

ART. III.—*On Ammonoids from the Abo Sandstone of New Mexico and the Age of the Beds which contain them;* by DR. EMIL BÖSE.

The Abo sandstone of New Mexico is the lowermost member of a group of sedimentary Paleozoic rocks comprised under the name of the Manzano group, the higher members of which are the Yeso formation and the San Andreas limestone. The fauna of this group has been described by G. H. Girty, who judged that the whole group belonged to the Pennsylvanian.

While studying the species figured by Girty, I had the impression that the fauna of the Manzano group as a whole represented a curious mixture of Carboniferous and Permian types. The species cited and described from the Yeso formation and the San Andreas limestone have certainly more Permian affinities than Carboniferous. In this opinion I was confirmed when together with Mr. Charles L. Baker, I collected a number of fossils in the Yeso formation between Anton Chico and Encino in northeast Torrance County, New Mexico. But at the same time there remained some doubt about the age of the Abo sandstone, which contained brachiopods of apparently Pennsylvanian character.

Fortunately Mr. Baker and Dr. N. F. Drake discovered a locality near Tularosa (1.25 miles due east on the road to the Mescalero Apache reservation), New Mexico, which contained a great number of ammonoids promising a better determination of the age of the beds. Mr. Baker had the kindness to submit those ammonoids to me for further study, the result of which I shall give in the following pages.

The beds which contain the ammonoids, as well as a great number of other fossils, are shales in the lower part of the Abo sandstone. The ammonoids are preserved in greater part as pseudomorphs after limonite and are generally of small size, while the larger ones are calcareous.

Although the number of ammonoids collected at Tularosa is relatively very great, only two genera appear to be represented: *Gonioloboceras* and *Gastrioceras*. The number of species is very small, *Gonioloboceras* being represented by only one, and *Gastrioceras* by about four. All of the species so far found are new, but two at least

belong to well known and characteristic groups, as will be seen in the following pages.

The most important species of our collection belongs to *Gonioloboceras*. This genus was created by Hyatt¹ for a species from New Mexico: *Goniatites goniolobus* Meek, characterized by flattened flanks, narrow rounded venter and extremely angular lobes. Unfortunately neither the horizon nor the locality where this species was found is known, but it is merely said to have come from the Carboniferous of New Mexico.

This species is entirely different from ours, notwithstanding that *Gonioloboceras* is a rather rare genus and that both forms come from the same state. It has much more rounded flanks and the venter is not flattened at all, while our species shows extremely flat flanks and in mature specimens a flattened venter or even a slight longitudinal depression on it, although no real furrow seems to be developed in medium sized individuals. The whorls of *G. goniolobus* are deeper embracing, and the cross-section is nearly elliptical, while in our species it is almost sagittal. The greatest difference, however, exists in the suture. On the whole, the lobes of *G. goniolobus* seem to be still more angular, although there is a general resemblance. The siphonal saddle which divides the ventral lobe in Meek's form is of an entirely different shape,—narrower and rather pointed, with an indentation at its end,—while in our species it is high and broad, with a tongue-like prolongation.

J. P. Smith² has described another species belonging to *Gonioloboceras*, *G. welleri*, from the Cisco formation of central Texas; and this form is much more intimately related to ours. The shape of the shell is very similar, but in our species the flanks are still flatter, while the venter is generally more rounded and does not show a real deep furrow like the adults of *G. welleri*. Still, the flattening of the venter and the development of a slight longitudinal depression in our species show that the relation between the two is very intimate; they certainly belong to the same group although they are specifically different.

The greatest difference appears in the younger indi-

¹ A. Hyatt, in Eastman-Zittel, Textbook of Paleontology, p. 551, 1900.

² J. P. Smith, The Carboniferous Ammonoids of America, U. S. Geol. Survey, No. 42, p. 125, pl. 20, figs. 9-11; pl. 21, figs. 1-7 6, 1903.

viduals. An immature specimen of about 7mm. diameter shows one constriction in *G. welleri* and three in our species. The cross-section of such a specimen is sub-quadrangular in *G. welleri* and nearly semicircular in ours.

There is little if any difference in the sutures of adults in both species, but the young ones are much more distinct, those of *G. welleri* showing more archaic features than those of the species from New Mexico.

While Hyatt regarded *Gonioloboceras* as belonging to the family Magnosellaridæ, J. P. Smith has shown that the suture of immature specimens of *G. welleri* has the character of *Muensteroceras*, a genus from the Lower Carboniferous, probably derived from *Aganides* (*Branccoceras* Hyatt 1884, not Steinmann 1881), and belonging to the family Glyphioceratidæ. I have been able to confirm these observations of Smith by others made on the young of our species from Tularosa. An immature individual of about 10mm. diameter already shows some marked differences from the adults. The flanks are slightly rounded and the venter is rather broad and rounded, the cross-section being helmet-shaped. The whorls are deeply embracing but indented to only one-fourth by the preceding volution. The border of the umbilicus shows a rather sharp edge and the wall has an inclination of 45 degrees, while that of the adult has a rounded border and its wall is less steep. The immature individual has an ornamentation consisting of fine sigmoidal lines on the flank which on the venter suddenly curve strongly backwards. The specimen shows one constriction on the oldest part of the external volution while the mature specimens have none at all. The youngest part of the immature specimen shows a suture quite similar to that of the adults, although the siphonal saddle is relatively somewhat lower. But only a quarter of a volution backwards, this siphonal saddle is already reduced in size to about one-fourth of the height of the external saddle, becomes much narrower and more slender in shape, and shows a distinct indentation at the front end. At the oldest part of the volution this saddle is still more reduced and the external saddles become less sharp and somewhat rounded at the point. The first lateral saddle also becomes gradually lower and relatively broader.

Another specimen of about 7mm. diameter shows still greater differences: the shell is in general similar to that of the preceding specimen but the flanks are more rounded, especially on the older half of the external volution where the cross-section appears to be nearly semi-circular, although the flanks are still a little flatter than the well rounded venter. The border of the umbilicus shows a sharp edge and the wall is very steep (about 75 degrees). The ornamentation is similar to that of the preceding specimen. The cast shows three deep constrictions, nearly radial, but very slightly curved backwards on the flank and more strongly so on the venter.

The suture is remarkably simple. The ventral lobe is broad and divided into two parts by a low siphonal saddle, both prongs being still rather sharply pointed in the youngest suture of the external whorl and rather blunt in the oldest. The first lateral lobe becomes gradually wider at the end and less pointed at the bottom and is nearly as deep as the ventral. The siphonal saddle is of pyramidal form, truncated and indented at the front, and only one-fourth as high as the external saddle. The external saddle becomes more and more round at the end and broad at the base, and also more or less symmetrical. The first lateral saddle becomes very low and rather resembles a broad undulation.

Thus the smallest individual described has all the features of *Muensteroceras* in form as well as in sutures; it seems to resemble especially the young of *M. oweni* Hall,³ although the similarity between its sutures and those of *M. parallelum* Hall,⁴ the type of the genus, is rather striking.

The similarity between our new species and *Gonioloboceras welleri* Smith is so great that there can be scarcely any doubt about their being more or less of the same age. They certainly belong to a group different from that of *G. goniolobus*. The new species is rather common at the locality near Tularosa, our collection containing about thirty specimens. Our species is so well characterized that we may distinguish it under the name of *Gonioloboceras discoidale* n. sp.

Another species of certain importance belongs to the genus *Gastrioceras*. It evidently forms part of the

³ J. P. Smith, op. cit., pl. 19, figs. 5, 6.

⁴ J. P. Smith, op. cit., p. 121, pl. 16, fig. 3; pl. 19, figs. 1-2.

group of *G. subcavum* Miller and Gurley and is so similar to the type that at first I thought it might even be specifically identical with it, but a close study showed a number of small but constant differences which allow us to separate it under the name of *Gastrioceras subtilicostatum* n. sp.

The group of *G. subcavum* is characterized by extremely angular umbilical shoulders and a wide, deep, funnel-shaped umbilicus without strong nodules on its border. Our species shows both these characteristics, but the umbilicus is still a little wider than in the type. The cross-section is nearly the same, although the inner whorls have a venter that is possibly a little more rounded. The suture is very similar in all species of *Gastrioceras* but the siphonal saddle is larger than that figured by Smith,⁵ and as the author says that *G. subcavum* agrees with *G. globulosum* Miller and Gurley in its septa, I presume that his figure is taken from an immature specimen. The suture of our species is very similar to that of *G. globulosum* except that the siphonal saddle is somewhat stouter.

The main difference between the New Mexico species and *G. subcavum* appears to consist in the ornamentation and the form of the constrictions. Our species shows a greater number of constrictions (5 to 7) and these are strongly curved forward on the venter, while in *G. subcavum* there are only about four constrictions, which show a very slight sinuosity.

The differences in ornamentation are still greater. *G. subcavum* shows only very faint lines of growth and according to Smith has no umbilical ribs. Our species, on the contrary, shows a very distinct ornamentation. On the umbilical wall we count over thirty very fine but well defined radial ribs or costæ which on the umbilical shoulder swell into small nodules; from each of these, one or two even bundles of three and four fine costæ (much finer still than those on the umbilical wall) start and run over the venter strongly curved forward. All this ornamentation is very coarse in immature specimens but in adults it becomes gradually finer and on fragments of the largest individuals where the shell is well preserved the fine umbilical ribs are rather distant from each other but very distinct, although extremely delicate.

⁵ Op. cit., p. 97, pl. 17, figs. 15-17.

The nodules on the umbilical shoulder are scarcely noticeable, and the costæ on the venter disappear altogether, leaving only traces of faint lines of growth; but in this stage of development we observe a very great number of fine but distinct spiral costæ separated by wide interstices. On the umbilical shoulder, three or four of these spiral lines become very distinct, and their crossing with the umbilical ribs and the fine radial costæ which disappear on the venter causes two, three or four rows of fine tubercles. These spiral lines can also be observed on the well preserved shell of small individuals (5mm. diameter and less) but there they are so fine and the strong radial sculpture is so prominent that they easily escape observation.

In our immature specimens the nodules of the umbilical shoulder recall somewhat those in *G. montgomeryense* Miller and Gurley,⁶ but in the larger individuals this ornamentation is extremely fine and nearly disappears on the casts.

Notwithstanding the difference in ornamentation, I am inclined to include our species, as well as *G. montgomeryense*, in the group of *G. subcavum*, which may have descended from forms like *G. entogonum* of the Mississippian.

The ornamentation described above nearly disappears from casts, and these thus appear remarkably similar to *G. subcavum*. This latter species was first described from the upper Pennsylvanian of Montgomery County, Illinois, but was also found in the Cisco formation of Graham, Young County, Texas, about 600 feet below the contact of the Permian. It is very common in the Abo beds of Tularosa, our collection containing at least forty specimens of it. It may be known as *G. subtilicostatum*, n. sp.

As we have already mentioned, the genus *Gastrioceras* is represented at our locality by quite a number of species, not all of them as characteristic as the above described type but of sufficient interest to be mentioned here.

There are two species which to a certain degree resemble the one described on the foregoing pages. Both have the deep funnel-shaped umbilicus with a rather sharp edge on the umbilical border although somewhat less than in the preceding form. Both are much less

⁶ J. P. Smith, op. cit., p. 95, pl. 5, figs. 8-10.

evolute, one of them more than the other. In both the venter is much more rounded and the cross-section is more subelliptical than crescent-shaped. The ornamentation is very similar in both, consisting of fine radial costæ on the umbilical wall which scarcely swell into fine nodules on the umbilical shoulder; from each of these start two fine costæ, which run across the venter curving strongly forward. No spiral lines were observed, even in very well preserved shells. Both have three to four constrictions on the external whorl which curve toward the front. The septa are of the common gastrioceran type. The differences between the two species are not very great, it being even possible that both represent variations of the same type. I do not know of any species very similar to these two although one might compare them to a certain degree with *Gastrioceras welleri*.

Quite different from the foregoing species is another one which seems to be related to *Gastrioceras illinoisense* Miller and Gurley although it is much less evolute. This species is characterized by strongly rounded flanks and venter, very narrow and deep umbilicus with a well round border, nearly semicircular cross-section, and the complete absence of nodules on the umbilical border. The ornamentation consists of fine radial striæ which begin on the umbilical wall, bifurcate on the flank and are slightly curved forward on the venter. Each volution shows four deep constrictions which are only very slightly curved forward on the venter. The septa are of the common gastrioceran type.

The nearest Carboniferous form is probably *G. illinoisense*, but it is much more globose than our species.

In its external shape our species resembles rather surprisingly the very young individuals of *Gastrioceras roadense* Böse⁷ from the lower Permian of the Glass Mountains, Texas, although the adults of this species are entirely different. Also similar to a certain degree is *G. modestum* Böse from the lowermost Permian of the Glass Mountains, but this form is much more globose.

All of the foregoing species of *Gastrioceras* are extremely common in the Abo beds of Tularosa, every one of them being represented by dozens of individuals of different sizes; but our collection contains several other

⁷ Compare especially Böse, Permo-Carboniferous Ammonoids of the Glass Mountains, Univ. of Texas. Bull. No. 1762, pl. 2, figs. 28-34, 1917.

forms represented only by a single shell each. None of them is very characteristic, or intimately related to any known form. One of these species shows a sculpture different from that of all the other species of the locality. It consists of thin radial costæ slightly curved forward on the venter; on the umbilical border, which is well rounded, they are crossed by rather strong spiral lines which cause a kind of crenulation, but which seemingly become very faint or disappear entirely on the venter. Unfortunately the suture could not be made visible.

Another form is characterized by a very great number of septa; the flanks of the external saddles of the different septa touch each other. The species is rather involute, has a deep narrow umbilicus with a well rounded border, well rounded flanks and venter, and a nearly semicircular cross-section. Three rather shallow constrictions are visible on the whorl. The specimen is a cast and does not show any ornamentation.

Another form has very numerous septa but the umbilical border is rather sharp; no ornamentation is preserved on it.

There is still a further species in our collection, the generic position of which has not been quite ascertained. It is represented by four specimens of different sizes, the largest one having a diameter of about 12mm. The suture resembles that of *Muensteroceras*, although the lobes are not quite as angular as in that genus and the first lateral saddle is rather high and not extremely broad. On the umbilical border we find a row of rather strong tubercles; each volution has four to five deep constrictions which are curved forward on the venter. The umbilicus is moderately narrow and with a rather sharp border; the wall is steep.

These specimens may be the young of some *Gonioloboceras* different from the one described above, or they may belong to a new genus. This question cannot be decided until more material has been found.

The fauna of ammonoids from the lower Abo beds of Tularosa is of considerable interest as it gives a quite precise determination of the age of this formation.

There is not a single form related to Permian species, but everything indicates that the beds belong to the Pennsylvanian and especially to the upper part of this system. *Gonioloboceras* is certainly a form character-

istic of the upper Pennsylvanian, notwithstanding that J. P. Smith has described some species from the Mississippian^s which he doubtfully refers to this genus. Still more important is the circumstance that our *Gonioloboceras* is very intimately related to *G. welleri* from the upper Pennsylvanian (Uralian) of Texas (about 600 feet below the Permian contact); this makes it almost certain that they are more or less of the same age.

Gastrioceras is a genus which occurs throughout the Carboniferous and the Permian, but the groups which are represented in our collection distinctly belong to Pennsylvanian types and especially to those from the Uralian. In the Permian most of the species of *Gastrioceras* belong to the very characteristic group of *G. zitteli*, while the Pennsylvanian types are rather rare in this system. In the Abo sandstone of Tularosa, on the contrary, the group of *G. zitteli* is entirely absent, while Pennsylvanian forms occur in abundance.

Thus we have to conclude that the Abo beds belong to the Pennsylvanian and that they belong in the upper part of this system (Uralian).

This is confirmed by still another fact. Mr. Baker, while studying the younger Paleozoic of the upper Pecos Valley in New Mexico, found that the Abo sandstone there rests unconformably on the Magdalena beds, which in their upper part also contain an upper Carboniferous fauna. Near Pecos village we collected in the lowermost Abo beds a number of brachiopods and pelecypods (mainly *Productus* and *Myalina*) among which not a single Permian form was present. Unfortunately the higher part of the Abo beds in this portion of the Pecos valley is entirely barren of fossils. It is covered by the so-called Glorieta sandstone, the age of which was unknown up to the present, but Mr. Baker and the author have followed the formation toward the south to Los Griegos and the Blanco Cañon, where it is unconform-

^s Haug, *Traité de Géologie*, p. 751, wants to replace the term Mississippian by the term Dinantian because the former name was used by Marcou in an entirely different sense (= Cambrian). Haug himself recognizes (p. 786) that the term Mississippian has been extremely well chosen, as no region is known where the lower Carboniferous is as well developed as in the Mississippi basin. It seems to me that the name Mississippian should be accepted as part of the universal nomenclature, because it is well chosen and has been in general use in America for a long time. Marcou's use of this name for the Cambrian never has been accepted and should simply be abandoned.

ably underlain by the Yeso formation and forms the base of the continental Trias. The Glorieta sandstone is a rather constant member of the Trias; it can be followed eastward to the Pecos Valley in the region between Anton Chico, Santa Rosa and Puerto de Luna, where it frequently contains bones of reptiles and shells of *Unio* and *Anodonta*.

The result thus gained appears to make it necessary to abandon the name "Manzano group," as this term would include Pennsylvanian and Permian beds. Perhaps "Manzano group" could be restricted to the Yeso and San Andreas formations, while the Abo sandstone could be united with the lower series, the Magdalena beds.

We have here one of the rather frequent cases in which unconformities do not always separate two different series but divide formations which belong to the same series, their contacts being entirely concordant. I have already had an opportunity to cite a similar case in the Glass Mountains of western Texas where an unconformity traverses the lower part of the Permian, while the lowest beds of this system rest conformably on the Schwagerina beds of the Uralian.

Santa Rosa, New Mexico.
November 6, 1919.