Table 106	**Micas**					
Minerals	*Formula*	*Color/Luster*	*SG*	*H*	*Crystal system/ habit*	*Occurrences*
Biotite for Jean Baptiste Biot (1774-1862), French physicist	$K(Mg, Fe)_3(Al, Fe)Si_3O_{10}(OH,F)_2$	green, black, dark brown, yellow; transparent - opaque; splendent, submetallic, vitreous	2.7 - 3.1	2½ - 3	monoclinic; short prismatic or tabular xls; massive aggregates of cleavable scales	mainly in granites, pegmatites, gabbros, norites, diorites, schists, phyllites, and gneisses
Lepidolite Greek *lepis* = *scale* and *lithos* = *stone* due to its micaceous structure	$K(Li,Al)_3(Si, Al)_4O_{10}(F,OH)_2$	rose-red, violet-gray, lilac, pink, purple, yellowish, grayish white, white; transparent - translucent; pearly	2.8 - 3.3	2½ - 3	monoclinic; tabular xls, thick cleavable masses, coarse to fine scaly aggregates	almost exclusively in granite pegmatites, and less commonly in granites, aplites, and high-temperature tin-bearing veins
Muscovite Muscovy glass, from Muscovy Province, Russia	$KAl_2(AlSi_3O_{10}(OH,F)_2$	colorless, gray, brown, pale green, violet, yellow, dark-olive green, ruby; transparent - translucent; vitreous - pearly or silky	2.77 - 2.88	2½ - 4	monoclinic; tabular xls, hexagonal or diamond-shaped in cross section; commonly lamellar or scaly massive	many geological environments, especially granites and granitic pegmatites; phyllites, schists and gneisses; in dendritic or authigenic sediments
Phlogopite Greek *phlogistos* = *to burn* or *inflame* alluding to its reddish tinge	$KMg_3(AlSi_3O_{10}(OH,F)_2$	yellowish brown, brown to brownish red, colorless, white, greenish; transparent to translucent; pearly	2.76 - 2.90	2 - 2½	monoclinic; prismatic xls, usually tapered, often long and course	in metamorphic limestones and ultrabasic rocks
Roscoelite Henry Enfield Roscoe (1833-1915), English chemist who first prepared pure vanadium	$K(V, Al,Mg)_2AlSi_3O_{10}(OH)_2$	clove brown to greenish brown, dark green; translucent; pearly	2.97	2½	monoclinic; minute scales	interlaminated with native gold; assoc. with telluride minerals, and with uranium-vanadium deposits
Zinnwaldite Zinnwald, Bohemia, named for the local tin (German Zinn) veins	$KLiFe^{+2}Al(AlSi_3)O_{10}(F,OH)_2$	gray, brown, sometimes dark green; transparent; vitreous	2.9 - 3.3	2½ - 4	monoclinic; short prismatic or tabular xls; disseminated scales or scaly aggregates	mainly in greisens, high-temperatu quartz veins, and in granite pegmatites.
Source: various including Roberts et al., 1990						

Consumption of ground mica in the United States
(tonnes)

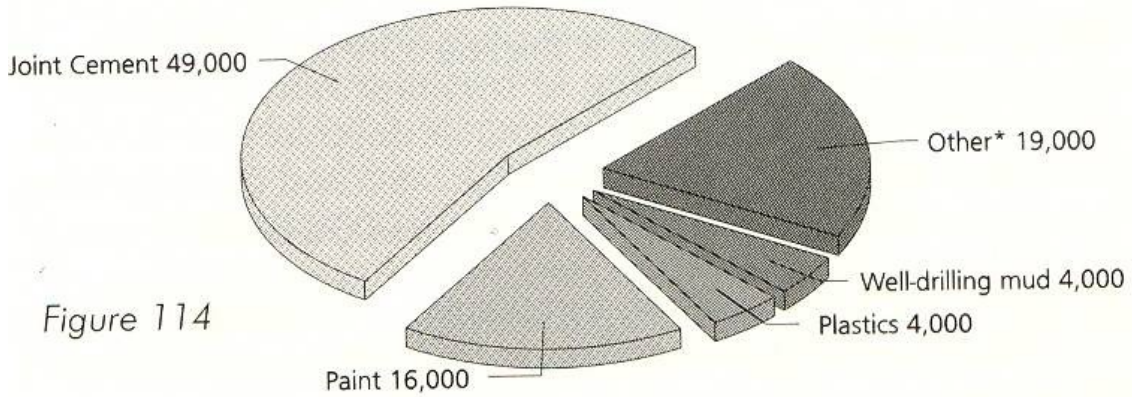


Figure 114

* includes mica used for molded electrical insulation, rubber, textile and decorative coatings, welding rods, and miscellaneous.

Source: USBM.

Grossularite Almandite

Table 73 Garnets

Minerals	*Formula*	*Color/Luster*	*SG*	*H*	*Crystal system/ habit*	*Occurrences*
Almandite Alabanda, Asia Minor, where garnets were cut and polished	$3FeO \cdot Al_2O_3 \cdot SiO_2$	deep red, brownish red & black; transparent - translucent; vitreous - resinous	4.1 - 4.3	7 - 7½	cubic; dodecahedrons or trapezohedrons; massive & compact, coarse granular	schists, gneiss, other metamorphic rocks; contact zones & some igneous rocks; detrital mineral in sedimentary deposits
Andradite J.B.d'Andrada e Silva (1763-1838), Brazilian mineralogist	$3CaO \cdot Fe_2O_3 \cdot SiO_2$	yellowish green, greenish brown, reddish brown, grayish black, black; transparent - opaque; vitreous - resinous	3.7 - 4.1	6½ - 7	cubic; dodecahedrons or trapezohedrons; massive & compact, coarse granular	chlorite schist and serpentinite; alkaline igneous rocks (melanite); metamorphosed limestone. or contact zones
Grossularite Latin *grossularium* = *gooseberry* for its pale green color	$3CaO \cdot Al_2O_3 \cdot SiO_2$	colorless, white, gray, yellow, yellowish brown, pink, red, green, black; transparent - opaque; vitreous - resinous	3.4 - 3.6	6½ - 7	cubic; dodecahedrons or trapezohedrons; massive, compact, fine or coarse granular	metamorphosed impure calcareous rocks, especially in contact zones, assoc. with wollastonite, idocrase, diopside, scapolite, and calcite; certain schist and in serpentine
Pyrope Greek pyr = fire and ops = eye due to its fire-red color	$3MgO \cdot Al_2O3 \cdot SiO_2$	pinkish red, purplish red, orange-red, deep crimson to nearly black; transparent - translucent; vitreous	3.5 - 3.8	6½ - 7½	cubic; usually dodecahedrons or trapezohedrons, often as rounded pebbles or embedded grains	peridotites and assoc. serpentinites, and sands & gravels derived from them; eclogites, hornblende-garnet-plagioclase rocks, Precambrian anorthosites, diamond-bearing peridotites
Spessartite Spessart in northwestern Bavaria, Germany	$3MnO \cdot Al_2O_3 \cdot SiO_2$	brownish-red to red, reddish orange, yellowish brown; transparent - translucent; vitreous	3.8 - 4.3	7 - 7½	cubic; usually dodecahedrons or trapezohedrons; often striated; massive and compact, or coarse granular	granite pegmatites, gneiss, quartzite, schist, and lithophysae in rhyolite, skarn deposits
Uvarovite Count Sergei Semeonovich Uvarov (1786-1855), Russian nobleman, St. Petersburg	$3CaO \cdot Cr_2O_3 \cdot SiO_2$	emerald green; transparent - translucent; vitreous	3.4 - 3.8	6½ - 7	cubic; usually dodecahedrons or trapezohedrons, often striated	in assoc. with chromite is serpentine, in skarn deposits, and metamorphosed limestone

Source: various including Roberts et al., 1990

Table 75	Grain Sizes of Commercial Garnet
End use	***Size ranges (mm)***
Sand blasting	1.1, 0.5, 0.6/0.4, 0.4/0.2, 0.3/0.15
Water filtration	2.5/1.7, 1.1, 1.4/0.6, 0.5, 0.6/0.4, 0.4/0.2
Water jet cutting	1.0/0.3, 0.25/0.18, 0.18, 0.15, 0.18/0.85, 0.12/0.06
Coated abrasives	0.34/0.1, 0.08/0.036
Polishing/lapping	0.15/0.18, 0.10/0.15, 0.030, 0.010
Single grain size indicates mean particle size	

Consumption of almandite garnet in the United States

(tonnes)

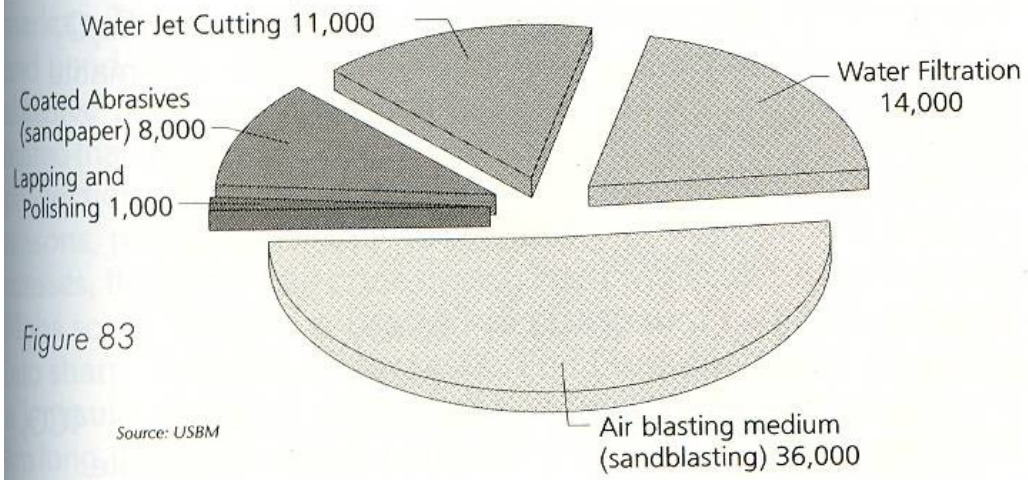


Figure 83

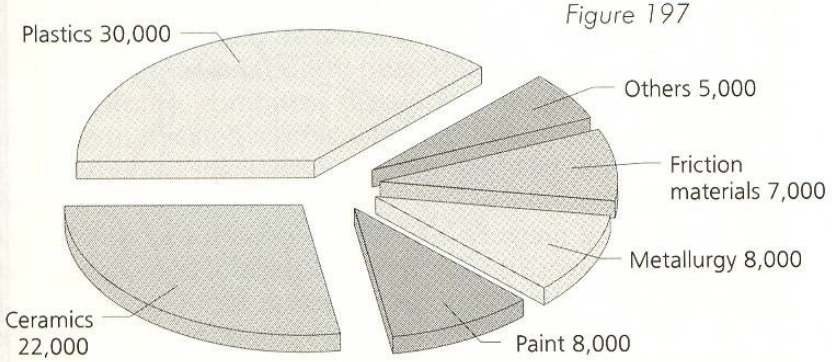
Source: USBM

Minerals	Formula	Color/Luster	SG	H	Mullitization/ vol. change	Crystal system/ habit	Occurrences
Andalusite locality at Andalusia, Spain	Al_2SiO_5 63.2% Al_2O_3 36.8% SiO_2	pink, reddish brown, rose red, grayish, whitish; transparent - nearly opaque; vitreous to subvitreous	3.13 - 3.16	6½ - 7½	1,380°C +5%	orthorhombic; prismatic xls, nearly square in x section; usually coarse; massive, compact	slates and argillaceous schists (contact); mica schist, gneiss, and related rocks (detrital); granites, granitic pegmatites
Dumortierite Eugène Dumortier (1802 - 1873), French paleontologist	$Al_7(BO_3)(SiO_4)_3O_3$	blue, violet, pinkish, brown; transparent - translucent; vitreous - dull	3.4	8½		orthorhombic; rare prismatic xls usually massive, columnar, fibrous, or granular	aluminum-rich metamorphic rocks and rarely pegmatites
Kyanite (disthene) Greek *kyanos = dark blue* reflecting its color	Al_2SiO_5 63.2% Al_2O_3 36.8% SiO_2	blue, white, gray, green, yellow, pink, or nearly black; transparent to translucent; vitreous to pearly	3.5 - 3.67	4 - 7½	1,350°C +18%	triclinic; long bladed xls, flattened	paragonite schists, gneiss, granite and granitic pegmatites
Mullite the island of Mull, Scotland	$3Al_2O_3{\cdot}2SiO_2$	colorless to pale pink; transparent to translucent; vitreous	3.03 - 3.6	6 - 7	–	orthorhombic; prismatic xls	in fused argillaceous inclusions in Tertiary eruptive rocks on Isle of Mull; in slags and firebricks upon heating
Sillimanite Professor Benjamin Silliman (1779-1864), American mineralogist, Yale	Al_2SiO_5 63.2% Al_2O_3 36.8% SiO_2	colorless, white to gray, yellowish, brownish, greenish, bluish; transparent - translucent; vitreous - silky	3.23 - 3.7	6½ - 7½	1,550°C +7%	orthorhombic; long prismatic xls; massive, fibrous to columnar, fine needle-shaped (hence "fibrolite" synonym)	schists, gneisses, and granites; detrital deposits
Topaz Greek Topazion, an island in the Red Sea, meaning to seek since it was often obscured by mist; Sanskrit *tapas = fire*	$Al_2SiO_4(F,OH)_2$	colorless, white, gray, bluish, greenish, yellowish, yellow-brown to orange, purple, pinkish to reddish; transparent to translucent; vitreous	3.49 - 3.57	8		orthorhombic; short to long prismatic xls, also massive, coarse to fine granular	pegmatites and high-temperature quartz veins; cavities in granites and rhyolites; contact zones; alluvial deposits

Source: *various including Roberts et al., 1990*

Wollastonite consumption in the United States

Figure 197



simple:

$SiO_2 + CaCO_3 \Leftrightarrow CaSiO_3 + CO_2$
quartz calcite wollastonite carbon dioxide

The temperature of this "wollastonite reaction" increases with pressure in a closed system, from which carbon dioxide cannot escape (at 506 MPa P_{CO2} at a temperature of almost 800°C). However, in an open system the temperature of wollastonite formation decreases slightly with rising pressure (at 506 MPa P_{CO2} the temperature is about 420°C). Triclinic a-wollastonite forms at 450°C and almost any pressure, and converts into triclinic pseudowollastonite (β-$CaSiO_3$) at 1,120 - 1,160°C. This occurs only in synthetic wollastonite products in ceramics, slags, cin-

Table 189 **Wollastonite**

Minerals	*Formula*	*Color/Luster*	*SG*	*H*	*Crystal system/ habit*	*Occurrences*
Wollastonite for William Hyde Wollaston (1766-1828), English chemist and mineralogist	$CaSiO_3$ 48.3% CaO 51.7% SiO_2	White, yellowish; vitreous to pearly luster	2.8 - 2.9	4.5 - 5.0	coarsely bladed crystalline masses that break down into acicular cleavage fragments	contact metasomatic or skarn; detrital deposits
Pseudo-wollastonite	β-$CaSiO_3$ 48.3% CaO 51.7% SiO_2	Colorless; transparent, vitreous	2.9	5	triclinic; equant grains, twinning	pyrometamorphosed Tertiary rocks

Source: various including Roberts et al., 1990