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No. 46, 27 pages, 2 figures, 2 plates. July 1, 1964

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By

Walter W. Wornardt, Jr.

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Introduction

The purpose of this investigation is to study and describe two diatom florules from ancient lake beds in California, each representing a different type of environment, and to compare the similarities and differences between them. It should be noted that the author has not visited either locality.

Beds of Mono Lake Basin

A diatomaceous clay was collected at California Academy of Sciences, Department of Geology, Locality Number 37113, on October 20, 1960, from an outcrop on the shore of Mono Lake (fig. 1) by G D. Hanna and C. W. Chesterman. The sampled locality is an exposed bank approximately 25 feet in height and about 100 feet above the surface of the lake. The beds are composed of a light gray, silty and ashy clay, horizontally bedded in thin layers up to two inches thick. The location is in Sec. 6, T1N, R28E, M.D.B. & M., as shown on the U. S. Geological Survey topographic map, Mt. Morrison quadrangle (30

* The results reported herein were made possible through National Science Foundation Grant No. 2958-C1, N.S.F. 11083.

minute series, 1914. Reprinted, 1950). The locality is just below an old abandoned cabin beside a seldom traveled dirt road.

Much has been written on the geology of the Mono Lake area (Russell, 1885) but no mention of fossil diatoms has been found in the literature except as pertains to Paohoa Island, which is located in the lake. There are extensive deposits of diatomaceous sediments on this island but the diatoms have not been studied in detail. A brief examination of them by G D. Hanna (personal communication) suggests that their age is much older than the material considered in this paper, perhaps as old as Pliocene.

The water in Mono Lake is saline at present and supports a very limited fauna and flora. A minute green alga was noted in one place but no living diatoms were found in a brief examination by Hanna (personal communication). The larvae of one or more species of flies were abundant and the brine shrimp, *Artemia*, has been reported by members of the Steinhart Aquarium of the California Academy of Sciences.

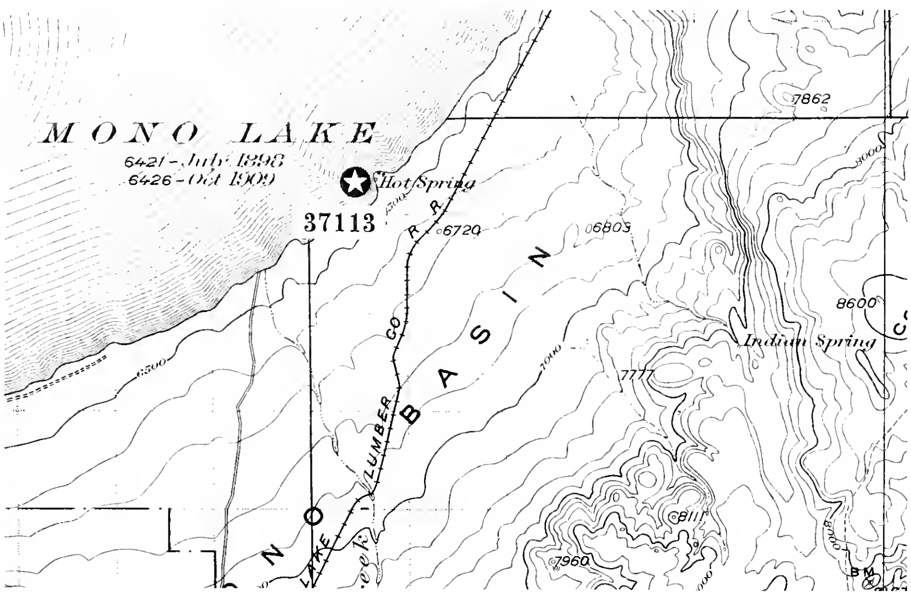

Figure 1. A portion of U. S. Geological Survey Topographic Map, Mt. Morrison Quadrangle, June, 1914 edition, Mono County, California, showing California Academy of Sciences locality no. 37133.

Lake Beds of Panamint Valley

A diatomaceous ash was collected at California Academy of Sciences, Department of Geology, Locality Number 37055, on December 26, 1960, by F.

Weidenbenner, G D. Hanna, and M. M. Hanna. The elevation of the outcrop is 1840 feet, or 800 feet above the present floor of Panamint Valley. These beds are located in Sec. 20, T21S, R43E, M.D.B. & M., U. S. Geological Survey topographic map, Maturango Peak quadrangle (15 minute series), Inyo County, California, 1951, (fig. 2).

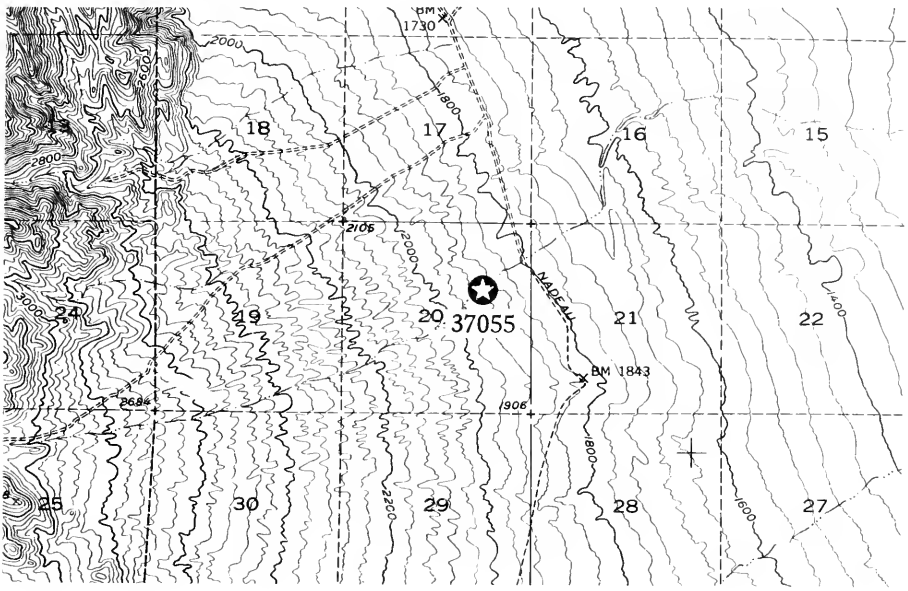

Figure 2. A portion of U. S. Geological Survey Topographic Map, Maturango Peak, California, Quadrangle, edition of 1951, showing California Academy of Sciences fossil collection locality no. 37055 in Panamint Lake basin.

Panamint Valley formed one of the many sumps in the Pleistocene chain of lakes that probably started with Lake Lahontan to the north. It received overflow drainage directly from Searles Lake basin to the west (Blanc and Cleveland, 1961, p. 5, map) and there is a possibility that it in turn overflowed into Death Valley. A complete and satisfactory drainage pattern has not been worked out because of changes in topography since Pleistocene time and lack of fossil evidence. Whatever the drainage pattern may have been, there can be no doubt that a very large and relatively pure freshwater lake occupied Panamint Valley during late Pleistocene time. The Pleistocene sediments which accumulated are largely covered with detrital outwash so that outcrops are extremely limited in the vicinity of the collecting station of this report. The total thickness of these sediments cannot be measured. Associated with the diatom-bearing strata are some soft, sandy beds containing a rather extensive fauna of well preserved freshwater mollusks. Hanna (1963, p. 5) stated that the molluscan species there are almost exactly the same as those found in the basin of Searles Lake. He therefore considered the fossils in the two lakes to be contemporaneous, and believed that they furnish evidence of a former connection between the two bodies of water. No diatoms were found in the Searles Lake basin. Scholl (1960) has published a general account of events pertaining to the geology of Searles Lake and an extensive bibliography of the area. A formal name for the lake beds in Panamint Valley has not been proposed.

Methods Used for the Identification of Species

The species described in this report were identified by comparison with the reference slides of G D. Hanna and H. E. Sovereign. Many identifications were made from published plates in the extensive diatom library at the California Academy of Sciences. The magnifications given for the diatom species on plates 1 and 2 have been given in round figures for the purpose of utility, and may be in error by a few per cent. Inasmuch as exact measurements of the illustrated diatoms are given, the precise magnifications may be obtained if so desired.

Acknowledgments

The writer is extremely grateful to Dr. G Dallas Hanna of the California Academy of Sciences, for suggesting this investigation, for critically reading the manuscript, and for aid and advice throughout this project. The writer is also indebted to Dr. Hanna for his instruction in preparing, mounting, and photographing these minute organisms. His type diatom slides, many strewn slides, and unpublished manuscripts were also made available.

Acknowledgements are likewise due to many others: Dr. Leo G. Hertlein, California Academy of Sciences, for his excellent advice on numerous editorial and systematic problems; Dr. R. M. Kleinpell of the Department of Paleontology, University of California, Berkeley, for his valuable advice on general systematics; the late Ignatius M'Guire, Librarian, California Academy of Sciences, for his assistance in locating numerous obscure publications, many of which were cited under inadequate references; Dr. George F. Pappenfuss, and Dr. Paul C. Silva, Department of Botany of the University of California, Berkeley, for their valuable discussions on plant taxonomy and classification; Dr. Taro Kanaya and Dr. Reimer Simonsen for their advice and discussions concerning diatoms. Finally, the writer would like to record his indebtedness to the California Academy of Sciences for the facilities provided, especially the use of the vast diatom library. Additional references were obtained from the Library of the University of California, Berkeley.

Class BACILLARIOPHYCEAE Fritsch
Order BACILLARIALES Schütt
Suborder DISCINEAE Schütt
Family COSCINODISCACEAE Kützing
Subfamily MELOSIROIDEAE Kützing

Genus **Melosira** (Ehrenberg) Kützing, 1844

Melosira undulata (Ehrenberg) Kützing.
(Plate 1, figure 1.)

Under high magnification, the valve surface is characterized by radiating lines of punctae that disappear toward the center. Under low magnification, the valve surface has a somewhat wavy appearance. This species is found in short cylindrical tubes. The valves range from 0.0590 to 0.650 mm. in diameter. The size ranges of the valves are taken from different individuals seen in the Panamint Valley samples.

Tempère and Peragallo (1915, p. 59) reported *Melosira undulata* from Tacoma, Washington, living. Sovereign (1958, pp. 105-106) reported it from Crater Lake and Emerald Pool, Oregon, and stated that Hustedt has said: ".. *M. undulata* as a recent species is known only from the tropics but that it occurs as a fossil in Tertiary deposits in the whole of Europe. This species now has been found as recent in eight locations in the Pacific Northwest in waters varying from pH 7.1 to 8.8."

This species was not only abundant in Europe during the Cenozoic, but it was also very abundant in North America through the same interval of time. It has been reported from the following deposits of many different ages. Ehrenberg (1870, table 12, opposite p. 68), Truckee River, Nevada; Fall River and Columbia River, Oregon. Tempère and Peragallo (1915), Reno, Nevada. Mann (1926, pp. 51-52), Mica, near Spokane, Washington, Miocene, Latah formation, probably a shallow inland freshwater lake with increasing amounts of mineral constituents. Lohman (1934, p. 10), Tipton, Oregon, Miocene, Mascall formation. Lohman (1936, p. 98), 49 Camp, Nevada, Miocene, Upper Cedarville formation. Lohman (1937), Kettleman Hills, Kings County, California, Tulare formation, fresh to brackish water. Sovereign (1958, pp. 105-106), stated that: "It also occurs as a fossil in Upper Miocene deposits of central Washington in approximate stratigraphic position with fossil trees of the Ginkgo State Park near Vantage, Washington. These tree fossils indicate a temperate zone forest and it is thought that no considerable climatic change occurred up to late Pliocene time when the Cascade Range was elevated, producing arid but still temperate conditions in central Washington. *Melosira undulata* has a long history as a temperate zone species in this area."

Subfamily COSCINODISCOIDEAE Schütt

Genus **Cyclotella** [1] Kützing, 1833

Cyclotella compta (Ehrenberg).

(Plate 1, figures 6, 9.)

Discoplea comta EHRENBERG, 1844. Beiträge zur Kenntniss des kleinsten Lebens im ägäischen Meere am Euphrat und auf den Bermuda-Inseln. Monatsber. Berlin Akad. Wissen., p. 267. "Kurdistan."

Cyclotella comta (Ehrenberg), KÜTZING, 1849. Spec. Algarum, p. 20. VAN HEURCK, 1882. Syn. Diat. Belgique, pl. 92, figs. 16-23. DE TONI, 1894. Syl. Algarum, p. 1353. FRICKE *in* SCHMIDT, 1900. Atlas Diat., pl. 224, figs. 1-5, 13-25. ELMORE, 1921. Diat. Nebraska, p. 40, pl. 1, fig. 18. BOYER, 1926. Syn. N. American Diat., p. 40. HUSTEDT, [1928]. Kieselagen, p. 354, fig. 183, 127-159; 1930, Bacillariophyta, p. 103, fig. 69.

Cyclotella comta var. *radiosa* GRUNOW *in* VAN HEURCK, 1892. Syn. Diat. Belgique, pl. 92, fig. 23; pl. 93, figs. 1-9.

Cyclotella comta var. *affinis* GRUNOW *in* VAN HEURCK, 1892. Syn. Diat. Belgique, pl. 93,, figs. 11-13, 21.

Valves with regular radiating costae which become a series of radiating beads as they approach the center of the valve. This species is found as very short cylinders, the diameter of which ranges from 0.0590 to 0.0650 mm.

Cyclotella comta is one of the most common species in the Panamint Valley deposit. It has been reported living in British Columbia, Wolle (1890, pl. 110); Bailey (1921, p. 6), Little and Big Quill Lakes, Saskatchewan, Canada, brackish water.

In the fossil record, it has been reported by Patrick (1936, p. 160), from Great Salt Lake, Utah. Lohman (1937, p. 48), Sprague River, Klamath County. Van Heurck (1892, pl. 93, figs. 11-13), Carson City, Nevada. Tempère and Peragallo (1915, p. 227), Orcas Island, Puget Sound, Washington.

Genus **Stephanodiscus** Ehrenberg, 1845

Stephanodiscus niagarae Ehrenberg.

(Plate 1, figure 2.)

Stephanodiscus niagarae EHRENBERG, 1845. Neue Unterschungen über das kleinste Leben als geologisches Moment, p. 80. Niagara Falls, Ontario, Canada. EHRENBERG, 1854. Mikrogeologie, pl. 35A, group 7, figs. 21, 22. VAN HEURCK, 1882. Syn. Diat. Belgique, pl. 95, figs. 13, 14. DE TONI, 1894. Syl. Algarum, p. 1152. WOLLE, 1890. Diat. N. America, pl. 66, figs. 28, 29. FRICKE *in* SCHMIDT, 1901.

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(1) This genus originally appeared as a subgenus in Kützing (1833b, p. 535). Most workers refer to the reprint (1834, p. 7) of the original article and not to the original itself.

Atlas Diat., pl. 227, figs. 1-9. ELMORE, 1921. Diat. Nebraska, p. 41, pl. 1, figs. 24, 25. BOYER, 1926. Syn. N. American Diat., pp. 60-61. HANNA, 1933. Diat. Florida Peat Dep., p. 90, pl. 2, fig. 3. LOHMAN, 1937. Diat. East. Oregon, pl. 4, figs. A-2, A-5, C-2. OKUNO, 1952. Atlas Fos. Diat. Japan, p. 34, pl. 3, fig. 1; pl. 4, fig. 6; pl. 7, figs. 1, 2; 1956a, Electron-Micro. Fos. Diat., p. 133, pl. 21, figs. 1a, 1b; 1956b, Diat. Earth, p. 345, pl. 1, figs. 1-3. SOVEREIGN, 1958. Diat. Crater Lake, Oregon, p. 106.

The valves are usually elevated at the center, with a depressed area between that and the margin. Radiating rows of costae are distinct as seen under high magnification. The marginal zone is characterized by fine beads which intersect at various angles. Spines are present on the outer margin of the various valves. The valves of this diatom from the Panamint Valley deposit range from 0.0600 to 0.0870 mm. in diameter.

Sovereign (1958, p. 106) reported the species in Diamond Lake and Upper Klamath Lake, Oregon, and stated that it is fairly common in the larger lakes in the Pacific northwest and may be found in streams and ditches with slowly moving water, usually having a pH of 6.2 to 9.5.

This species has been found as a fossil at the following localities: By Lohman (1937, p. 22), Klamath Lake, Oregon, Holocene; (p. 26), Davis Lake district, Deschutes County, Oregon, Holocene; (pp. 21, 31), Terrebonne, Deschutes County, Oregon, Pleistocene; and (p. 42-43), Klamath Falls, Klamath County, Oregon, Pliocene?.

Suborder ARAPHIDINEAE Smith, H. L.
Family FRAGILARIACEAE Kützing
Subfamily FRAGILARIOIDEAE Schütt

Genus **Synedra** Ehrenberg, 1830

Synedra species.
(Plate 2, figure 7.)

Characters used for specific identification were not found on any specimens of this genus from the Mono Lake assemblage. All forms were badly corroded, probably owing to the leaching activity of alkaline solutions after deposition, or the contact of the frustules with alkaline waters while the diatoms were living. This corrosion is very common in fossil diatoms. This form ranges from 0.1905 to 0.2150 mm. in length and from 0.0150 to 0.0195 mm. in breadth.

Suborder MONORAPHIDINEAE Østrup
Family ACHNANTHACEAE Kützing
Subfamily COCCONEIOIDEAE Kützing

Genus Cocconeis Ehrenberg, 1833

Cocconeis placentula Ehrenberg.

(Plate 2, figures 8, 11.)

Cocconeis placentula EHRENBERG, 1838. Infusionsthierchen, p. 194. VAN HEURCK, 1880. Syn. Diat. Belgique, p. 133, pl. 30, figs. 26, 27. DE TONI, 1891. Syl. Algarum, p. 454. SCHMIDT, 1894. Atlas Diat., pl. 192, figs. 38-44, 46, 47, 49, 50. BOYER, 1927. Syn. N. American Diat., p. 244. HUSTEDT, 1930. Bacillariophyta, p. 189, fig. 260; 1933, Kieselalgen, p. 347, fig. 802, a. b. LOHMAN, 1938. Pliocene Diat. Kettleman Hills, California, p. 83.

Cocconeis placentula var. *lineata* (Ehrenberg), CLEVE, 1895. Naviculoid Diat., p. 169. MEISTER, 1912. Kieselalgen Schweiz, p. 94, pl. 12, fig. 6, 7. HUSTEDT, 1930, Bacillariophyta, p. 190, fig. 262; 1933, Kieselalgen, p. 348, fig. 802 d.

Cocconeis euglypta EHRENBERG, 1854. Mikrogeologie, pl. 34, gr. 6 A, fig. 2.

Cocconeis lineata var. *euglypta*, VAN HEURCK, 1880. Syn. Diat. Belgique, pl. 30, figs. 33, 34.

Cocconeis placentula var. *euglypta*, CLEVE, 1895. Naviculoid Diat., p. 170. HUSTEDT, 1930. Bacillariophyta, p. 190, fig. 261; 1933, Kieselalgen, p. 349, fig. 802 c.

Cocconeis pellucida var. *lineata* Grunow, PERAGALLO, 1897. Diat. France, pl. 3, figs. 22, 23.

Cocconeis bonnieri HERIBAUD AND PERAGALLO, 1903. Diat. Fos. d'Auvergne, pl. 11, Figs. 24, 25.

These forms from Panamint Valley deposit are characterized by a distinct linear, somewhat lanceolate medial line. Under low magnification, the valve surfaces appear to have many wavy lines, but properly resolved, fine puncta appear in their place (as shown in the illustrations on plate 2). These forms range from 0.0201 to 0.0360 mm. in length and from 0.0135 to 0.0270 mm. in breadth.

Many diatomists may be inclined to call the illustrated form on plate 2, figure 11, *Cocconeis placentula* var. *lineata* or *C. lineata*, while other diatomists may refer the illustration on plate 2, figure 8, to *Cocconeis placentula* var. *euglypta*. It is doubtful, however, that these "varieties" really have taxonomic and therefore phylogenetic significance.

Cocconeis placentula has been reported from many freshwater fossil deposits. Ehrenberg (1870, table 12 opposite p. 68), reported it from Fall River and Columbia River, Oregon and from the Great Salt Lake area in Utah. Patrick (1936, p. 160) also reported the species from the Great Salt Lake area and stated that *Cocconeis placentula* is a euryhaline species. Boyer (1926b, table opposite p. 26, column E) recorded the species from deposits from Pukaist Creek, Kamloops District, and from Vancouver Island, British Columbia. Tempère and Peragallo (1915) reported it from many western North American deposits such as Orcas Island, Puget Sound, Washington (p. 179); "Washington County" (p. 311); Pit River, California (originally reported as "Pitt River, Oregon" (p. 312). Lohman (1937) reported the species from a deposit at Klamath Lake, Oregon (p. 22); from Burns, Harney County, Oregon (p. 34), and Terrebonne, Deschutes County, Oregon (p. 31). Hasler and Crawford (1938) p. 25) reported a marl deposit south of Sevier Lake, Millard County, Utah, Pleistocene. Lohman (1935, p. 456) reported it from a Quaternary deposit at Clovis, New Mexico, and stated that the species is now "...living sparingly in freshwater lakes, but more frequently in saline lakes and brackish estuaries." Hanna and Grant (1929, p.91) reported the species from the Etchegoin formation, Kettleman Hills, Fresno County, California.

Suborder BIRAPHIDINEAE Hustedt

Family NAVICULACEAE Kützing

Subfamily NAVICULOIDEAE Schütt

Genus **Navicula** Bory, 1822

Navicula oblonga (Kützing).

(Plate 2, figure 5.)

Frustulia oblonga KÜTZING, 1834. Syn. Diatomearum, p. 20, pl. 2, fig. 24.
Navicula oblonga KÜTZING, 1844. Bacillarien, p. 97, pl. 4, fig. 21. SCHMIDT, 1876. Atlas Diat., pl. 47, figs. 63-68. VAN HEURCK, 1880. Syn. Diat. Belgique, p. 81, pl. 7, fig. 1. DE TONI, 1891. Syl. Algarum, p. 37. CLEVE, 1895. Naviculoid Diat., p. 21. BOYER, 1916. Diat. Philadelphia, p. 97, pl. 27, fig. 21; 1927, Syn. N. American Diat., p. 395. HUSTEDT, 1930. Bacillariophyta, p. 307, fig. 550.
Pinnularia oblonga WM. SMITH, 1853. British Diat., p. 55, pl. 18, fig. 165.

This diagnostic species is characterized by terminal convergent striae that are angularly bent. There are about seven striae in 0.01 mm. This form ranges from 0.0800 to 0.1100 mm. in length and from 0.0100 to 0.0150 mm. in breadth.

A very striking but not very abundant species found in the Panamint Valley beds is *Navicula oblonga*. Tempère and Peragallo (1915, p. 180) reported it in Big Lake, Arlington, Washington, living. Bailey (1921, p. 7) found it living in brackish water at Little and Big Quill lakes, Saskatchewan, and (p. 8) at Airdrie, Alberta. Sovereign (1958, p. 20) gave the location of Emerald Pool, Crater Lake, Oregon and stated that this seems to be a common species in the Pacific northwest, especially in more alkaline waters with a pH of 7.0 to 9.0.

In the fossil record, *Navicula oblonga* has been reported by Patrick (1936, p. 163) from Great Salt Lake, Utah, in fresh to brackish water. Ehren-

PLATE 1

Figure 1. *Melosira undulata* (Ehrenberg) Kützing. Hypotype no. 3460. (Calif. Acad. Sci., Dept. Geol. Type Coll.), from locality 37055 (CAS), Panamint Valley, California, Pleistocene. Diameter 0.0640 mm. ×735.

Figure 2. *Stephanodiscus niagarae* Ehrenberg. Hypotype no. 3461. (Calif. Acad. Sci., Dept. Geol. Type Coll.) from locality 37055 (CAS), Panamint Valley, California, Pleistocene. Diameter 0.0870 mm. ×400.

Figure 3. *Campylodiscus noricus* var. *hibernica* (Ehrenberg) Grunow. Hypotype no. 3535 (Calif. Acad. Sci., Dept. Geol. Type Coll.), from locality 37055 (CAS), Panamint Valley, California, Pleistocene. Diameter 0.0715 mm. ×615.

Figure 4. *Surirella ovata* var. *utahensis* Grunow. Hypotype no. 3536. (Calif. Acad. Sci., Dept. Geol. Type Coll.), from locality 37113 (CAS), Mono Lake, California, Pleistocene. Length 0.0903, width 0.0920 mm. ×450.

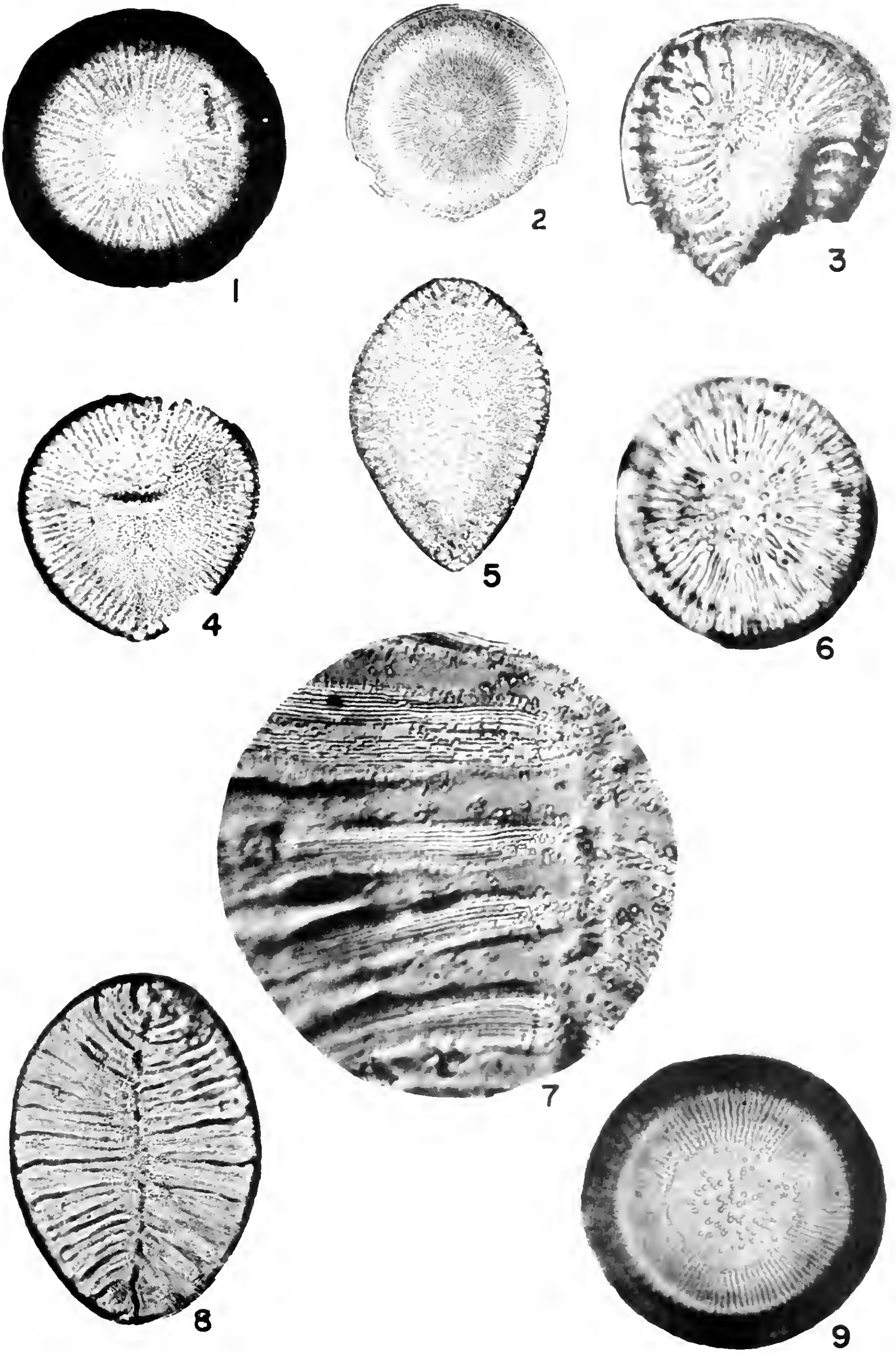
Figure 5. *Surirella ovalis* Brebisson. Hypotype no. 3537. (Calif. Acad. Sci., Dept. Geol. Type Coll.), from locality 37113 (CAS), Mono Lake, California, Pleistocene. Length 0.0870, width 0.0590 mm. ×550.

Figure 6. *Cyclotella compta* (Ehrenberg) Kützing. Locality 37055 (CAS), Panamint Valley, California, Pleistocene. Diameter 0.0190 mm. ×2250.

Figure 7. *Surirella striatula* var. *testudo* Ehrenberg. Hypotype no. 3538. (Calif. Acad. Sci., Dept. Geol. Type Coll.), from locality 37113 (CAS), Mono Lake, California, Pleistocene. Same specimen as figure 8 enlarged to show details of the valve surface. × 2000.

Figure 8. *Surirella striatula* var. *testudo* Ehrenberg. Hypotype no. 3538. (Calif. Acad. Sci., Dept. Geol. Type Coll.), from locality 37113 (CAS), Mono Lake, California, Pleistocene. Length 0.1400, width 0.1060 mm. ×400.

Figure 9. *Cyclotella compta* (Ehrenberg) Kützing. Hypotype no. 3448. (Calif. Acad. Sci., Geol. Dept. Type Coll.), from locality 37055 (CAS), Panamint Valley, California, Pleistocene. Diameter, 0.0480 mm. ×1000.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berg (1870, table 12 opposite p. 68) reported the species from a Great Salt Lake deposit and also from "Fall River, Oregon." Boyer (1926b, table opposite p. 26, column E) listed Pukaist Creek, Kamloops District and Deadman River, north of Kamloops Lake, British Columbia. Hasler and Crawford (1938, p. 26) reported it from a marl south of Sevier Lake, Millard County, Utah, Pleistocene. In Mexico, Ehrenberg, (1869, table opposite p. 60) reported it from Barranca Honda [freshwater fossil].

Genus **Pinnularia** Ehrenberg, 1840

Pinnularia viridis (Nitzsch), Ehrenberg.

(Plate 2, figure 4.)

Bacillaria viridis NITZSCH, 1817. Beitrag Infusorienkunde, p. 97, pl. 6, figs. 1-3.
Pinnularia viridis (Nitzsch), EHRENBERG, 1841 [1843]. Verbreitung und Einfluss des mikroskopischen Lebens in Süd- und Nord-Amerika, pl. 1, gr. 1, figs. 4, 7; gr. 3, fig. 3; pl. 2, gr. 1, fig. 22 [see MILLS, 1934, p. 1309]. CLEVE, 1895. Naviculoid Diat., p. 91. DE TONI, 1891. Syl. Algarum, p. 11. BOYER, 1927. Syn. N. American Diat., p. 446. HUSTEDT, 1930. Bacillariophyta, p. 334, fig. 617a; 1949. Süsswasser-Diat. Albert Park, p. 109, pl. 6, fig. 21. PATRICK, 1936. Diat. Siam and Malay States, p. 427.
Navicula viridis (Nitzsch), EHRENBERG, 1876. Infusionsthierchen, p. 182, pl. 13, fig. 16; pl. 21, fig. 12. KÜTZING, 1844. Bacillarien, p. 97, pl. 30, fig. 12. SCHMIDT, 1876. Atlas Diat., pl. 42, figs. 11-14.

It is important to call attention to the complex undulating raphe, and the terminal comma-shaped fissure so common in this species. There are about six striae in 0.01 mm. This form ranges from 0.2200 to 0.2300 mm. in length and from 0.0330 to 0.0395 mm. in breadth and is therefore somewhat larger than those recorded by Cleve (1895, p. 91) and Hustedt (1930, p. 334). It differs from *Pinnularia flexuosa* Cleve (1895, p. 93), which has 4.4 to 4.5 striae in 0.01 mm. This species is not common in the Panamint Valley deposit.

Although *Pinnularia viridis* is very commonly found in freshwater lakes in western North America, it was rare in the "Panamint Valley" samples. It has been reported living from the following localities: Ehrenberg (1841, p. 36), Kotzebue Sound, Alaska; Cleve (1895, p. 91), Santa Rosa Mountains and Sierra Nevada; Bailey (1921, p. 8), Airdrie, Alberta, brackish water; Tempère and Peragallo (1915, p. 59), Tacoma, Washington; (p. 166, Orcas Island, Puget Sound, Washington; and (p. '80), Big Lake, Arlington, Washington.

Pinnularia viridis is one of the more common species in the western North America Cenozoic diatomaceous formations. It has been reported from the following localities: Patrick (1936, pp. 160, 162), Great Salt Lake, Utah, freshwater; Boyer (1926b, table opposite p. 26, column E), north end of Prospect Lake, Lake District, and Quamichan Lake, Vancouver Island, British

Columbia; six miles south of Chilliwack, and Pukaist Creek, Kamloops District, British Columbia; Ehrenberg (1870, table 12 opposite p. 68), Salt Lake, Utah; Humboldt Valley, Nevada; Truckee River, Nevada; Fall River and Columbia River, Oregon; Tempère and Peragallo (1915, p. 228), Orcas Island and Puget Sound, Washington; (p. 280), Lost Spring Ranch, California; (p. 310), Carson City, Nevada; (p. 312), Pit River, California; and (p. 328), Reno, Nevada. Ehrenberg (1869, p. 11), Nahe von Regla, 6114′; (p. 12), Istalahuaca, 7740′; and (p. 18), Guadalupe Hidalgo, Mexico. Lohman (1935, p. 456), Clovis, New Mexico, Quaternary. Boyer (1926b, p. 9), Blackwater River, Cariboo and Coast Districts, British Columbia, Tertiary. Lohman (1937, p. 84), Kettleman Hills, Kings County, California, Pliocene, Tulare formation. Mann (1926, p. 53), Mica, near Spokane, Washington, Miocene, Latah formation.

Genus **Anomoeoneis** Pfitzer, 1871

Anomoeoneis costata (Kützing), Hustedt.

(Plate 2, figures 1, 2.)

Navicula costata KÜTZING, 1844. Bacillarien, p. 93, pl. 3, fig. 56.
Anomoeoneis costata (Kützing), HUSTEDT, 1959. Kiesselalgen, p. 744, fig. 1111.
Anomoeoneis polygramma Ehrenberg, CLEVE, 1895. Naviculoid Diat., p. 6. BOYER, 1927. Syn. N. American Diat., p. 324.
Anqmoeoneis polygramma var. *pannonica,* FRENGUELLI, 1934. Diat. Plioceno Superior, p. 355, pl. 2, fig. 9.
Anomoeoneis sculpta (Ehrenberg), HANNA and GRANT, 1931. Diat. Pyramid Lake, Nevada, p. 285, pl. 25, figs. 7, 8.
Anomoeoneis sphaerophora (Ehrenberg), HANNA, 1932. Pliocene Diat. Kansas, p. 373, pl. 31, fig. 3.
Anomoeoneis sphaerophora var. *polygramma* (Ehrenberg), O. Müller, HUSTEDT, 1930, Bacillariophyta, p. 262, fig. 425.
Navicula bohemica EHRENBERG, 1854. Mikrogeologie, pl. 10, gr. 1, fig. 4a, b. SCHMIDT, 1877. Atlas Diat., pl. 49, figs. 43-45. PERAGALLO, 1897. Diat. France, p. 62, pl. 8, fig. 1.
Navicula perdurrans PANTOCSEK, 1902. Balaton Floraja, p. 58, pl. 5, fig. 120.
Navicula rostrata Ehrenberg, ELMORE, 1921. Diat. Nebraska, p. 86, pl. 11, figs. 390-392.

This robust species, abundant in the Mono Lake assemblage, is characterized by obtuse apices. The broad axial area is bordered by a row of puncta that more or less converge from the transverse central area toward the apices. There are 13-16 transverse striae in 0.01 mm. Size ranges from 0.1060 to 0.2070 mm. in length and from 0.0295 to 0.0560 mm. in breadth. An outline of history of this "*Anomoeoneis sphaerophora-Anomoeoneis costata*" complex, can be found in Hanna (1932, p. 373-375), and Hustedt (1959, pp. 746-747).

This is the most abundant and characteristic species in either of the two deposits. It was originally described from Saxony, "Im Bergmehl von St. Fiore," by Kützing (1844, p. 93). Tempère and Peragallo (1915, p. 180) reported the species living from several localities: Big Lake, Arlington, Washington [originally recorded as "Big Lake, Arlington - Washington Co."], and (p. 165) Orcas Island, Puget Sound, Washington [originally as "Climacum Valley - Orcas Islands"]; (p. 193) ["Swan Lake, Klamath City [County], Oregon"]. Boyer (1927 p. 324) reported it from the Gulf of California, and considered it to be characteristic of brackish water.

This species has been reported from the following fossil deposits: Ehrenberg (1870, table 12 opposite page 68, pl. 1, gr. 1, fig. 2; pl. 2, gr. 1, fig. 34); Tempère and Peragallo (1915, p. 328), Reno Nevada; Lohman (1935, p. 456), Clovis, New Mexico. He stated that individuals of this species, "...are living sparingly in freshwater lakes, but more frequently in saline lakes and brackish estuaries." Lohman (1937, p. 34), "freshwater pond deposits, Burns, Harney County, Oregon, Pleistocene." According to Hanna (1932, p. 376), "At the present time it [*A. costata*] is a definite indicator of more or less saline waters."

Subfamily Pleurosigmoideae Heiden and Kolbe

Genus **Gyrosigma** Hassal, 1845

Gyrosigma attenuatum (Kützing), Rabenhorst.

(Plate 2, figures 6, 10.)

Frustulia attenuata Kützing, 1833. Algarum aquae dulcis Germaniae, Decas 9.

Gyrosigma attenuatum (Kützing), Rabenhorst, 1853. Süsswasser-Diat., p. 47, pl. 5, fig. 2. Cleve, 1894. Naviculoid Diat., p. 115. Elmore, 1921. Diat. Nebraska, p. 106, pl. 23, fig. 857. Boyer, 1927. Syn. N. Amer. Diat., p. 455. Hustedt, 1930. Bacillariophyta, p. 224, fig. 330. Lohman, 1938. Pliocene Diat. Kettleman Hills, California, p. 84, 1852.

Pleurosigma attenuatum Wm. Smith, 1852. Notes on Diat. p. 11, pl. 2, figs. 11-13, 18. 1853, British Diat., vol. 1, p. 68, pl. 22, fig. 216. Peragallo, 1891, Mono. *Pleurosigma*, p. 16, pl. 7, fig. 9. De Toni, 1891. Syl. Algarum, p. 248.

Pleurosigma attenuatum var. *caspium* Grunow, Peragallo, 1891. Mono. *Pleurosigma*, p. 18, pl. 7, fig. 8.

Pleurosigma attenuata Kützing, Van Heurck, 1880. Syn. Diat. Belgique, p. 117, pl. 21, fig. 11.

Pleurosigma hippocampus Wm. Smith, Peragallo, 1891. Mono. *Pleurosigma*, p. 18, pl. 7, figs. 4-7. Van Heurck, 1880. Syn. Diat. Belgique, p. 117, pl. 20, fig. 3.

The central or nearly central median line, is slightly sigmoidal in outline. The transverse striae are not as well developed or as close together as the longitudinal striae. The transverse striae number about 12 in 0.01 mm., while the longitudinal striae about 14 in 0.01 mm. This form ranges from 0.2090 to 0.2250 mm. in length, and from 0.0220 to 0.0270 in breadth.

Only a few individuals of *Gyrosigma attenuatum* were found in the Panamint Valley samples. Tempère and Peragallo (1915, pp. 144, 203) reported it from "Yagiana [=Yaquina] Bay, Oregon"; and (p.180) from Big Lake, Arlington, Washington. Bailey (1921, p. 7) reported it from the Little and Big Quill lakes, Saskatchewan, living in brackish water.

Gyrosigma attenuatum has been reported from the following fossil deposits: Lohman (1935, p. 456) Clovis, New Mexico, Quaternary; Lohman (1937, p. 84), Kettleman Hills, Fresno County, California, Pliocene, Tulare formation; Lohman (1934, pp. 10-11), Tipton, Oregon, Miocene, Mascal formation.

Family CYMBELLACEAE Agardh
Subfamily CYMBELLOIDEAE Karsten

Genus **Cymbella** Agardh, 1830

Cymbella mexicana (Ehrenberg) Cleve.

(Plate 2, figure 7.)

Cocconema mexicanum EHRENBERG, 1844. Einfluss des unsichtbar kleinen organischen Lebens aus die Bildung von Bimestein, Tuff und anderen vulkanischen Gesteinen, p. 342; 1854, Mikrogeologie, pl. 33, gr. 7, figs. 6, 7. SCHMIDT, 1875. Atlas Diat., pl. 10, figs. 32, 33? WOLLE, 1890. Diat. N. America, pl. 6, fig. 4.

Cymbella mexicana (Ehrenberg) CLEVE, 1894. Naviculoid Diat., p. 177. HANNA and GRANT, 1931. Diat. Pyramid Lake, Nevada, p. 287, pl. 25, fig. 3. HUSTEDT *in* SCHMIDT, 1931. Atlas Diat., pl. 376, figs. 1, 2. HANNA, 1938. Pliocene Diat. Kansas, pl 379, pl. 32, fig. 4. LOHMAN, 1938. Pliocene Diat. Kettleman Hills, California, p. 84, pl. 23, fig. 14. OKUNO, 1956. Elect.-Micro. Fos. Diat., p. 136, pl. 21, figs. 2 a-c. SOVEREIGN, 1958. Diat. Crater Lake, Oregon, p. 125.

Cymbella kamtschatica GRUNOW *in* SCHMIDT, 1875. Atlas Diat., pl. 10, fig. 31.

Cymbella gastroides Kützing, HANNA and GRANT, 1929. Brackish-water Pliocene Diat., Etchegoin formation, California, p. 92, pl. 12, fig. 3.

This conspicuous diatom is characterized by a distinct stigma in the middle of the central nodule. The costae, about six to eight in 0.01 mm., are coarsely punctate, with 10 to 12 puncta in 0.01 mm., and are usually alternately long and short in the central portion of this particular form. Valves range in length from 0.0143 to 0.01780 mm. and in breadth from 0.0320 to 0.0360. It is common in the Panamint Valley assemblage.

Cymbella mexicana was first described by Ehrenberg (1844) from a diatomite locality in Mexico. Cleve (1894, p. 177) reported it living in fresh water in Washington and Vancouver Island. Tempère and Peragallo (1915) p. 194) reported the species from Swan Lake, Klamath County, Oregon; (p. 59), Tacoma, Washington; (p. 165), Orcas Island, Puget Sound, Washington; (p. 179), Big Lake, Arlington, Washington. Hanna and Grant (1931, pp. 287-288), reported it from Pyramid Lake, Nevada, living, brackish water, and stated that

Cymbella mexicana is very common in many lakes in the western part of North America, especially those slightly saline. Sovereign (1958, p. 125), reported it from Crater Lake, Emerald Pool, Diamond Lake, and Upper Klamath Lake, Oregon, living in waters with a pH of 7.0 to 9.0.

This species has been found in the following fossil deposits in western North America: Boyer (1926, table opposite p. 26, column E), Deadman River, north of Kamloops Lake, British Columbia. Ehrenberg (1869, p. 11), near Tulancingo, Stadt Mexiko A. 6840'; (p. 12), Istlahuaca, 7740'; (p. 13), San Andres Chalchicomula, 7100', Stadt Mexiko B. 6480'; Hacienda Escalera A.; (p. 20), Stadt Mexiko K. 6840', (p. 21), Stadt Mexiko L. 6840', and Hacienda Escalera D., all in Mexico. Tempère and Peragallo (1915) (p. 279), Lost Spring Ranch, (p. 312), Pit River, California. Okuno (1956, p. 139), Terrebonne, Oregon. Lohman (1937, p. 84), Kettleman Hills, Kings County, California, Pliocene, Tulare formation, fresh to brackish water, and the upper part of the Etchegoin formation, fresh to brackish water. Hanna and Grant (1929, p. 92), Kettleman Hills, Fresno County, California, Pliocene, Etchegoin formation.

Family EPITHEMIACEAE Grunow

Subfamily EPITHEMIOIDEAE Hustedt

Genus **Epithemia** Brébisson, 1838

Epithemia argus (Ehrenberg) Kützing.

(Plate 2, figure 12.)

Eunotia arcus EHRENBERG, 1838. Infusionsthierchen, p. 191, pl. 21, fig. 22.

Epithemia argus (Ehrenberg) KÜTZING, 1844. Bacillarien, p. 35, pl. 29, fig. 55. FRICKE *in* SCHMIDT, 1904. Atlas Diat., pl. 251, figs. 12, 14. BOYER, 1916. Diat. Philadelphia, pl. 31, figs. 15, 21; 1927, Syn. N. American Diat., p. 489. HUSTEDT, 1930. Bacillariophyta, pp. 383-384, fig. 727a.

Epithemia argus (Ehrenberg) Kützing var. *alpestris* GRUNOW, 1860. Ueber neue oder ungenugend gekannte Algen, pl. 3, fig. 28. GRUNOW, 1862. Österreichischen Diat., p. (329) 15.

Epithemia argus (Ehrenberg) var. *amphicephala,* GRUNOW *in* VAN HEURCK, 1881. Syn. Diat. Belgique, pl. 31, fig. 19.

Epithemia argus (Ehrenberg) var. *angusta,* FRICKE *in* SCHMIDT, 1904. Atlas Diat., pl. 251, fig. 5.

Epithemia argus (Ehrenberg) var. *capitata,* FRICKE *in* SCHMIDT, 1904. Atlas Diat., pl. 251, fig. 14.

Epithemia alpestris WM. SMITH, 1853. British Diat., pl. 1, fig. 7.

Eunotia argus EHRENBERG, 1854. Mikrogeologie, pl. 15, gr. A, fig. 59.

Eunotia comta EHRENBERG, 1840. Characteristik von 274 neuen Arten von Infusorien, p. 210; 1854, Mikrogeologie, pl. 6, gr. 2, fig. 17 e-f.

Cystopleura argus (Ehrenberg) KUNTZE, 1891. Rev. Gen. Plant., p. 891. DE TONI, 1892. Syl. Algarum, p. 782. ELMORE, 1921. Diat. Nebraska, p. 129, fig. 661; pl. 23, figs. 851, 854.

Several varieties of this species have been named. After searching the literature and different diatom strewn slides, all of them, with the exception of *Epithemia argus* var. *longicornis*, seem to grade into one another.

In zone (edge) view the frustule is rectangular and characterized by two rows of large nodules which are formed from the thickening of robust costae. These are about one to two costae in 0.01 mm. A well developed canal raphe extends almost to the dorsal margin of the valve. This species varies considerably.

Although this species is abundant in the Panamint Valley fossil assemblage, it has been reported living from only one western locality: Tempère and Peragallo (1915, p. 179), Big Lake, Arlington, Washington.

It has been reported from many fossil deposits, such as: Patrick (1936 p. 164), Great Salt Lake, Utah. Ehrenberg (1870, table opposite p. 68), has also reported this species from the same area. Hasler and Crawford (1938, p. 25), south of Sevier Lake, Millard County, Utah, Pleistocene. Boyer (1926b, table opposite p. 26, column E), north of Kamloops Lake, British Columbia. Ehrenberg (1870, table 12 opposite p. 68), Fall River, Oregon. Tempère and Peragallo (1915, p. 179), Lost Spring Ranch, California. Lohman (1935, pp. 455, 457), Clovis, New Mexico, Quaternary. He stated that *Epithemia argus* is, "...living in fresh-water lakes, but more frequently in saline lakes and brackish estuaries." Ehrenberg (1869, p. 13), San Andres Chalchicomula, 7200'; (p. 14), Stadt Mexiko C. 6840'; and (p. 20), Stadt Mexiko K. 6840'. Lohman (1937, p. 84), Kettleman Hills, Fresno County, California, Pliocene, Tulare formation.

Epithemia argus var. **longicornis** (Ehrenberg), Grunow.

(Plate 2, figure 13.)

Epithemia longicornis (Ehrenberg), WM. SMITH, 1853. British Diat., p. 13, pl. 30, fig. 247.

Epithemia argus var. *longicornis* GRUNOW, 1862. Österreich Diat. p. (329) 15. FRICKE *in* SCHMIDT, Atlas Diat., 1904, pl. 251, figs. 1, 6, 9. VAN HEURCK, 1881. Syn. Diat. Belgique, p. 139, pl. 31, figs. 15, 16. HUSTEDT, 1930. Bacillariophyta, p. 384, fig. 727.

This form is characterized by obtuse extremities (not capitate or constricted in any way). As such it seems to be a good variety. There are four or more striae (12-14 in 0.01 mm.) between two consecutive costae. The length of the valves range from 0.0550 to 0.0680 mm. while the breadth ranges from 0.0100 to 0.0120. Only a few individuals of this species were found in the Panamint Valley assemblage.

The variety *longicornis*, has not been reported living in western North America. It has been noted in fossil deposits, probably of Holocene age, from the Great Salt Lake area by Ehrenberg (1870, table 12 opposite p. 68). It has also been recorded from "Utah," probably near Great Salt Lake, by A. Schmidt (1904, pl. 251).

PLATE 2

Figure 1. *Anomoeoneis costata* (Kützing) Hustedt. Hypotype no. 3449. (Calif. Acad. Sci., Geol. Dept. Type Coll.), from locality 37113 (CAS), Mono Lake, California, Pleistocene. Length 0.2070 breadth 0.0560 mm. x 400.

Figure 2. *Anomoeoneis costata* (Kützing) Hustedt. Locality 37113 (CAS), Mono Lake, California, Pleistocene. Length 0.1860, breadth 0.0390 mm. x 475.

Figure 3. *Rhopalodia gibba* (Ehrenberg) O. Müller. Hypotype no. 3450. (Calif. Acad. Sci., Geol. Dept. Type Coll.), from locality 37055 (CAS), Panamint Valley, California, Pleistocene. Length 0.1340, breadth 0.0270 mm. x 700.

Figure 4. *Pinnularia viridis* (Nitzsch) Ehrenberg. Hypotype no. 3451. (Calif. Acad. Sci., Geol. Dept. Type Coll.), from locality 37055 (CAS), Panamint Valley, California, Pleistocene. Length 0.2430, breadth 0.0400 mm. x 375.

Figure 5. *Navicula oblonga* (Kützing). Hypotype no. 3452. Calif. Acad. Sci., Geol. Dept. Type Coll.), from locality no. 37055 (CAS), Panamint Valley, California, Pleistocene. Length 0.0805, breadth 0.0104 mm. x 600.

Figure 6. *Gyrosigma attenuatum* (Kützing) Rabenhorst. Hypotype no. 3453. (Calif. Acad. Sci., Geol. Dept. Type Coll.), from locality 37055 (CAS), Panamint Valley, California, Pleistocene. Length 0.2140, breadth 0.0250 mm. x 20.

Figure 7. *Dynedra* sp., Hypotype no. 3454. (Calif. Acad. Sci., Geol. Dept. Type Coll.), from locality 37113 (CAS), Mono Lake, California, Pleistocene. Length 0.2040, breadth 0.0180 mm. x 470.

Figure 8. *Cocconeis placentula* Ehrenberg. Hypotype no. 3455. (Calif. Acad. Sci., Geol. Dept. Type Coll.), from locality 37055 (CAS), Panamint Valley, California, Pleistocene. Length 0.0280, breadth 0.0170 mm. x 1570.

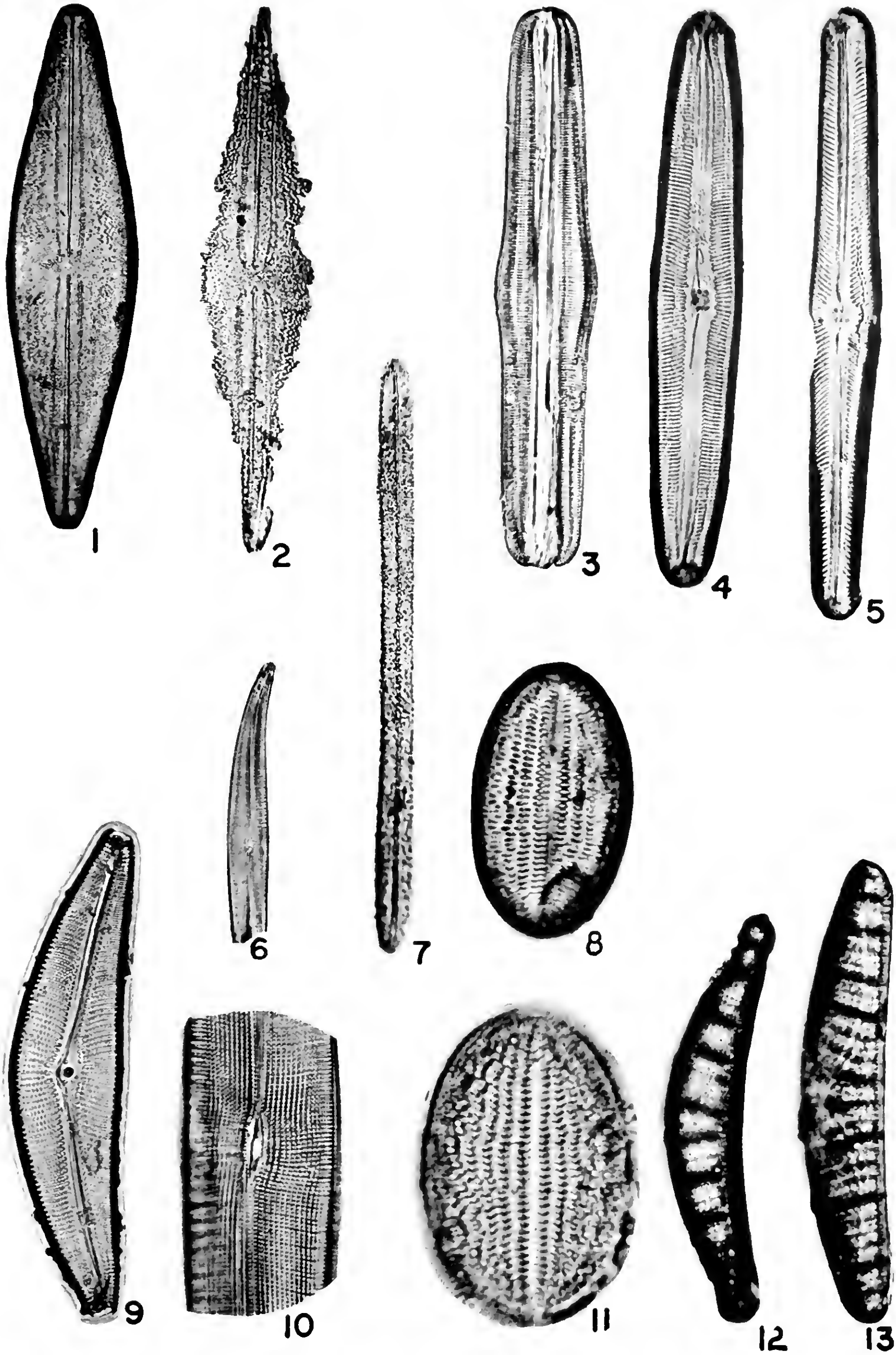
Figure 9. *Cymbella mexicana* (Ehrenberg) Cleve. Hypotype no. 3456. (Calif. Acad. Sci., Geol. Dept. Type Coll.), from locality 37055 (CAS), Panamint Valley, California, Pleistocene. Length 0.1510, breadth 0.0320 mm. x 1200.

Figure 10. *Gyrosigma attenuatum* (Kützing) Rabenhorst. Same specimen as in figure 6, enlarged to show details of valve. x 1000.

Figure 11. *Cocconeis placentula* Ehrenberg. Hypotype no. 3457. (Calif. Acad. Sci., Geol. Dept. Type Coll.), from locality 37055 (CAS), Panamint Valley, California, Pleistocene. Length 0.0260, breadth 0.0190 mm. x 2000.

Figure 12. *Epithemia argus* (Ehrenberg) Kützing. Hypotype no. 3458. (Calif. Acad. Sci., Geol. Dept. Type Coll.), from locality 37055 (CAS), Panamint Valley, California, Pleistocene. Length 0.0665, breadth 0.0125 mm. x 1000.

Figure 13. *Epithemia argus* var. *longicornis* Grunow. Hypotype no. 3459. (Calif. Acad. Sci., Geol. Dept. Type Coll.), from locality 37055 (CAS), Panamint Valley, California, Pleistocene. Length 0.0550, breadth 0.0100 mm. x 1365.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Subfamily Rhopalodoideae Hustedt

Genus **Rhopalodia** O. Müller, 1897

Rhopalodia gibba (Ehrenberg) O. Müller.

(Plate 2, figure 3.)

Navicula gibba Ehrenberg, 1830 [1832]. Beiträge zur Kenntniss der Organisation der Infusorien und ihrer geographischen Verbreitung, besonders in Siberien, p. 64.
Rhopalodia gibba (Ehrenberg), O. Müller, 1897. *Rhopalodia*, neues Genus Bacill., p. 65, pl. 1, figs. 15-17. Hustedt *in* Schmidt, 1905. Atlas Diat., pl. 253, figs. 1-13. Schonfeldt, 1907. Deutschen Diat., p. 206, pl. 14, fig. 14. Meister, 1912. Kieselalgen Schweiz, p. 200, pl. 35, fig. 6. Boyer, 1916. Diat. Philadelphia, p. 112, pl. 31, fig. 23; 1927. Syn. Diat. N. America, p. 481. Hustedt, 1930. Bacillariophyta, p. 390, fig. 740. Hanna, 1932. Pliocene Diat. Kansas, p. 386, pl. 34, figs. 2, 3. Patrick, 1936. Diat. Siam and Malay States, p. 428; 1936, Diat. Linseley Pond, Connecticut, p. 86. Lohman, 1937. Pliocene Diat. Kettleman Hills, California, p. 84, pl. 23, figs. 1, 2. Krasske, 1939. Kieselalgenflora Sudchiles, p. 408.
Epithemia gibba Kützing, 1844. Bacillarien, p. 35, pl. 4, fig. 22. Van Heurck, 1881. Syn. Diat. Belgique, p. 139, pl. 32, figs. 1, 2. Wolle, 1890. Diat. N. America, pl. 35, figs. 1, 2, 8, 9.
Cystopleura gibba (Ehrenberg) Kuntze, 1891. Rev. Gen. Plant., p. 891. Elmore, 1921. Diat. Nebraska, p. 127, pl. 17, fig. 654.
Eunotia gibba Ehrenberg, Bailey *in* Fremont, 1842-1844 [1845]. Rept. Explor. Exp., p. 302, pl. 5, figs. 4, 5.

The raphe is characteristically found along the convex edge or keel of the linear valves in this genus (not present in view shown on plate 2, figure 3). The central portion of the frustule is gibbous, while the ends tend to be slightly reflexed. There are about seven costae in 0.01 mm. The length ranges from 0.1240 to 0.1310 mm. and in breadth from 0.0280 to 0.3050 mm.

A few individuals of *Rhopalodia gibba* were found in the Panamint Valley samples. The species was originally described by Ehrenberg (1830 [1832], p. 64) from a locality in Siberia. Tempère and Peragallo (1915, p. 59) have reported it from Tacoma, Washington; (p. 165), Orcas Island, Puget Sound, Washington; (p. 179), Big Lake, Arlington, Washington; and (p. 194), Swan Lake, Klamath County, Oregon. Sovereign (1958, p. 127) reported the species living in waters with a pH of 6.0 to 11.0 but having its optimum in water with a pH of 9.0, in Emerald Pool and Diamond Lake, Oregon.

Rhopalodia gibba has been reported in fossil deposits from Canada to Mexico, such as: Boyer (1926b, table opposite p. 26, column E), near Cobble Hill, Vancouver Island, British Columbia. Patrick (1936, p. 162), Great Salt Lake, Utah [Holocene], fresh to brackish water. Ehrenberg (1870, table 12 opposite p. 68), Truckee River, Nevada. Tempère and Peragallo (1915) (p. 280), Orcas Island, Puget Sound, Washington; (p. 328), Reno, Nevada. Bailey (1845, p. 302), Deschutes Rives, Oregon, freshwater, fossil. Lohman (1935, pp. 455-457), "...living sparingly in fresh-water lakes, but more frequently in saline lakes and brackish estuaries."; Lohman (1938, pp. 84, 90), Kettleman Hills, Kings County, California, Pliocene, Tulare formation, fresh to brackish water.

Suborder SURIRELLINEAE West

Family SURIRELLACEAE Kützing
Subfamily SURIRELLOIDEAE Schütt

Genus **Surirella** Turpin, 1928

Surirella ovalis Brébisson.

(Plate 1, figure 5.)

Surirella ovalis BRÉBISSON, 1838. Considerations sur les Diatomées et essai d'une classification des genres et des espèces appartenant a cette famille, p. 17. KÜTZING, 1844. Bacillarien, p. 61, pl. 30, fig. 64. RABENHORST, 1853. Süsswasser-Diat., p. 30, pl. 3, fig. 24. WM. SMITH, 1853. Syn. British Diat., p. 33, pl. 9, fig. 68. PRITCHARD, 1861. Infusoria, p. 796. SCHMIDT, 1885 [1875], pl. 24, figs. 1-4. VAN HEURCK, 1881. Syn. Diat. Belgique, p. 188, pl. 73, figs. 2-4. BOYER, 1927. Syn. N. American Diat., p. 541. HUSTEDT, 1930. Bacillarophyta, p. 441, figs. 860, 861.

Valves ovate and somewhat lanceolate. The apices of the valves are both cuneate or rounded or one may be rounded and the other cuneate. One end of the valve is usually somewhat broader than the other. The costae are short, marginal, and radiate. The central portion is indistinctly striated. This form ranges from 0.0710 to 0.0870 mm. in length and from 0.0410 to 0.0590 mm. in breadth. Hustedt (1930, pp. 440-445), has unraveled most of the confusion concerning the identification of *Surirella angusta, S. crumena, S. minuta, S. ovalis, S. ovata, S. pinnata, and S. salina.*

A few individuals of *Surirella ovalis* were found in the sample from the Mono Lake beds. Although the species has been reported as living, it is probably fairly common in only one area of western North America; viz., in the brackish water of the Little and Big Quill lakes, in Saskatchewan, Canada, (Bailey, 1921, p. 7). It has been found in several fossil deposits. Lohman (1935, p. 457) reported the species in Quaternary lake beds from Clovis, New Mexico. He stated that the species is "...living sparingly in fresh-water lakes, but more frequently in saline lakes and brackish estuaries." Hasler and Crawford (1938, p. 26) noted its occurrence in a marl deposit of "Bonneville Age" (Pleistocene) from south of Sevier Lake, in Millard County, Utah.

Surirella ovata var. **utahensis** Grunow.

(Plate 1, figure 4.)

Surirella ovata Kützing, 1844. Bacillarien, p. 62, pl. 7, figs. 1-4. Boyer, 1927. Syn. N. American Diat., p. 541.

Surirella ovata var. *utahensis* Grunow *in* Schmidt, 1885 [1875]. Atlas Diat., pl. 24, figs. 11-13. Patrick, 1936. Diat. Great Salt Lake, p. 163.

Surirella ovalis Brébisson, Wolle, 1894 [1890]. Diat. N. America, pl. 53, figs. 7, 8.

Not *Surirella utahensis* Grunow, Hanna and Grant, 1929. Brackish-water Diat., Etchegoin formation, California, p. 100, pl. 14, fig. 6; 1931, Diat. Pyramid Lake, Nevada, p. 290, pl. 26, figs. 5, 6.

The distinguishing character of this variety is given in Grunow's original definition, "*S. ovata* K. var. *utahensis* Grunow. hat zu ausgepragte Eigenthumlichkeit, als dass ich sie unter *S. ovata* stellen mochte; man beachte die bogenformige Falte in der Mittel!" (Schmidt's Atlas Diat., 1885, pl. 24, figs. 11-13.)

This transverse fold is present on all forms of the variety, and is located about two-thirds the distance from the acute apex. The submarginal moderately long costae (four in 0.01 mm.) with fine striae between, radiate from an indistinct medial line. The forms range in length from 0.0820 to 0.1100 and in breadth from 0.0900 mm.

Surirella ovata var. *utahensis* is found in the lake beds at Mono Lake, but was first obtained in material from the Great Salt Lake area, Utah. It was also reported from a Holocene deposit in Great Salt Lake area by Patrick (1936, p. 163), who stated that the species is commonly found in fresh and brackish water.

Surirella striatula Turpin var. **testudo** Ehrenberg.

(Plate 1, figures 7, 8.)

Surirella Testudo Ehrenberg, 1840. Characteristik von 274 neuen arten von Infusorien, p. 215; 1869. Über mächtige Gegirgs-schichten vorherrschend aus Mikro. Bacill. unter und bei der Stadt Mexiko, pl. 1, gr. E, fig. E-4; 1870, Über die wachsende Kenntnis des unsichtbaren Lebens als felsbildende Bacillarien in Californien, pl. 1, figs. 1, 2; pl. 2, gr. 1, fig. 6. Hanna and Grant, 1931. Diat. Pyramid Lake, Nevada, p. 290, pl. 27, figs. 2-4, 1931.

Surirella striatula Turpin, Schmidt, 1875. Atlas Diat., pl. 24, fig. 17. Wolle, 1894 [1890]. Diat. N. America, pl. 55, fig. 6.

Not *Surirella striatula* Turpin, 1828. Observations sur le nouveau genus *Surirella*, p. 362, pl. 15.

Surirella baileyana Mackay or *S striatula* var. *baileyana* McKay, Bailey, 1921 [1922]. Diat. Saskatchewan, Albe a, p. 158, pl. 1, figs. 3-6. Boyer, 1927. Syn. N. American Diat., p. 539.

The diagnostic features of this variety are that the parallel valves of the frustule are twisted in the same plane, sometimes at both ends or sometimes just at one end. The pseudoraphe is therefore asymmetrical. Canaliculi are distinct, about 7-15 on each side of the valve surface; striae range between 15-20 in 0.01 mm. There is a distinct row of beads along the margin of each lobe. The diatom was fairly common in the Mono Lake bed sample.

This variety was originally described from the Great Salt Lake area, Utah, by Ehrenberg (1871, table 12 opposite p. 68), but it has never been determined whether or not these specimens were living or fossil. I think it is reasonable to assume that the sample was from a fossil deposit because Patrick (1936, p. 165) stated, "No diatom flora is found living in the lake proper today." She has, however, reported many individuals of this species from deposits in and around the Great Salt Lake area. These deposits are probably of Holocene age. According to L. W. Bailey (1921, p. 4), the species is living in the brackish waters of the Little and Big Quill lakes in Saskatchewan, Canada. Hanna (1939, p. 290) also has reported it living in the brackish waters of Pyramid Lake, Nevada.

In 1926 Mann (p. 53) reported the species from fresh to brackish water sediments of the Latah Formation, of Miocene age, exposed near the town of Mica, near Spokane, Washington. He made the following statement:

"This species seems to flourish in waters high in mineral content. It often holds its place in lakes that show a gradual increase in salinity after other species have been exterminated by the high percentage of salts. Thus in samples of borings made at the site of a prehistoric lake in the Black Rock district of Nevada, which slowly changed from fresh water to salt water, this species was the last diatom to succumb to the growing salinity. It is also sometimes the dominant species in such saline water as Devils Lake, N. Dak., and Salt Lake, Utah."

This variety, therefore, would be considered a euryhaline form.

Subfamily CAMPYLODISCOIDEAE Heiden and Kolbe

Genus **Campylodiscus** Ehrenberg, 1838

Campylodiscus noricus var. **hibernica** (Ehrenberg) Grunow.

(Plate 1, figure 3.)

Campylodiscus noricus var. *hibernicus* GRUNOW, 1862. Österreichischen Diatomaceen, p. (439) 125. MAYER, 1912. Bacill. Regensburger Gewasser, p. 347, pl. 26, fig. 4. HUSTEDT, 1914. Bacill. aus den Sudeten, p. 127; 1930, Bacillariophyta, p. 446, fig. 872. DAHM, 1956. Diatomeenuntersuchungen zur Geschichte der westlichen Ostsee, pl. 6, fig. 5. SOVEREIGN, 1958. Diat. Crater Lake, Oregon, p. 132.

Not *Campylodiscus noricus* var. *hibernicus* Grunow, MEISTER, 1912. Kieselalgen Schweiz, p. 231, pl. 43, fig. 2.

Campylodiscus costatus WM. SMITH, 1851. Notes on the Diatomaceae; *Campylodiscus, Surirella,* and *Cymatopleura,* p. 6, pl. 1, fig. 1; 1853, Brit. Diat., p. 29, pl. 6, fig. 52; pl. 7, fig. 52. MEISTER, 1912. Kieselalgen Schweiz, p. 230, pl. 47, fig. 3.

Campylodiscus hibernicus EHRENBERG, 1842. Samples of Infusorial Earths from the Mourne Mountains, Ireland, p. 337; 1845, Vorläufige zweite Mittheilung über die weitere Erkenntniss der Beziehungen des kleinsten organischen Lebens zu den vulkanischen Massen der Erde, p. 154; 1854, Mikrogeologie, pl. 15, gr. A, fig. 9. SCHMIDT, 1878 [1877]. Diat., pl. 55, fig. 13. WOLLE, 1894 [1890]. Diat. N. America, pl. 69, fig. 13.

Campylodiscus noricus Ehrenberg, MEISTER. 1912. Kieselalgen Schweiz, p. 230.

Campylodiscus noricus var. *costatus* Grunow, MEISTER, 1912. Kieselalgen Schweiz, p. 230, pl. 47, fig. 3.

Campylodiscus noricus var. *sublaevis* MEISTER, 1912. Kieselalgen Schweiz, p. 230, pl. 47, fig. 2.

This variety is characterized by robust costae, two in 0.01 mm., with many fine striae between. The central portion of the valve is usually finely punctate. Valves are usually bent or saddle-shaped. Size ranges from 0.0715 to 0.0750 mm. in diameter. Most of the confusion concerning *Campylodiscus costatus*, *C. noricus*, and their varieties has been resolved by Hustedt (1914, pp. 127, 128; 1930, pp. 446-448). Grunow originally spelled the name of this variety "*hibernicus*" (1860, p. 439), as did Hustedt (1914, p. 127). Hustedt then changed the spelling to "*hiberica*" (1930, p. 446), and was followed by Dahm (1956, pl. 6, fig. 5), and Sovereign (1958, p. 132).

One of the least common but most diagnostic species found in the Panamint Valley sample was *Campylodiscus noricus* var. *hibernica.* It has been reported in Big Lake, Arlington, Washington, by Tempère and Peragallo (1915, p. 179), and probably was living there. In 1958, Sovereign (p. 132) noted its occurrence in Diamond Lake and Upper Klamath Lake, Oregon, and he stated that the species was fairly common in the Pacific Northwest. He also noted that it was common in waters with a pH between 7.0 and 9.0 but that it had its optimum in waters with a pH of 8.0 to 9.0.

Campylodiscus noricus var. *hibernica* has been reported from only two fossil localities in western North America, both being noted by Tempère and Peragallo (1915). The first was from the Lost Spring Ranch, California, probably from a freshwater fossil deposit (p. 279). The second is from Conrad's Red Bluff, California, and is probably also from a freshwater fossil deposit (p. 426). The exact location of these places has not been found.

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