Major and trace element analysis of garnet crystals from a hornblendeite block and rind on Santa Catalina Island, CA: Insights into metasomatic processes in subduction mélangé

Nathaniel Bess1, Eric Hasegawa2, Paige Voss3, Jade Star Lackey3, and F. Zeb Page4

1Department of Earth and Environment, Franklin and Marshall College, Lancaster, PA 17604-3003, 2Department of Geology, Amherst College, 11 Barrett Hill Dr, Amherst, MA 01002-5000, 3Department of Geology, Pomona College, 185 E. 6th St, Claremont, CA 91711, and 4Department of Geology, Oberlin College, 52 West Lorain Street, Oberlin, OH 44074

Overview
Santa Catalina Island off of the coast of southern California is iconic for demonstrating subduction and metasomatic processes. The subject of this study is a tectonic block from the amphibolite facies mélangé which is located in Ripper’s Cove on the island. This block and its rind are unusual due to the amount of the rind which remains visible and the existence of garnets within this rind. As a result, it has been the subject of previous studies including major element analysis (Penniston-Dorland et al., 2014, Chem. Geol.) and oxygen isotope analysis (Leuz et al., 2016, GSA Abstr). Here analysis of garnet zoning patterns, inclusions, and trace elements are used to further understand these metasomatic processes.

Figure 1. Map of Catalina Island, located off the coast of Los Angeles, California (after Platt, 1975). The block and rind we studied was found as float on the beach at Ripper’s Cove.

Figure 2. A. Backscattered electron mosaic of the rind sample RIPC. The sample has clearly defined sugary garnet crystal veins, indicated by an orange box. B. SEM zoning map of calcium in garnet crystal RIPC-B9. Calcium is concentrated in the center. C. SEM zoning map of magnesium in the same garnet crystal on sample RIPC.

Figure 3. A. Garnet hornblende block (yellow star) with garnet-bearing actinolite-rich rind (red star). Field notebook is 19cm long. B. Detail of garnet-rich block (bottom of image) to garnet-poor rind transition. Coin is ~2.5cm in diameter.

Figure 4. Ternary diagram of garnet major element compositions in block and rind. The rind contains abundant ~200mm-scale small garnet crystals and rare ~2mm-scale larger garnet crystals.

Figure 5. Prograde major element zoning found in block garnet crystals.

Figure 6. Large rind garnet cores resemble block garnet cores, but zoning in rims is extended to lower Ca and higher Mg compositions.

Figure 7. Almandine analysis of garnet crystals from a hornblendeite block and rind on Santa Catalina Island, CA: Insights into metasomatic processes in subduction mélangé

Figure 8. HREE+Y is elevated in block garnet cores and rims, occasionally with intermediate annuli.

Figure 9. Large rind garnet crystal has similar HREE +Y peak in its core, but with greater concentrations, and an annulus near the rim.

Figure 10. 200mm small garnet crystal has low HREE+Y concentrations (similar to large rind garnet rims) and minimal zoning.

Discussion and Conclusion
The different scales of the trace element data for the block and large rind garnet crystals are likely a product of heterogeneous distribution of HREE throughout the entire block. The major and trace element findings indicate that this block and rind experienced three metamorphic events. The first formed garnet crystals in a mafic rock (presumably during subduction, the second formed a reaction rind that traps some of the garnet crystals from the first metasomatism, and the third formed new garnet crystals (and rinds on relict garnet crystals) in the rind. The composition of this block is very similar to another block with unusually large garnet crystals that a fellow group in this Keck project researched, indicating a common mafic origin. Overall, this analysis provides a platform for further understanding not only the history of Santa Catalina Island, but also the geochemical interactions of blocks in subduction zone mélanges.

Figure 11. Schematic diagram illustrating the path of the block through the mélangé.

Acknowledgements
Special thanks to the Departments and Facilities at Pomona College and Oberlin College, the Catalina Island Conservancy, GlóriaMarie Flood, Nicole Mitchell, Nigel McMillan, and Belle McGarty. This study was funded by the Keck Geology Consortium and the National Science Foundation (REU1658922). The October 10th leaves were funded by a grant from the Sloane Foundation (G185417). The SEM at Oberlin College was funded by a grant from the National Science Foundation.

References
Page, F. Zeb, and Barfield, T., 1993, Metasomatism and submarine volcanism in the Catalina Island, California: some insights from the Keck Geology Consortium, GeoMag and ABLE (MRI162627).