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Foraminifera from the Tertiary of California

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WITH TWO PLATES

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FORAMINIFERA FROM THE TERTIARY OF CALIFORNIA.

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PLATES XXIX, XXX.

INTRODUCTION.

IN consideration of the value of Foraminifera as indices of the relative age of a fossiliferous deposit, not so much with regard to isolated species, but with the general faunal aspect of the group, the present collection affords many points of interest.

Presuming the conditions of life and surroundings to be equal, we may fairly expect to find foraminiferal assemblages in many different areas of the earth's superficial deposits very closely related as to their percentage of species in common, provided they are comparable with one another, either homotaxially (with regard to higher groups of animal remains), or chronologically. On the other hand, we rarely find foraminiferal assemblages from deposits of decidedly different ages with a high percentage of species in common.

In March, 1897, I was favored by Dr. J. C. Merriam of the University of California with a sample of Tertiary marl from California, accompanied by a request that I would investigate the rock for its Foraminifera.

In November of the same year Dr. Merriam supplied me with further specimens of a somewhat similar rock, and which was richer in organisms than that first sent.

All the samples have now been examined and yield the following results.

The sample first received, labeled "Miocene (?) California," is a close-textured grey-brown marl. The fractured surface of the rock when examined with a lens reveals numerous foraminiferal shells, broken across, and with the chambers quite empty. This sample did not afford

any species which was not present in the richer sample received afterwards.

The second samples bear the label "from a well in Santa Clara Co." The rock is a grey-brown marl, somewhat paler than the first specimen, rather shaley, and crowded with Foraminifera, which appear as minute white specks disseminated through it.

The matrix of the foraminiferal marl when seen in a thin section is of a rich brown color, and appears to be derived from the decomposition of basaltic or palagonitic material.

From the fact that the foraminiferal shells have their chambers, in nearly all cases, quite empty, it seems reasonable to conclude that the enveloping mud was quickly hardened around the organisms; thus leaving the shells without an infilling, which is so usual elsewhere in the case of Foraminifera of these particular genera.

In making a comparison of the various foraminiferal faunas, we find that this of the Californian Tertiary has its nearest analogue in the beds of Monte Bartolomeo on the Lago di Garda, Italy, the Foraminifera of which were so well described and figured by Dr. Egger in 1895,[1] and classed as Older Pliocene. The Foraminifera of the two deposits are strikingly similar, with the chief difference that the Californian marl is not quite so rich in species.

Another noteworthy assemblage, containing a large proportion of the Californian species, is that of the tertiaries of the Vienna Basin, probably of Miocene age.[2]

The Miocene of America, so far as the beds have yet been examined for Foraminifera, does not yield a very large proportion of species in common with this present deposit, but bears a general resemblance to it. The Miocene beds of the States of New Jersey, Alabama, Virginia and Maryland have been examined for Foraminifera by Drs. A. Woodward[3] and R. M. Bagg.[4]

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[1] "Fossile Foraminiferen von Monte Bartolomeo am Gardasee," Jahresbericht XVI, des Naturhistorischen Vereins Passau, 1895.

[2] d'Orbigny, 1846, "Foraminifères fossiles du Bassin tertiare de Vienne." Paris.

[3] "Note on the Foraminiferal Fauna of Miocene Beds at Petersburg, Virginia." *Journ. N. York Microscopical Soc.*, Vol. III, 1887, pp. 16, 17. Also "Foraminifera found in the Borings from Artesian Wells located in New Jersey and Alabama." *Journ. N. York Micr. Soc.*, Jan., 1898, pp. 1–3.

[4] "The Tertiary and Pleistocene Foraminifera of the Middle Atlantic Slope." *Bull. Amer. Palæont.*, Vol. II, No. 10, 1898.

DESCRIPTION OF THE SPECIES.

Family TEXTULARIIDÆ.

Subfamily BULIMININÆ.

Bulimina *d'Orbigny* [1826].

Bulimina elongata *d'Orbigny*.

PLATE XXIX, FIG. 1.

Bulimina elongata D'ORBIGNY, 1846, Foram. Foss. Vien., p. 187, Pl. XI, figs. 19, 20.

Bulimina cocena HANTKEN, 1872, Jahrb. d. k. ung. geol. Anstalt, Bd. I, p. 136, Pl. II, fig. 16.

Bulimina elongata HANTKEN, 1875, ibid., Bd. IV, Pt. 1, pp. 61, 62, Pl. X, figs. 7 *a*, *b*. EGGER, 1895, Naturhist. Ver. Passau, Jahresber. XVI, pp. 15, 16, Pl. III, figs. 12 *a*, *b*. A. WOODWARD, 1898, Journ. N. York Micr. Soc., p. 1. BAGG, 1898, Bull. Amer. Palæont., Vol. II, No. 10, p. 316.

This species is quite typical in the present collection. It also occurs in many of the tertiary deposits of Europe, and it has been recorded by A. Woodward from the Miocene of Atlantic City, New Jersey, and by R. M. Bagg from Plum Point, Maryland, in beds of the same age.

Santa Clara County, California; very common.

Bulimina elegantissima *d'Orbigny*.

PLATE XXIX, FIG. 2.

Bulimina elegantissima D'ORBIGNY, 1839, Foram. Amér. Mérid., p. 51, Pl. VII, figs, 13, 14.

Bulimina pulchra TERQUEM, 1882, Mém. Soc. géol. France, Sér. 3, Tome II, Mém. 3, p. 114, Pl. XII, figs. 8–12.

Bulimina elegantissima BRADY, 1884, Chall. Rept., Vol. IX, pp. 402, 403, Pl. L, figs. 20–22. A. WOODWARD, 1898, Journ. N. York Micr. Soc, p. 3.

Although not quite typical, several of the specimens found are without doubt referable to this species. As a fossil it occurs in several Eocene and Post-tertiary deposits. Dr. A. Woodward has found this species in the Miocene of Mobile, Alabama.

Santa Clara County, California; frequent.

Bulimina elegans *d'Orbigny*.

PLATE XXIX, FIG. 3.

Bulimina elegans D'ORBIGNY, 1826, Ann. Sci. nat., Tome VII, p. 270, No. 10, Modèles No. 9. PARKER, JONES AND BRADY, 1865, Ann. and Mag. Nat. Hist., Ser. 3, Vol. XVI, p. 20, Pl. II, fig. 64. BRADY, 1884, Chall. Rept., Vol. IX, pp. 398, 399, Pl. L, figs. 1–4. EGGER, 1895, Naturhist. Ver. Passau, Jahresber. XVI, p. 16, Pl. III, fig. 9. T. RUPERT JONES, 1895, Foram. Crag, Pt. II, (Pal. Soc. Mon.), pp. 162, 163, woodcut fig. 17. A. WOODWARD, 1898, Journ. N. York Micr. Soc., pp. 1 and 3.

Until lately this species was known only from recent deposits, but has since been obtained from the Upper Chalk (Chapman), from the Older Pliocene (Egger), and from the Pliocene of Suffolk and Antwerp (Rupert Jones). A. Woodward has found this form also in the Miocene of Atlantic City, New Jersey, and Mobile, Alabama.

The specimen of *B. elegans* here figured is somewhat more elongated than is usual, but it is in other respects characteristic.

Santa Clara County, California; very rare.

Bulimina affinis *d'Orbigny*.

PLATE XXIX, FIG. 4.

Bulimina affinis D'ORBIGNY, 1839, Foram. Cuba, p. 109, Pl. II, figs. 25, 26.
Bulimina ovulum REUSS, 1850, Haidinger's Naturw. Abhandl., Bd. IV, p. 38, Pl. IV, fig. 9.
Bulimina affinis BRADY, 1884, Chall. Rept., Vol. IX, pp. 400, 401, Pl. L, figs. 14 *a*, *b*. EGGER, 1895, Naturhist. Ver. Passau, Jahresber. XVI, pp. 14, 15, Pl. IV, figs. 4, 5.

The geological range of this species is more extensive than that of the other *Buliminæ* of this series, since it first appears in the Lower Greensand of Surrey, England.

Santa Clara County, California; frequent.

Bulimina buchiana *d'Orbigny*.

PLATE XXIX, FIG. 5.

Bulimina buchiana D'ORBIGNY, 1846, Foram. Foss. Vienne, p. 186, Pl. XI, figs. 15–18.
Bulimina truncana GÜMBEL, 1868, Abhandl. d. k. bayer. Akad. Wiss., II. Cl., Bd. X, p. 644, Pl. II, figs. 77, *a*, *b*.

Bulimina buchiana BRADY, 1884, Chall. Rept., Vol. IX, pp. 407, 408, Pl. LI, figs. 18, 19. EGGER, 1895, Naturhist. Ver. Passau, Jahresber. XVI, p. 18, Pl. IV, figs. 9–11. BAGG, 1898, Bull. Amer. Paleont., Vol. II, No. 10, pp. 315, 316, Pl. II, fig. 4.

Bulimina buchiana has been noticed in many Tertiary beds. It was originally described from the Miocene of the Vienna Basin and it has been found by Dr. Bagg in the Miocene of Norfolk, Virginia. It was also found by Dr. Egger in the Older Pliocene of Monte Bartolomeo.

California (first sample very rare), and from a well in Santa Clara County, California; frequent.

Bolivina *d'Orbigny* [1839].

Bolivina dilatata *Reuss*.

PLATE XXIX, FIG. 6.

Bolivina dilatata REUSS, 1849, Denk. Akad. Wiss. Wien, Bd. I, p. 381, Taf. XLVIII, fig. 15. TERRIGI, 1880, Atti dell' Accad. Pont., Ann. XXXIII, p. 197, Pl. II, fig. 42. BRADY, 1884, Chall. Rept., Vol. IX, p. 418, Pl. LII, figs. 20, 21. EGGER, 1895, Naturhist. Ver. Passau, Jahresber. XVI, pp. 10, 11, Pl. I, figs. 6 *a–c*.

This species first makes its appearance in the Miocene and it occurs in succeeding deposits to the Recent. Egger records it from the Older Pliocene of Monte Bartolomeo.

The specimens from California are very variable as to proportionate length and breadth.

Santa Clara County, California; very common.

Bolivina dilatata *Reuss*, var. angusta *Egger*.

PLATE XXIX, FIG. 7.

Bolivina dilatata REUSS, var. *angusta* EGGER, 1895, Naturhist. Ver. Passau, Jahresber. XVI, p. 11, Pl. I, fig. 7; figs. 12 *a*, *b*.

Egger describes this variety from Monte Bartolomeo. It is characterized by the lengthened test and the comparatively sharp-pointed aboral end.

Santa Clara County, California; common.

Bolivina ænariensis *(Costa)*.

PLATE XXIX, FIG. 8.

Brizalina ænariensis COSTA, 1856, Atti dell' Accad. Pont., Tome VII, p. 297, Pl. XV, fig. 1, *A*, *B*.

Bolivina ænariensis BRADY, 1882, Proc. Roy. Soc. Edin., Vol. XI, p. 711, — Table. Idem, 1884, Chall. Rept., Vol. IX, p. 423, Pl. LIII, figs. 10, 11. BRADY, PARKER and JONES, 1888, Trans. Zool. Soc. Lond., Vol. XII, Pt. 7, p. 221, Pl. XLIII, figs. 2, 4, 5. MALAGOLI, 1889, Boll. Soc. Geol. Ital., Vol. VII, p. 377, Pl. XIV, figs. 11, 12. JONES, 1895, Monogr. Crag Foram. (Pal. Soc.), Pt. II, pp. 169, 170, Pl. VI, fig. 21.

This is a shallow-water species. Its geological range commences from the Miocene age. It is very common in the material from a well in Santa Clara County, California.

Family LAGENIDÆ.

Subfamily LAGENINÆ.

Lagena *Walker & Jacob* [1784].

Lagena sulcata *(Walker & Jacob)*.

PLATE XXIX, FIG. 9.

Serpula (Lagena) sulcata W. & J., 1798, Adams' Essays, Kanmacher's Ed., p. 634, Pl. XIV, fig. 5.

Lagena sulcata BRADY, 1884, Chall. Rept. Vol. IX, pp. 462, 463, Pl. LVII, figs. 23, 26, 33, 34. JONES, 1895, Monogr. Crag Foram. (Pal. Soc.), Pt. II, pp. 186–188, Pl. I, figs. 40, 41.

This species is, geologically speaking, one of the oldest of the genus, its range extending as far back as the Ordovician. As to depth of water, it is not restricted, although generally found in shallow or moderately shallow deposits. From a well in Santa Clara County, California; frequent.

Lagena crenata *Parker & Jones*.

PLATE XXIX, FIG. 10.

Lagena crenata PARKER AND JONES, 1865, Phil. Trans., Vol. CLV, p. 420, Pl. XVIII, figs. 4 *a*, *b*. BRADY, 1866, Rep. Brit. Assoc., Trans. Sections, p. 70; Idem, 1884, Chall. Rept., Vol. IX, p. 467, Pl. LVII, figs. 15, 21.

This rare species makes its first appearance in Miocene deposits. At the present day it is found usually in shallow or moderately shallow water, but has occasionally been found at depths of over 2,000 fathoms.

From a well in Santa Clara County, California; one specimen.

Subfamily NODOSARIINÆ.

Nodosaria *Lamarck* [1816].

Nodosaria radicula *(Linné)*.

PLATE XXIX, FIG. 11.

Nautilus radicula LINNÉ, 1767, Syst. Nat., 12th Ed., pp. 285, 1164; —1788, Ibid., 13th (Gmelin's) Ed., Vol. I, Pt. 6, p. 3373, No. 18. MONTAGU, 1803, Test. Brit., p. 197, Pl. VI, fig. 4.

Nodosaria radicula D'ORBIGNY, 1826, Ann. Sci. nat., Tome VII, p. 252, No. 3, Modèle No. 1. BRADY, 1884, Chall. Rept., Vol. IX, p. 495, Pl. LXI, figs. 28–31. EGGER, 1895, Naturhist. Ver. Passau, Jahresber. XVI, p. 20, Pl. II, fig. 3.

A species having a wide range both as to depth and geographical distribution. Its geological range is also extensive, dating as far back as the Permian.

Santa Clara County, California; occasional.

Nodosaria pauperata *d'Orbigny*.

PLATE XXIX, FIG. 12.

Dentalina pauperata D'ORBIGNY, 1846, For. Foss. Vienne, p. 46, Pl. I, figs. 57, 58.

Nodosaria (Dentalina) pauperata BRADY, 1884, Chall. Rept., Vol. IX, pp. 500, 501; woodcuts, figs. 14 *a–c*. RUPERT JONES, 1896, Monograph Crag Foram., Part III, 1895, pp. 224–226, Pl. I, figs. 13–18, 20.

This species ranges from the Lias to deposits of recent date. It is a variable form in the Californian deposits; some of the specimens closely approach *N. consobrina*, whilst others pass into *N. farcimen* or *N. soluta*.

Santa Clara County, California; frequent.

Nodosaria farcimen *Reuss* (after *Soldani*).

PLATE XXIX, FIG. 13.

"*Orthoceras farcimen*" SOLDANI, 1791, Testaceographia, Vol. I, Pt. 2, p. 98, Pl. CV, fig. *O*.
Dentalina farcimen REUSS, 1861, Bull. Acad. Roy. Belg., Ser. 2, Tome XV, p. 146, Pl. I, fig. 18.
Nodosaria (D.) farcimen BRADY, 1884, Chall. Rept., Vol. IX, pp. 498, 499, Pl. LXII, figs. 17, 18; woodcuts figs. 13 *a–c*.
Nodosaria farcimen EGGER, 1895, Naturhist. Ver. Passau, Jahresber. XVI, p. 21, Pl. II, fig. 13.

Another species with an extensive geological range, and which was met with in the Older Pliocene of Monte Bartolomeo.

In both samples from California; a few fragments.

Nodosaria soluta *Reuss*.

PLATE XXIX, FIG. 14.

Dentalina soluta REUSS, 1851, Zeitschr. d. deutsch. geol. Gesellsch., Bd. III, p. 60, Pl. III, figs. 4, *a*, *b*.
Nodosaria (D.) soluta BRADY, 1884, Chall. Rept., Vol. IX, pp. 503, 504, Pl. LXII, figs. 13–16. EGGER, 1895, Naturhist. Ver. Passau, Jahresber. XVI, pp. 21, 22, Pl. II, figs. 6, 14, 15. A. WOODWARD, 1898, Journ. N. York Micr. Soc., p. 17.

The specimens of *N. soluta* from California are represented by fragments only. The smaller and neater specimens appear to pass into *N. adolphina*, which latter is here represented by the non-aculeate variety.

It has been previously recorded from the Miocene of an artesian well in Atlantic City, New Jersey, by A. Woodward.

Santa Clara County, California; frequent.

Nodosaria longiscata *d'Orbigny*.

PLATE XXIX, FIG. 15.

Nodosaria longiscata D'ORBIGNY, 1846, Foram. Foss. Vienne, p. 32, Pl. I, figs. 10–12.
Nodosaria arundinea SCHWAGER, 1866, Novara-Exped., geol. Theil, Bd. II, p. 211, Pl. V, figs. 43–45. SHERBORN & CHAPMAN, 1886, Journ. Roy. Micr. Soc., Ser. 2, Vol. VI, p. 747, Pl. XIV, figs. 28, 29.
Nodosaria longiscata BRADY, 1888, Quart. Journ. Geol. Soc., Vol. XLIV, p. 6. CHAPMAN, 1898, Quart. Journ. Geol. Soc., Vol. LIV, p. 554.

Some detached segments of *Nodosaria*, without doubt belonging to the above species, were found in the Californian foraminiferal rock. *N. longiscata* is well known as a species occurring in the Eocene, Miocene and Pliocene formations.

Santa Clara County, California; very rare.

Nodosaria adolphina *d'Orbigny*.

PLATE XXIX, FIG. 16.

Dentalina adolphina D'ORBIGNY, 1846, Foram. Foss. Vienne, p. 51, Pl. II, figs. 18–20. BORNEMANN, 1855, Zeitschr. deutsch. geol. Gesellsch., Bd. VII, p. 324, Pl. XIII, fig. 5. NEUGEBOREN, 1856, Denk. Wiss. Wien, Bd. XII, Pt. 2, p. 88, Pl. IV, figs. 8*a* and *b*.
Nodosaria adolphina SCHWAGER, 1866, Novara-Exped., geol. Theil, p. 235, Pl. VI, figs. 72, 73.
Dentalina adolphina GÜMBEL, 1868 (1870), Abhandl. m.-ph. Cl. k.-bayer. Ak. Wiss., Bd. X, p. 623, Pl. I, fig. 32. SHERBORN & CHAPMAN, 1886, Journ. Roy. Micr. Soc., Ser. 2, Vol. VI, p. 750, Pl. XV, figs. 11*a* and *b*, 12.

This Tertiary foraminifer is here represented by small specimens comparable in form but without the spinose segments which the species exhibits when fully grown.

Santa Clara County, California; frequent.

Nodosaria obliqua *(Linné)*.

PLATE XXIX, FIG. 17.

Nautilus obliquus LINNÉ, 1767, Syst. Nat., 12th Ed., pp. 281, 1163; —1788, ibid., 13th (Gmelin's) Ed., p. 3372, No. 14.
Orthocera obliqua LAMARCK, 1822, Anim. sans Vert., Vol. VII, p. 594, No. 4.
Nodosaria obliqua BRADY, 1884, Chall. Rept., Vol. IX, pp. 513, 514, Pl. LXIV, figs. 20–22.

A fragment of an obliquely costate shell was found in the material examined, which appears to belong to the above typical species. It has also been recorded from the Miocene of Norfolk, Virginia.

Santa Clara County, California.

Cristellaria *Lamarck* [1816].

Cristellaria cassis *(Fichtel & Moll).*

PLATE XXIX, FIG. 18.

Nautilus cassis FICHTEL & MOLL, 1798, Test. Micr., p. 95, Pl. XVII, figs. *a-l.*

Cristellaria cassis LAMARCK, 1816, Tabl. Encycl. et Méthod., Pl. CCCCLXVII, figs. 3 *a-d.* D'ORBIGNY, 1825, Tabl. Méth. Céphal., p. 124, No. 3. BRADY, 1884, Chall. Rept., Vol. IX, pp. 552, 553, Pl. LXVIII, fig. 10. FORNASINI, 1893-94, Mem. R. Accad. Sci. Bologne, Ser. 5, Vol. IV, p. 221, Pl. III, figs. 21, 21*a;* p. 222, Pl. III, figs. 22, 23. A. SILVESTRI, 1899, Mem. Accad. Pont. Lincei, Vol. XV, pp. 206-212, Pl. VII, figs. 13-17.

This species is extremely variable and has been described under as many names as its variations. The specimens are very like some figured by Dr. A. Silvestri from the Pliocene of Siena. They are devoid of the beaded ornamentation, are much compressed, and have the sutural margins at the periphery terminating in a point which gives a serrate aspect to the shell-margin.

C. cassis is found in most Tertiary deposits, and at the present time appears to be restricted to fairly shallow deposits of tropical or warm temperate areas.

Santa Clara County, California; common.

Cristellaria miocenica, sp. nov.

PLATE XXX, FIGS. 1 AND 1*a*.

Test subcircular or suboval, much compressed. The sutural lines reflexed; septa thick and swollen on surface. A distinct umbilical depression is observable in nearly all specimens. Average breadth of test, .87 mm.; thickness, .16 mm.

This species most nearly resembles *C. complanata* Reuss,[1] but the latter species is in outline of the *C. crepidula* type, whilst *C. miocenica* belongs to the more discoidal type of *C. rotulata*. The specimen here figured is one of the more lengthened forms.

Santa Clara County, California; common.

[1] Verstein. böhm. Kreidef., 1845-6, Pt. 1, p. 33, Pl. XIII, fig. 54.

Cristellaria arcuata *d'Orbigny*.

PLATE XXX, FIG. 2.

Cristellaria arcuata D'ORBIGNY, 1846, Foram Foss. Vienne, p. 87, Pl. III, figs. 34–36. EGGER, 1857, Neues Jahrbuch für Min., p. 296, Pl. XIV, figs. 28–30. NEUGEBOREN, 1872, Arch. Ver. Siebenbürg. Landeskunde N. F. X (2), p. 276, Pl. I, figs. 3 and 4. HANTKEN, 1875 (1876), Magyar kir. földt. int. évkönyve, Vol. IV, p. 45, Pl. V, figs. 5 and 6; and Mitth. a. d. Jahrb. k. ungar. geol. Anstalt, IV; 1875 (1881), p. 53, Pl. I, figs. 3 and 4. JONES, 1876, M. Micr. Journ., Vol. XV, Pl. 128, figs. 9*a*, *b* and 20*a*, *b*; 21*a*, *b*.

Some very fine examples of the above were found; they are especially characterized by the well developed final chamber. This Tertiary species closely approaches the Cretaceous *C. triangularis* of the same author, if indeed it can be considered a distinct species.

Santa Clara County, California; common.

Cristellaria gibba *d'Orbigny*.

PLATE XXX, FIG. 3.

Cristellaria gibba D'ORBIGNY, 1839, Foram. Cuba, p. 63, Pl. VII, figs. 20, 21. BRADY, 1884, Chall. Rept., Vol. IX, pp. 546, 547, Pl. LXIX, figs. 8, 9.

The specimen here figured is of somewhat irregular growth but without doubt belongs to the above species. Its range in geological time dates from the Cretaceous or even earlier.

Santa Clara County, California; one specimen.

Cristellaria rotulata *(Lamarck)*.

PLATE XXX, FIG. 4.

Lenticulites rotulata LAMARCK, 1804, Annales du Muséum, Tome V, p. 188, No. 3.—Tabl. Encycl. et Méthod, Pl. CCCCLXVI, fig. 5.

Cristellaria rotulata PARKER & JONES, 1865, Phil. Trans., Vol. CLV, p. 345, Pl. XIII, fig. 19. BRADY, 1884, Chall. Rept., Vol. IX, pp. 547, 548, Pl. LXIX, figs. 13*a*, *b*.

The specimens under notice are somewhat strongly septate, otherwise they are typical of the species.

The occurrence of *C. rotulata* in the Miocene of America is recorded by A. Woodward as follows:—from artesian wells, Atlantic City and Quinton, New Jersey.

California, from both samples; very common.

Subfamily POLYMORPHININÆ.

Uvigerina *d'Orbigny* [1826].

Uvigerina tenuistriata *Reuss.*

PLATE XXX, FIG. 5.

Uvigerina tenuistriata REUSS, 1870, Sitzungsb. Akad. Wiss. Wien, Bd. LXII, p. 485. SCHLICHT, 1870, Foram. Pietzpuhl, Pl. XXII, figs. 34–36. BRADY, 1884, Chall. Rept., Vol. IX, p. 574, Pl. LXXIV, figs. 4–7. BAGG, 1898, Bull. Am. Paleont., Vol. II, No. 10, pp. 326, 327.

This species was originally described from the Septaria-clay of Pietzpuhl. In recent deposits it occurs in fairly shallow water. It has been recorded from the Miocene of America by Dr. Bagg, who found it at Norfolk, Virginia, and also in material, probably of the same age, from an artesian well at Crisfield, Maryland.

Santa Clara County, California; rare.

Family GLOBIGERINIDÆ.

Pullenia *Parker & Jones* [1862].

Pullenia sphæroides *(d'Orbigny).*

PLATE XXX, FIG. 6.

Nonionina sphæroides D'ORBIGNY, 1826, Ann. Sci. nat., Tome VI, p. 293, No. 1, Modèle, No. 43.

Nonionina bulloides, id., ibid., p. 293, No. 2. Id., 1846, Foram. Foss. Vienne, p. 107, Pl. V, figs. 8–10.

Pullenia sphæroides CARPENTER, 1862, Introd. Foram., p. 184, Pl. XII, fig. 12. BRADY, 1884, Chall. Rept., Vol. IX, pp. 615, 616, Pl. LXXXIV, figs. 12, 13. JONES, 1896, Monogr. Foram. Crag, Pt. III, pp. 286–288, Pl. II, (Pt. II, 1895), figs. 31, 32.

The range of this species commences with the Cretaceous, and it is frequent in many deposits of Miocene age.

Santa Clara County, California; frequent.

Pullenia multilobata, sp. nov.

PLATE XXX, FIGS. 7 AND 7*a*.

The test bears a general resemblance to *P. quinqueloba* Reuss, but is more compressed and has the sutural lines only faintly marked. Its chief distinction is the larger number of chambers visible on the last whorl; in the case of the specimen figured there are nine, and consequently these are narrower than those of *P. quinqueloba*. Width of test, 1 mm.; thickness, .5 mm.

Santa Clara County, California; very rare.

Family ROTALIIDÆ.

Subfamily ROTALIINÆ.

Discorbina *Parker & Jones* [1862].

Discorbina allomorphinoides *(Reuss).*

PLATE XXX, FIG. 8.

Valvulina allomorphinoides REUSS, 1860, Sitzungsb. Akad. Wiss. Wien, Vol. XL, p. 223, Pl. XI, fig. 6.
Discorbina allomorphinoides BRADY, 1884, Chall. Rept., Vol. IX, p. 654.

This interesting species was found by Reuss in the Cretaceous of Westphalia. Its present occurrence helps to complete its range in time, since it was also found by Brady in recent deposits at three stations and at depths from 10 to 155 fathoms.

The specimens from California in some respects resemble *Pulvinulina hancrii* d'Orb., sp., but the test is coarser and bears stronger affinities towards *Discorbina*.

California, from both samples; very abundant.

Anomalina *d'Orbigny* [1826].

Anomalina grosserugosa *(Gümbel).*

PLATE XXX, FIG. 9.

Truncatulina grosserugosa GÜMBEL, 1868, Abhand. d. k. bayer. Akad. Wiss., m.-ph. Cl., Vol. X, p. 660, Pl. II, fig. 104 *a*, *b*.
Anomalina grosserugosa SHERBORN & CHAPMAN, 1889, Journ. Roy. Micr. Soc., p. 487, Pl. XI, fig. 34.

A well known Tertiary species; this form has been previously noted by A. Woodward from artesian well borings at Atlantic City, Quinton and Beach Haven, in New Jersey.

A. grosserugosa is somewhat difficult to separate from *Nonionina umbilicatula*, inasmuch as the aperture is not always a safe distinction, for the obliquely apertured Anomalines pass insensibly into the symmetrical Nonionine forms. *A. grosserugosa* is perhaps coarser in shell structure and has its chambers more strongly inflated than *N. umbilicatula*.

Santa Clara County, California; frequent.

Anomalina rotula *d'Orbigny*.

PLATE XXX, FIG. 10.

Anomalina rotula D'ORBIGNY, 1846, Foram. Foss. Vienne, p. 172, Pl. X, figs. 10–12.

Planorbulina rotula SHERBORN & CHAPMAN, 1886, Journ. Roy. Micr. Soc., Ser. 2, Vol. VI, p. 757, cut in text No. 155. TERRIGI, 1889, Mem. Accad. Lincei; Ser. 4, Vol. VI, p. 116, Pl. VII, fig. 4.

This species by gradational forms appears to pass into *Truncatulina ungeriana* d'Orb., sp. It is well known as an Eocene and Miocene fossil.

Santa Clara County, California; frequent.

Truncatulina *d'Orbigny* [1826].

Truncatulina pygmæa *Hantken*.

PLATE XXX, FIG. 11.

Truncatulina pygmæa HANTKEN, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, Vol. IV, 1881, p. 78, Pl. X, fig. 8. BRADY, 1884, Chall. Rept., Vol. IX, pp. 666, 667, Pl. XCV, figs. 9 and 10.

This species was found in the Oligocene of Hungary, and in deposits at the present day at considerable depths.

California, in both samples; very common.

Rotalia *Lamarck* [1804].

Rotalia orbicularis *d'Orbigny*.

PLATE XXX, FIG. 12.

Rotalia (Gyroidina) orbicularis D'ORBIGNY, 1826, Ann. Sci. nat., Vol. VII, p. 278, No. 1, Modèle, No. 13.
Rotalia orbicularis BRADY, 1864, Trans. Linn. Soc. Lond., Vol. XXIV, p. 470, Pl. XLVIII, fig. 16. Id., 1884, Chall. Rept., Vol. IX, p. 706, Pl. CVII, fig. 5; Pl. CXV, fig. 6.

The range of *R. orbicularis* is throughout the Tertiary formations.

It occurs in the Miocene of Southern Italy and of Norfolk, Virginia, and in the Older Pliocene of Monte Bartolomeo.

California, in both samples; common.

Subfamily POLYSTOMELLINÆ.

Nonionina *d'Orbigny* [1826].

Nonionina communis *d'Orbigny*.

PLATE XXX, FIG. 13.

Nonionina communis D'ORBIGNY, 1826, Ann. Sci. nat., Vol. VII, p. 294, No. 20. Id., 1846, Foram. Foss. Vienne, p. 106, Pl. V, figs. 7 and 8.

Amongst other occurrences this species has been recorded from the Older Pliocene of Monte Bartolomeo.

Santa Clara County, California; frequent.

Nonionina boueana *d'Orbigny*.

PLATE XXX, FIGS. 14 AND 14*a*.

Nonionina boueana D'ORBIGNY, 1846, Foram. Foss. Vienne, p. 108. Pl. V, figs. 11 and 12. BRADY, 1884, Chall. Rept., Vol. IX, p. 729, Pl. CIX, figs. 12 and 13.

The specimens here figured are very pretty and extreme variations of the type, having the thickened sutures very distinct, the peripheral edge sharp, and the septal face with limbate edges.

N. boueana has been previously recorded from the Miocene of Norfolk, Virginia.

California, in both samples; very common.

Nonionina umbilicatula *(Montag.)*.

PLATE XXX, FIG. 15.

Nautilus umbilicatulus MONTAGU, 1803, Test. Brit., p. 191; Suppl., p. 78, Pl. XVIII, fig. 1.
Nonionina soldanii D'ORB., 1846, Foram. Foss. Vienne, p. 109, Pl. V, figs. 15, 16.
Nonionina umbilicatula BRADY, 1884, Chall. Rept., Vol. IX, p. 726, Pl. CIX, figs. 8, 9.

This is a Tertiary species, and it has been noted, amongst other occurrences, from the Older Pliocene of Monte Bartolomeo (under the name of *N. soldanii*).

California, in both samples; frequent.

Nonionina pompilioides *(Fichtel & Moll)*.

PLATE XXX, FIGS. 16 AND 16*a*.

Nautilus pompilioides FICHTEL & MOLL, 1798, Test. Micr., p. 31, Pl. II, figs. *a–e*.
Nonionina umbilicata D'ORBIGNY, 1826, Ann. Sci. nat., Vol. VII, p. 293, Pl. 15, figs. 10–12, No. 5, Modèles, No. 86.
Nonionina pompilioides BRADY, 1884, Chall. Rept., Vol. IX, p. 727, Pl. CIX, figs. 10, 11.

The specimens from California are very typical examples, with a broad terminal septal face.

Santa Clara County, California; rare.

EXPLANATION OF PLATE XXIX.

Figs. 1–10 forty-five times enlarged; 11–17 thirty times enlarged; 18 twenty times enlarged.

Fig. 1. *Bulimina elongata* D'ORB.
Fig. 2. " *elegantissima* D'ORB.
Fig. 3. " *elegans* D'ORB.
Fig. 4. " *affinis* D'ORB.
Fig. 5. " *buchiana* D'ORB.
Fig. 6. *Bolivina dilatata* REUSS.
Fig. 7. " " var. *angusta* EGGER.
Fig. 8. " *ænariensis* (COSTA).
Fig. 9. *Lagena sulcata* (W. & J.).
Fig. 10. " *crenata* P. & J.
Fig. 11. *Nodosaria radicula* (L.).
Fig. 12. " *pauperata* D'ORB.
Fig. 13. " *farcimen* REUSS.
Fig. 14. " *soluta* REUSS.
Fig. 15. " *longiscata* D'ORB.
Fig. 16. " *adolphina* D'ORB.
Fig. 17. " *obliqua* (L.).
Fig. 18. *Cristellaria cassis* (F. & M.)

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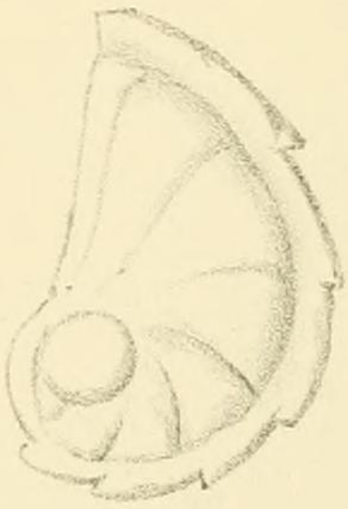

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EXPLANATION OF PLATE XXX.

All the figures are thirty times enlarged.

Figs. 1 and 1*a*. *Cristellaria miocenica*, sp. nov.
Fig. 2. " *arcuata* D'ORB.
Fig. 3. " *gibba* D'ORB.
Fig. 4. " *rotulata* (LAM.).
Fig. 5. *Uvigerina tenuistriata* REUSS.
Fig. 6. *Pullenia sphæroides* (D'ORB.).
Figs. 7 and 7*a*. *Pullenia multilobata*, sp. nov.
Fig. 8. *Discorbina allomorphinoides* (REUSS).
Fig. 9. *Anomalina grosserugosa* (GÜMBEL).
Fig. 10. " *rotula* D'ORB.
Fig. 11. *Truncatulina pygmæa* HANTKEN.
Fig. 12. *Rotalia orbicularis* D'ORB.
Fig. 13. *Nonionina communis* D'ORB.
Figs. 14 and 14*a*. " *boueana* D'ORB.
Fig. 15. " *umbilicatula* (MONTAG.).
Figs. 16 and 16*a*. " *pompilioides* (F. & M.).

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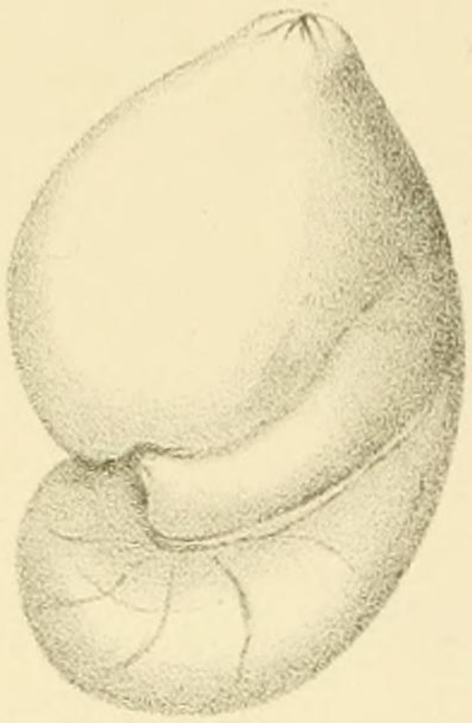

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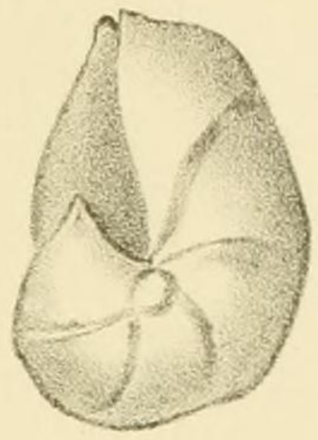

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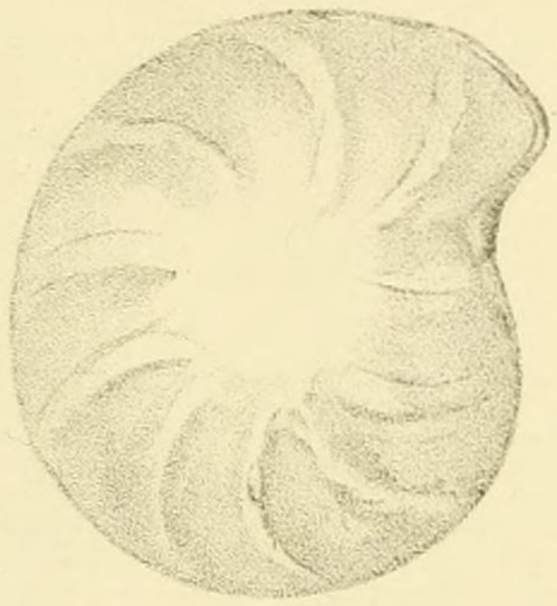

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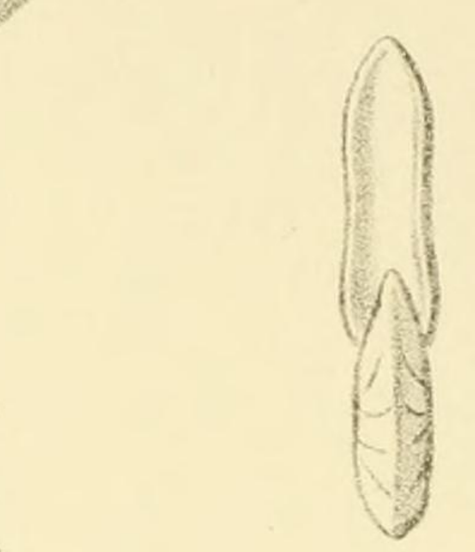

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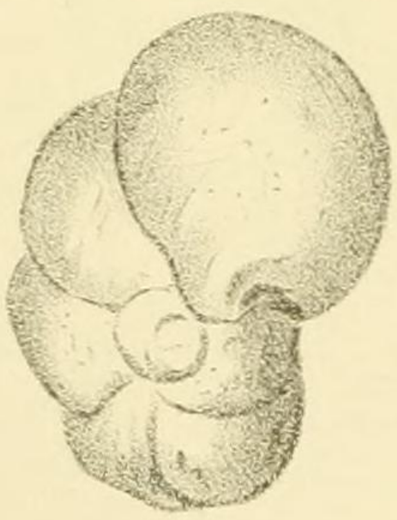

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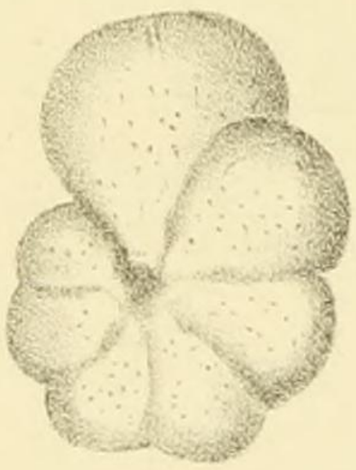

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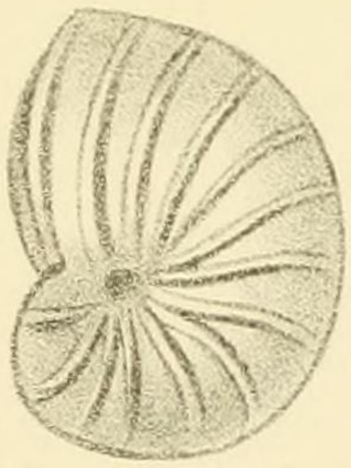

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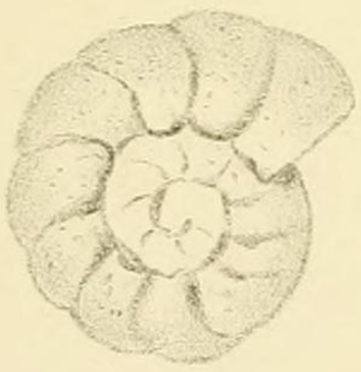

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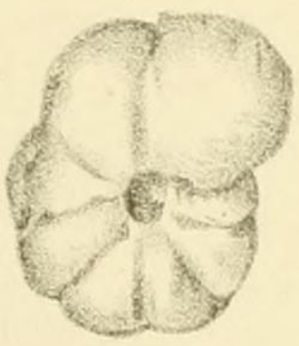

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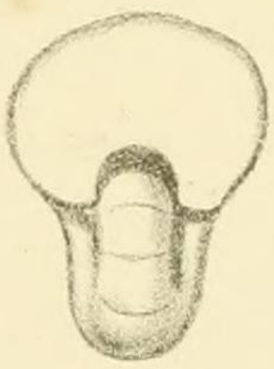

16 *a*

14 *a*

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