The Fauna from the *Tyrannosaurus rex* Excavation, Frenchman Formation (Late Maastrichtian), Saskatchewan

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Abstract

The quarry that contained the partial skeleton of the Tyrannosaurus rex*, familiarly known as "Scotty," has yielded a diverse faunal and floral assemblage. The site is located in the Frenchman River valley in southwestern Saskatchewan and dates from approximately 65 million years, at the end of the Cretaceous Period. The faunal assemblage from the quarry is reviewed and the floral assemblage is summarized. Together, these assemblages provide some insight into the biological community that lived in southwestern Saskatchewan during the latest Cretaceous.*

Keywords: *Frenchman Formation, Maastrichtian, Late Cretaceous, southwestern Saskatchewan,* Tyrannosaurus rex.

1. Introduction

a) Geological Setting

The Frenchman Formation, of latest Maastrichtian age, is extensively exposed in southwestern Saskatchewan (Figure 1; Fraser *et al*., 1935; Furnival, 1950). The lithostratigraphic units in the formation consist largely of fluvial sandstones and greenish grey to green claystones. Outcrops of the Frenchman Formation are widely distributed in the Frenchman River valley, southeast of Eastend. Chambery Coulee, on the north side of the valley, includes Royal Saskatchewan Museum (RSM) locality 72F07-0022 (precise locality data on file with the RSM), the site that contained the disarticulated skeleton of a *Tyrannosaurus rex*. McIver (2002) subdivided the stratigraphic sequence at this locality into "lower" and "upper" beds. The lower bed consists of a sandstone unit together with a series of thin siltstone and claystone beds or lenses (McIver,

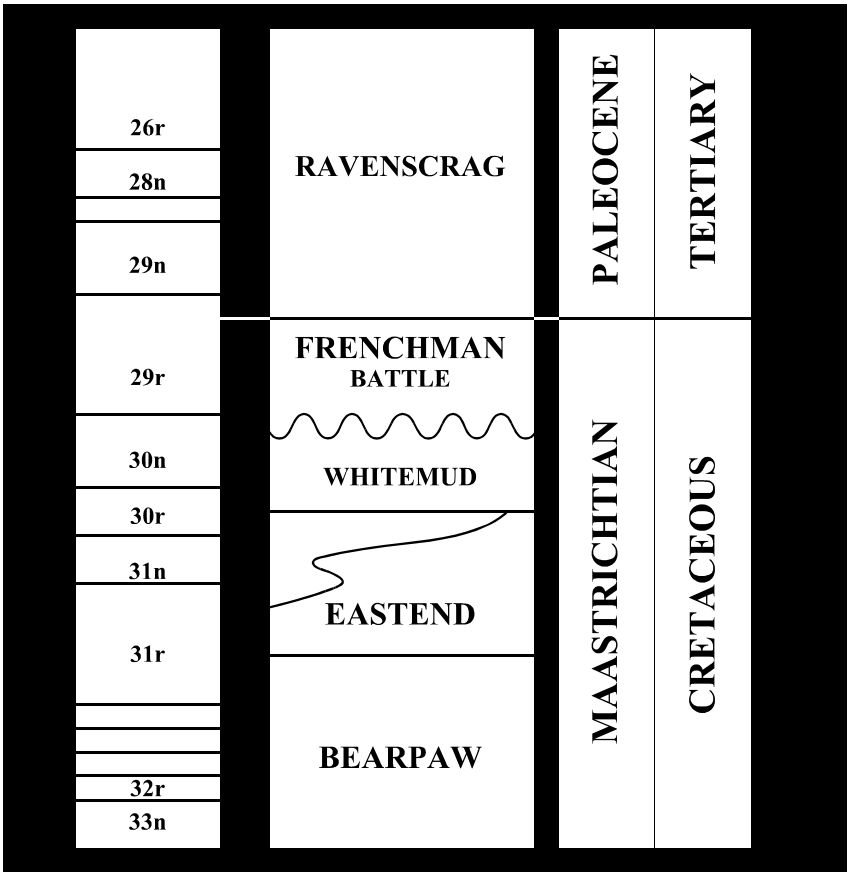

Figure 1 - Paleomagnetic, stratigraphic, and temporal chart of southwestern Saskatchewan (from McIver, 2002).

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2002) and contains the fossils discussed here. Excavation at RSM locality 72F07-0022 has been described by Tokaryk (1997a, 2001, 2002) and McIver (2002).

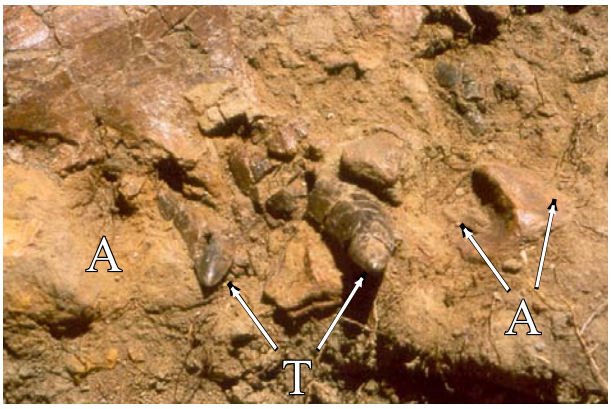

Figure 2 - Maxilla of* Tyrannosaurus rex *(RSM P2523.8) in situ (RSM locality 72F07-0022), summer 1994. Anterior to the right. A, alveoli; and T, teeth (photo credit Royal Saskatchewan Museum).

b) History of Collecting

Chambery Coulee was explored by John Storer and Tim Tokaryk of the RSM in summer 1991. In August of that year, they were joined by Robert Gebhardt, a teacher from Eastend. During exploration of the eastern wall of the coulee, Gebhardt discovered several weathered bone fragments; the initial investigation indicated there were probably more bones *in situ* and that the remains belonged to a large saurischian dinosaur. Excavation of the site began in spring 1994, when Tim Tokaryk and Grant Schutte (a volunteer with RSM) again located the site. Additional *in situ* material, including part of a maxilla (Figure 2), with teeth, was discovered. Preliminary identification of the specimen as that of a *Tyrannosaurus rex* was based solely on the fact that it is the only known large theropod from the latest Maastrichtian. Full-scale excavation began in mid-June 1994. By the end of 1995, researchers at the site concluded that all the *Tyrannosaurus rex* material had been collected, together with many of the specimens listed below. In 1998, Beth McIver of the University of Saskatchewan visited the site to collect additional plant fossils and, while doing so, discovered additional portions of the *T. rex* skeleton. Renewed excavations between 2000 and 2003 added considerably to the completeness of the skeleton. Although the excavation was primarily a "large-quarry" operation, remains of the associated fauna were retrieved whenever possible. The fact that members of the associated fauna, which consist primarily of much smaller taxa, were recognized and collected can be attributed to the talent and dedication of the many staff and volunteers, together with the fortuitous nature of deposition at the site.

The purpose of this paper is to provide a preliminary faunal list with comments rather than a formal description of the fossil material. In some cases, specimens are part of ongoing, descriptive research.

2. The Fauna

MOLLUSCA

The classic biostratigraphic work on the Frenchman Formation (Fraser *et al*., 1935; Furnival, 1950) focused on the vertebrates rather than the invertebrates. The first mention of invertebrates from the Frenchman Formation was by Sternberg (1924, p69) who stated "from [a] nearby [some skull bones of a *Triceratops*] and at about the same level were collected some invertebrates which have been identified by Dr. F. H. McLearn as *Compeloma producia* [*Lioplacodes nebrascensis producta* today] and *Unio danae*." The only other reference to invertebrates from the formation is McIver's (2002, p209) statement that gastropods occur at the *Tyrannosaurus rex* quarry. This paucity of information probably is the result of both collecting and preservational biases.

The specimens listed below were examined and identified by Joseph Hartman (University of North Dakota, Grand Forks) as part of ongoing research. Revisions and refinement may follow in subsequent publications.

GASTROPODA
VIVIPARIDAE
Viviparus thompsoni?

Referred material: P2523.277, impression.

PLEUROCERIDAE
?Lioplacodes tenuicarinata

Referred material: P2523.135, impression.

BIVALVIA
UNIONIDAE

Many of the unionid specimens listed below are incomplete impressions that have an elongate right valve, lack sculpture, and have incomplete anterodorsal margins.

Gen. et sp. 1, indet.

Referred material: P2523.181, P2523.279, P2523.281, impressions.

Gen. et sp. 2, indet.

Referred material: P2523.93, P2523.280, P2523.284, impressions.

SPHAERIDAE
Sphaerium sp. cf. *S. subellipticum*

Referred material: P2523.278, P2523.282, P2523.283, impressions.

ARTHROPODA
INSECTA
Gen. et sp. indet.

Referred material: P2523.125, P2523.227, P2523.228, exoskeleton fragments.

Fossils of insect fauna at the site are taxonomically indeterminate. The exoskeletal fragments are preserved in cemented sandstone. Although much of the record of North American Late Cretaceous insects is preserved in amber rather than clastic sedimentary rocks, amber collected from the *Tyrannosaurus rex* quarry and elsewhere in the Frenchman Formation is extremely friable and is unlikely to contain any organic material.

OSTEICHTHYES
ASPIDORHYNCHIFORMES
LEPISOSTEIDAE
Lepisosteus
Lepisosteus sp.

Referred material: P2691.16, opercular?; P2523.193, scale.

The probable opercular is well preserved and has a highly crenulated lateral surface, with a distinct smooth margin on the articulating end. The scale is diamond shaped, slightly pitted in the centre, and bears a pronounced ridge at one end. Gar scales are the most common element in microvertebrate sites in the Frenchman Formation and were noted in the first faunal list of the Frenchman Formation by Sternberg (1924).

OSTEICHTHYES
Gen. et sp. indet.

Referred material: P2691.11, P2691.12, jaw fragments; P2691.4, P2691.7, skull bones; P2691.6, P2691.24, vertebrae; P2943.11, rib?; P2523.285, P2691.8, P2691.10, P2691.18, scales; P2523.120, P2523.121, P2691.19, P2943.9, indeterminate bone fragments.

P2691.11 is part of an elongated maxilla bearing a single row of teeth that are closely packed, conical, and opaque at the tip. No smaller, more exterior, secondary teeth are preserved. The best represented long-snouted bony fishes from the Late Cretaceous are the aspidorhynchid *Belonostomus* and the lepisosteid *Lepisosteus*; however, neither of

these taxa has a primary tooth row that is as tightly packed as in P2691.11 (Estes, 1964; also see Bryant, 1987). Of the two vertebrae, P2691.6 resembles "Teleost D" (Brinkman, 1990; also see Peng *et al*., 2001), and, particularly, "morphoseries IIA" of Brinkman and Neuman (2002). Morphoseries IIA is characterized by two large pits separated by a smaller one in the ventral surface of the centrum. The scales are extremely thin. P2692.10 and P2692.18 are rectangular in outline, pitted in the centre, and have a smooth margin, unlike Holostean A of Brinkman (1990). P2523.285 and P2691.8 lack this type of margin and, instead, have veins radiating from one end of the scale to the other. The remaining specimens are too fragmentary or nondescript to warrant discussion at this time.

AMPHIBIA
CAUDATA
BATRACHOSAUROIDIDAE
Opisthotriton sp.
Figure 3A

Referred material: P2523.290, right dentary.

P2523.290 is the anterior portion of a right dentary. In lateral view the dentary is narrow anteriorly and deepens posteriorly; in dorsal view it curves strongly medially, as in specimens of *Opisthotriton* described by Estes (1964; see Figure 39). The specimen is 14.51 mm long and would have contained at least 17 teeth. As in most specimens from the Maastrichtian, all tooth crowns are missing (Estes, 1964). *Opisthotriton,* which was only recently discovered from the Frenchman Formation (Tokaryk, 1997b), is common in the Hell Creek Formation of Montana (Bryant, 1989).

REPTILIA
CHORISTODERA
CHAMPSOSAURIDAE
Champsosaurus sp.

Referred material: P2523.124, vertebral centrum; P2523.123, P2691.26, rib fragments.

At least two individual champsosaurs are known from the site. The larger is represented by a dorsal vertebral centrum with a length of 18 mm. The smaller individual(s) are represented by partial ribs; P2691.26 has a maximum proximal diameter of only 11.42 mm and a greatest mid-shaft diameter of 6.32 mm, measurements that are noticeably smaller than those that would match the individual represented by P2523.124. The occurrence of *Champsosaurus* in the Frenchman Formation was recorded previously by Sternberg (1924) and Tokaryk (1997b).

CROCODYLIA
CROCODILIDAE
Gen. et sp. indet.

Referred material: P2689.2, tooth.

P2689.2 is a small tooth that is slightly bulbous at the base, but with a pointed apex. Peng *et al.* (2001) listed two general morphotypes of *Leidyosuchus* teeth from Campanian microvertebrate sites in southeastern Alberta; some are slender and conical, whereas others are more bulbous. P2689.2 is intermediate between these extremes. This morphological variation is probably not taxonomically significant, but is related to the position of the tooth in the mouth. Isolated crocodilid skeletal elements have been recorded elsewhere in the Frenchman (Sternberg, 1924; Tokaryk, 1997b), but precise taxonomic identifications have not been possible.

TESTUDINES

Part of George M. Dawson's original fossil collection from the Killdeer badlands (now Grasslands National Park) as part of British North American Boundary Commission was examined by Cope (1875), who erected several new taxa, including the turtles *Plastomenus coalescens* and *P. costatus*. These species names are now considered *nomina dubia* (see Gardner *et al.*, 1995, p640). Sternberg (1924) listed eight testudine species from the Frenchman. Tokaryk (1997b) reduced the number to five: *Aspideretes* sp., *Thescelus insiliens*, *"Baena" hatcheri*, *Basilemys praeclara*, and an undescribed chelydrid. Don Brinkman (pers. comm., 2004), in reviewing some of the material from the Frenchman Formation, has also identified *Plesiobaena*. The turtle assemblage deserves re-examination in light of new discoveries from the Frenchman Formation and elsewhere, and recent developments in turtle research.

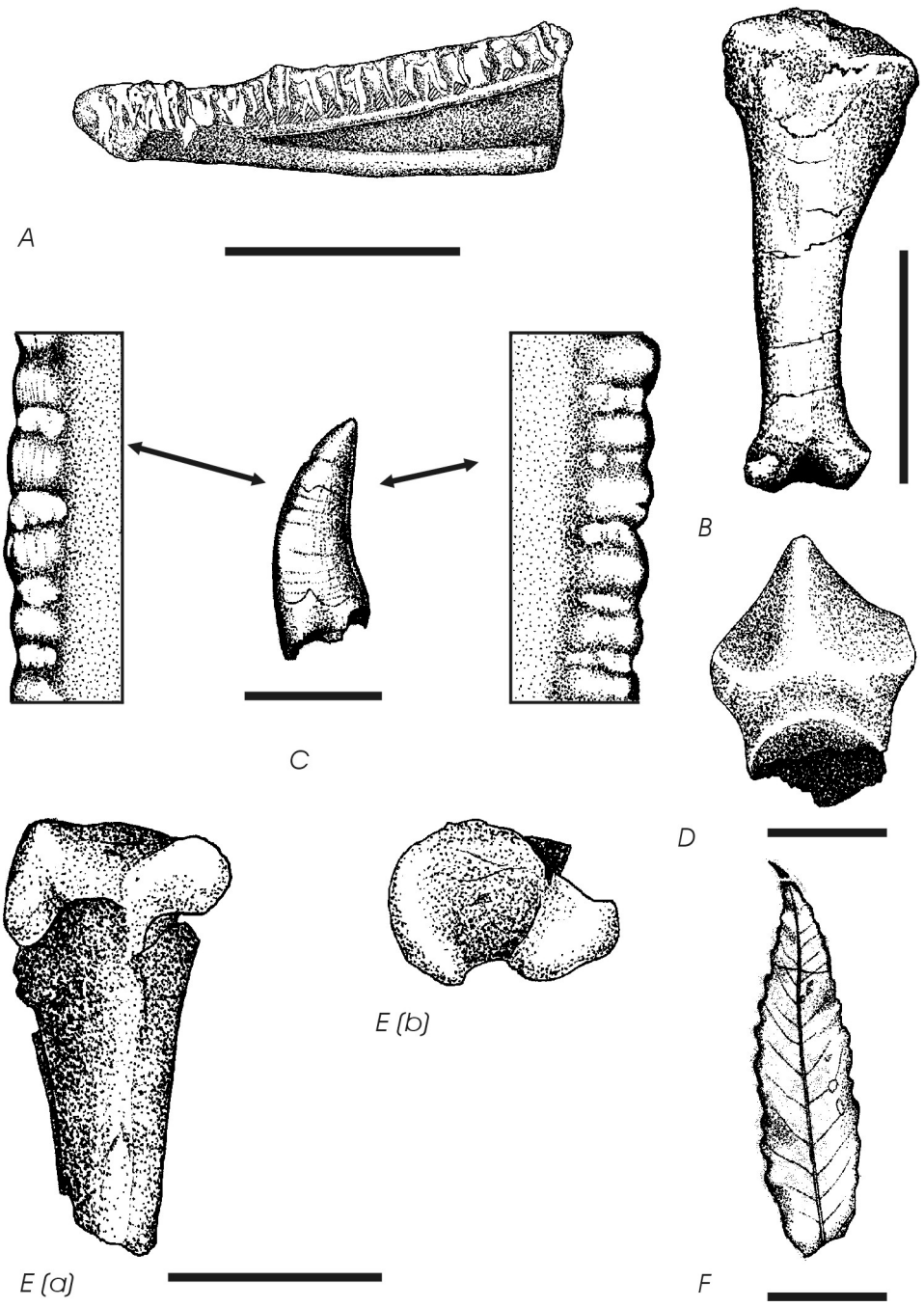

Figure 3 - A)* Opisthotriton *sp., P2523.290, right dentary (scale bar equals approx. 7.25 mm); B)* Basilemys *sp., P2523.292, tibia (scale bar equals approx. 43 mm); C)* ?Dromaeosaurus *sp., P2689.1, tooth, lateral view (scale bar equals approx. 15 mm), with magnified anterior and posterior denticles; D) cf. Pachycephalosauridae, gen. et sp. indet, P2943.5, tooth (scale bar equals approx. 3.5 mm); E) Aves, gen. et sp. indet., P2523.276, partial right tibiotarsus, a) lateral and b) proximal view (scale bar equals approx. 15 mm); and F) Plantae, gen. et sp. indet., P2943.1, leaf (scale bar equals approx. 28 mm).

For example, some of the material historically referred to as *Aspideretes* from the Judith River Group (Campanian) of North America is now referred to as *Aspideretoides* (Gardner *et al.*, 1995).

TRIONYCHIDAE
Gen. et sp. indet.

Referred material: P2691.9, P2943.13, pleural fragments.

Both pleural fragments appear to be from small individuals. Taxonomic identification of trionychids at the generic level is not possible based solely on the morphology of the carapace fragments (Gardner and Russell, 1994).

NANHSIUNGCHELYIDAE
Basilemys sp.
Figure 3B

Referred material: P2523.292, tibia.

P2523.292 has a longest dimension of 86.9 mm and is missing only a portion of the proximal head. The only postcranial descriptions of *Basilemys* (Sukhanov and Narmandakh, 1977; Brinkman, 1998) do not include the hind limbs. This specimen appears similar to TMP 96.12.211, a tibia of *Basilemys* currently under study by Don Brinkman at the Royal Tyrrell Museum of Palaeontology. The proximal end of P2523.292 is broad with shallow femoral articulating surfaces; there is a slight mid-shaft rugosity and the distal end has a comparatively narrow but well defined trough for the astragulus. *Basilemys* is one of the largest Late Maastrichtian turtles known from North America. Brinkman and Nicholls (1993) described material of *B. praeclara* from the Frenchman Formation. Brinkman (1998) described parts of another specimen of *Basilemys* from a site less than 20 m east, and approximately 4 m above, the *Tyrannosaurus rex* excavation. The specimen described by Brinkman (1998) consists of a partial carapace, skull fragments, and cervical vertebrae.

SAURISCHIA
THEROPODA
DROMAEOSAURIDAE
?Dromaeosaurus sp.
Figure 3C, Table 1

Referred material: P2523.116, P2523.119, P2689.1, teeth.

These teeth are laterally compressed and recurved. The anterior carina begins lingually at the base then twists medially near the apex (see Currie *et al.*, 1990; Peng *et al.*, 2001; and Sankey *et al.*, 2002) The denticles are chisel-like. Specimens P2523.116 and P2689.1 are possibly from one or two large individuals. The considerably smaller tooth, P2523.119, is worn at the tip of the anterior carina. These characteristics suggest that these teeth can be assigned to *Dromaeosaurus,* a genus not listed by Sternberg (1924) or Tokaryk (1997b), making this the first record of this genus from the Frenchman Formation. Examination of a broader assemblage of specimens from the Frenchman Formation should allow this identification to be confirmed.

TYRANNOSAURIDAE
Tyrannosaurus rex

Referred specimen: P2523.8, partial skeleton.

Table 1 - Measurements (in mm) of* ?Dromaeosaurus *sp. teeth from the Tyrannosaurus rex site, Frenchman Formation, Saskatchewan.

Specimen No.	Anterior-Posterior	Dorsal-Ventral	Labial-Lingual
P2523.116	13.72	28.63	7.00
P2523.119	9.05	18.17	4.42
P2689.1	15.04	30.95	7.4

The disarticulated skeleton includes a nearly complete skull (lacking the basio-occipital region), much of the vertebral column, some shoulder and forelimb elements, the pelvis, and a hind limb. The large size of this specimen, its taphonomic arrangement, and the hardness of the surrounding sandstone and ironstone has delayed the complete preparation and subsequent scientific examination of the skeleton. The unfused cranial elements have been completely prepared and are currently being described by the senior author. *Tyrannosaurus rex* is the only large theropod known from the latest Maastrichtian of North America (Molnar *et al.*, 1990).

SAURISCHIA
THEROPODA
Gen. et sp. indet.

Referred material: P2523.117, P2523.118, P2691.21, P2691.22, teeth.

These teeth are incomplete, either at the base or the apex, preventing more precise identification.

ORNITHISCHIA
CERATOPSIDAE
cf. *Triceratops* sp.

Referred material: P2523.110, P2523.111, P2523.112, P2523.113, P2523.114, P2523.115, P2523.138, P2523.142, P2523.144, P2523.235, P2689.11, P2943.3, P2943.4, P2943.6, P2943.7, P2943.8, P2943.14, P2689.3, P2689.4, P2691.23, teeth.

These teeth are tentatively assigned to *Triceratops* because this genus, based on several complete and incomplete skulls and skeletons, is the most common ceratopsid from the Frenchman Formation (Tokaryk, 1986, 1997b, 2002); only a single specimen of *Torosaurus* is known (Tokaryk, 1986). The teeth range considerably in size; all were functional teeth with worn crowns.

Triceratops sp.

Referred material: P2691.1, right humerus.

This specimen is of a juvenile and was described by Tokaryk (2002).

HADROSAURIDAE
HADROSAURINAE
Gen. et sp. indet.

Referred material: P2523.288, P2523.289, teeth.

The hadrosaurids constitute a far smaller proportion of the Frenchman fauna than the ceratopsids, the only other group of large ornithischians. The type specimen of *Edmontosaurus saskatchewanensis* (Sternberg, 1926), from the east block of Grasslands National Park in south-central Saskatchewan, is the only hadrosaurid specimen that has been formally described from the Frenchman Formation and only a few other isolated hadrosaur elements have been reported from the Frenchman Formation (see Tokaryk, 1997b). As a result of this paucity of data, it is difficult to identify these specimens of worn teeth (P2523.288, P2523.289) and other isolated hadrosaurid teeth.

cf. PACHYCEPHALOSAURIDAE
Gen. et sp. indet.
Figure 3D

Referred material: P2943.5, tooth.

This tooth, which appears to have been abraided during transport, resembles those of pachycephalosaurids because it is small, labiolingually compressed at its apex, with a weak vertical ridge, and swelling at the base. Any denticles have eroded away. Only one other pachycephalosaurid tooth is known from the Frenchman Formation (Tokaryk, 1997b).

AVES
Gen. et sp. indet.
Figure 3E

Referred material: P2523.276, proximal end and shaft of right tibiotarsus; P2943.10, shaft of limb bone.

Specimen P2523.276 is generally well preserved, except for *postmortem* erosion near the proximal end and internally, and is interpreted as a partial tibiotarsus. The width of the proximal end is 16.61 mm. Unlike most extant avian taxa, P2523.276 lacks cnemial and fibular crests, and the rotular crest is enlarged, forming a rim. The interarticular area, which makes up most of the proximal end, is shallow and the external articular surface is rounded and somewhat distally deflected. In lateral view, a small trough separates the articular surfaces from the base of the rotular crest. P2943.10 is a small, hollow, extremely thin-walled bone that lacks the proximal and distal ends. Previous avian records from the Frenchman Formation include *Cimolopteryx rara* from the Gryde local fauna (Tokaryk and James, 1989) and various isolated, indeterminate postcranial elements (Tokaryk, 1997b).

MAMMALIA
MARSUPIALIA
DIDELPHIMORPHIA
DIDELPHIDAE
Alphadon sp.

Referred material: P2943.1, partial right dentary with posterior root of p1, p2-m1, trigonid of m2, and m4; P2943.12, partial left dentary with broken p3, p4 and talonid of m1.

P2943.1 is missing the portion of the jaw between the posterior margin of the m2 trigonid and the anterior surface of m4. The teeth on P2943.1 are well preserved and closely resemble the isolated teeth from the Gryde locality, Frenchman Formation, that were referred to *Alphadon jasoni* by Storer (1991). Specimen P2943.12 is less well preserved, but the discernable morphology and proportions match those of P2943.1. *Alphadon jasoni* is the most common marsupial in the Gryde fauna and is also present elsewhere in the Frenchman Formation at the Wounded Knee locality (Fox, 1997). Both of these sites are within 12 km of the *Tyrannosaurus rex* quarry.

PLACENTALIA
LEPTICTIDA
Gypsonictops sp.

Referred material: P2523.293, partial right dentary with c1, p1, p2 alveoli, pc, p3 alveoli, damaged p4, and m1 alveoli.

Although the tooth interpreted here as the p4 is badly broken, its proportions and discernable morphology indicate that it is p4, rather than m1. The presence of eight roots or sediment-filled alveoli between the p4 and c1 indicates that this jaw contained five double-rooted premolars. *Gypsonictops* is the only known Late Cretaceous mammal with five premolars. The morphology and relatively small size of the extra (third) premolar in the series (designated pc by Lillegraven, 1969) matches descriptions by Lillegraven (1969) and Clemens (1973) of specimens referred to *Gypsonictops* from the contemporaneous Scollard Formation of Alberta and Lance Formation of Wyoming, respectively. *Gypsonictops* material from the nearby Gryde locality was referred to *G. illuminatus* by Storer (1991), whereas that from the Wounded Knee locality was referred to *Gypsonictops* sp., cf. *G. illuminatus* by Fox (1997).

MAMMALIA
Gen. et sp. indet.

Referred material: P2523.260, partial right dentary with c1, alveoli for p4-m2, m3.

This specimen is currently under study by Richard C. Fox, University of Alberta, Edmonton.

Miscellaneous

Referred material: P2523.130, P2523.231, coprolites.

The internal composition of these two incomplete coprolites has not been examined. Their overall external morphology matches that of specimens from microvertebrate sites in the Frenchman Formation. The originators of these remains are not known.

3. Plant Fossils

Leaves and seeds have been recovered in some quantity from the Frenchman Formation of Saskatchewan (McIver, 2002). The combination of plant and animal fossils at RSM locality 72F07-0022 (Table 2) is unusual given that the depositional requirements for plant fossils (Figure 3F) include low pH, whereas preservation of vertebrate and invertebrate remains requires a high pH (Retallack, 1997).

Table 2 - Floral and faunal lists from the* Tyrannosaurus rex *locality (RSM locality 72F07-0022). The floral list from the "lower bed" is from McIver (2002).

Flora
Equisetum sp.
Fern (cf. *Dryopteris carbonensis*)
Ginko sp.
Parataxodium sp.
Fokienia ravenscragensis
Trochodendroides flabella
T. speciosa
cf. *Juglans denveriana*
Trapago angulate
Vitis stantonii
Dombeyopsis obtuse
Dryophyllum subfalcatum
cf. *Ulmaceae* leaves
Spinifructus antiquus
Carpites ulmiiformis
Nyssidium arcticum
cf. *Nyssidium arcticum* (small) = *Leguminosites arachioides*-minor
Carpolithes kneehillensis
cf. *Carpites lakesii*
Numerous small nut-like fruits and seeds
Monocotyledon stems
Medium- to large-sized logs
cf. water lily roots
Fauna
Viviparus thompsoni?
?Lioplacodes tenuicarinata
Unionidae, gen. et sp. 1
Unionidae, gen. et sp. 2
Sphaerium sp. 1, cf. *subellipticum*
Insecta, gen. et sp. indet.
Osteichthyes, gen. et sp. indet.
Lepisosteus sp.
Opisthotriton sp.
Champsosaurus sp.
Crocodylidae, gen. et sp. indet.
Trionychidae, gen. et sp. indet.
Basilemys sp.
Theropoda, gen. et sp. indet.
?Dromaeosaurus sp.
Tyrannosaurus rex
Triceratops sp.
Hadrosaurinae, gen. et sp. indet.
cf. Pachycephalosauridae, gen. et sp. indet.
Aves, gen. et sp. indet.
Mammalia, gen. et sp. indet.
Alphadon sp.
Gypsonictops sp.
Coprolites of unknown origin

Material from this quarry allowed McIver (2002) to infer that this community was living "in a mesothermal climate without significant winter frost, but with seasonal precipitation. Summer vegetation is interpreted as mixed broad-leaved and coniferous, and luxuriant; however, the deciduousness of these forests, which supported the presumed prey of the *T. rex*, including herbivores such as *Triceratops*, hadrosaurs, and others, suggests that winter food supplies may have been scarce" (McIver, 2002, p215). If winter supplies were scarce for the herbivores, the animals may have migrated to avoid this potential stress. With the change in seasons, the megafauna may have moved on to more suitable areas. Migratory behaviour has been suggested for some Late Cretaceous herbivores (see Paul, 1997, and references therein). Alternatively, the seasonality of food supplies may have been a stress on the ecosystem that directly affected the large latest Cretaceous herbivores. Because this seasonality was present prior to the K-T extinction event, it may have contributed to the decline in dinosaurian diversity at the end of the Cretaceous Period (Sarjeant and Currie, 2001).

4. Acknowledgments

Although attempts have been made elsewhere, it would be difficult to name each of the many people who have worked the *Tyrannosaurus rex* excavation over the years. All are commended for keeping their eyes peeled, not for just the large bones, but for the small ones as well. Illustrations were drawn by Wes Long, and technical assistance with computer graphics was given by Marlon Janzen, both of the Royal Saskatchewan Museum. We thank Don Brinkman and James Gardner, Royal Tyrrell Museum of Palaeontology, Drumheller, and Joseph Hartman, University of North Dakota, Grand Forks, for providing useful comments and assistance. This paper is dedicated to the memory of Drs. William Anthony Swinton Sarjeant and Elizabeth McIver.

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