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 mélange

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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 mélange 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.Geo.) and oxygen isotope analysis (Leung et al., 2016, GSA Abstr). Here analysis of garnet zoning patterns, inclusions, and trace elements are used to further understand these metasomatic processes.

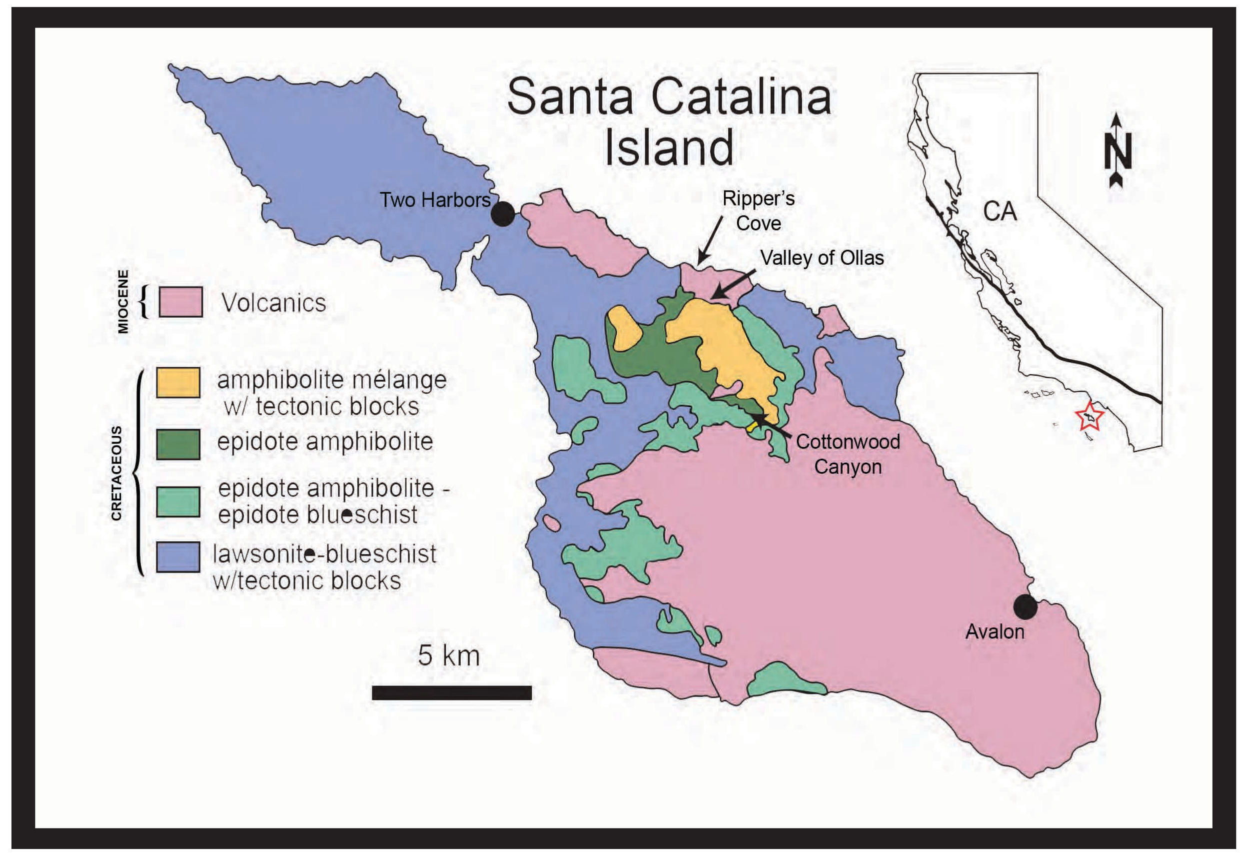
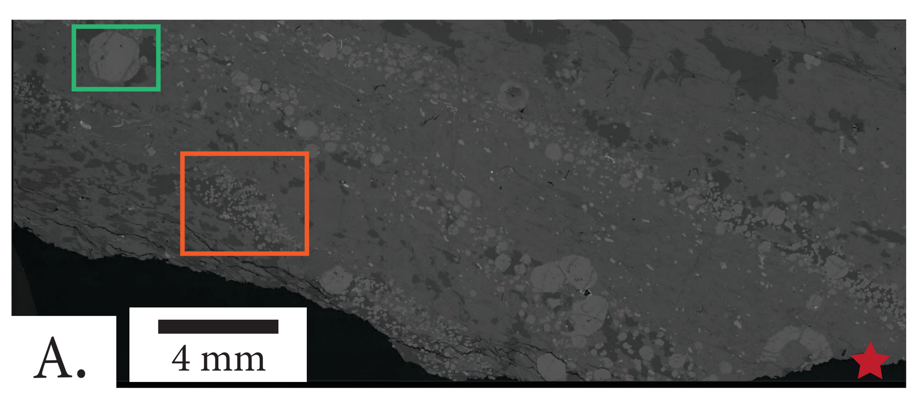


Figure 1. Map of Catalina Island, located off the coast of Los Angeles, California (after Platt, 1975). The block and rind we studied was found as float on the beach at Ripper's Cove.



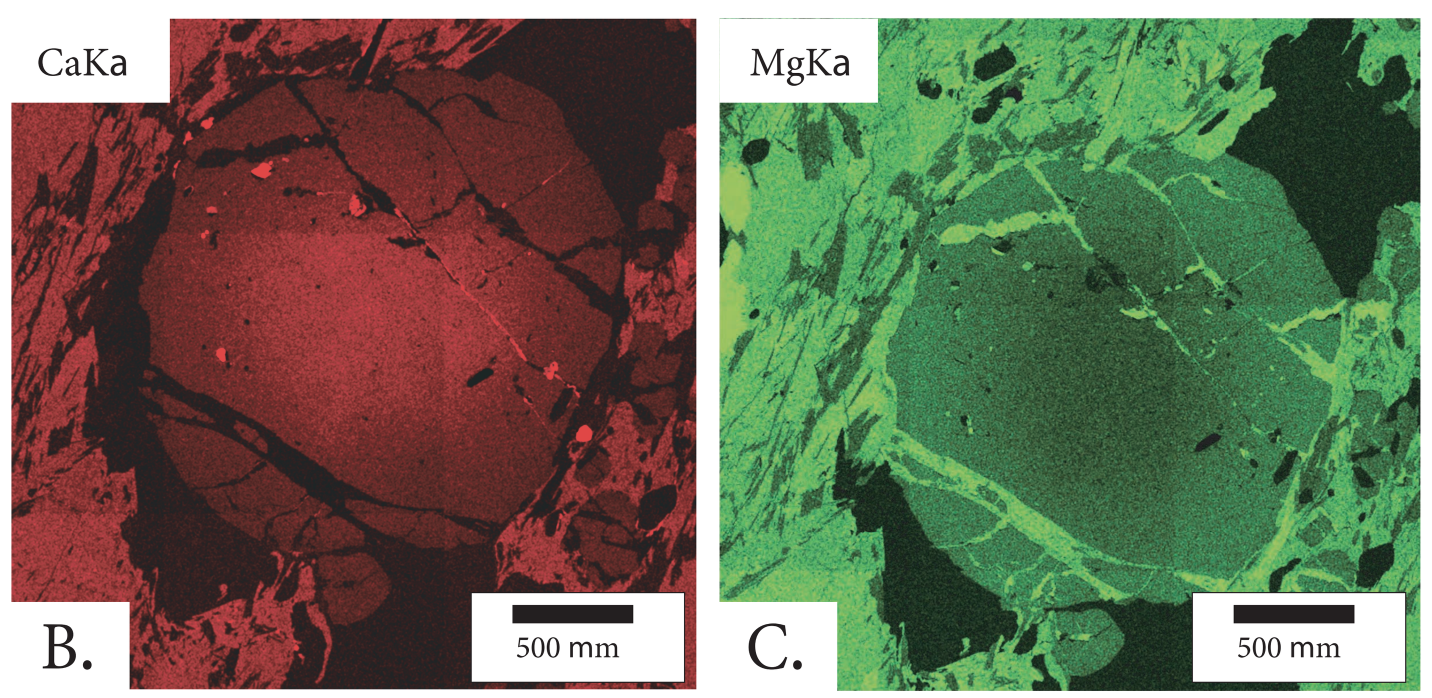


Figure 2. A. Backscattered electron mosaic of the rind sample RIPC. The samples has clearly defined sugary garnet crystal veins, indicated by an orange box. Garnet crystal RIPC-B9 is indcated by a green box. **B.** SEM zoning map of calcium in garnet crystal RIPC-B9. Calcium is concentrated in the center. **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.

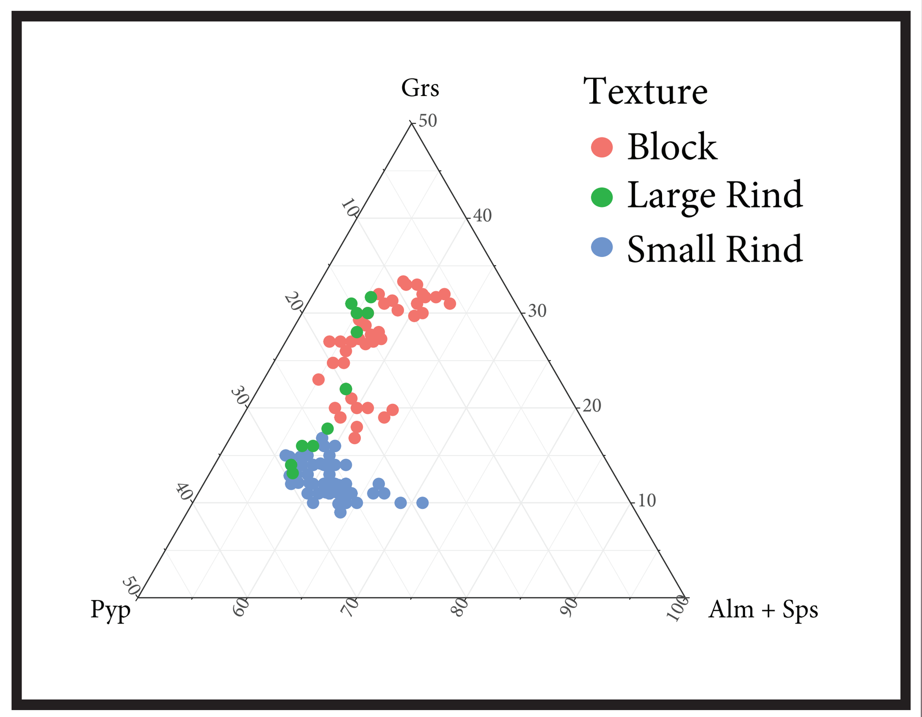


Figure 4. Ternary diagram of garnet crystal major elements in block and rind. The rind contains abundant ~200mm-scale small garnet crystals and rare ~2mm-scale larger garnet crystals.

Major Element Zoning

Analysis of major element concentration was completed using Tescan Vega 3 SEM Oxford EDS system.

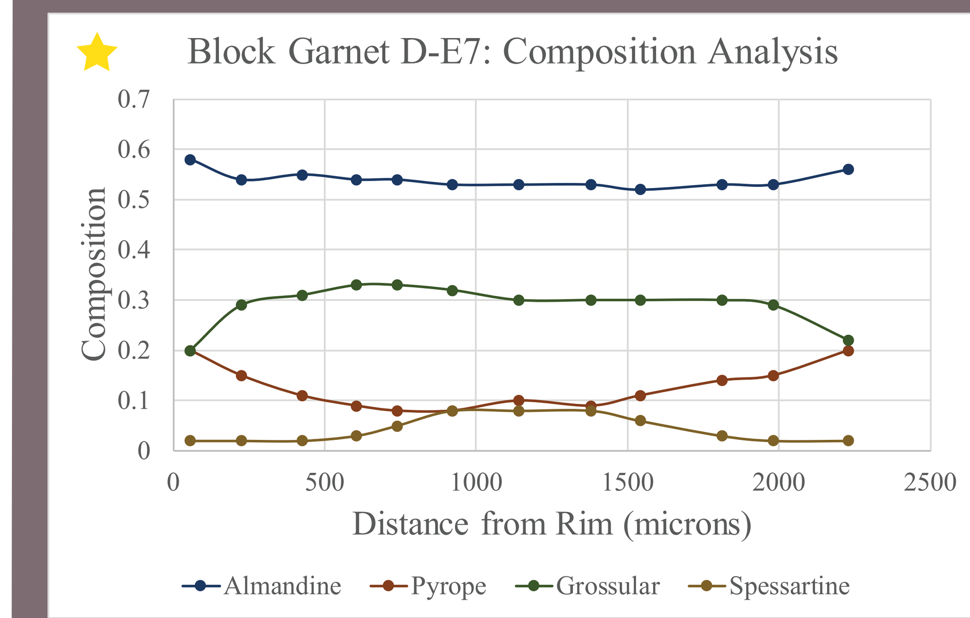


Figure 5. Prograde major element zoning found in block garnet crystals.

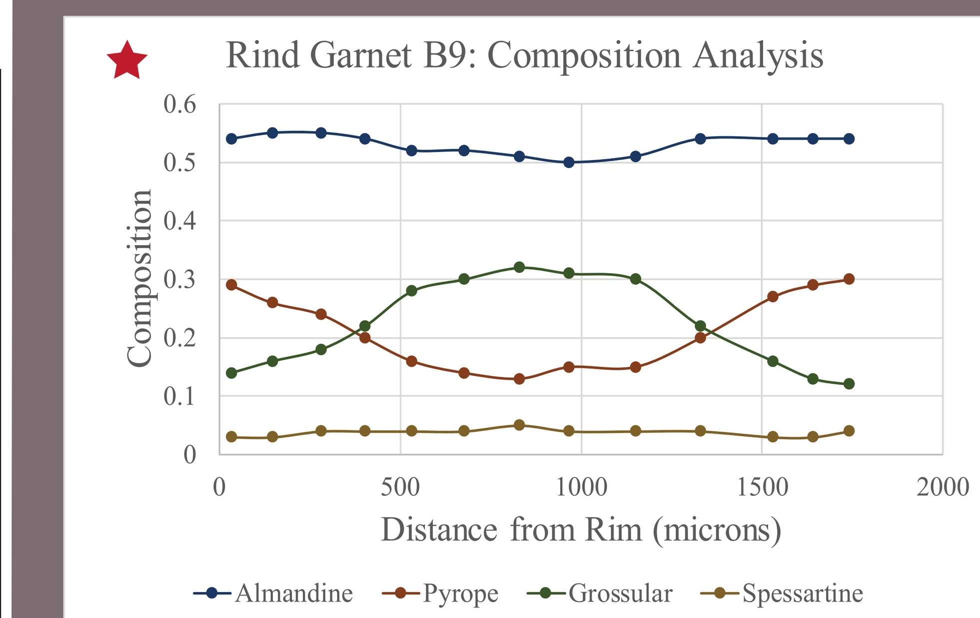


Figure 6. Large rind garnet cores resemble block garnet cores, but zoning in rims is extended to lower Ca and higher Mg compositions.

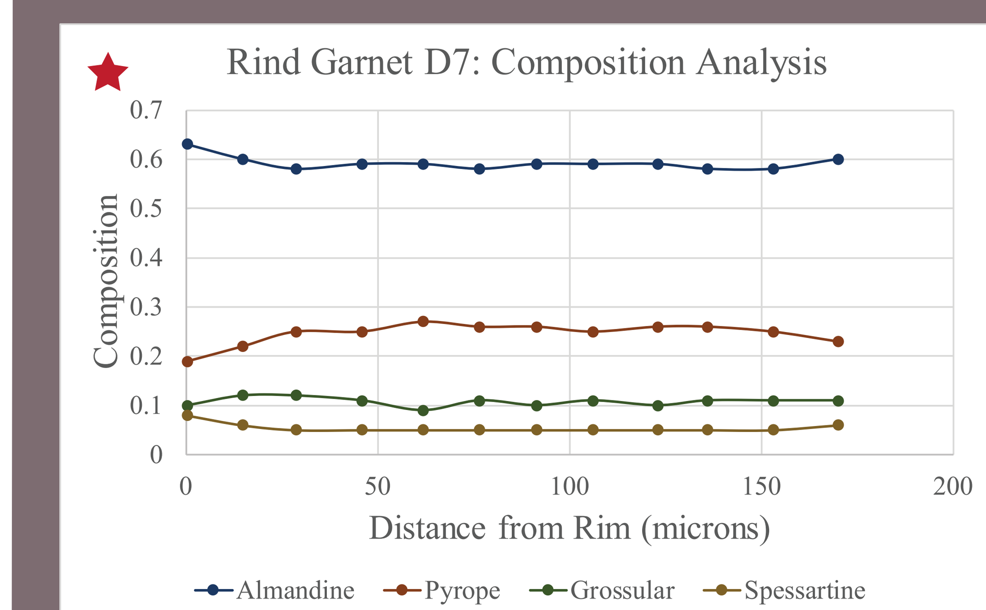


Figure 7. Small garnet crystals in rinds are homogeneousin major elements and resemble large rind garnet rims.

Trace Element Zoning

Analysis of trace element concentrations was completed using laser ablation ICP-MS on an Agilent 8900 in ammonia-oxygen gas blend mode.

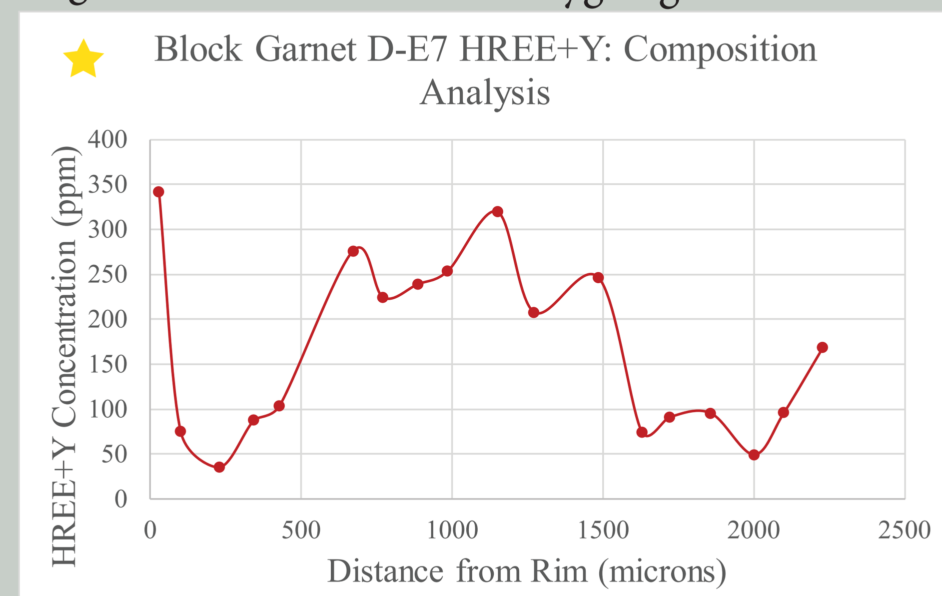


Figure 8. HREE+Y is elevated in block garnet cores and rims, occaisionally with intermediate annuli.

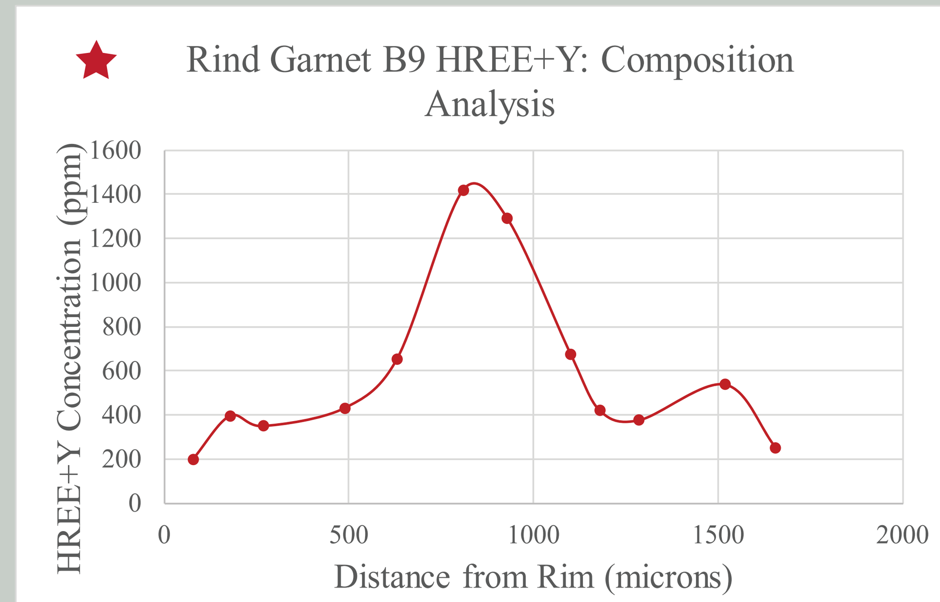


Figure 9. Large rind garnet crystal has similar HREE +Y peak in its core, but with greater concentrations, and an annulus near the rim.

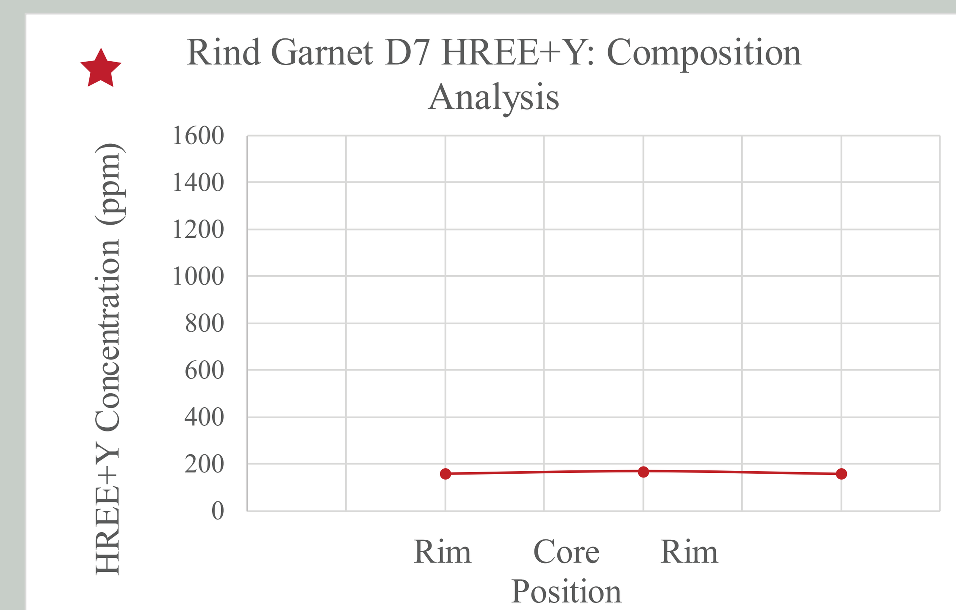


Figure 10. 200mm small rind garnet crystal has low HREE+Y concentrations (similar to large rind garnet rims) and minimal zoning.

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 metamorphism, and the third formed new garnet crystals (and rims 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.

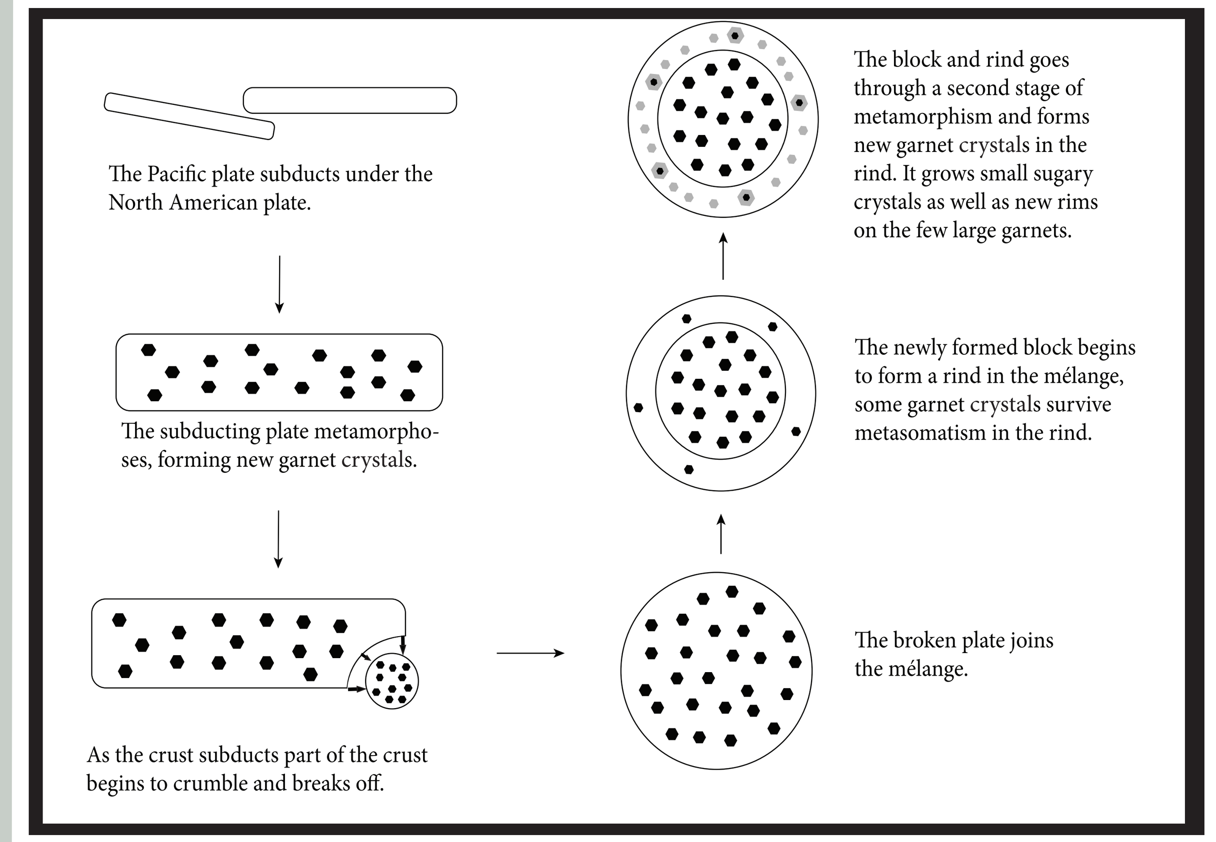


Figure 11. Schematic diagram illustrating the path of the block through the mélange.

References

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Acknowledgements

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