Garnets are diverse compositionally, physically, and in mode of occurrence:
- the garnet structure accommodates cations with a wide range of sizes and valence states
- cation ordering lowers symmetry
  (Takeuchi and Haga, 1976)

The color ranges from white through shades of Red, brown, yellow and green, to black.

Stable phases in a wide range of pressures, temperatures, and chemical environments.

Garnet Structure

Crystal system = Isometric
Point group/crystal class = 4/m –3 2/m
Space group = Ia 3d
a=11.459-12.058
Z=8
Garnet Structure

Site   X   Y   Z
C. N.  8   6   4

Fractional Coordinate

x   1/8   0   3/8
y   0   0   0
z   1/4   0   1/4

Garnet End-Members

(Winchell, 1933)

- **Ugrandite Group**
  - Uvarovite \( \text{Ca}_3\text{Cr}_2(\text{SiO}_4)_3 \)
  - Grossular \( \text{Ca}_3\text{Al}_2(\text{SiO}_4)_3 \)
  - Andradite \( \text{Ca}_3\text{Al}_2(\text{SiO}_4)_3 \)

- **Pyrralspite Group**
  - Pyrope \( \text{Mg}_3\text{Al}_2(\text{SiO}_4)_3 \)
  - Almandine \( \text{Fe}_3\text{Al}_2(\text{SiO}_4)_3 \)
  - Spessartine \( \text{Mn}_3\text{Al}_2(\text{SiO}_4)_3 \)

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Figure 3. A ternary temperature-pressure plot of reaction trends for the six common garnet end-members: 1. coesite-epidote-garnet, 5. coesite-epidote-spessartine, 5. websterite-melanite, melilitine and spinel-inclusion garnets, 5. melilitine-grossularite. Bold lines indicate the temperature-pressure trends for the reactions. The isopleths of garnet are solid and continuous. Data from Harker (1972).
Garnet Occurrences

Pyrope
- mineral of the upper mantle
- ultra-basic rocks
- common garnet in metamorphic rocks
- regional metamorphism of argillaceous sediments
- Spessartine
- occurs in skarn deposits and Mn-rich deposits

Almandine
- common garnet in metamorphic rocks
- regional metamorphism of impure limestones

Spessartine
- occurs in skarn deposits and Mn-rich deposits

Grossular
- contact or regional metamorphism of impure limestones

Andradite
- may be the result of metamorphism of impure siliceous environments similar

Uvarovite
- rarest of garnets
- found in serpentinite associated with chromite

Compression of Garnet at 300K

<table>
<thead>
<tr>
<th>End Member</th>
<th>Pyrope</th>
<th>Grossular</th>
<th>Andradite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pmax (GPa)</td>
<td>5.6</td>
<td>6.1</td>
<td>19.0</td>
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</tbody>
</table>

Site bulk moduli (GPa)

<table>
<thead>
<tr>
<th></th>
<th>x</th>
<th>y(Al)</th>
<th>z(Si)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P&lt;sub&gt;a&lt;/sub&gt;</td>
<td>130(30)</td>
<td>220(30)</td>
<td>300(100)</td>
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<tr>
<td>P&lt;sub&gt;Si&lt;/sub&gt;</td>
<td>115(33)</td>
<td>320(33)</td>
<td>300(100)</td>
</tr>
</tbody>
</table>

Reference

Hazen & Finger (1989)
Hazen & Finger (1978)
Hazen & Finger (1989)
Garnets are differentiated by slight variations in color, density, and index of refraction.

- They have high indices of refraction
- Range of beautiful colors
- Transparent
- Lack cleavage and are durable

Thus, make good candidates for gemstones
- Semi-precious
- Abundant
- Not as hard as other gemstones