An investigation of the Catalina garnet-blueschist: Major and trace element composition and zoning in garnet and lawsonite from multiply subducted block

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Introduction

Within the blueschist unit of Santa Catalina Island, blocks of garnet bearing lawsonite-blueschist were identified and sampled for further exploration. This specific block, found along the west coast, is approx. 155 Ma, which isolder that other garnet-bearing Catalina blocks of approx. 115 Ma (Grove et al, 2008; Awalt et al, 2013). Based on existing hypotheses about this block, we investigated the possibility of the blueschist undergoing multiple subduction events.

The mineralogy of the garnet-blueschist includes (in order of abundance) glaucophane, phengite, lawsonite, garnet, and sphene, along with trace amounts of apatite, albite, rutile, quartz, zircon and barite. Additionally, the garnet end-member composition overall is 50-60mol% Almandine, 20-30mol% Grossular, 8-12mol% Pyrope, 10-15mol% Spessartine, many garnets are strongly fractured.

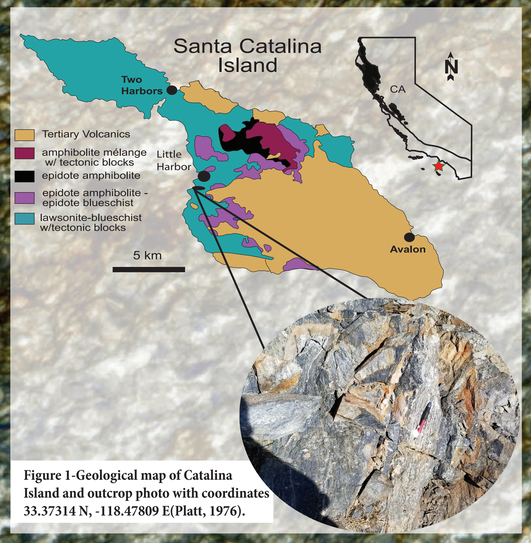


Figure 1-Geological map of Catalina Island and outcrop photo with coordinates 33.37314 N, -118.47809 E(Platt, 1976).

Major Element Analysis of Garnets

By using SEM, 8 garnets ranging from 326 µm to 1200 µm were transversed from rim to rim.

-The majority of Garnets across the three samples displayed at least minor zoning, exhibited by significant decreases in Mn/spessartine and an increase in Fe/almandine from core to rim. Minor increases in pyrope and grossular were also observed from core to rim (Fig. 5).

-During exploration, we found further evidence of changing metamorphic conditions such as zoned glaucophane, and rutile with a sphene reaction rim.

-Textural features include clearly fractured garnets, often with quartz, phengite and lawsonite growth within the cracks.

-Quartz, mica, and feldspar veins and inclusions are frequent throughout the garnets. Typically, lawsonite could be found adjacent to the garnet.

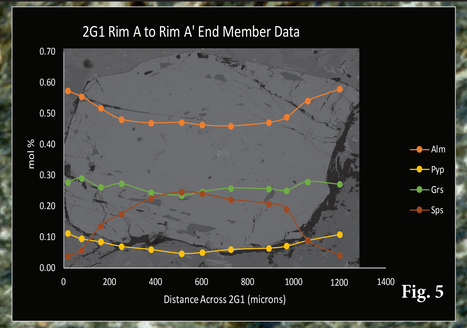


Fig. 5

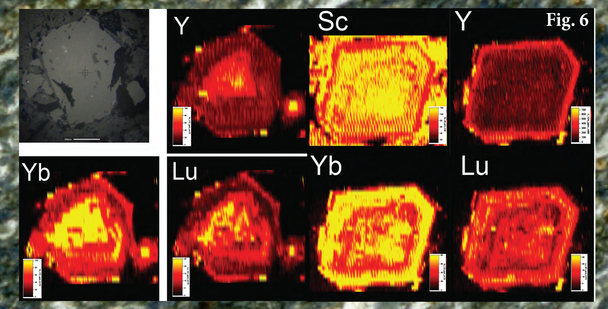


Fig. 6

Figure 5- Garnet (2G1) endmember zoning measured with data obtained from EDS transverse.

Figure 6- Trace element maps displaying variation of heavy rare earth element concentration in two garnets.

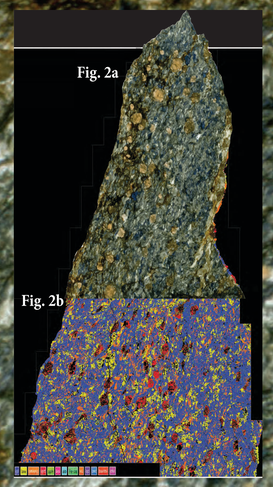


Figure 2a) Photo of thick section sample. b) Mineral identification-map of thick section sample. Figure 3a) Back-scattered electron image of fractured garnet with lawsonite and phengite crystal growth within the cracks. b) detail of same image

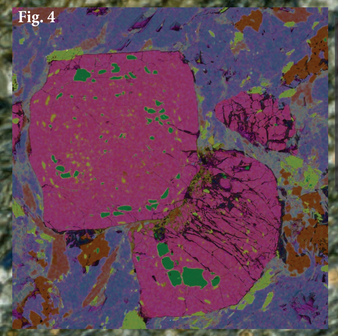
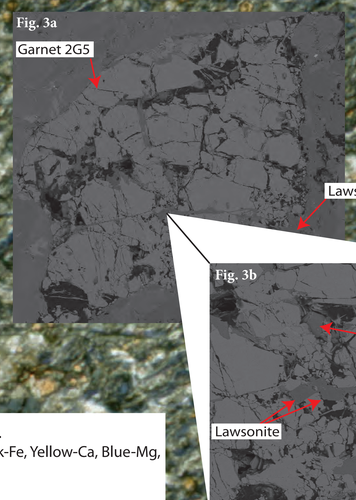


Figure 4- Elemental map of 2G6-7s. Legend: Dark Green-Si, Red-Al, Pink-Fe, Yellow-Ca, Blue-Mg, Light Green-Mn



Bulk Composition

-Overall, there are no trends or significant differences in the bulk composition of garnet-bearing and non-garnet bearing blueschist, contrary to thoughts after field observation (Fig 8, below). Thus the chemical variability across the block is unliky the control on garnet growth.

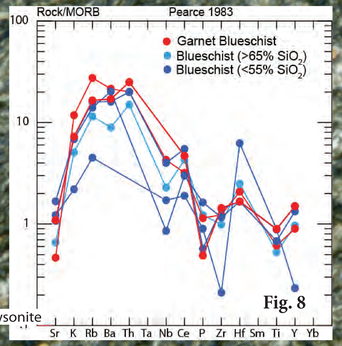


Fig. 8

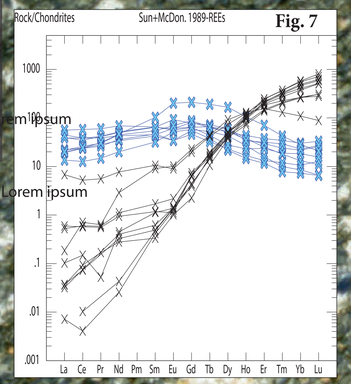


Fig. 7

Figure 7- Comparing REE between lawsonite (blue) and garnet (black) with LA-ICP-MS system.

Figure 8- Using mid oceanic ridge basalt (MORB) to compare the bulk composition of garnet bearing lawsonite blueschist with non-bearing lawsonite blueschist.

Trace Element Analysis

-Major element zoning data collected with the LAICP-MS supported the SEM data obtained by traverses on the SEM.

-Lu levels -- which have previously been used in the relative growth dating of lawsonite and garnets (Mulachy, et. al, 2014) -- were similar in both garnet and lawsonite. Also, mapping displays irregular zonation rings of some trace elements (Fig. 6)

-In general, the heavy rare earth elements are more abundant in garnet than lawsonite in the blueschist (fig. 7).

Methods

- Major elements were analyzed at Oberlin College with a Tescan Vega 3 Scanning Electron Microscope with an Oxford Instruments Energy Dispersive Spectrometer.

- Trace elements were analyzed in the David W. and Claire B. Oxtoby Environmental Isotope Lab, at Pomona. Samples are ablated with and ESI NWR193 ArF laser and isotopes are analyzed with an Agilent 8900 triple quadrupole ICP-MS operated in a NH3-O2 gas cell mode to minimize interferences among rare earth elements. Glasses NIST-612 and BCR-2 were used for standardization of trace and major elements, respectively using Al from SEM analyses as an internal standard.

- X-ray Fluorescence (XRF) was used to compare bulk chemical composition between non-garnet-bearing lawsonite blueschist and garnet bearing lawsonite-blueschist samples.

Discussion and Conclusion

Evidence for multiple subduction events includes textural differences of garnets within the same sample; fragmented garnets are seen only a couple hundred microns away from untattered garnets. Lawsonite growth within cracks of garnets suggests infiltration occurred after the garnets fractured, thus placement took place during a possible second subduction event. Additionally, irregular zoning of trace elements in the garnets indicates an interruption during the garnet's growth, likely caused by a second subduction event. During the second subduction event, surrounding minerals break down releasing a new influx of heavy rare earth metals to the garnets. The lack of an overall trend in the bulk composition of garnet-bearing versus non-garnet-bearing blueschist, indicated composition of the blueschist does not affect the placement of garnet growth.

References

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