Processes and timescales of magmas: U-series, 40Ar/39Ar chronology, and ternary feldspars, for the Quaternary Suswa volcano, Central Kenya Peralkaline Province, East African Rift

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Abstract

Processes and timescales of magmas: U-series, 40Ar/39Ar chronology, and ternary feldspars, for the Quaternary Suswa volcano, Central Kenya Peralkaline Province, East African Rift Vanessa V. Espejel-García a, Elizabeth Y. Anthony b, Peter A. Omenda c, Alan L. Deino d, John C. White e a Facultad de Ingeniería, Universidad Autónoma de Chihuahua, Circuito No. 1, Campus Universitario 2, C.P. 31125, Chihuahua, Chih., México. b University of Texas at El Paso, El Paso, TX 79968, USA c Scientific and Engineering Power Consultants, P.0. Box 38991, Nairobi, Kenya d Berkeley Geochronology Center, Ridge Road, Berkeley, CA, 94709, USA. e Eastern Kentucky University, Richmond, KY 40475, USA Corresponding author. Vanessa V. Espejel-García, vespejel@uach.mx, Tel. (52) 614 221 7549. ORCID a 0000-0002-0486-8726 b 0000-0001-7951-1724 c —- d 0000-0002-0099-9382 e 0000-0001-5107-6847 Suswa is a Late Pleistocene to recent volcano in the axis of the East African Rift. Early activity saw construction of a trachytic shield volcano, followed by mafic-felsic magma mixing, explosive volcanism, and caldera collapse. Recent activity includes drawn down of the magma chamber to create a second, inner caldera, a resurgent dome, and eruption of phonolites (White et al., 2012, Lithos, 152, 88-104). 40Ar/39Ar ages for the initial shield volcano are ca. 110 ka. Formation of the outer caldera occurred at ca. 46 ka, and initial post-caldera eruptions followed soon thereafter at 32.5 ka. Final eruptions are ca. 11 ka to “zero age”. 230Th/232Th confirms simultaneity of mafic eruptions in the peripheral fields and the youthfulness of the final events. The 203Th/232Th data also demonstrate that depth for initial magma generation lies below the spinel peridotite field within garnet peridotite. Ground deformation includes deflation of 4.6 cm from 1997 to 2000 (Biggs et al., 2009) and subsequent inflation of 4.3 +/- 0.8 cm/yr from 2015 to 2020 (Albino and Biggs, 2021, G3). Alkali feldspar from pre- and most syn-caldera has a limited compositional range. Feldspars in mingled lavas include bimodal distribution of these alkali feldspar and plagioclase identical in composition to similar-age cinder cones and fissure flows adjacent to the volcano. Alkali feldspar shifts to greater An content in the post-caldera phonolite. Oscillatory and tabular textures record rapid crystal growth and turbulence in the phonolite magma chamber. However, neither the textures nor the composition range necessitate renewed addition of mafic material.

Processes and timescales of magmas: U-series, $^{40}Ar/^{39}Ar$ chronology, and ternary feldspars, for the Quaternary Suswa volcano, Central Kenya Peralkaline Province (CKPP), East African Rift

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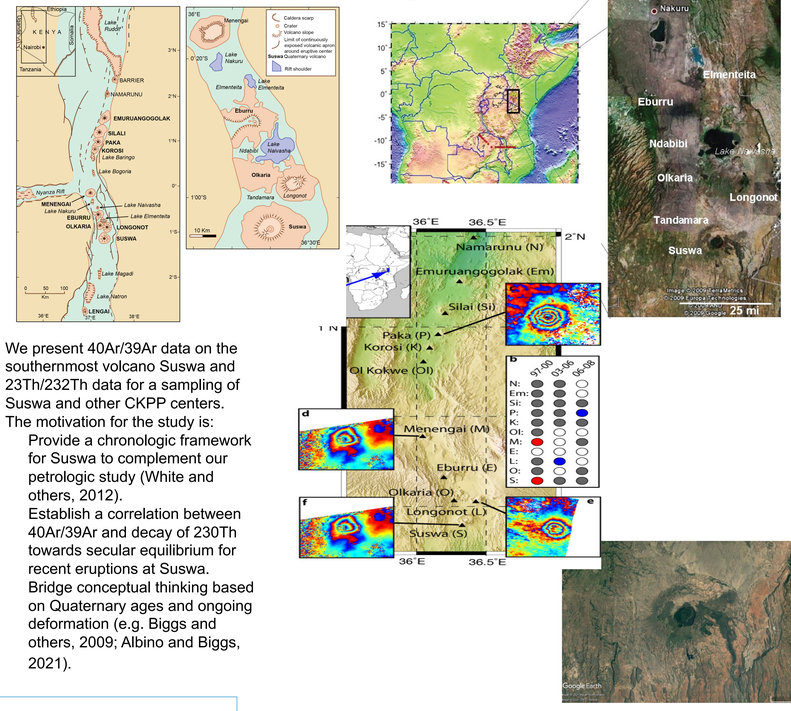
I. Abstract

Suswa is a Late Pleistocene to recent volcano in the axis of the East African Rift. Early activity saw construction of a trachytic shield volcano, followed by mafic-felsic magma mixing, explosive volcanism, and caldera collapse. Recent activity includes drawn down of the magma chamber to create a second, inner caldera, a resurgent dome, and eruption of phonolites (White et al., 2012, Lithos, 152, 88-104). $^{40}Ar/^{39}Ar$ ages for the initial shield volcano are ca. 110 ka. Formation of the outer caldera occurred at ca. 46 ka, and initial post-caldera eruptions followed soon thereafter at 32.5 ka. Final eruptions are ca. 11 ka to "zero age". $^{230}Th/^{232}Th$ confirms simultaneity of mafic eruptions in the peripheral fields and the youthfulness of the final events. The 203Th/232Th data also demonstrate that depth for initial magma generation lies below the spinel peridotite field within garnet peridotite. Ground deformation includes deflation of 4.6 cm from 1997 to 2000 (Biggs et al., 2009) and subsequent inflation of 4.3 +/- 0.8 cm/yr from 2015 to 2020 (Albino and Biggs, 2021, G3). Alkali feldspar from pre- and most syn-caldera has a limited compositional range. Feldspars in mingled lavas include bimodal distribution of these alkali feldspar and plagioclase identical in composition to similar-age cinder cones and fissure flows adjacent to the volcano. Alkali feldspar shifts to greater An content in the post-caldera phonolite. Oscillatory and tabular textures record rapid crystal growth and turbulence in the phonolite magma chamber. However, neither the textures nor the composition range necessitate renewed addition of mafic material.

Series *(White et al., 2012)*	Stages *(Omenda, 1997)*	Groups *(Skilling, 1993)*		
C1	Pre-Caldera	Pre-caldera Lava Group	PLG	S1
	Syn-caldera	Syn-caldera Phreatomagmatic Group	SPG	S2
		Ring Feeder Group	RFG	S3
		Western Pumice Group	WPG	S4
		Enkorika Fissure Group	EFG	S5
C2	Post-caldera I	Early Post-caldera Lava Group	EPLG	S6
		Ol-Doinyo Nyoke Group	ODNG	S7
	Post-caldera II	Ring Trench Group	RTG	S8

Introduction and Geological Setting



We present 40Ar/39Ar data on the southernmost volcano Suswa and 23Th/232Th data for a sampling of Suswa and other CKPP centers.

The motivation for the study is:

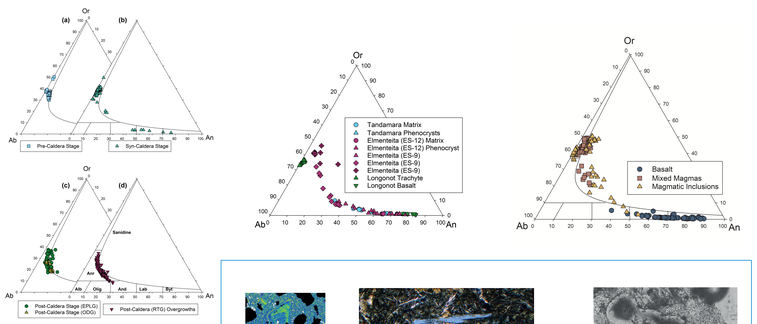
- Provide a chronologic framework for Suswa to complement our petrologic study (White and others, 2012).
- Establish a correlation between 40Ar/39Ar and decay of 230Th towards secular equilibrium for recent eruptions at Suswa.
- Bridge conceptual thinking based on Quaternary ages and ongoing deformation (e.g. Biggs and others, 2009; Albino and Biggs, 2021).

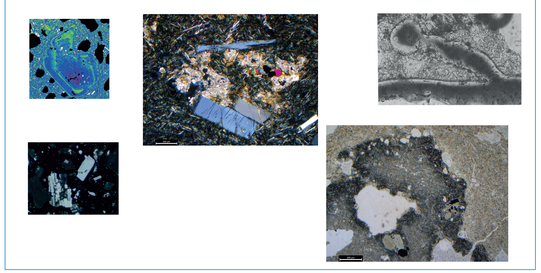
Magma mingling

We use feldspar compositions to track mingling between mafic and trachytic magmas.

The feldspars document mingling synchronous with caldera-forming eruptions at 46 ka.

Subsequent phonolitic (post-caldera") eruptions occur from shortly after 46 ka to essentially present-day. These feldspars lack a plagioclase population and thus strongly suggest that additional mafic input has not occurred.





40Ar/39 Ar chronology of Suswa

Ages from our study are:

Pre-caldera trachytes -- 110 ka

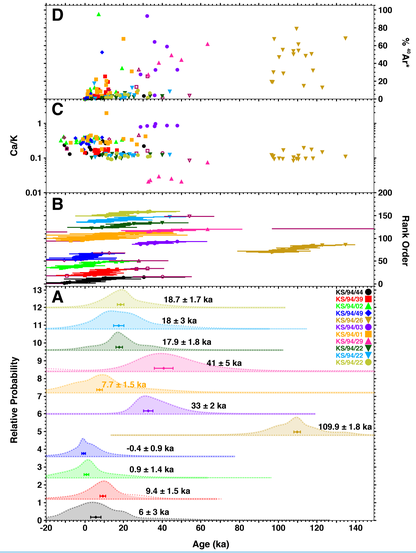
Syn-caldera (magma injection and mingling event) -- 41 ka

Post-caldera phonolites -- 33 ka to "zero-age.

These ages add to a growing data base for East African Rift volcanoes, e.g. Paka (Mibei and others, 2021), Aluto (Hutchison and others, 2016).

Applications of the Ar chronology include:

Volcano evolution and eruption frequency (e.g. White and others, 2021; Biggs and others, 2009; Albino and Biggs, 2021).



U-series disequilibria for CKPP

These data were collected with two objectives:

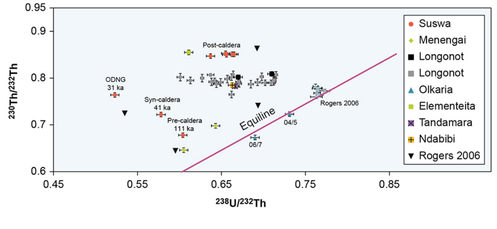
To correlate 230Th/232 Th and 40Ar/39Ar for the Suswa samples.

To document the decay of 230 Th from a horizontal array characteristic of eruptions less than 20 ka towards the equiline.

Additional benefits which resulted from the study are:

Confirmation that mafic and felsic eruptions have similar 230Th/232Th values and that both originate by melting in the garnet peridotite mantle (Rogers and others, 2004).

Comendites in the Greater Olkaria Volcanic Complex (GOVC) differ from all other eruptive products in lying on the equiline. This has been interpreted imply crustal anatexis for the comendites (Macdonald and others, 2008; Rogers and others, 2004).



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