United States Department of the Interior

U. S. Geological Survey

Computerized Database of the Optical Properties of the Opaque Minerals

[Compiled From "Tables For Microscope Identification of Ore Minerals", by Uytenbogaardt and Burke]

by

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Open-File Report 88-260 ·A

This database was last revised in January, 1989. The database consists of the optical and pertinent physical properties of 288 opaque minerals. These properties are: 1, chemical composition*; 2 and 3, reflected light color and tints (in air)*; 4 and 5, reflected light color and tints (in oil)*; 6, bireflectance*; 7, anisotropy*; 8, crystallographic class*; 9, percent reflectance in green light (540nm)*; 10, Vickers Hardness Number; 11, possible internal reflections; 12, polishing hardness; and 13, a brief listing of common associations and textures. The database can be searched on those properties that are starred.

The database was written with Filemaker Plus™ and and is compatible with Filemaker 4™ and Filemaker II™ also. It was created on a Macintosh Plus™ but will also run on the Macintosh SE™, II™, and IIx™.

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[Compiled From "Tables For Microscopic Identification of Ore Minerals", by Uytenbogaardt and Burke]

This open file report arose from frustrations which I have perpetually encountered in attempting to identify those small grains of gray- (or white-, or yellow-, etc) reflecting minerals under the microscope. Almost without exception, the texts and tables most commonly available to aid the ore microscopist in his quest for identity (sic), fail to group the opaque minerals by their most distinctive, most obvious, and certainly most easily described characteristic - their color! The Delft punch card system (Kühnel et al.,1982) sorts the minerals by their color in reflected light, but it is somewhat expensive and not commonly available. The software described here allows one to sort through the 260 odd minerals listed and extract only those fitting the observed property(ies).

The data compiled here were taken, almost verbatim, from "Tables for Microscopic Identification of Ore Minerals" by W. Uytenbogaardt and E. A. J. Burke (1971). Supplemental data were taken from Picot and Johan (1982) and Criddle and Stanley 1986); citations from these references are noted in the individual records by (P&J) and (QDF2), respectively. The data were compiled using Filemaker Plus™ with each mineral and its characteristic properties listed as a separate record.

A typical record is shown below:

Mineral Name: Pyrite **Chem. Comp.:** Fe.S2
Crystall.: cubic
Color: yellow **Tint:** white cream
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: often weakly to distinctly anisotropic, blue-green to orange-red

%R: 54 hi **VHN:** 913-2056

Int'l Reflects:

Polish. Hard.: >aspy, cobaltite; slt>marc, hem; <sperrylite, laurite, cassiterite

Comments: Generally idiomorphic, coarser grains showing rect or square outlines; also coarse grained aggregates of xl fragments, coarse grained sphere-like aggregates, fine grained idiomorphic, fine-grained skeletal, very fine grained spherical (often with colloidal texture); cleavages // to (100), (311), and (111) may be visible; twinning lamellae rare; zoning not uncommon; higher Co, Ni, or Cu contents result in pinkish, reddish, or violet tints; may also contain significant quantities of Au or As or Sb; p. 206; 791.

Although the table is comparatively self-explanatory, a brief discussion of the information in each field and how the different fields can be used to group the minerals is appropriate. Manipulations are described in terms of the capabilities of Filemaker Plus™.

Mineral Name - the name of the mineral whose properties are listed in that record. The "FIND" command can be used to bring up the record of a specific mineral by typing its name in this field.

Chem. Comp. - the chemical composition of the mineral, as given by Uytenbogaardt and Burke (1971). While searching, Filemaker Plus™ will find only those items that are preceded by punctuation (i.e., spaces, commas, periods, parentheses, etc.). Therefore, it was necessary to insert periods within the chemical formulas of the minerals to permit this field to be searched for minerals containing a particular element or group of elements. This search procedure is not without some idiosyncrasies. Searching for sulfides by specifying the letter "S" in this field will find all sulfides; it will also find all antimonides (Sb), selenides (Se), and other elements which start with a

capital S. With the present version of Filemaker Plus™, this must be endured; perhaps a future version will be more selective.

Crystall. - simply the crystallographic system the mineral belongs to; listed as cubic, hexagonal, hexagonal-rhombohedral, tetragonal, orthorhombic, monoclinic, or triclinic. The file may be searched for any of these.

Color - this is the color of the mineral as listed in Uytenbogaardt and Burke (1971). This field categorizes the minerals as white, gray, blue, red, yellow, brown, green, orange, violet, black, cream, and pink. Because color is subjective, more than one color is often listed in this field; red listed with pink or orange, for instance. Uytenbogaardt and Burke (1971) also report the color of most minerals in comparison to commonly associated minerals. This information was not included in this compilation. If one is observing a yellow mineral, simply search this field for yellow minerals and Filemaker Plus™ will extract them from the database. Again, however, specifying more than one color will find only minerals whose color fields list both colors, not either color.

Tint - faint color deviations from the dominant color of the mineral. Search as for color. "Blu" will find both blue and bluish.

Color (oil) and Tint (oil) - lists those colors when they differ noticeably from the color of the mineral in air.

Bireflectance - degree of bireflectance is listed as nil, weak, distinct, strong, and v strong. Color variations shown by the mineral in different orientations are described. This field is most easily searched for degree of bireflectance, color descriptions being extremely subjective and affected by the kind and quality of microscope being used.

Anisotropy - degree of anisotropy is listed as isotropic, weak, distinct, strong, and v strong. Colors shown by the mineral under crossed polars are described. This field is most easily searched for degree of anisotropy.

%R - this field lists the percent reflectance in air at 540nm, or as close to this wavelength as published values permit. Because the reflectance of anisotropic minerals varies with orientation, the reflectance is often given as a range of values. Because Filemaker Plus™ will not search for a range, this field also contains a text modifier. Reflectance is categorized as v low (0 to 10%), low (10 to 30%), mod (30 to 50%), hi (50 to 70%), and v hi (>70%); this field can be searched using these modifiers.

Int'l Reflects. - any internal reflections that the mineral may display are listed here. This field is most conveniently searched by color.

Polish. Hard. - the polishing hardness of the mineral in comparison to those minerals with which it is frequently in contact is listed here. This field, because it usually contains so few comparative hardnesses, is not suitable for searching. An unknown mineral may clearly have a lower polishing hardness than pyrite, but if that comparison is not listed in this field for the unknown mineral, as "<py", then a search of this field would not find it.

Comments - this field lists the typical form of the mineral, describes what, if any, twinning or cleavage may occur, and describes any other characteristic features of the mineral. This field does not list the common associates of the mineral, nor its common position in the paragenetic sequence. That information can be found in either Uytenbogaardt and Burke (1971) (the first page number listed) or Ramdohr (1980) (the second page number listed).

The "Comments" field is actually two three-line fields pasted together. This limits the contents of each of the fields to about 240 characters. This

limiting will facilitate the transport of this information into a different database, should that be desirable. Details concerning such transport can be found in the Filemaker Plus™ manual, and probably within the manual of the destination database, as well.

Filemaker Plus™ has a host of features that the user may find helpful. Furthermore, users can modify the database in any way they wish. Information can be added to a field, and minerals can be added to the database. The compilation currently contains about one-half of the minerals listed in Uytenbogaardt and Burke (1971). If you would like a copy of the database, please send me a 3.5 inch microfloppy disk and I will send you the database. I am also very interested in receiving comments or suggestions from future users.

Finally, this effort was reviewed by B.F. Leonard of the U.S. Geological Survey. His comments and suggestions, based on a lifetime of observing ore minerals in reflected light and struggling with the problems of their identification, was literally invaluable. Only a few individuals are around who possess Ben's expertise, and there are even fewer who would have been as thorough and as encouraging as Ben was. My sincerest thanks.

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ABBREVIATIONS USED IN THE COMPILATION

Aspy - arsenopyrite
Bn - bornite
Cc - chalcocite
Cov - covellite
Cpy - chalcopyrite
Degs - degrees
Ft - faint
Gn - galena
Hem - hematite
Hexa - hexagonal
Ilm - ilmenite
IR - internal reflection
Lt - light
Marc - marcasite
Mod - moderate
Moly - molybdenite
Mono - monoclinic
Mt - magnetite
Ortho - orthorhombic
Pent - pentlandite
Pleo - pleochroism
Po - pyrrhotite
Py - pyrite
Rect - rectangular
Rhombo - rhombohedral (trigonal)
Sl - sphalerite
Slt - slightly
Ten - tennantite
Tet - tetrahedrite
V - very
Xl - crystal
Xlites - crystallites
Xln - crystalline

Mineral Name: Acanthite (see Argentite) **Chem. Comp.:** Ag2.S
Crystall.: mono
Color: gray **Tint:** light green
Color (oil): "smudgy gray" **Tint (oil):** distinctly green
Bireflectance: weak (oil)

Anisotropy: distinct with good polish

%R: 33-37 mod **VHN:** 20-61
Int'l Reflects.:

Polish. Hard.: <cc, gn; one of the softest minerals known.

Comments: Very soft; argentite (cubic) is stable phase above 177C; p. 34; 471

Mineral Name: Aeschynite (eschynite) **Chem. Comp.:** (Ce,Nd,Th,Y)(Ti,Nb)2.O6
Crystall.: ortho
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic (metamict)

%R: < columbite (<15) low **VHN:** 593-754
Int'l Reflects.: weak dark brown

Polish. Hard.:

Comments: Generally prismatic, sometimes tabular or lamellar; usually metamict; associated with pegmatitic or magmatic hydrothermal veins; may occur with zircon, minerals of the betafite group, muscovite, biotite, Ti-oxides, pyrochlore, columbite, sphene, corundum, or arfvedsonite; all data from pp. 489-496 of Vlasov (1966).

Mineral Name: Aguilarite **Chem. Comp.:** Ag4.Se.S
Crystall.: ortho <-133C-> cubic
Color: gray **Tint:** green
Color (oil): **Tint (oil):**
Bireflectance: not observable or very weak

Anisotropy: v weak, shades of gray; sometimes isotropic

%R: 35 mod **VHN:** 25-35
Int'l Reflects.:

Polish. Hard.: v low

Comments: Accompanied and replaced by argentite, electrum, stephanite, pearcite, and Cu- and Ag-selenides; p. 218; 478.

Mineral Name: Aikinite **Chem. Comp.:** (2.PbS)(Cu2S)(Bi2.S3)
Crystall.: ortho
Color: white **Tint:** cream
Color (oil): **Tint (oil):** distinctly pink, yellow
Bireflectance: distinct, creamy white to white or light brown

Anisotropy: strong, blue-gray-white to pinkish-gray-white to white

%R: 39-46 mod **VHN:** 165-246
Int'l Reflects.:

Polish. Hard.: >gn;~bismuthinite, gn-bismuthinite; <bournonite

Comments: Forms idiomorphic acicular or columnar xls; may occur in bundles of prismatic xls; perfect cleavage // (010); sharp extinction, some orientations with deep indigo blue color; p. 292; 738.

OPAQUE MINERAL OPTICS

Mineral Name: Alabandite **Chem. Comp.:** Mn.S
Crystall.: cubic
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance:

Anisotropy: isotropic

%R: 25 low **VHN:** 138-266
Int'l Reflects.: brownish / dark green

Polish. Hard.: <sl

Comments: idiomorphic xls and coarse aggregates; lamellar twinning common; p. 124; 642

Mineral Name: alpha-Vredenburgite **Chem. Comp.:** (Mn,Fe)3.O4
Crystall.: tetragonal
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: weak, shades of gray

Anisotropy: distinct, gray to black

%R: 18-20 low **VHN:**
Int'l Reflects.:

Polish. Hard.: <bixbyite, braunite

Comments: Occurs as irregular masses, commonly as definite pseudomorphs after bixbyite; marked lamellar parting; no cleavage; p. 346; 943.

Mineral Name: Altaite **Chem. Comp.:** Pb.Te

Crystall.: cubic

Color: bright white **Tint:** slight yellow or green

Color (oil): high %R in oil **Tint (oil):**

Bireflectance:

Anisotropy: isotropic

%R: 71 v hi **VHN:** 34-57

Int'l Reflects.:

Polish. Hard.: sl>tellurobismuthite, petzite;<gn

Comments: v. high reflectivity (oil); may be included in gn; usually as granular aggregates of xenomorphic xls; may be as tiny idiomorphic disseminations in gn; p. 240; 661.

Mineral Name: Anatase **Chem. Comp.:** Ti.O2

Crystall.: tetragonal

Color: gray **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: v weak

Anisotropy: masked by internal reflections

%R: 20 low **VHN:** 576-623

Int'l Reflects.: white to bluish and blue gray; strong and abundant

Polish. Hard.: <rutile

Comments: Occurs as idiomorphic xls and as rounded grains; replaces ilmenite; p. 178; 1010.

Mineral Name: Andorite **Chem. Comp.:** Pb(Ag,Cu)Sb3.S6 (gen'l)
Crystall.: ortho
Color: white **Tint:**
Color (oil): gray **Tint (oil):** yellow
Bireflectance: weak (air), distinct on grain boundaries in oil

Anisotropy: distinct, gray green to gray blue, violet gray or pinkish gray

%R: 30 mod **VHN:** 140-206
Int'l Reflects.: red (rare)

Polish. Hard.: >pyrargyrite, stibnite; slt<semseyite; ~jamesonite; <bournonite; <<sl, stannite

Comments: Occurs as idiomorphic prismatic xls and as aggregates of rounded grains; lamellar twinning very common, often in different directions; a parquet-like texture may result; p. 260; 742.

Mineral Name: Anglesite **Chem. Comp.:** PbSO4
Crystall.:
Color: dark gray **Tint:**
Color (oil): darker **Tint (oil):**
Bireflectance: none

Anisotropy: none

%R: v low **VHN:**
Int'l Reflects.: probably common?

Polish. Hard.: low, like cerrusite

Comments: Cerrusite is v similar but shows pleo and anisotropy; common as fine-grained and rhythmic encrustations on gn, often with interlayered secondary gn; cleavage is scarcely visible in polished section; p. 1109.

Mineral Name: Antimony **Chem. Comp.:** Sb (usually contains some As)
Crystall.: hexagonal
Color: white **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: weak

Anisotropy: distinct, yellowish gray, brownish, bluish gray

%R: 70-75 v hi **VHN:** 45-135
Int'l Reflects.:

Polish. Hard.: >stibnite; <dyscrasite, stibarsenic, arsenic

Comments: Commonly occurs as fine-granular aggregates; idiomorphic cube-like xls rarely occur enclosed in gn; cleavage commonly visible; twinning lamellae, often polysynthetic, usually occur; p. 76; 373.

Mineral Name: Argentite (see Acanthite) **Chem. Comp.:** Ag2.S
Crystall.: cubic
Color: gray **Tint:** light green
Color (oil): "smudgy gray" **Tint (oil):** distinctly green
Bireflectance: weak (oil)

Anisotropy: distinct with good polish

%R: 33-37 mod **VHN:** 20-61
Int'l Reflects.:

Polish. Hard.: <cc, gn; one of the softest minerals known.

Comments: The stable Ag2S phase above 177°C; p. 34; 471.

OPAQUE MINERAL OPTICS

Mineral Name: Argentopyrite **Chem. Comp.:** Ag.Fe2.S3
Crystall.: ortho
Color: gray or white **Tint:** yellow
Color (oil): darker **Tint (oil):**
Bireflectance: distinct, pale yellow to brownish or grayish yellow

Anisotropy: strong, light greenish yellow, pink, red-brown (P&J)

%R: 27-37 mod (P&J; QDF2) **VHN:** 250-252
Int'l Reflects.:

Polish. Hard.: >po; <py

Comments: Pseudo-hex xls; intricate intergrowths of xls; with py, argentite, po; lamellar twinning present; p. 268; 639

Mineral Name: Arsenic **Chem. Comp.:** As (usually contains some Sb)
Crystall.: hexagonal
Color: white **Tint:** tarnishes in air in one day
Color (oil): **Tint (oil):**
Bireflectance: distinct in oil, grayish white with a yellow tint to light bluish gray

Anisotropy: v distinct, steel gray, yellow gray or dark gray tints

%R: 47 to 56 hi (P&J &QDF2) **VHN:** 57-167
Int'l Reflects.:

Polish. Hard.: >>Bi; >Ag, Sb; slt>dyscrasite, stibarsenic

Comments: May show a fine to coarse xln texture; smaller grains tending to be equigranular, coarser xls showing a plume- or sheaf-like appearance; usually shows a colloform texture with concentric layers or spheroids with radiated texture; idiomorphic xls may occur as an alteration product of geocronite; a basal cleavage is often visible; twinning lamellae very common; zonal colloform textures are developed by exposure to air for some days; p. 84; 365.

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Mineral Name: Arsenopyrite **Chem. Comp.:** Fe.As.S

Crystall.: mono

Color: white **Tint:** cream pink

Color (oil): **Tint (oil):**

Bireflectance: weak, but noticeable

Anisotropy: strong, blue, green, reddish brown-yellow

%R: 51-52 hi **VHN:** 715-1354

Int'l Reflects.:

Polish. Hard.: >>skutterudite, loellingite, magnetite; slt>glaucodot; <cobaltite, pyrite

Comments: Usually idiomorphically developed with characteristic rhomb-shaped sections, also skeleton-shaped, hypidiomorphic granular, elongated (in spherulites), fine-grained, or extremely fine grained; cleavage commonly absent; lamellar twinning very common; zonal texture not uncommon; p. 190; 863.

Mineral Name: Aurostibite **Chem. Comp.:** Au.Sb2

Crystall.: cubic

Color: white **Tint:** pink

Color (oil): **Tint (oil):**

Bireflectance: nil

Anisotropy: isotropic

%R: 61 hi **VHN:** 248-262

Int'l Reflects.:

Polish. Hard.: >Au

Comments: Occurs as angular xenomorphic grains; no apparent cleavage; practically always associated with Au, often as a reaction product between Au and stibnite; p. 72; 824.

OPAQUE MINERAL OPTICS

Mineral Name: Awaruite **Chem. Comp.:** (Ni.Fe)
Crystall.: cubic
Color: white **Tint:** green?
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 60-61 hi **VHN:** 209-420
Int'l Reflects.:

Polish. Hard.: slt>heazlewoodite; ~pent; <mt

Comments: Always occurs in serpentinized rocks, commonly as coarse granular aggregates; also as veins in mt and silicates; mostly occurs as rounded grains; may form skeletal xls or elongated tabular grains, and reniform or botryoidal aggregates, sometimes with alternating layers of Cu; rarely observed as tiny needles or as almost perfect cubes a few microns across; p. 128; 356.

Mineral Name: Baumhauerite **Chem. Comp.:** Pb12.As16.S36
Crystall.: triclinic
Color: white **Tint:** pink brown
Color (oil): **Tint (oil):** blue green
Bireflectance: distinct

Anisotropy: distinct to strong, remarkable blue gray color in lightest position

%R: 34-39 mod **VHN:** 128-182
Int'l Reflects.: not uncommon, dark red

Polish. Hard.:

Comments: Often occurs as granular aggregates; twins // (100) very common; p. 300; 751.

Mineral Name: Benjamite **Chem. Comp.:** Pb2(Ag,Cu)2.Bi4.S9

Crystall.: mono

Color: white **Tint:** yellow

Color (oil): **Tint (oil):**

Bireflectance: weak, distinct in oil

Anisotropy: strong, blue to pale brown

%R: 41-42 mod **VHN:** 161-194

Int'l Reflects.:

Polish. Hard.:

Comments: Irregular and spindle-shaped aggregates; no cleavage; intergrowths with emplectite; p. 284; 747.

Mineral Name: Berthierite **Chem. Comp.:** Fe.Sb2.S4

Crystall.: mono

Color: white gray **Tint:** pink brown

Color (oil): **Tint (oil):**

Bireflectance: strong, brownish pink, gray white, white

Anisotropy: v strong, blue, gray white, brown, pinkish brown

%R: 36-41 mod **VHN:** 67-126

Int'l Reflects.:

Polish. Hard.: ~stibnite, pyrargyrite; <<sl

Comments: Radial textute with fibrous or spathic form; needle-like xls, sometimes as aggregates; forms oriented intergrowths with stibnite and myrmekitic ones with cpy; sharp extinction; p. 48; 724.

Mineral Name: Berzelianite **Chem. Comp.:** Cu(2-x)Se
Crystall.: cubic
Color: pale blue or white **Tint:** blue; rapidly tarnishes to dark blue
Color (oil): **Tint (oil):** distinctly blue
Bireflectance: nil

Anisotropy: isotropic

%R: 28 low **VHN:** 22-99
Int'l Reflects.:

Polish. Hard.: ~clausthalite

Comments: Similar to cc.; color deepens to indigo blue soon after preparation; may contain oriented inclusions of klockmannite; p. 216; 467.

Mineral Name: Betekhtinite **Chem. Comp.:** Pb2(Cu,Fe)21.S15
Crystall.: ortho
Color: white **Tint:** yellow cream
Color (oil): **Tint (oil):**
Bireflectance: distinct, light cream to yellow cream

Anisotropy: strong, dark gray black to dark yellow brown to dark blue green

%R: >gn mod **VHN:**
Int'l Reflects.:

Polish. Hard.: >bn

Comments: Occurs as tabular, long prismatic, or needle-like xls; may form granular aggregates; alters to bn and gn; p. 94.

Mineral Name: Birnessite
Chem. Comp.: Mn(4+),Mn(2+)(O,OH)2 may contain minor Ca,Mg,Na,K
Crystall.: ?
Color: gray
Tint:
Color (oil):
Tint (oil):
Bireflectance: weak

Anisotropy: weak to distinct, gray shades; undulatory extinction

%R: ~25 low
VHN: no data
Int'l Reflects.:

Polish. Hard.: >ranceite

Comments: Occurs as reniform or botryoidal masses; only found as supergene or secondary mineral; p. 352.

Mineral Name: Bismuth
Chem. Comp.: Bi (may contain some Te or As)
Crystall.: hexagonal
Color: white
Tint: cream pink (after quickly tarnishing) brown
Color (oil):
Tint (oil):
Bireflectance: weak but distinct, creamy white to creamy grayish white

Anisotropy: distinct to strong

%R: 60-65 hi
VHN: 10-26
Int'l Reflects.:

Polish. Hard.: <bismuthinite and all other minerals which may accompany it

Comments: A basal cleavage may be visible; commonly polysynthetically twinned, often with parquet-like or feather-like appearance; p.36; 374.

Mineral Name: Bismuthinite **Chem. Comp.:** Bi2.S3
Crystall.: ortho
Color: white **Tint:**
Color (oil): gray white **Tint (oil):** blue
Bireflectance: weak to distinct, creamy white, bluish gray white, gray white

Anisotropy: v strong, slate gray to yellowish brown or gray violet

%R: 38-59, mod to hi **VHN:** 67-216
Int'l Reflects.:

Polish. Hard.: slt> emplectite; < cpy; ~gn

Comments: Lighter, with less bireflectance and anisotropy than stibnite, with which it forms a solid solution; straight extinction, large xls commonly show undulatory extinction; usually radial-fibrous form; cleavage // (010) not uncommon; lamellar twinning or "spindle-like" texture reported; p. 66; 710.

Mineral Name: Bixbyite **Chem. Comp.:** (Mn,Fe)2.O3
Crystall.: cubic
Color: gray **Tint:** cream yellow
Color (oil): **Tint (oil):**
Bireflectance: usually not present, sometimes v weak in oil

Anisotropy: isotropic, sometimes weak anomalous anisotropism

%R: 23 low **VHN:** 882-1168
Int'l Reflects.:

Polish. Hard.: >hausmannite; ~braunite; >or<hollandite, depending on orientation of hollandite

Comments: Occurs as well-developed idiomorphic xls and as granular aggregates; cleavage // (111) may be distinct; coarse lamellar twinning, sometimes forming a regular network not uncommon; zoning occurs; p. 352; 959.

Mineral Name: Bornhardtite **Chem. Comp.:** Co3.Se4
Crystall.: cubic
Color: white **Tint:** pink
Color (oil): **Tint (oil):**
Bireflectance:

Anisotropy: isotropic

%R: no data **VHN:**
Int'l Reflects.:

Polish. Hard.:

Comments: Idiomorphic xls; intergrown with trogtalite, hastite, clausthalite; p. 220; 702.

Mineral Name: Bornite **Chem. Comp.:** Cu5.Fe.S4
Crystall.: cubic
Color: lt brown - orange **Tint:** pink; rapidly tarnishes to purple
Color (oil): darker **Tint (oil):**
Bireflectance: usually v. weak (tarnishes quickly)

Anisotropy: weak to distinct; usually visible

%R: 26 low **VHN:** 68-124
Int'l Reflects.:

Polish. Hard.: >cc, gn; slightly <cpy

Comments: Other brown minerals have stronger pleo; po is much harder; commonly occurs as aggregates of rounded grains; idiomorphic xls very rare; often twinned; two cleavages often visible; zonal texture not observed; p. 88; 487

Mineral Name: Boulangerite **Chem. Comp.:** (3.PbS)(2.Sb2.S3)

Crystall.: mono

Color: white **Tint:** blue green

Color (oil): much darker **Tint (oil):**

Bireflectance: distinct, gray white or white with a bluish green tint to darker green gray

Anisotropy: strong, light tan to brown to bluish gray

%R: 38-42 mod **VHN:** 90-182 (?)

Int'l Reflects.: rare, red

Polish. Hard.: slt<gn; <bournonite

Comments: Usually as granular or fibrous aggregates or as needle-shaped or tabular xls; cleavage or twinning or zonal texture not observed; polarization colors more variegated in air than in oil (in contrast to jamesonite); bireflectance weaker than for jamesonite; p. 272; 770.

Mineral Name: Bournonite **Chem. Comp.:** (2.PbS)(Cu2S)(Sb2.S3)

Crystall.: ortho

Color: white **Tint:** gray blue green

Color (oil): **Tint (oil):**

Bireflectance: weak (air), visible only on grain boundaries; distinct (oil), bluish green white to olive brown white

Anisotropy: distinct (oil), pale blue, greenish gray, brownish yellow, dark brown, purplish

%R: 35-39 mod **VHN:** 132-213

Int'l Reflects.:

Polish. Hard.: >boulangerite, jamesonite, stibnite; slt>gn; <cpy, tet, sl

Comments: Usually as aggregates of polygonal grains; no cleavage; twinning after (110) very common and characteristic, parquet-like pattern common; p. 68; 734.

Mineral Name: Braggite **Chem. Comp.:** (Pt,Pd,Ni)S
Crystall.: tetragonal
Color: white **Tint:** cream violet
Color (oil): **Tint (oil):**
Bireflectance: distinct (oil), bluish tints

Anisotropy: strong, blue to brown, similar to arsenopyrite

%R: 35 mod **VHN:** 742-1030
Int'l Reflects.:

Polish. Hard.: slt>Pt, cooperite, stibiopaladinite; <<sperrylite

Comments: Occurs as idiomorphic tabular xls; twinning rare; alternating layers and myrmekitic intergowths with Pt; p. 330; 695.

Mineral Name: Brannerite **Chem. Comp.:** (U,Th,Ca)(Ti,Fe)2.O6
Crystall.: mono
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: usually metamict

Anisotropy: usually metamict

%R: 17 low **VHN:** 387-907
Int'l Reflects.: brownish gray or grayish white in coarse xls; blue-gray to bluish white to dark brown & yellowish in fine xls;
Polish. Hard.:

Comments: Occurs as idiomorphic columnar, prismatic, or needle-shaped xls, or as aggregates of these; also as rounded or irregularly shaped grains; twinning or cleavage not observed; practically always contains very small laths of po and exsolution or alteration bodies of anatase; may show a characteristic dusting of radiogenic gn; p. 196; 1043.

Mineral Name: Braunite **Chem. Comp.:** MnMn6(O8/SiO4)
Crystall.: tetragonal
Color: gray **Tint:** brown
Color (oil): **Tint (oil):**
Bireflectance: weak but distinct in oil, shades of dark gray

Anisotropy: weak but distinct, brownish gray to slate blue

%R: 20-22 low **VHN:** 280-1187
Int'l Reflects.: dark brown to deep red, rare

Polish. Hard.: slt>mt; slt<bixbyite; <most sections of hollandite

Comments: Usually forms compact or finely granular masses, hypidiomorphic xls or well-developed xls resembling octahedrons; cleavage not observed, twinning rare; zonal texture may occur; p.350; 962.

Mineral Name: Bravoite (see Cattierite, Vaesite) **Chem. Comp.:** (Fe,Ni,Co)S2
Crystall.: cubic
Color: cream brown **Tint:** pink violet
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 31-52 mod to hi **VHN:** 668-1535
Int'l Reflects.:

Polish. Hard.: slt>pent; ~po

Comments: Zonal texture very common due to compositional variations; zones may differ in color and H; high Ni coincides with low reflectivity; Cattierite is the Co end member and Vaesite the Ni endmember of the complete solution series; Cattierite is pinkish (pinkish violet in oil), and Vaesite is gray; p. 132; 809.

Mineral Name: Breithauptite **Chem. Comp.:** Ni.Sb
Crystall.: hexagonal
Color: pink **Tint:** violet
Color (oil): **Tint (oil):**
Bireflectance: strong, light pinkish to bright pinkish violet

Anisotropy: bluish green, bluish gray, violet-red

%R: 37-48 mod **VHN:** 412-584
Int'l Reflects.:

Polish. Hard.: slt<niccolite; <rammelsbergite, safflorite, skutterudite;<<cobaltite, aspy, glaucodot

Comments: Can be confused only with niccolite; commonly allotriomorphic granular, also idiomorphic; no cleavage or twinning; zonal texture very common; p. 148; 624.

Mineral Name: Briartite **Chem. Comp.:** Cu2(Fe,Zn)Ge.S4
Crystall.: tetragonal
Color: gray **Tint:** blue
Color (oil): **Tint (oil):**
Bireflectance: not observable

Anisotropy: weak to distinct (oil), gray green and reddish tints

%R: 28 low **VHN:**
Int'l Reflects.:

Polish. Hard.: =cpy

Comments: May show lighter and darker colored zones; polysynthetic twinning visible in oil, in parallel laths in two directions perpendicular to each other; p.90; 548.

Mineral Name: Calaverite **Chem. Comp.:** Au.Te2
Crystall.: mono
Color: white **Tint:** cream yellow
Color (oil): **Tint (oil):**
Bireflectance: weak to distinct, light yellow white to light yellow brown

Anisotropy: weak to distinct, grayish red, green, greenish brown (or light gray to dark gray with brownish tints)
%R: 64 hi **VHN:** 198-237
Int'l Reflects.:

Polish. Hard.: >pyrargyrite, sylvanite; slt<gn; <krennerite

Comments: Usually occurs as idiomorphic needle-shaped xls sometimes radially developed, penetrating the other tellurides, or as irregular lath-shaped xls; cleavage generally absent; multiple twinning may occur; p. 240; 431.

Mineral Name: Carrollite **Chem. Comp.:** Co2.Cu.S4
Crystall.: cubic
Color: white **Tint:** creamy (pink)
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 43 mod **VHN:** 351-566
Int'l Reflects.:

Polish. Hard.: ~linnaeite group (siegenite, polydymite)

Comments: Occurs as euhedral, subhedral, and anhedral grains; p. 146; 697.

Mineral Name: Cassiterite **Chem. Comp.:** Sn.O2
Crystall.: tetragonal
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: distinct, light to dark gray

Anisotropy: very distinct, gray to dark gray (in oil, masked by internal reflections)

%R: 11-12 low **VHN:** 811-1532
Int'l Reflects.: light yellow or whitish to yellow brown, abundant

Polish. Hard.: very high

Comments: Occurs in coarse grained xls, intergrown xls or irregular grains, often beautifully zoned; in very fine grained aggregates acicularly developed, sometimes with radiated texture (pinwheel-like clusters); banded; as colloform aggregates; prismatic cleavage occasionally visible; twinning very common; p. 208; 1013.

Mineral Name: Cattierite (see Bravoite, Vaesite) **Chem. Comp.:** Co.S2 (may contain some Ni and Cu)
Crystall.: cubic
Color: pink **Tint:**
Color (oil): pink violet **Tint (oil):** pink
Bireflectance: nil

Anisotropy: isotropic

%R: 33 mod **VHN:** 953-1113
Int'l Reflects.:

Polish. Hard.: slt>sl; >siegenite

Comments: Forms granular intergrowths with a linnaeite-group mineral; larger xls may show a perfect cubic cleavage; p. 134; 809,816.

Mineral Name: Cerargyrite group **Chem. Comp.:** Ag.Cl to Ag.Br

Crystall.: cubic

Color: dull gray to brown **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: isotropic

Anisotropy: isotropic

%R: ~11%? Ramdohr **VHN:**

Int'l Reflects.: common

Polish. Hard.: ~acanthite

Comments: Forms shells, crusts and fracture fillings, also beautiful idimorphic xls; often replaces Ag; p. 1110.

Mineral Name: Cerrusite **Chem. Comp.:** PbCO3

Crystall.: pseudohexagonal

Color: gray **Tint:**

Color (oil): darker **Tint (oil):**

Bireflectance: strong,

Anisotropy: strong, but obscured by internal reflections

%R: ~12 **VHN:**

Int'l Reflects.: bright and abundant

Polish. Hard.: ~or > gn

Comments: Weathering product of gn and other Pb-bearing sulfides; gn cleavage is often preserved; strong pleo and aniso are characteristic (cf anglesite); p. 1108.

Mineral Name: Chalcocite **Chem. Comp.:** Cu2.S

Crystall.: ortho (>103C hex)

Color: white **Tint:** blue to gray

Color (oil): white **Tint (oil):** blue gray

Bireflectance: v weak if present

Anisotropy: weak to distinct (emerald green to light pink); parallel extinction

%R: 30-33 mod **VHN:** 58-98

Int'l Reflects.:

Polish. Hard.: <<argentite; <cov,bn; ~gn, digenite

Comments: Chalcocite formed above 103C is generally coarse-grained and shows intergrowths with digenite; lamellar twinning common; p. 58; 441.

Mineral Name: Chalcophanite **Chem. Comp.:** (Zn,Mn,Fe)Mn3.O7(3.H2O)

Crystall.: triclinic

Color: white gray **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: v strong, bright white to dark gray

Anisotropy: v strong, white and gray-white tints

%R: 10-27 v low to low **VHN:** 71-194

Int'l Reflects.: intense carmine to deep red is common in Zn-rich; Zn-poor has none

Polish. Hard.: low

Comments: Occurs as aggergates of tabular xls and as radiating blades; as tiny prismatic xls in secondary Mn ores; also as crypto-xln colloform bands or layers which line or fill cavities in earlier Mn oxides; p. 344; 1085.

Mineral Name: Chalcopyrite **Chem. Comp.:** Cu.Fe.S2
Crystall.: tetragonal
Color: brassy yellow **Tint:** green
Color (oil): yellow (darker) **Tint (oil):**
Bireflectance: weak; rare

Anisotropy: weak, but recognizable in oil, gray-blue and greenish yellow

%R: 45 mod **VHN:** 174-219
Int'l Reflects.:

Polish. Hard.: >gn; <sl, po, pent

Comments: Twinning very common; lamellae may be differentially developed; very small grains similar to Au; millerite lighter and more cream; may show inclusions of valleriite, cubanite, mackinawite, stannite, sphalerite, or tetrahedrite; p. 92; 526.

Mineral Name: Chalcostibite **Chem. Comp.:** (Cu2S)(Sb2.S3)
Crystall.: ortho
Color: white **Tint:** pink gray
Color (oil): **Tint (oil):**
Bireflectance: distinct (oil), creamy white to light brown

Anisotropy: distinct, pinkish, greenish gray, bluish gray

%R: 36-44 mod **VHN:** 183-287
Int'l Reflects.: pale red, rare

Polish. Hard.: >Ag; slt<cpy, sl

Comments: Anisotropy more vivid than for bournonite; occurs as allotriomorphic grains, rarely as tabular prismatic xls; cleavage // (001) commonly visible; may show triangular pits; forms intergrowths with enargite; p. 86; 717.

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Mineral Name: Chromite **Chem. Comp.:** (Fe,Mg)(Cr, Al,Fe)2.O4

Crystall.: cubic

Color: dark gray **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: nil

Anisotropy: isotropic, may show anomalous anisotropism

%R: 12-13 low **VHN:** 1036-2000

Int'l Reflects.: red-brown, very common

Polish. Hard.: >mt, hem

Comments: Usually forms homogeneous rounded idiomorphic xls or coarsely xln aggregates; cataclastic texture very common; cleavage commonly not visible, in some specimens distinct; twinning not obs; zonal texture not uncommon; p. 174; 946.

Mineral Name: Cinnabar **Chem. Comp.:** Hg.S

Crystall.: hexagonal

Color: white gray **Tint:** blue

Color (oil): gray **Tint (oil):** blue

Bireflectance: distinct (pinkish to yellowish)

Anisotropy: distinct (commonly masked by IR's)

%R: 24-30 low **VHN:** 51-98

Int'l Reflects.: intense red

Polish. Hard.: slt>Sb, metacinnabar; <<cuprite

Comments: Somewhat similar to proustite, or proustite is brighter and more bluish; idiomorphic and granular aggregates; idiomorphic xls; commonly as granular aggregates; p. 78; 673.

Mineral Name: Clausthalite **Chem. Comp.:** Pb.Se
Crystall.: cubic
Color: bright white **Tint:**
Color (oil): similar **Tint (oil):**
Bireflectance:

Anisotropy: isotropic

%R: 50 hi **VHN:** 46-72
Int'l Reflects.:

Polish. Hard.: <<gn; slt > tiemannite

Comments: Forms a complete solid solution with galena; lighter color next to galena; cubic cleavage less perfect than gn, but triangular pits may occur; commonly as allotriomorphic grains, sometimes as colloform aggregates; no indication of zoning or twinning; p. 220; 659.

Mineral Name: Cobaltite **Chem. Comp.:** (Co,Fe)As.S
Crystall.: ortho
Color: white **Tint:** pink violet brown
Color (oil): **Tint (oil):**
Bireflectance: weak, white to pinkish white

Anisotropy: weak to distinct, blue gray and brown color shades

%R: 56 hi **VHN:** 948-1367
Int'l Reflects.:

Polish. Hard.: >>skutterudite, loellingite; >aspy; <py

Comments: Commonly as idiomorphic xls, also skeletons or allotriomorphic aggregates; cleavage in coarser grains; twinning lamellae often visible; zoning occurs; p. 192; 827.

Mineral Name: Coffinite **Chem. Comp.:** U(SiO4)1-x(OH)x

Crystall.: tetragonal

Color: gray **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: v weak

Anisotropy: appears isotropic

%R: 7-10 v low **VHN:** 236-333

Int'l Reflects.: brownish tints, rare and weak

Polish. Hard.: <=pitchblende

Comments: Occurs as idiomorphic xls with tetragonal outlines, or as submicroscopic aggregates, in colloform textures; may form veinlets, surrounded by carbonaceous material; forms botryoidal encrustations; occurs as intergranular films between quartz and fluorite; as inclusions in niccolite; p. 196; 1097.

Mineral Name: Cohenite **Chem. Comp.:** (Fe,Ni,Co)3.C

Crystall.: ortho

Color: white **Tint:** cream

Color (oil): **Tint (oil):**

Bireflectance: weak but distinct

Anisotropy: weak but distinct

%R: no data **VHN:**

Int'l Reflects.:

Polish. Hard.: >>pearlite; >iron, po; <schreibersite

Comments: Terrestrial cohenite forms fine-lamellar intergrowths with iron, so called pearlite; p. 142; 358.

Mineral Name: Coloradoite **Chem. Comp.:** Hg.Te
Crystall.: cubic
Color: gray **Tint:** pink or brown
Color (oil): **Tint (oil):**
Bireflectance:

Anisotropy: isotropic

%R: 34 mod **VHN:** 23-35
Int'l Reflects.:

Polish. Hard.: <calaverite and sylvanite; usually >petzite

Comments: Similar to petzite; cleavage not observed; included in and molded by granular hessite; practically always associated with Au; p. 234; 524.

Mineral Name: Columbite-Tantalite **Chem. Comp.:** (Fe,Mn)(Nb,Ta)2.O6
Crystall.: ortho
Color: white gray **Tint:** brown
Color (oil): **Tint (oil):**
Bireflectance: weak, only visible at grain boundaries

Anisotropy: distinct, straight extinction

%R: 15-18 low **VHN:** 240-1021
Int'l Reflects.: distinct; Mn = yellow-brown, Fe = deep-red

Polish. Hard.: very high; ~tapiolite

Comments: Usually occurs as euhedral xls and as granular aggregates; cleavage // (100) may be distinct, // (010) less distinct; twinning rare, zonal texture may occur; p. 202; 1039.

Mineral Name: Cooperite **Chem. Comp.:** Pt.S
Crystall.: tetragonal
Color: brown **Tint:** orange pink
Color (oil): **Tint (oil):** coffee brown to olive brown
Bireflectance: v weak, only visible in oil on grain boundaries

Anisotropy: strong (oil), gray pink to gray green

%R: 39 mod **VHN:** 505-588
Int'l Reflects.:

Polish. Hard.: <Pt; <<sperrylite

Comments: Xenomorphic grains and prismatic xls; simple and polysynthetic twinning; intergrowths with Pt, sperrylite, and braggite; p. 322; 696.

Mineral Name: Copper **Chem. Comp.:** Cu (may contain some Ag or As)
Crystall.: cubic
Color: pink **Tint:** soon tarnishing brown (ish)
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 65 hi (QDF2) **VHN:** 48-143
Int'l Reflects.:

Polish. Hard.: >cc; <cuprite

Comments: Occurs coarse- and fine-grained (as concretions), with allotriomorphic or panidiomorphic texture, as xl aggregates; supergene Cu may show a dendritic or spear-like form; cleavage not observed; after etching a lamellar twinning is always visible; zonal texture not uncommon; p.116; 308.

Mineral Name: Coronadite **Chem. Comp.:** Pb<=2.Mn8.O16
Crystall.: tetragonal
Color: white **Tint:** gray
Color (oil): **Tint (oil):**
Bireflectance: distinct

Anisotropy: strong, white to dark gray to dark brown; straight extinction; cross sections appear isotropic
%R: 27-33 low to mod **VHN:** 327-357
Int'l Reflects.:

Polish. Hard.:

Comments: Occurs as platy xls, arranged in sheaf-like aggregates; cleavage often distinct; twinning, polysynthetic and mosaic-like, often occurs; p. 356; 1036.

Mineral Name: Cosalite **Chem. Comp.:** (2.PbS)(Bi2.S3)
Crystall.: ortho
Color: white **Tint:** pink gray
Color (oil): **Tint (oil):**
Bireflectance: distinct, light creamy white to darker greenish gray

Anisotropy: weak, pinkish yellow, bluish or violet gray

%R: 43 mod **VHN:** 74-161
Int'l Reflects.:

Polish. Hard.: slt>gn

Comments: Occurs as minute needle-shaped xls and fibers or as short-prismatic xls, often forming bundle or sheaf-like aggregates; also as granular aggregates; cleavage very rare; twinning not observed; p. 286; 778.

Mineral Name: Covellite **Chem. Comp.:** Cu.S

Crystall.: hexagonal

Color: indigo blue **Tint:**

Color (oil): deeper blue **Tint (oil):**

Bireflectance: bluish white to deep blue; oil, blue gray to purple-violet red

Anisotropy: v strong, fiery orange to reddish brown

%R: 7 to 24 v low to low **VHN:** 59-129

Int'l Reflects.:

Polish. Hard.: >>argentite; slt<gn; >cpy; ~cc

Comments: Alteration product of many Cu-sulfides; Blaubleibender means blue-remaining and refers to its behavior in oil; usually occurs as idiomorphic tabular xls; perfect basal cleavage; no twinning or zoning observed; p. 54; 676.

Mineral Name: Crednerite **Chem. Comp.:** Cu.Mn.O2

Crystall.: mono

Color: white **Tint:** cream

Color (oil): **Tint (oil):**

Bireflectance: v strong, white or yellowish white to gray

Anisotropy: strong and vivid, white to yellowish white to light gray to violet gray; undulatory extinction

%R: 24-35 low to mod **VHN:**

Int'l Reflects.:

Polish. Hard.:

Comments: p. 356; 906.

Mineral Name: Cryptomelane **Chem. Comp.:** A<=2B8.O16
A=chiefly K, some Na and Ba; B=chiefly Mn4+, some
Crystall.: mono (pseudotetragonal)
Color: white brown gray **Tint:** tan blue
Color (oil): **Tint (oil):**
Bireflectance: distinct

Anisotropy: strong, shades of gray; crypto-xln is isotropic

%R: 27 low **VHN:** 325-1048
Int'l Reflects.:

Polish. Hard.: varying, fibrous masses show very low hardness

Comments: With pyrolusite commonest of the Mn minerals; occasionally occurs as well-developed fibrous or acicular xls; usually forms very fine-grained masses, less commonly botryoidal masses; also as colloform layers concentric with, or alternating with, layers of pyrolusite or nsutite; p. 354; 1030.

Mineral Name: Cubanite **Chem. Comp.:** Cu.Fe2.S3
Crystall.: ortho
Color: gray or brown **Tint:** creamy, pink, yellow
Color (oil): darker **Tint (oil):**
Bireflectance: distinct, cream gray / lt brown gray (oil)

Anisotropy: strong, rose brown to deep blue gray

%R: 40 mod **VHN:** 150-264
Int'l Reflects.:

Polish. Hard.: slt>cpy; <sl; <<po

Comments: Intimately intergrown with bn, po, and cpy; lamellar shape; occurs as irregular granular or polygonal aggregates; commonly occurs as exsolution lamellae in cpy; p. 96; 630.

Mineral Name: Cubic Cubanite **Chem. Comp.:** Cu.Fe2.S3?
Crystall.: cubic
Color: brown **Tint:** pink
Color (oil): **Tint (oil):**
Bireflectance:

Anisotropy: isotropic

%R: 35 mod **VHN:**
Int'l Reflects.:

Polish. Hard.: >cpy; <po

Comments: Can be confused with cubanite and po; occurs intergrown with ortho. cubanite; as fine rims on exsolution bodies of ortho. cubanite in cpy; often replaces ortho. cub. with development of parallel fissures from volume decrease; p. 96; 545.

Mineral Name: Cuprite **Chem. Comp.:** Cu2.O
Crystall.: cubic
Color: gray **Tint:** blue
Color (oil): much darker **Tint (oil):** distinctly bluish
Bireflectance: weak, visible on close examination

Anisotropy: strong (anom), deep gray blue to olive green (masked in oil by internal reflections)

%R: 25-30 low **VHN:** 179-218
Int'l Reflects.: deep red, always visible

Polish. Hard.: >cpy, Cu, tenorite; <goethite

Comments: Occurs as idiomorphic xls and in earthy form, which may be intimately associated; cleavage // (111) rarely visible; no twinning; p. 118; 893.

Mineral Name: Cuprobismutite **Chem. Comp.:** Cu.Bi.S2
Crystall.: mono
Color: white **Tint:** cream pink
Color (oil): **Tint (oil):**
Bireflectance: distinct, white to gray-white with a creamy tint

Anisotropy: distinct

%R: 37-41 mod **VHN:**
Int'l Reflects.:

Polish. Hard.:

Comments: Occurs as tiny prismatic xls elongated // b; and as massive grains; associated with cpy, wolframite, cassiterite, gn, tet, emplectite, aikinite, benjaminite, berryite, tetradymite, and bismuthinite; p. 294; 718. (Optical data from P&J).

Mineral Name: Cylindrite **Chem. Comp.:** (6.PbS)(6.SnS2)(Sb2.S3) (?)
Crystall.: ortho
Color: white **Tint:** gray creamy
Color (oil): **Tint (oil):**
Bireflectance: distinct, creamy white to bluish gray white

Anisotropy: distinct, dark blue-black to yellow white

%R: 28-31 low to mod **VHN:** 31-131
Int'l Reflects.:

Polish. Hard.: slt>franckeite; <cpy, sl, stannite

Comments: Transverse sections show a concentric texture with layers of different thicknesses; these appear as twin lamellae in longitudinal sections, that approach each other at the end of the xls; franckeite may occur between the layers; cross sections exhibit a spherulitic cross between crossed polars; may show radial twinning; p.316; 748.

Mineral Name: Davidite **Chem. Comp.:** (Fe,Ce,U,La)2(Ti,Fe,Cr,V)5 .O12
Crystall.: hexagonal
Color: gray **Tint:** brown
Color (oil): **Tint (oil):**
Bireflectance: not present

Anisotropy: usually metamict

%R: 15-20 low **VHN:** 693-890
Int'l Reflects.: deep brown, rare

Polish. Hard.: ~ilm; <<hem, rutile

Comments: Occurs as rounded grains or as tabular xls; may form colloform textures; cleavage // (0001); p. 174; 1004.

Mineral Name: Delafossite **Chem. Comp.:** Cu.Fe.O2
Crystall.: hexagonal
Color: brown **Tint:** rose red yellow
Color (oil): gray brown **Tint (oil):** pink yellow
Bireflectance: see colors

Anisotropy: distinct to strong, bluish gray; straight extinction

%R: 20-25 low **VHN:**
Int'l Reflects.:

Polish. Hard.: <cuprite, goethite

Comments: Forms aggregates of subparallel xls, also sheaf-like or coarse laminated aggregates, or very fine grained inclusions in goethite, etc., with concentric or botryoidal texture and then very similar to tenorite; cleavage may be visible; basal sections appear isotropic; p. 116; 903.

Mineral Name: Diaphorite **Chem. Comp.:** (4.PbS)(3.Ag2S)(3.Sb2.S3)
Crystall.: mono
Color: white **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: distinct on grain boundaries, white to lemon-gray

Anisotropy: weak to distinct, brownish gray to dull purplish gray; oblique extinction

%R: 38 mod **VHN:** 197-242 ?
Int'l Reflects.:

Polish. Hard.: <gn (VHN implies that it should be considerably harder than gn)

Comments: Aggregates of rounded or slightly elongated grains; well-developed twinning is generally present and diagnostic; p. 264; 745.

Mineral Name: Digenite **Chem. Comp.:** Cu(1.765)S-Cu(1.79)S
Crystall.: cubic
Color: clear blue **Tint:** sometimes gray white
Color (oil): **Tint (oil):**
Bireflectance:

Anisotropy: isotropic

%R: 21 low **VHN:** 56-83
Int'l Reflects.:

Polish. Hard.: ~cc, gn

Comments: Octahedral cleavage often visible; often exsolves cc or cov; p. 60; 441.

Mineral Name: Djurleite **Chem. Comp.:** Cu1.96.S

Crystall.: ortho

Color: white **Tint:** bluish

Color (oil): **Tint (oil):**

Bireflectance: v weak

Anisotropy: weak

%R: ~30 low **VHN:**

Int'l Reflects.:

Polish. Hard.:

Comments: Similar to cc; cannot exist above 93C; breaks down to hexagonal cc and high digenite; p. 60; 441.

Mineral Name: Dufrenoysite **Chem. Comp.:** (2.PbS)(As2.S3)

Crystall.: mono

Color: white **Tint:** faint gray blue

Color (oil): **Tint (oil):**

Bireflectance: distinct, only on grain boundaries and twin lamellae

Anisotropy: strong, brownish violet to dark green

%R: 37-41 mod **VHN:** 145-156

Int'l Reflects.: may occur, dark red

Polish. Hard.:

Comments: Occurs as idiomorphic and xenomorphic grains; abundant polysynthetic twins of varying width; p. 302; 752.

Mineral Name: Dyscrasite **Chem. Comp.:** Ag3.Sb
Crystall.: ortho
Color: white **Tint:**
Color (oil): grayer **Tint (oil):**
Bireflectance: weak, white to creamy white

Anisotropy: weak to distinct

%R: 62-65 hi **VHN:** 152-178
Int'l Reflects.:

Polish. Hard.: >>gn; slt>Ag and Sb; slt<As, cpy

Comments: May occur idiomorphically (with prismatic, square, or rhombic sections) or allotriomorphically; cleavage rarely visible; usually untwinned; irregular jig-saw twinning occurs; p. 84; 407

Mineral Name: Electrum **Chem. Comp.:** (Au,Ag) 25% and more Ag
Crystall.: cubic
Color: white cream **Tint:** cream yellow
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic (improper polishing may impart strong anomalous anisotropy)

%R: 66 hi **VHN:** 34-44
Int'l Reflects.:

Polish. Hard.: see at gold

Comments: Occurence similar to that of gold; commonly as irregular grains of different size and as veinlets; p. 72.

Mineral Name: Emplectite **Chem. Comp.:** Cu.Bi.S2
Crystall.: ortho
Color: white **Tint:** cream yellow
Color (oil): **Tint (oil):**
Bireflectance: distinct (oil), blue-green, light greenish or creamy

Anisotropy: strong, brown to bluish, dark violet

%R: 36-42 mod **VHN:** 158-249
Int'l Reflects.:

Polish. Hard.: >>bismuth

Comments: Darker and more yellowish than bismuthinite, reddish brown tint next to other Cu-Bi sulfides; usually in fibrous or needle-like xls or aggregates; cleavage // (001) may be visible; twinning occurs; p. 294; 719.

Mineral Name: Enargite-Stibioenargite (Famatinite) **Chem. Comp.:** Cu3(As,Sb)S4
Crystall.: ortho
Color: gray or brown **Tint:** pink
Color (oil): darker gray **Tint (oil):** brown, violet, pink
Bireflectance: weak, distinct (oil) - grayish pink (yellow tint), pinkish gray, grayish violet

Anisotropy: strong - bluish, greenish, reddish, and orange tints

%R: 25 low **VHN:** 133-383
Int'l Reflects.: deep red may occur

Polish. Hard.: >gn, bn, cc, chalcostibite, cpy; ~tet, luzonite; <sl

Comments: Hardness and anisotropy are characteristic; stibioenargite, "famatinite", is much rarer; as prismatic xls and allotriomorphic or rounded grains; (110) cleavage nearly always visible; usually untwinned (stress twinning may occur); often shows zonal texture when etched; p. 110; 583.

Mineral Name: Eskebornite **Chem. Comp.:** Cu.Fe.Se2
Crystall.: hexagonal
Color: lt yellow **Tint:** brown
Color (oil): much darker **Tint (oil):**
Bireflectance: distinct, especially along grain edges (oil), yellowish white to brassy yellow

Anisotropy: strong, but without pronounced colors, grayish white with yellowish or greenish tints

%R: 24-35 low to mod **VHN:** 141-202
Int'l Reflects.:

Polish. Hard.: slt >clausthalite, naumannite, tiemannite, umangite, klockmannite; <<cpy

Comments: With selenides; softer than po; good basal cleavage, sections // (0001) may show triangular pits; wedge-shaped deformation twins may occur; p. 222; 613.

Mineral Name: Eskolaite **Chem. Comp.:** Cr2.O3
Crystall.: hexagonal
Color: gray **Tint:**
Color (oil): gray **Tint (oil):** blue
Bireflectance: distinct in oil on grain boundaries and twin lamellae

Anisotropy: strong, (air) gray blue and greenish, (oil) gray to brownish gray

%R: 19-21 low **VHN:** 2077-3200
Int'l Reflects.: emerald green

Polish. Hard.: >chromite

Comments: Usually occurs as euhedral, tabular, or prismatic xls; weak zoning may be visible on the darker outer parts of the xls; p. 212; 968.

Mineral Name: Eucairite **Chem. Comp.:** alpha (Cu2.Se)(Ag2Se)

Crystall.: ortho - pseudotetragonal

Color: white **Tint:** yellowish

Color (oil): **Tint (oil):** creamy yellow

Bireflectance: distinct (oil), creamy yellow with a pinkish brown tint to white with a greenish yellow tint

Anisotropy: strong, olive brown to steel blue with a purplish tint

%R: 37 mod (P&J & QDF2) **VHN:** 79-90

Int'l Reflects.:

Polish. Hard.: slt>klockmannite; ~clausthalite

Comments: Similar to naumannite; usually granular; no evidence of cleavage, twinning or zoning; forms myrmekitic intergrowths with klockmannite and umangite; occurs as needles in umangite; p. 224; 484.

Mineral Name: Ferberite **Chem. Comp.:** Fe.W.O4

Crystall.: mono

Color: gray **Tint:**

Color (oil): gray **Tint (oil):** cream yellow

Bireflectance: not observable

Anisotropy: distinct, greenish yellow to dark gray

%R: 16-19 low (P&J) **VHN:** 387-418

Int'l Reflects.:

Polish. Hard.: ~wolframite

Comments: May occur in large xls or in concentric aggregates with radial texture; cleavage may be distinct; p. 186.

Mineral Name: Ferroselite **Chem. Comp.:** Fe.Se2
Crystall.: ortho
Color: cream **Tint:** pink
Color (oil): **Tint (oil):**
Bireflectance: weak to distinct, creamy to white with pinkish tints

Anisotropy: distinct to strong, greenish gray to lilac

%R: 47-50 mod **VHN:** 700-933
Int'l Reflects.:

Polish. Hard.: <<py

Comments: Occurs as idiomorphic prismatic to needle-like xls or aggregates; perfect cleavage // to elongation; twinning // (101); occurs as inclusions in eskebornite; p. 228; 845.

Mineral Name: Franckeite **Chem. Comp.:** (5.PbS)(3.SnS2)(Sb2.S3)
Crystall.: triclinic
Color: white **Tint:** gray
Color (oil): **Tint (oil):**
Bireflectance: weak, gray white to gray white with a brown tint

Anisotropy: distinct, light brownish gray to dark gray

%R: 27-34 low to mod **VHN:** 13-108
Int'l Reflects.:

Polish. Hard.: slt>gn; <teallite; <<sl

Comments: May form tabular xls, prisms, fibers (with feathery apperance) or spheroidal aggregates with radial texture; cleavage // (010) often visible; displacement twins distinguish it from teallite; wedge-shaped twins also occur; p. 316; 747.

Mineral Name: Franklinite **Chem. Comp.:** (Zn,Fe,Mn)(Fe,Mn)2O4
Crystall.: cubic
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 18 low **VHN:** 667-847
Int'l Reflects.: deep red, abundant in oil

Polish. Hard.: >zincite

Comments: Cleavage may be distinct; twinning // (111) and (100) and zoning occur; forms oriented intergrowths with magnetite, hematite, gahnite, or other spinels, or hetaerolite; p. 342; 940.

Mineral Name: "Freibergite" **Chem. Comp.:** Ag-tetrahedrite (Ag>Cu)3.Sb.S3.25
Crystall.: cubic
Color: gray **Tint:**
Color (oil): **Tint (oil):** faint yellow brown
Bireflectance: nil

Anisotropy: isotropic

%R: 30 mod **VHN:** 252-375
Int'l Reflects.: brownish red

Polish. Hard.: >Ag sulfosalts;

Comments: Cleavage rarely visible; freibergite in the strict sense has been redefined as having more Ag than Cu in atoms; p. 106.

Mineral Name: Freieslebenite **Chem. Comp.:** (4.PbS)(2.Ag2S)(Sb2.S3)
Crystall.: mono
Color: white gray **Tint:**
Color (oil): **Tint (oil):** yellow
Bireflectance: weak

Anisotropy: distinct, without color effects

%R: 35 mod **VHN:** 85-140
Int'l Reflects.:

Polish. Hard.: <gn ? (not in clear agreement with VHN)

Comments: Irregular aggregates of xls with idiomorphic boundaries; cleavage in two directions, // (110) and (001) may be visible; synthetic twinning // (110) occurs; observed as small inclusions in gn, which is distinctly reddish (oil) in comparison; p. 264; 744.

Mineral Name: Frohbergite **Chem. Comp.:** Fe.Te2
Crystall.: ortho
Color: pink red **Tint:** purple lilac
Color (oil): **Tint (oil):**
Bireflectance: v weak in oil, visible only on grain boundaries

Anisotropy: strong, orange red to inky blue

%R: 45 mod **VHN:** 250-297
Int'l Reflects.:

Polish. Hard.: >cpy; <tet

Comments: Occurs as inclusions in Au, petzite, cpy, melonite; cleavage and twinning not observed; p. 244; 858.

Mineral Name: Froodite **Chem. Comp.:** Pd.Bi2
Crystall.: mono
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance:

Anisotropy: strong, light to dark gray

%R: 50 mod **VHN:**
Int'l Reflects.:

Polish. Hard.:

Comments: Occurs in the As and Pd-Cu-rich Ni-ores of Sudbury; p. 330; 826.

Mineral Name: Fülöppite **Chem. Comp.:** (3.PbS)(4.Sb2.S3)
Crystall.: mono
Color: white **Tint:**
Color (oil): **Tint (oil):**
Bireflectance:

Anisotropy: distinct, bluish green to reddish brown

%R: 32-42 mod (P&J & QDF2) **VHN:**
Int'l Reflects.:

Polish. Hard.:

Comments: No cleavage; occurs as clusters or as irregularly intergrown xls associated with needles of zinkenite, with sl, dolomite and sulfur; p. 272; 762.

Mineral Name: Galena **Chem. Comp.:** Pb.S
Crystall.: cubic
Color: bright white **Tint:** pink
Color (oil): darker **Tint (oil):**
Bireflectance:

Anisotropy: isotropic; weak anomalous anisotropy sometimes

%R: 44 mod **VHN:** 56-116
Int'l Reflects.:

Polish. Hard.: >>argentite; >proustite, covellite; ~cc;<bn, cpy, tet

Comments: Triangular pits characteristic; similar to clausthalite; as idiomorphic cubes; as granular aggregates and as skeletal xls; very often developed with crystallographic boundaries; perfect cubic (100) cleavage is nearly always visible; twinning caused by mechanical deformation or pressure may occur; zonal texture not uncommon, may be brought out by etching; p.64; 646.

Mineral Name: Galenobismutite **Chem. Comp.:** (PbS)(Bi2.S3)
Crystall.: ortho
Color: white **Tint:** cream
Color (oil): **Tint (oil):**
Bireflectance: strong, yellowish white to pinkish gray or bluish gray

Anisotropy: strong, yellow to dark brown

%R: 42 mod **VHN:** 88-150
Int'l Reflects.:

Polish. Hard.: <<cpy

Comments: Usually as radial aggregates of fibrous and feathery xls, intergrown with bismuthinite; cleavage // c and perpendicular to c may be visible; may show simple or polysynthetic twinning; p. 286; 777

Mineral Name: Gallite **Chem. Comp.:** Cu.Ga.S2
Crystall.: tetragonal
Color: gray **Tint:** brown violet
Color (oil): **Tint (oil):**
Bireflectance: distinct on grain boundaries, brownish gray to violet gray

Anisotropy: distinct, gray-blue tints

%R: 21 low **VHN:** 446-471
Int'l Reflects.:

Polish. Hard.: >gn, renierite; slt>germanite;

Comments: Lighter gray than sl; harder than tn; exsolution bodies in sphalerite and germanite; common associate of germanite; twinned // (112) and (111), also lamellar; p. 112; 542.

Mineral Name: Geikielite **Chem. Comp.:** Mg.Ti.O3
Crystall.: hexagonal -rhombohedral
Color: gray **Tint:** brown (less brown than ilm)
Color (oil): **Tint (oil):**
Bireflectance: distinct

Anisotropy: strong, pinkish brown to dark brown, more vivid than ilmenite

%R: 12-15 low **VHN:** 560-930
Int'l Reflects.: orange red, more common than ilmenite

Polish. Hard.: slt>ilm

Comments: Occurs as irregular to rounded grains; may contain exsolution lamellae of mt; forms solid solution with ilmenite; p. 176; 980.

Mineral Name: Geocronite **Chem. Comp.:** (27.PbS)(7(Sb,As)2.S3)
Crystall.: mono
Color: white **Tint:** blue green
Color (oil): **Tint (oil):**
Bireflectance: weak (air) only on grain boundaries; (oil) light yellow white to greenish white

Anisotropy: distinct, light gray to dark gray, bluish gray or steel blue, creamy tan to brownish gray; oblique extinction
%R: 38-42 mod **VHN:** 95-206
Int'l Reflects.:

Polish. Hard.: >boulangerite; ~franckeite

Comments: Occurs as tabular xls and as granular aggregates; rounded grains not uncommon; cleavage may be visible; twinning lamellae very common and characteristic; usually developed in one direction (as distinct from bournonite), exactly //; p. 274; 774.

Mineral Name: Germanite **Chem. Comp.:** Cu3(Ge,Fe)S4
Crystall.: cubic
Color: gray **Tint:** pink or violet
Color (oil): more colored **Tint (oil):**
Bireflectance:

Anisotropy: isotropic

%R: 20-26 low **VHN:** 372-450
Int'l Reflects.:

Polish. Hard.: slt<ten; >gn

Comments: Similar to enargite, luzonite, and bornite; as fine-granular aggregates; common with ten, gn, and enargite; may be distinctly zoned or mottled; p. 106; 572.

Mineral Name: Gersdorffite **Chem. Comp.:** (Ni,Co,Fe)As.S
Crystall.: cubic
Color: white **Tint:** yellow pink cream
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 47-54 mod to hi **VHN:** 520-907
Int'l Reflects.:

Polish. Hard.: >linnaeite; ~skutterudite, ullmannite, loellingite; <<py, aspy

Comments: Commonly forms idiomorphic xls often showing zonal texture (etching); also as skeletal xls, or as fine grains with irregular boundaries; cleavage // (100) nearly always distinct and typical; triangular pits not uncommon; twin lamellae have been observed; p. 158; 833.

Mineral Name: Getchellite **Chem. Comp.:** As.Sb.S3
Crystall.: mono
Color: white gray **Tint:** gray blue
Color (oil): **Tint (oil):**
Bireflectance: distinct in oil

Anisotropy: weak, obscured by internal reflections

%R: 26-27 low **VHN:** 30-50
Int'l Reflects.: strong, blood red

Polish. Hard.: ~orpiment

Comments: Perfect cleavage // (001); p. 42; 704.

Mineral Name: Glaucodot **Chem. Comp.:** (Co,Fe)As.S
Crystall.: ortho
Color: white **Tint:** cream
Color (oil): **Tint (oil):**
Bireflectance: weak

Anisotropy: distinct

%R: 45-50 mod **VHN:** 841-1277
Int'l Reflects.:

Polish. Hard.: slt<aspy; <cobaltite

Comments: More bluish, with weaker bireflectance and anisotropic color effects than aspy; commonly idiomorphically developed, often showing inclusions; cleavage in two directions may be distinct, // (001) and (110); occurs as inclusions in skeletal xls of cobaltite; p. 190; 871.

Mineral Name: Goethite **Chem. Comp.:** alpha - Fe.O.OH
Crystall.: ortho
Color: gray dull to bright **Tint:** blue
Color (oil): **Tint (oil):**
Bireflectance: weak, in oil more distinct but often masked by internal reflections

Anisotropy: distinct, gray-blue, gray-yellow, brownish, greenish gray; masked in oil

%R: 15-20 low **VHN:** 525-1010
Int'l Reflects.: brownish yellow or reddish brown

Polish. Hard.: ~lepidocrocite; <mt, maghemite, ilmenite, hem

Comments: Principal constituent of most limonites; colloform texture and spherulitic aggregates very common; banding or intimate intergrowths with hematite and ilvaite occur; the centers of zoned grains often have highest %R; p. 160; 1071.

Mineral Name: Gold **Chem. Comp.:** Au (May contain Ag, Pd, Cu, Bi, Pt, Hg, Rh)
Crystall.: cubic
Color: yellow **Tint:** bright golden
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 66 hi **VHN:** 41-94
Int'l Reflects.:

Polish. Hard.: >gn; <tet, sl; <<cpy

Comments: The color changes with varying metal content; the different phases do not only occur as separate grains but are frequently intergrown with each other in intricate patterns; rarely occurs as euhedral pentagonal or dodecahedral xls but normally as isolated grains of different size, as fine veinlets, skeletal grains, clustered, sheaf-like masses, pseudohexagonal xls, fine acicular, as xl aggregates, in colloidal form, or as solid solution in pyrite, aspy, and sl; forms rims on py, cpy, and gn; p. 70; 321.

Mineral Name: Graphite **Chem. Comp.:** C
Crystall.: hexagonal - rhombohedral
Color: brown v dark **Tint:**
Color (oil): orange to black **Tint (oil):**
Bireflectance: v strong, brownish to almost black (in air bluish gray)

Anisotropy: v strong, straw-yellow to dark brown or violet-gray; basal sections appear isotropic

%R: 5-20 v low to low **VHN:** 7-12
Int'l Reflects.:

Polish. Hard.: <<cpy; <moly

Comments: Forms small plates, blades or laths, and sheaf-like aggregates; rarely radial-fibrous shells; the basal cleavage in usually well-visible; twinning and zonal texture not observed; parallel displacements and curved or wave-like texture very common; p. 104; 384.

Mineral Name: Gratonite **Chem. Comp.:** (9.PbS)(2.As2.S3)
Crystall.: hexagonal
Color: white **Tint:** pink
Color (oil): **Tint (oil):**
Bireflectance: v weak, visible only on grain boudaries

Anisotropy: distinct, but weaker than any other lead-silver sulfosalt; straight extinction

%R: 33-34 mod **VHN:** 123-156
Int'l Reflects.: red, rarely visible

Polish. Hard.: ~gn; slt<jordanite

Comments: Always occurs in sheaf-like aggregates of idiomorphic xls; cross-sections may have hexagonal or trigonal outlines; zonal texture may occur; p. 298; 757.

Mineral Name: Greenockite **Chem. Comp.:** Cd.S
Crystall.: hexagonal
Color: light gray **Tint:** blue
Color (oil): med gray **Tint (oil):**
Bireflectance:

Anisotropy: nil

%R: 17 low **VHN:** 52-91
Int'l Reflects.: abundant lt yellow, brownish red, blood-red

Polish. Hard.: <sl

Comments: Lighter and more bluish than sl; forms coatings on sl, py, franckeite, canfieldite; commonly associated with wurtzite; p. 124; 582.

Mineral Name: Greigite **Chem. Comp.:** Fe3.S4
Crystall.: cubic
Color: white **Tint:** cream
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: no data **VHN:**
Int'l Reflects.:

Polish. Hard.: slt>po

Comments: Very similar to bravoite and the linnaeite group; tends to form idiomorphic xls; no cleavage; p. 140; 697.

Mineral Name: Groutite **Chem. Comp.:** alpha MnOOH (may contain some Sb)
Crystall.: ortho
Color: grayish white **Tint:** brown
Color (oil): **Tint (oil):**
Bireflectance: distinct, lightest perpendicular to elongation

Anisotropy: v strong, but no vivid colors; // elongation, dark violet-brown; perpendicular elongation, pale brownish gray
%R: 13-19 (QDF2) **VHN:** 613-813
Int'l Reflects.: abundant in sections // (010) (oil), deep red-brown; rare in other sections

Polish. Hard.: no data

Comments: Ossurs as platy, tabular, wedge- or lens-shaped xls, or as radiating aggregates of platy xls; cleavage // to (010) and (100); p. 340; 1081.

Mineral Name: Guanajuatite **Chem. Comp.:** Bi2(Se,S)3

Crystall.: ortho

Color: white **Tint:** cream pink

Color (oil): **Tint (oil):**

Bireflectance: distinct (air), strong (oil), yellowish white to bluish gray white to pinkish white

Anisotropy: strong, color effects subdued, sharp extinction

%R: 55 hi **VHN:** 42-150

Int'l Reflects.:

Polish. Hard.: >paraguanajuatite; <melonite, gn

Comments: Lighter than paraguanajuatite, weaker anisotropy than bismuthinite; radiated or granular aggregates; also as idiomorphic xls; distinct cleavage in two directions; may be intergrown with clausthalite; p. 230; 714.

Mineral Name: Gudmundite **Chem. Comp.:** Fe.Sb.S

Crystall.: mono

Color: white **Tint:** cream

Color (oil): **Tint (oil):** pink

Bireflectance: distinct, white (faint green) to pinkish cream to pinkish white

Anisotropy: strong, white, gray, green, blue, black, purple, pink, brown

%R: 41-57 mod to hi **VHN:** 588-683

Int'l Reflects.:

Polish. Hard.: >sl, po; <<aspy

Comments: Often forms idiomorphic, needle-shaped xls or xl aggregates; twinning very common; almost invariably associated with tet, gn, po, sulfosalts; forms regular or irregular intergrowths with po and Pb-Sb- or Cu-Sb-sulfosalts; occurs as decomposition product of tet; p. 130; 872.

Mineral Name: Hastite **Chem. Comp.:** Co.Se2
Crystall.: ortho
Color: red violet **Tint:** brown red
Color (oil): more vivid **Tint (oil):**
Bireflectance: distinct to strong, brown red to red violet

Anisotropy: strong, with vivid colors often in meat red tints

%R: no data **VHN:**
Int'l Reflects.:

Polish. Hard.:

Comments: Forms idiomorphic xls, arranged in radial aggregates around a core of trogtalite or Au, the whole included in clausthalite; lamellar twinning abundant; p. 226; 845.

Mineral Name: Hauchecornite **Chem. Comp.:** (Ni,Co)9(Bi,Sb)2.S8
Crystall.: tetragonal
Color: brown yellow **Tint:** gray cream
Color (oil): **Tint (oil):**
Bireflectance: weak

Anisotropy: distinct to strong, brown and blue gray tints

%R: 40 mod **VHN:**
Int'l Reflects.:

Polish. Hard.: slt>millerite

Comments: Usually occurs as granular aggregates, seldom as idiomorphic tabular xls; no cleavage; p. 122; 403.

Mineral Name: Hauerite **Chem. Comp.:** Mn.S2
Crystall.: cubic
Color: white gray **Tint:** brown
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 25 low **VHN:** 485-508
Int'l Reflects.: always present; commonly red as in cuprite, or brownish red as in manganite

Polish. Hard.:

Comments: Generally as idiomorphic octahedral xls; cubic cleavage usually distinct; triangular pits may occur; associated with sulfur-rich clays in volcanic rocks; p. 162; 826.

Mineral Name: Hausmannite **Chem. Comp.:** (Mn,Fe)Mn2.O4
Crystall.: tetragonal
Color: gray **Tint:** brown blue
Color (oil): **Tint (oil):**
Bireflectance: distinct in oil, gray with a faint bluish tint to dark brownish gray

Anisotropy: strong, yellowish or yellowish brown, light gray, or bluish gray

%R: 17-21 low **VHN:** 466-724
Int'l Reflects.: blood red, not uncommon

Polish. Hard.: >manganite, pyrolusite, cryptomelane; <jacobsite; <<bixbyite

Comments: Usually forms coarse-grained aggregates often with mosaic texture or well-developed xls, also as fine-grained veinlets replacing bixbyite; irregular twinning very common and characteristic, lamellae often intersecting each other and of unequal width and hardness, untwinned specimens rare but may occur; numerous fine scratches appear in the lightest bireflectant and anisotropic positions; p. 346; 955.

Mineral Name: Heazlewoodite **Chem. Comp.:** Ni3.S2

Crystall.: hexagonal

Color: cream yellow **Tint:** yellow

Color (oil): **Tint (oil):**

Bireflectance: v weak, visible on grain boundaries only (oil)

Anisotropy: strong, lilac to grayish green

%R: 53 hi **VHN:** 221-321

Int'l Reflects.:

Polish. Hard.: slt>cpy, bn; slt< pent, awaruite, po; < millerite

Comments: Always occurs in serpentinized rocks, in a granular or interlocking mosaic texture; cleavage // (1011) may be visible; may show twin lamellae; p. 122; 405.

Mineral Name: Hematite **Chem. Comp.:** Fe2.O3

Crystall.: hexagonal - rhombohedral

Color: gray white **Tint:**

Color (oil): **Tint (oil):** blue sometimes

Bireflectance: distinct, (in oil) yellowish white to grayish blue or brownish

Anisotropy: v distinct, especially on twin boundaries, grayish blue to grayish yellow

%R: 26-30 low **VHN:** 739-1114

Int'l Reflects.: deep red, common

Polish. Hard.: >>goethite,lepidocrocite, mt; >ilmenite; ~rutile; py; <cassiterite

Comments: Usually idiomorphically developed, tabular or thin tabular, also laminated, fibrous or as radiated aggregates of needle-shaped xls; two pseudo-cleavages often distinct. Lamellar twinning very common; often caused by strain, lamellae may occur in different systems and show transverse twinning, they may be curved, tapering off, showing alternating wedges; p. 198; 969.

Mineral Name: Herzenbergite **Chem. Comp.:** Sn.S

Crystall.: ortho

Color: white **Tint:** gray

Color (oil): **Tint (oil):**

Bireflectance: weak, bluish to yellowish white

Anisotropy: strong, bright to yellowish red / blue-violet

%R: 42-44 mod **VHN:** 48-114

Int'l Reflects.: (oil) red-brown

Polish. Hard.:

Comments: Very similar to teallite and franckeite; thin tabular xls in subparallel aggregates; zonal xls are common; p. 318; 669.

Mineral Name: Hessite **Chem. Comp.:** Ag2.Te

Crystall.: mono <-155C-> cubic

Color: gray white **Tint:** ft purple against gn

Color (oil): gray **Tint (oil):** brown

Bireflectance: distinct in oil; pinkish or brownish, to bluish

Anisotropy: strong, dark gold brown or orange to dark blue gray or blue

%R: 39-41 mod **VHN:** 24-44

Int'l Reflects.:

Polish. Hard.: lowest of all tellurides; >argentite; slt<altaite; <<gn, Au

Comments: Occurs as rounded aggregates or as allotriomorphic xls, also as skeleton-shaped xls; cleavage not observed; high temperature form practically always displays inversion twin lamellae; inclusions in gn not rare; commonly intergrown with petzite and Au; p. 242; 421.

Mineral Name: Hetaerolite **Chem. Comp.:** Zn.Mn2.O4
Crystall.: tetragonal
Color: dark gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: weak to distinct

Anisotropy: strong, yellowish and brownish gray

%R: 13-18 low **VHN:** 585-813
Int'l Reflects.: reddish brown, common and abundant

Polish. Hard.: ~hausmannite

Comments: Occurs as idiomorphic xls and as polygonal aggregates, also forms lamellar aggregates often with radiated texture or concentric intergrowths with chalcophanite; replaces manganite; "hydrohetaerolite" is very similar in all respects to hetaerolite; p. 338; 958.

Mineral Name: Heterogenite **Chem. Comp.:** Co.O.OH(H2O)
Crystall.: hexagonal
Color: white **Tint:** cream
Color (oil): darker **Tint (oil):** brown
Bireflectance: v strong, creamy white to grayish brown

Anisotropy: v strong, brown to gray, basal sections appear isotropic

%R: 10-25 v low to low **VHN:**
Int'l Reflects.:

Polish. Hard.:

Comments: Cleavage or parting often visible; basal sections show hexagonal outline and often a fine concentric texture; spherulites and radiated aggregates very common; central parts usually very fine-grained, coarsening outward; p. 162; 1081.

Mineral Name: Heteromorphite **Chem. Comp.:** (7.PbS)(4.Sb2.S3)
Crystall.: mono
Color: white **Tint:** green
Color (oil): **Tint (oil):**
Bireflectance: distinct to strong

Anisotropy: strong

%R: 37-41 mod **VHN:** 137-187
Int'l Reflects.:

Polish. Hard.:

Comments: Forms intergrowths with plagionite and semseyite; very similar to jamesonite; p. 274; 763.

Mineral Name: Högbomite **Chem. Comp.:** (Fe,Mg)6(Al,Fe)16.Ti.O32
Crystall.: hexagonal
Color: dark gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: weak; in oil distinct on twin boundaries

Anisotropy: distinct, masked in oil by internal reflections

%R: 10 v low **VHN:** 1048-1214
Int'l Reflects.: yellowish brown, abundant and strong

Polish. Hard.: slt>spinel; >ilmenite, mt

Comments: Forms small idiomorphic xls, basal sections show hexagonal outline; also occurs as tabular, prismatic, and barrel-shaped xls and as irregular grains; twinning very common; replacement product of spinel; p. 182; 998.

Mineral Name: Hollandite **Chem. Comp.:** (Ba<=2)R8.O16 R=mainly Mn4+, also Mn2+,Fe, and Co

Crystall.: mono and pseudotetragonal

Color: white **Tint:** yellowish

Color (oil): **Tint (oil):**

Bireflectance: distinct (oil), white to light gray

Anisotropy: strong, gray to yellowish to pinkish white to bluish to violet-gray; basal sections are practically isotropic

%R: 26-33 low to mod **VHN:** 272-1048

Int'l Reflects.:

Polish. Hard.: slt<bixbyite; most sections >>braunite

Comments: Forms well-developed prismatic or tabular xls, fibrous aggregates of needle-like xls, or coarse-grained and fine-grained, compact or botryoidal masses; cleavage commonly distinct; twinning may occur, similar to that of hausmannite or hematite; p. 356; 1035.

Mineral Name: Huebnerite **Chem. Comp.:** Mn.W.O4

Crystall.: mono

Color: gray **Tint:** brown

Color (oil): **Tint (oil):**

Bireflectance: distinct

Anisotropy: strong

%R: <wolframite low **VHN:**

Int'l Reflects.: red, lighter than wolframite

Polish. Hard.: ~wolframite

Comments: Occurs as coarse, separate xls or as finely xln aggregates; zonal xls occur due to differences in Fe/Mn ratio; p. 186.

Mineral Name: Hutchinsonite **Chem. Comp.:** (Tl,Pb)2.As5.S9

Crystall.: ortho

Color: white **Tint:** gray blue

Color (oil): **Tint (oil):** blue

Bireflectance: weak, bluish violet-white to bluish white with a green tint

Anisotropy: distinct to strong, violet to deep blue; in oil obscured by internal reflections; straight extinction

%R: 30-31 mod **VHN:** 170-171

Int'l Reflects.: carmine red

Polish. Hard.:

Comments: Radiating aggregates of needle-like xls; no twinning or zoning observed; good cleavage // (010); p. 298; 740.

Mineral Name: Idaite **Chem. Comp.:** Cu3.Fe.S4

Crystall.: hexagonal

Color: brown to orange **Tint:** red

Color (oil): more vivid **Tint (oil):**

Bireflectance: v. strong, reddish orange / red-brown / bright yellowish gray

Anisotropy: v strong, vivid green to grayish green

%R: 21-29 low **VHN:** 176-202

Int'l Reflects.:

Polish. Hard.: somewhat > cov

Comments: Supergene, as alteration of bornite; hypogene, large hexagonal tabular xls; p. 56; 693.

Mineral Name: Ilmenite **Chem. Comp.:** Fe.Ti.O3

Crystall.: hexagonal - rhombohedral

Color: brown **Tint:** ft pink violet

Color (oil): **Tint (oil):**

Bireflectance: distinct, light pinkish brown to dark brown

Anisotropy: strong, light greenish gray to brownish gray

%R: 17-20 low **VHN:** 501-752

Int'l Reflects.: dark brown, rare

Polish. Hard.: >mt; slt<hem

Comments: Cleavage not observed, parting // (0001) may occur; lamellar twinning usually well developed, lamellae of equal width; forms complete solid solution with geikielite; pyrophanite is the Mn analog of ilmenite; p. 176; 980.

Mineral Name: Ilvaite **Chem. Comp.:** CaFe2.Fe(OH/O/Si2O7)

Crystall.: ortho mono

Color: gray blue **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: v strong (air), blue and gray; extreme (oil), dark red or reddish purple to gray or slightly bluish gray

Anisotropy: v strong (air), blue, pink, reddish orange (45 degs, fiery orange) ; (oil), dark blue, purplish red (45 degs, bluish orange)

%R: 8-9 v low **VHN:** 703-1055

Int'l Reflects.: orange to brown to red, rare

Polish. Hard.: >>graphite; >sl; ~hem; >mt; <py

Comments: Occurs as idiomorphic xls or as aggregates; also as hypidiomorphic grains; twinning rare, lamellae following two systems; p. 198; 1095.

Mineral Name: Indium **Chem. Comp.:** In
Crystall.: tetragonal
Color: white **Tint:** pink
Color (oil): **Tint (oil):**
Bireflectance: not present
Anisotropy: weak
%R: 90-95 v hi **VHN:** 130-159
Int'l Reflects.:
Polish. Hard.:
Comments: Occurs in close association with native lead in greisenized and albitic granites; p. 104.

Mineral Name: Iridium **Chem. Comp.:** Ir (may contain up to 32% Os - see Osmiridium; and Ru and Pt)
Crystall.: cubic
Color: white **Tint:** bluish next to Pt; yellowish next to Os
Color (oil): **Tint (oil):**
Bireflectance: nil
Anisotropy: isotropic
%R: 82 v hi **VHN:** 681-743
Int'l Reflects.:
Polish. Hard.: >>Pt
Comments: Only found as exsolution bodies in Pt; as rounded or octahedral grains, lamellae // (100) of Pt, worm-like; may contain in turn exsolutions of Pt; p. 328; 339.

OPAQUE MINERAL OPTICS

Mineral Name: Iron
Chem. Comp.: alpha - Fe (usually contains some C and Ni)
Crystall.: cubic
Color: white
Tint: gray blue
Color (oil):
Tint (oil):
Bireflectance: nil

Anisotropy: isotropic

%R: 65 hi
VHN: 116-288
Int'l Reflects.:

Polish. Hard.: <mt, cohenite

Comments: Usually occurs as drop-like aggregations; intimate exsolution intergrowths with fine-lamellar cohenite, oriented // (111) of iron, are called pearlite; no cleavage, zoning or twinning were observed in natural terrestrial iron; p. 128; 353.

Mineral Name: Jacobsite
Chem. Comp.: (Mn,Fe,Mg)(Fe, Mn)2.O4
Crystall.: cubic
Color: brown gray
Tint: rose pink brown
Color (oil):
Tint (oil):
Bireflectance: nil

Anisotropy: isotropic

%R: 20 low
VHN: 690-875
Int'l Reflects.: deep red, may occur; more common with increasing Mn content

Polish. Hard.: ~mt; slt<braunite

Comments: Forms polygonal grains, rounded idiomorphic xls and fine grained aggregates; twinning and cleavage not observed; p. 248; 943.

Mineral Name: Jalpaite **Chem. Comp.:** Ag3.Cu.S2

Crystall.: tetragonal

Color: white gray **Tint:** green ?

Color (oil): **Tint (oil):**

Bireflectance: weak, only visible in oil, brownish gray to gray

Anisotropy: distinct, blue green and light green; stonger than acanthite, less pronounced than stromeyerite and mckinstryite

%R: 30 low **VHN:** 23-30

Int'l Reflects.:

Polish. Hard.: ~argentite; <gn

Comments: Forms lamellated and granular aggregates; good prismatic cleavage; occurs intergrown with acanthite or pearcite, and as inclusions in gn and sl; difficult to distinguish from acanthite; p. 38; 486.

Mineral Name: Jamesonite **Chem. Comp.:** (4.PbS)(FeS)(Sb2.S3)

Crystall.: mono

Color: white **Tint:** ft green, especially in contact with gn

Color (oil): **Tint (oil):**

Bireflectance: strong, bright white with a slt yellow-green tint

Anisotropy: strong, gray, tan, brown, light blue, dark blue; basal sections are nearly isotropic

%R: 37-41 mod **VHN:** 67-126

Int'l Reflects.: Bi-jamesonite has red

Polish. Hard.: <gn

Comments: Occurs as needle-shaped xls and in aggregates of these; cleavage perpendicular to elongation usually visible; twinning lamellae very common developed // elongation; p. 48; 765.

Mineral Name: Jarosite
Chem. Comp.: X.Fe3{(OH)6(SO4)2}, where X = K or Na, NH4, Ag, or 1/2Pb
Crystall.: rhombohedral
Color:
Tint:
Color (oil):
Tint (oil):
Bireflectance: strong
Anisotropy:
%R:
VHN:
Int'l Reflects.: common, nearly colorless
Polish. Hard.:
Comments: In gossan of pyritic ore deposits; may accumulate in the rhythmically banded limonitic crusts of cpy and py; p. 1111.

Mineral Name: Jordanite
Chem. Comp.: (27.PbS)(7.As2.S3)
Crystall.: mono
Color: white
Tint: faint green
Color (oil):
Tint (oil):
Bireflectance: distinct, white to yellowish gray white to faint greenish gray white
Anisotropy: strong, dark gray, yellowish gray, greenish gray, dark brownish gray
%R: 37-41 mod
VHN: 149-204
Int'l Reflects.:
Polish. Hard.: slt>semseyite, gratonite; ~gn
Comments: Idiomorphic grains rare; usually as concentric or botryoidal masses with undulatory extinction and weak anisotropy; layers may alternate with gn; cleavage may be present; regular twinning very common; p. 302; 754.

Mineral Name: Joseite-A and Joseite-B **Chem. Comp.:** A: Bi(4+x)Te(1-x)S2
B: Bi(4+x)Te(2-X)S
x= 0 to 0.3

Crystall.: hexagonal

Color: white **Tint:** yellow; B is slightly lighter than A

Color (oil): **Tint (oil):** yellow stronger

Bireflectance: not present

Anisotropy: weak, gray to yellow gray, distinct in sections // c; air, lt pinkish gray to dark brownish gray; oil, light gray to slate gray with a pink tint; basal sections appear isotropic

%R: A=49-53; B=52-58 **VHN:** 29-87

Int'l Reflects.:

Polish. Hard.: slt<tetradymite; <bismuthite

Comments: Forms platy xls; perfect basal cleavage; a "spindle"-like texture, due to folding has been observed; p. 236; 439.

Mineral Name: Karelianite **Chem. Comp.:** V2.O3

Crystall.: hexagonal

Color: gray brown **Tint:** green brown

Color (oil): **Tint (oil):**

Bireflectance: weak

Anisotropy: strong, reddish brown to gray

%R: 18 low **VHN:** 1790

Int'l Reflects.:

Polish. Hard.: very high

Comments: Forms prismatic xls; contains inclusions of po, cpy, py; p.212; 969.

Mineral Name: Kermesite **Chem. Comp.:** Sb2.S2.O
Crystall.: triclinic or monoclinic
Color: gray **Tint:** blue
Color (oil): **Tint (oil):**
Bireflectance: distinct, bluish gray-white to brownish gray-white (P&J)

Anisotropy: strong, violet to blue green; in oil masked by internal reflections

%R: 25-32 low (P&J & QDF2) **VHN:** 36-99
Int'l Reflects.: intense, deep-red with a violet tint

Polish. Hard.:

Comments: Occurs as irregular grains or as radiated aggregates; also as single needle-like xls; produced as alteration of stibnite; p. 42; 715.

Mineral Name: Kesterite **Chem. Comp.:** Cu2.Sn.Zn.S4
Crystall.: tetragonal
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: not present

Anisotropy: weak

%R: 25 low (QDF2) **VHN:** 328-348 (QDF2)
Int'l Reflects.:

Polish. Hard.: ~stannite

Comments: Zn-analog of stannite; may be identical to the "stannite (?) II) of Ramdohr (1944); occurs as exsolution and replacement intergrowths with stannite and "hexastannite"; it is replaced by cassiterite; p. 310; 548.

Mineral Name: Klockmannite **Chem. Comp.:** Cu.Se

Crystall.: hexagonal

Color: gray **Tint:** green blue

Color (oil): **Tint (oil):**

Bireflectance: v. strong, grayish brown (violet) / bluish gray

Anisotropy: v. strong, creamy white to orange; (brownish blue to fiery orange)

%R: 12-36 low to mod **VHN:** 57-86

Int'l Reflects.:

Polish. Hard.: ~umangite; <eucairite

Comments: Basal cleavage common; commonly replaces umangite and eucairite; twinning not observed; p. 222; 681.

Mineral Name: Kobellite-Tintinaite **Chem. Comp.:** (5.PbS)(4(Bi><Sb)2.S3)

Crystall.: ortho

Color: white **Tint:** yellow green

Color (oil): **Tint (oil):**

Bireflectance: distinct, greenish white to violet gray

Anisotropy: distinct, steel gray to gray brown; apparently straight extinction

%R: 37-45 mod **VHN:** 69-173

Int'l Reflects.:

Polish. Hard.: >>bismuth; slt<gn

Comments: Occurs as granular aggregates and as radial aggregates of columnar and needle-like xls; good cleavage // (010) (// elongation); twinning not uncommon; p. 290; 780.

Mineral Name: Kotulskite **Chem. Comp.:** Pd(Te,Bi)1-2
Crystall.: hexagonal
Color: cream yellow **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: distinct, light cream to slightly darker grayish cream

Anisotropy: strong, gray or brownish to dark blue gray

%R: 59-64 hi **VHN:** 236
Int'l Reflects.:

Polish. Hard.: >cpy; ~michenerite; <pent, moncheite, merenskyite

Comments: Cleavage not observed; forms intergrowths with moncheite, michenerite, and merenskyite; p. 332; 838.

Mineral Name: Krennerite **Chem. Comp.:** Au.Ag.Te4
Crystall.: ortho
Color: white **Tint:** cream
Color (oil): **Tint (oil):**
Bireflectance: weak, yellowish creamy to same with violet-gray tint

Anisotropy: strong, light gray, yellow, brown; no definite extinction

%R: 72 v hi **VHN:** 36-130
Int'l Reflects.:

Polish. Hard.: slt>petzite, pyrargyrite; >sylvanite, calaverite

Comments: Idiomorphic thin tabular xls are rare; cleavage in two directions, less perfect than for sylvanite; multiple twinning may occur; p. 252; 430.

Mineral Name: Laurite **Chem. Comp.:** Ru.S2
Crystall.: cubic
Color: white **Tint:**
Color (oil): **Tint (oil):** blue gray
Bireflectance: nil

Anisotropy: isotropic

%R: 42-43 mod **VHN:** 1393-2167
Int'l Reflects.:

Polish. Hard.: highest of all sulfides

Comments: Occurs as diamond-shaped inclusions in chromite; replaced by platinum; p. 322; 820.

Mineral Name: Lautite **Chem. Comp.:** Cu.As.S
Crystall.: ortho
Color: white to gray **Tint:** brown to pink
Color (oil): **Tint (oil):** brown to pink
Bireflectance: weak; only at grain boundaries in oil; brownish pink to bluish

Anisotropy: distinct, bluish green or bluish violet to violet-brown

%R: 27-32 low to mod **VHN:** 142-147
Int'l Reflects.: v weak

Polish. Hard.: <<enargite;<arsenic

Comments: Similar to enargite, but less anisotropic; rather commonly twinned; always occurs as xenomorphic aggregates; p. 68; 525. (P&J)

Mineral Name: Lead
Chem. Comp.: Pb (may contain some Ag or Sb)
Crystall.: cubic
Color: white
Tint:
Color (oil):
Tint (oil):
Bireflectance: nil

Anisotropy: isotropic

%R: 60-65 hi
VHN: 4-6
Int'l Reflects.:

Polish. Hard.: very low

Comments: Tarnishes rapidly, becoming black; usually occurs as granular aggregates and as dendritic, skeletal xls; twinning may occur; p.36; 337.

Mineral Name: Lengenbachite
Chem. Comp.: Pb37.Ag7.Cu6.As23.S78
Crystall.: triclinic
Color: white
Tint:
Color (oil):
Tint (oil):
Bireflectance: nil

Anisotropy: distinct on grain boundaries

%R: 34-37 mod
VHN: 29-40
Int'l Reflects.:

Polish. Hard.:

Comments: Aggregates of foliated grains; twinning lamellae may occur; p. 300; 754.

Mineral Name: Lepidocrocite **Chem. Comp.:** gamma - Fe.O.OH
Crystall.: ortho
Color: white gray **Tint:** gray
Color (oil): **Tint (oil):** blue green
Bireflectance: weak to distinct, stronger than for goethite

Anisotropy: strong, shades of gray

%R: 15-25 low **VHN:** 147-782
Int'l Reflects.: reddish, less abundant than in goethite

Polish. Hard.: <goethite

Comments: Usually occurs as thin plates or tabular xls in goethite; often associated with mt and hem; also in intergrowths called "limonite"; p. 160; 1076.

Mineral Name: Lillianite **Chem. Comp.:** (3.PbS)(Bi2.S3)
Crystall.: ortho
Color: white **Tint:** creamy
Color (oil): **Tint (oil):**
Bireflectance: distinct (oil), creamy white to darker and less creamy

Anisotropy: distinct, more in air than in oil

%R: 45 mod **VHN:** 120-195
Int'l Reflects.:

Polish. Hard.: slt>Ag

Comments: Usually occurs as aggregates of tabular, needle-like or platy xls; unstable and readily decomposes to gn, bismuthinite, and argentite or to galenobismutite and gn or to cosalite and gn; a prominant cleavage is present; p. 286; 781.

Mineral Name: Linnaeite **Chem. Comp.:** Co3.S4
Crystall.: cubic
Color: white **Tint:** cream (pink, brown, yellow)
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 45-50 mod **VHN:** 351-566
Int'l Reflects.:

Polish. Hard.: >>cpy; >sl, po ; ~skutterudite; <gersdorffite; << aspy

Comments: Occurs as idiomorphic xls and as anhedral grains; cleavage or parting // (100) commonly visible; twinning and zonal texture not observed; p. 146; 697.

Mineral Name: Lithiophorite **Chem. Comp.:** (Al,Li)Mn.O2(OH)2
Crystall.: mono
Color: white dark gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: v strong (oil), white to dark gray

Anisotropy: v strong, black to white, sometimes with a steel-blue tint

%R: 10-20 low **VHN:** 60-100
Int'l Reflects.:

Polish. Hard.: >crypto-xln cryptomelane; <pyrolusite

Comments: Usually occurs as fine-grained masses, sheet-like coatings, botryoidal crusts and colloform layers; rarely as pseudohexagonal xls; mica-like cleavage; p. 344; 1038.

Mineral Name: Liveingite **Chem. Comp.:** Pb19.As13.S28
Crystall.: mono
Color: white **Tint:** brown green (faint) against gn
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: distinct

%R: 34-36 mod **VHN:** 173-1183
Int'l Reflects.: rather rare, clear red

Polish. Hard.:

Comments: Shows no twinning; forms prismatic needles; p. 300; 751.

Mineral Name: Livingstonite **Chem. Comp.:** Hg.Sb4.S8
Crystall.: mono
Color: gray **Tint:** cream
Color (oil): **Tint (oil):**
Bireflectance: distinct, creamy gray to creamy brown with a violet tint

Anisotropy: strong, dark violet to light green gray

%R: 35-40 mod **VHN:** 74-131
Int'l Reflects.: blood red

Polish. Hard.: >gn; <cpy

Comments: Occurs as prismatic xls; cleavage usually visible; parallel displacement often occurs causing a wedge-shaped or digitate structure with differently oriented lamellae; internal relfections not as abundant as in proustite or cinnabar; p. 80; 733.

Mineral Name: Loellingite **Chem. Comp.:** Fe.As2

Crystall.: ortho

Color: white **Tint:** yellow

Color (oil): **Tint (oil):**

Bireflectance: weak to distinct, white or bluish white to yellowish white

Anisotropy: v strong, bright orange-yellow to reddish brown to pale brown to blue to pale slaty blue to green

%R: 55 hi **VHN:** 368-1048

Int'l Reflects.:

Polish. Hard.: >>cpy, sl; slt>po, safflorite, rammelsbergite; ~gersdorffite; slt<mt; << aspy

Comments: Zoned coarse xls may occur, not as common as for rammelsbergite or safflorite; usually forms idiomorphic xls, radiated aggregates, or fine-grained massive aggregates, also as skeleton-shaped aggregates, thin crusts (e.g. enclosing arsenic spheroids), or as interlocking masaics with safflorite; cleavage not observed; twinning, simple or compound, very common; p. 156; 854.

Mineral Name: Lorandite **Chem. Comp.:** Tl.As.S2

Crystall.: mono

Color: white gray **Tint:** blue

Color (oil): **Tint (oil):**

Bireflectance: weak, but noticeable

Anisotropy: strong, obscured by abundant internal reflections

%R: 31-33 mod **VHN:** 39-57

Int'l Reflects.: dark red

Polish. Hard.: >realgar, metacinnabar; , <cinnabar

Comments: Much lighter than realgar; cleavage visible only in large xls; twinning not observed; replaces raguinite; p. 44; 732.

Mineral Name: Ludwigite (see Vonsenite) **Chem. Comp.:** (Mg,Fe)2(Fe,Al)B.O5

Crystall.: ortho

Color: gray blue **Tint:**

Color (oil): much darker **Tint (oil):** blue more intense

Bireflectance: strong (Mg-rich), gray to brownish gray; very strong (Mg-poor), bluish, gray to brownish gray

Anisotropy: strong; Mg-rich, gray to black; Mg-poor, dark blue to bright pinkish gray

%R: 8-10 v low **VHN:** 537-1486

Int'l Reflects.: Mg-rich, faint reddish brown

Polish. Hard.: >lepidocrocite; ~mt

Comments: Occurs as single prisms, clusters of prisms and radiating aggregates of minute fibers; lamellar twinning is rarely visible in sections // c; p. 164; 1094.

Mineral Name: Luzonite-Stibioluzonite **Chem. Comp.:** Cu3(As,Sb)S4

Crystall.: tetragonal

Color: lt brown to yellow **Tint:** pink or orange

Color (oil): **Tint (oil):** yellow orange to violet red

Bireflectance: distinct to strong (oil) - light orange brown to grayish violet

Anisotropy: v. strong, dark brown, grayish green,

%R: 25-27 low **VHN:** 205-397

Int'l Reflects.:

Polish. Hard.: >gn,bn, cpy; slt >tet;~enargite; ~sl

Comments: Colors brighter than enargite; ubiquitous lamellar twinning; forms irregular, rounded and isometric grains; cleavage not observed; concentric textures with enargite occur; p. 110; 588.

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Mineral Name: Mackinawite **Chem. Comp.:** Fe (Ni,Co,Cu,Cr)S

Crystall.: tetragonal

Color: gray **Tint:** pink red

Color (oil): **Tint (oil):**

Bireflectance: distinct to strong, pinkish gray to gray

Anisotropy: v. strong, grayish white to dark gray or black

%R: 22-45 low to mod **VHN:** 52-181

Int'l Reflects.:

Polish. Hard.: ~po

Comments: As idiomorphic xls, exsolved from pent, po, cpy, and cubanite, and as alteration; no bronze or brown colors as for valleriite; anisotropy decreases markedly after a few weeks; idiomorphic xls; perfect basal cleavage; reaction rims between cpy and po; p. 140; 683.

Mineral Name: Maghemite **Chem. Comp.:** gamma - Fe2.O3

Crystall.: cubic

Color: gray **Tint:** blue

Color (oil): **Tint (oil):**

Bireflectance: nil

Anisotropy: isotropic

%R: 26 low **VHN:** 357-988

Int'l Reflects.: brownish red, very rare

Polish. Hard.: slt>mt; <<hem

Comments: Formed by oxidation of mt, all stages in the oxidation of mt into maghemite may occur in nature, which may explain the differences in VHN; p. 170; 1000.

OPAQUE MINERAL OPTICS

Mineral Name: Magnetite **Chem. Comp.:** Fe3.O4
Crystall.: cubic
Color: gray **Tint:** brown (pink w/ Ti)
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 21 low **VHN:** 440-1100
Int'l Reflects.:

Polish. Hard.: >>po; commonly <ilmenite; <braunite, <<hematite

Comments: Usually as euhedral xls, tabular xls may be pseudomorphs after hematite, also forms irregular strings and granular aggregates, rarely colloform aggregates; cleavage commonly not distinct; lamellar twinning // (111) and zonal texture not uncommon; p. 168; 911.

Mineral Name: Magnetoplumbite **Chem. Comp.:** Pb(Fe,Mn,Al,Ti)12.O19
Crystall.: hexagonal
Color: **Tint:**
Color (oil): gray **Tint (oil):**
Bireflectance: v weak

Anisotropy: distinct only in oil

%R: 22-24 low **VHN:** 841-868
Int'l Reflects.: very rare, even in oil

Polish. Hard.:

Comments: Occurs as idiomorphic barrel-shaped xls; replaced by hematite; p. 184; 966.

Mineral Name: Maldonite **Chem. Comp.:** Au2.Bi
Crystall.: cubic
Color: white to cream **Tint:** green (cf Bi)
Color (oil): **Tint (oil):** blue (cf Bi)
Bireflectance: nil

Anisotropy: isotropic

%R: 50-60 hi **VHN:**
Int'l Reflects.:

Polish. Hard.: >>Bi;>gn, Au

Comments: Supply of Bi causes disintegration to a myrmekitic intergrowth of Bi and Au; the asociated Bi has no twin lamellae; p. 72; 336.

Mineral Name: Manganite **Chem. Comp.:** gamma - Mn.O2
Crystall.: mono
Color: gray **Tint:** brown
Color (oil): **Tint (oil):**
Bireflectance: weak to strong (oil), light grayish brown, dark brownish gray, darker with olive tint

Anisotropy: strong // elongation; yellowish, bluish gray, dark violet-gray

%R: 15-21 low **VHN:** 367-803
Int'l Reflects.: blood red, very common

Polish. Hard.: <hausmannite, jacobsite, braunite, mt; <<pyrolusite

Comments: Forms prismatic xls or lamellar xl aggregates sometimes with radiated texture; cleavage // (010) and (110) often distinct, especially in cross sections; twinning lamellae very common; p. 342; 1079.

OPAQUE MINERAL OPTICS

Mineral Name: Manganosite **Chem. Comp.:** Mn.O

Crystall.: cubic

Color: gray **Tint:** green

Color (oil): **Tint (oil):**

Bireflectance: nil

Anisotropy: isotropic

%R: 14 low **VHN:** 314-325

Int'l Reflects.: always present, emerald green on fresh surfaces, red appearing with time

Polish. Hard.:

Comments: Commonly occurs as granular aggregates; forms oriented intergrowths with zincite or periclase; replaced by pyrochroite; p. 338; 897.

Mineral Name: Marcasite **Chem. Comp.:** Fe.S2

Crystall.: ortho

Color: white yellow **Tint:** yellow

Color (oil): **Tint (oil):**

Bireflectance: strong, brownish white to bluish greenish gray

Anisotropy: strong, blue to green-yellow to purplish to violet-gray

%R: 47-53 mod to hi **VHN:** 762-1561

Int'l Reflects.:

Polish. Hard.: >po; commonly <py but > gel-pyrite

Comments: Commonly shows colloform texture; forms alternating layers with py or crusts on gel-pyrite; idiomorphic, lath-shaped xls less common; radiated aggregates may occur; cleavage may be distinct; twinning(both coarse and fine lamellar) and zonal texture very common; whiter than py; p. 204; 839.

Mineral Name: Matildite (=Schapbachite) **Chem. Comp.:** Ag.Bi.S2+Pb.S

Crystall.: hexagonal

Color: white **Tint:** pink

Color (oil): white **Tint (oil):** yellow

Bireflectance: weak in oil: yellowish white / ft greenish white

Anisotropy: strong, lt to dark gray

%R: 44 mod **VHN:** 68-91

Int'l Reflects.:

Polish. Hard.: slt>gn; <cpy

Comments: Common exsolution textures with gn; always with gn; complete solid solution with gn above 215C; lamellar twinning; p. 282; 665.

Mineral Name: Mawsonite **Chem. Comp.:** Cu(2+x)Fe.Sn(1-x)S10

Crystall.: tetragonal

Color: orange **Tint:** brown

Color (oil): **Tint (oil):**

Bireflectance: v. strong; lt orange/orange/brown

Anisotropy: v. strong; bright straw yellow to prussian blue to dark grayish blue

%R: 25 low **VHN:** 166-210

Int'l Reflects.:

Polish. Hard.: <~bn

Comments: Much brighter than bn, especially in oil; no cleavage or twinning observed; as rounded or irregular inclusions in bn; as reaction rims between cassiterite and bn; p. 90; 575.

Mineral Name: Mckinstryite **Chem. Comp.:** Cu.8+x.Ag1.2-x.S
Crystall.: ortho
Color: white gray **Tint:** gray blue
Color (oil): **Tint (oil):**
Bireflectance: distinct

Anisotropy: strong, gray, pale grayish blue, light tan

%R: 30-35 mod **VHN:** 60
Int'l Reflects.:

Polish. Hard.:

Comments: Occurs as coarse-grained aggregates of intergrown xls; forms intergrowths with jalpaite; p. 44; 484.

Mineral Name: Melonite **Chem. Comp.:** NiTe2 - forms a SS with merenskyite (may contain some Se)
Crystall.: hexagonal
Color: pink cream **Tint:** cream pink
Color (oil): **Tint (oil):**
Bireflectance: v weak, O more creamy, E more pinkish

Anisotropy: distinct, grayish mauve to yellowish brown; straight extinction

%R: 57-62 hi (QDF2) **VHN:** 46-59 (QDF2)
Int'l Reflects.:

Polish. Hard.: usually >=cpy; >Au, krennerite; sometimes <<Au and < montbrayite

Comments: Occurs as isolated euhedral or subhedral xls enclosed in krennerite, altaitie or montbrayite, with or without partial rims of petzite; because of its softness it is often deformed and exhibits wavy extinction; p. 252; 420.

Mineral Name: Meneghinite **Chem. Comp.:** (Cu2S)(26.PbS)(7.Sb2.S3)

Crystall.: ortho

Color: white **Tint:** blue

Color (oil): **Tint (oil):**

Bireflectance: weak, white (brownish yellow) to grayish white (reddish or faint greenish)

Anisotropy: strong, light tan, brown, blue gray; straight extinction

%R: 40-46 mod **VHN:** 113-183

Int'l Reflects.: rare, red

Polish. Hard.: slt<gn; <cpy

Comments: Occurs as acicular or needle-like idiomorphic xls and as granular aggregates; one perfect cleavage // (010); twinning and parquet-like texture have been observed (resembling jamesonite); zonal texture not observed; anisotropy stronger than jamesonite and boulangerite; bireflectance much weaker than for jamesonite; p. 50; 772.

Mineral Name: Merenskyite **Chem. Comp.:** (Pd,Pt)(Te,Bi)2

Crystall.: hexagonal - rhombohedral

Color: white **Tint:** cream

Color (oil): **Tint (oil):**

Bireflectance: weak to distinct, white (creamy tint) to light grayish white

Anisotropy: distinct to strong, dark brown to light greenish gray

%R: 63-65 hi **VHN:**

Int'l Reflects.:

Polish. Hard.: >cpy, kotulskite; <pent

Comments: Pd endmember of series, moncheite is the Pt endmember; forms a solid solution series with melonite; occurs intergrown with kotulskite; p. 332; 838.

Mineral Name: Metacinnabar **Chem. Comp.:** Hg.S
Crystall.: cubic
Color: white **Tint:** gray
Color (oil): much darker **Tint (oil):** brown
Bireflectance: v. weak on grain boundaries if present

Anisotropy: isotropic

%R: 28 low **VHN:** 73-161
Int'l Reflects.:

Polish. Hard.: <cinnabar;<<tet-tn

Comments: Twin lamellae almost always present; very often intergrown with cinnabar, which has distinct anisotropy; p. 78; 521.

Mineral Name: Metastibnite **Chem. Comp.:** Sb2.S3
Crystall.: noncrystalline
Color: white **Tint:** blue
Color (oil): **Tint (oil):**
Bireflectance: none

Anisotropy: distinct (air), in oil masked by internal reflections

%R: mod, <stibnite **VHN:**
Int'l Reflects.: intense, deep-red

Polish. Hard.:

Comments: Commonly with colloform texture, which is more distinct under crossed nicols; darker and lower %R than stibnite; p. 44; 709.

OPAQUE MINERAL OPTICS

Mineral Name: Miargyrite **Chem. Comp.:** Ag.Sb.S2
Crystall.: mono
Color: white **Tint:**
Color (oil): much darker **Tint (oil):** gray sometimes blue
Bireflectance: strong, white / lt bluish gray / gray

Anisotropy: strong, lt gray / blue gray / brownish, often masked by internal reflections

%R: 30-35 mod **VHN:** 88-130
Int'l Reflects.: deep red

Polish. Hard.: slt>pyrargyrite;<gn, stephanite; << freibergite

Comments: v. similar to freibergite, polybasite, pyrargyrite, and stephanite; granular aggregates; twinning has been observed; p. 262; 662.

Mineral Name: Michenerite **Chem. Comp.:** (Pd,Pt)Bi.Te
Crystall.: cubic
Color: white **Tint:** gray
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 56 hi **VHN:**
Int'l Reflects.:

Polish. Hard.: >cpy; ~kotulskite; <moncheite

Comments: With hessite, maucherite, moncheite, kotulskite; p. 324; 825.

OPAQUE MINERAL OPTICS

Mineral Name: Millerite **Chem. Comp.:** Ni.S

Crystall.: rhombo

Color: pure yellow **Tint:** cream

Color (oil): similar **Tint (oil):**

Bireflectance: distinct (oil), grayish yellow / bright yellow

Anisotropy: strong, lemon-yellow / iris-blue / violet; straight, but incomplete extinction

%R: 51-56 hi **VHN:** 192-376

Int'l Reflects.:

Polish. Hard.: >cpy;<sl, pent, linnaeite

Comments: Distinguished from other yellow minerals by hardness (cpy) and anisotropy (py); basal sections appear isotropic; radiated or bundle-like aggregates of needle-shaped xls; cleavage // to (1011) commonly visible; p. 122; 626.

Mineral Name: Minium **Chem. Comp.:** Pb3.O4

Crystall.: tetragonal

Color: gray **Tint:** normally blue, pink yellow from internal reflections

Color (oil): **Tint (oil):**

Bireflectance: weak, yellowish-gray to orange gray to gray blue

Anisotropy: obscured by internal reflections

%R: 20 low **VHN:**

Int'l Reflects.: pink and yellow, abundant and strong

Polish. Hard.: <gn, lithargite, massicotite

Comments: Generally extremely fine-grained; replaces and forms pseudomorphs after gn and cerrusite; p. 50.

Mineral Name: Molybdenite **Chem. Comp.:** Mo.S2

Crystall.: rhombohedral-hexagonal

Color: white to dull gray **Tint:** blue

Color (oil): **Tint (oil):**

Bireflectance: v. strong, white to dull blue gray

Anisotropy: v strong, white with pinkish tint, dark blue (characteristic)

%R: 22-42 low to mod **VHN:** 16-101

Int'l Reflects.:

Polish. Hard.: in fine-grained aggregates slt>cpy; <graphite

Comments: Often more or less curved plates or xls with undulatory extinction; may show colloform texture; forms rosette-shaped aggregates; cleavage // (0001) nearly always visible; Parallel displacement very common, often producing a twinning-like texture; polysynthetic twinning of primary origin is indicated by marked variations in polarization effects in sections // c; observed as minute inclusions in many sulfides; p. 103; 874.

Mineral Name: Moncheite **Chem. Comp.:** (Pt,Pd)(Te,Bi)2

Crystall.: hexagonal

Color: white gray **Tint:** gray

Color (oil): **Tint (oil):**

Bireflectance: weak to distinct

Anisotropy: distinct to strong, light yellowish brown to dark brown

%R: 53-59 hi **VHN:**

Int'l Reflects.:

Polish. Hard.: >kotulskite; michenerite; ~pent; <cpy

Comments: Pt end member of a series, the Pd member is merenskyite; distinct cleavage // (0001); generally as blebs or fine laths; forms intergrowths with michenerite, kotulskite, ferroplatinum; p. 332; 838.

Mineral Name: Montbrayite **Chem. Comp.:** Au2.Te3
Crystall.: triclinic
Color: white **Tint:** cream
Color (oil): **Tint (oil):**
Bireflectance: weak

Anisotropy: weak to distinct, light gray, light yellow-brown, blue-gray

%R: 64 hi **VHN:** 198-228
Int'l Reflects.:

Polish. Hard.: >tellurobismuthite; ~melonite

Comments: Occurs as coarse, solid mosaics with optically continuous areas, often several mm in width; cleavage occurs, no evidence of twinning; p. 238; 435.

Mineral Name: Montroseite **Chem. Comp.:** (V,Fe)O.OH
Crystall.: ortho
Color: white gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: weak

Anisotropy: strong, bright grayish yellow to dark brown

%R: 15-17 low (P&J) **VHN:** 266-300
Int'l Reflects.:

Polish. Hard.:

Comments: Occurs as bladed xls; replaces karelianite; p. 100; 1081.

Mineral Name: Murdochite **Chem. Comp.:** Cu6.Pb.O8
Crystall.: cubic
Color: gray **Tint:** yellow brown
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 17 low **VHN:** 519-657
Int'l Reflects.:

Polish. Hard.: slt>plattnerite

Comments: Occurs as euhedral xls; twinning not uncommon, zonation always present; octahedral cleavage has been observed; p. 166; 906.

Mineral Name: Nagyagite **Chem. Comp.:** Au(Pb,Sb,Fe)8(S,Te)11 (?) or Pb5Au(Te,Sb)4S5-8 (P&J)
Crystall.: tetragonal
Color: gray **Tint:** slt purple
Color (oil): **Tint (oil):**
Bireflectance: weak, gray to brownish gray

Anisotropy: distinct, light gray (bluish) to dark brownish or greenish gray in sections which transverse the cleavage; no definite extinction; sections // to cleavage near isotropic
%R: 39-43 mod (P&J) **VHN:** 60-94 (QDF2)
Int'l Reflects.:

Polish. Hard.: slt>sylvanite

Comments: Usually occurs as thin-tabular laminated xls, often bent; perfect cleavage // (010); polysynthetic twinning may occur in sections // (010); with Au and other tellurides; p. 236; 433.

Mineral Name: Naumannite **Chem. Comp.:** beta-Ag2Se <-133C-> alpha-Ag2.Se

Crystall.: ortho <133C> cubic

Color: gray **Tint:** green

Color (oil): much darker **Tint (oil):**

Bireflectance: weak (oil), brownish gray to darker greenish gray-brown

Anisotropy: distinct, light to dark gray

%R: ~35 mod **VHN:** 27-56

Int'l Reflects.:

Polish. Hard.: <clausthalite

Comments: Usually shows traces of cubic cleavage, probably due to parting associated with the alpha-beta inversion; mimetic twinning may be very distinct; may form myrmekitic intergrowths with clausthalite; p. 224; 478.

Mineral Name: Niccolite **Chem. Comp.:** Ni.As

Crystall.: hexagonal

Color: pink to lt brown **Tint:** yellow or brown

Color (oil): similar, less white **Tint (oil):**

Bireflectance: strong, yellowish pink to brownish pink to light pink

Anisotropy: v. strong, yellowish, grayish green, violet-blue, bluish gray; straight, but incomplete extinction; basal sections appear isotropic

%R: 48-53 mod to hi **VHN:** 308-533

Int'l Reflects.:

Polish. Hard.: >>Ag; >cpy; ~breithauptite, po; <rammelsbergite, skutterudite; <<loellingite, py

Comments: Pink colors and hardness are distinctive; chevron-like twinning may occur; sometimes forms concentric aggregates, often with radiated texture; idiomorphic xls and cross-shaped twins also occur; forms pseudo-eutectic intergrowths with po, cpy, and maucherite; p. 150; 615.

Mineral Name: Nickel **Chem. Comp.:** Ni
Crystall.: cubic
Color: white **Tint:** blue
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 63 hi **VHN:** 186-210
Int'l Reflects.:

Polish. Hard.: <heazlewoodite

Comments: Occurs as euhedral grains (cubes) in heazlewoodite; also as anhedral "spider-like" irregular masses in the intergranular spaces of heazlewoodite aggregates; p. 122; 362.

Mineral Name: Nsutite **Chem. Comp.:** Mn1-xMnx.O2-2x(OH2x)
Crystall.: hexagonal
Color: white **Tint:** cream
Color (oil): **Tint (oil):**
Bireflectance: crypto-xln aggregates are isotropic; coarse xls, distinct, white gray to dark gray

Anisotropy: strong, light and dark gray

%R: 30-40 mod **VHN:** 350-1288
Int'l Reflects.:

Polish. Hard.: >pyrolusite

Comments: Occurs as coarse-grained xls resembling pyrolusite, or as crypto-xln aggregates; nsutite shows shrinkage cracks in fine-grained colloform aggregates, which may be caused by transition from Mn-nsutite to nsutite; may form fan-like aggregates of fine fibers; p. 358; 1029.

Mineral Name: Orcelite **Chem. Comp.:** Ni(5-x)As2
Crystall.: hexagonal
Color: brown bronze **Tint:** pink
Color (oil): **Tint (oil):**
Bireflectance: weak (weaker than niccolite or breithauptite)

Anisotropy: distinct to strong, green and violet tints

%R: 49 (QDF2) **VHN:** no data
Int'l Reflects.:

Polish. Hard.: no data

Comments: Shows a lamellar structure; only observed in serpentinized rocks; occurs as inclusions inawaruite; may contain inclusions of pentlandite; p. 148; 399.

Mineral Name: Oregonite **Chem. Comp.:** Ni2.Fe.As2
Crystall.: hexagonal
Color: white **Tint:** pinkish cream (P&J)
Color (oil): **Tint (oil):**
Bireflectance: weak

Anisotropy: weak, only visible at grain boundaries

%R: 49-50 mod **VHN:** 605-635
Int'l Reflects.:

Polish. Hard.: >po

Comments: Occurs as aggregates of rounded to oval grains, as crusts around niccolite; p. 142; 400.

Mineral Name: Orpiment **Chem. Comp.:** As2.S3
Crystall.: mono
Color: gray **Tint:**
Color (oil): much darker **Tint (oil):**
Bireflectance: strong (air), white to dull gray to dull gray white, in oil darker with reddish tint

Anisotropy: strong, masked by internal reflections

%R: 25 low **VHN:** 22-58
Int'l Reflects.: abundant and intense, white to light yellow

Polish. Hard.: slt>realgar

Comments: May occur as needle-formed or tabular xln masses, often sheaf-like or radiating, but usually as alteration product around realgar; forms oriented intergrowths with realgar; p. 40; 890.

Mineral Name: Osmium **Chem. Comp.:** Os (Os content >80%)
Crystall.: hexagonal
Color: white **Tint:** against Pt it is bluish gray
Color (oil): **Tint (oil):**
Bireflectance: not present

Anisotropy: strong, vivid orange red tints

%R: 62 (QDF2) **VHN:** no data
Int'l Reflects.:

Polish. Hard.: v hi

Comments: As tiny tabular or elongated hexagonal xls; often enclosed within Pt or as small lamellae within Pt; p. 334; 350.

Mineral Name: Owhyeeite **Chem. Comp.:** Pb5.Ag2.Sb6.S15

Crystall.: ortho

Color: grayish white **Tint:** green olive

Color (oil): **Tint (oil):**

Bireflectance: distinct, greenish to olive gray-white; not as strong as for jamesonite

Anisotropy: v strong, straw or brownish white, grayish white and pale blue-gray to dark blue just before extinction; straight extinction

%R: 38-45 (P&J) **VHN:** 98-129

Int'l Reflects.:

Polish. Hard.: >=pyrargyrite; ~boulangerite; slt<gn?; <<tet

Comments: Like jamesonite, it is fibrous; occurs as acicular and fusiform xls; also as irregular fine-grained aggregates; triangular pits may occur in poorly polished grains; cleavage // (001) in prismatic sections; occasionally twinned // elongation; p. 268; 745.

Mineral Name: Palladium **Chem. Comp.:** Pd

Crystall.: cubic

Color: white **Tint:** cream

Color (oil): **Tint (oil):**

Bireflectance: nil

Anisotropy: isotropic

%R: ~70 v hi **VHN:**

Int'l Reflects.:

Polish. Hard.: <Pt

Comments: Occurs as small octahedral single xls and as xenomorphic grains; forms rims around Pt-sulfides embedded in Pt; p. 326; 338.

Mineral Name: Paraguanajuatite **Chem. Comp.:** Bi2(Se,S)3

Crystall.: hexagonal - rhombohedral

Color: gray white **Tint:**

Color (oil): **Tint (oil):** pink

Bireflectance: strong (oil), lighter to darker slightly bluish gray

Anisotropy: v distinct, but practically no color effects

%R: 45 mod **VHN:** 30-160

Int'l Reflects.:

Polish. Hard.: <guanajuatite

Comments: Darker than guanajuatite and with pinkish tint in oil; occurs as lamellar bodies, granular or curved; forms pseudomorphs after guanajuatite; cleavage // (0001) is perfect; p. 228; 714.

Mineral Name: Pararammelsbergite **Chem. Comp.:** Ni.As2

Crystall.: ortho

Color: white **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: v weak to distinct (oil), yellowish to bluish white

Anisotropy: strong, usually without the bluish colors of rammelsbergite

%R: 56-58 hi **VHN:** 673-824

Int'l Reflects.:

Polish. Hard.: >niccolite; <Ni-skutterudite, loellingite

Comments: Usually forms tabular xls with rectangular transverse sections, occasionally radial subrectangular xls or mosaics of interlocking grains; cleavage may be visible; twinning rare and not lamellar; zonal texture occurs; whiter than associated white arsenides, including rammelsbergite; p. 154; 860.

Mineral Name: Parkerite (see shandite; p. 62) **Chem. Comp.:** alpha - Ni3(Bi,Pb)2.S2

Crystall.: monoclinic

Color: white **Tint:** cream mauve

Color (oil): **Tint (oil):**

Bireflectance: distinct, creamy white to grayish creamy white

Anisotropy: strong, greenish gray to yellowish brown or slate-blue to salmon pink

%R: 44-48 mod **VHN:** 111-142

Int'l Reflects.:

Polish. Hard.: slt< or ~gn

Comments: Usually occurs as xenomorphic grains; also as irregular rounded and subhedral particles; as veinlets and stringers; usually polysynthetically twinned, especially well visible in oil; may be crossed by less pronounced transverse lamellae; notched cleavage traces; p. 62; 404.

Mineral Name: Patronite **Chem. Comp.:** V.S2

Crystall.: mono

Color: gray **Tint:** brown

Color (oil): **Tint (oil):** yellowish

Bireflectance: v strong, light gray to yellowish gray to brown

Anisotropy: v strong, light gray to blue green in oil, no color effects in air

%R: ~20 low **VHN:**

Int'l Reflects.:

Polish. Hard.:

Comments: Forms aggregates of very fine short prismatic needle-like xls; basal cleavage is present; twinning not observed; p. 38; 887.

Mineral Name: Pavonite **Chem. Comp.:** (Ag2S)(Bi2.S3)
Crystall.: mono
Color: white gray **Tint:** gray pink blue
Color (oil): **Tint (oil):** stronger tints
Bireflectance: distinct (air) to strong (oil), white, white with a grayish pink tint, bluish gray white

Anisotropy: strong, pale to intense blue and light tan to brown

%R: 42 mod **VHN:**
Int'l Reflects.:

Polish. Hard.: ~cpy; <sl

Comments: Occurs as tiny bladed xls; cleavage is present; p. 282; 716.

Mineral Name: Penroseite **Chem. Comp.:** (Ni,Co,Cu)Se2
Crystall.: cubic
Color: white **Tint:** brown
Color (oil): much darker **Tint (oil):** olive green
Bireflectance: nil

Anisotropy: isotropic

%R: 35 mod **VHN:** 407-550
Int'l Reflects.:

Polish. Hard.: >cpy

Comments: Cleavage // (100) may be visible; zonal texture very common; p. 218; 818.

OPAQUE MINERAL OPTICS

Mineral Name: Pentlandite **Chem. Comp.:** (Fe,Ni)9.S8
Crystall.: cubic
Color: white or yellow **Tint:** cream
Color (oil): **Tint (oil):**
Bireflectance:

Anisotropy: isotropic

%R: 40-55 mod to hi **VHN:** 202-303
Int'l Reflects.:

Polish. Hard.: >cpy;~<po

Comments: May have good cleavage; associated with cpy and po; idiomorphic or xenomorphic xls; flame-like segregations, and feather-like, finger-like, or star-like bodies in po; also with cpy and cubanite; p. 130; 497.

Mineral Name: Perovskite-group **Chem. Comp.:** (Ca,Na, REE)(Ti,Nb)O3
Crystall.: pseudocubic
Color: dark gray **Tint:**
Color (oil): dark gray **Tint (oil):** blue
Bireflectance: nil

Anisotropy: nil

%R: 15 low **VHN:** 490-895
Int'l Reflects.: white to brown, strong and always present

Polish. Hard.: > or ~mt

Comments: Usually occurs in alkaline rocks or carbonatites as idiomorphic cubic or octahedral xls, sometimes rounded or with carious or allotriomorphic texture; cleavage in fine-grained material not observable; complicated lamellar twinning always present, may be visible by the internal reflections; very difficult to identify in polished section; p. 182; 1004.

Mineral Name: Petzite **Chem. Comp.:** Ag3.Au.Te2

Crystall.: cubic

Color: white gray **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: nil

Anisotropy: isotropic

%R: 37 mod **VHN:** 35-74

Int'l Reflects.:

Polish. Hard.: <sylvanite, coloradoite, hessite, altaite, calaverite

Comments: Cubic cleavage less perfect than for gn; triangular pits may occur; p. 234; 424.

Mineral Name: Pitchblende **Chem. Comp.:** U.O2

Crystall.: cubic

Color: shades of gray **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: nil

Anisotropy: isotropic

%R: 10-15 low **VHN:** 314-803

Int'l Reflects.: dark brown and yellow brown

Polish. Hard.: variable

Comments: Pitchblende high in UO2 takes a good polish, homogeneous, comparatively hard; pitchblende high in UO3 (oxidation product of above) polishes poorly, has a rough surface, and is comparatively soft. Occurs in great variety of forms, showing all gradations such as: botryoidal, colloform, cellular, dendritic, spherulitic, oolitic, ring-like, brecciated, or vein forms; concentric or circular cross sections commonly show radiating cracks; 194; 1050.

Mineral Name: Plagionite **Chem. Comp.:** (5.PbS)(4.Sb2.S3)
Crystall.: mono
Color: white **Tint:** gray
Color (oil): **Tint (oil):**
Bireflectance: distinct, white or light gray to brownish pink

Anisotropy: distinct, pinkish, brownish, blue; oblique extinction

%R: 35-38 mod **VHN:** 120-165
Int'l Reflects.: dark red, occasionally visible

Polish. Hard.:

Comments: May occur as tabular xls or as coatings; forms aggregates of needle-shaped or prismatic grains; cleavage observable only in coarse-grained specimens; p. 276; 762.

Mineral Name: Platinum **Chem. Comp.:** Pt
Crystall.: cubic
Color: white **Tint:** cream
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: ~70 v hi **VHN:** 297-339 (QDF2)
Int'l Reflects.:

Polish. Hard.: >sl; <po

Comments: Commonly forms irregular xenomorphic grains, seldom idiomorphic xls; zonal texture not uncommon; may contain exsolution bodies of iridium; p. 326; 340.

Mineral Name: Plattnerite **Chem. Comp.:** Pb.O2
Crystall.: tetragonal
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: weak, distinct on grain boundaries, gray to blue gray

Anisotropy: distinct in xln material, blue to greenish

%R: 17-18 low **VHN:** 490-642
Int'l Reflects.: reddish brown, abundant

Polish. Hard.: >> all associated minerals

Comments: Occurs as short needle-like xls; p. 162; 1021.

Mineral Name: Plumboferrite **Chem. Comp.:** (PbO)(Fe2.O3)
Crystall.: hexagonal
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: not observable

Anisotropy: weak

%R: 15-20 low **VHN:**
Int'l Reflects.:

Polish. Hard.:

Comments: Occurs as rounded grains; two cleavages visible; prismatic and // (0001); twinning rare; p. 184; 967.

Mineral Name: Polybasite and Pearceite (and [illegible]) **Chem. Comp.:** (Ag,Cu)16(As,Sb)2.S11
Crystall.: mono- pseudohexagonal
Color: gray **Tint:** green brown
Color (oil): **Tint (oil):**
Bireflectance: distinct (oil), greenish to dark gray with a violet blue-gray tint

Anisotropy: distinct (air), strong (oil), blue, gray, green, and yellowish colors

%R: 30-35 mod **VHN:** 108-164
Int'l Reflects.: deep-red nearly always visible

Polish. Hard.: >argentite; ~pyrargyrite; <stephanite; << ten

Comments: Idiomorphic pseudohexagonal plates and tablets; sometimes arranged in subparallel and rosette-like groups; cleavage // (001); basal sections may appear isotropic; p. 262; 729.

Mineral Name: Polydymite **Chem. Comp.:** Ni3.S4
Crystall.: cubic
Color: white **Tint:** yellow
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 46 mod **VHN:** 437-444
Int'l Reflects.:

Polish. Hard.: ~other minerals of the linnaeite group

Comments: Idiomorphic xls; no twinning or zonal texture; p. 146; 697.

Mineral Name: Proustite **Chem. Comp.:** (3.Ag2S)(As2.S3)
Crystall.: hexagonal
Color: gray **Tint:** blue
Color (oil): **Tint (oil):**
Bireflectance: strong: air, white (yellowish) to bluish gray (darker); oil, grayish blue (brownish) to grayish blue (darker)
Anisotropy: strong, in oil masked by internal reflections

%R: 25-28 low **VHN:** 50-156
Int'l Reflects.: scarlet-red, always visible

Polish. Hard.: ~pyrargyrite

Comments: Occurs as irregular grains, as allotriomorphic aggregates or as idiomorphic needle-shaped xls; twinning and zonal texture may occur; p. 258; 783.

Mineral Name: Pseudobrookite **Chem. Comp.:** Fe2.Ti.O5
Crystall.: ortho
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: weak

Anisotropy: distinct

%R: 15 low **VHN:**
Int'l Reflects.: reddish yellow

Polish. Hard.: <rutile

Comments: Sometimes idiomorphically developed; occurs intergrown with hematite formed by oxidation of ilmenite and titanomagnetite; p. 178; 1046.

OPAQUE MINERAL OPTICS

Mineral Name: Psilomelane (romanechite) **Chem. Comp.:** A3X6Mn8O16
A= Ba, Mn, Al, Fe, Si,etc
X=(O, OH)6 with OH=5

Crystall.: ortho

Color: white gray **Tint:** blue gray

Color (oil): **Tint (oil):**

Bireflectance: strong, almost white to dull gray to bluish gray

Anisotropy: strong, white to gray; straight extinction

%R: 15-30 low **VHN:** 203-813

Int'l Reflects.: brown, occasionally visible

Polish. Hard.: fine-grained form hard; coarse-grained commonly <coarse-grained Mn minerals

Comments: Common Mn mineral, only pyrolusite and cryptomelane are encountered more frequently; forms finely xln aggregates or minute acicular xls not unlike fine-grained pyrolusite; most commonly botryoidal masses sometimes consisting of concentric layers, which layers may also contain pyrolusite or cryptomelane; also irregular or cellular masses; rarely long prismatic xls; p. 354; 1030.

Mineral Name: Pyrargyrite **Chem. Comp.:** (3.Ag2S)(Sb2.S3)

Crystall.: hexagonal

Color: gray **Tint:** blue (violet)

Color (oil): **Tint (oil):**

Bireflectance: distinct to strong, no great color differences

Anisotropy: strong, pale to dark gray, in oil masked by internal reflections

%R: 28-31 low to mod **VHN:** 50-156

Int'l Reflects.: Intense, carmine-red

Polish. Hard.: >>argentite;>polybasite; <stephanite, gn, and most other accompanying minerals

Comments: Occurs as idiomorphic xls, and as aggregates of irregular grains; often twinned and with zonal texture; internal reflections less pronounced than in proustite; p. 258; 785.

OPAQUE MINERAL OPTICS

Mineral Name: Pyrite **Chem. Comp.:** Fe.S2
Crystall.: cubic
Color: yellow **Tint:** white cream
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: often weakly to distinctly anisotropic, blue-green to orange-red

%R: 54 hi **VHN:** 913-2056
Int'l Reflects.:

Polish. Hard.: >aspy, cobaltite; slt>marc, hem; <sperrylite, laurite, cassiterite

Comments: Generally idiomorphic, coarser grains showing rect or square outlines; also coarse grained aggregates of xl fragments, coarse-grained sphere-like aggregates, fine-grained idiomorphic, fine-grained skeletal, very fine grained spherical (framboidal); cleavages // to (100), (311), and (111) may be visible; twinning lamellae rare; zoning not uncommon; higher Co, Ni, or Cu contents result in pinkish, reddish, or violet tints; may also contain significant quantities of Au or As or Sb; p. 206; 791.

Mineral Name: Pyrochlore group **Chem. Comp.:** A2B2X7; A=Ca,Na,U,REE,Fe,Th,Mn ,Mg,Sr,K,Ba,Pb,Bi,Cs,Sb.
Crystall.: cubic
Color: dark gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 12-16 low **VHN:** 173-916
Int'l Reflects.: colorless to dark brown, always present

Polish. Hard.: <columbite

Comments: Usually occurs as single, idiomorphic xls; rarely as aggregates; fairly often partially or completely metamict; zoning very common; twinning rare, spinel law // (111); p.188; 1046.

Mineral Name: Pyrolusite **Chem. Comp.:** beta - Mn.O2
Crystall.: tetragonal
Color: white **Tint:** cream
Color (oil): **Tint (oil):** cream
Bireflectance: distinct, yellowish white to distinctly darker white gray

Anisotropy: v strong, yellowish to dark brown to greenish blue to slate gray; straight extinction

%R: 30-36 mod **VHN:** 76-1500
Int'l Reflects.:

Polish. Hard.: depending on orientation and type of xl aggregates, may be as high as braunite

Comments: Occurs as coarse-grained euhedral tabular to prismatic xls; commonly fine-grained showing intersecting irregular prisms, also massive or in radiated xls; banded texture not uncommon; cleavage // (110) usually distinct in coarse xls; twinning, single and lamellar, may occur; p. 358; 1025.

Mineral Name: Pyrrhotite **Chem. Comp.:** Fe.S
Crystall.: hexagonal - mono
Color: cream brown **Tint:** pink
Color (oil): brown **Tint (oil):**
Bireflectance: very distinct to strong, brownish creamy to reddish brown

Anisotropy: v.strong, yellow-gray, greenish gray, or grayish blue

%R: 34-39 mod **VHN:** 230-390
Int'l Reflects.:

Polish. Hard.: >>cpy; >sl; ~pent, niccolite;<<aspy, py

Comments: Hardness and lively anisotropy distinctive; cubanite softer; cleavage, especially in altered specimens; pentlandite exsolutions common; twinning and zonal texture not uncommon; p. 138; 592.

Mineral Name: Rammelsbergite **Chem. Comp.:** Ni.As2
Crystall.: ortho
Color: white **Tint:** yellow
Color (oil): **Tint (oil):**
Bireflectance: weak to distinct (oil), yellowish white to bluish white

Anisotropy: strong, pinkish, brownish, bluish, and greenish

%R: 60 hi **VHN:** 459-830
Int'l Reflects.:

Polish. Hard.: ~minerals of the skutterudite-series, niccolite; slt<safflorite, loellingite;<<aspy, cobaltite, glaucodot
Comments: Forms compact or fine-grained aggregates or mosaics of interlocking grains; zonal spherulitic and radiated textures very common, in the latter case with fibrous or bladed xls; skeletal xls also occur; cleavage // (110) rarely visible; simple and lamellar twinning very common; shows intergrowths with niccolite and with minerals of the skutterudite-series; whiter than other Ni-Co-Fe arsenides; p. 154; 852.

Mineral Name: Ramsdellite **Chem. Comp.:** gamma - Mn.O2
Crystall.: ortho
Color: white yellow **Tint:** yellow
Color (oil): **Tint (oil):**
Bireflectance: distinct to strong (oil), yellowish white to more grayish

Anisotropy: strong, yellow-brown to dark gray

%R: 12-33 low to mod **VHN:** 93-1200
Int'l Reflects.: deep violet red (oil), very common

Polish. Hard.: <pyrolusite

Comments: May show diamond-shaped cross sections; commonly as small patches of fine-grained fibrous and easily cleavable xls; cleavage // (110) and (010); olive to brownish tint against pyrolusite; p. 352; 1028.

Mineral Name: Rathite I **Chem. Comp.:** (Pb,Tl)3As4(As,Ag)S10

Crystall.: mono

Color: white **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: distinct on twin lamellae

Anisotropy: v strong, olive-green to yellow to violet-blue to blue

%R: 34-39 mod **VHN:** 159-163

Int'l Reflects.: very common, brown to clear red

Polish. Hard.:

Comments: Polysynthetic twinning; cleavage // (010) often distinct; p. 300; 752.

Mineral Name: Realgar **Chem. Comp.:** As.S

Crystall.: mono

Color: gray **Tint:**

Color (oil): much darker **Tint (oil):**

Bireflectance: weak but distinct, reddish gray to bluish gray

Anisotropy: strong, but masked by internal reflections

%R: 20-21 low **VHN:** 47-660

Int'l Reflects.: abundant and intense, yellowish red

Polish. Hard.: <orpiment; <<stibnite

Comments: Usually occurs interstitial to other ore minerals; as inclusions in orpiment; forms striated intergrowths with orpiment; p.41; 889.

Mineral Name: Renierite **Chem. Comp.:** (Cu,Fe,Ge,Zn)S

Crystall.: tetragonal

Color: orange brown **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: distinct; orange to bronze with a violet tint

Anisotropy: distinct to strong, easily visible in oil; yellow-brown to dark brown or grayish yellow to bluish gray

%R: 23-25 low **VHN:** 295-425

Int'l Reflects.:

Polish. Hard.: <~cpy; > bn; <ten

Comments: Similar to bornite, but doesn't tarnish; occurs as granular aggregates and as idiomorphic xls in cpy, gn, sl, ten, bn, and cc; polysynthetic and parquet-like twinning have been observed; p. 90; 574.

Mineral Name: Rickardite **Chem. Comp.:** Cu(2-x)Te

Crystall.: tetragonal

Color: red purple **Tint:** red violet blue

Color (oil): **Tint (oil):**

Bireflectance: v strong, bight pinkish red to purplish blue-gray

Anisotropy: v strong, canary yellow to deep brown red, fiery orange, white blue-gray, dark blue; basal sections appear isotropic

%R: 12-20 low (QDF2) **VHN:** 72-85 (QDF2)

Int'l Reflects.:

Polish. Hard.: low, but >wessite, Bi-tellurides

Comments: May show a complex pattern of polysynthetic twinning along two sets of planes probably at right angles to each other; occurs as exsolution lamellae in two sets in vulcanite; forms coatings on Te; p. 242; 416.

Mineral Name: Robinsonite **Chem. Comp.:** (7.PbS)(6.Sb2.S3)
Crystall.: triclinic
Color: white **Tint:** blue green
Color (oil): darker **Tint (oil):** darker colors
Bireflectance: distinct, gray white or white with a bluish green tint to greenish gray

Anisotropy: strong, light tan to brown to bluish gray

%R: 38-42 mod **VHN:** 118-123
Int'l Reflects.: rare, red

Polish. Hard.:

Comments: Occurs as inclusions in boulangerite; p. 276; 764.

Mineral Name: Rutile **Chem. Comp.:** Ti.O2
Crystall.: tetragonal
Color: gray **Tint:** ft blue
Color (oil): **Tint (oil):**
Bireflectance: distinct in oil,

Anisotropy: strong, colors usually masked by the internal reflections

%R: 20-24 low **VHN:** 933-1280
Int'l Reflects.: white, yellowish, brown, reddish brown, brownish violet, green; strong and abundant

Polish. Hard.: >ilmenite; <hematite, cassiterite

Comments: Often idiomorphically developed; in minute needle-shaped xls arranged // crystallographic directions of original host minerals; cleavage often distinct; lamellar twinning very common; p. 180; 1005.

OPAQUE MINERAL OPTICS

Mineral Name: Safflorite **Chem. Comp.:** (Co,Fe,Ni)As2
Crystall.: ortho
Color: white **Tint:** blue gray
Color (oil): **Tint (oil):**
Bireflectance: v weak, bluish to grayish

Anisotropy: strong, highly variable polarization colors

%R: 55-60 hi **VHN:** 430-988
Int'l Reflects.:

Polish. Hard.: >Skutterudite-series; ~niccolite; <loellingite; <<aspy, cobaltite, glaucodot

Comments: Usually shows concentric or radiated textures forming alternating zones with other minerals (such as niccolite, glaucodot, skutterudite, etc,); also tubercle-like textures; occurs as aggregates of idiomorphic xls; cleavage not observed; twinning very common and typical (star-shaped or compound trillings); p. 156; 848.

Mineral Name: Samarskite **Chem. Comp.:** (Fe,Y,U)2(Nb,Ti,Ta)2.O7
Crystall.: orthorhombic
Color: lt gray **Tint:** creamy
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 14.8 to 16.6 low **VHN:** 736-897
Int'l Reflects.: faint reddish brown

Polish. Hard.:

Comments: Generally prismatic, sometimes lamellar or needles; cleavage indistinct; forms intergrowths with columbite; common in granite pegmatites; may occur with columbite, monazite, biotite, muscovite, garnet, tourmaline, magnetite, topaz, phenakite, sphene, zircon, etc.; all data from pp. 526-534 of Vlasov (1966).

Mineral Name: Samsonite **Chem. Comp.:** (2.Ag2S)(MnS)(Sb2.S3)

Crystall.: mono

Color: gray **Tint:** blue

Color (oil): **Tint (oil):**

Bireflectance: distinct, olive green gray to blue gray

Anisotropy: weak, greenish gray to purple

%R: 28 low **VHN:**

Int'l Reflects.: deep red, very common

Polish. Hard.:

Comments: Occurs as single xls and as radial aggregates ; triangular pits may occur; twinning not observed; very similar to pyrargyrite; p. 260; 790.

Mineral Name: Sartorite **Chem. Comp.:** (PbS)(As2.S3)

Crystall.: mono

Color: white **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: weak

Anisotropy: distinct, gray-blue to yellowish gray

%R: 35-39 mod **VHN:** 194-197

Int'l Reflects.: very common, deep-red

Polish. Hard.:

Comments: Abundantly twinned // (100); commonly broad lamellae of equal width; p. 302; 750.

Mineral Name: Scheelite **Chem. Comp.:** Ca.W.O4
Crystall.: tetragonal
Color: gray white **Tint:**
Color (oil): much darker **Tint (oil):**
Bireflectance: not observable

Anisotropy: distinct, but highly masked by internal reflections

%R: 10 v low **VHN:** 285-464
Int'l Reflects.: abundant, white

Polish. Hard.: <wolframite

Comments: Replaces wolframite or is interstitial to it; the replacing scheelite may show a pale yellow internal reflection; p. 184; 1093.

Mineral Name: Schirmerite **Chem. Comp.:** (PbS)(2.Ag2S)(2.Bi2.S3)
Crystall.: orthorhombic
Color: white **Tint:** cream
Color (oil): **Tint (oil):**
Bireflectance: weak, visible at grain boundaries

Anisotropy: weak, visible at grain boundaries

%R: 42-47 mod (P&J) **VHN:** 150-206*
Int'l Reflects.:

Polish. Hard.:

Comments: Granular aggregates of elongated grains; cleavage may be visible; p. 282; 746.

*Karup-Moller, 1973, Can. Mineral., v. 11, p. 954.

Mineral Name: Selenium **Chem. Comp.:** Se
Crystall.: hexagonal - rhombohedral
Color: white **Tint:**
Color (oil): darker **Tint (oil):** brown gray
Bireflectance: v strong (air), creamy white to brownish; (oil) bluish gray white to dull brown

Anisotropy: v strong, green to greenish gray, vivid

%R: 25-35 low to mod **VHN:**
Int'l Reflects.:

Polish. Hard.: <clausthalite, gn

Comments: Forms acicular xls or aggregates; occurs as a decomposition product of selenides, forming bundles of xls, single prismatic xls, and gel-textures; a lamellar structure occurs; often included in clausthalite; p. 224; 382.

Mineral Name: Seligmannite **Chem. Comp.:** (2.PbS)(Cu2S) ((As,Sb)2.S3)
Crystall.: ortho
Color: white gray **Tint:**
Color (oil): **Tint (oil):** pink
Bireflectance: weak, distinct on twin lamellae

Anisotropy: strong, brown to green to greenish blue

%R: 36-40 mod **VHN:** 149-167
Int'l Reflects.:

Polish. Hard.: slt>gn; <<ten

Comments: Usually forms xenomorphic grains; needle-like idiomorphic grains in stromeyerite; commonly polysynthetically twinned; parquet-like twinning occurs, similar to bournonite; anisotropy stronger than bournonite; p. 304; 734.

Mineral Name: Semseyite **Chem. Comp.:** (9.PbS)(4.Sb2.S3)
Crystall.: mono
Color: white **Tint:** green yellow
Color (oil): **Tint (oil):**
Bireflectance: distinct, white with a yellow-green tint to greenish gray

Anisotropy: strong, light gray to bluish gray to brown to dark gray

%R: 40 mod **VHN:** 109-173
Int'l Reflects.:

Polish. Hard.: <gn

Comments: Occurs as lath-like or prismatic coarsely xln aggregates, or as fine granular aggregates; cleavage oblique to the elongation of the grains; twinning or zonal texture not observed; p. 276; 764.

Mineral Name: Siegenite **Chem. Comp.:** (Ni,Co)3.S4
Crystall.: cubic
Color: white **Tint:** cream slt pink
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 45 mod **VHN:** 336-579
Int'l Reflects.:

Polish. Hard.: ~linnaeite, <cattierite

Comments: Occurs as idiomorphic xls and as irregular grains; cubic cleavage not always visible; p. 146; 697.

OPAQUE MINERAL OPTICS

Mineral Name: Silver
Chem. Comp.: Ag (may contain minor amounts of Au,Hg,As,Sb,Pt,Ni,Pb, and
Crystall.: cubic
Color: white cream
Tint: cream (tarnishes quickly to creamier or pinkish tints)
Color (oil):
Tint (oil):
Bireflectance: nil

Anisotropy: isotropic

%R: 90-95 v hi
VHN: 40-118
Int'l Reflects.:

Polish. Hard.: >>proustite; >gn; slt <dyscrasite; < As, tet; <<sl

Comments: Twinning and zoning not uncommon; cleavage not observed; occurs as dendrites, as skeleton- or cross-shaped xls surrounded by niccolite, rammelsbergite, or Ni-skutterudite; as irregular masses, as disseminated grains or leaves; as tubercle-like grains, as inclusions in other minerals; p. 74; 313.

Mineral Name: Sinnerite
Chem. Comp.: Cu1.4.As0.9.S2.1
Crystall.: triclinic
Color: gray white
Tint: yellow brown (against gn)
Color (oil):
Tint (oil):
Bireflectance: nil

Anisotropy: distinct, gray-brown to gray blue

%R: 30-32 mod
VHN: 357-390
Int'l Reflects.:

Polish. Hard.:

Comments: Under crossed nicols abundant twinning is visible which is remotely similar to that of aspy; p. 68; 571.

Mineral Name: Skutterudite-series **Chem. Comp.:** (Co,Ni,Fe)As3-x
Crystall.: cubic
Color: white **Tint:** cream gray blue
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 53 hi **VHN:** 268-974
Int'l Reflects.:

Polish. Hard.: Ferroan>Cobaltian>Nickelian; H with respect to rammelsberite, niccolite, safflorite, linnaeite varies with composition; all members >maucherite; < loellingite, ullmannite,
Comments: Cleavage may be distinct, on cobaltian skutterudite rare; twinning not observed; differences in H may be sufficient to distinguish texture in composite xls; pure skutterudite commonly forms homogeneous idiomorphic xls; zonal xls may occur; all other members form coarse xls with very fine zonal texture, or zonal intergrowths with other members of the series or with rammelsbergite or safflorite; xl aggregates not uncommon; p. 152; 881.

Mineral Name: Smithite **Chem. Comp.:** Ag.As.S2
Crystall.: mono
Color: white **Tint:**
Color (oil): white **Tint (oil):** blue
Bireflectance: distinct, bluish white to bluish gray in oil

Anisotropy: distinct, but obscured by internal reflections

%R: 40 mod **VHN:**
Int'l Reflects.: strong and abundant, bright orange

Polish. Hard.: <proustite

Comments: Occurs as fine-bladed, tabular xls, sometimes pseudohexagonal; nearly indistinguishable from trechmannite; p. 266; 726.

Mineral Name: Smythite **Chem. Comp.:** Fe3.S4
Crystall.: hexagonal
Color: cream **Tint:** pink
Color (oil): **Tint (oil):**
Bireflectance: strong, grayish yellow to reddish brown

Anisotropy: strong, yellow to blue gray

%R: 35 mod **VHN:**
Int'l Reflects.:

Polish. Hard.:

Comments: Occurs as clusters of very fine patches in radial, more rarely in parallel, arrangement; perfect basal cleavage; very similar to po, but has stronger bireflectance; p. 140; 612.

Mineral Name: Sperrylite **Chem. Comp.:** Pt.As2
Crystall.: cubic
Color: white **Tint:**
Color (oil): **Tint (oil):** cream blue
Bireflectance: nil

Anisotropy: isotropic

%R: 56 hi **VHN:** 960-1277
Int'l Reflects.:

Polish. Hard.: >>Pt; >braggite, geversite; ~py; <laurite, hollingworthite

Comments: Usually as idiomorphic cubic xls; cleavage // (100) occasionally visible; no twinning or zoning observed; forms intergrowths, sometimes myrmekitic, with Pt and magnetite; p. 324; 821.

Mineral Name: Sphalerite **Chem. Comp.:** Zn.S
Crystall.: hextetrahedral
Color: gray **Tint:**
Color (oil): dark gray **Tint (oil):**
Bireflectance: isotropic

Anisotropy: isotropic

%R: 18 low **VHN:** 128-276
Int'l Reflects.: red and orange; sometimes white

Polish. Hard.: <po,mt;>cpy,tet-ten

Comments: Similar to alabandite; lower %R than magnetite (oil); cleavage // (110) commonly visible in coarse grains; lamellar twinning and zonal texture common; p. 126; 506.

Mineral Name: Spinel-series (spinel, hercynite, galaxite, gahnite) **Chem. Comp.:** Mg or Fe or Mn or Zn Al2.O4
Crystall.: cubic
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 7 v low **VHN:** 861-1650
Int'l Reflects.: abundant and intense, colourless to various shades of green and brown

Polish. Hard.: very high

Comments: Usually as idiomorphic xls, also massive, coarse-granular to compact and as irregular or rounded embedded grains; twinning lamellae // (111) may be visible; p. 210; 906.

Mineral Name: Stannite **Chem. Comp.:** Cu2.Fe.Sn.S4
Crystall.: tetragonal
Color: gray **Tint:** brown or green
Color (oil): darker **Tint (oil):**
Bireflectance: distinct, light brown to brownish olive-green

Anisotropy: distinct (violet-gray, slate green, bluish, yellowish brown)

%R: 26-29 low **VHN:** 140-326
Int'l Reflects.:

Polish. Hard.: >cp;~tetrahedrite;<sl

Comments: Zonal or spotty mottling common; similar to tet-ten; very fine compound twinning common; may have triangular cleavage pits; p. 312; 549.

Mineral Name: Stannite Jaune **Chem. Comp.:** Cu2+x.Sn1-x.Fe.S4
Crystall.: tetragonal
Color: brown yellow **Tint:** yellow orange brown
Color (oil): **Tint (oil):**
Bireflectance: strong, yellowish to orange brown

Anisotropy: strong, reddish, bluish and greenish tints

%R: 23-25 low **VHN:**
Int'l Reflects.:

Polish. Hard.: >bn

Comments: Stannite jaune is yellow stannite, an intermediate member of the stannite-idaite series; occurs as exsolution lamellae in stannite; also as reaction rims between cpy and stannite, and between cassiterite and bn; p. 310.

OPAQUE MINERAL OPTICS

Mineral Name: Stephanite **Chem. Comp.:** (5Ag2S)(Sb2.S3)

Crystall.: ortho

Color: gray **Tint:** pink violet

Color (oil): **Tint (oil):**

Bireflectance: weak, gray, gray with a brownish pink tint, pink

Anisotropy: strong (oil), dark violet to dull grayish green; sharp extinction; basal sections appear isotropic

%R: 25-30 low **VHN:** 31-124

Int'l Reflects.:

Polish. Hard.: >>argentite; >polybasite and pyrargyrite; <tet

Comments: Occurs as columnar xls and xenomorphic aggregates; fine compound twinning is not uncommon; p. 256; 727.

Mineral Name: Sternbergite **Chem. Comp.:** Ag.Fe2.S3

Crystall.: ortho

Color: brown **Tint:**

Color (oil): darker **Tint (oil):**

Bireflectance: distinct, light to dark brown (P&J)

Anisotropy: strong, vivid bluish and reddish to lilac (P&J)

%R: 24-37 low to mod(P&J & **VHN:** 31-44

Int'l Reflects.:

Polish. Hard.: >bismuth; ~pyrargyrite, proustite; slt< argyropyrite, < gn, Ag

Comments: Occurs as thin tabular xls, mostly of pseudo-hexagonal outlines due to interpenetrating twinning; sometimes very fine-grained; perfect basal cleavage // (001), better than for argentopyrite; memetic twinning very common; somewhat darker than po; p. 268; 639.

Mineral Name: Stibnite **Chem. Comp.:** Sb2.S3

Crystall.: ortho

Color: white gray **Tint:** gray

Color (oil): **Tint (oil):**

Bireflectance: strong, dull gray white, brownish gray, pure white

Anisotropy: v. strong, blue, gray white, brown, pinkish brown

%R: 31-47 mod **VHN:** 42-153

Int'l Reflects.:

Polish. Hard.: >orpiment, realgar; ~berthierite, gn, bournonite; <<cpy

Comments: Irregular granular masses or as radiated aggregates; pressure twins, crumpling lamellae, and deformation very common; may show fine growth-zoning; p. 42; 705.

Mineral Name: Stilleite **Chem. Comp.:** Zn.Se

Crystall.: cubic

Color: gray **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: nil

Anisotropy: isotropic

%R: ~30 low **VHN:**

Int'l Reflects.: deep gray, rare

Polish. Hard.: >tet

Comments: Occurs as xenomorphic inclusions in linnaeite and Se-vaesite; twin lamellae may be observed; p. 216; 520.

Mineral Name: Stromeyerite **Chem. Comp.:** Cu.Ag.S

Crystall.: ortho

Color: dull white **Tint:** faint gray violet

Color (oil): **Tint (oil):** violet pink tint stronger

Bireflectance: weak(air); strong(oil)-grayish brown / cream / ft bluish green

Anisotropy: strong - blue / deep violet

%R: 26-30 low **VHN:** 27-62

Int'l Reflects.:

Polish. Hard.: <cc, gn

Comments: Needle-like idiomorphic xls are rare; an oleander-leaf texture is not uncommon; often late; with cc and silver; p. 52; 481.

Mineral Name: Sulfur **Chem. Comp.:** S

Crystall.: ortho or mono

Color: gray **Tint:**

Color (oil): much darker **Tint (oil):**

Bireflectance: distinct in air, in oil masked by internal reflections

Anisotropy: distinct in air, in oil masked by internal reflections

%R: 10-15 low **VHN:** 24-66

Int'l Reflects.: white to light yellowish, abundant and intense

Polish. Hard.: very low

Comments: Usually fine-granular; easily recognized; an alteration product of sulfides; p. 40; 381.

Mineral Name: Sylvanite **Chem. Comp.:** Au.Ag.Te4
Crystall.: mono
Color: white **Tint:** cream
Color (oil): **Tint (oil):**
Bireflectance: distinct, creamy white to creamy brown

Anisotropy: strong, light bluish gray to dark brown

%R: 50-58 hi **VHN:** 60-250
Int'l Reflects.:

Polish. Hard.: >>argentite, hessite; >altaite, Bi-tellurides; slt>nagyagite; <pyrargyrite

Comments: Often forms skeleton-shaped xls; cleavage // (010) perfect, // (100) less distinct; polysynthetic twinning is always present; p. 248; 426.

Mineral Name: Talnakhite **Chem. Comp.:** Cu.Fe.S2
Crystall.: cubic
Color: dark yellow **Tint:** pink
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 39 mod **VHN:**
Int'l Reflects.:

Polish. Hard.:

Comments: Occurs as intergrowths with fine plates and mesh structures of cpy; fills the spaces between these plates and mesh structures; p. 94.

Mineral Name: Tapiolite **Chem. Comp.:** (Fe,Mn)(Ta,Nb)2.O6

Crystall.: tetragonal

Color: white gray **Tint:** blue gray

Color (oil): **Tint (oil):**

Bireflectance: distinct to strong

Anisotropy: strong, slaty gray to red-brown or dark blue to greenish gray

%R: 16-18 low **VHN:** 796-1132

Int'l Reflects.: red or red-brown, not abundant

Polish. Hard.: > or = columbite

Comments: Twin lamellae // (011) always present; occurs as reaction rims in columbite, as exsolution bodies in the form of fine needles in cassiterite; p. 202; 1042.

Mineral Name: Teallite **Chem. Comp.:** Pb.Sn.S2

Crystall.: ortho

Color: white **Tint:** cream pink

Color (oil): **Tint (oil):**

Bireflectance: weak, white to yellowish

Anisotropy: v distinct, lt-brownish-dk gray / steel blue / violet

%R: 40-47 mod **VHN:** 31-125

Int'l Reflects.:

Polish. Hard.: >franckite; <<sl

Comments: Coarse laths, radiating aggregates; basal cleavage; polysynthetic twinning; wave-like textures and twinning occur; p. 318; 670.

Mineral Name: Tellurium **Chem. Comp.:** Te (may contain some Se, Au, Ag, or Fe)
Crystall.: hexagonal
Color: white **Tint:** gray cream
Color (oil): **Tint (oil):**
Bireflectance: distinct, white to brownish gray

Anisotropy: strong, bluish and brownish grays, similar to stibnite but not so bright

%R: 57-69 hi (P&J) **VHN:** 25-87
Int'l Reflects.:

Polish. Hard.: <empressite, montbrayite, krennerite, calaverite; >sylvanite, tellurobismuthite, altaite

Comments: Occurs as prismatic or acicular xls and as dense columnar, sometimes fine-grained masses; cleavage occasionally observed; twinning not observed; p. 246; 383.

Mineral Name: Tellurobismuthite **Chem. Comp.:** Bi2.Te3
Crystall.: hexagonal
Color: white **Tint:** cream pink
Color (oil): **Tint (oil):**
Bireflectance: v weak, creamy to grayish white

Anisotropy: distinct, gray or grayish blue to yellowish gray

%R: 64 hi **VHN:** 32-93
Int'l Reflects.:

Polish. Hard.: >tetradymite

Comments: Forms exsolution intergrowths with tetradymite; may occur as idiomorphic inclusions in cpy; perfect cleavage // (0001); lamellar twinning has been observed; p. 250; 436.

Mineral Name: Tennantite **Chem. Comp.:** Cu12.As4.S13 (minor Ag, Fe, Sb, Zn not rare)
Crystall.: cubic
Color: gray **Tint:** blue or green
Color (oil): **Tint (oil):**
Bireflectance:

Anisotropy: isotropic

%R: 27-31 low to mod **VHN:** 251-425
Int'l Reflects.: various shades of red

Polish. Hard.: >>gn; ~cpy;

Comments: Forms myrmekitic intergrowths with gn, stromeyerite, cpy, py, pyrargyrite; cleavage not always discernible; p. 108; 549.

Mineral Name: Tenorite **Chem. Comp.:** Cu.O
Crystall.: mono
Color: gray white **Tint:**
Color (oil): much darker **Tint (oil):** brown cream
Bireflectance: strong, creamy to brownish to yellowish gray

Anisotropy: strong, blue to light creamy gray

%R: 20-25 low **VHN:** 203-254
Int'l Reflects.:

Polish. Hard.: >cc; <cuprite, goethite

Comments: Forms sheaves of acicular xls, concentric aggregates, fine grained mosaics or pseudomorphic; lamellar twinning not uncommon; p. 118; 899.

Mineral Name: Tetradymite **Chem. Comp.:** Bi2.Te2.S
Crystall.: hexagonal
Color: white **Tint:** cream or light yellow
Color (oil): **Tint (oil):**
Bireflectance: weak, greenish tints

Anisotropy: distinct, bluish gray or yellow gray, (perhaps with pinkish or brownish tints)

%R: 53-60 hi (P&J & QDF2) **VHN:** 30-44 (QDF2)
Int'l Reflects.:

Polish. Hard.: <tellurobismutite, wehrlite

Comments: Chemically similar to joseite and grünlingite; may show anhedral texture; a "spindle"-like texture occurs due to folding; forms idiomorphic needle-shaped xls with straight extinction and hexa cross sections; perfect basal cleavage is always present; fine lamellar twinning is rarely visible; p. 248; 436.

Mineral Name: Tetrahedrite **Chem. Comp.:** Cu12.Sb4.S13 (minor Ag, As, Bi, Fe, Hg, Pb, Te, Zn not rare)
Crystall.: cubic
Color: light gray **Tint:** olive green or brown
Color (oil): **Tint (oil):**
Bireflectance:

Anisotropy: isotropic

%R: 31-33 mod **VHN:** 251-425
Int'l Reflects.: brown red

Polish. Hard.: >>gn;~cpy;

Comments: Cleavage not always distinct; zonal texture may be developed by etching; distinguished from stephanite, polybasite, miargyrite by isotropy; much lighter than sl in oil; p. 108; 562.

Mineral Name: Thorianite **Chem. Comp.:** (Th,U,Ce)02
Crystall.: cubic
Color: gray **Tint:** darker than uraninite
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 15 low **VHN:** 920-1235
Int'l Reflects.: red and yellow brown, often visible in oil

Polish. Hard.: >uraninite

Comments: Usually occurs as cubic xls, as rounded grains in alluvial deposits, or as aggregates of these; also as rounded or irregularly shaped grains; twinning or cleavage not observed; p. 196; 1070.

Mineral Name: Tiemannite **Chem. Comp.:** Hg.Se
Crystall.: cibic
Color: white, gray **Tint:** delicate brown
Color (oil): much darker **Tint (oil):** distinctly brown
Bireflectance:

Anisotropy: isotropic

%R: ~30 mod **VHN:** 26-39
Int'l Reflects.:

Polish. Hard.: <clausthalite;<<gn

Comments: Allotriomorphic grains, sometimes enclosed by clausthalite; p. 216; 523.

Mineral Name: Titanomagnetite **Chem. Comp.:** Fe(1-x)Fe(2-2x)Ti(x)O4

Crystall.: cubic

Color: white gray **Tint:** brown

Color (oil): brown **Tint (oil):**

Bireflectance: nil

Anisotropy: isotropic

%R: 17 low **VHN:** 715-734

Int'l Reflects.:

Polish. Hard.: slt>mt

Comments: Homogeneous Ti-mt is only formed by rapid cooling of a high temperature solid solution of mt with ilm or ulvospinel; p. 168.

Mineral Name: Todorokite **Chem. Comp.:** (H2O,...)<=2(Mn,...)<=8(O,OH)16

Crystall.: mono

Color: pale gray **Tint:**

Color (oil): **Tint (oil):**

Bireflectance: weak, shades of gray with yellowish or brownish tints

Anisotropy: strong, white to gray, undulatory extinction

%R: 20-23 low **VHN:**

Int'l Reflects.:

Polish. Hard.:

Comments: Occurs as columnar aggregates, fine fibrous and as irregular masses with botryoidal or layered structure; also as fan- or sheaf-like aggregates of radiating fibers or acicular xlites; cleavage perpendicular to the basal plane and parallel to the elongation; p. 350; 1084.

Mineral Name: Trogtalite **Chem. Comp.:** Co.Se2
Crystall.: cubic
Color: violet blue **Tint:** pink
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 41 mod (P&J) **VHN:**
Int'l Reflects.:

Polish. Hard.: very hard

Comments: Occurs as idiomorphic grains in clausthalite; often radially enveloped by hastite and bornhardtite; p. 218; 819.

Mineral Name: Tungstenite **Chem. Comp.:** W.S2
Crystall.: hexagonal
Color: white gray **Tint:** blue
Color (oil): **Tint (oil):**
Bireflectance: v strong, white to dull gray with a dark bluish tint

Anisotropy: v strong, pinkish white to dark blue

%R: 18-36 (P&J) **VHN:** 15 (on basal sections only)
Int'l Reflects.:

Polish. Hard.: >gn

Comments: Impossible to distinguish from molybdenite; occurs as fine scaly aggregates; also as inclusions in safflorite and skutterudite; basal sections have ~50%R; p. 102; 880.

Mineral Name: Ullmannite **Chem. Comp.:** Ni.Sb.S
Crystall.: cubic
Color: white **Tint:**
Color (oil): **Tint (oil):** blue gray
Bireflectance: nil

Anisotropy: isotropic

%R: 45 mod **VHN:** 460-560
Int'l Reflects.:

Polish. Hard.: >linnaeite; ~gersdorffite; <<py

Comments: Commonly idiomorphically developed; cleavage // (100) often visible; triangular pits may occur, but more rare than in gersdorffite; zonal texture occurs; p. 158; 836.

Mineral Name: Ulvöspinel **Chem. Comp.:** Fe2.Ti.O4
Crystall.: cubic
Color: brown **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 18 low (P&J) **VHN:**
Int'l Reflects.:

Polish. Hard.: >mt

Comments: Rarely as idiomorphic octahedral xls; usually as very fine exsolution bodies in Ti-rich mt, // to (100) and (110) of the mt; these mts may also contain exsolution lamellae of spinel and ilmenite; p. 170; 923.

Mineral Name: Umangite **Chem. Comp.:** Cu3.Se2

Crystall.: tetragonal

Color: violet **Tint:** brown red

Color (oil): nearly red **Tint (oil):**

Bireflectance: v strong, bright violet red to greenish blue-gray

Anisotropy: v strong, (air) orange red to orange yellow; (oil) yellow to dark orange; extinction parallels the cleavage directions

%R: 13-16 low **VHN:** 77-112

Int'l Reflects.:

Polish. Hard.: ~klockmannite

Comments: Always xenomorphic; forms massive or fine-grained aggregates of needle-like and granular xls; two cleavage directions, poorly developed; polysynthetic twinning often wedge-shaped, in several directions; may contain lamellae or veinlets of klockmannite; p. 222; 681.

Mineral Name: Uraninite **Chem. Comp.:** U.O2

Crystall.: cubic

Color: gray **Tint:** brown

Color (oil): much darker **Tint (oil):**

Bireflectance: nil

Anisotropy: isotropic

%R: 17 low **VHN:** 625-929

Int'l Reflects.: v dark brown or reddish brown, not uncommon

Polish. Hard.: very high, >mt; <or=py

Comments: Forms well-developed xls; cleavage // (100) and (111) may be visible; twinning // (111) often occurs; zonal texture very common, may be evident by oriented inclusions; p. 194; 1050.

Mineral Name: Vaesite (see Bravoite, Cattierite) **Chem. Comp.:** Ni.S2 (may contain some Co and Cu)
Crystall.: cubic
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 31 mod **VHN:** 773-856
Int'l Reflects.:

Polish. Hard.: no data

Comments: Ni end member of the bravoite series; occurs as octahedral and cubic xls, and as aggregates; may show cubic cleavage almost as perfect as that of gn; formed by alteration of Ni-skutterudite and other Ni-sulfides and -arsenides; p. 134; 809,815.

Mineral Name: Valleriite **Chem. Comp.:** Cu.Fe.S2.(Mg,Al,Fe)(OH)2
Crystall.: hexagonal
Color: brown **Tint:** bronze
Color (oil): **Tint (oil):**
Bireflectance: v. strong, creamy bronze / grayish pink-violet / bluish gray

Anisotropy: v strong, white to gray bronze

%R: 14-20 low **VHN:** 30
Int'l Reflects.:

Polish. Hard.: <or= graphite (Ramdohr)

Comments: Needle, thread, myrmekite, lath, bleb, star inclusions in cpy, po, and pent; also occurs as fine-laminated or pisolitic aggregates; p. 98; 683.

Mineral Name: Villamaninite **Chem. Comp.:** (Cu,Ni,Co,Fe)S2

Crystall.: cubic

Color: gray **Tint:** idiomorphic (red violet), nodular (blue violet)

Color (oil): **Tint (oil):**

Bireflectance: nil

Anisotropy: isotropic

%R: 25-30 low **VHN:** 440-710

Int'l Reflects.:

Polish. Hard.: >>cpy; >penroseite; ~linnaeite; <bravoite, py

Comments: Idiomorphic form is Cu-rich, whereas the Cu-poor form is nodular; nodular form often surrounds the idiomorphic, the two separated by a rim of bravoite; p. 144; 816.

Mineral Name: Violarite **Chem. Comp.:** (Ni,Fe)3.S4

Crystall.: cubic

Color: white **Tint:** violet cream

Color (oil): **Tint (oil):**

Bireflectance: nil

Anisotropy: isotropic

%R: 42 mod **VHN:** 241-458

Int'l Reflects.:

Polish. Hard.: >cpy, sl; ~pent; slt<bravoite, po; <<aspy, py

Comments: Cubic and octahedral cleavage commonly well-developed; twinning and zonal texture not observed; usually as alteration product, often with braovoite, of pentlandite or millerite; alteration commonly starts along cleavages; p. 132; 697.

Mineral Name: Vonsenite (see Ludwigite) **Chem. Comp.:** (Fe,Mg)2(Fe,Al)B.O5

Crystall.: ortho

Color: gray brown blue **Tint:** pinkish

Color (oil): darker **Tint (oil):** colors more intense

Bireflectance: v strong (air), blue or blue gray to brownish gray to brown or pinkish brown; colors darker in oil

Anisotropy: v strong, blue to pink to reddish brown to fiery orange @ 45 degrees

%R: 10-15 v low to low **VHN:** 707-1003

Int'l Reflects.:

Polish. Hard.: ~mt; <hem

Comments: Occurs as aggregates of polygonal to subrounded grains; sometimes as lath- wedge- and diamond shaped xls, commonly with rounded corners; locally broad twin lamellae may be visible; p. 164; 1094.

Mineral Name: Vrbaite **Chem. Comp.:** Tl4.Hg3.Sb2.As8.S20

Crystall.: ortho

Color: white gray **Tint:** blue

Color (oil): **Tint (oil):**

Bireflectance: ?

Anisotropy: distinct, blue or bluish green to reddish yellow

%R: 30-33 mod **VHN:** ?

Int'l Reflects.: abundant, red

Polish. Hard.: >chalcothallite; <<cuprite

Comments: Anisotropy not as strong as lorandite; occurs as single grains, and as inclusions in chalcothallite; p. 46; 732.

Mineral Name: Vulcanite **Chem. Comp.:** Cu.Te

Crystall.: ortho

Color: yellow white blue **Tint:** yellow white blue

Color (oil): **Tint (oil):**

Bireflectance: v strong, bright yellow or yellow white to medium blue

Anisotropy: v strong, brilliant yellow white, grayish yellow white, yellow orange, gray; extinction // cleavage and elongation of laths

%R: 15-68! low to hi (QDF) **VHN:** 34-40 (QDF2)

Int'l Reflects.:

Polish. Hard.: no data

Comments: Occurs as elongated irregular laths or as equidimensional grains; two cleavages, one // elongation and the other at right angles; extremely thin twinning occurs at 45° to the prominent cleavage; may be secondary; p. 244; 419.

Mineral Name: Vysotskite **Chem. Comp.:** (Pd,Pt,Ni)S

Crystall.: tetragonal

Color: white **Tint:** blue

Color (oil): **Tint (oil):**

Bireflectance: distinct (oil), grayish blue to grayish lilac

Anisotropy: distinct, bluish and brownish

%R: 45 mod **VHN:**

Int'l Reflects.:

Polish. Hard.: high

Comments: Occurs as well-formed prismatic xls; p. 330; 695.

Mineral Name: Wairauite **Chem. Comp.:** Co.Fe
Crystall.: cubic
Color: white **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 54 hi **VHN:** 185-329
Int'l Reflects.:

Polish. Hard.: = awaruite

Comments: Occurs as euhedral xls with cubic or octahedral forms in serpentines; closely associated with awaruite, with which it forms zoned grains; p. 128; 357.

Mineral Name: Wittichenite **Chem. Comp.:** (3.Cu2S)(Bi2.S3)
Crystall.: ortho
Color: gray **Tint:** cream brown
Color (oil): **Tint (oil):**
Bireflectance: weak, only visible at grain boundaries

Anisotropy: distinct (oil), dull brown colors

%R: 33-36 mod (P&J & QDF2) **VHN:** 161-216
Int'l Reflects.:

Polish. Hard.: >>bismuth; >emplectite; ~cc; <cpy, tet, ten,

Comments: Commonly coarse granular; also as acicular and elongated rectangular euhedra; no cleavage or twinning; p. 292; 721.

Mineral Name: Wolframite **Chem. Comp.:** (Fe,Mn)W.O4
Crystall.: mono
Color: gray **Tint:**
Color (oil): **Tint (oil):** faint brown or yellow
Bireflectance: weak to distinct at twin boundaries, gray to brownish gray

Anisotropy: weak to distinct, yellow to gray, sometimes with a violet or green tint

%R: 16-19 low **VHN:** 258-657
Int'l Reflects.: deep red

Polish. Hard.: >mt, scheelite; <<py, aspy, cassiterite

Comments: Forms tabular idiomorphic xls, irregular grains also occur; zoning occurs (growth zones), sometimes with scheelite; cleavage often distinct in two directions; twinning very common; p. 186; 1087.

Mineral Name: Woodruffite **Chem. Comp.:** (Zn,H2O)<=2·(Mn,Zn...)<=8·(O, OH)16
Crystall.: monoclinic
Color: gray **Tint:** yellow
Color (oil): **Tint (oil):**
Bireflectance: distinct, gray to yellowish gray

Anisotropy: v distinct

%R: 26 low **VHN:** 744
Int'l Reflects.:

Polish. Hard.:

Comments: Occurs as very fine grains; alteration product of franklinite; p. 352; 1084.

Mineral Name: Wuestite **Chem. Comp.:** Fe.O
Crystall.: cubic
Color: gray **Tint:** greenish against mt
Color (oil): **Tint (oil):**
Bireflectance: nil

Anisotropy: isotropic

%R: 18 low (QDF2) **VHN:**
Int'l Reflects.:

Polish. Hard.: ~magnetite

Comments: Occurs with magnetite, hematite, goethite and iron as curved bodies in a tuff breccia; also with magnetite and hematite in a natural coke; p. 166; 898.

Mineral Name: Wulfenite **Chem. Comp.:** Pb.Mo.O4
Crystall.: tetragonal
Color: gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: weak, distinct in oil

Anisotropy: obscured by the internal reflections

%R: 17 low **VHN:** 211-233
Int'l Reflects.: colorless, yellow and orange-yellow, strong and abundant

Polish. Hard.: <descloizite

Comments: Occurs as idiomorphic xls and as aggregates in the oxidation zone; p. 144.

Mineral Name: Wurtzite **Chem. Comp.:** Zn.S
Crystall.: hexagonal
Color: gray, like sl **Tint:**
Color (oil): dark gray **Tint (oil):**
Bireflectance:

Anisotropy: nil

%R: 18 low **VHN:** 146-264
Int'l Reflects.: abundant yellow-brown

Polish. Hard.: like sl

Comments: Distinguishable from sl only by X-ray; p. 126; 577.

Mineral Name: Xanthoconite-Pyrostilpnite **Chem. Comp.:** (3.Ag2S)((As,Sb)2.S3)
Crystall.: mono
Color: gray **Tint:** blue
Color (oil): **Tint (oil):**
Bireflectance: similar to proustite-pyrargyrite

Anisotropy: similar to proustite-pyrargyrite

%R: low **VHN:**
Int'l Reflects.: yellowish or yellowish brown

Polish. Hard.: ~proustite and pyrargyrite

Comments: Differs from proustite and pyrargyrite only in internals; p. 258; 789.

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Mineral Name: Zincite **Chem. Comp.:** Zn.O
Crystall.: hexagonal
Color: brown **Tint:** pink
Color (oil): **Tint (oil):**
Bireflectance: masked by the internal reflections

Anisotropy: " " "

%R: 10 v low **VHN:** 150-318
Int'l Reflects.: abundant, yellowish or red

Polish. Hard.: <<franklinite

Comments: Occurs as rounded and xenomorphic grains; cleavage // (0001) may be distinct in not well polished sections; forms oriented intergrowths with hausmannite and manganosite; p. 162; 896.

Mineral Name: Zinkenite **Chem. Comp.:** (PbS)(Sb2S3) or (6PbS)(7Sb2.S3)
Crystall.: hexagonal
Color: white gray **Tint:**
Color (oil): **Tint (oil):**
Bireflectance: weak, but perceptible

Anisotropy: distinct, light gray to dark gray; straight extinction

%R: 38-43 mod **VHN:** 123-207
Int'l Reflects.: rare, dark red

Polish. Hard.:

Comments: Occurs as felted masses of tiny acicular or hair-like xls; as coatings; as vein- and fracture-fillings; or as radial fibrous aggregates; p. 278; 761.