Liu *et al.* Supplementary Information File

A new assemblage of juvenile Ediacaran fronds from the Drook Formation, Newfoundland.

Contents

Section 1: Figured specimens of juvenile fronds

The following images document the variation within the Pigeon Cove frondose community. Images are arranged by taxon where possible. Figure labels, rather than following the usual A,B,C, or 1,2,3 system, reflect the original field labels assigned to the specimens. These correspond to their location on the maps of the surface (Supplementary Map), and also to the dataset presented in Supplementary Table 1.

Scales are not included in individual images of fronds and filaments, since accurate measurements (to the nearest millimetre) relating to each specimen are presented in Supplementary Table 1. All images of fossils and casts in this document show the top surface of bedding planes, with fossils preserved in positive epirelief.

Several of the small fronds on the surface appear to possess a positive epirelief rim around their outer edge, and occasionally a structure similar to a basal holdfast (Fig. A1.1). These features are similar to those seen in *Charniodiscus* specimens from other Avalonian beds, and therefore hint at a possible affinity with this taxon. Some specimens show similarities with *Charniodiscus spinosus* Laflamme *et al*. 2004 (Fig. A1.1 [C16, C117]), with a short stem, and a broad frond which tapers distally to a point. Definite *C. spinosus* specimens are not currently known from the Drook Formation, and therefore it is not possible to confidently classify these examples without further occurrences of larger, more mature specimens. All possible *Charniodiscus* juveniles possess alternating primary branching along a distally tapering frond. Holdfast structures are either circular (e.g. Fig. A1.1 [C16]), or angular (e.g. Fig. A1.1 [C6, C81]), though this latter morphology could result from a combination of tectonic deformation acting upon the disc, and/or preservation only of the side

not covered by the frond. If these specimens really are *Charniodiscus* juveniles, they would considerably extend the range of that taxon in Newfoundland (Text Fig. 8).

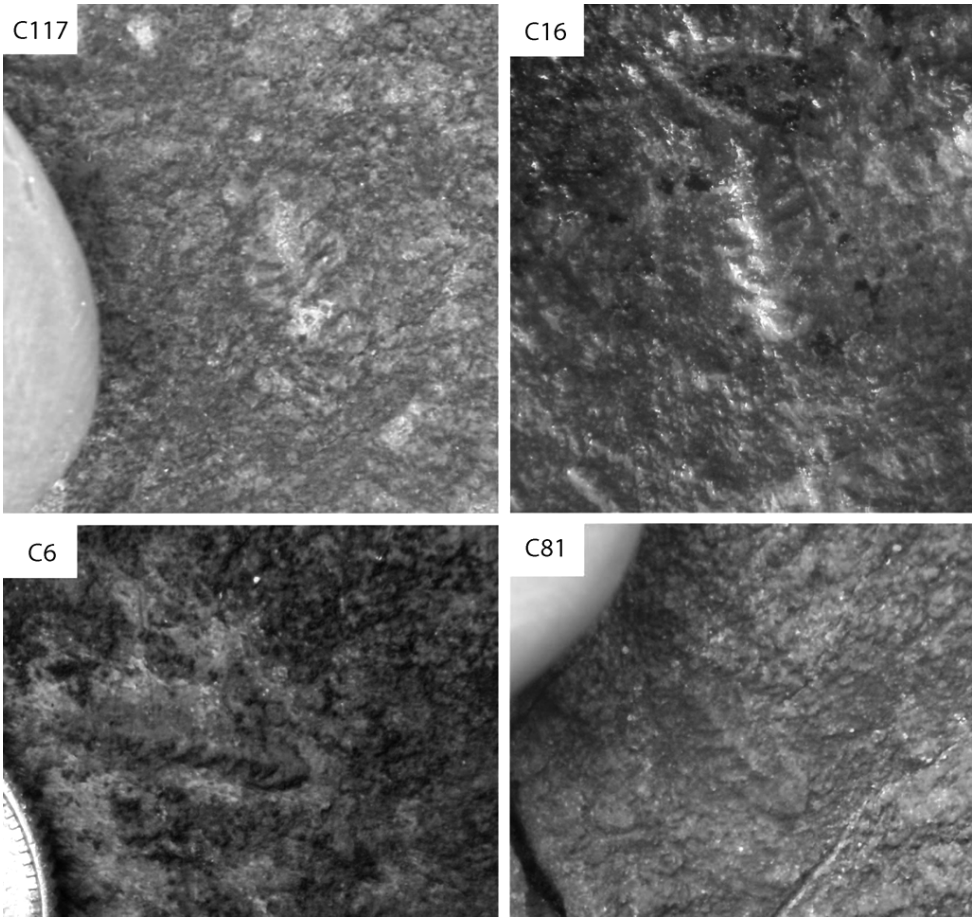

Fig. A1.1. Potential *Charniodiscus* specimens from the Drook Formation, Pigeon Cove. For exact dimensions of specimens, see Supplementary Table 1.

Multiple specimens akin to *Charnia* are preserved at Pigeon Cove (Fig. A1.2). These exhibit furled, undisplayed rangeomorph branching, alternating along an elongate frond, with no stem extending up the central axis (Fig. A1.2). In some specimens, these primary branches are arranged parallel to one another along each row, in a manner typical of *Charnia masoni* Ford 1958 (e.g. Fig. A1.2 [C1, C63]). In other specimens, the primary branches appear to radiate and change their angles in a similar style to *Charnia antecedens* Laflamme *et al*. 2007 (Fig. A1.2 [C8]). Other specimens show rather more complex rangeomorph branching, with variable branching angles and broader frond morphologies (e.g. Fig. A1.2 [C13]). Such

specimens resemble rangeomorph taxa such as *Beothukis* Brasier and Antcliffe 2009, but the lack of resolvable higher-order branching precludes classification of these individuals.

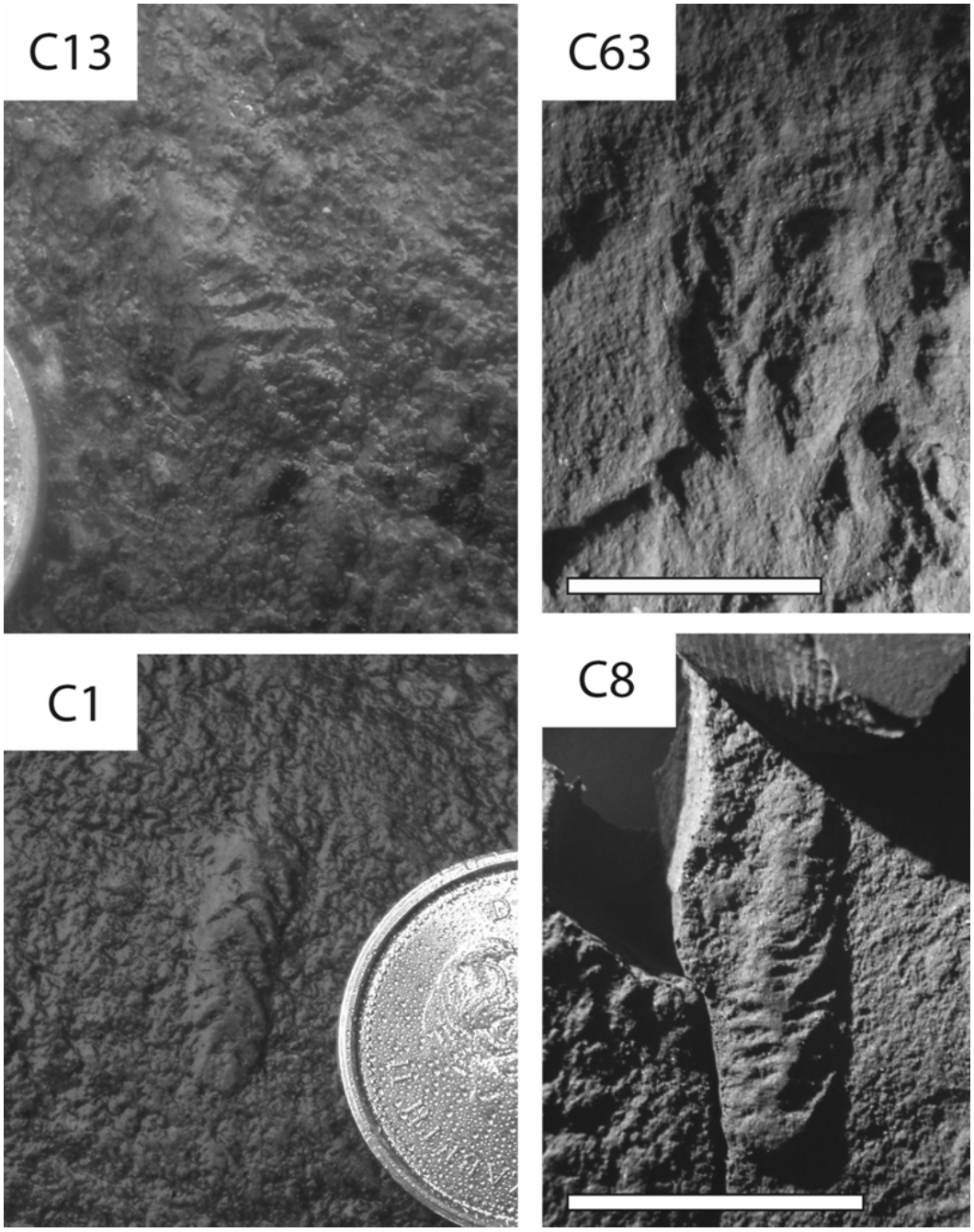

Fig. A1.2. *Charnia masoni* [C1, C63] and spatulate aff. *Charnia* [C8, C13] fronds from the Drook Formation, Pigeon Cove, Newfoundland. Scale bar = 10 mm. Images of specimens [C8] and [C63] are taken from casts housed in the collections of the Palaeobiology Group, Department of Earth Sciences, University of Oxford.

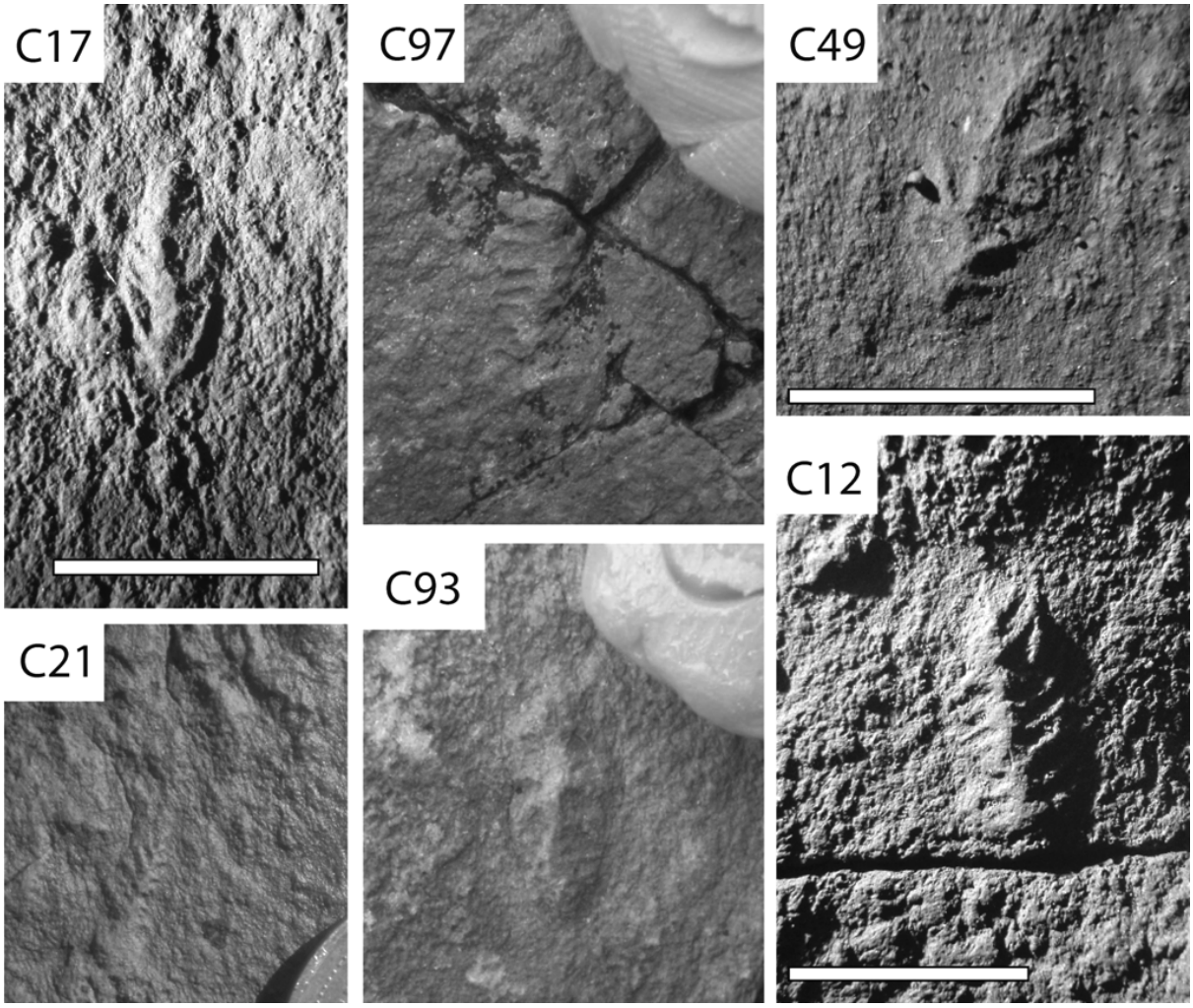

Fig. A1.3. Short fronds from the Drook Formation, Pigeon Cove, Newfoundland. Some possess 'lanceolate' fronds [C17, C49, C93], while others taper gradually (e.g. [C21]). Several specimens may be incomplete, since they do not possess either basal holdfast structures, or tapering points [C12, C97]. The small rounded lumps in [C49] are bubbles formed during the casting process. Scale bars where present = 10 mm.

A large number of fronds on the Pigeon Cove surface are short and do not possess sufficient features to be classified within a specific rangeomorph genus. Some of these appear to be complete, with fronds distally tapering to a point, and possible evidence for a holdfast disc, while others appear to be incomplete, showing no convincing evidence of tapering at either end (Fig. A1.3). All such specimens possess a central stem running up the length of the frond, while primary branching angles vary substantially through the population, and often even within individual specimens (e.g. Fig. A1.3 [C12]).

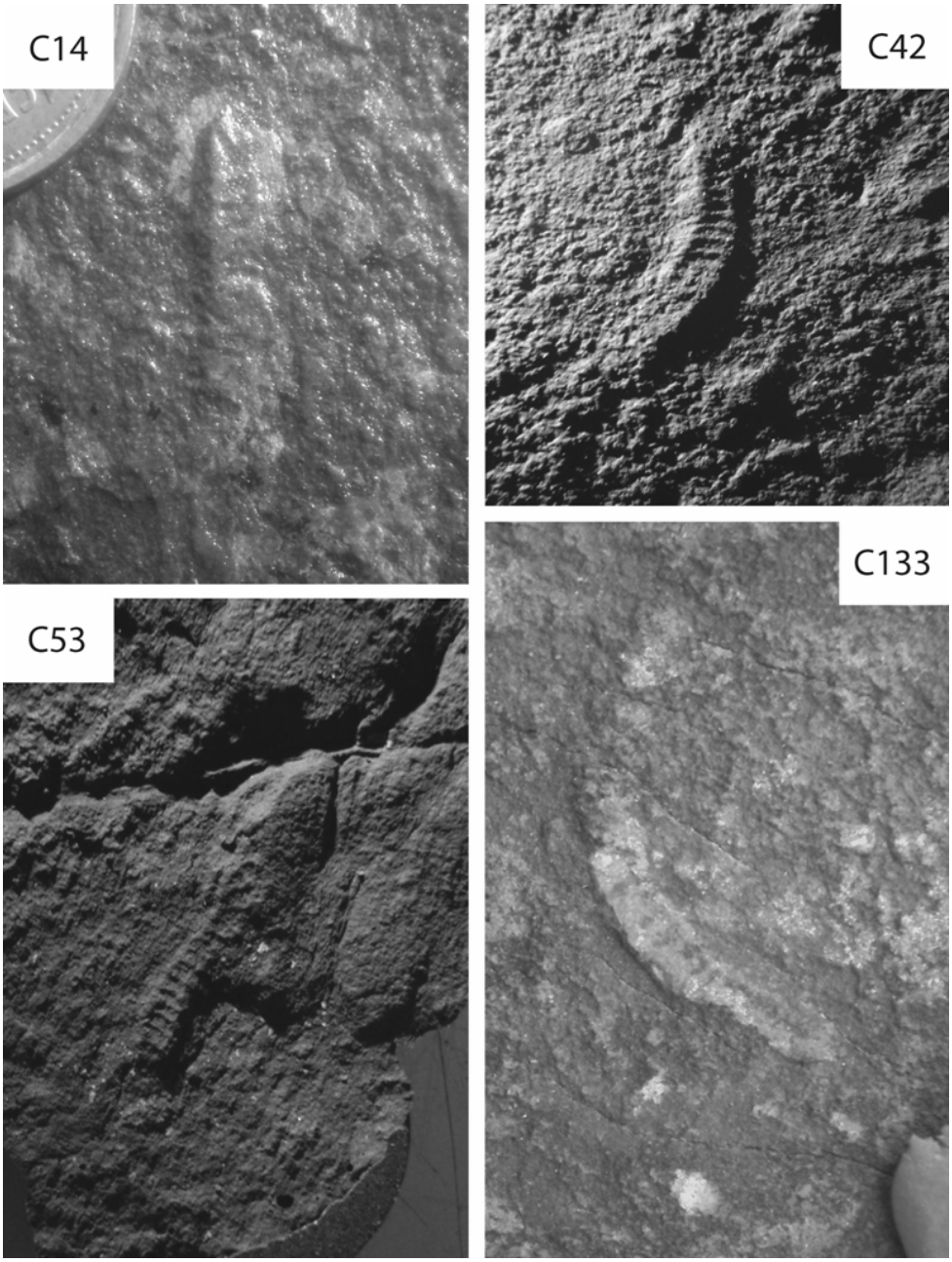

Fig. A1.4. ‘Furled’ small fronds from the Drook Formation, Pigeon Cove, Newfoundland. These specimens appear to show only one row of rangeomorph primary branches, but faint evidence in some specimens (e.g. [C14, C42]) of a second row demonstrates that they are actually long fronds (similar to *Trepassia*) which are folded along their midline. Images [C42 and C53] are taken from casts.

Some of the small fronds seemingly only show one set of transverse ridges, with no central frond axis (e.g. Fig. A1.4 [C53, C133]). These initially show some resemblance to Ediacaran tubular body fossils, but on closer inspection, it is clear that they are likely to be

unipolar rangeomorph fronds where only one row is visible. Crucially, some of these specimens do show evidence for a second row, but this often possesses much shorter primary branches than its neighbour, oriented at different angles (e.g. Fig. A1.4 [C14, C42]). This suggests that rather than preserving a different member of the Ediacara biota, these specimens represent rangeomorph specimens where the second row lies outside the plane of preservation. Possible mechanisms that could explain this include one row being folded beneath the rest of the frond, embedded within the sediment, or even raised above the sediment-water interface. These specimens hint at what may be happening laterally in rangeomorph construction, and demonstrate the flexibility of the organic matter. It does not appear that the juvenile fronds were particularly three-dimensional, since these specimens, which presumably fell to one side of their central axis, collapsed upon themselves and folded back such that part of the frond 'front' or 'back' is always preserved.

Finally, the most common small fronds on the surface are long, narrow specimens exhibiting first order branching patterns. These individuals are likely to possess an affinity with the *Trepassia* genus (Narbonne *et al*. 2009; Fig. A1.5). Such specimens are long and thin, and often clearly taper to a finely-branched tip (Fig. A1.5 [C31, C55, C136]). The vast majority exhibit a central stem running down the length of the frond, with primary branches propagating alternately ([C136] is the anomaly). It appears that the smallest, youngest branches are added distally ([C31, C136]), and a variety of branching angles exist within the assemblage (Fig. A1.5).

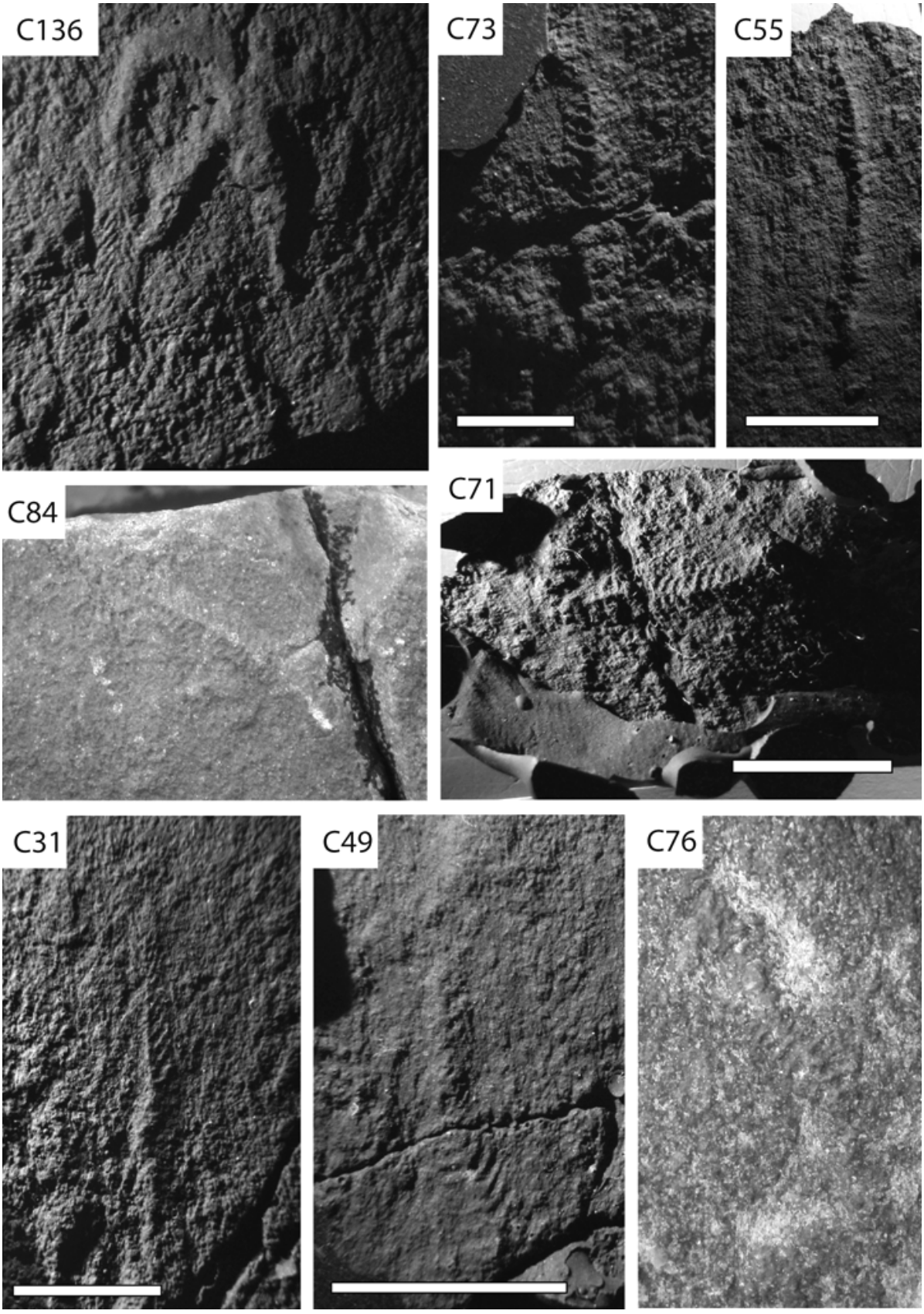

Fig. A1.5. aff. *Trepassia* specimens from Pigeon Cove, Newfoundland. Scale bars (where present) = 10 mm. All images except [C76] and [C84] are taken from casts.

Section 2: Specimens of the filamentous fossils from Pigeon Cove

The following figures present examples of the filamentous fossils from the Drook Formation of Pigeon Cove, documenting a representative selection of morphologies, and the variation within the assemblage. Again, rather than conventional labelling of component images, each figure is labelled with the field codes for the specimens, which correlate with the data presented in the Supplementary Table, and the position of the specimen on the overall map of the surface.

The filamentous fossils are all ~1 mm in width, several centimetres in length (see table in Section 3), and preserved on the Pigeon Cove surface in positive epirelief, rising up to 1 mm above the surface of the preserved bedding plane (e.g. Figs. A2.1–A2.4). All filaments, like their neighbouring fronds, are preserved beneath a 300 mm thickness of tuff. Filaments mostly lie broadly straight on the bedding plane, but some specimens are seen to loop back on themselves (e.g. Fig. A2.1 [F1]), demonstrating the flexible nature of the original organic material. They all exhibit a long, thin morphology, with little in the way of additional morphological features (Figs. A2.1–A2.3). Rare specimens are observed to branch (e.g. Fig. A2.1 [F7]; Fig. A2.2 [F112]), and it is apparent that the filaments lie on top of ivesheadiomorph impressions found on the same bed (for example, the specimen in Fig. A2.1 [F58] is draped over the lobe of a pizza disc ivesheadiomorph). Their spatial relationship with rangeomorphs is unknown, since no examples of contact between the two types of fossil were observed on the Pigeon Cove bedding plane.

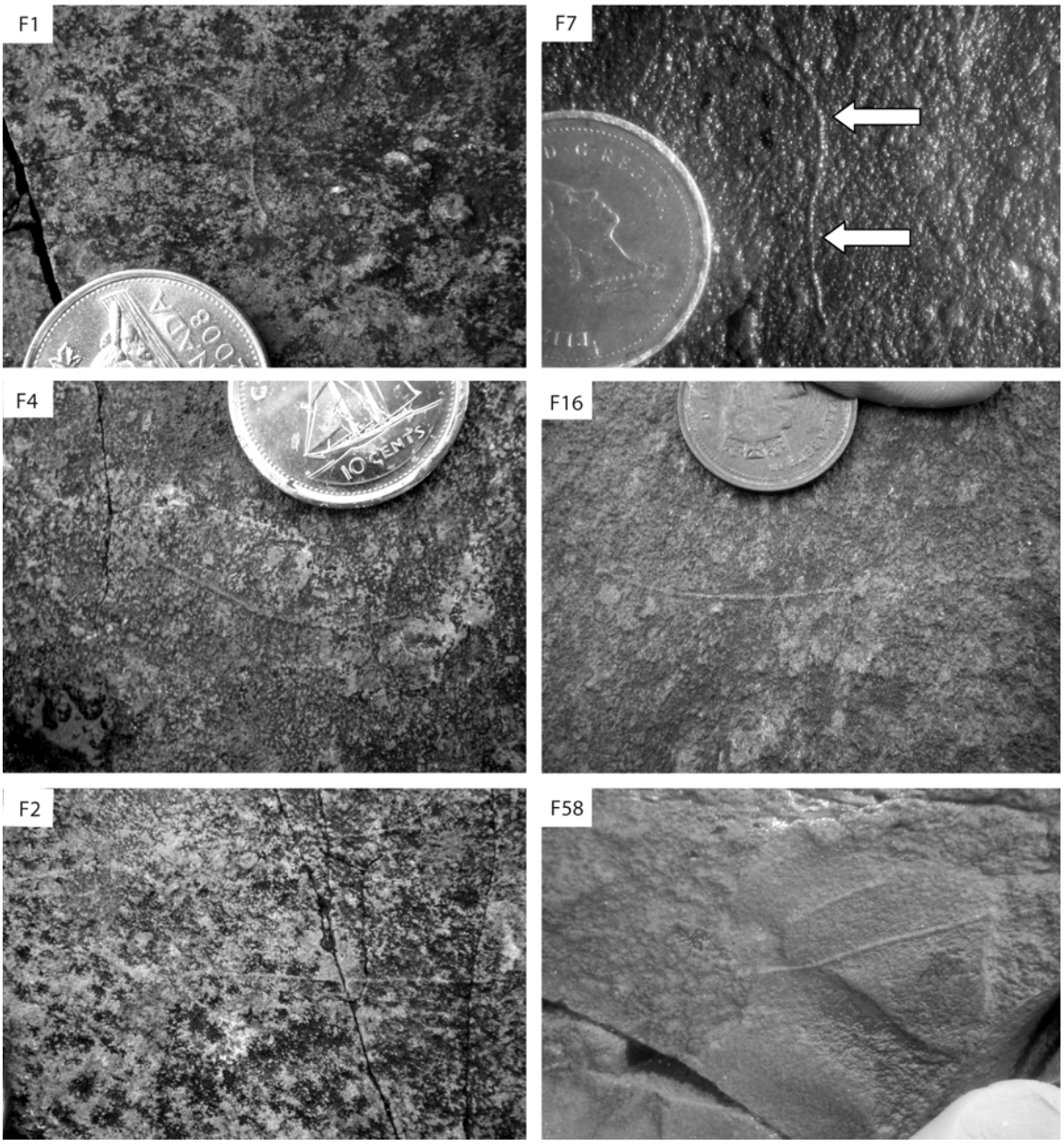

Fig. A2.1. A selection of filamentous fossils from the Pigeon Cove surface, Drook Formation, MPER, Newfoundland. Note the positive epirelief preservation, evidence for branching in [F7] (arrowed), the looping morphology of [F1], and the superimposition of a filament over an ivesheadiomorph on [F58]. Coins for scale are either Canadian or British. For accurate dimensions for each specimen, refer to Supplementary Table 1.

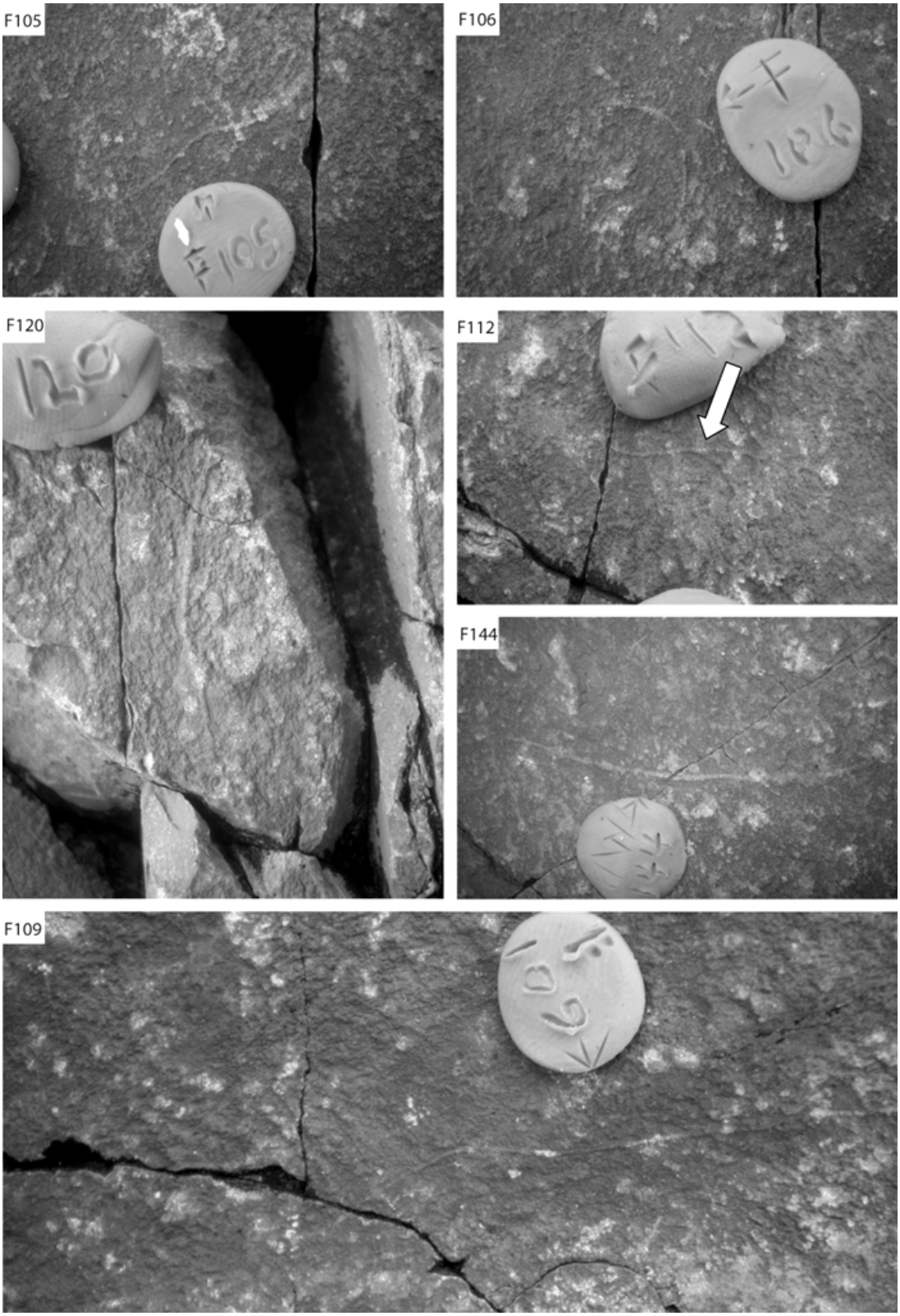

Fig. A2.2. A selection of filamentous fossils from the Pigeon Cove surface, Drook Formation, MPER, Newfoundland. Note the consistency in filament thickness, and branching in the filament in [F112] (arrowed). Letters carved into the plasticine have a width of 1 mm.

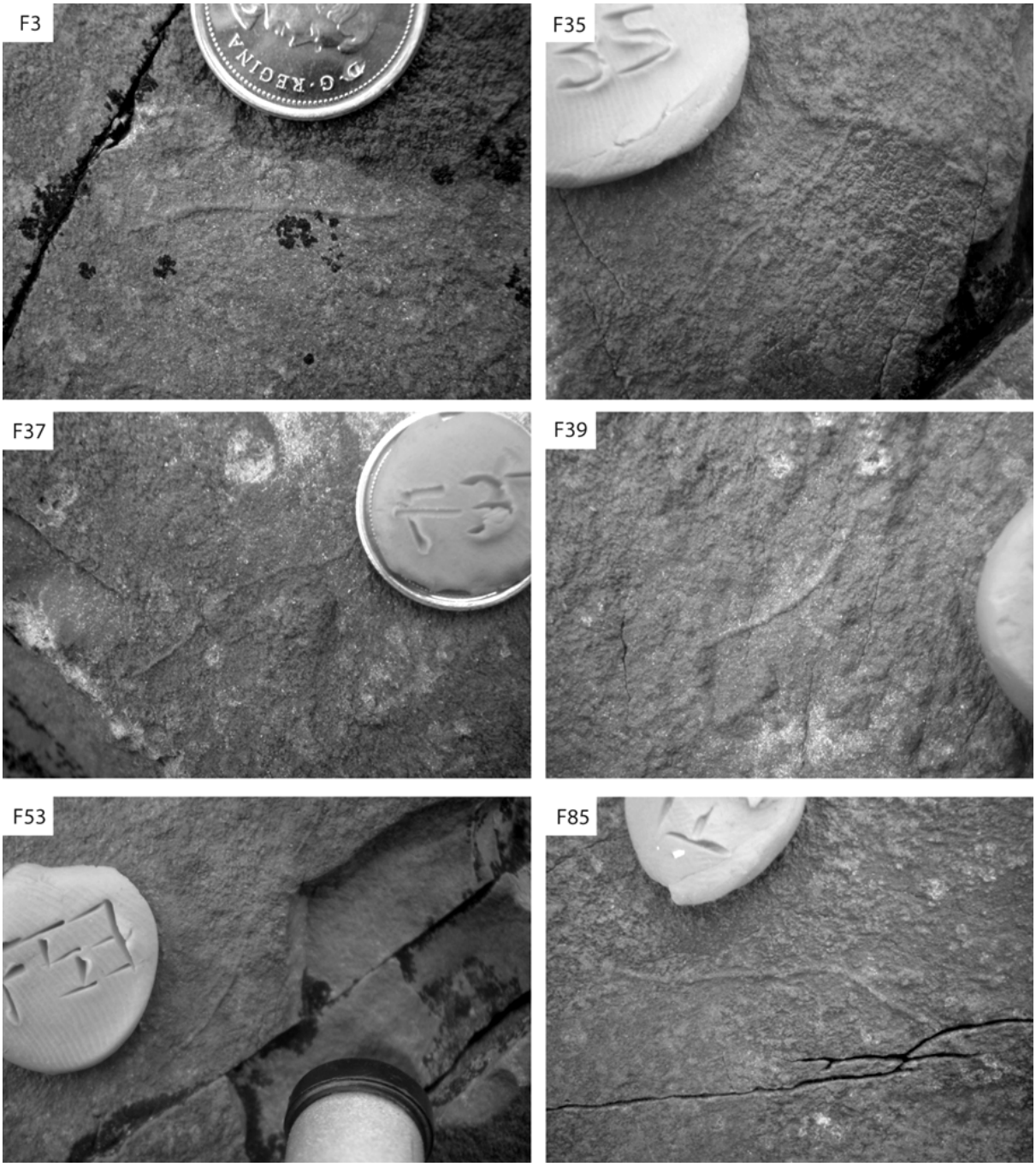

Fig. A2.3. A selection of filamentous fossils from the Pigeon Cove surface, Drook Formation, MPER, Newfoundland. Note the lack of distinctive morphological features, the long, thin morphology of the specimens, and their apparently flexible nature.

Section 3: Table of data relating to the Pigeon Cove fossil assemblage

The following table presents length, width and orientation data for each of the possible biological impressions preserved on the Pigeon Cove surface of the Drook Formation, Mistaken Point Ecological Reserve, Newfoundland, Canada. Ivesheadiomorph data was not collected. A series of graphs show the general patterns observed in the data from this assemblage.

Code	Length (mm)	Width (mm)	Orientation º	Classification
A01	27	6	-	
A02	30	5	8	
A02	30	10	143	
A03	6	5	-	
A04	30	5	-	
A05	7	2	78	
A06	7	2	25	
A07	7	2	80	
A08	4	0.5	183	
A09	30	9	65	
A10	12	3	61	
A11	14	6	79	
A12	40	12	42	
A13	6	1	3	
A14	40	25	N/A	
A15	7	2	224	
A16	24	5	343	
A17	18	13	14	
A18	6	7	n/a	
A20	7	3	83	
A21	24	4	324	
A23	4	2	47	
A24	60	11	16	
A25	52	24	67	
A26	32	25	N/A	
A27	18	2	58	
A28	63	5	178	
A29	17	4	188	
A30	72	17	132	

Code	Length (mm)	Width (mm)	Orientation º	Classification
A31	11	7	62	
B1	250	22	N/A	
C001	13	4	315	Charnia masoni
C002	12	1	253	Trepassia (probable)
C003	10	1	178	Unclear
C004	5	3	332	Unclear
C005	15	2	353	Unclear
C006	8	1	45	Charnia sp? Alternating central axis
C007	20	2	99	Unclear
C008	17	5	233	Charnia (antecedens?)
C009	20	2	201	Trepassia (probable)
C010	8	3	341	Charnia/Charniodiscus
C011	10	2	248	Charnia sp.
C012	14	4	275	Charniomorph
C013	14	2	38	Avalofractus/Beothukis?
C014	15	2	20	Trepassia
C015	19	3	80	Charniodiscus (spinosus?)
C016	9	3	47	Charniodiscus sp.
C017	7	3	232	Unclear (Avalofractus?)
C021	9	2	45	Charnia sp? Alternating central axis
C022	5	4	355	Unclear
C023	10	2	79	Charnia sp.
C024	30	2	N/A	Unclear, central axis
C026	3	2	311	Unclear (Charniodiscus?)
C027	22	2	73	Unclear
C028	10	3	256	Trepassia
C029	10	4	228	Unclear
C030	19	4	6	Unclear
C031	15	2	340	Trepassia
C032	15	2	220	Unclear
C033	10	2	57	Trepassia
C034	3	1	67	Trepassia (probable)
C035	11	2	72	Unclear
C036	6	2	79	Charniomorph
C038	13	3	78	Unclear
C039	20	1	127	Trepassia (probable)
C040	9	3	333	Charnia sp.
C042	10	3	356	Trepassia (probable)
C043	10	2	92	Unclear
C044	5	1	66	Trepassia (probable)
C045	10	2	43	Trepassia (probable)
C047	10	2	59	Unclear
C048	9	4	267	Unclear
C049	12	3	224	Trepassia
C050	10	3	284	Unclear, bifurcating central axis
C051	16	2	23	Trepassia
C052	11	2	45	Charniomorph
C053	15	3	125	Trepassia
C054	16	4	88	Trepassia (probable)
C055	6	2	43	Trepassia (probable)

Code	Length (mm)	Width (mm)	Orientation º	Classification
C056	7	4	50	Unclear
C057	10	4	124	Charniomorph?
C058	14	2	199	Unclear
C059	9	3	80	Unclear
C060	10	5	179	Unclear
C061	11	2	57	Unclear
C062	8	3	86	Unclear
C063	10	2	74	Charnia masoni
C064	4	2	140	Unclear
C065	14	4	179	Unclear
C066	5	3	18	Charnia sp.
C067	5	2	79	Unclear
C068	23	2	70	Unclear
C069	8	2	37	Unclear
C070	4	2	130	Unclear
C071	15	3	49	Charnia sp.
C072	10	5	197	Unclear, bifurcating central axis
C073	15	4	32	Charniomorph
C074	9	4	82	Unclear
C075	7	2	100	Unclear
C076	17	3	53	Trepassia?
C077	8	3	249	Charniomorph
C078	8	2	60	Unclear
C079	10	3	75	Unclear
C080	7	2	56	Unclear
C081	6	2	1	Charnia sp? Alternating central axis
C082	6	2	72	Charniodiscus sp.
C083	10	3	76	Unclear
C084	20	3	27	Trepassia
C085	12	3	28	Trepassia (possible)
C086	9	2	106	Trepassia (possible)
C087	7	3	22	Unclear
C088	19	2	80	Unclear
C089	21	2	209	Unclear
C090	6	2	259	Unclear
C091	10	4	207	Unclear
C092	13	2	256	Unclear
C093	9	3	241	
C094	28	2	246	Trepassia (probable)
C095	20	3	21	Trepassia (probable)
C096	7	3	154	Trepassia (possible)
C097	9	4	223	Charniomorph
C098	7	2	74	Unclear
C099	9	2	90	Unclear
C100	10	2	102	Unclear
C101	8	2	292	Unclear
C102	8	2	265	Unclear
C103	7	2	299	Unclear
C104	21	3	80	Trepassia (probable)
C105	7	2	233	Unclear

Code	Length (mm)	Width (mm)	Orientation º	Classification
C106	11	2	232	Unclear
C107	13	5	87	Trepassia (probable)
C108	7	3	61	Unclear
C109	6	2	270	Unclear
C110	4	2	160	Unclear
C111	24	6	104	
C112F	12	1	210	Actually a filament on closer inspection
C113	9	3	68	Trepassia (possible)
C114	10	2	48	Unclear
C115	9	2	69	Unclear
C116	13	2	357	Trepassia (possible)
C117	4	4	161	Charniodiscus sp.
C118	18	3	358	Unclear
C119	8	2	340	Rangeomorph
C120	8	3	75	Charnia sp.
C121	5	3	6	Unclear
C122	8	2	62	Unclear, central axis
C123	9	2	0	Unclear
C124	10	2	25	Trepassia
C125	16	3	18	Trepassia (possible)
C126	12	3	17	Unclear
C128	8	3	71	Unclear
C129	5	3	30	Unclear
C130	20	3	0	Unclear
C131	14	2	27	Trepassia (possible)
C132	11	3	76	Unclear
C133	18	3	79	Unclear but shape resembles furled Trepassia
C134	7	2	6	Unclear
C135	7	1	24	Trepassia
C136	11	3	230	New Species? Or Trepassia?
C137	10	2	46	Unclear
C138	6	3	347	Charnia sp? Alternating central axis
D1	25	20	266	Disc
D2	25	12	258	Disc
D3	35	22	128	Disc
D4	14	1	-	Disc
D5	15	14	-	Disc
D6	30	21	64	Disc
F001	-	-	-	
F002	-	-	228	
F003	23	1	9	
F004	27	1	181	
F005	65	2	52	
F006	30	1	53	
F007	23	1	50	
F010	50	1	65	
F011	25	1	35	
F012	17	1	48	
F013	27	1	6	
F014	15	1	57	

Code	Length (mm)	Width (mm)	Orientation º	Classification
F016	65	1	150	
F017	15	1	264	
F018	8	1	150	
F019	22	1	59	
F020	20	1	161	
F021	16	1	317	
F022	45	1	54	
F023	27	1	50	
F024	15	1	24	
F025	20	1	10	
F026	30	1	31	
F027	40	2	45	
F028	26	1	-	
F029	30	1	-	
F030	25	1	165	
F031	30	1	163	
F032	35	1	237	
F033	25	1	25	
F034	35	1	165	
F035	28	1	268	
F036	25	1	102	
F037	18/23	1	144	
F038	13	1	110	
F039	20	1	134	
F040	18	1	8	
F041	50	1	87	
F042	23	1	63	
F043	24	1	65	
F044	38	1	0	
F045	20	1	42	
F046	20	1	31	
F047	10	1	91	
F048	17	1	78	
F049	20	1	31	
F050	10	1	84	
F051	25	1	N/A	
F052	40	3	357	
F053	30	1	272	
F054	23	1	191	
F055	10	1	168	
F056	33/25	1	39/55	
F057	6	1	316	
F058	41	1	62	
F059	14	1	114	
F060	40	1	232	
F061	11	1	14	
F062	13	1	48	
F063	6	1	200	
F064	12	1	241	
F065	7	1	165	

Code	Length (mm)	Width (mm)	Orientation º	Classification
F066	50	4	95	
F067	80	1	233	
F068	33	1	40	
F069	16	1	278	
F070	45	1	52	
F071	33	1	21	
F072	14	1	35	
F073	9	1	153	
F074	11	1	15	
F075	10	1	-	
F076	14	1	52	
F077	33	1	35	
F078	7	1	344	
F079	14	1	323	
F080	32	1	191	
F081	32	1	172	
F082	10	1	258	
F083	12	1	358	
F084	10	1	305	
F085	41	1	80	
F086	18	1	-	
F087	13	1	142	
F088	13	1	112	
F089	15	1	81	
F090	5	1	40	
F091	4	1	5	
F092	16	1	308	
F093	15	1	108	
F094	14	1	344	
F095	9	1	103	
F096	12	1	116	
F097	23	1	292	
F098	12	1	51	
F099	130	1	12	
F101	50	1	62	
F102	28	1	111	
F103	12	1	145	
F104	6	1	85	
F105	25	1	128	
F106	14	1	63	
F107	11	1	80	
F108	7	1	27	
F109	103	1	65	
F110	8	1	102	
F111	22	1	124	
F112	21	1	164	
F113	15	1	56	
F114	10	1	330	
F115	59	1	320	
F116	27	1	70	

Code	Length (mm)	Width (mm)	Orientation º	Classification
F117	70	3	54	
F118	10	2	247	
F119	19	1	45	
F120	34	1	76	
F121	43	1	48	
F122	32	1	75	
F123	44	1	44	
F124	10	1	50	
F125	19	1	82	
F126	21	1	55	
F127	11	1	67	
F127	14+	1	40	
F128	27	1	56	
F130	9	1	55	
F131	33	1	27	
F132	14	1	122	
F133	22	1	55	
F134	30	1	164	
F135	40	1	42	
F136	15	1	96	
F137	10	1	24	
F138	17	2	58	
F139	17	1	11	
F140	24	1	84	
F141	14	1	95	
F142	6	1	65	
F143	6	0.2	85	
F144	65	1	12	
PF1	80	25	79	
PF2	160	15	77	
PF3	100	50	55	
PF4	280	50	48	
PF5	35	20	58	
PF6	190	25	80	
PF7	60	10	202	
PS1	130	1	16	
PS2	790	1	18	
T1	30	12	95	Thectardis?
T2	72	24	216	Thectardis?
T3	70	30	124	Thectardis?

Table 1. Dimension, location and orientation data for the small fronds and filaments observed on the Pigeon Cove bed. For field codes, C = frond, F = filament, B = bubble mat, A = anomalous impression, T = *Thectardis*, D = discoidal fossil, PF = Pizza filament, PS = Pizza string.

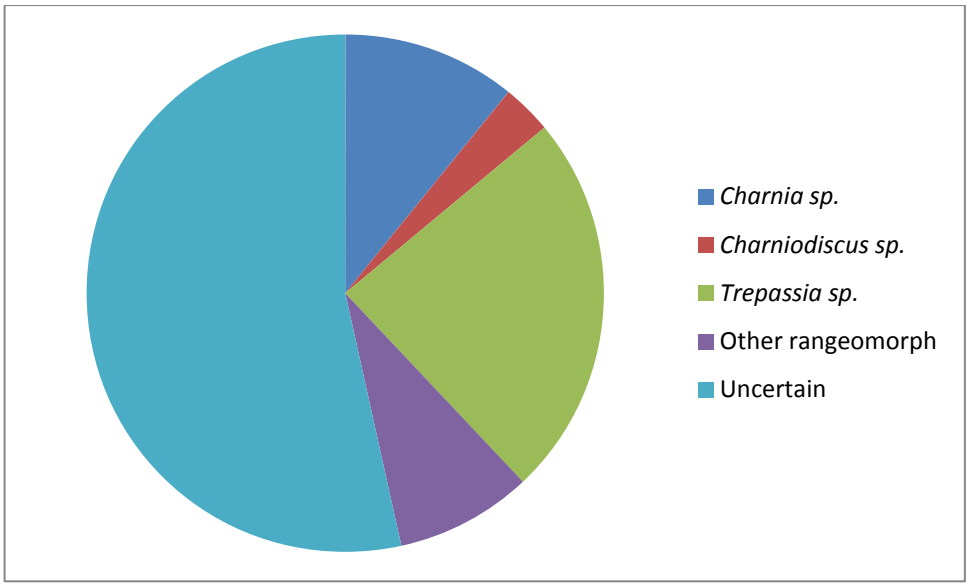

Fig. A3.1. Pie chart showing the relative proportions of identifiable frondose genera in the Pigeon Cove small-frond assemblage. n = 129. The difficulty involved in identifying these small fronds accounts for the large proportion of 'uncertain' taxa. Specimens were assigned as 'uncertain' rather than as 'other rangeomorphs' since it was not always possible to determine whether true rangeomorph branching was present (though it is considered highly likely that it was).

References

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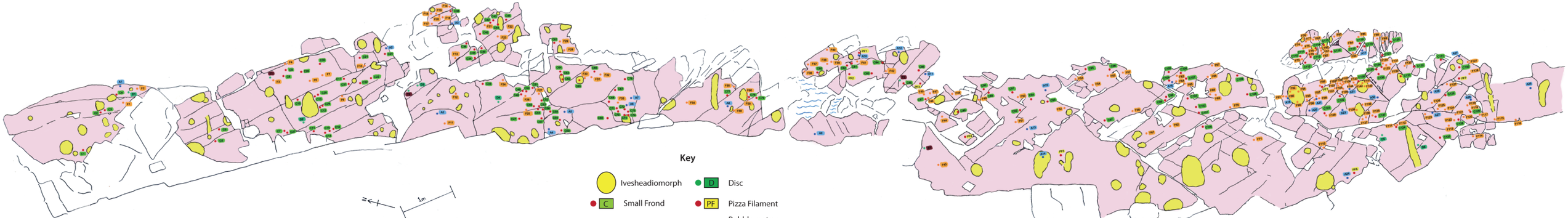

Complete digitised map of the Pigeon Cove surface
August 2008