Petrography, Geochemistry, and Geochronology of the Green Mountain Shield Volcano, Oregon

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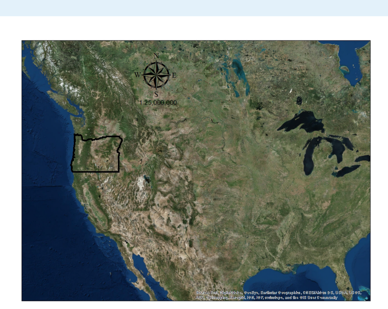
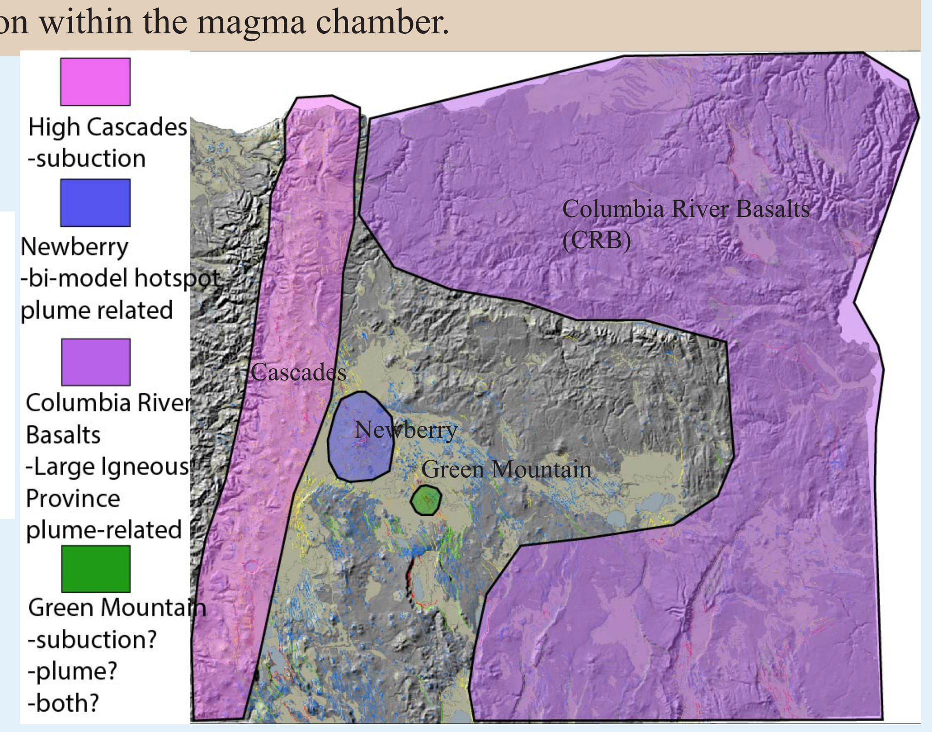
Background

Abstract:

Green Mountain (GM) is a small (~25km³) shield volcano located in central Oregon. The ~740,000 year old shield, and associated young (~13,000 ya; Mackey et al., 2014) lava fields, are approximately ~50 km southeast of the Newberry Caldera on the northwest side of an age progressive trend of bi-model volcanism from southeastern Oregon to Newberry (Jordan, 2004). In a previous study (Friedrichs and Castonguay, 2014), XRF results were reported and interpreted as evidence of a single magma chamber that had undergone fractional crystallization and a significant magma recharge event before the most recent volcanism. This study aims to expand on this existing knowledge by applying geochronology, detailed petrographic analysis, and additional XRF analysis.

Surrounding and underlying the GM shield are several rhyolitic to dacitic domes, one dated at ~4 Ma (Ford, 2011) and thought to be associated with Newberry volcanism. Also below the GM basalt flows are remnants of basaltic tuff cones with central lava lakes that erupted through the Pleistocene lake that occupied Fort Rock basin, suggesting that GM initiated as geographically distinct vents on the northern edge of the lake. The additional XRF data continue to support the previous hypothesis that the tholeiitic basalts have a short residence time in a crustal magma chamber before eruption. Detailed petrographic analysis also supports this hypothesis. Basalts from several intervals show glomeroporphyritic textures, while others have abundant zoned olivine (Fo80 cores to Fo40 rims); both suggesting at least some crystallization within the magma chamber.

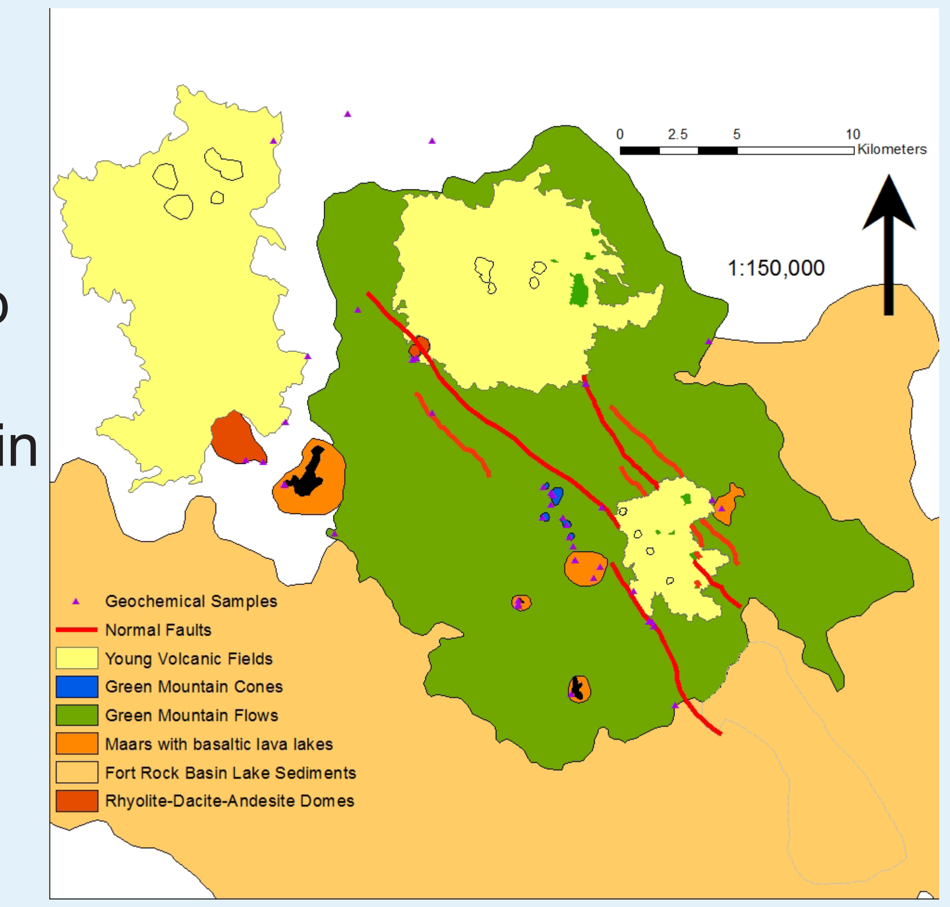




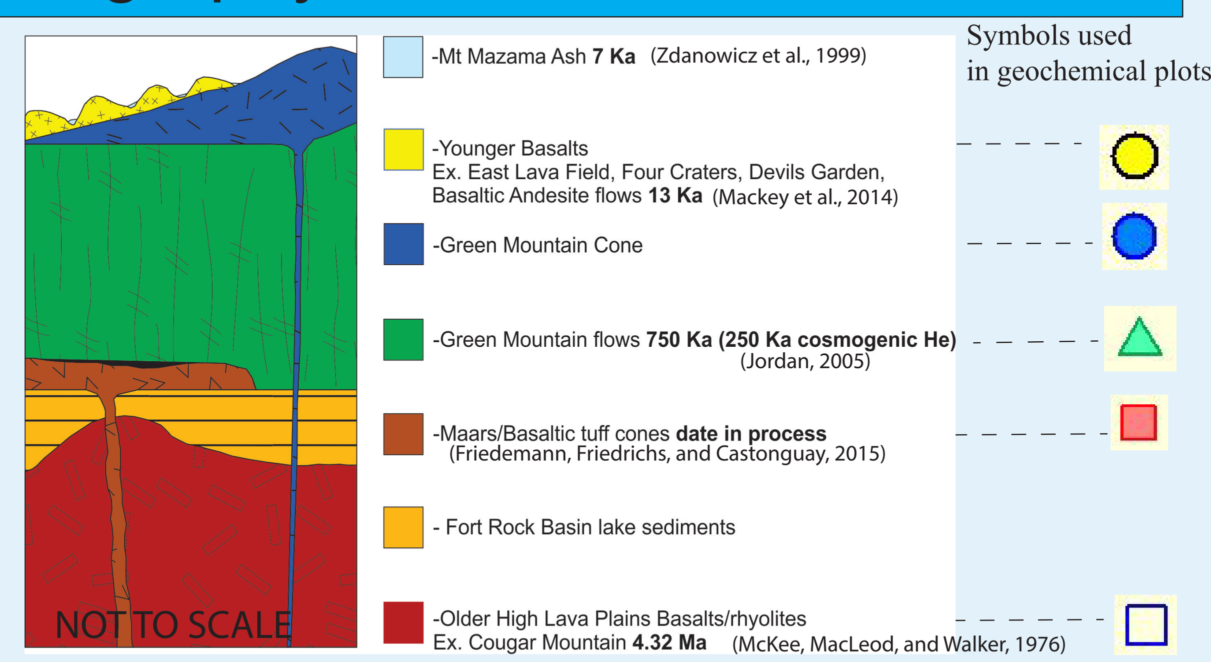
Previous Studies:

- Weldon et al., 2002 – Map of Quaternary Volcanism and Faulting of Central Oregon
- Jordan, 2005 – Age progression of High Lava Plains Volcanism and its relationship to the Yellowstone Hotspot
- Graham et al., 2009 – He isotope ratio of young basalts of High Lava Plains have mantle plume signature
- Eager et al., 2011 – Crust beneath High Lava Plains is ~30 km thick
- Castonguay et al., 2010 – Paleoseismic trench identified an increase in slip rate during volcanism
- Mackey et al., 2014 – Synchronous Volcanism and Faulting using cosmogenic He exposure dating and identified the opening of Crack-In-The-Ground hinge as synchronous with volcanism
- Ford, 2011 – Suggests HLP may not have mantle plume contribution
- Friedrichs and Castonguay, 2014 –Geochemical evidence for shared magma chamber and magma recharging

Geologic Map of Green Mountain Area

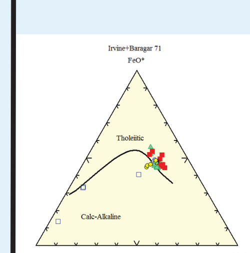


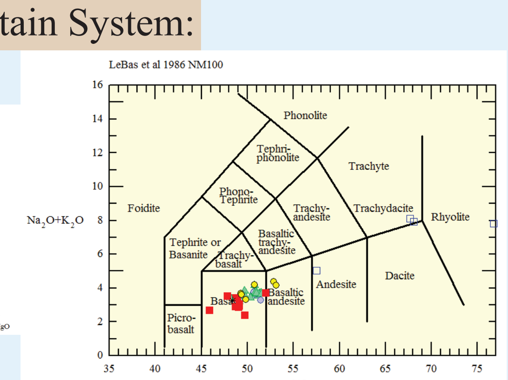
Stratigraphy of Green Mountain Area



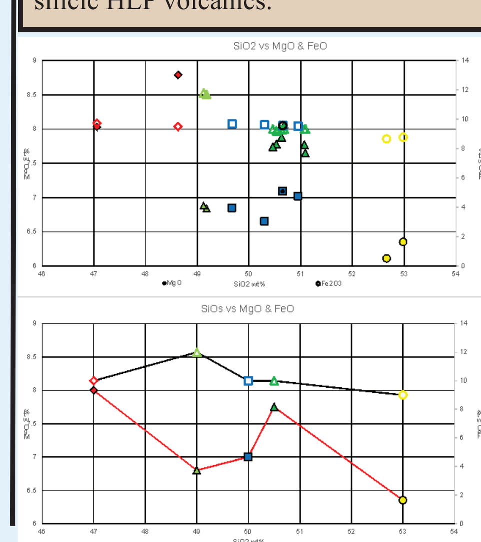
Previous Results

Green Mountain System:



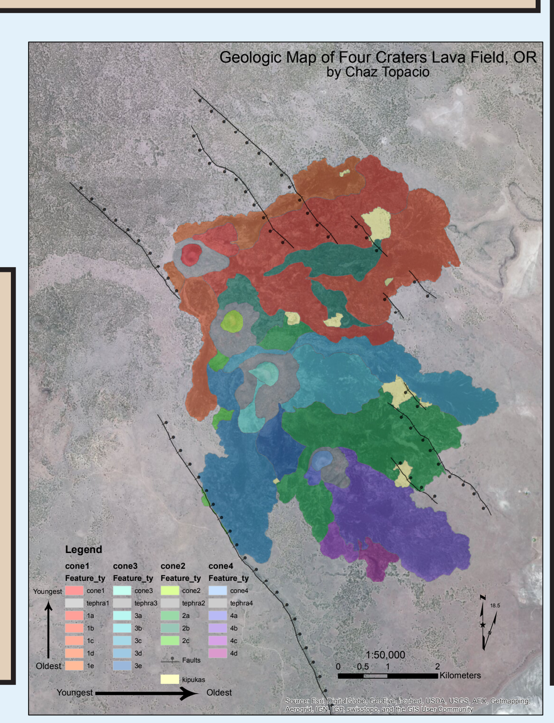


In general, the GM system is tholeiitic and composed of basalts and basaltic-andesites erupted on top of the older silicic HLP volcanics.



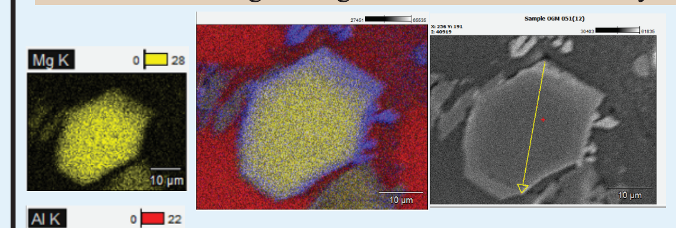
From previous geochemical results (left), Friedrichs and Castonguay, 2014 suggested a shared magma chamber between the maars, Green Mnt flows and cones, and the young volcanic fields. We interpreted these the requilibartion of MgO and FeO as a magma recharge event.

The map below shows the observed field relationships of the Four Craters Lava Field (by St. Norbert College student Chaz Topacio while attending University of Oregon Field Camp). Samples from each cone and an associated flow were collected and XRF results are shown to the right.
The field is suprisingly homogenous.

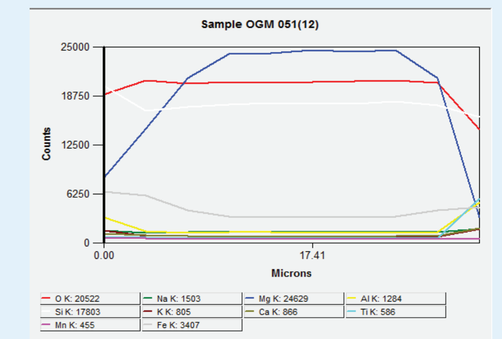


SEM/Petrography

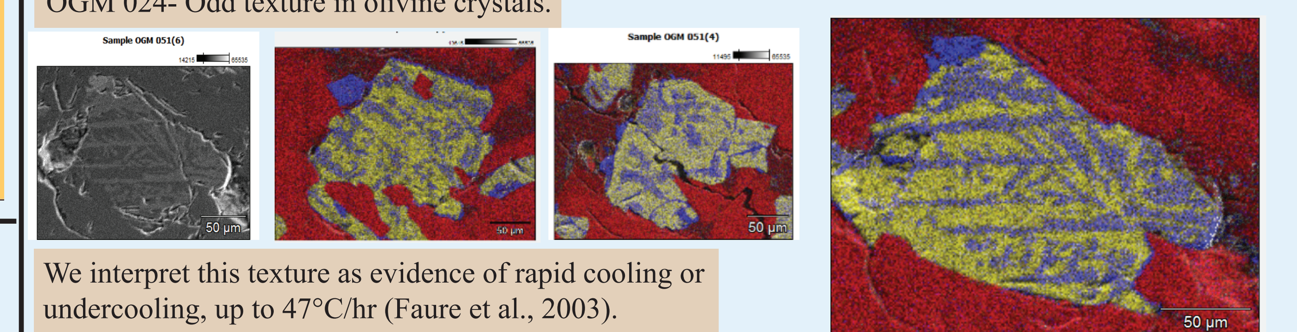
OGM 001- Strong zoning in Olivine. Forsterite crystals with fayalite rims.



We interpret these as evidence of fractional crystallization within the magma chamber, depleting Mg and growing a Fe rich rim.

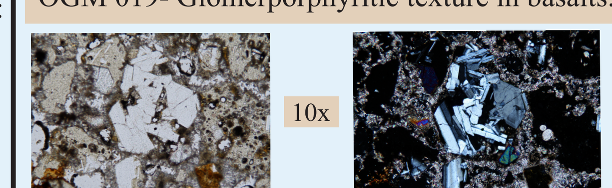


OGM 024- Odd texture in olivine crystals.



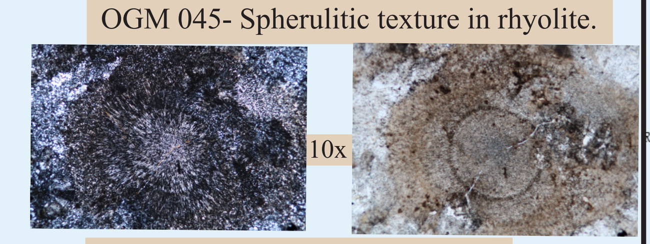
We interpret this texture as evidence of rapid cooling or undercooling, up to 47°C/hr (Faure et al., 2003).

OGM 019- Glomerporphyritic texture in basalts.



We interpret this texture as evidence of at least some crystallization within the magma chamber.

OGM 045- Spherulitic texture in rhyolite.

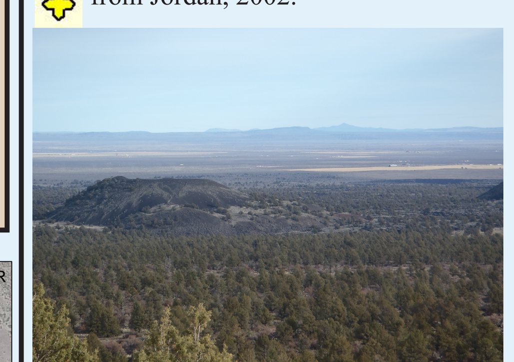


We interpret this texture as devitrification of the rock after its emplacement.

Geochemistry

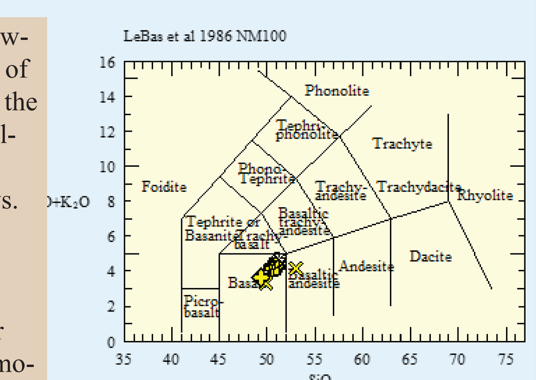
Young Volcanics:

Four Craters, hollow symbols from Jordan, 2002.
East Lava Field, hollow symbols from Jordan, 2002.
Devil's Garden, hollow symbols from Jordan, 2002.

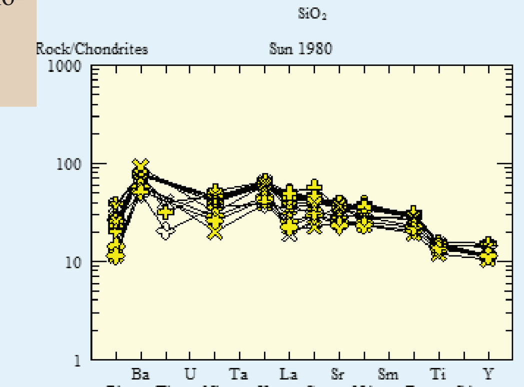


These spider diagrams show the minor element geochemistry of the young lava fields. All fields have a prominent Nb trough that reflects subduction related basalts

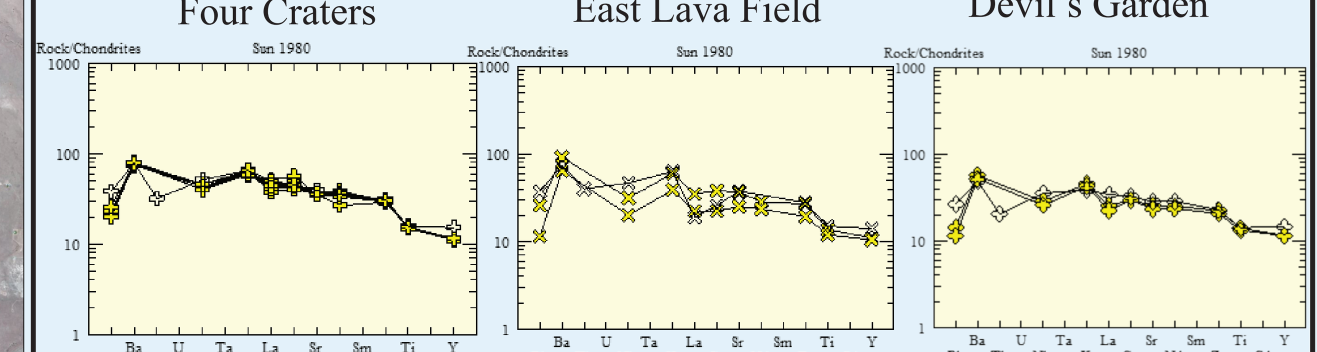
In these diagrams showing the compiled data of the young lava fields, the flows are mostly basaltic, but do have some basaltic-andesite flows.



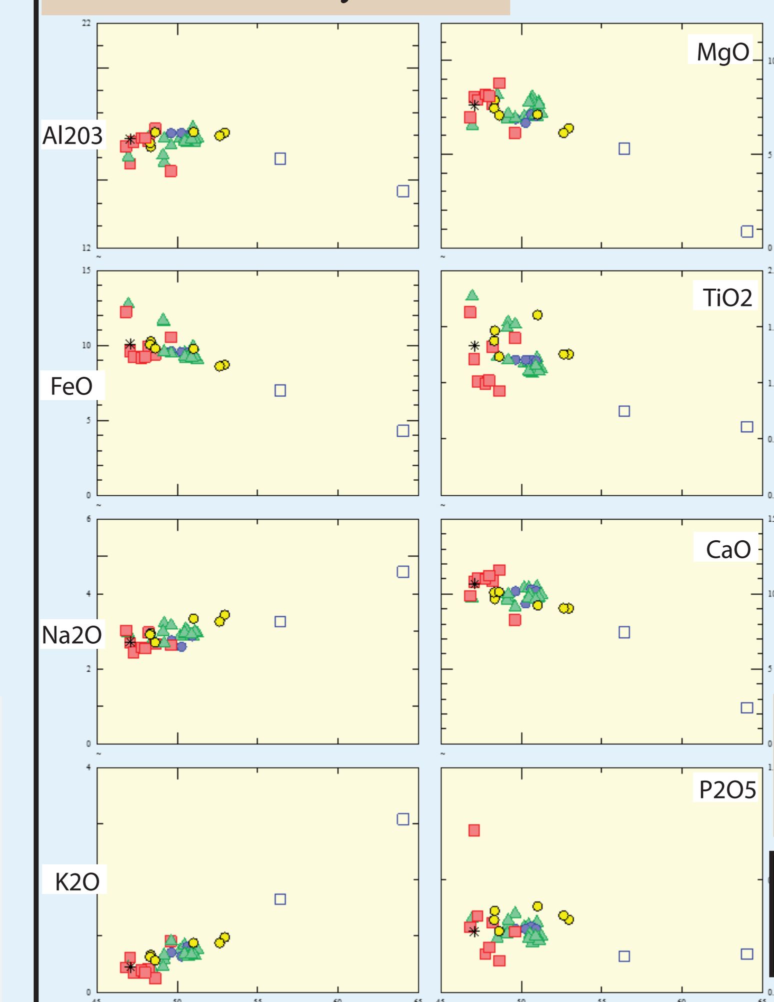
This composite spider diagram show the homogeneity of the mafic rocks lavas.



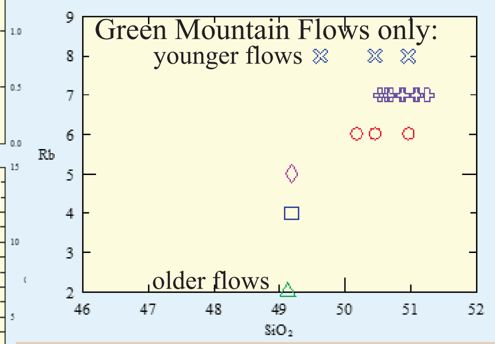
Four Craters | East Lava Field | Devil's Garden



Green Mountain System:



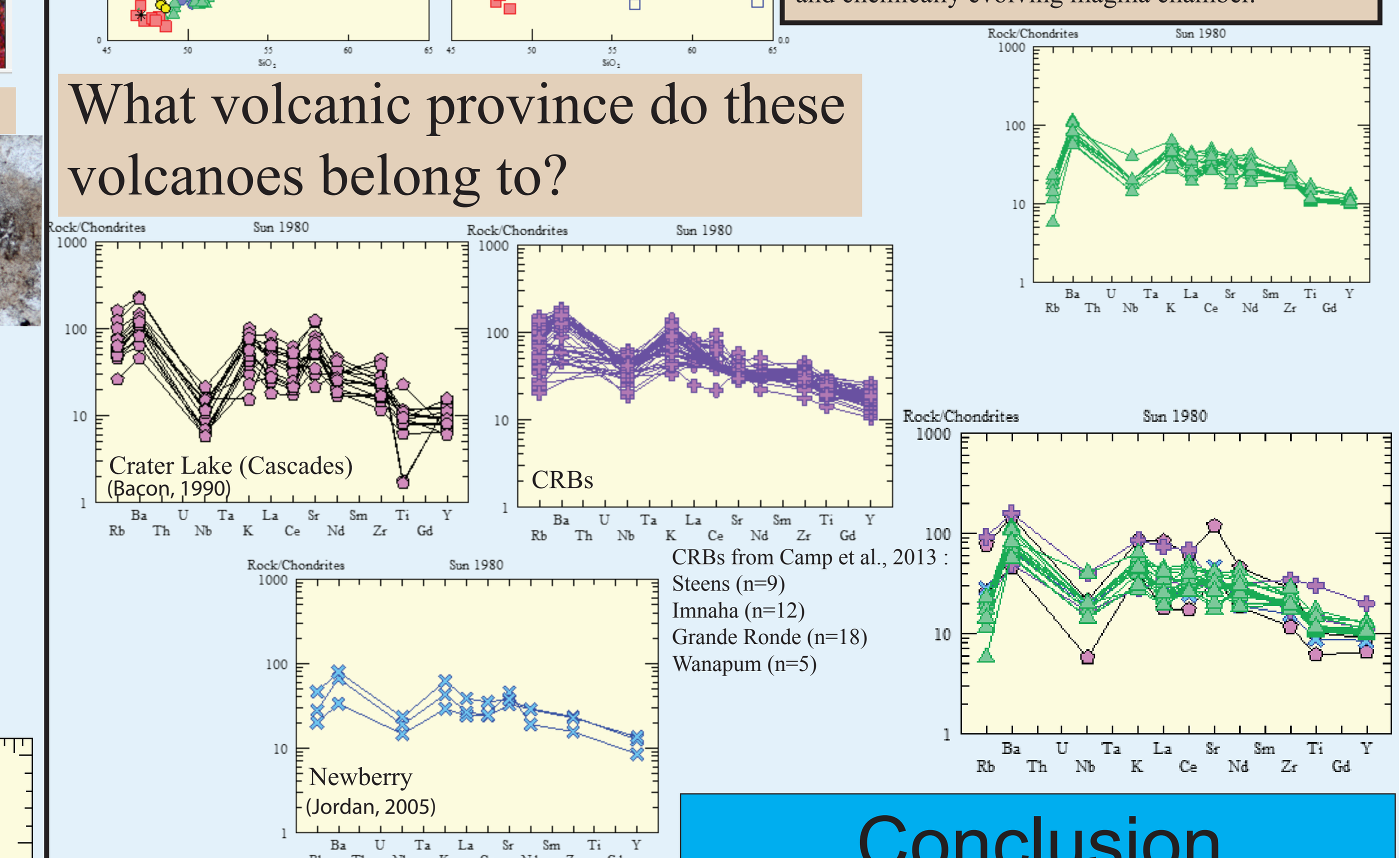
These Harker plots of the basalts and basaltic-andesites of the Green Mountain system show a systematic evolution of the volcanic system through time.
For example, MgO values decrease from the older marrs to the younger lava fields, while there is an enrichment of potassium from oldest to youngest.



Similarly, the Green Moutnain flows (green on other plots and maps) show an enrichment of the incompatible element Rb with increasing silica through time.

These geochemical trends strengthen our hypothesis, suggesting the Green Mountain system has a shared and chemically evolving magma chamber.

What volcanic province do these volcanoes belong to?



CRBs from Camp et al., 2013 :
Steens (n=9)
Imnaha (n=12)
Grande Ronde (n=18)
Wanapum (n=5)

Conclusion

The Green Mountain Shield Volcano shows signatures of magma evolution, both chemically and texturally.

The geochemistry of the basalts suggests the volcano had a similar source as Newberry, but also shows a significant subduction signature.

Future Work:

- Refine mapping of Green Mountain lava flows to determine 'flow-age' relationships. Collect samples for XRF analysis.

Acknowledgements:

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