Variations of Seminula Argentea (Shepherd)

by Raymond Foster Miller

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Submitted to the Department of Geology of the University of Kansas in partial fulfillment of the requirements for the Degree of Master of Arts

--::VARIATIONS OF SEMINULA ARGENTEA (SHEPHERD)::--

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A Thesis Presented to the Faculty of the University of Kansas in Partial Fulfillment of the Requirements for the Degree of Master of Arts.

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Table of Contents.

Introduction

It has long been recognized that Seminula Argentea perhaps the most common of Pennsylvanian brachiopods, varies quite markedly in shape and size in different regions and at different horizons. In order to determine the kind and the amount of the variation and to discover if possible, its faunal and geological value, the investigation recorded in this paper has been carried out. Study was made of over 1000 individuals from over 60 localities in Kansas, nearly every geological horizon of the state, in which are contained marine fossils, being represented. In addition there were some specimens from Illinois, Missouri, and New Mexico.

Grateful acknowledgement is here made for much valuable assistance received from Professors E. Haworth and W. H. Twenhofel.

Geological Range

Seminula argentea, in its geological range is one of the most extended of the species of the Carboniferous. Its earliest occurrence is in the St. Louis Limestone of the Mississippian at Pella, Iowa.[1]

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1. Hall and Clarke, Pal. N. Y. Vol.VIII pt II page 95.

Typically it is a Pennsylvanian species, and in the Kansas section it is present in every formation which is typically marine, occurring in abundance not only throughout the Coal Measures, but also in the Lower Permian, holdind a prominent place in the faunas to the top of the Chase Stage. In the Guadaloupian section of the El Paso Region of Texas, considered of Permian age, and younger than any portion of the Kansas Section, are specimens of Seminula described by Girty as distinct species, but which are only varietally, if at all distinct from the Kansas Seminula argentea. (2)

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2. Geo.H.Girty,Prof.Paper 58,1908:388-9 pt XV. figs 1-7 b.

Geographical Distribution.

Seminula argentea is a world-wide species, and is not excelled in width of distribution by any other fossil of the Pennsylvanian, or for that matter, of any period. In the

Himalayas, in Russia, Belgium, England, South America, and in North America, wherever Pennsylvanian rocks occur, this ubiquitous fossil appears. It must have had an extraordinary hardihood, withstanding changes which meant extinction to many of its kind and passing barriers which by other species were insurmountable. In the western Coal Measures few localities can be found where this extremely common fossil does not occur. The collections upon which the present study is based, were derived from the following Kansas localities: Leavenworth, Farlington, Erie, Pawnee Station, Loring, Edwardsville, Frisbee, Iola, Eudora, Lecompton, Melvern, Lebo, Burlington, Lawrence, Fame, Severy, Howard, Moline, Americus, Elmdale, Cottonwood Falls, Manhattan, Grand Summit, Marysville, Cleburne, Wakefield, Herington, Fort Scott.

External Variation

Previous Work. --Variations in shape, of Seminula argentea have been studied by Hall and Clarke (1) and Prof. J. W. Beede (2).

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1. Hall and Clarke, Pal. N. Y. Vol. VIII, pt II, 95 pt XLVII figs 17-31.

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2. J. W. Beede, K. U. Science Bulletin, Sept. 1902; 155-157.

Hall and Clarke state that all degrees of variation from very long, narrow forms, to wide, trilobed forms, are found, and that the sinus varies from a mere line to a broad and deep depression. They were unable to separate the forms into distinct species, because the variations were not constant.

Prof. Beede made no attempt to work out the variations in shape of the species but merely mentions the fact that both broad and compressed forms occur and that the young shells are much flatter than the adults. In a recent letter to Professor Twenhofel, Doctor Beede states his belief that at least two varieties of the species exist in Kansas, each with a definite geological range. He says that the forms from the Garrison formation, (Florena shales and Neosho formation) are strikingly different from the others and are confined to this formation and possibly a few closely associated beds. The last statement must be amended to include nearly all of the Coal Measure and Permian strata, for forms similar in every way are found in the Pawnee, Iola, Oread, Burlingame and Americus limestones, and in the beds of the Chase Stage of the Permian. A description of the variety referred to will be given later under the title "Forms with massive shell."

Kansas Variations.--In order to clearly define the variations found among the Kansas examples of this species, it appears advisable to give a description of that variety which is regarded as the type of the species. It is taken from Meek (1) and is as follows:

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1. 1859 Meek, Proc. Acad. Nat. Sci. Phil. 20.

"Shell ovoid, being usually widest a little in advance of the middle, and nearly always somewhat longer than wide; moderately convex, becoming rather gibbous with age. Ventral valve usually a little more convex than the other, its greatest convexity being generally behind the middle, beak prominent, rounded, and distinctly incurved upon that of the other valve; foramen round, of moderate size, and truncating the immediate apex of the beak; mesial sinus absent or very shallow in young or compressed individuals, but well defined and round, flattened or angular in adult gibbous specimens, in which it rapidly increases in size, from near the middle, to the front, where it produces a more or less prominent marginal projection, fitting into a corresponding sinuosity in the margin of the opposite valve. Dorsal valve moderately convex, the greatest convexity in small or compressed specimens often near the middle, or between it and the umbo, but in large gibbous individuals with a well defined prominent mesials fold, sometimes near the front; beak rather distinctly incurved under that of the opposite valve. Surface of both valves nearly smooth, or with mere lines of growth in young shells, but in large or mature specimens with well defined inbricating marks of growth on the anterior half, exfoliated surfaces also show under a magnifier obscure traces of radiating striae."

Hall and Clarke describe the type as "an elongate shell, broad over the pallial region." Combining the descriptions given by Hall and Clarke, and by Meek, the type of the species may be briefly defined as follows: Shell ovoid, elongate, broad over pallial region, sinus and fold well developed, surface smooth except for well defined lines of growth. (Fig. 3, plate I.)

In the Kansas specimens the study of a large number of individuals has made clear that three fairly well marked varieties occur. In the present paper these will be characterized as (1) forms longer than wide; (2) forms as wide as long; (3) forms with massive shell.

(1) Forms longer than wide.--Under this heading it is intended to include all thin shelled forms which are longer than wide. The shell is narrow, elongate, widest in pallial region; beak long and narrow; sinus very deep anteriorly, but fading out on the umbo; fold distinct only on anterior third of shell; surface smooth except for distinct lines of growth, which number on an average, about 10 to the centimeter. The dimensions of an average sized shell are: length 21 mm, width 15 mm, thickness 12 mm.

Variations. --Many specimens vary in shape and in depth of sinus, from the average. Some are extremely narrow, thick and without sinus, wile in a few specimens the sides are nearly parallel, and the anterior margin is reentrant. Others have well rounded sides, with the greatest width about the middle. Nearly all of the individuals of this variety are narrower than the type form of the species. (Plate I, figs 1-2; Plate II, figs 1,2,4,7)

This variety is found in the following localities; Pawnee Station, Bourbon Co. (Pawnee limestone-; Kansas City, Mo., Lenape, Loring, Edwardsville, Frisbee, (Iola Limestone); Iola, Eudora, (Allen l.); Lawrence, Lecompton, Melvern, Burlington, (Oreadl.); Fame, Greenwood Co.,(Lecompton l.); Moline,(Topeka l.); Americus, (Americus l.); Cottonwood Falls Grand Summit,(Florena shales); Marysville (Riley formation); Cleburne, Rile Co., Wakefield, Clay Co., (Matfield shales); Herington, (Winfield formation).

2. Forms as wide as long.-- Under this head are grouped forms in which the width is equal to or greater than the length, and the shell substance is thin. The greatest width is usually about the middle and the sinus is illdefined, usually represented by a narrow median line from beak to margin Shell very flat, surface smooth, growth lines faint and wide apart (about 8 to the cm), pearly luster very noticable.

Dimensions of an average shell: length 20 mm, width 20 mm, thickness 12 mm.

There is very little variation from the average in this form. some specimens have a well developed sinus, while others have no trace of it. The entire margin is sometimes flattened for a distance of two or three mm. from the edge. Radiating striae are present in many exfoliated shells. This variety differs radically from the type of the species in its greater width and poorly developed sinus. (Plate II, figs 3,5,8,9,10)

Specimens of this form have been found in all of the Coal Measure and Permian strata where the species is found except the Burlingame limestone. Below the Iola limestone wide forms predominate in all of the beds. The following localities are represented in the university collection: Ft. Scott (Ft. Scott limestone, Pawnee l., Labette shales); Farlington, (Pawnee l.); Erie, (Bethan Falls l.); Leavenworth (Cherokee shales); K. C. Mo., Lenape, Edwardsville, Loring, (Iola l.); Eudora (Allen l.); Lawrence, Lecompton, Burlington (Oread l.); Fame (Lecompton l.); Americus (Americus l.); Manhattan, (Eskridge shales); Cottonwood Falls, Grand Sumit, (Florena shales); Marysville, (Florence Flint, Riley Formation); Cleburne, (Riley formation); Wakefield, Herington, (Permian)

3. Forms with Massive Shell.--In this group are placed all large thick-shelled forms regardless of shape. A sinus is always present, usually very deep; shell substance greatly thickened, muscular impressions deep and narrow; surface quite rough, owing to the lamellose growth-lines, which are usually closely crowded together on the anterior margin. Dimensions of an average shell: length 32 mm, width 32 mm, thickness 20 mm.

Variations. --The relative dimensions, and the depth of the sinus vary quite largely. Forms in which the width and length are subequal predominate in numbers, but elongate shells are not rare. The sinus is usually deep at the anterior margin but may be only slightly developed. (Plate I, figs 4-5).

This variety occurs at Pawnee Station (Pawnee limestone; K. C. Mo., Edwardsville, Lenape, (Iola l.); Lecompton, (Oread l.); Fame, Howard, (Lecompton l); Moline (Topeka l.); Lebo (Burlingame l.); Americus, (Americus l.); Elmdale, (Elmdale formation); Manhattan (Eskridge shales); Cottonwood Falls, Grand Summit, (Florena shales); Marysville, Cleburne, Wakefield, Herington, (Permian).

General Discussion of External Variation.

The very young shells of Seminula argentea show two variations in form,--narrow and wide. This fact shows that the divergence of the varieties begins during the development of the protegulum or initial shell, for after this stage the shell retains its characteristic shape. The same thing is shown by the lines of growth, which are simply the record of the successive positions of the margin. The growth lines on any individual shell are all of the same general shape and this fact proves that the shell has not changed much in outline during its growth. So then, the shape of the adult shell can be used as a criterion in separating the varieties. Since the forms with massive shells may be either narrow or wide, they must have been derived from the other two varieties each form from the small variety which has a similar shape. (Plate II, Figs. 2,3,6,9)(Plate I, Figs 4-5).

Internal Variation.

Previous work.--Some of the interior characters of Seminula argentea were described by Hall and Clarke, (1)

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1. Hall and Clarke, Pal. N.Y., Vol. VIII pt II; 95-96.

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as follows: "The saddle (of the loop) is deeply bilobed, its anterior margin and the edges of the secondary solutions fimbriate. The precise value of this pectination of the saddle and coils it is difficult to determine; it appears to be developed differently in different individuals." No variation in shape or position of the spiralia or loop was discovered by these authors.

Doctor J. W. Beede has discussed the variation of the Spiralia of Seminula argentea (2), and he figures several

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J. W. Beede, K.U. Science Bulleton, Sept. 1902:155-157.

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specimens in which the spires are turned through various angles from the usual lateral position and draws the conclusion that these positions were due to natural variation. Recently, however, in a letter to Professor Twenhofel, Professor Beede said that the conclusions given in the paper refered to were wrong and that the spires which are not in the lateral position have been broken loose and distorted.

Spiralia.--The explanation offered by Professor Beede in his letter is abundantly confirmed by a study of many specimens. Out of thirty-five shells in which the spires could be seen thirty one had them directed laterally, three showed them turned through ninety degrees, with the tips pointing to the beak and ventral margin, and one specimen had one spiral lateral, and the other turned to the center of the ventral valve. The lateral position is without doubt the natural one. The second position would be impossible during the life of the animal for the attachment of the spiralia to the hinge plate is made at the base, not the tips of the spires. The rarity of examples of the third position indicates that it is due to accident, rather than natural variation. (Plate III, Figs 1-3).

In all cases where the position is natural, the bases of the spires are in contact along the ventral side, except for a short space near the anterior margin of the shell, where they flare widely apart. They are separated entirely along the dorsal side. (Plate III, Figs 4a, 6a).

The tip of the spire is generally acute, but not always. The outline of the spire is usually convex posteriorly and ventrally, but concave anteriorly and dorsally. Sometimes it is concave all the way around, but is never entirely convex.

The relative dimensions of the spires vary with the shape of the shell. In narrow elongate shells the spirals are laterally compressed, deep and wide across the anterior margin while in wide shells they are laterally expanded, flattened and relatively narrow across the anterior margin.

The width in front varies somewhat with the depth of the sinus. When the sinus is deep the spires are close together in front and visa versa. (Plate III, figs 5-6.)

The outer edges of the volutions usually show many tiny spines or fimbriae, but many spires seem to lack them entirely. In gerontic individuals, the fimbriae are short and rugose, (Plate III figs. 4-6).

The number of volutions in the coils varies with the age of the shell, the smallest number observed being five, and the largest eighteen.

The Loop.--There is considerable variation in the shape of the loop in different individuals. In wide flat shells the loop is correspondingly flattened, and the stem makes a wide angle with the jugum. In thick narrow shells the stem descends abruptly from the jugum, and the lateral branches are nearer vertical than in wide forms. The loop in individuals of the massive variety lacks the forked tip on the saddle but in other respects is similar to the loop in the other varieties.

In young shells the loop is very large in proportion to the size of the shell, sometimes reaching two thirds of the distance from beak to anterior margin. In mature shells it rarely extends more than half the distance. (Plate IV. figs 1-6).

Muscular Impressions.--In the muscular scars of the ventral valve there is also considerable variation between the varieties. In the narrow variety the scar is oval in shape, slightly impressed about one fifth the width and half the length of the shell, while in an adult specimen of the wide form the scar is nearly rectangular in shape, deeply impressed less than one sixth the width of the shell, and fully two thirds its length. In depth and outline the scars in these two varieties are in striking contrast with that of the Massive variety, in which the muscular impression is nearly three mm deep, and extends the full length of the shell. Posteriorly it is very narrow, almost linear, but widens somewhat toward the anterior border. At no place however, is it more than one tenth the width of the shell. (Plate V,figs. 1-3).

Suggestions as to Cause of Variation.

In searching for evidence of some relationship between the character of the rock strata and the different variations of Seminula argentea, it was found that wide forms are most abundant in shale beds, while narrow forms predominate in massive limestones. These facts throw considerable light upon the character of the environment in which each variety developed. The shale beds were formed in shallow water close to shore, while the limestones were deposited in the deeper clearer water at some distance from land. From this the conclusion may be drawn that the wide variety developed in the shallow muddy water close to the shore lines while the narrow forms flourished farther out in the clearer waters of the Pennsylvanian sea. It is probable that an excess of sediment in suspension in the water was unfavorable to the species, regardless of varieties, for Seminulas are generally scarce in beds containing many mollusks, which as a rule thrive best in turbid water.

Another very striking peculiarity in the distribution of the varieties is the abundance of large thick shelled forms in the higher strata of the Coal Measures and in the Permian. In some of these beds the Massive variety occurs to the exclusion of all other forms, while in all of the beds above the Topeka limestone it is the predominant form. This variety evidently did not develop in response to merely local changes in the environment for similar forms are found in the Pennsylvanian strata of New Mexico, and occasionally in the lower Coal Measure beds of Kansas. However, the great changes in land and sea near the close of the Pennsylvanian Period seem to have produced an environment more favorable for the Massive variety than to others and this may have resulted in a migration of the variety from some other locality.

On the other hand, it may be that the appearance of large thick shelled forms in such abundance was due simply to natural decadence or senility of the species. It is a well attested fact that many species of invertebrates fossils show an extraordinary thickening and ornamentation of the shell, just prior to the final disappearance of the species. The chief objections to such an explanation are, the occurence of this form in the lower Pennsylvanian beds, and the great lapse of time before the extinction of the species in the Permian.

The Massive variety seems to have reached its highest development in the Florena shales, for all of the specimens from higher beds are comparatively small in size, although in other respects they resemble the shells from the Florena shales. This pauperization or tendency toward smallness in size may have been caused by an increase in the saline content of the water, for the occurrence of vast beds of salt and gypsum in the Permian strata prove that, locally at least, such a concentration of the solids in solution did take place. To be sure, no fossils have been found in the gypsiferous beds, but they do occur in the shales below, and therefore may have existed in some of the great shallow lagoons after the latter became land locked. In such a case all forms of life would disappear long before the water became concentrated enough to deposit gypsum.

Conclusions.

The facts which have been set forth in the preceding pages seem to warrant the following conclusions:

1. There are three fairly distinct varieties of Seminula argentea in Kansas, here designated as (1) Forms longer than wide; (2) Forms as wide as long; (3) Forms with massive shell.

2. Wide forms predominate in shale beds, and also in the limestones below the Iola.

3. Narrow forms are most abundant in the beds from the

Iola through the Topeka limestone.

4. Massive or senile shells are rare in all strata below the Lecompton limestone, except locally in the Iola. In all beds above the Lecompton, senile forms predominate.

5. Variations in shape and size of internal structures correspond approximately to variations in the form and size of the shell.

6. The loop in massive forms is distinctively characterized by its lack of a forked tip on the saddle.

7. The wide forms dwelT in greater abundance close to the shore line while the narrow forms inhabited the clearer waters at some distance from the land.

8. The smallness in size of Permian forms may be accounted for by the concentration of salt in the waters of the lagoons along the shore of the Permian sea.

Bibliography and Synonymy.

1838 Terabratula argentea, Shepherd, Am. Journ. Sci. (1) Vol. 34, p 152, fig. 8.

1842 Terebratula Roissyi. D'Orbigny (non L'Eveille), Voyage dans l'Amerique Meridionale, Pal., p 46.
Carboniferous: Yarbichambi.

1852 Terebratula plano-sulcata. Owen, Geol. Surv. Wisconsin Iowa, and Minnesota, Rept., pl. 5, fig. 9.
Carboniferous limestone: Near Council Bluffs.

1852 Terebratula subtilita. Hall, Stansbury's Exped. Great Salt Lake, Rept., p 409, pl. 2, figs. 1a, b, 2a, b.
Carboniferous: Missouri River, near Weston.

?1853 Terebratula subtilita. Shumard, Marcy's Expl. Red River of Louisiana, Rept., Thirty-second Congress, second session, Senate Doc. No. 54 (reprintes everal times with different pagination), p 202, pl. 4, fig. 8.
Carboniferous: Washington County, Ark.

1855 Terebratula subtilita. Schiel, Pacific Railroad Rept., vol. 2, p. 108, pl. 1, figs. 2a, b.
Carboniferous limestone: 8 miles west of Westport.

1856 Terebratula subtilita. Hall, Pacific Railroad Rept., vol. 3, p. 101, pl. 2, figs. 3-5.
Carboniferous: Pecos Village, N. Mex.

1857 Terabratula (?) subtilita. Davidson, Mon. British Carb.

Brach., Pal. Soc., p 18, pl. 1, figs. 21,22.

Carboniferous: Mayen Wais, England.

1858 Terebratula plano-sulcata. Marcou, Geol. North America, p. 52, pl. 6, figs. 8, 8 b.

Mountain limestone: Tigerus, N. Mex.; Ohio; Indiana; Illinois; Kentucky; Arkansas.

1858 Terebratula roysii Marcou, Geol. North America, p 51, pl. 6, figs. 10, 10b.

Mountain limestone: Salt Lake city, Utah; El Paso, Chihuahua; headwaters of the Rio Colorado Chiquito.

1858 Terebratula subtilita. Marcou, Geol. North America, p. 52, pl. 6, figs. 9-9f.

Mountain limestone: Sierra Madre; Sierra de Mogollon; Great Salt Lake; Tigeras and Pecos Village, N. Mex.; summit of Sierra de Sandia and Sierra de Mogollon; El Paso, Chihuahua; junction of rivers San Pedro and Gila, Arizona; sources of Rio Colorado Chiquito; Shasta County, Cal.; Vancouver Island.

1858 Terebratual subtilita. Hall, Geol. Surv. Iowa, Rept., vol. 1, pt. 2, p. 714.

Coal Measures: Ohio; Indiana; Illinois; Iowa; Missouri; Kansas; Nebraska and Pecos Village, N. Mex.

1859 Spirigera subtilita. Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc. p. 28.

Upper Coal Measures: Kansas.

1860 Terebratula? subtilita. Davidson, Mon. British Carb. Brach., Pal. Soc., p. 86, pl. 1, figs. 21,22; pl. 17, figs. 8-10.

Carboniferous: Mayen Wais, England; Tournay, Belgium.

1861 Athyris subtilita. Salter, Geol. Soc. London, Quart. Jour. vol. 17, p. 64, pl. 4, fig. 4.

Carboniferous: Isthmus of Copacabana, in the Lake of Titicaca.

1861 Athyris subtilita. Newberry, Ive's Colorado River Expl. Exped., Rept., p. 126.

Upper Carboniferous: Cherty limestone on banks of Colorado between Little Colorado and Diamond rivers; Pecos Village, east of Santa Fe.

1862 Terebratula (?) subtilita. Davidson, Mon. British Carb. Brach., Pal. Soc., p 217, pl. 17, figs. 8-10.

Carboniferous limestone: Bolland; Kendal in Westmoreland.

1866 Athyris subtilita. Geinitz, Carb. und Dyas in Nebraska p. 40, tab. 3, figs. 7-9.

Upper Coal Measures: Omaha City, Plattsmouth, Bennett's Mill, and Nebraska; City, Nebr.

1869 Spirifera (Athyris) subtilita. Toula, Kais. Akad. der Wissensch. Wien, Sitzb. vol. 59, 1. Abth., p 438, pl.1 fig. 5.

Carboniferous limestone: 10 miles from Cochebamba, Bolivia

1872 Athyris subtilita. Meek, U. S. Geol. Surv. Nebraska, Final Rept., p. 180, pl. 1, fig. 12; pl. 5, fig. 8; pl. 8, fig. 4.

Upper Coal Measures: Nebraska City, Bennett's Mill, Wyoming City, Cedar Bluff, Rock Bluff, Plattsmouth, Bellevue and Omaha, Nebr.

Coal Measures: Illinois; Missouri; Iowa; West Virginia; Ohio; Kansas; Pecos Village, N. Mex.

1873 Athuris subtilita. Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 3, p. 570, pl. 25, fig. 14.

Coal Measures: Illinois.

1874 Athyris subtilita. Derby (pars), Cornell Univ., (Science) Bull., vol. 1, No. 2, p. 7, pl. 1, figs. 5,8 (not fig. 7 Spirigerlla Derbyi); pl. 3, figs. 8, 16, 19; pl. 6, fig. 2; pl. 9, fig. 4.

Coal Measures: Bomjardim, Itaituba, and Paredao, Brazil.

1875 Spirigera subtilita. White, U. S. Geog. Surv. W. 100th Mer., Rept., vol. 4, p. 141, pl. 10, figs. 6a-c. (Whole volume published in 1877).

Carboniferous: Carizo Creek, Maricopa County; Camp Apache Tenney's Ranch; Kaibab Plateau; confluence of White mountains and Black rivers; Grass Mountain, 35 miles north of Pioche, and foothills of Dragoon Mountains, Arizona; Fossil Hill, White Pine county, and Camp Cottonwood, Nev.;

15 miles south of St. George; near Ophir City; Rock Canyon, Wasatch range, near Provo; and near Minersville, Utah.

1876 Spirigera subtilita. White, U. S. Geol. Geog. Surv. Terr., second Division; Powell's Rept. Geol. Uinta Mountains, p. 90.

Lower Aubrey group: Confluence of Grand and Green rivers and near Echo Park, Itah.

Upper Aubrey group: Beehive Point, near Horseshoe Canyon, Utah.

1876 Athyris subtilita. Meek. Simpson's Expl. Great Basin, Utah, Rept., p. 350, pl. 2, figs. 4a, b.

Yellow limestone, Coal Measures: Humboldt Mountains.

1876 Athyris subtilita. Newberry, Macomb's U. S. Expl. Exped. Santa Fe to Grand and Green rivers, Rept. p 138.

Upper Carboniferous: On the Colorado; west of the San Francisco Mountains; junction of Grand and Green rivers; in the Sierra la Plata; at Santa Fe; Pecos.

1876 Athyris subtilita. Derby, Mus. Comp. Zool. Bull., vol. 3, p. 279.

Coal Measures: Yampopata, Brazil.

1876 Athyris subtilita. Meek, U. S. Geol. Geog. Surv. Terr. Bull., vol. 2, p. 355, pl. 1, figs. 2, 2a.

Carboniferous: Katlahwoke, Rocky Mountains.

1877 Athyris subtilita. Meek, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 83, pl. 8, figs. 6, 6a.

Carboniferous limestone: Ruby group; Moleen Peak, near Humboldt River, Nevada.

1884 Athyris subtilita. White, Geol. Surv. Indiana, Thirteenth Rept. p 136, pl. 35, figs. 6-9.

Coal Measures: Indiana.

1887 Athyris subtilita. Herrick, Sci. Lab. Denison Univ. Bull., vol. 2, p. 44, pl. 1, figs. 18 (16 a-c?).

Coal Measures: Flint Ridge, Ohio.

1887 Athyris subtilita. De Koninck, Musee Royal d'Histoire Naturelle de Belgique, Ann., vol. 14, p. 73, pl. 18, figs. 1-4,7-10, 12-28; pl. 19, figs. 47-56.

1888 Athyris subtilita. Keyes, Acad. Nat. Sci. Philadelphia Proc., p. 231.

Lower Coal Measures: Des Moines, Iowa.

1891 Athyris subtilita. Whitfield, New York Acad. Sci. Ann. vol. 5, p. 604, pl. 16, figs. 7-9.

Coal Measures: Hocking County, Ohio.

1893 Seminula subtilita. Hall and Clarke, Geol. Surv. New York, Pal., vol. 8, pt. 2, p. 95, figs. 66, 67 on p. 95, and figs. 58, 59 on p. 86; pl. 47, figs. 17-31. (Advance distribution in fascicles).

?Chester limestone: Caldwell County, Ky.; Chester, Ill.

Coal Measures: Manhattan and Miami County, Kans.; Kansas City and Chariton County, Mo.; Coppers Creek, and Winterset, Iowa; Ohio.

1895 Seminula subtilita. Hall and Clarke, State Geologist (New York), Fourteenth Ann. Rept. for 1894, pl. 35, figs. 16-19.

1895 Athyris argentea.. Keyes, Missouri Geol. Surv. Rept., vol. 5, p. 92, pl. 39, figs. 11a-d. (Date of imprint 1894)

Coal Measures: Kansas City, Lexington and Clinton, Mo.

1895 Seminula subtilita. Hall and Clarke, Geol. Surv. New York, Pal., vol. 8, pt. 2, p. 95, figs. 66,67, and 58, 59 on p. 86; pl. 47, figs. 17-31.

Coal Measures: Manhattan, Kansas; Coppers Creek, Iowa; Chariton County, Mo.; Winterset, Iowa; Miami County, Kans.; Kansas City, Mo.; Ohio.

(?) Chester limestone: Caldwell County, Ky. Chester, Ill.

1895 Athyris subtilita. Whitfield, Geol. Surv. Ohio, Rept. vol. 7, p. 488, pl. 12, figs. 7-9.

Coal Measures: Falls Township and Webb Summit, Hocking County, Ohio.

1896 Athyris subtilita. Smith, Am. Phil. Soc., Proc., vol. 35, p. 241.

Upper Coal Measures: Sebastian County, sec. 12, T 8 N., r. 32 W., Arkansas; Poteau Mountain, Indian Territory.

(?) Burlington or Lower Keokuk (Boone chert): Stone County, N. W.1/4 sec. 9, T. 14 N., R. 10 W., Arkansas.

1896 Athyris subtilita. Smith, Leland Standford Junior Univ. Publ.; Cont. Biol. Hopkins Seaside Lab., No. 19, p. 31.

Upper Coal Measures: Sebastian County, Sec. 12, T. 8 N., R. 32 W., Arkansas; Poteau Mountain, Indian Territory.

(?) Burlington or Lower Keokuk (Boone chert): Stone County, N. W. 1/4 sec. 9, T. 14 N., R.10 W., Arkansas.

1900 Seminula argentea. Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 105, text-fig. 3c.

Upper and Lower Coal Measures: Marmaton Station, Bourbon County, Iola, Kansas City, Eudora, Lawrence, Lecompton, Topeka, Manhattan, Grand Summit, Kans.

1900 Seminula argentia. Knight, Univ. Wyoming, Wyoming Exp Sta. Bull. No. 45, pl. 3, fig. 6.

1900 Athyris argentea (subtilita). Herrick and Bendrat, Am. Geol. Vol. 25, No. 4, p. 240.

Coal Measures: Sandia Mountains, N. Mex.

1902 Seminula argentia. Beede, Kansas Univ. Sci. Bull., vol. 1., pp 155-157, pl. 6.

1902 Seminula argentia, Beede, Ind. Acad. Sci. Proc. for 1901. pp. 221-222.

1903 Seminula subtilita. Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 403, pl. 7, figs. 1-1b, 2, 2a, 3, 3a, 4-7, 7a, 8-10.

Molas formation: San Juan region, Colorado.

Hermosa formation: San Juan region and Ouray, Colo.

Rico formation: San Juan region, Colorado.

Maroon formation: Crested Butte district, Colo.

Robinson limestone: Leadville district, Colo.

Carboniferous: Glenwood Springs, Colo.

1904 Seminula subtilita. Girty, U. S. Geol. Surv., Prof. Paper No. 21, p. 53, pl. 11, figs. 15, 16.

Pennsylvanian (Naco limestone): Bisbee quadrangle, Arizona.

Seminula argentea

1. Typical specimen of Narrow Variety
   All figures are natural size.

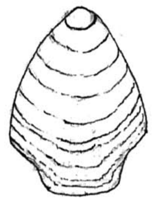
2a. Side view of a very thick narrow shell
2b. Ventral view of same.

3a. Ventral view of type of the species
3b. Side view of same.

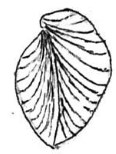
4. Ventral view of a wide specimen of the Massive Variety.

5. Ventral view of a narrow specimen of the Massive Variety.

Plate I



I.



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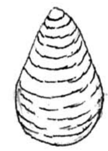

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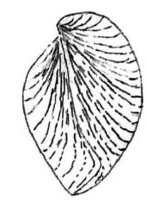
3a.



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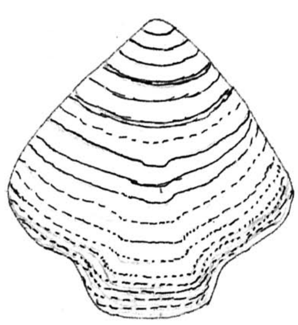

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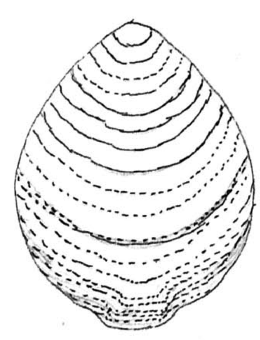


5.

Seminula argentea

1a & 1b. Narrow form without sinus, natural size.

2. Very young shell of narrow variety.

3. Young shell of wide variety.

4a & 4b. Narrow shell with parallel sides, and anterior emargination (x).

5. Wide variety, without sinus.

6. Young specimen of narrow variety.

7. Oval shell, without sinus.

8. wide variety with deep sinus (x).

9. Small wide shell.

10. wide shell with flattened margin (m)

Plate II

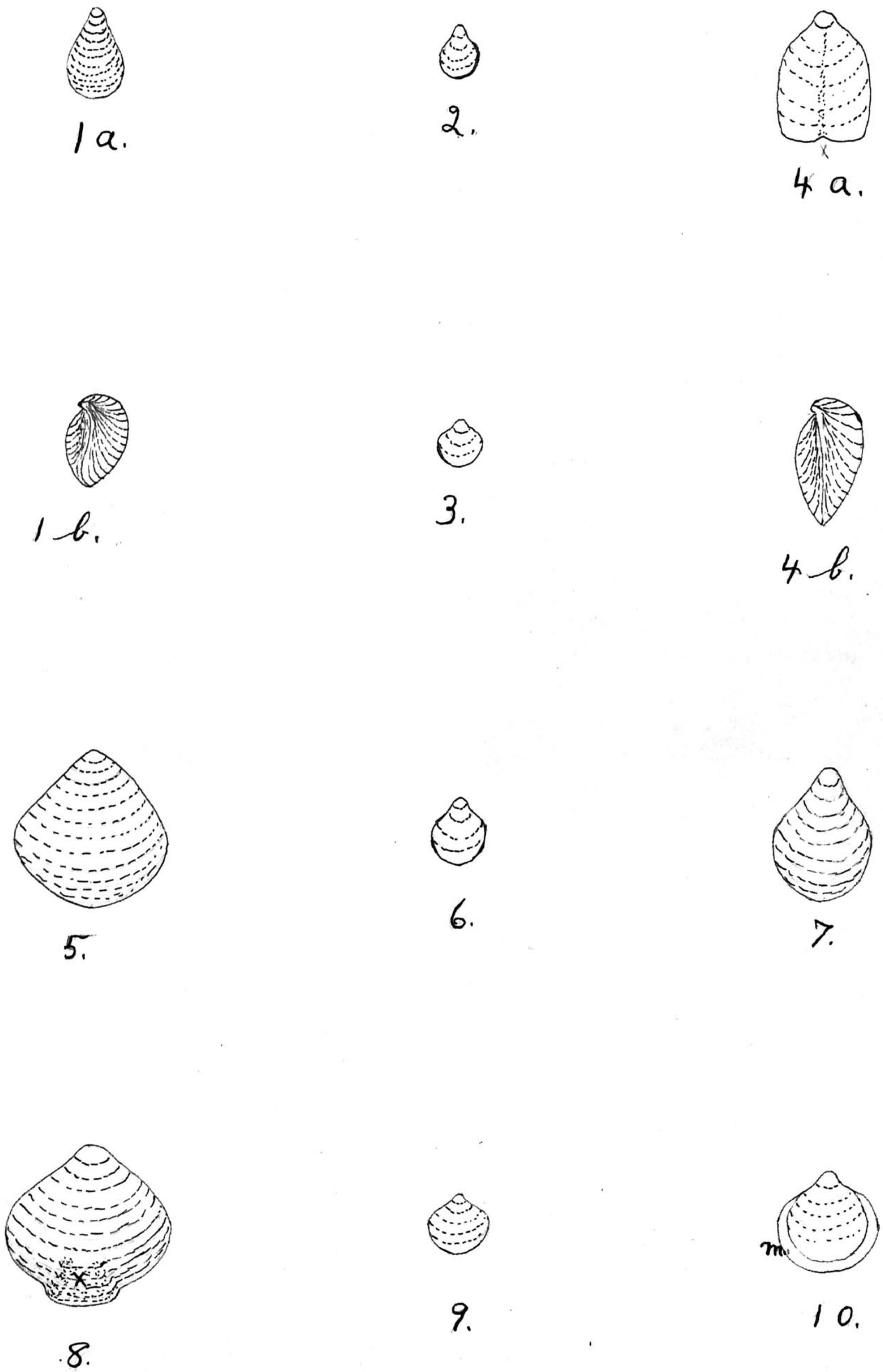


Plate III.

Spiralia of Seminula argentea.

1. Dorsal view of wide shell, natural size.

   a. Anterior end. b. Posteior end. c. Tip of spire

   d. Base of spire.

2. Ventral view of shell with spiralia turned through 90 degrees.

   a. Anterior end of shell. a' anterior end of spiralia.

3. Anterior view of specimen with right spire (a) turned to cente of ventral valve (x).

   (b) Left spire in natural position.

4a. Dorsal aspect of a narrow specimen.

4v. Lateral view of same.

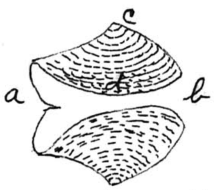
   (a) Tip of right spire.

5. Senile shell, showing spires close together at anterior margin. (a) in order to fit into the deep sinus. Ventral view.

6a. Ventral aspect of spiralia of a senile shell.

6b. Anterior-dorsal view of same, showing loop (x).

Plate III



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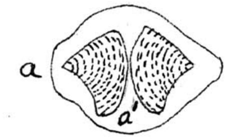

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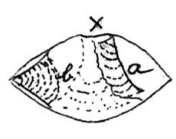

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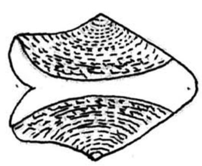
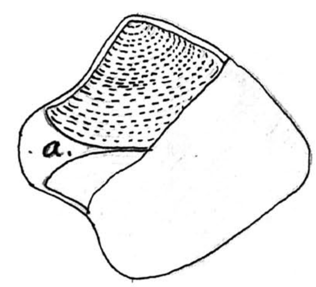


4 a.



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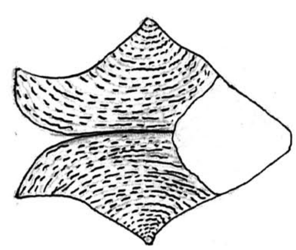
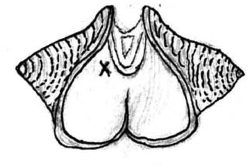


6 a.

4 b.



6 b.

Loop of Seminula argentea.

1. Diagram of loop from Hall & Clarke. Enlarged.
   a. Primary lamellae. b. Accessory lamellae, c. lateral branches of primary lamella. d. Saddle. e. Crura. x jugum s stem.

2. Diagram of loop of wide specimen. Enlarged. Lettering in this and following diagrams same as for figure 1.

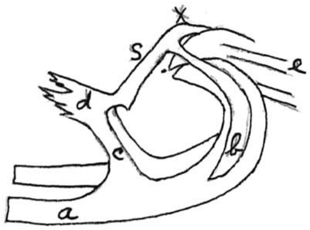
3. Ventral view of loop and spiralia of a small wide shell x 2.

4. Loop from a deep narrow shell, x 1 1/2.

5. Lateral view of a narrow shell, showing loop in its natural position.

6. Loop from a senile specimen, x 2. The saddle (d) lacks the forked tip.

Plate IV



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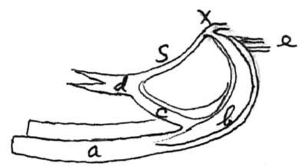

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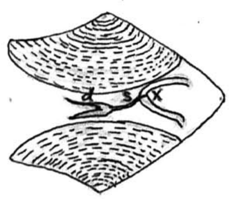

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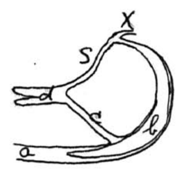

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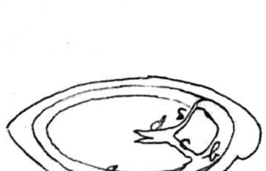

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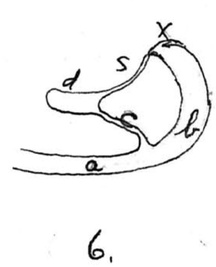


6.

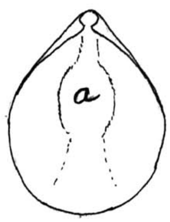
Muscle Scars of Seminula argentea.

1. Narrow shell, with shallow, oval muscle scar (a). Ventral valve x 1.

2. Ventral valve of a wide shell, with broad, parallel-sided scar (a) x 1.

3. Ventral valve of a very senile specimen, in which the excessive thickening of the shell has crowded together the sides of the muscle scar (a).

Plate V



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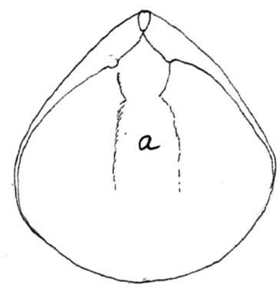

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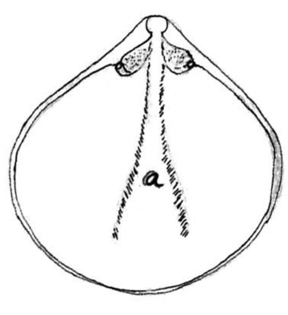

3.