

Supplementary file for:

Diffusion kinetics of ^3He in pyroxene and plagioclase and applications to cosmogenic exposure dating and paleothermometry in mafic rocks.

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Table S1 Amount of ^3He gas released during each heating step for the plagioclase step-degassing experiments. All measurements are blank-corrected. Hyphen indicates heating steps below blank level and are treated as a zero gas release step in the forward MDD model inversion.

Table S1A. LABCO-Plag-Da – Ferrar Dolerite plagioclase

Step	Temperature (°C)	time (min)	^3He (10^6 atoms)	\pm	cumulative fractional release
1	24.4	60	-	-	0.0000
2	80.0	30	0.085	0.017	0.0013
3	90.0	30	0.147	0.021	0.0037
4	100.0	30	0.237	0.022	0.0074
5	100.0	60	0.405	0.028	0.0139
6	100.0	120	0.821	0.036	0.0269
7	69.9	80	0.076	0.016	0.0281
8	70.0	160	0.101	0.018	0.0297
9	70.0	240	0.143	0.020	0.0320
10	90.0	120	0.299	0.024	0.0367
11	90.0	180	0.493	0.027	0.0445
12	100.0	180	1.002	0.038	0.0604
13	120.0	60	1.030	0.041	0.0768
14	120.0	120	1.805	0.052	0.1054
15	120.0	180	2.386	0.062	0.1433
16	140.0	60	2.203	0.055	0.1782
17	140.0	120	3.245	0.071	0.2297
18	140.0	180	3.801	0.072	0.2900
19	160.0	60	3.229	0.078	0.3413
20	160.0	120	4.781	0.089	0.4171
21	160.0	180	4.462	0.088	0.4879
22	180.0	60	3.316	0.064	0.5405
23	180.0	120	4.436	0.090	0.6109
24	180.0	180	3.728	0.083	0.6701
25	200.0	60	2.410	0.054	0.7083
26	200.0	120	2.917	0.065	0.7546
27	200.0	180	2.496	0.055	0.7942
28	249.9	30	2.123	0.053	0.8279
29	250.0	60	2.271	0.060	0.8639
30	299.9	30	3.139	0.063	0.9137
31	300.0	60	2.046	0.054	0.9462
32	324.9	30	1.066	0.039	0.9631
33	325.0	60	0.906	0.036	0.9775
34	349.9	30	0.523	0.027	0.9858
35	350.0	60	0.498	0.033	0.9937
36	335.0	60	0.130	0.018	0.9958
37	310.0	60	0.022	0.015	0.9961
38	290.0	90	0.026	0.013	0.9965
39	360.0	60	0.086	0.017	0.9979

Supplement for Bergelin et al., “Diffusion kinetics of ^3He in pyroxene and plagioclase and applications to cosmogenic exposure dating and paleothermometry in mafic rocks.”

40	380.0	60	0.052	0.016	0.9987
41	399.9	30	0.005	0.013	0.9988
42	399.9	60	0.039	0.014	0.9994
43	424.9	30	0.007	0.012	0.9995
44	424.9	60	0.007	0.011	0.9996
45	449.9	30	0.022	0.013	1.0000

Table S1B. LABCO-Plag-Db – Ferrar Dolerite plagioclase

Step	Temperature (°C)	Time (min)	^3He (10^6 atoms)	\pm	Cumulative fractional release
1	24.7	60	-	-	0.0000
2	100.0	30	0.416	0.030	0.0039
3	100.0	60	0.712	0.041	0.0105
4	100.0	120	1.279	0.048	0.0225
5	69.9	80	0.152	0.025	0.0239
6	70.0	160	0.290	0.028	0.0266
7	70.0	240	0.292	0.030	0.0293
8	90.0	120	0.482	0.033	0.0338
9	90.0	180	0.708	0.039	0.0404
10	100.0	180	1.276	0.051	0.0523
11	120.0	60	1.291	0.046	0.0644
12	120.0	120	2.431	0.068	0.0871
13	120.0	180	2.875	0.068	0.1139
14	140.0	60	2.639	0.067	0.1385
15	140.0	120	4.172	0.088	0.1775
16	140.0	180	4.698	0.092	0.2213
17	160.0	60	3.721	0.087	0.2560
18	160.0	120	5.38	0.11	0.3062
19	160.0	180	5.89	0.12	0.3612
20	180.0	60	4.112	0.095	0.3996
21	180.0	120	6.10	0.13	0.4565
22	180.0	180	6.45	0.12	0.5167
23	200.0	60	4.044	0.095	0.5544
24	200.0	120	6.08	0.12	0.6112
25	200.0	180	6.66	0.13	0.6733
26	249.9	30	14.52	0.23	0.8088
27	250.0	60	4.051	0.092	0.8466
28	299.9	30	6.57	0.12	0.9080
29	300.0	60	4.193	0.089	0.9471
30	324.9	30	1.908	0.061	0.9649
31	325.0	60	1.609	0.053	0.9799
32	349.9	30	0.639	0.037	0.9859
33	350.0	60	0.567	0.037	0.9912
34	335.0	60	0.153	0.027	0.9926
35	310.0	60	0.051	0.022	0.9931
36	290.0	90	0.037	0.022	0.9934
37	250.0	90	0.007	0.022	0.9935
38	250.0	120	0.016	0.022	0.9936
39	215.0	180	-	-	0.9936
40	265.0	120	0.020	0.021	0.9938
41	285.0	90	0.028	0.022	0.9941
42	300.0	60	0.045	0.022	0.9945
43	330.0	60	0.070	0.023	0.9951
44	360.0	60	0.149	0.025	0.9965
45	380.0	60	0.131	0.027	0.9977

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46	399.94	60	0.145	0.026	0.9991
47	424.95	60	0.097	0.024	1.0000

Table S1C. ROB-Plag-Da – Ferrar Dolerite plagioclase

Step	Temperature (°C)	Time (min)	^3He (10^6 atoms)	\pm	Cumulative fractional release
1	28.1	30	1.070	0.044	0.0039
2	100.0	20	63.64	0.82	0.2346
3	100.0	30	43.98	0.58	0.3940
4	70.0	30	4.63	0.10	0.4108
5	70.0	60	7.80	0.14	0.4390
6	70.0	90	9.72	0.16	0.4743
7	90.0	30	9.89	0.16	0.5101
8	90.0	60	15.06	0.24	0.5647
9	100.0	30	10.08	0.17	0.6013
10	120.0	10	8.22	0.14	0.6311
11	120.0	20	11.69	0.19	0.6734
12	120.0	30	10.95	0.18	0.7131
13	140.0	10	6.47	0.12	0.7366
14	140.0	20	8.07	0.14	0.7658
15	140.0	30	7.42	0.13	0.7928
16	159.9	10	3.968	0.083	0.8071
17	160.0	20	5.27	0.10	0.8262
18	160.0	30	5.372	0.098	0.8457
19	179.8	6	2.041	0.059	0.8531
20	179.9	10	2.706	0.065	0.8629
21	179.9	20	3.954	0.085	0.8772
22	199.9	10	3.361	0.073	0.8894
23	200.0	25	5.21	0.10	0.9083
24	249.8	10	6.03	0.12	0.9302
25	249.9	15	4.127	0.089	0.9451
26	279.8	10	4.960	0.096	0.9631
27	279.9	20	3.120	0.070	0.9744
28	260.0	30	1.277	0.043	0.9790
29	190.0	45	0.137	0.017	0.9795
30	170.0	60	0.089	0.014	0.9799
31	150.0	90	0.065	0.014	0.9801
32	200.0	60	0.248	0.018	0.9810
33	240.0	60	0.672	0.033	0.9834
34	299.9	30	1.376	0.045	0.9884
35	300.0	60	1.189	0.041	0.9927
36	324.9	30	0.590	0.026	0.9949
37	325.0	60	0.482	0.028	0.9966
38	349.9	30	0.234	0.020	0.9975
39	350.0	60	0.167	0.020	0.9981
40	325.0	60	0.069	0.013	0.9983
41	374.9	30	0.112	0.015	0.9987
42	375.0	60	0.120	0.014	0.9992
43	399.9	40	0.100	0.023	0.9995
44	400.0	60	0.073	0.013	0.9998
45	424.9	30	-	-	0.9998

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46	424.9	30	0.022	0.010	0.9999
47	449.9	30	0.018	0.011	0.9999
48	499.9	30	0.017	0.012	1.0000

Table S1D. ROB-Plag-Db – Ferrar Dolerite plagioclase

Step	Temperature (°C)	Time (min)	^3He (10^6 atoms)	\pm	Cumulative fractional release
1	23.9	30	0.365	0.024	0.0022
2	59.7	30	9.65	0.16	0.0612
3	59.8	60	15.26	0.24	0.1545
4	75.0	30	20.12	0.31	0.2774
5	75.0	60	26.42	0.39	0.4389
6	90.0	30	23.37	0.34	0.5817
7	90.0	60	23.88	0.35	0.7277
8	24.0	30	0.064	0.014	0.7281
9	100.0	15	6.57	0.13	0.7682
10	100.0	30	7.80	0.13	0.8159
11	120.0	10	4.88	0.10	0.8457
12	120.0	20	4.528	0.099	0.8734
13	120.0	30	3.044	0.068	0.8920
14	140.0	10	1.778	0.049	0.9029
15	140.0	20	2.075	0.062	0.9155
16	140.0	30	2.001	0.054	0.9278
17	160.0	10	1.095	0.040	0.9345
18	160.0	20	1.527	0.044	0.9438
19	160.0	30	1.476	0.049	0.9528
20	179.9	6	0.508	0.026	0.9559
21	179.9	10	0.678	0.031	0.9601
22	180.0	20	0.930	0.044	0.9658
23	199.8	10	0.644	0.034	0.9697
24	200.0	25	1.061	0.040	0.9762
25	249.8	10	1.171	0.041	0.9833
26	249.9	15	0.664	0.031	0.9874
27	279.8	10	0.530	0.026	0.9906
28	279.9	20	0.394	0.022	0.9930
29	259.9	30	0.160	0.017	0.9940
30	190.0	45	0.040	0.012	0.9943
31	170.0	60	0.021	0.011	0.9944
32	150.0	90	0.025	0.011	0.9945
33	200.0	60	0.048	0.013	0.9948
34	240.0	60	0.096	0.015	0.9954
35	299.9	30	0.132	0.017	0.9962
36	300.0	60	0.098	0.016	0.9968
37	324.9	30	0.030	0.012	0.9970
38	325.0	60	0.036	0.012	0.9972
39	349.9	30	0.020	0.012	0.9973
40	350.0	60	0.022	0.012	0.9975
41	325.0	60	0.021	0.011	0.9976
42	300.0	60	0.009	0.011	0.9977
43	275.0	52	0.001	0.010	0.9977
44	250.0	90	0.013	0.012	0.9978
45	200.0	120	0.016	0.011	0.9978

Supplement for Bergelin et al., “Diffusion kinetics of ^3He in pyroxene and plagioclase and applications to cosmogenic exposure dating and paleothermometry in mafic rocks.”

46	269.8	60	0.005	0.011	0.9979
47	300.0	60	0.007	0.010	0.9979
48	374.9	30	0.022	0.012	0.9981
49	375.0	60	0.034	0.011	0.9983
50	399.9	40	0.016	0.011	0.9984
51	400.0	60	-	-	0.9984
52	424.9	30	0.013	0.010	0.9984
53	424.9	30	-	-	0.9984
54	449.9	30	0.244	0.019	0.9999
55	499.9	30	0.012	0.012	1.0000

Table S1E. FCs-Kspar-Da – Fish Canyon Tuff sanidine

Step	Temperature (°C)	Time (min)	^3He (10^6 atoms)	\pm	Cumulative fractional release
1	24.7	60	0.0064	0.0081	0.0006
2	100.0	30	0.147	0.015	0.0140
3	100.0	60	0.269	0.021	0.0385
4	100.0	120	0.414	0.029	0.0761
5	70.0	80	0.071	0.011	0.0826
6	70.0	160	0.078	0.016	0.0897
7	70.0	240	0.135	0.016	0.1020
8	90.0	120	0.204	0.020	0.1205
9	100.0	180	0.433	0.050	0.1600
10	120.0	60	0.67	0.12	0.2211
11	120.0	120	0.680	0.039	0.2829
12	120.0	180	0.886	0.044	0.3635
13	139.9	60	0.756	0.042	0.4322
14	140.0	120	0.986	0.047	0.5219
15	140.0	180	1.008	0.047	0.6136
16	160.0	60	0.442	0.033	0.6538
17	160.0	120	0.551	0.032	0.7039
18	160.0	180	0.422	0.029	0.7423
19	180.0	60	0.211	0.023	0.7615
20	180.0	120	0.323	0.029	0.7908
21	180.0	180	0.263	0.023	0.8148
22	199.9	60	0.195	0.035	0.8325
23	200.0	120	0.273	0.022	0.8573
24	200.0	180	0.290	0.024	0.8837
25	249.8	30	0.223	0.021	0.9040
26	249.9	60	0.396	0.025	0.9400
27	299.9	30	0.338	0.024	0.9707
28	300.0	60	0.230	0.019	0.9916
29	324.9	30	0.040	0.012	0.9953
30	325.0	60	0.0068	0.0093	0.9959
31	349.9	30	-	-	0.9959
32	350.0	60	-	-	0.9959
33	335.0	60	-	-	0.9959
34	310.0	60	0.0027	0.0077	0.9961
35	290.0	90	0.012	0.012	0.9972
36	250.0	90	0.0036	0.0077	0.9976
37	250.0	120	0.0021	0.0085	0.9978
38	215.0	180	0.025	0.011	1.0000
39	265.0	120	-	-	1.0000

Table S1F. ML-Plag-Da – Mono Lake oligoclase

Step	Temperature (°C)	Time (min)	^3He (10^6 atoms)	\pm	Cumulative fractional release
1	100.1	30	5.48	0.32	0.0193
2	100.0	60	8.66	0.50	0.0498
3	100.0	120	14.18	0.81	0.0998
4	70.0	80	1.330	0.086	0.1045
5	70.0	160	2.56	0.16	0.1135
6	70.0	240	2.37	0.15	0.1218
7	90.0	120	6.65	0.38	0.1453
8	90.0	180	7.99	0.46	0.1734
9	100.0	180	8.48	0.49	0.2033
10	120.0	60	12.58	0.72	0.2476
11	120.0	120	13.53	0.77	0.2952
12	120.0	180	17.9	1.0	0.3583
13	140.0	60	14.77	0.84	0.4104
14	140.0	120	24.0	1.4	0.4948
15	140.0	180	39.9	2.3	0.6353
16	160.0	60	22.1	1.3	0.7133
17	160.0	120	18.2	1.0	0.7776
18	160.0	180	17.18	0.98	0.8381
19	180.0	60	7.50	0.43	0.8645
20	180.0	120	9.85	0.56	0.8992
21	180.0	180	8.59	0.49	0.9295
22	200.0	60	4.65	0.30	0.9459
23	199.9	120	3.83	0.22	0.9594
24	200.0	180	3.53	0.21	0.9718
25	249.9	30	1.323	0.086	0.9765
26	250.0	60	1.87	0.11	0.9831
27	299.9	30	1.61	0.10	0.9887
28	300.0	60	1.430	0.088	0.9938
29	324.9	30	0.786	0.056	0.9966
30	325.0	60	0.230	0.024	0.9974
31	349.9	30	0.063	0.016	0.9976
32	350.0	60	0.027	0.015	0.9977
33	335.0	60	0.025	0.014	0.9978
34	310.0	60	0.028	0.014	0.9979
35	290.0	90	0.037	0.014	0.9980
36	250.0	90	0.027	0.014	0.9981
37	249.9	120	0.047	0.015	0.9983
38	215.0	180	0.237	0.027	0.9991
39	265.0	120	0.043	0.014	0.9992
40	285.0	90	0.036	0.016	0.9994
41	300.0	60	0.022	0.013	0.9995
42	330.0	60	0.019	0.013	0.9995
43	360.0	60	0.036	0.015	0.9996
44	380.0	60	0.036	0.015	0.9998
45	399.7	60	0.021	0.014	0.9998

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46	425.0	60	0.033	0.014	1.0000
47	599.7	15	0.012	0.013	1.0000

Table S1G. SURTp-Plag-Da – Surtsey labradorite

Step	Temperature (°C)	Time (min)	^3He (10^6 atoms)	\pm	Cumulative fractional release
1	24.5	60	0.067	0.012	0.0001
2	100.2	30	144.9	1.3	0.1140
3	100.1	60	179.5	1.6	0.2553
4	100.0	120	28.07	0.29	0.2773
5	70.0	80	2.527	0.061	0.2793
6	70.0	160	9.31	0.14	0.2867
7	70.0	240	62.94	0.62	0.3362
8	90.0	120	18.98	0.22	0.3511
9	90.0	180	169.7	1.5	0.4846
10	120.1	60	60.12	0.56	0.5319
11	120.0	120	449.8	3.9	0.8858
12	140.1	60	73.60	0.68	0.9437
13	140.0	120	63.33	0.59	0.9935
14	160.0	60	2.073	0.054	0.9951
15	160.0	120	3.790	0.081	0.9981
16	180.0	60	1.704	0.049	0.9995
17	180.0	120	0.068	0.012	0.9995
18	200.0	60	0.050	0.013	0.9996
19	200.0	120	0.040	0.010	0.9996
20	200.0	180	0.050	0.012	0.9996
21	249.9	30	0.004	0.010	0.9996
22	249.9	60	0.0164	0.0092	0.9996
23	299.7	30	0.008	0.010	0.9996
24	299.9	60	0.016	0.010	0.9997
25	324.7	30	0.039	0.012	0.9997
26	324.8	60	0.0062	0.0088	0.9997
27	349.6	30	-	-	0.9997
28	350.0	60	0.023	0.010	0.9997
29	334.7	60	0.0035	0.0088	0.9997
30	309.9	60	0.0039	0.0094	0.9997
31	290.0	90	0.015	0.010	0.9997
32	250.0	90	0.023	0.010	0.9998
33	250.0	120	0.026	0.010	0.9998
34	215.0	180	0.097	0.014	0.9998
35	265.0	120	0.054	0.010	0.9999
36	284.9	90	0.023	0.011	0.9999
37	300.0	60	0.013	0.010	0.9999
38	330.0	60	0.019	0.010	0.9999
39	359.8	60	0.020	0.010	1.0000
40	380.0	60	0.022	0.010	1.0000
41	399.9	60	0.0173	0.0084	1.0000
42	425.0	60	0.022	0.010	1.0000

Table S1H. SW-1-Plag-Da – Stillwater Complex bytownite

Step	Temperature (°C)	Time (min)	^3He (10^6 atoms)	\pm	Cumulative fractional release
1	24.6	60	-	-	0.0000
2	100.0	30	0.459	0.037	0.0024
3	100.0	60	0.874	0.044	0.0070
4	100.0	120	1.611	0.059	0.0154
5	70.1	80	0.215	0.034	0.0166
6	70.0	160	0.281	0.035	0.0180
7	70.0	240	0.371	0.038	0.0200
8	90.0	120	0.653	0.042	0.0234
9	90.0	180	1.083	0.047	0.0291
10	120.0	60	1.957	0.063	0.0394
11	120.0	120	3.517	0.083	0.0578
12	140.0	60	4.44	0.10	0.0811
13	140.0	120	6.97	0.14	0.1177
14	160.0	60	6.83	0.14	0.1535
15	160.0	120	10.11	0.18	0.2065
16	180.0	60	8.54	0.15	0.2514
17	180.0	120	12.48	0.22	0.3169
18	200.0	60	9.41	0.18	0.3662
19	200.0	120	13.41	0.23	0.4366
20	200.0	180	14.07	0.24	0.5104
21	249.9	30	8.85	0.16	0.5568
22	250.0	60	13.47	0.23	0.6275
23	299.9	30	17.93	0.29	0.7216
24	299.7	60	19.50	0.31	0.8239
25	324.9	30	10.11	0.19	0.8769
26	325.0	60	10.99	0.21	0.9345
27	349.9	30	4.92	0.11	0.9603
28	350.0	60	4.54	0.10	0.9841
29	335.0	60	1.302	0.057	0.9910
30	310.0	60	0.430	0.037	0.9932
31	290.0	90	0.267	0.034	0.9946
32	250.0	90	0.069	0.030	0.9950
33	250.0	120	0.089	0.030	0.9954
34	215.0	180	0.042	0.030	0.9957
35	265.0	120	0.100	0.030	0.9962
36	285.0	90	0.120	0.031	0.9968
37	300.0	60	0.101	0.030	0.9973
38	330.0	60	0.198	0.031	0.9984
39	360.0	60	0.175	0.032	0.9993
40	380.0	60	0.095	0.030	0.9998
41	400.0	60	0.038	0.029	1.0000

Table S2 Amount of ^3He gas released during each heating step for pyroxene step-degassing experiments. All measurements are blank-corrected. Hyphen indicates heating steps below blank level and are treated as a zero-gas release step in the forward MDD model inversion.

Table S2A. LABCO-Px-Db – Ferrar Dolerite pyroxene

Step	Temperature (°C)	Time (min)	^3He (10^6 atoms)	\pm	Cumulative fractional release
1	24.1	20	0.017	0.011	0.0001
2	199.9	20	5.11	0.11	0.0181
3	249.7	10	2.203	0.067	0.0259
4	249.9	30	1.626	0.056	0.0316
5	299.7	10	2.598	0.068	0.0408
6	299.9	30	4.360	0.098	0.0562
7	349.8	15	13.17	0.23	0.1027
8	374.8	15	23.83	0.39	0.1869
9	399.4	6	17.36	0.29	0.2482
10	399.7	10	21.51	0.36	0.3242
11	399.8	15	20.22	0.34	0.3956
12	449.8	15	48.33	0.76	0.5663
13	474.8	15	32.08	0.51	0.6797
14	499.4	6	11.56	0.21	0.7205
15	499.6	10	11.02	0.20	0.7594
16	524.3	6	6.85	0.13	0.7836
17	524.6	10	6.96	0.14	0.8082
18	549.3	6	4.68	0.10	0.8247
19	574.3	6	5.07	0.11	0.8426
20	574.6	10	4.97	0.11	0.8602
21	574.8	20	5.32	0.12	0.8790
22	624.2	6	3.089	0.074	0.8899
23	639.2	6	2.990	0.079	0.9005
24	599.9	30	3.686	0.083	0.9135
25	599.8	30	2.325	0.064	0.9217
26	599.9	30	1.714	0.056	0.9277
27	499.9	60	0.315	0.025	0.9289
28	400.0	120	0.099	0.018	0.9292
29	400.0	180	0.088	0.018	0.9295
30	300.0	240	0.039	0.013	0.9297
31	649.9	60	5.74	0.12	0.9499
32	699.7	15	2.493	0.068	0.9587
33	699.9	30	2.649	0.075	0.9681
34	749.6	15	2.060	0.057	0.9754
35	749.6	15	1.064	0.040	0.9791
36	849.4	6	1.733	0.050	0.9853
37	874.2	6	1.000	0.040	0.9888
38	849.1	6	0.296	0.025	0.9898
39	824.0	6	0.173	0.018	0.9904
40	774.8	30	0.185	0.021	0.9911
41	600.0	120	0.019	0.012	0.9912

Supplement for Bergelin et al., “Diffusion kinetics of ^3He in pyroxene and plagioclase and applications to cosmogenic exposure dating and paleothermometry in mafic rocks.”

42	849.6	15	0.347	0.025	0.9924
43	899.6	15	0.532	0.030	0.9943
44	899.8	30	0.537	0.028	0.9962
45	874.0	6	0.041	0.013	0.9963
46	874.8	30	0.169	0.018	0.9969
47	844.8	30	0.073	0.016	0.9972
48	799.6	15	0.010	0.013	0.9972
49	749.6	15	-	-	0.9972
50	699.8	30	-	-	0.9972
51	600.0	180	0.020	0.012	0.9973
52	699.8	30	-	-	0.9973
53	774.6	15	-	-	0.9973
54	874.7	15	0.064	0.014	0.9975
55	899.6	15	0.090	0.015	0.9978
56	899.6	15	0.059	0.015	0.9980
57	899.6	15	0.061	0.015	0.9982
58	949.6	15	0.158	0.017	0.9988
59	999.0	6	0.176	0.018	0.9994
60	999.6	15	0.164	0.019	1.0000

Table S2B. LABCO-Px-Da – Ferrar Dolerite pyroxene

Step	Temperature (°C)	Time (min)	^3He (10^6 atoms)	\pm	Cumulative fractional release
1	24.6	60	0.036	0.013	0.0001
2	125.0	30	0.240	0.023	0.0004
3	150.0	30	0.626	0.030	0.0014
4	175.0	30	0.829	0.036	0.0026
5	175.0	60	0.660	0.035	0.0036
6	175.0	120	0.543	0.032	0.0044
7	199.9	30	0.509	0.028	0.0052
8	199.9	30	0.317	0.023	0.0057
9	224.8	15	0.549	0.029	0.0065
10	224.9	30	0.646	0.031	0.0075
11	249.8	15	0.849	0.037	0.0087
12	249.9	30	0.809	0.037	0.0100
13	249.9	30	0.472	0.027	0.0107
14	274.9	15	0.792	0.036	0.0119
15	274.6	30	0.817	0.039	0.0131
16	299.8	15	1.027	0.041	0.0146
17	299.9	30	1.198	0.046	0.0164
18	324.9	20	2.132	0.057	0.0197
19	349.8	15	3.661	0.077	0.0252
20	349.9	30	4.170	0.083	0.0315
21	374.4	6	2.238	0.065	0.0348
22	374.8	15	4.424	0.090	0.0415
23	399.5	6	4.575	0.088	0.0484
24	399.8	15	8.31	0.14	0.0609
25	424.8	15	13.71	0.19	0.0815
26	424.9	30	14.53	0.20	0.1034
27	449.8	15	12.64	0.19	0.1225
28	449.9	30	15.87	0.21	0.1464
29	474.8	15	14.07	0.21	0.1675
30	474.9	30	18.82	0.24	0.1959
31	499.4	6	8.32	0.14	0.2084
32	499.6	10	10.49	0.15	0.2242
33	529.7	15	29.68	0.53	0.2689
34	559.7	15	45.79	0.54	0.3379
35	599.7	15	73.00	0.81	0.4478
36	629.8	20	82.43	0.93	0.5719
37	669.7	20	68.90	0.77	0.6757
38	699.8	20	36.15	0.43	0.7302
39	749.8	30	30.43	0.38	0.7760
40	774.8	30	8.60	0.14	0.7889
41	799.5	15	4.775	0.095	0.7961
42	829.5	15	7.01	0.13	0.8067
43	869.5	15	10.10	0.17	0.8219
44	899.4	15	10.04	0.15	0.8370
45	649.9	60	0.254	0.023	0.8374

Supplement for Bergelin et al., “Diffusion kinetics of ^3He in pyroxene and plagioclase and applications to cosmogenic exposure dating and paleothermometry in mafic rocks.”

46	350.0	180	0.026	0.014	0.8374
47	500.0	120	0.047	0.014	0.8375
48	600.0	120	0.049	0.013	0.8376
49	699.8	30	0.127	0.019	0.8378
50	749.6	15	0.237	0.021	0.8381
51	849.5	15	2.244	0.059	0.8415
52	899.4	15	5.62	0.11	0.8500
53	929.4	15	8.72	0.14	0.8631
54	959.4	15	11.67	0.17	0.8807
55	999.4	15	21.22	0.29	0.9126
56	1099.4	15	27.02	0.34	0.9533
57	1099.6	30	17.98	0.24	0.9804
58	1099.8	60	9.37	0.14	0.9945
59	32.8	60	-	-	0.9945
60	1149.5	15	2.109	0.054	0.9977
61	1149.8	60	1.374	0.047	0.9998
62	1149.3	90	0.126	0.017	0.9999
63	1149.7	90	0.022	0.012	1.0000
64	1149.8	120	0.014	0.012	1.0000

Table S2C. ROB-Px-Da – Ferrar Dolerite pyroxene

Step	Temperature (°C)	Time (min)	^3He (10^6 atoms)	\pm	Cumulative fractional release
1	24.2	60	0.042	0.019	0.0001
2	125.0	60	3.714	0.081	0.0068
3	150.0	30	0.459	0.027	0.0076
4	175.0	30	0.732	0.032	0.0089
5	175.0	60	0.587	0.031	0.0099
6	175.0	120	0.635	0.033	0.0111
7	200.0	30	0.722	0.031	0.0124
8	200.0	30	0.383	0.023	0.0131
9	224.9	15	0.768	0.036	0.0145
10	225.0	30	0.751	0.033	0.0158
11	249.9	15	1.016	0.039	0.0176
12	250.0	30	0.888	0.037	0.0192
13	250.0	30	0.522	0.030	0.0202
14	274.9	15	0.841	0.036	0.0217
15	275.0	30	1.014	0.037	0.0235
16	299.9	15	1.636	0.050	0.0264
17	300.0	30	2.122	0.058	0.0303
18	324.9	20	4.237	0.090	0.0379
19	349.9	15	7.51	0.13	0.0514
20	350.0	30	7.97	0.15	0.0657
21	373.7	6	4.340	0.089	0.0735
22	374.9	15	7.68	0.13	0.0873
23	399.7	6	7.36	0.13	0.1005
24	399.9	15	11.24	0.18	0.1207
25	424.9	15	20.19	0.29	0.1570
26	425.0	30	19.83	0.30	0.1927
27	449.8	15	19.19	0.28	0.2272
28	450.0	30	24.14	0.36	0.2706
29	474.9	15	22.35	0.33	0.3107
30	475.0	30	28.66	0.39	0.3623
31	499.5	6	11.67	0.19	0.3832
32	499.7	10	15.44	0.24	0.4110
33	529.8	15	44.19	0.60	0.4904
34	559.8	15	57.31	0.76	0.5934
35	599.8	15	68.36	0.89	0.7163
36	629.9	20	58.82	0.78	0.8220
37	669.8	20	41.38	0.56	0.8964
38	699.8	20	17.23	0.26	0.9274
39	749.9	30	6.41	0.11	0.9389
40	774.8	30	2.608	0.068	0.9436
41	799.6	15	1.324	0.047	0.9460
42	829.6	15	1.958	0.053	0.9495
43	869.6	15	3.570	0.079	0.9559
44	899.6	15	4.372	0.097	0.9638
45	649.9	60	0.230	0.020	0.9642

Supplement for Bergelin et al., “Diffusion kinetics of ^3He in pyroxene and plagioclase and applications to cosmogenic exposure dating and paleothermometry in mafic rocks.”

46	350.0	180	0.032	0.012	0.9642
47	500.0	120	0.044	0.012	0.9643
48	599.7	120	0.073	0.013	0.9645
49	699.8	30	0.021	0.013	0.9645
50	749.7	15	0.047	0.012	0.9646
51	849.6	15	0.649	0.033	0.9657
52	899.6	15	1.740	0.052	0.9689
53	929.6	15	2.399	0.063	0.9732
54	959.5	15	2.929	0.070	0.9784
55	999.4	15	3.343	0.073	0.9845
56	1099.0	15	4.602	0.099	0.9927
57	1100.0	3	0.471	0.026	0.9936
58	1099.5	30	2.717	0.066	0.9985
59	1149.3	15	0.600	0.030	0.9995
60	1150.0	26	0.205	0.020	0.9999
61	1150.0	33	0.052	0.014	1.0000
62	33.8	60	-	-	1.0000

Table S2D. GEM-CPx-Da – Clinopyroxene

Step	Temperature (°C)	Time (min)	^3He (10^6 atoms)	\pm	Cumulative fractional release
1	24.4	30	-	-	0.0000
2	70.1	60	0.0035	0.0078	0.0000
3	70.1	120	-	-	0.0000
4	100.0	120	0.0064	0.0077	0.0000
5	135.0	60	-	-	0.0000
6	175.0	60	0.0186	0.0077	0.0001
7	200.0	60	0.0086	0.0079	0.0002
8	225.0	30	-	-	0.0002
9	225.0	60	0.0095	0.0073	0.0002
10	249.9	30	0.0045	0.0079	0.0002
11	274.9	15	0.0088	0.0082	0.0002
12	274.9	30	0.0066	0.0074	0.0003
13	274.9	15	0.0022	0.0078	0.0003
14	299.9	15	0.0115	0.0078	0.0003
15	299.9	30	0.0085	0.0099	0.0004
16	300.0	60	0.0281	0.0093	0.0005
17	324.9	15	0.0234	0.0091	0.0006
18	324.9	30	0.0353	0.0096	0.0007
19	349.9	15	0.065	0.012	0.0010
20	349.9	30	0.090	0.013	0.0013
21	374.6	6	0.0543	0.0098	0.0016
22	374.9	15	0.102	0.014	0.0020
23	399.7	6	0.109	0.014	0.0024
24	399.8	15	0.222	0.016	0.0033
25	424.8	15	0.484	0.026	0.0053
26	424.9	30	0.671	0.029	0.0081
27	449.8	15	0.589	0.027	0.0105
28	449.9	30	0.860	0.032	0.0140
29	474.8	15	0.980	0.035	0.0180
30	474.9	30	1.448	0.048	0.0239
31	499.5	6	0.631	0.028	0.0265
32	499.7	10	0.880	0.034	0.0300
33	529.8	15	3.063	0.075	0.0426
34	559.8	15	5.92	0.12	0.0667
35	599.7	15	13.05	0.22	0.1200
36	629.8	20	23.52	0.37	0.2160
37	669.7	20	37.68	0.58	0.3698
38	699.7	20	40.53	0.61	0.5352
39	749.8	30	51.87	0.77	0.7469
40	774.8	30	40.45	0.62	0.9121
41	799.5	15	14.43	0.24	0.9709
42	829.6	15	4.371	0.090	0.9888
43	868.4	15	1.235	0.043	0.9938
44	899.4	15	0.693	0.026	0.9967
45	649.9	60	0.0096	0.0082	0.9967

Supplement for Bergelin et al., “Diffusion kinetics of ^3He in pyroxene and plagioclase and applications to cosmogenic exposure dating and paleothermometry in mafic rocks.”

46	350.0	180	-	-	0.9967
47	500.0	120	-	-	0.9967
48	600.0	120	0.0215	0.0083	0.9968
49	699.8	30	0.0113	0.0088	0.9968
50	749.6	15	0.0262	0.0091	0.9969
51	799.5	15	0.028	0.016	0.9971
52	849.5	15	0.116	0.013	0.9975
53	899.3	15	0.152	0.015	0.9982
54	929.7	15	0.177	0.017	0.9989
55	959.7	15	0.115	0.013	0.9993
56	999.0	15	0.038	0.010	0.9995
57	1099.5	15	0.0371	0.0091	0.9996
58	32.7	30	-	-	0.9996
59	1099.6	30	0.0043	0.0091	0.9997
60	1099.7	60	0.0112	0.0090	0.9997
61	1150.0	15	0.034	0.010	0.9999
62	1198.8	15	0.0237	0.0096	0.9999
63	1199.2	23	0.0126	0.0084	1.0000

Table S2E. GEM-OPx-Da – Orthopyroxene

Step	Temperature (°C)	Time (min)	^3He (10^6 atoms)	\pm	Cumulative fractional release
1	24.1	30	-	-	0.0000
2	70.1	60	0.008	0.011	0.0000
3	70.0	120	-	-	0.0000
4	100.0	120	0.012	0.011	0.0000
5	135.0	60	0.009	0.011	0.0000
6	175.0	60	0.030	0.012	0.0000
7	200.0	60	0.055	0.013	0.0000
8	224.9	30	0.026	0.012	0.0000
9	224.9	60	0.016	0.010	0.0001
10	249.8	30	0.017	0.011	0.0001
11	274.8	15	0.058	0.012	0.0001
12	274.8	30	0.091	0.014	0.0001
13	274.7	15	0.021	0.011	0.0001
14	299.5	15	0.212	0.021	0.0002
15	299.8	30	0.097	0.016	0.0002
16	300.0	60	0.168	0.021	0.0003
17	324.9	15	0.461	0.036	0.0005
18	324.9	30	0.347	0.029	0.0006
19	349.8	15	0.293	0.025	0.0007
20	349.9	30	0.947	0.063	0.0010
21	374.5	6	0.625	0.044	0.0012
22	374.8	15	1.584	0.096	0.0018
23	399.4	6	1.067	0.067	0.0022
24	399.8	15	2.59	0.15	0.0031
25	424.8	15	2.88	0.17	0.0041
26	424.9	30	8.83	0.49	0.0072
27	449.8	15	2.09	0.12	0.0080
28	449.9	30	3.63	0.21	0.0092
29	474.8	15	9.38	0.52	0.0125
30	474.9	30	10.03	0.55	0.0161
31	499.4	6	4.08	0.23	0.0175
32	499.7	10	6.55	0.37	0.0198
33	529.7	15	12.79	0.71	0.0243
34	559.7	15	86.5	4.7	0.0549
35	599.7	15	87.6	5.4	0.0858
36	629.8	20	177.7	9.6	0.1485
37	669.7	20	364	20	0.2769
38	699.7	20	735	40	0.5363
39	749.8	30	1018	55	0.8957
40	774.8	30	194	11	0.9640
41	799.5	15	24.6	1.7	0.9726
42	829.3	15	24.7	1.4	0.9814
43	867.8	15	24.7	1.4	0.9901
44	900.0	4.17	4.03	0.23	0.9915
45	649.9	60	1.453	0.088	0.9920

Supplement for Bergelin et al., “Diffusion kinetics of ^3He in pyroxene and plagioclase and applications to cosmogenic exposure dating and paleothermometry in mafic rocks.”

46	350.0	180	0.030	0.011	0.9920
47	500.0	120	0.066	0.013	0.9921
48	600.0	120	0.470	0.036	0.9922
49	699.8	30	0.702	0.049	0.9925
50	749.6	15	0.743	0.051	0.9927
51	799.6	15	1.78	0.11	0.9934
52	849.6	15	4.46	0.25	0.9949
53	899.5	15	7.14	0.40	0.9975
54	929.6	15	4.67	0.27	0.9991
55	959.7	15	1.61	0.10	0.9997
56	999.7	15	0.352	0.029	0.9998
57	1099.8	15	0.029	0.012	0.9998
58	32.5	30	0.0026	0.0096	0.9998
59	1099.8	30	0.060	0.013	0.9998
60	1099.9	60	0.078	0.016	0.9999
61	1149.4	15	0.044	0.012	0.9999
62	1149.9	60	0.129	0.017	0.9999
63	1149.9	90	0.141	0.018	1.0000
64	1150.0	2.5	0.060	0.014	1.0000

Table S3 Total measured ^3He and ^4He concentrations in Fish Canyon sanidine (FCs) grains

Sample name	Storage time (yr)	Aliquot	Mass (mg)	Mean radii (μm)	Measured ^3He (10^9 atoms g^{-1})	Measured ^4He (10^{12} atoms g^{-1})
FCs-504	1.86	a	1.40	471	163.9 ± 3.4	93.10 ± 0.60
		b	1.70	502	406.5 ± 8.6	107.64 ± 0.61
FCs-496	2.70	a	1.12	215	88.0 ± 2.1	31.37 ± 0.32
		b	0.90	197	65.8 ± 1.6	18.88 ± 0.19
FCs-492PR	3.85	a	0.89	225	91.3 ± 2.2	5.400 ± 0.056
		b	1.37	260	78.8 ± 1.9	3.303 ± 0.034
FCs-456PR	8.40	a	0.64	301	75.8 ± 3.9	2.906 ± 0.025
		b	0.34	190	79.4 ± 1.9	3.769 ± 0.033
FCs-443PR	9.65	a	0.53	173	83.2 ± 2.1	12.89 ± 0.11
		b	0.95	173	70.1 ± 1.7	3.863 ± 0.032
FCs-400c	13.64	a	1.61	496	14.17 ± 0.35	1.2247 ± 0.0098
		b	1.23	430	9.34 ± 0.25	2.096 ± 0.018
FCs-391	14.69	a	1.24	335	21.90 ± 0.54	4.145 ± 0.044

Table S4 Summary of modeled MDD diffusion kinetics results for ^3He in proton-irradiated quartz grain sample HU-08-03.

Sample name	radii (μm)	modeled initial conditions	misfit	Ea (kJ mol^{-1})	$\ln(D_0/a^2)$ $\ln(\text{s}^{-1})$	Fractional release	irradiation loss	storage loss
HU-08-03	0.0256	no loss	9.0	100.3	17.8	0.33	-	-
					16.5	0.17		
					13.7	0.18		
					12.1	0.14		
					9.3	0.075		
					6.8	0.11		
		loss	5.5	94.3	16.9	0.28	0.0126	0.1579
					15.4	0.29		
					12.4	0.14		
					10.9	0.13		
					8.0	0.072		
					5.7	0.080		

Supplementary figures

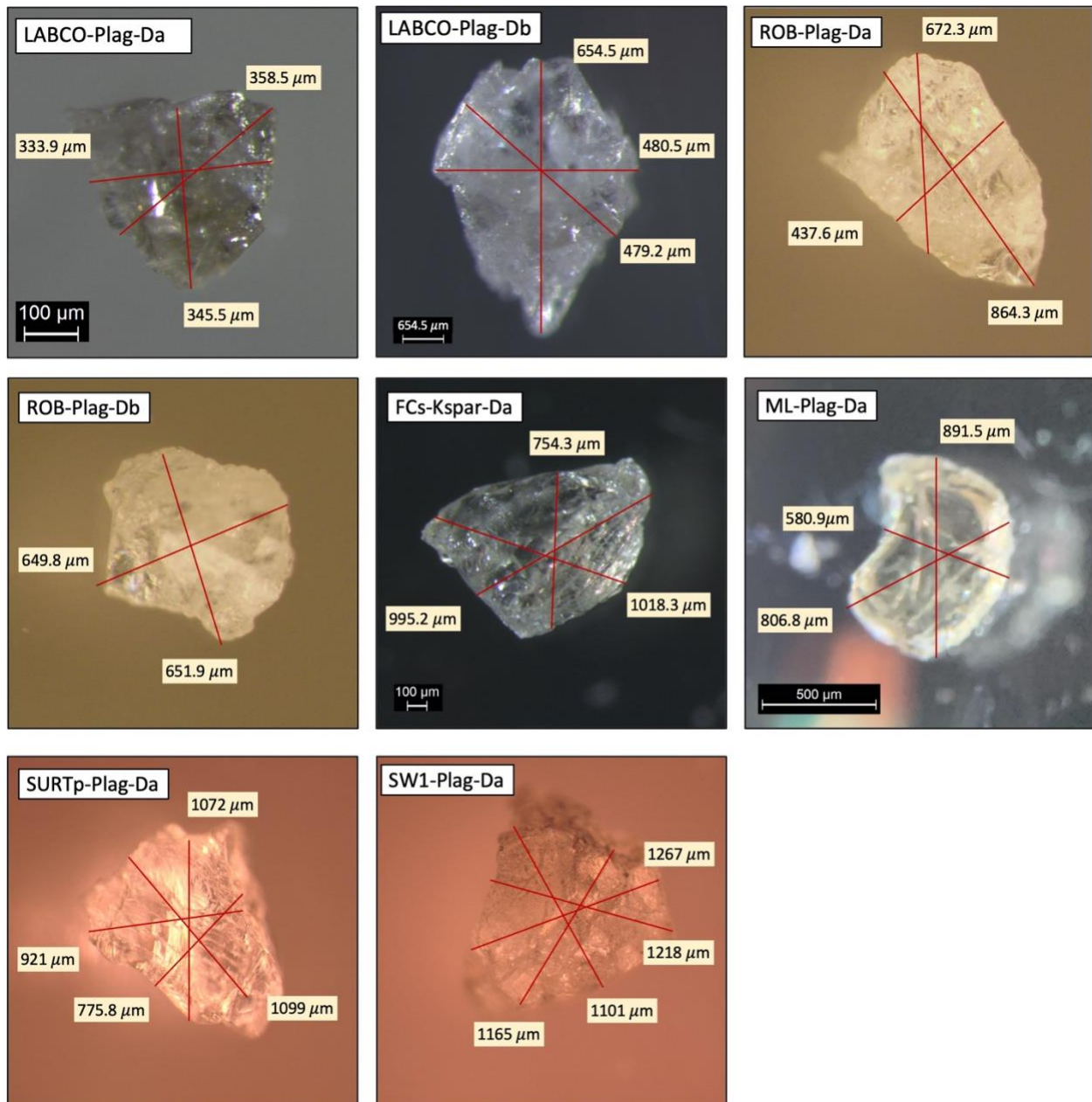


Figure S1 Photographs of irradiated plagioclase grains

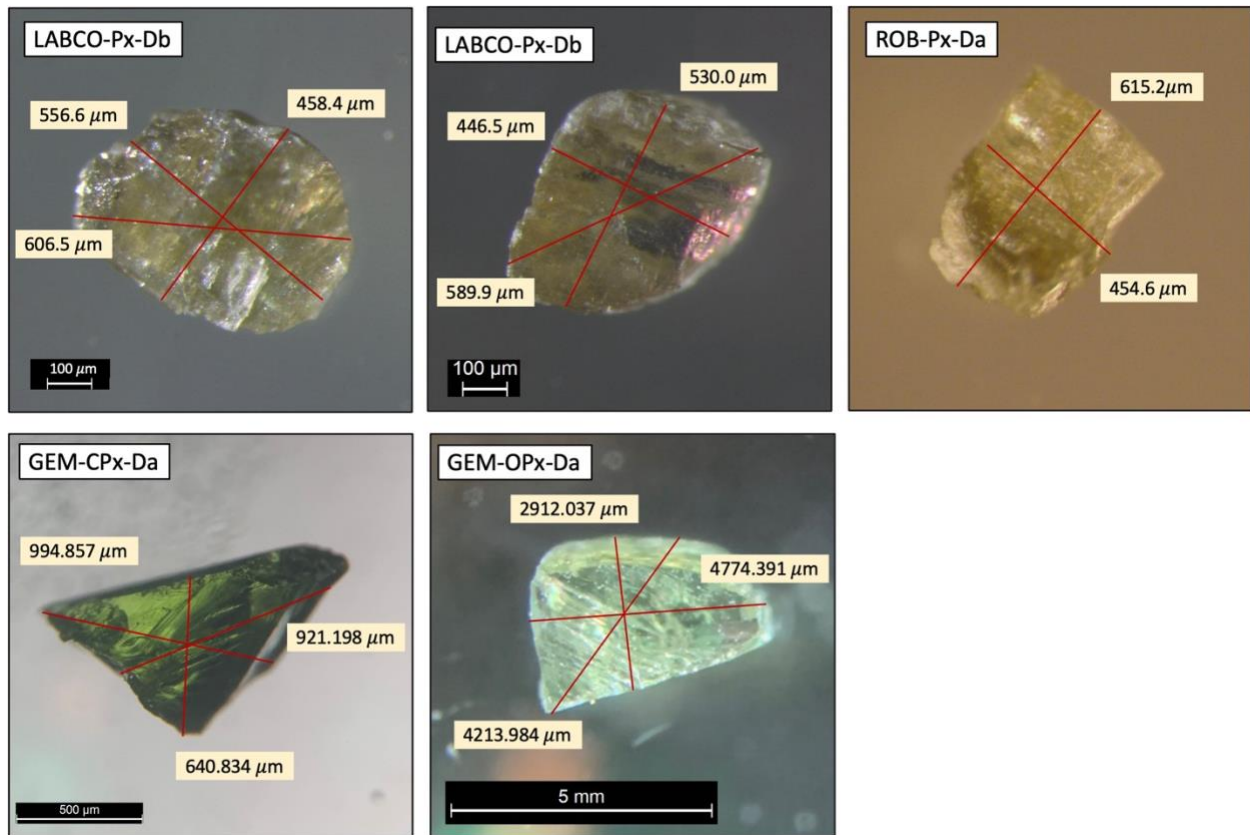


Figure S2 Photographs of irradiated pyroxene grains

Figure S3 Forward-modeled MDD results for the HU-08-03 quartz grains, when (a) excluding and (b) including forward modeled irradiation and storage loss prior to step degassing experiment. Each result is displayed in the Arrhenius, fractional release, and residual plots. Colored circles show the observed apparent ^3He diffusivity from the step-heating experiment. Vertical lines show the uncertainty in $\ln(D/a^2)$. Black dots show the modeled predicted apparent diffusivity from the best reduced misfit, where the grey lines represent the diffusion kinetics of each individual domain modeled, with the line thickness being proportional to the fractional size of the domain. The Fractional release plot compares the measured and predicted fractional gas release from each heating step during the diffusion experiment. The residuals are defined as the difference between the calculated $\ln(D/a^2)$ from a given heating step and the expected $\ln(D/a^2)$ from the first MDD model domain at that same temperature and plotted against the cumulative gas release.

