**Mineral structures O-R**

Updated to 091806 by J V Smith

**obertiite** $NaNa_2Mg_3FeTiSi_8O_{22}O_2$. *Amphibole* structure type.
Occurrence & SC-XRD: **FC Hawthorne & 3 others** 2000 AM 85 236-41.
**oboyerite** $Pb_6H_6(TeO_3)_3(TeO_6)_2.2aq$.
XRPD, indexed triclinic: **AC Roberts** 1980 Geol Surv Canada Paper 80-113 = AM 66 220.
Structure determination not found.
Occurrence: **SA Williams** 1979 MM 43 453-7.
**obradovicite** $H_4(K,Na)CuFe_2(AsO_4)(MoO_4)_5.12aq$.
Structure determination not found.
Occurrence: **JJ Finney SA Williams RD Hamilton** 1986 MM 50 283-4.
**obruchevite** $\sim Na_6(Ca,Fe)_4\ Y_6(U,Th)O_{18}$. *Pyrochlore* group.
Occurrence; MM 31 969.
**o'danielite** $H_2Na(Zn,Mg)_3(AsO_4)_3$. Structure related to *johillerite* & *nickenichite*.
Structure: **P Keller H Hess** 1988 NJMM 395-404.
Occurrence: MM 46 523.
**odinite** $(Fe^{3+}_{0.78}Mg_{0.77}Al_{0.56}Fe^{2+}_{0.28}Mn_{0.15})(Si_{1.79}Al_{0.21})O_5(OH)_4$.
1:1 *serpentine*-type layer; mixed di- & tri-octahedral; mixture of 1M & 1T polytypes.
Occurrence & crystallography: **SW Bailey** 1988 ClM 23 237-47;
**GS Odin & 4 others** 1988 Developments in Sedimentology 45 159-206;
**GS Odin** 1990 ClM 25 477-83;
**PC Ryan RC Reynolds Jr** 1996 AM 81 213-25.
**odintsovite** $K_2Na_4Ca_3Ti_2Be_4Si_{12}O_{38}$.
Structure: **RK Rastsvetaeva VG Evsyunin AA Kashaev** 1995 CrR 40 228-32.
Occurrence: **AA Konev** 1995 ZVMO 124 92-6;
Ilimaussaq, **OV Peterson RA Gault T Balic-Zunic** 2001 NJMM 235-40.
**oenite** CoSbAs. Probable relation to *marcasite* structure.
Occurrence & XRPD (matches *synthetic*): **RTM Dobbe MA Zakrzewski** 1998 CM 36 855-60.
**offretite** $\sim(K_2,Ca)_5Al_{10}Si_{26}O_{72}.30aq$. *Zeolite* mineral group.
IZA-SC code OFF. Consortium for Theoretical Frameworks net 106.
Structure: **JA Gard JM Tait** 1972 AC B28 825-34 (G325);
dehydrated natural offretite with stacking faults of *erionite* type, **WJ Mortier JJ Pluth JV Smith** 1975 N 256 718-9, **do** 1976 ZK 143 319-32 (M1328);
CO absorption complex, **WJ Mortier JJ Pluth JV Smith** 1976 ZK 144 32-41 (M1327);
crystal chemistry & structural epitaxy of offretite-erionite intergrowths, Sasbach, **R Rinaldi** 1976 NJMM (4) 145-56;
Bohemia, **R Rychly M Danek J Siegl** 1982 CEr 41 263-8 = MA 83M/1827;
EM images of dealuminated, **GR Millward JM Thomas** 1984 JCSCC 77-9;
Si NMR, **JH Raeder** 1984 Z 4 311-8 (225);
EM images of intergrowths with other ABC-6 zeolites, **GR Millward S Ramdas JM Thomas** 1985 Proc R Soc London A 399 57-71;
ESR of Cu in gallosilicate, **J Yu& 4 others** 1996 JPC 100 12624-30;
Adamello, Italy, **A Alberti & 3 others** 1996 Z 17 457-61 (A719);
Verona, Italy, **E Passaglia A Tagliavini R Gutoni** 1996 NJMM 412-28 (P654).
Molecular dynamics, site selectivity: **L Campana & 3 others** 1995 JPC 99 16351-6;
**L Campana A Selloni J Weber** 1997 JPCB 101 9932-9 (C999).
Crystal chemistry & structure: **E Passaglia G Artioli A Gualtieri** 1998 AM 83 577-89, 590-606.
*Synthetic* TMA-offretite: random faults blocking 12-ring channels, **NY Chen & 3 others** JCa 86 24-31.
*Synthetic* offretite & Omega: $^{29}Si$ & $^{27}Al$ NMR, **CA Fyfe & 8 others** 1985 Z 5 179-83.
*Synthetic*: hydrothermal de-alumination 870K, hole formation & residual Al in pores after HCl

extraction, **C Fernandez & 3 others** 1986 Z 6 484-90.
*Synthesis* with various templates: **MG Howden** 1987 Z 7 255-9 & 260-4.
*Synthetic* H-exchanged: **B Tyburce P Cartraud** 1990 J Chim Phys Phys-Chim Biol 87 289-99.
*Synthetic* K-H offretite: hydrothermal dealumination, XRPD & $^{29}Si/^{27}Al$ NMR, **AP Carvalho & 5 others** 1993 Z 13 462-9.
*Synthetic* $Cu^{II}$-exchanged K-offretite, ESR & ESEM: **J Yu & 5 others** 1997 JCSF 93 1225-31.
*Synthetic* H-: **ML Occelli & 5 others** 1997 MiMa 10 123-35.
*Synthetic* Al/Ga, XRPD/NMR: **A Wolker & 4 others** 1997 Solid State Nucl Magn Reson 9 143-53.
**ogdensburgite** $(Ca,Zn)_4Fe_6(AsO_4)_5(OH)_{11}.5aq$.
Structure determination not found.
Occurrence: **PJ Dunn** 1981 MR 12 369-70 = AM 67 858.
**ohmilite** $Sr_3(Ti,Fe)(Si_2O_6)_2(O,OH).2\text{-}3aq$.
Structure: **T Mizota M Komatsu K Chihara** 1983 AM 68 811-7.
Occurrence: MM 48 579.
**ojuélaite / ojuelaite** $ZnFe_2(AsO_4)_2(OH)_2.4aq$.
*Arthurite* structure group from crystallography.
Structure: **JM Hughes & 3 others** 1996 MM 60 519-21.
Occurrence: **F Cesbron M Romero SA Williams** 1981 BM 104 582-6 (C750).
**okamayalite** $Ca_2B_2SiO_7$. Analog of *gehlenite* in *melilite* structure group.
Structure, XRPD: **G Giuli L Bindi P Bonazzi** 2000 AM 85 1512-5.
Occurrence & XRD: **S Matsubara & 4 others** 1998 MM 703-6.
Occurrence & TEM of intergrowth with silica: **F Olmi et al** 2000 AM 85 1508-11.
*Synthetic* $Ca_2SiB_2O_7$ '*boron-gehlenite*': **H Bauer** 1962 NJMM 127.
**okanoganite-Y** $\sim(Na,Ca)_4(Y,Ce,Nd,La)_{12}(Fe,Ti)_1Si_7B_3O_{34}OH_4F_{10}$.
Structure: SC-XRD, **M Boiocchi & 3 others** 2004 AM 89 1540-5.
Similar to *vicanite-Ce.*
Occurrence: **RC Boggs** 1980 AM 65 1138-42.
Review: (different formula) **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**okenite** $Ca_5Si_9O_{23}.9aq$.
Structure: **XaS Mamedov NV Belov** 1958 DAN SSSR 121 720-3;
**S Merlino** 1983 AM 68 614-22.
**okhotskite** $\sim Ca_2(Mn^{2+},Mg)(Mn^{3+},Al,Fe^{3+})_2(SiO_4)(Si_2O_7)(OH)_2.aq$.
*Pumpellyite* structure group from XRPD.
Occurrence: **K Togari M Akasaka** 1987 MM 51 611-4.
Site preferences of $Fe^{3+}$ & $Mn^{3+}$, Mössbaüer: **Y Kimura & 3 others** 1995 MJ 17 382 (K830).
Hydrothermal *synthesis*: **M Akasaka H Watanabe** 1995 MJ 17 378 (A697);
**M Akasaka Y Suzuki H Watanabe** 2003 MP 77 25-37 (8732).
**oldhamite** (Ca,Mg,Fe,Mn)S. *Galena/halite* structure type: **Wells** Table 17.1 p 606.
Occurrence: Dana;
in meteorites, **AE Rubin** 1997 MPS 32 231-47.
*Synthetic* MgS, compression <54 GPa: **SM Peiris AJ Campbell DL Heinz** 1994 JPCS 55 413-9 (P717).
**olekminskite** $Sr(Sr,Ca,Ba)(CO_3)_2$. Isostructural with BaCa analog *paralstonite*.
Occurrence: **AA Konev & 4 others** 1991 ZVMO 89-96 (K664).
**olenite** $Na_{1-x}Al_3Al_6B_3Si_6O_{27}(O,OH)_4$. *Tourmaline* structure group.
Structure, B-rich: SC-XRD, **JM Hughes & 6 others** 2000 CM 38 861-8;
NMR & IR, **B Marler A Ertl** 2002 AM 87 364-7;
*synthetic*, **B Marler & 3 others** 2002 EJM 14 763-72;
vs tetrahedral B, SC-XRD, **JM Hughes & 5 others** 2004 AM 89 447-66;
Mg-bearing, SC-XRD structure, Mössbauer, FTIR, **A Ertl& 4 others** CM 41 1363-70;
Fe-rich, SC-XRD structure, Mössbauer, **A Ertl & 6 others** CM 42 1057-64;
Fe-rich, tetrahedral Al, SC-XRD, **J Cempírek & 5 others** CM 44 23-30.
Tetrahedral B in natural: **W Schreyer & 5 others** 2002 EJM 14 935-42 (8349).
Complete s s excess-B olenite & magnesian *schorl*: **A Kalt & 5 others** 2001 EJM 13 1191-205.
Occurrence: & crystallography, **PB Sokolov & 5 others** 1986 ZVMO 115 119-23;

Mn-rich, Li,Fe-, Austria, **S Prowatke A Ertl JM Hughes** 2003 NJMM 385-95 (9621).

**olgite** $(Ba,Sr)(Na,Sr,REE)_2Na(PO_4)_2$. *Glaserite* (*aphthitalite*) structure group.
Isostructural with*bario-olgite*.
Structure: SPC 29 633-5 (S1323);
refinement & revised composition, **EV Sokolova & 2 others** 2005 CM 43 1521-6.
Occurrence: MM 43 1065

**olkhonskite** $(Cr,V)_2Ti_3O_9$. Forms (incomplete?) series with *schreyerite*.
Occurrence: **AA Koneva & 3 others** 1994 ZVMO 123 100-5.

**oligoclase** Feldspar structure group. Used for plagioclase An 10-30 in rocks.

**olivenite** $Cu_2(AsO_4)(OH)$. *Adamite* structural group. *Andalusite* topology.
Early papers used orthorhombic symmetry: **H Heritsch** 1938 ZK 99 466-79.
Actually monoclinic: **K Toman** 1977 AC B33 2628-31 (T429);
XRPD structure, **PC Burns FC Hawthorne** 1995 CM 33 885-8 (B1602).
IR & Raman: OH vibration & dehydration, **WN Martens & 3 others** 2003 AM 88 501-8.

**OLIVINE STRUCTURE GROUP** Includes:
(a) silicates

| | | |
|---|---|---|
| *olivine* | mineral series: forsterite-fayalite | |
| *forsterite* | $Mg_2SiO_4$ | |
| *fayalite* | $Fe_2SiO_4$ | |
| *kirschsteinite* | $CaFeSiO_4$ | |
| *glaucochroite* | $CaMnSiO_4$ | |
| *liebenbergite* | $(Ni,Mg)_2SiO_4$ | |
| *monticellite* | $CaMgSiO_4$ | |
| *tephroite* | $Mn_2SiO_4$ | |

(b) nonsilicate oxides

| | | |
|---|---|---|
| *chrysoberyl* | $Al_2BeO_4$ | |
| *ferrisicklerite* | $Li(Fe,Mn)PO_4$ | compare with *triphylite* |
| *heterosite* | $(Fe,Mn)PO_4$ | |
| *lithiophilite* | $Li(Mn,Fe)PO_4$ | compare with *sicklerite* |
| *natrophilite* | $NaMnPO_4$ | |
| *purpurite* | $(Mn,Fe)PO_4$ | |
| *sicklerite* | $Li(Mn,Fe)PO_4$ | compare with *lithiophilite* |
| *simferite* | $LiMg_2(PO_4)_2$ | |
| *sinhalite* | $MgAlBO_4$ | |
| *triphylite* | $Li(Fe,Mn)PO_4$ | compare with *ferrisicklerite* |

(c) non-oxides; non-minerals

| | |
|---|---|
| *synthetic* | $(Fe,[Mg/Mn/Zn])_2GeS_4$ |
| *synthetic* | $(Fe,Mn])_2SiS_4$ |
| *synthetic* | $Fe_2(Si/Ge)S_4$ |
| *synthetic* | $Li_2ZnI_4$ |
| *synthetic* | $(Mg_{1.4}Fe_{0.6})_2SiS_4$ |
| *synthetic* | $MgGaScS_4$ |
| *synthetic* | $Mn_2SiS_4$ |

Summary 52 crystal structures of natural/synthetic: **GR Lumpkin PH Ribbe** 1983 AM 68 164-76.
XANES of Mg/Fe edges in *forsterite/fayalite/kirschteiite/monticellite*: **ZY Wu & 5 others** 2004 PRB 69 104106 (10256).

*Synthetic* oriented precipitates in Fe-rich: **K Iishi K Torioe XJ Han** 1997 PCM 25 8-14 (I222).
*Synthetic* $Cd_2SiO_4$: **H Hayashi & 7 others** 1965 = MM 35 1129.
*Synthetic* high-P $Mn_2GeO_4$: **AD Wadsley AF Reid AE Ringwood** 1968 AC B24 740-2;
Raman, 7-9 GPa, transition to spinelloid, **B Reynard C Remy F Takir** 1997 PCM 24 77-84 (R725).
*Synthetic* Co,Mg: **S Ghose C Wan** 1974 CMP 47 131-40;
**M Miyake & 3 others** 1987 AM 72 594-8;
**D Böstrom** 1989 Acta Chem Scand 43 121-7 (B1323) = MA 91-0171;
polarized optical absorption, **MN Taran GR Rossman** 2001 AM 86 889-95.
*Synthetic* $Co_2SiO_4$, 3 polymorphs: **N Morimoto & 3 others** 1974 AM 59 475-95;
polarized optical absorption, **MN Taran GR Rossman** 2001 AM 86 889-95.
*Synthetic* $Fe_2(Si/Ge)S_4$: **E Vincent & 3 others** 1976 AC B32 1749-55.
*Synthetic* $Li_2ZnI_4$: 1989 ZN 44B 1047 = SR 56A 273.
*Synthetic* $Mg_2GeO_4$: 1989 ZK 188 169 = SR 56A 273
martensitic change to spinel, **PC Burnley** 2005 AM 90 1315-24..
*Synthetic* $Mn_2SiS_4$: **J Fuhrmann J Pickardt** 1989 AC C45 1808-9 (F438).
*Synthetic* $(Mg_{1.4}Fe_{0.6})SiS_4$: **do** 1990 AC C46 1996-8 (F440).
*Synthetic* $MnGaScS_4$, SC-XRD structure: **H Haeuseler HJ Stork** 1990 JAlCo 253-61.
*Synthetic* $[Fe,(Mg/Mn/Zn)]_2GeS_4$: **T Ericsson AG Nord**1995 NJMM 202-10 (E364).
*Synthetic* $Ca_2SiO_4$-gamma: [$Ca_2SiO_4$ hss 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*) & high-P ($K_2NiF_4$); summary, complex literature, **C Remy F Guyot M Madon** 1995 PCM 22 419-27 (R608).]
*Synthetic* $Mn_2SiSe_4$: **S Jobic & 3 others** 1995 JAlCo 230 16-22 (J267).
*Synthetic* $(Co/Ni)_2SiO_4/Mg_2GeO_4$, high-P transition to *spinel*: **PC Burnley WA Bassett T Wu** 1995 JGR 100B 17715-23.
*Synthetic* $LiScSiO_4$: structure to 5.6 GPa, **RM Hazen RT Downs LW Finger** 1996 AM 81 327-34.
*Synthetic* $(Mg/Ca)_2GeO_4/CaMgGeO_4$: XRPD/XAS <30 GPa, **PE Petit & 3 others** 1996 PCM 23 173-85 (P160).
*Synthetic* $Ca_2GeO_4$, Raman, 7 to 9 GPa indicating phase transition, **B Reynard C Remy F Takir** 1997 PCM 24 77-84 (R725).
*Synthetic* $CaMgGeO_4$: **J van Duijn RAG de Graaff DJW IJdo** 1995 MRB 30 1489-93 (V246);
Raman to 20 GPa, **B Reynard C Remy F Takir** 1997 PCM 24 77-84 (R725).
*Synthetic* $(Fe_{0.5}Mn_{0.5})_2SiO_4$, ND of cation order vs cooling rate: **SAT Redfern & 4 others** 1996 N 381 407-9 (R659).
*Synthetic* $MgGaScS_4$, SC-XRD structure: **H Haeuseler HJ Stork** 1996 JAlCo 238 65-7 (H1100).

*Synthetic* $Li_2ZnCl_4$, structure: **M Sassmannshausen I Solinas HD Lutz** 1996 ZK 211 819-20.
*Synthetic* Co,Mg, cation distribution, XRPD: **M Müller-Sommer R Hock A Kirfel** 1997 PCM 24 17-23 (M1457).
*Synthetic* Cr-doped $Mg_2SiO_4$ & $Ca_2GeO_4$, Cr XAS: **KE Miyano & 3 others** 1997 Appl Phys Lett 71 1168-70 (M1534).
*Synthetic* $(Fe/Mg_{0.5}Mn_{0.5})_2SiO_4$, high-T disorder, ND: **SAT Redfern & 3 others** 1997 EJM 9 283-300 (R720).
*Synthetic* (Mg,Mn,Fe,Co)-, SC hydrostatic compression to 10 GPa: **L Zhang** 1998 PCM 25 308-12 (Z162).
*Synthetic* (Co,Ni,Zn)-, cation distribution from SC-XRPD: **K Tsukimura S Sasaki** 2000 PCM 27 234-41 (T643).
*Synthetic* (Co,Ni)-, Raman & IR: **C Lin** 2001 JSSC 157 102-9 (1751).
*Synthetic* $(Fe,Mn])_2SiS_4$, Mössbauer at RT: **T Ericsson O Amcoff** 2001 NJMM 403-13 (3583).
**olivine** $(Mg,Fe)_2SiO_4$. *Forsterite-fayalite* mineral series with olivine structure type.
Structure: **JD Birle & 3 others** 1968 AM 53 807-24;
**F Princivalle L Secco** 1985 TMPM 34 105-15 (P539);
$Fo_{88}$, Penghu ultramafic: **S-C Yu** 1994 J Geol Soc China 37 279-90 = MA 96M/0191;
*synthetic*, Raman, **BA Kolesov CA Geiger** 2004 PCM 32 142-54 (10221)
*synthetic* $Mg_{0.5}Fe_{0.5}$, Mössbauer, **M Morozov & 5 others** 2005 EJM 17 495-500.
Thermal parameters, vibration spectra & transferable force fields: **T Pilati F Demartin CM Gramaccioli** 1995 AC B51 721-33 (P580).
Thermodynamic model: **RG Berman LYa Aranovich** 1996 CMP 126 1-24 (B1572).
O & point defects, thermogravimetry: **T Tsai R Dieckmann** 2002 PCM 29 680-94 (8583).
Strain & local heterogeneity: **SC Tarantino MA Carpenter MC Domeneghetti** 2003 PCM 30 495-502.
Ol in dunite, shocked to 5 – 59 GPa: Raman, **S Farrell-Turner & 3 others** 2005 MPS 40 1311-28.

*Variable occupancy of the two octahedral sites*.

Cation distributions: Fe/Mg order-disorder vs T, oxygen fugacity: **NR Khisina VS Urusov** 1995 GI 32 28-45;
interlaboratory test, **A Kirfel** 1996 PCM 23 503-19 (K886);
Raman, forsterite-fayalite: **BA Kolesov JV Tanskaya** 1996 MRB 31 1035-44 (K850);
Fe,Mg vs T, SC-XRD structure: **R Heinemann & 5 others** 1999 AM 84 1400-5;
Fe,Mg order high T: mantle olivines, SC-ND, **R Rinaldi & 3 others** 2000 PCM 27 623-;
*synthetic* $MgFeSiO_4$, do., **SAT Redfern & 5 others** 2000 PCM 27 630-7 (319);
Fe/Mg distribution, data collection & refinement: **F Martignago** 2000 EJM 12 1165-84;
**M Merli R Oberti F Caucia L Ungaretti** 2001 AM 86 55-65.
Lamellae in Divnoe achondrite attributed to Fe,Mg exsolution, analytical TEM: **MI Petraev AJ Brearley** 1994 S 266 1545-7 (P873).
Brenham pallasite, high-T ND reveals reversed M1/M2 cation occupancy, **G Artioli & 3 others** 1995 AM 80 197-200.
Exsolution texture, in augite syenite: **G Markl M Marks R Wirth** 2001 AM 86 36-46.
Fo92 mantle-, heated 973 K, IR, UV, TEM: **NR Khisina & 4 others** 2001 GI 39 327-35 (1649).

*At high P, olivine transforms to wadsleyite & ringwoodite at upper-mantle conditions; under shock it may go amorphous. See Introduction- High Pressure.*

Compression/amorphization of (Mg,Fe) to 70 GPa: **D Andrault & 3 others** 1995 PCM 22 99-107.
Elastic moduli: San Carlos olivine & *synthetic* forsterite <13 GPa, **G Chen B Li RC Liebermann** 1996 S 272 979-80 (C833);
<17 GPa, **EH Abramson & 3 others** 1997 JGRB 102 12253-63 (A754).
Topotactic transformation of San Carlos olivine to *spinelloid* & *perovskite* + *magnesiowüstite* at 26 GPa & 973-1473 K: **Y Wang & 3 others** 1997 S 275 510-3 (W784).

*Minor & trace elements*

Lunar: minor elements as petrologic indicator, **IM Steele JV Smith** 1975 Proc Lunar Sci Conf 6th 451-7 (S2166);
Al,P,Ca,Ti,Cr,Mn,Fe, EPMA: **JV Smith EC Hansen IM Steele** 1980 Proc Lunar Sci Conf 11th 555-69 (S2165).
Enhanced H & F in borian: **D Sykes & 3 others** 1994 AM 79 904-8.
San Carlos, Ni distribution, EXAFS: **L Galoisy G Calas GE Brown Jr** 1995 AM 80 1089-92.
Water in α/β/γ $(Mg,Fe)_2SiO_4$: **DL Kohlstedt H Keppler DC Rubie** 1996 CMP 123 345-7 (K844).
H & trace elements in mantle olivines: **M Kurosawa H Yurimoto S Sueno** 1997 PCM 24 385-95.
Phosphoran, Pine Canyon, Utah, & review of meteorite occurrences: **SO Agrell NR Charnley GA Chinner** 1998 MM 62 265-9.
Structural OH in mantle, IR & TEM: **NR Khisina R Wirth M Andrut** 2002 GI 40 332-41 (7236);
quantitative measure from IR, **DR Bell & 4 others** 2003 JGRB 108 ECV 8-1 (9129).
H, Li & B in mantle olivine: **AJR Kent GR Rossman** 2002 AM 87 1432-6.
$Cr^{3+}$ doping centers, EPR: **RM Mineeva & 5 others** 2003 GI 41 182-6 (8782).
Ni olivine/melt vs S: **C Li EM Ripley EA Mathez** 2003 ChG 201 295-306 (9537).
Co-bearing, T vs polarized electronic absorption: **K Ulrich & 3 others** 2004 PCM 31 247-60 (10320).
OH, mantle xenoliths, Siberian kimberlites: **SS Matysuk K Langer** 2004 CMP 147 413-7 (10407).
Cr/Fe/Ti/V in planetary basalts, also *spinel /pyroxene*: **JJ Ppaike JM Karner CK Shearer** 2005 AM 90 277-90.

*Miscellaneous*

Chemical weathering of San Carlos <383 K, crystal direction vs kinetics: **A Awad & 2 others** 2000 GCA 64 1765-72 (A934).
External reduction: **L Lemelle & 3 others** 2001 AM 86 47-54.
Extrinsic & intrinsic H, FTIR & TEM: **NR Khisina & 3 others** 2001 PCM 28 291-301 (2133).
Thermal conductivity, vibrational spectroscopy, theory: **AM Hofmeister** AM 86 1188-209.
Gibbs energy of alpha, beta & gamma: **MHG Jacobs HAJ Oonk** 2001 PCM 28 572-85 (3587).
OH vs. silica activity, IR, possible fingerprint for metasomatism: **S Matveev & 4 others** 2001 JP 42 721-9 (1606).
Water-induced fabric transition: **H Jung S Karato** 2001 S 293 1460-2 (2950).

Nucleation/growth of *serpentine*, *synthetic* alteration: **C Normand & 3 others** 2002 AM 87 1699 709.
(010) surface, Rutherford back-scattering: **L Lemelle & 3 others** 2002 AM 87 327-32.
Oxidation to *hematite* <1400 K & *magnetite* >: **AF Gualtieri & 2 others** 2003 AM 88 1560-74.
Melting with water: **AP Maksimov** 2003 GI 41 947-58 (9618).
Nanoscale waviness low-angle grain boundary: **CL Johnson MJ Hÿtch PR Buseck** 2004 PNAS 101 17036-9 (10898).
H solubility vs T & Fe: **Y Zhao SB Ginsberg DL Kohlstedt** 2004 CMP 147 155-61.
In planetary basalts: chemical signatures, **J Karner JJ Papike CK Shearer** 2003 AM 88 806-16.
In meteorites: **AE Rubin** 1997 MPS 32 231-47;
coalescence of Mg & SiO smoke particles, **C Kaito & 9 others** 2003 MPS 38 49-57;
dusty in chondrites, TEM, **H Leroux & 3 others** 2003 MPS 38 81-94;
pallasites, minor element zoning, **W Hsu** 2003 MPS 38 1217-41;
Ca,Al-rich forsterites in primitive, **A Pack H Palme** 2003 MPS 38 1263-81;
supernova olivine from comet dust: **S Messenger LP Keller DS Lauretta** 2005 S 309 737-40.
Occurrence on Mars: Nili Fossae, **TM Hoefen & 5 others** 2003 S 302 627-30 (9565).
Occurrence in protoplanetary disks: **R van Broekel & 23 others** 2004 N 432 479-82 (10824).
*Synthetic* $LiInSiO_4$: SC-XRD structure, **GJ Redhammmer G Roth** 2003 ACC 59 i38-40 (9147).

**olkonskite** $(Cr,V)_2Ti_3O_9$. Compare *schreyerite*.

**olmsteadite** $KFe_2(Nb,Ta)(PO_4)_2O_2.2aq$.
Essentially isostructural with Mn analog *johnwalkite*.
Contains same kind of vertex-linked octahedral chain as *montgomeryite* & *vauxite*.
Structure: **PB Moore & 3 others** 1976 AM 61 5-11.
*Synthetic* $KFe_3(PO_4)_2O_2.2aq$, SC-XRD: **ZAD Lethbridge & 6 others** 1999 JSSC 142 455-60.

**olsacherite** $Pb_2(SO_4)(SeO_4)$.
XRD indicates same topology as *anglesite*, but lower space group. Review: **Sabelli** p. 28-9.
Structure determination not found.
Occurrence: **CS Hurlbut Jr LF Aristarian** 1961 AM 54 1519-27.

**olshanskyite** $Ca_2[B_3O_3(OH)_6]OH.3aq$. Neso-triborate, analogous to *nifontonite*.
Structure: SC-XRD, **A Callegari F Mazzi C Tadini** 2001 CM 39 137-44.
Occurrence: **MA Bogomolov IB Nikitina NN Pertsev** 1969 DAN 184 1398-401 = AM 54 1737-8;
& SC-XRD, **I Kusachi C Henmi** 1994 MM 58 279-84.

**olympite** New formula: $LiNa_5(PO_4)_2$.
Structure: **Yu A Malinovskii EA Genkina** 1992 SPC 37 772-6 (M1104);
**RK Rastsvetaeva AP Khomyakov** 1992 SPD 37 567-9 (R494), 1994 CrR 39 35-41.
Occurrence: MM 46 523.

**omeiite** $(Os,Ru)As_2$.
*Löllingite* (compressed *marcasite*) structure subgroup in marcasite supergroup: **Wells** p 615.
Occurrence: **Y Ren Q Hu J Xu** 1978 Acta Geol Sinica 52 163-7 = AM 64 464.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**ominelite** $(Fe,Mg)Al_3BSiO_9$. *Grandidierite* analog.
Occurrence & SC-XRD structure: **Y Hiroi & 12 others** 2002 AM 87 160-70.

**omphacite** $(Ca,Na)(Mg,Fe,Al)Si_2O_6$. *Pyroxene* structure group; monoclinic subgroup.
Structure: **T Matsumoto M Tokonami N Morimoto** 1975 AM 60 634-41 (M583);
high-P, **TC McCormick RM Hazen RJ Angel** 1989 AM 74 1287-92;
to 1373 K, **A Pavese R Bocchio G Ivaldi** 2000 MM 983-93.
Equation of state to 10 GPa & 1000 K: **Y Nishihara & 3 others** 2003 AM 80-6.
Landau model cation ordering: **MA Carpenter & 2 others** 1990 EJM 2 7-18 & 19-28;
**R Oberti FA Caporuscio** 1991 AM 76 1141-52.
**FE Brenker DJ Prior WF Müller** 2002 *Cation ordering in omphacite and effect on deformation mechanism and lattice preferred orientation*, JStG 24 1991-2005 (8093).
**FE Brenker WF Müller GF Brey** 2003 *Variation of antiphase domain size in omphacite: A tool to determine the temperature time history of eclogites revisited*, AM 88 1300-11.
**WF Müller & 3 others** 2004 *Chain multiplicity faults in deformed omphacite from eclogite*, EJM 16 37-48 (10126).
Ca XANES: **E Paris Z Wu A Mottana A Marcelli** 1995 EJM 7 1065-70.
Cell data, 13 GPa, XRPD: **A Pavese V Diella D Levy M Hanfland** 2001 PCM 28 9-16 (1404).

**oneillite** $Na_{15}Ca_3Mn_3Fe_3Zr_3Nb(Si_{25}O_{73})(O,OH,aq)_3(OH,Cl)_2$. *Eudialyte* group.

Occurrence & structure: **O Johnsen JD Grice RA Gault** 1999 CM 37 1295-301.

**onoratoite** $Sb_8O_{11}Cl_2$.

Structure: *synthetic*, **S Menchetti C Sabelli R Trosti-Ferroni** 1984 AC C40 1506-10 (M1242), also structure of hexahydrate.

Earlier papers not listed.

Occurrence: MM 36 1155.

**oosterboschite** ?$(Pd,Cu)_7Se_5$. See *chrisstanleyite* $Ag_2Pd_3Se_4$.

Structure: [**D Topa & 3 others** 2002 IMA Mtg Abstr B30-22.]

Occurrence: **Z Johan P Picot R Pierrot T Verbeek** 1970 BSFMC 93 476-81= AM 57 1553.

**[opal** amorphous to finely crystalline. Impure silica used as gem.

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

**orcelite** $Ni_{5-x}As_2$.

Structure: *synthetic*, **M El-Boragy S Bhan K Schubert** 1970 J Less-Common Metals 22 445-58.

Occurrence: MM 32 974.

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

**ordonezite** $ZnSb_2O_6$. *Tapiolite/trirutile* structure group.

Structure: synthetic, **A Byström B Hök B Mason** 1942 Ark Kemi Min Geol 153 4 1-8 occurrence & SC-XRD, **TS Ercit EE Foord JJ Fitzpatrick** 2002 CM 40 1207-10.

Occurrence: MM 30 742.

**örebroite** $Mn_6(Sb,Fe)_2Si_2(O,OH)_{14}$. *Mcgovernite* group.

Isostructural with V analog *franciscanite* & W analog *welinite*.

Structure determination not found.

Occurrence: **PJ Dunn & 3 others** 1986 AM 71 1522-6.

**oregonite** ~$Ni_2FeAs_2$.

Structure determination not found.

Occurrence: **P Ramdohr M Schmitt** 1959 NJMM 239-47 (R555).

**organovaite-Mn** $K_2Mn(Nb,Ti)_4(Si_4O_{12})_2(O,OH)_4.6aq$. *Labuntsovite* mineral group.

Occurrence: **NV Chukanov & 5 others** 2001 ZVMO 39(2) 46-53.

**organovaite-Zn** $K_2Zn(Nb,Ti)_4(Si_4O_{12})_2(O,OH)_4.6aq$. Labuntsovite mineral group.

Occurrence: **IV Pekov & 6 others** 2002 ZVMO 131 29-34 (7817).

**orickite** ~$CuFeS_2$[? 0.5aq].

Probably distorted *wurtzite*-2H structure type from crystallography.

Structure determination not found.

Occurrence: **RC Erd GK Czamanske** 1983 AM 68 245-54.

**orientite** ~$Ca_8Mn^{3+}_{10}[(SiO_4)(Si_3O_{10})_3(OH)_{10}].4aq$.

3 structural models in 6x9 Å modular sheet structure family differing in chemical composition & connecting slab.

The above composition is from the structural model in the MMP 1986 paper.

Structure: **PB Moore J Shen T Araki** 1985 AM 70 171-81;
**M Mellini S Merlino M Pasero** 1984 PCM 10 99-105;
SC-XRD/HRTEM, refined, faulting & new 38 Å polytype, **do** 1986 AM 71 176-87.

**orlandiite** $Pb_3Cl_4(SeO_3).aq$.

Occurrence & SC-XRD structure: **I Campostrini CM Gramaccioli F Demartin** 1999 CM 37 1493-8; twinning & disorder, **F Demartin CM Gramaccioli T Pilati** 2003 CM 41 1147-54.

**orlymanite** $Ca_4Mn_3Si_8O_{20}(OH)_6.2aq$.

Model of layer structure intermediate between *gyrolite*-family minerals & conventional phyllosilicates, but no atomic coordinates published.

Structure: XRPD & TEM, **DR Peacor PJ Dunn JA Nelen** 1990 AM 75 923-7.

**[orpheite** $H_6Pb_{10}Al_{20}(PO_4)_{12}(SO_4)_5(OH)_{40}.11aq$. Review: **Sabelli** no structure.

Structure determination not found.

Occurrence: **B Kolkovski** 1971-2 Ann Univ Sofia Fac Geol Geogr 64 107-30 = AM 61 176; MM 39 922.

jvs: caution because may be a variety of *hinsdaleite*.]

**orpiment** $As_2S_3$. Isostructural with Se analog *laphamite*.
Structure: **N Morimoto** 1954 MJJ 1 160-9 (M257);
**DJE Mullen W Nowacki** 1972 ZK 136 48-65 (M443);
Raman, 298 & 77K, **RL Frost WN Martens JT Kloprogge** 2002 NJMM 469-80 (8335).
Oxidation at 298-313 K & ph 6.8-8.2: **MF Lenoke RN Tempel** 2002 66 3281-91 (8008).
**orschallite** $Ca_3(SO_3)_2SO_4.12aq$.
Structure: **C Weidenthaler E Tillmanns G Hentschel** 1993 MP 48 167-77 (W631) = AM 79 572.
**ortho-antigorite**
Occurrence: MM 30 742.
[orthobrannerite $U^{6+}U^{4+}Ti_4O_{12}(OH)_2$. Metamict.
Not orthorhombic polymorph of *brannerite*. Ignore. MM 43 1065.]
**orthochamosite** $(Fe^{2+},Mg,Fe^{3+})_5Al(Si_3Al)O_{10}(OH,O)_8$.
Orthohexagonal polymorph of *chamosite*.
Occurrence: **F Novak & 4 others** 1957 Czech Acad Sci 315-44 = AM 43 792.
**orthochevkinite** Occurrence: MM 30 742.
**ortho-chrysotile** $Mg_3Si_2O_5(OH)_4$. *Kaolinite-serpentine* structure group.
Polymorphic with *antigorite*, *clinochrysotile*, *lizardite* & *parachrysotile*.
Definition: MM 30 742.
**orthoclase** $KAlSi_3O_8$. *Feldspar* structure group.
Name used by petrologists for low-T monoclinic K-feldspar.
Commensurate modulated structure: **H Xu DR Veblen G Luo** 1995 AC A51 53-60 .
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**orthoenstatite** $MgSiO_3$. *Pyroxene* mineral group.
See *enstatite*.
Equation of state: **RJ Angel JM Jackson** 2002 AM 87 558-61.
Thermal expansion to 1473 K: **JM Jackson & 7 others** 2003 EJM 15 469-73 (9169).
Acoustic mode softening before phase change, SC-Brillouin: **JM Jackson & 3 others** 2004 AM 89 239-45.
Ca vs elasticity & structure to 10 GPa: **F Nestola & 2 others** 2006 AM 91 809-15.
**orthoericssonite** $BaMn_2(FeO)Si_2O_7OH$. Dimorphic with *ericssonite*.
Structure: **S Matsubara** 1980 MJJ 10 107-21.
Fe Mössbauer: **U Halenius** 1995 MJJ 1995 17 363-71 (H1085).
Occurrence: MM 38 996.
**orthoferrosilite = ferrosilite** $FeSiO_3$. *Pyroxene* mineral group.
Transformation to clino C2/c 4.2 GPa: **D Hugh-Jones & 3 others** 1996 EJM 8 1337-45 (H1144).
**orthojoaquinite-Ce** $Na(Ba,Sr)_2Ce_2FeTi_2Si_8O_{26}(OH,F).aq$.
*Joaquinite* structure group; orthorhombic subtype.
Dimorphic with *joaquinite*.
Structure: **T Kato T Mizota** 1990 J Fac Liberal Arts Yamaguchi Univ 24 23-32.
Occurrence: MM 48 579.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**orthojoaquinite-La** $Na(Ba,Sr)_2La_2FeTi_2Si_8O_{26}(OH,F).aq$.
*Joaquinite* structure group; orthorhombic subtype.
Dimorphic with *joaquinite*.
Redefinition: **S Matsubara JA Mandarino EI Semenov** 2001 CM 39 757-60.
**orthominasragrite** $VO(SO_4).5aq$. Orthorhombic analog of monoclinic *minasragrite &* triclinic *anorthominasragrite*..
Occurrence & SC-XRD structure: **FC Hawthorne & 3 others** 2001 CM 39 1325-31.
**orthopinakiolite** $(Mg,Mn)_2(Mn,Fe)(BO_3)O_2$.
6 Å Zigzag Borate: **MA Cooper FC Hawthorne** 1998 CM 36 1171-93.
Structure: **Y Takéuchi & 3 others** 1978 CM 16 475-85 (T259).
Occurrence: MM 32 974.
Modular interpretation of oxyborates: **BB Zvyagin GA Siderenko** 1995 AC B51 7-11 (Z87).
**orthopyroxene** $(Mg,Fe)SiO_3$.

Orthorhombic member of *pyroxene* group with composition between *enstatite* & *ferrosilite*.
Variable occupancy of 2 octahedral sites; interlab test of cation distributions: **A Kirfel** 1996 PCM 23 503-19 (K886).
Hyperfine Mössbauer, 17-490 K: **A Van Alboom E De Grave RE Vandenberghe** 1993 PCM 20 263-75.
Structural disorder 1000-1300K: **H Yang S Ghose** 1994 AM 79 633-43, 1995 80 9-20.
Fe/Mg order/disorder: **M Stimpfl J Ganguly G Molin** 1999 CMP 136 297-309 (S2094).
Thermal expansion to 1300 K: **H Yang S Ghose** 1994 PCM 20 575-86.
Tetrahedral compression to 6 GPa: **D Hugh-Jones A Chopelas R Angel** 1997 PCM 24 301-10 (H117).
Sound velocity to 10 G Pa: **LM Flesch B Li RC Liebermann** 1998 AM 83 444-50.
Structure & contribution of C2/c pyroxene, Serra de Magé meteorite:
**MC Domeneghetti & 3 others** 1995 AM 80 923-9;
refinement, **do** 1996 AM 81 842-6.
Structure of Pbca opx's on *diopside-enstatite* join: **F Nestola M Tribaudino** 2003 EJM 15 365-72.
Crystal-chemical model: **MC Domeneghetti GM Molin V Tazzoli** 1995 AM 80 253-67.
Fe XANES: **E Paris TA Tyson** 1994 PCM 21 299-308 (P505);
Bamble enstatite, **C Closmann E Knittle F Bridges** 1996 AM 81 1321-31.
Thermodynamic model: **RG Berman LYa Aranovich** 1996 CMP 126 1-24 (B1572).
Isothermal annealing & continuous cooling, XRD site distribution: **H Schlenz H Kroll MW Phillips** 2001 EJM 13 715-26 .
Water solubility in *synthetic*, FTIR: **M Rauch H Keppler** 2002 CMP 143 525-36 (8130).
H diffusion: **R Stalder H Skogby** 2003 PCM 30 12-9.
Ca content & kinetics of disordering: **M Zema & 3 others** 2003 EJM 15 373-80.
SC-high-P electronic adsorption: **MN Taran K Langer** 2003 EJM 15 689-95 (9314).
H vs Al/Cr/Fe: FTIR, **R Stalder** 2004 EJM 16 703-11 (10839).
In meteorites: **AE Rubin** 1997 MPS 32 231-47;
equilibrated ordinary chondrites, SC-XRD, thermal history from Mg/Fe ordering, **L Folco M Mellini CT Pillinger** 1996 MPS 31 388-93 & 1997 32 567-75;
Johnstown, equilibrated 973-1273 K, Fe,Mg distribution: **R Heinemann & 3 others** 2000 EJM 12 163-76 (H1468).
*Synthetic* $Mg(Cu_{.56}Mg_{.44})Si_2O_6$, structure: **T Tachi H Horiuchi H Nagasawa** 1997 PCM 24 463-76 (T556).

**orthoserpierite** $Ca_{1.1}(Cu_{3.5}Zn_{0.6})S_{1.7}O_{17}H_{13.3}$.
Orthorhombic polymorph of *serpierite*.
Occurrence: & crystallography, **H Sarp** 1985 SMPM 65 1-7;
Pinal Co, AZ: **D Shannon** 1996 MR 27 189-90.

**orthowalpurgite** $(UO_2)Bi_4O_4(AsO_4)_2.2aq$. Orthorhombic polymorph of *walpurgite*.
Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
Structure: **W Krause H Effenberger F Brandstätter** 1995 7 1313-24 (K818).

**osarizawaite** $PbCu(Al,Fe)_2(SO_4)_2(OH)_6$. *Alunite* structure group.
Isostructural with Fe analog *beaverite*. Reviews: **Sabelli** p.25; (E289).
Structure: **G Giuseppetti C Tadini** 1980 NJMM 401-7 (G755).
Occurrence: MM 33 1146.

**osarsite** (Os,Ru)AsS. *Arsenopyrite* structure group.
Structure: **F Hulliger** 1964 N 201 381-2.
Occurrence: MM 38 996.

**osbornite** TiN. *Halite* structure type.
Solid solution with random vacancy from TiN to $TiN_{0.42}$ , annealing generates ordering : **P Ehrlich** 1949 Z Anorg Chem 259 1-41.
Atomic thermal parameters, elastic NPD, **J Bashir & 4 others** 1996 JACr 29 471-3 (B1521).
[delta'-$Ti_2N$, tetragonal ordering of vacancies: **AN Christensen A Alamo JP Landesman** 1985 AC C41 1009-11.]
Electrochemical synthesis: **LE Griffiths & 5 others** 2001 ChC 579-80 (1433).
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
Industrial use as hard coating on cutting tools, diffusion barrier for microelectronic devices, optical coating & golden surface on jewellery.
[Hexagonal TiS: JSSC 114 346-58 1995.]

**osmium** (Os,Ir). Hexagonal closest packing of spheres.
Isostructural with *rhenium* & *ruthenium.*
Os-Ir-Ru alloys: nomenclature, **DC Harris LJ Cabri** 1973 CM 12 104-12;
in Western Sayan: **N Tolstykh A Krivenko L Pospelova** 1997 EJM 9 457-65 (T517);

in peridotite, **FE Brenker A Meibom R Frei** 2003 AM 88 1731-40;
Fe-rich & W-rich (California), **AY Barkov & 4 others** 2006 AM 91 191-5.

**OSUMILITE STRUCTURE GROUP** Includes:

| | | |
|---|---|---|
| *almarudite* | $K(void,Na)_2(Mn,Fe,Mg)_2(Be,Al)_3Si_{12}O_{60}$ | |
| *armenite* | $BaCa_2Al_6Si_9O_{30}.2aq$ | |
| *berezanskite* | $KLi_3Ti_2Si_{12}O_{30}$ | |
| *brannockite* | $KLi_3Sn_2Si_{12}O_{30}$ | |
| *chayesite* | $K(Mg,Fe)(Mg,Fe)_2Fe^{3+}Si_{12}O_{30}$ | |
| *darapiosite* | $(K,Na)_3Li(Mn,Zn)_2ZrSi_{12}O_{30}$ | |
| *dusmatovite* | $K_{1.4}Na_{0.6}(Mn,Zr,Y)_2(Zn,Li)_3[Si_{12}O_{30}]$. | |
| *eifelite* | $KNa_3Mg_4Si_{12}O_{30}$ | |
| *emeleusite* | $Na_4Li_2Fe_2Si_{12}O_{30}$ | |
| *merrihueite* | $(K,Na)_2(Fe,Mg)_5Si_{12}O_{30}$ | |
| *milarite* | $KCa_2AlBe_2Si_{12}O_{30}.aq$ | |
| *osumilite* | $(K,Na)(Mg,Fe)_2(Al,Fe)_3(Si,Al)_{12}O_{30}.aq$ | |
| *[osumilite-Mg* | probably an unnecessary name] | |
| *poudretteite* | $KNa_2B_3Si_{12}O_{30}$ | |
| *roedderite* | $(Na,K)_2(Mg,Fe)_5Si_{12}O_{30}$ | |
| *sogdianite* | $(K,Na)_2Li_2(Li,Fe,Al)_2ZrSi_{12}O_{30}$ | |
| *sugilite* | $KNa_2(Fe,Mn,Al)_2Li_3Si_{12}O_{30}$ | |
| *trattnerite* | $(Fe,Mg)_2(Mg,Fe)_3Si_{12}O_{30}$ | |
| *tuhualite* | $(Na,K)Fe^{2+}Fe^{3+}Si_6O_{15}$ | distorted orthorhombic |
| *yagiite* | $(Na,K)_3Mg_4Al_6(Si,Al)_{24}O_{60}$ | |
| *zektzerite* | $LiNa(Zr,Ti,Hf)Si_6O_{15}$ | distorted orthorhombic |

Consortium for Theoretical Frameworks tetrahedral net 279.
Summary: **PA Sandomirskii MA Simonov NV Belov** 1978 SPD 23 101-3 (S1266);
**FC Hawthorne & 5 others** 1991 AM 76 1836-56.
Na-poor,Zr-rich analog of *berezanskite*: AM 86 379.
Nearly alkali-free, occurrence: AM 86 1114.
*Synthetic* $BaMg_2Al_6Si_9O_{30}$, $SrMg_2Al_6Si_9O_{30}$ & $Mg_2Al_4Si_{11}O_{30}$: **W Winter T Armbruster C Lengauer** 1995 EJM 7 277-86 (W679).

**osumilite** $(K,Na)(Mg,Fe)_2(Al,Fe)_3(Si,Al)_{12}O_{30}.aq$. Osumilite structure group.
Structure: **A Miyashiro** 1956 AM 41 104-16 (M37);
**GE Brown GV Gibbs** 1969 AM 54 101-16 (B366);
**K Hesse F Seifert** 1982 ZK 160 179-86;
**T Armbruster R Oberhänsli** 1988 AM 71 585-94;
optical spectra, **MN Taran GR Rossman** 2001 AM 86 973-80.
Occurrence: MM 30 742.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**[**osumilite-Mg See above.]

**oswaldpeetersite** $(UO_2)_2CO_3(OH)_2.4aq$.
Occurrence & XRPD: **R Vochten M Deliens O Medenbach** 2002 CM 39 1685-9.

**otavite** $CdCO_3$. *Calcite* structre group.
Structure: **VL Borodin & 3 others** 1979 DAN SSSR 245 1099-101.
Calcite-aragonite transition at high-P: **L Liu C Lin** 1997 AM 82 643-6.

**otjisumeite** $PbGe_4O_9$. Triclinic pseudohexagonal (K729).
*Synthetic* hexagonal polymorph is isotypic with hexagonal *benitoite*.
Occurrence & crystallography: **P Keller PJ Dunn** 1981 NJMM 49-55 (K729).

**ottemannite** $Sn_2S_3$-beta.
Structure: **R Kniep & 3 others** 1982 AC B38 2022-3.
Occurrence: MM 35 1149.

**ottrelite** $(Mn,Fe,Mg)_2Al_4Si_2O_{10}(OH)_4$.
*Chloritoid* structure group from crystallography; monoclinic & triclinic polymorphs.
Occurrence: **A-M Fransolet** 1978 BM 101 548-57;
almost pure Mn endmember, **T Theye A-M Fransolet** 1994 EJM 6 547-55.
**otwayite** $(Ni,Mg)_2(CO_3)(OH)_2.aq$.
Structure determination not found.
Occurrence: **EH Nickel BW Robinson CES Davis** 1977 AM 62 999-1002;
**DA Henry WD Birch** 1992 MM 56 252-5.
**oulankaite** $(Pd,Pt)_{5+x}(Cu,FeAg)_{4-x}SnTe_2S_2$.
Structure determination not found.
Occurrence & XRPD: **AYu Barkov & 3 others** 1996 EJM 8 311-6 (B1509);
composition range & argentoan series, **AY Barkov & 3 others** 2004 CM 439-53..
**ourayite** $Pb_4Ag_3Bi_5S_{13}$. (Latest composition; other compositions listed earlier.)
*Lillianite* homologous series, subtype 11,11.
B- & P- crystallographic types.
Structure determination not found.
Occurrence: **E Makovicky S Karup-Møller** 1977 NJMA 131 56-82 (M1210);
**do** 1984 CM 22 565-75.
Occurrence: MM 42 527-8.
**oursinite** $(Co,Mg)(UO_2)_2Si_2O_7.6aq$. Possibly isotypic with *uranophane*.
Structure determination not found.
Occurrence: **M Deliens P Piret** 1983 BM 106 305-8.
**ovamboite** $Cu_{10}(Fe,Cu,Zn)_3WGe_3S_{16}$. *Germanite* structure group.
Occurrence & XRPD: **EM Spiridonov** 2003 DES 393A 9 1329-32.
**OVERITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *lun'okite* | $(Mn,Ca)(Mg,Fe,Mn)Al(PO_4)_2(OH).4aq$ |
| *manganosegelerite* | $(Mn,Ca)(Mn,Fe,Mg)Fe(PO_4)_2(OH).4aq$ |
| *overite* | $CaMgAl(PO_4)_2(OH).4aq$ |
| *segelerite* | $CaMgFe(PO_4)_2(OH).4aq$ |
| *wilhelmvierlingite* | $(Ca,Zn)MnFe(PO_4)_2(OH).2aq$. |

[$CaMgSc_6(PO_4)_2(OH).4aq$. IMA 96-060. Analog of *overite* & *segelerite*.]
Summary of XRPD: **IV Voloshin YaA Pakhomovsky FN Tjusheva** 1992 ZVMO 96-103 (V205).
**overite** $CaMgAl(PO_4)_2(OH).4aq$. *Overite* structure group.
Structure: **PB Moore T Araki** 1977 AM 62 692-702.
Occurrence: MM 25 640.
**owensite** $(Ba,Pb)_6(Cu,Fe,Ni)_{25}S_{27}$.
*Djerfisherite* mineral group; structural topology similar to *djerfisherite* & *thalfenisite*, but site occupancy differs because of valence changes; general relation to *argentopentlandite*.
Structure: **JT Szymanski** 1995 CM 33 671-7.
Occurrence: **JHG Laflamme & 3 others** 1995 CM 33 665-70.
**owyheeite** $Pb_{10-2x}Ag_{3+x}Sb_{11+x}S_{28}$, x = 0.13-0.2.
Structure determination not found.
Occurrence: **SC Robinson** 1949 AM 34 398-401 (R556).
**oxammite** $(NH_4)_2C_2O_4.aq$.
Structure: early papers; at 30K, **JH Robertson** 1965 AC 18 410-9.
Occurrence: in fertilizers, **JR Lehr & 4 others** EH 1966 *Crystallographic Properties of Fertilizer Compounds*, Tenn Valley Auth Chem Eng Bull 6, 163p (L758);
caves, Raman, **RL Frost MI Weier** 2004 NJMM 27-48 (10083).
**oxykaersutite**
Occurrence: MM 32 974.
**oxykinoshitalite** $Ba(Mg_2Ti)(Si_2Al_2)O_{10}O_2$. 1M polytype of mica.
Occurrence & SC-XRD structure: **LN Kogarko & 5 others** 2005 CM 43 1501-10 = AM 91 1204-5.
**oxypetscheckite / oxy-petscheckite**

Alteration product of *petscheckite* that has XRPD matching *synthetic* $UTa_2O_8$ (structure: **M Gasparin** 1960 BSFMC 83 1-21), & whose Fe is assigned to position 0,0,0.5 in space group Pbar31m: occurrence & crystallography, **A Mücke H Strunz** 1978 AM 63 941-6.

**oyelite** $Ca_{10}Si_8(B,Al)_2O_{29}.12.5aq$.

Structure determination not found.
Occurrence: **I Kusachi C Henmi K Henmi** 1984 JJAMPEG 79 267-75 = AM 71 230.

**pääkkönenite** $Sb_2AsS_2$. Compare with *stibnite*.

Structure: *synthetic*, **P Bonazzi D Borrini F Mazzi F Olmi** 1995 AM 80 1054-8.
Occurrence: MM 46 523-4.
*Synthetic*, thermal properties & XRPD: **GP Bernardini & 6 others** 1996 EJM 8 639-48 (B1517).

**paarite** $Cu_{1.6}Pb_{1.6}Bi_{6.4}S_{12}$.

56 Å member of *bismuthinite-aikinite* series, stuffed *stibnite*.
Compare *salzburgite* with different superstructure 45 Å.
Occurrence & structure: SC-XRD, **E Makovicky D Topa T Balic-Zunic** 2001 CM 39 1372-82; **D Topa E Makovicky T Balic-Zunic** 2005 CM 43 909-17 = AM 91 218.

**pabstite** $Ba(Sn,Ti)Si_3O_9$. *Benitoite* structure group.

Structure: **FC Hawthorne** 1987 NJMM 16-30 (H816).
Occurrence: MM 35 1149.

**paceite** $CaCu(CH_3COO)_4.6aq$.

Occurrence & XRPD = *synthetic*: **DE Hibbs & 4 others** 2002 MM 66 459-64.

**pachnolite** $NaCaAlF_6.aq$. Dimorphic with *thomsenolite*.

Structure: **FC Hawthorne RB Ferguson** 1983 CM 21 561-66 (H719).

**padëraite** $Cu_{5.9}Ag_{1.3}Pb_{1.6}Bi_{11.2}S_{22}$. *Cuprobismutite-hodrushite* group.

Structure: **WG Mumme** 1986 CM 24 512-21.
Occurrence: MM 50 754.

**padmaite** PdBiSe. XRPD matches *synthetic*: [jvs: check for structure.]
Occurrence: **YuS Polekhovskiy & 7 others** 1991 ZVMO 120 85-8 (P488) = MM 60 678.

**paganoite** $NiBiAsO_5$. Similar topology to *jagowerite*.

Occurrence & SC-XRD structure: **AC Roberts & 5 others** 2001 EJM 13 167-75 (1752).

**pahasapaite** $(Ca,Li,K,Na)_{10.5}Li_8Be_{24}P_{24}O_{96}.38aq$. *Zeolite* mineral family.

Structure originally determined from synthetic zeolite *rho*; IZA-SC code RHO.
Consortium for Theoretical Frameworks tetrahedral net 206.
Structure: **RC Rouse & 5 others** 1987 NJMM 433-40;
**RC Rouse DR Peacor S Merlino** 1989 AM 74 1195-202;
dehydration, **DR Corbin & 4 others** 1991 Z 11 364-7 (C630).
*Synthetic* rho-A: **HE Robson & 3 others** 1973 Advances in Chemistry Series 121 106-15.
*Synthetic* Cs-exchanged, 293 & 493K, ND: **JB Parise E Prince** 1983 MRB 18 841-52.
*Synthetic* $NH_4$- & H-: **LB McCusker** 1984 Z 4 51-5 (M759).
*Synthetic* rho: before & after dehydration, **LB McCusker C Baerlocher** 1984 Proc Int Zeolite Conf 6th 812-22;
framework flexibility 11-573 K, ND: **JB Parise & 3 others** 1984 JPC 88 2303-7;
dehydration, ND, DLS model: **JB Parise & 3 others** 1984 JPC 88 1635-40 (P365).
adsorbed Xe, ND: **PA Wright & 3 others** 1984 JCSCC 1338-9;
do, **I Gameson & 3 others** 1986 Chem Phys Lett 123 145-9 (G564);
deuterated calcined 773 & 923 K: **RX Fischer & 6 others** 1986 JPC 90 4414-23 (F255);
neutron inelastic scattering of framework OH: **MJ Wax & 5 others** 1986 JPC 90 532-4;
shallow-bed calcined 773/873 K, ND: **WH Baur & 7 others** 1987 ZK 179 281-304 (B885).
deuterated dehydrated calcined shallow bed steam 773K, XR&ND: **RX Fischer & 3 others** 1987 JPC 91 2227-30, **do** 1988 ACB 44 321-34(F320).
sorbed methyl chloride: **I Gameson & 3 others** 1988 JPC 92 988-91 (G564).
*Synthetic* Na,Ce-: ND, **WH Baur & 3 others** 1989 ZK 187 253-66.
*Synthetic* Ca-exchanged-, ND: **DR Corbin & 5 others** 1989 JCSCC 42-3 (C589).
*Synthetic* $NH_4$-loaded/part deammoniated, ND: **RX Fischer & 5 others** 1989 ACC 45 983-9 (F333).

*Synthetic* H-, nature of OH: **RD Shannon & 5 others** 1989 JPC 93 2019-27 (S995).
*Synthetic* divalent cation-exchanged, XR&ND: **DR Corbin & 6 others** 1990 JACS 112 4821-30.
*Synthetic* Rb-exchanged /$Rb_{24}Be_{24}As_{24}O_{96}$.3.2$D_2O$, ND: **JB Parise & 5 others** 1992 Z 12 360-8 (P700).
*Synthetic* Rb-doped, microwave conductivity, NPD structure: **PA Anderson & 5 others** 2004 DT 3122-8 (10855).
*Synthetic* $NH_4$-exchanged-, low-high phase change: **A Bieniok WH Baur** 1993 ACB 49 817-22.
*Synthetic* Cd-exch-, Xe absorption/release: **DR Corbin & 4 others** 1993 JCSCC 1027-9 (C667).
*Synthetic* AlSi-, BeAs- & BeP- exchanged Tl/Rb, N&XRD: **JB Parise & 6 others** 1994 Z 14 25-34 (P439).
*Synthetic* gallosilicate ECR-10 rho type: **JM Newsam & 2 others** 1995 JPC 99 9924-32 (N371).
*Synthetic*, loaded with methylamines:
mono-, hydrated & dehydrated, N&XRPD, **C Weidenthaler & 3 others** 1997 ACB 53 429-39 (W801);
di-, hydrated & dehydrated, N&XRPD, **C Weidenthaler RX Fischer L Abrams** 1997 ACB 53 429-39 (W802);
tri-, hydrated & dehydrated, N&XRPD, **C Weidenthaler & 3 others** 1997 ACB 53 429-39 (W801).
*Synthetic* Co-, Mn- & Mg-: **P Feng X Bu GD Stucky** 1998 MMM 23 315-22 (F630).
*Synthetic* LiAl(Ge/Si)-, XRPD: **GM Johnson & 5 others** 1999 ChM 11 2780-7 (J358).
*Synthetic* Cd- & Pb-exchanged RHO, N&XRPD: **Y Lee & 8 others** 2001 JPCB 105 7188-99.
Understanding negative thermal expansion & cation relocation: **BA Reisner & 9 others** 2000 ChC 2221-2 (371).
Compressibility to 3 GPa vs cations: **Y Lee & 7 others** 2001 JAChS 123 8418-9 (2963).
**painite** $CaZrBAl_9O_{15}$. Isotypic with *fluoborite*, *jaffeite* & *jeremejevite*.
Structure: **PB Moore T Araki** 1976 AM 61 88-94;
revision, SC-XRD, **T Armbruster & 5 others** 2004 AM 89 610-3.
Occurrence: MM 31 969.
**pakhomovskyite** $Co_3(PO_4)_2.8aq$. *Vivianite* group.
Occurrence & structure: **VN Yakovenchuk & 4 others** 2006 CM 44 117-23.
*Synthetic* : structure, **A Riou Y Cudennec Y Gerault** 1989 ACC 45 1412-3.
**palarstanide** $Pd_5(Sn,As)_2$. Matches *synthetic* $Pd_5As_2$. [jvs: check for structure of synthetic.]
Redefinition with revised composition: **TL Evstigneeva AD Genkin** 1986 Proc 13th IMA Mtg Sofia 165-74 = AM 74 1219-20.
Occurrence: **VD Bezigov EM Zav'yaolv EG Pavlov** 1981 ZVMO 110 487-92 = MM 46 524.
**palenzonaite** $Ca_{2.4}Na_{0.6}Mn_2V_{2.4}As_{0.3}Si_{0.3}O_{12}$. *Garnet* structure type.
Structure: **R Basso** 1987 NJMM 136-44.
**palermoite** $(Li,Na)_2(Sr,Ca)Al_4(PO_4)_4(OH)_4$. Compare structural linkage with *carminite*.
Cell data match *bertossaite* $(Li,Na)_2(Ca,Fe,Mn)Al_4(PO_4)_4(OH,F)_4$, possibly isostructural.
Structure: **PB Moore T Araki** 1975 AM 60 460-5.
Occurrence: MM 30 742.
[*Unnamed Ca,Sr analog*: **O Von Knorring** 1965 Rep Rwandaise Ministere Econ Bull Serv Geol 2 11-4 = AM 51 1819.]
**palladinite** PdO.
Rediscovery: **J Jedwab & 7 others** 1993 Terra Nova 5 Abstr Suppl no. 3 p. 21.
Occurrence, and Cu substitution: **GR Olivo M Gauthier** 1995 MM 59 455-63.
Pd oxides, possible hydrates & hydroxides, Madagascar: **I McDonald & 3 others** 1999 MM 63 345-52.
**palladium** Pd. Cubic closest packing = face-centered cubic. *Copper* structure group.
Occurrence: **Dana**.
**palladium bismuthide** $PdBi_3$. Distinct from *froodite*.
Occurrence: MM 36 1156.
**palladium diantimonide** $PdSb_2$.
Occurrence: MM 43 1065.
**palladium plumborsenide** PdPbAs.
Occurrence: MM 40 911.
**palladoarsenide** $Pd_2As$. Matches low-T *synthetic*.
[jvs: check for structure of synthetic.]
Occurrence & crystallography: **VD Begizov & 2 others** 1974 ZVMO 103 104-7 = AM 60 162.
**palladobismutharsenide** $Pd_2(As,Bi)$.
Structure determination not found. [jvs: look for synthetic.]
Occurrence: **LJ Cabri & 3 others** 1976 CM 14 410-3; MM 32 528.
**palladodymite** $(Pd,Rh)_2As$. Isostructural with *rhodarsenide*; polymorphic with *palladoarsenide* & *palladobismutharsenide*.

Occurrence & XRPD: **SN Britvin & 3 others** 1999 ZVMO 28 39-42.
**palladseite** $(Pd,Cu,Hg)_{17}Se_{15}$. [jvs: look for structure of synthetic.]
Oxidation in mineralized vein: **AR Cabral & 4 others** 2002 MM 66 327-36.
Occurrence: **RJ Davis AM Clark AJ Criddle** 1977 MM 41 123 & M10-3;
**GR Olivo M Gauthier** 1995 MM 59 455-63.
**palmierite** $(K,Na)_2Pb(SO_4)_2$. Isostructural with *kalistrontite* based on crystallography.
Review: **Sabelli** p 34.
Structure: **HG Bachmann W Kleber** 1953 Fortschr Mineral 31 9-11 = MA 12-434;
**PB Moore** 1973 AM 58 32-42 (M425);
**H Saalfeld** 1973 NJMM 75-8.
*Synthetic* $K_2Pb(SO_4)_2$, XRPD: **RG Tissot & 3 others** 2001 PD 16 92-7 (3584).
*Review of synthetic members*: **VA Efremov VK Trunov** 1975 SPC 19 613-5 (E300).

| | |
|---|---|
| $(K/Rb)_2Pb(SO_4)_2$ | $K_5(La/Nd/Sm/Eu/Gd)(MoO_4)_4$ |
| $(NH_4)_2Pb(SO_4)_2$ | $K_5(Dy/Ho/Er/Tm/Yb/Lu/Y)(MoO_4)_4$ |
| $Tl_2Pb(SO_4)_2$ | $Rb_5(La/Pr/Nd/Sm/Eu/Gd)(MoO_4)$ |
| $K_2(Pb/Sr)(MoO_4)_2$ | $(Ca/Sr/Ba/Pb)(PO_4)_2$ |
| $(Ca/Sr/Ba/Pb)_3(VO_4)_2$ | $(Sr/Ba)_3(AsO_4)_2$ |
| $(K/Rb)_3(MnO_4)_2$ | $Pb_2Ba(MoO_4)_2$ |
| ?-$K_5(Dy/Ho/Er/Tm/Yb/Lu/In)(MoO_4)_4$ | $K_5La(MoO_4)_4$ |

*Synthetic* double molybdates: **VA Efremov AR Gizhinskii VK Trunov** 1975 SPC 20 78-80.
**palygorskite** $\sim(Mg,Al)_2Si_4O_{10}(OH).4aq$.
Analog of *tuperssuatsiaite* $NaFe_3Si_8O_{20}.4aq$ & *yofortierite* $(Mn,Mg)_5Si_8O_{20}(OH)_2.4$-5aq.
Maya Blue is a *synthetic* pigment of indigo and palygorskite/*sepiolite.*
Revised composition *sepiolite* & palygorskite: **E Galan MI Carretero** 1999 ClCIM 47 399-409 (G1179).
Structure: **A Bellanca** 1946 PMR 15 5-25;
**VA Drits GV Sokolova** 1971 SPC 16 183-5 (D475);
XRPD & models, **JE Chisholm** 1992 CM 30 61-73 (C877);
XRPD, **G Artioli & 4 others** 1994 NJMM 217-29 (A738)
octahedral, FTIR, **A Chahi S Petit A Decarreau** 2002 ClCIM 50 306-13 (7467)
XRPD of Maya Blue, **G Chiari R Giustetto G Ricchiardi** 2003 EJM 15 21-33 (8915);
Raman/FTIR, lattice dynamics, **DA McKeown JE Post ES Etz** 2002 ClCIM 50 667-80 (9080);
NPD, **R Giustetto G Chiari** 2004 EJM 16 521-32 (10474)
mid-/near IR, **V Gionis & 3 others** 2006 AM 91 1125-33.
Models, TEM clays used for Maya Blue pigment: **ME Fernandez & 4 others** 1999 JMS 34 5243-55 (F681).
Dehydration/rehydration: TGA/NMR: **W Kuang GA Facey C Detellier** 2004 ClCIM 52 633-42 (10744).
Occurrence, fractured granite pluton: **DC Kamineni LY Griffault R Kerrich** 1993 CM 31 173-83.
Substituted type, Argentina, XRD, FTIR, Mössbauer: **MS Augsburger & 4 others** 1998 JPCS 59 175-80.
Transition to *smectite*, microscopy: **MPS Krekeler & 3 others** 2005 ClCIM 53 92-9.
**panasqueiraite** $CaMg(OH,F)PO_4$. *Titanite* structure type.
Structure: **AM Isaacs DR Peacor** 1981 CM 19 380-92.
**pandaite** $(Ba,Sr)_{2-x}Nb_2O_{7-x}.xaq$. *Pyrochlore* structure group.
Occurrence: MM 32 975.
**panethite** $(Na,Ca,K)_2(Mg,Fe,Mn)_2(PO_4)_2$.
Occurrence, Dayton octahedrite, *synthesis* Fe-free, suggested possible structural relation with *arrojadite*: **LH Fuchs E Olson EP Henderson** 1967 GCA 31 1711-9 = AM 53 509.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**panunzite** $K_{0.7}Na_{0.3}AlSiO_4$.
Stuffed *tridymite* structure type with 4-repeat superstructure = *synthetic tetrakalsilite*.
Structure: **S Merlino & 4 others** 1985 NJMM 322-8.
**paolovite** $Pd_2Sn$.
Matches *synthetic*: **Schubert et al** 1959 Z Metallkunde 50 [jvs; check for possible structure.]
Occurrence: **AD Genkin & 4 others** 1974 Geol Rudn Mestorozhdenii 16 98-103 = AM 59 1333.
**pao-t'ou-k'uang** $Ba(Ti,Nb,Fe)_2SiO_7$.
Structure determination not found. [jvs: check for *synthetic*.]

Occurrence: **C Peng** 1959 Ti-chik K'o-hsueh 10 289 = AM 45 754.

**papagoite** $CaCuAlSi_2O_6(OH)_3$. Review; E289).

Structure: **M Le Bihan** 1965 BSFMC 88 119-21;
**LA Groat FC Hawthorne** 1987 TMPM 87-96 (G633).

Occurrence: MM 32 975.

**papikeite** $(Mn_{0.7}Fe_{0.3})_2(Fe_{0.8}Mg_{0.2})_5Si_4O_{11}(OH)_2$. *Protoamphibole*.

Structure: (S1160).

[para-alumohydrocalcite $CaAl_2(CO_3)_2$ $(OH)_4.6aq$. Ignore for now. AM 63 794. MM 42 528.]

**parabariomicrolite** $BaTa_4O_{10}(OH)_2.2aq$.

Structure: **TS Ercit FC Hawthorne P Cerny** 1986 CM 24 655-63.

**parabrandtite** $Ca_2Mn(AsO_4)_2.2aq$. *Fairfieldite* structure group.

Mg analog is *talmessite*. Polymorphic with *brandtite*.

Description: **PJ Dunn & 4 others** 1987 NJMA 157 113-9 (D536); no detailed structure.

**parabutlerite** $Fe(SO_4)(OH).2aq$. Review: **Sabelli** p.15.

Hydroxyl-bridged octahedral/tetrahedral chain, similar to chain in *butlerite* & *synthetic* $In[SO_4](OH).2aq$; stereoisomeric with chain in *fibroferrite*.

Structure: **J Borène** 1970 BSFMC 93 185-9.

Occurrence: MM 25 640.

**paracelsian** $BaAl_2Si_2O_8$. Dimorphic with *celsian*.

Same net connectivity as *danburite*, *hurlbutite*, *slawsonite*.

Structure: **JV Smith** 1953 AC 6 613-20;
**VV Bakakin NV Belov** 1960 SPC 5 826-9;
**G Chiari & 4 others** 1985 AM 70 969-74.

*Synthetic* $Na_3Li(BeF_4)_2$: **J Vicat & 3 others** 1974 AC B30 2678-82.

*Synthetic* $SrGa_2(Ge/Si)_2O_8$: **MW Phillips & 3 others** 1975 AM 60 659-66.

*Synthetic* $Na_2ZnSi_3O_8$: **GF Plakhov MA Simonov NV Belov** 1974 SPD 19 173-5 (P462);
**MA Simonov YuE Egorov-Tismenko NV Belov** 1976 SPD 21 547-8 (S1270);
**GF Plakhov NV Belov** 1977 SPD 22 709-11 (P456);
**K Hesse & 4 others** 1977 AC B33 1333-7 (H709).

*Synthetic* Sr & $BaZn_2P_2O_8$, structure: **F Lucas & 4 others** 1998 CM 36 1045-51.

*Synthetic* ammonium-ZnCa phosphates, analogs of *analcime* & paracelsian, SC-XRD structure:
**NZ Logar M Mrak V Kaucic** 2001 JSSC 156 480-6 (1320).

**parachrysotile** $Mg_3Si_2O_5(OH)_4$. *Kaolinite-serpentine* structure group.

Polymorphic with *antigorite*, *clinochrysotile*, *lizardite* & *orthochrysotile.*

Occurrence & ED: **EJW Whittaker J Zussman** 1956 MM 31 107-26;
**J Zussman GW Brindley JJ Comer** 1957 AM 42 133-53.

**paracoquimbite** $Fe_2(SO_4)_3.9aq$. Dimorphic with *coquimbite*. Review: **Sabelli** p.13.

Structure: **PD Robinson JH Fang** 1971 AM 56 1567-72 (R443).

Occurrence: MM 23 635.

**paracostibite** CoSbS. Isostructural with *pararammelsbergite*.

Structure: **X-ray Laboratory Wuhan, etc** 1976 Sci Geol Sinica 227-34 = MA 77-1489.

Occurrence & crystallography: **LJ Cabri DC Harris JM Stewart** 1971 CM 10 232-46.

**paradamite** $Zn_2(AsO_4)OH$. Dimorphic with *adamite*. Isostructural with P analog *tarbuttite*.

Structure: **T Kato Y Miura** 1977 MJJ 8 320-8;
**FC Hawthorne** 1979 AC B 35 720-2;
**TJ Bennett** 1980 AM 65 353-4.

Occurrence: MM 31 969.

**paradocrasite** $Sb_2(Sb,As)_2$.

Structure determination not found.

Jvs: check against *calaverite* & *stibarsen*.

Occurrence & crystallography: **BF Leonard CW Mead** 1971 AM 56 1127-46.

**paraduttonite** $\sim V_2O_5.aq$. Oxidation product of *duttonite*.

Occurrence: MM 33 1147.

**parafransoletite** $Ca_3Be_2(PO_4)_2(PO_3OH)_2.4aq$. Dimorph of *fransoletite*.
Structure: **AR Kampf** 1992 AM 77 848-56.
**paragonite** $NaAl_2AlSi_3O_{10}(OH)_2$. *Mica* structure group; dioctahedral.
Structure: 1M polytype, **SV Soboleva OV Sidorenko BB Zvyagin** 1977 SPC 22 291-3;
3T polytype, **OV Sidorenko BB Zvyagin SV Soboleva** 1977 SPC 22 557-60;
**C Lin SW Bailey** 1984 AM 69 122-7 (L375);
to 1073 K, SC-XRD, **P Comodi PF Zanazzi** 2000 PCM 27 377-85 (C1158).
P dependence to 4 GPa: **P Comodi PF Zanazzi** 1997 PCM 24 274-80 (C909).
Stability at 973 K vs aq-NaCl fluid: **P Tropper CE Manning** 2004 CoMP 147 740-9 (10632).
**paraguanajuaite** $Bi_2(Se,S)_3$. Dimorpic with *guanajuaite*.
*Tetradymite* mineral/structure group; tetradymite subgroup.
Structure: **P Bayliss** 1991 AM 76 257-65.
Occurrence: MM 28 735.
**parahilgardite / hilgardite-3Tc / hilgardite-3A** $Ca_2[B_5O_9]Cl.aq$.
Trimorphic with *hilgardite* & *Cl-tyretskite.*
Consortium for Theoretical Frameworks octahedral-tetrahedral net 1063.
Structure: **C Wan S Ghose** 1983 AM 68 604-13 (W106).
**parahopeite** $Zn_3(PO_4)_2.4aq$. Dimorphic with *hopeite*.
Structure: **I Kumbasar JJ Finney** 1968 MM 36 621-4;
**GY Chao** 1969 ZK 130 261-6 = MA 20-2141.
**parajamesonite** $Pb_4FeSb_6S_{14}$. Dimorphic with *jamesonite*.
Structure determination not found.
Occurrence: **V Zsivny I von Naray-Szabo** 1947 SMPM 27 183-9 = AM 34 133.
**parakeldyshite** $(Na,Ca)_2ZrSi_2O_7$.
Consortium for Theoretical Frameworks octahedral-tetrahedral net 1084.
Occurrence & crystal structure: **AA Voronkov & 2 others** 1970 Zhurn Struct Khim 11 932-3;
MM 43 1065;
**G Raade MH Mladeck** 1977CM 15 102-7 (R489).
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** 1995.
*Synthetic* XRPD: **G Wilson FP Glasser** 1987 PD 2 176-9.
**parakhinite** $Cu^{2+}_3PbTe^{6+}O_6(OH)_2$.
Structure: **PC Burns MA Cooper FC Hawthorne** 1995 CM 33 33-40 (B1598).
Occurrence: MM 43 1065.
**parakuzmenkoite-Fe** $(K,Ba)_2Fe(Ti,Nb)_4(Si_4O_{12})_2(O,OH)_4.7aq$. *Labuntsovite* group.
Occurrence: **NV Chukanov & 5 others** 2001 ZVMO 130 63-6 (7820).
**paralaurionite** PbClOH. Dimorphic (polytypic) with *laurionite*.
Structure: **S Merlino M Pasero N Perchiazzi** 1993 MM 57 323-8.
**paralstonite** $(Ba,Sr)Ca(CO_3)_2$. Trimorphic with *alstonite* & *barytocalcite*.
Isostructural with Sr analog *olekminskite.*
Structure: **H Effenberger** 1980 NJMM 353-63.
Occurrence: MM 46 524.
*Synthesis*, sputter-deposition: **KJ Blobaum & 4 others** 2003 JMR 18 1535-9 (9255).
**paramelaconite** $Cu^+_2Cu^{2+}_2O_3$.
Structure: **N Datta JW Jeffrey** 1978 AC B34 22-6 (believed to have serious errors);
**M O'Keeffe J Bovin** 1978 AM 180-5;
*synthesis* & errors in earlier structures, **PED Morgan & 3 others** 1996 JSSC 121 33-57 (M1350).
**paramendozavilite** $NaAl_4Fe_7(PO_4)_5(PMo_{12}O_{40})(OH)_{16}.56aq$. Related to *mendozavilite*.
[jvs: check inorganic literature for heteropolyacids.]
Occurrence: **SA Williams** 1986 Boletin de Mineralogia 2 13-9 = MM 50 754.
**paramontroseite** $VO_2$. *Diaspore* structure group.
Structure: **HT Evans Jr S Block** 1953 AM 38 1242-50;
**HT Evans Jr ME Mrose** 1955 AM 40 861-75.
**paranatisite** $Na_2TiOSiO_4$. Orthorhombic polymorph of tetragonal *natisite*.

Derivative of *sulfohalite* type: **OV Yakubovich OK Mel'nikov** 1995 Phys-Dokl 40 279-84 (Y164).
Structure: **EV Sokolova & 3 others** 1985 SPD 30 822-5 (S1296);
**A Ziadi & 3 others** 1996 JSSC 123 324-30 (Z114);
**E Sokolova FC Hawthorne** 2002 CM 40 947-60.
Occurrence: **AP Khomyakov LI Polezhaeva EV Sokolova** 1992 ZVMO 133-7 (K671);
in hyperagpaitic alkaline rocks: **Khomyakov** 1995.

**paranatrolite** $Na_2Al_2Si_3O_{10}.3aq$. See *natrolite* for overall view.

Structure: SC-XRD, **YV Seryotkin VV Bakakin IA Belitsky** 2004 EJM 16 545-60 (10475).
P-induced stabilization & structure of ordered at 1 GPa: **Y Lee & 3 others AM** 90 252-7.
Occurrence: **G Chao** 1980 CM 18 85-8;
**AP Khomyakov GE Cherepivskaya NG Mikheeva** 1986 DAN SSSR 228 214-7.
Heat capacity: **IE Oaukov IA Belitskii YuA Kovalevskaya** (7974).
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** 1995.

**paraniite-Y** $Ca_2Y(AsO_4)(WO_4)_2$.

Structure: **F Demartin CM Gramaccioli T Pilati** 1992 AC C48 1357-9 (D537).
Second occurrence: **J Brugger & 3 others** 1998 AM 83 1100-10.
Review: (*paranite*?)**AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**paraotwayite** $Ni(OH)_{2-x}(SO_4,CO_3)_{0.5x}$.

Occurrence, electron diffraction & XRPD: **EH Nickel J Graham** 1987 CM 25 409-11.

**parapierrotite** $Tl(Sb,As)_5S_8$. Compare with *pierrotite*.

Structure: *synthetic*, **P Engel** 1980 ZK 151 203-16 (E324).

**pararammelsbergite** $NiAs_2$. Trimorphic with *krutovite* and *rammelsbergite*.

Similar XRPD to *paracostibite* CoSbS.
Structure: **ME Fleet** 1972 AM 57 1-9;
**A Kjekshus T Rakke** 1979 Acta Chem Scand A33 609-15 (K716).
Occurrence: MM 25 640.
*Synthetic* $(Co,Ni)As_2$ & $NiAs_{2-x}S_x$: [jvs: check references.]

**pararealgar** AsS. Polymorph of realgar.
Structure: **P Bonazzi S Menchetti G Pratesi** 1995 AM 80 400-3.
Occurrence: MM 46 524.
*Occurrence* in 13C ms with *vermilion*, *lazurite* & *realgar*: **RJH Clark PJ Gibbs** 1997 ChC 1003-1 (C905).

**pararobertsite** $Ca_2Mn_3(PO_4)_3O_2.3aq$.

Close structural relation with *robertsite*.
See *sailaufite* $(Ca,Na,void)_2Mn_3O_2\ (AsO_4)_2(CO_3).3aq$.
Structure: SC-XRD, **AR Kampf** 2000 AM 85 1302-6.
Occurrence: **AC Roberts & 3 others** 1989 AM 27 451-5.

**pararsenolamprite** As. Polymorph of *arsenic*.
Occurrence & XRPD: **S Matsubara & 3 others** 2001 MM 65 807-12.

**paraschachnerite / para-schachnerite** $Ag_3Hg_2$.

Orthorhombic symmetry in comparison with hexagonal *schachnerite*, the beta phase.
Cell dimensions but not space group match *dyscrasite* $Ag_3Sb$;
also compare with *allargentum*.
Occurrence: **E Seeliger A Mücke** 1972 NJMA 117 1-18.

**paraschoepite** $UO_3.2aq$?. Natural dehydration product of *schoepite*.

Structure determination not found.
Occurrence: MM 28 735; **CL Christ JR Clark** 1960 AM 45 1026-61.

**parascholzite** $CaZn_2(PO_4)_2.2aq$. Dimorphic with *scholzite*.

Essentially a distorted superstructure of *scholzite.*
Structure: **K Taxer H Bartl** 1997 ZK 212 197-202 (T513).
Occurrence: **BD Sturman RC Rouse PJ Dunn** 1981 AM 66 843-51.

**parascorodite** $FeAsO_4.2aq$. Dimorph of *scorodite*.

ED, XRPD, IR, SEM/TEM, TG, DTA: **P Ondrus R & 5 others** 1999 AM 84 1439-44.
Structure: XRPD, **N Perchiazzi & 2 others** 2004 EJM 16 1003-7 = AM 90 1469.

**parasibirskite** $Ca_2B_2O_5.aq$. Polymorph of *sibirskite*.

Description: **I Kusachi & 3 others** 1998 MM 62 521-5.

**paraspurrite** $Ca_5(SiO_4)_2CO_3$. Dimorphic with *spurrite*.

Occurrence & structure model: **AA Colville PA Colville** 1977 AM 62 1003-5.

**parasymplesite** $Fe_3(AsO_4)_2.8aq$. Dimorphic with *symplesite*. *Vivianite* structure type.

Detailed structure determination not found.

Occurrence: **T Ito H Minato K Sakurai** 1954 Proc Japan Acad 30 318-24 = AM 40 368.

**paratacamite** $Cu_2(OH)_3Cl$.

**[herbertsmithite** $Cu_3Zn(OH)_6Cl_2$. Solid solution with *Zn-stabilized paratacamite*.

New definition: **RSW Braithwaite & 3 others** 2004 MM 68 527-39.]

Probably quadrimorphic with *atacamite, botallackite* & *clinoatacamite.* Review: (E289).

Structure: **ME Fleet** 1975 AC B31 183-7;

Raman/FTIR & implications for copper /brass corrosion, **W Martens RL Frost PA Wiliams** 2003 NJMA 197-215 (8927)..

**paratellurite** $TeO_2$-alpha. [Not *rutile* structure group**]**. Dimorphic with *tellurite*-beta.

Structure: early papers; **O Lindqvist** 1968 Acta Chem Scand 22 977-82 (L701).

Occurrence: **G Switzer HE Swanson** AM 45 1272-4.

*Synthetic*, Raman evidence for gamma & delta polymorphs: **AP Mirgorodsky et al** 2000 JPCS 61 501-9 (M1829).

**paratooite-La** $\sim(REE,Ca,Na,Sr)_6Cu(CO_3)_8$.

Occurrence S Australia & XRPD: **A Pring & 3 others** 2006 MM 90 131-8 = AM 91 1455-6.

**paratsepinite-Ba** $(Ba,Na,K)_{2-x}(Ti,Nb)_2(Si_4O_{12})(OH,O)_2.4aq$. *Labuntsovite* group.

Occurrence: **NV Chukanov & 6 others** 2003 ZVMO 132 38-51.

**paratsepinite-Na** $(Na,K,Ba)_{2-x}(Ti,Nb)_2(Si_4O_{12})(OH,O)_2.4aq$. *Labuntsovite* group.

Structure: **NV Organova & 5 others** 2004 CrR 49 949-52 (10967).

**paraumbite** $\sim K_3Zr_2H(Si_3O_9)_2.\sim 7$ aq. Similar to *umbite*, but with double *c*.

Structure determination not found.

Occurrence: **AP Khomyakov & 3 others** 1983 ZVMO 112 462-9 = MM 48 580;

in hyperagpaitic alkaline rocks, **Khomyakov** 1995.

**PARAVAUXITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *gordonite* | $MgAl_2(PO_4)_2(OH)2.8aq$ |
| *laueite* | $MnFe_2(PO_4)_2(OH)_2.8aq$ |
| *mangangordonite* | $(Mn,Fe,Al)Al_2(PO_4)_2(OH)_2.8aq$ |
| *paravauxite* | $FeAl_2(PO_4)_2(OH)_2.8aq$ |
| *sigloite* | $Fe^{3+}Al_2(PO_4)_2(OH)_3.7aq$ |
| *ushkovite* | $MgFe^{3+}{}_2(PO_4)_2(OH)_2.8aq$ |

**paravauxite** $FeAl_2(PO_4)_2(OH)_2.8aq$. *Paravauxite* structure type.

Structure: **WH Baur** 1969 NJMM 430-3.

**paravinogradovite** $(Na,\square)_2(Ti,Fe)_4(Si_2O_6)_2(Si_3AlO_{10})(OH)_4.aq$.

Related to *vinogradite*.

Occurrence & SC-XRD structure: **AP Khomyakov & 4 others** 2003 CM 41 989-1002.

**parawollastonite** $CaSiO_3$-(monoclinic beta).

Quadrimorphic with *triclinic-beta-$CaSiO_3$* (*wollastonite*), *$CaSiO_3$-alpha* (*pseudowollastonite*) & *high-pressure-$CaSiO_3$*.

Isostructural with *pectolite-M2abc* from ED.

Structure: **J Tolliday** 1958 N 182 1012-3 (T3);

**FJ Trojer** 1968 ZK 127 291-308;

**MG Vincent JW Jeffery** 1979 AC A35 938-41;

**K Hesse** 1984 ZK 168 93-8;

**WH Baur** 1986 ZK 309-11.

Occurrence: MM 24 620.

*Synthetic* $NaPO_3$: **K Dornberger-Schiff F Liebau E Thilo** 1954 Nw 41 551.

**pargasite** $NaCa_2(Mg,Fe)_4AlSi_6Al_2O_{22}(OH)_2$.

*Amphibole* structure group; monoclinic subtype.

Structure: **K Robinson & 3 others** 1973 AJS 273A 522-35;
15 pargasites & pargasitic hornblendes from Finero mantle peridotite, **R Oberti & 3 others** 1995 CM 33 867-78;
NPD of cation ordering, **MD Welch KS Knight** 1999 EJM 11 321-31 (W963);
Al/Si disorder, SC-XRD, **KT Tait FC Hawthorne G Della Ventura** 2001 CM 39 1725-32.

Enthelpy of formation: **W Kahl WV Maresch MD Welch** 2003 EJM 15 617-28 (9312).

*Synthetic* $NaCa_2Mg_4(Al/Cr/Ga/Sc/In)Si_6Al_2O_{22}(OH)_2$: XRPD structure, IR & NMR, **M Raudsepp & 4 others** 1987 AM 72 580-93.

*Synthetic fluoropargasite*: **R Oberti & 4 others** 1995 CM 33 25-31;
Ga-substituted, **R Oberti & 3 others** 1998 CM 36 1245-52.

*Synthetic* pargasite & Co-substituted: IR, XRPD structure, **G Della Ventura** 1998 CM 36 1237-44.

*Synthetic* pargasite-*richterite* series: SEM, XRPD, HRTEM, IR, **G Della Ventura & 5 others** 1999 EJM 11 79-94 (D766).

*Synthetic* Cr-substituted: FTIR, **C Fialips-Guedon J Robert F Delbove** 2000 AM 85 687-93.

*Synthetic* pargasite-*fluoropargasite* 1.5 kb aq 1123 K: **J Robert & 3 others** 2000 AM 85 926-31.

**PARISITE STRUCTURE GROUP** Includes:

| | | |
|---|---|---|
| *baiyuneboite-Ce* | $?NaCaCe_2(CO_3)_4F_2$ | *c* = 23Å |
| *bastnaesite-Ce* | $(Ce,La)(CO_3)F$ | 10 |
| *bastnaesite-Nd* | $(Nd,etc.)(CO_3)F$ | |
| *bastnaesite-Y* | $(Y,Ce)(CO_3)F$ | |
| *cordylite-Ce* | $(Na_{1-x}Ca_{x/2})Ba(Ce,etc)_2(CO_3)$ | 23 |
| *huanghoite* | $BaLn(CO_3)_2F$ | 20 |
| *hydroxybastnaesite* | $(Ce,La)(CO_3)(OH,F)$ | 10 |
| *parisite* | $Ca(Ce,La)_2(CO_3)_3F_2$ | 14 |
| *parisite-Ce* | $Ca(Ce,La)_2(CO_3)_3F_2$ | many polytypes |
| *[parisite-Nd* | $Ca(Nd,Ce, La)_2(CO_3)_3F_2$ | 14] |
| *röntgenite* | $Ca_2(Ce,La)_3(CO_3)_5F_3$ | 69 |
| *synchisite* | $Ca(Ce,La)(CO_3)_2F$ | 55 |
| *synchisite-Nd* | $Ca(Nd,La)(CO_3)_2F$ | 55? |
| *synchisite-Y* | $Ca(Y,Ce)(CO_3)_2F$ | 55? |

Polytypism & possible polysomatism complicate the nomenclature. [jvs: above data are copied from the literature; thorough study should reveal many subtleties.]

Parisite-Nd has not been approved as a mineral species: AM 73 1496-7.

TEM of *parisite-Ce*: polytypes 42R (*c* = 59 Å), 48R (67) & 16H (23), **G Yang X Wu Z Pan** 1993 Acta Mineral Sinica 13 331-4 = AM 80 188;
6R, 8H, 14H, 36R, 42R, **D Meng X Wu T Mou D Li** 2002 CM 39 1713-24 [jvs: caution with name because of possible relations with *cordylite* & *röntgenite*].

Occurrence of *parisite-Ce & synchisite-Ce* in *talc-chlorite*, Trimouns, French Pyrenees: **P de Parseval F Fontan T Aigouy** 1997 CRASP 324 IIa 625-30 (D639).

**parisite-Ce** $Ca(Ce,La)_2(CO_3)_3F_2$. Parisite structure group.

Polytypes 3R, 4H, 6R, 8H, 10H, 16H, 18R, 24R, 30R, 42R & 48R.

Structure: **G Donnay JDH Donnay** 1953 AM 38 932-63;
SC-XRD, **Y Ni JE Post JM Hughes** 2000 AM 85 251-8.

6 polytypes: EM, **D Meng X Wu T Mou D Li** 2001 MM 65 797-806.

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

Four Chinese papers = AM 81 253-4, 83 1119.

**parisite-Nd** $Ca(Nd,Ce,La)_2(CO_3)_3F_2$.

Chinese paper; not fully characterized = MM 54 668.

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

**parkerite** $Ni_3(Bi,Pb)_2S_2$. Derivative of *shandite* $Ni_3Pb_2S_2$.

Related to *laflammeite* $Pd_3Pb_2S_2$.
Structure: ignore early paper;
*synthetic* $Ni_3Bi_2S_2$, **ME Fleet** 1973 AM 58 435-9;
proposal that Fleet structure is average, description of superstructure revealed by XRPD of annealed *synthetic*, **WS Brower HS Parker RS Roth** 1974 AM 59 296-301.
Occurrence: MM 24 620 (ignore); MM 27 267;
Sb-, Northeast Russia: **NA Goryachev & 4 others** 2004 DES 399A 1260-3 (10900).

**parkinsonite** $(Pb,Mo,void)_4O_4Cl$.
Occurrence:
& struct model akin *synthetic* Pb-Mo-oxybromide, **B Aurivillius & 3 others** 1982 Chemica Scripta 19 97-107):
**RF Symes & 5 others** 1994 MM 58 59-68;
cation ordering, **MD Welch & 3 others** 1996 AM 81 1350-9.

**parnauite** $Cu_9(AsO_4)_2(SO_4)(OH)_{10}.7aq$. Review: **Sabelli**, no structure.
Occurrence: **WS Wise** 1978 AM 63 704-8.

**parsettensite** Modulated island type layer structure.
Structure: **RA Eggleton S Guggenheim** 1994 AM 79 426-37;
models for, & *stilpnomelane*, **S Guggenheim RA Eggleton** 1994 AM 79 438-42.

**parsonsite** $Pb_2(UO_2)(PO_4)_2.n\ aq$.
*Hallimondite* is As analog.
Structure: **F Mazzi CL Garavelli F Rinaldi** 1958 Atti Soc Tosc Sci Nat A65 135-?;
SC-XRD, **P Burns** 2000 AM 85 801-5;
**AJ Locock PC Burns TM Flynn** 2005 AM 90 240-6.
Occurrence: **C Bignand** 1955 BSFMC 78 1-26;
**C Frondel** 1958 USGS Bull 1064 233-6.
*Synthesis* of anhydrous parsonsite & HCa-analog: **V Ross** 1956 AM 41 915-26.

**partheite / parthéite** $CaAl_2Si_2O_8.2aq$. IZA-SC code -PAR.
Consortium for Theoretical Frameworks interrupted tetrahedral net 973.
Structure: **N Engel K Yvon** 1984 ZK 169 165-75 (E201).
Occurrence: **H Sarp J Deferne H Bizouard BW Liebich** 1979 SMPM 59 5-13 (S1528).
[*Partridgeite* has lower Fe than *bixbyite*, and appears anisotropic: **J Gutzmer NJ Beukes** 1997 MM 61 213-31. It was not approved as a new mineral, proposal: **JE De Villiers** 1943 AM 28 336-8.]

**partzite** $Cu_2Sb_2(O,OH)_7$? *Pyrochlore* structure group; *stibiconite* subgroup.
Occurrence, chemistry & XRPD: **B Mason CJ Vitaliano** 1953 MM 30 100-12.

**parvo-mangano-edenite** $Na(CaMn)Mg_5Si_7AlO_{22}(OH)_2$. Amphibole.
Occurrence & SC-XRD structure: **R Oberti &4 others** 2006 AM 91 526-32.

**parvo-mangano-tremolite** $(CaMn)Mg_5Si_8O_{22}(OH)_2$. Amphibole.
Occurrence & SC-XRD structure: **R Oberti &4 others** 2006 AM 91 526-32.

**parwelite** $(Mn,Mg)_5Sb(As,Si)_2O_{12}$.
Structure: **PB Moore T Araki** 1977 IC 16 1839-47 (M646).
Occurrence: MM 37 962.

**pascoite** $Ca_3V_{10}O_{28}.17aq$.
Structure: SC-XRD, **JM Hughes M Schindler C Francis** 2005 CM 43 1387-91 = AM 91 715.
Occurrence: **Dana**.

**patronite** $VS_4$.
Structure: **A Kutoglu R Allmann** 1972 NJMM 339-45.

**paulingite** $(K_2,Ca,Na_2,Ba)_5Al_{10}Si_{32}O_{84}.34\text{-}44aq$. *Zeolite* mineral group.
IZA-SC code FAU. Consortium for Theoretical Frameworks tetrahedral net 203.
Structure: **EK Gordon S Samson WB Kamb** 1966 S 154 1004-6 (G132);
alternate description, **S Andersson L Faelth** 1983 JSSC 46 265-8;
2 refinements, **A Bienok W Joswig WH Baur** 1996 NJMA 2 119-34 (B1557);
$K_{2.3}Na_{0.4}Ca_{2.6}Ba_{1.4}Al_{11.5}Si_{30.6}O_{84}$, XRPD of hydrated & dehydrated, SC-XRD, **CL Lengauer G Giester E Tillmanns** 1997 MM 61 591-606;
dehydration, SC-XRD 293 to 523 K, **A Bieniok** 1997 NJMM 498-504 (B1792).

Composition variation: **RW Tschernich WS Wise** 1982 AM 67 799-803.
Crystal chemistry: **E Passaglia AF Gualtieri E Marchi** 2001 EJM 13 113-9 (1676).
Occurrence: **WB Kamb WC Oke** 1960 AM 45 79-91;
**ML Speckels** 1991 Rocks & Minerals 66 226-31;
**HJ Foy** 1992 UK J Mines & Minerals 11 24;
**CL Lengauer G Giester E Tillmanns** 1994 IMA Mtg Pisa 238; MM 32 976.
*Synthetic* ECR-18: **DEW Vaughan KG Strohmaier** 1999 MMM 28 233-9 (V337).
*Synthetic gallosilicate*: **DJ Kim C Shin SB Hong** 2005 MMM 83 319-25.

**paulkellerite** $Bi_2Fe(PO_4)O_2(OH)_2$.
Structure: **JD Grice LA Groat** 1988 AM 73 873-5.
Occurrence: **PJ Dunn & 3 others** 1988 AM 73 870-2.

**paulkerrite** $K(Mg,Mn)_2(Fe,Al,Ti,Mg)_2(PO_4)_4(OH)_3.15aq$.
From crystallography essentially isostructural *benyacarite* $(aq,K)_2(Mn,Fe)_2(Fe,Ti,Al)_2Ti(PO_4)_4(O,F)_2.14aq$ & *mantiennite* $KMg_2Al_2Ti(PO_4)_4(OH)_3.15aq$.
Occurrence: **DR Peacor PJ Dunn WB Simmons** 1984 MR 15 303-6.

**paulmooreite** $Pb_2As_2O_5$.
Structure: **T Araki PB Moore GD Brunton** 1980 AM 65 340-5.
Occurrence: MM 43 1065.

**pautovite** $CsFe_2S_3$. *Rasvumite* structure type.
Occurrence: Lovozero alkaline complex, XRPD = *synthetic*, **IV Pekov & 3 others** 2005 CM 43 965-72 = AM 91 712.

**PAVONITE HOMOLOGOUS SERIES** Includes:

| | |
|---|---|
| *benjaminite* | $(Ag,Cu)_3(Bi,Pb)_7S_{12}$ |
| *borodaevite* | $[Ag_5(Fe,Pb)Bi_7]_{13}(Sb,Bi)_2S_{17}$ |
| *mummeite* | $Ag_{2.5\text{-}2.8}Cu_{1.2\text{-}1.0}Pb_{1.6\text{-}1.3}Bi_{6.3\text{-}6.4}S_{13}$ |
| *pavonite* | $(Ag,Cu)(Bi,Pb)_3S_5$ |

Review: **S Karup-Møller E Makovicky** 1992 NJMM 555-76 (M1276).
XRPD of homologues: **G Ilinca E Makovicky** 1999 EJM 11 691-708 (I252).
*Synthetic* $HgBi_2S_4$: **WG Mumme JA Watts** 1980 AC B36 1300-4.

**pavonite** $(Ag,Cu)(Bi,Pb)_3S_5$. Pavonite homologous series type $^5P$.
Structure **E Makovicky WG Mumme JA Watts** 1977 CM 15 339-48;
**WG Mumme** 1990 NJMM 193-204.
Occurrence: MM 30 743;
Ikuno mine, Japan, **M Shimizu A Kato** 1996 CM 34 1323-7.

**paxite** $Cu_2As_3$. ?*stibnite* structure group; perhaps with double *c.*
XRPD indexed on stibnite-type cell.
Occurrence & crystallography: **Z Johan** 1962 Acta Univ Carolinae Geol 77-86 = AM 47 1484-5.

**pearceite** $Ag_{16}As_2S_{11}$.
*Synthetic* series with Sb analog *antimonpearceite*: **HT Hall** 1967 AM 52 1311-21.
Dimorphic with *antimonpolybasite* with double cell repeats.
Structure determination not found.

**pecoraite** $Ni_3Si_2O_5(OH)_4$. *Kaolinite-serpentine* structure group. Dimorphic with *nepouite*.
Structure determination not found.
Occurrence: **GT Faust et al** 1969 S 165 59-60;
**Y Song H-S Moon H-T Chon** 1995 CIM 30 211-24.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
*Synthesis* at low T, IR, TEM & XRPD: **JT Kloprogge M Hammond RL Frost** 2000 NJMM 193-206 (K1255).

**pectolite** $NaCa_2Si_3O_8OH$. *Pyroxenoid* mineral group.
Isostructural series with Mn analog *serandite*.
Dimorphic with *pectolite-M2abc*.
Structure: **MJ Buerger CT Prewitt** 1961 PNAS 47 1884-8 (B186);
**CT Prewitt MJ Buerger** 1963 MSA Special Paper 1 293-302 (P45);
**CT Prewitt** 1967 ZK 125 298-316 (P90);
**Y Takéuchi Y Kudoh** 1977 ZK 146 281-92;

**Y Ohashi LW Finger** 1978 AM 63 274-88 (O148).
Is *denisovite* $(K,Na)Ca_2Si_3O_8(F,OH)$ the K-analog of *pectolite*?
*Synthetic* $NaCa_2Si_3O_8F$: **PS Rogers** 1970 MM 37 741.
*Synthetic* $NaHCd_2Ge_3O_9$: **EL Belokoneva & 3 others** 1974 SPC 19 94-5 (B1138).
*Synthetic* $NaHCd_2Si_3O_9$: **MA Simonov & 3 others** 1978 SPC 23 365-7 (S1263).
**pectolite-M2abc** $NaCa_2Si_3O_8OH$. Dimorphic with *pectolite.*
Electron diffraction, matches *parawollastonite*: **WF Müller** 1976 ZK 144 401-8.
**[pehrmanite** $(Be,Zn,Mg)FeAl_4O_8$. Renamed *ferrotaaffeite-6N'2S.*]
**peisleyite** $Na_3Al_{16}(SO_4)_2(PO_4)_{10}(OH)_{17}.20aq$. Review: **Sabelli**, no structure.
Occurrence: **ES Pilkington ER Segnit R Watts** 1982 MM 46 449-52.
**pekoite** $PbCuBi_{11}(S,Se)_{18}$.
Structure has 4 slabs of *bismuthinite* & 2 of *krupkaite*.
Structure: **WG Mumme JA Watts** 1976 CM 14 322-3;
**A Pring** 1989 AM 74 250-5.
**pekovite** $SrB_2Si_2O_8$. Analog of *danburite* & *maleevite*.
Occurrence & SC-XRD structure: **LA Pautov & 3 others** 2004 CM 42 107-19.
*Synthetic* $SrB_2Si_2O_8$, high-P: **T Berger K-J Range** 1996 ZN 51b 172-4 (B1470).
**pellouxite** $(Cu,Ag)_{2-x}Pb_{21-x}Sb_{23+x}S_{55}ClO$. *Zinkenite* family.
Related to *scainiite*.
Structure: **P Palvadeau & 3 others** 2004 EJM 16 845-55 (10841).
Occurrence: **P Orlandi & 4 others** 2004 EJM 16 839-44 (10840);
& XRD structure: **P Orlandi & 3 others** 2002 18th IMA Mtg Abstr A12-11.
**pellyite** $Ba_2Ca(Fe,Mg)_2Si_6O_{17}$. Tetrahedral net with 1 dangle; CTF net 1125.
Structure: **EP Meagher** 1976 AM 61 67-73.
Optical spectra for Fe(II): **GR Rossman MN Taran** 2001 AM 86 896-903.
Occurrence: MM 38 997; 39 923.
**[pendletonite**
Coronene in complex mixture of polycyclic aromatic hydrocarbons: MM 36 1156;
**M Blumer** 1975 Chem Geol 16 245-56 = AM 61 1055.]
**penfieldite** $Pb_2Cl_3(OH)$.
Average structure: **S Merlino & 3 others** 1955 MM 59 341-7;
also ED of 12c (common), 15c (rare) & 9c (after heating) polytypes.
Merensky Reef, possibly occurs in *chalcopyrite*: **AY Barkov & 3 others** 2001 CM 39 1397-403.
*Laurelite* may prove similar.
**penginite** $(Ag,Cu)_4Au(S,Se)_4$.
Structure determination not found.
Occurrence: **LI Bochek & 3 others** 1984 ZVMO 113 356-60 = AM 70 875-6.
**penikisite** $Ba(Mg,Fe)_2Al_2(PO_4)_3(OH)_3$. Isostructural series with Fe analog *kulanite*.
Structure determination not found.
Occurrence: **JA Mandarino BD Sturman MI Corlett** 1977 CM 15 393-5.
**penkvilksite-1M & penkvilksite-2O** $\sim Na_4Ti_2Si_8O_{22}.4aq$. 1M & 2O polytypes.
1M- isotypic with *tumchaite* $Na_2(Zr,Sn)Si_4O_{11}.2aq$.
2-connected octahedral-tetrahedral net; CTF 1235 for 1M polytype; number not assigned for 2O.
Similar to but different from *lemoynite*.
Structure: **S Merlino & 3 others** 1994 AM 79 1185-93.
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;
& Na, possible 2M polytype, **BL Sherriff B Zhou** 2004 CM 42 1027-35.
Occurrence: MM 40 912;
in hyperagpaitic alkaline rocks, **Khomyakov** 1995.
*Synthetic* orthorhombic-2O type labeled AM-3, XRPD, NMR & SEM: Z Lin & 7 others 1997 JPCB 101 7114-20 (L857);

probably has 5 aq, of which 1 is zeolitic, **IV Bussen & 5 others** 1974 DAN 217 126-9.
*Synthetic*, new analog: **Y Liu H Du F Zhu W Pang** 1997 ChC 1467-8.
**Y Liu H Du Y Xu H Ding W Pang Y Yue** 1999 MMM 28 511-7 (L589).

**pennantite** $Mn_5Al(Si_3Al)O_{10}(OH)_8$. *Chlorite* structure group.
Polytypes: **P Bayliss** 1983 AM 21 545-7.
Occurrence: MM 27 273.

**penninite** $Mg_{9.8}Al_{1.6}Fe_{0.6}(Si_{6.3}Al_{1.7})O_{20}(OH)_{16}$.
*Chlorite* structure group; 1-layer triclinic - IIb-4 stacking type.
Structure: **W Joswig & 4 others** 1980 AM 65 349-52.

**penobsquisite** $\sim Ca_2FeB_9O_{13}(OH)_6Cl.4aq$.
Complex tetrahedra-triangle framework with dangles.
Occurrence & structure: **JD Grice RA Gault J Van Velthuizen** 1996 CM 657-65.

**penroseite** $(Ni,Co,Cu)Se_2$. *Pyrite* structure group.
Dimorphic with *kullerudite*, *marcasite* structure group.
Occurrence: MM 21 573.
Crystallography & cell dimensions: **P Bayliss** 1989 AM 74 1168-76 (includes earlier data on natural & *synthetic*).
3d transition metal L-edge XAS, **JM Charnock & 3 others** 1996 PCM 23 403-8 (C878).

**pentagonite** $Ca(VO)(Si_4O_{10}).4aq$. Dimorphic with *cavansite*.
Structure: **HT Evans Jr** 1973 AM 58 412-24.
Occurrence: MM 39 923.
*Synthetic* $K_2(VO)(Si_4O_{10}).aq$ & $Cs_2(VO)(Si_4O_{10}).3aq$, similar structures to *cavansite* & *pentagonite*: **X Wang L Liu AJ Jacobson** 2001 AnCh 40 2174-6 (2073).

**pentahydrite** $MgSO_4.5aq$. *Chalcanthite* structure group. Review: **Sabelli** p. 16.
Structure: **WH Baur JL Rolin** 1972 AC B28 1448-55 = MA 72-2786.
Synthesis: MM 29 987.
[Occurrence: MM 29 991; = *allenite*; MM 29 974.]

**pentahydroborite** $CaB_2O(OH)_6.2aq$.
Structure: **YuK Egorov-Tismenko & 4 others** 1973 SPD 18 102-3 (E289);
**EV Kazanskaya & 4 others** 1977 SPC 22 35-6 (K654).
Occurrence: MM 33 1147.

**PENTLANDITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *argentopentlandite* | $Ag(Fe,Ni)_8S_8$ |
| *cobalt pentlandite* | $(Co,Fe,Ni)_9S_8$ |
| *geffroyite* | $(Cu,Fe,Ag)_9(Se,S)_8$ |
| *kharaelakhite* | $(Pt,Cu,Pb,Fe,Ni)_9S_8$: possible, but not proven |
| *pentlandite* | $(Fe,Ni)_9S_8$ |
| *shadlunite* | $(Pb,Cd)(Fe,Cu)_8S_9$ |

**pentlandite** $[Fe,Ni)_9S_8$.
Structure: **AD Pearson MJ Buerger** 1956 AM 41 804-5;
**V Rajamani CT Prewitt** 1973 CM 12 178-87 (R693);
high-T, **V Rajamani CT Prewitt** 1975 AM 60 39-48;
anomalous X-ray scattering, **K Tsukimura H Nakazawa** 1984 AC B40 364-7;
**K Tsukimura** 1989 MJ 14 323-37 = MA 91M/2631;
high form & thermal stability, **A Sugaki A Kitakaze** 1998 AM 83 133-40.
*Violarite* formation: surface alteration, XPS, AES, etc: **S Richardson DJ Vaughan** 1989 MM 53 213-22;
mild hydrothermal, 355 & 395 K, pH 3-5, **C Tenailleau & 5 others** 2006 AM 91 706-9.
Low-T heat capacity: **GA Berezovskii VA Drebushchak TA Kravchenko** 2001 AM 86 1312-3.
Exsolution from monosulfide s s, kinetics: **B Etschmann & 4 others** 2004 AM 89 39-50.
Oxidation/alteration at pH 9.3: XPS & chemistry, **DL Legrand & 2 others** AM 90 1042-54;
effects of xanthrates & dissolved oxygen, **do** 1055-61.
Occurrence: black smokers, Rainbow & Logachev hydrothermal fields, **NN Mozgova & 3 others** 2005 ZVMO 134 69-81.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**peprossiite-Ce** $(Ce,La)Al_2B_3O_9$.
Mineralogy & structure: **G Della Ventura & 3 others** 1993 EJM 5 53-8 (D583).

Structure: SC-XRD, **A Callegari & 5 others** 2000 AM 85 586-93.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**percleveite-Ce** $(Ce,La,Nd)Si_2O_7$.
Occurrence & structure: **D Holtstam R Norrestam UB Andersson** 2003 EJM 15 725-31.
**percylite** $PbCuCl_2(OH)_2$.
No useful crystallographic data.
Occurrence: **Dana**. [jvs: check for synthetic.]
**peretaite** $CaSb_4O_4(SO_4)_2(OH)_2.2aq$. Review: **Sabelli** p. 28.
Structure: **S Menchetti C Sabelli** 1980 AM 65 940-6.
Occurrence: **N Cipriani & 3 others** 1980 AM 65 936-9.
**perhamite** $(Ca,Sr)_3Al_{7.7}Si_3P_4O_{23.5}(OH)_{14.1}.8aq$.
Structure: SC-XRD, **S Mills & 3 others** 2006 MM 70 201-9.
Occurrence: **PJ Dunn DE Appleman** 1977 MM 41 437-42.
**PERICLASE MINERAL GROUP OF OXIDES** Includes:

| | |
|---|---|
| *bunsenite* | NiO |
| *ferropericlase* | (Fe,Mg)O |
| *manganosite* | MnO |
| *monteponite* | CdO |
| *periclase* | MgO |
| *wüstite* | FeO. |

*Halite*/periclase structure type.
Ferropericlase = magnesian *wüstite* is believed to be major component of lower mantle.
Density functional perturbation theory for lower mantle: **BB Karki & 3 others** 1999 S 286 1705-7 (K1205).
*Synthetic* PdO & PtO: 1989 J Less-Common Metals 146 161 = SR 56A 271.
**periclase** MgO. *Periclase* mineral group. *Halite*/periclase structure type.
Structure: **RM Hazen** 1976 AM 61 266-71;
charge density, **G Vidal-Valat JP Vidal K Kurki-Suonio** 1978 AC A34 594-602;
charge density, **M Causa RC Pisani C Roetti** 1986 AC B42 247-53;
electron density, 1989 SPC 34 191 = SR 56A 272;
high-P to 23 GPa, **TS Duffy RJ Hemley H Mao** 1995 PRL 74 1371-4 (D509);
expansion 5-2900 K, **RR Reeber K Goessel K Wang** 1995 EJM 7 1039-47 (R609);
model & elasticity to 150 GPa, **BB Karki & 5 others** 1997 AM 82 51-60;
expansion to melting, **LS Dubrovinsky SK Saxena** 1997 PCM 24 547-50 (D689);
XRD & ED, **VG Tirelson & 5 others** 1998 AC B54 8-17 (T565);
expansion, 300-3000 K: **G Fiquet P Richet G Montagnac** 1999 PCM 27 103-11 (F683).
Elasticity to 20 GPa: **SV Sinogeikin JD Bass** 2000 PEPI 120 43-62 (S2187).
PVT to 53 GPa & 2500 K: **A Dewaele & 3 others** 2000 JGRB 105 2869-77 (D793).
Contraction to 8.2 GPa: **J Zhang** 2000 PCM 27 145-8 (Z224).
*Surface structure*.
CO physi- & chemisorption, calculated step & edge: **G Pacchioni** 1993 SuS 281 207-19 (P426).
Ir clusters, EXAFS: **FBM Van Zon & 3 others** 1993 JAChS 115 10317-26.
Adsorption water/hydrogen/ammonia, IR: **E Knozinger & 3 others** 1993 SuS 290 388-402 (K934).
Ion scattering study: **JB Zhou HC Lu T Gustafsson P Haberle** 1994 SuS 302 350-62.
Methane adsorption, FTIR: **C Li G Li Q Xin** 1994 JPC 98 1933-8 (L586).
Surface hydroxylation during dissolution, elastic recoil detection: **RA Wogelius & 4 others** 1995 GCA 59 1875-81.
CO adsorption, computation energy: **YA Snyder & 5 others** 2000 JPC B 104 4717-22 (S2186).
Occurrence: carbonaceous chondrites, **A Greshake & 3 others** 1996 S 272 316-8 (G853);
meteorites: **AE Rubin** 1997 MPS 32 231-47.
**perite** $PbBiO_2Cl$. Isostructural with Sb analog *nadorite* from cell data.
Matches *synthetic*.
Structure determination not found.
Occurrence: **M Gillberg** 1960 Ark Mineral Geol 2 565-70 = MM 32 976 .
**perlialite** $K_9Na(Ca,Sr)Al_{12}Si_{24}O_{72}.15aq$. *Zeolite* mineral group.
Matches *synthetic* Linde Type L. IZA-SC structure code LTL. CTF tetrahedral net 631.
*Structure*: synthetic LTL, **RM Barrer H Villiger** 1969 ZK 128 352-70;

**G Artioli Å Kvick** 1990 EJM 2 749-59 (A507).
Occurrence: MM 50 755.
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** 1995.
*Synthetic* containing Pt particles, saturated with H at RT & after desorption in He, XAS: **BJ McHugh G Larsen GL Haller** 1990 JPC 94 8621-4 (M1791).
*Synthetic* reacted with K vapor, structure, ESR & electrical properties: **PA Anderson & 4 others** 1997 JPC B 101 9892-900 (A805).
*Synthetic* LTL, surface structure, HREM: **T Ohsuna Y Horikawa K Hiraga O Terasaki** 1998 ChM 10 688-91 (O378); **T Ohsuna & 9 others** 2004 CEJ 10 5031-40 (10786)..
*Synthetic* Ba(K/Li)-GL, ND, structure: **A Burton RF Lobo** 1999 MMM 33 97-113 (B1978).
*Synthetic* K-L: location of sorbed benzene upon coadsorption of ammonia & methylamine, IR **B Su V Norberg C Hansenne** 2000 La 16 1132-40 (S2142);
high-T hydrothermal, morphology, **SD Bhat & 5 others** 2004 MMM 76 81-9 (10911).
*Synthetic* Fe-substituted-L, XRD, FTIR, EM, XPS: **K Latham CI Round CD Williams** 2000 MMM 38 333-44 (201).
Dealuminated-L, FTIR, MAS-NMR: **P Bartl WF Holderich** 2000 MMM 38 279-86 (202).
*Synthesis,* morphology vs chemical composition: **O Larlus VP Valychev** 2004 ChM 16 3381-9 (10581).
Modified channel entrance with triethoxysilylated coumarin: **T Ban & 2 others** 2004 JPCB 108 16348-52 (10770).
**perloffite** $Ba(Mn,Fe)Fe_2(PO_4)_3(OH)_3$.
Isostructural with Al analog *bjarebyite* from cell data.
Structure determination not found.
Occurrence: **AR Kampf** 1977 MR 8 112-4; MM 52 408-11.
**permingeatite** $Cu_3(Sb,As)Se_4$. *Stannite* structure group.
Isostructural with S analog *famatinite* from cell data. Structure determination not found.
Occurrence: **Z Johan & 3 others** 1971 BSFMC 94 162-5 = AM 57 1554-5.
**PEROVSKITE STRUCTURE FAMILY** Only a few of the many types are listed here.
Includes the following representative minerals:

| | | |
|---|---|---|
| *diaboléite* | $Pb_2CuCl_2(OH)_4$ | defect type |
| *elpasolite* | $K_2NaAlF_6$ | atomic ordering |
| *hematophanite* | $Pb_4Fe_3O_8(OH,Cl)$ | |
| *latrappite* | $(Ca,Na)(Nb,Ti,Fe)O_3$ | |
| *loparite* | $(Ce,Sr,Na,Ca)(Ti,Nb)O_3$ | |
| *lueshite* | $NaNbO_3$ | orthorhombic |
| *isolueshite* | $(Na,La,Ca)(Nb,Ti)O_3$ | cubic |
| *macedonite* | $PbTiO_3$ | |
| *natroniobite* | $NaNbO_3$ | monoclinic |
| *neighborite* | $NaMgF_3$ | |
| *perovskite* | $CaTiO_3$ | |
| *tausonite* | $SrTiO_3$ | |

$(K,Na)MgF_3$: A-site cation radius vs ordering, relation to lower mantle, **CD Martin & 4 others** 2005 AM 90 1522-33; crystal chemistry of $NaMgF_3$ at high P & T, **J Chen & 4 others** 2005 AM 90 1534-9.
Classification 23 types of tilted octahedra in perovskites, 64 materials: **AM Glazer** 1972 AC B28 3384.
General theory: **DM Giaquinta H Zur Loye** 1994 ChM 6 365-72 (G672).
Composition vs octahedral tilting in orthorhombic and tetragonal: **NW Thomas** 1966 AC B52 16-31 (T463).
$FeTiO_3$ inclusions in Alpe Arami peridotite massif + 3 other variants = inversion from high-P perovskite: **L Dobrzhinetskaya HW Green II S Wang** 1996 S 271 1841-5.
Sr-bearing perovskite & loparite in lamproite & agpaitic nepheline syenite pegmatites: **RH Mitchell AR Chakmouradian** 1999 CM 37 99-112.
Solubility & stability in *calcite-portlandite* system: **RH Mitchell** 1997 JAfES 25 147-58 (M1611).
3 composition varieties in kimberlites, Canada: **AR Chakhmouradian RH Mitchell** 2001 MM 65 133-48.
Crystal structures & industrial use of oxides: **MA Pena JLG Fierro** 2001 ChR 101 1987-2017 (2333).
*Synthetic* Mo- & W-: **A Magnéli** 1956 J Inorg Nucl Chem 2 330-9 (M1114).
*Synthetic* $KSbO_3$, EM of ordering: **K Yagi JM Cowley** 1978 ACA 34 625-34 (Y155).
*Synthetic* $CaZrO_3$, NPD, **KJA Koopmans GMH van de Velde PJ Gellings** 1983 ACC 39 1323-5.
*Synthetic* $(Ba/Sr)_2CaUO_6$: **WA Groen DJW IJdo** 1987 AC C43 1033-6 (G800).

*Synthetic* orthorhombic (Ca/Cd)$TiO_3$: **S Sasaki & 3 others** 1987 AC C43 1668-74 (S1497).

*Synthetic* $CaZrO_3$: **CM Sung MR Notis CE Lyman** 1989 AC B45 218-27.

*Synthetic* $ScAlO_3$: **W Sinclair RA Eggleton AE Ringwood** 1979 ZK 149 307-14;
**RJ Hill I Jackson** 1990 PCM 17 89-96.

*Synthetic* $(Ca_xSr_{i-x})_{n+1}Ti_nO_{3n+1}$: **K Hawkins TJ White** 1991 Phil Trans Roy Soc Phys Sci Eng 336 541-9.

*Synthetic* $CaFe_3Ti_4O_{12}$ & $CaFeTi_2O_6$: **K Leinenweber & 4 others** 1995 PCM 22 251-8 (L670).

*Synthetic* $Na_xSr_{1-2x}La_xTiO_3$, XRPD, structure: **RH Mitchell & 2 others** 2000 PCM 27 583-9 (431).

*Perovskite-structure materials are expected to be major components of the lower mantle.*

*Synthetic* aluminous Mg,Fe silicates, approximately isochemical with *garnet*, synthesized at 55-70 GPa: **SE Kesson & 3 others** 1995 EPSL 134 187-201.

*Synthetic* $CaFeTi_2O_6$, 12-15 GPa, 1473-1673 K: **K Leinenweber J Parise** 1995 JSSC 114 277-81 (L649);
ED/HREM: **N Yao A Navrotsky K Leinenweber** 1996 JSSC 123 73-82 (Y169).

*Synthetic* $MgSiO_3$: **T Yagi H-K Mao PM Bell** 1978 PCM 3 97-110 (Y57);
**H Horiuchi E Ito DJ Weidner** 1987 AM 72 357-60;
**Y Kudoh E Ito H Takeda** 1987 PCM 14 350-4;
**NL Ross RM Hazen** 1989 PCM 16 415-20 (R429);
electronic structure calculation, **P D'Arco & 4 others** 1993 PCM 20 407-14;
XANES of Fe, **F Farges** 1995 22 318-22 (F540);
thermoelasticity 30 GPa/2000 K, **M Funamori & 4 others** 1996 JGR 101 8257-69(F487);
HRTEM, **I Hassan Y Kudoh PR Buseck E Ito** 1996 MM 60 799-804;
possible sink for $Fe^{3+}$ in lower mantle, Mössbauer of natural Al-bearing orthopyroxene converted 25 GPa 1873 K, **C McCammon** 1997 N 387 694-6 & 653-4 (M488);
inferred in shocked Acfer L5-6 chondrite with *ilmenite*: **TG Sharp & 3 others** 1997 S 277 352-5 (S1707);
XRD 82 GPa 300-1780 K, phase transition & dissociation, **SK Saxena & 3 others** 1998 EJM 10 1275-81 (201);
equation of state, **SK Saxena & 3 others** 1999 AM 84 226-32;
Al substitution vs compressibility in Earth's mantle, mechanism, **JP Brodholt** 2000 N 407 620-2 (B2945);
elastic constants, molecular dynamics model for mantle PT, **AR Oganov JP Brodholt GD Price** 2001 N 411 934-6 (2136);
Al substitution, NMR, **JF Stebbins & 3 others** 2003 AM 88 1161-4.

*Synthetic* $(Mg,Fe)SiO_3$: optical & near-IR, **H Keppler CA McCammon DC Rubie** 1994 AM 79 1215-8;
Mössbauer, **Y Fei & 4 others** 1994 AM 79 826-37;
XAFS, **F Farges & 3 others** 1994 EJM 6 303-12;
maximum solubility FeO 26 GPa, **Y Fei Y Wang LW Finger** 1996 JGR 101 11525-30 (F493);
XRPD structure, **AP Jephcoat & 5 others** 1999 AM 84 214-20.

*Synthetic* $CaSiO_3$:
thermal equation of state: **Y Wang DJ Weidner F Guyot** 1996 JGR 101 661-72 (W673)
PVT to 108 GPa at 300 K, **S Shim TS Duffy G Shen** 2000 PEPI 120 327-38 (S2185).

*Synthetic* Mg-Ca, partition 27 trace elements/melt, multi-anvil: **H Taura & 3 others** 2001 PEPI 124 25-32 (2135).

Certain diamond inclusions = P-release CaSi-perovskite: RE, **W Wang T Gasparik RP Rapp** 2000 EPSL 291-300 (201).

*Synthetic* $CaGe/SiO_3$, calorimetry: **H Kojitani A Navrotsky M Akaogi** 2001 PCM 28 413-20 (2958).

*Synthetic* $Ca_2TiSiO_6$, XRPD structure: **K Leinenweber J Parise** 1997 AM 82 475-8.

*Synthetic* $CaTi/SiO_3$ & ordered $Ca_2TiSiO_6$: **K Leinenweber & 5 others** 1997 PCM 24 528-34 (L923).

*Synthetic* high-P polymorph of $Ca_3Al_2Si_3O_{12}$ made from grossular at 30 GPa & ~ 1500 K: **H Yusa T Yagi N Shimobayashi** 1995 PEPI 92 25-31 (Y165).

*Synthetic* $Sr_5Mn_4CO_3O_{10}$: **V Caignaert B Domengés B Raveau** 1995 JSSC 120 279-89(C802).

*Synthetic* $K(Mg_{1-x}Cu_x)F_3$: **PC Burns & 3 others** 1996 PCM 23 141-50 (B1619).

*Synthetic* BaUO & (Ba,Sr)UO: **EHP Cordfunke & 4 others** 1997 JSSC 131 341-9 (C937).

*Synthetic* $CaSiO_3$: tilting/distortion to 7 GPa, **J Zhai K Ross RJ Angel** 2004 PCM 31 299-303 (10542).

*Synthetic* $(Ca_{1-x}Na_xTi_{1-x}Ta_xO_3$: XRPD structure, **RM Mitchell RP Liferovich** 2004 MMM 76?

**perovskite** $CaTiO_3$. Perovskite structure group.

Structure: **HF Kay PC Bailey** 1957 AC 10 219-26;
**M Hu H-R Wenk D Sinitsyna** 1992 AM 77 359-73;
**RH Buttner EN Maslen** 1992 AC A49 644-9;
*synthetic*, ND, **KJA Koopmans GMH van de Velde PJ Gellings** 1983 AC C39 1323-5;

natural, TEM, **Y Wang RC Lieberman** 1993 PCM 20 147-58;
XRPD, high T, **X Liu R Lieberman** 1993 PCM 20 171-5;
SC-IR & XRD, **A Beran E Libowitzky T Armbruster** 1996 CM 34 803-9;
ferroelastic transition, **SAT Redfern** 1996 AC A52 Suppl C-436;
microtwins, **AV Arakcheeva & 4 others** 1997 CrR 42 46-54 (A730);
electron density to 1674 K, **M Yashima M Tanaka** 2004 JAC 37 786-90 (10919).
Structure changes with P for (Ca,Sr): **T Yamanaka N Hirai Y Komatsu** 2002 AM 87 1183-9.
Twinning in meteoritic & *synthetic*: **LP Keller PR Buseck** 1994 AM 79 73-9 (1420).
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**perraultite** $(Na,Ca)_2(Ba,K)_2(Mn,Fe)_8(Ti,Nb)_4Si_8O_{32}(OH,F)_4$. Analogous to *jinshajiangite* & Ca-F analog *surkhobite*.
Structure: **NA Yamnova YuK Egorov-Tismenko IV Pekov** 1998 CrR 43 401-10 (Y231);
SC-XRD, **IV Pekov & 5 others** 2000 ZVMO 128 112-20.
Occurrence: **GY Chao** 1991 CM 29 355-8.

**PERRIERITE/CHEVNIKITE MINERAL GROUP**

| | |
|---|---|
| *chevkinite-Ce* | $(Ce,La,Ca,Na,Th)_4(Fe,Mg)_2(Ti,Fe)_3Si_4O_{22}$ |
| *matsubaraite* | $Sr_4Ti_5(Si_2O_7)_2O_8$ |
| *perrierite* | $(Ca,Ce,Th)_4(Mg,Fe)_2(Ti,Fe)_3Si_4O_{22}$. |
| *rengeite* | $Sr_4ZrTi_4Si_4O_{22}$ |
| *strontiochevkinite* | $(Sr,La,Ce,Ca)_4(Fe^{2+},Fe^{3})(Ti,Zr)_4O_{22}$. |

*Synthetic* $La_4Mn_5Si_4O_{22}$: **C Gueho & 4 others** 1995 ChM 7 486-92 (G746).
*Synthetic* $La_4Mn_3Si_{0.8}Ge_{5.2}O_{22}$: **C Taviot-Guého & 5 others** 1999 JSSC 147 247-50 (T629).

**perrierite** $(Ca,Ce,Th)_4(Mg,Fe)_2(Ti,Fe)_3Si_4O_{22}$.
Structure: **G Gottardi** 1960 AM 45 1-14;
**E Galli** 1965 Min Petrog Acta 11 39-48 = MA 19-178;
**C Calvo R Faggiani** 1974 AM 59 1277-85.
Occurrence: MM 29 991.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**perroudite** $Hg_5Ag_4S_5Cl_2(I,Br)_2$.
Structure: **WG Mumme EH Nickel** 1987 AM 72 1257-62;
SC-XRD, **P Keller F Lissner T Schleid** 2005 NJMA 181 1-9 = AM 90 1469.
Occurrence: MM 52 729.

**perryite** $(Ni,Fe)_8(Si,P)_3$.
Structure: **A Okada K Kobayashi T Ito T Sakurai** 1991 ACC 47 1358-61 (O281).
Occurrence: MM 36 1156.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
*Synthetic* isostructural $Pd_8Sb_3$: **W Wopersmow K Schubert** 1976 J Less-Common Metals 48 79-87.
*Synthetic* $Pd_5Sb_2$, partial structural relation: **M El-Boragy S Bhan K Schubert** 1970 J Less-Common Metals 22 445-58.

**pertsevite** $Mg_2BO_3F$.
Occurrence & XRD structure: **W Scheyer & 3 others** 2003 EJM 15 1007-18 (10002).

**petalite** $LiAlSi_4O_{10}$. Consortium for Theoretical Frameworks tetrahedral net 597.
Structure: **F Liebau** 1961 AC 14 399-406;
**H Effenberger** 1980 TMPM 27 129-42 (E334);
**T Tagai & 3 others** 1982 ZK 160 159-70;
Li/H exchange, **H Effenberger & 3 others** 1991 ZK 197 27-40.
Heat of formation: **DW Fasshauer L Cemic** 2001 PCM 28 531-3 (3582).

**petarasite** $Na_5Zr_2Si_6O_{18}(Cl,OH).2aq$. Not isostructural with *lovozerite*.
Structure: **S Ghose C Wan GY Chao** 1980 CM 18 503-9 (G402,680);
**AP Khomyakov & 4 others** 1981 DAN 257 622-4.
Symmetry difference between Canadian & Russian specimens.
Occurrence: MM 46 524.
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** 1995.
*Synthetic* AV-3: structure, **J Rocha & 4 others** 1998 ChC 1269-70 (R831);

Zr/Ti range, XRPD, SEM, NMR, TGA: **Z Lin & 5 others** 1999 JPC B 103 957-63 (L974).

**petedunnite** $CaZnSi_2O_6$. Pyroxene structure group, monoclinic subtype.

Structure: **EJ Essene DR Peacor** 1987 AM 72 157-66.

**peterbaylissite** $Hg_3(CO_3)(OH).2aq$.

Structure: **AC Roberts & 5 others** 1995 CM 33 47-56..

**petersenite-Ce** $Na_4(REE)_2(CO_3)_5$. Superstructure based on *burbankite* structure type.

Occurrence & crystallography: **JD Grice J Van Velthuizen RA Gault** 1994 CM 32 405-14.

**petersite-Y** $Cu_6(Y,Ce,Nd,Ca,Sm,La,Fe)(PO_4)_3(OH)_6.3aq$.

*Mixite* structure group from crystallography.

Occurrence: **DR Peacor PJ Dunn** 1982 AM 67 1039-42.

Review: (different formula) **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**petewilliamsite** $(Ni,Co)_2(As_2O_7)$.

Occurrence & SC-XRD structure: **AC Roberts & 4 others** 2004 MM 68 231-4.

**petitjeanite** $Bi_3(PO_4)_2O(OH)$.

Isotypic with *preisingerite* $Bi_3(AsO_4)_2O(OH)$ & *schumacherite* $Bi_3(V,etc.O_4)_2O(OH)$.

Occurrence & crystallography: **W Krause K Belendorff H-J Bernhardt** NJMM 487-503.

Structure determination not found.

**[petroporphyrin**

Structure: **A Ekstrom & 5 others** 1983 N 306 173-4 = MA 84M/3855.]

**petrovicite** $PbHgCu_3BiSe_5$.

Structure determination not found: similar to *mazzetteite* $Ag_3HgPbSbTe_5$.

Occurrence: **Z Johan M Kvacek P Picot** 1976 BSFMC 99 310-3.

**petrovskaite** AuAg(S,Se).

Structure determination not found.

Occurrence: **GV Nesterenko & 3 others** 1984 ZVMO 113 602-7.

**petrukite** $(Cu,Fe,Zn,Ag)_3(Sn,In)S_4$. Isostructural with *enargite* $Cu_3AsS_4$ from cell data.

Occurrence & crystallography: **SA Kissin DR Owens** 1989 CM 27 673-88.

**petscheckite** $\sim UFe(Nb,Ta)_2O_8$. Metamict.

Alters to *hydroxypetscheckite* & *oxypetscheckite*.

Loss of Fe gives *liandratite* $U(Nb,Ta)_2O_8$.

XRPD matches *synthetic* $UTa_2O_8$ (structure: **M Gasparin** 1960 BSFMC 83 1-21 (G740)); Fe 0,0,0.5 in Pbar31m.

Occurrence & crystallography, **A Mücke H Strunz** 1978 AM 63 941-6.

REE-bearing, Norway: heating products, *wolframoixiolite*, **N Tomasic G raade V Bermanec** 2004 NJMM 163-75 (10288).

**petterdite** $PbCr_2(CO_3)_2(OH)_4.aq$. *Dundasite* structure group.

Occurrence & XRPD structure: **WD Birch & 4 others** 2000 CM 38 1467-76.

**petzite** $Ag_3AuTe_2$.

Isostructural with Se analog *fischesserite* & S analog *uytenbogaardite. Garnet* structure type.

Structure: **AJ Frueh Jr** 1959 AM 44 693-701;
**S Chamid & 3 others** 1979 SPC 23 267-9.

**pezzottaite** $Cs(Be_2Li)Al_2Si_6O_{18}$. *Beryl* structure group.

Occurrence: & IR/Raman/XRD, **BM Laurs & 11 others** 2003 GG 39 284-301 (9891);
& XRPD, **FC Hawthorne & 9 others** 2004 MR 35 369-78.

**pharmacolite** $CaHAsO_4.2aq$. *Gypsum* structure group.

Structure: **G Ferraris** 1969 AC B25 1544-50;
**G Ferraris DW Jones J Yerkess** 1971 AC B27 349-54.

**PHARMACOSIDERITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *alumopharmacosiderite* | $KAl_4(AsO_4)_3(OH)_4.6.5aq$ |
| *barium-alumopharmacosiderite* | $Ba(Al,Fe)_4(AsO_4)_3(OH)_4.5aq$ |
| *barium-pharmacosiderite* | $BaFe_4(AsO_4)_3O_2(OH)_5.5aq$ |
| *[barium-zinc alumopharmacosiderite* | $(Ba,K)_{0.5}(Zn,Cu)_{0.5}(Al,Fe)_4(AsO_4)_3.5aq$ |
| | Not submitted to IMA: AM 80 184.] |
| *[calcium-pharmacosiderite* | Occurrence: MM 39 909.] |
| *pharmacosiderite* | $KFe_4(AsO_4)_3(OH)_4.6\text{-}7aq$ |

*sodium pharmacosiderite* $Na_2Fe_4(AsO_4)_3(OH)_5.7aq$.

2-vertex-connected octahedral-tetrahedral net: Consortium for Theoretical Frameworks net 1071.

*Unnamed mineral* $Na_2Ti_2O_3SiO_4.2aq$: structure, **EV Sokolova & 5 others** 1989 DAN 307 114;
matches *synthetic* $Na_2Ti_2O_3SiO_4.2aq$, tetragonal, **DM Poojary RA Cahill A Clearfield** 1994 ChM 6 2364;
ion-exchanged with $H_2$-, $K_{0.5}H_{0.5}$- & $K_{1.4}H_{0.6}$-, **DM Poojary & 3 others** 1996 IC 35 6131-9 (P638).

*Synthetic* $K(H_3O)_3[Ge_7O_{16}]$: **GI Sturua & 3 others** 1978 SPD 23 703-5 (S1274).

*Synthetic* K/Ba/Na: **G Mutter & 3 others** 1984 NJMM 183-92.

*Synthetic* $Cs_3Mo_4P_3O_{10}$: **RC Haushalter** 1987 JCSCC 1566-8 (H762).

*Synthetic* (K/Cs/H)TiSi: **DM Chapman AL Roe** 1990 Z 10 730-7 (C640).

*Synthetic* $(NH_4)_3Mo_4O_4P_3O_{12}$: **HE King Jr & 3 others** 1991 JSSC 92 154-8 (K539).

*Synthetic* $K_3HGe_7O_{16}.4aq$, superstructure: **R Bialek V Gramlich** 1992 ZK 198 67-77 (B1098).

*Synthetic* $Na_3H_x(H_2PO_4)_x[(GeO)_4(GeO_4)_3].4aq$: **TM Nenoff WTA Harrison GD Stucky** 1994 ChM 6 525-30 (N327).

*Synthetic* $Cs_4HTi_4O_4(SiO_4)_3.4aq$: **WTA Harrison TE Gier GD Stucky** 1995 Z 15 408-12 (H967).

*Synthetic* $H(H/K/Cs)_3Ti_4O_4(SiO_4)_3.4aq$, XRPD structure/ion-exchange: **EA Behrens & 2 others**1996 ChM 8 123-44.

*Synthetic* $(K/Rb/Cs)HGe_7O_{16}$.n aq, XRPD: **MA Roberts AN Fitch** 1996 ZK 211 378-87 (R669).

*Synthetic* metallogermanate: **R Bedard LM King** 1996 US Pat 5,518,707 = CA 125:103532d.

*Synthetic* $Na_4[(TiO)_4(SiO_4)_3.6aq$, structure: **MS Dadachov WTA Harrison** 1997 JSSC 134 4015 (D707).

*Synthetic* Ge/Si *sitinakite*/pharmacosiderite intergrowth: **RL Bedard** US Patent 5,935,552.

*Synthetic* $(K,Sc)_3Si_3O_{15}(OH).4$-6aq: **H Xu & 3 others** 2004 MMM 72 209-18 (10466).

**pharmacosiderite** $KFe_4(AsO_4)_3(OH)_4.6$-7aq. Pharmacosiderite structure type.

Structure: **J Zemann** 1948 TMPM 1-13;
**MJ Buerger W Dollase I Garaycochea-Wittke** 1967 ZK 125 92-108 (B1046).

*Synthetic* Ti-: **EA Behrens A Clearfield** 1997 MiMa 11 65-75;
ion-exchanger removal of Sr/Cs from DoE waste: **EA Behrens P Sylvester A Clearfield** 1998 EST 32 101-7.

**phaunouxite** $Ca_3(AsO_4)_2.11aq$. Compare with *rauenthalite* $Ca_3(AsO_4)_2.10aq$.

Structure: **M Catti G Ivaldi** 1983 AC B39 4-10.

Occurrence: MM 48 580.

**phenakite / phenacite** $Be_2SiO_4$. Dense 3-connected structure.

Isostructural with *alpha-eucryptite* & *willemite*.

Structure: **WH Zachariasen** 1972 SPC 16 1021-5 (Z75);
**RM Hazen AY An** 1986 PCM 13 69-78 (H621);
**JW Downs GV Gibbs** 1987 AM 72 769-77;
**RM Hazen LW Finger** 1987 PCM 14 426-34 (H697);
**VG Tsirel'son YeV Sokolova VS Urusov** 1987 GI 24 101-10;
synthetic pure & V-doped blue-green, **S Yu J Lee** 1995 J Geol Soc China [Taiwan] 38 381-96.

*Synthetic* Ge-: MM 31 960.

*Synthetic* $Zn_2SiO_4$, $Li_2BeF_4$, $Li_2SeO_4$, $Li_2WO_4$ & alpha-Li(Al/Ga)[Si/Ge]$O_4$: **ME Fleet** 1987 ZK 180 63.

*Synthetic* LiGaSi, LiAlGe, LiGaGe: MA 88M/5091.

*Synthetic* $Li_2CrO_4$: MA 76-1445.

*Synthetic* $Li_2SeO_4$: 1989 AC C45 158-9 = SR 56A 240-1.

*Synthetic* $LiZnPO_4$: **X Bu TE Gier GD Stucky** 1996 AC C52 1601-3 (B1521).

*Synthetic* $Li_2CrO_4$: SC-XRD structure, **U Kolitsch** 2001 ZK 216 449-54 (3586).

**phengite** High-silica *muscovite*. Mica structure type.

Structure: **N Güven** 1971 ZK 134 196-212;
**AC Rule SW Bailey** 1985 CICIM 33 403-9 (R381);
NPD, Al order in $2M_1$ polytype vs T, **A Pavese & 3 others** 1999 EJM 11 309-20 (P833);
do, 3T polytype 293/873 K, **do** MM 64 11-8;
NPD/FTIR of OH, heating, **M Mookherjee SAT Redfern M Zhang** 2001 EJM 13 545-55 (2137);
NPD of 3T & $2M_1$ at low-T, **A Pavese & 3 others** 2001 EJM 13 1071-8 (3802)
high-T FTIR, **M Mookherjee SAT Redfern** 2002 CIM 37 323-36 (7352).

3T, cation ordering, **A Pavese & 3 others** 1997 EJM 9 1183-90 (P763);
& deprotonation vs T, ND & Mossbauer, **A Pavese & 5 others** 2003 EJM 15 357-64;
Al-Si &Al-Mg, **EJ Palin & 4 others** 2003 PCM 30 293-304.

Ultra-high-metamorphic: HRTEM, AEM, EMPA, SEM, **C Ferraris C Chopin R Wessicken** 2000 AM 85 1195-201.

**philipsbornite** $PbAl_3H(AsO_4)_2(OH)_6$. *Crandallite* structure group.

Structure determination not found.

Occurrence: **K Walenta M Zwiener PJ Dunn** 1982 NJMM 1-5.

**philipsburgite** $(Cu,Zn)_6(As/PO_4)_2(OH)_6.aq$.

Isostructural with Zn,Cu analog *kipushite*.

Structure determination not found.

Occurrence: **DR Peacor & 4 others** 1985 CM 23 255-8;
**RSW Braithwaite G Ryback** 1988 MM 52 529-33.

**phillipsite** $K_2(Ca_{0.5},Na)_4(Al_6Si_{10}O_{32}).12aq$. *Zeolite* mineral group.

IZA-SC structure code PHI. Consortium for Theoretical Frameworks tetrahedral net 24.

Crystal chemistry: **E Galli GL Ghittoni** 1972 AM 57 1125-45.

Structure: **H Steinfink** 1962 AC 15 644-51 (S95);
**R Rinaldi JJ Pluth JV Smith** 1974 AC B30 2426-33;
Al ordering from XRD & NMR, **T Takaishi M Kato** 1995 Z 15 689-700 (T449);
Al ordering from NMR, **M Kato H Nishido** 2003 MMM 61 261-72.

Identification of gismondine & *phillipsite* using XRD: MA 96M/3988.

Occurrence: cell dimension, from Pacific & Indian Oceans, **RA Sheppard AJ Gude III JJ Griffin** 1970 AM 55 2053-62;
do, from silicic tuffs, **RA Sheppard JJ Fitzpatrick** 1989 ClClM 37 243-7 (S988);
authigenic in Mn nodules, NE Pacific, **C H Lee S Lee** 1998 MG 148 125-33.

*[Wellsite* $(Ba,Ca,K_2)Al_2Si_6O_{16}.6aq$. May be discredited, and replaced by *barian phillipsite*.]

*Synthetic* Ge-: **G Poncelet ML Dubru T Lux** 1976 MRB11 813-20.

Identification problems from XRPD of *gismondine* & : **A Yoshida** 1995 Clay Sci 9 275-83.

*Synthetic* $NH_4AlCo_3P_4O_{16}$, structure: **P Feng X Bu GD Stucky** 1997 N 388 735-40 (F556).

Cs ion-exchange, XRPD structure: **AF Gualtieri D Caputo C Colella** 1999 MMM 32 319-29 (G1181).

*Sr-exchanged*, XRPD structure: **AF Gualtieri & 3 others** 1999 MMM 31 33-43 (G1176).

Ion-exchange vs type of dehydration: **TM Guliev DI Mirzai AA Isirikyan** 1999 Russ Chem Bull 48 1178-80.

$NH_4$-exchanged, XRPD/ IR structure 3 natural hydrated: **AF Gualtieri** 2000 AC B 56 584-93.

Dehydration dynamics, XRPD: **A Sani G Cruciani AF Gualtieri** 2002 PCM 29 351-61 (7682).

**philolithite** $Pb_{12}O_6Mn(Mg,Mn)_4(Mn,Mg)_4(SO_4)(CO_3)_4Cl_4(OH)_{12}$.

Structure: SC-XRD, **PB Moore AR Kampf PK Sen Gupta** 2000 AM 85 810-6.

Occurrence & structure: **AR Kampf & 3 others** 1998 MR 29 201-6.

**phlogopite** $KMg_3AlSi_3O_{10}(OH,F)_2$.

Mica structure group; trioctahedral subtype; polytypic variants. See *fluorphlogopite.*

Structure: **H Steinfink** 1962 AM 47 886-96 (S94);
**W Joswig** 1972 NJMM 1-11;
**RM Hazen CW Burnham** 1973 AM 58 889-900;
NPD, **JH Rayner** 1974 MM 39 850-6;
tetra-ferri-, **TF Semenova & 2 others** 1977 SPC 22 680-3;
**RM Hazen LW Finger** 1978 AM 63 293-6 (H505);
Mn-substituted, **S Guggenheim T Kato** 1984 MJ 12 1-5;
XRPD & Mössbauer of *annite*-phlogopite: **G Cruciani PF Zanazzi** 1994 AM 79 289301;
XANES & Mössbauer, **G Cruciani P Zanazzi S Quartieri** 1995 EJM 7 255-65;
high-Al, **E Alietti MF Brigatti L Poppi** 1995 MM 59 149-57;
**GJ Redhammer E Dachs G Amthauer** 1995 PCM 22 282-94 (R585);
tetrahedral ferric, XANES/Mössbauer, **G Cruciani PF Zanazzi S Quartieri** 1995 EJM 7 255-65 (C924);
ferric-rich, Tapira carbonatite, Brazil, **MF Brigatti & 3 others** 1996 AM 81 913-27;
Rb,Cs-, SC-XRD, **FC Hawthorne DK Teertstra P Cerny** 1999 AM 84 778-81;
Raman & vibration analysis, **DA McKeown MI Bell ES Etz** 1999 AM 84 970-6;
SC-XRD to 873 K, **RL Russell S Guggenheim** 1999 CM 37 711-20;
1M twin simulating 3T polytype, **M Nespolo Y Kuwahara** 2001 EJM 13 1047-56 (3800);
coexisting 3T & $2M_1$ polytypes, **G Ivaldi & 3 others** 2001 EJM 13 1025-34 (3798);
F influence on Al, NMR, **M Fechtelkord & 6 others** 2003 AM 88 1046-54;
SC-XRD to 6 GPa, **P Comodi & 3 others** 2004 AM 89 747-53;
SC-XRD, EMP/SIMS, Mt Vulture, Italy, **E Mesto & 3 others** 2006 AM 91 182-90.

Expansion, 300-1323 K, XRD: **F Tutti LS Dubrovinsky M Nygren** 2000 PCM 27 599-603 (314).
Equation of state & compressibility: **A Pavese & 5 others** 2003 EJM 15 455-63 (9169).
Mantle-derived, H-deficiency: **D Virgo RK Popp** 2000 AM 85 753-9.
Exsolution from *muscovite*, HRTEM & AEM: **C Ferraris B Grobety R Wessicken** 2001 EJM 13 15-26.
Stability at 5-15 GPa: **RG Tronnes** 2002 MP 74 129-48 (7136).
Kovdor deposit, Kola Peninsula, Russia: **NI Krasnova** 2001 CM 39 33-44.
*Manganophyllite* variety of *-1M*: structure, **RA Knurr SW Bailey** 1986 ClClM 34 7-16 (K408).
*Synthetic* Ga-: MM 31 960.
*Synthetic* Ni-: MM 31 968.
*Synthetic* $K(MgAl_2)(Si_3B)O_{12}$, isostructural except for empty OH site: **P Reig G Demazeau R Naslain** 1995 CRASP 321 IIb 199-203 (R600).
*Synthetic* Al-, intersite OH-F ratio: **A Papin J Sergent JL Robert** 1997 EJM 9 501-8 (P681).
*Synthetic* Al,F-rich, MAS-NMR: **M Fechtelkord & 5 others** 2003 AM 88 47-53.
*Synthetic* $NH_4$, H & D: IR & XRPD structure, **DE Harlov M Andrut S Melzer** 2001 PCM 28 77-86; low-T IR, **M Mookherjee & 3 others** 2002 EJM 14 1033-9 (8675).
*Synthetic* organic- layered composite: **C Trobajo & 8 others** 2001 ChM 13 4457-62 (3874).
**phoenicochroite** $Pb_2O(CrO_4)$. Isostructural with S analog *lanarkite*. Layer structure.
Structure: [jvs: low accuracy] **SA Williams WJ McLean JW Anthony** 1970 AM 55 784-92.
**phosgenite** $Pb_2(CO_3)Cl_2$.
Structure: **LG Sillén R Pettersson** 1944 Ark Kem Mineral Geol 21A 10-7 = MA 9-229 [also $Pb_2(CO_3)Br_2$]; **I Oftedahl** 1945 Norsk Geol Tids 24 79-88 [do]; **G Giuseppetti C Tadini** 1974 TMPM 21 101-9 (G352).
**phosinaite-Ce** $Na_{13}Ca_2CeSi_4O_{12}(PO_4)_4$.
Structure: **VM Krutik & 4 others** 1980 SPC 25 138-42 (K649).
*Clinophosinaite* is monoclinic analog without significant Ce substitution, $Na_3CaPSiO_7$: **do** 1982 SPC 26 679-82 (K646).
Occurrence: MM 40 913.
*Phosphinaite-Ce*, structure & new formula, ideally $Na_{13}Ca_2(Ce,La)Si_4O_{12}(PO_4)$: **AM McDonald** 1992 PhD Carleton University, Ottawa; **AM McDonald GY Chao** 1996 CM 34 107-14.
Occurrence in hyperagpaitic alkaline rocks (revised formula): **Khomyakov** 1995.
Review: (different formula) **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**phosphammite** $(NH_4)_2HPO_4$.
Structure: **AA Khan JP Roux WJ James** 1972 AC B28 2065-9.
**[phosphocerite** $?(La,Ce)PO_4$.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.]
**phosphoellenbergite** $(Mg_{0.9}void_{0.1})_2Mg_{12}P_2P_6O_{38}H_{8.4}$. *Ellenbergite* group.
IR & NMR of protons: **F Brunet T Schaller** 1996 AM 81 385-94.
*Synthesis*: **F Brunet C Chopin F Seifert** 1996 CMP **in press**.
$CO_3$-substituted, description & structure: **G Raade C Rømming O Medenbach** 1998 MP 62 89 -101 (R829).
**PHOSPHOFERRITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *landesite* | $(Mn,Mg)_9Fe^{3+}{}_3(PO_4)_8(OH)_3.9aq$ |
| *phosphoferrite* | $(Fe,Mn)_3(PO_4)_2.3aq$ |
| *reddingite* | $(Mn,Fe)_3(PO_4)_2.3aq$ |

**phosphoferrite** $(Fe,Mn)_3(PO_4)_2.3aq$. Phosphoferrite structure type.
Structure: **PB Moore** 1971 AM 56 1-17; **PB Moore T Araki** 1976 IC 15 316-21 (M1058).
**phosphofibrite** $KCuFe_{15}(PO_4)_{12}(OH)_{12}.12aq$.
Supposed to be structurally related to *kidwellite* [jvs: cell data quite different.]
Structure determination not found.
Occurrence: **K Walenta PJ Dunn** 1984 CEr 43 11-6 = AM 69 1192.
**phosphogartrellite** $PbCuFe(PO_4)_2OH.aq$. *Tsumcorite* group.
P analog of *gartrellite*: **W Krause & 3 others** 1998 NJMM 111-8.
**phosphophyllite** $Zn_2(Fe,Mn)(PO_4)_2.4aq$.

Complex 1,2,3-connected octahedral-tetrahedral structure. Polytypic relation to *hopeite*.
Structure: [ignore poor data, 1961 AC 14 795 (K778)];
correction, **W Kleber E Piatkowick F Liebau** 1965 AC 18 127;
**RJ Hill** 1977 AM 62 812-7.
Occurrence: Mn substitution only up to 1:1 ratio with Fe, **PJ Dunn J Norberg** 1977 AM 62 818.

**phosphorösslerite / phosphoresslerite/ phosphoroesslerite** $MgH(PO_4).7aq$.

Isostructural As analog *rösslerite* from XRPD of *synthetic*: **RLT Street A Whitaker** 1973 ZK 137 246-55.
Structure determination not found.
Occurrence: **Dana**;
Occurrence in fertilizers: **JR Lehr & 4 others** EH 1966 *Crystallographic Properties of Fertilizer Compounds*, Tenn Valley Auth Chem Eng Bull 6, 163p (L758).

**phosphovanadylite** $(Ba,Ca,K,Na)_x(V,Al)_4P_2(O,OH)_{16}.12aq$.

Framework-cluster structure with encapsulated water.
Occurrence & structure: **MD Medrano & 3 others** 1998 AM 83 889-95.

**phosphowalpurgite** $(UO_2)Bi_4O_4(PO_4)_2.2aq$. *Walpurgite* analog.

Occurrence & XRPD/IR structure: **J. Sejkora & 4 others** 2004 CM 42 963-72;
occurrence, Smrkovec, **J Sejkora & 4 others** 2002 NJMM 353-67 (8110).

**PHOSPHURANYLITE MINERAL GROUP** Includes:

| | | *Geometrical isomer* |
|---|---|---|
| *althupite* | $ThAl(UO_2)[(UO_2)_3O(OH)(PO_4)_2]_2.15aq$ | uudduuO |
| *arsenuranylite* | $Ca(UO_2)_4(AsO_4)_2(OH)_4.6aq$ | |
| *bergenite* | $Ba_4Ca_2[(UO_2)_3(PO_4)_2O_2]_3.16aq.$ | uuduudSSO |
| *coconinoite* | $?Fe_2Al_2(UO_2)_2(PO_4)_4(SO_4)(OH)_2.20aq$ | |
| *dewindtite* | $Pb_3[H(UO_2)_3O_2(PO_4)_2]_2.12aq$ | uudduuS |
| *dumontite* | $Pb_2(UO_2)_3O_2(PO_4)_2.5aq$ | udududS |
| *françoisite-Nd* | $(Nd,Ce,Sm)(UO_2)_3O(OH)(PO_4)_2.6aq$ | uudduuS |
| *furongite* | $Al_2(UO_2)(PO_4)_2(OH)_2.8aq$ | |
| *huegelite* | $Pb_2\ (UO_2)_3(AsO_4)_2(OH)_4.3aq$ | |
| *kivuite* | $?(Th,Ca,Pb)H_2(UO_2)(PO_4)_2(OH)_8.7aq$ | |
| *moreauite* | $Al_3(UO_2)(PO_4)_3(OH)_2.13aq$ | |
| *mundite* | $Al(UO_2)_3(PO_4)_2(OH)_3.\sim5.5aq$ | |
| *phosphuranylite* | $?KCa(H_3O)_3(UO_2\ )_7(PO_4)_4O_4.8aq$ & $Ca(UO_2)[(UO_2)_3(OH)_2(PO_4)_2]_3.12aq$ | uudduuS |
| *phuralumite* | $Al_2(UO_2)_3(PO_4)_2(OH)_6.10aq$ | uudduuO |
| *phurcalite* | $Ca_2(UO_2)_3O_2(PO_4)_2.7aq$ | uudduuO |
| *renardite* | $Pb(UO_2\ )_4(PO_4)_2(OH)_4.7aq$ | |
| *upalite* | $Al(UO_2)_3(PO_4)_2O(OH).7aq$ | uudduuS |
| *vanmeersscheite* | $U(UO_2)_3(PO_4)_2(OH)_6.4aq$ | udududS |
| *xiangjiangite* | $(Fe,Al)(UO_2)_4(PO_4)_2(SO_4)_2(OH).22aq$ | |
| *yingjiangite* | $(K_{1-x}Ca_x)(UO_2)_3(PO_4)_2(OH)_{1+x}.4aq$ | |

The structural relations are complex, including pseudosymmetry, and chemical formulae are uncertain and may vary considerably.
Geometrical isomer: **AJ Locock PC Burns** 2003 CM 41 91-101.
Sheet structure with topological resemblance to *guilleminite* $Ba(UO_2)_3(SeO_3)_2O_23aq$.
The *coconinoite* subgroup is incorporated for convenience.

**phosphuranylite** $?KCa(H_3O)_3(UO_2)_7(PO_4)_4O_4.8aq$ & $Ca(UO_2)[(UO_2)_3(OH)_2(PO_4)_2]_3.12aq$.

Phosphuranylite mineral group; beware of problems.
Structure: poor, ignore, **DP Shashkin GA Sidorenko** 1975 DAN 220 123-6 (S1356).
New structure with revised composition: **F Demartin & 3 others** 1991 ACB 47 439-46 (D540).
New structure & different composition: **P Piret J Piret-Meunnier** 1991 EJM 3 69-77 (P514).

Occurrence: **L Van Wambeke** 1958 Bull Soc Belge Geol Paleontol Hydrol 67 383-403 = AM 44 1326-7.
See *bergenite*, *mundite* & *upalite* for possible structural similarities.

**phuralumite** $Al_2(UO_2)_3(PO_4)_2(OH)_6.10aq$.

*Phosphuranylite* structure group; geometrical isomer uudduuO; beware of problems.
Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
Structure: **P Piret J Piret-Meunier J-P Declercq** 1979 AC B35 1880-2.
Occurrence: MM 42 528; 43 1066.

**phurcalite** $Ca_2(UO_2)_3O_2(PO_4)_2.7aq$.

*Phosphuranylite* structure group; geometrical isomer uudduuO; beware of problems.
Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
Structure: [**P Piret J-P Declercq** 1978 AC 34B 1677-9, modified];
**D Atencio & 3 others** 1991 CM 29 95-105 (A504).

**phyllotungstite** $?CaFe_3H(WO_4)_6.10aq$.

Structure determination not found.
Occurrence: **K Walenta** 1984 NJMM 529-35 = AM 71 846.

**pianlinite** $Al_2Si_2O_6(OH)_2$. Nearly amorphous. MM 46 524.

**pickeringite** $MgAl_2(SO_4)_4.22aq$.

Isostructural series with Fe analog *halotrichite*.
Review: **Sabelli** p. 11.
Structure: **A Ferrari G Succini** 1950 PM 19 143-53;
XRPD, **S Quartieri M Triscari A Viani** 2000 EJM 12 1131-8 (302).

**picotpaulite** $TlFe_2S_3$. *Rasvumite* structure type.

Structure determination not found.
Occurrence: **Z Johan R Pierrot H-J Schubnel F Permingeat** 1970 BSFMC 93 545-9.

**PICROMERITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *boussingaultite* | $(NH_4)_2Mg(SO_4)_2.6aq$ |
| *cyanochroite* | $K_2Cu(SO_4)_2.6aq$ |
| *mohrite* | $(NH_4)_2Fe(SO_4)_2.6aq$ |
| *nickel-boussingaultite* | $(NH_4)_2(Ni,Mg)(SO_4)_2.6aq$ |
| *picromerite* | $K_2Mg(SO_4)_2.6aq$ |

**picromerite** $K_2Mg(SO_4)_2.6aq$. Picromerite structure group. Review: Sabelli p. 30.
Structure: **KK Kannan MA Viswamitra** 1965 ZK 122 161-74;
**M Carapezza L Rivadi Sanseverino** 1970 Mineral Petrogr Acta 16 5-11 = MA 72-954.

**picropharmacolite** $H_2Ca_4Mg(AsO_4)_4.11aq$.

Compare with *chudobaite*, *ferrarisite*, *guerinite*, *ihrtemite* & *sainfeldite*.
Structure: **M Catti G Ferraris G Ivaldi** 1981 AM 66 385-91.

**piemontite** $(Ca,Sr)_2(Al,Fe,Mn)_3Si_3O_{12}OH$. *Epidote* structure type.

Structure: **WA Dollase** 1969 AM 54 710-7 (D128);
heated Sr-, **M Catti G Ferraris G Ivaldi** 1988 AM 73 1370-6;
Sr-, **M Catti G Ferraris G Ivaldi** 1989 NJMM 357-66 (C757);
Sr-, **G Ferraris & 3 others** 1989 ZK 187 145-51;
heated-REE, **P Bonazzi S Menchetti** 1994 AM 79 1176-84;
Pb,RE-rich, **V Bermanec & 3 others** 1994 SMPM 74 321-8;
*synthetic*, XRPD, **M Nagashima M Akasaka** 2004 AM 89 1119-29.
*Synthesis*, Sr-Ca system, maximum Sr = Ca: **M Akasaka Y Zheng Y Suzuki** MA 03M/0331.

**piergorite-Ce** $Ca_8Ce_2(Al_{0.5}Fe_{0.5})(void,Li,Be)_2Si_6B_8O_{36}(OH,F)_2$.

Contains modified *hellandite* chain.
Occurrence & SC-XRD structure: **M Boiocchi & 2 others** 2006 AM 91 1170-7.

**pierrotite** $Tl_2(Sb,As)_{10}S_8$. Compare with *parapierrotite*.

Structure: **P Engel M Gostojic W Nowacki** 1983 ZK 165 209-15 (E324).
Occurrence: MM 37 962.

**piezotite** $Al_3Si_2O_7(OH)_3$.

*Synthetic* high-P phase known as Pi: **B Wunder & 3 others** 1993 EJM 5 637-49 (W843).

Structure: **PA Vaughan R Berman** 1963 AC 16 A13-4, full paper not found;
**P Daniels B Wunder** 1993 Z K 206 103-5 (D451);
**do**, 1996 EJM 8 1283-92 (D621.
Occurrence: **B Wunder W Schreyer** 1991 EJM 3 302.

**pigeonite** $(Mg,Fe,Ca)(Mg,Fe)Si_2O_6$. *Pyroxene* structure type, monoclinic subtype.

Structure: **N Morimoto N Güven** 1970 AM 55 1195-209;
SC-XRD & TEM of heated, **D Pasqual G Molin M Tribaudino** 2000 AM 85 953-62;
high-T SC-XRD, **F Camara & 2 others** 2002 PCM 29 331-40 (7679);
microtextures, SC-XRD, **M Tribaudino & 3 others** 2003 MP 77 161-76 (8922).

C2/c-$P2_1/c$ transition vs non-convergent ordering: **F Camaro & 3 others** 2003 AM 88 1115-28.

Ca segregation at antiphase boundaries, energy-filtered TEM: **KT Moore DR Veblen JM Howe** 2001 AM 86 1314-8.

*Synthetic* $Di_{15}En_{85}$: <6.5 GPa, SC-XRD, phase change, **F Nestola & 2 others** 2004 AM 89 189-96.

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

*Synthetic* $LiGaSi_2O_6$: **A Sato T Osawa H Ohashi** 1995 AC C51 1959-60 (S1523).

**pillaite** $Pb_9Sb_{10}S_{23}ClO_{0.5}$. *Zinkenite* mineral group of PbSb sulfides.

Structure: **A Meerschaut & 3 others** 2001 EJM 13 779-90 (3580).

Occurrence & X-ray crystallography: **P Orlandi & 3 others** 2001 EJM 13 605-10 (2009).

**pilsenite** $Bi_4Te_3$. *Tetradymite* structure group; *josëite* subgroup.

Review: **P Bayliss** 1991 AM 76 257-65.

Redefinition: **T Ozawa H Shimazaki** 1982 Proc Japan Acad 58 291-4 = AM 69 215.

**pinalite** $Pb_3WO_5Cl_2$.

Structure determination not found.

Occurrence & crystallography: **PJ Dunn JD Grice RA Bideaux** 1989 AM 74 934-5.

**PINAKIOLITE STRUCTURE FAMILY OF BORATES**

Several structural subtypes related by polytypism. Includes:

| | |
|---|---|
| *azoproite* | $(Mg,Fe)_2(Fe,Ti,Mg)(BO_3)O_2$ |
| *blatterite* | $(Mn,Mg)_2(Mn,Sb,Fe)(BO_3)O_2$ |
| *bonnacordite* | $Ni_2Fe(BO_3)O_2$ |
| *chestermanite* | $Mg_{2.2}Al_{0.1}Fe_{0.4}Sb_{0.1}BO_3O_2$ |
| *fredrikssonite* | $Mg_2Mn(BO_3)O_2$ |
| *hulsite* | $(Fe^{2+}Mg,Fe^{3+})_2(Fe^{2+},Fe^{3+},Sn,Mg)(BO_3)O_2$ |
| *ludwigite* | $(Mg,Fe)_2Fe(BO_3)O_2$ |
| *magnesiohulsite* | $(Mg,Fe)_2(Fe,Sn,Mg)(BO_3)O_2$ |
| *orthopinakiolite* | $(Mg,Mn)_2(Mn,Fe)(BO_3)O_2$ |
| *pinakiolite* | $(Mg,Mn)_2(Mn,Fe)(BO_3)O_2$ |
| *takéuchiite* | $(Mg,Mn)_2(Mn,Fe)(BO_3)O_2$ |
| *vonsenite* | $(Fe,Mg)_2Fe(BO_3)O_2$ |

Monoclinic: P2/m parent, *hulsite & magnesiohulsite*; monoclinic C2/m ordered derivative, *pinakiolite*.

Orthorhombic Pbam 2t2t polytype: *azoproite*, *bonaccordite*, *fredrikssonite* , *ludwigite*, *vonsenite*.

Orthorhombic higher polytypes: 4t4t Pnnm, *chestermanite & orthopinakiolite*; 6t6t Pnmm, *takéuchiite*; 8t8t Pnmm, *blatterite*.

**pinakiolite** $(Mg,Mn)_2(Mn,Fe)(BO_3)O_2$.

6 Å Zigzag Borate: **MA Cooper FC Hawthorne** 1998 CM 36 1171-93.

Pinakiolite subgroup of pinakiolite structure family.

Trimorphic with *orthopinakiolite* & *takéuchiite*.

Structure: **Y Takéuchi T Watanabé T Ito** 1950 AC 3 98-107;
**PB Moore T Araki** 1974 AM 59 985-1004.

Sb-rich: **R Norrestam S Hansen** 1990 ZK 191 105-16 (N331);
ED, **S Hansen & 2 others** 1988 NJMM 231-9 (H973).

Defects: MA 85M/2418.

Modular interpretation of oxyborates: **BB Zvyagin GA Siderenko** 1995 AC B51 7-11 (Z87).

**pinchite** $Hg_5O_4Cl_2$.
Structure: **FC Hawthorne M Cooper PK Sen Gupta** 1994 AM 79 1199-203.
MM 40 912.
**pingguite** $Bi^{3+}{}_6Te^{4+}{}_2O_{13}$.
Occurrence & crystallography: **Z Sun & 3 others** 1994 Acta Mineral Sinica 14 315-21 = AM 81 767.
**pinnoite** $MgB_2O(OH)_6$. Isolated $BO_4$ tetrahedra.
Structure: **F Paton SGG MacDonald** 1957 AC 10 653-6;
**J Krogh-Moe** 1967 AC 23 500-1 = MA 69-193;
**EA Genkina YuA Malinovskii** 1983 SPC 28 475-7 (G701).
[pintadoite $Ca_2V_2O_7$.9aq. Ignore: insufficient data.]
**piretite** $Ca(UO_2)_3(SeO_3)_2(OH)_4$.4aq.
Occurrence & indexed XRPD: **R Vochten & 3 others** 1996 CM 34 1317-22.
**pirquitasite** $Ag_2ZnSnS_4$. *Stannite* structure group.
Occurrence & crystallography: **Z Johan P Picot** 1982 BM 105 1229-35.
**pirssonite** $Na_2Ca(CO_3)_2$.2aq.
Structure: **E Corazza C Sabelli** 1967 AC 23 763-6;
**B Dickens WE Brown** 1969 IC 8 2093-103.
Dehydration, FTIR: **ME Böttcher P-L Gehlken** 1996 NJMM 73-91 (B1465).
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** 1995.
**[pisekite** $(Y,As,Ca,Fe,U)(Nb,Ti,Ta)O_4$.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.]
**pitiglianoite** $\sim Na_6K_2Si_6Al_6O_{24}(SO_4)$.2aq. *Cancrinite* structure group.
Structure: **S Merlino & 5 others** 1991 AM 76 2003-8.
**pitticite** $\sim Fe_2(AsO_4)(SO_4)OH$.n aq. Inadequate description.
Amorphous: AM 67 414. [jvs: look for *synthetic*.]
**piypite** $K_4Cu_4O_2(SO_4)_4$.KCl [= *caratiite* discontinued name, MR 30 174].
Structural analog of *klyuchevskite*.
Structure of *caratiite*: **H Effenberger J Zemann** 1984 MM 48 541-6.
*Synthetic* Na-analog, SC-XRD structure: **V Kahlenberg & 2 others** 2000 MM 64 1099-108.
Occurrence: MM 48 580.
**plagioclase** Group name for Na-Ca *feldspar*s, between *albite* & *anorthite*.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**PLAGIONITE HOMOLOGOUS SERIES** Includes:

| | |
|---|---|
| *fülöppite* | $Pb_3Sb_8S_{15}$ |
| *heteromorphite* | $Pb_7Sb_8S_{19}$ |
| *plagionite* | $Pb_5Sb_8S_{17}$ |
| [*?rayite* | $\sim Pb_8(Ag,Tl)_2Sb_8S_{21}$] |
| *semseyite* | $Pb_9Sb_8S_{21}$ |

Review: **JJ Kohatsu BJ Wuensch** 1974 AC B30 2935-7;
**A Skowron ID Brown** 1994 AC B50 524-38 (S13374).
**plagionite** $Pb_5Sb_8S_{17}$. *Plagionite* homologous series: n = 1.
Structure: **S Cho BJ Wuensch** 1974 ZK 139 351-78.
**plancheite** $Cu_8Si_8O_{22}(OH)_4$.aq. Review: (E289).
Compare with *shattuckite*; double vs single chains.
Structure: **M Le Bihan** 1967 BSFMC 90 3-7;
**HT Evans Jr ME Mrose** 1977 AM 62 491-502.
**[planerite** $Al_6(PO_4)_2(PO_3OH)_2(OH)_8$.4aq. Variety of *turquoise*.
Occurrence in Japan: MA 97M/2008.
Revalidation: **EE Foord JE Taggart Jr** 1998 MM 62 93-111.]
**platarsite** PtAsS. *Cobaltite* structure group.
Structure: *synthetic*, **F Hulliger** 1963 N 198 382-3;
**F Hulliger E Mooser** 1965 JPSC 26 429-33;

**JT Szymanski** 1979 CM 17 117-23;
**P Bayliss** 1986 CM 24 27-33.
Occurrence: MM 42 528.
[platiniridium (Ir,Pt).
Redefined as variety *platinian iridium*: **DC Harris LJ Cabri** 1991 CM 29 231-7.]
**platinum** Pt. Cubic closest packing = face-centered cubic. *Copper* structure group.
*Ferroan platinum* $Pt_3Fe$ is face-centered cubic: **LJ Cabri JH G Laflamme** 1997 MR 28 97-105.
*Isoferroplatinum* is primitive cubic: **do**.
Pt-Fe-Cu alloys, Western Sayan: **N Tolstykh A Krivenko L Pospelova** 1997 EJM 9 457-65 (T517).
Pt-Ir-Fe-S phase relations 1373 & 1400 K: **E Makovicky S Karup-Moller** 2000 MM 64 1047-56.
In meteorites: **AE Rubin** 1997 MPS 32 231-47; also *PGE-dominated alloys*.
Platinum-iron alloys: **JFW Bowles** 1990 MP 43 37-47.
Pt(111) surface, reconstruction: **G Gruebel & 5 others** 1993 PR B 48 18119-24 (1756).
Pt alloys from *chromite*, Urals: **G Garuti EV Pushkarev F Zaccarini** 2002 CM 40 1127-46.
Platinum-group elements; petrology, geochemistry, mineralogy: CM 42 211-694. [30 articles.]
[*yixunite* ~PtIn. Might merely be indian platinum solid solution.
Occurrence: **T Yu & 4 others** 1974 Acta Geol Sinica 2 202-18 = AM 61 185-6.]
**plattnerite** $PbO_2$. Rutile structure group.
Structure: **P D'Antonio A Santoro** 1980 AC B36 2394-7.
**[platynite** (Bi,Pb)(Se,S). ?*tetradymite* mineral/structure group, *tsumoite* subgroup.
May be variety *plumbian sulfurian nevskite*: **P Bayliss** 1991 AM 76 257-65.
Discredited: CM 37 1313-5.]
**playfairite** $Pb_{16}Sb_{18}S_{43}$.
Structure determination not found.
Occurrence & crystallography: **JL Jambor** 1967 CM 9 191-213 (J235).
**plazolite** See *hydrogrossular*.
**[pleochroite** $Ca_{22}Fe_3Al_{14}(Al_2O_7)_8(AlO_4)_4(SiO_4)_2$. *Synthetic* in high-alumina cements.]
**pleonaste** $(Mg,Fe)Al_2O_4$. *Spinel* mineral family.
Temperature dependent cation distribution: **L Larsson** 1995 NJMM 173-84.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**plombierite** $Ca_5H_2Si_6O_{18}.6aq$?
Structure determination not found.
Occurrence & crystallography: **L Heller HFW Taylor** 1956 Crystallographic Data for the Calcium Silicates, HM Stationary Office.
**plumalsite** $Pb_4Al_2(SiO_3)_7$.
Structure determination not found.
Occurrence & crystallography: **GYa Gornyi MG Dyadchenko TA Kudykina** 1967 Dopovidi Akad Nauk Ukraine RSR B Geol Geofiz Khim 514-7 = AM 53 349-50 (inadequate description).
**plumboagardite** $(Pb,REE,Ca)Cu_6(AsO_4)_3(OH)_6.3aq$. *Mixite* group.
Occurrence & XRPD: **K Walenta T Theye** 2005 NJMA 181 219-22.
**[plumboalunite** $PbAl_6(SO_4)_4(OH)_{12}$. Endmember.]
**plumbobetafite** $(Pb,U,Ca)(Nb,Ti)_2O_6(OH,F)$. *Pyrochlore* structure group.
Structure determination not found.
Occurrence/crystallography: **NV Skorobogatova & 3 others** 1966 Geol Mestorozhd Redk Elem 30 84-95 = AM 55 1068; MM 38 997.
**plumboferrite** $Pb_2(Mn,Fe)_{0.33}Fe_{10.67}O_{18.33}$. *Plumboferrite* structure group.
Defect *magnetoplumbite* structure type with double *a* & *c*.
Structure: **D Holtstam R Norrestam A Sjödin** 1995 AM 80 1065-72.
*Synthetic* $Pb_2(Mn,Fe)_{0.33}Fe_{10.7}O_{18.3}$: structure done, reference?
**plumbogummite** $PbAl_3(PO_4)_2(OH)_5.aq$.
*Crandallite* structure group; related to *hinsdalite*.
Structure: $PbAl_3(P_{0.95}As_{0.05}O_4)_2(OH,aq)_6$, SC-XRD & ED: **U Kolitsch & 4 others** 1999 EJM 11 513-20 (K1164).
*Synthesis*, XRPD: **RG Schwab & 3 others** 1990 NJMM 113-26(S1453).
In soil, Pb-mineralized sandstone, Largentiere, France: **G Morin & 6 others** 2001 AM 86 92-104.

Potential host for toxic elements including radioactive fission products.
**plumbojarosite** $PbFe_6(SO_4)_4(OH)_{12}$. *Alunite* structure group. Review: **Sabelli** p. 25.
Structure: **T Kato** 1979 Min Soc Japan 26;
**JT Szymanski** 1985 CM 23 659-68;
Raman, **K Sasaki O Tanaike H Konno** 1998 CM 36 1225-35.
Unnamed phosphate analog: **P Orlandi** 1994 IMA Pisa p. 31.
**plumbomicrolite** $(Pb,Ca,U)_2Ta_2O_6OH$. *Pyrochlore* structure group.
Review: **DD Hogarth** 1977 AM 62 403-10.
Structure determination not found.
Occurrence & crystallography: **A Safiannikoff L Van Wambeke** 1961 BSFMC 84 382-4.
**plumbonacrite** $Pb_5O(CO_3)_3(OH)_2$.
Structure, *synthetic*, SC-XRD: **SV Krivovichev PC Burns** 2000 MM 64 1069-75.
Basic lead carbonates, review of *hydrocerussite* & : **JK Olby** 1966 J Inorg Nucl Chem 28 2507-12 = AM 52 563.
Stability: **DF Haacke PA Williams** 1981 J Inorg Nucl Chem 43 406.
Occurrence: **Heddle** 1889 MM 8 200-3.
Lead corrosion product in industry, rapidly changes to *hydrocerussite*.
**plumbopalladinite** $Pd_3Pb_2$.
Stated to have *niccolite* structure type [jvs: if so, must be defect type].
XRPD matches *synthetic*.
Structure determination not found.
Occurrence & crystallography: **AD Genkin & 4 others** 1970 Geol Rud Mestorahzd 5 63-8 = AM 56 1121.
**plumbopyrochlore** $\sim(Pb,Y,U,Ca)_2Nb_2O_6(OH)$. *Pyrochlore* structure group.
Occurrence: MM 36 1156-7.
New occurrence & EM: **PM Kartashov & 3 others** 1992 DES 323 142-6.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**plumbotellurite** $PbTeO_3$.
Redefinition pending, MR 30 175.
Matches *synthetic* alpha type. Dimorphic with *fairbankite*.
Structure determination not found.
Occurrence/crystallography: **EM Spiridonov OI Tananaeva** 1982 DAN 262 1231-5 = AM 67 1075.
**plumbotsumite** $Pb_5Si_4O_8(OH)_{10}$.
Structure determination not found.
Occurrence & crystallography: **P Keller PJ Dunn** 1982 CEr 41 1-6 = AM 67 1075.
**poitevinite** $(Cu,Fe,Zn)SO_4.aq$. *Kieserite* structure type.
Structure: XRPD, **G Giester CL Lengauer G Redhammer** 1994 CM 32 873-84.
*Synthetic* Cu- & Zn-, described as monoclinic: **CWFT Pistorious** 1961 AC 14 534.
Occurrence: **JL Jambor GR Lachance S Courville** 1964 CM 8 109-10.
Series with *kieserite*, XRPD: **CL Lengauer G Giester** 1995 PD 10 189-94.
*Synthetic* $CuSO_4aq$ & $CuSeO_4.aq$, refined as triclinic: **G Giester** 1988 MP 38 277-84.
**pokrovskite** $Mg_2(CO_3)(OH)_2.0.5aq$. *Lansfordite* mineral group of hydrous carbonates.
Isostructural with Cu analog *malachite*.
Structure determination not found.
Occurrence & crystallography: **OK Ivanov & 2 others** 1984 ZVMO 113 90-5 = AM 70 217.
**polarite** $BiPbPd_2$. **Pearson** code oC32.
Review: **P Bayliss** 1990 CM 28 751-5.
Occurrence: MM 37 963.
Structure: *synthetic*, **HW Mayer YC Bhatt K Schubert** 1979 J Less-Common Metals 66 1-9.
**poldervaartite** $Ca(Ca_{0.5}Mn_{0.5})(SiO_3OH)(OH)$.
Probably isostructural dicalcium silicate alpha-hydrate: **Y Dai GE Harlow AR McGhie** 1993 AM 78 1082-7.
**polhemusite** (Zn,Hg)S.
Structure determination not found.
Occurrence & crystallography plus speculations on possible defect *sphalerite* structure: **BF Leonard GA Desborough CW Mead** 1978 AM 63 1153-61.
**polkanovite** **(**Rh,Ni, Pd, Os, Ir, $Pt)_{12}As_7$.

Occurrence & XRPD (= *synthetic*): **SN Britvin & 3 others** 1998 ZVMO 127 60-2 (B1986).

**polkovicite** ~$(Fe,Pb)_6(Ge,Fe)_{\sim 1}S_8$. *Germanite* structure group.

Structure determination not found.

Occurrence: **C Haranczyk** 1975 Rudy Metalle 20 288-93 = AM 66 437.

**pollucite** $(Cs,Na)_2Al_2Si_4O_{12}.aq$.

*Analcime/leucite* structure family in *zeolite/feldspathoid* mineral groups. ANA type of net.

Structure: **St Naray-Szabo** 1938 ZK 99 277-82;
**RA Newnham** 1967 AM 52 1515-8;
**RM Beger MJ Buerger** 1967 PNAS 58 853-4 (B339);
**RM Beger** 1969 ZK 129 280-302 (B406);
XRPD to 1073 K, **J Schneider HL Meyerheim** 1996 AC A52 Suppl C-338;
XRPD at 473 & 873 K, **do** 1996 AC A52 Suppl C-338;
tetragonal/cubic, 93-298 K, XRPD, **I Yanase & 3 others** 1997 JACS 80 2693-5 (Y214).

Natural $Cs_{0.7\text{-}0.8}Na_{0.1}Al_{0.8}Si_{2.2}O_6.0.3\text{-}0.2$ aq: **OV Frank-Kamenetskaya & 5 others** 1995 CrR 40 645-54 (F460).

Occurrence: nearly pure Cs endmember, **DK Teertstra P Cerny** 1995 EJM 7 1137-48 (T450);
with *polylithionite*, China, **RC Wang & 4 others** 2004 CM 42 883-96;
Sweden: MA 97M/1940;
pegmatite & re-equilibration, Altai, China, **RC Wang & 5 others** 2006 AM 91 729-39..

*Synthetic* $CsAlSiO_4$: **R Dimitrijevic V Dondur N Petranovic** 1991 JSSC 95 335-45.

*Synthetic* Fe analog: **OC Kopp & 3 others** 1963 AM 48 100-9.

*Synthetic* $Cs_2CuSi_5O_{12}$: **AR Heinrich C Baerlocher** 1991 AC C47 237-41 (H795).

*Synthetic* $RbAlSi_2O_6$: **AA Kosorukov LG Nadal** 1986 SPC 31 148-51.

*Synthetic* $Cs_2BeSi_5O_{12}$: **LM Torres-Martinez & 3 others** 1984 JSSC 51 100-3.

*Families* of $Cs_2MSi_5O_{12}$ with M = Be, Mg, Fe, Co, Ni, Zn, Cd) & $Rb_2MgSi_5O_{12}$ with M = Mg, Fe, Co, Zn: **LM Torres-Martinez AR West** 1986 ZK 175 1-7.

$A_2BX_5O_{12}$ & $ACX_2O_6$ families of pollucite & *leucite* related phases: **do** 1989 ZaaC 573 223-30.

*Synthetic* $CsFeSi_2O_6$, XRPD & Mössbauer: **AM Bychkov & 3 others** 1996 GI 33 17-32 (B1524).

*Synthetic* $CsTiSi_2O_6$, NP & SC-XRD, disordered Ti/Si:
**ML Balmer & 4 others** 1997 JSSC 130 97-102 (B1635);
XRPD, **DE McCready ML Balmer KD Keefer** 1997 PD 12 40-6;
MAS-NMR, $^{29}Si$: **ML Balmer & 4 others** 1997 JPCB 101 9170-9 (B1738).

*Synthetic* $Cs_2TiSi_6O_{15}$, new structure type similar to pollucite: **IE Grey RS Roth ML Balmer** 1997 JSSC 131 38-42 (G917).

*Synthetic* Co-Al-P, high-T, acentric site-ordered structure: **JP Hirst & 3 others** 2003 ChC 684-5.

**polyakovite-Ce** $(REE,Ca)_4(Mg,Fe)(Cr,Fe)_2(Ti,Nb)_2Si_4O_{22}$. Near dimorph of *perrierite*.

Possible relative of *chevnikite-Ce*.

Occurrence & SC-XRD structure: **VA Popov & 5 others** 2001 CM 39 1095-104.

**polybasite** $(Ag,Cu)_{16}Sb_2S_{11}$.

*Synthetic* series with As analog *arsenpolybasite*: **HT Hall** 1967 AM 52 1311-21.

Dimorphic with *antimonpearceite* with half cell repeats.

Structure not known.

Occurrence: **C Frondel** 1963 AM 48 565-72.

**polycrase-Y** $(Y,Ca,Ce,U,Th)(Ti,Nb,Ta)_2O_6$.

*Columbite* structure type from cell data; commonly metamict.

Series with Nb-rich analog *euxenite* $(Y,Ca,Ce,U,Th)(Nb,Ta,Ti)_2O_6$.

Series with *uranopolycrase* $(U,Y)(Ti,Nb)_2O_6$.

Structure: non-metamict but disordered, **O Johnsen & 3 others** 1999 NJMM 1-10 (J337).

Occurrence: **Dana**.

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

**polydymite** $Ni_3S_4$. *Linnaeite* structure group. *Siegenite* is *Ni-cobaltpolydymite*.

*Synthetic* $Co_3S_4$, structure: **D Lundqvist A Westgren** 1938 ZaaC 239 85-8.

**polyhalite** $K_2MgCa_2(SO_4)_4.2aq$. Review: **Sabelli** p.35.

Structure: **M Schlatti A Zemann J Zemann** 1970 TMPM 14 75-86 (S404).
Occurrence in fertilizers: **JR Lehr & 4 others** EH 1966 *Crystallographic Properties of Fertilizer Compounds*, Tenn Valley Auth Chem Eng Bull 6, 163p (L758).

**polylithionite** $KLi_2AlSi_4O_{10}(F,OH)_2$. *Mica* structure group; 1M & $2M_2$ polytypes.
Series with *trilithionite.*

Structure: $2M_2$ polytype, **MF Brigatti & 4 others** 205 EJM 17 476-81.
Occurrence & crystallography: **KA Vlasov** 1966 Mineralogy of Rare Elements II 25-9 Israel Program for Scientific Translations.
[*fluor-polylithionite* $KAlLi_2Si_4O_{10}F_2$.
*Synthetic* mica: **H Takeda CW Burnham** 1969 MJJ 6 102-9.
Al XANES: **A Mottana & 6 others** 1997 AM 82 497-502.]
[polymignite $(Ti,Ca,Zr)O_{2-x}$.
Confused literature. = *zirkelite*, MR 30 175.
See *zirconolite* for approved nomenclature and combined references.]
**polyphite** $Na_5(Na_4Ca_2)Ti_2[Si_2O_7][PO_4]_3O_2F_2$. *Lomonosovite* mineral group.
Structure: revised, SC-XRD **E Sokolova & 2 others** 2005 CM 43 1527-44.
Occurrence & crystallography: **AP Khomyakov & 3 others** 1992 ZVMO 121 105-12 (K660).
**ponomarevite** $K_4Cu_4OCl_{10}$.
Structure: **TF Semenova & 3 others** 1989 DAN 304 427-30 = AM 75 709.
Occurrence: MM 54 668. MM 52 730.

**poppiite** $Ca_2(V^{3+},Fe,Mg,Mn)(V^{3+},Al)_2(SiO_4)(Si_2O_7)(OH)_2.aq$.
$V^{3+}$-member of *pumpellyite group.*
Occurrence & SC-XRD structure: **MF Brigatti & 2 others** 2996 AM 91 584-8.
**portlandite** $Ca(OH)_2$. *Brucite* structure type.
Structure: ND, **WR Busing HA Levy** 1957 JCP 26 563-8 (B1409);
**HE Petch** 1961 AC 14 950-7 (P18);
vibration spectrum at P, **MB Kruger Q Williams R Jeanloz** 1989 JCP 91 5910-5;
thermal motion of H, **L Desgranges & 5 others** 1993 AC B49 812-7.
Occurrence: MM 23 636;
NPD to 11 GPa, **A Pavese & 3 others** 1997 PCM 24 85-9 (P709).
Melting to 6 GPa: **H Fukui & 5 others** 2000 PCM 27 367-70 (F6970.
High-P phase transition:
static compression & H disorder <11 GPa, NPD, **M Catti & 3 others** 1995 PCM 22 200-6;
equation of state to 11 GPa, NPD, **A Pavese & 3 others** 1997 PCM 24 85-9 (P680);
structure to 10 GPa, XRPD, **T Nagai & 3 others** 2000 PCM 27 462-6 (N529);
low-T DSC, enthalpy, **M Schoentz & 2 others** 2000 PCM 27 604-9 (315).
High-P $EuI_2$-type quenched to ambient, NPD: **K Leinenweber & 4 others** 1997 JSSC 132 267-73 (L920).
High-P, new phase with Raman indicating $Sr(OH)_2$ type, & amorphization: **S Ekbundit & 5 others** 1996 JSSC 126 300-7 (E391).
Structure modules based on *shannonite*, *portlandite* & *monticellite* structures: **BB Zvyagin DYu Pushcharovsky** 1993 ZK 208 1-10.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
Colloidal particles used in fresco restoration: **M Ambrosi & 4 others** 2001 La 17 4251-5 (2951).
**posnjakite** $Cu_4(SO_4)(OH)_6.2aq$. Review: chain structure, **Sabelli** p. 24; (E289).
Polymorphic with *langite* & *wroewolfite*.
Structure: **M Mellini S Merlino** 1979 ZK 149 249-57;
**T Ridkosil P Povondra** 1982 NJMM 16-28.
Raman vs OH: **RL Frost & 4 others** 2004 AM 89 1130-7.
Occurrence: MM 36 1157.
**potarite** PdHg. Matches *synthetic*.
Structure type AuCu, tetragonal superstructure of fcc = ccp: $L1_0$.
Structure: **K Terada FW Cagle Jr** 1960 AM 45 1093-7.
Occurrence: MM 21 574;

MM 63 369-77;
Au-bearing, **ME Fleet CM De Almeida N Angeli** 2002 CM 40 341-55.

**potassicarfvedsonite** $KNaFe_4FeSi_8O_{22}(OH)_2$. *Amphibole*.
Occurrence & structure: **IV Pekov & 8 others** 2004 NJMM 12 555-74.

**potassic-carpholite** $(MnLi)Al_4Si_4O_{12}(OH)_4F_4$. *Carpholite* group.
Occurrence & XRPD: **KY Tait & 4 others** 2004 CM 42 121-4.
Corrected occurrence: **WC Van Laer** 2005 CM 43 1125-6.

**potassic-chloropargasite** $(K,Na)Ca_2(Mg,Fe,Al)_5(Si,Al)_8O_{22}Cl(OH)$. *Amphibole*.
Occurrence, XRPD, IR: **NV Chukanov & 4 others** 2002 ZVMO 58-61 (8772).

**potassicferrisadanagaite** *Amphibole*.
Structure: XRPD & Mössbauer, **EV Sokolova & 4 others** 2000 CM 38 669-74.
Occurrence: **AG Bazhenov et al** 1999 ZVMO 128 50-5 = AM 85 1563,

**potassicpargasite** $(K,Na)Ca_2(Mg,Fe,Al)_5(Si,Al)_8O_{22}(OH,F)$. *Amphibole*.
Occurrence & structure: **GW Robinson & 3 others** 1997 CM 35 1535-40.

**potassicrichterite, strontian** 4 wt. % SrO. *Amphibole*.
Occurrence & structure: **EV Sokolova & 4 others** 2000 MM 64 19-23.

**potassium alum** $KAl(SO_4)_2.12aq$. *Alum* structure group. Review: **Sabelli** p.9-10.
Structure: **AC Larson DT Cromer** 1967 AC 22 793-800.

**potassium-fluor richterite** *Amphibole*. MM 60 679-80.

**potassium taranakite / taranakite** $?H_6K_3Al_5(PO_4)_8.18aq$.
Uncertain chemical composition for hydrated layer structure.
Important for P storage in soils.
Matches *synthetic* phase A, XRPD: **JP Smith WE Brown** 1959 AM 44 138-42.
Speculation on composition & structure: **D McConnell** 1976 AM 61 329-31.
Occurs with *brushite*.
Occurrence: **JW Murray RV Dietrich** 1956 AM 41 616-26;
in fertilizers: **JR Lehr & 4 others** EH 1966 *Crystallographic Properties of Fertilizer Compounds*, Tenn Valley Auth Chem Eng Bull 6, 163p (L758).

**potosiite** $Pb_{48}Sn_{18}Fe_7Sb_{16}S_{115}$. *Cylindrite* structure group.
Structure: **SA Kissin DR Owens** 1986 CM 24 45-50.
Occurrence: MM 48 580.

**pottsite** $HPbBi(VO_4)_2.2aq$.
Structure determination not found.
Occurrence & crystallography: **SA Williiams** 1988 MM 52 389-90.

**poubaite** $PbBi_2Se_2(Te,S)_2$. *Tetradymite* structure group; *josëite* subgroup.
Structure review: **P Bayliss** 1991 AM 76 257-65.
Occurrence: **F Cech I Vavrin** 1978 NJMM 9-19.

**poudretteite** $KNa_2B_3Si_{12}O_{30}$. *Osumilite* structure type.
Structure of Mont Saint-Hilaire specimen: **JD Grice & 3 others** 1987 CM 25 763-6.
Occurrence: gem, Mogok, Burma, **CP Smith & 6 others** 2003 GG 39 Spring 24-31 (8923).

**poughite** $Fe_2(TeO_3)_2(SO_4).3aq$. Review: **Sabelli** p.26.
Structure: **F Pertlik** 1971 TMPM 17 279-90 (P549).
Occurrence: MM 37 963.

**povondraite** $NaFe^{2+}{}_3Fe^{3+}{}_6(BO_3)_3Si_6O_{18}(O,OH)_4$. Redefinition of *ferridravite*.
Description: MM 60 680.

**powellite** $Ca(Mo,W)O_4$. *Scheelite* structure type.
Structure: **VB Aleksandrov LV Gorbatyi VV Ilyukhin** 1968 SPC 414-5 (A555);
**RM Hazen LW Finger JWE Mariathasan** 1985 JPCS 46 253-63 (H612).
*Synthetic* $CaMoO_4$, ND: **G Wandahl A Nørlund Christensen** 1987 ACSc A41 358-60.
*Synthetic* $(Ca/Sr)(Mo/W)O_4$, ND: **E Gürmen E Daniels JS King** 1971 JCP 55 1093-7 (G749).
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**poyarkovite** $Hg_3ClO$.

Structure & second occurrence: **Vl Vasil'ev & 4 others** 1999 CM 37 119-26.
Occurrence & crystallography: **Vl Vasil'ev YuG Lavrent'ev NA Pal'chik** 1981 ZVMO 110 501-6.
**[**pozzuolite $As_2S_3.aq$.
Occurrence: MM 29 992.]
**prassoite** $(Rh,Pd,Pt,Ir,Ni,Cu)_{17}S_{15}$.
*Synthetic*: structure, **S Geller** 1962 AC 15 1198.
Occurrence: Sierra Leone, **JFW Bowles** 2000 MP 68 75-84 (B2018).
**prehnite** $Ca_2Al_2Si_3O_{10}(OH)_2$.
Structure: **A Preisinger** 1965 TMPM 10 491-504 (P56);
**JJ Papike T Zoltai** 1967 AM 52 974-84 (P73);
**F Aumento** 1968 CM 9 485-92;
**TB Zunic S Scavnicar G Molin** 1990 EJM 2 731-4;
ED, Pncm, **W Xhao X Liu Q Wang Q Zhang** 2003 MM 67 73-8.
Prehnite & *orthoprehnite*: **WH Baur & 3 others** 1990 JSSC 86 330-3 (B1440).
Fe-rich, Sumatra & California: **RS Wheeler PRL Browne KA Rodgers** 2001 MM 65 397-406.
Occurrence: **L Gautron N Meisser** 2001 MR 32 223-32.
**preisingerite** $Bi_3(AsO_4)_2O(OH)$.
Isotypic with *petitjeanite* $Bi_3(PO_4)_2O(OH)$ & *schumacherite* $Bi_3(V,etc.O_4)_2O(OH)$.
Structure: **D Bedlivy K Mereiter** 1982 AM 67 833-40.
**preiswerkite** $NaMg_2Al_3Si_2O_{10}(OH)_2$. *Mica* structure type.
Structure: **R Oberti & 4 others** 1963 AM 78 1290-8.
Occurrence: MM 46 525; AM 84 977-82.
Al XANES: **A Mottana & 6 others** 1997 AM 82 497-502.
Occurrence in eclogites: **G Godard D Smith** 1999 CMP 136 20-32 (G1168).
**preobrazhenskite** $Mg_3B_{11}O_{15}(OH)_9$.
Structure: **IM Rumanova ZP Razmanova NV Belov** 1972 SPD 16 518-21 (R469);
**PC Burns FC Hawthorne** 1994 CM 32 387-96 (B1599).
Occurrence: MM 31 970.
**pretulite** $ScPO_4$. *Zircon* type.
Occurrence and structure: **F Bernhard & 4 others** 1998 AM 83 625-30.
Occurrence: with scandian zircon, **Y Moelo & 5 others** 2002 CM 40 1657-73.
**prewittite** $(Fe_{0.8}Mn_{0.2})_2(Fe_{0.98}Mg_{0.02})_5Si_4O_{11}(OH)_2$. *Protoamphibole*.
Structure: (S1160).
**priceite** $Ca_2B_5O_7(OH)_5.aq$. (= *pandermite*).
Structure, XRPD: **KS Wallwork & 3 others** 2002 CM 40 1199-206;
boron K-edge XANES, **ME Fleet S Muthupari** 2000 AM 85 1009-21.
Occurrence: Dana.
**priderite** $(K,Ba)(Ti,Fe)_8O_{16}$. *Cryptomelane* structure type.
Structure: **JE Post RB Von Dreele PR Buseck** 1982 AC B38 1056-65;
**W Sinclair GM McLaughlin** 1982 AC B38 245-6;
incommensurate superlattice ordering, **A Pring DA Jefferson** 1983 MM 47 65-8;
**MT Dmitriyeva & 3 others** 1994 DES 326 158-62 (D486);
natural $(K_{0.56}Ba_{0.36})_2(Ti_{0.93}Fe_{0.06})_6O_{13}$, AN **Bagshaw & 3 others** 1977 Australian J Chem 30 1195-200 (B1308);
Mössbauer, **C McCammon RH Mitchell AR Chakhmouradian** 1999 CM 37 991-5.
Occurrence: MM 29 992.
[Unnamed K-V-Ba-titanate, **RH Mitchell SE Haggerty** 1986 NJMM 376-84 (M806).]
See *Ba-priderite*.
High-P synthesis priderite & *lindsleyite-mathiasite* & *hawthorneite-yimengite* series: **S Foley H Höfer G Brey** 1994 CMP 117 164-74 (F559).
Natural K-Cr-priderite, not submitted to CNMN: **H Zhou Q Lu** 1994 Acta Mineral Sinica 14 234-40 = AM 81 766.
*Synthetic* K- & Ba-: **K Norrish** 1951 MM 29 500.
*Synthetic* $Ba_{1.1}V_8O_{16}$: **Y Kanke & 3 others** 1995 JSSC 115 88-91 (K711).

*Synthetic* $Na_xCr_xTi_{8-x}O_{16}$: **Y Michiue M Watanabe** 1995 JSSC 116 296-9 (M1230);
**Y Michiue A Sato M Watanabe** 1999 JSSC 145 182-5 (M1743).
*Synthetic* KGa-, catalytic reduction NO with propylene: **T Mori & 3 others** 1996 JMS 31 1469-73 (M1366).
*Synthetic* $K_xZn_yTi_{8-y}O_{16}$, crystallography & electrical conductivity: **AK Bhattacharya RG Biswas KK Mallick** 1996 JMS 31 6463-8 (B1555).

**pringleite** $Ca_9B_{26}O_{34}(OH)_{24}Cl_4.13aq$. Dimorph of *ruitenbergite*.
Structure: **JD Grice PC Burns FC Hawthorne** 1994 CM 32 1-14 (G707).

**prismatine** B-rich endmember of *kornerupine* series.
Occurrence: **DA Young** 1995 CM 33 1255-62;
**ES Grew MA Cooper FC Hawthorne** 1996 MM 60 483-91.

**probertite** $NaCaB_5O_7(OH)_4.3aq$.
Structure: **KhM Kurbanov IM Rumanova NV Belov** 1964 SPD 8 956-9;
**IM Rumanova KhM Kurbanov NV Belov** 1966 SPC 10 513-22 (R503);
**S Menchetti C Sabelli R Trosti-Ferroni** 1982 AC B38 3072-5;
boron K-edge XANES, **ME Fleet S Muthupari** 2000 AM 85 1009-21.
Occurrence: MM 22 626.

**prosopite** $CaAl_2(F,OH)_8$.
Structure: **C Giacovazzo S Menchetti** 1969 Atti Accad Naz Lincei Cl Sci Fis Mat Natur Rend 47 55-68;
**ZV Pudovkina YuA Pyatenko** 1970 DAN 190 131-3 (P491) = MA 73-3482;
**ZV Pudovkina NM Chernikova JuA Piatenko** 1973 J Struct Chem 13 345-7.

**prosperite** $HCaZn_2(AsO_4)_2OH$.
Structure: **P Keller H Riffel H Hess** 1982 ZK 158 33-42 (K616).
Occurrence: MM 43 1066.

**protasite** $Ba(UO_2)_3O_3(OH)_2.3aq$.
Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
Structure: **MK Pagoaga DE Appleman JM Stewart** 1987 AM 72 1230-8.
Review: **V Baran M Unzeitig** 1991 NJMM 63-75 (B1358).
Occurrence: MM 50 755.
Crystal chemistry: NJMA 174 159-80 (C1076).

**[protoamphibole** Originally *synthetic* phase in *amphibole* structure group.
Structure: **GV Gibbs** 1969 Mineral Soc Am Spec Paper 2 101-9.
*Synthesis*: MM 32 976.
Occurrence: **S Sueno S Matsura GV Gibbs** 1997 Eos AGU Fall Mtg V11A-2.]

[protoastrakhanite = *konyaite*, MR 30 175. $Na_2Mg(SO_4)_2.5aq$. Review: **Sabelli,** no structure.
Occurrence: **B Friedel** 1976 NJMA 126 187-98.]

**protoanthophyllite** $(Mg,Fe)_7(Si_4O_{11})_2(OH)_2$. *Amphibole.*
Structure: SC-XRD, **H Konishi & 5 others** 2003 AM 88 1718-23.
Occurrence in 3 metamorphosed serpentinites: **H Konishi I Dodony PR Buseck** 2002 AM 87 1096-103.

**[protodolomite** $\sim CaMg(CO_3)_2$. *Synthesis*: MM 31 970.]

**[protoenstatite** $MgSiO_3$.
*Synthetic* high-T phase in pyroxene structure group.
Definition: MM 28 736.
Structure: ortho-proto transition structure 1353 K, **T Murakami & 2 others** 1982 ZK 160 299-312; ZK 166 263-75.
Lattice dynamics & Raman: **S Ghose & 4 others** 1994 PCM 20 469-77.]

**protoferro-anthophyllite** $(Fe_{0.8}Mn_{0.2})_2(Fe_{0.98}Mg_{0.02})_5(Si_4O_{11})_2(OH)_2$.
*Amphibole* type, proto subtype.
Occurrence & structure: **S Sueno & 3 others** 1998 PCM 25 366-77 (S1917).

**[protohydromagnesite** $MgCO_3.2aq$. *Lansfordite* mineral group of hydrous carbonates.
Structure determination not found.
Occurrence: **WM Last P De Deeckker** 1990 Sedimentology 37 967-81.]

**protoimogolite** Amorphous. MM 43 1066.]

**protojoseite / protojosëite** $\sim Bi_{5.5}Te_{1.9}S_{1.6}$.
*Tetradymite* structure group; *protojosëite* subgroup with large supercell.

Review of crystallography: **P Bayliss** 1991 AM 76 257-65.
Occurrence: MM 50 755.

**protolithionite-3T** *Mica* structure group; 3-layer trigonal polytype.
Structure: **VI Pavlishin TF Semenova IV Rozhdestvenskaya** 1981 MZh 3 47-60 = MA 81-3798.

**protomanganoferro-anthophyllite** $(Mn_{0.7}Fe_{0.3})_2(Fe_{0.82}Mg_{0.18})_5(Si_4O_{11})_2(OH)_2$.
*Amphibole* type, proto subtype.
Occurrence & structure: **S Sueno & 3 others** 1998 PCM 25 366-77 (S1917).

**proudite** $Cu_xPb_{7.5}Bi_{9.67-0.33x}(S,Se_{1-y})_{22}$; x 0.04-0.98, y 0.57-0.82.
Structure closely related to *junoite*; ribbon of edge-shaped octahedra matching *galena*.
Structure: **WG Mumme** 1976 AM 61 839-52.
Occurrence: MM 42 529.

**proustite** $Ag_3AsS_3$. Isostructural with Sb analog *pyrargyrite*.
Dimorphic with *xanthoconite*.
Structure: **P Engel W Nowacki** 1966 NJMM 181-4 (E45).
Of interest in quantum electronics because of high transmission in visible & IR.
Effect of Si impurity on optics: **VE Distanov AG Kirdyashkin** 2002 IMa 38 865-9 (8055).

**przhevalskite** $Pb(UO_2)_2(PO_4)_2.4aq$.
XRPD not indexed [jvs: check for possible relation with *meta-autunite* structure group.]
Occurrence: Russian books abstracted in AM 43 381-2.

**pseudoautunite** $?(H_3O)_4Ca_2(UO_2)_2(PO_4)_4.5aq$.
Occurrence & ED of hexagonal plates: **AG Sergeev** 1964 Mineral Geokhim Leningrad Univ Sbornik Statei 1 31-9 = AM 50 1505-6 (sceptical remarks from reviewer).

**pseudoboléite** $Pb_{31}Cu_{24}Cl_{62}(OH)_{48}$.
Structure: **G Giuseppetti F Mazzi C Tadini** 1992 NJMM 113-26 (G775) = MA 92M/3853.

**PSEUDOBROOKITE STRUCTURE GROUP** Includes

| | |
|---|---|
| *"anosovite"* | $Ti_3O_5$, synthesized, occurs in slag |
| *armalcolite* | ideal $Fe_{0.5}Mg_{0.5}Ti_2O_5$, solid sol between $MgTi_2O_5$, $FeTi_2O_5$, $FeMg_{0.5}Ti_{1.5}O_5$ & $Mg_{0.5}Ti_{2.5}O_5$, |
| *pseudobrookite* | Ideal $Fe_2TiO_5$, solid sol between $FeTi_2O_5$ & $FeMg_{0.5}Ti_{1.5}O_5$ |
| *[tieilite* | $Al_2TiO_5$. not mineral, *synthetic* industrial abrasive.] |

Definition and chemical range of natural minerals: **JFW Bowles** 1988 AM 73 1377-83.
Occurrence: Katzenbuckel Complex, Germany, **V Stähle M Koch** 2004 SMPM 83 145-58 (10842).
*Synthesis* of $Sc_2TiO_5$: **J Ito** 1971 AM 56 1105-8.
*Synthetic* CaTiO, structure: **MP Rogge & 5 others** 1998 JSSC 141 338-42 (R870).

**pseudobrookite** $(Fe^{3+},Fe^{2+})_2(Fe^{3+},Ti)O_5$. *Pseudobrookite* structure group.
Structure: **L Pauling** 1930 ZK 73 97-112;
**S Akimoto T Nagata T Katsura** 1957 N 179 37-8;
**MF Brigatti & 3 others** 1993 EJM 5 73-84.
Increased compressibility for higher disorder: **RM Hazen H Yang** 1997 S 277 1965-7 (H1218).
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
*Synthetic* $MgTi_2O_5$, SC-XRD, crystals annealed <1673K: **H Yang RM Hazen** 1998 JSSC 138 238-44 (Y234).

**pseudocotunnite** $?K_2PbCl_4$. [jvs: look for structure determination of *synthetic*.]
Occurrence: **Dana**.

**pseudograndreefite** $Pb_6SO_4F_{10}$. Similar to *grandreefite*.
Structure partly done: **AR Kampf** 1994 IMA Mtg Pisa p. 193.
Occurrence: **AR Kampf PJ Dunn EE Foord** 1989 AM 74 927-31.

**pseudojohannite** $Cu_{6.5}[(UO_2)_4(SO_4)_2](OH)_5.25aq$. *Zippeite* group.
Cf. with *johannite*.
Occurrence & XRPD structure: **J Brugger & 5 others** 2006 AM 91 929-36.

**pseudolaueite** $MnFe_2(PO_4)_2(OH)_2.8aq$. Compare with *laueite*.
Structure: **WH Baur** 1969 AM 54 1312-23.
Occurrence: MM 31 970.

**pseudomalachite** $Cu_5(PO_4)_2(OH)_4.aq$. Isostructural with As analog *cornwallite*.
Trimorphic with *ludjibaite* & *reichenbachite*.
Polymorphism: **JB Anderson & 3 others** 1977 AM 62 115-21;
**GL Shoemaker JB Anderson E Kostiner** 1981 AM 66 169-75 & 176-81.
Review: (E289).
Structure: **S Ghose** 1963 AC 16 124-8 (G20);
**GL Shoemaker JB Anderson E Kostiner** 1977 AM 62 1042-8.
IR & Raman: **W Martens RL Frost** 2003 AM 88 37-46.
**pseudorutile** $Fe_2Ti_3O_9$.
Structure: **IE Grey AF Reid** 1975 AM 60 898-906;
mineral revalidated, **IE Grey JA Watts P Bayliss** 1994 MM 58 597-600.
Hydroxylian: occurrence, Cameroon, **S Tetsopgang & 3 others** 2003 MM 67 509-16;
Murray basin, Australia, **IE Grey C Li** 2003 MM 67 733-47.
[*kleberite* is OH-pseudorutile.]
**pseudosinhalite** $Mg_2Al_3O[BO_4]_2OH$.
Structure similar to *chondrodite*: **H Strunz EH Nickel** 2000 AM 85 1828-9;
**P Daniels W Schreyer** 2001 AM 86 581-4.
*Synthesis*, phase characterization, crystal structure & PT-stability: **P Daniels & 3 others** 1997 CMP 128 261-71 (D682).
Occurrence in Siberian skarn: **W Schreyer & 4 others** 1999 CMP 133 382-8 (S2006).
**pseudotetrahedrite** Variant of *tetrahedrite*. MM 39 924.]
**pseudowollastonite** $CaSiO_3$-alpha.
Quadimorphic with *triclinic-beta-*$CaSiO_3$ (*wollastonite*), *monoclinic-beta-*$CaSiO_3$ (*parawollastonite*) & *high-P-*$CaSiO_3$.
Cement/slag mineral.
*Synthetic*, occurs as 4-, 6- & disordered-layer polytypes.
Single-crystal XRD of 4-layer polytype, enumeration of polytypes:
**T Yamanaka H Mori** 1981 AC B37 1010-7 (Y152);
*synthetic*, SC-XRD, **H Yang CT Prewitt** 1999 AM 84 929-32;
earlier studies not listed.
Structure: SC-XRD 2-layer type, compression <10 GPa, **H Yang CT Prewitt** 1999 AM 84 1902-5.
High-T XRPD & Raman: **P Richet BO Mysen J Ingrin** 1998 PCM 25 401-14 (R836).
*Synthetic* $SrGeO_3$, similar 6-layer structure: **J Dornberger-Schiff** 1962 SPD 6 694-700;
**W Hilmer** 1963 SPC 7 537-6.
**[psilomelane** Name now used for mixture of manganese oxide minerals including *romanechite*.
Occurrence as $(Ba,aq)_2Mn_5O_{10}$ in hyperagpaitic alkaline rocks: **Khomyakov** 1995.]
**pucherite** $BiVO_4$. Trimorphic with *clinobisvanite* & *dreyerite*.
Structure: **MM Qurashi WH Barnes** 1953 AM 38 489-500;
**J Granzin D Pohl** 1984 ZK 169 289-94;
**K Mereiter A Preisinger** 1986 Österreich Akad Wiss Math-nat Kl Anz 123 79-81.
**PUMPELLYITE STRUCTURE GROUP** Includes

| | |
|---|---|
| *julgoldite* | $Ca_2Fe(Fe,Al)_2(SiO_4)(Si_2O_7)(OH)_2.aq$ |
| *okhotskite* | $\sim Ca_2(Mn^{2+},Mg)(Mn^{3+},Al,Fe^{3+})_2(SiO_4)(Si_2O_7)(OH)_2.aq$ |
| *poppiite* | $Ca_2(V^{3+},Fe,Mg,Mn)(V^{3+},Al)_2(SiO_4)(Si_2O_7)(OH)_2.aq$ |
| *pumpellyite* | $Ca_2MgAl_2(SiO_4)(Si_2O_7)(OH)_2.aq$ |
| *pumpellyite-Fe* | $Ca_2FeAl_2(SiO_4)(Si_2O_7)(OH)_2.aq$ |
| *pumpellyite-Mn* | $Ca_2Mn^{2+}(Al,Mn^{3+})_2(SiO_4)(Si_2O_7)(OH)_2.aq$ |
| *shuiskite* | $Ca_2(Mg,Al,Fe)(Cr,Al)_2(SiO_4)(Si_2O_7)(OH)_2.aq$ |

Nomenclature of pumpellyites & *julgoldite*s: **E Passaglia G Gottardi** 1973 CM 12 219-23.
$^{57}Fe$ Mössbauer: **M Akasaka & 5 others** 1997 MP 61 181-98 (A814).
Fe XANES: **G Artioli & 4 others** 1991 NJMM 413-21.
*Synthetic* $Ca_4MgAl_5Si_6O_{21}(OH)_7$: **P Schiffman JG Liou** 1980 JP 21 441-74.
*Synthetic* $Mg_4(MgAl)Al_4Si_6O_{21}(OH)_7$: **W Schreyer & 3 others** 1986 N 321 510-1 (S842);
structure, **G Artioli P Fumagalli S Poli** 1999 AM 84 1906-14.

Natural *vanadoan pumpellyite-(Mg)*: **Y Pan ME Fleet** 1992 CM 30 153-62.

**pumpellyite** $Ca_2Mn(Al,Mn)_2(Si,Al)O_4(Si_2O_7)(OH)_2.aq.$ *Pumpellyite* structure group.

Structure: **G Gottardi** 1965 TMPM 10 115-9 (G101);
**E Galli A Alberti** 1969 AC B25 2276-81 (G202);
**R Allmann G Donnay** 1971 AC B27 1871-5;
**A Yoshiasa T Matsumoto** 1985 AM 70 1011-9;
XRPD & Mössbauer, **G Artioli CA Geiger** 1994 PCM 20 443-53;
Mn resonant scattering XRPD, **G Artioli & 4 others** 1996 AM 81 603-10.

Occurrence: MM 21 574;
Schneeberg Complex, Austria, metapelites, **K Krenn & 2 others** 2004 EJM 16 661-9 (10623).

In ocean crust: **H Ishizuka** 1999 MM 63 891-900.

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

**pumpellyite-Fe** $Ca_2FeAl_2(SiO_4)(Si_2O_7)(OH)_2.aq.$

Pumpellyite structure group from physical properties.

Structure: SC-XRD, **M Ohkawa & 3 others** 1999 MJ 21 151-6 (O414).

Occurrence: **PB Moore** 1971 Li 4 98.

**pumpellyite-Mn** $Ca_2Mn^{2+}(Al,Mn^{3+})_2(SiO_4)(Si_2O_7)(OH)_2.aq.$

Pumpellyite structure group.

Structure: **A Yoshiasa T Matsumoto** 1985 AM 70 1011-9.

Occurrence: MM 48 581.

**purpurite** $(Mn,Fe)PO_4$. *Triphylite* subgroup of phosphates in *olivine* structure group.

Structural series with Fe-rich analog *heterosite*.

Structure determination not found.

Occurrence: **Dana**.

**pushcharovskite** $Cu(AsO_3,OH).aq.$ Polymorph of *geminite*.

Structure: SC-XRD, **DY Pushcharovsky et al** 2000 EJM 12 95-104 (P876).

Occurrence & crystallography: **H Sarp J Sanz-Gysler** 1997 Archs Sci Geneve 50 177-86 = AM 84 196-7.

**putoranite** $Cu_{16-18}(Fe,Ni)_{18-19}S_{32}$. *Chalcopyrite* structure group.

Matches *synthetic*: **LJ Cabri** 1973 EcG 68 443-54.

Occurrence & crystallography: **AA Filimonova & 2 others** 1980 ZVMO 109 335-41.

**putzite** $Cu_{4.7}Ag_{3.3}GeS_6$. *Aryrodite* group.

Structure: SC-XRD, and occurrence, **WH Paar & 5 others** 2004 CM 42 1757-69.

**p-veatchite** $Sr_2B_{11}O_{16}(OH)_5.aq.$ Trimorphic with *veatchite* & *veatchite-A*.

Structure: **JR Clark CL Christ** 1971 AM 56 1934-54;
**O Gandymov IM Rumanova NV Belov** 1969 DES 180 152-5 = MA 71-883;
**IM Rumanova O Gandymov** 1971 SPC 16 75-81 (R515).

**pyatenkoite-Y** $Na_5(Y,Dy,Gd)TiSi_6O_{16}.6aq.$ Isostructural with *sazykinite-Y*.

*Hilairite* mineral family.

Occurrence & XRPD: **AP Khomyakov GN Nechelyustov RK Rastsvetaeva** 1996 ZVMO 4 72-9 (K889) = AM 82 622.

**pyrargyrite** $Ag_3SbS_3$. Dimorphic with *pyrostilpnite*. Isostructural with As analog *proustite*.

Structure: **P Engel W Nowacki** 1966 NJMM 181-4 (E45).

*Synthetic*: **LL Chang** 1963 AM 48 429-32.

**PYRITE STRUCTURE GROUP** Includes

| | |
|---|---|
| *aurostibite* | $AuSb_2$ |
| *bravoite* | $(Ni,Fe)S_2$ |
| *cattierite* | $CoS_2$ |
| *dzharkenite* | $FeSe_2$ |
| *erlichmanite* | $OsS_2$ |
| *fukuchilite* | $Cu_3FeS_8$ |
| *geversite* | $PtSb_2$ |
| *hauerite* | $MnS_2$ |

| | |
|---|---|
| *insizwaite* | $Pt(Bi,Sb)_2$ |
| *krutaite* | $CuSe_2$ |
| *krutovite* | $NiAs_2$ |
| *laurite* | $RuSe_2$ |
| *malanite* | $Cu(Pt,Ir)S_4$ |
| *maslovite* | PtBiTe |
| *michenerite* | $PdBi_2$ |
| *penroseite* | $NiSe_2$ |
| *pyrite* | $FeS_2$ |
| *sperrylite* | $PtAs_2$ |
| *testibiopalladinite* | PdTe(Sb,Te) |
| *trogtalite* | $CoSe_2$ |
| *vaesite* | $NiS_2$ |
| *villamaninite* | $(Ni,Cu)S_2$ monoclinic |

[$(Fe,Ru)S_2$. Occurrence: **AYu Barkov YeY Savchenko AA Zhangurov** 1995 MP 54 249-60 = AM 81 768. May be variety of *pyrite*.]

Structural chemistry of pyrite & *marcasite* type structures: **ME Fleet** 1975 ZK 142 332-46 (F459).

Unnamed $(Ir,Os)Te_2$, Western Sayan: **N Tolstykh A Krivenko L Pospelova** 1997 EJM 9 457-65 (T517).

*Synthetic* $CuS_2$: high-P *synthesis*, **RA Munso**n 1966 IC 5 1296-7(M1329);
XRD at 8 GPa, **E Hintze A Neuhaus** 1969 Nw 56 136;
phase equilibria, **LA Taylor G Kullerud** 1972 NJMM 458-63 (T452).

Electronic structures of $(Mn/Fe/Co/Ni/Cu/Zn)S_2$: **WM Temmermann & 2 others** 1993 PCM 20 249-62.

*Synthetic* $RuSe_2$: **HD Lutz & 3 others** 1990 ACC 46 2003-5 (L660).

*Synthetic* $RuTe_2$: **HD Lutz M Jung G Aäschenbach** 1987 ZaaC 554 87-91.

*Synthetic* $PdAs_2$: **RD Heyding LD Calvert** 1961 Can J Chem 39 955-7 (H1041);
**GS Saini & 3 others** 1964 Can J Chem 42 620-9 (S1529).

*Synthetic* $Ni(S,Se)_2$, Mott-Hubbard transition: **A Husmann & 5 others** 1996 S 274 1874-6.

**pyrite** $FeS_2$. Pyrite structure type. Dimorphic with *marcasite*.

Structure: **SL Finklea III L Cathey EL Amma** 1976 AC A32 529-37;
**P Bayliss** 1977 AM 62 1168-72;
**do** 1989 AM 74 1168-76.

Charge density: **ED Stevens ML DeLucia P Coppens** 1980 IC 19 813-20.

Fermi-level spin at electrolyte contact: **KK Mishra K Osseo-Asare** 1992 J Electrochem Soc 139 749-52.

Aqueous oxidation: **RT Lowson** 1982 ChR 82 461-97.

Aqueous oxidation by dissolved oxygen & Fe(III): **CO Moses & 3 others** 1987 GCA 51 1561-71.

Trace elements in *marcasite* & pyrite, East Midlands coals, XRF: **RN White & 4 others** 1989 F 68 1480-6 (422).

High-T hydrothermal precipitation of noble metals on surface: **A Starling & 4 others** 1989 N 340 298-300 (S1012).

Divalent cations on surface: **WA Kornicker JW Morse** 1991 GCA 55 2159-71.

Oxidation at circumneutral pH: **CO Moses JS Herman** 1991 GCA 55 471-82.

STM of 100 surface: **CM Eggleston MF Hochella Jr** 1992 AM 77 221-4.

XPS of pristine surface reacted with water vapor & air: **HW Nesbitt IJ Muir** 1994 GCA 58 4667-9.

XPS of water adsorption on Fe sulfide minerals: **SW Knipe & 4 others** 1995 GCA 59 1079-90.

XAS of pyrite, *marcasite*, Co/Ni/Cu-disulfides, FeAsS & CoAsS: **JFW Mosselsmans & 6 others** 1995 PCM 22 311-7.

3d transition metal L-edge XAS: **JM Charnock & 3 others** 1996 PCM 23 403-8 (C878).

Electronic structure, XAS, band structure calculation: **M Womes & 6 others** 1997 JPCS 58 345-52 (W847).

*Marcasite*-type faults, ED, HRTEM: **I Dodony M Posfai PR Buseck** 1996 AM 81 119-25 (1419).

XPS & LEED of cleaned surface: **S Chaturvedi & 4 others** 1996 AM 81 261-4.

Surface oxidation, XPS-UPS, STM, model: **CM Eggleston JJ Ehrhardt W Stumm** 1996 AM 81 1036-56.

Secondary products on pyrite & *arsenopyrite* reacted with mine water & air: **HW Nesbitt IJ Muir** 1998 MP 62 123-44.

FeS surface species on pristine fracture, XPS: **HW Nesbitt & 5 others** 2000 AM 85 850-7;
resonant XPS, **HW Nesbitt & 3 others** 2003 AM 88 1279-86.

Alteration, depth analysis, XPS, AES & RBS: **G Pratesi C Cipriani** 2000 EJM 12 397-409 (P889).

Oxidation of surfaces prepared variously, XPS: **AR Elsetinow et al** 2000 AM 85 623-6.

Lattice dynamics, polarizable-ion model: **HD Lutz J Zwinscher** 1996 PCM 23 497-502 (L803).

Microstructure & stoichiometry, TEM & XRPD: **S Fiechter & 6 others** 1997 JMR 7 1829-32.
Surface oxidation, REFLEXAFS: **KER England & 3 others** 1999 MM 63 559-66.
Reaction of Cu/Cd with powder in water, XAS & surface-structure models: **RH Parkman & 4 others** 1999 AM 84 407-19.
Au & As in Carlin-type pyrite, XANES: **G Simon & 4 others** 1999 AM 84 1071-9.
Electronic structure of clean surfaces, LEED, STM; interaction with oxygen & water: **KM Rosso U Becker MF Hochella Jr** 1999 AM 84 1535-48, 1549-61.
Valence band from XR photoelectron spectroscopy: **HW Nesbitt & 5 others** 2004 AM 89 382-9.
Unoccupied states, EELS: **LAJ Garvie PR Buseck** 2002 AM 89 485-91.
Surface defects, UHV STM & model: **do** 2000 AM 85 1428-36.
Anoxic persistence of *mackinawite* to 393 K, & oxic transformation to *greigite*/pyrite/*magnetite*/*goethite*, time-resolved XRD: **CL Cahill & 3 others** 2000 ChG 167 53-63 (C1145).
Ruthenian, Imandra Complex, nw Russia: **AY Barkov & 4 others** 1997 CM 35 887-97.
Discs in coal, evidence for bacteria: **G Southam & 3 others** 2001 G 29 47-50 (2138).
Sedimentary, Arabian Sea: **SJ Schenau & 3 others** 2002 MG 185 393-402 (7540).
Rounded in Archean siliclastic sediments, placer grains & O-deficient atmosphere: **GV England & 3 others** 2002 Se 49 1133-56 (8702).
Auriferous, crystal controls on trace elements: **A Chouinard & 2 others** 2005 CM 43 951-63.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
In antique books as framboids: **J Garcia-Guinea & 2 others** 1997 N 388 631 (G727).
Reaction with sulfur dioxide, XRPD & SEM: **MG Aylmore FJ Lincoln** 2000 JAlCo 309 61-74.
Argon dating: **PE Smith & 4 others** 2001 G 29 403-6.
Hg(II) sorption, XAS & XPS: **P Bera & 4 others** 2001 La 17 3970-9 (2952).
$PO_4$ vs oxidation: **AL Elsitinow MAA Schoonen DR Strongin** 2001 EST 35 2252-7 (2953).
Carbonate effect on dissolution: **M Descostes & 5 others** 2002 BSGF 173 265-70 (8020).
Differential adsorption molybdate/tetrathiomolybdate vs pH, XAS: **BC Bostick S Fendorf GR Helz** 2003 EST 37 285-91.
Oxidation by Fe(III), vibrational spectroscopy: **MJ Borda DR Strongin MA Schoonen** 2003 AM 88 1318-24.
High-P Raman to 55 GPa: **AL Kleppe AP Jephcoat** 2004 MM 68 433-41.
& *marcasite* coated grains, Winnipeg Formation, Canada, microbes, etc.: **J Schieber L Riciputi** 2005 JSR 75 907-20.

**HYDROTALCITE/PYROAURITE STRUCTURE GROUP** Includes

| | |
|---|---|
| *eardleyite* | ~$Ni_5Al_3(CO_3)_2(OH)_{14}.5aq$ |
| *hydrohonessite* | $Ni_6Fe_2(SO_4)_2(OH)_{16}.4aq$ |
| *hydrotalcite* | $Mg_6Al_2(CO_3)_2(OH)_{16}.8aq$ |
| *iowaite* | $Mg_6Fe_2(OH)_{16}Cl_2.4aq$ |
| *pyroaurite* | $Mg_6Fe_2(CO_3)_2(OH)_{16}.8aq$ |
| *reevesite* | $Ni_6Fe_2(CO_3)_2(OH)_{16}.8aq$ |
| *stichtite* | $Mg_6Cr_2(CO_3)_2(OH)_{16}.8aq$ |
| *takovite* | $Ni_6Al_2(CO_3)(OH)_{16}.4aq$ |

Review: **HFW Taylor** 1973 *Crystal structures of some double hydroxide minerals* MM 39 377-89.
*Synthetic* $Co_{0.68}Fe_{0.31}(OH)_2(CO_3)_{0.14}.yaq$: **HCB Hansen CB Koch** 1994 IC 33 5363-5(H912).
*Synthetic* Zn-Cr-sulfate: **M Khaldi & 3 others** 1997 JSSC 130 66-73 (K914).
[jvs: requires thorough search of all possible minerals to sort out chemistry/layer type/stacking polytypism.]

**pyroaurite** $Mg_6Fe_2(CO_3)(OH)_{16}.4aq$. *Hydrotalcite*/pyroaurite structure group.
Dimorphic with *sjögrenite*.
Structure: **L Ingram HFW Taylor** 1967 MM 36 465-79;
**R Allman** 1968 AC B24 972-7.
Cation ordering, XRD, XAS: **M Vucelic W Jones GD Moggridge** 1997 ClClM 45 803-13 (V299).
*Synthesis*: **HCB Hansen CB Koch** 1995 Appl Clay Sci 10 5-19 = MA 96M/1413.
Radioactive U & Tc incorporated by electrochemical synthesis: **Y Roh & 3 others** 2000 ClClM 48 266-71 (473).

**pyrobelonite** $PbMnVO_4OH$. *Conichalcite/descloizite* structure type.
*Descloizite* mineral group.
Structure: **DM Donaldson WH Barnes** 1955 AM 40 580-96.

**PYROCHLORE STRUCTURE GROUP** Normal & inverse subtypes. Includes:

| | |
|---|---|
| *bariomicrolite* | $BaTa_2O_7$ |
| *bariopyrochlore* | $BaNb_2O_7$ |

| | | |
|---|---|---|
| *betafite* | $Ca_2(Ti,Nb,Ta)_2O_6OH$ | |
| *bindheimite* | $Pb_2Sb_2O_6(O,OH)$ | |
| *bismutomicrolite* | $BiTa_2O_7$ | |
| *bismutopyrochlore* | $(Bi,U,Ca,Pb)_{1+x}(Nb,Ta)_2O_6(OH)$.n aq | |
| *bismutostibiconite* | $Bi(Sb,Fe)_2O_7$ | |
| *calciobetafite* | $(Ca,Ln,Th,U)_2(Nb,Ta,Ti)_2O_7$ | |
| *calcirtite* | $CaZr_3TiO_9$ | approximate structure match |
| *ceriopyrochlore* | $Ce_2Nb_2O_6OH$ | |
| *cesstibtantite* | (Cs,Sb,Ta)etc. | |
| *[djalmaite* | Ta analog of *betafite]* | |
| *ferritungstite* | $(aq_{0.59}Ca_{0.06}Na_{0.02})(W_{1.46}Fe_{0.54})(O_{4.7}OH_{1.3})(aq_{0.8}K_{0.2})$ | |
| *ingersonite* | $Ca_3MnSb_4O_{14}$ | |
| *jixianite* | $Pb(W,Fe)_2(O,OH)_7$ | |
| *kalipyrochlore* | $K_2Nb_2O_6OH$ | |
| *lewisite* | $(Ca,Mn,Na)_{1.1}Sb_{0.6}(Sb,Ti,Fe,Al)_2O_6(OH)_{0.9}$ | |
| *microlite* | $Na_2Ta_2O_6O$ | |
| *natrobistantite* | $NaBiTa_4O_{12}$ | |
| *obruchevite* | $\sim Na_6(Ca,Fe)_4Y_6(U,Th)O_{18}$ | |
| *oméite* | $(Ca,Fe,Mn,Na)_2(Sb,Ti)_2O_6(O,OH,F)$ | |
| *pandaite* | $(Ba,Sr)_{2-x}Nb_2O_{7-x}$.xaq | |
| *parabariomicrolite* | $BaTa_4O_{10}(OH)_2$.2aq | |
| *plumbobetafite* | $PbNb_2O_6OH$ | |
| *plumbomicrolite* | $PbTa_2O_6OH$ | |
| *plumbopyrochlore* | $PbNb_2O_6OH$ | |
| *pyrochlore* | $NaNbO_6OH$ | |
| *ralstonite* | $Na_xMg_xAl_{2-x}(F,OH)_6$.aq | |
| *rijkeboerite* | $\sim Ba_{0.3}Ta_2O_{5.3}$.2aq | |
| *stannomicrolite* | $Sn_2Ta_2O_7$ | |
| *stetefeldtite* | $Ag_2Sb_2(O,OH)_7$ | |
| *stibiconite* | $Sb^{3+}Sb^{5+}{}_2O_6OH$ | |
| *stibiobetafite* | $(Ca,Sb)(Ti,Nb,Ta)_2(O,OH)_7$ | |
| *strontiopyrochlore* | $(Sr,Ce,Ca)_{0.66}(Nb,Fe)_2(O,OH)_7$ | |
| *uranmicrolite* | $U_2Ta_2O_6OH$ | |
| *uranpyrochlore* | $U_2Nb_2O_6OH$ | |
| *yttrobetafite* | $Y_2TiO_6OH$ | |
| *yttromicrolite* | $(Y_{0.4}RE_{0.3}Ca_{0.3}Mn_{0.1}Mg_{0.1}U_{0.1})(Ta_{1.0}Nb_{0.7}Fe_{0.1}Sn_{0.1})O_6$ | |
| *yttropyrochlore* | $YNb_2O_6$ | |

Classification: **DD Hogarth** 1977 AM 62 403-10.
General: **H Nyman & 3 others** 1978 JSSC 26 123-31.
Pseudomorphic replacement, relevance to nuclear waste: **T Geisler & 4 others** 2005 AM 90 1683-7.
Strategic mineral, Nb enrichment during lateritic weathering, Lueshe carbonatite, Zaire: **A Woolley** 1998 Geoscientist 5-1 13-5 (W888).
Fresh & weathered, FTIR & DSC: **M Nasraoui E Bilal R Gibert** 1999 MM 63 567-78.
"Silicified", Julianehaab, Greenland, SC-XRD & TEM: **P Bonazzi &4 others** 2006 AM 91 794-801.
Extreme compositions, Oka carbonatite complex: **SE Zurevinski RH Mitchell** 2004 CM 42 1159-67.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
*The following synthetic phases are just a hint of the wealth of chemistry: requires systematic*

*search of all possible candidate minerals*.
*Synthetic* $Mn_2Sb_2O_7$: MA 91M/13368.
*Synthetic* $DTaWO_6$: MA 83M/0177.
*Synthetic* $K_{1+x}Ta_{1+x}W_{1-x}O_6.0$-1aq: **J Grins M Nygren T Wallin** 1980 MRB 15 53-61.
*Synthetic* defect pyrochlore, ND, $TaWO_{5.5}/HTaWO_6/H_2Ta_2O_6/HTaWO_6$.aq: **D Groult & 2 others** 1982 JSSC 41 277-85.
*Synthetic* $K_{0.5}Sb_{0.7}Sb_2O_{6.3}$: **Y Piffard M Dion M Tournoux** 1978 ACB 34 366-8.
*Synthetic* $Y_2Ru_2O_7$, NPD: **BJ Kennedy** 1995 ACC 51 790-2 (K727).
*Synthetic* $Pb_2TiSbO_{6.5}$, defect pyrochlore: 1989 ACC 45 3-7.
*Synthetic* $CaUTi_2O_7$: 1989 JSSC 82 146-50.
*Synthetic* (K/Rb/Cs)$GeTeO_6$: 1989 IC 28 1701-3.
*Synthetic* $Al_2(OH,F)_6.0$ or 1 aq: 1989 Eur J Solid State Inorg Chem 25 535.
*Synthetic* $Bi_4O_7$-triclinic: 1989 J Less-Common Metals 156 123.
*Synthetic* $(Bi,Pb)_2(Pt,Ru)_2O_7$: 1989 JSSC 79 34.
*Synthetic* $(K/Rb/Cs/Tl)Ti_{0.5}Te_{1.5}O_6/(Rb/Cs/Tl)Ti_{0.5}W_{1.5}O_6/Cs(Zr/Hf)_{0.5}W_{1.5}O_6$: 1989 JSSC 80 227.
*Synthetic* $Pb_2(Cr,Sb)_2O_{6.5}$ & $Pb_2TiSbO_{6.5}$: 1989 Physica B 156-7 107.
*Synthetic* $Zr_2Gd_2O_7$: 1989 Solid State Ionics 31 319 = SR 56A 273.
*Synthetic* (Na/K/Rb/Cs/Tl)$TeO_6$: 1989 Russian J Inorg Chem 34 463 = SR 56A 274.
*Synthetic* $Pb_2[TiSb]O_6$: **JA Alonso & 3 others** 1989 AC C45 3-7 (A612).
*Synthetic* (Li/Al)(Nb/Ta/Sb)$O_6$.aq: **C Michel D Groult B Raveau** 1975 J Inorg Nucl Chem 37 247-50.
*Synthetic* $Pb_2Ir_2O_{6.5}/Bi_2Ir_2O_{7-y}$, O vacancy, NPD: **BJ Kennedy** 1996 JSSC 123 14-20 (K827).
*Synthetic* $Tl_2Mn_2O_7$: **Y Shimakawa Y Kubo T Manako** 1996 N 379 53-5 (S1582);
**MA Subramanian & 5 others** 1996 S 273 81-4 (S1605).
*Synthetic* $Hg_2(Nb/Sb/Ta)_2O_7$: **AW Sleight** 1968 IC 7 1704-**?**
*Synthetic* $(Pr/Nd/Tb/Yb)_2Ru_2O_7$: **BJ Kennedy T Vogt** 1996 JSSC 126 261-70 (K880).
*Synthetic* defect PbTa-: **N Menguy F Thuries C Caranoni** 1996 JSSC 126 253-60 (M1441).
*Synthetic* $Nd_2Pt_2O_7$: **M Zabel & 3 others** 1997 ZK 212 137 (R710).
*Synthetic* $Pb_2((Ti/Sn)_{0.5}W_{0.5})O_{6.5}$: **Ismunandar BJ Kennedy BA Hunter** 1997 JSSC 130 81-9.
*Synthetic* $(Y/La/Pr/Nd/Tb\text{-}Lu/Sm/Eu)_2Sn_2O_7$: **BJ Kennedy BA Hunter CJ Howard** 1997 JSSC 130 58-65 (K915).
*Synthetic* $Tl_2Ru_2O_7$, low-T structures: **T Takeda & 5 others** 1999 JMC 9 215-22 (T606).
*Synthetic* $Li_2GeTeO_6$, $Na_2TiTeO_6$, $Na_2SnTeO_6$, $Na_2GeTeO_6$: **PM Woodward AW Sleight L Du CP Grey** 1999 JSSC 147 99-116 (W990).
*Synthetic* $Mn_2(Y/In/La/Pr/Nd/Sm\text{-}Lu)_2[MnSb_3]O_{14}$: **P Garcia Casado & 4 others** 2000 ChM 12 1217-21 (474).
*Synthetic* $Tl_2Nb_2O_{6+x}$: **S Uma & 5 others** 2000 JSSC 155 225-8 (672).
*Synthetic* $(Tl/Pb)_2Os_2O_{7-x}$: **J Redaing CS Knee MT Weller** 2002 JMC 112 2376-82 (7884).
*Synthetic* Ti-rich: **GD Blundred CA Bridges MJ Rosseinsky** 2004 AnCh 43 3562-5 (10524).

**pyrochroite** $Mn(OH)_2$. *Brucite* structure group.
Structure: NPD <9 GPa, OH bonding, **JB Parise & 5 others** 1998 PCM 25 130-7 (P780).
Occurrence: Dana.
*Synthetic* pyrochroite & *hydrohausmannite*, & conversion to mesoporous $MnO_x$: **J Luo SL Suib** 1997 ChC 1031-2 (L840).

**[pyrocoproite** $Mg(K,Na)_2P_2O_7$. Not submitted to CNMMN. AM 84 197.]

**pyrolusite** $MnO_2$. *Rutile* structure group. Dimorphic with *ramsdellite*.
Structure: **JuD Kondrasev Al Zaslavskiy** 1951 Izv Akad Nauk SSSR Fiz 15 179-86;
**WH Baur** 1976 AC B32 2200-4;
textures revealed by HRTEM, **N Yamada M Ohmasa S Horiuchi** 1986 AC B42 58-61;
*synthetic*, EPR: **MV Ananth K Dakshinamurthi** 1997 JMC 7 517-20 (A739).
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** 1995.
*Synthetic* alpha- & Li-, XRPD structure: **MF Mansuetto & 7 others** 1996 AC A52 Suppl C-412.

**pyromorphite** $Pb_5(PO_4)_3Cl$. *Apatite* structure type.
Structure: **Y Dai JM Hughes** 1989 CM 27 189-92.

*Synthetic* Br-: **H Wondratschek** 1959 ZaaC 300 41 = MM 33 1129.
*Synthetic* F-: **EL Belokoneva & 4 others** 1982 SPC 27 476-7 (B1134).
*Synthetic* OH-: **AV Barinova & 5 others** 1998 CrR 43 189-92 (B1806).
Identification in mine waste by ATEM & EXAFS: **JD Cotter-Howells & 3 others** 1994 European J Soil Sci 45 393-402.
Occurrence, SEM/EDAX-analysis/IR/Raman/XRPD: **IL Botto & 3 others** 1997 JMS 32 6549-53 (B1774).
Growth from goethite saturated with Pb(II) & hydroxyapatite or NaH-phosphate; model for soil remediation: **P Zhang JA Ryan LT Bryndzia** 1997 EST 31 2673-8 (Z146).
In roots of heavy-metal grass cultivar *Agrostis capillaris L.*, ATEM & XAS: **JD Cotter-Howells PE Champness JM Charnock** 1999 MM 63 777-89.
Dissolution kinetics, XAS, XRPD, TGA: **KG Scheckel JA Ryan** 2002 EST 36 2198-204 (7327).

**pyrope** $Mg_3Al_2Si_3O_{12}$. *Garnet* structure type.

Structure: **GV Gibbs JV Smith** 1965 AM 50 2023-39;
**EP Meagher** 1975 AM 60 218-28;
**RM Hazen LW Finger** 1978 AM 63 297-303 (H506);
ND, **G Pieper & 3 others** 1983 NJMA 147147-59 (P552);
**RM Hazen LW Finger** 1989 AM 74 352-9;
**T Armbruster CA Geiger GA Lager** 1992 AM 77 512-21;
**H Sawada** 1993 ZK 203 41-8;
30-973 K, **A Pavese G Artioli M Prencipe** 1995 AM 80 457-64;
**GA Novak GV Gibbs** 1971 AM 56 791-825;
SC-ND 30-1173 K, **G Artioli & 3 others** 1997 CM 1009-19;
hydrostatic compression & structure to 33 GPa, **L Zhang H Ahsbahs A Kutoglu** 1998 PCM 25 301-7 (Z163), **L Zhang & 3 others** 1999 PCM 27 52-8 (Z217).
Umweganregung, symmetry reduction: **E Rossmanith T Armbruster** 1995 ZK 210 645-9 (R605).
Dispersion acoustic phonons, inelastic neutron scattering: **G Artioli A Pavese O Moze** 1996 AM 81 19-25.
SC-absorption spectra: **VM Khomenko & 4 others** 1994 PCM 21 434-40.
Cr-substituted: structure, **GA Novak HO Meyer** 1970 AM 55 2124-7;
compression to 8 GPa, **K Langer MN Taran AN Platonov** 1997 PCM 24 109-14 (L842).
Ti substitution & OH defects: **VM Khomenko & 4 others** 1994 PCM 20 483-8.
Solubility of water to 10 GPa: **R Lu H Keppler** 1997 CMP 129 35-42 (L896).
Inelastic neutron scattering: **A Pavese G Artioli O Moze** 1998 EJM 10 59-69 (P767).
Transition to orthorhombic at 37 GPa: **E Ito & 4 others** 1998 GRL 25 821-4 (I230).
Polarized Raman at 273 & 5 K: **BA Koselov CA Geiger** 2000 PCM 27 645-9 (320).
*Synthetic -grossular* series, XRPD, 20-295 K: **A Bosenick CA Geiger** 1997 JGR B10 22649-57.
Computer simulation of IR & Raman: **T Chaplin GD Price NL Ross** 1998 AM 83 841-7.
*Synthetic* Co/Cr/Ni/Ti/V at 1223-1323 K & 25 kbar, SC-IR & UV/VIS, incorporation of OH: **CA Geiger A Stahl GR Rossman** 2000 EJM 12 259-71 (475).
*Synthetic* Ti(III)-, SC-EPR: **H Rager CA Geiger A Stahl** 2003 EJM 15 697-9 (9309).
Elasticity to 20 GPa: **SV Sinogeikin JD Bass** 2000 PEPI 120 43-62 (S2187).
Phase boundary vs *perovskite* + *corundum*: **K Hirose & 4 others** 2001 EPSL 184 567-73 (1153).
Fe(II) oxidation/decomposition, Mössbaur/XRD/AFM/TG/DTA: **R Zboril & 5 others** 2003 PCM 30 620-7.
Deuteration, kinetics: **M Blanchard J Ingrin** 2004 EJM 16 567-76 (10622).
H diffusion, 1073-1323, variable redox, Dora Maira: **M Blanchard J Ingrin** 2004 PCM 31 593-605 (10899).
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**pyrophanite** $MnTiO_3$. Ordered superstructure of *corundum* structure type.

Isostructural with *ecandrewsite* $ZnTiO_3$, *geikielite* $MgTiO_3$, *ilmenite* $FeTiO_3$ & *melanostibite* $Mn(Sb,Fe)O_3$.
Structure: **K Kidoh & 3 others** 1984 AC B40 329-32.
High-P transition to $LiNbO_3$ type: **J Ko CT Prewitt** 1988 PCM 15 355-62 (K885).
Alteration to Mn-pseudorutile, Brazil: **AR Cabral C Sattler** 2004 NJMM 97-103 (10212).
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**pyrophyllite** $Al_2Si_4O_{10}(OH)_2$. Isostructural with *ferripyrophyllite* $Fe^{3+}{}_2Si_4O_{10}(OH)_2$.

Structure: **GW Brindley R Wardle** 1970 AM 55 1259-72;
**R Wardle GW Brindley** 1972 AM 57 732-50;
**JH Lee S Guggenheim** 1981 AM 66 350-7;
superstructure, **A Wiewiora T Hida** 1996 Clay Science 10 15-35 = MA 97M/3534

density-functional theory of dehydroxylation, **S Stackhouse & 2 others** 2004 JPCB 108 9685-94 (10476).
Molecular dynamics modeling: **BJ Teppen & 4 others** 1997 JPCB 101 1579-87 (T504);
dehydration, **CI Sainz-Diaz & 3 others** 2004 AM 89 1092-100..
Computational model, -1Tc: **K Refson S Park G Sposito** 2003 JPCB 107 13376-83 (9604.
Hydrothermal *synthesis*: **JT Kloprogge & 2 others** 1996 NJMM 135-44 (K831).
Equation of state: **AR Pawley SM Clark NJ Chinnery** 2002 AM 87 1172-82.
XRPD: **A Bentayeb & 4 others** 2000 PD 15 51-4 (477).
*[lunijianlaite*, regular alternation of *cookeite*/pyrophyllite: **Y Kong X Peng D Tian** 1990 Acta Mineral Sinica 10 289-98.]
Zn surface precipitates, XAFS: **RG Ford DL Sparks** 2000 EST 34 2479-83 (476).
Ni sorption, thermodynamics vs T: **KG Scheckel DL Sparks** 2001 SSSAJ 65 719-28 (2097).
$CO_2$ incorporation during dehydroxylation, IR: **L Wang M Zhang SAT Redfern** 2003 ClCIM 51 439-44 (9269).
*[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*.]

**pyrosmalite** $(Fe,Mn)_8Si_6O_{15}(OH,Cl)_{10}$.
General name for *ferropyrosmalite-manganopyrosmalite* series.
*Friedelite* structure group; trigonal subtype.
Structure: **AA Kashaev** 1968 SPC 12 934-4 (K638);
**Y Takéuchi I Kawada S Irimaziri R Sadanaga** 1969 MJJ 5 450-67 (T142);
**AA Kashaev VA Drits** 1970 SPC 15 40-3 (K635);
manganpyrosmalite, **T Kato Y Takéuchi** 1983 CM 21 1-6;
polytypism, **Y Takéuchi T Ozawa T Takahata** 1983 CM 21 19-27.
Occurrence & nomenclature: **JP Vaughan** 1986 MM 50 527-31 & 51 174.
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** 1995.
**[**brokenhillite $(Mn,Fe)_{32}[Si_{21}O_{60}](OH)_{29}Cl_{11}$. Supposed member of *pyrosmalite* group.
Occurrence: MM 54 661. Not approved by IMA.]

**pyrostilpnite** $Ag_3SbS_3$. Dimorphic with *pyrargyrite*.
Structure: **A Kutoglu** 1968 NJMM 145-60.
*Synthetic*: **LL Chang** 1963 AM 48 429-32.

**PYROXENE STRUCTURE FAMILY** Includes 3 sub-families of monoclinic, orthorhombic and proto- pyroxenes. All have 2-repeat vertex-connected tetrahedral chain $TO_3$ & two non-tetrahedral sites: M(1), near-octahedral & M(2) distorted. The standard formula is $M(1)M(2)T_2O_6$.
Extensive solid solution in natural pyroxenes forces arbitrary composition ranges for specific mineral names, particularly for petrologists. Some names are for theoretical endmembers.
Minerals include:

| | | |
|---|---|---|
| *aegirine* | $NaFeSi_2O_6$ | |
| *augite* | $(Ca,Na)(Mg,Fe,Al)Si_2O_6$ | |
| *clinoenstatite* | $MgMgSi_2O_6$ | |
| *clinoferrosilite* | $(Mg,Fe)(Mg,Fe)Si_2O_6$ | |
| *diopside* | $CaMgSi_2O_6$ | |
| *donpeacorite* | $(Mn,Mg)MgSi_2O_6$ | |
| *[clino & ortho]enstatite* | $MgMgSi_2O_6$ | |
| *essenite* | $CaFeAlSiO_6$ | |
| *[clino & ortho]ferrosilite* | $FeFeSi_2O_6$ | |
| *[halagurite* | $FeMnSi_2O_6$ | not yet approved] |
| *hedenbergite* | $CaFeSi_2O_6$ | |
| *hypersthene* | $(Mg,Fe)(Mg,Fe)Si_2O_6$ | |
| *jadeite* | $Na(Al,Fe)Si_2O_6$ | |
| *jervisite* | $(Na,Ca,Fe)(Sc,Mg,Fe)Si_2O_6$ | |
| *johannsenite* | $Ca(Mn,Fe)Si_2O_6$ | |
| *kanoite* | $(Mn,Mg)(Mn,Mg)Si_2O_6$ | |
| *kosmoclor* | $NaCrSi_2O_6$ | |
| *namansilite* | $NaMnSi_2O_6$ | |

| | |
|---|---|
| *natalyite* | $Na(V,Cr)Si_2O_6$ |
| *nchwaningite* | |
| *omphacite* | $(Ca,Na)(Mg,etc.)Si_2O_6$ |
| *petedunnite* | $CaZnSi_2O_6$ |
| *pigeonite* | $(Mg,Fe,Ca)(Mg,Fe)Si_2O_6$ |
| *spodumene* | $LiAlSi_2O_6$ |

Review: **JJ Papike & 3 others** 1973 ZK 138 254-73 (P655);
**M Cameron JJ Papike** 1981 AM 66 1-50.
Residual electron density at M2 site: **G Rossi & 4 others** 1987 PCM 146 514-20.
Topology: analysis of electron density, **RT Downs** 2003 AM 88 556-66;
Ideal, **RM Thompson RT Downs 2003** AM 88 653-66.
XANES: Ti, natural diopsides, **S Quartieri & 3 others** 1993 EJM 5 1101-9;
Ca, omphacites, **E Paris & 3 others** 1995 EJM 7 1065-70 (479);
Na in Ca-Na, **A Mottana & 4 others** 1997 PCM 24 500-9 (480);
Mg & Al, **A Mottana & 6 others** 1999 PCM 27 20-33 (481).
Raman of Mg-Fe-Ca-: **E Huang & 4 others** 2000 AM 85 473-9.
Alternative interpretation of supposed $P2_1ca$ orthopyroxene: **S Sasaki CT Prewitt GE Harlow** 1984 AM 69 1082-9.
Structure model, Pbca: **MC Domenghetti GM Molin V Tazzoli** 1995 AM 80 253-67.
Tetrahedral kink angle vs site occupancy in volcanic C2/c: **L Secco & 2 others** 1995 MP 54 213-24 (S1583).
Optical properties of C2/c: **RN Abbott Jr** 1996 CM 34 595-603.
High-T crystal chemistry of C2/c $CaMgSi_2O_6$-$CaAl_2SiO_6$: **M Tribaudino** 1996 EJM 8 273-9.
Thermal expansion of $(Mg/Fe)SiO_3$ ortho/clino: **D Hugh-Jones** 1997 AM 82 689-96.
Energy-filtered TEM of intergrown: **KT Moore DC Elbert DR Veblen** 2001 AM 86 814-25.
Natalyite-kosmochlor-diopsides, Sludyanka, Russia, SC-XRD structure: **L Secco & 4 others** 2002 AM 87 709-14.
Coexisting ortho- & clino- in ureilite, TEM: **M Tribaudino & 3 others** 1997 MPS 32 671-8.
Zagami shergottite, XRF & EMP: **AH Treiman SR Sutton** 1992 GCA 56 4059-74 (1755).
Planetary, characterization by Raman: **A Wang & 4 others** 2001 AM 86 790-806.
Water content, spinel-peridotitic, FTIR: **AH Peslier JF Luhr J Post** 2002 EPSL 201 69-86 (7528).
SC-XRD leverage analysis, orthopyroxene & pigeonite: **M Merli & 3 others** 2002 EJM 14 763-72.
Natural sodic pyroxenes (17) from metamorphic rocks: **G Rossi & 2 others** 1981 Proc XI IMA Mtg 20-45.
Clinopyroxene structure vs O fugacity of host basalt-pantellerite: **C Carbonin & 3 others** 1991 CMP 108 34-42.
Clinopyroxenes from mantle eclogites: **R Oberti FA Caporuscio** 1991 AM 76 1141-52.
Chromian omphacite/diopside, Cr vs immiscibility: **T Tsujimori JG Liou** 2004 AM 89 7-14.
Clinopyroxene from lunar basalt 74275: **S Manoli GM Molin** 1988 MP 39 187-200.
Chondritic meteorites: sigmoidal exsolution by internal shear stress, **C Ferraris & 2 others** 2003 PCM 30 503-10.
High Ca- vs igneous differentiation in asteroids/meteorites: **JM Sunshine & 5 others** 2004 MPS 39 1343-58.

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*Synthetic* ortho & clino $CoGeO_3$: **A Tauber JA Kohn** 1963 AMM 50 13-21.
*Synthetic* $NaScSi_2O_6$: **FC Hawthorne HD Grundy** 1973 AC B29 2615-6;
**H Ohashi T Osawa A Sato** 1994 AC C50 838-40.
*Synthetic* $NaInSi_2O_6$: **FC Hawthorne HD Grundy** 1974 AC B30 1882-4.
*Synthetic* $CaAlAlSi_2O_6$, 1.8 GPa 1573K: **FP Okamura S Ghose H Ohashi** 1974 AM 59 549-57.
*Synthetic* hedenbergite-clinoferrosilite, 2 GPa 1220K: **Y Ohashi CW Burnham LW Finger** 1975 AM 60 432-4 (O121).
*Synthetic* $CaScAlSiO_6$: **H Ohashi N Ii** 1978 JJAMPEG 73 267-73 = MA 82M/1134.
*Synthetic* $CaSc_{0.84}Ti_{0.27}Al_{1.16}Si_{0.73}O_6$: **H Ohashi T Fujita N Ii** 1979 JJAMPEG 280-6 = MA 83M/1196.
*Synthetic* $MnSiO_3$, 10 GPa 1473K: **M Tokonami & 4 others** 1979 MJ 9 424-6.
*Synthetic* $NaLiV_2O_6$: **RS Bubnova & 3 others** 1980 SPD 25 734-6.
*Synthetic* Ca-rich clinopyroxenes: **E Bruno S Carbonin G Molin** 1982 TMPM 29 223-40.
*Synthetic* $Na_xLi_{2-x}V_2O_6$: **VS Grunin ZN Zonn** 1982 SPC 27 654-6.
*Synthetic* $NaTiSi_2O_6$, 5 GPa 1773K: **H Ohashi T Fujita T Osawa** 1982 JJAMPEG 77 305-9 = MA 85M/1342.
*Synthetic* $MgSiO_3$, $MgCoO_3$, $FeSiO_3$: **S Sasaki & 3 others** 1982 ZK 158 279-7.
*Synthetic* $NaGaSi_2O_6$, 6 GPA 1773K: **H Ohashi T Fujita T Osawa** 1983 JJAMPEG 78 159-63 = MA 86M/1411.
*Synthetic* ortho- & clino- $MgGeO_3$: **M Ozima** 1983 AC C39 1169-72.

*Synthetic* clinopyroxenes with superstructure: Mg,Sc,Li,Si-, **Y Takéuchi Y Kudoh J Ito** 1984 AC B40 115-25;
Mg,Sc,Mg,Si-, **Y Takéuchi H Mori Y Kudoh** 1984 AC B40 126-32.
*Synthetic* $CaCuGeO_3$: **M Behruzi K-H Breuer W Eysel** 1986 ZK 176 205-17.
*Synthetic* $CaFeAlSiO_6$, 2 GPa 1528K: **S Ghose FP Okamura H Ohashi** 1986 CMP 92 530-5.
*Synthetic* Ca/$SrMgSi_2O_6$: **P Benna G Ghiari E Bruno** 1987 MP 36 71-84.
*Synthetic* $CaCoSi_2O_6$ & $CaNiSi_2O_6$: **S Ghose C Wan FP Okamura** 1987 AM 72 375-81.
*Synthetic* $NaMnSi_2O_6$, 6 GPa 1743K: **H Ohashi T Osawa K Tsukimura** 1987 AC C43 605-7.
*Synthetic* high-P $Na(Mg_{0.5}Si_{0.5})Si_2O_6$, 1900K 15 GPa: **RJ Angel & 5 others** 1988 N 335 156-8.
*Synthetic* $CaMg_{0.5}AlSi_{1.5}O_6$, 1.4 GPa 1373K: **P Benno M Tribaudino E Bruno** 1988 MP 38 189-200.
*Synthetic* $Mg_{1.42}Cr_{0.61}Si_{1.96}O_6$ clinoenstatite: **RJ Angel T Gasparik LW Finger** 1989 AM 74 599-603.
*Synthetic* $Na(In,Sc)Si_2O_6$, 6 GPa & 1770K: **H Ohashi T Osawa A Sato** 1990 AC B46 742-7.
*Synthetic* $(Co/Ni/Zn)SiO_3$: 1990 AC B46 493-7 = SR 57A 305.
*Synthetic* $NaVSi_2O_6$: **H Ohashi T Osawa A Sato** 1994 AC C50 1652-5.
*Synthetic* $LiGaSi_2O_6$: **A Sato T Osawa H Ohashi** 1995 AC C51 1959-60;
*Synthetic* $Ca(Co/Ni)Si_2O_6$, structure & magnetics: **G Durand & 5 others** 1996 JSSC 124 374-80.
*Synthetic* $Li_2(Mg,Cu)Cu_2[Si_2O_6]_2$, related to pyroxene by "oblique I-beam": **H Horiuchi & 3 others** 1997 AM 82 143-8.
*Synthetic* high-P K-rich: **GE Harlow** 1997 AM 82 259-69.

*Synthetic* $Mg(Cu_{0.6}Mg_{0.4})Si_2O_6$: **T Tachi H Horiuchi H Nagasawa** 1997 PCM 24 463-76.

*Synthetic* $LiVSi_2O_6$, XRD, structure: **C Satto P Millet J Gajy** 1997 AC C53 1727-8 (S1864).
*Synthetic* Mg,Co, polarized optical absorption, **MN Taran GR Rossman** 2001 AM 86 889-95.
*Synthetic* $NaTiSi_2O_6$, SC-XRD structure, 100-298 K: **GJ Redhammer & 2 others** 2003 ACB 59 730-46 (9880).
*Synthetic* $CaMgiSi_2O_6$ –$CaAl_{0.5}Si_2O_6$: **NV Surkov YuG Gartvich YuV Babich** 2004 DES 398 1038-42 (10826).

**PYROXENOID MINERAL/STRUCTURE GROUP OF CHAIN SILICATES EXCLUSIVE OF PYROXENE**

| | Includes |
|---|---|
| *babingtonite* | $Ca_2Fe^{2+}Fe^{3+}Si_5O_{14}(OH)$ |
| *bustamite* | $(Ca,Mn)_2Si_2O_6$. |
| *[cyclowollastonite]* | |
| *ferrobustamite* | $Ca(Fe,Ca,Mn)Si_2O_6$ |
| *manganbabingtonite* | $Ca_2(Mn,Fe)FeSi_5O_{14}(OH)$ |
| *marsturite* | $NaCaMn_3Si_5O_{14}OH$ |
| *nambulite* | $LiNaMn_8Si_{10}O_{28}(OH)$ |
| *natronambulite* | $(Na,Li)(Mn,Ca)_4Si_5O_{14}OH$ |
| *pectolite* | $NaCa_2Si_3O_8OH$ |
| *pectolite-M2abc* | $NaCa_2Si_3O_8OH$ |
| *pyroxferroite* | $(Fe,Mn,Ca)SiO_3$ |
| *pyroxmangite* | $(Mn,Fe)SiO_3$ |
| *rhodonite* | $MnSiO_3$ |
| *santaclaraite* | $CaMn_4Si_5O_{14}(OH)_2$.aq |
| *serandite* | $NaMn_2Si_3O_8OH$ |
| *vistepite* | $Mn_4SnB_2Si_4O_{16}(OH)_2$ |
| *wollastonite* | $CaSiO_3$-*triclinic-beta*. Quadrimorphic with *monoclinic-beta-*$CaSiO_3$ (*parawollastonite*), *alpha-*$CaSiO_3$ (*pseudowollastonite*) & high-P $CaSiO_3$; further complications involve polytypes. |

**pyroxferroite** $(Fe,Mn,Ca)SiO_3$. Isostructural series with Mn analog *pyroxmangite*.
First new mineral found on Moon.
Structure: **CW Burnham** 1971 Proc 2nd Lunar Sci Conf 1 47-57 = MA 72-2754.
Occurrence: MM 38 997.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**pyroxmangite** $(Mn,Fe)SiO_3$. Isostructural series with Fe analog *pyroxferroite*.
Structure: **F Liebau** 1959 AC 12 177-81 (L155);
**H Narita K Koto N Morimoto** 1977 MJJ 8 329-42 (N188);
**LR Pinckney CW Burnham** 1988 AM 73 798-808 (P666);
high-T, **LR Pinckney CR Burnham** 1988 AM 73 809-17 (P665).
*Synthetic* CdGeSi, Si NMR: **M Czank MD Welch S Liu** 2000 PCM 27 713-8 (947).

**pyrrhotite** $Fe_{1-x}S$.
Defect *niccolite* structure: several subtypes with different superstructures related in part to x.
*Troilite* is endmember with x 0.
Structure: **F Bertaut** 1953 CRASP 234 1295-7;
**ME Fleet** 1971 AC B27 1864-7 (F156);
summary, **N Morimoto & 3 others** 1971 MA 73-1329;
monoclinic $Fe_7S_8$, **M Tokonami K Nishiguchi N Morimoto** 1972 AM 57 1066-80;
**K Koto N Morimoto A Gyobu** 1975 AC B31 2759-64 (K310);
4C-5C, **N Morimoto & 3 others** 1975 AM 60 240-8 (M511);
4C, **H Nakazawa N Morimoto E Watanabe** 1975 AM 60 359-66;
nA(2A,3C), **CA Francis JR Craig** 1976 AM 61 21-5;
3C, **A Nakano M Tokonami N Morimoto** 1979 AC B35 722-4 (N219);
superstructure II, $Fe_9S_{10}$-$Fe_{11}S_{12}$, **K Koto M Kitamura** 1981 AC A37 301-8;
2A & 3C $Fe_{11}S_{12}$, **RA Zvinchuk GS Shipova MA Nemoitin** 1983 MZh 5 77-81;
3C $Fe_7S_8$, **F Keller-Besrest G Collin R Comes** 1983 AC B39 296-303;
incommensurate $Fe_9S_{10}$-$Fe_{11}S_{12}$, **K Koto M Kitamura** 1984 AC A37 301-9;
**M Posfai I Dodony** 1990 EJM 2 525-8 & 529-35;
**O Kruse** 1990 AM 75 755-63;
high-T XRD of ordering, incommensurate structure, & thermomagnetics of natural & *synthetics*, **F Li HF Franzen** 1996 JSSC 126 108-20 (L775);
XPS, weak Fe-Fe pi bond, **HW Nesbitt & 3 others** 2002 PCM 29 72-7 (7288);
ND, 873-373 K, **C Tenailleau & 5 others** 2005 MM 69 205-16.
Point defects vs fugacity: **E Froese** 2003 CM 41 1061-7.
Mössbauer of vacancies, Tanzania specimen: **JWA Kondoro** 1999 JAICo 289 36-41 (K1172)
Intergrowth hexagonal & monoclinic: **L Gu FM Vokes** 1996 MM 60 303-16;
TEM $Fe_7S_8$, **F Li HF Franzen MJ Kramer** 1996 JSSC 124 264-71.
Ti-rich, Kola Peninsula, nw Russia: **AY Barkov & 4 others** 1997 CM 35 875-85.
Reaction with sulfur dioxide, XRPD & SEM: **MG Aylmore FJ Lincoln** 2000 JAICo 309 61-74.
Surface species from XPS, *millerite*?: **HW Nesbitt AG & 4others** 2001 AM 86 318-26.
Surface composition of *synthetic* associated with *greenockite*: **VL Tauson NV Smagunov** 2004 GI 42 377-82 (10265).
Oxidation/alteration at pH 9.3: XPS & chemistry, **DL Legrand & 2 others** AM 90 1042-54;
effects of xanthrates & dissolved oxygen, **do** 1055-61.
German Continental Deep Drilling, varieties, TEM: **M Posfai TG Sharp A Kontny** 2000 AM 85 1406-15;
magnetism, **A Kontny & 3 others** 2000 AM 85 1416-27.
In meteorites: **AE Rubin** 1997 MPS 32 231-47;
Dynamic pyrometamorphism during atmospheric entry, **FJM Rietmeijer** 2004 MPS 39 1869-88.
In interplanetary dust particles with cubic sulfide: **ZR Dai JP Bradley** 2001 GCA 65 3601-12 (3581).
Remanent magnetization of SNC meteorites & Mars: EPSL 190 1-12 (2316).
*Kansite* $Fe_7S_8$ is listed as mineral: occurrence on iron pipes, **FH Meyer** 1957 = MM 33 1140.
*Synthetic* 3C-$Fe_7Se_8$: **JB Parise & 3 others** 1979 AC B35 1210-2.
*Synthetic* delta FeSe: **O Amcoff T Ericsson A Gimelseed** 1994 ZK 209 197-205.
*Synthetic* S/Se, superstructure: **T Ericsson Ö Amcoff P Nordblad** 1997 EJM 9 1131-46 (E430).

**qandilite** $Mg_2TiO_4$. Inverse-*spinel* structure type. MM 50 755-6.
*Synthetic* $Mg_2TiO_4$: structure, NPD, **B Wechsler RB Von Dreele** 1989 AC B45 542-9 (W698);
$^{17}O$ NMR & XRPD, **RL Millard RC Peterson BK Hunter** 1995 AM 80 885-96;
electron density, **H Sawada** 1996 MRB 31 355-60 (S1573);
NPD to 1689 K, **HSC O'Neill & 3 others** 2003 AM 88 860-5.

Phase transition 933 K, high-T cubic to low-T tetragonal: **BA Wechsler A Navrotsky** 1984 JSSC 165-80.

**qilianshanite** $NaHCO_3.H_3BO_3.2aq$.

Occurrence: **S Luo J Lu JL Wang J Zhu** 1993 Acta Min Sinica 13 97 = MM 60 681.

**qingheiite** $Na_2NaMn_2Mg_2(Al,Fe)_2(PO_4)_6$. Isostructural with *ferrowyllieite* & *wyllieite*.

Structure: **M Zhesheng S Nicheng P Zhizhong** 1983 Sci Sinica B 25 876-84 = AM 69 567-8.

Occurrence: MM 50 756.

**qitianlingite** $(Fe_{1.3}Mn_{0.6}Nb_{0.1})(Nb_{1.5}Ta_{0.4}Ti_{0.1})(W_{0.9}Nb_{0.1})O_{10}$.

Family of complex oxides related to alpha-$PbO_2$ (*scrutinyite*).

Occurrence: **G Yang S Wang Z Peng J Bu** 1985 Acta Mineral Sinica 5 193-8 = AM 73-1497.

Structure: **Z Peng Z Ma W Su G Yang** 1987 1987 Sci Sinica 759-**?** (see Y158).

**quadratite** $Ag(Cd,Pb)(As,Sb)S_3$.

Occurrence & XRD: **S Graeser W Lustenhouwer P Berlepsch** 1998 SMPM 78 489-94 (G1139).

**qadridavyne** *Cancrinite* structure type.

Occurrence & crystallography: **E Bonaccorsi & 4 others** 1994 EJM 6 481-7.

**quadruphite** $Na_7CaTi_4[Si_2O_7][PO_4]_2O_2F$. *Lomonosovite* mineral group.

Close relation with *nacaphite*.

Structure: SC-XRD, **E Sokolova FC Hawthorne** 2001 CM 39 1275-94.

Occurrence & crystallography: **AP Khomyakov & 3 others** 1992 ZVMO 121 105-12 (K660) = AM 78 1316.

**quartz-low (alpha)** $SiO_2$.

*Quartz* structure type: high-low transition near 846 K; many stuffed derivatives.

*Berlinite* $AlPO_4$ & *alarsite* $AlAsO_4$ have ordered superstructure.

Polymorphs include *coesite*, *cristobalite*, *moganite*, *stishovite* & *tridymite* plus dozens of *synthetic* materials called zeolitic by chemists.

Survey of quartz & quartz-like materials: **E Phillipot & 3 others** 1996 JSSC 123 1-13 (P609).

Seismic detection of high-low in Tibetan crust: **J Mechie & 9 others** 2004 G 32 601-4 (10431).

Structure: early papers not listed; **RA Young B Post** 1962 AC 15 337-46 (Y82);
**WH Zachariasen HA Plettinger** 1965 AC 18 710-6 (Z45);
**Y Le Page G Donnay** 1976 AC B32 2456-9;
compression, Si/$GeO_2$ to 2.5 GPa, ND, **JD Jorgensen** 1978 JAP 49 5473-8 (J155);
charge-density refinement, *berlinite*, **N Thong D Schwarzenbach** 1979 AC A35 658-64;
high-P, **H D'Amour W Denner H Schulz** 1979 AC B35 550-5;
**L Levien CT Prewitt DJ Weidner** 1980 AM 65 920-30;
**Y Le Page LD Calvert EJ Gabe** 1980 JPCS 11 721-5;
ND at 298K, **AF Wright MS Lehmann** 1981 JSSC 36 371-80 (W539);
high-P of quartz, oxynitride & nitrides, **L Cartz JD Jorgensen** 1981 JAP 52 236-44;
low-T, 13-296 K, **GA Lager JD Jorgensen FJ Rotella** 1982 JAP 53 6751-6 (L410);
high-P to 2.3 Mbar & 538 K, **K Ogata Y Takéuchi Y Kudoh** 1987 ZK 179 403-13;
**K Kihara** 1990 EJM 2 63-77 (K519);
high-P, also $GeO_2$, **J Glinnemann & 5 others** 1992 ZK 198 177-212;
transition to 1120K & 1100 MPa, **AH Shen WA Bassett I-M Chou** 1993 AM 78 694-8;
OH orientation from polarized IR, **K Shinoda N Aikawa** 1993 PCM 20 308-14;
high-P to 213 GPa, **KJ Kingma H Mao RJ Hemley** 1996 High Press Res 14 363-74 (K853);
high T, cell dimensions, **E Bourova P Richet** 1998 GRL 25 2333-6 (B1835);
IR of OH at high T, **S Suzuki S Nakashima** 1999 PCM 26 217-25 (S2032);
do, **K Grant SA Gleeson S Roberts** 2003 AM 88 262-70;
electron density, first principles, **GV Gibbs & 5 others** 1999 J Mol Str 485-6 13-25 (G1184);
EELS & TEM, **Garvie & 5 others** 2000 AM 85 732-8;
elasticity 20 GPa, Brillouin spectr, **E Gregoryanz & 3 others** 2000 PRL 84 3117-20 (G1193);
molecular dynamics, **K Kihara** 2001 PCM 28 365-76 (2956);
EPR & triple state of O vacancy, **J Laegsgaard** 2002 PRB 66 024107 (8066);
EPR vs origin, **M Duttine & 3 others** 2002 CRG 334 946-55 (8520);
IR of recrystallized: **N Nimi N Aikawa K Shinoda** 1999 MM 63 693-701;
EPR of H-double Li center, **NS Lees & 4 others** 2003 PCM 30 131-41 (9131);
modulated, lattice dynamics, **SV Dimitriev & 5 others** 2003 PRB 68 052101 (9393);

P/T vs symmetry & chirality, **D Yogev-Einot D Avnir** 2004 ACB 60 163-73 (10224);
morphology of Japan twins, **I Sunagawa & 3 others** 2004 EJM 16 91-7 (10138);
double transition, intermediate phase for 1.5 K, to 0.6 GPa, **U Raz & 2 others** 2003 SMPM 83 175-82 (10843);
mid-infra red 2nd-order susceptibility, **DK Hore & 2 others** 2004 JCP 121 12589-95 (10974).
Thermal expansion <973 K 0.35 GPa, dilatometry: **U Raz S Girsperger AB Thompson** 2002 SMPM 82 561-74 (8720).
Amorphization: **RM Hazen RJ Hemley HK Mao** 1989 Solid State Comm 72 507-11;
**P Cordier JC Donkham J Peyronneau** 1993 PCM 20 176-89;
**F Langenhorst** 1994 EPSL 128 683-98.
Chemical substitutions: **JV Smith IM Steele** 1984 NJMM 137-44.
H, ion probe: **IM Steele** 1986 NJMM 193-202 (211).
Al/H zoning in hydothermal, EMP/FTIR: **N Miyoshi & 2 others** 2005 AM 90 310-5.
Surface reconstruction, (0001), LEED: **F Bart M Gautier** 1994 SuS 311 L671-6.
Agate texture: **PJ Heaney AM Davis** 1995 S 269 1562-5 (1758).
Lamellae *moganite*/quartz in chalcedony/quartzine agates, TEM: **C Wahl G Miehe H Fuess** 2002 CMP 143 360-5 (7468).
Agate, XRD demonstrating crystallization with rock age: **T Moxon** 2002 EJM 14 1109-18 (8679).
Natural/*synthetic* amethyst: IR & identification, **VS Balitsky & 3 others** 2004 DES 394 120-3 (10012).
Generation of H ions & gas in –water crushing: **K Saruwatari J Kaneda H Tanaka** 2004 PCM 31 176-82.
In mudstone, diagenesis & silica cycling, electron back-scatter & cathodoluminescence images:
**J Schieber D Krinsley L Riciputi** 2000 N 406 981-5 (S2193).
Cathodoluminescence: Keuper sandstones, Paris basin, **C Demars & 3 others** 1996 AM 81 891-901;
& trace-element zoning of phenocrysts/xenocrysts, **GR Watt P Wright S C McLean** 1997 GCA 61 4337-48;
vs crystallographic orientation & rock provenance, **O Walderhaug J Rykkje** 2000 JSR A70 545-8 (W1016);
in ancient mud rocks, **A Kemp** 2000 N 406 951-3 (194).
shocked quartz, MPS 36 783-92;
review, **J Götze M Plötze D Habermann** 2001 MP 71 225-50 (2139);
volcanic, plutonic, metamorphic & hydrothermal, **S Boggs Jr & 5 others** 2002 JSR 72 408-15 (7203);
from topaz granites, Czech Republic, CL & trace elements, **A Müller & 3 others** 2003 MP 79 167-92.
pegmatitic, structure & luminescence, EPR, **J Götze M Plötze T Trautmann** 2005 AM 90 13-2;
SEM/cathodoluminescence, hydrothermal vein, **MR Landtwing T Pettke** 2005 AM 90 122-31.
Cathodoluminescence/EMP/SIMS/ACP-MS & trace elements: **A Müller & 4 others** 2003 EJM 15 747-63 (9308);
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).
Heterogeneous fluid inclusions in zoned quartz, Industrialnoe tin deposit: **VS Kamenetsky & 5 others** 2002 G 30 459-62 (7169).
Adsorption: Co(II) complexes, XAS: **PA O'Day et al** 1996 GCA 60 2515-32 (O338);
EXAFS, formation of trioctahedral "clay": **A Manceau & 3 others** 2000 JCIS 220 181-97 (M1786);
Hg(II) quartz/*gibbsite*, experiment/model: **D Sarkar ME Essington KC Misra** 1999 SSSAJ 63 1626-36 (S2141);
Fe(III), grazing-incidence EXAFS, *hematite* nuclei: **G Waychunas & 2 others** 1999 J Synchr Radiation 6 615-7;
long-chain alkylamines: **IV Chernyshova KH Rao A Vidyadhar** 2000 La 16 8071-84 (81).
Length-fast chalcedony & types A & B quartz from mid-Atlantic Ridge, IR & EPMA: **L Hopkinson & 3 others** 1999 CMP 137 342-50 (H1454).
Raman 296-1073 K 0.1 MPa to 2.1 GPa, P sensor for diamond-anvil cell: **C Schmidt MA Ziemann** 2000 AM 85 1725-34.
Heat transfer up to 1073 K: **M Hofer FR Schilling** 2002 PCM 29 571-84 (8449)
Cement in oil field sandstones, review of ideas on origin & development: **RH Worden S Morad** 2000 Spec Publ Int Assoc Sediment 29 1-20 (W1017).
"Toasted" quartz at impact sites: **J Whitehead JG Spray RAF Grieve** 2002 G 30 431-4 (7168).
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
With *cristobalite/tridymite/glass* in enstatite chondrites: **M Kimura & 5 others** 2005 MPS 40 855-68.
Silica cathodoluminescence as shock index in shergottites: **H Chennaoui Aoudjehane & 3 others** 2005 MPS 40 967-80.
Ledges & edge pits, AFM: **AG Gratz S Manne PK Hansma** 1991 S 251 1343-6 (S615).
Dissolution in Pb/Na electrolytes: **Berger E Cadore J Schott PM Dove** 1994 GCA 58 541-51.
Growth rate of faces, micro-IR spectroscopy: **PD Ihinger SI Zink** 2000 N 404 865-9 (I255).
Rose color attributed to fibers with Fe-Ti intervalence: **JS Goreva C Ma GR Rossman** 2001 AM 86 466-72.
Silica biomineralization of unicellular microbes: **R Asada K Takazi** 2001 CM 39 1-16.
Synchrotron XRF: Cu/Zn/As in an inclusion, **P Philippot & 5 others** 2001 CG 173 151-8(1358);
Mn/Fe/Cu/Zn/As/Rb/Nb/Sn/SbCs, natural/*synthetic* incl, **K Rickers & 2 others** 2004 EJM 16 23-35 (10125).
*Halite* crystal inclusion: **AR Campbell SAW Lundberg NW Dunbar** 2001 CG 173 179-91 (1357).
Fluid inclusions, porphyry copper, PIXE/SXRF: **DA Vanko & 4 others** 2001 CG 173 227-38 (1356).
Dumortierite inclusions in rose quartz: **C Ma JS Goreva GR Rossman** 2002 AM 87 269-70.
IR of natural, synthetic & irradiated synthetic: **J Bachheimer** 2000 EJM 12 975-86 (275).

Agate, invalidity of Al thermometer for quartz: MM 65 407-13;
trace elements & stable isotopes: **J Gotze & 4 others** 2001 CG 175 523-41 (2144).
Aerial transport of large grains: **NJ Middleton PR Betzer PA Bull** 2001 M 177 411-7 (2955).
Piezoelectric properties of quartz & *cristobalite* airborne particles re adverse health effects: **BJ Williamson S Pastiroff G Cressey** 2001 AEI 35 3539-42 (2086).
Zoned phenocrysts from Bishop Tuff: **BT Peppard & 4 others** 2001 AM 86 1034-52.
X-ray reflectivity & AFM of natural faces with water, annealing at <673 K: **ML Schlegel & 3 others** 2002 GCA 66 3037-54 (7981).
Neutral oxygen vacancy: **VB Sulimov & 4 others** 2002 PRB 66 024108 (8067).
Metals in -hosted melt inclusions: **VS Kamenetsky LV Danyushevsky** 2005 AM 90 1674-8.
Trace elements in Norway pegmatites: **RB Larsen & 3 others** 2004 147 615-28 (10553).
Weathering in shocked quartz from Ries impact crater: **H Leroux** 2005 MPS 40 1347-52.
Tectonic deformation lamellae: experimental reproduction, **MGC Vernooij F Langehorst** 2005 MPS 40 1353-62.
Shock metamorphism, submarine crater, Barents Sea: **PT Sandbakken & 2 others** 2005 MPS 40 1363-76.
*Tiger's eye*: **PJ Heaney DM Fisher** 2003 G 31 323-6 (9211). [See *riebeckite*.]
*Synthetic* $GeO_2$: **GS Smith PB Isaacs** 1964 AC 17 842-6;
T dependence of Raman spectra, **TP Mernagh L Liu** 1997 PCM 24 7-16 (M1456);
transition to dense phase with edge-sharing octahedra 6 GPa, **J Haines JM Leger C Chateau** 2000 PRB 61 8701-6 (H1463);
NPD at 293 & 1344 K, **J Haines & 4 others** 2002 JSSC 166 434-41 (7712).
*Synthetic* III-V analogs $AlPO_4$(*berlinite*)/$AlAsO_4$/Ga(P/As)$O_4$/ /$FePO_4$: **K Kosten H Arnold** 1980 ZK 152 119-33 (1392).
Structure deformations and alpha-beta transition in $MXO_4$ quartz-like materials; alpha $BPO_4$, $BAsO_4$, $SiO_2$, $AlPO_4$, $GaPO_4$, $MnPO_4$, $GeO_2$, $FePO_4$, $AlAsO_4$, $GaAsO_4$, $FeAsO_4$: **E Philippot & 3 others** 1994 JSSC 110 356-62.
*Synthetic* $AlAsO_4$: 1989 ZK 187 125-31;
amorphization & new high-P phase, **H Sowa H Ahsbahs** 1996 ZK 211 96-100 (S1584).
*Synthetic* $LiAlSiO_4$-$SiO_2$, T expansion & transformations, XRD: **H Xu PJ Heaney A Navrotsky** 2001 PCM 28 302-12.
[*ximengite* $BiPO_4$. XRPD matches synthetic hexagonal polymorph.
jvs: do the cell data indicate *quartz* structure type?
Occurrence & XRPD: **J Shi** 1989 Acta Mineral Sinica 9 15-9 = AM 76 1436.]
*Synthetic* $GaPO_4$: structure at ~6 GPa, **H Sowa** 1994 ZK 209 954-60;
molecular dynamics simulation of transfomation to new phase at 9 GPa: **VV Murashov** 1996 PRB 53 107-10 (M1357);
SC-XRD, 293-747K, **H Nakae & 3 others** 1995 ZK 210 746-53 (N393);
crystal growth, **P Yot & 6 others** 2001 JCG 224 294-302 (2143).
*Synthetic* (Al,Ga)$PO_4$, polymorph stability/phase transitions: **R Barz & 3 others** 2001 ZK 216 501-8 (3588).
*Synthetic* metal-organic open frameworks with quartz topology: **J Sun & 6 others** 2002 AnCh 41 4471-3.
*Synthetic* $FePO_4$, NPD 294-1073 K, α-β change: **J Haines O Cambon S Hull** 2003 ZK 218 192-200 (9132).
*Synthetic* BPO4 & BAsO4: SC-XRD structure, ZK 219 32-7 (10224).
*Synthetic* Ge,Si series: **VS Balitsky & 5 others** 2004 DES 296 500-3 (10377).
**quartz-high (beta)** $SiO_2$.
Quartz structure type: high-low transition near 846K; many stuffed derivatives.
Structure: 927K, **H Arnold** 1962 ZK 117 467-9;
NPD at 873K, **AF Leadbetter MS Lehmann** 1981 JSSC 36 371-80;
**K Kihara** 1990 EJM 2 63-77;
lattice dynamics, **do** 1993 PCM 19 492-501.
Melting to 2 GPa: **P Hudon I Jung DR Baker** 2002 PEPI 130 159-74 (7755).
Amorphization: **F Langenhorst** 1994 EPSL 128 683-98.
*Virgilite* has stuffed high-quartz structure, composition gamma-*spodumene* $(LiAlSi_2O_6)_{61}quartz_{39}$: **BM French PA Jezek DE Appleman** 1978 AM 63 461-5.
Beta-*eucryptite* $LiAlSiO_4$: **V Tscherry H Schulz F Laves** 1972 ZK 135 161-74 (T385).
*Synthetic* $LiAlSi_2O_6$*-III*: **CT Li** 1968 ZK 127 327-48.
*Synthetic* $Li_2Al_2Si_3O_{10}$: **C-T Li** 1970 ZK 132 118-28;
diffuse scattering, **H Böhm** 1981 ZK 157 27-37.
*Synthetic* $MgAl_2Si_3O_{10}$: **H Schulz W Hoffman GM Muchow** 1971 ZK 134 1-27;
annealing, **H Schulz** 1971 ZK 134 253-61;

transition to 1120K & 1100 MPa, **AH Shen WA Bassett I-M Chou** 1993 AM 78 694-8.
*Synthetic $HAlSi_2O_6$*: **H Paulus & 3 others** 1990 NJMM 232-40 (P398).
*Synthetic $NaHAl_2Si_4O_{12}$*: **G Müller H Paulus J Stiefel** 1990 NJMM 493-503 (M1274).
Structure deformation, alpha-beta transition, $MXO_4$ quartz-like beta $SiO_2$, $AlPO_4$, $FePO_4$, $AlAsO_4$: **E Philippot & 3 others** 1994 JSSC 110 356-62 (P452).
*Synthetic* $LiAlSi_2O_6$ & $Na_{0.5}H_{0.5}AlSi_2O_6$: NJMM 493-503.
**quatrandorite** = **andorite-IV** $Pb_{18}Ag_{15}Sb_{47}S_{96}$. *Lillianite* homologous series; 4,4 subtype.
**queitite** $Pb_4Zn_2(SO_4)(SiO_4)(Si_2O_7)$. Review: **Sabelli** p.41.
Structure: **P Keller PF Dunn H Hess** 1979 NJMM 203-9;
**H Hess P Keller** 1980 ZK 151 287-99 (H978).
**quenselite** $PbMnO_2OH$.
Structure: **A Byström** 1945 Ark Chem Mineral Geol 19A no. 35 1-9 = MA 9-228;
**RC Rouse** 1971 ZK 134 321-3.
Occurrence: MM 21 575.
**quenstedtite** $Fe_2(SO_4)_3.10aq$. Review: **Sabelli** p.11.
Structure: **JN Thomas PD Robinson JH Fang** 1974 AM 59 582-6.
**quetzalcoatlite** $Cu_3Zn_6(TeO_3)_2O_6(OH)_6(Ag_xPb_y)Cl_{x+2y}$, x+ y near 2.
Structure: SC-XRD, **PC Burns & 5 others** 2000 AM 85 604-7.
Occurrence and crystallography: **SA Williams** 1973 MM 39 261-3.
**quintinite-2H** $Mg_4Al_2(OH)_{12}CO_3.3aq$. *Manasseite* group.
Occurrence & XRPD: **GY Chao RA Gault** 1997 CM 35 1541-9.
New mineral CNMN 92-028, c 15 Å, Pbar62m, structure including H atoms: AV Arakcheeva & 4 others 1996 CrR 41 972-81 (A729).
**quintinite-3T** $Mg_4Al_2(OH)_{12}CO_3.3aq$. *Hydrotalcite* group.
Occurrence & XRPD: **GY Chao RA Gault** 1997 CM 35 1541-9.

**raadeite** $Mg_7(PO_4)_2(OH)_8$. Iso with *allactite.*
Occurrence, SC-XRD structure, *synthesis* at high P: **C Chopin & 4 others** 2001 EJM 13 319-27 (2006).
**rabbittite** $Ca_3Mg_3(UO_2)_2(CO_3)_6(OH)_4.18aq$.
Structure determination not found.
Occurrence & crystallography: **ME Thompson AD Weeks AM Sherwood** AM 40 201-12.
**rabejacite** $Ca(UO_2)_4(SO_4)_2(OH)_6.9aq$.
Structure determination not found.
Occurrence & crystallography: **M Deliens P Piret** 1993 EJM 5 873-7.
**radhakrishnaite** $PbTe_3(Cl,S)_2$.
Structure determination not found.
Occurrence & crystallography: **AD Genkin & 7 others** 1985 CM 23 501-6.
**radovanite** $Cu_2Fe(AsO_4)(AsO_2OH)_2.aq$.
Occurrence & structure: **H Sarp L Guenee** 2002 Arch Sci Genève 55 47-55.
**radtkeite** $Hg_3S_2ClI$ (chloride iodide).
XRPD matches *synthetic*.
Structure: *synthetic*, SC-XRD, **NV Pervukhina & 4 others** 2004 CM 42 87-94.
Occurrence & crystallography: **JK McCormack FW Dickson MP Leshendok** 1991 AM 76 1715-21.
**raguinite** $TlFeS_2$. Deformed *chalcopyrite* structure from orthorhombic cell.
Structure determination not found.
Occurrence & crystallography: **Y Laurent & 4 others** 1969 BSFMC 92 38-48 = AM 54 1495;
**Z Johan P Picot R Pierrot** 1969 BSFMC 92 237 = AM 54 1741.
**raite** $\sim Na_3Mn_3Ti_{0.25}Si_8O_{20}(OH)_2.10aq$.
Structure: **JJ Pluth & 7 others** 1998 PNAS;
& geochemistry: **DY Pushcharovskii & 8 others** 1999 CrR 44 565-74 (P847).

Occurrence & crystallography: **AN Mer'kov & 5 others** 1973 ZVMO 102 54-62.
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).
**rajite** $CuTe_2O_5$. XRPD matches *synthetic*.
Structure determination not found.
Occurrence & crystallography: **SA Williams** 1979 MM 43 91-2.
**ralstonite** $Na_xMg_xAl_{2-x}(F,OH)_6.aq$. *Pyrochlore* structure type.
Structure: **A Pabst** 1939 AM 24 566-76 (P455);
**H Effenberger F Kluger** 1984 NJMM 97-108.
*Synthetic* $AlF_3$-$Al_2O_3$-aq-HF: 673-973 K, 6 solids, including *corundum, diaspore*, "tohdite" & ralstonite-like phase, **PE Rosenberg** 2006 CM 44 125-34.
**rambergite** MnS-gamma/hexagonal.
Occurrence: AM 83 1117-21; NJMM 1999 35-9 (W954).
**ramdohrite** $Pb_6Ag_3Sb_{11}S_{24}$. *Lillianite* homologous series; 4,4 subtype.
Structure: **I Kawada E Hellner** 1971 NJMM 551-60;
**E Makovicky WG Mumme** 1983 NJMM 147 58-79 (M1281);
**H Sawada & 3 others** 1987 ZK 180 141-50.
Occurrence: MM 22 626.
**rameauite** $K_2CaU_6O_{20}.9aq$.
Structure determination not found.
Occurrence & crystallography: **F Cesbron & 3 others** 1972 MM 38 781-9.
**rammelsbergite** $NiAs_2$. *Marcasite* structure subgroup in marcasite supergroup.
Structure: **EH Roseboom** 1963 AM 48 271-99;
**A Kjekshus T Rakke AF Andresen** 1974 Acta Chem Scand A28 996-1000 (K726).
-lollingite & -safflorite series minerals, Noril'sk ore field: **YuD Gritzenko EM Spiridonov** 2005 ZVMO 134 53-68.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**ramsbeckite** $(Cu,Zn)_{15}(SO_4)_4(OH)_{22}.6aq$. Review: (E289).
Structure: **H Effenberger** 1988 NJMM 38-48 (E337).
Occurrence, exceptional crystals Penrhiw mine: **JS Mason DL Green** 1995 UK J Mines & Minerals 15 21-7.
MM 50 756.
**ramsdellite** gamma-$MnO_2$. Dimorphic with *pyrolusite*. Related to *groutellite.*
Structure: **AM Byström** 1949 Acta Chem Scand 3 163-73 = MA 11-238,
correction, **LAH MacLean FL Tye** 1995 Acta Chem Scand 49 467-8 (M1297);
**D Kondrasev Al Zaslavskiy** 1951 Izv Akad Nauk SSSR Fiz 15 179-86;
NPD, **C Fong BJ Kennedy MM Elcombe** 1994 ZK 209 941-5.;
N & XRPD, & dehydration, **JE Post PJ Heaney** 2004 AM 89 969-75.
Occurrence: MM 27 274.
*Synthetic* $Li_2Ti_3O_7$: 1989 JSSC 78 170-7 = SR 56A 130.
*Synthetic* $Li_{0.5}TiO_2$: structure, **J Akimoto & 5 others** 1994 JSSC 110 150-5;
topotactic oxidation, **do** 1994 JSSC 113 27-36 (A569).
*Synthetic* $LiTi_2O_4$, *spinel* to *ramsdellite*, 1148-1198 K, NPD: **RKB Gover JTS Irvine AA Finch** 1997 JSSC 132 382-8.
*Synthetic* $LiTi_2O_4$ - $Li_2Ti_3O_7$, N/XRD: **RKB Gover JTS Irvine** 1998 JSSC 141 365-72 (G1140).
**ranciéite [rancieite & ranciete in chemical literature]** $(Ca,Mn)Mn_4O_9.3aq$.
Compare with *birnessite* & *takanelite*.
Structure: Friesach, Austria, XRPD structure, probably trigonal, **A Ertl & 6 others** 2005 EJM 19 163-72 (11029)
Occurrence: & crystallography, **WE Richmond M Fleischer ME Mrose** 1969 BSFMC 92 191-5;
karstic bauxite, **G Bardossy GW Brindley** 1978 AM 63 762-7;
**SJ Kim** 1980 J Geol Soc Korea 16 105-13 = AM 69 814-5;
Mazzano Romano, **E Barrese & 3 others** 1986 MM 50 111-8.
Zn-analog, Korea:**SJ Kim H Choi S Chang** 2002 18th IMA Mtg Abstr 140.
*Synthetic*: **F Leroux D Guyomard Y Piffard** 1995 Solid Sate Ionics 80 299-306;
H/Li/Na-exchanged types, **do** 1995 Solid State Ionics 80 307-16.
Synthetic relatives studied as electrodes for Li batteries.
**rankachite** $CaFeV^{5+}_4W_8O_{36}.12aq$.
Structure determination not found.

Occurrence & crystallography: **K Walenta PJ Dunn** 1984 NJMM 289-95.
See AM 91 1208 for data on Fe-poor.

**rankamaite** $(Na,K,Pb,Li)_3(Ta,Nb,Al)_{11}(O,OH)_{30}$.

XRPD indicates *tungsten bronze* structure group.
Structure determination not found.
Occurrence & crystallography: **O Von Knorring A Vorma PH Nixon** 1969 Bull Geol Soc Finlande 41 47-56 = AM 55 1814.

**rankinite** $Ca_3Si_2O_7$. Dimorphic with *kilchoanite*.

Structure: **I Kusachi & 3 others** 1975 MJJ 8 34-47 = MA 79-2100;
**S Saburi & 5 others** 1976 MJJ 8 240-6 (S1498) = MA 80-4143.
Occurrence: MM 26 340.

**ranquilite** $Ca_2[(UO_2)_3(Si_2O_5)_4(OH)_2].18aq$. *Weeksite* mineral group.

Occurrence: MM 32 976.

**ransomite** $CuFe_2(SO_4)_4.6aq$. Octahedral sheet structure. Review: **Sabelli** p. 17-8.

Structure: **MM Wood** 1970 AM 55 729-34.

**[ransomite** $CuFe_2(SO_4)_4.7aq$. Burning ore. Occurrence: MM 21 575.]

**ranunculite** $HAl(UO_2)(PO_4)(OH)_3.4aq$.

XRPD indicates structural resemblance to *seelite* (P498) [jvs: cell dimensions do not match].
Structure determination not found.
Occurrence & crystallography: **M Deliens P Piret** 1979 MM 43 321-3.

**rapidcreekite** $Ca_2(SO_4)(CO_3).4aq$. Related to *gypsum* structure by twin geometry.

XRPD matches unnamed As analog.
Structure: **MA Cooper FC Hawthorne** 1996 CM 34 99-106.
Occurrence & crystallography: **AC Roberts & 4 others** 1986 CM 24 51-4.

**rappoldite** $Pb(Co,Ni)_2(AsO_4)_2.2aq$. Co-analog of *helmutwinklerite* in *tsumcorite* .

Occurrence & SC-XRD structure, IR: **H Effenberger & 3 others** 2000 MM 64 1109-26.

**raslakite** $Na_{15}Ca_3Fe_3(Na,Zr)_3(Si,Nb)Si_{25}O_{73}(OH,aq)_3(Cl,OH)_2$. *Eudialyte* group.
Occurrence: **NV Chukanov & 4 others** 2003 ZVMO 132 22-33 (10514).

**raspite** $PbWO_4$. Trimorphic with *stolzite* & high-pressure type.

Structure: **T Fujita I Kawada K Kato** 1977 AC B33 162-4.

**rasvetaevite** $Na_{27}K_8Ca_{12}Fe_3Zr_6Si_{52}O_{144}(O,OH,aq)_6Cl_2$. Eudialyte group.

Occurrence: in prep.

**RASVUMITE STRUCTURE GROUP**

- **pautovite** $CsFe_2S_3$
- **picotpaulite** $TlFe_2S_3$
- **rasvumite** $KFe_2S_3$

**rasvumite** $KFe_2S_3$. *Rasvumite* structure type.

Structure: **JR Clark GE Brown Jr** 1980 AM 65 477-82.
Occurrence: MM 38 998.
Mn,F-analog at Oldoinyo Lengai: **BC Jago J Gittins** 1999 MM 63 53-5.

**rathite-I** $Pb_8Pb_{4-x}(Tl_2As_2)_{x3}[Ag_2As_2)As_{16}S_{40}$. *Sartorite* mineral group.

Complex relations with *rathite-II* (*livingeite*), -III & -IV that may involve twin-type superstructures.
Modulations of parent structure: EPMA & SC-XRD structure: **B Berlepsch T Armbruster D Topa** 2002 ZK 217 581-99.
Structure of rathite-I: **F Marumo W Nowacki** 1965 ZK 122 433-56 (M171).
Rathite I, II, III: MM 32 977.
Rathite-IV & occurrence: **T Ozawa W Nowacki** 1974 NJMM 530-1 (O124).
138 Å superstructure, TEM: **T Ozawa O Tachikawa** 1996 MJ 18 97-101 (O327).

**rauenthalite** $Ca_3(AsO_4)_2.10aq$. Compare with *phaunouxite* $Ca_3(AsO_4)_2.11aq$.

Structure: **M Catti G Ivaldi** 1983 AC B39 4-10.
Occurrence: MM 35 1150-1.

**rauvite** $Ca(UO_2)_2V_{10}O_{28}.16aq$.

Structure determination not found.

Occurrence & crystallography: **C Frondel** 1958 USGS Bull 1064 263-4.

**ravatite** $C_{14}H_{10}$. Natural analog of *synthetic phenanthrene*.

Structure determination not found.

Occurrence & crystallography: **L Nasdala IV Pekov** 1993 EJM 5 699-705; MA 96M/2493.

**rayite** ~$Pb_8(Ag,Tl)_2Sb_8S_{21}$.

Cell data indicate resemblance to *semseyite* $Pb_9Sb_8S_{21}$, member of *plagionite* structure group.

Structure determination not found.

Occurrence & crystallography: **K Basu & 5 others** 1983 NJMM 296-304.

**realgar** AsS-beta. Dimorphic with *pararealgar*. Also $As_4S_4$-beta-(xi) & $As_4S_4$(III).

Structure: **T Ito N Morimoto R Sadanaga** 1952 AC 5 775-82 (I37);
**GB Street Z Munir** 1970 J Inorg Nucl Chem 32 37 64-74;
**DJE Mullen W Nowacki** 1972 ZK 136 48-65 (M443);
Raman, 298 & 77K, **RL Frost WN Martens JT Kloprogge** 2002 NJMM 469-80 (8335).

Beta(low)- transforms to alpha(high)-, structure: **S-C Yu T Zoltai** 1972 AM 57 1873-6.

Light-induced changes: in realgar & $As_4S_4$-beta, **P Bonazzi & 4 others** 1996 AM 81 874-80;
degradation in realgar, SC-XRD & XR photoelectron spectroscopy, **A Kyono & 2 others** 2005 AM 90 1563-70.

XPS, core level electron binding energy: **AR Pratt HW Nesbitt** 2000 AM 85 619-22.

*Natural alpha-*: **AH Clark** 1970 AM? 1338-44 = MM 38 988.

*Synthetic* AsSe: **AL Renninger BL Auerbach** 1973 AC B29 1583-9;
**EJ Smail GM Sheldrick** 1973 AC B29 2014-6.

**rebulite** $Tl_5Sb_5As_8S_{22}$.

Structure: **T Balic-Zunic S Scavnicar P Engel** 1982 ZK 160 109-25. MM 48 581.

Modular description: **E MakovickyT Balic-Zunic** 1998 NJMA 174 181-210 (M1684).

**rectorite** Interstratified 1:1 dioctahedral *mica/smectite*.

Structure: **GW Brindley** 1956 AM 41 91-103 (B93);
**HJ Jakobsen NC Nielsen H Lindgreen** 1995 AM 80 247-52.

Surface microtomography: **R Kitagawa** 1997 CIM 32 89-95 (K906).

Dehydroxylation, IR, compare *beidellite* & *paragonite*: **JT Kloprogge RL Frost** 2000 NJMM 149-57 (K1231).

*Synthetic* pillared rectorite: surface, AFM: **ML Occelli SAC Gould** 2001 JCa 198 41-6 (1430);
microporosity, **JP Olivier ML Occelli** 2003 MMM 57 291-6 (8576).

K-rich, in kaolinized mica-schist: **E Benincasa & 3 others** CIM 36 421-33 (3071).

*Synthetic* $GaAl_{12}$-pillared : **SA Bagshaw RP Cooney** 1995 ChM 7 1384-9 (B1402).

*Synthetic* Ti-pillared: **F Kooli J Bovey W Jones** 1997 JMC 7 153-8 (K884).

**reddingite** $(Mn,Fe)_3(PO_4)_2.3aq$. *Phosphoferrite* structure group.

Isostructural series with Fe analog *phosphoferrite*.

Structure determination not found.

Occurrence: **Dana**.

**redgillite** $Cu_6(SO_4)(OH)_{10}.aq$.

Occurrence & SC-XRD structure: **JJ Pluth & 3 others** 2005 MM 69 973-80 = AM 91 1456.

**redingtonite** $(Fe,Mg,Ni)(Cr,Al)_2(SO_4)_4.22aq$.

Supposed to belong to *halotrichite* structure group but no structure determination found [jvs: check for *synthetic*].

Review: **Sabelli** p.11.

Occurrence: **Dana**.

**redledgeite** ~$Ba[Ti_6Cr_2]O_{16}.?1aq$. *Hollandite/cryptomelane* structure group.

Occurrence: MM 33 1148.

Structure $Ba_{1.1}(Cr_{1.8}Ti_{6.0}Fe_{0.1}V_{0.1})O_{16}/Ba_{1.3}(Cr_{2.5}Ti_{5.5})O_{16}$: **BM Gatehouse & 3 others** 1986 MM 50 709-15.

Structure of $Ba_x(Cr,Fe,V)_{2x}Ti_{8-2x}O_{16}$: **JA Foley JM Hughes JW Drexler** 1997 CM 35 1531-4.

New chemical formula & proposal that essentially isostructural with *mannardite*, perhaps with additional Ba-aq order: **JD Scott GR Peatfield** 1986 CM 24 55-66.

**reederite-Y** $(Na,Mn,Fe)_{15}(Y,REE)_2(CO_3)_9(SO_3F)Cl$.

Structure: **JD Grice RA Gault GY Chao** 1995 AM 80 1059-64.

**reedmergnerite** $NaBSi_3O_8$. *Feldspar* structure group.

Structure: **DE Appleman JR Clark** 1965 AM 50 1827-50;
**ME Fleet** 1992 AM 77 76-84.
Occurrence: MM 30 745.

**reevesite** $Ni_6Fe_2(CO_3)(OH)_{16}.4aq$. *Hydrotalcite/pyroaurite* structure group.
Structure review: **HFW Taylor** 1973 MM 39 377-89 (T186).
Occurrence: MM 36 1157.
New data & Co-analog: **Y Song H-S Moon** 1998 CIM 33 285-96.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**refikite** $C_{20}H_{32}O_2$. Matches *synthetic* dihydro-d-pimaric acid.
Occurrence: **H Strunz B Contag** 1965 NJMM 19-25 = AM 50 2110.

**reichenbachite** $Cu_5(PO_4)_2(OH)_4$. Trimorphic with *ludjibaite* & *pseudomalachite*.
Review: (E289). Layer structure.
Compare with *arsenoclasite*, *cornubite*, *gatehousite* & *reppiaite*.
Structure review: **J Barbier** 1996 EJM 8 77-84.
Structure: **JB Anderson & 3 others** 1977 AM 62 115-21.
Occurrence: MM 52 730.

**reidite** $ZnSiO_4$. *Scheelite* structure type.
High-P shock polymorph of *zircon*.
Occurrence & XRPD: **BP Glass S Liu PB Leavens** 2002 AM 87 562-5.

**reinerite** $Zn_3(AsO_3)_2$.
Structure: **S Ghose & 3 others** 1977 AM 62 1129-34;
XRPD, **B Breidenstein** 1994 NJMM 174-8.
Occurrence: MM 32 977.

**reinhardbraunsite** $Ca_5(SiO_4)_2(OH,F)_2$. *Chondrodite* structure type in *humite* group.
Structure: **A Kirfel H-M Hamm G Will** 1983 TMPM 31 137-50 (K734).
Natural equivalent of "calcio-chondrodite": *synthetic*: **EW Buckle HFW Taylor** 1958 AM 43 818-23 (P458).
Occurrence: MM 48 581.

**remnykhite** $Pb_3Zn_3TeO_6(VO_4)_2$.
Compare with *dugganite* (As) & *kuksite* (P).
Occurrence: **AA Kim NV Zayakima VF Makhotko** 1990 ZVMO 50-7.

**remondite-Ce** $Na_3(Ce,La,Ca,Na,Sr)_3(CO_3)_5$. *Burbankite* structure group.
Structure: **D Ginderow** 1989 AC C45 185-7 = MA 85M/0212.
Occurrence: MM 54 669.
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**remondite-La** $Na_3(La,Ce,Ca)_3(CO_3)_5$. *Burbankite* structure group.
Occurrence, XRPD, IR: **IV Pekov & 4 others** 2000 ZVMO 129 53-60 = AM 86 377.

**renardite** $Pb(UO_2)_4(PO_4)_2(OH)_4.7aq$.
*Phosphuranylite* mineral group; beware of problems.
*Dewindtite* appears isostructural but chemically different.
Structure determination not found.
Occurrence: MM 22 627; **C Frondel** 1958 US Geol Surv Bull 1064 227-30.
*Synthesis*: **V Ross** 1956 AM 41 915-26.

**rengeite** $Sr_4ZrTi_4Si_4O_{22}$. *Perrierite-chevnikite* group.
Occurrence & XRPD structure: **H Miyajima & 4 others** 2001 MM 65 111-20.

**renierite** $Cu_{10}(Zn,Cu)Ge_{2-x}As_xFe_4S_{16}$.
*Germanite* structure group with superstructure based on *sphalerite*.
Structure: **LR Bernstein DG Reichel S Merlino** 1989 AM 74 1177-81.
Occurrence: MM 28 737.
Cu-Zn-Fe & As-Ge substitutions: MP 1992 46 55-65.

**reppiaite** $Mn_5(OH)_4(VO_4)_2$. Layer structure.
Compare with *arsenoclasite*, *cornubite*, *gatehousite*, *ludjibaite*, *pseudomalachite* & *reichenbachite*.
Structure: **R Basso & 3 others** 1992 ZK 201 223-4 (B1101).

*Synthetic* $Ni_5(AsO_4)_2(OH)_4$ & structure review: **J Barbier** 1996 EJM 8 77-84.

**retgersite** $NiSO_4.6aq$. Tetragonal dimorph of monoclinic *nickel-hexahydrite*.

Review: **Sabelli** p. 9.
Structure: **CA Beevers H Lipson** 1932 ZK 83 123-35;
NPD, **BH O'Connor DH Dale** 1966 AC 21 705-9.
Absolute configuration: **K Stadnicka AM Glazer M Koralewski** 1987 AC B43 319-25 (S1464).
Bonding & electron density: **GJ McIntyre H Ptasiewicz-Bak I Olovsson** 1990 AC B46 27-39;
**RJ Angel LW Finger** 1988 AC C44 1869-73 (A618).
Occurrence: MM 28 737.

**retzian-Ce** $Mn_2Ce(AsO_4)(OH)_4$. *Retzian* structure type.

Composition changed from Y to Ce: **PJ Dunn BD Sturman** 1982 AM 67 841-5.
Structure: assuming Y now changed to Ce, **PB Moore** 1967 AM 52 1603-13.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
Occurrence: MM 48 581.

**retzian-La** $(Mn,Mg)_2(La,Ce,Nd)(AsO_4)(OH)_4$. *Retzian* structure type.

Occurrence: **PJ Dunn DR Peacor WB Simmons** 1984 MM 48 533-5.
Occurrence: MM 48 581.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**retzian-Nd** $Mn_2(Nd,Ce,La((AsO_4)(OH)_4$. Retzian structure type.

Occurrence: **PJ Dunn BD Sturman** 1982 AM 67 841-5; MM 48 581.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**revdite** $Na_{16}[Si_4O_6(OH)_5]_2[Si_8O_{15}(OH)_6](OH)_{10}.28aq$.

Structure: **RK Rastsvetaeva & 3 others** 1992 SPC 37 632-6 (R481).
Occurrence: MM 46 525.
See *grumantite* $NaHSi_2O_5.aq$, *kanemite* $NaHSi_2O_4(OH)_2.2aq$, *makatite* $NaSi_2O_4OH.2aq$
& *natrosilite* $Na_2Si_2O_5$.

*Synthetic* $(K/Cs)_4(NbO)_2Si_8O_{21}$: IMA Pisa 321.

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

**reyerite** $(Na,K)_4Ca_{14}(Si,Al)_{24}O_{60}(OH)_5.5aq$.

Structurally related to *gyrolite*, *minehillite* & *truscottite*.
Structure: **PJ Dunn & 3 others** 1984 AM 69 1150-5;
**S Merlino** 1972 Nature Phys Sci 238 124-5;
**do** 1988 MM 52 247-56.

**RHABDOPHANE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *brockite* | $(Ca,Th,Ce)(PO_4).aq$ |
| *grayite* | $(Th,Pb,C)(PO_4).aq$ |
| *ningyoite* | $(U,Ca,Ce)(PO_4).0.5\text{-}1aq$ |
| *rhabdophane -Ce* | $(Ce,La)(PO_4).aq$ |
| *rhabdophane-La* | $(La,Y)(PO_4).aq$ |
| *rhabdophane-Nd* | $(Nd,Ce,La)(PO_4).aq.$ |
| *[?saryarkite* | $Ca(Y,Th)Al_5(SiO_4)_2(P/SO_4)_2(OH)_7.6aq$ |
| | suggested member from XRPD but mismatch with chemistry & cell data] |
| *tristramite* | $(Ca,U,Fe)(P/SO_4).2aq$ |
| *unnamed* | $(Ca,REE)PO_4.naq$ |

Occurrence: **OA Doynikova & 4 others** 1993 ZVMO 122 79-88 = AM 80 632-3.
*Synthetic* $YPO_4.aq$: **Y Hikichi & 3 others** 1996 MJ 18 87-96 (H1141).

*Synthetic* Yb & Lu: **W Min & 4 others** 2001 MRB 35 2199-205 (2141).

**rhabdophane-Ce** $(Ce,La)(PO_4).aq$. *Rhabdophane* structure group.

Structure: *synthetic* $(Ce/La/Nd)PO_4$, **RCL Mooney** 1950 AC 3 337-40 (M1335).

*Silicorhabdophane*: natural Si-rich variant, MM 32 990.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**rhabdophane-La** $(La,Ce)(PO_4).aq$. *Rhabdophane* structure group.

Occurrence: PDF 12-277.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**rhabdophane-Nd** $(Nd,Ce,La)(PO_4).aq$. *Rhabdophane* structure group.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**rhenium** Re. Hexagonal closest packing of spheres.
Isostructural with *osmium* & *ruthenium*.
[Flattened hcp can also occur in metals: eg *schachnerite* $Ag_{1.1}Hg_{0.9}$-beta & *weishanite* (Au,Ag,Hg).]
Occurrence: two papers = AM 63 1283-4; MM 43 1066.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
Occurrence, lunar regolith, Crises Sea: **OA Bogatikov & 5 others** 2002 DES 382 83-5 (7553).
**rhodarsenide** $(Rh,Pd)_2As$. Isostructural with *palladodymite*.
Occurrence & XRPD (matches *synthetic*): **M Tarkian & 3 others** 1997 EJM 9 1321-5 (T564).
**RHODESITE MINERAL GROUP** To be completed.
*rhodesite* $(Ca,Na/K_2)_8Si_{16}O_{40}.11aq$.
*seidite-Ce* $Na_4(Ce,Sr)_2Ti(OH)_2(Si_8O_{18})(O,OH,F)_4.5aq$
**rhodesite** $(Ca,Na/K_2)_8Si_{16}O_{40}.11aq$.
Structure: **KF Hesse F Liebau S Merlino** 1992 ZK 199 25-48 (H883).
Occurrence: MM 31 971.
*Synthetic* $KHCa_2Si_8O_{19}.6aq$, XRPD/MAS-NMR/FTIR/Raman, TGA/DSC: **J Rocha & 5 others** 1998 JPCB 102 4739-44.
**rhodium** (Rh,Pt). ?Cubic closest packing of spheres = *copper* structure group.
Occurrence: **LJ Cabri JHG LaFlamme** 1974 CM 12 399-403.
**rhodizite** $(K,Cs)Al_4Be_4B_{11}O_{25}(OH)_4$. Analog of *londonite* $(Cs,K,Rb)Al_2Be_2(B,Be)_6O_{14}$.
Structure: **MJ Buerger K Taxer** 1966 S 152 500-2 (B771);
**KJ Taxer MJ Buerger** 1967 ZK 125 423-36 (T373).
**rhodochrosite** $MnCO_3$. *Calcite* structure type.
Structure: **H Effenberger K Mereiter J Zemann** 1981 ZK 156 233-43;
**EN Maslen VA Streltsov NR Streltsova** 1993 AC B49 636-41;
XRD & electron density, **EN Maslen & 3 others** 1995 AC B51 929-39.
*Synthetic* (Ca,Mn)CO3: Mn EXAFS, **YJ Lee & 3 others** 2002 PCM 29 583-94 (8450).
Surface complex model: **OW Duckworth ST Martin** 2003 GCA 67 1787-801 (8981).
Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).
In sediments adjacent orebody, Ghana: **FK Nyame & 3 others** 2002 SG 154 159-75 (8447).
Fe,Zn-bearing, structure: **EE Galloni** 1950 AM 35 562-70.
*Synthetic* rhodochrosite-*smithsonite* series, XRPD & IR: **ME Böttcher** 1995 MM 59 481-8.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**RHODONITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *marsturite* | $NaCaMn_3Si_5O_{14}OH$ |
| *nambulite* | $LiNaMn_8Si_{10}O_{28}(OH)_2$ |
| *natronambulite* | $(Na,Li)(Mn,Ca)_4Si_5O_{14}OH$ |
| *rhodonite* | $MnSiO_3$ |

*Synthetic* $NaCd_4Ge_5O_{14}(OH)$: **EL Belokoneva MA Simonov NV Belov** 1974 SPD 18 768-70 (B1117).
*Synthetic* $LiHCdGe_5)_{15}$: **MA Simonov & 3 others** 1976 SPD 21 611-3 (S1268).
*Synthetic* $LiHMn_4Si_5O_{15}$: **T Murakami Y Takéuchi T Tagai** 1977 ACB 33 919-21 (M582).
*Synthetic* $CaMn_4Si_5O_{15}/NaHCd_4Ge_5O_{15}/LiHCd_4Ge_5O_{15}$: **MA Simonov & 3 others** 1977 SPD 22 241-2.
*Synthetic* $Mn_{0.68}Mg_{0.32}$: **T Murakami Y Takéuchi** 1979 MJJ 9 286-304.
**rhodonite** $MnSiO_3$. Rhodonite structure group. *Pyroxenoid* mineral group. Chain silicate.
Structure: **F Liebau W Hilmer G Lindemann** 1959 AC 12 182-7 & 1962 15 622;
**DR Peacor M Niizeki** 1963 ZK 119 98-116;
**H Narita K Koto N Morimoto** 1977 MJ 8 329-42 (N188);
**LR Pinckney CW Burnham** 1988 AM 73 798-808;
stacking faults, **DA Jefferson & 5 others** 1980 ACA 36 1058-65;
direct electron images, **DJ Smith DA Jefferson LG Mallinson** 1981 ACA 37 273-80;
Zn-rich, SC-XRD, “fowlerite”, **WR Nelson DT Griffen** 2005 AM 90 969-82.

High-P transition to II *pyroxmangite*, III *pyroxene* & IV *garnet*: **S Akimoto Y Syono** 1972 AM 57 76-84.
Surface oxidation, glancing-incidence-XAS: **ML Farquhar & 7 others** 2003 MM 67 1205-19.
*Sphalerite/galena/quartz/fluorite/ilmenite/liquid* inclusions, Broken Hill: **PW Millsteed & 3 others** 2005 GG Fall 246-54.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**rhodostannite** $Cu_2FeSn_3S_8$. Disordered *spinel* structure type.

Related to *toyohaite* $Ag_2FeSn_3S_8$ and *silver-rhodostannite* $AgCuFeSn_3S_8$.
Structure: **JC Jumas E Philippot M Maurin** 1979 AC B35 2195-7.
Occurrence: MM 37 963.

**rhodplumsite** $Rh_3Pb_2S_2$.

Occurrence & crystallography: **AD Genkin & 4 others** 1983 Min Zh 5 87 = MM 48 581.

**rhomboclase** $H_5O_2[Fe(SO_4)_2.2aq]$. Review: **Sabelli** p. 26.

Structure: **K Becherer** 1970 TMPM 14 159-67 (B449);
**K Mereiter** 1974 TMPM 21 216-32 (M1237).

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

Structure: **E Bonnaccorsi S Merlino M Pasero** 1990 EJM 2 203-18.
Occurrence: & XRPD, **KL Cameron MF Carman JC Butler** 1970 AM 55 864-74;
Antarctica, **RH Grapes RJ Wysoczanski PWO Hoskin** 2003 MM 67 639-51.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

**[rhythmite** $Ca_4[SiO_4]_2.3CaCl_2$.

Not allowed as official mineral name because occurs in burnt coal waste: AM 82 1038-41.]

**ribbeite** $Mn_5(SiO_4)_2(OH)_2$. *Humite* structure group. Dimorphic with *alleghanyite*.

Structure: **RL Freed RC Rouse DR Peacor** 1993 AM 78 190-4.
Occurrence: MM 52 730.

**richellite** $Ca_3Fe_{10}(PO_4)_8(OH,F)_{12}.n\ aq$. Amorphous.

**richelsdorfite** $Ca_2Cu_5Sb(AsO_4)_4(OH)_6Cl.6aq$.

Structure: **P Süsse B Tillmann** 1987 ZK 179 323-34.
XRPD: **H Sarp B Dominik P-J Chiappero** 1994 SMPM 74 273-7 = AM 80 849.
Occurrence: MM 48 581;
**H Sarp et al** 1994 SMPM 74 273-7 (S1367).

**richetite** $M_xPb_{8.6}[(UO_2)_{18}O_{18}(OH)_{12}]_2.41aq$.

Structure: **P Burns** 1998 CM187-99.
Occurrence & crystallography: MM 28 737;
**C Frondel** 1958 USGS Bull 1064 91-2;
**P Piret M Deliens** 1984 BM 107 581-5 = AM 70 1335.

**richterite** $Na_2Ca(Mg,Fe)_5Si_8O_{22}(OH)_2$. *Amphibole* structure group; monoclinic subtype.

Structure: **G Della Ventura J-L Robert J-M Be'ny** 1991 AM 76 1134-40;
**R Oberti & 3 others** 1992 EJM 44 25-39 ;
Mn-, **R Oberti & 3 others** 1993 EJM 5 43-51.
Richterite-Ti-richterite, Ti XAS: **E Paris & 3 others** 1993 EJM 5 455-64 (1759).
*Synthetic* $(K/Na)NaCaMg_5Si_8O_{22}F_2$: **M Cameron & 3 others** 1983 AM 68 924-43.
*Synthetic* KNiMgCo-: **GD Ventura & 3 others** 1993 AM 78 633-40;
XRPD structure & IR, **G Della Ventura & 4 others** 1997 AM 82 291-301.
*Synthetic* Ti-free & Ti-bearing, XRPD & FTIR: **G Della Ventura & 3 others** 1996 AM 81 56-60.
*Synthetic* K-amphibole stability in peralkaline system <8.5 GPa: **J Konzett & 3 others** 1997 JP 38 537-68 (K918).
*Synthetic* (Na,K), EMP, HRTEM, XRD, OH-spectroscopy: **M Gottschalk M Andrut** 1998 PCM 25 101-11 (G1007).
*Synthetic* K(KCa), SC-XRD structure: **H Yang & 3 others** 1999 AM 84 681-4.
*Synthetic pargasite*-richterite series, SEM, XRPD, HRTEM, IR: **G Della Ventura & 5 others** 1999 EJM 11 79-94 (D766).
*Synthetic* K-richterite-richterite-*tremolite* series, SEM/EMP/XRD/HRTEM/IR: **S Melzer & 3 others** 2000 EJM 12 273-91.
K-, stability at 5-15 GPa: **RG Tronnes** 2002 MP 74 129-48 (7136).
*Synthetic* (Si,Ge): XRPD structure & FTIR: **K Senda & 2 others** 2005 AM 90 1062-71.

**rickardite** $Cu_7Te_5$.

Structure: **A Forman MA Peacock** 1949 AM 34 441-51.

**riebeckite** $Na_2(Fe,Mg)_3Fe_2Si_8O_{22}(OH)_2$. Amphibole structure group; monoclinic subtype

*Crocidolite* is asbestos variety with blue color.
*Tiger's eye*, was believed to be silicified variety, now suggested to be primary fibrous *quartz*.

Structure: F-, **FC Hawthorne** 1978 CM 16 187-94;
**JH Ahn PR Buseck** 1991 AM 76 1467-78.

T dependence of $^{57}Fe$ Mössbauer: **A Van Alboom E De Grave** 1996 PCM 23 377-86 (V258).

**rijkeboerite** ~$Ba_{0.3}Ta_2O_{5.3}$.2aq. *Pyrochlore* group.

Occurrence: MM 33 1148.

**[***rilandite* no other info at this time.]

**rimkorolgite** $BaMg_5(PO_4)_4$.8aq. *Bakhchisaraitsevite* framework interrupted by Ba.

Structure: SC-XRD, **SV Krivovichev & 3 others** 2002 EJM 14 397-402 (7133).

Occurrence: **SN Britvin & 4 others** 1995 ZVMO 124 90-5.

**ringwoodite** $(Mg,Fe)_2SiO_4$. *Spinel* structure type.

Gamma phase trimorphic with *forsterite* (alpha, *olivine*) & *wadsleyite* (beta phase).

Occurrence: **RA Binns RJ Davis SJB Reed** 1969 N 221 943-4 = AM 54 1219.

Solubility of water in alpha-, beta- & gamma $(Mg,Fe)_2SiO_4$: **DL Kohlstedt H Keppler DC Rubie** 1996 CMP 123 345-7.

*Synthetic* hydrous: SC-XRD structure, IR/Raman, **Y Kudoh & 3 others** 2000 PCM 27 474-9 (K1227A);
compressibility & mantle discontinuities, **H Yusa T Inoue Y Ohisho** 2000 GRL 27 413-6 (Y262);
~20 GPa 1700K, 0.2-1.1 wt % H, Fe/Mg 0-0.12, SC-XRD/TEM/IR/Mössbauer, **JR Smyth & 5 others** 2003 AM 88 1402-7;
elasticity, **J Wang & 3 others** 2003 AM 88 1608-11.

Structural relation of hydrous ringwoodite & *wadsleyite*: **Y Kudoh** 2001 PCM 28 523-30 (3587).

Phase boundary with *wadsleyite*, XRD: **A Suzuki & 9 others** 2000 GRL 27 803-6 (S2161).

High-P transition to metastable *stishovite* + *periclase*, & stable *ilmenite* + *perovskite* structures: **T Kubo & 8 others** 2000 GRL 27 807-10 (K1227).

Sound velocity, elasticity: **SV Sinogeikin T Katsura JD Bass** 1998 JGR 103 20819-25 (S1978);
**JM Jackson SV Sinogeikin JD Bass** 2000 AM 85 296-303.

Single-crystal elasticity: <16 GPa 923K; **SV Sinogeikin JD Bass T Katsura** 2001 GRL 28 4335-8 (3589);
to high P & T, implications for 520 km discontinuity, **do** PEPI 136 3-10.

Thermal expansion 300-2000 K 15-24 GPa: **T Katsura & 11 others** 2004 JGR 109 B12209 (10927).

Compressional/shear wave velocities to 12 GPa: **B Li** 2003 AM 88 1313-7.

Flow-law for subduction zone: **Y Xu & 5 others** 2003 PEPI 136 3-10.

$Fo_{90}$ : XRPD to 45 GPa, equation of state, MH Maghnani & 6 others 2005 MM 69 317-24.

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

*Synthetic* $Co_2SiO_4$, *olivine*, *wadsleyite* & *spinel* polymorphs: **N Morimoto M Tokonami M Watanabe K Koto** 1974 AM 59 475-95.

*Synthetic* $Mg_2GeO_4$: H incorporation, IR, **B Hertweck J Ingrin** 2005 MM 69 337-44.

**rinkite** Possibly a distinct structure type. See *mosandrite* & *seidozerite.*

**rinkolite** Possibly a distinct structure type. See *mosandrite* & *seidozerite.*

Occurrence: MM 21 575.

**rinmanite** $ZnSbMgFe_2O_7(OH)$. *Nolanite* structure type.

Occurrence & SC-XRD structure: **D Holtstam & 3 others** 2001 CM 39 1675-83.

**rinneite** $K_3NaFeCl_6$. Isostructural with *chlormanganokalite* $K_4MnCl_6$.

Structure: **A Bellanca** 1948 PMR 16 199-213.

**[risörite** $(Y,Er)(Nb,Ti,Ta)(O,OH)_4$.

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

**rittmannite** $(Mn,Ca)^{2+}Mn^2Al_2(PO_4)_2(OH)_2$.8aq. *Jahnsite-whiteite* structure group.

Structure determination not found.

Occurrence: **Y Marzoni Fecia di Cossato P Orlandi G Vezzalini** 1989 CM 27 447-9.

**rivadavite** $Na_6MgB_{24}O_{28}(OH)_{24}$.10aq.

Structure: **A Dal Negro L Ungaretti** 1973 Nw 60 350 (N146).

Occurrence: MM 36 1157.

**riversideite** $Ca_5Si_6O_{16}(OH)_2$.2aq.

Structure determination not found.

Occurrence: **AS Eakle** 1917 Univ California Bull Dept Geol 10 344-6;
**HFW Taylor** 1953 MM 30 155-65.

**roaldite** $(Fe,Ni)_4N$.
Isostructural with *synthetic* $Fe_4C$: **ZG Pinsker SV Kaverin** 1956 SPC 1 48-53.
Structure: **P Bayliss** 1990 CM 28 751-5.
Occurrence: MM 46 %25.
**robertsite** $Ca_6Mn_9O_6(PO_4)_9aq_6.3aq$. *Mitridatite* structure group from crystallography.
Structure determination not found.
Occurrence: **PB Moore** 1974 AM 59 48-59;
**SJ van Kauwenbergh M Cooper-Fleck MR Williams** 1988 MM 52 505-8.
**robinsonite** $Pb_4Sb_6S_{13}$.
Structure: **IV Petrova & 4 others** 1979 SPD 23 448-9;
**A Skowron ID Brown** 1990 AC C46 527-31;
review, **do** 1994 AC B50 524-38 (S1374)
refinement, cation distribution/modular description, **E Makovicky & 4 others** 2004 NJMA 49-67 (10063).
Occurrence & *synthesis*: MM 29 992-3.
Solid solution *zinckenite*/*robinsonite*/*meneghinite*: **KL Pryseth B Mishra HJ Bernhardt** 1998 CM 36 207-13.
*Synthetic* with monoclinic symmetry: **N Wang** 1977 NJMM 501-3.
**rockbridgeite** $(Fe,Mn)Fe_4(PO_4)_3(OH)_5$. Isostructural series with Mn-analog *frondelite*.
Structure: **PB Moore** 1970 AM 55 135-69.
Occurrence: MM 29 993.
**rodalquilarite** $H_3Fe_2(TeO_3)_4Cl$.
Structure: **Y Dasausoy J Protas** 1969 AC B25 1551-8
*synthetic*, **CR Feger & 3 others** 1999 JSSC 143 254-9 (646).
Occurrence: MM 36 1157-8.
**rodolicoite** $FePO_4$. Iso with AlAs analog *alarsite* & Al analog *berlinite*.
Occurrence, XRPD, IR, TEM: **C Cipriani & 3 others** 1997 EJM 9 1101-6 (C987).
**roeblingite** $Pb_2Ca_6(SO_4)_2(OH)_2$ $[Mn(Si_3O_9)_2].4aq$. Review: **Sabelli** p. 41.
Revised composition: **PJ Dunn JA Norberg PB Leavens** 1982 MM 46 341-2.
Structure: **PB Moore J Shen** 1984 AM 69 1173-9 (M1265).
**roedderite** $(Na,K)_2(Mg,Fe)_5Si_{12}O_{30}$. *Osumilite* structure type.
Structure: **T Armbruster** 1989 EJM 1 715-8 (A487).
Occurrence: MM 36 1158.
Chayesite- roedderite series: **E Alietti & 3 others** 1994 MM 58 655-62.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**[rogersite** $Fe_2(SO_4)_3.6aq$. Burning ore. Occurrence: MM 21 575.]
**roggianite** $Ca_{14}(Na,K)[Be_5Al_{15}Si_{28}O_{90}(OH)_{14}](OH)_2.34aq$.
IZA-SC structure code -ROG.
Consortium for Theoretical Frameworks interrupted tetrahedral net 974.
Structure: (ignore earlier papers), **G Giuseppetti & 3 others** 1991 NJMM 307-14 (M1106).
**rohaite** $TlCu_5SbS_2$.
Structure determination not found.
Occurrence: **S Karup-Møller** 1978 Bull Grønland Geol Unders 126 23-45 = AM 65 208-9.
**rokühnite** $FeCl_2.2aq$.
Structure determination not found, but *synthetic* mentioned in **Wells** p 560.
Occurrence & crystallography: **R Hodenberg G Struense** 1980 NJMM 125-30 = AM 66 219.
**rollandite** $Cu_3(AsO_4)_2.4aq$.
Occurrence & SC-XRD structure: **H Sarp R Cerny** 2000 EJM 12 1045-50 (240).
**romanechite / romanéchite** $BaMn^{2+}Mn^{4+}{}_8O_{16}(OH)_4$.
*Manganomelane* mineral group.
Reviews in Mineralogy 25, p 51 covers romanechite.
Structure: **AD Wadsley** 1953 AC 6 433-8 [originally named *psilomelane*];
**S Turner JE Post** 1988 AM 73 1155-61 (T510).
Thermochemistry framework/layer manganese dioxides: **S Fritsch & 3 others** 1998 ChM 10 474-9 (F596).
*Synthetic* $Rb_{0.27}MnO_2$: 2x5 tunnel, **O Tamada N Yamamoto** 1986 MJ 13 130-40 (T376).

**romarchite** SnO. Tetragonal PbO (*litharge*) structure from cell data.
Matches *synthetic*.
Occurrence: **RM Organ JA Mandarino** 1971 CM 10 916;
corrosion of pewter, **RA Ramik RM Organ JA Mandarino** 2003 CM 41 649-57 .·
**roméite / romeite** $(Ca,Fe,Mn,Na)_2(Sb,Ti)_2O_6(O,OH,F)$. *Stibiconite* structure group.
Structure: **O Zedletz** 1932 ZK 81 253.
Crystal chemistry: **J Brugger & 3 others** 1997 CMP 127 136-46 (B1585).
Occurrence: (M1450).
Na-dominant, occurrence: **S Matsubara & 4 others** 1996 MJJ 18 155-60 = AM 82 1264.
*Synthetic* $Ca_2Sb_2O_7$: **M Baccaredda** 1936 Gazz Chim Ital 66 539-43 = MA 8-12.
**römerite / roemerite** $Fe^{2+}Fe^{3+}_2(SO_4)_4.14aq$. Review: **Sabelli** p. 11.
Structure: **L Fanfani A Nunzi PF Zanzani** 1970 AM 55 78-89.
**rondorfite** $Ca_8Mg(SiO_4)_8Cl_2$.
Occurrence & SC-XRD structure: **T Mihajlović & 4 others** 2004 NJMA 179 265-94 (10060).
**ronneburgite** $K_2MnV_4O_{12}$.
Occurrence & SC-XRD: **T Witzke & 5 others** 2001 AM 86 1081-6.
**röntgenite-Ce / roentgenite-Ce** $Ca_2(Ce,La)_3(CO_3)_5F_3$.
Belongs to *bastnaesite-parisite-roentgenite-synchisite* ?polysomatic group.
Structure: **I Oftedal** 1931 ZK 78 462-9;
**G Donnay JDH Donnay** 1953 AM 38 932-63.
Occurrence: MM 30 745.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
**rooseveltite** $BiAsO_4$-alpha. Monoclinic polymorph.
Dimorphic with *tetrarooseveltite* with *scheelite* structure.
Structure: *synthetic*, **D Bedlivy K Mereiter** 1982 AC B38 1559-61;
**T Sejkora T Ridkosil V Srein** 1994 NJMM 40-8 (S1255).
Occurrence: MM 28 737.
**roquesite** $CuInS_2$. *Chalcopyrite* structure group.
Occurrence & crystallography: **P Picot R Pierrot** 1963 BSFMC 86 7-14;
**JK Boorman** 1969 AM 54 1202-3.
Unnamed mineral: $AgInS_2$, Ag analog of *roquesite* in chalcopyrite group. IMA 95-005.
**rorisite** CaFCl. *Matlockite* structure group.
Occurrence: **BV Chesnokov TP Nishanbaev LF Bazhenova** 1990 ZVMO 119 73 = MM 60 680.
*Synthetic*: **BW Liebich D Nicollin** 1977 AC B33 2790-4.

**ROSASITE MINERAL GROUP** Includes:

| | | |
|---|---|---|
| *glaukosphaerite* | $CuNi(CO_3)(OH)_2$ | |
| *kolwezite* | $CuCo(CO_3)(OH)_2$ | |
| *mcguinnessite* | $MgCu(CO_3)(OH)_2$ | |
| *nullaginite* | $Ni_2(CO_3)(OH)_2$ | |
| *pokrovskite* | | |
| *rosasite* | $CuZn(CO_3)(OH)_2$ | |
| *zincrosasite* | $(Zn,Cu)_2(CO_3)(OH)_2$ | inadequate description |

May be part of *malachite* structure group (see).
**rosasite** $(Cu,Zn)_2(CO_3)(OH)_2$. Rosasite structure group.
Structure determination not found.
XRPD: **AC Roberts JL Jambor JD Grice** 1986 PD 1 56-7.
FTIR/EPR/optical absorption, **BJ Reddy F Nieto AS Navas** 2004 NJMM 302-16 (10659).
Occurrence: **EH Nickel LG Berry** 1981 CM 19 315-24.
**roscherite** $Ca_2(Mn,Fe)_5Be_4(PO_4)_6(OH)_4.6aq$. *Greifensteinite* is (Fe,Mn) analog.
*Zanazzite* has similar properties, and may be Mg-rich analog. Chain structure.
Review: **AR Kampf** 1992 AM 77 848-56.
Structure: monoclinic, **L Fanfani & 3 others** 1975 TMPM 22 266-77;

triclinic, **L Fanfani PF Zanazzi AR Zanzari** 1977 TMPM 24 167-78 (F428).

**roscoelite** $K(V,Al,Mg)_2AlSi_3O_{10}(OH)_2$.

*Mica* structure group; one-layer monoclinic subgroup.

Structure: **MF Brigatti & 3 others** 2003 ClCIM 51 301-8.

Occurrence: Devonian red belts, Banffshire, **M van Panhuys-Sigler NH Trewin J Still** 1996 SJG 32 127-32 (V277).

**ROSELITE STRUCTURE GROUP** Includes:

| | |
|---|---|
| *brandtite* | $Ca_2Mn(AsO_4)_2.2aq$ |
| *kröhnkite* | $Na_2Cu(SO_4)_2.2aq$ |
| *roselite* | $Ca_2(Co,Mg)(AsO_4)_2.2aq$ |
| *wendwilsonite* | $Ca_2Mg(AsO_4)_2.2aq$ |
| *zincroselite* | $Ca_2Zn(AsO_4)_2.2aq$ |

Polymorphic relation with *fairfieldite* structure group.

*Synthetic* $Ca_2(Mn/Cd)(SO_4)_2.2aq$ & $Ca_2(Mn/Cd)(SeO_4)_2.2aq$: SC-XRD structures, **M Wildner D Stoilova** 2003 ZK 218 201-9 (9128).

Natural & *synthetic* compounds with roselite/ *kröhnkite* chain: **M Fleck U Kolitsch B Hertweck** 2002 ZK 217 435-43 (8220).

**roselite/ roselite-alpha** $Ca_2(Co,Mg)(AsO_4)_2.2aq$. Roselite structure group.

Dimorphic with *roselite-beta* in *fairfieldite* group.

Structure: **NM Mustafayev VV Ilyukhin NV Belov** 1965 DAN 155 122-5 = MA 18-87; **FC Hawthorne RB Ferguson** 1977 CM 15 36-42.

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

Dimorphic with *roselite-alpha* in roselite group.

Structure determination not found.

Occurrence: **C Frondel** 1955 AM 40 828-33.

**rosemaryite** $(Na,Ca,Mn)(Mn,Fe)(Fe,Mg)Al(PO_4)_3$. *Wyllieite* structure group.

Structure determination not found.

Occurrence: **PB Moore J Ito** 1979 MM 43 227-35.

**rosenbergite** $AlF_3.3aq = AlF[F_{0.5}aq_{0.5}]_4.aq$.

Structure: **F Olmi C Sabelli R Trosti-Ferroni** 1993 EJM 5 1167-74.

**rosenbuschite** $(Ca,Na)_3(Zr,Ti)Si_2O_8F$.

*Wöhlerite/låvenite* supergroup, *wöhlerite* structure group.

Structure: **RP Shibaeva VI Simonov NV Belov** 1963 SPC 8 406-13 (S1260) = MA 17-22; **RP Shibaeva NV Belov** 1964 DAN 143 113-6 = MA 17-141.

**rosenhahnite** $Ca_3Si_3O_8(OH)_2$. Isolated $SiO_3OH$ tetrahedra.

Structure: **JW Jeffery PF Lindsley** 1973 N 241 42-3; **C Wan S Ghose GV Gibbs** 1977 AM 62 503-12.

Occurrence: **AYe Zadov & 7 others** 2000 ZVMO 129 85-96 = AM 87 184.

**roshchinite** $Ag_{19}Pb_{10}Sb_{51}S_{96}$.

Structure determination not found.

Occurrence: **EM Spiridonov & 4 others** 1990 DAN 312 197-200 = AM 77 450; **do** 1990 ZVMO 119 32-43 (S1351).

**rosiaite** $PbSb_2O_6$.

Occurrence & structure: **R Basso & 3 others** 1996 EJM 8 487-92 (B1518).

*Synthetic*, structure: **RJ Hill** 1987 JSSC 71 12-8.

Review of $MSb_2O_6$ structures: (B1518).

**rosickyite** S-gamma. Trimorphic with *sulfur-alpha* & *garibaldite*-S-beta.

Structure: **Y Watanabe** 1974 AC B30 1396-401 = MA 75-162.

Occurrence: MM 23 637; **N Meisser KJ Schenk JE Spangenburg** 2000 SMPM 80 299-303 (779); Death Valley CA, **S Douglas H Yang** 2002 G 30 1075-8 (8441).

**rosiérésite** Ignore. Amorphous.

**rossite** $CaV_2O_6.4aq$.

Structure: **FR Ahmed WH Barnes** 1963 CM 7 713-26.

Occurrence: MM 21 575.

**rösslerite / roesslerite** $MgH(AsO_4)_4.7aq$.

Isostructural with P analog *phosphorösslerite*. Dehydrates to *brassite* 4aq.

Structure: **G Ferraris A Franchini-Angela** 1973 AC B29 286-92;
**A Whitaker** 1973 ZK 137 194-219;
**RLT Street A Whitaker** 1973 ZK 137 246-55.

**rossmanite** $void(LiAl_2)Al_6B_3Si_6O_{27}(OH)_4$. *Tourmaline* structure type.

Description & structure: **JB Selway & 5 others** 1998 AM 83 896-900.

Mn-bearing "oxyrossmanite": occurrence, SC-XRD structure, **A Ertl & 4 others** 2005 AM 90 481-7.

**rostite** $Al(SO_4)(OH,F).5aq$.

Supposed analog of *khademite* $Al(SO_4)(F,OH).5aq$; confused literature in **V Zacek** 1988 NJMM 476-80 = AM 74 951; MM 43 1066.

[jvs: assumes that *rostite* & *khademite* will ultimately be accredited.]

Review: **Sabelli** p.10.

**rouaite** $Cu_2(NO_3)(OH)_3$. Dimorphic with *gerhardtite*.

Occurrence & SC-XRD structure: **H Sarp R Cerny L Guenee** 2001 Riviera Scientific 85 3-12 = AM 87 998.

**roubaultite** $Cu_2(UO_2)_3(CO_3)_2O_2(OH)_2.4aq$.

Review: (E289); **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.

Structure: **D Ginderow F Cesbron** 1985 AC C41 654-7 (G797).

Occurrence: MM 38 998.

**rouseite** $Pb_2Mn(AsO_3)_2.2aq$. Crystallographic relation to *trigonite*.

Structure determination not found.

Occurrence & crystallography: **PJ Dunn & 3 others** 1986 AM 71 1034-6.

**routhierite** $(Tl,Cu,Ag)(Hg,Zn)(As,Sb)S_3$. Isotypic with *stalderite* $(Tl,Cu)(Zn,Fe,Hg)AsS_3$.

Dimorphic with *christite*.

Occurrence & crystallography: **Z Johan J Mantienne P Picot** 1974 BSFMC 97 48-53.

**rouvilleite** $Na_3(Ca_{1.7}Mn_{0.3})(CO_3)_3F$.

Structure determination: **NA Yamnova & 3 others** 1991 Kr 36 30-3.

Occurrence: **AP Khomyakov et al** 1991 Vest Mosk Univ Se 4 Geologiya 1 85-8;
**AM McDonald GY Chao RA Ramik** 1991 CM 29 107-11;
in hyperagpaitic alkaline rocks, **Khomyakov** 1995.

**rouxelite** $Cu_2HgPb_{22}Sb_{28}S_{64}(O,S)_2$.

Occurrence: Apuan Alps, & SC-XRD structure: **P Orlandi & 4 others** 2005 CM 43 919-33.

**roweite** $Ca_2Mn_2B_4O_7(OH)_6$. Isostructural series with Mg analog *fedorovskite*.

Structure: **PB Moore T Araki** 1974 AM 59 60-5;
**NA Yamnova MA Simonov NV Belov** 1975 SPD 20 240-6 (Y121).

Occurrence: MM 24 622.

**rowlandite** $?Y_4FeSi_4O_{14}F_2$. Amorphous.

Review: (different composition) **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

**roxbyite** $\sim Cu_{1.5}Fe_{0.02}S$. Structure possibly related to *low-chalcocite* & *djurleite*.

Occurrence & crystallography: **WG Mumme GJ Sparrow GS Walker** 1988 MM 52 323-30.

Check for *synthetic*.

Occurrence: MM 52 730.

| **ROZENITE STRUCTURE GROUP** | Includes |
|---|---|
| *aplowite* | $(Co,Mn,Ni)SO_4.4aq$ |
| *boyleite* | $(Zn,Mg)SO_4.4aq$ |
| *ilesite* | $(Mn,Zn,Fe)SO_4.4aq$ |
| *rozenite* | $FeSO_4.4aq$ |
| *starkeyite* | $MgSO_4.4aq$ |

**rozenite** $FeSO_4.4aq$. *Rozenite* structure type. Review: Sabelli p.12.

Structure: **WH Baur** 1962 AC 15 815-26.

Distinct from *siderotile* 5aq: **P Bayliss** 1987 MM 51 176.

Melanterite-rozenite equilibria: **I Chou RR Seal II BS Hemingway** 2001 AM 87 108-14.
**ruarsite** RuAsS. *Arsenopyrite* structure group.
XRPD matches *synthetic*: **F Hulliger** 1964 N 201 381-2.
Occurrence & crystallography: **T Yu H Chou** 1979 Sci BullChina 24 310-6 = AM 65 1068.
**rubicline** $(Rb,K)AlSi_3O_8$. *Feldspar* group.
Occurrence & crystallography: **DK Teertstra & 5 others** 1998 AM 83 1335-9.
**ruby** see corundum.
**rucklidgeite** $(Bi,Pb)_3Te_4$. *Tetradymite* mineral/structure group, *josëite* subgroup.
Structure: **P Bayliss** 1991 AM 76 257-65.
Solid solution $(Pb,Ag,Bi,Sb)_3Te_4$ in Yanahara specimen: **K Kase I Kusachi S Kishi** 1993 CM 31 99-104.
Occurrence: MM 42 529.
**rudenkoite** $Sr_3Al_{3.5}Si_{3.5}O_{10}(OH_{7.5}O_{0.5}).aq$.
Occurrence & XRD: **NV Chukanov & 4 others** 2004 ZVMO 133 (3) 37-41.
**ruitenbergite** $Ca_9B_{26}O_{34}(OH)_{24}Cl_4.13aq$. Dimorph of *pringleite*.
Structure: **JD Grice PC Burns FC Hawthorne** 1994 CM 32 1-14 (G707).
Occurrence: MM 60 681.
**ruizite** $CaMnSi_2O_6OH.2aq$.
Structure: **FC Hawthorne** 1984 TMPM 33 135-46;
**PB Moore T Araki** 1985 AM 70 171-81.
Occurrence: MM 42 529.
**rusakovite** $(Fe,Al)_5(V/PO_4)_2(OH)_9.3aq$. Structure determination not found.
Occurrence: **EA Ankinovich** 1960 ZVMO 89 440-7 = AM 45 1316.
**russellite** $Bi_2WO_6$. Isostructural with *koechlinite*.
Structure: *synthetic*, **RW Wolfe RE Newnham MI Kay** 1969 Solid State Comm 7 1797-801;
**VK Yanovskii & 3 others** 1975 DAN 222 94-5;
**KS Knight** 1992 MM 56 399-409.
Polymorphism: **A Watanabe** 1982 JSSC 41 160-5.
Occurrence: MM 25 643.
**rustenburgite** $(Pt,Pd)_3Sn$.
Isostructural with *atokite* $(Pd,Pt)_3Sn$ & *zvyagintsevite* $(Pd,Pt,Au)_3(Pb,Sn)$.
Occurrence & crystallography: **P Mihaalik SA Hiemstra JPR deVilliers** 1975 CM 13 146-50.
Occurrence in meteorites: **AE Rubin** 1997 MPS 32 733-4.
**rustumite** $Ca_{10}(Si_2O_7)_2(SiO_4)Cl_2(OH)_2$.
Structure: **RA Howie VV Ilyukhin** 1977 N 269 231;
**NN Nevskii VV Ilyukhin NV Belov** 1980 SPC 24 598-600;
**NN Nevskii RA Khaui NV Belov** 1980 SPC 24 812-4.
Occurrence: MM 35 1151.
**ruthenarsenite** RuAs. MnP structure type.
XRPD matches *synthetic*: **RD Heyding LD Calvert** 1961 Can J Chem 39 955-7.
Occurrence: **DC Harris** 1974 CM 12 280-4 (H1036).
**ruthenium** Ru. Hexagonal closest packing of spheres.
Isostructural with *osmium* & *rhenium*.
[Flattened hcp also occurs in metals: eg *schachnerite* $Ag_{1.1}Hg_{0.9}$-beta & *weishanite* (Au,Ag,Hg).]
Occurrence: **Y Urashima & 3 others** 1974 MJJ 7 438-44;
**J Jedwab** 1990 MP 43 137-46.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.
**rutheniridosmine** ((Os,Ir,Ru,etc.) Redefined, MR 30 175.
Occurrence in Ohil Hills, Scotland: **P Davidson** 1995 J Russell Soc 6 54-5.
**ruthenosmiridium** (Ir,Os,Ru).
Presumably *copper* structure group with cubic closest packing of spheres.
Occurrence: **DC Harris LJ Cabri** 1973 CM 12 104-12 [= *iridium*, MR 30 175, reviewer would prefer fewer mineral species].
**rutherfordine** $UO_2(CO_3)$. Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
Structure: **CL Christ JR Clark HT Evans Jr** 1955 S 121 472-3 (C45);

**DT Cromer PE Harper** 1955 AC 8 847-8;
revised, **RJ Finch & 3 others** 1999 CM 37 929-38.

EXAFS: **HA Thompson GE Brown Jr GA Parks** 1997 AM 82 483-96.

Enthalpy of formation: **OA Devina El Sergeeva IL Khodakosky** 2003 GI 41 1108-17;
**K Kubatko & 3 others** 2005 AM 90 1284-90.

**RUTILE STRUCTURE GROUP**. Includes:

| | |
|---|---|
| *argutite* | $GeO_2$ |
| *cassiterite* | $SnO_2$ |
| *[ilmenorutile* | $(Ti,Nb,Fe)O_2$] |
| *paratellurite* | $TeO_2$ |
| *plattnerite* | $PbO_2$ |
| *pyrolusite* | $MnO_2$ |
| *rutile* | $TiO_2$ |
| *sellaite* | $MgF_2$ |
| *squawcreekite* | $(Fe,Sb,Sn)O_2$ |
| *stishovite* | $SiO_2$ |
| *strüverite* | $(Ti,Ta,Nb,Sn,Fe)O_2$ |
| *tripuhyite* | $FeSbO_4$ |

Review: **WH Baur** 1994 ZK 209 143-50 (B1209);
**WH Baur AA Khan** 1971 AC B27 2133-9.

Structural-electronic properties of rutile family: **JK Burdett** 1995 AC B51 547-58;
molecular-orbital calculation, **J Mimaki T Tsuchiya T Yamanaka** 2000 ZK 215 419-23 (M1830).

Sb-rich, occurrence: **DC Smith E Perseil** 1997 MM 61 655-69.

Exsolution of *ferrocolumbite,* pegmatite, Greenbushes, Australia: **M Klementova M Rieder** 2004 CM 42 1859-70.

*Synthesis*: kinetics of oxidation in air of Ti at 1123 K, **KA Solntsev & 3 others** 2004 Inorg Mater 40 829-32 (10643).

*Synthetic* $(Ge/Ru/Sn/Ir)O_2$, NPD structure; crystal chem. $(Ti/V/Cr/Mn/Nb/Ru/Ir/Si/Ge/Sn/Pb)O_2$:
**AA Bolzan & 3 others** 1997 AC B53 373-80 (B1639).

*Synthetic* $(Si/Ge/Sn)O_2$, XRD, charge density: **T Yamanaka R Kurashima J Mimaki** 2000 ZK 215 424-8 (Y268).

*Synthetic* $FeF_2$: **MJM de Almeida MMR Costa JA Paixao** 1989 AC B45 549-55.

*Synthetic* $MnF_2$: NPD, **W Jauch GJ McIntyre AJ Schulz** 1990 AC B46 739-42.

*Synthetic* $NbO_2$: high-T polymorph 1300 K, NPD, **AA Bolzan & 3 others** 1994 JSSC 113 9-14 (B1171).

*Synthetic* $Fe_{0.5}Ti_{0.5}O_2$ & $Fe_{0.45}Nb_{0.53}O_2$: MA 81-2414;

*Synthetic* $Mn_{1-x}Sb_{1+x}O_4$ (W682).

*Synthetic* $Al(O,F)_2$: **A Kutoglu** 1992 ZK 199 197-201.

*Dirutile type*, $LiCoF_4$: 1989 JSSC 79 1-11.

*Trirutile structure type*:
$Li(Nb/Ta)WO_6$, **W Viebahn W Rüdorff HZ Kornelson** 1967 ZN 22B 1218;
**G Blasse ADM de Pauw** 1970 J Inorg Nucl Chem 32 3960;
**JL Fourquet A Le Bail PA Gillet** 1988 MRB 23 1163;
$Co(Sb/Ta)_2O_6$, 1989 JSSC 83 20-30;
$ZnTa_{1.8}Sb_{0.2}O_6$, 1989 ZaaC 568 22-8;
$Li(Nb/Ta)MoO_6$ & proton derivatives, **NSP Bhuvanesh J Gopalakrishnan** 1995 IC 34 3760-4 (B1385);
*staringite* $Fe_{0.5}Sn_{4.5}TaO_{12}$ may belong.

*Synthetic* $(Cr,W)_2O_4$: 1989 ZaaC 569 153.

*Synthetic* $(Ta,Fe,Mn)(O,F)_2$: 1989 JSSC 81 112.

Crystallographic shear relative: zeta-$Nb_2O_5$ (E326).

*Synthetic* $Li_xTi_3O_6$, 2:1 tunnel: **J Akimoto Y Gotoh Y Oosawa** 1997 JSSC 129 7-11 (A741).

*Synthetic* (Cr/Mo/W)-: XRD &EPR, **D Cordischi & 3 others** 2000 JSSC 152 412-20 (C1159).

*Synthetic* FeOF, ED of O/F ordering: **FJ Brink RL Withers JG Thompson** 2000 JSSC 155 359-65 (801).

*Synthetic* $CoF_2$ & $ZnF_2$, electron density: **NJ O'Toole VA Streltsov** 2001 AC B 128-35 (1476).

Particles for polymer encapsulation, XPS & FTIR: **B Erdem & 5 others** 2001 La 17 2664-9 (2142).

**rutile** $TiO_2$. Rutile structure type. Trimorphic with *anatase* & *brookite*.

Structure: **L Vegard** 1916 Phil Mag 32 505-18;
**DT Cromer K Herrington** 1955 JAChS 77 4708-9 (C1114);
cell dimensions vs Ti/O, **ME Straumanis T Ejima WJ James** 1961 AC 14 493-7 (S2070);
**SC Abrahams JL Bernstein** 1971 J Chem Phys 55 3206-11 (A894);
Raman to 40 kbar, **M Nicol MY Fong** 1971 J Chem Phys 54 3167-70 (N513);
lattice dynamics, **JG Traylor & 3 others** 1971 PRB 3 3457-72 (T602);
X-ray band spectra, **DWFischer** 1972 PRB 5 4219-26 (F665);
Raman & structure to 155 kbar, **Y Hara M Nicol** 1979 phys stat sol 94 317-22 (H1421);
**H Shintani S Sato Y Saito** 1975 AC B31 1981-2 (S2067);
**EP Meagher GA Lager** 1979 CM 17 77-85 (M1755);
**W Gonschorek** 1982 ZK 160 187-203 (G1169);
SC-ND, **W Gonschorek R Feld** 1982 ZK 161 1-5 (G1170);
NPD, **TM Sabine CJ Howard** 1982 ACB 38 701-2 (S2068);
NPD, **JK Burdett & 4 others** 1987 JAChS 109 3639-46;
**R Restori D Schwarzenbach JR Schneider** 1987 AC B43 251-7;
NPD, **GJ Howard TM Sabine F Dickson** 1991 B47 462-8 (H989);
high-T, **K Sugiyama Y Takéuchi** 1991 ZK 194 305-13;
electron density using max entropy XRPD, **M Sakata & 3 others** 1992 ACB 48 591-8;
max entropy analysis of ND, **S Kumazawa M Takata M Sakata** 1995 ACA 51 651-8;
chemical state of Fe, **E Murad & 3 others** 1995 MM 59 557-60;
SC-N & XRD of H-bearing, **RJ Swope JR Smyth AC Larson** 1995 AM 80 547-58;
EPR of Fe(III), **TA Egerton & 4 others** 2001 PCCP 3 497-504 (1050);
Nb-, XRPD, **M Okrusch & 5 others** 2003 AM 88 986-95;
charge density & chemical bonding, **B Jinag & 4 others** 2003 ACA 59 341-50 (9114).

STM in ultrahigh vacuum: **GS Rohrer VE Henrich DA Bonnell** 1990 S 250 1239-41 (R733).

Surface interaction of water, TPD/XPS: **MB Hugenschmidt L Gamble CT Campbell** 1994 SuS 302 329-40.

Atomic surface model: **PM Oliver & 3 others** 1997 JMC 7 563-8 (O330).

Adsorption of Co(II) complexes, XAS: **PA O'Day et al** 1996 GCA 60 2515-32 (O338);
**SN Towle GE Brown Jr GA Parks** 1999 JCIS 217 299-311 (198).

Electronic adsorption by Ti (III) in *synthetic* blue: **VM Khomenko & 3 others** 1998 PCM 25 338-46 (K1051).

*Anatase*/rutile stability vs grain size: **AA Gribb JF Banfield** 1997 AM 82 717-28.

Surface XRD of 1x3 superstructure $TiO_{1.68}$ on (100) surface bombarded with Ar & annealed to 1373K: **H Zajonz & 4 others** 1997 EJM Suppl 9-1 21 (Z138).

Surface/electronic structure, photo-catalyst: **SA Bilmes & 3 others** 2000 JPCB 104 9851-8 (85);
**TJ Beck & 5 others** 2004 PRL 93 036104 (10528).

Photo-induced species on hydroxylated surface, IR: **SR Szczepankiewicz & 2 others** 2000 JPCB 104 9842-50 (86).

Photo-catalytic dehydrogenation of 2-propanol on hot surface: **D Brinkley T Engel** 2000 JPCB 104 9836-41(87).

Wet electrons at water/ (110), 2-photon photoemission: **K Onda & 5 others** 2005 S 308 1154-7.

Oxygen vacancies on (110): active for water dissociation, **R Schaub & 6 others** 2001 PRL 87 266104-1-4 (3986);
O-mediated diffusion, **R Schaub & 5 others** 2003 S 299 377-9 (8721);
Time-resolved STM, **E Wahlstrom & 7 others** 2004 S 303 511-3 (9912).

Occurrence: in meteorites: **AE Rubin** 1997 MPS 32 231-47;
carbonaceous chondrites: **A Greshake & 3 others** 1996 S 272 1316-8 (G853).

High-P transformation to *baddeleyite* & *scrutinyite*: **H Sato & 5 others** 1991 S 251 786-8 (S1802);
**L Gerward JS Olsen** 1997 JAC 30 259-64 (G964).

Occurrence of *scrutinyite* type inside *garnet* of *diamond*-bearing granite: **S Hwang P Shen H Chu T Yui** 2000 S 288 321-4 (H1465).

P-T of *anatase, brookite* & rutile, & TiO-II (alpha-PbO type): **F Dachille PY Simons R Roy** 1968 AM 53 1929 (D784).

High-T calorimetry, nanocrystalline rutile, *anatase & brookite*: **MR Ranade & 9 others** 2002 PNAS 99 6476-81 (7173).

Exsolution of scandian & tungstenian Nb-Ta-Ti-Fe-Mn phases: **P Cerny R Chapman** 2001 CM 39 93-102.

Direct extraction of Ti: **M Freemantle** C&EN 9/25 12-3 (199).

*Synthetic* Ti/Sn/Ge/$RuO_2$ & $MnF_2$, bulk moduli & high-P structure, **RM Hazen LW Finger** 1981JPCS 42 143-51 (H1423).

*Synthetic* Cr(Ge/Te/Ti/Sn)$O_6$: **J Isasi ML Veiga C Pico** 1996 JMSL 15 1022-4 (I144).

*Synthetic* $CuF_2$: **PC Burns FC Hawthorne** 1991 PD 6 156-8 (B1612).

*Synthetic* Al-doped, XRPD & FTIR: **U Gesenhues T Rentschler** 1999 JSSC 143 210-8 (G1156).

*Cassiterite*-rutile, Mössbauer: **VS Urusov DA Khramov K Langer** 1999 EJM 11 295-8 (U360).
Magneto-optical devices, room-T ferromagnetism, transparent transition-metal-doped: **Y Matsumoto & 9 others** 2001 S 291 854-6 (1054).
OH absorption, NRA, FTIR: **J Maldener & 3 others** 2001 MP 71 21-9 (1421).
Trace elements, from eclogite & garnet mica schist: **T Zack & 3 others** 2002 CG 184 97-122 (7028).
Heat capacity, entropy: **D de Ligny P Richet EF Westrum Jr J Roux** 2002 PCM 29 267-72 (7758).
Photoreactivity, nano-$TiO_2$ doped Nd (III)/Pd(II)/Pt(IV)/Fe(III): **SI Shah & 4 others** 2002 PNAS 99 6482-6 (7174).

Rutile-type $TiO_2$ & Magnéli-phases $V_nO_{2n-1}$: **H Katzke R Schögl** 2003 ZK 218 432-9 (9167).
Ca surface complex at water <523 K, model: **MK Ridley & 3 others** 2004 GCA 68 239-51 (9792).
Hydrogen adsorption on 110 surface: **M Kunat U Burghaus C Woll** 2004 PCCP (10733).
Zr substitution as thermometer: **T Zach R Moraes A Kronz** 2004 CMP 148 471-88 (10901).
*Synthetic* H & Fe plus Al/Ga/Cr/Mg/Ca, 2 GPa 1373 K: **GD Bromiley N Hilairet** 2005 MM 69 345-58.
**rynersonite** $Ca(Ta,Nb)_2O_6$. *Aeschynite* structure type.
*Synthetic* $CaTa_2O_6$: **L Jahnberg** 1963 Acta Chem Scand 17 2548-59.
Occurrence: MM 43 1066.