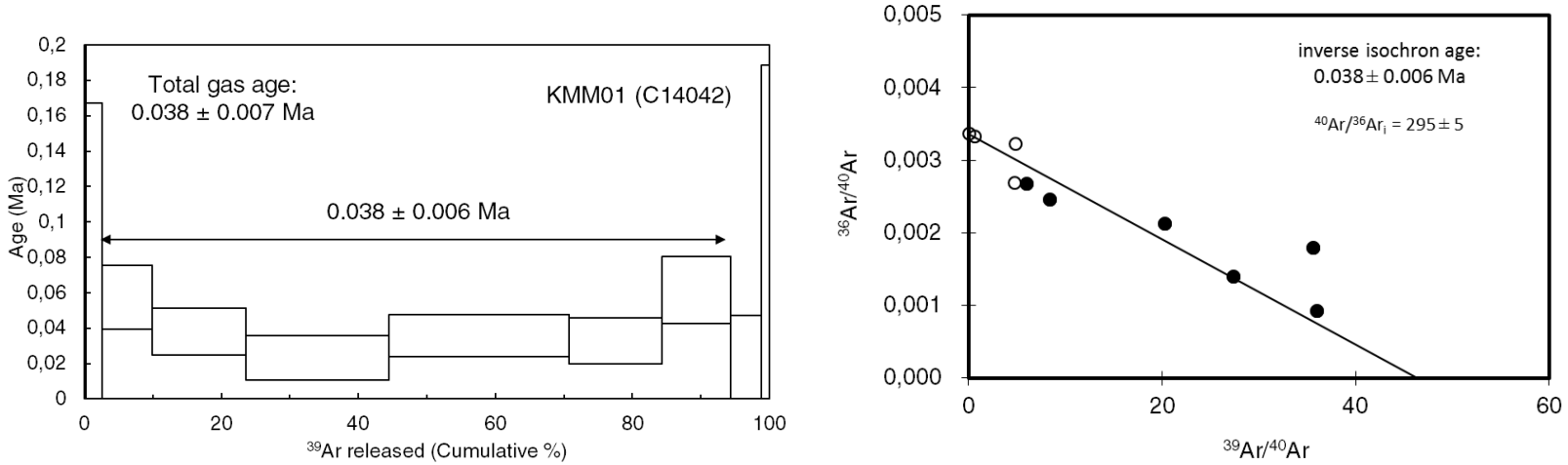
Continental rifting at magmatic centres: structural implications from Late Quaternary Menengai caldera, central Kenya Rift

Supplementary material: ^{40}Ar-^{39}Ar chronology of sample KMM01

SI Figure 1. Summary figure for incremental heating analysis: age plateau (left panel), inverse isochron age (right panel)



Incremental heating results for sample KMM01. The sample processing follows the methodology of Uto *et al.* (1997). Multiple grains were incrementally heated using a 50 W CO_2 laser (10.6 µm wavelength). Isotope abundances were measured using a Micromass 5400 single detector noble gass mass spectrometer. All age calculations are based on decay constant values reported in Steiger & Jäger (1977). (**left panel**) Plateau age and age spectrum derived from incremental heating analysis. The plateau age was obtained from the weighted average of plateau steps in the stepwise-heating age-spectra diagrams according to the criteria outlined in Fleck *et al*. (1977): (1) two ages of the contiguous two steps in the "plateau" agree within 2 σ error excluding J value error; (2) the total fraction of the plateaucovers more than 50% of the total amount of analyzed ^{39}Ar; and (3) each plateau step has more than 3% of the total amount of analyzed ^{39}Ar. Given the young age of the sample, the following additional criteria were applied (4) the two ages at both ends of the plateau agree within a 2 σ error range; (5) the last step is not considered in the plateau age when the central value of the last step is beyond the 2 sigma range of the weighted average age of the remaining plateau steps; (6) the error of each "plateau" step is less than 0.1 Ma as well as the 1 σ error. (**right panel**) inverse isochron plots ($^{36}Ar/^{40}Ar$ *vs.* $^{39}Ar/^{40}Ar$ isotope correlation diagrams). The age is derived from the x-axis intercept and shown with 1σ error.

SI Table 1. Summary table of incremental heating analysis, sample KMM01

Laser output	$^{37}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar \times 10^{-3}$	K/Ca	$^{40}Ar^*$	$^{39}Ar_K$	Fraction of released ^{39}Ar %	$^{40}Ar^*/^{39}Ar_K$	Age ± 1σ
1.4%	44.81 ± 0.27	0.135 ± 0.038	151.14 ± 2.73	4.37	0.36	0.17	0	0.16 ± 0.77	0.29 ± 1.38
1.8%	1.714 ± 0.018	0.073 ± 0.006	5.7 ± 0.2	8.04	1.43	2.40	2	0.02 ± 0.07	0.04 ± 0.12
2.0%	0.119 ± 0.006	0.062 ± 0.003	0.31 ± 0.03	9.54	27.06	7.28	7	0.032 ± 0.010	0.057 ± 0.018
2.2%	0.037 ± 0.006	0.0564 ± 0.0017	0.067 ± 0.014	10.43	58.50	13.72	14	0.021 ± 0.007	0.038 ± 0.013
2.4%	0.028 ± 0.006	0.0432 ± 0.0013	0.063 ± 0.011	13.60	46.72	20.86	21	0.013 ± 0.007	0.023 ± 0.013
2.8%	0.028 ± 0.006	0.0436 ± 0.0010	0.038 ± 0.008	13.50	72.50	26.38	26	0.020 ± 0.007	0.036 ± 0.012
3.2%	0.049 ± 0.006	0.088 ± 0.003	0.129 ± 0.013	6.71	37.10	13.46	13	0.018 ± 0.007	0.033 ± 0.013
3.8%	0.168 ± 0.006	0.198 ± 0.004	0.51 ± 0.03	2.97	20.56	10.07	10	0.034 ± 0.011	0.061 ± 0.019
4.4%	0.209 ± 0.007	0.215 ± 0.004	0.73 ± 0.05	2.73	4.55	4.55	5	0.010 ± 0.017	0.02 ± 0.03
5.0%	0.213 ± 0.009	0.119 ± 0.009	0.6 ± 0.2	4.96	20.33	1.12	1	0.04 ± 0.06	0.08 ± 0.11

Summary of isotope fractions derived from incremental heating analysis. The abundances were corrected for background, mass discrimination, radioactive decay and interfering isotopes. Irradiation data is given in SI table 2. Raw isotope abundances are given in SI table 3, background abundances in SI table 4.

SI Table 2. Irradiation data and values for nuclear interference reactions

Irraditation ID	**J value $\times 10^{-3}$**	**J value 1σ $\times 10^{-3}$**	**$(^{40}Ar/^{36}Ar)_{air}$**	**$(^{39}Ar/^{37}Ar)_{Ca}$**	**± 1σ**	**$(^{36}Ar/^{37}Ar)_{Ca}$**	**± 1σ**	**$(^{40}Ar/^{39}Ar)_K$**	**± 1σ**	**$(^{38}Ar/^{39}Ar)_K$**	**± 1σ**
PO-1	0.988	0.003952	287.36	0.00085669	0.00029115	0.00027508	3.2138E-06	0.00357045	0.0061842	0.01207061	4.3104E-05

The sample was irradiated on 24 Feb 2014 at Oregon State University Reactor (OSTR). The Fish Canyon Tuff Sanidine (FC3S) was used as neutron flux monitor during irradiation. Alder Creek Sanidine (ACs-2) was co-irradiated to check the accuracy of the system. Crystals of K_2SO_4 and CaF_2 were co-irradiated to determine the values for nuclear interfering reactions during the irradiation. The analysis of the sample was done on 24 Aug 2014.

SI Table 3. Relative isotope abundances of incremental heating analysis (raw values, uncorrected)

Lab ID#	Heating %	Laser Power (W)	^{40}Ar $\times10^{-3}$	± 1σ $\times10^{-3}$	$^{39}Ar/^{40}Ar$	± 1σ	^{38}Ar $\times10^{-3}$	± 1σ $\times10^{-3}$	^{37}Ar $\times10^{-3}$	± 1σ $\times10^{-3}$	^{36}Ar $\times10^{-3}$	± 1σ $\times10^{-3}$
C1404201	1.40%	0.7	2.0378	1.9	0.021956	0.0016583	54	0.00021509	130	0.0071837	15	0.0016583
C1404202	1.80%	0.9	1.1598	5.8	0.55758	0.0082807	26	0.0014619	79	0.0041905	35	0.0082807
C1404203	2.00%	1	0.29459	7.1	6.6425	0.02426	21	0.0035325	41	0.0010207	47	0.02426
C1404204	2.20%	1.1	0.21009	5.1	17.563	0.044427	14	0.0060186	25	0.00066633	37	0.044427
C1404205	2.40%	1.2	0.23958	7.5	23.413	0.066137	13	0.0069896	27	0.00077309	55	0.066137
C1404206	2.80%	1.4	0.27762	3.7	25.552	0.086927	11	0.0088558	21	0.00072348	75	0.086927
C1404207	3.20%	1.6	0.24716	3.8	14.647	0.046729	11	0.0090788	33	0.00092751	47	0.046729
C1404208	3.80%	1.9	0.51854	4.8	5.2225	0.036401	10	0.015207	19	0.0018538	36	0.036401
C1404209	4.40%	2.2	0.31613	6	3.8716	0.016485	23	0.0075271	15	0.0013737	37	0.016485
C1404210	5.00%	2.5	0.1224	12	2.4597	0.0042064	21	0.0011249	64	0.00064207	76	0.0042064

Isotope abundances of sample KMM01 determined during incremental-heating analysis. Given are the raw abundances before corrections were applied.

SI Table 4. Relative isotope abundances of blank measurements, used for correction

Lab ID#	Heating %	Laser Power (W)	$^{40}Ar_{blank}$ ± 1σ $\times10^{-3}$		$^{39}Ar_{blank}$ ± 1σ $\times10^{-3}$		$^{38}Ar_{blank}$ ± 1σ $\times10^{-3}$		$^{37}Ar_{blank}$ ± 1σ $\times10^{-3}$		$^{36}Ar_{blank}$ ± 1σ $\times10^{-3}$	
C1404201	1.40%	0.7	0.045657	13	0.000034247	1000	0.000084926	180	0.000044915	870	0.00027523	150
C1404202	1.80%	0.9	0.055861	16	0.00013255	180	0.000088677	390	0.00012525	70	0.00039847	51
C1404203	2.00%	1	0.055861	16	0.00013255	180	0.000088677	390	0.00012525	70	0.00039847	51
C1404204	2.20%	1.1	0.062815	7.2	0.00038778	310	0.000090345	490	0.00014894	480	0.00041403	110
C1404205	2.40%	1.2	0.062815	7.2	0.00038778	310	0.000090345	490	0.00014894	480	0.00041403	110
C1404206	2.80%	1.4	0.056434	14	0.00074496	120	0.000072996	610	0.00014466	330	0.00044893	29
C1404207	3.20%	1.6	0.056434	14	0.00074496	120	0.000072996	610	0.00014466	330	0.00044893	29
C1404208	3.80%	1.9	0.057623	7.8	0.00078358	120	0.00007835	280	0.00012317	240	0.00045542	86
C1404209	4.40%	2.2	0.057623	7.8	0.00078358	120	0.00007835	280	0.00012317	240	0.00045542	86
C1404210	5.00%	2.5	0.057623	7.8	0.00078358	120	0.00007835	280	0.00012317	240	0.00045542	86

Isotope abundances of blank measurements during incremental-heating analysis. The given values were used to apply background correction on the analysis.

SI Table 5. Sample geochemistry

Compound	**SiO_2**	**TiO_2**	**Al_2O_3**	**FeO**	**MnO**	**MgO**	**CaO**	**Na_2O**	**K_2O**	**ZrO_2**	
%	62.8	0.7	11.2	11.2	0.5	0.1	1.0	7.7	4.6	0.2	
Element	**Si**	**Ti**	**Al**	**Fe**	**Mn**	**Mg**	**Ca**	**Na**	**K**	**Zr**	**O**
Weight %	29.37	0.42	5.9	8.69	0.35	0.05	0.73	5.74	3.84	0.16	44.75
Weight % 1σ	0.24	0.1	0.12	0.28	0.14	0.06	0.09	0.13	0.12	0.2	0.31

Sample geochemistry derived from EDX (Energy-dispersive X-ray spectroscopy) analysis.

SI Table 6. Sample location

Sample identifier	**Dated unit**	**Location**	**Analysis identifier**
KMM01	consolidated Menengai tuff mantling Athinai trachytes	0° 6.0326' S 36° 2.8787' E Emy quarry, El Bonwala ridge N of Menengai	C14042

Location data for the sample analysed by Ar-Ar geochonology.

SI References

Fleck, R.J., Sutter, J.F. & Elliot, D.H. 1977. Interpretation of discordant 40Ar/39Ar age-spectra of mesozoic tholeiites from antarctica. *Geochimica et Cosmochimica Acta*, **41**, 15–32, https://doi.org/10.1016/0016-7037(77)90184-3

Steiger, R.H. & Jäger, E. 1977. Subcommission on geochronology: Convention on the use of decay constants in geo- and cosmochronology. *Earth and Planetary Science Letters*, **36**, 359–362, https://doi.org/10.1016/0012-821X(77)90060-7

Uto, K., Ishizuka, O., Matsumoto, A., Kamioka, H. & Togashi, S. 1997. Laser-heating 40Ar/39Ar dating system of the Geological Survey of Japan: System outlines and preliminary result. *Bulletin of the Geological Survey of Japan*, **48**, 23–46.