STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
702 Woodlark Building
Portland 5, Oregon

Bulletin No. 36
Parts I–V, pp. I–III, plates 1–13, 4 figures in text

Five Papers on Foraminifera From the Tertiary of Western Oregon

by

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Prepared Under a Joint Project of the
State Department of Geology and Mineral Industries
and the
United States Geological Survey

JULY 1947

INTRODUCTION

This bulletin represents work done by the Oregon State Department of Geology and Mineral Industries in co-operation with the United States Geological Survey in the development of stratigraphic projects which both the State Department and the Geological Survey have had under way in Oregon over a period of years.

The object of this work, insofar as the microfossils are concerned, is to determine the character of their distribution in the sedimentary formations of Oregon, to establish microfossil zones for the correlation of strata within the geologic province of which Oregon is a part, and then to apply this information to the solution of stratigraphic problems.

As shown in outline form, the procedure for this work will be as follows:

I. *Descriptive work*

a. Identify and record species found in Oregon that have already been named and described from various parts of the world in published literature.

b. Name, describe, and illustrate new species.

II. *Stratigraphic work*

a. Determine the lateral and vertical ranges and relationships of genera and species found in strata of known geologic age.

b. Determine the ages and ecologic significance of strata of unknown age encountered in the field by comparing their faunas with faunas from strata of known age.

c. Apply these correlations (age determinations) and ecologic data to the solution of stratigraphic and structural problems, both economic and academic.

These correlations apply to the solution of many stratigraphic and structural problems which are continually being presented, such as proper age relationships in constructing geologic maps, especially the state geologic map now in prepa-

ration, and studies of oil and gas possibilities in which age and succession of strata are all-important.

The five papers in this bulletin are all primarily descriptive, as will be several others to follow. However, stratigraphic work is now in progress and will receive increasing attention as descriptive work increases the size of our usable fauna.

Very little has been published on the micropaleontology of the Pacific Northwest; so it offers a practically virgin field for research. However, the descriptive part of the work, which must of necessity precede publication on stratigraphic micropaleontology, requires far greater library facilities and type fossil collections of approximately worldwide scope than are to be found in the Northwest at the present time. Consequently, many workers who might otherwise make valuable contributions to Oregon micropaleontology and stratigraphy hesitate to enter this field of research. One of the purposes of this project in stratigraphic micropaleontology is to open the field to many such workers.

Interest will be concentrated on formations in the State of Oregon, but, in some cases in which they are vital to the solution of Oregon problems, formations from adjoining areas may be studied. The processes of geology were never appreciably influenced by political boundaries.

The figures of species which appear on the thirteen plates in this bulletin were drawn by Mrs. Vivian Clay, Miss Elizabeth V. Bauman, and Mrs. Elizabeth E. Bruhn, whose careful work is much appreciated.

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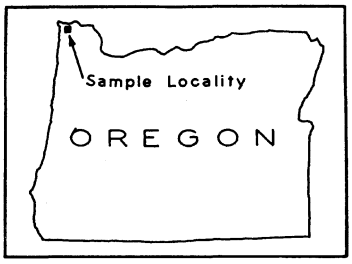
Part I

ASTORIA MIOCENE FORAMINIFERA FROM THE NORTHWEST CORNER OF TENTH STREET AND HARRISON AVENUE, ASTORIA, CLATSOP COUNTY, OREGON



ASTORIA MIOCENE FORAMINIFERA

From the Northwest Corner of Tenth Street and Harrison Avenue, Astoria, Clatsop County, Oregon*

By

JOSEPH A. CUSHMAN[1]
and
ROSCOE E.[2] and KATHERINE C.[3] STEWART

The city of Astoria, which is located at the mouth of the Columbia River in Clatsop County, Oregon, is the type locality of both the Astoria formation of Oregon and Washington and the Miocene of the west coast.[4]

The Astoria formation underlies much of the area in and around Astoria. From 1848 to about 1918 it was variously assigned to the Eocene, Oligocene, and Miocene,[5] but during the past 25 or 30 years the Miocene age has been quite generally accepted and research has indicated that the Astoria formation belongs in the middle Miocene.

The material for this paper was collected by E. M. Baldwin and R. E. Stewart from a road cut at the northwest corner of Tenth Street and Harrison Avenue, where mouse-colored gray shales of the Astoria formation occur in association with very minor amounts of sandstone and greensand. This is Washburne's locality 5318[6] from which he lists a number of fossils identified by W. H. Dall. Another locality, 5314[7], is described simply as "Tenth and Harrison Streets, Astoria," and may include an exposure at the southeast corner as well as the one at the northwest corner of this intersection.

The foraminiferal assemblage from the northwest corner of Tenth Street and Harrison Avenue contains a considerable

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[4] Howe, H. V., Astoria, mid-Tertic type of the Pacific coast: Pan-Am. Geologist, vol. 45, no. 4, p. 295, May 1926.

[5] Ethrington, T. J., Stratigraphy and fauna of the Astoria Miocene of southwest Washington: California, Univ., Dept. Geol. Sci., Bull., vol. 20, no. 5, pp. 36-40, May 20, 1931.

[6] Washburne, C. W., Reconnaissance of the geology and oil prospects of northwestern Oregon: U. S. Geol. Survey Bull. 590, p. 28, 1914.

[7] Idem., p. 27.

number of species which, because of rare occurrence or poor preservation, are not recorded in this paper. If further investigation produces sufficient well-preserved specimens of these species to serve as sound bases for identification, they may be brought out in a subsequent paper.

Samples of the shale and greensand were examined petrographically by W. D. Lowry and a spectrographic analysis was run by T. C. Matthews, both of the Oregon Department of Geology and Mineral Industries. They state:

> The shale is bentonitic and made up predominantly of beidellite (?). The greensand consists largely of a glauconite-like mineral and gypsum with a minor amount of detrital grains of quartz and plagioclase. Spectrographic analysis of the greensand shows the presence of approximately 3 per cent potassium, which indicates its glauconitic nature.

Family LITUOLIDAE

Genus CYCLAMMINA H. B. Brady, 1876

CYCLAMMINA INCISA (Stache) (Pl. 1, fig. 1)

Haplophragmium incisum Stache, *Novara*-Exped., Geol. Theil, vol. 1, 1864, p. 165, pl. 21, fig. 1.

Cyclammina incisa Chapman, New Zealand Geol. Survey, Pal. Bull. No. 11, 1926, p. 29, pl. 2, fig. 1.—Cushman and Laiming, Journ. Pal., vol. 5, 1931, p. 93, pl. 9, fig. 6.—Chapman and Crespin, Pal. Bull. No. 1, 1932, p. 15, pl., fig. 6.—Cushman and Barbat, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 32, pl. 5, fig. 2.—Cushman and Hobson, l. c., vol. 11, 1935, p. 55, pl. 8, fig. 4.—Parr, Journ. Roy. Soc. W. Australia, vol. 24, 1937-38, p. 89, text fig. 1.—Cushman and LeRoy, Journ. Pal., vol. 12, 1938, p. 122, pl. 22, fig. 3.—Kleinpell, Miocene Stratig. Calif., 1938, p. 188.—Crespin, Bull. 9 (Pal. Ser. No. 4), Commonwealth of Australia, Min. Res. Survey, (mimeographed), 1943, p. 78 (list).—Weaver, Univ. Washington Publ. Geol., vol. 6, No. 1, 1944, p. 24 (list).—Colom, Num. 2, Estudios Geologicos, Instit. Invest. Geol., 1945, p. 10, pl. 1, fig. 17; pl. 2, fig. 26; l. c., Num. 3, 1946, p. 50, pl. 5, fig. 146.

This species has been widely recorded from the Miocene, particularly from California. Like other species of the genus it is subject to much deformity in fossilization but the general characters seem to be rather constant. It is fairly common in this Astoria Miocene material.

Family LAGENIDAE

Genus ROBULUS Montfort, 1808

ROBULUS NIKOBARENSIS (Schwager) (Pl. 1, fig. 2)

Cristellaria nikobarensis Schwager, *Novara*-Exped., Geol. Theil, vol. 2, 1866, p. 243, pl. 6, fig. 87.

Robulus nikobarensis Cushman, Stewart, and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, 1930, p. 53, pl. 2, figs. 5, 7.—R. E. and K. C. Stewart, Bull. Amer. Assoc. Petr. Geol., vol. 14, 1930, p. 1448.—Cushman and Laiming, Journ. Pal., vol. 5, 1931, p. 97, pl. 10, fig. 4.—Cushman and Parker, Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 2, pl. 1, fig. 2.—Cushman, Bull. 119, Bernice P. Bishop Mus., 1934, p. 109.—Woodring, Bramlette, and Kleinpell, Bull. Amer. Assoc. Petr. Geol., vol. 20, 1936, p. 141 (list).—Yabe and Asano, Sci. Rep't Tohoku Imp. Univ., ser. 2 (Geol.), vol. 19, No. 1, 1937, p. 99 (13), pl. 18 (2), fig. 12.—Asano, l. c., No. 2, 1938, p. 204 (26), pl. 28 (5), figs. 5, 6; pl. 29 (6), fig. 8.

This species was described from the Pliocene of Kar Nicobar. It is recorded from numerous localities in the Pliocene and Miocene of California and from the Miocene of Java and the Tertiary of Japan. The Astoria specimens seem to be identical with this species.

ROBULUS cf. CALCAR (Linné) (Pl. 1, fig. 3)

Rare specimens in the Astoria material have a spinose periphery and may be referred questionably to this species until more specimens are available to show the range of variation.

ROBULUS sp. (Pl. 1, fig. 4)

The form which is here figured is very rare in the Miocene material from Astoria and must await the finding of more material before a specific name is justified.

Genus MARGINULINA d'Orbigny, 1826

MARGINULINA cf. DUBIA Neugeboren (Pl. 1, fig. 7)

Rare specimens may be assigned to this species with some question.

Genus SARACENARIA Defrance, 1824

SARACENARIA cf. ACUTAURICULARIS (Fichtel and Moll) (Pl. 1, fig. 5)

Very rare specimens may be referred questionably to this species until more specimens are available. From the figures referred to this species, it is very variable.

SARACENARIA sp. (Pl. 1, fig. 6)

The figured specimen is incomplete but seems to be distinct from the preceding. It does not seem to be identical with any described species.

Genus DENTALINA d'Orbigny, 1826

DENTALINA PAUPERATA d'Orbigny (Pl. 1, fig. 10)

Dentalina pauperata d'Orbigny, Foram. Foss. Bass. Tert. Vienne, 1846, p. 46, pl. 1, figs. 57, 58.—Bornemann, Zeitschr. deutsch. geol. Ges., vol. 7, 1855, p. 324, pl. 13, fig. 7.—Galloway and Morrey, Bull. Amer. Pal., vol. 15, No. 55, 1929, p. 13, pl. 1, fig. 8.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 5, 1929, p. 85, pl. 12, figs. 23, 24.—Cushman and Laiming, Journ. Pal., vol. 5, 1931, p. 99, pl. 10, figs. 11, 12.—Tolmachoff, Annals Carnegie Mus., vol. 23, 1934, p. 302, pl. 40, figs. 22, 23.—Cushman and LeRoy, Journ. Pal., vol. 12, 1938, p. 124, pl. 22, fig. 16.—Kleinpell, Miocene Stratig. Calif., 1938, p. 213, pl. 11, fig. 6.—Coryell and Rivero, Journ. Pal., vol. 14, 1940, p. 326, pl. 41, figs. 20, 21.—Cushman, Foraminifera, 3rd Ed., 1940, Key, pl. 21, fig. 10.—Weaver, Univ. Washington Publ. Geol., vol. 6, No. 1, 1944, p. 24 (list).—Colom, Num. 3, Estudios Geologicos, Instit. Invest. Geol., 1946, p. 144, pl. 9, figs. 147, 148.

This species described by d'Orbigny from the Miocene of the Vienna Basin has been widely recorded, especially from the Miocene of North and South America. There are numerous other references in addition to those given above but they do not seem to refer to typical material. The species is fairly common in the Astoria material.

DENTALINA QUADRULATA Cushman and Laiming (Pl. 1, figs. 8, 9)

Dentalina quadrulata Cushman and Laiming, in Cushman and Parker, Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 3, pl. 1, figs. 9-11.—Cushman and Laiming, Journ. Pal., vol. 5, 1931, p. 99, pl. 10, fig. 13.—Barbat and von Estorff, l. c., vol. 7, 1933, p. 169, pl. 23, figs. 1, 3, 4.—Palmer and Bermudez, Mem. Soc. Cubana Hist. Nat., vol. 10, 1936, p. 261.—Kleinpell, Miocene Stratig. Calif., 1938, p. 214.—Palmer, Mem. Soc. Cubana Hist. Nat., vol. 14, 1940, p. 280.—Schenck and Childs, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, No. 2, 1942, p. 26 (list).

This species was described from the Miocene, Temblor formation, of California. It has been recorded from several Miocene localities and one Oligocene locality, all in California, and from the Oligocene of Cuba. There are a number of typical specimens in the Astoria material.

Genus NODOSARIA Lamarck, 1812

NODOSARIA ANOMALA Reuss (Pl. 1, fig. 12)

Nodosaria anomala Reuss, Denkschr. Akad. Wiss. Wien, vol. 25, 1865, p. 129, pl. 1, figs. 20-22; Sitz. Akad. Wiss. Wien, vol. 62, pt. 1,

1870, p. 470, in von Schlicht, Foram. Sept. Pietzpuhl, 1870, pl. 6, fig. 25; pl. 7, figs. 5-7.—Cushman and Parker, Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 4, pl. 1, figs. 12-14.—Cushman and Laiming, Journ. Pal., vol. 5, 1931, p. 100, pl. 10, fig. 10.—Barbat and von Estorff, l. c., vol. 7, 1933, p. 169.—Cushman and Hobson, Contr. Cushman Lab. Foram. Res., vol. 11, 1935, p. 58, pl. 8, fig. 16.—Kleinpell, Miocene Stratig. Calif., 1938, p. 216.—LeRoy, Nat. Tijdschr. Nederl.-Indie, vol. 99, pt. 6, 1939, p. 237, pl. 5, figs. 7, 8; Colorado School Mines Quart., vol. 36, No. 1, pt. 1, 1941, p. 26, pl. 3, fig. 90.

This species was originally described from the middle Oligocene of Germany and specimens apparently identical have been recorded from a number of localities in the Miocene of California, and in Sumatra and Borneo. The specimens from the Astoria Miocene seem typical.

NODOSARIA PAREXILIS Cushman and K. C. Stewart (Pl. 1, fig. 11)

Nodosaria parexilis Cushman and K. C. Stewart, in Cushman, Stewart, and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, 1930, p. 55, pl. 2, figs. 13-15.—R. E. and K. C. Stewart, Bull. Amer. Assoc. Petr. Geol., vol. 14, 1930, p. 1448.—Cushman and Parker, Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 6, pl. 1, fig. 15.—Parr, Trans. Roy. Soc. New Zealand, vol. 64, 1934, p. 142.—Kleinpell, Miocene Stratig. Calif., 1938, p. 219, pl. 10, fig. 1.

This species was described from the Pliocene of Humboldt County, California, and has been recorded from several Miocene localities in California and from the Miocene of New Zealand. Our specimens from the Astoria Miocene seem typical. The figured specimen is evidently microspheric.

Family NONIONIDAE

Genus NONION Montfort, 1808

NONION cf. BELRIDGENSE Barbat and Johnson (Pl. 2, fig. 1)

Nonion belridgensis Barbat and Johnson, Journ. Pal., vol. 8, 1934, p. 11, pl. 1, figs. 8, 9.—Hedberg, Journ. Pal., vol. 11, 1937, p. 674, pl. 91, fig. 11.—Kleinpell, Miocene Stratig. Calif., 1938, p. 229.—Cushman, U. S. Geol. Survey Prof. Paper 191, 1939, p. 18, pl. 5, fig. 1.

The types of this species are from the upper Miocene, Reef Ridge shale, California. It is also recorded from the upper Oligocene of Venezuela. The figured specimen may not be entirely typical but seems to be nearer this species than any other.

Family HETEROHELICIDAE

Genus PLECTOFRONDICULARIA Liebus, 1903

PLECTOFRONDICULARIA CALIFORNICA Cushman and R. E. Stewart (Pl. 2, fig. 2)

Plectofrondicularia californica Cushman and Stewart, Contr. Cushman Lab. Foram. Res., vol. 2, pt. 2, 1926, p. 39, pl. 6, figs. 9-11.—Church, Journ. Pal., vol. 1, 1928, p. 268.—Nuttall, Quart. Journ. Geol. Soc., vol. 84, 1928, p. 92, pl. 6, fig. 9.—Galloway and Morrey, Bull. Amer. Pal., vol. 15, No. 55, 1929, p. 36, pl. 5, fig. 11.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 5, 1929, p. 90, pl. 13, figs. 18, 19.—R. E. and K. C. Stewart, Bull. Amer. Assoc. Petr. Geol., vol. 14, 1930, p. 1448.—Cushman, Stewart, and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, 1930, p. 63, pl. 4, figs. 3, 4.—Cushman, Special Publ. 5, Cushman Lab. Foram. Res., 1933, pl. 26, figs. 24, 25.—Kleinpell, Miocene Stratig. Calif., 1938, p. 239, pl. 4, figs. 17, 19.—Cushman, Foraminifera, 3rd Ed., 1940, Key, pl. 26, figs. 24, 25.—Hanna and Hertlein, Calif. Div. Mines, Bull. 118, pt. 2, 1941, p. 182, fig. 67 [plate], figs. 48, 49.—LeRoy, Journ. Pal., vol. 15, 1941, p. 623 (list).—Renz, Proc. 8th Amer. Sci. Congress, 1942, pp. 554, 556 (lists).—Weaver, Univ. Washington Publ. Geol., vol. 6, No. 1, 1944, p. 25 (list).

This species is common in the Miocene and lower Pliocene of the California region and is recorded also from the Miocene of South America and Trinidad. The species is very common in the Astoria Miocene and seems to be typical.

PLECTOFRONDICULARIA MIOCENICA Cushman, var. DIRECTA Cushman and Laiming (Pl. 2, fig. 3)

Plectofrondicularia miocenica Cushman, var. *directa* Cushman and Laiming, Journ. Pal., vol. 5, 1931, p. 105, pl. 11, fig. 12.—Kleinpell, Miocene Stratig. Calif., 1938, p. 241, pl. 7, fig. 11.

Both records for this variety are from the Miocene of California. There are a few rather typical specimens in this Astoria material.

PLECTOFRONDICULARIA sp. (Pl. 2, fig. 4)

Rare specimens, one of which is figured, occur in the Astoria material. None of them is complete and no specific name can safely be given. In some respects it is like *P. garzaensis* Cushman and Siegfus from the Eocene of Garza Creek, California; and it also remotely resembles *P. vaughani* Cushman.

Genus NODOGENERINA Cushman, 1927

NODOGENERINA ADVENA Cushman and Laiming (Pl. 2, figs. 5, 6)

Nodogenerina advena Cushman and Laiming, Journ. Pal., vol. 5, 1931, p. 106, pl. 11, fig. 19.—Cushman and Ponton, Bull. 9, Florida State Geol. Survey, 1932, p. 75, pl. 11, fig. 10.—Barbat and von Estorff,

Journ. Pal., vol. 7, 1933, p. 171, pl. 23, fig. 2.—Cushman, Special Publ. 5, Cushman Lab. Foram. Res., 1933, pl. 26, fig. 38.—Woodring, Bramlette, and Kleinpell, Bull. Amer. Assoc. Petr. Geol., vol. 20, 1936, pp. 136, 141, 144 (lists).—Kleinpell, Miocene Stratig. Calif., 1938, p. 243, pl. 9, fig. 10.—Cushman, Foraminifera, 3rd Ed., 1940, Key, pl. 26, fig. 38.—Weaver, Univ. Washington Publ. Geol., vol. 6, No. 1, 1944, p. 24 (list).—Cushman and Todd, Special Publ. 15, Cushman Lab. Foram. Res., 1945, p. 38, pl. 6, fig. 5.

The types of this species are from the Miocene of Los Sauces Creek, Ventura County, California. It is also recorded from a number of Miocene localities in California, Florida, and Jamaica. There is considerable variation in the amount of inflation of the chambers and consequent depression of the sutures. Two of the Astoria Miocene specimens are figured, but some of the other specimens show less inflation of the chambers.

NODOGENERINA sp. (Pl. 2, figs. 9, 10)

Rare and somewhat variable specimens, two of which are figured, occur in the Astoria Miocene but not enough specimens are available to warrant a specific identification.

Family BULIMINIDAE

Genus BULIMINELLA Cushman, 1911

BULIMINELLA SUBFUSIFORMIS Cushman (Pl. 2, fig. 7)

Buliminella subfusiformis Cushman, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 2, 1925, p. 33, pl. 5, fig. 12; pt. 3, 1926, p. 55.—Cushman, Stewart, and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, 1930, p. 64, pl. 4, fig. 8.—Cushman and Moyer, Contr. Cushman Lab. Foram. Res., vol. 6, 1930, p. 56, pl. 7, fig. 20.—Cushman and Laiming, Journ. Pal., vol. 5, 1931, p. 106, pl. 11, fig. 14.—Cushman and Parker, Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 8, pl. 1, fig. 29.—Barbat and von Estorff, Journ. Pal., vol. 7, 1933, p. 171, pl. 23, fig. 9.—Woodring, Bramlette, and Kleinpell, Bull. Amer. Assoc. Petr. Geol. vol. 20, 1936, pp. 136, 141, 144 (lists).—Kleinpell, Miocene Stratig. Calif., 1938, p. 251, pl. 9, fig. 8; pl. 22, fig. 5(?).—LeRoy, Nat. Tijdschr. Nederl.-Indie, vol. 99, pt. 6, 1939, p. 243, pl. 5, figs. 16-18; Colorado School Mines Quart., vol. 39, No. 3, pt. 1, 1944, p. 25, pl. 1, fig. 19.—Weaver, Univ. Washington Publ. Geol., vol. 6, No. 1, 1944, p. 23 (list).—Cushman and Parker, U. S. Geol. Survey Prof. Paper 210-D, 1947, p. 64, pl. 16, fig. 21.

The types of this species are from the Miocene of California. It has been recorded from many Miocene localities and off the coast of California as well as from the Miocene of Sumatra. It is common in the Astoria material.

Genus BULIMINA d'Orbigny, 1826

BULIMINA OVATA d'Orbigny (Pl. 2, fig. 8)

This species, described from the Miocene of the Vienna Basin, has been very widely recorded. Our Astoria specimens seem to be typical.

BULIMINA ALLIGATA Cushman and Laiming (Pl. 2, fig. 11)

Bulimina inflata Seguenza, var. *alligata* Cushman and Laiming, Journ. Pal., vol. 5, 1931, p. 107, pl. 11, fig. 17.—Kleinpell, Miocene Stratig. Calif., 1938, p. 254, pl. 7, fig. 1.—Schenck and Childs, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, No. 2, 1942, p. 26 (list).—Weaver, Univ. Washington Publ. Geol., vol. 6, No. 1, 1944, p. 23 (list).—Cushman and Parker, U. S. Geol. Survey Prof. Paper 210-D, 1947, p. 112, pl. 26, fig. 14.

This form was described from the Miocene of Los Sauces Creek, Ventura County, California, and has been recorded from other Miocene localities and one Oligocene locality, all in California. Our specimens are very common and seem to be typical. This form seems enough different from *Bulimina inflata* Seguenza to warrant a specific rank.

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA ADVENA Cushman (Pl. 2, fig. 12)

Bolivina advena Cushman, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 2, 1925, p. 29, pl. 5, fig. 1; vol. 2, pt. 3, 1926, p. 54—Cushman, Stewart, and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, 1930, p. 67.— Woodring, Bramlette, and Kleinpell, Bull. Amer. Assoc. Petr. Geol., vol. 20, 1936, pp. 136, 141, 144, 147 (lists).—Cushman, Special Publ. 9, Cushman Lab. Foram. Res., 1937, p. 95, pl. 10, fig. 16; pl. 12, fig. 16.—Kleinpell, Miocene Stratig. Calif., 1938, p. 264, pl. 7, fig. 6; pl. 9, fig. 7.—Cushman and McCulloch, Allen Hancock Pacific Exped., vol. 6, No. 4, 1942, p. 186, pl. 21, figs. 4-6.—Weaver, Univ. Washington Publ. Geol., vol. 6, No. 1, 1944, p. 23 (list).

The types of this species are from the Miocene, Monterey shale, of California and it is recorded from other Miocene localities in California as well as living off the coast. The species is quite variable but not all of the forms assigned to it in the literature seem identical. The Astoria specimens also show considerable variation.

BOLIVINA MARGINATA Cushman, var. ADELAIDANA Cushman and Kleinpell (Pl. 2, fig. 13)

Bolivina marginata Cushman, var. *adelaidana* Cushman and Kleinpell, Contr. Cushman Lab. Foram. Res., vol. 10, 1934, p. 10, pl. 2, figs. 1, 2.—Cushman, Special Publ. 9, 1937, p. 87, pl. 10, figs. 11-14.—Kleinpell, Miocene Stratig. Calif., 1938, p. 277.—Schenck and Childs, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, No. 2, 1942, p. 26 (list).—Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, No. 4, 1942, p. 200, pl. 24, figs. 2, 3.

This variety, described from the Miocene of California, occurs in typical form in the Astoria material. It is recorded from the Miocene and Oligocene of California and as living in the eastern Pacific off the coasts of California, Mexico, and Colombia. There is a considerable amount of variation in the breadth and the amount of spinosity at the periphery.

Genus UVIGERINA d'Orbigny, 1826

UVIGERINA SUBPEREGRINA Cushman and Kleinpell (Pl. 2, figs. 14, 15)

Uvigerina subperegrina Cushman and Kleinpell, Contr. Cushman Lab. Foram. Res., vol. 10, 1934, p. 12, pl. 2, figs. 9-11.—Woodring, Bramlette, and Kleinpell, Bull. Amer. Assoc. Petr. Geol., vol. 20, 1936, pp. 141, 145 (lists).—Kleinpell, Miocene Stratig. Calif., 1938, p. 298.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 17, 1941, p. 52, pl. 14, figs. 19-23.

The types of this species are from the Miocene of California and it is recorded also from the Miocene of Florida and Virginia. Specimens are common in the Astoria Miocene material.

Genus ANGULOGERINA Cushman, 1927

ANGULOGERINA ASTORIENSIS Cushman, and R. E. and K. C. Stewart, n. sp. (Pl. 2, figs. 16, 17)

Test about twice as long as broad, initial end acute, greatest width above the middle, triangular in transverse section, the angles acute to subacute; chambers of the earlier portion indistinct, not inflated, those of the last-formed whorl distinct and inflated; sutures distinct only in the later portion, where they are depressed; wall with a few rather indistinct longitudinal costae; aperture terminal with a short neck and phialine lip. Length 0.80–1.10 mm.; breadth 0.45–0.63 mm.

Holotype (Cushman Coll. No. 48797) and paratypes (Oregon State Dept. Geology and Min. Industries Coll. No. 26 and Stewart Coll. No. 26) from the Astoria Miocene, Tenth Street and Harrison Avenue, NW corner, Astoria, Clatsop County, Oregon.

This species is represented by a number of specimens from the type locality. It shows a considerable amount of variation in the sharpness of the angles of the test and in the development of the longitudinal costae. It may be distinguished from *A. occidentalis* (Cushman) in the broader and shorter form, more rhomboid outline in longitudinal section, less inflated chambers in the earlier portion, and less well developed costae.

Genus SIPHOGENERINA Schlumberger, 1883

SPIHOGENERINA BRANNERI (Bagg) (Pl. 2, fig. 18)

Sagrina branneri Bagg, Bull. 268, U. S. Geol. Survey, 1905, p. 40, pl. 7, fig. 4.

Siphogenerina branneri Cushman, Proc. U. S. Nat. Mus., vol. 67, Art. 25, 1926, p. 7, pl. 1, figs. 7-9; pl. 4, fig. 7.—Kleinpell, Miocene Stratig. Calif., 1938, p. 299, pl. 7, fig. 22; pl. 11, figs. 1, 5.

Sagrina californiensis Bagg, Bull. 268, U. S. Geol. Survey, 1905, p. 41, pl. 7, fig. 5.

Sagrina elongata Bagg, l. c., p. 41, pl. 7, fig. 6.

This species, described from the Miocene, Monterey shale, of California, occurs in typical form in the Astoria Miocene of Oregon.

SIPHOGENERINA KLEINPELLI Cushman

Siphogenerina kleinpelli Cushman, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 1, 1925, p. 3, pl. 4, fig. 5; Proc. U. S. Nat. Mus., vol. 67, Art. 25, 1926, p. 7; Contr. Cushman Lab. Foram. Res., vol. 2, pt. 3, 1926, p. 59.—Kleinpell, Miocene Stratig. Calif., 1938, p. 301, pl. 7, fig. 24; pl. 11, fig. 4.

This species was also described from the Miocene, Monterey shale, of California. Some specimens seem to tend toward *S. reedi* Cushman but the group as a whole seems to belong to *S. kleinpelli*. It is not common in the Astoria Miocene.

Family ROTALIIDAE

Genus VALVULINERIA Cushman, 1926

VALVULINERIA ARAUCANA (d'Orbigny) (Pl. 3, fig. 1)

Rosalina araucana d'Orbigny, Voy. Amér. Mérid., vol. 5, pt. 5, "Foraminifères," 1839, p. 44, pl. 6, figs. 16-18.

Valvulineria araucana Cushman, Bull. Scripps Instit. Oceanography, Tech. Ser., vol. 1, No. 10, 1927, p. 160, pl. 4, figs. 7, 8.—Palmer and Bermudez, Mem. Soc. Cubana Hist. Nat., vol. 9, 1935, p. 251.—Woodring, Bramlette, and Kleinpell, Bull. Amer. Assoc. Petr. Geol., vol. 20, 1936, pp. 141, 145, 147 (lists).—Kleinpell, Miocene Stratig. Calif., 1938, p. 307.—LeRoy, Nat. Tijdschr. Nederl.-Indie, vol. 99, pt. 6, 1939, p. 254, pl. 9, figs. 1-3.—Palmer, Mem. Soc. Cubana Hist. Nat., vol. 15, 1941, p. 191, pl. 15, figs. 15-17; Bull. Amer. Pal., vol. 29, No. 115, 1945, p. 57.—Colom, Num. 3, Estudios Geológicos, Instit. Invest. Geol., 1946, p. 164.

This species, described from off the coast of Chile, has been widely recorded in Recent and Tertiary collections, especially in the Miocene of California. Specimens which seem fairly typical occur in some numbers in the Astoria Miocene collections.

Genus EPONIDES Montfort, 1808

EPONIDES UMBONATUS (Reuss) (Pl. 3, figs. 2, 3)

This species, originally described from the Oligocene of Hermsdorf, Germany, has been very widely recorded from the Tertiary and also from Recent collections. As not all of the records apparently are of a single species no attempt is here made to give the various references. The material from the Astoria Miocene is very close to the species from the type locality.

EPONIDES HEALDI R. E. and K. C. Stewart (Pl. 3, fig. 4)

Eponides healdi R. E. and K. C. Stewart, Journ. Pal., vol. 4, 1930, p. 70, pl. 8, fig. 8.—Woodring, Bramlette, and Kleinpell, Bull. Amer. Assoc. Petr. Geol., vol. 20, 1936, pp. 145, 147 (lists).—Kleinpell, Miocene Stratig. Calif., 1938, p. 319.

The types of this species are from the Pliocene of California and it has been recorded also from the Miocene of California. Specimens from the Astoria Miocene seem identical.

Genus CANCRIS Montfort, 1808

CANCRIS CANCRIFORMIS (Kleinpell) (Pl. 3, fig. 5)

Baggina cancriformis Kleinpell, Miocene Stratig. Calif., 1938, p. 324, pl. 9, fig. 24.

Cancris cancriformis Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 105.

This species has been recorded only from the Miocene of California. Rare specimens from the Astoria Miocene seem to resemble the description and figures of this species.

Family CASSIDULINIDAE

Genus CASSIDULINA d'Orbigny, 1826

CASSIDULINA cf. GLOBOSA Hantken (Pl. 3, fig. 6)

A few specimens with a rather thick test somewhat resemble this species but more and better preserved specimens are needed to make a positive identification.

CASSIDULINA LAEVIGATA d'Orbigny, var. CARINATA Cushman (Pl. 3, fig. 7)

This variety has been widely recorded and the records may refer to more than one form. The references are therefore not given. There are a few records from the Miocene of California. Specimens are rare in the Astoria Miocene and seem to be more compressed than the following species.

CASSIDULINA MODELOENSIS Rankin (Pl. 3, fig. 8)

Cassidulina modeloensis Rankin, in Cushman and Kleinpell, Contr. Cushman Lab. Foram. Res., vol. 10, 1934, p. 23, pl. 3, fig. 12.—Woodring, Bramlette, and Kleinpell, Bull. Amer. Assoc. Petr. Geol., vol. 20, 1936, pp. 145, 147 (lists).—Kleinpell, Miocene Stratig. Calif., 1938, p. 334.

Rare specimens in the Astoria Miocene material may be referred to this species, previously recorded only from the Miocene of California.

Family CHILOSTOMELLIDAE

Genus SPHAEROIDINA d'Orbigny, 1826

SPHAEROIDINA cf. BULLOIDES d'Orbigny (Pl. 4, figs. 1, 2)

Well-preserved specimens from the Astoria Miocene are very much like topotypes of this species from the Mediterranean with which they have been compared. From the many records this species would appear to have a very wide distribution and long range in the geologic series, but it is apparent from the numerous records with figures that not all of them refer to the same species.

Family ANOMALINIDAE

Genus ANOMALINA d'Orbigny, 1826

ANOMALINA GLABRATA Cushman (Pl. 4, fig. 3)

Anomalina glabrata Cushman, Publ. 342, Carnegie Instit. Washington, 1924, p. 39, pl. 12, figs. 5-7; Bull. 27, Bernice P. Bishop Mus., 1925 (1926), p. 133.—Cushman and Laiming, Journ. Pal., vol. 5, 1931, p. 118, pl. 14, fig. 1.—Chapman, Parr, and Collins, Journ. Linn. Soc., Zool., vol. 38 (No. 262), 1934, p. 570, pl. 11, fig. 39.—Chapman and Parr, Australasian Antarctic Exped., ser. C, vol. 1, pt. 2, 1937, p. 117.—Kleinpell, Miocene Stratig. Calif., 1938, p. 346.—Chapman, Trans. Roy. Soc. So. Australia, vol. 65, 1941, p. 175.—LeRoy, Colorado School Mines Quart., vol. 36, No. 1, pt. 1, 1941, p. 45, pl. 1, figs. 90-92; pt. 2, 1941, p. 88, pl. 3, figs. 16-18; pt. 3, 1941, p. 119, pl. 2, figs. 19-21.—Crespin, Bull. 9 (Pal. Ser. No. 4), Commonwealth of Australia, Min. Res. Survey, (mimeographed), 1943, p. 77 (list).—LeRoy, Colorado School Mines Quart., vol. 39, No. 3, pt. 2, 1944, p. 92, pl. 6, figs. 16-18.

This species was originally described from Recent Pacific material and has been recorded from off Australia and the Antarctic as well as from the Pliocene and Miocene of California, Australia, and the East Indies. There is evidently some variation in the number of chambers in the adult whorl but in general the characters are fairly constant. The species is rather rare in the Astoria Miocene material.

Genus PLANULINA d'Orbigny, 1826

PLANULINA MEXICANA Cushman (Pl. 4, fig. 6)

Planulina mexicana Cushman, Contr. Cushman Lab. Foram. Res., vol. 3, 1927, p. 113, pl. 23, fig. 5; Journ. Pal., vol. 1, 1927, p. 170.—Nuttall, l. c., vol. 6, 1932, p. 31, pl. 7, fig. 7.—Hadley, Bull. Amer. Pal., vol. 20, No. 70A, 1934, p. 28, pl. 4, fig. 12.—Palmer and Bermudez, Mem. Soc. Cubana Hist. Nat., vol. 10, 1936, p. 312.—Bermudez, l. c., vol. 12, 1938, p. 18.—van Bellen, de Witt Puyt, Rutgers, and van Soest, Proc. Ned. Akad. Wetenschappen, vol. 44, 1941, p. 1145.—Galloway and Heminway, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Ids., vol. 3, pt. 4, 1941, p. 399, pl. 26, fig. 3.

The types of this species are from the Oligocene, Alazan clay, of Mexico. It has been recorded from the Miocene, Oligocene, and Eocene of Cuba and Porto Rico. Some of the records for this species are evidently not of typical specimens. Our specimens from the Astoria Miocene are very typical.

PLANULINA ASTORIENSIS Cushman, and R. E. and K. C. Stewart, n. sp. (Pl. 4, figs. 4, 5)

Test very strongly compressed, periphery subacute, slightly thickened; chambers distinct, numerous, ten to fourteen in the adult whorl, increasing very gradually in size as added, all visible from the dorsal side, the last two whorls visible on the ventral side, not inflated; sutures very distinct, limbate and often distinctly raised above the general surface, curved; wall smooth except for the raised border of the chambers, coarsely perforate; aperture a low opening at the inner margin of the last-formed chamber at the periphery and extending over onto the dorsal side. Diameter 0.60–0.75 mm.; thickness 0.10–0.12 mm.

Holotype (Cushman Coll. No. 48819) and paratypes (Oregon State Dept. Geology and Min. Industries Coll. No. 40 and Stewart Coll. No. 40) from the Astoria Miocene, Tenth Street and Harrison Avenue, NW corner, Astoria, Clatsop County, Oregon.

This species is abundant in this Astoria Miocene material and should make a good index fossil. It differs from *Planulina mexicana* Cushman in the much smaller size, less curved sutures, and the strongly raised borders of the chambers.

Genus CIBICIDES Montfort, 1808

CIBÍCIDES FLORIDANUS (Cushman) (Pl. 4, fig. 7)

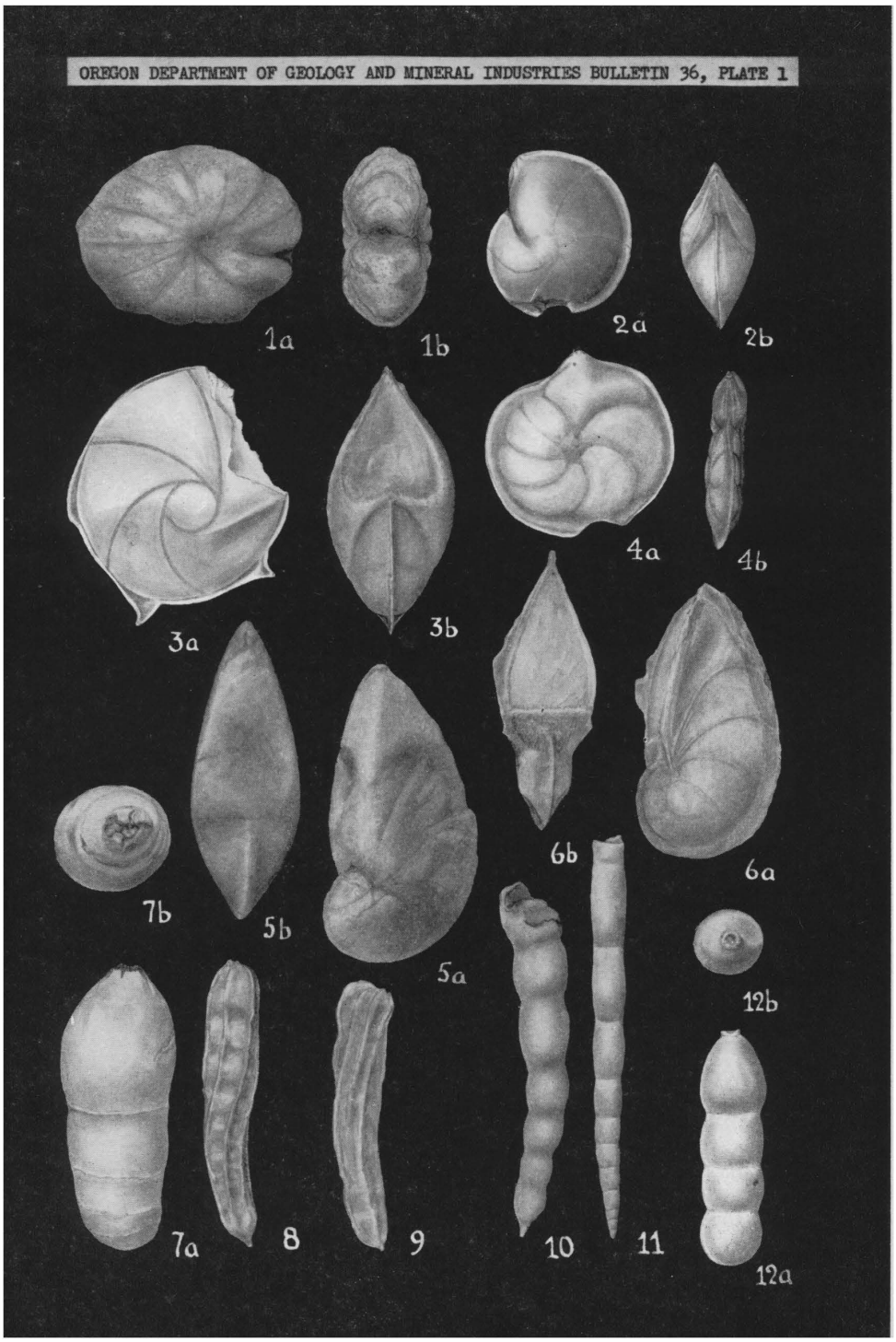
Truncatulina floridana Cushman, Bull. 676, U. S. Geol. Survey, 1918, p. 62, pl. 19, fig. 2.—Nuttall, Quart. Journ. Geol. Soc., vol. 84, 1928, p. 98, pl. 7, figs. 14, 16.

Cibicides floridana Cushman, Bull. 4, Florida State Geol. Survey, 1930, p. 61, pl. 12, fig. 3.—Cushman and Laiming, Journ. Pal., vol. 5, 1931,

p. 119, pl. 14, fig. 8.—Cushman and Parker, Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 16, pl. 3, fig. 2.—Cushman and Ponton, Bull. 9, Florida State Geol. Survey, 1932, p. 100.—Cushman and Cahill, U. S. Geol. Survey Prof. Paper 175-A, 1933, p. 34, pl. 13, fig. 1.—Kleinpell, Miocene Stratig. Calif., 1938, p. 353.—Coryell and Rivero, Journ. Pal., vol. 14, 1940, p. 334, pl. 44, fig. 10.—Ellisor, Bull. Amer. Assoc. Petr. Geol., vol. 24, No. 3, 1940, pl. 6, fig. 10.—Galloway and Heminway, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Ids., vol. 3, pt. 4, 1941, p. 392, pl. 23, fig. 2.—Cushman and Frizzell, Contr. Cushman Lab. Foram. Res., vol. 19, 1943, p. 88, pl. 15, figs. 11, 12.—Weaver, Univ. Washington Publ. Geol., vol. 6, No. 1, 1944, p. 23 (list).—Cushman and Todd, Special Publ. 15, Cushman Lab. Foram. Res., 1945, p. 71, pl. 12, fig. 8.

This species was described from the Miocene of Florida and has been widely recorded. In the western part of the United States it is recorded from the Miocene of California and the Oligocene, Lincoln formation, of Washington. The Astoria Miocene specimens seem typical.

Explanation of Plate 1


OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES BULLETIN 36, PLATE 1
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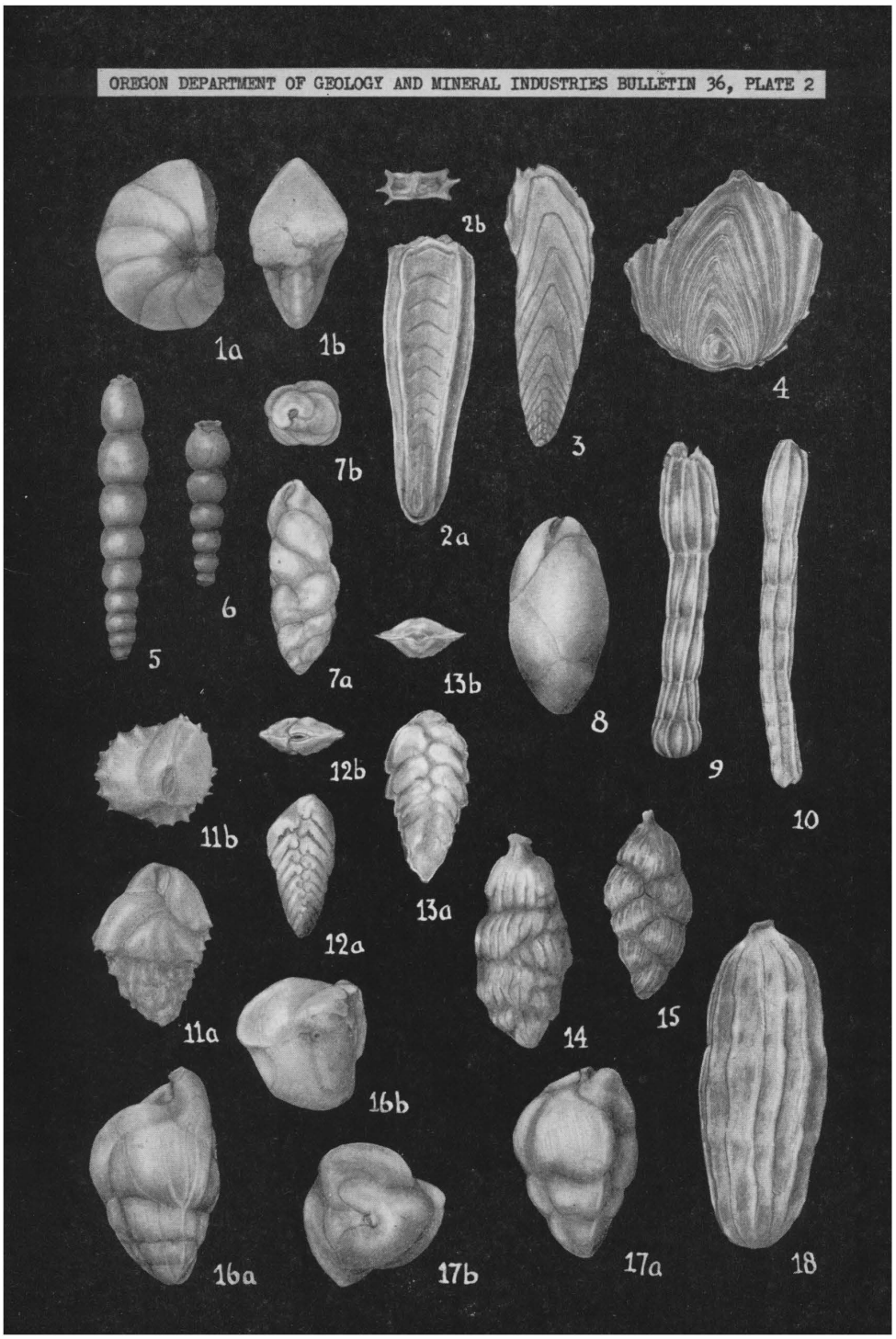
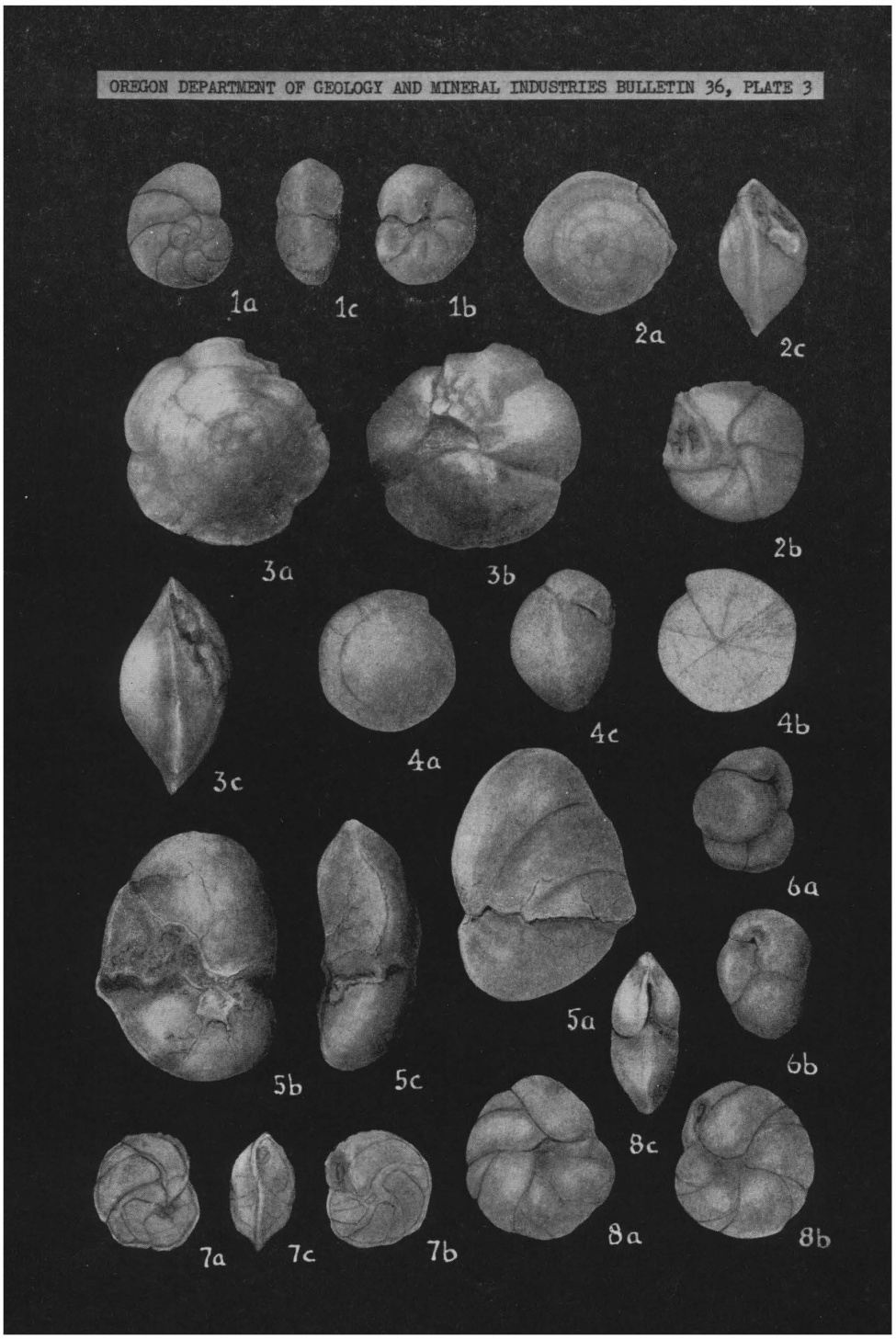
1b
2a
2b
3a
3b
4a
4b
5a
5b
6a
6b
7a
7b
8
9
10
11
12a
12b

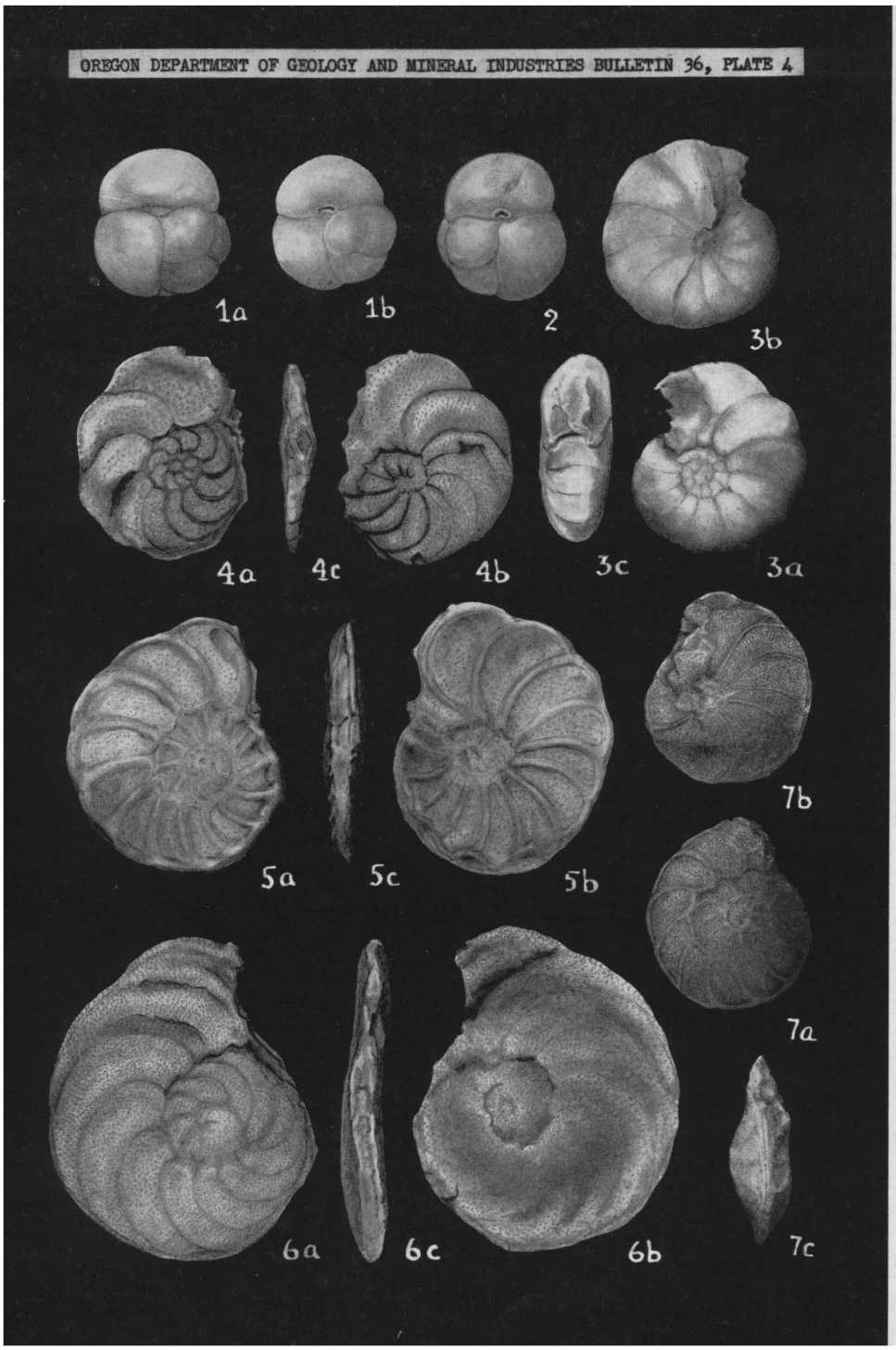
Explanation of Plate 2


OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES BULLETIN 36, PLATE 2
1a
1b
2b
2a
3
4
5
6
7b
7a
13b
8
9
10
11b
12b
13a
12a
11a
14
15
16b
16a
17b
17a
18

Explanation of Plate 3

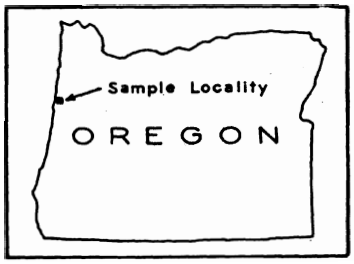

OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES BULLETIN 36, PLATE 3
1a
1c
1b
2a
2c
3a
3b
2b
3c
4a
4c
4b
6a
5a
6b
5b
5c
8c
7a
7c
7b
8a
8b

Explanation of Plate 4


OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES BULLETIN 36, PLATE 4
1a
1b
2
3b
4a
4c
4b
3c
3a
5a
5c
5b
7b
7a
6a
6c
6b
7c

Part II

ASTORIA MIOCENE FORAMINIFERA
FROM
AGATE BEACH, LINCOLN COUNTY, OREGON



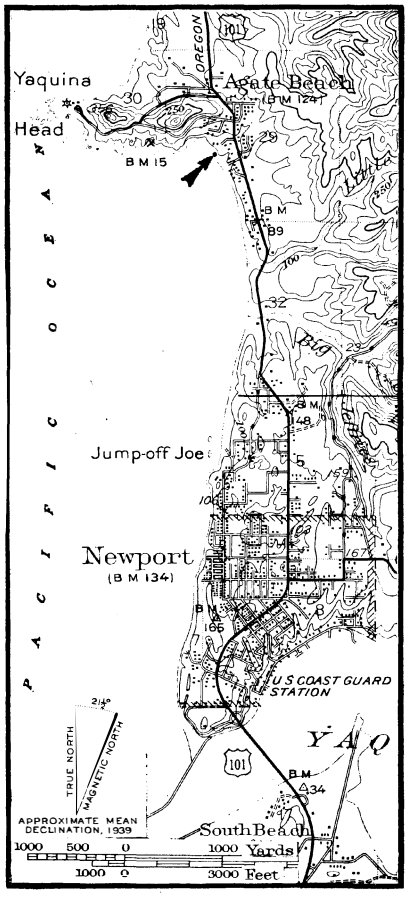


Figure 1. Map showing sampled locality (heavy black arrow) at Agate Beach, Lincoln County, Oregon. Adapted from a portion of the Yaquina quadrangle of the U. S. Geological Survey's topographic maps. Contour interval 50 feet.

ASTORIA MIOCENE FORAMINIFERA
From Agate Beach, Lincoln County, Oregon*

By
JOSEPH A. CUSHMAN
and
ROSCOE E. and KATHERINE C. STEWART

The Oregon coast from Newport northward to and beyond Yaquina Head is marked by prominent seacliffs which have been cut in rocks composed largely of westerly dipping, medium- to coarse-grained, predominantly massive, tuffaceous sandstones. Associated with these sandstones in minor amounts are dark, grayish, micaceous sandy shales which weather to reddish-brown, and it is from these shales that the material for this paper was taken. The sample was collected by W. C. Warren and R. E. Stewart from the base of the cliff about 700 feet southeast of Yaquina Head, as indicated on the accompanying map (figure 1), which is adapted from the Yaquina quadrangle of the United States Geological Survey's topographic maps.

The nature and distribution of these sediments in the Newport area have been described by Packard and Kellogg[1] and by Weaver[2], who assign them to the Astoria formation of Miocene age. The foraminifera support this correlation.

Packard and Kellogg also give a number of references to the work of earlier authors who have published on the Astoria Miocene.

Family MILIOLIDAE

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA cf. VULGARIS d'Orbigny (Pl. 5, fig. 1)

A single specimen, not perfectly preserved, resembles this species.

Genus PYRGO Defrance, 1824

PYRGO sp. (Pl. 5, fig. 2)

The figured specimen is the only one found in this material. It is somewhat crushed but apparently belongs in this genus.

* Published by permission of Director, U. S. Geological Survey.

① Packard, Earl L., and Kellogg, Remington. A new Cetothere from the Miocene Astoria formation of Newport, Oregon: Publ. 447, Carnegie Instit. Washington, 1934, pp. 4-19, fig. 1.

② Weaver, Charles E., Tertiary stratigraphy of western Washington and northwestern Oregon: Univ. Washington Publ. Geol., vol. 4, 1937, pp. 180-182, pl. 15B.

Family LAGENIDAE

Genus ROBULUS Montfort, 1808

ROBULUS cf. ORBICULARIS (d'Orbigny) (Pl. 5, fig. 3)

Two small specimens may be assigned to this species with some question, as they are evidently young stages.

ROBULUS sp. (Pl. 5, fig. 4)

The figured specimen is a rather unusual one in the very strongly compressed test and somewhat convex ventral face. More specimens are needed to place it specifically.

Family NONIONIDAE

Genus NONION Montfort, 1808

NONION COSTIFERUM (Cushman) (Pl. 5, fig. 5)

Nonionina costifera Cushman, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 4, 1926, p. 90, pl. 13, fig. 2; vol. 2, pt. 3, 1926, p. 65.

Nonion costifera Cushman, Stewart, and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, 1930, p. 60, pl. 3, fig. 13.—Cushman and Parker, Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 7, pl. 1, fig. 27.—Cushman and Laiming, Journ. Pal., vol. 5, 1931, p. 104, pl. 11, fig. 9.—Woodring, Bramlette, and Kleinpell, Bull. Amer. Assoc. Petr. Geol., vol. 20, 1936, p. 136 (list).—Kleinpell, Miocene Stratig. Calif., 1938, pp. 229, 231, pl. 7, fig. 21; pl. 15, fig. 13.—Cushman, U. S. Geol. Survey Prof. Paper 191, 1939, p. 15, pl. 4, fig. 5.—Renz, Proc. 8th Amer. Sci. Congress, 1942, p. 559 (list).

Nonionina boueana Chapman (not d'Orbigny), Proc. Calif. Acad. Sci., ser. 3, Geol., vol. 1, 1900, p. 255, pl. 30, fig. 14.

The types of this species are from the Miocene, Monterey shale, of San Luis Obispo County, California, and it has been recorded from a number of other localities in the Miocene of California. Typical specimens are fairly common in the Astoria material.

Genus NONIONELLA Cushman, 1926

NONIONELLA MIOCENICA Cushman (Pl. 5, fig. 6)

Nonionina auris Cushman (not d'Orbigny), Contr. Cushman Lab. Foram. Res., vol. 1, pt. 4, 1926, p. 91, pl. 13, fig. 4.

Nonionella miocenica Cushman, Contr. Cushman Lab. Foram. Res., vol. 2, pt. 3, 1926, p. 64; Bull. Scripps Instit. Oceanography, Tech. Ser., vol. 1, No. 10, 1927, p. 149.—Cushman, Stewart, and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, 1930, p. 61, pl. 8, fig. 6.—Cushman and Parker, Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 8.—Cushman, Special Publ. 5, Cushman Lab. Foram. Res., 1933, pl. 23, fig. 3.—Barbat and Johnson, Journ. Pal., vol. 8, 1934, p. 11, pl. 1, figs. 1-4.—Woodring, Bramlette, and Kleinpell, Bull. Amer. Assoc. Petr. Geol., vol. 20, 1936, p. 144 (list).—Kleinpell, Miocene Stratig. Calif., 1938, p. 237.—Cushman, U. S. Geol. Survey Prof. Paper 191, 1939, p. 31, pl. 8, fig. 9; Foraminifera, 3rd Ed., 1940, Key, pl. 23,

fig. 3.—Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, 1940, p. 161, pl. 10, fig. 1.—Hanna and Hertlein, Calif. Div. Mines, Bull. 118, pt. 2, 1941, p. 180, fig. 67 [plate], figs. 26-28.

The types of this species are from the Miocene, Monterey shale, of California. It has been recorded also from the Miocene, Temblor formation and Reef Ridge shale, of California, at a number of localities, and appears to be living off the West Coast of America from Alaska to Costa Rica.

Family BULIMINIDAE

Genus BULIMINELLA Cushman, 1911

BULIMINELLA ELEGANTISSIMA d'Orbigny (Pl. 5, fig. 7)

Bulimina elegantissima d'Orbigny, Voy. Amér. Mérid., vol. 5, pt. 5, "Foraminifères," 1839, p. 51, pl. 7, figs. 13, 14.—Williamson, Recent Foram. Gt. Britain, 1858, p. 64, pl. 5, figs. 134, 135.—Schlumberger, Feuille Jeunes Nat., vol. 12, 1881, pl. 1, fig. 14.—H. B. Brady, Rep. Voy. *Challenger,* Zoology, vol. 9, 1884, p. 402, pl. 50, figs. 20-22.—Reade, Geol. Mag., dec. 4, vol. 7, 1900, pp. 100, 101 (lists), pl. 5, fig. 6.—Sidebottom, Mem. Proc. Manchester Lit. Philos. Soc., vol. 49, No. 5, 1905, p. 11, pl. 2, fig. 6.—Bagg, Bull. 513, U. S. Geol. Survey, 1912, p. 38, pl. 9, fig. 8.—Heron-Allen and Earland, *Discovery* Rep'ts., vol. 4, 1932, p. 351, pl. 8, figs. 35-37.

Buliminella elegantissima Cushman, Proc. U. S. Nat. Mus., vol. 56, 1919, p. 606; Bull. 100, U. S. Nat. Mus., vol. 4, 1921, p. 168; Contr. Cushman Lab. Foram. Res., vol. 1, pt. 2, 1925, p. 40, pl. 6, fig. 5.—Cushman and Wickenden, Proc. U. S. Nat. Mus., vol. 75, Art. 9, 1929, p. 8, pl. 3, fig. 12.—Cushman and Kellett, l. c., Art. 25, 1929, p. 6, pl. 3, figs. 1-3.—Cushman, Stewart, and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, 1930, p. 64, pl. 4, fig. 7.—Cushman, Bull. 4, Florida State Geol. Survey, 1930, p. 42, pl. 8, figs. 2, 3.—Cole, l. c., Bull. 6, 1931, p. 39, pl. 2, fig. 8.—Cushman and Parker, Proc. U. S. Nat. Mus., vol. 80, Art. 3, 1931, p. 13, pl. 3, figs. 12, 13.—Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 67, pl. 8, figs. 20, 21; Bull. 9, Florida State Geol. Survey, 1932, p. 75.—Howe and Wallace, Louisiana Geol. Bull. No. 2, 1932, p. 61, pl. 11, fig. 3.—Cushman, Special Publ. 4, Cushman Lab. Foram. Res., 1933, pl. 22, fig. 3; Special Publ. 5, 1933, pl. 27, fig. 4.—Cushman and Cahill, U. S. Geol. Survey Prof. Paper 175-A, 1933, p. 23, pl. 7, figs. 13, 14.—Barbat and Johnson, Journ. Pal., vol. 8, 1934, p. 12, pl. 1, figs. 12, 13.—Cushman, Bull. Geol. Soc. Amer., vol. 47, 1936, p. 431.—Kleinpell, Miocene Stratig. Calif., 1938, p. 249, pl. 16, fig. 10.—Cushman and McGlamery, U. S. Geol. Survey Prof. Paper 189-D, 1938, p. 107, pl. 25, fig. 15.—Cushman, Foraminifera, 3rd Ed., 1940, pl. 22, fig. 3; Key, pl. 27, fig. 4.—Cushman and Henbest, U. S. Geol. Survey Prof. Paper 196-A, 1940, pl. 9, fig. 20.—Cushman and Parker, Contr. Cushman Lab. Foram Res., vol. 16, 1940, p. 21.—Hanna and Hertlein, Calif. Div. Mines, Bull. 118, pt. 2, 1941, p. 178, fig. 67 [plate], figs. 5-7.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 7, pl. 2, fig. 6.—Cushman and Parker, U. S. Geol. Survey Prof. Paper 210-D, 1947, p. 67, pl. 17, figs. 10-12.

This species has a wide range in the Tertiary and is found in the present oceans. It occurs in the Miocene and Pliocene of California. It seems to be rare in the Miocene Astoria formation. Only those references are given that have figures, or where original material was seen.

BULIMINELLA BASSENDORFENSIS Cushman and Parker (Pl. 5, fig. 8)

Buliminella bassendorfensis Cushman and Parker, Contr. Cushman Lab. Foram. Res., vol. 13, 1937, pp. 40, 53, pl. 4, fig. 13; U. S. Geol. Survey Prof. Paper 210-D, 1947, p. 66, pl. 17, fig. 6.

This species was described from the Bastendorf shale, south side of Alsea Bay, Lincoln County, Oregon. It has not been recorded elsewhere. The Astoria specimens have been compared with the types and seem identical. They are fairly common.

Genus BULIMINA d'Orbigny, 1826

BULIMINA OVATA d'Orbigny (Pl. 5, fig. 9)

Bulimina ovata d'Orbigny, Foram. Foss. Bass. Tert. Vienne, 1846, p. 185, pl. 11, figs. 13, 14.

No attempt is made to give the complete references to this species as many different species have been included under this name. The types are from the Miocene of the Vienna Basin. It has been recorded at a number of localities in the Miocene and Pliocene of California. A number of specimens were found in the Astoria material.

Genus VIRGULINA d'Orbigny, 1826

VIRGULINA PUNCTATA d'Orbigny (Pl. 6, fig. 1)

Virgulina punctata d'Orbigny, in De la Sagra, Hist. Fis. Pol. Nat. Cuba, 1839, "Foraminifères," p. 139, pl. 1, figs. 35, 36.—Cushman, Publ. 291, Carnegie Instit. Washington, 1919, p. 35; Proc. U. S. Nat. Mus., vol. 59, 1921, p. 52, pl. 11, fig. 15; Publ. 311, Carnegie Instit. Washington, 1922, p. 31, pl. 3, fig. 9; Bull. 104, U. S. Nat. Mus., pt. 3, 1922, p. 117; Publ. 344, Carnegie Instit. Washington, 1926, p. 77; Bull. 4, Florida State Geol. Survey, 1930, p. 44, pl. 8, fig. 7.—Cushman and Parker, Proc. U. S. Nat. Mus., vol. 8, 1932, p. 9, pl. 2, fig. 1.—Cushman and Ponton, Bull. 9, Florida State Geol. Survey, 1932, p. 79.—Bermudez, Mem. Soc. Cubana Hist. Nat., vol. 9, 1935, p. 194.—Palmer and Bermudez, l. c., vol. 10, 1936, p. 288.—Chapman and Parr, Australasian Antarctic Exped., ser. C, vol. 1, pt. 2, 1937, p. 88.—Cushman, Special Publ. 9, Cushman Lab. Foram. Res., 1937, p. 23, pl. 3, figs. 25-27; Smithsonian Misc. Coll., vol. 99, No. 9, 1941, p. 9.—Palmer, Bull. Amer. Pal., vol. 29, No. 115, 1945, p. 46.

Virgulina subsquamosa Flint (not Egger), Ann. Rep. U. S. Nat. Mus., 1897 (1899), p. 291, pl. 37, fig. 7.

The records for this species are mostly from the Western Atlantic and as a fossil from the Miocene and Oligocene of the same region. Specimens are evidently very rare in the Astoria material but seem identical with this species.

VIRGULINA CALIFORNIENSIS Cushman (Pl. 6, fig. 2)

Virgulina californiensis Cushman, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 2, 1925, p. 32, pl. 5, fig. 11; vol. 2, pt. 3, 1926, p. 54.—Cushman and Laiming, Journ. Pal., vol. 5, 1931, p. 108, pl. 12, fig. 2.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 20, pl. 3, fig. 8.—Barbat and Johnson, Journ. Pal., vol. 8, 1934, p. 14, pl. 1, figs. 21-24.—Woodring, Bramlette, and Kleinpell, Bull. Amer. Assoc. Petr. Geol., vol. 20, 1936, pp. 133, etc. (lists).—Cushman, Special Publ. 9, Cushman Lab. Foram. Res., 1937, p. 20, pl. 3, figs. 10-14.—Kleinpell, Miocene Stratig. Calif., 1938, p. 261, pl. 8, fig. 4; pl. 15, fig. 8(?).—Weaver, Univ. Washington Publ. Geol., vol. 6, No. 1, 1944, p. 25 (list).

The types of this species are from the Miocene of California where it is widely distributed. It is very rare in the Astoria material but the figured specimen seems typical.

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA ASTORIENSIS Cushman, R. E. and K. C. Stewart, n. sp. (Pl. 6, fig. 3)

Test small, about twice as long as broad, gradually tapering, greatest breadth near the apertural end, the microspheric forms sometimes slightly twisted, early portion strongly compressed, but the later adult portion becoming much thickened, periphery acute, very slightly keeled; chambers distinct, not inflated, earlier ones low and broad, in the adult becoming much higher, the base tending to become slightly lobulated near the inner end; sutures distinct, somewhat limbate and occasionally slightly raised in the earlier portion and in the adult with a slight forward projection near the middle; wall smooth except for the slightly raised sutures; aperture narrow, with a slight lip. Length 0.45–0.50 mm.; breadth 0.20–0.23 mm.; thickness 0.15 mm.

Holotype (Cushman Coll. No. 44207) and paratypes (Oregon State Dept. Geology and Min. Industries Coll. No. 92 and Stewart Coll. No. 92) from the Miocene shale of the Storia formation, 700 feet southeast of Yaquina Head, Yaquina Quadrangle, Oregon.

This is the commonest species in the Astoria material and should make a good index fossil. It differs from *B. dilatata* Reuss, which it resembles, in the much thicker test, more definite keel, and usually higher chambers in the adult stage.

Family ROTALIIDAE

Genus EPONIDES Montfort, 1808

EPONIDES MANSFIELDI Cushman, var. OREGONENSIS Cushman, R. E. and K. C. Stewart, n. var. (Pl. 6, fig. 4)

Eponides mansfieldi Cushman and Parker (not Cushman, 1930), Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 12, pl. 2, fig. 10.

Variety differing from the typical in the smoother surface, the sutures not raised, and the whorls somewhat narrower.

Holotype of variety (Cushman Coll. No. 44208) and paratypes (Oregon State Dept. Geology and Min. Industries Coll. No. 93 and Stewart Coll. No. 93), from the Miocene shale of the Astoria formation, 700 feet southeast of Yaquina Head, Yaquina Quadrangle, Oregon.

The reference given above is from the Miocene, Temblor, from the east side of San Joaquin Valley, California. The material was re-examined and seems to belong to this variety. There are a few other records from the Miocene of California but the original specimens would have to be examined before their position is certain.

Family CASSIDULINIDAE

Genus PULVINULINELLA Cushman, 1926

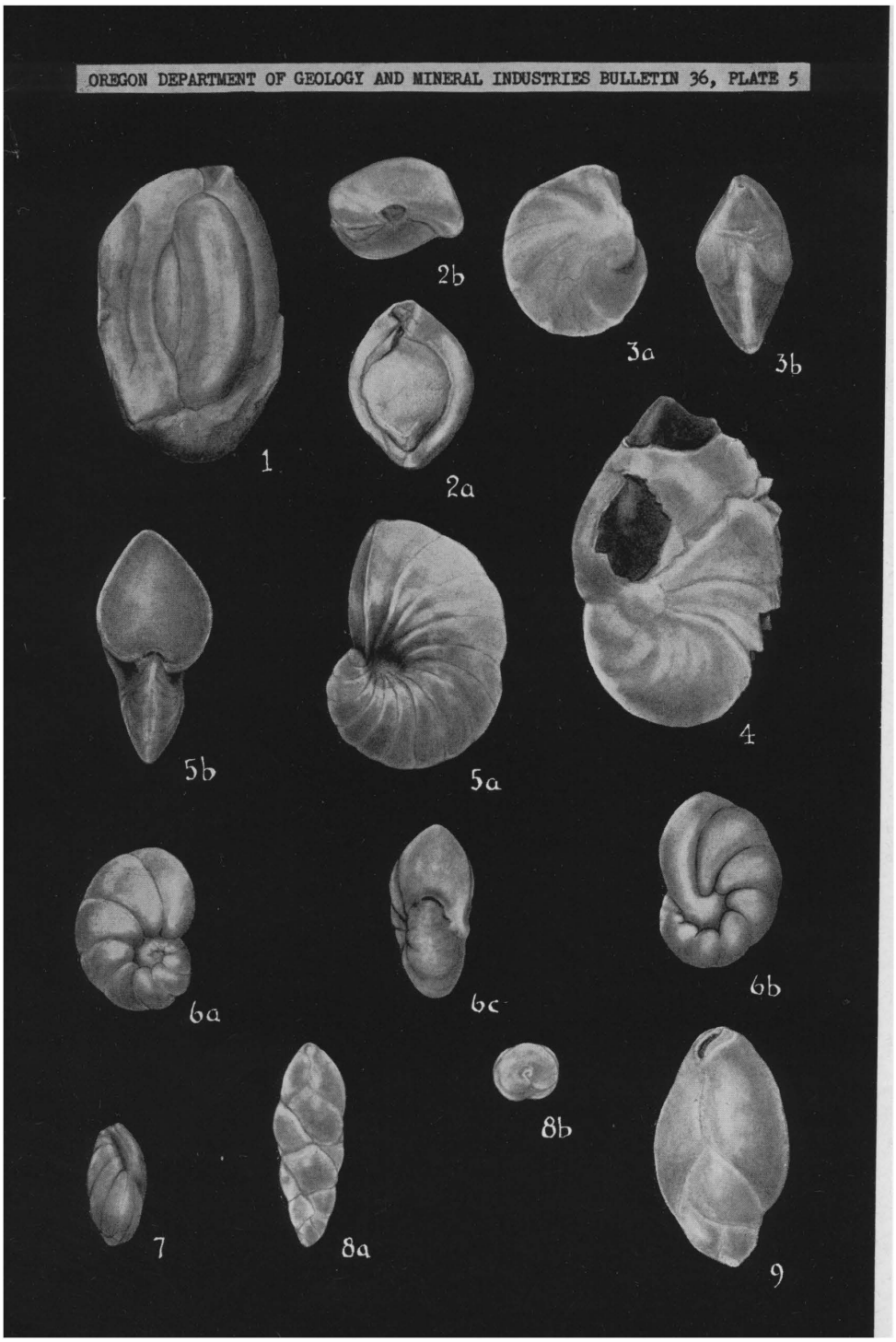
PULVINULINELLA PARVA Cushman and Laiming (Pl. 6, fig. 5)

Pulvinulinella parva Cushman and Laiming, Journ. Pal., vol. 5, 1931, p. 115, pl. 13, fig. 5.—Kleinpell, Miocene Stratig. Calif., 1938, p. 329.—Weaver, Univ. Washington Publ. Geol., vol. 6, No. 1, 1944, p. 25 (list).

Pulvinulinella cf. *smithi* Cushman and Parker, Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 14, pl. 2, fig. 12.

The types of this species are from the Miocene of California. It is also recorded from several Miocene localities in California, Oregon, and Washington.

Explanation of Plate 5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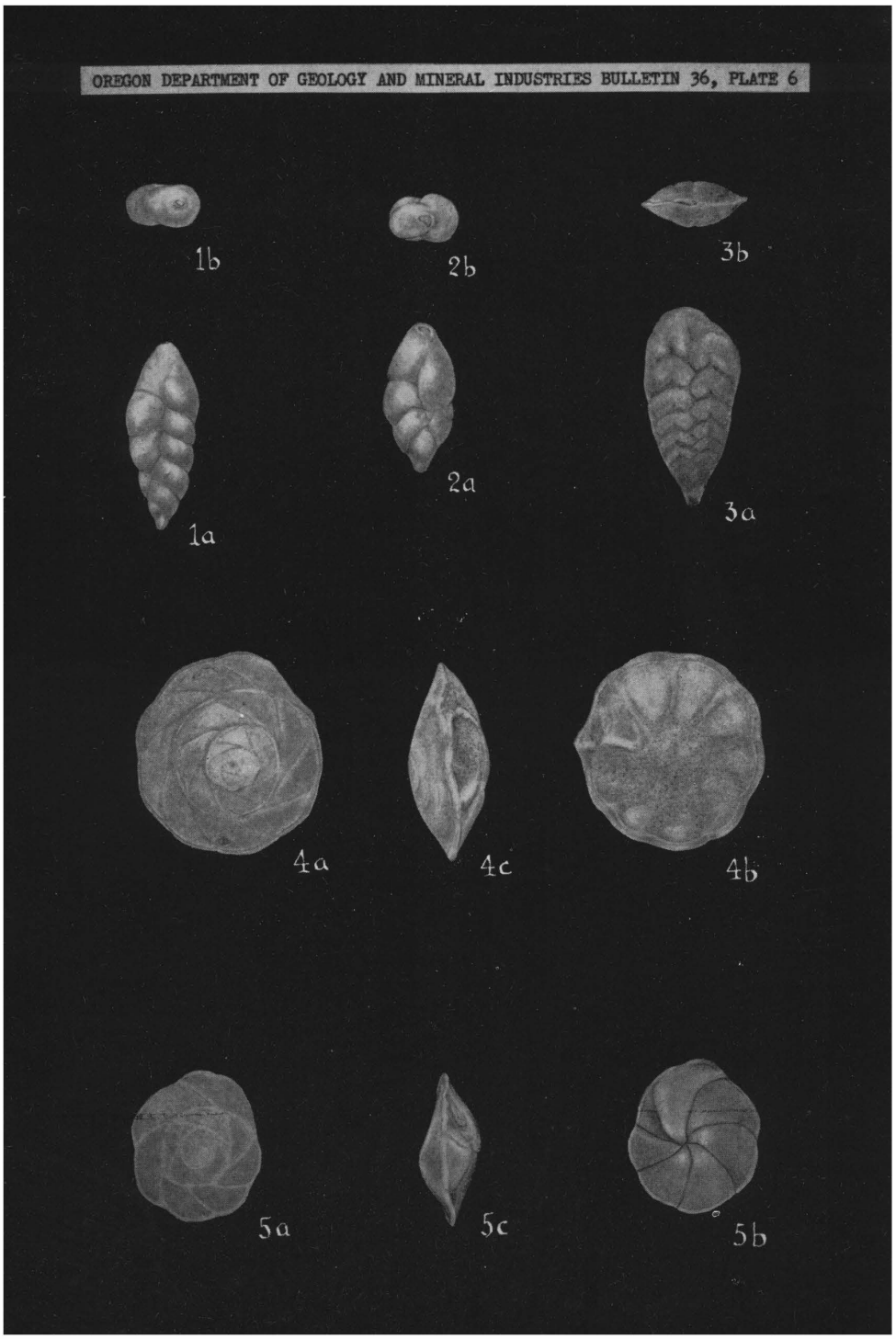
Explanation of Plate 6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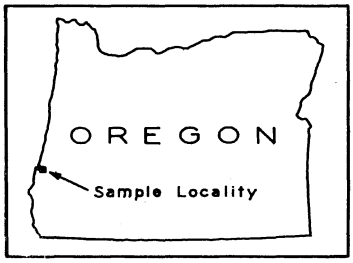
Part III

UPPER COALEDO (UPPER EOCENE) FORAMINIFERA FROM YOKAM POINT, COOS COUNTY, OREGON



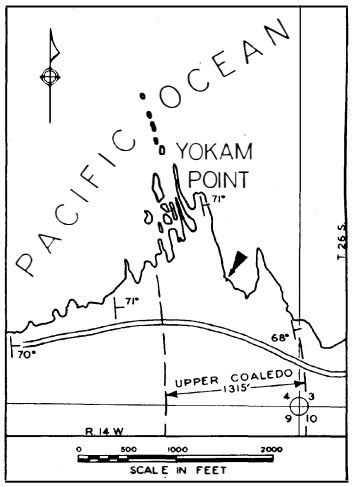


Figure 2. Map showing sampled locality (heavy black arrow) in cove on south side of Yokam Point, Coos County, Oregon. Adapted from Allen, J. E., and Baldwin, E. M., Geology and coal resources of the Coos Bay quadrangle, Oregon: Oregon Dept. Geology and Min. Industries Bull. 27, pl. 5, 1944.

UPPER COALEDO (UPPER EOCENE) FORAMINIFERA
From Yokam Point, Coos County, Oregon*

By

JOSEPH A. CUSHMAN
and
ROSCOE E. and KATHERINE C. STEWART

Yokam Point, the type locality of the upper member of the Coaledo formation, is a mile southwest of the entrance to Coos Bay, Coos County, Oregon.

The upper Coaledo is composed largely of hard, gray, predominantly medium- to fine-grained, tuffaceous sandstone with less indurated carbonaceous sandstone members, sandy shales, carbonaceous shales, and coal.

Foraminifera appear to be absent from most of the shales, but a few species occur in shale beds at the head of a cove on the east side of Yokam Point where the material for this paper was collected by E. M. Baldwin and R. E. Stewart.

The upper Eocene Coaledo formation was named by Diller① and was well described by Turner②. It has also been discussed by numerous other authors, including Beck③, Allen and Baldwin④, Weaver⑤, and Detling⑥.

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* Published by permission of the Director, U. S. Geological Survey.

① Diller, J. S., The Coos Bay coal field, Oregon: U. S. Geol. Survey 19th Ann. Rept., pt. III, p. 320, 1899.

② Turner, F. E., Stratigraphy and Mollusca of the Eocene of Western Oregon: Geol. Soc. America Spec. Papers 10, pp. 27-29, June 1, 1938.

③ Beck, R. S., Eocene Foraminifera from Cowlitz River, Lewis County, Washington: Jour. Paleontology, vol. 17, no. 6, pp. 590-591, November 1943.

④ Allen, J. E., and Baldwin, E. M., Geology and coal resources of the Coos Bay quadrangle, Oregon: Oregon Dept. Geology and Min. Industries Bull. 27, pp. 21-27, 1944.

⑤ Weaver, C. E., Stratigraphy and paleontology of the Tertiary formation at Coos Bay, Oregon: Washington, Univ., (Seattle) Pub. in Geology, vol. 6, no. 2, pp. 31-46, June 1945.

⑥ Detling, M. R., Foraminifera of the Coos Bay lower Tertiary, Coos County, Oregon: Jour. Paleontology, vol. 20, no. 4, pp. 348-352, July 1946.

Family LITUOLIDAE

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES cf. HOCKLEYENSIS Cushman and Applin (Pl. 7, fig. 1)

Rare specimens in the Yokam Point material somewhat resemble this species described from the upper Eocene of Texas.

Family MILIOLIDAE

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA cf. MINUTA Beck (Pl. 7, fig. 2)

Rare and rather poorly preserved specimens from the Yokam Point locality seem related to this species recently described from the upper Eocene of Cowlitz River, Washington.

Family LAGENIDAE

Genus ROBULUS Montfort, 1808

ROBULUS INORNATUS (d'Orbigny) (Pl. 7, fig. 3)

(For references, see p. 74)

Specimens from Yokam Point seem identical with those from the lower Coaledo material of Sunset Bay and from the Eocene of Helmick Hill, Oregon.

Genus DENTALINA d'Orbigny, 1826

DENTALINA (?) sp. (Pl. 7, fig.4)

The specimen from Yokam Point here figured seems to have a peculiar arrangement of the early chambers and it may not be a *Dentalina.* It is here figured for future reference.

Family NONIONIDAE

Genus NONION Montfort, 1808

NONION APPLINI Howe and Wallace (Pl. 7, figs. 5, 6)

(For references, see p. 99)

This species is recorded from the lower Coaledo of Sunset Bay and from the Eocene of Helmick Hill, Oregon. The Yokam Point material is very similar but specimens show considerable variation.

NONION cf. INEXCAVATUM (Cushman and Applin) (Pl. 7, fig. 7)

Very small specimens somewhat resemble this species which is rather widely distributed in the American upper Eocene.

NONION sp. (Pl. 7, fig. 8)

The very small single specimen here figured is not sufficient for a definite identification but is noted here for future reference.

Genus NONIONELLA Cushman, 1926

NONIONELLA JACKSONENSIS Cushman (Pl. 8, fig. 1)

(For references, see p. 100)

Typical specimens occur in the material from Yokam Point and seem identical with this upper Eocene species. It is also recorded from the Helmick formation, Helmick Hill, Oregon.

Family HETEROHELICIDAE

Genus PLECTOFRONDICULARIA Liebus, 1903

PLECTOFRONDICULARIA cf. SEARSI Cushman, R. E. and K. C. Stewart
(Pl. 8, figs. 2, 3)

Fragmentary specimens, two of which are figured, seem to belong to this species described from the Eocene, lower member of the Coaledo formation, of Sunset Bay, Coos County, Oregon.

Family BULIMINIDAE

Genus BULIMINA d'Orbigny, 1826

BULIMINA SCHENCKI Beck (Pl. 8, figs. 4, 5)

Bulimina schencki Beck, Journ. Pal., vol. 17, 1943, p. 605, pl. 107, figs. 28, 33.—Cushman and Parker, U. S. Geol. Survey Prof. Paper 210-D, 1947, p. 98, pl. 30, fig. 16.

This species, which is also recorded from the Eocene of Helmick Hill, Oregon, was described from the Eocene of Cowlitz River, Lewis County, Washington. The material from Yokam Point seems identical.

Genus GLOBOBULIMINA Cushman, 1927

GLOBOBULIMINA PACIFICA Cushman, var. OREGONENSIS Cushman, R. E. and K. C. Stewart (Pl. 8, fig. 6)

This variety is described from the Eocene of Helmick Hill and recorded also from the lower Coaledo of Sunset Bay, Oregon. The specimens from Yokam Point are identical.

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA BASISENTA Cushman and Stone (Pl. 8, fig. 7)

Bolivina basisenta Cushman and Stone, Special Publ. 20, Cushman Lab. Foram. Res., 1947, p. 15, pl. 2, fig. 20.

This species described from the upper Eocene, Chira shale, of Peru is also recorded from the Eocene of Helmick Hill. The material from Yokam Point has typical specimens.

BOLIVINA cf. KLEINPELLI Beck (Pl. 8, fig. 8)

Rare specimens in the material from Yokam Point seem close to this species recently described from the upper Eocene of Cowlitz River, Washington.

Genus ANGULOGERINA Cushman, 1927

ANGULOGERINA cf. HANNAI Beck (Pl. 8, fig. 9)

Poorly preserved specimens are questionably referred to this species recently described from the upper Eocene of Cowlitz River, Washington, and recorded from the lower Coaledo of Sunset Bay and upper Eocene of Helmick Hill, Oregon.

Family ROTALIIDAE

Genus GYROIDINA d'Orbigny, 1826

GYROIDINA cf. PLANULATA Cushman and Renz

The specimens from Yokam Point are similar to those recorded from the Eocene of Helmick Hill, Oregon.

GYROIDINA sp. (Pl. 8, fig. 11)

The figured incomplete specimen needs more and better preserved specimens with it specifically to determine the species.

Genus EPONIDES Montfort, 1808

EPONIDES cf. MINIMUS Cushman (Pl. 8, fig. 10)

(For references, see p. 103)

This species is widely distributed in the American upper Eocene. The specimens from Yokam Point are similar to those recorded from the Helmick formation, Helmick Hill, Oregon, but not as typical.

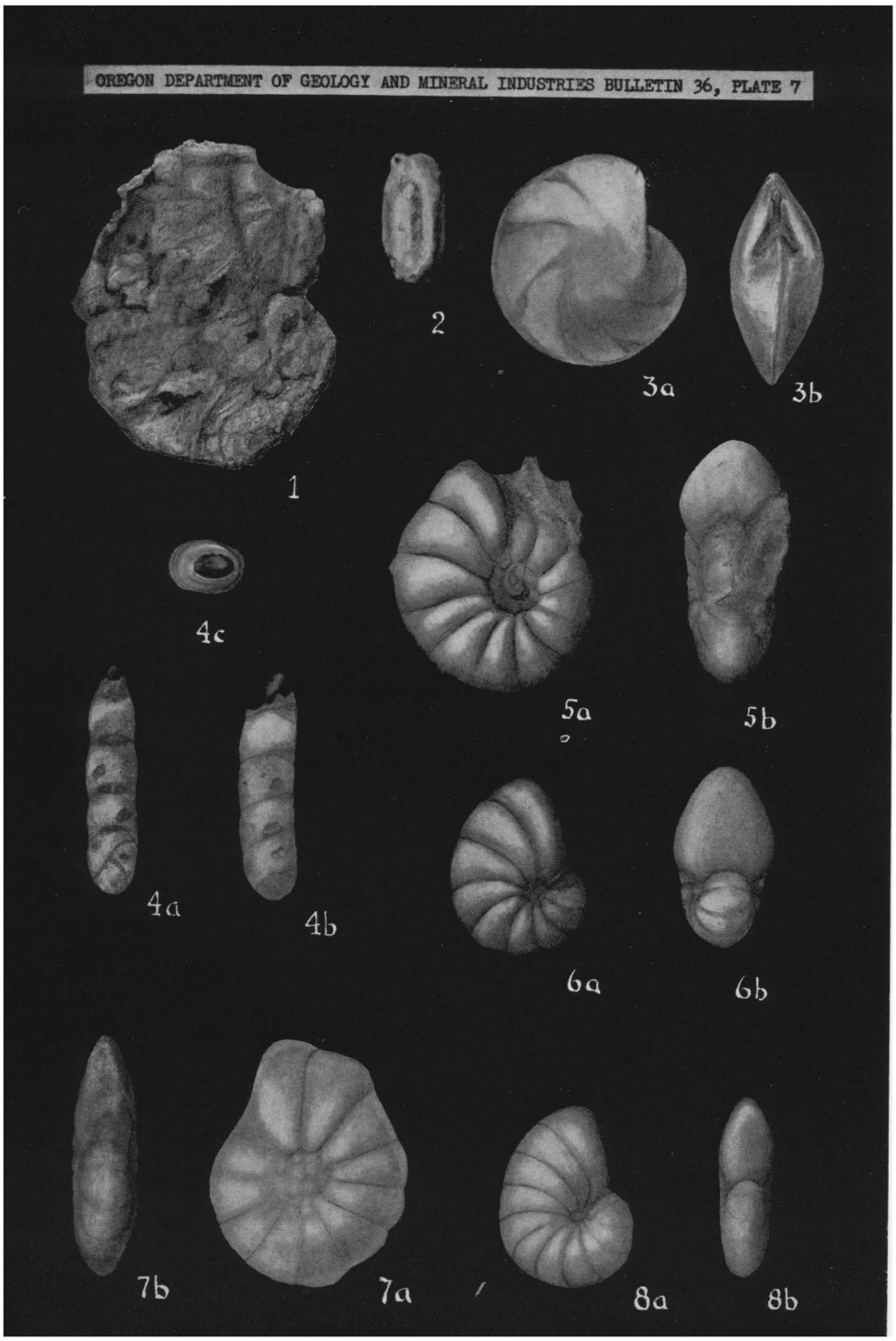
Family ANOMALINIDAE

Genus CIBICIDES Montfort, 1808

CIBICIDES cf. COOPERENSIS Cushman (Pl. 8, fig. 12)

Rare and small specimens from Yokam Point somewhat resemble this upper Eocene species but more and better specimens are needed to confirm the identification.

Explanation of Plate 7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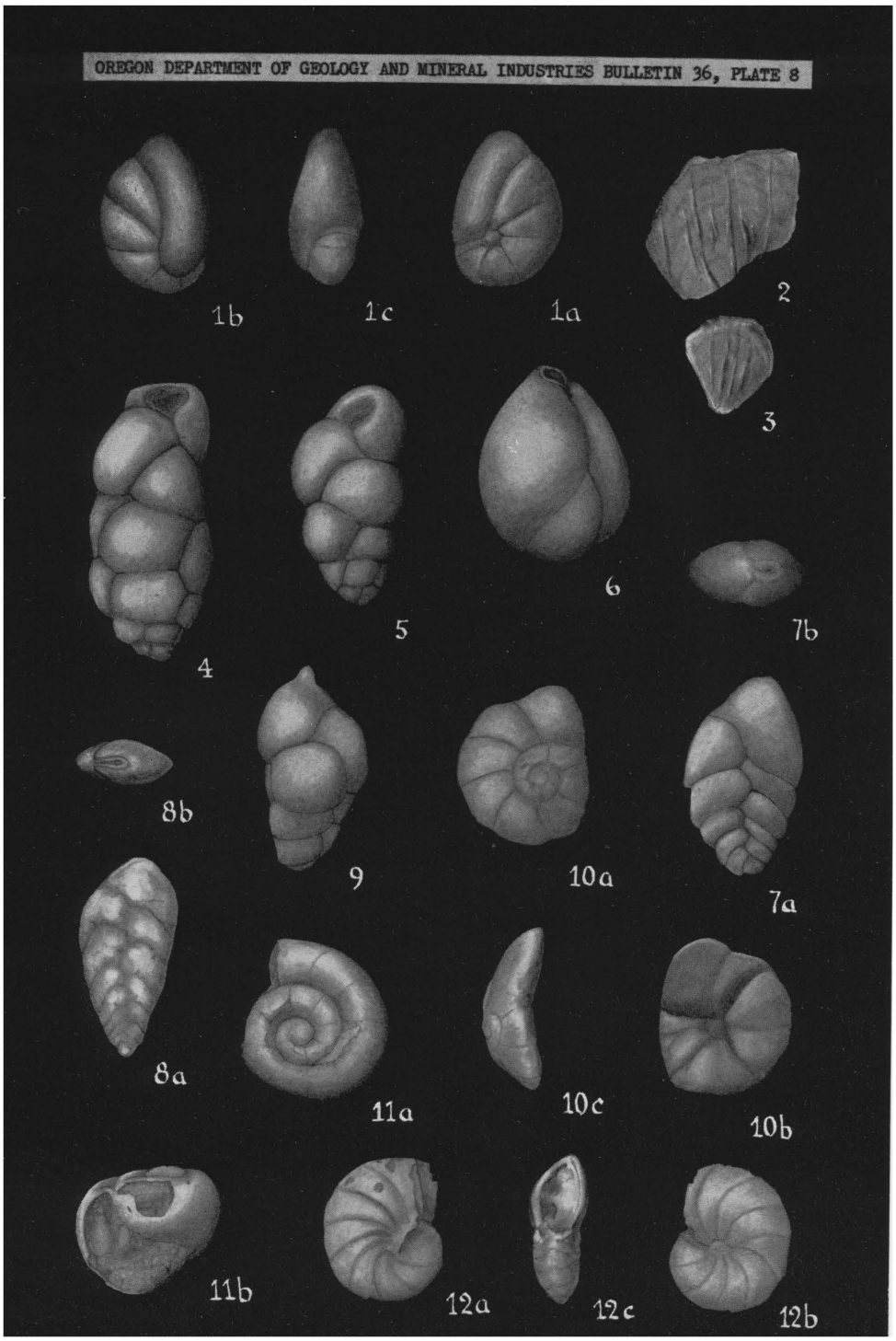
Explanation of Plate 8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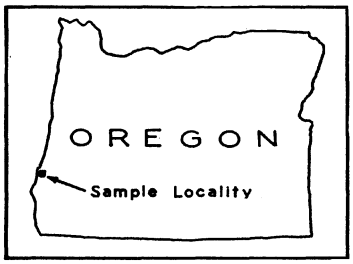
Part IV

LOWER COALEDO (UPPER EOCENE) FORAMINIFERA FROM SUNSET BAY, COOS COUNTY, OREGON



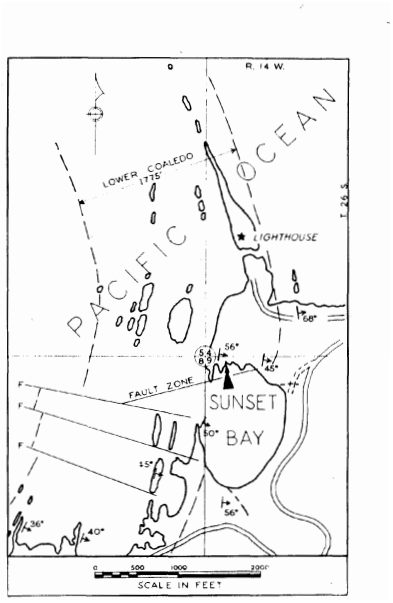


Figure 3. Map showing sampled locality (heavy black arrow) on north side of Sunset Bay, Coos County, Oregon. The clay shale was best exposed near the top of the seacliff. Adapted from Allen, J. E., and Baldwin, E. M., Geology and coal resources of the Coos Bay quadrangle, Oregon: Oregon Dept. Geology and Min. Industries Bull. 27, pl. 5, 1944.

LOWER COALEDO (UPPER EOCENE) FORAMINIFERA

From Sunset Bay, Coos County, Oregon*

By

JOSEPH A. CUSHMAN

and

ROSCOE E. and KATHERINE C. STEWART

Sunset Bay lies about 2½ miles southwesterly from the entrance to Coos Bay in Coos County, Oregon. Its northern and southwestern shores are bordered by high cliffs composed largely of sandstones, silty sandstones, and sandy shales of the upper portion of the lower member of the Coaledo formation. Relatively thin bedding predominates, but some of the sandstones are massive and protrude from the base of the cliffs to form reef beds. One bed of massive clay shale about 25 feet thick was observed. No other clay shale was noted in the lower Coaledo of Sunset Bay. Favorable conditions for sampling this section exist only at low tide when the truncated edges of these beds form a broad, flat beach along the north side of the bay.

Foraminifera in considerable abundance occur in the clay shale and are sparsely but quite uniformly scattered throughout the sandy shales and many of the silty sandstones. The clay shale from which the foraminifera recorded in this paper were obtained was found by D. H. Sears of the Shell Oil Company of California while on a field trip with R. S. Mason, E. M. Baldwin, and R. E. Stewart of the Oregon Department of Geology and Mineral Industries. This foraminiferal assemblage probably contains at least twice as many species as appear in this paper, and it is hoped that additional material will give sufficient well-preserved specimens to justify recording them in a subsequent paper.

For references on the Coaledo formation see page 59.

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Family LITUOLIDAE

Genus CYCLAMMINA H. B. Brady, 1876

CYCLAMMINA PACIFICA Beck (Pl. 9, figs. 1, 2)

Cyclammina pacifica Beck, Journ. Pal., vol. 17, 1943, p. 591, pl. 98, figs. 2, 3.—Detling, l. c., vol. 20, 1946, p. 352, pl. 46, fig. 1.

This species was described from the Eocene of Cowlitz River, Lewis County, Washington, and also recorded from the Eocene of Coos Bay, Oregon. Excellent specimens occur in our material from Sunset Bay.

Family VERNEUILINIDAE

Genus GAUDRYINA d'Orbigny, 1839

GAUDRYINA sp. A (Pl. 11, fig. 1)

A very few specimens similar to that figured occur in our lower Coaledo material. The early portion is triserial and the section distinctly triangular but becomes biserial at a very early stage and the chambers increase rapidly in size. Not enough specimens are available to give full adult characters.

GAUDRYINA sp. B (Pl. 11, fig. 2)

Very rare specimens, one of which is figured, have a much more elongate and compressed test. They do not seem to be identical with any described forms but, without more specimens to give the full characters, no name can be given.

Family MILIOLIDAE

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA IMPERIALIS G. D. and M. A. Hanna (Pl. 9, fig. 3)

Quinqueloculina imperialis G. D. and M. A. Hanna, Univ. Washington Publ. Geol., vol. 1, No. 4, 1924, p. 58, pl. 13, figs. 7, 8, 10.—Beck, Journ. Pal., vol. 17, 1943, p. 592, pl. 98, figs. 9, 10.—Cushman and Frizzell, Contr. Cushman Lab. Foram. Res., vol. 19, 1943, p. 82, pl. 14, fig. 1.

The types of this species are from the Eocene of Cowlitz River, Lewis County, Washington, and it has also been recorded from the Oligocene, Lincoln formation, of Washington. Our specimens from the lower Coaledo seem to be typical.

Family LAGENIDAE

Genus ROBULUS Montfort, 1808

ROBULUS INORNATUS (d'Orbigny) (Pl. 11, fig. 6)

Robulina inornata d'Orbigny, Foram. Foss. Bass. Tert. Vienne, 1846, p. 102, pl. 4, figs. 25, 26.

Cristellaria inornata Sherborn and Chapman, Journ. Roy. Micr. Soc., ser. 2, vol. 6, 1886, p. 754, pl. 15, fig. 27.—Cushman and G. D. Hanna, Proc. Calif. Acad. Sci., ser. 4, vol. 16, 1927, p. 217, pl. 14, fig. 5.

Robulus inornatus Cushman and M. A. Hanna, Trans. San Diego Soc. Nat. Hist., vol. 15, 1927, p. 51, pl. 4, figs. 4, 6.—Cushman and Schenck, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 17, 1928, p. 307, pl. 42, fig. 3.—Cushman and Barksdale, Contr. Dept. Geol., Stanford Univ., vol. 1, No. 1, 1930, p. 62, pl. 11, figs. 2, 3.—Israelsky, Proc. 6th Pac. Sci. Congress, 1939, p. 573, pl. 3, fig. 1.—Toulmin, Journ. Pal., vol. 15, 1941, p. 577, pl. 78, fig. 19; text fig. 2B.—Beck, l. c., vol. 17, 1943, p. 595, pl. 104, figs. 1-4, 10, 14.—Kelley, Bull. Amer. Assoc. Petr. Geol., vol. 27, 1943, p. 11 (list).—Curran, l. c., pp. 1378, 1381 (lists).—Martin, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, No. 3, 1943, p. 12 (list).—ten Dam, Med. Geol. Stichting, ser. C-V, No. 3, 1944, p. 88.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 22, 1946, p. 48, pl. 7, fig. 9.

This species is widely recorded from the Eocene of America and from the later Tertiary also. There are numerous records from various Eocene formations of California and it is also recorded from the Eocene of Cowlitz River, Lewis County, Washington. Our specimens are similar to those figured from the American Eocene.

ROBULUS ARTICULATUS (Reuss), var. TEXANUS (Cushman and Applin)
(Pl. 9, fig. 8)

Cristellaria articulata Reuss, var. *texana* Cushman and Applin, Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 170, pl. 8, figs. 1, 2.

Robulus articulatus (Reuss), var. *texanus* Ellisor, l. c., vol. 17, No. 11, 1933, pl. 2, fig. 3.—Cushman and Dusenbury, Contr. Cushman Lab. Foram. Res., vol. 10, 1934, p. 53, pl. 7, figs. 2, 3.—Cushman, U. S. Geol. Survey Prof. Paper 181, 1935, p. 16, pl. 4, figs. 16, 17.—Bergquist, Bull. 49, Mississippi State Geol. Survey, 1942, p. 28, pl. 3, fig. 6.—Cushman and Frizzell, Contr. Cushman Lab. Foram. Res., vol. 19, 1943, p. 83, pl. 14, fig. 10.—Cushman and Simonson, Journ. Pal., vol. 18, 1944, p. 194, pl. 30, fig. 7.

This variety is recorded from the upper Eocene of South Carolina, Mississippi, Texas, and California and from the Oligocene of California and Washington. Specimens from the lower Coaledo seem to belong in this variety.

Genus LENTICULINA Lamarck, 1804

LENTICULINA cf. THETA Cole (Pl. 11, fig. 3)

Very rare specimens, one of which is figured, occur in the lower Coaledo material. It is somewhat like the species described by Cole from the Eocene, Guayabal formation, of Mexico (Bull. Amer. Pal., vol. 14, No. 51, 1927, p. 14, pl. 1, fig. 17).

It also resembles the form described from the Eocene of Cowlitz River, Lewis County, Washington (Journ. Pal., vol. 17, 1943, p. 595, pl. 104, fig. 6) as *Robulus propinquus* (Hantken), var. *cowlitzensis* Beck. More specimens are necessary definitely to place this form.

Genus MARGINULINA d'Orbigny, 1826

MARGINULINA cf. SUBBULLATA Hantken (Pl. 9, fig. 4)

A few specimens showing a considerable amount of variation are referred with some question to this species.

Genus DENTALINA d'Orbigny, 1826

DENTALINA cf. APPROXIMATA Reuss (Pl. 11, fig. 7)

Specimens, somewhat like that figured, have been recorded under this name from the Paleocene, Martinez formation (Cushman and Barksdale, Contr. Dept. Geol., Stanford Univ., vol. 1, No. 1, 1930, p. 65, pl. 11, fig. 11) and from the Llajas formation (Cushman and McMasters, Journ. Pal., vol. 10, 1936, p. 512, pl. 75, figs. 7, 8), both from California.

DENTALINA DUSENBURYI Beck (Pl. 10, figs. 1-3)

Dentalina dusenburyi Beck, Journ. Pal., vol. 17, 1943, p. 599, pl. 105, figs. 20, 23.

This species was described from the Eocene of Cowlitz River, Lewis County, Washington. Similar specimens occurred in the lower Coaledo material but were all somewhat broken.

DENTALINA COMMUNIS d'Orbigny (Pl. 9, fig. 9)

There are a great many records for this species, widely ranging both geographically and stratigraphically. From the figures it is probable that more than one species may have been recorded under this name. Specimens similar to that figured are fairly common in the lower Coaledo material.

Family POLYMORPHINIDAE

Genus GLANDULINA d'Orbigny, 1826

GLANDULINA LAEVIGATA (d'Orbigny), var. OVATA Cushman and Applin (Pl. 9, fig. 7)

Nodosaria (Glandulina) laevigata d'Orbigny, var. *ovata* Cushman and Applin, Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 169, pl. 7, figs. 12, 13.

Glandulina laevigata d'Orbigny, var. *ovata* Ellisor, l. c., vol. 17, No. 11, 1933, pl. 2, fig. 6.—Cushman and Dusenbury, Contr. Cushman Lab.

Foram. Res., vol. 10, 1934, p. 60.—Cushman, U. S. Geol. Survey Prof. Paper 181, 1935, p. 29, pl. 10, figs. 16, 17.—Israelsky, Proc. 6th Pac. Sci. Congress, 1939, p. 576, pl. 6, fig. 7.

This variety is known from the Eocene of Texas and California. It occurs in typical form in the Oregon material.

Family NONIONIDAE

Genus NONION Montfort, 1808

NONION APPLINI Howe and Wallace (Pl. 9, fig. 6)

Nonionina scapha (Fichtel and Moll), var. Cushman and Applin, Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 182, pl. 10, figs. 12, 13.

Nonion applini Howe and Wallace, Louisiana Geol. Bull. 2, 1932, p. 51, pl. 9, fig. 4.—Cushman and McMasters, Journ. Pal., vol. 10, 1936, p. 513, pl. 75, fig. 16.—Cushman, U. S. Geol. Survey Prof. Paper 191, 1939, p. 8, pl. 2, fig. 7.—Howe, Journ. Pal., vol. 16, 1942, p. 267 (list).

This species was described from the Jackson Eocene of Louisiana and has been recorded from the Eocene, Llajas formation, of California, the Eocene of Mexico, and the Oligocene of Alabama.

NONION DANVILLENSE Howe and Wallace (Pl. 9, fig. 5)

Nonion danvillense Howe and Wallace, Louisiana Geol. Bull. 2, 1932, p. 51, pl. 9, fig. 3.—Cushman, U. S. Geol. Survey Prof. Paper 191, 1939, p. 5, pl. 1, fig. 19.—Howe, Journ. Pal., vol. 16, 1942, p. 267 (list).—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 92, pl. 15, fig. 4.—Cushman, Special Publ. 16, 1946, p. 21, pl. 4, fig. 25.

The previous records for this species are from the Eocene of Jackson age of Louisiana, Mississippi, and Alabama and also from the lower Oligocene of Alabama. Our specimens from the lower Coaledo seem to be typical and occur in some numbers.

Family HETEROHELICIDAE

Genus PLECTOFRONDICULARIA Liebus, 1903

PLECTOFRONDICULARIA OREGONENSIS Cushman, R. E. and K. C. Stewart (Pl. 10, fig. 4)

(See p. 100)

Specimens of this species described from the Eocene of Helmick Hill occur also in the lower member of the Coaledo formation. The thin wall of this species often shows the interior filling of the test, as in the case of the figured specimen, giving a punctate appearance, although the actual wall is smooth.

PLECTOFRONDICULARIA SEARSI Cushman, R. E. and K. C. Stewart, n. sp.
(Pl. 10, fig. 5; pl. 11, fig. 8)

Test slightly more than twice as long as broad, strongly compressed, periphery very slightly carinate, sides tapering, slightly contracted toward the apertural end, initial end rounded; chambers distinct, earlier ones biserial, then uniserial, increasing very slightly in size and height in the adult; sutures distinct, usually appearing to be raised due probably to the collapsing of the thin wall, very strongly curved backward near the periphery; wall smooth except for the earlier portion which has several fine, longitudinal costae; aperture terminal with a very slight, thickened border. Length 1.10–1.80 mm.; breadth 0.50–0.70 mm.

Holotype (Cushman Coll. No. 48756) and paratypes (Oregon State Dept. Geology and Min. Industries Coll. No. 143 and Stewart Coll. No. 143) from the Eocene, lower member of the Coaledo formation, Sunset Bay, Coos County, Oregon.

This species differs from the preceding in the larger size, broader test, and more numerous and longer costae of the early portion. It is abundant in the material from Sunset Bay and should make a good index fossil for this part of the Eocene of this region.

Family BULIMINIDAE

Genus GLOBOBULIMINA Cushman, 1927

GLOBOBULIMINA PACIFICA Cushman, var. OREGONENSIS Cushman, R. E. and K. C. Stewart (Pl. 11, fig. 4)
(See p. 101)

This variety, described from the Eocene of Helmick Hill, Salem Quadrangle, Oregon, also occurs in the lower Coaledo material.

Genus ANGULOGERINA Cushman, 1927

ANGULOGERINA COOPERENSIS Cushman (Pl. 10, fig. 8)

Angulogerina cooperensis Cushman, U. S. Geol. Survey Prof. Paper 181, 1935, p. 42, pl. 16, fig. 9.—Bermudez, Mem. Soc. Cubana Hist. Nat., vol. 11, 1937, p. 338.—Galloway and Heminway, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Ids., vol. 3, pt. 4, 1941, p. 436, pl. 34, fig. 13.—Cushman and Herrick, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 66, pl. 10, fig. 28.—Cushman and Todd, l. c., p. 99, pl. 15, fig. 24.

This species has been recorded from the upper Eocene Cooper marl of South Carolina and Moodys Branch formation

of Mississippi, from the middle Eocene McBean formation of Georgia, from the Eocene of Cuba, and the Oligocene Cibao formation of Porto Rico. The specimens from the lower member of the Coaledo formation are not very well preserved as to details but seem to belong to this species.

Family ELLIPSOIDINIDAE

Genus ELLIPSONODOSARIA A. Silvestri, 1900

ELLIPSONODOSARIA sp. (Pl. 11, fig. 5)

A very few incomplete specimens from the Sunset Bay locality probably belong to this genus but better specimens are necessary before specific identification can be made.

Family ROTALIIDAE

Genus GYROIDINA d'Orbigny, 1826

GYROIDINA cf. SOLDANII d'Orbigny (Pl. 10, fig. 6)

Many records are assigned to this species, ranging from Upper Cretaceous to Recent. The group needs revision and the name is used with some question for this Eocene form from the lower Coaledo.

Genus EPONIDES Montfort, 1808

EPONIDES ELLISORAE Garrett (Pl. 10, fig. 7)

Eponides ellisorae Garrett, Journ. Pal., vol. 13, 1939, p. 579, pl. 66, figs. 6-8.—Galloway and Heminway, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Ids., vol. 3, pt. 4, 1941, p. 372, pl. 17, fig. 4.—Ellisor, Bull. Amer. Assoc. Petr. Geol., vol. 28, No. 9, 1944, pl. 6, figs. 6-8.—Cushman and Ellisor, Journ. Pal., vol. 19, 1945, p. 569.

Most of the records for this species are from the Oligocene. Our Oregon specimens are very similar but have more chambers in the adult whorl and may prove to be distinct.

Family CASSIDULINIDAE

Genus CASSIDULINA d'Orbigny, 1826

CASSIDULINA GLOBOSA Hantken (Pl. 10, fig. 10)

(For references, see p. 103)

This species already recorded from the Eocene of California, Oregon, and Washington occurs in the lower Coaledo material.

Family ANOMALINIDAE

Genus PLANULINA d'Orbigny, 1826

PLANULINA cf. HAYDONI Cushman and Schenck (Pl. 10, fig. 9; pl. 11, fig. 10)

Planulina haydoni Cushman and Schenck, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 17, 1928, p. 316, pl. 45, fig. 7.—Cushman and Simonson, Journ. Pal., vol. 18, 1944, p. 202, pl. 34, figs. 11, 12.

This species has been recorded from the Oligocene of Oregon and California. The specimens from the lower Coaledo material do not seem quite typical but have the main characters of this species.

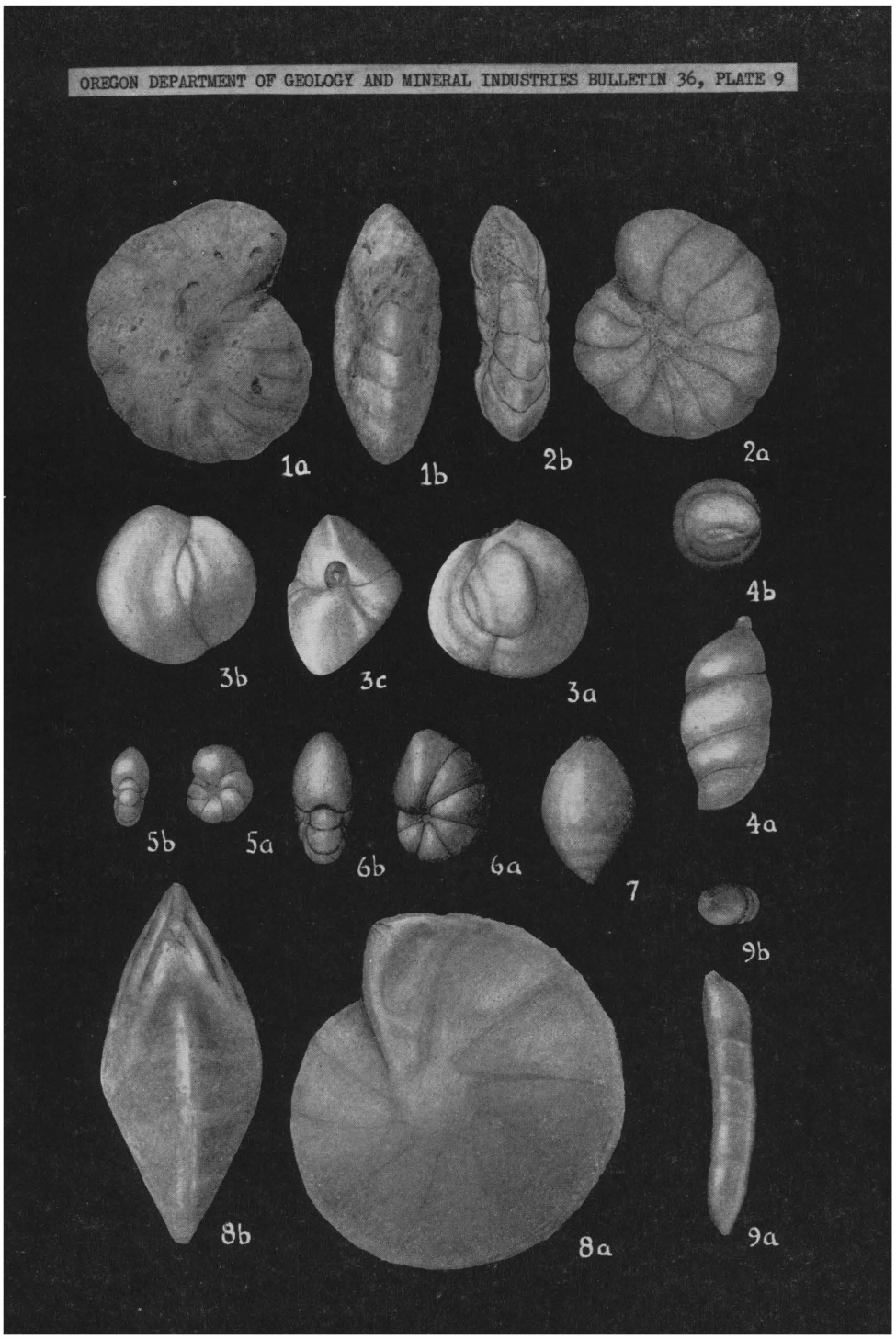
Genus CIBICIDES Montfort, 1808

CIBICIDES NATLANDI Beck, var.. OLEQUAENSIS Beck (Pl. 11, fig. 9)

Cibicides natlandi Beck, var. *olequaensis* Beck, Journ. Pal., vol. 17, 1943, p. 612, pl. 109, figs. 3, 20, 22.

The types of this variety are from the Eocene of Cowlitz River, Lewis County, Washington. Specimens in the lower Coaledo material seem to be identical.

Explanation of Plate 9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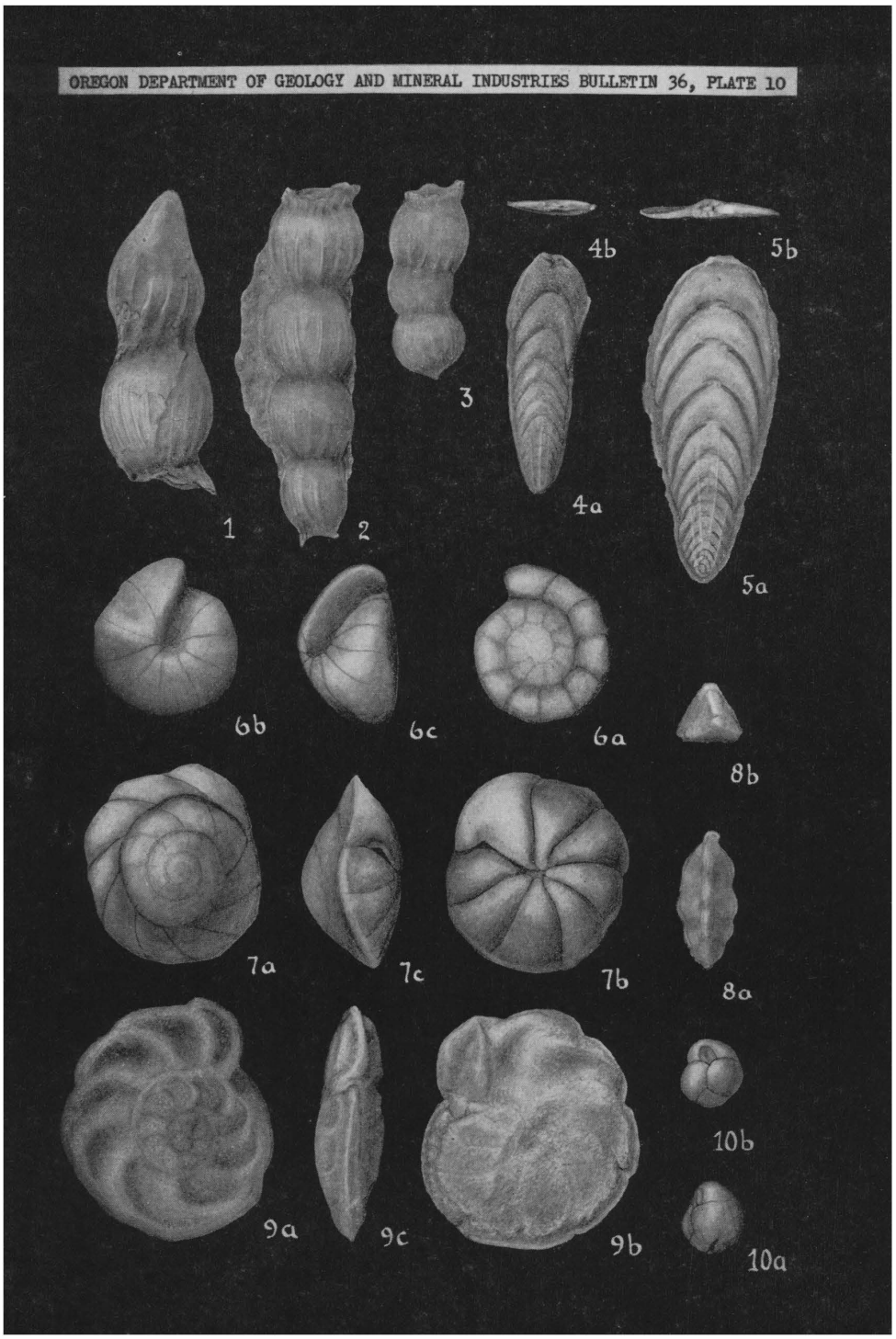
8a
9a

Explanation of Plate 10


OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES BULLETIN 36, PLATE 10
1
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3
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6c
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8b
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9c
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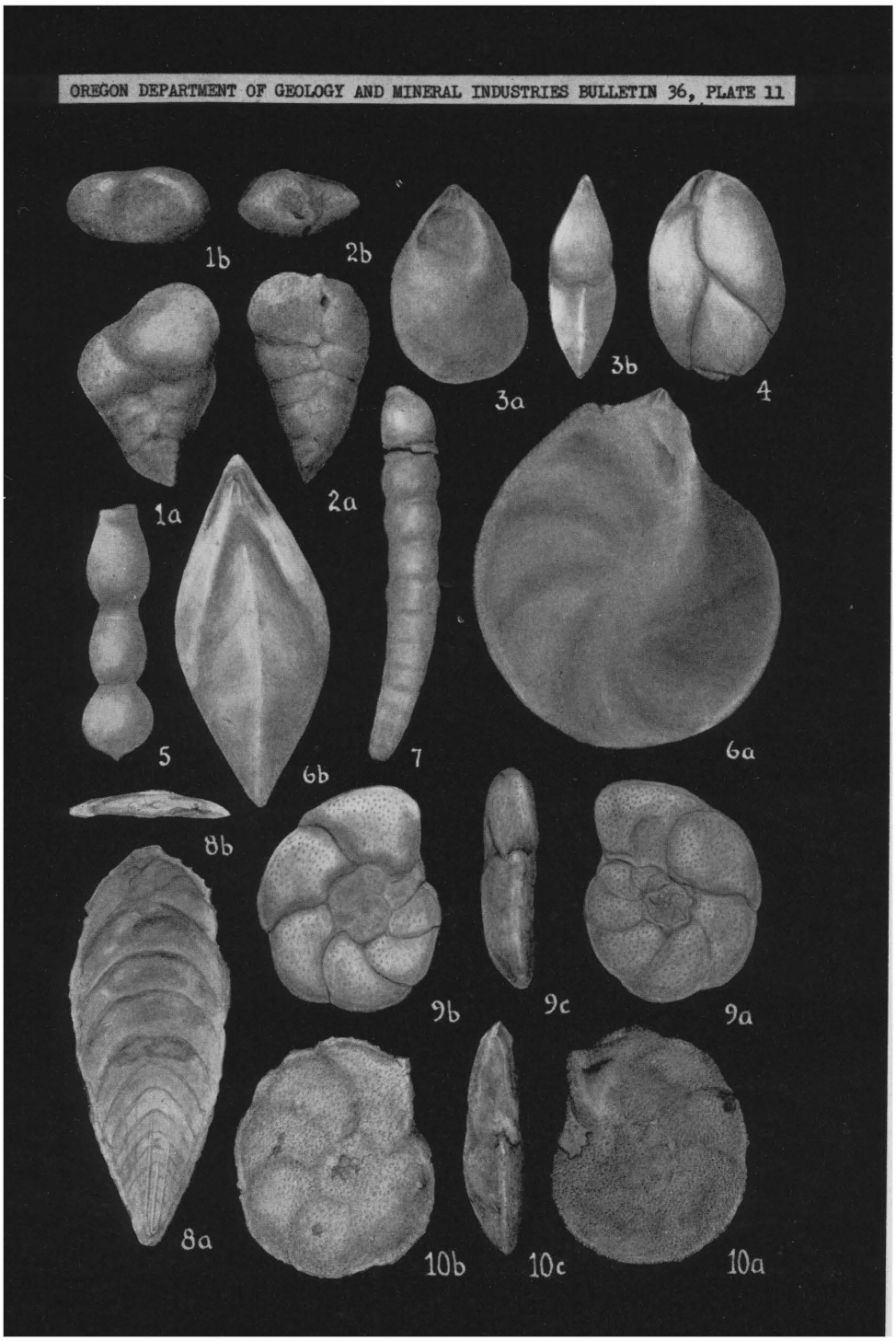
10b
10a

Explanation of Plate 11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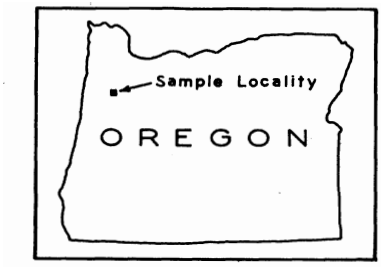
Part V

EOCENE FORAMINIFERA
FROM
HELMICK HILL, POLK COUNTY, OREGON



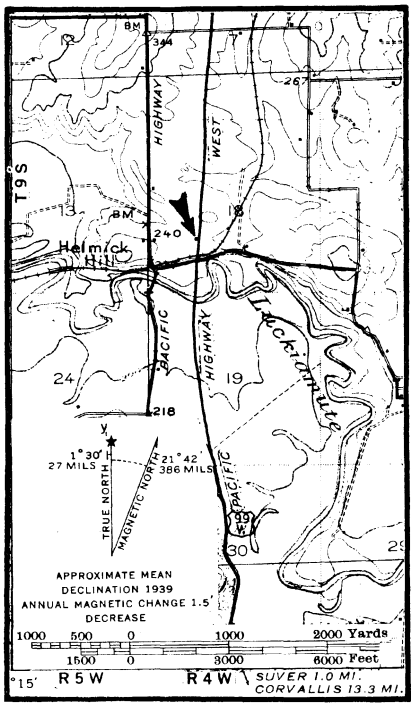


Figure 4. Map showing sampled locality (heavy black arrow) at Helmick Hill, Polk County, Oregon. Adapted from a portion of the Salem quadrangle of the U. S. Geological Survey's topographic maps. Contour interval 25 feet.

EOCENE FORAMINIFERA
From Helmick Hill, Polk County, Oregon*

By

JOSEPH A. CUSHMAN
and
ROSCOE E. and KATHERINE C. STEWART

Helmick Hill is located about 15 miles southwest of Salem in the Willamette Valley of western Oregon. It is 2¼ miles north of the southwest corner of the Salem quadrangle in sec. 13, T. 9 S., R. 5 W., and sec. 18, T. 9 S., R. 4 W.

Two north-south highways pass Helmick Hill, the westerly one being the old route of Pacific Highway West (U. S. 99 W.) and the other, about one-quarter mile to the east, a relocated route of the same highway constructed during World War II.

Sediments exposed in the southwest corner of the Salem quadrangle are described in considerable detail in a master's thesis by Mundorff①. For the material there called "Helmick beds" the term "Helmick formation" is used in this paper. From Mundorff's thesis the following is quoted with slight rearrangement in order of statement:

> The Eocene rocks, which for convenience may be called the Helmick beds . . . cover an area of approximately 20 square miles of the southwest corner of the quadrangle [with an unknown extent out under the valley fill]. . . . [As] typically exposed in the highway road cut at Helmick Hill and along the [Willamette] river at Buena Vista . . . they consist chiefly of micaceous sandstone with some clay shales and an occasional concretionary lens firmly cemented with calcite. . . . The sandstones are typically medium-grained, thin-bedded, friable, bluish-gray rocks, which turn buff or brown from limonite stain on exposure. . . . The concretions frequently thin out to nothing, only to continue a few feet farther on. Examination discloses that these

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① Mundorff, Maurice J., The geology of the Salem quadrangle, Oregon, Master's Thesis (MS) Oregon State College, pp. 20-34, Corvallis, 1939. Oregon State College Library number LD 4330, 1939, 55.

> concretions often contain material of an organic nature, such as carbonized leaves and stems of plants. The shales exposed at Buena Vista, are buff-colored, fine-grained, thin-bedded [clay] shales. They are rather brittle when dry, but [when wet] are soft, slack readily, and erode very easily. . . . The uppermost member of the Helmick beds appears to be the clay shales of which at least 40 feet and possibly much more are exposed along the river about a quarter of a mile north of Buena Vista.

Mundorff notes the exposure of two complete anticlines and synclines in a distance of about two miles along the river.

His fauna consists of 10 molluscs which he assigns to the upper Eocene.

The material for the present paper was collected in November 1944 by W. C. Warren of the U. S. Geological Survey and R. E. Stewart. The sample was taken from a bed of clay shale at the base of a road-cut on the west side of relocated Pacific Highway West about 140 yards north of the Valley and Siletz Railroad overpass, as indicated by the heavy black arrow on the accompanying map (figure 4).

This shale was not exposed at the time of Mundorff's investigation. It is blue-gray when freshly exposed and later takes on the buff color ascribed by Mundorff to the shale at Buena Vista.

Foraminifera are abundant in the sampled material. Only about half of the species noted are recorded in this paper because many are represented by only one or two specimens and others are too poorly preserved or too badly broken to serve as sound bases for identification.

The foraminifera indicate a correlation with the Coaledo and Cowlitz formations, and, therefore, support Mundorff's assignment of his molluscan fauna to the upper Eocene.

The authors are indebted to Dr. E. L. Packard, Head of the Department of Geology, Oregon State College, for assistance in obtaining Mundorff's thesis for reference, and to Mr. R. H. Baldock, Oregon State Highway Engineer, for a map location of the New Pacific Highway West.

Family RHIZAMMINIDAE

Genus BATHYSIPHON M. Sars, 1872

BATHYSIPHON EOCENICA Cushman and G. D. Hanna (Pl. 12, figs. 1, 2)

Bathysiphon eocenica Cushman and G. D. Hanna, Proc. Calif. Acad. Sci., ser. 4, vol. 16, 1927, p. 210, pl. 13, figs. 2, 3.—Cushman and McMasters, Journ. Pal., vol. 10, 1936, p. 508, pl. 74, fig. 1.—Cushman and Siegfus, Trans. San Diego Soc. Nat. Hist., vol. 9, 1942, p. 400, pl. 15, fig. 1.—Kelley, Bull. Amer. Assoc. Petr. Geol., vol. 27, 1943, p. 11 (list).—Curran, l. c., pp. 1378, 1381 (lists).—Martin, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, No. 3, 1943, p. 9 (list).—Cushman and Simonson, Journ. Pal., vol. 18, 1944, p. 193, pl. 30, fig. 1.—Cushman and Stone, Special Publ. 20, Cushman Lab. Foram. Res., 1947, p. 2, pl. 1, fig. 1.

Typical specimens occur in the Helmick formation. The species was described from the Eocene of California. It has been recorded from the Eocene, Llajas formation, Kreyenhagen shale, "Cozy Dell" shale, Tejon, and Lodo formations, and from the Oligocene, Tumey formation, of California. It is also known from the upper Eocene, Chira shale, of Peru.

Family LITUOLIDAE

Genus CYCLAMMINA H. B. Brady, 1876

CYCLAMMINA cf. ACUTIDORSATA (Hantken) (Pl. 12, fig. 3)

Specimens similar to those described from the upper Eocene of Hungary occur in the Helmick Hill material.

Family LAGENIDAE

Genus ROBULUS Montfort, 1808

ROBULUS WELCHI Church (Pl. 12, fig. 4)

Robulus welchi Church, Rep't. State Min. Calif., 1931, p. 212, pl. C, figs. 13, 14; Calif. Div. Mines, Bull. 118, pt. 2, 1941, p. 182.— Cushman and Siegfus, Trans. San Diego Soc. Nat. Hist., vol. 9, 1942, p. 404, pl. 15, fig. 22.—Beck, Journ. Pal., vol. 17, 1943, p. 596, pl. 102, figs. 4, 8.—Kelley, Bull. Amer. Assoc. Petr. Geol., vol. 27, 1943, p. 11 (list).—Cushman and Simonson, Journ. Pal., vol. 18, 1944, p. 195, pl. 30, fig. 11.

This species was described from the Eocene, Kreyenhagen formation, of California and is also recorded from the Eocene of Washington and the Oligocene, Tumey formation, of California. Specimens in the Helmick formation seem to be typical.

ROBULUS INORNATUS (d'Orbigny) (Pl. 13, fig. 2)

(For references, see p. 74)

Specimens similar to those occurring in the lower Coaledo material from Sunset Bay occur in the Helmick formation.

ROBULUS CHIRANUS Cushman and Stone (Pl. 12, fig. 5)

Robulus chiranus Cushman and Stone, Special Publ. 20, Cushman Lab. Foram. Res., 1947, p. 5, pl. 1, fig. 15.

This species was described from the upper Eocene, Chira shale, of Peru. Very typical specimens occur in the Helmick formation.

Genus MARGINULINA d'Orbigny, 1826

MARGINULINA cf. SUBBULLATA Hantken

Rare specimens from the Helmick formation are apparently the same as those already referred to this species from the lower Coaledo of Oregon.

Genus DENTALINA d'Orbigny, 1826

DENTALINA COMMUNIS d'Orbigny

This widely recorded species is already recorded from the lower Coaledo material of Oregon. It is rare in the Helmick formation.

Genus NODOSARIA Lamarck, 1812

NODOSARIA cf. LONGISCATA d'Orbigny (Pl. 13, fig. 1)

Fragmentary specimens, one of which is figured, occur in the Helmick formation and until more complete specimens are available may be referred to this widely recorded species.

Genus LAGENA Walker and Jacob, 1798

LAGENA cf. COSTATA (Williamson) (Pl. 12, fig. 6)

The figured specimen may be referred with some question to this widely recorded species. There is some irregularity in the costae of the surface. It is rather rare in our material from the Helmick formation.

LAGENA cf. ACUTICOSTA Reuss (Pl. 13, fig. 3)

The single specimen here figured from the Helmick formation is distinct from the preceding species and seems close to if not identical with Reuss' species, which is widely recorded.

Family POLYMORPHINIDAE

Genus GLANDULINA d'Orbigny, 1826

GLANDULINA LAEVIGATA (d'Orbigny), var. OVATA Cushman and Applin

(For references, see p. 76)

Specimens in the collections from the Helmick formation seem identical with those found in the lower Coaledo material.

Genus SIGMOMORPHINA Cushman and Ozawa, 1928

SIGMOMORPHINA SEMITECTA (Reuss) (Pl. 13, fig. 4)

Polymorphina semitecta Reuss, Sitz. Akad. Wiss. Wien, vol. 55, pt. 1, 1867, p. 91, pl. 3, fig. 10.

Sigmomorphina semitecta Cushman and Ozawa, Proc. U. S. Nat. Mus., vol. 77, Art. 6, 1930, p. 129, pl. 33, figs. 6, 7.—Howe and Wallace, Louisiana Geol. Bull. 2, 1932, p. 50, pl. 8, fig. 4.—Howe, Geol. Bull. 14, Louisiana Geol. Survey, 1939, p. 55, pl. 7, figs. 9, 10.—Cushman and Applin, Contr. Cushman Lab. Foram. Res., vol. 19, 1943, p. 36, pl. 7, fig. 22.—Cushman and Todd, l. c., Special Publ. 15, 1945, p. 35, pl. 5, fig. 21.

The single specimen in the material from the Helmick formation seems to belong to this species. Most of the American records for the species are from the Eocene.

Family NONIONIDAE

Genus NONION Montfort, 1808

NONION APPLINI Howe and Wallace (Pl. 12, fig. 7)

Nonionina scapha (Fichtel and Moll), var. Cushman and Applin, Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 182, pl. 10, figs. 12, 13.

Nonion applini Howe and Wallace, Louisiana Geol. Bull. 2, 1932, p. 51, pl. 9, fig. 4.—Cushman and McMasters, Journ. Pal., vol. 10, 1936, p. 513, pl. 75, fig. 16.—Cushman, U. S. Geol. Survey Prof. Paper 191, 1939, p. 8, pl. 2, fig. 7.—Howe, Journ. Pal., vol. 16, 1942, p. 267 (list).

The types of this species are from the Eocene of Jackson age, in Louisiana. It is also recorded from the Eocene, Llajas formation, of California and the Eocene of Mexico. Howe records it from the Oligocene of Alabama. The specimens from Helmick Hill seem to be typical.

NONION FLORINENSE Cole

Nonion florinense Cole, Bull. Amer. Pal., vol. 14, No. 51, 1927, p. 22, pl. 4, fig. 4.—Cushman, U. S. Geol. Survey Prof. Paper 191, 1939, p. 5, pl. 1, figs. 17, 18.—Howe, Geol. Bull. 14, Louisiana Geol. Survey, 1939, p. 57, pl. 7, figs. 17, 18.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 15, pl. 3, figs. 30, 31.

The types of this species are from the Eocene, Guayabal formation, of Mexico. It has also been recorded from the Claiborne Eocene, Cook Mountain formation, of Louisiana and Lisbon formation of Alabama. The specimens in the material from the Helmick formation seem very close to if not identical with this species.

Genus NONIONELLA Cushman, 1926

NONIONELLA JACKSONENSIS Cushman (Pl. 13, fig. 5)

Nonionella jacksonensis Cushman, Contr. Cushman Lab. Foram. Res., vol. 9, 1933, p. 10, pl. 1, fig. 23; U. S. Geol. Survey Prof. Paper 181, 1935, p. 31, pl. 12, figs. 3, 4; Prof. Paper 191, 1939, p. 29, pl. 8, fig. 2.—Howe, Geol. Bull. 14, Louisiana Geol. Survey, 1939, p. 59, pl. 8, figs. 5-7.—Bergquist, Bull. 49, Mississippi State Geol. Survey, 1942, p. 62, pl. 6, fig. 23.—Martin, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, No. 3, 1943, p. 11 (list).—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 16; p. 93, pl. 15, fig. 8.—Cushman and Ellisor, Journ. Pal., vol. 19, 1945, p. 560, pl. 75, fig. 6.—Cushman, Special Publ. 16, Cushman Lab. Foram. Res., 1946, p. 22, pl. 4, fig. 26.

This is a characteristic upper Eocene species. The specimens in the material from the Helmick formation seem to be very typical.

Family HETEROHELICIDAE

Genus PLECTOFRONDICULARIA Liebus, 1903

PLECTOFRONDICULARIA OREGONENSIS Cushman, R. E. and K. C. Stewart, n. sp. (Pl. 13, figs. 8, 9)

Test about two and a half times as long as broad, in the adult elongate-oval, in the early stages about twice as long as broad and irregularly rhomboid in shape, periphery acute but usually not keeled; chambers distinct, earlier ones hidden by the high costae, in the adult low and broad; sutures fairly distinct, very strongly curved; wall in the early portion with usually two very strong median costae with a slightly developed one at either side, later portion smooth; aperture terminal, elongate. Length 1.00–2.00 mm.; breadth 0.50–0.75 mm.

Holotype (Cushman Coll. No. 48840) and paratypes (Oregon State Dept. Geology and Min. Industries Coll. No. 186 and Stewart Coll. No. 186) from the Eocene, Helmick formation, Helmick Hill, Salem Quadrangle, Oregon.

The series of specimens of this species are not all well preserved but it seems to be a distinct species. It differs from *P. packardi* Cushman and Schenck in the much more delicate test, more curved sutures, and the long median costae.

PLECTOFRONDICULARIA PACKARDI Cushman and Schenck (Pl. 13, fig. 7)

Plectofrondicularia packardi Cushman and Schenck, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 17, 1928, p. 311, pl. 43, figs. 14, 15.—Condit, Journ. Pal., vol. 4, 1930, pp. 260, 262 (lists).—Cushman and Frizzell, Contr. Cushman Lab. Foram. Res., vol. 19, 1943, p. 85.—Kelley, Bull.

Amer. Assoc. Petr. Geol., vol. 27, 1943, p. 11 (list).—Cushman and Simonson, Journ. Pal., vol. 18, 1944, p. 197, pl. 31, figs. 17, 18; pl. 32, fig. 1.—Detling, l. c., vol. 20, 1946, p. 355, pl. 49, fig. 1.—Cushman and Stone, Special Publ. 20, Cushman Lab. Foram. Res., 1947, p. 11, pl. 2, fig. 4.

This species was described from the Tertiary of Oregon and is recorded from Eocene to Miocene in the area including Washington, Oregon, and California and from the upper Eocene, Chira shale, of Peru. While most of the specimens have the characteristic curved costae on the early chambers of the test they vary considerably in size, most of the specimens in the material from the Helmick formation being distinctly smaller than the types.

Family BULIMINIDAE

Genus BULIMINA d'Orbigny, 1826

BULIMINA SCHENCKI Beck (Pl. 12, figs. 10-12)

Bulimina schencki Beck, Journ. Pal., vol. 17, 1943, p. 605, pl. 107, figs. 28, 33.—Cushman and Parker, U. S. Geol. Survey Prof. Paper 210-D, 1947, p. 98, pl. 30, fig. 16.

The types of this species are from the Eocene of Cowlitz River, Lewis County, Washington. Our specimens have been compared with paratypes and the shorter forms seem entirely identical. In the series from the Helmick formation there is a considerable range in form from the shorter, stouter forms (Pl. 12, figs. 11, 12) to the more elongate and slenderer form (Pl. 12, fig. 10). There seem to be gradations between the extreme forms and all are here placed under this species.

Genus GLOBOBULIMINA Cushman, 1927

GLOBOBULIMINA PACIFICA Cushman, var. OREGONENSIS, Cushman, R. E. and K. C. Stewart, n. var. (Pl. 12, fig.13)

Variety differing from the typical in the much broader form and more contracted basal and apertural ends. Length 0.60 mm.; diameter 0.45 mm.

Holotype of variety (Cushman Coll. No. 48844) and paratypes (Oregon State Dept. Geology and Min. Industries Coll. No. 190 and Stewart Coll. No. 190) from the Eocene, Helmick formation, Helmick Hill, Salem Quadrangle, Oregon.

This variety seems distinct from the typical form of the species which is recorded from the later Tertiary and from Recent material from the Pacific.

Genus VIRGULINA d'Orbigny, 1826

VIRGULINA cf. ZETINA Cole

Very rare specimens in the material from the Helmick formation may belong to this species described from the Eocene, Guayabal formation, of Mexico. The figures referred to this species show considerable variation and our specimens from Oregon are not entirely typical. More specimens may show it to belong elsewhere.

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA BASISENTA Cushman and Stone (Pl. 13, fig. 6)

Bolivina basisenta Cushman and Stone, Special Publ. 20, Cushman Lab. Foram. Res., 1947, p. 15, pl. 2, fig. 20.

This species described from the upper Eocene, Chira shale, of Peru is found in typical form in the material from the Helmick formation. It is probably the same form as that figured by Beck from a single broken specimen as *Bolivina* ? sp. A from the Eocene of Cowlitz River, Lewis County, Washington (Journ. Pal., vol. 17, 1943, p. 607, pl. 107, fig. 11). It is fairly common in the Helmick formation.

Genus ANGULOGERINA Cushman, 1927

ANGULOGERINA HANNAI Beck (Pl. 12, fig. 16)

Angulogerina hannai Beck, Journ. Pal., vol. 17, 1943, p. 607, pl. 108, figs. 26, 28.

This species was described from the Eocene of Cowlitz River, Lewis County, Washington, and very similar specimens occur in our material from the Helmick formation.

Family ELLIPSOIDINIDAE

Genus ELLIPSONODOSARIA A. Silvestri, 1900

ELLIPSONODOSARIA sp. (Pl. 12, figs. 8, 9)

A very few incomplete specimens, evidently belonging in this genus, occurred in our material from the Helmick formation. It does not seem to be identical with any of the described species but more and better specimens are needed to give the full specific characters.

Family ROTALIIDAE

Genus GYROIDINA d'Orbigny, 1826

GYROIDINA cf. PLANULATA Cushman and Renz (Pl. 12, fig. 15)

A few specimens similar to the one figured seem more nearly related to this species described from the Tertiary of Venezuela than to any other.

Genus EPONIDES Montfort, 1808

EPONIDES MINIMUS Cushman (Pl. 13, fig. 10)

Eponides minima Cushman, Contr. Cushman Lab. Foram. Res., vol. 9, 1933, p. 17, pl. 2, fig. 8; U. S. Geol. Survey Prof. Paper 181, 1935, p. 47, pl. 19, fig. 3.—Cushman and McMasters, Journ. Pal., vol. 10, 1936, p. 514, pl. 76, fig. 2.—Beck, l. c., vol. 17, 1943, p. 608, pl. 108, figs. 16, 17, 19.—Kelley, Bull. Amer. Assoc. Petr. Geol., vol. 27, 1943, p. 11 (list).—Curran, l. c., pp. 1379, 1381 (lists).—Cushman, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 9, pl. 2, fig. 12; Special Publ. 16, 1946, p. 34, pl. 6, fig. 17.

This species occurs in the upper Eocene of Jackson age of Georgia, South Carolina, and Alabama. It is also recorded from the Eocene of California and Washington. Specimens are common in the material from the Helmick formation but are very small in size.

Family CASSIDULINIDAE

Genus CASSIDULINA d'Orbigny, 1826

CASSIDULINA GLOBOSA Hantken (Pl. 12, fig. 14)

Cassidulina globosa Hantken, Magyar kir. földt. int. evkön., vol. 4, 1875 (1876), p. 54, pl. 16, fig. 2; Mitth. Jahrb. K. Ungar. geol. Anstalt, vol. 4, 1875 (1881), p. 64, pl. 16, fig. 2.—Liebus, Neues Jahrb. für Min., 1901, p. 125; Jahrb. k. k. geol. Reichsanst., vol. 56, 1906, p. 357, text fig. 5.—Martinotti, Atti Soc. Ital. Sci. Nat., vol. 62, 1923, p. 328.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 3, 1925, p. 56, pl. 9, figs. 25, 26.—Cole, Bull. Amer. Pal., vol. 14, No. 51, 1927, p. 32.—Cushman, Journ. Pal., vol. 1, 1927, p. 167, pl. 26, fig. 13.—Cole, Bull. Amer. Pal., vol. 14, No. 53, 1928, p. 216 (16).—Cole and Ponton, Bull. 5, Florida State Geol. Survey, 1930, p. 44, pl. 7, fig. 7.—Church, Rep't. State Min. Calif., 1931, p. 212, pl. C, figs. 4, 5.—Cushman, U. S. Geol. Survey Prof. Paper 181, 1935, p. 49, pl. 20, fig. 12.—Israelsky, Proc. 6th Pac. Sci. Congress, 1939, p. 577, pl. 6, fig. 6.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 73.—Cushman and Siegfus, Trans. San Diego Soc. Nat. Hist., vol. 9, 1942, p. 421, pl. 18, fig. 3.—Beck, Journ. Pal., vol. 17, 1943, p. 609, pl. 108, figs. 7, 13, 14.—Kelley, Bull. Amer. Assoc. Petr. Geol., vol. 27, 1943, p. 11 (list).—Curran, l. c., pp. 1379, 1381 (lists).—Martin, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, No. 3, 1943, p. 9 (list).—Cushman and Simonson, Journ. Pal., vol. 18, 1944, p. 202, pl. 34, fig. 7.—Weaver, Univ. Washington Publ. Geol., vol. 6, No. 1, 1944, p. 23 (list).—ten Dam, Med. Geol. Stichting, ser. C-V, No. 3, 1944, p. 124.—Cushman and Herrick, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 70.—Cushman and Stainforth, Special Publ. 14, Cushman Lab. Foram. Res., 1945, p. 64, pl. 12, fig. 4.—Cushman, Special Publ. 16, 1946, p. 36, pl. 7, fig. 13.—Detling, Journ. Pal., vol. 20, 1946, p. 358, pl. 51, fig. 3.—Cushman and Stone, Special Publ. 20, Cushman Lab. Foram. Res., 1947, p. 23, pl. 3, fig. 8.

This species was described from the Eocene of Austria and is widely recorded in the Eocene of Europe and America with

a few records from the American Oligocene. On the west coast of America it is recorded from the Eocene of California, Oregon, and Washington and from the upper Eocene, Chira shale, of Peru. Our specimens in material from the Helmick formation seem to be typical.

Family ANOMALINIDAE

Genus CIBICIDES Montfort, 1808

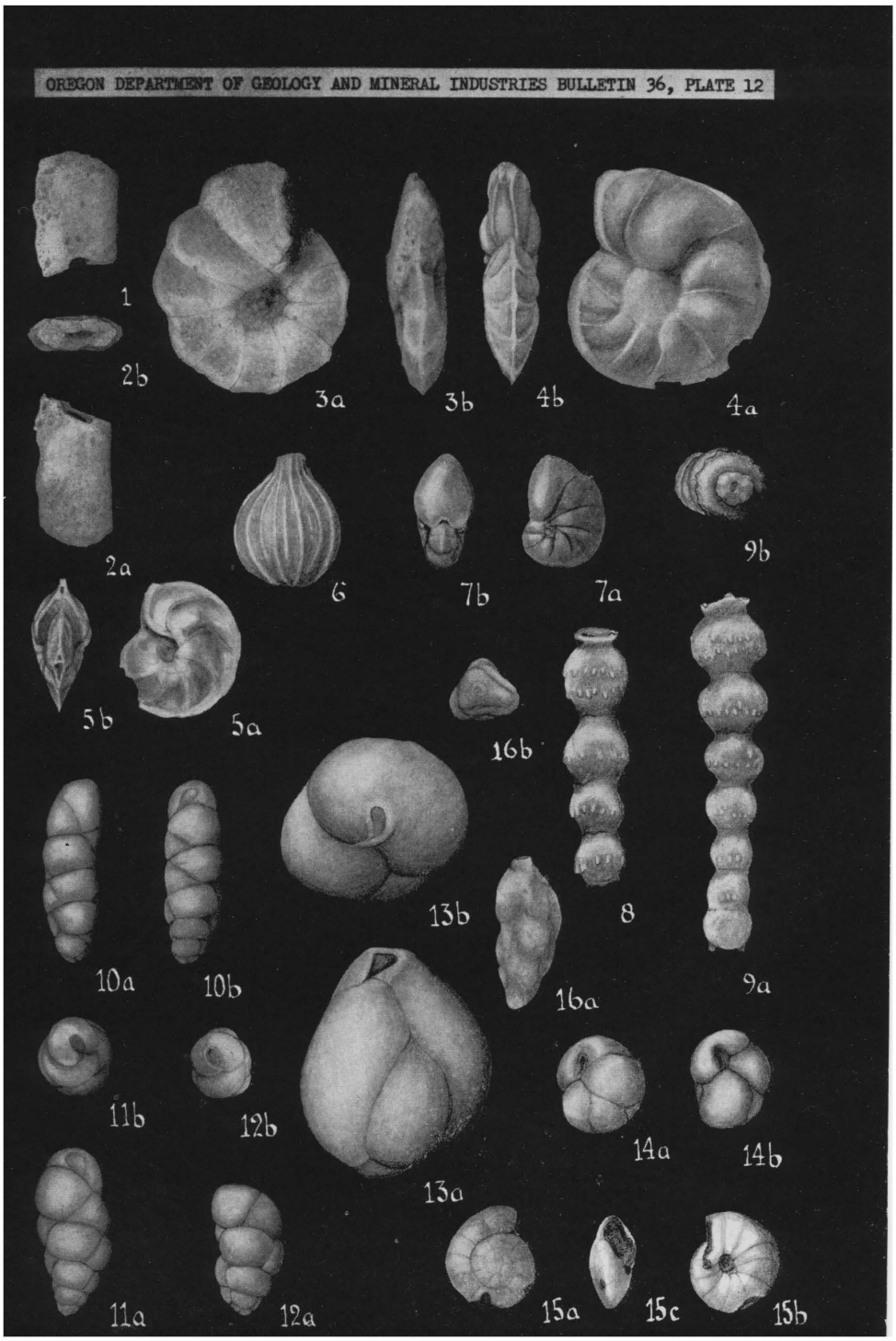
CIBICIDES WARRENI Cushman, R. E. and K. C. Stewart, n. sp. (Pl. 13, fig. 11)

Test planoconvex, dorsal side flat or slightly concave, ventral side convex with a depressed umbilical area, periphery broadly rounded; chambers distinct, about eight in the adult whorl, increasing rather gradually and evenly in size as added, slightly inflated, especially on the ventral side; sutures distinct, strongly curved, dorsally slightly limbate, ventrally distinctly depressed; wall fairly smooth; aperture at the periphery and extending over onto the dorsal side with a slight lip on the inner end. Diameter of holotype up to 0.65 mm.; thickness 0.20 mm.

Holotype (Cushman Coll. No. 49006) and paratypes (Oregon State Dept. Geology and Min. Industries Coll. No. 200 and Stewart Coll. No. 200) from the Eocene, Helmick formation, Helmick Hill, Salem Quadrangle, Oregon.

This species somewhat resembles *C. concentricus* (Cushman) from the Miocene but differs in the more rounded periphery, more curved sutures, and the slight lobes on the ventral side.

Explanation of Plate 12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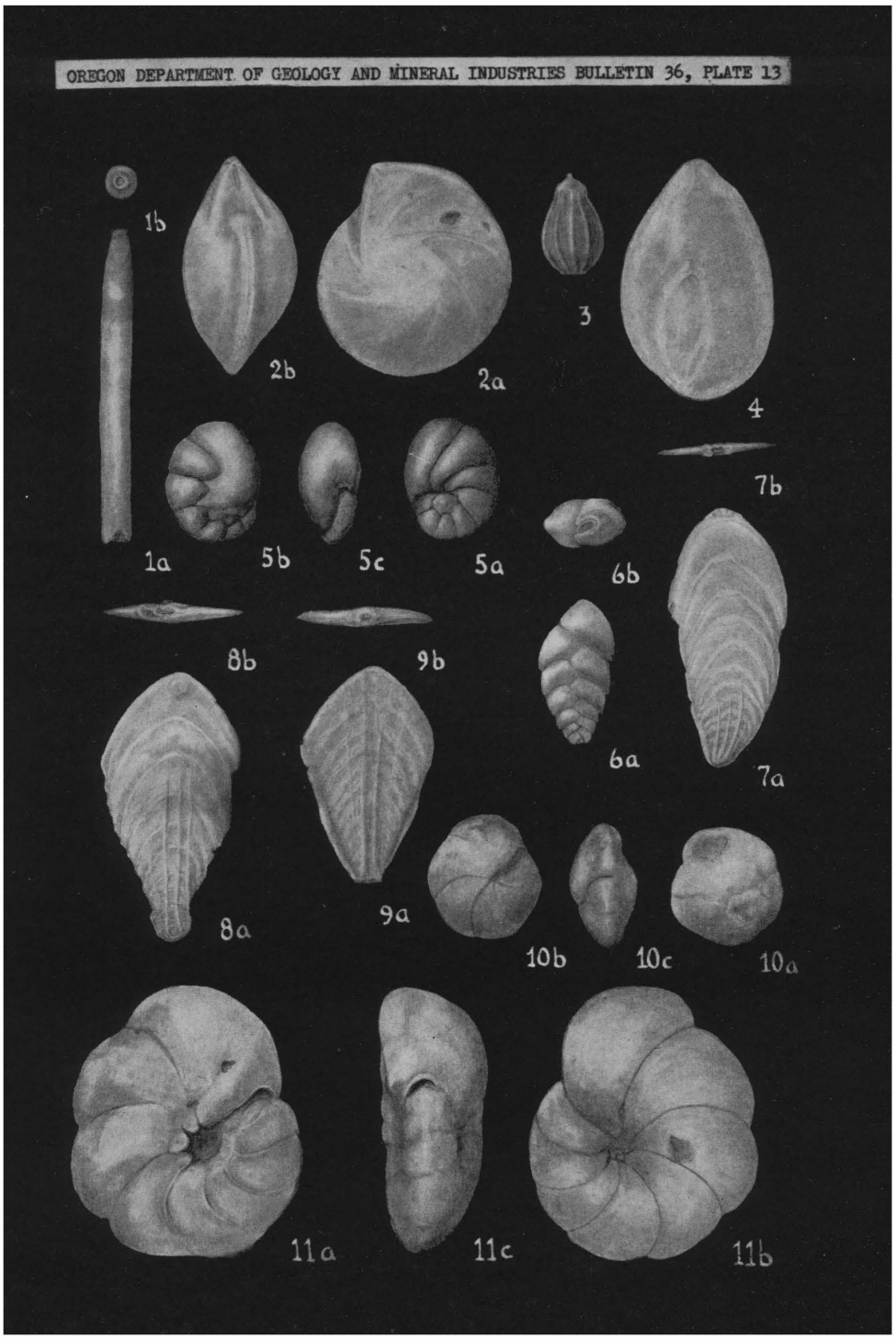
Explanation of Plate 13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