GSA DATA REPOSITORY 2018393

Bridging the gap: $^{40}Ar/^{39}Ar$ dating of volcanic eruptions from the 'Age of Discovery'

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Dating young volcanic eruptions

For a comprehensive understanding of the history of a volcano and the potential hazards it may produce, it is important to explicate complete patterns of past activity. A survey of the Volcanoes of The World (VOTW) database (Global Volcanism Program, 2013), maintained by the Smithsonian Institution Global Volcanism Program, reveals that the timing of the last eruption is unknown for 40 % of sub-aerial Holocene volcanoes worldwide (total number = 1325) (Fig. DR1). This number includes only volcanoes thought to have erupted during the Holocene, and excludes submarine volcanoes and those catagorised as having "Unrest". Of the last eruptions that are dated for these volcanoes, the ^{14}C technique is the most frequently used method (59 %), whereas the $^{40}Ar/^{39}Ar$ technique has only been used in < 2 % of cases (Fig. DR1a).

In comparison, 30 % of sub-aerial Holocene intraplate and rift volcanoes, situated on oceanic or intermediate crust, (total number = 98) have unknown dates for the last eruption (Fig. DR1b). Tephrochronology is the most utilized method (35 %) and the ^{14}C technique has been used to date 29 % of those dated last eruptions. The $^{40}Ar/^{39}Ar$ method has been used at only one volcano (Fig. DR1b).

The low percentage of last eruptions dated using the $^{40}Ar/^{39}Ar$ method reflects the current complexity in dating young Holocene eruptions with the $^{40}Ar/^{39}Ar$ technique. In addition, the comparitively low use of the ^{14}C method on oceanic volcanoes, compared to volcanoes globally, is perhaps due to often remote oceanic volcanoes frequently being colonised by little or no vegetation, making ^{14}C dating difficult or impossible. Therefore, obtaining reliable absolute ages for young eruptions, especially in an oceanic setting are currently hindered. The results of this study offer new prospects for dating young volcanic eruptions globally, essential for hazards assessments as well as for understanding evolution and magmatism in any tectonic setting.

Reference

Global Volcanism Program, 2013, Venzke, E. (ed.) Volcanoes of the World, v. 4.5.0. Smithsonian Institution. http://dx.doi.org/10.5479/si.GVP.VOTW4-2013 (Accessed on 22 August 2016)

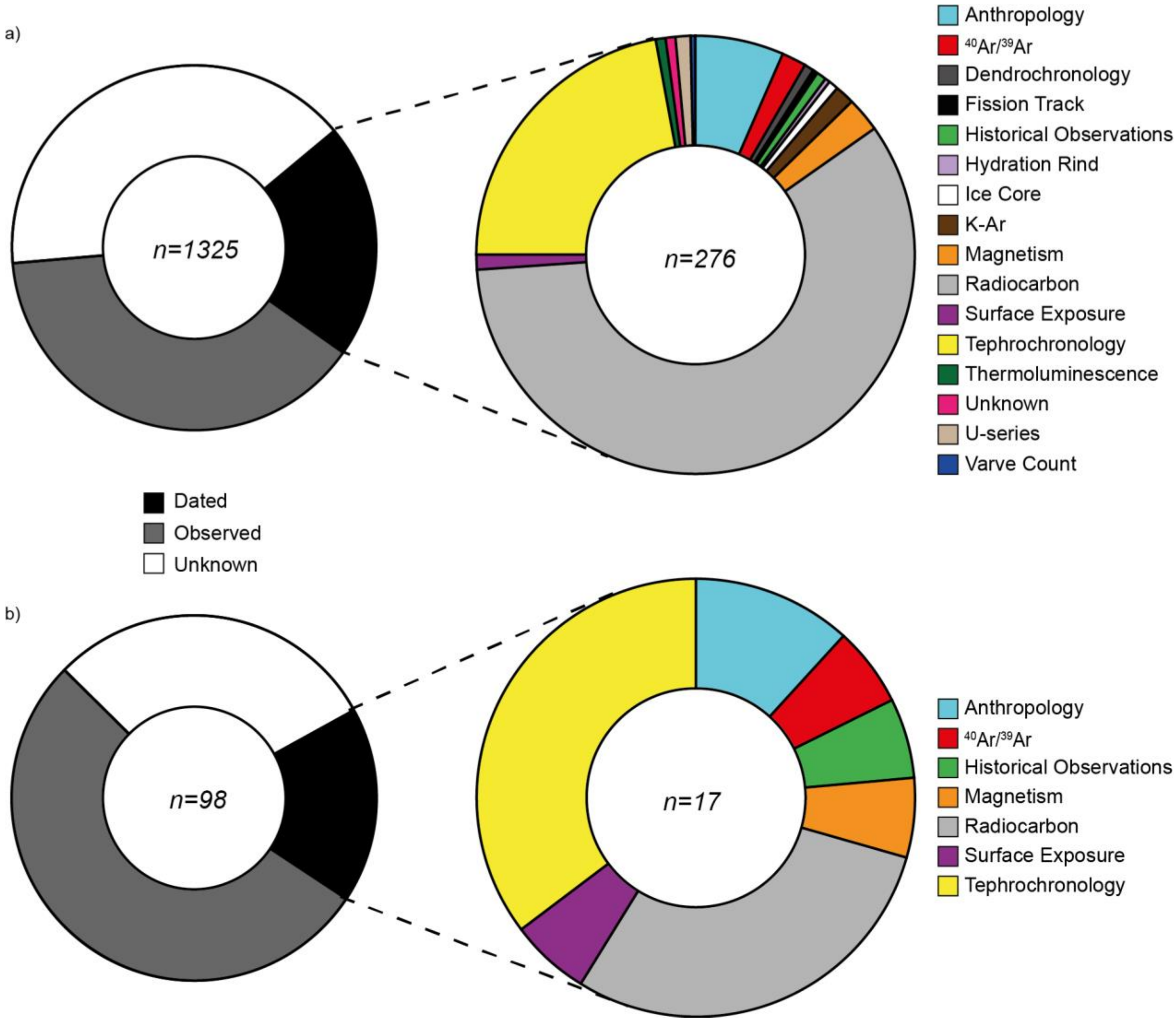

Figure DR1: Pie charts classifying the last eruption at Holocene volcanoes as dated, observed or unknown, with a close-up of dating techniques used; (a) sub-aerial Holocene volcanoes; (b) sub-aerial Holocene intraplate and rift volcanoes, situated on oceanic or intermediate crust. All data taken and categories from VOTW database (Global Volcanism Program, 2013).

Lava flow and sample descriptions

South Sisters Flow

Sample AI14-412; co-ordinate 567420, 9123992 (WGS 84 co-ordinate system):

A hawaiite lava flow originating from a fissure on the south-western side of Sister's Peak scoria cone complex, extending approximately 1.7 km west. This rugged ʻaʻā lava flow varies in thickness from 1 – 5 m, and occupies a volume of ~ 0.68 km^3 (± 25 %). The flow has a vent proximal subsided area at the western-most extent of the fissure where lava has ponded and subsequently drained, either to the advancing lava flow front or due to drain back at the vent. The lava flow has advanced over the surrounding plain which is a sediment infilled weathered lava flow surface. The lava has a low vesicularity, with vesicles < 1 mm. The sample was taken from a non-vesicular portion. The lava is fine-grained, with a microcrystalline groundmass of olivine, plagioclase and Fe-Ti oxides. Phenocrysts phases are olivine (up to 2 mm) and plagioclase (up to 10 mm), and constitute < 5% of the rock.

Comfortless Cove Flow

Sample AI14-414; co-ordinate 565826, 9125656 (WGS 84 co-ordinate system):

A mugearite ʻaʻā lava flow emanating from a previously unmapped vent at Comfortless Cove. This lava flow has variations in thickness typically ~ 2 – 3.5 m thick. Field observations suggest that the lava flow sampled at Comfortless Cove is part of a lava flow field that occupies a minimum of 0.15 km^2 that reached the coastline and may be present offshore. Flow surfaces are rugged, with sections of toothpaste lava surface textures and prominent pressure ridges perpendicular to the dominant flow direction. The sample was taken from the northern side of Comfortless Cove. The sample is a fine grained mafic lava, which is variably vesicular (vesicular areas avoided during sampling) with < 2% phenocrysts (plagioclase only phase visible in hand sample, < 1 cm). Groundmass is fresh and microcrystalline.

Davidson Flow

Sample AI15-625; co-ordinate 570425, 9125292 (WGS 84 co-ordinate system):

A hawaiite lava flow emplaced from the north-eastern side of Sisters Peak, extending at least 3 km to the NE coast. The rubbly ʻaʻā lava flow occupies ~ 3.7 km^2 and is channelized by the pre-existing topography, including the Broken Tooth scoria cone which bifurcates the flow into two lava flows. The sample was taken between Hollow Tooth and Broken Tooth scoria cones. Sample taken from dense, non-vesicular core of lava flow. Sample taken from dense, non-vesicular core of lava flow. The lava contains ~ 8 % phenocrysts, with plagioclase and olivine (both < 2 mm) visible in hand sample.

Data Repository Table DR1

Whole rock major and trace element compositions (XRF) of dated samples

Lava Flow	South Sisters Flow	Comfortless Cove Flow	Davidson Flow
Sample	**AI14-412**	**AI14-414**	**AI15-625**
Major Elements (wt. %)			
SiO_2	48.05	51.32	48.91
TiO_2	3.08	2.55	3.24
Al_2O_3	14.82	15.64	15.25
Fe_2O_3 *	12.18	11.15	12.69
MnO	0.22	0.24	0.23
MgO	4.12	3.58	4.32
CaO	8.47	6.87	7.95
Na_2O	4.08	4.70	4.13
K_2O	1.46	1.86	1.46
P_2O_5	1.06	1.45	0.90
LOI	1.10	-0.21	-0.65
Total	98.63	99.16	98.43
Trace Elements (ppm)			
Sc	20	14	21
V	217	131	235
Cr	<10	<10	<10
Ni	<10	<10	11
Cu	<10	<10	<10
Zn	120	126	123
As	<10	<10	<10
Rb	32	38	32
Sr	457	458	453
Y	40	49	41
Zr	274	337	275
Nb	52	61	51
Mo	<10	<10	<10
Ba	247	353	246
La	39	47	40
Ce	91	121	86
Pb	<20	<20	<20
Th	<10	<10	<10
U	<10	<10	<10

***All iron reported as Fe_2O_3**

XRF Methods

Whole rock compositions were obtained from interior portions of fresh samples, which were washed in ultrapure water in a sonic bath and dried overnight at > 100°C, and powdered before fused glass discs and pressed powder pellets were prepared for major and trace element analysis respectively. Element abundances were determined using a Bruker AXS S4 Pioneer instrument at the University of East Anglia. Loss in Ignition (LOI) was carried out by heating ~ 1 g of sample powder in a furnace at 1050°C for 4 hours. Reproducibility and accuracy were monitored using several international standards and is better than 1 % relative.

$^{40}Ar/^{39}Ar$ Methods

Samples were collected from fresh, low-vesicularity, interior portions of the lava flows. Examination of the lava flows across ca. 100s m show that the amount of phenocrysts in the lava varies and as such, we specifically targeted areas with minimum phenocrysts. These samples were excavated using a large sledgehammer. At least 50 cm of surface material was excavated to ensure we were sampling the dense core of the lava flow and not material from an exterior weather surface. Samples were crushed in a jaw crusher, then sieved and washed, before the 250 – 500 µm portions were subsequently magnetically separated to remove phenocrysts. The phenocryst-free fractions were leached in HCl then repeatedly washed (sonicated) in de-ionized water until the water ran clear (ca. 9 leaching steps per sample), before being leached in HNO_3 (ca. 5 leaching steps per sample) prior to further repeated sonification in de-ionized water. Samples were then hand-picked under a binocular microscope to eliminate phenocryst-rich or altered fragments. Note - we have tried to date such young materials previously and have failed to isolate (beyond analytical uncertainty) a radiogenic ^{40}Ar ($^{40}Ar^*$) signal from an atmospheric ^{40}Ar signal. We place much of our success in these experiments to the meticulous sample preparation. As an example of the effort involved, it took approximately four weeks per sample to go from whole rock to prepared sample, the majority of the time spent at the binocular microscope screening each individual piece of groundmass to ensure it was phenocryst-free and displayed no signs of alteration. Such meticulous work is required as, for example, a 500 year old sample with 1.5 wt. % K_2O will contain approximately 1×10^{-16} moles $^{40}Ar^*$ for 100 mg, which with a system sensitivity of 7×10^{-14} moles/volt, equates to ca. 1.5 mV of $^{40}Ar^*$ to be measured.

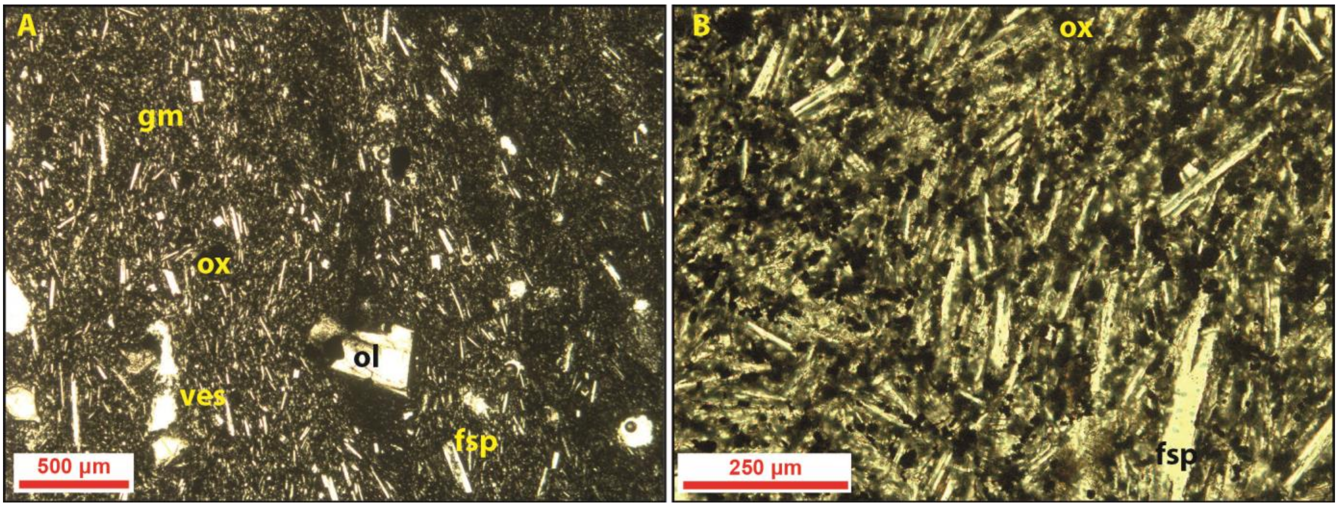

Figure DR2: Photomicrographs (PPL) of South Sisters Flow: A) overview of lava showing low vesicularity and low percentage of phenocrysts; B) lava groundmass showing no phenocrysts or vesicles, as was used for $^{40}Ar/^{39}Ar$ dating in this study.

Approximately 330 mg of groundmass for each sample was parcelled into Cu packets, stacked in small glass vials and sealed in a large glass vial for irradiation. International standard Alder Creek sanidine (ACs; with an age of 1.1891 ± 0.0008 Ma; Niespolo et al., 2017) and a secondary standard, Fish Canyon sanidine (FCs; with age of 28.294 ± 0.036 Ma, Renne et al., 2011) from the EK-collection (Morgan et al., 2013) were used as fluence monitors for J-determination, and packaged throughout the stack at known spacing (geometry) in between samples.

Samples were irradiated in two batches. Samples and standards were irradiated for 1 hour in the Cd-lined (CLICIT) facility of the Oregon State University (USA) TRIGA reactor. ACs and FCs grains (*n*30 and *n*30, respectively) were analysed by total fusion with a CO_2 laser. The ACs grains were used to determine the J-parameters. The FCs grains were obviously under-irradiated and although yielded low precision ages (due to the short irradiation and high $^{40}Ar^*/^{39}Ar$ ratio), overlapped (within uncertainty) of 28.294 Ma. Although we expected samples to be young, sub-1 ka ages were not expected and as such, the samples are over-irradiated. This makes the reactor derived $^{40}Ar_K$ correction very important. For example, a 500 year old sample will have a $^{40}Ar^*/^{39}Ar_K$ value of about 0.001 for a J-parameter value of 0.000272 and a reported $(^{40}Ar/^{39}Ar)_K$ of 0.00073, making the $^{40}Ar_K$ correction -360 years. Hence the $^{40}Ar_K$ correction utilized is a running average of measurements made on a variety of different duration irradiations to ensure accuracy.

Samples were split into 100 – 110 mg aliquots and loaded into a large well (1.5 cm^2) in a copper planchette as a mono-layer of material. The mono-layer is of critical importance to allow uniform step-heating of the samples and accurate resolution of the atmospheric and radiogenic argon components. Three aliquots from each sample were measured. We decided to run such large aliquots of material in the laser system to allow for precise measurement of the ion beams, especially for the minor isotope ^{36}Ar. It is important to note that we are not measuring small ion beams (see table DR2) – we want to measure at the highest precision possible using the technology available to us. Owing to the anticipated young age of these materials and high atmospheric components, samples were baked at low temperature (~ 100 ˚C) for 4-5 days to remove surface atmospheric contamination. Samples were subsequently step-heated incrementally using a CO_2 laser with a homogeniser lens to produce a flat top laser beam. A 5 mm laser spot-size was rastered across the surface of the sample for 6 minutes using a pre-programmed automated routine. The extracted gases were cleaned by exposure to three SAES GP50 getters, two operated at 450 ˚C and one operated at room temperature for 15 minutes. Isotope data were collected using the ARGUS multicollector noble gas mass spectrometer (Mark et al., 2009).

Since the publication of Mark et al. (2009) there have been a series of system upgrades to the noble gas instrument – most notably the replacement of the 100 Gohm (10^11 ohm) and 1 Tohm (10^12 ohm) GVI Faraday resistors (GVI-generation) with TIA Systems 100 Gohm and 1 Tohm resistors supplied to SUERC by Scott Hamilton (co-author). The new TIA resistors have significant improvements in noise over the GVI resistors, 0.9 x 10^{-6} and 2.9x 10^{-6} V for the 100 Gohm and 1 Tohm resistors, respectively. Given that for run times of 1800 s (measurement duration) Johnson-Nyquist noise is predicted to be 0.8 x 10^{-6} and 2.7 x 10^{-6}, the resistors are operating at the maximum performance attainable. To maximize analytical precision, the normal run routine detailed in Mark et al. (2009) was modified. Whereas data were previously collected for 300 seconds, for this study data were collected over 1800 seconds, to improve the precision of the t_0 regressions for each isotope. In addition, although 30 s of baseline measurement were made during gas equilibration, as detailed by Mark et al. (2009) to account for any pressure effects, 1800 s of baseline measurements (again to maximize measurement precision) were also made following the 1800 s of peak measurement. The baseline measurements are critical for accurate reduction of data where the $^{40}Ar^*$ component is exceptionally small. Taken as a whole, the system delivers a ca. 3-fold improvement in data precision relative to the summary reported by Mark et al. (2009). Reproducibility is controlled by ion source stability. We use a voltage smoother to ensure a constant uniform voltage is delivered to the mass spectrometer to promote ion source stability (as well as magnet controller stability).

Ages were computed from the blank-, discrimination- and decay-corrected Ar isotope data after correction for interfering isotopes based on the production ratios, determined from fluorite and Fe-doped $KAlSiO_4$ glass reported below in this data repository as well as previous experiments. Given the young age of the samples it was critical that backgrounds and mass discrimination were monitored as closely as possible. Following the measurement of every unknown step, two background measurements were made, followed by two air calibrations and subsequently two more background measurements, prior to conducting analysis of the next unknown. Such characterization of the backgrounds and mass discrimination is critical for the dating of materials this young – not only with respect to achievable precision, but it is also critical to ensure background reproducibility was maintained. Although it is tempting to simply use a previous run background measurement to improve precision, we actually believe the background ± standard deviation from an entire run sequence is a more accurate and robust approach to handling the data. Accounting for the reproducibility informs about machine performance and stability. With measuring samples that are young background corrections can impact accuracy and precision, the latter especially if one is measuring small ion beam intensities (which we are not). The average background measurements ± standard deviation for *n*189 background measurements is provided for each sample in Table DR2. Background measurements were subtracted from ion beam intensities. The discrimination factor (D) ± standard deviation for *n*105 air calibrations is also provided in Table DR2. Mass discrimination was computed based on a power law relationship (Renne et al., 2009) using the isotopic composition of atmospheric Ar (Lee et al., 2006) that has been independently confirmed (Mark et al., 2011). Corrections for radioactive decay of ^{39}Ar and ^{37}Ar were made using the decay constants reported by Stonner et al. (1965) and Renne & Norman (2001), respectively. Ingrowth of ^{36}Ar from decay of ^{36}Cl was corrected using the $^{36}Cl/^{38}Cl$ production ratio and methods of Renne et al. (2008) and was determined to be negligible.

Ages and their uncertainties are calculated using the methods of Renne et al. (2010), the decay constant parameters of Renne et al. (2011) and the ACs age of Niespolo et al., 2017 (1.1891 ± 0.0008 Ma), except where noted. For the age comparisons made herein, contributions from sources of systematic uncertainty (i.e., uncertainties in $^{40}Ar/^{40}K$ of the standard and ^{40}K decay constants) are neglected and only analytical uncertainties in isotope measurements of samples and standards are included. These uncertainties are referred to herein as "analytical precision". For the purposes of this study, analytical uncertainties include contributions from uncertainties in the interference corrections because these interference corrections have variable effects due to the slightly variable chemistry of the samples considered.

Within the main text, the global isochrons for each sample are shown. Table DR2 shows the data that were plotted on these isotope correlation plots.

References

Lee, J.-Y., Marti, K., Severinghaus, J.P., Kawamura, K., Yoo, H.-S., Lee, J.B., Kim, J.S.A., 2006, redetermination of the isotopic abundances of atmospheric Ar: Geochim. Cosmochim. Acta., v. 70, p. 4507-4512.

Mark, D.F., Barford, D., Stuart, F.M., Imlach, J., 2009, The ARGUS multicollector noble gas mass spectrometer: Performance for $^{40}Ar/^{39}Ar$ geochronology: Geochem. Geophy. Geosy., v. 10, Q0AA02.

Mark, D.F., Stuart, F.M., de Podesta, M., 2011, New high-precision measurements of the isotopic composition of atmospheric argon: Geochim. Cosmochim. Acta., v. 75, p. 7494-7501.

Morgan, L.E., Mark, D.F., Imlach, J., Barfod, D., Dymock, R., 2013, FCs-EK: a new sampling of the Fish Canyon Tuff $^{40}Ar/^{39}Ar$ neutron flux monitor: Geological Society Special Publication, v. 378, p. 63-67

Niespolo, E., Rutte, D., Deino, A.L., Renne, P.R., 2017, Intercalibration and age of the Alder Creek sanidine $^{40}Ar/^{39}Ar$ standard: Quat. Geochronol., v. 39, p. 205-213.

Renne, P.R., Norman, E.B., 2001, Determination of the half-life of ^{37}Ar by mass spectrometry: Physical Review C – Nuclear Physics, v. 63, p. 473021-473023

Renne, P.R., Sharp, Z.D., Heizler, M.T., 2008, Cl-derived argon isotope production in the CLICIT facility of OSTR reactor and the effects of Cl-correction in $^{40}Ar/^{39}Ar$ geochronology: Chem. Geol., v. 255, p. 463-466.

Renne, P.R., Mundil, R., Balco, G., Min, K., Ludwig, K.R., 2010, Joint determination of ^{40}K decay constants and $^{40}Ar^{*}/^{39}Ar$ for the Fish Canyon Sanidine standard, and improved accuracy for $^{40}Ar/^{39}Ar$ geochronology: Geochim. Cosmochim. Acta., v. 74, p. 5349-5367.

Renne, P.R., Balco, G., Ludwig, K.R., Mundil, R., Min, K., 2011, Response to comment by W.H. Schwarz et al. on "Joint determination of ^{40}K decay constants and $^{40}Ar^{*}/^{39}Ar$ for the Fish Canyon Sanidine standard, and improved accuracy for $^{40}Ar/^{39}Ar$ geochronology" by P.R Renne et al. (2010): Geochim. Cosmochim. Acta., v. 75, p. 5097-5100.

Renne, P.R., Deino, A.L., Hames, W.E., Heizler, M.T., Hemming, S.R., Hodges, K.V., Kopper,s A.A.P., Mark, D.F., Morgan, L.E., Phillips, D., Singer, B.S., Turrin, B.D., Villa, I.M., Villeneuve, M., Wijbrans, J.R., 2009, Data reporting norms for $^{40}Ar/^{39}Ar$ geochronology: Quat Geochronol., v. 4, p. 346-352.

Stoenner, R.W., Schaeffer, O.A., Katcoff, S., 1965, Half-lives of Argon-37, Argon-39 and Argon-42: Science, v. 148, p. 1325-1328.

$^{40}Ar/^{39}Ar$ Parameters

Nucleogenic production ratios, OSU TRIGA reactor

$(^{36}Ar/^{37}Ar)_{Ca}$	2.650	± 0.2	$\times 10^{-4}$
$(^{39}Ar/^{37}Ar)_{Ca}$	6.950	± 0.9	$\times 10^{-4}$
$(^{38}Ar/^{37}Ar)_{Ca}$	0.196	± 0.00816	$\times 10^{-4}$
$(^{40}Ar/^{39}Ar)_{K}$	7.300	± 3	$\times 10^{-4}$
$(^{38}Ar/^{39}Ar)_{K}$	1.220	± 0.027	$\times 10^{-2}$
$(^{36}Ar/^{38}Ar)_{Cl}$	320.000		
Ca/K	1.960		
Cl/K	2.900		

Isotopic constants & decay rates

$\lambda(^{40}K_{\varepsilon})$/yr	5.757	± 0.016	$\times 10^{-11}$
$\lambda(^{40}K_{\beta-})$/yr	4.955	± 0.0134	$\times 10^{-10}$
$\lambda(^{40}$Ktotal)/yr	5.5307		$\times 10^{-10}$
$\lambda(^{37}Ar)$/d	0.01975		
$\lambda(^{39}Ar)$/d	7.068		$\times 10^{-6}$
$\lambda(^{36}Cl)$/d	6.308		$\times 10^{-9}$
$(^{40}Ar/^{36}Ar)_{atm}$	298.56	± 0.31	
$(^{40}Ar/^{38}Ar)_{atm}$	1583.7	± 2	
$^{40}K/K_{total}$	0.1167	± 0.001	

$^{40}Ar/^{39}Ar$ Irradiation Details

All samples were irradiated in the OSU CLICIT reactor.

Sample	Reference	Duration (minutes)	Date
AI15-625	EK72 L	60	05/05/2016
AI14-412	EK71 I	60	29/10/2015
AI14-414	EK71 I	60	29/10/2015

Data Repository Table DR2

$^{40}Ar/^{39}Ar$ data

Run_ID	Sample	Material	Isochron step	40Ar	±	39Ar	±	38Ar	±	37Ar	±	36Ar	±
Comfortless Cove lava flow, J: 0.000273 ± 0.000001 (ACs, n20), D: 1.000421 ± 0.000083 (n35)													
92181-01A	AI14-414	Groundmass	x	0.5358327	0.0015	0.1099291	0.00013	0.0082282	0.000026	0.0029048	0.000014	0.0017995	0.000018
92181-01B	AI14-414	Groundmass	x	2.211821	0.0014	0.5018656	0.00022	0.0067547	0.000021	0.0388436	0.000043	0.0074592	0.000011
92181-01C	AI14-414	Groundmass	x	1.878586	0.0015	0.3652177	0.0003	0.0072035	0.000024	0.0583481	0.00004	0.0063695	0.000013
92181-01D	AI14-414	Groundmass	x	1.64968	0.00101	0.8067542	0.00037	0.008179	0.000025	0.0829296	0.000073	0.0056309	1.00E-06
92181-01E	AI14-414	Groundmass	x	1.229124	0.00065	0.992057	0.00031	0.0059874	0.00003	0.0761514	0.000082	0.0042147	3.00E-06
92181-01F	AI14-414	Groundmass	x	1.063682	0.00082	0.2477129	0.00017	0.0041811	0.000018	0.1455276	0.000097	0.0037539	0.000015
92181-01G	AI14-414	Groundmass	x	0.7592422	0.00053	0.3603399	0.00015	0.0034321	0.00002	0.0939464	0.000085	0.0026693	0.000013
92181-02A	AI14-414	Groundmass	x	0.751794	0.00038	0.0137933	0.00006	0.0015083	9.10E-06	0.005367	0.000023	0.0025266	1.00E-05
92181-02B	AI14-414	Groundmass	x	2.389835	0.00066	0.4000495	0.000085	0.0064966	0.000026	0.0306286	0.00003	0.0080564	6.00E-06
92181-02C	AI14-414	Groundmass	x	2.275746	0.0006	0.3790659	0.00015	0.0076912	0.00003	0.049175	0.000041	0.007703	8.00E-06
92181-02D	AI14-414	Groundmass	x	1.859178	0.001	0.7087304	0.0003	0.0086778	0.000016	0.0681149	0.000046	0.0063166	4.00E-06
92181-02E	AI14-414	Groundmass	x	1.354802	0.00097	0.9922118	0.00022	0.0065441	0.000018	0.0624098	0.000044	0.0046443	5.00E-06
92181-02F	AI14-414	Groundmass	x	1.244499	0.00085	0.195999	0.00016	0.0044563	0.000015	0.1250079	0.000075	0.0043787	0.000015
92181-02G	AI14-414	Groundmass	x	0.7716003	0.0011	0.40364	0.00024	0.0033339	0.000022	0.0713351	0.000079	0.0026992	0.000015
92181-03B	AI14-414	Groundmass	x	0.1203309	0.00056	0.0156766	0.000086	0.0003797	0.000019	0.0035679	0.000024	0.000412	1.00E-06
92181-03C	AI14-414	Groundmass	x	0.4313176	0.0005	0.0982482	0.00022	0.0016541	0.000024	0.0140012	0.00005	0.0014787	6.00E-06
92181-03D	AI14-414	Groundmass	x	1.088988	0.0006	0.3243149	0.00043	0.0052996	0.000031	0.0392014	0.00006	0.0037486	3.00E-06
92181-03E	AI14-414	Groundmass	x	1.36824	0.0014	0.9225107	0.00057	0.0060023	0.000021	0.0615278	0.00007	0.0047291	5.00E-06
92181-03F	AI14-414	Groundmass	x	1.292882	0.0013	0.5598241	0.00037	0.0056344	0.000021	0.0687659	0.000082	0.004502	0.000015
92181-03G	AI14-414	Groundmass	x	1.136898	0.0011	0.2045251	0.0003	0.0050344	0.000019	0.0878824	0.000091	0.0040244	0.000019
Average background (n71)				*0.005910*	*0.000030*	*0.000207*	*0.000018*	*0.000041*	*0.000012*	*0.000161*	*0.000013*	*0.000097*	*0.000007*
South Sisters lava flow, J: 0.000272 ± 0.000002 (ACs, n20), D: 1.000410 ± 0.000087 (n35)													
92191-03B	AI14-412	Groundmass	x	0.128987	0.00047	0.0198376	0.000057	0.0003876	0.00002	0.0034255	0.000016	0.0004405	9.40E-06
92191-03C	AI14-412	Groundmass	x	0.3806668	0.0008	0.0899182	0.00018	0.0014408	0.00002	0.01476	0.000032	0.0013123	0.000018
92191-03D	AI14-412	Groundmass	x	0.9041527	0.0014	0.4107948	0.00049	0.004786	0.000024	0.0471106	0.000087	0.0031467	6.00E-06
92191-03E	AI14-412	Groundmass	x	1.028987	0.00092	0.7913616	0.00037	0.0057628	0.000028	0.0603878	0.00008	0.0035924	8.00E-06
92191-03F	AI14-412	Groundmass	x	0.8682725	0.001	0.4761174	0.00017	0.002409	0.000017	0.0498846	0.000061	0.0030318	0.00001
92191-03G	AI14-412	Groundmass	x	0.922911	0.0011	0.1396564	0.0002	0.0026417	0.000025	0.0884698	0.00013	0.0033059	0.00002
92191-01A	AI14-412	Groundmass	x	0.6359415	0.0012	0.0537109	0.00011	0.0013036	0.000025	0.0066435	0.000032	0.0021369	0.000014
92191-01B	AI14-412	Groundmass	x	1.907024	0.0015	0.2552839	0.00022	0.0056562	0.000019	0.0363551	0.000039	0.0064428	0.000014

92191-01C	AI14-412	Groundmass	x	2.064415	0.0036	0.6557472	0.00061	0.0068497	0.000031	0.062005	0.00012	0.0070202	0.000011
92191-01D	AI14-412	Groundmass	x	1.649563	0.0019	0.992437	0.00054	0.0070887	0.000019	0.094659	0.00012	0.0056647	0.00001
92191-01E	AI14-412	Groundmass	x	1.048392	0.00086	0.2940073	0.0002	0.0037126	0.000016	0.0652584	0.000069	0.0036189	9.00E-06
92191-01F	AI14-412	Groundmass	x	0.8391509	0.00076	0.0815949	0.000073	0.0017918	0.000025	0.0898924	0.000093	0.0029555	0.000019
92191-02A	AI14-412	Groundmass	x	0.4349145	0.001	0.0383381	0.00008	0.0009751	0.000021	0.0053959	0.000024	0.0014605	0.000018
92191-02B	AI14-412	Groundmass	x	1.791429	0.0008	0.493922	0.00014	0.004918	0.000014	0.0344847	0.000032	0.0060289	9.00E-06
92191-02C	AI14-412	Groundmass	x	1.81757	0.0013	0.3988764	0.00022	0.0062768	0.000025	0.0572487	0.000045	0.0061912	0.000012
92191-02D	AI14-412	Groundmass	x	1.485405	0.0021	0.5438761	0.00059	0.0067165	0.000032	0.0871324	0.00012	0.0051187	0.000011
92191-02E	AI14-412	Groundmass	x	1.085641	0.00054	0.8569096	0.00014	0.0035411	0.000013	0.0599596	0.000054	0.0037323	8.00E-06
92191-02F	AI14-412	Groundmass	x	0.8144155	0.00077	0.4097739	0.000081	0.0016921	0.000026	0.080728	0.000088	0.0028681	1.00E-05
92191-02G	AI14-412	Groundmass	x	0.8793126	0.00044	0.1422379	0.000091	0.0023964	0.000025	0.1089199	0.000061	0.0031421	9.40E-06
Average background (n63)				*0.005562*	*0.000006*	*0.000165*	*0.000016*	*0.000075*	*0.000013*	*0.000232*	*0.000011*	*0.000091*	*0.000007*

Davidson lava flow, J: 0.000278 ± 0.000001 (ACs, n20), D: 1.000419 ± 0.0000091 (n35)

92506-01A	AI15-625	Groundmass	x	0.5261549	0.0016	0.0341475	0.00011	0.0009816	0.000022	0.0090728	0.000044	0.0017627	0.000011
92506-01B	AI15-625	Groundmass	x	1.732733	0.00081	0.3614026	0.00024	0.0068228	0.00002	0.1346353	0.000092	0.0058965	6.00E-06
92506-01C	AI15-625	Groundmass	x	0.3282602	0.001	0.0971167	0.0001	0.0016598	0.000032	0.0387946	0.00016	0.0011224	8.00E-06
92506-01D	AI15-625	Groundmass	x	1.1002	0.00098	0.7095299	0.00044	0.0061347	0.000026	0.174037	0.00017	0.0037959	7.00E-06
92506-01E	AI15-625	Groundmass	x	1.636196	0.0011	0.9790883	0.00035	0.0070453	0.000017	0.2194779	0.00014	0.0055855	0.00001
92506-01F	AI15-625	Groundmass	x	2.420438	0.0009	0.1666893	0.000081	0.0039456	0.000022	0.2596966	0.00011	0.0082734	6.00E-06
92506-01G	AI15-625	Groundmass	x	1.371249	0.0011	0.1683599	0.00014	0.0032785	0.000023	0.3004878	0.00024	0.0047593	0.000016
92506-02A	AI15-625	Groundmass	x	0.648817	0.0016	0.0370927	0.000099	0.0011419	0.000027	0.0093521	0.00003	0.0021785	0.000025
92506-02B	AI15-625	Groundmass	x	1.769985	0.00078	0.3592473	0.00019	0.006757	0.000027	0.1329767	0.000068	0.0059754	0.000022
92506-02C	AI15-625	Groundmass	x	0.3721442	0.0015	0.0981046	0.0004	0.0016001	0.000025	0.0387117	0.00015	0.0012697	8.00E-06
92506-02D	AI15-625	Groundmass	x	1.626664	0.0011	0.7118229	0.00022	0.006382	0.000021	0.1728491	0.000096	0.0055498	8.00E-06
92506-02E	AI15-625	Groundmass	x	2.254941	0.002	1.587439	0.00027	0.0075358	0.000023	0.220682	0.00012	0.0076758	6.00E-06
92506-02F	AI15-625	Groundmass	x	2.357224	0.00099	0.3696348	0.000085	0.0039757	0.000021	0.2554497	0.00011	0.0080519	9.00E-06
92506-02G	AI15-625	Groundmass	x	1.464926	0.0013	0.1665528	0.00013	0.0033175	0.00002	0.2932361	0.00021	0.0051014	0.000016
92506-03A	AI15-625	Groundmass	x	0.9296276	0.0013	0.0262823	0.000065	0.0010848	0.000018	0.0058835	0.00002	0.003112	0.000019
92506-03B	AI15-625	Groundmass	x	2.287039	0.00098	0.3375298	0.00018	0.0067988	0.000023	0.1111728	0.000066	0.0077441	0.000011
92506-03C	AI15-625	Groundmass	x	0.7356635	0.0012	0.0998208	0.00022	0.0019683	0.00002	0.0353413	0.000077	0.0024858	0.000017
92506-03D	AI15-625	Groundmass	x	1.816334	0.0008	0.9413448	0.00024	0.0070546	0.000019	0.1693769	0.00008	0.0062034	7.00E-06
92506-03E	AI15-625	Groundmass	x	2.149857	0.00081	1.66744	0.00022	0.0083845	0.000025	0.2290589	0.000085	0.0073391	9.00E-06
92506-03F	AI15-625	Groundmass	x	4.567885	0.001	0.210551	0.000073	0.0058604	0.000022	0.2656441	0.000071	0.0154927	0.000019
92506-03G	AI15-625	Groundmass	x	2.107262	0.0012	0.2181719	0.00012	0.0044387	0.000025	0.3399211	0.00019	0.0072896	0.000013
Average background (n55)				0.004359	0.000068	0.0002045	0.000013	0.0000842	0.000011	0.0002347	0.00001	0.0000725	0.000009

Historical written accounts of Ascension Island geology

Oral accounts during conversations with Ascension Island residents hint at reports of recent volcanic activity, which may have taken place shortly before or after the island's discovery. Similar statements can also be found in popular accounts published during the 20th Century.

Joshua Slocum, the first person to circumnavigate the world alone, wrote of Ascension during his visit there in April 1898: "*It is a mass of volcanic matter, thrown up from the bed of the ocean to the height of two thousand eight hundred and eighteen feet at the highest point above sea level. It is a strategic point, and belonged to Great Britain before it got cold*" (Slocum, 1900).

In addition, a guide to Ascension, first published in the 1960s states that the last eruption of lava from Sisters Peak may have occurred within the last 500-700 years (Packer, 1983). The evidence for this seems to be limited to the presence of lava flows with youthful-looking features (fresh, unweathered and unvegetated surfaces).

In order to elucidate whether there are written accounts of eruptions shortly after the discovery of the island in the early 16th Century, we provide a review of documentation dating from that time until colonization of the island by the British in 1815. Below we provide selected information for written accounts, related to timing of visits, location of visits and geological information.

In summary, despite the fact that the island was frequently visited by ships who used the island as a stopping place to take on provisions of turtle and goat meat, we have found no clear written evidence of eye-witness accounts of volcanic activity. This suggests that the last activity was prior to discovery.

Written accounts of Ascension Island until colonization by the British

João da Nova, 1501: Discovery. See Da Barros (1552).

Afonso de Albuquerque, 1503: Sighted the island. See Da Barros (1552).

Portuguese sightings recorded in 1508 and 1512. See Da Barros (1552).

Jan van Linschoten, 28 May 1589

"…there commeth not a ship in twentie yeares into that Iland, because there is nothing in it to be had"

"There is not any fresh water in the Iland, nor one greene leafe or branch. It hath many hilles of a reddish colour, which shew like a certaine Earth in Spain called Almagro [almagre = red ochre] and tis full of stonie hilles, and dryed land, [it is] like Saint Helena. There hath beene some shippes there, that missed Saint Helena, and sought fresh water in that Iland, but could find none." (Burnell and Tiele, 1884)

Peter Mundy, 1638 and 1656

19 October 1638

"Wee had sightt off the Iland off Ascension, itt being aboutt the biggnesse of St Elena and allmost as Farre From any other land, For St Helena afforesaid is the Farthest Distantt From any other Iland or Mayne whatsoever then any other Iland elce yet Discovered in the whole world, as May bee perceaved by the globe, For the Nearest unto itt is Ascension, which are Near 200 leagues asunder and this Ascention aboutt 140 From some Ilands on the Coast off Guynny."

7-8 June 1656

"The 7th June anno 1656. Att evening wee arrived att Ascention and anchored on the NW side of the iland. On our rightt hand was a faire sandy bay and on our left were multi[tu]de of rarreg [ragged], craggy, sharpe pointed hard rocks for many miles along the shoare, and up toward the land, appearing white with the dung of sea foule, of which were innumerable of several kinds. The most desolate, barren [land] (and like a land that God has cursed) that ever my eies beeheld (worse than Kerne Ky, etts. in Cornewall). I co[n]ceave the whole world affoards not such another peece of ground: most part of the collour of burnt bricke, reddish, the substance of stones, somewhat like pumice stones, the rest like cinders and burnt earth. The hills, of which there are many, were meere heapes of the same. It may bee supposed thatt the fire in former ages hath consumed the substance therof, hath made it incapable of producing any vegetalls. Only the topps of the high mountains in the middle appeared somwhatt greene, there beeing a kind of rushes and spicy [?spiky] grasse. Some of our company went up and broughtt downe six or seven goates, doubtlesse att first left there by the Portugalls."

"8 June. This evening wee set saile from Ascention, being Sonday." (Temple and Anstey, 1936)

Souchu de Rennefort, 17- 18 April 1666

"Le 17. elle parut à porte du jour & quoy que basse sut apperceuë de loin…"

"Nous poussmes à toutes voiles jusques à trois heures après midy pour ateindre la rade devant cette Isle ou nous jettasmes les ancres du côté du Nord-Est à dix-sept brasses de fond."

"…les Chaloupes porterent vingt hommes à terre pour travailler à la pesches des tortuës, & j'y allay & quelques autres avec moy pour en avoir le divertissement… Nous grimpasmes de petits rochers sur lesquels il sur receüilly grand nombre d'oeufs des oiseaux qui étoient venus regaler les plus affamés de viande fraiche; & grosses pierres qui paroissoient tres-materielles fondoient sous nos pieds & se découvroient feüilletées aux dépens des jambes qui étoient blessées par les brisures."

"Deux François des plus curieux étoient partis pour reconnoître l'Isle; & sur son plus haut d'où ils n'appercevoient ny hommes, ny bêtes, ny ruisseaux, ny arbres, pour marquer l'endroit où ils étoient, avoient, mis à six heures du soir, le feu à des herbes sec qu'ils trouverent, & qui se communiqua si vîte qu'il parut à neuf un vaste embrasement, s'attachant sans doute aux pierres sulphureuses & au charbon de terre." (Rennefort, 1668)

Translation:

On the 17th it appeared at dawn and although low was seen from afar…

Under full sail, we sailed until 3 in the afternoon to reach the natural harbour in front of this Island where we cast our anchors on the North-East side, at a depth of seventeen fathoms.

… the rowboats carried twenty men to the land to catch turtles, and I went with some others to entertain ourselves… We climbed some small rocks on which we gathered many eggs from birds, and the birds were eaten by those who were craving fresh meat the most; the big rocks, which looked very solid, moved below our feet and had in fact sharp edges, and the legs of some were injured by the broken rocks.

Two Frenchmen among the most curious went to explore the Island, and on its highest point from where they could see no men, no beasts, no rivers, no trees, in order to mark their position at six in the evening they lit up dry grass they found there. The fire spread so fast that it looked like a large flashover, probably due to the sulphur-bearing rocks and to coal.

Jans Struys, 1673

"The next day we were ordered to go aboard directing our course for Ascension Island, which serv the English for a Rendezvous, where we arrived in the 19 of June"

"It is altogether rocky and produces nothing of growth, having in it high Hills, yet not so high as those in Saint Helena. The whole Island is white with the Dung of Mews, Cormorants, and a sort of wild-geese that come thither to build and breed, as also to prey upon dead Fish which lies in heaps upon the shore, and in small Inlets, and Creeks. There is no fresh water upon the Island, which if there had we had bin very unhappy, for the English had intended to leav us there with a little Provision, till our own Ships should come to fetch us off: but seeing there was none, they were so kind as to carry us for England. The reason of their design to do so, was because they had very many sick aboard, and grew every day weaker and weaker by the Death of their men, fearing therefore that we should rise and make ourselves masters of the ship when we found an Opportunity, being about 300 Dutch in all. On the 23 of June we left Ascension Island, and set our course N.W……" (Struys, 1684)

Domingo Navarette, January 1673

"On the 4th we had sight of the island, and the 5th anchor'd opposite a little Bay, from which rises a high Pyramidal Mountain, on top whereof are two great Crosses set up by the Portuguese; three French men went up thither. The island is but small, lies in 8 degrees of South Latitude, no Water has yet been found there. It lies almost half way between Guinea and Brazil, which are 400 Leagues asunder East and West. They found Letters ashore of French and English, who had pass'd by there the Year before; those that sail this way are so curious, as to write Letters, put them into Bottles of thick Glass and leave them in a safe place but visible, by which the next Comers have intelligence who is gone by, and what Voyage, Weather and Delays they had. It was the Twelth-day or Epiphany ……….. Some Seamen having spent a whole night Fishing for Tortoises, got but one; tho it was a great one……." (Cummins, 1962)

John Ovington, 1691

"…..is the Isle of Ascention, so denominated by Tristan Acunna its first Discoverer, who in his Return from the Indies in the Year 1508, espyed it upon Ascention Day."

"The Land is Mountainous, as most other Lands are that situate remotely from the Continent. And excepting some very few places, it is all steril and Desart, and the Surface Cinerous, cover'd with a kind of Sinders or Ashes, which gives occasion to some of thinking it formerly to have been a Fogo or Burning Island: Yet in some parts the Soil seems fit for Culture and Fructification."

"Marriners feed deliciously, for the space of ten or 15 Days sometimes together."

"Upon this Island is a certain Post-Office from the Letters left there by the Last Commander that came thither, giving an Account of the time he came there, when he departed from the Island, and what of News of the moment he thinks convenient. The Letter is commonly thrust into a Bottle corked close, which the succeeding Commander breaks in pieces to come to it, and leaves another instead." (Ovington, 1696)

Robert Everard, 1693

"In our way we touch'd at an island call'd Ascension, which shews itself like a burnt cinder. Here we stopt to take in some turtles, as most English ships so that come that way. When we had anchor'd, our captain went ashore in the pinnace, to see if there was a letter left in a bottle in a hole in a rock near the landing-place, which every ship that comes to that place, leaves there, the island being uninhabited: we took the bottle out of the hole, and found thereby, that the Kemthorne was the last ship that was there."

"….ten of them got leave to go ashore, well arm'd, to try to find them; and accordingly they took a survey from the top of a hill, where they found a cross, and named it Cross-hill; so looking, but seeing nothing like a ship or man they return'd on board again."

"…..and then the captain sent the boat ashore with a letter in a bottle, to be put in the same place where the other was taken out; and having remain'd here about 30 hours, we got up anchor, and made the best of our way for Barbadoes." (Churchill, 1745)

William Dampier, 1701

“In the afternoon with the help of a seabreeze I ran into 7 fathom and anchored; then carried a small anchor ashore and warped in till I came into 3 fathom and a half. Where having fastened her I made a raft to carry the men's chests and bedding ashore; and before 8 at night most of them were ashore. In the morning I ordered the sails to be unbent, to make tents; and then myself and officers went ashore. I had sent ashore a puncheon and a 36 gallon cask of water with one bag of rice for our common use: but great part of it was stolen away before I came ashore, and many of my books and papers lost. On the 26th following we, to our great comfort, found a spring of fresh water about 8 miles from our tents, beyond a very high mountain which we must pass over: so that now we were, by God's Providence, in a condition of subsisting some time; having plenty of very good turtle by our tents, and water for the fetching. The next day I went up to see the watering-place, accompanied with most of my officers. We lay by the way all night and next morning early got thither; where we found a very fine spring on the south-east side of the high mountain, about half a mile from its top: but the continual fogs make it so cold here that it is very unwholesome living by the water. Near this place are abundance of goats and land-crabs. About 2 mile south-east from the spring we found 3 or 4 shrubby trees, upon one of which was cut an anchor and cable, and the year 1642. About half a furlong from these we found a convenient place for sheltering men in any weather. Hither many of our men resorted; the hollow rocks affording convenient lodging; the goats, land-crabs, men-of-war-birds and boobies good food; and the air was here exceeding wholesome. About a week after our coming ashore our men that lived at this new habitation saw two ships making towards the island. Before night they brought me the news; and I ordered them to turn about a score of turtle to be in readiness for their ships if they should touch here: but before morning they were out of sight, and the turtle were released again. Here we continued without seeing any other ship till the second of April; when we saw 11 sail to windward of the island: but they likewise passed by. The day after appeared 4 sail, which came to anchor in this bay. They were His Majesty's ships the Anglesey, Hastings and Lizard; and the Canterbury East India ship. I went on board the Anglesey with about 35 of my men; and the rest were disposed of into the other 2 men-of-war. We sailed from Ascension the 8th; ……” (Dampier, 1709)

Pehr Osbeck, 1752

“The 4th of April
Generally clear weather and middling wind.
We steered from W. by N. to get to the longitude of Ascension Island, near which we sailed in the forenoon; and at last cast anchor in the Cross-bay on the same island, with twenty-four fathoms ground.”

“The 5th of April
“I never saw a more disagreeable place in all the world than this island…… The island everywhere is covered with stones; they are not pebbles, but angulated pumice-stones, containing more or less iron. When you meet with a plain, it is covered between the stones with a coarse earth which looks like soot, and under it you meet with a reddish fine sand. Here and there, especially on the shore, are some rocks. On the low places, where the water gathers during the rainy season, the earth was covered with brown crust which would break like thin ice under ones’ feet. Here and there, some pieces of glimmer were found. A mineralogist might have collected many sorts of stones here, which are not to be met with in other places. The heat is intolerable, and disables one from carrying any thing, it being difficult to support even the clothes upon one’s back, especially as walking is so difficult. He who chooses to walk here must wear shoes with thick soles; and must notwithstanding expect to bring aching feet home at night. If the stony Arabia is like this place, I pity those who are forced to wander through it. There are several great hills on this island, which consist of the above mentioned earth and coarse blackish brown sand: in the latter lie larger or smaller pumice stones, which are dangerous to walk on, as by their rolling down one may break one’s limbs. As soon as we got onshore I went to a conic mountain a good way off the place where we landed. It was steep, and of difficult access, because with each step the sand and stones rolled down: the heat increased, and I was forced to rest several times. In my opinion, this mountain was quite as large as our Kinnekulle. Neither on the sides, nor at the top, did I meet with one single plant; on the summit, where the air was very cool, stood a pole three fathoms long, which was provided with the necessary ropes for hoisting a flag. From the pole hung two crosses, the lower of which was wooden, and had the letters I.N.R.I. carved on it. Scarce a fathom above the wooden cross was a brazen one, at the bottom of which we could see 1748, the 15th of November; and higher up a French Inscription, which could not be read, it being too high. On the pole and the wooden cross several dates of years, and several names were carved.

The country hereabouts looks like the rocks about our mines. The birds rested here and there without being frightened, after they had filled themselves with fishes in the sea. In some places they had stained with their dung the heaps of stones quite white, which then looked like ruined towers, of which nothing but some whitewashed chimneys remained."

"The 8th of April
Clear weather, little wind.
After we had got all our men on board again, and 41 tortoises on deck, we weighed anchor. Wit the cable we pulled u a piece of coral, on which a red shell (*Pecten Adscensionis*) was growing, which on its valves represented many branches. We took it with us, and at present it is preserved in one of the greatest cabinets of natural curiosities in Sweden. In the forenoon, we set sail towards Fayal, in company with the Göta Lejon." (Hanson, 2009)

Olef Torén, 1752

This time we did not touch at St. Helena, but bore for the island of Ascension, where we anchored THE 6TH OF APRIL. This country has no fresh water than what the rain sometimes affords, for which reason it is dry and barren, and only seems to be destined by Providence to be the habitation of tortoises, and to serve as a place of some refreshment for seamen. Goats, pelicans and many seabirds breed here, notwithstanding the intolerable heat of the day, and the coldness of the night. The few low shores where we can land are covered with a loose pearl sand, in which the tortoises bury their eggs. I did not see how much the tide falls, nor could any estimation be made, on account of the strong breakers; these are likewise so violent against the wind, that in 1749 a sloop with four men sunk very near the shore." (Hanson, 2009)

Vaclav Prutky, 1753

"…..Being located in latitude 7º57' the island has an indescribably hot climate, and being almost wholly volcanic is uninhabited and deserted: there are likewise in many places dangerous invisible holes, as it were chasms covered with sand, which draw the unwary walker into their depths, as many of the rash and curious have already proved at the cost of their life. It is however possible to pick one's way carefully, though the earth trembles and moves beneath the feet, and it is thought that quite soon the whole island will sink into the sea, despite its rocky composition; the force of the sun and the volcanic activity heat the stones almost to dust, and they display a variety of colours, glassy, iron-like, white and red. A remarkable feature in an almost wholly volcanic terrain is a tall high peak which rears up in the centre, as it were part of terra firma, its six leagues extent providing in the higher parts a reliable source of food and pasture to a great number of roaming wild deer and goats brought here previously by Europeans and multiplied by breeding, watered also by permanent lakes and pools which are fed by frequent rain storms: the provider of all this, the green mountain, stands in sole superiority the other lower peaks being dry and coloured black, white or red…"

"We reached Ascension Island at about 4.30 pm on March 31 and cast anchor there, it being common practice for shipping to put in there to recruit their strength….. we weighed anchor on the night of April 2…" (Arrowsmith-Brown, 1991)

Nicholas Louis de la Caille, 1754

"…. Cette Isle est petite, & n'a gueres plus de trois lieus du Nord au Sud, ni plus de deux de l'Est à l'Ouest: elle est visiblement formée ou brûlée par un Volcan: elle est couverte d'une terre rouge, semblable à de la brique pilée, ou à de la glaise brûlée. Il y a dans quelques endroits une terre jaune, comme de l'ochre, & dans quelques autres, & surtout dans les fonds, une terre noire & fine. L'Isle est composée de plusiers montagnes d'élévation moyenne, comme de 100 à 150 toises. Il y en a une plus grosse, qui est au Sud-Est de l'Isle, haute d'environ 400 toises. On l'appelle la Montagne-Verte. Son sommer est double & allongé: mais tous les autres sont terminées en cone assez parfait, & couvertes de terre rouge. La terre & une partie des montagnes sont jonchées d'une quantité prodigieuse de roches criblées d'une infinité de trous, de pierre calcinées & fort légeres, dont un grand nombre ressemble à du laitier. Quelques une sont recouverts d'un vernis blanc-sale, tirant sur la verd. Il y a aussi beaucoup pierres-ponce. Les roches sont posées, les unes (?) sur les autres fort irréguliérement, & la plupart sur le penchant des montagnes;

de sorte qu'elles laissant d'assez grands voides dans leurs intervalles; & comme elles sont très-légeres & de peu de consistence, elles manquent souvent sous les pieds, & mettent les voyageurs peu attentifs dans le danger d'être entraînés, & même ensevelis dans leurs écroulemens. La vue de ces montagnes, & en général de toute l'Isle, présente aux yeux un spectacle affreux & capable d'inspirer de l'horreur. Vers le milieu de l'Isle & entre les montagnes, il y a de petites plaines qui sont divisées en petits espaces, & si singuliérement distribués, qu'on diroit qui c'étoit autrefois de petits champs couverts de pierres; qu'on auroit ensuite accumulé les pierres par tas pyramidaux, & par longues rangées en façon de murailles séches, pour avoir de petits terreins séparés les uns des autres, & nétoyés de toutes pierres. Il n'y a aucune riviere ni source coulante dans cette Isle. On y voit des lits de torrens & des ravins formés par les pluies. On trouve cependant au pied de la Montange Verte, de l'eau a massée dans quelches fonds; mais elle s'évapore ou se perd en peu de mois."

"Le bord de la me rest formé par la roche noire & fort doures, qui ne paroissent pas avoir été calcines, ou par des plage de sable qui n'est qu'un debris de coquillages…." (de La Caille, 1763)

Translation:

This Island is small, no more than 3 leagues from North to South and no more than 2 from East to West: it is visibly formed or burned by a volcano, covered with red soil which looks like hammered bricks or burned clay. There is in some places a yellow soil similar to ochre, and in some other places, especially in depressions, a black and fine-grained soil. The Island contains several middle-sized mountains, reaching about 600 to 900 feet. There is a bigger one, in the South-East of the Island, which is about 2400 feet high. It is called the Green-Mountain. Its summit has two points and is shaped like a crest; but all the other ones look like almost perfect cones, covered in red soil. The ground and part of the mountains are covered with an abundance of rocks riddled with an infinite amount of holes, burned and extremely light stones, which often look like slag. Some are covered with an off-white, almost green, glaze. There are also a lot of pumice stones. The rocks are stacked on each other irregularly, and most are on the slopes of the mountains; this means there are empty spaces between them, and as they are very light and easy to move, they often shift below the feet. This puts the unwary travellers at risk of being swept from their feet or even buried in their collapse. The appearance of those mountains, and of all the Island, is an awful sight, likely to cause dread. In the middle of the Island and between the mountains, there are small plains divided in smaller spaces, so peculiarly distributed that one could believe they were small fields covered with rocks; and that the rocks were then heaped in pyramidal piles as well as in long lines like small walls, in order to have small plots separated from each other, and emptied of all rocks. There are no rivers or source of flowing water on the Island. We can see the bed of mountain streams and ravines formed by the rain. However at the foot of the Green Mountain water can be found massed in ponds in some depressions, but they evaporate or are otherwise lost in a few months.

The coast is made of very hard black rock, which do not appear burned, or beaches were the sand is made only of broken shells...

Philip Carteret, 1769

"On 31st January they anchored in a bay off the Island of Ascension, where they found an abundance of turtle, many of which were taken; and the ship sailed again on the following day. It had been accustomed to leave on this island (which is uninhabited) a letter in a bottle, containing an account of the name ad destination of any ship which might touch there and with this custom Captain Carteret complied". (Henry, 1773)

Louis de Bougainville, 4-6 February 1769

"At day break [4th Feb 1769] we saw the isle nearly nine leagues distant, and at eleven o'clock we anchored in the north west creek, or Creek of the Mountain of the Cross, in twelve fathoms, bottom of sand and coral. According to Abbé la Caille's observations, this anchorage is in 7° 54' fourth latitude, and 16°19' west longitude from Paris…….. sent out three detachments to catch turtle; the first in N.E. Creek, the second in N.W. Creek and the third in English creek which is in the S.W. of the island…………In the afternoon the bottle was brought with me which contains the paper whereon the ships of every nation generally write their name, when they touch at Ascension Island. This bottle is deposited in a cavity of the rocks of this bay, where it is equally sheltered from rain and the spray of the sea. In it I found written the Swallow, the English ship which Captain Carteret commanded… he arrived here on 31st of January and set sail again the first of February." (Forster, 1772)

Captain Lesley, February 1775

"But Ascension can never be inhabited by man, from want of soil; the whole island, both mountain and valley, being one entire cinder, just as if it were newly spit out of a volcano; so much the better, for a well is all that could be wanted, and settling it would be fatal to the poor turtle, which, I hope, will at least have this place left." (D'Aprés de Mannevillette et al., 1816)

James Cook, 28-31 May 1775

"In the morning of the 28th I made the island; and the same evening anchored in Cross Bay on the N.W. side, in ten fathoms water, the bottom a fine sand, and half a mile from the shore. The Cross Hill, so called on account of a cross, or flag-staff erected upon it, bore by compass S. 38 deg. E.; and the two extreme points of the bay extended from N.E. to S.W. We remained here till the evening of the 31st, and notwithstanding we had several parties out every night,

The island of Ascension is about ten miles in length, in the direction of N.W. and S.E., and about five or six in breadth. It shews a surface composed of barren hills and vallies, on the most of which not a shrub or plant is to be seen for several miles, and where we found nothing but stones and sand, or rather flags and ashes; an indubitable sign that the isle, at some remote time, has been destroyed by a volcano, which has thrown up vast heaps of stones, and even hills. Between these heaps of stones we found a smooth even surface, composed of ashes and sand, and very good travelling upon it; but one may as easily walk over broken glass bottles as over the stones. If the foot deceives you, you are sure to be cut or lamed, which happened to some of our people. A high mountain at the S.E. end of the isle seems to be left in its original state, and to have escaped the general destruction. Its soil is a kind of white marl, which yet retains its vegetative qualities…….I was told, that about this part of the isle is some very good land on which might be raised many necessary articles; and some have been at the trouble of sowing turnips and other useful vegetables. I was also told there is a fine spring in a valley which disjoins two hills on the top of the mountain above-mentioned; besides great quantities of fresh water in holes in the rocks, which the person who gave me this information, believed was collected from rains. But these supplies of water can only be of use to the traveller; or to those who may be so unfortunate as to be shipwrecked on the island; which seems to have been the fate of some not long ago, as appeared by the remains of a wreck we found on the N.E. side.

On the 31st of May, we left Ascension, and steered to the northward with a fine gale at S.E. by E. (Cook, 1777)

George Maxwell, 1793

"Ascension is an uninhabited island, about 20 miles in circumference; composed of porous rock, calcined earth, and pumice-stone: the surface in general is powdered as it were with sulphur, and hot vitriolic fumes issuing from the mountains, destroying all vegetation; not a blade of grass to be seen, though there are many wild goats; these may possible have reservoirs of water, and hardy plants, to glean on the windward side, where the destructive vapours cannot reach". (D'Aprés de Mannevillette et al., 1816)

James Holman, 1801 and 1828

Was there 25 – 27 June 1828 and describes the first settlement and population. No mention of geology. Reflects on a journey in 1801, when they passed near the uninhabited island on the H.M.S Cambrian, and fired a shot towards the island, to alert any remaining shipwrecked passengers that had not managed to be rescued the year before by H.M.S Endymion. (Holman ,1834)

1815-16: Colonisation by the English, Sir George Cockburn.

"In the year 1829 I received instructions from Admiralty to proceed to the island of Ascension, to make a report and survey of the island…"

"Ascension was first occupied as a post by Admiral Sir George Cockburn on the arrival of Napoleon Buonaparte at St. Helena, to aid the surveillance of that island; and was placed on the establishment of a sloop of war."

"The whole character of the island is volcanic, and it's surface broken into mountains, hills, and ravines. The mountain district extends principally over the south-east portion of the island; and the "Peak", or greatest elevation, is 2870 feet above the level of the sea. The plains or table-land surrounding the "Peak" vary in height from 1200 to 2000 feet. On the north side they sweep gradually down towards the shore, but on the south they terminate in high and bold precipices. Steep and rugged ravines intersect these plains, which commencing from the highest lands, open into small bays and coves on the shore, fenced on each side with masses of compact and cellular lava. The sides of these ravines disclose extensive beds of cinders and ashes."

"The hills dispersed over the island vary in height from 1000 to 1500 feet above the sea, and offer, with few exceptions, no evidence whatever of having undergone any change since their volcanic origin. They abound with cinders, scoriae, and ashes and are surrounded at their bases with compact and cellular lava, and occasionally with obsidian. They in general possess vestiges of an original conical form, having the surface smooth and regular towards the north ; but on the south they are broken, hollow and precipitous, with here and there the appearance of lateral discharge of lava, which may be traced in its course towards the shore."

"Plains of cinders, ashes, and scoriae, and finely pulverized earth, spread over that portion of the island which lies to the north-west of the mountain district, intersected with water-courses of fine gravel, and pebbles of lava and silex. Masses of lava and scoriae also occur on these plains, 20 or 30 feet high, heaped together as if by art, and for the purposes of clearing the land. Extensive beds of lava and scoria surround the island, indenting the line of the coast with small bays, coves and inlets. From north-east bay, south, to south-west bay, the coast is singularly bold and precipitous. On the opposite coast the beds of lava spread out into the sea, and assume a variety of forms, columnar, arched or cavernous; and their surface are remarkably rugged, splintery, and difficult, and even dangerous for the stranger to traverse. These formations are locally termed "climpers."

"The dark and rugged beds of lava, the deep red colour of the hills, the wild and capricious forms of the mountains and precipices, and the prevailing *apparent* recent indications of volcanic action, impart to the aspect of the island a character of total sterility and desolation that does not really belong to it." (Brandreth, 1860)

References:

Arrowsmith-Brown, J.H. (trans. & ed.), *Prutky's travels in Ethiopia and other countries*. Hakluyt Society, London (1991).

Brandreth, H.R. *Notes in the Island of Ascension.* In: *Papers on subjects connected with the duties of the Corps of the Royal Engineers*, vol. 4. John Weale, London (1860)

Burnell, A.C., (vol. 1) & Tiele, P.A. (vol. 2) (eds), The voyage of John Huyghen van Linschoten to the East Indies. Hakluyt Society, London (1884).

Churchill, J. '*The Three Years Suffering of Robert Everard*', in: *Collection of Voyages and Travels*, London (1745).

Cook, J. *A voyage towards the South Pole and round the world, performed in his Majesty's ships, the Resolution and Adventure, in the years 1772, 1773, 1774 and 1775*. London (1777)

Cummins, J.S. (ed.) *The travels and controversies of Friar Domingo Navarrete, 1616-1686*. Hakluyt Society, Cambridge (1962).

D'Aprés de Mannevillette, J. B., Stevens, J., Purdy, J. *The Oriental Navigator: or directions for sailing to, from and upon the coasts of , the East-Indies, China, Australia etc*. 3rd Ed. James Whittle and Richard Holmes Laurie, London (1816).

Da Barros, J., 1552-1616, Decadas da Asia: Lisbon.

Dampier, W. *A continuation of a voyage to New Holland… in the year 1699: wherein are described the islands of Timor… The coast of Java… The Cape of Good Hope, St. Helena, Ascention…* London (1709).

de La Caille, N. L. *Journal historique du voyage fait au Cap de Bonne Espérance*. Paris (1763).

Forster, J. R. (trans.) *Louis Antoine de Bougainville: a voyage around the world, performed by order of his most Christian Majesty, in the years 1766, 1767, 1768 and 1769.* London (1772).

Hanson, L. (Ed.) *The Linnaeus Apostles*, vol. 7. IK Foundation and Company, London & Whitby (2009).

Henry, D. *An historical account of all the voyages round the world, performed by English navigators; including those lately undertaken by order of His present Majesty. The whole faithfully extracted from the journals of the voyagers…in four volumes.* London (1773)

Holman, J. Voyage around the World, including travels to Africa, Asia, Australasia, America. Smith Tudor and Co. London (1834).

Ovington, J. *A voyage to Suratt, 1689, giving a large account of that city… and of the English factory there… description of Madeira, St Jago, St Helena, Johanna, Bombay, the Cape of Good Hope…* London (1696)

Packer, J.E., 1983, The Ascension Handbook. A concise guide to Ascension Island, South Atlantic (3rd Ed.).

Rennefort, S. *Relation du premier voyage de la Compagnie des Indes Orientales en l'Isle de Madagascar ou Dauphine par M. Souchu de Rennefort*. Paris (1668).

Slocum, J., 1900, Sailing alone around the world: The Century Company, New York.

Struys, J. *The voiages and travels of John Struys through Italy, Greece… and other countries in Europe, Africa and Asia… Done out of the Dutch by John Morrison*. London (1684).

Temple, R. C., Anstey, L. M. (eds.) *The travels of Peter Mundy in Europe and Asia, 1608-1667*. Hakluyt Society, London (1936)