

## Appendix E: Geochemical Data

### 1. Procedures

#### 1.1 General

The samples were crushed in a Tema swing mill grinder and then dissolved with hydrofluoric and perchloric acids and also by fusion with lithium metaborate and analysed by ICP-AES. The elements measured included: Si, Al, Fe, Mg, Ca, Na, K, Ti, P, Mn (quoted as weight per cent (wt%) oxides; Ba, Co, Cr, Cu, Li, Nb, Ni, Sc, Sr, V, Y, Zn & Zr (quoted as parts per million (ppm) element).

Precision for the measurement of the major elements (notably Si) was improved by the use of internal standardisation. Accuracy was monitored by the analysis of internal laboratory and international reference materials.

#### 1.2 HF digestion of the sample

0.2 g of the powdered sample was then dissolved in 6 ml of HF and HClO<sub>4</sub> (2:1 mixture). This was then evaporated to dryness, cooled and dissolved in 20 ml of 10% HNO<sub>3</sub>. This solution was analysed by ICP-AES for Na, K, Ti, P, Mn, Ba, Co, Cr, Cu, Li, Ni, Pb, Sc, Sr, V & Zn.

#### 1.3 Lithium metaborate fusion

0.2 g of powdered sample was weighed into a graphite crucible and 1.0 g of LiBO<sub>2</sub> added. The powders were carefully mixed and fused at 900 °C for 20 minutes. The resulting mixture was dissolved in 200 ml of cold 5% nitric acid. Ga is added to the flux to act as an internal standard to achieve an instrumental precision of better than 1% for the major elements. This solution was then analysed by ICP-AES for Si, Al, Fe, Mg, Ca, & Zr.

#### 1.4 Detection limits

Realistic working detection limits are quoted below. These values are an opinion based on analysis of many Certified International Reference materials. It is possible to quote 'detection limits' based on instrumental detection limits and dilution of the sample prior to analysis. This gives much lower detection limits but does not take into account sample preparation problems, longer term drift of instruments, etc.

ICP-AES Working detection limits for the trace elements:  
µg/g (ppm)

Ba	Co	Cr	Cu	Li	Ni	Sc	Sr	V	Zn	Zr
5	2	2	2	2	4	2	2	2	2	4

## Appendix E: Geochemical Data

### 2 – Major Oxides

*raw values (values recalculated for 100% total oxides used for plots)*

	code	SiO <sub>2</sub> wt %	Al <sub>2</sub> O <sub>3</sub> wt %	Fe <sub>2</sub> O <sub>3</sub> wt %	MgO wt %	CaO wt %	Na <sub>2</sub> O wt %	K <sub>2</sub> O wt %	TiO <sub>2</sub> wt %	P <sub>2</sub> O <sub>5</sub> wt %	MnO wt %
<b>Cleveland Dyke Sectors</b>											
<b>East of River Nith ERN</b>	CD39	56.07	13.35	11.11	4.25	6.91	2.73	1.87	1.16	0.22	0.17
	CD41	57.26	13.41	11.12	4.24	6.90	2.75	1.89	1.17	0.22	0.18
	CD88	54.68	13.43	11.93	4.50	7.52	2.49	1.65	1.23	0.25	0.19
	CD101	56.93	13.55	11.78	4.40	7.14	2.72	1.27	1.28	0.16	0.19
<b>Lochanhead LNH</b>	CD23	56.62	13.77	11.72	4.50	7.44	2.91	1.58	1.23	0.22	0.19
	CD25	55.62	13.68	12.34	4.69	7.80	2.96	1.22	1.28	0.21	0.20
	CD34	56.88	13.51	11.42	4.40	7.27	2.91	1.39	1.19	0.21	0.19
	CD38	54.24	13.66	13.28	4.59	7.99	2.60	1.49	1.41	0.22	0.20
	CD94	56.30	13.73	11.60	4.41	7.39	2.96	1.32	1.20	0.25	0.18
	CD105	56.13	13.54	12.35	4.61	7.46	2.70	1.08	1.27	0.14	0.19
<b>Braco BRA</b>	CD57	53.89	13.49	13.97	4.43	6.84	2.59	1.66	1.47	0.20	0.20
	CD58	59.02	13.71	10.77	3.82	5.56	2.35	2.92	1.18	0.22	0.17
	CD59	56.15	13.84	11.59	4.52	6.00	2.22	2.90	1.18	0.20	0.19
	CD78	54.85	13.79	12.70	4.64	7.16	2.51	1.42	1.30	0.23	0.20
	CD79	55.91	13.72	11.49	4.50	6.78	2.57	2.31	1.19	0.26	0.17
<b>Skeoch-Darngarroch SKD</b>	CD21	58.78	13.54	10.47	3.84	5.79	2.90	2.47	1.17	0.22	0.18
	CD22	58.13	13.65	10.64	3.92	5.48	2.46	3.85	1.17	0.23	0.18
	CD26	58.07	13.83	10.75	3.89	5.34	2.88	3.53	1.19	0.22	0.19
	CD27	58.85	13.53	10.82	3.87	5.49	2.89	3.01	1.18	0.22	0.19
	CD28	55.27	13.88	12.10	4.69	7.54	2.68	1.88	1.25	0.20	0.21
	CD30	56.39	13.66	11.49	4.69	6.73	2.98	1.86	1.21	0.22	0.21
	CD31	56.36	13.71	11.57	4.83	6.95	2.66	2.13	1.19	0.21	0.19
	CD56	59.18	13.69	10.73	3.73	4.96	2.59	3.04	1.18	0.22	0.18
	CD80	57.81	13.65	10.40	3.94	5.20	3.04	3.18	1.14	0.26	0.17
CD81	56.29	13.67	11.67	4.62	6.59	2.84	2.47	1.21	0.24	0.19	
<b>Castramon Hill CAS</b>	CD61	55.96	13.78	11.42	4.52	7.24	2.87	1.51	1.19	0.26	0.18
	CD89	56.41	13.94	11.63	4.60	7.41	2.97	1.47	1.22	0.28	0.18
	CD90	56.05	13.74	11.45	4.54	7.30	3.05	1.23	1.20	0.25	0.18
	CD92	56.15	13.66	11.21	4.32	7.21	3.07	1.32	1.19	0.26	0.18
<b>Craigmuir Moor CRM</b>	CD12	55.58	13.59	11.94	4.63	7.38	2.73	1.70	1.23	0.21	0.21
	CD13	55.57	13.69	11.46	4.62	7.33	2.70	1.81	1.22	0.22	0.21
	CD15	55.33	13.88	11.92	4.62	6.78	2.79	1.81	1.22	0.22	0.31
	CD51	57.31	13.79	11.75	4.73	6.74	2.85	1.33	1.21	0.21	0.18
	CD52	56.68	13.58	11.87	4.77	6.34	2.53	1.86	1.21	0.21	0.17
	CD55	56.90	13.76	11.74	4.66	6.25	2.49	2.13	1.19	0.21	0.19

	code	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
		wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %
<b>Shield Burn</b> SHB	CD1	57.45	13.48	10.59	3.92	5.66	3.09	2.45	1.14	0.22	0.18
	CD10	55.63	13.77	11.52	4.53	6.08	3.24	2.65	1.21	0.22	0.18
	CD2	54.42	13.75	11.98	4.72	7.48	2.70	1.71	1.25	0.21	0.20
	CD4	61.50	13.74	9.72	2.35	4.76	3.48	2.45	1.22	0.25	0.16
	CD46	63.97	13.27	8.64	1.91	2.93	2.53	3.57	1.15	0.26	0.13
	CD47	58.33	13.60	10.91	3.96	4.74	2.87	3.10	1.15	0.22	0.16
	CD5	54.11	13.77	12.99	4.87	7.50	2.74	1.65	1.36	0.22	0.22
	CD6	57.41	13.74	11.25	4.06	5.37	3.16	2.98	1.22	0.23	0.18
	CD7	54.66	13.54	12.43	4.88	7.15	2.82	1.71	1.29	0.21	0.20
CD8	52.75	13.42	13.46	4.69	6.99	2.88	1.74	1.45	0.21	0.21	
<b>Windy Standard</b> WST	WK3	56.70	13.79	11.78	4.57	6.82	2.82	1.34	1.22	0.21	0.18
	WK4	56.25	13.55	11.56	4.37	6.36	2.51	1.66	1.18	0.20	0.17
	CD82	56.13	13.85	11.36	4.40	7.39	2.86	1.47	1.21	0.26	0.18
	CD73	55.54	13.53	11.80	4.55	6.98	2.16	1.56	1.19	0.22	0.19
	CD75	55.58	13.73	12.19	4.66	7.34	2.36	1.41	1.27	0.22	0.19
	CD86	54.61	13.37	11.88	4.48	7.51	2.48	1.67	1.23	0.24	0.19
	CD93	55.02	13.42	11.44	4.51	7.42	2.76	1.38	1.21	0.26	0.18
	CD100	56.92	13.55	11.36	4.50	7.15	2.32	1.75	1.20	0.15	0.20
	CD102	55.52	12.89	11.53	4.57	6.98	2.54	1.11	1.20	0.14	0.19
CD103	56.02	13.38	11.86	4.73	7.17	2.67	1.14	1.23	0.15	0.19	
<b>Other Dykes</b>											
Coatshill Quarry	E1	60.03	13.87	8.58	4.44	6.39	2.56	2.74	0.84	0.21	0.13
Breconside	E2	58.18	14.21	9.13	4.91	6.38	2.63	2.49	0.90	0.23	0.14
Stoneyburn	S1	52.70	13.94	11.46	6.18	9.91	2.45	1.12	1.25	0.24	0.16
Stoneyburn	S4	55.87	13.69	10.45	5.30	8.27	2.56	1.82	1.14	0.24	0.16
Kello Water	KW1	51.80	13.67	14.06	5.35	7.81	2.34	1.08	1.39	0.22	0.23
Kello Water	KW2	50.99	14.02	13.30	4.78	8.21	2.23	0.95	1.43	0.22	0.17
Afton Water	AW1	50.76	13.23	15.30	4.41	7.35	2.67	1.31	2.07	0.31	0.22
Dalleagles Burn	AW5	51.58	13.07	14.65	4.17	7.54	2.84	1.38	2.04	0.26	0.24
Mossdale	M1	51.96	13.47	15.40	4.06	7.45	3.04	1.44	2.08	0.26	0.23
Dalgig Burn	DB	57.55	16.17	8.00	4.00	7.91	2.12	1.91	0.75	0.12	0.17
Vennel	V1	56.23	15.93	8.10	4.65	8.67	2.08	1.53	0.74	0.10	0.14

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### 3 - Trace Elements

	code	Ba	Co	Cr	Cu	Li	Nb	Ni	Sc	Sr	V	Y	Zn	Zr
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
<b>Cleveland Dyke Sectors</b>														
<b>East of River Nith</b> ERN	CD39	449	30	43	48	20	11	34	34	215	237	41	90	188
	CD41	468	29	43	35	19	11	26	34	214	238	44	89	192
	CD88	474	31	38	34	22		32	37	247	276	43	98	221
	CD101	444	31	34	40	12		23	37	225	262	43	98	209
<b>Lochanhead</b> LNH	CD23	507	31	44	40	15	11	32	37	246	260	45	97	218
	CD25	400	33	42	35	17	9	29	38	231	296	43	99	187
	CD34	473	30	43	39	18	11	29	35	228	253	43	95	189
	CD38	605	34	37	22	20	9	24	39	383	359	41	105	177
	CD94	448	30	43	39	14		32	36	231	252	43	99	235
	CD105	409	33	31	35	13		20	39	232	296	42	98	266
<b>Braco</b> BRA	CD57	438	36	37	22	37	10	23	41	261	391	49	92	160
	CD58	556	27	42	38	31	11	29	34	210	208	53	82	222
	CD59	521	30	47	39	28	10	30	37	211	251	47	80	144
	CD78	450	34	29	33	33	8	34	39	237	309	45	91	215
	CD79	486	29	45	53	66		39	37	234	250	44	92	217
<b>Skeoch-Darngarroch</b> SKD	CD21	593	26	41	35	34	12	28	31	201	206	46	94	249
	CD22	778	27	43	38	44	11	28	32	211	215	48	96	248
	CD26	707	27	40	34	39	13	29	31	202	214	48	97	226
	CD27	670	27	41	36	36	12	30	32	213	216	48	99	205
	CD28	474	31	43	29	47	10	26	38	228	282	43	104	174
	CD30	493	30	43	39	39	11	31	35	221	256	44	105	177
	CD31	532	31	46	40	36	10	30	37	217	263	41	96	175
	CD56	700	25	51	33	38	13	30	33	215	207	52	83	204
	CD80	552	26	52	76	36		55	32	201	195	46	94	273
	CD81	460	30	41	33	28		34	38	212	259	45	97	221
<b>Castramon Hill</b> CAS	CD61	440	30	43	40	19		31	37	233	250	43	98	226
	CD89	482	31	44	39	18		31	37	239	257	44	100	229
	CD90	443	31	43	39	21		34	37	229	253	43	100	221
	CD92	438	30	43	38	25		34	35	230	242	44	100	297
<b>Craigmuie Moor</b> CRM	CD12	448	33	45	33	23	8	24	38	223	270	45	86	82
	CD13	464	31	44	44	27	9	24	37	222	256	44	88	94
	CD15	485	33	39	39	26	8	26	37	222	256	46	87	68
	CD51	476	31	47	44	12	10	30	38	236	255	49	82	182
	CD52	465	31	48	59	19	10	34	38	215	253	49	87	180
	CD55	500	31	48	45	20	10	32	37	211	250	49	84	170

	<b>code</b>	<b>Ba</b>	<b>Co</b>	<b>Cr</b>	<b>Cu</b>	<b>Li</b>	<b>Nb</b>	<b>Ni</b>	<b>Sc</b>	<b>Sr</b>	<b>V</b>	<b>Y</b>	<b>Zn</b>	<b>Zr</b>
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
<b>Shield Burn</b>	CD1	600	26	46	42	39	10	25	32	209	199	46	79	165
SHB	CD10	521	31	39	40	25	9	24	37	201	250	46	86	84
	CD2	450	34	40	34	30	8	22	39	224	282	45	88	59
	CD4	794	19	29	23	18	13	16	26	234	142	56	89	244
	CD46	875	12	23	17	31	17	14	21	206	97	62	82	270
	CD47	546	27	42	45	22	11	30	34	175	211	53	80	192
	CD5	424	35	33	30	22	8	20	40	243	334	45	94	56
	CD6	570	28	38	35	26	10	23	33	184	221	49	88	104
	CD7	447	35	39	33	26	8	19	39	222	305	45	90	79
	CD8	458	35	32	18	28	7	13	40	237	374	41	96	73
<b>Windy Standard</b>	WK3	449	31	44	43	15	10	30	38	223	265	48	82	157
WST	WK4	435	30	43	45	23	10	26	36	214	256	45	80	164
	CD82	416	30	40	37	19		33	37	275	252	44	97	223
	CD73	606	31	39	31	18	9	38	37	263	254	44	86	220
	CD75	438	32	30	38	14	9	33	39	282	281	44	90	205
	CD86	458	32	38	34	23		30	37	245	275	43	99	210
	CD93	506	31	40	36	16		30	37	262	266	42	98	219
	CD100	467	30	33	35	17		21	37	280	251	42	97	224
	CD102	404	31	29	34	24		19	38	220	278	41	94	227
	CD103	410	32	31	34	19		21	38	219	281	41	97	214
<b>Other Dykes</b>														
Coatshill Quarry	E1	493	25	179	64	33		49	32	164	160	43	68	263
Breconside	E2	516	26	185	65	50		46	33	150	183	41	79	266
Stoneyburn	S1	302	35	181	65	24		51	43	208	278	38	89	219
Stoneyburn	S4	380	32	154	82	25		58	38	185	231	41	84	230
Kello Water	KW1	358	36	37	38	32	7	33	43	230	366	42	99	172
Kello Water	KW2	315	34	37	28	32	7	31	45	253	381	43	99	170
Afton Water	AW1	453	29	24	46	19	11	29	39	255	382	54	113	242
Dalleagles Burn	AW5	471	39	14	41	18		16	38	258	366	51	120	249
Mossdale	M1	487	40	12	42	20		16	39	259	284	53	121	252
Dalgig Burn	DB	594	23	156	64	16		27	28	220	146	33	79	210
Vennel	V1	408	26	181	76	17		31	31	196	158	31	77	204

## Appendix E: Geochemical Data

### 4 – Rare Earth Elements: Lanthanide Series

	code	La ppm	Ce ppm	Nd ppm	Sm ppm	Eu ppm	Dy ppm	Yb ppm
<b>Cleveland Dyke Sectors</b>								
<b>East of River Nith</b> ERN	CD39	30	56	23	7.0	1.4	5.7	3.3
	CD41	31	58	24	7.2	1.4	5.9	3.5
	CD88	23	46	31	5.9	1.3	5.7	2.8
	CD101	21	49	26	3.3	3.6	6.4	4.4
<b>Lochanhead</b> LNH	CD23	30	56	25	7.1	1.5	6.0	3.6
	CD25	26	49	21	6.3	1.4	5.8	3.6
	CD34	29	56	25	7.2	1.4	6.0	3.4
	CD38	25	47	20	6.3	1.4	5.6	3.4
	CD94	26	51	33	6.1	1.3	5.7	3.1
	CD105	21	44	23	3.2	3.5	6.2	4.5
<b>Braco</b> BRA	CD57	28	46	19	6.0	1.5	6.3	3.7
	CD58	39	66	29	6.7	1.5	6.7	4.0
	CD59	32	54	25	6.2	1.4	6.2	3.5
	CD78	27	47	21	5.6	1.4	6.1	3.5
	CD79	25	50	32	5.9	1.4	5.6	3.0
<b>Skeoch-Darngarroch</b> SKD	CD21	35	66	29	8.0	1.5	6.4	3.7
	CD22	35	66	29	7.8	1.5	6.5	3.7
	CD26	35	66	28	7.5	1.5	6.4	3.8
	CD27	35	67	27	7.6	1.5	6.3	3.7
	CD28	28	49	20	6.1	1.4	5.7	3.4
	CD30	29	55	24	7.0	1.4	5.9	3.4
	CD31	28	54	23	6.7	1.4	5.7	3.2
	CD56	39	70	32	7.9	1.6	6.8	4.0
	CD80	31	63	38	6.5	1.4	5.9	3.2
CD81	26	50	32	5.9	1.4	5.7	3.1	
<b>Castramon Hill</b> CAS	CD61	25	50	33	6.1	1.3	5.7	2.9
	CD89	26	52	34	6.3	1.4	5.9	2.8
	CD90	25	51	34	6.3	1.3	5.7	2.9
	CD92	26	52	34	6.0	1.4	5.7	3.0
<b>Craigmuiie Moor</b> CRM	CD12	26	49	22	5.2	1.2	5.3	3.1
	CD13	26	49	23	5.1	1.2	5.3	3.1
	CD15	26	49	21	4.9	1.2	5.5	3.1
	CD51	33	56	24	6.5	1.5	6.4	3.7
	CD52	33	56	25	6.4	1.4	6.3	3.8
	CD55	34	57	24	6.5	1.4	6.5	3.7

	<b>code</b>	<b>La</b> ppm	<b>Ce</b> ppm	<b>Nd</b> ppm	<b>Sm</b> ppm	<b>Eu</b> ppm	<b>Dy</b> ppm	<b>Yb</b> ppm
<b>Shield Burn</b> SHB	CD1	31	59	26	5.6	1.2	5.6	3.1
	CD10	27	51	24	5.6	1.2	5.6	3.2
	CD2	24	45	20	4.7	1.2	5.4	3.1
	CD4	42	82	37	7.6	1.4	6.7	3.8
	CD46	52	99	42	9.5	1.8	8.0	4.7
	CD47	38	64	28	6.8	1.5	6.6	3.9
	CD5	23	43	20	4.8	1.2	5.4	3.0
	CD6	32	60	26	5.9	1.3	5.8	3.3
	CD7	24	43	20	4.8	1.1	5.3	3
CD8	23	40	19	4.7	1.2	5.2	2.7	
<b>Windy Standard</b> WST	WK3	32	56	25	6.6	1.4	6.4	3.7
	WK4	31	53	26	6.1	1.4	6.2	3.6
	CD82	26	51	32	5.9	1.3	5.7	3.1
	CD73	29	51	24	5.9	1.3	5.8	3.4
	CD75	28	50	24	5.9	1.3	6.0	3.6
	CD86	23	47	31	5.8	1.3	5.6	2.9
	CD93	24	48	31	3.0	1.3	5.6	3.1
	CD100	21	51	20	3.1	3.4	6.4	4.3
	CD102	18	45	23	3.3	3.0	6.2	4.3
CD103	20	43	23	3.2	3.2	6.2	4.3	
<b>Other Dykes</b>								
Coatshill Quarry	E1	32	64	38	6.6	1.1	5.7	3.1
Breconside	E2	29	57	35	6.2	1.2	5.5	2.8
Stoneyburn	S1	17	37	26	5.3	1.2	5.2	2.5
Stoneyburn	S4	24	48	32	5.9	1.2	5.4	2.8
Kello Water	KW1	22	36	19	5.0	1.3	5.7	3.3
Kello Water	KW2	21	36	18	5.1	1.3	5.6	3.3
Afton Water	AW1	30	56	31	7.9	1.8	7.7	4.2
Dalleagles Burn	AW5	26	56	29	4.1	4.5	9.6	5.4
Mossdale	M1	20	54	31	4.8	4.8	8.1	5.6
Dalgig Burn	DB	26	54	24	2.5	1.8	5.2	3.1
Vennel	V1	23	47	21	2	1.8	4.6	3