First Bat (Mammalia: Chiroptera) Reported From The Oligocene Of North Dakota

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Abstract

The reported vertebrate fauna of the Brule Formation within North Dakota is largely based on preliminary faunal lists presented without detailed discussion. An effort is underway to refine our knowledge of that fauna, including a thorough review of the microvertebrates collected in the Little Badlands area (Stark County, North Dakota) and held within the North Dakota State Fossil Collection (NDGS). We report a right maxilla fragment with P4-M3 (NDGS 1691) collected from the Fitterer Ranch locality. The labial edges of M1 and M2 are damaged, but the size (tooth row length 5.11 mm) and overall morphology (M1-2 lack a hypocone; M3 with reduced parastyle,and mesostyle, no metacone, metastyle, or metacristae; P4 non-molariform, unicuspate and triangular) of this new specimen compares favorably with *Chadronycteris rabenae*, which was previously known only from a left maxilla fragment with P4-M3 collected from the Raben Ranch local fauna of northwestern Nebraska (Chadron Formation). Taxa found in association with NDGS 1691 include *Eumys elegans*, *Leptomeryx* cf. *evansi*, *Paradjidaumo trilophus*, and *Palaeolagus haydeni*, indicating that these specimens are referable to the middle to late Orellan "age" (Or2-Or4). *Oligomyotis casementi* is the only bat taxon definitely reported from the Oligocene of North America; however, the type and only known specimen consists of the distal portion of a humerus that cannot be compared to any known material of *Chadronycteris*. This new occurrence not only extends the geographic and biostratigraphic range of *Chadronycteris*, but fills an important gap in our current understanding of early chiropteran evolution.

Introduction

A chiropteran right maxilla (P4-M3, NDGS 1691) was recovered from the Brule Formation, Fitterer Ranch Natural Area locality, Stark County, North Dakota. The jaw was discovered by the authors during routine maintenance of the North Dakota State Fossil Collection. The exact date of collection is unknown but was likely collected during the 1990s by Dr. John W. Hoganson, North Dakota Geological Survey Emeritus Paleontologist.

The Fitterer Ranch locality has been producing a wealth of White River fossils for more than 70 years. The American Museum of Natural History Frick Laboratory first collected material here from 1944 to 1964 (Hoganson and Lammers, 1992). After this initial surge of collecting, little work was done in this area for 20 years. In 1984 the Manitoba Museum of Man and Nature along with the North Dakota Geological Survey (NDGS) started intensive study of the White River formations at Fitterer Ranch and other locations in southwestern North Dakota. The NDGS has continued operations at this locality nearly continuously since 1984.

Besides NDGS 1691, only three other genera of bat are known from the Eocene or Oligocene of North America. Ostrander (1983) described a bat left maxilla (P4-M3) from the Chadronian of Nebraska Raben Ranch (*Chadronycteris rabenae*) (Figure 1). Galbreath (1962) described a distal left humerus from a bat from the Orellan of northeast Colorado (*Oligomyotis casementi*) (Figure 2). That specimen is now thought to be lost to science (Czaplewski et al., 2008). *Wallia scalopidens* (Storer, 1984) is from the Swift Current Creek Local Fauna from the Eocene of Saskatchewan, is known only from isolated teeth (Figure 3), and is the third Eocene or Oligocene bat from North America. These three genera are the only published bats from the Chadronian or Orellan of North America.

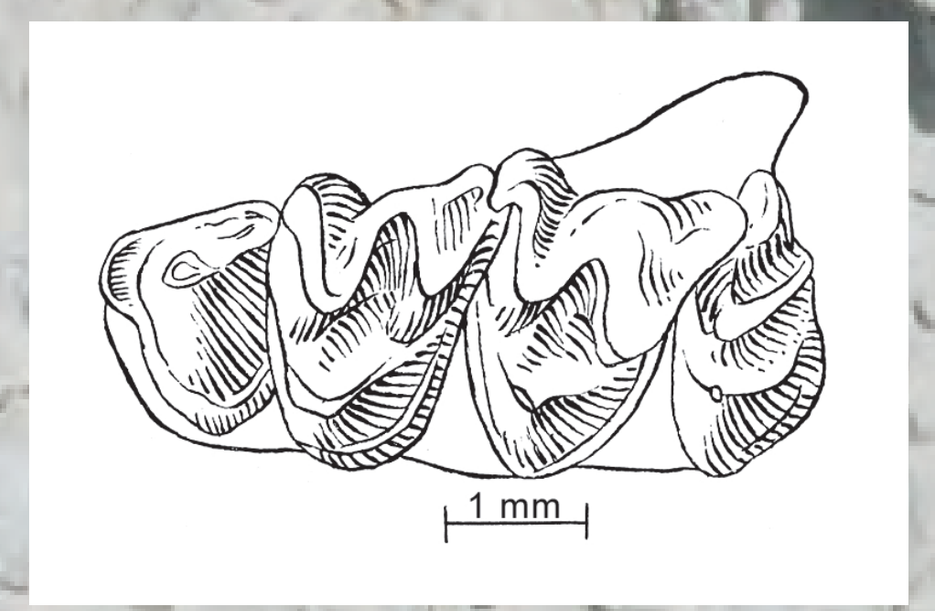


Figure 1. *Chadronycteris rabenae* (SDSM 09931) left maxilla with P4-M3, from Ostrander, 1983. Specimen from Museum of Geology, South Dakota School of Mines and Technology.

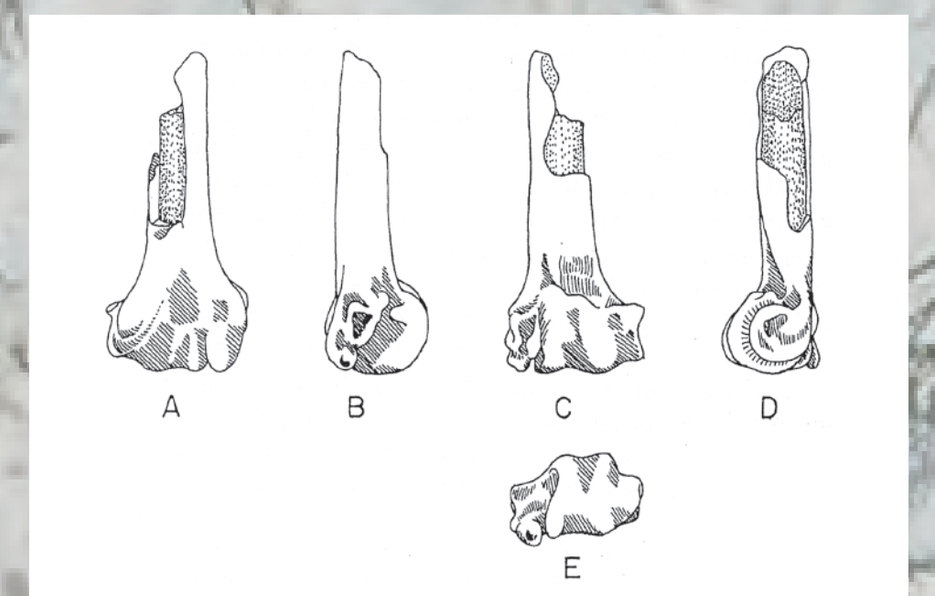


Figure 2. *Oligomyotis casementi* (Southern Illinois University P-418) left humerus in (A) posterior, (B) medial, (C) anterior, (D) lateral, and (E) distal views, approximately 5X, from Galbreath, 1962.

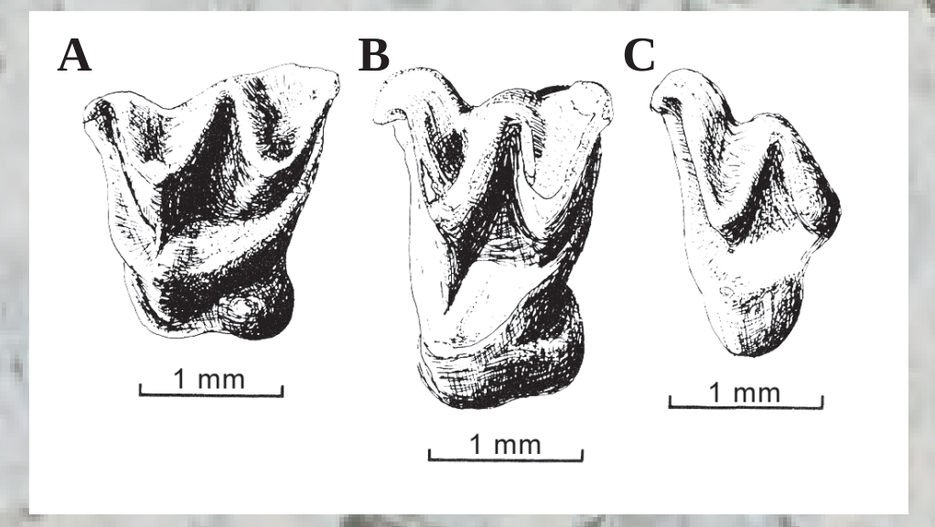


Figure 3. *Wallia scalopidens* (A) left M1, P1654.311, (B) left M2, P1654.313, (C) left M3, P1654.314, from Storer, 1984. Specimens from Saskatchewan Museum of Natural History.

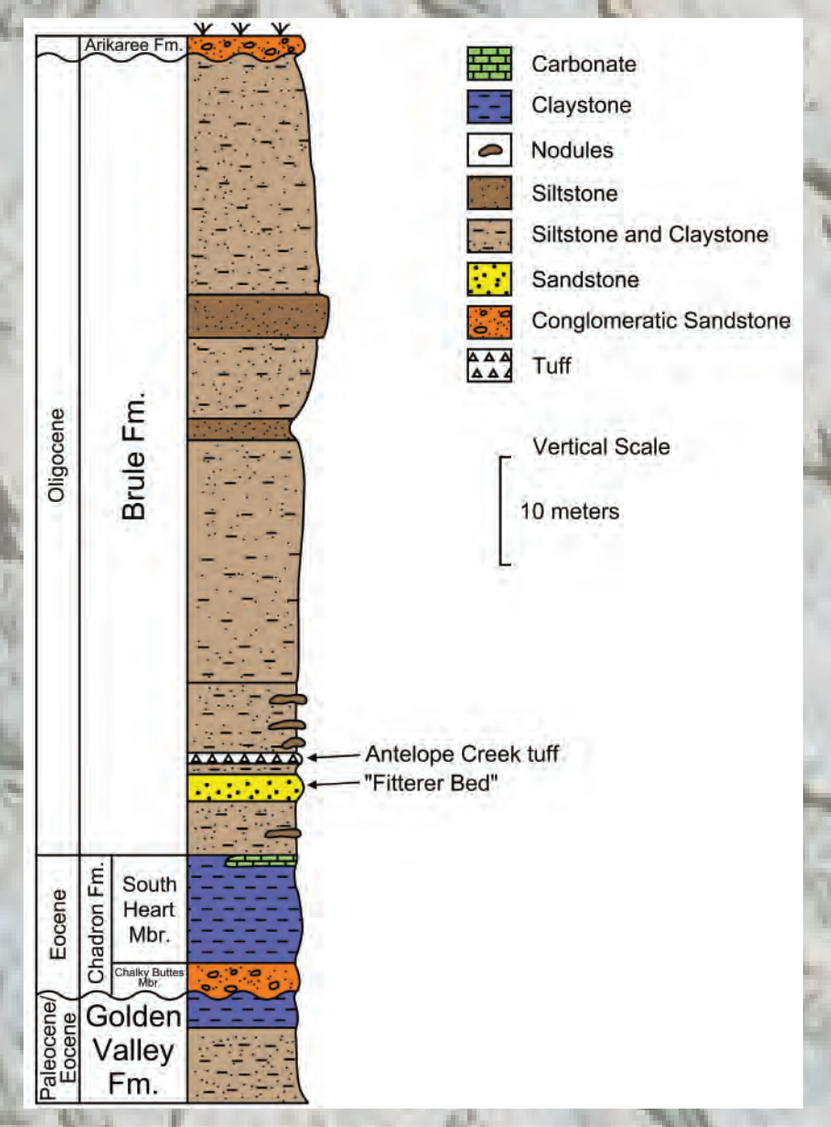


Figure 4. Stratigraphic section of the Fitterer Ranch locality.

Stratigraphy

The Fitterer Ranch locality consists of typical White River siltstones, claystones, mudstones, and sandstones (Figure 4) and is located in Stark County, ND (Figures 5-6). Over 200 feet of continuous Brule Formation section is present at the Fitterer Ranch locality, making it one of the most complete sections of White River Group outcrops in North Dakota (Murphy et al., 1993; Hoganson et al., 1998). The typical haystack buttes of the upper Chadron Formation (South Heart Member) are present at Fitterer Ranch and conformably underlay the Brule Formation; The tops of some of the Brule Formation buttes are unconformably capped by the Arikaree Formation at Fitterer Ranch (Murphy et al., 1993; Hoganson et al., 1998) (Figure 4). The exact stratigraphic position of the NDGS bat within the Brule Formation was not recorded, requiring the use of biostratigraphy to obtain an approximate age of this specimen.

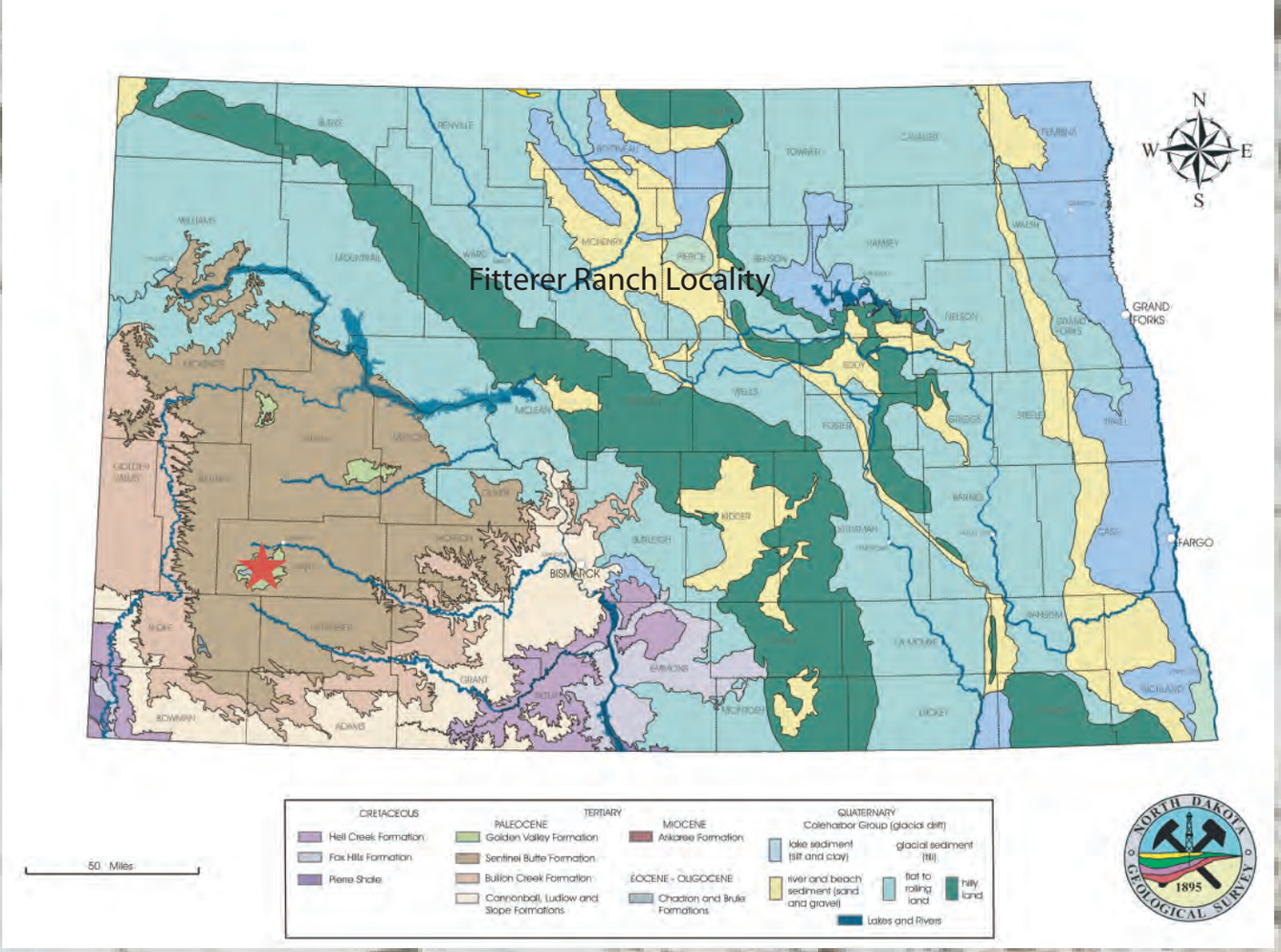


Figure 5. Generalized geologic map of North Dakota. Red star indicates location of Fitterer Ranch locality.

Figure 6. Photo of Fitterer Ranch locality. View is to the northwest.

Biostratigraphy

The Fitterer Ranch locality has been an integral place for deciphering the age of the Brule Formation in North Dakota since the Frick laboratory and Morris Skinner first collected material from there in the 1940s and 1950s (Skinner, 1951). More than 40 years later geologists and paleontologists from the North Dakota Geological Survey and other institutions studied (among other things) the Brule Formation at Fitterer Ranch (Prothero et al., 1983; Hoganson and Lammers, 1992; Murphy et al., 1993; Hoganson et al., 1998). These studies all agree on an Oligocene age for the lower beds of the Brule Formation. Hoganson and Person (2010) suggested an Or4 age for a locality in the lower beds of the Brule Formation at Fitterer Ranch. A Whitneyan age has been suggested for the upper beds of the Brule Formation at Fitterer Ranch (Prothero et al., 1983), but the paucity of fossils from the these beds has restricted a definitive answer.

Fossil specimens found in association with the bat specimen (NDGS 1691) include unidentified Osteichthyes, Reptilia, Canidae, Cricetidae, and Eomyidae. Also found in association were specimens of *Leptomeryx evansi*, *Paradjidaumo trilophus*, *Eumys elegans*, and *Palaeolagus haydeni*. *Leptomeryx evansi* has a FAD in Or1, and *Leptomeryx* last occurs at the Whitneyan/Arikareean boundary (Prothero and Emry, 2004). *Eumys elegans* is a characteristic taxon of Or2 and *Eumys* last appears at the Whitneyan/Arikareean boundary (Prothero and Emry, 2004). *Paradjidaumo trilophus* is a long occurring species and is known from the Duchesnean (Tabrum et al., 1996), and last appearing in Or4 (Prothero and Emry, 2004). *Palaeolagus haydeni* first occurs in the Chadronian (Evanoff, 1992) and last appears in Ar2 (Albright et al., 2008). All of this information allows us to conservatively bracket the age of the bat to Or2-Or4 (Figures 7-8).

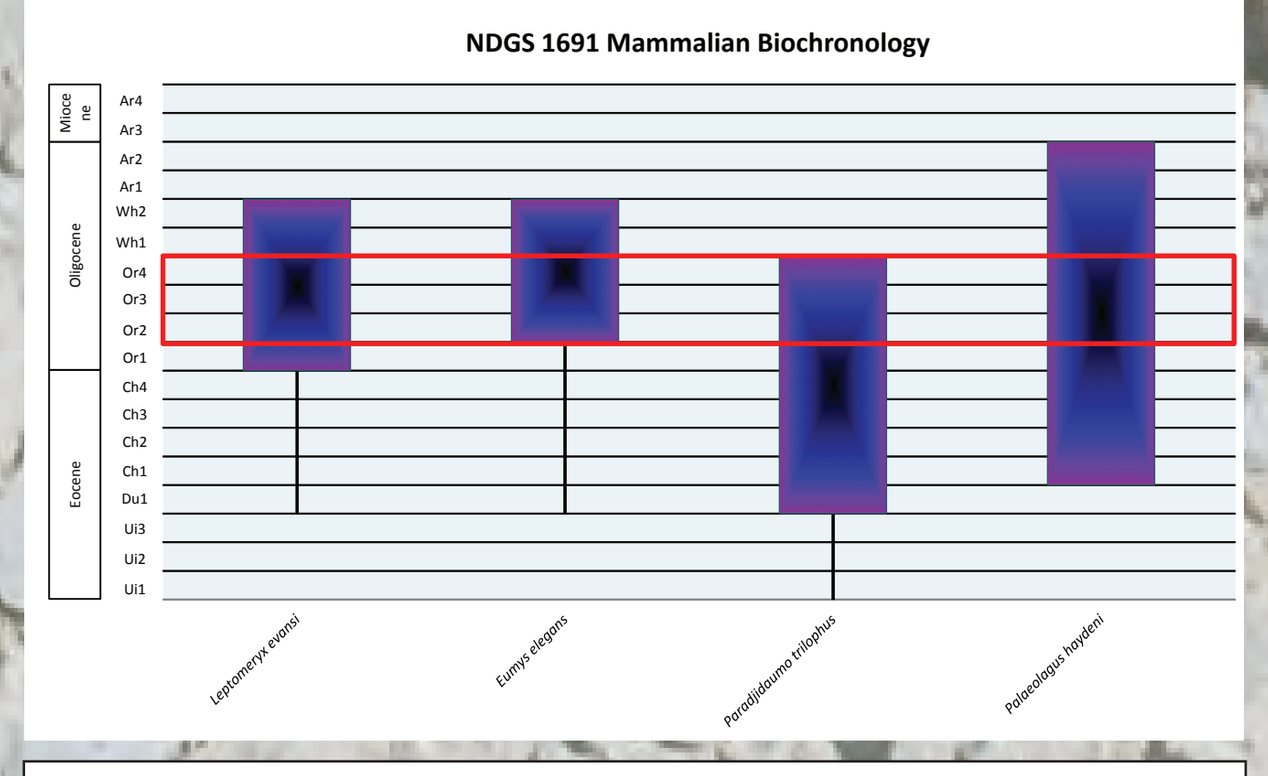


Figure 7. Age of the material found in association with NDGS 1691. This chart shows the biostratigraphic ranges of known mammalian taxa from the site and mammal intervals. Lines are ranges of genera and boxes are ranges of species. Red box indicates interpreted age of NDGS bat specimen.

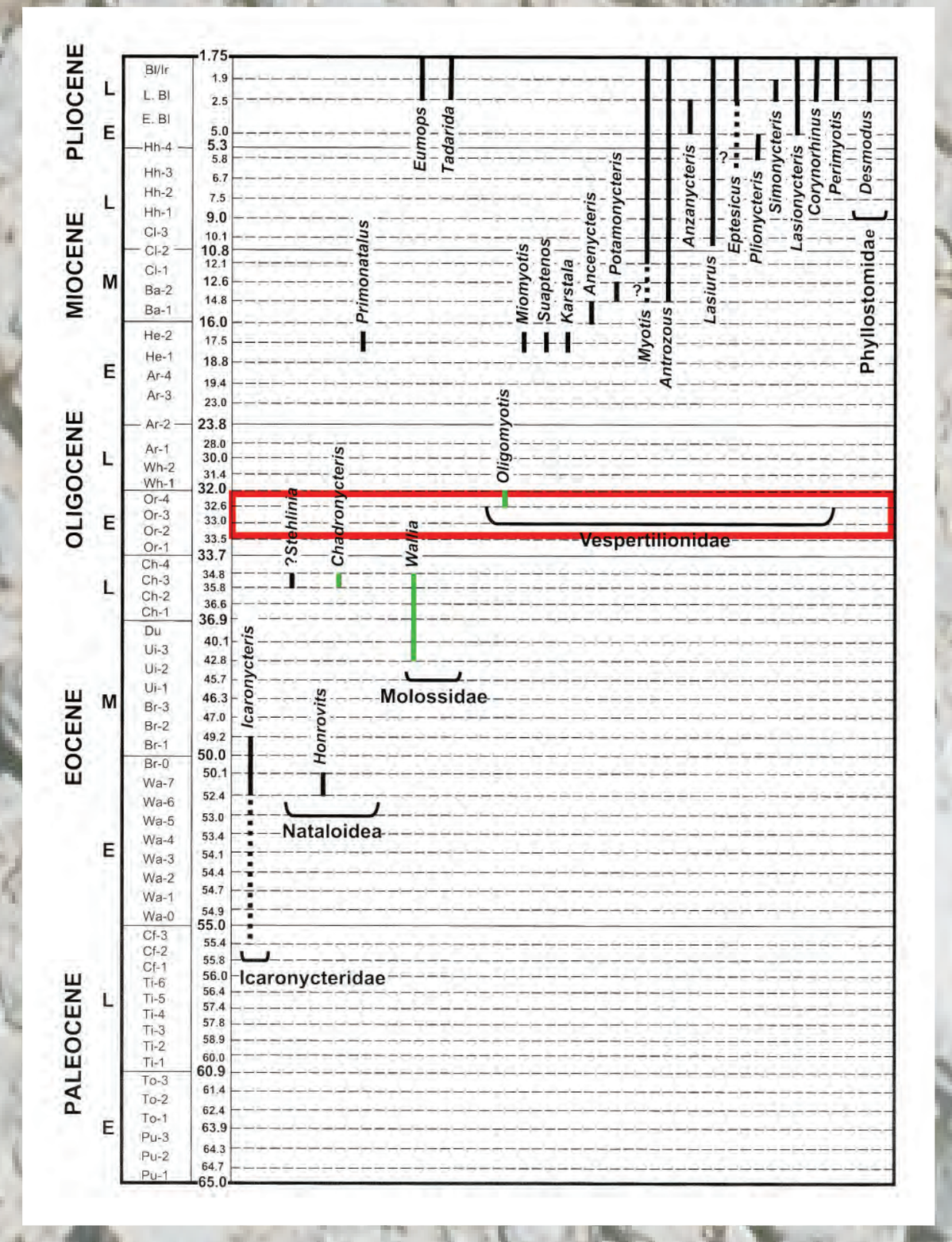


Figure 8. Biostratigraphic chart of published Chiroptera specimens modified from Czaplewski et al., 2008. Red box indicates interpreted age of NDGS bat specimen. Green boxes highlight North American Eocene and Oligocene bats.

Discussion

Due to the paucity of published Oligocene bat fossils, even a single specimen can add tremendous insight to our understanding of early bat evolution. NDGS 1691 is the second bat from the Orellan, doubling the known fossil record (Figure 8). NDGS 1691 is a partial right maxilla with P4-M3 (Figure 9). Unfortunately, the only other Orellan bat, *Oligomyotis casementi*, is known from a distal humerus (Figure 2) and cannot be compared to any other Chadronian or Orellan bats from North America. Due to the limited availability of fossil bats from the same age, comparisons must be made with much older specimens. Therefore, the most meaningful comparisons are with the North American Chadronian bats *Chadronycteris rabenae* and *Wallia scalopidens*, which are known from a partial maxilla and isolated upper molars (Figures 1, 3, 10).

A more detailed comparison between NDGS 1691 and the known specimens of *Chadronycteris rabenae* and *Wallia scalopidens* is forthcoming. However, even some superficial comparisons can be made with the Ostrander (1983, fig. 2) drawing of *Chadronycteris* (Figure 10C), the Storer (1984, fig. 4D-F) drawing of *Wallia* (Figure 10A), the Czaplewski et al. (2008) descriptions (below) of those corresponding specimens, and listed measurements for all referred specimens (Table 1).

Chadronycteris diagnosis from Czaplewski et al. (2008, p. 181):

> "M1-2 lack a hypocone and talon and with rounded subtriangular occlusal outline; parastyle on the M1 reduced; M3 with reduced parastyle and mesostyle and no metacone, metastyle, or metacristae; P4 nonmolariform, unicuspate, triangular, and three-rooted."

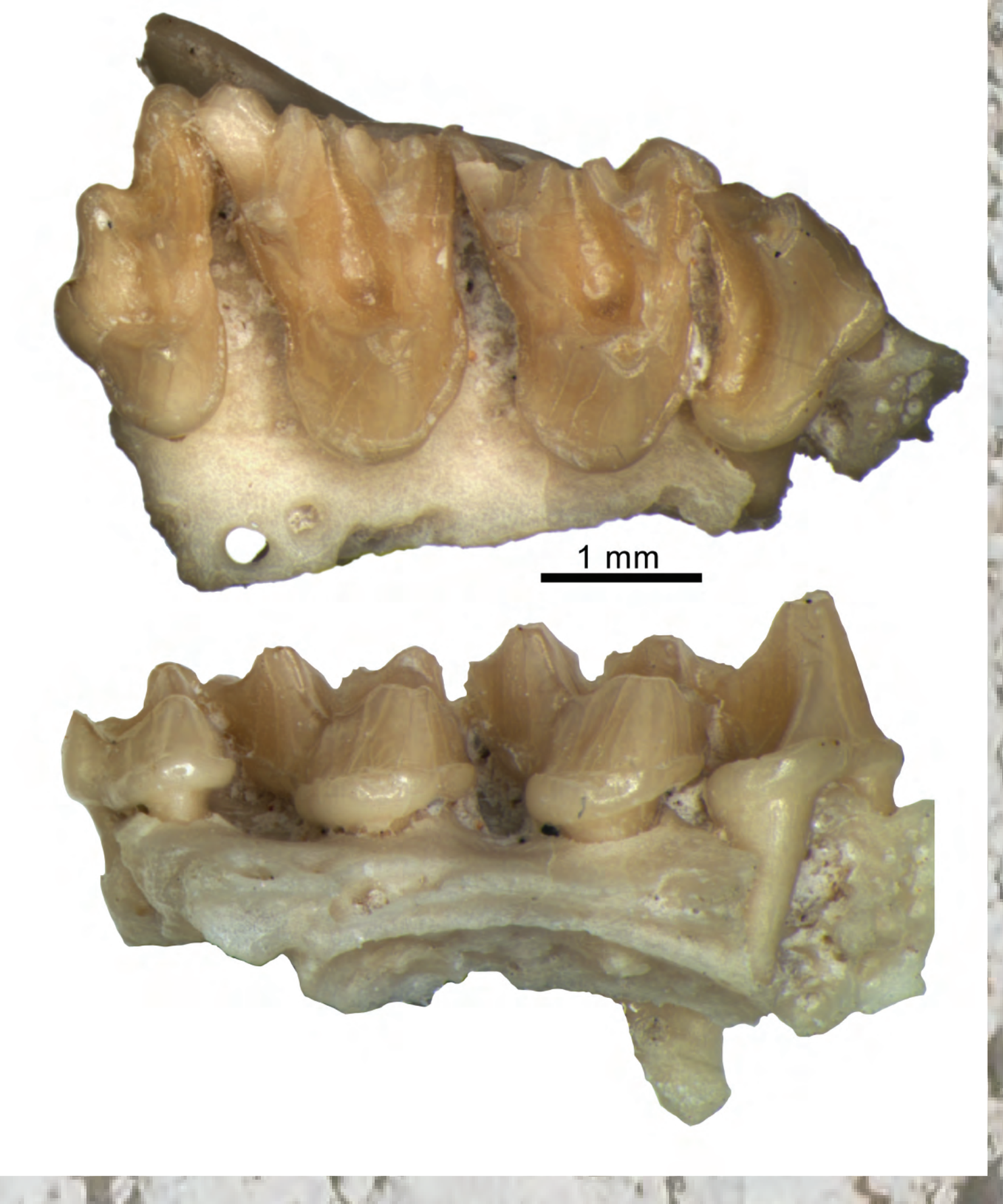
The generic diagnosis of *Chadronycteris* compares favorably with that of NDGS 1691 except for the reduced parastlye on M3 seen in *Chadronycteris rabenae*, as a strong parastyle is present on NDGS 1691.

Wallia diagnosis from Czaplewski et al. (2008, p. 182):

> "Upper molars strongly dilambdodont; preprotocristae extends as a paracingulum to parastyle; M1 and M2 with indistinct para- and metaconule and with large, low, cuspate hypocone not fused to posterolingual wall of postprotocrista; M1 and M2 with lingual cingulum at anterior base of protocone; M3 lacks hypocone, postprotocrista, and postmetacrista."

The generic diagnosis of *Wallia* is a less favorable comparison with NDGS 1691. *Wallia* retains a cuspate hypocone on M1-2 which NDGS 1691 is lacking. The lingual cingulum on M1-2 of *Wallia* is present at the anterior base of the protocone, while it is present along the entire lingual border of NDGS 1691. Finally *Wallia* lacks a postprotocrista, which is present on NDGS 1691.

Although a more detailed study is needed, placing NDGS 1691 within *Chadronycteris* or as a closely related taxon seems more appropriate than within *Wallia* or a related taxon.



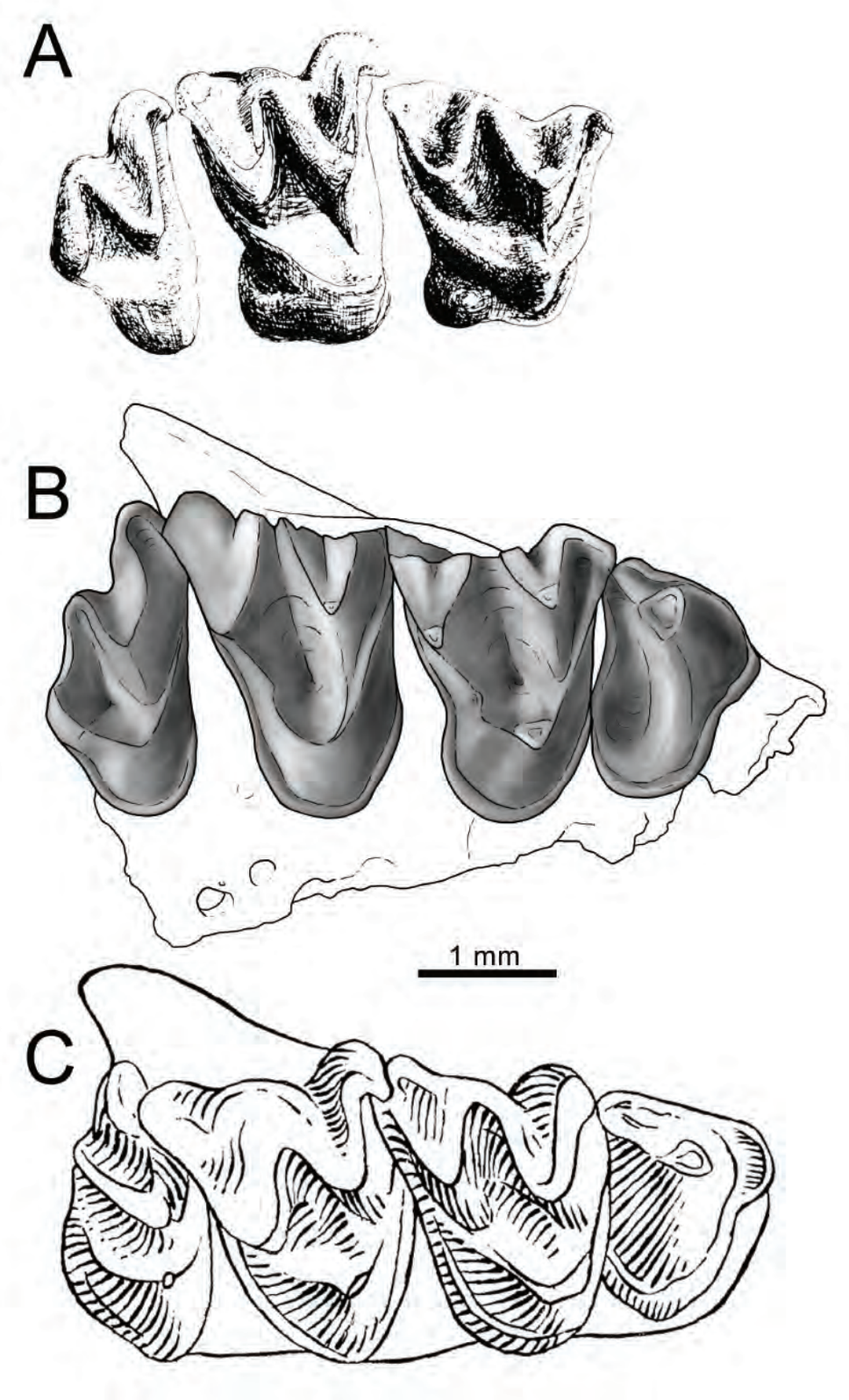


Figure 10. (A) *Wallia scalopidens* M1-M3 (SMNH P1654.311, P1654.313, P1654.314) images are reversed and reoriented from original to make complete maxilla, from Storer, 1984, (B) Chiroptera, right maxilla with P4-M3 (NDGS 1691) drawing by Becky Barnes, (C) *Chadronycteris rabenae* P4-M3 (SDSM 09931) image reversed from original.

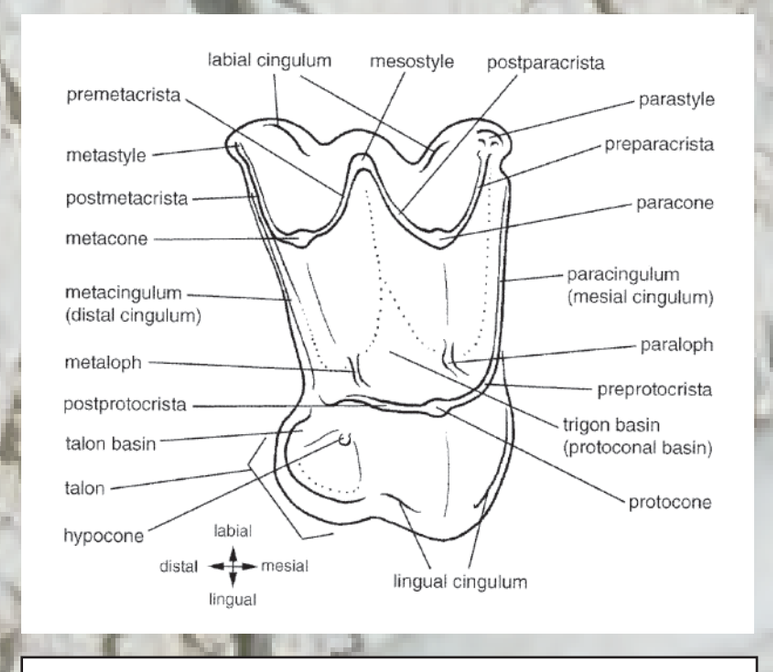


Diagram of tooth morphology used in this study from Czaplewski et al. (2008).

		P4-M3	P4		M1		M2		M3	
		length	length (AP)	width (BL)	length (AP)	width (BL)	length (AP)	width (BL)	length (AP)	width (BL)
Chiroptera incertae sedis	NDGS 1691	5.11	0.97	1.54	1.55*		1.51*		1.05	2.21
Wallia scalopidens	mean (2)				1.61	1.99				
	P1654.313						1.56	2.25		
	P1654.314								1.3	1.95
Chadronycteris rabenae	SDSM 09930				1.59	2.26				
	SDSM 09931	5.14	1.23	1.69	1.54	2.32	1.58	2.4	0.79	2.19
		* = broken edge of tooth								

Table 1. List of measurements taken from referred specimens (*Chadronycteris* from Ostrander, 1983; *Wallia* from Storer, 1984).

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NDGS = North Dakota State Fossil Collection housed at the North Dakota Heritage Center in Bismarck, ND.

SDSM = Museum of Geology, South Dakota School of Mines and Technology, Rapid City, SD.

P = Saskatchewan Museum of Natural History registration number, Regina, Saskatchwan.