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SYSTEMATICS OF THE NORTH AMERICAN HIGH NORTHERN LATITUDE VERY SHALLOW COLD WATER FORAMINIFERAL FAUNA

BY

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ABSTRACT

Representative Pleistocene fossil faunas from four areas (in west coastal Alaska and Canada) of the world-wide high northern latitude shallow water foraminiferal faunal province are described systematically. The 106 (107 ?) species fauna is dominated by *Elphidium excavatum clavatum*, with subdominants *Buccella tenerrima*, *B. frigida*, *Islandiella helenae* ((?) and *Cassidulina teretis)*, *Cibicides lobatulus*, *Cassidulina barbara*, *Elphidium frigidum sensu lato*, *Nonionella auricula*, *Epistominella vitrea*, *Fursenkoina fusiformis*, *Elphidium bartletti*, *Nonionellina labradorica*, *Quinqueloculina*, and unilocular nodosariaceans. *Elphidium excavatum clavatum* greatly outnumbers all other taxa, individually, and, in many samples, collectively. These latter are interpreted as reduced-salinity faunas. The next eight listed taxa occur in abundance in many (nearly) normal salinity samples, the others more locally or consistently but not in great numbers. Overall, the most characteristic elements (of the province) are *E. excavatum clavatum* and a complex of other elphidiid/nonionid taxa. Bucellas and Islandiellas and Cassidulinas (and *Eggerella advena* locally) follow in importance. Study of named taxa in these groups reveals many possible synonyms and it is likely that the faunal province is even more widespread than originally realized, though always restricted to very shallow water.

INTRODUCTION

Twenty-nine Pleistocene sediment (mainly glacio-marine) samples from Vancouver, Lakelse, and Queen Charlotte Islands, British Columbia and Juneau, Alaska, show strikingly similar foraminiferal faunal composition. Initially the author had expected different faunas, assuming latitudinal changes would reflect significant differences in Pleistocene shallow-water faunas. Instead it became apparent that faunas represented a single province found in quite shallow, cold water of varying salinities (15-35‰). Comparison with other similar fossil and modern faunas provided another striking conclusion: there is a Pleistocene-Holocene world-wide high northern latitude shallow-water foraminiferal faunal province. It grades into several others to the south and probably fewer others with depth increase. Southern limits are fairly well marked by species composition and dominance changes, though the low-salinity aspect of the fauna continues to be represented in estuaries north of

35° N in North America at least. (Also, as Murray (1973, pp. 31, 44) demonstrated, many synonymous shallow water species may be masquerading under different names, obscuring greater extension and overlap of Arctic—boreal—next southerly faunal provinces.) The shallowest water dominants (*Elphidium excavatum clavatum*, *Buccella frigida*, and *Eggerella advena*) may not even characterize any deeper faunas.

The geology and stratigraphy of the present four areas was described earlier (Smith, 1970, including maps and check list) along with ecological and paleoecological considerations and comparisons with other similar modern and fossil faunas. The faunal province also was delineated. These four areas provide excellent examples of faunas representative of the province. Other workers may be able to recognize "their" faunas herein.

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SYSTEMATIC CATALOG

Herein the classification of the *Treatise of Paleontology* (*Protista 2*, vols. 1 and 2, by Loeblich and Tappan, 1964) is followed for convenience, though the author disagrees with both some of its broad and fine classificatory criteria. Locality numbers refer to collections in the Museum of Paleontology of the University of California, Berkeley. Detailed locality descriptions are on file at the same (all B numbers are in Alaska and D numbers in British Columbia), along with materials, under accession number 1955. Sets of types are on file at the same; at the Department of Geology, University of British Columbia, Vancouver, Canada; and at the National Museum of Natural History, Washington, D. C., sole repository of single-specimen taxa and source of type numbers. Synonymies herein mainly include pertinent North American West Coast to Arctic late Cenozoic works whose referenced specimens have been examined by the author.

Subphylum SARCODINA Schmarda, 1871
Class Rhizopodea von Siebold, 1845
Subclass Lobosia Carpenter, 1861
Order FORAMINIFERIDA Eichwald, 1830
Suborder TEXTULARIINA Delage and Hérouard, 1896
Superfamily Lituolacea Blainville, 1825
Family ATAXOPHRAGMIIDAE Schwager, 1877
Subfamily Globotextulariinae Cushman, 1927
Genus *EGGERELLA* Cushman, 1933
Eggerella advena (Cushman)

Plate 1, Figure 3

Eggerella advena (Cushman) Cushman, 1937*a*, p. 51, pl. 5, figs. 12-15; 1944, p. 13, pl. 2, figs. 6, 7; 1948, p. 32, pl. 3, fig. 12; Cushman and McCulloch, 1939, p. 95, pl. 10, fig. 1; Cushman and Todd, 1947*a*, p. 5, pl. 1, fig. 9; Parker, 1952*a*, p. 404, pl. 3, figs. 12, 13; 1952*b*, pl. 2, fig. 3; Phleger, 1952, p. 83, pl. 13, fig. 24; Loeblich and Tappan, 1953, p. 36, pl. 3, figs. 8-10; Ronai, 1955, p. 143, pl. 20, fig. 6; Detling, 1958, p. 25, pl. 7, fig. 2; Lankford and Phleger, 1973, p. 119, pl. 1, fig. 18.

Eggerella arctica Höglund, 1947, p. 193, pl. 16, fig. 4, t. f's. 166-168.

not *Verneuilina advena* Cushman, Höglund, 1947, p. 185, pl. 13, fig. 11, t.f. 169. Hypotype No. 241962, Loc. B-7074.

Eggerella advena occurs at four Juneau localities. As tests disintegrate very easily, it probably was much more abundant in the biocoenoses, in keeping with its distribution in similar modern faunas.

Rarely Occurring Other Textulariina

The following taxa are represented by only one or two specimens each: the astrorhizid ammodiscacean *Saccorhiza* (?) sp. (Hypotype 242405, Loc. B-7072); the hormosinid lituolaceans *Reophax longicollis* (Wiesner, as *Proteonina*, 1929, p. 82, pl. 6, fig. 55; Cushman and McCulloch, 1939, p. 42, pl. 1, figs. 7-9) (Hypotype 242402, Loc. D-1211) and *Reophax* (?) sp., resembling *R. longicollis* but with test appearing composed of cemented sponge spicules (Hypotype 242403, Loc. B-7068), lituolid *Haplophragmoides* cf. *H. subglobosum* (G. O. Sars) of Cushman and McCulloch (1939, p. 80, pl. 6, figs. 7, 8) (Hypotype 242008, Loc. B-7068) and *H.* sp., a small, coarsely arenaceous test with five outer-whorl chambers, resembling *H. pusillum* Höglund (Hypotype 242009, Loc. B-7071), and trochamminid *Trochammina* (?) sp., indistinctly coiled (Hypotype 242408, Loc. B-7068).

Suborder Miliolina Delage and Hérouard, 1896
Superfamily Miliolacea Ehrenberg, 1839
Family MILIOLIDAE Ehrenberg, 1839
Subfamily Quinqueloculininae Cushman, 1927
Genus *QUINQUELOCULINA* d'Orbigny, 1826
Quinqueloculina akneriana d'Orbigny subsp. *bellatula* Bandy

Plate 1, Figure 1

Quinqueloculina akneriana d'Orbigny var. *bellatula* Bandy, 1950, p. 273, pl. 41, fig. 1; Goodwin and Thomson, 1954, p. 172, pl. 32, figs. 19, 25, 26; Lankford and Phleger, 1973, p. 125, pl. 2, fig. 7.

Hypotypes No. 242393 and 242394, Loc. B-7066; 242395, Loc. B-7065.

These numerous *Quinqueloculina*, some very large, reflect Bandy's differentiation from d'Orbigny's form by having less depressed sutures also. Those from Queen Charlotte Islands are broader than the others, most similar to *Q. akneriana* d'Orbigny of Galloway and Wissler (1927, p. 38, pl. 7, fig. 3) and Cushman, Stewart, and Stewart (1939, p. 52, pl. 2, figs. 1, 2). Modern cold water forms referred to *Q. seminula* (Linné), as by Parker (1952a, p. 406, pl. 3, figs. 21, 22; pl. 4, figs. 1, 2), may be *Q. akneriana bellatula.*

Quinqueloculina stalkeri Loeblich and Tappan

Plate 1, Figure 2

Quinqueloculina fusca Brady, Cushman, 1948, p. 33, pl. 3, figs. 16, 17.

Quinqueloculina stalkeri Loeblich and Tappan, 1953, p. 40, pl. 5, figs. 5-9.
Hypotype No. 242398, Loc. B-7065.

Characteristic specimens are numerous, especially from Lakelse.

Genus *PYRGO* Defrance, 1824

Pyrgo rotalaria Loeblich and Tappan

Plate 1, Figure 5

Biloculina murrhyna Schwager, Cushman, 1917 (part) (not Schwager, 1886), p. 75, pl. 29, fig. 1 (not pl. 23, fig. 3).

Pyrgo rotalaria Loeblich and Tappan, 1953, p. 47, pl. 6, figs. 5, 6.
Hypotype No. 242388, Loc. B-6891.

Pyrgo (?) cf. *P. rotalaria* Loeblich and Tappan

Plate 1, Figure 6

Hypotypes No. 242389, Loc. B-6891; 242390 and 242391, Loc. D-1211.

These may be immature *Pyrgo rotalaria* (or similar species) but in numbers they equal it and most are much smaller. Mainly biloculine, they tend toward triloculine, thus resembling *Flintia.*

Test free; when viewed as with *Pyrgo*, outline ovate, much inflated, with sharp but not carinate border; penultimate chamber not smoothly meeting final, as typical of *Pyrgo*, but with inflated central part bordered, sometimes with sharp angle change, by an area nearly 20° to the vertical axial plane of test, sometimes with divided final suture exposing previous chamber, creating a triloculine form;

aperture on slight neck, somewhat elongate, contains a very low, though broad, bifid tooth.

Rarely Occurring Other Miliolacea

Miliolacean taxa present in small numbers follow. A few *Gordiospira* cf. *G. arctica* Cushman (Hypotype 242007, Loc. B-7065), more involute than that species and with a small, rectangular umbo, represent Fischerinidae.

Miliolidae includes *Quinqueloculina*, *Pateoris*, *Triloculina*, *Sigmoilina*, and *Miliolinella* species as follows. *Quinqueloculina* has *Q. agglutinata* Cushman (1917, p. 43, pl. 9, fig. 2; 1948, p. 33; pl. 3, fig. 13; Cushman and Valentine, 1930, p. 9, pl. 1, fig. 7; Cushman and Todd, 1947*b*, p. 61, pl. 14, figs. 12, 13; Loeblich and Tappan, 1953, p. 39, pl. 5, figs. 1-4) (Hypotype 242392, Loc. B-7077); *Q. arctica* Cushman (1933*a*, p. 2, pl. 1, fig. 3; 1948, p. 35, pl. 4, fig. 2; Parker, 1952*a*, p. 405, pl. 3, fig. 19; Loeblich and Tappan, 1953, p. 40, pl. 5, figs. 11, 12) (Hypotypes 242396, Loc. B-7065; 242397, Loc. B-7066); *Q.* cf. *Q. stalkeri* Loeblich and Tappan, wider and with a smoother, though still rough, surface than the species (Hypotype 242399, Loc. D-1212); and two *Q.* spp., not possible of closer identification (Hypotypes 242400, Loc. B-7077; 242401, Loc. D-1216).

Pateoris includes *P. hauerinoides* (Rhumbler) (*Quinqueloculina subrotunda* (Montagu) *forma hauerinoides* Rhumbler, 1936, pp. 206, 217, 226, t.f's. 167, 208-212; and referred to *Q. subrotunda* (Montagu) by Cushman (1948), Parker (1952*a*), and Todd and Low (1961); to *Q. disciformis* (Macgillivray) by Cushman (1944) and Cushman and Todd (1947*a*); and to *Pateoris hauerinoides* (Rhumbler) by Loeblich and Tappan (1953) and Lankford and Phleger (1973))—two variants like 1) Loeblich and Tappan's and 2) Cushman's and Parker's (Hypotypes 242381, Loc. B-7065; 242382, Loc. B-7066) and *P.* sp. (Hypotype 242383, Loc. B-6891), distinct, with one flat and one convex side and an angular periphery.

Triloculina has *T. inornata* d'Orbigny (1846, p. 279, pl. 17, figs. 16-18; Lankford and Phleger, 1973, p. 130, pl. 2, fig. 19) (Hypotype 242409, Loc. D-1214) and *T. trihedra* Loeblich and Tappan (1953, p. 45, pl. 4, fig. 10) (Hypotype 242410, Loc. B-7073). Note that probably "*T. tricarinata* d'Orbigny" Cushman (1917, p. 66, pl. 25, fig. 2, t. f. 32) and Cushman and Gray (1946, p. 6, pl. 1, fig. 18) and others from northern waters are *T. trihedra*, very similar species.

There is one *Sigmoilina* (?) sp. (Hypotype 242406, Loc. D-1210). That concludes Quinqueloculininae. Miliolinellinae includes one *Miliolinella californica* Rhumbler (1936, p. 215; Lankford and Phleger, 1973, p. 123, pl. 2, fig. 8) and a few *M. oblonga* (Montagu) of Cushman (1921, p. 459, pl. 92, fig. 3; 1948, p. 38, pl. 4, figs. 5, 6; Cushman and Valentine, 1930, p. 16, pl. 4, figs. 5, 6 (all as *Triloculina*); Lankford and Phleger, 1973, p. 123, pl. 2, fig. 9) (Hypotypes 242033 and 242034, respectively, Loc. B-7076).

Suborder Rotaliina Delage and Hérouard, 1896
Superfamily Nodosariacea Ehrenberg, 1838
Family NODOSARIIDAE Ehrenberg, 1838
Subfamily Nodosariinae Ehrenberg, 1838
Genus *DENTALINA* Risso, 1826
Dentalina spp.

The few *Dentalina* are referred as follows: 1) *D. costai* (Schwager) of Cushman (1933*b*, p. 11, pl. 3, fig. 6) and Cushman and McCulloch (1950, p. 311, pl. 41, figs. 15, 16) (Hypotype 241954, Loc. B-7067); 2) *D. ittai* Loeblich and Tappan (1953, p. 56, pl. 10, figs. 10-12; and called *D.* cf. *calomorpha* (Reuss) by Cushman (1948, p. 44, pl. 5, figs. 4, 5) and Cushman and McCulloch (1950, p. 317, pl. 41, fig. 6)) (Hypotype 241955, Loc. B-6891); 3) and *D. pauperata* d'Orbigny (1846, p. 46, pl. 1, figs. 57, 58); Cushman (1929*b*, p. 85, pl. 12, figs. 23, 24); Cushman and Laiming (1931, p. 99, pl. 11, figs. 11, 12); Loeblich and Tappan (1953, p. 57, pl. 9, figs. 7-9) (Hypotype 241956, Loc. B-7073).

Genus *LAGENA* Walker and Jacob, 1798
Lagena spp.

Herein *Lagena* comprise many species, each found in very small numbers. So frequently is this situation the case that it is very hard to understand infraspecific variation and an unrealistically large number of taxa probably have been erected for these unilocular forms. Here I identified specimens mainly on this "morphotype" basis as it was impossible to do otherwise. Included are the following: *L.* cf. *L. amphora* Reuss (Hypotypes 242015, Loc. B-7065; 242016, Loc. D-1211); *L. distoma* Parker and Jones (Hypotype 242017, Loc. D-1211); *L. flatulenta* Loeblich and Tappan (Hypotype 242018, Loc. B-7074); *L. gracillima* (Seguenza) (Hypotype 242019, Loc. B-7073); *L. laevis* (Montagu) (*L. vulgaris* Williamson is an objective synonym of *L. laevis* (Montagu) (Hypotype 242020, Loc. B-7075); *L. mollis* Cushman (Hypotype 242021, Loc. B-7074); *L. parri* Loeblich and Tappan (Hypotype 242022, Loc. B-7073); *L. perlucida* (Montagu) (?) (Hypotype 242023, Loc. B-7075); *L. semilineata* Wright (Hypotype 242024, Loc. D-1211); *L. setigera* Millett (Hypotype 242025, Loc. B-7075); *L. substriata* Williamson (Hypotype 242026, Loc. D-1211); *L. sulcata* (Walker and Jacob) (Hypotype 242027, Loc. B-7065); and *L.* spp. (Hypotypes 242028 and 242029, Loc. B-7067; 242030, Loc. B-6892). Many conspecific foraminifers are included in the literature on West Coast and Pacific Northwest late Cenozoic occurrences. At least some of the above taxa are included in each of the following, as well as some conspecific forms under other names: Bagg, 1912; Cushman, 1913, 1923, 1927, 1929*a*, 1933*a*, 1944, 1948; Cushman, Stewart, and Stewart, 1930; Cushman and Gray, 1946; Cushman and McCulloch, 1950; Cushman and Todd, 1947*a*; Loeblich and Tappan, 1953; and Martin, 1952.

Family GLANDULINIDAE Reuss, 1860
Subfamily Oolininae Loeblich and Tappan, 1961
Genus *OOLINA* d'Orbigny, 1839
Oolina collaris (Cushman)

Plate 1, Figures 7, 8, 9, 10

Lagena collaris Cushman, 1913, p. 10, pl. 1, fig. 2.
(?) *Oolina heteromorpha* Parr, 1950, p. 304, pl. 8, fig. 6.

Hypotypes No. 242045, 242046, 242047, and 242048, Loc. D-1209.

Smooth surfaced and costate *Oolina* most numerous at Shannon Creek (D-1209) are of *O. collaris*, described originally from deep water in the North Pacific. They are rather elongate, subovate, with sides tending to be parallel. The short, very wide, sometimes tapering neck has a round aperture. The internal tube shows clearly on some specimens. The somewhat flattened base sometimes carries a distinct small central knob, not described by Cushman. The surface varies from smooth to featuring a few to several poorly to well developed costae which extend part way up the test, varying from near the base only to close to the aperture. Parr's description and holotype figure of *O. heteromorpha* strongly suggest conspecificity with the earlier described *O. collaris*, which is the only unilocular nodosariacean here represented commonly enough to get a picture of infraspecific variety.

Oolina spp.

As with other nodosariaceans here, *Oolina* comprises several taxa, with most in small numbers. These, summarized as *O.* spp., include: 1) *O.* aff. *O. alcocki* (White) (Hypotype 242040, Loc. B-7075); 2) *O. apiopleura* (Loeblich and Tappan) (usually recorded as *O. acuticosta* (Reuss) from the Pacific Northwest) (Hypotype 242041, Loc. B-6892); 3) *O.* cf. *O. apiopleura* (Loeblich and Tappan) (Hypotype 242042, Loc. B-7077); 4) *O. borealis* Loeblich and Tappan (conspecific Pacific Coast specimens were called *Lagena sulcata* (Walker and Jacob) by Bagg (1912); Cushman, Stewart, and Stewart (1930); and Cushman and Gray (1946); *L. costata* (Williamson) by Cushman (1913, 1923, 1929*a*, 1944), Cushman and Todd (1947*a*), and Cushman and McCulloch (1950), and called *Oolina costata* by Lankford and Phleger (1973), and *O. borealis* by Cockbain (1963)) (specimens were hard to separate from *O. apiopleura*) (Hypotype 242043, Loc. D-1214); 5) *O. caudigera* (Wiesner) (Hypotype 242044, Loc. B-7072); 6) *O. lineata* (Williamson) and of Loeblich and Tappan (1953) and "*Lagena*" *lineata* of Cushman (1923, 1933*a*) ("*L.*" *lineata* of Cushman and Gray (1946) and Cushman (1948) are probably *Oolina caudigera*) (Hypotype 242377, Loc. B-7074); *O. melo* d'Orbigny (also conspecific with forms ascribed to *O. melo* by Bagg (1912, as *Lagena*), Loeblich and Tappan (1953),

Detling (1958), Lankford and Phleger (1973), and to the species or varieties ("*Lagena*" and "*Entoselenia*") *catenulata* and *scalariformis* (both Williamson) by Cushman (1913, 1921, 1923, 1944, 1948); Cushman and Gray (1946); Cushman, Stewart, and Stewart (1930); Cushman and Todd (1947*a*, 1947*b*); and Martin (1952) (Hypotype 242378, Loc. B-7067); 8) *Oolina striatopunctata* (Parker and Jones) and of Bagg (1912), Cushman (1913, 1923, 1948), Cushman and Gray (1946), Cushman and McCulloch (1950), and Loeblich and Tappan (1953) (all "*Lagena*") (Hypotype 242379, Loc. B-7070).

Genus *FISSURINA* Reuss, 1850

Fissurina cf. *F. marginata* (Montagu)

Plate 1, Figure 11

Hypotypes No. 241991 and 241992, Loc. B-7075; 241993, Loc. B-7070; 241994, Loc. D-1211.

Test free, unilocular, somewhat compressed, outline rounded to ovate, apertural and aboral ends slightly produced, the latter mucronate or with small spine; wall calcareous, finely perforate, smooth; aperture terminal, slit to ovate, with collar surrounding and internal tube. It differs from the species *sensu stricto* in the slightly produced mucronate or spinose base and from the original description in lacking a keel (*Vermiculum marginatum* Montagu, 1803, *Testacea Britannica*, p. 524). Montagu's type illustration shows a broad keel. Many forms have been ascribed to the species, illustrating more than infraspecific variation, though such might include keeled and keeless forms. All the present specimens are keeless. Loeblich and Tappan (1953, p. 77, pl. 14, figs. 6-9) described a keel but figured a form with it poorly developed. In any case, the present specimens' bases appear distinct. They occur at several Juneau localities. They differ from *Fissurina cucurbitasema* Loeblich and Tappan in being shorter, keeless, and more mucronate. Three (Hypotype 241994) much smaller fissurinas most closely resemble "*Lagena marginata* var." Cushman (1933*b*, p. 17, pl. 5, fig. 4).

Fissurina spp.

Fissurina here mainly comprises several taxa in small numbers. These include: 1) *F.* cf. *F. cucurbitasema* Loeblich and Tappan (smaller than the species and with opaque bands along test sides, Hypotype 241987, Loc. B-7070); 2) *F. lucida* (Williamson) and of Cushman (1923, part; ? 1948), Cushman and Cole, (1930), Cushman and Gray (1946), Cushman and Todd (1947*a*, 1947*b*) (all as "*Lagena*" or "*Entoselenia*"), Bandy (1950), Loeblich and Tappan (1953), Detling (1958), Cockbain (1963), and Lankford and Phleger (1973) (Hypotypes 241988, Loc. D-1211; 241989 and 241990, Loc. D-1214); 3) *Fissurina* cf. *F. quadrata* (Williamson) (Hypotype

241995, Loc. B-7065); 4) *F. serrata* (Schlumberger) (?) (Hypotype 241996, Loc. B-7065); and 5) *F.* sp. (Hypotype 241997, Loc. D-1215).

Rarely Occurring Other Nodosariacea

Besides the above groups, nodosariids include four *Lenticulina* sp. (Hypotype 242032, Loc. B-7074) and one *Planularia californica* (Galloway and Wissler) (Hypotype 242384, Loc. B-7077). Polymorphinids include one *Polymorphina kincaidi* Cushman and Todd (Hypotype 242385, Loc. B-7076) and one (?) *Sigmomorphina charlottensis* (Cushman) (Hypotype 242407, Loc. D-1215). Glandulinids are two (?) *Laryngosigma hyalascidia* Loeblich and Tappan (Hypotype 242031, Loc. B-7072). Much infraspecific to infrafamilial variation confuses identification of polymorphine taxa, widely recorded from the West Coast late Cenozoic.

Superfamily Buliminacea Jones, 1875
Family TURRILINIDAE Cushman, 1927
Subfamily Turrilininae Cushman, 1927
Genus BULIMINELLA Cushman, 1911
Buliminella elegantissima (d'Orbigny)

Plate 2, Figure 1

Bulimina elegantissima d'Orbigny, 1839, p. 51, pl. 7, figs. 13, 14; Brady, 1884, p. 402, pl. 50, figs. 20-22; Bagg, 1912, p. 38, pl. 9, fig. 8.
Hypotype No. 241948, Loc. B-6892.

This very widely reported shallow water species is found locally at Juneau.

Family BOLIVINITIDAE Cushman, 1927
Genus *BOLIVINA* d'Orbigny, 1839
Bolivina robusta Brady

Plate 1, Figures 3, 4

Bolivina robusta Brady, Bagg, 1912, p. 42, pl. 10, figs. 11-13; Cushman, 1921, p. 129.
Hypotypes No. 241940, Loc. B-7075; 242002, Loc. B-7066.

Test compressed to slightly rounded, elongate, tapering from acute or subacute initial end, two to three times as long as broad, usually broadest across final chambers; periphery slightly rounded, usually more so in later chambers, varying from almost straight to strongly lobate; sutures usually oblique, limbate, varying from merely sinuate to having reentrants (such variation may be present in single specimens), slightly depressed, often obscured by surface ornamentation; surface rough, tending to be opaque because of presence of numerous small pores, marked on many

individuals by distinct lobate sculpturing, in part corresponding in position with sinuation and reentrance of sutures, degree of lobation of surface variable, from barely present to fairly strongly developed; chambers many, varying in shape from much wider than high in the early part of test to about equally high and broad in later chambers, shape modified by sinuation and reentrance of sutures, which, in less sinuate forms, causes curved chambers and, in sinuate-tending-to-reentrant forms, causes angulation of chamber shapes; aperture a straight slit from base almost to apex of final chamber, with slight lip.

I have examined many U.S. National Museum *Bolivina* ascribed to *B. robusta* by Cushman and others and to several "similar" "species" (*B. advena* and *B. plicatella* Cushman, *B. decussata* Brady, *B. pseudoplicata* Heron-Allen and Earland, *B. compacta* Sidebottom, *B. subexcavata* Cushman and Wickenden, etc.). Although this form is distinct, one cannot be certain it is Brady's species as that has no type figure and the depository is not given. It seems best to retain this taxon rather than erecting a new one, however.

Genus *BRIZALINA* Costa, 1856
Brizalina pacifica (Cushman and McCulloch)
Plate 2, Figure 2

Bolivina acerosa Cushman var. *pacifica* Cushman and McCulloch, 1942, p. 185, pl. 21, figs. 2, 3; Cushman and Gray, 1946, p. 36, pl. 6, fig. 6; Cushman and Todd, 1947*a*, p. 18, pl. 3, fig. 4.

Bolivina pacifica Cushman and McCulloch, Cockbain, 1963, table 2.

Brizalina pacifica (Cushman and McCulloch) Lankford and Phleger, 1973, p. 115, pl. 4, fig. 7.

Bolivina pseudopunctata Höglund, Loeblich and Tappan, 1953, p. 111, pl. 20, figs. 13, 14.

Hypotype No. 241941, Loc. B-7072.

Family ISLANDIELLIDAE Loeblich and Tappan, 1964
Genus *ISLANDIELLA* Norvang, 1958
Islandiella helenae Feyling-Hanssen and Buzas
Plate 6, Figures 1, 2, 3

Cassidulina laevigata d'Orbigny, Brady 1884 (part ?), p. 428, pl. 54, figs. 1-3; Cushman, 1948 (part), p. 73, pl. 8, fig. 8.

Cassidulina teretis Tappan, Loeblich and Tappan, 1953 (part), p. 121, pl. 24, figs. 3, 4.

Cassidulina norcrossi Cushman, Phleger 1952 (part ?), p. 83, pl. 14, fig. 22.

Islandiella helenae Feyling-Hanssen and Buzas, 1976, p. 155.
Hypotypes No. 242010, Loc. B-7077; 242011, Loc. D-1209; 242012, Loc. D-1211.

Islandiella helenae is similar to *I. limbata* (Cushman and Hughes), but lacks the "pinched in" central chamber part. Here it differs some from Tappan's *Cassidulina teretis* description of a specifically distinctive keel; often keels are missing on later chambers or poorly developed throughout, with complete keel variation occurring in some samples. Further, some sutures are slightly depressed, especially between later chambers, and limbation varies from slight to moderate. (Some here may, in fact, be *C. teretis*, a problem not resolved in this study.)

(?) *Islandiella helenae* Feyling-Hanssen and Buzas

Plate 6, Figure 13

Hypotype No. 242013, Loc. D-1211.

A few probable *Islandiella* from D-1211 seem immature megalospheric *I. helenae*; it occurs abundantly with them. Three or four cassiduline chambers, with cassiduline aperture, follow the large proloculus. Four specimens with more chambers show uncoiling, as *Cassidulinoides*. Perhaps "wild growing", these are tentatively retained in *Islandiella helenae*. (See Feyling-Hanssen and Buzas, 1976, for analysis of some *Islandiella-Cassidulina* problems.)

Islandiella norcrossi (Cushman)

Cassidulina norcrossi Cushman, 1933*a*, p. 7, pl. 2, fig. 7; 1944, p. 35, pl. 4, fig. 26; 1948, p. 75, pl. 8, fig. 12; Nørvang, 1945, p. 44, t. f. 10; Parker, 1948, pl. 6, fig. 2; 1952*a*, p. 422, pl. 6, figs. 24, 25.

not *Cassidulina norcrossi* Cushman, Phleger, 1952, p. 83, pl. 14, fig. 22 (= "*C. teretis* Tappan")

Hypotype No. 242014, Loc. B-1215.

Family BULIMINIDAE Jones, 1875
Subfamily Bulimininae Jones, 1875
Genus *GLOBOBULIMINA* Cushman, 1927
Globobulimina auriculata (Bailey)

Plate 2, Figure 8

Bulimina auriculata Bailey, 1851, p. 12, pl. 1, figs. 25-27.

Bulimina (Desinobulimina) auriculata Bailey, Cushman and Parker, 1940, p. 20, pl. 3, figs. 19-21; 1947, p. 129, pl. 29, figs. 22-24; Cushman, 1944, p. 26, pl. 3, fig. 48; Cushman and Todd, 1945, p. 40, pl. 6, fig. 14; 1947*a*, p. 18, pl. 3, fig. 3; Cushman and Gray, 1946, p. 26; Cushman and McCulloch, 1948, p. 249, pl. 31, fig. 4; Cockbain, 1963, table 2.

Hypotype No. 242006, Loc. B-7067.

Family UVIGERINIDAE Haeckel, 1894

Genus *UVIGERINA* d'Orbigny, 1826

Uvigerina cushmani Todd

Plate 2, Figures 9, 10

Uvigerina cushmani Todd, *In* Cushman and Todd, 1947*b*, p. 66, pl. 16, figs. 4, 5; Cushman and McCulloch, 1948, p. 257, pl. 33, fig. 1.

Uvigerina juncea Cushman and Todd, Cockbain, 1963, table 2.

Hypotypes No. 242411 and 242412, Loc. D-1211.

Genus *TRIFARINA* Cushman, 1923

Trifarina fluens (Todd)

Plate 2, Figures 11, 12

Angulogerina fluens Todd, *In* Cushman and Todd, 1947*b*, p. 67, pl. 16, figs. 6, 7; Cushman and McCulloch, 1948, p. 288, pl. 36, fig. 1; Loeblich and Tappan, 1953, p. 112, pl. 20, figs. 10-12.

Hypotypes No. 241934, Loc. B-7075; 241935, Loc. D-1211.

Continuous chamber size increase gives these numerous costate *Trifarina* a more conical shape plus more costae than *T. semitrigona* (Galloway and Wissler) or *T. angulosa* (Williamson) with which they and conspecific forms could have been confused and may overlap.

Trifarina hughesi (Galloway and Wissler)

Plate 2, Figures 13, 14

Uvigerina hughesi Galloway and Wissler, 1927, p. 76, pl. 12, fig. 5.

Angulogerina hughesi (Galloway and Wissler) Cushman, Stewart, and Stewart, 1930, p. 70, pl. 5, fig. 16; Cushman and Todd, 1941, p. 76, pl. 18, fig. 4; pl. 19, fig. 17; 1947*a*, p. 19, pl. 3, fig. 8; Cushman and McCulloch, 1948, p. 289, pl. 36, fig. 2.

Hypotypes No. 241936 and 241937, Loc. D-1211.

Among the few smooth *Trifarina* so referred, some fall within the range fo variation of *T. baggi* (Galloway and Wissler). Close relationship and possible conspecificity exists among these two and *T. semitrigona*. No significant chamber lobation difference exists here by specimen size, so all were placed in the "larger" *hughesi* rather than *baggi*. A few are faintly striate, falling between *T. fluens* and *T. hughesi*; these two always occur together and may well be conspecific variants. Thus, perhaps all aforementioned *Trifarina* are conspecific; if so they are *T. angulosa* (Williamson) by priority.

Superfamily Discorbacea Ehrenberg, 1838
Family DISCORBIDAE Ehrenberg, 1838
Subfamily Discorbinae Ehrenberg, 1838
Genus *BUCCELLA* Anderson, 1952
Buccella frigida (Cushman)

Plate 3, Figures 3, 4

Pulvinulina frigida Cushman, 1922, p. 12 (144).

Eponides frigida (Cushman) var. *calida* Cushman and Cole, 1930, p. 98, pl. 13, fig. 13; Cushman, 1931, p. 47.

Eponides frigida (Cushman) Cushman, 1931, p. 45.

Eponides frigidus (Cushman) Cushman, 1941, p. 37, pl. 9, figs 16, 17; Cushman and Todd, 1947*a*, p. 21, pl. 3, fig. 20; 1947*b*, p. 67, pl. 16, figs. 10-13.

Eponides frigidus (Cushman) var. *calidus* Cushman and Cole, Cushman, 1944, p. 34, pl. 4, figs. 19, 20; Cushman and Gray, 1946, p. 39, pl. 7, figs. 3-5; Parker, 1952*b*, p. 459, pl. 5, fig. 3.

Buccella frigida (Cushman) Anderson, 1952, p. 144, figs. 4-6; Loeblich and Tappan, 1953, p. 115, pl. 22, figs. 2, 3; Ronai, 1955, p. 148, pl. 21, fig. 16; Todd and Low, 1961, p. 18, pl. 1, figs. 24, 25.

Buccella spp. Cockbain, 1963 (part), table 2.

Hypotypes No. 241942 and 241943, Loc. B-7073.

Mainly, these abundant *Buccella* clearly belong to *B. frigida* and *B. tenerrima* (Bandy), difficult to separate here. (See *B. tenerrima* for further discussion.)

(?) *Buccella frigida* Cushman

Hypotype No. 241944, Loc. D-1211.

Some *Buccella* trend away from characteristic *B. frigida*, being higher spired ventrally, flat dorsally, smaller, and having quite lobate ventral sutures. The aperture cannot be seen. Of these, a few differ so much that genus and species are questioned.

Buccella tenerrima (Bandy)

Plate 3, Figures 1, 2

Eponides peruviana (d'Orbigny) Cushman and Kellett, 1929, p. 10, pl. 4, fig. 5.

Eponides frigidus (Cushman) Cushman, 1948, p. 71, pl. 8, fig. 7; Parker, 1952*a*, p. 419, pl. 6, fig. 12; 1952*b*, p. 449, pl. 5, fig. 2; Phleger, 1952, p. 84, pl. 14, figs. 23, 24.

Rotalia tenerrima Bandy, 1950, p. 278, pl. 42, fig. 3.

Buccella inusitata Anderson, 1952, p. 148, figs. 11, 12; Loeblich and Tappan, 1953, p. 116, pl. 22, fig. 1.

Buccella tenerrima (Bandy) Lankford and Phleger, 1973, p. 116, pl. 4, fig. 19.

Hypotypes No. 241945, 241946, and 241947, Loc. B-7066.

Several quite similar species of *Buccella* include *B. frigida* (Cushman), *B. tenerrima* (Bandy), *B. parkerae* Anderson, *B. depressa* Anderson, and some "*Eponides peruviana* (d'Orbigny)". Of the two recognized here, many characteristic *B. frigida* and *B. tenerrima* are easily separated on presence or absence of a keel (and last whorl chamber number), but many are difficult. They are partially to fully rimmed by clear but not projecting shell material, continuous with sutures, around a subacute periphery. In a sequence of specimens this rim either grades away or into a pronounced, though never wide nor platelike, keel. Further, no constancy is showed in relative height of sides, another suggested specifically distinctive character. Thus, species separation may prove arbitrary and prove two to several *forma* only (*B. frigida* by priority).

Genus *EPISTOMINELLA* Husezima and Maruhasi, 1944

Epistominella pacifica (Cushman)

Plate 3, Figure 8

Pulvinulinella pacifica Cushman, 1927, p. 165, pl. 5, figs. 14, 15; Cushman, Stewart, and Stewart, 1930, p. 73, pl. 6, fig. 5.

Epistominella pacifica (Cushman) Martin, 1952, p. 136, pl. 24, fig. 8; Cockbain, 1963, table 2.

Hypotype No. 241983, Loc. B-6892.

Widespread and abundant in the late Cenozoic of the west coast, this species here is poorly represented at Juneau, but no doubt of its identity exists.

Epistominella vitrea Parker

Plate 3, Figures 5, 6, 7

Epistominella vitrea Parker, *In* Parker, Phleger, and Peirson, 1953, p. 9, pl. 4, figs. 34-36.

Hypotypes No. 241984, 241985, and 241986, Loc. B-7073.

A few *Epistominella vitrea*, described from the Gulf Coast, occur at most localities of this study. Closely resembling *E. exigua* (Brady), to which conspecific specimens probably were ascribed, it differs in lacking a pronounced lobate periphery and having more oblique sutures and a consistently greater number of outer-whorl chambers. Also similar are *E. bradyana* (Cushman) and the Neogene western Pacific *E. hardyana* (LeRoy), *E. pulchella* Husezima and Maruhasi, and *E. takayanagii* Iwasa.

Family EPISTOMARIIDAE Hofker, 1954

Genus *EPISTOMAROIDES* Uchio, 1952

Epistomaroides cf. *E. rimosa* (Parker and Jones)

Plate 3, Figure 9

Hypotype No. 241982, Loc. B-6892.

These few interesting specimens compare favorably with "*Discorbina rimosa*" and clearly belong to *Epistomaroides*. They may be *E. rimosa* but original description problems and paucity of specimens dictated this designation. These are small, compressed, rounded but slightly elongate in outline, spirally evolute, with peripheral whorl chambers much larger than earlier. Alar projections or secondary chambers cover the umbilicus. Relations between these and basic whorls are indeterminate. One secondary flap's inner edge shows it an alar projection. Some apertures occur at the flap's outer edges. The important ventral apertures between chambers along sutures often are hard to discern and some such appear dorsally. Primary sutures are quite depressed and curved. Seven chambers usually comprise the outer whorl. The test surface is glossy but plainly perforate.

Superfamily Rotaliacea Ehrenberg, 1839

Family ELPHIDIIDAE Galloway, 1933

Subfamily Elphidiinae Galloway, 1933

Genus *ELPHIDIUM* Montfort, 1808

Elphidium bartletti Cushman

Plate 4, Figures 1, 2, 3

Nonionina striatopunctata (Fichtel and Moll) Parker and Jones, 1865, p. 402, pl. 4, figs. 31-34; pl. 17, fig. 60.

Elphidium bartletti Cushman, 1933*a*, p. 4, pl. 1, fig. 9; 1939, p. 64, pl. 18, fig. 10; 1941, p. 34, pl. 9, figs. 2, 3; 1948, p. 59, pl. 6, fig. 13; Loeblich and Tappan, 1953, p. 96, pl. 18, figs. 10-14; Ronai, 1955, p. 145, pl. 21, fig. 6.

Cribroelphidium arcticum Tappan, 1951, p. 6, pl. 1, figs. 27, 28.

Elphidium articulatum (d'Orbigny) Parker, 1952*a*, p. 411, pl. 5, figs. 5-7.

(?) *Cribroelphidium bartletti* (Cushman) Phleger, 1952, p. 83, pl. 14, fig. 9.

(?) *Elphidium articulatum* (d'Orbigny) Cushman and Valentine, 1930, p. 21, pl. 5, fig. 10; Cushman, 1939, p. 53, pl. 14, figs. 18, 19 (not fig. 17); Cushman and McCulloch, 1940, p. 171, pl. 19, fig. 7; Cushman and Todd, 1947*a*, p. 14, pl. 2, fig. 17.

(?) *Elphidium* cf. *articulatum* (d'Orbigny) Cushman, 1944, p. 26, pl. 3, fig. 41.

Hypotypes No. 241965, 241966, and 241967, Loc. D-1209.

Elphidium bartletti is fairly distinct here. Its greatest relative abundance is at Vancouver. It is important in the cold, shallow water fauna. The aperture varies from 1) an obscure row of pores (various numbers) to 2) a few pores and small medial slit to 3) only a small slit—all at the base of the apertural face, with supplementary apertural pores in the face. (A few do not have pores.) Granular material in the umbilicus may extend out along the depressed sutures and may also cover the apertural face. *E. bartletti* and *E. articulatum* (d'Orbigny) may be conspecific (first suggested by Parker (1952*a*, p. 411)) or some "*E. articulatum*" may be *E. bartletti*, for, as Loeblich and Tappan (1953, p. 96) pointed out, d'Orbigny's type figure shows a sharp, acutely angled periphery, not found on *E. bartletti*. I am here assuming both species valid. Phleger's figure shows an entire margin, flush sutures, and more chambers than characteristic. Five from Queen Charlotte Islands retained in *E. bartletti* are more compressed than typical and lack apertural face pores.

Elphidium excavatum (Terquem) *clavatum* Cushman

Plate 4, Figures 4, 5

Elphidium incertum (Williamson) var. *clavatum* Cushman, 1930, p. 20, pl. 7, fig. 10; 1939, p. 57, pl. 16, figs. 1, 2; ? 1944, p. 25, pl. 3, figs. 32, 33; 1948, p. 57, pl. 6, fig. 8; ? Cushman and Cole, 1930, p. 96, pl. 13, figs. 8, 9; ? Parker, 1952*a*, p. 412, pl. 5, figs. 10, 11; Phleger, 1952, p. 83, pl. 14, fig. 10; Cockbain, 1963, table 2.

(?) *Elphidium incertum* (Williamson) variants Parker, 1952*b* (part ?), p. 448, pl. 3, figs. 14, 16, 17; pl. 4, figs. 1, 2.

Elphidium clavatum Cushman, Loeblich and Tappan, 1953, p. 98, pl. 19, figs. 8-10; Ronai, 1955, p. 146, pl. 21, figs. 7, 8; Todd and Low, 1961, p. 18, pl. 2, fig. 1.

(?) *Elphidium* cf. *E. incertum* (Williamson) Detling, 1958, p. 28, pl. 8, fig. 2.

Elphidium incertum (Williamson) Cockbain, 1963, table 2.

Elphidium excavatum (Terquem) *forma clavata* Cushman, Feyling-Hanssen, 1972, p. 339, pl. 1, figs. 1-9; pl. 2, figs. 1-9.

Hypotypes No. 241968, 241969, and 241970, Loc. D-1212.

Of all species considered in relation to *Elphidium excavatum* (Terquem) *clavatum* Cushman, most similar are *E. hughesi* Cushman and Grant, *E. translucens* Natland, and *E. tumidum* Natland. Of these, *E. hughesi* has either a rather sharp periphery (not found in the present material) or a lobate periphery and a coarser surface than the present specimens. (Groups of *E. hughesi* paratypes from both Stanford and U.S. National Museums include some not *E. hughesi.*) The holotype of *E. translucens* has more chambers than present *E. excavatum clavatum*, with a slightly depressed supra-umbilical area. The holotype of *E. tumidum* is thicker than that of *E. translucens* and has fewer (10 vs. 12) outer whorl chambers, and the slightly depressed supra-umbilical area is smaller. Both have small umbilical papillae. Both may be *E. excavatum.*

In the present material two fairly distinct types exist, but often intergrade. (Both are represented in Loeblich and Tappan's (1953) hypotype material.) Yet they are different enough to question one group's reference to *E. excavatum clavatum.* All synonymy is included under the taxon *sensu stricto*, however.

The groups were separated in assemblages permitting but in most they were lumped. Some specimens might be included in *E. subarcticum* Cushman, as might some others here ascribed to other species. Mainly, *E. excavatum clavatum*, *sensu lato*, here are distinct from other elphidiids. Many in both groups lack the umbonal boss originally considered characteristic. The "less specifically typical" group could be ascribed to "*E. excavatum* (Terquem) *forma alba*" Feyling-Hanssen (1972, p. 340, pl. 3, figs. 1-9), which taxon was erected for the group erroneously called *E. incertum* Williamson by Cushman. They are, however, usually not white. Comparison between the two groups reveals the following umbonal area and other characteristic differences:

More specifically typical group	*Less specifically typical group*
(Many have) prominent umbonal boss	(Many have) roughly papillate patches of thickened shell material in umbonal area
(Many have) poorly developed retral processes	Well developed retral processes

(All have) depressed sutures	Subacute peripheries, flush sutures
(All are) fairly flat surfaced	Umbonally thicker than at periphery
Much smaller	Much larger
Thinner walls	Thicker walls

(Really immature specimens are often difficult to assign to either group and to differentiate from juveniles of some other species.) These differences may reflect phylogeny or ecologic variables (or both). Locally, one finds either one or the other variant entirely or mainly or both forms in large numbers. If the latter, one may find two distinct groups or complete intergradation. The queries in the synonymy are based on 1) poor or lack of descriptions or figures or 2) seeming differences in morphology from *E. excavatum clavatum.*

Elphidium excavatum (Terquem) *clavatum* Cushman (?)

Plate 4, Figures 6, 7, 8, 9

Hypotypes No. 241971 and 241972, Loc. D-1215; 241973 and 241974, Loc. D-1211.

Foraminifera referred to *Elphidium excavatum clavatum, sensu lato* greatly predominate over all other species in this study. With thousands available, presumably all morphological variants from the areas studied were observed.

Elphidium frigidum Cushman

Plate 5, Figure I

Elphidium frigidum Cushman, 1933*a*, p. 5, pl. 1, fig. 8; 1939, p. 64, pl. 18, fig. 8; 1948, p. 57, pl. 6, figs. 9-11; Cushman and McCulloch, 1940, p. 171, pl. 19, figs. 6, 8; Cushman and Todd, 1947*a*, p. 14, pl. 2, fig. 18; Loeblich and Tappan, 1953, p. 99, pl. 18, figs. 4-9; Ronai, 1955, p. 147, pl. 21, fig. 12.

Cribrononion frigidum (Cushman) Lankford and Phleger, 1973, p. 118, pl. 3, fig. 20.

Hypotype No. 241975, Loc. B-7074.

Some elphidiums are characteristic of the species, although they occur with more numerous *E.* (?) sp. cf. *E. frigidum.* Specimens, including primary types, of "*E. subarcticum* Cushman" and "*Nonion pauciloculum* Cushman" do not form a cohesive group divisible from other species, and especially from *E. frigidum.* Some here could be referred to *E. subarcticum*; I decided to exclude it herefrom as it may well be a junior synonym of *E. frigidum.* Buzas (1966) considered "*E. pauciloculum* a junior synonym of *E. subarcticum* and (1975, personal communication) said that although he had not studied *E. frigidum* he agreed it could be the valid taxon.

Elphidium frigidum Cushman (?)

Plate 5, Figures 2, 3

Hypotypes No. 241976, Loc. B-7076; 241977, Loc. D-1210.

Most *Elphidium* from B-7076 and a few from elsewhere are set off because they form a cohesive block separable from other taxa, although a similar few are included in other species. Most similar to "*E. subarcticum*", they have a more regular outline, with smooth margin, than *E. frigidum*.

Elphidium (?) sp. cf. *E. frigidum* Cushman

Plate 5, Figures 4, 5

Hypotypes No. 241978, Loc. B-7077; 241979, Loc. B-7066.

Test free, subelliptical with little apertural face indentation, medium sized for genus, planispiral and mainly involute, sides nearly flat and parallel with slightly depressed umbilicus; periphery broadly rounded, usually only slightly or not lobulate; eight or nine outer whorl chambers, increasing gradually in size; sutures flush to slightly depressed, obscured by rugose wall, curved, with numerous small sutural pores, slight retural process development, rarely fine grooves from sutures outward or linear arrangement of pores causing pseudostriations; wall calcareous, rather coarsely perforate and/or finely rugose (demonstrating this was impossible in the present illustrations); aperture a row of pores across apertural face base. This form may be *Elphidiella*. Most specimens' sutural pores cannot be seen but one showed an apparently double row on part of the test.

These locally numberous foraminifers differ from *E. frigidum* and *E. frigidum* (?) here, and "*E. subarcticum*" by having 1) a less lobate periphery, especially in later chambers, 2) more obscure and nearly flush sutures, 3) less well-developed retral processes and/or grooves, and 4) in lacking the porate apertures in the apertural face called for by Loeblich and Tappan (1953, p. 99) for *E. frigidum*. Further, their surface is more rugose and less transparent and they are more elliptical in outline and perhaps with less indented apertural face, larger, and with more chambers. The final chamber is broken off so many specimens, disallowing determining if it extended out from the general test outline as typical of *E. frigidum*. These also closely resemble *E. granulosum* (Galloway and Wissler) but test surface and degree of umbilical depression appear different.

Taxonomically these elphidiums may be new, but they may fall within the range of variation of a valid species; the confusion among cool/cold water elphidiids mitigates against erecting a new taxon without further work.

Elphidium spp.

Hypotypes No. 241980, Loc. B-7077; 241981, Loc. D-1210.

One very large *Elphidium* (241980) is *E. oregonense* Cushman and Grant (1927, p. 79, pl. 8, fig. 3; Cushman, Stewart, and Stewart, 1930, p. 62, pl. 4, figs. 1, 2; Cushman, 1939, p. 50, pl. 13, figs. 14-16; van Voorthuysen, 1952, p. 22, pl. 5, t. f. 1; and referred to *Elphidiella* by Cushman in 1941 (p. 34 (part), pl. 9, figs. 8, 9 (not fig. 7) and by Bandy (1950, p. 227, pl. 41, fig. 13)). Hypotype 241981 represents a few elphidiums likely of taxa herein recorded but specifically unidentifiable.

Genus *ELPHIDIELLA* Cushman, 1936

Elphidiella spp.

Hypotypes No. 241963, Loc. D-1210; 241964, Loc. B-6892.

Three worn specimens are of *Elphidiella arctica* (Parker and Jones) (*Polystomella arctica* Parker and Jones, *In* Brady, 1884, p. 471, pl. 48, fig. 18; and ascribed to *Elphidium arcticum* by Cushman in 1930 (p. 27, pl. 11, figs. 1-6) and 1933 (1933*a*, pl. 23, fig. 6) and to *Elphidiella* by Cushman in 1939 (p. 65, pl. 18, figs. 11-14) and 1948 (p. 59, pl. 6, fig. 15) and by Cushman and Todd (1947*b*, p. 65, pl. 15, fig. 20)) (Hypotype 241963). A few others (241964) are referred to *E. nitida* Cushman (1941, p. 35, pl. 9, fig. 4; Loeblich and Tappan, 1953, p. 107, pl. 19, figs. 11, 12; and specimens referred to *Elphidium hannai* Cushman and Grant by Cushman and Grant, (as "var.") in 1927 (p. 76, pl. 8, fig. 2); Cushman, Stewart, and Stewart in 1930 (p. 62, pl. 3, figs. 16, 17); and *Elphidiella hannai* (Cushman and Grant) by Cushman in 1939 (p. 66 (part), pl. 19, fig. 2 (not fig. 1), Cushman and McCulloch in 1940 (p. 177, pl. 20, fig. 11), Cushman and Todd in 1947 (1947*a*, p. 15, pl. 2, fig. 22), Bandy in 1950 (p. 276, pl. 41, fig. 10), Goodwin and Thomson in 1954 (p. 174, pl. 32, figs. 27, 28), and Lankford and Phleger in 1973 (p. 119, pl. 3, fig. 26)). Much discussion (see Cushman (1941), Bandy (1950), Loeblich and Tappan (1953), and Lankford and Phleger (1973)) centers on supposed differences between *E. hannai* and *E. nitida*. I have retained *E. nitida* because the present specimens have very fine sutural pores and many have tapering sutures; lesser suture width and sutural pore size appear to distinguish *E. nitida* from *E. hannai*. If conspecific, all are *E. hannai* by priority.

Genus *PROTELPHIDIUM* Haynes, 1956

Protelphidium orbiculare (Brady)

Plate 5, Figure 6

Nonionina orbicularis Brady, 1881, p. 415, pl. 21, fig. 5; 1884, p. 737, pl. 109, figs. 20, 21; Cushman, 1922, p. 13 (145).

Nonion orbiculare (Brady) Cushman, 1930, p. 12, pl. 5, figs. 1-3; 1939, p. 23, pl. 6, figs. 17-19; 1948, p. 53, pl. 6, fig. 3.

Elphidium orbiculare (Brady) Loeblich and Tappan, 1953, p. 102, pl. 19, figs. 1-4.

Elphidium orbiculare (H. B. Brady) Ronai, 1955, p. 145, pl. 21, fig. 1.

Protelphidium orbiculare (Brady) Todd and Low, 1961, p. 20, pl. 2, fig. 11.
Hypotype No. 242386, Loc. D-1215.

Differing from *Elphidium*, *Protelphidium* has a porate aperture yet lacks sutural pores and retral processes, though verifying absence of pores is difficult. Apertural pores and minor but distinct sutural excavation near the umbilicus (no retral processes) mark these few specimens. Among the confused relations of cold water elphidiids, note that *P. orbiculare*, "*Nonion pauciloculum*" and "*N. tisburyensis*" are very similar and possibly conspecific. Further, transitional stages (? conspecificity) between these three and between them and *Elphidium bartletti*, *E. articulatum*, *E. subarcticum*, and *E. frigidum* may exist.

(?) *Protelphidium pauciloculum* (Cushman)

Plate 5, Figure 7

(?) *Nonion pauciloculum* Cushman, 1944, p. 24, pl. 3, fig. 25.
Hypotype No. 242387, Loc. B-7065.

The holotype clearly shows the "typical" sutural slits and pores of this species. Sutural openings are obscure here. Small numbers of chambers and deep sutural depression separate (?) *Protelphidium pauciloculum* from other taxa here, although perhaps invalidly.

Superfamily Globigerinacea Carpenter, Parker, and Jones, 1862
Family GLOBIGERINIDAE Carpenter, Parker, and Jones, 1862
Subfamily Globigerininae Carpenter, Parker, and Jones, 1862
Genus *GLOBIGERINA* d'Orbigny, 1826
Globigerina bulloides d'Orbigny

Plate 5, Figure 8

Globigerina bulloides d'Orbigny, 1826, p. 277, nos. 17, 76; Galloway and Wissler, 1927, p. 40, pl. 7, fig. 4; Bandy, 1950, p. 279, pl. 42, fig. 2; Cifelli and Smith, 1970, p. 18, pl. 1, figs. 5, 6.
Hypotype No. 241999, Loc. B-7068.

"*Globigerina*" *pachyderma* (Ehrenberg)

Plate 5, Figure 9

Globigerina pachyderma (Ehrenberg) Brady, 1884, p. 609, pl. 114, figs. 19, 20; Galloway and Wissler, 1927, p. 43, pl. 7, fig. 13; Cushman and Todd, 1947*b*, p. 70, pl. 16, figs. 27, 28.
Hypotype No. 242000, Loc. D-1214.

"*Globigerina*" *quinqueloba* Natland subsp. *egelida* Cifelli and Smith

Plate 5, Figure 10

Globigerina quinqueloba egelida Cifelli and Smith, 1970, p. 32, pl. 3, fig. 4-7.
Hypotype No. 242001, Loc. B-7072.

Subfamily Catapsydracinae Bolli, Loeblich, and Tappan
Genus *GLOBIGERINITA* Bronnimann, 1951
Globigerinita glutinata (Egger)

Globigerinita glutinata (Egger) Cifelli and Smith, 1970, p. 35, pl. 4, fig. 5.
Hypotypes No. 242003, 242004, and 242005, Loc. D-1215.

The few *Globigerinita* make this the most abundant plankter here.

Superfamily Orbitoidacea Schwager, 1876
Family CIBICIDIDAE Cushman, 1927
Subfamily Cibicidinae Cushman, 1927
Genus *CIBICIDES* Montfort, 1808
Cibicides lobatulus (Walker and Jacob)

Plate 6, Figure 12

Nautilus lobatulus Walker and Jacob, 1798, *In* Adams' Essays, Kanmacher's ed., p. 672, pl. 14, fig. 36.

Truncatulina lobatula (Walker and Jacob) Bagg, 1912, p. 82, pl. 24, figs. 9-14; Cushman, 1913, p. 31, t. f. 34, pl. 15, fig. 1.

Cibicides lobatus (Walker and Jacob) Galloway and Wissler, 1927, p. 64, pl. 11, fig. 1; Bandy, 1950, p. 279, pl. 42, fig. 9.

Cibicides lobatulus (Walker and Jacob) Cushman, 1931, p. 118, pl. 21, fig. 3; 1944, p. 36, pl. 4, figs. 27, 28; 1948, p. 78, pl. 3, fig. 14; Cushman and Gray, 1946, p. 45, pl. 8, fig. 14; Cushman and Todd, 1947*a*, p. 23, pl. 4, fig. 6; 1947*b*, p. 71,

pl. 16, fig. 33; Parker, 1952*a*, p. 422, pl. 6, fig. 26; 1952*b*, p. 446, pl. 5, fig. 11; Phleger, 1952, p. 83, pl. 14, fig. 20; Todd and Low, 1961, p. 21, pl. 2, fig. 20; Cockbain, 1963, table 2.
Hypotypes No. 241952, Loc. B-7076; 241953, Loc. B-7077.

Many forms have been referred to this wide and long ranging species. It occurs in most present samples. Those from Highbury Tunnel, Vancouver (oldest) have more regular shapes than from elsewhere.

Genus *DYOCIBICIDES* Cushman and Valentine, 1930
Dyocibicides biserialis (Cushman and Valentine)

Truncatulina variabilis d'Orbigny, Bagg, 1912, p. 84, pl. 24, figs. 5 and ?4; ? Cushman, 1914, p. 33, t. f. 35.

Dyocibicides variabilis Cushman and Valentine, 1930, p. 31, pl. 10, figs. 1, 2; Cushman, 1931, p. 126, pl. 24, fig. 2; 1955, pl. 28, fig. 7, Key Pl. 36, fig. 12; Cushman and Gray, 1946, p. 46, pl. 8, figs. 18, 19; Cushman and Todd, 1947*a*, p. 23, pl. 4, fig. 8; 1947*b*, p. 72, pl. 16, figs. 34, 35; Lankford and Phleger, 1973, p. 119, pl. 6, figs. 16, 17.
Hypotype No. 241961, Loc. B-7076.

Some "*Cibicidella variabilis* (d'Orbigny)" may be conspecific with *Dyocibicides biserialis*. Juveniles may have been retained in the much more abundant *Cibicides lobatulus*, though it may have fewer close coiled whorls. If many adult *Dyocibicides* do not uncoil, as some suggest, many present "*Cibicides*" may be *Dyocibicides*. Taxonomy of attached forms probably misrepresents possible range of variation; attachment allows much more morphological variety than does free living.

Superfamily Cassidulinacea d'Orbigny, 1839
Family CAUCASINIDAE Bykova, 1959
Subfamily Fursenkoininae Loeblich and Tappan, 1961
Genus *FURSENKOINA* Loeblich and Tappan, 1961
Fursenkoina fusiformis (Williamson)

Plate 2, Figure 7

Bulimina pupides var. *fusiformis* Williamson, 1858, p. 63, pl. 5, figs. 129, 130.

Virgulina fusiformis (Williamson) Parker, 1952*a*, p. 417, pl. 6, figs. 3-6; 1952*b*, p. 461, pl. 4, fig. 6; Phleger, 1952, p. 87, pl. 14, figs. 17, 18.

(?) *Bulimina exilis* Brady, Cushman, 1948, p. 62, pl. 7, fig. 1; Loeblich and Tappan, 1953, p. 110, pl. 20, figs. 4, 5.

not *Virgulina fusiformis* Cushman, 1937*b*, p. 18, pl. 2, fig. 29.
Hypotype No. 241998, Loc. B-7074.

As tests break easily the species perhaps was much more abundant in the biocoenoses.

Family CASSIDULINIDA d'Orbigny, 1839
Genus *CASSIDULINA* d'Orbigny, 1826
Cassidulina barbara Buzas

Plate 6, Figures 4, 5

Cassidulina islandica Nørvang, 1945, p. 41, t. f's. 7, 8*d-f*; Loeblich and Tappan, 1953, p. 118, pl. 24, fig. 1.

Cassidulina islandica Nørvang *forma minuta* Nørvang, 1945, p. 43, t.f's. 8*a-c*; Parker, 1952*a*, p. 421, pl. 6, figs. 22, 23; Phleger, 1952, p. 83, pl. 14, fig. 30.

Cassidulina islandica Nørvang var. *minuta* Nørvang, Cushman, 1948, p. 75, pl. 3, fig. 11.

Cassidulina islandica Nørvang var. *norvangi* Thallmann, *In* Phleger, 1952, p. 83, footnote.

Cassidulina barbara Buzas, 1965, p. 25, pl. 5, figs. 2, 3.
Hypotypes No. 241949, Loc. B-7077; 241950, Loc. D-1214.

The present specimens are more compressed than typical.

Cassidulina barbara Buzas (?)

Plate 6, Figure 6

Hypotype No. 241951, Loc. B-6891.

These few occur with *Cassidulina barbara* but differ in having sutures not much indented, a sharper periphery, and larger size. Similar in shape to *Islandiella helenae*, these are opaque and less sharp-peripheried than typical or even keeless *I. helenae*.

Family NONIONIDAE Schultze, 1854
Subfamily Nonioninae Schultze, 1854
Genus *ASTRONONION* Cushman and Edwards, 1937
Astrononion gallowayi Loeblich and Tappan

Plate 6, Figure 9

Astrononion stellatum Cushman and Edwards, 1937 (not *Nonionina stellata* Terquem, 1882), P. 32, pl. 3, figs. 9-11; Cushman, 1939, p. 36, pl. 10, figs. 3-5; 1948,

p. 56; Cushman and McCulloch, 1940, p. 168, pl. 18, fig. 11; Cushman and Todd, 1947*a*, p. 13, pl. 2, fig. 15; Parker, 1952*a*, p. 410, pl. 5, figs. 2, 3.

Astrononion stelligerum (d'Orbigny) Cushman, 1948, p. 55, pl. 6, fig. 6.

Astrononion gallowayi Loeblich and Tappan, 1953, p. 90, pl. 17, figs. 4-7; Detling, 1958, p. 28, pl. 8, fig. 1.
Hypotype No. 241938, Loc. B-6891.

Genus *NONIONELLA* Cushman, 1926
Nonionella auricula Heron-Allen and Earland

Plate 6, Figure 10

Nonionella auricula Heron-Allen and Earland, 1930, p. 192, pl. 5, figs. 68-70; Cushman, 1939, p. 33, pl. 9, figs. 7-9; 1944, p. 25, pl. 3, figs. 26, 27; Cushman and McCulloch, 1940, p. 159, pl. 17, figs. 6, 7; Parker, 1952*a*, p. 413, pl. 5, figs. 13, 14; Loeblich and Tappan, 1953, p. 92, pl. 16, figs. 6-10; Cockbain, 1963, table 2.
Hypotype No. 242036, Loc. B-7077.

Nonionella turgida (Williamson) subsp. *digitata* Nørvang

Plate 6, Figure 11

Nonionella turgida (Williamson) var. *digitata* Nørvang, 1945, p. 29, t. f. 4; Cushman, 1948, p. 55, pl. 6, fig. 5; Parker, 1952*a*, p. 413, pl. 5, figs. 15, 16; Cockbain, 1963, table 2.
Hypotype No. 242413, Loc. B-7077.

Genus *NONIONELLINA* Voloshinova, 1958
Nonionellina labradorica (Dawson)

Plate 6, Figure 8

Nonion labradoricum (Dawson) Cushman, 1939, p. 23, pl. 6, figs. 13-16; 1944, p. 24, pl. 3, fig. 23; 1948, p. 52, pl. 6, fig. 2; 1955, Key Pl. 23, fig. 2; Nørvang, 1945, p. 37; Loeblich and Tappan, 1953, p. 66, pl. 17, figs. 1, 2; Loeblich *In* Miller, 1953, p. 30.

Nonion labradoricus (Dawson) Martin, 1953, p. 123, pl. 19, fig. 1.
Hypotype No. 242035, Loc. B-7077.

All these nonionids help characterize the cold, shallow water faunas.

Rarely Occuring Other Nonionidae

Four individuals are referred as follows: 1) one (?) *Astrononion viragoense* Cushman and Edwards (Hypotype 241939, Loc. B-7072); 2 and 3) one *Nonionella* cf. *N. auricula* Heron-Allen and Earland, with slightly more depressed sutures than *N. auricula* and steeper apertural face and lesser test elongation, and one *N.* (?) sp. (Hypotypes 242037 and 242038, respectively, Loc. B-7072) has a duller, coarser surface, more rounded periphery and outline, and few chambers; and 4) one *N.* (?) sp. (Hypotype 242039), not referable to any species.

Rarely Occuring Other Calcareous Perforate Taxa

Besides the more numerous members, the Discorbacea includes the discorbid genus *Discorbis* Lamark, 1804, rarely represented by four species. *D.* sp. (Hypotype 241957) differs in pore sizes from *D. globularis* (d'Orbigny) of Cushman and Gray (1946) and Cushman (1948); *D.* (?) sp. (Hypotype 241959) differs by strong convexity of ventral side and much less lobation of periphery. *D.* sp. (Hypotype 241958) and *D.* (?) sp. (Hypotype 241960, all discorbid hypotypes, Loc. B-7066) could not be closely identified.

The few *Patellina corrugata* Williamson from Juneau (a widely distributed cool/cold shallow water species) are the only representatives of superfamily Spirillinacea. (Hypotype 242380, Loc. B-7067).

The aragonitic Robertinacea includes only one broken (?) *Robertina charlottensis* (Cushman) (1925*a*, 1925*b*, and 1933 as *Cassidulina*); also recorded from cool, shallow waters by Cushman and Parker, 1936, 1947; Cushman and Todd, 1947*a*; Cushman and McCulloch, 1948; Loeblich and Tappan, 1953; and Detling, 1958), also much like *R. arctica* d'Orbigny, similarly widely reported.

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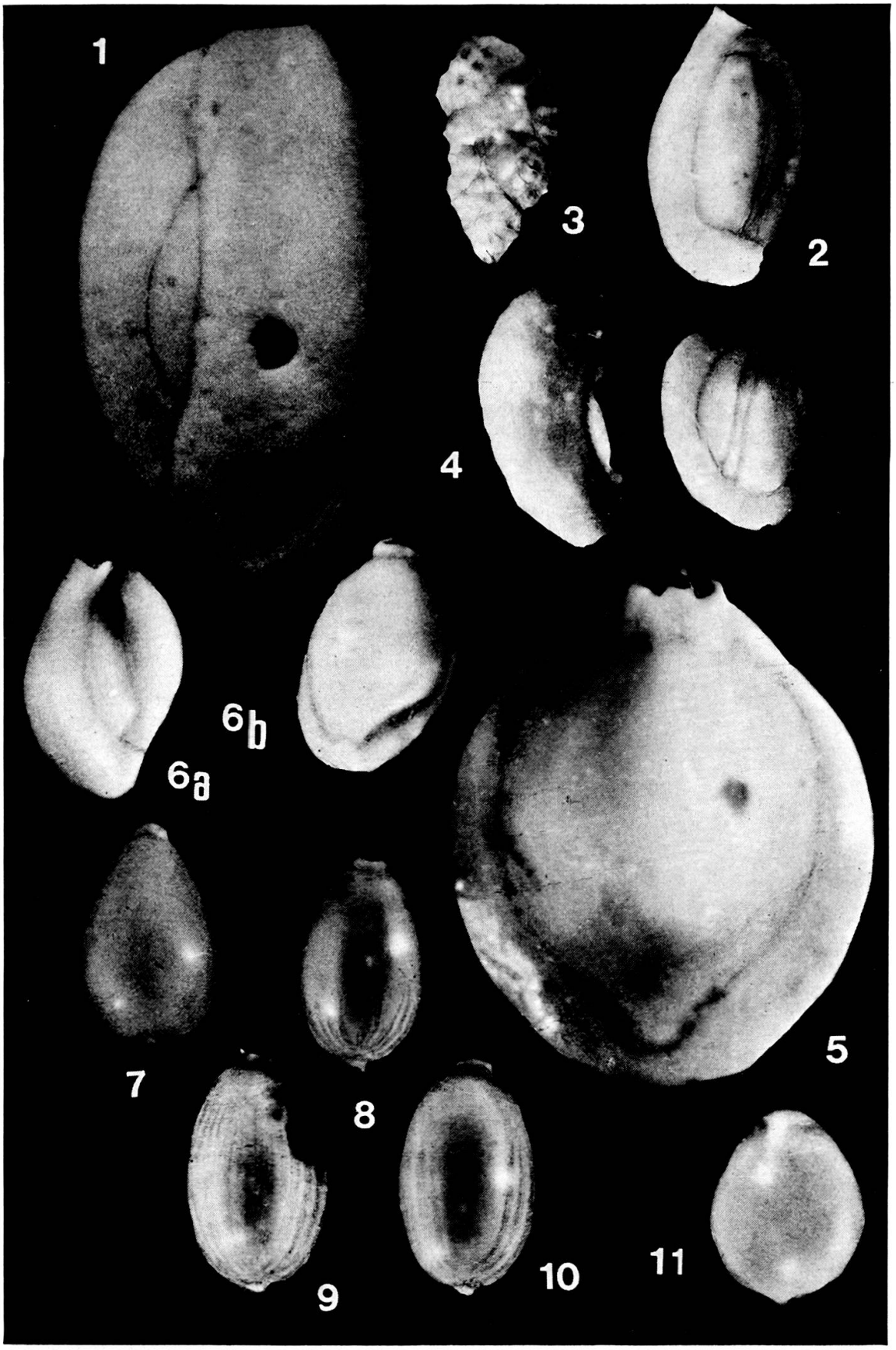
Magnification of all specimens is 145 ×.

Figure		*U.S.N.M. Hypotype Number*	*Locality Number*	*Page*
1.	*Quinqueloculina akneriana* d'Orbigny subsp. *bellatula* Bandy. Side view.	242393	B-7066.	135
2.	*Quinqueloculina stalkeri* Loeblich & Tappan. Side view.	242398	B-7065.	136
3.	*Eggerella advena* (Cushman). Side view.	241962	B-7074.	134
4.	*Pateoris hauerinoides* (Rhumbler). Side view. Broken spec.	242381	B-7065.	137
5.	*Pyrgo rotalaria* Loeblich & Tappan. Front view.	242388	B-6891.	136
6.	*Pyrgo* (?) cf. *P. rotalaria* Loeblich & Tappan. a: side; b: front views.	242389	B-6891.	136
7, 8, 9, 10.	*Oolina collaris* (Cushman). Side views.	242045, 242046, 242047, 242048	D-1209. D-1209.	139
11.	*Fissurina* cf. *F. marginata* (Montagu). Side view.	241991	B-7075.	140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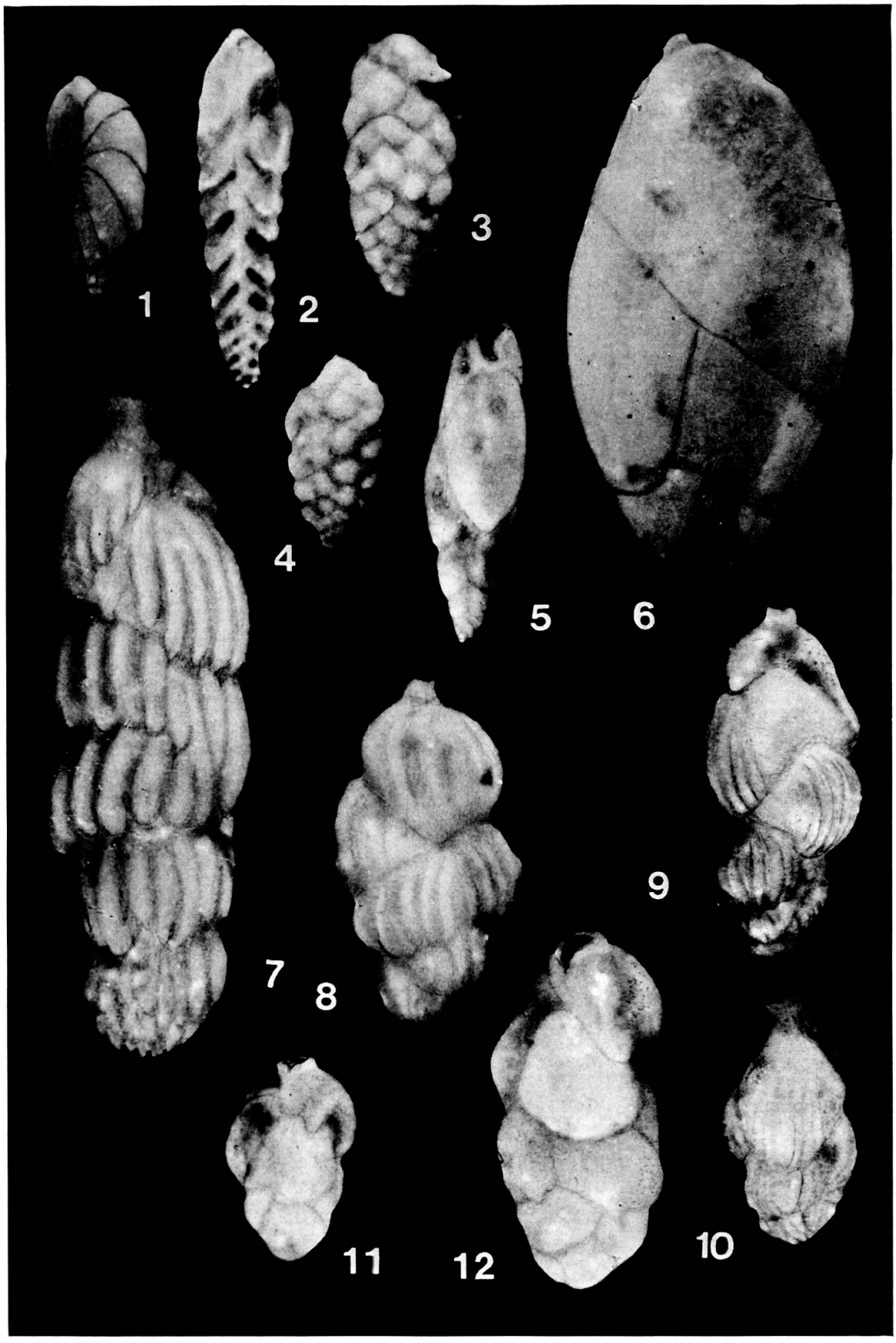
1.	*Buliminella elegantissima* d'Orbigny. Side view.	241948	B-6892.	141
2.	*Brizalina pacifica* (Cushman & McCulloch). Side view.	241941	B-7072.	142
3, 4.	*Bolivina robusta* Brady. Side views.	242002	B-7066.	141
		241940	B-7075.	141
5.	*Fursenkoina fusiformis* (Williamson). Side view.	241998	B-7074.	155
6.	*Globobulimina auriculata* (Bailey). Side view.	242006	B-7067.	143
7, 8.	*Uvigerina cushmani* (Todd). Side views.	242411,	D-1211.	
		242412	D-1211.	144
9, 10.	*Trifarina fluens* (Todd). Side views.	241935	D-1211.	144
		241934	B-7075.	144
11, 12.	*Trifarina hughesi* (Galloway & Wissler). Side views.	241936	D-1211.	144
		241937	D-1211.	144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1, 2.	*Buccella tenerrima* Bandy. a: spiral; b: umbilical views.	241945 241946	B-7066. B-7066.	146 146
3, 4.	*Buccella frigida* (Cushman). a: spiral; b: umbilical views.	241942 241943	B-7073. B-7073.	145 145
5, 6, 7.	*Epistominella vitrea* Parker. a: spiral; b: umbilical views.	241984, 241985, 241986	B-7073. B-7073.	 147
8.	*Epistominella pacifica* (Cushman). a: spiral; b: umbilical view.	241983	B-6892.	146
9.	*Epistomaroides* cf. *E. rimosa* (Parker & Jones). a: spiral; b: umbilical view.	241982	B-6892.	147

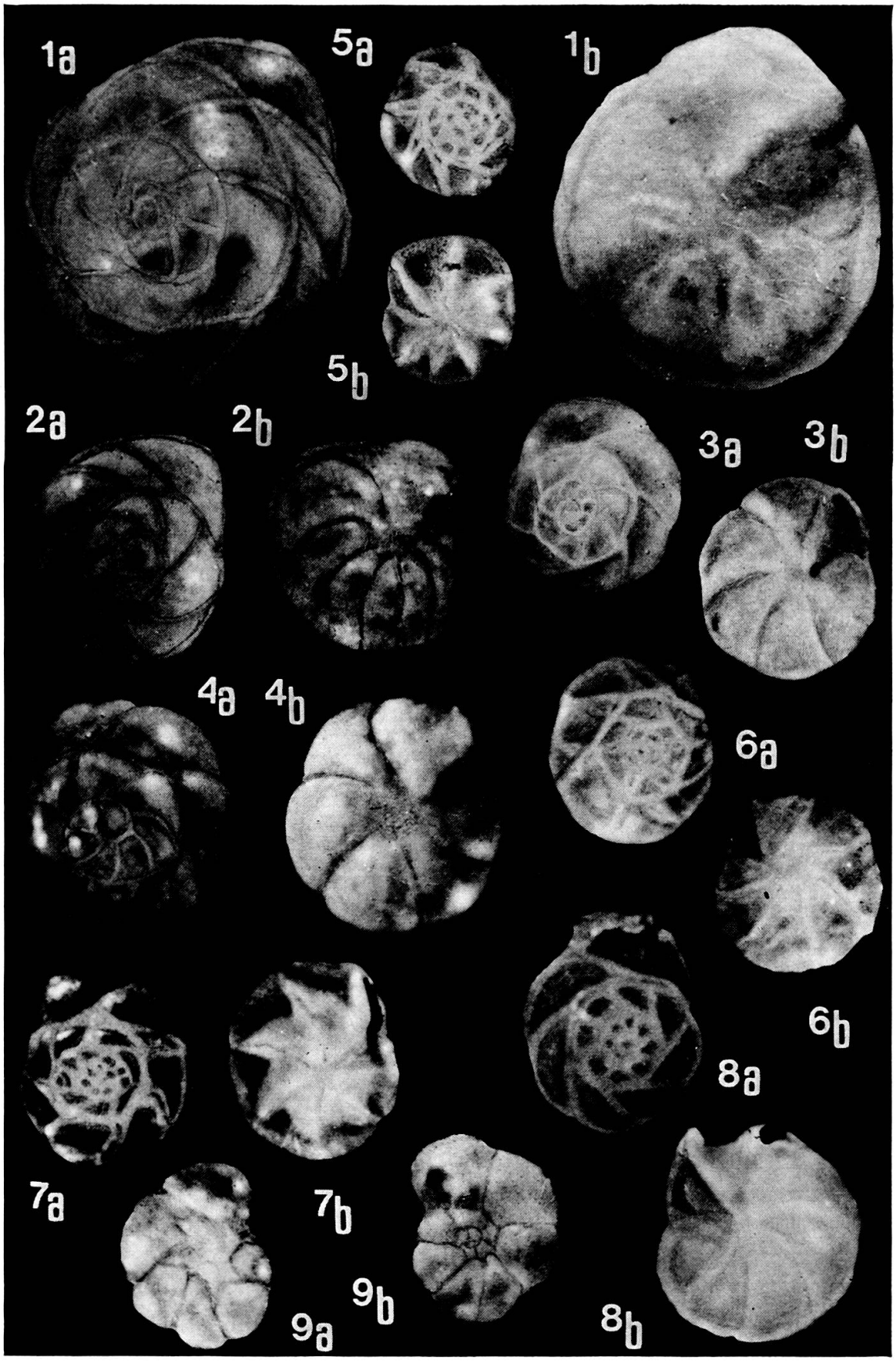
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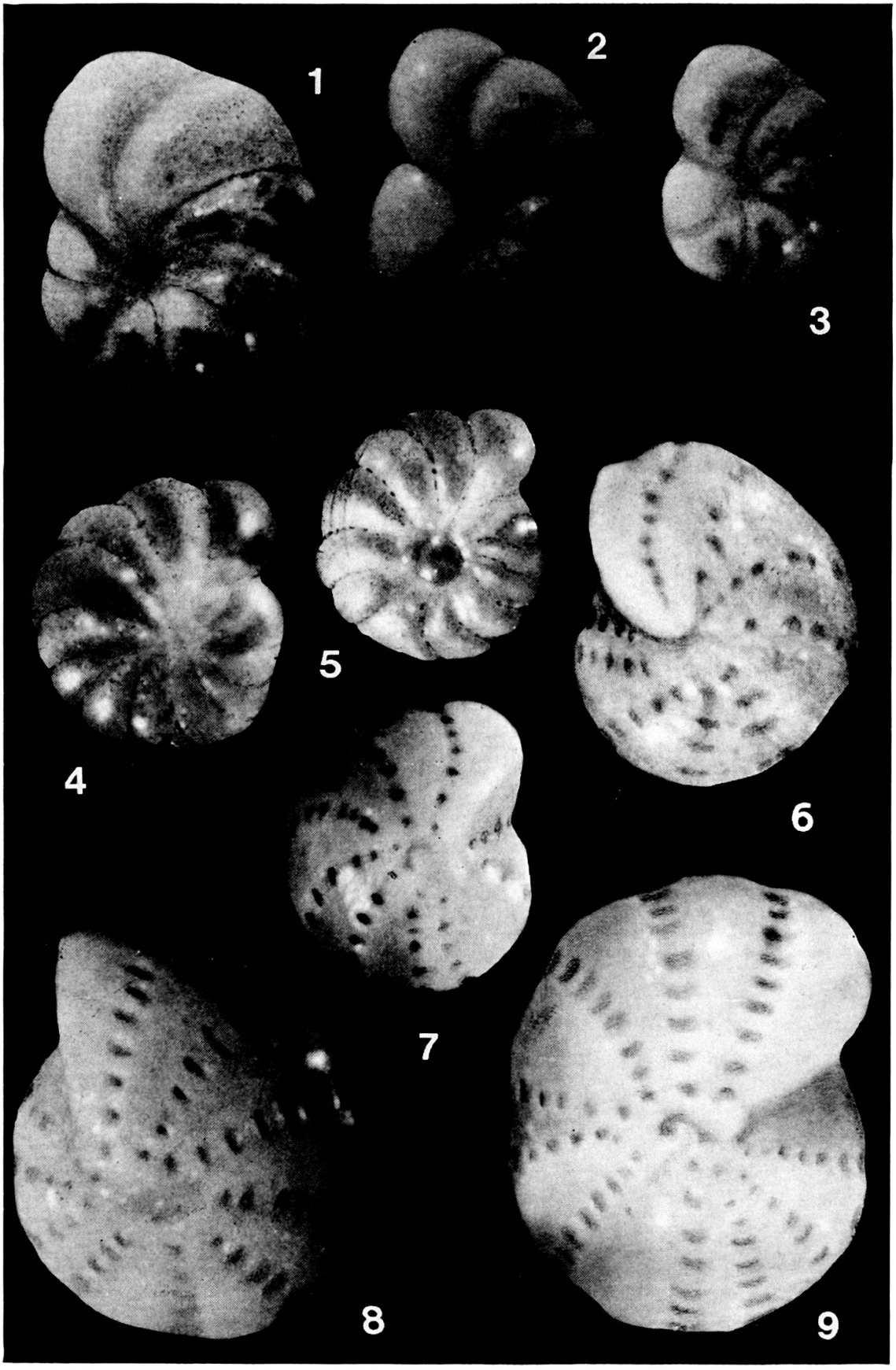
Figure		*U.S.N.M. Hypotype Number*	*Locality Number*	*Page*
1, 2, 3.	*Elphidium bartletti* Cushman. Side views.	241965, 241966, 241967	D-1209. D-1209.	147
4, 5.	*Elphidium excavatum* (Terquem) subsp. *clavatum* Cushman. Side views.	241968, 241970	D-1212. D-1212.	147
6, 7, 8, 9.	*Elphidium excavatum* (Terquem) subsp. *clavatum* Cushman (?). Side views.	241971, 241972, 241973, 241974	D-1215. D-1211.	150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1.	*Elphidium frigidum* Cushman. Side view.	241975	B-7074.	150
2, 3.	*Elphidium frigidum* Cushman (?). Side views.	241976	B-7076.	151
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4, 5.	*Elphidium* (?) sp. cf. *E. frigidum* Cushman. Side views.	241978	B-7066.	151
		241979	B-7077.	151
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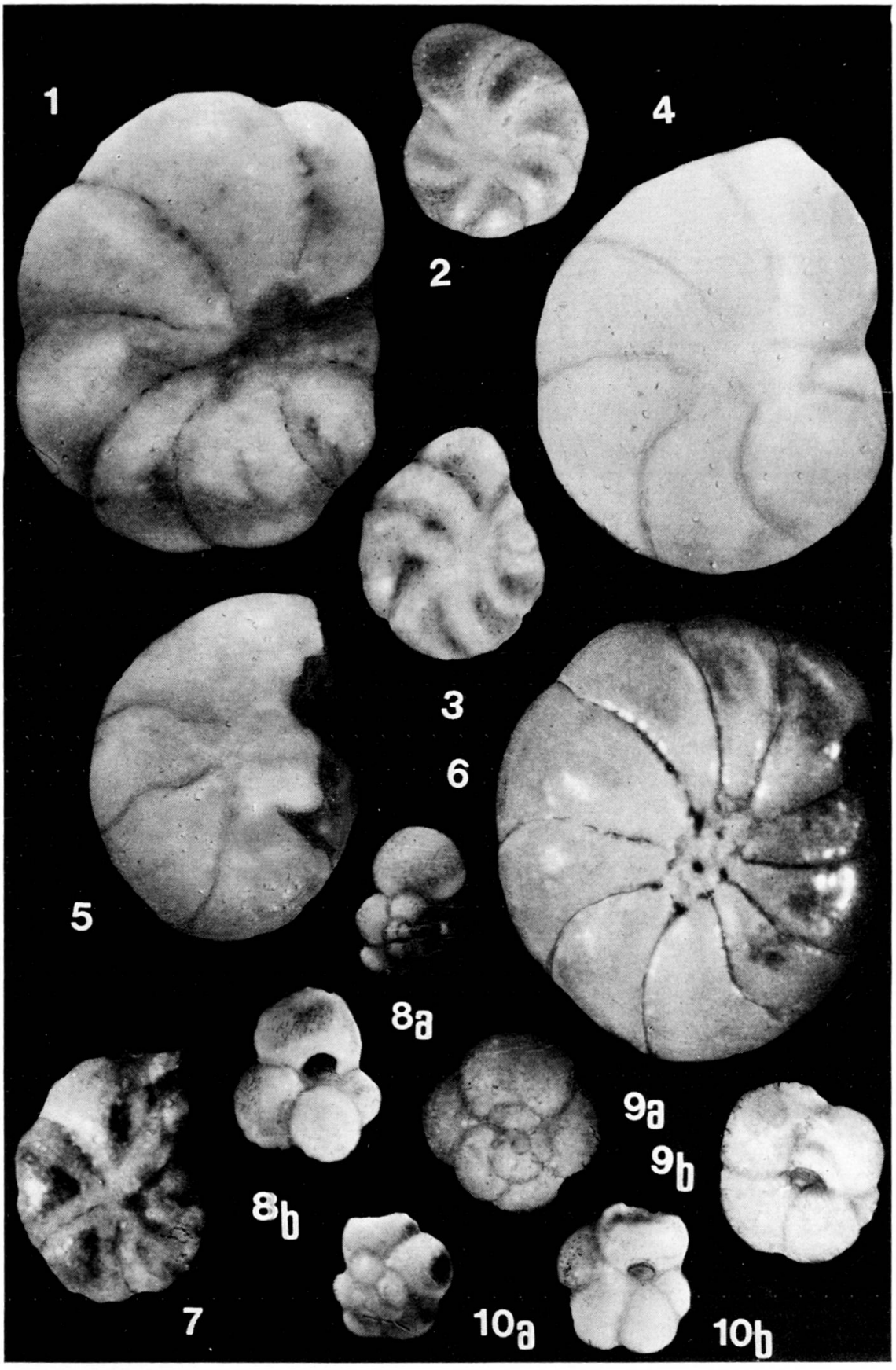
7.	(?) *Protelphidium pauciloculum* (Cushman). Side view.	242387	B-7065.	153
8.	*Globigerina bulloides* d'Orbigny. a: spiral; b: umbilical views.	241999	B-7068.	153
9.	" *Globigerina* " *pachyderma* (Ehrenberg). a: spiral; b: umbilical views.	242000	D-1214.	154
10.	*Globigerina quinqueloba* Natland subsp. *egelida* Cifelli & Smith. a: spiral; b: umbilical views.	242001	B-7072.	154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1, 2, 3.	*Islandiella helenae* Feyling-Hanssen & Buzas. Side views.	242010	B-7077.	142
		242011	D-1209.	142
		242012	D-1211.	142
13.	(?) *Islandiella helenae* Feyling-Hanssen & Buzas. Side views.	242013	D-1211.	143
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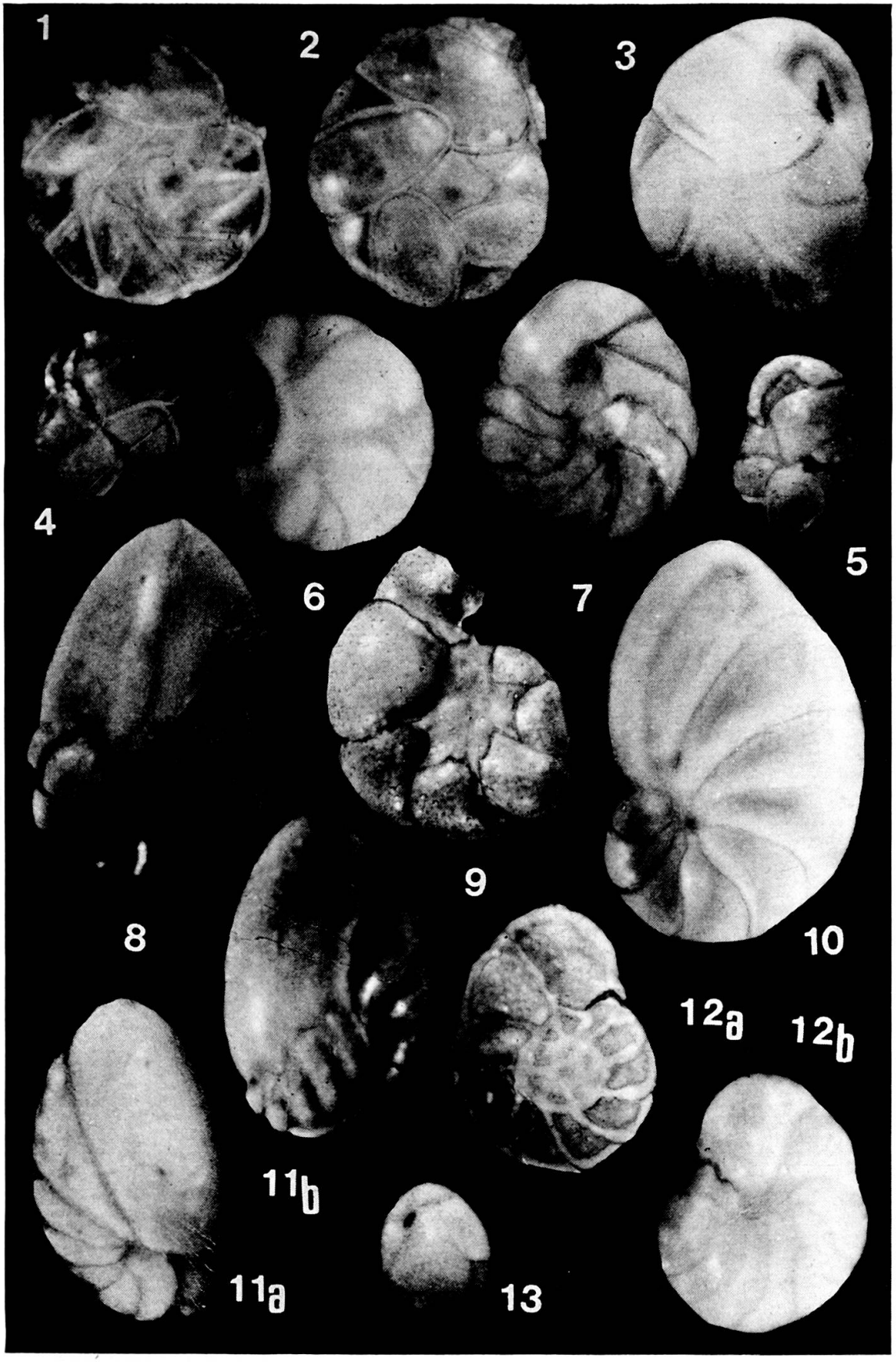
8.	*Nonionellina labradorica* (Dawson). Side view.	242035	B-7077.	157
9.	*Astrononion gallowayi* Loeblich & Tappan. Side view.	241938	B-6891.	156
10.	*Nonionella auricula* Heron-Allen & Earland. Side view.	242036	B-7077.	157
11.	*Nonionella turgida* (Williamson) subsp. *digitata* Nørvang. a: spiral,; b: umbilical views.	242413	B-7077.	157
12.	*Cibicides lobatulus* (Walker & Jacob). a: spiral; b: umbilical views.	241953	B-7077.	154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