

Mineral structures U-Z

Updated 092306 by J V Smith

uchucchacuaite $\text{AgMnPb}_3\text{Sb}_5\text{S}_{12}$. *Andorite* series.

Occurrence: MM 50 759.

uduminelite $\text{Ca}_3\text{Al}_8(\text{PO}_4)_2\text{O}_{12}\cdot 2\text{aq}$.

Occurrence: MM 39 929.

ufertite $20\text{FeO}\cdot 8\text{Fe}_2\text{O}_3\cdot 4\text{REE}\cdot 74\text{TiO}_2$.

Occurrence: MM 31 974.

uhligite $\text{Ca}_3(\text{Ti,Al,Zr})_9\text{O}_{20}$.

uklonskovite $\text{NaMg}(\text{SO}_4)\text{F}\cdot 2\text{aq}$.

Structure: **SV Borisov RF Klevstova NV Belov** 1964 DAN 158 94-7 = MA 18-245;

SV Borisov FA Brusentsev 1965 J Struct Chem SSSR 6 753-5;

C Sabelli 1985 BM 108 133-8 (S1516).

Occurrence: MM 33 1158.

[jvs: Sabelli argues that the original composition incorrectly had OH instead of F.]

ulexite $\text{NaCaB}_5\text{O}_6(\text{OH})_6\cdot 5\text{aq}$.

Structure: **JR Clark DE Appleman** 1964 S 145 1295-6 = MA 18-86;

S Ghose C Wan JR Clark 1978 AM 63 160-71;

boron K-edge XANES, **ME Fleet S Muthupari** 2000 AM 85 1009-21.

ullmannite NiSbS . *Cobaltite* structure group.

Structure: **Y Takéuchi** 1957 MJJ 2 90-102;

P Bayliss 1977 AM 62 369-73;

cobaltian, **JL Pratt P Bayliss** 1980 AM 65 154-6;

P Bayliss 1986 CM 24 27-33.

Synthetic substitutions: **P Bayliss** 1969 AM 54 426-30.

ulrichite $\text{CaCu}(\text{UO}_2)(\text{PO}_4)_2\cdot 4\text{aq}$.

Structure: SC-XRD, **U Kolitsch G Giester** 2001 MM 65 717-24.

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

Occurrence: **WD Birch WG Mumme ER Segnit** 1988 Austral Min 3 125 = MM 54 670.

[Originally defined as cubic UO_2 : MM 21 579-80.

ulvöspinel Fe_2TiO_4 . *Spinel* structure group.

Structure: XR & N, **RH Forster EO Hall** 1965 AC 18 857-62;

ferrian-, **MZ Stout P Bayliss** 1980 CM 18 339-41.

Definition: MM 28 740.

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

umangite Cu_3Se_2 .

Structure: **N Morimoto K Koto** 1986 S 152 345 (M311).

umbite $\text{K}_2(\text{Zr,Ti})\text{Si}_3\text{O}_9\cdot \text{aq}$. Dimorphic with monoclinic *kostylevite*.

Related to *paraumbite* with double c. CTF octahedral-tetrahedral net 1130.

Structure: **GD Ilyushin & 6 others** 1981 SPD 26 118-20 (I110);

Ti substitution, etc, **GD Ilyukhin** 1993 IMA 29 1128-33 (I102).

Occurrence: MM 48 584-5.

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

Synthetic $\text{K}_2\text{ZrSi}_3\text{O}_9\cdot \text{aq}$, XRPD structure, orthorhombic cell: **DM Poojary & 3 others** 1997 IC 36 3072-9 (P682).

Synthetic Ti-endmember labeled AM-2: XRPD, NMR & SEM, **Z Lin & 7 others** 1997 JPCB 101

7114-20 (L857), **do & 5 others** 1999 JPCB 103 957-63 (L974);

XRPD, **SR Jale A Ojo FR Fitch** 1999 ChC 411-2 (J335).

Synthetic $\text{K}_2\text{TiSi}_3\text{O}_9\cdot \text{aq}$: structure, **MS Dadachov A Le Bail** 1997 Eur J Solid State Inorg Chem 34 381-90;

SC-XRD structure, **X Zou MS Dadachov** 2000 AC C56 738-9 (Z223);

synthesis, characterization & ion-exchange to Na & H derivatives, **AI Bortun & 4 others** 2000 ChM 12 294-305 (B1990).

Ion-exchanged (NH₄/Li/Na/Rb/Cs), NMR, XRPD structure: **V Valtchev & 3 others** 1999
 MMM 32 287-96 (V357).

umbozerite Na₃Sr₄ThFeSi₈O₂₄OH. Metamict. MM 40 915.
 Occurrence in hyperagpaitic alkaline rocks (revised formula): **Khomyakov** (1995).

umohoite UO₂MoO₄.4aq. Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
 Structure: **SR Kamhi** 1959 AM 44 920-5;
LI Anikina ES Makarov 1961 DAN SSSR 137 942-3;
ES Makarov LI Anikina 1963 Geochemistry 14-21;
 corrected, **P Burns** 1999;
 SC-XRD, **RK Rastsvetaeva AV & 3 others** 2000 DAN 373 202-5 = AM 86 942.
 Occurrence: MM 30 747.
Synthetic alpha-UO₂MoO₄.2aq, different XRPD: **VN Serezhkin VA Efremov VK Trunov** SPC 25 494-7 (S1332).

ungarettiite NaNa₂Mn²⁺₂Mn³⁺₃Si₈O₂₂O₂. *Amphibole* type.
 Structure: **FC Hawthorne & 6 others** 1995 AM 80 165-72 (H1167).
 Occurrence: **Y Kawachi & 3 others** 2002 EJM 14 375-7 (7131).

ungavaite Pd₄Sb₃. See *naldrettite*.
 Occurrence : **AM McDonald & 8 others** 2005 ZVMO 134-4 1735-44.

ungemachite K₃Na₈Fe(SO₄)₆(NO₃)₂.6aq.
 Isostructural with *humberstonite* K₃Na₇Mg₂(SO₄)₆(NO₃)₂.6aq.
 Structure: **LA Groat FC Hawthorne** 1986 AM 71 826-9.
 Occurrence: MM 24 625.
 See *clino-ungemachite* ~K₃Na₉Fe(SO₄)₆(OH)₃.9aq.

upalite Al(UO₂)₃(PO₄)₂O(OH).7aq.
Phosphuranylite mineral group; geometrical isomer uudduuS; beware of problems.
 Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
 Structure: twinned monoclinic pseudo-orthorhombic, **P Piret JP Leclercq** 1983 BM 106 383-9.
 Occurrence: MM 43 1068.

uralborite CaB₂O₂(OH)₄. Dimorphic with *vimsite*.
 Structure: **DP Shashkin MA Simonov NV Belov** 1970 SPD 14 1044-6;
MA Simonov YuK Egorov-Tismenko NV Belov 1977 SPD 22 277-9 (S1303).
 Occurrence: MM 33 1154.

uralolite Ca₂Be₄(PO₄)₃(OH)₃.5aq.
 Layer structure with 3-, 4- (BeBeBeP), & 8-rings.
 Compare *bearsite* & *moraesite*.
 Structure: **K Mereiter G Niedermeyr F Walter** 1994 EJM 6 887-96 (M1207).
 Occurrence: MM 33 1154.

uramphite (NH₄)(UO₂)(PO₄).3aq. *Meta-autunite* structure group from crystallography.
 Structure determination not found.
 Occurrence: **ZA Nekrasova** 1957 Voprosy geologii urana Atomizdat 67-72 = AM 44 464.

urancalcarite Ca(UO₂)₃(CO₃)(OH)₆.3aq.
 Occurrence & crystallography: MM 48 585.

uraninite UO₂. *Fluorite* structure group. Isostructural series with *thorite* ThO₂.
 Structure: **VA Leonova** 1959 DAN SSSR 126 1342-6;
 SC-ND, **M Sakata MJ Cooper KD Rouse BTM Willis** 1978 AC A34 336-41;
 NPD at 293-1733 K, **A Albinati & 4 others** 1980 AC A36 265-70;
 SC-ND, UO_{2.11} & UO_{2.13}, **AD Murray BTM Willis** 1990 JSSC 84 52-7 (M1333).
Synthetic UO_{2.1}: neutron, JSSC 84 52-7.
 Chemistry in Variscan granites: **H Förster** 1999 MM 63 239-52.
 Mechanism of Pb release, natural reactor, Gabon: **J Janeczek RC Ewing** 1995 GCA 59 1917-31.
 Cation substitution, alteration & dating: **P Alexandre TK Kyser** 2005 CM 43 1005-17.

uranmicrolite (U,Ca,Ce)₂(Ta,Nb)₂O₆(OH,F). *Pyrochlore* structure group.
 Structure determination not found.
 Occurrence: **DD Hogarth** 1977 AM 62 403-10.

Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
uranocircite $\text{Ba}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 12\text{aq}$. *Autunite* structure group.
Synthetic: MM 29 976.

uranophane [-alpha] $\text{Ca}(\text{UO}_2)_2(\text{SiO}_3\text{OH})_2 \cdot 5\text{aq}$. Dimorphic with -beta.
Possibly isotypic with *oursinite* $(\text{Co},\text{Mg})(\text{UO}_2)_2\text{Si}_2\text{O}_7 \cdot 6\text{aq}$.
Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
Structure: **DK Smith JW Gruner WH Lipscomb** 1957 AM 42 594-618;
FV Stohl DK Smith 1981 AM 66 610-25;
D Ginderow 1988 AC C44 421-4 (G792);
synthesis, XRD, etc, **F Cesbron P Ildefonse M-C Sichere** 1993 MM 57 301-8.
EXAFS: **HA Thompson GE Brown Jr GA Parks** 1997 AM 82 483-96.
Effect of ionizing radiation: **S Utsunomiya & 4 others** 2003 AM 88 159-66.
Natural *barium uranophane*, incomplete description: MM 32 945.
Compare with *swamboite* $\text{UH}_6(\text{UO}_2\text{SiO}_4)_6 \cdot 30\text{aq}$.
Synthetic $\text{Ba}(\text{NpO}_2)(\text{PO}_4) \cdot \text{aq}$: SC-XRD structure, nuclear waste, **TZ Forbes PC Burns** 2006 AM 91 1089-95.

uranophane-beta $\text{Ca}(\text{UO}_2)_2(\text{SiO}_3\text{OH})_2 \cdot 5\text{aq}$. Dimorphic with [-alpha].
Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
Structure: **DK Smith FV Stohl** 1972 GSA Memoir 135 281-8;
K Viswanathan O Harnett 1986 AM 71 1489-93
SC-XRD, **AV Barinova & 3 others** 2001 CrR 48 12-5 (8792).

uranopilite $(\text{UO}_2)_6(\text{SO}_4)(\text{OH})_{10} \cdot 12\text{aq}$. Review: **Sabelli**, no structure.
Structure: **PC Burns** 2001 CM in press (2012).
Occurrence: **C Frondel** 1958 USGS Bull 1064 135-40.
Compare with *jáchymovite* $(\text{UO}_2)_8(\text{SO}_4)(\text{OH})_{14}$.

uranopolycrase $(\text{U},\text{Y})(\text{Ti},\text{Nb})_2\text{O}_6$. *Columbite* structure group.
Series with *polycrase*-(Y). Nearly metamict.
Occurrence: **G Aurisicchio & 3 others** 1993 EJM 5 1161.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

uranosilite $\text{USi}_7\text{O}_{17}$. Structure determination not found.
Occurrence: **K Walenta** 1983 NJMM 259.

uranospathite $\text{Al}_{1-x}\text{U}_x(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 20\text{aq} + 3x\text{F} - 3x$
Isostructural with *arsenuranospathite* $\text{HAl}(\text{UO}_2)_4(\text{AsO}_4)_4 \cdot 40\text{aq}$ from cell data.
Structure: SC-XRD, **AJ Locock WS Kinman PC Burns** 2005 CM 43 989-1003.
Occurrence: **C Frondel** 1058 USGS Bull 1064 194-5;
K Walenta 1978 MM 42 117-28.

uranosphaerite $\text{Bi}(\text{UO}_2)\text{O}_2\text{OH}$.
Structure: natural & *synthetic*, **K Hughes PC Burns U Kolitsch** 2003 CM 41 677-85.
Occurrence: **R Berman** 42 905-8;
C Frondel 1058 USGS Bull 1064 194-5.

uranospinite $\text{Ca}(\text{UO}_2)_2(\text{AsO}_4)_4 \cdot 10\text{aq}$. *Autunite* structure group.
Structure determination not found.
Occurrence: **C Frondel** 1058 USGS Bull 1064 183-7.
Synthetic $\text{Ca}/\text{H}/\text{Na}/\text{NH}_4$ -: MM 29 984; **ME Mrose** 1953 AM 38 1159-68.

uranotungstite $(\text{Fe},\text{Ba},\text{Pb})(\text{UO}_2)_2(\text{WO}_4)(\text{OH})_4 \cdot 12\text{aq}$.
Structure determination not found.
Occurrence: **K Walenta** 1986 TMPM 34 25-34 (W687) = AM 71 1547.

uranpyrochlore $(\text{U},\text{Ca},\text{Ce})_2(\text{Nb},\text{Ta})_2\text{O}_6(\text{OH},\text{F})$. *Pyrochlore* structure group.
Structure determination not found.
Occurrence: **DD Hogarth** 1977 AM 62 403-10.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

urea $\text{CO}(\text{NH}_2)_2$. [Look for structure of *synthetic*.]
Occurrence: **PJ Bridge** 1973 MM 39 346-8.

urhite $\text{UO}_3 \cdot 2.3\text{-}3.1\text{aq}$.

Occurrence: MM 31 974.

[uric acid dihydrate $C_5H_4N_4O_3 \cdot 2aq$.

Structure: **G Artioli N Masciocchi E Galli** 1997 AC B53 498-503 (A755).

See *weddellite* & *whewellite*.]

[ammonium acid urate] (S256)

uricite $C_5H_4N_4O_3$. [jvs: look for structure of *synthetic*.]

Occurrence: **PJ Bridge** 1974 MM 39 889-90.

Two types: **R Shirley DJ Sutor** 1967 S 159 544 (S256);

R Boistelle C Rinaudo 1981 JCG 53 1-9

ursilite AM 44 464-5.

urusovite $CuAlAsO_5$.

Structure: **SV Krivovichev AV Molchanov SK Filatov** 2000 CrR 45 723-7 (1763) = AM 86 769.

Occurrence: **LP Varsagova & 5 others** 2000 EJM 12 1041-4 (219).

urvantsevite $Pd(Bi,Pb)_2$ -beta. Dimorphic with *froodite* $PdBi_2$ -alpha.

Description: MM 42 531.

usihite $R(UO_2)_2Si_2O_7 \cdot naq$. Occurrence: MM 31 974.

ushkovite $MgFe^{3+}_2(PO_4)_2(OH)_2 \cdot 8aq$. *Paravauxite/laueite* structure group.

Structure: **MA Galliski FC Hawthorne** 2002 CM 40 929-37.

Occurrence: MM 48 585.

usovite $Ba_2CaMgAl_2F_{14}$.

Structure: **AL Litvin & 3 others** 1980 Dopov Akad Nauk Ukr RSR Geol Khim Biol Nauki 47-50.

Occurrence: **AD Nozhkin VA Gavrilenko VA Moleva** 1967 ZVMO 96 63-6 = AM 52 1582;
AM 60-739.

Synthetic $Ba_2Ca[Mn/Fe]V_2F_{14}$, $Ba_2CaMnFe_2F_{14}$, $Ba_2CaCu[Mn/Fe/Ga]_2F_{14}$: SC-XRD
structure, **V Kaiser & 5 others** 2002 ZaaC 628 2617-24 (8326).

ussingite $Na_2AlSi_3O_8(OH)$.

Structure: **G Rossi V Tazzoli L Ungaretti** 1974 AM 59 335-40 (R298);

H MAS-NMR & IR: **EA Johnson GR Rossman** 2004 PCM 31 115-21 (10123).

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

ustarasite $Pb(Bi,Sb)_6S_{10}$.

Structure determination not found.

Occurrence: MM 31 975.

utahite $\sim Cu_5Zn_3(Te^{6+}O_4)_4(OH)_8 \cdot 7aq$.

Occurrence & crystallography: **AC Roberts & 5 others** 1997 MR 28 175-9 = AM 83 187.

uvanite $U^{6+}_2V^{5+}_6O_{21} \cdot 15aq$.

Structure determination not found.

Occurrence: **C Frondel** 1958 USGS Bull 1064 261-3.

uvarovite $Ca_3Cr_2Si_3O_{12}$. *Garnet* structure type.

Structure: **GA Novak GV Gibbs** 1971 AM 56 791-825;

natural, 40%Al substitution for Cr, **H Sawada** 1997 JSSC 132 432-3 (S1801);

Compression moduli to 8 GPa, **K Langer MN Taran AN Platonov** 1997 PCM 24 109-14 (L842).

Cell dimension to 25 GPa, XRPD: **V Diella & 3 others** 2004 AM 89 371-6.

Heat capacity, 4-400 K, anomaly at 9 K: **S Klemme & 3 others** 2005 AM 90 663-6.

Birefringent natural: optics & UV-VIS-IR, **M Wildner M Andrut** 2001 AM 86 1219-30;

SC-XRD structure, **M Andrut M Wildner** 1231-51;

polarized IR, **M Andrut M Wildner A Beran** 2002 EJM 14 1019-26 (8694)..

Synthetic cubic: optics/UV-VIS-IR/SC-XRD, **M Andrut M Wildner** 2002 PCM 29 595-608 (8451).

uvite $(Ca,Na)(Mg,Fe)_3Al_5Mg(BO_3)_3Si_6O_{18}(OH,F)_4$. *Tourmaline* structure group.

Structure: **MC Taylor MA Cooper FC Hawthorne** 1995 CM 33 1215-21.

uytenbogaardtite Ag_3AuS_2 .

Isostructural with Se analog *fischesserite* & Te analog *petzite*. *Garnet* structure type.

Synthetic, XRPD: & structure, **RB Graf** 1968 AM 53 496-500.

Occurrence: **MD Barton et al** 1978 CM 16 651-59;
SB Castor JJ Sjoberg 1993 CM 31 89-98.

"liujinyinite" = : AM 65 810.

[uzbekite $\text{Cu}_3\text{V}_2\text{O}_8.3\text{aq}$.

Occurrence: MM 21 580.]

uzonite As_4S_5 .

Structure: SC-XRD: **L Bindi V Popova P Bonazzi** 2003 CM 41 1463-8.

Occurrence: **VI Popova VO Polyakov** 1985 ZVMO 114 369 = MM 50 760.

vaesite NiS_2 . *Pyrite* structure type.

Structure: **P Bayliss** 1989 AM 74 1168-70;

charge density, **E Nowacki D Schwarzenbach T Hahn** 1991 AC B47 650-9 (N376);

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

Occurrence: MM 27 275.

vajdakite $(\text{MoO}_2)_2\text{aq}_2\text{As}_2\text{O}_5.\text{aq}$.

Occurrence & structure: **P Ondrus & 5 others** 2002 AM 87 983-90.

valentinite Sb_2O_3 . Dimorphic with *senarmontite*.

Structure: **MJ Buerger SB Hendricks** 1937 ZK 98 1-30;

C Svensson 1974 AC B30 458-61.

Gudmundite-antimony mineralization, Quebec ophiolite, late hypogene *kermesite*, *senarmontite* & *valentinite*: **C Normand M Gauthier M Jebrak** 1996 EG 91 149-63 (N408).

valleriite $(\text{Fe,Cu})_4(\text{Mg,Al})_3\text{S}_4(\text{OH})_6$.

Essentially isostructural with *haapalaite* $(\text{Fe,Ni})_4\text{Mg}_3\text{S}_4(\text{OH})_6$.

Structure: **HT Evans Jr R Allmann** 1968 ZK 127 73-93.

vanadinite $\text{Pb}_5(\text{VO}_4)_3\text{Cl}$. *Apatite* structure type.

Structure: **J Trotter WH Barnes** 1958 CM 6 161-73;

Y Dai JM Hughes 1989 CM 27 189-92.

Synthetic iodide, SC-XRD: **F Audubert J Savariault J Lacout** 1999 AC C55 271-3 (A885).

vanadiocarpholite $\text{MnVAl}(\text{Si}_2\text{O}_6)(\text{OH})_4$.

Carpholite group.

Occurrence, XRD structure, TEM: **R Basso & 4 others** 2005 EJM 17 501-7.

VANADIUM BRONZE STRUCTURE GROUP

Includes

		subgroup	
<i>bannermanite</i>	$\text{Na}_{0.7}\text{V}_6\text{O}_{15}$		other
<i>bariandite</i>	$\text{Al}_{0.6}\text{V}_8\text{O}_{20.9\text{aq}}$		straczekite
<i>barnesite</i>	$(\text{Na,Ca})\text{V}_6\text{O}_{16.6\text{aq}}$	hewettite	
<i>bokite</i>	$(\text{Al,Fe})_{1.4}(\text{V,Fe})\text{V}_8\text{O}_{20.7.4\text{aq}}$		straczekite
<i>corvusite</i>	$(\text{Na,K,Ca,Mg})_2\text{V}_8\text{O}_{20.6-10\text{aq}}$		straczekite
<i>fernandinite</i>	$\text{Ca}_{0.6}\text{V}_8\text{O}_{20.10\text{aq}}$		straczekite
<i>fervanite</i>	$\text{Fe}_4\text{V}_4\text{O}_{16.5\text{aq}}$		other
<i>grantsite</i>	$(\text{Na,Ca})\text{V}_6\text{O}_{16.4\text{aq}}$	hewettite	
<i>hendersonite</i>	$\text{Ca}_{1.3}\text{V}_6\text{O}_{16.6\text{aq}}$	hewettite	
<i>hewettite</i>	$\text{CaV}_6\text{O}_{16.9\text{aq}}$	hewettite	
<i>melanovanadite</i>	$\text{CaV}_4\text{O}_{10.5\text{aq}}$		other
<i>metahewettite</i>	$\text{CaV}_6\text{O}_{16.3\text{aq}}$	hewettite	
<i>navajoite</i>	$\text{Ca}_{0.05}(\text{V,Fe})_{10}\text{O}_{24.12\text{aq}}$		other
<i>schubnelite</i>	$\text{Fe}_{2-x}\text{V}_2\text{O}_4(\text{OH})_8$		other
<i>shcherbinaite</i>	V_2O_5		other
<i>straczekite</i>	$(\text{Ca,K,Ba})_2\text{V}_8\text{O}_{20.6\text{aq}}$		straczekite

Review: **HT Evans Jr JM Hughes** 1990 AM 75 508-21.

Synthetic $\text{Na}_{2-x}\text{V}_6\text{O}_{15}$: **AD Wadsley** 1955 AC 8 695-701.

Synthetic $\text{Li}_{1+x}\text{V}_3\text{O}_8$: **do** 1957 AC 10 261-7.

Synthetic $\text{Ag}_{0.7}\text{V}_2\text{O}_5$: **S Andersson** 1965 Acta Chem Scand 19 1371-5.
Synthetic LiV_2O_5 : **J Galy A Hardy** 1965 AC 19 432-5.
Synthetic $\text{Cu}_x\text{V}_4\text{O}_{11}$: **J Galy D Lavaud** 1971 AC B27 1005-9.
Synthetic CsV_2O_5 : **WG Mumme JA Watts** 1971 JSSC 3 319-22.
Synthetic $\text{Ag}_{1.4}\text{V}_4\text{O}_{10}$: **YuN Drozdov EA Kuz'min NV Belov** 1973 SPD 18 290-1.
Synthetic $\text{Ag}_3\text{V}_4\text{O}_{12}$: **do** 1973 SPC 19 36-8.
Synthetic $\text{NaVO}_5 \cdot 1.9\text{aq}$: **A Björnberg B Hedman** 1977 Acta Chem Scand A31 579-84.
Synthetic $\text{Cs}_{0.35}\text{V}_3\text{O}_7$: **K Waltersson B Forslund** 1977 AC B33 775-9.
Synthetic $\text{Cs}_{0.3}\text{V}_3\text{O}_7$: **do** 1977 AC B33 780-4.
Synthetic $\text{Ca}_x\text{V}^{4+}_{2-x}\text{V}^{5+}_{2-x}\text{O}_5$: **A Kutoglu** 1983 ZK 162 263-72.
vanadomalayaite CaVOSiO_4 . *Titanite* structure type.
Structure: **R Basso & 3 others** 1994 NJMM 489-98 (B1208).
vanalite $\text{NaAl}_8\text{V}_{10}\text{O}_{38} \cdot 30\text{aq}$.
Structure determination not found.
Occurrence: **EA Ankinovich** 1962 ZVMO 91 307-14 = AM 48 1180;
FA Kurmakaeva 1972 ZVMO 100 523-6 = AM 57 597.
vandenbrandeite $\text{Cu}(\text{UO}_2)(\text{OH})_4$.
Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
Structure: **A Rosenzweig RR Ryan** 1977 Cryst Chem Comm 6 53-6;
IR & thermal change, **J Cejka** 1994 NJMM 112-20 (C696);
IR & Raman, **IL Botto VL Barone MA Sanchez** 2002 JMS 37 177-83 (6149).
Occurrence: MM 23 638-9.
vandendriesscheite $\text{PbU}_7\text{O}_{22} \cdot 12\text{aq}$.
Structure & implications for mineral paragenesis & corrosion of spent nuclear fuel: **PC Burns**
1997 AM 82 1176-86 (B1574).
Occurrence: MM 28 740; **CL Christ JR Clark** 1960 AM 45 1026-61.
vanmeersscheite $\text{U}(\text{UO}_2)_3(\text{PO}_4)_2(\text{OH})_6 \cdot 4\text{aq}$.
Phosphuranylite mineral group; geometrical isomer *udududS*; beware of problems.
Metavanmeersscheite has 2aq.
Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
Structure determination not found.
Occurrence: **P Piret M Deliens** 1982 BM 105 25-8.
vanoxite $?\text{V}^4_4\text{V}^{5+}_2\text{O}_{13} \cdot 8\text{aq}$. No X-ray data.
Structure determination not found.
Occurrence: **Dana**.
vantasselite $\text{Al}_4(\text{PO}_4)_3(\text{OH})_3 \cdot 9\text{aq}$. Sheet structure similar to *matulaite* & *vashegyite*.
Structure determination not found.
Occurrence & crystallography: **A-M Fransolet** 1987 BM 110 647-56.
vanthoffite $\text{Na}_6\text{Mg}(\text{SO}_4)_4$. Review: **Sabelli** p.35.
Structure: **W Fischer E Hellner** 1964 AC 17 1613.
vanuralite $\text{Al}(\text{UO}_2)_2(\text{VO}_4)_2\text{OH} \cdot 11\text{aq}$. *Metavanuralite* has 8aq.
Structure determination not found.
Occurrence & crystallography: MM 33 1155;
F Cesbron 1970 BSFMC 93 242-8.
vanuranylite $(\text{H}_3\text{O})_2(\text{UO}_2)_2(\text{VO}_4)_2 \cdot \sim 4\text{aq}$.
Structure determination not found.
Occurrence & crystallography: **EZ Buryanova GS Strokova VA Shitov** 1966 ZVMO 94 437-43.
varennesite $\text{Na}_8\text{Mn}_2\text{Si}_{10}\text{O}_{25}(\text{OH},\text{Cl})_2 \cdot 12\text{aq}$.
Unique layer structure but resembles *apophyllite*, *bementite* & *manganpyrosmalite*.
Structure: **JD Grice RA Gault** 1995 CM 33 1073-81.
VARISCITE STRUCTURE GROUP Includes:
mansfieldite $\text{AlAsO}_4 \cdot 2\text{aq}$

<i>scorodite</i>	FeAsO ₄ .2aq
<i>strengite</i>	FePO ₄ .2aq
<i>variscite</i>	AlPO ₄ .2aq
<i>yanomamite</i>	TlAsO ₄ .2aq

Based on vertex-connected tetrahedral net 5 of Consortium for Theoretical Frameworks; the first cation has two water molecules as extra ligands.

Dimorphic with monoclinic *clinovariscite* structure group.

Review crystallography natural/synthetic: **NF Botelho & 3 others** 1994 EJM 6 245-54 (B1151);

S Dick 1997 ZN 52b 1337-40 (D697).

Check *barrandite* & *clinobarrandite*, (Al,Fe)PO₄.2aq: MM 26 335.

Synthetic (In/Tl)AsO₄.2aq: **RCL Mooney-Slater** 1961 AC 14 1140-6 (9291);

P Tarte MT Paques-Ledent 1968 Bull Soc chim France special issue 1750-6.

Synthetic GaAsO₄.2aq: **MT Paques-Ledent P Tarte** 1969 Spectrochim Acta 25A 1115-25;

M Ronis F d'Yvoire 1974 Bull Soc chim France 1-2 78-82.

Synthetic GaPO₄.2aq: **MT Paques-Ledent P Tarte** 1969 Spectrochim Acta 25A 1115-25.

Synthetic CrAsO₄.2aq: **M Ronis F d'Yvoire** 1974 Bull Soc chim France 1-2 78-82.

Synthetic MnSeO₄.2aq: PDF 20-721.

Synthetic CdSeO₄.2aq: PDF 20-186.

Synthetic GaAlSO₄.2aq, XRD, structure: **S Dick** 1997 ZN 52b 1337-40 (D697).

Synthetic InPO₄.2aq (variscite type), InPO₄.aq & InPO₄: **X Tang A Lachgar** 1998 IC 37 6181-5 (9287).

variscite AlPO₄.2aq. *Variscite* structure group.

Structure: **J Borensztajn** 1966 BSFMC 89 428-38 (9289);

R Kniep D Mootz A Vegas 1977 AC B33 263-5 (9288).

Origin of green color: **G Calas & 2 others** 2005 AM 90 984-90.

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

varlamoffite Sn_{1-x} Fe_xO_{2-x}(OH)_x, x ~ 0.33.

Broad XRPD lines; probably a valid mineral requiring redefinition, related to *cassiterite*: **GA**

Siderenko & 6 others 1993 Mineral Zhurnal 15 94-101 = AM 80 850.

Old descriptions: MM 28 740;

AM 34 618;

RG Taylor WR Morgan DN Phillips 1970 MM 37 624-8.

varulite (Na,Ca)Mn(Mn,Fe)₂(PO₄)₃. *Alluardite* structure group from XRPD.

Structure determination not found.

Occurrence: MM 24 625-6;

PB Moore J Ito 1979 MM 43 227-35.

Synthetic NaMn₃(PO₄)(HPO₄)₂: **F Leroux & 5 others** 1995 JSSC 115 240-6 (L633).

vashegyite Al₆(PO₄)₅(OH)₃.23aq.

Layer structure, but no details: **D McConnell** 1974 MM 39 802-6.

Compare with amorphous *bolivarite* & *evansite*.

vasilite (Pd,Cu)₁₆(S,Te)₇. Structure matches *synthetic* Pd₁₆S₇. [jvs: check].

Occurrence & crystallography: **AV Atanosov** 1990 CM 28 687-9.

vasilyevite Hg₂₀O₆I₃Br₂Cl(CO₃).

Structure: SC-XRD, **MA Cooper FC Hawthorne** 2003 CM 41 1173-82.

Occurrence: Clear Creek Claim, CA, **AC Roberts & 7 others** 2003 CM 41 1167-72.

vastmanlandite-Ce (Ce,La)₃CaAl₂Mg₂(Si₂O₇)(SiO₄)₃F(OH)₂. *Dollaseite-Ce/tornebohmite-Ce* polysome. Nearly isotypic with *gatelite-Ce*.

Occurrence & SC-XRD structure: **D Holtstam & 2 others** 2005 EJM 17 129-41 (11030).

vaterite CaCO₃. Trimorphic with *aragonite* & *calcite*.

Structure: **JDC McConnell** 1960 MM 32 534-44;

SR Kamhi 1963 AC 16 770-2;

H Meyer 1969 ZK 128 183-212;

M Sato S Matsuda 1969 ZK 129 405-10.
 Surface structure & morphology: **NH de Leuw SC Parker** 1998 JPCB 102 2914-22.
 Mortar at Florence cathedral: **S Signorelli & 3 others** 1996 MM 60 663-5.
 Uranyl/carbonate/hydroxide coating on pure vaterite, IR, XPS, XRD etc: **A Boughriet & 5 others**
 2000 PCCP 2 1059-68 (B2014).
 Otolith in freshwater fish: **D Lenaz M Miletic** 2000 NJMA 522-8 (296).
 In sulfur spring, Canadian High Arctic: **SE Grasby** 2003 GCA 67 1659-66 (8984).
I Lee SW Han HJ Choi K Kim 2001 *Nanoparticle-directed crystallization of calcium carbonate*,
 AdM 13 1617-20 (3508). [Gold nanoparticles capped with 4-mercaptobenzoic acid etc. to make
 spheres of *vaterite* & *aragonite* needles.]
Synthetic YBO₃: MA 18-15.
Synthetic Cd(II)-doped, EPR: **V Noethig-Laslo L Brecevic** 2000 PCCP 2 5328-32 (673).
vaughanite TIHgSb₄S₇.
 Structure determination not found.
 Occurrence & crystallography: **DC Harris AC Roberts** 1989 MM 53 79-83 (H944).
vauquelinite Pb₂Cu(CrO₄)(PO₄)OH. Review: (E289). Chain structure.
 Structure: **L Fanfani PF Zanazzi** 1968 ZK 126 433-43.
vauxite FeAl₂(PO₄)₂(OH)_{2.6aq}.
 Contains same vertex-linked octahedral chain as *johnwalkite*, *montgomeryite* & *olmsteadite*.
 Structure: **WH Baur BR Rao** 1968 AM 53 1025-8.
väyrynenite MnBePO₄(OH,F). *Datolite-gadolinite-herderite* mineral group.
 Structure: **ME Mrose DE Appleman** 1962 ZK 117 16-36 (M58);
 Fe-substituted, SC-XRD, **DMC Huminicki FC Hawthorne** 2000 CM 38 1425-32.
 Occurrence: MM 30 748.
veatchite Sr₂B₁₁O₁₆(OH)_{5.aq}. Trimorphic with *veatchite-A* & *p-veatchite*.
 Cell dimensions match *biringuccite* Na₄B₁₀O₁₆(OH)_{2.2aq}, but compositions do not.
 Structure: **JR Clark CL Christ** 1971 AM 56 1934-54;
IM Rumanova O Gandymov NV Belov 1971 SPC 16 236-40 (R514);
JR Clark CL Christ 1968 Nw 55 648.
veatchite-A Sr₂B₁₁O₁₆(OH)_{5.aq}. Trimorphic with *veatchite* & *p-veatchite*.
 Structure determination not found.
 Occurrence: MM 25 647; **I Kumbasar** 1979 AM 64 362-6.
veatchite-p Primitive polymorph of *veatchite*. Definition: MM 32 985.
veenite Pb₂(Sb,As)₂S₅.
 Structure determination not found.
 Occurrence: **JL Jambor** 1967 CM 9 7-24.
velikite ~Cu₂HgSnS₄. Structure similar to *stannite* Cu₂FeSnS₄.
 Structure: **LN Kaplunnik EA Pobedimskaya NV Belov** 1977 SPC 22 99-100 (V204).
 MM 42 531; MM 52 731.
Synthetic: **YK Kabalov TL Evstigneeva EM Spiridonov** 1998 CrR 43 16-20 (K1037).
 Mineral description: **VS Gruzdev & 8 others** 1997 ZVMO 4 71-4 = AM 83 1118-2.
verbeekite PbSe₂. Monoclinic polymorph of orthorhombic *synthetic*.
 May be substructure of *calaverite*.
 Occurrence & XRPD: **AC Roberts & 5 others** 2002 MM 66 173-9.
vergasovaite Cu₃O(Mo,S)O₄SO₄.
 Structure: SC-XRD, *synthetic* S-free, **P Berlepsch & 4 others** 1999 EJM 11 101-10 (B1901).
 Occurrence & XRD: **EY Bykova & 5 others** SMPM 78 479-88 (A869).
vermiculite (Mg,Fe,Al)₃(Al,Si)₄O₁₀(OH)_{2.4aq}. Group name.
 Structure: **JW Gruner** 1934 AM 19 557-75;
SB Hendricks ME Jefferson 1938 AM 23 851-62;
A Grudemo 1954 Swedish Cement Concrete Res Inst Proc 22;
 Mg-, **AM Mathieson GF Walker** 1954 AM 39 231-55;
 Mg-, **AM Mathieson** 1958 AM 43 216-27;
 water, **WF Bradley JF Serratos** 1960 Clays Clay Minerals Proc 7th Clay Conf 260-70;

2-layer Mg-, **H Shirozu SW Bailey** 1966 AM 51 1124-43 (S182);
 water, ND of Na/Ni-exchanged, **NT Skipper et al** 1991 JCP 94 5751-60 (S1211);
 de- & rehydration phlogopitic Mg-, **H Graf von Reichenbach J Bayer** 1994 CIM 29 327-40;
 hydrated Ca-, ND, **NT Skipper AK Soper MV Smalley** 1994 JPC 98 942-5 (S1593);
 hydrated Li-, ND, **NT Skipper & 4 others** 1995 JPC 99 14201-4 (S1521);
 de- & rehydration phlogopitic Ca-, **H Graf von Reichenbach J Bayer** 1995 CIM 30 273-86;
 K/Ca exchange in phlogopite-, far-IR, **R Badreddine R Le Dred R Prost** 2002 CIM 37 59-70 (6982);
 K/Rb/Cs & Na/Ca exchange in phlogopite-, far-IR, **do** 2002 CIM 37 71-81 (6983);
 K/Ca/NH₄ exch, far-IR, **VP Angelou J Lumbanraga** 2002 SSSAJ 66 445-55 (6626);
 9 natural, XRD/Mössbauer/NMR, **R Badreddine & 5 others** 2002 CIM 37 367-76 (7534);
 surface, contact mode AFM, **C Marcos & 3 others** 2004 EJM 16 597-607 (10621).

Metamorphic product series from *chlorite*: **MD Ruiz Cruz** 1999 EJM 11 533-48 (C1111);
 metaclasts, Betic Cordillera, Spain, XRD/TEM/EPMA, **MD Ruiz Cruz JM Nieto** 2006 CM 44 249-65.

Acidification by different trees, vermiculite placed in soil: **L Augusto & 3 others** 2001 Eur J Soil Sci 52 41-92 (1764).

Fingerprinting from bulk chemistry: **ME Gunter & 4 others** 2005 AM 90 749-54.

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

Nickel-vermiculite with 9% NiO: MM 31 968.

Synthetic hexamethylene-diamine- complex: **DJ Haase EJ Weiss H Steinfink** 1963 AM 48 261-70.

Synthetic H-/D-trimethylammonium pillared, elastic/inelastic N scattering: **Y Fan & 3 others** 1992 JCP 96 7064 (F498).

Synthetic butyl-ammonium, ND: **J Swenson & 4 others** 1997 La 13 6654-7 (S1857).

Synthetic TMA-exchanged: **A Vahedi-Faridi S Guggenheim** 1997 CICIM 45 859-66 (V298).

Synthetic La-, SC-XRD structure: **PG Slade PG Self JP Quirk** 1998 CICIM 46 629-35 (S2017).

Synthetic di/tri-methyl ammonium-exch, SC-XRD structure: **A Vahedi-Faridi S Guggenheim** 1999 CICIM 47 36-47.

Synthetic tetramethyl phosphonium-exch, SC-XRD structure: **do** 1999 CICIM 47 219-25 (V347).

Synthetic Al-pillared: **FJ del Rey-Perez-Caballero G Poncelet** 2000 MMM 37 313-27 (D811).

Synthetic U(6+) sorption complex, XANES, EXAFS, **EA Hudson & 8 others** 1999 CICIM 47 439-57 (H1439).

Synthetic Na-, revised interlayer structures 1-/2-layer hydrates: **J Beyer H Graf von Reichenbach** 2002 CIM 37 157-68.

Cs adsorption, EXAFS: **BC Bostick & 3 others** 2002 EST 36 2670-6 (7394).

K/Rb/Cs/ NH₄-exchanged, IR & XRD, **M Diaz E Huard R Prost** 2002 CICIM 50 284-95 (7144).

HTMA-order & influence of solvents: **PG Slade WP Gates** 2004 CICIM 52 204-10 (20228).

vernadite Mn(OH)₄.
 Structure: **FV Chukhrov & 4 others** 1987 ?
 Occurrence: MM 27 275.
 Possible new mineral: **MF Hochella & 4 others** 2005 AM 90 718-24.

verplanckite Ba₁₂Cl₉[(Mn²⁺,Fe,Ti)₆(OH,O)₄(Si₄O₁₂)₃](OH,aq)₇.
 Three square pyramids containing divalent Mn/quadrivalent Ti share (OH,O) vertex, 4-ring of SiO₄ tetrahedra, channels with 7 Å diameter.
 Structure: **AR Kampf AA Khan WH Baur** 1973 AC B29 2019-21 (K686).
 Occurrence: MM 35 1158-9.

versiliaite (Fe,Zn,Fe)₈(Sb,Fe,As)₁₆O₃₂S₂.
 Structure: **M Mellini S Merlino** 1979 AM 64 1235-42.
 Occurrence: MM 43 1069.

vertumnite Ca₄Al₄Si₄O₆(OH)₂₄·3aq.
 Structural polytype of *strätlingite*, but somewhat different chemically.
 Structure: **E Galli E Passaglia** 1978 TMPM 25 33-46 (G766).
 Occurrence: MM 42 531.

vésigniéite BaCu₃(VO₄)₂(OH)₂.
 Essentially isostructural with *bayldonite* HCu₃Pb(AsO₄)₂O₂(OH)₂.
 Structure: **C Guillemin** 1956 BCFMC 79 219-75;
Z Ma R He X Zhu 1990 Acta Geol Sinica 64 302-8.
 Occurrence: MM 31 975.

vesuvianite Ca₁₀ Mg₂Al₄(SiO₄)₅(Si₂O₇)₂(OH)₄.
 Isostructural with *wiluite* Ca₁₉(Al,Mg,Fe,Ti)₁₃(B,Al,void)₅Si₁₈O₆₈(O,OH)₁₀,
manganvesuvianite Ca₁₉Mn³⁺(Al,Mn³⁺,Fe³⁺)₁₀(Mg,Mn²⁺)₂Si₁₈O₆₉(OH)₉
 & *fluorvesuvianite* Ca₁₉(Al,Mg,Fe)₁₃(SiO₄)₁₀(Si₂O₇)₄O(F,OH)₉.

Low-Si,OH-subst, B- variety, Yakutia: IR/Raman, **EV Galuskin & 3 others** 2003 CM 41 833-42.
 High-F whiskers, Yakutia: FTIR/SC-XRD, **EV Galuskin & 4 others** 2003 CM 41 843-56.
 Structure: **BE Warren DI Modell** 1931 ZK 78 422-32;
JE Arem CW Burnham 1969 AM 54 1546-50;
G Giuseppetti F Mazzi 1983 TMPM 31 277-88;
S Fitzgerald AL Reingold JA Nelen 1987 AM 72 625-8;
 Cu-bearing, & **3 others** 1986 AM 71 1011-4;
do 1986 AM 71 1483-8;
A Yoshiasa T Matsumoto 1986 MJ 13 1-12;
DR Veblen MJ Wiechmann 1991 AM 76 397-404;
FM Allen CW Burnham 1992 CM 30 1-18;
LA Groat FC Hawthorne TS Ercit 1992 CM 30 19-48, 1065-75;
M Ohkawa A Yoshiasi S Takeno 1992 AM 77 945-53;
 symmetry, 76 samples 50 localities, **LA Groat & 3 others** 1993 CM 31 617-35;
M Ohkawa A Yoshiasi S Takeno 1994 MJ 17 1-20 (O253);
 excess Y, **LA Groat FC Hawthorne TS Ercit** 1994 CM 32 497-504;
 B incorporation, **do** 1994 CM 32 505-23;
 SCXRD & EXAFS, **M Ohkawa** 1994 J Sci Hiroshima Univ C 10 119-49 ;
 IR, OH stretching, **W Zabinski C Paluszkiwicz** 1994 Mineral Polonica 25 51-8;
 IR, **LA Groat & 3 others** 1995 CM 33 609-26;
 optical absorption, Mn²⁺, **AN Platonov & 2 others** 1995 EJM 7 1345-52 (P591);
 Fe³⁺-EPR: **H Rager W Zabinski** 1995 NJMM 264-72;
 EPR, ferric, **K Dryek Z Sojka W Zabinski** 1995 Mineral Polonica 26 9-16;
 SC-XRD & ND of B-bearing, **LA Groat & 4 others** 1996 CM 34 1059-70;
J Lee S Yu 1996 J Geol Soc China (Taiwan) 39 105-16;
 SC-XRD & ND, **A Pavese & 3 others** 1998 CM 36 1029-37;
 H in P4/nnc, SC-ND, **GA Lager & 5 others** 1999 CM 37 763-8;
 P4/n, 570, 770, 1070 K, SC-XRD, **M Tribaudino M Prencipe** 1999 EJM 11 1037-42;
 SC-XRD of P4/n & P4nc, **T Armbruster E Gnos** 2000 AM 85 563-9;
 tetrahedral vacancies, cation ordering in Mn-, **do** 570-7;
 rod polytypism, SC-XRD, **do** 2000 SMPM 80 109-16 (191);
 compression of P4/n, **M Tribaudino M Prencipe** 2001 CM 39 145-52;
 triclinic growth sectors, SC-XRD, **T Tanaka M Akizuki Y Kudoh** 2002 MM 66 261-74;
 IR of OH, skarns, **VS Kurazhikovskaya YeYu Borovikova** 2003 ZVMO 132-6 54-9 (10520);
 rod polytypism vs metamorphic grade and chemical composition, **E Gnos TN Armbruster** 2006 AM 91 862-70.

veszelyite (Cu,Zn)₂Zn(PO₄)(OH)₃.2aq. Review: (E289).
 Structure: **S Ghose SR Leo C Wan** 1974 AM 59 573-81.
 Zn-rich variety was called *kamiokalite*: MM 30 736.

viaeneite (Fe,Pb)₄S₈O.
 XRPD & TEM: **H Kucha W Osuch J Elsen** 1995 NJMM 433-43 (K798) = AM 81 1015.
 Occurrence: **do** 1996 EJM 8 93-102 (K816).

vicanite-Ce ~ (Ca,RE,Th)₁₅As⁵⁺(As³⁺_{0.5}Na_{0.5})Fe³⁺B₄Si₆O₄₀F₇.
 Structure: **P Ballirano & 5 others** 2002 AM 87 1139-43; cell matches *okanoganite*.
 Occurrence: **A Maras & 3 others** 1995 EJM 7 439-46.

vigezzite (Ca,Ce)(Nb,Ta,Ti)₂O₆. *Aeschynite* structure type.
 Structure: **G Giuseppetti C Tadini** 1990 NJMM (7) 301-8 (G778).
 Occurrence: MM 43 1069.
 Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

viitaniemiite Na(Ca,Mn)Al(PO₄)(F,OH)₃.
 Structure: **A Pajunen SI Lahti** 1984 AM 69 961-6.
 Occurrence: MM 46 528.

vikingite Pb₈Ag₅Bi₁₃S₃₀. *Lillianite* homologous series; 4,7 subtype.
 Structure: **E Makovicky WG Mumme IC Madsen** 1992 NJMM 454-68.
 Occurrence: MM 42 531.

villamaninite (Cu,Ni,Co,Fe)(S,Se)₂. *Pyrite* structure group; monoclinic subgroup.
 Structure: **P Bayliss** 1989 AM 74 1168-76;
C Marcos & 4 others 1996 AC B52 899-904 (M1446).
 Should be redefined: AM 82 823.
Synthetic CuS₂: **HE King Jr CT Prewitt** 1979 AM 64 1265-71.

villiaumite NaF. *Halite* structure type.
 Atom displacements, electron density, **VC Sharma** 1974 AC A29 514-20, correction A31 157;
G Böbel & 3 others 1983 AC A39 400-7.

[villiersite (Ni,Mg,Fe,Co)₇Si₈O₂₂(OH)₂ jvs:?*amphibole*. Occurrence: MM 29 996.]

villyaellenite (Mn,Ca)₅(AsO₃OH)₂(AsO₄)₂.4aq.
 Isostructural *sainfeldite* Ca₅(AsO₄)₂(AsO₃OH)₂.4aq & *hureaulite* Mn₅(PO₄)₂[PO₃OH]₂.4aq.
 Structure: AR Kampf CR Ross II 1988 AM 73 1172-8.
 Occurrence: MM 50 760.

vimsite CaB₂O₂(OH)₄. Dimorphic with *uralborite*.
 Structure: **DP Shashkin MA Simonov NV Belov** 1969 SPD 13 974-7 (S1315);
MA Simonov YuK Egorov-Tismenko NV Belov 1976 SPC 21 332-3.
 Occurrence: MM 37 966.

vincentite (Pd,Pt)₃(As,Sb,Te).
 Structure determination not found.
 Occurrence: **EF Stumpfl M Tarkian** 1974 MM 39 525-7.

vinciennite Cu₁₀Fe₄Sn(As,Sb)₁₆.
 Structure determination not found.
 Occurrence & XRD: **F Cesbron & 3 others** 1985 BM 108 447-56;
JL Jmabor DR Owens 1987 CM 25 227-8;
 near As endmember from Peru, **E Marcoux Y Moëlo P Milési** 1994 MP 51 21-36;
 Bulgaria, **K Kouzmanov & 3 others** 2004 CM 42 1501-21.

vinogradovite various formulae, eg Na₄Ti₄O₄(Si₂O₆)₂(Si₃AlO₁₀)₂(aq,Na,K)₄.
 Related to *paravinogradovite* (Na,□)₂(Ti,Fe)₄(Si₂O₆)₂(Si₃AlO₁₀)(OH)₄.aq.
 (3,2)-connected octahedral-tetrahedral net.
 Structure: Na₄Ti₄[Si₂O₆]₂[Si₄O₁₀]₂.n aq, **RK Rastsvetaeva VI Simonov NV Belov** 1968 SPD 12 1090-2;
RK Rastsvetaeva VI Adrianov 1984 SPC 29 403-6 (R488);
 Na₁₀K_{0.7}Si₁₄Al_{1.2}Be_{0.8}Ti_{7.4}Nb_{0.5}Fe_{0.1}, etc, 295 & 110K, **N Kalsbeek JG Rønso** 1992 ZK 200 237-45.

MAS-NMR, ²⁹Si: **ML Balmer & 4 others** 1997 JPCB 101 9170-9 (B1738);
A Labouriau TG Higley WL Earl 1998 JPCB 102 2897-904.
 Mineralogy/crystal: **JG Rønso OV Petersen ES Leonardsen** 1990 NJMM 481-92 (R474).
 Occurrence: MM 31 975.
 Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).

violan Violet variety of *pyroxene*.
 Structure: **A Mottana & 3 others** 1979 TMPM 26 187-201 (M662).

violarite FeNi₂S₄. *Spinel* structure group; *linnaeite* subgroup of sulfides.
 Structure determination not found. [jvs: check for *synthetic*.]
 Secondary, experimentally altered *pentlandite*: **S Richardson DJ Vaughan** 1989 MM 53 213-22.
 Occurrence: **Dana**;
 hypogene exsolution, **BA Grguric** 2002 MM 66 313-26.
 In meteorites: **AE Rubin** 1997 MPS 32 231-47.

virgilite Li_{0.3}Al_{0.3}Si_{0.7}O₂. Stuffed high-**quartz** structure type.
 Structure: **BM French PA Jezek DE Appleman** 1978 AM 63 461-5.
 [viséite Not a zeolite; now regarded as a Si-rich defective *crandallite*: **F Di Renzo Z Gabelica**
 1995 *Natural Zeolites* 93 **DW Ming FA Mumpton** eds 173-85;
 MAS-NMR of mixed phases, **Y Kim RJ Kirkpatrick** 1996 MM 60 957-62.
 Occurrence: early papers; **PJ Dunn DE Appleman** 1977 MM 41 437-42; MM 27 275.]

vishnevite ~ (Na,Ca,K)₃(Si,Al)₆O₁₂(SO₄,CO₃,Cl)₁₋₂.naq. Sulfate-rich *cancrinite*.
 Cancrinite structure group. Review: Sabelli p. 41.

Structure: **P Bariand F Cesbron R Giraud** 1968 BSFMC 91 34-42;
I Hassan HD Grundy 1984 CM 22 333-40;
potassian, **DYu Pushcharovskii NA Yamnova AP Khomyakov** SPC 34 37-9 (P390).

Occurrence: MM 23 639.

vismirnovite $\text{ZnSn}(\text{OH})_6$. ReO_3 structure type. *Schoenfliesite/stottite* structure group.

Structure determination not found.

Occurrence: **NK Marshukova & 3 others** 1981 ZVMO 110 492-500 = MA 67 1077.

Synthetic $\text{ZnSn}(\text{OH})_6$, cell dimension: **AN Christensen RG Hazell** 1969 ASc 23 1219-24
(C804); also Mn/Fe/Co/Ca varieties.

vistepite $\text{Mn}_4\text{SnB}_2\text{Si}_4\text{O}_{16}(\text{OH})_2$. Isotypic with *bustamite*.

Structure: **J Hybler & 4 others** 1998 CM 35 1283-92.

Occurrence & XRD: **LA Pautov & 5 others** ZVMO 104-12 (P490) = MM 60 685.

vitimite $\text{Ca}_6\text{B}_{14}(\text{SO}_4)\text{O}_{19}(\text{OH})_{14.5\text{aq}}$.

Occurrence, XRPD, ED, IR: **NV Chukanov & 4 others** 2002 ZVMO 131-4 41-6.

vitusite-Ce $\text{Na}_3(\text{Ce,La,Nd})(\text{PO}_4)_2$. *Glaserite/apthithalite* structure group.

Structure: **OG Karpov & 4 others** 1980 SPC 25 650-3;
description, **AA Finch JG Fletcher** 1992 MM 56 235-9;
F Mazzi L Ungaretti 1994 NJMM 49-66 (M1107).

Occurrence: MM 43 1069.

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

[*erikite* Pseudomorph after *vitusite*.

History & occurrence: **IV Pekov & 3 others** 1997 NJMM 97-112
(P677).]

VIVIANITE STRUCTURE GROUP Includes:

<i>annabergite</i>	$\text{Ni}_3(\text{AsO}_4)_2.8\text{aq}$
<i>arupite</i>	$\text{Ni}_3(\text{PO}_4)_2.8\text{aq}$
<i>baricite</i>	$(\text{Mg,Fe})_3(\text{PO}_4)_2.8\text{aq}$
<i>bobierite</i>	$\text{Mg}_3(\text{PO}_4)_2.8\text{aq}$
<i>erythrite</i>	$\text{Co}_3(\text{AsO}_4)_2.8\text{aq}$
<i>hörnesite</i>	$\text{Mg}_3(\text{AsO}_4)_2.8\text{aq}$
<i>köttigite</i>	$\text{Zn}_3(\text{AsO}_4)_2.8\text{aq}$
<i>manganhörnesite</i>	$(\text{Mn,Mg})_3(\text{AsO}_4)_2.8\text{aq}$
<i>pakhomovskiyite</i>	$\text{Co}_3(\text{PO}_4)_2.8\text{aq}$
<i>parasymplesite</i>	$\text{Fe}_3(\text{AsO}_4)_2.8\text{aq}$
<i>vivianite</i>	$\text{Fe}_3(\text{PO}_4)_2.8\text{aq}$

See *metavivianite* structure group.

Synthetic $\text{Co}_3(\text{PO}_4)_2.8\text{aq}$: **A Riou Y Cuddenec Y Gerault** 1989 AC C45 1412-3 (R570).

Synthetic $\text{Mg}_{2.5}\text{Ni}_{0.5}(\text{AsO}_4)_2.8\text{aq}$, structure: **JM Rojo & 5 others** 1996 MRB 31 925-34 (R668).

Synthetic $(\text{Mg},[\text{Ni}/\text{Co}])_3(\text{AsO}_4)_2.8\text{aq}$, characterization: **do** 1996 MRB 31 925-34 (R668).

vivianite $\text{Fe}_3(\text{PO}_4)_2.8\text{aq}$. *Vivianite* structure type.

Structure: **H Mori T Ito** 1950 AC 3 25-30;

PB Moore 1971 AM 56 1-17 (M1160);

P Fejdi JF Poullen M Gasperin 1980 BM 103 135-8;

ND, 1989 Z anal Chem 333 401-3 = SR 56A 215;

IR & Raman, **RL Frost & 3 others** 2002 MM 66 1063-72;

Raman of Fe-OH stretch, **RL Frost M Weier** 2004 NJMA 445-63 (10945)..

Electronic & magnetic modeling: **M Grodzicki G Amthauer** 2000 PCM 27 694-702 (946).

Auto-oxidation: **AR Pratt** 1997 PCM 25 24-7 (P750).

Experimental alteration to *lepidocrocite*: **R Roldan V Barron J Torrent** 2002 CIM 37 709-18.

Mg-, Roman camp, Utrecht: Raman/SEM, **JT Kloprogge & 4 others** 2003 Netherlands J Geosciences 82 209-14 (9586).

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

Oxidation, Mössbauer: **J-L Dormann M Gasperin JF Poullen** 1982 BM 105 147-60.

Synthetic Co-: **A Riou Y Cuddenec Y Gerault** 1989 AC C45 1412-3.

vladimirite $\text{Ca}_5\text{H}_2(\text{AsO}_4)_4 \cdot 5\text{aq}$.

Structure determination not found.

Occurrence: MM 30 748;

XRPD, **R Pierrot** 1964 BSFMC 877 169-211 = AM 50 813.

Revised composition, agrees with Pierrot, **LK Yakhontova TI Stolyarova** 1970 ZVMO 99 362-4.

[Triclinic dimorph from dehydration of *ferrarisite*: **M Catti G Ivaldi** 1981 ZK 157 119-30.]

vasovite $\text{Na}_2\text{ZrSi}_4\text{O}_{11}$. 2-connected octahedral-tetrahedral net. CTF net 1123.

Compare *narsarsukite* $\text{Na}_2(\text{Ti,Fe})\text{Si}_4(\text{O,F})_{11}$, net 1126.

Structure: **AA Voronkov YuA Pyatenko** 1962 SPC 6 755-60;

YuA Pyatenko AA Voronkov 1963 DAN 141 1294-6 = MA 17-21;

AA Voronkov TA Zhdanova YuA Pyatenko 1974 SPC 19 152-6 (V203);

cell dimensions, *synthetic*, **G Wilson FP Glasser** 1987 PD 2 176-9.

Occurrence: MM 32 985;

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

vlodavetsite $\text{Ca}_2\text{Al}(\text{SO}_4)_2\text{F}_2\text{Cl} \cdot 4\text{aq}$.

Structure: **GL Starova & 3 others** 1995 MM 59 159-62.

Occurrence: **LP Vergasova & 4 others** 1996 DAN 173-6 = MM 60 685.

vochtenite $(\text{Fe,Mg})\text{Fe}^{3+}[\text{UO}_2/\text{PO}_4]_4\text{OH} \cdot 12\text{-}13\text{aq}$.

Structure determination not found.

Structure: **PC Zwaan CES Arps E de Grave** 1989 MM 53 473-8.

voggite $\text{Na}_2\text{Zr}(\text{PO}_4)(\text{CO}_3)\text{OH} \cdot 2\text{aq}$.

Structure: **JT Szymanski AC Roberts** 1990 MM 54 495-500.

Occurrence: MM 54 670.

voglite $\text{Ca}_2\text{Cu}(\text{UO}_2)(\text{CO}_3)_4 \cdot 6\text{aq}$.

Structure determination not found.

Occurrence: **C Frondel** 1958 USGS Bull 1064 126-8.

PDF 33-274.

volborthite $\text{Cu}_3\text{V}_2\text{O}_7(\text{OH})_2 \cdot 2\text{aq}$. Review: (E289).

3,2-connected octahedral-tetrahedral framework.

Structure: **AA Kashayev VV Bakakin** 1969 DAN 181 123-5;

R Basso A Palenzona L Zefiro 1988 NJMM 385-94 (B1351);

synthetic, **MA Lafontaine A Le Bail G Férey** 1990 JSSC 85 220-7 = SR 57A 177.

[**volfsonite** $\text{Cu}^{1+}_{10}\text{Cu}^{2+}\text{Fe}^{2+}\text{Fe}^{3+}_2\text{Sn}_3\text{S}_{16}$.

Occurrence: **VA Kovalenker IYa Nekrasov VS Malov** 1986 Geol Rudn Mest 28 67

= MM 52 731. Not approved by IMA.]

volkonskoite

Poorly defined fibrous silica-rich material similar to a smectite occurring in fossilized wood.

Various information: AM 82 823.

volkovskite $\text{KCa}_4\text{B}_{22}\text{O}_{32}(\text{OH})_{10}\text{Cl} \cdot 4\text{aq}$.

Layer structure containing fragment found in other borates [jvs: needs detailed check].

Structure: refer to abstract, **JA Mandarin & 7 others** 1990 CM 28 351-6;

monoclinic, **RK Rastsvetaeva & 4 others** 1992 SPC 37 163-7 (R479).

Occurrence with different formula: MM 33 1159.

voltaite $\text{K}_2\text{Fe}^{2+}_5\text{Fe}^{3+}_4(\text{SO}_4)_{12} \cdot 18\text{aq}$.

Zincovoltait $\text{K}_2\text{Zn}_5\text{Fe}^{3+}_3\text{Al}(\text{SO}_4)_{12} \cdot 18\text{aq}$ is analog. Review: Sabelli p. 34.

Structure: **K Mereiter** 1972 TMPM 18 185-202 (M406);

disordered octahedra & water, **K Mereiter** 1971 Anz Osterr Akad Wiss Math-Naturw KL 108 147-8;

disordered/ordered octahedra, **do** 1972 109 317-9 = MA 74-1966;

1989 ZK 186 272.

Occurrence in meteorites: **AE Rubin** 1997 MPS 32 733-4.

volynskite AgBiTe_2 . *Tetradymite* structure group; *tsumoite* subgroup.

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

Occurrence: MM 35 1159.

vonbezingite $\text{Ca}_6\text{Cu}_3(\text{SO}_4)_3(\text{OH})_{12}\cdot 2\text{aq}$.
Occurrence and structure: **Y Dai GE Harlow** 1992 AM 77 1292-300.

vonsenite $(\text{Fe},\text{Mg})_2\text{FeBO}_3\text{O}_2$.
6 Å Zigzag Borate: **MA Cooper FC Hawthorne** 1998 CM 36 1171-93.
2t2t polytype of *ludwigite* subgroup of *pinakiolite* structure family.
Structure: **Y Takéuchi** 1956 MJJ 2 19-26;
JS Swinnea H Steinfink 1983 AM 68 827-32;
P Bonazzi S Menchetti 1989 NJMM 69-83 (B1352);
boron K-edge XANES, **ME Fleet S Muthupari** 2000 AM 85 1009-21.

vozhminite $(\text{Ni},\text{Co})_4(\text{As},\text{Sb})\text{S}_2$. Structure determination not found.
Occurrence: **NS Rudashevskii & 6 others** 1982 ZVMO 111 480-5 = AM 68 645.

vredenburgite-alpha $(\text{Mn},\text{Fe})_3\text{O}_4$. Pure tetragonal type.
Occurrence. **B Mason** 1943 GFF 65 263 = MM 27 266.

vrbaite $\text{Ti}_4\text{Hg}_3\text{Sb}_2\text{As}_8\text{S}_{20}$.
Structure: **M Ohmasa W Nowacki** 1971 ZK 134 360-80 (O276).

[V-rich magnetite
In meteorites: **AE Rubin** 1997 MPS 32 231-47.]

vuagnatite $\text{CaAlSiO}_4\text{OH}$. *Conichalcite/descloizite* structure type. *Adelite* mineral group.
Structure: **E McNear MG Vincent E Parthé** 1976 AM 61 831-8.
Occurrence: MM 42 531.

[vudyavrite $\sim\text{Ce}_2\text{Ti}_3\text{O}_9\cdot n\text{SiO}_2\cdot \text{maq}$.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.]

vulcanite CuTe . Pearson oP4 structure type classified as defect superstructure of *fluorite*.
Structure: **K Anderko K Schubert** 1954 Metallkunde 4 371-8;
RV Beranova ZG Pinsker 1964 SPC 9 83-5 (B1495);
synthetic, **F Pertlik** 2001 MP 71 149-54 (2009).
Occurrence: MM 32 985.

vuonnemite $\text{Na}_{11}\text{TiNb}_2\text{Si}_4\text{P}_2\text{O}_{25}(\text{F},\text{OH})$. *Lomonosovite-murmanite* family.
Structure: **YuN Drozdov & 3 others** 1974 DAN 216 78-81;
TS Ercit MA Cooper FC Hawthorne 1998 CM 36 1311-20.
Occurrence: **IV Bussen & 5 others** 1973 ZVMO 102 423-6 = MM 39 930;
JG Rønsbo & 3 others 1983 NJMM 451-60.
alkaline rocks, **Khomyakov** 1995.

vuorelainenite $(\text{Mn},\text{Fe})(\text{V},\text{Cr})_2\text{O}_4$. *Spinel* structure group.
Occurrence & XRPD: **MA Zakrewski EAJ Burke WJ Lustenhouwer** 1982 CM 20 281-90.

vuoriyarite $(\text{K},\text{Na})(\text{Nb},\text{Ti})\text{Si}_2\text{O}_6(\text{O},\text{OH})\cdot 2\text{aq}$. Related to *labuntsovite* & *nenadkevichite*.
Occurrence & crystallography: **VV Subbotin & 5 others** 1998 DES 358 73-5 (S2049).

vroite $\text{Pb}_{10}\text{Sn}(\text{Bi},\text{As})_{11}\text{S}_{27}\text{Cl}_3$. See *kirkiite*.
Occurrence & crystallography: **A Garavelli & 6 others** 2005 CM 43 703-11.

vyacheslavite $\text{U}(\text{PO}_4)(\text{OH})_{1.8}\cdot 0.35\text{aq}$.
Occurrence & electron diffraction: **LN Belova & 5 others** 1984 ZVMO 113 360-5 = AM 70 878.

vyalsovite $\text{FeS}\cdot\text{Ca}(\text{OH})_2\cdot\text{Al}(\text{OH})_3$.
Structure determination not found.
Occurrence, XR&ED: **TL Evstigneeva & 3 others** 1992 AM 77 201-6.

vysotskite $(\text{Pd},\text{Ni})\text{S}$. Isostructural with *braggite*, which is dimorphic with *cooperite*.
Cooperite mineral group.
Structure: **NE Brese PJ Squattrito JA Ibers** 1985 AC C41 1829-30.
Occurrence: MM 33 1155;
Sierra Leone, **JFW Bowles** 2000 MP 68 75-84 (B2018).

vyuntspakhite $\text{Y}_4\text{Al}_2\text{AlSi}_5\text{O}_{18}(\text{OH})_5$.
Structure: **OV Yakubovich & 3 others** 1984 SPC 29 141-3.
Occurrence: MM 48 585.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

wadalite $\text{Ca}_6\text{Al}_5\text{Si}_2\text{O}_{16}\text{Cl}_{13}$. Consortium for Theoretical Frameworks net 986.
 Structure: **K Tsukimura & 3 others** 1993 AC C49 205-7 (T372).
 Description & occurrence: **Y Kanazawa M Aoki H Takeda** 1997 Bull Geol Surv Japan 48 413-20 = AM 83 909-10;
achtarandite = pseudomorph of *hibschite hydrogarnet*, **E Galuskin I Galuskina** 2002 NJMA 63-74 (8797).

wadeite $\text{K}_2\text{ZrSi}_3\text{O}_9$.
 Based on same vertex-connected octahedral-tetrahedral net (CTF 1146) as *catapleiite*.
 Not isostructural with *benitoite*. (CTF net 1112).
 Different from other structures with similar chemistry: jvs needs literature search.
 Structure: **DE Henshaw** 1955 MM 30 585-95 (H910);
VA Blinov & 4 others 1977 SPC 22 31-5.
 Occurrence: MM 25 647.
 ?Ti analog: **AA Kim VYu Pankov** 1991 *First find of a potassium-titanium silicate ($\text{K}_2\text{TiSi}_6\text{O}_{15}$) in platinum metals of the Inagli pluton* DES 309 155-7;
RH Mitchell I Steele 1992 CM 30 1153-9.
 Synthetic $\text{K}_2\text{Ge}_4\text{O}_9$: **H Völlenknecht A Wittman** 1971 Monatsch Chem 102 1245-54;
 Synthetic $\text{Na}_6\text{Si}_3[\text{Si}_9\text{O}_{27}]$, similar but not same as *wadeite* type: **ME Fleet** AM 81 1105-10.
 Synthetic $\text{K}_2\text{TiSi}_3\text{O}_9$: **NG Shumyatskaya & 4 others** 1973 SPD 18 17-9 (S1282);
CE Gulliver AD Edgar RH Mitchell 1998 CM 36 1339-46.
 Synthetic $\text{K}_2\text{Si}^{\text{VI}}\text{Si}^{\text{IV}}_3\text{O}_9$, high-P: **N Kinomura S Kume M Koizumi** 1975 MM 40 401-4;
DK Swanson CT Prewitt 1983 AM 68 581-5.
 Synthetic $\text{Na}_2\text{Ge}_4\text{O}_9$, SC-XRD structure: **ME Fleet S Muthupari** 1999 JSSC 140 175-81 (F647).
 Synthetic wadeite-Ti 2-3 GPa: **A Orlando Y Thibault AD Edgar** 2000 CMP 139 136-45 (429).
 Synthetic Ba/Sr/Na-substituted, glass surface for cathode-ray tube: SC-XRD structure, **K Sakai & 3 others** 2000 J Mineral Petr Sci 95 24-31 = MA 02M/2545.
 Synthetic $\text{Cs}_2\text{ZrSi}_3\text{O}_9$, XRPD structure: **ML Balmer & 5 others** 2001 JACeS 84 153-60 (918).

wadsleyite Mg_2SiO_4 -beta.
 Medium-P polymorph, trimorphic with low-P *olivine*-alpha & high-P *ringwoodite*-gamma.
 Often called *modified-spinel structure*, but actually distinct variant of stuffed closest-cubic-packing of oxygen atoms.
 Polymorphic transformations, mechanisms & elastic strain: **L Kerschhofer & 5 others** 1998 MM 62 617-38.
 Structural relation of hydrous *ringwoodite* & wadsleyite: **Y Kudoh** 2001 PCM 28 523-30 (3587).
 Contains aq/OH at high pressure: **JR Smyth** 1994 AM 79 1021-4.
 Occurrence: MM 48 585.
 Sound velocity, elasticity: **SV Sinogeikin T Katsura JD Bass** 1998 JGR 103 20819-25 (S1978);
B Li RC Liebermann 2000 AM 85 292-5
B Li RC Liebermann DJ Weidner 2001 JGR B106 30575-91 (3982);
 moduli vs T, **N Mayama & 5 others** 2004 GRL 31 L04612 (10110).
 Structure: **PB Moore JV Smith** 1969 N 221 653-5;
do 1970 PEPI 3 166-77;
WH Baur 1971 Nature Phy Sci 233 135-7 (B505);
H Horiuchi H Sawamoto 1981 AM 66 568-75;
 model & elasticity, **M Matsui T Matsumoto** 1985 AC B41 377-82;
JR Smyth 1987 AM 72 1051-5;
 $\text{Mg}_{0.9}\text{Fe}_{0.1}$, **H Sawamoto H Horiuchi** 1990 PCM 17 293-300;
 OH, **PF McMillan & 4 others** 1991 AM 76 354-60;
 Fe-free up to 4.8 GPa, **J Zhang RM Hazen J Ko** 1991 ARDGL 115-20 = MA 92M/2603;
 Fe-bearing, **LW Finger & 3 others** 1993 PCM 19 361-8;
Y Wang T Gasparik RC Liebermann 1993 AM 78 1165-73;
 IR & OH vibration in Fe-bearing, **H Cynn AM Hofmeister** 1994 JGR 99 17717-27;
 high-T Raman & XRD, **B Reynard & 5 others** 1996 AM 81 585-94;
 SC-XRD <10 GPa, Mg/Fe 0 & 3, **RM Hazen & 3 others** 2000 AM 85 770-7;
 OH ordering, **SC Kohn & 4 others** 2002 AM 87 293-301.
 hydrous, synthesized at 1673 K & 17 GPa, **JR Smyth & 5 others** 1997 AM 82 270-5
 hydrous -II, Raman to 51 GPa, **AK Kleppe & 2 others** AM 91 1102-9..

Water in $\alpha/\beta/\gamma$ (Mg,Fe)₂SiO₄: **DL Kohlstedt H Keppler DC Rubie** 1996 CMP 123 345-7 (K844).
 SC elasticity to 410 km seismic discontinuity: **C Zha & 5 others** 1997 EPSL 147 E9-15 (Z127).
²⁹Si & ¹H NMR: **BL Phillips & 3 others** 1997 PCM 24 179-90 (P672).
 Relaxation of transformation stress: **JL Mosenfelder & 3 others** 2000 PEPI 120 63-78 (M1822).
 Incorporation Fe(III) into *forsterite* & wadsleyite: **NC Richmond JP Brodholt** 2000 AM 85 1155-8.
 Structure and elasticity: **B Kiefer & 3 others** 2001 AM 86 1387-95.
 Plastic deformation in shear/compression: **E Thurel et al** 2003 PCM 30 256-66, 267-70, 271-9.
 Water solubility, Fe-free, 15-18 GPa, 1173-1673 K: **S Demouchy & 3 others** 2005 AM 90 1084-91.
 In meteorites: **AE Rubin** 1997 MPS 32 231-47.
Synthetic Mn₂GeO₄: wadsleyite analog, **N Morimoto & 3 others** 1969 S 165 586-8;
 wadsleyite & Sr₂PbO₄ analogs, **do** 1972 AM 57 62-75.
Synthetic olivine, wadsleyite & *spinel* polymorphs Co₂SiO₄: **N Morimoto & 3 others** 1974 AM 59 475-95.
Synthetic Ni₃Al₂SiO₈: **CB Ma K Sahl** 1975 AC B31 2141-3.
Synthetic Mg₃Ga₂GeO₈: **J Barbier BG Hyde** 1986 PCM13 382-93.
Synthetic Mg₁₀Si₃(OH)₄O₁₄: **REG Pacalo JB Parise** 1992 AM 77 681-4 (P528);
Y Kudoh & 4 others 1994 Am Inst Phys Conf 309 469-72 (K684).
Synthetic at 15.5 GPa, 3 wt % aq: **T Inoue H Yurimoto Y Kudoh** 1995 GRL 22 117-20 (I128);
 structure *hydrous* wadsleyite 1573 K 15 GPa, **Y Kudoh T Inoue H Arashi** 1996 PCM 23 461-9 (K885).
Synthetic wadsleyite II, 1673 K 17.5 GPa: **JR Smyth T Kawamoto** 1997 EPSL 146 E9-16 (S1673).
Synthetic Fe_{2.45}Si_{0.55}O₄, 1373 K & 5.6 GPa, structure: **AB Woodland RJ Angel** 1998 AM 83 404-8.
Synthetic olivine/wadsleyite transition, vs trace elements: **GH Gudfinnson BJ Wood** 1998 AM 83 1037-44.
Synthetic hydrous, SC-XRD structure, Mg-vacancy & lower symmetry: **Y Kudoh T Inoue** 1999 PCM 26 382-8 (K1156).
Synthetic ferric SC-XRD structure to 9 GPa: **RM Hazen H Yang CT Prewitt** 2000 AM 85 778-83.
wagnerite-M2ab (Mg,Fe,Mn)₂(PO₄)(F,OH). *Triplodite* structure group.
 Structural series with (Mn,Fe,Mg,Ca)₂(PO₄)(F,OH) *triplite* & (Fe,Mn,Mg,Ca)₂(PO₄)(F,OH)
zwieselite.
 Polytypic with –Ma5bc.
 Structure: **L Waldrop** 1969 ZK 130 1-14.
wagnerite -Ma5bc
 Occurrence & SC-XRD structure, **L Ren ES Grew M Xiong Z Ma** 2003 CM 41 393-411.
Synthetic Cd₂(PO₄)F: **JR Rea E Kostiner** 1974 AC B30 2901-3.
Synthetic beta-OH analog: **G Raade C Rømming** 1986 ZK 177 15-26.
Synthetic (OH)-substituted, MAS-NMR, XRD & ND structure: **KI Taasti & 6 others** 2002 JSSC 164 42-50 (6780).
wairakite CaAl₂Si₄O₁₂.2aq. *Alcime/leucite* structure family. *Zeolite* mineral group.
 Structure: **Y Takéuchi & 3 others** 1979 AM 64 993-1001;
synthetic, XRPD/MAS-NMR ²⁹Si & ²⁷Al, **CMB Henderson & 3 others** 1998 MM 62 165-78;
 high-T to 873 K, SC-XRD, **YV Seryotkin & 4 others** 2003 EJM 15 475-84 (9172).
 Occurrence: MM 30 748.
 Subtypes with different symmetry: **DS Coombs** 1955 MM 30 699-707;
 tetragonal, **W Nakajima** 1983 Bull Fac Ed Kobe University 70 39-46.
 Thermochemistry & phase equilibria of Ca zeolites: **I Kiseleva & 3 others** 1996 AM 81 658-67.
Laumontite to wairakite + water transformation: **C Jové BR Hacker** 1997 AM 82 781-9.
wairauite CoFe. CsCl structure type.
 Structure: **P Bayliss** 1990 CM 28 751-5.
 Occurrence: **GA Challis JVP Long** 1964 MM 33 942-8;
X Hua DD Eisenhour PR Buseck 1995 M 30 106-9.
 in meteorites, **AE Rubin** 1997 MPS 32 231-47.
wakabayashilite [(As,Sb)₆Sg][S₄S₅].
 Structure & revised formula: **P Bonazzi & 3 others** 2005 AM 90 1108-14.
 Occurrence: **A Kato KI Sakurai K Ohsumi** 1970 Geol Survey Japan 92-3 = AM 57 1311-2.
 New crystallographic data: **JD Scott W Nowacki** 1975 CM 13 418-9.
wakefieldite-Ce (Ce,Pb)VO₄. *Zircon* structure group.
 Structure: **C Baudracco-Gritti & 5 others** 1987 BM 110 657-63.
 Occurrence with Sr-rich zeolites, Yellow River, BC, Canada: **DG Howard RW Tschernich GL Klein** 1995 NJMM 127-32.

Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
Synthesis: CeVO₄-I(wakefieldite structure) at ambient P, & -II (*monazite*) & -III (*scheelite*) at high-P, structure of -I & -II: **K-J Range H Meister U Klement** 1990 ZN 45b 598-602 (R617).
wakefieldite-Y YVO₄. *Zircon* structure group.
Structure: **JA Baglio G Gashurov** 1968 AC B24 292-3 (B1443).
Occurrence: MM 37 966.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

walentaite ~H₂(Ca,Mn,Fe)₂Fe³⁺₆(AsO₄)₅(PO₄)₃.~14aq.
Structure determination not found.
Occurrence: **PJ Dunn & 4 others** 1984 NJMM 169-74.

walfordite (Fe,Te)Te₃O₈. Analog of *wistanleyite*. Based on *fluorite* structure.
Occurrence: Chile, **ME Back & 4 others** 199 CM 37 1261-8.

walkerite Ca₁₆(Mg,Li,void)₂[B₁₃O₁₇(OH)₁₂]₄Cl₆.28aq.
Occurrence & SC-XRD structure: **JD Grice & 3 others** 2002 CM 40 1675-86.

wallisite TIPb(Cu,Ag)As₂S₅. Isostructural with *hatchite* TIPbAgAs₂S₅.
Structure: **Y Takéuchi H Ohmasa W Nowacki** 1968 ZK 127 349-65 (T139);
-hatchite ss, SC-XRD, **M Boiocchi A Callegari** 2003 NJMM 399-406 (9620).
Occurrence: MM 35 1159.

walkilldellite Ca₂Mn²⁺₃As⁵⁺₂O₈(OH)₄.9aq.
Isostructural with Si analog *kittatinnyite* Ca₂Mn²⁺Mn³⁺₂Si₂O₈(OH)₈.9aq from crystallography.
Structure determination not found.
Occurrence: **PJ Dunn DR Peacor** 1983 AM 68 1029-32.

walkilldellite-Fe (Ca,Cu)₂Fe²⁺₃(As,Si)₂O₈(OH)₄.9aq.
Occurrence & crystallography: **H Sarp G Mari P Chiappero** 1999 Riviera Sci 5-12 = MR 32 312.

walpurkite Bi₄(UO₂)As₂(Si)O₄)₂O₄.2aq. See *orthowalpurkite*.
phosphowalpurkite (UO₂)Bi₄O₄(PO₄)₂.2aq is analog.
Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
Structure: **K Mereiter** 1982 TMPM 30 129-39 (M1255) = MA 83M/1226.

walstromite BaCa₂Si₃O₉. Isostructural with *margarosanite* PbCa₂Si₃O₉.
Occurrence: MM 33 1159.
Structure: **LS Dent Glasser FP Glasser** 1968 AM 53 9-13.
High-P CaSiO₃ (= *wollastonite*-II) has matching cell dimensions but the Si-O ring has inverse
axiality: structure, **FJ Troger** 1969 ZK 130 185-206 (T148);
inclusion in diamond from Guinea, **W Joswig & 4 others** 1999 EPSL 173 1-6;
do, structure, **W Joswig & 3 others** 2003 ZK 218 811-8 (10109).

walthierite Ba_{0.5}void_{0.5}Al₃(SO₄)₂(OH)₆. *Alunite* structure group. Analog of *huangite*.
Occurrence and crystallography: **G Li & 4 others** 1992 AM 77 1275-84.

wardite NaAl₃(PO₄)₂(OH)₄.2aq.
Isostructural with *cyrilovite* NaFe₃(PO₄)₂(OH)₄.2aq & *millisite* (Na,K)CaAl₆(PO₄)₄(OH)₉.3aq.
Structure: **L Fanfani A Nunzi PF Zanazzi** 1970 MM 37 598-605.

wardsmithite Ca₅MgB₂₄O₄₂.30aq.
Structure determination not found.
Occurrence: **RC Erd JF McAllister AC Vlisidis** 1970 AM 55 349-57.

warikahnite Zn₃(AsO₄)₂.2aq.
Structure: **H Riffel P Keller H Hess** 1980 TMPM 27 187-99 (R560).
Occurrence: MM 43 1069.
Cf *köttigite* 8aq & *synthetic* 1.33 aq: **P Feng X Bu GD Stucky** 1997 AC C53 997-1000 (F549).

warwickite Ideally Mg₃TiB₂O₈.
Isostructural with *yuanfuliite* Mg(Fe³⁺,Fe²⁺,Al,Ti,Mg)(BO₃)O. Isolated BO₃ group.
Structure: **Y Takéuchi T Watanabé T Ito** 1950 AC 3 98-107;
JJ Cappoini J Chenavas JC Joubert 1973 JSSC 7 49-??;

PB Moore T Araki 1974 AM 59 985-1004;
S Bigi MF Brigatti S Capedri 1991 AM 76 1380-8.
 Al-rich, occurrence: **PWU Appel** 1997 MM 61 693-8.
Synthetic Mg₂Ti₂B₂O₈: **JC Fernandes & 5 others** 1994 PRB 50 16754;
 electronic structure & bonding, **M Matos 3 others** 1996 ChM 8 2324-30 (M410).
Synthetic FeCoBO₄: **MJ Buerger V Venkatakrishnan** 1972 MRB 7 1201-7;
V Venkatakrishnan MJ Buerger 1972 ZK 135 321-38.
Synthetic Mg_{0.76}Mn_{1.24}OBO₃: **R Norrestam** 1989 ZK 189 1-11 (N330).
Synthetic MgScOBO₃: **R Norrestam** 1989 ZK 189 1-11 (N330).
Synthetic NiScBO₄: **K Bluhm H Müller-Buschbaum** 1990 ZaaC 585 87-92 (B1444).
Synthetic Ni₂(Ga/Fe/Al/Cr)BO₄: **do** 1990 ZaaC 582 15-20 (B1445).
Synthetic ZnFe(BO₃)O: **S Busche K Bluhm** 1995 ZN 50b 1450-4 (B1448).
Synthetic Mn₂OBO₃: **R Norrestam M Kritikos A Sjödin** 1995 JSSC 114 311-6 (N405).
Synthetic Ca(Y/Yb/Lu)₂S₄ & Yb₃S₄, based on warwickite structural connectivity: **CK Lowe-Ma
 TA Vanderah TE Smith** 1995 JSSC 117 363-72 (L689).
watanabeite Cu₄(As,Sb)₂S₅.
Tetrahedrite type structure from XRPD, but with subsidiary diffractions.
 Occurrence & crystallography: **M Shimizu & 4 others** 1993 MM 57 643-9.
Synthetic Cu₂₄As₁₂S₃₁: **F Maske BJ Skinner** 1971 EG 66 901-8.
watsumiite KNa₂LiMn₂V₂Si₈O₂₄. Isostructural with *neptunite*.
 Occurrence & structure: **S Matsubara & 3 others** 2003 J Miner Petrol Sci 98 1142-50.
waterhouseite Mn₇(PO₄)₂(OH)₈.
 Occurrence & SC-XRD/Raman structure: **A Pring U Kolitsch WD Birch** 2005 CM 43 1401-10.
watkinsonite Cu₂PbBi₄(Se,S)₈.
 Structure determination not found.
 Occurrence & SC-XRD: **Z Johan P Picot F Ruhlmann** 1987 CM 25 625-38.
 Occurrence, Erzgebirge: **H Förster & 2 others** 2005 CM 43 899-908 = AM 91 224.
wattersite Hg⁺₄Hg²⁺Cr⁶⁺O₆.
 Structure: **LE Groat AC Roberts Y LePage** 1995 CM 33 41-6.
wattervilleite Na₂Ca(SO₄)₂.4aq?
 Doubtful species, but see: **E Ordonez J Twilley** 1997, *Clarifying the haze. Efflorescence on
 works of art*, AnC Jul 1 416-22A (O336).
wavellite Al₃(PO₄)₂(OH,F)₃.5aq.
 Structure: **P Fu** 1966 Sci Geol Sinica 116-35 = MA 19-181;
T Araki T Zoltai 1968 ZK 127 21-33.
wawayandaite Ca₆Mn₂BBegSi₆O₂₃(OH,Cl)₁₅.
 Structure determination not found.
 & XRPD: **PJ Dunn & 4 others** 1990 AM 75 405-8.
waylandite (Bi,Ca)Al₃(P,SiO₄)₂(OH)₆. *Crandallite* structure group.
 Structure determination not found.
 Occurrence: **O Von Knorring ME Mrose** 1962 GSA Spec Paper 73 256 = AM 48 215;
AM Clark 3 others 1986 MM 50 731-3 (C848).
Arsenowaylandite BiAl₃(AsO₄)₂(OH)₆, As analog, approval for mineral name not requested from
 CNMMN: **B Scharm M Scharnova M Kundrat** 1994 Ves Cesk geol ustavu 69 79-85 = AM 84 184.
weberite Na₂MgAlF₆.
 Structure: **G Giuseppetti C Tadini** 1978 TPM 25 57-62 (G767).
 Occurrence: MM 25 647.
Synthetic Na₂(Cu/Zn)ScF₇: **P Dahlke D Babel** 1994 ZaaC 620 1692-7 (D488).
Synthetic Na₂NiFeF₇: 1989 JSSC 78 66-77 (L708) = SR 56A 83.
Synthetic Pb₂Sb₂O₇, deformed weberite type: SPC 1990 35 494-7 = SR 57A 160.
Synthetic MnVF₅.2aq, inverse-weberite type: **F Leroux A & 3 others** 1995 CRASP 320 IIb 147-53 (L632).

Synthetic Na₂CoAlF₇: **P Gravereau & 4 others** 1992 AC C48 2108-11 (G787).

Synthetic Ca₂Os₂O₇: **J Redaig CS Knee MT Weller** 2002 JMC 112 2376-82 (7884).

Synthetic Ca_{1.9}Ta_{1.9}Nd_{0.1}Zr_{0.1}O_{7-3T} & -4M: SC-XRD structure, **IE Grey & 4 others** 2003 JSSC 174 285-95 (9330).

Synthetic Ca₂Ta₂O₇: 8O stacking, SC-XRD, **SG Ebbinghaus & 4 others** 2005 ZK 220 269-75 (11038).

weddellite CaC₂O₄.2aq.
 Structure: **C Sterling** 1965 AC 18 917-21;
V Tazzoli C Domenghetti 1980 AM 65 327-34.
 Occurrence: MM 28 740.
 Compare *whewellite* 1aq & *caoxite* 3 aq.
 Occurrence in lichen crusts: **HGM Edwards** 1997 USA Microscopy & Analysis May 13-5 (E399);
 also Cu & Mn oxalates.

WEEKSITE MINERAL GROUP Includes:
calcursilite Ca₄[(UO₂)₄(Si₂O₅)₅(OH)₆].15aq
haiweeite Ca(UO₂)₂Si₆O₁₅.5aq
ranquillite Ca₂[(UO₂)₃(Si₂O₅)₄(OH)₂].18aq
weeksite K₂(UO₂)₂(Si₂O₅)₃.4aq
 See *couthoite* Th_xBa_{1-2x}aq_y(UO₂)₂Si₅O₁₃.aq.
Synthetic sodium-weeksite: **R Vochten N Blaton O Peeters** 1997 NJMM 569-76 (V301).

weeksite K₂(UO₂)₂(Si₂O₅)₃.4aq. Weeksite mineral group.
 Review: **PC Burns ML Miller RC Ewing** 1996 CM 34 845-80.
 Structure: **FV Stohl DK Smith** 1981 AM 66 610-25;
SV Baturin GA Sidorenko 1985 SPD 30 435-7 (B1121);
 revised structure, SC-XRD, **JM Jackson PC Burns** 2001 CM 39 A-187-95.
 Occurrence: MM 32 985.
 Occurrence of *gastunite*, now listed as weeksite, and *synthetic* K, K-Na, Na, NH₄ & H₃O analogs:
RM Honea 1959 AM 44 1047-56.

wegscheiderite Na₅(CO₃)(HCO₃)₃.
 Structure: **NG Fernandes R Tellgren I Olovsson** 1990 AC B46 466-74.
 Occurrence: MM 33 1155.

weibullite Pb₃Bi₄(S,Se)₉. Higher homolog of *galenobismutite*.
 Structure: **WG Mumme** 1980 CM 18 1-12.

weilerite BaAl₃(AsO₄)(SO₄)(OH)₆? *Beudantite* structure group.
 Review: **Sabelli** p.26.
 Structure: **K Walenta** 1966 TPM 11 121-64.
 Occurrence: MM 32 991.

weilite CaHAsO₄. Isostructural with *monetite* CaHPO₄.
 Structure determination not found.
 Occurrence & XRPD: **P Herpin R Pierrot** 1963 BSFM 86 368-72.
Synthetic SrHAsO₄: **MA Nabar AP Dalvi** 1977 BSFMC 100 353-4.

weinebeneite CaBe₃(PO₄)₂(OH)₂.4aq.
 Consortium for Theoretical Frameworks tetrahedral net 962.
 Structure: **F Walter** 1992 EJM 4 1275-83.

weishanite (Au,Ag)₃Hg₂ or (Au,Ag,Hg).
 XRPD matches synthetic Au₃Hg: PDF 4-808.
 [jvs: Cell data indicate flattened hexagonal closest packed structure, as in *schachnerite* Ag_{1.1}Hg_{0.9}-beta; if so, composition should be (Au,Ag,Hg); check for structure of *synthetic. Osmium, rhenium & ruthenium* have normal hcp.]
 Occurrence: **Y Li O Shan P Tian** 1984 Acta Mineral Sinica 4 102 5 = AM 73 196.

weissbergite TlSbS₂. Triclinic superstructure of SnS prototype.
 See *lorandite* TlAsS₂ for monoclinic superstructure.
 Structure: **Jumas et al** 1983 ?;
 XPS, **I Grzetic TB Zunic** 1993 PCM 20 286-96.

Occurrence: **FW Dickson AS Radke** 1978 AM 63 720-4.
weissite Cu_5Te_3 . Structure: **P Bayliss** 1990 CM 28 751-5.
Occurrence: MM 21 580-1.
welinite $\text{Mn}_6[\text{W},\text{Mg}]_2\text{Si}_2(\text{O},\text{OH})_{\sim 14}$. *Mcgovernite* group.
Isostructural with V analog *francisanite* & Sb,Fe analog *örebroite*.
Review & revision of earlier data, **PJ Dunn 3 others** 1986 AM 71 1522-6.
Structure: **PB Moore** 1968 Ark Mineral Geol 4 459-66 (M245) = MA 69-1988.
[wellsite(Ba,Ca,K₂)Al₂Si₆O₁₆.6aq. Discredited, and replaced by *barian phillipsite*.]
weloganite $\text{Na}_2\text{Sr}_3\text{Zr}(\text{CO}_3)_6.3\text{aq}$. *Mckelveyite* structure group.
Structure: **JD Grice G Perrault** 1975 CM 13 209-16.
Occurrence: MM 37 966.
welshite $\sim\text{Ca}_2\text{Mg}_3.8\text{Mn}_0.6\text{Fe}_0.7\text{Sb}_1.5\text{Si}_2.8\text{Al}_0.7\text{Be}_1.7\text{As}_0.2\text{O}_{20}$.
Aenigmatite structure group.
Structure determination not found.
Occurrence: **PB Moore** 1978 MM 42 129-32.
New composition: **ES Grew & 3 others** 2001 MM 65 665-74.
wendwilsonite $\text{Ca}_2\text{Mg}(\text{AsO}_4)_2.2\text{aq}$. *Roselite* structure group.
Dimorph of *talmessite* in *fairfieldite* group.
Structure determination not found.
Occurrence: **PJ Dunn BD Sturman JA Nelen** 1987 AM 72 217-21.
wenkite $\text{Ba}_4\text{Ca}_6(\text{Al}_8\text{Si}_{12})\text{O}_{39}(\text{OH})_2(\text{SO}_4)_3.n \text{ aq}$.
Consortium for Theoretical Frameworks interrupted tetrahedral net 976.
Review: **Sabelli** p. 41.
Structure: **H-R Wenk** 1973 ZK 137 113-26 (W729);
S Merlino 1974 AC B30 1262-6 = MA 75-160.
Occurrence: MM 33 1155.
werdingite $(\text{Mg},\text{Fe})_2\text{Al}_{12}(\text{Al},\text{Fe})_2\text{Si}_4(\text{B},\text{Al})_2\text{O}_{37}$.
Structure: **ML Niven DJ Waters JM Moore** 1991 AM 76 246-56.
Occurrence: MM 54 670.
Occurrence in granitic pegmatites: **ES Grew & 6 others** 1998 CM 36 399-414.
wermlandite $\text{Mg}_7(\text{Ca},\text{Mg})(\text{Al},\text{Fe})_2(\text{SO}_4)_2(\text{OH})_{18}.12\text{aq}$.
Layer structure somewhat similar to *pyroaurite*: **HFW Taylor** 1973 MM 39 377-89 (T186).
Structure determination not found.
Superstructure: **J Ruis R Allman** 1984 ZK 168 133-44.
Occurrence: **PB Moore** 1971 Li 4 213-7 (M1157).
wernerite Intermediate member of *scapolite* series.
Structure: **SB Lin BJ Burley** 1974 TMPM 21 196-215;
SB Lin BJ Burley 1975 AC B31 1806-14.
wesselsite $\text{SrCuSi}_4\text{O}_{10}$. *Gillespite* structure group.
Occurrence & XRPD: **G Giester B Rieck** 1996 MM 60 795-8.
Structure: *synthet*, **BC Chakoumakos JA Fernandez-Baca LA Boatner** 1993 JSSC 103 105-13.
westerveldite $(\text{Fe},\text{Ni},\text{Co})\text{As}$.
Matches *synthetic* FeAs: XRPD 12-799.
[jvs: structure determination not found; ?orthorhombic distortion of hexagonal *niccolite*; search for structure of synthetic.]
Occurrence: **IS Oen 3 others** 1972 AM 57 354-63.
wheatleyite $\text{Na}_2\text{Cu}(\text{C}_2\text{O}_4)_2.2\text{aq}$.
Structure matches *synthetic*: **P Chananont & 3 others** 1980 AC B36 2145-7;
A Gleizes F Maury J Galy 1980 IC 19 2074-8.
Occurrence, structure, other *synthetic* oxalates: **RC Rouse & 4 others** 1986 AM 71 1240-2.
whelanite $\text{Ca}_5\text{CuSi}_6\text{O}_{17}(\text{CO}_3)(\text{OH})_2.4\text{aq}$.
Listed in **RA Bideaux TC Wallace** 1997 Rocks & Minerals 72/1-2 10-27 (B1568).
wherryite $\text{Pb}_7\text{Cu}_2(\text{SO}_4)_4(\text{SiO}_4)_2(\text{OH})_2$.

Macquartite $Pb_7Cu_2(CrO_4)_4(SiO_4)_2(OH)_2$ may prove isostructural.

Structure: **M Cooper FC Hawthorne** 1974 CM 32 373-80.

Occurrence: MM 29 996.

whewellite $CaC_2O_4 \cdot aq.$

Structure: **S Deganello** 1980 ZK 152 247-52;

Z Tazzoli C Domeneghetti 1980 AM 65 327-34;

at 328 K, **S Deganello** 1981 AC B37 826-9;

synthetic, **S Deganello OE Piro** 1981 NJMM 81-8;

& dehydration of *caoxite*, **T Echigo & 4 others** 2005 MM 69 77-88 = AM 90 1469.

Compare with dihydrate *weddellite* & trihydrate *caoxite*.

Morphology: PBC theory, **A Millan** 2001 CrGD 1 245-54 (2152);

chiral crystals with associated biomolecules in tomato & tobacco plants, **N Bouropoulos**

S Weiner L Addadi 2001 CEJ 7 1881-5 (2153).

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

Occurrence in lichen crusts: **HGM Edwards** 1997 USA Microscopy & Analysis May 13-5 (E399);

also Cu & Mn oxalates.

[**white rust** **JB Parise et al** 2000 AM 85 189-93.]

whiteite-CaFeMg $Ca(Fe,Mn)Mg_2Al_2(PO_4)_4(OH)_2 \cdot 8aq.$ *Jahnsite-whiteite* structure group.

Structure determination not found.

Occurrence: **PB Moore J Ito** 1978 MM 42 309-23.

Nomenclature: **JD Grice PJ Dunn RA Frank** 1989 CM 27 699-702.

whiteite-CaMnMg $CaMnMg_2Al_2(PO_4)_4(OH)_2 \cdot 8aq.$ *Jahnsite-whiteite* structure group.

Structure determination not found.

Occurrence: **PB Moore J Ito** 1978 MM 42 309-23.

Nomenclature: **JD Grice PJ Dunn RA Frank** 1989 CM 27 699-702.

whiteite-MnFeMg $MnFeMg_2Al_2(PO_4)_4(OH)_2 \cdot 8aq.$ *Jahnsite-whiteite* structure group.

Structure determination not found.

Occurrence: **PB Moore J Ito** 1978 MM 42 309-23.

Nomenclature: **JD Grice PJ Dunn RA Frank** 1989 CM 27 699-702.

WHITLOCKITE STRUCTURE GROUP Includes:

cerite $(Ce,Ca)_9(Mg,Fe)Si_7(O,OH,F)_{28}$

strontiowhitlockite $Sr_9Mg(PO_3OH)(PO_4)_6$

whitlockite $Ca_9(Mg,Fe)H(PO_4)_7$

[*tuite* $Ca_3(PO_4)_2$ -gamma. High-P polymorph of *whitlockite*.]

Polytypic series: *cerite* & *whitlockite* are nearly isostructural but differ polytypically from *strontiowhitlockite* that is similar to beta- $Ca_3(PO_4)_2$: **R Gopal C Calvo** 1972 Nature Phys Sci 237 30-2.

Synthetic $(Sr,Mg)_3(PO_4)_2$: **JF Sarver MV Hoffman FA Hummel** 1961 J Electrochem Soc 108 1103-10.

Synthetic $Ca_3(VO_4)_2$: **R Gopal C Calvo** 1973 ZK 137 67-85.

Synthetic beta- $Ca_3(PO_4)_2$: **B Dickens LW Schroeder WE Brown** 1974 JSSC 10 232-48.

Synthetic $Ca_9MgH(PO_4)_7$: **R Gopal 3 others** 1974 Can J Chem 52 1155-64.

Synthetic $Ca_9MnH(PO_4)_7$: **E Kostiner JR Rea** 1976 AC B32 250-3.

Synthetic monoclinic alpha- $Ca_3(PO_4)_2$: **M Mathew & 3 others** 1977 AC B33 1325-33.

Synthetic Mg- beta- $Ca_3(PO_4)_2$: **LW Schroeder B Dickens WE Brown** 1977 JSSC 22 253-65.

Synthetic $Ca_3(CrO_4)_2$: **D Gyepesova M Handlovic S Durovic** 1981 Silikaty 25 113-6 = MA 82M/3933.

Synthetic $Ca_{10}(Li/Na/K)(PO_4)_7$, $Ca_9Mg(Li/Na/K)(PO_4)_7$, $Ca_9.5Mg(PO_4)_7$ & $Ca_{10.5}(PO_4)_7$,

Mössbauer: **VA Morozov & 3 others** 1995 CR 40 478-85.

Synthetic $Ca_9Fe(PO_4)_7$ & $Ca_9FeH_{0.9}(PO_4)_7$: **BI Lazoryak & 4 others** 1996 JSSC 122 15-21.

Synthetic $Na_3Ca_{18}Fe(PO_4)_{14} \cdot o$: **TV Strunenkova & 5 others** 1997 CrR 42 55-66 (S1661).

Synthetic $Ca_{19}Cu_2(PO_4)_{14}$, XRPD structure: **N Khan VA & 3 others** 1997 MRB 32 1211-20 (K944).

Synthetic $Ca_8MgCe(PO_4)_6 SiO_4$, structure: **RN Kotov VA & 3 others** 1997 Kr 42(6) 1027-33.

whitlockite $Ca_9(Mg,Fe)H(PO_4)_7$. *Whitlockite* structure group.

Structure: **C Calvo R Gopal** 1975 AM 60 120-33.

Occurrence: MM 26 343;

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

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

Synthetic triple phosphates of Ca, Na & Eu/Nd/Fe: **BI Lazoryak & 4 others** 1996 MRB 31 207-16 (L740).

Synthetic $\text{Ca}_8\text{CeMg}(\text{PO}_4)_6\text{SiO}_4$, XRPD structure: **RN Kotov & 3 others** 1997 CrR 42 951-7 (K1041).

Synthetic $\text{Ca}_9\text{Fe}(\text{PO}_4)_7$, Mössbauer, IR, NPD structure: **AA Belik & 4 others** 2002 ChM 14 3937-45 (7925).

whitmoreite $\text{Fe}^{2+}\text{Fe}^{3+}_2(\text{PO}_4)_2(\text{OH})_2.4\text{aq}$. *Arthurite* structure group.

Structure: **PB Moore AR Kampf AJ Irving** 1974 AM 59 900-5.

Occurrence: MM 40 915.

wickenburgite $\text{CaPb}_3\text{Al}_2\text{Si}_{10}\text{O}_{24}(\text{OH})_6$.

Sheet structure with hexagonal connectivity of octahedra & tetrahedra.

Structure: **AE Lam & 3 others** 1994 CM 32 525-32 (L683). Occurrence: MM 37 966.

wickmanite $(\text{Mn,Ca})\text{Sn}(\text{OH})_6$. *Schoenfliesite* structure group. ReO_3 structure type.

Cubic dimorph of tetragonal *tetrawickmanite*.

Structure: NPD, **LC Basciano & 3 others** 1998 CM 36 1203-10.

Synthetic $\text{MnSn}(\text{OH})_6$: **H Strunz B Contag** 1960 AC 13 601-3 (S1542).

Occurrence: **PB Moore JV Smith** 1968 Arkiv Mineral Geol 4 395-9 = AM 53 1063.

Unnamed Ge-wickmanite $(\text{Mn,Fe})(\text{Sn,Fe})(\text{OH})_6$: **BH Geier J Ottemann** 1970 NJMA 114 89-107.

wicksite $\text{NaCa}_2(\text{Fe,Mn})_4\text{MgFe}^{3+}(\text{PO}_4)_6.2\text{aq}$.

Isostructural *bederite* $\text{Ca}_2\text{Mn}_2\text{Fe}_2\text{Mn}_2(\text{PO}_4)_6.2\text{aq}$ & *grischunite* $\text{NaCa}_2\text{Mn}_2[\text{Fe,Mn}]\text{Mn}_2(\text{AsO}_4)_6.2\text{aq}$.

Structure: **MA Cooper FC Hawthorne** 1997 CM 35 777-84.

Occurrence & SCXRD: **BD Sturman DR Peacor PJ Dunn** 1981 CM 19 377-80.

widenmannite $\text{Pb}_2(\text{UO}_2)(\text{CO}_3)_2$.

Structure determination not found.

Occurrence & SCXRD: MM 32 991;

K Walenta 1976 SMPM 56 167-85 (W671);

Cornwall, XRPD & IR, **NJ Elton JJ Hooper** 1995 MM 59 745-9.

widgiemoolthalite $(\text{Ni,Mg})_5(\text{CO}_3)_4(\text{OH})_2.4-5\text{aq}$.

Isostructural with Mg analog *hydromagnesite* $\text{Mg}_5(\text{CO}_3)_4(\text{OH})_2.4\text{aq}$. & Cu analog

cuprohydromagnesite $(\text{Cu,Mg})_5(\text{CO}_3)_4(\text{OH})_2.4\text{aq}$.

Structure determination not found.

Occurrence & XRPD: **EH Nickel BW Robinson WG Mumme** 1993 AM 78 819-21.

wightmanite $\text{Mg}_5(\text{BO}_3)\text{O}(\text{OH})_5.2\text{aq}$.

Structure: **PB Moore T Araki** 1972 Nature Phys Sci 239 25-6 (M415);

do 1974 AM 59 985-1004.

Occurrence: MM 33 1156.

wilcoxite $\text{MgAl}(\text{SO}_4)_2\text{F}.18\text{aq}$. **Sabelli**: no structure.

Structure determination not found.

Occurrence & SCXRD: **SA Williams FP Cesbron** 1983 MM 47 37-40.

wilhelmkleinite $\text{ZnFe}_2(\text{AsO}_4)_2(\text{OH})_2$.

Description: **J Schlüter & 4 others** 1999 NJMM 558-64 (S2016).

Structure: SC-XRD, **G Adiwidjaja & 3 others** 2000 ZK 215 96-101 (A929).

wilhelmvierlingite $(\text{Ca,Zn})\text{MnFe}(\text{PO}_4)_2(\text{OH}).2\text{aq}$. *Overite* structure group.

Structure determination not found.

Occurrence: **A Mücke** 1983 Der Aufschluss 34 267-74 = AM 69 568.

wilkinsonite $\text{Na}_2\text{Fe}^{2+}_4\text{Fe}^{3+}_2\text{Si}_6\text{O}_{20}$. *Aenigmatite* structure group.

Occurrence: **MB Duggan** 1990 AM 75 694-701;

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

wilkmanite Ni_3Se_4 . Dimorphic with *spinel trüstedtite*.

Isostructural with *brezinaite* Cr_3S_4 from cell dimensions.

Structure determination not found. [jvs: check for *synthetic*.]
 Occurrence & XRPD: **Y Vuorelainen A Huhma A Häkli** 1964 Compt rend Soc geol Finlande 36 113-25 = AM 50 519.
willemite (-I, -alpha) Zn_2SiO_4 . Isostructural with *alpha-eucryptite* & *phenakite*.
 Structure: **C Hang MA Simonov NV Belov** 1970 SPC 15 387-90 (H891);
 phase II, **F Marumo Y Syono** 1971 AC B27 1868-70;
KH Klaska JC Eck D Pohl 1978 AC 34 3324-5;
MA Simonov & 3 others 1978 SPD 22 622-3 (W630).
Synthesis: **L Reynaud & 3 others** 1996 MRB 31 1133-9 (R679).
Synthetic Ge-analog: **C Hang MA Simonov NV Belov** 1970 SPC 15 387-90 (H891).
Synthetic Co-doped, absorption & luminescence spectroscopy: **TC Brunold HU Guedel E Cavalli** 1996 Chem Phys Lett 252 112-20.
Synthetic Eu(III)/Mn(II) in Ba/Zn orthosilicate, luminescence: **AM Pires MR Davolos** 2001 ChM 13 21-7 (1008).
Synthetic pure & Mn-doped, fluorescent spectroscopy of green phosphor: **TS Ahmadi M Haase H Weller** 2000 MRB 35 1869-79 (937).
 Industrial use as green phosphor in cathode ray tubes and lamps.
willemseite $(Ni,Mg)_3Si_4O_{10}(OH)_2$. = *pimelite*?
 Essentially isostructural with Mg analog *talca* & Fe analog *minnesotaitaite*, but complications from polytypism.
 Structure determination not found.
 Occurrence: MM 37 966-7;
SA De Waal 1970 AM 55 31-42.
 Check *villiersite* $(Ni,Mg,Fe,Co)_7Si_8O_{22}(OH)_2$, whose formula fits better with amphibole.
willhendersonite $KCaAl_3Si_3O_{12} \cdot 5aq$. *Zeolite* mineral group. *Chabazite* structure type.
 Structure: **E Tillmanns RX Fischer WH Baur** 1984 NJMM 547-58 (T288).
 Occurrence: **DR Peacor & 4 others** 1984 AM 69 186-9.
Willhendersonite-pure-Ca, occurrence Teri, Italy, & structure with different cation positions: **G Vezzalini S Quartieri E Galli** 1997 Z 19 75-9 (V279).
willyamite $(Co,Ni)SbS$. *Cobaltite* structure group.
 Structure: **P Bayliss** 1986 CM 24 27-33.
wiluite $\sim Ca_{19}(Al,Mg,Fe,Ti)_{13}(B,Al,void)_5Si_{18}O_{68}(O,OH)_{10}$.
 Isostructural with *vesuvianite*: **LA Groat FC Hawthorne TS Ercit JD Grice** 1998 CM 36 1301-4;
 controversy, CM 38 763-6.
 New occurrence, Ariccia, Latium: SC-XRD & XAFS structure, complex composition, **F Bellatreccia & 5 others** [2005 CM 43 1457-68].
winchite $NaCa(Mg,Fe)_4AlSi_8O_{22}(OH)_2$. *Amphibole* structure group; monoclinic subtype.
 Structure: ferrian, & nomenclature problems, **EV Sokolova & 4 others** 2001 CM 39 171-7.
 Occurrence: **VK Nayak BE Leake** 1975 MM 40 395-9;
BE Leake & 3 others 1986 MM 50 173-5.
winstanleyite $TiTe_3O_8$. Analog of *walfordite* $(Fe,Te)Te_3O_8$.
 Based on *fluorite* structure.
 Compare with *cliggordite* UTe_3O_9 .
 Matches *synthetic*: **S Galy G Meunier** 1969 CRASP C 268 1249-52.
 Structure: SC-XRD, **L Bindi C Cipriani** 2003 CM 41 1469-73.
 Occurrence & SCXRD: **SA Williams** 1979 MM 43 453-7.
 $[(Fe,Te,Ti,Mg)Te_3O_8]$. IMA 96-003. Ferric analog of *winstanleyite*.]
wiserite $[(Mn,Mg)_{14}(B_2O_5)_4(OH)_8][(Si,Mg)(O,OH)_4Cl]$. 3 Å-wallpaper structure type.
 Structure: **F Pertlik PJ Dunn** 1989 AM 74 1351-4.
witherite $BaCO_3$. *Aragonite* structure group.
 Structure: **JPR de Villiers** 1971 AM 56 758-67.
 Phase transition at high-P, diamond-anvil cell: **C Lin L Liu** 1997 PCM 24 149-57 (L843).
 Low-T heat capacity: **VM Gurevich & 5 others** 2001 GI 39 1007-14 (5010).
Strontianite-witherite solid solution, FTIR: **ME Böttcher & 3 others** 1997 EJM 9 519-28 (B1646).
wittichenite Cu_3BiS_3 .
 Polymorphic transitions with increasing T; related to transitions in *skinnerite* Cu_3SbS_3 .
 Structure: **E Matzat** 1972 TMPM 18 312-6 (M1267);

V Kocman EW Nuffield 1973 AC B29 2528-35;
polymorphism, **E Makovicky** 1994 NJMA 168 185-212 (M1211).

wittite $\text{Pb}_9\text{Bi}_{12}(\text{S},\text{Se})_{27}$.

?Merely a Se-substituted *cannizzarite*: **NN Mozgova & 4 others** 1992 MP 46 137-53 (M1244);
Description of Vulcano specimens, **YS Borodaev & 7 others** 2000 CM 38 23-34.

wodginite $\text{Mn}(\text{Sn}_{0.6}\text{Ta}_{0.2}\text{Ti}_{0.1}\text{Fe}_{0.1})(\text{Ta}_{0.9}\text{Nb}_{0.1})\text{O}_8$. Titano-, ferro-, & lithio- variants.
Alpha- PbO_2 (*scrutinyite*) structure type; monoclinic-distorted superstructure of *ixiolite*.

Structure: **J Graham MR Thornber** 1974 AM 59 1040-4;

RB Ferguson FC Hawthorne JD Grice 1976 CM 14 550-60;

TS Ercit FC Hawthorne P Cerny 1992 CM 30 597-611;

TS Ercit P Cerny FC Hawthorne CA McCammon 1992 CM 30 613-31.

Occurrence: MM 33 1156.

Classification, **TC Ercit P Cerny FC Hawthorne** 1992 CM 30 633-8;

summary of *scrutinyite*-related structures, **NA Yamnova DYu Pushcharovskii AV
Volshin** 1995 CrR 40 428-33 (Y158).

WOHLERITE/LAVENITE STRUCTURE SUPERGROUP Includes:

<i>baghdadite</i>	$\text{Ca}_3\text{ZrSi}_2\text{O}_9$	CTF net 1086
<i>cuspidine</i>	$\text{Ca}_4\text{Si}_2\text{O}_7(\text{F},\text{OH})_2$	CTF net 1083
<i>hiortdahlite</i>	$(\text{Ca},\text{Na})_3\text{ZrSi}_2\text{O}_7(\text{O},\text{OH},\text{F})_2$	CTF net 1086
<i>janhaugite</i>	$\text{Na}_3\text{Mn}_3\text{Ti}_2\text{Si}_4\text{O}_{15}(\text{OH},\text{F},\text{O})_3$	CTF net 1083
<i>kochite</i>	$\text{Na}(\text{Na},\text{Ca})_2\text{Ca}_2(\text{Mn},\text{Ca})\text{ZrTi}(\text{Si}_2\text{O}_7)_2(\text{O},\text{F})_2\text{F}_2$	CTF net 1086
<i>lâvenite</i>	$(\text{Na},\text{Ca})_3\text{ZrSi}_2\text{O}_7(\text{O},\text{OH})_2$	CTF net 1083
<i>niocalite</i>	$\text{Ca}_7\text{Nb}(\text{Si}_2\text{O}_7)_2\text{O}_3\text{F}$	CTF net 1083
<i>normandite</i>	$\text{Na}_{1.1}\text{Ca}_{1.0}(\text{Mn}_{1.5}\text{Fe}_{0.3})(\text{Ti}_{0.8}\text{Nb}_{0.1}\text{Zr}_{0.1})\text{Si}_2\text{O}_8\text{F}$	CTF net 1083
<i>rosenbuschite</i>	$(\text{Ca},\text{Na})_3(\text{Zr},\text{Ti})\text{Si}_2\text{O}_8\text{F}$	CTF net 1086
<i>wöhlerite</i>	$\text{NaCa}_2(\text{Zr},\text{Nb})\text{Si}_2\text{O}_8(\text{O},\text{OH},\text{F})$	CTF net 1086

The lâvenite & wöhlerite subgroups have different topologies of the octahedral-tetrahedral nets specified by numbers 1083 & 1086 in the Consortium for Theoretical Frameworks.

[jvs: perhaps this nomenclature should be reconsidered: thus *cuspidine* might be used instead of lâvenite. Check whether polytypic relation. Check all structures for correct assignment to net type.]

wöhlerite = woehlerite $\text{Na}(\text{Ca},\text{REE})_2(\text{Zr},\text{Nb})\text{Si}_2\text{O}_8(\text{O},\text{OH},\text{F})$.

Wöhlerite/*lâvenite* supergroup; wöhlerite structure group.

Structure: **RI Shibayeva NV Belov** 1962 DAN USSR ES 146 128-331;

VM Golyshev & 3 others 1973 SPD 18 287-9 (G689);

M Mellini S Merlino 1979 TMPM 26 109-23 (M1268) = MA 81-1197.

Occurrence: **J Keller CT Williams U Koberski** 1995 MM 59 561-5.

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

wolfeite $(\text{Fe},\text{Mn})_2(\text{PO}_4)\text{OH}$. *Triploidite* structure group. Dimorph of *satterleyite*.

Structure determination not found.

Occurrence: MM 29 996.

WOLFRAMITE STRUCTURE GROUP Includes:

<i>cuproscheelite</i>	CuWO_4 mineral species questioned]
<i>ferberite</i>	FeWO_4
<i>huebnerite</i>	MnWO_4
<i>sanmartinite</i>	$(\text{Zn},\text{Fe},\text{Ca},\text{Mn})\text{WO}_4$
<i>wolframite</i>	$(\text{Fe},\text{Mn})\text{WO}_4$
<i>wolframoixiolite</i>	$(\text{Fe},\text{Mn},\text{Nb})_2(\text{Nb},\text{W},\text{Ta})_2\text{O}_8$

Synthetic NiWO_4 : **RO Keeling** 1957 AC10 209-213.

Synthetic FeNbO₄: trimorphic, low-T monoclinic to orthorhombic, & to high-T *rutile*, **RS Roth JL Waring** 1964 AM 49 243-6. [jvs: other synthetics need checking.]

Synthetic CdWO₄: **AP Chichagov VV Ilyukhin NV Belov** 1966 SPD 11 11-3.

Synthetic ZnWO₄: **OS Filipenko EA Pobedinskaya NV Belov** 1968 SPC 13 127-9.

Synthetic MgWO₄: **OS Filipenko & 3 others** 1969 SPC 13 933-5.

Synthetic MnWO₄ -monoclinic: **VB Kravchenko** 1969 Russ J Struct Chem 10 139-40.

Synthetic CuWO₄, distorted *wolframite* type: **L Kihlberg E Gebert** 1970 AC B26 1020-6.

Synthetic (Co/Ni/Cu)WO₄, magnetic structure: **H Weitzel** 1970 Solid State Comm 8 2071-2.

Synthetic (Mn/Co/Ni)WO₄, NPD, **do** 1976 ZK 144 238-58 (W716).

Synthetic CoWO₄ & NiWO₄: **C Wilkinson MJ Sprague** 1977 ZK 145 96-107.

Synthetic (Cd/Mg/Mn)WO₄: diamond cell to 8 GPa, **J Macavei H Schulz** 1993 ZK 207 193-208.

Synthetic MnMoO₄-alpha: NPD, magnetic structure, **G Lautenschläger & 3 others** 1994 ZK 209 936-40 (L627).

Synthetic (Li/Na/K/Cs)Cr(WO₄)₂, spectroscopy & magnetics: **J Hanuza & 6 others** 1999 JSSC 148 468-78 (H1449).

wolframite (Fe,Mn)WO₄. *Ferberite-huebnerite* solid solution. Wolframite structure group. Based on alpha-PbO₂ (*scrutinyite*) connectivity.

Structure: **F Laves G Bayer A Panagos** 1963 SMPM 43 217-34 = MA 16-246.

Raman, *scheelite*, wolframite & *wulfenite*: **JT Kloprogge RL Frost** 1999 NJMM 193-211 (K1165).

wolframioxiolite ~-(Fe,Mn,Nb)₂(Nb,W,Ta)₂O₈. *Wolframite* structure group.

Structure & redefinition: **S Wang Z Ma Z Peng** 1988 Kexue Tongbao 33 1363-6 = AM 75 1215.

wollastonite CaSiO₃-*triclinic-beta*. *Pyroxenoid* mineral group. Wollastonite structure type. Quadrimorphic with *monoclinic-beta-CaSiO₃* (*parawollastonite*), *alpha-CaSiO₃* (*pseudowollastonite*) & high-P CaSiO₃ (special isomorph of *wollastonite II*); further complications involve polytypes.

Structure: **MJ Buerger CT Prewitt** 1961 Proc Nat Acad Sci 47 1884-8; relation to *bustamite*, **DR Peacor CT Prewitt** 1963 AM 48 588-96 (P35); **H-R Wenk** 1969 CMP 22 238-47; **DA Jefferson MG Bown** 1973 NPS 245 43-4; **JL Hutchison AC McLaren** 1976 CMP 55 303-9; **7T, C Henmi & 3 others** 1978 MJJ 9 169-81; **Y Ohashi LW Finger** 1978 AM 63 274-88 (O148); electron image, **DJ Smith DA Jefferson LG Mallinson** 1981 AC A37 273-80; 3T, 4T & 5T polytypes, **C Henmi & 4 others** 1983 AM 68 156-63; **Y Ohashi** 1984 PCM 10 217-29; stacking variation in *wollastonite* & *bustamite*, **RJ Angel** 1985 MM 49 37-48.

Ca-EXAFS & Si NMR: **N Lequex A Morau S Philippot P Boch** 1999 JACeS 82 1299-306 (L987).

High-P CaSiO₃: triclinic with Si₃O₉ rings polytypic with *pseudowollastonite*, **FJ Trojer** 1969 ZK 130 185-206 (T148).

Trace-element partition with silicate-carbonate melt 3 GPa 1693 K: **KM Law J & 3 others** 2000 MM 64 651-61.

Wollastonite II, **E Essene** 1974 CMP 45 247-50; **K-F Hesse** 1984 ZK 168 93-8; polymorph of *walstromite*, **W Joswig & 3 others** 2003 ZK 218 811-8.

Crystallization kinetics of polytypes: **E Mazzucato AF Gualtieri** 2000 PCM 27 565-74 (M1843).

Surface leaching, Raman: **WH Casey & 4 others** 1993 N 366 253-6 (C678).

Incongruent dissolution & leached layer: **EJ Weissbart ID Rimstidt** 2000 GCA 64 4007-16 (327).

Contact-metamorphic, Sierra Nevada: **JM Ferry BA Wing D Rumble III** 2001 JP 42 1705-28 (3040).

Sterling Hill Fe-Zn-Mn ore: **A Dúzs-Moore & 3 others** 2003 MP 79 225-42.

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

Synthetic CaGeO₃, *wollastonite*-1T type: **J Barbier D Lévy** 1997 ZK 212 519-28 (B1085); also structure of *synthetic* Ca₅Ge₃O₁₁.

wölsendorfite (Pb,Ca)U₂O₇.2aq.

Structure: **PC Burns** 1999 AM 84 1661-73.

Occurrence: MM 31 975.

Compare *bauranoite* BaU₂O₇.4-5aq & *metacalcouranoite* (Ca,Na,Ba)U₂O₇.1.7aq that may be related & justify membership in proposed *wölsendorfite* group: **LN Belova & 3 others** 1985 = AM 75 246.

Structure: partial, **J Toussaint** 1960-1 Bull Soc Géol Belgique 84 365-73;
 SC-XRD, **PC Burns** 1999 preprint (B1890).
 Occurrence: **J Protas** 1957 CRASP 244 2942-4.
wonesite (Na,K)(Mg,Fe,Al)₆(Si,Al)₈(OH,F)₄.
Mica structure group; one-layer monoclinic subgroup.
 Structure: **DR Veblen** 1983 AM 68 554-65
 True, HRTEM, **T Kogure & 2 others** 2005 AM 90 725-31.
 Occurrence: MM 46 528.
woodallite Mg₆Cr₂(OH)₁₆Cl₂.4aq. *Hydrotalcite* mineral group.
 Occurrence & XRPD: **BA Grguric IC Madsen A Pring** 2001 MM 65 427-35.
woodhouseite CaAl₃(PO₄)(SO₄)(OH)₆. *Beudantite* structure group.
 Review: **Sabelli** p.25.
 Structure: **T Kato** 1971 NJMM 241-7, 1977 54-8.
 Early diagenesis of *woodhouseite* & *crandallite* in sandstones: **G Pe-Piper LM Dolansky** 2005 AM 90 1434-41.
 Occurrence: MM 25 647.
wooldridgeite Na₂CaCu₂(P₂O₇)₂.10aq.
 Structure: **MA Cooper FC Hawthorne** 1999 CM 37 73-81.
 Occurrence: **FC Hawthorne & 5 others** 1999 MM 63 13-6.
woodruffite (Zn,Mn)Mn₃O₇.1-2aq. 3 x 4 tunnel octahedral structure.
 Occurrence: Mexico & structure: SC-XRD/TEM, **JE Post & 3 others** 1999 AM 88 1697-702;
 & crystallography, *synthetic*, **C Frondel** 1953 AM 38 761-9.
woodwardite Cu₄Al₂(SO₄)(OH)₁₂.2-4aq.
Hydrotalcite-pyroaurite structure group: **G Raade CJ Elliott VK Din** 1985 MM 49 583-90.
 Structure determination not found. Review: **Sabelli** p.21.
 Occurrence & XRPD: **EH Nickel** 1976 MM 40 644-7.
[wretbladite (MM 29 996) is *stibarsen*.]
wroewolfeite Cu₄(SO₄)(OH)₆.2aq. Review: chain structure, (E289).
 Polymorphic with *langite* & *posnjaite*.
 Structure: **FC Hawthorne LA Groat** 1985 AM 70 1050-5.
 Raman vs OH: **RL Frost & 4 others** 2004 AM 89 1130-7.
 Occurrence: MM 40 915.
wulfenite PbMoO₄. *Scheelite* structure group.
 Structure: **L Vegard** 1926 Phil Mag 1 1151;
LG Sillén AL Nylander ? Arkiv Kemi Mineral Geol 17A = MA 9-44;
T Araki 1957 Mem Coll Sci Univ Kyoto B 24 155-60 = MA 15 99;
 ND, **J Leciejewicz** 1965 ZK 121 158-64;
 SC-XRD, **C Lugli L Medici D Saccardo** 1999 NJMM 281-8;
 tungstenian, SC-XRD, **DE Hibbs & 4 others** 2000 MM 64 1057-62.
 Raman, *scheelite*, *wolframite* & *wulfenite*: **JT Kloprogge RL Frost** 1999 NJMM 193-211 (K1165).
 Occurrence: Crich, MA 96M/4917.
wülfingite Zn(OH)₂-epsilon. Trimorphic with *ashoverite* & *sweetite*.
Synthetic: **RB Corey RWG Wyckoff** 1933 ZK 86 8-18;
HG Schnering 1964 ZaaC 330 170-8.
 Occurrence: (S1484); MM 50 760.
wupatkiite (Co,Mg,Ni)Al₂(SO₄)₄.22aq. *Halotrichite* structure type.
 Occurrence, XRPD: **SA Williams FP Cesbron** 1995 MM 59 553-6.
WURTZITE STRUCTURE GROUP Includes:

<i>bromellite</i>	BeO	
<i>greenockite</i>	CdS	
<i>manganous sulfide-beta</i>	MnS	unnamed mineral
<i>orickite</i>	~CuFeS ₂ .0.5aq	distorted
<i>wurtzite</i>	(Zn,Fe)S	
<i>zincite</i>	ZnO	

Regular & random structures: **Wells** p 630.

Various synthetic phases: **RC Erd GK Czamanske** 1983 AM 68 245-54.
 Review of oxides: **AR West** 1975 ZK 141 422-36 (W711).
 Review of ordering of metal atoms: **J Hauck K Mika** 1998 JSSC 138 334-41(W912).
 Synthetic In-doped-Sn-oxide *Transparent Conducting Oxide* films are used in optoelectronic devices; HRTEM, SAED, EDS of analogous In-Zn TCO film revealed *bixbyite* & *wurtzite* structure types: **L Dupont & 4 others** 2001 JSSC 158 119-33 (2057).
 Synthetic CdSe: **AW Stevenson Z Barnes** 1984 AC B40 530-7.
 Synthetic NH₄F: 1989 AC B45 212-8 =SR 56A 72.
 Synthetic (Ga/In)N, transition to *halite* structure high-P: **M Ueno & 4 others** 1994 PRB 49 14-21.
 Synthetic GaN, wurtzite, *sphalerite* + *halite* types: **Y Xie & 5 others** 1996 APL 69 334-6 (X21).
 Synthetic Cd_{2-x}GeO_{4-x-3y}N_{2y} derivative: **C Louis & 4 others** 1995 JSSC 119 304-10.
 Synthetic BeO, AlN, GaN, ZnO, CdSe & CdS: anisotropic thermal expansion, XRPD, **H Iwanaga A Kunishige S Takeuchi** 2000 JMS 35 2451-4 (I255).
 Synthetic Al-silicate-oxynitrides: **AL Ivanovskii SV Okatov GP Shveikin** 1999 DAN 366 54-7.
wurtzite (Zn,Fe)S. Trimorphic with *matraite* & *sphalerite*.
 Structure: SC-ND, **J Albertsson SC Abrahams ?**;
 NPD, **EH Kisi ML Elcombe** 1989 AC C45 1867-70 (K754).
 Anharmonic temperature factors & charge density: **MK Rabadonov** 1995 CrR 40 17-22 (R396).
 4H & 8H polytypes: **GY Chao RA Gault** 1998 CM 36 775-8.
 Surface-driven nanoparticles: **B Gilbert & 10 others** 2004 JCP 120 11785-95 (10383).
 In meteorites: **AE Rubin** 1997 MPS 32 231-47.
wüstite Fe_{1-x}O; x = 0.04-0.12. *Periclase/halite* structure type with defects.
 Structure: **F Koch JB Cohen** 1969 AC B25 275-87 (K155);
 modulated structure, **A Yamamoto** 1982 AC B38 1451-6;
 nonstoichiometry & physical properties, **R Jeanloz RM Hazen** 1983 N 304 620-2;
 Mössbauer, **CA McCammon DC Price** 1985 PCM 11 250-4;
 commensurate cluster in quenched Fe_{0.9}O, **G Nihoul J-R Gavarrri C Carel** 1991 AC B47 333-7 (N375);
 diffuse scattering from incommensurate structure, **TR Welberry AC Christy** 1995 JSSC 117 398-406;
 ND, **H Fjellvåg F Grønvold S Stølen B Hauback** 1996 JSSC 124 52-7 (F506);
 displacive transition to rhombohedral symmetry > 17 GPa 300 K, & second transition to *niccolite* type, **Y Fei H Mao** 1994 S 266 1678-70 (F563); **H Mao & others** 1996 EPSL 96 135-45 (M1420);
 defect distribution, diffuse XRD, **TR Welberry AG Christy** 1997 PCM 24 24-38 (M787);
 defect-cluster effect on high-P behavior, XRD, **C Haavik & 3 others** 2000 PCCP 2 5333-40 (674);
 magnetic structure, NPD, 10 K, **H Fjellvåg BC Hauback Y Vogt S Stølen** 2002 AM 87 347-9;
 elastic tensor to 10 GPa, x 0.06, **AP Kantor & 6 others** 2004 PRL 93 215502 (10971).
 Occurrence: MM 23 639;
 in meteorites, **AE Rubin** 1997 MPS 32 231-47.
 Synthetic *magnesiowüstite* is (Mg,Fe)O phase believed to occur in lower mantle, based on diamond-cell XRD.
 Synthetic Ca_{0.03}Fe_{0.83}O: **A Tazi & 3 others** 1995 MRB 30 829-37 (T442).
 Synthetic, cell dimensions from XRD, inclusions of *magnetite* from EMP: **JHL Voncken T Bakker RH Heerema** 1997 NJMM 410-22 (V297).
wyartite Ca₃(UO₂)₆U⁴⁺(CO₃)₂(OH)₁₈.3-5aq.
 Phase I, distinguished from phase II produced by chemical alteration without loss of crystal form:
JR Clark 1960 AM 45 200-8.
 Must be carefully distinguished from *ianthinite*.
 Structure: **PC Burns RJ Finch** 1999 AM 84 1456-60.
 Occurrence: **C Guillemin J Protas** 1959 BSFMC 82 80-6 (G737).
wycheproofite NaAlZr(PO₄)₂(OH)₂.aq.
 Structure: SC-XRD, **U Kolitsch** 2003 EJM 15 1129-34 (10070).
 Occurrence & crystallography: **WD Birch & 3 others** 1994 MM 58 635-9.
WYLLIEITE STRUCTURE GROUP Includes
ferrowyllieite (Na,Ca,Mn)(Fe,Mn)(Fe,Mg)Al(PO₄)₃
ferrorosemaryite NaFe²⁺Fe³⁺Al(PO₄)₃
wyllieite (Na,Ca,Mn)(Mn,Fe)(Fe²⁺,Fe³⁺,Mg)Al(PO₄)₃

rosemaryite (Na,Ca,Mn)(Mn,Fe)(Fe,Mg)Al(PO₄)₃
 Nomenclature & relation to **alluardite** structure group: **PB Moore J Ito** 1979 MM 43 227-35.
wyllieite (Na,Ca,Mn)(Mn,Fe)(Fe,Mg)Al(PO₄)₃. *Wyllieite* structure group.
 Structure: **PB Moore J Molin-Case** 1974 AM 59 280-90.
 Occurrence: MM 39 931.

xanthiosite Ni₃(AsO₄)₂. Polysomatic series of *olivine/halite* layers with *aerugite*.
 Synthesis & XRPD: **JB Taylor RD Heyding** 1958 Can J Chem 36 597-606 (T460).
Synthetic: **J Barbier C Frampton** 1991 AC B47 457-62 (B1370).
 Also orthorhombic dimorph isostructural with Ni₃(VO₄)₃ & Co₃(VO₄)₂.
xanthoconite Ag₃AsS₃. Dimorphic with *proustite*.
 Structure: **P Engel W Nowacki** 1968 AC B24 77-81 (E325);
J Rosenstingl F Pertlik 1993 Mitt Oster Mineral Ges 138 9-15 = MA 94M/4148.
xanthoxenite Ca₄Fe₂(PO₄)₄(OH)₂.3aq. *Fairfieldite* structure group.
 Structure determination not found.
 Redefinition: **PB Moore J Ito** 1978 MM 42 309-23.
xenotime-Y YPO₄. *Zircon* structure type.
 Structure: **L Vegard** 1927 Phil Mag ser 7 4 511-25;
I Krstanovic 1965 ZK 121 315-6.
 Crystal chemistry of *monazite* & xenotime structure groups, structure of xenotime & *synthetic*
 (Y/Tb/Dy/Ho/Er/Tm/Yb/Lu)PO₄: **Y Ni JM Hughes AN Mariano** 1995 AM 80 21-6.
 Occurrence in talc-chlorite, Trimouns, French Pyrenees: **P de Parseval F Fontan T Aigouy** 1997
 CRASP 324 Ila 625-30 (D639).
 Immiscibility of *monazite* & xenotime in *synthetic* (Ce/Y)PO₄, XRPD: **R Gratz W Heinrich** 1997 AM 82 772-80.
 Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
 [ScPO₄. IMA 96-024. *Xenotime* group.]
xenotime-Yb YbPO₄.
 Occurrence & XRPD: **HM Buck et al** 1999 CM 37 1303-6.
xiangjiangite (Fe,Al)(UO₂)₄(PO₄)₂(SO₄)₂(OH).22aq.
Coconinoite subgroup of *phosphuranylite* mineral group.
 Review: **Sabelli**, no structure. Structure determination not found.
 Crystallography: **LN Belova & 3 others** 1994 IMA Pisa 36-7.
 Occurrence: **Hunan Team** 1978 Sci Geol Sinica 183-8 = AM 64 466.
xifengite Fe₅Si₃.
 XRPD matches *synthetic*: PDF 11-615.
 Cell data match *synthetic* Mn₅Si₃: structure, Pearson type hP16, **K Åmark B Borén A Westgren**
 1936 Svensk Kem Tid 48 273 & Metallwirt 15 835; XRPD, PDF 3-1039.
 Occurrence & XRPD: **Z Yu** 1984 Acta Petrol Mineral 3 231-8 = AM 71 228.
xilingolite Pb_{3+x}Bi_{2-2/3x}S₆.
 Not synthesized: **H Liu LLY Chang** 1994 AM 79 1159-66.
 Not a dimorph of *lillianite*.
 Structure: SC-XRD, **P Berlepsch & 5 others** 2002 CM 39 1653-63.
 Occurrence & crystallography: **H Hong & 3 others** 1982 Acta Petrol Mineral Anal 1 14-8 = AM 69 409.
ximengite BiPO₄. 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.
[xinganite (Y,Ce)BeSiO₄OH Should be renamed *hingganite-Y*. *Datolite* structure group.
 Structure: **X Lulu Z Peng** 1985 Acta Mineral Sinica 5 289-93 = AM 73 441-2.]
[xingzhongite (Pb,Cu,Fe)(Ir,Pt,Rh)₂S₄ or (Ir,Cu)S.
 [jvs: ignore for now, data confusing, may be more than one mineral.]
 Occurrence: AM 61 185; AM 69 412;
T Augé 1988 CM 26 177-92. MM 40 916.]

xitieshanite $\text{Fe}^{3+}(\text{SO}_4)\text{Cl}_6\text{aq}$.
Structure: **J Zhou J Li W Dong** 1988 Kexue Tongbao 33 502-5 = AM 74 1404.
Occurrence: MM 50 761;
Mine waste, Indiana, **E Melchiorre & 3 others** 2005 AM 90 15188-21.

xocomecatlite $\text{Cu}_3\text{TeO}_4(\text{OH})_4$.
Structure determination not found.
Occurrence & XRPD: **SA Williams** 1975 MM 40 221-6.

xonotlite $\text{Ca}_6\text{Si}_6\text{O}_{17}(\text{OH})_2$.
Structure: **KS Mamedov NV Belov** 1955 DAN 104 615-8 (M51);
Y Kudoh Y Takéuchi 1979 MJ 9 349-73.
Ca-EXAFS & Si NMR: **N Lequex A & 3 others** 1999 JACeS 82 1299-306 (L987).
Polytypism, XRD & models: **C Hejoy T Armbruster** 2001 ZK 216 396-408 (2959).
Product of quartz-portlandite reaction: **J Wang A Tomita** 1997 Ind Eng Chem Res 36 1464-9.
Phase relations of *gyrolite*, *tobermorite* & xonotlite: **SG Zürn KT Fehr** 1997 EJM 9-1 406 (Z139).
Occurrence: & chemistry, (D782);
& XRPD of M2a2b2c & Ma2b2c polytypes, **JJ Esteban & 3 others** 2003 CM 41 161-70.
Dehydration of *hillebrandite*, *tobermorite* & xonotlite, TGA/DSC, SAXS/WAXS: **S Shaw CMB Henderson BU Komanschek** 2000 ChG 167 141-59 (S2150).

yafsoanite $(\text{Ca,Pb})_3\text{Te}^{6+}_2\text{Zn}_3\text{O}_{12}$. Garnet structure type.
Structure: **IV Rozhdestvenskaya NV Zayakina AA Kim** 1984 = MA 85M/0176;
D Jarosch J Zemann 1989 MP 40 111-6 (J248) = MA 89M/0197.
Occurrence: MM 46 528.

yagiite $(\text{Na,K})_3\text{Mg}_4\text{Al}_6(\text{Si,Al})_{24}\text{O}_{60}$. *Osumilite* structure group.
Structure determination not found.
Occurrence & XRPD: **TE Bunch LH Fuchs** 1969 AM 54 14-8.
In meteorites: **AE Rubin** 1997 MPS 32 231-47.

yakhontovite $\text{Ca}_{0.2}(\text{Fe}_{0.8}\text{Cu}_{0.8}\text{Mg}_{0.7})\text{Si}_4\text{O}_{10}(\text{OH})_2$.
Smectite structure group.
Occurrence, crystallography & ED: **VP Postnikova & 3 others** 1986 MZh 8 80-4 = AM 76 668-9.

[yamatoite $\text{Mn}_3\text{V}_2\text{Si}_3\text{O}_{12}$.
Hypothetical *garnet* endmember, not occurring in sufficient concentration to yield a mineral species: **T Yoshimura H Momoi** 1964 Sci Rep Fac Sci Kyushu Univ Geol 7 85-90 = AM 50 810 = MM 33 1160.]

yanomamite $\text{InAsO}_4.2\text{aq}$. *Variscite* structure group. Matches *synthetic*.
Occurrence & crystallography: **NF Botelho & 4 others** 1994 EJM 6 245-54 (B1151).
Synthetic $\text{TlAsO}_4.2\text{aq}$: **RCL Mooney-Slater** 1961 AC 14 1140-6;
P Tarte MT Paques-Ledent 1968 Bull Soc chim France special issue 1750-6.

yaroslavite $\text{Ca}_3\text{Al}_2\text{F}_{10}(\text{OH})_2.\text{aq}$.
Structure determination not found.
Occurrence: **MI Novikova GA Sidorenko MN Kuznetsova** 1966 ZVMO 95 39-44 = AM 51 1546.

yarrowite Cu_9S_8 .
Structure determination not found.
Occurrence & crystallography: **RJ Goble** 1980 CM 18 511-8.

yavapaiite $\text{KFe}(\text{SO}_4)_2$.
Relation to Cmc structure of FeSO_4 : **D Samaras J Coing-Boyat** 1970 BSFMC 93 190-4.
Structure: **EJ Graeber A Rosenzweig** 1971 AM 56 1917-33;
JW Anthony WJ McLean RB Laughon 1972 AM 57 1546-9.
Occurrence: MM 32 986.
Synthetic $(\text{Na/K/Rb/Cs})\text{Cr}(\text{CrO}_4)_2$: **K-A Wilhemi** 1957 Nw 22 580-1;
JJ Foster AN Hambly 1976 Australian J Chem 29 2137-48.
Synthetic $\text{NaFe}(\text{CrO}_4)_2$: **A Bonnin** 1970 Thesis, Univ Rennes.
Synthetic $\text{KSc}(\text{SO}_4)_2$: **R Perret** 1970 BSFMC 93 493-4;

P Couchot & 3 others 1971 Bull Soc Chim France 360-2.
Synthetic $KV(SO_4)_2$: **R Perret** 1971 BSFMC 94 84-5.
Synthetic $(Ca/Sr/Ba)(Ge/Zr/Hf/Ti/Sn)(PO_4)_2$: **R Masse A Durif** 1972 CRASP C 274 1692-5.
Synthetic $Na(Al/Ga/Fe/V/Rh)(SO_4)_2$: **R Perret A Thierri-Sorel P Couchot** 1972 BSFMC 95 521-4;
R Perret M Devaux P Couchot 1975 J Less-Common Metals 42 43-50;
R Fehrmann & 5 others 1991 Acta Chem Scand 45 961-4.
Synthetic $NaCr(SO_4)_2$: **R Perret P Couchot** 1974 JACr 7 336-7.
Synthetic $KFe(CrO_4)_2$: **P Gravereau A Hardy** 1976 BSFMC 99 206-10.
Synthetic $(Na/K)(CrO_4)_2$: **Y Cuddenec A Bonnin** 1977 J Inorg Nucl Chem 39 155-6.
Synthetic $(Rb/Cs)(PO_4)_2$: **VP Nikolaev & 3 others** 1983 Izv Akad Nauk SSSR Neorg Mater 19
972-7, 1986 22 1369-73.
Synthetic $NaFe[SeO_4]_2$: **G Giester** 1993 MP 48 227-33 (G695).
Synthetic $KMn^{3+}(SeO_4)_2$: **do** 1995 MPI 53 165-71 (G754).
Synthetic $BaMo(PO_4)_2$: **A Leclaire & 3 others** 1995 JSSC 116 364-8 (L643).
yeatmanite $Mn_7Zn_8Sb_2Si_4O_{28}$. Octahedral-tetrahedral sheet.
Structure: **PB Moore** 1966 AM 51 1494-500;
T Kato 1986 MJJ 13 53-64.
Occurrence: MM 25 647;
P Nysten 2003 CM 41 201-6.
yecoraite $Fe_3Bi_5(TeO_3)(TeO_4)_2O_9.n$ aq.
Structure determination not found.
Occurrence, XRPD (broad): **SA Williams FP Cesbron** 1985 Soc Mexicana Mineral 1 10-6 = AM 71 1547.
yedlinite $Pb_6CrCl_6O_6(OH)_8$.
Structure: **MM Wood WJ McLean RB Laughon** 1974 AM 59 1160-5.
Occurrence: MM 40 916.
ye'elimite $Ca_4Al_6O_{12}(SO_4)$.
Matches *synthetic* phase known as *intermediate* in Portland cement-sulphuric acid industry.
Structure determination not found.
Occurrence: **S Gross** 1983-4 Geol Sci Israel Current Research 1-4 = AM 72 226-7;
Austria, **H Heritsch** 1990 Mitt Abt Mineral Landesmuseum Joanneum 58-35 = AM 78 674.
yftisite $(Y,Dy,Er)_4(Ti,Sn)O(SiO_4)_2(F,OH)_6$.
Contains $M(TO_4)_2$ chain also found in *labuntsovite*, *metasideronatrite*, *nenadkevichite*,
sideronatrite & *tancoite*.
Structure: **VP Balko VV Bakakin** 1975 Zh Strukt Khim 16 837-42.
Occurrence: MM 46 528. MM 42 531.
Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
yimengite $K(Cr,Ti,Fe,Mg,Al)_{12}O_{19}$. *Magnetoplumbite* structure group.
Structure: **Z Peng Q Lu** 1985 Sci Sinica B 28 882-7.
Occurrence: China, **Z Dong J Zhou Q Li Z Peng** 1983 Kexue Tongbao 15 932-6 = AM 70 218;
Venezuela, **PH Nixon E Condliffe** 1989 MM 53 305-9.
 $[KCa_2Mg_2Fe_3Ti_5O_{19}]$ & $BaMg_2CrFe_4Ti_5O_{19}$.
New members of *yimengite* group.
Occurrence: **Q Lu H Chou** 1994 Acta Mineral Sinica 14 228-33 = AM 81 769.]
yingjiangite $(K_{1-x}Ca_x)(UO_2)_3(PO_4)_2(OH)_{1+x}.4aq$.
Phosphuranylite structure group from crystallography.
Occurrence & crystallography: **Z Chen Z Huang X Gu** 1990 Acta Min Sinica 10 102 = MM 60 686.
yixunite $\sim Pt_3In$.
Occurrence: **Z Yu** 1997 Acta Geol Sinica 71 332-5 = AM 83 655. MM 40 916.
yoderite $(Al,Mg,Fe)_2Si(O,OH)_5$.
Structure: **SG Fleet HD Megaw** 1962 AC 15 721-8 (F28);
JB Higgins PH Ribbe Y Nakajima 1982 AM 67 76-84.
Occurrence: MM 32 986.

yofortierite $(\text{Mn,Mg})_5\text{Si}_8\text{O}_{20}(\text{OH})_{2.4-5\text{aq}}$.
 Analog of *palygorskite* $(\text{Mg,Al})_2\text{Si}_4\text{O}_{10}(\text{OH})_{.4\text{aq}}$ & *tuperssuatsiaite* $\text{NaFe}_3\text{Si}_8\text{O}_{20} \cdot 4\text{aq}$.
 Structure determination not found.
 Occurrence & XRPD: **G Perrault Y Harvey R Pertsowsky** 1975 CM 13 68-74 (P671).

yoshikawaite $\text{Mg}_5(\text{CO}_3)_4(\text{OH})_{2.8\text{aq}}$. *Lansfordite* mineral group of hydrated Mg carbonates.
 Isostructural with Ni analog *widgiemoolthalite* $(\text{Ni,Mg})_5(\text{CO}_3)_4(\text{OH})_{2.4-5\text{aq}}$ & Cu analog
cuprohydromagnesite $(\text{Cu,Mg})_5(\text{CO}_3)_4(\text{OH})_{2.4\text{aq}}$
 Occurrence: MM 43 1069.
Yoshikawaite $\text{Mg}_5(\text{CO}_3)_4(\text{OH})_{2.8\text{aq}}$ is a higher hydrate that decomposes to *hydromagnesite*.

yoshimuraite $\text{Ba}_2\text{Mn}_2\text{TiO}(\text{Si}_2\text{O}_7)(\text{PO}_4)(\text{OH})$.
 BM_n *heterophyllosilicate polysomatic series*.
 Structure: SC-XRD, **AM McDonald JD Grice GY Chao** 2000 CM 38 649-56..
 Occurrence: MM 32 986.

yoshiokaite $\text{Ca}_{8-0.5x}\text{Al}_{16-x}\text{Si}_x\text{O}_{32}$, $x = 2.8-6.0$.
 Stuffed derivative of high *tridymite*; similar to *nepheline*.
 Structure: **IM Steele JJ Pluth** 1990 AM 75 1186-9.
 Occurrence: MM 54 671.

yttrialite-Y $(\text{Y,Th})_2\text{Si}_2\text{O}_7$.
 Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

ytrotetrafite-Y $(\text{Y,U,Ce})_2(\text{Ti,Nb,Ta})_2\text{O}_6\text{OH}$. *Pyrochlore* structure group.
 Structure determination not found.
 Occurrence: DD Hogarth 1977 AM 62 403-10.
 Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

ytrocerite $(\text{Ca,Ce,Y,La})\text{F}_3 \cdot n\text{aq}$.
 Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

ytrocolumbite-Y $(\text{Y,U,Fe}^{2+})(\text{Nb,Ta})\text{O}_4$.
 Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

ytrocrasite-Y $(\text{Y,Th,Ca,U})(\text{Ti,Fe})_2(\text{O,OH})_6$. Cell data match *euxenite* structure type.
 New occurrence & SCXRD: **WW Crook III** 1977 AM 62 1009-11.
 Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

ytrofluorite $(\text{Ca,Y})\text{F}_{2-3}$.
 Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

ytromicrolite-Y $(\text{Y}_{0.4}\text{RE}_{0.3}\text{Ca}_{0.3}\text{Mn}_{0.1}\text{Mg}_{0.1}\text{U}_{0.1})(\text{Ta}_{1.0}\text{Nb}_{0.7}\text{Fe}_{0.1}\text{Sn}_{0.1})\text{O}_6$.
Pyrochlore structure group.
 Structure determination not found.
 Occurrence & SCXRD: **WW Crook III** 1979 AM 64 890-2.

ytropyrochlore-Y $(\text{Y,Ce,Nd,Th})(\text{Nb,Ti,Ta})_2\text{O}_6$. *Pyrochlore* structure group.
 Structure determination not found.
 Occurrence: **DD Hogarth** 1977 AM 1977 62 403-10.
 Review (different formula): **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

ytrotantalite-Y $(\text{Y,U,Fe})(\text{Ta,Nb})\text{O}_4$. Metamict. Structure determination not found.
 Occurrence: **Dana**.
 Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

ytrotungstite-Y $\text{YW}_2\text{O}_6(\text{OH})_3$.
 Compare with *alumotungstite* $(\text{W,Al})(\text{O,OH})_3$ & probable structural analog *cerotungstite*.
 Structure: **RJ Davis GW Smith** 1971 MM 38 261-85.
 Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.

yuanfuliite $(\text{Mg,Fe}^{2+})(\text{Fe}^{3+},\text{Al,Ti,Mg})(\text{BO}_3)\text{O}$. Fe^{3+} -dominant analog of *warwickite*.
 Structure: SC-XRD & TEM, **PWU Appel S Bigi MF Brigatti** 1999 EJM 11 483-91 (A892).
 Occurrence & crystallography: **Z Huang P Wang** 1994 Acta Petrologica Mineralogia 13 328-34 = AM 81 252-3.

yuanjiangite AuSn . Isostructural with *nickeline*.
 Occurrence & XRPD: **L Chen et al** 1994 ? 13 232-8.

yugawaralite $\text{CaAl}_2\text{Si}_6\text{O}_{16}\cdot 4\text{aq}$. *Zeolite* mineral group.
 Consortium for Theoretical Frameworks tetrahedral net 630.
 Structure: **IS Kerr DJ Williams** 1967 ZK 125 220-5 (K120);
do AC B25 1183-90 (K120);
HW Leimer M Slaughter 1969 ZK 130 88-111;
 SC-ND, 13 K, **A Kvick G Artioli JV Smith** 1986 ZK 174 265-81 (K797);
 sector zoning, **M Akizuki** 1987 MM 51 615-20;
 dehydration, **A Alberti S Quartieri G Vezzolini** 1994 Stud Surf Sci Catal 84 637-44 (A561);
do 1996 EJM 8 1273-82 (A733);
 in situ dehydration, 315-791 K, XRD, **G Artioli & 4 others** 2001 AM 86 185-92;
 growth sectors, SC-XRD, **T Tanaka & 3 others** 2002 MM 66 409-20.
 Occurrence: MM 30 748.
 Thermochemistry & phase equilibria of Ca zeolites, **I Kiseleva & 3 others** 1996 AM 81 658-67.

yukonite $\sim(\text{Ca},\text{K},\text{Mg})\sim 6.5(\text{Fe},\text{Al})\sim 11\text{-}15(\text{AsO}_4)\text{gOH}\cdot 9\text{-}15.25\text{aq}$.
 [Amorphous in old literature.]
 New chemistry & XRPD: **DR Ross JE Post** 1997 PD 12 113-6 (R922).
 Occurrence, XRPD & electron diffraction: **AB Makeev & 5 others** 1984 MZh 6 91-7 = AM 71 846.
 Re-study, minor Cu, EPMA, IR: **Y Moelo O Rouer L Cario B Cervelle** 1999 MM 63 879-89.
 Symmetry & composition, TEM, Kamchatka & Yukon Territory: **O Nishikawa & 5 others** 2006 MM 70 73-81.

yuksporite $\text{K}_4(\text{Sr},\text{Ba})_2(\text{Ca},\text{Na})_{14}(\text{void},\text{Mn},\text{Fe})(\text{Ti},\text{Nb})_4(\text{O},\text{OH})_4(\text{Si}_6\text{O}_{17})_2(\text{Si}_2\text{O}_7)_3(\text{aq},\text{OH})_n$.
 Structure: SC-XRD, **SV Krivovichev & 6 others** 2004 AM 89 1561-5.
 Occurrence & XRD: **AE Fersman** 1923 Trans Northern Sci Econ Mineral 16 16-73;
 AM 71 1547-8; revised, ED, AM 89 253.

yvonite $\text{Cu}(\text{AsO}_3\text{OH})\cdot 2\text{aq}$.
 Description & crystal structure: **H Sarp R Cerny** 1998 AM 83 383-9.
 Occurrence: MR 28 60.

zabuyelite Li_2CO_3 .
 Structure: *synthetic*, **J Zemann** 1957 AC 10 664-6.
 Occurrence & XRPD: **M Zheng W Liu** 1987 Acta Mineral Sinica 7 221-6 = AM 75 243-4;
 fluid inclusions in *spodumene*, **AJ Anderson AH Clark S Gray** 2001 CM 39 1513-27.

zaccagnaite $\text{Zn}_4\text{Al}_2(\text{OH})_{12}(\text{CO}_3)_{0.5}\cdot 3\text{aq}$. *Hydrotalcite-manasseite* group.
 Occurrence & SC-XRD structure: **S Merlino P Orlandi** 2001 AM 86 1293-301.

zaherite $\text{Al}_{12}(\text{SO}_4)_5(\text{OH})_{26}\cdot 20\text{aq}$. Review: **Sabelli** no structure.
 Structure determination not found.
 Occurrence: **AP Ruotsala LL Babcock** 1977 AM 62 1125-8;
 XRPD & revised cell dimensions, **H de Bruijn & 4 others** 1985 MM 49 145-6.

zajacite-Ce $\text{Na}_0.9(\text{Ce},\text{other REE})_{1.1}\text{Ca}_0.9\text{F}_6$. Compare with *gagarinite*.
 Occurrence & crystallography: **JL Jambor & 3 others** 1996 CM 34 1299-304.

zakhirite $\text{Na}_4\text{Mn}_5\text{Si}_{10}\text{O}_{24}(\text{OH})_6\cdot 6\text{aq}$.
 Structure determination not found.
 Occurrence & ED: **AP Khomyakov & 4 others** 1982 ZVMO 111 491-5 = AM 68 1040.

zaireite $\text{Bi}(\text{Fe},\text{Al})_3(\text{PO}_4)_2(\text{OH})_6$. *Crandallite* structure group.
 Structure determination not found.
 Occurrence: **L Van Wambeke** 1975 BSFMC 98 351-3 = AM 62 174-5.

zajacite $\text{Na}(\text{REE}_x\text{Ca}_{1-x})(\text{REE}_y\text{Ca}_{1-y})\text{F}$. CM 34 1299-304. **Check.**

zalesiite $\text{CaCu}_6(\text{AsO}_4)_2(\text{AsO}_3\text{OH})(\text{OH})_6\cdot 3\text{aq}$. *Mixite* structure group.
 Occurrence, XRPD, IR: **J Sejkora T Ridkosal V Srein** 1999 NJMA 175 105-24 (S2126).

[zamboninite CaMg_2F_4 .
 Occurrence: MM 22 627.]

zanazziite
 $\text{Ca}_2(\text{Mg}_{0.6}\text{Fe}_{0.4})(\text{Mg}_{2.4}\text{Fe}_{1.1}\text{Mn}_{0.2}\text{Al}_{0.3}\text{Fe}^{3+}_{0.1})\text{Be}_4(\text{P}_{5.7}\text{Be}_{0.1}\text{Si}_{0.1})\text{O}_{24}(\text{OH})_{3.4}\cdot 6\text{aq}$.
 Similar to (Mn,Fe)-rich analog *roscherite* & (Fe,Mn) *greifensteinite*.

Structure determination not found.

Occurrence: **PB Leavens JS White JA Nelen** 1990 MR 21 413-7 = MM 60 686.

zapatalite $\text{Cu}_3\text{Al}_4(\text{PO}_4)_3(\text{OH})_9 \cdot 4\text{aq}$.

Structure determination not found.

Occurrence & XRPD: **SA Williams** 1972 MM 38 541-4.

zaratite $\text{Ni}_3(\text{CO}_3)(\text{OH})_4 \cdot 4\text{aq}$.

Problems: **KL Williams IM Threadgold AW Hounslow** 1959 AM 44 533-8;

DA Henry WD Birch 1992 MM 56 252-5.

[jvs: perhaps unstable in museum drawers.]

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

zavaritskite BiOF *Matlockite* structure type.

Synthetic: **B Aurivillius** 1948 Ark Kemi Min Geol 26B no. 2 6p. = MA 10-534.

zdenekite $\text{NaPbCu}_5(\text{AsO}_4)_4\text{Cl} \cdot 5\text{aq}$.

Isostructural with CaAs analog *lavendulan* $\text{NaCaCu}_5(\text{AsO}_4)_4\text{Cl} \cdot 4\text{aq}$ & CaP analog *sampleite* $\text{NaCaCu}_5(\text{PO}_4)_5\text{Cl} \cdot 5\text{aq}$; related to *mahnerite*.

Structure: **NV Zubkova & 4 others** 2003 CrR 48 939-43.

Occurrence: **P-J Chiappero H Sarp** 1995 EJM 7 553-7 (C764).

zektzerite $\text{NaLi}(\text{Zr,Ti,Hf})\text{Si}_6\text{O}_{15}$. Distorted *osumilite* structure type. 2,3-connected net.

Structure: **ME Cradwick HFW Taylor** 1972 AC B28 3583-7 (C635);

S Ghose C Wan 1978 AM 63 304-10.

zellerite $\text{Ca}(\text{UO}_2)(\text{CO}_3)_2 \cdot 5\text{aq}$. Dehydrates to *metazellerite* 3aq.

Structure determination not found.

Occurrence & SCXRD of mixed crystals: MM 33 1157-8;

RG Coleman DR Ross R Meyrowitz 1966 AM 51 1567-78.

zemannite $\text{Mg}_{0.5}\text{ZnFe}(\text{TeO}_3)_3 \cdot 4.5 \text{aq}$.

Isostructural with Ni analog *keystoneite* & Mg,Mn analog *kinichilite*.

Structure: **E Matzat** 1967 TMPM 12 108-17 (M1059);

synthetic Zn-, **R Miletich** 1989 Anz Österr Akad Wiss math-natur KI 126 77-9 (M973);

R Miletich 1995 EJM 7 509-23 (M1258).

Occurrence: MM 38 1001.

Synthetic $\text{K}_2[(\text{Co/Ni})_2(\text{SeO}_3)_3] \cdot 2\text{aq}$: **M Wildner** 1993 MP 48 215-25 (W632); MA 96M/1576.

Synthetic $\text{NaGa}(\text{TeO}_3)_2 \cdot 2.4 \text{aq}$, SC-XRD: **NSP Bhuvanesh PS Halasyamani** 2001 IC 40 1404-5 (1765).

zemkorite $(\text{Na,K})_2\text{Ca}(\text{CO}_3)_2$.

XRPD indicates hexagonal symmetry similar to *nyerereite* that is orthorhombic pseudo-hexagonal. Should also be compared with *natrofairchildite* listed as trigonal.

Occurrence: Yakutia kimberlite, XRPD, **KN Yegorov & 4 others** 1988 DAN 301 188-93 (Y223);

India kimberlite, FTIR: **G Parthasarathy TRK Chetty SE Haggerty** 2002 AM 87 1384-9.

zenzénite $\text{Pb}_3(\text{Fe}^{3+}, \text{Mn}^{3+})_4\text{Mn}^{4+}_3\text{O}_{15}$.

Essentially isostructural with *synthetic* $\text{Pb}_3\text{Mn}_7\text{O}_{15}$: **B Darriet M Delavette B Latourrette** 1978 ACB 34 3528-32.

Structure: **D Holtstam & 3 others** 1991 CM 29 347-54.

ZEOLITE FAMILY OF MINERALS AND RELATED INDUSTRIAL COMPOUNDS

A complete list of tetrahedral and other structure types is maintained by the Consortium of Theoretical Frameworks (CTF) at the University of Chicago; contact jvs to see it in Chicago - not on web.

The first book published by Springer, Landolt-Bornstein volume, New Series IV/14-1 **A**, "*Microporous and other Framework Materials with Zeolite-Type Structures*", lists all tetrahedral nets and minerals up to Dec 1999: **JV Smith** 2000 1-276. Plans are in progress to update the LB volume in 2007, and to prepare a new volume on mixed nets containing octahedra, tetrahedra, triangles, etc. Volumes 1 & 2 of a 3-volume set by **WH Baur RX Fischer** are published: 2000 **B Zeolite Structure Codes ABW to CZP**; 2002 **C ...DAC to LOV**. A revision is needed of: **JM Bennett WJ Dytrych JJ Pluth JW Richardson Jr JV Smith** 1986 *Structural features of aluminophosphate materials with $A/P = 1$, Z 349-63 (9294)*.

Plans are also underway to publish the theoretical nets in the CTF database.
The Structure Commission of the International Zeolite Association maintains a web site, and published "Atlas of Zeolite Framework Types", 5th ed, **C Baerlocher WM Meier DH Olson** (2001) Elsevier. This is the detailed authorized list of zeolites chosen for possible use in industry, but is not as comprehensive as the CTF list.

Detailed survey for industrial uses: **H van Bekkum EM Flanigen PA Jacobs JC Jansen ed** 2001 *Introduction to Zeolite Science and Practice*, 2nd ed, Elsevier, TP159.M6I58. [22 chapters:

The zeolite scene; Zeolites and molecular sieves. An historical perspective; Zeolite structures; How to build zeolites; The preparation of oxide molecular sieves; Secondary synthesis methods; Clays: from two to three dimensions; Techniques of zeolite characterization; Solid state NMR spectroscopy applied to zeolites; Introduction to zeolite theory and modelling; Ion exchange in zeolites; Diffusion in zeolite molecular sieves; Adsorption of gases in zeolite molecular sieves; Introduction to acid catalysis with zeolites in hydrocarbon reactions; Preparation of zeolite catalysts; Coke formation on zeolites; Hydrocarbon processing with zeolites; Zeolites and related materials in organic syntheses; Metal ions associated to molecular sieve frameworks as catalytic sites for selective oxidation reactions; Zeolite-based supramolecular assemblies; Beyond twelve membered rings.]

Definition & nomenclature: **JV Smith** 1984 Z 4 309-10 (238).

IUPAC Recommendations: **LB McCusker F Liebau G Engelhardt** 2001 *Nomenclature of structural and compositional characteristics of ordered microporous and mesoporous materials with inorganic hosts*, PAC 73 381-94 (3505); **F Liebau** 2003 *Ordered microporous and mesoporous materials with inorganic hosts: definitions of terms, formula notation, and systematic classification*, MMM 58 15-72 (8779).

See individual minerals for specific information on themselves and *synthetic* analogs.

Natural zeolites: general & environment:

Books & Conference Proceedings in chronological order

Mineralogy and Geology of Natural Zeolites: **FA Mumpton ed** 1977 ReM 4 1-233.

Natural Zeolites: Occurrence, Properties, Use: **LB Sand FA Mumpton ed** 1978 Pergamon.

Zeo-Agriculture: The Use of Natural Zeolites in Agriculture and Aquaculture: **WG Pond FA Mumpton eds** 1984 Int Comm Natural Zeolites, Brompton NY.

Occurrence, Properties, and Utilization of Natural Zeolites: **D Kallo HS Sherry ed** 1988 Academiai Kiado, Budapest.

Natural Zeolites '93: Occurrence, Properties, Use: **DW Ming FA Mumpton ed** 1995 ICNZ, Brompton NY.

Natural Zeolites - Sofia '95: **G Kirov L Filizova O Petrov ed** 1997 Pensoft Publisher, Sofia.

Natural Zeolites for the Third Millenium: **C Colella FA Mumpton ed** 2000 De Frede Editore, Naples, QE391.Z5Z465. [40 papers classified under *Crystal Structure and Mineralogy; Occurrence and Genesis; Physical and Chemical Properties; Industrial Utilization; Agricultural Applications* (3817).]

Natural Zeolites: Occurrence, Properties, Applications: **DL Bish DW Ming ed** 2002 ReMG. [18 chapters on structure, crystal chemistry, occurrence, thermal behavior, cation exchange; industrial uses in water treatment, building stone, solar energy heating/cooling, agronomy.]

Zeolite '02. Proceedings of the 6th International Conference on the Occurrence, Properties and utilization of natural Zeolites: **P Misaelides D Zamboulis M Stöcker ed** MMM 61 1-289. [*Bikitaite/chabazite/clinoptilolite/edingtonite/erionite/FAU/GIS/HEU/LTA/mordenite/PHI/scolecite/stilbite/yugawaralite*. Adsorption of Cu/Cr/Fe/Pb/Zn/nuclear/mycotoxins; gas separation; surfactant-modified & environmental remediation; fly-ash to GIS; AFM; ion-exchange of Na-Cu/Cd/Pb; high-P; reduction of N loss in fertilizer by surfactant-modified; early hydration of pozzolanic Portland cement; ultramarine analogs in pigments;

zeoponics; drug support.]

The Chemistry of Nanomaterials. 2 vols, **CNR Rao A Muller AK Cheetham ed**
QC176.8.N35.C44.

Micro- and Mesoporous Mineral Phases, **G Ferraris S Merlino ed** 2005 RMG 57 1-445. Covers IUPAC Nomenclature, topology, polysomatism, heterosilicates with tetra-octahedral nets, microporous silicates with rare & transition elements, octa-pentahedral-tetrahedral silicates, sodalites, cancrinite-davyne group & C-S-H phases, tunnel oxides, apatite, sulfide & selenide structures, micro- & meso- carbons, chrysotile & clathrates.

Papers and Books in alphabetical order

- P Bernhard U Barth-Wirsching** 2002 *Zeolitization of a phonolitic ash flow by groundwater in the Laach volcanic area, Eifel, Germany*, CICIM 50710-25 (8654). [Analcime, chabazite, K-feldspar, phillipsite.]
- RL Braithwaite** 2003 *Geological and mineralogical characterization of zeolites in lacustrine tuffs, Ngakuru, Taupo Volcanic Zone*, CICIM 51 589-98.
- P Cappelletti & 3 others** 1999 *Diagenetic chabazite-phillipsite beds in northern Latium, potential for toxic metal cleanup*, PM 68 127-44 (C1146).
- G Cerri & 3 others** 2001 *Zeolitization of volcanoclastic rocks, Sardinia*, CMP 140 404-21 (915).
- DS Coombs & 3 others** 2005 *A silica-deficient, shallow-marine zeolite assemblage in the Foveaux Formation, Bluff Peninsula, New Zealand*, MM 69 137-44.
- WA Deer RA Howie J Zussman ed** 2004 *Rock Forming Minerals Vol 4B. Framework Silicates. Silica Minerals, Feldspathoids and Zeolites*, 2nd ed, 1-862390144-0.
- M de'Gennaro & 4 others** 2000 [Genesis of zeolites in Neapolitan Yellow Tuff], CMP 139 17-35 (D810).
- T Fridriksson PS Neuhoff DK Bird** 1999 *Clays and zeolites record alteration history at Teigarhorn, eastern Iceland*, In *Geochemistry of the Earth's Surface*, 90-5809-073-6 (7051).
- H Ghobarkar & 3 others** 2003 *Zeolite synthesis by simulation of their natural formation conditions from macroscopic to nanosized crystals*, JSSC 173 27-31 (9816). [Heulandite.]
- AF Gualteri** 2001 *Synthesis of sodium zeolites from a natural halloysite*, PCM 28 719-28 (3825). [Na-X/Na-P/analcime.]
- IT Graham & 3 others** 2003 *Zeolite crystal habits, compositions, and paragenesis: Blackhead Quarry, Dunedin, New Zealand*, MM 67 625-38. [Chabazite/gismondine/gonnardite/natrolite/phillipsite/thomsonite.]
- AG Hampson** 2004 *Zeolites and associated minerals of the Wolf Creek Pass Area, Mineral and Archuleta Counties, Colorado*, RoM 316-24. [Analcime/celadonite/heulandite/laumontite/mordenite/nontronite/wellsite.]
- K Ibrahim** 2004 *Mineralogy and chemistry of natrolite from Jordan*, CIM 39 47-55 (10329). [Analcime/chabazite/calcite/phillipsite/smectite.]
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Industrial & synthetic zeolites, etc not necessarily matching minerals.

Arranged in order of 3-letter IZA-SC code, if coded by IZA-SC; otherwise with jvs code in bold. See individual minerals as well. Alphabetical order. Competely up to date to Aug 2005.

General chemistry and physics

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N Zheng X Bu B Wang P Feng 2002 *Microporous and photoluminescent chalcogenide zeolite analogs*, S 298 2366-9 (8740). [4-connected nets. (Ga/Ge/In/Sn)(S,Se)₂.organic. >12 distinct types in 4 families: UCR-20 = 12-ring decorated-M₄S₁₀ sodalite; UCR-21 = decorated-M₄S₁₀ sphalerite; UCR-22 = M₁₆X₃₄ interpenetrating sphalerite; UCR-23 = M₄S₁₀-decorated CrB₄. Details. **Jvs to assign CTF numbers.**]
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Zeolite Framework Types

Papers on synthetic zeolites are entered here: (see individual mineral if a structural analog).
 Currently only recent papers are entered. Older ones will be added if time and money permit.

ABW = Li-A(Barrer & White)

RM Barrer EAD White 1951 J Chem Soc 1267.

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V Kahlenberg RX Fischer CSJ Shaw 2001 *Polymorphism of strontium monogallate: The framework structures of beta-SrGa₂O₄ and ABW-type gamma-SrGa₂O₄*, JSSC 153 294-300 (3721).

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A Trpathi & 3 others 2000 *Synthesis and single-crystal structure of a lithium aluminogermanate with the ABW topology*, MMM 34 273-9 (3752).

H Zhang & 6 others 2001 *Hydrothermal synthesis of new beryllophosphate molecular sieve phases from concentrated amines*, H Zhang & 6 others 2001 ChM 13 2042-8 (2098). [SC-XRD structure.]

X Zhang 2004 [Zn phosphonocarboxylatehydrate. (10243).]

ACO = ACP-1

P Feng X Bu GD Stucky 1997 N 388 735.

AEI = AIPO-18

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JM Bennett & 3 others 1987 Z 7 160.

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AEN = calcined AIPO-EN3; JDF-2 GaPO-EN3; MCS-1; AIPO-53(A); UiO-12; Mu-18; CoIST-2
C Borges & 6 others 2004 *Structural state and redox behavior of framework Co(II) in CoIST-2: A novel cobalt-substituted alumiophosphate with AEN topology*, JPCB 108 8344-54 (10351).

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RM Kirchner & 5 others 2000 *The structures of as-synthesized AIPO₄-53(A), calcined dehydrated AIPO₄-53(B), and AIPO₄-53(C), a new phase determined by the FOCUS method*, MMM 39 319-22 (3760). [B is AEN type; A has dangles; C is brw*(h,z) - **CTF #1246.**]

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ETC Vogt JW Richardson Jr 1990 JSSC 87 469.

AFG = afghanite

AFI = AIPO₄-5

T Blasco & 5 others 2000 *Magnetic resonance studies on V-containing, and V,Mg-containing AFI aluminophosphates*, MMM 39 219-28 (3698).

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M Rozwadowski & 3 others 1999 Sorption of benzene on AIPO₄-5 containing various heteroatoms and analytical description of the system, La 15 5857-62 (3699). [Mg, Si, Co, Zr, V, Fe, Cu, Cd, Ni, Mo.]

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JB Parise 1986 ACC 42 670.

L Shi & 5 others 2004 [Mn-II-substituted], IC 43 2703-7 (10229).

AFO = AIPO-41

S Caldarelli A Meden A Tuel 1999 Solid-state nuclear magnetic resonance study of the microporous aluminophosphate AIPO₄-41, JPCB 103 5477-87 (3678).

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A Meden C Baerlocher LB McCusker 1997 Rietveld refinement of the calcined form of SAPO-40, MMM 11 247-51.

JP Lourenco & 6 others 2000 Synthesis and characterization of new CoAPSO-40 and ZnAPSO-40 molecular sieves. Influence of the composition and hydrothermal stability of the AIPO₄-40-based materials, MMM 38 267-78 (3763).

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JM Bennett BK Marcus 1988 Stud Surf Sci Catal 37 269.

AFT = AIPO-52

NK McGuire & 3 others 1995 Z 15 460.

AFX = SAPO-56

P Feng X Bu C Yang 2001 Synthesis and single crystal structure of an AFX-type magnesium aluminophosphate, MMM 50 145-9 (3977).

AFY = CoAPO-50

NN Tusar & 3 others 2000 Large-pore molecular sieve MnAPO-50: synthesis, single-crystal structure analysis and thermal stability, MMM 37 303-11 (3765).

AHT = AIPO-H2

H Li & 3 others 1993 JCSCC 403.

ANA = analcime

APC = AIPO-C

JJ Pluth JV Smith 1986 ACC 42 1118.

APD = AIPO-D

K Wang J Yu G Zhu Y Zou R Xu 2000 Synthesis and characterization of a new microporous aluminophosphate [Al₂P₂O₈][OCH₂CH₂NH₃] with an open-framework analogous to AIPO₄-D, MMM 39 281-9 (3707).

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H Li OM Yaghi 1998 JChS 120 10569-70.

ATN = MAPO-39

LB McCusker GO Brunner AF Ojo 1990 ACA Suppl 46 C59.

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B Abbad M Attou H Kessler 1998 *Synthesis of the silicoaluminophosphate molecular sieve SAPO-31 in the presence of fluoride ions and its characterization*, MMM 21 13-8 (A840).

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JV Smith JJ Pluth KJ Andries 1993 *Mg-Al-P, MAPO-36, SC- & P-XRD structure*, Z 13 166-9 (219).

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MH Zahedi-Niaki & 4 others 1999 *Synthesis and characterization of AIPO₄-36: a novel aluminophosphate molecular sieve with ATS structure*, MMM 32 241-50 (3701).

ATT = AIPO-12-TAMU

JW Richardson Jr JJ Pluth JV Smith 1989 [SC-XRD structure], Nw 76 467-9 (218).

PR Rudolf C Saldarriaga-Molina A Clearfield 1986 JPC 90 6122-5.

ATV = AIPO-25

JW Richardson Jr JV Smith JJ Pluth 1990 JPC 94 3365.

AWO = AIPO-21

JM Bennett & 4 others 1985 IC 24 188-93.

J Li & 4 others 2001 *A simulation study on the topotactic transformations from aluminophosphate AIPO₄-21 to AIPO₄-25*, IC 40 5812-7 (3512).

AWW = AIPO-22

JW Richardson Jr JJ Pluth JV Smith 1989 Nw 76 467-9.

*BEA Beta: see *tschernichite*

BEC Beta-C

A Corma & 3 others 2001 *Synthesis of pure polymorph of Beta zeolite in a fluoride-free system*, CC 1486-7 (2966).

A Corma & 4 others 2001 *Pure polymorph C of zeolite Beta synthesized by using framework isomorphous substitution as a structure-directing mechanism*, ACIE 40 2277-80 (3070).

BIK see *bikitaitite*

BOG see *boggsite*

BPH Berylllophosphate-H

G Harvey 1988 ZK 201 123-4.

V Patinec & 7 others 1999 ChM 11 2456-62 (3703). [STA-5 = magnesoaluminophosphate synthesized with triquatarnary alkylammonium.]

BRE see *brewsterite*

CAN see *cancrinite*

CAS Cesium AluminoSilicate

T Araki 1980 ZK 152 207-13.

RW Hughes MT Weller 2002 *The structure of the CAS type zeolite, Cs₄[Al₄Si₂₀O₄₈] by high-resolution powder neutron diffraction and ²⁹Si MAS NMR*, MMM 51 189-96 (7056).

CFI = CIT-5

P Wagner & 5 others 1997 ChC 2179-80.

Y Kubota and 8 others 2000, *Synthetic investigation of CIT-5 catalyst*, MMM 37 291-301 (3711).

CGF = Co-Ga-Phosphate-5

AM Chippindale AR Cowley 1997 Z 18 176.

CGS = Co-Ga-Phosphate-6

SB Hong & 5 others 1999 *Synthesis of microporous gallosilicates with the CGS topology*, JMaCh 9 2287-9 (3758).

Y Lee & 3 others 2000 *Structural and Sr²⁺ ion exchange studies of gallosilicate TsG-1*, ChM 12 1597-603 (3725).

CHA see *chabazite*

Y Huang D Machado CW Kirby 2004 *A study of molecular sieve SAPO-44*, JPCB 108 1855-65 (10244)

-CHI see *chiavennite*

-CLO = *cloverite, not a mineral*

M Estermann & 4 others 1991 N 352 320.

A Merrouche & 5 others 1992 Z 12 226.

CON = CIT-1

RF Lobo & 7 others 1993 S 262 1543.

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CZP = Chiral zincophosphate

I Boy G Schaefer R Kniep 2001 *Crystal structure of sodium nickel diaqua catena-[monoboro-diphosphate] monohydrate, NaNi(H₂O)₂[BP₂O₈].H₂O, at 293 K and 198 K*, ZK NCS 216 11-2 (1344). [tetra net if remove 2 aq from Zn.]

W Liu & 4 others 2004 *A new zincoborophosphate templated by diethylenetriamine (DETA): Synthesis and characterization of [C₄N₃H₁₆][Zn₃B₃P₆O₂₄].H₂O*, DT 2847-9 (10785).

WTA Harrison & 4 others 1996 ChM 8 145.

DAC see *dachiardite*

DDR Deca-dodecasil 3R

H Gies 1986 ZK 175 63.

DFO DAF-1

PA Wright & 6 others 1993 ChC 633.

DFT DAF-2

X Bu & 4 others 1998 JChS 120 13389.

KO Kongshaug H Fjellvag KP Lillerup 2000 *Synthesis and crystal structure of the organically templated open framework magnesium phosphate UiO-20 with DTF topology*, ChM 12 1095-9 (3731). [DFT not DTF.]

DOH Dodecasil 1H
H Gerke H Gies 1984 ZK 166 11.

DON = UTD-1F
T Wessels & 3 others 1999 *An ordered form of the extra-large-pore zeolite UTD-1: synthesis and structure analysis from powder diffraction data*, JChS 121 6242-7 (3675).

EAB = TMA-E: see *bellbergite*

EDI see *edingtonite*

EMT EMC-2: also see *faujasite*
D Bougeard & 5 others 1998 *Spectroscopic investigations and molecular dynamics studies of cationic exchanged EMT zeolites*, JPCB 102 10805-16 (3664).
Y Luo & 4 others 2002 *Synthesis of zeolite EMT with aid of sodium phosphate*, ChM 14 1906-8 (7303).

EPI see *epistilbite*

ERI see *erionite*

ESV = ERS-7
R Millini & 6 others 1999 Proc 12th IZC 541.
BJ Campbell & 6 others 2001 *The determination of Brønsted acid sites in zeolite ERS-7 by neutron and X-ray diffraction*, JPC B 105 1947-55 (1431).

EUO = EU-1
NA Briscoe & 4 others 1988 Z 8 74.
B-: **R Millini & 3 others** 2001 MMM 46 191-201 (2319).
I Peral & 3 others 2004 *Structural comparison of two EUO-type zeolites investigated by neutron diffraction*, MMM 71 125-33 (10369).

FAU see *faujasite*

FER see *ferrierite*
[AIITQ-6 & TiITQ-6 are related to FER: PreFER is expanded & dealuminated to make ITQ-6 (3723).]

FRA see *franzinite*

GIS see *gismondine*
M Li & 5 others *NH₄[BPO₄F]: a novel open-framework ammonium fluorinated borophosphate with a zeolite-like structure related to gismondine topology*, ChC 1272-3 (10414).

GME see *gmelinite*

GON = GUS-1
J Plévert & 4 others 2000 *GUS-1: a mordenite-like molecular sieve with the 12-ring channel of ZSM-12*, ChCo 2363-4 (685). [jvs: new net that matches 792 in CTF database = theoretical net in **Han & Smith** 1999 AC A55 342-59.]

GOO see *goosecreekite*

HEU see *heulandite*

IFR = ITQ-4:
I Bull & 6 others 2000 *Imposition of polarity on a centrosymmetric zeolite host: The effect of fluoride ions on template ordering in zeolite IFR*, JChS 122 7128-9 (3665).
C Chen & 8 others 1998 *Synthesis, structure, and physicochemical and catalytic characterization of the novel high-silica large-pore zeolite SSZ-42*, CEJ 4 1312-23 (C1073).
V Petkov & 4 others 2002 *Structure of intercalated Cs in zeolite ITQ-4: An array of metal ions and*

correlated electrons confined in a pseudo-1D nanoporous host, PRL 89 075502-1 (7902).

LA Villaescusa & 4 others 2001 *Synthesis and physicochemical characterization of an aluminosilicate zeolite with IFR topology, prepared by the fluoride route*, ChM 13 2332-41 (2966).

LA Villaescusa & 3 others 2001 *Variable-temperature microcrystal X-ray diffraction studies of negative thermal expansion in the pure silica zeolite IFR*, JACS 123 5453-9 (2981).

ISV = ITQ-7:

T Blasco & 5 others 2002 *Preferential location of Ge in the double four-membered ring units of ITQ-7 zeolite*, JPCB 106 2634-42 (6734).

P Botella A Corma G Sastre 2001 *Al-ITQ-7, a shape-selective zeolite for acylation of 2-methoxynaphthalene*, JCa 197 87-90 (1012).

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A Corma MJ Diaz-Cabanas V Fornes 2000 *Synthesis, characterization, and catalytic activity of a large-pore tridirectional zeolite, H-ITQ-7*, ACIE 39 2346-9 (3766).

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LA Villaescusa PA Barrett MA Cambor 1999 AnCh 38 1997-2000 (V346).

ITE = ITQ-3, SSZ-36

MA Cambor & 4 others 1997 AnCh 36 2659.

GS Lee SI Zones 2002 *Polymethylated [4.1.1] octanes leading to zeolite SSZ-50*, JSSC 167 289-98 (8088).

V Valthev & 4 others 2000, *Synthesis and characterization of Mu-14: an aluminosilicate zeolite with ITE-type topology*, MMM 38 177-85 (3764).

P Wagner & 6 others 2000 JACHS 122 263-73.

ITW = ITQ-12

DH Olson X Yang MA Cambor 2004 *ITQ-12: A zeolite having temperature dependent adsorption selectivity and potential for propene separation*, JPCB 108 11044-8 (10498).

X Yang & 4 others 2004 *Synthesis and crystal structure of the as-synthesized and calcined pure silica zeolite ITQ-12*, JACHS 126 10403-9 (10460).

JBW Na-J (Barrer and White)

AM Healey GM Johnson MT Weller 2000 *The synthesis and characterisation of JBW zeolites. Part A: Sodium/potassium aluminogermanate, Na₂K[Al₃Ge₃O₁₂].0.5H₂O*, MMM 37 165-74 (3750).

AM Healey & 5 others 2000 *The synthesis and characterisation of JBW zeolites. Part B: Sodium/rubidium aluminogermanate, Na₂Rb[Al₃Ge₃O₁₂].H₂O*, MMM 37 165-74 (3746).

KFI ZK-5

RX Fischer & 6 others 1986 Z 6 378.

LAU see *laumontite*

LEV see *levyne*

LIO see *liottite*

LOS = Losod

LOV see *lovdarite*

LTA = Linde Type A

MW Anderson L Kevan 1986 *Electron spin echo study of Cu²⁺-doped zeolite K-ZK-4: Cation location and absorbate interaction*, JPC 90 3206-12 (9358).

EY Choi Y Kim K Seff 2000 *Structure of a cyclopropane sorption complex of dehydrated fully-exchanged Cd²⁺-exchanged zeolite A*, MMM 41 61-8 (457).

A Dyer H Enamy 1984 *Self-diffusion of Zn & Cd*, Z 4 319-22 (224).

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and *ex situ* XRPD, MMM 54 105-12 (7436).

NH Heo W Cruz-Patainghug K Seff 1986 *Crystal structure of zeolite 4A exchanged to the limit of its stability with nickel(II)*, JPC 90 3931-5 (5359).

NH Heo & 6 others 2002 *Reaction of fully indium-exchanged zeolite A with hydrogen sulfide. Crystal structures of indium-exchanged zeolite A containing In_2S , InSH , sorbed H_2S , and $(\text{In}_3)^{7+}$* , JPCB 106 4578-87 (7157).

GP Holland BR Cherry TM Alam 2004 *^{15}N solid-state NMR characterization of ammonia adsorption environments in 3A zeolite molecular sieves*, JPCB 108 16420-6 (10769).

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PS Neuhoff P Zhao JF Stebbins 2002 *Effect of extraframework species on ^{17}O NMR chemical shifts in zeolite A*, MMM 55 239-51 (8094).

D Navembre 2 others 2005 *Synthesis of Na-A zeolite from 10Åhalloysite and a new crystallization kinetic model for the transformation of Na-A into HS zeolite*, CICIM 53 28-36.

H Paoli & 6 others 2002 *Comparative QENS and PFG NMR diffusion studies of water in zeolite NaCaA*, MMM 55 147-58 (8100).

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A Saig & 3 others 2003 *Study of Type-A zeolites. Part 2. Effect of dehydration on the effective aperture dimension*, JPCB 107 13414-8 (9605).

PS Singh & 3 others 1999 PCCP 1 4125-30 (S2087). [Light and X-ray scattering during early growth.]

PS Singh JW White 1999 PCCP 1 4131-8 (S2088). [Nucleation and growth under reagent controlled conditions.]

M Smaih O Barida V Valtchev 2003 *Investigation of the crystallization stages of LTA-type zeolite by complementary characterization techniques*, EJIC 4370-7. [MAS-NMR/SAXS/XRD/SEM.]

VV Terskikh & 6 others 2001 *Alkali metal loaded zeolite LiA: Evidence for highly symmetrical Rb^- and K^-* , JChS 123 2891-2 (1694). [Anion, not cation.]

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H Wang L Huang BA Holmberg Y & 3 others, ChC 1708-9 (7888).

RA Rakoczy Y Traa 2003 *Nanocrystalline zeolite A: synthesis, ion exchange and dealumination*, MMM 60 69-78 (9106).

LTL = Linde Type L: see *perialite*

LTN = Linde Type N

MAZ see *mazzite-Mg* & *mazzite-Na*

MEI = ZSM-18

MJ Sabater G Sastre 2001 *A computational study on the templating ability of the trispyrroliidium cation in the synthesis of ZSM-18 zeolite*, ChM 13 4520-6 (3877).

MEL = ZSM-11

PM Piccione ME Davis 2001 *A new structure-directing agent for the synthesis of pure-phase ZSM-11*, MMM 49 163-9 (3488).

V Ramaswamy & 5 others 2001 *Structure and redox behavior of zirconium in microporous Zr-silicates studied by EXAFS and ESR techniques*, J Catal 200 250-8 (2972).

MEP see *melanophlogite*

MER see *merlinoite*

S Natarajan & 3 others 2000 *Three-dimensional cobalt(II) phosphates by novel routes*, IC 39 1426-33 (3667). [# 1 reported to resemble *merlinoite*: check against CTF catalog.]

MFI = ZSM-5: see *mutinaite*

MFS = ZSM-57

JA Martens & 3 others 2000 *Tailored alkene oligomerization with H-ZSM-57 zeolite*, ACIE 39 4376-9 (708).

MON see *montesommaite*

MOR see *mordenite*

MSO = MCM-1

MTF = MCM-35

MTN = ZSM-39

MTT = ZSM-23

MTW = ZSM-12

S Gopal K Yoo PG Smirniotis 2001 *Synthesis of Al-rich ZSM-12 using TEOH as template*, MMM 49 149-56 (3486).

I Kinski & 4 others 2002 *Structure and properties of the composite zeolite silica-ZSM-12/para-nitroaniline*, MMM 56 11-25 (8137).

DF Shantz & 3 others 1999 *Guest-host interactions in as-made Al-ZSM-12: Implications for the synthesis of zeolite catalysts*, JPC B 103 10858-65 (3708).

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K Yoo & 5 others 2003 *TEABr directed synthesis of ZSM-12 and its NMR characterization*, MMM 60 57-68 (9107).

MWW = MCM-22

H Du & 3 others 2000 *Hydrocarbon sorption properties of pure silica MCM-22 type zeolite*, MMM 40 305-12 (232).

A Frache & 5 others 2002 *NO and CO adsorption on over-exchanged Cu-MCM-22: a FTIR study*, La 18 6875-80 (7938).

GJ Juttu RF Lobo 2000 *Characterization and catalytic properties of MCM-56 and MCM-22 zeolites*, MMM 40 9-23 (221). [MCM-56 is very thin MWW. MCM-22 is MWW.]

D Ma & 4 others 2001 *MAS NMR studies on the dealumination of zeolite MCM-22*, JPCB 105 1770-9 (2929).

D Ma & 5 others 2002 *An investigation of the roles of surface aluminum and acid sites in the zeolite MCM-22*, CEJ 8 162-70 (4313).

B Onida & 4 others 2002 *H-bond formation and proton transfer in H-MCM-22 zeolite as compared with H-ZSM-5 and H-MOR: An FTIR study*, JPCB 106 1684-90 (6194).

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G Sastre V Fornes A Corma 2000 *Preferential siting of bridging hydroxyls and their different acid strengths in the two-channel system of MCM-22 zeolite*, JPCB 104 4349-54 (3744).

SI Zones S Hwang ME Davis 2001, *Studies of the synthesis of SSZ-25 zeolite in a "mixed-template" system*, CEJ 7 1990-5 (2158).

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P Wu T Tatsumi 2002 *Preparation of B-free Ti-MWW through reversible structural conversion*, ChCo 1026-7 (7308).

NAT see *natrolite*

NES = NU-87

NON = Nonasil

OFF see *offretite*

OSI = UiO-6

OSO = OSB-1

-PAR see *partheite*

PAU see *paulingite*

PHI see *phillipsite*

Phi-ABC-D6R family-disordered

GW Skeels & 6 others 1999, *Synthesis and characterization of phi-type zeolites*, MMM 30 335-46 (S2065).

RHO = RHO: see *pahasapite*

-RON see *roggianite*

RSN = RUB-17

RTE = RUB-3

B Marler A Grunewald-Luke H Gies 1998 *Structure refinement of the as-synthesized and the calcined form of zeolite RUB-3 (RTE)*, MMM 26 49-59.

RTH = RUB-13

GS Lee SI Zones 2002 *Polymethylated [4.1.1] octanes leading to zeolite SSZ-50*, JSSC 167 289-98 (8088).

RUT = RUB-10

A Bhaumik T Tatsumi 2000 *Pure silica NU-1 and Na- and Al-free Ti-NU-1 synthesized by the dry gel conversion method*, MMM 34 1-7 (3753).

B Marler U Werthmann H Gies 2001 *Synthesis and structure of pure silica-RUB-10 (structure type RUT) obtained with pyrrolidine as structure directing agent*, MMM 43 329-40 (1621).

RWR = RUB-18

B Marler N Stroter H Gies 2005 *The structure of the new pure silica zeolite RUB-24, Si₃₂O₆₄, obtained by topotactic condensation of the intercalated layer silicate RUB-18*, MMM 83 201-11.

SAO = STA-1

SAS = STA-6

PA Wright & 6 others 2000 *Cation-directed syntheses of novel zeolite-like metalloaluminophosphates STA-6 and SRA-7 in the presence of azamacrocyclic templates*, JCSD 1243-8 (3743). [Small pore 1D-channel.]

SAT = STA-2

SAV = Mg-STA-7

PA Wright & 6 others 2000 *Cation-directed syntheses of novel zeolite-like metalloaluminophosphates STA-6 and SRA-7 in the presence of azamacrocyclic templates*, JCSD 1243-8 (3743).

SBE = UCSB-8Co

SBS = UCSB-6GaCo

SBT = UCSB-10GaZn

SFE = SSZ-48

GS Lee SI Zones 2000 *US Patent 6,080,382*.

GS Lee & 6 others 2002 *Organocations in zeolite synthesis: Fused bicyclo [1. m. O] cations and the discovery of zeolite SSZ-48*, JChS 124 7024-34 (7640).

SFF = SSZ-44

P Wagner & 3 others 1999 *SSZ-35 and SSZ-44: two related zeolites containing pores circumscribed by ten- and eighteen-membered rings*, AnCh 33 1269-72.

LA Villaescusa & 3 others 2004 *Synthesis, characterization and control of faulting in STF/SFF topologies, a new family of intergrowth zeolites*, JMC 14 1982-7 (10532).

SGT = Sigma-2

SOD see *sodalite*

SSY = SSZ-60

A Burton S Elomari 2004 *SSZ-60: a new large-pore zeolite related to ZSM-23*, ChC 2618-9 (10863). [Sigma-expansion of MTT, **assign CTF number.**]

STF = SSZ-35

P Wagner & 3 others 1999 *SSZ-35 and SSZ-44: two related zeolites containing pores circumscribed by ten- and eighteen-membered rings*, AnCh 33 1269-72.

STI see *stilbite*

STT = SSZ-23

MA Cambior & 5 others 1999 *A synthesis, MAS NMR, synchrotron X-ray powder diffraction, and computational study of zeolite SSZ-23*, ChM 11 2878-85 (9034).

TER see *terranovaite*

THO see *thomsonite*

TON = Theta-1

F Geobaldo & 5 others 2003 *An FTIR study of zeolite Theta-1*, JPCB 107 1258-62 (9111).

Nu-10:

C Pellegrino & 5 others 2001 *Multinuclear high resolution solid state NMR characterization of zeolites Nu-10 and ZSM-5 synthesized in the presence of tetraethylenepentamine and diaminopropane*, MMM 47 85-96 (3034).

TSC see *tschörtnerite*

UOZ = IM-10

Y Mathieu & 3 others 2004 *Synthesis and characterization of IM-10: a new microporous silicogermanate with a novel topology*, MMM 75 13-22 (10763). [Clathrate family with *cub* units. **Assign CTF number.**]

VET = VPI-8

VFI = VPI-5

J de Onate Martinez LB McCusker C Baerlocher 2000 *Characterization and structural analysis of differently prepared samples of dehydrated VPI-5*, MMM 34 99-113 (3751).

E Fois A Gamba A Tilocca 2002 *Structure and dynamics of the flexible triple helix of water inside VPI-5 molecular sieves*, JPC B 106 4806-12 (7158).

A Ristić & 6 others 2004 *Investigations of iron substitution in VPI-5 and its redox behavior*, MMM 76 61-9 (10912).

VNI = VPI-9

VSV = VPI-7

WEI see *weinebeneite*

-WEN see *wenkite*

YUG see *yugawaralite*

ZON = ZAPO-M1

A Bailly JP Amoureux JW Wiench M Prushki 2001 *Structural analysis of ZON-type aluminophosphates by solid state NMR*, JPCB 105 773-6 (1015).

L Sierra J Patarin JL Guth 2000 *Synthesis of aluminophosphate and derived materials with the ZON structure-type*, MMM 38 123-33 (3768).

Not coded by IZA-SC: useful for CTF data base, includes non-microporous tetrahedral nets and various other types of nets, including octa-tetra nets

AIPO₄-CJB2

W Yan & 6 others 2001 *An anionic framework aluminophosphate [(CH₂)₆N₄H₃.H₂O] Al₁₁P₁₂O₄₈] and computer simulation of the template positions*, MMM 50 151-8 (3978). [Octa-tetra; **assign CTF#.**]

AIPO₄-H3

K Kunii K Narahara S Yamanaka 2001 *Template-free synthesis and adsorption properties of microporous crystal AIPO₄-H3*, MMM 50 181-5 (3979).

AM-2, STS, UND-1 see *umbite*

AM-3, ETS-14 see *penkvilksite*

AM-4

ASU-14; UCSB-40 & 41

X Bu P Feng GD Stucky 2000 *Host-guest symmetry and charge matching in two germanates with intersecting three-dimensional channels*, ChM 12 1505-7 (3729). [Same topo: octa-tetra; **assign CTF #.**]

H Li M Eddaoudi OM Yaghi 1999 *An open-framework germanate with polycubane-like topology*, ACIE 38 653-5 (3053).

ASU-15; NGH-5

H Li & 4 others, JACS 122 12409-10

RJ Francis AJ Jacobson 2001 *Synthesis, structure, and properties of a three-dimensional open-framework niobium fluorogermanate (NGH-5)*, ChM 13 4676-80 (3881). [Ge₂NbO₇F.org. octa-tetra: **assign CTF#.**]

ASU-16

J Plevert & 6 others 2001 *A flexible germanate structure containing 24-ring channels and with very low framework density*, JChS 123 12706-7 (3871). [tetra, trigonal bipyramids & octahedra. jvs: assign CTF #.]

ASU-25

J Plevert & 6 others 2003, *Synthesis and characterization of zirconogermanates*, IC 42 5954-8 [9422; related to Umbite].

ASU-26

J Plevert & 6 others 2003, *Synthesis and characterization of zirconogermanates*, IC 42 5954-8 [9422].

AV-7 see *kostylevite*

kostylevite K₂ZrSi₃O₉.aq. Dimorphic with *umbite*. [Octahedral-tetrahedral net. CTF ?.]
Synthetic K₂SnSi₃O₉.aq. XRPD structure: Z Lin & 3 others 2000 *JMC* 10 1353-6 (3715).

CDS-1

T Ikeda & 4 others 2004 *The topotactic conversion of a novel layered silicate into a new framework zeolite*, AnCh 43 4892-6 (10726). [Similar to FER: assign CTF #.]

Clathrate hydrate high-pressure tetrahydrofuran hydrate

AV Kurnosov & 4 others 2004 *New clathrate hydrate structure: high-pressure tetrahydrofuran hydrate with one type of cavity*, AnCh 43 2922-4 (10395). [Pmnb, 11.44x12.5x6.60, $4^1 4^1 4^2 5^2 5^2 6^1 6^1 6^2 6^2$. needs CTF number and polyhedron code.]

CoAPO-NH2

Synthetic ammonium-CoAPO-NH2, XRPD structure:

RP Bontchev SC Sevov 1999 JMC 9 2679-82 (3722). [Octa-trig pyramid-tetra net. CTF?]

CuSH-1A

X Wang L Liu AJ Jacobson 2003 *Nanoporous copper silicates with one-dimensional 12-ring channel systems*, AnCh 42 2064-7 (9023). [$\text{Na}_4\text{Cu}_2\text{Si}_{12}\text{O}_{27}(\text{OH})_2(\text{AOH})_{-1}(\text{NaOH})_{-1.6}$ aq with A = Na/K/Rb/Cs. 3D net of Cu octahedra & Si tetrahedra. Not ajoite.]

ECR-34

KG Strohmaier DEW Vaughan 2003 *Structure of the First Silicate Molecular Sieve with 18-Ring Pore Openings*, ECR-34, JChS 125 16035-9 [10008]

ETS-4 see zorite

ETS-10, ETAS-10

KN Bozhilov VP Valtchev 1993 [TEM of TMA-], MRB 28 1209-14 (B1060);

T Ohsuna & 4 others 1994 [electron microscopy], Stud Surf Sci Catal 84 413-20 (O256);

MW Anderson & 7 others 1994 *Structure of the microporous titanosilicate ETS-10*, N 367 347-51.

MW Anderson & 4 others 1995 [Al avoidance in ETAS-10], AnCh 34 1003-5.

G Sankar & 5 others 1996 [XAS & computer modeling], JPC 100 449-52 (S1549).

J Rocha & 5 others 2000 *Photoluminescence of new Er^{3+} -doped titanosilicate materials*, JMC 10 1371-5 (3670). [Precursor to narsarsukite.]

X Yang & 4 others 2001 *Synthesis of microporous titanosilicate ETS-10 with TiF_4 or TiO_2* , MMM 46 1-11 (2971).

P Brandao & 4 others 2001 *Synthesis and characterisation of chromium-substituted ETS-10*, PCCP 3 1773-7 (2155).

A Zecchina & 5 others 2001 *Alkyne polymerization on the titanosilicate molecular sieve ETS-10*, PCCP 3 1228-31 (1439).

H Xu Y Zhang A Navrotsky 2001 *Enthalpies of formation of microporous titanosilicates ETS-4 and ETS-10*, MMM 47 285-91 (3134).

A Eldewik RF Howe 2001 *Cobalt substitution in ETS-10*, MMM 48 65-71 (3503).

CC Pavel & 6 others 2002 *Synthesis and characterization of the microporous titanosilicates ETS-4 and ETS-10*, MMM 56 227-39 (8274). [Zorite.]

B Zibrowius C Weidenthaler W Schmidt 2003 *Sorbate-induced changes in the framework of the titanosilicate ETS-10 as detected by ^{29}Si MAS NMR spectroscopy and X-ray powder diffraction*, PCCP 5 773-7 (8806).

M Kishima T Okubo 2003 *Characterization of microporous titanosilicate ETS-10 by infrared spectroscopy with methane as a probe molecule for basic sites*, JPCB 107 8462-8 (9226).

CC Pavel & 5 others 2005 *Synthesis and characterization of ET(P)S-4 and ET(P)S-10*, MMM 80 263-8 (11038).

FDZG-3

Z Liu & 3 others 2003, *Synthesis and characterization of a novel organically templated open framework zirconogermanate with three- and seven-membered rings*, IC 42 5960-5 [9421].

IM-12

J Paillaud & 3 others 2004 *Extra-large-pore zeolites with two dimensional channels formed by 14 and 12 rings*, S 304 990-2 (10266). [Silicogermanate; **needs analysis for CTF.**]

ITQ-2

Delaminated MWW.

A Corma & 5 others 2000 *Preparation, characterisation and catalytic activity of ITQ-2, a delaminated zeolite*, MMM 38 301-9 (3762).

A Corma & 4 others 2001 *Prevalence of the external surface over the internal pores in the spontaneous generation of tetrathiafulvalene radical cation incorporated in the novel delaminated ITQ-2 zeolite*, PCCP 3 1218-22 (1440).

ITQ-15

A Corma & 4 others 2004 *ITQ-15: The first ultralarge pore zeolite with a bidirectional pore system formed by intersecting 14- and 12-ring channels, and its catalytic implications*, ChC 1356-7 (10478). [**check for CTF catalog.**]

ITQ-21

A Corma & 4 others 2002 *A large-cavity zeolite with wide pore windows and potential as an oil refining catalyst*, n 418 514-7 (7861). [**check for CTF catalog.**]

JLU-1

Y Liu & 4 others 2000 *Synthesis and characterization of a novel microporous titanosilicate JLU-1*, ChM 12 665-70 (3720). [**check for CTF catalog.**]

MCM-65

DL Dorset GJ Kennedy 2004 *Crystal structure of MCM-65: An alternative linkage of ferrierite layers*, JPCB 108 15216-22 (10700). [**check for CTF catalog.**]

MCV-3

K Schwendtner U Kolitsch 2004 *Alkali scandium arsenates. I. The framework structures of KSc(HAsO₄)₂ and RbScAs₂O₇*, ACC 60 i79-83 (10800). [**check for CTF catalog.**]

MIL-20

T Loiseau G Férey 2000 *The structure of a fluorinated gallium phosphate templated with N,N,N',N'-tetramethylethyldiamine: Ga₃(PO₄)₃F, 0.5N₃C₆H₁₈ (MIL-20)*, MMM 35-36 609-16 (3729). [2-vertex-tetra net; **check type and assign CTF number.**]

MIL-31

C Sassoie & 3 others 2000 *A new open-framework fluorinated gallium phosphate with large 18-ring channels (MIL-31)*, ChC 843-4 3713). [Tetra-octa-trig bipyramid; may be tetra net when OH removed; **assign CTF #.**]

MIL-34

T Loiseau & 7 others 2001 *Chemistry-structure-simulation or chemistry-simulation-structure sequences? The case of MIL-34, a new porous aluminophosphate*, JChS 123 9642-51 (3142). [Related to, but differs from AIPO-14. **Needs checking in CTF catalog.**]

MIL-74

L Beitone & 6 others 2003 *Order-disorder in the super-sodalite Zn₃Al₆(PO₄)₁₂.4tren, 17H₂O (MIL-74): A combined XRD/NMR assessment*, JChS 125 9102-10 (9519). [**check for CTF catalog.**]

MIL-101

G Férey et al 2005 S 309 2040. [Described in S 309 2008-0. Cr clusters linked by organic. Large cages 29 & 34 Å across.]

Mu-2

P Reinert B Marler J Patarin 2000 *Structure analysis and general characterization of the fluorogallophosphate Mu-2: A new microporous material built from double-four-ring units hosting F anions*, JMS 35 2965-72 (3718). [**check for CTF catalog.**]

Mu-15

A Matijasic J Paillaud J Patarin 2000 *Synthesis, characterization and structure determination of Mu-15: a new fluorogallophosphate with fluoride as a specific template of the D4R units*, JMC 10 1345-51 (3728). [related to Mu-2 & -5: **check structure.**]

Mu-11

A Matijasic & 5 others 2000, *Structural characterization of the new porous sodium silicate Mu-11 by ^{29}Si and ^{23}Na solid-state NMR*, PCCP 2 2807-13 (3726). [**1,2-tetra net: needs CTF #.**]

Mu-19

A Simon & 3 others 2001 *Synthesis and characterization of Mu-19, a new zincophosphate with a three-dimensional 12-membered ring channel system*, MMM 47 133-46 (3128). [1,2-vertex tetra. **Needs CTF catalog #.**]

Nu-6(2)

S Zanardi & 5 others 2004 *Crystal structure determination of zeolite Nu-(2) and its layered precursor Nu-6(1)*, AnCh 43 4933-7 (10727). [Similar to CAS: **needs CTF #.**]

RIPS-4

RW Broach & 5 others 2001 *Crystal structure and chemistry of RIPS-4, (ethylenediammonium) $\text{In}_3\text{P}_3\text{O}_{12}(\text{OH})_2$* , 13th Int Zeolite Conf: Recent Research Reports (3625). [**jvs: new octa-tetra vertex net: needs CTF catalog #.**]

RUB-23

SH Park P Daniels H Gies 2000, *RUB-23: a new microporous lithosilicate containing spiro-5 building units*, MMM 37 129-43 (3754). [**new tetra net: needs CTF catalog #.**]

SOMS

H Xu & 3 others 2004 *Prototype Sandia octahedral molecular sieve (SOMS) $\text{Na}_2\text{Nb}_2\text{O}_6 \cdot \text{H}_2\text{O}$: Synthesis, structure and thermodynamic stability*, ChM 16 2034-40 (10292). [Related to perovskite.]

UiO-17

KO Kongshaug H Fjellvag KP Lillerud 1999 *The synthesis and crystal structure of a new open-framework zincophosphate UiO-17*, JMC 9 3119-23 (3716). [**check for CTF catalog.**]

SNL-A

M Nyman & 7 others 2000, ChM 12 3449

M Nyman & 3 others 2001, *First Rb silicotitanate phase and its K-structural analogue: New members of the SNL-A family ($\text{Cc-A}_2\text{TiSi}_6\text{O}_{15}$; A = K, Rb, Cs)*, ChM 13 4603-11 (3878). [**assign CTF #.**]

SSZ-31

RF Lobo & 6 others 1997 JChS 119 3732.

GS Lee & 6 others 2002 *Organocations in zeolite synthesis: Fused bicyclo [1. m. O] cations and the discovery of zeolite SSZ-48*, JChS 124 7024-34 (7640).

SSZ-43

GS Lee & 6 others 2002 *Organocations in zeolite synthesis: Fused bicyclo [1. m. O] cations and the discovery of zeolite SSZ-48*, JChS 124 7024-34 (7640).

SSZ-48 See SFE

SSZ-53

A Burton & 9 others 2003 *SSZ-53 and SSZ-59: Two Novel Extra-Large Pore Zeolites*, CEJ 9 5737-5748 [10009]

SSZ-59

A Burton & 9 others 2003 *SSZ-53 and SSZ-59: Two Novel Extra-Large Pore Zeolites*, CEJ 9 5737-5748 [10009]

SU-16

Y Li X Zou 2005 *SU-16: a three-dimensional open-framework borogermanate with a novel zeolite topology*, ACIE.

UCR-8

X Bu & 3 others 2003 *Templated assembly of sulfide nanoclusters into cubic-C₃N₄ type framework*, JChS 125 6024-5 [9004].

UiO-18 Layered aluminophosphate & 2 high-T derivatives.

UiO-20 See DFT

UiO-21 See CHA.

UiO-22

KO Kongshaug H Fjellvag KP Lillerud 2000 *The synthesis and crystal structure of two novel 3D open-framework zinc phosphates UiO-21 and UiO-22*, MMM 39 341-50 (3682). [**1,2-vertex-tetra net: needs CTF catalog #.**]

UiO-28

KO Kongshaug H Fjellvag KP Lillerud 2001 *Synthesis and characterization of the open-framework magnesium aluminophosphate UiO-28*, J Mater Chem 11 1242-7 (1693).

ULM-5

RJ Francis & 6 others 1997 *Formation of an intermediate during the hydrothermal synthesis of ULM-5 studied using time-resolved, in situ X-ray powder diffraction*, ChC 521-2 (2999).

M Mrak & 5 others 2002 *Incorporation of heteroatoms (Me = Zn, Co, Mn) into framework sites of the gallophosphate molecular sieve ULM-5*, MMM 56 257-66 (8000).

UND-1 see *kostylevite*

UTM-1

J Plevert K Yamamoto G Chiari T Tatsumi 1999 *UTM-1, an eight-membered ring zeolite with the basic building chains of the MFI topology*, JPC B 103 8647-9 (3674). [**check against CTF catalog.**]

UZM-4

CS Blackwell & 15 others 2003 *Open-framework materials synthesized in the TMA⁺/TEA⁺ mixed-template system: The new low Si/Al ratio zeolites UZM-4 and UZM-5*, AnCh 42 1737-1740 [9010].

UZM-5

CS Blackwell & 15 others 2003 *Open-framework materials synthesized in the TMA⁺/TEA⁺ mixed-template system: The new low Si/Al ratio zeolites UZM-4 and UZM-5*, AnCh 42 1737-1740 [9010].

VPI-8

M Yoshikawa SI Zones ME Davis 1997 *Synthesis of VPI-8. I. The effects of reaction components. II. Mechanism of crystallization*, MiMa 11 127-36, 137-48 (3743).

VSF-5

SH Jhung & 5 others 2004 *Template-free synthesis of the nanoporous nickel phosphate VSF-5 under microwave irradiation*, ChM 16 1394-6 (10230).

ZSM-48

RF Lobo H van Koningsveld 2002 *New description of the disorder in zeolite ZSM-48*, JChS 124 13222-30 (8366). [Family of materials.]

[Cd₁₆In₆₄S₁₃₄]⁴⁴⁺

H Li & 3 others 2003 *[Cd₁₆In₆₄S₁₃₄]⁴⁴⁺: 31-Å tetrahedron with a large cavity*. AnCh 42 1819-21

[9006].

Cd₃Ge₉O₁₈.org.(OH)₄

Z Lin & 3 others 2004 *Syntheses and structures of two new 3D open-framework germanates constructed from Ge₉O₁₈(OH)₄ clusters*, MMM 744 205-11 (10725). [Complex, assign CTF #.]

Co₆(PO₄)₅(HPO₄)₃.H₂O

S Natarajan & 3 others 2000, *Three-dimensional cobalt(II) phosphates by novel routes*, IC 39 1426-33 (3667). [# 2 is 1,2-tetra net: assign number in CTF catalog.]

Cs₃ScSi₈O₁₉

U Kolitsch E Tillmanns 2004 *Synthesis and crystal structure of a new microporous silicate with a mixed octahedral-tetrahedral framework: Cs₃ScSi₈O₁₉*, MM 68 677-86. [assign number in CTF catalog.]

Cs₃Zn₄O(AsO₄)₃.4H₂O

WTA Harrison MLF Phillips X Bu 2000 *Synthesis and single-crystal structure of Cs₃Zn₄O(AsO₄)₃.4H₂O, an open-framework zinc arsenate*, MMM 39 359-65 (3680). [Complex tetra structure with OZn₄ structural unit check whether needs CTF catalog #.]

Ge₉O₁₈.org.(OH)₄

Z Lin & 3 others 2004 *Syntheses and structures of two new 3D open-framework germanates constructed from Ge₉O₁₈(OH)₄ clusters*, MMM 744 205-11 (10725). [Complex, assign CTF #.]

Ga₂(PO₄)₃

J Lesage & 3 others 2004 *The anionic 3D-framework [Ga₃(PO₄)₃]_∞: a microporous hpst lattice for various species*, JSSC 177 3381-9 (10908). [Intersecting tunnels. Assign CTF #.]

In₂(PO₄)₂F_{0.5}.org.aq

Z Yi & 7 others 2004 *Hydrothermal synthesis and characterization of two new three-dimensional fluorindium phosphates*, JSSC 177 4073-80 (10860). [Complex, assign CTF #.]

In₃(HPO₄)₆.org.H₃O

C Chen & 8 others 2005 *Template synthesis and characterization of a novel three-dimensional open-framework indium phosphate*, MMM 83 301-8.

Mo₂P₄O₁₅

SE Lister & 4 others 2004 *Mo₂P₄O₁₅ – the most complex oxide structure solved by single crystal methods?*, ChC 2540-1 (10862). [Compact, complex octa-tetra, assign CTF #.]

Na_{3/4}(NH₄)_{1/4}ZnPO₄

WTA Harrison 2000 *Na_{3/4}(NH₄)_{1/4}ZnPO₄, a new framework zincophosphate. Survey of MZnPO₄ tetrahedral topologies*, ZK 215 288-92 (3719). [hex-UD net to be identified from CTF catalog.]

NaZnSiO₃OH

AM Healey MT Weller AR Gage 1999 *Synthesis and structure of NaZnSiO₃OH, a new chiral zincosilicate framework material*, IC 38 455-8 (3056). [1,2-tetra net: assign CTF #.]

K₆Co₃W₄P₄O₂₈.4aq & (enH₂)₃Co₃W₄P₄O₂₈.4aq

B Yan & 3 others 2004 *Hydrothermalsynthesis, structures and catalytic properties of the new open-framework cobalt tungsten phosphates (enH₂)₃[Co₃W₄P₄O₂₈].4H₂O and K₆[Co₃W₄P₄O₂₈].4H₂O*, JMC 14 1567-71 (10411). [octa-tetra net: check for CTF.]

NH₄Co₂(HVO₂)(H₂O)₂(PO₄)₂

S Boudin J Chardon B Raveau 2001 *A novel cobalt (II) vanadophosphate with a quasi zeolitic intersecting tunnel structure: NH₄Co₂(HVO₂)(H₂O)₂(PO₄)₂*, ChM 13 4101-4 (3629). [complex octa-tetra net: assign CTF #.]

(NH₄)₂ZrGe₃O₉ 2003 *(NH₄)₂ZrGe₃O₉: A new microporous zirconogermanate*, ACC 59 i29-31 [9244].

Rb₃Zn₂O(HPO₄)₃

TR Jensen & 3 others 2000 *New rubidium hydrogen phosphate, Rb₃Zn₂O(HPO₄)₃, Synthesis, crystal structure, and ³¹P single-crystal NMR*, IC 39 2026-32 (3669). [1,2-tetra net: assign CTF #.]

Zn₂(HPO₄)₃.org-D

Y Song & 4 others 2004 *A new 3-D open-framework zinc phosphate [C₂H₁₆N₂].Zn₂(HPO₄)₃ synthesized by a solvothermal combinatorial approach*, EJIC 3718-23 (10724). 1,2-tetra net: assign CTF #.]

[Co(en)₃][Sb₁₂S₁₉]

P Vaqueiro AM Chippindale AV Powell 2004 *[Co(en)₃][Sb₁₂S₁₉]: A new antimony sulfide with a zeolite-like structure containing one-dimensional channels*, IC 43 7963-5 (10919). [Vertex- & edge-sharing SbS₃.]

zeophyllite Ca₄Si₃O₈(OH,F)₄.2aq.

Structure: **S Merlino** 1972 AC B28 2726-32;

& IR, **W Mikenda & 3 others** 1997 MP 61 199-209 (M1607).

zeravshanite Cs₄Na₂(Si₁₈O₄₅).2aq.

Structure: SC-XRD, **YA Uvarova & 4 others** 2004 CM 42 125-34 = AM 91 220.

Occurrence: **LA Pautov & 4 others** 2004 CM 42 125-34.

zeunerite Cu(UO₂)₂(AsO₄)₂.10-16aq. *Autunite* structure group.

Structure determination not found.

Occurrence: **R Berman** 1958 AM 42 905-8;

C Frondel 1958 USGS Bull 1064 191-4.

zhemchuzhnikovite NaMg(Al,Fe)(C₂O₄)₃.8aq.

Cell dimensions do not match *stepanovite* NaMgFe(C₂O₄)₃.8-9aq.

Structure determination not found.

Occurrence & SC-XRD: **YuN Knipovich AI Komkov EI Nefedov** 1963 *Trudy Vses Nauchno-Issled Geol Inst* 96 131-5 = AM 49 442.

zhanghengite CuZn. Matches *synthetic alloy beta-brass*.

CsCl structure type: **Pearson** 186.

Occurrence: **K Wang** 1986 *Acta Min Sinica* 6 220 = MM 54 671.

zharchikite AlF(OH)₂.

Occurrence: **SV Bolokhontseva** 1988 ZVMO 117 79 = MM 52 732;

MA 02M/1209.

zhemchuzhnikovite NaMg(Fe,Al)(C₂O₄)₃.8aq. Compare *stepanovite*.

Occurrence: MM 333 1158.

zhonghuacerite-(Ce) Ba₂Ce(CO₃)₃F.

Compare with *cebaite* Ba₃Ce₂(CO₃)₅F₂ & *huanghoite* BaCe(CO₃)₂F.

Structure: *synthetic*, **N Mercier M Leblanc** 1993 *Eur J Solid State Chem* 30 207-16.

Occurrence: MM 46 528.

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

Polysomatic *huanghoite*-zhonghuacerite: **Z Yang K Tao P Zhang** 1996 NJMM 264-70 (Y181).

ziesite Cu₂V₂O₇-beta-high.

Reconstructive transition to *blossite* alpha-low: **PD Robinson JM Hughes ML Malinconico** 1987 AM 72 397-400.

Review: (E289).

Structure: early paper with errors ignored;

JM Hughes MA Brown 1989 NJMM 41-7 (H974).

Occurrence: MM 46 528.

zimbabweite Na(Pb,Na,K)₂As₄(Ta,Nb,Ti)₄O₁₈.

2-vertex-connected net with trigonal pyramid & octahedron. CTF net 1069.

Structure: **EN Duesler BC Chakoumakos EE Foord** 1988 AM 73 1186-90 (D437).

Occurrence: MM 50 761.

zinalsite $Zn_7Al_4(SiO_4)_6(OH)_2 \cdot 9aq.$

What is relation to *fraipontite* $(Zn,Al)_3(Si,Al)_2O_5(OH)_4$?

Occurrence & XRPD: **FV Chukhrov** 1958 ZVMO 87 487-8 = AM 44 208-9.

zinc Zn. Distorted hexagonal closest packing.

Isostructural with Cd. Wells 4th ed. p.1011. SR 52A 94.

Occurrence: early papers;

AH Clark RH Sillitoe 1970 AM 55 1019-21.

Occurrence, lunar regolith, Crises Sea: **OA Bogatikov & 5 others** 2002 DES 382 83-5 (7553).

XRPD to 126 GPa, stays in hcp: **T Kenichi** 1997 PRB 5170-9 (K936).

[*zincopperite* Cu_7Zn_4 . jvs?, MA 03M/3142.]

zinc blende ZnS

P transformation to *halite* type: **S Desgreniers L Beaulieu I Lepage** 2000 PRB 61 8726-33.

zincaluminite $Zn_3Al_3SO_4(OH)_{13} \cdot 2.5aq.$ Inadequate mineral description.

Review: **Sabelli** no structure.

Occurrence: **Dana**.

zincblödite $Na_2Zn(SO_4)_2 \cdot 4aq.$ *Blödite* structure type. Review: **Sabelli** p.12.

Structure: *synthetic*, **M Giglio** 1958 AC 11 789-96.

zincgartrellite $Pb(Zn,Fe,Cu)_2(AsO_4)_2 \cdot 2(aq,OH).$

Zn-analog of *gartrellite* in *tsumcorite* group.

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

zincite $(Zn,Mn)O.$ *Wurtzite* structure type.

Structure: **TM Sabine S Hogg** 1969 AC B25 225 4-6

SC Abrahams JL Bernstein 1969 AC B25 1233-6;

EH Kisi MM Elcombe 1989 AC C45 1867-70 (K754);

residual electron density, **H Sawada R Wang AW Sleight** 1996 JSSC 122 148-50.

Synthetic, SC-ND: **J Albertsson SC Abrahams A Kwick** 1989 AC B45 34-40.

Surface adsorption: water, FTIR, **S Kittaka T Sasaki N Fukuhara** 1992 La 8 2598-600 (K577);

orientation of formate and carbonate, C K-edge NEXAFS, **R Davis & 5 others** 1993 Surf Sci Lett 298 L196-202 (D455).

zinc-melanterite $(Zn,Cu,Fe)SO_4 \cdot 7aq.$ *Melanterite* structure group.

Review: **Sabelli** p. 9.

Structure determination not found. [jvs: check for *synthetic*.]

Occurrence & crystallography: **T Liu G Gong L Ye** 1995 Acta Mineral Sinica 15 268-90 = AM 81 1518.

zincobotryogen $(Zn,Mg,Mn)Fe(SO_4)_2OH \cdot 7aq.$

Isostructural with *botryogen* $MgFe(SO_4)_2OH \cdot 7aq.$

Structure: *synthetic*, **P Süsse** 1968 AC B24 760-7.

Occurrence: MM 35 1161.

zincochromite $ZnCr_2O_4.$ *Spinel* structure group.

Structure: electron density of *synthetic*, **H Sawada** MRB 32 873-9 (S1700).

Frustrated magnetic interactions, inelastic ND: **S Lee & 6 others** 2002 N 418 856-8 (7934).

Raman to 70 GPa: **Z Wang & 3 others** 2002 JSSC 165 165-70 (7064).

Entropy: **S Klemme JC van Miltenburg** 2004 MM 68 515-22.

PVT equation of state of *synthetic*: **D Levy & 4 others** 2005 AM 90 1157-62.

Occurrence & XRD: **AR Nesterov YeV Rumyantseva** 1987 ZVMO 116 367-71 = AM 73 931-2.

zincocopiapite $ZnFe_4(SO_4)_6(OH)_2 \cdot 18aq.$ *Copiapite* structure group.

Review: **Sabelli** p. 20.

Structure determination not found. [jvs: check for *synthetic*.]

Occurrence: **T Kuang H Li H Hsieh S Yin** 1964 Ti Chih Hsueh Pao 44 99-101 = AM 49 1777.

zincohögbomite-2N2S & -2N6S

$Zn_{0.79}Fe_{0.65}Mg_{0.04}Co_{0.01}Ni_{0.05}Cr_{0.01}Ti_{0.24}Al_{3.98}O_8.$

Zn-rich analogs of *högbomite*.

Structure: **T Armbruster** 1998 SMPM 78 464-8 (A868).

Occurrence & XRPD: **E Ockenga & 3 others** 1998 EJM 10 1361-6 (O386).

zincolibethenite CuZnPO_4OH . Solid solution with *libethenite*.
 Occurrence: Zambia, SC-XRD, IR, synthesis, **RSW Braithwaite & 3 others** 2005 MM 69 145-53.

zinconigerite-6M6S $\text{Sn}_{5.2}\text{Ti}_{0.8}\text{Li}_{1.7}(\text{Zn}_{6.1}\text{Fe}_{5.7}\text{Mn}_{0.1})(\text{Al}_{44.8}\text{Mg}_{0.8})\text{O}_{90}(\text{OH})_6$.
Nigerite/högbomite group.
 Occurrence: & XRD, **T Armbruster A Feenstra** 2004 EJM 16 247-54 = AM 89 1578.

zincosite ZnSO_4 . Isostructural with *chalcocyanite* CuSO_4 . Review: **Sabelli** p. 33.
 Structure: *synthetic*, **PA Kokkoros PJ Rentzperis** 1958 AC 11 361-4;
M Wildner G Giester 1988 MP 39 201-9.

zincospiroffite $\text{Zn}_2\text{Te}_3\text{O}_8$. Iso *spiroffite*.
 Occurrence & XRPD structure: **P Zhang & 4 others** 2004 CM 42 763-8.
Synthetic: structure, **K Hanke** 1966 Nw 53 273.

zincostaurolite *Staurolite* analog.
 Occurrence & SC-XRD: **C Chopin & 3 others** 2003 EJM 15 167-76 (8909).
 Li-rich: **A Feenstra & 3 others** 2003 AM 88 789-805.

zincovoltaita $\text{K}_2\text{Zn}_5\text{Fe}^{3+}_3\text{Al}(\text{SO}_4)_{12}$.18aq. Analog of *voltaita*.
 Occurrence: **W Li G Chen S Sun** 1987 Acta Min Sinica 7 307 = MM 54 671.

zincowoodwardite $[\text{Zn}_{1-x}\text{Al}_x\text{OH}_2](\text{SO}_4)_{x/2}$.n aq. *Hydrotalcite* structure group.
 Occurrence & XRD, 3R & 1T polytypes: **T Witke** 2000 NJMM 455-65 (Z118).

zincrosasite $(\text{Zn,Cu})_2(\text{CO}_3)(\text{OH})_2$. *Rosasite* structure group.
 Structure determination not found. [jvs: check for *synthetic*.]
 Occurrence: **H Strunz** 1959 Fortschr Mineral 37 87-90 = AM 44 1323.

zincroselite $\text{Ca}_2\text{Zn}(\text{AsO}_4)_2$.2aq.
 Zinc-rich member of *roselite* structure group; no structure determination.
 Monoclinic polymorph of *gaitite* in *fairfieldite* group.
 Occurrence: **P Keller J Innes PJ Dunn** 1986 NJMM 523-7 (K761).

zincsilite $\text{Zn}_3\text{Si}_4\text{O}_{10}(\text{OH})_2$.4aq.
 Compare with *sauconite*; considered as intermediate member in *montmorillonite* series.
Montmorillonite mineral group.
 Occurrence & XRPD: **NN Smol'yaninova VA Moleva NI Organova** 1960 AM 46 241-2.

zinc-stottite $\text{ZnFeGe}_2(\text{OH})_{12}$. *Stottite* group.
 AM 56 1488; MM 39 931.

zinc-zippeite $\text{Zn}_2(\text{UO}_2)_6(\text{SO}_4)_3(\text{OH})_{10}$.16aq. *Zippeite* structure group.
 Review: **Sabelli**, no structure.
 Structure determination not found.
 Occurrence: **C Frondel & 3 others** 1976 CM 14 429-36.

zinkenite / zinckenite $\text{Pb}_9\text{Sb}_{22}\text{S}_{42}$.
 Review: **A Skowron ID Brown** 1994 AC B50 524-38 (S1374).
 Structure: **JC Portheine W Nowacki** 1975 ZK 141 79-96 (P210);
G Lebas MT Le Bihan 1976 BSFMC 99 351-60;
E Makovicky WG Mumme 1983 NJMA 147 58-79;
 HRTEM, **PPJ Smith** 1986 AM 71 194-201.
 Solid solution, *zinckenite/robinsonite/meneghinite*: **KL Pryseth & 2 others** 1998 CM 36 207-13.
 See *pillaita* $\text{Pb}_9\text{Sb}_{10}\text{S}_{23}\text{ClO}_{0.5}$.

zinnwaldite $\text{KLiFeAl}(\text{AlSi}_3)\text{O}_{10}(\text{F,OH})_2$.
Mica structure group; commonly 2-layer monoclinic subtype.
 1-layer monoclinic polytype: structure, **S Guggenheim SW Bailey** 1977 AM 62 1158-67 (G374).
 2-layer monoclinic polytype: structure, **M Rieder & 3 others** 1996 EJM 8 1241-8 (R705).
 AI XANES: **A Mottana & 6 others** 1997 AM 82 497-502.

ZIPPEITE STRUCTURE GROUP Includes:

<i>cobalt-zippeite</i>	$\text{Co}_2(\text{UO}_2)_6(\text{SO}_4)_3(\text{OH})_{10}$.16aq
<i>magnesium-zippeite</i>	$\text{Mg}(\text{UO}_2)_2(\text{SO}_4)\text{O}_2$.3.5aq
<i>marecottite</i>	$\text{Mg}_3\text{aq}_{18}[(\text{UO}_2)_4\text{O}_3(\text{OH})(\text{SO}_4)_2]_2$.10aq

<i>nickel-zippeite</i>	$\text{Ni}_2(\text{UO}_2)_6(\text{SO}_4)_3(\text{OH})_{10} \cdot 16\text{aq}$
<i>pseudojohannite</i>	$\text{Cu}_{6.5}[(\text{UO}_2)_4(\text{SO}_4)_2](\text{OH})_5 \cdot 25\text{aq}$
<i>sodium zippeite</i>	$\text{Na}_4(\text{UO}_2)_6(\text{SO}_4)_3(\text{OH})_{10} \cdot 4\text{aq}$
<i>zinc-zippeite</i>	$\text{Zn}_2(\text{UO}_2)_6(\text{SO}_4)_3(\text{OH})_{10} \cdot 16\text{aq}$
<i>zippeite</i>	$\text{K}_4(\text{UO}_2)_6(\text{SO}_4)_3(\text{OH})_{10} \cdot 4\text{aq}$

Review of mineralogy: **C Frondel & 3 others** 1976 CM 14 429-36 (F393).

Review of structures: **J Brugger PC Burns N Meisser** 2003 AM 88 676-85.

Structure: 8 *synthetic zippeite compounds*, SC-XRD, **PC Burns KM Deely LA Hayden** 2003 CM 41 687-706.

zippeite $\text{K}(\text{UO}_2)_2\text{SO}_4(\text{OH})_3 \cdot \text{aq}$ *Zippeite* structure group. Layer structure.

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

Synthetic $\text{K}(\text{UO}_2)_2\text{SO}_4(\text{OH})_3 \cdot \text{aq}$: structure matches natural XRPD, **R Vochten & 4 others** 1995 CM 33 1091-101.

Synthetic Zn-: **VI Spitzyn & 4 others** 1982 Izv AN Khim 807-12.

ZIRCON STRUCTURE GROUP Includes:

<i>behierite</i>	$(\text{Ta}, \text{Nb})\text{BO}_4$
<i>chernovite</i>	YAsO_4
<i>chromatite</i>	CaCrO_4
<i>coffinite</i>	$\text{U}(\text{SiO}_4)_{1-x}(\text{OH})_{4x}$
<i>dreyerite</i>	BiVO_4
<i>hafnon</i>	$(\text{Hf}, \text{Zr})\text{SiO}_4$
<i>pretulite</i>	ScPO_4
<i>schivinatoite</i>	$(\text{Nb}, \text{Ta})\text{BO}_4$
<i>thorite</i>	ThSiO_4
<i>thorogummite</i>	$(\text{Th}, \text{U})(\text{SiO}_4)_{1-x}(\text{OH})_{4x}$
<i>wakefieldite</i>	YVO_4
<i>wakefieldite-Ce</i>	$(\text{Ce}, \text{Pb})\text{VO}_4$
<i>wakefieldite-Y</i>	YVO_4
<i>xenotime</i>	YPO_4
<i>zircon</i>	ZrSiO_4

Review: ReM 51.

Comparison of *hafnon*, *thorite* & zircon: **JA Speer BJ Cooper** 1982 AM 67 804-8.

Crystallographic twin operations relating anhydrite to zircon, *scheelite*, etc: (N373).

Review of REEXO₄ compounds & stability fields: **U Kolitsch D Holtstam** 2004 EJM 16 117-26 (10133).

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

Reidite is high-P shock polymer with *scheelite* structure.

Radiation damage in *thorite* & zircon, Zr & Th EXAFS: **F Farges G Calas** 1991 AM 76 60-73.

Thermal recovery metamict zircon, Raman: **T Geisler & 3 others** 2001 EJM 13 1163-76 (3805).

Point defects: EPR, **WC Tennant & 3 others** 2004 PCM 31 203-23 (10330).

Synthetic CeVO₄: 1990 Z Naturforschung 45B 598-602.

Synthetic ErVO₄-I: 1990 AC C46 1093-4.

Synthetic LnPO₄: 1990 Inorg Chem Acta 174 155-9.

Synthetic Zr_{0.88}V_{0.06}Tb_{0.06}Si_{0.96}V_{0.04}O₄: 1990 ZaaC 583.

Synthetic V & RE doped: **A Siggel M Jansen** 1990 ZaaC 583 67-77 (S1544).

Synthetic LaPO₄: **DF Mullica EL Sappenfield LA Boatner** 1990 Inorganica Chimica Acta 174 155-9 (M1346).

Synthetic LuPO₄, neutron spectroscopy of phonon density of states: **JC Nipko & 5 others** 1997 JAICo 250 573-6 (N436).

Synthetic fluoro-, XRPD structure: **R Valéro & 5 others** 1999 JMC 9 117-23 (V329).

Synthetic RE/P doped, radio- & thermo-luminescence: **T Karali & 4 others** 2000 AM 85 668-81.

Synthetic ZrGeO₄: zircon to *scheelite* at 1453 K, ZrSiO₄, **M Hirano H Morikawa** 2003 ChM 15 2561-3 (9307).

zircon ZrSiO₄. Zircon structure group.

Structure: **K Robinson GV Gibbs PH Ribbe** 1971 AM 56 782-90;

LW Finger 1974 Carnegie Inst Washington Year Book 73 544-7;

RM Hazen LW Finger 1979 AM 64 196-201 (H509);
synthetic, ND, displacive change 1100 K, **Z Mursic T Vogt F Frey** 1992 ACB 48 584-90;
Raman & SC-XRD, **BA Kolesov CA Geiger T Armbruster** 2001 EJM 13 939-48 (3509);
SAXS, **AP Radlinski & 4 others** 2003 PCM 30 631-40.

High-P transition to *reidite (scheelite)* type: diamond-cell, **L-G Liu** 1979 EPSL 44 390-6;
shock, **K Kusaba & 3 others** 1985 EPSL 72 433-9;
equations of state & transition at 10 GPa, **S Ono & 3 others** 2004 AM 89 185-8;
20 GPa, onset, **W van Westrenen & 5 others** 2004 AM 89 197-203;
transition at ~ 9 GPa, **S Ono & 4 others** 2004 CMP 147 505-9;
IR & Raman, shocked to 80 GPa, **A Gucsik & 4 others** 2004 MM 68 801-11.

Free energy of formation: **HStC O-Neil** 2006 AM 91 1134-41.

Slow O diffusion in metamorphic: **WH Peck JW Valley CM Graham** 2003 AM 88 1003-14.

Shock-metamorphosed: cathodoluminescence, EM, Raman: **A Gucsik & 4 others** 2002 EPSL 202 495-509 (8065);
terrestrial impact craters, **A Wittmann & 3 others** 2005 MPS 40 433-54..

Coesite/quartz inclusions in Babieshan zircons, Raman, overpressure: **K Ye J Liou B Cong S Maruyama** 2001 AM 86 1151-5.

Metamict: EXAFS, **F Farges** 1994 PCM 20 504-14;
diffuse XRD, **EKH Salje J Chrosch RC Ewing** 1999 AM 84 1107-16;
TEM, **GC Capitani & 5 others** 2000 PCM 27 545-56 (C1169);
annealing of natural, **L Nasdala & 5 others** 2001 CMP 141 125-44 (2157);
chemical durability vs, **E Balan & 5 others** 2001 AM 86 1025-33;
3-stage isothermal annealing, **T Geisler** 2002 PCM 29 420-9 (7813);
Raman, **CS Palenik L Nasdala RC Ewing** 2003 AM 88 770-81;
low-T hydrothermal alteration, **T Geisler & 7 others** 2003 MM 67 485-98;
U/TH/Pb transport, low-T hydrothermal: **do & 3 others** 2002 ChG 191 141-54;
experimental hydrothermal alteration, **do & 4 others** 2003 AM 88 1496-513;
aperiodic, molecular-dynamics, **E Balan & 4 others** 2003 AM 88 1769-77;
periodic precipitation pattern in hydrothermally treated, **T Geisler & 9 others** 2004 AM 1341-7.

U/Pb isotope fractionation, HF acid leaching: **F Chen W Siebel M Satir** 2002 ChG 191 155-64.

Heavy-ion irradiation, decomposition, amorphization, recrystallization: **A Meldrum & 3 others**
1999 PRB 59 3981-6 (M1707).

In veins, harzburgite xenolith: **JB Dawson PG Hill PD Kinny** 2001 CMP 140 720-33 (1612).

Water adsorption, theory: **E Balan & 3 others** 2001 AM 86 910-4.

OH & water: **L Nasdala A Beran E Libowitzky D Wolf** 2002 AJS 301 831-57 (7202).

Melt inclusions, REE/Ba/Rb/B/Sr/Ti/Y/Nb partition: **JB Thomas & 3 others** 2002 GCA 66 2887-901 (7832).

Igneous, trace elements vs rock type: **EA Belousova & 3 others** 2002 CMP 143 602-22 (8128).

Inclusions of *diamond*, [*coesite = quartz*], *garnet*, *clinopyroxene*, *micas*, *feldspars* in Erzegebirge
rock: **H Massonne L Nasdala** 2003 AM 88 883-9.

Reduction of Ce(IV) to Ce(III) by radiation in Cretaceous zircons, XANES: **Y Takahashi T Sakashima H Shimizu** 2003 GRL 30 15548 (8990).

Growth in slate: **TJ Dempster DC Hay BJ Bluck** 2004 G 32 221-4 (10101).

U-Pb ages for Karoo volcanism: **TB Riley & 6 others** 2004 JGSL 161 547-50 (10449).

U-Pb age depth profile, Barrow zone, Scotland: **CM Breeding & 3 others** AM 89 11067-77.

Low-T recrystallization, *thortveitite/yttrialite/xenotime* inclusions: **C Spandler & 2 others** 2004 AM 89 1795-806.

Recrystallization texture, ocean-floor metamorphism, CL: **E Puga & 3 others** 2005 CM 43 183-202.

Ti thermometer gives low T for earliest Earth crust: **EB Watson TM Harrison** 2005 S 308 841-4 (11023).

Low-T Zr mobility: **C Schmitdt & 4 others** 2006 AM 91 1211-5.

Oldest surviving mineral on Earth.

zirconium carbide ZrC.

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

ZIRCONOLITE MINERAL GROUP:

Approved nomenclature CaZrTi₂O₇ minerals: **P Bayliss F Mazzi R Munno TJ White** 1989 MM 53 565-69.

<i>zirconolite</i>	non-crystalline (metamict) mineral	CaZrTi ₂ O ₇
<i>zirconolite-2M</i>	2-layer monoclinic polytype	CaZrTi ₂ O ₇
<i>zirconolite-3O</i>	3-layer orthorhombic polytype	CaZrTi ₂ O ₇
<i>zirconolite-3T</i>	3-layer trigonal polytype	CaZrTi ₂ O ₇

zirkelite cubic (Ti,Ca,Zr)O_{2-x}
 [*polymignite* discarded in favor of *zirconolite*]
 Anion-deficient superstructure of *fluorite*.
 Modular structure relationships & chemistry: **TJ White** 1984 AM 69 1156-72.
 Most natural specimens are metamict; monoclinic crystals form at 1373-1473K.
 References on occurrences & structures without any attempt to sort out individual minerals:
 XRPD, **HJ Rossell** 1980 N 283 282-3;
 W Sinclair RA Eggleton 1982 AM 67 615-20;
 F Mazzi R Munno 1983 AM 68 262-76;
 Y-, MA Zakrzewski & 3 others 1992 MM 56 27-35;
 Mg-Al yttrian zirconolite, **SL Harley** 1994 MM 58 259-69.
 Site occupancy, XRPD CaZr_xTi_{3-x}O₇ x 0.83-1: **RW Cheary AA Coelho** 1997 PCM 24 447-54.
 321 chemical analyses from 39 of 46 known localities: **CT Williams R Gieré** 1996 Bull Nat Hist
 Mus London (Geol) 52 1-24 (W760).
 Crystal chemistry vs. geochemistry: **R Gieré CT Williams GR Lumpkin** 1998 SMPM 78 432-59.
 Polytypes, Vico volcano: **F Bellatreccia & 5 others** 2002 EJM 14 809-20.
 Inclusions of *apatite*, *calcite*, *coesite*, *diamond*, *diopside*, *dolomite*, *garnet*, *graphite*, *phlogopite* in
 Kazakhstan marble: **I Katayama M Ohta Y Ogasawara** 2002 EJM 14 1103-8 (8678).
 New U-Pb chronometer: **B Rasmussen IR Fletcher** 2004 G 32 785-8 (10620).
 In meteorites: **AE Rubin** 1997 MPS 32 231-47.
Synthetic CaZrTi₂O₇: structure proposal, **YuA Pyatenko ZV Pudovkina** 1964 Kr 9 98-100.
Synthetic CaZr_xTi_{3-x}O₇, x 0.85 & 1.3: **BM Gatehouse & 3 others** 1981 ACB 37 306-12 (G781).
Synthetic Ca_{0.71}Ti_{1.16}Yb_{0.66}Zr_{1.46}O₇-zirconolite-2M: **NJ Calos & 3 others** 1996 ZK 211 703-4 (C876).
Synthetic Nd-substituted 4M: **AA Coelho RW Cheary KL Smith** 1997 JSSC 129 346-59 (C892).
Synthetic Ca_{0.8}Zr_{1.3}Ti_{1.3}Th_{0.15}Al_{0.4}O_{7-3T}, SC-XRD structure, **IE Grey & 4 others** 2003 JSSC 174 285-95 (9330).
zirconolite ~CaZrTi₂O₇. Confused literature.
 See zirconolite structure group for approved nomenclature and combined references.
 Ti K-edge XANES: **F Farges** 1997 AM 82 44-50.
 Niobian-: **CT Williams** 1996 MM 60 639-46.
 Mn,Nb-rich, Eifel: **G Della Ventura F Bellatreccia CT Williams** 2000 CM 38 57-65.
 Review: (more complex formula) **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
 Crystal chemistry, from Jacupiranga: **F Bellatreccia & 4 others** 1999 MM 63 649-60.
 Metamict: EXAFS, **F Farges RC Ewing GE Brown Jr** 1993 JMR 8 1983-95 (F405).
 Occurrence, metarodrigite, Alps, chemical substitutions: **A Stucki V Trommsdorff D Guenther**
 2001 SMPM 81 257-65 (3014).
zircophyllite (K,Na)₃(Fe,Mn)₇(Zr,Ti)₂SigO₂₄(O,OH,F)₇. .
Astrophyllite structure group. MM 39 931.
zircosulfate / zircosulphate Zr(SO₄)₂.4aq. Review: Sabelli no structure.
 XRPD matches synthetic.
 Occurrence: **YuL Kapustin** 1965 ZVMO 94 530-3 = AM 51 529.
[zirfesite ZrFe-silicate hydrate.
 Occurrence: MM 27 276.]
zirkelite (Ti,Ca,Zr)O_{2-x}. Confused literature.
 See *zirconolite* structure group for approved nomenclature and combined references.
 Occurrence, Kola: MM 62 837-46.
 Review: **AP Jones F Wall CT Williams** 1996 Rare earth minerals.
 Occurrence in meteorites: **AE Rubin** 1997 MPS 32 733-4.
zirklerite (Fe,Mg,Ca)₉Al₄Cl₁₈(OH)₁₂.14aq. Inadequate description.
 Occurrence: **Dana**.
zirsillite-Ce (Na,¹)₁₂(REE,Na)₃Ca₆Mn₃Zr₃Nb(Si₂₅O₇₃)(OH)₃(CO₃).aq.
Eudialyte group.
 Occurrence: **AP Khomyakov & 5 others** 2003 ZVMO 132 40-51 (10516).
zirsinalite Na₆(Ca,Mn,Fe)ZrSi₆O₁₈. *Lovozerite* structure group; type I.
 Structure: **ZV Pudovkina & 3 others** 1980 SPD 25 69-70 (P461).

Occurrence: MM 40 916.
 Occurrence in hyperagpaitic alkaline rocks: **Khomyakov** (1995).

zlatogorite CuNiSb_2 .
 Structure & occurrence: **EM Spiridonov & 4 others** 1995 Vest Moscow Univ ser 4 5 57-64 = AM 81 1015.

znucalite $\text{Zn}_{12}(\text{UO}_2)\text{Ca}(\text{CO}_3)_3(\text{OH})_{22.4\text{aq}}$.
 Structure determination not found.
 Occurrence & XRPD: **P Ondrus F Veselovsky R Rybka** 1990 NJMM 393-400 (O277);
 MA 96M/2493.

zodacite $\text{Ca}_4\text{MnFe}_4(\text{PO}_4)_6(\text{OH})_4$. *Montgomeryite* structure group.
 Structure determination not found.
 Occurrence: **PJ Dunn JD Grice WC Metropolis** 1988 AM 73 1179-81.

zoisite $\text{Ca}_2\text{Al}_3(\text{SiO}_4)_3\text{OH}$. *Epidote* structure group; orthorhombic subtype.
 Dimorphic with *clinozoisite*.
 Structure: **WA Dollase** 1965 AM 53 1882-98 (D119);
 ND, **JV Smith & 3 others** 1987 ZK 179 305-21;
 heated blue tanzanite, **MR Sundberg & 4 others** 1988 ZK 185 617 (1 page).
 Calorimetry: **EA Smelik G Franz A Navrotsky** 2000 AM 86 80-91.
 Thermal expansion to 1023K: **AR Pawley SAT Redfern TJB Holland** 1996 AM 81 335-40.
 Compressibility to 5 GPa, SC-XRD diamond cell: **P Comodi PF Zanazzi** 1997 AM 82 61-8;
 to 6 GPa 1073K, XRPD: **AR Pawley NJ Chinnery SM Clark** 1998 AM 83 1030-6.
 High-P stability: **S Poli MW Schmidt** 1998 CMP 130 162-75 (P760).
 Equation-of-state to 7 GPa & 1273 K, **K Grevel et al** 2000 AM 85 206-16.
 Sr-, eclogites & paraschists, Su-Lu province, China: **A Nagasaki M Enami** 1998 AM 83 240-7.
 Synthetic Fe/Al: substitution, IR/XRPD <2 GPa 1023 K, **A Liebscher M Gottschalk G Franz** 2002 AM 87 909-21;
 IR of phase change, **A Liebscher M Gottschalk** 2004 AM 89 31-8.

zoltaiite $\text{BaV}^{3+}_{12}\text{V}^{4+}_2\text{Si}_2\text{O}_7$.
 Occurrence & SC-XRD structure: **PR Bartholomew & 4 others** 2005 AM 90 1655-60.

zorite $\text{Na}_3(\text{Ti,Al})_2\text{Si}_4(\text{O,OH})_{14.3\text{aq}}$.
 2-connected octahedral/square-pyramidal/tetrahedral net. CTF net 1094.
 Synthetic ETS-4 is related to zorite: potential industrial molecular sieve.
 Synthetic ETS-10 has a distinct structure from zorite.
 Related to *haineaultite* $(\text{Na,Ca})_5\text{Ca}(\text{Ti,Nb})_5(\text{Si,S})_{12}\text{O}_{34}(\text{OH,F})_{8.5\text{aq}}$ & *chivruvalite*
 $\text{Ca}_4(\text{Ti,Nb})_5(\text{Si}_6\text{O}_{17})_2[(\text{OH,O})_5]_{.13-14\text{aq}}$.
 Structure: **PA Sandomirskii NV Belov** 1979 SPC 24 686-93 (S1093).
 Occurrence: MM 39 932;
 in hyperagpaitic alkaline rocks: **Khomyakov** (1995).
 Synthetic 'zorite': **DM Chapman AL Roe** 1990 Z 10 730-7 (C641) = CA 114:34721y.
 Synthetic ETS-4: **SM Kuznicki** 1989 US Patent 4,853,202;
SM Kuznicki AK Thrush 1990 European Patent 0405978A1;
SM Kuznicki & 6 others 1992 Synth Microporous Mater 1 427-56 = CA 121:314317t;
 proposal that ETS-4 is an intergrowth of *nenadkevichite* & *zorite*, **A Philippou MW Anderson** 1996 Z 16 98-107 (P590);
 XRPD, Raman, IR, TG/DTA of ETS-4 & Kola zorite indicate same structure type with
 different chemistry, **V Valtchev & 3 others** 1996 MRB 31 163-9 (V247);
 phase transformation of synthetic ETS-4 (~ *zorite* structure type) to *narsarsukite*: **M Naderi MW Anderson** 1996 Z 17 437-43 (N416);
 MAS-NMR, ^{29}Si : **ML Balmer & 4 others** 1997 JPC B 101 9170-9 (B1738);
A Labouriau TG Higley WL Earl 1998 JPCB102 2897-904;
 structure, XRPD & Si MAS-NMR, **G Cruciani & 3 others** 1998 MMM 21 143-53 (C1054);
 water & ammonia adsorption, XRPD, FT-IR, Raman, TPD, **T Armaroli & 8 others** 2000
 JMC 10 1699-705 (3684);
 adjustable pores, **SM Kuznicki & 7 others** 2001 N 412 720-4 (2967);
 enthalpy of formation, **H Xu Y Zhang A Navrotsky** 2001 MMM 47 285-91 (3134);
 synthesis & SC-XRD structure, **S Nair & 5 others** 2001, ChM 13 4247-54 (3672);
 Sr-exch & Na-, XRPD structure, **C Braunbarth & 7 others** 2000 ChM 13 1857-65 (3704);

heat-induced framework contraction, PND/Raman, **S Nair & 3 others** 2001 JChS 123 12781-90 (3870);
with controlled morphology, **B Yilmaz & 3 others** 2004 MMM 71 167-75 (10373);
different alkalinity, **J Warzywoda & 3 others** 2004 MMM 71 177-85 (10374);
ET(P)S-4, P NMR, **CC Pavel & 5 others** 2005 MMM 80 263-8 (11038).

zoubekite $\text{AgPb}_4\text{Sb}_4\text{S}_{10}$.
Structure determination not found.
Occurrence & XRPD: **L Megarskaya D Rykl Z Taborsky** 1986 NJMM 1-7 (M1299) = AM 72 227.

zugshunstone-Ce $(\text{Ce,Nd,La})\text{Al}(\text{SO}_4)_2(\text{C}_2\text{O}_4)\cdot 12\text{aq}$.
Related composition but different structure to *levinsonite-Y*.
Occurrence & SC-XRD structure: **RC Rouse & 4 others** 2001GCA 65 1101-15 (1642).

zunyite $\text{Al}_{13}\text{Si}_5\text{O}_{20}(\text{OH,F})_{18}\text{Cl}$.
Structure: **WB Kamb** 1960 AC 13 15-27 (K427);
YuG Zayal'skaya NV Belov 1964 SPD 8 429-32 (Z71);
ND, **H Bartl** 1970 NJMM 12 552-7;
SJ Louisnathan GV Gibbs 1972 AM 57 1089-108, 1973 58 138;
WH Baur T Ohta 1982 AC B38 390-401;
 ^{27}Al MAS-NMR, **PJ Dirken & 4 others** 1995 AM 80 39-45;
 $^{27}\text{Al}/^{29}\text{Si}/^{19}\text{F}$ MAS-NMR, **B Zhou & 3 others** 2003 CM 41 891-903.

zussmanite $\text{K}(\text{Fe,Mg,Mn})_{13}(\text{Si,Al})_{18}\text{O}_{42}(\text{OH})_{14}$.
Structure: **AL Lopes-Vieira J Zussman** 1967 MM 36 292-3, 1969 37 49-60;
polytypism, **DA Jefferson** 1976 AM 61 470-83.
Occurrence: MM 35 1162; & IR, MM 62 869-76.

zvyagintsevite $(\text{Pd,Pt,Au})_3(\text{Pb,Sn})$.
Isostructural with *atokite* $(\text{Pd,Pt})_3\text{Sn}$ & *rustenburgite* $(\text{Pt,Pd})_3\text{Sn}$.
Occurrence: MM 33 116;
& XRPD: **AD Genkin & 2 others** 1966 Geol Rud Mest 8 94-100 = AM 52 299;
LJ Cabri RJ Traill 1966 CM 8 541-50.
Pt-bearing: **LJ Cabri JH G Laflamme** 1997 MR 28 97-105.

zwieselite $(\text{Fe,Mn,Mg,Ca})_2(\text{PO}_4)(\text{F,OH})$.
Structural series with $\text{Mg}_2\text{PO}_4\text{F}$ *wagnerite* & $(\text{Mn,Fe})_2(\text{PO}_4)\text{F}$ *triplite*.
Structure determination not found.
Occurrence: **Dana**.

zykaite $\text{Fe}_4(\text{AsO}_4)_3(\text{SO}_4)\text{OH}\cdot 15\text{aq}$.
Review: **Sabelli** no structure.
Structure determination not found.
Occurrence: **F Cech J Jansa F Novak** 1978 NJMM 134-44 (C702).