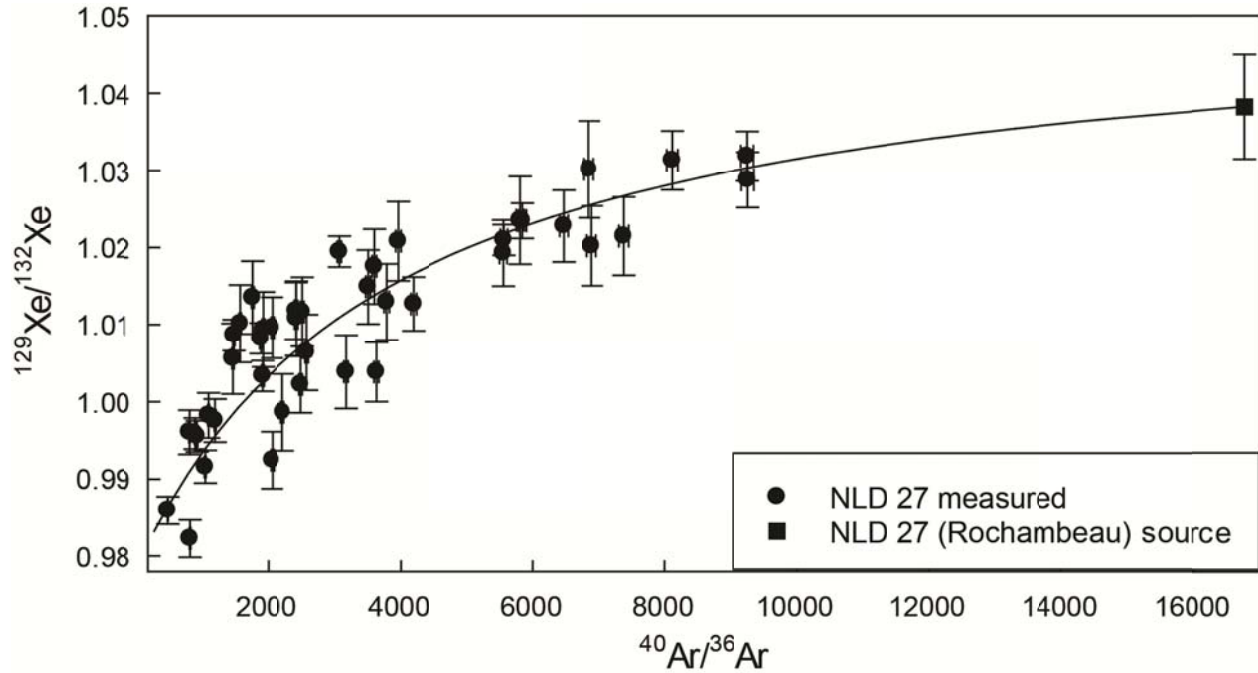
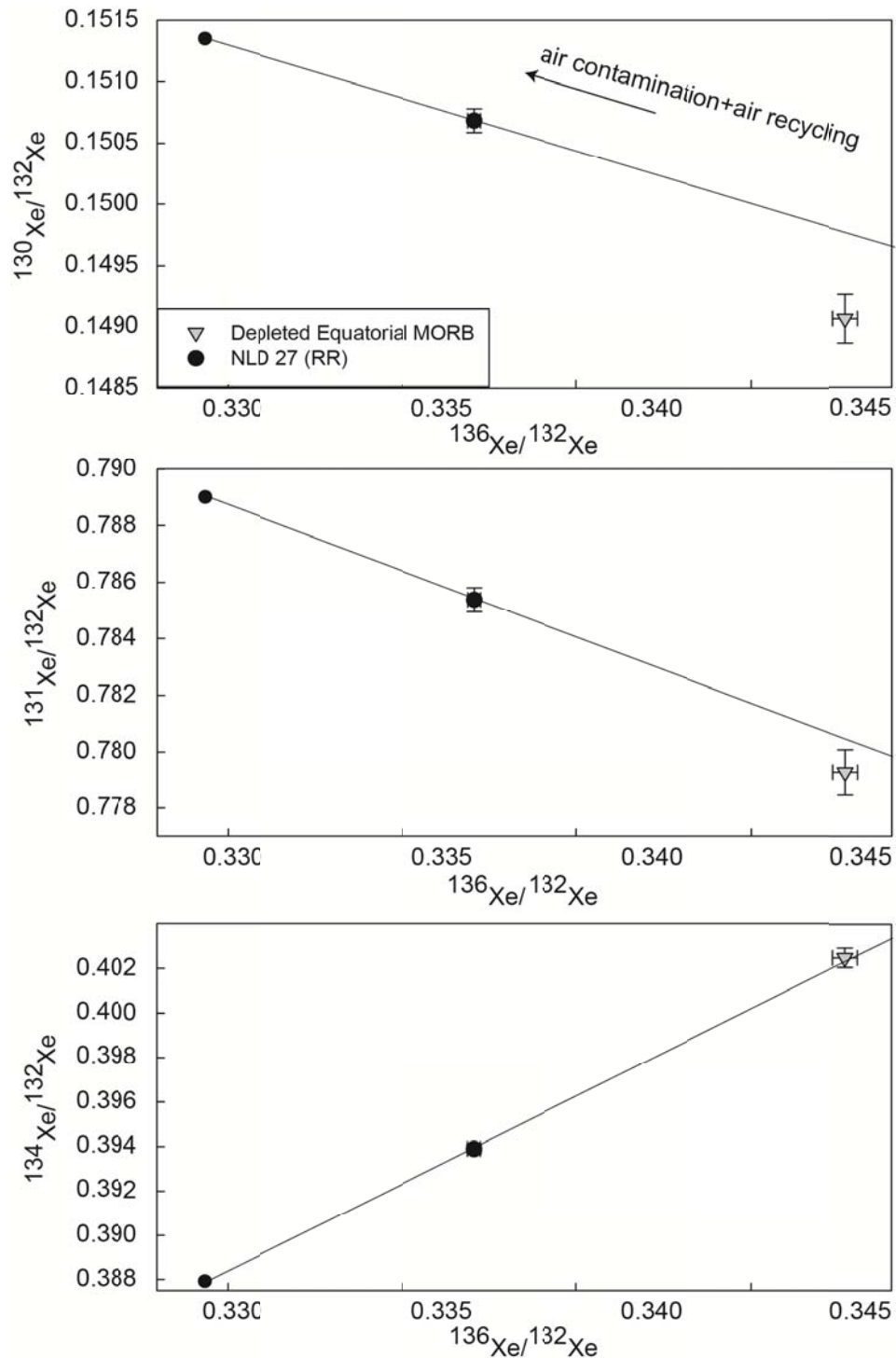


## Supplemental Information



**Supplemental Figure 1:** Hyperbolic mixing between Ar-Xe defined by addition of shallow level atmospheric contaminations to magmatic gases in vesicles. Since the mantle  $^{40}\text{Ar}/^{36}\text{Ar}$  of the NLD 27 sample was determined to be  $16,763 \pm 1144$ , a least-squares hyperbolic fit defines the  $^{129}\text{Xe}/^{132}\text{Xe}$  ratios in the NLD 27 mantle source at a  $^{40}\text{Ar}/^{36}\text{Ar}$  of 16,763 to be  $1.0382 \pm 0.0068$  ( $1\sigma$ ). Note that given the curvature in Ar-Xe space, the defined  $^{129}\text{Xe}/^{132}\text{Xe}$  in the NLD 27 mantle source is not particularly sensitive to the exact choice of the mantle  $^{40}\text{Ar}/^{36}\text{Ar}$  ratio.



**Supplemental Figure 2:** The error-weighted average of the measured Xe isotopic composition of the NLD 27 sample compared to depleted MORBs from the equatorial Atlantic (Tucker et al., In press). In  $^{130,131}\text{Xe}/^{132}\text{Xe}$  -  $^{136}\text{Xe}/^{132}\text{Xe}$  space, the NLD 27 sample is not co-linear with the atmospheric and depleted MORB compositions. In  $^{134}\text{Xe}/^{132}\text{Xe}$  -  $^{136}\text{Xe}/^{132}\text{Xe}$  space, however, NLD 27 appears to be co-linear with atmospheric Xe and MORB Xe.

**Supplemental Table 1: He, Ne, and Ar abundance and isotopic ratios**

Sample	crush#	<sup>4</sup> He (10 <sup>-6</sup> cc)	1σ	<sup>22</sup> Ne (10 <sup>-12</sup> cc)	1σ	<sup>20</sup> Ne/ <sup>22</sup> Ne	1σ	<sup>21</sup> Ne/ <sup>22</sup> Ne	1σ	<sup>36</sup> Ar (10 <sup>-12</sup> cc)	1σ	<sup>40</sup> Ar/ <sup>36</sup> Ar	1σ
<b>NLD13 I</b>	1st	1.3	0.04	9.2	0.3	10.34	0.02	0.0316	0.0002	180.9	4.7	1382	14
<b>(3.19g)</b>	2nd	1.7	0.05	16.5	0.5	9.92	0.01	0.0304	0.0001	323.1	8.4	1011	11
<sup>3</sup> He/ <sup>4</sup> He	3rd	0.8	0.02	6.5	0.2	10.22	0.02	0.0310	0.0002	114.8	3.0	1147	12
<b>28.1 R<sub>A</sub></b>	4th	0.4	0.01	4.6	0.4	10.10	0.02	0.0306	0.0002	85.2	2.1	777	8
	5th	0.2	0.01	2.3	0.6	10.12	0.03	0.0302	0.0003	33.6	1.1	973	10
	6th	0.2	0.01	2.5	0.7	10.11	0.02	0.0305	0.0003	37.5	1.3	885	9
<b>NLD13 II</b>	1st	0.4	0.01	3.0	0.4	10.34	0.02	0.0314	0.0003	50.1	0.3	1457	17
<b>(3.13g)</b>	2nd	0.7	0.02	4.7	0.2	10.37	0.02	0.0313	0.0002	79.3	1.3	1511	16
	3rd	0.7	0.02	2.3	0.5	11.02	0.03	0.0347	0.0004	29.3	0.4	3800	38
	4th	1.2	0.04	3.9	0.3	11.02	0.03	0.0348	0.0003	39.1	1.0	4828	49
	5th	1.3	0.04	4.8	0.2	10.86	0.02	0.0336	0.0002	50.4	1.3	3909	41
	6th	0.6	0.02	3.2	0.3	10.58	0.02	0.0322	0.0003	39.8	0.5	2430	25
	7th	0.2	0.01	0.9	0.8	10.52	0.04	0.0325	0.0005	9.4	0.2	2645	26
<b>NLD13 III</b>	1st	0.6	0.02	1.9	0.2	11.11	0.03	0.0349	0.0004	30.3	0.1	3943	40
<b>(2.86g)</b>	2nd	0.9	0.03	13.8	0.1	10.04	0.02	0.0303	0.0001	276.2	2.0	789	8
						<sup>21</sup> Ne/ <sup>22</sup> Ne <sub>E</sub> = 0.0454±0.0003							
<b>NLD14 I</b>	1st	1.8	0.06	7.2	0.2	11.12	0.03	0.0365	0.0002	81.7	2.1	4196	42
<b>(3.82g)</b>	2nd	2.2	0.07	6.5	0.2	11.67	0.03	0.0391	0.0002	98.0	2.5	3555	36
<sup>3</sup> He/ <sup>4</sup> He	3rd	5.4	0.16	138.7	1.5	9.99	0.10	0.0300	0.0001	4461.1	115.4	644	7
<b>17.9 R<sub>A</sub></b>	4th	2.5	0.08	33.3	1.5	10.10	0.10	0.0310	0.0001	787.6	20.4	927	10
	5th	3.4	0.10	25.3	1.5	10.32	0.10	0.0320	0.0001	519.8	13.4	1441	15
	6th	3.4	0.10	64.6	1.5	10.06	0.10	0.0300	0.0001	1808.6	46.8	764	8
	7th	2.6	0.08	27.0	1.5	10.21	0.10	0.0310	0.0001	545.2	14.1	1179	12
	8th	4.8	0.14	24.1	1.5	10.59	0.10	0.0340	0.0001	1021.0	26.4	1179	12
	9th	1.8	0.05	10.9	0.4	10.64	0.02	0.0337	0.0002	119.7	3.1	2473	25
	10th	2.4	0.07	19.8	0.5	10.44	0.01	0.0325	0.0001	197.6	5.1	2283	23
	11th	2.0	0.06	21.8	0.5	10.32	0.01	0.0317	0.0001	232.2	6.0	1808	19
	12th	1.3	0.04	17.9	0.5	10.18	0.01	0.0306	0.0001	145.8	3.8	1473	15
	13th	1.3	0.04	25.9	1.5	10.04	0.10	0.0300	0.0001	348.1	9.0	871	9
	14th	0.5	0.02	12.2	0.4	10.08	0.02	0.0304	0.0001	104.2	2.9	958	10
	15th	0.6	0.02	12.4	0.5	10.08	0.02	0.0303	0.0001	91.8	2.5	1173	12
	16th	0.1	0.00	2.8	0.7	9.96	0.02	0.0295	0.0003	15.8	0.4	527	6
						<sup>21</sup> Ne/ <sup>22</sup> Ne <sub>E</sub> = 0.0476±0.0002							

Sample	crush#	<sup>4</sup> He (10 <sup>-6</sup> cc)	1σ	<sup>22</sup> Ne (10 <sup>-12</sup> cc)	1σ	<sup>20</sup> Ne/ <sup>22</sup> Ne	1σ	<sup>21</sup> Ne/ <sup>22</sup> Ne	1σ	<sup>36</sup> Ar (10 <sup>-12</sup> cc)	1σ	<sup>40</sup> Ar/ <sup>36</sup> Ar	1σ	
<b>NLD 20 I</b> <b>(3.78g)</b>	1st	0.5	0.01	2.6	0.7	10.67	0.03	0.0316	0.0003	22.5	0.3	450	5	
	2nd	0.8	0.02	2.0	0.5	11.75	0.03	0.0360	0.0004	9.4	0.1	944	10	
	3rd	0.6	0.02	2.9	0.7	10.81	0.02	0.0324	0.0003	34.9	1.1	437	5	
<b>18.6 R<sub>A</sub></b>	4th	0.6	0.02	2.8	0.7	10.81	0.02	0.0323	0.0003	22.1	0.4	491	5	
	5th	0.7	0.02	2.7	0.7	11.09	0.03	0.0337	0.0003	22.6	0.5	523	6	
<b>NLD20 II</b> <b>(4.24g)</b>	1st	0.1	0.00	0.5	0.1	10.57	0.06	0.0309	0.0006	6.8	0.1	468	5	
	2nd	0.6	0.02	6.9	0.1	10.11	0.02	0.0302	0.0002	121.6	0.9	354	4	
	3rd	0.6	0.02	2.0	0.2	10.76	0.03	0.0327	0.0004	38.5	0.5	453	5	
	4th	0.6	0.02	0.9	0.1	11.89	0.03	0.0364	0.0005	6.7	0.1	1744	18	
	5th	1.1	0.03	1.7	0.1	11.94	0.03	0.0367	0.0004	10.5	0.2	1328	14	
	6th	1.9	0.06	3.5	0.2	11.69	0.03	0.0363	0.0003	30.3	0.3	1045	10	
	7th	1.1	0.03	2.1	0.2	11.43	0.03	0.0355	0.0004	19.2	0.3	815	9	
	8th	0.3	0.01	0.6	0.1	11.36	0.06	0.0336	0.0006	4.9	0.1	840	10	
						<sup>21</sup> Ne/ <sup>22</sup> Ne = 0.0423±0.0004								
<b>NLD27 I</b> <b>(3.86g)</b> <sup>3</sup> He/ <sup>4</sup> He	1 st	2.7	0.08	22.7	1.5	10.33	0.10	0.0320	0.0001	659.1	17.0	1914	20	
	2nd	2.3	0.07	18.4	1.5	10.28	0.10	0.0330	0.0001	448	1.2	1886	19	
	3rd	1.7	0.05	92.0	1.6	9.90	0.09	0.0290	0.0001	2767.3	71.6	540	6	
	<b>15.4 R<sub>A</sub></b>	4th	2.0	0.06	23.2	1.5	10.30	0.10	0.0310	0.0001	530.8	13.7	1483	15
		5th	3.0	0.09	7.9	0.3	12.15	0.03	0.0427	0.0002	145.5	3.8	9261	93
		6th	4.1	0.12	21.0	1.4	10.73	0.10	0.0340	0.0002	612.4	15.8	3080	31
		7th	3.5	0.10	13.4	0.4	11.32	0.01	0.0379	0.0002	256.6	6.6	5572	56
		8th	2.7	0.08	6.8	0.2	12.22	0.03	0.0430	0.0002	66.4	1.7	9269	93
		9th	3.5	0.10	10.9	0.4	11.59	0.02	0.0395	0.0002	152.3	3.9	5847	59
		10th	2.6	0.08	7.4	0.2	11.83	0.03	0.0407	0.0002	65.7	1.7	8116	82
		11th	0.8	0.02	5.4	0.1	10.56	0.02	0.0337	0.0002	64.9	1.7	2525	26
		12th	0.8	0.02	2.3	0.6	11.58	0.03	0.0397	0.0004	21.7	0.6	6885	69
		13th	0.4	0.01	1.2	0.4	11.58	0.03	0.0392	0.0005	11.3	0.3	6858	69
<b>NLD27 II</b> <b>(3.61g)</b>	1st	2.2	0.07	78.2	0.7	9.79	0.09	0.0290	0.0002	2578.5	66.3	638	7	
	2nd	1.2	0.03	18.4	0.7	10.09	0.09	0.0310	0.0002	433.1	11.1	1106	11	
	3rd	1.1	0.03	10.3	0.2	10.35	0.02	0.0327	0.0002	189.0	4.9	2063	21	
	4th	1.2	0.04	19.7	0.7	10.16	0.09	0.0310	0.0002	450.7	11.6	1057	11	
	5th	0.8	0.02	5.8	0.2	10.62	0.02	0.0336	0.0002	106.8	2.7	2591	26	
	6th	1.1	0.03	6.2	0.2	10.85	0.02	0.0346	0.0002	107.8	2.8	3179	32	

Sample	crush#	$^4\text{He}$ ( $10^{-6}$ cc)	$1\sigma$	$^{22}\text{Ne}$ ( $10^{-12}$ cc)	$1\sigma$	$^{20}\text{Ne}/^{22}\text{Ne}$	$1\sigma$	$^{21}\text{Ne}/^{22}\text{Ne}$	$1\sigma$	$^{36}\text{Ar}$ ( $10^{-12}$ cc)	$1\sigma$	$^{40}\text{Ar}/^{36}\text{Ar}$	$1\sigma$
	7th	1.6	0.05	36.2	0.7	10.13	0.09	0.0300	0.0002	747.6	19.2	932	10
	8th	1.4	0.04	5.7	0.2	11.26	0.03	0.0372	0.0004	116.1	3.0	3633	37
	9th	2.2	0.07	10.1	0.1	11.12	0.02	0.0365	0.0001	163.3	4.2	4189	42
	10th	1.9	0.06	6.8	0.2	11.46	0.03	0.0382	0.0003	105.3	2.7	5563	56
	11th	1.2	0.04	62.4	0.7	9.82	0.09	0.0290	0.0002	1431.1	36.8	543	6
	12th	1.5	0.04	34.8	0.7	10.11	0.09	0.0300	0.0002	759.9	19.5	905	9
	13th	1.0	0.03	5.0	0.2	10.99	0.03	0.0356	0.0004	79.6	2.0	3785	38
	14th	1.1	0.03	17.5	0.7	10.01	0.09	0.0310	0.0002	368.6	9.5	1203	12
	15th	0.7	0.02	4.6	0.2	10.76	0.02	0.0344	0.0003	65.8	1.7	3508	35
	16th	0.9	0.03	10.2	0.2	10.33	0.02	0.0318	0.0001	170.3	4.4	1764	18
	17th	0.6	0.02	2.1	0.5	11.37	0.03	0.0380	0.0001	29.5	0.8	5814	59
	18th	0.9	0.03	6.9	0.2	10.64	0.02	0.0337	0.0003	125.8	3.2	2437	25
	19th	0.9	0.03	14.9	0.1	9.90	0.01	0.0303	0.0001	461.7	11.9	821	9
	20 <sup>th</sup>	0.9	0.03	3.1	0.3	11.39	0.03	0.0380	0.0002	38.2	1.0	6468	65
	21st	0.8	0.03	2.3	0.4	11.86	0.03	0.0402	0.0001	32.4	0.8	7388	74
	22nd	0.9	0.03	13.2	0.1	10.23	0.02	0.0314	0.0001	211.7	5.4	1469	15
	23rd	0.8	0.03	7.2	0.2	10.50	0.02	0.0329	0.0003	106.4	2.7	2434	25
	24th	0.8	0.02	6.7	0.2	10.50	0.02	0.0327	0.0003	93.9	2.4	2502	25
	25th	0.7	0.02	4.1	0.3	10.80	0.02	0.0347	0.0003	53.2	1.4	3960	40
	26th	0.5	0.01	4.1	0.3	10.51	0.02	0.0330	0.0003	66.6	1.5	2227	23
	27th	0.9	0.03	9.2	0.2	10.45	0.02	0.0323	0.0002	149.4	3.8	1925	20
	28th	0.7	0.02	17.5	0.7	10.11	0.09	0.0300	0.0002	394.4	10.1	830	9
	29th	0.5	0.01	29.4	0.7	9.90	0.09	0.0290	0.0002	646.0	16.6	498	5
	30th	1.2	0.04	7.0	0.2	10.88	0.02	0.0349	0.0003	100.7	2.6	3605	36
	31st	0.7	0.02	7.1	0.2	10.41	0.02	0.0323	0.0003	118.0	3.0	2063	21
	32nd	0.5	0.02	7.9	0.2	10.46	0.02	0.0314	0.0002	107.3	2.7	1579	16
$^{21}\text{Ne}/^{22}\text{Ne}_E = 0.0484 \pm 0.0002$													

$^{21}\text{Ne}/^{22}\text{Ne}_E$  is the mantle  $^{21}\text{Ne}/^{22}\text{Ne}$  corrected for shallow level air contamination.

Sample locations (latitude and longitude) are presented in Lupton et al., 2009.

**Supplemental Table 2: Xe abundance and isotopic measurements**

Sample	Step	<sup>130</sup> Xe	<sup>129</sup> Xe/ <sup>130</sup> Xe	1σ	<sup>129</sup> Xe/ <sup>136</sup> Xe	1σ	<sup>130</sup> Xe/ <sup>132</sup> Xe	1σ	<sup>131</sup> Xe/ <sup>132</sup> Xe	1σ	<sup>134</sup> Xe/ <sup>132</sup> Xe	1σ	<sup>136</sup> Xe/ <sup>132</sup> Xe	1σ
<b>NLD13 I</b>	1st	3.64	6.63	0.03	2.983	0.017	0.1508	0.0008	0.7837	0.0036	0.3888	0.0016	0.3349	0.0014
<b>(3.19g)</b>	2nd	6.49	6.56	0.02	2.942	0.011	0.1501	0.0006	0.7780	0.0025	0.3926	0.0010	0.3350	0.0012
	3rd	2.39	6.60	0.04	2.970	0.015	0.1508	0.0009	0.7829	0.0045	0.3911	0.0022	0.3347	0.0012
	4th	1.38	6.61	0.06	3.028	0.017	0.1505	0.0012	0.7874	0.0053	0.3874	0.0027	0.3286	0.0013
	5th	0.47	6.58	0.05	3.007	0.025	0.1492	0.0017	0.7912	0.0085	0.3881	0.0046	0.3269	0.0022
	6th	0.51	6.53	0.05	3.003	0.025	0.1516	0.0017	0.8047	0.0087	0.3884	0.0046	0.3295	0.0022
<b>NLD13 II</b>	1st	0.78	6.68	0.07	2.979	0.018	0.1505	0.0014	0.7946	0.0058	0.3967	0.0030	0.3381	0.0014
<b>(3.13g)</b>	2nd	1.91	6.58	0.05	3.008	0.016	0.1521	0.0011	0.7814	0.0049	0.3915	0.0024	0.3330	0.0012
	3rd	0.95	6.85	0.07	3.020	0.018	0.1502	0.0014	0.7796	0.0056	0.3962	0.0029	0.3406	0.0014
	4th	1.48	6.89	0.06	3.010	0.017	0.1494	0.0012	0.7802	0.0052	0.3986	0.0027	0.3425	0.0013
	5th	1.62	6.84	0.06	2.994	0.016	0.1497	0.0011	0.7912	0.0050	0.3964	0.0025	0.3418	0.0013
	6th	1.12	6.74	0.07	2.989	0.017	0.1498	0.0013	0.7898	0.0056	0.3908	0.0028	0.3377	0.0014
<b>NLD13 III</b>	1st	0.14	6.93	0.02										
<b>(2.86g)</b>	2nd	0.71	6.59	0.12										
<b>NLD14 I</b>	1st	2.78	6.63	0.03	2.985	0.015	0.1528	0.0008	0.7808	0.0042	0.3973	0.0021	0.3391	0.0012
<b>(3.82g)</b>	4th	14.43	6.58	0.02	3.003	0.006	0.1506	0.0004	0.7826	0.0020	0.3881	0.0008	0.3303	0.0006
	5th	10.63	6.59	0.02	2.977	0.007	0.1512	0.0005	0.7925	0.0020	0.3886	0.0009	0.3348	0.0009
	7th	8.99	6.57	0.02	3.014	0.007	0.1522	0.0005	0.7898	0.0020	0.3911	0.0010	0.3319	0.0010
	9th	3.56	6.74	0.04	2.996	0.017	0.1494	0.0008	0.7948	0.0037	0.3915	0.0016	0.3358	0.0014
	10th	4.96	6.67	0.03	2.983	0.014	0.1508	0.0007	0.7859	0.0032	0.3938	0.0013	0.3374	0.0013
	11th	4.69	6.67	0.03	2.982	0.015	0.1507	0.0007	0.7865	0.0033	0.3941	0.0014	0.3370	0.0014
	12th	3.07	6.58	0.03	2.976	0.015	0.1516	0.0008	0.7872	0.0040	0.3920	0.0019	0.3351	0.0012
	13th	4.86	6.58	0.03	2.991	0.015	0.1509	0.0007	0.7860	0.0032	0.3917	0.0014	0.3319	0.0013
	14th	1.75	6.57	0.05	3.004	0.016	0.1512	0.0011	0.7893	0.0050	0.3920	0.0025	0.3303	0.0012
	15th	1.68	6.47	0.05	2.999	0.016	0.1540	0.0011	0.7865	0.0050	0.3894	0.0025	0.3320	0.0013
<b>NLD 20 I</b>	1st	4.40	6.55	0.03										
<b>(3.78g)</b>	2nd	0.21	6.79	0.12										
	3rd	1.86	6.51	0.05										
	4th	0.70	6.61	0.07										

Sample	Step	$^{130}\text{Xe}$	$^{129}\text{Xe}/^{130}\text{Xe}$	$1\sigma$	$^{129}\text{Xe}/^{136}\text{Xe}$	$1\sigma$	$^{130}\text{Xe}/^{132}\text{Xe}$	$1\sigma$	$^{131}\text{Xe}/^{132}\text{Xe}$	$1\sigma$	$^{134}\text{Xe}/^{132}\text{Xe}$	$1\sigma$	$^{136}\text{Xe}/^{132}\text{Xe}$	$1\sigma$
	5th	0.89	6.63	0.06										
<b>NLD20 II</b>	1st	0.02	6.90	0.13										
<b>(4.24g)</b>	2nd	0.25	6.46	0.03										
	3rd	0.18	6.50	0.04										
	4th	0.03	6.70	0.13										
	5th	0.04	6.46	0.12										
	6th	0.08	6.61	0.13										
	7th	0.06	6.54	0.13										
	8th	0.02	6.68	0.12										
<b>NLD27 I</b>	1st	11.44	6.72	0.02	3.007	0.006	0.1494	0.0004	0.7880	0.0020	0.3941	0.0008	0.3338	0.0009
<b>(3.86g)</b>	2nd	9.15	6.72	0.02	2.987	0.007	0.1500	0.0005	0.7897	0.0020	0.3967	0.0010	0.3372	0.0011
	4th	9.01	6.72	0.02	2.989	0.007	0.1500	0.0005	0.7822	0.0020	0.3930	0.0010	0.3373	0.0011
	5th	6.47	6.92	0.02	3.004	0.011	0.1489	0.0006	0.7755	0.0025	0.3991	0.0010	0.3434	0.0012
	6th	13.27	6.80	0.02	3.002	0.006	0.1498	0.0004	0.7794	0.0020	0.3969	0.0008	0.3396	0.0007
	7th	9.49	6.79	0.02	3.011	0.007	0.1501	0.0005	0.7782	0.0020	0.3966	0.0010	0.3387	0.0010
	8th	5.68	6.90	0.03	2.996	0.012	0.1491	0.0006	0.7773	0.0028	0.3988	0.0012	0.3434	0.0013
	9th	8.06	6.83	0.02	3.002	0.008	0.1498	0.0005	0.7798	0.0024	0.3980	0.0010	0.3410	0.0011
	10th	5.36	6.84	0.03	3.000	0.013	0.1507	0.0007	0.7834	0.0029	0.4011	0.0013	0.3439	0.0013
	11th	2.07	6.79	0.05	2.989	0.016	0.1489	0.0009	0.7783	0.0045	0.3938	0.0023	0.3382	0.0012
	12th	1.36	6.85	0.06	2.998	0.017	0.1488	0.0011	0.7669	0.0049	0.3917	0.0027	0.3401	0.0013
	13th	0.53	6.84	0.08	3.010	0.018	0.1506	0.0015	0.7838	0.0059	0.3962	0.0031	0.3414	0.0014
<b>NLD27 II</b>	2nd	7.26	6.66	0.02	2.980	0.010	0.1500	0.0005	0.7857	0.0024	0.3911	0.0009	0.3350	0.0012
<b>(3.61g)</b>	3rd	5.61	6.69	0.03	2.952	0.013	0.1485	0.0007	0.7813	0.0029	0.3924	0.0012	0.3362	0.0013
	4th	8.67	6.56	0.02	2.993	0.007	0.1512	0.0005	0.7865	0.0022	0.3922	0.0010	0.3315	0.0011
	5th	3.43	6.74	0.04	2.985	0.017	0.1493	0.0008	0.7883	0.0037	0.3963	0.0017	0.3372	0.0015
	6th	3.73	6.69	0.04	2.996	0.017	0.1501	0.0008	0.7852	0.0036	0.3959	0.0016	0.3352	0.0014
	7th	11.45	6.58	0.02	2.987	0.007	0.1514	0.0004	0.7855	0.0020	0.3933	0.0009	0.3333	0.0009
	8th	5.34	6.62	0.03	2.983	0.014	0.1517	0.0007	0.7853	0.0030	0.3938	0.0013	0.3366	0.0013
	9th	6.11	6.74	0.02	2.991	0.012	0.1502	0.0006	0.7870	0.0028	0.3959	0.0011	0.3383	0.0013
	10th	4.65	6.72	0.03	2.980	0.015	0.1517	0.0007	0.7823	0.0033	0.3967	0.0014	0.3419	0.0014
	12th	12.14	6.55	0.02	2.982	0.007	0.1523	0.0004	0.7909	0.0020	0.3902	0.0009	0.3339	0.0009

Sample	Step	<sup>130</sup> Xe	<sup>129</sup> Xe/ <sup>130</sup> Xe	1σ	<sup>129</sup> Xe/ <sup>136</sup> Xe	1σ	<sup>130</sup> Xe/ <sup>132</sup> Xe	1σ	<sup>131</sup> Xe/ <sup>132</sup> Xe	1σ	<sup>134</sup> Xe/ <sup>132</sup> Xe	1σ	<sup>136</sup> Xe/ <sup>132</sup> Xe	1σ
	13th	3.20	6.63	0.04	2.988	0.018	0.1527	0.0008	0.7838	0.0038	0.3964	0.0017	0.3390	0.0014
	14th	7.53	6.54	0.02	2.981	0.010	0.1525	0.0005	0.7835	0.0023	0.3920	0.0009	0.3348	0.0012
	15th	1.88	6.70	0.05	2.983	0.016	0.1514	0.0010	0.7850	0.0049	0.3947	0.0024	0.3398	0.0013
	16th	3.91	6.64	0.03	2.984	0.017	0.1526	0.0008	0.7903	0.0036	0.3951	0.0016	0.3396	0.0014
	17th	1.17	6.66	0.07	2.995	0.017	0.1533	0.0013	0.7803	0.0055	0.4002	0.0029	0.3419	0.0014
	18th	3.65	6.63	0.04	2.992	0.017	0.1523	0.0008	0.7893	0.0037	0.3956	0.0016	0.3377	0.0014
	19th	7.14	6.52	0.02	2.975	0.010	0.1528	0.0006	0.7938	0.0024	0.3898	0.0009	0.3347	0.0012
	20st	1.98	6.79	0.05	3.008	0.016	0.1507	0.0010	0.7877	0.0048	0.3932	0.0024	0.3400	0.0013
	21nd	1.60	6.75	0.06	2.983	0.016	0.1513	0.0011	0.7924	0.0051	0.3968	0.0026	0.3422	0.0013
	22rd	4.19	6.61	0.03	3.001	0.016	0.1520	0.0008	0.7949	0.0035	0.3936	0.0015	0.3346	0.0014
	23th	3.02	6.71	0.03	3.006	0.014	0.1507	0.0007	0.7920	0.0041	0.3987	0.0020	0.3361	0.0011
	24th	2.92	6.67	0.03	2.992	0.014	0.1502	0.0007	0.7872	0.0041	0.3925	0.0020	0.3348	0.0011
	25th	1.60	6.72	0.06	2.968	0.016	0.1519	0.0011	0.7943	0.0051	0.3957	0.0026	0.3433	0.0013
	26th	1.62	6.66	0.06	2.980	0.016	0.1498	0.0011	0.7828	0.0051	0.3939	0.0026	0.3348	0.0013
	27th	3.51	6.70	0.04	3.011	0.017	0.1506	0.0008	0.7920	0.0037	0.3908	0.0016	0.3349	0.0014
	28th	8.14	6.48	0.02	2.967	0.009	0.1517	0.0005	0.7844	0.0021	0.3884	0.0008	0.3311	0.0011
	29th	9.95	6.53	0.02	2.996	0.007	0.1510	0.0005	0.7904	0.0014	0.3883	0.0009	0.3291	0.0010
	30st	3.42	6.73	0.04	2.994	0.018	0.1513	0.0008	0.7817	0.0038	0.3942	0.0017	0.3399	0.0014
	31nd	2.51	6.71	0.03	3.011	0.015	0.1506	0.0008	0.7856	0.0043	0.3927	0.0021	0.3356	0.0012
	32rd	1.52	6.78	0.06	3.020	0.016	0.1491	0.0011	0.7901	0.0051	0.3943	0.0026	0.3339	0.0013

<sup>130</sup>Xe abundance is in units of 10<sup>-14</sup> cc

Fission isotopes were not determined for NLD 20 because of the very low abundance.

Xenon abundance for six steps were higher than the largest calibrated air standard; Isotopic compositions for these steps were not determined.



**Table S3: NLD 27 source and end-member compositions used in the Pu-U-I deconvolutions**

<b>Sample</b>	$^{130}\text{Xe}/^{132}\text{Xe}$	$^{131}\text{Xe}/^{132}\text{Xe}$	$^{134}\text{Xe}/^{132}\text{Xe}$	$^{136}\text{Xe}/^{132}\text{Xe}$
<b>NLD 27<sup>1</sup></b>	0.1497	0.7793	0.4018	0.3457
	±0.0002	±0.0010	±0.0005	±0.0005
<b>Atm.<sup>2</sup></b>	0.15135	0.7890	0.3879	0.3294
	±0.00012	±0.0011	±0.0006	±0.0004
<b>SW<sup>3</sup></b>	0.1661	0.8272	0.367	0.299
	±0.0009	±0.0053	±0.015	±0.001
<b>AVCC<sup>4</sup></b>	0.1626	0.8200	0.3836	0.3233
	±0.0007	±0.0058	±0.0027	±0.0024
<b>U-fission<sup>5</sup></b>	0	0.144	1.437	1.737
		±0.001	±0.002	±0.003
<b>Pu-fission<sup>6</sup></b>	0	0.279	1.048	1.124
		±0.012	±0.005	±0.014

1. NLD 27 composition was determined by linear regression between  $^{129}\text{Xe}/^{132}\text{Xe}$  and  $^{130,131,134,136}\text{Xe}/^{132}\text{Xe}$  forced through the atmospheric composition ( $y=mx$ ) and projecting to  $^{129}\text{Xe}/^{132}\text{Xe}$  of 1.0382 (Supplemental Figure 1, see main text for details).
2. Atmospheric composition is from Basford et al. (1973).
3. SW is for solar wind and solar wind composition is from Wieler and Baur (1994) and Pepin et al. (1995).
4. AVCC is Average Carbonaceous Chondrite and AVCC composition is from Pepin 1991, 2000.
5. U-fission composition is the error-weighted average of the data presented by: Wetherill (1953), Hebeda et al. (1987), Eikenberg et al. (1993), Ragettli et al. (1994).
6. Pu-fission composition is the error-weighted average of the data presented by Alexander et al. (1971), Lewis et al. (1975) and Hudson et al. (1985).