Garnet: The effect of composition and zoning on crystal shape

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Introduction

Garnets are commonly found in metamorphic rocks. Garnets ($X_3Y_2Si_3O_{12}$) can have a variety of chemical compositions even within a single crystal (e.g. Spear et. al., 2001). The composition of garnets can change during growth, this is known as zoning. Garnets crystallize in a number of different shapes including rhombic dodecahedron and trapezoidal (Deer et. al., 1992). Rhombic dodecahedron is the more common shape for pyrope (Mg), almandine (Fe), and spessartine (Mn) garnets while trapezoidal is more commonly the shape of grossular (Ca) garnets. The substitutions of Ca, Mg, Fe, and Mn in the X site and its effects on certain characteristics of the garnets, specifically the shape, is the focus this research.

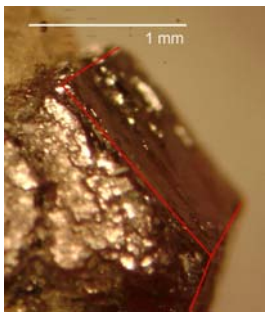


Image of GRT-Amp-1 with a binocular microscope. The red lines highlight the rhombic docedahdron crystal shape.

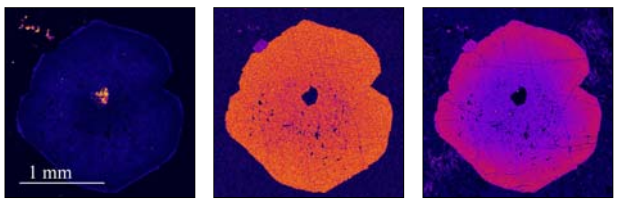
Methods

For this study we examined eight samples from a variety of different rock types. The garnets within the samples also had a variety of shapes, sizes and compositions.
Garnet shapes were determined from mechanical separation and microscope analysis (left). Chemical compositions of the garnets were obtained with a JEOL 8900 electron microprobe in the Department of Geology and Geophysics at the University of Minnesota.

Results

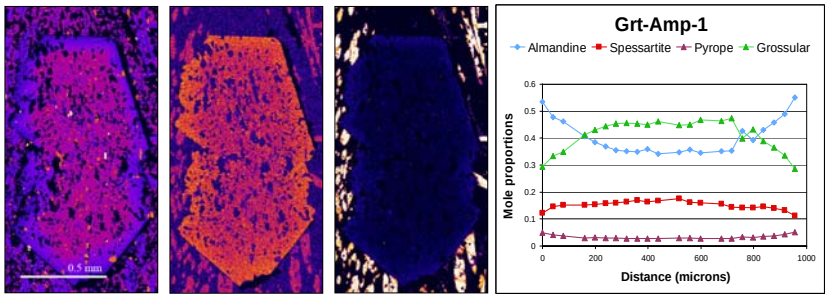
After detailed compositional analysis the samples can be categorized into four groups based on composition and zoning of the garnets.

- **Group 1**, indicated with red on the triplot to the right, contains samples with garnets that are less than 0.10 mol fraction grossular and strongly zoned. Strongly zoned being defined as a having a minimum of 0.05 mol fraction difference between the core and the rim in at least one component, i.e. almandine, grossular, spessartine, or pyrope.
- **Group 2**, indicated with blue points, contains samples with garnets that are weakly zoned and are less than 0.10 mol fraction grossular.
- **Group 3**, indicated with magenta points, contains samples with garnets that are strongly zoned and are more than 0.25 mol fraction grossular.
- **Group 4**, indicated with green points, contains samples with garnets that are weakly zoned and are more than 0.25 mol fraction grossular.



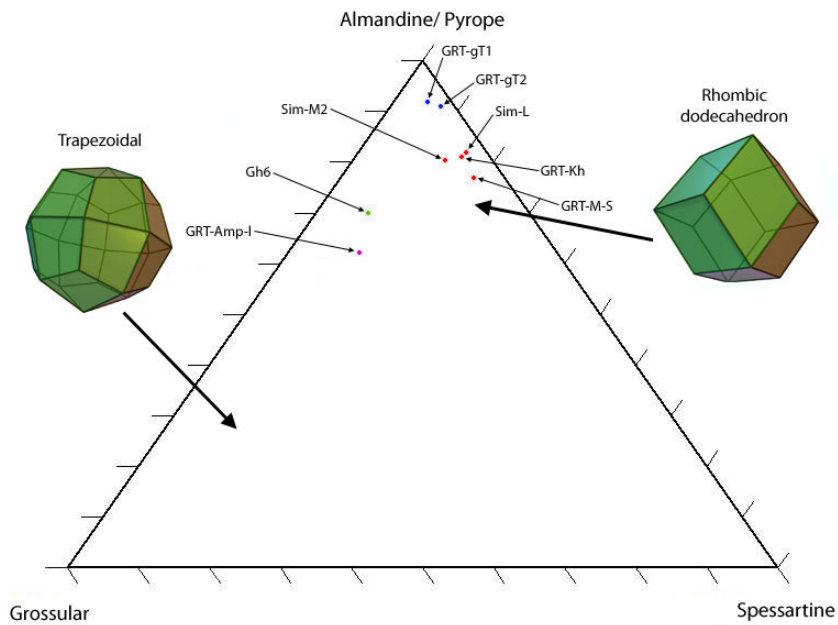
Electron microprobe composition maps of Sim-L (Ca, Fe, Mg from left to right)

Electron microprobe composition maps of Grt-Amp-1 (Ca, Fe, Mg from left to right) and a plot of the mole percents of Fe, Mn, Mg, Ca as a function of distance across the grain.



Discussion

- **Ca ions are larger than Mg, Fe, and Mn ions, thus the garnet structure is slightly distorted when there is calcium present.**
- **Based purely on composition it could be extrapolated that the garnets from group 1 and group 2 should display a rhombic dodecahedron shape and group 3 and group 4 are garnets that should display a trapezoidal shape.**
- **Thorough shape analysis has provided evidence that all of the garnets examined in this study are of the shape rhombic dodecahedron.**
- **This implies that the crystal habit of garnet transitions from rhombic dodecahedron to trapezoidal at a composition that is more calcium rich than any sample examined in this study.**



References

Spear, F.S. and Daniel, C.G. (2001) Diffusion control of garnet growth, Harpswell Neck, Maine, USA. *Journal of Metamorphic Geology*, 19, 179-195.

Deer, W.A., Howie, R.A. and Zussman, J. (1992) *An introduction to the rock forming minerals -2nd ed*. Pearson Education Limited, New York.

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