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PART I

NOTES ON SOME UPPER CRETACEOUS VOLUTIDÆ,  
WITH DESCRIPTIONS OF NEW SPECIES AND A  
REVISION OF THE GROUPS TO WHICH  
THEY BELONG<sup>1</sup>

BY WILLIAM HEALEY DALL

While engaged in the study of the Tertiary fauna of Coos Bay, Oregon, it became necessary for me to investigate the systematic position of certain forms of *Volutes* which were contained in it. Their relations to certain Upper Cretaceous forms had been assumed and they had even been referred to the same genus. An investigation of the question was made possible by the kindness of Dr. T. W. Stanton, of the U. S. Geological Survey, in whose official province the Cretaceous forms belong and who placed at my disposition for study all the material which he had brought together.<sup>2</sup>

An examination of these fossils showed that a larger number of species existed than had been supposed, and that the Upper Cretaceous seems to have been marked by an efflorescence of related large *Volutes* in all parts of the world where the fauna of that period has been explored. A comparison of these groups of species with each other and with our American forms, a revision of their systematic arrangement, a description of the new species and the application of new names to those forms which had been described in the literature under names not properly applicable to them, have been attempted in the present paper.

<sup>1</sup> Published by permission of the Director of the United States Geological Survey.

<sup>2</sup> I am also under obligations to Dr. J. F. Whiteaves, of the Dominion Geological Survey, and Dr. Ralph Arnold, of the U. S. Geological Survey, for the loan of material and other courtesies.

## Family VOLUTIDÆ

The inception of the Volutidæ, Fasciolariidæ, and Turbinellidæ appears to have begun in the Cretaceous from a stock of Prosobranchiate Gastropods apparently also the progenitors of another series in which plaits were not developed on the pillar. I have elsewhere described the dynamic principles concerned in the development of plaits in spiral shells of any genus,<sup>1</sup> and it is only necessary to recall the fact that the horizontality or obliquity of the plaits is a function of the plane of enrollment of the whorls, more or less modified by the shape of the aperture and canal. Other things being equal, the shell whose whorls are coiled most nearly in the same plane will have the most nearly horizontal plaits.

To small forms which illustrate the inception of plaits upon the pillar, as would synthetic types of the family groups above referred to, Meek gave the name of *Picstochilus*.<sup>2</sup> Another form, called by him *Mesorhytis*, and still persisting in the deep-sea fauna, is referred by many paleontologists to the genus *Mitra*, and may be more closely related to the Mitridæ than to the group we are discussing.

The forms which appear early, and in which the generic type seems hardly settled into equilibrium, are usually lumped by authors under the inappropriate name of *Volutilithes*; the true *Volutilithes* having a different development, a membranous instead of a shelly protoconch, and first appearing in the Eocene. The antithetic genus, *Plejona* (Bolten) Dall, is more closely related to these Cretaceous types from which it is no doubt descended. The species which may be properly associated with *Plejona* among these early mutable types are those which have an excavated columella with an anterior heavy plait, behind which may be several smaller and less distinct plications.

The forms which are developing in the direction of the Volutidæ of the future and which first show the Volutoid characteristics appear in the middle Cretaceous, and it is this line of evolution which this discussion is intended to follow.

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<sup>1</sup> Am. Naturalist, xxviii, Nov., 1894, pp. 909-914, figs. 1-3; see also Trans. Wagner Inst., III., p. 58, 1890, *et seq.*

<sup>2</sup> Smithsonian Check list N. Am. Cret. Foss., p. 22, 1864. Since the species of *Picstocheilus* named by Meek come from high up in the Cretaceous, while the most nearly related American Volutes come from the Pugnellus sandstone (Turonian?), it is not intended to regard the former otherwise than as later representatives of Mid-Cretaceous forms which, through the imperfection of the geological record, are yet unknown to us, but presumably resembled *Picstocheilus*.

The forms developed somewhat later in all the upper Cretaceous areas which have been explored have a notable family likeness, together with features which in each case lend a certain local facies to the species of each special local fauna. We find also that among the species which make up the group in each fauna are usually repeated certain types of form, each of which probably corresponds to some special conditions which make it fittest to survive, while each faunal locality probably includes about the same groups of conditions each of which impinges upon a particular species or group of species more effectively than on the others. To illustrate the case metaphorically, it seems as if each faunal district resembles a temple containing a number of niches of different shapes, in which the species of each genus or family resident in the district are obliged by the pressure of the environment and the action of natural selection to take their places, those which fail to conform to some one of these protective and formative niches being unable to survive.

Whether the types preserved by these conditions, with their pronounced analogies of form and ornament, should be classed by dynamically developed characters, when it is probable that their genetic connections are closer with the local group rather than with their analogues in other districts and exotic groups, is a subject which naturally opens up the whole question of the proper relations between classification and nearness of genetic ties. Those systematists who claim that degrees of genetic relationship should govern classification, to the exclusion of all other factors, will have no difficulty in deciding the question. Others, with perhaps greater appreciation of the complexity of organic relations and who believe that classification is a means by which we may obtain an end and not an end in itself, must hesitate longer. Without losing sight of genetic connections in a broad sense, in the present state of science at least, it is more convenient, and not less suggestive to the student, to recognize in the system the community of response to the environment at a particular stage of evolution, as well as the more hypothetical connections believed or suspected to conform to the "line" of descent. It may even be doubted whether response to the environment is not in many cases the more potent factor in evolutionary progress than the tendencies inherited from an ancestral reticulum; for it is certain that no organism is of purely, or even potentially, linear descent for any long series of generations.

The possibility of migration complicates the question somewhat, though in geological horizons believed to be nearly contemporaneous and representing equivalent stages of evolution it is probable that migrations play a very minor part.

Among the features common to the Gastropoda of both the upper Cretaceous and Eocene, one is quite conspicuous. It is the frequency with which forms of diverse lineage develop a tendency to produce a coat of enamel over the whole surface of the shell, often very profusely, in species belonging to groups which in the recent fauna have not the habit. As examples, reference may be made to such forms as *Volutomorpha*, *Liopeplum*, *Liomelon*, *Athleta*, and *Psilocochlis*, while numerous others will occur to the reader.

We may now proceed to examine the Volutoid population of different upper Cretaceous districts, where the invertebrate fauna has been well worked out or is sufficiently known.

The chief districts are situated in India; in the Gosau district of the eastern Alps, and the Aachener chalk of northern Germany; the Greensand marls of New Jersey, the Ripley group of the Gulf States, the *Pugnellus* sandstone at the top of the Benton group in Colorado, and the Chico group of California. These range from the middle (Turonian) to the uppermost Cretaceous.

Dr. Stanton, while disclaiming the practicability of exact correlation between the subdivisions of the Cretaceous in the United States and those of foreign countries, is disposed to regard the Colorado, Trichinopoly, Chico, and Gosau horizons as in part representing the Turonian, while Ripley and Aachen correspond to some portion of the Senonian.

In India the fauna of the series known as the Trichinopoly group has been discussed by Sowerby, Forbes, and Stoliczka. The latter author had an unfortunate tendency toward uniting under one specific name very different things, if only they possessed a superficial resemblance—a course more fatal to scientific accuracy than going to the opposite extreme. However, he worked with great industry and erudition and gave good figures of the fossils, so that paleontologists are under serious obligations to him for his work in India. His early review of the Gosau fauna was hasty and insufficient; it is replete with erroneous conclusions. Zekeli, whom he criticized severely, is—if any confidence is to be placed in the illustrations of his monograph—a far more discriminating author than his critic. Naturally, in the discussion of these exotic faunas one must assume that the illustrations of a reputable author are at least approximately accurate in depicting the species figured.

The Volutidæ of the Trichinopoly group, with one or two exceptions, have a somewhat similar sculpture while varying widely in form. The slender, widely separated spiral ridges are more pronounced than the axial sculpture, in proportion to their size the

shells are only moderately thick, the posterior sinus of the aperture is well marked in the adults, and the columellar plaits are small, slender, not crowded, and three or more in number. The characteristics of *Volutoderma*, which is the most typical of these volutes, include a posterior sinus for the protrusion of a part of the mantle, which in the enameled species (*Volutomorpha*) serves to distribute the glaze.<sup>1</sup> Judging by recent species, many of which have a similar sinus, the mantle edge as a whole is not extended over the shell except in the genus *Zidona*. Those authors who have referred members of this group to the Pleurotomidæ have therefore insufficient basis for that opinion.

Beside the sinus, the small smooth shelly protoconch, the appressed suture, the whorl often excavated above the shoulder, the reticulate sculpture, and the three plaits on the pillar often lagging behind the aperture, are characteristic of most of the species where ever found. In many cases the edge of the outer lip where the spiral ridges terminate is provided with a small denticle corresponding to each ridge, and it is not uncommon to find a ridge of enamel in the wake of the posterior sinus, which forms a sort of fasciole.

Among the types represented are the *piruliform*, in which the spire is almost involved within the outer whorls and elevated very little above them, while the whorls are rounded and inflated behind. This has been named *Ficulopsis* by Stoliczka. Its analogue in the Aachen chalk is *Ficulomorpha* Holzapfel; in the Martinez of California, *Retipirula* Dall<sup>2</sup>; in the Eocene of Gatun, Panama, this type has a successor in *Glyptostyla* Dall. In these forms there are two to five plaits.

Another type has also a low spire, but with the shoulder keeled or angular, the whorl behind it flattish and the sides of the whorl in front of the keel flattened as in the genus *Conus*. This is named by Stoliczka *Gosavia*, and has representative species in the Gosau and Aachen formations and probably one in New Jersey. According to Stoliczka and d'Archiac, there is an Eocene species *G. dentata* (Sowerby) in the Nummulitic of India, which Noetling also reports from the Miocene of Burma.

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<sup>1</sup> This sinus differs in function from that of the Pleurotomidæ. In the latter group it allows the protrusion of an elongated tube which carries the fecal matter outside the cavity of the mantle (as in *Pleurotomaria*) and thus prevents fouling the water which has access to the gills. In the Volutidæ the anus is anterior and its products are ejected more or less laterally, as in the majority of Prosobranchs.

<sup>2</sup> *Turbinella crassitesta* Gabb, Pal. Cal., II, pl. xxvi, fig. 37, 1869, is the type.

The prevalent type belongs to a section of *Volutoderma* having a peculiar facies already alluded to, and which we propose to call *Rostellinda*. Of these there are five species confounded by Stoliczka under one name which belongs to none of them. They are mostly large shells with axial ribs and shouldered whorls, the whorl excavated in front of the suture, the sinus near the suture, the axial sculpture feeble, the spiral sculpture stronger on the spire or weaker or obsolete on the last whorl. The species are *Volutoderma* (*Rostellinda*) *stoliczkana* Dall<sup>1</sup> (type); *V. (R.) excavata* Dall<sup>2</sup>; *V. (R.) tenua* Dall<sup>3</sup>; *V. (R.) media* Dall<sup>4</sup>; *V. (R.) teinostoma* Dall<sup>5</sup> and perhaps *V. (R. ?) trichinopolitensis* Forbes<sup>6</sup>; and *V. (R.) multistriata* Stoliczka.<sup>7</sup> Besides these, there is a species resembling *Caricella* Conrad, but which according to Stoliczka has a globular nucleus and a complete layer of enamel over the whole shell. It was described as *Voluta pyriformis* by Forbes and will form the type of a new genus *Liomelon* Dall.<sup>8</sup> There are one or two other species which probably belong to *Volutoderma*, but which, owing to their imperfect state, it is more prudent to leave undiscussed.

In addition to the species belonging to the group under discussion, there are a number of forms belonging to the Volutidæ of the Indian Cretaceous which, by the peculiarity of their columellar folds and general type of form, are evidently the forerunners of the genus *Plejona*, which only attains its fully characteristic development in the Eocene, and of *Volutocorbis*, which has persisted through subsequent ages and is represented in the recent fauna by several species. The anatomical examination of one of these has shown that *Volutocorbis* is a well characterized genus perfectly distinct from *Plejona* or *Volutolithes*, and, in the adult, with a thickened and internally dentate outer lip.

The analogous fauna of the Gosau district among the northeastern Alps was treated by Sowerby and Stoliczka, and monographed by Zekeli. The synonymy of the species has been vastly confused by

<sup>1</sup> Cret. Gastr. India, Stoliczka, pl. VII, figs. 7 (type) and 6. The names here given by the present writer are new.

<sup>2</sup> *Opus cit.*, pl. VII, fig. 5.

<sup>3</sup> *Opus cit.*, pl. VII, fig. 3.

<sup>4</sup> *Opus cit.*, pl. VII, figs. 9 (type), 4, and 8.

<sup>5</sup> *Opus cit.*, pl. VII, figs. 2, 2a (type), and fig. 1.

<sup>6</sup> *Opus cit.*, pl. VI, fig. 6, *Scapha gravida* Stoliczka.

The figures agree so perfectly that I cannot doubt their identity. The form referred to Forbes' species by Stoliczka, at any rate, cannot be identical with it.

<sup>7</sup> *Opus cit.*, pl. VIII, figs. 1, 2, 3, very imperfect.

<sup>8</sup> *Opus cit.*, pl. VI, figs. 9, 9a, *Melo pyriformis* Stol.

indiscriminate "lumping" of species. The fauna comprises, as well as can be determined from the fine illustrations given by Zekeli, without an opportunity of also consulting the fossils, two species of *Gosavia*, *G. gradata* Zekeli, and *G. squamosa* Zekeli, the latter a very coniform species and the type of the genus. There are typical species of *Volutoderma*; *V. perlonga* Zekeli (*prælonga* in the legend to the plate); *V. fenestrata* Müller (*non* Zekeli), and the less characteristic species *V. Mülleri* Dall<sup>1</sup> (= *fenestrata* Zekeli *non* Müller) and *V. (Rostellaca) subsemiplicata* Orbigny. The group of short species having a somewhat nassoid aspect, usually with rather numerous axial ribs and feeble spiral sculpture, which I propose to separate sectionally under the name of *Rostellana* with *V. Bronni* Zekeli<sup>2</sup> as type, comprises also *V. gasparini* Orbigny (*acuta* Zekeli *non* Sowerby), *V. acuta* Sowerby (*non* Zekeli), *V. coxifera* and *V. cristata* Zekeli. This group is also represented in the Pugnellus sandstone of Huerfano Park, Colorado, by allied species.

In the analogous group of forms from Aachen admirably illustrated by Holzapfel in the *Paleontographica*, we find a different and much rougher type of sculpture, with nodulation of the intersections, the axial and spiral ridges more nearly equal in strength, the shells smaller, the shoulder less emphasized and the posterior sinus less conspicuous. In the coexisting genus *Ficulomorpha* we find an absence of axial sculpture, the nucleus is subglobular, the shoulder evanescent, the spire largely involute, giving a pyriform aspect to the shell, which has a wide recurved canal in the adult. The aspect strongly suggests *Ficula* if it were not for the heavy shell and plaited pillar. This external resemblance has led several authors to regard the species as a plaited precursor of *Ficula*. But the young shell has a relatively higher spire and straighter canal with the oblique plaits and globular nucleus of the *Volutidæ*, and is not more pyriform than *Callipara*, which no one doubts belongs to the *Volutidæ*. In fact, the difference in form is almost entirely, in this case, due to the gradual involution of the spire with age, and the resemblance to *Ficula* is purely superficial. This genus retains the posterior sinus characteristic of nearly all Mesozoic and many subsequent *Volutidæ*.

A very close ally, probably only sectionally distinct from *Ficulomorpha*, is *Glyptostyla* Dall, described from the Gatun Eocene on the line of the Panama canal. It differs from the Aachen fossil by

<sup>1</sup> Zekeli, *Gosaugebilde*, taf. XII, fig. 6. New name.

<sup>2</sup> Zekeli, *Op. cit.*, taf. XII, fig. 9.

its reticulate instead of spiral sculpture, its better differentiated canal, and in having two instead of three columellar plaits. The type, *F. (G.) panamensis* Dall, is figured in the Transactions of the Wagner Institute of Science, volume III, plate XIII, figure 5, 1892.

The *Volutoderma* of the Aachen chalk are characterized, as above noted, by a quite different type of sculpture from those of India or even of Gosau, not to speak of the United States. They vary considerably in form, as do the analogous groups in other regions, but have a distinctly common facies. For these I propose the sectional name *Rostellaca*, with *R. zitteliana* Holzapfel as type.<sup>1</sup>

The fauna also contains the following other species which I refer to the same section: *V. (R.) subsemiplicata* Orbnigny; *V. (R.) fenestrata* Roemer; *V. (R.) gosseleti* Holzapfel and *V. (R.) holzapfeli* Dall,<sup>2</sup> the last being obviously distinct from *V. fenestrata* Roemer, with which it is united in Holzapfel's monograph.

Passing over for the moment the Greensand marls of New Jersey, we may consider next the group of species described by Stanton<sup>3</sup> from the Pugnellus sandstone of Huerfano Park, Colorado, which form probably the oldest assembly of this family yet described from the United States.

In this group the number of species known is not large, and none of them are typical *Volutoderma*. The list comprises *Volutoderma (Rostellinda) dalli* Stanton and a varietal or possibly specific form *plicatula* Dall<sup>4</sup>; *V. ambigua* Stanton; *V. (Rostellana?) gracilis* Stanton; and *V. (Rostellana?) constricta* Dall,<sup>5</sup> the latter two being nearly intermediate smooth types.

The Greensand marls of New Jersey contain a large Volutoid fauna, which, unfortunately, is preserved only in the form of internal casts. This forbids very satisfactory identifications specifically. Still the impressions distinctly convey the idea that a number of the shells belonged to the genus *Volutoderma* in the strict sense, while the others, as usual, assume a variable aspect. Altogether there are five or six species of *Volutoderma* in the lower marls and four species of *Volutomorpha* Gabb. The latter genus differs from *Volutoderma* by its sculpture, by having a single strong plait on the columella, and especially by the fact that the outer surface in the adult is covered with a varnish-like enamel. The principal character

<sup>1</sup> Holzapfel, *Paleontographica*, Bd. xxxiv, taf. viii, fig. 4a-b.

<sup>2</sup> Holzapfel, *op. cit.*, taf. viii, fig. 6.

<sup>3</sup> Bull. No. 106, U. S. Geological Survey, 1893, pp. 155-158, pls. xxiii, xxiv.

<sup>4</sup> Stanton, *op. cit.*, pl. xxxiii, fig. 10. New name.

<sup>5</sup> Stanton, *op. cit.*, pl. xxxiv, fig. 3. New name.



in Gabb's eyes was the possession of the single strong plait; and his type, an internal cast, upon which the name of *V. conradi* was bestowed, exhibited plainly only this character. The others are taken from other species, but which are probably correctly referred to this genus. The middle marl contains two or three species of *Volutoderma*; the upper marls three, of which one probably may be referred to the subgenus *Gosavia*.

The upper Cretaceous (Ripley) beds of the Gulf states were more fortunate in the state of preservation of their fossils. In Texas was obtained *Volutoderma texana* Conrad, upon which Conrad founded his genus *Rostellites*, a name preoccupied by Fischer since 1806. The later *Volutoderma* Gabb, is based upon a Californian species. There are three species of this genus in the Ripley formation, one of which is new, and of *Volutomorpha*, beside the *V. eufaulensis* Conrad, there are five very remarkable species yet unpublished. All these are large, brilliantly polished shells.

Some time since<sup>1</sup> I described a recent shell under the name of *Volutilithes philippiana* from off the southwest coast of Chile, in 677 fathoms. It has very much such sculpture as the northern one we have been considering. The nucleus was eroded, but evidently had not been swollen or conspicuously large. A series of other forms, including some half dozen species, occur in the Santa Cruz Tertiary beds of Chile and Patagonia, which from the similarities of decoration seemed at that time likely to belong to the same group as the abyssal recent shell. This was supposed to belong with the Volutoid series having a shelly nucleus, and was so referred by me in a later publication.<sup>2</sup> All were tentatively referred to the Volutoid series and associated with Conrad's *Rostellites*; but more recent explorations in Patagonia have furnished perfect nuclei of several of these fossils, which have been figured by Ortmann,<sup>3</sup> who shows them to belong to the Caricelloid series (formerly called Scaphelloid), which have membranous and deliscent protoconchs. It is altogether probable that the recent *V. philippiana* Dall is related to the regional fossil forms, and had, before erosion, a Caricelloid tip, in which case it would belong to *Adelomelon* as finally revised. The question now arises whether the northern *Mioleiona* is of the same stock, which, if so determined, would place it in a different subfamily from the *Volutoderma*, which is known to have a small shelly protoconch.

<sup>1</sup> Proc. U. S. Nat. Mus., XII, p. 313, pl. IX, fig. 4, 1889.

<sup>2</sup> Trans. Wagner Inst. III, p. 69, 1890.

<sup>3</sup> Ortmann, Princeton Univ. Exp. Patagonia, IV, p. 234, 1902. cf. pl. XXXV, fig. 4d, and pl. XXXVI, fig. 1c.

Until specimens preserving the nuclear whorls are obtained the decision must rest in abeyance.

We now come to the Cretaceous of the Pacific slope, where, in the Chico series, we have the typical species of *Volutoderma*, *V. californica* Dall<sup>1</sup>; a larger and more robust species, figured and described by Dr. C. A. White<sup>2</sup> under the name of *Fulguraria gabbi*, and *V. (Rostellinda) dilleri* White.<sup>3</sup> A fourth species occurs in the Cretaceous of Sucia Island, British Columbia, which I have named *Volutoderma suciana*.<sup>4</sup>

This species is most nearly related to *V. gabbi* White, and not to *V. texana* (+ *navarroënsis*); it differs from *V. gabbi* in its more slenderly fusiform shape, its higher and more acute spire, more delicate spiral ridges, the more anterior periphery to the last whorl, and in the absence of marked axial ribbing.

I am indebted to Dr. J. F. Whiteaves, of the Dominion Geological Survey, for the opportunity to examine the original specimens from Sucia Island. It may be added that the figure above cited gives an insufficient idea of the strength and disposition of the spiral sculpture, the specimen from which it was made having evidently been more or less decorticated.

In the lowest Eocene of the Martinez horizon in California was collected *Retipirula crassitesta* Gabb, before alluded to, but, with the exception of *Ficulomorpha (Glyptostyla) panamensis* Dall, from the far south, no relatives of the genus *Volutoderma* have yet been made known from the Californian or Oregonian Eocene. *Retipirula* differs from *Ficulopsis* by having a sculpture reticulate with rather wide intervals and strong nodulation at the intersections. It also resembles

<sup>1</sup> Gabb, Pal. Cal. 1, p. 102, pl. XIX, fig. 56, (1864). New name for *V. navarroënsis* Gabb, not Shumard.

<sup>2</sup> Bull. U. S. Geological Survey, No. 51, pl. III, fig. 1, 1889.

<sup>3</sup> Bull. U. S. Geological Survey, No. 51 (as *Scobinella dilleri*), pl. IV, figs. 1, 2, 3.

<sup>4</sup> Whiteaves, in Mesozoic Fossils, Geol. Survey of Canada, vol. I, part II, 1879, p. 117, pl. xv, figs. 3, 3a, under the name of *Fulguraria navarroënsis* Shumard, the true *navarroënsis* being identified with *Volutoderma texana* Conrad, a sufficiently distinct species.

The following notes will indicate the distinctions:

*V. suciana* has seven whorls; three strong plaits, of which the anterior is weakest; an appressed suture; an evident posterior sinus; and sculpture consisting of four simple spirals in front of the suture; then two nodulous spirals, a peripheral nodulous spiral with wider interspaces on each side of it; then eleven more or less nodulous spirals, followed by two faint simple ones on the canal. The axial ribbing found in several other species is obsolete or absent. Length 120; spire behind the posterior sinus 44; max. diam. 45 mm.

*Glyptostyla* and *Mioleione* in having two strong plaits, rather than four or five feeble ones, as in *Ficulopsis* and its associates, *Gosavia* and *Rostellinda*. In each case the presumption is that the species is an offshoot from a local group with more elevated spire and not genetically connected with its exotic analogue.

In the Oligocene concretions from the Astoria, Oregon, beds below the Miocene, the United States exploring expedition under Wilkes in 1841 collected a specimen of a species belonging to a genus related to *Volutoderma* which was later described by Conrad under the name of *Rostellaria indurata*. It was associated with *Aturia* and other Oligocene types. The original specimen is an internal cast retaining only small fragments of the shell. With more material, it appears that the species is common to the Oligocene of Washington, and is represented in the Miocene and Pliocene of Oregon and California by a related but distinct species. For these the name *Mioleione* is proposed, and it is not absolutely impossible that deep-sea dredgings off the coast may reveal in the future a recent representative.

The Eocene connecting link between the Cretaceous *Volutoderma* and the Oligocene representative, on the Pacific coast, is not yet known; but recent investigation by Dr. Ralph Arnold, of the U. S. Geological Survey, under the writer's direction, have fortunately discovered specimens of Conrad's *V. indurata* which retain portions of the outer surface. From these we learn that this species was characterized by slender, elongated form, long strap-like axial ribs, with slightly wider interspaces, which reach nearly to the base of the whorls (in a specimen 70 mm. long), while the whole surface is sculptured by fine, close, threadlike, spiral striations. The plaits are of the type of *Volutomorpha* and not like those of *Volutoderma*, and the sutural constriction is obsolete. The genus continues into the Miocene, where it appears in a species in which the presutural constriction (but not the posterior sinus) has vanished, though the suture is still slightly appressed; the spire is shorter and blunter and the whole form less attenuated. The axial sculpture is still of slender, elongated ribs, but there is no spiral sculpture. The columellar plaits are unchanged. This will take the name of *M. oregonensis*.

Having described the origin and distribution of this interesting group of Volutacea, we may close the discussion with a tabular exhibit of the groups arranged to show the recurrence of specialized types of form in successive horizons, and with descriptions of the new Cretaceous species previously alluded to.

In the following table, after the Cretaceous, no attempt has been made to include groups not represented in America (unless *Athleta*

be so regarded), nor is the arrangement intended to be systematic. It is intended rather to illustrate the feature referred to earlier in this paper, viz., the recurrence of similar types of form in successive ages or horizons; or, in widely separated regions in the same age, without regard to close genetic connection. The subordinate sections of *Volutoderma* are omitted here, but will be found elsewhere.

The year indicates the date of publication of the name following, to which is added the general region and the name of the typical species. When a group-name recurs in the table the type species is mentioned only in connection with the earliest appearance of the group, which, however, may have a type species belonging to a later horizon.

The names preceded by an asterisk belong to the Caricellinæ, those without the asterisk to the Volutinæ. All are grouped with reference to external forms.

#### PARTIAL LIST OF FOSSIL VOLUTIDÆ

##### CRETACEOUS

###### *Piruliform*

1868. *Ficulopsis* Stoliczka, India. *F. pondicherriensis* Forbes.  
 1888. *Ficulomorpha* Holzapfel, Aachen. *F. pyruliformis* Müller.

###### *Coniform*

1865. *Gosavia* Stoliczka, Gosau. *G. squamosa* Zekeli.

###### *Muriciform*

1906. *Plejona* (Bolten) Dall, worldwide. *P. spinosa* Lam.

###### *Fusiform*

1876. *Volutoderma* Gabb, worldwide. *V. californica* Dall.  
 1876. *Volutomorpha* Gabb, American. *V. couardi* Gabb.  
 1864. *Picstochilus* Meek, worldwide. *P. scarboroughi* Meek & Hayden.

###### *Bucciniform*

1890. *Volutocorbis* Dall, worldwide. *V. limopsis* Conrad.

###### *Meloniform*

1907. *Liomelon* Dall, India. *L. pyriformis* Forbes.

##### Eocene

###### *Piruliform*

1907. *Retipirula* Dall, California. *R. crassitesta* Gabb.  
 1892. *Glyptostyla* Dall, Panama. *G. panamensis* Dall.

*Muriciform*

1831. \**Volutilithes* Swainson, worldwide. *V. muricina* Lamarck.  
 1906. *Plejona* (Bolten) Dall.

*Bucciniform*

1890. *Volutocorbis* Dall.

*Fusifiform*

1835. \**Caricella* Conrad, America. *C. pratensis* Conrad.  
 1890. \**Volutopupa* Dall, Europe. *V. cithara* Lamarck.  
 1906. \**Maculopeplum* Dall, America. *M. Junonia* Hwass.  
 1890. *Liopeplum* Dall, America. *L. lioderma* Conrad.

*Mitriiform*

1855. \**Lapparia* Conrad, America. *L. dumosa* Conrad.

*Strombiform*

1847. *Lyria* Gray, America and Europe. *L. nucleus* Lam.

## OLIGOCENE

*Fusifiform*

1835. \**Caricella* Conrad.  
 1907. *Miopleiona* Dall, West America. *M. indurata* Conr.

*Strombiform*

1847. *Lyria* Gray.

*Meloniform*

1890. \**Eucymba* Dall. Florida. *E. ocalana* Dall.

## MIOCENE

*Fusifiform*

1853. \**Aurinia* H. and A. Adams, America. *A. dubia* Brod.  
 1906. \**Maculopeplum* Dall.  
 1906. \**Adelomelon* Dall, America. *A. ancilla* Solander.  
 1907. \**Miomelon* Dall, S. America. *M. philippiana* Dall.

*Strombiform*

1758. *Voluta* Linné, Atlantic shores. *V. musica* Linné.  
 1847. *Lyria* Gray.  
 1853. *Enaeta* Adams, America. *E. barnesii* Gray.

*Cassidiform*

1853. *Athleta* Conrad, Europe. *A. rarispina* Lamarck.

## PLIOCENE

(Same series as the Miocene except *Athleta*.)

## PLEISTOCENE

(Same series as the Pliocene with the addition of :)  
1853. *Volutomitra* Gray, Boreal. *V. grönlandica* Beck.

We may now consider the undescribed or unfigured species in hand.

## GENUS VOLUTOMORPHA GABB

## VOLUTOMORPHA EUFAULENSIS Conrad

## (FIGURE 1)

*Volutilithes eufaulensis* CONRAD, Journ. Acad. Nat. Sci., Phila., 2nd ser.,  
IV, p. 286, pl. 47, fig. 18, Feb., 1860.

*Volutomorpha cretacea* (Conrad) GABB, Proc. Acad. Nat. Sci., Phila., 1876,  
p. 290 (= *eufaulensis* Conrad, *op. cit.*).

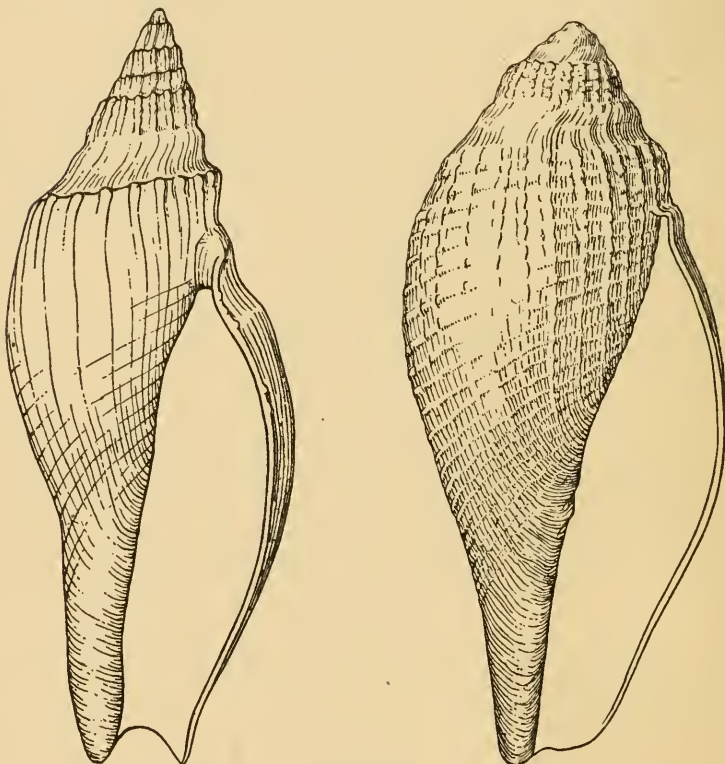


FIG. 1.—*V. eufaulensis* Conrad.  $\frac{3}{4}$ .  
Ripley, Miss.

FIG. 2.—*V. retifera* Dall.  $\frac{3}{4}$ . Kauf-  
man, Texas.

Shell with one moderately elevated plait in the penultimate whorl, obsolete at the aperture; fourteen to sixteen straight axial ribs, extending from shoulder to suture, with wider interspaces; behind the suture each rib has three obscure nodulations; suture appressed and swollen by a deposit of callus in the wake of the posterior sinus of the aperture; sinus situated at the suture, in the adult wide and deep; whorl in front of the suture constricted, carrying strong lines of growth and obsolete distant spiral cords, which also exist over the body; where each cord terminates at the outer lip appears a small projecting denticle; outer lip in the adult somewhat expanded; the whole shell at maturity covered by a coating of enamel which still further obscures the sculpture and sutures; whorls about five, the nucleus shelly, defective. Lon. of shell, 162; of aperture, 110; diam., 58 mm.<sup>1</sup>

Ripley formation of upper Cretaceous at Ripley, Miss.; the same horizon at Eufaula, Alabama; Bullock's Mill, near Dumas, Miss. (20,576); and near Mt. Olivet Church, Union county, Miss. (20,534); U. S. Nat. Mus. and Acad. Nat. Sci., Philadelphia.

The plait on the pillar in the fully adult shell becomes obsolete in the vicinity of the aperture and is invisible from in front. In the earlier whorls it is strong, lying in front of a shallow channel on the pillar; the posterior border of this channel, in the early stages of the shell, forms a second fairly well-marked plait. The substance of the shell as preserved is chalky white with a yellow-brown coating of enamel.

#### VOLUTOMORPHA RETIFERA Dall, n. sp.

(FIGURES 2, 3)

Shell with one evident plait in the adult, two in the early stages, lagging behind the aperture and hardly visible from in front; penultimate whorl with eighteen to twenty-one rounded ribs, most prominent at the shoulder, obsolete on the last half of the last whorl, but earlier extending well toward the base, with subequal interspaces; posterior sinus of the aperture deep, narrow, in the adult recurved (see figure 3), leaving a prominent ridge of callus in front of and close to the suture, in front of which the whorl is excavated, markedly so in the earlier whorls, and spirally obsoletely striated; the rest of the surface with about twenty-two spiral, strap-like ridges, very

<sup>1</sup> Conrad's original figure, though characteristic, was taken from a crushed specimen which is abnormally wide.

evenly disposed, prominent but hardly nodulous at the intersections, forming with the ribs a coarse, rather regular reticulum; spire short, conic; suture appressed; the whole shell in the fully adult stage with a very thin coat of enamel; outer lip thin, expanded, slightly reflected; more or less denticulate at the extreme margin. Lon. of shell, 143; of aperture, 103; max. diam., 44 mm.

Ripley horizon of Upper Cretaceous at Kaufman, Texas (U. S. N. M., 20,996); collected by Dr. T. W. Stanton, U. S. Geological Survey.

This has somewhat the aspect of *V. eufaulensis*, but the spire is shorter and more blunt, the maximum diameter is more posterior, the sculpture is much more distinct and regular, the brilliant polish is wanting, and the substance of the shell has a peculiar brownish tint and subtranslucent character, which is probably not entirely due to conditions of fossilization.

#### VOLUTOMORPHA DUMASENSIS Dall, n. sp.

(FIGURE 4)

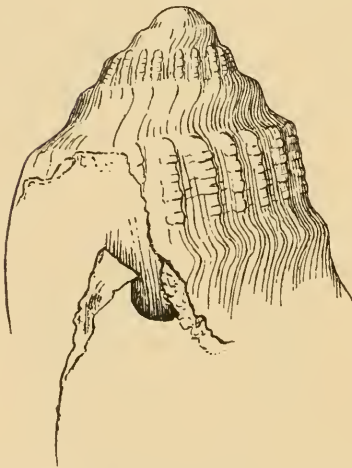


FIG. 3.—*V. retifera* Dall. 1/1. Side view of fragment, showing mold of recurved posterior sinus.

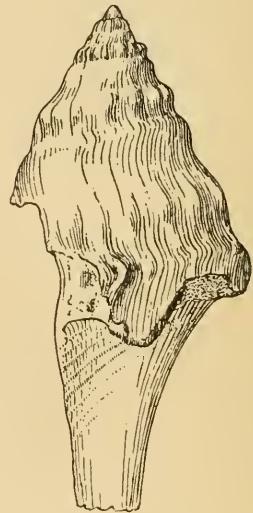


FIG. 4.—*V. dumasensis* Dall. 1/1. Fragment, showing character of spire and shallow posterior sinus.

Specimens all imperfect, but showing one strong and one obsolescent plait; penultimate whorl with thirteen short riblike swellings at the periphery, weaker in front and absent behind, where there is a wide shallow constriction of the whorl extending from the periphery



to the swollen fasciole by the posterior sinus, the whole with faint sparse spiral threads with slightly wider interspaces; posterior sinus strong, short, not deep; whole shell with a thick coat of enamel, and about six whorls, anterior portion defective in all the specimens. Lon. of spire above the posterior sinus 48, diameter about 45 mm.

Ripley formation of Upper Cretaceous at Bullock's Mill, near Dumas, and Mount Olivet Church, Union county, Miss. (20,503 and 20,576 in part, U. S. Nat. Mus.).

Although imperfect, the form and sculpture indicate a distinct species easily recognizable from the differential characters of the diagnosis. The substance of the shell is soft and chalky.

**VOLUTOMORPHA ASPERA** Dall, n. sp.

(FIGURE 5)

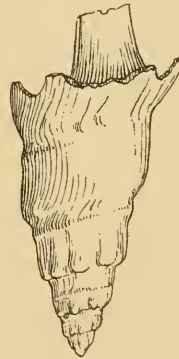
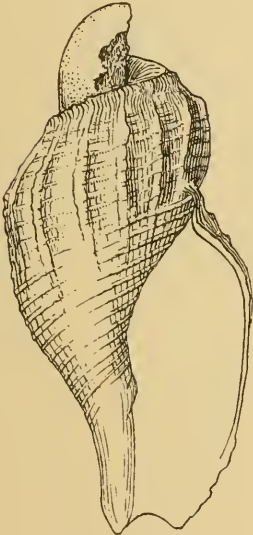


FIG. 5.—*V. aspera* Dall. 1/1. Ripley, Miss.

FIG. 6.—*V. turricula* Dall. 1/1. Upper part of spire, showing sculpture and form. Bullock's Mill, near Dumas, Miss.

Shell considerably crushed and wanting the earlier whorls, but showing one well-marked plait; the last whorl with about thirteen narrow ribs, obsolete in front of the suture, prominent at the shoulder, weaker over the body; the whorl between suture and shoulder constricted and more or less axially wrinkled; posterior sinus at the appressed suture; the sinus is narrow and shallow; spiral sculpture

of rather close-set cords with narrower interspaces; there are about twenty-six spirals in front of the shoulder on the last whorl; surface with a thin wash of enamel and an obscure callous ridge in front of the suture; outer lip thin, slightly expanded, strongly denticulate at the edge in front; spire elevated, but defective in the type. Lon. of last whorl 62, of aperture 47, max. diam. 32 mm.

Ripley formation of the Upper Cretaceous, at Ripley, Miss. U. S. Nat. Mus., 20,404.

The rough surface sculpture and strong spiral threading sufficiently distinguish this species from any of the others.

**VOLUTOMORPHA TURRICULA** Dall, n. sp.

(FIGURES 6 AND 7)

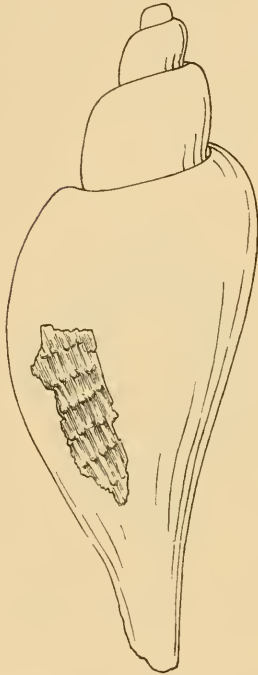


FIG. 7.—*V. turricula* Dall.  $\frac{1}{2}$ . Showing general proportions of the shell and a small patch of the external sculpture. Bullock's Mill, near Dumas, Miss.

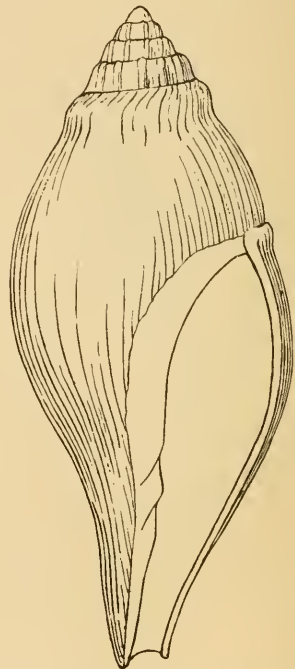


FIG. 8.—*V. lioica* Dall.  $\frac{3}{4}$ . Nearly adult shell. Ripley formation at Eufaula, Ala.

Shell with the plaits as in *V. eufaulensis*; whorls about six and a half, the whole shell thickly enameled; spire elevated, slender, not

swollen at the suture, in front of which there is a moderate constriction, behind which there is a single spiral cord, obsolescent on the later whorls; the apical whorls have nine peripheral nodules at the shoulder; nucleus shelly, minute; posterior sinus shallow, situated at the suture (see figure 6); anterior portion wanting. Lon. of spire in fragment 38, diam. 20 mm. U. S. Nat. Mus., 20,573.

A decorticated and much larger specimen from the same locality appears to belong to the same species; if so, the last whorl develops near the anterior part of the outer lip distant and oblique spiral threads (which appear on a patch of surface remaining), which break up into low rounded pustules and seem not to have extended far from the margin, but probably correspond to the denticulations of the outer lip in the adult. This specimen, with an allowance of 14 mm. for its missing apex, measured: Lon. of shell 195, of aperture 131; diam. at post. sinus about 48; max. diam. of last whorl about 62 mm. (U. S. Nat. Mus., 20,576, part.)

Upper Cretaceous of Bullock's Mill, near Dumas, Miss. U. S. Geological Survey.

This large species is well distinguished by its slender elongate spire, its sculpture and the small number of its riblets. I am quite confident, though not absolutely certain, that the large decorticated specimen represents the adult of what I regard as the type specimen (fig. 6); in which case it is probably the largest species of the genus, of which the shell is known. Both specimens were collected at the same time and in the same locality.

### VOLUTOMORPHA LIOICA Dall, n. sp.

(FIGURE 8)

Shell large, solid, with one strong plait between two shallow excavations, probably with two well-marked plaits in the early stages; spire short, conic, with about fourteen obsolete axial riblets on the antepenultimate and earlier whorls; sutural callus prominent, the whorl in front of it slightly or not at all constricted; body of shell smooth, anterior third with sparse obsolete sulci, becoming closer on the canal; posterior sinus deep, narrow, outer lip hardly reflected, but with a few small pustular prominences on its outer edge; the whole shell enameled. Lon. 117, max. diam. 47 mm.

Collected by the U. S. Geological Survey from the Ripley formation of the Upper Cretaceous at Eufaula, Alabama. U. S. Nat. Mus., 21,127.

This species, by its smooth surface, is strongly contrasted with the others and is easily discriminated. The substance of the shell is soft and chalky, the enamel yellowish. Two precisely similar and rather well preserved specimens were obtained.

GENUS VOLUTODERMA GABB

VOLUTODERMA TEXANA Conrad

(FIGURE 9)

*Rostellites texano* CONRAD, in Emory's Report on the Mexican Boundary, p. 158, pl. XIV, fig. 2, 1855.

*Volutilithes navarroënsis* SHUMARD, Proc. Bost. Soc. Nat. History, VIII, p. 192, 1861.

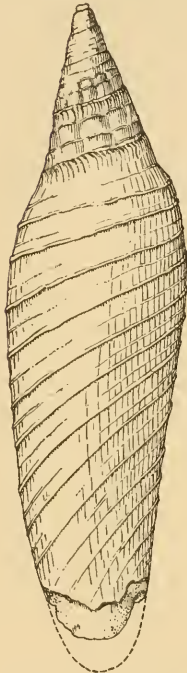


FIG. 9 — *V. texana* Conrad, dorsal view showing form and exterior sculpture. <sup>23</sup>.

By plating the dimensions and filling in the details given in Shumard's very full description, it is easy to make a diagrammatic figure which is recognizable. Conrad's species was figured from an internal cast, preserving only a narrow strip of the outer surface near the pillar. The spiral cords were taken to be columellar plaits, which gave a wholly erroneous idea of this portion of the fossil. Only three plaits are present. Conrad's type is preserved in the U. S. Nat. Museum (No. 9886). There is no reasonable doubt that his species is identical with that of Dr. Shumard, having been collected from the same horizon and region and agreeing essentially. Since Shumard's species was never figured and the figure given by Conrad represents only the internal cast, it seemed advisable to figure the better-preserved form which later researches have brought to light and which retains the substance of the shell. Figure 9 represents such a specimen, No. 20,992 U. S. Nat. Museum, from Kaufman, Texas. The following data, additional to those given by Conrad, are deducible from the material brought together by Dr. Stanton from various places in Texas, especially near Webberville, Texas, No. 21,183.

Pillar with three feeble plaits, becoming obsolete near the aperture, the "numerous plaits" of Conrad being based on remnants of

the external spiral cords, and not on the true plaits; early whorls with 8-10 rounded axial riblets, obsolete on the last whorl; suture appressed, the whorl in front of it flattish, with no well-marked shoulder, but more or less distinct axial wrinkling just in front of the suture; on the last whorl there are 15-17 prominent, distant, sharp spiral ridges, without nodulations; separated by much wider, slightly excavated, axially striate interspaces in which occasional much finer intercalary spirals sometimes appear; outer lip thin, in the adult anteriorly expanded, slightly reflected; the posterior sinus narrow, well marked, close to the suture. Lon. 124; of aperture, 87; max. diam. 33 mm.

**VOLUTODERMA PROTRACTA** Dall, n. sp.

(FIGURE 10)

Shell very elongate, thin, with 8 whorls; pillar straight, with three feeble plaits lagging behind the aperture; on the early whorls 7-8 rounded axial ribs, obsolete on the later whorls; whorls slightly constricted in front of the appressed suture; sutural margin with conspicuous imbricated scales and striation axially directed, crossed by 3-5 faint spiral threads; on the body of the last whorl are 19-20 sharp spiral ridges with much wider, somewhat excavated interspaces; the spiral ridges are sometimes gently undulated but not nodulous, and there are occasionally faint intercalary spiral threads; outer lip thin, slightly reflected; posterior sinus close to the edge of the suture. Lon. 155; of spire above the first whorl, about 40; max. diam. 36 mm.

Types are from the Ripley formation at Eu-faula, Alabama, U. S. Nat. Mus., No. 21,129; other specimens are from the same horizon at Owl Creek bluff, Ripley, Miss. (20,430); and Kaufman, Texas (20,992).

The figure given of this remarkable species is diagrammatic, being a restoration from a number of fragmentary specimens. The shell is so thin that no specimen was collected showing an entire shell of adult stature. The specimen from Texas is partially an internal

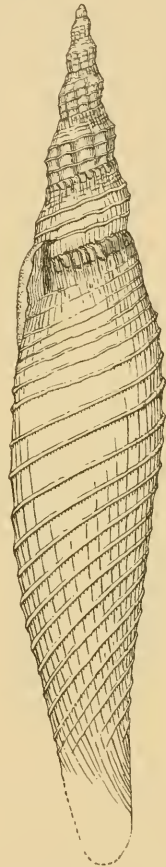


FIG. 10.—*V. protracta* Dall.  $\frac{3}{4}$ . Posterior sinus shown in profile.

cast, and is defective both at the apex and the end of the canal, but still measures 142 mm. in length and about 32 mm. in maximum diameter. The shell in this specimen, which is more solid than those from the more eastern localities, has a maximum thickness in the last whorl of about 3 mm. The surface, as in all the species of this genus, is dull and rude, contrasting strongly with the brilliant polish of the species of *Volutomorpha* from the same horizon. The shell is proportionately more slender than any *Volute*, recent or fossil which is known to me.

## TURBINELLIDÆ

### GENUS PSILOCOCHLIS DALL

#### PSILOCOCHLIS McCALLIEI Dall

(FIGURES 11, 12, 13)

*Turbinella (Psilocochlis) McCalliei* DALL, *Nautilus*, XVIII, No. 1, pp. 9-10, May, 1904.

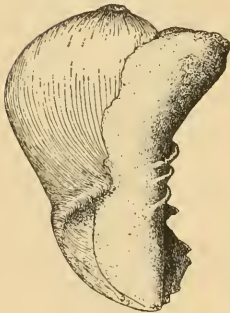


FIG. 11.—*Psilocochlis McCalliei* Dall. 4/5. Outer lip wanting; the enamel worn off a large part of the shell. Type specimen. Eocene of Georgia.

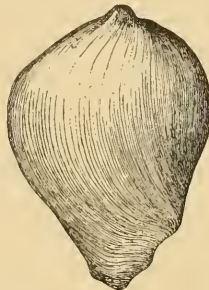


FIG. 13.—*Psilocochlis McCalliei* Dall. 4/5. Dorsal view of another specimen, showing complete investiture by a coat of enamel concealing the sutures.

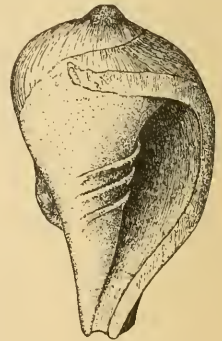


FIG. 12.—Same as figure 11, turned so as to show the plait on the pillar. The projection on the left is the siphonal fasciole.

Shell of about four whorls, of which the earlier three are comparatively small, the apex hardly rising above the general dome of the spire, and still further concealed in the adult by a coating of enamel with which the entire shell is varnished, concealing the sutures; shell widest at about the posterior angle of the aperture, the last whorl diminishing forward and slightly constricted behind

the strong and flaring siphonal fasciole; umbilical funnel smooth and almost filled by a smooth appressed mass of callus, continuous over the body and much thickened on the posterior part of the inner lip; surface without any sculpture except microscopic incremental and revolving lines; outer lip defective but apparently simple and sharp. Length (fig. 11) 50, max. breadth about 38 mm.

Collected from the Claibornian Eocene of Richmond county, Georgia, by Mr. S. W. McCallie, of the State Geological Survey, one-half mile north of Hephzibah, Georgia.

This was first described from a specimen (figs. 11, 12) in which the external coating of enamel had been largely removed by decay or wear. It was supposed to be a subgenus of *Turbinella*, but the discovery of other specimens, later, has led me to assign it full generic rank. One of these (fig. 13), though in some respects poorly preserved, showed that the adult shell is completely covered by a coat of enamel, something hitherto unknown among the *Turbinella* species, recent or fossil. This character, therefore, must be added to those given in the original subgeneric diagnosis, to render the generic description complete.

Though representing a collateral branch of the stem from which the Volutidæ are descended, this genus is sufficiently allied to find a place in this paper without incongruity; and this is the more desirable since no figure of the fossil has been published up to the present time.

The specimens figured form part of the collection of Tertiary fossils of the U. S. Nat. Museum, No. 110,379.