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CONTENTS

INTRODUCTION

A DISPLAY OF FOSSILS arranged in August, 1947, by Mr. Howard Timmel of Greybull for the members of the "Field Conference in the Bighorn Basin," then visiting that town, included a representative specimen of the species hereinafter named *Dunveganoceras pondi* and thus first called my attention to the subject of the present paper.

After finding out the locality from which these ammonites come, I visited it on August 9, 1947.

My sincere thanks are due to Mr. Timmel for information about the locality; to Mr. W. F. Pond, former State Geologist of Tennessee and now with the Magnet Cove Barium Corporation, then living at Greybull, for generously providing transportation and for his kind interest in my field work there; to Mr. W. J. Greene of Greybull for guiding me to the place, and to him and Mr. A. G. Voorhees of Greybull for efficient support in locating and collecting the most spectacular specimens; finally, to Mr. Timmel and Mr. Greene for assistance in packing and shipping the collection.

Furthermore, I am greatly indebted to Dr. John B. Reeside, Jr., of the United States National Museum, for most valuable suggestions as to the faunistic and stratigraphic correlation of the present assemblage with others more or less contemporaneous and for permission to quote unpublished data from his letters, and to him and the authorities of the United States National Museum for the loan of several unpublished specimens from the Eagle Ford shale of Texas, Tropic shale of Utah, and Belle Fourche shale of Montana for comparison. I also have to thank Mr. W. A. Cobban, Department of Geology, the Johns Hopkins University, for kindly calling my attention to the similarity of one of the species here described to forms from northern Alberta (previously published by Warren and Warren and Stelck, respectively).

The place where the fossils under discussion occur is situated about 6 miles east and 7 miles north of Greybull, in the north central part of T. 53 N., R. 92 W. The new geologic map of the Bighorn Basin (Andrews *et al.*, 1947) indicates Cody shale (Upper Cretaceous) for that place and gives the following description of the Cody shale: "Upper part buff sandy shale and thinly laminated buff sandstone; lower part dark gray thin-bedded shale." As a matter of fact, two zones, also morphologically differing from each other, can be clearly distinguished on the spot: a lower zone of dark shales forming soft, gently rounded, barren slopes, and an upper one, beginning about 350 feet above the bottom of the valley, with somewhat steeper slopes, sparsely overgrown with sage brush. It is in this upper zone that the fossils occur. Wherever rocks can be seen to crop out there, they agree well with the lithological description of the upper part of the Cody shale, quoted above. However, the fossils never occur in the outcropping rocks themselves but in concretions lying on, or surficially buried in, the ground; some of them measure up to 2 feet in diameter. They consist of a very dark, somewhat arenaceous limestone and, when cracked by frost, disclose the fossils, most of which are badly weathered. With some of the fossil mollusks pieces of fossil wood are found which is, here and there, charred. With regard to the lithological difference between the outcropping rocks and the concretions the possibility cannot quite be excluded that the latter might have rolled down from an even higher stratigraphic member, since removed by denudation.

Although the symbols occurring in the tables of dimensions have been used, with the same meaning, in previous papers, it might be advisable to repeat that D indicates, unless otherwise noted, the greatest diameter that could be measured, H the height of the last whorl from the umbilical seam to the periphery, H′ its height from the dorsum to the periphery,[1] W the width of the intercostal (internodal) section, W′ that of the costal (nodal) one, and U the width of the umbili-

[1] Contrary to the usage I followed in previous ammonitological papers, the shape of the ventral portions of the ammonites dealt with in the present paper made it advisable to include the height of external tubercles ("horns") in D, H, and H′.

cus. D is always expressed in millimeters and tenths thereof, the other dimensions in per cent of D, decimals having been reduced or increased, respectively, to full or half per cent.

For the significance of terms used in the descriptions, reference is made to Haas, 1942b, pages 7 and 8, and text figure 1.

The suture line drawings accompanying this paper were expertly made by Miss Helen Babbitt, and the photographs by Mr. Robert Adlington who also efficiently assisted me in the preparation of the material.

DESCRIPTIONS

ACANTHOCERATIDAE Douvillé

Whereas Hyatt (1900, pp. 585–589) distinguishes two separate families of the Acanthoceratidae and the Mammitidae (with each as the leading family of a corresponding superfamily), J. P. Smith (1913, p. 669) relegates both these groups together to a mere subfamily Acanthoceratinae of the Cosmoceratidae. In the present paper, however, the Acanthoceratidae are treated as a family, in the circumscription given to it by Roman (1938, pp. 421–454).

MANTELLICERAS Hyatt

Much confusion as there has prevailed for the last half century in the nomenclature of most groups of Mesozoic ammonites, the peak seems to have been reached in the groups of *Ammonites mantelli* Sowerby and *A. navicularis* Mantell and in the genera founded on them and closely allied ones, viz., *Mantelliceras*, *Calycoceras*, *Paracalycoceras*, *Eucalycoceras*, and *Metacalycoceras*. It seems that Spath's changes of opinion have contributed most to this confusion.

After considering in 1926 (p. 83) Hyatt's (1900, p. 589) generic name *Calycoceras* a synonym of *Mantelliceras* and proposing for some closely related forms the new name *Metacalycoceras*, Spath in 1937 (pp. 278–279) restored *Calycoceras* (type: the specimen figured by Sharpe, 1856, pl. 18, fig. 3, as *Ammonites navicularis*, renamed "*Eucalycoceras*" *subgentoni* by Spath, 1926, p. 83)[1] and dropped *Metacalycoceras* as a synonym of *Calycoceras*.[2] In the present paper this (as far as I could find out, latest) opinion of Spath's on this subject is followed.

[1] When preparing my paper on "Some Upper Cretaceous ammonites from Angola," I unfortunately overlooked Spath's remarks of 1937 on *Calycoceras* versus *Mantelliceras* and was thus misled by those of 1926 to assign the fragment from locality 3095, north of Cabiri, to *Mantelliceras*, while, according to Spath, 1937, it is evidently a *Calycoceras*.

[2] This elimination of *Metacalyoceras* as a generic name is the more to be welcomed since it was based on the specimen figured in D'Orbigny's (1840–42) plate 103 under the name of *Ammonites mantelli*, which, however, as refigured by Collignon (1937, pl. 10), proves to look entirely different. It has been renamed "*Metacalycoceras*" *orbignyi* by Collignon (1937, p. 45).

Collignon's (1937, pp. 60–65) attempt at regrouping the ammonite forms concerned unfortunately coincided in time with, and is bound to be superseded by, Spath's 1937 paper.[3]

When establishing his genus *Mantelliceras*, Hyatt (1903, p. 113) failed to give a concise diagnosis of it, but since he designated *Ammonites mantelli* Sowerby (1814, p. 110, pl. 55) as the genotype, the distinctive characters of *Mantelliceras* are beyond doubt, the more so since they have been pointed out again and again by such authorities as Pictet and Campiche (1858–1860, pp. 202 ff.), Pictet (1863, p. 45), Schlüter (1871–1872, p. 12, pl. 5, figs. 1–8, pl. 6, figs. 1, 2, 11), and Pervinquière (1907, p. 288, pl. 16, fig. 18). From all these interpretations, as well as from Sowerby's original description ("edge three sided, broad and flattish; sides flattish"), it follows that what has been called "section polygonale" by Pervinquière (*loc. cit.*) and what I would prefer to call a trapezoidal outline of the external portion of the whorl section is, along with the lack of a median row of tubercles, characteristic of *Ammonites mantelli* and, therefore, of the genus *Mantelliceras*. This conception is supported by the fact that Spath (1926, pl. 82) calls his *M. cantianum* (based on Sharpe's, 1856, pl. 18, figs. 1, 8, 2), which clearly exhibits the above characters, "a true *Mantelliceras*."

To this genus, thus conceived, the two following forms from Greybull are referred.

Mantelliceras canitaurinum,[4] new species
Plates 1–3, plate 4, figures 1, 2, 4;
text figures 1–4
A.M.N.H. No. 26413

Dimensions: The following table must be supplemented by the statement that in the largest specimen present (no. 3) the relative intercostal width is markedly greater at the fracture about a third of a volution apicad of the front end, corresponding to a diameter of

[3] Moreover, Collignon's (1937, p. 63) proposal to keep *Calycoceras* as the generic name and relegate *Eucalycoceras*, *Metacalycoceras*, and *Paracalycoceras* to subgeneric rank fails to designate any group within *Calycoceras* as *Calycoceras, sensu stricto*.

[4] Latinized version of "from Greybull."

Specimen Nos.	D	H	H′	W	W′	U	Remarks
1	165 mm.	42	38	43	47+[a]	31	Syntype A
2	*ca.* 270 mm.	*ca.* 36½	*ca.* 35½	*ca.* 46	*ca.* 48	*ca.* 39	Syntype B
3	287 mm.	*ca.* 34½	*ca.* 33½	*ca.* 42	*ca.* 45½	*ca.* 35	

[a] Measured about 40 mm. apicad of front end.

about 210 mm., than at the anterior end, the ratio W/H amounting to 1.28 at the fracture,[1] but to only 1.22 at the front end. The former value even exceeds that of 1.26 found, for the same ratio, at the front end in specimen number 2. This species shows the usual increase in U and the corresponding decrease in H; furthermore, there is, except for the very latest ontogenetic stage, an increase in W and W′.

In syntype A the last septum is found at a diameter of about 140 mm., but fragment number 5, whose anterior end corresponds to a diameter of at least 180 mm., is septate throughout. In the two largest individuals, numbers 2 (syntype B) and 3, the last septum is at diameters of about 200 and 225 mm., respectively, and in a short whorl fragment (no. 4) its site also corresponds to about the latter diameter. In specimen number 2 (syntype B) the body chamber, though clearly incomplete, occupies about a third of the outer volution. In the largest shell present (no. 3), however, it occupies only somewhat more than a quarter of a volution, although the outer whorl seems to be preserved up to the aperture or nearly so. Anyway, this species may well be assumed to have reached a diameter of 300 mm.

Selection of Types: Specimen number 1 is by far the most complete and best preserved shell. Since, however, it does not exhibit the mature stage, the largest specimen but one (no. 2), in which parts of both penultimate and last whorls are preserved, was selected to serve as a syntype together with number 1.

Description: Shell only little involute. Although the width of the whorls about equals their height at the earliest stage at which this ratio could be examined, i.e., at a diameter of about 70 mm., and considerably exceeds it later on (see above and footnote 1), the conch does not appear quite so sturdy as it really is; this impression seems to be caused by the flatness of the sides which, in turn, is more noticeable at an early stage when the ribs are less prominent than they become later.

The whorl section has its greatest width immediately ventrad of the umbilical shoulder, approximately at the first sixth of the sides. In costal section this point is still accentuated by the circumumbilical nodes. From here the sides converge ventrad, first gently, then more rapidly. The venter is, throughout development, truncate, flat, and broad. The umbilical shoulder is rounded, the umbilical wall high and steep, in syntype A almost perpendicular. With increasing width the intercostal whorl profile gradually assumes a reniform shape, best seen at the fracture of specimen number 3 (pl. 4, fig. 4). At all stages the upper (ventral) half of the costal whorl section shows the trapezoidal outline characteristic of this genus.

The earliest stage at which the ornamentation could be studied is represented by a small fragment, consisting of the ventral portion of a quarter whorl and part of its left side, and corresponding to a diameter of about 30 mm. (specimen no. 7). Since, however, the next size at which the ornamentation of the venter can be examined is almost twice as large, this fragment, though considered congeneric, cannot with certainty be referred to the present species. In whorl section it seems to agree better with it than with the following form. It shows on its side equally spaced, moderately strong, straight radial ribs, five of which can be counted per quarter whorl; on the latero-ventral shoulder they end in rather large, blunt nodes which seem to be obliquely elongated towards the median line. Across the venter the nodes of both sides are connected by straight, blunt, broad folds which can be seen in the middle

[1] At the opposite face of the same fracture (pl. 4, fig. 4) the ratio W′/H amounts even to 1.41.

of this fragment to be slightly overtopped by the nodes; at the anterior end, however, they are perfectly even across the venter just as they are in the larger individuals of the species here dealt with. Faint indications of median elevations are observable on the third and fourth of these folds; on the former this elevation is spirally elongated, but it is bullate on the latter.

Only a very short part of the venter of the antepenultimate whorl, where it may correspond to a diameter of about 50 mm., is visible in syntype B (specimen no. 2); it shows moderately strong ribs running straight and evenly across the venter, without any nodes.

On the inner volutions of syntype A (specimen no. 1) the surface is worn; only from a diameter of about 55 mm. can the ornamentation of the sides be studied, and that of the venter from about 70 mm. All that can be seen between these two diameters is that there are, on the sides, longer and shorter ribs, one or two of the latter being intercalated between two each of the former, and that the primary ribs originate from radially elongated tubercles at the umbilical shoulder.

At a somewhat later stage these primary ribs can be recognized to begin on the upper part of the umbilical wall and to rise in a rursiradiate direction up to the shoulder where, in forming the circumumbilical tubercles, they turn rather briskly forward. They run in a slightly prorsiradiate direction straight across the sides. The same direction is followed by the secondary ribs which begin at about the inner third of the flanks and which alternate not quite regularly with the primary ones. All the ribs continue uninterruptedly, in a straight line or in a slightly orad convex arc, across the venter where they are broader than on the sides and where they can be seen to slope steeply apicad but gently orad. A slight swelling of the ribs is recognizable on either shoulder where they change, with a short joint running obliquely forward towards the median line, from the sides to the venter. It is worth noting that the costae are in no case lowered between these nodes. At this stage the costation is rather dense, there being 11 ribs on the posterior quarter of the outer whorl of syntype A.

The character of ornamentation begins to change some time before the last septum is reached; this change becomes there quite pronounced (pl. 1, fig. 1). The ribs become stronger and sharper; they move farther apart (on the anterior quarter of the same whorl there are only eight); they gradually change from a prorsiradiate to a radial, then to a slightly rursiradiate direction. Simultaneously, the circumumbilical nodes of the primary ribs move farther ventrad, until they culminate at about the first sixth of the sides, and become more elongated so as to cover almost a third of the length of these ribs which now assume a slightly sigmoidal course. Longer and shorter ribs now alternate quite regularly, and the latter begin, as a rule, only at the middle of the flanks. The latero-ventral nodes, still running obliquely forward towards the median line, become much more pronounced and separated from the lateral parts of the ribs by a shallow depression in their crests which makes those nodes assume a horn-like appearance. All the costae still cross the venter straight and horizontally.

Whereas the ornamentation of the penultimate whorl of syntype B is in general the same as that of syntype A before the above change, except that the ribs are somewhat broader on the venter and accordingly less numerous (eight only per quarter whorl), that of the outer whorl of syntype B agrees essentially with the last stage described. The same holds true for the largest shell present (specimen no. 3), although its posterior part is still septate, for the short fragment number 4, representing about the same stage, and for the whorl fragment number 5 which attains a somewhat greater diameter than syntype A but is still septate throughout. With increasing size the ribs move still farther apart; on the outer volution of syntype B there are only seven per quarter whorl, and in the largest specimen (no. 3) only 13 per half whorl. Furthermore, there are, of course, individual peculiarities: near the anterior end of syntype B the secondary ribs become longer again, reaching as far dorsad as the inner third of the sides, and there are two of them intercalated in an unusually wide intercostal between two primary ones. In the short fragment number 4 the median part of one rib is clearly lower than its left horn and, even more so, than the right one. The preceding rib, however, is quite horizontal as usual, and the aforementioned case seems to be the only exception among all the specimens present. That in the largest individual present (no. 3) the last rib follows the last but one after an unusually short interval seems to indicate the proximity of the apertural margin.

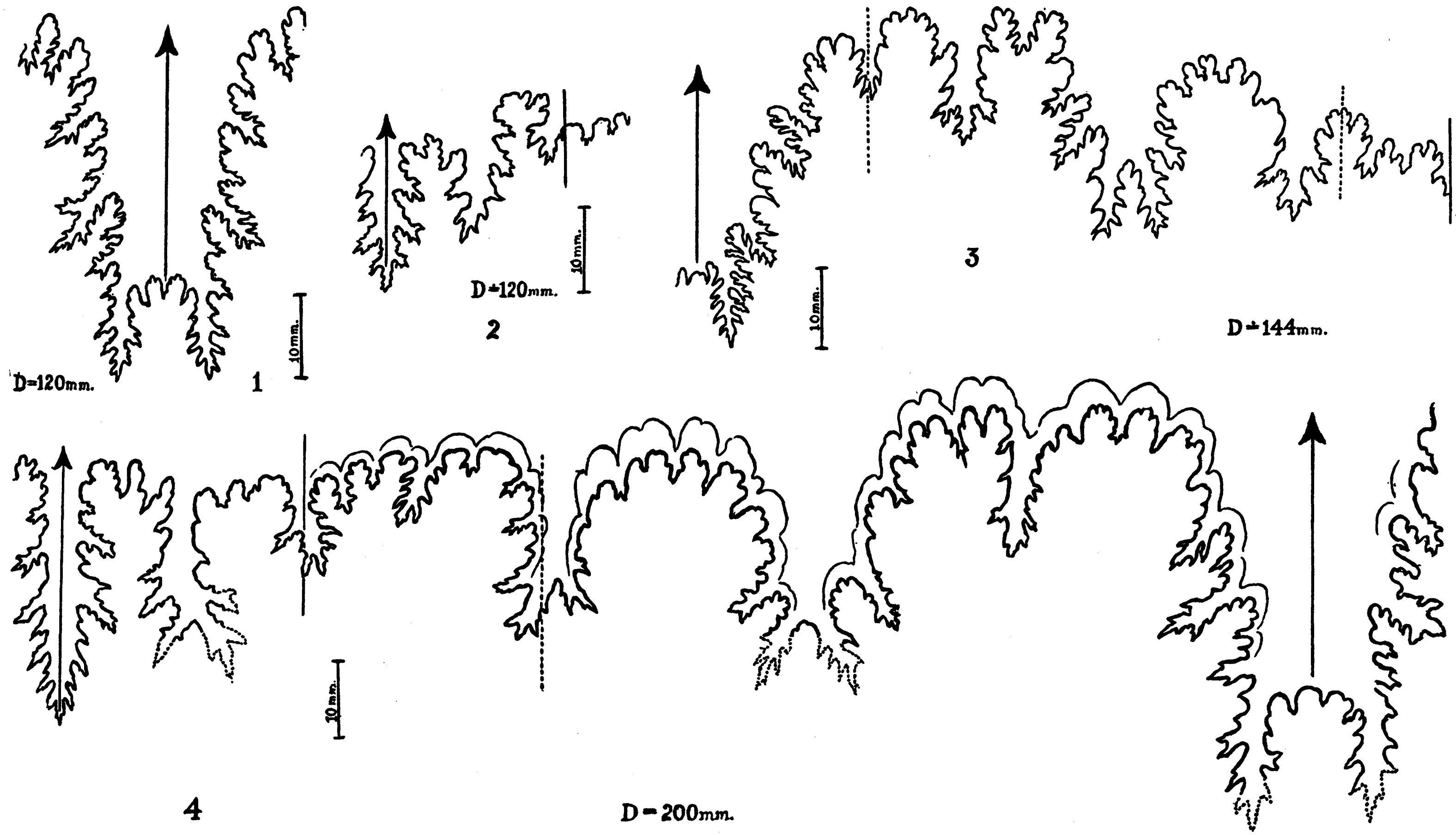
SUTURE LINES: Their external parts can best be studied in syntype A, at diameters of from 80 to about 140 mm.; the last suture is shown in figure 3. It is worth noting that in this individual the last septa are not crowded, as they are, at a considerably greater diameter, in specimens numbers 2, 3, and 4; this seems to prove that it did not reach adulthood.

The siphonal lobe is deep and divided by a rather low, slender, trapezoidal median knob into two only little diverging, slender points which exhibit, in addition to a long and pointed terminal prong, many more on their sides. The top of the median knob is, not quite symmetrically, indented by two notches with one leaflet in the middle and two somewhat higher ones on the sides. The external saddle is extraordinarily wide, even for an acanthoceratid, occupying, as it does, about two-fifths of the width of the venter and almost half the side. The main lobule cutting it in half is about half as deep as the first lateral lobe. It is trifid, with a three-pronged middle point and two-pronged lateral ones. Of the two main stems of the external saddle, both of which are subdivided by rather deep and slender secondary lobules, the outer one is markedly wider than the inner. The margin of the former that borders the siphonal lobe is remarkable for its rich indentation. The first lateral lobe is shorter than the siphonal one, rather wide and clearly bifid. A strong leaflet, rising to about two-fifths of the depth of this lobe, separates two trifid arms which seem to end in three-pronged points. The lateral saddle, though less than half as wide as the external one, makes an even sturdier impression, owing to the fact that it is considerably lower and less deeply intersected; there are two bi-lobate leaves, separated by a short lobule, on its top. The second lateral lobe which is, six sutures farther apicad, still clearly on the flank, has moved, in the last sutures of syntype A, to the umbilical shoulder. Still, it may be granted even here the designation lateral lobe, just coming, as it does, within the spiral of involution. In the suture line under discussion it attains only two-thirds of the depth of the first lateral lobe and is clearly trifid, with a strong, three-pronged middle point. The first auxiliary saddle, situated in part on the umbilical shoulder, in part on the umbilical wall, resembles the lateral one in shape but is less broad and asymmetrically trilobate. On the remainder of the umbilical wall there follow two short auxiliary lobes, the first of which is three-pronged, the second two-pronged, and, at the umbilical seam, the beginning of a third, with two more rather narrow and inconspicuous auxiliary saddles between them.

In figure 1 a siphonal lobe, taken from the penultimate whorl of syntype B (specimen no. 2), is shown for comparison with figure 3; whereas there the median knob divides, on its top, into three leaflets the middle one of which is over-topped by the lateral ones, it is here split into four leaflets, the two middle ones of which are the highest, with a notch, not a leaflet, in the median line. Such divergences in sutural details are quite common within a species.

The penultimate left suture line of the same individual, corresponding to a diameter of about 200 mm., is depicted in figure 4. The external part agrees well with the suture of syntype A, as described above, except that, as usual at such a late stage, the lobes are shallower and the saddles lower which lends an even sturdier appearance to all sutural elements. In this suture line the internal branch, too, is clearly visible: immediately below the umbilical seam there is a broad saddle, rectangular in shape and divided at its top into three unequal leaves. There follow a long, slender, bifid lobe, a tall, richly indented antisiphonal saddle, and a very deep and narrow antisiphonal lobe, ending in a long, dagger-like, three-pronged point.

The internal suture lines of the specimens numbered 3 and 4 are, at the same or an even greater diameter, very much like the one just described, but that of fragment number 5, depicted in figure 2, deviates, at a diameter of about 120 mm., in some details, particularly in the fact that here the saddle



Figs. 1–4. Suture lines of *Mantelliceras canitaurinum* Haas. 1, 4. Syntype B, A.M.N.H. No. 26413:2. 1. A siphonal lobe of penultimate whorl. 4. Last suture line but one of outer whorl. Outer contours duplicating outlines of external and lateral saddles indicate thickness of septa. 2. Paratype A.M.N.H. No. 26413:5, an internal suture line with adjacent part of external one. 3. Syntype A, A.M.N.H. No. 26413:1, external part of last suture line. Scale and diameter of disk (D) indicated for each drawing.

adjacent to the internal one is much higher than the latter.

OCCURRENCE: Represented by only six (or seven?) specimens, including fragments, this form is the rarest named species in the assemblage under examination.

REMARKS: Both in the character of ornamentation, as it appears in side view, and in the width, though not in the shape of the whorl section, the figures of D'Orbigny's (1840–1842) plate 103 resemble the present form remarkably, but this resemblance is of no avail since neither character can be found in the original of those drawings, as shown in Collignon's (1937, pl. 10) photographs.

Another form published in the earlier literature which is well comparable with this species is the one illustrated under the name "*Ammonites navicularis*" in Sharpe's (1856) plate 18, figures 1 and 2, and renamed *Mantelliceras cantianum* by Spath (1926, p. 82). There is undoubtedly considerable similarity, especially in costation, but *M. cantianum* shows two circumumbilical tubercles where there is only one radially elongated one in *M. canitaurinum*, its ribs are narrower and sharper, particularly so on the venter, and its whorl section is different in so far as the sides remain nearly parallel in their inner two-thirds but converge the faster in the outermost third, whereas in our species they converge first gently, then more rapidly without such an abrupt change in direction as observable in Sharpe's figure 2. Furthermore, the English form obviously never reaches the size of that from Wyoming.

In side view the shell from Dj. Trozza, Tunisia, considered by Pervinquière (1907, pl. 16, fig. 18) to be referable to *M. mantelli* just as well as to *M. martimpreyi* (Coquand), also resembles our syntype A, but since it is much less thick, conspecificity is out of the question. The suture line of *M. martimpreyi* figured by Pervinquière (*ibid.*, p. 294) in text figure 111 agrees well with the suture lines of our species, but its saddles are not nearly so wide, as is natural in a conch which is much slenderer.

When establishing *Mantelliceras*, Hyatt (1903, pp. 114, 115) listed not a single American form among the species he referred to this genus.

The only species recorded as a *Mantelliceras* from the Tarrant formation of the Eagle Ford group of Texas, *M. sellardsi* Adkins (1928, p. 239, pl. 25, fig. 1, pl. 26, fig. 4; Moreman, 1942, p. 207) differs considerably from *M. canitaurinum* in its small size, its co npressed shell shape, its closely set ribs, and in having, even at an early stage, a pair of shoulder tubercles on either side.

On the other hand, there is some similarity, particularly in costation, between the latter and the form from the Britton formation of the Eagle Ford first figured as "*Acanthoceras* sp. A" by Moreman (1927, pl. 15, fig. 2) and later renamed *Eucalycoceras indianense*, described and refigured by the same author (1942, p. 206, pl. 33, figs. 9, 10, text fig. 21), but the Texas species, apart from being much smaller, has quite a different whorl section, especially a narrower venter (*loc. cit.*, text fig. 2,l), and five tubercles, including a median one, on each rib, even in maturity.

The surficial resemblance between adult whorl fragments of this species on the one hand and of *Dunveganoceras pondi* on the other and the means of telling them from one another will be dealt with in the discussion of the latter species.

Mantelliceras sp. indet.
Plate 4, figures 3, 5
A.M.N.H. No. 26414

DIMENSIONS: The two fragments present are too incomplete to be properly measured; they may correspond to diameters of 70 mm. and 125 mm., respectively.

DESCRIPTION: Both differ from *M. canitaurinum* in their whorl section which is decidedly polygonal, there being a sharp break at, or slightly above the middle of, the sides; up to this point the sides converge only a little, but from there they rise at an angle of about 45 degrees ventrad; the uppermost portion of the whorl profile assumes the shape of a depressed trapezoid whose top seems to be shorter than either of the sides. Thus, the slanted shoulder parts are very much wider and the truncate median part of the venter is much narrower than in *M. canitaurinum*. In the larger fragment (no. 2) the umbilical shoulder can be seen to be rounded, and the umbilical wall is high and steep.

The costation is somewhat less dense than in *M. canitaurinum* at the same stage, there being only nine ribs per quarter whorl, but they are stronger and, on the sides of the larger fragment (no. 2), sharper. Whereas they are here about as wide as the intercostals, they are twice as wide as the latter and well rounded at the earlier stage represented by fragment number 1. In both specimens longer and shorter costae alternate.

The boundary between the truncate median part of the venter and the slanting shoulder parts is marked in fragment number 1 by blunt, spirally elongated tubercles which sit on the broad ribs, whereas there are in the larger fragment (no. 2) merely marked angulations of the ribs, just like those observable in *M. canitaurinum* at the same stage before they assume in that species the horn-like appearance mentioned in its description. Only in this fragment is a circumumbilical node recognizable inasmuch as the only costa whose innermost portion is preserved is there sharply raised. The median line is not preserved in the smaller fragment; in the larger one it is, and there are no median tubercles.

Specimen number 1 seems to be a fragment of the test only; therefore, it cannot be decided if it is from a septate or an unseptate part of a conch. Fragment number 2 is septate throughout, but no suture lines can be examined.

OCCURRENCE: Two fragments only.

REMARKS: The form represented by the two whorl fragments described above resembles *Ammonites mantelli* Sowerby and other "true *Mantelliceras*" even more than *M. canitaurinum* and can therefore, in our opinion, safely be assigned to this genus. However, the specimens at hand are too incomplete to venture any specific determination.

Comparison with *M. canitaurinum* has been integrated in the above description.

METOICOCERAS HYATT

Although considered by Hyatt (1903, p. 115) the type (and only) genus of the family Metoicoceratidae, *Metoicoceras* is here, following Roman's (1938, pp. 422, 437) example, referred to the Acanthoceratidae (subfamily Acanthoceratinae).

In the assemblage under discussion, it is represented by the following form only:

Metoicoceras whitei Hyatt,[1] **praecox,**
new subspecies
Plates 5–7; text figures 5–9
A.M.N.H. No. 26415

DIMENSIONS

SPECIMEN No.	D	H	H′	W	W′		U	REMARKS
1	34.9 mm.	51	36	36½	39		17½	
2 Penult.						Left side	18	
whorl	51.2 mm.	50	36	32½	33½			Holotype
						Right side	21	
3	116.6 mm.	45½	33½	*ca.* 30½	?		22½	
4	125.0 mm.	43	36	28	?		25½	

From the above table it can be seen that H and W decrease and U increases with growth.

The last septum is found at diameters of approximately 50 mm. in specimen number 5, 70 mm. in specimen number 4, less than 75 mm. in specimen number 2, and 85 mm. in specimen number 3. In none of these individuals can the apertural margin be observed. Where most completely preserved, i.e., in specimen number 4, the body chamber measures about two-thirds of a volution.[2] Most

[1] Synonymy:
1876 *Buchiceras swallovi* Shumard; WHITE, p. 202, pl. 20, figs. 1a–c.
1893 *Buchiceras swallovi* Shumard (sp.); STANTON, p. 168, pl. 37, fig. 1, pl. 38, figs. 1–3.
1903 *Metoicoceras whitei* n. sp.; HYATT, p. 122, pl. 13, figs. 3–5, pl. 14, figs. 1–10, 15.
1927 *Metoicoceras whitei* Hyatt; MOREMAN, p. 94, pl. 15, fig. 1.
1928 *Metoicoceras whitei* Hyatt; ADKINS, p. 249, *pro parte; non* pl. 26, figs. 1, 2.
1938 *Metoicoceras whitei* Hyatt; ROMAN, p. 437.
1942 *Metoicoceras whitei* Hyatt; MOREMAN, p. 210.
1944 *Metoicoceras whitei* Hyatt; SHIMER AND SHROCK, p. 591, pl. 245, figs. 8–10.

[2] According to Hyatt (1903, p. 123), however, the living chamber is, in the typical form, "invariably one-half of a volution in length."

of the whorl fragments present, the largest of which may correspond to a diameter of about 140 mm., are unseptate.

SELECTION OF TYPE: Although specimen number 4 is an almost complete adult individual, specimen number 2, though incomplete, was selected as holotype because it exhibits the characters of both inner and outer whorls.

DESCRIPTION: Conch discoidal, rather involute. The phenomenon previously (Haas, 1942b, p. 213) called "egression of the spiral" of involution can well be observed in several specimens present, e.g., in the paratype number 4 (pl. 6, fig. 4). The whorl section is, in the young, widest at the first third of the height whence it tapers gently towards the venter which is truncate in this stage (pl. 5, fig. 4). At a later stage, however, the point of greatest width moves farther ventrad, to about the middle of the sides which now hardly converge before approaching the latero-ventral shoulders, and the venter becomes decidedly rounded (pl. 5, fig. 8). It is worth noting that the outer part of the last whorl appears to be more compressed and the rounded venter accordingly narrower in some specimens (posterior parts of paratypes nos. 3 and 4, pl. 6, figs. 1 and 3) than in others (e.g., the holotype, pl. 5, fig. 5, or no. 8). It cannot be decided with any certainty if in the former compression is not, at least to a certain extent, due to crushing, but it will have to be kept in mind that it is, according to Hyatt (1903, pp. 122, 123), one of the distinctive characters of *M. whitei*. This change in the aspect of the venter is, of course, connected with the ontogenetic changes in its ornamentation, to be discussed below. The umbilical wall is moderately steep and high in the young (pl. 5, fig. 4), but flattens considerably in maturity (pl. 6, fig. 1). Accordingly, the umbilical shoulder, which is not very pronounced at an early stage, becomes even more indistinct in mature shells.

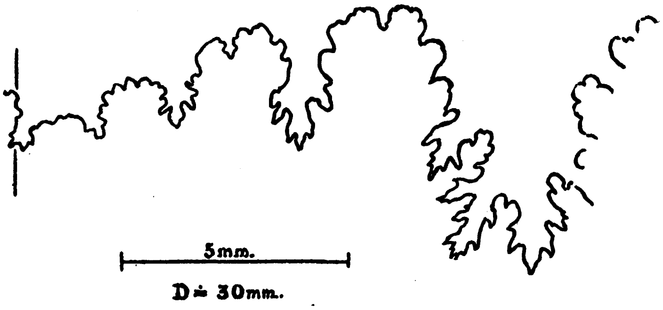
The ornamentation could be studied in the present material from a diameter of only about 10 mm. At this early stage, best observable in the inner whorls of the holotype and the paratype number 3 and in paratype number 1, strong, though not high, radially elongated circumumbilical tubercles, occupying most of the inner third of the sides, appear to be the outstanding sculptural feature. They might just as well be characterized as the raised innermost portions of the primary ribs; actually they give rise to two broad, fold-like ribs each, which cross the sides in a radial direction, forming, at least in specimen number 1, a shallow, orad concave arc. Here and there single ribs, beginning at about the middle of the sides, are intercalated between those pairs of ribs. Upon reaching the venter the costae form blunt tubercles on either edge. At the earliest stage (diameter 9 mm.) observable in the holotype these tubercles are just swellings of the ribs which run obliquely forward. At the posterior end of the paratype number 1, at a diameter of about 21 mm., and, better still, in an otherwise poorly preserved fragment corresponding to diameters of from 30 to 45 mm. (no. 7, pl. 5, fig. 7), they can be recognized to be spirally elongated, but in the former shell they assume a bullate appearance immediately afterwards. Simultaneously they begin to be connected across the venter by a blunt ridge. Whereas these ridges are still far less pronounced than the ribs of the sides in the anterior part of paratype number 1, at diameters from 30 to 35 mm., they reach about the same strength as the latter in the middle of the penultimate whorl of the holotype, at a diameter of only somewhat more than 25 mm., so that here the ribs may well be said to cross the venter uninterruptedly. At this stage the aforementioned tubercles can just be seen to disappear, but the costal (nodal) section still keeps a narrowly trapezoidal outline, with the ribs crossing the venter in a horizontal straight line (pl. 5, fig. 8). At all later stages observable, however, the costae, which are now broad and fold-like, cross the venter in an evenly rounded arc, "cutting it into waves" (Hyatt, 1903, p. 123). As a rule, no trace of the ventral tubercles is left, just as the circumumbilical ones have entirely disappeared. There are 12 ribs in the small half-disk number 1, or 24 to the whorl, whereas in most of the full-sized individuals or fragments thereof, as in the holotype, rib counts result in a number of 28 per whorl, as in the large shell figured by Hyatt (1903) in figures 3 and 4 of plate 13; his type (*ibid.*, pl. 14, fig. 6), however, has only 11 ribs per half whorl. In all other characters, the costation shows in maturity a wide range of variation. In some individuals, as in the body chamber fragment attaining the largest size (paratype no. 6, pl. 7, figs. 1, 2) or in two other such fragments telescoped into each other (specimen no. 8), the ribs maintain their full strength to the very end; in others, e.g., paratypes numbers 3 and 4 (pl. 6, figs. 2–4), they become gradually less pronounced on the body chamber and almost vanish at the anterior ends. Another body chamber fragment (no. 9; pl. 7, fig. 4) is virtually smooth for about a sixth of a volution but then ribs reappear, though more or less restricted to the outer half of the flanks where they assume the aspect of blunt, radially elongated nodes. On the same fragment they are here and there accompanied or replaced by bundles of growth striae which can also be observed in two other unseptate fragments (no. 10, pl. 7, fig. 3, and no. 12). In profile the costae are, especially on the venter, mostly broadly rounded, but exceptionally rather sharp; nowhere, however, could the "abrupt forward edges" mentioned in Hyatt's (1903, p. 123) description of his two large fragments be observed. Sometimes the ribs can be followed right to the umbilical shoulder, sometimes they end at the inner third of the sides, or, if they tend altogether to disappear, at their middle or even farther ventrad. Similar variation prevails in the direction and course of the costae. Whereas they run, as a rule, more or less radially and in a straight or slightly sigmoidal course across the sides (paratypes nos. 3, 4; pl. 6, figs. 2, 4), they may form an orad concave arc (fragment no. 11; pl. 5, fig. 6) or else become decidedly prorsiradiate (fragment no. 10; pl. 7, fig. 3) towards the aperture. All the irregularities noted above seem to come under the general phenomenon, so frequently observed in ammonites, of degeneration of ornamentation on the body chamber. At this late stage, bifurcation of ribs or intercalation of shorter ones between two longer ones occurs only occasionally.

Paratype number 5 is remarkable for the unusual thickness of its test which attains or even exceeds 3 mm. at a diameter of only about 80 mm. and a width of the whorl (without the test) of less than 30 mm. Since this extraordinary feature cannot be found in any other individual, even among much larger ones, it might be due to some special (?pathological) reason.

Suture Lines: The earliest sutural stage that could be studied is at a diameter of somewhat more than 10 mm. in paratype number 5 (fig. 6). As the outer part of the whorl is concealed by the succeeding volution, only part of the second lateral lobe can be seen. It seems to be trifid; its margins are comparatively richly indented. The following saddle is rather low and broad, trapezoidal in shape, and indented by a shallow lobule. The first auxiliary lobe is triangular in outline and neatly three-pronged. There follow two broad and low auxiliary saddles and two more auxiliary lobes; the second is short and triangular, the third is just cut in half by the umbilical seam.

The next stage could be studied in the same shell, about three-quarters of a volution farther orad, at a diameter of about 30 mm. (fig. 5). The first element visible in this suture line is the first lateral lobe; it shows two strong, three-pronged main points which are separated by an oblique leaflet. The first lateral saddle is apparently higher than the external one and has a short lobule slightly ventrad of the middle of its top; in addition, there are from two to three indentations on either side. The second lateral lobe is a little less than half as deep as the first and clearly trifid, with a three-pronged middle point and two-pronged lateral ones. The second lateral saddle resembles the first in shape and is divided a little dorsad of the middle of its top by a three-pronged lobule. All three auxiliary lobes seem to be three-pronged; the two auxiliary saddles between them are markedly low and broad. Beyond the umbilical seam the outer half of a much taller saddle of the internal suture can be seen.

About the same sutural stage could be studied at the anterior end of the paratype number 1, at a diameter of about 35 mm. (fig. 7). Here the external part of the suture line could be made accessible to examination. The siphonal lobe, which is moderately wide, ends in two only slightly diverging, two-pronged points which are separated from each other by a broad and low median knob; the latter is somewhat higher on the left side than on the right. It shows three shallow notches on its top and two fine indentations on either side. The external saddle, extending from the venter beyond the outer third of the side, is subdivided by a trifid lobule, with a two-pronged middle point, into two main stems, the outer of which is about twice as wide as the inner. The former is trilobate; the latter shows only minor identations. The first lateral lobe is rather wide and about as deep as the siphonal one; at its bottom it is symmetrically bifid, with both its terminal points two-pronged. The lateral margins of this lobe, too, are rather richly indented; the fact that the strongest of these lateral points is more developed on the external than on the internal margin causes some asymmetry of this lobe on the whole. Although the following saddles are unfortunately scalped, the first lateral one can be recognized to have had at least one indentation on its top; it is much lower than the external saddle. The general plan of the following sutural elements is the same as in the suture line just described, except that here a third auxiliary saddle can be



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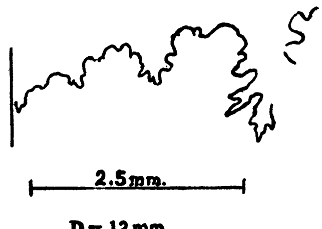

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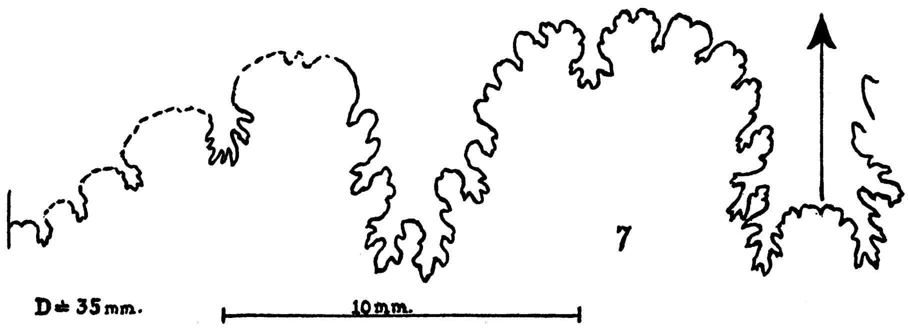

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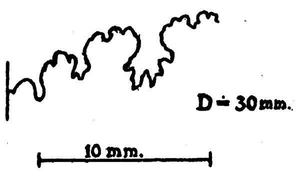

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FIGS. 5–9. Suture lines of *Metoicoceras whitei* Hyatt, subspecies *praecox* Haas. 5, 6. Paratype A.M.N.H. No. 26415:5. 5. A suture line of outer whorl from first lateral lobe to umbilical seam. 6. A suture line of penultimate whorl from second lateral lobe to umbilical seam. 7. Paratype A.M.N.H. No. 26415:1; dashed lines indicate scalped saddles. 8, 9. Paratype A.M.N.H. No. 26415:3. 8. A suture line of penultimate whorl from first lateral saddle to umbilical seam. 9. One of the last suture lines of outer whorl. Scale and diameter of disk (D) indicated for each drawing.

seen immediately at the umbilical seam. Furthermore, it is worth noting that the second lateral lobe is here four-pronged rather than trifid, that the second lateral saddle nearly equals the first in width, and that the second auxiliary lobe is markedly shorter than either the first or the third.

For comparison with the two suture lines just discussed, one from the penultimate whorl of paratype number 3, corresponding to a diameter of about 30 mm., is shown in figure 8 from the first lateral saddle dorsad. Here the second lateral lobe is clearly bifid, with a three-pronged inner main point and a simple outer one; the second lateral saddle is more distinctly indented on its top, and the first auxiliary lobe is three-pronged. There seem to be only two auxiliary lobes and two such saddles in this suture line.

The most complete suture lines of this genus in the present material and those representing the most advanced ontogenetic stage are found on the outer whorl of the same individual, at diameters from 75 to 85 mm., where they are crowded together, as the last suture lines usually are (fig. 9). These suture lines may well be said to convey the same over-all impression as that of the type specimen of the typical form (Hyatt, 1903, pl. 14, figs. 7, 8) at about the same stage. This holds particularly true of the degree of indentation. Otherwise there are some differences. The first lateral saddle does not exceed the external one in height but is slightly lower. The first lateral lobe is clearly trifid, not asymmetrically bifid as in Hyatt's suture line. There are only two auxiliary lobes and two such saddles, whereas Hyatt's drawing shows four each of both. Both first and second auxiliary lobes are slender and clearly three-pronged in the present suture line, whereas in Hyatt's drawing the first is unusually wide and divided into two branches, the outer of which is two-pronged and the inner three-pronged, and the second auxiliary lobe is two-pronged.

However, all these differences and all those observable between the various suture lines within the present material, as described above, are by no means greater than those observed and studiously listed by Hyatt in his chart (p. 126) for the typical form of this species. This applies to the bifidity or trifidity of the main lobes and saddles as well as to the number of auxiliary elements. The latter just depends on the degree of involution, a narrower umbilicus permitting of the development of more auxiliaries.

OCCURRENCE: In the assemblage under study this form is less common than *Dunveganoceras pondi* but more so than *Mantelliceras canitaurinum*. In addition to five more or less complete disks and half disks, there are 16 fragments; altogether 21 specimens.

REMARKS: The shells from Greybull have in general a wider umbilicus than those of the typical *M. whitei* from Texas and Utah. The ribs are less stiff and crowded in the young than in Hyatt's (1923, pl. 14) figure 4. The outer nodes disappear much earlier, and there is no second row of tubercles accompanying the former at the inside at any stage, but also according to Hyatt (1903, p. 123) it "is not present at any stage in some specimens." Except for the last all these differences are believed to be due merely to the fact that development is accelerated in the Greybull specimens which do not reach the same size as Hyatt's[1] and attain certain characters of both shell shape and ornamentation at an earlier ontogenetic stage. This assumption is fully confirmed by the examination of an almost complete disk, measuring 200 mm. in diameter, of *M. whitei* from the Tropic shale of locality 5289, near Alton, Kane County, Utah, and of four fragments labeled "*Metoicoceras*, probably *M. whitei* Hyatt" from the Eagle Ford shale of localities 13828 and 14585, Grayson and Johnson counties, respectively, Texas, which correspond to about the same size and ontogenetic stage as the former, all of which were lent to me by the United States National Museum through the courtesy of Dr. Reeside.[2] Thus, it is believed that the Greybull form can well be left with Hyatt's species, but its ac-

[1] A greater diameter than that of 145 mm. shown in Hyatt's (1903, pl. 13) figures 3 and 4 is attained by the disk from Utah depicted, under the name *Buchiceras swallovi*, by White (1876, pl. 20) which measures 170 mm. According to Moreman (1942, pl. 210) *M. whitei* grows 12 inches (=300 mm.) large in the Eagle Ford of Texas.

[2] The two unseptate fragments discussed by Hyatt (1903, bottom of p. 123 and top of p. 124) could not be located in the National Museum.

celerated development seems to warrant the creation of a separate subspecies,[1] in whose name it is indicated, the more so since it can be found in all individuals of this population without exception. This seems to be one more of the cases in which differential speed of development accounts for considerable intraspecific differences between individuals of the same size (cf. Haas, 1946, p. 148).

From this very angle both Moreman's and Adkins' (*loc. cit.* in synon.) diagnoses of *M. whitei* and *M. swallovi* may seem somewhat too static, since they do not take the ever-changing aspects of these species sufficiently into account. Moreover, both Moreman's (about one-tenth) and Adkins' (0.12) figures for the width of the umbilicus are considerably lower than those of 15 and 14½ per cent, respectively, that can be measured from Hyatt's figures of the type (1903, pl. 14, fig. 7) and of his largest shell (pl. 13, fig. 4). Furthermore, it can clearly be seen from the above table of dimensions how U increases with growth. Rather than the characters enumerated in Moreman's and Adkins' diagnoses, Hyatt's (1903, pp. 122, 123) distinction between *M. whitei* and *M. swallovi* is here depended on: "More compressed volutions without such prominent nodes on the umbilical shoulders. They have nodes, but these are more a part of the costae and less prominent, the sides are consequently flatter than in *swallovi*. . . . The sutures are more complex at an earlier stage and remain more complex throughout life as regards their marginal digitations." In other words, the sutures of *whitei* are not so pseudo-ceratitic as those of *swallovi*.

It may be doubted if the fragment figured by Adkins (*loc. cit.* in synon.) with its narrow, sharp, markedly sigmoidal ribs and its pronounced, pointed, but not spirally elongated tubercles of the "second row" is conspecific with Hyatt's type. *M. irwini* Moreman (1927, p. 92, pl. 13, figs. 3, 4; 1942, p. 211) somewhat resembles by its compressed shell shape, flat costation, and hardly prominent marginal tubercles the specimens from Greybull, but the latter exhibit umbilical tubercles, said by Moreman to be lacking in his species. Comparison is, however, made difficult by the uncertainty as to the true size of the holotype whose diameter is given as 220 mm. in the description, whereas it would amount to only half that length according to the explanation of plates (1927, p. 100).

[1] Not a variety; see Haas, 1942b, page 207, footnote 1.

DUNVEGANOCERAS WARREN AND STELCK

The descriptions of the two forms dealt with under this heading and the accompanying illustrations will not, I believe, leave any doubt but that they belong to the above genus, established only some years ago by Warren and Stelck (1940, p. 149) with *Acanthoceras albertense* Warren (1930, p. 21, pl. 1, figs. 1, 2) as its type species.

It must, however, be pointed out from the outset that *D. albertense*, although the type species, is a somewhat aberrant representative of the genus[2]; neither the slenderness of its conch nor the ogival cross section shown by its outer whorl is encountered in *D. pouce-coupense* or *D. pondi*, both of which species seem to be much more common than *D. albertense*, all in their respective localities. Apparently it is these peculiarities of the chosen genotype which induced Warren and Stelck (1940, p. 150) to assume that the differences between the two species known to them "are probably more than of specific rank" and to think it probable that in the future "a new genus will have to be erected for the reception of *D. poucecoupense*." In the writer's opinion, however, all three of the species now referred to this genus, viz., *D. albertense*, *D. poucecoupense*, and *D. pondi*, have so many distinctive characters in common that they should be left in the same genus, regardless of the quite considerable differences between their mature whorl sections. Foremost of these common characters is the peculiar way in which the ribs become dominant in maturity, incorporate the tubercles and cross the venter; another is the surprising constancy of their number (18 per whorl) in all three of the species described so far.

On the strength of the material now known, Warren and Stelck's generic diagnosis might be amplified as follows: Little to moderately involute, discoidal shells attaining consider-

[2] Similar cases of type species that are not typical of their genera have previously been discussed with regard to the Albian genera *Neokentroceras* and *Elobiceras* (Haas, 1942b, pp. 48, 98, 124).

able size. Intercostal whorl section first subquadratic, then oval, and in maturity inverted heart-shaped, costal one first subrectangular with flatly trapezoidal top, in maturity ogival (in the type species only) or trapezoidal; venter, except in the type species, truncate throughout development, sometimes sunk in the median zone. Early ornamentation consists of moderately strong, more or less straight and radial ribs which carry radially elongated circumumbilical tubercles varying in strength, conical latero-ventral tubercles pointing outward, and compressed, spirally elongated ventral tubercles. Vestigial, spirally elongated median tubercles only rarely present at an early stage. At maturity the ribs, 18 per whorl in number, become high and sharp, incorporate the various tubercles, and continue across the venter, forming more or less distinct horns on the latero-ventral shoulders.

Suture lines moderately indented, characterized by broad external and lateral saddles, the former more or less deeply indented by its main lobule. The width of these saddles makes the corresponding lobes appear slender in comparison and dislodges to a varying degree the second lateral lobe towards the umbilical shoulder. In addition to the two lateral lobes there are two or three inconspicuous auxiliary ones. Antisiphonal lobe short, flanked by tall, slender saddles; there are from three to four more lobes and the corresponding number of saddles between those internal saddles and the umbilical seam.

Hitherto this genus was known only from the uppermost beds of the Dunvegan sandstone and the lowermost beds of the Smoky River shale (Pouce Coupe sandstone and just above) of the Pouce Coupe district, at the Alberta-British Columbia boundary, and from the base of the Alberta shale near Luscar in the foothills of southern Alberta. All the beds mentioned are assigned a late Cenomanian age by Warren and Stelck (1940, pp. 144, 147, 149–150). The present report extends the geographic range of this genus far southward to north central Wyoming, where it occurs in beds of the Cody shale of late Cenomanian or early Turonian age; the latter dating is believed to be the more probable (see pp. 35, 36). The distance of nearly 950 miles between the Pouce Coupe district and the region of Greybull (which have yielded the best representatives of this genus and the only figured ones) is certainly remarkable, the more so since ammonites of this size (up to 400 mm. diameter) are not likely to be overlooked by field geologists or collectors. Only about a fourth of this gap is bridged by the occurrence of this genus near Luscar, Alberta, about 225 miles southeast of the Pouce Coupe district.

Warren and Stelck (1940, p. 149) consider *Dunveganoceras* "to a certain extent intermediate in character between *Acanthoceras* and *Mantelliceras*." There exists indeed some relationship with both these genera, but the forms referred to *Dunveganoceras* cannot be assigned to *Acanthoceras*, among whose generic characters Pervinquière (1907, p. 250) lists "une rangée médiane [de tubercules] qui peut disparaître avec l'âge," nor to *Mantelliceras*, whose most distinctive generic character is seen in the trapezoidal outline of the external portion of the whorl section, with a broad and flat truncate venter (cf. p. 9).

The earlier ontogenetic stages of *Dunveganoceras* undoubtedly closely resemble those of *Mammites* Laube and Bruder also, but in maturity the sculpture of both genera is quite different, *Dunveganoceras* being then distinguished by straight, sharp, high ribs, whereas heavy circumumbilical and marginal tubercles dominate the mature ornamentation of *Mammites*. Furthermore, both genera are remarkably similar in the general character of their suture lines.

Although close relations to members of both the subfamilies Acanthocerinae and Mammitinae (see Roman, 1938, pp. 427 and 449, respectively) prevail, the question as to which of these two subfamilies *Dunveganoceras* should be assigned cannot well be decided within the scope of the present paper, less so since neither of them appears to be very clearly defined in literature.

Some similarities between *Dunveganoceras* and the Acanthoceratidae in general on the one hand and some members of the younger family Prionocyclidae (Haas) Breistroffer (1947)[1] on the other will be discussed in the Paleontological Summary (pp. 32–34).

[1] Coëxtensive with Prionotropidae Zittel. See also Haas, 1948.

Dunveganoceras pondi,[1] new species
Plate 8, figures 1–5, 8, plate 9, figures 1, 3, 4, plates 10–14; text figures 11–13, 16, 17
A.M.N.H. No. 26416

In the two half whorls just mentioned, in which all of the living chamber is believed to be preserved, it is about half a volution long. In both these half whorls as well as in fragment number 7 and in specimen number 4

DIMENSIONS

Specimen No.		D	H	H′	W	W′	U	Remarks
1		152 mm.	43½	?	*ca.* 33	*ca.* 38	31½	
2	a Nucleus	26 mm.	48	42½	?	*ca.* 45½	?	
	b Outer whorl	223 mm.	45	40	35	40	29	
3	a Penultimate whorl	87.6 mm.	47	?	41	48½	25½	Holotype
	b Outer whorl	*ca.* 280 mm.	*ca.* 43	*ca.* 33½	*ca.* 36½	*ca.* 41	*ca.* 28½	
4	a At fracture	222 mm.	45	*ca.* 39½	36½	40½	28	
	b At anterior end	*ca.* 294 mm.	*ca.* 33	*ca.* 28½	*ca.* 31½	*ca.* 38	*ca.* 35	
5	a One-sixth whorl apicad of anterior end	297 mm.	41½	?	?	?	28	
	b At anterior end	331.5 mm.	36	?	?	?	33	
6		*ca.* 330 mm.	*ca.* 35	*ca.* 28½	*ca.* 27	*ca.* 31½	*ca.* 35½	
7		324 mm.	38½	33	35	41½	32½	
8		*ca.* 350 mm.	*ca.* 36½	*ca.* 28½	*ca.* 31½	*ca.* 36½	*ca.* 33	

From the above table it can be seen that in general H decreases and U increases with size; in other words, the shells become less involute with growth. Especially towards the end of the body chambers the egression of the spiral of involution (cf. Haas, 1942b, p. 213, footnote 1) becomes quite noticeable in some specimens (e.g., no. 7, pl. 13, fig. 4).

It is interesting to note that all four of the largest specimens measured (nos. 5–8) reach about the same size, namely, diameters of from 324 to 350 mm. The greatest size represented in the present material was reached by a shell of which only the unseptate anterior third of the last volution (fragment no. 9) is preserved and which must have attained at least 400 mm. in diameter. This fragment, as well as the half whorls numbers 6 and 8 (both measured above), seems to be preserved to the aperture or nearly so, as may be inferred from the way the last rib (which is also less sharp and strong than the preceding one) becomes decidedly prorsiradiate so that it converges quite markedly with the penultimate one towards the umbilical shoulder. Thus the diameter reached by full-grown individuals of this species may be estimated at from 330 to 400 mm.

the last septum is found at a diameter of about 220 mm., and the same seems to hold true for some other fragments. In specimen number 5, however, the last septum is located at a diameter of about 240 mm. and in the holotype at as much as 260 mm., so that the holotype may well be assumed to have reached, when complete, like fragment number 9, a diameter of about 400 mm. Observations on the sizes of shells that are septate throughout on the one hand and of entirely unseptate fragments on the other bear out, however, the above assumption that, as a rule, the site of the last septum was at a diameter of about 220 mm.

Selection of Holotype: Although among the more or less complete disks the largest (no. 5), still sticking in its concretion, is by far the most spectacular, and among those not reaching 300 mm. in diameter number 4 is in side view much more complete than number 3, the latter has been designated holotype because it permits best the study of both penultimate and outer whorls, so different from each other as to shell shape, ornamentation, and sutures.

Description: Shell discoidal, moderately involute. By breaking up paratype number 2 its nucleus could be freed and studied from a diameter of about 10 mm. on. At this very

[1] Named in honor of Mr. W. F. Pond (see p. 7).

early stage the whorls are rather sturdy and subquadratic in section. The flatly trapezoidal outline of the peripheric part of the whorl section, caused by the flat median zone of the truncate venter and the slanting ventro-lateral shoulder zones, is already indicated but not yet pronounced, so that the ventral part of the volutions still looks rather rounded. From this point the whorl increases much faster in height than in width; about one volution farther orad, at a diameter of 31 mm., the internodal section has assumed an oval shape (pl. 8, fig. 5). The flanks are only gently vaulted, with the greatest width at about their inner third. In costal section the trapezoidal outline of the ventral portion of the whorl section has become quite pronounced, there being a median band, flanked by the two rows of ventral tubercles, and two slanting bands between each of them and the row of ventrolateral tubercles of the same side; the latter rise at an angle of about 30 degrees. All three of these bands are gently concave. The next stage at which the whorl section can well be studied, between the diameters of 45 and 85 mm., is represented by the penultimate volutions of both the holotype and the paratype number 2, and is best exemplified by a fracture of the latter, corresponding to a diameter of about 65 mm. and shown in plate 8, figure 3. Here the section is still oval and comparatively slender, the flanks are still gently vaulted, and the section attains its maximum width still at about the inner third of its height. The umbilical shoulder is pronounced, though rounded, the umbilical wall rather high. The section of the penultimate whorl of the holotype at the same stage is similar in general, but shows somewhat flatter flanks, so that it might almost be called subrectangular rather than oval, and a steeper, in places almost perpendicular umbilical wall. Furthermore, the point of its greatest width, which is accentuated in costal section by the peaks of the radially elongated circumumbilical tubercles, is a little farther dorsad than in the section just described, at about the first fourth of the flanks.

This phase persists up to a diameter of about 150 mm., with the umbilical shoulder becoming less and less pronounced and the umbilical wall less and less high; simultaneously, the latero-ventral bands begin to slope somewhat more steeply, namely, at an angle of from 40 to 45 degrees. Above that diameter the intercostal section gradually assumes an inverted heart shape and the costal one gradually becomes trapezoidal, though with a sunk median part of its top line (pl. 9, fig. 4; pl. 10, fig. 4). The venter is truncate throughout development, but while this has been true at earlier stages for its median zone only (see pl. 8, figs. 1, 3–5; pl. 9, fig. 3), later on, after the amalgamation of both rows of outer tubercles into strong horns, the truncate part of the venter spreads over the space earlier occupied by the shoulder bands, thus becoming much broader.

The earliest stage at which the ornamentation can be studied, though only on the venter and on the outer zone of the sides, is represented by the nucleus of the paratype number 2, mentioned above, corresponding to diameters from 10 to 31 mm. On the sides (pl. 8, fig. 2) the ribs, which seem to run in a radial direction, appear to be blunt and fold-like, but it cannot be safely decided if and how far this is due merely to corrosion of the surface. Anyway, they become distinct only upon reaching the latero-ventral tubercles, which are blunt and inconspicuous in the posterior half of this whorl but become quite sharp and prominent in the anterior one, where they can already be recognized to be conical and to point outward and slightly upward. The ribs then continue, connecting the latero-ventral tubercles with the ventral ones. In this part of their course they seem to be somewhat sharper in the posterior half of this volution than in the anterior one, where they gradually assume the ridge-like aspect of later stages. The ventral tubercles are clearly bullate in the posterior part of this whorl; just about at its middle they begin to become laterally compressed and spirally elongated. Between the ventral tubercles of both sides the costae are as a rule less distinct than beyond them, or are entirely lacking. At about the middle of this whorl, however, two or three folds can be observed between those tubercles, hardly weaker than those on the shoulders and forming flatly orad convex tongues across the venter (pl. 8, figs. 4, 5). Nine ribs can be counted on the anterior half of this volution.

At a somewhat greater diameter (*ca.* 23 mm.), where no traces of ribs can be seen on the ventral band, it shows a faint indication of a median elevation which is the only one seen anywhere in this species.

The above observations can well be supplemented, as far as the inner zone of the sides is concerned, by those made on the antepenultimate whorl of the holotype between the diameters of 15 and 40 mm. (pl. 9, fig. 1). Strong and high primary ribs, which start on the umbilical wall and form high, radially elongated tubercles on and immediately above the umbilical shoulder, are the outstanding sculptural character; they seem to cross the shoulder in a shallow, orad convex arc but are otherwise straight and radial. Four of them are present on half a whorl. Towards the end of this stage less conspicuous secondary ribs, beginning at about the inner third of the flanks and lacking circumumbilical tubercles, are intercalated between the primary ones. From a diameter of about 40 mm. the ornamentation of the holotype is visible all around the whorl, and the same stage as in the posteriormost quarter of its penultimate whorl can be studied in that of the paratype number 2 also. Now both primary and secondary ribs can be seen to end on the latero-ventral shoulder in a prominent conical tubercle that points laterally outward. Between the diameters of 45 and 80 mm. nine such tubercles per half whorl are present in the holotype. These tubercles are connected by blunt ridges, which are just a little higher than their interspaces, with those of the outermost row which are spirally elongated and slope more steeply orad than apicad. Each of these rows in its entirety resembles a cockscomb. Between them the venter forms a gently concave, gradually widening band which, at a diameter of 70 mm., can be seen gently to undulate. It is higher between tubercles than between their interspaces, thus reminiscent, on the one hand, of the tongue-like folds crossing the venter at one place of the nucleus of paratype number 2, and foreshadowing, on the other hand, the crossing of the venter by the ribs again at a much later ontogenetic stage. At that under discussion, the circumumbilical nodes are less conspicuous than at the earliest one; the primary ribs are just somewhat raised in the inner zone of the sides, whereas in the outer one both primary and secondary ribs are rather broad and low.

The stage just described can be seen to persist up to diameters of 125 and 140 mm. in paratypes 11 (pl. 8, fig. 8) and 1, respectively. There are still nine pairs of outer tubercles, or primary and secondary ribs together, per half whorl. The circumumbilical tubercles have moved farther ventrad, as often happens in the course of growth; they now culminate somewhat above the inner third of the sides. At and beyond the diameter of 140 mm. the ribs crowd together in specimen number 1, there being six on a quarter whorl, become more or less uniform and assume a rursiradiate direction, forming an apicad concave arc. However, this may well be a local irregularity.

The change in ornamentation from this stage to the mature one is in side view best seen in paratype number 4 where it takes place, rather abruptly, within about a sixth of a volution between the diameters of 160 and 190 mm. (pl. 10). The ribs become high and strong again and slightly prorsiradiate, with no more difference between primary and secondary ones, but still number nine per half whorl. The radially elongated circumumbilical tubercles are much more prominent than in the preceding stage; their peak has moved somewhat dorsad again so as to be slightly below the inner third of the sides. On the outer shoulder there is no more trace of the pairs of tubercles described above, but the ribs rise instead to form strong horns whose peaks point upward and somewhat outward. The strong development of these horns, which in side view can be seen to slope gently orad but rather steeply apicad, makes for a markedly scalloped appearance of the periphery. Only between the diameters of 270 and 295 mm. is the venter of this shell more or less complete, so that the costae can be seen to continue across it but to sink rather deeply in the median zone between the horns, where they are considerably less prominent and sharp than on the sides. Another specimen that shows this stage of ornamentation particularly well, the fragment number 10, is illustrated in plate 12, figures 1 to 3. In the posterior part of this fragment the ribs show a slight depression on the outer third of the sides between their raised inner parts and the horns.

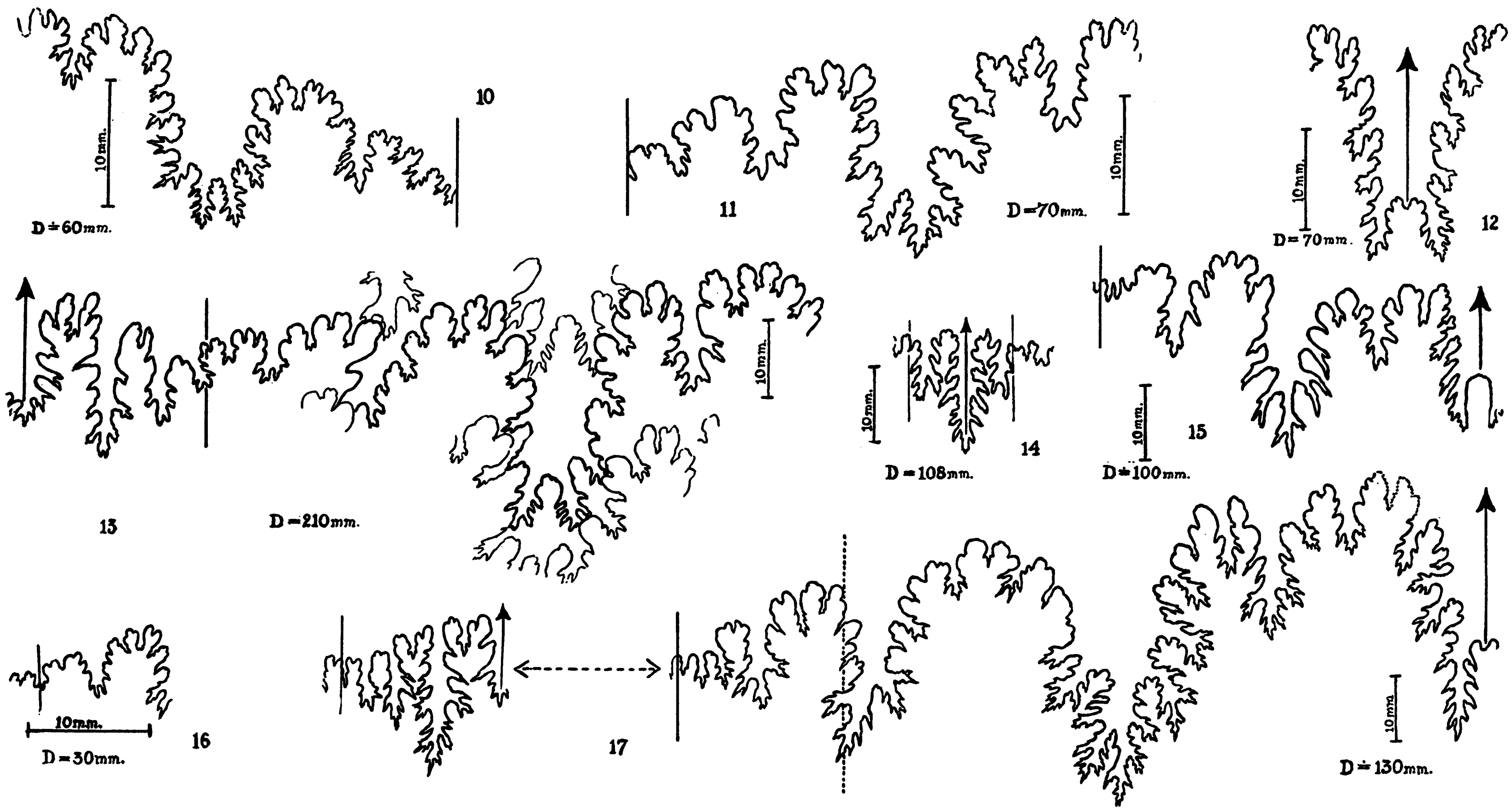
The kind of costation just described is found in all individuals of this species above the diameter of 200 mm., but there are, of course, some minor variations. Thus on the outer whorl of the holotype, which approximately agrees in size with specimen number 4, the ribs are slightly rursiradiate rather than prorsiradiate, as they are in the latter (compare pl. 9, fig. 1, with pl. 10). In the anterior portion of the outer whorl of the largest complete disk present (no. 5) the costae become so low and rounded in the median zone of the venter that they should here be called folds rather than ribs. In some fragments, as in numbers 6, 12, and 13, the horns move closer together than in specimens number 3 and 10, described above and figured, thus considerably narrowing the sunk portion of the ribs between them; as an example, fragment number 13 is shown in ventral view (pl. 14, fig. 1). Finally, the anteriormost portions of the living chambers believed to be complete (fragments nos. 6, 8, 9) show the usual degeneraton of the sculpture at this stage. The last ribs become strongly prorsiradiate and their horns lose prominence or almost disappear; one of these fragments, number 8, is illustrated in plate 14, figure 2. With all these individual differences there is, however, a remarkable constancy in the number of ribs, which is almost regularly nine per half whorl.

As an abnormality, perhaps due to some lesion of the shell, it may be noted that in specimen number 6 the symmetry of the ornamentation is disturbed for about a sixth of a whorl, only two ribs on the right side corresponding to three on the left (pl. 13, fig. 1).

The test is 3 mm. thick in specimen number 11 at about 100 mm. diameter but attains thicknesses of 5 and 6 mm. and, in the fragments numbered 9 and 18, even of 7½ mm., in maturity. This thickness of the test is illustrated on plate 13 by figures 2 and 3.

SUTURE LINES: The earliest stage at which they can be studied in this species, though on the inner two-thirds of the sides only, is on the antepenultimate volution of the holotype at diameters between 20 and 40 mm. (fig. 16). Immediately within the umbilical seam the inner margin of the first lateral lobe and the first lateral saddle are visible. The latter is broad and intersected by two lobules into three terminal leaves, the innermost of which is the widest. The second lateral lobe is moderately deep and, in the best-preserved suture line, clearly deflected ventrad, but no such deflection is observable in the following lines; this lobe ends in two points which are both two-pronged. There follows a remarkably wide second lateral saddle, divided by a comparatively deep lobule into two stems, the outer of which is both higher and wider than the inner; they are subdivided into two leaflets each. A three-pronged first auxiliary lobe, only half as deep as the second lateral one, rides on the umbilical shoulder. On the umbilical wall there follow two auxiliary saddles, the first indented by a lobule, with a short second auxiliary lobe between them.

Complete external suture lines are first observable on the penultimate whorl of the holotype between diameters of 45 and 80 mm. The best-preserved siphonal lobe, corresponding to a diameter of about 70 mm., is depicted in figure 12. It is deep and rather narrow and ends in two main points which diverge at an angle of about 45 degrees and are both trifid, with a three-pronged middle point. The median knob separating them reaches about a third of the depth of this lobe in height and is of a slender, trapezoidal shape; on its top it is, not quite symmetrically, halved by a lobule. The rest of the external suture is best studied in the preceding and following lines (fig. 11). The external saddle is broad, reaching somewhat dorsad of the latero-ventral tubercles so as to cover the outer third of the whorl height. The main lobule dividing it is more than half as deep as the first lateral lobe, shows parallel margins, and is two-pronged. Of the two main stems into which it divides the external saddle the outer one, though not entirely visible, can be seen to overtop the inner, which is subdivided by a secondary lobule into a slender outer and a much broader inner leaf. The first lateral lobe is moderately wide and asymmetrically bifid, the outer one of the two three-pronged terminal points being markedly stronger than the inner. The first lateral saddle appears at this stage less broad than at the preceding one. The



FIGS. 10–17. Suture lines of *Dunveganoceras* and *Texanites*. 10. *Dunveganoceras* sp. indet. Only specimen present, A.M.N.H. No. 26417; second suture line before the last from external saddle to umbilical seam. 11–13, 16, 17. *Dunveganoceras pondi* Haas. 11, 12, 16. Holotype, A.M.N.H. No. 26416:3. 16. A suture line of antepenultimate whorl from inner margin of first lateral lobe to umbilical seam. 11. A suture line of penultimate whorl from external saddle to umbilical seam. 12. A siphonal lobe of penultimate whorl. 13. Paratype A.M.N.H. No. 26416:16, a suture line, complete except for the siphonal lobe, with parts of the preceding and following suture lines. 17. Paratype A.M.N.H. No. 26416:14, left half of outer suture line and right half of inner one. 14, 15. *Texanites shoshonensis* (Meek), A.M.N.H. No. 26419:3. 14, 15. Respectively, inner and outer suture lines, shown for comparison with figures 10–13, 16, and 17 (see pp. 30, 33). Scale and diameter of disk (D) indicated for each drawing.

second lateral lobe can now be seen to be about half as deep as the first. Otherwise the inner section of the external suture line agrees well with the one described above from the antepenultimate whorl.

The next sutural stage is represented by the anteriormost part of the penultimate whorl of the holotype on the one hand and by the fragment number 14 on the other. In the former the external suture line is visible, at a diameter of about 120 mm., from the inner margin of the external saddle dorsad; it still follows the same plan as in the last stage described; in particular, the degree of indentation does not seem markedly increased. The fragment number 14, on the other hand, is remarkable not only for exhibiting, at diameters between 100 and 160 mm., complete external and internal suture lines, but also for their somewhat different habitus. As seen from figure 17, the main lobes of the external suture line are here more slender than in other individuals studied, and apparently in consequence the saddles seem to be even broader and sturdier. The main points of the siphonal lobe are markedly narrower and hardly diverge; consequently the median knob appears taller and slenderer; at its top, it is still indented by a median lobule. The outer main stem of the external saddle can be seen to attain almost twice the width of the inner and to be about symmetrically subdivided by a three-pronged secondary lobule. The main lobule exceeds half the depth of the first lateral lobe and is slender and trifid, with a three-pronged middle point and two-pronged lateral ones. The first lateral lobe is at this stage, too, divided at its bottom by a slender, upright leaflet into two terminal points, the outer of which is longer than the inner, but at the lower third of its length it is so much straitened by oblique leaflets on either side that it might be called trifid with a bifid middle point as well as bifid. This is another example of the seemingly important changes brought about in many ammonite sutures by only a slight shift in the mutual proportions of minor elements. There is a similar change in the second lateral lobe whose inner terminal point has by far outgrown the outer one. This lobe might thus be interpreted either still as an (asymmetrically) bifid one or else as a trifid lobe, deflected dorsad. It also has moved nearer to the umbilical shoulder. The following saddle, which is in this specimen beyond the spiral of involution and cannot therefore be called any longer the second lateral, is less broad than in the sutures discussed previously. The first auxiliary lobe is still trifid and slightly deflected ventrad; its middle point is three-pronged with a two-pronged middle prong. On the left side of the conch there follow two more, narrow and three-pronged auxiliary lobes and, close to the umbilical seam, a fourth which is just a single, sharp point, whereas on the right side there is only one three-pronged one and that innermost. The auxiliary saddles separating all these lobes from one another are single, slender leaflets.

Immediately beyond, not to say right at, the umbilical seam there is a narrow lobe corresponding in shape and size to the last auxiliary. Between this first lobe of the internal suture line and the antisiphonal one there are three more, increasing rapidly in size towards the median line, all slender and ending in three-pronged points. The same rapid increase in size holds true for the saddles bordering these lobes, the third and fourth of which are divided by comparatively deep lobules into two terminal leaves each. The fourth and tallest of these saddles borders the antisiphonal lobe which attains only three-fifths of the length of its immediate neighbors and ends in a three-pronged point.

Another internal suture line is accessible to study in the posterior portion of the preserved part of the outer whorl of the holotype at a diameter of somewhat less than 200 mm. It agrees well with the one just described, except that the outermost small and simple lobe is missing and the first and smallest of the three three-pronged internal lobes is right at the umbilical seam. This slight difference is readily explained by the decrease in involution at this stage, as compared to the preceding one.

Accordingly, there are fewer auxiliary elements in the external suture line as well. The last sutures of the holotype, corresponding to a diameter of about 220 mm., exhibit only two auxiliary lobes, both rather short and three-pronged, as compared to three, or even four, in the suture described above. The mature sutural stage, to which the observation just made on the auxiliary lobes refers, follows otherwise the general pattern of the earlier stages but is characterized in general by sturdier saddles. This applies in particular to the lateral saddle and the first auxiliary one (called second lateral saddle at an earlier stage) which extends all over the umbilical shoulder. Furthermore, the first lateral lobe is now symmetrically bifid. This mature sutural stage, characterized by the usual crowding of the septa towards the last, is well represented in the holotype, in the largest complete disk present (no. 5), and in the whorl fragments numbers 13, 15, 16, and 17. As an example, a suture line of specimen number 16 at a diameter of about 210 mm. from the external saddle to the antisiphonal lobe is shown in figure 13. It is worth noting that there are at this stage only three lobes between the umbilical seam and the antisiphonal lobe, as compared to four in the preceding stage, described above.[1]

OCCURRENCE: Represented by altogether 28 specimens (including fragments), this species is the commonest in the present assemblage and may well be considered its index fossil.

REMARKS: From the type species of *Dunveganoceras*, *D. albertense* (Warren), the species under discussion is readily distinguishable by its much sturdier shell and by its mature whorl section, which shows a broad and truncate, though sunk venter, whereas that of *D. albertense* becomes ogival in the outer volution. Also height and width of the volution never differ by more than 10 per cent one way or the other in *D. pondi*, whereas the ratio H/W′ amounts to 1.83 in *D. albertense*. Finally, the latter lacks the horns present in the species here discussed.

The last difference holds true for its comparison with *D. poucecoupense* Warren and Stelck (1940, p. 150, pl. 2, pl. 3, figs. 2, 5) as well; accordingly, the venter is flat at the mature stage in that species, not sunk between horns as in *D. pondi*. Also the whorl section of the Albertan species tapers more decidedly ventrad than that of the Greybull species (compare Warren and Stelck's pl. 3, fig. 5, with our pl. 12, fig. 2) and the circumumbilical nodes are less developed there than here. Being, however, equally sturdy and having about the same H/W′ ratio as some of our specimens (0.94 in the shell measured by Warren and Stelck, 0.93 in our specimen no. 7), *D. poucecoupense* is much closer to *D. pondi* than the type species, and were the genus really, as Warren and Stelck expect, to be split in two (see p. 20), the form from Greybull would have to go into the same genus as *D. poucecoupense* but not to be left in *Dunveganoceras*, as then restricted.

The only other form of this genus occurring in the present assemblage will be compared with *D. pondi* below (p. 31).

Of representatives of other genera comparable with this species those of *Mammites* Laube and Bruder should be discussed first, starting with the genotype *M. nodosoides* (Schlotheim). The young individual of its var. *afra* Pervinquière, as illustrated by that author on figure 3 of his plate 18 (1907), strikingly resembles the penultimate whorl of the holotype of *D. pondi* in both shape and sculpture. At this stage the suture lines also show the same general pattern, except for the greater width of the saddles in *D. pondi* (compare Pervinquière's text fig. 118 with our figs. 11 and 16). In its earlier stages, represented by a disk of about 40 mm. in diameter and an incomplete half disk corresponding to a diameter of about 120 mm., a form from the Belle Fourche shale of locality 12621, Carter County, southeastern Montana, labeled "'*Mammites*' n. sp." in the collections of the United States National Museum, which I was given the opportunity to compare by the courtesy of Dr. Reeside, is also very similar to the corresponding stages of *D. pondi*. They differ merely by having, up to 40 mm. diameter, a clearly perceptible median row of spirally elongated tubercles which might be called a faint, discontinuous keel as well. It gradually vanishes already at that early stage and is replaced at the beginning of the outer whorl of the half disk mentioned above (diameter about 75 mm.) by a thread-like median elevation, hardly deserving the name of a keel, which soon disappears. Here, too,

[1] Similar observations on reduction of the elements of the internal suture line in the mature stage have been previously recorded for both *Collignoniceras* (=*Prionotropis* Meek, *non* Fieber) *woollgari* and *Prionocyclus wyomingensis* (Haas, 1946, pp. 185, 214–215, figs. 29, 45, 94, 96, 108).

the lobes, especially the first lateral one, are wider than, and the saddles not quite so broad as, in *D. pondi.* Were only those earlier stages known, the present species would certainly be considered congeneric with the forms here compared. However, comparison of the mature stages excludes such an assumption. In those of both *M. nodosoides*, var. *afra* (Pervinquière, 1907, pl. 18, fig. 2[1]), and the Belle Fourche form, of which I have before me a whorl fragment corresponding at its anterior end to a diameter of about 280 mm., there is no trace of the continuous, straight, prominent ribs characteristic of this stage in *Dunveganoceras*, but strong circumumbilical and marginal tubercles dominate the sculpture. In the Belle Fourche form these tubercles assume the shape of strong and sharp, spine-like horns pointing up and outward at an angle of about 45 degrees.[2]

Of representatives of other acanthoceratid genera, *Acanthoceras? amphibolum* Morrow (1935, p. 470, pl. 49, figs. 1–4, 6, pl. 51, figs. 3, 4, text fig. 4) from the early Turonian Graneros shale of Kansas also remarkably resembles *D. pondi* at its early and middle ontogenetic stages (*ibid.*, pl. 49, figs. 2b, 3b, 4), but in side view only. The pronounced row of median tubercles which temporarily "fuse to form a very low keel" proves that Morrow's species is not even congeneric with ours. Also the mature ornamentation of *Acanthoceras? amphibolum* is quite different, the horns being not parts of the ribs, as they are in *D. pondi*, but, to quote Morrow's description once more, "bluntly rounded, horn-like spines."

Acanthoceras validum Moreman (1942, p. 203, pl. 32, fig. 1, text fig. 2J) from the Tarrant formation of the Eagle Ford group of Texas attains a size similar to the present species and strikingly resembles it in side view (compare Moreman's fig. 1 with our pl. 10). The profile of the outer whorl, as delineated by Moreman,[3] is not so dissimilar from that of *D. pondi*, but that of the penultimate volution is quite different, even generically, there being in this species too a low median keel. Also the venter is broad and flat, lacking the slanted shoulder faces so characteristic of the earlier stages of *Dunveganoceras*. Moreman unfortunately does not figure any suture lines of his species, and their description is not sufficiently precise to permit comparison.

"*Metacalycoceras*" (?) *tarrantense* Adkins (1928, p. 241, pl. 28, fig. 3, pl. 29, fig. 1) from the same formation, considered by Moreman (1942, p. 201) a synonym of *Acanthoceras inaequiplicatum* (Shumard) (neotype, according to Moreman, 1942, p. 202, *Acanthoceras rotomagense in* Scott, 1926, p. 621, pl. 22, fig. 1, refigured by Moreman, 1927, pl. 13, fig. 1), also shows a certain similarity but is not congeneric either, there being according to Moreman (1942, p. 202) a mid-ventral row of tubercles. Furthermore, the outermost tubercles are, as seen from Moreman's (1942, pl. 32) figure 2, still at a diameter of about 80 mm. pointed, not spirally elongated.

The same association of spirally elongated ventral tubercles and conical ventro-lateral ones as in *Dunveganoceras* is, however, found at a diameter of about 100 mm. in another acanthoceratid from the same formation, *Acanthoceras stephensoni* Adkins (1928, p. 246, pl. 31, figs. 1, 2). It can clearly be seen in Adkins' figure 2, although his description calls both kinds of tubercles conical. Otherwise this species, as well as the closely allied *A. evolutum* Spath (1926, p. 82, =*Ammonites sussexiensis* Sharpe, 1854, pl. 15, fig. 1), has not much in common with the present form from which they differ most in their ventral ornamentation, which includes a median row of tubercles.

Within the fauna from Greybull, outer

[1] Reproduced, as "*Mammites nodosoides* Schl.," without reference to Pervinquière's variety, by Roman, 1938, plate 45, figure 429.

[2] The mature ornamentation of this form is almost identical with that of the three crushed giant disks from the vicinity of Edgemont, South Dakota, which I (Haas, 1946, pp. 153, 197) doubtfully referred to the typical form of *Collignoniceras* (=*Prionotropis* Meek, *non* Fieber) *woollgari*, and one of which I figured (*ibid.*, pl. 14, fig. 11). Those shells were labeled "Pierre shale" by their collector, Dr. Barnum Brown, and tentatively referred to the Benton shale instead by me. Should, however, the similarity pointed out above not prove to be merely homeomorphic, they would have to be assigned to a considerably lower stratigraphic level as well as to another genus.

[3] The scale given for his text figure 2J ("×½") seems inconsistent with the one given in the explanation of his plate 32 for figure 1 of that plate ("×¼") and with the dimensions given in the text. It seems that the cross section diagram, too, is reduced four, not just two, times.

whorls of this species somewhat resemble those of *Mantelliceras canitaurinum*, but the latter can readily be distinguished by their denser costation, in which longer and shorter ribs alternate throughout development, by their less prominent ribs, and by their depressed, reniform whorl section. There the ribs cross the venter, with a single exception, quite horizontally and maintain the same strength and sharpness as on the sides, but in the present species they are sunk in the median zone of the venter between the horns and are, there, weaker and blunter than on the sides. The sutures of both species are not so different in general pattern; various deviations in details can best be seen by comparing, e.g., our suture line drawings figures 3 and 17 or 4 and 13.

There is, finally, some resemblance between the earlier stages of *D. pondi* and the Coniacian "*Mortoniceras*" *shoshonense* Meek (1876, p. 449, pl. 6, fig. 3; Reeside, 1927, p. 9, *cum synon.*, pl. 6, figs. 16–23, pl. 7, figs. 1–11, pl. 8, figs. 1–15 [including the var. *crassa* Reeside]), but Meek's species is more evolute, more densely ribbed, especially so in youth, and has a median keel which gradually vanishes only at a late ontogenetic stage. Sutural differences, too, serve readily to distinguish both forms. A line connecting the tops of the two main saddles slopes dorsad in *D. pondi*, but rises in the same direction in "*M.*" *shoshonense*. In the internal suture line of the latter species there is only one lobe on either side of the antisiphonal one, as compared to three or even four in *D. pondi*, and the antisiphonal lobe itself is short in our species but long in Meek's. Finally, the lobes of "*M.*" *shoshonense* have, in maturity, longer and more slender, slightly curved points. For comparison late suture lines of a specimen of "*M.*" *shoshonense* from the typical Cody shale near Cody, Wyoming (A.M.N.H. No. 26419:3), are delineated in figures 14 and 15.

Dunveganoceras sp. indet.
Plate 15, figures 1–3; text figure 10
A.M.N.H. No. 26417

DIMENSIONS

D	H	H′	W	W′	U
106.2 mm.	49	42½	33	35	19½

The only disk present is deformed, except for the anterior two-thirds of the outer whorl, but this fact does not affect the exactness of the above measurements.

No traces of septa can be found above the diameter of about 75 mm.; the anterior third of the outer volution belongs to the living chamber. Hence it cannot be safely inferred that this shell was full grown, especially since no crowding of the septa towards the last is noticeable, except in one place.

DESCRIPTION: Shell markedly involute, rather rapidly increasing in whorl height. The profile of the posterior third of the outer whorl and farther apicad cannot reliably be judged since it is distorted by crushing. At the anterior end the whorl attains its maximum width at the inner two-fifths of its height. The intercostal section is oval, with gently vaulted sides and truncate venter. In costal section the sides are only slightly more vaulted, and the venter shows on either side of the flat median zone the slanted, gently concave bands, bordered by the two rows of outer tubercles. The umbilical shoulder is just recognizable at this stage and the umbilical wall slopes only very gently towards the seam (pl. 15, figs. 1, 3).

On what little is visible of the penultimate whorl and on the posterior third of the last the ornamentation is rather coarse and sharp; there are five more or less straight and radial, strong, and broad ribs per quarter whorl. On the left side of the shell four start at the umbilical shoulder; the fifth begins only a little dorsad of the latero-ventral tubercle. Except for this one, the ribs carry radially elongated nodes on the umbilical shoulder. Furthermore, each rib ends in a conical, sharp, latero-ventral tubercle which, for its part, is connected by a blunt ridge with the corresponding spirally elongated tubercle of the outermost row. Between these rows of either side the venter is flat, except for a faint, intermittent elevation along the median line which is visible in the posteriormost quarter of the outer volution between the ventral tubercles but not between their internodals. In the following quarter whorl the venter is too deformed to permit any statement in this respect.

On the anterior two-thirds of the last volution the costation becomes gradually less pronounced, and the ribs change into blunt folds, deserving the former name only where they are raised to form circumumbilical nodes. As a rule, they are still straight and radial, but sometimes slightly sinuous and deviating, forward or backward, from the radial course. There are longer and shorter ones, the latter beginning at the inner third or at the middle of the sides, but they do not alternate regularly. The latero-ventral tubercles become larger but less sharp than in the preceding stage; towards the anterior end they, too, tend to become spirally elongated. Twelve such tubercles and ribs, respectively, can be counted on the last half whorl. Except for increase in size, no change is noticeable in the tubercles of the two cockscomb-like outermost rows. The flat ventral band between them seems to widen beyond the general growth rate of the shell. In the anterior half of this whorl extremely faint vestiges of the median elevation, mentioned above, can be perceived, in oblique illumination only, between the outermost tubercles in three isolated places, corresponding to diameters of 68, 85, and 95 mm.

In figure 10 the external part of the second suture line before the last, corresponding to a diameter of about 60 mm., is illustrated from the main lobule of the external saddle to the umbilical seam. It seems altogether somewhat more elaborate than that of *D. pondi* at about the same size (cf. fig. 11). Other distinctive features are the extraordinary height of the external saddle, amounting to one and a half times that of the first lateral one, and the strictly symmetrical plan of the first lateral lobe whose two main points hardly diverge. The symmetry of this lobe and the higher degree of indentation, mentioned above, both occurring at this comparatively small size, seem to indicate accelerated development in sutural characters. That a minute third auxiliary lobe is present beyond the small second auxiliary saddle, right at the umbilical seam, is only natural in view of the higher degree of involution of this form as compared to that of *D. pondi.*

Occurrence: One specimen only.

Remarks: The most obvious difference of this shell from *D. pondi* is its markedly higher degree of involution. Were this difference the only one, it might still be believed to fall within the scope of individual variation, but there are others. The conch is slightly thinner. There are here and there faint traces of a median elevation on the venter. The costation is denser throughout development, coarser at an early stage but less distinct at the latest one observable in this form. This form also seems to have been much smaller than *D. pondi*, although this cannot be safely asserted since only one individual is present and there is no certain indication that it is adult. The fading of the costation and the flattening of the umbilical wall in the anterior part of its outer whorl as well as the comparatively early appearance of mature sutural characters would favor such a belief. However, we may be dealing with merely a stunted individual.

Be that as it may, with all the differences enumerated above taken into account, this single shell cannot be considered conspecific with *D. pondi.* However, we refrain from establishing a named species on a single individual particularly with regard to the possibility, indicated above, of its being stunted.

On the other hand, it is in every respect so close to the preceding species that there cannot be any doubt as to their congenerity. It cannot be compared in every detail with the Albertan species of this genus, *D. albertense* and *D. poucecoupense*, since the earlier stages of the latter (up to a diameter of somewhat more than 100 mm.) are not sufficiently well known, but it is certainly distinguishable from these two species by its much higher degree of involution.

PALEONTOLOGICAL SUMMARY

PALEOECOLOGICAL REMARKS

THE COLLECTION HERE DEALT WITH, including 55 ammonites, a dozen *Inoceramus* shells, two small specimens of another pelecypod genus, and three small gastropods, cannot be considered more than a population sample. Only a very small percentage of the fossils visible on the surface could actually be collected, and the rather limited section from which those collections were made is only a small part, on the whole, of the fossil-bearing outcrop.

Comparatively small as the material under examination may be, it seems nonetheless quite representative of the population from which it is taken. Under this assumption the present assemblage must be considered essentially an ammonite fauna, though remarkable for the complete absence of the genus *Baculites*, so common in younger Upper Cretaceous faunas of the same region and represented also in the apparently contemporaneous Upper Eagle Ford fauna by *B. gracilis* Shumard (Adkins, 1928, p. 206, pl. 24, fig. 3; Moreman, 1942, pp. 196, 210). Also absent are all kinds of scaphitids.

Ecologically most remarkable in this ammonite assemblage is the considerable size attained by two out of three genera present. *Dunveganoceras pondi* reaches diameters up to 400 mm., of about the same order of magnitude as those of 350 and 290 mm. attained by the Albertan species of the same genus, *D. albertense* and *D. poucecoupense*, respectively, and *Mantelliceras canitaurinum* diameters up to 300 mm. *Metoicoceras whitei praecox*, however, does not exceed a diameter of 125 mm. which is far below the diameters reached by the typical form of this species in Texas and Utah (see above, p. 19, footnote 1). The dimensions of the two other species just mentioned suggest favorable living conditions at the time when, and in the part of the sea where, they lived. For this conclusion it seems irrelevant whether these ammonites lived at the spot where they are found as fossils or only their empty shells were buried there after being transported from their actual living habitat which, even in such a case, cannot have been very far away.

SOME OBSERVATIONS ON ACANTHOCERATIDAE AND PRIONOCYCLIDAE[1]

The following remarks are prompted by certain similarities between *Dunveganoceras pondi*, described and discussed above (pp. 22ff.), and the Niobrara (Coniacian) species "*Mortoniceras*" *shoshonense* Meek (for references, see above, p. 30),[2] which is, however, not a dipoloceratid, as the above generic name would indicate, but a prionocyclid belonging to the genus *Texanites* Spath (1932, p. 379).[3]

In the course of a comparative study of several representatives of both families named in this heading from various stages of the Upper Cretaceous I was struck by the fact that both have some characters in common which might well be homologous.

There is, first, the presence of three tubercles (umbilical, latero-ventral, and ven-

[1] Since *Prionotropis* Meek is a homonym, the family name Prionotropidae Zittel must be replaced by Prionocyclidae (Haas) Breistroffer (1947; see also Haas, 1948).

[2] Originally I was misled by this similarity even to consider both these species as congeneric; thus I intended to include *Texanites shoshonensis*, together with *Dunveganoceras pondi*, in a new genus of the Prionocyclidae (Haas, 1947). Only at a late stage of the present study did I succeed in preparing a nucleus of the latter species. Examination of its early stages proved it to be a true acanthoceratid which was later recognized as belonging to the genus *Dunveganoceras*. Thus Meek's species is left with *Texanites*.

[3] From Reeside's (1927, p. 9) mention, in the discussion of Meek's species, of *Ammonites texanus* Roemer "as the true genotype" of *Mortoniceras* it follows that Reeside, too, would have referred *shoshonensis* to *Texanites*, had this genus then existed. Collignon, in his forthcoming memoir on the genus *Texanites*, also includes both "*Mortoniceras*" *shoshonense* Meek and its var. *crassa* Reeside in this genus. (Letter to the writer, dated Chambéry [France], September 21, 1947.)

tral) on every rib (if the median row of tubercles is left out of account for the time being). There is furthermore the trapezoidal outline of the ventral portion of the whorl profile, formed by a median band, which is flanked by the two outermost rows of spirally elongated tubercles, and two slanting ventrolateral bands, which are bordered by one row of the ventral, and another row of conical ventro-lateral, tubercles.

Both these characters, so common in many Cenomanian and Turonian acanthoceratids, also occur in the genus *Texanites*. They are found, for example, in *T. shoshonensis* and, with certain modifications, in the *Texanites* of the Santonian. The same characters are observable in other prionocyclid genera as well, such as *Collignoniceras*[1] and *Prionocyclus*.

It is true that there is a more or less persistent median keel in the Prionocyclidae, but even this character is not without precedent in the Acanthoceratidae. Primarily, there is in many members of the latter family a row of median tubercles. In several forms, e.g., "*Mammites* n. sp." from the Belle Fourche shale discussed above, *Acanthoceras? amphibolum* Morrow (1935, p. 472, pl. 49, figs. 2, 3), *A. validum* Moreman (1935, p. 203, text fig. 2j), and *A. alvaradoense* Moreman (*ibid.*, p. 205, text fig. 20), these median tubercles tend to merge into an intermittent or even continuous keel which is, however, restricted to certain growth stages.[2] It is this relation that accounts for Roman's (1938, p. 422) passing[3] attempt to derive the cockscomb keel of *Collignoniceras* (=*Prionotropis* Meek, *non* Fieber) from the intermittent row of spirally elongated siphonal tubercles of the acanthoceratids.

Here it might be inserted that among the Prionocyclidae undulating median keels are found not only in *Collignoniceras*, where they are most pronounced, and *Prionocyclus*, but also in at least some individuals of *Texanites shoshonensis*. One such specimen from the typical Cody shale near Cody (A.M.N.H. No. 26419: 2), illustrated in plate 9, figure 2, shows a gently undulating keel which is always a little higher between two ventral nodes than between their internodals.[4]

I am well aware that all the similarities noted might be merely homeomorphic rather than truly homologous. However, there is also remarkable resemblance in sutural characters, believed to be comparatively immune to homeomorphy (see Haas and Simpson, 1946, p. 339). Comparison of some acanthoceratid suture lines (e.g., Roman, 1938, figs. 417–419, 429; text figs. 1–4, 10–13, 16, 17 of this report) with some prionocyclid ones (e.g., Reeside, 1927, pls. 7, 8; text figs. 14, 15 of this report; and those figured in Haas, 1946) bears this out.

All the similarities listed above might indicate a phyletic connection between Acanthoceratidae and Prionocyclidae.

Roman, in his family tree (1938, p. 461), tentatively derives the Prionocyclidae (then called Prionotropidae) from the Dipoloceratidae, whereas Spath (1926, p. 79) states that the Pervinquieridae[5] and the group later named by him *Texanites* are "somewhat homoeomorphous but unrelated." I have not succeeded in finding any positive statement by Spath as to which group he considers the ancestors of the Prionocyclidae. However, in his introductory remarks on the Acanthoceratidae, Roman (1938, p. 422) wrote the following sentence: "Ils [i.e., les tubercules siphonaux] peuvent arriver à former dans le jeune une carène discontinue, c'est le genre *Prionotropis*."[6] Mention of "*Prionotropis*" (now replaced by *Collignoniceras*) in this connection

[1] New name proposed by Breistroffer (1947) to replace *Prionotropis* which is a homonym.

[2] In "*Prionotropis*" *borealis* Warren (1930, p. 25, pl. 3, figs. 1–4, pl. 4, fig. 1), made the type species of a new genus *Selwynoceras* by Warren and Stelck (1940, p. 151), on the other hand, the median row of tubercles "shows no tendency towards development into a keel." The fact that Warren originally referred this species to "*Prionotropis*" makes it, however, another case in point. It is indeed somewhat transitional between Acanthoceratidae and Prionocyclidae, but in my opinion more likely to be a late acanthoceratid than an early prionocyclid. The somewhat younger "*Prionotropis*" *caurinus* McLearn (1926, p. 126, pl. 23, figs. 6, 7) from the same general area seems to be a true prionocyclid.

[3] See below.

[4] Neither Meek (1876) nor Reeside (1927) mentions this character in his description. Dr. Reeside informs me in a letter, dated November 12, 1947, that he has not observed it in any of the specimens studied by him, in all of which "the low, rounded keel is straight and even, when undistorted. [Where there is] simulation of undulation [it] is due to secondary deformation. . . . "

[5] Now included as a subfamily (Pervinquierinae according to Haas, 1944, or Mortoniceratinae according to Spath, 1942) in the Dipoloceratidae.

[6] Cf. above.

does not permit of any other interpretation than that Roman, when writing that sentence, included the genus in, or at least derived it—and most likely along with it the whole family "Prionotropidae" (now Prionocyclidae)—from, the Acanthoceratidae. It is true that this conception of his is inconsistent with the definitive version of his book which does not assign "*Prionotropis*" to the latter family but makes it the leading genus of the "Prionotropidae" (p. 454). It seems that such discrepancies can never be entirely avoided in a work of the scope of Roman's.

Be that as it may, the derivation of the Prionocyclidae indicated by Roman's remark, although it was apparently recanted as his work went on, is just the one suggested by the observations reported above.

Such a phylogenetic connection between Acanthoceratidae and Prionocyclidae is, of course, so far purely hypothetical. Should it really exist, it might turn out to be a polyphyletic one. The late Turonian *Collignoniceras* (=*Prionotropis* Meek, *non* Fieber) might stem from some Cenomanian or early Turonian acanthoceratid with a median line of tubercles, such as *Selwynoceras* Warren and Stelck, believed by those authors to be probably of lowermost Turonian age (see p. 33, footnote 2). *Prionocyclus*, for its part, can be derived from *Collignoniceras*.[1] *Texanites*, on the other hand, whose earliest representative, *T. shoshonensis*, appears in the Coniacian (Niobrara), might be derived from some other late acanthoceratid, perhaps along a line independent from that leading to *Collignoniceras* and *Prionocyclus*, unless the undulating keel only quite occasionally found in *T. shoshonensis* should be interpreted as derived from the cockscomb keel of *Collignoniceras*.

It seems worth noting that, should the cockscomb keel of some Prionocyclidae like *Collignoniceras* (=*Prionotropis* Meek, *non* Fieber) really be inherited from some Acanthoceratidae, this might be considered a case of cenogenesis or proterogenesis.[2] For in the examples quoted above (p. 33), as in many other acanthoceratids, the median row of tubercles, or the keel into which they merge, becomes obsolete in maturity, whereas in the Prionocyclidae it persists, though sometimes becoming modified in the gerontic stage (see, e.g., *Collignoniceras woollgari*, var. *alata* in Meek, 1876, pl. 6, fig. 2, and Haas, 1946, text fig. 22). An even clearer example of proterogenesis is given by the phylogenetic history of the median keel within the genus *Texanites*. Whereas it "becomes relatively less and less conspicuous," almost to the vanishing point, at the largest size (diameter 150 mm.) reached by the earlier (Coniacian) species *T. shoshonensis* (see Reeside, 1927, p. 10, pl. 7, fig. 2), it persists, together with other outstanding sculptural features, throughout development in the later (Santonian) species, although some of them, like *T. soutonii* (Baily), (1855, p. 455, pl. 11, fig. 1), *T. stangeri* (Baily), (*ibid.*, pl. 11, fig. 2), or the forms described by the writer (1942a, pp. 10–20, figs. 8–12) from Angola, attain diameters of from 250 to 300 mm. or, in the case of *T. soutonii*, even 400 mm. Thus it would seem that the new character gives way in later development to an ancestral (?acanthoceratoid) one in the older members of the stock, but pushes through, as it were, in the younger ones.

Finally, attention may be called to the striking contrast between the momentous ontogenetic changes occurring in some Upper Cretaceous ammonite genera, e.g., *Collignoniceras* (=*Prionotropis* Meek, *non* Fieber) or *Dunveganoceras*, as studied in a previous paper (Haas, 1946) for the former and in the present one for the latter, and the comparative ontogenetic stability of others, like *Texanites*. It is not feasible to assign the former character to the phylogenetic youth of a lineage and the latter to its phylogenetic age, since, for instance, *Dunveganoceras* must be considered one of the later, if not of the latest, members of the family Acanthoceratidae, as here circumscribed. Nor can a high degree of ontogenetic change as such be considered an inherited family character, since one and the same family may include genera of both kinds, as, e.g., both *Collignoniceras* (=*Prionotropis* Meek, *non* Fieber) and *Texanites* belong to the Prionocyclidae. However, the problem here broached might well deserve further study.

[1] See Haas, 1946, page 219, footnote 1.

[2] For quotations from Spath and Schindewolf, see Haas, 1942b, page 143.

STRATIGRAPHIC CONCLUSIONS

ALTHOUGH THE PRESENT PAPER proposes to deal paleontologically with the Ammonoidea of this assemblage only, for stratigraphic purposes the *Inoceramus* shells should also be taken into consideration. Four more or less complete shells with both valves still connected (though ajar in three) and eight single valves and fragments thereof could be examined; imprints of some more are present. The largest of these specimens, none of which is entirely preserved, may be estimated to have attained close to 70 mm. in height, up to 60 mm. in width, and about 15 mm. in thickness of one valve. By their characteristic outline, namely, the straight hinge line, beyond which the slender and pointed umbo projects only a little, and the slightly concave anterior margin, and by their ornamentation, consisting of more or less irregular concentric undulations covered by finer growth striae, all these shells can readily be identified as *Inoceramus fragilis* Hall and Meek (see Meek, 1876, p. 42, text figs. 1, 2, pl. 5, fig. 5; Adkins, 1928, p. 94; Moreman, 1942, p. 199, ? pl. 34, fig. 11). Two right valves (A.M.N.H. Nos. 26418: 1, 26418: 2) which, though incomplete, show the above specific characters best, are illustrated in plate 8, figures 6 and 7.

Shells or fragments, for that matter, of *Mantelliceras canitaurinum* and *Dunveganoceras pondi* have been found on the spot within the same concretions, and several fragments of *Metoicoceras whitei praecox* were embedded in the living chambers of large whorl fragments of *Dunveganoceras pondi*, as was a complete shell, with both valves still connected, of *Inoceramus fragilis*. The smaller fragment of *Mantelliceras* sp. indet. was prepared from a piece of rock crowded with specimens and fragments of *I. fragilis*. All these facts, taken together, do not leave the slightest doubt as to the contemporaneity of all the mollusks encountered in the present assemblage. It may therefore well be considered a faunistic unit in time as well as in space.

In an attempt at dating this fauna the peculiar genus *Dunveganoceras* is certainly helpful. The type species, *D. albertense*, was originally assigned a Turonian age by Warren (1930, p. 22), but in their more recent paper Warren and Stelck (1940, pp. 144, 147, 149–150) consider this genus an Upper Cenomanian one. However, all the strata from which it has been collected, viz., the lowermost beds of the Smoky River shale (Pouce Coupe sandstone and just above), the equivalent lowermost part of the Alberta shale, and the uppermost beds of the Dunvegan sandstone,[1] are very close to the Cenomanian-Turonian boundary, as drawn by Warren and Stelck (*ibid.*, p. 144) "just above the Pouce Coupe sandstone member of the Smoky River shale." Exactly the same horizon is given, a few lines earlier, for the type species of *Dunveganoceras* which thus comes right from that boundary. Warren and Stelck's motivation (*loc. cit.*), that "no true Turonian fauna was found with [*Dunvenganoceras*] or below it," for their assigning an Upper Cenomanian age to that genus does not appear to be absolutely convincing; for no other ammonites are associated with the two species of *Dunveganoceras* in that assemblage (*ibid.*, p. 145), and all the other species listed, except for a single gastropod, are pelecypods, all of which can be less safely relied on stratigraphically than ammonites. Furthermore, "a large percentage of these forms are new species described from this area and their distribution in other areas is not known." Thus, not more can be inferred from Warren and Stelck's findings than that the Albertan and British Columbian species of *Dunveganoceras* are either late Cenomanian or early Turonian in age, and this alternative applies even more to the new species of the genus occurring so much farther south, as described in the present report.

Of the *Mantelliceras* present, the unnamed species is too poorly represented to be of any stratigraphic value, and *M. canitaurinum* is a new species. The genus as such is in general assigned an early Cenomanian age (see Mul-

[1] It is rather surprising that, although the types and most of the other specimens of both *D. albertense* and *D. poucecoupense* are from the Smoky River formation and only two fragments referable to the genus *Dunveganoceras* were collected from the Dunvegan sandstone (Warren and Stelck, 1940, p. 149), the authors named the genus after the latter formation.

ler and Schenck, 1943, chart fig. 6, pp. 272, 273), which is also that of some of its species close to *M. canitaurinum*, like *M. cantianum* Spath. On the other hand Adkins (1928, p. 239, pl. 25, fig. 1, pl. 26, fig. 4) and Moreman (1942, p. 207) record a *Mantelliceras*, *M. sellardsi* Adkins, from the Tarrant formation of the Eagle Ford group of Texas, correlated with the Upper Cenomanian by Moreman (1942, p. 194).

All the other acanthoceratids compared in the descriptive part of this report with either *Mantelliceras canitaurinum* or *Dunveganoceras pondi* are either of late Cenomanian age, as those from the Belle Fourche shale[1] of southeastern Montana and from the Tarrant formation of the Eagle Ford group of Texas, or of early Turonian age, as those from the Graneros shale of Kansas, from the Britton formation of the Texas Eagle Ford, and from the Salmurian of Tunisia (see, for *Mammites nodosoides* and its var. *afra*, Pervinquière, 1907, pp. 312, 419–420; also Muller and Schenck, *loc. cit.*).

If the subspecies *praecox* of *Metoicoceras whitei* may be considered contemporaneous with the typical form of this species, it would indicate early Turonian age, as does *Inoceramus fragilis*, recorded earlier in this heading from the assemblage under discussion; both occur in the Britton formation of the Eagle Ford group of Texas (see Moreman, 1942, pp. 194, 199, 210).

When all the above data are taken into account and particularly when the early Cenomanian age suggested by some *Mantelliceras* species resembling *M. canitaurinum* is excluded as too far antedating the early Turonian for which there are much stronger indications, the stratigraphic range for the present fauna is still the one arrived at in the discussion of *Dunveganoceras*, namely, late Cenomanian-early Turonian. Within this range, I feel inclined to assume early Turonian rather than late Cenomanian, without claiming any certainty for this assumption. It is, however, supported by the early Turonian age of those formations with which this assemblage has definite species in common, namely, *Metoicoceras whitei* and *Inoceramus fragilis*, and furthermore by the following considerations.

Reeside, in his letter of October 30, 1947, mentions a fauna from a zone near the base of the Cody shale of the eastern side of the Bighorn Basin, "much like the undescribed fauna of the Belle Fourche shale of the Black Hills," and tentatively assigns a late Cenomanian age to both these faunas. Now, according to my field observations, the Cody shale might in the area under consideration well include a still lower faunal zone than that which has yielded the fauna here discussed, even if, at the locality where I collected, the bottom of the valley should mark the very base of the Cody shale, which is by no means certain. For the upper part of the Cody shale in which the fossils were found begins only about 350 feet above that valley bottom. Should, however, the concretions that yielded the fossils have rolled down from an even higher stratigraphic member since removed by denudation, as thought possible in the Introduction (p. 7), then the vertical distance of the original horizon of these fossils from the valley bottom and, even more, from the very base of the Cody shale would be even greater. At any event, its stratigraphic position within the Cody shale leaves enough leeway for the presence in it of a still older faunal zone. This possibility—that we might deal here with a fauna somewhat younger than the faunas mentioned by Reeside as late Cenomanian in age—is still increased by faunistic differences, since the index fossil of the Greybull assemblage, *Dunveganoceras pondi*, is certainly generically different from the *Mammites* of the basal Cody and Belle Fouche shales, some specimens of which have been compared with it above (pp. 28, 29), and might have evolved from the latter. Also Reeside does not recall the occurrence of any forms of *Mantelliceras* or *Metoicoceras*, both of which are represented in the assemblage under discussion, in those faunas of the basal Cody and Belle Fourche shales.

Whether the age of the fauna from near Greybull be early Turonian or late Cenomanian, at any rate it considerably affects opinions hitherto prevailing in literature as to the lower stratigraphic boundary of the Cody shale. Reeside's views, quoted above from correspondence, on the late Cenomanian

[1] The above age is assigned to this formation by Dr. Reeside (letter to the writer, dated October 30, 1947).

age of the basal Cody shale have not yet been published, nor have I been able to find any statement in literature that would place that boundary lower than at the base of the Carlile, i.e., of the Upper Turonian. This is the view expressed by Bartram (1932, chart facing p. 2), McCabe (1947, p. 248), and Sielaff (1947, p. 267), whereas Fox (1941, p. 1967) and Downs (1947, p. 138) draw that boundary even at the base of the Niobrara, of Coniacian age, thus excluding the Carlile.[1] The results of the present investigation, however, extend the stratigraphic range of the Cody shale back in time to include the Lower Turonian, if not the late Cenomanian, which in any case must be taken in on the strength of Reeside's yet unpublished findings. All these facts strongly suggest that the Cody shale of northern Wyoming should be considered a facies, ranging all the way from late Cenomanian to Lower Campanian (Eagle formation, see Reeside, 1927, p. 1), rather than a truly time-stratigraphic unit.

[1] When creating the term Cody shale, Lupton (1916, p. 171, table facing p. 166) used it for the top formation of the Colorado group, overlying the Frontier formation.

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PLATES 1–15

Unless otherwise indicated, all specimens figured are from the (? late Cenomanian or) early Turonian Cody shale of the north central part of T. 53 N., R. 92 W., about 6 miles east and 7 miles north of Greybull, Wyoming.

Unless otherwise indicated, figures are natural size.

2

1

PLATE 1

Mantelliceras canitaurinum Haas, syntype A, A.M.N.H. No. 26413:1. 1. Right side view. 2. Frontal view. Both somewhat reduced. (See also pl. 3, fig. 1.)

PLATE 2

Mantelliceras canitaurinum Haas, left side view of the largest paratype, A.M.N.H. No. 26413:3, $\times$ *ca.* $\frac{2}{3}$. (See also pl. 3, figs. 2, 3, and pl. 4, fig. 4.)

3

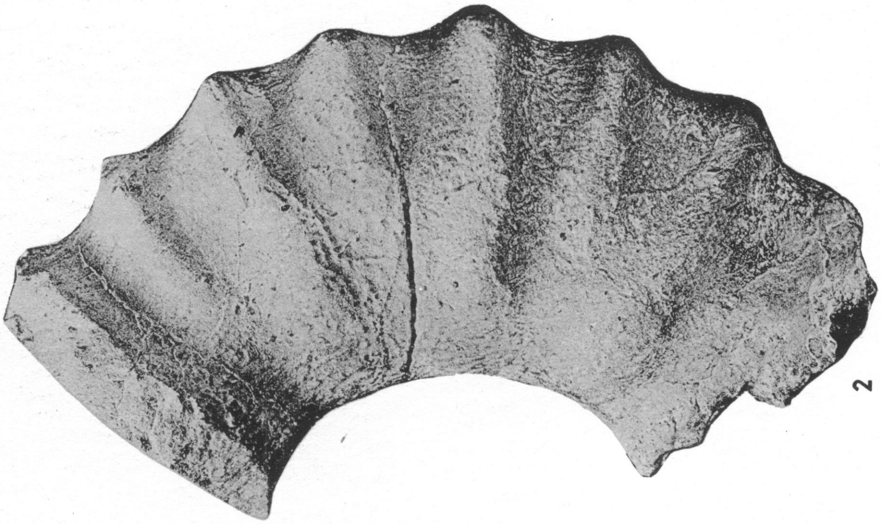

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PLATE 3

Mantelliceras canitaurinum Haas. 1. Syntype A, A.M.N.H. No. 26413:1, ventral view, somewhat reduced. (See also pl. 1, figs. 1, 2.) 2, 3. The largest paratype, A.M.N.H. No. 26413:3. 2. Left side view of anterior fragment, $\times\frac{1}{2}$, to show mature ornamentation. 3. Ventral view, $\times$ *ca.* $\frac{1}{2}$, shown for comparison with figure 1; note, however, difference in scale. (See also pl. 2 and pl. 4, fig. 4.)

PLATE 4

Mantelliceras canitaurinum Haas. 1, 2. Syntype B, A.M.N.H. No. 26413:2. 1. Left side view, × *ca.* $\frac{1}{2}$. 2. Outer whorl seen from inside, with posterior end above, × *ca.* $\frac{3}{5}$. 4. The largest paratype, A.M.N.H. No. 26413:3, frontal view of posterior fragment, × *ca.* $\frac{1}{2}$, shown for comparison with figure 2; note, however, difference in scale. (See also pl. 2 and pl. 3, figs. 2, 3.)

Mantelliceras sp. indet. 3. A.M.N.H. No. 26414:1, oblique left side view, to show latero-ventral tubercles. 5. A.M.N.H. No. 26414:2, oblique left side view, slightly reduced.

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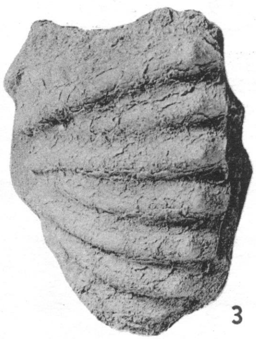

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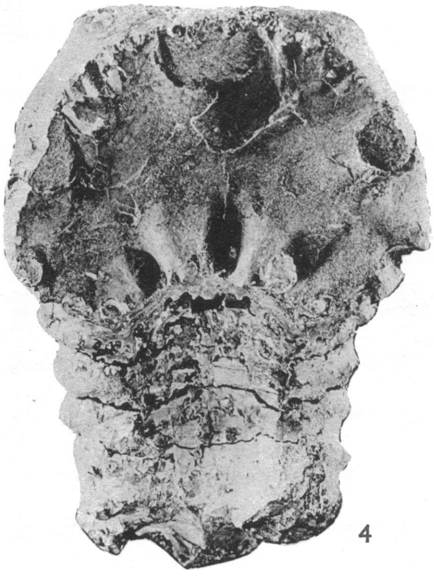

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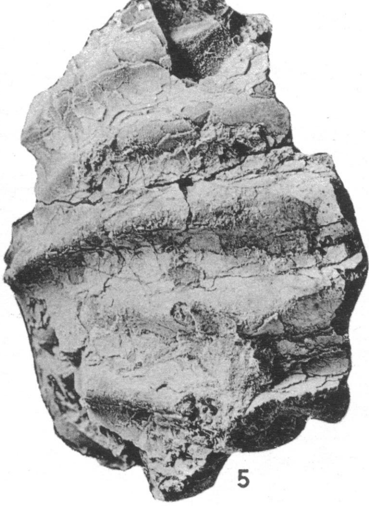

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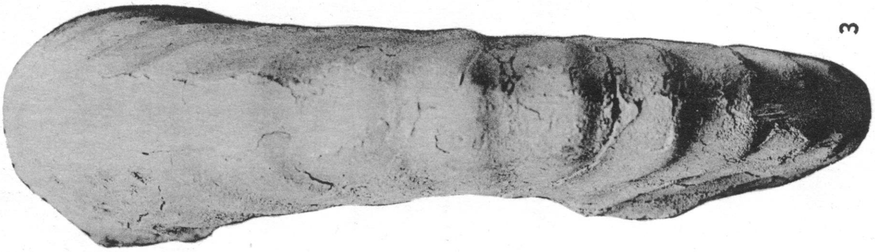
PLATE 5

Metoicoceras whitei Hyatt, subspecies *praecox* Haas. 1, 5, 8. Holotype, A.M.N.H. No. 26415:2. 1. Left side view. 5. Ventral view. 8. Sectional view with posterior end above, showing ventral ornamentation of penultimate whorl. 2–4. Paratype A.M.N.H. No. 26415:1. 2. Left side view. 3. Ventral view. 4. Frontal view. 6. Paratype A.M.N.H. No. 26415:11, left side view, to show mature ornamentation. 7. Paratype A.M.N.H. No. 26415:7, oblique side view, to show right row of latero-ventral tubercles.

PLATE 6

Metoicoceras whitei Hyatt, subspecies *praecox* Haas. 1, 2. Paratype A.M.N.H. No. 26415:3. 1. Right half of sectional view. 2. Left side view. 3, 4. Paratype A.M.N.H. No. 26415:4. 3. Ventral view. 4. Right side view.

4



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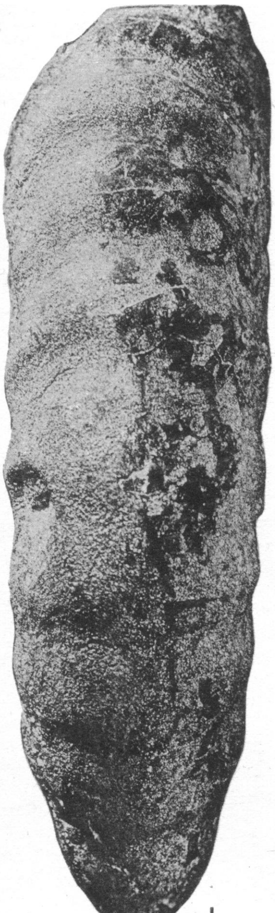

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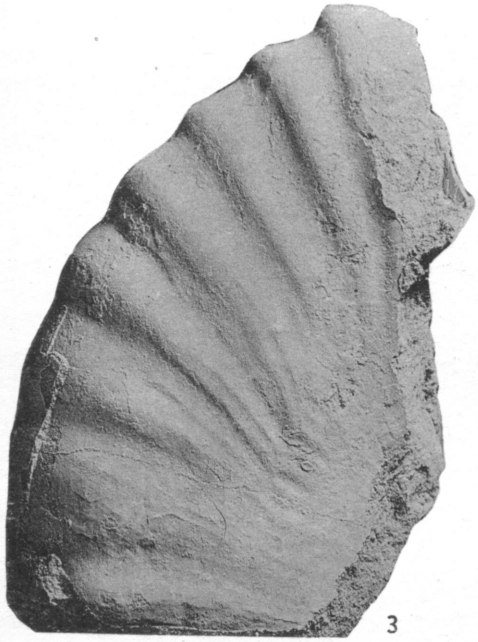

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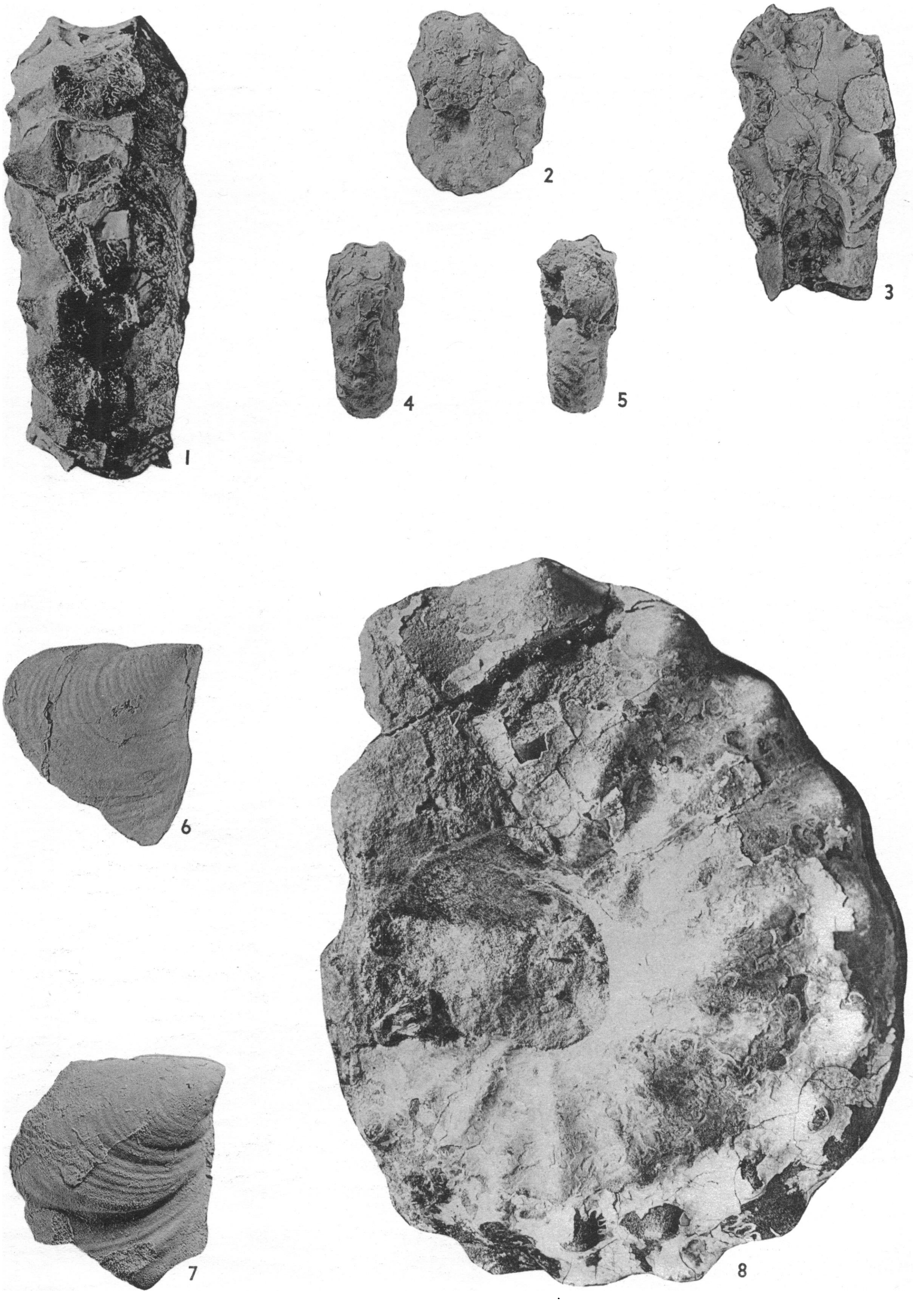
PLATE 7

Metoicoceras whitei Hyatt, subspecies *praecox* Haas. 1, 2. Paratype A.M.N.H. No. 26415:6. 1. Ventral view. 2. Right side view. Both somewhat reduced. 3. Paratype A.M.N.H. No. 26415:10, right side view. 4. Paratype A.M.N.H. No. 26415:9, right side view. Figures 3 and 4 are to show peculiarities of mature ornamentation.

PLATE 8

Dunveganoceras pondi Haas. 1. Holotype, A.M.N.H. No. 26416:3, ventral view of penultimate whorl. (See also pl. 9, figs. 1, 4.) 2–5. Paratype A.M.N.H. No. 26416:2. 2, 4, 5. Left side, ventral, and frontal views, respectively, of nucleus. 3. Sectional view, at anterior end, of a fragment of penultimate whorl. 8. Paratype A.M.N.H. No. 26416:11, left side view.

Inoceramus fragilis Hall and Meek. 6, 7. Two right valves, A.M.N H. Nos. 26418:1, 26418:2. (See p. 35.)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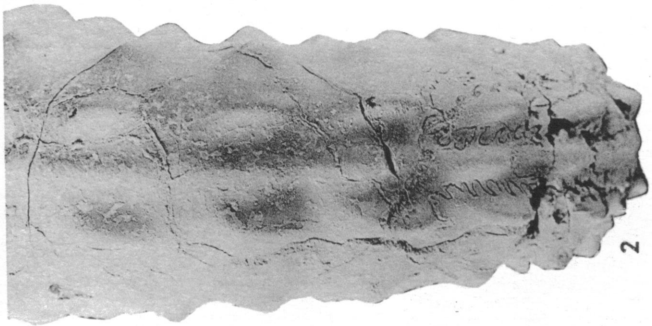

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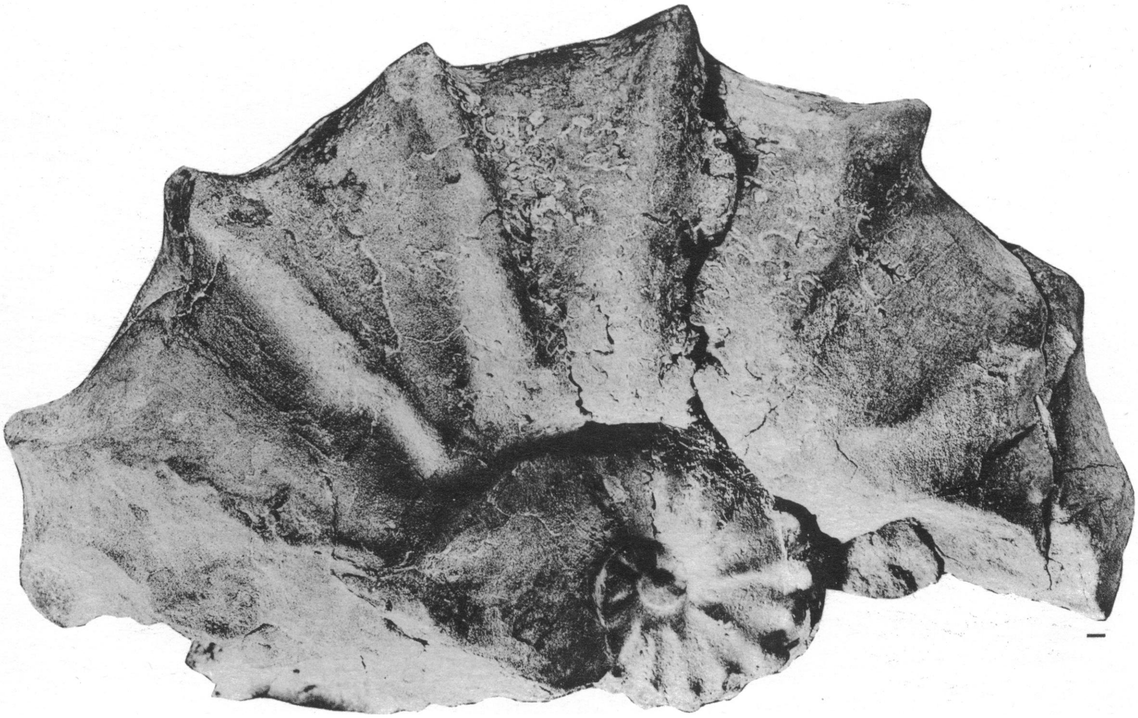

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PLATE 9

Dunveganoceras pondi Haas. 1, 4. Holotype, A.M.N.H. No. 26416:3. 1. Left side view. 4. Sectional view of outer whorl at fracture. Both × *ca.* $\frac{1}{2}$. (See also pl. 8, fig. 1.) 3. Paratype A.M.N.H. No. 26416:4, ventral view of penultimate whorl. (See also pl. 10.)

Texanites shoshonensis (Meek). 2. Specimen A.M.N.H. No. 26419:2 from the Cody shale of the north bank of Shoshone River, east of Husky Refinery, near Cody, Wyoming; part of ventral view, somewhat reduced, to show undulating median keel. (See p. 33.)

PLATE 10

Dunveganoceras pondi Haas, paratype A.M.N.H. No. 26416:4, right side view, $\times$ *ca.* $\frac{2}{3}$. (See also pl. 9, fig. 3.)

PLATE 11

Dunveganoceras pondi Haas, paratype A.M.N.H. No. 26416:5, right side view, × *ca.* ½.

PLATE 12

Dunveganoceras pondi Haas. Paratype A.M.N.H. No. 26416:10. 1. Ventral view, $\times$ *ca.* 7/10. 1. Left half of sectional view at anterior end, $\times$ *ca.* 7/10. 3. Right side view, $\times$ *ca.* $\frac{2}{3}$.

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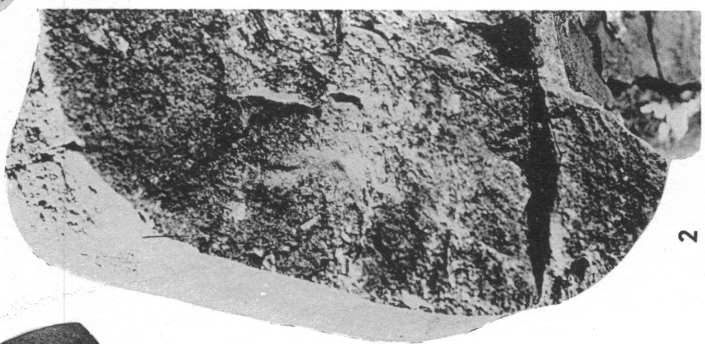

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PLATE 13

Dunveganoceras pondi Haas. 1. Paratype A.M.N.H. No. 26416:6, ventral view, $\times$ *ca.* $\frac{1}{2}$, to show asymmetry in costation. 2, 3. Piece of the test from a horn of paratype A.M.N.H. No. 26416:9, to show thickness; 2, from inside; 3, in profile. 4. Paratype A.M.N.H. No. 26416:7, left side view, $\times$ *ca.* 9/20, to show egression of spiral of evolution.

PLATE 14

Dunveganoceras pondi Haas. 1. Paratype A.M.N.H. No. 26416:13, ventral view, $\times$*ca.* $\frac{4}{5}$, to show horns standing closer together than usual. 2. Paratype A.M.N.H. No. 26416:8, left side view, $\times$ *ca.* 9/20, showing what is believed to be the apertural margin.

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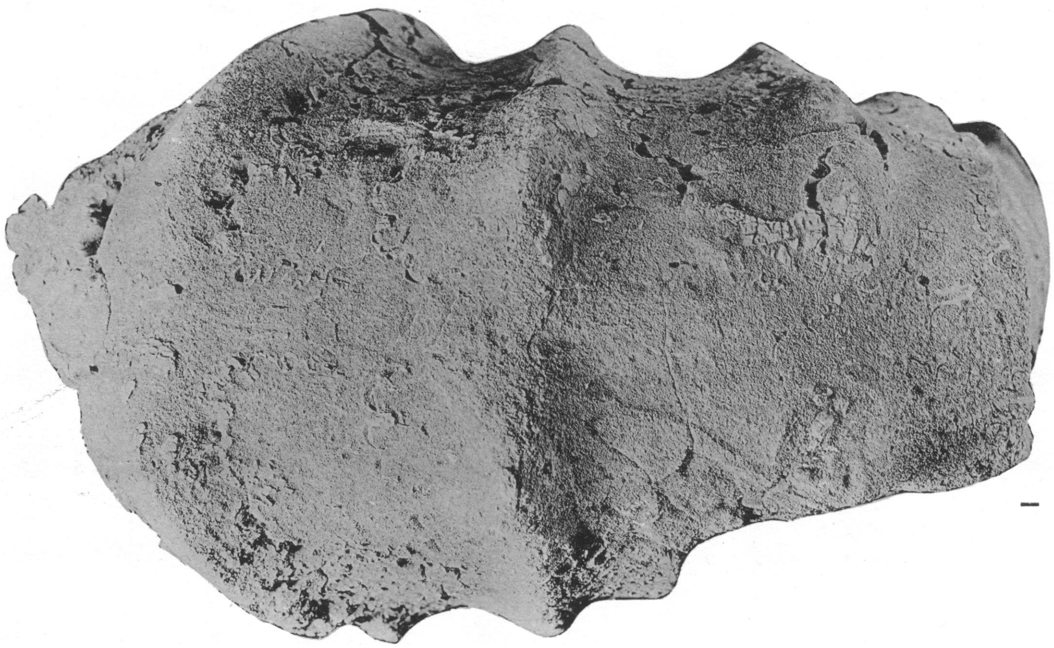

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Dunveganoceras sp. indet., only specimen present, A.M.N.H. No. 26417. 1. Frontal view. 2. Right side view. 3. Ventral view