Deep Time And Ancient Life In The Columbia Basin

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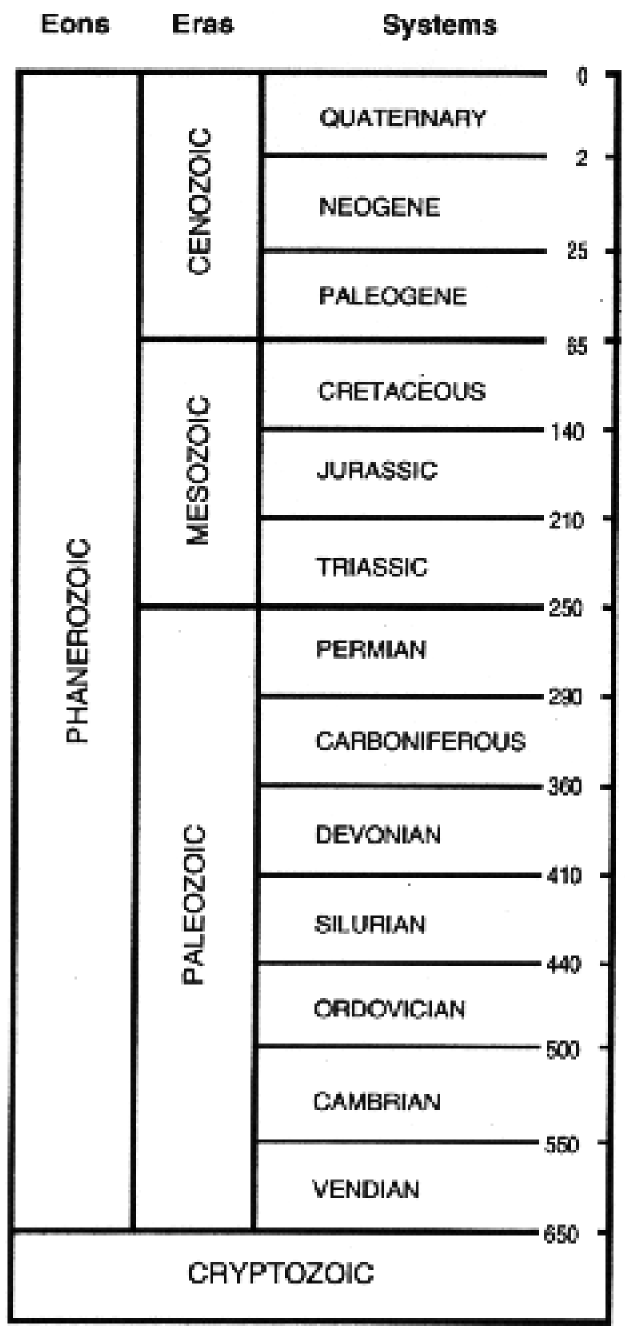
Introduction

The term "deep space" alludes to the unimaginably vast distance between stars measured in millions of light years. The American writer John McPhee coined a parallel term "deep time" to capture the full sweep of geologic time that is scaled off in billions or millions of years. Both defy understanding by the human mind.

In the corner of the Cordillera called the Columbia Basin, deep time extends back a thousand million years. Geologists assign these rocks to an older Cryptozoic (or Precambrian) Eon, and a younger Phanerozoic Eon. The boundary is approximately at 650 million years ago. The Phanerozoic Eon has a rich fossil record and the succession of fossils is used to divide these strata into eras, systems and series. The Columbia Basin includes fossil-bearing rocks of Palaeozoic, Mesozoic and Cenozoic age, but the best preserved and most informative fossils come from Cambrian strata (550 to 500 million years old) and Ordovician strata (500 to 440 million years old) that are exposed in the eastern part of the Columbia Basin. This paper explores a few of these fossil sites, their discovery and their significance.



Geologic time scale of the Phanerozoic Eon, divided into era, systems and series, and measured in millions of years.

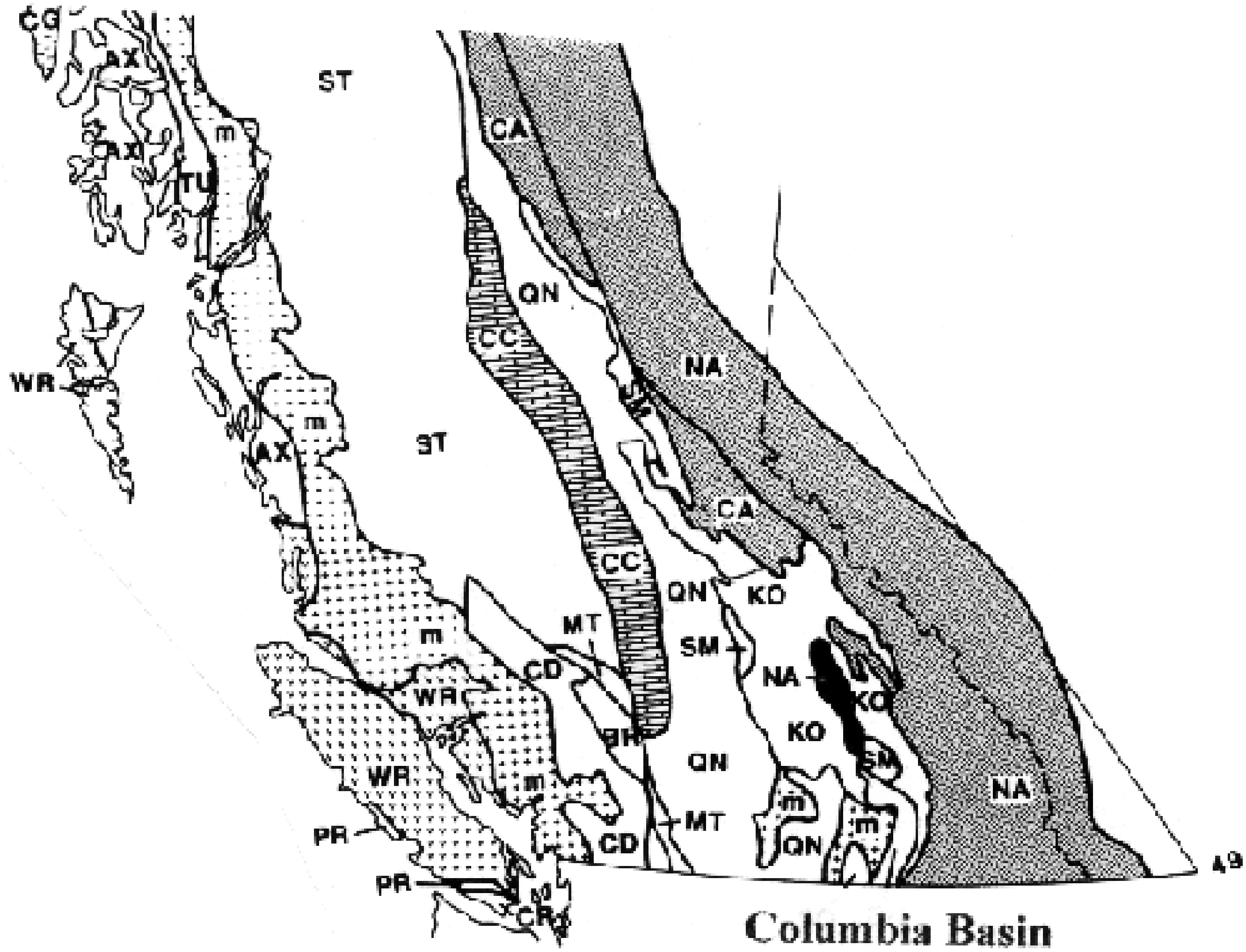
Geology

The Columbia Basin is that large, triangular mountainous region in southeastern British Columbia that is drained by the Columbia and Kootenay rivers. It includes the Main Ranges of the Rocky Mountains to the east, the Purcell Mountains, the Selkirk Mountains and, to the west, the Monashee Mountains. The Columbia Basin does not correspond to a coherent geologic region -- in fact, it is crossed by a fundamental geologic boundary that separates Laurentia, ancient North America, from exotic terranes that collided with Laurentia during the Mesozoic.

The strata making up the Rocky Mountains are largely limestones and shales of Palaeozoic age, deposited as a thick apron on the seaward side of Laurentia. Even though these rocks are faulted and upthrust, they have not been significantly altered or metamorphosed and their contained fossils are generally well-preserved. The rocks of the Purcell and Selkirk mountains are mainly sandstones and grits of late Cryptozoic (late Precambrian) age. These rocks are commonly highly deformed and metamorphosed, and locally they are intruded by younger granites. They were deposited on the margin of ancient North America. The Monashees and related mountain ranges in the western Columbia Basin are made up of a crazy quilt of rocks -- including exotic terranes of Late Palaeozoic and Mesozoic volcanics and sedimentary rocks, as well as large masses of granites.

During the Jurassic, Laurentia, with its thick packages of late Cryptozoic and Palaeozoic strata, collided with large exotic terranes that had formed out in the palaeo-Pacific Ocean during the late Palaeozoic. This collision pushed the entire package of Palaeozoic rock eastward in a series of overlapping faults to form the Rocky Mountains. The late Cryptozoic rocks were squeezed and faulted up to form the structures now seen in the Purcell and Selkirk mountains. The colliding terranes on the west were shoved onto the granitic basement, making the crust much thicker, altering and heating it, and causing the melted rocks to be intruded as large granitic masses.

The geology of the entire Cordillera is covered in considerable detail by Gabrielse and Yorath (1992). Yorath (1997) is a more accessible account of the geology of the Rocky Mountains that is written for a non-technical audience. (**Generalized geologic map of the Columbia Basin**.)



Generalized geologic map of the Columbia Basin.

Episodes of Cambrian and Ordovician Life

The Trilobite Beds

After the last spike was driven at Craigellachie in 1885, the General Manager of the Canadian Pacific Railway, Cornelius Van Horne, ordered the construction of a series of dining chalets along the main line through the mountains. These chalets were to service the flood of tourists who were expected to come west on the CPR to experience the splendour of mountain wilderness (and diminish the massive debt load from the construction of the mountain sections of the CPR). Some of the workmen building the chalet in Field, Mount Stephen House, spent their free Sundays scrambling across the steep slopes of the surrounding mountains. One day a group of carpenters with now-forgotten names came across abundant "stone bugs" in shales high on Mount Stephen above Field. The authorities were promptly notified and, later in the summer of 1886, a couple of government men (a geologist and a surveyor) followed the carpenters up the mountain to make large collections of these well-preserved fossils. The collections were sent to different palaeontologists who recognized that these were some of the best Middle Cambrian trilobites known anywhere. One of these palaeontologists was Charles D. Walcott who, 20 years hence, was to come to Field to collect more fossils from the Trilobite Beds, as the locality on Mt Stephen came to be known. Walcott returned to the Canadian Rocky Mountains and, in 1909, he discovered the soft-bodied Burgess Shale fossils at a nearby locality.

Trilobites, especially large complete trilobites, are rather uncommon fossils at virtually all Cambrian sites. A first-time visitor to the Trilobite Beds is startled by the realization that virtually every slab on this mountainside contains large, complete and articulated trilobites. Many are gleaming black and stand out conspicuously from the buff-coloured shale, others are evident by being slightly raised from the matrix in bas-relief. *Ogygopsis*, the most common trilobite here, has the outline and size of a kid's shoeprint. A close second is *Olenoides,* which is easy to recognize because it has a spiny tail. A few other trilobites are found, and non-trilobite fossils are not uncommon. Particularly interesting is the curved and segmented fossil called *Anomalocaris* that was considered to be the body of a crustacean.

The sheer abundance of large fossils in the Trilobite Beds attracted many visitors to this site in Yoho National Park. To conserve the site, access was initially restricted to small, guided parties. But regrettably, because visitors walking across a mountainside thickly covered by fossiliferous slabs have, over the years, inadvertently damaged this important site, Parks Canada has recently found it necessary to close off all access to the Trilobite Beds.

Complete trilobites (*Ogygopsis* and *Olenoides*) from the Trilobite Beds.
Photo by L. MacKenzie McAnally, Univ. of Victoria.

Anomalocaris was thought to be the body of a crustacean.
Photo by B. Chatterton, Univ. of Alberta.

The Burgess Shale

On the last day of August, 1909, Charles D. Walcott and his field crew were wrapping up work for the season. They were travelling by horseback along a well-established trail on the ridge between Mount Wapta and Mount Field above Emerald Lake, on their way to the comfort of Mount Stephen House in the village of Field. The lead horse was halted by a slab of shale that had fallen across the narrow trail. Before the crew could dislodge it, Walcott caught sight of some faint and shiny, but well-defined, outlines of fossils. He knew Cambrian fossils better than anyone in the world, and immediately recognized that these were unknown types of arthropods. The non-mineralized cutile of these animals was clearly evident, but they also displayed, in astonishing detail, their soft-bodied anatomy — spindly legs, antennae, comblike gills, even guts and muscles. Walcott also spotted segmented worms and sponges among the fossils as well as a few familiar trilobites, establishing that these strange fossils were of Middle Cambrian age.

Walcott knew that he had made the discovery of a lifetime and, from then on, palaeontologists and biologists would never again consider Cambrian life to be primitive, simple or impoverished.

Walcott returned to the site now known as the Burgess Shale every summer until 1914. In 1911 he directed workmen to excavate a quarry in order to expose the two-metre thick layer, the Phyllopod Bed, that contained the bulk of the fossils. When he finally left Yoho National Park in 1917, he had amassed an incredible collection of 30,000 fossiliferous slabs, which became the centrepiece of the vast fossil holdings of the Smithsonian Institution in Washington.

In the late 1960s the Geological Survey of Canada reopened Walcott's Quarry to secure the first collections of Burgess Shale fossils for a Canadian museum. Harry Whittington of Cambridge University was invited to take charge of a reinvestigation of the fossils, and he and his students Simon Conway Morris and Derek Briggs began to revise the arthropods and the worms. Whittington first tackled *Marrella,* which is the most abundant fossil in the Burgess Shale. This small arthropod carries two pairs of long horns on its head and two pairs of annulated antennae. The triangular body consists of more than twenty segments, each with a pair of spindly, jointed walking legs, and a pair of feathery gills. Adjacent to many specimens are dark blotches -- the squeezed out body fluids of the animal; a few even include an expelled intestine. These anatomical details are visible on a fossil not much larger than a housefly.

In the late 1970s Des Collins of the Royal Ontario Museum expanded collecting activity of Burgess Shale fossils to other localities in Yoho National Park. In addition to a variety of unclassifiable animals, the Burgess Shale bestiary now includes arthropods (trilobites, crustaceans, chelicerates), onychophorans, annelids, priapulids, comb jellies, chordates, sea weed; in addition to sponges, brachiopods and echinoderms.

Other soft-bodied fossil sites have since been discovered on other continents. Of these, the most important is the Chengjiang fauna of southern China, but the Phyllopod Bed discovered by Walcott in 1909 remains as the source of the most diverse, best studied and most informative group of fossils in Cambrian rocks anywhere. And, for what they disclose about the Cambrian evolutionary explosion of animals, these fossils

The arthropod *Marrella* is the most common fossil in the Burgess Shale.
Photo by B. Chatterton, Univ. of Alberta.

The onychophoran Aysheaia from the Burgess Shale is a close relative of living velvet worms.
Photo by R. Ludvignsen

Lower Cambrian Trilobites

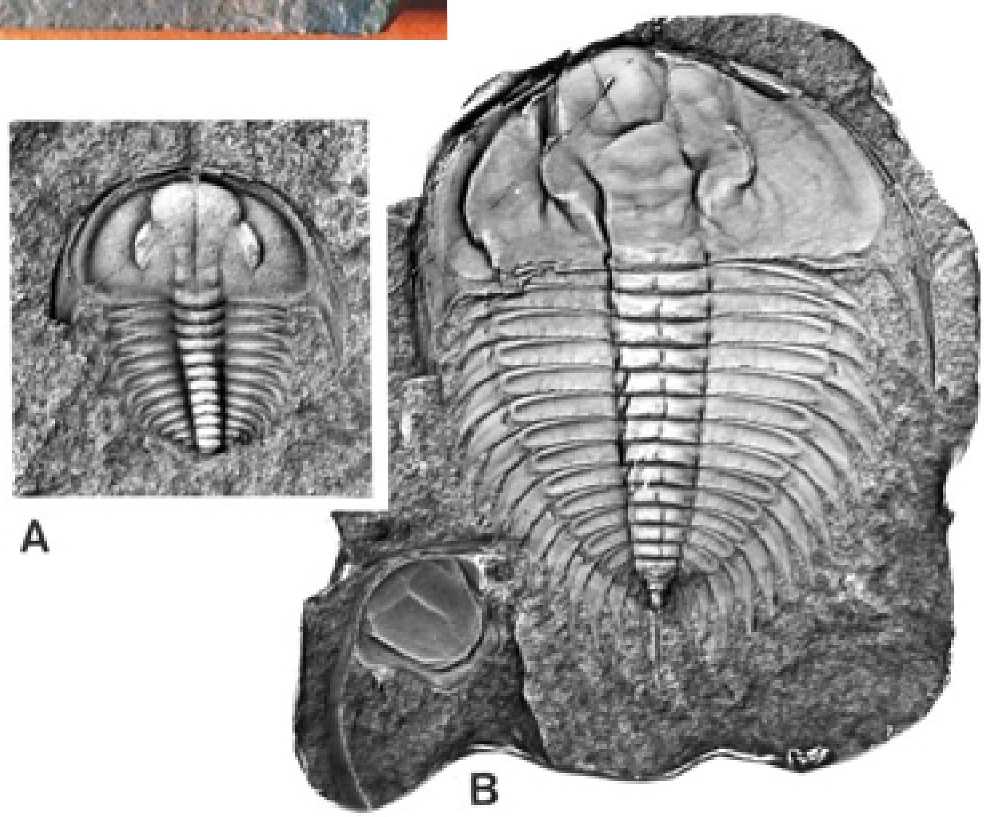
Brown and grey shales that make up the Lower Cambrian Eager Formation in the vicinity of Cranbrook and Fort Steele contain numerous fragments and many complete specimens of olenellid trilobites. These trilobites are invariably the oldest trilobites found at localities on all continents, but they are fully formed trilobites and not obviously primitive. These fossils have been avidly collected by amateurs and professionals since 1921, when they were first made known to palaeontologists by Colonel C.H. Pollen of Cranbrook.

The most abundant trilobite in the Eager Formation is *Olenellus* -- which has a large, semi-circular head, a body of 15 segments (of which the third is much longer than the others), a long spine on the 15th segment, and a minute tail. A less common olenellid trilobite is *Wanneria* -- which has a large head lacking conspicuous furrows, and a broad body without an expanded third segment.

The shales of the Eager Formation are widely exposed in the valleys of the Kootenay and Columbia rivers but, by far, the most fossiliferous site is located on Crown Lands leased to the Cranbrook Rifle Club, located just outside Fort Steele. Abundant collections from this site proved critical to the recently completed Ph.D. thesis by Lisa Bohach, who was able to place them in the upper part of the Lower Cambrian, but not the uppermost. Bohach also used these rich collections to establish a new classification of olenellid trilobites based on the different growth history (ontogeny) of major groups.

The Rifle Range Site has recently been subjected to very intense collecting pressure by both amateur fossil collectors and by professional fossil dealers. A number of websites offering fossils for sale include specimens of *Olenellus* and *Wanneria* from Crown Lands leased by the Cranbrook Rifle Club.

The olenellid trilobite *Olenellus* is common at the Rifle Range Site.
Photo by R. Ludvignsen



An immature and a mature olenellid trilobite *Wanneria* from the Rifle Range Site.
Photo by L. Bohach, Univ. of Victoria.

Top-of-the-World Plateau

Top-of-the-World is a saddle-shaped plateau located 2,600 metres up in the Hughes Range east of Skookumchuk. Archaeological evidence suggests that the plateau was regularly used by native peoples, particularly the Ktunaxa Nation, who hunted there and quarried slabs of dark grey chert from the limestone outcrops; perhaps starting as early as 11,000 years ago. The chert became the most popular tool stock in the Canadian Rocky Mountains, and the object of extensive trade.

The limestones at Top-of-the-World were deposited in shallow, tropical seas when Laurentia lay isolated and astride the palaeoequator in the Late Ordovician, some 450 million years ago. At this time, sea levels were unusually high and, as a result, most of Laurentia was covered by shallow seas. These warm seas supported a characteristic assemblage of animals that has been called "the Arctic Ordovician Fauna" -- "arctic" because these tropical fossils were first described from exposures in the Canadian Arctic Islands and Greenland. This fossil fauna consists typically of bottom-dwelling organisms with robust shells -- mainly brachiopods, corals, receptaculitids (extinct calcareous algae), stromatoporoids and large straight cephalopods (distant relatives of the pearly nautilus).

In the limestones at Top-of-the-World, the fossils are particularly impressive because the original calcite shells of these organisms have been replaced by silica (silicon dioxide -- the same composition as the chert). Silica is resistant to weathering and, therefore, the silicified fossils stand high and conspicuous above the rock because the limestone is readily leached.

Corals -- both solitary and colonial -- are common fossils at Top-of-the-World. Silicified colonies of tabulate corals such as *Catenipora* are domal in shape and some are as large as 30 cm across. The individual corallites in these colonial corals are arranged in meandering chains.

Stromatoporoids are the most striking fossils at Top-of-the-World, and they are arguably the most significant. These spongelike colonial organisms, looking like weathered fence posts, belong to *Aulacera*. They are unusual because the knobby surface texture is preserved as well as the pronounced longitudinal ridges. The largest *Aulacera* found is two metres long but, in life, they may have stood erect and five metres high. This would make these stromatoporoids the tallest organic constructions in the Ordovician seas.

A silicified colony of the tabulate coral Catenipora.
Photo by W. Stetski, B.C. Parks.

A metre-long silicified stromatoporoid Aulacera weathering out of limestone.
Photo by W. Stetski, B.C. Parks.

Tanglefoot Creek Trilobites

Fossils are exceptionally rare in archaeological sites. A few examples have been documented from sites in Europe; none have previously been reported from Canada. The single documented example is a calcite wafer with a well-preserved trilobite that came from a Coast Salish site on the Fraser River, north of Yale. The fossil was associated with projective points, scrapers and knives of basalt and nephrite that appear to date from the last 2,000 years, but may be as old as 5,000 years. The Fraser River trilobite is identifiable as a species of *Labiostria,* a rather obscure Late Cambrian trilobite about 510 million years old. This fossil is of additional interest because it could not have come from anywhere near the Fraser River or, indeed, from any locality in central British Columbia where all the rocks and fossils known are all much younger than Cambrian.

Cambrian rocks and fossils are widespread in B.C., but only in the eastern portion that was part of Laurentia, geological North America. When we (Chatterton and Ludvigsen, 1998) found out about the Fraser River trilobite, we had just started work on a remarkable collection of close to 4,000 specimens of Upper Cambrian trilobites that came from a single site on Tanglefoot Creek, east of Cranbrook. Like the specimen from the Fraser River, these trilobites were all complete specimens and preserved individually on calcite wafers. The Tanglefoot Creek site included more than 1,000 specimens of the identical species of *Labiostria* that was found in the archaeological site. The Fraser River trilobite must have come from Tanglefoot Creek, some 500 km to the east.

In all likelihood, the Fraser River trilobite was picked up from among the pebbles in Tanglefoot Creek hundreds or possibly thousands of years ago by a native traveller, presumably because it had curious and intriguing markings. It was probably considered to be a talisman that was carried or traded person to person across the Columbia Mountains and the entire Okanagan Plateau; eventually ending up at the site of the Fraser River north of Yale.

Calcite nodule with the tribolite *Labiostria* from a Coast Salish archaeological site on the Fraser River. It was collected from shales on Tanglefoot Creek.
Photo by R. Ludvignsen

A moulted Labiostria from Tanglefoot Creek.
Photo by R. Ludvignsen

David Thompson: Mammoth Hunter

Properly celebrated as Canada's mapmaker, David Thompson charted the entire western interior from Hudson Bay to the Pacific Ocean in 22 years of travels starting in 1789. He is, of course, closely associated with the Columbia Basin and the Kootenay region. In 1806 he established a trading post on Windermere Lake, and in 1811 he was the first European to travel the full length of the Columbia River from its origin at Canal Flats to Astoria near the mouth of the Columbia River.

Thompson could also claim a palaeontologic first because he launched the earliest systematic search for fossils in Canada. In 1797 when he quit the Hudson's Bay Company to become surveyor for the rival North West Company, he was given a short list of tasks to complete. In addition to items such as determining the precise location of company posts and promoting trade with the Mandan villages on the upper Missouri River, the partners of the company requested that, "in the interest of science and history he was to look for the fossils of large animals, and any monuments". No written record exists that explains the background or rationale of this remarkable directive. It might indeed have been for scientific purposes, but is it probably more likely that it alluded to mammoth ivory, which was already the object of lucrative trade in Siberia.

From his "Narrative of Exploration in Western North America", it is clear that Thompson took the directive to look for fossils seriously, but his searches along river banks across the prairies were all unsuccessful. However, mammoths were still on the mind of David Thompson and the Nor'Westers in 1811, when he led twelve men with eight dogsleds and four horses across the Athabasca Pass in the dead of winter to reach the Columbia River at the Big Bend on his way to the Pacific. His men were startled to see a set of large tracks in the snow. Each footprint measured 14" long by 8" wide. Thompson thought that the track belonged to a large grizzly bear, but his hunters had a different idea: "Strange to say, here is a strong belief that the haunt of the Mammoth is about this defile, I questioned several, none could positively say they had seen him, but their belief I found firm and not to be shaken. They all agreed this animal was not carnivorous, but fed on moss and vegetables" (Nisbet, 1994).

David Thompson retired to Montreal in 1812 and never went west again. Mammoth bones and tusks were discovered in the 1840s, but in the Yukon and by an employee of the Hudson's Bay Company.

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