Supplementary Information for Gilfillan et al., Noble gases confirm plume related mantle degassing beneath Southern Africa

Supplementary Table 1: *List of samples and sample locations depicted on Fig. 1.* Water temperature in °C, pH, Total Dissolved Solids as measured in the field using a Hanna Instruments 991301 portable EC, TDS, pH and temperature meter and a description of the seep morphology are also provided.

Sample Name	Location (Latitude, Longitude)	Temperature (°C)	pH	TDS (ppt gl^{-1})	Seep description
A - Baker Farm	-30.69472, 30.04166	Dry well - no water present			Partially sealed but active gas venting well bore, originally drilled as a groundwater well.
B - Mjaja	-30.75388, 29.97305	23.5	6.95	6.29	Bubbling seep in stream
C - Umtamvuna Mound 2 (UM)	-30.80722, 29.96222	20.9	5.41	2.31	Seep emitting from a 100 m wide, 30 m high travertine mound. No evidence of recent precipitation.
C - Umtamvuna River Spring (URS)	-30.80861, 29.96250	20.2	5.56	2.81	Stream of bubbles seeping from the river
C- East Cape Small Travertine (ECST)	-30.80861, 29.96250	20.5	6.22	3.29	Bubbling spring contained within a 1m diameter travertine cone
C - East Cape Large Travertine (ECLT)	-30.80819, 29.96224	20.1	6.24	3.18	Bubbling spring contained within a 2.5 m diameter travertine cone

Supplementary Table 2: *Measured noble gas concentrations in $cm^3(STP)cm^{-3}$.* 1σ errors to last significant figure are provided in brackets, with bracketed letters for sample localities corresponding to Fig. 1.

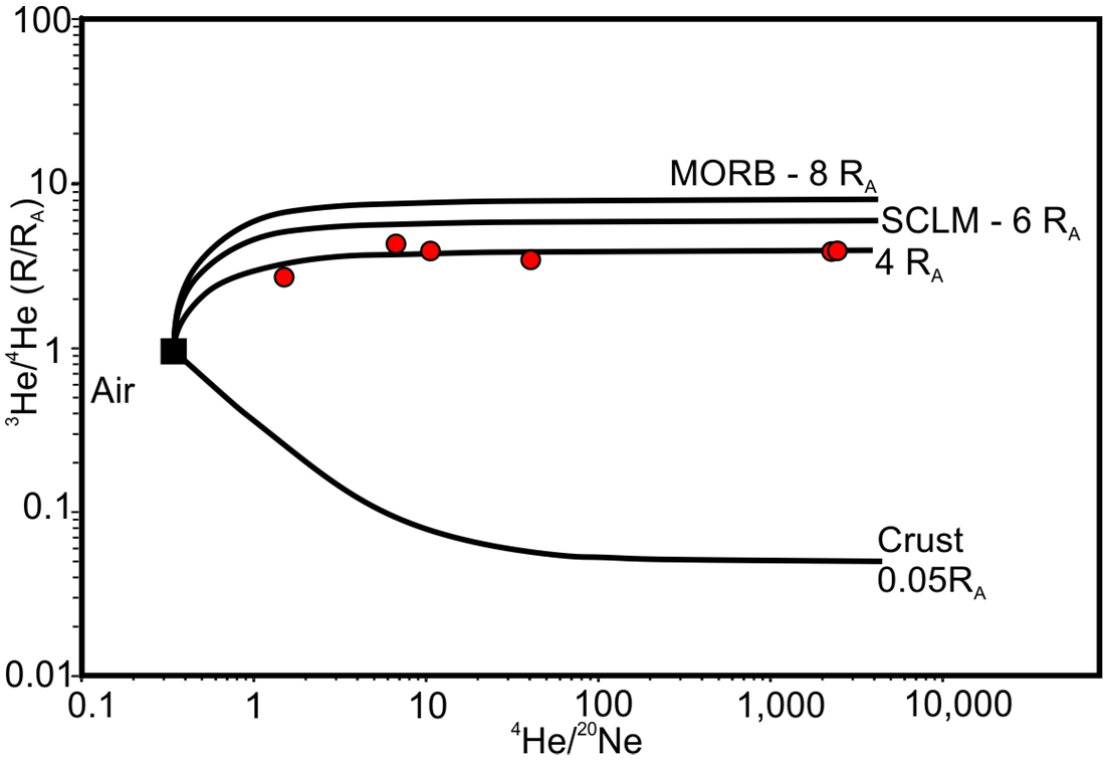
Sample	$\delta^{13}C_{CO2}$ (‰)	^{4}He (10^{-6})	^{20}Ne (10^{-8})	^{40}Ar (10^{-5})
A - Baker Farm 1	-2.0 (2)	96.2 (46)	4.13 (18)	7.83 (29)
B - Mjaja	-2.0 (2)	26.6 (13)	1.19 (5)	3.71 (14)
C - Umtamvuna Mound 2 (UM)	-3.4 (2)	0.00480 (15)	0.40 (2)	0.634 (24)
C - East Cape Large Travertine (ECLT)	-2.9 (2)	0.713 (35)	1.75 (7)	2.87 (11)
C - East Cape Small Travertine (ECST)	-3.4 (2)	0.290 (9)	2.82 (10)	
C - Umtamvuna River Spring (UM-RS)		0.164 (5)	2.49 (9)	

Supplementary Table 3: *Noble gas isotope ratios, $CO_2/^3He$ and stable isotope values*. $^3He/^4He$ are reported relative to the atmospheric ratio (R_A: 1.399×10^{-6} after[37]). R_c = measured $^3He/^4He$ corrected for air contamination using equation [1]. $\delta^{13}C_{CO2}‰ = [(^{13}C/^{12}C_{sample} - ^{13}C/^{12}C_{standard})/(^{13}C/^{12}C_{standard})] \times 1000$; the standard used is the Vienna PeeDee Belemnite. 1σ errors to last significant figure provided in brackets with the letters for sample localities corresponding to Fig. 1.

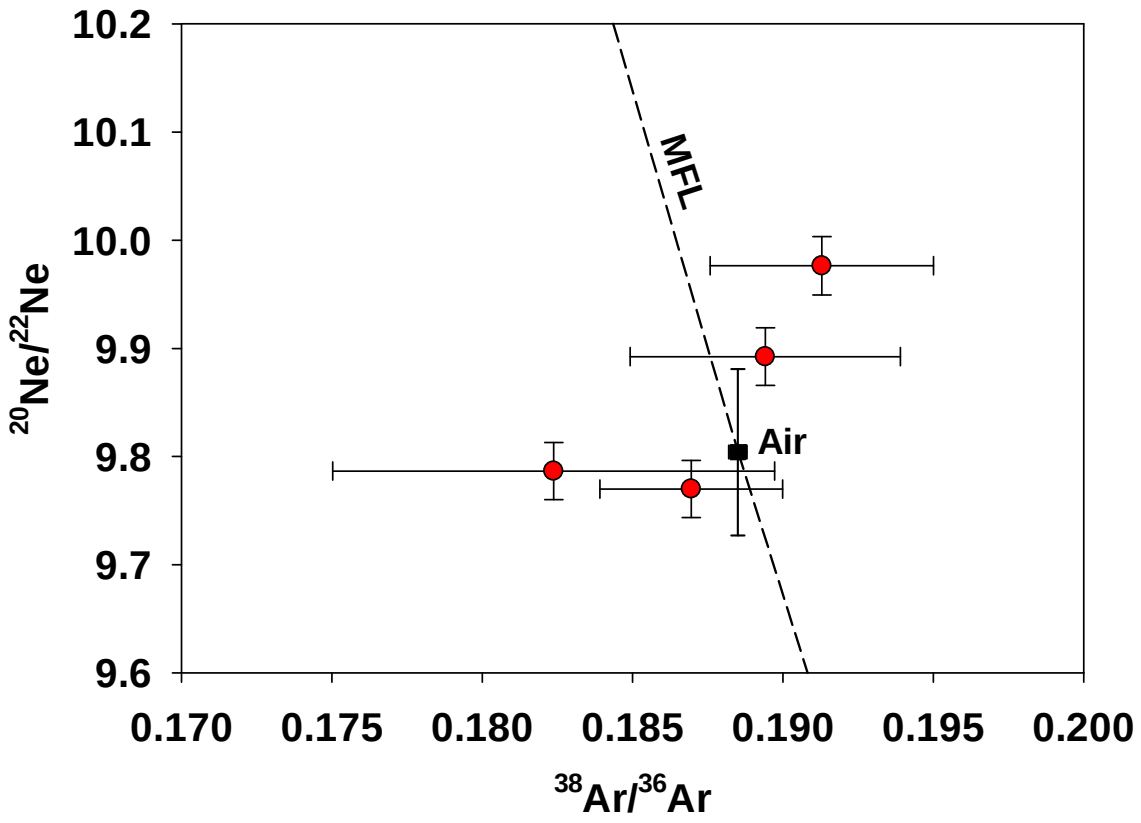
Sample	$^3He/^4He$ (R_m/R_A)	$^3He/^4He$ (R_c/R_A)	$^{20}Ne/^{22}Ne$	$^{21}Ne/^{22}Ne$	$^{40}Ar/^{36}Ar$	$^{38}Ar/^{36}Ar$	$^4He/^{20}Ne$	$CO_2/^3He$ (10^{10})
A - Baker Farm 1 - MAP	3.92 (5)	3.9 (3)	9.98 (3)	0.0304 (2)	961 (4)	0.191 (4)	2311 (149)	0.188 (10)
B - Mjaja 1 - MAP	3.93 (4)	3.9 (3)	9.89 (3)	0.0300 (2)	549 (2)	0.189 (4)	2229 (144)	0.677 (35)
C- Umtamvuna Mound 2 (UM)	2.80 (2)	3.6 (2)	9.79 (3)	0.0292 (2)	298 (3)	0.182 (7)	1.19 (7)	5238 (474)
C - East Cape Large Travertine (ECLT)	3.58 (4)	3.6 (2)	9.77 (3)	0.0292 (2)	302 (2)	0.187 (3)	41.0 (26)	27.7 (14)
C - East Cape Small Travertine (ECST)	3.95 (7)	4.1 (2)	9.79 (3)	0.0288 (2)			10.3 (5)	61.8 (22)
C- Umtamvuna River Spring (UM-RS)	4.27 (8)	4.5 (2)	9.76 (3)	0.0286 (2)			6.59 (30)	101 (4)

Supplementary Table 4: *Results of the high precision analysis of Ne isotopes performed on the ARGUS mass spectrometer.* $^{20}Ne/^{22}Ne$, $^{21}Ne/^{22}Ne$ uncorrected for the contribution from $^{20}NeH^{+}$ and $^{21}Ne/^{22}Ne$ corrected for the contribution from $^{20}NeH^{+}$ are provided. 1σ errors to last significant figure provided in brackets with the letters for sample localities corresponding to Fig. 1.

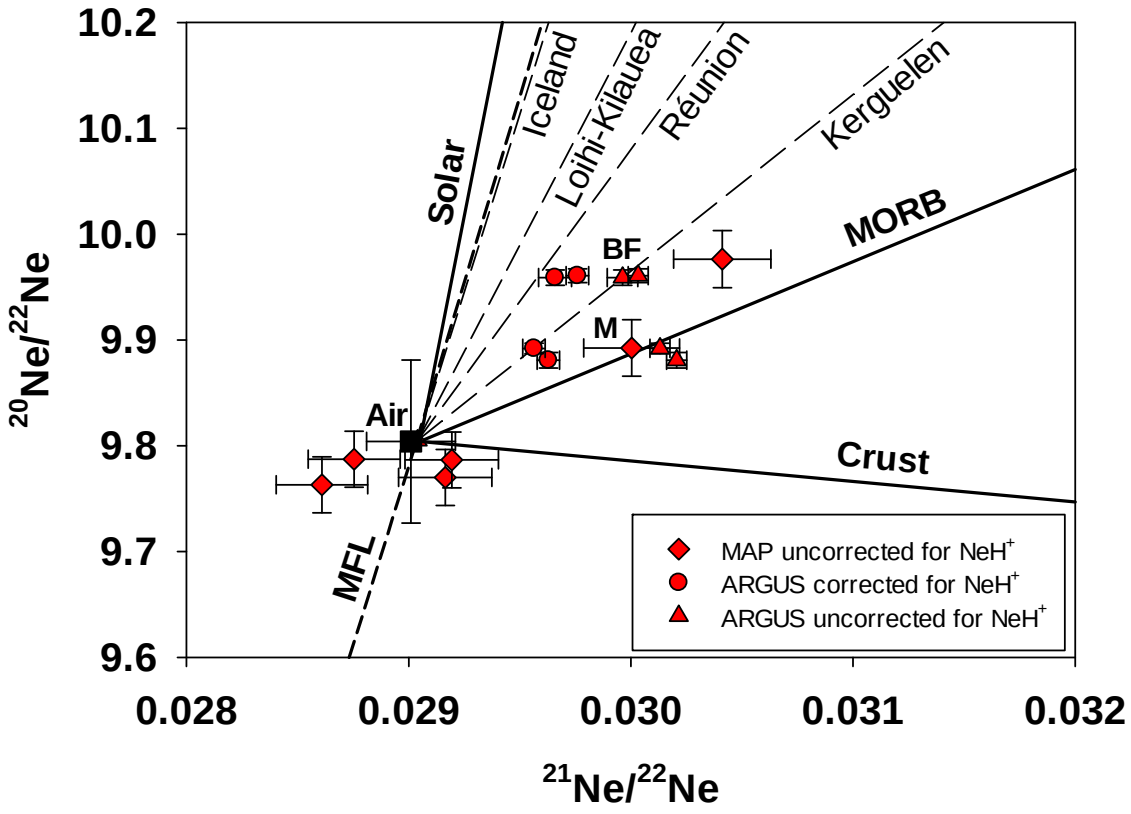
Sample	$^{20}Ne/^{22}Ne$	$^{21}Ne/^{22}Ne$ uncorrected for $^{20}NeH^{+}$	$^{21}Ne/^{22}Ne$ corrected for $^{20}NeH^{+}$
A - Baker Farm 2a - ARGUS	9.959 (7)	0.02996 (7)	0.02966 (8)
A - Baker Farm 2b - ARGUS	9.961 (7)	0.03003 (5)	0.02976 (6)
B - Mjaja 2a - ARGUS	9.881 (7)	0.03021 (5)	0.02963 (5)
B - Mjaja 2b - ARGUS	9.892 (5)	0.03013 (5)	0.02956 (5)



Supplementary Figure 1: *Plot of air corrected ^{3}He/^{4}He (R/R$_A$) against ^{4}He/^{20}Ne for the Bongwan CO$_2$ samples (red circles).* Also plotted is the atmospheric air value (black square) and mixing lines between the air value and: typical average crust (^{3}He/^{4}He = 0.05 R$_A$ and ^{4}He/^{20}Ne = >5000 [41]), Mid Ocean Ridge Basalt (MORB) mantle (^{3}He/^{4}He = 8 R$_A$ and ^{4}He/^{20}Ne = >5000 [46]) and Sub-continental Lithospheric mantle (SCLM) (^{3}He/^{4}He = 6 R$_A$ and ^{4}He/^{20}Ne = >5000 [46]). This highlights that the ^{3}He/^{4}He and ^{4}He/^{20}Ne of the Bongwan CO$_2$ samples can be explained by mixing between mantle, crustal and atmospheric air components with a consistent mantle-crust mixing ratio, and a ^{3}He/^{4}He end member of ~4 R$_A$. All errors are smaller than printed symbols.



Supplementary Figure 2: *Plot of $^{20}Ne/^{22}Ne$ against $^{38}Ar/^{36}Ar$ for the Bongwan CO_2 samples (red circles).* 1σ errors associated with each measurement are shown and the atmospheric air (black square) and the mass fractionation line (MFL) are also plotted. All of the Bongwan CO_2 samples exhibit $^{38}Ar/^{36}Ar$ that are within error of the air value, as are the $^{20}Ne/^{22}Ne$, other than that of Baker Farm, which exhibits $^{20}Ne/^{22}Ne$ above air and does not lie on the MFL. 1σ error envelopes are also plotted.



Supplementary Figure 3: *Plot of $^{20}Ne/^{22}Ne$ against $^{21}Ne/^{22}Ne$ for all of the measured Bongwan CO_2 samples*. 1σ errors associated with each measurement are provided and the plot includes lower precision analysis uncorrected for NeH^+ (red diamonds); higher precision analysis uncorrected for NeH^+ (red diamonds) and the higher precision analysis corrected for NeH^+ (red triangles). This highlights that the Mjaja sample is within the error envelope of the low precision measurement, which was not corrected for the $^{20}NeH+$ contribution to ^{21}Ne. The uncorrected high precision Baker Farm sample plots further above the air-MORB line than the low precision measurement. This can be explained by the fact that the high precision analysis was performed on a separate sample of the CO_2 from the Baker Farm well, which was collected at a later time, after the well had been sealed off from the atmosphere for a greater period of time. The approximately 1 hour period of magmatic gas accumulation in the sealed well between sample collection can account for the more mantle enriched signature of the uncorrected high precision sample.