JOURNAL OF PALEONTOLOGY, V. 32, NO. 3, P. 587–594, 9 TEXT-FIGS., MAY 1958

ARIKAREEAN RHINOCEROSES FROM SOUTH DAKOTA

MORTON GREEN
Museum of Geology, South Dakota School of Mines and Technology, Rapid City, South Dakota

ABSTRACT—Only one species of rhinoceros, *Diceratherium gregorii*, has been described from Lower Miocene deposits in South Dakota. Additional specimens with unworn dentitions adds to the knowledge of this species. *D. armatum* is added to the fauna and is used as a basis for correlating the deposits of Gering type lithology with the John Day formation in Oregon. The temporal range of *Hyracodon* is extended into the early Miocene.

INTRODUCTION

IN 1920, Peterson described *Diceratherium gregorii* from Lower Miocene deposits (*i.e.*, "Lower Rosebud") in South Dakota. Since that time few contributions have been made relative to that fauna and none on rhinoceroses. Neither have there been any rhinoceros remains described from equivalent deposits (Gering and Monroe Creek formations) in Nebraska. The discovery of some remains from Arikaree deposits in South Dakota, though fragmentary, warrants reporting. These specimens were collected by field parties from the Museum of Geology, South Dakota School of Mines and Technology, during the 1953 and 1954 field seasons by J. R. Macdonald and myself.

ACKNOWLEDGMENTS

A research grant from the South Dakota School of Mines and Technology Endowment Association has helped support this project. The drawings were made by Mildred Ahrlin. Thanks are expressed to H. E. Wood, 2nd for suggesting to me the identity of the specimen referred to *Diceratherium armatum*.

MEASUREMENTS

No standard method for measuring upper rhinoceros teeth has yet been recommended. This has led to a diversity of measurements on the part of different authors for the same specimen. In addition, the curvature of the upper tooth modifies the crown measurements as the tooth is worn thus rendering measurements at the crown useless. This is true of the lower teeth also, but to a lesser degree. On the suggestion of H. E. Wood, 2nd (per. comm.) the measurements of the upper teeth given in this paper are as follows. All are taken at the base of the crown at and including the cingulum; antero-posterior dimension is taken along the approximate midline of the tooth through the postfossette, not the ectoloph; transverse dimension is taken across the tooth from the base of the paracone to the opening of the median valley, or, if the median valley is closed, to the approximate center of the lingual side of the tooth. Lower teeth are similarly measured, at the base of the crown, including the cingulum. Antero-posterior diameter is taken from the antero-labial corner to the postero-lingual corner; transverse width is taken across the metalophid.

SDSM LOCALITIES

V5350. SE¼ SW¼ Sec. 26, T. 38 N., R. 44 W.
V5354. Corner of sec. 13, 14, 23, 24, T. 39 N., R. 43 W.
V5358. SE¼ sec. 31, T. 40 N., R. 43 W. and NE¼ sec. 6, T. 39 N., R. 43 W.
V5360. N½ sec. 17, T. 39 N., R. 43 W.
V542. N½ sec. 30, T. 30 N., R. 43 W.
V543. S½ SW¼ sec. 32, T. 40 N., R. 43 W. and NW¼ sec. 5, T. 39 N., R. 43 W.
V545. Sec. 23, T. 39 N., R. 45 W.
V549. NW¼ sec. 35 and S½ sec. 26, T. 41 N., R. 43 W.

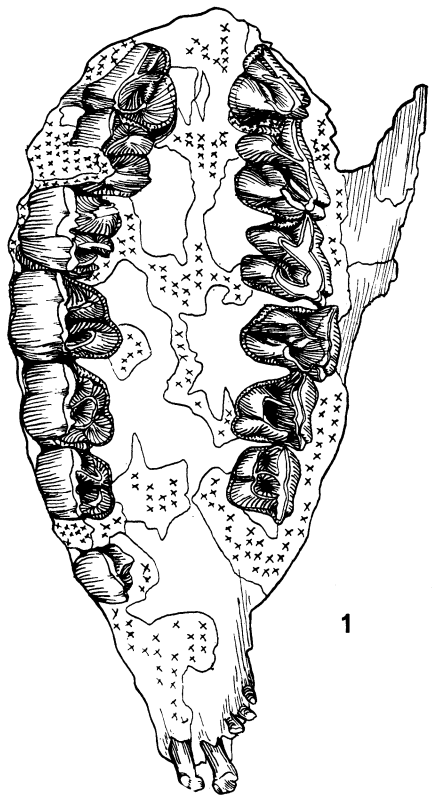
SYSTEMATIC DESCRIPTIONS

Family HYRACODONTIDAE
Subfamily HYRACODONTINAE
HYRACODON APERTUS Sinclair, 1922

Loc. V545. SDSM No. 54141; palate with right I^{1-3}, C, P^2–M^3; partial right mandible with I_{1-3}, P_2–M_3; partial left mandible with P_2–M_3 and two loose incisors.

This specimen was found five feet above the basal ash of the Arikaree deposits and represents an extension of the temporal range of the genus into the early Lower Miocene.

Description.—P^1: protoloph present only as a projecting cusp, the antero-lingual cingulum, not connected to the ectoloph. P^2: similar to the type in that the hypocone



TEXT-FIG. *1*—*Hyracodon apertus* SDSM No. 54141, palate. ×½.

has a posteriorly directed spur. P^3: similar to the type; no posterior spur from the hypocone; small crista on right side, on left side the crista is only a swelling; antecrochet present, crochet absent. P^4: molariform, antecrochet and crista present, median valley open. Molars: with some indication of crista; M^3 unerupted but exposed. The lower dentition is not unusual; M_3 is unerupted. The length of the molar series (M^1–M^3) is 68.8 mm. which is near the upper limit of size range given by Sinclair (1922, p. 74).

TABLE 1—MEASUREMENT IN MILLIMETERS OF *Hyracodon apertus* SDSM No. 54141

	Left	Right
P^1 A–P	11.3	
P^1 Tr	13.4	
P^2 A–P	17.2	17.3
P^2 Tr	18.1	19.7
P^3 A–P	17.7	18.5
P^3 Tr	21.4	21.6
P^4 A–P	19.8	19.5
P^4 Tr	23.3	24.6
M^1 A–P	broken	21.4
M^1 Tr	broken	25.0
M^2 A–P	23.4	24.3
M^2 Tr	broken	25.4
M^3 A–P	22.7	22.5
M^3 Tr	22.3	22.4
M^1–M^3		68.8

Cf. HYRACODON

Loc. V549; No. 54183; partial right mandible with broken P_4–M_3. This specimen is referred here because it is nearer in size to specimens of *Hyracodon* I have seen. The teeth are one-third smaller than those in *Diceratherium gregorii*. If the specimen is correctly referred then the temporal range is extended but slightly as this specimen is from a higher level than the referred *H. apertus*.

Family RHINOCEROTIDAE
Subfamily CAENOPINAE
DICERATHERIUM GREGORII Peterson 1920

Additional diagnostic characters.—Premolars and molars with crista, differing from *D. niobrarense* Peterson. M^{2-3} with well developed crochet.

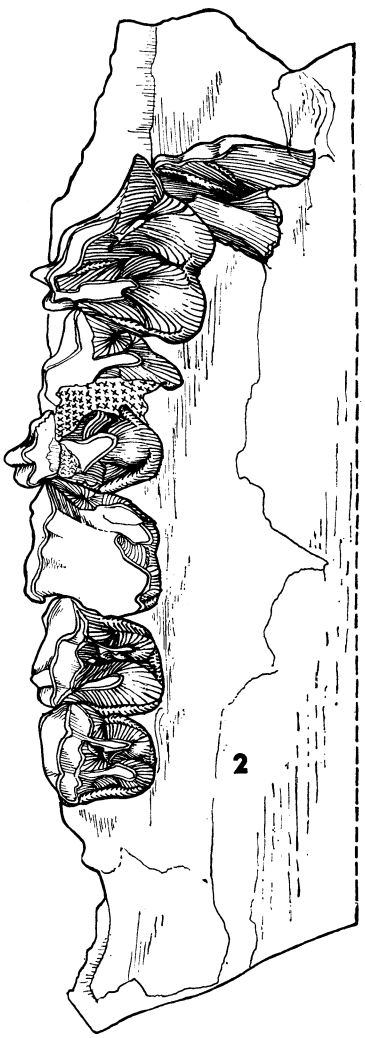
Referred specimens.—Loc. V5354; SDSM No. 54339; right P^{2-4} inner half of M^1. Loc V542; SDSM No. 54165; left M^2. SDSM No. 54198; unerupted M_1. SDSM No. 54188; partial right mandible with roots of P_{2-4}, worn M_{1-2}. Loc. V543; SDSM No. 54144; crushed palate with left roots P^1, P^{2-3}, DP^4 over P^4, M^{1-2}, M^3 unerupted, right P^4–M^2, fragmentary right mandible with roots P_2, P_3–M_2.

All of these specimens are from a nodular zone above the basal ash with the exception of No. 54144 which is from a slightly higher nodular layer.

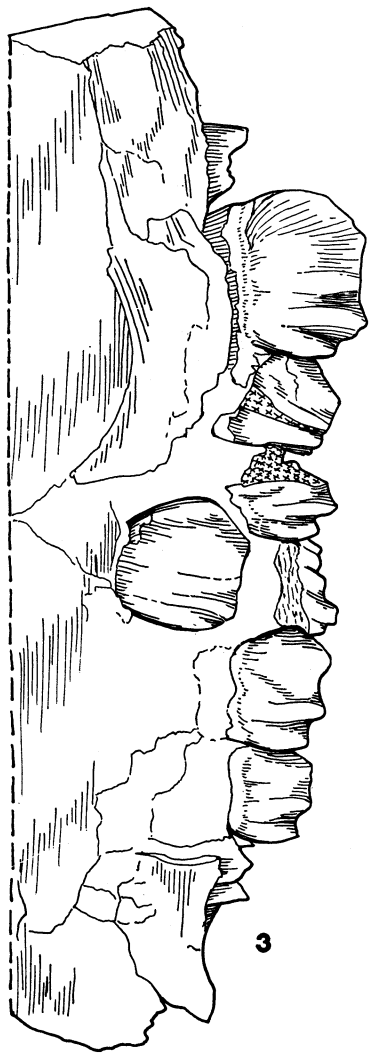
Description of specimens.—No. 54144. P^2 lingual cingulum slightly interrupted by protoloph and metaloph, labial cingulum not strongly developed, weak mure between protoloph and metaloph, crista weakly developed, crochet faintly indicated. P^3; lingual cingulum as in P^2, crista well developed but low in medifossette, crochet strong and double. DP^4; worn and without character. P^4; cingula as in P^3, crista well developed, crochet double, weak mure. M^1:

lingual cingulum poorly developed, strong crochet and crista, median valley opens widely. M^2; as in M^1. M^3; unerupted, with crista and crochet. P_3–M_2; the external wall of the talonid crest is parallel with the long axis of the jaw, the anterior end of the talonid crest does not curve inward in M_{1-2} and only slightly in P_{3-4}.

No. 54339. These teeth are not as heavily worn as those in the type. The labial cingula are more strongly developed than in the teeth of No. 54144 and in this respect bears a greater resemblance to the type specimen.



TEXT-FIG. *2*—*Diceratherium gregorii* SDSM No. 54144, left side of crushed palate. ×½.

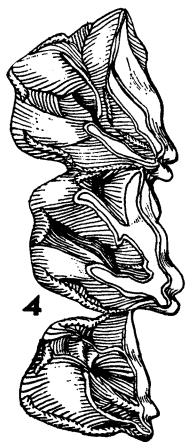


TEXT-FIG. *3*—*Diceratherium gregorii* SDSM No. 54144, labial view of left side. ×½.

No. 54165. M^2; The anterior half of the ectoloph is missing. The median valley opens widely.

No. 54198. M_1; same configuration as M_1 in No. 54144.

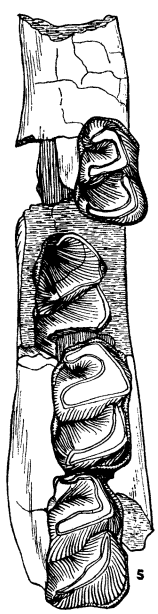
No. 54188. M_1; much worn and the outer enamel is missing. M_2; also worn and the back end is broken. There is no evidence of M_3 having been present. The bone behind M_2 is pitted but not deeply. Removal of the bone displays no sign of any root. This speci-



TEXT-FIG. 4—*Diceratherium gregorii* SDSM No. 54144, right side of palate. ×½.

men is referred here because of size and because the external portion of the talonid wall is parallel to the long axis of the jaw.

Comments.—The lingual cingula in the type are well developed. My measurements of the type are close to Peterson's (1920, p. 424) except for M^{2-3} where my measurements of transverse width are much narrower.



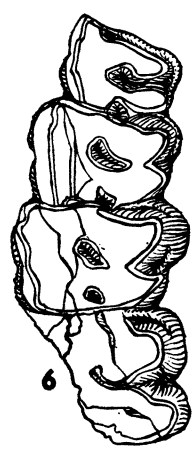
TEXT-FIG. 5—*Diceratherium gregorii* SDSM No. 54144, left lower jaw. ×½.

This species seems valid on the cranial characters given by Peterson (1920, p. 421). No cristae are present in the teeth of *D. niobrarense* Peterson. Crochets in *D. niobrarense* are simple; in *D. gregorii* they are double. M^3 in *D. niobrarense* possesses a crista but no crochet. M^3 seems to be relatively smaller in *D. gregorii*. The lingual cingulum in both the premolars and molars is strongly developed and continuous around the protoloph and metaloph in *D. niobrarense*. In *D. gregorii* these cingula are not so strongly developed and are interrupted by the lophs. The doubling of the crochet in *D. gregorii* is sometimes seen in *D. cooki* Peterson. The interrupted cingulum is also present in *D. cooki* and *D. annectens* (Marsh). It is continuous in *D. armatum* Marsh in some specimens.

DICERATHERIUM ?GREGORII

Loc. V5360: No. 53419; left DP_{2-3}. DP_2 possesses the extra anterior accessory lophid so often seen in rhinoceros deciduous lower teeth. The outer edge of the talonid wall is nearly parallel with the long axis of the jaw. The bone between the two teeth is missing as is the anterior edge of DP_3. These teeth are much larger than corresponding milk teeth in *D. cooki*. DP_2: A–P 30.5 mm.; Tr 13.7 mm.

Loc. V5358: No. 53418; left P^1, DP^{2-3}. These teeth are the proper size for occlusion with the above mentioned lower milk



TEXT-FIG. 6—*Diceratherium gregorii* SDSM No. 54339, right side, ×½.

TABLE 2—MEASUREMENTS IN MILLIMETERS OF *Diceratherium gregorii* UPPER DENTITIONS

	AMNH* 12933	AMNH† 12933		SDSM‡ 54144		SDSM 54144		SDSM‡ 54339	SDSM 54339	SDSM‡ 54165	SDSM 54165
		L	R	L	R	L	R				
P^2 A–P	26			28.4		23.1		25.1	21.7		
P^2 Tr				27.3		27.3		28.5	29.3		
P^3 A–P	31			29.8		25.6		27.4	24.2		
P^3 Tr	44			32.7		32.7		37.0	37.5		
DP^4 A–P				29.6		28.2					
DP^4 Tr				30.7		30.7					
P^4 A–P	34				33.0		29.0	30.2	26.4		
P^4 Tr	48				36.5		36.4	42.7	37.2		
M^1 A–P	38			41.0	41.4	37.8	34.8			41.8	36.6
M^1 Tr	45			34.4	37.6	32.6	37.1				
M^2 A–P	45		44.5	44.5	43.7	36.2	36.9				
M^2 Tr	47		38.6	39.6	40.7	37.4	38.4				
M^3 A–P	38		38.7	37.6		24.6					
M^3 Tr	44		28.5	27.0		29.7					
P^2–P^4		87.6	86.0	82.8		76.4		78.8	71.5		
M^1–M^3		115.5	112.3	102.0							

* After Peterson 1920.
† These measurements were taken by the author in 1955. A–P is across the ectoloph: Tr is across the widest portion of the tooth. They are included for comparison with Peterson's measurements.
‡ These measurements are taken across the ectoloph and greatest width for comparative purposes. All other columns are measured as stated in the text.

teeth. They are barely worn. P^1; parastyle in direct line with ectoloph, not twisted toward lingual side. DP^2; lingual cingulum raised into sharp cone at median valley, crista not extending across tooth as in deciduous teeth in *D. cooki* but only part of the way as in *D. annectens*. DP^3; lingual cingulum interrupted by lophs, crista as in DP^2, median valley opens widely.

TABLE 3—MEASUREMENTS IN MILLIMETERS OF *Diceratherium gregorii* LOWER DENTITIONS

	SDSM 54144	SDSM 54188	SDSM 54198
P_3 A–P	28.4	22.6*	
P_3 Tr	17.3		
P_4 A–P	33.3	24.5*	
P_4 Tr	19.5*		
M_1 A–P	34.2	29.6	34.9
M_1 Tr	22.0	17.3	20.0
M_2 A–P	23.0	17.8	

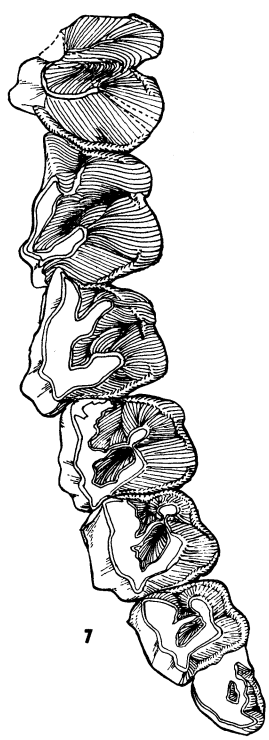
* Approximate measurements.

DICERATHERIUM ARMATUM Marsh 1875
= D. LOBATUM Troxell 1921

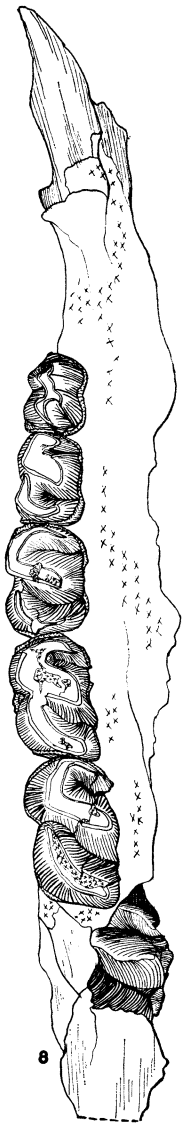
Loc. V5350. SDSM No. 53584. Left P^2–M^3, right I^2, P^2–P^4, left mandible with C, P_3–M_3, portion of right mandible with C, P_2–M_3.

Loc. V543. SDSM No. 54150, left M_2.

Description.—Upper dentition. I^2: slightly crushed; inner moiety about one half diameter of outer. P^1: medifossette barely isolated; cingula well developed. P^2: anterior, lingual, and posterior cingula well developed and continuous; hypocone connected to protocone by narrow bridge (mure); metaloph thin, curving anteriorly, connected to hypo-



TEXT-FIG. 7—*Diceratherium armatum* SDSM No. 53484, left side: P^1 drawn in reverse from right side. ×½.



TEXT-FIG. 8—*Diceratherium armatum* SDSM No. 53484, left lower jaw; P_2 drawn in reverse from right side. $\times\frac{1}{3}$.

cone near its anterior end; hypocone round. P^3: cingula as in P^2; faintly indicated crista and crochet; metaloph thin, curving anteriorly and connected to protocone; hypocone connected to metaloph by thin bridge; hypocone slightly compressed antero-posteriorly. P^4: similar to P^3 but hypocone more compressed. M^1: lingual cingulum lacking except remnants on protoloph and metaloph at median valley; antecrochet bulbous. M^2: as M^1 except cingular remnant on protoloph only. M^3: an unerupted tooth, typically rhinocerotoid. Lower dentition. C: triangular, robust. The length of the diastema is unknown. In the restored portion of the jaw the diastema was estimated on the basis of dentitional size. Cheek teeth: not peculiar, typically rhinocerotoid. M_3 is unerupted but exposed in the jaw.

Loc. V543. No. 54150, a left M_2 is referred here because of its size. It is from the same level as that of No. 54144, *D. gregorii*.

Discussion.—I have not seen the type of *D. lobatum* or *D. armatum* but judging from the published figures and descriptions the South Dakota specimen is referable to *D. armatum* and *D. lobatum* is synonymous with it. Troxell's (1921) figure of the type of *D. armatum* seems to be a much clearer illustration than that of Peterson (1920). Comparison of measurements among the several specimens shows a degree of size range not incompatible with accepted limits of variation. It is the variation of enamel pattern seen in the few known specimens which is most striking. USNM No. 11682 from Montana has the most worn dentition. Consequently, its enamel pattern is reduced to simplicity and the medifossettes are closed in P^2–M^1 and possibly in M^2. In the type specimen, there is a true mure in P^{2-3} and cristae or at least rudiments of cristae in P^{2-4}. SDSM No. 53484 has true mures in P^{2-4} and cristae in P^3. The type of *D. lobatum* is an exaggerated variation in which the cristae and crochet are more prominent (in P^{3-4}) than is usual. Each of these specimens displays the development of mures and cristae in varying degree. This, along with size proximity is deemed sufficient for placing *D. lobatum* Troxell in the synonymy of *D. armatum* Marsh.

STRATIGRAPHY AND CORRELATION

Current stage of exploration and study of the fauna collected prevents anything more conclusive than to state that the bulk of the SDSM collections come from deposits of Gering type lithology and that these specimens represent a lower Arikareean fauna from a probable Gering equivalent. Whether these deposits are actually an extension of

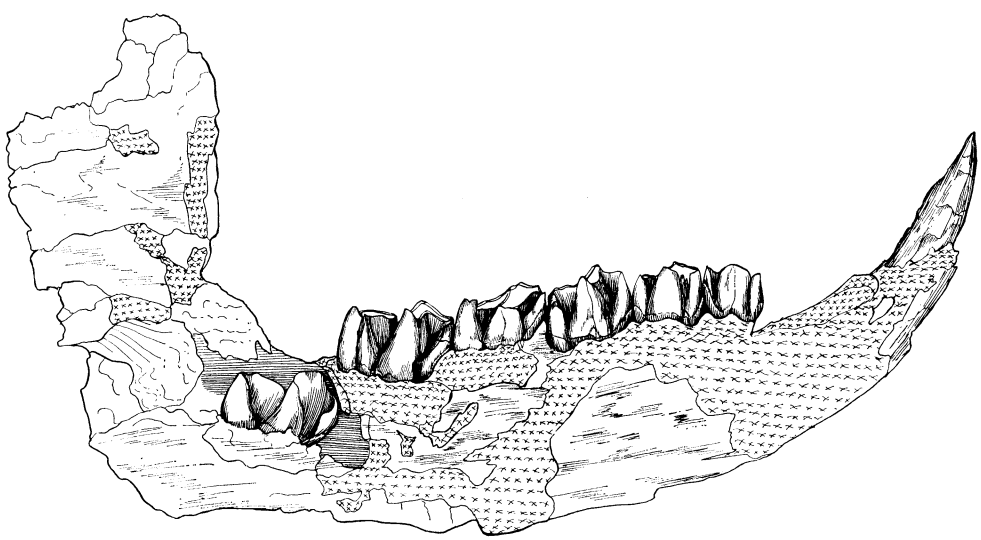
TABLE 4—MEASUREMENTS IN MILLIMETERS OF *Diceratherium armatum* SDSM No. 53584

Upper Dentition			Lower Dentition		
	L	R		L	R
I^2 A–P		14.5	C Tr	27.4	
I^2 Tr		8.6	P_2 A–P		31.7
P^1 A–P		27.5	P_2 Tr		23.4
P^1 Tr		25.5	P_3 A–P	42.5	40.2
P^2 A–P	32.5	31.8	P_3 Tr	25.5	29.3
P^2 Tr	40.2	38.6	P_4 A–P	49.9	46.3
P^3 A–P	34.6	38.6*	P_4 Tr	30.0	31.4
P^3 Tr	49.3	46.1*	P_2–P_4		117.5
P^4 A–P	37.9	49.8*	M_1 A–P	49.3	50.6†
P^4 Tr	53.8	46.5*	M_1 Tr	35.5	31.7†
P^1–P^4	150.0		M_2 A–P	59.0	62.0
P^2–P^4	104.3	116.1*	M_2 Tr	34.8	37.7
M^1 A–P	46.2		M_3 A–P	60.7 (approximate)	
M^1 Tr	54.8		M_3 Tr	32.4	34.4
M^2 A–P	52.6		M_1–M_3	174.5 (approximate)	
M^2 Tr	56.9				
M^3 A–P	55.1				
M^3 Tr	53.5				
M^1–M^3	155.5				

* Crushed.
† Crushed laterally and spread apart antero-posteriorly.

the Gering formation is yet to be determined. These beds are those called, "Rosebud beds," by Gidley (1904). The name, "Wounded Knee fauna," has been proposed by Macdonald (in press) to replace the names, "Lower and Upper Rosebud Faunas" of Matthew (1907). I support this change wholeheartedly.

The presence of *D. armatum* from the middle and upper portion of these Gering-like deposits suggests a correlation with the fossiliferous vertebrate beds of the John Day



TEXT-FIG. 9—*Diceratherium armatum* SDSM No. 53484, left lower jaw, lingual side; P_2 drawn in reverse from right side. $\times\frac{1}{2}$.

formation. The type of *D. armatum* is from the John Day. This correlation has been suggested by Green (1954) as opposed to the suggestion of Schultz and Falkenbach (1949) that the John Day is correlative with the Harrison formation basing their conclusion on oreodon phylogeny. Unfortunately, the precise stratigraphic position of John Day specimens, particularly old types, is not known. One reason for the diametrically opposed opinions on correlation of the John Day with Great Plains deposits is that the John Day may encompass a greater time span than has been suspected and Gering through Harrison equivalents may exist within the confines of the John Day formation.

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MANUSCRIPT RECEIVED NOVEMBER 12, 1957.