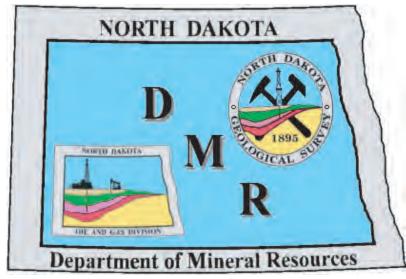


# **TOOTH PUNCTURE MARKS ON A SKULL OF** *DINICTIS* **(NIMRAVIDAE) FROM THE OLIGOCENE BRULE FORMATION OF NORTH DAKOTA ATTRIBUTED TO PREDATION BY HYAENODON (HYAENODONTIDAE)** John W. Hoganson (jhoganso@nd.gov) Jeff J. Person (jjperson@nd.gov) North Dakota Geological Survey, 600 East Boulevard Ave., Bismarck, ND 58505

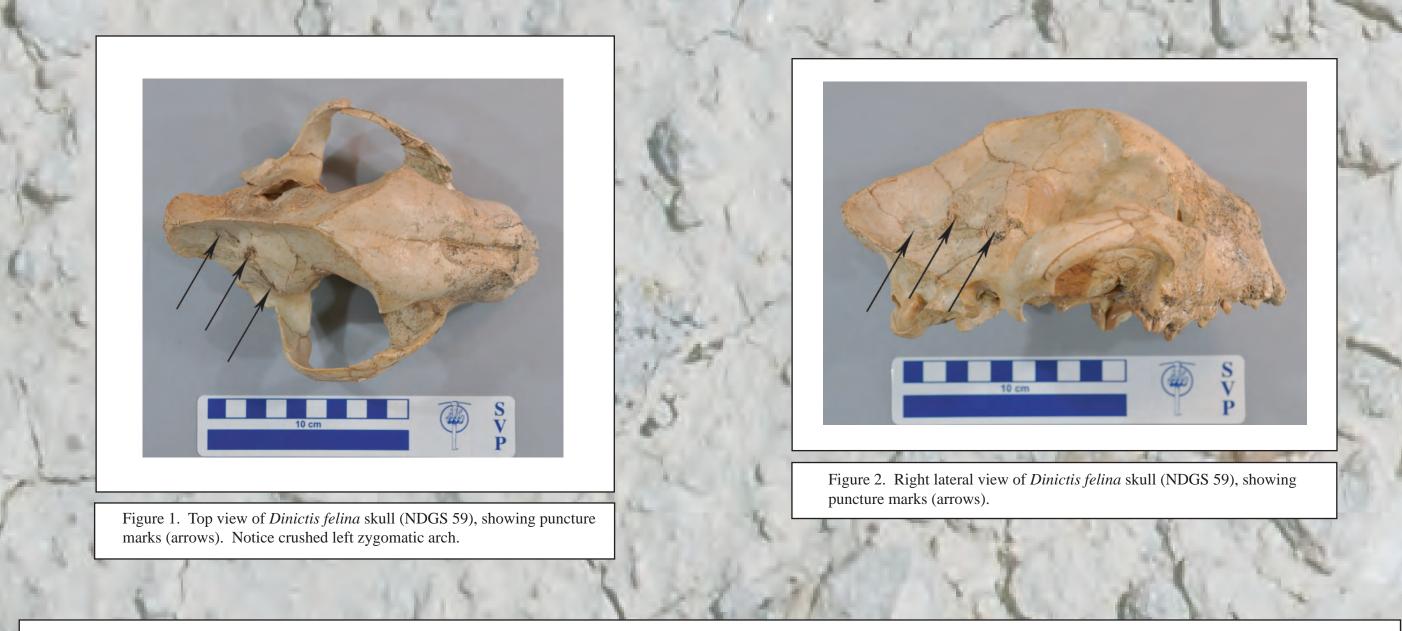


# ABSTRACT

lia: Carnivora: Nimravidae) (NDGS 59) was recovered from a clave siltstone in the lower part of the Oligocene Brule Formation, from a North Dakota registered natural area in Stark County. The right other teeth are broken or have been sheared off at the bone line, and the right zygomatic arch was andible was not recovered. This fossil occurred 5.55 meters above the contact with the South Heart ormation, and 3.15 meters below the Antelope Creek tuff of the Brule Formation. fossils including Mesohippus bairdii and Palaeolagus burkei indicate a latest Orellan (Or4) interval zone (32.5-32.0 Ma). Other associated vertebrates include Stylemys sp., ?Subhyracodon sp., Ischyromys sp., Hesperocyon gregarius, Eumys elegans, Leptictis dakotensis, Leptomeryx evansi, and a small eomyid (possibly Paradjidaumo). Also associated were the gastropod Skinnerelix leidyi, the trace fossil Pallichus sp., and seeds from Celtis sp. During preparation of the Dinictis skull, distinct and well defined tooth puncture marks were noted on the right temporal and parietal bones, with another possible bite mark present on the left parietal, although this latter mark is less distinct because of missing and fractured bone. Three possible gnaw marks are present on the left maxilla, near the orbit and suture with the frontal. No evidence of healing was observed around the puncture marks. Comparisons with other puncture marked specimens are made. Measurements of the geometry of the punctures, spacing between the punctures, and comparison to skulls and dentaries of potential predators indicate that *Hyaenodon* (Mammalia: Creodonta: Hyaenodontidae) was the likely attacker of this *Dinictis*. Although not recovered from this locality *Hyaenodon* is known from the Brule Formation and has been recovered from Stark County.

## Introduction

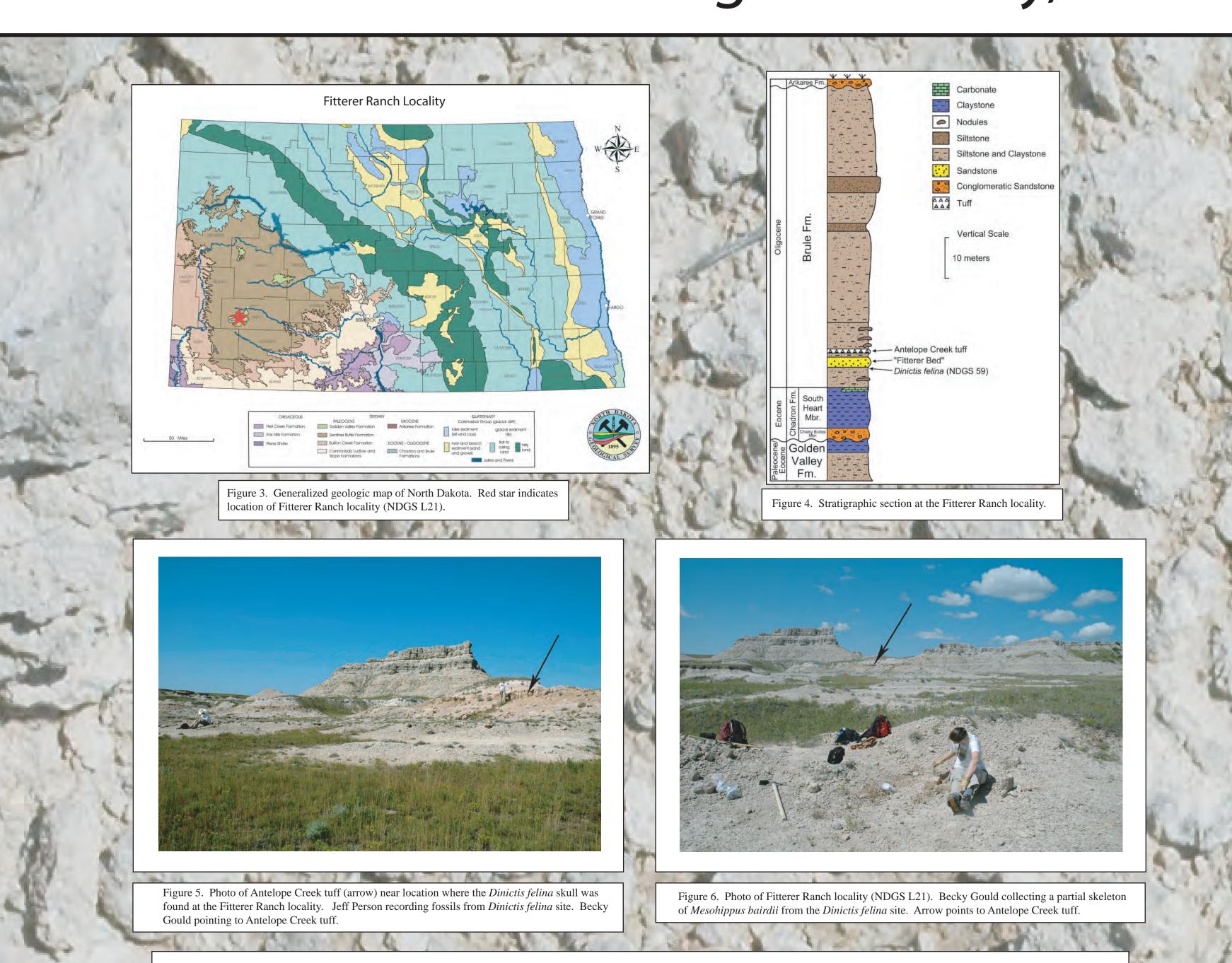
During a comprehensive study to define the lithostratigraphy, paleontology, and biochronology of the Oligocene White River Group in North Dakota, an exquisitely preserved skull of the nimravid *Dinictis felina* (NDGS 59) (Figures 1 & 2) was recovered from the lower Brule Formation at the Fitterer Ranch Natural Area locality (Hoganson and Lammers, 1992; Murphy et al., 1993; Hoganson et al., 1998). The Fitterer Ranch locality was apparently first discovered by an American Museum of Natural History Frick Laboratory expedition to North Dakota led by Morris Skinner. Skinner collected Brule fossils from the Fitterer Ranch locality and other sites in North Dakota from 1944 to 1964. He did not describe the North Dakota Brule fossils and apparently did not collect Dinictis from Fitterer Ranch. Hoganson and Lammers (1992) were first to report Dinictis from Fitterer Ranch based on the skull specimen described here, although they did not identify the specimen to species. Murphy et al. (1993) and Hoganson et al. (1998) also did not identify this specimen to species. Here we confidently assign this skull to *Dinictis felina* Leidy, 1854. Distinct tooth puncture marks were found on this skull during preparation. Morphology and geometry of these punctures suggests that they were caused by a bite or bites from an unknown predator. This prompted our quest to determine the predator that caused the demise of this Dinictis felina.



## Stratigraphy

A complete section of the Brule Formation is exposed at the Fitterer Ranch locality (Murphy et al., 1993; Hoganson et al., 1998) (Figures 3 & 4). The lower part of the Brule consists of pinkish-brown to gray-green complexly interbedded claystones, mudstones, siltstones, freshwater limestones, tuffaceous beds, and crossbedded channel sandstones. The channel sandstones, such as the "Fitterer Bed" are difficult to trace for long distances and usually contain disarticulated mammalian remains (Figures 5 & 6). A useful tuffaceous marker bed in the lower Brule was termed the Antelope Creek tuff by Murphy et al. (1993). The upper part of the Brule Formation at the Fitterer Ranch locality is less variable and consists primarily of alternating siltstones, mudstones, and claystones that are ledge forming. The Brule Formation is about 65 meters thick at this locality.

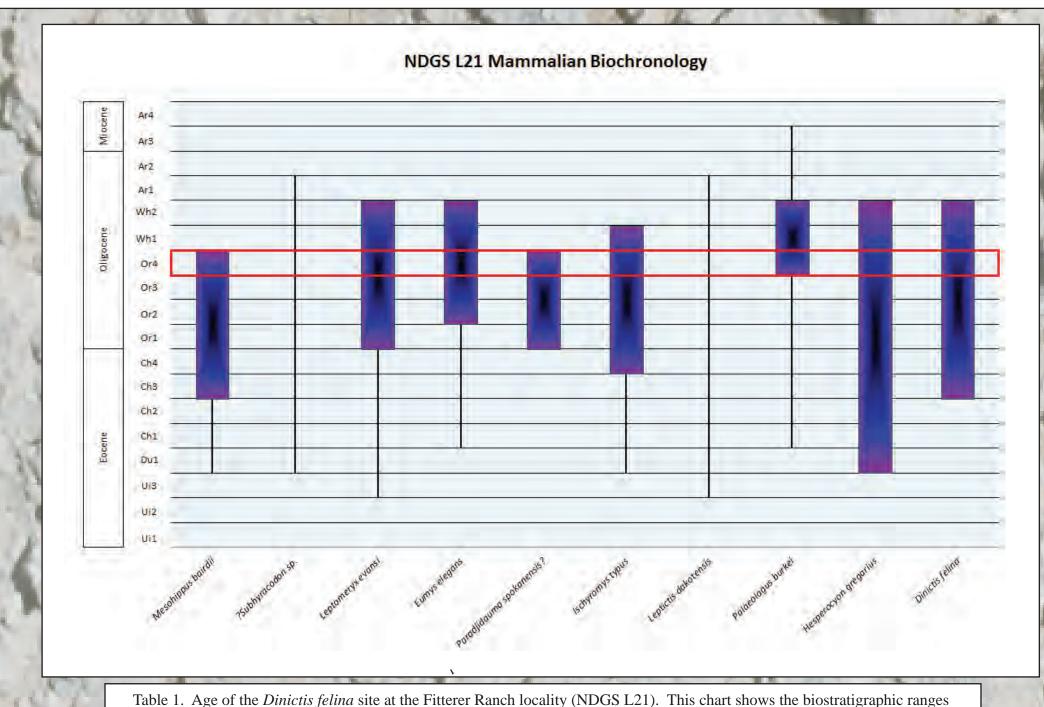
At the Fitterer Ranch locality, the Brule Formation is unconformably underlain by the grey-green claystone of the South Heart Member of the Eocene Chadron Formation and unconformably overlain by a conglomeratic sandstone of the Arikaree Formation.



# **Biostratigraphy**

Skinner (1951) was first to suggest that at least the lower part of the Brule Formation in North Dakota was Orellan in age. This was confirmed by Hoganson and Lammers (1992), Murphy et al. (1993), and Hoganson et al. (1998), mostly based on fossils from the Fitterer Ranch locality. Mammalian fossils are sparse in the upper part of the Brule Formation but a possible Whitneyan age is suggested by meager evidence (Hoganson et al., 1998). Magnetostratigraphic interpretation appears to corroborate an Orellan age for the lower Brule and a Whitneyan age for the upper Brule in North Dakota (Prothero et al., 1983).

The *Dinictis felina* skull under consideration here was found in a Brule Formation clayey siltstone 5.55 meters above the South Heart Member of the Chadron Formation and 3.15 meters below the Antelope Creek tuff. The specimen was found in the Orellan (Or4) interval zone (32.5-32.0 Ma) based on associated fossils including *Mesohippus bairdii* and *Palaeolagus burkei* (Table 1) (Tedford et al., 2004).



# Discussio

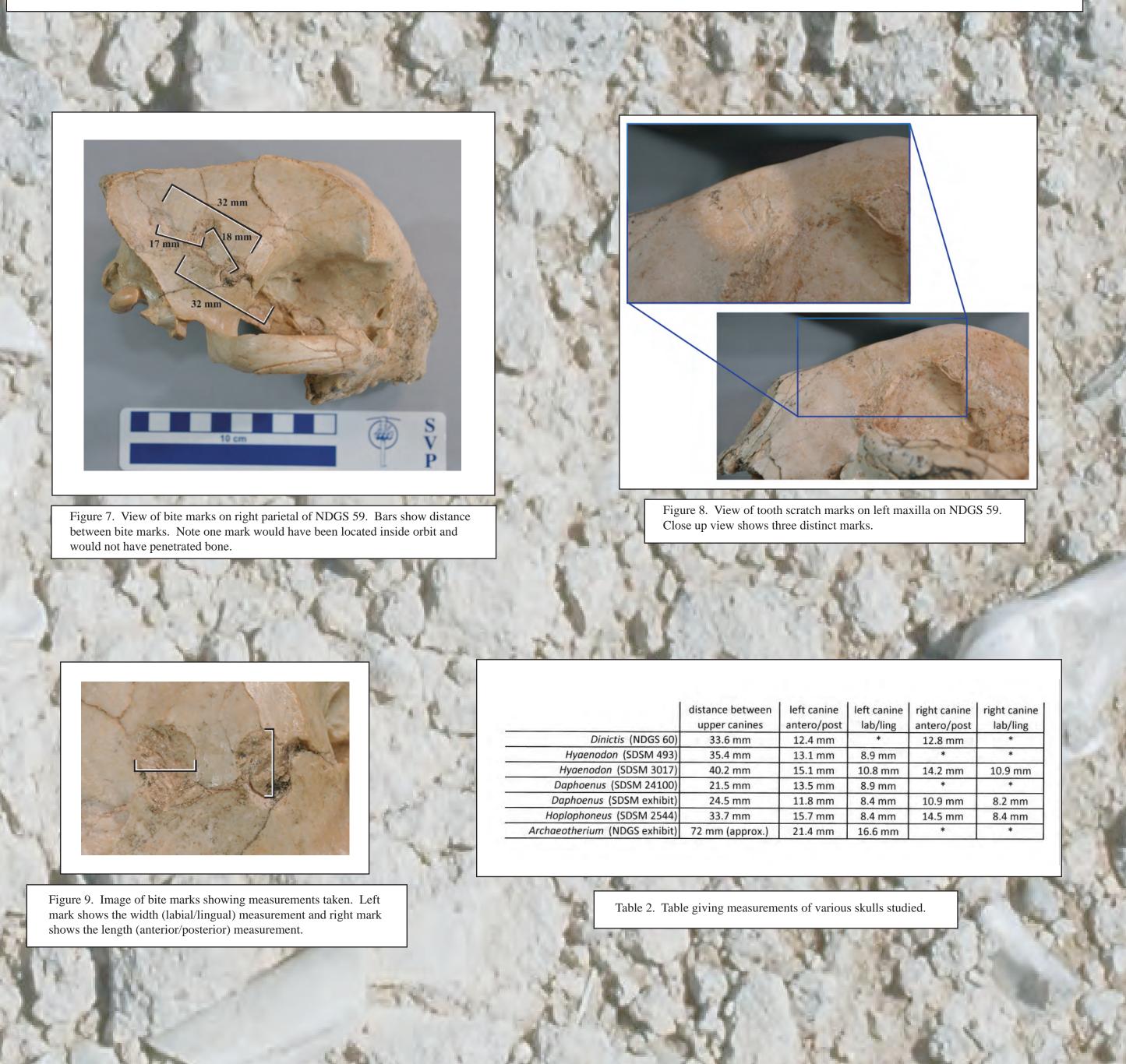
Three distinct and well defined tooth puncture marks are present on the right temporal and parietal bones of this *Dinictia* felina skull (Figure 7). Another possible bite mark occurs on the left parietal, although this mark is less obvious because of missing and fractured bone. Three tooth scratch marks are present on the left maxilla, near the orbit and suture with the frontal (Figure 8). Also, the left zygomatic arch is broken and distorted (Figure 1). We believe the tooth puncture marks, scratches, and broken zygomatic arch reflect an act of predation because it is likely that a scavenger would have concentrated on fleshy areas of the carcass not the skull. There is no indication that the punctures were healing, suggesting that the blow to the skull was fatal.

The posterior bite mark is on the right parietal near the sagittal crest and occipital. This mark is longer than it is wide and is perpendicular to the other two marks visible on this side of the skull. It is 7.3 mm long (anterior/posterior) and 14.0 mm wide (labial/lingual). Unlike the other two marks, this mark is "sunken" producing a depression in the bone, but the bone was not pierced. The ventral portion of the mark has a small asymmetrical concavity giving the mark the shape of a footprint suggesting multiple bites, slipping of the penetrating tooth, or shaking of the skull.

The middle bite mark is located on the right parietal and is the largest of the three. This puncture is 15.9 mm long (anterior/posterior) and 10.0 mm wide (labial/lingual). There are pieces of small crushed bone along the anterior and ventral edges of the mark which are broken concentrically, otherwise the puncture is oval.

The anterior bite mark is located near the right parietal/temporal suture and is the smallest of the three marks. Th puncture is 13.5 mm long (anterior/posterior) and 10.0 mm wide (labial/lingual). There is a piece of small crushed bone along the ventral edge of the mark which is broken concentrically, otherwise the puncture is oval.

To determine the animal that caused these bite marks we compared the puncture marks on our specimen to others reported in the literature, to a skull of *Nimravus* also exhibiting a cranial puncture in the collection of the South Dakota School of Mines & Technology, and by comparing the morphology and geometry of the punctures on our skull to teeth of potential Brule Formation predators. Animals that we considered potential predator candidates were crocodilian, *Dinictis*, Hoplophoneus, Archaeotherium, Daphoenus, and Hyaenodon, all of which have been reported from the Brule Formation in Stark County, North Dakota (Table 2).







We envision that *Hyaenodon horridus* attacked this *Dinictis felina* from the rear on its left side (Figure 10). dispatched the *Dinictis* by multiple bites to the skull. After at least two bites, its upper front canines created two incipient bite marks on the right parietal near the sagittal crest and two crushing and deep penetrating punctures on the right parietal. During the attack, the lower jaw of *Hyaenodon* crushed the left zygomatic arch and lower premolars created scratches on the left maxilla and created another bite mark on the left parietal.

### Acknowledgements

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Figure 10. Authors interpretation of how bite marks were produced on the skull of Dinictis felina by Hyaenodon horridus

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

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