

Cretaceous Park

Glacial meltwater and subaerial erosion after the ice age has sculptured a badlands landscape within Upper Cretaceous clastic sedimentary rocks. Abundant dinosaur fossil bones and skeletons have been exposed making the Dinosaur Provincial Park in Canada the richest dinosaur locality in the world.



The gently rolling prairie grasslands cease abruptly, plunging the visitor into a world of hoodoos, pinnacles, deep ravines and flat-topped, steep-sided hills (buttes). The Red Deer River has been eroding into the Cretaceous sedimentary rocks since the end of the last ice age. The badlands landscape the river is creating, with deeply eroded rocks, little vegetation and a wilderness of slopes, scarps and narrow, twisting valleys, stretches from the border to Saskatchewan and all the way up to Edmonton. Sandstones, siltstones and shales containing complete dinosaur skeletons belong to the 80 m thick Dinosaur Park Formation, overlying the Oldman Formation which only yields fragments of fossil bones. On top of the Oldman Formation are the dark marine shales of the Bearpaw Formation, witnessing a transgression in Late Cretaceous times.



A trip to Dinosaur Provincial Park is a 75 million-year foray back in time. This region was then a subtropical paradise, featuring lush vegetation similar to the coastal plains of the southeastern United States today, populated by turtles, crocodiles and sharks. Here, on the shores of an inland sea that, at times, extended from the Arctic Ocean to the Gulf of Mexico, dinosaurs once hunted and mated. This is also where they ultimately met their demise, leaving an amazingly rich fossil and bone record for paleontologists, geologists and ordinary tourists to discover. The park lies only two hours east of Calgary and is thus easily accessible by car. Two hours north of the park you reach Drumheller, which hosts the outstanding Royal Tyrrell Museum of Paleontology (<http://www.tyrrellmuseum.com/>), with numerous exhibits that illustrate geological evolution throughout the Phanerozoic eon (Cambrian through Quaternary, compare page 12). Hundreds of thousands of visitors each year spend a day or two in this small town situated within the valley carved by the Red Deer River.



Photo: Halidan Carstens

In the Late Cretaceous, the landscape in what is now known as Alberta was very different. The climate was subtropical, and the low swampy country was home to a variety of animals, including 30 species of dinosaurs. The conditions were also perfect for the preservation of their bones as fossils. Today, after a century of excavations, more than 150 complete dinosaur skeletons have been discovered, as well as numerous scattered concentrations of bones called "bone beds". Visitors can find the "bone beds" without the skills of an experienced paleontologist. Visitors are, however, only allowed in designated areas.

Halfdan Carstens

In the Western Canadian Sedimentary Basin due east of Calgary (GEO ExPro 2/3, 2005), within a unique geological setting caused by rivers eroding into soft sandstones, creating a badlands landscape, huge amounts of dinosaur fossils are found in Upper Cretaceous rocks. For petroleum geoscientists concerned with the environment, it is interesting to learn that the park lies above producing oil and gas fields.

The Dinosaur Provincial Park in Alberta, Canada, with its famous assemblage of dinosaurian fossils, badlands landscape and cottonwood trees, has been a UNESCO World Heritage Site since 1979. With this designation, it is within the ranks of other globally significant areas such as the Grand Canyon (GEO ExPro No. 2, 2004) and the Norwegian Fjordlands (GEO ExPro No. 4, 2005).

The park is situated within the badlands, named so by early French explorers who were thought to be the first to refer to 'les mauvaises terres a traverser,' which, in Eng-



Byron Waight, conservation officer of the Dinosaur Provincial Park, is himself a geologist and spends the summer season in the park with the objective of pursuing a career specializing in resource protection and public safety. In winter he works in Kimberlite Exploration for various agencies.

Before entering the park, on top of the grassland, visitors can have the benefit of informative signs explaining everything about the park. The signs are located on the grasslands, a flat to gently rolling plain with a few major hills; characterized by cold winters, warm summers, high winds and low precipitation. Dinosaur Provincial Park is located in the warmest and driest sub-region in Alberta, with a few permanent streams that have exposed Cretaceous shales and sandstones, creating the extensive badlands that visitors can see below the prairie.



The Royal Tyrrell Museum of Palaeontology is one of the world's largest palaeontological museums and is one of Alberta's main tourist attractions. The museum is named after Joseph B. Tyrrell who stumbled across a huge Albertosaurus skull in the badlands along the Red River more than 100 years ago. Drumheller thereafter became a Mecca for paleontologists, not only Canadians, but from all over the world. The museum was opened in 1985 and offers a world class exhibit hall with more than 35 complete dinosaur skeletons and a Cretaceous Garden containing the plants dinosaurs ate millions of years ago. The museum is also a center for excavations in the park.

lish, means "bad lands which are hard to cross." Badlands occur at several locations in southern Alberta and are found principally along the steep sides of major valleys, especially the Red Deer River Valley, where they extend more or less continuously for about 300 km.

The story behind the scenery

In Late Cretaceous times, a shallow, subtropical sea covered the interior of North America. The Park lies close to the former shoreline and was an environment of moist deltas with thriving swamps. The rocks that we observe along the Red Deer

Valley tell the story of the ancient sea's fluctuating water levels and the changing position of the shoreline. These rock layers have been divided into three units, each representing different ages and depositional environments.

The oldest and lowermost exposed unit, approximately 30 m thick, is named the **Oldman Formation**. It consists of pale yellow sandstones and siltstone deposited about 77 million years ago. The park was a low-lying flood plain across which rivers and streams wove their way eastwards to the sea. The climate was hot and dry and frequent flash floods carried sediments

Living in harmony

The only development pressure affecting Dinosaur Provincial Park is ongoing development of natural gas. Producing hydrocarbons from sedimentary rocks below the park does not, however, appear to harm the environment.



All wells are drilled outside the boundary of the World Heritage Site. Well heads are kept low and painted neutral colors to minimize visual impacts. No roads are built to the well sites. Access is by dirt trails across grazing lands, thus minimizing new public access to Dinosaur Provincial Park World Heritage Site boundaries. There are no direct impacts on fossil resources in the Dinosaur Provincial Park World Heritage Site.



Exploration and production wells are drilled on the prairie grasslands next to the canyon. As evident, the well is inclined to reach a target directly below the badlands. Stringent environmental standards within the park require oil and gas companies to distance their activities at least 150 m from the edge of the valley and to return the land to its original state before leaving the site.



Great rivers that flowed through this area some 75 million years ago left the sand and mud deposits that make up the valley walls and hills of modern-day Dinosaur Provincial Park. At the end of the last ice age, about 15,000 years ago, water from the melting ice carved the valley through which the Red Deer River now flows. Today, water from prairie creeks and run-off continues to sculpt the layers of these badlands, the largest in Canada. As a result, new fossils appear every year, making fossil hunting an exiting experience for the few palaeontologists who are allowed to explore the valley on their own.

and broken dinosaur bones into the area.

The **Dinosaur Park Formation**, 80 m thick, consists of red sandstones, siltstones, shales and thin layers of coal. Meandering rivers and estuaries deposited these sediments as the sea level rose and the shoreline of the inland sea advanced westwards. Dinosaurs flourished in the subtropical climate, and the complete skeletons collected in the park come from these rocks. More than 30 different species of dinosaurs have been found.

The **Bearpaw Formation**, only 10 m thick, consists of dark brown and black marine sediments, which were deposited only two million years later as the sea made its final advance over Alberta. These rocks contain abundant marine fossils, but no dinosaur fossils.

There is a huge gap in the sedimentary record, as the rocks above the Bearpaw Formation are glacial deposits that came into place during the last ice age. This absence of rocks – representing a hiatus of

some 74 million years – is the result of mountain building as the Rocky Mountains came into existence during the Tertiary. Periods of stability with deposition of fluvial deposits on the plains alternated with periods of uplift which produced rapid erosion of both the mountains and the plains. Huge quantities of Cretaceous rocks were consequently washed away and deposited on the plains.

The badlands began to form around 15,000 years ago as the glaciers, advancing from the Hudson Bay to the east, melted, and the scouring action of the glaciers exposed the soft, easily eroded rocks. Glacial meltwater cut them deeply, creating step-sided channels. In present times a strongly seasonal climate, with intense summer rains and prolonged winter frost, enhances the effectiveness of erosion. Weathered material is stripped at a faster rate than soils can form or plants establish, so that runoffs cut deeply incised rills and channels.

Oil and gas

The creation of much of Alberta's oil and gas began about 400 million years ago, in



Photo: Halidan Carstens

While Cottonwood and willow trees share the moist riverbanks with saskatoon, rose and buffalo-berry bushes, cacti, greasewood and many species of sage survive in the hot and dry badlands. Here we see a Prickly Pear Cactus. Prairie grasses dominate the landscape above the valley rim.

the Devonian Period, when the ancient Pacific ocean flooded Alberta.

Reefs flourished in these shallow warm waters, and when they died their skeletons remained, and the next generation of reefs started to build on top of the dead remains. In this way, as thousands and millions of years passed, the reefs grew and stood up like underwater "skyscrapers" that later formed traps for oil and gas.

These carbonate Devonian rocks underlie the prairies and outcrop both against the Canadian Shield to the north and in the Rocky Mountains to the west. When water levels were high, the reefs were drowned in mud mixed with dead plants. These argillaceous rocks with abundant organic matter were exposed to heat as they were buried and started generating oil and gas.

Important pools of natural gas were also formed less than 100 million years ago in the Cretaceous. They accumulated closer to the surface in sandstones, remnants of ancient beaches.

Some of the oil and gas fields lie direct below the Red Deer River and the park itself. Drilling rigs and production wells are therefore frequently seen in this area. With the strict enforcement of environmental standards it has been proved that a national park can coexist with petroleum activity.

The ultimate experience

The next time you are in Calgary, make sure you set aside a couple of extra days for sightseeing, one day for Dinosaur Provincial Park, and one day for Royal Tyrrell Museum of Paleontology. In the park you will find more dinosaur bones than you would ever dream of, and in the museum you will meet both skeletons and replicas of these fascinating animals that are now extinct. Moreover, it is a journey through geological time featuring the spectacular history and diversity of life on Earth.

For geologists, geophysicists and reservoir engineers interested in our geological past, a visit to the Canadian badlands must be the ultimate experience when it comes to dinosaurs and museums.



Photo: Halidan Carstens

Dinosaur Provincial Park contains numerous landforms produced by erosion. The most familiar ones are hoodoos. A hoodoo is a pillar of sediment carved by wind and water erosion. Because the underlying rock is more susceptible to the forces of nature, it erodes more quickly than the surface rock (also known as the cap stone). This process creates the unusual landscape known as the badlands.



Photo: Halidan Carstens

The Royal Tyrrell Museum in Drumheller, north of the park, has excellent exhibits and offers a tour through geological time, with galleries and feature exhibitions that celebrate the spectacular history and diversity of life on Earth, as well as honoring the paleontologists who bring the stories to life. The dinosaur on display is an ornithomimid, or "bird-mimic", probably belonging to the genera *Ornithomimus* ("bird-mimic") OR *Struthiomimus* ("ostrich-mimic"), according to R. Fred Hammer, Heritage Appreciation Program Supervisor of the Dinosaur Provincial Park-World Heritage Site. It is currently at the Royal Tyrrell Museum in Drumheller, but was apparently originally on display from the late 1960s until 1984 at the Provincial Museum of Alberta in Edmonton, and then moved to Drumheller in preparation for the museums opening in 1985.