EDMONTON GEOLOGICAL SOCIETY

Second Annual Field Trip
Guide Book

ROCK LAKE

August 1960

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1960 EXECUTIVE

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INTRODUCTION
AND
ACKNOWLEDGMENTS

We welcome you most heartily to the second annual Field Trip of The Edmonton Geological Society.

The area north of the Jasper Highway and Athabasca River, centered on Rock Lake, was chosen for our Field Trip partially by default as the better known Jasper area had been covered so admirably by the 1955 Field Conference of the A.S.P.G. We now look on this as a most fortunate choice. It will be seen by reading the included papers that the Athabasca River approximates a geological boundary between the Central Alberta Foothills province and the Northern Alberta Foothills. The area is thus one of transition stratigraphically and to some extent structurally. All of the papers contain original data, both descriptive and interpretive, and we are confident the guide book will find a lasting place in the list of valuable works on the geology of Alberta and that it will help to bridge the geological gaps corresponding to the geographic River Athabasca.

The greatest individual contributor to the guide book has been the Assistant Editor, Walter Ziegler who contributed a paper plus the road logs and also made most of the arrangements for reproduction of the papers.

The greatest corporate contributor to the guide book has been Imperial Oil Limited whose employees contributed three of the eight papers submitted as well as the road logs. Imperial also carried the bulk of the load in respect to the stenographic and reproduction work. To all contributing authors and companies we tender our thanks with the hope that the guide book will provide its own justification to them in pride and satisfaction and in proportion to the sacrifices involved.

ROBERT H. J. ELLIOTT
EDITOR

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THE ATHABASCA-SMOKY COUNTRY

J. G. MACGREGOR *

The area drained by the Smoky River and all its tributaries on the onehand and on the other by streams entering the Athabasca River from its left bank as far down as Whitecourt contains some 25,000 square miles. This area, which for ease of reference we will call the Athabasca-Smoky country, is bounded on the North by the arable lands of the Peace River, on the southwest by the summit of the Rocky Mountains, and on the South by the Athabasca River and is today and always has been scantily populated. This is not strange when its generally high elevation and its poor soil are taken into account. In any event, the aboriginal population was very sparse and, so far at any rate, the exploitation of any resources it contains has not been profitable enough to attract white settlement. It is today the home of a handful of white trappers and forest rangers and a hundred or so half-breeds.

For the first one hundred years that it was known to white men they were so engrossed in hurrying past it along the great river that formed its southern boundary that they paid little heed to what lay out of sight of the river. Then, fifty years ago, two Trans-continental Railways were built west from Edmonton to the Yellowhead Pass and the old water highway gave way to the twin pairs of rails and then a thin line of white settlement became its southern boundary. While the railways gave white men a chance to export its riches little was accomplished in the vast area until very recently, when the Hinton pulp mill began to cut timber in the old wilderness and oil and gas wells began to scratch out winter roads and to clear tiny squares out of the bush.

In all this vast area of the Athabasca-Smoky region there are no full-blooded Indians. At one time, before the coming of the white man, this region had been inhabited by small bands of various Indians, each an integral part of its tribe whose lands touched these regions. There were Beavers in the north, Stonies (Assiniboines) and Chippewa (Saulteaux) along the east and south sides, and in its southwest corner Snakes and Shuswaps, - people from the mountains who pushed through the Yellowhead Pass into the Jasper valley. These then, Beavers, Stonies, Snakes and Shuswaps, had been living in parts of this region before the white man's influence was felt.

Strangely enough this influence had first made itself felt by an invasion of Crees from the east and the northeast. These virile Indians were the first to come in touch with white men along the shores of Hudson's Bay. Soon, by trading with the white strangers, they acquired fire-arms and then started out on an era of militant expansion. Before long they had driven the Chipewyans north to Lake Athabasca, the Beavers back to the mountain passes along the Peace, the Assiniboines further west and south, and the Blackfeet south into Alberta's prairies. The Crees maintained fairly friendly relations with the Assiniboines and intermingled with them. At the same time they became the dominant tribe as far west as Lac St. Anne, Lesser Slave Lake and Sturgeon Lake and thus entered the Athabasca -Smoky River region. Soon there were more Crees in this area than all other tribal stocks put together,

* Alberta Power Commission

while the Beavers withdrew and the Snakes and Shuswaps returned through the mountain passes, leaving only a handful of their people in the Jasper valley.

Then into the region came infusions of the blood of two other tribes, total strangers to the area, the Chippewa, and, strangest of all, the Iroquois. No-one is too sure how the small band of Chippewa came into the region. A much greater, and in fact a dominating influence was exerted by the other foreign people, the Iroquois. They were imported prior to 1820 by the Hudson's Bay Company and possibly by the North-West Company. They seem to have been brought west to act as voyageurs and company trappers. By 1820 at least, the Hudson's Bay Company was using them as trappers and there are records of several of them going up the sources of the Smoky River into this area. In time their period of service with the fur-trade companies expired and then several of them became so-called free-trappers and remained in the Athabasca-Smoky River area and in the region along the head-waters of the Peace River. Many of them also went on to become voyageurs, guides and packers for the Hudson's Bay Company in the old Oregon country. Today, however, the greatest distinguishable concentration of their descendents is in the Athabasca-Smoky country and includes the Plante, Moberly, Wanyandi, Caraconti, Joachim, Gauthier, Findlay and Callihoo families. Victoria Callihoo, who in 1960 celebrated her 100th birthday, was the wife of Louis, a grandson of a Callihoo who came west before 1820 to work for the Hudson's Bay Company. She believes that he and some of the other Indians were married before coming west and brought their wives with them. The Iroquois were taller and finer featured than the Crees and amongst the intermarried half-breeds in the area today it is usually possible to pick out the Iroquois strain by the larger stature of their descendants. The Iroquois people were the natives most highly regarded by the fur-traders, trappers and forest rangers who came to know them.

So, in the vast friendly wilderness of the Athabasca-Smoky country, many remnants of ancient tribes grew up together in peace, asking for nothing more than the right to live their own lives quietly and unobtrusively in the territories claimed so long ago by their ancestors -- an honest, hospitable, kindly people. As a result of the influx of the Crees that language became universal within the area. Until some ninety years ago Indian blood had dominated and it was possible to find rare cases of full-blooded Indians, but gradually this has been diluted - always by the same route - white fathers, who spent a year or so in the country, and native mothers, who took their fair-skinned offspring back to the teepees to be raised in the native ways.

So much, then, for the half-breed population of the area. The use of the Athabasca River as part of a great highway across the continent is a fascinating story. This story, however, has been so well told in the Guide Book of the A.S.P.G. Fifth Annual Field Conference 1955, that there is no point in repeating it here. Instead of doing so the following brief summary is inserted for the benefit of any to whom that Guide Book is not available.

David Thompson, working for the North-West Company appears to have been the first white man to use the Athabasca River as a means of crossing the

Rocky Mountains. About Christmas, 1810, he set out to cross the Athabasca Pass to the headwaters of the Columbia. His employee, William Henry, built the first Henry House early in 1811. It was located near the point on the railway known today as Henry House. It appears to have been in use a very short time because a later Henry House, situated near the mouth of the Miette River, was soon started and remained in use by the North-West Company, and its successor, the Hudson's Bay Company, for several years.

In January, 1811, Thompson of course had great difficulty getting over the summit of the Athabasca Pass. It was necessary for his party to make several trips over the worst part of the summit because they could not take all of their goods over in one trip. Finally, when the last of the goods was brought over, Thompson took stock and discovered that a bag of musket balls was missing. He suspected that a wolverine had carried it off. Search for it, however, proved unavailing. Indeed it was not found for 110 years, when, in August, 1921, one of the party of the Interprovincial Boundary Commission found 114 deeply corroded musket balls just north of the summit of the Pass.

To obtain the furs of the Indians of the Smoky-Athabasca region, Jasper Hawes built Jasper House at the north end of Brule Lake in 1813. About fifteen years later it was abandoned and the Jasper House known to everyone was built on the left bank of the Athabasca River opposite the mouth of the Rocky River. This was in use intermittently until 1884 when it was finally abandoned by the Hudson's Bay Company.

Various North-West Company brigades such as Franchere's in 1814 and Ross Cox in 1817, used this route to cross the mountains. Then in 1824 Sir George Simpson, Governor of the Hudson's Bay Company, which by this time had absorbed its rival, used this pass and set his seal of approval on this route over the mountains. From that time on until the C.P.R. was built to the coast via Calgary in 1885, the Athabasca River and Pass became the first Trans-Canada Highway. Over this route for sixty years passed men, messages and materials from Montreal and from York Factory on Hudson's Bay to the Hudson's Bay Company's Fort Vancouver (near Portland) and even further - to Hawaii. It was the only practical route of transport across Western Canada. This transport route was well organized. All goods, of course, came up the Saskatchewan River to Edmonton. In 1824 Sir George Simpson ordered a road cut across the seventy mile portage from Edmonton to Fort Assiniboine on the Athabasca River. At each end and at St. Albert and Lac La Nonne herds of horses were kept to supply the needs of travellers for rapid transport. From Fort Assiniboine brigades destined to Jasper or the coast could pass westward up the Athabasca River, while those destined for the Peace River Country went downstream to the mouth of Lesser Slave River and thence up this to the Peace River Country. A herd of horses was also maintained in what is now Jasper Park.

As stated in the Guide Book of the Fifth Annual Conference, Thomas Drummond, David Douglas, Father De Smet, Paul Kane, the Overlanders of 1862, Milton and Cheadle, Dr. Hector and many others, came and went by this great Trans-Canada Highway.

Father De Smet, a missionary better known in the Western States, made a trip to Edmonton and in 1846 went home by way of Jasper. He spent twenty-six days there and has left us a record of the appetites of his companions and the voyageurs. He says that during this interval 54 persons ate 12 deer, 2 caribou, 50 sheep, 2 porcupines, 210 hares, 50 ducks, 21 grouse, 1 quail and 1 eagle, on top of a daily ration of 30 to 50 whitefish and 20 trout. "Yet", he explained, "they complained that life was hard and the country very poor."

Perhaps the most moving record of what a good meal meant to hungry men has been left us by Paul Kane who in 1846 descended the Athabasca to Fort Assiniboine. The trip took much longer than was expected because the ice of the river was particularly rough. On the last night before reaching Fort Assiniboine he said that the party had a long consultation over their camp fire as to whether or not they should eat their dogs but he says, "Their thinness saved them. The two would not have furnished us with a sufficient meal; besides, they could draw the sledge still and that was a great consideration to us in our weak state."

They started early the next morning and by four o'clock in the afternoon they reached Fort Assiniboine. Then he goes on to describe his enjoyment of the meal.

"No sooner had we arrived than all hands set to work cooking; luckily for us this post is plentifully supplied with white fish --- whether it was the hunger from which I was suffering or the real goodness of the fish, I know not now; but certainly they seemed to be the most delicious I had ever tasted and the memory of that feast hung over me, even in my dreams, for many a day afterwards --- and soon, seated on a pile of buffalo skins before a good fire, I commenced the most luxurious repast of which it had ever been my fate to partake. I had no brandy, spirits, nor wine, neither had I tea or coffee --- nothing but water to drink. I had no Harvey's Sauce, or catsup, or butter, or bread, or potatoes or any other vegetable. I had nothing but fish; no variety, save that some were broiled on the hot coals and some were boiled. But I had been suffering for days from intense cold and I had now had rest; I had been starving and I now had food; I had been weary and in pain, without rest or relief and now I had both rest and ease. How many fish the men ate, I do not know, but having satiated themselves, they all lay down to sleep. In the middle of the night they woke me up to ask me if I would not join them in another feast, but I did not, much to their astonishment, as the woman had told them that she was afraid I was sick as I only ate four fish out of seven (weighing 2 to 4 pounds) she had prepared for me. However, in the morning about five o'clock, I commenced again and made another hearty meal; and then how happy I was when I lay down and slept again, instead of clambering over the rugged bourdigneaux."

Two brothers, by the name of Moberly, made two entirely different contributions to the story of the Athabasca valley. The first to arrive was Henry John Moberly, a rugged Hudson's Bay Company trader, who was in charge of Jasper House from 1855 to 1861 and who in 1857 was the first man to take a train of pack horses more or less along the route of the present highway from Edmonton to Jasper instead of following the longer time-worn trail up the Athabasca River.

In 1859 the geologist, Hector, spent some time at Jasper House with Moberly. He says that at that time Moberly fed his people on lynx and up to that date had killed 83. Going on, he says "As the mountain mutton was very lean at this season, while the cats were fat, we used to combine them by stuffing the cat with minced mutton and roasting it whole. This made a very savory dish."

Henry John was the most definite donor of white paternity to the half-breeds of the Athabasca-Smoky area and seems to have partaken of the fruits of the valley with gay abandon, at the same time ensuring that the name Moberly would live long in the valley's story.

Walter Moberly was one of the outstanding railway location engineers of British Columbia and spent some years in the employ of the Canadian Pacific Railway. In 1872 he was at Jasper seeking a practical route from the summit of the Yellowhead Pass towards Edmonton. While his brother Henry John seems to have enjoyed the proximity of primitive beauty, Walter seems to have been abashed by its presence. One day as he was moving his camp east towards the present site of Hinton he had an experience which to us has its amusing elements.

"We took two dog-sleighs but, there being no snow on the flat and side of the hill beyond Fiddle River, Louis, one of the Iroquois hunters, sent back for his two daughters to pack the loads to the top of the ridge. One of the girls who was a tall and very powerful young woman, took an enormous load without any difficulty and, on partly crossing the ridge, we came to a large pond some two hundred yards in width and a long way round. There was about six inches of water on the ice so, telling the Indians and half-breeds to camp in the woods on the opposite side, as night was coming on, I sat down thinking that as I must get wet feet I might as well have a smoke and get to camp by the time the fire was burning and the supper cooked. I saw the huge woman wading back and wondered why she was returning, but soon found out, for she told me her father had sent her to pack me over the ice. I had travelled by every known mode but to be packed by a woman was a novelty, so I protested; but she insisted, saying I was much lighter than the load she had just packed over and if she did not take me her father would be very angry, so I resigned myself to my fate and was ignominiously packed over. Louis was very proud of the girl's strength and that evening, as we were smoking a pipe, he pointed out the great advantages in having such a powerful girl and, as he wished to get a horse I had, he made me an offer to make an exchange --- I to give him the horse and a few other things and take the girl instead, to which she did not object; but as I had no idea of becoming a permanent resident of that country and hardly liked the idea of presenting her in the civilized world, I was obliged to decline what might have turned out a troublesome investment in the end."

E. W. Jarvis, another C.P.R. surveyor, made a most difficult trip in the middle of the winter of 1875. He started from Prince George with two other white men and some Indians to ascend the MacGregor River so as to study the pass leading from its headwaters to those of the Kakwa River. After descending the Kakwa for some distance they decided to swing south towards Jasper. Many days later, after the loss of several dogs, the party, exhausted and near starvation, reached the Iroquois Indians living near Jasper House, which was not open at that time. From them they obtained some supplies and, leaving their dogs, started east towards the Hudson's Bay Company's Lake St. Anne Post. The snow was deep and travelling most difficult and after leaving the Macleod River there was a grave doubt that they would make it the rest of the way. As Jarvis says, "A curious sensation of numbness now began to take hold of our limbs with an unwillingness, or rather inability, to push one snowshoe before the other after lifting it up; this gave us the appearance occasionally of 'marking time' and would no doubt have been amusing to a well-fed bystander; but to us it was no laughing matter. Frequent cramps in the hands, caused probably by the pressure of the pack-straps on the shoulders, also added to our discomfort. A couple of rabbits opportunely appearing near camp gave us an apology for a breakfast; and the evening of the third day after, we reached the Hudson's Bay Company's post at Lake St. Anne. The intervening time was probably spent in a sort of mechanical progress, for nobody seemed to have any very distinct ideas except on the subject of looseness in the region of the waistband. We were kindly received by Mr. McGillivray, the officer in charge, who set us down at once to a good meal of whitefish and potatoes; and after the manner of starving men in general, we ate a great deal more than was good for us. There never was a more welcome riddance of a burden than when we threw down our packs and took off our snowshoes at Mr. McGillivray's door."

It was not only white men that endured hardship and overcame it, in the Athabasca-Smoky country. Perhaps one of the most remarkable cases of fortitude and endurance on record is that of a Snake Indian girl. The remnant of her tribe were camped on the hillside just west of Jasper House. A larger camp of Assiniboines was located at the north end of Lake Brule. There had been enmity between these two groups, but one day the Assiniboines approached the Snakes and invited them to a pow-wow, obstensibly to make peace for all time. When, however, they had the Snakes, who had not brought their guns, seated around them, the Assiniboines turned on them and killed all of the males and went over to the camp and killed all the remainder of the camp except for three young girls. They took these girls with them as prisoners and descended the Athabasca River to Fort Assiniboine. Here they stripped and bound the three girls and placed them in the tent, possibly to be tortured and finally dispatched at a great scalp dance to be held the next day. During the night, however, a half-breed by the name of Bellerose was able to creep into the lodge and cut their bonds. All he could provide them with was a scalping knife, a file and a bag containing flint, steel and punk. The three young women, naked, made their escape and followed the Athabasca River to its junction with the Baptiste (Berland) River. Here they could not agree as to their further course. Two decided to follow the Athabasca, while one of them decided to go up the Baptiste. The two, making a raft, and taking with them the fire bag, crossed the Baptiste and were never heard of afterwards.

But we will let H. J. Moberly go on from here and quote from his book "When Fur was King"; "The third, left only with the knife, travelled up the Baptiste some thirty miles and there made preparations for wintering. Berries were still to be had, she managed to kill a few squirrels and with the sinews from their tails made snares for rabbits. She killed some porcupines and groundhogs, too, dried them, and out of the rabbit skins made herself a dress. She kindled a fire in the primitive way, by revolving the point of one dry stick rapidly in a hole made by another, and collected a large pile of dry wood. By the time winter had set in she was prepared for it.

"Thus she lived until midsummer, gathering gum from the poplars and making dried meat from rabbits and other small animals she killed. Then she removed several days' journey to another good hunting ground.

"Three months later an Iroquois hunter, wandering far from his accustomed haunts, came upon a series of strange tracks and traces. They puzzled him. He was unable to decipher what kind of animal could have made them. So many tales of "weetigoes" and other mysterious beings were current that none thought it worth while to travel so far to look into this one and for a time the whole matter died out.

"Next summer, however, when the hunters were in camp some little distance from the Baptiste, this man decided to return to the spot and try to find out what animal had made the mystifying tracks. He struck the river where the Snake woman was living, saw snares set, trees barked and fresh prints in the ground that resembled those of a human being. He was sure he had now run upon a real weetigo (cannibal) and, being a plucky man, determined to hunt and kill him.

"Creeping round cautiously, with his gun at full cock and prepared at any moment to be pounced upon, he came to a high bank where an immense collection of dry wood with a little fire near it was piled not far from the entrance of a small cave. He could see no other sign of life.

"He hid himself close to the cave and presently a wild creature in a short skirt of rabbit skins approached with a load of rabbits. Throwing down the pack, this grotesque object picked up some sticks with which to replenish the fire, and recognizing the sex the hunter knew at once that she must be one of the three women who had escaped two years before from the Assiniboines.

"Noticing him at length she made a frenzied effort to escape but was soon overtaken. She had become perfectly wild and he had much difficulty in bringing her to the camp. She remained with his family for two years. Then the officer in Jasper House kept her for another two years as servant to his wife, at the end of which time she married a Shushwap. She was the only survivor of her tribe."

In spite of the work of Walter Moberly and Jarvis the Canadian Pacific Railway did not go through the Yellowhead Pass and for many years after the railway survey parties had abandoned their work it fell back to its ancient calm. The Iroquois and Cree half-breeds, dominated by the intelligent and growing Moberly clan, continued to live in peace and relative plenty throughout the area with a special concentration of them in the valley at Jasper. Each spring they took their furs out to any one of the five Hudson's Bay Company posts around the periphery of their vast area; Fort Dunvegan on the Peace River, Lesser Slave House on the west end of the lake of that name, Lac St. Anne, Fort Assiniboine and Jasper House, and their woes to the missionaries at the first three points. In their wanderings to and fro they worked out many pack-trail routes governed always by the need to camp each night where the horses could find pasture.

Although Jasper Park was created in 1907, it was about two years later before a Commissioner from Ottawa came out to buy out the rights of the few people who lived in the park. Of these, Lewis Swift, who settled there in the early nineties and subsequently obtained a patent to his land, was the only white man. Swift had a thriving frontier establishment and refused to sell at any price. In consequence his quarter section is today the only free-hold land within the Park. The three or four other settlers there were half-breeds, mainly of the Moberly clan, who ranched on a scale sufficient to feed their horses which they used in their main business as packers and guides.

They were told that if they would sell out they could settle "anywhere outside the park." Some of them moved east to Prairie Creek and set up again. Others moved further back and settled at Grande Cache along the Smoky River. These had no sooner built new homes and got nicely started again than the Federal Government created the Athabasca Forest Reserve, mainly north and west of Jasper Park, and then instructed the half-breeds to move again. These authorities maintained that the half-breeds had been told to settle "anywhere outside the park, except in the Forest Reserve." The half-breeds, however, refused to move in spite of the Mounted Police who unwillingly tried to eject them. Fortunately they had too many friends among the oldtimers in the Jasper area who insisted that the restrictions about the Forestry Reserve were not contained in the original verbal bargain; so, to this day, there remains at Grande Cache a flourishing colony of half-breeds and of Indians who have never yielded their necks to the yoke of the white man's treaty. For nearly fifty years they have subsisted well in the way of life led by their maternal ancestors. With the building of the pulp mill at Hinton two years ago they turned their hands to forestry operations, and, while continuing to haunt their ancestral valleys, appear to have found for themselves a permanent niche in the white man's world.

The building of the grand Trunk Pacific and the Canadian Northern, two intercontinental railways, along the south boundary of the Athabasca-Smoky country some fifty years ago, was a prime piece of folly. As explained in the Guide Book of the Fifth Annual Conference the inexorable logic of economics soon brought this useless waste down upon the heads of the two companies in the form of bankruptcy. After that the Federal Government had to step in and create the Canadian National Railway, which was then able to utilize the best parts of each grade on which to run one railroad. Once the steel was removed from the grade that was left it remained to be used as a road which in the course of forty years has evolved into the Edmonton-Jasper Highway. For some forty miles west of Styal and some thirty miles west of Edson and for many other shorter stretches, the modern tourist follows the uniform grade and easy curves where once, half a century ago, the headlights of straining locomotives bored their way into the blackness of the forest night.

When the Grand Trunk Railway reached Edson in 1910, it touched off a stampede of settlers along a trail that was to strike out for more than two hundred miles through the untrod vastness of the Athabasca-Smoky country. Many hundreds of settlers had set their hearts on a homestead in the Peace River country and a great many of these planned to settle in the Grande Prairie area. The customary summer route, by way of Lesser Slave Lake, was 500 miles long but in winter it could be reduced to 400 by using the Sturgeon Lake cut-off. In a straight line the distance from Edson to the hamlet of Grande Prairie was only one hundred and ten miles.

So urgent was the need for a short cut to the Grande Prairie by way of Edson that in 1910 the Provincial Government sent an expedition to make a preliminary survey of the route. After the survey these men reported that it would be at best a "primitive road." They decided to hasten the work of cutting the trail and men were sent in to corduroy its worst stretches, find easy grades down its hills, bridge the smaller creeks and put ferries over the larger rivers.

By the end of March, 1911, MacQuarrie had cut the road over hill and dale, across rivers and muskegs, all the way to Sturgeon Lake. There the road connected with the older trail from Lesser Slave Lake to Grande Prairie. Ferries were placed on the Athabasca, Little Smoky and also across the Big Smoky at Bezanson. It had been no small feat. In planning it, the Department of Public Works had envisaged at best "a primitive road." In their report of 1911 they stated that it had been put in fairly good condition.

The first twenty miles were not too bad but even in this stretch small muskegs were encountered. They were short but a good foretaste of what lay ahead. Here many realized for the first time how puny is the strength of a man and two oxen when pitted against the sucking mud of a muskeg. A few feet was all that was needed for the wagon to go in over axles and the oxen to flounder in mud up to their bellies. Oxen were used much on this trail because they endured the heartbreak of mudholes better than horses.

When they got stuck this way nothing could be done but unload and carry the goods piece by piece to the other side of the muskeg. This meant an endless number of trips, up to the knees in mud every step. Then, with the wagon empty, it was all the oxen could do to pull it out. It was hard work and heartbreaking enough without the hot sun which poured down and the mosquitoes and bulldog flies. If, instead, it was raining - and it rained much of the time - it was even more depressing. Many a time the slogan of the settlers - "Hell bent for the Peace" - came near being abandoned.

After the first twenty miles the trail reached higher ground until at Mile 35 it reached the peak of the range of hills south of the Athabasca River. To achieve this point meant a long, hard climb. By the time the settlers reached the top they were beginning to realize what the Edson Trail meant in terms of fatigue and discouragement. To get their goods up the worst hill they had to unload and make two or three trips up with partial laods. Either that or they had to hitch two teams to one load and, having brought it to the top, go back for the other load. On this section of the road many abandoned the heavier and less useful part of their goods. A piano sat by the roadside near Mile 35 for a long time. Heavy cumbersome furniture, some of it heirlooms, was abandoned here. Mowers and other farm machinery were left here to be retrieved during the winter or even the next year.

This trail started out at Edson and ran north and west till at Mile 53 it crossed the Athabasca River upstream from the mouth of the Berland River, than called the Baptiste. In a few miles it crossed the Berland, then, after crossing the height of land, it followed down in the vicinity of the Little Smoky River and finally emerged at Sturgeon Lake where it intersected the winter trail from Lesser Slave Lake to Grande Prairie. This was the only road cut out through the Athabasca-Smoky country so as to be passable for wheeled vehicles. There were other trails over which pack-trains passed but then, with judicial handling, a pack-train can go almost anywhere. Perhaps the most clearly defined of these pack-trails used by white men was that which, when looked back upon from the Grande Prairie end, came to be called the Hinton Trail, - that is the trail leading to Hinton. It started out at Hinton or Entrance and then went northwest along the foothills, finally emerging at the little hamlet known today as Hinton Trail, (Twp. 70-10-6), but no vehicle ever passed over it.

The Edson Trail, however, was the famous one, a trail of suffering, fortitude and heroism. It fell into disuse in 1916 when the railway arrived in the Grande Prairie country, but in spite of its short life it left its marks upon the country and its pioneers. Their proudest memories today are that they came in over the Edson Trail.

PRECAMBRIAN ROCKS IN THE VICINITY OF JASPER, ALBERTA

H. A. K. Charlesworth [1]

D. B. Remington [2]

INTRODUCTION

The town of Jasper, situated in the heart of the Canadian Rocky Mountains at latitude 52° 52' and longitude 118°05', lies almost on the boundary between the eastern and main ranges (fig. 1). The eastern ranges, consisting dominantly of Upper Palaeozoic rocks, have been relatively well mapped, especially by oil companies, whereas the main ranges, largely comprised of Precambrian and Lower Palaeozoic strata, remain almost unexplored. The senior author is in the process of mapping the Precambrian rocks along the Yellowhead highway from Jasper to the Alberta-British Columbia boundary. The work, of a reconnaissance nature, will be augmented by more detailed studies carried out by graduate students at the University of Alberta.

The country around Jasper, of which some 30 square miles have so far been studied, is mountainous with a relief of nearly 6000 feet. On the lower ground where, because of its accessibility, all the mapping has been carried out, there is a dense tree cover and many areas are underlain by superficial deposits. Aerial photographs, enlarged to a scale of about 4 inches to the mile, were used in the field, while maps belonging to the National Topographic 1:50,000 Series, enlarged to a scale of 4 inches to the mile, served as base-maps.

[1] University of Alberta, Edmonton

[2] Petroleum and Natural Gas Conservation Board, Calgary

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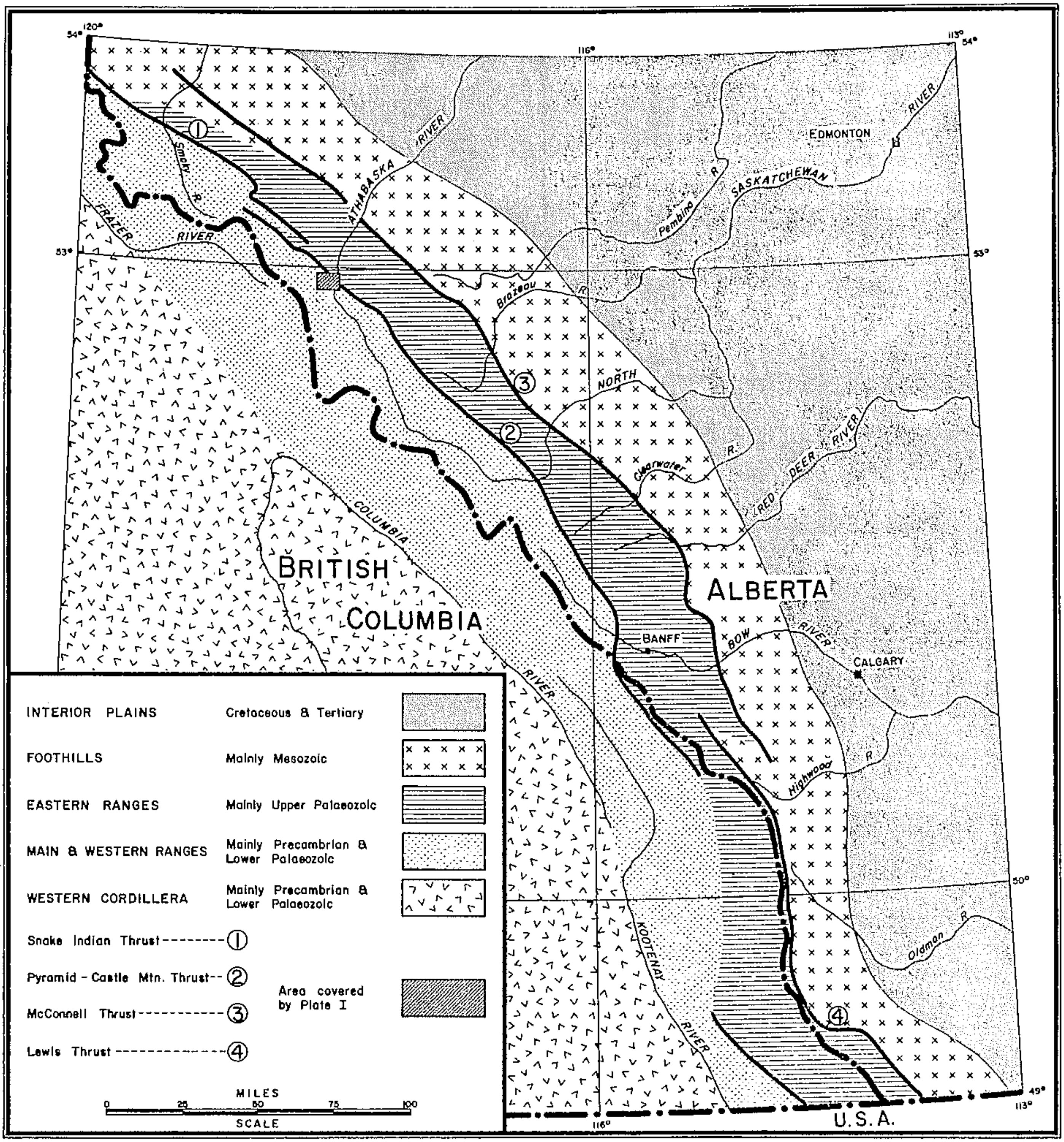
HISTORICAL REVIEW AND GENERAL SUCCESSION

The Precambrian of the Jasper region was first described by McEvoy (1901, p. 31D), who recognized three sets of beds. The first was described as consisting of fine-grained conglomerates; the second as interbedded fine-grained conglomerates and slates; and the third as argillites with some calcareous sandstones. Later, Walcott (1913, p. 340) used the term Miette formation for the "massive-bedded, grey sandstones with thick bands of grey and greenish siliceous shale", 2000 feet or more in thickness, which outcrop in the valley of the Miette River, west of Jasper. Allan et al (1932, p. 231) described a series of buff-coloured quartzites, argillites, sedimentary breccias, slates and many conglomerate beds from the neighbourhood of Jasper which they termed the Jasper series. Collet and Parejas (1932, p. 47) were the first to mention the occurrence of carbonates at the top of the Precambrian.

In ascending order, the Precambrian succession in the neighbourhood of Jasper is here divided into the Old Fort Point, Miette and Jasper formations. The Old Fort Point formation, which may correspond to McEvoy's third set of beds, is named after Old Fort Point, southeast of Jasper, where excellent exposures are present. It consists mainly of greenish-grey phyllites with interbedded edgewise conglomerates, carbonates and siltstones. The interbedded sandstones, conglomerates and phyllites which overlie the Old Fort Point formation, are grouped under the term Miette formation, after the Miette River, along whose banks the strata are excellently displayed. It was decided to use Walcott's name for these beds since his lithologic description is consistent with the present use of the name. The formation may correspond to McEvoy's second set of beds. The uppermost Precambrian rocks in the Jasper area are referred to as the Jasper formation. Consisting of sandstones and pebble-conglomerates with carbonates near the contact with the Lower Cambrian Cavell quartzite, the formation may be equivalent to McEvoy's first set of beds. The term Jasper formation, first used by Allan et al (1932, p. 231), is retained since their description of the lithology and the area of outcrop is generally consistent with the present usage. No estimate of the thickness of the various formations has been made as yet, but the combined thickness may be as much as 5000 feet.



BRITISH COLUMBIA
ALBERTA
EDMONTON
CALGARY
BANFF
U.S.A.
ATHABASKA RIVER
Smoky R.
FRAZER RIVER
Pembina R.
SASKATCHEWAN RIVER
Brazeau R.
NORTH
Clearwater R.
RED DEER RIVER
BOW RIVER
Highwood R.
Oldman R.
COLUMBIA RIVER
KOOTENAY RIVER
INTERIOR PLAINS Cretaceous & Tertiary
FOOTHILLS Mainly Mesozoic
EASTERN RANGES Mainly Upper Palaeozoic
MAIN & WESTERN RANGES Mainly Precambrian & Lower Palaeozoic
WESTERN CORDILLERA Mainly Precambrian & Lower Palaeozoic
Snake Indian Thrust ①
Pyramid - Castle Mtn. Thrust ②
McConnell Thrust ③
Lewis Thrust ④
Area covered by Plate I
MILES
0 25 50 75 100
SCALE
120°
116°
113°
54°
53°
50°
49°

STRATIGRAPHY

Old Fort Point formation. The Old Fort Point formation is made up mainly of greenish-grey silty phyllites, often finely laminated and calcareous. Interbedded with them are edgewise conglomerates and carbonates. The rectangular fragments in the conglomerates, comprised mainly of very fine-grained limestone, are up to 2 feet long. The matrix may be either calcareous siltstone, or very fine-grained limestone similar to that of the fragments, or coarse-grained calcareous sandstone. The conglomerates, which are more resistant than the associated phyllites, are lenticular. The limestones and dolomites, in beds up to several feet thick, are greyish, generally very fine-grained, sometimes laminated, and occasionally pyritic. Some very fine-grained, greyish, somewhat friable sandstones and siltstones occur near the top of the formation.

Miette formation. The Miette formation is divisible into a large number of alternating arenaceous and argillaceous units; the units are lenticular and the contacts often gradational. The arenaceous units, which are usually between 50 and 150 feet thick, are essentially made up of pebble-conglomerate and sandstone. A few thin interbeds of phyllite usually occur within each unit and shale-cobble intraformational conglomerates are common. Beds within the units are not persistent for more than a few tens of feet along strike. Graded bedding, in units about 5 feet thick, is the most prominent sedimentary feature in the arenaceous sequences. The base of a graded bed is generally a fine pebble-conglomerate or pebbly sandstone which grades upward into a medium-or coarse-grained sandstone and sometimes into a very thinly bedded, fine-grained micaceous sandstone. Cross-stratification is also a common sedimentary feature. It is of the simple and trough type, each set being 1 to 3 feet thick. Attitudes of a number of randomly selected sets were measured, the results indicating that at the time of deposition the original dip was westerly. Other sedimentary features present include ripple marks and load casting. The arenaceous units, which are greyish in colour, are all very poorly sorted and bedding is often indistinct. Sixty to seventy per cent of the sandstones and conglomerates are comprised of quartz grains, about twenty per cent is albite, and the remainder consists of mica, calcite, siderite (often completely altered to limonite), chlorite, and interstitial silt-and clay-sized material.

Somewhat thinner units of laminated and very thinly bedded phyllite, with occasional thin beds of sandstone or pebble-conglomerate, separate the arenaceous units. Commonly an olive colour, the phyllites weather rusty brown. They consist of sericite and chlorite, with variable amounts of fine sand-and silt-sized quartz . Graded bedding is as common in the phyllitic units as it is in the arenaceous. The upper part of the Miette formation appears to be largely argillaceous, accounting for the scarcity of outcrop immediately southwest of the outcrop of the Jasper formation (Plate I).

Jasper formation. The Jasper formation is comprised largely of coarse-grained sandstones and pebbly sandstones, with subsidiary amounts of pebble-conglomerate. The beds, although poorly sorted, do not contain nearly as much argillaceous and silty interstitial material as the Miette sandstones. Quartz is the dominant constituent with feldspar present in amounts up to 20%; limonite occurs sporadically.

At the base the predominant colour is yellowish grey, while higher up in the succession reddish hues appear. At the top of the formation a series of grey phyllites and dark grey and reddish carbonates occur. Algaloid structures are abundant in the reddish-coloured carbonates.

General Considerations. The entire succession appears to have been deposited in very shallow water, as indicated by the presence of intraformational conglomerates in the Old Fort Point and Miette formations, and cross-stratification in the arenaceous beds of all three formations. While the Old Fort Point formation may be marine, the sediments of the Miette formation are probably deltaic in origin, the arenaceous units being the products of deposition by distributaries and the phyllites of deposition in inter-distributary lagoonal areas. The graded bedding was probably developed as the result of waning currents in the distributaries. The intraformational conglomerates, lenticular strata, poor sorting, cross-stratification, and ripple marks are all consistent with this type of environment. The relatively homogeneous nature of the Jasper formation, together with the possible presence of algae in the carbonates, suggests marine deposition.

During Old Fort Point time the area was receiving only fine-grained clastic material from the adjacent land-mass. Cross-stratification studies suggest that, in Miette time, the land lay to the east, and there is little reason to doubt that the source of the Old Fort Point sediments lay in the same direction. The beginning of Miette time saw the influx of large quantities of much coarser material, which may have been a reflection of renewed uplift in the land-mass to the east. The presence of abundant metamorphic and plutonic (?) quartz, as well as coarse feldspar in the sandstone-conglomerate units, suggests that the source-area consisted in large measure of metamorphic and igneous rocks and was not far away from the site of deposition. It probably consisted of the igneous and metamorphic rocks of the Churchill Province of the Canadian Shield.

The Jasper and Miette formations are probably of Windermere (late Precambrian) age, and equivalent to the Hector and Corral Creek formations of the Bow Valley (Walcott 1910, p. 428). No equivalents of the Old Fort Point formation are known from the Canadian Rocky Mountains, but it is interesting to note that the Siyeh limestones of Montana also contain edgewise conglomerates (Willis, 1902, p. 323), leading one to entertain the possibility that the formation may be of Purcell age.

THE LARAMIDE OROGENY

INTRODUCTION

The Precambrian strata of the Jasper area have undergone orogeny, as indicated by structural deformation, metamorphism, and veining. Although no direct evidence was found as to its age, the orogeny is assumed to be the Laramide which, in the case of the Canadian Rocky Mountains, occurred in Lower Tertiary times (Russell 1954, p. 68). The Lower Cambrian Cavell formation, consisting dominantly of massive quartzites, has undergone much gentler folding than the underlying Precambrian, a fact which is attributed to the much greater competency of the

Cavell formation. If the observation by Walcott (1913, p. 340) that the Precambrian is overlain unconformably by the Cambrian be correct, some of the structural deformation in the former may be Precambrian in age.

STRUCTURE . The main structural element of the Jasper area (Plate I) is the Pyramid thrust-fault, which brings Precambrian strata on the southwest against Devonian and Mississippian on the northeast. The fault, first recognized by McEvoy (1901, p. 31D), is equivalent to the Castle Mountain fault of the southern Canadian Rockies (North & Henderson 1954, p. 28) while to the north it is replaced by the Snake Indian fault (Ziegler 1960, p. 746. It has been referred to by Collet and Parejas (1932, pp. 46-7).

The fault, which strikes at about N. 60° W., forms the northeastern boundary of the map-area. Northwest of the Athabasca River it approximately follows the line of Pyramid Creek before crossing the east shoulder of Pyramid Mountain. Southeast of the river the fault crosses Edith Lake before continuing up the western side of the Maligne River valley. Although in places the Pyramid fault is associated with considerable deformation of both the underlying and overlying strata, the contact is sharp where seen in the south bank of Pyramid Creek, about 1/4 mile northwest of the railway. As noticed by Collet and Parejas (1932, p. 47), the fault, with a stratigraphic throw in the order of 10,000 feet, has a relatively steep southwesterly dip of about 45° in the vicinity of Pyramid Creek, although it appears to flatten farther north.

The Precambrian strata of the Jasper area, which lie within the Pyramid thrust-sheet, have been severely deformed. The major fold is the Jasper anticline, in the core of which outcrop beds belonging to the Old Fort Point formation. These strata are enveloped by outcrops of the Miette formation, while on the northeastern limb Jasper strata make their appearance. The trend of the anticline changes from about N. 75° W. northwest of the Athabasca River to N. 50° W. southeast of the river. Judging from the attitude of cleavage planes (see p.16) the axial plane of the fold dips steeply southwest. The northwesterly plunge of the Jasper anticline within the map area is reflected in decreasing width of the Old Fort Point formation outcrop in that direction.

The Jasper anticline is not a simple structure, being more in the nature of a faulted anticlinorium. On the southwest limb a number of small folds within the Miette formation have been recognized; thrust-faults may also be present. The folds tend to be grouped in pairs, with the anticlines only a short distance southwest of the synclines so that, in general, younger beds are exposed towards the southwest. West of the map-area, however, this situation is reversed causing Old Fort Point beds to reappear at the surface. Dips are steep, averaging about 60°. East of the Athabasca River the base of the Miette formation appears to be displaced southwards, which may be the result of movement along a southwesterly trending wrench-fault (see p.16).

Outcropping in the core of the Jasper anticline the Old Fort Point formation has behaved very incompetently, being folded into a number of closely spaced anticlines and synclines. The folds are asymmetrical, the northeastern limbs of the anticline usually being overturned and sometimes partially replaced by thrusts. The northeastern boundary of the Old Fort Point formation may well be faulted, a situation which may be associated with the zone of inversion in the Miette formation immediately to the northeast.

The Miette formation is poorly exposed on the northeastern limb of the Jasper anticline. However, a number of small folds with steep and in places overturned dips have been recognized; thrust-faults may also occur.

West of the Athabasca River, overlying the Miette formation, are sandstones and conglomerates of the Jasper formation. Steep northeasterly to vertical dips predominate, although overturning may develop as the Pyramid fault is approached. The structure of these beds is undoubtedly much more complex than that shown on the map. East of the river the outcrop of the Jasper sandstones is displaced southward. In between these strata and the Pyramid fault are carbonates, phyllites and quartzites belonging to the upper part of the formation. Both sandstones and carbonates are cut by a number of thrust-faults and are characterized by relatively gentle (5-40°) south-southwesterly dips. The dissimilarity of the structure across the valley is attributed to a southwesterly trending wrench-fault, the trace of which is not known with any degree of accuracy. The fault may have developed contemporaneously with and terminate against the Pyramid fault. It may be continuous with the fault which cuts the southwestern limb of the Jasper anticline (see p. 15), although its effect on the northeastern boundary of the Old Fort Point formation is not known.

METAMORPHISM That the Precambrian rocks of the Pyramid thrust-sheet have undergone metamorphism, as well as structural deformation, is readily apparent in the case of the argillaceous beds of the Old Fort Point and Miette formations. In these beds recrystallization of the original clay minerals to sericite and chlorite has led to the development of slaty cleavage. To a first approximation the cleavage parallels the axial planes of the folds, although a fan-like arrangement invariably appears to be present. Thus, the dip of the cleavage planes may be up to 30° steeper than the axial plane on the southwest limbs of anticlines and up to 30° gentler on the northeast limbs. This situation may have been the result of cleavage lagging behind folding during the orogenic process. During the metamorphism of some calcareous shales of the Old Fort Point formation, calcite, presumably evenly disseminated throughout the original sediment, has tended to segregate into lenticular nodules whose orientation is controlled by the cleavage.

Petrographic studies on the arenaceous rocks indicate that they too have been metamorphosed, although the essentially unaltered fabric of the coarser beds suggests that the effects have been slight. Fractured pebbles in the conglomerates, together with the well indurated nature of many of the rocks and the presence of fracture cleavage, are the most obvious results of metamorphism. The greenish colour of all rocks, coarse and fine, is caused by the presence of the metamorphic mineral, chlorite. Albitization of the original potash feldspar and plagioclase has also taken place. During albitization, escaping K^+ ions from the potash feldspar were probably adsorbed by immediately adjacent argillaceous material to form sericite, while migrating Ca^{++} ions from the plagioclase formed calcite (and perhaps ankerite).

VEINING. Veins are a prominent feature in the arenaceous rocks of the Miette formation and in the limestones of the Old Fort Point formation. They are rare in the arenaceous rocks of the Jasper formation and in the argillaceous members of the lower formations. Up to two feet wide, the veins are often concentrated along the axes of anticlines. Comprised mainly of quartz, calcite, chlorite, siderite (often altered to limonite), and albite, the veins are compositionally similar to the host rocks. The material of the veins was probably derived locally as the result of the activity of hydrothermal solutions. The almost complete absence of veins from argillaceous rocks is probably the result of these rocks' inability to sustain open fractures. Lack of minor folds and of impermeable interbeds of argillaceous material may explain the scarcity of veins in the strata belonging to the Jasper formation.

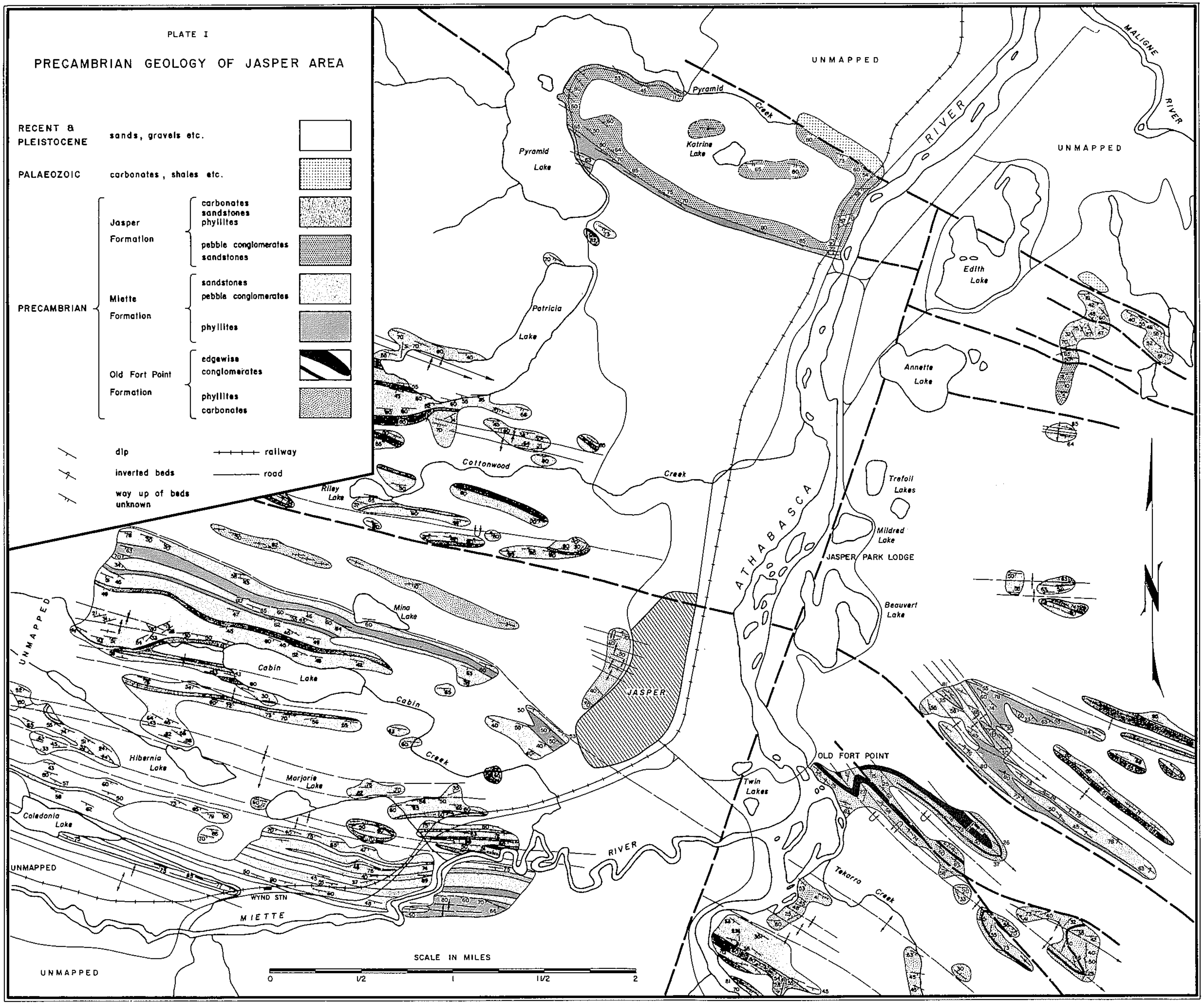


PLATE I
PRECAMBRIAN GEOLOGY OF JASPER AREA
RECENT & PLEISTOCENE
sands, gravels etc.
PALAEOZOIC
carbonates, shales etc.
PRECAMBRIAN
Jasper Formation
carbonates sandstones phyllites
pebble conglomerates sandstones
Miette Formation
sandstones pebble conglomerates
phyllites
Old Fort Point Formation
edgewise conglomerates
phyllites carbonates
dip
inverted beds
way up of beds unknown
railway
road
UNMAPPED
MALIGNE RIVER
RIVER
Pyramid Creek
Pyramid Lake
Katrine Lake
Edith Lake
Patricia Lake
Annette Lake
Cottonwood Creek
Riley Lake
Trefoil Lakes
Mildred Lake
JASPER PARK LODGE
ATHABASCA
Beauvert Lake
Mina Lake
Cabin Lake
Cabin Creek
JASPER
Hibernia Lake
Marjorie Lake
Caledonia Lake
OLD FORT POINT
Twin Lakes
Tekarra Creek
RIVER
WYND STN
MIETTE
SCALE IN MILES
0
1/2
1
1 1/2
2

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THE UPPER DEVONIAN JASPER BASIN *

R. D. ORR

Imperial Oil Limited, Edmonton

ABSTRACT

Devonian sediments in the Jasper area are divisible into a uniform upper (Palliser) and a variable lower (Alexo - Fairholme) unit. Two distinct biostratigraphic provinces, "reef" and "off-reef", are evident within the Fairholme group. Four facies:- the Flume, Perdrix, Lower Mount Hawk and Upper Mount Hawk comprise the Fairholme of the Jasper "off-reef" province. This pronounced shale basin (off-reef) received silts and sands from a western source in Upper Mount Hawk and Alexo time. The resulting clastic facies of the Mount Hawk contains a faunal assemblage normally attributed to the younger Alexo formation.

INTRODUCTION

The Devonian of the Jasper area comprises a sequence of strata some 2400' thick which can be broken up into a gross upper and lower unit. The upper unit consists of the relatively uniform Palliser formation while the lower is made up of the Alexo formation and the highly variable Fairholme group.

Within the Fairholme group (McLaren, 1955) of the Rocky Mountains, there are two major biostratigraphic provinces, the areas of carbonate buildup or "reef" and the "off-reef" shale areas. This paper is mainly concerned with the off-reef shale facies of the Jasper basin. The Fairholme shale province in this area is composed of four main facies types; the discussion of which forms the bulk of the paper.

CORRELATION

A correlation within the Jasper basin extending into the clastic province east of the Windfall Reef was made, using the following stratigraphic sections:

Section #1 Medicine Lake (McLaren)

#2 Jacques Pass (I. O. L.)
26-46-28-W. 5M

#3 Mt. Strange (I. O. L.)
10-49-4-W. 6M

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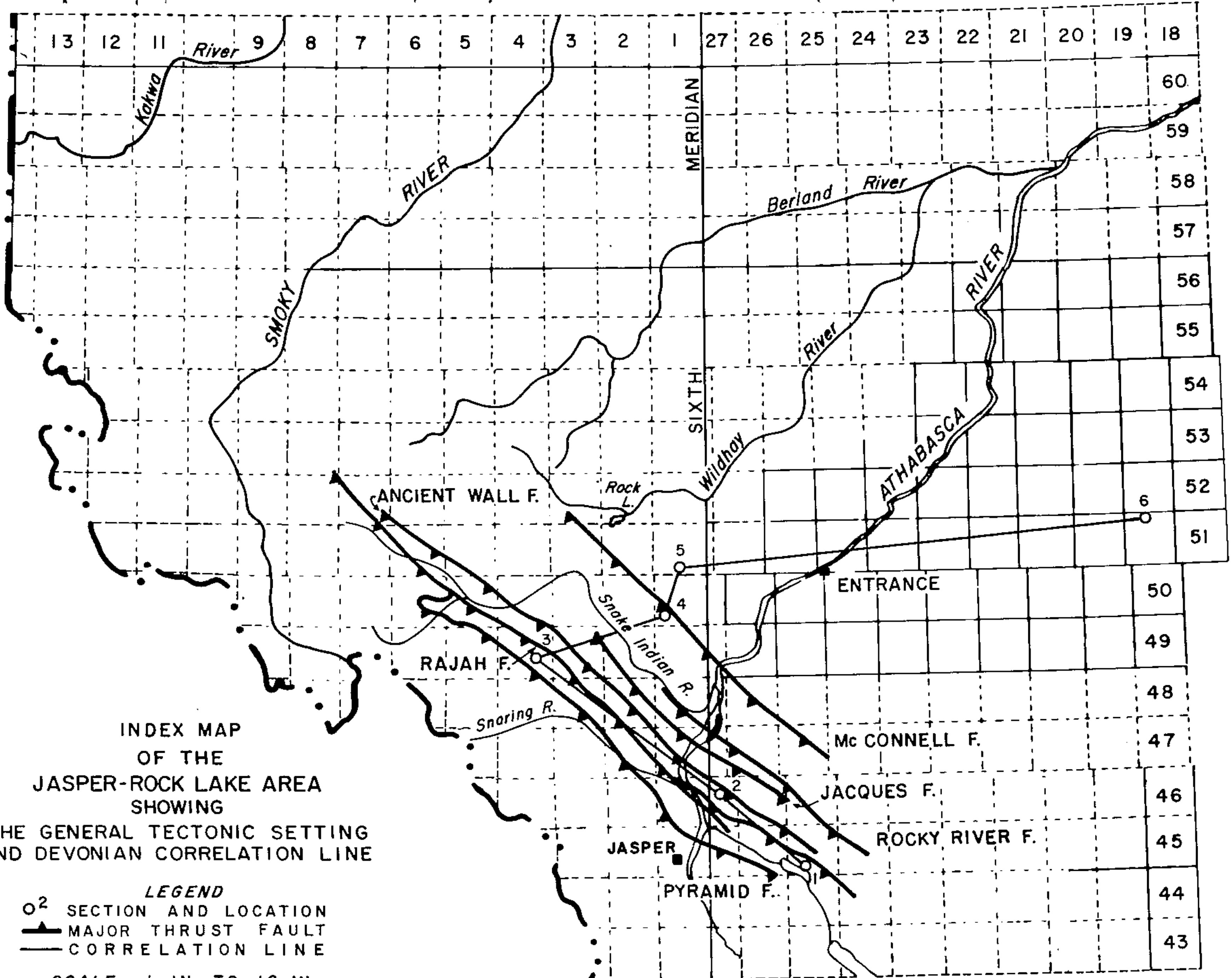


INDEX MAP
OF THE
JASPER-ROCK LAKE AREA
SHOWING
THE GENERAL TECTONIC SETTING
AND DEVONIAN CORRELATION LINE

LEGEND
O² SECTION AND LOCATION
MAJOR THRUST FAULT
CORRELATION LINE

SCALE · 1 IN TO 16 MI

R.D. ORR JUNE 1960

FIG. 1

Section #4 Moosehorn Creek (I. O. L.)
17-50-1-W. 6M

#5 Mt. Kephala (I. O. L.)
3-51-1-W. 6M

#6 H.B. Richfield Oil Corp. Edson #1
10-33-51-19-W. 5M

This detailed lithological correlation (Fig. 2) traverses the basin from west to east. The apparent anomalous thickness of the Alexo in the Mount Strange section (3) becomes more compatible when one realizes that it is situated on a fault block which is tectonically equivalent to that of the Medicine Lake section (1) while the Jacques Pass section (2) belongs to the more easterly (lower) Ancient Wall thrust element (Fig. 1). The Medicine Lake section is well within the basinal province while the Mount Strange section is on the southern extremity of the Ancient Wall reef. The Mount Strange section is, in fact, a partial reef section with a well-developed Cairn and a very abbreviated Southesk, overlain by the clastic Mount Hawk facies and the Alexo. Mount Strange itself, a short distance to the south of where Section 3 was measured, is completely off-reef.

On the eastern side of the basin, between Mount Kephala and the Hudson's Bay Richfield Edson #1 well, the Windfall reef forms an eastern limit to the basin. Correlation across the reef into the Edson #1 well is relatively good, as far as gross lithologies are concerned. Its proximity to the Windfall reef undoubtedly influences the carbonate content of the Perdrix interval.

SEDIMENTARY UNITS OF THE BASIN

Flume:

The Flume is a very widespread unit of a varying biostromal character, which appears to thicken towards the carbonate buildups and is correlated with the cherty lower member of the Cairn in reefal areas. Under favorable conditions, Fairholme reef grew upon this Flume platform facies. In the Jasper area, the Ancient Wall, Windfall and Miette reefs are developed. The Miette reef outcrops for a distance of eight miles along the Miette Range, immediately south of Miette Hot Springs, while the Ancient Wall Reef is involved in the Front Range Structures from Mount Strange to the Berland River headwaters north of Eagle's Nest Pass. The Windfall reef on the eastern edge of the basin is known from subsurface information alone.

Perdrix:

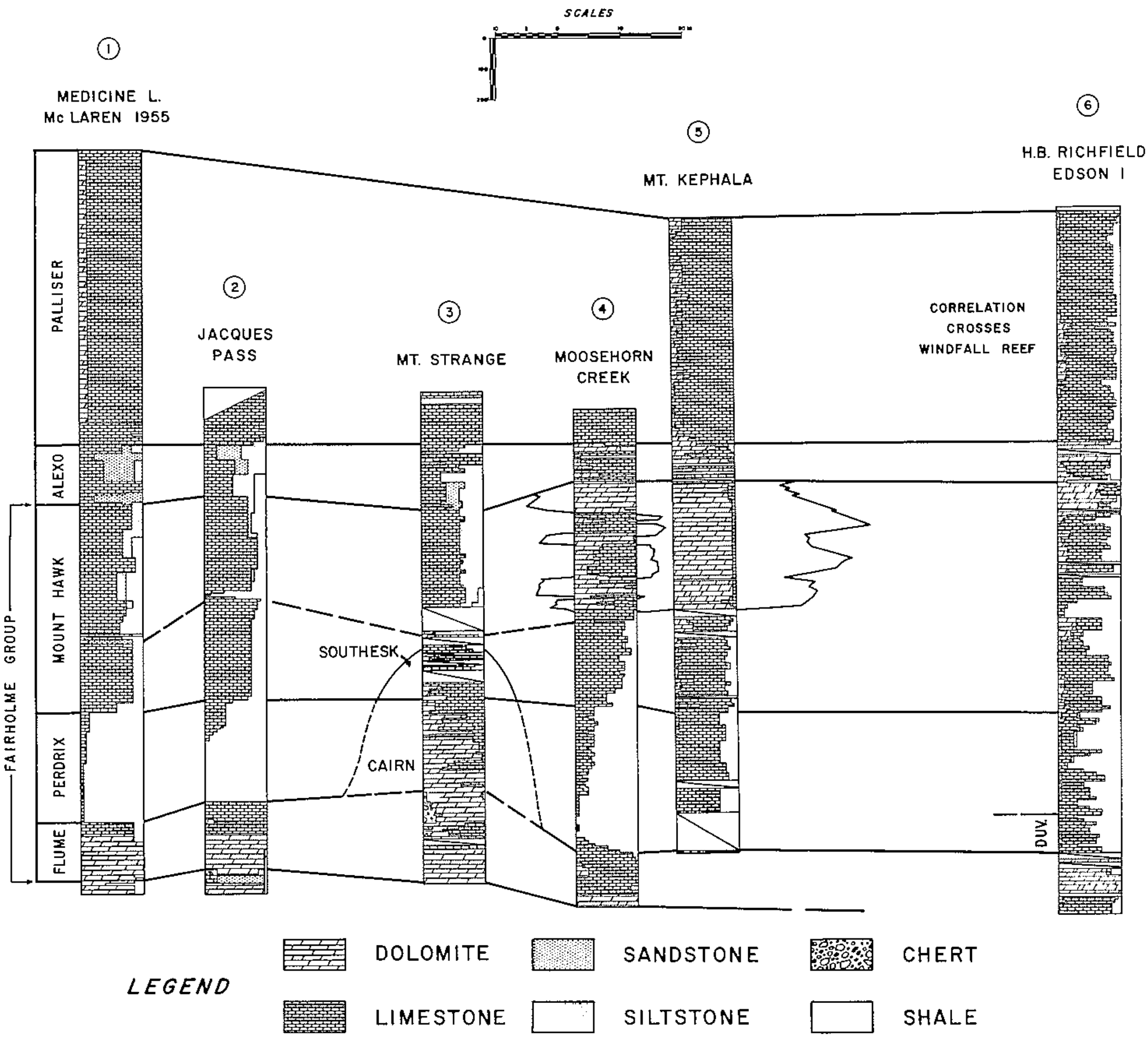
The Perdrix black, pyritic shale facies is present throughout the basin. Regionally, it is of relatively uniform thickness and lithology (Fig. 2). In individual outcrop sections, it is often difficult to pick a definite Perdrix - Mount Hawk contact, as the changes from black to grey and from fissile shale to mudstone are very subtle ones. Regionally, there is a noticeable carbonate increase from the Perdrix

FIG. 2

DEVONIAN CORRELATION

IN THE JASPER AREA

BY · R. D. ORR JUNE 1960



to the Mount Hawk. This composition change becomes less distinctive towards reef, as the Perdrix shales grade into argillaceous limestones.

Mount Hawk:

The Mount Hawk and Alexo units are the most controversial as well as the most informative Devonian strata of the Jasper area. Figures 2 and 3 illustrate the conditions that existed in the basin during those times. The relatively higher clastic composition in the western sections definitely points to a western source of sediments during Upper Mount Hawk and Alexo time. The more normal argillaceous limestone and calcareous shale facies is replaced within the upper part of the Mount Hawk interval by the more clastic "Alexo type" facies in these western sections. This clastic phase was initiated with a sand-silt tongue which "shales out" eastward, i.e. Moosehorn Creek section of Fig. 2.

This high clastic facies is replaced eastward by a comparatively clean carbonate facies. The partly dolomitized Moosehorn Creek and completely dolomitized Mount Kephala sections were deposited under high energy conditions away from the more strongly basinal western area. Any correlation of this facies with the Nisku of the Southern Rockies and Plains areas is questionable since we are dealing with a distinctly different depositional province.

Taylor's contention that the Alexo-Mount Hawk boundary is diachronous in the Jasper area is obviously true if one places this contact where McLaren and Taylor do. The commencement of Alexo-type deposition in Upper Mount Hawk time, we feel, presents the most logical explanation of the anomalously thick (six hundred foot) Alexo section described by McLaren at Medicine Lake. The often mentioned faunal deletion at the silty horizons (Alexo) actually occurred earlier in this area due to the clastic influx from a western source. Although we do not advocate a western source for all the silts deposited prior to Palliser time; there is sufficient evidence in the Jasper area to indicate that a source was functional from that direction.

Alexo:

The thick Alexo section at Medicine Lake (Described by McLaren) includes all of our clastic upper Mount Hawk sequence except the basal sandstone and siltstone tongue. Correlation of this tongue into the Moosehorn Creek section indicates that the overlying clastic sequence at Medicine Lake and Jacques Pass is correlatable to beds of a definite Mount Hawk lithofacies. Our correlation of the upper silts and sands in the western sections with the Alexo of our eastern sections is believed to be a much better time-rock correlation. Similar observations were made by Mountjoy in his detailed correlation along the Miette Range. He correlates 120' of strata included in the Alexo at Roche Miette (type section of the Mount Hawk) by McLaren to beds containing a definite Mount Hawk fauna at the headwaters of the Fiddle River some eighteen miles to the south along strike.

The Alexo of the Jasper area becomes a less distinct lithological break in a northerly direction. In the Winnifred Pass area and at the headwaters of the

Berland River, silt is a very minor constituent of the Alexo interval. This may well be the factor which allows the faunal assemblage normally suppressed at the base of the Alexo to range higher, as McLaren indicates it does at Winnifred Pass.

Palliser:

By the end of Alexo time basin fill must have progressed to the point where relatively little relief existed between the reef and off-reef areas. On this surface the remarkably uniform Palliser carbonate bank deposits were formed. The Palliser thickens from about 700 feet in the eastern front ranges of the Jasper area to over 900 feet in the west.

SUMMARY

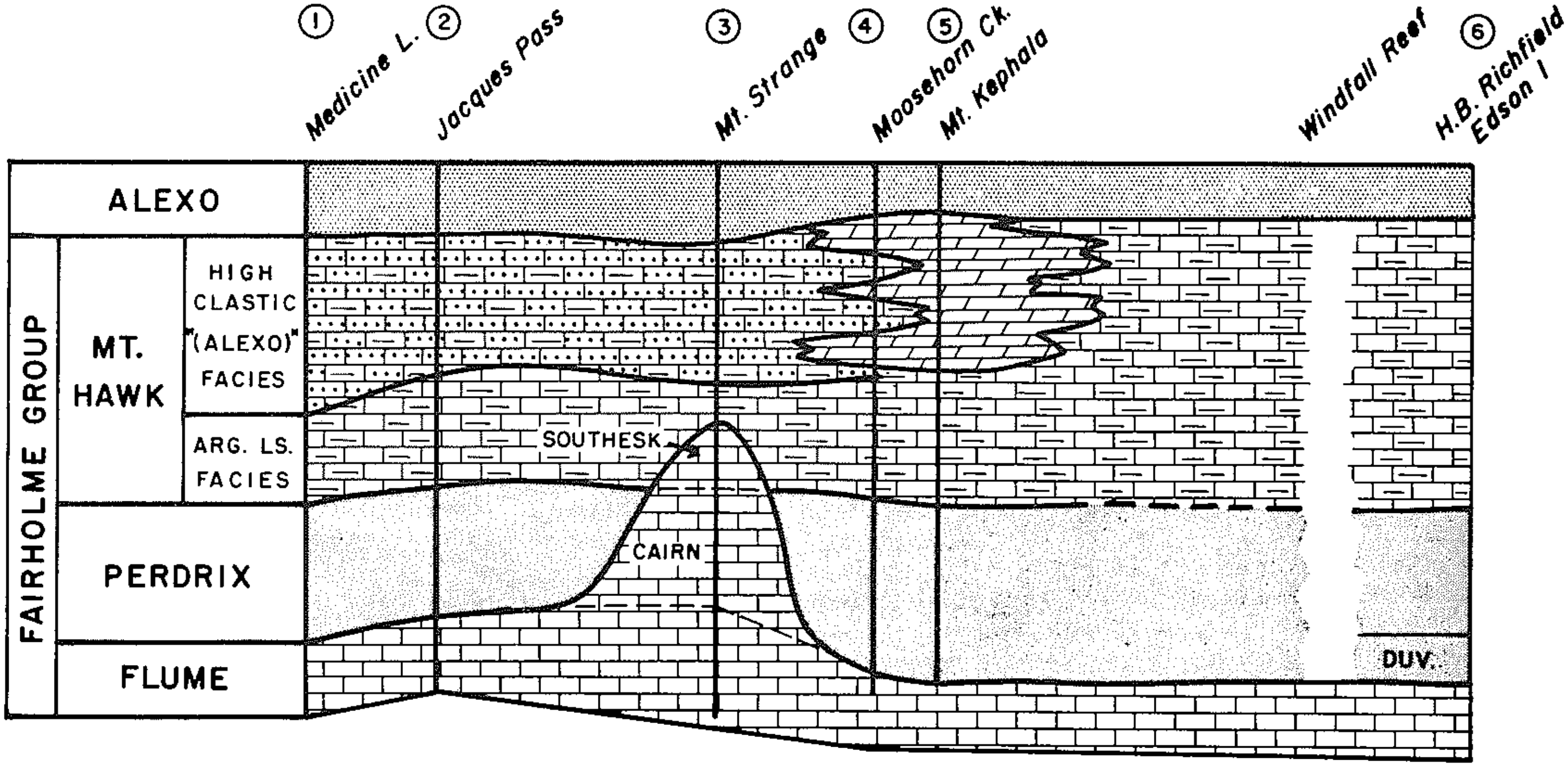
The Devonian of the Jasper area consists of strata deposited on Cambrian sediments in the east and Ordovician in the west and overlain by the Exshaw and Banff shales of Mississippian age. An extensive carbonate bank deposit, the Palliser, overlies the Alexo formation and the Fairholme group.

A western source contributed clastics to the Jasper Basin in upper Fairholme and Alexo times. The upper Mount Hawk of the western sections is in a clastic "Alexo" facies while to the east it inter-tongues with a belt of high energy limestone deposits which are partly to completely dolomitized.

Carbonate devlopments within the Fairholme group consist of the Ancient Wall, Miette and the Windfall reefs. The latter forms an eastern limit to the Jasper basinal area.

DIAGRAM ILLUSTRATING

THE FACIES WITHIN THE FAIRHOLME



- grey brown, silty, argillaceous limestones, siltstones and occasional sandstones in the west.
- grey brown to dark grey, very fine to fine crystalline dolomite with minor relict coraline material.
- grey to grey brown, argillaceous limestone, mudstone and calcareous shale.
- dark grey to black, fissile, shales and argillaceous limestone.
- dark grey to black, cherty, biostromal dolomites with an upper argillaceous limestone member (Maligne formation of Taylor) plus Cairn and Southesk in reef area.

NOTE· *SECTIONS ARE BUNCHED TOGETHER DUE TO FAULTING.*

FIG. 3

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THE TRIASSIC OF THE ROCK LAKE AREA *

E. M. Manko

June 27, 1960

ABSTRACT

The Triassic of the Rock Lake area is divided into the Whitehorse formation and the Sulphur Mountain formation. The Whitehorse is subdivided into a lower Evaporitic member, which includes the Evaporitic facies and part or all of the Dolomite-sandstone facies established by E. W. Best in the North-Saskatchewan-Athabasca Rivers area to the south and an overlying Carbonate member. A new unit, the Red Bed member, is introduced in the upper Whitehorse of the Front Ranges. The Sulphur Mountain formation is subdivided into four distinct correlatable units:- the Lower Black Siltstone unit, the Blocky Brown Siltstone unit, the Black Shale unit, and the Upper Siltstone unit, which are traceable into the Peace River region to the north and into the Cadomin area to the southeast. The Beyrichites-Gymnotoceras fault and the Phosphate zone are cited as markers for correlation into the Peace River subsurface. A stratigraphic correlation chart is presented illustrating the lithology, thickness and stratigraphic relationships of the Whitehorse and Sulphur Mountain formations and their members from the foothills edge across strike to immediately below the main ranges, the western limits of Triassic exposure. The thickening of the Sulphur Mountain formation (520' to 1100') and the Whitehorse formation (91' to 1452') in a westerly direction is considerable. A major unconformity truncates older members of the Whitehorse formation progressively eastward.

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THE TRIASSIC OF THE ROCK LAKE AREA *

E. M. Manko

June 27, 1960

INTRODUCTION

One important feature of the 1960 E.G.S. Field Trip in the Rock Lake area is the opportunity it affords participants of viewing a complete section of the Triassic. The Wildhay River section is one of the few readily accessible sections within the limits of the exposed Triassic of the Rocky Mountains.

This paper is based primarily on field work conducted in the area by Imperial Oil Limited. Some well information is included.

In the area of study, Triassic exposure is generally good. Triassic rocks occur as narrow belts in the Front Ranges and Inner Foothills. A correlation section is presented illustrating sections extending from the Snake Indian fault, the western limit of the Triassic exposure, to Collie Creek, the easternmost exposed Triassic. An attempt has been made to correlate surface information with the Triad Wildhay #9-35 well immediately the east (Fig. 2).

Throughout the area, the Triassic is easily recognized in outcrop by the distinctive rusty-brown, flaggy weathering of the Sulphur Mountain formation and the white weathering overlying Whitehorse formation. With increased thickening of the Whitehorse formation westward, yellows, buffs, maroons, greys and reds become notably diagnostic. The distinctiveness of the Triassic makes it a valuable aid in reconnaissance mapping and structural interpretation.

HISTORICAL REVIEW

In 1887, McConnell, working in the Bow Valley area, included the Triassic and the Rocky Mountain formation in the Carboniferous and called the entire sequence of strata the Upper Banff shales. Dowling, in 1907, established the Rocky Mountain formation, and tentatively placed the remainder of the Upper Banff shale section in the Permo-Triassic. Shimer, in 1911, indicated from fossil evidence that the Upper Banff shale was Permian in age with Pennyslvanian affinities. From fossils collected by E. M. Kindle, L.D. Burling and H. W. Shimer; Girty (in an article by Lambe (1916)), assigned a Triassic age to the Upper Banff shale. In 1924 Kindle established the Triassic as the sequence of strata underlain by the Rocky Mountain quartzite (Pennsylvanian) and overlain by the Fernie formation. He applied the term "Spray River formation" to these rocks and designated the type section as the Spray River Gorge section, located at the south end of Sulphur Mountain.

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P. S. Warren, in his paper on the Triassic faunas (1945), divided the Spray River formation into the Lower Triassic Sulphur Mountain member and the Middle Triassic Whitehorse member. No lithologic descriptions of these two members were given. The Spray River Gorge section was designated as the type section of the Sulphur Mountain, and his original thickness of 3,400' (1927) was amended to 1,853'. A type section was not given for the Whitehorse member.

E. W. Best, in a paper on the Triassic of the North Saskatchewan-Athabasca Rivers area (A.S.P.G. Guidebook - 1958) described a section at the junction of Whitehorse and Drummond Creeks south of Cadomin, Alberta, as the type for the Whitehorse member.

To date, no regional studies of the Triassic in the Rock Lake area have been published. The Geological Survey of Canada reports briefly describe the Triassic of the Foothills. Allan (1934) described the Triassic gypsum deposits at Mowich Creek. McLearn (1953) discussed the regional correlations of the Triassic of Canada. Parejas and Collet (1931) published a paper on the Triassic of Jasper National Park.

E. W. Mountjoy, in his doctorate thesis of the Miette area, proposed the elevation of the Whitehorse and Sulphur Mountain members of Warren to formation status. His nomenclature is followed in this paper. The Sulphur Mountain formation comprises the lower unit consisting predominantly of siltstones, sandstones, sandstones and minor shales; the Whitehorse formation constitutes the overlying, dominantly white, buff, grey and red evaporite-carbonate group of strata. Informal lithologic subdivisions are applied to both formations.

SULPHUR MOUNTAIN FORMATION

The Sulphur Mountain formation in the Rock Lake area, characterized by a buff, brown, black and sometimes purplish sequence of strata, is divisible into four distinct lithologic units. These units are, in ascending order, the Lower Black Siltstone member, Blocky Brown Siltstone member, Black Shale member and the Upper Siltstone member. All of these members present in the Wildhay River section and their salient features will be self-evident (See Fig. 2 and Appendix).

LOWER BLACK SILTSTONE MEMBER

This unit, ranging from about 200' on the eastern edge of the Foothills to 400' near the Snake Indian Fault, assumes generally homogeneous low weathering characteristics, black to dark grey in the Front Ranges, becoming increasingly brown in weathering color at the Foothills edge.

Lithologically the unit consists dominantly of dark grey, brownish-grey and blue-grey, argillaceous, micromicaceous, slightly calcareous or dolomitic, pyritic, finely laminated to varved and cross-laminated, evenly thin-bedded siltstone. Black carbonaceous material is present, accentuating the banding. Thin shale beds are common throughout the unit, and generally, the siltstones grade to shales in the lower 50' to 100'. Thin beds, from 1" to 1' thick, of brown, very fine-grained sandstone are scattered randomly throughout the unit.

In the Front Ranges westward to the Snake Indian Fault, the section consists entirely of this homogeneous, monotonous sequence of silts and minor shales. In the Outer Foothills the unit is somewhat more diversified, becoming coarser grained, with local fine-grained sand developments from 5' to 20' thick in the lower half of the unit. In one or two localities sand flow rolls occur at the basal contact with the Mississippian (e.g., Seep Creek Headwaters).

Where the Sulphur Mountain on-laps the Mississippian, a rusty weathering, rubbly, chert, dolomite and quartzite pebble conglomerate bed is present, ranging from 4" to 1' in thickness.

The Lower Black Siltstone unit is relatively barren of fossils. Poorly preserved ammonites of the Flemingites sp., pelecypods of the Claria sp., and rare ganoid fishes have been observed in this unit. Fossil content increases progressively westward.

BLOCKY BROWN SILTSTONE MEMBER

The Blocky Brown Siltstone member, uniformly 200' in thickness over its areal development, comprises a sequence of brown weathering, resistant, blocky beds, ranging from several inches to 10', of brownish-grey and grey, coarse, argillaceous, pyritic, well-indurated siltstones or very fine-grained sandstones, alternately interbedded with dark grey and brownish-grey, very thin-bedded siltstones, lithologically similar to the underlying Lower Black Siltsone member. Thin shale interbeds are common, particularly in the basal one-third of the unit.

The dolomite content in the blocky silt beds increases progressively upward and also increases progressively southward, grading to a silty dolomite in the upper 40' of the Wildhay River section.

Flow rolls and ripple marks are common throughout the Blocky Brown Siltsone unit, with their maximum development in the upper 50' to 100'. Some excellent examples of these flow rolls will be seen in the Wildhay River section (See Photo 1).

Except for Flemingites-type ammonites and Claria-type pelecypods, similar to those in the Lower Black Siltstone member, the Blocky Brown Siltstone member is generally unfossiliferous.

BLACK SHALE MEMBER

The Black Shale unit islow weathering and often partially to totally covered. Immediately to the east of the Snake Indian fault it is in excess of 100' in thickness, thinning gradually to 20' at the Foothills edge, and probably pinches out immediately eastward into the Plains. It can be traced laterally northwestward into

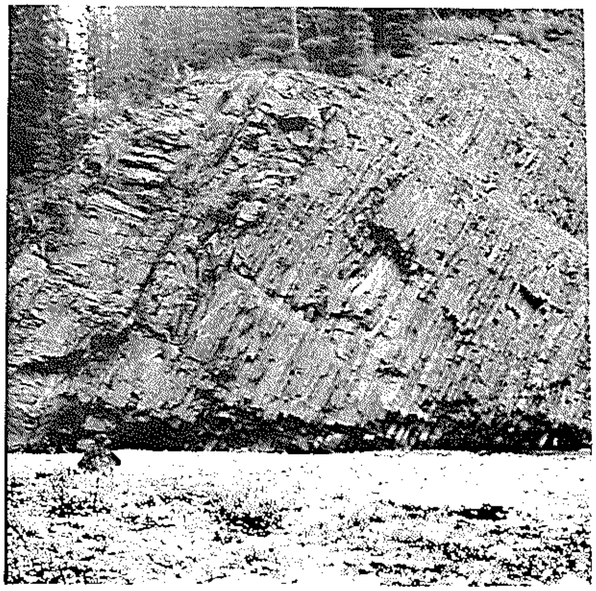

Photo 1. Wild Hay River
Subaquatic flow rolls and typical bedding of Blocky Brown Siltstone Unit of Sulphur Mountain formation.

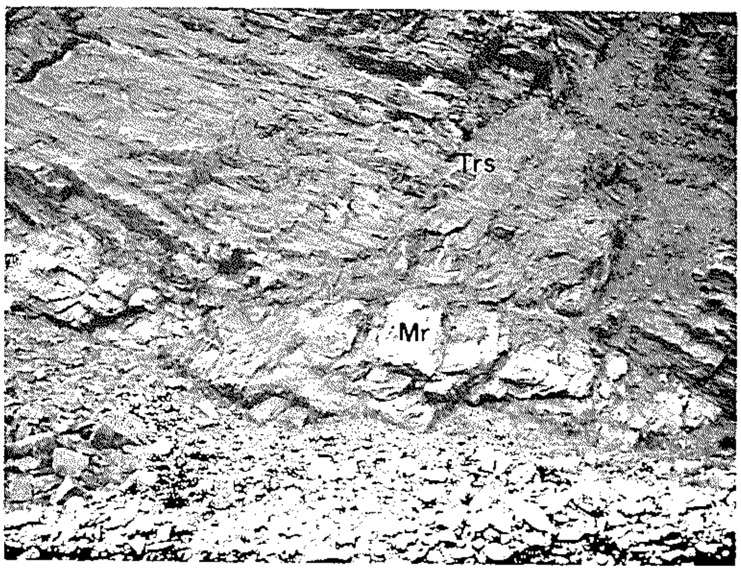

Photo 2. Wild Hay River
Contact between Mississippian (Rundle) and Lower Black Siltstone Unit of the Sulphur Mountain formation.

See hammer at contact.

the Peace River region. Its development southward is not known. Dark grey to black weathering, black, silty, phosphatic, clayey, carbonaceous shales are characteristic of this unit. Interbeds of siltstone are common. Of particular significance in this unit, in the upper 5' to 15', is the occurrence of a prolific Beyrichites-Gymnotoceras fauna, ammonites and brachiopods, usually in two or three nodular beds of limestone. In this same horizon nodules of phosphate occur, and persist into the overlying unit. The Beyrichites fauna and the phosphate should afford excellent correlation markers into the Peace River region, particularly into the Peace River sub-surface.

UPPER SILTSTONE MEMBER

The Upper Siltstone member constitutes a sequence of brown, buff and reddish weathering, relatively resistant, massive-bedded strata, ranging from about 400' in thickness adjacent to the Snake Indian fault to 100' at the foothills edge to the east.

Brown, buff and brown-grey siltstones or very fine-grained sandstones comprise the bulk of the unit. The silts or sands are argillaceous at the base, becoming increasingly more dolomitic or calcareous towards the top. Thin dolomite and limestone beds are locally present in the upper half of the unit. Thin coquina beds are common in the eastern outcrops. Minor shale beds have been observed near the top of the unit in the Mowich Creek section. Locally, thin dolomite breccias occur also. Phosphate nodules and chips are common throughout this unit. They occur in greatest concentration at the base of the unit where some of the nodules are in excess of 1" in diameter.

This unit, like the remainder of the Sulphur Mountain formation, is generally devoid of fossils. Buchia sp., Coenothyris sp., Gervillia sp., Lima sp., and Thracia sp. have been collected which have been dated from Middle or Early to Late Upper Triassic.

WHITEHORSE FORMATION

The Whitehorse formation comprises that group of strata bounded by the Sulphur Mountain formation below and by the Jurassic-Nordegg member of the Fernie group above. It constitutes a unique and complex sequence of rocks, increasingly variable progressively westward. The published literature to date and the type section established is not truly representative of the formation.

In the Rock Lake area, the Whitehorse formation outcrops in readily recognizable narrow belts, white to light grey, buff and cream, relatively resistant weathering in the outer foothills, becoming more polychromous-rusty, grey, yellow and red to the west.

The Whitehorse formation is divisible into three distinct gross, lithologic units, which in ascending order, are the lower Evaporitic member, the Carbonate member and the Red Bed member. In this paper, the Evaporitic member includes the entire evaporite facies established by Best south of the Athabasca River and part or all of his Dolomite-Sandstone facies. (See Fig. 2). The Evaporitic member constitutes the entire Whitehorse formation from the outer foothills to just east of the Wildhay River section. Progressively westward it thickens very rapidly and forms the bulk of the formation at the Snake Indian fault.

The Carbonate member wedges out immediately to the east of the Wildhay River section. It too thickens westward and attains its maximum development in the Mowich Creek-Monoghan Creek area. The Red Bed member is restricted to a very narrow wedge extending from the Snake Indian fault on the west to just east of the Ancient Wall. It can be traced northward along structural strike to the Smoky River.

EVAPORITIC MEMBER

This member ranges in thickness from 91' at Triad Wildhay #9-35 where it forms the entire Whitehorse formation, to in excess of 900' below the Snake Indian fault where it forms the bulk of the formation. It consists of a heterogeneous mixture of sediments showing pronounced facies changes from east to west, with considerable interfingering and wedging out.

In the Inner Foothills (on the Nelson and Hoff blocks), extending east to the Triad Wildhay #9-35 well, the dominant lithologic types of the Evaporitic member are white, grey, cream and buff weathering, resistant, crypto to microcrystalline, silty or sandy, well-bedded, laminated, chalky dolomites with some purer beds containing low concentrations of skeletal and leached skeletal (pelecypods, gastropods, bryozoa and crinoid fragments), and locally of pelletoidal carbonate textures. Pyrite is common, often weathered to limonite. Thin interbeds of siltstone and sandstone are present, and the sand also occurs as floating, rounded, frosted grains, as lenses, and as cross-beds. Minor chert and iron carbonate pebbles have been observed. Fossils are generally rare, and where they have been found, are undiagnostic and poorly preserved. Throughout these dolomites, thin breccia beds are developed. Because of this occurrence, coupled with the primary character of the dolomites, these dolomites have been included in the Evaporitic member.

Beginning immediately to the west of Collie Creek, the Evaporitic member assumes a distinct, recessive weathering basal zone consisting of interbedded buff, cream and grey, cryptograined limestones, chalky argillaceous limestones, and buff and reddish weathering, dolomitic and calcareous siltstones and sandstones. Especially characteristic of this zone are the rusty weathering, rubbly, massive collapse breccias. This zone thickens very rapidly, the overlying dolomites disappear, grading laterally into siltstones and sandstones, until at the western extremities of Whitehorse development the Evaporitic member is comprised totally of this heterogeneous low weathering complex.

The Evaporitic member thickens very rapidly in a westerly direction as mentioned previously. Accompanying the thickening is an increase in sand and argillaceous content. The most significant feature is the marked increase in magnitude and quantity of the collapse breccias. In the Mowich Creek, Blue Creek areas (as indicated in Fig. 2), the breccias can attain thicknesses in excess of 100'. These breccias are extremely variable, consisting of fragments ranging from 1/4" to blocks up to several feet in diameter, of vari-colored dolomites, dolomitic siltstone and sandstones, chalky and crypto to micrograined limestones, and minor shales, predominantly recrystallized calcite-cemented, with a matrix of clear and frosted, unsorted, rounded quartz sand grains in varying concentrations. These breccias are usually massive, unbedded, with strong clear and white secondary calcite veining.

The breccias are the result of collapse due to solution and removal of gypsum and anhydrite. They serve as a fairly reliable indicator of the extent of the original evaporite development within the Whitehorse formation, although the amount of thinning of the sedimentary sequence resulting from this removal is difficult to ascertain. To date the genesis of the breccias has not been published in the literature. A treatise on the Alpine Triassic of Europe, by W. Bruckner is cited here as a logical and comprehensive explanation of the Whitehorse breccias which bear strong similarities to those in the Alps and Jura.

A detailed account of the origin of the breccias cannot be undertaken in this paper. It will only be stated that the "Rauhwacken" and "cargneule" - type breccias and "primary breccias" are found in our Triassic. The "Rauhwacken" and "cargneule" (cellular dolomite) type predominate in the eastern foothills, while the primary breccias are more prevalent in the western areas. The "Rauhwacken" and "cellular dolomites" consist usually of fragments of powdery dolomite or siltstones or sandstones in a sandy, calcite-cemented matrix, whereas the primary breccias can contain a heterogeneous mixture of rock types and are generally much coarser and thicker.

The original sediments must have consisted primarily of dolomite, some sandstone, siltstones and limestones, with intercalation of anhydrite and/or gypsum. Water circulation at low temperatures caused solution of the $CaSO_4$. The SO_4 was removed while the Ca recrystallized into $CaCO_3$, incorporating the sand and silt grains so common in the matrix. The formation of "cargneules" and cellular dolomites is a recent weathering phenomenon associated with circulating ground waters from the surface down to 2000', rarely deeper. The "primary breccias" are genetically related but occur in marine environments, contemporaneous with, or shortly after deposition. The removal of evaporites resulted in collapse of dolomites and limestones into massive chaotic masses.

The breccias are not easily correlatable partly because of insufficient exposure and perhaps more-so because of the irregular pan-like deposition of the evaporites.

Bands of carbonates occur throughout the Evaporitic member. Some of the limestones and dolomites attain thicknesses in excess of 50'. It is interesting to note that in these carbonates some skeletal material is usually present, but conditions were not conducive for a sufficient length of time for good organic growth. The cleanest limestone development, rich in crinoids, pelecypods, gastropods, bryozoa and algae, occurs near the top of the Evaporitic member. It reaches its maximum development of some 200' in the Blue Creek area, wedging out rapidly eastward. It is correlatable along strike beyond the Smoky River.

Gypsum deposits have been previously described in the Mowich Creek area (Allan, 1934). Two gypsum pans have been examined in the Mowich Creek section (See Fig. 2), 400' from the base of the Whitehorse. These pans are about 10' to 15' thick and about 150' in length, of relatively clean, crystalline, cross-laminated gypsum. A larger deposit immediately to the north was seen from a distance, in the same stratigraphic horizon. Some gypsum outcrops also south of the Snake Indian Valley, east of Mount Sassenach, on strike with the afore-mentioned occurrences. These gypsum deposits are quite extensive and form notable karst and kettle-hole type topography in the Snake Indian Valley (W. H. Ziegler, personal communication).

Fossils are generally lacking in the Evaporitic member. Undiagnostic Lingula sp. have been seen at the base of the unit and Pleuromya sp. and Corbula sp. were observed in beds somewhat higher.

CARBONATE MEMBER

The Carbonate member forms a sequence of relatively resistant, grey to dark grey weathering, banded, well-bedded strata overlying, in gradational contact, the Evaporitic member. It's eastern erosional edge occurs in the Nelson and Hoff blocks, and from there west to the Mowich-Monoghan blocks it forms the top of the Whitehorse formation, disconformably overlain by the Nordegg member of the Fernie group. West to the Snake Indian fault it is overlain by the Red Bed member.

The unit thickens quite rapidly from its erosional edge to about 200' to 300' at its maximum development, and thicknesses of this magnitude persist beyond the Smoky River to the northwest. The dominant lithologic types include medium to dark grey, micro to fine crystalline, argillaceous and silty dolomites, micrograined limestones and some siltstones and sandstones. Skeletal material (crinoids, gastropods, bryozoa and pelecypods) is present. Pyrite is abundant. Chert lenses and nodules are common, particularly in the basal third of the unit, and silicification is a characteristic feature of these sediments. Few fossils have been observed in this unit.

RED BED MEMBER

As mentioned previously, the Red Bed member is confined to a narrow wedge adjacent to the Snake Indian fault, extending eastward to the Mowich-Monoghan blocks and as far north as the Smoky River. It is a recessive weathering unit distinct by its reddish-buff coloration. It consists of a hetergeneous intercalation of dolomitic siltstone and sandstone, some crypto to microcrystalline, silty and argillaceous dolomites, silty, micrograined and somewhat chalky limestones, occasional mudstones, and thin dolomite breccia interbeds.

STRATIGRAPHIC RELATIONSHIPS

The Triassic rests disconformably on the Rocky Mountain formation to just west of the Hoff Block where the Rocky Mountain wedges out and the Triassic then overlaps the Rundle group. In the Outer Foothills, beyond the erosional edge of the Rocky Mountain, a thin conglomerate separates the Sulphur Mountain formation from the Rundle (See Photo 2). To the west, a conglomerate may or may not be present. At Blue Creek, the contact of the Sulphur Mountain with the Rocky Mountain is gradational. In all the contacts observed, no discordance of beds was evident.

The Whitehorse formation is disconformably overlain by the Jurassic-Nordegg member of the Fernie group. In the more westerly sections the base of the Nordegg usually consists of a fossiliferous, chert pebble-sandstone ranging in thickness from 1' to several feet. In the eastern sections, as will be observed at the Wildhay River section, the uppermost beds of the Whitehorse formation contain chert pebbles. From west to east, the Nordegg overlaps the Red Bed member, the Carbonate member then the Evaporitic member. Here again, discordance of the Nordegg and Whitehorse beds is not evident. A hiatus of considerable magnitude exists because the oldest Fernie is Sinemurian and the youngest Triassic, at least in the eastern area, is probably Middle Triassic.

The Whitehorse-Sulphur Mountain contact is conformable and transitional. At Collie Creek, pebbly sandstone beds at the base of the dolomites may indicate a diastem. To the west evidence of disconformable relationships is non-existent.

The various units of the Sulphur Mountain formation are gradational with each other, but are quite distinct. The phosphate occurring at the top of the Black Shale Unit and persisting into the overlying Upper Siltstone Unit may indicate a slight hiatus in deposition.

The units of the Whitehorse formation are also gradational with each other.

DISTRIBUTION AND THICKNESS

Both the Sulphur Mountain and Whitehorse formations extend from the Snake Indian fault eastward into the Plains, extending progressively farther into the Plains northward. To the south, the Whitehorse is entirely confined to the Rockies and Lower Foothills as is the Sulphur Mountain south of Edson (Best, 1958). The eastern limits of both formations are erosionally controlled, and the Whitehorse probably disappears in the subcrop a short distance to the east of the Triad Wildhay #9-35 well.

The Sulphur Mountain formation ranges from 463' at Triad Wildhay #9-35 to 1200' at the Snake Indian fault. Thicknesses of this magnitude persist along structural strike to the north. All units exhibit some sedimentary thinning from west to east, with the most pronounced thinning occurring in the Upper Siltstone member.

The thickening to the west is probably the result of more rapid sedimentation and addition of section, particularly in the Upper Siltstone member, the Black Shale member and the Lower Black Siltstone member.

The Whitehorse formation thickens extremely rapidly, from 91' at Triad Wildhay #9-35 to 1452' at Blue Creek, adjacent to the Snake Indian fault. The marked thickening is due to addition of sediments in all units, particularly the Evaporitic member, and the devlopment of the Red Bed member. Eastward thinning is largely the result of erosional bevelling at the top of the formation.

The marked thickening westward is accentuated by structural foreshortening. It should be borne in mind, however, that the original sedimentary thickness of the Whitehorse, especially the Evaporitic member, was considerably greater prior to removal of the evaporites. The amount of thinning due to leaching of evaporites is impossible to ascertain.

PALEONTOLOGY AND AGE

As in the Triassic to the south and north, fossils in the Triassic of the Rock Lake area are rare and poorly preserved.

Fossils have been collected from all units of the Sulphur Mountain formation. Claria sp. and Flemingites type fauna have been obtained from the Lower Black Siltsone member and Blocky Brown Siltstone member which are of lower Triassic (Scythian) age. The Beyrichites-Gymnotoceras fauna present at the top of the Black Shale member, coincidental with the Phosphate zone, have been assigned to the (Upper Anisian) Middle Triassic. Coenothyris sp., Gervillia sp., Lima sp., and Thracia sp., obtained from the Upper Siltstone member were dated as Middle or Early Upper Triassic. The sediments of the upper portion of the Upper Siltstone Unit are considered to be Ladinian in age.

Except for Pleuromya sp., Corbula sp., and Lingula sp., near the base of the Evaporitic member, no diagnostic fossils have been found in the Whitehorse of the Rock Lake area. Irish (1954) reports Upper Triassic (Karnian) fossils from near the top of the Triassic, his unit (A) which is lithologically similar to the Whitehorse, and Middle Triassic Anisian fossils from his unit (B) which seems to correspond to the Sulphur Mountain in part. It is felt that the Carbonate member and possibly the very upper part of the Evaporitic member may be Karnian in age. Parejas (1931) reported Monotis cf. M. subcircularis Gabb, the index fossil for the Upper Triassic Pardonet beds, from Triassic at Vine Creek. This fossil was never illustrated and is believed to be a misidentified Jurassic pelecypod by most workers on the Triassic. Though evidence for Upper Triassic (Norian) in this area is inconclusive, the possibility should not be discarded. The Red Bed member, not recognized to the south of the Rock Lake area, consists of definitely younger Whitehorse sediments which may be Norian in age, at least in part.

ECONOMIC IMPORTANCE

The New Superior et al Solomon Creek well (Lsd. 6, Sec. 17, Twp. 51, Rge. 27, W. 5th), obtained a small quantity of salt water from the Whitehorse. The Triad Wildhay well (Lsd. 9, Sec. 35, Twp. 52, Rge. 2, W. 6), yielded gas estimated at 10,000 cubic feet per day. A small amount of gas was also obtained from the N.F.A. Muskeg #1 well (Lsd. 15, Sec. 13, Twp. 57, Rge. 6, W. 6th) from the same zone. The Middle Dolomite unit of the Sulphur Mountain from which B.S. Triad et al Mountain Park (Lsd. 5, Sec. 36, Twp. 47, Rge. 22, W. 5) produced gas at an open flow of thirteen million cubic feet per day, is not developed in the Rock Lake area.

The gypsum deposits in the Snake Indian-Mowich Creek valleys are not economically workable.

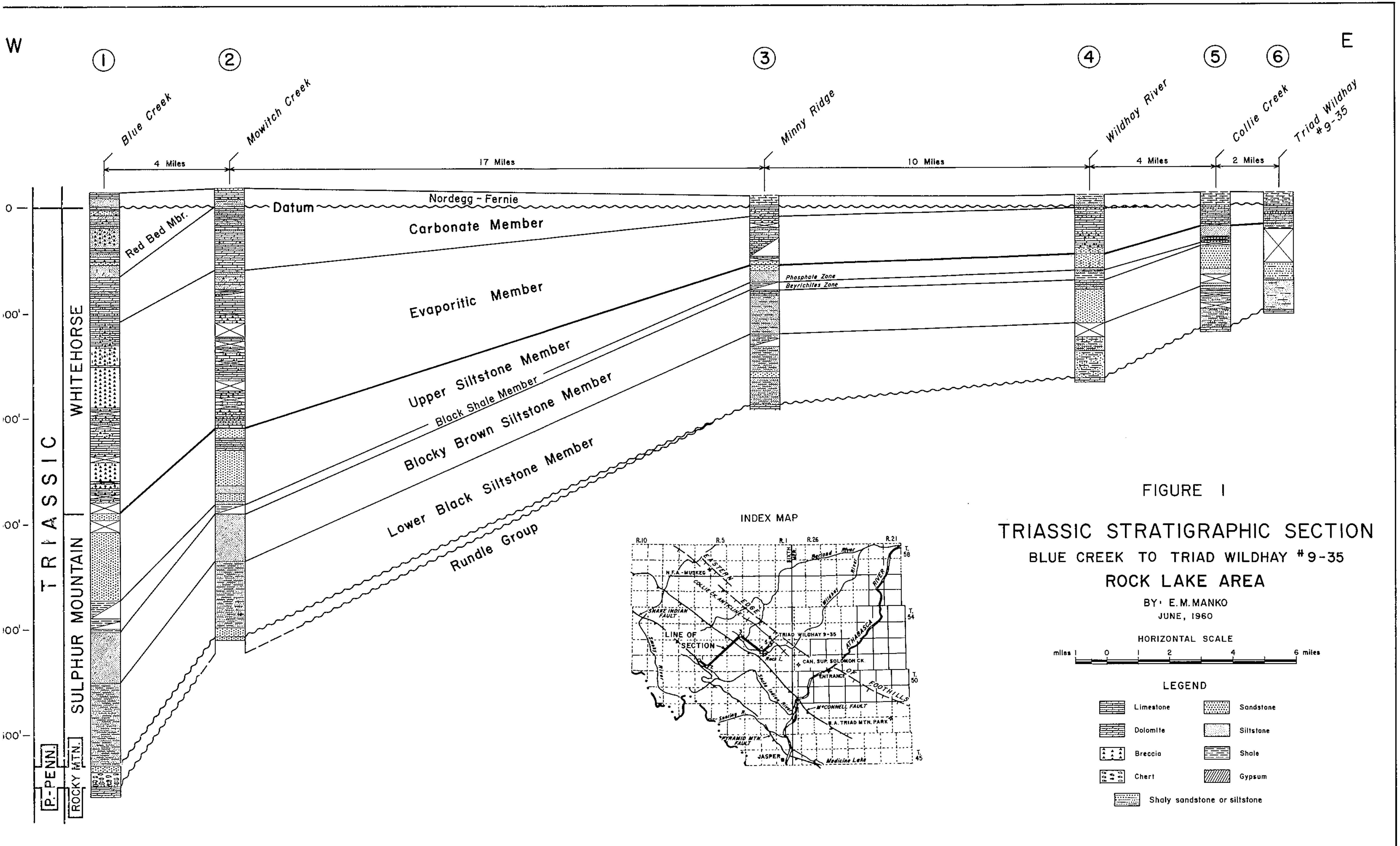

FIGURE I

TRIASSIC STRATIGRAPHIC SECTION
BLUE CREEK TO TRIAD WILDHAY #9-35
ROCK LAKE AREA

BY: E.M. MANKO
JUNE, 1960

APPENDIX

Section #4 Wildhay River

Sec. 7 S. E. and S. W., Twp. 52, Rge. 2, W.6

Thickness in Feet	Detailed Description
JURASSIC	
	Fernie Formation
60'	Partially covered. Shale, black, thin bedded, fissile, with thin interbeds of sandstone and scattered interbeds and concretions of clay ironstone.
	Rock Creek Member (Sensu stricto)
8' 6"	Quartzose sandstone, orange to tan weathering, dark grey, very fine-grained, silica-cemented, with blebs and fine disseminated pyrite, few pyritized belemnites and worm traces.
3' 6"	Shale (50%) and sandstone (50%) interbedded.
5'	Quartz sandstone, as above, with 10% thin black shale interbeds.
	Total Rock Creek member 12'.
129'	Covered. Poorly exposed slumped outcrops of black shale with ironstone concretions in upper 30'.
NORDEGG MEMBER	
14' 6"	Shale (75%), dark grey weathering, black, calcareous, bituminous, very thin-bedded, 20% black, shaly siltstone, 5% black, bituminous limestone.
3' 6"	Limestone (80%), dark grey weathering, black, micrograined, bituminous, silty, 20% black shale partings and interbeds.
5'	Shale, black, calcareous, bituminous, micromicaceous.
2'	Limestone, black, micrograined, silty, bituminous, laminated.
5'	Shale, similar to above.
3'	Limestone and shale, as above.

NORDEGG MEMBER (Continued)

Thickness in Feet	Detailed Description
3' 2"	Shale, as above, with poorly preserved belemnites.
4"	Bentonite or bentonitic ash, green.
6"	Sandstone, grey, very fine-grained, glauconitic (?)
11'	Shale (60%), black, bituminous, calcareous, phosphatic, with belemnites and pelecypods, limestone (30%), black, micrograined, bituminous, phosphatic, thin to medium-bedded, siltstone (10%), calcareous, bituminous, argillaceous.
	Total Nordegg member - 48'
	Total Fernie measured - 254'
	Contact - disconformable.

TRIASSIC

Whitehorse Formation

Carbonate Member (9')

4'	Siltstone, dark grey-brown weathering, dark grey, dolomitic, partially silicified, trace finely disseminated organic matter, trace pyrite, thick-bedded. Some 1/4 to 1/2", varicolored chert pebbles in upper 6".
5'	Dolomite, brown-grey weathering, dark grey mottled, microcrystalline, very silty, partially silicified, thick-bedded.

Evaporitic Member (221')

3'	Dolomite, buff weathering, buff-grey mottled, microcrystalline, with 30% to 40% fine to medium quartz sand grains in lenticular laminae, partly silicified, trace pyrite.
3'	Dolomitic quartz sandstone, buff-weathering, buff-grey, fine to coarse-grained (subangular to subrounded, pitted), trace buff dolomite rock fragments, trace vague skeletal bodies, thin to thick bedded.
15' 6"	Dolomite, buff and light grey weathering, light to buff-grey, crypto to microcrystalline, with 10% partially leached skeletal, slightly silty and argillaceous, few anhedral quartz 1 inch vugs, trace pyrite, laminated, thick-bedded.

Thickness in Feet	Detailed Description
2' 6"	Dolomitic Quartz Siltstone, reddish-brown weathering reddish-brown hematitic, laminated, very thin-bedded, with 10% buff-grey microcrystalline dolomite interbeds.
17'	Dolomite, buff and grey weathering, buff-grey mottled, microcrystalline, with 5 - 10% leached skeletal, sub-chalky matrix, slightly silty and argillaceous, few authigenic euhedral quartz-lined vugs, laminated, thick bedded.
1'	Dolomite, buff, cryptocrystalline, silty, very thin-bedded.
4'	Dolomitic quartz sandstone, buff weathering, light grey, very fine to fine-grained, subangular to subrounded, thick-bedded.
6'	Dolomitic quartz siltstone, buff to brown, with 20% light grey, cryptocrystalline dolomite interbeds.
19'	Dolomite, buff and grey weathering, light grey, microcrystalline, with 10% skeletal and leached skeletal, sub-chalky matrix, slightly silty and argillaceous, scattered authigenic, euhedral quartz lined vugs, trace pyrite and siderite, unevenly bedded, laminated.
15'	Limestone, buff weathering, light grey, cryptograined with 20% fine to coarse skeletal (pelecypods), dolomitic, slightly silty and argillaceous, medium to thick-bedded.
5'	Dolomite, buff-grey, microcrystalline, 5% fine to coarse skeletal (pelecypods), silty, slightly argillaceous, thick-bedded.
10'	Limestone, grey weathering, earthy grey to buff, skeletal, microgranular, (60-70% leached medium to coarse skeletal), trace dead oil infilling, argillaceous in part, brecciated in part.
10'	Dolomite, buff weathering, buff, microcrystalline, silty, few vugs, thin to medium bedded.
3'	Limestone, buff, microgranular with 30 to 40% fine skeletal, 30% lenticular dolomite laminae, silty.
10'	Dolomitic quartz sandstone, buff weathering, buff, very fine-grained, subrounded, dolomitic and calcareous, friable and porous in lower 7', thin to thick bedded.

TRIASSIC (Continued)

Thickness in Feet	Detailed Description
11'	Breccia, grey to buff, rubbly weathering, grey and buff, angular to subrounded fragments (6" to 1'), of buff, fine-grained, calcareous sandstone and buff, chalky limestone in a sandy limestone matrix, with 25% partially leached fossil casts. 30% thin interbeds of microgranular skeletal limestone.
3'	Limestone, buff to grey-buff, skeletal microgranular to microgranular skeletal, with partially leached fossil casts, few scattered chalky limestone rock fragments.
1'	Dolomite, buff, microcrystalline, very argillaceous, thin-bedded.
4'	Breccia, buff-grey, rubbly, fragments of buff, very fine-grained sandstone, buff, calcareous siltstone, and buff limestone in a micrograined limestone matrix with 20% subrounded, frosted floating sand grains.
30'	Limestone, grey and buff weathering, skeletal cryptogranular (65% leached pelecypods?), argillaceous, slightly silty, partly brecciated.
19'	Breccia, grey and buff weathering, buff-grey, similar to above, massive and cavernous.
29'	Dolomitic quartz sandstone, buff, brown and purple weathering, buff and maroon, very fine to fine-grained, subangular to subrounded, abundant blue phosphatic Lingula shells and fragments, medium-bedded.
	Total Whitehorse measured - 230'.
	Contact - gradational.

SULPHUR MOUNTAIN FORMATION

Upper Siltstone Member

28'	Dolomitic quartz sandstone, buff weathering, buff and grey mottled, very fine-grained, slightly calcareous in part, slightly argillaceous, trace black phosphate chips, laminated, poorly bedded.
1'	Limestone, brown, micrograined, with fine, subrounded to rounded frosted, floating quartz sand grains, thin-bedded.

Thickness in Feet	Detailed Description
8'	Quartz sandstone, buff to brown weathering, buff to brownish-grey, very fine-grained, calcareous, unevenly bedded, few interbeds of microgranular skeletal limestone.
1'	Limestone coquina, buff, composed predominantly of pelecypod shell fragments.
1'	Quartz sandstone, buff, very fine-grained, calcareous with trace fine phosphate chips.
1'	Limestone coquina, buff, sandy, argillaceous, composed of brachiopods and pelecypods.
8'	Quartz sandstone, buff weathering, grey-buff, very fine-grained, calcareous, 2% to 3% black phosphate chips, medium bedded.
2'	Limestone, buff, micrograined with trace skeletal, sandy, argillaceous, partially dolomitized, trace phosphate chips.
10'	Quartz sandstone, buff to grey-brown weathering, buff to grey-buff, fine grained, argillaceous, calcareous, 5% phosphate fragments scattered, poorly preserved ammonites and brachiopods, evenly medium bedded.
	Black Shale Member
48'	Shale, poorly exposed in part, dark grey to dark brownish-grey weathering, dark brownish-grey to black, silty in part, grading to siltstone in intervals of variable thickness, carbonaceous, phosphatic, abundant ammonite casts in upper 10', very thin-bedded.
	Blocky Brown Siltstone Member
42'	Dolomite, grading to dolomitic siltstone, grey-brown weathering, grey, fine to medium crystalline, sandy, slightly argillaceous, trace pyritic, thick-bedded to massive, with scattered 1/2" sandy, argillaceous interbeds. Well developed flow rolls in upper 20'.
89'	Sandstone (90%), grey-brown and buff weathering, grey, very fine-grained, slightly argillaceous, dolomitic, thin to medium-bedded, 10% thin fissile sandy shale interbeds, few flow rolls near top of interval.

SULPHUR MOUNTAIN FORMATION (Continued)

Thickness in Feet	Detailed Description
60'	Sandstone, brown weathering, grey-brown, fine-grained, slightly calcareous, slightly argillaceous, very thin to thin-bedded, laminated, some 6" blocky, hard interbeds 6" thick, increasing in quntity towards top of interval.
11'	Sandstone, poorly exposed, similar to above.
67'	Covered.
64'	Shale, brown to black weathering, dark brown to black, sandy, carbonaceous, trace pyritic, thin-bedded, laminated, platy, 50% very calcareous sandstone interbeds in upper 20'.
29'	Sandstone, brown weathering grey and grey-brown, fine grained, trace micromicaceous, shaly, very thin to thin-bedded, platy, laminated and cross-laminated.
42'	Sandstone, brown weathering, grey and grey-brown, fine grained, slightly calcareous, shaly, pyritic, micromicaceous, very thin to thin-bedded, laminated and cross-laminated.
46'	Sandstone, brown weathering, very thin to thin-bedded, generally similar to above.
18'	Sandstone, grey-brown weathering, grey-brown, medium-grained, shaly, non-calcareous, thin-bedded, laminated, platy to flaggy.
1 - 1 1/2"	Conglomerate, grey, composed of rounded, black siltstone, grey quartzite and chert pebbles 1/4" to 1" in diameter, in a fine-grained, argillaceous sandstone matrix.
	Contact - unconformable.
	Total Sulphur Mountain measured - 594'.

MISSISSIPPIAN

Rundle Formation

5'	Dolomite, light grey weathering, light grey, microcrystalline, slightly silty, brecciated in upper 1 foot, thick-bedded.

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THE MINNES FORMATION *

W. H. Ziegler
and
S. A. J. Pocock

June, 1960

ABSTRACT

A Jurassic and Cretaceous sequence of strata between the Fernie formation (below) and the Cadomin formation (above) is described from the area north of the Athabasca River. This sequence is predominantly composed of clastic sediments. A marine and a brackish-continental, coal-bearing facies development has been recognized. These facies differences have been largely responsible for the original distinction of two formations in this interval - i.e. the Kootenay formation (continental, etc.) and the Nikanassin formation (marine). These two facies developments, however, occur in practically all sections of this interval - in varying proportions. To prevent any further ambiguities in the use of these names, it is proposed to rename the entire sequence as the Minnes formation and to reduce the former formation names to designate the two facies developments - e.g. continental-Kootenay facies, marine Nikanassin facies. A type section for the formation at Mt. Minnes (British Columbia) is described.

Facies studies show that the sediments were deposited in very shallow marine to swampy and continental environment.

Paleontological studies permit one to assign an Oxfordian age to the oldest strata of the type section. The Jurassic-Cretaceous boundary can also be recognized paleontologically. The upper part of the section is of Barremian age. The top of the formation is marked by a minor unconformity, below the Cadomin formation, whereas the basal contact to the Fernie is indistinct and is suspected to be diachronous.

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INTRODUCTION

During the summers of 1957 to 1959 considerable work was undertaken by Imperial Oil in the area between the Athabasca River and the Narraway River. Much attention was given to the stratigraphic study of the Jurassic and Cretaceous series of this area. In particular the complex of strata between the Fernie group (below) and the Cadomin Formation (above) was studied in detail. This group of strata is usually known as the Nikanassin Formation and is considered to be an approximate equivalent to the Kootenay Formation of the Southern Alberta Foothills. The concept of the original definition of these two formations is largely based on the differing facies character of the two fromations, e.g. where established originally - the Kootenay Formation comprises a predominantly continental coal-bearing shale-sand sequence with only minor parts of marine sediments. On the other hand, the Nikanassin sediments are of predominantly marine origin; - continental, coal-bearing sediments form only a relatively minor part in the sequence. (See A.S.P.G. Lexicon, Norris, 1959; Mountjoy, 1959; A. Kryczka, 1959, for discussion of type section, - areas and nomenclature).

It was observed in many parts of the foothills that the occurrence of marine and non-marine facies developments of the sedimentary sequence between the Fernie and the Cadomin formations is extremely variable. Sections of the eastern foothills sections usually consist of a lower sequence of sediments, showing a marine character, whereas the upper sediments are of continental origin. Farther to the west and to the north it becomes more and more apparent that the two facies developments are strongly interfingering, i.e. marine and continental facies succeed each other laterally and vertically in the section.

Similar conditions can be observed throughout the foothills. Locally, especially in the south, the continental facies prevails, (e.g. Kootenay type area), whereas in other areas the marine facies development of the section is more prominent.

It is, therefore, proposed to re-define the entire sequence which lies between the Fernie and the Cadomin, as one formation which is composed of sediments of varying facies character, i.e. of marine sediments and continental sediments. These two facies types, which are quite distinct, will thus be defined as follows: (a) continental or brackish and coal-bearing - the <u>Kootenay facies</u>, (b) marine to brackish - the <u>Nikanassin facies.</u> Strata of these two facies types would thus form a new formation - the <u>Minnes Formation,</u> which is bounded at the base by the Fernie

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group and at the top by the Cadomin Formation. As type location of the new formation we propose Mt. Minnes - Long: 120°04' - Lat: 54°09' 45" (approximately). This mountain is situated just across the B.C. - Alberta boundary, to the northeast of Kakwa Lake. There a complete, exceedingly thick and relatively undisturbed and unfaulted section is exposed and was measured and sampled during the summers of 1957 and 1958. The measured section starts on the west slope of Mt. Minnes in a cirque drained by the northeast headwaters of Hannington Creek. The section then extends eastward to the top of Mt. Minnes and down the prominent east ridge to Mt. Gorman at the head of Gorman Creek. From there it extends to the base of the large erosional remnant of Cadomin just east of Gorman Pass. The base of the measured section lies somewhere in the upper portion of the Passage beds of the Fernie group, whereas the top is formed by the distinct Cadomin conglomerate base. The following is a detailed description of the section as measured by Dr. D. Roeder and Messrs. R. Bland, C. Riddel and G. Trimble, in the summer of 1957 and checked and sampled by E. M. Manko and J. R. Wood in 1958:

SECTION DESCRIPTION

MOUNT MINNES, BRITISH COLUMBIA

Location: Long: 120° 04'
54° 09' 45"

Blairmore Formation	Interbedded SANDSTONE, medium to light grey, brown weathering, very fine grained, calcareous, and SILTSTONE, rusty brown, slightly calcareous.
Cadomin Formation	
0 - 128' (128')	CONGLOMERATE pebbles well rounded to subspherical; 10-300 m.m. in diameter; average size of pebbles 15-16 m.m. 30% black cherts, 30% white, pink, red quartzites, 30% limestones (especially the upper 2/3). Matrix: 25-40% of medium grained, subrounded to sub-angular sandstone. Large flat boulders form fine trace of bedding; pebbles slightly imbricated in places. Some very thin sandstones interrupt the uniform conglomerate sequence. In lower third coaly sandstone lense pinching out laterally; one layer of large pink quartzite boulders; almost complete absence of carbonate components in lower 30 feet.
Thickness in Feet	
0' - 103' (103')	Interbedding of: SANDSTONE: dark grey to black, very argillaceous, carbonaceous, non-calcareous. Angular, very fine, poorly sorted, quartz, slaty, cross-bedded, regularly bedded.

SILTSTONE: dark brown, very argillaceous, slightly carbonaceous, slaty, laminated.
SHALE: dark grey to black, carbonaceous, slightly silty in part, forming thin breaks between other members.

103' - 104' (1')	COAL: dark grey, dull, black, with polished inhomogenties, very argillaceous, embedded at both sides in SHALE as above.
104' - 158' (54')	Interbedding of: SILTSTONE: brownish-grey, argillaceous, sandy, carbonaceous, slaty, cross-bedded. MUDSTONE: dark grey, composed of shale, sand and silt, in 5' - 10' beds. SHALE: dark grey, silty.
158' - 159' (1')	COAL: dark grey, dull, black, with polished inhomogenties, very argillaceous, embedded at both sides in shale as above.
159' - 187' (28')	Interbedding of: SANDSTONE: light brownish-grey, dark grey, argillaceous, carbonaceous, micaceous, medium to coarse, angular, salt and pepper, poorly sorted, forming 3' - 10' beds, cross-bedded, slaty weathering. SILTSTONE: dark brownish-grey, argillaceous, slaty. MUDSTONE: dark grey, black, composed of shale, silt sand.
187' - 206' (19')	MUDSTONE: dark grey, composed mainly of shale and minor amount of sand, carbonaceous, with two intercalated COAL seams, very argillaceous, of 2' thickness each.
206' - 220' (14')	MUDSTONE: as above, with few intercalated 1' sand bands, brownish-grey, very fine and medium, angular, salt and pepper, and some 1" coal seams.
220' - 237' (17')	SANDSTONE: brownish-grey, slightly silty, slightly argillaceous, with coal particles 3" in diameter, poorly sorted, coarse, angular, salt and pepper, faintly laminated in part, with indication of pre-diagenetic slumping, or mudstone-type destratification, grading into:
237' - 244' (7')	CONGLOMERATE: grey, 5 m.m. in diameter, rounded to sub-angular pebbles of black and grey chert in coarse sandstone matrix.

Thickness in Feet

244' - 277' (33')	Interbedding of: MUDSTONE: light grey, dark grey, composed of argillaceous sand and silt, carbonaceous in part, with COAL seams (thin), very argillaceous, sandy. SANDSTONE: dark grey, brownish-grey, fine salt and pepper, non-carbonaceous in part, very irregular bedded, finely laminated in part.
277' - 307' (30')	COVERED: probably sandstone and mudstone.
307' - 310' (3')	SANDSTONE: brownish-grey, coarse to fine, strongly cross-bedded.
310' - 353' (43')	COVERED.
353' - 414' (61')	SANDSTONE: dark grey, brownish-grey, coarse to medium, angular to sub-rounded, salt and pepper, very carbonaceous. Irregularly laminated, finely bedded.
414' - 425' (11')	SANDSTONE: as above, with 1' - 3' thick lenses of conglomerates, 10 m.m. in diameter, pebbles of dark grey and white chert, angular to sub-rounded. Single pebbles 5 m.m. in diameter, disseminated in sandstone.
425' - 442' (17')	SANDSTONE: light grey, brownish-grey, fine, sub-rounded, salt and pepper, wavy bedding.
442' - 475' (33')	COVERED.
475' - 490' (15')	SANDSTONE: light brownish-grey, fine, sub-angular, salt and pepper, cross-bedded.
490' - 556' (66')	COVERED.
556' - 563' (7')	SANDSTONE: light brownish-grey, medium, angular, salt and pepper, cross-bedded; interbedded with SILTSTONE, light brownish-grey, laminated.
563' - 728' (165')	COVERED.
728' - 760' (32')	SANDSTONE: dark grey, brownish-grey, argillaceous, fine and coarse, angular, salt and pepper, with few thin

	shale breaks, carbonaceous, with very irregular sequence of conglomerates at centre. Lenses rapidly changing laterally, interbedded with sand, 20 m.m. in diameter; sub-angular to sub-rounded, black and grey chert, embedding of petrified wood fragments (maximum 1' diameter at some places).
760' - 963' (203')	<u>COVERED.</u>
963' - 980' (17')	<u>SANDSTONE:</u> light brownish-grey, rusty weathering, coarse, subangular, salt and pepper, flaggy, slaty, very intensively cross-laminated.
980' - 988' (8')	<u>CONGLOMERATE:</u> 20 - 30 m.m. in diameter, sub-rounded, black and grey chert, white quartzite, "dyke quartz", in coarse sandy matrix. No bedding except diastem in lower third.
988' - 997' (9')	<u>SHALE:</u> dull black, dark grey, very carbonaceous.
997' - 1125' (128')	<u>SANDSTONE:</u> light brownish-grey, brown to orange weathering, fine to medium, sub-angular, salt and pepper, some (20%) coarse stringers, slightly argillaceous in parts. No visible shale breaks in upper part. Lower part extremely slaty and laminated, with increasing number of 3" - 2' shale breaks downward.
1125' - 1182' (57')	Interbedding of: <u>SANDSTONE:</u> brownish-grey, orange weathering, very coarse, subrounded - sub-angular, salt and pepper, irregular bedding, slaty, flaggy, with plant tests irregularly embedded. <u>SHALE:</u> dark grey, silty in part, mudstones, light grey, carbonaceous in part.
1182' - 1188' (6')	<u>SANDSTONE:</u> brownish-grey, fine, medium, sub-angular, salt and pepper, flaggy to slaty.
1188' - 1189' (1')	<u>COAL SEAM:</u> argillaceous, grading downward into shale.
1189' - 1196' (7')	<u>SHALE:</u> dark grey, carbonaceous, grading downward into next mudstone.
1196' - 1200' (4')	<u>MUDSTONE:</u> light grey, medium grey, composed of shale (50%) and sand, fine (50%).

1200' - 1206' (6')	SANDSTONE: light brownish-grey, cross-bedded, flaggy, slaty.
1206' - 1207' (1')	COAL SEAM: argillaceous, grading downward into:
1207' - 1225' (18')	Interbedding of: SHALE: dark grey, carbonaceous, finely bedded to unbedded, MUDSTONE: composed of silt and shale, with faint traces of very irregular silt laminae. COAL: in 1" - 6" seams.
1225' - 1245' (20')	SANDSTONE: bluish-grey, brown weathering, slightly calcareous in part, fine banded and laminated, cross-bedded, some intercalated beds argillaceous, with mudstone texture (1' thick).
1245' - 1310' (65')	SHALE: dark grey, silty in part, with mudstone texture in part, with 4' calcareous SILT band at 1286' - 1290'. COAL seams at top, below sand of previous unit and below calcareous silt band.
1310' - 1400' (90')	Interbedding of: SANDSTONE: brownish-grey, fine, slaty, carbonaceous. SHALE: dark grey, silty, with mudstone texture in part. Occasional thin 3" - 6" coal seams below sands.
1400' - 1445' (45')	COVERED.
1445' - 1487' (42')	SANDSTONE: grey, yellow weathering, very coarse, rounded, salt and pepper, fine banded, cross-bedded, with central COAL break, with some SHALE and silty MUDSTONE underneath.
1487' - 1530' (43')	COVERED.
1530' - 1600' (70')	Interbedding of: SANDSTONE: brownish-grey, fine, slaty, carbonaceous. SHALE: dark grey, silty, with MUDSTONE texture in part. Occasional thin 3" - 6" COAL seam below sands.
1600' - 1680' (80')	COVERED.

1680' - 1776' (96')	Fine interbedding (1' - 3') of: SANDSTONE: brownish-grey, fine, angular, salt and pepper, cross-bedded, laminated in part, COAL seams, 3" - 6" at base of sandstone, MUDSTONE, SHALE, dark grey, silty in part.
1776' - 1856' (80')	COVERED.
1856' - 1918' (62')	SANDSTONE: dark grey, very coarse, some parts very fine to siltstone, sub-angular, salt and pepper; interbedded with breaks of COAL, MUDSTONE and SHALE Some zones of sand show intensive pre-diagenetic slumping.
1918' - 2000' (82')	Fine interbedding (1' - 3') of: SANDSTONE: brownish-grey, fine angular, salt and pepper, cross-bedded, laminated in part, COAL seams, 3" - 6" at base of SANDSTONE; MUDSTONE, SHALE, dark grey, silty in part.
2000'	Folded zone, approximately 30' of unit 1918' - 2000' involved.
2000' - 2049' (37')	SHALE: dark grey to black, silty, MUDSTONE textures in part; few intercalated 6" sand breaks and thin coal seams underneath.
2049' - 2060'	SILTSTONE: light brownish-grey, laminated, cross-bedded, with coaly breaks.
2060' - 2070' (10')	SHALE: dark grey to black, very carbonaceous, with some coal breaks.
2070' - 2090' (20')	Interbedding of SANDSTONE, yellow, fine grained, in 1' - 3' beds with silty SHALE, grey.
2090' - 2147' (57')	MUDSTONE: dark grey, light grey, composed of more shale than silt, with some ironstone lenses and bands at centre.
2147' - 2193' (46')	Interbedding of: SILTSTONE: light grey, yellow weathering, flaggy, slaty, cross-laminated, MUDSTONE, silty, light grey, dark grey, SHALE, slightly carbonaceous.
2193' - 2210' (17')	SILTSTONE: light grey, yellow weathering, flaggy, slaty, non-laminated, with few minor shale breaks.

2210' - 2350' (140')	SHALE: dark grey to black, carbonaceous, in part silty with mudstone texture, with 1' SANDSTONE interbeds, coarse in part, grey, angular, salt and pepper, well sorted without lamination, COAL, seams underneath sands; SILTSTONE in 10' - 12' units at 2250', 2270', 2300', 2340', light grey, yellow weathering, laminated, slaty, with minor shale breaks.
2350' - 2683' (333')	Interbedding of: SHALE: dark grey to black, carbonaceous, in part silty with mudstone texture; SANDSTONE, 10' - 12' beds, as above; COAL seams below sands, thin.
2683' - 2689' (6')	CONGLOMERATE: 5 m.m. to 15 m.m. in diameter, subangular, sub-rounded, grey and white chert and quartzite in 50% coarse, angular, sand matrix.
2689' - 2721' (32')	SANDSTONE: grey, brown-orange weathering, fine and very fine, sub-angular to rounded, salt and pepper. Laminated, irregular bedding, cross-bedded, weathers slaty, flaggy, some breaks of silty shale in higher part.
2721' - 2723' (2')	COAL: black, argillaceous.
2723' - 2730' (7')	MUDSTONE: light grey, composed of silt and argillaceous material.
2730' - 2739' (9')	SANDSTONE: grey, cross-bedded, laminated.
2739' - 2740' (1')	COAL: black, fissile, argillaceous.
2740' - 2748' (8')	MUDSTONE: light grey, composed of silt and argillaceous material.
2748' - 2759'	SANDSTONE: light grey, weathers brown-orange, very fine, salt and pepper, irregular bedding, slightly calcareous, slightly argillaceous, some plant stems.
2759' - 2800' (41')	Interbedding of: SANDSTONE: light brownish-grey, grey, orange-yellow weathering, very fine, sub-rounded, salt and pepper, slightly calcareous, slightly argillaceous, with vertical plant stems, some layers of finely laminated COAL, in 6" - 24" seams, very argillaceous, carbonaceous concentration at top of units, lower parts sometimes MUDSTONES, composed of silt, sand, argillaceous material.

2800' - 2816' (16')	Interbedding of: SANDSTONE: light brownish-grey, brown-orange weathering, very fine, sub-rounded, salt and pepper, very regularly bedded (laminated in part) in 1' beds, SHALE, black, very carbonaceous, fissile and finely bedded, in 3" - 6" beds.
2816' - 2826' (10')	COAL: black, argillaceous, massive, textureless, fractured.
2826' - 2900' (74')	Regular interbedding of: SANDSTONE: brownish-grey, brown weathering, very fine sub-rounded, salt and pepper, laminated, cross-bedded, slaty. SILTSTONE: light brownish-grey, brown-yellow weathering, laminated, slaty. MUDSTONE: dark and light grey, carbonaceous, composed of silt and argillaceous material. COAL: in 1' - 3" beds, argillaceous, rhythmic development from sand to silt to mudstone to shale to coal to sand. Argillaceous and carbonaceous. Parts of rhythms decrease in thickness gradationally downward, lower third only coal and shale interbedding, in 1' - 2' beds, between 10' - 15' beds of interbedded sand and silt.
2900' - 2952' (52')	Interbedding of: SHALE: dark grey, black, carbonaceous, with some ironstone nodules, five thin COAL seams, SANDSTONE, brown, silty, very fine, sub-angular, salt and pepper, laminated, forming 1' - 5' beds.
2952' - 2967' (15')	SANDSTONE: brownish-grey, irregular bedding, slaty, laminated.
2967' - 3085' (118')	Interbedding of: SANDSTONE: brownish-grey, brown-orange weathering, argillaceous, silty, very fine and medium, poorly sorted, sub-angular - rounded, salt and pepper, irregular bedding laminated to non-bedded with mudstone texture. SILTSTONE, light brownish-grey, forming laminae in SANDSTONE and in MUDSTONES. SHALE: dark grey, carbonaceous, silty; COAL forming relatively constant 1' - 3' seams.
3085' - 3100' (15')	COVERED.

3100' - 3108' (8')	SANDSTONE: brownish-grey, dark grey, brown weathering, very coarse, angular, chert and quartz, salt and pepper, fair sorting; grading downward into sand, fine and very fine, sub-angular, chert and quartz grains; well bedded, laminated in part.
3108' - 3178' (70')	Fine, regular (6" - 2') interbedding of: SANDSTONE: brownish-grey, medium, salt and pepper, SHALE: light grey, silty, laminated.
3173' - 3206' (33')	Interbedding of: SANDSTONE: brownish-grey, medium, salt and pepper. SHALE: light grey, silty, laminated. Irregular thickness of interbedded members 2' - 12' thick.
3206' - 3370' (164')	Folded zone max. 150' of strata involved. No repetition.
3370' - 3473' (103')	Interbedding of: SHALE: black, dark brownish-grey, in 4' beds. SANDSTONE: light brownish-grey, yellow weathering, laminated, in 1' - 3' beds. SHALE in lower part increasingly carbonaceous.
3473' - 3499' (26')	SANDSTONE: brownish-grey, fine, angular, salt and pepper, carbonaceous, slightly argillaceous, slaty, laminated, with coaly, argillaceous breaks.
3499' - 3510' (11')	Interbedding of: SHALE: dark brownish-grey, black, carbonaceous, COAL seams (1-3'), argillaceous, SANDSTONE, brownish-grey.
3510' - 3534' (24')	SANDSTONE: brownish-grey, very fine to coarse, poorly sorted, angular and sub-rounded, salt and pepper, with carbonaceous, slaty sand zones; intercalated minor shale breaks.
3534' - 3574' (40')	SHALE: dark brown to black, fissile in part, carbonaceous, with thin intercalated SAND zones and COAL seams underneath sands.
3574' - 3604' (30')	SANDSTONE: light brownish-grey, buff-yellow, weathering, fine sub-rounded salt and pepper, laminated, cross-bedded, with 10% shale partings, dark, medium grey, finely bedded. This sandstone, base of weakly developed rhythmic unit with top at 3534' (70' thickness).

3604' - 3713' (109')	Rhythmic unit, interbedding of: SHALE: dark brownish-grey, black, carbonaceous with some coal seams, thin, very argillaceous. SANDSTONE: brownish-grey, fine argillaceous, silty, carbonaceous, in 0.5' - 3' beds. Grain size, thickness and number of sand zones increasing downward. Coal seams frequently underneath sand beds. Basal 40' sandstone, brownish-grey, coarse with very coarse laminae and irregular stringer, cross-bedded, with thin carbonaceous shale breaks concentrated in central 20' of zone. Sharp lithologic break at base.
3713' - 3823' (110')	Rhythmic unit, interbedding of: SHALE: black, carbonaceous, with 50% COAL seams, usually underneath sand beds. MUDSTONE: dark and light grey, composed of silt and shale, carbonaceous in part. SANDSTONE: yellow-brown, light grey, silty, grading to siltstone, carbonaceous. Grain size decreasing downward with increasing spacing of 1' - 5' sand breaks. Lowermost 35' sandstone, light grey, light buff weathering, coarse and very coarse, sub-angular, quartzitic, slightly carbonaceous in part, with some sandy, argillaceous mudstone lenses increasing in number towards top. Extremely irregular bedding, steep-angle cross-bedding.
3823' - 3900' (77')	Rhythmic unit, interbedding of: SHALE: dark brownish-grey, black, carbonaceous, well-bedded in 3' - 5' beds. SANDSTONE: brownish-grey, slightly argillaceous, slightly carbonaceous in part. Slaty, laminated, slightly cross-bedded, in 1' - 3' beds. Frequency and thickness of sand beds decreasing downward. No basal sand.
3900' - 4011' (111')	Rhythmic sequence interbedding of: SANDSTONE: light brownish-grey, very fine, rounded, salt and pepper, carbonaceous in 3' - 5' beds. SHALE: dark grey-black, carbonaceous, with coal seams only in lower part. Average grain size decreasing downward.
4011' - 4050' (39')	COVERED.

4050' - 4080' (30')	Interbedding of: SANDSTONE: light brownish-grey, coarse, angular, quartzitic, cross-bedded, some beds carbonaceous. SHALE:, dark grey, silty, in part with mudstone texture.
4080' - 4103' (23')	SILTSTONE: light grey, buff-brown weathering, well bedded, homogeneous texture, argillaceous.
4103' - 4141' (38')	COVERED.
4141' - 4158' (17')	MUDSTONE: dark grey, carbonaceous, composed of sand and argillaceous material, very irregular traces of bedding.
4158' - 4270' (112')	COVERED.
4270' - 4440' (170')	Poorly exposed, probably: SANDSTONE: light brown, mostly fine-grained, slaty, fine bedded, some horizons with ripple marks, interbedded with shaly SILTSTONE, carbonaceous in part, some silt-shale MUDSTONES. Some intercalated beds of SANDSTONE, dark brown, high weathering, coarse, subangular, salt and pepper, in 1' - 3' beds. Clay ironstone horizon near top.
4440' - 4500' (60')	COVERED.
4500' - 4743' (243')	Interbedding of: SANDSTONE: light brownish-grey, fine and very fine, sub-rounded and rounded quartz sand, laminated, sub-parallel bedding; cross-bedded, with traces of benthonic activity. MUDSTONE: dark grey, composed of sand, silty and argillaceous material, trace carbonaceous material, with worm burrows of different kinds.
4743' - 4770' (27')	Interbedding as above, with much carbonaceous material in dark grey to black MUDSTONE. Lower SANDSTONES, slightly pebbly.
4770' - 4771' (1')	Local diastem.
4770' - 4771' (1')	CONGLOMERATE: sub-rounded 5 m.m. to 30 m.m. in diameter, pebbles of high sphericity of chert and quartzite, irregular lensy. Diastem at base.

4771' - 4830' (59')	<u>SANDSTONE:</u> light brown, coarse and very fine, sub-rounded to angular, quartz sand and light colored chert, cross-laminated, sub-parallel, laminated, with some thin shale partings.
4830' - 4920' (90')	Interbedding of: <u>SANDSTONE</u>: light brownish-grey, fine and very fine, sub-rounded and rounded quartz sand, laminated, sub-parallel bedding; cross-bedded, with traces of benthonic activity. <u>MUDSTONE:</u> dark grey, composed of sand and silty argillaceous material, trace carbonaceous material, with worm burrows of different kinds.
4920' - 5310' (390')	<u>SANDSTONE</u>: yellow to buff weathering, medium to light brownish-grey, fine, sub-rounded salt and pepper, and light grey quartz sand, with bandy concentrations of argillaceous material showing cross-bedding within 2' - 3' beds, small plant stems and finely disseminated carbonaceous material. Several layers of 2 to 5 m.m. pebbles and 5 to 10 m.m. thick layers of <u>Dentalium</u> spec. Fossil Suite: Pentacrinus; sp. n. at 5300'
5310' - 5430' (120')	<u>SANDSTONE:</u> medium brown, yellow-brown to rusty-brown weathering, very fine to fine-grained, argillaceous thin bedded, with interbeds of black shale, trace carbonaceous.
5430' - 5870' (440')	<u>SANDSTONE</u>: medium brown, weathering yellowish to rusty brown, very fine to fine-grained, argillaceous, cross-bedded, cross-laminated, ripple marks at 5750', some calcareous silt in massive beds.
5870' - 5910' (40')	<u>SANDSTONE:</u> medium grey to medium brown, very fine, rounded to sub-rounded quartz, argillaceous, cross-bedded, thin bedded with a few plant remains.
5957' - 6020' (63')	<u>SANDSTONE</u>: medium grey to medium brown, very fine, rounded to sub-rounded quartz, argillaceous, cross-bedded, thin bedded with carbonaceous plant remains.
6020' - 6380' (360')	<u>SANDSTONE</u>: light grey to brownish-grey, yellow-brown to rust-brown weathering, very fine to fine-grained, argillaceous, cross-bedded, few thin siltstone interbeds between 6020' and 6080'. Fossil Suite: at 6180' Crinoidea sp. Ostrea sp. ind. Buchia (?) sp. Entolium sp.

6380'	Fernie Formation Passage Beds Member
6380' - 6670' (290')	Interbedding of: <u>SANDSTONE:</u> medium grey to brown, very fine, grading to siltstone, extremely argillaceous, <u>SHALE:</u> dark grey, with mudstone texture in part, some very finely bedded to fissile, in paper thin partings. Fossil Suite at 6600' Buchia sp. n. (cf. sinzovi)
6670' - 7600' (930')	Same as above, mostly covered. Exposed intervals show great similarity to previous unit, very argillaceous.
7600'	End of Section.

DISCUSSION OF FACIES DEVELOPMENTS

A. Nikanassin Facies:

The sediments which compose the bulk of the Nikanassin Formation are undoubtedly of a predominantly marine origin. These sediments are mainly shales and mudstones, silt and sandstones, and in the western sections also some minor amounts of conglomerate. The SHALES and MUDSTONES are usually grey to black, silty and sandy; ripple marks are quite common and vary in size. The shales contain locally a great abundance of traces of various benthonic life, such as pelecypod and worm burrows, feeding traces, etc. This benthonic activity was in places so abundant that it lead to a near complete or complete de-stratification of the shales and silty shales, thus causing the textureless mudstones, referred to in this paper. The de-stratification of the shales is usually much more evident in the western section than to the east. Pelecypod shells can occasionally be found embedded in various positions in these shales, where they are often associated with burrow traces. Occasionally thin layers of various pelecypods and Dentaliums, as well as occasional crinoid fragments, can be found on top of such biogene mudstone sequences.

The SILT and SANDSTONES of the Nikanassin facies are usually very quartzose, sometimes feldspathic and often quite clean, especially in the eastern section. Cementation is usually provided by siliceous material and carbonates. The sandstones are perceptively more siliceous in the eastern sections than to the west. Bedding and sorting of the sands also improves eastward, whereas generally the grain size decreases markedly from west to east. Cross-bedding, graded bedding and lamination is very common in the sands and silts. Dentalium-pelecypod assemblages, remarkably similar to the Macoma incongrna-Dentalium assemblages as found in the northwest Pacific off Japan (See G. Thorson in Hedgpeth, 1959), occur frequently in thin layers on top of these graded sandstones but occur also within these sands. These assemblages are very common throughout the western sections of the area. Occasional strings of small pebbles are associated with such fossil assemblages. These fossil accumulations (Coquina) may be interpreted as near-shore accumulations caused by storm bedding. All these factors point to relatively shallow water depths, as is also indicated by the biosphere of the recent equivalent faunas (5 meters to 60 meters for recent Macoma assemblage). Conglomerates are few and usually very thin. Their components are of relatively small size and rarely exceed one inch in diameter. They are only found in the western part of the area under investigation; these pronounced conglomerate concentrations are found in the northwest as at Hannington Creek, Mt. LaCreche and Promenade Mountain. At Mt. LaCreche several layers and lenses up to 20' thick occur within the lower part of the Minnes section. Their constituents reach up to 2" to 4" in diameter and are mainly formed by quartzites of various colors and grain sizes, varicolored cherts, carbonates, and occasional white "dyke quartz" (? pegmatite) and greenish quartz porphyries with pink to white orthoclase phenocrysts. (A sample of these quartz porphyries has been

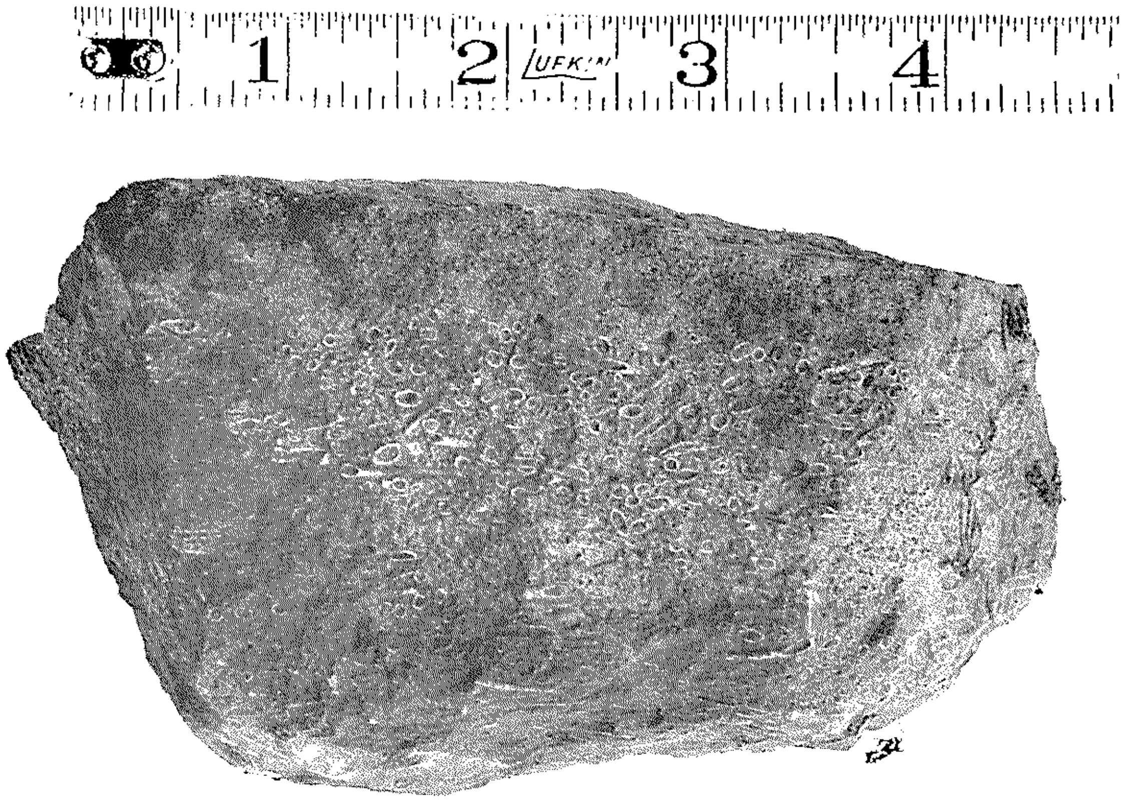


Photo 1 Dentalium Coquina; Nikanassin Facies; Minnes Formation; West Slope of Mt. May.

Photo 2 Dinosaur Tracks; Kootenay Facies; Minnes Formation; West Slope of Dinosaur Ridge on Narraway River. Photo, R. Meneley.

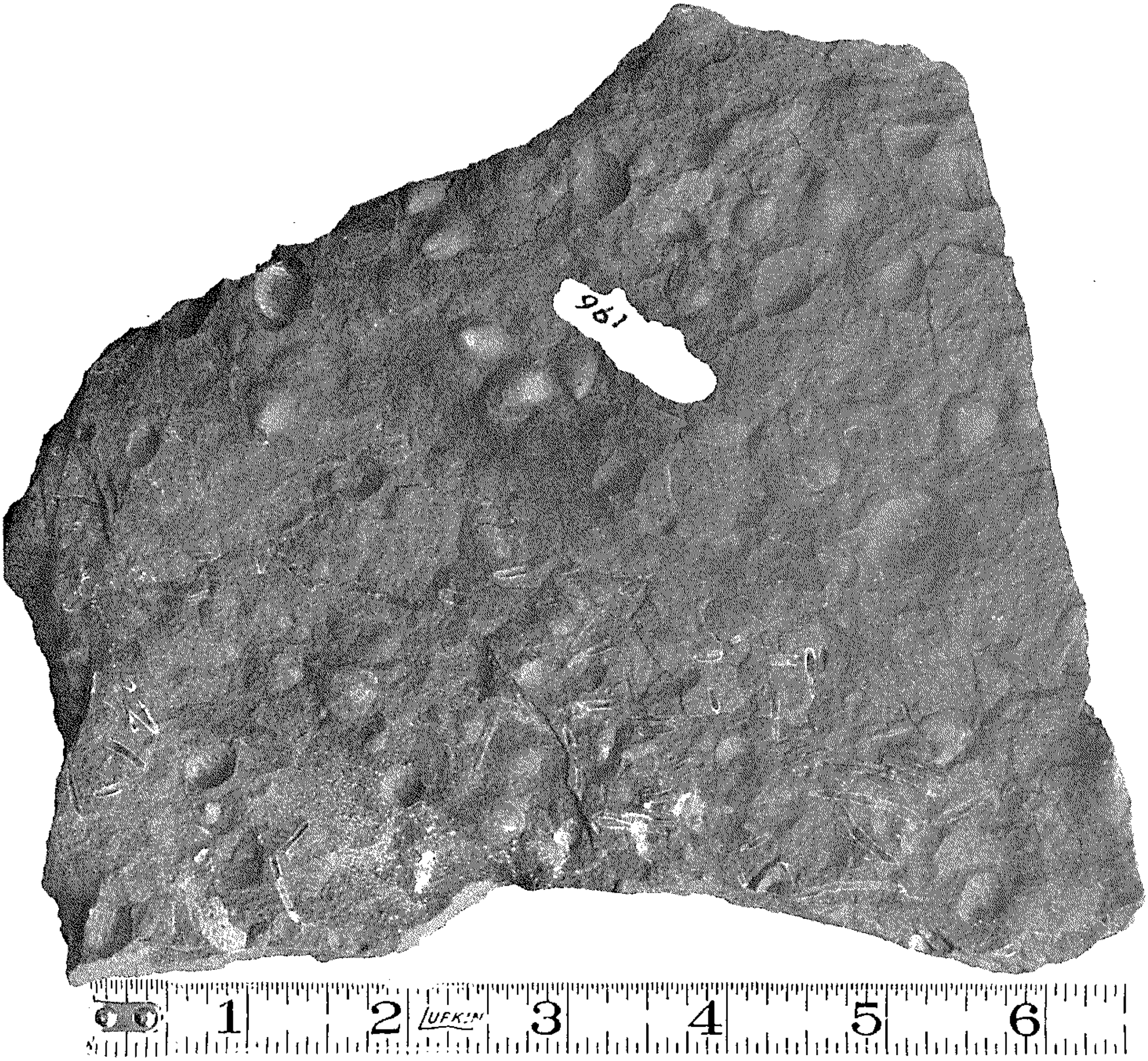


Photo 3 Pelecypod -- Dentalium Assemblage in Fine Sandstone; Nikanassin Facies; Minnes Formation; West Slope of Mt. May.

submitted to the Dept. of Geology of the University of Alberta for a possible age determination). Some of these conglomerate lenses, have been observed to be distinctly convex upwards; they must be regarded, at least in part, as sub-aquatic gravel bars. In eastern sections conglomerates are very rare.

B. The Kootenay Facies

The lithofacies development of the Kootenay is in most respects similar to the Nikanassin facies with the basic and decisive difference that the facies indicates clearly a continental or possibly brackish depositional environment. During deposition a very abundant plant growth was sustained in the depositional area. The SANDSTONES are usually quartzitic, feldspathic, coarse to fine grained, and show a definite decrease in grain size from west to east. They become better cemented and harder from west to east. Sedimentary phenomena such as ripple marks and graded bedding are very common. The sands are often very carbonaceous; coaly plant hash is quite abundant in most sands. The sandstones usually grade into the siltstones and shales. SILTS and SHALES are usually extremely carbonaceous to coaly and contain abundant plant hash. Often the gradational cycle terminates with a minor, or as the case may be, major COAL development. Coal horizons up to 3' thick and more have been recognized. The coal is often textureless, occasionally fissile and argillaceous. Recognizable plant fragments are not very often encountered, with the exception of frequent broad, parallel veined leaves. Fine plant rootlets in their natural growth position can frequently be recognized in the upper part of sand, silt or shale beds. The sedimentation of the Kootenay is very clearly rhythmical. The rhythms develop from sandstones to siltstones and coal. The coal is often overlain by another rhythm of the same character. The bases of these new rhythms are occasionally marked by a small diastem, showing slight erosion and the development of minor grit or conglomerate beds. Occasionally coal fragments and chunks of coal are embedded in the sands, immediately above the erosional contacts. There are numerous variations in the development of the rhythms which may be partially missing or are abbreviated. Superimposed on these sand, silt, shale and coal rhythms are larger rhythms of extremely thick sand developments which terminate in turn in a number of cycles of the fine rhythms. The rhythms can change laterally very rapidly, e.g. in two neighboring sections on Mt. May no similarity could be found between sections only a few thousand feet apart. This may indicate great variations in the rate of sediment influx and deposition from place to place at any particular time.

Fossil tree trunks and other large recognizable plant fragments are much less abundant than in the overlying Blairmore sediments. The relative scarcity of tree fragments and the great abundance of plant hash and remnants of reed-like plants may possibly be indicative of the degree of brackish contamination of the waters during deposition of the sequence. During less brackish periods and on relatively higher grounds, tree growth could establish itself temporarily, whereas in the lower lying areas and in times of greater inundation only rushes and

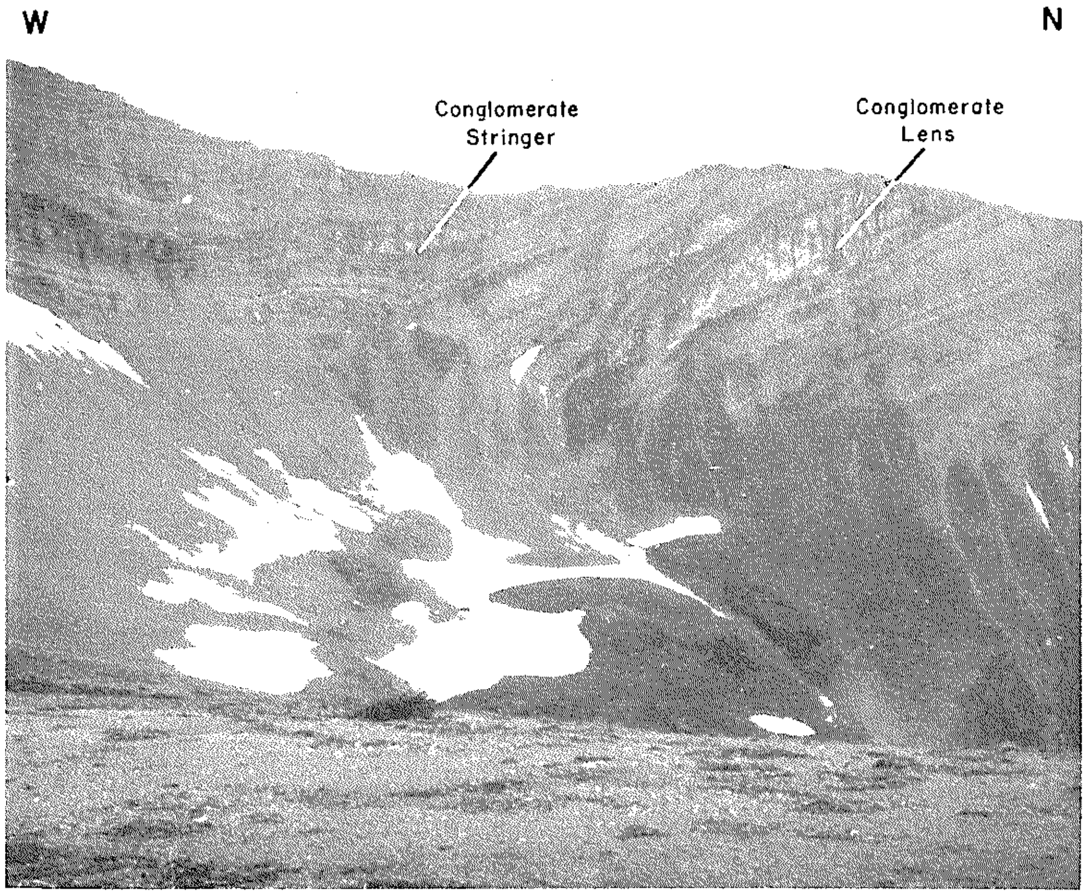


Photo 4 Conglomerate Stringers and lenses; Nikanassin Facies, Minnes Formation; East Flank of Mt. La Creche.

reeds were growing. Tracks of Dinosaurs have been observed on bedding planes (Dinosaur Ridge on Narraway River). They obviously substantiate this picture of a very shallow, and at times swampy depositional environment. (See also palynological evidence).

ENVIRONMENT AND FACIES

It thus becomes evident that the biofacies developments of the Nikanassin and the Kootenay are indicative of an extremely shallow marine to brackish to continental environment. Minor oscillations of the land surface or of the sea level caused the development of one or the other facies type. The extreme variability in the lateral and vertical distribution of either facies type thus becomes understandable. Furthermore, it illustrates the fallacy of describing the stratigraphic interval between Fernie and Cadomin either as Kootenay or Nikanassin, as by original definition both terms really designate only a different facies type or development of one and the same sequence. Hence a new formation name - the MINNES FORMATION which bears no biofacies connotation is proposed. The Minnes Formation is thus formed by a uniform lithofacies composed of clastic sediments, of conglomerates, sands, shales, and silts. Marine environment during deposition is indicated in the Nikanassin facies development, whereas the Kootenay facies is of continental origin.

PALEONTOLOGICAL EVIDENCE FOR THE DATING OF THE MINNES FORMATION

Despite a considerable amount of research, and an even greater volume of discussion and argument the problem of the precise age and stratigraphic position of the Minnes formation and the relationship between its two component facies, Kootenay and Nikanassin, remains the subject of disagreement among geologists.

By definition the Kootenay formation at its type locality at Grassy Mountain underlies the Mountain Blairmore formation (Blairmore formation sensu stricto) being separated from it by the Basal Blairmore Conglomerate (Cadomin Conglomerate in the central and northern foothills). It is itself underlain by the Fernie Shale into which it passes by alternation, the junction between the formations being diachronous. An ammonite Titanites occidentalis Frebold (1957) recorded by Newmarch (1953) from strata towards the top of the Moose Mountain Member suggests a Portlandian age for that stratum, a dating supported by the record of Oxfordian foraminifera from towards the base of the formation. The Blairmore and Cadomin conglomerates are overlain by the Calcareous Member of the Blairmore formation which carries a fauna rich in Ostracodes, frequently termed the "Metacypris persulcata" fauna which, despite some statements to the contrary, is certainly Neocomian and probably Upper Barremian in age. Thus the undated part of the section must fall within the interval Portlandian to Upper Neocomian. The interval has yielded an extensive megaflora comprising twenty six named species (Bell 1956, p. 7), not 15 as stated in his earlier memoir (Bell 1946, p. 522). Of these twenty six species the following have been recorded from the lower part of the English Wealden (Berriasian - Valanginian).

Onychiopsis psilotoides (Stokes and Webb) Ward
Sphenopteris cardai (Dunker) Schenk
Equisetites lyelli (Mantell) Unger
Ginkgo pluripartita (Schimer) Heer
Ginkgo nana Dawson = Baiera brauniana Dunker
Nilssonia schaumburgensis (Dunker) Nathorst

The following six species have been recorded from the Potomac group of the United States.

Cladophlebis virginiensis Fontaine (Berry)
Sphenopteris latiloba Fontaine
Onychiopsis psilotoides (Stokes and Webb) Ward
Coniopteris brevifolia (Fontaine) Bell
Equisitites lyelli (Mantell) Ungr
Podozamites lanceolatus (Lindley and Hutton) Schinifer

The age of the Potomac group ranges from Neocomian (probably Upper Barremian) to Cenomanian. Two species Baiera cf. furcata (Lindley and Hutton) Braun and Czekanowskia cf. rigida Heer are typical Jurassic forms. That only two typically Jurassic species should be found in such a large flora from this part of the section is surprising and this evidence, together with the presence of moderate proportion of typical Wealden and Potomac species in the assemblage strongly suggests a basal Cretaceous (Neocomian) age for the entire assemblage. Bell's assignment of a Neocomian-Barremian age for the Kootenay flora appears to the author to be most probable and is in complete agreement with the faunal evidence previously cited. All Kootenay megaflora was recorded from above the Moose Mountain member, and mainly from above the overlying Adanac member and thus the age of the latter member is in some doubt, but from the above evidence a Purbeckian or Lower Neocomian assignment appears reasonable. An erosional contact between the Adanac and overlying Hillcrest members is suggestive of unconformity between the two members and would favour the placing of the Jurassic-Cretaceous boundary at the top of the Adanac member, assigning that member a Purbeckian age.

In the foothills and mountains north ofthe Athabaska River it is the practice to split the beds bridging the Jurassic-Cretaceous boundary into two formations, the upper sand-coal sequence being termed the Kootenay and an underlying marine sand unit, the Nikanassin. There can be no doubt that the basal part of the Kootenay formation at its type locality is equivalent to the Nikanassin formation and would be picked as such further north. Such a situation, where the same formation name is used with different stratigraphic significance in different areas, is undesirable and in this instance, unnecessary.

In an attempt to create a more orderly terminology a complete section of these strata, that at Mount Minnes, British Columbia, has been sampled in detail and subjected to detailed lithological and palaeontological study.

Seven thousand five hundred feet of strata were recorded, the lowest eleven hundred feet belonging to the Fernie group not being sampled in detail. Thus six thousand four hundred feet of strata assigned to the Kootenay - Nikanassin interval and including the Jurassic - Cretaceous boundary were sampled in detail and subjected to paleontological analysis.

A. Microfauna

Few reliable foraminifera were recorded from the Mount Minnes section, but towards the base of the section (Nikanassin facies) foraminifera of Upper Oxfordian type were recorded including the species.

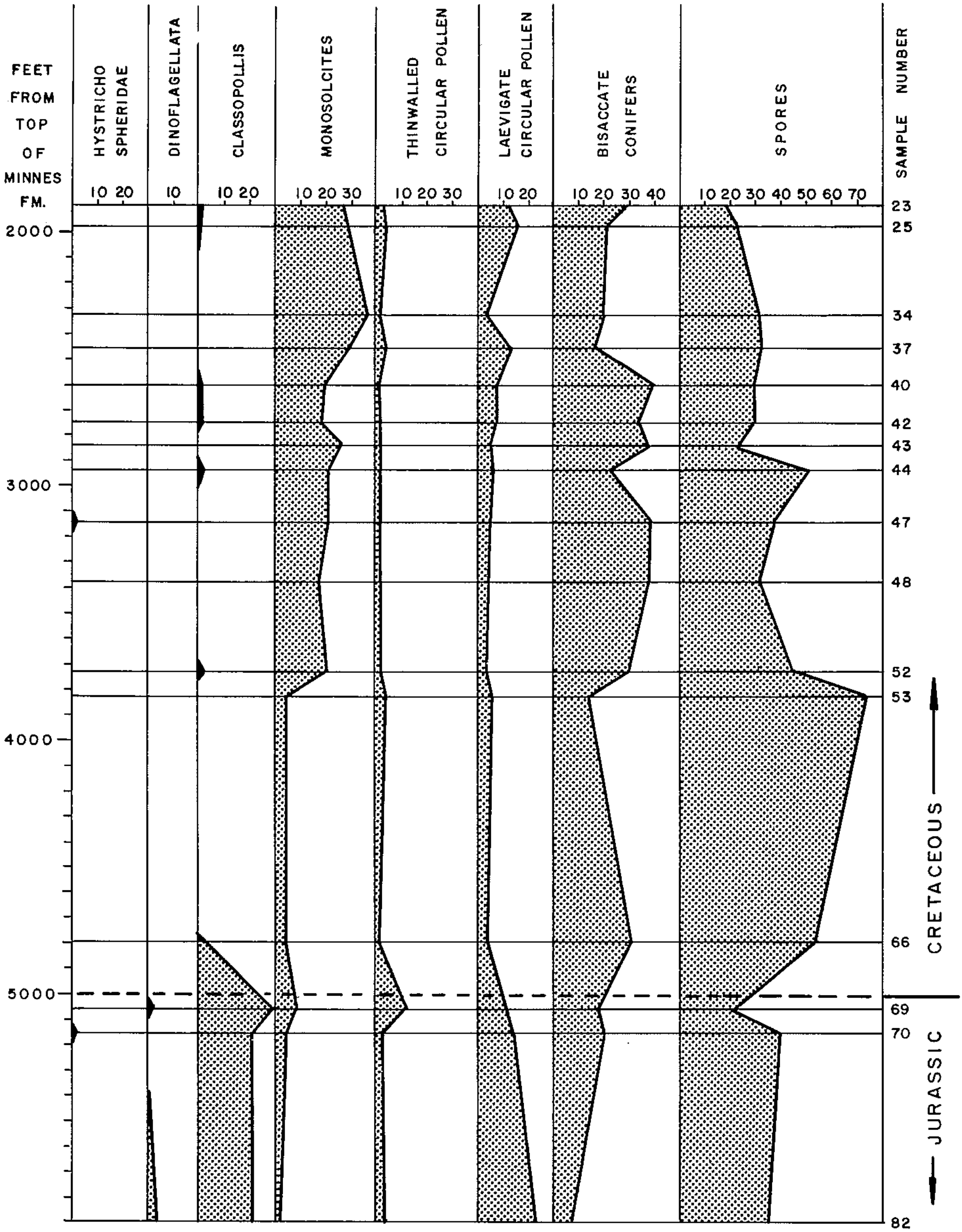
Ammobaculites stomatum n. sp.
Haplophragmoides biexcarata n. sp.
Trochammina gryci Tappan 1955
Trochammina canningensis Tappan 1955
Ammobaculites cf. infravalgensis Myatlink 1939
Lenticulina sp.
Robulus sp.
Sarcenaria sp.

Positive identification of Trochammina gryci Tappan, 1955 indicates that the interval containing it is of Upper Oxfordian in age, being equivalent to the upper part of the Kingak formation of Alaska. Trochammina canningensis Tappan, 1955 has an extended range in the Jurassic and has also been recorded from the upper part of the Kingak formation of Alaska.

B. Microflora

Samples from between 2000' and 5900' were disintegrated and subjected to both specific and statistical analysis. Preservation of samples ranged from good to poor, but in almost all instances preservation was sufficiently good to enable age determination to be made. Assemblages from 1800 feet to 5000 feet yield typical basal Cretaceous assemblages rich in conifer pollen and trilete spores, and poor in Classopollis pollen and marine microflora. Between 5000' and 5050' there is a sharp floral break with an abrupt change in specific content and relative abundance of the various components of the assemblages. Classopollis becomes very abundant, and there is a gradual increase in abundance of laevigate circular pollen below 5050'. Below 5500' marine microflora becomes increasingly abundant. Bisaccate conifer pollen and trilete spores both decline in abundance below 5000'. The histograms and specific composition of the assemblages from this part of the section compare closely with those from Upper Jurassic assemblages from other parts of the

PLATE 2



MT. MINNES

VERTICAL VARIABILITY DIAGRAM OF MICROFLORAL GROUPS

Western Canada Basin, the upper samples yielding assemblages similar to those from the Upper Vanguard formation of Saskatchewan, the lower assemblages being close to those from the Middle Vanguard. This would give an age range of Oxfordian at the base to Post-Kimmeridgian - Pre Upper Purbeckian for the top of the Jurassic strata at Mount Minnes.

In detail the Cretaceous assemblages at Mt. Minnes fall into two distinct groups:

a. Between 1900' and 3800' Monosulcate pollen and bisaccate conifers are very abundant. Laevigate circular pollen is quite common. Classopollis and thin walled circular pollen is very scarce. Trilete spores are abundant, but not to the extent that they become below 3800'.

b. At 3800' assemblages change in character. Monosulcate pollen becomes quite scarce and Conifer pollen and Laevigate circular pollen declines in abundance. Trilete spores become dominant.

It is here suggested that it is possible that these two groups of assemblages correlate with the Quartz Sand Member (above) and the Deville member (below) of the Ellerslie formation of the Alberta Plains. Regarding age determination the Deville member is Beriasian to Valanginian in age and the Quartz Sand member Barremian. This age determination is in complete accord with Bell's age assignment of Neocomian - Barremian for the Kootenay.

It appears probable, however, that the base of the Mount Minnes Cretaceous section probably represents a rather lower horizon in the Beriasian than the Deville member of the Alberta Plains since the unconformity between Jurassic and Cretaceous strata decreases from East to West. Also there is reason to believe that the break between the Deville and Quartz Sand Members of the Ellerslie formation is also of less magnitude in the West so that it is possible that Hauterivian sediments may be represented although this cannot be proven at present time.

DEPOSITIONAL ENVIRONMENT

The microflora of the Mount Minnes section also provides a valuable clue to depositional environment. The lowest assemblages are quite rich in marine microflora, mainly belonging to the Dinophyceae. Pollen of the gymnospera genus Classopollis, from a plant which evidently grew in large numbers in coastal regions under dry climatic conditions, is abundant. Bisaccate conifer pollen is quite scarce, indicating a locality removed from the well drained upland environment favoured by the plants producing such pollen.

Trilete spores are quite abundant indicating proximity to a shoreline. Monosulcites, probably the pollen of Cyends which thrive in a hot dry climate is rare as is thin walled circular pollen, possibly in part from members of the Araucaracea. Laevigate circular pollen grains, apparently from plants of a similar type to those producing Classopollis pollen are quite abundant. Thus the environment indicated by assemblages from the lower part of the section, below about 5500' was near-shore marine. The coastline was low lying but apparently not swampy. An upland area supporting a population of conifers was present to the West, lying some distance back from the coastline. The climate was probably dry temperate. The assemblage from the uppermost Jurassic strata (5000' - 5500') contain rare marine microflora and show an increase in Classopollis, Monosulcites and thin walled circular pollen grains. Bisaccate conifer pollen is as abundant, or slightly more abundant than in lower assemblages whilst trilete spores show a sharp decline in abundance. These assemblages are indicative of a dry coastal environment. The decline in trilete spores also appears to correlate with the drier and possibly warmer environment.

Basal Cretaceous assemblages from below 3800' show a very marked change in character indicative of a sharp change in environment. Classopollis is extremely rare or absent and Monosulcites, thin walled circular pollen and laevigate circular pollen are all scarce. Bisaccate conifer is fairly abundant towards the base of this interval but declines gradually towards the top. Trilete spores are dominant in all assemblages, and become most abundant towards the top of the interval. No marine microflora were recorded from the interval. The absence or rarity of Classopollis, Monosulcites, thin walled circular and laevigate circular pollen grains, together with a great abundance of trilete spores, particularly of the Sphagnumsporites and Gleicheniidites types is indicative of a change from the dry environment conditions to wet, swampy conditions. The moderate abundance of bisaccate conifer pollen suggests that well drained uplands occurred a fairly short distance to the West of Mount Minnes area. The spore-pollen spectrum from some of the samples within this interval is similar to that encountered in recent low lying sphagnum bogs.

The upper part of the Mount Minnes section (to 3800') yields assemblages indicative of dryer and better drained environmental conditions. An abundance of trilete spores including Sphagnumsporites and Gleicheniidites indicates that Swampy conditions still prevailed over part of the area. A large increase in the abundance of Monosulcites probably correlates with a warmer dry climate whilst the increased abundance of bisaccate conifer pollen, which is dominant in some assemblages, indicates that well drained uplands were present immediately westward of the Mount Minnes area. Classopollis is rare in all samples and possibly indicates that the area was fairly remote from the sea, although the general decline in abundance of this genus in Cretaceous times may also explain its rarity in these assemblages.

One character of the Kootenay microfloral assemblages that has been previously remarked upon is the absence of typical Schizaeaceous fern spores such as Cicatricosisporites and Appendicisporites (Rouse 1959, p. 308) which are frequently abundant in Cretaceous assemblages. The absence of these forms appears to be due to environmental factors and does not have a stratigraphic significance as has been suggested by Rouse (1959). The recent Schizaeacea do not normally occur in abundance either in a swampy environment, or in association with upland conifer communities such as prevailed in the Western foothills and mountains during Kootenay times. In fact such spores are abundant in assemblages from the Ellerslie formations in the Alberta Plains and become progressively rarer to the West.

Thus, to summarize, the stratigraphic interval represented by the Minnes formation is the same as that named the "Kootenay formation" in Southern Alberta and includes both the "Kootenay" and "Nikanassin" formations of the foothills and mountains north of the Athabaska River. It includes the Jurassic-Cretaceous boundary which is always unconformable, although the unconformity is not always lithologically recognizable, and ranges from Oxfordian to Barremian in age, correlating with the Middle and Upper Vanguard formations and part of the Ellerslie formation of the Western Canada Plains. Palaeontological data may, at a later date, permit further subdivision of this formation, but at the present time the proposed nomenclatural system provides the best subdivision possible and avoids the situation now existing where two formation names are being used with different significance in different areas.

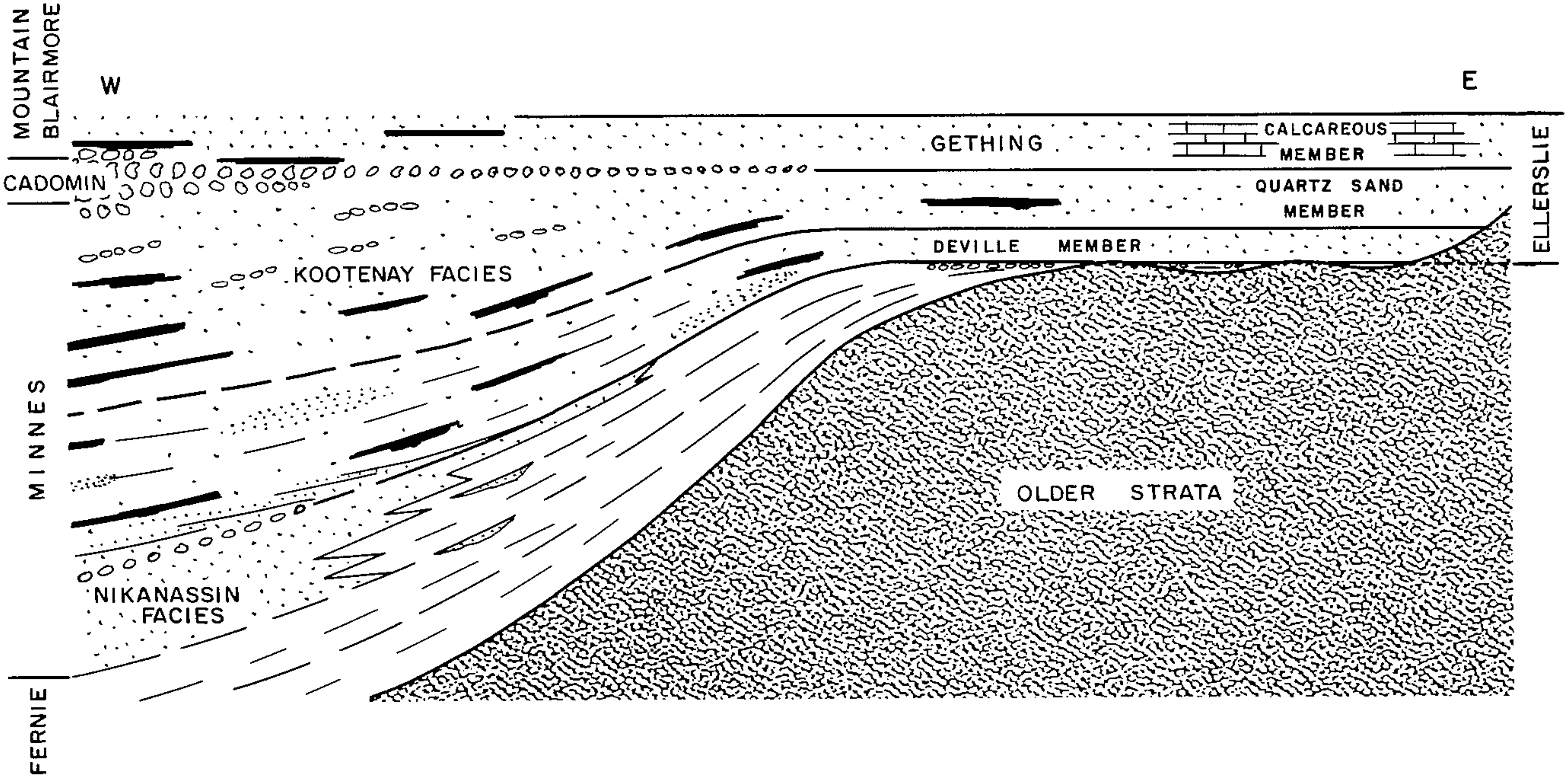
THE TOP OF THE MINNES FORMATION

The top of the Minnes Formation is invariably formed by the remarkable Cadomin conglomerates. Although the contact between Cadomin and Minnes sediments has been described often, there still exists some question about the nature of the observed diastem or unconformity between the two formations. Pitted surfaces - some channelling of the Kootenay top and local angular disconformities were observed on many locations - so at Stinking Springs, Roddy Creek, Minny Ridge, Mount Minnes, Mount McQueen, Coral Creek, Mount May, Miette area, Rock Lake, etc. On the other hand on several locations, notably at Mount Gorman, it has been well observed that the basal Cadomin conglomerates interfingers laterally with Kootenay sediments although angular disconformities exist on top of some Kootenay beds. This shows that there must have existed a certain phase of contemporaneous deposition of Kootenay facies sediments and Cadomin sediments. It is, therefore, not very likely that the hiatus at the top of the Minnes Formation was of great duration.

THE BASE OF THE MINNES FORMATION

The position of the base of the Minnes Formation is highly problematic and is very arbitrarily chosen. Whereas in the eastern sections the choice is somewhat less difficult, it becomes of necessity quite arbitrary in the

PLATE 3



DIAGRAMMATIC SECTION SHOWING RELATIONSHIP BETWEEN MINNES FORMATION IN THE FOOTHILLS AND STRATA ON THE ALBERTA PLAINS western sections. Generally speaking, the base of the eastern Minnes sections is taken at the first appearance of massive sandstone developments on top of the Passage beds of the Fernie group. This pick is made entirely in accordance with the practice of previous workers in this and in other areas. Sandy developments within the Passage beds are common throughout the area. They usually constitute only a relatively small fraction of the total sedimentary contents of the Passage bed complex. The first appearance of the massive sandstones generally marks the change to predominantly sandy sediments. In the western sections the change from the Passage beds to the Minnes Formation is much more gradual. The Passage beds are of a lithofacies and biofacies development which is extremely similar to the one of the Nikanassin facies. The sediments form a highly variable sequence of sands, shales and mudstones with associated clay, ironstone bands and nodules. As in the Nikanassin sediments, biogene tracery and burrows are very common. Fossils become quite abundant. The sandiness of the sediments increases very gradually upwards. The base of the Minnes Formation has been arbitrarily taken at the point where the character of the sediments changes to a predominantly sandy sequence; this change usually occurs above a zone of large yellow clay ironstone nodules and boulders which has been recognized over a large area, along Cote Creek between Kakwa Lake and Sulphur River. This boundary, however, is not necessarily a time line. To date no well developed and consistent marker horizon has been found, which could serve as a consistent and easily correlatable base; thus we are forced to rely on such rather indistinct formation picks. Until such times as more palaeontological data become available, it will be quite impossible to define a clear time line at the base of the Minnes Formation. It may well be that the deposition of sediments of the Nikanassin facies was diachronous from west to east, e.g. that Nikanassin facies sediments were deposited in the northern and western sections at a time when the normal Passage bed sediments of the Fernie group were laid down to the east.

THE MINNES TROUGH

In the preceding discussion we have shown that much of the sediments forming during Minnes times were deposited in very shallow marine to brackish continental environment. The main part of the preceding Fernie Formation was laid down in a marine though fairly shallow environment. There are abundant indications that shore-lines were in close proximity, (E. Mountjoy, 1959). The sediments laid down during this period are predominantly shales. Only towards the end of Fernie time, as indicated by the Passage beds, sands were deposited in significant amounts. The influx of clastic material increased considerably as time progressed and finally led to a complete infilling of the trough - first leading to deposition of the shallow marine Nikanassin and then the brackish continental Kootenay facies types. Shoals and land areas shifted position frequently during the entire time. A western sedimentary source supplied the trough in the area of our present eastern Rocky Mountains with large amounts of sediments. The strong sand developments, accompanied by some conglomerates, reflect the initiation of a phase of marked denudation of the early Nevadan structural nuclei to the west or northwest. The presence of igneous material is highly significant. Exceedingly large amounts of sediments were deposited within the Minnes trough; over 6000' in the west, (Mount Minnes, Mount McQueen, etc.), 2000' on the Nelson Block (Minny Ridge), 1692' at Planet Creek (Hoff Block), 767' at Cabin Creek, and only 280' some distance east of the present Foothills edge at Texaco N.F.A. Simonette. Farther out, in the Plains the amount of sediment is still smaller. The facies developments indicate strongly that the entire trough area remained very close to sea level during the entire time of deposition. Marine and continental conditions shifted position laterally as time progressed, thus causing the great variability in the distribution of the sediments of either the Kootenay or Nikanassin facies. We thus get a clear picture of a very rapidly sinking but equally rapidly infilling sedimentary trough or foredeep to the east of a strongly active Nevadan source. This source, which became highly active from Oxfordian time onwards, dumped large amounts of sedimentary material into the miogeosynclinal space, which was deformed into our present Rocky Mountains during Laramide time.

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LOWER CRETACEOUS COAL DEPOSITS IN THE FOOTHILLS BETWEEN SHEEP CREEK AND WILDHAY RIVER, ALBERTA

G. R. PEARSON

Research Council of Alberta

INTRODUCTION

This contribution concerns itself with coal deposits of the Inner Foothills between Wildhay River to the southeast and Sheep Creek to the northwest.

Topography in this district is controlled by northwesterly trending ridges and valleys which parallel the structural trend, and have developed due to differential resistance to erosion of the underlying rocks. Smoky River lies in a broad, flat-bottomed, glaciated valley which cuts across the northwesterly trending structures. The highest points are in the southeast of the district where elevations of over 8,00 feet are reached. The lowest elevations are in the northeast along Smoky and Muskeg Rivers where elevations are below 3,200 feet. Timber line is at about 6,500 feet above sea level, and so the higher ridge slopes are bare of tree growth.

HISTORY OF COAL EXPLORATION

Interest was first developed in coal deposits of the foothills of central Alberta in 1908 when the Grand Trunk Pacific Railway was being built through the Yellowhead Pass. A mine was opened at Pocahontas in 1911 by Jasper Park Collieries. The Canadian Northern Railway line was built along the north side of Athabasca River in 1914, and in 1917 Jasper Park Collieries opened another mine on this side of the river to supply the railway. The two railways were united to form the Canadian National Railway in 1916, since when a single line has been operated along Athabasca River and through Yellowhead Pass. Both Pocahontas collieries were abandoned in 1921.

A mine was opened at Brûlé on the west side of Brule Lake in 1914 to supply the railway with steam coal. The mine was acquired by Blue Diamond Coal Company in 1917 and was abandoned on August 1st, 1928.

Canadian Northern Railways began sending prospectors and geological parties into the foothills country north of Athabasca River in search of further coal deposits shortly after prospecting began along the river valley. The foothills at least as far north as Smoky River were intensively examined during the years 1909 to 1913, when coal exposures were located and claims staked. At this time, and until 1935, the leasing of mining properties in Alberta was a federal responsibility.

The first recorded prospecting activity north of Wildhay River was in

1909. D. M. McDonald, C. H. Tory, F. Wells and W. N. Lafaire filed application for leases near the headwaters of Moberly Creek on June 24th, 1909. These applications were refused, but on July 7th, 1909, G. L. Cairns, E. V. C. Featherstonhaugh and P. M. Filders were granted leases in a similar area.

First application for leases at Gustavs Flats on Smoky River was made on February 12th, 1910, by G. B. O'Connor. The year 1911 appears to have been a quiet season, but during 1912 and 1913 many leases were taken out along Wildhay, South Berland and Smoky Rivers and along Sheep Creek.

There was very little prospecting activity in the region from 1913 until 1918, probably due to a realization that there were sufficient coal reserves in the vicinity of Brûlé and Pocahontas. However, during the period 1918 to 1921 there was renewed activity and a number of new leases were taken out. Probably many of the old leases had been cancelled by this time. On October 16th, 1919, the Department of the Interior created, by Order-in-Council, a National Coal Reserve including Tps. 55-59, Rs. 7-9, W. 6th Mer. This area along Smoky River was withdrawn from public lease, and so most prospecting work was done along the Wildhay valley. Diamond drilling is known to have been carried out in Thoreau Creek valley in 1923-24. The drilling equipment and steam boiler were pulled up from Brûlé by sled.

A further period of inactivity lasted until 1928, when for two years leases were once more taken out along the Wildhay valley. Blue Diamond Coal Company began to develop an interest in the coal possibilities of the region about this time, after the closing of their Brûlé mine. They began to acquire leases in 1930, and by 1932 held all the leases which were then outstanding. A number of leases were taken out for coal prospects along the Smoky River on May 1st, 1932, as by then the National Coal Reserve had ceased to exist. Blue Diamond Coal Company re-leased its properties in 1935 for a period of 21 years. In 1956, the leases were transferred to McIntyre-Porcupine Co. Ltd.

During the last two years renewed interest has been shown in the coal potential of the Smoky River area. Private interests have re-examined coal exposures between Athabaska and Smoky Rivers in search of coking coals. In the summer of 1959 a road was constructed west from the Muskeg Road down Grande Cache valley and north to Smoky River at Gustavs Flats, where a private ferry was operated across the river. Tunnels were made along a number of seams exposed in the mountainside west of Gustavs Flats and extensive sampling was carried out. Further underground work and diamond drilling is planned for the 1960 and 1961 field seasons.

F. E. O'Neal (1914) published a short description of the Smoky River coal field during the early phase of exploration. The first detailed geological examinations of coal occurrences between Athabasca and Smoky Rivers were made by John MacVicar in 1909 and 1912, whilst working for commercial interests. He again visited the area in 1916 and 1919 when employed by the Geological Survey of Canada. His work is described in three reports (MacVicar, 1917, 1920, 1924).

James McEvoy was sent by the National Fuel Board in 1924 to make a geological appraisal of the National Coal Reserve (McEvoy, 1925).

GEOLOGY

The geological map (Fig. 1) has been compiled from the writer's own observations, from a map of part of Wilderness Provincial Park by Govett (1960) and from maps published by the Geological Survey of Canada (Irish, 1947, 1951, 1954, 1955; Thorsteinson, 1952, Eccles, 1957). The map district is underlain by rocks ranging in age from Precambrian or early Paleozoic up to late Cretaceous or Tertiary. They lie in a series of northwesterly-trending folds which have been disturbed by strike thrust faulting. Precambrian (?) and Paleozoic rocks occur principally in the southwest part of the district, Lower Cretaceous strata outcrop in a broad, northwesterly-trending zone through the center, and Upper Cretaceous and Paleocene (?) rocks underlie the northeast part and outcrop in a few narrow belts near the center of the district.

The Sheep Creek - Wildhay River district extends across parts of the Foothills, Front Ranges and Main Ranges sub-provinces of the Rocky Mountains. There is no major break between the Foothills and Front Ranges sub-provinces in this district but it appears, from extrapolation of the Nikanassin - Boule thrust zone northwestwards from Brûlé Lake, that the Rocky Pass fault separates the two sub-provinces. However, this fault, a major structural feature of the southeast part of the district, disappears before reaching Sulphur River. Farther northwest a zone of smaller thrust faults paralleling the Llama Mountain anticline probably marks the northeast boundary of the Front Ranges sub-province.

Three Paleozoic limestone ridges occur within this section of the Foothills sub-province, but all pitch to the northwest and disappear south of Muskeg River. Two limestone blocks are brought up by the Mahon and Tip Top thrust faults and the other is exposed along the axis of Cabin Creek anticline.

Coal deposits of economic interest occur in the Luscar formation, the stratigraphic position of which is given in the following sequence of Lower Cretaceous strata.

Formation or group		Approximate thickness (feet)	Lithology
Fort St. John group		400 - 500	Shale and sandy shale (marine)
Blairmore group	Luscar	2,000	Sandstone, shale, grey wacke, conglomerate, coal (non-marine)
	Cadomin	50 - 200	Pebble - and cobble-conglomerate (non-marine)
Nikanassin		1,000 - 4,000	Quartzite sandstone, siltstone, shale, minor coal (marine and non-marine)

LEGEND

4d	Brazeau group
4c	Fort St. John group, Alberta group.
4b	Cadomin and Luscar formation
4a	Nikanassin formation
3b	Jurassic
3a	Triassic
3	Triassic and Jurassic, undifferentiated
2b	Mississippian, Pennsylvanian, Permian
2a	Devonian
2	Upper Paleozoic, undifferentiated
1	Lower Paleozoic and Precambrian, undifferentiated

Geological boundary
Fault (arrow indicates direction of dip)
Anticlinal axis
Synclinal axis
Direction of dip
Coal outcrop
Location of tunnels made into coal seams in 1959
Wildcat oil well (abandoned)
Road, graded
Road, ungraded
Boundary, Wilderness Provincial Park
Township boundary (unsurveyed)

The following Geological Survey of Canada publications have been used in compilation of this map-sheet
Moon Creek, map 968A
Adams Lookout (West half) Preliminary map 54-19
Adams Lookout (East half) map 5-1957
Grande Cache, map 1049A
Pierre Greys Lakes, map 996A

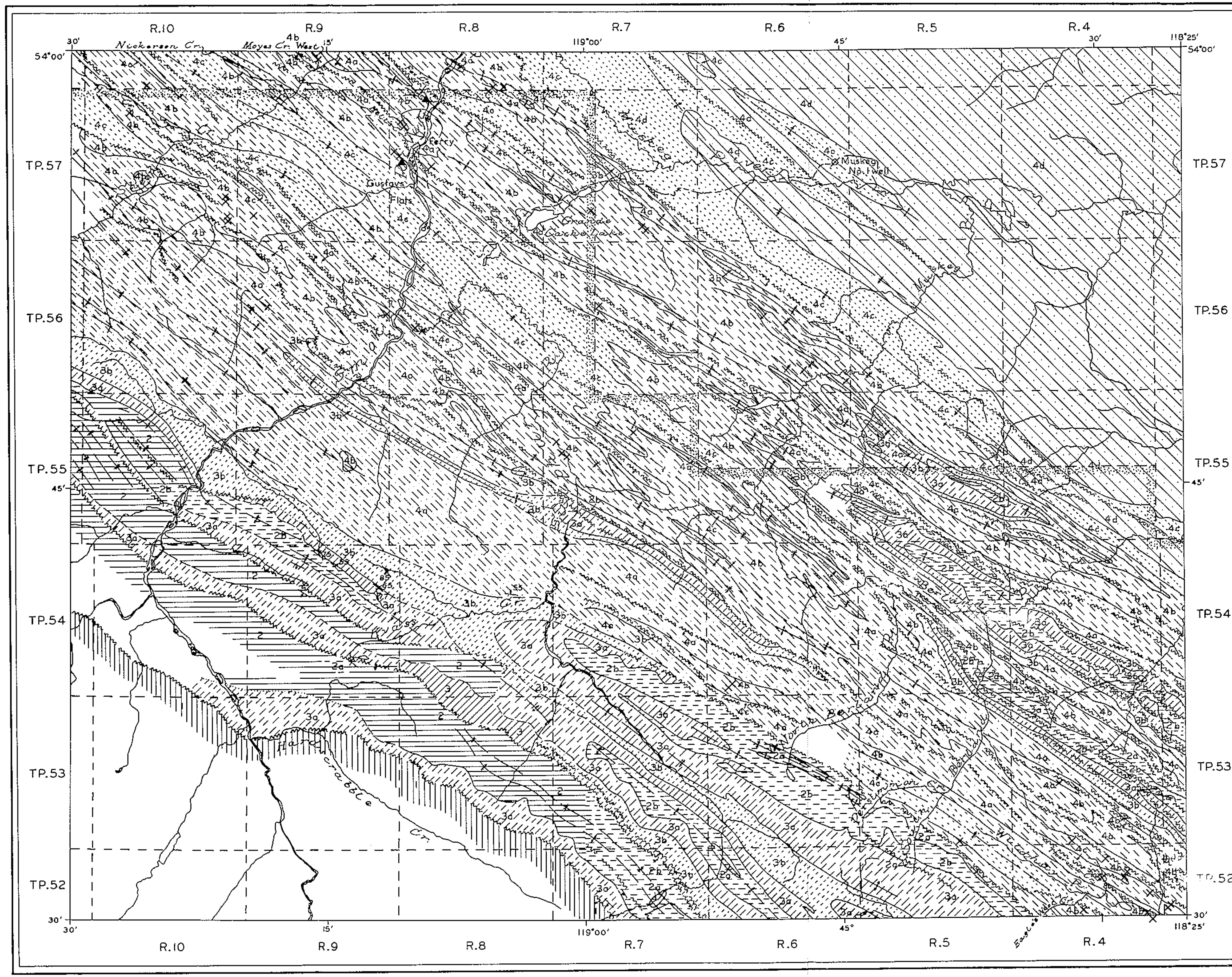

FIGURE I
THE SHEEP CREEK – WILDHAY RIVER DISTRICT, ALBERTA
WEST OF SIXTH MERIDIAN
Scale in Miles
2 1 0 2 4 6 8

PLATE I


FACIES CORRELATIONS
of the
MINNES FORMATION
W.H. ZIEGLER
S.A.J. POCOCK
JUNE 1960
SCALE
0
6
12
24
30
36
100'
200'
300'
TECTONIC POSITION OF SECTIONS
PLANET CREEK
MINNY RIDGE
McQUEEN MTN.
CORRAL CREEK
PROMENADE MTN.
MT. MAY
MT. MINNES
HOFF BLOCK
NELSON BLOCK
LANCASTER FAULT
ZONE WEST OF
BRIDGET CK. FAULT
LEGEND
Dolomite
Limestone
Conglomerate
Sandstone
Siltstone
Shale
Coal
PREDOMINANTLY NIKANASSIN FACIES
PREDOMINANTLY KOOTENAY FACIES
NOTE— BREAKDOWN IN STAGES IS ONLY VALID FOR THE SECTION AT MOUNT MINNES.
THE EASTERN SECTIONS PROBABLY CONTAINS ALL STAGES IN A CONDENSED SECTION.
THE CORRELATED BASE OF MINNES FORMATION MAY NOT BE A TIME LINE.
NELSON BLOCK
HOFF BLOCK
LANCASTER FAULT
BRIDGET CK. FAULT
PLANET CK.
MINNY RIDGE
MT. McQUEEN SULPHUR MTN.
CORRAL CK. & LLAMA MTN.
PROMENADE MTN.
MT. MAY
MT. MINNES
LOCATION: PLANET CREEK
LOCATION: MINNY RIDGE
LOCATIONS: Mc QUEEN & SULPHUR MNTNS.
LOCATIONS: CORRAL CREEK HDWTRS LLAMA MOUNTAINS
LOCATION: MOUNT MAY
LOCATION: PROMENADE MTN.
LOCATION MOUNT MINNES
DATUM BASE OF CADOMIN
Formation
Lithopercentage
Bedding
Age
CADOMIN
MINNES
FERNIE
PASSAGE BEDS
DISTURBED ZONE
TOP OF MOUNTAIN
MINOR FOLDING
LOWER CRETACEOUS
BARREMIAN
VALANGINIAN
BERRIASIAN
JURASSIC
PORTLANDIAN
KIMMERIDGIAN
OXFORDIAN

The Nikanassin formation is a series of sandstones and greywackes interbedded with thinner siltstones and shales. According to Thorsteinson (1952) it is at least 4,000 feet thick on Smoky River near Gustavs Flats, but Irish (1954) found that it thinned to about 1,000 feet to the south and east. The sandstones are medium to dark grey, weathering buff or brownish-grey, and are fine to medium grained. They are generally well bedded or flaggy, but massive beds up to 10 feet thick do occur. The Nikanassin formation is almost barren of faunal remains, but a few poorly preserved pelecypods were found towards the base. Irish (1954) notes that fossils collected from the lower 600 to 700 feet may be of Jurassic age, which would place the Jurassic-Cretaceous boundary within the formation.

The Nikanassin formation is disconformably overlain by the Cadomin formation, a hard, massive conglomerate varying from 50 to 200 feet in thickness. It is a very good marker due to its distinctive character and its ability to produce numerous and conspicuous outcrops. The conglomerate consists of black, grey, green, yellow and white chert pebbles and boulders, usually averaging 1 to 3 inches in diameter, in a sandstone matrix.

The Luscar formation conformably overlies the Cadomin conglomerate. It consists of medium-to-dark-grey, green-grey and brown-grey greywackes, sandstones, siltstones and silty shales, and coal seams. In the vicinity of Gustavs Flats it is about 2,000 feet in thickness, although this must be considered a very approximate figure due to the complexity of folding and faulting.

The formation is considered to be entirely nonmarine. It contains a few poorly-preserved pelecypods and there is an abundance of floral remains. Some sandstone and greywacke beds contain very numberous leaf impressions. Coarser grained rocks of the Luscar formation vary from impure sandstones to low rank greywackes. Sandstones consist of angular to sub-angular quartz grains in a calcite cement. The low rank greywackes contain quartz, plagioclase and perthite grains and rock fragments in an authigenic matrix of calcite, dolomite, chlorite and kaolinite.

Dark grey shales and silty shales of the "Fort St. John" group conformably overlie the Luscar formation. Due to their relative ease of weathering they occur mainly along valley floors, and are not commonly found in outcrop. Very little organic life has been found preserved in the marine "Fort St. John" beds, and there is doubt as to whether they are early or late Cretaceous in age.

COAL DEPOSITS

Thick coal seams are present in the Luscar formation throughout the Sheep Creek-Wildhay River district, and also along strike to the northwest and southeast. Thin seams, up to 6 inches thick, have been reported from the lowest Upper Cretaceous Dunvegan formation (Thorsteinson, 1952). Coal is probably also present in the Uppermost Cretaceous Brazeau formation and in Paleocene strata since thick seams of these ages occur southeast of Athabasca River. None has so bar been reported north of the river.

Coal in the Luscar formation is of the same age as deposits which have been mined at Brûlé, Mountain Park, Cadomin and Luscar to the southeast. Seams occur throughout the formation apart from the upper 400 feet which may represent a northwesterly continuation of the Mountain Park formation facies.

A number of thick coal seams are exposed along the valleys of Wildhay River and its tributary creeks. The biggest seam is over 35 feet thick. It is exposed alongside Thoreau Creek, at the summit of Thoreau Creek pass and near the Wildhay Trail summit. Coal deposits along Wildhay valley are in the extreme southwest part of the Foothills sub-province, close to the Rocky Pass thrust fault. Due to its nearness to the thrust plane, the coal in most outcrops is badly shattered. A very thick seam was reported by MacVicar (1924) near the summit between Wildhay and South Berland Rivers (Sec. 2, Tp. 53, R. 5, W. 6th Mer.). The outcrop is high up on the hillside and only a few hundred feet from the thrust which carried Upper Devonian Palliser limestones over Lower Cretaceous beds. MacVicar described the seam as over 100 feet thick, but this great width is actually because the seam lies along the axis of a small syncline.

There is a lack of coal exposures between Berland and Sulphur Rivers, although no doubt the Luscar formation is coal bearing in this region. Many outcrops have been reported along Sulphur and Smoky Rivers, along Sheep Creek, and at intermediate localities. Excellent exposures of the Luscar formation are to be found on the slopes of Mount Hamell facing Smoky River north of Gustavs Flats. Numerous coal seams are visible in this section and also along small tributary creeks of Smoky River. Thorsteinson (1952) reports 19 seams in a logged section of the upper 958.8 feet of the Luscar formation, but the top 401.5 feet of this section contain only a 1.8-foot seam of poor quality coal. The 18 seams in the lower 557.3 feet of Thorsteinson's section vary in thickness between 0.8 and 28.7 feet.

During the summer of 1959, a party employed by private interests used a bulldozer to strip a section of the Luscar formation on the west side of Smoky River at Gustavs Flats. Nine coal seams, totalling 71 feet in thickness, were exposed in the lower 1,200 feet of the formation. Three of these seams were again exposed near Fox Creek, about two and a quarter miles to the northeast. At Gustavs Flats, tunnels were driven into the mountain side along seven of the seams for distances of from 30 to 80 feet, until unweathered coal was encountered. Several 1-ton samples were taken from each addit for analytical and coking tests. Seam No. 1 is about 50 feet above the Cadomin conglomerate, and seam No. 9 is approximately 1,200 feet above the base of the formation. Table 1 gives details of total seam thicknesses and the high quality sections which were channel sampled by the writer.

TABLE I

COAL SEAMS SAMPLED AT GUSTAVS FLATS, SMOKY RIVER

Seam No.	Total seam width (feet)	Sampled width (feet)	Distance along tunnel (feet)
1	10.2	7.7	70
2	11.3	8.1	52
3	11.5	8.8	70
4	10.7	10.2	80
5	5.0	3.5	50
7	6.3	4.8	33
9	10.7	5.0	20

Proximate analyses made on samples collected at Gustavs Flats and Sheep Creek show the coal to be of low-volatile bituminous rank. At least four seams (Nos. 2, 4, 5, and 7) have good coking properties.

Analyses of samples collected in the past by field officers of the Geological Survey of Canada indicate that the coal occurrences in the Wildhay River area are of high volatile C bituminous rank and do not have coking properties. It should be borne in mind however, that the samples were probably collected from weathered outcrops and do not fully represent the coal present at depth.

MacVicar (1924) estimated that coal reserves in the region between Sheep Creek and Wildhay River totalled more than nine billion tons. A more conservative figure for coal deposits which could be recovered by mining would be of the order of four billion tons.

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WILDHAY STRUCTURE

F. G. FOX *

The Wildhay structure lies in townships 52 and 53, ranges 1 and 2, west of the sixth meridian, in the western part of the northern foothills of Alberta. Its presence has been known for many years, and it was mapped by the Geological Survey of Canada in 1946 (Geol. Surv. Canada, Map 963A, "Moberly Creek" by A. H. Lang). However, despite the fact that it is an obvious structural culmination, it was not tested until 1955, when drilling of the Triad Wildhay 9-35 well (Lsd. 9, Sec. 35, Twp. 52, Rge. 2, W6M) was started.

In this part of the foothills, the stratigraphic sequence is generally similar to the succession in the central and southern foothills. There are, however, minor differences. The Exshaw formation is not present at Wildhay or in the front ranges immediately to the west. Another notable absentee is the Nordegg member of the Fernie formation. It is represented at Wildhay by about ten to fifteen feet of black calcareous siltstone. The Cretaceous closely resembles the Cretaceous further south, except that the interval between the Luscar and Cardium formations is occupied by Fort St. John, Dunvegan, and Blackstone, rather than only Blackstone beds. The presence of the Dunvegan, although it is only 20 feet thick, makes necessary particular care in mapping, as the Dunvegan sandstone closely resembles Cardium sandstone in small outcrops.

In the vicinity of the well, the outcrops are all of the Nikanassin, Cadomin, and Luscar formations.

The structure is anticlinal at the surface, and the crest maximum of the fold is outlined by the Cadomin formation. It is a local culmination on a long narrow uplift, of which the Solomon Creek and Cabin Creek anticlines are also elements. The apparent local closure at Wildhay is about 400 feet to the northwest, as measured on the Cadomin, and somewhat more than this to the southeast; the true all-around closure is considerably more. Northeasterly closure is provided by a series of imbricate thrust faults.

Northeast of the core of the structure, the geology is difficult to map and to interpret. Exposures are fairly good in the stream valleys for about 1 1/2 miles, to the base of the Brazeau formation, and they show the northeast flank of the structure to dip at 30 to 80 degrees. Further northeast lies a belt, about 3 miles wide, of poor exposures of the Brazeau formation. The rocks are much faulted, by both northeast and southwest dipping thrusts. Lang (Op. Cit) shows a series of klippen in this belt, with repetition of the Solomon sandstone (base of the Brazeau) and the lowermost beds of the Brazeau formation. Lang's interpretation is of particular interest, as the most obvious root for the klippen is the northeasterly dipping Fox Fault (named for Fox Creek, which was not named after the writer). The cross section, Figure 1, does not admit the presence of

* Triad Oil Co. Ltd., Calgary, Alberta. The permission of the management of Triad Oil C. Ltd. to publish this note is gratefully acknowledged.

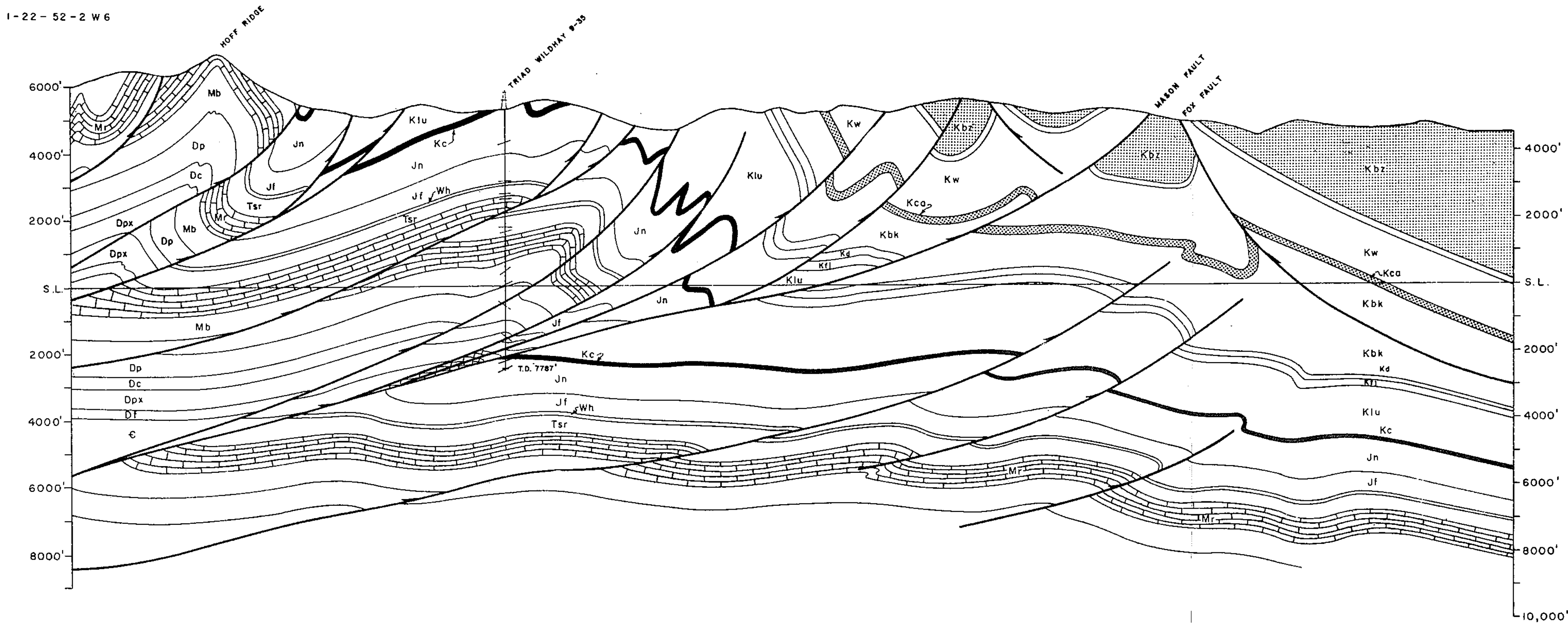


FIGURE No. 1

WILDHAY STRUCTURE
NORTHERN FOOTHILLS OF ALBERTA

F. G. FOX, Triad Oil Co. Ltd. JULY 1960

SCALE

1 1/2 0 1 2 MILES

klippen, the apparent klippen being shown as underlain by a west dipping major and an east dipping minor thrust. Nevertheless, Lang may be right in suggesting the presence of klippen. It is entirely possible that the supposed klippen are the remains of a gliding sheet that slid northeastward off the flank of the rising Solomon Creek - Wildhay - Cabin Creek uplift. Their apparent relationship to the Fox Fault is probably spurious.

The Triad Wildhay 9-35 well was originally drilled as a Mississippian test after a geological survey but without the assistance of a geophysical survey. It seemed clear that a well could be expected to reach the Rundle formation at a depth of no more than 2900 feet, and possibly as little as 2600 feet. In fact the Rundle was found at 2672 feet. A fault was encountered at 3026' and the lowermost Fernie and all of Triassic beds were re-drilled. The Rundle was encountered a second time at 3745 feet, and after 293 feet of non-porous beds had been drilled, drilling was suspended at 4038'.

Some months later, after reconsideration of the structural data and after more stratigraphic data had been obtained, drilling was resumed with the intent of testing the Devonian, then believed to be involved in the structure. The Palliser, Alexo, Mount Hawk, and part of the Perdrix formations were penetrated in sequence, but at 7020 feet, the first of three faults was met, with Perdrix thrust over Whitehorse and lower in the hole, Whitehorse over Nikanassin beds. Drilling was continued to a total depth of 7787 feet, the bottom being in Nikanassin beds.

Figure 1 illustrates the structure as presently interpreted. It is clearly a much faulted drag fold on a major sole thrust. The place of emergence of the sole thrust is in doubt - indeed it may not emerge as a major fault at all. It is probable, however, that the sole thrust is the southerly extension of the Mason fault, which is a prominent thrust some 20 miles northwest of Wildhay area. At Wildhay, it has, with its subsidiary faults, about 6000 feet of throw and 13,000 feet of displacement.

The Fox fault is apparently a northeast dipping thrust; it probably is not, as may be suggested, the easterly dipping limb of a folded west dipping thrust. It is of moderate throw - 1000 to 1500 feet - but can be traced many miles along strike northwest, to the Muskeg River. Its displacement is clearly demonstrated in many places by easterly dipping repetitions of the Solomon sandstone.

The broad belt of Luscar beds east of the core of the structure is moderately to tightly folded. There are probably more faults cutting the Luscar than the section suggests, but there can be none of major throw.

The Wildhay area is intermediate, geographically and geologically, between the central and southern foothills of Alberta, where there are few if any folds not formed over thrusts, and the foothills of British Columbia and the Smoky River area in Alberta, where faulted and non-faulted folds are common. The structure at Wildhay shows characteristics of both regions. Thus, Hoff Ridge (Figure 1) is clearly a faulted fold, whereas the Wildhay anticline is equally clearly a drag fold.

Concomitant and causative with the gradual change of style of structure from southeast to northwest in the foothills are thickness and facies changes in the sedimentary sequence. Some of these are, as has been said, evident in the Wildhay area.

CONCENTRIC FOLDING

C. D. A. DAHLSTROM

California Standard Company

INTRODUCTION

The purpose of this paper is to illustrate the principles of concentric folding with examples from the foothills and mountains of central Alberta. The writer is indebted to the California Standard Company for permission to publish the low level oblique aerial photographs which were taken for company use by K. T. Hyde under the direction of G. G. L. Henderson.

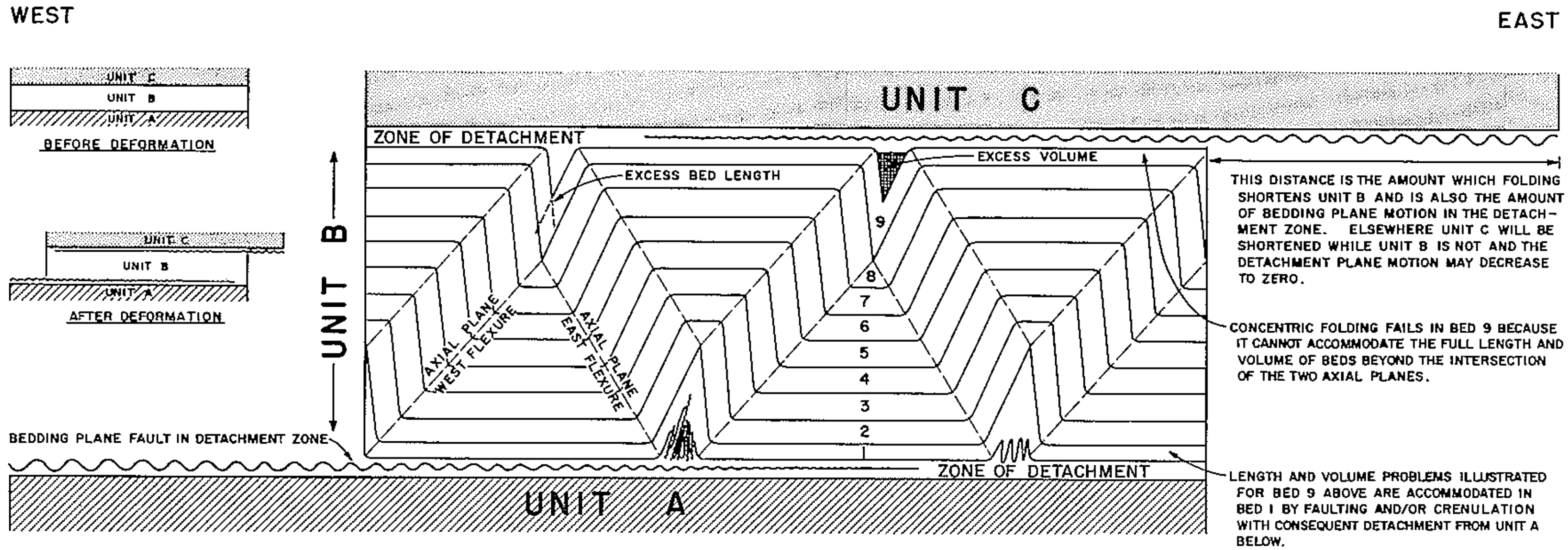
PRINCIPLES OF CONCENTRIC FOLDING

Concentric folding, by definition, is characterized by consistent thickness of individual beds throughout the folds. Since this degree of folding produces no significant change in rock volume it follows that the length of individual beds must also remain consistent. These two factors of constant length and thickness impose limitations upon the vertical extent of concentric folding. In Figure 1 the two common types of concentric folding are shown in idealized form. As illustrated, the anticlines increase in size upwards and the synclines downwards, the increase in one being neatly compensated by the decrease in the other. This balance cannot persist beyond the centre of curvature in simple concentric folds or the intersection of the axial planes of the flank flexures in box folds. Thereafter excess volume and length must be accommodated through non-concentric folding, flowage or faulting. This non-concentric shortening produces bed thickening which fills the synclinal and anticlinal cores thereby causing detachment from the adjacent units. (See Figure 1). This detachment ordinarily takes place along incompetent horizons and divides the stratigraphic section into a number of units. Each unit will be shortened by an equivalent amount but not necessarily by concentric folding. The nature of the unit generally determines which one of the shortening mechanisms will apply. Neither is it necessary that the shortening in all units take place in the same general area because bedding plane displacement within the detachment zone provides a means of transferring motion over considerable distances. (See Figure 1).

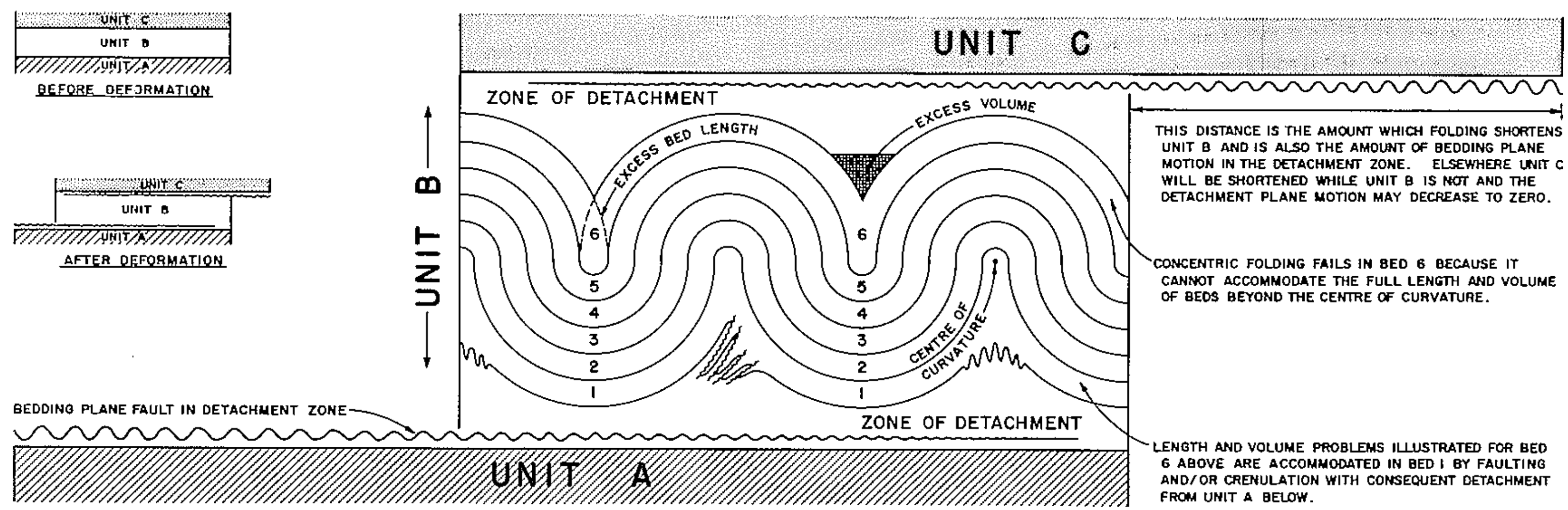
In the mountains and foothills the upper units are generally shortened in the east and the lower units are shortened in the west.

ILLUSTRATIONS

The existence of the simplest form of concentric folds in the Paleozoic rocks of the foothills is illustrated by the anticline and syncline of Figures 2 and 3. The centre of curvature in the Cabin Creek anticline (Figure 2) is in the sharply flexed crestal beds just above the tree line. In the syncline (Figure 3) the centre of curvature is at the headwaters of the creek which flows down the



SIMPLE BOX FOLD



IDEAL CONCENTRIC FOLD

trough of the syncline.

The ideal examples of Figure 1 show the concentric folds terminating both upward and downward against detachment zones. In the sub-horizontally plunging structures of the foothills and mountains it is generally impossible to see the full thickness of a concentrically folded unit. Consequently pairs of examples were selected which show the upper half of one structure and the lower half of another. The inference that the two can be combined into one typical structure is probably justified when care is exercised in choosing comparable examples from the same general area.

A comparable anticline - syncline pair is present in mountain Paleozoic rocks in both Figures 4 and 5. Upwards from the Palliser in Figure 4 the anticline increases in size and the syncline decreases toward a zone of detachment somewhere in the Triassic. The example is not perfect since there is a minor amount of non-concentric thickening and detachment within the Banff in the synclinal trough in the right foreground. In Figure 5 the Palliser anticline at Roche Ronde dies out downward into crenulations in the Cambrian on the Miette thrust. The Miette thrust is not a simple detachment zone since it is gradually cutting up section to the north. When considered together Figures 4 and 5 represent as near an approach to the ideal example of Figure 1 as one can expect in nature.

Similarly the simple box fold of Figure 1 is approximated in foothills Mesozoic rocks by the structures in Figures 6 and 7. In the Sterne Creek anticline in Figure 6 the upper part of a box anticline above the point where the axial planes of the two flank flexures intersect is shown. Two minor detachment zones, one in the Nikanassin and the other in the Luscar are indicated by the "ears" on the east and west shoulders of the anticline. In Figure 7 a similar box anticline is seen to pinch off downward in crenulations on the Mount Russel thrust. The Mount Russel thrust, like the Miette thrust of Figure 5, is cutting up section.

CONCLUSIONS

Relatively simple concentric folds are present in the Paleozoic and Mesozoics of the mountains and foothills of central Alberta. The major deviation from the ideal is evident in the underlying faults which generally cut up section rather than remaining in the bedding plane position illustrated in Figure 1. It is believed that these represent compound detachment zones consisting of a thrust cutting up section from one bedding plane zone to another.

LIST OF FIGURE TITLES