Alberta Palæontological Society Bulletin

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ALBERTA PALÆONTOLOGICAL SOCIETY

The Society was incorporated in 1986, as a non-profit organization formed to:

a. Promote the science of palaeontology through study and education.

b. Make contributions to the science by:
1) discovery 2) collection 3) description
4) education of the general public
5) preservation of material for study and the future

c. Provide information and expertise to other collectors.

d. Work with professionals at museums and universities to add to the palaeontological collections of the province (preserve Alberta's heritage).

MEMBERSHIP: Any person with a sincere interest in palaeontology is eligible to present their application for membership in the Society. (Please enclose membership dues with your request for application.)

Single membership	**$20.00 annually**
Family or Institution	**$25.00 annually**

THE BULLETIN WILL BE PUBLISHED QUARTERLY: March, June, September and December. Deadline for submitting material for publication is the 15th of the month prior to publication.

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UPCOMING APS MEETINGS

Meetings take place at 7:30 p.m., in Room **B108** (or **B101**, across the hall)
Mount Royal College: 4825 Richard Road SW, Calgary, Alberta

Friday, May 28, 2004—Leslie Eliuk, GeoTours Consulting, Inc.
"Reefs of the Maritimes: Primarily the Jurassic-Cretaceous Abenaki offshore."
June, July, August, 2004—No meetings. See Field Trip Update, Page 32.
Friday, September 17, 2004—Topic to be announced.

ON THE COVER: Reconstruction of an adult Pipestone Creek (Alberta) pachyrhinosaur, by U.S. artist Katy Hargrove. Copyright ©. Used by permission. Feature article on northern Alberta fossils begins on Page 3.

President's Message

by Dan Quinsey

Congratulations to all our members for their contributions and involvement this past year. It was my personal goal to try to get more members involved, and many have stepped up to the plate. The Alberta Palaeontological Society (APS) can only measure its success through the personal achievements of each and every member; and believe me when I say we are very successful.

Our membership numbers have fluctuated around the 140 mark this year. However, the quality and enthusiasm of our members both new and old have reached new heights. It is very rewarding to watch the Society grow in this way. You are doing a great job—keep up the good work.

The Board of Directors welcomes new faces to an already successful team who will do everything in their power see the APS continues to reach new heights. I am excited to serve the Alberta Palaeontological Society as president and will do my best to continue to motivate everyone in a direction we can all be proud of. ❏

Calgary Rock and Lapidary Club Gem, Mineral & Fossil Show 2004

by Dan Quinsey

The annual CRLC Show was held May 1–2, 2004 at the West Hillhurst Arena in Calgary. Once again, the show was a huge success. Many dealers were on hand offering a variety of supplies for the enthusiast. There were many displays to view and several experts on hand exhibiting their various skills. Congratulations go out to the Calgary Rock and Lapidary Club for another job well done.

The Alberta Palaeontological Society was on hand as usual with a new look and many fossil and mineral give-aways. Thanks to **Les Adler**, **Lyle Hartwig**, **Harvey Negrich**, **Geoff Barrett**, **Roslyn Osztian**, and **Mike Clark** for their contributions and assistance this year. Special thanks also go out to **Wayne Braunberger** (CRLC Chairman) for putting on a great show and assisting in the APS booth when time permitted. ❏

Field Trip

Coal Mine Geology and Technology in the Canadian Badlands

Put on your hiking boots and join Dr. David Eberth, sedimentologist for the Royal Tyrrell Museum of Palaeontology, and Fred Orosz, local mine buff, for a fascinating field trip in the Canadian badlands. Climb to a coal seam and hear how coal formed and how it was mined. Explore historic mine ruins and hear stories of the men and machines that laboured there. Ponder the future of coal in Canada. Hear about and experience the historic ambiance of Drumheller's coal mining communities, and the astonishing beauty of the Canadian badlands, with two leading experts.

Sunday, June 27, 10:30 A.M.–4:00 P.M.

Cost: $15/person. Includes lunch at the East Coulee School Museum. Participants must provide their own transportation. Meet at the Atlas Coal Mine National Historic Site.

To register: phone the Atlas at (403) 822-2220.

Sponsored by the Drumheller Regional Science Council in partnership with the Atlas Coal Mine National Historic Site. ❏

Help Excavate Mongolian Dinosaurs this September

by Mona Marsovsky

Dr. Philip Currie and Dr. Eva Koppelhus will be leading an expedition to the Gobi Desert of

(see "Mongolian Dinosaurs," page 31)

Mosquitoes and Mud

The 2003 Royal Tyrrell Museum of Palaeontology Expedition to the Grande Prairie Region (Northwestern Alberta, Canada)

by Darren H. Tanke (Copyright © 2004)

Introduction

In July 2003, the Dinosaur Research Program and other staff of the Royal Tyrrell Museum of Palaeontology (TMP), with logistical and volunteer support from Grande Prairie Regional College (GPRC) and other local help, conducted field work in the Grande Prairie region, in northwestern Alberta. The author carried out additional exploratory work with Grande Prairie volunteer Sheldon Graber in mid-September that year.

These efforts marked the first full-scale palaeontological expedition in the area since those of 1986–1989, when TMP excavations of a rich horned dinosaur bonebed on Pipestone Creek (Tanke, 1988; Langston, Currie and Tanke, in prep.) and limited local explorations were carried out.

Examined only sporadically, the Late Cretaceous Wapiti Formation has nevertheless yielded some important fossils including hadrosaur and ceratopsian-dominated bonebeds, dinosaur skeletons, dinosaur footprint localities, insects in amber and megaplant fossils. Multigeneric bonebeds and microvertebrate remains are rare, but efforts to relocate both and especially the latter are certainly underachieved.

Fifteen Wapiti Formation sites in the Grande Prairie region (Figure 1) were reexamined, explored and/or sampled. This report summarizes previous efforts and describes the results of the 2003 work. It is, in part, an effort to help summarize the widely scattered historical (including newspaper), geological and especially vertebrate palaeontological literature carried out in the Peace River districts in northwestern Alberta and northeastern British Columbia (Tanke, in prep. a). The resultant large bibliography will also serve as a useful starting point for others wishing to do research in this region. Some recent Grande Prairie tourism information and media zeal regarding Grande Prairie region fossil resources has introduced some important factual errors, which are addressed below. Exact locality for the sites described herein are on file at TMP and are available to qualified investigators.

Abbreviations: Fm.: Formation; MYA: million years ago; ROM: Royal Ontario Museum; TMP: Royal Tyrrell Museum of Palaeontology.

When one thinks of traditional dinosaur collecting in southern Alberta, images of hot, arid badlands and short grass prairie come to mind. However, the terrain in the Grande Prairie district, 500–800 km northwest of these localities is for the most part completely different.

Unlike the badlands, the region is within aspen parkland and largely boreal forest biomes. It is traversed with numerous deep river and creek valleys. The region has a cooler and moister climate, averaging some 450 mm of precipitation annually. All this precipitation leads to luxuriant plant growth and is thus heavily forested with deciduous and coniferous trees. Much of the prairie regions are now under plow, but one does not have to go far west or south or deep into any river valley to be in remote bush country, complete with black and grizzly bears, moose, elk, mountain goats and other big game.

As with northern bush country across Canada, the air is filled with mosquitoes and other bloodsucking insects that make life miserable for the field palaeontologist. 2003 was not too bad in this regard; but 1986 was a particularly bad year, the author on several occasions killing five mosquitoes in one swat.

Heavy rains and shading trees make for muddy back roads, shorelines and slopes. Uncovering fossils often entails digging through slimy mud or the

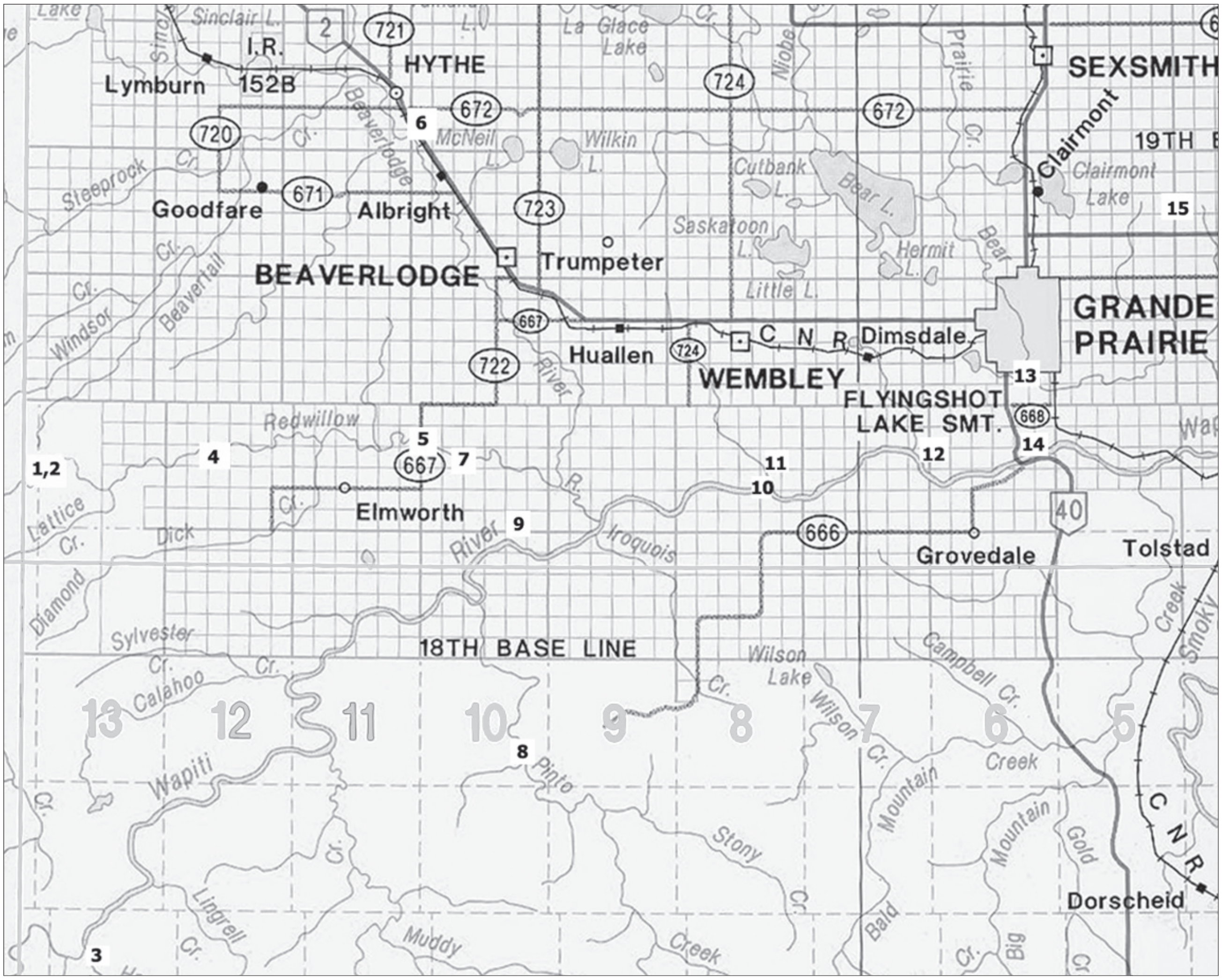


Figure 1. Map of Grande Prairie district in NW Alberta showing palaeontological sites (numbered) as described in the text. 1. George Robinson Bonebed; 2. Red Willow River Falls Bonebed; 3. Narraway River; 4. Red Willow River Hadrosaur Ichnites Site #1; 5. Red Willow River Hadrosaur Skeleton; 6. Hythe Roadcut; 7. Red Willow River Hadrosaur Ichnites Site #2; 8. Pinto Creek Bridge; 9. Wapiti River Pachyrhinosaur Bonebed; 10. Wapiti River/Pipestone Creek Bonebed; 11. Pipestone Creek Pachyrhinosaur Bonebed; 12. Spring Creek Hadrosaur Bonebed; 13. Bear Creek; 14. Roadside Outcrops South of Grande Prairie; 15. Kleskun Hills.

infamous "Peace River gumbo." In the dry and open southern Alberta badlands, a 4x4 truck, sturdy hiking boots, a broad-brimmed hat and a large supply of drinking water are necessities. In the damp and forested Grande Prairie district, an all-terrain vehicle, rubber boots, mosquito net and insect repellent are often preferred.

European fur traders and missionaries first explored this rugged and remote region in the late 1700s. The local economy was first based on fur-trading and then, with slowly growing settlement, agriculture (Imrie, 1931; Ellis, 1956; Campbell, 1968; Wight, 1976; Kostash, 1996). Today, with massive population and development growth, the economy has diversified with forestry, pulp and paper, farming (grain crops)/cattle ranching and gas—the main area we worked is underlain by the Elmworth Gas Field, one of the largest natural gas fields discovered in North America (Masters, 1984a,b). Oil and gas production and exploration is currently booming in the Peace River District (Anonymous, 2003c). Tourism also plays an ever-increasing role due to Grande Prairie's through route to Alaska and the recent completion of the $5.5 million Centre 2000 tourist facility and completion of the Heritage Discovery Centre therein in 2003. Plans for a new dinosaur museum in the Grande Prairie area (Holubitsky, 2003; Talbot, 2003b-d, f; Ruhl, 2004) will vastly bolster this growth industry which radio reports in March, 2004 stated contributes $20 million in Alberta annually.

The Wapiti Formation

Compared to other geological formations in Alberta, the nonmarine Late Cretaceous Wapiti Fm. has been comparatively little studied. This is no doubt due to the minor nature it plays in the formation or production of gas and oil, its remoteness and its comparative paucity of vertebrate fossils.

The formation is present over much of the Edmonton (Roed, 1978; Rutter *et al.*, 1998) to north and northwestern Alberta plains regions, including Grande Prairie. It also occurs in northeastern British Columbia (Stott, 1972, 1975, 1984) and extends into the Northwest Territories (Dixon, 1999; Lane *et al.*, 2001), although no vertebrate fossils have yet been reported in the latter region.

The Wapiti Fm. is a thick unit, measuring up to 1,525 m in the foothills west of Edmonton (Williams and Burk, 1964). In the Grande Prairie district, the formation measures about 1,310 m in thickness (Allan and Carr, 1946).

In 1879, George M. Dawson, from the Geological Survey of Canada, conducted the first work on the Wapiti Fm. in the Grande Prairie area. On the Smoky River, downstream from Grande Prairie, he first named the Wapiti Fm. (Dawson, 1881, p. 115) for "Wapiti River Sandstones," exposed about 16.8 km below the confluence with the Wapiti River.

Soon after the Wapiti Fm. was named, dinosaur bones were discovered in the Drumheller Valley and Dinosaur Provincial Park. Ever since, the rich fossil resources there have been extensively collected and studied, with the Grande Prairie region left largely ignored and unexplored.

The continental Wapiti Fm. contains minor oil and gas reserves, bentonites (Byrne, 1955; Scafe, 1975), and massive coal reserves: most research has focused on this latter aspect (Allan and Carr, 1946; Kramers and Mellon, 1972; Chu, 1978; Nurkowski, 1984; Dawson *et al.*, 1994b and others). The formation consists of interbedded massive sandstones, clays, siltstones and coals with minor ironstone development.

During our 2003 field work it became readily apparent that the stratigraphically higher sections of the formation contain softer, more "dirty" sandstone sediments that acquire the typical badland fluting or "rille" morphology. These higher outcrops also appear to retain moisture and on steeper slopes, massive slumping can occur. Generally, these outcrops appear lithologically similar to those seen in the Upper Horseshoe Canyon Fm., exposed upstream from Drumheller. Lower in section, the Wapiti sandstones appear cleaner, are harder and better cemented. The sandstones can form steep cliffs or large sheets of exposed flat rock along river edges. They erode out as loose slabs, which litter the streams and shorelines in countless numbers. In some places, white quartzite and black chert extrabasinal clasts ranging in size from 5–100 mm across can be found associated with these hard sandstones (pers. field observation, 1986). The hard sandstones can preserve leaves, coniferous twigs and cones and other plants as well as dinosaur bones and footprints. Coals excepted, lithologically, these lower outcrops remind one of those of the Dinosaur Park Fm. exposed in Dinosaur Provincial Park, 50 km northeast of Brooks, Alberta.

Early geological expeditions to the Grande Prairie district were looking for productive coal deposits for domestic and industrial use, but also found scrappy dinosaur bone (Evans and Caley, 1930; Rutherford, 1930; Allan and Carr, 1946; Gleddie, 1949). However, nothing of real significance was recovered. A hadrosaur ungual was the only identifiable dinosaur bone noted, the rest being water-worn scraps.

This created a long-standing myth that there were no vertebrate fossils of any importance to be found in the Wapiti Fm. As a seeming confirmation, in the 70 years after Dawson first named the formation, only one vertebrate specimen of interest was ever described. Sternberg (1951) described and figured a small lizard jaw collected by local amateur collector Robert Cochrane from Kleskun Hill, located 20 km northeast of Grande Prairie. Sternberg referred the jaw to the teiid *Chamops segnis*. Keqin and Fox (1991) concluded this specimen was not referable to *Chamops*, but they could not determine its phylogenetic relationships and expressed the need for this specimen to be restudied. For many years, this small, problematic specimen remained the only described vertebrate from the Wapiti Fm. In a twenty-four page review of northwestern North American Cretaceous non-marine faunas, the Wapiti Fm. warranted but three sentences (Russell, 1964).

Dinosaur bones were known to Grande Prairie region collectors at this point, but evidently not so among the larger palaeontological community. A promising local newspaper report (Anonymous, 1961) of a complete dinosaur skeleton or "…maybe even more than one…" on the Red Willow River was evidently never followed up.

The first examination of the Wapiti Fm. by professional vertebrate palaeontologists did not occur until 1966. That summer, Dr. Dale A. Russell and a small crew from the National Museum of Canada (Ottawa) briefly surveyed various Cretaceous formations ranging from Dawson Creek, British Columbia, east to the Swan Hills in Alberta.

In Alberta Wapiti-aged deposits, they had a few minor finds, one of which was a 76 cm long dinosaur femur secured alongside the highway in the roadside exposures between the towns of Beaverlodge and Hythe (see Site 6 below).

Subsequent minor expeditions by Dr. John Storer and others from the Provincial Museum of Alberta (Edmonton) were conducted during the early to mid-1970s. But again, these short expeditions did not dedicate enough time and manpower to the pursuit of good-quality fossils and as a result only found scattered and fragmentary, non-diagnostic dinosaur material. The only "articulated" dinosaur to that point was a series of three poorly preserved, articulated hadrosaur caudal vertebrae collected by Grande Prairie resident Al Lakusta. A rib cage was apparently found with this specimen but the specimen could not be relocated in 1986 and was believed lost under a slump.

The first serious look at the vertebrate palaeontological potential of the Wapiti Fm. was that conducted by the author and others with the TMP during the summers of 1986–1989. These expeditions dedicated much more time and experienced manpower than previous work, with the result that the Wapiti Fm. began slowly revealing its palaeontological secrets.

Correlating the Wapiti Fm. to laterally equivalent rocks and their classic dinosaur faunas in southern Alberta has always been a problem. Evidence suggests the Bearpaw Sea did not extend into the Grande Prairie region and the Wapiti Fm. developed as one continuous package of continental rocks and thus cannot presently be accurately subdivided for biostratigraphic purposes. Due to the absence of the distinctive Bearpaw unit, scattered outcrop, a dearth of palaeofaunal and floral studies and age testing of volcanic ash, subdividing the Wapiti Fm. into units directly correlatable to laterally equivalent rocks in southern Alberta is difficult.

The Wapiti Fm. is generally accepted as being roughly equivalent with the Campanian Dinosaur Park Fm. and continuous right up to the Battle Fm. in central Alberta (Dawson *et al.*, 1994a, p. 396). Further south, the Wapiti may be the equivalent of the Scollard Fm. in south-central Alberta, thus including the Cretaceous-Tertiary boundary and preserving the dinosaur extinction event. Elliott (1958, 1960) noted that the widespread and distinctive volcanic ash layer, the "Kneehills Tuff" occurred in the Simonette area and will thus serve as a useful stratigraphic marker in some subsurface sections. The portion of the Wapiti Fm. in the region worked by TMP (Wapiti and Red Willow Rivers and their tributaries) is mapped as Upper Wapiti (Cooper, 2000), roughly equivalent to the upper Dinosaur Park Fm., Bearpaw and lower Horseshoe Canyon formations exposed in southern Alberta. This correlation is also borne out by a number of palynological analyses from samples collected across the study area (Braman, pers. comm., 2003).

Sites Examined

Field work covered sites within an area roughly 95 x 80 km (7,600 km^2), much of it in rugged and remote areas. Moving from the British Columbia/Alberta border and working east, the following fifteen sites were examined in 2003:

Site 1.—George Robinson Hadrosaur Bonebed.

George Robinson (1892-c.1981) was an amateur fossil collector from Sexsmith, Alberta. He collected over a large area of the Peace District. Part of his fossil collection was acquired by the Provincial Museum of Alberta (Edmonton) in 1973; it was later transferred to the TMP (see TMP73.11, TMP87.56 and TMP89.53 catalogue series). Among the Robinson collection were a number of well-preserved uncrushed hadrosaur bones and bone fragments as well as some tyrannosaurid teeth.

Locality information on this material was poor, in-

Figure 2. Large hadrosaur pedal ichnite, dorsal view. Red Willow River, near George Robinson bonebed. Typical of the loose dinosaur ichnites found in the Grande Prairie region. Hammer is 31.2 cm long.

dicating they had been collected about "one half mile upstream from the Red Willow River Falls." The falls were relocated in 1989 and additional washed-out hadrosaur material was seen upstream from there, although the bonebed was not relocated.

In 2003 the author was finally able to relocate the bone layer *in situ*. The bone occurs about halfway up the south slope at the base of a fine-grained, carbonaceous, grey siltstone that weathers out a buff tan to yellow color. This layer outcrops very sporadically in the area owing to vegetation cover and slumping.

All material appears referable to adult-sized hadrosaurs. What type of hadrosaur is there is uncertain, but several incomplete jugals from this site housed in TMP collections (TMP73.11.1900; TMP73.11.2634) demonstrate the potential future recovery of diagnostic skull elements from this site.

Figure 3a. Ventral view of three in situ articulated hadrosaur mid-caudal vertebrae (TMP2003.66.12) in ventral view from the Red Willow River Falls bonebed.

TMP73.11.2634 is a thick and massive element. Also from this bonebed, the caudal portion of a partial sacrum (TMP73.11.1525) includes a grooved ventral surface. This anatomical feature has been variably interpreted in recent years. Earlier work stated it was indicative of hadrosaurine (flat-headed) hadrosaurs (Weishampel and Horner, 1990, p. 548). However more recent work (Weishampel *et al*., 1993) indicates this is a lambeosaurine (crested) hadrosaur feature.

More work should be done at this site, given the possibility that crested hadrosaurs are there. Given the discovery of skull bones noted above, it may be possible to determine what type of hadrosaur is represented. Due to the hard rock and remoteness of the area, only sampling of the bonebed edge and monitoring should be conducted in the future.

It is possible this bonebed is the "complete hadrosaur skeleton" reported in Anonymous (1961) and noted earlier in this report. This is suggested because virtually all Robinson-collected dinosaur bones in TMP collections came from this locality.

Several unrelated fossils were also found, in loose sandstone blocks littering the river's edge below. A perfect tyrannosaur tooth with root (TMP2003.66.1) was collected. Nearby, on a sandstone slab that had split along a thin clay parting, a number of small, scattered trace fossils were located. The markings resemble small mammal tracks but possibly represent small reptile (lizard?) tracks, which can resemble those of small mammals (Lockley and Foster, 2003). All of these rare fossils were collected (TMP2002.66.12; TMP2003.66.2-3,6).

A number of well-preserved hadrosaur ichnites (Figure 2) were observed here also, but due to their weight and the remoteness of the site, were not collected, though they are worthy of such an effort in the future. A helicopter would likely be required to collect them. The westernmost of the sites in this area is only about 0.75 km east of the British Columbia/ Alberta border and with well-exposed, tall outcrops. This bodes well for the eventual discovery of good Late Cretaceous dinosaur footprints and bone material in northeastern British Columbia.

Figure 3b. Same, after preparation by author, left lateral view. Canadian $2.00 coin for scale is 2.8 cm across.

Site 2.—Red Willow River Falls Bonebed.

This locality was first recognized in 2003. A ten-year-old local girl, Lori Paslawski, found a set of three articulated hadrosaur mid-caudal vertebrae (TMP2003.66.12; Figure 3a-b) there. This is the third example of articulated dinosaur material in the Grande Prairie area. The bone is not particularly well preserved, but the two anterior-most neural spines show well-healed fractures without misalignment. Such osteopathy is a common occurrence in hadrosaurs (Tanke, 1989; Rothschild, 1997, fig. 31.7).

During their collection the bonebed was recognized. The bones occur between two thick and massive sandstone units, in a 20–30 cm thick siltstone with numerous small, green clay pellets. Most of the bone was broken-up and abraded prior to burial and visible on the ceilings of deeply undercut, cliff-forming outcrops along the river. All bones, where identifiable, are hadrosaurian.

Figure 4. Examining Wapiti Fm. outcrops along the Wapiti River at the mouth of Calahoo Creek. Exposed massive channel sandstones are visible in middle background. Slump blocks along river can contain dinosaur bone and plant fossils. Blocks split along bedding planes can exhibit dinosaur footprints and smaller trace fossils. The flat-bottomed jet boat is the preferred mode of transportation on the swift rivers in the Peace River-Grande Prairie districts.

This is an interesting and noisy place to work, with the 4–5 m tall Red Willow Falls dropping straight down into a deep pool just 8 m away. Several hundred metres downstream in a loose sandstone block that appears to be an extension of this same bonebed, a large hadrosaur tibia and other dinosaur bones were observed. Also in this area, two silicified logs have been found *in situ* (one in 1989, the other in 2003). These are the only silicified tree trunks known from the Grande Prairie region—all others observed were carbonized. Also in 1989 part of a badly eroded ornithomimid(?) or small theropod trackway, consisting of two prints was found on a sandstone slab. It could not be relocated in 2003.

Further downstream, TMP volunteer Sheldon Graber reported seeing good quality deciduous leaf fossils in sandstone slabs. It is hoped that some of these can be collected in 2004 or that latex rubber peels can be made from them.

Site 3.—Narraway River.

In 2002, Grovedale, Alberta resident Gwen Smith and family members boated far up the Wapiti River to the mouth of the Narraway River, close to the British Columbia border. There she found a large portion of an adult hadrosaur maxilla (TMP2002.5.2) and other dinosaur bone scraps.

Several Grande Prairie Regional College (GPRC) staff subsequently visited the site with the Smiths and collected additional dinosaur bone material, now numbering about a dozen specimens in the two visits. One of these was a complete dorsal centrum of a half-grown hadrosaur (TMP2002.66.9).

The author, volunteer Sheldon Graber and Mr. and Mrs. Smith revisited the locality on September 19, 2003. The Smith's flat-bottomed jet boat was launched on the Wapiti River, SSE of Beaverlodge, Alberta, at a place known locally as Wapiti Gardens, a few kilometres upstream from the mouth of Pinto Creek. After a trip of 65 km upriver, the locality was reached. Unfortunately, the site had recently been completely buried under a slump of wet clay, so no *in situ* material was seen. One skull(?) bone fragment was found on this trip (TMP2003.79.1).

Mrs. Smith delineated the previous bone occurrences at the site, which suggested a bonebed exposed for a distance of about 35 m. Bone is not abundant, but it is extremely well permineralized. A large flood will be needed to wash away the slumped material and expose the bone bed anew. Despite its remoteness, this site should be checked at least annually.

During this trip we viewed numerous Wapiti Fm.

Figure 5. Red Willow River Hadrosaur Ichnite Site #1 looking upstream (west). Ichnite impressions are found in hard *in situ* sandstone bench exposed during low water.

outcrops. Along the 65 km route, several dozens of kilometres of outcrops, ranging from several metres to several hundred metres in height were observed (Figure 4). The taller outcrops showed series of stacked interbedded clays, shales (some with ironstone nodules) and coals with massive hard thick channel sandstones. A number of these outcrops were briefly examined on the return trip. Nearly all localities yielded evidence of water-worn dinosaur bone or plant fossils. The best of these, roughly 15 km southwest of Elmworth, Alberta, yielded three unassociated dinosaur bones in a single loose piece of coarse, white sandstone. One of these, a somewhat water-worn hadrosaur proximal caudal vertebra (TMP2003.80.1) is typical of the condition of dinosaur bones recovered from Wapiti Fm. channel lag deposits. This element does not exhibit a flat, blade-like neural spine base such as seen in crested hadrosaurs (lambeosaurine), indicating it is a hadrosaurine or flat-headed form.

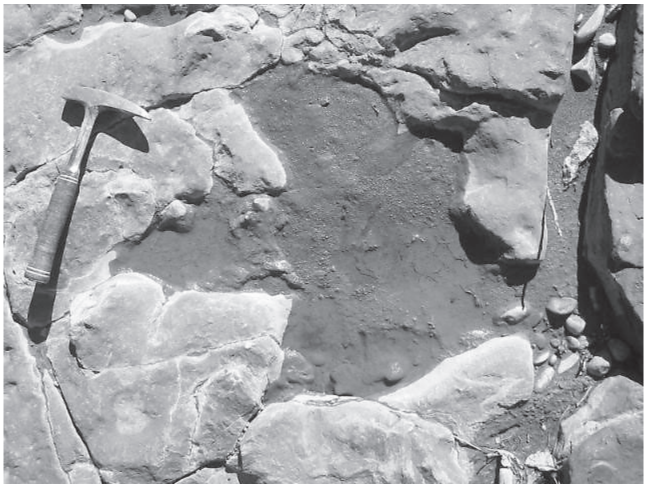
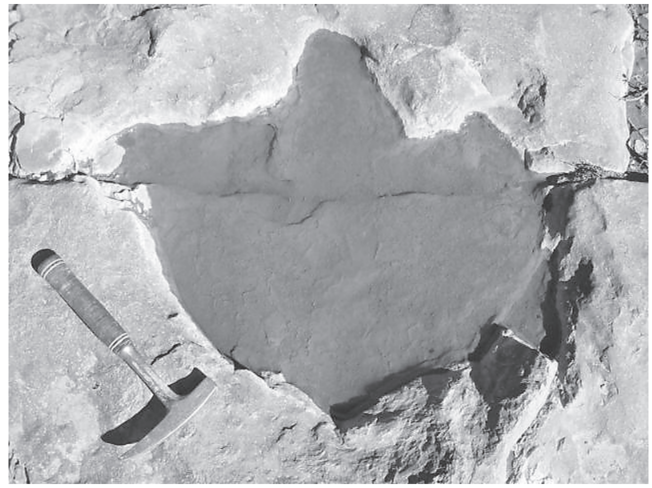
Site 4.—Red Willow River Hadrosaur Ichnites Site #1.

TMP staff first discovered this site (Figure 5) in 1989. Large sheets of hard sandstone are exposed on the south bank during low water. While isolated dinosaur ichnites (footprints) are known from the Grande Prairie district (see review in Currie, 1989a), this is the first *in situ* ichnite locality. All ichnites appear referable to the large ornithopod (almost certainly hadrosaur) ichnogenus *Amblydactylus*. Approximately one dozen ichnites are visible, though most are highly eroded and some along the tree line are being seriously damaged by recreational off road four-wheel ATV traffic (Figure 6). Some of the better dinosaur tracks were plainly visible as they were infilled with water (Figures 7-8). This site requires some salvage efforts and research attention before the prints are lost forever. A major cutline and ATV path leads right to the site where ATV operators are unknowingly damaging and destroying the tracks.

Figure 6. Heavily damaged hadrosaur pedal ichnite, Site #1, Red Willow River. The ichnite is difficult to see. View is essentially right dorso-lateral. The roll of mud, made as the animal's heel stepped into the soft substrate is visible on left and lower left. Mud rolls have been loosened or knocked off by ATV (all terrain vehicle) traffic, tire marks visible in soft sediment above hammer.

Site 5. —Red Willow River Hadrosaur Skeleton.

This specimen marks the most complete associated/articulated dinosaur skeleton in the Grande Prairie district and the furthest north articulated dinosaur remains in terrestrial deposits in North

Figures 7 and 8. Hadrosaur ichnites (naturally water-filled), Site #1, Red Willow River.

America. Reports (Talbot, 2003e) of "…numerous top-notch duck-billed dinosaur skeletons …" in the Grande Prairie area are in error. There is only one skeleton, this one, of average quality (compared to hadrosaur skeletons in southern Alberta) presently known from the Grande Prairie district. However, the occurrence of one demonstrates that the depositional environment conditions were right for preservation of dinosaur skeletons, so there are likely more skeletons awaiting discovery.

This specimen was found 6.4 km NNE of Elmworth, directly across from the Red Willow Park campground, just upstream from the Secondary Highway 722 bridge. The skeleton, that of a near adult-sized individual was originally discovered in 1989. That summer, while work proceeded on the pachyrhinosaur bonebed at Pipestone Creek, the author sent TMP field assistant Sue Marsland and volunteer Hans Larsson to explore river outcrops in the region. They quickly discovered the skeleton after climbing up a scree slope to examine the vertical exposures at Red Willow Park.

A quick exploratory excavation that summer revealed several small patches of good skin impressions, a partial ilium, aligned ossified tendons in rock, chevrons, pedal elements and about ten proximal caudal vertebrae (TMP89.92.1).

Heavy rains in June 1990 caused widespread regional flooding and the scree slope access up to the specimen was completely washed away. Some of the exposures there also collapsed into the river and were swept away. After the flood, several on-site examinations looking for the specimen were conducted. It could not be seen protruding from the cliff wall and was believed to have been lost (Eamon, 1991b).

It took close to a decade for the scree slope to redevelop and in the fall of 2002, the author returned to the area and relocated the skeleton. It was noted that much of the pelvic region was now lost, but that additional new bones (articulated mid-dorsal vertebrae, hind limb bones and ribs) were now exposed. Parts of the specimen were in danger of collapsing into the river, so a decision was made to collect it.

Overburden removal operations began July 2, 2003. With a work crew averaging 3 people, it took 4.5 days to dig down with pick and shovel through mostly Pleistocene clays and gravels to get down to the specimen.

Traces of unionid clam, Pleistocene mammal bone, and even reworked Late Cretaceous silicified dinosaur bone were found in the glacial clay.

A large portion of a well permineralized skeleton and partial skull were subsequently uncovered. The specimen has suffered some serious but mostly repairable/restorable damages through ground movement, frost action, rootlets and water. This damage has posed some technical challenges during preparation. While the bone is permineralized (even more so than dinosaur bone from Dinosaur Provincial Park—DPP), the erosive processes noted above have made the bone splintery. For example, on the dentary, some teeth are near perfect, yet only a few centimetres away, the shattered rock, ground water, rootlets and other aspects have conspired to ruin the teeth there.

The skull is incomplete and disarticulated but consists of both jugals and maxillae with teeth, quadratojugal, quadrate, left dentary with teeth, surangular/articular, angular, and a number of loose teeth. Despite the individual bones being apart for some 75 million years, the skull elements prepared so far still rearticulate as if the animal only died days earlier. The hard nature of the entombing Late Cretaceous rock, disarticulated nature of the bones and a short field season did not permit a full field assessment of the specimen. However, the following scenario can be envisioned:

The carcass, which was evidently largely complete and articulated at the time of stranding, lay on its right side. Skin impressions found in 1989 (but none in 2003) suggest perhaps the carcass was desiccated. It became stranded on the downside of an advancing sandbar or point bar and thus lay, not flat, but at about a 3–4 degree angle with the head lowermost. The carcass lay on and in a layer of white sand with numerous logs, branches and other smaller plant debris suggesting it had became entangled in a developing logjam as it floated down river (Figure 9). A few unionid clam steinkerns, blebs of amber, small ironstone nodules and fusinite (charcoal) chips were also observed.

Figure 9. Modern sediment-filled logjam near Red Willow River hadrosaur. The numerous carbonized logs and other plant material surrounding the hadrosaur indicate it was entombed in a similar situation.

Once ensnared, decay and disarticulation ensued. The carcass bloated and all upper ribs (except one posterior dorsal) were washed away. The lower rib cage, which could not be traced out fully, appears to be articulated, at least in the anterior portion. The skull was fully disarticulated, with the snout and skull roof elements being completely washed away; however there is a chance some of these are still in the block containing the neck as this area could not be delineated fully. Roughly 12 m of the corner of the quarry yielding the skull bones has yet to be excavated and might produce additional skull elements in 2004. The neck and anterior dorsal vertebrae and lowermost ribs remained articulated or associated. The posterior dorsal vertebrae were lost prior to burial. Forelimbs were complete upon stranding. One remained loosely articulated while the other became fully disarticulated; however a number of smaller elements from it such as metacarpals and phalanges were located, suggesting the water was not moving particularly fast or they would have been washed away. The larger portions of the pelvic (ilia and ischia) and tail regions were lost to contemporary erosion.

After burial and fossilization, much of the overlying Wapiti Fm. was removed by Pleistocene glaciation. In many places, the harder overlying and protective Late Cretaceous bedrock was scraped to within 10 cm of the skeleton. If this rock had been softer it is unlikely the skeleton would have survived. As a testament to this suggestion, in one part of the quarry, the olecranon process of a fully *in situ* ulna was partially eroded off, the rounded stump now resting in the deeply penetrating wedge of Pleistocene cobbles and sands.

Headless hadrosaurs are often difficult to identify to the genus level. Fortunately, enough of the skull and several other postcranial bones of diagnostic utility from the Red Willow River hadrosaur were preserved, which allows a reasonable attempt to be made. The evidence at hand suggests we are dealing with a hadrosaurine or flat-headed hadrosaur.

Horner (1988) demonstrated the taxonomic usefulness of hadrosaurine jugals (cheek bones). The jugals in TMP89.92.1 have now been prepared. The ventral profiles of these elements are a close match for a specimen of "*Kritosaurus*" *incurvimanus* as figured by Horner (1988, fig. 2D) and other figured Alberta specimens of *Kritosaurus* (Parks, 1920; Lull and Wright, 1942; Vialli, 1960; Pinna, 1979; Horner, 1992) and DPP skull TMP80.22.1. The dentary teeth are similar to those seen in other *Kritosaurus*/*Gryposaurus* specimens.

Hadrosaur humeri (upper arm bone) are also diagnostic to the subfamily level. Lambeosaurine humeri differ from their hadrosaurine counterparts in having a well-developed deltoid crest which extends outward and far down the thick humeral shaft (Weishampel *et al.*, 1993). Both humeri were well preserved in TMP89.92.1 and one, the left, has now been prepared. Here, the deltoid crest is more weakly developed and does not extend far down the thinner shaft, hinting at its hadrosaurine affinities. The TMP89.92.1 humeri are a close match for those figured for *Kritosaurus* (Parks, 1920; Brett-Surman, 1975; Pinna, 1979).

Lower Vertebrates
Class Osteichthyes (Fish)
- Holosteans
  - † holostean A; *sensu* Brinkman (1986, 1990).
  - † holostean B; *sensu* Brinkman (1986, 1990).
- Teleosts
  - Acipenseridae (Sturgeons)
    - cf. *Acipenser* sp.
  - Lepisosteidae (Gars)
    - *Lepisosteus* sp.
  - Amiidae (Bowfins)
    - † *Kindleia* sp.
  - † Aspidorhynchidae
    - *Belonostomus* sp.
  - Albulidae (Bonefish)
    - cf. † *Paralbula* sp.

Class Amphibia
- Order Urodela
  - salamander indet.

Class Reptilia
- Order Sauria (Lizards)
  - Teiidae
    - † *Chamops* sp.*
  - Varanidae (Varanids)
    - † *Palaeosaniwa* sp.
- Order Crocodilia (Crocodilians)
  - Crocodylidae
    - Gen. et sp. indet.
- Order Eosuchia (Champsosaurs)
  - † Champsosauridae
    - *Champsosaurus* sp.
- Order Chelonia (Turtles)
  - Trionychidae (Softshell turtles)
    - Gen. et sp. indet.
    - † Indeterminate extinct smooth-shelled (non-baenid) form

† Dinosaurs
- Order Saurischia
  - Theropoda
    - Ornithomimidae indet.
    - Tyrannosauridae
      - *Albertosaurus* sp.
    - Troödontidae
      - *Troödon* sp.
    - Dromaeosauridae
      - *Saurornitholestes* n. sp.? (elongate frontal)
  - Theropoda incertae sedis
    - *Richardoestesia* sp.
- Order Ornithischia
  - Ornithopoda
    - Hadrosauridae
      - *Edmontosaurus* sp.
      - cf. *Kritosaurus* sp.
      - *Saurolophus* sp.
      - Hadrosauridae indet.
    - Hypsilophodontidae
      - ? cf. hypsilophodontid indet.
    - Ankylosauridae
      - cf. *Euoplocephalus* sp.
    - Pachycephalosauridae
      - cf. *Stegoceras* sp.
  - Ceratopsia
    - Centrosaurinae
      - pachyrhinosaurine n. gen. et. sp.?
    - Chasmosaurinae
      - Chasmosaurine indet.

Marine reptiles
- † Order Sauropterygia
  - plesiosaur indet.

Class Mammalia
- Order † Multituberculata
  - multituberculate indet.
- Order: Marsupialia
  - cf. † *Pediomys* sp. (primitive grade)

Table 1. Compiled Late Cretaceous Wapiti Fm. (stratigraphically undifferentiated) vertebrate faunal list; Edmonton, Swan Hills and Grande Prairie, AB districts. Sources: Russell, 1931, 1967; Sternberg, 1951; Roed, 1978; Tanke, 1984, this paper; Taylor, 1934; TMP catalogued specimens; author's field observations. * = taxonomic placement doubtful (Kequin and Fox, 1991). † = extinct. 31 species or indeterminate forms make up the Wapiti Fm. faunal list. By comparison, Late Cretaceous formations in southern/central Alberta have yielded the following numbers of known or unspeciated taxa/family/group: Oldman Fm. (77); Dinosaur Park Fm. (129); Horseshoe Canyon Fm. (51); Scollard Fm. (66). Data from Eberth *et al*., 2001.

No. of dinosaur taxa	0*	4	6	13
Citation	Weishampel and Weishampel, 1983.	Weishampel, 1990, p. 114.	Ryan and Russell, 2001, p. 296.	Tanke, this report.

Table 2. Number of dinosaur taxa recognized from the Wapiti Fm. (Edmonton-Grande Prairie corridor) over the past two decades, showing the rapid increase in knowledge. The number in the last column includes the hadrosaur *Saurolophus* for which scientific confirmation is still awaited.
* = Wapiti Fm. not mentioned.

The pubic bones, which form part of the pelvis, are also useful for taxonomic purposes. Crested or lambeosaurine hadrosaur pubes have a dorso-ventrally expanded fan-shaped anterior blade, whereas flat-headed hadrosaurines have a reduced and more rectangular-shaped pubic blade. Southern Alberta and Montana specimens of *Kritosaurus* have a distinctive downward-angled pubic blade (sometimes likened to a hockey stick blade) and this morphology can be also seen in the Red Willow River hadrosaur. The pubes of TMP89.92.1 have not been prepared, but a field comparison to that of a cast of ROM 764 and TMP80.22.1, both *Kritosaurus/Gryposaurus* on display at TMP demonstrated a striking similarity. As noted earlier, the animal was not full adult-sized. A pedal digit II, phalanx 1 measured 119 mm long, which is slightly smaller than those seen in fully adult DPP hadrosaurs. Also, a mid-dorsal vertebra, with a centrum height of 119 mm and transverse width of 91 mm showed a neural arch suture visible along its entire length, as do all the caudal vertebrae. It could not be determined whether these sutures were partially fused or still fully open, though one mid-caudal is missing its arch.

Figure 10. Ichnite site #2, located by the author. Ichnites are preserved on flat sheets of in situ rock exposed between logjam and near shoreline. ATV's or "quads" such as the one seen here are a common mode of transportation in the Peace River/Grande Prairie districts. They are very handy for accessing remote localities, carrying supplies and heavy fossils. The heavy forestation typical of the region can be seen here.

Cause of death of this relatively young adult animal could not be determined. There were no obvious signs of palaeopathology or predation. An unspeciated tyrannosaur tooth crown was found on the east side of the quarry but appears to be unrelated and transported in from elsewhere.

Taken collectively, the morphology of the jugals, humeri and pubes are all indicative that the specimen is an uncrested hadrosaur similar, if not identical to, *Gryposaurus* (*Kritosaurus*), a well-known genus from 75 MYA deposits in Dinosaur Provincial Park, Montana, New Mexico (Brown, 1910; Horner, 1992; Williamson, 2000), Texas (Sankey, 2001), Mexico (Hernandez *et al*., 2003) and Argentina (Bonaparte *et al*., 1984), although additional material from the latter locality is required for generic confirmation. The 75 MYA age is in accordance with palynological findings (Braman, pers. comm., 2002), which indicated a Late Campanian age for the Red Willow River hadrosaur locality.

A few microvertebrate specimens were found in the quarry, these adding to the slowly growing Wapiti Fm. vertebrate faunal list (Table 1). Microvertebrate fossils are commonplace in southern Alberta, but in northern Alberta, there is such a dearth of microvertebrates that even the smallest of fragments are potentially important. Among these, the most important were a tooth (TMP2003.66.7), large complete dorsal rib (TMP89.92.2), and possible clavicle, all of the piscivorous eosuchian reptile *Champsosaurus.* A small fragment of a trionychid (soft-shell) turtle shell (TMP2003.66.4) was also collected. Compared to common champsosaur material from DPP, the dorsal rib came from a relatively large individual and compares favorably to posterior ribs as figured by Russell (1956). The champsosaur and trionychid specimens currently are the northernmost North American range extensions of these two groups in Late Campanian times.

The megaflora of the Wapiti Fm. is also incompletely known (Bell, 1949, 1965), so the recovery of several good deciduous leaves (TMP2003.66.9, 11) in sandstone slabs below the hadrosaur are noteworthy additions. The first of these two leaves preserves a toothed margin and appears referable to the Betulaceae (Birches). A latex peel and plaster cast of a third specimen (TMP2003.66.10) is of the platanoid (Sycamore) type. Given the high quality of their preservation and lack of taphonomic alteration, it seems likely that the trees these leaves originated from grew alongside the river and close to where the hadrosaur carcass became buried (Spicer and Greer, 1986; Martín-Closas and Gomez, 2004).

Outcrops up and downstream of the hadrosaur site were also investigated. Only one other *in situ* dinosaur bone was observed. However, after the 1990 flood a number of interesting finds were made. A block of water-worn sandstone (TMP90.124.1) containing about ten associated ceratopsian bones, including a maxilla with teeth was found and collected 100 m below the bridge by GPRC staff. Where the rest of this skeleton is located has not been determined. Also during this time, local residents found Pleistocene woolly mammoth (*Mammuthus* sp.) tusk sections and a juvenile Mammoth mandible with teeth.

Over the month that TMP staff were there, the Red Willow River hadrosaur generated much public and, later on, Canada-wide media interest. Grande Prairie newspaper reports of problems with local citizens were greatly exaggerated. The author's field notes record positive encounters with 475 visitors to the quarry or our field camp (Tanke, 2003) of which about thirty were repeat visitors. This large number is impressive for several reasons. First, in order to enhance site security and specimen safety, no media were contacted until after the specimen was safely extracted. News of the ongoing excavation travelled by word-of-mouth only. Second, of the 475 site/camp visitors, virtually all were from the immediate area, not Grande Prairie, which is the largest population centre (40,000+), 45 km to the northeast.

A news release on the hadrosaur skeleton was issued by TMP on August 1, 2003, which resulted in a number of newspaper articles (Anonymous, 2003a, b; Evans, 2003; Johnsrude, 2003; Toneguzzi, 2003) across Canada and Alberta-wide radio news stories.

Site 6.—Hythe Road Cut.

TMP staff first examined this kilometre long road cut paralleling Highway 43 in 1986. At that time, the author discovered fragmentary tyrannosaurid jaw pieces (TMP86.81.5) with porous bone surfaces suggestive of a young animal. In 2003, additional fragmentary juvenile tyrannosaur maxilla pieces were discovered. The occurrence of the bone pieces is curious. Not only do the fragments occur washing down slope, but also occur laterally for tens of metres. This first suggested material from multiple individuals were represented. No *in situ* tyrannosaur bones were discovered. There was some initial thought that this site might represent another tyrannosaur mass mortality bonebed *sensu* Currie (1998), but another more likely possibility is that road construction included a grader which scraped up the road cut, unearthing and destroying what would have been a complete solitary maxilla and scattering the pieces laterally as the blade moved forward.

Hadrosaur material, consisting of tendon fragments, a lingual plate fragment and eroded bone scrap was also seen at this locality. One highly eroded *in situ* bone was seen. Some of the sedimentology at this road cut is suggestive for potential microvertebrate fossils, but this will have to be explored in the future.

Site 7.—Red Willow River Hadrosaur Ichnites Site #2.

The author discovered this new locality (Figure 10) on July 26, 2003. Extensive sheets of flat sandstone, some showing ripple marks, are exposed along both shores and under water. Mostly on the eastern shore, deeply impressed ichnites are either plainly visible (Figure 11) along with a good number of deep and empty or water-filled "potholes" probably representing pedal footprints or trackways, now long eroded (Figure 12). However, better-preserved

Figure 11. Hadrosaur pedal ichnite cast *in situ*, site #2, Red Willow River. Ripple marks are visible at upper right. Knife is 19.5 cm long.

Figure 12. Hadrosaur ichnites, Site #2, Red Willow River. The water-filled potholes are highly eroded hadrosaur pedal footprints.

Amblydactylus-type (hadrosaur) tracks can be found including some loose footprint casts. Several of these were collected in September. These loose casts are highly weathered and fragile. More work needs to be done at this locality to collect and preserve the footprint information before they are forever lost to erosive processes. Fortunately the site is rather remote and off road vehicle access extremely limited so the prints are in better shape than site #1 above.

Site 8.—Pinto Creek Bridge.

TMP staff first examined the remote Pinto Creek Bridge locality in 1987. A possible partial ankylosaur ichnite (TMP87.56.39) was collected at that time. The area is a good producer of dinosaur bone, but owing to steep slopes plunging straight into the creek below, it is difficult to trace their origins. The author located *in situ* dinosaur material just upstream from the bridge on the east bank. High in the section, at the base of a coarse and thick white sandstone, a 30–40 cm layer with much carbonized plant material, ironstone nodules and occasional dinosaur bone was observed.

Eroded-out bone in the region is heavily permineralized and tends to be uncrushed but the adhering ironstone matrix is usually very hard with only poor to fair separation. A large number of dinosaur bone pieces are found in the creek bed and are encased in hard ironstone nodules. So numerous are they, that GPRC staffer Bert Hunt noticed campers have unknowingly included them in the circle of stones for their campfires! *In situ* ironstone nodules can be found locally, but none contain bone so the source layer(s) may be further upstream. All bone is hadrosaur where identification can be made.

TMP staff revisited the Pinto Creek Bridge area in 2003 and found a few more bone pieces, but nothing significant. TMP collections contain a small number of hadrosaur jaws (some with teeth) secured by amateur collector Robert Guest in 1966 (see TMP66.38 series). Locality information for these fossils is poor, but appears to be somewhere close to the mouth of this creek, but the locality has not been rediscovered.

Site 9.—Wapiti River Pachyrhinosaur Bonebed.

This locality was first reported to the TMP by a British Columbia resident in 1988 (Sollid, 1988). The site is characterized by widespread slumping, making the source layer difficult to trace. The bone is abundant, relatively uncrushed and well preserved, with thousands of bone pieces littering the base of the outcrop. All bones are ceratopsian and one tyrannosaur tooth impression in rock has been observed. A partial pachyrhinosaur skull (TMP2001.11.1) was collected from a slump block section in 2001 (Evans, 2001). In 2003, TMP staffer Dr. David Eberth located some *in situ* bone high in the section. The author uncovered this and it turned out to be the nasal boss and facial bones of another large pachyrhinosaur skull. However, this specimen was missing the diagnostic nasal and especially basal frill portions so it was not collected.

The Wapiti River pachyrhinosaur bonebed is, by handheld GPS measurement, about 120 metres higher in section than the pachyrhinosaur bonebed on Pipestone Creek. The presence of the palynomorph *Wodehouseia edmontonicola* from sediment in the former bonebed suggests an age of 70.5–71.8 MYA (Braman, pers. comm., 2002). The presence of *W. edmontonicola* is of especial interest as it has a restricted age range, occurring mostly between coal seams 2 and 7 of the Horseshoe Canyon Fm. in the Drumheller Valley. This knowledge, plus radiometric dating would indicate the Wapiti River bonebed having an age of 70.5–71.8 MYA (Lerbekmo and Braman, 2002). This would also correlate to approximately coal seam 7.5 near Drumheller and just slightly older than the Drumheller *Pachyrhinosaurus* skull described by Langston (1967, 1968). Thus the Drumheller and Wapiti River pachyrhinosaurs were roughly contemporaneous.

Given the large stratigraphic difference between this site and the pachyrhinosaur bed at Pipestone Creek, there has been some speculation that the two are related but different species. Certainly the adult Wapiti River pachyrhinosaurs appear slightly larger in size and one unprepared skull (TMP2001.11.1) appeared to have orbital bosses with a strikingly different surface texture (smooth instead of rough), but these differences have yet to be quantified. Immature Pipestone Creek pachyrhinosaurs show a dorsally-directed bump or longitudinal row of bumps on the proximal parietal bar midline. These bumps quickly transform into an upward-pointing horn or horns upon reaching adult size (Sampson, Ryan and Tanke, 1997; Langston, Currie and Tanke, in prep.). A subadult pachyrhinosaur proximal parietal bar (TMP88.92.7) collected from the Wapiti River bonebed appears in all aspects identical to similar-sized parietal bars from the Pipestone Creek bonebed, so it is just a matter of time before spiked adult-sized parietal bars turn up at the Wapiti River site as well.

This site is apparently well known to local and British Columbia amateur collectors. On one recent trip the author caught several BC families at the site digging up bones in the slumped area with gardening tools. Signs of digging *in situ* material have also been observed. Future work is possible at this site but would entail the extensive use of heavy equipment and resultant landowner impact would be a concern (Knutson, 1994; Lehay, 2003). Much of the bone is encased in hard siltstone with variable separation, making preparation endeavours expensive and time-consuming compared to the Pipestone Creek pachyrhinosaur bonebed.

Site 10.—Wapiti River/Pipestone Creek Bonebed.

This small bonebed was discovered by the author on September 1, 1986. It occurs about 100 metres upstream from the mouth of Pipestone Creek on the north bank of the Wapiti River. The fossil-producing layer can only be seen when water levels on the Wapiti River are low. Owing to water and overburden, the lateral extent of this site has yet to be determined. The horizon is at the base of a thick white sandstone unit in a soft light grey sandstone, chock-full of small, irregularly-shaped ironstone nodules. Above this is a distinctive layer with four to five very thin coaly stringers. The bone at this site is of poor quality, being highly eroded prior to its deposition. All bone appears referable to hadrosaurs. Two TMP teams investigated the area in 2003, but the bonebed could not be relocated. It may be washed away or buried under shifting river silts and sands.

Additional *in situ* and loose dinosaur bone and amber has also been collected from this area. Local residents found dinosaur bone in this area around 1940 and local amateur palaeontologist Robert Cochrane called the area "Dinosaur Park," even erecting a sign bearing that name (Neufeld, 1987).

Site 11.—Pipestone Creek Pachyrhinosaur Bonebed.

This bonebed is currently the single most important dinosaur site in the Grande Prairie area. Crystal Park School science teacher Al Lakusta of Grande Prairie found and reported this important locality in 1975 (Fleming, 1975), not a "GPRC professor in the mid-1980s" (Anonymous, 2004, p. 9).

TMP staff, including the author, first briefly examined the site in 1983, but the identity of the horned dinosaurs contained therein was at first elusive. The Pipestone Creek bonebed preserves a considerable mass mortality event, similar to those observed in ceratopsian bonebeds in southern Alberta (Currie, 1981; Currie and Dodson, 1984; Ryan *et al.*, 2001), among extant herding mammals (Schaller, 1973:31-32; Sullivan, 1984; Scott, 1988) or taxonomically diverse animals killed simultaneously (Ralrick, 2004).

Mr. Lakusta collected material from this site for several years. The fossils were stored at the then-named Grande Prairie Pioneer Museum where the author realized their *Pachyrhinosaurus* identity in the summer of 1985. At the time, *Pachyrhinosaurus* was the most poorly-known ceratopsian in North America. Given this fact, the fossils were then donated to the TMP in early November 1985 (Skidnuk, 1985).

Ensuing study and discoveries of other western North American ceratopsians resembling *Pachyrhinosaurus*, but ascribed to, or suspected of being new genera (*i.e. Achelosaurus*; Sampson, 1995) have raised questions as to whether the Pipestone Creek animal is in fact *Pachyrhinosaurus* or a new, but related genus. The spatial and stratigraphic differences, plus a number of cranial osteological differences between the Pipestone Creek animal and *Pachyrhinosaurus* and other pachyrhinosaurines in southern Alberta and Montana suggest the Pipestone Creek animal may represent a new genus although there has been some debate on this point. Therefore it is considered hereinafter as a "pachyrhinosaurine" until this matter is settled.

The Pipestone Creek site, a very rich ceratopsian bonebed dominated by an unusual pachyrhinosaurine, was worked by TMP in the summers of 1986–1989. This site is by far the best-known

Figure 13. Composite Pipestone Creek adult pachyrhinosaur skeleton casts as part of the Ex Terra Foundation travelling world tour. Skull reconstructions and bone (cranial/postcranial) preparations by the author. The skull is a composite. From the tip of the rostrum to the parietal bar behind the upward pointing "unicorn" spike is TMP86.55.258. Lower jaws, jugals, squamosals and lateral parietal ramii are added on elements from the same bonebed. The skeleton cast in the background went to GPRC in the summer of 2002.

horned dinosaur bonebed in North America (Anonymous, 1989b; Ogle, 1989; Struzik, 1989; Rowland, 1990) due to the extremely high abundance of well preserved bone (>150 elements per square metre), good cranial and postcranial element representation across four size classes and especially the occurrence of large adult skulls typically 50–75% complete every 1.5–2 square metres. Even the best horned dinosaur bonebeds in the Drumheller Valley or DPP don't come close by comparison. However, spatially it is not "…one of the largest dinosaur bonebeds in North America…" as reported in Talbot (2003d).

Disarticulation of skeletal elements is nearly total, suggesting that the carcasses were exposed to the elements for some duration of time, perhaps several years (Hill and Behrensmeyer, 1984).

No other North American horned dinosaur bonebed worked so far is as rich as this one; >99% of the bones uncovered are ceratopsian. The bones are preserved in a damp/wet and mostly soft carbonaceous grey siltstone, which usually separates fairly cleanly from the bone. Often, once the damp rock dries out, it just flakes off the bone. Patches of harder rock are easily removed with an air scribe followed by an air abrasive unit loaded with commercial grade sodium bicarbonate (baking soda). Specimens are easily extracted, prepared and can be made into research specimens and/or display quality items in short time. A good adult pachyrhinosaur skull from this site takes an experienced preparator about one month to fully prepare. Smaller specimens are completed more quickly. Equipped with the proper tools, an experienced preparator can finish the smaller specimens (phalanges, small vertebrae) in as little as fifteen minutes to one or two hours. Over about half a year the author, working alone, was able to prepare and reassemble the greater part of a full adult skeleton, minus the head. A reconstructed adult skull for this composite skeleton took about 1.5 months to complete.

Using the potassium-argon method, volcanic ash 27 m above the site yielded a date of 73.27 MYA, ± 250,000 years (D. Eberth, pers. comm.). Such an age is roughly equivalent with the early Bearpaw Sea marine shale facies in southern Alberta. This date is also close to a recent discovery of a new, nearly complete pachyrhinosaurine skull and partial skeleton (Quarry 239; TMP2002.76.1) high in the section and close to the Dinosaur Park/Bearpaw Fm. contact in Dinosaur Provincial Park. While this skull is missing its diagnostic parietal and remains unprepared, field observations of the preserved portions of the skull indicate it is closely related to, perhaps the same as the Pipestone Creek pachyrhinosaurine. Another closely related pachyrhinosaur is known from an isolated skull and rich bonebed on the North Slope of Alaska (May and Gangloff, 1999; Fiorillo and Gangloff, 2003).

The Pipestone Creek bonebed is also noteworthy in having some well-preserved insects in hard amber, allowing us the first-ever opportunity to learn about truly contemporaneous dinosaur and insect faunas. The author is unaware of any other site in the world where this true co-occurrence of dinosaurs and insects in one site occurs.

Material from the Pipestone Creek bonebed has been worked into a few minor research projects (Tanke, 1988; Currie, 1989b; Rothschild and Tanke, 1992; Chinsamy, 1994; Edwards and Russell, 1994; Rothschild and Tanke, 1997; Harper *et al.*, 2002) or in support of others (Sampson, 1995; Sampson, Ryan and Tanke, 1997; Rothschild, *et al.*, 2003; Tanke and Rothschild, 2002; Tanke and Farke, 2003, submitted). Material and research from this site led to a feature video documentary (Robichauld and Robichauld, 1993).

Bones and skulls enough to reconstruct five com-

Figure 14. 1:10 scale sculptures of the Pipestone Creek pachyrhinosaur made by American artists. Top: "The Old Guard" by Dan LoRusso; 1994; Bottom: *Pachyrhinosaurus* by Cliff Green, c. 1996. The upward pointing spikes on the midline of the frill are a major distinctive feature of the Pipestone pachyrhinosaurs. While most adult specimens show a single upward pointing horn, a few specimens show three, which these artists have elected to include in their sculptures. The author was a consultant on both these renditions. Both sculptures in the author's collection.

posite juvenile and adult pachyrhinosaur skeletons were prepared by the author (Anonymous, 1989a; Figure 13) and others assembled by staff of the Ex Terra Foundation for the Alberta-Canada-China Dinosaur Project travelling exhibit, which was viewed by millions worldwide during 1993–1996. One of these adult skeletons finally found its way to GPRC in the summer of 2002, in consideration of GPRC's many years of assistance to TMP with field work in the Grande Prairie district (Ruhl, 2002a,b).

The finder of the bonebed, now-retired science teacher Al Lakusta received a cast of a skull which he donated to Crystal Park School in Grande Prairie (Ruhl, 2002c, 2003). Another composite skeleton, using mostly real bones was built for TMP galleries and put on display in May 1993.

Pipestone pachyrhinosaurs have even appeared in several Hollywood films. Disney's 2000 animated movie *Dinosaur* and their own spinoff juvenile literature features pachyrhinosaurs throughout. Most recently, a Pipestone pachyrhinosaur skeleton appears several times in the museum scenes near the beginning of the 2003 release *X-MEN II*—more so than a *Tyrannosaurus rex* skeleton in the same sequences. A static model of a Pipestone pachyrhinosaur appears in the mid-December 2003 Discovery Channel's *Dinosaur Planet* release, "Little Das' Hunt." This is one of about half-a-dozen adult (Figure 14) and several juvenile scale or life-size sculptures rendered by American, Canadian and Japanese artists. Numerous artists worldwide enjoy creating drawings [see *Bulletin* cover] and paintings of the Pipestone pachyrhinosaur; dozens can be found on the Internet or in popular dinosaur books published over the past fifteen years. Several companies have also made children's toys based on the Pipestone pachyrhinosaur.

A major research paper, describing the cranial osteology and ontogeny of the bizarre Pipestone Creek pachyrhinosaur is still in progress (Langston, Currie and Tanke, in prep.) and the author has been preparing a large backlog of material in support of this venture. The resultant publication will be the third largest ceratopsian paper written and the biggest since 1933. The Pipestone Creek bonebed has been one of the best-kept secrets in the palaeontological community. Not only has this site shed light on the osteology of the bizarre pachyrhinosaur preserved therein, but it can provide volumes of

Figure 15. Pleistocene elk, *Cervus elaphus* antler and skull fragment as found, Pipestone Creek, Alberta.

information on multidisciplinary studies such as individual variation, sexual dimorphism, ceratopsian systematics, phylogeny, and evolution, cladistics, dinosaur behaviour/herd structure, histology, ontogenetic changes, palaeopathology (Rothschild and Tanke, 1997), taphonomy and palaeoecology. These data, in turn, will have important bearing on other ceratopsian research worldwide. In fact, it was the Pipestone Creek bonebed that really helped solve the issue of the validity of the problematic ceratopsian *Monoclonius* and our understanding of the revolutionary cranial growth changes that occur from young to adult animals (Sampson, Ryan and Tanke, 1997). Fellow ceratopsian aficionado Dr. Peter Dodson in Philadelphia mentions the Pipestone Creek site in his definitive horned dinosaur book published in 1996. He writes (Dodson, 1996, p. 180): "It is a fossil deposit of the greatest significance," and (p. 181) "…the Pipestone Creek bonebed is of extraordinary importance…"

While recognized by many palaeontologists as an important locality, the Pipestone Creek site is not "…western Canada's second richest known dinosaur area." (Holler, 2002, p. 12), or "…the second richest area for dinosaur fossils in Canada" (Grande Prairie Regional Tourism Association, 2004, p. 18).

No excavation work was done at the site in 2003, but the bonebed was examined in case any new skull material showed up, as was the case in early May, 2002 when a 75% complete adult skull (TMP2002.29.1) was collected with GPRC assistance under severe spring blizzard conditions.

Close to the bonebed, a large section of Pleistocene elk (*Cervus elaphus*) antler and adjoining skull fragment were found resting on the edge of a small gravel bar in the creek (Figure 15). A number of Pleistocene-aged mammal discoveries have been made in the Peace region over the years (Sternberg, 1930); in recent years, most notable was a virtually complete 10,000-year-old elk (*Cervus elaphus*) collected in the mid 1980s (Erlendson, 1985; Geiger, 1985). This past Easter, a raised ceratopsian manus print was found in a sandstone slab in the creek bed downstream from the Pipestone Creek bonebed. This rare find will be collected this coming summer.

There have been some suggestions of building a major museum or interpretive centre on the bonebed itself. However, the terrain there is perpetually wet and unstable. Underground springs keep the bone layer and overlying sediments wet, which freeze and expand in winter. Annual rainfall ensures these springs have a steady water supply. A series of parallel cracks, filled with slimy mud run through the bonebed and are themselves oriented parallel with the creek. The cracks widen as one approaches the edge of the bank overlooking Pipestone Creek and demonstrate how the bonebed is imperceptibly calving off in sections into the creek below. This scenario does not immediately endanger the bonebed, but engineers studying this locality may find it not conducive towards building a permanent structure there.

There have also been recent suggestions that this would be a good place for a public participation dig. Such was done in 1987–1989 but with mixed results. There are simply too many bones lying in wet mud that makes the fossils hard to see and delineate during the exposing and extraction phases. With so many technical and multitasking challenges, it is not a place for the inexperienced. At times we had crews of up to ten people and removed ten to twenty-five bones a day. The author, alone and on a really good day could remove 125 bones!

Site 12.—Spring Creek Hadrosaur Bonebed.

GPRC staff first examined this bonebed around 1988. The hadrosaur bones are preserved in soft, dark grey, carbonaceous shale, which separates cleanly. The bonebed is exposed for a several tens of metres on the north bank (shoreline) of the Wapiti River about 150 m downstream from the mouth of Spring Creek. Its exposure is sporadic due to high river levels and especially slumping of the nearby riverbank.

The GPRC did some minor excavation work at this locality in 1991, securing fifty bones in two days (Eamon, 1991a); all the material is now catalogued under the TMP88.94 and TMP91.137 series. In 2003 the site was revisited, but found to be slumped over so little more could be learned. However, the site is interesting as it is dominated by the well-preserved, disarticulated remains of subadult (slightly under half-grown) animals.

The site does not contain baby dinosaurs or nests as reported in Eamon (1991a). Once thought to nest only in upland areas, hadrosaur eggshell and embryonic/hatchling-sized hadrosaur bones have been found in lowland palaeoenvironments (Clouse, 1995; Ryan *et al*., 2000; Tanke and Brett-Surman, 2001). Hadrosaurs and other animals probably nested in the Grande Prairie area, but unique depositional environmental parameters have to be met before there is a chance of these fragile items being preserved (Paik *et al*., 2004). For example, great stands of coniferous trees of that time increased the acidity of the soil (think of the dead circle of grass under a conifer tree) and groundwater. These acidic conditions were not conducive to the preservation of eggshell calcium carbonate—it simply dissolved away (Clayburn *et al*., 2004).

Despite the lack of true baby dinosaurs, the site is of interest as it is suggestive of the decimation of a "bachelor herd," *sensu* Varricchio and Horner (1993). Bonebeds dominated by subadult hadrosaurs are rare, the Spring Creek locality is one of several such sites in Alberta (Lam and Ryan, 2001) and Montana. However, the material in the Spring Creek site is of much better quality, being essentially complete albeit slightly crushed. The site does include skull material, but nothing diagnostic that could establish a generic identification has been located thus far. However, the humeri, with their low deltoid crests are suggestive of flat-headed hadrosaurs.

This interesting bonebed could warrant future work, but road access to the site and massive overburden removal would be needed. The site sits close to river level and can be easily flooded during periods of high water. If opened up, this would be an ideal public participation site similar to those run by TMP and other museums (Sander and Gee, 1992; Eberth *et al*., 2001; Lam and Ryan, 2001).

Site 13.—Bear Creek.

Bear Creek, which flows through the city of Grande Prairie, was also briefly examined. Only a few minor outcrops were seen, mostly consisting of Pleistocene clays. Mosquitoes and mud were plentiful. This waterway needs a rigorous examination, especially near its confluence with the Wapiti River, as there are consistent rumors from the local populace that dinosaur bones have been found there.

Site 14.—Roadside outcrops south of Grande Prairie.

On highway 40, south of Grande Prairie and north of the Wapiti River bridge, several roadside outcrops can be seen. They show good, fluted "rille" development such as seen in the badlands of southern Alberta. Those on the east side revealed several small *in situ* carbonized tree stumps in life position. Outcrops on the west side of the highway appeared barren. Several hundred metres to the west of the highway, a large exposure was examined. Here the sediments have undergone widespread slumping. Only one badly preserved and eroded dinosaur bone was found *in situ*.

Site 15.—Kleskun Hills.

Until the Pipestone Creek discovery, this area was long touted as the most important dinosaur locality in the Grande Prairie area. The Kleskun Hills (Figure 16) present a marked departure from the terrain typically seen and worked in the Grande Prairie district. Here, on prairie level and away from any waterways, several hectares of Drumheller-like badlands are present, complete with prickly pear cactus (*Opuntia fragilis*)—the most northerly occurrence of both in Alberta.

Volcanic ash from the hills was analysed for dating purposes; it was found to contain much contamination, but disclosed a date of 73.77 MYA ±1.46 MYA (D. Eberth, pers. comm.).

The Kleskun Hills have had their share of controversy in palaeontological circles (Charlton, 1983). In his lifetime, local fossil collector Robert Cochrane (1880–1965) found many duck-billed dinosaur bones in the Grande Prairie district. A composite panel-mounted adult hadrosaur skeleton, utilizing Cochrane's collection, was built by GPRC for the Grande Prairie Museum in 1988 (Anonymous, 1988)—the first dinosaur mounted in Grande Prairie.

A number of other hadrosaur bones from his collection ended up at TMP (see TMP64.6 series), where, despite their excellent preservation and completeness, the locality information is simply given as "Grande Prairie area." Where exactly all of these fossils came from is still unknown, which is unfortunate, as differing types of adhering rock indicate the material is derived from perhaps as many as three separate hadrosaur bonebeds. Cochrane-collected hadrosaur bones embedded in hard sandstone, ironstone and a calcium carbonate-like rock have been observed. As it is unlikely these three diverse rock types would be present in one site, three separate bonebeds are suspected, yet remain undiscovered by contemporary workers.

Allan and Carr (1946) and Cochrane himself apparently claimed these bones came from the Kleskun Hills, Cochrane naming one of the hills in 1946 as "Dinosaur Hill". Travelogue books (Readers Digest, 1974), local tourism information (Anonymous, 1950, p. 13) and period highway signage touted the Kleskun Hills as an important source for dinosaur fossils. A Kleskun Hills internet website also states "…many dinosaur fossils were found…" (Anonymous, 2003d), but subsequent investigations there by TMP staff and others to corroborate these claims have proved largely fruitless. Only small fragments of scrappy dinosaur bone can be found at the main hill localities. The mode of fossil preservation and types of rock adhering to the Cochrane hadrosaur bones are completely dissimilar (in hardness and types) to rocks exposed at the Kleskun Hills.

Recent publications (Charlton, 1983; Hervieux, 2002a,b, 2003; Tanke, in prep. b) have challenged the veracity of Cochrane's claims. The dinosaur bones are simply not there in the numbers, size and quality as suggested by the Cochrane collection and the Sternberg (1951) lizard jaw remains the only described vertebrate fossil from the Kleskun Hills locality. Efforts are being made to relocate Cochrane's lost hadrosaur bonebeds, but the clues are slow in coming and it is a difficult endeavor without photographic documentation (Tanke, 2001; submitted).

Analysis of fossil pollen within the rock attached to the Cochrane-collected bones show they come from rocks the same age as those exposed around Grande Prairie and WSW to the Alberta/British Columbia border. In the mid 1980s, the author encountered several Grande Prairie residents who, as children, helped Cochrane collect dinosaur bones. None could remember where the site(s) were, but all independently stated they were "…in a valley…"

Figure 16. Kleskun Hill Park, looking northwest.

Despite this dilemma, some small and undescribed material has been recovered from these hills. Canadian Museum of Nature (Ottawa) records indicate that accession CMN 38450 are "[plaster] casts of teeth" of the pachycephalosaurid dinosaur *Stegoceras*, collected by Cochrane in October 1949 from "Kleskun Hill." The author saw these casts many years ago, but they will have to be examined for confirmation of identification. What became of the original teeth is presently unknown.

A survey of the Kleskun Hills in 2003 again revealed no useful large vertebrate fossils at the main hill localities, but off to the south a small new multigeneric bonebed/microsite was located among some minor outcrops. Fossil material and matrix here again was dissimilar to any in the Cochrane collection. A small dinosaur pedal phalanx, found in 2003 from this bonebed may be referable to the Hypsilophodontidae, a family of small bipedal herbivorous dinosaurs.

Several hundred kilograms of the bone-producing sediment layer were collected for wet screen washing. Sediment was thoroughly soaked in water and then the resultant sludge washed through door screen to capture the small fossils, bits of undissolved clay particles, and ironstone. Volunteer Patty Ralrick spent several weeks carefully sorting through the resultant concentrate. The results of this endeavor were not as encouraging as what has been recovered from classic microvertebrate localities in southern Alberta, but nevertheless, some important vertebrate material, including several new groups for the Wapiti Fm. are now confirmed or recognized, namely: several primitive fish, ankylosaurs (armored dinosaurs), salamanders and, important for biostratigraphic work, multituberculate and marsupial mammals. More work at this site is anticipated. Plans are to collect more fossiliferous matrix in June and July 2004 and screen the same that fall. It appears that with continued microvertebrate sampling, the Grande Prairie region will eventually yield the northernmost taxonomically diverse Late Cretaceous microvertebrate assemblages in North America. If true, they will serve an important comparative function to microvertebrate assemblages stretching down to the south all the way to Texas (Sankey, 2001).

The Kleskun Hills were the site of popular annual "geological picnics" during c.1946–1952. Other similarly themed events were held in 1961 and 2002 (Hervieux, 2003). Here, hundreds of local folk would gather around, socialize and listen to an invited academic guest speak outdoors about palaeontology and/or geological matters (Tanke, in prep. b). It may be through these popular picnics that the legend of the Kleskun Hills as a rich source of dinosaur bones began. Certainly many Grande Prairie and district citizens the author has talked to over the years still believe this to be true.

The recent discovery of a newspaper article (Anonymous, 1944), relating to Cochrane's dinosaur bone discoveries places his locality at "…valley of the Deep Creek in the east end…" This corroborates the comments made by the then children who helped Cochrane collect his dinosaur bones. Hopefully future explorations in this area will resolve the whereabouts of these important lost localities.

Closing comments and future considerations

The future potential for important palaeontological discoveries in the Grande Prairie district looks good. Despite poorer road access, moist climate, vegetation cover, discontinuous and remote outcrops and resultant logistical challenges, the Wapiti Fm. nevertheless continues to reward the patient and resourceful palaeontologist. No matter where one looks, something new is always found, be it amber, ichnites of various species, dinosaur bones or plants.

Even as this manuscript was undergoing final editing, the TMP received a number of calls reporting new finds. An experienced amateur reported dinosaur bones and a small theropod footprint from the Kakwa River about 100 km southwest of Grande Prairie, in Scollard Fm. equivalent beds of the Wapiti Fm. GPRC staffer Dr. Robert Hunt and Grande Prairie resident Sheldon Graber investigated and discovered a sparse bonebed containing water-worn but heavily permineralized dinosaur bone fragments. This was a first occurrence for the Scollard Fm. in this region and bodes well for future discoveries.

In September 2003, a TMP crew successfully investigated a new Paleocene shell hash layer 95 km south of Grande Prairie that is producing vertebrate material. New dinosaur bones were discovered some 55 km SW of Grande Prairie during grading operations at a gas well site in the Nose Mountain region. The site was investigated by Graber and Hunt who found as-yet unidentified dinosaur bones and an unspeciated tyrannosaur tooth tip. Reports of *Tyrannosaurus rex* in this site or region (*i.e.*, Talbot, 2003a) are grossly premature and unfounded.

Moving further afield to the north and northeast of Grande Prairie, a number of marine Late Cretaceous vertebrate fossils have been reported or recovered. Amateur collector George Robinson collected an incomplete and eroded, articulated mosasaur skull (TMP73.11.2416) from Kakut Creek near Wanham. In 1985, the author saw plesiosaur vertebrae from this area on display in the Wanham museum. Sheldon Graber recently examined an elasmosaur (long-necked plesiosaur) cervical vertebra collected from the Spirit River area.

The marine Late Cretaceous invertebrate fossils from the Badheart, Peace and Smoky Rivers and Kakut Creek have long been known and studied, but underutilized as display items. Shark teeth, fish material and an *Ichthyornis* (tern-like bird) humerus and other fossils have been recovered from Early Turonian-aged deposits near Watino, Alberta (Fox, 1984). Shark teeth have long been known as fossils in Alberta but were usually just considered as curio items. They have only just recently come into their own as research-worthy material in the province (Beavan and Russell, 1999; Brinkman and Ralrick, 2004; Ralrick and Brinkman, 2004). Future comparative work on Late Cretaceous shark faunas in Alberta is anticipated and the Watino assemblage will provide an important component in this growing research.

In the Buffalo Head Hills area, a beautifully preserved snout section (TMP2003.83.1) of the mid-Cretaceous ichthyosaur *Platypterygius* was recently discovered along a road cut near Red Earth Creek, Alberta. The fossil shows fresh breaks on both ends, boding well for more of the skull and body being present. It is hoped this will yield a good specimen when the site is eventually investigated. If so, it would be only the second good ichthyosaur skeleton from the province. There are recent reports of never-before explored lower–mid Wapiti Fm. outcrops in this area as well (Alberta Energy and Utilities Board, 2002; Pawlowicz and Fenton, 2002).

The Swan Hills have yielded an encouraging number of small vertebrate fossils (Russell, 1967) but the locality has not been examined since. Far to the east, the author discovered a very rich *in situ* hadrosaur bonebed in Wapiti Fm. deposits exposed along the Athabasca River near Blue Ridge, Alberta (Anonymous, 2002; Deregowski, 2002). Many hundreds of large, well-preserved bone pieces littered the shoreline for nearly 100 m. Limited time did not allow for a proper site assessment. Amateur discoveries of dinosaur bones have also been reported from the Wapiti Fm. on the Freeman River near Fort Assiniboine, Alberta (Nielsen, 1977).

The older Dunvegan Fm. north and northwest of Grande Prairie offers additional opportunities. This formation is yielding turtle and dinosaur bones and dinosaur footprints in British Columbia. Fox (1972, p. 16) noted a diverse brackish/marine fauna secured from the Dunvegan Fm. (probably from near the Dunvegan Bridge) after a 3 week expedition in 1971. Several microvertebrate concentrations containing "…at least two kinds of sharks, a ray, a gar [primitive fish], a possible pycnodont [extinct fish], two or possibly three turtles, including *Compsemys*, and a crocodile" were sampled. Further work was planned on this 90-million-year-old assemblage, but nothing further resulted.

Even the smallest of fragments can be important. Hirayama *et al*. (2000, p. 190) noted a small but important record of a trionychid turtle shell fragment (TMP94.384.1) from the Dunvegan Bridge area. Relocation and sampling of these sites would be of extreme interest as vertebrates from this period of geological history are virtually unknown in Alberta and poorly known in the Peace District of British Columbia. The fish material could be particularly interesting when compared to other high latitude fish faunas (Friedman *et al*., 2003).

A large sandstone slab (TMP94.183.1) of Dunvegan Fm. dinosaur footprints (with skin impressions) referable to the ichnogenus *Tetrapodosaurus* was collected by the author in 1994 (Anonymous, 1994; McCrea *et al*., 2001; Wilkins, 1994). Other dinosaur footprints and rare dinosaur bone has recently been found in the Dunvegan Fm., in the Pouce Coupe area of Alberta (Scott *et al*., 2001; McCarthy, 2002). The bone occurrences are small but significant as they demonstrate the potential for bone preservation in this formation. Results from the Dunvegan Fm. on the Alberta side of the border would compliment work recently started in northeast British Columbia by the Tumbler Ridge Museum Society (Helm, 2001; Golightly, 2002; McCrea and Buckley, 2004; Tremblay and Kelly, 2004).

The Grande Prairie district and its dinosaurs could potentially play an important role in hadrosaur and ceratopsian evolutionary studies. In southern Alberta and Montana, the marine Bearpaw Fm. separates two distinct hadrosaur and ceratopsian faunas. While hadrosaurs are known from this intervening marine unit (Horner, 1979; Tokaryk, 1987; TMP98.50.1: *Prosaurolophus*), the picture remains incomplete and still totally unknown for ceratopsians and other dinosaur groups.

The Wapiti Fm. lacking the dividing Bearpaw Fm., preserves a continuous series of terrestrial deposits and potentially their dinosaur faunas. This material could shed new light on research into evolutionary patterns in hadrosaurs and ceratopsians (Horner *et al*., 1992).

Also, given its distance from other classic faunas in southern Alberta, Montana and further south, the potential for the discovery of new dinosaurian taxa remains good. Lehman (1997, 2001), pointed out that the spatial distinctiveness of Late Cretaceous dinosaurian faunas across North America and the Grande Prairie district is so far away from those areas studied that it seems likely that some of the dinosaurs there will prove different. This is true when one examines the Pipestone Creek pachyrhinosaur, which differs markedly from the type species in southern Alberta and the elongate frontal of a Pipestone Creek *Saurornitholestes* (TMP89.55.47), which is suggestive of a new species with an elongated snout. The Kleskun Hill lizard jaw, identified as *Chamops* by Sternberg (1951) could not be referred to that genus or any other lizard in a review of Late Cretaceous lizards conducted forty years later (Kequin and Fox, 1991), suggesting it may also be new to science.

Most of the Grande Prairie hadrosaur material preserving diagnostic features appears attributable to flat-headed hadrosaurs. The only possible exception is material from the George Robinson hadrosaur bonebed (Site #1, above). This at first seems curious, but when roughly equivalent beds in southern Alberta are examined and stratigraphic context of hadrosaur specimens there accurately recorded by advanced GPS technology (Pryor *et al*., 2002), a similar pattern emerges. The portions of the Wapiti Fm. worked by TMP staff are roughly equivalent to the southern Alberta upper Dinosaur Park Fm. exposed near Brooks (oldest), marine Bearpaw Fm. (intermediate) and the lower Horseshoe Canyon Fm. (youngest) exposed in Drumheller. While crested hadrosaurs such as *Corythosaurus* and *Lambeosaurus* are common in the lower Dinosaur Park Fm., as one moves higher in section, they become rare until, near the top, the massive hadrosaurine "flat-headed" *Prosaurolophus* dominates. Above this, a few hadrosaur skeletons are known from the overlying and younger marine Bearpaw Fm. and where identifiable, all again were *Prosaurolophus*. In the still younger overlying lower Horseshoe Canyon Fm., *Prosaurolophus* appears to have become extinct and the ponderous flat-headed hadrosaur *Edmontosaurus* now dominates. Not until one examines the still younger upper Horseshoe Canyon Fm. rocks do crested hadrosaurs reappear as *Hypacrosaurus.*

The chance of finding more exotic crested hadrosaurs in the Grande Prairie area will be improved if we look for and examine stratigraphically older Wapiti Fm. beds, which are still largely unexplored in the Saddle Hills region (where dinosaur bone has been reported) to the north or younger sediments along the Kakwa River corridor to the south.

The growing number of important fossil sites in the Grande Prairie district demands their accurate spatial and stratigraphic measurement by the same GPS mapping techniques currently ongoing in southern and central Alberta (Pryor *et al*., 2002). This will give us a better understanding of the stratigraphic context of the Wapiti Fm. sites and specimens discovered so far and allow us the first real opportunity to properly biostratigraphically subdivide the Wapiti Fm. into discrete members or units. This work would need to be complemented with sedimentological and magnetostratigraphic research, which is still largely lacking.

Collection and study of Wapiti Fm. insects in amber and plant megafossils could also provide information on palaeoenvironments and their evolutionary patterns. Given the dearth of Upper Cretaceous insects in amber sites in Alberta (only one good site known) and fossil insect studies in Canada coupled with massive insect diversity then and now, it is certain new forms will be discovered.

Invertebrate fossils from the Wapiti Fm. are known (Tozer, 1956), but are probably undersampled and in need of rigorous reappraisal. Unionid clam steinkerns (internal casts of shells) were noted throughout the 2003 field work, testifying to the strictly freshwater nature of the Late Cretaceous depositional environment. Through concerted efforts, the unique Late Cretaceous ecosystems (Fastovsky, 2002) of the Grande Prairie/Peace District are slowly being revealed.

The Late Cretaceous vertebrate fauna of Alaska, which bears a striking resemblance to that of Grande Prairie, has been touted as an important dinosaur "through route" via the then emergent Bering Land Bridge. Given the narrow palaeogeography of western North America at these times, Grande Prairie would, by extension, similarly qualify: dinosaurs (Russell, 1993; Lucas and Sullivan, 2000) and other, smaller animals (such as fish, turtles and lizards) moved back and forth along this narrow corridor, passing through the Grande Prairie/Peace River district. Gangloff and Fiorillo (2003, p. 53A) write: "Alaska holds the key to the distribution and movements of important Cretaceous clades such as the troödontids, tyrannosaurids, marginocephalians, thyreophorans, and hadrosaurines."

Ongoing exploratory work for dinosaurs in the Canadian Arctic (Brazeau, 2003) and the Yukon could be tied in with the Grande Prairie findings.

These regional finds and observations, plus recent high-level discussions of building a major new multi-million-dollar dinosaur museum or interpretive centre in the Grande Prairie area (Anonymous, 2004; Fooks, 2003; Holubitsky, 2003; Kolafa, 2003; Talbot, 2003b-d,f, 2004a,b) bode well for long-awaited multidisciplinary professional investigations in this region. Certainly our recent efforts have been rewarded with increased knowledge of the dinosaur and non-dinosaur vertebrate fauna of the Wapiti Fm. (Tables 1, 2).

Grande Prairie district amateur palaeontologists and the public, with an enhanced awareness of fossils are increasingly reporting their finds to the TMP. This is an important consideration as many important palaeontological discoveries are made by members of the public (Robinson, 1988; Pojeta, 2000; McCrea, 2003). The Pipestone Creek and Wapiti River pachyrhinosaur bonebeds are two fine examples of public-discovered and reported localities.

These are exciting times for Grande Prairie/Peace River District vertebrate palaeontology. So many fossils have already been found and much learned, yet professional palaeontologists have examined probably less than 1% of the available outcrops. The Grande Prairie district can thus be considered virgin territory for dinosaur explorations. Once thought to have relatively little palaeontological potential, now important future discoveries in the Grande Prairie district are eagerly anticipated.

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Mongolian Dinosaurs

(*continued from page 2*)

Mongolia September 5–20, 2004. They are looking for participants for this tour/excavation. Participants will fly to Ulaanbaatar, the capital of Mongolia, and tour the Academy of Sciences museum and palaeontological lab, before flying to the Nemegt Basin in the Gobi Desert. Here participants will spend 6 days prospecting and excavating a wealth of Late Cretaceous fossils to support the research of Dr. Philip Currie, Dr. Eva Koppelhus and Dr. Badamgarav.

All fossils collected go to the Academy of Sciences of Mongolia. Participants on previous expeditions have found scientifically important specimens at this location such as a partial skeleton of a juvenile *Tarbosaurus*, leg bones of *Elimisaurus*, ornithomimid fossils and numerous track sites. Afterwards, participants will visit Ukhaa Tolgod (American Museum site) and will continue working at the Tugrigiin Shiree site (where the "Fighting Dinosaurs" were found: a *Protoceratops* and *Velociraptor* locked in combat) and the "Flaming Cliffs", where the first nest of dinosaur eggs was discovered in 1922.

The cost is from US$3,645 plus flight per person. For more information and for application forms go to **www.nomadicexpeditions.com** and look up "Dinosaurs of the Gobi" or contact Dr. Philip Currie of the Royal Tyrrell Museum of Palaeontology or the author. Be sure to apply early to reserve your seat and to allow enough time to obtain the required Mongolian visa. ❑

Dinosaur Sculpture Unveiling, Lecture, Open House Celebrates 20th Anniversary of Cooley & Co.

by Mona Marsovsky

The Dinosaur Research Institute (DRI) and Cooley and Co. hosted an open house on Saturday, April 24, 2004 at Brian Cooley's studios in Airdrie, Alberta. Brian Cooley was celebrating his 20th year of operation and the completion of ten dinosaur sculptures. This was the one time that the public could view all of these sculptures in one location before they were shipped the next day to their final homes at the Indianapolis Children's Museum and the Royal Tyrrell Museum of Palaeontology. The sculptures included:

- A life-sized *Alamosaurus* family (Texas sauropod from the Cretaceous), including one adult and two juveniles. A small model of the museum illustrated how these sculptures will be "breaking out" of the Indianapolis Children's Museum.
- A life-sized *Pachyrhinosaurus* family (Alberta Cretaceous ceratopsians) including two adults and two juveniles.
- A life-sized *Oviraptor* skeleton (Cretaceous Mongolian theropod).
- A miniature ceratopsian skeleton.
- Two life-sized dromaeosaurs (Alberta Cretaceous theropods)

There were also fossils on display, courtesy of Canada Fossils.

After the open house, Dr. Philip Currie of the Royal Tyrrell Museum of Palaeontology gave a lecture entitled "Argentina, Land of Giant Sauropods," describing his most recent expedition to Argentina. The lecture provided "up-to-the-minute" information—Dr. Currie and Eva Koppelhus had just returned that morning from Argentina. Dinosaurs have been found in Argentina since 1880, but the country has not yet been thoroughly explored for fossils. Argentina has yielded dinosaurs from its most southerly tip to its northern borders and from the earliest dinosaurs to the dinosaur extinction.

Dr. Currie described the importance of the fossils from the Neuquén area in Argentina. They were deposited during the period when North American hadrosaurs were invading Argentina at the end of the Cretaceous and when South American titanosaurs (*e.g.* the *Alamosaurus* on display at the open house) were invading North America. He contrasted Argentinian dinosaurs of that time with those in Alberta.

Argentinosaurus was the largest sauropod and the largest land animal (by weight, about 100 t) of all time. *Giganotosaurus* had a longer body and longer skull (1.7 m) than *T. rex*, but was also more primitive than *T. rex*.

In their excavations, the researchers have also found duckbilled dinosaurs and their nests, small theropods, 100-million-year-old bird tracks, a titanosaur skeleton and 100-million-year-old termite mounds. Normally their excavation area yields only isolated bones, rather than complete skeletons; however, even isolated bones can provide important information. This year the tibia of a meat-eating dinosaur, possibly related to *Megaraptor*, was found in a higher layer than expected, which extended the known period over which this dinosaur lived.

Dr. Currie showed slides of the excavation area and the hazards of typical camp life. Drs. Currie and Koppelhus worked with Dr. Rodolfo Coria of the Museo Carmen Funes in Plaza Huincul, Argentina.

Attendees had the chance to win door prizes including eight copies of *A Moment in Time*, written by Drs. Currie and Koppelhus and a replica raptor claw. About 175 people packed the studio for this very successful event, earning DRI approximately $2,000, which will be applied to dinosaur research. ❏

Science Is…

by Dan Quinsey

Recently, I set out on a quest looking for a supplier of hydrochloric acid to use in fossil preparation. I found a home based business in NW Calgary called Science Is…owned and operated by George P. Pastirik, M.Sc.

Catering to the educational community, Science Is…offers a large variety of equipment and educational materials for the chemist, physicist, biologist, geologist, engineer, astronomer and much more, and at very reasonable prices. My visit to the store was enjoyable and rewarding. George Pastirik was a pleasure to deal with and made sure my needs were met to my satisfaction.

Although Science Is… is an internet business, George Pastrik is willing to bring Calgary clients to his home on an appointment basis any time during the day. Please take some time to visit their website: **www.science-is.com** and consider giving them a visit. You can also reach George Pastrik by email: **pastrik@science-is.com** or by telephone (403) 547-4422. ❏

2004 Field Trip Updates

by Wayne Braunberger and Vaclav Marsovsky

NOTE! A registration form (yellow) with fee details was included with your March 2004 Bulletin. If you've lost it, download a copy from our website, www.albertapaleo.org/fieldtrips.htm, or contact Wayne or Vaclav (see below).

• Trip 2004-1

Saturday and Sunday, June 26 & 27, 2004
Badlands, southeastern Alberta.
Registration deadline is June 18, 2004.

All stops on this trip will be along the South Saskatchewan River north of Medicine Hat. On Saturday stops will be made at Sandy Point and the ferry crossing and on Sunday sites to the west of Hilda will be visited. If there has been significant rain in the area, the sites west of Hilda cannot be visited.

Accommodations

As with all APS trips, accommodations are the responsibility of the trip participants. Motels and campgrounds are available in the Medicine Hat area.

Driving conditions

Allow at least 3 to 4 hours driving time from the Calgary city limits to Medicine Hat. Travel will be on paved, gravel and dirt trails.

Potential Hazards

Red Deer River, steep slopes, sinkholes, falling rocks, ticks, mosquitoes (West Nile virus), rattlesnakes.

• Trip 2004-2

Saturday and Sunday, July 17 & 18, 2004
Alexo, Alberta
Registration deadline is July 9, 2004.

Day 1: Saturday, July 17, 10:00 A.M. Meet at the Alexo turnoff, located on the south side of Highway 11, approx. 65 km west of Rocky Mountain House. We will then drive & hike to a Paleocene plant locality. **Georgia Hoffman** will once again lead us on this trip to an exceptionally prolific site where we will collect material in support of Georgia's research.

Accommodations

Motel accommodation is available at the David Thompson Resort and Nordegg. A full-service campground is also available at David Thompson Resort and there are forestry campgrounds in the area.

Driving conditions

Allow at least 3 hours driving time from the Calgary city limits to Alexo turnoff. Travel will be on paved highway with very short stretches of gravel.

Potential Hazards

Steep slopes, falling rocks, bears, mosquitoes (West Nile virus).

• Trip 2004-2a

Sunday, July 18, 2004
North Sask. River, south of Alexo, Alberta
Registration deadline is July 9, 2004.

Day 2: Sunday, July 18, 9:00 A.M. Meet at the Alexo turnoff. This trip is for those who would like a challenge. Travel to this location will be by **mountain bike** along an old forestry road that is no longer driveable by standard vehicles. **This will be a long, strenuous day involving pedalling a considerable distance.** An old guide indicates that the one-way distance is approximately 16 km (32 km return). If you are interested **you should be physically capable of cycling long distances over rough and/or steep terrain and have experience in backcountry cycling (including emergency bike repairs!)** There is no guarantee that we will find the site or any fossils.

Accommodations, driving conditions

As for Day 1.

Potential Hazards

Steep slopes, falling rocks, bears, mosquitoes.

• Trip 2004-3

Saturday and Sunday, August 21 & 22, 2004
Limestone Mountain, Alberta
Registration deadline is August 13, 2004.

The Limestone Mountain area will allow a number of fossil bearing formations to be examined. Limestone Mountain is located northwest of Sundre, off the Forestry Trunk Road.

Accommodations

Motel accommodation is available in Sundre, Caroline and Rocky Mountain House. There are forestry campgrounds in the Limestone Mountain area.

Driving conditions

Meeting place to be announced. Travel will be along gravel roads (often narrow and winding). Allow at least 2 hours driving time from the Calgary city limits to the meeting place.

Potential Hazards

Steep slopes, falling rocks, bears, mosquitoes (West Nile virus).

• Trip 2004-4

Saturday, July 31 & Sunday, August 1, 2004
Tumbler Ridge, British Columbia
Registration deadline is July 22, 2004.

This trip is for those who don't mind the long travel distance of **11 hours** driving time from Calgary to Tumbler Ridge.

If you heard Richard McCrea speak at the 2004 APS Symposium about the exciting new discoveries near Tumbler Ridge, you will have some idea about what we will see. This trip will be to the newly-discovered British Columbia localities where dinosaur tracks and dinosaur bones have been found in the same beds near the town of Tumbler Ridge.

Richard McCrea will lead us to the dinosaur bone excavation site and tracksites in Quality Creek Canyon. On the second day we will go to look at several of the other tracksites in the area including two tracksites at Flatbed Creek and one at Wolverine River.

If you are interested in this trip please contact **Vaclav Marsovsky, c/o 7 Edgeridge Court NW, Calgary, Alberta, T2W 2G7. Phone (403) 547-0182, email: vaclav@telusplanet.net**

• Trip 2004-5

Saturday, September 18, 2004
Ghost River, Alberta
Registration deadline is September 10, 2004.

This trip is planned as a one-day trip to the Ghost River area to examine the Devonian Yahatinda Formation on "End Mountain". This will be a sequel to the trip that was made in September 2000. A long day trip is planned as access to the site is anticipated to be difficult. A long access hike plus a strenuous vertical hike is anticipated but the rewards my be outstanding as this is one of the few Devonian plant and fish sites known in the Front Ranges.

Driving conditions

The approach will be made via Highway 1a, west of Cochrane (paved) and the Forestry Trunk Road (gravel). Allow at least 1.5 hours driving time from Calgary. Meeting place to be announced.

Potential Hazards

Steep slopes, falling rocks, bears, mosquitoes (West Nile virus).

If you are registered you will be contacted before each trip by email or phone. I must receive your registration and accompanying fees on or before the deadline. Late registrations will not be accepted. All trips will be held regardless of weather and number of registrants.

Information on all other trips (except Tumbler Ridge) should be obtained from: **Wayne Braunberger, APS Events Director, c/o 544 Queensland Place SE, Calgary, AB, T2J 4T3. Phone (403) 278-5154, email: events@albertapaleo.org.**

Field Trip Guidelines

by Wayne Braunberger, APS Events Director

A full list of field trip guidelines was published in the March 2004 *Bulletin* (page 8). Copies are also available on the APS website at **www.albertapaleo.org/fieldtrips.htm**

These guidelines are under development and changes will be made from time to time as the need arises. The events director, field trip co-ordinator and field trip leader(s) reserve the right to limit the number of participants on a field trip. Please contact me (above) if you have any questions or concerns.

In addition to the guidelines published previously, the following section has been added:

9) No Alcohol or Drugs

Persons under the influence of alcohol or drugs are a danger to themselves, other field trip participants and the general public. We would ask that the consumption of alcoholic beverages be limited to after the day's activities. Any persons using illegal substances while on the field trip will be asked to leave immediately and their participation on future trips will be in question. ❑

APS T-Shirt Design Contest

The APS will be in the market to purchase new T-shirts in early 2005. We are looking for a new design that will focus in on the APS 20th Anniversary (1986–2006).

Deadline will be the 2004 November General Meeting. More information will follow.

Submissions can be hand drawn or electronically produced. Remember, although we have some fantastic artists in the Society, your submission should be one that is easily printable on a T-shirt. We encourage everyone to participate. A prize for the winning entry will be determined at a later date.

Submissions can be made to Dan Quinsey in person, electronically through the links in our website: **www.albertapaleo.org**, or by mail, using the APS address on page 1 of the *Bulletin*. ❑

Fossils in the News

BBC News Online, March 4, 2004

Fossil louse reveals last meal

LONDON—A bird's life was just as lousy 44 million years ago as it is today, according to a group of researchers writing in the Royal Society's *Biology Letters.* The evidence is in the form of an exquisitely preserved louse fossil found in volcanic crater lake deposits near Manderscheid, Germany. The louse, dubbed *Megamenopon rasnitsyni*, is very similar to those that infest modern waterfowl. Working with a microscope, Dr. Vincent Smith, of the University of Glasgow and his colleagues spotted tiny barbules—the smallest parts of a feather—in the louse's gut.

Smith hopes to use the louse fossil to calibrate the "molecular clock" of the louse family tree. If it turns out that the lice are older than birds, then, according to Smith, "the original host must have been a dinosaur."

Science, March 26, 2004

Big Spanish dino

RIODEVA, Spain—Europe's biggest sauropod has been unearthed in the fossil-rich Spanish province of Teruel. The bones, including limb, hip and spinal material, were recovered over an 18-month period from rocks dated between 110 and 130 million years old. The fossil may represent a new species, and at an estimated living weight of 50 t and 35 m in length, it is in the same league as the world's biggest known sauropod, *Argentinosaurus*, from South America. ❑

[*Thanks to Phil Benham and Georgia Hoffman for submitting news clippings. – ed.*]

ALBERTA PALAEONTOLOGICAL SOCIETY

Calgary, Alberta

Operating Statement for 2003 (Audited)

January 1, 2003 to December 31, 2003

Revenues		**Expenses**	
Memberships	$2660.00	Bulletin Printing	$649.66
US$ Exchange	115.92	Bulletin Postage	523.88
T-shirts	360.00	Speaker Expenses	0
Pins	0	PO Box Rental	0
Field Trip Guides	50.00	Membership Printing	0
Abstract Volumes	50.00	Membership Postage	29.70
CD-ROM	0	Field Trip Expenses	620.40
Postage for Sales	39.00	Workshop Expenses	575.00
Misc. Sales	86.00	Symposium Speaker	465.53
Refreshments	71.47	Symposium Abstract Printing	352.61
Field Trip Fees	715.00	Postage for Sales	27.20
Workshop Fees	1075.00	Website Expenses	185.90
Donations	48.20	Refreshments	13.92
Symposium Abstract Sales	500.00	Bank Charges	197.54
Symposium Donations	850.00	Lawyer and Insurance	0
Fund Raising	1286.50	Miscellaneous	74.44
		Special Projects	141.39
Subtotal Revenues	**7907.09**	**Subtotal Expenses**	**3857.17**
Plus Revenue Received in 2002 for 2003		Plus Expenses paid in 2002 for 2003	
2003 Membership Fees	1355.00	PO Box Rental for 2003	77.04
2003 Workshop Fees	55.00		
Subtract Revenue Received in 2003 for 2004		Minus Expenses paid 2003 for 2004	
Symp. Donation for 2004	532.29	PO Box Rental for 2004	104.86
2004 Memberships Fees	885.00		
T-shirt purchase for 2006	2000.00		
Fund Raising Proceeds	1286.50		
Total Revenues	**4613.30**	**Total Expenses**	**3829.35**

Excess of Revenues over Expenses = $783.95

Inventory Sale Value	2086.00
(Values Current to January 20, 2004)	

For Years 2002 & 2003	
Total Fund Raising Proceeds	1945.50
Total Fund Raising Costs	151.54
Net Fund Raising	1793.96

Treasurer: Mona Marsovsky
Audited by Norine Fortier and Howard Allen