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Surficial sediments of Parry Channel, Northwest Territories and Nunavut

R. Bennett

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Introduction

Geological data is sparse in the channels of the Canadian Arctic Archipelago and the seabed geology in this region is likely the least understood in Canada. MacLean et al. (1989) and Niessen et al. (2009) have described the subsurface geology from the seabed to about ~100 m depth using acoustic data (airgun seismic reflection, Huntec deep-towed seismic reflection, sub-bottom profilers) and sediment samples (piston cores, box cores, grab samples). However, there is a thin layer of surface sediment, up to a few centimetres thick, that cannot be resolved by acoustic profiles (MacLean et al., 1989). Dirschl (1982) mapped this thin layer of surface sediment in Lancaster Sound and Barrow Strait (Figure 1) using all seabed sediment samples available at the time, mainly grab samples from Geological Survey of Canada (GSC) cruises 73014 and 74015, to create a surficial geology map showing the distribution of sand / gravel, silt, and clay. The objective of this report is to use seabed data collected since 1982 to refine the existing Dirschl (1982) map and extend it west into Viscount Melville Sound.

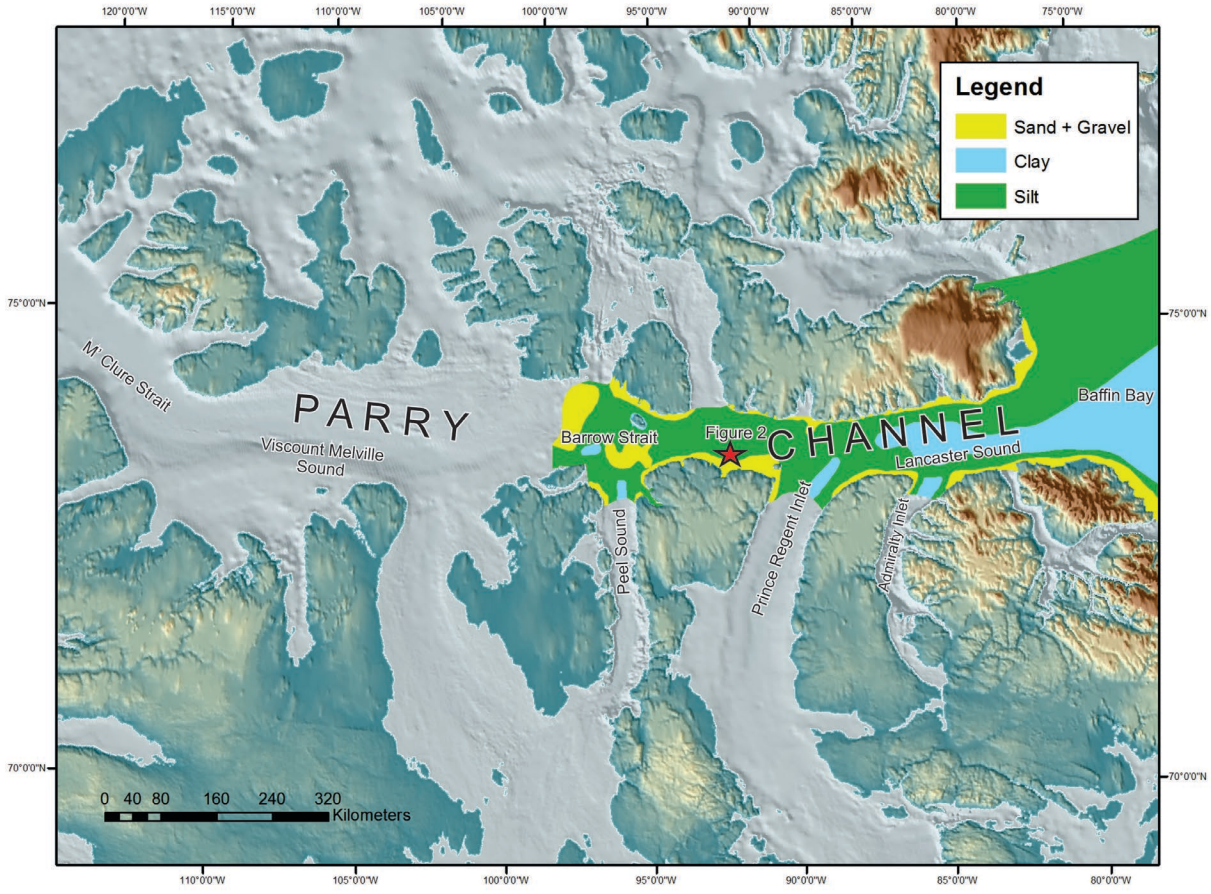

Figure 1: Distribution of sand / gravel, silt, and clay in Barrow Strait and Lancaster Sound digitized from Dirschl (1982).

Regional Geology

Parry Channel (Figure 1) is an east – west oriented channel through the center of the Canadian Arctic Archipelago connecting Baffin Bay with the Arctic Ocean. It is the named waterbodies (from west to east) M' Clure Strait, Viscount-Melville Sound, Barrow Strait, and Lancaster Sound. During the last glaciation, the Canadian Arctic Archipelago was covered by glacial ice (Dyke, 2003) that has heavily influenced the surficial sediments of the inter-island channels. Parry Channel was the approximate location of the boundary between the Laurentide Ice Sheet to the south and the Innuitian Ice Sheet to the north (England et al., 2009). Glacial features are preserved on the seabed throughout Parry Channel. Ice scours are observed over much of the area (MacLean et al., 1989; MacLean et al., 2006; Bennett et al., 2014) in water depths up to ~650 m. These scours were likely formed during glaciation when thick ice, up to 1600 m thick in Lancaster Sound (Klassen and Fisher, 1988; Dyke et al., 2003), was present. Mega-scale glacial lineations have been mapped in Viscount-Melville Sound (MacLean et al., 2006), Barrow Strait (with DeGeer moraines; Figure 2), and Lancaster Sound (Bennett et al., 2014).

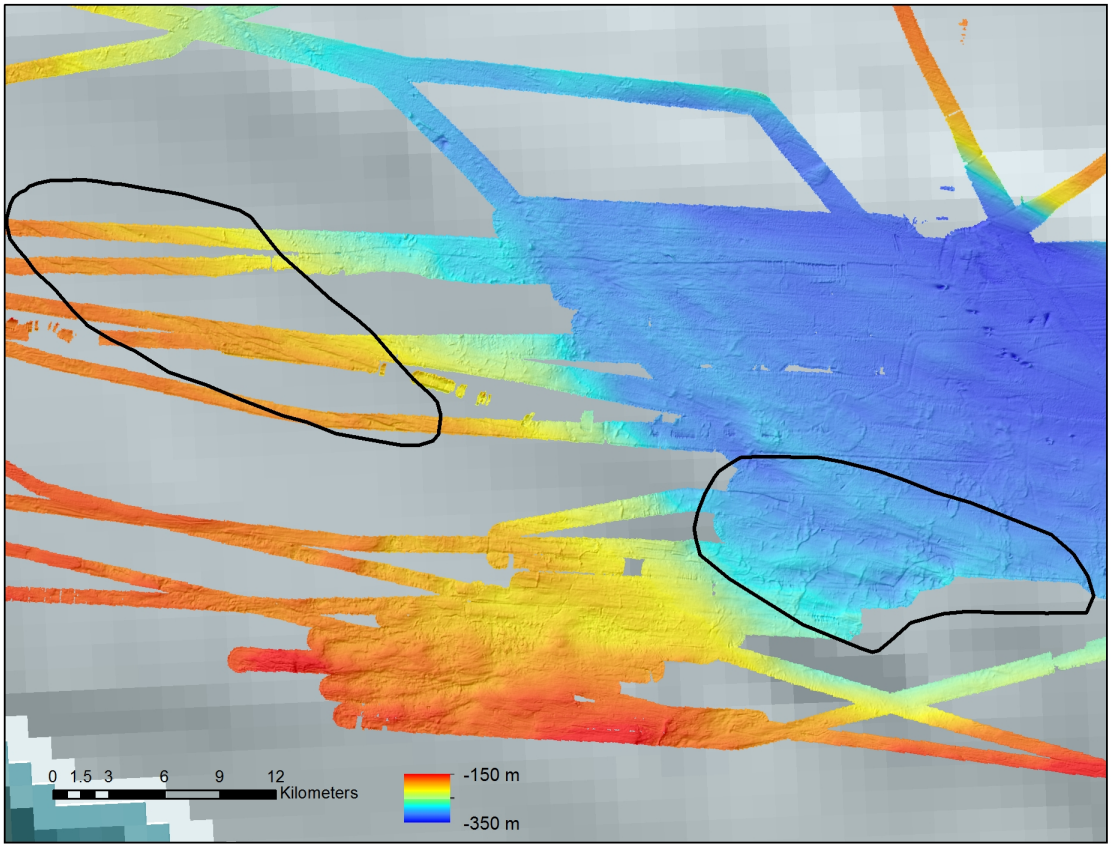

Figure 2: Mega-scale glacial lineations (highlighted by black outline) mapped using multibeam echosounder (data source: Ocean Mapping Group at the University of New Brunswick). DeGeer moraines are observed on top of the lineations. Location shown on Figure 1.

The regional shallow geology of Parry Channel records a Late Quaternary cycle of glacial sedimentation where ice-contact till and ice-proximal glaciomarine sediments are overlain discontinuously by variable thicknesses of postglacial sediments (MacLean et al., 1989, Bennett et al., 2006). Only Lancaster Sound and Barrow Strait contain post-glacial sediments of notable thickness (>0.2 – 10 m) (Niessen et al., 2009). Current sedimentation rates in Parry Channel are low (MacLean et al., 1989; Andrews et al., 1991; Pienkowski et al., 2012) due to the lack of large fluvial systems or other significant sediment inputs in the Canadian Arctic Archipelago. The upper few centimeters of sediment that cannot be resolved by acoustic profiles comprises particles with a large range of grain sizes (clay to gravel), suggesting that they are derived from ice rafting (MacLean et al., 1989).

Methods

The Dirschl (1982) map was digitized, georeferenced, and imported into ArcMap (Figure 1). The sediment distribution polygons were then clipped at the eastern extent of Parry Channel as the Dirschl map contained information for Baffin Bay which is not part of this study.

All available grain size analyses for surface sediments in the study area were extracted from the GSC Expedition Database (ED) and then compiled in a Geographic Information System (GIS). The ED database contained 8 analyses in western Parry Channel in the area not covered by the Dirschl (1982) map, and 11 analyses in eastern Parry Channel in the area that was previously mapped by Dirschl (1982). The positions of all existing sediment samples were then extracted from ED and added to the GIS for use in the selection of samples for further grain size analyses.

Data coverage in western Parry Channel is sparser than the east therefore all available sediment samples that did not have existing surface grain size data were analyzed in the GSCA sedimentology lab (17 samples). In eastern Parry Channel, 9 sediment samples distributed somewhat evenly across the area were selected to check and refine the Dirschl (1982) map. In total, 45 grain size analyses were compiled in the GIS (Figure 3; Table 1).

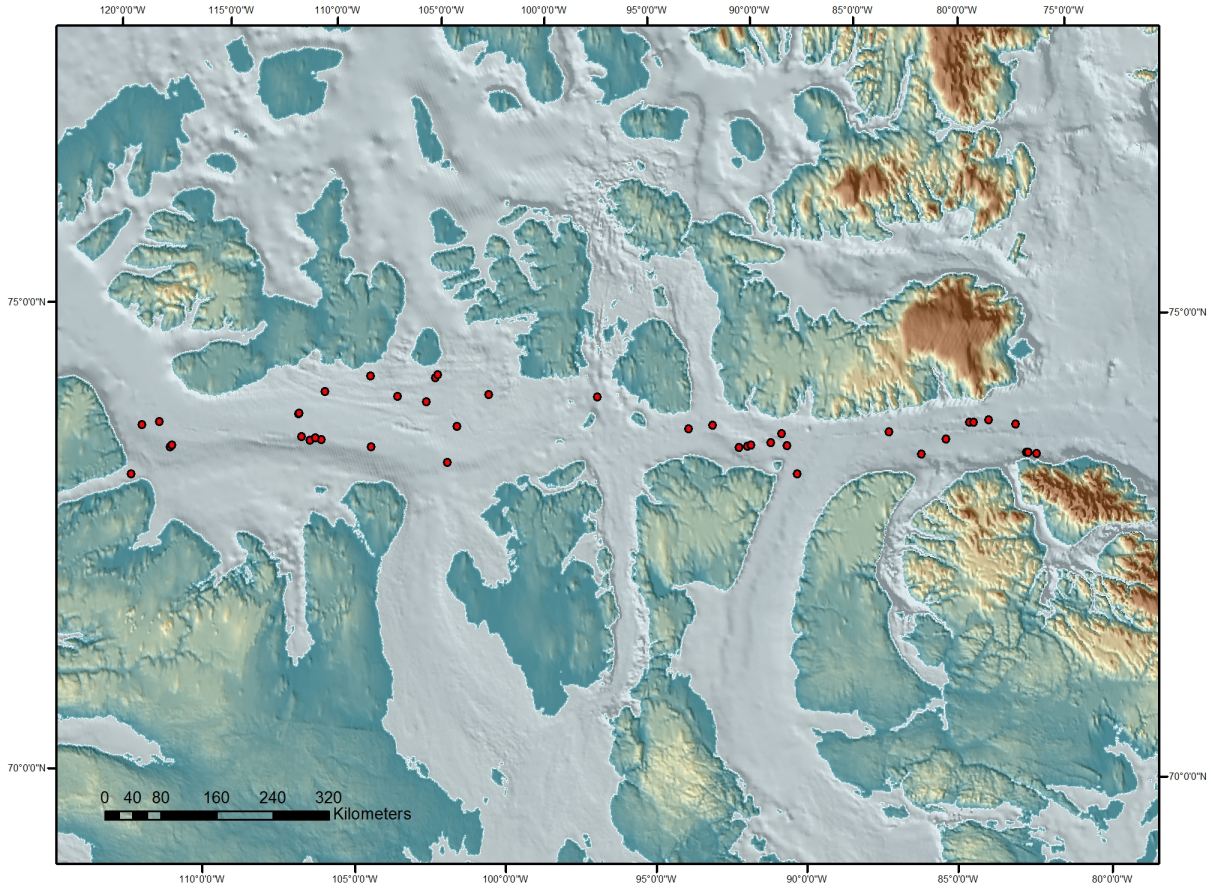

Figure 3: Locations of the 45 grain size analyses compiled for this report (represented by red dots).

All grain size analyses used in this report were performed in the GSC-Atlantic sedimentology lab at the Bedford Institute of Oceanography. Twelve of these analyses were done in the early 1970's (all analyses on sediment samples collected during cruise 69050) by settling / sieving. The other 33 analyses were performed from 2008 to present by laser diffraction, digital image particle size analysis, or a combination of these two methods.

Table 1- Station and grainsize information for this study.

ID	Expedition	Station No.	Station Type	% Gravel	% Sand	% Gravel + % Sand	% Silt	% Clay	Latitude	Longitude	Water Depth (m)
1	98JOS	20	IKU grab	3.8188	2.1239	5.9427	47.0547	47.0026	73.948983	-115.076016	500
2	69050	809	grab	0.71	1.1	1.81	56.21	41.98	73.40333	-115.06667	84
3	69050	812	piston core	3.92	11.9	15.82	47.52	36.66	73.40333	-115.06667	84

4	99LOUIS_ST_ LAURENT	6	box core	0.0473	11.9145	11.9618	37.5316	50.5066	74.023833	-114.426	511
5	2013804	2	box core	50.0192	0.9217	50.9409	27.5256	21.5335	73.778	-113.819833	456
6	69050	5413	grab	0.5	1.09	1.59	57.42	41.43	73.80167	-113.75833	475
7	69050	5430	piston core	0	0.55	0.55	50.34	49.11	73.80167	-113.75833	475
8	9722	8618	box core	6.9781	20.9042	27.8823	34.6243	37.4934	74.375	-109.08	425
9	9722	3875	gravity core	0	3.6024	3.6024	42.6018	53.7958	74.38167	-109.06917	245
10	9722	8619	gravity core	0	32.158	32.158	35.1511	32.6909	74.38167	-109.06917	245
11	2013804	1	box core	50.0413	4.0058	54.0471	22.4496	23.5032	74.139666	-108.8295	563
12	2011804	5	piston core	0	0.05	0.05	48.85	51.10	74.115	-108.484833	560
13	2011804	6	box core	10.9242	4.9588	15.883	35.3248	48.7922	74.146833	-108.281166	550
14	69050	5414	grab	1.96	0.87	2.83	37.09	60.08	74.65	-108.175	225
15	69050	5431	piston core	3.16	4.84	8.0	55.92	36.07	74.65	-108.175	225
16	98JOS	19	IKU grab	0.7086	5.8611	6.5697	40.5024	52.9279	74.134883	-108.04705	550
17	86027	9661	grab	39.5151	27.8456	67.3607	21.7694	10.87	74.875	-106.41333	70
18	98JOS	18	IKU grab	1.0781	9.259	10.3371	45.8144	43.8486	74.127966	-106.067516	528
19	69050	5435	piston core	5.18	42.14	47.32	26.20	26.49	74.69667	-105.25833	173
20	9722	8615	box core	0	20.8198	20.8198	48.1357	31.0444	74.66667	-104.08	203
21	86027	2744	grab	43.1371	31.9192	75.0563	19.5756	5.3681	74.93067	-103.7875	82
22	86027	9668	grab	56.9697	30.2152	87.1849	8.6583	4.1568	74.96333	-103.71667	88
23	2011804	4	box core	1.8589	11.3767	13.2356	46.7613	40.0032	74.0395	-103.0365	368
24	89200	1	gravity core	0	14.5782	14.5782	41.3065	44.1153	74.435666	-102.771666	499
25	69050	5436	piston core	18.1	23.23	41.33	37.98	20.69	74.79833	-101.58667	168
26	9722	8612	box core	0	0.02	0.02	29.82	99.98	74.81333	-97.185	272
27	69050	5438	piston core	4.98	43.99	48.97	20.06	51.03	74.46667	-93.5333	226
28	9722	8610	box core	0	10.29	10.29	20.19	89.71	74.5	-92.58	209
29	2011804	7	piston core	0	1.94	1.94	26.33	98.06	74.2505	-91.5652	300

30	86027	9682	piston core	0	1.21	1.21	35.86	98.79	74.25933	-91.2368	330
31	2005804	10	box core	0	0.04	0.04	29.60	99.96	74.269466	-91.074166	350
32	69050	813	piston core	0	0.52	0.52	39.12	99.48	74.28	-90.2833	246
33	86027	9696	piston core	0	1.27	1.27	24.41	98.73	74.36683	-89.8543	329
34	2006804	11	box core	0	36.66	36.66	18.52	63.34	74.232683	-89.656166	229
35	73014	7819	piston core	0	6.32	6.32	24.82	93.68	73.925	-89.35	335
36	2004804	49	box core	0	2.95	2.95	37.40	97.05	74.281666	-85.601666	534
37	81045	5401	gravity core	0	2.94	2.94	40.18	97.06	73.99667	-84.45	628
38	2011804	9	box core	0	1.22	1.22	33.62	98.78	74.122333	-83.409166	685
39	2008029	59	piston core	0	6.00	6.00	39.38	94.00	74.25962	-82.3842	800
40	2008029	61	piston core	0	9.98	9.98	33.74	90.02	74.25821	-82.2304	791
41	2008029	62	piston core	0	2.15	2.15	39.64	97.85	74.25253	-81.6348	822
42	2011804	11	box core	0	3.38	3.38	30.25	96.62	74.159666	-80.600333	779
43	2008029	53	piston core	0	83.04	83.04	3.97	16.96	73.84055	-80.3946	918
44	2008029	54	piston core	0	23.46	23.46	29.50	76.54	73.83897	-80.3121	887
45	2011804	10	piston core	0	6.42	6.42	32.77	25.75	73.80833	-80.009	837

Discussion

For the purpose of generating a revised map of surficial sediment distribution in Parry Channel, each grain size sample was assigned a sediment type according to what Wentworth classification comprised the majority of the sample. Wentworth sub-classes (i.e. course, medium, fine, etc.) were not used and sand and gravel were combined so that the new analyses would be consistent with those from the Dirschl (1982) map. Grab samples and box cores provide the best representation of the surficial sediment type, so if two grain size analyses were located close to each other, analyses from grab samples and box cores were given preference over piston cores and gravity cores.

The existing surficial geology map for eastern Parry Channel (Dirschl, 1982) was checked using grain size analyses from 20 new seafloor sediment samples. The new analyses agreed with the Dirschl map in all but six cases (analyses 26, 27, 36, 37, 38, and 43 on Table 1; Appendix A, Figure A1) and the sediment distribution boundaries were modified accordingly. In western Parry Channel where there had been no previous surficial sediment mapping, grain size analyses from 25 seafloor sediment samples were used to interpret the distribution of sand / gravel, silt, and clay (Appendix A, Figure A2).

Silt is the predominant sediment type, distributed throughout most of Parry Channel. Clay is observed mainly in eastern Lancaster Sound (leading to Baffin Bay) and in northwest Viscount Melville Sound (leading to M'Clure Strait). Smaller occurrences of clay are mapped where Peel Sound, Prince Regent Inlet, and Admiralty Inlet join into Parry Channel. Clay appears to be ponded in lower energy areas such as deeper water in Parry Channel, e.g. in Lancaster Sound and northwestern Viscount Melville Sound, and in the center of narrower tributary channels such as Peel Sound, Prince Regent Inlet, and Admiralty Inlet.

Sand / gravel is observed in close proximity to the islands of eastern Parry Channel (Appendix A, Figure A2). Sand /gravel may also be located near the islands of western Parry Channel, however there are no sediment samples collected in this area with the closest sample 10 km from shore in western Parry Channel. Sand / gravel has been mapped in two large areas of Barrow Strait as well as in northern Viscount Melville Sound. Several analyses that are comprised mostly of gravel are located in northern Viscount Melville Sound (analyses 17, 21 and 22 on Table 1 and Appendix A, Figure A3) and two other very localized areas, one in central Viscount Melville Sound (analysis 11 on Table 1 and Appendix A, Figure A3) and one in western Viscount Melville Sound (analysis 5 on Table 1 and Appendix A, Figure A3). All of the coarse sediment (sand and gravel) is located in the shallower areas of Parry Channel. MacLean et al. (1989) suggest that currents may be modifying surficial sediments in these areas due to the presence of exposed gravel armoring the seabed that has been observed in bottom photographs. The presence of coarse sediment near the islands of Eastern Parry Channel could also be influenced by coastal erosion.

The amount of data available at present only provides a low-resolution image of the surficial sediments of western Parry Channel. The sparse sample coverage required interpolation between data points that were as much as ~150 km apart. A limited amount of backscatter data is available in western Parry but the data quality is poor. Additional high-quality backscatter and seabed sediment

samples, especially in the near-shore, are required to improve the resolution of the map. The data coverage in eastern Parry Channel is much better than the west but any additional sediment samples or high-quality backscatter would further refine the map.

Acknowledgements

Grain size analyses shown on Table 1 (except for samples from cruise 69050) were performed by Owen Brown in the GSCA sedimentology laboratory. Scott Hayward digitized the Dirschl map and Calvin Campbell provided a review of this report.

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Appendix A: Distribution Maps of Seabed Sediments in Parry Channel

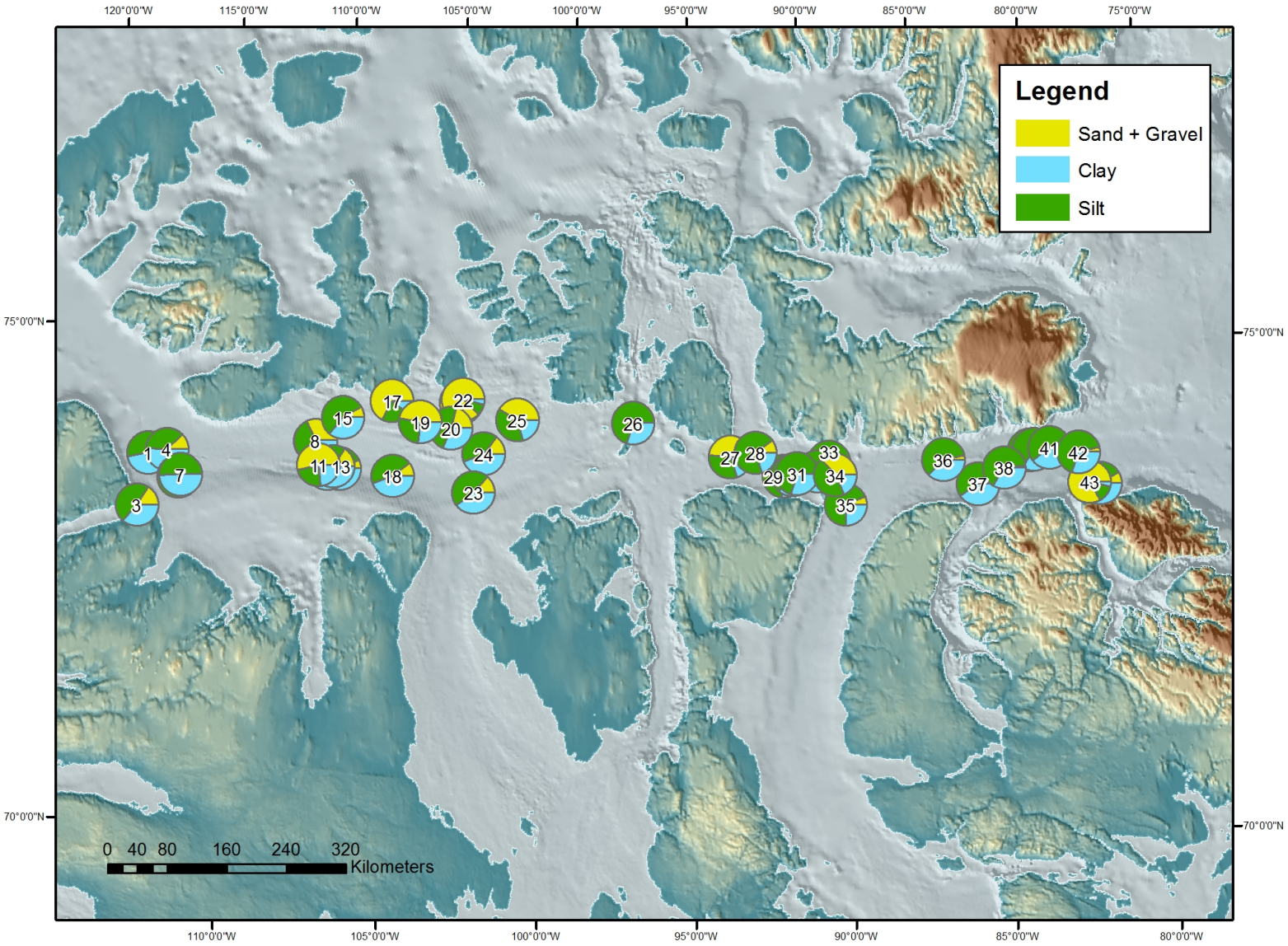

Figure A1: Pie charts of grain size distribution at each sediment sample site listed in Table 1.

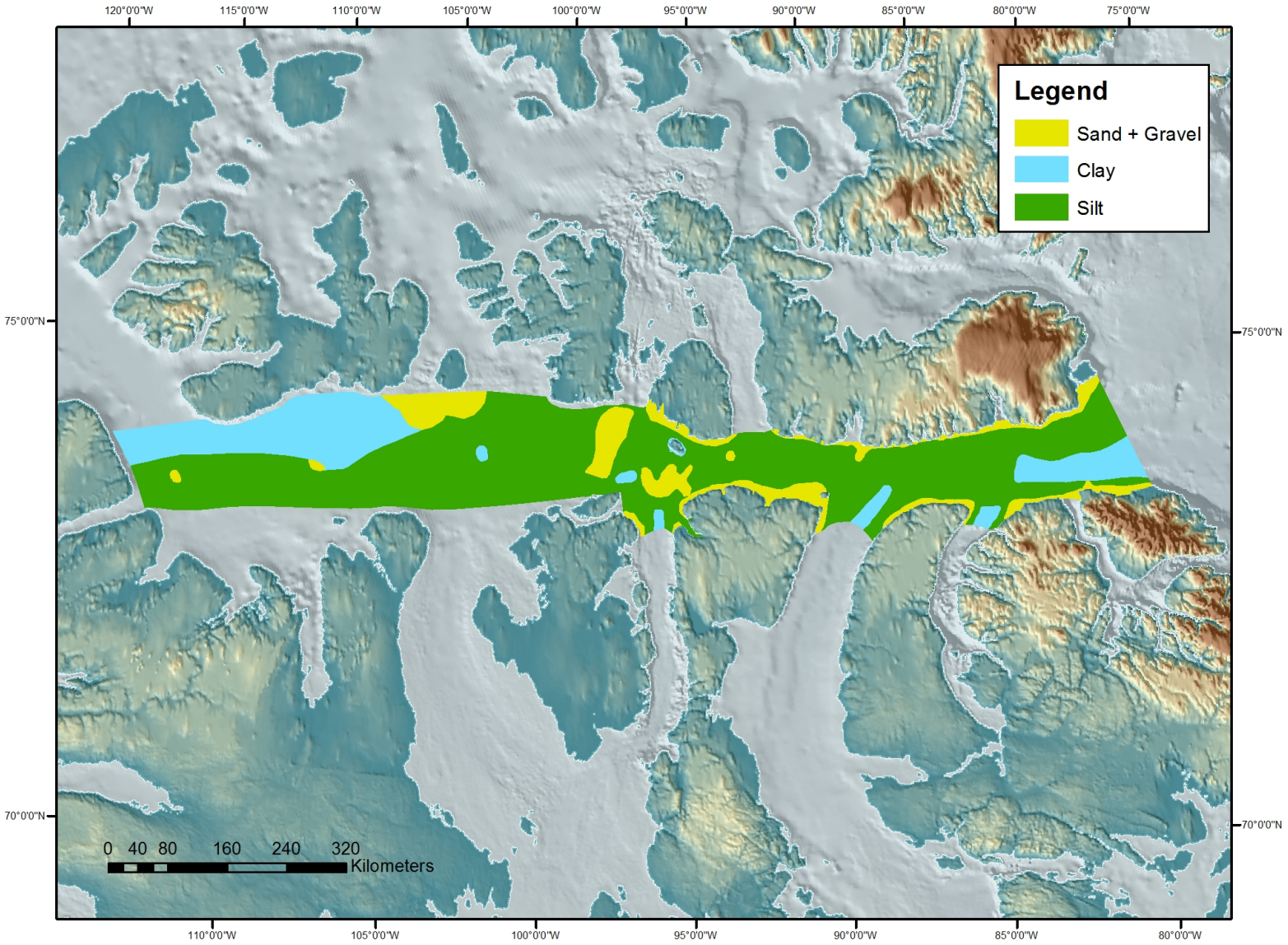

Figure A2: Grain size distribution of surface sediments in Parry Channel.

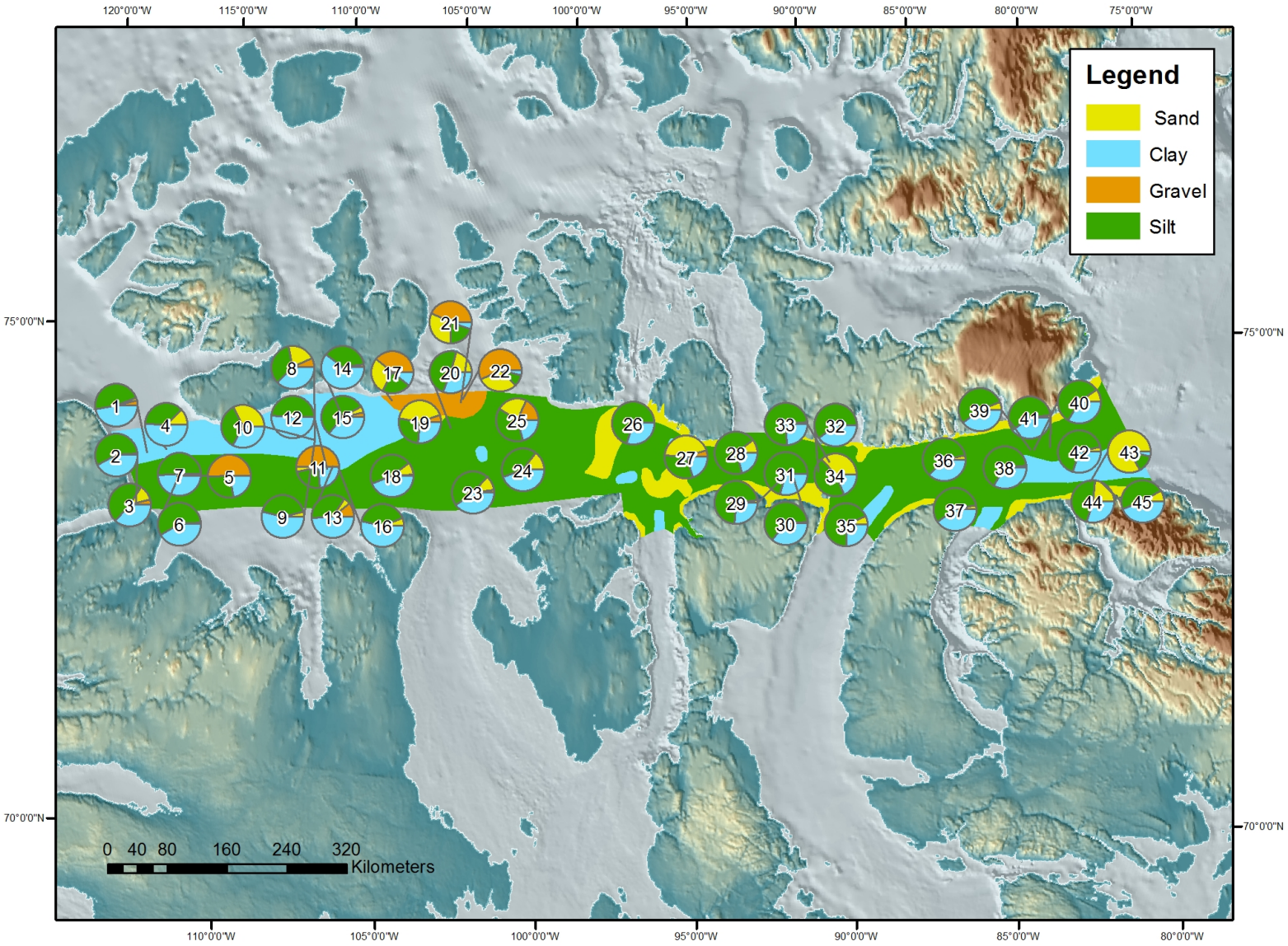

Figure A3: Grain size distribution of samples from Table 1 showing differentiation between sand and gravel (pie charts offset for clarity).