

FOSSILS FROM THE MANCOS-DAKOTA-TUNUNK
FORMATION IN THE VICINITY OF
STEAMBOAT, ARIZONA.

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The invertebrate fossils from the Mancos-Dakota-Tununk formation, collected in the vicinity of Steamboat, Arizona, and identified by the writer, as given below, show the formation to be transitional between the true Dakota and the overlying Colorado group. Many of the fossils occur in both divisions, but reach their maximum development in the Colorado. Again, the fossils that run through the whole Dakota series here are small in size in the lower beds and increase in size upward, apparently indicating that they began their life-circle in the lower beds.

VERTEBRATE—PISCES.

Ichthyodectes etenodon Cope(?). (Fig. 2.) Proc. Amer. Phil. Soc., Nov., 1870; Hayden's Geol. Surv. Wyoming, etc., 1871, p. 421, part; U. S. Geol. Surv. of Terr., vol. II, 1875, pp. 207-8, pl. XLVI, figs. 1-4. (Figure 4 is a cervical vertebra like the ones here figured.)

The specimen described by Cope was found by Professor Mudge on the North Fork of the Smoky Hill River and he states that the species is common in many other localities. The writer's specimen was found in a coal mine at Steamboat, Arizona, in a clayey rock at the base of the Dakota. It was found by an Indian workman who called the mine owner's attention to it, and he saved the specimen for the writer, after the Indian had taken out some of the vertebrae for "medicine." Only cervical vertebrae were obtained but these are apparently identical with cervical vertebrae figured by Cope on the plate cited above as belonging to this species.

INVERTEBRATE—RADIATA.

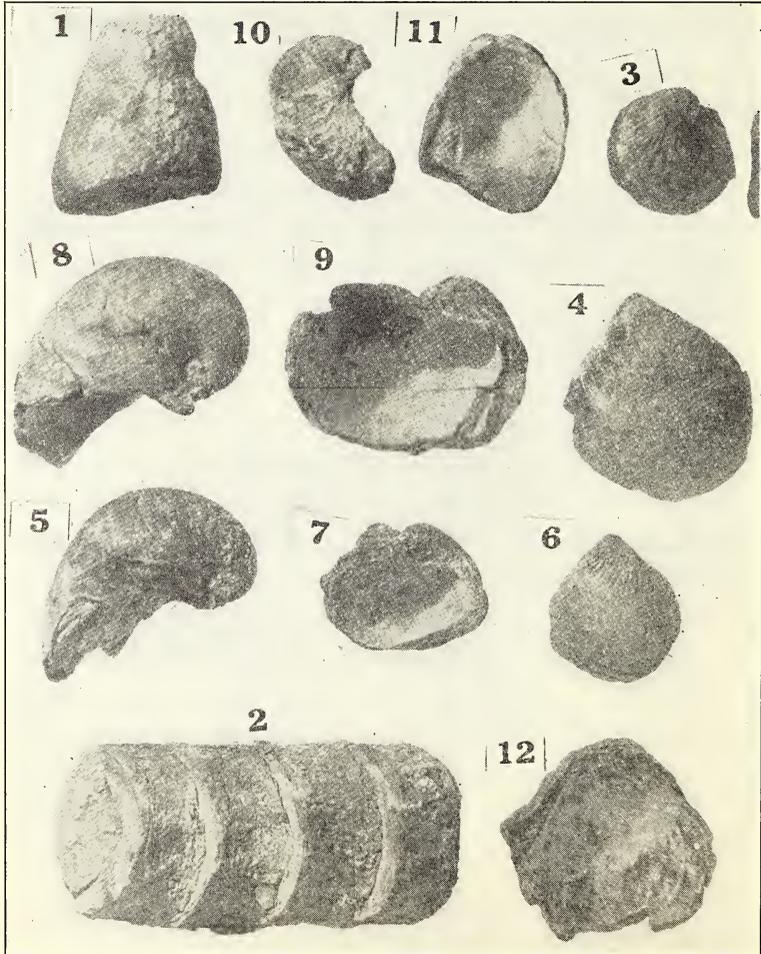
Coral sp. (Fig. 1.) A coral, whose size and form (much reduced) are shown by the figure, was found in the beds under consideration. The whole of the interior of the corallum has decayed, therefore the genus cannot be determined. Locality: Near Hogay Ruin (No. 99), Steamboat, Arizona.

LAMELLIBRANCHIATA—MONOMYARIA—OSTREIDAE.

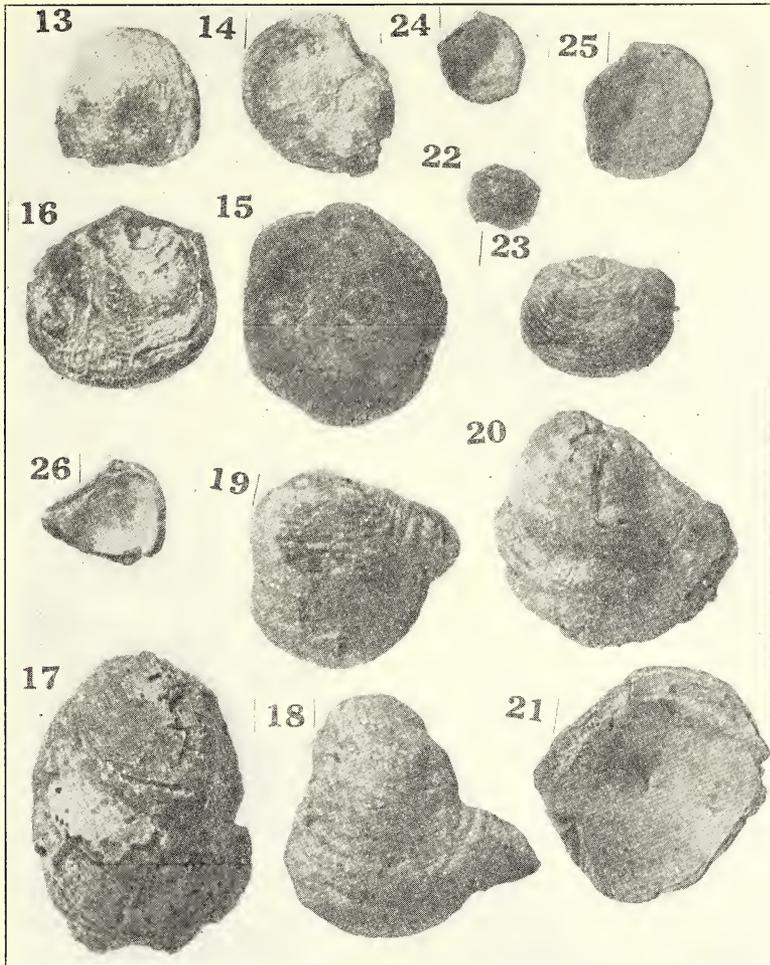
Ostrea (Gryphaea?) patina Meek and Hayden. (Figs. 15-26.) Proc. Acad. Nat. Sci., Phila., p. 277; U. S. Geol. Surv. Terr., 1876, Vol. IX, pp. 16-19, pl. 10, figs. 2a, b, d; a, b (bis), and e, f; also pl. 11; White, 4th Ann. Rept. U. S. Geol. Surv. ("Fossils Ostreidae of North America"), p. 278, pl. XLVII, figs. 4-6; Schuchert-Gregory, Geol. of the Navajo country (U. S. Geol. Surv., Professional paper 93, 1917), p. 74.

Ostrea prudentia White(?), 1876, U. S. Geol. Surv. West 100th Meridian, vol. IV, p. 181, pl. 14, figs. 2a-b; 1884, 4th Ann. Rept. U. S. Geol. Surv., p. 299, pl. 40, figs. 5 and 6.

This is a very variable species, resembling the Gryphaeas very much and especially *Gryphaea vesicularis*. A description of the more regular shells here follows:



Figs. 1-12. 1, *Coral* sp.; 2, *Ichthyoactes etnodon* Cope (?), cervical vertebrae; 3-7, *Exogyra columbella* Meek. 3, outside of upper valve looking down on the whorl, which shows radiating lines, characteristic of the species, 4, looking across back and showing radiating lines, 5, side view of broken specimen, showing the striated beak-part of shell, 6, young specimen showing radiating lines near beak, 7, inside view showing muscular impression; 8-9, *E. lacriuseula* Roem. 8, inside view of much broken valve, showing whorl, 9, inside view of much broken valve showing muscular impression; 10-12, *Gryphaea newberryi* Stant. 10, side view of complete, undistorted lower valve, 11 and 12, inside views of lower valve. These specimens except 2, from transitional Dakota-Mancos series at Steamboat, Ariz. Number 2 from bank of Dakota formation at same locality.



Figs. 13-26. 13, *Exogyra suborbiculata* Lamark, outside view of the upper valve showing lines of growth and, 14, inside view of a similar valve of another specimen of same species; 15-26, *Ostrea patina* M. and H. 15, inside view of the upper flattish valve showing muscular impression, 16, a reverse view of a similar valve, 17-20, outside views of distorted, adult lower valves, 21 and 24-26 inside views of the larger valves, 22-23, outside of the large valves from rear. All of the above from the transitional Dakota-Mancos series at Steamboat, Ariz., obtained from a stratum that caps the mesa west of Steamboat rock.

Shell almost circular to subovate (some shells are irregularly subovate to elongate-ovate), a little oblique, some compressed. Upper valve concave above, rather thin, but thickened near the beak where it is truncate; area rather broad, triangular, standing nearly at right angles to the plane of the shell, and broadly depressed in the middle; lateral margins near the area more or less constricted,—the valve resembling a little shield or a painter's palette in shape. Lower valve thicker to rather thick, quite a bit concave; latter margins near the

beak usually considerably thickened and distinctly lamello-striate; beak triangular, broadly depressed to much compressed, extending beyond the cardinal border and slightly curved upward at the front, without any visible scar of attachment, often very much distorted; area comparatively small, broad, triangular, having a wide, shallow depression along the middle. Muscular impression is nearly circular to triangular oval, varying much with different shells, moderately distinct, located near the left side and about halfway between the beaks and the postero-ventral extremity. Surface marked by more or less strong lines of growth. Length and breadth of a medium sized specimen, each about 2.50 inches; concavity of lower valve, from .50 to .75 inch.

The above description is of the average shells, on both sides of which there is a wide range of variation and even the above would almost be a good description of *Gryphaea vesicularis* Lam. (*G. convexa* S. and M.); yet they present well-marked and constant differences from all the varieties of that variable species. The lower valve of the shells at hand is never so ventricose as that of *G. vesicularis* or its common varieties. It also differs from that species in its being auriculate at the extremities and in its having its cardinal margin sloping from the beaks instead of being extended in a right line. Furthermore, its hinge prominence is never nearly so gibbous nor so much incurved as is usual in that species.

It agrees with *G. mutabilis* Morton (which is now regarded by most paleontologists as a marked variety of *G. vesicularis*) in its under valve being rather shallow and in its having a compressed beak; but it differs from that species in that it has its cardinal margin more or less straight, in its extremities being distinctly articulate and in its smaller valve being more strongly marked with radiating lines than the more convex varieties of *G. vesicularis*.

Some of the variable forms of this species differ from the type species only in having the umbo of the lower valve somewhat distorted by the scar of attachment. Others show still more and more distinct marks of attachment, become more ovate or elongate in form, and have the left anal margin near the beak more and more sinuous. These changes continue till the shells differ widely from the typical forms. It would seem that even *Ostrea inornata* M. and M. might be one of the elongated varieties of this shell, the principal difference being that it is a longer shell, it being irregularly subovate to elongate-ovate, oblique, narrow near the beaks, somewhat compressed, and abruptly widened by an expansion of the left border near the other extremity.

Some of the other, more prominent varieties of this species, as shown by the shells at hand, are here given:

Variety A.—Shell nearly round, but quite variable and irregular in shape, oblique, narrow near the beaks, and abruptly widened by an expansion of the left border near the other extremity; umbo of under valve distorted and curved upward; border of left side of valve thin and quite sinuous, but thickened on the right side of the beak; area of upper valve inclined obliquely toward the cardinal extremity. This variety resembles *O. inornata* nearly as much as it does *O. patina*,

being less in length than the former and this apparently being the only difference. As all the shells were collected in an area less than 200 feet square and all from the same stratum it would seem best, however, to consider them as *O. patina*. Length of several shells examined, 3 to 3.50 inches; breadth, an average of about 2.40 inches; breadth near beaks, 1.10 to 1.30 inches.

Variety B.—Shell broadly oval; beak of under valve much distorted; area usually or nearly obliterated by scar of attachment; anterior and antero-ventral border forming an almost semi-circular curve, while the anal side has a broad sinus near the hinge. Length and breadth, each about 3.00 inches for adults; concavity of under valve a little less than an inch.

Variety C.—Shell ovate, narrow near the beaks, much wider toward the extremities; beak of lower valve usually distorted on the left side by the scar of attachment, usually curving slightly upward; margin of shell thin, except near the right side of the beak, where it is noticeably thickened. Length, about 3.00 inches; breadth from 2.10 to 2.40 inches; concavity of under valve, an average of about .40 inches.

Locality and Position: Two hundred miles above the mouth of Milk River on the Missouri; in Fort Pierre group, or formation No. 4 of the Cretacic series (Meek); at Tuba coal mine in the Mancos shales (Gregory-Schuchert); at Steamboat, Apache Co., Arizona, in the Dakota (and Tununk) sandstone (Reagan). The specimens figured are from the latter location. Specimens were obtained from the base of the series as presented at Steamboat, also from the middle and from the top of the series in the vicinity of Hogay Ruin (No. 99), the fossils from the latter place being those described and figured.

Gryphaea newberryi Stanton (Figs. 10-12). *G. pitcheri* White, 1876, U. S. Geog. and Geol. Surv. West 100th Meridian, vol. IV, p. 171, pl. 17, figs. 1a-f; *G. pitcheri* N. and M., 1876, in Macomb's Exploring Expd., from Santa Fe to Junct. of Grand and Green Rivers; nec *G. pitcheri* Morton, 1834, Synopsis Org. Rem. Cret. Group, p. 55, pl. 15, fig. 9; *G. newberryi* Stanton, 1893, U. S. Geol. Surv. Bull. 106, pp. 60-62, pl. V, figs. 1-5. It is this species that Newberry called *G. pitcheri* and *G. pitcheri var navia*.¹ Mr. Gregory² reports it from Red Wash, near the Carrizo Mountains in the lower part of the Mancos. The writer's specimens are both from the base and the upper part of the Dakota and Dakota-Mancos transition. (Tununk) area as represented at Steamboat, in the vicinity of Hogay Ruin (No. 99).

Adult shell moderately large, very variable in shape, generally irregularly subovate in marginal outline, sometimes shorter than broad, but usually much longer than broad. Under valve spacious-roomy, boat-shaped, bow-shaped, more or less lobed, the rear lobe often wing like; shell rather thick; umbo conspicuous, large and incurved, though sometimes short and flattened; scar of attachment small or wanting; surface usually marked by concentric lines of growth, at other times smooth. Upper valve nearly flat, shield shaped, usually quite thin ex-

¹ Newberry, J. S., Ives Expedition, pp. 80-96, 117-132.

² Loc. Cit., p. 74.

cept where thickened in the umbonal region; hinge line straight; area distinct; ligamental groove small; inner surface more or less crenulated at the lateral edge, otherwise smooth; outer surface marked by concentric, overlapping lines of growth, and sometimes by faint radiating striae. Average length from umbo to basal margin, about 1.50 inches.

The collection which the writer furnished Stanford University contains numerous examples of this widely known species, none of which, however, are of so large a size as are some of those figured by Conrad, Roemer, and others. It might further be added that in this collection there are two distinct varietal types of this species. One resembles *G. vesicularis* and the other *G. pitcheri*, var. *navia*.

Position and Location: Lower part of the Upper Cretacic shales in southwestern Utah and adjacent portions of Colorado, Arizona, and New Mexico (Stanton); 350 feet above the base of the Cretacic in Upper Kanab valley, Utah (White, Walcott); Mancos, Colorado, from shales overlying sandstone referable to the Dakota formation (Stanton); Lower Cretacic strata at the Hopi village of Shongnovi (which species he called *G. pitcheri* and var. *navia* (Newberry); at the base of the Dakota, three miles east of Steamboat, Arizona, at the top of the Dakota near Hogay Ruin (No. 99), where it is abundant; at the base of the Mancos and top of the Dakota, one mile west of Salina Springs and in the Tununk formation in the transitional Dakota-Mancos series at Steamboat, Arizona (Reagan).

Exogyra suborbiculata Lamark (sp.) (Figs. 13-14). *Gryphaea suborbiculata* Lamark, 1802, Systeme des Animaux sans Vertebres, p. 398; *G. ratisbonensis* Sch., 1913, Minn. Taschen., vol. VII, p. 105; *G. columba* Lamark, 1919, Op. cit., vol. VI, p. 198; *Ostrea ratisbonensis* Coquand, 1869 (with full synonymy), Monog. Gen. Ostrea, Terr. Cret., p. 121; *Exogyra suborbiculata* Atoliczka, 1871, Cret. Pelecypoda of Southern India, p. 462; *Exogyra suborbiculata* (Lamark) Stanton, 1893, U. S. Geol. Surv. Bull. 106, pp. 62-63, pl. V, fig. 6; pl. VI, figs. 1 and 2; pl. VIII, fig. 1. Several upper valves of this species were found in the lower division of the Dakota at Steamboat. Shell large, thin, from almost circular to subovate in outline. Lower valve quite convex; umbonal region narrow but prominent; beaks small, coiled, somewhat separated from the body of the shell; a distinct depression extends from the umbonal region to the posterior basal margin. Surface marked by lines of growth, otherwise smooth. Upper valve nearly flat, with coiled beak and marked by faint to distinct concentric ridges near the margin. Average length from base to beak, about 3.25 inches; greatest transverse breadth 3.13 inches; convexity, about 1.63 inches.

This species much resembles the European species *Ostrea* or *Exogyra columba*. It is also reported as occurring throughout Europe and in Southern India in the Middle Cretacic (Cenomanian and Turonian). It is also said to be best developed in the zone with *Inoceramus labiatus*. It might also be added that *Exogyra columbella* Meek may prove to be only the young or a variety of this species, though it seems to favor *E. laeviuscula* more, as will be noted later.

Position and Locality: In the Pugnellus sandstone near Malchite postoffice and Poison Canyon, in Huerfano Park, and at about the same horizon at Rattlesnake butte and on the Arkansas River, 20 miles above Pueblo, Colorado (Stanton); in the lower division of the Dakota in the vicinity of Steamboat, Arizona (Reagan).

Eogyra columbella Meek (Figs. 3-7). *E. costata* var. *fluminis* White, 1876, U. S. Geog. and Geol. Surv. West 100th Meridian, vol. IV, p. 174, pl. 17, figs. 3a-d; *E. columbella* Meek, 1876, Macomb's Expl. Expdn. from Santa Fe to junction of Grand and Green rivers, p. 124, pl. 1, figs. 3a-d; White, 1884, 4th Ann. Rept., U. S. Geol. Surv., p. 304, pl. 55, figs. 5 and 6; Stanton, 1893, U. S. Geol. Surv. Bull. 106, pp. 63-64, pl. VIII, figs. 2, 3, 4. This species is found throughout the Dakota series but is most abundant at the top near Hogay Ruin (No. 99). It is also found abundantly in the Tununk (Dakota-Mancos transition series) both at Steamboat and at Salina Springs.

Professor Meek's description of the species is, in part, as follows: "Shell small, rather thin, ovate; posterior side forming a semi-oval curve from the umbo to the ventral edge; anterior side rounded below the beak; ventral margin rounded. Lower valve convex, the most gibbous part sometimes forming an obtuse umbonal prominence, which is not separated from the front by a sulcus; beak slender, pointed, and distinctly coiled to the left; surface ornamented by small, but distinct, rather regular, radiating costae, which bifurcate along the umbonal ridge; marks of growth rather obscure. Upper valve flat, oval, apparently smooth, or only having obscure lines of growth."

This species closely resembles *E. laeviuscula* Roemer, but its shells are more oval in form and have a less distinctly spiral beak than the forms described by Roemer or those which the writer has in the collection at Stanford University. It also differs in its having the under valve always marked by regular radiating costae, while in the other species the costae are usually wanting or if present at all they are generally broad plications. Its shells are also thinner and less robust than those of *E. laeviuscula*. On the other hand, it closely resembles *E. columba* (Anim. sans Vert. VI, 198), though it is a much smaller species. It may prove to be the young of *E. laeviuscula*, or *E. suborbiculata*, as previously pointed out, the weight, at present, being in favor of its being the young of the former.

At times the surface of the larger valve, to about the middle of the shell from the beak, also shows some indistinct, flattish, rounded off, radiating folds, and especially are they noticed as such among smaller, younger specimens.

From the above, based on a comparison of the shells, some 40 in number, which the writer has in his possession, and the literature which he has at hand, it would appear that the species given as *E. columbella* should be considered as *E. laeviuscula*.

Position and Locality: From the Lower Cretacic of Dr. Newberry's New Mexican section at Covero, New Mexico, and from the base of the Middle Cretacic of the same section at Galisteo, and in the Sierra Abajo. The specimens described by White came from the east bank

of the Rio Puerco, six miles below Casa Salazar, New Mexico, and it has also been collected in the Lower Cross Timber (=Dakota) sands and in the Eagle Ford (=Colorado group) shales of Texas (Stanton). In places this formation (Dakota) is lacking altogether (in the Navajo country) and shale carrying *Exogyra columbella* Meek? lies directly upon the McElmo formation (Gregory). Dr. Gregory also reports this species being found in the Mancos shales in a three-foot bed of coquina 60 feet above the base of the formation at Lalomi Point, also at Round Top Butte, and in the Hopi volcanic field. The writer found it in the Dakota, principally at the top of the formation, where it might be just as appropriately considered at the base of the Mancos. (This transitional section is designated as Tununk formation in this paper.)

Exogyra laeviuscula Roemer (Figs. 8-12), 1852, Kreidebildungen von Texas, p. 70, pl. 9, figs. 3a-c; Conrad, 1857, U. S. & Mex. Bound. Surv., p. 154, pl. 7, figs. 4a, b; White, 1876, U. S. Geog. & Geol. Surv. West 100th Meridian, p. 173, pl. 17, figs. 2a-d; 1884, 4th Ann. Rept., U. S. Geol. Surv., p. 305, pl. 52, figs. 3, 4, 5; Stanton, 1893, U. S. Geol. Surv. Bull. 106, pp. 64-65, pl. VIII, figs. 5 and 6; *Ostrea ferdinandi* Coquand, 1889, Monog. Gen. Ostrea, Terr. Cret. p. 33; *E. ponderosa* Hill, 1889, Check List Cret. Invert. Fossils of Texas, p. 6. Specimens of this species are very common in the Dakota near the top of the formation, being very abundant in the vicinity of Hogay Ruin (No. 99), the writer collected specimens even from the base of the formation about three miles east of Steamboat store. They are always found associated with the characteristically marked shells of the *E. columbella* type.

Shell is of moderate size, is oval to semi-ovate in form and is high arched and suborbicular in marginal outline; test not massive. The larger valve is "puffed-up," almost hemispherically divided into two almost equal halves through the blunt, rounded-off, medium keel, which slopes downward toward the border with approximately equal inclination; but more prominent near the beak. On some specimens this feature is wholly wanting. The umbo is small, developing into a rapidly tapering, rolled-in, closely incurved spire which is outstanding, sometimes nearly free but not so free as those of the Texas species figured by Roemer, rarely in-grown, making about two volutions, often very closely curved, giving the posterior side an umbilical character, sometimes having a very small scar of attachment; but never is the attachment so large that by it, as in other kinds of the genus, the whirl is wholly atrophied, and the form of the shell made generally irregular thereby. However, it is usually without such scar, and always quite symmetrical, or at least not distorted, as the beak often is in other species of the same genus; periphery of its curve usually extending beyond the hinge line, but sometimes not; the indistinct hinge is often wanting. The outside of the valve is smooth, only showing up to the transverse-middle circumference-line some irregular, somewhat squamous, projecting, increasing striation-lines. The border of the valve is almost round, thin, fragile. The smaller valve is nearly flat or slightly and somewhat irregularly concave, suborbicular to palette-shape in

outline; surface marked by faint to almost indistinct lines of growth, otherwise smooth. Diameter of average examples in the collection about 2 inches; transverse diameter from 1.50 to 1.75 inches; depth of larger valve a little less to a little over an inch.

This and allied species have been the subject of much discussion in the past. R. T. Hill maintains that the shells which are considered as of the species *E. laeviuscula* are young individuals of *E. ponderosa*. The fact that they occur together would cause one to suspect their identity. However, even when the shells are of the same size, those described under *E. ponderosa* are more angular in the umbonal region, less circular in outline and not so smooth as those described under *E. laeviuscula*. However, the writer would conclude that *E. columbella* Meek and *E. laeviuscula* Roemer are one and the same, as is probably *E. suborbiculata* Lamark and that they are probably the more or less young individuals of *E. ponderosa*, as was Hill's conclusion, *E. ponderosa* being very similar to *E. laeviuscula*, only very much larger, and probably the maturer shell.

Position and Locality: Strata of the Cretacic period, Linear Plateau, southwestern Utah (Stanton); Cretacic from near San Antonio, Texas (Roemer); 60 feet above the base of the Mancos at Lolomi Point and in the base of the Mancos on Navajo Mountain in the Navajo country, Arizona (Gregory); in the Dakota at Steamboat, Arizona, but found principally at the top of the series on the transitional line (in the Tununk formation) between the Dakota and the Mancos in the vicinity of Hogay Ruin (No. 99) (Reagan).

