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Channel geometry data set for the northwest Scottish Highlands

Geology and Landscape Scotland Programme

Open Report OR/15/040

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GEOLOGY AND LANDSCAPE SCOTLAND PROGRAMME

OPEN REPORT OR/15/040

Channel geometry data set for the northwest Scottish Highlands

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Keywords

Channel geometry; bedrock channels; postglacial.

Front cover

River Carron at Deanich, view looking northeast. © K Whitbread/NERC

Bibliographical reference

WHITBREAD, K. 2015. Channel geometry data set for the northwest Scottish Highlands. *British Geological Survey Open Report*, OR/15/040. 12pp.

Keyworth, Nottingham British Geological Survey 2015

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Foreword

This report presents the channel geometry data set to accompany the open access paper "Substrate, sediment and slope controls on bedrock channel geometry in postglacial streams" published in the Journal of Geophysical Research – Earth Surface by Whitbread et al. (2015).

The research was funded by a NERC doctoral training grant to the University of Glasgow.

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Summary

This report provides the channel geometry data set to accompany the paper "Substrate, sediment and slope controls on bedrock channel geometry in postglacial streams" by Whitbread et al. (2015), published in the Journal Geophysical Research – Earth Surface (available from http://onlinelibrary.wiley.com/doi/10.1002/2014JF003295/full).

The data set includes reach average channel geometry data (width and depth) for 139 reaches in the River Elchaig, River Canaird and River Carron (Dornoch Firth) in the northwest Scottish Highlands. The study reaches are classified according to the main substrate making up the banks and bed of the stream (Alluvial, Mixed bedrock – alluvial and Bedrock). Whitbread et al. (2015) use these data to assess differences in the downstream scaling of channel width and depth with catchment area (or discharge) for reaches developed in different substrates, and analyse the roles of slope and sediment in constraining channel geometry.

1 Introduction

Channel geometry data were collected for 139 reaches forming 77 km of main stem channel of three montane rivers in the northwest Scottish Highlands between October 2009 and April 2011. Reaches were designated as stretches of channel between 50 – 2000 m in length characterised by the channel morphology and dominant substrate making up the bed and banks of the stream, i.e. the percentage of alluvial bed cover. Bedrock reaches were defined as having less than 30% bed cover and where both banks are in intact rock. Reaches with over 99% of the channel were defined as alluvial, and reaches with between 99 and 30% bedcover, and/or at least one alluvial bank, were defined as mixed bedrock-alluvial. The method of estimating bed cover is described by Whitbread et al. [2015].

The reach average channel width and depth were derived from 450 individual bankfull measurements as the arithmetic mean of between 2 and 10 measurements per reach. Uncertainty on the channel width and depths (*U(W)* and *U(D)* respectively) were derived as standard error of the mean reach average value. Full details of the reach designation and measurement methods are provided by Whitbread et al., [2015] and Whitbread [2012].

The three study catchments are:

- The River Carron, which drains north and east from the northeast slopes of Beinn Dearg into the Kyle of Sutherland; the catchment reaches a maximum area of 300 km^2, and 78 reaches were surveyed along 44 km of channel length;
- The River Elchaig, which drains west from the mountain slopes west of Glen Affric to the head of Loch Long at Killilan; the catchment reaches a maximum area of 97 km^2, and 42 reaches were surveyed along 18 km of channel length;
- The River Canaird, which drains west from the ice-scoured uplands northeast of Ullapool in to Loch Kanaird (Loch Broom). The catchment reaches a maximum area of 95 km^2, and 19 reaches were surveyed along 15 km of channel length.

Hydrological analysis of the 5 m grid, 1 m vertical resolution NEXTMap digital terrain model (Intermap Technologies, 2007) was conducted to derive channel slope, catchment area and along-stream distance for each reach. Channel slope is recorded as the elevation fall per unit reach length. Catchment area is taken as the mean of all catchment areas derived for points at 5 to 7.5 m spacing along the reach length (no reach includes a major tributary junction). The along-stream distance is measured from the mouth to the top of each reach along the channel line extracted from the digital terrain model; this method yields channel lengths that are typically longer than measurements derived from channel lines on topographic maps.

The northwest Scottish Highlands are dominated by metasedimentary rocks including gneissose to schistose psammites and pelites. The main lithology underlying each reach was determined from published geological maps and field observations. In some areas the channels are developed along the lines of faults. The faults typically occur as zones of fractured rock with localised fault gouge and mineralisation. Affected reaches are recorded as ‘Fault’ in the geology column of the following table.

These data form the basis for the analyses of substrate, slope and sediment controls on channel geometry developed and discussed by Whitbread et al. [2015].

2 Channel Geometry Data

The channel geometry data for each reach are given in Table 1.

Table 1 Channel Geometry Data

Catchment	Reach No.	Type	Cover	Main lithology	Distance[a]	Slope[b]	Area[b]	Width[c]	U(*W*)[d]	Depth[c]	U(*D*)[d]
			%		m		km^2	m		m	
River Canaird	CN 2	BR	5	Gneiss	8130	0.123	25.7	14.60	1.00	2.95	0.80
	CN 3	BR-AL	85	Gneiss	8250	0.005	25.6	11.68	1.50	1.85	0.50
	CN 4	AL	100	Gneiss	8580	0.009	25.1	17.20	1.68	1.17	0.09
	CN 5	BR-AL	90	Gneiss	9096	0.007	24.8	12.07	1.50	1.00	0.50
	CN 6	BR	15	Gneiss	9190	0.021	24.8	9.55	1.00	2.50	0.80
	CN 7	BR-AL	90	Gneiss	9300	0.011	24.3	17.65	1.50	0.75	0.50
	CN 8	AL	100	Gneiss	9640	0.010	23.8	16.18	1.36	0.95	0.05
	CN 9	BR	5	Gneiss	9990	0.066	23.5	12.95	1.00	1.70	0.70
	CN 10	BR	50	Psammite	10220	0.060	23.3	7.90	2.19	4.67	1.72
	CN 11	BR-AL	90	Psammite	11000	0.006	22.3	13.00	1.50	1.00	0.50
	CN 12	BR	50	Psammite	11100	0.027	22.2	9.18	0.46	1.80	0.60
	CN 13	BR	60	Psammite	11250	0.022	22.0	8.20	1.00	1.60	0.70
	CN 14	BR-AL	95	Psammite	11500	0.030	21.9	11.79	1.50	1.20	0.50
	CN 15	BR	70	Psammite	11540	0.028	21.7	10.00	1.00	2.50	0.70
	CN 16	BR-AL	70	Psammite	12070	0.017	20.5	11.92	1.82	1.40	0.06
	CN 17	BR	15	Psammite	12660	0.033	19.8	10.24	0.97	1.35	0.07
	CN 18	BR-AL	75	Psammite	12770	0.018	19.7	16.02	3.71	3.71	0.29
	CN 19	BR	60	Psammite	13000	0.073	17.5	7.66	2.78	3.55	0.72
	CN 22	AL	100	Psammite	15830	0.007	8.2	6.09	0.75	0.80	0.07
River Carron	CR 1	AL	100	Psammite	1682	0.004	300.6	51.69	2.14	2.62	0.20
	CR 2	AL	100	Psammite	2014	0.003	300.0	44.90	1.80	3.15	0.18
	CR 3	BR	70	Psammite	2530	0.003	299.5	28.48	3.43	3.85	0.08
	CR 4	BR-AL	90	Psammite	2848	0.003	298.4	34.81	3.25	4.15	1.35
	CR 5	BR	5	Psammite	3319	0.003	297.5	31.13	2.21	2.90	0.22
	CR 6	BR-AL	60	Psammite	4058	0.004	294.7	32.52	1.40	2.96	0.46
	CR 7	BR	40	Psammite	4643	0.003	289.3	22.84	2.16	4.28	0.57
	CR 8	BR-AL	90	Psammite	5745	0.002	281.5	35.31	0.87	2.47	0.20
	CR 9	AL	99.9	Psammite	8064	0.004	268.1	46.00	4.17	2.55	0.23
	CR 10	BR-AL	50	Psammite	8654	0.004	261.4	39.29	4.74	2.57	0.41
	CR 11	AL	100	Psammite	9731	0.005	256.8	41.09	2.23	2.54	0.26
	CR 12	BR-AL	50	Psammite	9973	0.009	255.8	31.07	0.88	3.43	0.23

Table 1 continued

Catchment	Reach No.	Type	Cover	Main lithology	Distance[a]	Slope[b]	Area[b]	Width[c]	U(*W*)[d]	Depth[c]	U(*D*)[d]
			%		m		km^2	m		m	
River Carron	CR 13	AL	100	Psammite	10523	0.010	253.5	40.61	2.46	2.63	0.06
	CR 14	BR	10	Psammite	11429	0.013	252.4	26.13	1.71	3.98	0.78
	CR 15	BR-AL	50	Psammite	11680	0.005	249.2	32.83	0.68	3.03	0.13
	CR 16	BR	5	Psammite	12509	0.017	246.9	16.99	1.87	5.97	1.01
	CR 17	BR-AL	80	Psammite	13142	0.005	244.9	33.24	2.34	2.76	0.34
	CR 18	AL	100	Psammite	13629	0.004	244.5	46.38	2.42	2.43	0.28
	CR 19	BR	30	Psammite	13920	0.012	236.5	28.97	3.08	3.05	0.73
	CR 20	BR-AL	50	Psammite	14217	0.001	235.7	35.72	1.88	3.25	0.45
	CR 21	BR	5	Psammite	14592	0.017	234.8	22.44	3.69	2.79	0.60
	CR 22	AL	100	Psammite	15169	0.006	234.2	40.05	1.48	2.03	0.27
	CR 23	BR	30	Psammite	15331	0.014	233.1	31.86	1.33	3.63	0.27
	CR 24	AL	90	Psammite	15803	0.007	232.4	29.74	0.34	2.32	0.17
	CR 25	BR-AL	40	Psammite	16651	0.007	172.1	29.45	2.27	2.91	0.24
	CR 26	AL	98	Psammite	17217	0.009	170.7	44.49	6.48	2.15	0.33
	CR 27	BR-AL	85	Psammite	17611	0.005	165.9	31.13	1.67	3.24	0.47
	CR 29	BR-AL	30	Psammite	18126	0.013	150.0	25.45	2.54	3.18	0.68
	CR 30	BR	5	Psammite	18570	0.008	132.3	12.62	1.71	3.52	0.58
	CR 31	BR-AL	85	Psammite	18701	0.007	114.8	23.83	0.56	2.38	0.63
	CR 32	BR	5	Psammite	19284	0.029	114.0	14.23	0.64	3.71	0.37
	CR 33	BR	5	Psammite	20516	0.014	110.1	19.61	2.49	3.42	0.61
	CR 35	BR	5	Psammite	21403	0.040	107.6	14.65	1.46	5.12	0.59
	CR 36	AL	100	Psammite	21615	0.013	91.3	23.76	0.78	2.10	0.12
	CR 37	BR	20	Psammite	22825	0.024	72.2	15.98	1.07	3.64	0.52
	CR 38	BR-AL	90	Psammite	23040	0.027	71.7	24.50	2.65	2.88	0.49
	CR 39	AL	98	Psammite	23522	0.005	70.8	23.07	2.25	2.20	0.38
	CR 40	AL	100	Psammite	23796	0.005	70.3	21.94	1.15	1.95	0.13
	CR 41	AL	95	Psammite	24106	0.005	70.0	20.45	0.40	1.90	0.05
	CR 42	BR	15	Psammite	24288	0.017	69.8	14.96	1.18	2.80	0.50
	CR 43	AL	99	Psammite	26061	0.004	68.0	27.32	1.85	1.91	0.12
	CR 44	AL	100	Psammite	26680	0.002	65.2	34.32	6.30	4.32	1.32
	CR 45	AL	100	Psammite	27818	0.003	63.8	27.23	3.60	2.16	0.60

Table 1 continued

Catchment	Reach No.	Type	Cover	Main lithology	Distance[a]	Slope[b]	Area[b]	Width[c]	U(*W*)[d]	Depth[c]	U(*D*)[d]
			%		m		km^2	m		m	
River Carron	CR 46	BR	5	Psammite	27929	0.028	62.8	19.76	1.16	1.88	0.46
	CR 47	AL	100	Psammite	28627	0.002	61.6	37.18	5.62	2.23	0.95
	CR 48	AL	99	Psammite	29532	0.004	59.3	30.14	3.06	1.45	0.13
	CR 49	BR	75	Semi-pelite	29834	0.014	58.2	18.13	0.98	2.36	0.42
	CR 50	AL	99	Psammite	30412	0.008	57.6	23.13	1.67	1.69	0.26
	CR 51	BR	25	Psammite	30991	0.035	55.4	17.00	0.91	2.12	0.24
	CR 52	AL	99	Psammite	31375	0.013	55.0	24.60	1.46	1.45	0.09
	CR 53	BR	5	Psammite	31873	0.031	54.4	21.11	1.67	1.34	0.18
	CR 54	AL	100	Psammite	32366	0.005	53.9	27.70	3.44	3.68	0.82
	CR 55	AL	100	Psammite	33569	0.004	46.2	20.19	2.39	1.46	0.06
	CR 56	AL	98	Psammite	34067	0.008	41.1	19.11	0.85	1.54	0.09
	CR 57	BR	10	Psammite	34653	0.028	35.7	16.71	0.96	1.51	0.10
	CR 58	BR-AL	70	Psammite	35167	0.015	32.7	15.79	0.39	1.55	0.06
	CR 59	BR	5	Psammite	35363	0.056	32.3	16.78	1.19	1.62	0.20
	CR 60	BR-AL	70	Psammite	36415	0.021	31.5	14.85	0.56	1.49	0.05
	CR 62	AL	100	Psammite	37385	0.006	27.6	16.76	1.33	1.91	0.06
	CR 63	AL	99	Psammite	38085	0.003	25.6	16.31	0.59	1.78	0.05
	CR 64	AL	100	Psammite	40393	0.009	19.3	18.84	0.93	1.24	0.13
	CR 65	BR	80	Pelite	40511	0.024	14.2	9.98	0.78	1.60	0.03
	CR 66	AL	98	Pelite	41300	0.027	10.1	12.87	1.73	1.23	0.05
	CR 67	BR	65	Pelite	41554	0.048	9.0	8.82	0.61	1.10	0.06
	CR 68	BR	30	Pelite	41712	0.072	8.8	9.06	0.59	1.57	0.14
	CR 69	BR	15	Pelite	42238	0.163	4.5	6.16	0.56	2.20	0.21
	CR 70	BR	50	Semi-pelite	42481	0.153	4.1	6.30	1.50	3.75	0.25
	CR 71	BR	75	Fault	42766	0.062	4.0	8.35	1.25	1.57	0.16
	CR 72	BR	30	Semi-pelite	42875	0.070	3.8	6.56	0.43	1.85	0.38
	CR 73	BR-AL	70	Psammite	43181	0.101	3.5	6.04	0.74	1.29	0.13
	CR 74	BR	50	Psammite	43501	0.130	2.4	5.24	0.51	1.36	0.15
	CR 75	BR	10	Psammite	43621	0.184	2.0	4.70	0.84	1.26	0.22
	CR 76	BR	80	Fault	43727	0.139	2.0	5.84	0.68	0.98	0.07

Table 1 continued

Catchment	Reach No.	Type	Cover	Main lithology	Distance[a]	Slope[b]	Area[b]	Width[c]	U(*W*)[d]	Depth[c]	U(*D*)[d]
			%		m		km^2	m		m	
River Carron	CR 77	BR	15	Psammite	43869	0.220	1.9	6.36	0.96	1.45	0.05
	CR 78	BR-AL	90	Psammite	44175	0.078	1.7	4.76	0.55	0.91	0.10
	CR 79	BR	50	Psammite	44275	0.129	1.3	4.45	0.83	0.82	0.09
	CR 82	BR-AL	99	Psammite	44635	0.089	0.3	2.91	0.21	0.57	0.07
	CR 83	BR-AL	85	Psammite	44681	0.026	0.3	3.79	0.95	0.57	0.09
River Elchaig	E 3	BR-AL	85	Psammite	5934	0.001	75.5	19.83	1.00	2.60	0.50
	E 4	AL	100	Psammite	6030	0.001	73.3	26.90	1.00	1.85	0.60
	E 5	BR-AL	80	Psammite	6210	0.014	72.9	22.58	1.00	2.70	0.50
	E 6	BR	10	Psammite	6423	0.054	72.8	19.15	1.78	2.30	0.16
	E 8	BR-AL	60	Gneiss	6825	0.0003	72.3	19.93	1.00	2.00	0.50
	E 9	AL	100	Gneiss	6913	0.006	72.2	28.53	1.00	1.20	0.50
	E 10	BR-AL	70	Gneiss	7031	0.016	71.8	24.05	1.88	2.05	0.05
	E 12	BR-AL	90	Gneiss	7392	0.007	71.4	28.15	1.00	1.80	0.50
	E 13	BR	15	Gneiss	7449	0.056	70.0	18.96	4.48	3.45	0.05
	E 14	BR	20	Gneiss	7615	0.026	67.2	13.45	0.81	2.77	0.22
	E 15	AL	100	Gneiss	7807	0.022	67.2	26.67	1.00	1.00	0.50
	E 16	BR	50	Gneiss	7870	0.007	67.2	12.58	3.93	2.70	0.10
	E 17	BR	60	Gneiss	7968	0.003	60.6	13.12	0.78	1.82	0.09
	E 18	BR-AL	80	Gneiss	8260	0.003	59.5	19.99	2.14	1.70	0.30
	E 20	AL	100	Gneiss	8855	0.009	58.7	24.21	1.81	1.50	0.00
	E 21	BR-AL	95	Gneiss	9111	0.014	58.4	31.06	3.00	1.20	0.20
	E 22	BR	90	Gneiss	9351	0.020	58.1	16.99	2.72	4.63	0.25
	E 23	AL	97	Gneiss	9639	0.001	57.8	18.88	0.72	1.50	0.00
	E 24	BR	60	Gneiss	9780	0.006	57.8	16.00	1.00	4.30	0.50
	E 25	AL	95	Gneiss	9820	0.004	57.7	21.34	1.00	2.50	0.50
	E 26	AL	99	Psammite	10006	0.008	56.7	24.47	0.21	1.45	0.25
	E 27	BR	2	Psammite	10496	0.089	32.3	23.22	1.78	1.63	0.17
	E 28	BR	70	Psammite	10603	0.016	32.3	18.01	2.72	1.74	0.46
	E 29	BR	60	Psammite	10862	0.019	32.1	21.48	1.43	1.43	0.24
	E 30	AL	100	Fault	13224	0.007	20.0	17.70	2.78	1.25	0.22
	E 31	AL	100	Fault	14025	0.010	17.1	17.27	0.07	1.40	0.30
	E 32	BR-AL	85	Fault	14395	0.013	17.0	10.13	1.73	2.10	0.40

Table 1 continued

Catchment	Reach No.	Type	Cover	Main lithology	Distance[a]	Slope[b]	Area[b]	Width[c]	U(*W*)[d]	Depth[c]	U(*D*)[d]
			%		m		km^2	m		m	
River Elchaig	E 33	AL	100	Fault	14535	0.016	16.9	14.19	1.00	1.60	0.50
	E 34	BR-AL	80	Fault	14745	0.018	15.7	8.82	1.00	1.30	0.50
	E 35	AL	100	Fault	14885	0.018	14.9	14.85	3.36	1.25	0.35
	E 36	BR	65	Fault	15195	0.025	13.4	11.17	1.32	1.45	0.15
	E 37	BR	40	Fault	15514	0.031	11.0	7.26	0.76	2.15	0.65
	E 38	BR	40	Psammite	15825	0.061	10.8	10.78	1.88	2.68	0.39
	E 39	AL	100	Fault	16002	0.032	10.6	12.55	0.53	1.67	0.08
	E 40A	BR	90	Fault	16110	0.062	10.4	12.03	1.46	2.33	0.27
	E 40B	BR	90	Fault	16450	0.118	5.3	10.37	3.16	1.60	0.42
	E 41	BR	50	Fault	16605	0.149	5.2	9.19	0.37	2.13	0.11
	E 42	BR	65	Pelite	16805	0.109	5.1	10.38	1.11	1.50	0.11
	E 43	BR	50	Psammite	16985	0.156	5.0	7.72	2.51	1.70	0.19
	E 44	BR-AL	95	Fault	17275	0.122	4.6	10.48	0.36	1.29	0.11
	E 45	BR	25	Fault	17715	0.167	4.1	8.04	1.68	1.49	0.17
	E 46	BR	40	Pelite	18155	0.071	3.3	4.86	2.79	1.44	0.29

[a] Distance from the river mouth to the top of the reach

[b] Slope and catchment area derived from the 5 m grid NEXTMap Digital Terrain Model (Intermap Technologies, 2007).

[c] Reach-averaged widths and depths derived as the mean of all measured widths and depths in each reach (n = 2 to 10).

[d] Uncertainty on width and depth is derived as the standard error of the mean of the values in each reach.

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