NEW MINERAL NAMES*

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Bowieite*

G.A. Desborough, A.J. Criddle (1984) Bowieite: A new rhodium-iridium-platinum sulfide in platinum-alloy nuggets, Goodnews Bay, Alaska. Can. Mineral., 22, 543–552.

Electron-microprobe analyses of inclusions, 0.02 to 0.05 mm in longest dimension, in three Pt nuggets from the Salmon River, Goodnews Bay, Alaska, gave compositions for which the Rh-Ir extremes are Rh 30.8, 42.5, Ir 35.4, 20.4, Pt 8.8, 10.5, S 25.3, 26.0, sums 100.3, 99.4 wt%, corresponding to $(Rh_{1.14}Ir_{0.70}Pt_{0.17})_{\Sigma2.01}S_3$ and $(Rh_{1.53}Ir_{0.39}Pt_{0.20})_{\Sigma2.12}S_3$. A metal-deficient *variety* with average composition $(Rh,Ir,Pt)_{1.77}S_3$ occurs as rims. In reflected light, bowieite is pale gray to pale brown-gray relative to the enclosing Pt-Ir alloy, not bireflectant or pleochroic, anisotropism colors from pale gray to dark brown. Reflectance values for five grains in air and in oil are given in 10 nm steps. Luminance values (relative to CIE illuminant C) for R_1 and R_2 are 45.8 and 48.2% in air, 30.5 and 33.0% in oil. $VHN_{100} = 1288$ (858–1635), $D_{calc} = 6.91$–6.96 g/cm³. X-ray powder data (114-mm Gandolfi camera, $CuK\alpha_1$ radiation), indexed on an orthorhombic cell, space group *Pnca* (by analogy with data for synthetic Rh_2S_3) gave $a = 8.454(7)$, $b = 6.002(7)$, $c = 6.121(8)$ Å. Strongest lines of the powder pattern in the front-reflection region are 3.00 (vvs) (211,020), 2.143(s)(022), 1.757(vs)(213), and 1.728(s)(420).

The new name is for S.H.U. Bowie, formerly of the Institute of Geological Sciences, London. Type material is in the British Museum (Natural History), London, and at the Smithsonian Institution, Washington, D.C.

Discussion. The publication of Chen et al. (1982) concerning sulrhodite (which see) is discussed and differences in the data for bowieite and sulrhodite are pointed out. Despite discrepancies in some of the reported properties, bowieite and sulrhodite clearly are the same mineral. Bowieite has been approved by the IMA—sulrhodite has not. **J.L.J.**

β-Iridisite

Zuxiang Yu (1984) A study of β-iridisite. Kexue Tongbao, 13, 100–102 (in Chinese).

At an unstated locality in China, platinum-group minerals were deposited in a placer derived from nearby ultramafic rocks. Associated with chromite, magnetite, ilmenite, zircon, native Au, galena, and PGM are widespread granular to shell-like grains for which electron-microprobe analyses of four grains gave Ir 66.0–68.2, Rh 0.0–2.2, Pt 0.0–0.2, Cu 0.3–0.9, Ni 0.0–0.5, Fe 0.0, S 28.7–30.2, As 0.0–0.2, sum 98.2–99.3 wt%; the formula ranges from $(Ir,Cu,Rh,Ni,Pt)_{0.77}S_{2.00}$ to $(Ir,Cu,Rh,Ni,Pt)_{0.82}S_{2.00}$. The mineral typically occurs in a host of osmiridium, commonly as euhedral to subhedral intergrowths, and as graphic intergrowths with it. Color steel gray, metallic luster, brittle, nonmagnetic, black streak, takes a moderately good polish, $VHN_{20} = 1033$. In reflected light, grayish-white, slightly reddish-brown adjacent to native platinum; color variations are large: Ir-rich grains are brownish, Ir-poor grains vary from dark gray to bluish-white; no cleavage or twinning, no bireflection. Reflectance varies with Ir content and crystallinity; percentages in air (WTiC standard) for R_1 and R_2 are 402, 43.7, 43.4; 439, 45.4, 44.0; 480, 45.4, 44.1; 495, 46.3, 44.4; 546, 47.3, 44.7; 590, 47.3, 44.8; 624, 47.4, 45.2; 644, 47.1, 45.4; 657, 46.7, 44.7 (for a grain of composition $Ir_{0.81}S_{2.00}$). The mineral gives a pyrite-type X-ray powder pattern (d values not listed); cell determinations of more than 20 grains gave $a = 5.617$ to 5.647 Å (mostly ~5.635 Å); $D_{calc} = 7.88$ g/cm³ for $Ir_{0.78}S_{2.00}$ with Z = 4. On the basis of the strong anisotropism, it is concluded that the mineral is pseudocubic. The general formula is $Ir_{1-x}S_2$ where $x \leq 0.25$; the end-member formula could be $Ir_{0.75}S_2$, equivalent to Ir_3S_8 reported in the system Ir-S. The name β-iridisite is intended to distinguish the mineral from "normal" iridium sulfide.

Discussion. The omission of the X-ray powder results is most unfortunate. A formal submission with complete data is needed to determine whether this mineral is a distinct species. **J.L.J.**

Kharaelakhite*

A.D. Genkin, T.L. Evstigneeva, L.N. Vyalsov, I.P. Laputina (1985) Mineral. Zhurnal, 7(1), 78–88 (in Russian).

Four electron-microprobe analyses gave Pt 34.10–34.70, Pd 0.12–0.24, Cu 12.20–12.90, Pb 23.40–25.00, Fe 5.35–5.80, Ni 3.90–4.40, S 18.70–19.70, sum 99.54–100.50 wt%; the most Pt-rich and Pt-poor analyses correspond to $(Pt_{2.44}Pd_{0.03}Cu_{2.63}Pb_{1.60}Fe_{1.31}Ni_{0.99})_{\Sigma9.01}S_{8.00}$, and $(Pt_{2.22}Pd_{0.02}Cu_{2.65}Pb_{1.60}Fe_{1.38}Ni_{0.99})_{\Sigma8.86}S_{8.14}$, ideally $(Pt,Cu,Pb,Fe,Ni)_9S_8$. The mineral forms thin rims (20 to 30 μm wide) and elongate crystals (30 by 120 μm) on

braggite-cooperite intergrowths in chalcopyrite associated with bornite and millerite in the Talnakh deposit, Noril'sk, USSR. In reflected light, grayish with a brownish-lilac tint, weak bireflection, distinct anisotropism from pink-lilac to bluish. Reflectance percentages (WTiC standard) in air are given in 20-nm steps; representative values for R_g and R_p are 460, 40.3, 36.8; 500, 41.4, 36.6; 540, 42.2, 37.1; 580, 42.8, 37.9; 620, 43.3, 38.6; 660, 44.1, 38.9; 700, 44.8, 39.1; 740, 45.8, 39.0. By analogy with the π phase of Me_9S_8, kharaelakhite is orthorhombic, diffraction class $Pmmm$; cell dimensions from the powder pattern are $a = 9.713(5)$, $b = 8.333(5)$, $c = 14.50(1)$ Å, $Z = 4$. Strongest lines of the powder pattern (57-mm camera, Fe radiation) are 3.03(100)(112), 1.865(40)(220), 1.854(80)(024), 1.591(60)(132), and 1.077(60)(244).

The new name is for the locality, the Kharaelakh plateau near the Talnakh deposit. Type material is in the Fersman Mineralogical Museum, Moscow, and in the mineralogical laboratory of the Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geology, Moscow. **J.L.J.**

Sulrhodite

Keqiao Chen, Nicheng Shi, Zhizhong Peng (1982) A preliminary study of sulrhodite—A new platinum-group mineral. Ko Hsueh Tung Pao, 27(8), 492–496 (in Chinese).

The mineral occurs in placer concentrates considered to have been derived from chromite-bearing dunite in the central part of an ultramafic stock at an unstated locality in China. The mineral was found as a single subhedral grain, ~85 × 67 × 50 μm, embedded in an irregular Pt-Fe grain about 1.2 × 0.8 × 0.8 mm. Color brownish-black, metallic luster, streak dark gray with a brownish tint, brittle, not difficult to polish, perfect {001} and imperfect {101} cleavages, $VHN_{20} = 575$. Not attracted to a magnet; insoluble in HCl, HNO_3, and H_2SO_4. In reflected light, bright greenish-gray with a creamy tint; distinct bireflectance from greenish-gray to light, creamy greenish-gray at low magnifications; strongly anisotropic from dark to light gray. Reflectance values in air (WC standard) R'_1 and R'_2 (nm, %) are 405, 44.84, 46.21; 436, 45.74, 47.20; 480, 49.47, 46.62; 526, 49.86, 46.98; 546, 51.42, 47.36; 578, 51.23, 47.19; 589, 51.25, 47.52; 622, 50.03, 47.07; 644, 49.17, 46.44; 656, 48.80, 46.77; 664, 49.37, 46.55; 700, 48.86, 45.09. Electron-microprobe analyses (avg. of four) gave Rh 68.80, S 31.04, sum 99.85 wt%, corresponding to $Rh_{2.072}S_{3.003}$. Single-crystal X-ray study gave $a = 6.167$, $b = 8.493$, $c = 5.987$ Å, space group $Pnca$, $D_{calc} = 6.452$ g/cm³ for Rh_2S_3 with $Z = 4$. The X-ray powder pattern (57-mm camera, Cu radiation) has strongest lines of 3.01(100)(211), 2.1609(70)(022), 1.761(60)(123), 1.729(80)(231,420), 1.350(60)(124,304), 1.2692(60)-(620,333+), in good agreement with data for synthetic Rh_2S_3 (PDF 21-1017). The name alludes to the chemical composition.

Discussion. No repository for type material is given, but

in an earlier publication (*Kexue Tongbao*, 26, p. 767, 1981; abstract only), the sample is stated as "on show in the Museum of the Ministry of Geology" [Beijing]. Despite differences in some of the data, sulrhodite and bowieite (which see) clearly are the same mineral. **J.L.J.**

Unnamed $(Ir,Cu)_2S_3$, unnamed Ir-rich sulfide

O. Legendre, T. Augé. (1986) Mineralogy of platinum-group mineral inclusions in chromitites from different ophiolitic complexes. *In* Metallogeny of Basic and Ultrabasic Rocks, Proc. Conf. 1985 (Edinburg, Scotland), 361–372. Inst. Mining, Metall., London.

Electron-microprobe analyses of two grains (compositions unstated) from the Tiébaghi mine, New Caledonia, correspond to $(Ir_{0.91}Cu_{0.50}Ru_{0.28}Ni_{0.16}Rh_{0.11})_{\Sigma 1.85}S_3$ and $(Ir_{0.95}Rh_{0.30}Cu_{0.65}Ni_{0.05})_{\Sigma 1.96}S_3$. The grains occur as euhedral elongate hexagons, 4 μm long, having a reflectance slightly higher than that of laurite.

T. Augé (1988) Platinum-group minerals in the Tiébaghi and Vourinos ophiolitic complexes: Genetic implications. Can. Mineral., 26, 177–192.

In the Tiébaghi massif, New Caledonia, dunite contains platinum-group minerals (PGM) as inclusions in chromite and chromian spinel. Grains of the PGM are 1 to 20 μm in largest dimension and average about 5 μm. Electron-microprobe results for the PGM are based on deductions of Cr and a proportional amount of Fe, as determined from the Cr/Fe ratio of the host spinel, and recalculation to 100 wt%. In dunite and chromitite at the Tiébaghi massif, New Caledonia, a mineral corresponding to $(Ir,Cu)_2S_3$ occurs as isolated grains, or associated with laurite, or with erlichmanite. Analyses of three grains gave compositions corresponding to $(Ir_{1.34}Cu_{0.67}Pt_{0.03}Ni_{0.09}Rh_{0.01})_{\Sigma 2.09}S_{2.91}$, $(Ir_{0.91}Cu_{0.49}Ru_{0.28}Ni_{0.16}Rh_{0.11}Os_{0.05})_{\Sigma 2.00}S_3$, b and $(Ir_{0.91}Cu_{0.66}Rh_{0.42}Ni_{0.09}Pt_{0.01})_{\Sigma 2.09}S_{2.91}$.

Also present with the PGM are inclusions of base-metal sulfides, mainly pentlandite and chalcopyrite, the former containing up to 43.7 wt% platinum-group elements in solid solution. One grain of a Fe-Ni-Cu sulfide, apparently a single crystal, from the Vourinos dunite, Greece, gave a composition of Ni 21.64, Cu 15.49, Fe 10.99, Pd 17.47, Ru 5.17, Rh 3.75, Ir 0.22, S 25.27 wt%, possibly $Cu_2(Fe,Ru)_2(Ni,Pd)_4S_7$.

Discussion. The mineral with the formula $(Ir,Cu)_2S_3$ has the same composition as kashinite (*Am. Mineral.*, 72, p. 223, 1987). More data are needed to characterize the base-metal sulfide. **J.L.J.**

Ir-Sb-S, Rh-Sb-S, Rh-Ni-Sb

M. Tarkian, H. M. Prichard (1987) Irarsite-hollingworthite solid-solution series and other associated Ru-, Os-, Ir-, and Rh-bearing PGM's from the Shetland ophiolite complex. Mineralium Deposita, 22, 178–184.

In a sample from the Shetland ophiolite complex, Scotland, a grain of IrAsS (irarsite) contains an irregular inclusion of IrSbS about 10 μm in diameter. Qualitative analyses indicate that the IrSbS is of end-member composition. The mineral is isotropic in reflected light, pale gray with a tinge of brown, estimated reflectance 45% in white light, hardness marginally less than that of irarsite.

Rh-Sb-S occurs as an anhedral inclusion, about 5 μm in diameter, adjacent to IrSbS. The Rh-Sb-S apparently is of end-member composition, possibly indicating a difference from (Rh,Ir)-Sb-S reported by Raicevic and Cabri (*CIM Bull.*, 69, 111–119, 1976). In polished section, the mineral is distinctly brown, weakly anisotropic, hardness similar to that of Ir-Sb-S, and estimated reflectance is 50% in white light.

Rh-Ni-Sb occurs as a single grain, 4 μm in diameter, rimmed by irarsite. Yellow in reflected light, weak anisotropism, softer than irarsite, estimated reflectance 55%.

Discussion. As the analyses are only qualitative, no metal ratios are implied. Presumably the unnamed IrSbS is tolovkite (*Am. Mineral.*, 67, 1076–1077, 1982). **J.L.J.**

Pt-Cu-Fe minerals

V.V. Distler, V.V. Kryachko, I.P. Laputina (1986) Evolution of platinum-group parageneses in Alpine-type ultramafics. Geol. Rudnykh Mestorozhdeniy, 1986(5), 16–33 (in Russian, English transl. available).

Chromitite bodies in three layered intrusions, apparently in the Koryak Range of northeastern Siberia, USSR, contain Cu-bearing platinum-group minerals that are considered to be discrete phases having variable but near-integral stoichiometries of the type A_3B. The Cu-bearing minerals occur as replacement rims on isoferroplatinum and as separate to coexisting grains in serpentine veinlets. Thirteen electron-microprobe analyses are tabulated, corresponding to $(Pt,Cu_2)_{\Sigma3}Fe$, $(Pt_2Cu)_{\Sigma3}Fe$, $(Cu_2Pt)_{\Sigma3}Fe$, Cu_3Pt, $(Ni,Cu,Fe)_3Pt$, Cu_2Pt_3Fe, and $(Cu,Fe,Ni)Pt$.

Discussion. More data are needed to permit assessment of the possibility that these compositions represent distinct minerals. $(Pt_2Cu)Fe$ could be tulameenite and $(Cu,Fe,Ni)Pt$ could be hongshiite. **J.L.J.**

Unnamed PGM

H.W. Stockman, P.F. Hlava (1984) Platinum-group minerals in alpine chromitites from southwestern Oregon. Econ. Geol., 79, 491–508.

Platinum-group minerals occur in alpine-type chromitites from two peridotites in southwestern Oregon. Electron-microprobe analyses of porous Ru-rich alloys, 3 to 30 μm in diameter, gave compositions corresponding in general to $(Ru,Os,Ir,Pt)_{0.40-0.45}(Fe,Ni,Cr)_{0.52-0.60}$. On the basis of phase diagrams relevant to this formula, the Ru-rich alloy probably has a hexagonal structure.

Analysis of an irregular, slightly porous Pt-rich alloy, 1 to 2 by 5 μm, at the edge of a laurite grain gave Fe 33.19,

Ni 7.91, Cr 2.05, Cu 1.57, Pt 51.48, Ir 2.65, Os 0.44, sum 99.29 wt%, corresponding to $(Fe,Ni,Cr,Cu)_{0.73}(Pt,Ir,Os)_{0.27}$, possibly analogous to the synthetic compound $PtFe_3$.

Analysis of a grain of unstated dimensions, but <10 μm, gave Os 41, Ir 14, Ru 10.1, Pt 3.3, Fe 34.0, sum 102 wt%, corresponding to $(Os,Ir,Ru,Pt)_{0.40}Fe_{0.60}$, or Os_2Fe_3.

Analyses of two grains of a gray sulfide gave Cu 8.51, 7.88, Cr 6.68, 3.49, Fe 1.90, 2.01, Ni 0.36, 1.69, Ir 51.05, 50.83, Rh 4.63, 5.12, Ru 0.18, 2.67, Os 0.65, 2.03, Pt 0, 0.26, S 20.30, 23.12, sums 94.26, 99.10 wt%, corresponding to $(\Sigma Cu)_{0.89}(\Sigma PGE)_{2.00}S_{4.00}$ and $(\Sigma Cu)_{0.91}(\Sigma PGE)_{1.96}S_{4.00}$ with Ir predominant. The grains are <5 μm in diameter, slightly less reflective than laurite, and possibly are isotropic.

Discussion. The last mineral, which has the simplified formula $CuIr_2S_4$, could be cuproiridsite (*Am. Mineral.*, 71, p. 1277, 1986). For Ru-Fe and Os-Fe solid solutions, see *Am. Mineral.*, 73, p. 197, 1988. **J.L.J.**

Unnamed Pd minerals

R.R. Loucks, M.E. McCallum (1980) Platinum-group minerals in the New Rambler copper-nickel deposit, Wyoming: A preliminary report. *In* Sulphosalts, Platinum Minerals and Ore Microscopy, 200–218. Proc. XI IMA Meet., Novosibirsk.

Massive and disseminated copper-nickel sulfide ore at the New Rambler mine, southeastern Wyoming, contains sperrylite, moncheite, merenskyite, michenerite, kotulskite, and four undefined palladium minerals. Phase A occurs as isolated laths and irregular grains, averaging 50 to 200 μm, and is thought to be an antimonian, platinian kotulskite of composition $(Pd,Pt)(Te,Bi,Sb)$. Phase B occurs in phase A as minute granules and intergrowths averaging 5 to 15 μm. A and B have a similar polishing hardness; B is rose-tan, weakly anisotropic from dark brownish to bluish-gray in air and oil, no bireflectance, no cleavage. Electron-microprobe analysis of one of two grains gave Pd 63.22, Pt 0.0, Bi 15.27, Sb 2.32, Te 18.61, sum 99.42 wt%, corresponding to $Pd_{5.00}(Te_{1.23}Bi_{0.61}Sb_{0.17})_{\Sigma2.00}$. The possibility that phase B may be the Te-Bi analogue of stibiopalladinite is considered, and the similarity to unnamed $Pd_{3-x}Te$ is noted.

Phase C occurs as granular intergrowths, 10 to 35 μm, with Bi-rich merenskyite. Microprobe analyses of three grains gave Pd 27.67–29.33, Bi 0.86–4.46, Te 67.92–70.35, sum 100.15–100.57, corresponding to an average of $Pd_{0.98}(Te_{1.98}Bi_{0.04})_{\Sigma2.02}$. Cream-colored, lower reflectivity and weaker anisotropy than merenskyite, but suggested possibly to be almost end-member merenskyite.

Phase D occurs in the oxidized zone as alteration rims on michenerite. Grain size of D is 5 to 15 μm; reflectivity only slightly greater than that of goethite, moderately bireflectant from yellowish to pinkish tan; extreme anisotropism, from bright yellow to dark blue. Electron-microprobe analyses of two grains gave Pd 27.20, 30.13, Pt 1.59, 1.17, Bi 36.36, 32.92, Te 20.20, 20.95, sum 85.62,

85.17 wt%. Assuming oxygen represents the difference from 100 wt%, a possible formula is $(Pd,Pt)(Te,Bi)O_3$.

Discussion. The composition and optical character of Phase B suggest that it likely is keithconnite. Phase D seems to be unique, but more data are needed. **J.L.J.**

Unnamed Pd minerals

A.D. Genkin, T.L. Evstigneeva (1986) Association of platinum-group minerals of the Noril'sk copper-nickel sulfide ores. Econ. Geol., 81, 1203–1212.

Among the minerals listed as occurring in the Noril'sk deposits are unnamed $Pd(As_{0.6}Te_{0.4})$, Pd_5As_2, $Pd_2Ni_6As_3$, $Pd_5(Sb,As)_2$, $Pd_2(Sn,Sb)$, Pd_6Sn_2As, and $Pd_4Bi_5Cl_3$. The first occurs in veinlet-disseminated and breccia ores, and the others in massive ores.

Discussion. The above unnamed minerals are listed in a summary table of Noril'sk platinum-group minerals; shown in photomicrographs and mentioned in the text (but not in the table) are the additional minerals $Pd_2(Sb,Sn)$ and $(Pd,Pt)_5(Sn,Sb)_2$. Analyses are not given for any of the unnamed phases. **J.L.J.**

Unnamed Pd minerals

T.L. Evstigneeva, A.D. Genkin (1986) The Pd, Sn, Sb, and As minerals; their relationships and crystal chemistry. *In* Proceedings 13th General Meeting IMA, Varna, Sept. 19–25, 1982, Sofia, p. 165–174. Sofia Publ. House, Bulgarian Acad. Sci. (in Russian).

Five electron-microprobe analyses tabulated for platinum-group minerals from the Oktyabrsk deposit, Noril'sk, USSR, correspond ideally to Pd_6SnAs, Pd_6SnSb, $Pd_{11}(Sb,Sn)_4$, $Pd_{11}(Sb,Sn,As)_4$, and $Pd_{11}As_2(Sb,Sn)_2$. Some of the compositions are grossly like that of isomertieite. Based on similarities of X-ray powder patterns (not given), some structural analogies with simpler known phases are suggested. Compositions of the minerals, and products synthesized in the study, indicate extensive solid solution of Sn-As and Sn-Sb in Pd compounds; either disordered phases, or ordered phases of intermediate composition, can be formed.

Discussion. The presence of hexagonal $Pd_2(Sn,As)$ and $Pd(As,Sn)$ also is reported, but detailed data are not given to clearly distinguish these from paolovite (Pd_2Sn, orthorhombic) and palladoarsenide (Pd_2As, monoclinic). **J.L.J.**

Unnamed Pd minerals

H. Kucha (1984) Palladium minerals in the Zechstein copper deposits in Poland. Chem. Erde, 43, 27–43.

Uraninite-bearing shale and adjacent dolomite in the Lubin and Polkwice mines in the Zechstein of Poland contain up to 5 wt% Pd in mixtures of Ni and Co arsenides.

Among the microprobe-analyzed palladium arsenides, Pd_2As may be palladoarsenide, and Pd_8As_2S is thought to be similar to stillwaterite [Pd_8As_2]. The following additional minerals are present.

PdAs$_2$ has a rectangular shape and is 20 to 30 μm. White in reflected light in air, lighter than rammelsbergite, isotropic, reflectance 55–60%. In oil, slightly more bluish than rammelsbergite, reflectance 47–50%, possibly weakly anisotropic. Polishing hardness similar to that of nickel diarsenides. Electron-microprobe analyses of two grains gave Pd 26.4, 38.5, Ni 7.3, 2.1, Co 1.9, 0.30, Cu 0.61, 0.80, Ag 0.52, <0.15, Fe 0.40, <0.08, As 55.7, 57.8, S 6.5, 0.62, sum 99.33, 100.12 wt%, corresponding to $(Pd_{0.58}Ni_{0.29}Co_{0.08}Cu_{0.02}Fe_{0.02}Ag_{0.01})_{\Sigma1.00}As_{1.75}S_{0.48}$, and $(Pd_{0.87}Ni_{0.09}Cu_{0.03}Co_{0.01})_{\Sigma1.00}As_{1.86}S_{0.05}$. $PdAs_2$ is known in the Pd-As system; cubic, pyrite-type.

Pd$_3$As$_5$. The most common of the Pd minerals in the deposits, occurs as grains up to 50 μm in size. White in reflected light, reflectance 57–60%, decreasing to 50–55% with lower As contents and changing from a grayish hue to light yellowish-pink. Isotropic in air, but may be weakly anisotropic in oil. Polishing hardness less than that of nickel diarsenides. Microprobe analysis [one of nine listed] gave Pd 44.5, Ag 2.00, As 53.5, sum 100.0 wt%, corresponding to $Pd_{2.87}Ag_{0.13}As_{4.92}$.

Pd$_2$As$_3$. The mineral occurs as tabular grains, up to 20 by 25 μm. In reflected light, white with a bluish tint, weakly anisotropic, reflectance about 60%; in oil, the bluish tint is more intense, anisotropy weak to distinct, brown to bluish gray polarization colors barely discernible, reflectance about 50%. Polishing hardness similar to that of calcite. Electron-microprobe analyses of four grains gave compositions corresponding to $(Pd,Ag,Au)_2As_3$; a representative analysis is Pd 42.60, Ag 5.20, Ni 0.44, Co 0.27, Au 0.68, As 51.20, sum 100.39 wt%, formula $(Pd_{1.73}Ag_{0.21}Au_{0.02}Ni_{0.03}Co_{0.02})_{\Sigma2.01}As_{2.95}$.

Pd$_5$As$_2$. Grain size generally does not exceed 15 μm. Reflectance about 52% in air; distinctly yellow-brown and darker than cobaltite in oil. Typically occurs as narrow rims on native gold, or forms a zone between Au and other Pd minerals. Electron-microprobe analysis of a grain, 5 by 15 μm, gave Pd 52.50, Ag 10.10, Au 10.70, Cu 4.20, Ni 3.10, Co 1.40, Fe 0.33, As 17.80, S 1.10, sum 101.23 wt%, corresponding to $(Pd_{3.12}Ag_{0.60}Au_{0.35}Cu_{0.42}Ni_{0.33}Co_{0.15}Fe_{0.06})_{\Sigma5.03}As_{1.52}S_{0.21}$, ideally Pd_5As_2.

Pd$_8$As$_2$S. Electron-microprobe analysis of a grain, 8 by 16 μm, gave Pd 70.50, Ag 5.60, Au 2.60, Cu 2.30, Fe 0.50, As 14.60, S 2.80, sum 98.90 wt%, corresponding to $(Pd_{6.86}Ag_{0.54}Cu_{0.37}Au_{0.14}Fe_{0.04})_{\Sigma7.95}As_{2.03}S_{0.91}$. The mineral occurs as irregular grains intergrown with native gold. In reflected light, light gray with a bluish tint, reflectance about 50%; in oil, bluish-pink and weakly anisotropic. The optical character and formula are considered to indicate that the mineral may be a S-substituted stillwaterite (Pd_8As_3).

Pd$_3$As. Electron-microprobe analysis of grain, 16 by 10 μm, gave Pd 68.98, Ni 3.88, Co 3.10, Ag 4.25, Cu 1.08, As 19.29, S 0.41, sum 100.99 wt%, corresponding to

$(Pd_{2.36}Ni_{0.24}Co_{0.19}Ag_{0.14})_{\Sigma 2.93}(As_{0.94}S_{0.09})_{\Sigma 1.03}$. Brown with a yellow tint, weakly anisotropic, reflectance 38–40% in air and decreases substantially in oil. Yellowish-brown in oil and strongly anisotropic. Softer than Pd_3As_5. Possibly guanglinite, or "vincentite" [*Am. Mineral.*, 59, p. 1332, 1974].

(Ni,Pd)$_3$As$_4$. The mineral is rarely >15 μm because of intimate intergrowth with native gold and $NiAs_2$. Reflectance 55% in air, weak to distinct anisotropism, grayish-blue color beside gold. Electron-microprobe analysis of a grain, 10 by 10 μm, gave Ni 20.10, Pd 20.00, Ag 3.00, Au 0.47, As 55.90, S 0.62 wt%, corresponding to $Ni_{1.83}Pd_{1.01}Ag_{0.15}Au_{0.01}As_{4.00}S_{0.10}$, ideally (Ni,Pd)$_3As_4$.

Pd$_4$As$_3$. Occurs with $NiAs_2$, digenite, covellite, native gold, and Pd minerals, often intergrown with Pd_3As. Typically anhedral, rarely as thin, elongate crystals of unstated size. Electron-microprobe analysis of a grain, 7 by 10 μm, gave Pd 51.60, Ni 3.50, Co 2.50, Cu 1.40, Ag 0.13, As 35.80, S 1.50, sum 98.50 wt%, corresponding to $(Pd_{3.09}Ni_{0.38}Co_{0.27}Cu_{0.14}Ag_{0.13})_{\Sigma 4.01}As_{3.05}S_{0.30}$, suggested to be a possible analogue of genkinite, (Pt,Pd)$_4$Sb$_3$. White-pink in reflected light, anisotropic, reflectance about 50% in air.

Majakite. A mineral reported to be similar to majakite (PdNiAs), but with Co exceeding Ni, occurs as 15–25 μm inclusions in cobaltite. No analyses are given.

Pd$_2$Cu$_5$As$_5$S$_7$. Electron-microprobe analysis of a 25 by 30 μm grain gave Pd 21.00, Cu 11.70, Ni 1.80, Ag 1.40, Co $\leq$ 0.11, Fe $\leq$ 0.08, As 39.40, S 26.00, sum 101.3 wt%, corresponding to $Pd_{1.85}Ag_{0.13}Cu_{1.72}Ni_{0.29}As_{4.95}S_{7.64}$. Grayish-blue in reflected light, weak bireflectance, reflectance about 30%, strong anisotropism. In oil, reflectance about 20%, gray color, strongly anisotropic in grayish-blue colors, bireflectant from light gray to dark gray. Occurs as needle-like crystals.

Electron-microprobe analysis of another grain, 10 by 50 μm, gave Pd 23.77, Ag 1.86, Cu 10.80, Ni 4.10, Co $\leq$ 0.11, Fe $\leq$ 0.08, As 42.75, S 19.10, sum 102.3 wt%, corresponding to $Pd_{1.85}Ag_{0.15}Cu_{1.42}Ni_{0.58}As_{6.03}S_{4.95}$, ideally $Pd_2Cu_2As_6S$. It is suggested that some As-S solid solution occurs and the formula, as indicated by the above two analyses, may be PdCu(As,S)$_6$.

Pd$_8$As$_6$S$_3$. Occurs as radiating needlelike aggregates containing electrum inclusions. Reflectance 29–30% in air, gray with a blue tint, anisotropic. In oil, olive-brown relative to Au, bireflectant from dark gray to a darker grayish-brown, strongly anisotropic. Electron-microprobe analysis of a 30 by 40 μm grain gave Pd 52.10, Ag 3.10, Cu 2.60, Ni 1.10, Fe 0.98, Co 0.12, As 33.2, S 7.30, sum 100.5 wt%, corresponding to $Pd_{6.45}Ag_{0.39}Cu_{0.55}Ni_{0.26}Fe_{0.24}Co_{0.03}As_{5.93}S_{3.07}$, ideally $Pd_8As_6S_3$.

In addition to the above, analyses are given for palladium arsenides whose compositions vary and whose reflectance varies from 18 to 32% in air. These form grains up to 50 μm in size and have isotropic and anisotropic components. Other minerals reported to occur with Pd_3As_5 are $CuMo_2S_5$, $CuMoS_3$, Cu_8MoS_9, and $Cu_3Mo_2AsS_5$, but no analyses or data are given for these copper-molybde-num sulfides or for an "unnamed high arsenic variety of castaingite."

Discussion. A great deal of caution is necessary in interpreting these results: grain sizes are small, and fluorescence effects and the possibility of mixtures cannot be discounted. For the copper-molybdenum sulfides, only $CuMo_2S_5$ has been reported previously (castaingite). The palladium arsenides are difficult to accept or to reject as new minerals because descriptions and data are incomplete. $PdAs_2$ is known as a synthetic phase, but Pd_3As_5 and Pd_2As_3 are not. The ideal formula Pd_5As_2 might seem to be speculative, but Cabri and Laflamme (*CANMET Report* 79–29, 1979) reported a grain, from the Lac des Iles area, Ontario, with the composition $(Pd_{0.66}Au_{0.29}Cu_{0.04})_{\Sigma 4.99}As_{2.01}Te_{<0.01}$; grains of similar composition also have been reported (*Can. Mineral.*, 13, 321–335, 1975) from the Stillwater Complex, and Pd_5As_2 is known as a phase in the Pd-As system. Pd_8As_2S has not been found in the system Pd-As-S, and the absence of S in previous analyses of confirmed grains of stillwaterite is a notable contrast. For Pd_3As, other incompletely described minerals with possibly the same formula have been reported (L. J. Cabri, *CIM Special Vol.*, 23, 175–195, 1981), but the absence of X-ray data negates meaningful comparisons. For *(Ni,Pd)$_3$As$_4$*, no equivalent Pd mineral or synthetic compound is known; needs more data. For Pd_4As_3, the formula possibly could be written also as Pd(Ni,Co,Cu,Ag)As, ideally Pd_3NiAs_3; neither Pd_4As_3 nor Pd_3NiAs is known in the relevant synthetic systems, and no mineral with either formula has been reported previously. Likewise, compounds with compositions similar to $PdCu(As,S)_6$ and $Pd_8As_6S_3$ have not been reported as natural or synthetic phases. **J.L.J.**

New Data
Palarstanide

Results of five electron-microprobe analyses of palarstanide from the Talnakh deposit, USSR, are tabulated and are in good agreement with original data (*Am. Mineral.*, 67, p. 858, 1982) from which the formula $Pd_8(Sn,As)_3$ was derived for palarstanide. The original and new analyses both can be recast into a new formula for palarstanide: Pd_5SnAs, or $Pd_5(Sn,As)_2$.

The X-ray powder pattern of palarstanide originally was indexed on a hexagonal cell with $a = 6.784$, $c = 14.80$ Å. On the basis of the structural similarity of palarstanide to Pd_5As_2 as synthesized by Saini et al. (*Can. J. Chem.*, 42, 150–164, 1964), the X-ray pattern can be re-indexed on a trigonal cell with $a = 7.50$, $c = 10.34$ Å. Extra lines present in the originally reported X-ray pattern of palar-

stanide correspond to those of pentlandite, which occurred intimately intergrown with the palarstanide.

Discussion. This is a significant redefinition of palarstanide; other than the microprobe results, however, specific data such as the X-ray powder patterns are not tabulated. **J.L.J.**

Xingzhongite, Prassoite

T. Augé (1988) Platinum-group minerals in the Tiébaghi and Vourinos ophiolite complexes: Genetic implications. Can. Mineral., 26, 177–192.

In the Tiébaghi massif, New Caledonia, dunite contains platinum-group minerals (PGM) as inclusions in chromite and chromian spinel. Grains of the PGM are 1 to 20 μm in largest dimension and average about 5 μm. Electron-microprobe results for the PGM are based on deductions of Cr and a proportional amount of Fe, as determined from the Cr/Fe ratio of the host spinel, and recalculation to 100 wt%. Recalculated analyses of two grains deemed to be xingzhongite associated with erlichmanite gave Ir 57.20, 61.78, Os 4.77, 0.55, Rh 0.88, 0.26, Ru 0.74, 0.03, Pt 0.54, 0.55, Pd not detected, 0.10, Cu 14.16, 15.63, Ni 0.39, 0.11, S 21.31, 21.00 wt%. The second of the analyses corresponds to $(Ir_{0.52}Cu_{0.40}Rh_{<0.01}Pt_{<0.01}Os_{<0.01}Ni_{<0.01})_{\Sigma0.94}S_{1.06}$, or $(Ir,Cu)S$.

Analysis of a grain, deemed to be prassoite in contact with laurite, gave Rh 54.85, Cu 5.36, Ru 6.44, Ni 1.30, Pd 0.61, Ir 0.83, Pt 0.45, S 30.16 wt%, corresponding to $(Rh_{2.25}Cu_{0.35}Ru_{0.26}Ni_{0.09}Pd_{0.02}Ir_{0.02}Pt_{0.01})_{\Sigma2.99}S_4$, simplified as $(Rh,Cu,Ru)_3S_4$.

Discussion. The simplified formula for xingzhongite corresponds to that proposed initially for the mineral, though the earlier analysis was reported to have Pb 8.0 wt% (*Am. Mineral.,* 61, p. 185, 1976; 65, p. 408, 1980). Subsequently, another analysis of the mineral gave Pb 12.8 wt% (*Am. Mineral.,* 69, p. 412, 1984), thereby leading to a possible Pb-dominant formula $(Pb,Cu)Ir_2S_4$. X-ray data for the two Pb-bearing phases differ substantially. The analyses abstracted here, and the previously reported discrepancies, indicate clearly that a proper definition or redefinition of xingzhongite is needed.

The formula of prassoite has been considered to be uncertain, but possibly $Rh_{17}S_{15}$ (see Cabri, *CIM Special Vol.,* 23, p. 132, 1981). The simpler formula Rh_3S_4 proposed as above does not give an appropriate calculated density. **J.L.J.**