

Structure determination not found. Occurrence: Dana.

**billietite** $Ba[(UO_2)_6O_4(OH)_6.4aq$. *Becquerelite* structure group.

Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.

Structure: **MK Pagoaga DE Appleman JM Stewart** 1987 AM 72 1230-8.

Occurrence: MM 28 724-5.

Review: **V Baran M Unzeitig** 1991 NJMM 63-78 (B1358).

Crystal chemistry: NJMA 174 159-80 (C1076).

**billingsleyite** $Ag_7(Sb,As)S_6$.

Isostructural with *synthetic* Ag & Sb endmembers of $Ag_7(Sb,As)S_6$.

Occurrence: MM 37 955.
Revised data: **P Bayliss** 1990 CM 28 751-5.
**bindheimite** ~$PbSb_2O_6$. Various compositions quoted: ?because of chemical alteration.
Simple composition consistent with proposed membership in *stibiconite* group.
Structure determination not found.
Occurrence: Dana.
**biotite** $K(Mg,Fe)_3(Al,Fe)Si_3O_{10}(OH,F)_2$.
*Mica* structure type; trioctahedral subtype; 1M, 2M, $5M_1$ & 6A polytypes.
Structure: **MF Brigatti P Davoli** 1990 AM 75 305-13;
**MF Brigatti E Galli L Poppi** 1991 AM 76 1174-83;
microstructures, **S Bigi MF Brigatti** 1994 AM 79 63-72;
IR/Raman, Fe-F/Al-F avoidance, **B Boukili & 3 others** 2002 SMPM 882 549-59 (8719);
high T, NPD, **C Chon SA Kim H Moon** 2003 ClClM 51 519-28.
Periodic & nonperiodic stacking; $5M_1$ polytype: **H Xu DR Veblen** 1995 ClClM 43 159-73 (X12).
Activity-composition in Tschermak-substituted Fe-: **B Denisek & 4 others** 1996 CMP 125 85-99 (B525).
XAS; oxidation & deprotonation: **B Guttler W Niemann SAT Redfern** 1989 MM 53 591-602.
Oxidation state of Fe, XPS: **SP Raeburn ES Ilton DR Veblen** 1997 GCA 21 4519-30, 4531-7 (R801).
Fe/Mg order-disorder vs T: **JJ Reece & 4 others** 2002 PCM 29 562-71.
Crystal chemistry in granites: **MF Brigatti & 3 others** 2000 AM 85 436-48.
Planar defects in oxybiotite: **T Kogura M Nespolo** 2001 AM 86 336-40.
Radiohaloes: **L Nasdala & 4 others** 2001 AM 86 498-512.
Crystal chemistry from volcanic rocks & xenoliths: **K Righter & 5 others** 2002 AM 87 142-53.
Ti substitution: metapelites, **DJ Henry CV Guidotti** 2002 AM 87 375-82;
polymetamorphic gneiss, **DJ Waters NR Charnley** AM 87 383-96.
IR, analysis of ammonium: **V Busigny and 3 others** 2004 AM 89 1625-30.
Experimental weathering of biotite, *muscovite & vermiculite*, Mössbauer: **EA Ferrow** 2002 EJM 14 85-95 (6136).
Oxidized in weathering profile of Korean granite, EMPA, XRPD, TEM: **GY Jeong HB Kim** 2003 AM 88 352-64.
Dissolution, laboratory/Nature, SEM/TEM, *vermiculite*: **T Murakami & 3 others** 2003 AM 88 377-86.
Anisotropic Fe/Mg diffusion: **T Usuki** 2002 AM 87 1014-7.
Geochemistry in metabentonite: **RA Batchelor** 2003 MM 67 807-18.
Stability of biotite/*phenghite* in eclogite: **D Nakamura** 2003 CMP 145 550-67 (9325).
Ti-saturation surface in metapelitic: **DY Henry & 3 others** 2005 AM 90 316-28.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**biphosphammite** $(NH_4,K)H_2PO_4$. Isostructural with *synthetic* $KH_2PO_4$.
Structure: **AA Khan WH Baur** 1973 AC B29 2721-6.
**biraite-Ce** $Ce_2Fe(CO_3)(Si_2O_7)$.
Occurrence & SC-XRD structure: **A Konev & 9 others** A 2005 EJM 17 715-21 =AM 91 1201-2.
**biringuccite** $Na_2B_5O_8(OH).aq$.
Closely similar to *veatchite*, but I have not checked differences.
Structure: **E Corazza S Menchetti C Sabelli** 1974 AM 59 1005-15.
Occurrence: MM 33 1128.
**birnessite** $Na_4Mn_{14}O_{27}.9aq$.
Layered manganate with one water layer containing cations; many complications, including several symmetry types.
Structure: **JE Post DR Veblen** 1990 AM 75 477-89;
**K Kuma & 4 others** 1994 MM 58 425-47;
*synthetic*, XRPD structure, triclinic not monoclinic, **JE Post PJ Heaney J Hanson** 2002 PD 17 218-20 (218).
Commonest Mn mineral in soils with general formula near $Na_{0.1}Ca_{0.04}MnO_2.0.4aq$.
The relation to *rancieite* is unclear.
Compare with b*userite* with double water layer straddling cations.
Na-, K-, & Mg-derivatives.
Thermochemistry, framework/layer manganese dioxides: **S Fritsch & 3 others** 1998 ChM 10 474-9 (F596).
*Synthesis*, oxidation-deprotonation, HRTEM/IR/XRD: **DS Yang MK Wang** 2001 ChM 13 2589-94 (2900).
Oxidation of aqueous Cr(III) at surface, XPS: **D Banerjee HW Nisbet** 1999 GCA 63 1671-87(B1932).

Mn cycle in eutrophic lakes, formation of *H-birnessite* in Lake Sempath, Switzerland: **G Friedl B Wehrli A Manceau** 1997 GCA 61 275-90 (F539).
Interlayer aq vs cation exchange & structure stability: **EA Jphnson JE Post** 2006 AM 91 609-18.
Occurrence: MM 31 954.
*Clinobirnessite* is a variety.
See *hollandite*, *todorokite* & *cryptomelane*.
Many industrial applications in separation, catalysis, batteries (preferred cathode in rechargeable Li), sensors & electromagnetic materials (S1659).
*Synthetic* microporous OL-1 has this structure type: synthesis of thin films, **SR Segal SH Park SL Suib** 1997 ChM 9 98-104 (S1659).
*Synthetic*, effect of pH & Mn: **S Tu GJ Racz TB Goh** 1994 ClClM 42 321-30 (T550).
*Synthetic* $Na_{0.4}Mn_{2.15}O_2.0.6aq$: **Q Feng H Kanoh Y Miyai K Ooi** 1995 ChM 7 1226-?
*Synthetic* $Na_{0.32}MnO_2.x$ aq, ion-exchanged Li/K/Ag/Mg/Ca/Ba/Ni/Mn/Zn/Co: **P Le Goff & 3 others** 1996 MRB 31 63-75 (L702).
*Synthetic* K-: sol-gel, **S Ching JA Landrigan ML Jorgensen** 1995 ChM 7 1604-6 (C792);
hydrothermal, **Q Feng & 3 others** 1996 JMSL 15 963-5 (F504);
synthesis, **Q Feng K Yanagisawa N Yamasaki** 1997 JMSL 16 110-2 (F522);
structure modeling, **KL Holland JR Walker** 1996 ClClM 44 744-8 (H1156);
nanometer Mn oxides from intercalation of organic ammonium ions in OL-1, **Q Gao & 3 others** 2001 ChM 13 778-86 (1724).
*Synthetic* $K_xMnO_2.7aq$, 443 K: **R Chen P Zavalij MS Whittingham** 1996 ChM 8 1275-80 (C843).
Hydrothermal transform to tunnel structure: **Q Feng K Yanagisawa N Yamasaki** 1996 ChC 1607-8 (F507).
*Synthetic* H & organic-ammonium-, conversion to mesoporous $MnO_x$: **J Luo SL Suib** 1997 ChC 1031-2 (L840).
*Synthetic* monoclinic Na-rich & hexagonal, XRD/SAED/chemistry/EXAFS:
**VA Drits & 3 others** 1997 AM 82 946-61;
**E Silvester A Manceau VA Drits** 1997 AM 82 962-78.
*Synthetic* $Na_4Mn_{14}O_{27}.9aq$, effect of Mg/anions, relation to stability of *manganite*, *buserite* & *todorokite*: **J Luo SL Suib** 1997 JPCB 101 10403-13 (L929).
*Synthetic* 4-layer Ca-exchanged, substructure/superstructure: **VA Drits & 3 others** 1998 AM 83 97-118.
*Synthetic*, reduction by selenious acid, XPS: **D Banerjee HW Nesbitt** 2000 AM 85 817-25.
H-exchanged hexagonal, *synthesized* from Na-rich, XRD structure: **B Lanson & 3 others** 2000 AM 85 826-38.
Intercalation of tetraalkyl ammonium: **Z Liu & 4 others** 2000 La 16 4154-64 (L1049).
Enthalpy of formation of *synthetic* (Na/K/Mg) variants with *birnessite, buserite* & *todorokite* structure: **Z Tian & 4 others** 2000 JPCB 104 5035-9 (T648).
Radio-Sr/Cs/Co removal with Na- & K-: **A Dyer & 3 others** 2000 JMC 10 1867-74 (D808).
*Synthetic* Na-Mn-, XRPD: **L Liu Q Feng K Yanagisawa** 2000 JMS 19 2047-50 (995).
*Synthetic* Mn(II,III,IV)-, dissolution by humate, XPS: **D Banerjee HW Nesbitt** 2001 GCA 63 1703-14 (2056).
Mn(III) control on oxidation of phenol & sulfide: **PC Nico RJ Zasoski** 2001 EST 35 3338-43(2916).
*Synthetic* Cu/Zn/Pb-sorbed, EXAFS: **A Manceau B Lanson VA Drits** 2002 GCA 66 2639-63 (7793).
*Synthetic* Na-: triclinic, 1-layer, XRPD **B Lanson & 3 others** 2002 AM 87 1662-71;
heavy-metal sorbed, structure, XRPD, **B Lanson & 5 others** 1631-45;
ED, **VA Drits & 4 others** 1646-61.
*Synthesis*: by air oxidation, **J Cai J Liu SL Suib** 2002 ChM 14 2071-7 (7305);
by oxygen in alkali, **XH Feng & 3 others** 2004 ClClM 52 240-50 (10208).

[**birunite** Ca silicate,carbonate,sulfate. Occurrence: MM 32 946.]

**[bisbeeite?]**

**bischofite** $MgCl_2.6aq$.

Probably isostructural with *albrittonite* (Co-) & *nickelbischofite* (Ni-), but check details.
Structure: **KR Andress J Gundermann** 1934 ZK 87 345-69;
neutron, **PA Agron WR Busing** 1985 AC C41 8-10.

**bismite** $Bi_2O_3$.

Structure: see **Wells** p 711. [Not dimorphic with *sillénite*, which contains Si.]
Occurrence: see **ND Tolstykh & 4 others** 2000 EJM 12 431-40 (T641).

**bismoclite** BiOCl. *Matlockite* structure type from cell data.

Isostructural with *daubreíte* & *zavaritskite*.
Occurrence: MM 24 603.

*Synthetic* BiOBr: **J Kettere V Kramer** 1986 AC C42 1098-9.
**bismuth** Bi.
*Arsenic* subgroup of *tetradymite* mineral/structure group: **P Bayliss** 1991 AM 76 257-65.
Bismuth-2 at 2.6 GPa: **RM Brugger RB Bennion T Worlton** 1967 Phys Lett A24 714-7.
Microcrystallography: **EF Skelton & 7 others** 1991 S 253 1123-5 (S1804).
Bismuth: III & III', structure: **JH Chen H Iwasaki T Kikegawa** 1996 High Pressure Res 15 143-58 (C865);
IV, structure **do** 1997 JPCS 58 247-55(C945).
High pressure, review: **H Iwasaki T Kikegawa** 1997 AC B53 353-7 (I201).
**bismuthinite** $Bi_2S_3$. *Stibnite* structure group.
Complex series with *aikinite (A)* & *krupkaite (K)*, with *gladite (2B + 2K)*, *hammarite (4K + 2A)*, *lindstromite (8K + 2A), freidrichite (2K + 4A)* & *pekoite (4B + 2K)* as intermediates:
**C Danti & 4 others** 2001 NJMM 221-34 (1994);
**D Topa E Makovicky WH Paar** 2002 CM 40 849-69.
Structure: **V Kupcik L Veselá-Nováková** 1970 TMPM 14 55-9 (K741);
structure review, **WG Mumme E Welin BJ Wuensch** 1976 AM 61 15-20;
**A Pring** 1989 AM 74 250-5;
*synthetic* –stibnite series, SC-XRD, **A Kyono M Kimata** 2004 AM 89 932-40.
Solid solution with *stibnite*, energetics: **S Ghosal RO Sack** 1999 MM 63 723-33.
New 45 Å member, Febertal, Austria, $Cu_{1.6}Pb_{1.6}Bi_{6.4}S_{12}$, SC-XRD structure: **D Topa T Balic-Zunic E Makovicky** 2000 CM 38 611-6.
**bismutite** $(BiO)_2CO_3O_2$.
Structure: **A Lagercrantz LA Sillen** 1948 Ark Kemi Min Geol 25A no. 20 1-21 = MA 11-256;
SC-XRD, **JD Grice** 2002 CM 40 693-8.
**bismutocolumbite** $Bi(Nb,Ta)O_4$. *Columbite* structure.
Structure: **NV Zubkova & 9 others** 2002 NJMM 145-59 (7090);
3&10 GPa 296K, SC-XRD of symmetry change, **SS Karantsev & 6 others** 2002 ZK 217 543-9 (8711).
Occurrence: **IS Peretazhko & 4 others** 1992 ZVMO 121 130 = MM 60 525.
**bismutoferrite** $BiFe_2(SiO_4)_2(OH)$. Isostructural with *chapmanite*.
Structure: **AP Zhukhlistov BB Zvyagin** 1977 SPC 22 419-23 = MA 78-2718.
**bismutohauchecornite** $Ni_9Bi_2S_8$. *Hauchecornite* structure type. Inadequate description.
Occurrence: **J Just** 1980 MM 43 873-6 = AM 66 436.
**bismutomicrolite / bismuthmicrolite** $(Bi,Ca)(Ta,Nb)_2O_6(OH)$.
*Pyrochlore* structure type from cell data.
Occurrence: MM 32 946; **DD Hogarth** 1977 AM 62 403-10.
**bismutoniobite** $BiNbO_4$. Endmember of *bismutotantalite* $Bi(Ta,Nb)O_4$ series.
Definition: **G Frenzel** 1955 NJMM 243 = MM 31 954.
**bismutopyrochlore** $(Bi,U,Ca,Pb)_{1+x}(Nb,Ta)_2O_6(OH)$.n aq. *Pyrochlore* type.
Occcurrence, amorphous, IR: **NV Chukanov et al** 1999 ZVMO 128 36-41 = AM 85 1561.
**bismutostibiconite** $Bi(Sb,Fe)_2O_7$. *Stibiconite* structure type from cell data.
Occurrence: **K Walenta** 1984 AM 69 1190. MM 48 570.
**bismutotantalite** $Bi(Ta,Nb)O_4$. Isostructural with *stibiotantalite*.
Structure, SC-XRD, occurrence: **MA Galliski & 4 others** 2001 CM 39 103-10.
*Synthesis*: **RS Roth JL Waring** 1963 AM 48 1348-56.
Occurrence: MM 22 616.
[**biteplapalladite** $CdI_2$ structure type: iso with *biteplatinite* & *merenskyite*.
Structure: MA 76-2362.
?Unnecessary name: AM 61 1174.]
[**biteplatinite** $CdI_2$ structure type: iso with *biteplapalladite* & *merenskyite*.
Structure: MA 76-2362.
?Unnecessary name: AM 61 1174.]
**bityite** $CaLiAl_2(BeAlSi_2)O_{10}(OH)_2$. *Mica* structure type.
Structure: **J Lin S Guggenheim** 1983 AM 68 130-42. [= *bowleyite*: MM 28 725.]
Al XANES: **A Mottana & 6 others** 1997 AM 82 497-502.
**bixbyite** $(Mn,Fe)_2O_3$-alpha. Isostructural with *avicennite*. *Fluorite* derivative structure.

Relation to *braunite*, genealogy of *fluorite* derivatives: **PB Moore T Araki** 19976 AM 61 1226-40.
General theory: **DM Giaquinta H-C von Louye** 1994 ChM 6 365-72 (G672).
Structure: **M Marezio** 1966 AC 20 723-?;
**CT Prewitt & 3 others** 1969 IC 8 1985-?;
**W Hase & 4 others** 1969 ZK 129 360-4;
*synthetic* $Mn_{0.983}Fe_{0.017}$, **S Geller** 1971 AC B27 821-8.
Stacking variations & nonstoichiometry in *-braunite* polysomatic group: **JP de Villiers PR Buseck** 1989 AM 74 1325-36.
*Partridgeite* has lower Fe than bixbyite, & appears anisotropic: **J Gutzmer NJ Beukes** 1997 MM 61 213-31.
*Synthetic* $Y_2O_3$: MA 84M/3830.
*Synthetic* $Cu_2(Mn/Fe/Ga)SbO_6$: (B1172).
*Synthetic* $(Sc/In/Y/Yb/Dy/Ho/Sm/Gd)_2O_3$: electric field gradient, **A Bartos & 3 others** 1993 AC B49 165-9.
*Synthetic* $(In/Tl/Sc/Y/Ln)_2O_3$: **A Ramos-Gallardo A Vegas** 1995 JSSC 119 131-3 (R601).
*Synthetic* $Mg/Zn_3N_2$, antibixbyite structure: **DE Partin DJ Williams M O'Keeffe** 1997 JSSC 132 56-9 (P699).
*Synthetic* In-doped-Sn-oxide *Transparent Conducting Oxide* films are used in optoelectronic devices; HRTEM, SAED, EDS of analogous In-Zn *TCO* film revealed bixbyite & *wurtzite* structure types: **L Dupont & 4 others** 2001 JSSC 158 119-33 (2057).

**BJAREBYITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *bjarebyite* | $(Ba,Sr)(Mn,Fe,Mg)_2Al_2(PO_4)_3(OH)_3$ |
| *johntomaite* | $BaFe_2Fe_2(PO_4)_3(OH)_3$ |
| *kulanite* | $Ba(Fe,Mn,Mg)_2(Al,Fe)_2(PO_4)_3(OH)_3$ |
| *penikisite* | $Ba(Mg,Fe)_2Al_2(PO_4)_3(OH)_3$ |
| *perloffite* | $Ba(Mn,Fe)_2Fe_2(PO_4)_3(OH)_3$ |

**bjarebyite** $(Ba,Sr)(Mn,Fe,Mg)_2Al_2(PO_4)_3(OH)_3$. Bjarebyite structure type.
Structure: **PB Moore T Araki** 1974 AM 59 567-72.
Description: MM 39 907.
**blakeite** $Fe_2(TeO_3)_2$.
Structure determination not found, but may be one for synthetic.
Occurrence: Dana; **C Frondel FH Pough** 1944 AM 29 211.
[Also used for a titano-zirconate: MM 29 976.]
**blatonite** $UO_2CO_3$.aq.
Occurrence & XRPD: **R Vochten M Deliens** 1998 CM 36 1077-81.
**blatterite** $(Mn,Mg)_{35}(Mn,Fe)_9Sb_3(BO_3)_{16}O_{32}$.
6 Å Zigzag Borate. 8t8t polytype in *pinakiolite* structure family from cell.
Structure: **MA Cooper FC Hawthorne** 1998 CM 36 1171-93.
$Mg_{1.3}Mn_{1.4}Fe_{0.1}Sb_{0.2}$ relative, SC-XRD & HREM: **J-O Bovin & 3 others** 1996 ZK 211 440-8 (B1525).
Occurrence: **G Raade & 4 others** 1988 NJMM 121-36 (R561).
Modular interpretation of oxyborates: **BB Zvyagin GA Siderenko** 1995 AC B51 7-11 (Z87).
**bleasdaleite** $(Ca,Fe)_2Cu_5(Bi,Cu)(PO_4)_4(aq,OH,Cl)_{13}$.
Occurrence, XRD/ED ~= *richelsdorfite*: **WD Birch A Pring U Kolitsch** 1999 Australian J Mineral 5 69-75 = AM 85 1321.
**blende** see **zinc blende**
**blixite** $Pb_2Cl(O,OH)_2$.
XRPD supposed to match *nadorite*, but cell dimensions in **Roberts** do not.
Occurrence: **O Gabrielson A Parwel FE Wickman** 1960 Ark Mineral Geol 2 411-5 = AM 45 908.
**bloedite / blödite** $Na_2Mg(SO_4)_2$.4aq.
Isostructural with analogs *nickelbloedite* & *changoite* $Na_2Zn(SO_4)_2$.4aq =?*zincblödite*.
Review: **Sabelli** p.12.
Structure: **IM Romanova** 1960 SPD 3 19-22 (R508);
**IM Romanova GI Malitskaya** 1960 SPC 4 481-95;
**FC Hawthorne** 1985 CM 23 669-74;
**C Vizcayno MT Garcia-Gonzalez** 1999 AC C55 8-11 (V331).
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
*Synthetic* Zn: **M Giglio** 1958 AC 11 789-94 (G5).
*Synthetic* Co: **VI Bukin YuZ Nozik** 1975 SPC 20 180-2 (B1144) = MA 76-1443.

**blossite** $Cu_2V_2O_7$- alpha-low. Reconstructive transition to high-beta = *ziesite*.
*Synthetic*: **D Mercurio-Lavaud MB Frit** 1973 CRASP C 277 101-4;
**C Calvo R Faggiani** 1975 AC B31 603-5.
Occurrence & structure determination: **PD Robinson JM Hughes ML**
**Malconico** 1987 AM 72 397-400.
*Synthetic* gamma:
**bobfergusonite** $Na_2Mn_5FeAl(PO_4)_6$.
Structure: **TS Ercit FC Hawthorne P Cerny** 1986 CM 24 605-14;
refinement, **KT Tait & 3 others** 2004 CM 42 705-16.
Description: MM 52 722-3.
**bobierrite** $Mg_3(PO_4)_2.8aq$. *Vivianite* structure type: double b.
Structure: **S Takagi M Mathew WE Brown** 1986 AM 71 1229-33;
IR & Raman, **RL Frost & 3 others** 2002 MM 66 1063-72.
Occurrence in fertilizers: **JR Lehr & 4 others** 1966 Crystallographic Properties of Fertilizer
Compounds, Tenn Valley Auth Chem Eng Bull 6, 163p (L758).
**bobjonesite** $VO(SO_4).3aq$.
Occurrence, *synthesis*, structure: **M Schindler & 5 others** 2003 CM 41 83-90.
*Synthetic*: deuterium, ND structure, **M Tachez F Theobald AW Hewat** 1982 ACB 38 1807-9.
**bobkingite** $Cu_5Cl_2(OH)_8.2aq$.
Occurrence & SC-XRD structure:**FC Hawthorne & 4 others** 2002 MM 66 301-11.
**bobkovite** $\sim(K,etc)_{0.5}AlSi_{29}O_{60}$
Structure: **Yu V Kazitsyn** 1955 [A new mineral aluminum-alkaline opal - bobkovite] Sbornik
Kristallography = SR 1955 19 358-9. [jvs: cubic 12.1Å cell matches
$CaB_2O_4$ structure type = Consortium for Theoretical Frameworks net 853.]

[**bodenite** Aluminosilicate of Ca, $Fe^{2+}$ & REE.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.]
**boehmite / böhmite** AlO(OH). Isostructural with *lepidocrocite*.
Alpha type. Dimorphic with *diaspore* (gamma type).
Cation array, Al oxides/hydroxides/oxyhydroxides: **A Ramos-Gallardo A Vegas** 1996 ZK 211 299-303 (R665).
Structure: **GG Christoph & 3 others** 1979 ClClM 27 81-6;
**RJ Hill** 1981 ClClM 29 435-45;
**CE Corbató RT Tettenhorst GG Christoph** 1985 ClClM 33 71-5.
Surface: enthalpy, **J Majzlan A Navrotsky WH Casey** 2000 ClClM 48 699-707 (901);
ab initio, molecular dynamics: **P Raybaud & 5 others** 2001 JCa 201 236-46 (2901);
time-dependent speciation, oxalate, water interface: **K Axe P Persson** 2001 GCA 24 4481-92 (3791).
Thermal decomposition, IR: **JT Kloprogge HD Ruan RL Frost** 2000 JMS 37 1121-9 (7252).
Occurrence: MM 21 559.
Synthetic: MA 10-16.
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).
*Pseudo-boehmite* is poorly crystallized boehmite with water: **JJ Fitzgerald & 4 others** 1997 JAChS 119 7832-42 (F546).
Spectral reflectance, implications for Mars: **EA Cloutis JF Bell III** 2000 JGR 105 7053-70 (C1141).
*Synthetic* high-P delta-, XRPD structure: **A Suzuki E Ohtani T Kamada** 2000 PCM 27 689-93 (945).
Lanthanide(III) ions on pristine & phosphated surfaces, XAS/magnetics: **S Yoon & 3 others** 2002 La 18 10128-36 (8551).
*Synthetic* intermediate, XRPD, IR, XPS: **M Nguefack & 3 others** 2003 PCCP 5 4279-89 (9544).
**bogdanovite** $(Au,Te,Pb)_3(Cu,Fe)$. Composition uncertain: **P Bayliss** 1990 CM 28 751-5.
Structure not known.
Occurrence: **EM Spiridonov TN Chvileva** 1979 AM 64 1329.
**bøggildite** $Na_2Sr_2Al_2(PO_4)F_9$.
Structure: **FC Hawthorne** 1982 CM 20 263-70 (H721).
Occurrence: MM 30 729.
**boggsite** $Na_{3-5}Ca_{8-5}\ Al_{18.4}Si_{77.6}O_{192}.70aq$.
*Zeolite* mineral family. IZA-SC code BOG. Consortium for Theoretical Frameworks net 636.
Structure: **JJ Pluth JV Smith** 1990 AM 75 501-7;
SC-XRD, dehydration/rehydration, **S Zanadi & 3 others** AM 89 1033-42..
Occurrence in Antarctica: **E Galli & 3 others** 1995 EJM 7 1029-32 (G817).

**bobtrailllite** $(Na,Ca)_{13}Sr_{11}(Zr,Y,Nb)_{14}Si_{42}B_6O_{132}(OH)_{12}.12aq$.
Structural hybrid of *benitoite*, *catapleiite* & *wadeite.*
Occurrence & SC-XRD structure: **AM McDonald GY Chao** 2005 CM 43 747-58.
**bøgvadite** $NaSrBa_2Al_4F_{20}$. Structure not known.
Occurrence: **H Pauly OV Petersen** 1988 Bull Geol Soc Denmark 37 21 = AM 76 1728-9.
**bohdanowiczite** $AgBiSe_2$. Analog of *matildite*.
*Tsumoite* subgroup of *tetradymite* mineral/structure group: **P Bayliss** 1991 AM 76 257-65.
With *nevskite & watkinsonite*, Erzgebirge, **H Forster G Tischendorf D Rhede** 2005 CM 43 889-908.
*Synthetic*: **S Geller JH Wernick** 1959 AC 12 46-54.
Occurrence: Erzegebirge **H Förster & 2 others** 2005 CM 43 899-908 = AM 91 224;
Elatsite Porphyry **T Augé R Petrunov L Bailly** 2005 CM 43 1355-72 = AM 91 715.
**bokite** $KAl_3Fe_6V^{4+}{}_6V^{5+}{}_{20}O_{76}.30aq$.
*Vanadium bronze* structure family; *straczekite* subtype.
Review: **HT Evans Jr JM Hughes** 1990 AM 75 508-21.
Occurrence: MM 33 1128.
[**boksputite** $6PbO.Bi_2O_3.3CO_2$. Occurrence: MM 24 603.]
**boldyrevite** $NaCaMgAl_3F_{14}.4aq$. Occurrence: MM 29 977.
**boleite** $KPb_{26}Ag_9Cu_{24}Cl_{62}(OH)_{48}$. Epitactic growth with *cumengeite* & *pseudoboleite*.
Structure: incomplete, **RC Rouse** 1973 JSSC 6 86-92;
SC-XRD & IR, **MA Cooper FC Hawthorne** 2000 CM 38 801-8.
**bolivarite** $Al_2(PO_4)(OH)_3.4$-5aq. Compare with *evansite* & *vashegyite*. Amorphous.
Occurrence: **L Van Wambeke** 1971 MM 38 418-23;
CM 33 59-65;
**J Garci-Guinea AM Chagoyen EH Nickel** 1995 CM 33 59-65.
**boltwoodite** $K(UO_2)(SiO_4).aq$.
Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
Structure: **FV Stohl DK Smith** 1981 AM 66 610-25;
different unit cell & twinning, **H Strunz C Tennyson** 1981 SPC 732-5 (S1326);
SC-XRD, **PC Burns** 1998 CM 36 1069-75.
Occurrence: **C Frondel J Ito** 1956 S 124 931 = MM 31 954.
May be related structurally to Na analog *sodium boltwoodite* $(H_3O)(Na,K)(UO_2)SiO_4.aq$, but change of symmetry would imply distortion.
*Synthetic* Cs-exchanged, structure: **PC Burns** 1998 J Nuclear Materials proof (B1891).
**bombiccite** $C_{20}H_{34}$. Diterpene structure.
Structure: **EF Serantoni & 4 others** 1978 AC B34 1311-6 = MA 79- 3431.
**bonaccordite** $Ni_2FeBO_5$.
3 Å Zigzag Borate: **MA Cooper FC Hawthorne** 1998 CM 36 1171-93.
Occurrence: **SA De Waal EA Viljoen LC Calk** 1974 Trans Geol Soc S. Africa 77 373 = AM 61 502.
**bonattite** $CuSO_4.3aq$. Partly dehydrated *chalcanthite*. Review: **Sabelli** p. 11-2; (E289).
Structure: **RF Zahrobsky WH Baur** 1968 AC B24 508-13 (Z68).
*Chalcanthite*-bonattite equilibria: **I Chou RR Seal II BS Hemingway** 2001 AM 87 108-14.
Occurrence: MM 31 954.
**bonchevite** $PbBi_4S_7$ or $Pb_3Bi_2S_6$?
Statement in TMPM 13 149-56 1969 = AM 55 1449 that structure to be published, but not seen.
Occurrence: **I Kostov** 1958 MM 31 821-8 = AM 43 1221.
**bonshtedtite** $Na_3Fe(PO_4)(CO_3)$. Fe analog of *bradleyite* (Mg) & *sidorenkite* (Mn).
Description: **TLT Trinh & 3 others** 1984 Mineral Zh 6 79-84. MM 48 570.
Unnamed Sr relative has similar layers linked differently: **EV Sokolova AP Khomyakov** 1992 SPD 37 14-6 (S1278).
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).
[**boodtite** $5Co_2O_3.CuO.Fe_2O_3.11aq$.
Occurrence: MM 24 603-4.]
**boothite** $CuSO_4.7aq$.
*Melanterite* structure group from cell data, but full structure determination not seen. **Sabelli** p. 9.

Review: (E289).

**BORACITE STRUCTURE GROUP** Orthorhombic members include:

| | |
|---|---|
| *boracite* | $Mg_3B_7O_{13}Cl$ |
| *chambersite* | $Mn_3B_7O_{13}Cl$ |
| *ericaite* | $(Fe,Mg,Mn)_3B_7O_{13}Cl$ |

Boracites may have a phase change to higher symmetry.

*Congolite* $(Fe,Mg,Mn)_3B_7O_{13}Cl$ is trigonal.

Phase transition in the series *boracite-trembathite-congolite*: **PC Burns MA Carpenter** 1996 CM 34 881-92; 1997 CM 35 189-202.

XRPD: **PC Burns** 1995 PD 10 250-60 (B1620).

*Synthetic* orthorhombic-$Pca2_1$ $Co/Ni_3B_7O_{13}$: **F Kubel SY Mao H Schmid** 1992 AC C48 1167-70 (K745).

*Synthetic* $Cr_3B_7O_{13}Br$: **M Yoshida & 3 others** 1992 AC B48 30-2 (Y153).

*Synthetic* cubic $Cr_3B_7O_{13}I$: **A Monnier & 3 others** 1987 AC C43 1243-5.

*Synthetic* $Cr_3B_7O_{13}Cl$: **SY Mao & 3 others** 1991 AC B47 692-6.

*Synthetic* cubic $Cu_3B_7O_{13}I$: **IG Berset & 3 others** 1985 AC C41 1694-6 (B1383).

*Synthetic* trigonal $Fe_3B_7O_{13}Cl$: **M-E Mendoza-Alvarez & 3 others** 1985 AC C41 1551-2 (M1298).

*Synthetic* ferroelectric/elastic orthorhombic $Fe_3B_7O_{13}I$: **F Kubel A-M Janner** 1993 AC C49 657-9 (K764).

3 polymorphs *synthetic* $Li_4B_7O_{13}Cl$, not iso with boracite: **W Jeitschko TA Bither PE Bierstedt** 1977 AC B33 2767-75.

*Synthetic* $Cd_3B_7O_{13}OH$, XRPD structure: **U Werthmann & 3 others** 2000 ZK 215 393-6 (W1013).

**boracite** $Mg_3B_7O_{13}Cl$. Boracite structure type.

Structure: **T Ito N Morimoto R Sadanaga** 1951 AC 4 310-6;
**E Dowty JR Clark** 1972 Solid State Communications 10 543-8 (D188);
**do**., 1973 ZK 138 64-99;
boron K-edge XANES, **ME Fleet S Muthupari** 2000 AM 85 1009-21.

Cubic polytype, **S Sueno JR Clark JJ Papike** 1973 AM 58 691-7 (S1247).

Low-T heat capacity: **VM Gurevich & 4 others** 2000 GI 38 615-8 = Gk 676-9 (G1205).

**boralsilite** $Al_{16}B_6Si_2O_{37}$. Related to *sillimanite*.

Structure: SC-XRD, **DR Peacor RC Rouse ES Grew** 1999 AM 84 1152-61.

Occurrence: **ES Grew & 9 others** 1998 AM 83 638-51.

*Synthesis*, disorder: **B Pöter & 3 others** 1998 EJM 220 (P808).

**borax** $Na_2B_4O_5(OH)_4.8aq$.

Structure: **N Morimoto** 1956 MJJ 2 1-18 (M45) = MA14-105;
neutron **HA Levy GC Lisensky** 1978 AC B34 3502-10;
boron K-edge XANES, **ME Fleet S Muthupari** 2000 AM 85 1009-21.

**borcarite** $Ca_4MgB_4O_6(OH)_6(CO_3)_2$. Only borate with 4-ring of vertex-shared tetrahedra; these T share 3 vertices with Mg-octahedra to give $[MgB_4O_6(OH)_6]^{4-}$ rods.

Structure: **LP Solov'yeva** 1968 DAN 180 1453-6 = MA 71-887;
**NA Yamnova & 3 others** 1976 SPD 20 799-801 1976 (Y121);
**PC Burns FC Hawthorne** 1995 MM 59 297-304 (B1600).

Occurrence: MM 35 1128.

[**borickyite** Probably = *foucherite* = *delvauxite*: **F Cech P Povondra** 1979 TMPM 26 79-86.]

**borishankite** $\sim Pd_{1+x}(As,Pb)_2$. Cell data match *polarite* Pd(Bi,Pb) but not chemical ratio.

Occurrence: **LV Razin et al.** 1976 ZVMO 104 57-61 = AM 61 502-3.

**bornemanite** $Na_4BaTi_2NbSi_4O_{17}(F,OH).Na_3PO_4$.

Polysome of *seidozerite-lomonosovite* series; *bafertisite*-like heterophyllosilicate HOH layer.

Similar to *bykovaite* $NaBa\{(Na,Ti)_4(Ti,Nb)_2(OH,O)_3Si_4O_{14}](OH,F)_2\}.3aq$.

Structure: model matching XPD, **G Ferraris & 5 others** 2002 CM 39 1665-73.

The $Na_3PO_4$ is leachable ; $Na_4BaTi_2NbSi_4O_{17}F.4aq$ has similar XRPD indicating loss of phosphate & hydration.

Occurrence: **YuP Men'shikov et al.** 1976 ZVMO 104 322-6 = AM 61 338;
hyperagpaitic alkaline rocks: **Khomyakov** (1995).

**bornhardtite** $Co_3Se_4$.

Cell data match *linnaeite*; detailed structure determination not found.
Occurrence: **P Ramdohr M Schmitt** 1955 NJMM 133-42 (R536) = AM 41 164-5.

**bornite** $Cu_5FeS_4$.

Phase transition low- to intermediate at 473 K & to 1a-solid-solution at 538 K, revised phase diagram of *digenite*-, NPD: **BA Grguric A Putnis RJ Harrison** 1998 AM 83 1231-9; **BA Grguric RJ Harrison A Putnis** 2000 MM 64 213-31.

Structure: **AJ Frueh** 1950 AM 35 185-92;
polytypism, **N Morimoto G Kullerud** 1961 AM 46 1270-82 (M50);
**N Morimoto** 1964 AC 17 351-60 (M135);
**K Koto N Morimoto** 1975 AC B31 2268-73 1975 (K289);
**Y Kanazawa K Koto N Morimoto** 1978 CM 16 397-404 (K333);
**L Pierce PR Buseck** 1978 AM 63 1-16;
HRTEM, 4a & 6a superstructures, **Y Ding DR Veblen CT Prewittt** 2005 AM 90 1256-64; possible Fe/Cu ordering in 2a superstructure, **do** 1265-9.

*Synthetic* non-stoichiometric, Cu XAS & electronic structure: **RAD Pattrick & 3 others** 2004 AM 89 541-6.
Fresh & tarnished surface, XPS/Auger/Mössbauer: **DJ Vaughan JA Tossell C Stanley** 1987 MM 51 285-93 (V168).
Alteration, depth analysis, XPS/AES /RBS: **G Pratesi C Cipriani** 2000 EJM 12 397-409 (P889).
Reconstruction of fracture surfaces: **SL Harner & 3 others** 2005 43 1619-30.
S-rich: AM 49 1084-98.
Occurrence: with *idaite*, Belgium, **F Hatert** 2003 EJM 15 1063-8.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**borocookeite** $Li_{1+3x}Al_{4-x}(BSi_3)O_{10}(OH,F)_8$. *Chlorite* group.

Occurrence & XRPD: **VY Zagorsky & 4 others** 2003 AM 88 830-6.

**borodaevite** $[Ag_5(Fe,Pb)Bi_7]_{13}(Sb,Bi)_2S_{17}$.

Reassigned to $^{6}L$ or $^{4,8}L$ type of *lillianite* homologous series: **G Ilinca E Makovicky** 1997 ? 337-53 (I226).

Occurrence [& assignment to *pavonite* homologous series]: type $^{11}P$, **SN Nenasheva & 3 others** 1992 ZVMO 113-20 (N353).

[**boroleucite** $KBSi_2O_6$. *Synthetic* analog of *leucite*.]

**boromuscovite** $KAl_2BSi_3O_{10}(OH,F)_2$. *Mica* group; boron analog of *muscovite*.

Structure: XRPD refinement of mix of 1M & $2M_1$ polytypes, **J-J Liang & 3 others** 1995 CM 33 859-65.
*Synthesis* & stability: **I Jung W Schreyer** 2002 CMP 143 684-93 (8048).
Occurrence: **EE Foord & 4 others** 1991 AM 76 1998-2002.

[**boron-edenite** *Synthetic*: MM 31 955.]
[**boron-phlogopite** *Synthetic*: MM 31 955.]

**borovskite** $Pd_3SbTe_4$.

Structure determination not found.
Occurrence: **AA Yalovoi et al** 1974 ZVMO 102 427-31 = AM 59 873.

**bostwickite** $CaMn_6Si_3O_{16}.7aq$.

Structure determination not found.
Occurrence: **PJ Dunn PB Leavens** 1983 MM 47 387-9 (D634).

**botallackite** $Cu_2Cl(OH)_3$.

Trimorphic with *atacamite* & *clinoatacamite* & perhaps polymorphic with *paratacamite*.
Review: (E289).
Structure: **AA Voronova BK Vainshtein** 1958 SPC 3 445-51 = MA 15-262;
**FC Hawthorne** 1985 MM 49 87-9.
Synthesis: MM 53 557-63.
*Synthetic* $Cu_2I(OH)_3$: **P Chirvinsky** 1906 = MM 33 1138;
**HR Oswald** 1961 Helv Chim Acta 44 2102 = MM 33 1138.
*Synthetic* $Cu_2Br(OH)_3$: **F Aebi** 1948 Helv Chim Acta 31 369-75 = MA 10-534;
**HR Oswald** 1961 Helv Chim Acta 44 2103 = MM 33 1129.
*Synthetic* $Cu_2(OH)_3(CH_3COO).aq$, XRPD, intercalated water: **N Masciocchi & 5 others** 1997 JSSC 131 252-62.

**botryogen** $MgFe(SO_4)_2OH.7aq$. Review: **Sabelli** p. 15.

Structure: **P Süsse** 1968 AC B24 760-1.

**bottinoite** $Ni(aq)_6[Sb(OH)_6]_2$. Isostructural with *brandholzite* $MgSb_2(OH)_{12}.6aq$.

Structure: **P Bonazzi F Mazzi** 1996 AM 81 1494-500;
**A Friedrich & 3 others** 2003 AM 88 462-3.
Occurrence: **P Bonazzi & 3 others** 1992 AM 77 1301-4.
Occurrence in UK: MM 57 543-4.
*Synthetic* Mg- & Ni-antimoniate, structure model: **J Beintema** 1936 Proc Sect Sci Roy Acad Amsterdam 39 241-52.

**boulangerite** $Pb_5Sb_4S_{11}$. Relation to *falkmanite* is unclear.

Review **A Skowron ID Brown** 1994 AC B50 524-38 (S1374).
Structure proposal: **L Born E Hellner** 1960 AM 45 1266-71.
Structure: **IV Petrova & 5 others** 1979 SPD 23 630-3 = MA 80-0161;
**E Mumme** 1989 NJMM 498-52 (M1273);
**A Skowron ID Brown** 1990 AC C46 531-4.
See *guettardite*.
*Synthetic* $Pb_7Sb_4S_{13}$, higher homolog of boulangerite: **A Skowron & 3 others** 1994 JSSC 112 307-11 (S1494).
*Synthetic* boulangerite*, falkmanite &* Cu-free *meneghinite*, XRPD & stability: **KL Pruseth B Mishra H Bernhardt** 2001 EJM 13 411-9 (1996).

**BOURNONITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *bournonite* | $CuPbSbS_3$ |
| *seligmannite* | $CuPbAsS_3$ |
| *soucekite* | $CuPbBiS_3$ |

**bournonite** $CuPbSbS_3$.

Structure: **E Hellner G Leineweber** 1956 ZK 107 149-54;
**A Edenharter W Nowacki Y Takéuchi** 1970 ZK 131 397-417 (E114);
**VV Bakakin AA Godovikov** 1980 SPD 25 145-6 (B1113) = MA 81-2424.

**boussingaultite** $(NH_4)_2Mg(SO_4)_2.6aq$. *Picromerite* structure group.

Review: **Sabelli** p. 30.
Structure: **M Montgomery EC Lingafelter** 1964 AC 17 1478-81;
**TN Margulis DH Templeton** 1962 ZK 117 344-57.

**bowieite** $(Rh,Ir,Pt)_2S_3$.

*Synthetic*: **E Parthé D Hohnke F Hulliger** 1967 AC 23 832-40.
Solid solution with *kashirite* $Ir_2S_3$.
Occurrence: MM 56 125-6.

**boyleite** $(Zn,Mg)SO_4.4aq$. *Rozenite* structure type. Review: **Sabelli** p.12.

Structure: **K Walenta** 1978 CEr 37 73 = MM 43 1058.

**brabantite** $CaTh(PO_4)_2$. *Monazite* structure type from cell data.

Structure determination not seen.
Occurrence: **D Rose** 1980 NJMM 247-57.
See *cheralite* which lies halfway between brabantite & *monazite*.
*Monazite-cheralite-Ce*-brabantite ss, occurs Erzgebirge-Fichtelgeburge, Germany: **H Förster** 1998 AM 83 259-72.

**bracewellite** $CrO(OH)$. *Diaspore* structure type from cell data.

Trimorphic with *grimaldite* & *guyanaite*.
Structure determination not found.
Occurrence: **C Milton et al** 1976 USGS Prof Paper 887 1-29 = AM 62 593.

**BRACKEBUSCHITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *arsenbrackebuschite* | $Pb_2(Fe,Zn)(AsO_4)_2(OH,aq)$ |
| *arsentsumebite* | $Pb_2Cu(AsO_4)(SO_4)(OH)$ |
| *bearthite* | $Ca_2Al(PO_4)_2(OH)$ |
| *brackebuschite* | $Pb_2(Mn,Fe)(VO_4)_2(OH)$ |
| *bushmakinite* | $Pb_2(Al,Cu)(PO_4)[(V,Cr,P)O_4](OH)$. |
| *feinglosite* | $Pb_2(Zn,Fe)(AsO_4)_2.aq$ |
| *fornacite* | $Pb_2Cu(CrO_4)(PO_4)(OH)$ |
| *gamagarite* | $Ba_2(Fe,Mn)(VO_4)_2(OH,aq)$ |
| *goedkenite* | $Pb_2(Fe,Zn)(AsO_4)_2(OH,aq)$ |
| *tokyoite* | $Ba_2Mn(VO_4)_2OH$ |

*tsumcorite* (probably: check) $PbZnFe(AsO_4)_2.aq$

*tsumebite* $Pb_2Cu(PO_4)(SO_4)(OH)$

*vauquelinite* $Pb_2Cu(CrO_4)(PO_4)(OH)$

*Synthetic* $Na_2Cr(CrO_4)_2(OH)$ & $K_2Cr(CrO_4)_2(OH)$: **O Jonsson** 1970 Acta Chem Scand 24 3627-44.

**brackebuschite** $Pb_2(Mn^{3+},Fe^{3+})(VO_4)_2(OH)$.

Structure & revised formula: **JA Foley JM Hughes D Lange** 1997 CM 35 1027-33.
Occurrence: **DM Donaldson WH Barnes** 1955 AM 40 597-613 (D529).
Fe analog: AM 83 652.

**bradaczekite** $NaCu_4(AsO_4)_3$. *Alluardite* structure type.

Structure: SC-XRD, **SV Krivovichev SK Filatov LP Burns** 2001 ZVMO 130 1-7 (7818).
Occurrence: Tolbachik volcano, Kamchatka, **SK Filatov & 5 others** 2001 CM 39 1115-9.

**bradleyite** $Na_3MgPO_4CO_3$. Mg analog of *bonshtedtite* & *sidorenkite* from cell data.

Structure determination not found.
Occurrence: **JJ Fahey G Tunell** 1941 AM 26 646-50;
**JJ Fahey** 1962 USGS Prof Paper 405 34-5; MM 26 335.

*Synthetic* $Na_3Sr[PO_4](CO_3)$, not bradleyite structure: **EV Sokoleva AP Komyakov** 1992 DAN 322(3) 531-5.

**braggite** (Pt,Pd,Ni)S. Isostructural with *vysotskite*. Dimorphic with *cooperite*.
Structure: **JD Ghilds SR Hall** 1973 AC B29 1446-51.
Occurrence: MM 23 626.
*Synthetic* (Pd,Pt,Ni)S, Raman: **RWK Merkle & 3 others** 1999 MM 63 363-7.

**braitschite-Ce** $(Ca,Na_2)_7(Ce,La)_2B_{22}O_{43}.7aq$.

Structure determination not found.
Occurrence: **OB Raup et al** 1968 AM 53 1081-95.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**brammallite** $(Na,H_3O)(Al,Mg,Fe)_2(Si,Al)_4[(OH)_2,aq]$. *Mica* structure group.

Structure determination not found.
Occurrence: **FA Bannister** 1944 AM 29 73; MM 26 335.

**brandholzite** $MgSb_2(OH)_{12}.6aq$. Isotypic with Ni analog *bottinoite*.

Isostructural in general with *synthetic* Mg/Co/Cu.
Structure: **A Friedrich & 3 others** 2000 AM 85 593-9;
**do** 2003 62-3.
Occurrence: **A Friedrich & 2 others** 1998 Mitt Österreich Mineral Ges 143 276-8 = MA 99M/1995.

**brandtite** $Ca_2Mn(AsO_4)_2.2aq$. *Roselite* structure group.

Dimorphic with *parabrandtite* in *fairfieldite* group.
Structure: **B Dahlman** 1952 Ark Mineral Geol 1 339-66 = MA 12-95;
**C Hejny & 3 others** 1997 EJM 9-1 Suppl 150 (H1247).

**brannerite** $(U,Ca,Y,Ce)(Ti,Fe)_2O_6$. Isostructural with *thorutite*.

Structure: **R Ruh AD Wadsley** 1966 AC 21 974-?;
refinement, **JT Szymanski JD Scott** 1982 CM 20 271-9.
*Synthetic*, crystallography, **JE Patchett EW Nuffield** 1960 CM 6 483-90.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
*Synthetic* (Li/Na)$VMoO_6$ & $KV_{0.8}Mo_{1.2}O_6$: **J Galy B Darriet** 1967 CRASP C 264 1477-?;
topotactic reduction by H, **J Kopalkrishnan & 3 others** 1997 JMC 7 307-10 (G891).
*Synthetic* $CuV_2O_6$: **C Calvo D Manolescu** 1973 AC B29 1743-5.
*Synthetic* $NaVMoO_6$: MA 69-1068.
*Synthetic* (Na/Ag/K/Rb/Cs/$NH_4$)$Mo_{5.3}H_3O_{18}$: **EM McCarron III DM Thomas JC Calabrese**1987 IC 26 371.
*Synthetic* $Cd_{0.73}Cu_{0.27}V_2O_6$: **S Münchau H Müller-Buschbaum** 1994 ZN 49b 927-30 (M1338).
*Synthetic* $Na_{0.13}(V_{0.13}Mo_{0.87})O_3.n$ aq: **Y Hu PK Davies** 1995 JSSC 119 176-90 (H1027).
*Synthetic* Y-doped: XR&NPD structure, **M James ML Carter JN Watson** 2003 JSSC 174 329-33 ((324).
Crystal chemistry and stabilization in air: **ER Vance & 4 others** 2001 JACeS 84 141-4 (917).
Minor component of Synroc ceramics for immobilization of nuclear waste.

**brannockite** $KLi_3Sn_2Si_{12}O_{30}$. *Osumilite* structure type.

Structure: **T Armbruster R Oberhänsli** 1988 AM 73 595-600. MM 39 907.
[$KLi_3Ti_2Si_{12}O_{30}$. IMA 96-041. Analog of *brannockite*.]

**brass-alpha** $Cu_{1.0\text{-}0.9}Zn_{0.0\text{-}0.1}$. Compare *copper*.

Description: **AH Clark RH Sillitoe** 1979 AM 55 1019-21.
Cubic closest-packed crystal structure inferred from phase diagram of synthetic Cu-Zn system.
XRPD: **JHL Voncken TW Verkroost** 1997 PD 12 228-9 (V354).
Corrosion of ammunition shells in Halifax harbor to *atacamite/copper/cuprite/djurleite hydrozincite/spertinite* & unidentified similar to *connellite*: **P Stoffyn-Egli DE Buckley JAC Clyburne** 1998 AG 13 643-50 = MA 99M/0314.

[**beta-brass**: structure type. See above.]

**brassite** $MgHAsO_4.4aq$.

Structure: **J Protas R Gindt** 1976 AC B32 1460-6.
Dehydration product of *roesslerite*. MM 39 907.

**BRAUNITE STRUCTURE GROUP.** Includes:

| | |
|---|---|
| *abswurmbachite* | $CuMn_6[O_8SiO_4]$ |
| *braunite* | $MnMn_6SiO_{12}$ |
| *neltnérite* | $CaMn_6SiO_{12}$ |
| *unnamed Mg-rich mineral* | [**SJ Cotkin** 1989 NJMM 201-11] |

**braunite** $Mn^{2+}Mn^{3+}{}_6SiO_{12}$. Braunite structure type.

Structure: **A Bystrom** 1943 Ark Kemi Min Geol 16B no. 15 = MA 9-44;
**JPR de Villiers** 1975 AM 60 1098-104;
**PB Moore** 1976 AM 61 1226-40;
**I Abs-Wurmbach G Amthauer** 1988 ZK 184 13-30;
magnetic, NPD, 1.4 to 300 K, **S Ohmann & 4 others** 1998 ZK 213 19-27 (O375).
Pressure dependence to 8 GPa: **R Miletich DR Allan RJ Angel** 1998 PCM 25 183-92 (M1620).
Alteration of ore: **P Marescotti ML Frezzotti** 2000 EJM 12 341-56.
Braunite-II: **JPR deVilliers** 1980 AM 65 756-65; MM 39 907.
*Bixbyite*-braunite polysomatic series, **JPR de Villiers PR Buseck** 1989 AM 74 1325-6.
Three composition types at Postmasburg, South Africa: **J Gutzmer NJ Beukes** MM 61 213-31.
Mg/Fe/(Cu + Ti)/Cu-, magnetic phase diagram: **I Abs-Wurmbach & 5 others** 2002 PCM 29 280-90 (7760).

[**bravoite** (discredited = *nickeloan pyrite*, MR 30 174) $(Ni,Fe)S_2$. *Pyrite* structure type.
Structure: **P Bayliss** 1989 AM 74 1168-76.]

**brazilianite** $NaAl_3(PO_4)_2(OH)_4$.

Structure: **BM Gatehouse BK Miskin** 1974 AC B30 1311-7.
Occurrence: MM 27 267.

**bredigite** $Ca_2SiO_4$-alpha-prime. Related to *glaserite* (= *aphthithalite*) & *larnite*.

Occurrence: MM 28 725.
Composition also listed as $(Ca,Ba)Ca_{13}Mg_2Si_8O_{32}$.
*Synthetic* $Ca_2SiO_4$-alpha-prime: **PB Moore T Araki** 1976 AM 61 74-87.
*Synthetic* $Ca_2SiO_4$-alpha in cement, structure: **L Heller** 1952 AC 5 724-8 = MA 12-335. [jvs: caution with this complex phase which may display further complexities.]
[$Ca_2SiO_4$ occurs as >6 types: gamma (*olivine*); beta (*larnite*, deformed low $K_2SO_4$ type); alpha (hexagonal, *glaserite* = high $K_2SO_4$ type); alpha-low (several orthorhombic derivatives including analog of *bredigite*) and high-pressure ($K_2NiF_4$): summary of complex literature, **C Remy F Guyot M Madon** 1995 PCM 22 419-27 (R608).
New *synthetic* monoclinic: **M Miyazaki & 4 others** 1998 JACeS 81 1339-43 (M1634).
Phase transformations, R: **C Remy B Reynard M Madon** 1997 JACeS 80 413-23 (R707).
New phase *chi*-: **H Toraya S Yamazaki** 2002 AC B58 613-21 (7821).]

**breithauptite** NiSb. *Niccolite* structure group.
Structure determination not found.
Occurrence: Dana.

**brendelite** $(Bi,Pb)_2FeO_2(OH)(PO_4)$. Related to *namibite*.

Occurrence & SC-XRD structure: **W Krause & 3 others** 1998 MP 63 263-77 (K1131).

**brenkite** $Ca_2(CO_3)F_2$.

Structure: **U Leufer E Tillmanns** 1980 TMPM 27 261-6 (L644).
Occurrence: MM 43 1058.
*Synthetic* $Pb_2CO_3F_2$: **B Aurivillius** 1963 Acta Chem Scand A37 159-71 (A589).

**brewsterite** $(Sr,Ba)Al_2Si_6O_{16}.5aq$. *Zeolite* family.

IZA-SC code BRE. Consortium for Theoretical Frameworks net 591.
Enumeration of 4-connected nets containing bru unit: **A Alberti** 1979 AM 64 1188-93.
Structure: **AJ Perrotta** AC 17 857-62 1964;
**JL Schlenker JJ Pluth JV Smith** 1977 AC B33 2907-10 (S1492);
neutron, **G Artioli JV Smith Å Kvick** 1985 AC C41 492-7 (A640);
growth sectors & order-disorder, **M Akizuki** 1987 AM 72 645-8;
growth sectors, **M Akizuki Y Kudoh T Kuribayashi**1996 AM 81 1501-6;
multiple cation sites in dehydrated, in-situ XRPD, **K Stahl JC Hanson** 1999 32 147-58 (S2110);
dehydration mechanism, SC-XRD, **M Sacerdoti G Vezzalini S Quartieri** 2000 MMM 41 107-18 (459).
Phase transformation upon heating, new 4- & 5-coordinated Si/Al: **A Alberti & 3 others** 1999 PCM 26 181-6 (A876).
Rehydration, reversible T-O-T breaking & T cation return: **A Alberti & 4 others** 2001 MMM 42 277-87 (984).
*Synthetic* analog CIT-4: **S Khodabandeh G Lee ME Davis** 1997 MiM 11 87-95.
Ba-analog, occurrence: **GW Robinson JD Grice** 1993 CM 31 687-90;
structure, **R Cabella & 4 others** 1993 EJM 5 353-60;
possible occurrence at Kongsberg, Norway, MR 32 197.

**brezinaite** $Cr_3S_4$. Occurrence: MM 37 956.

In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**brianite** $Na_2CaMg(PO_4)_2$. *Merwinite* structure type.

Structure: **PB Moore** 1975 AM 60 717-8;
XRPD, **J Maixner H Hejdová** 1996 AC A52 Suppl C-318.
Occurrence: MM 36 1149.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**brianyoungite** $Zn_{12}(CO_3)_3(SO_4)(OH)_{16}$.

Layer structure similar to *hydrozincite* but with different layer repeat.
Occurrence: **A Livingstone PE Champness** 1993 MM 57 665-70.

**briartite** $\sim Cu_2(Zn,Fe)GeS_4$. *Chalcopyrite* structure type.

Structure determination not seen.
New composition data: **NN Mozgova & 4 others** 1994 DAN 335 780-3 = AM 80 849.
Orthorhombic & Cu-mineral with similar composition: **SN Nanasheva LA Pautov** 2002 ZVMO 4 84-92.
Occurrence: MM 35 1129.
*Synthesis*: **R Ottenburghs H Goethals** 1972 BSFMC 95 458-63.
[$Cu_2CdGeS_4$. IMA 96-050. Analog of briartite.]

**brindleyite** $(Ni,Mg,Fe)_3Al(Si,Al)O_5(OH)_4$. *Kaolinite-serpentine* group.

Occurrence: **Z Maksimovic DL Bish** 1978 AM 63 484-9. MM 42 522.

**brinrobertsite** $(Na_{0.2}K_{0.1}Ca_{0.1})(Al_{3.8}Mg_{0.1}Fe_{0.1})(Si_{7.8}Al_{0.2})O_{20}(OH)_4.3.5aq$.

Ordered, mixed-layer, dioctahedral *pyrophyllite-smectite*.
Occurrence, XRPD, TEM: **H Dong & 3 others** 2002 MM 66 605-17.

**britholite-Ce** $(Ce,Ca,La,\text{etc})_5(Si,PO_4)_3(OH,F)$. *Apatite* structure group.

Structure: **D Li P Wang J Liu** 1981 J Chinese Silicate Soc 9 422-32;
**N Kalsbeek S Larsen JG Ronsbo** 1990 ZK 191 249-63;
SC-XRD, **R Oberti & 3 others** 2001 AM 86 1066-75.
Sr-: **EA Genkina YuA Malinovskii AP Khomyakov** 1991 SPC 36 14-21.
Ce: **DC Noe & 4 others** 1993 ZK 206 233-?.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
*Hellandite* intergrowth: **G Della Ventura & 5 others** 1999 EJM 11 843-54.
Occurrence in meteorites: **AE Rubin** 1997 MPS 32 733-4.
*Synthetic* $(Ca/Sr/Ba/Pb/Mn/Ca)_4(Ln,Y)_6Si_6O_{24}(OH)_2$ & $(Na,Li)_2(Ln,Y)_5Si_6O_{24}(OH)_2$ & $Na_2Ca_x(Ln,Y)_{8-x}Si_{6-x}P_xO_{24}(OH)_2$: **J Ito** 1968 AM 53 890-907.
*Synthetic* Na-REE-Si: **JM Hughes AN Mariano JW Drexler** 1992 NJMM 311-9 (H975).
*Synthetic* Nd-substituted, SC-XRD structure: **L Boyer & 3 others** 1998 AC C54 1057-9 (B1846).

**britholite-Y** $(Y,Ca)_5(Si,PO_4)_3(OH,F)$. *Apatite* structure group.
Structure: **DC Noe & 4 others** 1993 ZK 206 233-46 ;
**J-H Zhang F Ze L-B Liao** 1994 J Rare Earths 12 130-7 (Z83).
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
Solid solution with *hydroxylapatite*: **J Ito** 1968 AM 53 890-907.
*Synthesis* of F-free *hydroxylapatite*-britholite-Y series: **J Imbach & 4 others** 2002 AM 87 947-57.
**brizziite** $NaSbO_3$. *Ilmenite* structure type.
Structure: **F Olmi C Sabelli** 1994 EJM 6 667-72 (O259).
**brochantite** $Cu_4SO_4(OH)_6$. Review: Sabelli, p. 26.
Structure: **G Cocco F Mazzi** 1958 PM 28 121-49;
revised in monoclinic, **M Helliwell JV Smith** 1997 AC C53 1369-71 (H1263);
OD character & polytypism, **S Merlino N Perchiazzi D Franco** 2003 EJM 15 267-76.
IR & Raman spectroscopy & H bonding: **M Schmidt HD Lutz** 1993 PCM 20 27-32 (S1862).
Raman vs OH: **RL Frost & 4 others** 2004 AM 89 1130-7.
**brockite** ~$(Ca,Th,Ce)PO_4$.aq. Series with *ningyoite*. *Rhabdophane* group from cell data.
Occurrence: **FG Fisher R Meyrowitz** 1962 AM 47 1346-55.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**brodtkorbite** $Cu_2HgSe_2$.
Occurrence & SC-XRD: **WH Paar & 5 others** 2002 CM 40 225-37.
[**brokenhillite** $(Mn,Fe)_{32}[Si_{21}O_{60}](OH)_{29}Cl_{11}$.
Supposed member of *pyrosmalite* group. MM 54 661. Not approved by IMA.]
[**bromapatite** *Synthetic* (E340).]
**bromargyrite** AgBr. *Halite* structure type. Not looked for specific paper.
**bromellite** BeO. *Wurtzite* structure type.
Structure: **TM Sabine S Hogg** 1969 AC B25 2254-6;
*synthetic*, neutron & gamma-ray, **JW Downs FK Ross GV Gibbs** 1985 AC B41 425-31;
high P & T, **RM Hazen LW Finger** 1986 JAP 59 3728-33 (H620);
**G Vidal-Valat JP Vidal K Kurki-Suonio** 1987 AC A43 540-50.
Occurrence: MM 21 559.
**bronze-nu-prime** $Cu_6Sn_5$.
Occurrence: **AH Clark** 1972 NJMM 108 = MM 39 908.
**brookite** $TiO_2$. Polymorphic with *rutile* & *anatase*.
Structure: **L Pauling JH Sturdivant** 1928 ZK 68 239-56;
**WH Baur** 1961 AC 14 214-6 (B1925).
High-T to 908 K: **EP Meagher GA Lager** 1979 CM 17 77-85 (M1755).
High-P: converts to alpha-$PbO_2$ type, **PY Simons F Dachille** 1967 AC 23 334-66.
P-T anatase/brookite/rutile, & $TiO_2$-II (α-$PbO_2$ type): **F Dachille PY Simons R Roy** 1968 AM 53 1929 (D784).
Nanoparticles from thermolysis $TiCl_4$ in acid: **A Pottier & 4 others** 2001 JMC 11 116-21 (1685).
Nb,Fe-rich, Namibia: **M Werner NJ Cook** 2001 MM 65 437-40.
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).
**brownmillerite** $Ca_2(Al,Fe)_2O_5$. 2-connected octahedral-tetrahedral net: Consortium for Theoretical Frameworks net 1098. Matches *srebrodol'skite* $Ca_2Fe_2O_5$.
First description: MM 26 335.
*Synthetic* $Ca_2Fe_1Al_1O_5$: **EF Bertaut P Blum A Sagnieres** AC 12 149-59 (B1349).
Discontinuous Fe,Al solid solution: **DK Smith** 1962 AC 15 1146-52 (S1441);
**AA Colville S Geller** 1971 AC B27 2311-5 (C695).
Mg and Ti substitution: **M Ecker H Pöllmann** 1996 Ber Deutsch Mineral Ges EJM 8 48.
*Synthetic* $Ca_2Fe_{1.4}Al_{0.6}O_5$: **AA Colville S Geller** 1972 AC B28 3196-200.
*Synthetic* $(Ca_{0.82}Pr_{0.18})Co[Co_{0.65}Al_{0.35}]O_5$: **JY Lee JS Swinnea H Steinfink** 1991 AC C47 1532-4 (L665).
*Synthetic* $Ca_2Al_xFe_{2-x}O_5$: **GY Kim SK Roh CH Yo** 1995 Bull Korean Chem Soc 16 934-8;
SC& XRPD structure 298-1273 K, **GJ Redhammer & 3 others** 2004 AM 89 405-20.
*Synthetic* $La_2Co_2O_5$, structure/magnetics: **OH Hansteen H Fjellvåg BC Hauback** 1998 JSSC 141 411-7 (H1144).
Doped Ca ferrite, growth/cation distribution: **V Kahlenberg RX Fischer** 2000 EJM 12 129-35 (K1234).

High-P $Ca_2Al_2O_5$, XRPD structure: **V Kahlenberg RX Fischer CSJ Shaw** 2000 AM 85 1061-5.
*Synthetic* Mg,Si doped, XRD&NPD structure, change during hydration: **AC Jupe & 5 others** 2001 JAC 34 55-61 (1267).
*Synthetic* $CaAlGaO_4/Ca_2Al_2O_5$, SC-XRD structure: **V Kahlenberg CSJ Shaw** 2001 JSSC 157 62-7 (1720).
*Synthetic* $Ca_2MnGaO_{5+x}$, SC-XRD structure: **AM Abakumov & 9 others** 2001 JSSC 158 100-11 (1663).
*Synthetic* $Sr_2MnGaO_5$, ED/EM: **AM Abakumov & 5 others** 2003 JSSC 174 319-28 (9323).
*Synthetic* $Ca_2Co_{1.6}Ga_{0.6}O_5$: **SYa Istomin & 3 others** 2004 JSSC 177 4251-7 (10879).
Environmental SEM of hydration: **N Meller C Hall J Crawshaw** 2004 JMS 39 6611-4 (10952).
Occurs in Portland cement, for which the nature of hydration depends on chemistry and T.

**BRUCITE STRUCTURE GROUP OF HYDROXIDES** Includes:

| | | |
|---|---|---|
| *amakinite* | $Fe,Mg(OH)_2$ | |
| *brucite* | $Mg(OH)_2$ | |
| *portlandite* | $Ca(OH)_2$ | |
| *pyrochroite* | $Mn(OH)_2$ | |
| *theophrastite* | $Ni(OH)_2$ | |
| [*transvaalite* | $Co(OH)_2$] | MM 32 983-4: no natural occurrence.] |

Topologically related to $CdI_2$ structure type: *berndtite* $SnS_2$, & *melonite* group of tellurides:
*melonite* $NiTe_2$, *moncheite* $PtTe_2$, *merenskyite* $PdTe_2$.
*Synthetic* $Co(OH)_2$, amorphic 11 GPa: **JH Nguyen MB Kruger R Jeanloz** 1997 PRL 78 1936-8 (N429).
*Synthetic* (Cd/Cu)OHCl, relation to brucite, SC-XRD structure, H-bonding: **Y Cudennec & 3 others** 2000 JSSC 151 308-12 (C1146).
Molecular dynamics model: **RJ Kirkpatrick AG Kalinichev J Wang** 2005 MM 69 289-308.
**brucite** $Mg(OH)_2$. Structure: early papers to search.
Structure: 7GPa 793 K, NPD, deuterated, **Y Le Godec & 14 others** 2001 MM 65 737-48.
NPD: **F Zigan R Rothbauer** 1967 NJMM 137-43;
>10 GPa, **JM Besson & 5 others** 1992 Physica B 180 & 181 907-10.
to 9.3 GPa, **JB Parise & 4 others** 1994 AM 79 193-6 (P533);
**D Partin & 3 others** 1994 JAC 27 581-4;
to 11 GPa, **M Catti & 3 others** 1995 PCM 22 200-6 (C788).
SC-ND at RT & 70K: **L Desgranges G Calvarin G Chevrier** 1996 AC B52 82-6 (D571).
Thermal expansion: **SAT Redfern BJ Wood** 1992 AM 77 1129-32;
at high-P, **H Fukui & 3 others** 2003 PCM 30 511-6.
XRD to 14 GPa: **TS Duffy & 3 others** 1995 PCM 22 277-81 (D555).
XRPD to 18 GPa, compression mechanism: **T Nagai T Hattori T Yamanaka** 2000 AM 85 760-4.
NMR: **DD Elleman DD Williams** 1956 J Chem Phys 25 742-4 = MA 13-490.
Raman: **TS Duffy 4 others** 1995 AM 80 222-30.
Polarized IR & interlayer proton transfer to 5 GPa: **K Shinoda N Aikawa** 1998 PCM 25 197-202 (S1895).
SC-Brillouin spectroscopy & powder P-V-T to 11 G Pa 873K: **X Xia DJ Weidner H Zhao** 1998 AM 83 68-74.
Vibration spectroscopy & molecular simulation: **PS Braterman T Cygan** 2006 AM 91 1188-200.
Dehydration: & molar volume to 15 GPa, **MC Johnson D Walker** 1993 AM 78 271-84 (J289);
static compression to 78 GPa, **Y Fei H Mao** 1993 JGR 98 11875-84 (F560);
to porous *periclase*, TEM/EXELFS/ELNES: **PA van Aken F Langenhorst** 2001 EJM 13 329-41 (2134);
fine structure up to 3.5 Gpa, anomalous PVT behavior, **PW Mirwald** 2005 EJM 17 537-42;
high-P proton disorder, quantum theory, **M Mookherjee L Stixrude** 2006 AM 91 127-34.
Dissolution, pH 2.5-12, 298 K, mixed-flow reactor, : **OS Pokrovsky J Schott** 2003 GCA 68 31-45 (9653).
Gamma-irradiation vs structure & thermal decomposition: **AP Shpak & 5 others** 2003 PCM 30 59-65.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**brüggenite** $Ca(IO_3)_2.aq$. Check for synthetic structure.
Occurrence: **ME Mrose GE Ericksen JW Marinenko** AM 57 1911;
**GE Ericksen et al.** 1974 J Res USGS 2 471-8.
**brugnatellite** $Mg_6FeCO_3(OH)_{13}.4aq$.
Brief structure reference: **HFW Taylor** 1973 MM 69 377 (T186).
Occurrence: Dana.
**brunogeierite** $Fe_2GeO_4$. *Spinel* structure.
Structure: **MD Welch MA Cooper FC Hawthorne** 2001 MM 65 441-4.

Occurrence: **J Ottemann B Nube** 1972 NJMM 263-7.

**brushite** $CaH(PO_4).2aq$. *Gypsum* structure group.

Structure: **CA Beevers** 1958 AC 11 273-7 (B1438);
**DW Jones JAS Smith** 1962 JCS I 1414-20;
**TS Margulis DH Templeton** 1962 ZK 117 344-57;
**NA Curry DW Jones** 1971 J Chem Soc A 3723-9 = MA 72-949;
calculated, **CI Saínz-Diaz & 2 others** 2004 AM 89 307-13;
NPD, 4-470 K, **PF Schofield 3 others** 2004 PCM 31 606-24 (10893).

Proton: magnetic resonance, **DW Jones JAS Smith** 1960 Trans Faraday Soc 56 638-47;
mobility from IR and quasi-elastic neutron scattering: **L Tortet & 3 others** 1997 JSSC 132 6-16 (T540).

*Synthetic*, correct polarity: **F Abbona & 3 others** 1994 NJMA 171-84 (A583).

Occurrence: **JR Lehr & 4 others** 1966 Crystallographic Properties of Fertilizer Compounds, Tenn Valley Auth Chem Eng Bull 6, 163p (L758);
bat guano, cave, Rumania, **D Dumitras & 2 others** 2004 NJMA 180 45-64 (10336);
Romania guano & cell dimensions: **S Marincea & 3 others** 2004 NJMA 464-8 (10913).

**buchwaldite** $NaCaPO_4$. Structure determination not found.

Occurrence: **E Olsen et al** 1977 AM 62 362-4.
Found in fertiliser. MM 42 522.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**buckhornite** $AuPb_2BiTe_2S_3$.

Electron diffraction: **Z Johan & 3 others** 1994 CRASP II 318 1225-31 (J257).
*Synthetic*, SC-XRD structure **H Effenberger & 3 others** 2000 ZK 215 10-6.
Occurrence: **CA Francis & 5 others** 1992 CM 30 1039-47.

**buddingtonite** $(NH_4)AlSi_3O_8$. *Feldspar* type. See Feldspar database.

Presence of 0.5aq is discredited. Early papers not listed.
Structure: **JHL Voncken & 3 others** 1993 AM 78 204-9;
IR/XRPD, H/deuterated: **DE Harlov M Andrut B Oeter** 2001 PCM 28 188-98 (1634)
NPD 11-280 K, **M Mookherjee & 3 others** 2004 PCM 31 643-9 (10894).
Enthalpy of formation: **GL Hovis D Harlov M Gottschalk** 2004 AM 89 85-93.
Occurrence: MM 35 1129.
Gibbs free energy: **UK Mäder & 3 others** 1996 EJM 8 755-66 (M 416).

**buergerite** $NaFe_3Al_6Si_6B_3O_{30}F$. *Tourmaline* type.

Structure: **R Barton Jr** 1969 AC B25 1524-33 (B414);
ND, **A Tippe WG Hamilton** 1971 AM 56 101-13 (T170).
Occurrence: MM 36 1149. [Name also used for ZnS-15R.]

**buetschiliite / bütschliite** $K_2Ca(CO_3)_2$. *Eitelite* structure type. Dimorphic with *fairchildite*.

Structure: **A Pabst** 1974 AM 59 353-8;
**D Knobloch F Pertlik J Zemann** 1980 NJMM 230-6;
**H Effenberger H Langhof** 1984 AC C40 1299-300 (E360).
Occurrence & synthesis: **C Milton J Axelrod** 1947 AM 32 607-24.
Thermochemistry: **A Navrotsky & 3 others** 1997 AM 82 546-8.
*Synthetic* $K_2Co(SeO_3)_2$ isotype: **M Wildner** AC C48 410-2 (W710); MA 96M/1576.

**bukovite** $Cu_{3+x}Tl_2FeSe_{4-x}$. Essentially isostructural with *murunskite* $K_2Cu_3FeS_4$ & *thalcusite* $Tl_2(Cu,Fe)_4S_4$ from cell data. Matches *synthetic*.

Bukovite packing is tetragonal layer type: **VV Dolivo-Dobrovolsky** 2004 ZVMO 63-9.
Structure determination not found.
Occurrence: **Z Johan M Kvacek** 1972 BSFMC 94 529-33 = AM 57 1910.

**bukovskyite** $Fe_2(AsO_4)(SO_4)(OH).7aq$.

Cell dimensions from ED: **Z Johan** 1986 NJMM 445-51 (J259).
Structure determination not found.
Occurrence: MM 37 956.

**bulachite** $Al_2(AsO_4)(OH)_3.3aq$.

Structure determination not found.
Occurrence: **K Walenta** AM 70 214;

XRPD, Sardinia, **F Frau S Da Pelo** 2001 NJMM 18-26 (949).

**bultfonteinite** $Ca_2SiO_2(OH,F)_4$.

Structure: **EJ McIver** 1963 AC 16 551-8 (M112).

Occurrence: MM 23 626.

**bunsenite** NiO. *Periclase* mineral group. *Halite* structure type.

Structure: Wyckoff.

In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**burangaite** $Na_{0.96}(Fe,Mg)Al_{4.9}(PO_4)_{4.1}(OH)_6.2aq$. Isostructural with *dufrenite*.

Structure: **JB Selway MA Cooper FC Hawthorne** 1997 CM 35 1515-22.

Occurrence: **O Von Knorring M Lehtinen ThG Sahama** 1983 Bull Geol Soc Finlande 49 33-6 = AM 63 793.

**BURBANKITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *burbankite* | $(Na,Ca)_3(Sr,Ca,REE,Ba)_3(CO_3)_5$ |
| *calcioburbankite* | $Na_3(Ca,REE,Sr)_3(CO_3)_5$ |
| *khanneshite* | $(Na,Ca)_3(Ba,Sr,Ce,Ca)_3(CO_3)_5$ |
| *petersenite-Ce* | $Na_4Ce_2(CO_3)_5$ |
| *remondite* | $Na_3(REE,Ca,Na,Sr)_3(CO_3)_5$ |

Occurrence, Khibiny: **IV Pekov NV Chukanov YuV Belovitskaya** 1998 ZVMO 92-100 (P684).

Alteration in rare-earth carbonatites: **AN Zaitsev & 3 others** 2002 Li 62 15-33 (7458).

**burbankite** $(Na,Ca)_3(Sr,Ca,REE,Ba)_3(CO_3)_5$. *Burbankite* structure type.

Structure: **AA Voronkov NG Shunyatskaya Yu Pyatenko** 1967 SPC 12 107 (V200);
**AA Voronkov NG Shunyatskaya** 1968 SPC 13 192-6 (V198);
**H Effenberger & 3 others** 1985 NJMM 161-70.

Occurrence: MM 30 729.

Occurrence: hyperagpaitic alkaline rocks: **Khomyakov** (1995);
Khibina carbonatite: **AN Zaitsev et al.** 1998 MM 62 225-50;
Namibia carbonatite, fluid inclusions, laser Raman, SEM-EDX, micro-XRF: **B Bühn & 4 others** 1999 AM 84 1117-25.

*Synthetic* $Na_3(RE_{0.75}Ca_{1.0}Ba_{0.6}Sr_{0.6})$: **D Ginderow** 1989 AC C45 185-7 (G789).

*Synthetic* $La_3Ca_3(BO_3)_5$: **B Kindermann** 1977 ZK 146 67-72.

Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**burckhardtite** $Pb_2(Fe,Mn)TeAlSi_3O_{12}(OH)_2.aq$.

Occurrence: **RV Gaines PB Leavens JA Nelen** 1979 AM 64 355-8.

Structure determination not found.

**burkeite** $NaCO_3(SO_4)_2$.

Structure: **G Giuseppetti F Mazzi C Tadini** 1988 NJMM 203-21 (G769);
*synthetic*, **B Shi RW Rousseau** 2003 JPCB 107 6932-7.

Occurrence: MM 21 559.

Occurrence in evaporite salt-crust: **F Mees** 2001 SG 48 1225-33 (3869).

*Synthetic*, use in detergents: **P Meenan & 3 others** 1995 JMS 30 3115-22.

**burnsite** $KCdCu_7O_2(SeO_3)_2Cl_9$. See *chloromenite, georgbokiite, ilinskite*.

Structure: SC-XRD, **PC Burns SV Krivovichev SK Filatov** 2002 CM 40 1587-95.

Occurrence: **SV Krivovichev & 6 others** 2002 CM 40 1171-5.

**burpalite** $Na_2CaZrSi_2O_7F_2$. *Cuspidine* type.

Structure: **S Merlino & 5 others** 1990 EJM 2 177-85.

**bursaite** $Pb_5Bi_4S_{11}$. *Lillianite* homologous series from crystallography.

ED & XRPD of *cannizzarite* & bursaite: **NN Mozgova & 6 others** 1988 NJMA 158 293-309 (M1284).

**burtite** $CaSn(OH)_6$. Distorted $ReO_3$ structure type. *Schoenfliesite/stottite* group.

Structure: NPD, **LC Basciano & 3 others** 1998 CM 36 1203-10.

Compressibility to 7 GPa: **MD Welch WA Crichton** 2002 MM 66 431-40.

Occurrence: **PM Sonnet** 1981 CM 19 397-401.

*Synthetic* $CaSn(OH)_6$, cell dimension: **AN Christensen RG Hazell** 1969 Acta Chem Scand 23 1219-24 (C804); also Mn/Fe/Co/Zn varieties.

**buryatite** $Ca_3(Si,Fe,Al)(SO_4)B(OH)_9O.12aq$. *Ettringite* group.
Occurrence: **SV Malinko & 4 others** 2001 ZVMO 2 72-8 = AM 87 1509.
**buserite** 10Å phase in manganese nodules with octahedral layer structure.
Occurrence: **R Giovanoli W Feitknecht F Fischer** 1971 Helv Chim Acta 54 1112 = MM 39 908.
Chemistry & dehydration: **H Choi SJ Kim** 1994 IMA Pisa 73.
*Synthesis* large crystals, transformation to OMS-1 = *todorokite*: **DT Fortin & 5 others** 1994 JCSCC 2211-2 (F499).
Structural mechanism of $Co^{2+}$ oxidation by: **A Manceau & 4 others** 1997 AM 82 1150-75.
*Synthetic* (Na/K/Mg) variants with *birnessite/buserite/todorokite* structure, enthalpy of formation:
**Z Tian & 4 others** 2000 JPC B 104 5035-9 (T648).
**bushmakinite** $Pb_2(Al,Cu)PO_4[(V,Cr,P)O_4](OH)$. *Brackebuschite* family.
Occurrence, SC-XRD structure: **OY Yakubovich V Massa IV Pekov** 2002 DES 382 100-5 (7448);
**IV Pekov & 6 others** 2002 ZVMO 62-7 (8773).
**bussenite** $Na_2Ba_2FeTiSi_2O_7(CO_3)_2O(OH)Faq$. Mica-like titanosilicate.
Structure: **H Zhou & 4 others** 2002 Krystallographiya 50-3.
Occurrence: **AP Khomyakov & 3 others** 2001 ZVMO 3 50-4.
**bustamite** $(Ca,Mn)_2Si_2O_6$. Pyroxenoid mineral/structure family.
Isotypic with *vistepite* $Mn_4SnB_2Si_4O_{16}(OH)_2$.
Structure: **DR Peacor MJ Buerger** 1962 ZK 117 331-43;
**DR Peacor** 1963 AM 48 588-96 (P35);
**Y Ohashi LW Finger** 1978 AM 63 274-88 (O148);
MA 85M/2358.
**butlerite** $FeSO_4(OH).2aq$. Hydroxyl-bridged octahedral/tetrahedral chain, similar to chain in *parabutlerite & synthetic* $In[SO_4](OH).2aq$; stereoisomeric with chain in *fibroferrite*.
Review: **Sabelli** p.15.
Structure: **L Fanfani A Nunzi PF Zanazzi** 1971 AM 56 751-7.
Occurrence: MM 21 560.
**buttgenbachite** $\sim Cu_{18}Cl_3(NO_3)(OH)_{32}.2\text{-}3aq$. Isostructural with *connellite*.
Structure: **L Fanfani A Nunzi PF Zanazzi** 1973 MM 39 264-70;
SC-XRD, **DE Hibbs P Leverett PA Williams** 2002 NJMM 225-40 (7345);
Sulfate-bearing, SC-XRD, **do** 2003 MM 67 47-60.
Compare with *cacoxenite*, *kambaldaite* & *szymanskiite*.
Occurrence: MM 21 560.
**byelorussite-Ce** $\sim NaMnBa_2Ce_2Ti_2Si_8O_{26}(F,OH)aq$. *Joaquinite* group.
Structure: SC-XRD, **NV Zubkova & 5 others** 2004 CrR 49 964-8 (10957.
Occurrence: **EP Shpanov & 3 others** 1989 ZVMO 118 100 = AM 76 665.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**bykovaite** $NaBa\{(Na,Ti)_4(Ti,Nb)_2(OH,O)_3Si_4O_{14}](OH,F)_2\}.3aq$. Similar to *bornemanite.*
Occurrence: **AP Khomakov & 4 others** 20o5 ZVMO 134 40-8 = AM 91 1452.
**bystrite** Sulfide-*cancrinite*.
Structure: **EA Pobedimskaya & 4 others** 1992 SPD 36 553-5 (P431) = AM 78 450.
**byströmite** $MgSb_2(O,OH)_6$. *Tapiolite* group.
Synthetic: **A Byström B Hök B Mason** 1941 Ark Kemi Min Geol 15B no. 4.
Occurrence: MM 29 976.
**bytownite** *Feldspar* type; part of *plagioclase* solid solution.