Getting in the Zone: Oxygen isotope and cation zoning in multiple generations of Franciscan garnets

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OVERVIEW

Two compositionally- and texturally-distinct populations of garnet in a hornblende-eclogite block from the Ring Mountain provide a unique opportunity to investigate fluid flow in the mélange of the Franciscan Complex. In situ analysis of oxygen isotopes reveals zoning throughout garnet populations. We correlate $\delta^{18}O$ and cation zoning in order to relate external fluid interactions for this rock to the nucleation of successive garnet populations.

SAMPLES AND METHODS

- The sample consists of garnet, hornblende, omphacite, phengite, zoisite, and rutile. Garnet occurs as matrix porphyroblasts (2-5 mm) and small crystals (5-50 μm) in 1-5 cm thick veins.
- Garnet chemistry was analyzed using the CAMECA SX100 electron microprobe at the University of Michigan using a 20 kV, 10 nA beam. The probe was calibrated using natural and synthetic silicate standards, and a CAMECA PAP-type correction was applied.
- Oxygen isotope analyses were performed on the WiscSIMS CAMECA IMS 1280 ion microprobe with 10 μm spot size on ten garnet grains and corrected for compositional bias following the method of Page et al. 2010.

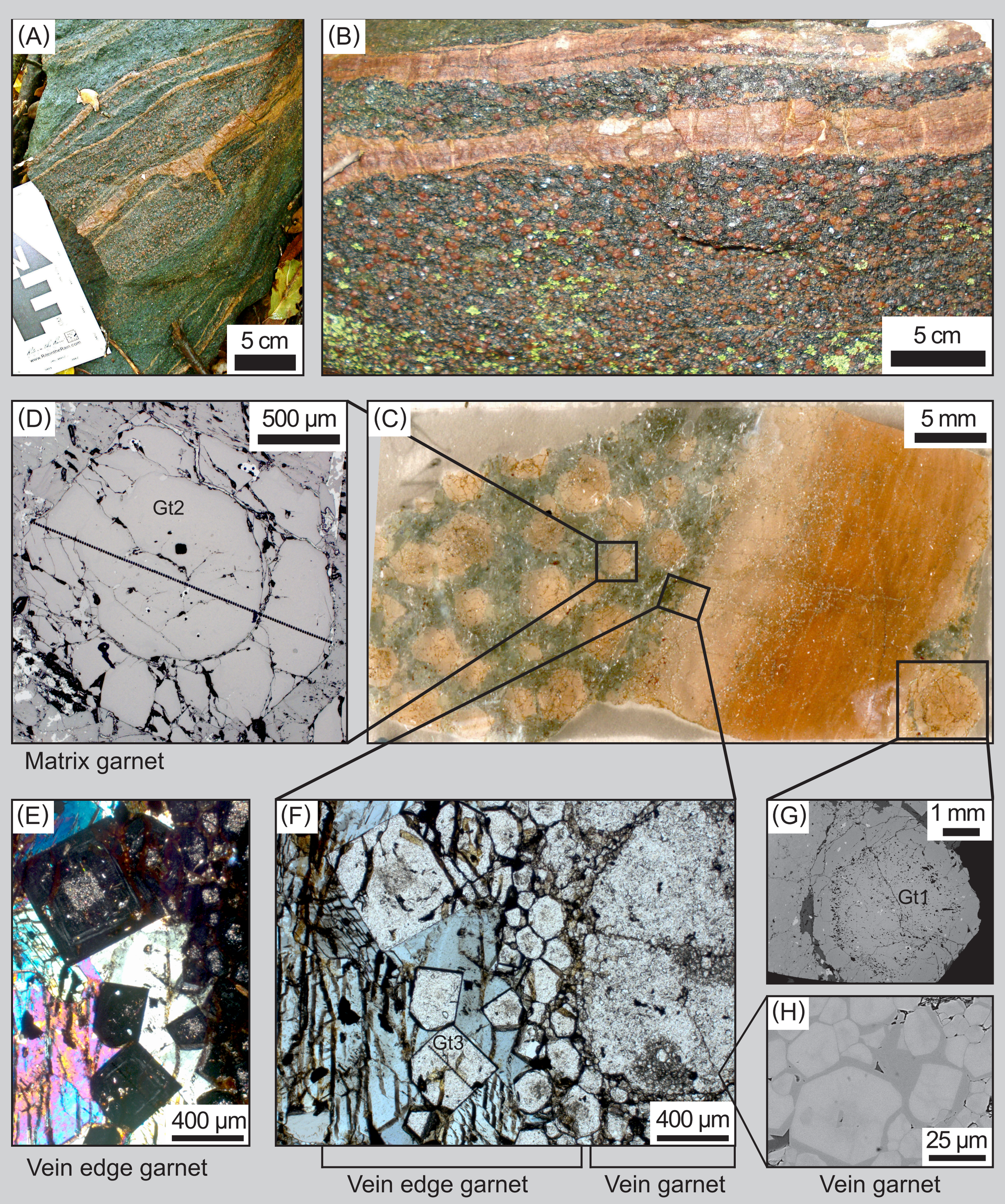

Figure 1. (above) A map of California showing the location of the Franciscan Complex.

Figure 2. (left) **A.** The block from which RM-1C and 13TIB-3 were sampled.

B. Detail of block showing size contrast between garnetite veins and matrix garnets.

C. RM-1C in thin section.

D. Reflected light image of matrix garnet G2 in RM-1C.

E. Cross-polarized light image of euhedral matrix garnets near vein in RM-1C.

F. Plane-polarized light image of euhedral matrix garnets near vein in RM-1C.

G. BSE image of single garnet near vein in RM-1C.

H. BSE image of vein garnets near vein edge in RM-1C.

MATRIX GARNETS

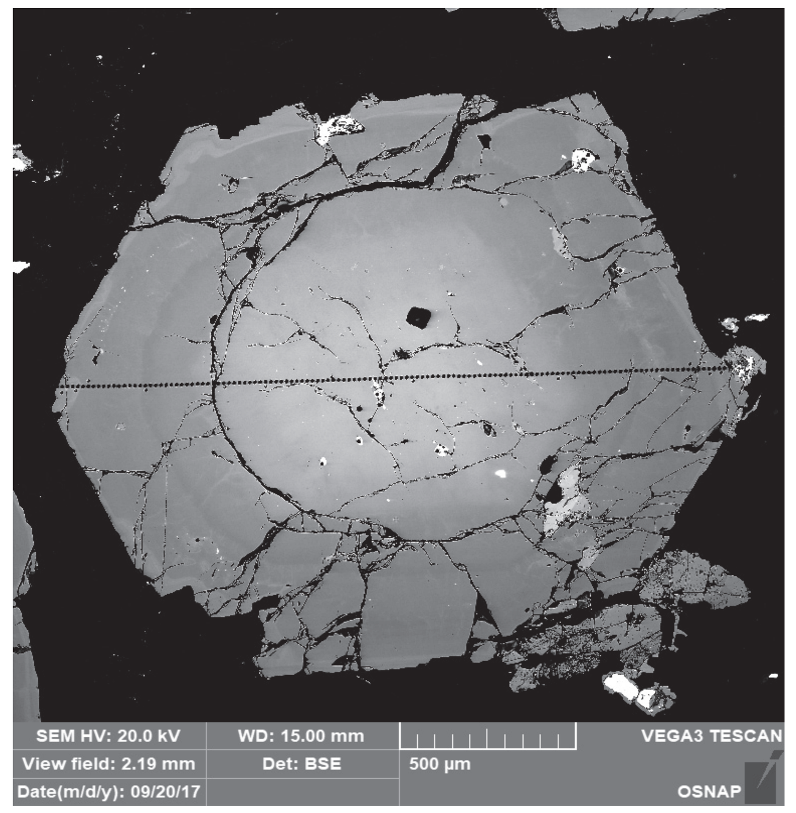

Figure 3. High contrast BSE image of a matrix garnet from sample RM-1C showing laser ablation pits (other study) and SIMS pits.

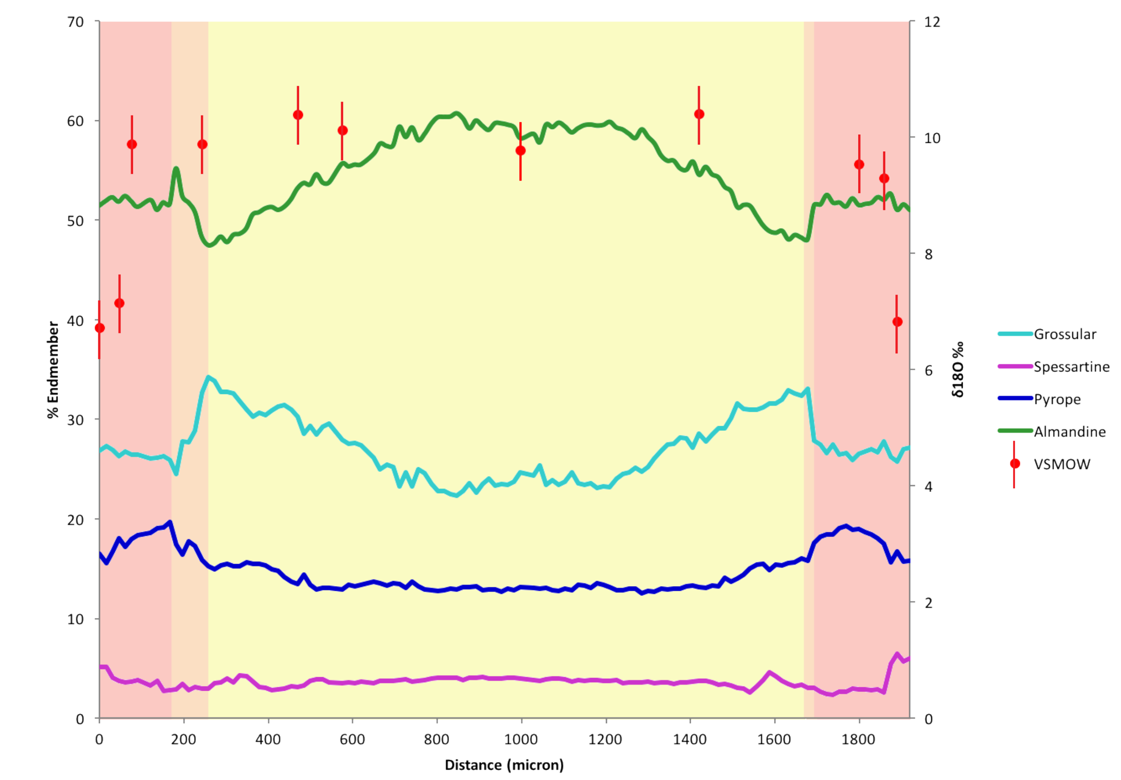

Figure 4. Traverse showing major element and oxygen isotope zoning of the garnet in Fig. 3 following laser ablation pits (other study).

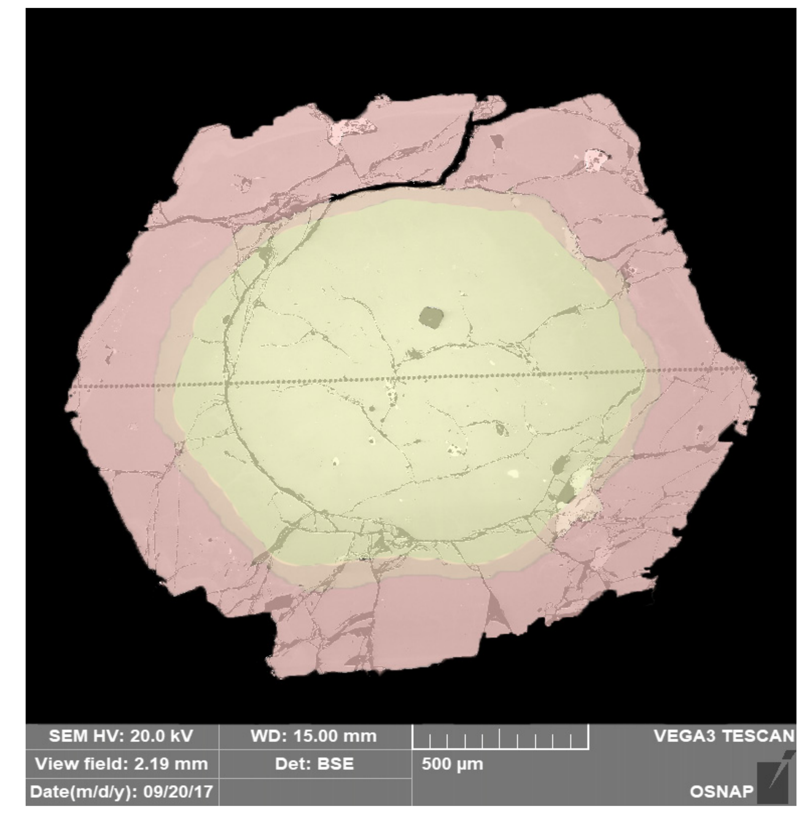

Figure 5. Colorized BSE image of the Fig. 3 garnet showing zones suggested by Fig. 4.

MAJOR ELEMENTS: MATRIX GARNETS

- Almandine zoning (60-48% core-to-mantle, 51% rim).
- Grossular zoning (22-34% core-to-mantle, 27% rim).
- Pyrope zoning (17-19% core-to-rim).
- Spessartine (5% core/mantle/rim, ~7% near edge).

MAJOR ELEMENTS: VEIN GARNETS

- Dramatic zoning in spessartine (20% core, 8% rim).
- Grossular zoning (9-26% core-to-rim).
- Pyrope zoning (13-16% core-to-rim).
- Almandine zoning (58-48% core-to-rim).

OXYGEN ISOTOPES

- Despite differing major element zoning, both garnet populations show similar $\delta^{18}O$ values.
- $\delta^{18}O$ values for matrix and vein garnets decrease from core (9.9±1.1‰, 2SD, VSMOW) to rim (6.8±1.0‰) - see Figs. 4 and 7.
- 3‰ drop is contemporaneous with spikes in spessartine content (see Major Elements).
- $\delta^{18}O$ values for garnet cores and rims are higher than those for zoned Ring Mountain garnets presented in Errico et al. 2013.

VEIN GARNETS

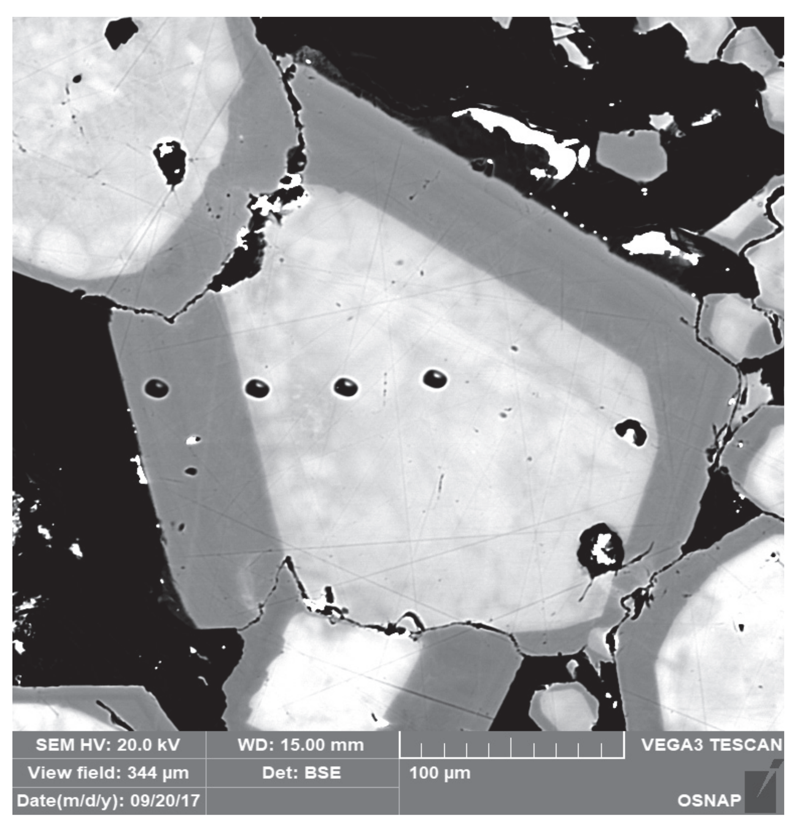

Figure 6. High contrast BSE image of a vein garnet from sample 13TIB-3 showing SIMS pits.

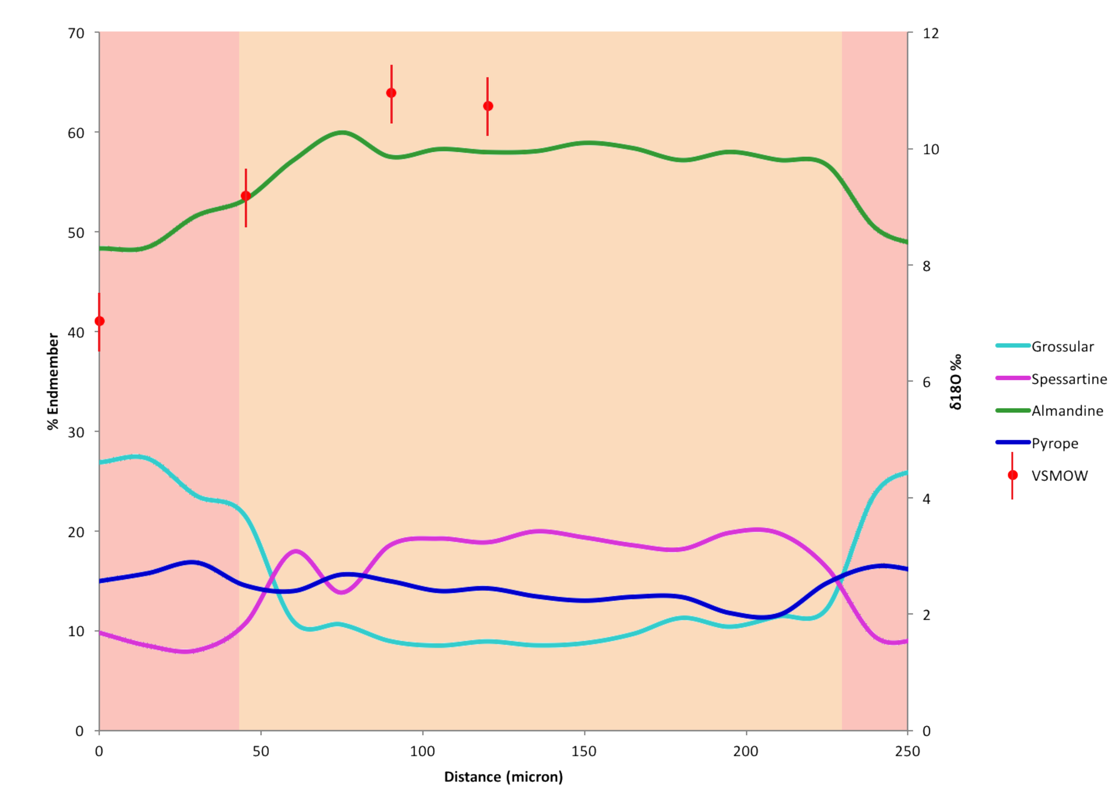

Figure 7. Traverse showing the major element and oxygen isotope zoning of the garnet pictured in Fig. 6.

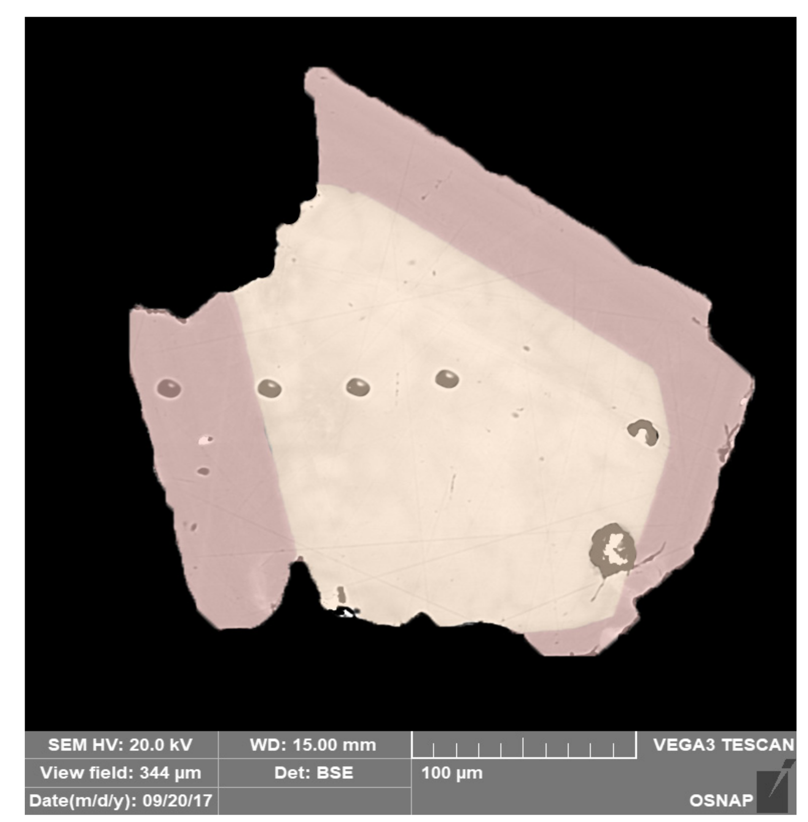

Figure 8. Colorized BSE image of the Fig. 6 garnet showing zones suggested by Fig. 7.

DISCUSSION & CONCLUSIONS

- Matrix garnets nucleated before vein garnets.
- Next, a low $\delta^{18}O$ fluid infiltrated, and $\delta^{18}O$ values decreased in all garnet populations.
- Decrease in $\delta^{18}O$ suggests single late influx of external fluid, but high Sps content in vein garnet points to more complexity.

FURTHER RESEARCH

- Analyses of zoned vein garnets have shown that the garnetite veins themselves are zoned.
- Further analysis of major elements and $\delta^{18}O$ values throughout the vein are needed to elucidate the metasomatic timeline of this rock.
- Further work is needed to determine what protoliths may have enabled the high spessartine content of vein garnets.

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- Errico, J.C., Barnes, J.D., Strickland, A., and Valley, J.W., 2013, Oxygen isotope zoning in garnets from Franciscan eclogite blocks: evidence for rock–buffered fluid interaction in the mantle wedge: Contributions to Mineralogy and Petrology, v. 166, no. 4, p. 1161–1176, doi: 10.1007/s00410-013-0915-0.
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