

## Aberystwyth University

### *Integrating the INTIMATE records using tephrochronology: rising to the challenge*

Davies, Siwan M. ; Abbott, Peter M.; Pearce, N. J. G.; Wastegård, Stefan; Blockley, Simon P. E.

*Published in:*  
Quaternary Science Reviews

*DOI:*  
[10.1016/j.quascirev.2011.04.005](https://doi.org/10.1016/j.quascirev.2011.04.005)

*Publication date:*  
2012

*Citation for published version (APA):*

Davies, S. M., Abbott, P. M., Pearce, N. J. G., Wastegård, S., & Blockley, S. P. E. (2012). Integrating the INTIMATE records using tephrochronology: rising to the challenge. *Quaternary Science Reviews*, 36, 11-27. <https://doi.org/10.1016/j.quascirev.2011.04.005>

**Document License**  
CC BY

**General rights**

Copyright and moral rights for the publications made accessible in the Aberystwyth Research Portal (the Institutional Repository) are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the Aberystwyth Research Portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the Aberystwyth Research Portal

**Take down policy**

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

tel: +44 1970 62 2400  
email: [is@aber.ac.uk](mailto:is@aber.ac.uk)

**Major oxide concentrations of shards from the NGRIP 1848 m tephra horizon. n = number of shards analysed. Mean and 1 standard deviations are shown. All oxides are presented as weight %. Total iron is expressed as FeO.**

n	SiO <sub>2</sub>	TiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	FeO	MnO	MgO	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	Total
<b>NGRIP 1848 m</b>											
1	51.54	3.35	12.62	14.07	0.32	4.09	8.25	3.16	0.66	0.63	98.69
2	50.86	3.36	11.99	14.07	0.31	4.19	8.79	2.60	0.65	0.54	97.37
3	50.61	3.48	12.42	13.50	0.24	4.40	8.74	2.92	0.64	0.55	97.50
4	49.97	3.61	12.29	14.25	0.32	4.51	8.66	3.02	0.63	0.50	97.77
5	49.96	3.68	12.40	14.75	0.20	4.60	9.12	2.89	0.61	0.54	98.77
6	49.90	3.76	12.41	15.52	0.16	4.55	8.92	2.89	0.60	0.53	99.24
7	49.84	3.74	12.02	15.47	0.28	4.75	9.08	2.80	0.58	0.47	99.03
8	49.82	3.60	12.42	14.86	0.26	4.66	8.84	2.85	0.58	0.53	98.41
9	49.36	3.74	12.33	14.62	0.25	4.48	9.06	2.75	0.50	0.47	97.55
10	49.27	3.79	12.21	14.38	0.22	4.76	9.09	2.87	0.52	0.48	97.59
11	49.22	3.58	12.22	14.83	0.40	4.84	9.18	2.83	0.57	0.44	98.11
12	49.12	3.63	12.25	14.29	0.19	4.63	9.00	2.89	0.55	0.49	97.05
13	48.93	3.63	12.33	15.07	0.26	4.72	9.01	2.83	0.54	0.50	97.82
14	48.84	3.63	12.52	15.21	0.23	4.75	9.29	2.80	0.55	0.48	98.32
15	48.72	3.66	12.54	15.33	0.24	4.85	9.21	2.86	0.51	0.45	98.38
<b>Mean</b>	<b>49.73</b>	<b>3.62</b>	<b>12.33</b>	<b>14.68</b>	<b>0.26</b>	<b>4.59</b>	<b>8.95</b>	<b>2.86</b>	<b>0.58</b>	<b>0.51</b>	<b>98.11</b>
St. Dev.	0.80	0.13	0.18	0.58	0.06	0.22	0.26	0.12	0.05	0.05	0.65

**Major oxide concentrations of shards from the LINK 17:634 tephra horizon. n = number of shards analysed. Mean and 1 standard deviations are shown. All oxides are presented as weight %. Total iron is expressed as FeO.**

n	SiO <sub>2</sub>	TiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	FeO	MnO	MgO	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	Total
<b>LINK 17:634</b>											
1a	49.12	3.68	12.45	15.02	0.28	4.66	9.06	2.87	0.57	0.51	98.22
1b	49.48	3.74	12.48	15.15	0.23	4.69	9.03	3.01	0.53	0.44	98.78
2a	49.82	3.78	12.75	15.14	0.20	4.25	8.98	3.15	0.61	0.47	99.13
2b	49.31	3.68	12.59	14.92	0.28	4.59	9.10	2.85	0.59	0.46	98.36
3a	49.90	3.88	12.63	15.14	0.19	4.76	9.14	2.77	0.55	0.47	99.43
3b	49.72	3.85	12.49	14.86	0.25	4.86	8.85	2.77	0.56	0.48	98.69
4a	48.92	3.86	12.55	15.18	0.34	4.61	8.93	2.94	0.54	0.47	98.34
4b	49.60	3.85	12.41	15.52	0.17	4.68	8.58	2.99	0.61	0.53	98.95
5a	49.00	3.65	12.40	15.25	0.23	4.56	8.91	2.92	0.56	0.46	97.95
6	49.35	3.89	12.73	15.86	0.33	4.73	9.00	2.99	0.58	0.53	99.98
7a	49.29	4.17	12.58	15.63	0.23	4.58	8.82	2.97	0.53	0.42	99.22
7b	49.69	3.73	11.57	14.13	0.32	6.49	9.70	2.57	0.51	0.48	99.20
8a	49.20	3.74	12.36	14.77	0.22	4.49	8.82	2.91	0.57	0.49	97.57
8b	48.80	3.90	12.44	15.53	0.26	4.81	9.03	2.85	0.55	0.46	98.62
9a	49.03	3.90	12.54	14.95	0.30	4.72	8.93	2.88	0.56	0.46	98.25
9b	49.21	3.86	12.36	14.54	0.17	4.69	9.04	2.85	0.55	0.52	97.79
10a	49.25	3.59	12.38	15.40	0.17	4.57	8.57	2.90	0.63	0.52	97.98
10b	49.55	3.77	12.40	14.75	0.29	4.56	8.58	2.96	0.55	0.52	97.93
<b>Mean</b>	<b>49.35</b>	<b>3.80</b>	<b>12.45</b>	<b>15.10</b>	<b>0.25</b>	<b>4.74</b>	<b>8.95</b>	<b>2.90</b>	<b>0.56</b>	<b>0.48</b>	<b>98.58</b>
St. Dev.	0.32	0.13	0.25	0.42	0.06	0.46	0.26	0.12	0.03	0.03	0.65

Trace element ratios from individual analyses of tephra shards from the NGRIP 1848 m tephra horizon. All elements have been ratioed to Ce. To calculate the average ratio of any element pair divide the ratios by each other, this will remove the influence of Ce. Mean and 1 standard deviations are shown.

<b>NGRIP 1848 m</b>							
<b>n</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>Mean</b>	<b>St. Dev.</b>
Sc	0.527	0.735	0.787	0.806	0.907	<b>0.752</b>	0.141
Rb	0.549	0.232	0.716	0.469	0.282	<b>0.450</b>	0.198
Sr	4.699	5.639	5.303	5.025	5.602	<b>5.253</b>	0.397
Y	1.234	1.191	1.157	1.029	1.117	<b>1.146</b>	0.078
Zr	6.331	5.781	6.971	5.808	5.820	<b>6.142</b>	0.517
Nb	0.575	0.570	0.563	0.461	0.553	<b>0.544</b>	0.047
Cs	0.008	-0.007	0.014	-0.005	0.013	<b>0.005</b>	0.010
Ba	4.287	3.341	6.643	4.445	3.600	<b>4.463</b>	1.303
La	0.474	0.417	0.535	0.406	0.482	<b>0.463</b>	0.052
Ce	1.000	1.000	1.000	1.000	1.000	<b>1.000</b>	0.000
Pr	0.122	0.158	0.148	0.123	0.144	<b>0.139</b>	0.016
Nd	0.742	0.845	0.577	0.566	0.761	<b>0.698</b>	0.122
Sm	0.187	0.188	0.239	0.215	0.188	<b>0.204</b>	0.023
Eu	0.052	0.052	0.081	0.030	0.069	<b>0.057</b>	0.019
Gd	0.194	0.214	0.263	0.175	0.214	<b>0.212</b>	0.033
Tb	0.039	0.028	0.027	0.020	0.023	<b>0.027</b>	0.007
Dy	0.245	0.256	0.198	0.190	0.253	<b>0.228</b>	0.032
Ho	0.039	0.051	0.043	0.034	0.050	<b>0.043</b>	0.007
Er	0.144	0.125	0.085	0.118	0.106	<b>0.116</b>	0.022
Tm	0.013	0.021	0.014	0.012	0.017	<b>0.015</b>	0.004
Yb	0.101	0.125	0.107	0.115	0.139	<b>0.117</b>	0.015
Lu	0.014	0.009	0.046	0.016	0.011	<b>0.019</b>	0.015
Hf	0.199	0.159	0.176	0.173	0.196	<b>0.181</b>	0.017
Ta	0.041	0.037	0.042	0.038	0.032	<b>0.038</b>	0.004
Th	0.049	0.043	0.043	0.035	0.029	<b>0.040</b>	0.008
U	0.009	0.015	0.013	0.011	0.012	<b>0.012</b>	0.002

Trace element ratios from individual analyses of tephra shards from the LINK 17:634 tephra horizon. All elements have been ratioed to Ce. To calculate the average ratio of any element pair divide the ratios by each other, this will remove the influence of Ce. Mean and 1 standard deviations are shown.

LINK 17:634																			
n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Mean	St. Dev.
Sc	0.744	0.946	0.921	0.851	1.041	0.889	0.660	0.889	0.768	1.045	0.745	0.816	0.664	0.733	0.903	0.691	0.734	<b>0.826</b>	0.122
Rb	0.246	0.303	0.300	0.399	0.273	0.293	0.525	0.275	0.510	0.282	0.304	0.254	0.269	0.325	0.516	0.276	0.248	<b>0.329</b>	0.096
Sr	5.449	5.900	5.439	5.008	5.192	5.134	4.646	5.115	4.473	4.864	5.093	4.605	3.820	4.965	5.031	4.689	4.524	<b>4.938</b>	0.468
Y	1.104	1.130	1.155	1.034	1.088	0.943	1.005	1.113	0.959	1.038	1.056	0.899	0.817	1.047	1.011	0.996	1.044	<b>1.026</b>	0.087
Zr	5.257	5.104	5.123	4.547	5.326	4.845	4.839	5.127	4.538	5.042	5.250	4.676	4.054	4.820	4.856	4.729	4.898	<b>4.884</b>	0.322
Nb	0.560	0.545	0.579	0.495	0.576	0.527	0.492	0.565	0.423	0.499	0.541	0.482	0.387	0.459	0.519	0.454	0.549	<b>0.509</b>	0.055
Cs	0.007	0.003	0.003	0.010	0.003	0.002	0.004	0.008	0.024	0.009	0.002	0.017	0.011	0.003	0.021	0.006	0.001	<b>0.008</b>	0.007
Ba	2.863	2.741	4.189	2.884	2.943	2.691	2.717	2.850	3.265	2.750	2.867	2.529	2.197	2.880	2.828	2.465	2.411	<b>2.828</b>	0.426
La	0.492	0.442	0.441	0.390	0.434	0.405	0.422	0.419	0.354	0.433	0.407	0.379	0.335	0.421	0.436	0.420	0.429	<b>0.415</b>	0.036
Ce	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	<b>1.000</b>	0.000
Pr	0.129	0.148	0.150	0.131	0.163	0.151	0.154	0.147	0.118	0.142	0.141	0.131	0.115	0.146	0.155	0.133	0.148	<b>0.141</b>	0.013
Nd	0.690	0.668	0.732	0.633	0.735	0.596	0.602	0.647	0.617	0.674	0.702	0.596	0.628	0.634	0.612	0.715	0.612	<b>0.653</b>	0.048
Sm	0.181	0.159	0.198	0.151	0.185	0.202	0.181	0.197	0.156	0.128	0.180	0.165	0.132	0.214	0.164	0.195	0.180	<b>0.175</b>	0.024
Eu	0.056	0.080	0.063	0.046	0.062	0.068	0.050	0.077	0.063	0.062	0.058	0.050	0.043	0.057	0.056	0.057	0.049	<b>0.059</b>	0.010
Gd	0.323	0.249	0.242	0.189	0.225	0.212	0.176	0.215	0.207	0.239	0.207	0.192	0.153	0.222	0.209	0.219	0.216	<b>0.217</b>	0.036
Tb	0.036	0.026	0.037	0.031	0.036	0.027	0.035	0.037	0.028	0.031	0.024	0.027	0.032	0.037	0.029	0.028	0.033	<b>0.032</b>	0.004
Dy	0.233	0.263	0.267	0.205	0.254	0.218	0.170	0.229	0.192	0.195	0.207	0.222	0.176	0.207	0.207	0.215	0.194	<b>0.215</b>	0.028
Ho	0.045	0.040	0.054	0.039	0.042	0.042	0.035	0.035	0.043	0.045	0.039	0.033	0.039	0.038	0.033	0.043	0.043	<b>0.041</b>	0.005
Er	0.122	0.113	0.153	0.100	0.123	0.110	0.147	0.129	0.097	0.101	0.099	0.111	0.094	0.113	0.148	0.112	0.125	<b>0.118</b>	0.018
Tm	0.017	0.022	0.021	0.017	0.020	0.015	0.019	0.020	0.016	0.014	0.017	0.010	0.024	0.016	0.016	0.015	0.016	<b>0.017</b>	0.003
Yb	0.095	0.081	0.106	0.113	0.117	0.078	0.081	0.126	0.109	0.106	0.092	0.089	0.077	0.105	0.099	0.102	0.116	<b>0.100</b>	0.015
Lu	0.019	0.016	0.036	0.021	0.025	0.020	0.013	0.019	0.012	0.018	0.009	0.015	0.013	0.011	0.018	0.016	0.018	<b>0.018</b>	0.006
Hf	0.116	0.142	0.174	0.152	0.129	0.139	0.138	0.137	0.138	0.125	0.148	0.139	0.109	0.136	0.128	0.140	0.154	<b>0.138</b>	0.015
Ta	0.041	0.036	0.048	0.038	0.047	0.045	0.043	0.057	0.036	0.025	0.045	0.035	0.033	0.040	0.041	0.037	0.038	<b>0.040</b>	0.007
Th	0.042	0.041	0.051	0.049	0.047	0.040	0.059	0.043	0.055	0.038	0.037	0.039	0.038	0.043	0.056	0.047	0.047	<b>0.045</b>	0.007
U	0.011	0.012	0.016	0.017	0.010	0.012	0.017	0.015	0.014	0.010	0.013	0.013	0.014	0.014	0.016	0.016	0.013	<b>0.014</b>	0.002

**Major oxide concentrations of shards from the GRIP 1528.61 m tephra horizon. n = number of shards analysed. Mean and 1 standard deviations are shown. All oxides are presented as weight %. Total iron is expressed as FeO.**

n	SiO <sub>2</sub>	TiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	FeO	MnO	MgO	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	Total
<b>GRIP 1528.61 m</b>											
1	48.32	2.69	12.59	13.18	0.22	5.69	10.04	2.50	0.41	0.30	95.94
2	48.13	3.06	12.49	13.31	0.28	4.87	9.23	2.73	0.47	0.43	95.01
3	47.72	2.88	12.38	13.49	0.18	5.38	9.79	2.56	0.50	0.36	95.25
4	47.71	2.71	12.07	13.67	0.29	6.87	8.99	2.53	0.46	0.35	95.65
5	48.61	2.63	12.93	13.61	0.22	5.10	9.89	2.35	0.44	0.36	96.14
6	48.18	2.72	12.68	12.40	0.14	5.81	9.93	2.42	0.38	0.36	95.02
7	47.63	2.75	12.54	13.42	0.20	5.69	9.95	2.54	0.37	0.30	95.39
8	47.92	2.81	12.61	12.53	0.11	5.79	10.08	2.44	0.41	0.43	95.14
9	47.82	2.79	12.73	13.06	0.17	5.62	9.78	2.40	0.41	0.36	95.13
10	47.65	2.72	12.55	13.58	0.21	5.73	9.89	2.61	0.36	0.35	95.64
11	47.87	2.84	12.54	13.20	0.14	5.79	9.91	2.44	0.42	0.40	95.55
12	47.94	2.80	12.60	13.01	0.27	5.69	10.09	2.48	0.42	0.37	95.67
13	47.91	2.61	12.64	13.05	0.15	5.68	9.86	2.44	0.40	0.37	95.11
14	47.80	2.53	12.62	13.02	0.28	5.72	9.93	2.42	0.44	0.34	95.11
15	48.06	2.98	12.42	14.05	0.23	5.19	9.41	2.44	0.45	0.52	95.75
16	48.03	2.81	12.66	13.50	0.25	5.72	10.00	2.40	0.41	0.38	96.16
17	47.96	2.78	12.69	13.02	0.27	5.65	10.18	2.29	0.43	0.33	95.59
18	48.32	2.84	12.80	12.82	0.16	5.54	9.81	2.56	0.41	0.41	95.68
19	48.00	2.70	12.32	12.57	0.24	6.64	10.36	2.31	0.39	0.32	95.84
20	47.84	2.71	12.52	13.06	0.35	5.67	10.09	2.35	0.42	0.38	95.40
21	48.56	3.06	12.99	13.86	0.23	4.23	9.01	2.81	0.46	0.31	95.52
22	48.11	3.07	12.47	13.59	0.34	5.40	9.64	2.53	0.41	0.38	95.93
<b>Mean</b>	<b>48.00</b>	<b>2.79</b>	<b>12.58</b>	<b>13.23</b>	<b>0.22</b>	<b>5.61</b>	<b>9.81</b>	<b>2.48</b>	<b>0.42</b>	<b>0.37</b>	<b>95.53</b>
St. Dev.	0.27	0.15	0.20	0.43	0.06	0.53	0.36	0.13	0.03	0.05	0.35

**Major oxide concentrations of shards from the LINK 14:185 tephra horizon. n = number of shards analysed. Mean and 1 standard deviations are shown. All oxides are presented as weight %. Total iron is expressed as FeO.**

n	SiO <sub>2</sub>	TiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	FeO	MnO	MgO	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	Total
<b>LINK 14:185</b>											
1	48.67	2.92	12.76	14.05	0.17	5.76	10.05	2.53	0.47	0.39	97.77
2a	49.37	3.22	12.84	14.47	0.24	5.59	10.07	2.35	0.48	0.39	99.03
2b	48.92	3.25	12.63	14.65	0.28	5.63	10.13	2.38	0.46	0.30	98.65
3a	48.40	3.22	12.42	14.53	0.26	5.39	9.61	2.59	0.46	0.29	97.17
3b	48.37	3.38	12.49	14.08	0.18	5.44	9.65	2.63	0.45	0.42	97.09
3c	48.01	3.26	12.32	14.60	0.30	5.33	9.79	2.74	0.49	0.41	97.24
4a	48.69	2.93	12.73	14.27	0.19	5.68	10.27	2.56	0.42	0.36	98.11
4b	48.56	3.12	12.71	14.45	0.26	5.80	10.17	2.42	0.42	0.32	98.24
4c	48.64	2.97	12.54	13.94	0.27	5.72	10.17	2.66	0.41	0.37	97.69
5a	47.82	2.90	12.70	14.26	0.31	5.60	9.99	2.57	0.42	0.34	96.92
5b	48.52	2.90	12.65	13.77	0.19	5.60	10.10	2.58	0.42	0.29	97.02
5c	48.79	2.87	12.71	13.60	0.20	5.66	10.12	2.56	0.41	0.31	97.23
<b>Mean</b>	<b>48.56</b>	<b>3.08</b>	<b>12.63</b>	<b>14.22</b>	<b>0.24</b>	<b>5.60</b>	<b>10.01</b>	<b>2.55</b>	<b>0.44</b>	<b>0.35</b>	<b>97.68</b>
St. Dev.	0.40	0.18	0.15	0.34	0.05	0.15	0.21	0.11	0.03	0.05	0.69

Trace element ratios from individual analyses of tephra shards from the GRIP 1528.61 m tephra horizon. All elements have been ratioed to Ce. To calculate the average ratio of any element pair divide the ratios by each other, this will remove the influence of Ce. Mean and 1 standard deviations are shown.

GRIP 1528.61 m											
n	1	2	3	4	5	6	7	8	9	Mean	St. Dev.
Sc	1.264	1.028	1.471	1.081	1.287	1.353	1.180	0.935	1.343	<b>1.216</b>	0.174
Rb	0.392	0.183	0.410	0.370	0.368	0.357	0.335	0.253	0.252	<b>0.324</b>	0.077
Sr	6.571	6.070	8.344	6.886	7.838	6.422	7.752	6.676	7.888	<b>7.161</b>	0.801
Y	1.382	1.203	1.495	1.328	1.544	1.290	1.520	1.264	1.287	<b>1.368</b>	0.124
Zr	6.222	6.828	6.895	6.232	5.881	5.725	6.540	5.782	6.838	<b>6.327</b>	0.469
Nb	0.562	0.538	0.513	0.643	0.465	0.565	0.549	0.650	0.653	<b>0.571</b>	0.066
Cs	0.005	0.019	-0.013	-0.002	0.005	0.023	0.001	0.010	0.002	<b>0.005</b>	0.011
Ba	3.809	2.899	4.674	3.504	4.320	3.906	3.149	3.429	3.650	<b>3.704</b>	0.553
La	0.418	0.457	0.475	0.429	0.412	0.409	0.431	0.453	0.475	<b>0.440</b>	0.026
Ce	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	<b>1.000</b>	0.000
Pr	0.140	0.168	0.147	0.158	0.144	0.151	0.150	0.166	0.127	<b>0.150</b>	0.013
Nd	0.609	0.640	0.810	0.753	0.829	0.663	0.566	0.418	0.609	<b>0.655</b>	0.129
Sm	0.154	0.205	0.225	0.219	0.123	0.105	0.217	0.144	0.236	<b>0.181</b>	0.050
Eu	0.058	0.080	0.153	0.087	0.108	0.082	0.080	0.115	0.101	<b>0.096</b>	0.027
Gd	0.198	0.227	0.272	0.174	0.215	0.186	0.287	0.178	0.233	<b>0.219</b>	0.040
Tb	0.040	0.044	0.048	0.045	0.033	0.039	0.028	0.043	0.031	<b>0.039</b>	0.007
Dy	0.261	0.240	0.283	0.317	0.253	0.260	0.286	0.196	0.303	<b>0.267</b>	0.036
Ho	0.058	0.032	0.047	0.055	0.049	0.039	0.045	0.046	0.044	<b>0.046</b>	0.008
Er	0.156	0.107	0.096	0.114	0.172	0.132	0.134	0.159	0.118	<b>0.132</b>	0.026
Tm	0.013	0.013	0.017	0.020	0.017	0.016	0.015	0.015	0.022	<b>0.016</b>	0.003
Yb	0.123	0.087	0.133	0.120	0.118	0.125	0.119	0.097	0.109	<b>0.115</b>	0.014
Lu	0.027	0.012	0.021	0.022	0.023	0.010	0.017	0.023	0.014	<b>0.019</b>	0.006
Hf	0.146	0.104	0.187	0.156	0.135	0.132	0.167	0.207	0.179	<b>0.157</b>	0.032
Ta	0.030	0.035	0.052	0.027	0.046	0.040	0.039	0.039	0.030	<b>0.038</b>	0.008
Th	0.041	0.033	0.054	0.039	0.035	0.038	0.026	0.034	0.039	<b>0.038</b>	0.008
U	0.008	0.008	0.010	0.012	0.012	0.011	0.005	0.011	0.012	<b>0.010</b>	0.003

Trace element ratios from individual analyses of tephra shards from the LINK 14:185 tephra horizon. All elements have been ratioed to Ce. To calculate the average ratio of any element pair divide the ratios by each other, this will remove the influence of Ce. Mean and 1 standard deviations are shown.

LINK 14:185											
n	1	2	3	4	5	6	7	8	Mean	St. Dev.	
Sc	0.979	0.825	0.622	0.730	0.785	0.814	0.732	0.676	<b>0.770</b>	0.109	
Rb	0.384	0.302	0.357	0.238	0.225	0.241	0.201	0.185	<b>0.267</b>	0.073	
Sr	9.477	5.883	7.241	5.200	4.928	6.990	5.444	5.529	<b>6.336</b>	1.514	
Y	1.073	1.065	0.917	1.101	1.080	1.001	1.028	0.863	<b>1.016</b>	0.085	
Zr	4.639	4.990	4.332	4.757	4.972	4.444	4.859	3.853	<b>4.606</b>	0.385	
Nb	0.439	0.478	0.404	0.457	0.496	0.410	0.458	0.368	<b>0.439</b>	0.042	
Cs	0.007	0.015	0.005	0.002	0.003	0.004	0.003	0.003	<b>0.005</b>	0.004	
Ba	2.136	3.721	3.318	2.416	2.262	2.156	2.205	1.923	<b>2.517</b>	0.643	
La	0.428	0.442	0.392	0.380	0.423	0.440	0.393	0.326	<b>0.403</b>	0.039	
Ce	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	<b>1.000</b>	0.000	
Pr	0.160	0.133	0.115	0.124	0.134	0.188	0.142	0.118	<b>0.139</b>	0.024	
Nd	0.468	0.702	0.629	0.654	0.665	0.612	0.672	0.571	<b>0.622</b>	0.074	
Sm	0.156	0.220	0.181	0.191	0.165	0.140	0.148	0.167	<b>0.171</b>	0.026	
Eu	0.055	0.063	0.052	0.045	0.056	0.045	0.066	0.047	<b>0.054</b>	0.008	
Gd	0.178	0.151	0.136	0.222	0.217	0.198	0.206	0.163	<b>0.184</b>	0.032	
Tb	0.037	0.029	0.030	0.030	0.033	0.030	0.030	0.026	<b>0.031</b>	0.003	
Dy	0.211	0.248	0.205	0.212	0.241	0.220	0.218	0.178	<b>0.217</b>	0.022	
Ho	0.040	0.043	0.040	0.050	0.049	0.038	0.049	0.044	<b>0.044</b>	0.005	
Er	0.141	0.102	0.092	0.139	0.125	0.125	0.174	0.106	<b>0.126</b>	0.026	
Tm	0.018	0.020	0.012	0.020	0.018	0.023	0.022	0.017	<b>0.019</b>	0.003	
Yb	0.112	0.116	0.137	0.139	0.123	0.115	0.131	0.105	<b>0.122</b>	0.012	
Lu	0.018	0.019	0.015	0.018	0.019	0.017	0.015	0.019	<b>0.018</b>	0.001	
Hf	0.156	0.161	0.104	0.160	0.145	0.133	0.164	0.129	<b>0.144</b>	0.021	
Ta	0.038	0.037	0.031	0.030	0.038	0.036	0.031	0.036	<b>0.035</b>	0.003	
Th	0.042	0.046	0.037	0.035	0.040	0.047	0.041	0.038	<b>0.041</b>	0.004	
U	0.055	0.028	0.024	0.013	0.012	0.017	0.014	0.012	<b>0.022</b>	0.015	

Average and standard deviation values of analyses of the reference standard glasses BCR2G, TB1G and Cannelto Lami Lava (Lipari) made throughout the EPMA analysis period during which the NGRIP 1848 m, LINK 17:634, GRIP 1528.61 m and LINK 14:185 horizons were analysed. EPMA operating conditions during the analysis period were (1) Accelerating voltage: 10 kV; Beam current: 10 nA; Beam diameter: 10 µm. Recommended values for BCR2G from [http://minerals.cr.usgs.gov/geo\\_chem\\_stand/basaltbcr2.html](http://minerals.cr.usgs.gov/geo_chem_stand/basaltbcr2.html) (accessed 14/05/10), for TB1G from Potts et al. (2002) and for Lipari (a) Sparks, R.S.J. (1990) – written communication to University of Edinburgh and (b) Hunt and Hill (1996).

Standard	n	SiO <sub>2</sub>	TiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	FeO	MnO	MgO	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	Cl	Total
BCR2G	60	53.68 (0.38)	2.37 (0.07)	13.19 (0.12)	12.98 (0.41)	0.21 (0.07)	3.69 (0.05)	7.27 (0.12)	3.09 (0.07)	1.78 (0.05)	0.37 (0.03)	n/a	98.65 (0.40)
<b>Recommended Values</b>		<b>54.1 (0.8)</b>	<b>2.26 (0.05)</b>	<b>13.5 (0.2)</b>	<b>12.42 (n/a)</b>	<b>0.20 (n/a)</b>	<b>3.59 (0.05)</b>	<b>7.12 (0.11)</b>	<b>3.16 (0.11)</b>	<b>1.79 (0.05)</b>	<b>0.35 (0.02)</b>	<b>n/a</b>	<b>98.49</b>
TB1G	60	53.77 (0.23)	0.89 (0.05)	16.33 (0.12)	8.61 (0.28)	0.19 (0.06)	3.64 (0.03)	6.88 (0.10)	3.20 (0.06)	4.45 (0.08)	0.60 (0.04)	n/a	98.55 (0.45)
<b>Recommended Values</b>		<b>54.22 (1.19)</b>	<b>0.85 (0.04)</b>	<b>16.68 (0.44)</b>	<b>8.14 (n/a)</b>	<b>0.18 (0.01)</b>	<b>3.64 (0.12)</b>	<b>6.87 (0.21)</b>	<b>3.20 (0.11)</b>	<b>4.37 (0.14)</b>	<b>0.59 (0.03)</b>	<b>n/a</b>	<b>98.74</b>
Lipari	56	74.25 (0.31)	0.07 (0.03)	12.93 (0.11)	1.57 (0.14)	0.07 (0.05)	0.04 (0.01)	0.75 (0.03)	4.02 (0.08)	5.17 (0.09)	-0.01 (0.03)	n/a	98.89 (0.40)
<b>Recommended Values</b>	<b>a</b> <b>b</b>	<b>74.03</b> <b>73.72</b>	<b>0.08</b> <b>n/a</b>	<b>12.72</b> <b>13.04</b>	<b>1.75</b> <b>1.76</b>	<b>0.08</b> <b>n/a</b>	<b>0.00</b> <b>0.03</b>	<b>0.72</b> <b>0.76</b>	<b>4.06</b> <b>4.06</b>	<b>5.18</b> <b>5.06</b>	<b>n/a</b> <b>n/a</b>	<b>0</b> <b>n/a</b>	<b>98.62</b> <b>98.43</b>

Trace element analytical data from USGS Glass secondary standards BCR-2G and BHVO-2G analysed as part of this study. Reference composition data from GeoReM database (see Jochum et al. 2005).

Element Isotope	USGS Glass Reference Material BCR-2G						USGS Glass Reference Material BHVO-2G					
	Geo ReM	Unc	Aber (n=5)	Unc	Aber/ Geo ReM	RSD %	Geo ReM	Unc	Aber (n=5)	Unc	Aber/ Geo ReM	RSD %
Sc 45	33	2	38.1	1.47	1.15	3.9%	33	2	37.3	1.71	1.13	4.6%
Rb 85	47	0.5	49.0	6.40	1.04	13%	9.2	0.04	7.73	0.66	0.84	8.6%
Sr 88	342	4	339	13.3	0.99	3.9%	396	1	394	15.6	0.99	3.9%
Y 89	35	3	32.3	1.63	0.92	5.1%	26	2	24.5	1.23	0.94	5.0%
Zr 90	184	15	163	12.4	0.89	7.6%	170	7	159	10.5	0.94	6.6%
Nb 93	12.5	1	13.1	1.36	1.05	10%	18.3	0.8	17.9	1.03	0.98	5.7%
Cs 133	1.16	0.07	1.3	0.19	1.16	14%	0.1	0.02	0.13	0.04	1.30	27%
Ba 138	683	7	695	42.9	1.02	6.2%	131	2	128	6.39	0.98	5.0%
La 139	24.7	0.3	24.0	1.50	0.97	6.3%	15.2	0.2	15.2	0.85	1.00	5.6%
Ce 140	53.3	0.5	52.7	3.44	0.99	6.5%	37.6	0.2	35.9	2.52	0.96	7.0%
Pr 141	6.7	0.4	6.54	0.44	0.98	6.8%	5.35	0.22	5.09	0.35	0.95	6.9%
Nd 146	28.9	0.3	27.8	1.04	0.96	3.7%	24.5	0.2	24.2	1.89	0.99	7.8%
Sm 147	6.59	0.07	6.09	0.57	0.92	9.4%	6.1	0.03	5.73	0.59	0.94	10%
Eu 151	1.97	0.02	1.94	0.16	0.99	8.4%	2.07	0.01	2.11	0.17	1.02	8.1%
Gd 157	6.71	0.07	6.33	0.31	0.94	4.8%	6.16	0.05	5.87	0.56	0.95	9.5%
Tb 159	1.02	0.08	0.91	0.04	0.90	4.9%	0.92	0.04	0.89	0.12	0.97	13%
Dy 163	6.44	0.06	6.26	0.43	0.97	6.8%	5.28	0.05	5.18	0.14	0.98	2.8%
Ho 165	1.27	0.08	1.20	0.14	0.94	12%	0.98	0.04	1.00	0.12	1.02	12%
Er 166	3.7	0.04	3.36	0.25	0.91	7.5%	2.56	0.02	2.35	0.29	0.92	13%
Tm 169	0.51	0.04	0.47	0.10	0.93	20%	0.34	0.02	0.34	0.01	1.00	3.7%
Yb 174	3.39	0.03	3.54	0.26	1.04	7.4%	2.01	0.02	2.19	0.42	1.09	19%
Lu 175	0.503	0.005	0.49	0.10	0.98	21%	0.279	0.003	0.26	0.03	0.94	13%
Hf 180	4.84	0.28	4.92	0.79	1.02	16%	4.32	0.18	4.40	0.59	1.02	13%
Ta 181	0.78	0.06	0.79	0.10	1.02	13%	1.15	0.1	1.21	0.21	1.05	17%
Th 232	5.9	0.3	5.85	0.46	0.99	7.8%	1.22	0.05	1.28	0.14	1.05	11%
U 238	1.69	0.12	1.76	0.17	1.04	9.5%	0.403	0.003	0.42	0.04	1.03	9.0%

#### References (not included in manuscript)

- Hunt, J. B., and Hill, P. G. 1996. An inter-laboratory comparison of the electron probe microanalysis of glass geochemistry. *Quaternary International* **34-36**, 229-241.
- Potts, P. J., Thompson, M., and Wilson, S. 2002. G-Probe-1 - An international proficiency test for microprobe laboratories - Report on round 1 February 2002 (TB-1 basaltic glass). *Geostandards Newsletter-the Journal of Geostandards and Geoanalysis* **26**, 197-235.