Petrology of Volcanic Rocks from Bequia and St. Vincent*

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Abstract

Volcanism in the Lesser Antilles is a manifestation of the westward subduction of the North American plate beneath the Caribbean plate. The compositions of the igneous rocks produced vary along the arc. The calc-alkaline rock suite, usually typified in its occurrence in subduction zones settings, is not ubiquitous in the Lesser Antilles volcanic arc. There is a chemical variation along the arc axis that can only be explained by the presence of more than one magma series: alkaline in the south, calc-alkaline in the central islands and tholeiitic to the north. The occurrence of different magma series within a close spatial and temporal setting provides an opportunity to assess the factors controlling erupted lava compositions in a modern intra-oceanic volcanic arc. Within this context, the geochemical affinities of neighbouring volcanic islands Bequia and St. Vincent have been found to be transitional between alkalic and calc-alkaline characteristics, reflecting their positions along the arc. Recent research has highlighted a petrological and geochemical boundary between Grenada and St. Vincent, but its position in the Grenadines has not yet been determined. This study uses petrological and geochemical data from lavas of Bequia and La Soufriere, St. Vincent to compare the evolution of the magmatic systems from both localities to help constrain the geochemical transition in the southern segment of the arc.

Phenocryst compositions from Bequia and Soufriere lavas were determined using electron probe microanalysis. These analyses and petrographical observations were used to explore the roles of differentiation processes involved in each system's magma

evolution. The lavas studied consisted of basalts and andesites (Bequia) and basaltic andesites (La Soufriere), the most mafic of which (pyroxene mg-number 82) came from Bequia. These phenocryst rich lava suites contained mineral assemblages dominated by mafic phases including clinopyroxene, Ti-magnetite, plagioclase and orthopyroxene for Soufriere, with the addition and exclusion of olivine and spinel respectively for Bequia. Both systems exhibited similar disequilibrium textures with phenocrysts showing evidence of compositional zoning, overgrowths, resorption and exsolution. Bequia olivines provided evidence for post magmatic alteration showing partial to complete replacement to iddingsite. While similar disequilibrium textures and mineral assemblages suggested similar evolutionary histories for both suites, this did not necessarily translate to their mineral chemistries being the same.

A comprehensive comparison of these lavas is not complete without the inclusion of geochemical analyses. Pending the inclusion of whole rock geochemical data, this preliminary study is based on phenocryst chemistry and petrography of the samples analysed, along with data from previous research in these areas.

References Cited

Brown, G.M., J.G. Holland, H. Sigurdsson, J.E. Tomblin, and R.J. Arculus, 1977, Geochemistry of the Lesser Antilles volcanic island arc: Geochim. Cosmochim. Acta, v. 41, p. 785-801.

Heath, E., R. MacDonald, H.E. Belkin, and C.J. Hawkesworth, 1998, Magmagenesis at the Soufriere St. Vincent Volcano, Lesser Antilles arc: Journal of Petrology, v. 39, p. 1721-1764.

Irvine, T.N., and W.R.A. Baragar, 1971, A guide to the chemical classification of the common volcanic rocks: Canadian Journal of Earth Sciences, v. 8, p. 523-548.

Miyashiro, A., 1974, Volcanic rock series and tectonic setting: Annual Review of Earth and Planetary Sciences, V. 3, p. 251

Robertson, R.E.A., A. Samuel, J.B. Shepherd, L. Lynch, and J.L. Latchman, 2003, Monitoring volcanic activity at the Soufrière volcano – a model for volcano monitoring operations in small-island nations: Web Accessed October 3, 2015, http://www.open.uwi.edu/sites/default/files/bnccde/svg/conference/papers/BeyondWalls_StVincentI.htm.

Robertson, R.E.A., 2005, St. Vincent: in Lindsay, J.M., Robertson, R.E.A., Shepherd, J.B., and Ali, S. (Eds.), Volcanic hazard atlas of the Lesser Antilles, University of the West Indies, Trinidad and Tobago, W.I., Seismic Research Unit, p. 241-273.

Sigurdsson, H., 1981, Geological observations in the crater of Soufriere volcano, St. Vincent: Seismic Research Unit, Spec. Publ., Univ. West Indies, Trinidad.

Smith, T.E., M.F. Thirlwall, and C. Macpherson, 1996, Trace Element and Isotope Geochemistry of the Volcanic Rocks of Bequia, Grenadine Islands, Lesser Antilles Arc: a Study of Subduction Enrichment and Intra-crustal Contamination: Journal of Petrology, v. 37, p. 117-143.

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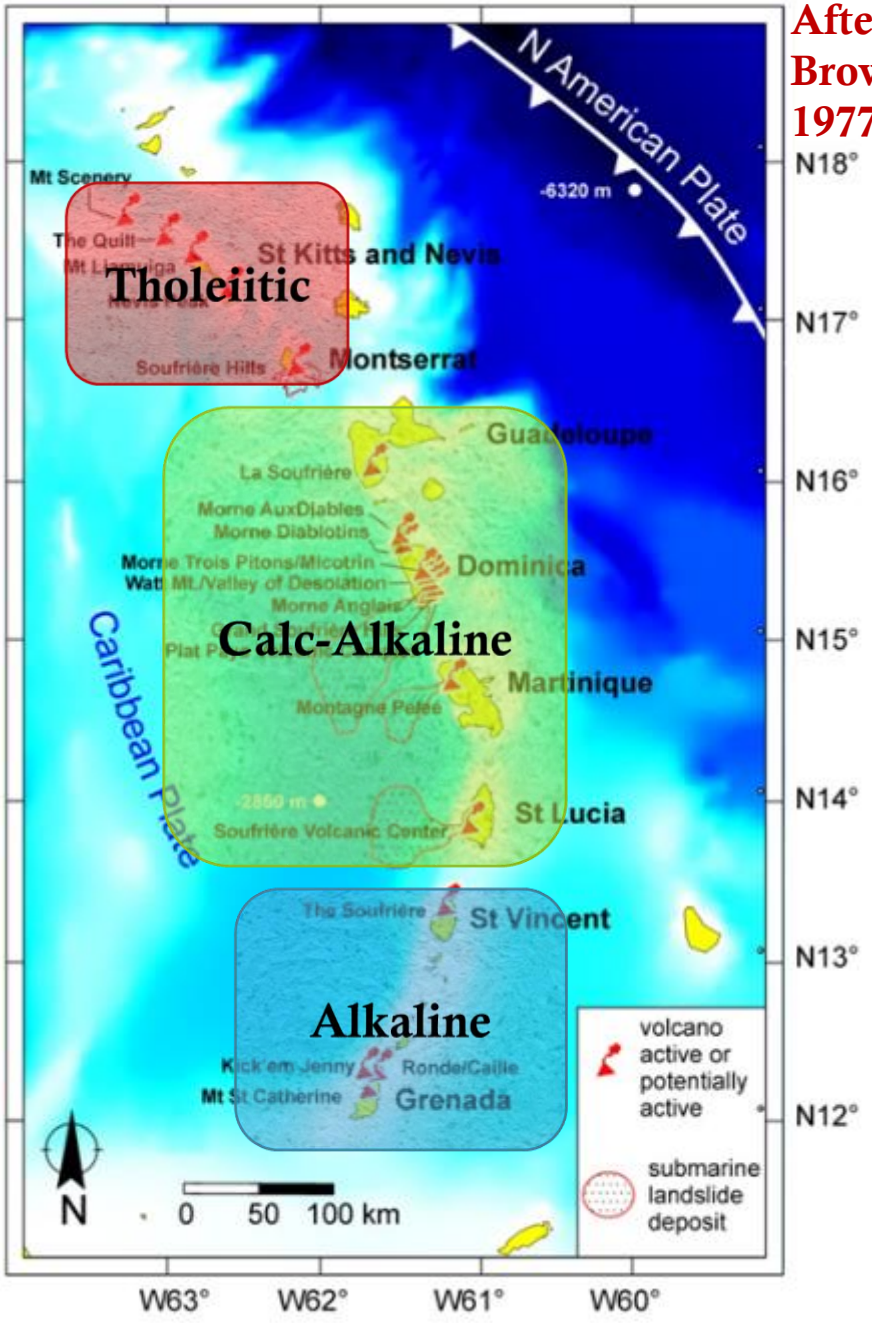
Presentation Outline

- Lesser Antilles island arc volcanism
- Bequia and St. Vincent: eruptive history, analyses
- The way forward

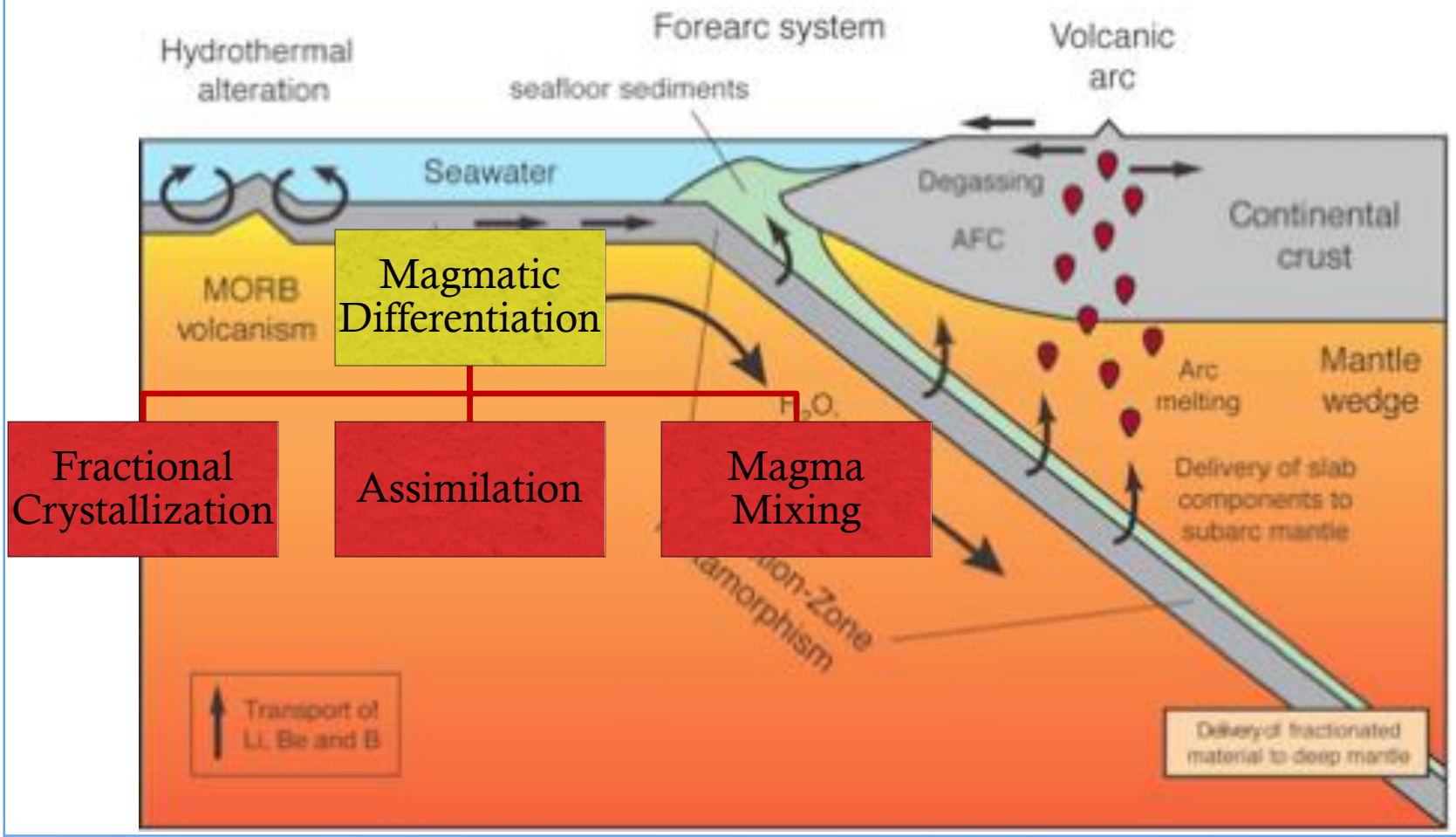
Lesser Antilles Volcanism

1812 eruption Soufrière, St. Vincent
Painting by Joseph Turner



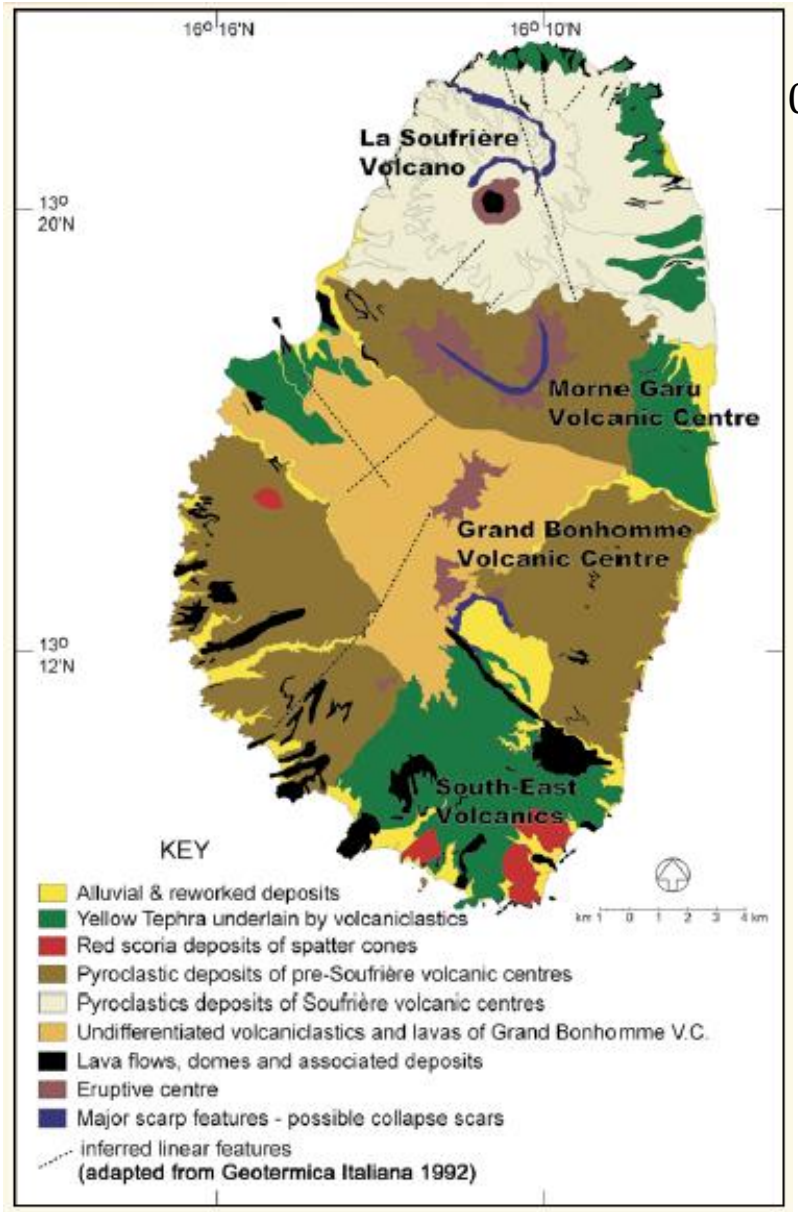
After Brown et al. 1977

Magma Generation at Subduction Zones



http://www.whoi.edu/science/GG/people/marschall/Horst_Marschall_WHOI/Subduction_Zones.html

St. Vincent Volcanism



La Soufrière

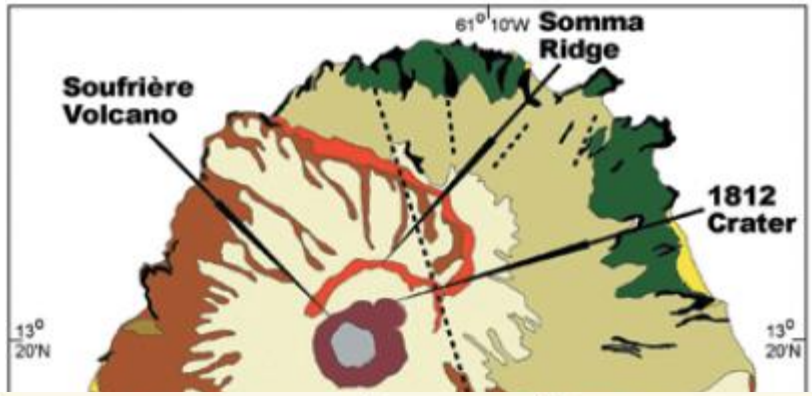
Historical activity

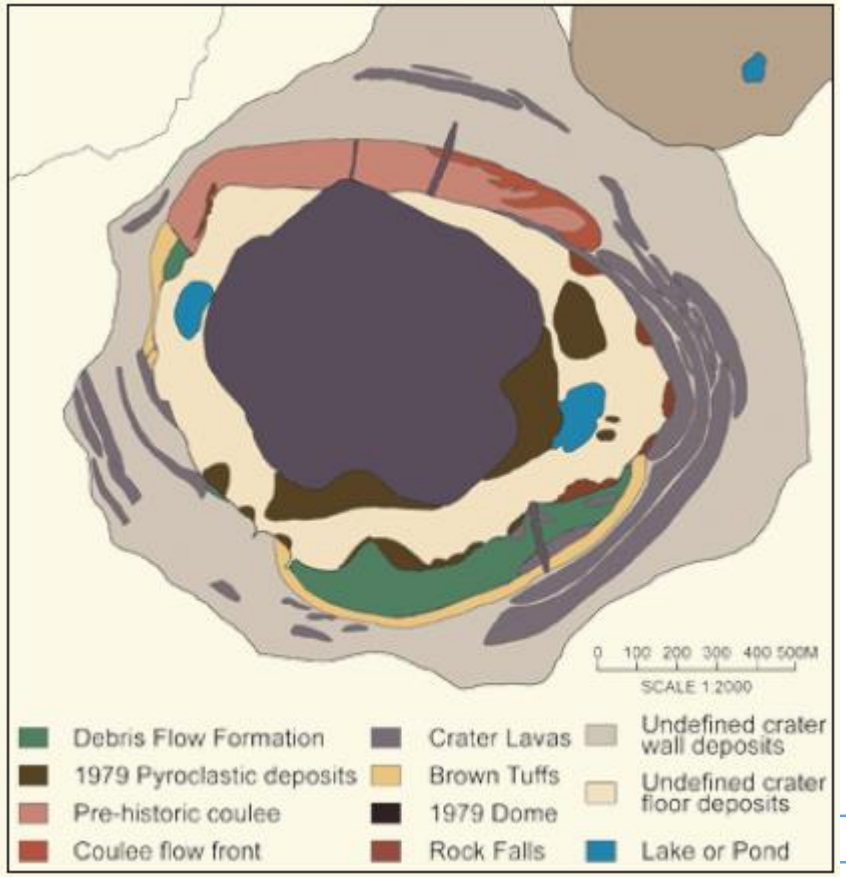
- highly explosive eruptions, preceded by frequent, strong earthquakes
- quietly effusive extrusions of viscous lava domes unaccompanied by earthquakes

Pre-historic activity

- Volcano flanks: basaltic lavas (Pre-Somma) overlain by Yellow Tephra Formation
- 4 formations identified in the crater: Debris Flow, Brown Tuff, Crater Lava and Pyroclastic Formations

Geological map of La Soufrière (Robertson 2005)





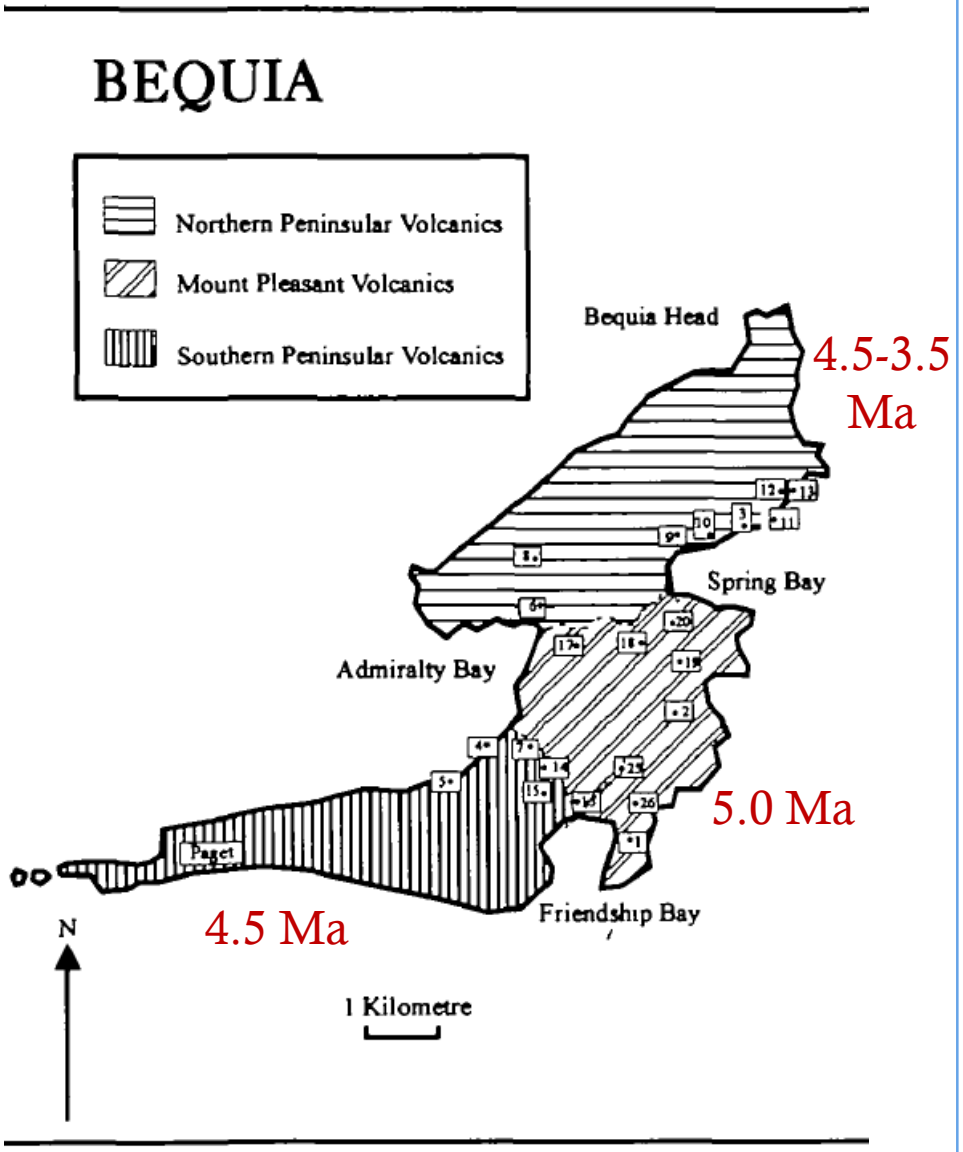
La Soufrière crater (Sigurdsson 1981)

Bequia Volcanism

Smith et al. 1996

Isotopically Homogenous Suite

Isotopically Diverse Suite

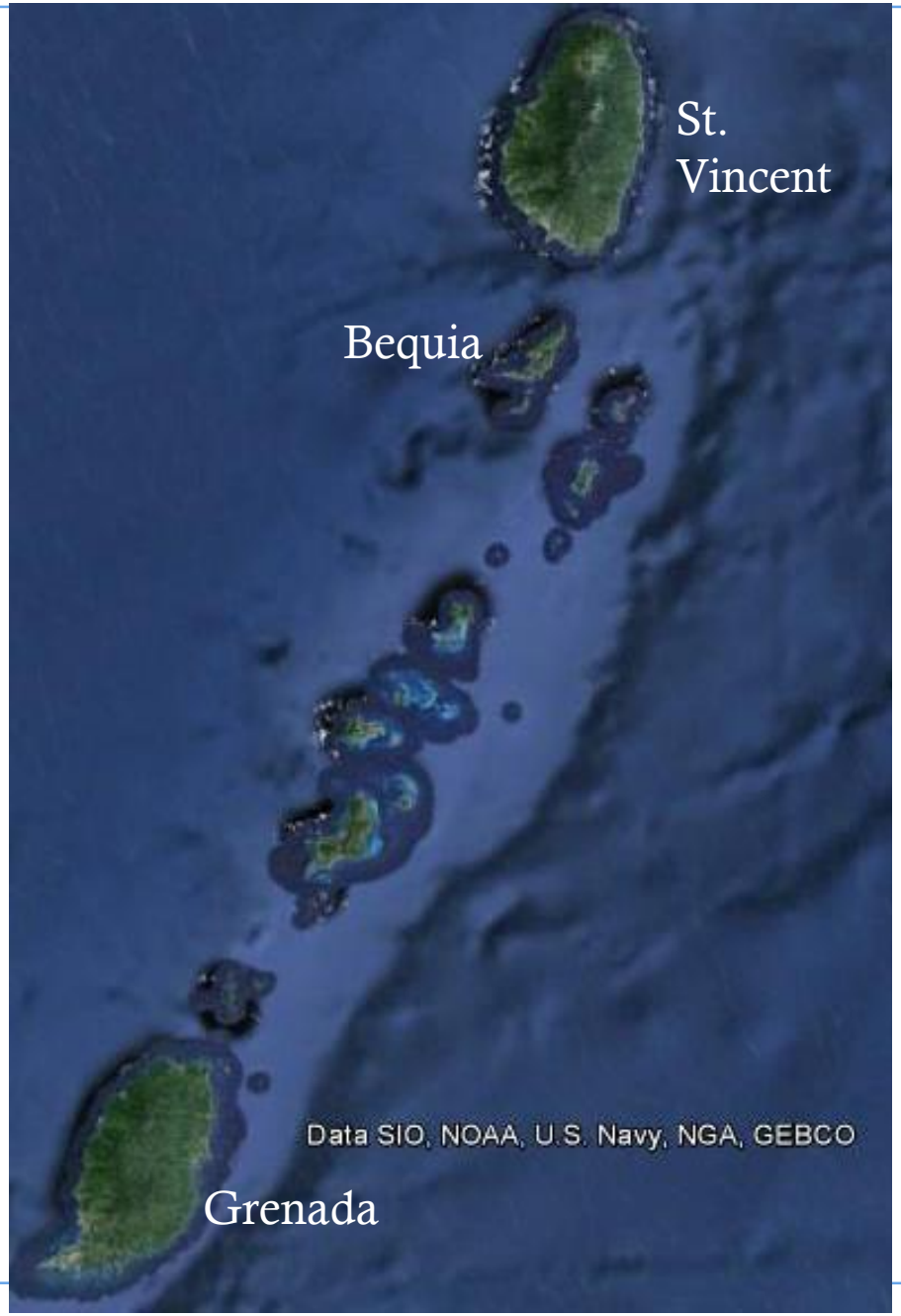


Source: Smith et al. 1996

Basis for Bequia-St.Vincent Comparison

- Bequia and St. Vincent are geographical neighbours

- Petrological and geochemical boundary between Grenada and St. Vincent



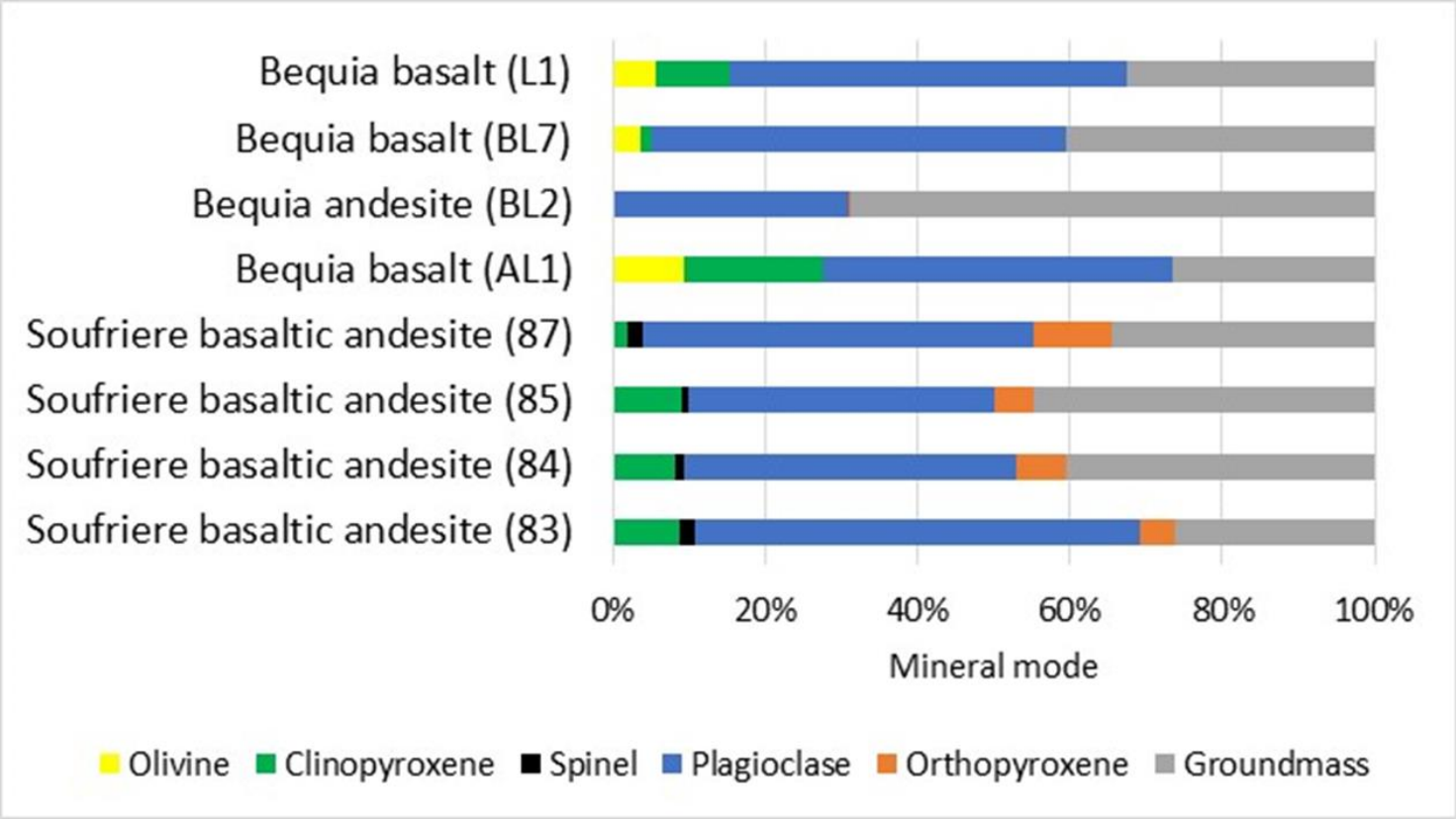
Methods

Lava samples collected from Bequia and Soufrière, St. Vincent

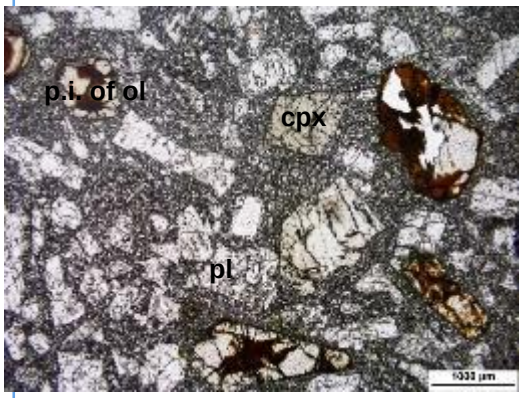
Lava Analyses

- Mineral Textures via Petrographic Microscope
- Phenocryst Compositions via Electron Probe Micro-Analysis

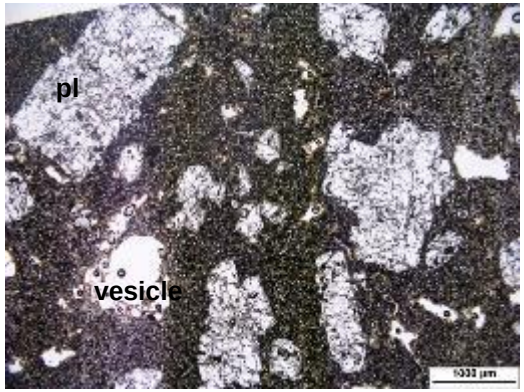
Phenocryst Mineral Modes



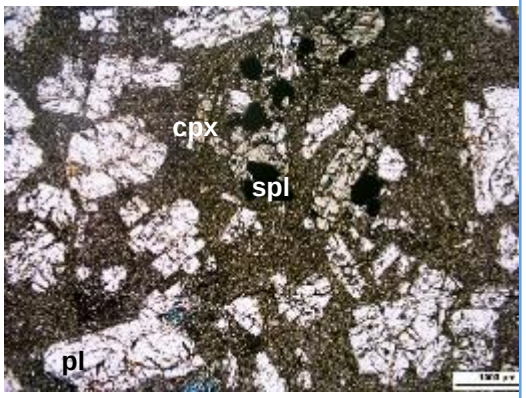
Photomicrographs (plane polarised light) of textural features in lavas



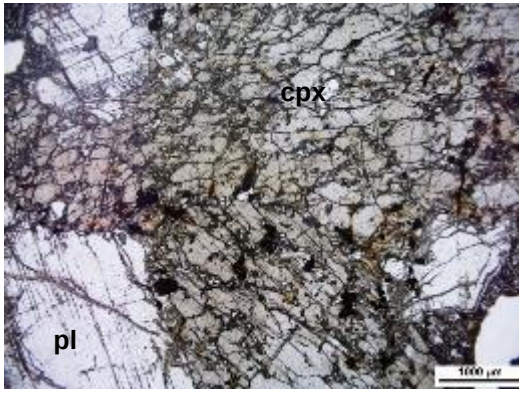
Bequia basalt (L1)



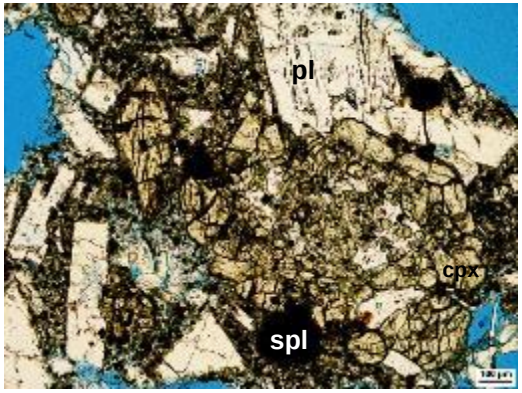
Bequia andesite (BL2)



Soufrière basaltic andesite (85)



Bequia glomerocryst cluster (AL1)

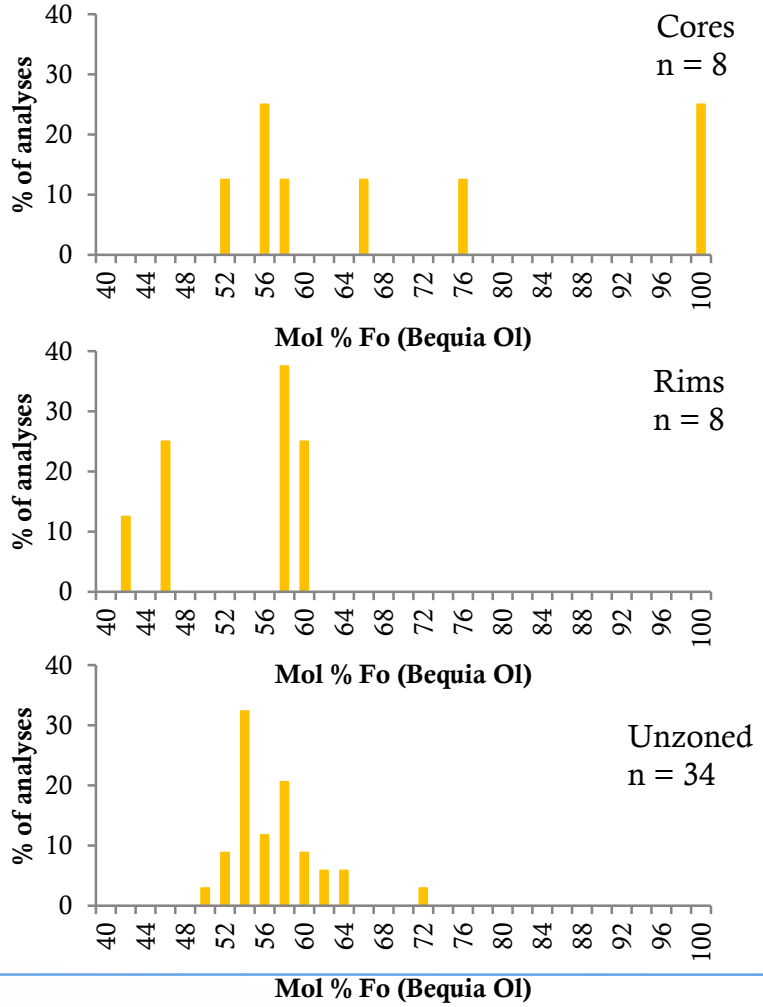


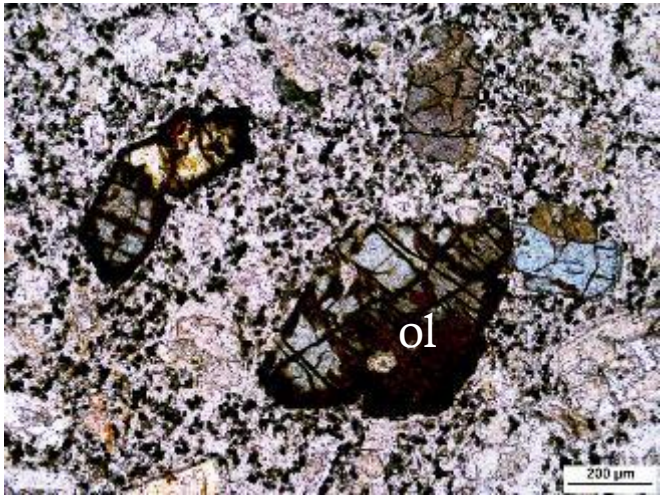
Soufrière glomerocryst cluster (83)

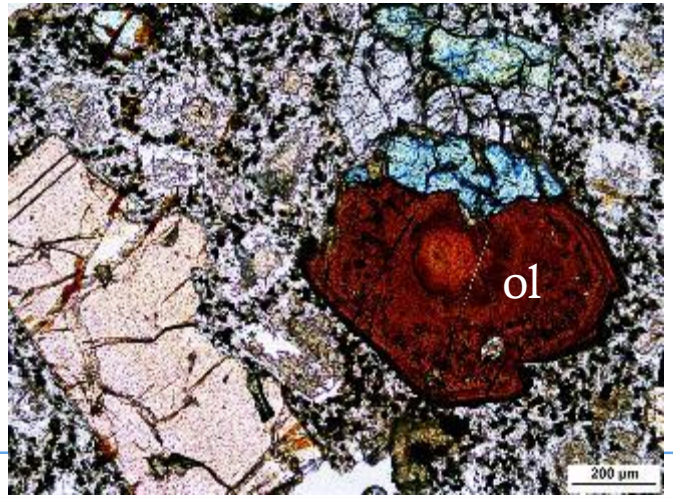
Minerals: ol, olivine; pl, plagioclase; cpx, clinopyroxene; spl, spinel

Alteration: p.i., partial iddingsitization

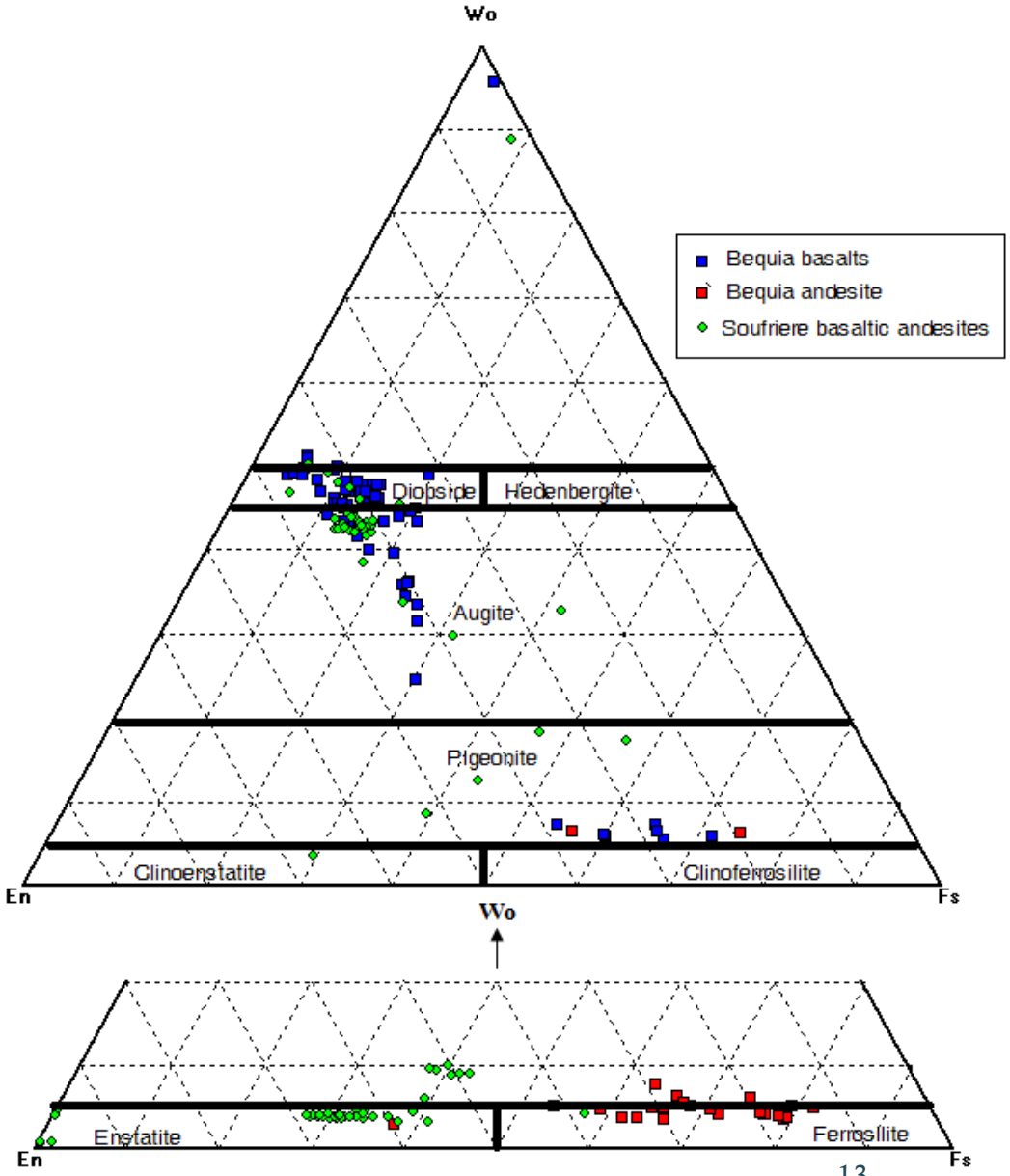
Olivine phenocryst compositions

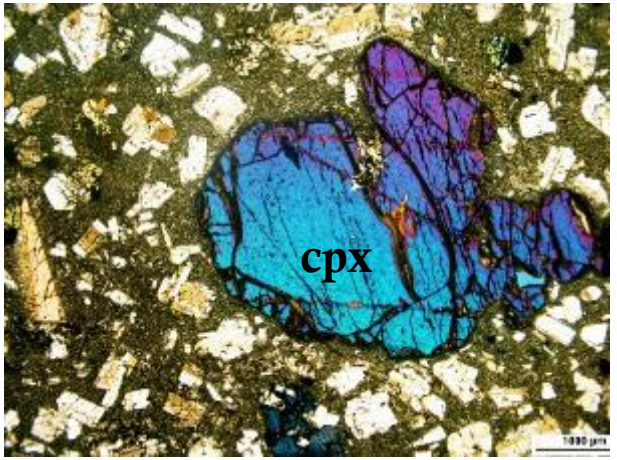


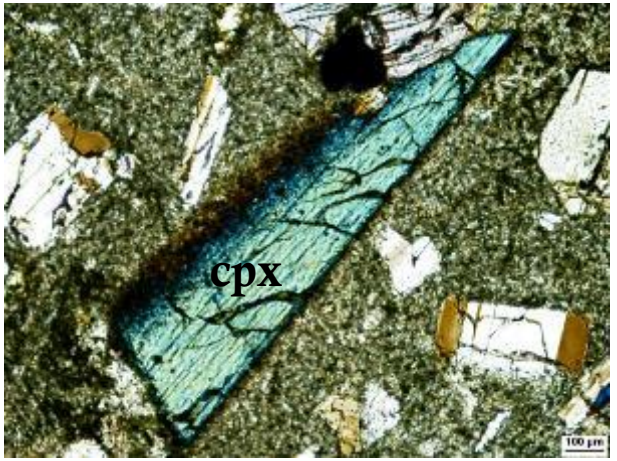




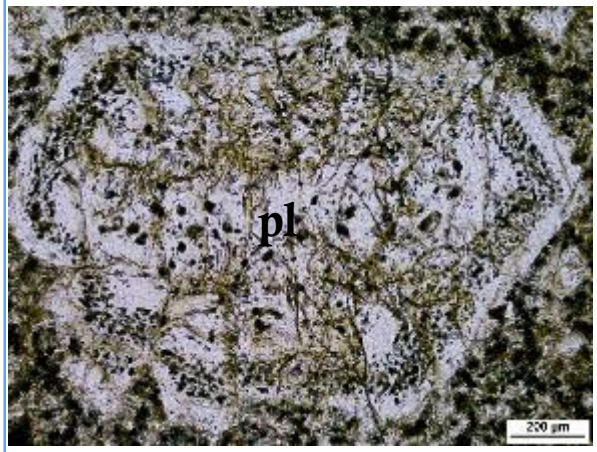
Pyroxene phenocryst compositions

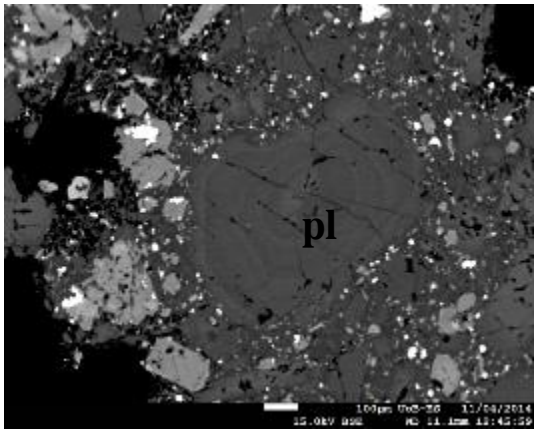


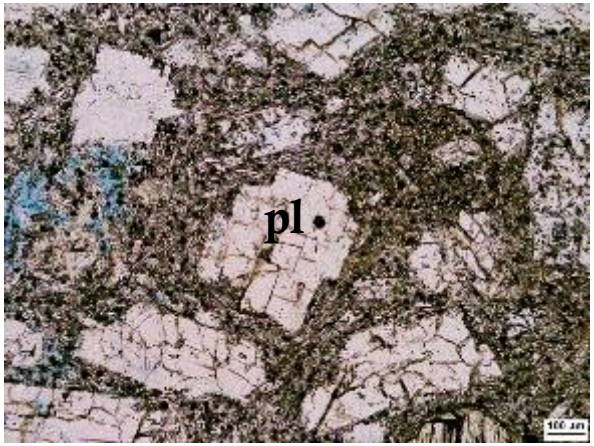


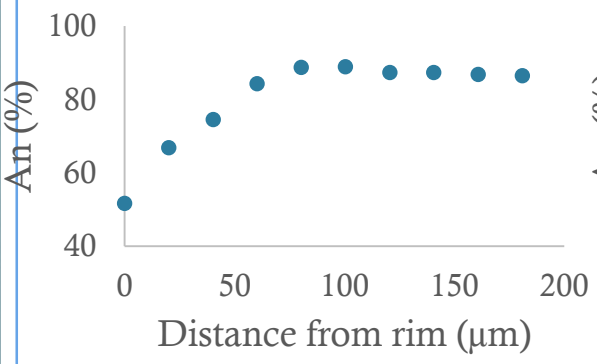


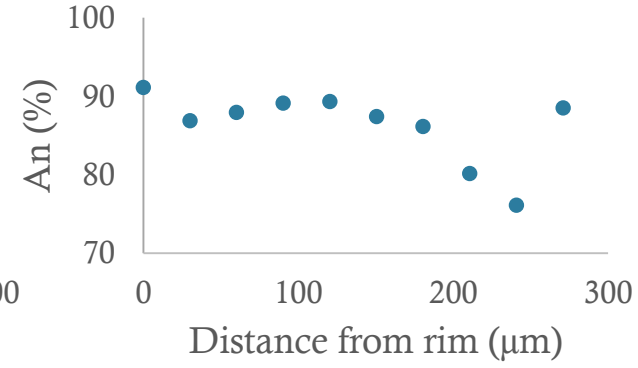
Plagioclase phenocryst compositions





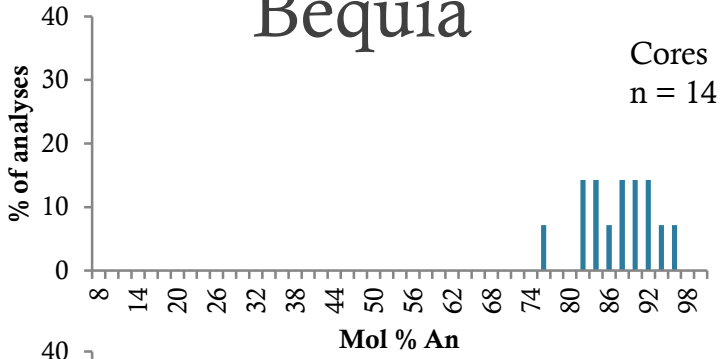


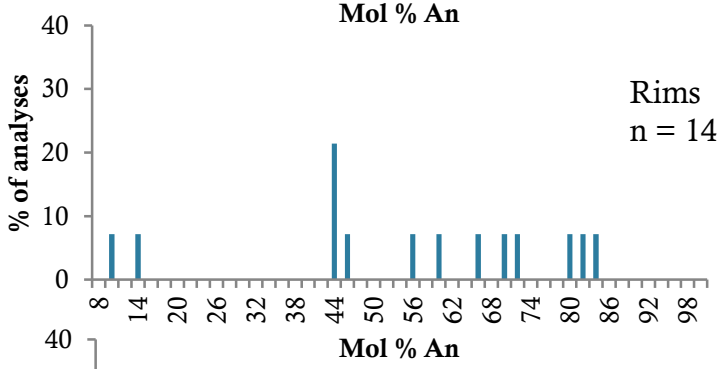


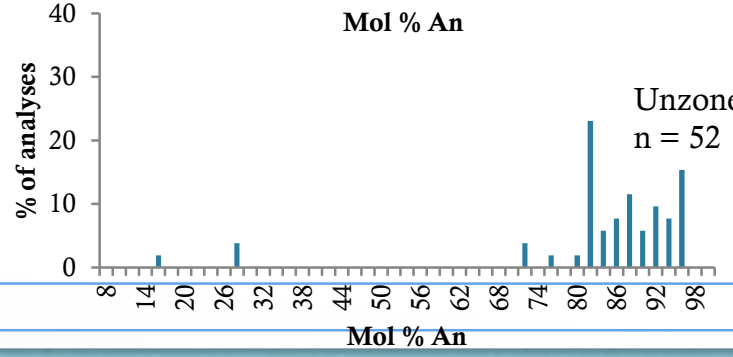


Plagioclase phenocryst compositions

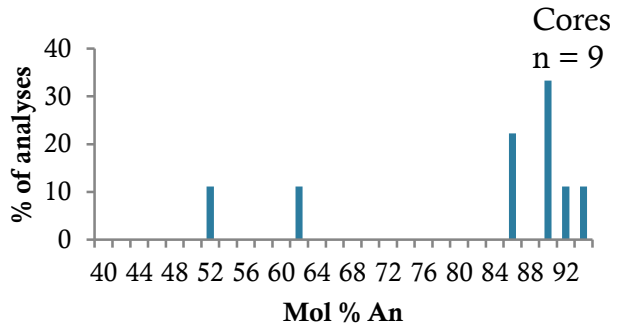
Bequia

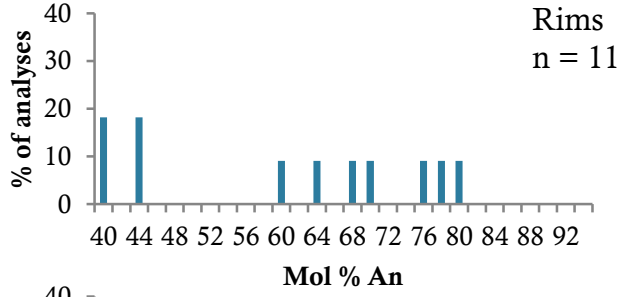


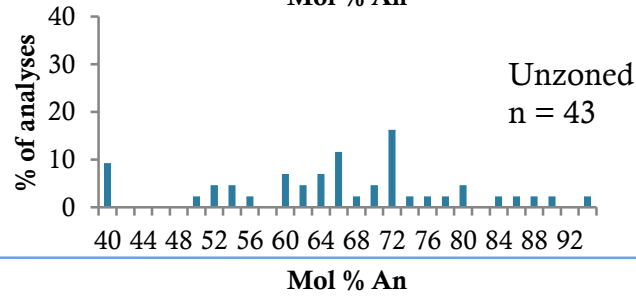




Soufrière

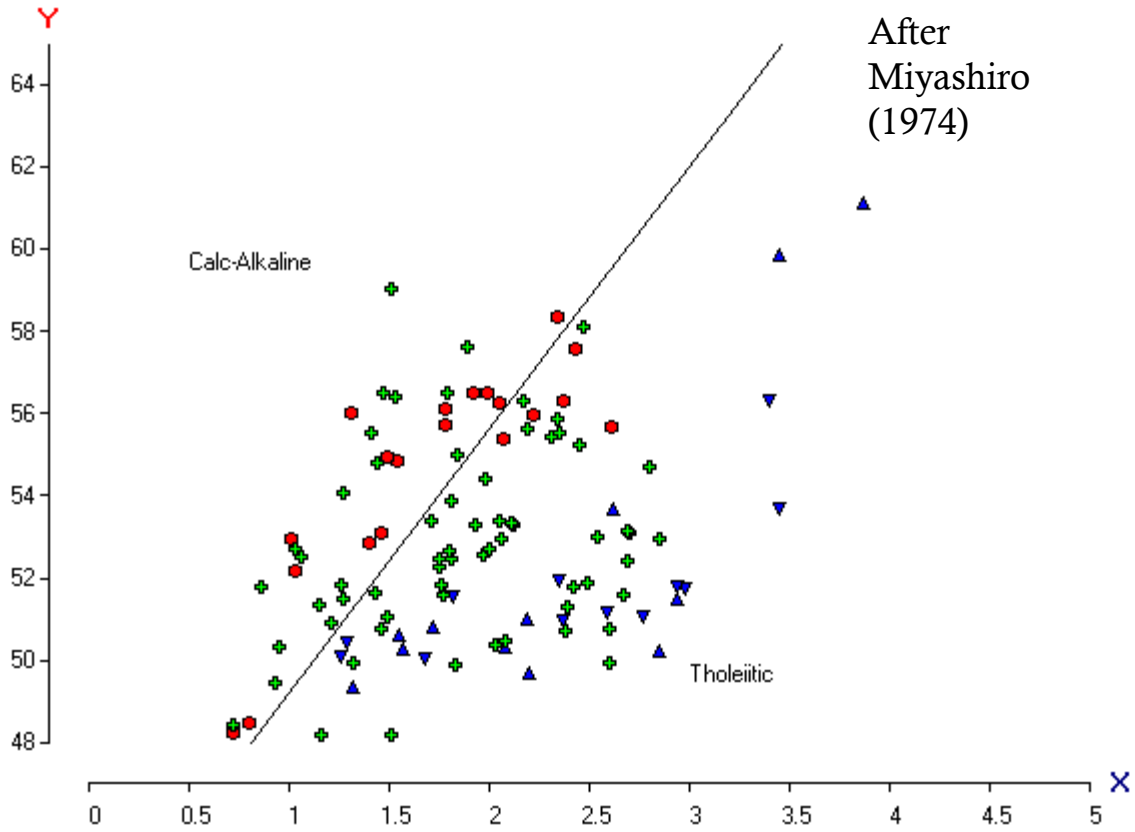






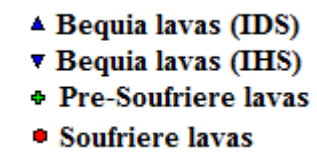
Preliminary Comparison

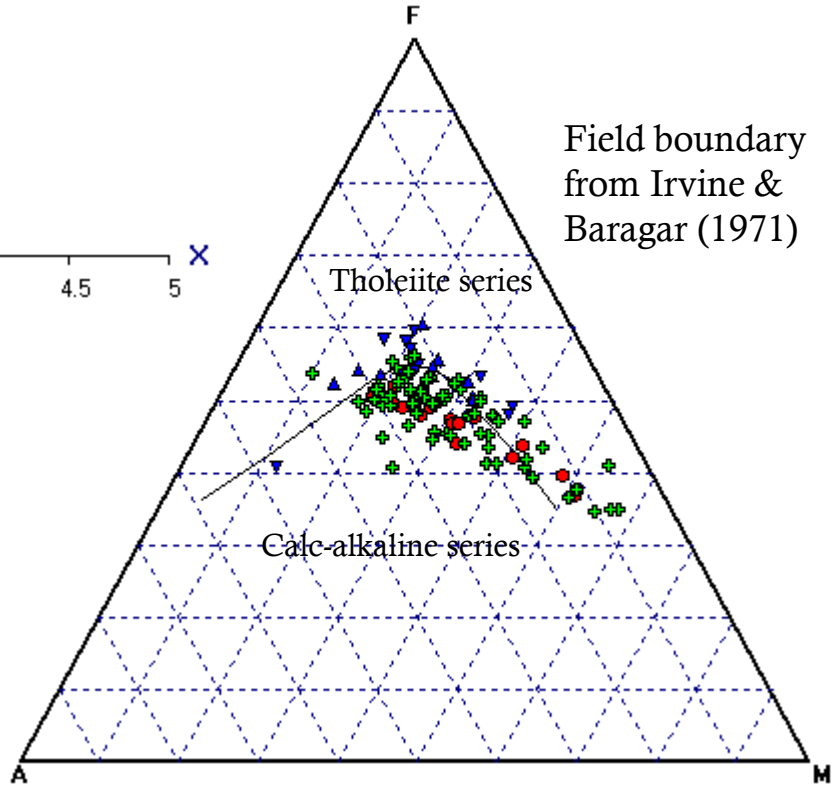
- Similar disequilibrium textures in both localities
- Need to include geochemical data to elucidate any differences in compositions



After Miyashiro (1974)

X = FeO*/MgO
Y = SiO_2





Field boundary from Irvine & Baragar (1971)

Whole Rock Data:

Smith et al. 1996
Robertson 2003
Heath et al. 1998

Further Work

- Conduct whole rock geochemical analyses (XRF)
- Collect and analyse more rock samples from Bequia and Soufrière
- Analyse rock samples from Kick ‘em Jenny and incorporate into study

Ultimate objectives of research

- Investigate processes and materials influencing magmatic evolution on both islands
- Determine what drives eruptions at La Soufrière
- Constrain petrological transition between Grenada and St. Vincent

Thanks for your attention