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SUPPLEMENTARY NOTES ON THE AMMONOID GENUS *DUNVEGANOCERAS*

By Otto Haas

In a previous paper (1949, p. 21) I called attention to the striking gap between the occurrences of the ammonite genus *Dunveganoceras* in British Columbia and Alberta on the one hand and at Greybull, Wyoming (the only one then known in the United States) on the other. Ever since the publication of that report evidence has accumulated to prove that this genus by no means occurs so sporadically as was assumed.

In the present paper two new forms of the genus are described, its diagnosis is amended inasmuch as this appears to be warranted by these descriptions, and an attempt is made to survey all its hitherto known occurrences and thus to establish its geographic and stratigraphic ranges as far as known.

I am greatly indebted to Dr. William A. Cobban, of the United States Geological Survey, and to Major Claud W. Wright, of London, England, for valuable information; to Professor W. T. Thom, Jr., of Princeton University, and to Dr. H. D. Thomas, State Geologist of Wyoming, for assistance in finding the correct location of the paratype of the species hereinafter named *D. conditum;* to Dr. Thomas and to Drs. Paul O. McGrew and Alan Shaw of the Geological Museum of the University of Wyoming for the loan of the holotype of that species and permission to publish it; and to Mr. J. F. Wolff, General Mining Engineer, Oliver Iron Mining Company, Duluth, Minnesota, for the same courtesies with regard to the specimen hereinafter described as *D.* cf. *pondi.*

The accompanying photographs were made by Mr. Robert Adlington, and the whorl section and suture line drawings by Miss

Helen Babbitt, both of whom I wish to thank for applying their expert skills to these tasks.

DESCRIPTIONS OF NEW FORMS

Dunveganoceras cf. **pondi** Haas

Figure 1

Cf. *Dunveganoceras pondi* HAAS, 1949, p. 22, pl. 8, figs. 1–5, 8, pl. 9, figs. 1, 3, 4, pls. 10–14, text figs. 11–13, 16, 17.

DIMENSIONS[1]

D	H	H′	W	W′	U
Ca. 378 mm.	*ca.* 39	*ca.* 32	*ca.* 22½	*ca.* 26½	*ca.* 34½

The present specimen is so far the largest complete disk of *Dunveganoceras* on record, exceeding both the holotype of *D. albertense* (see Warren, 1930, p. 21) and the largest paratype of *D. pondi* (see Haas, 1949, p. 22) by 28 mm. in diameter. It is true that fragments of *D. pondi* indicate diameters of at least 400 mm. (Haas, *loc. cit.*), but this size may easily have been reached, if not surpassed, by the present specimen also, since its last septum can be located at a diameter of about 300 mm., about a quarter of a whorl apicad from the anterior end, and since about half a volution is usually occupied by the living chamber.

DESCRIPTION: Since the specimen here dealt with is in its taxonomic designation compared with *D. pondi*, it might best be described by pointing out its differences from the latter species. One difference is clearly seen from the above dimensions, as compared with those of *D. pondi;* the present form is considerably thinner than even the largest paratypes of that species. It cannot safely be decided if, and to what extent, this is due to crushing; however, examination of the specimen under study in ventral view does not give the impression of a crushed shell, at least not of a shell crushed to any considerable degree.

Another difference closely connected with the one just discussed concerns the whorl section and in particular its ventral portion. However, only the last volution of the present specimen is accessible to examination in this respect. This examination shows that the sides converge increasingly ventrad the more the aperture is approached, thus causing the costal whorl profile to assume a

[1] For the significance of symbols in the tables of dimensions, see Haas, 1949, pages 7, 8.

slender trapezoidal shape rather than a subrectangular one as in *D. pondi.* The aforementioned increasing convergence of the sides towards the periphery accounts for a development exactly

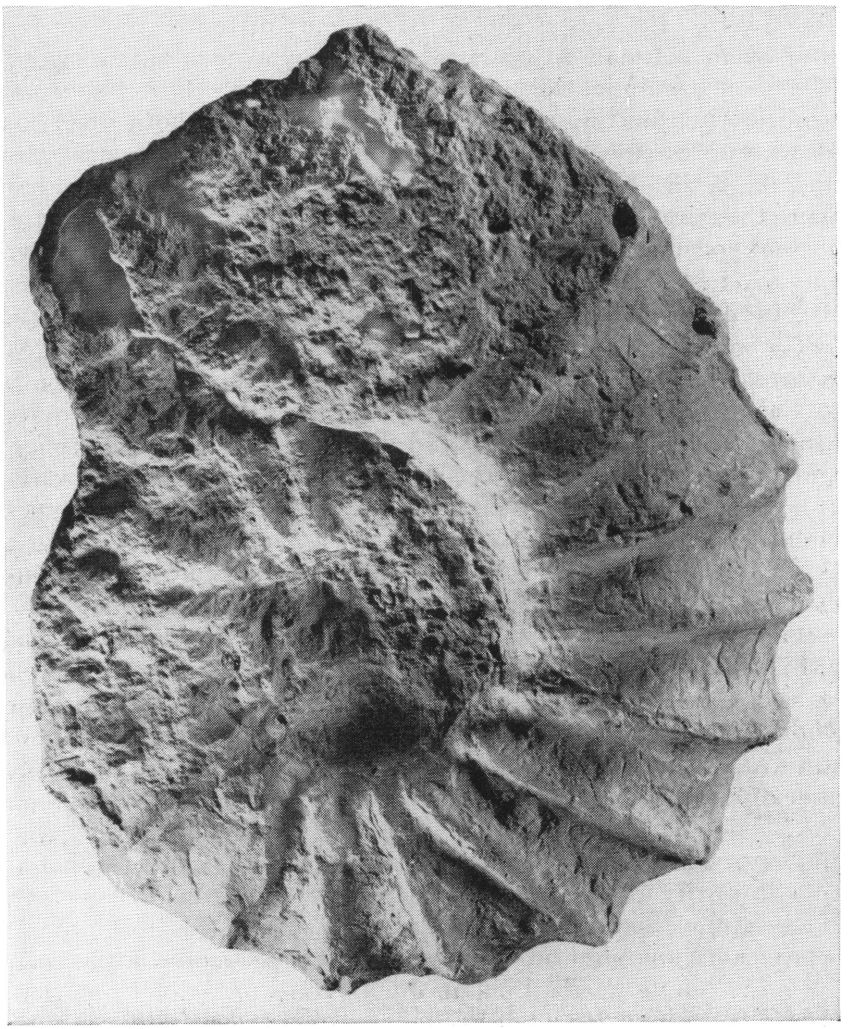


FIG. 1. *Dunveganoceras* cf. *pondi* Haas. Left side view, × 1/3.

contrary to the one observed in that species, in which "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" (Haas, 1949, p. 23).

Simultaneously with the narrowing of the venter, described above for *D.* cf. *pondi*, the horns from both sides tend to coalesce, and towards the end of the preserved part of the body chamber they seem actually to coalesce, thus producing a single strong prominence culminating on the ventral middle line. A trend towards such mutual approach of the horns from both sides has also been described in certain specimens of *D. pondi* (paratypes nos. 6, 12, 13, the last figured by Haas, 1949, pl. 14, fig. 1), but there they are still far from coalescing. On the other hand, in the present specimen they by no means disappear altogether to give way to a fastigiate venter, as they do, at an even somewhat smaller size, in the holotype of *D. albertense* (see Warren, 1930, pl. 1, fig. 2).

The costation of this form is slightly denser than that of *D. pondi*, there being 10 rather than nine ribs per half whorl in both the last volution and the penultimate one. These ribs are quite prominent and rather straight and stiff, as they are in that species, and, at about the middle of the last volution, somewhat prorsiradiate, as they can be seen to be, at about the same size, in paratypes numbers 4 and 5 of *D. pondi* (Haas, 1949, pls. 10, 11) also. Their circumumbilical tubercles are radially elongated but quite prominent (better seen on the right than on the figured left side of the specimen). Here and there (e.g., on the two earliest ribs clearly visible in fig. 1) the strong, conical, latero-ventral tubercle can well be seen as it impresses itself into the umbilical wall of the outer whorl, but nowhere in this specimen are ventral tubercles observable; at the beginning of the last volution both kinds of tubercles have already merged into horns.

Although traces of sutures, including those of the last (see above, p. 2), are observable here and there, they are much too poor to justify any attempt at description.

REMARKS: The far-reaching resemblance of this form to *D. pondi* leaves no doubt but that it is a *Dunveganoceras*, but, as seen from the above description, it differs too markedly from that species to be referred to it without reservation. Only study of more abundant material would warrant a decision as to whether this form represents another species of this genus or is just a somewhat aberrant individual. Despite the differences, it comes closer to *D. pondi* than to any other known species of this genus and has, therefore, been labeled as above. It deviates much more

both from the type species, *D. albertense*, which is unique within this genus by assuming in maturity a sharply ogival whorl profile, and from *D. poucecoupense* which, on the other hand, is far sturdier and keeps a decidedly truncate venter to the end. Furthermore, both these species lack the horns present in *D. pondi* and in the form here dealt with. *D.* sp. indet. from Greybull (Haas, 1949, p. 30, pl. 15, figs. 1–3, text fig. 10) attains only a little more than one-fourth of the size of the present form and is thus difficult to compare, but its inconspicuous costation readily distinguishes it from the latter as well as from other species of this genus. For a comparison with *D. conditum*, see under that species.

OCCURRENCE: Found, according to Mr. J. F. Wolff, on the western Mesabi Range in or near Sect. 16, T. 56 N., R. 23 W., Itasca County, Minnesota.

REPOSITORY: Oliver Iron Mining Company, Duluth, Minnesota. A plaster cast (A.M.N.H. No. 27172) has been retained for the collections of the American Museum of Natural History.

Dunveganoceras conditum,[1] new species

Figures 2–9

? *Dunveganoceras* cf. *albertense* Warren McLEARN, 1945, p. 3, pl. 5, fig. 2.

DIMENSIONS

SPECIMEN	D	H	H′	W	W′	U
Holotype	*ca.* 340 mm.	*ca.* 32 1/2	*ca.* 28 1/2	*ca.* 27 1/2	*ca.* 31 1/2	*ca.* 38 1/2
Paratype	372.5 mm.	34 1/2	29 1/2	27 1/2	30 1/2	39 1/2

The last septum is situated at a diameter of 265 mm. in the holotype, but at almost 300 mm. in the paratype. More than a third of the last whorl is occupied by the living chamber in the former, but only about a quarter in the latter which, when complete, may well have attained, if not exceeded, a diameter of 400 mm. The holotype, on the other hand, shows at its anterior end indications of degeneration of the sculpture which in this genus as in others suggests the vicinity of the apertural margin, so that it cannot be far from complete.

DESCRIPTION: Shell discoidal, rather evolute in maturity. The whorl profile of the holotype can be studied only where it comes

[1] *Conditus*, hidden. This trivial name alludes to the fact that the paratype lay for almost 20 years (including the time when I prepared my 1949 paper, a considerable part of which is devoted to the genus *Dunveganoceras*) unnoticed in the rear of a drawer.

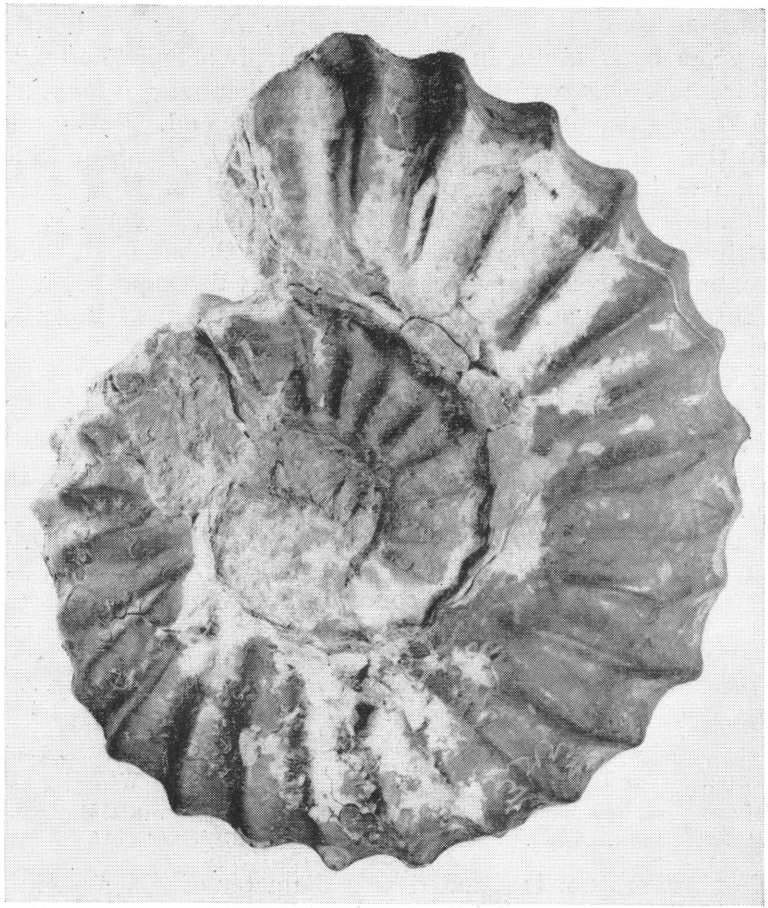


FIG. 2. *Dunveganoceras conditum* Haas, holotype. Left side view, × 1/3.

to light at a diameter of about 150 mm. (fig. 6). The intercostal section is, in its upper part, roughly trapezoidal, if the gentle convexity of the sides is disregarded. The costal section is greatly influenced by the two pairs of external tubercles which give it a strongly scalloped appearance. It is dominated by the high outermost tubercles, between which the median part of the venter forms a deep, crescent-shaped concavity. Similar, though somewhat less deep concavities separate the outermost tubercles from the latero-ventral ones. The latter point outward and slightly upward, the former upward and slightly outward. The maximum width of this whorl section is reached at the inner

FIG. 3. *Dunveganoceras conditum* Haas, paratype. Right side view, × 1/3.

third of the sides; from this point it slopes gently to the rounded umbilical shoulder; beyond the latter, the umbilical wall is quite steep, almost perpendicular. There are at this stage no more pronounced circumumbilical tubercles; rather the ribs are raised throughout the inner half of the sides; between this raised portion and the latero-ventral tubercles they are slightly depressed.

In the posterior third of the last whorl all four outer tubercles disappear gradually, but while the latero-ventral ones are soon absorbed by the ribs, the outermost ones seem to persist somewhat

longer, reduced to blunt nodes. At any rate, even before the middle of the last volution is reached, the ribs have entirely absorbed all four of those tubercles and run uninterruptedly across the venter, where they somewhat gain in strength. Simultaneously, both the costal and intercostal whorl profiles have become well rounded in their ventral portions which are in the holotype not at all truncate.

All the above details are taken from the holotype which, as seen from the dimensions, does not quite attain the size of the paratype. In the latter the development just described is considerably retarded. Whereas the two external tubercles on each side disappear rather suddenly between the diameters of 180 and 200 mm. in the holotype, they remain easily discernible in the paratype up to a diameter of about 210 mm. Then the latero-ventral tubercles gradually disappear, but only four or five ribs later the outermost ones also become reduced to blunt nodes. Between the diameters of 280 and 330 mm. the narrow venter is at first slightly sunk, then truncate between these two nodes, with the ribs crossing it in profile horizontally. Only beyond the diameter of 330 mm., that is, in the anteriormost sixth of the last volution, does the venter become well rounded in the paratype also. The last change causes the whorl profile to assume in both specimens a broadly elliptical shape (if the impressed zone is left out of consideration).

Costae and nodes have been dealt with above only in so far as they affect the whorl profile. In side view the ribs are seen to run radially at the beginning of the last quarter of the penultimate whorl of the holotype but then to assume a prorsiradiate direction which they maintain with only few exceptions up to the anterior end of the last volution. A similar, but less persistent change in the direction of the costae takes place in the paratype, where they are more or less radial, if not rursiradiate, in the penultimate whorl but become slightly prorsiradiate in the first half of the last. In its anterior half, however, they change back first to a radial, then even to a rursiradiate direction which they maintain throughout the anteriormost third of this volution. In both specimens the ribs assume, from a diameter of 120 or 130 mm. on, a more or less sigmoidal, at times almost falciform course. They run obliquely forward as far as about the first fourth of the whorl height, that is, the point where the circumumbilical tubercles, as long as they are discernible, culminate; then they turn rather sharply backward and run in a gentle, orad concave arc across the

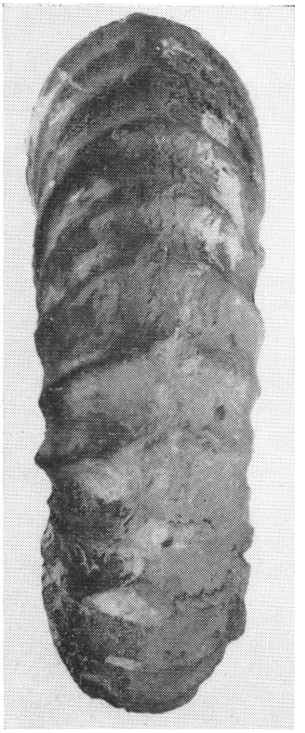


FIG. 4. *Dunveganoceras conditum* Haas, holotype. Ventral view, × 1/3, to show that the mature whorl profile is elliptic.

rest of the flanks. After having absorbed all four of the external tubercles they cross the venter in a straight or nearly straight line, somewhat broadening in its median part. In the last two or three ribs preserved in the holotype these broadened median parts tend to project somewhat forward, thus assuming to a certain extent the aspect of tongues pointing orad.

On the anterior half of the penultimate volutions 11 ribs can be counted in the holotype and 12 in the paratype; the latter number is present in the posterior halves of the last whorls of both also, whereas 15 and 14, respectively, are counted in their anterior halves. This is a total of 27 and 26 for the last volutions of the holotype and the paratype, respectively.[1] In the former shell the

[1] In the above counts slight irregularities of the costation, which always occur, have been disregarded.

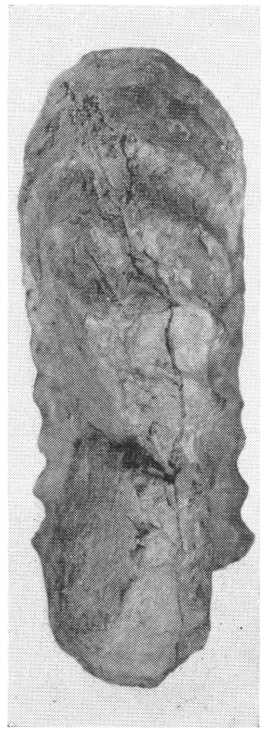


FIG. 5. *Dunveganoceras conditum* Haas, paratype. Ventral view of second and third quarters of outer whorl, × 1/3, to show that venter, in upper half of photograph, is narrow and first slightly sunk, then truncate.

last rib has degenerated to a rather flat fold which is separated by an interval markedly narrower than the preceding ones from the last but one, towards which it seems to converge dorsad more decidedly than usual. As in *D. pondi*, these characters are believed to indicate the nearness of the apertural margin (cf. Haas, 1949, p. 22, and above, p. 5).

The aforementioned circumumbilical tubercles are quite pronounced and prominent up to diameters of 130 mm. in the holotype and 145 mm. in the paratype; then they gradually disappear. As is characteristic of this genus, the latero-ventral tubercles are conical, but the outermost ones are somewhat compressed and decidedly elongated in the spiral sense; the latter are seen in side view to slope somewhat more gently apicad than orad.

Owing to the absence of horns, at least in the last ontogenetic

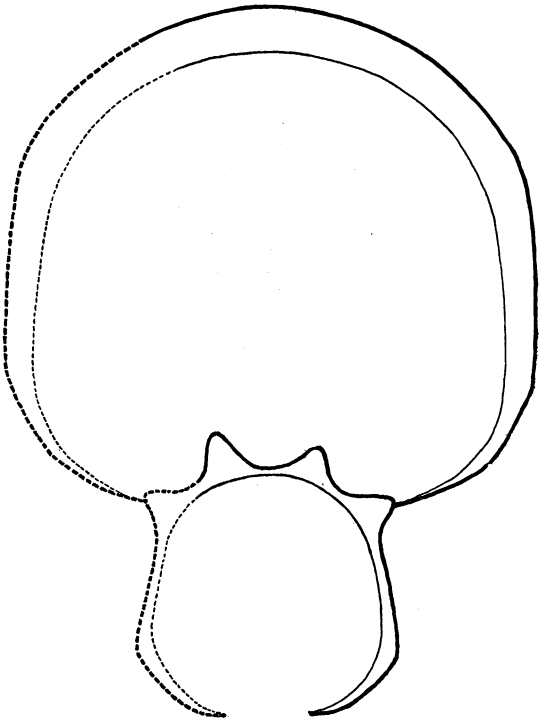


FIG. 6. *Dunveganoceras conditum* Haas, holotype. Costal and intercostal section of last and penultimate volutions at anterior end, × *ca.* $^3/_5$.

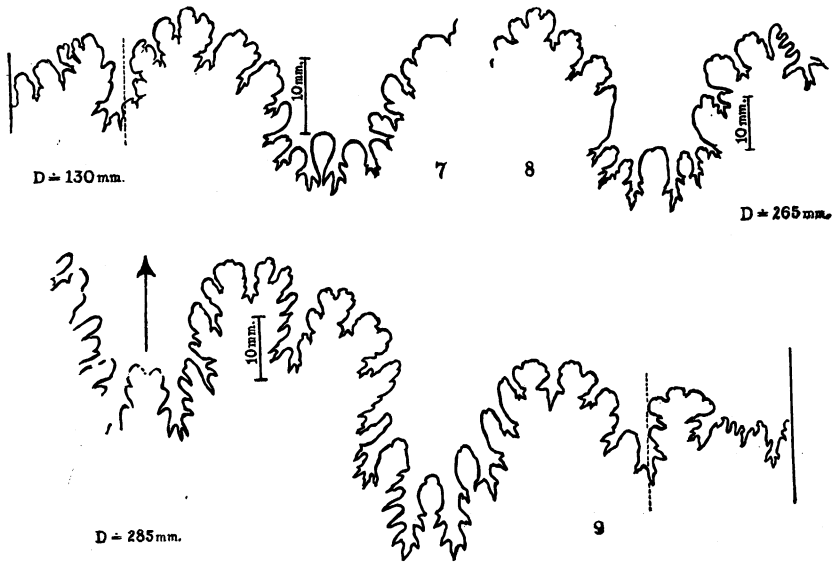
stage, the intercostals appear considerably less deeply sunk and the outline of the shell in side view is accordingly less scalloped than in *D. pondi* (compare figs. 2 and 3 with Haas, 1949, pl. 10).

The test, where fully preserved, attains about the maximum thickness recorded for *D. pondi* (see Haas, 1949, p. 25, pl. 13, figs. 2, 3).

Suture lines are well seen between diameters of *ca.* 120 mm. and *ca.* 300 mm. One near the end of the penultimate whorl of the holotype, corresponding to a diameter of about 130 mm., is depicted in figure 7. In its general plan it greatly resembles those of *D. pondi* illustrated in text figures 11 and 13 (Haas, 1949, p. 26), but the first lateral lobe is markedly shallower and wider and its club-shaped middle leaf much stronger. The lateral saddle exceeds the external one in height. The saddle following the lateral one is not so much lower than the latter. Having been shifted to the umbilical wall, it can no longer be called a lateral one, any

more than the slender lobe which rides on the umbilical shoulder can be termed the second lateral, although it is homologous to those of earlier ontogenetic stages. Beyond the aforementioned saddle there follow, farther down on the umbilical wall, a short, bifid auxiliary lobe which points strongly ventrad, a trapezoidal auxiliary saddle slightly indented on its top and considerably lower than the preceding one, another auxiliary lobe, one more auxiliary saddle, and the outer half of still another auxiliary lobe.

A suture line studied at an only slightly greater diameter in the



FIGS. 7–9. Suture lines of *Dunveganoceras conditum* Haas. 7. Holotype, a suture line from middle of external saddle to umbilical seam, taken from penultimate whorl near its end. 8. Holotype, first lateral lobe of last suture with adjacent parts of external and lateral saddles. 9. Second suture before the last of paratype from siphonal lobe to umbilical seam. Scale and diameter of disk (D) indicated for each drawing.

paratype differs from the one just described only in that the lateral saddle here considerably overtops the following one, as it does in *D. pondi* also.

As an example of a suture line of the mature stage the second before the last of the paratype, corresponding to a diameter of about 285 mm., is illustrated in figure 9. It exhibits an unusually shallow and rather wide siphonal lobe; the extremely broad external saddle characteristic of the Acanthoceratidae, with its outer stem

considerably overtopping the inner; a remarkably wide lateral lobe, divided by a club-shaped leaf into two main branches, both of which are subdivided by similar leaves (the outer one of which is even a little stronger than the middle one); a sturdy lateral saddle which is nearly symmetrically divided by a three-pronged lobule and which attains only about two-thirds of the height of the inner main stem of the external saddle; a bifid second lateral lobe whose inner branch is much longer than the outer; and, on the umbilical shoulder and the umbilical wall, four auxiliary saddles separated by three auxiliary lobes; the first of these saddles is not so much lower than the outer stem of the lateral saddle, the following ones are markedly lower than the first but almost equal in height.

The last suture lines of the holotype agree in general character with the one just described, but there are various differences. Most notable among them is the fact that here, as in the earlier stage described above, the lateral saddle still overtops the external one. Other differences can be recognized in the shape of the first lateral lobe which is here even shallower and exhibits a stout, rectangular rather than club-shaped middle leaf which is larger and higher than the leaves in the lower corners of this lobe (fig. 8). In figure 9, on the other hand, they can be seen to be as large as, if not even larger than, the middle one and to be situated considerably higher.

REMARKS: The fragment from the base of the Kaskapau formation illustrated by McLearn (1945, pl. 5, fig. 2) under the designation *D.* cf. *albertense* corresponds in size to the anteriormost quarter of the last whorl of the paratype. The density of the costation (seven per quarter whorl) is the same as in the present species, with which McLearn's fragment also has in common the comparative shallowness of the intercostals on the periphery. However, its ribs look stiff, as compared with those of *D. conditum*, so that fragment may or may not be conspecific with our new species.

From all the hitherto known species of *Dunveganoceras* the present one is readily distinguished by its considerably denser costation (26 or 27 per whorl, as compared to 20 in the preceding form and to 18 in all others) and by the sigmoidal course which the ribs assume in maturity. It differs furthermore from all those species, except *D. poucecoupense*, by being more evolute and from *D. pondi* and *D.* cf. *pondi*, described above, by lacking the horns so characteristic of *D. pondi*. As seen by comparing our figure 6 with Warren and Stelck's (1940, pl. 3) figures 4 and 5, its mature whorl

section is quite different from that of *D. albertense*, of *D. poucecoupense*, and also of *D. pondi* (compare in this respect the accompanying fig. 6 with fig. 2, pl. 12, of Haas, 1949). For sutural differences from the last species, reference is made to the description above of the suture lines of this species, but the taxonomic significance of these differences should not be overestimated.

OCCURRENCE: The holotype was collected from the Frontier formation in Sect. 16, T. 38 N., R. 84 W., near Willow Creek, the paratype on the Kenneth McDonald ranch on Willow Creek, probably in T. 39 N., R. 83 W., roughly 10 miles northeast of the first locality. Thus it may reasonably be assumed to be also from the Frontier formation, especially since both specimens agree lithologically. Both localities are in Wyoming near the southern end of the Big Horn Mountains.

REPOSITORIES, SELECTION OF HOLOTYPE: The holotype, which has been selected as such for exhibiting better the two pairs of external tubercles so characteristic of early and medium growth stages of this genus, has been returned to the Geological Museum of the University of Wyoming at Laramie (No. IT-1). The paratype is in the collections of fossil invertebrates of the American Museum of Natural History (A.M.N.H. No. 27686).

EMENDATION OF GENERIC DIAGNOSIS

Some of the characters recorded in the preceding descriptions of new forms necessitate certain modifications of the generic diagnosis of *Dunveganoceras* given previously (1949, pp. 20, 21). Thus emended, it should read as follows:

Moderately involute to evolute, discoidal shells attaining considerable size (up to 400 mm. in diameter). Intercostal whorl section at first subquadratic to trapezoidal, then oval, in maturity inverted heart shaped; costal section at first slender-trapezoidal or subrectangular, with flatly trapezoidal top, and scalloped, particularly so by a pair each of latero-ventral and outermost tubercles, in maturity ogival (in the type species only), trapezoidal, or broadly elliptical Venter, except in the type species, truncate, or even sunk in its median zone, up to and including medium growth stages; in maturity fastigiate, truncate, or well rounded. 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 essentially outward, and compressed, spirally elongated

ventral tubercles. Vestigial, spirally elongated median tubercles only rarely present at an early stage. At maturity the ribs, numbering from 18 to 27 per whorl, absorb the various tubercles, become prominent or even high and sometimes gently sigmoidal, and continue straight or with a slight forward convexity across the venter, forming, in some species, on the latero-ventral shoulders distinct horns which sometimes tend to coalesce on the median line.

The part of the diagnosis relating to the suture lines requires only the modification that in most, although not all, species the saddles appear quite wide as compared to the adjacent lobes.

GEOGRAPHIC AND STRATIGRAPHIC RANGES

GEOGRAPHIC RANGE: Prior to 1949 occurrences of the genus *Dunveganoceras* had been recorded only from the Pouce Coupe district at the Alberta-British Columbia boundary (Warren, 1930; Warren and Stelck, 1940), from near Luscar in the southern foothills of Alberta, some 200 miles farther to the south (Warren, 1930),[1] and, in a single fragment, by McLearn (1945) from a locality whose exact site is not given but which, to judge by the title of his paper, must be somewhere in northeastern British Columbia or northwestern Alberta, that is, in the Peace River area or farther to the north.

The first extension of this range to the south was brought about by the find of a characteristic and comparatively abundant species of this genus near Greybull, Wyoming (Haas, 1949). Since that time Gleddie (1949, fig. 2, p. 515) has recorded the genus *Dunveganoceras* from both the Pouce Coupe River and the Spirit River areas, but on page 527 of his paper he includes *D. pouce-coupense* and *D. albertense* in the faunal list for the former area only, not in that for the latter. Both these areas form parts of the western Peace River plains of Alberta and thus of the same general area which includes also the Pouce Coupe district. Thus Gleddie's paper does not record essentially new areas in which this genus occurs.

Other really new occurrences have, however, become known since. Proceeding from the Peace River area in a (roughly) southeasterly direction, the following should be mentioned first,

[1] Warren and Stelck (1940, p. 147) mention but do not name two localities in the southern foothills at which *Dunveganoceras* has been collected.

quoting from a letter of Dr. W. A. Cobban, dated Washington, D. C., March 13, 1950:

"During the past two field seasons I have collected from the Mosby sandstone member of the Colorado shale of central Montana. This sandstone contains an interesting fauna which Dr. Reeside and I are going to describe. The ammonites are characterized by a species of *Dunveganoceras*, which is very close to *D. albertense* (Warren). This fauna is younger than the zone of *D. pondi*. From the Mosby we now have parts of some 50 individuals of *Dunveganoceras* and about 75 *Metoicoceras*."

Proceeding farther to the south, Dr. Cobban (*ibid.*) reports that:

"*Dunveganoceras pondi* Haas is present in the lower 275 feet of the Cody shale of the Crow Indian Reservation of south central Montana. In the upper part of the Frontier formation, in the same area, are large concretions with *Acanthoceras? amphibolum* Morrow. The 60 to 100 feet of shale immediately overlying the *Dunveganoceras* zone contains a Greenhorn (Turonian) fauna. This is followed by unfossiliferous sandy shale that is probably of basal Carlile age. . . . In the Dayton quadrangle (Wyoming) which adjoins the Crow Indian Reservation, H. N. Darton[1] mentions (p. 7) the occurrence of '*Prionotropis woolgari*'[2] in concretions in the shales a few hundred feet above the Mowry. These ammonites are quite likely either *Dunveganoceras* or *Acanthoceras? amphibolum* or both."

To the south and southeast of the area just dealt with, comprising the Crow Indian Reservation and the Dayton quadrangle, there follow the occurrences of *D. pondi* and *D.* sp. indet., described in my 1949 paper, near Greybull, and those of *D. conditum*, described above, near the southern end of the Big Horn Mountains. About 90 or 100 miles from there to the south-southwest, "several fragments of an undescribed *Dunveganoceras*-like ammonite" were, according to Dr. Cobban (letter, dated Washington, D. C., June 2, 1950), collected recently by a graduate student of the University of Wisconsin from the Frontier formation of the Bell Springs district about 15 miles north of Rawlins, Wyoming; Dr. Cobban suspects these fragments belong to *D. conditum*.

[1] 1906, Description of the Bald Mountain and Dayton quadrangles: U. S. Geol. Survey Geol. Atlas, Bald Mountain-Dayton folio (no.141), 15 pp., illus.

[2] Dr. Cobban (*ibid.*) asserts, however, that he has "never seen *Collignoniceras woollgari* (Mantell) from the Bighorn Mountain area."

According to the same letter, that species might occur also in the Belle Fourche shale of the Black Hills, about 175 miles to the east-northeast from its type locality.

More than 600 miles farther to the east-northeast several specimens of this genus have been found, according to Mr. J. F. Wolff (letter, dated Duluth, June 27, 1949), on the western Mesabi Range of Minnesota, one of which has been described above under the designation *D.* cf. *pondi.*

Finally, the genus has been identified by Major C. W. Wright in the Cenomanian of Devonshire, southwestern England (letter, dated London, April 23, 1949), in three fragments, two in the collections of the British Museum (Natural History). In a letter, dated London, January 6, 1950, Major Wright records this form as *D.* cf. *pondi.*

Summarizing, this genus can be seen to range, though rather discontinuously, over a wide part of the North American continent, whose extreme points can be located at the Peace River area at the British Columbia-Alberta boundary in the northwest, probably north of Rawlins, south central Wyoming, in the south, and at the western Mesabi Range of Minnesota in the east, and to occur furthermore in southwestern England. Thus, the known geographic range of *Dunveganoceras,* which until two years ago was considered to be restricted to a comparatively limited area of British Columbia and Alberta, has expanded quite markedly.

STRATIGRAPHIC RANGE: Warren (1930, p. 22) recorded the type species, *D. albertense,* from the basal beds of the Smoky River shales on Pouce Coupe River near the Alberta-British Columbia boundary, and from the basal beds of the Colorado shale near Luscar, Alberta; to both of these beds he then assigned a Turonian age.

According to Warren and Stelck (1940, pp. 149, 150), most of the specimens of this genus (including the three referred to their species *D. poucecoupense* from the Pouce Coupe sandstone[1]) were obtained from the base of the Smoky River shales in the Pouce Coupe district or from the base of the Alberta (= Colorado) shales farther to the south, but these authors record two fragments "undoubtedly referred to this genus" also "from a horizon 200 feet below the top of the Dunvegan sandstone." They now assign an Upper Cenomanian age to all these occurrences, drawing the

[1] McLearn (1945, p. 3), however, places the Pouce Coupe sandstone at the top of the Dunvegan formation which underlies the Smoky River shales.

Cenomanian-Turonian boundary "just above the Pouce Coupe sandstone member of the Smoky River shale."

Gleddie (1949, fig. 2, p. 517, table 2, p. 527) lists both *D. poucecoupense* and *D. albertense* within his *Dunveganoceras* fauna, lowest one of the Smoky River group, as occurring between 120 and 300 feet above the base of this group, and restricts *Dunveganoceras* to the basal part of the Kaskapau formation (including the Pouce Coupe sandstone member), which is now considered the lowest of three formations of the Smoky River group, immediately overlying the Dunvegan formation.

McLearn (1945, p. 3) also reports the *D.* cf. *albertense* figured in his report (pl. 5, fig. 2) from the base of the Kaskapau formation.

With regard to the correlation of that formation with the European stages of the Upper Cretaceous, McLearn (1945, p. 4) expresses some doubt as to its definite reference to the Cenomanian by Warren and Stelck, justly pointing out "that no typical Cenomanian species is present,"[1] but eventually he deems it at present "best to accept a Cenomanian age for this formation."

Gleddie (1945, table 2, p. 526) accepts this late Cenomanian age without reservation, drawing the Cenomanian-Turonian boundary just above his *Dunveganoceras* zone, to which he assigns about the lower third of the Kaskapau formation, so that this boundary does not coincide with that between the Dunvegan and Kaskapau formations.

Despite some reservations made in both my previous paper and the preceding footnote, a late Cenomanian age of the British Columbian and Albertan occurrences of this genus, as appears now to be established by the consensus of authors, may well be accepted for the purpose of the present investigation also, especially since it follows from all the details and sections given by Warren and Stelck and by Gleddie that the horizon at which they occur lies very close to the Cenomanian-Turonian boundary and can thus be placed not only in the upper but in the uppermost Cenomanian.

[1] I previously (1949, p. 35) voiced similar doubts as to the late Cenomanian age assigned to the *Dunveganoceras* horizon by Warren and Stelck, and for a similar reason. There are indeed some elements of a vicious circle involved in those authors' procedure; they first infer from the fact "that the Turonian fauna appears just above the '*Acanthoceras*' [i.e., *Dunveganoceras albertense*] horizon" a pre-Turonian age of that horizon (an inference which is by no means cogent), then proceed to consider *Dunveganoceras* "a typical Upper Cenomanian form," and eventually date all beds in which this genus occurs as late Cenomanian.

Following the sequence in the preceding discussion of the geographic range of the genus, I deal next with the occurrence in the Mosby sandstone member of the Colorado shale of central Montana. This member, as far as I could ascertain from the literature, might be dated as Cenomanian or Turonian; the *Metoiceras* forms reported by Dr. Cobban to be associated there with *Dunveganoceras* would seem to favor an age close to the Cenomanian-Turonian boundary.

In the Crow Indian Reservation of south central Montana *D. pondi* occurs in the lower 275 feet of the Cody shale; thus, this occurrence can be assigned the same age as the Greybull assemblage containing the same species.[1] That age has been assumed in my previous paper (1949, p. 36) to be late Cenomanian-early Turonian, with preference given, considering the associated fossils, to the younger dating.

The probable *Dunveganoceras* forms in the Dayton quadrangle of Wyoming, mistaken by Darton for "*Prionotropis woolgari*," occur, according to Dr. Cobban, in concretions in the shales a few hundred feet above the Mowry. These shales should then be referred to the Frontier formation which, however, may well extend from the Cenomanian into the Turonian. If the association, considered possible by Dr. Cobban, of *Dunveganoceras* with ?*Acanthoceras amphibolum* Morrow in those concretions should prove to be correct, it would make an (early) Turonian age more probable, since the Graneros formation of Kansas, from which the latter species was first described, is considered to be Turonian (Morrow, 1935, p. 472).

Both localities near the southern end of the Big Horn Mountains where our types of *D. conditum* were collected can be referred to the Frontier formation, which also yielded the fragments from the Bell Springs district believed by Dr. Cobban to belong to the same species. Thus the question whether to date these occurrences as late Cenomanian or early Turonian remains open. The occurrence in the Belle Fourche shale of the Black Hills recorded by Dr. Cobban should be assigned a late Cenomanian age.[2]

Fossils from the isolated patches of Cretaceous shales and con-

[1] The tendency in that region of the Cody shale to reach farther down in the stratigraphic column the farther east it extends might account for the somewhat higher site, within the Cody shale, of the *Dunveganoceras* horizon near Greybull, where this genus appears at least 350 feet above its base.

[2] *Fide* Dr. J. B. Reeside, Jr. (see Haas, 1949, p. 36, footnote 1).

glomerates found in the Mesabi Range of Minnesota were dated by Dr. T. W. Stanton, more than half a century ago, as "unquestionably Upper Cretaceous, . . . not older than the Fort Benton and probably not younger than the Fort Pierre horizon" (Leith, 1903, p. 190; repeated in Van Hise and Leith, 1911, p. 179), that is, Turonian to Campanian. Among the fossils identified some time later by Dr. C. A. White was the only ammonite hitherto recorded from there, recognized by him as a *Sphenodiscus* close to *S. lenticularis*, suggesting an even younger, viz., Maestrichtian, age. The *D.* cf. *pondi* described earlier in this report might be assigned the same age as *D. pondi* from Greybull, namely, early Turonian or perhaps late Cenomanian; that would put it at the very bottom of Stanton's time range, if not somewhat below it.

Finally, in Devonshire (southwestern England) a form listed by Major Wright as *D.* cf. *pondi* was collected by him from "phosphates at junction [of the Devon Cenomanian Limestone proper] with or in base of Turonian," where it is associated with members of the genera *Schloenbachia*, *Euhystrychoceras*, *Forbesiceras*, *Calycoceras*, *Eucalycoceras*, *Acanthoceras*, *Protacanthoceras*, *Euomphaloceras*, *Neocardioceras*, *Desmoceras*, *Puzosia*, and *Scaphites* (Major Wright's letter, dated London, January 6, 1950). He concludes that this assemblage probably represents the uppermost Cenomanian, thus exactly the age that must be assumed, on the strength of the most recent literature, for the *Dunveganoceras* species of the Peace River and southern foothills areas of Alberta and British Columbia.

In conclusion, the genus *Dunveganoceras* can be stated to occur in the late Cenomanian and probably also in the early Turonian, preferably close to the boundary of these two stages. A more precise correlation of the various strata with *Dunveganoceras*, it is hoped, will be given in a paper on the zoning of the faunas of the Belle Fourche-Greenhorn age planned by Dr. Cobban.

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