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LATE MIOCENE BEAVER FROM SOUTHEASTERN MONTANA

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The geologic age of the youngest consolidated formation of southeastern Montana and northwestern South Dakota has never been established. One of the problems that I undertook for the field season of 1941 was to determine the age of this 200-foot, cliff forming sandstone, which overlies the White River series and caps Slim Buttes and Short Pine Hills in Harding County and Castle Rock and Deer Ears Butte in Butte County, South Dakota, and Chalk Buttes, Long Pine Hills, Ekalaka Hills, and smaller mesas in Carter County, Montana. (For maps see Bauer, 1924; Perry, 1935; Kirby, 1932; Rothrock, 1937.) These beds were first recognized by Todd (1895) in South Dakota. He considered them as "doubtless of the Loup Fork age," though without tangible evidence. Following Darton (1909), they have always been called either "Arikaree" or "Arikaree (?)," chiefly because they overlie the White River, like the type Arikaree in northern Nebraska and the comparable deposits of southern South Dakota. After the usual lack of success in attempting to collect fossils in these deposits, in northwestern South Dakota, I was delighted to discover (on June 30, 1941) an unidentified rodent jaw, obviously of late Tertiary aspect, in the museum of the Carter County Geological Society at Ekalaka, Montana. This specimen had been collected in 1914 by Mr. Thorvald Senrud, a local ranchman, on top of "Fighting Butte" (also known as "Starvation Butte" or "Poverty Butte"), a small outlier, not shown on any published map, at the northwest tip of fish-hook-shaped Chalk Buttes, just off the barb. Mr. Senrud presented this specimen to the Geological Society Museum in June, 1939. In view of the scientific value of including the specimen in a large research collection, the Carter County Geological Society has generously presented it to the American Museum of Natural History.

State Senator Walter H. Peck, Director of the Museum of the Carter County Geological Society, courteously lent me this specimen for study and authorized its transfer to the American Museum of Natural History. Miss Idella Kennedy, of the Society, guided me to the Fighting Butte locality, which she had previously visited with Senator Peck. Dr. Florence Dowden Wood collaborated with me in the field and made the accompanying illustrations with the assistance of Mr. John C. Germann. Lt. Col. Albert Elmer Wood offered suggestions at various stages of this study and read the manuscript critically. The field work was assisted by the Penrose Fund of the Geological Society of America, project grant No. 389/41.

Although, morphologically, this specimen can speak for itself, its stratigraphic significance depends on the authenticity of the locality. Senator Peck's good faith and competence are known to all his friends in vertebrate paleontology, and he vouches for Mr. Senrud's reliability. Senator Peck, with his customary methodical approach, revisited the locality with Mr. Senrud, who pointed out exactly where, on top of the butte, he had found this jaw (loose, according to Senator Peck's recollection).

Since then, a rock fall has changed the top of Fighting Butte from being merely difficult of access to being inaccessible (except for a mountaineer with special equipment), but the cap rock is clearly the same as that of the adjoining Chalk Buttes, and agrees with the adhering matrix remnants of the beaver jaw. I found a loose slab in the debris of the rock slide, apparently of the cap rock and definitely not of the underlying Brule, containing unidentifiable fragments of fossil bone and teeth, suggesting that this locality is a little less unfossiliferous than the rest of the formation.

A severe critic can readily imagine possibilities of error. Up to a generation ago, Indian skeletons and artifacts were still numerous on top of Fighting Butte, marking the site of a battle and siege between two Indian tribes, which resulted in the eventual death of the besieged group and gave the butte its name. This fossil might have been in the medicine bag of one of the dead Indians; or a later curio hunter could conceivably have picked it up elsewhere, and then left it on top of the butte; Mr. Senrud might have obtained it elsewhere and become confused about it (although this seems hardly likely, in view of his precise recollection). All of these and other objections, however, conflict with the following considerations. There is no higher formation from which this specimen could have been washed or otherwise brought down. A rodent of late Miocene affinities could not have been carried up from the Oligocene White River, which is the next older unit exposed anywhere in the area, still less from any older formation. There are various remnants of the matrix adhering; in particular the pulp cavity of the incisor is filled with a fine light gray sandstone, which agrees lithologically with the finer grained parts of the Carter County "Arikaree." The only bed that could possibly be of the right age to contain this rodent, within at least 200 miles in any direction, is the "Arikaree" cap rock itself. In view of all these circumstances, and since no one had previously suspected the correlative significance of this specimen, it would be an extraordinarily improbable coincidence if either an Indian or anyone else had brought this specimen some hundreds of miles and then left it on one of the relatively minute remnants of this lithologically suitable formation of, possibly, the correct age. Certainly, the principle of parsimony would make us assume that the jaw is actually from the cap rock, hence assigning an age of either upper Miocene (Barstovian) or thereabouts, thus, in essentials, returning to Todd's guess. These deposits may now be considered the northernmost outliers of the Ogallala group, but, in view of the distance from any other outcrops of the Ogallala and of the lithological distinctness of this cap rock, it will probably be desirable to distinguish it as a distinct unit. Except for the Flaxville gravel of northern Montana (Collier and Thom, 1918) and the Wood Mountain gravels of Saskatchewan (Sternberg, 1930) to which this consolidated cliff forming sandstone shows little resemblance, this is by far the northernmost deposit of this general age in the Great Plains area (Wood *et al.*, 1941) and helps to enlighten our previous ignorance regarding the geological history of the northern plains between the Oligocene and Pleistocene.

ORDER RODENTIA

Family **Castoridae**

Monosaulax senrudi, new species

Figure 1

TYPE: A.M.N.H. No. 39415. Greater part of left ramus mandibuli, with P_4 and M_{1-3} essentially intact, and the base of the incisor.

HORIZON: About Barstovian (upper Miocene).

LOCALITY: On top of Fighting Butte, at the northwest tip of Chalk Buttes, section 30, Township 1 South, Range 57 East, Carter County, Montana, about 22 miles from Ekalaka by road and trail, but about 14 miles southwest of it by air, and about 3 miles beyond the Poncelet Ranch, C.C.G.S. Locality No. V-39-6.

DIAGNOSIS: Size and evolutionary stage intermediate between *Monosaulax* and *Amblycastor;* fine, slightly divergent striations on the convex enamel face of the incisor; posterior end of incisor definitely lingual to the coronoid process; cheek teeth almost hypsodont; internal end of hypoflexid interpolated between mesofossettid and metafossettid; fossettids (enamel lakes) usually simple and nearly transverse; P_4 considerably longer than any of the molars, mesio-distally; M_2 the widest of the cheek teeth, bucco-lingually; M_3 definitely the smallest cheek tooth; coronoid process more prominent and distinct than in either *Amblycastor* or *Monosaulax.*

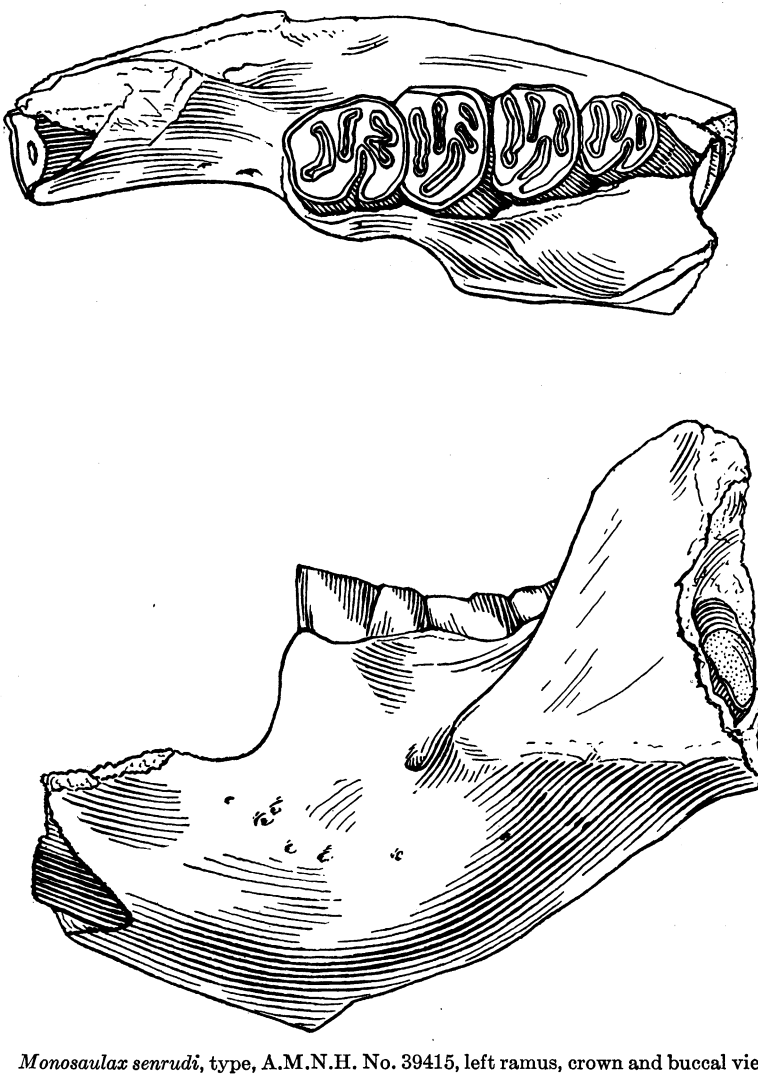

Fig. 1. *Monosaulax senrudi*, type, A.M.N.H. No. 39415, left ramus, crown and buccal views, × 2.

GENERIC ASSIGNMENT: This is obviously a castorid rodent, showing special resemblances only to *Amblycastor* and *Monosaulax*, from North America, and to "*Steneofiber*" *depereti*, from the French Burdigalian. The Montana specimen shows faint, slightly divergent striations on the enamel face of the incisor almost exactly like those of "*Steneofiber*" *depereti*, A.M.N.H. Nos. 15588 and 22524, from the Sables d'Orléans, but the incisor is more rounded in cross section, and there is no special resemblance in the cheek teeth, since "*S.*" *depereti* is much more specialized, hypsodont, and *Dipoïdes*-like.

Comparisons with *Monosaulax*, especially with *M. pansus*, A.M.N.H. No. 18902, and four mandibular rami lumped as No. 17216, and with *Amblycastor fluminis*, especially A.M.N.H. Nos. 22068 and 18908, are considerably closer. These two genera show the closest analogues to the simple, transversely trending fossettids of the Montana form. The enamel surface of the incisor of *Monosaulax* is smooth, unlike the Montana specimen, but the shape in cross section is similar, as is the size of the geniohyoid pit. All previously described species of *Monosaulax* are markedly smaller than *M. senrudi.* In little-worn *Monosaulax* cheek teeth, the hypoflexid seems to continue the curve of the metafossettid; wear would make it closer to, but still distinct from, the Montana specimen. In the other direction, *Amblycastor fluminis* is much larger than the Montana specimen, with heavy parallel grooves on the enamel surface of the incisor, and the incisor is compressed mesiodistally. There are some special resemblances in the pattern of the cheek teeth not found in *Monosaulax pansus,* especially the anterior concavity of the parafossettid and a tendency for the metafossettid to be twinned, although the metafossettid of *M. pansus* does not show the distortion found in the anterior teeth of the Montana form. The hypoflexid continues the curve of the metafossettid in A.M.N.H. No. 22068; on the other hand, in A.M.N.H. No. 18908, it projects lingually between the mesofossettid and metafossettid, much as in *M. senrudi.* The geniohyoid pit is less prominent in *Amblycastor fluminis,* and the coronoid process is relatively smaller and less sharply modeled. In A.M.N.H. No. 22068, the posterior end of the incisor is well outside (buccal to) the plane of the coronoid process, but in A.M.N.H. No. 18908, it is nearly in the same plane as the coronoid process, and thus much closer to the Montana specimen.

Altogether it is clear that there are significant resemblances to (as well as real differences from) both *Monosaulax* and *Amblycastor.* I originally intended to call this a small, primitive species of *Amblycastor;* however, Lt. Col. A. E. Wood considers the assignment to *Monosaulax* more convenient, although we suspect that a more complete specimen would be generically distinct from any known form. I have been glad to be guided by his special knowledge of the Rodentia. The intermediate position between *Monosaulax* and *Amblycastor,* in both size and structure, may indicate a more or less intermediate phyletic stage, tending to associate these two genera more closely than Stirton (1935) apparently considered probable.

DESCRIPTION: The jaw is thoroughly infiltrated and quite strong. Remains of a thin limonitic film are attached to various parts of the jaw and teeth. A number of larger quartz grains stand out in the adhering remnants of a fine sandstone matrix. All the bone behind M_3 is lost, thereby exposing the broken tip of the backward directed posterior root of M_3 and the open pulp cavity of the incisor, directly under the rear border of M_3. The mental foramen is ventral to the rear of the diastema. The anterior border of the symphysis is a straight slope to the rear, with a ventral projection, as in beavers generally. A fair-sized pit, just behind the rear border of the symphysis, doubtless lodged the insertion of the geniohyoid muscle. The crown of the incisor is broken off flush with the alveolar border, forming a cross section with the shape of a rounded isosceles triangle. The enamel face of the incisor carries fine striations as in *"Steneofiber" depereti,* making a surface which seems almost smooth in comparison with the coarse striations of *Amblycastor.* (Previously described species of *Monosaulax* have entirely smooth incisors.) The row of cheek teeth is inclined lingually, out of the plane of the jaw, as in other beavers. The animal was presumably an individual in fairly late maturity, as the teeth are worn down until the root divisions are in sight; for the same reason, the pattern remnants of the crown are relatively simplified. (Stirton's convenient terminology [1935] is followed.) The three valleys on each tooth which, in less worn teeth, would have lingual outlets are isolated on each tooth as the parafossettids, mesofossettids, and metafossettids; the single valley with a buccal outlet still escapes freely on P_4 and M_3, and barely on M_2, as a hypoflexid; it forms an isolated hypofossettid on M_1. P_4 shows a faint median vertical groove on the anterior (mesial) surface, and a sharper groove, the hypostriid, down the buccal surface from the hypoflexid; its parafossettid is concave anteriorly. The metafossettid shows a tendency to be twinned in the mesial members of the series: on P_4, it has the shape of a compressed Z; on M_1, at this stage of wear, it is separated into two lakes which are off-set; on M_2, this condition is incipiently suggested by a wavy metafossettid. All the other fossettids are rather simple, flattened loops, trending transverse to the tooth row. There is considerable interproximal wear (cf. Wood, 1938) between the cheek teeth, chiefly from the tooth in front grinding into the tooth behind it. It would appear that M_1 has ground through the enamel on the anterior (mesial) surface of M_2, and M_2 through that of M_3, after which some dentine was worn away. As an alternative interpretation, it is possible that enamel had never been deposited on the anterior (mesial) surfaces this close to the roots of the teeth (cf. A. E. Wood, 1940, fig. 116). X-rays of the specimen, courteously furnished by Dr. Ramsay Spillman, do not point conclusively to either interpretation, but such evidence as exists is in favor of originally continuous enamel. Another, and possibly more decisive, line of evidence is the profile, along the median line of the tooth, of the most anterior portion of the dentine surface of the crown. It is concave superiorly, indicating previous partial protection from attrition (i.e., by enamel) both mesially and distally, with not enough wear since the removal of the enamel from the mesial surface of the tooth to alter the profile essentially. When, however, a rodent tooth has lacked this protection for the mesial surface from the start of coronal attrition, the corresponding profile is a convex curve forward and upward, that is, the mesial and crown surfaces merge into a curve at the edge, presumably due to the attrition of food, in particular, striking the dentinal edge from both directions. The most striking of all the effects of interproximal wear is the deep concave recess which P_4 has ground into the anterior (mesial) surface of M_1.

Geologic Inferences: It has already been pointed out that the assignment of this species to *Monosaulax* is largely a matter of convenience and is open to considerable doubt. Nevertheless, whether this is really a specialized *Monosaulax*, or a primitive *Amblycastor*, or a borderline species, or a new genus related to both, it would still indicate an age that could hardly be far from late Miocene (i.e., Barstovian), and would strongly oppose any assignment to the lower Miocene, whether to the Arikaree group proper or to Arikareean time. Therefore, the late Miocene sandstone of Harding and Carter counties can be thought of as the only known northern remnant of the thin Ogallala veneer, which is still spread so widely over the Great Plains, farther south. One would assume that much or all of the intervening area was

Measurements of Type of *Monosaulax senrudi* in Millimeters

Length I_1 root, along outer curve	149 (est.)
Diastema	14.7
P_4–M_3, greatest length, mesio-distally	25.9 (actual)
M_1–M_3, greatest length, at base of crown	17.8 (actual) 18.1 (est.)[1]
P_4, greatest length (crown)	8.2
P_4, greatest width (crown)	6.9
M_1, greatest length (crown)	5.2 (actual) 6.1 (est.)[1]
M_1, greatest width (base of crown)	7.3
M_2, greatest length (crown)	6.1
M_2, greatest width (crown)	6.7
M_3, greatest length (base of crown)	5.9 (crown, 5.5)
M_3, greatest width (crown)	5.7
Depth jaw below P_4, buccal surface	22.0
Depth jaw below P_4, lingual surface	19.3
Depth jaw below M_3, buccal surface	17.9
Depth jaw below M_3, lingual surface	14.0
Length of symphysis	20.2

[1] Although a good-sized embayment has been ground into the anterior face of M_1 by interproximal wear against P_4, it is possible to estimate closely what the original contour must have been.

covered with this Ogallala veneer in the late Tertiary, but that it has since been stripped off. The considerable time interval between the Oligocene White River series and the upper Miocene, at Slim Buttes, South Dakota, leaves time for local diastrophism and peneplanation (Wood, 1942) as an alternative to the hypothesis of large scale slumping, which seems generally accepted currently (Toepelman, 1923).

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