

Distribution of garnet grain sizes and morphologies across the Moine Supergroup, northern Scottish Caledonides

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Garnet is used in a wide range of geologic studies due to its important physical and chemical characteristics. While the mineral is useful for thermobarometry and geochronology constraints and can often be correlated to deformation and fabric development, difficulties remain in making meaningful interpretations of such data. In this study, we characterize garnet grain sizes and crystal morphologies from 141 garnet-bearing metasedimentary rock samples collected from the northern part of the Moine Supergroup in the Scottish Caledonides. Larger, euhedral crystals are indicative of prograde metamorphic growth and are typically associated with the most recent phase of orogenesis (Scandian, ~430 Ma). Small, rounded (“pin-head”) garnets are interpreted as detrital in origin. A subhedral classification is more subjective and is used when garnets contain portions of straight boundaries but have rounded edges or rims that have been altered through retrograde metamorphic reactions. From our collection, 88 samples contain anhedral garnets (maximum measured grain size $d = 0.46 \pm 0.21$ mm), 34 bear subhedral garnets ($d = 2.0 \pm 1.0$ mm), and the remaining 19 samples contain garnets with euhedral grains ($d = 4.4 \pm 2.6$ mm). Plotting the distribution of garnets relative to the mapped thrust contacts reveals an abrupt change in morphology and grain size when traced from the Moine thrust sheet across the Ben Hope and Sgurr Beag thrusts into the higher-grade, more hinterland-positioned thrust sheets. The dominance of anhedral garnets in the Moine thrust sheet suggests that these grains should not be used for peak $P - T$ estimation associated with relatively low temperature (<500 °C) Scandian metamorphism, as they are likely detrital in origin and contain protolith chemical signatures that would not have been reset due to sluggish diffusivities at greenschist facies temperatures. However, chemical and isotopic data from these grains may provide information into the provenance of these metasediments. A thermal/chemical break must occur at the Ben Hope thrust, because hanging wall garnets contain euhedral (Scandian?) rims that are distinct from the garnet grains observed in the underlying Moine thrust sheet. In addition to morphology, the propensity of garnet to include minerals during growth makes it a useful phase for obtaining a historical perspective on growth conditions. The distribution and chemistries of minerals included/encapsulated by garnet was studied for various samples to gain insight into metamorphic evolution and to distinguish garnets that likely contain multiple generations of growth. Although our results are specific to the Caledonides of northern Scotland, this work highlights the general necessity of a comprehensive petrographic assessment of garnet grains in advance of interpreting large suits of garnet-derived thermodynamic and geochronologic data.