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Petrogenesis of Cinder Cones on Villarrica Volcano, Southern Chile

Jordan Engstrom

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Introduction

The goal of this project is to determine the compositional heterogeneity of lavas erupted along a fissure system at Villarrica Volcano. Variations in geochemistry (major and trace elements) are used to evaluate the role of fractional crystallization down the fissure system.

- 12 samples were collected from Villlaririca:
  - 10 samples along a NE-SW trending cinder cone fissure system noted by ▭ on the map
  - 2 tephra from the 2015 eruption (9a and 9b)

Examining the composition along the fissure will allow us to determine if the fissure samples are related to each other and the 2015 tephra.

Research Questions

- Are lavas from the entire fissure system compositionally similar?
- Are lavas from a single cinder cone compositionally similar?
- Can differences be explained by fractional crystallization?

- Samples 9A and 9B are from the 2015 eruption
- Glassier than fissure samples

- Example of a typical fissure system sample
- Fissure system samples are more oxidized and weathered than the 2015 tephra

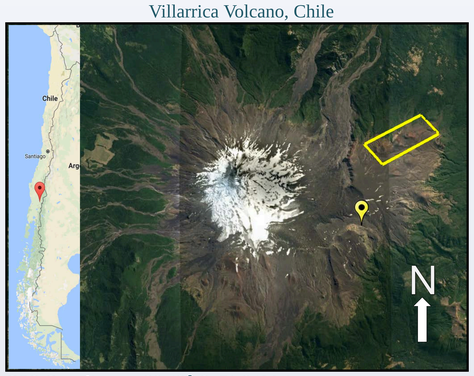
Villarrica Volcano

Proyecto De Observacion Villarrica (POVI, 2015)

- Villarrica is a subduction zone volcano in Southern Volcanic Province of Chile
- Most active volcano in Chile (Palma et al., 2008)
- Basaltic-basaltic andesite stratovolcano (Leach, 2012)
- Last eruption: March 3, 2015
- 42 recorded eruptions since 1900

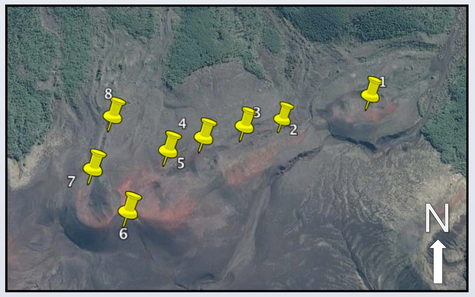
Study Site

Villarrica Volcano, Chile



GPS Coordinates: 39.43° S, 71.94° W

Fissure System

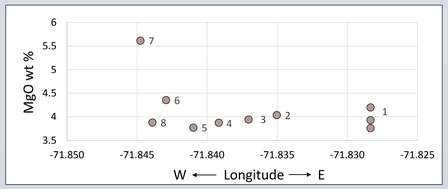


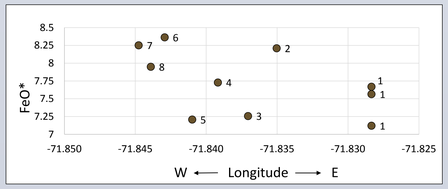
GPS Coordinates: 39.40° S, 71.84° W

Methods

- 12 samples collected from Villarrica in March 2015
- 3 samples collected from cone 1 to evaluate heterogeneity
- Processed by crushing, sieving, cleaning, and picking
- Weighed and dissolved samples for analyses
- Measured major and trace elements by solution ICP-MS

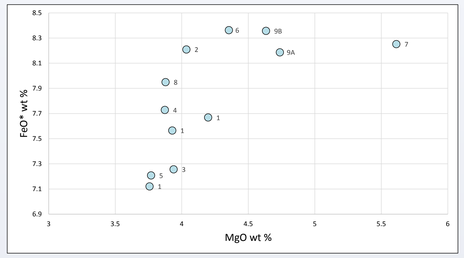
Compositions vs. Longitude

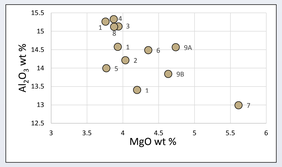


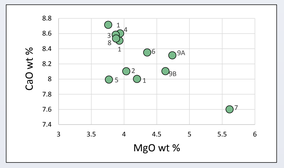


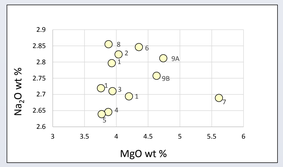
- Lava compositions are heterogeneous
- No consistent variation with longitude
- Slight variation in lavas collected from cinder cone 1, suggesting crystallization during eruption

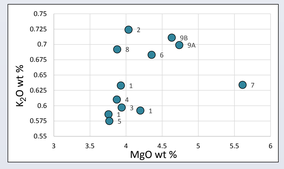
Major Elements





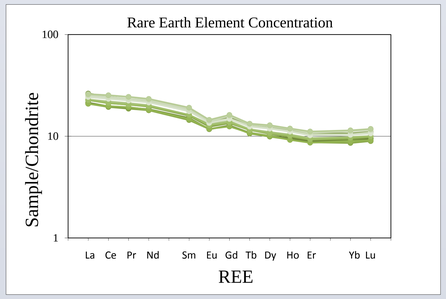




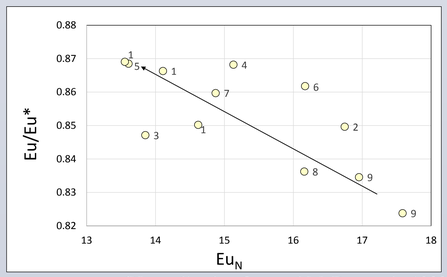


- Lavas have a range of major element contents, indicating that they are compositionally distinct
- Differences may be attributed to fractional crystallization

Trace Elements



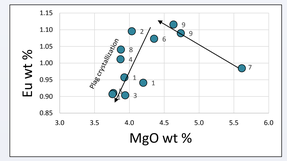
- Lavas have parallel REE patterns, consistent with fractional crystallization
- Europium anomaly evidence for plagioclase crystallization



(Normalized to Sun and McDonough, 1989)

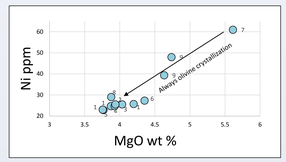
$$\frac{Eu}{Eu^*} = \frac{Eu_N}{\sqrt{(Sm_N)(Gd_N)}}$$

Crystallization Trends



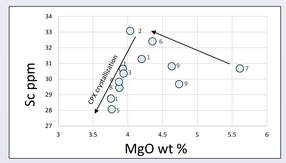
Plagioclase crystallization

- Eu^{2+} substitutes into plagioclase for Ca^{2+}



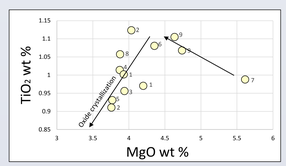
Olivine crystallization

- Ni^{2+} substitutes for Mg^{2+} in olivine



Clinopyroxene crystallization

- Sc^{3+} substitutes into CPX for Fe^{3+}



Fe-oxide crystallization

- Fractionating oxides supported by FeO* plot

Conclusions

- Are lavas from *a single cinder cone* compositionally similar?
  - In a single cone, samples are heterogeneous and show evidence for crystallization
- Can any differences be explained by fractional crystallization?
  - Geochemical evidence for crystallization of olivine, plagioclase, clinopyroxene, and Fe-oxide
- Are lavas from the *entire fissure system* compositionally similar?
  - Samples are compositionally heterogeneous

Future Research

- Pick sample for more accurate major element contents with XRF
- Use Melts program (Ghiorso and Sack, 1995) to model fractional crystallization trends using a range of parameters:

		QFM +1			QFM +2		
		P1	P2	P3	P1	P2	P3
Si 51%	H2O 1%						
	H2O 2%						
Si 52%	H2O 1%						
	H2O 2%	x	x	x			

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References

- Ghiorso M.S., Sack R.O. (1995). Chemical mass transfer in magmatic processes IV. A revised and internally consistent thermodynamic model for the interpretation and extrapolation of liquid–solid equilibria in magmatic systems at elevated temperatures and pressures. Contributions to Mineralogy and Petrology, 119 (2/3), pp. 197–212
- Hickey-Vargas, R., Moreno-Roa, H., Lopez-Escobar, L., Frey, F.,1989. Geochemical variations in Andean basaltic and silicic lavas from the Villarrica-Lanin volcanic chain (39.5 °S): an evaluation of source heterogeneity, fractional crystallization and crustal assimilation. Contributions to Mineralogy and Petrology, 103, 361-386.
- Leach, R. A. (2012). A textural and chemical study of lavas from Villarrica and Llaima volcanoes, Chile: Evidence for magma recharge and mixing (Masters thesis). Retrieved from GeoRef database.
- Palma, J. L., E. S. Calder, D. Basualto, S. Blake, and D. A. Rothery (2008), Correlations between SO2 flux, seismicity, and outgassing activity at the open vent of Villarrica volcano, Chile, J. Geophys. Res., 113, B10201.
- Sun, S.S. McDonough, W.F., 1989, Chemical and isotopic systematics of oceanic basalts: Implications for mantle composition and processes, in Sauders , A.D., and Norry, M.J., eds., Magmatism in the Ocean Basins: Geological Society of London Special Publication 42, p. 313-345.