Original Garnet EMP Analyses

While compiling samples for this dataset, we identified a clear discrepancy in the number of mineral species represented (Fig. 1). To mitigate this concern, we analyzed samples to identify differences across specific mineral species with samples that contained both locality information and paragenesis, as well as samples that were unknown. The samples were chosen to identify gaps and inconsistencies in specific mineral species, compositions, and paragenetic modes in the existing dataset.

The mineral samples chosen contained a green grossular, orange grossular, spessartine, black andradite, pyrope, and visibly zoned uvarovite as well as garnet grains taken from rock samples of an unknown eclogite, garnet staurolite schist, and almandine schist, which were donated by Dr. Julia Nord at George Mason University and Dr. Robert Hazen from his private collection. The samples were analyzed for their major oxide components and a majority of the samples yielded expected results for their total weight percent. The average major oxide compositions of each sample and major inclusions are recorded in Supplement B. EMP samples, zoned areas, and inclusions were analyzed based on the current IMA classification of the garnet group. The black andradite sample, zoned uvarovite, and garnet staurolite yielded unexpected values.

The black andradite sample was originally measured for FeO and systemically reported a low total oxide average of 95.38 wt%. As a result, the sample was recalculated including both Fe_2O_3 and FeO which reported a more acceptable total oxide average of 97.97 wt% with a standard deviation of 0.43 wt% across 35 point analyses. A few points originally chosen for analysis had a low weight percent total and may have a poor location on the grains, thus, an additional 10 points were chosen to verify the results. Given a consistently low total wt%, we performed a spectrum analysis to identify if any major elements were missing from the analysis, which came back negative. Therefore, we hypothesize that the sample may be hydrated or have a large total concentration of several trace elements. The main oxides that comprise this sample are 35.13 wt% SiO_2, 32.03 wt% CaO, and 24.44 wt% Fe_2O_3 with secondary components of 3.78 wt% Al_2O_3 and 1.35 wt% FeO as well as less than 1.00 wt% of TiO_2, MgO, Na_2O, K_2O, MnO, and Cr_2O_3.

The uvarovite sample was visibly zoned from a black core to an outer bright green rim. A total of 49 point analyses were taken in a direct line from the core to rim and across two inclusions. The main uvarovite grain, excluding the inclusions, has an average of 38.46 wt% SiO_2, 34.33 wt% CaO, 17.10 wt% Al_2O_3, and 6.21 wt% Cr_2O_3. The inclusions in the uvarovite grain appeared light and dark in the EMP in comparison to the surrounding grain and were labeled as such the dataset. A light inclusion in the grain's middle zone has an average of 0.02 wt% SiO_2 content, below the required amount to be classified as a garnet. The main components of the inclusion are 66.12 wt% Cr_2O_3, 20.20 wt% Fe_2O_3, 8.24 wt% MgO, and 4.66 wt% Al_2O_3. Thus, this could be an inclusion of chromite within the uvarovite grain due to the high Cr_2O_3 and low SiO_2 contents. In addition, the chromite inclusion's distinct chemical composition tends to show higher concentrations of Fe_2O_3, MgO, and TiO_2. The composition of the dark inclusion in the uvarovite sample includes an average of 48.64 wt% SiO_2, 22.77 wt% CaO, 13.09 wt% MgO, 8.20 wt% Al_2O_3, 2.66 wt% Cr_2O_3, and

2.28 wt% FeO. A few uvarovite samples, most likely the dark inclusion, display high MgO and FeO concentrations. The dark inclusion could be a calcic pyroxene which typically features 49 wt% SiO_2 and 23 wt% CaO.

The garnet staurolite schist sample was chosen as these two minerals are commonly associated in nature. The garnet grains from this rock sample are euhedral, purple dodecahedrons, which were isolated for EMP analysis. The main components of the garnet staurolite schist grains include an average of 36.53 wt% SiO_2, 21.04 wt% Al_2O_3, 36.03 wt% FeO, with minor 2.64 wt% MgO, 1.15 wt% CaO, 1.36 wt% MnO. However, the sample also has a high FeO content of 36.03 wt%, just shy of the almandine sample, which recorded an average of 36.13 wt% excluding the inclusions. This sample from the garnet staurolite schist is most similar in composition to the almandine analyses with a maximum difference of 0.33 wt% SiO_2 and 0.84 wt% MgO.

The green and orange grossular samples were chosen to identify whether color would have a significant impact on the composition of major oxides. Yet, the average concentration for each major oxide examined is within 0.75 wt% for each sample with the largest discrepancies in FeO, Al_2O_3, and MnO; therefore, major-element composition was not a controlling factor in the color of the sample. The green and orange grossular contain 38.99 wt% and 39.09 wt% SiO_2, respectively. The major oxides comprising the composition of the grossular samples include SiO_2, CaO, Al_2O_3, and minor components of Fe_2O_3, FeO, and MnO.

The spessartine sample did not feature any visible inclusions, however, two point analyses indicate a significantly different chemistry. Excluding those two points, the average SiO_2 content is 39.04 wt%, compared to 53.92 wt% for the two analyses, which is consistent with diopsidic calcic pyroxene. The average Al_2O_3 content of the garnet is 19.15 wt% while the inclusion contains 1.08 wt%, the average MgO content is 0.82 wt% in the garnet and 17.68 wt% in the inclusion, and finally the average CaO content of the garnet is 35.53 wt% while the inclusion contains only 24.95 wt%. The spessartine sample overall is largely characterized by SiO_2, CaO, and Al_2O_3 with some Fe_2O_3 while the inclusion is likely diopside which typically contains ~55 wt% SiO_2, 25 wt% CaO, and 18 wt% MgO with Fe, Cr, Al, or Ti impurities and commonly occurs in association with garnet (Deer et al., 1982).

The eclogite sample was chosen due to the high proportion of eclogites featured in the overall dataset despite not identifying a mineral species name upon selection. The red garnet grains were identified in the rock sample and separated for EMP analysis. The grain features an average SiO_2 content of 41.81 wt%. The composition of the garnet grain selected records an average Al_2O_3 content of 21.56 wt%, 20.25 wt% MgO, 7.83 wt% FeO, 4.36 wt% CaO, 2.10 wt% Cr_2O_3, 0.60 wt% Fe_2O_3, 0.56 wt% TiO_2, 0.32 wt% MnO, 0.08 wt% Na_2O, and finally 0.01 wt% K_2O. The garnet grain from the eclogite sample is mainly composed of SiO_2, Al_2O_3, MgO, with components of FeO and CaO, thus, the sample is likely pyrope, which commonly incorporates iron, calcium, and manganese impurities.

We chose a pyrope sample as we originally thought there were few represented in the dataset despite being a major end-member species. However, EarthChem consists of a majority of pyropes based on the calculation of end-member species using the spreadsheets from Locock (2008) and Grew et al. (2013). The averages of the major oxides in our pyrope sample include 38.92 wt% SiO_2, 22.56 wt% Al_2O_3, 20.51 wt% FeO, with secondary components of MgO and CaO. The sample has a notably wide range of MgO and FeO values. MgO has an average of 8.79 wt% with a standard deviation of 1.36 wt% and FeO has a standard deviation of 1.77 wt%. This pyrope sample has a significant iron concentration in its overall composition. An additional three point analyses were taken of an ‘Pyrope Unknown’ sample, which was used as a control and standardized the EMP; these point analyses are excluded from the pyrope sample analysis calculations.

The almandine schist sample was chosen due to the frequency of almandine present in regional metamorphism. Small, euhedral grains were isolated from the schist for EMP analysis. The almandine grain contained two visible inclusions: light and dark inclusions with distinct boundaries. These inclusions were labeled as such by how they appear under the EMP. The average SiO_2 content of the main grain is 36.20 wt% while the light inclusion contains 0.07 wt%. The dark inclusion has a range of SiO_2 content from 35.72 wt% to 99.46 wt%. The main almandine grain exhibits an average 36.20 wt% SiO_2, 36.13 wt% FeO, and 20.91 wt% Al_2O_3. The light inclusion contains a high proportion of TiO_2 at 51.79 wt% and 45.31 wt% FeO with a low composition of other oxides. This composition is indicative of a titanium-iron rich inclusion, potentially a variant of iron-rich ilmenite. Meanwhile, the dark inclusion contains a wide range of values for TiO, FeO, and MnO with an average composition of 72.76 wt% SiO_2, 15.09 wt% FeO, and 8.91 wt% Al_2O_3 thus it is likely an inclusion of silica in the almandine grain.

The averages for the major oxides measured in EMP analysis of each grain is reported in Supplement B for comparison while the geochemical data for all of the original sample analyses and calculations are included in the dataset within the “Original EMPA Calculations” sheet. The obvious inclusions within the garnet grains are excluded from the main dataset. The compositions of the two unknown garnet grains, from the eclogite rock sample and the garnet staurolite schist, were compared to the composition of known garnet species. The grain obtained from the eclogite does not closely resemble any of the previously analyzed species. This grain is most likely a sample of pyrope owing to the high amounts of SiO_2, MgO, and Al_2O_3 with the common FeO and CaO impurities. This grain compared to the analyzed pyrope sample is relatively similar within 2.89 wt% SiO_2 and 1.00 wt% Al_2O_3; however, they feature opposite compositions of FeO and MgO varying by 12.68 wt% and 11.46 wt% respectively. The pyrope features a higher concentration of CaO than the eclogite rock sample by 3.43 wt%. Therefore, these samples are distinctly different based on their impurities despite aligning with the same end-member species. Meanwhile, the grain obtained from the garnet staurolite schist most closely resembles the almandine grain within 0.42 wt% for the major oxides present including SiO_2, FeO, and Al_2O_3. The largest compositional difference between these grains is 0.84 wt% MgO from 2.64 wt% in the garnet staurolite to 1.79 wt% in the almandine. Thus, the garnet staurolite schist likely contains grains of almandine.