Pyroxenoid Group

$X_3Si_3O_9$  

$X$ is a large-radius divalent cation, typically Ca, Mn, or Fe. The symmetry is usually triclinic and results from a mismatch between the sizes of the divalent cation and the silicate chain. The repeat integer $n$, increases as the mean size of the divalent cation decreases. For wollastonite and bustamite, $n = 3$; for rhodonite, $n = 5$, for pyroxmangite and pyroxferroite, $n = 7$, and for ferrosilite III, $n = 9$. In addition to the above anhydrous pyroxenoids, there is also a series of hydrous pyroxenoids in which Na+H substitute for one of the divalent cations giving us pectolite (NaH$Ca_2Si_3O_9$) and serandite (NaHMn$Si_3O_9$).

Pyroxenoid End Members

<table>
<thead>
<tr>
<th>Member</th>
<th>Wollastonite</th>
<th>Rhodonite</th>
<th>Pyroxferroite</th>
<th>Pyroxmangite</th>
<th>Ferrosilite III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formula</td>
<td>$Ca_3Si_3O_9$</td>
<td>$Mn_3Si_3O_9$</td>
<td>$Fe_3Si_3O_9$</td>
<td>$X_3Si_3O_9$</td>
<td>$Ca_3Si_3O_9$</td>
</tr>
<tr>
<td>Crystal System</td>
<td>Triclinic</td>
<td>Triclinic</td>
<td>Triclinic</td>
<td>Triclinic</td>
<td>Triclinic</td>
</tr>
<tr>
<td>$a$</td>
<td>3.98</td>
<td>3.88</td>
<td>3.84</td>
<td>3.80</td>
<td>3.98</td>
</tr>
<tr>
<td>$c$</td>
<td>9.54</td>
<td>9.38</td>
<td>9.40</td>
<td>9.40</td>
<td>9.54</td>
</tr>
<tr>
<td>Volume ($Å^3$)</td>
<td>2807</td>
<td>2740</td>
<td>2807</td>
<td>2810</td>
<td>2810</td>
</tr>
<tr>
<td>Density (kg/m$^3$)</td>
<td>3.0</td>
<td>3.0</td>
<td>2.9</td>
<td>2.9</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Pyroxenoid Occurrences

*Ferrosilite*: Found in basic and ultrabasic igneous rocks.

*Bustamite*: In manganese ores formed by metamorphism of manganese-bearing sediments with attendant metasomatism.

*Rhodonite*: Hydrothermal, metamorphic and, metasomatic rocks.

*Pyroxferroite*: Gabbroic rocks. Forms a series with pyroxmangite.

*Pyroxmangite*: Metamorphic and contact metasomatism of Mn-bearing rocks. Forms a series with pyroxferroite.
**Pyroxenoid Uses**

**Wollastonite:** Wollastonite is an industrially important mineral. It is a necessary ingredient in heat-resistant refractory ceramics and is used as a filler in paint. It is also used in the manufacture of paper and plastics.

**Rhodonite:** Rhodonite is a popular mineral among collectors. It is also a minor gemstone, being cut and polished into cabochons, beads, and other ornamental objects. Rhodonite is also a minor ore of manganese.

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**Pyroxenoid: Bustamite**

Physical Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>brown red, light pink, or pink.</td>
</tr>
<tr>
<td>Density</td>
<td>3.32 - 3.43, Average = 3.37</td>
</tr>
<tr>
<td>Diaphanity</td>
<td>Transparent to Translucent</td>
</tr>
<tr>
<td>Hardness</td>
<td>5-6.5</td>
</tr>
<tr>
<td>Luster</td>
<td>Vitreous (Glassy)</td>
</tr>
<tr>
<td>Streak</td>
<td>white</td>
</tr>
</tbody>
</table>

**Optical Properties**

- Optical Data: Biaxial (-), a=1.64-1.695, b=1.651-1.708, g=1.653-1.71, birefringence=0.0130-0.0150, 2V(Calc)=44-50, 2V(Meas)=40. Dispersion r > v distinct.
- Pleochroism (x): colorless.
- Pleochroism (y): colorless.
- Pleochroism (z): colorless.

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**Pyroxenoid: Wollastonite**

Physical Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>white, yellow, gray, red, or brown.</td>
</tr>
<tr>
<td>Density</td>
<td>2.8 - 2.9, Average = 2.84</td>
</tr>
<tr>
<td>Diaphanity</td>
<td>Subtransparent to translucent</td>
</tr>
<tr>
<td>Hardness</td>
<td>5 - Apatite</td>
</tr>
<tr>
<td>Luster</td>
<td>Vitreous - Silky</td>
</tr>
<tr>
<td>Streak</td>
<td>white</td>
</tr>
</tbody>
</table>

**Optical Properties**

- Optical Data: Biaxial (-), a=1.615-1.646, b=1.627-1.659, g=1.629-1.662, birefringence=0.0140-0.0160, 2V(Calc)=34-38, Dispersion r > v distinct.
- Pleochroism (x): colorless.
- Pleochroism (y): colorless.
- Pleochroism (z): colorless.
**Pyroxenoid: Rhodonite**

Physical Properties
- Cleavage: (110) Perfect, (111) Poor
- Color: pink, rose red, brownish red, or yellow.
- Density: 3.5 - 3.7, Average = 3.6
- Diaphanous: Transparent to translucent
- Hardness: 6 - Orthoclase
- Luster: Vitreous (Glassy)
- Streak: White

Optical Properties
- Optical Data: Biaxial (+), a=1.711-1.738, b=1.714-1.741, g=1.724-1.751, birefringence=0.0130, 2V(Calc)=58, 2V(Meas )=58-73.
- Pleochroism: x, yellow, y, z, colorless.
- Pleochroism: x, y, z, colorless.

**Pyroxenoid: Pyroxferroite**

Physical Properties
- Cleavage: (110) Perfect, (010) Poor, (001) Poor
- Color: colorless, yellow, orange, or pink orange.
- Density: 3.68 - 3.76, Average = 3.72
- Diaphanous: Transparent to translucent
- Hardness: 4.5-5.5
- Luster: Vitreous (Glassy)
- Streak: White

Optical Properties
- Optical Data: Biaxial (+), a=1.746-1.756, b=1.75-1.758, g=1.764-1.768, birefringence=0.0120-0.0180, 2V(Calc)=50-58, 2V(Meas )=30-40.

**Pyroxenoid: Pyroxmangite**

Physical Properties
- Cleavage: (110) Perfect, (111) Perfect
- Color: pink, rose pink, purple pink, yellowish red brown, or brown.
- Density: 3.8
- Diaphanous: Transparent to translucent
- Hardness: 5.5 - 6 - Knife Blade-Orthoclase
- Luster: Vitreous - Pearly
- Streak: White

Optical Properties
- Optical Data: Biaxial (+), a=1.726-1.748, b=1.728-1.75, g=1.744-1.764, birefringence=0.0160-0.0180, 2V(Calc)=40-42, 2V(Meas )=35-46. Dispersion r > v moderate.
Pyroxenoid: Ferrosilite III

Physical Properties
Color: Colorless, green, dark brown, or nearly black.
Cleavage: 210, Good, 100, Parting
Density: 3.96 - 4.02, Average = 3.95
Diaphanecty: Translucent to opaque
Habit: Anhedral to acicular, lunular, with round ends, in clusters of granular variety
Hardness: 5 - 6 - Between Apatite and Orthoclase
Luster: Vitreous
Streak: pale brown

Optical Properties
Optical Data: Index, n: 1.71-1.767, b: 1.723-1.77, g: 1.726-1.788,
Birefringence: 0.0160-0.0210
Pleochroism: (x): pinkish brown, (z): greenish brown

From: http://www.webmineral.com/data/Ferrosilite.shtml

Wollastonite Elasticity

Figure 1. (a) MO-simulated pressure dependence of volume (V) of cubic crarnellite, wollastonite, dolomite, and anorthite liquids at 1900 K. (b) Simulated temperature dependence of volume of the four liquids at 0 GPa.

Wollastonite Elasticity

Table 1. MO Simulated Molar Volumes, T. Amounts to & Pressures Determined with a K [Mo:K], (eGPa) and Volume Thermal Expansions, in. of Crarnellite, Wollastonite, Dolomite, and Anorthite Liquids at 1900 K (0 GPa). Compiled from Observations at High Temperatures and 0 GPa.

<table>
<thead>
<tr>
<th></th>
<th>a (GPa)</th>
<th>b (GPa)</th>
<th>c (GPa)</th>
<th>T (K)</th>
<th>V (cm^3/mol)</th>
</tr>
</thead>
</table>

From: Hearing (1989)