Chesapeake Bay Benthic Foraminifera

By Scott E. Ishman, Alex W. Karlsen, Thomas M. Cronin

Benthic foraminifera are single-celled organisms similar to amoeboid organisms in cell structure. The foraminifera differ in having granular rhizopodia and elongate filopodia that emerge from the cell body. Foraminifera are covered with an organic test that varies from a simple single chamber with an aperture to a complex, multichambered, perforate, calcitic wall, to an agglomeration of mineral grains embedded in the organic test. Benthic foraminifera occupy a wide range of marine environments, from brackish estuaries to the deep ocean basins and occur at all latitudes. Many species have well defined salinity and temperature preferences making them particularly useful for reconstructing past trends in ocean water salinity and temperature.

The distribution of modern benthic foraminifera from the Atlantic coastal margin of the United States and Gulf of Mexico have been studied extensively over the past several decades (see Buzas and Culver, 1980 and 1981 for comprehensive reviews). Many of the taxa have widespread distributions, inhabiting marshes, coastal estuaries, bays, lagoons, and the continental shelf. Comprehensive studies of benthic foraminiferal distributions and ecology in the Chesapeake Bay and its estuaries include papers by Ellison *et al*., 1965; Nichols and Norton, 1969; Ellison, 1972; Buzas, 1974; and Ellison and Nichols, 1976; and in Gulf Coast Bays by Phleger, 1951, 1954, 1965; Parker *et al.*, 1953; Bandy, 1954; Phleger and Lankford, 1957; Benda and Puri, 1962; Frerichs, 1969; Lamb, 1972; Otvos, 1978; and Poag, 1981.

Several studies have contributed toward our understanding of the distribution of modern benthic foraminifera in Chesapeake Bay estuaries. Ellison *et al.* (1965) and Ellison and Nichols (1970) clearly illustrated distinct benthic foraminiferal assemblage distributions

associated with environmental changes from the marsh to the estuary, into the Bay and culminating on the Atlantic Shelf. Buzas (1974) described the vertical distribution of living *Ammobaculites* from the Rhode River estuary of the Chesapeake Bay. These studies have contributed greatly to the interpretation of benthic foraminiferal assemblages recovered from sediment cores to evaluate past changes in salinity, water temperature, and sea level. Ellison and Nichols (1976) have shown significant environmental changes in the Rappahannock River Estuary for the past 1500 to 3000 years.

The present study is part of a large study to document the benthic foraminiferal fauna in the Chesapeake Bay and its estuaries, and to determine temporal changes in the benthic foraminiferal communities throughout the last few millennia in the sedimentary record. Following the format used for other microfossil groups, there are two sections given here. The first consists of five plates of scanning electron photomicrographs illustrating 11 benthic foraminiferal taxa found in the mesohaline parts of the bay (Table 2). The species illustrated include the most common benthic foraminiferal species now living, or having lived in the middle regions of Chesapeake Bay over the past millennium. The second part consists of species census data for benthic foraminifera obtained from the box, piston, and gravity cores (Table 1).

Table 2. Some Benthic Foraminifer species from mid-Chesapeake Bay

Ammobaculites exiguus (Cushman and Bronnimann 1948)

Ammonia tepida (Cushman 1926)

Ammotium salsum (Cushman and Bronnimann 1948)

Buccella frigida (Cushman 1922)

Elphidium clavatum Cushman 1930

Elphidium excavatum (Terquem 1876)

Elphidium selseyense (Heron-Allen and Earland 1911)

Polymorphinidae

Quinqueloculina sp.

Trochammina macrescens (Brady 1870)

Trochammina inflata (Montagu 1808)

Trochammina sp.

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Plate 1

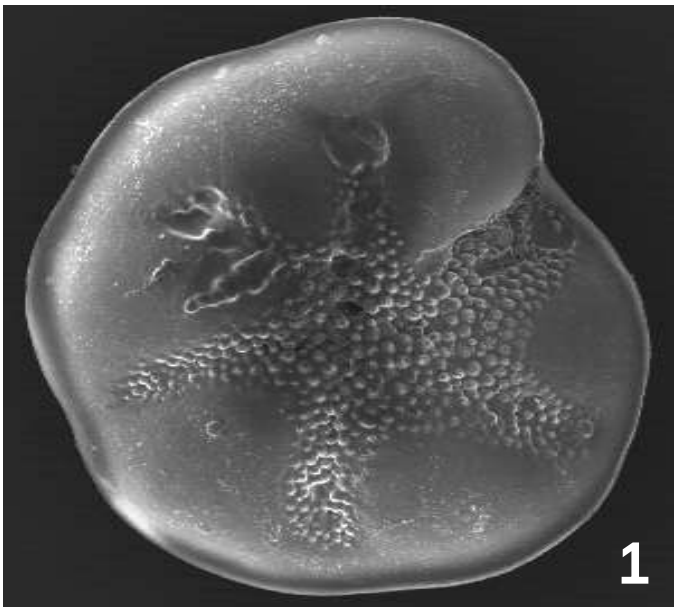
1) *Buccella frigida*, umbilical, PTMC 3-P-2 224-226 cm., x 212.

2) *Buccella frigida*, dorsal, PTMC 3-P-2 224-226 cm., x 242.

3) *Trochammina macrescens*, umbilical, JP-3 0-10 cm., x 160.

4) *Trochammina inflata*, dorsal, JP-3 0-10 cm., x 200.

5) *Trochammina* sp., dorsal, JP-3 0-10 cm., x 180.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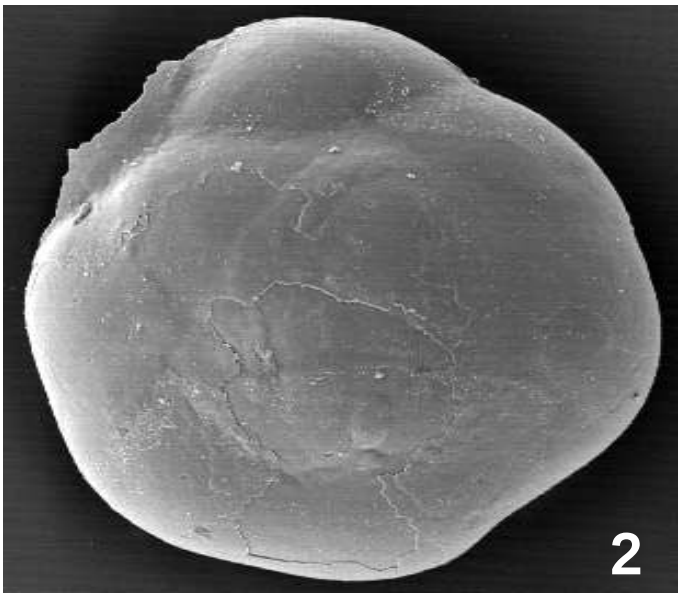
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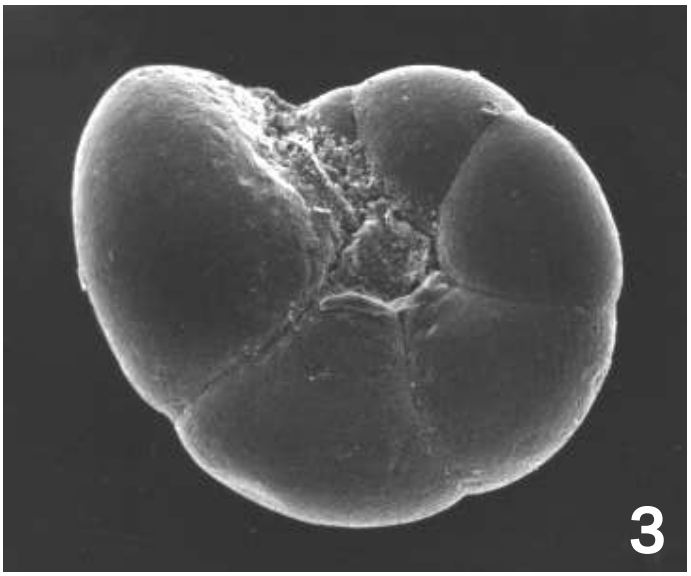
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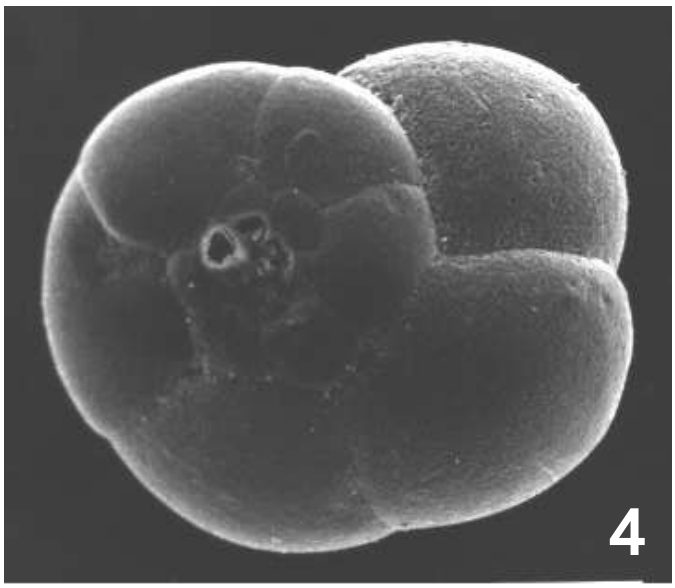
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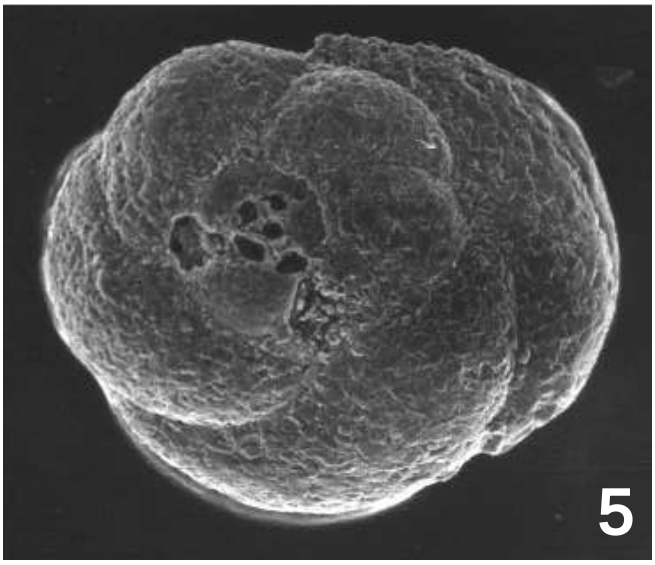
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Plate 2

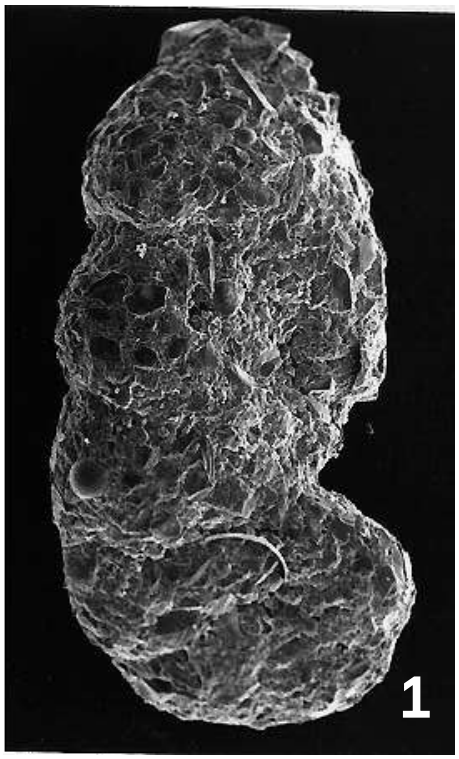
1) *Ammobaculites* sp., side view, PRCK 3-P-2 0-2 cm., x 220.

2) *Ammobaculites* sp., side view, BUVA 0-2 cm., x 200.

3) *Ammobaculites* sp., side view, RGPT 8/96 19-20 cm., x 160.

4) Polymorphinid, PTMC-3 Archive 358-360 cm., x 130.

5) *Miliammina fusca*, side view, JP-3 0-10 cm., x 300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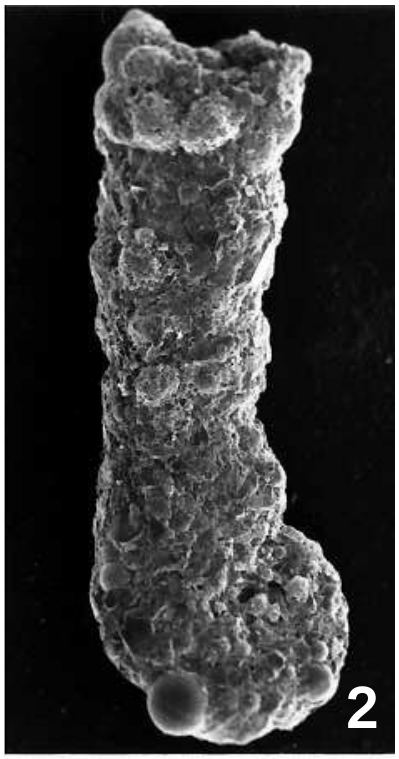
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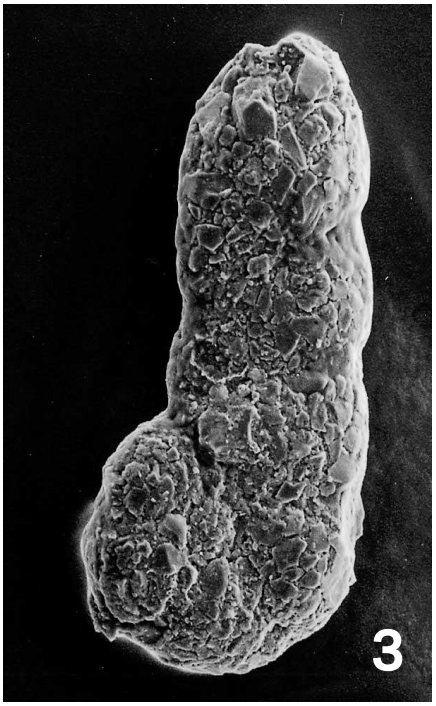
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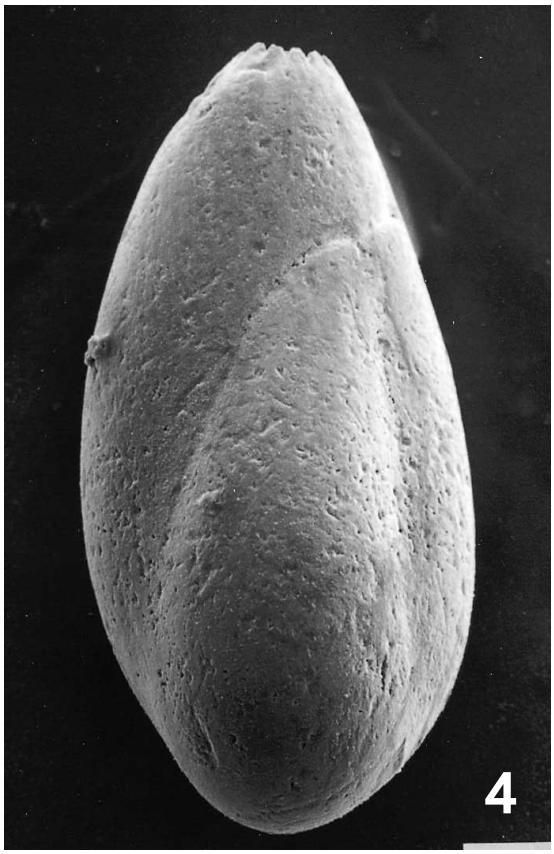
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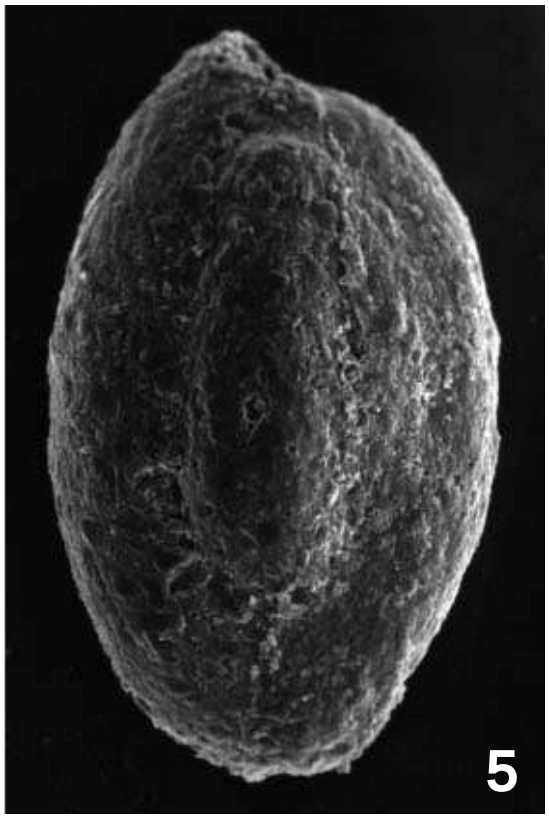
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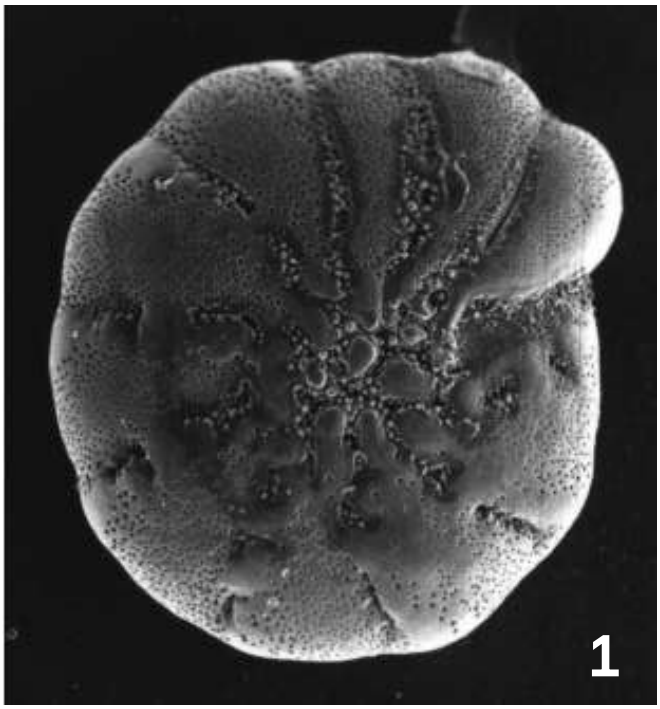
Plate 3

1) *Elphidium selseyense*, umbilical, R-64 0-2 cm., x 220.

2) *Elphidium selseyense*, large, PTMC 3-P-2A 36-38 cm., x 130.

3) *Elphidium clavatum*, small, PTMC 3-P-2A 36-38 cm., x 200.

4) *Elphidium clavatum*, small, PTMC-3 Archive 344-346 cm., x 200.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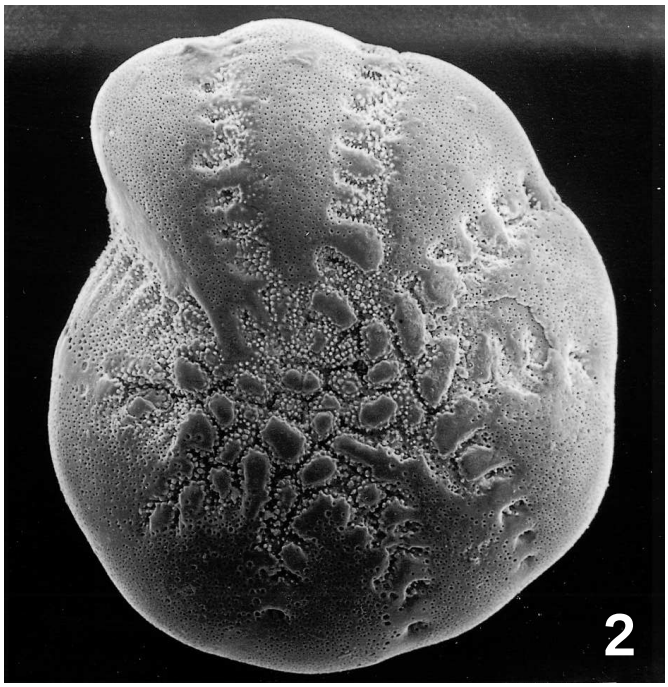
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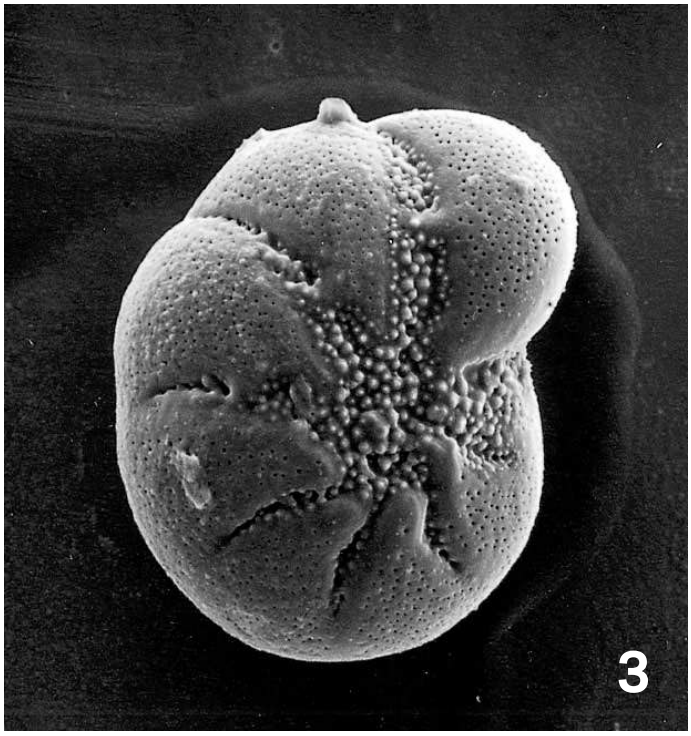
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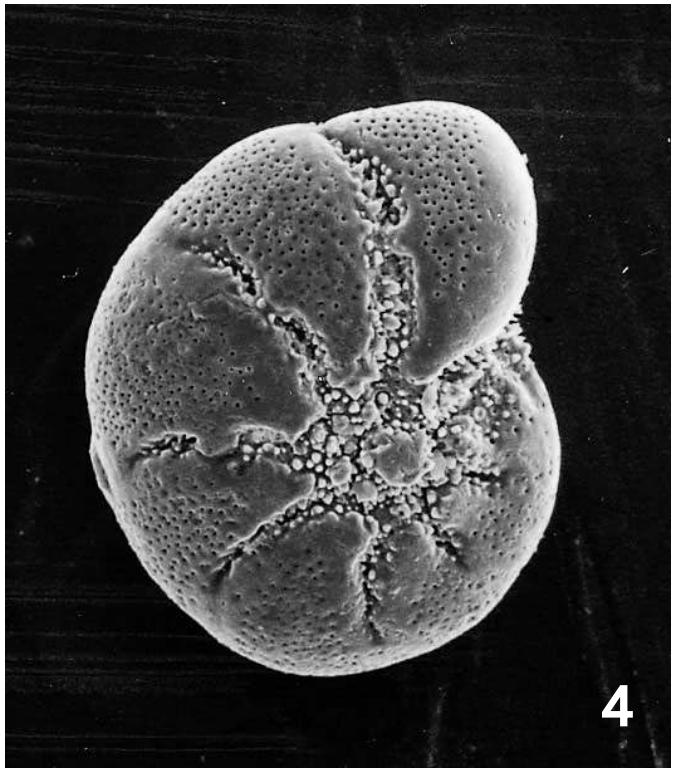
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Plate 4

1) *Ammonia tepida,* dorsal, Tangiers-5 0-2 cm., x 160.

2) *Ammonia tepida,* umbilical, Tangiers-5 0-2 cm., x 200.

3) *Ammonia tepida,* spiral view, PTXT 2-P-5 286-288 cm., x 260.

4) *Ammonia tepida,* umbilical view, PTXT 2-P-5 214-216 cm., x 260.

5) *Ammonia tepida,* umbilical view, RGPT 8/96 7-8 cm., x 130.

6) *Ammonia tepida,* spiral view, PTXT 2-P-5 10-12 cm., x 130.


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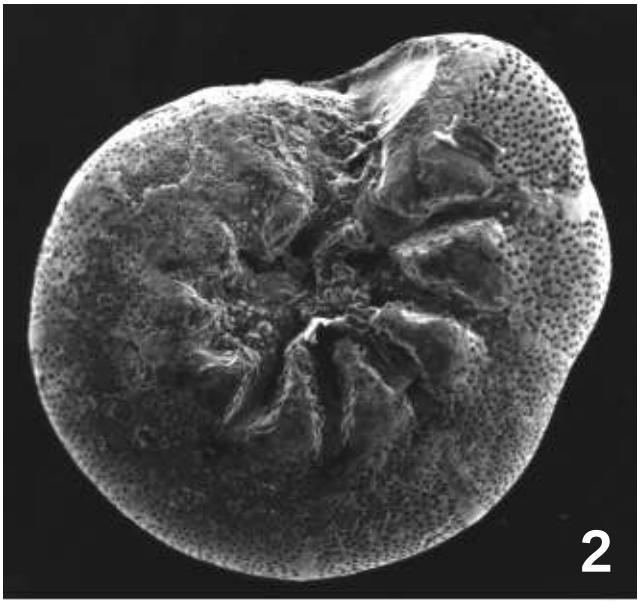
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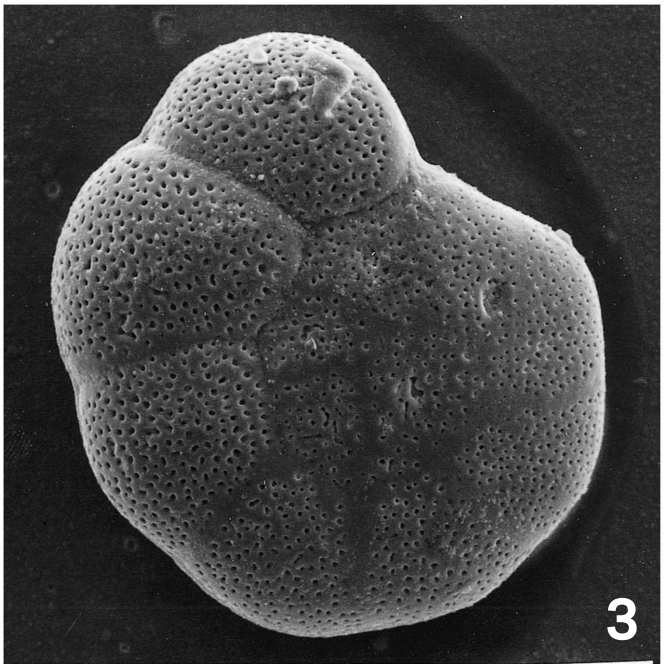
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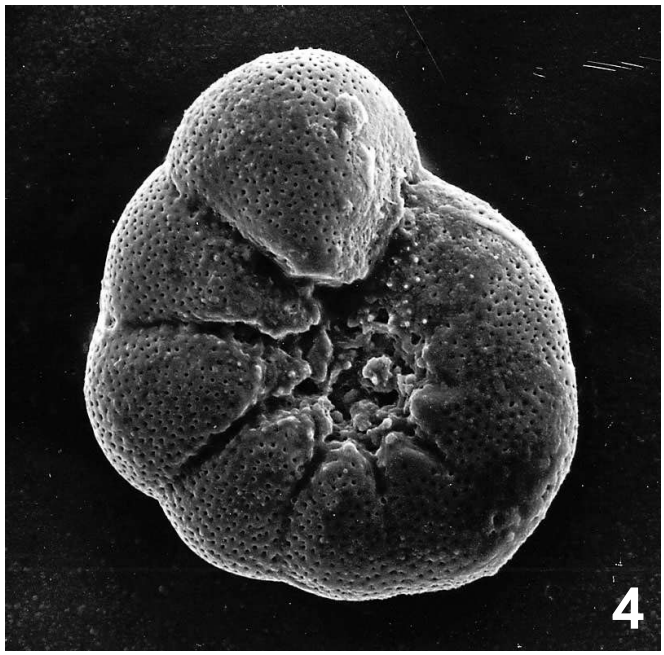
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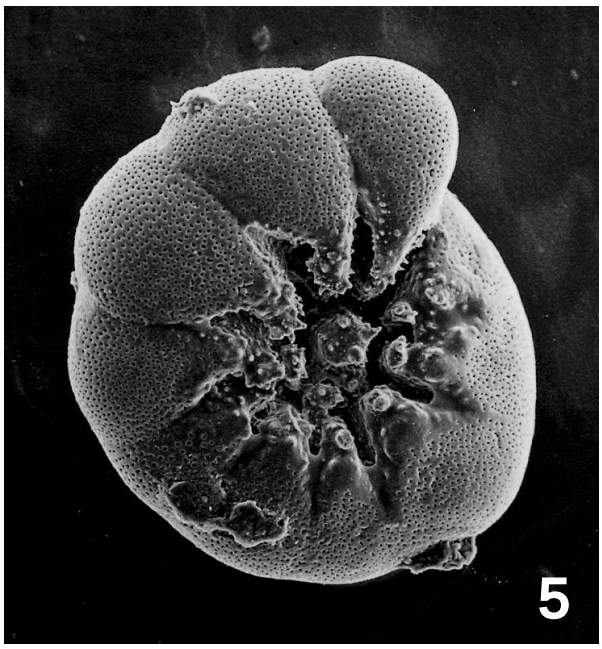
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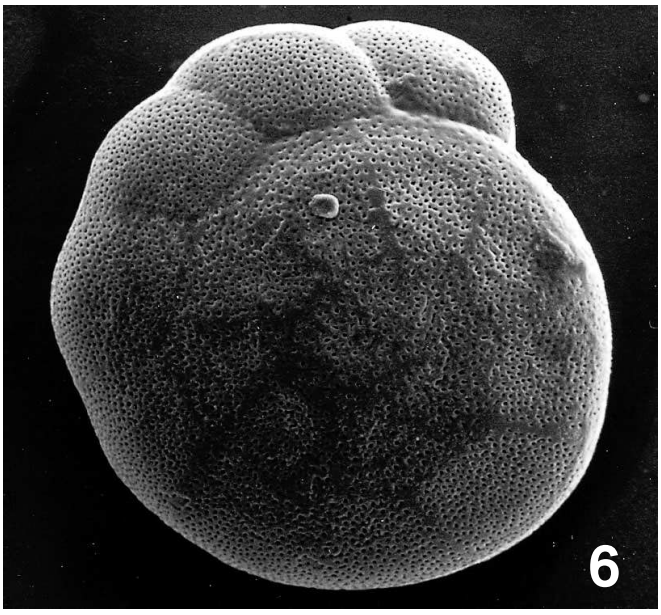
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Plate 5-Deformed Foraminifera

All photographs are of *Ammonia*

1) Normal test, dorsal view, BRIS 6/97 0-10 cm., x 160.

2) Normal test, umbilical view, BRIS 6/97 0-10 cm., x 180.

3) Abnormal chamber shape, HNPT 7/96 0-10 cm., x 300.

4) Reduced-size chamber, HNPT 7/96 0-10 cm., x 260.

5) Distorted chamber shape or change in coiling direction, PTXT 2-P-5 0-10 cm., x 240.

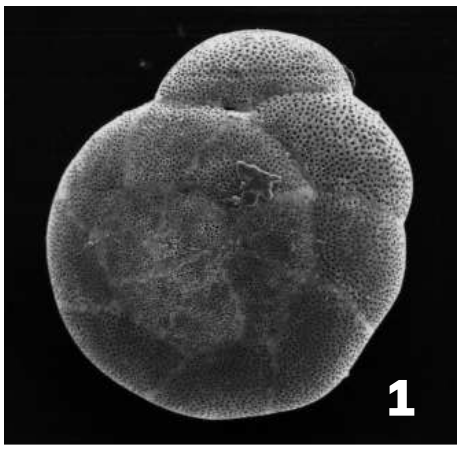
6) Development of the high spiral face, PRCK 3-P-2 0-10 cm., x 180.

7) Non-developed test, BRIS 6/97 0-10 cm., x 130.

8) “Protruded umbilical”, HNPT 7/96 0-10 cm., x 130.

9) Distorted chamber shape or change in coiling direction, PTXT 2-P-5 0-10 cm., x 320.

See Geslin *et al*. 1998 for discussion of terminology of test morphological deformities.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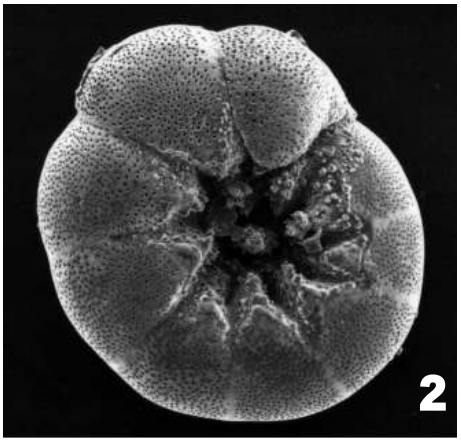
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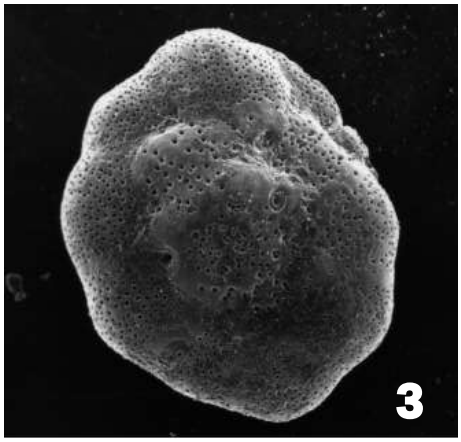
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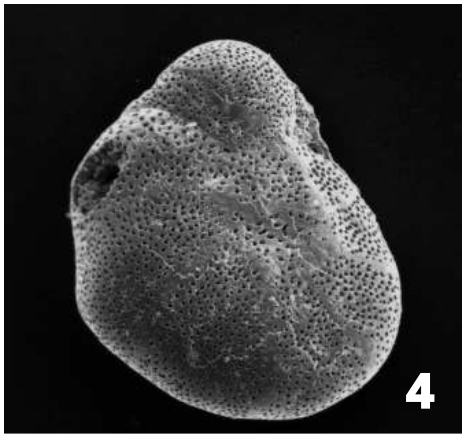
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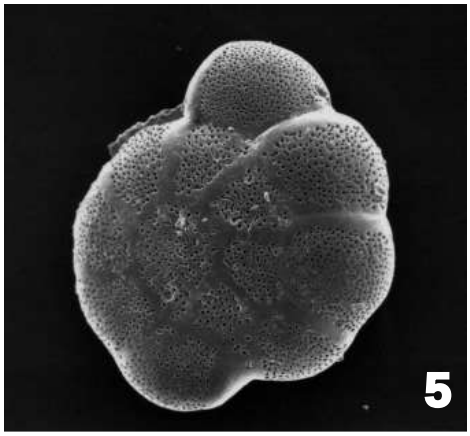
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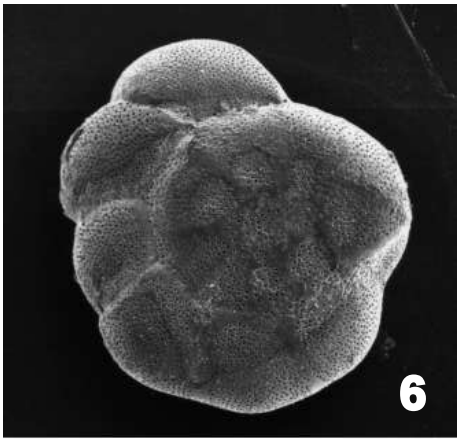
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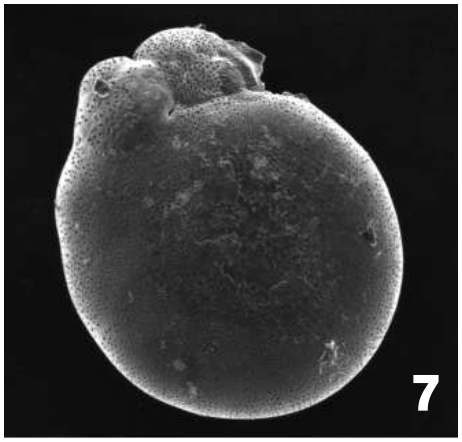
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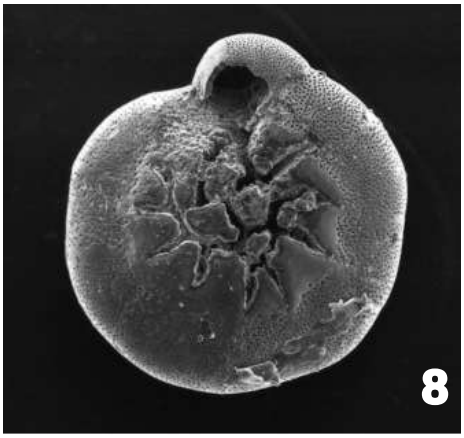
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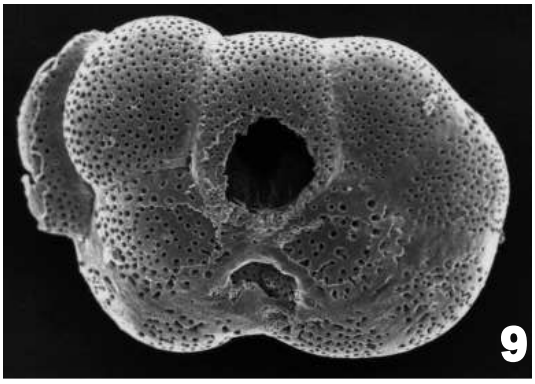
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Depth (cm)	*E. selseyense/excavatum*	*E. clavatum*	*A. tepida*	*Ammobaculites*	*B. frigida*	Total
1	4		1			5
3	48		44	3		95
5	10			1		11
7	33			3		36
9	101	3				104
11	24					24
13	25					25
15	110	11				121
17	106	3	2			111
19	70	15	1			86
21	54	21		2		77
23	79	23				102
25	92	8				100
27	65	28	2	2		97
29	72	20	13			105
31	16	15	2			33
33	21	85				106
35	47	49	4			100
37	56	45	1			102
39	48	27	2			77
41	43	18	2			63
43	22	1				23
45	29	3	1			33
47	1					1
49	16	3	3			22
51	94	20				114
53	21	82				103
55	11	97				108
57	1	92				93
59	15	83				98
61	6	26	4			36
63	14	78				92
65	15	77				92
67	2	86				88
69	18	72				90
71	10	35				45
73	20	40				60
75	18	64				82
77	38	53				91
79	4	69				73
81	3	91				94
83	3	25				28
85		10				10
87	5	83				88
89		7				7
91	1	24				25
93		16		6		22
95		11		3		14
97		54				54
99	4	97				101
101	3	65		1		69
103	1	6				7
105		25				25
107	25	61		1		87
109	24	29				53
111	60	35				95
113	32	64	3			99
115	26	89				115
117	12	70	3	12		97
119	9	36				45
121		17				17
123	1	54	1			56
125	1	28				29
127	1	27				28
129	10	90				100
131		44				44
133	4	96				100
135	9	33				42
137	4	32	1			37
139	6	35				41
141	7	24	1			32
143	1	25				26

Depth (cm)	*E. selseyense/excavatum*	*E. clavatum*	*A. tepida*	*Ammobaculites*	*B. frigida*	Total
145	6	11				17
147	25	12	2			39
149						0
151						0
153	2					2
155	1					1
157	4	1		1		6
159						0
161	8					8
163	8		1			9
165	3					3
167	6	1				7
169	6	1				7
171	27					27
173	4					4
175	20		1			21
177	5					5
179	21					21
181	121	1				122
183	40	4				44
185	39					39
187	12					12
189	52					52
191	76					76
193	98	1	1		1	101
195	104					104
197	76					76
199	100					100
201	82	16			1	99
203	15	6	2			23
205	6		1			7
207	4					4
209	66	15				81
211	5					5
213	14					14
215	63					63
217	29					29
219	37					37
221	53	47	1			101
223	73	24	5			102
225	52	4	25		3	84
227	17	4	3			24
229	41	64	5			110
231	5		1			6
233	4					4
235	8					8
237	49	10	15			74
239	24					24
241	17					17
243	89				1	90
245	6					6
247						0
249	51	30				81
251	9					9
253	16					16
255	8					8
257	9					9
259	12					12
261	59	40	1			100
263	7					7
265	2					2
267	1					1
269	1					1
271	28	8				36
273	4					4
275	6					6
277	1					1
279	1					1
281	1					1
283	93	6				99
285	2					2
287	2					2
289	2					2
291	15					15
293	89	11				100
295	1					1
297	3					3

Depth (cm)	*E. selseyense/excavatum*	*E. clavatum*	*A. tepida*	*Ammobaculites*	*B. frigida*	Total
299						0
301						0
303						0
305						0
307	6					6
309						0
311	2					2
313	1					1
315	1					1
317	6					6
319						0
321						0
323	3					3
325	23	4				27
327	9					9
329	2					2
331	8					8
333	3					3
335	30	4				34
337						0
339	1					1
341						0
343						0
345	4	8			3	15
347						0
349						0
351	3					3
353						0
355	1					1
357	57	48			2	107
359	1					1
361	100					100
363	77				3	80
365	36		5			41
367	66	33	4		5	108
369						0
371	1					1
373						0
375	2					2
377	6					6
379	56	5	2		3	66
381						0
383	3					3
385	3					3
387						0
389	8					8
391						0
393						0
395	21	2				23
397						0
399	3					3
401	4					4
403	32	3				35
405	34	1				35
407						0
409	2					2
411	89	1	2		3	95
413	33		7			40
415	2					2
417						0
419	40					40
421	65	1	1			67
423	2					2
425						0
427	73	1			1	75
429	8					8
431	3					3
433						0
435	3					3
437						0
439	27					27
441	8	1	1			10
443	5					5
445	6					6
447	40					40
449	3					3

Depth (cm)	*Elphidium*	*Ammonia*	*Ammobaculites*	Total
1	8	1	2	11
6	5	12	1	18
11	5	1		6
16	107	3	2	112
21	11			11
26	34	27	31	92
31	53	28	22	103
36	47	17	24	88
41	101		17	118
46	88	1	1	90
51	76	1	3	80
56	64	3	8	75
61	53	18	25	96
66	39	9	49	97
71	79	26	48	153
76	53	25	32	110
81	79	5	33	117
86	90	3	41	134
91	117	1	1	119
96	118			118
101	100			100
106	93		12	105
111	102			102

Depth (cm)	*E.selseyense/excavatum*	*E.clavatum*	*A. tepida*	*Ammobaculites*	*Quinqueloculina sp.*	Total
1	21		77	5		103
3	23		73	3		99
5	23		69			92
7	37	3	60			100
9	22	4	68			94
11	11	3	86			100
13	16		83			99
15	55	10	30			95
17	84	14	6			104
19	84	17	2	5		108
21	62	42	2			106
23	60	22	13			95
25	51	15	29	3		98
27	39	34	32	1		106
29	38	29	19	13		99
31	24	38	10	28		100
33	46	16	32	1		95
35	47	8	26	19		100
37	39	3	25	33		100
39	26	16	37	21		100
41	32	15	42	6		95
43	36	12	53	16		117
45	55	5	54	19		133
47	42	6	33	15		96
49	54	9	52	8		123
51	69	14	11			94
53	81	14	4	1		100
55	78	17	12	4		111
57	77	14	7	5		103
59	62	27	8	9		106
61	58	29	7	2		96
63	62	41	3	3		109
65	52	58		1		111
67	65	39	2	4		110
69	77	36				113
71	62	32				94
73	59	41		1		101
75	61	25	3	2		91
77	69	17	2	4		92
79	81	17	7	1		106
81	61	23	8	5		97
83	56	29	7			92
85	63	13	19	9		104
87	51	19		10		80
89	52	23	10			85
91	48	6	23	25		102
93	43	11	20	33		107
95	65	52	9	14		140
97	16	2	3	106		127
99	26	8	11	93		138
101	7		6	89		102
103	60	10	26	68		164
105	10		6	77		93
107	63	8	63	48		182
109	10		20	66		96
111	25	1	7	59		92
113	32	12	25	48		117
115	17	7	12	115		151
117	32	3	12	56		103
119	37	9	13	98		157
121	18	1	3	77		99
123	71	11	14	10		106

Depth (cm)	*E.selseyense/excavatum*	*E.clavatum*	*A. tepida*	*Ammobaculites*	*Quinqueloculina sp.*	Total
125	33	8	11	21		73
127	74	11	24	23		132
129	51	7	16	44		118
131	47	23	11	8		89
133	64	24	10	6		104
135	42	17	19	14		92
137	58	36	7	4		105
139	50	36	27	4		117
141	65	29	8			102
143	88	21	6			115
145	86	21	2	1		110
147	83	8	3			94
149	70	29	4	3		106
151	30	33	5	26		94
153	127	50	1	5		183
155	68	67		2		137
157	57	34		5		96
159	73	13		28		114
161	40	21	13	28		102
163	28	2		70		100
165	64	11	1	16		92
167	58	8	2	32		100
169	65	9	1	29		104
171	61	8		13		82
173	87	22	1	1		111
175	60	31	2	7		100
177	64	39		1		104
179	14	90	1	12		117
181	43	72	2	1		118
183	55	56	7	8		126
185	87	13				100
187	76	30	3	9		118
189	82	14	3	16		115
191	63	20		37		120
193	59	22	2	18		101
195	56	7	24	17		104
197	84	21	1	2		108
199	57	13	8	14		92
201	70	23		1		94
203	53	14	24	7		98
205	69	37	13	2		121
207	43	15	33	5		96
209	101	18	1			120
211	79	16	33	5		133
213	90	37	32			159
215	33	18	54			105
217	51	4	11	61		127
219	56	8	34	5		103
221	70	27	8			105
223	86	22	11			119
225	149	61	2			212
227	63	22	12	3		100
229	112	16	13	35		176
231	89	13	4	2		108
233	163	30	4			197
235	69	19	5			93
237	89	21	4			114
239	53	48	1			102
241	78	32	1			111
243	69	35	8			112
245	45	38	8			91
247	87	11	7			105
249	96	8	1	10		115
251	45	10	6	46		107
253	58	4	1	58		121
255	23	7	2	60		92
257	77	16	2	7		102
259	57	28	3	17		105
261	108	22	4	5		139

Depth (cm)	*E.selseyense/excavatum*	*E.clavatum*	*A. tepida*	*Ammobaculites*	*Quinqueloculina sp.*	Total
263	36	69	1	7	1	114
265	148	32	1	2		183
267	90	27	1	2		120
269	82	14		3		99
271	85	3		12		100
273	119	11	3			133
275	73	18	1	16		108
277	124	14	4	1		143
279	81	13	2	4		100
281	106	14	4	1		125
283	44	8		38		90
285	93	6	2	3		104
287	9	3	3	86		101
289	56	8		36		100
291	28	3	1	65		97
293	33	1		58		92
295	61	7		33		101
297	105	6	2	2		115
299	64	24	2	3		93
301	72	15		4		91
303	75	28	1	4	1	109
305	81	28	1			110
307	93	27	1	2		123
309	91	18	1	1		111
311	55	38	3	2		98
313	76	27		1		104
315	73	56	1	1		131
317	51	39				90
319	34	81	2	2		119
321	33	61	1			95
323	58	45				103
325	61	50		1		112
327	94	32	1	1		128
329	69	19		3		91
331	62	27	5	9		103
333	59	46	1			106
335	68	22		7		97
337	67	20	1	6		94
339	71	15	4	10		100
341	74	12		6		92
343	78	21	2	10		111
345	57	20	3	4		84
347	59	13	1	19		92
349	49	12				61
351	12	1	6	86		105
353	28	8	1	66		103
355	38	14	1	40		93
357	49	35	2	4		90
359	65	11	2	15		93
361	87	6	2	6		101
363	15	3		3		21
365	84	4	3			91
367	86	11	5	1		103
369	138	4				142
371	74	21				95
373	62	45				107
375	66	43				109
377	64	37				101
379	56	46				102
381	65	19				84
383	74	14	1			89
385	111	38	1	2		152
387	72	20				92
389	41	55				96
391	71	21	1			93
393	75	38				113
395	105	24	1			130
397	103	15				118
399	116	18	1	9		144

Depth (cm)	*E.selseyense*	*E.excavatum*	*E.clavatum*	*A.tepida*	*Ammobaculites*	Total
1			1		1	2
3			8	23	5	36
5			10	54	2	66
7		1	43	57	0	101
9		5	20	75	2	102
11		5	39	59	0	103
13		14	61	23	2	100
15		10	78	11	1	100
17		3	87	5	5	100
19		1	90	8	1	100
21		6	50	11	33	100
23		4	44	6	50	104
25		9	34	1	57	101
27		4	61	7	54	126
29		4	25	11	60	100
31		1	28	37	37	103
33		2	28	42	28	100
35			42	21	41	104
37		6	65	19	16	106
39		3	63	27	10	103
41			57	17	26	100
43		10	64	10	16	100
45		6	88	3	5	102
47		1	93	1	5	100
49		2	96		4	102
51		7	66	8	19	100
53		8	53	9	34	104
55		3	57	9	31	100
57		2	81	13	4	100
59		2	67	24	13	106
61		2	80	13	9	104
63		3	99	2		104
65			47	33	30	110
67		1	32	24	44	101
69		2	36	24	46	108
71		1	43	30	26	100
73		2	41	40	19	102
75		3	41	32	24	100

Depth (cm)	*E.selseyense*	*E.excavatum*	*E.clavatum*	*A.tepida*	*Ammobaculites*	Total
77		2	29	29	40	100
79		1	18	21	60	100
81		2	20	10	73	105
83		2	30	3	67	102
85		4	16	6	74	100
87		4	30	4	68	106
89		8	36	6	57	107
91		7	58	5	43	113
93	3	9	52	6	36	106
95	2	15	73	3	13	106
97		5	98	1	2	106
99		1	96	2	1	100

Depth (cm)	*E. selseyense/excavatum*	*E.clavatum*	*A.tepida*	*Ammobaculites*	Total
101	75	13	16	1	105
111	93	5	6		104
121	78	8	13	1	100
131	79	8	17	1	105
141	74	18	9	1	102
151	60	12	14	2	88
161	85	16			101
171	87	9		1	92
181	82	9	2		93
191	88	11	2		101
201	78	9	3		90
211	75	4			79
221	94	10	3		107
231	63	5	13		81
241	75	8	6		89
251	73	4	13		90

Depth (cm)	*E. selseyense/clavatum*	*E. excavatum*	*A.tepida*	*Ammobaculites*	Total
91	5	93	2		100
101	75	13	16	1	105
111	93	5	6		104
121	78	8	13	1	100
131	79	8	17	1	105
141	74	18	9	1	102

Depth (cm)	*E.selseyense/excavatum*	*E.clavatum*	*A.tepida*	*Ammobaculites*	Total
1	5	3	91	183	282
6	9		17	331	357
11	17	2	12	240	271
16	18	38	1	257	314
21	49	3	6	364	422
26	18	11		195	224
31	19		152	240	411
36	24	20	60	163	267
41	53	19	41	313	426
46	45	37	9	142	233
51	2			1	3
56	79	15	2	1	97
61	84	7	1	1	93
66	90	5			95
71	76	7			83
76	29	3			32
81	84	7			91
86	60	26	3		89
91	77	1			78
96	81	7	1		89
101	97		2		99
106	6				6
111					0
116	20				20
121	2				2

Depth (cm)	*E.seleyense/excavatum*	*E.clavatum*	*A.tepida*	*B. frigida*	Total
1	6	4	90		100
3	30	19	58		107
5	20	41	39		100
7	65	20	17		102
9	43	40	19		102
11	62	33	5		100
13	46	54	2		102
15	66	18	16		100
17	35	47	18		100
19	63	25	13		101
21	31	55	15		101
23	55	37	16		108
25	36	28	37		101
27	51	38	18		107
29	36	55	10		101
31	33	65	7		105
33	5	90	5		100
35	20	42	40		102
37	20	10	29		59
39	20	3	78		101
41	23	9	9		41
43	58	41	3		102
45	53	37	10		100
47	54	50	3		107
49	65	35			100
51	72	28	3		103
53	57	40	3		100
55	55	27	3		85
57	35	23	2		60
59	89	12	2		103
61	93	5	2		100
63	76	18	6		100
65	75	11	15		101
67	75	13	5		93
69	80	12	8		100
71	90	8	2		100
73	84	17	1		102
75	79	18	3		100
77	69	26	6		101
79	49	45	4		98
81					0
83					0
85					0

Depth (cm)	*E.seleyense/excavatum*	*E.clavatum*	*A.tepida*	*B. frigida*	Total
87					0
89					0
91					0
93					0
95					0
97					0
99					0
101					0
103					0
105					0
107					0
109					0
111					0
113					0
115					0
117					0
119					0
121	97	7	5	2	111
123	87	4	9		100
125	19	1	3		23
127	56	2	3		61
129	78	7	9	1	95
131	2		2		4
133	51		1	2	54
135	83	17			100
137	63	3	1		67
139	61	36	3		100
141	80	19	1	1	101
143	88	17	1		106
145	106	14		1	121
147	107	9	2	1	119
149	92	8	2	1	103
151	87	9	4		100
153	100	9			109
155	57	15	2		74
157	76	24			100
159	87	14	1		102
161	66	13	2		81
163	73	8			81
165	52	15	6	3	76
167	15	15	2		32
169	71	7	2	2	82
171	93	2	5		100
173	66	2	7		75
175	75	3	1	3	82
177	3				3
179	91	8	1		100
181	38	3	4		45
183	33		2	1	36

Depth (cm)	*E.seleyense/excavatum*	*E.clavatum*	*A.tepida*	*B. frigida*	Total
185	94	6	2		102
187	90	3			93
189	16	2	9		27
191	86	1	1	1	89
193	97	4	2		103
195	96	1			97
197	87	2	1		90
199	74		1		75
201	51			1	52
203	95	5			100
205	90	10			100
207	93	7			100
209	88	12			100
211	86	14			100
213	79	19		2	100
215	81	17	2		100
217	92	7		1	100
219	81	23	1		105
221	77	23			100
223	58	42			100
225	75	25			100
227	79	21			100
229	104	34			138
231					0
233	61				61
235	109				109
237	81	17	3		101
239					0
241					0
243					0
245					0
247					0
249					0
251					0
253					0
255					0
257					0
259	1				1
261	3				3
263					0
265					0
267	1				1
269					0
271					0
273					0
275					0
277					0
279					0
281					0

Depth (cm)	*E.seleyense/excavatum*	*E.clavatum*	*A.tepida*	*B. frigida*	Total
283					0
285					0
287	1				1
289	18				18
291	107		1		108
293	99		1		100
295	100				100
297	90		5		95
299	84	16			100
301	34				34
303	37				37
305	74	18	1		93
307	98	2			100
309	94	7			101
311	98		2		100
313	63	33	2	2	100
315	78	14	2	1	95
317	28	72			100
319	68	32			100
321	48	52			100
323	72	27		1	100
325	92	6		2	100
327	85	14	1		100
329	81	19		1	101
331	76	22	1	1	100
333	66	31		3	100
335	97	3			100
337	74	26			100
339	65	35			100
341	68	43	1		112
343	29	71			100
345	55	49			104
347	86	18			104
349	79	37			116
351	97	4	3		104
353	95	2	1	2	100
355	97	4	1		102
357	81	19			100
359	86	10	3	1	100
361	96	4			100
363	97	2		1	100
365	92	8			100
367	97	4		1	102
369	75	24		1	100

Depth (cm)	*E.selseyense/excavatum*	*E.clavatum*	*A.tepida*	*Ammobaculites*	Total
10	27	48	25		100
15	3	92	8		103
20	13	68	24		105
25	8	81	11		100
40	10	90			100
50	19	84	1		104
60	27	65	8		100
70	9	104	1		114
80	31	70			101
90	31	53	8	8	100
100	83	12	6	3	104
110	72	23	5	2	102
120	68	15	9	8	100
130	37	27	34	5	103
140	80	18	9	2	109
150	34	65	1		100
160	79	11	6	4	100
170	94	10	6		110
180	82	12	8		102
190	85	11	4	5	105
200	72	15	12	1	100
210	85	20	11	5	121
220	62	38	3		103
230	74	15	11	2	102
240	27	1	2		30
250	110		2		112

Depth (cm)	*Elphidium*	*Ammonia*	*Ammobaculites*	*Miliammina*	Total
0.5		84	6	10	100
1.5		9		7	16
2.5		1		1	2
3.5		1			1
4.5					0
5.5		1			1
6.5	10	90			100
7.5	12	88			100
8.5	37	74	1		112
9.5	33	65	2		100
10.5	44	55	4		103
11.5	29	65	10		104
12.5	82	18			100
13.5	1	6	4		11
14.5	9	4	6		19
15.5	1	0	41	1	43
16.5	5	3	3		11
17.5			2		2
18.5	8	1	11		20
19.5	2		1		3

Depth (cm)	*Elphidium*	*Ammonia*	*Ammobaculites*	*Miliammina*	Total
0.5	2	102	12	3	119
2.5		109	7	2	118
4.5		90	12	2	104
6.5	1	101	3		105
8.5	14	72	20	3	109
10.5	32	15	50	6	103
12.5	32	15	56	1	104
14.5	12	3	93	1	109
16.5	14	3	82	2	101

Depth (cm)	*Elphidium*	*Ammonia*	*Ammobaculites*	Total
0.5		86	2	88
2.5		54		54
4.5		15		15
6.5		7		7
8.5		28		28
10.5		12	3	15
12.5		10	5	15
14.5	2	34	13	49
16.5	1	19	8	28
18.5	5	68	3	76
20.5	6	60	7	73
22.5	17	72	3	92
24.5	16	24	4	44

Depth (cm)	*Elphidium*	*Ammonia*	*Ammobaculites*	*Miliammina*	Total
0.5	24	3	1		28
2.5	44	9	5		58
4.5	8	19	31	1	59
6.5	3	42	15	2	62
8.5	4	35			39
10.5	3	80	14		97
12.5		62	21		83
14.5	8	86	3		97
18.5		36			36

Depth (cm)	*Elphidium* sp.	*Ammonia tepida*	*Ammotium salsum*	Total
0.5	1	1		2
2.5				0
4.5	1	2		3
6.5	19	10	6	35
8.5	93	21	2	116
10.5	129	11	1	141
12.5	127		2	129
14.5	139			139
16.5	142	2	5	149

Depth	*Elphidium*	*Ammonia*	*Ammobaculites*	Total
0.5				0
1.5				0
2.5			1	1
3.5			2	2
4.5				0
5.5				0
6.5	16	22		38
7.5	2	86	9	97
8.5		14	6	20
9.5			2	2
10.5				0
11.5	23	4	3	30
12.5	43		8	51
13.5	10		5	15
14.5			2	2
15.5				0
16.5	18			18
17.5	17	1	1	19
18.5	36	2	4	42
19.5			1	1
20.5	100			100
21.5	2			2

Depth (cm)	*Elphidium* sp.	*Ammonia tepida*	*Ammotium salsum*	Total
1.0	68	26	12	106
2.5	47	46		93
4.5	50	52		102
6.5	46	53		99
8.5	33	40	14	87
10.5	51	21		72
12.5	50		17	67
14.5	93			93
16.5	10	1	36	47
18.5	24	1	59	84
20.5	23		25	48
22.5	8	10	54	72

Depth (cm)	*Elphidium*	*Ammobaculites*	*Ammonia*	Total
0.5	58	4	39	101
1.5	15	55	7	77
2.5	17	50	33	100
3.5	18	39	42	99
4.5	2	61	29	92
5.5	1	67	34	102
6.5	4	83	7	94
7.5	48	47	6	101
8.5	7	90	1	98
9.5		100		100
10.5		100		100
11.5	4	96		100
12.5	28	69	3	100
13.5	31	69		100
14.5	10	87		97
15.5		100		100
16.5		100		100
17.5	5	95		100
18.5	7	93		100
19.5	1	99		100
20.5	4	101		105
21.5		82		82

Depth (cm)	*Elphidium* sp.	*Ammonia tepida*	*Miliammina fusca (?)*	*Ammotium salsum*	*Globigerinoides spp.*	*Textularia earlandi (?)*	Total
0.5		96	1	14			111
2.5		37	1	48			86
4.5		48	3	90			141
6.5		54	5	69		1	129
8.5	1	103	20	111			235
10.5		27	2	67			96
12.5		37	2	61			100
14.5	1	56	5	38			100
16.5	7	23	4	57		1	92
18.5	18	64	33	227	1		343
20.5	11	3		50			64

Depth (cm)	*Ammobaculites*	*Elphidium*	*Ammonia*	*Milimmina fusca (?)*	Total
0.5	71	0	4	4	79
1.5	84	0	11	12	107
2.5	92	0	4	8	104
3.5	77	0	4	10	91
4.5	100	0	23	0	123
5.5	89	0	0	4	93
6.5	72	0	0	5	77
7.5	106	0	6	7	119
8.5	101	0	3	2	106
9.5	86	0	1	2	89
10.5	97	0	0	2	99
11.5	90	0	1	1	92
12.5	100	0	0	0	100
13.5	105	0	0	2	107
14.5	100	0	0	0	100
15.5	101	0	0	3	104
16.5	93	0	0	3	96
17.5	99	0	0	3	102
18.5	93	0	0	4	97
19.5	100	0	0	4	104
20.5	88	3	6	5	102
21.5	98	0	0	3	101