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Suswa volcano, Kenya rift: evidence of magma mixing, Na-F complexing and eruptions triggered by recharge.

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Suswa volcano, Kenya rift: evidence of magma mixing, Na-F complexing and eruptions triggered by recharge

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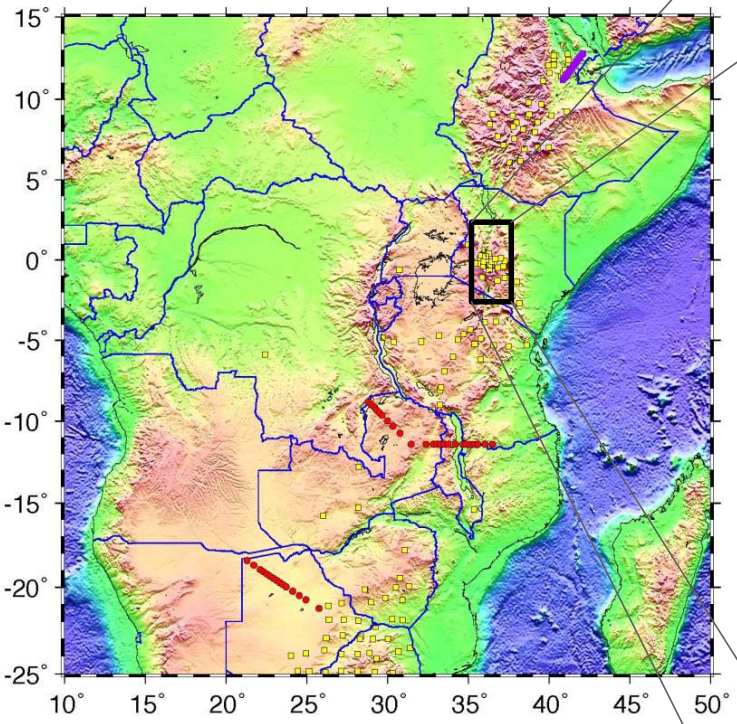
University of Texas at El Paso
August 2009

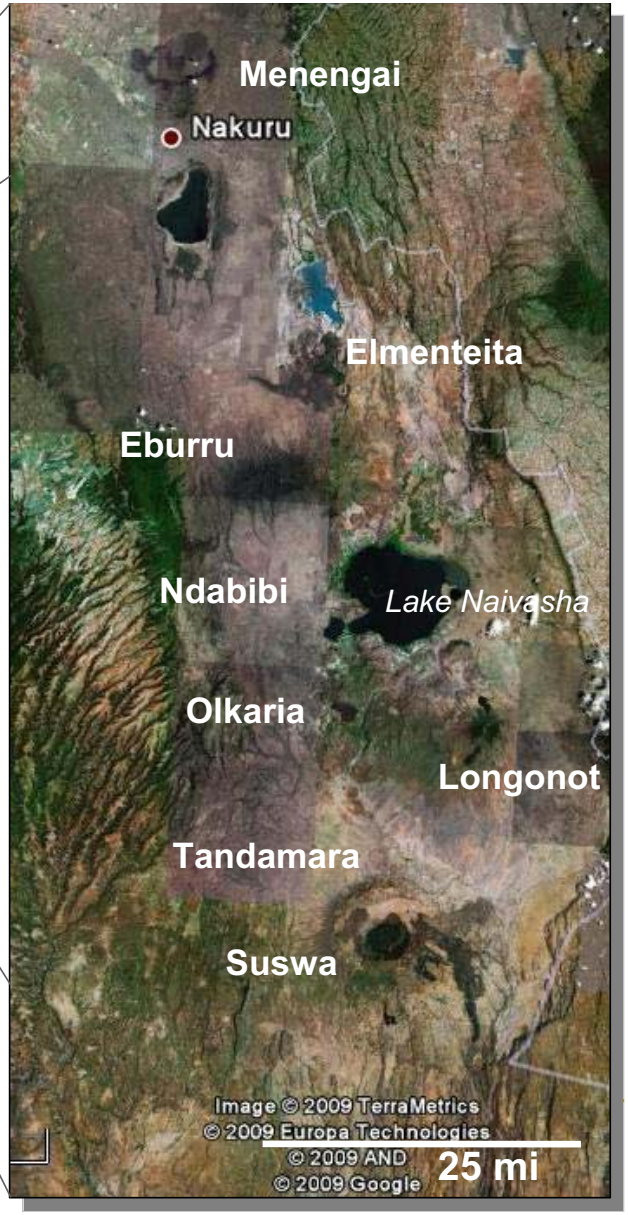
Ph.D. dissertation pdf file available at: http://digitalcommons.utep.edu/dissertations/

Outline

- Location of Central Kenya Peralkaline Province
- Major element compositions
- Processes
  - Magma mixing
  - Na-F complexing
- Magma evolution
- Recent geodetic studies
- Magma injection model

Central Kenya Peralkaline Province





- Current review:
  - Macdonald and Baginski, 2009, "*The Central Kenya Peralkaline Province: a unique assemblage of magmatic systems*", Mineral Magazine, 73(1), 1-16.

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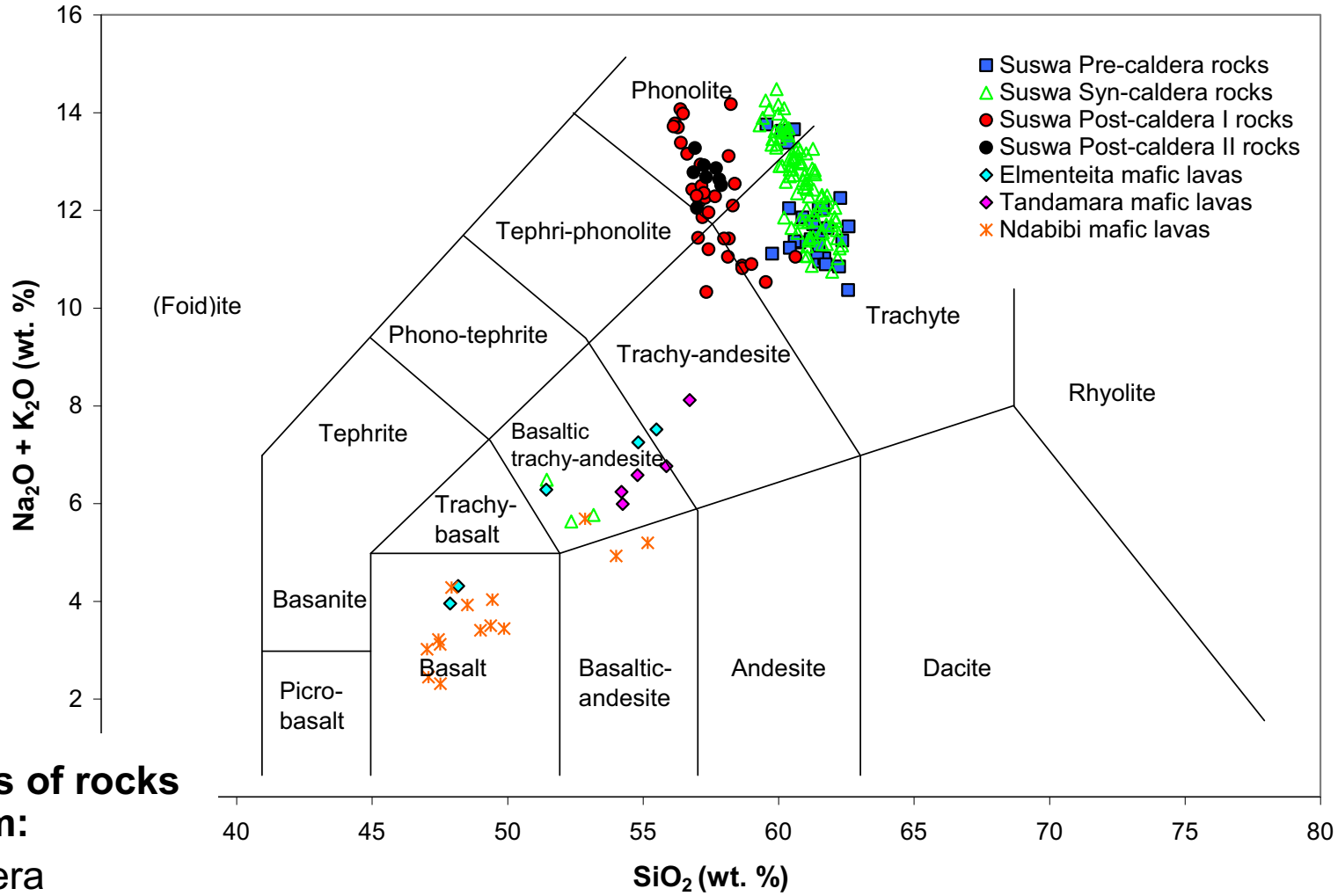
Whole-rock compositions



- **Three major sets of rocks at Suswa system:**
  - Pre-/syn-caldera
  - Post-caldera
  - Mafic rocks

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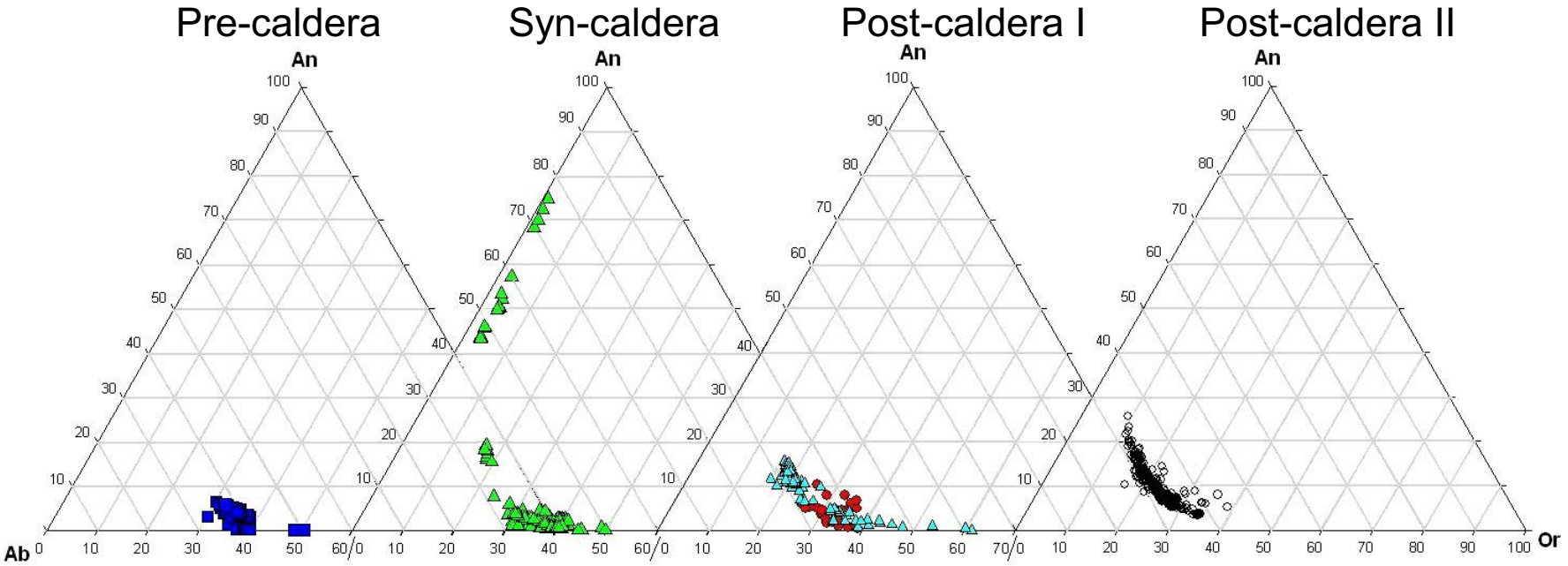
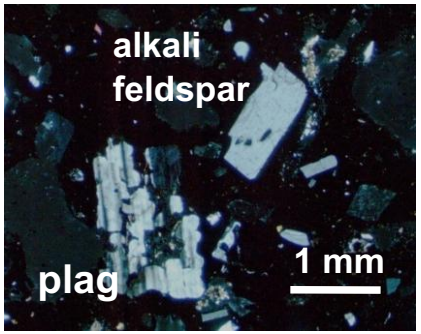
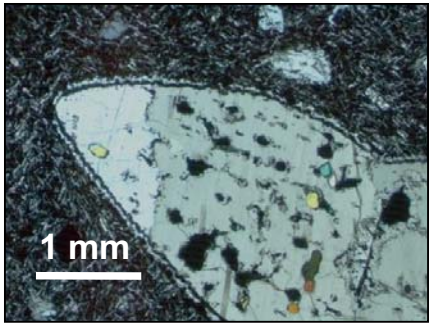
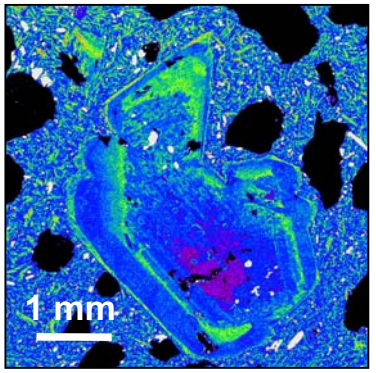
Magma mixing

- Evidence in alkali feldspar compositions.

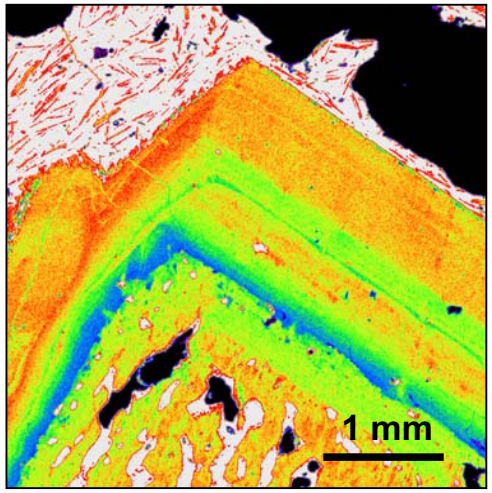


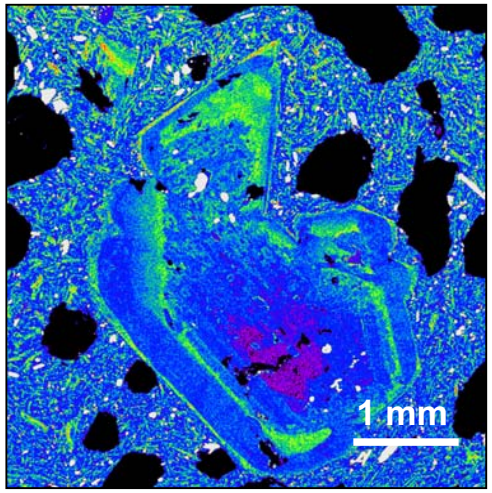


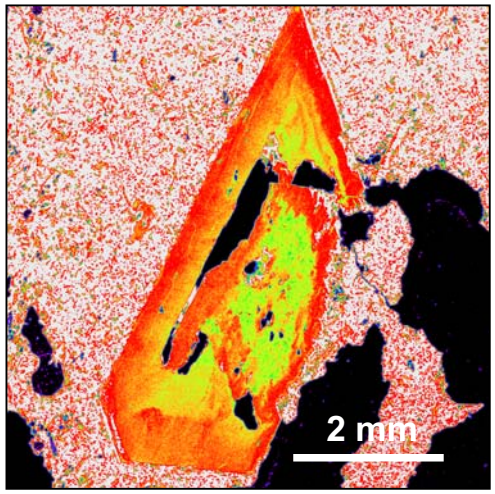


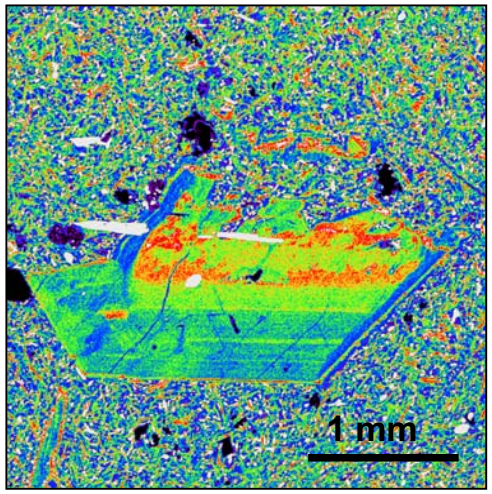


Post-caldera zoned feldspars



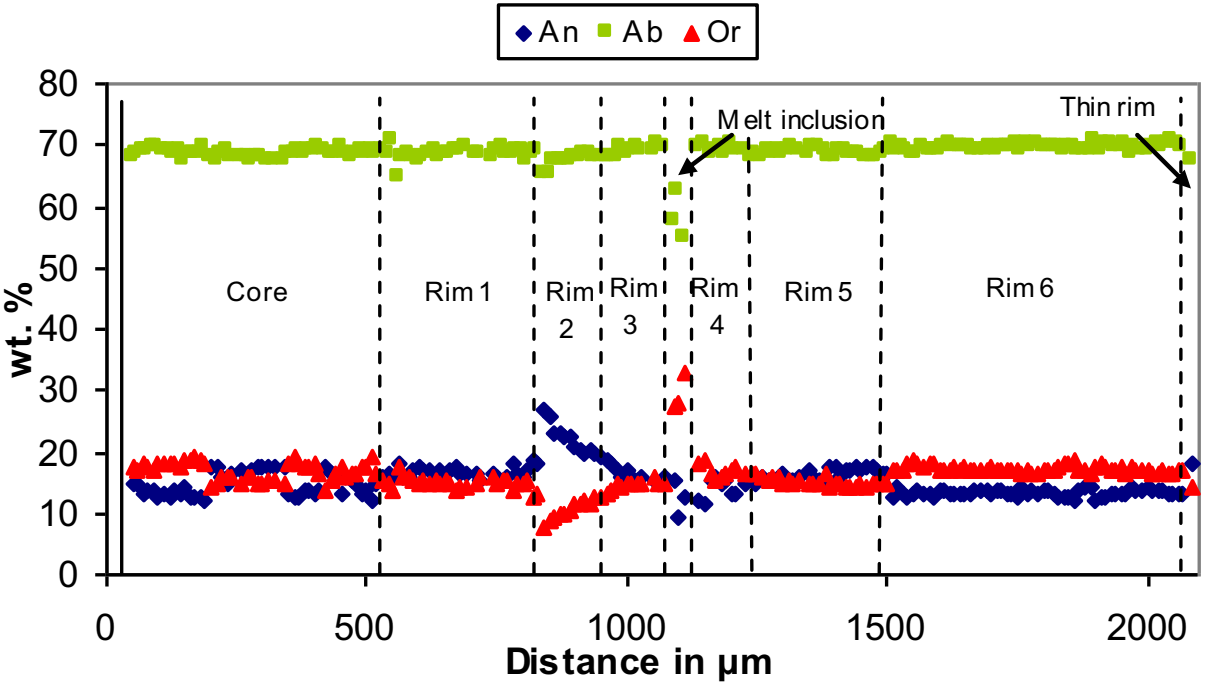


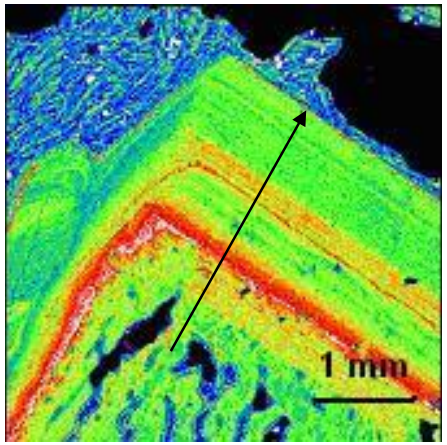




Zoned feldspars

- Oscillatory zoning.
- Variations between: CaO (anorthite, in blue) and K_2O (orthoclase, in red).
- Na_2O (albite, in green) is essentially constant.

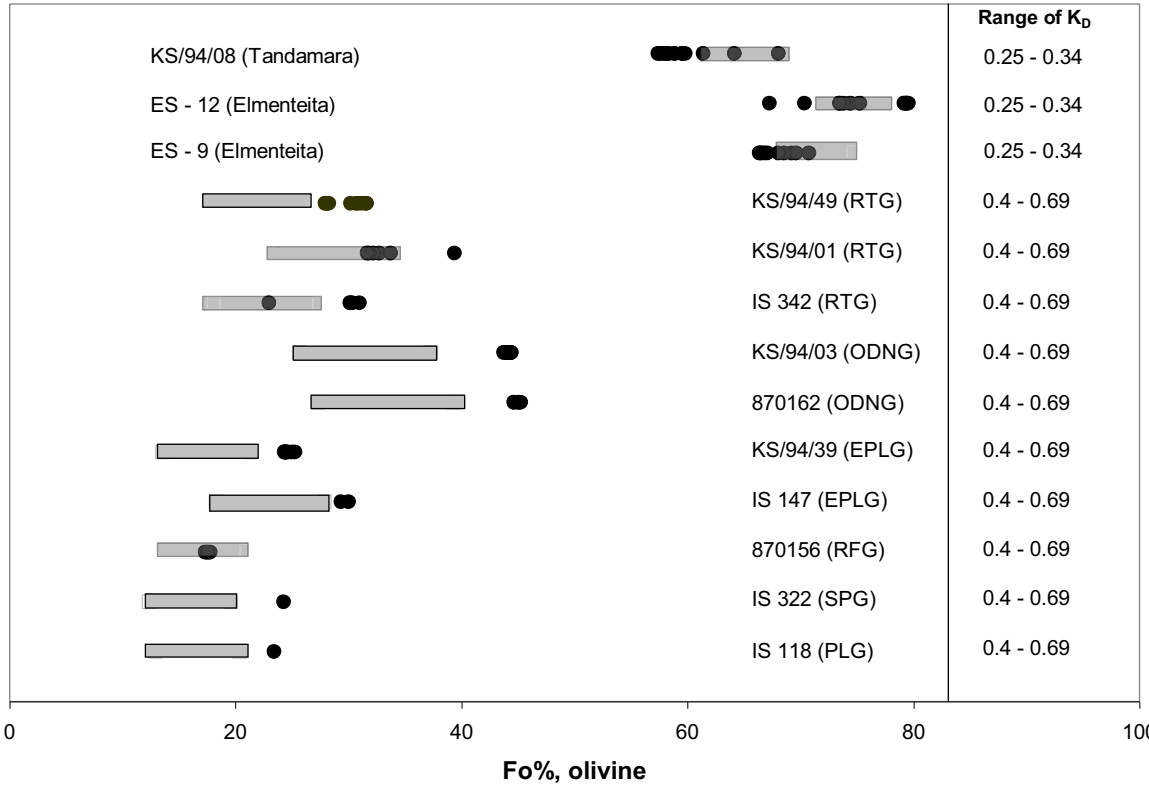


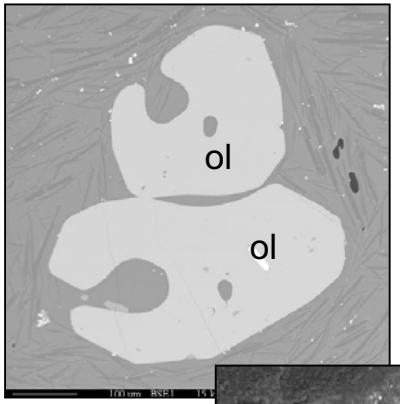


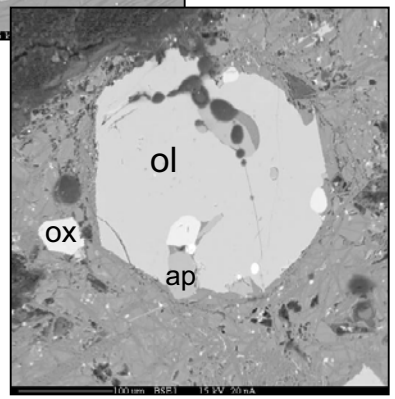
Ca X-ray map

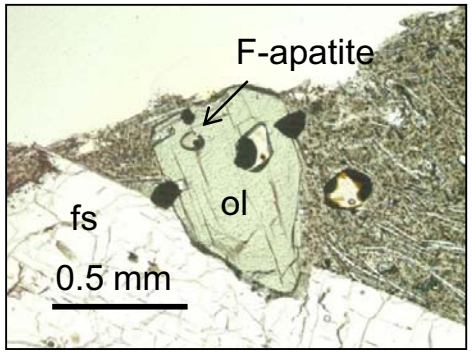
Olivine in disequilibrium

- Olivine is in equilibrium with whole-rock composition for the mafic samples.
- Olivine is not in equilibrium for the majority of trachytic and phonolitic compositions.



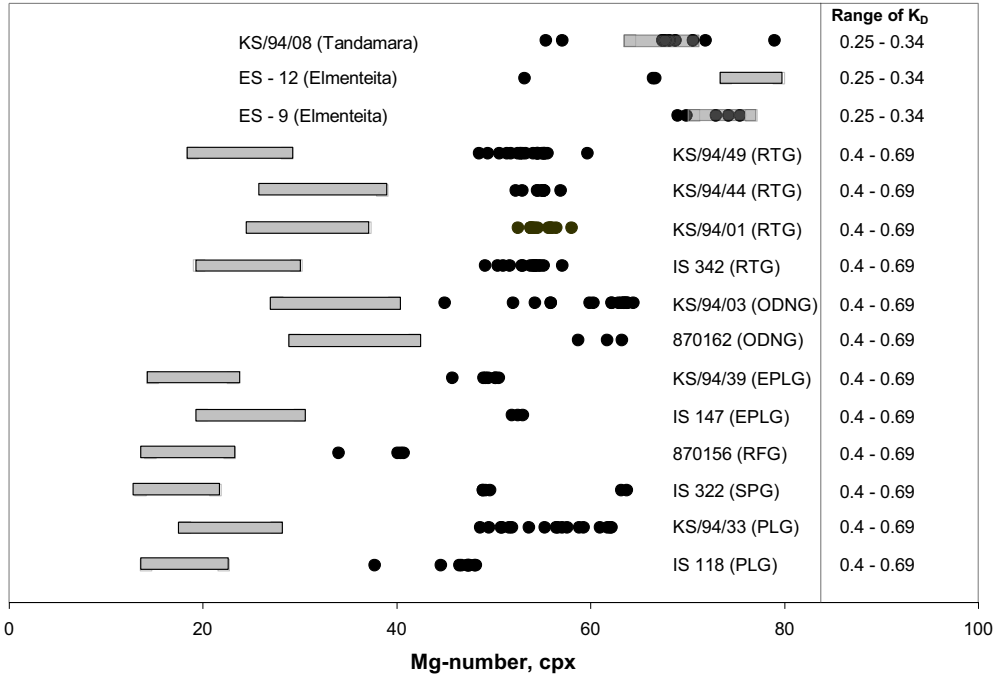


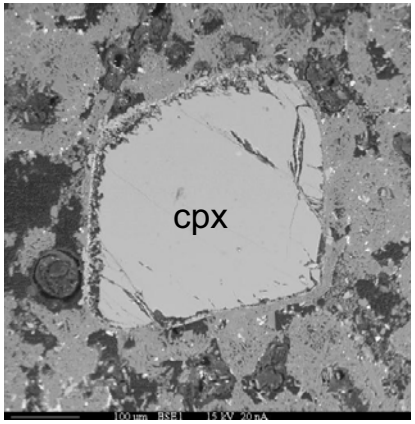


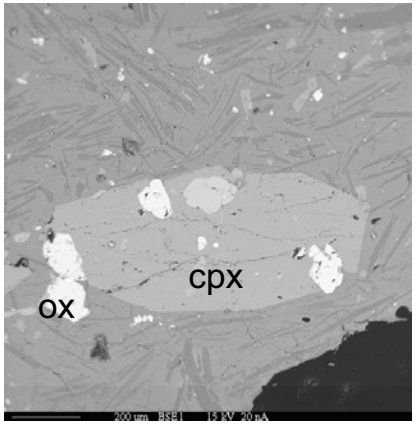


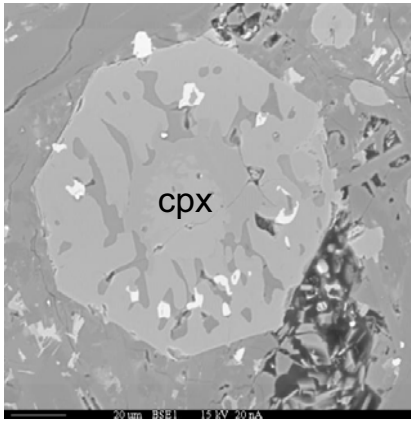
Clinopyroxene in disequilibrium

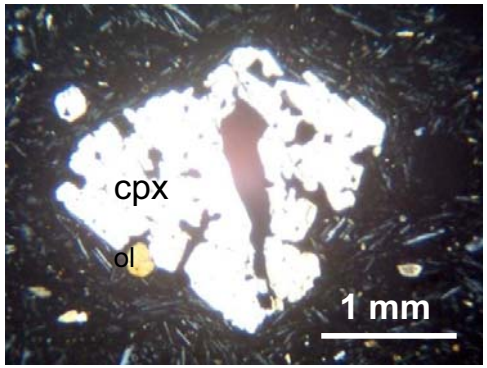
- Cpx is in equilibrium with whole-rock composition for the mafic samples.
- Cpx is not in equilibrium for the trachytic and phonolitic compositions.











Mixing ratios

- For many elements, the ratio (mafic:trachyte) mean is: 15:85%
- Na_2O, Al_2O_3, Ba and Eu fall out this range because of the presence of other magmatic processes.

		Low Na_2O			
	Mafic endmember	***trachytic endmember***	**Mixed rock**	x(maf) + y(trach) = mixed rock	
	a	***b***	**c**	x(maf) + (1-x)(trach) = mixed rock	
Stage	Elmenteita	SPG	EPLG	x(a) + (1-x)(b) = c	
Sample	ES-8	KS/94/38	KS/94/23	x = (c-b)/(a-b)	
				y = 1-x	
				*x	*y
Major elements					
SiO_2	48.4	61.0	56.3	0.4	0.6
TiO_2	2.6	0.8	1.1	0.2	0.8
Al_2O_3	14.7	14.9	16.5	-8.1	9.1
FeO	14.2	7.9	9.1	0.2	0.8
MnO	0.2	0.3	0.3	0.0	1.0
MgO	5.8	0.5	0.8	0.1	0.9
CaO	9.7	1.1	2.3	0.1	0.9
Na_2O	3.3	6.5	7.1	-0.2	1.2
K_2O	1.1	5.1	5.0	0.0	1.0
P_2O_5	0.6	0.1	0.2	0.2	0.8
Total	100.5	98.2	98.8		
Trace elements					
Ba	562	97.0	415	0.7	0.3
Hf	4.1	23.2	22.8	0.0	1.0
Nb	35.0	312	288	0.1	0.9
Rb	22.0	170	159	0.1	0.9
Sc	37.0	4.0	4.0	0.0	1.0
Sr	499	12.0	81.0	0.1	0.9
Ta	2.0	23.3	22.5	0.0	1.0
Th	3.4	31.0	32.7	-0.1	1.1
Y	35.0	124	90.6	0.4	0.6
Zn	108	190	170	0.2	0.8
Zr	171	1028	883	0.2	0.8
REE					
La	35.7	181	188	0.0	1.0
Ce	62.0	300	304	0.0	1.0
Nd	34.7	106	102	0.1	0.9
Sm	7.6	20.3	19.5	0.1	0.9
Eu	2.5	3.5	3.70	-0.3	1.3
Tb	1.1	3.5	2.86	0.3	0.7
Yb	3.1	14.0	11.5	0.2	0.8
Lu	0.5	2.1	1.69	0.3	0.7

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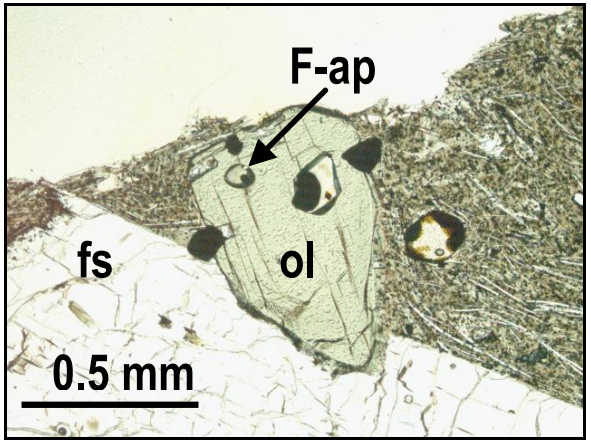
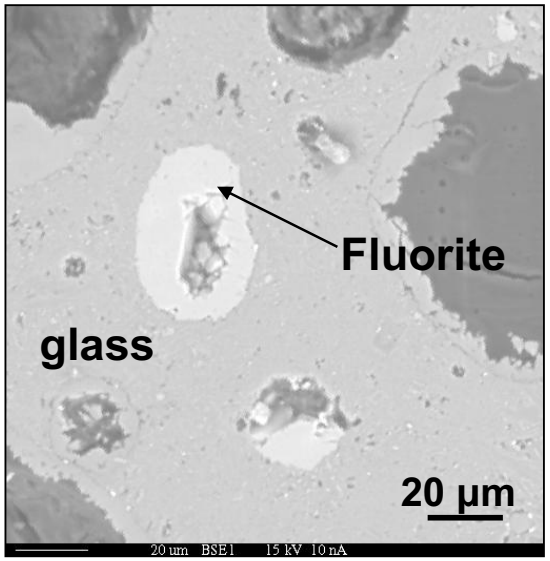
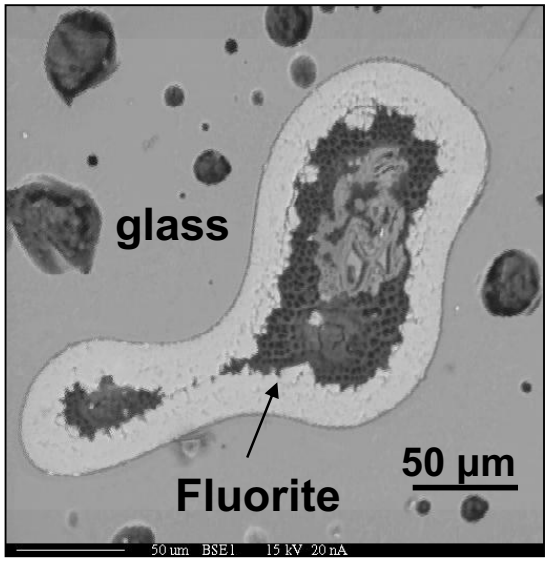
Na-F complexing

- **F-rich minerals**:
  - F-apatite (F = 4.5 – 6wt.%).
  - Fluorite

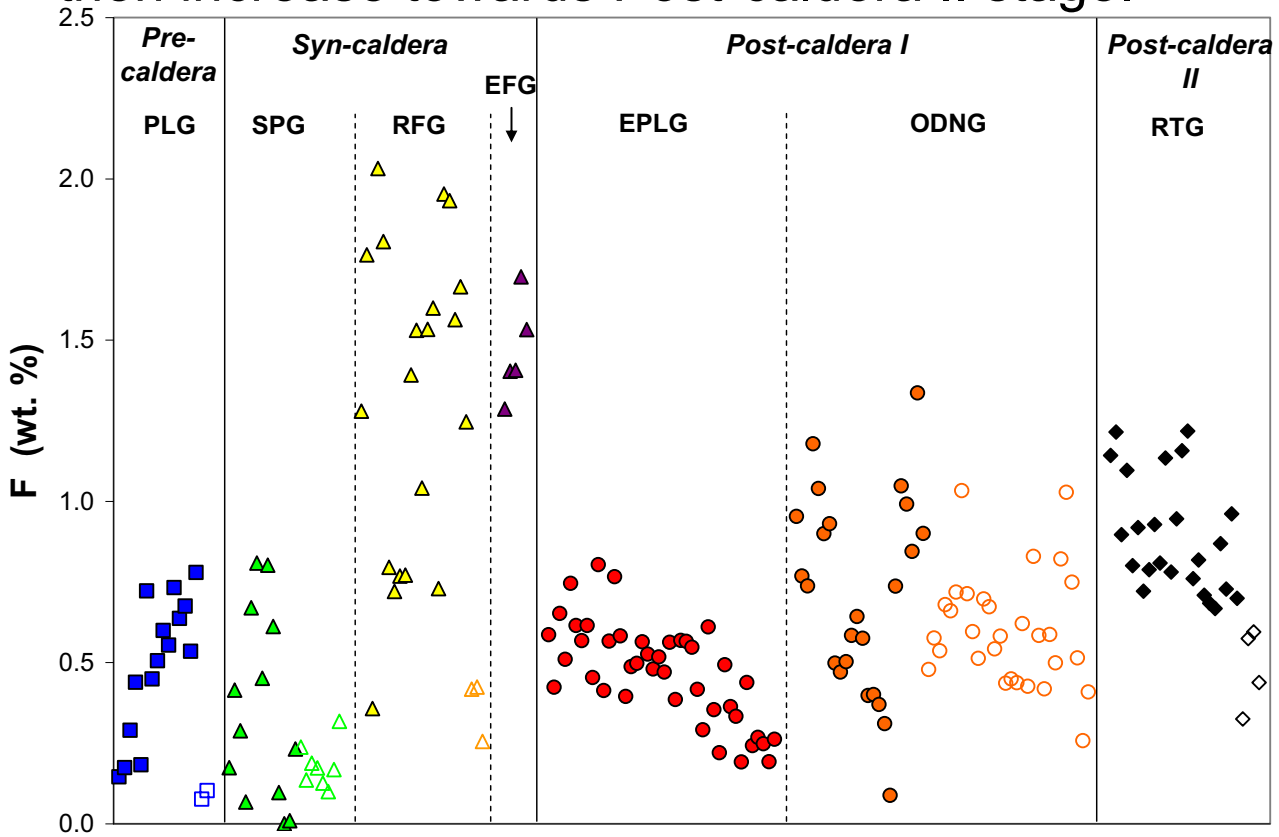


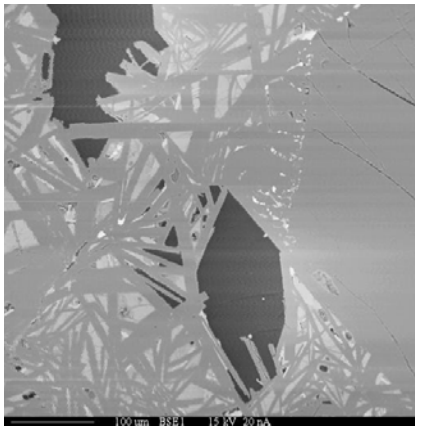




F content in matrix glass

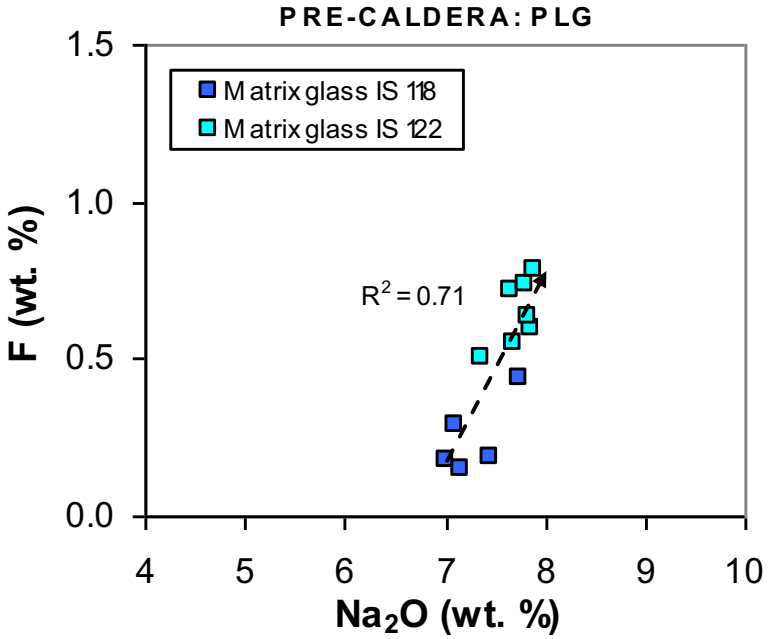
- Syn-caldera stage: highest fluorine contents.
- Post-caldera stage: fluorine values start similar to pre-caldera, then increase towards Post-caldera II stage.

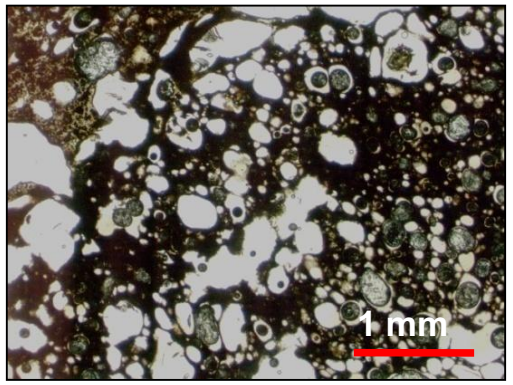


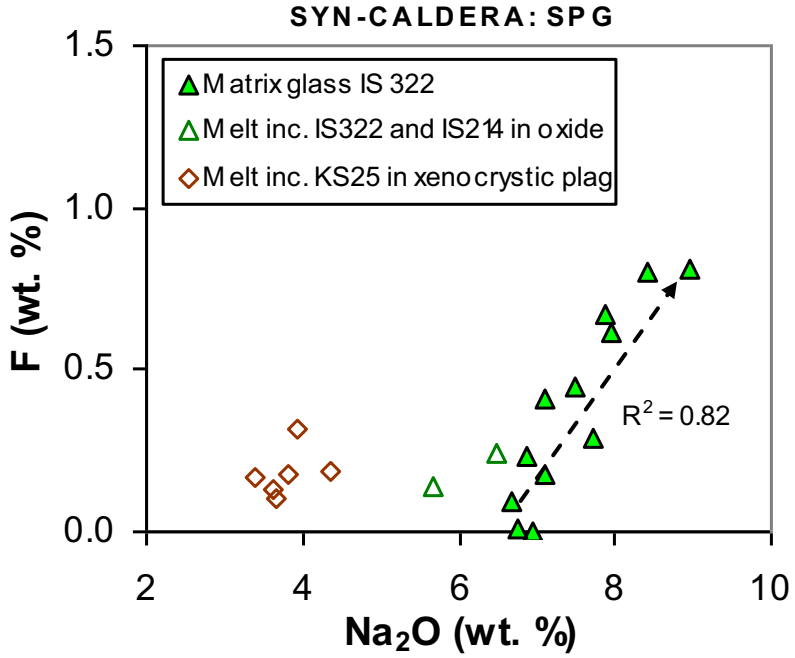


Matrix glass: filled symbols; melt inclusion glass: open symbols

Na_2O and F correlation







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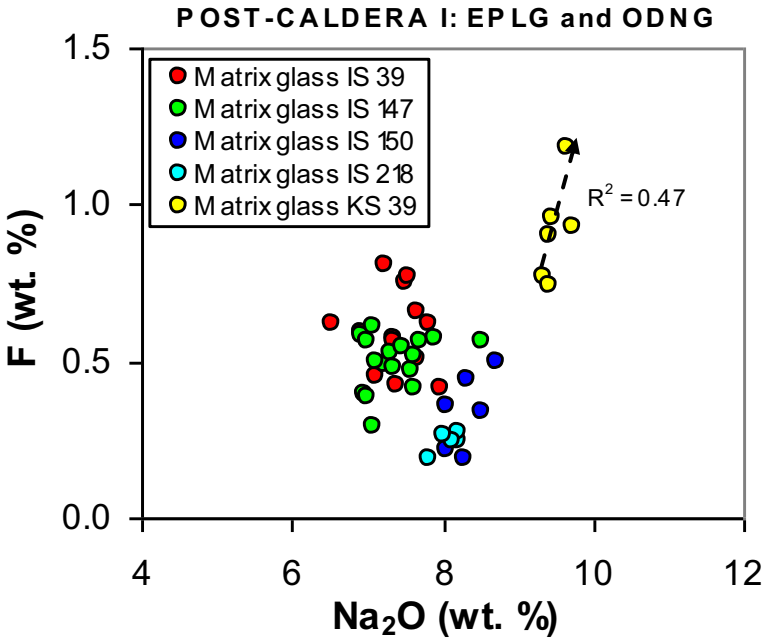

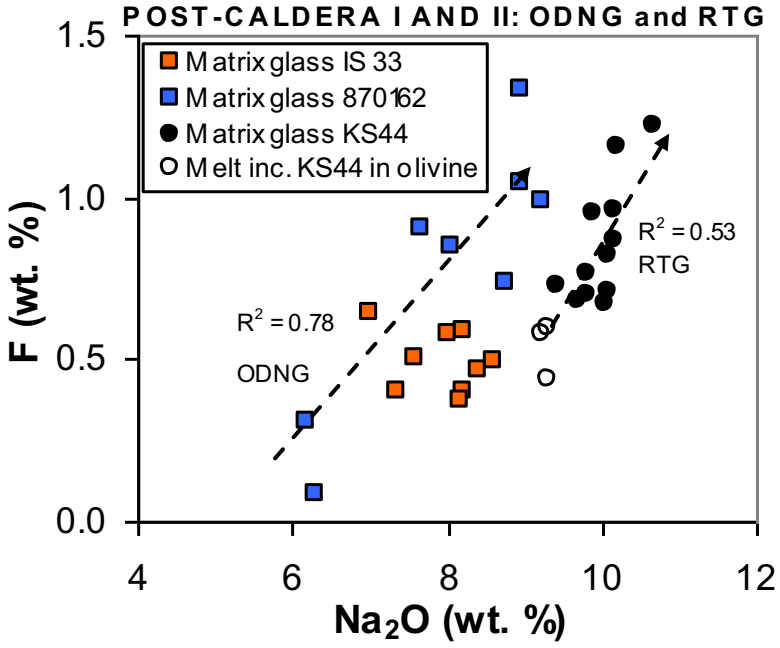

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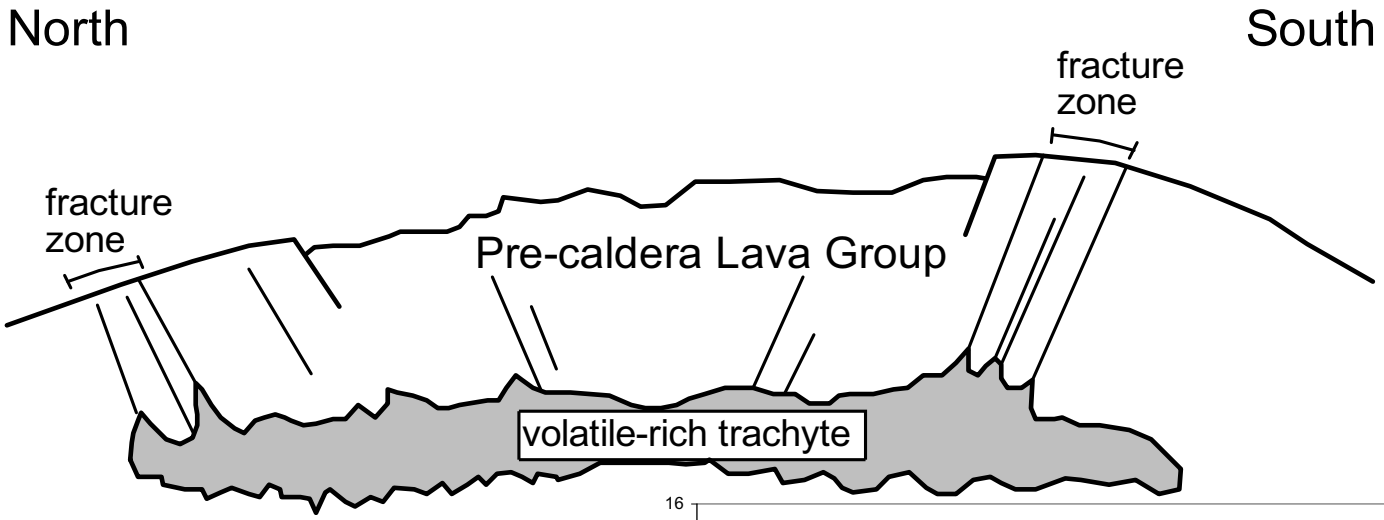
Pre-caldera stage



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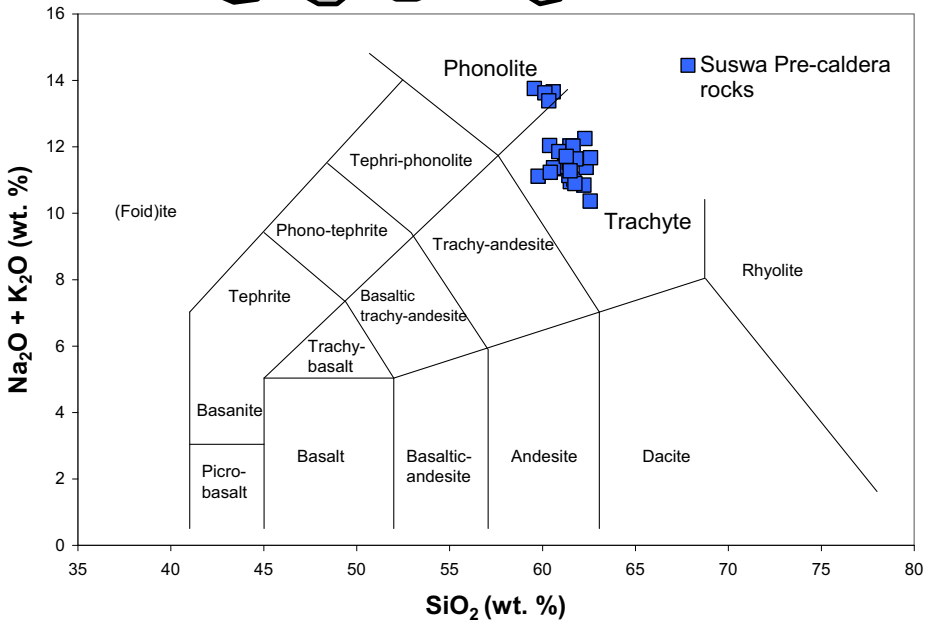
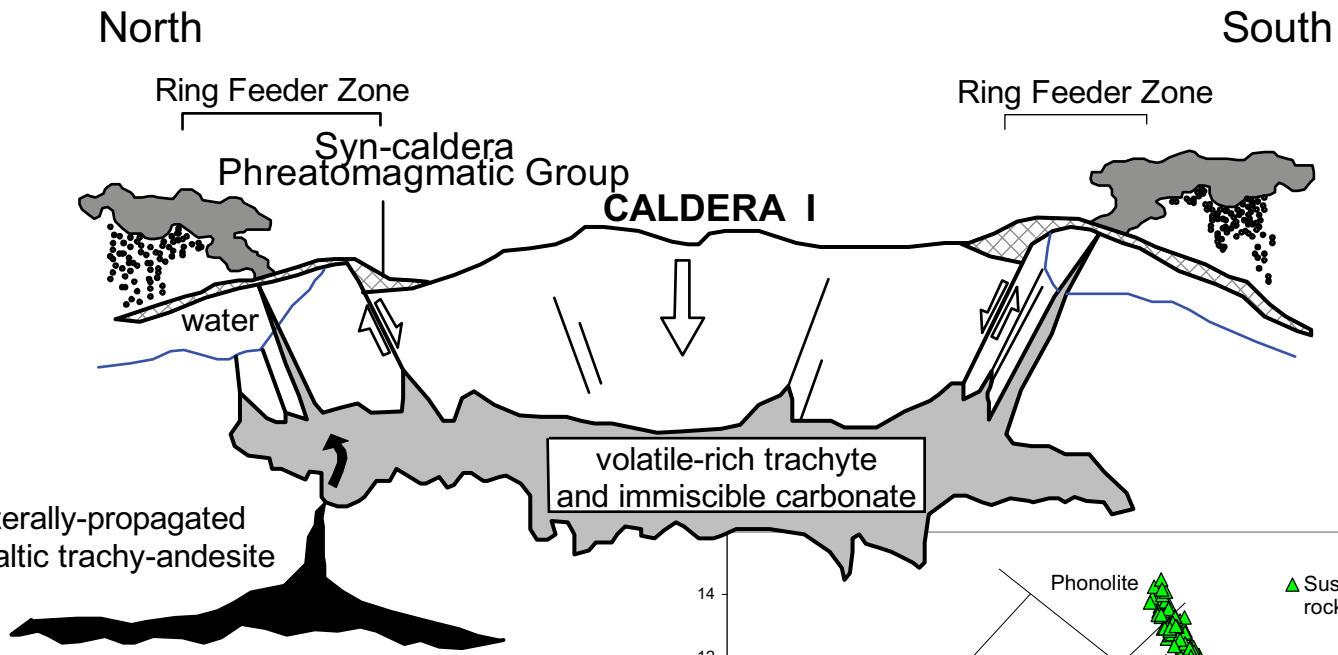


Syn-caldera stage



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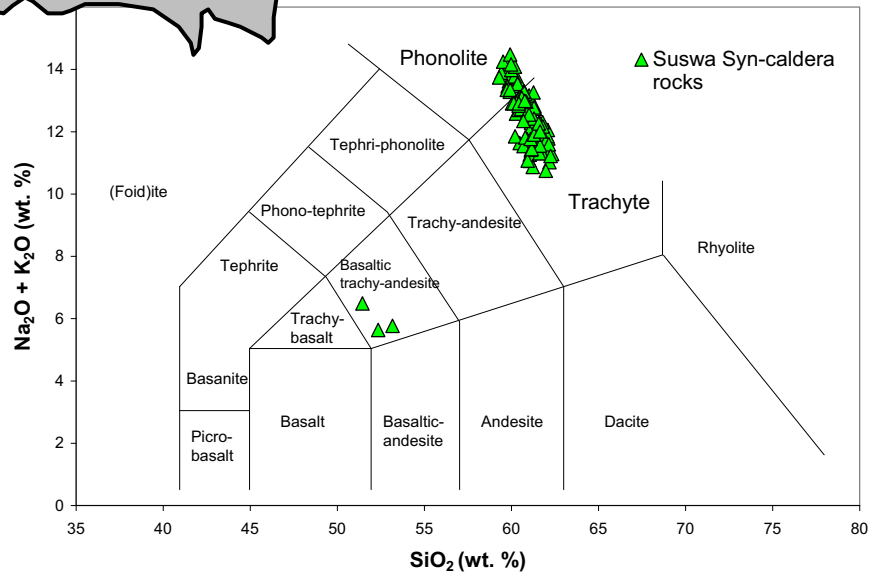
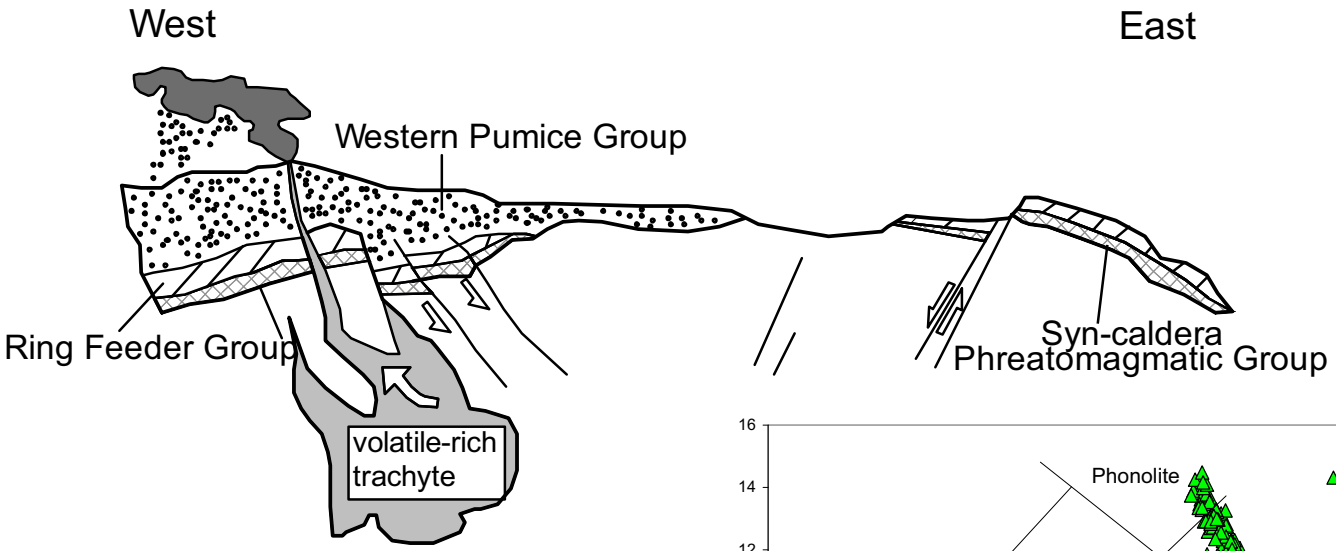


Syn-caldera stage



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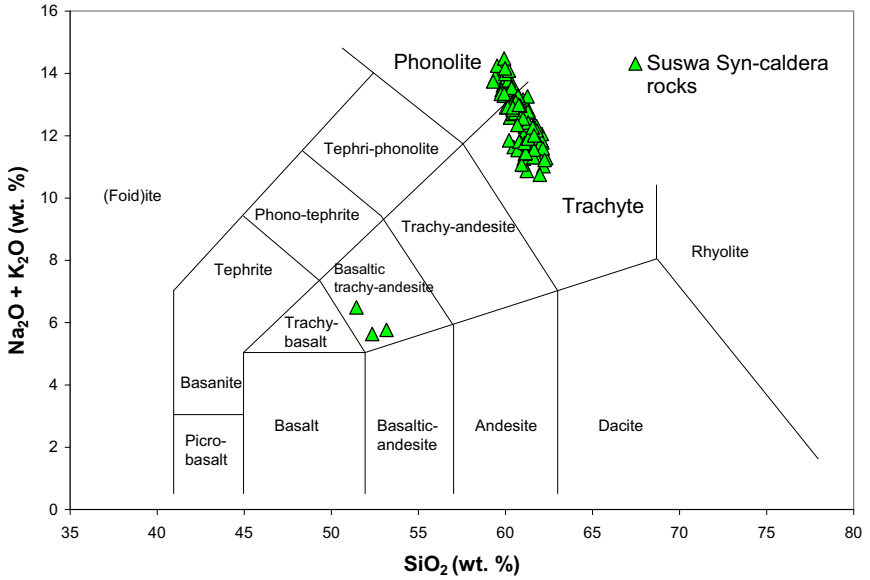
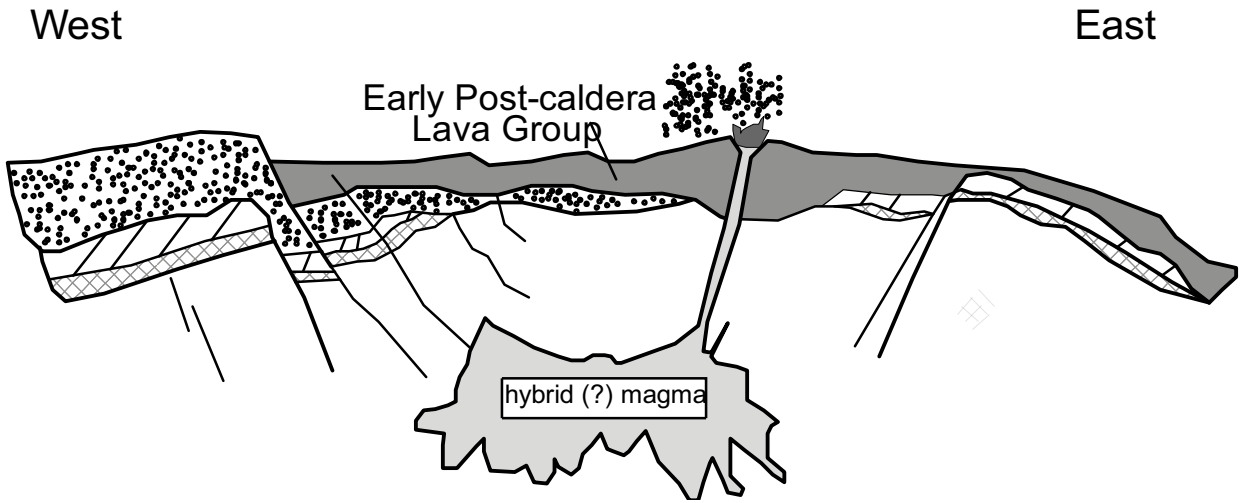
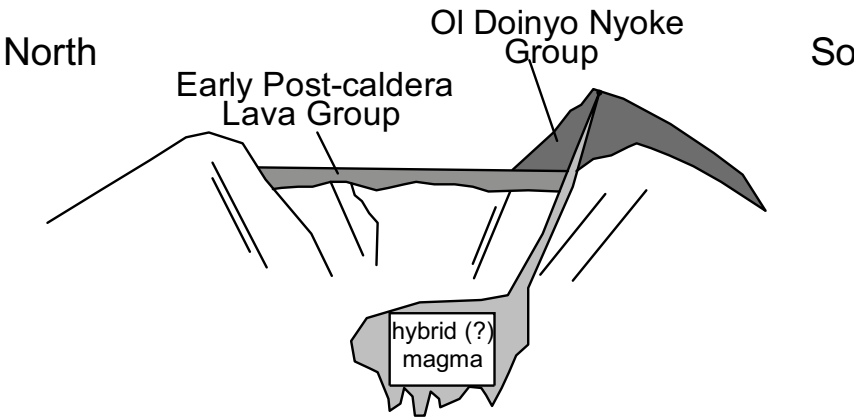


Post-caldera I stage





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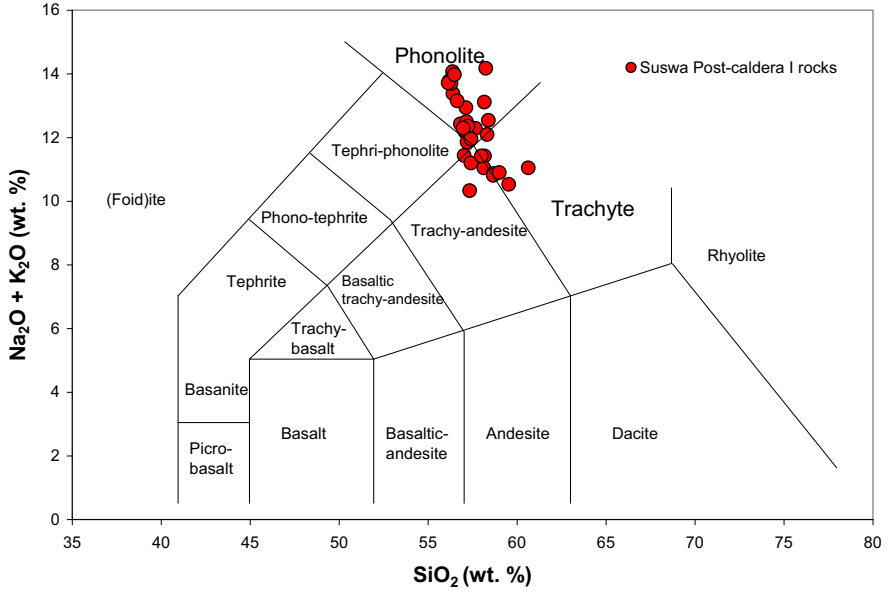
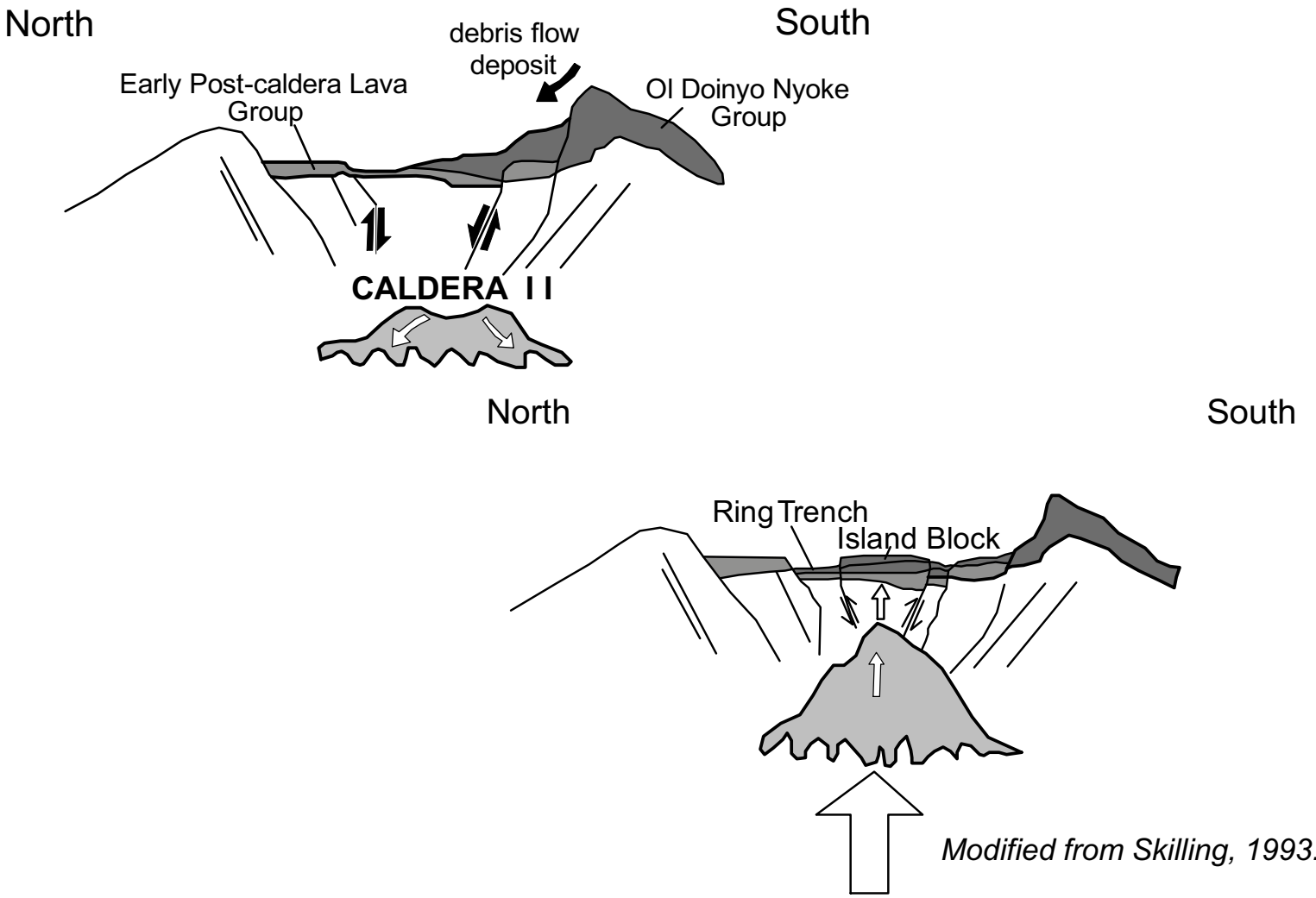


Caldera II



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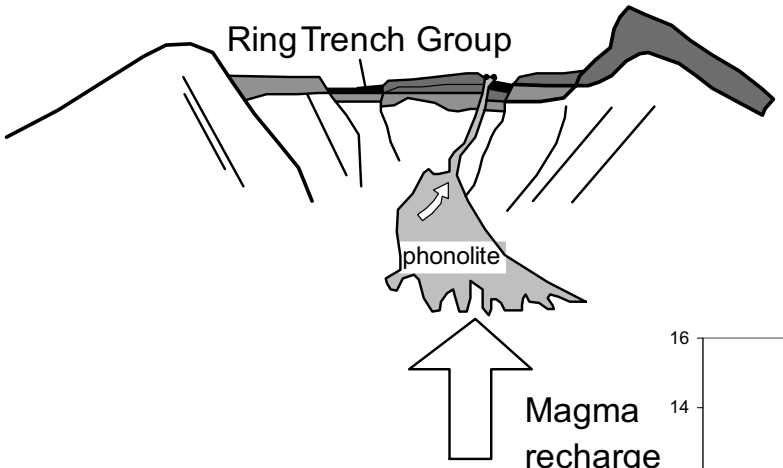
Post-caldera II stage

North South



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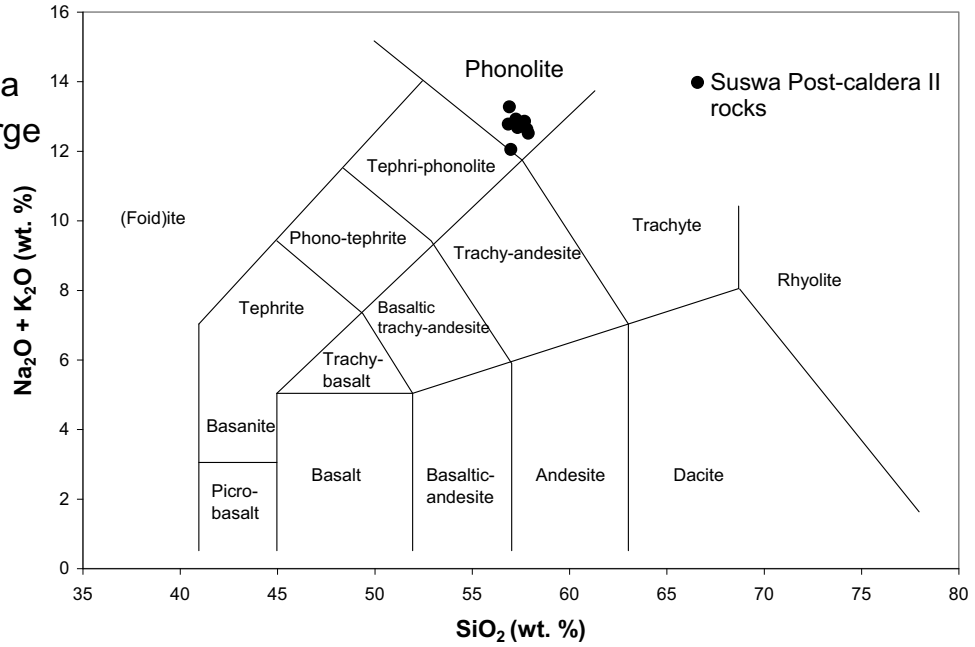

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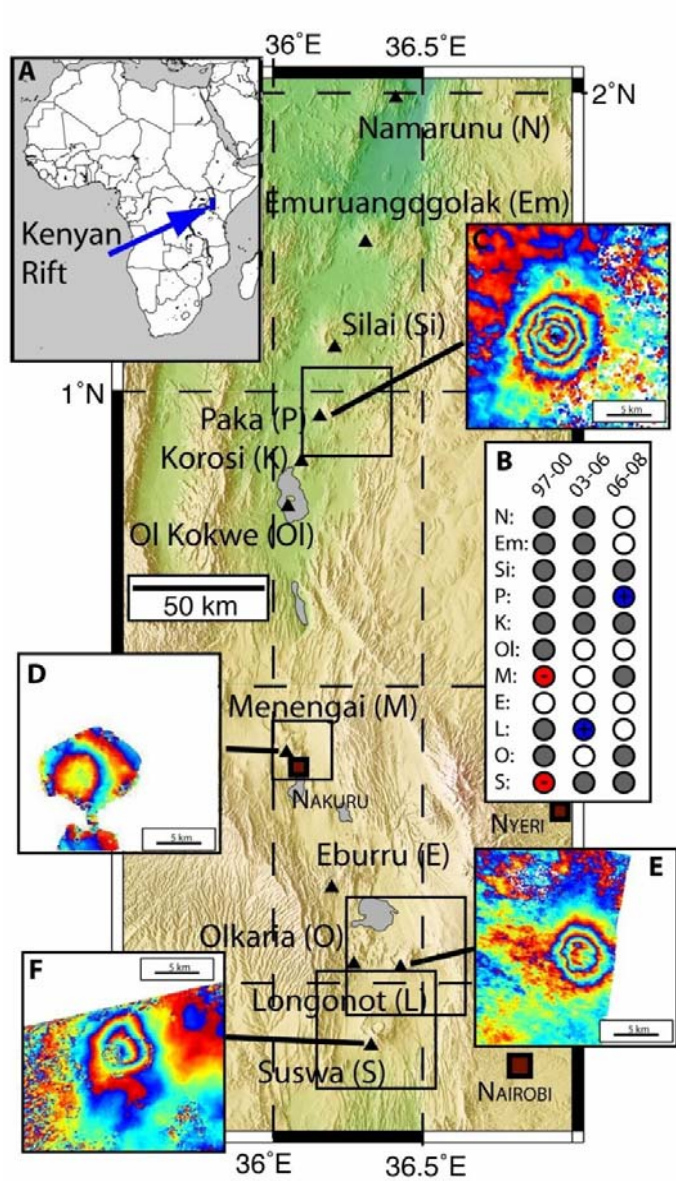
InSAR data

- Biggs, Anthony and Ebinger (Geology, in press), report multiple inflation/deflation in Central Kenya Peralkaline Province, and as far north as Paka.

- Suswa volcano in a period from 1997 to 2000 showed about 5 cm. of subsidence.



Biggs, J., Anthony, E.Y., Ebinger, C.J.
Figure 1. biggs_fig1.jpg

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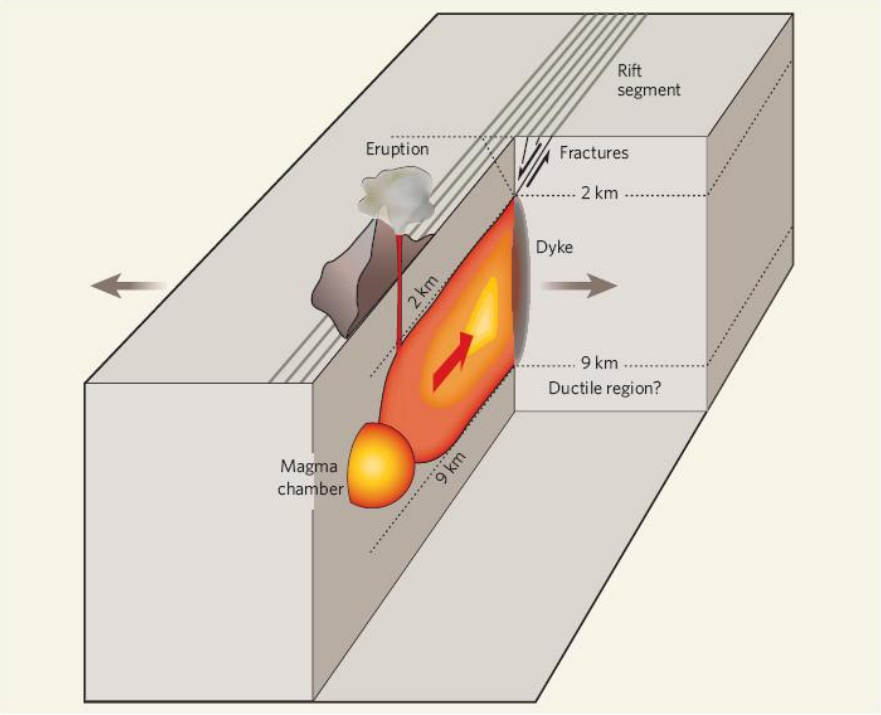

- Wright et al., 2006, *Magma maintained rift segmentation at continental rupture in the 2005 Afar dyking episode*, Nature 442, 291-294.
- Sigmundsson, 2006, *Magma does the splits*, Nature 442, 251-252.
- Yirgu et al., 2006, *Recent seismovolcanic crisis in northern Afar, Ethiopia*, Eos 87(33), 325-329.

THANK YOU

QUESTIONS???

Faulting control

- This figure shows that one of the faults is the locus for the pantelleritic flows and has the majority of active fumaroles associated with it.
- The rest of fumaroles are located within craters.
- This observations shows the strong structural control for fumarole discharge in this area.