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GEOLOGY OF THE GROUNDHOG COALFIELD
UPPER SKEENA RIVER AREA
BRITISH COLUMBIA
FOR
B. C. HYDRO AND POWER AUTHORITY

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ABSTRACT

Semi-anthracite coal occurs in rocks of the Bowser assemblage in the upper Skeena River area, northern British Columbia. The deposits were discovered 75 years ago by surveyors who were mapping rail routes for the Federal Government.

The Groundhog coalfield lies in a relatively remote part of the Province and all early workers in the coalfield noted that rail access will be necessary for coal mine development. It is significant therefore that the northern extension of B. C. Railway passes through the coalfield and rail steel is just 20 miles from the coalfield at the time of this writing.

Fish, wildlife and water supplies are important resources of the area, and the British Columbia Fish and Wildlife Branch have made specific recommendations to minimize the effects of coal mining operations. Compliance with these recommendations is not considered to be an obstacle in the development of a mine.

Exploration work in the coalfield commenced in 1904, and preliminary studies were made of a rail route. All work ceased with the advent of World War I. No further work was done in the coalfield until 1968, when a geological survey was made by a mining company. In 1969 and 1970 a joint venture of three mining companies conducted a geological mapping program and drilled six diamond drill holes.

Four rock stratigraphic units are recognized, one of which contains seams of semi-anthracite coal which are from one foot to 11 feet or more in thickness. The coal bearing rock unit is known to occur over an area of about 119 square miles, but of that area 58 square miles contains coal seams which are believed to offer the greatest potential for economic development. An area of 35 square miles is designated as the primary target area due to its' geographical location, geological setting and coal quality.

The rocks throughout much of the coalfield are known to be folded and faulted. However certain areas exist where thick coal seams are relatively undisturbed.

Raw coal quality throughout the coalfield varies widely.

Coal which was cleaned by heavy media separation is of excellent quality and no difficulty is anticipated in cleaning coal to acceptable limits for specific uses. Coal cleaning methods will be designed to remove as much ash as specific uses demand by using heavy media, water cyclone or froth flotation.

Coal samples were cleaned at various specific gravities during the testing. The average coal quality of all seams greater than 3.0 feet in thickness, from both surface sampling and diamond drilling is summarized:

Average yields at various specific gravities from 1.58 to 1.75	38.8 %
Ash	9.8 %
Volatile matter	7.2
Moisture	.5
Fixed carbon	82.4
Sulfur	.6
Btu/lb.	13,366

The coal is a high quality thermal coal, suitable for thermal power generating stations.

It is estimated that 50 million tons of coal reserves will be required to operate a 500 megawatt thermal power generating plant for 35 years.

It may be assumed that coal production will be from open pit and underground mining operations. Normal underground mining procedures are anticipated as roof rocks are competent sandstones and shales. Early workers in the coalfield noted normal underground mining conditions. Minor gas was noted in fresh drill core. However gas commonly occurs in anthracite coal measures. Spontaneous combustion in the coal seams is not considered to be a problem.

The coalfield is in the very early stages of exploration, so therefore it is not possible to accurately calculate the coal reserves or the tonnages of recoverable clean coal. However, it is shown that the area between Evans Creek and Discovery Creek is underlain by relatively undisturbed coal seams. In the Upper Discovery Creek - Evans Creek area there are inferred about 12 million tons of open pit coal to a depth of 200 feet. In the Lower Discovery Creek area about 46 million tons of open pit coal reserves are inferred to a depth of 100 feet. An additional underground reserve of 290 million tons are inferred underlying the Discovery Creek - Evans Creek area.

A three year exploration program is proposed. The first years' work includes detailed geological studies and trenching. The cost of this work is expected to be about $348,000.

Diamond drilling, geological work and trenching during the second year of exploration would cost $610,000.

During the third year of exploration diamond drilling would be intensified and exploration adits would be driven in order to test underground mining conditions. Large coal samples would be taken for pilot plant tests. Costs of this program would be about $2,000,000.

Total estimated cost of the three year program is $2,958,000.

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PROPERTY AND LOCATION

The Groundhog coalfield lies in northwestern British Columbia in the Cassiar Land District and in the Omineca Mining Division (Figs. 1 and 2).

The area is shown on the northeast part of the Bowser Lake topographic map (National Topographic Series 104A, scale, 1:250,000) and on the McEvoy Flats topographic map (National Topographic Series 104A/16, scale, 1:50,000). The Groundhog coalfield continues westward and beyond the limits of the McEvoy Flats map and in that area topographic coverage is from maps which were made in 1969 and 1970 for a study of the coalfield (Tompson, Jenkins and Roper, 1970).

The coalfield occurs within the area bounded by 56°47' to 56°58' north latitude and 128°07' to 128°30' west longitude.

Three important rivers have their headwaters near the Groundhog coalfield. Skeena River (Fig.1) rises 15 miles northwest of the coalfield and flows southeasterly through the center of the coalfield. Nass River heads 3 miles west of the coalfield and flows southeasterly along its' western edge. Stikine River rises 20 miles north of the coalfield and flows northeasterly around Spatsizi Plateau.

Stewart, B.C. at the head of Observatory Inlet on Portland Canal is the nearest town and is about 95 miles southwest from the Groundhog. There is no road nor rail connection between Stewart and the coalfield.

The road between Stewart, B.C. and Dease Lake, B.C. lies about 50 miles southwest from the coalfield. However there is no connection between the coalfield and the Stewart-Dease Lake road, except along the grade of B.C. Railway.

B.C. Railway bisects the coalfield as it traverses the area westerly and northwesterly from Kluatantan Creek and along Skeena River to Beirnes Creek (Plate 1 and Fig.1). At the time of this writing the end of railway steel is at Chipmunk Creek, about 20 miles southeasterly from the Groundhog coalfield. Steel is expected to be in the coalfield by summer, 1977.

The distance by rail from the coalfield to Fort St. James is 237 miles; to Prince George, 309 miles; to Prince Rupert via B.C. Railway and C.N. Railway, 767 miles and to Vancouver, 804 miles.

Early workers in the Groundhog coalfield (Malloch, 1912 and Campbell-Johnston, 1912) wrote that a direct route to tidewater exists down Nass River to Nasoga Gulf, near the mouth of the Nass. Nasoga Gulf is 130 miles from the coalfield and offers a natural, deep water port site. The Gulf is about one mile wide and 6 miles long. It is undeveloped.

There are no Coal Licences in good standing in the Groundhog coalfield as the last Licences which were held by National Coal Corp., forfeited in December, 1974. At that time a Coal Reserve was in effect and the forfeited ground became part of the Reserve. The Reserve is still in effect at the time of this writing.

HISTORY

The earliest published record of coal occurrences in the Groundhog area was a report by Dupont (1900) for the Canadian Department of Railways and Canals. The discovery by Dupont was made near the confluence of Didene Creek and Spatsizi River, some 20 miles northwest of the area with which this report is concerned.

Malloch (1912, p.73) reported,

"The first authentic discovery of coal in the Groundhog field was made by Mr. James McEvoy in 1903, who staked a number of claims on his discoveries".

The locality where McEvoy made his discoveries, he called Discovery Creek, a name which has endured. W. W. Leach stripped and sampled some of the seams in 1904 for Western Development Company. By 1904 Western Development Company owned 16 sections which had been acquired through prospectors in their employ or by purchase from prospectors. The 16 sections were surveyed in the summer of 1905 by A. W. Harvey and the registered owners were 16 different prospectors, including James M. McEvoy and W. W. Leach. It is noteworthy that McEvoy was the recorded owner of Lot 126 in which the Upper Discovery Creek seam occurs and Leach was the recorded owner of Lot 136 in which the Abraham Creek seam occurs. At that time the Upper Discovery Creek seam and the Abraham Creek seam were the best seams which were known in the Groundhog and were thought to be the same, although they outcrop 2½ miles apart.

In 1908 and 1909, J. Fredrick Walter and Charles Fergie worked at Discovery Creek and at Abraham Creek opening and sampling new coal seams (Malloch, 1912, p.73). This work was apparently done under an agreement with Western Development Company. Malloch notes (1912, p.73) that McEvoy was back in the field in 1911 with a large work force. However, Robertson (1912, p.k88) states that Western Development was, "quite unrepresented in the field during the season of 1912".

The sections which were owned by Western Development Company covered the area of Evans Creek, Davis Creek, Currier Creek and Abraham Creek and were comprised of Lots 126 to 141.

In 1909 Amos Godfrey and Frank A."Groundhog" Jackson staked some coal claims on Trail Creek. McEvoy and Leach, had undoubtedly ridden past the coal occurrences on Trail Creek many times, but did not stake ground here. It may be concluded therefore that they recognized that the rocks on lower Trail Creek are intensely folded and faulted and are not likely to contain workable coal seams. The claims which were staked by Godfrey and Jackson were subsequently acquired by B.C. Anthracite Coal, Ltd. who were financed by National Finance Company. They were surveyed in September, 1911 by A. P. Augustine, B.C.L.S. and by T. H. Taylor, B.C.L.S. B.C. Anthracite Coal, Ltd. ultimately owned 40 surveyed Coal Licences; Lot numbers 978 to 999 and 2179 to 2196 and 20 unsurveyed licences. These claims surrounded Western Development Company on the north, south and east.

Robertson (1912, p.k87-94) reported, that in 1912, B.C. Anthracite Coal, Ltd. established an exploration camp at Jackson Flats under the direction of H. F. Glassey. The company also established a good base camp on Trail Creek about 1¼ miles above its' confluence with Skeena River. The camp buildings were well constructed log buildings with plank floors and spruce shake roofs. The main camp buildings which were photographed by Evans (1912) are still standing (Tompson, et.al., 1970).

During the winter of 1911-1912, F. B. Chettleburgh and a party of miners drove two tunnels into coal seams on the east side of Trail Creek.

During the summer of 1912, Arthur Challoner, mine foreman for B.C. Anthracite Coal and a group of miners were actively engaged in driving 9 prospect tunnels on Trail Creek, Jackson Creek, Brewer Creek and Currier Creek. According to Robertson (1912, p.93) Challoner and 6 to 8 miners would be working at Trail Creek during the winter of 1912.

During the summer of 1911, B.C. Anthracite Coal, Ltd. had a group of miners working on 7 or 8 adits at Telfer Creek. The foreman at Telfer Creek was Seth Godfrey, who according to Robertson, would be occupied driving tunnels during the winter of 1912. This writer does not believe that either of those winter programs were actually done. A log house and shop building were constructed at Telfer Creek in much the same style as that at the Trail Creek site. The walls are still standing, but the roof is collapsed.

Another log house of similar design and construction was found by the writer near the junction of Falconer Creek and Skeena River. It probably was also built by B.C. Anthracite Coal, Ltd., but no records of prospects in that area have been found. This log building is in relatively good condition.

In the late summer of 1911, George Watkin Evans, a coal mining engineer from Seattle examined the B.C. Anthracite Coal, Ltd. properties and the Western Development Company properties (Evans, 1912). Evans had a distinct advantage in examining the coalfield at that time, as the prospects were newly dug and the miners and prospectors were actively engaged in making the cuts fresh so that Evans could make satisfactory evaluations of them. As a result, he was able to make a thorough examination of the southern half of the coalfield. He made these comments:

> "Portions of the field will prove fairly regular, while other portions are probably so severely faulted and folded as to be valueless.
>
> "There are some beds containing coal of excellent quality - the best domestic coal, in fact in the writers' knowledge, on the Pacific coast. For coal of this quality, a reasonably good market is assured. In portions of the field mining conditions admit of production at reasonable costs. In other portions costs will be prohibitive. Railway communication to tidewater is feasible, and transportation charges will, in relation to the grade of coal be moderate. Within the Skeena, Clappan and Nass watersheds will be found, it is believed, a sufficient quantity of high-grade mineable coal to warrant the building of a railway".

In June, 1910 R. C. Campbell-Johnston, a coal mining engineer formerly with the Cardiff collieries, examined some coal lands in the Kispiox Valley for J. G. Scott of Quebec and Leon Benoit, of Winnipeg. Benoit, in correspondence with Campbell-Johnston later that summer (August 5) said that he had employed George M. Beirnes to stake 20 sections of coal lands north of Groundhog Mountain. This is probably a misrepresentation of the facts, although George Beirnes did actually stake some claims, but probably for his own account, and subsequently sold them to Benoit. Benoit wanted Campbell-Johnston to examine the claims in the Groundhog, but Campbell-Johnston did not receive word of this until September. He immediately left for Hazelton by steamer, arriving on September 24. He enlisted the aid of George M. Beirnes who functioned as guide and packer.

George Beirnes was one of British Columbias' most famous packers. He lived at Hazelton and packed between Babine Lake and Telegraph Creek, supplying prospectors, miners, and telegraph operators along the Yukon telegraph line. With George Beirnes' pack string and some Indians whom Campbell-Johnston hired for backpacking, they travelled the telegraph trail from Hazelton to Blackwater (Damdochax) Lake, a distance of 135 miles.

From Blackwater Lake they planned to backpack over Groundhog Pass, where they would need to use snowshoes, then down Trail Creek to Jackson Flats on Skeena River and up the trail past McEvoy's camp to Beirnes Creek. The distance is 45 miles.

At Blackwater Lake however, the Indians refused to go further, due to the lateness of the season. Campbell-Johnston wrote (1910-2,p.4);

> "Discretion and diplomacy had to come into play to prevent the Indians deserting us and returning alone to their village at Kispiox..."

He observed that,

> "... our journey had inadvertently delayed until really too late in the fall of the year, and was commenced and undertaken against the advice of over careful old timers among the white settlers, and also the wiseacres and weather prophets among the Indians. 'Witch' Mabel with uplifted hands warned us at Blackwater of certain death for the whole packtrain and starvation for ourselves.
>
> "...A hasty start was made from Blackwater up the North Fork with three Indians and three dogs to pack full loads ..."

Campbell-Johnston, Beirnes and their packers spent 6 days examining the coal occurrences on Beirnes Creek and then backpacked out to Blackwater Lake. From a telegraph station (presumably the one at Fifth Cabin near Blackwater Lake) he wired Benoit in Winnipeg on October 24;

> "... examined coalfields finding property very much in prospect stage found one continuous unbroken commercial seam high class hard coal four feet thick am anticipating one or two more ... racing snow hoping to save packtrain".

J. G. Scott and Alexander Hardy formed the B.C. Anthracite Syndicate in November or December, 1910 and through the Syndicate raised $150,000 for another expedition to the Groundhog in 1911.

On June 17, 1911, the newspaper "Omineca Herald" recorded as the lead column on the front page;

> "A large party, including Leon Benoit of Winnipeg and R. C. Campbell-Johnston, mining engineer of Vancouver, arrived on the Port Simpson en route to Groundhog Mountain and the coalfield of the upper Skeena".

The Herald quoted Campbell-Johnston;

> "Besides Mr. G. F. Monckton, a well known mining engineer and geologist, we have a party of seventeen men".

He further said:

> "The government has granted $3,000 for a trail along the Skeena from Fourth Cabin to enable people to get in and out later in the year ..."

The Herald noted:

> "A pack train of 58 horses had been secured for the first trip which leaves the party a little short as it had been intended to take seventy. As the train will be working all summer packing supplies, no shortage is looked for ..."

In 1920, writing to J. G. Scott, then Chairman of the British Columbia Skeena Coal Co., Ltd., Campbell-Johnston reminded him that they had a crew of 50 miners with 100 horses working the Groundhog in 1911. The variation in numbers of men can be explained in that he apparently added miners as the season progressed.

It is remarkable that from mid-June, 1911, until they departed Groundhog, probably in early October, that they prospected about 50 square miles of area, dug more than 400 feet of trenches, some up to 14 feet wide and some up to 12 feet deep, drove at least 100 feet of tunnel, and sank 55 feet of winzes, all by hand, and using wheel barrows and windlasses all of which had to be made by hand, on site. In addition, they achieved a good understanding of the geology of the area and a fairly complete understanding of the geography, which was necessary in planning for railroad access to the coalfield.

In 1911, G. S. Malloch conducted a geological evaluation of the Groundhog coalfield for the Geological Survey of Canada (Malloch, 1912). Malloch did most of his work in the area in which McEvoy and Campbell-Johnston were working and made a definite contribution to the geology of the area. He noted that the coal-bearing rocks do not occur between Groundhog basin and the Kispiox area (p.78). He produced a topographic map and geological map of the area and measured three stratigraphic sections. Unfortunately his time in the Groundhog coalfield was limited to 7 weeks.

Malloch and Campbell-Johnston had some differences of opinion regarding sampling. Malloch took continuous chip samples of the coal seams, including shale partings and bone. Campbell-Johnston said that in a product for markets, shale and bone would be removed by picking, screening, and washing and so in taking his samples he omitted shale and bone and reported as such. He wrote Benoit in December, 1911;

> "Malloch seems hopeless. He drove us distracted with his assinine propensities this summer. McEvoy and I were fondly hoping we had steered him right, but apparently not.
>
> "We have to educate people that the analysis of coal put on the market does not correspond to coal in the seam, plus shale partings, bone, roof, etc."

A large block of 145 sections was owned by Angus Beaton and Anthony Kobes. These sections lay west of Western Development Company and B.C. Anthracite Syndicate, at the headwaters of the Nass River and on Anthony Creek, Panorama Lake, Currier Creek and upper Beirnes Creek.

Several coal occurrences were observed by this writer within the area covered by the Kobes-Beaton claims, but no evidence of earlier physical work was found although old campsites were found. Campbell-Johnston (1911) examined some of the claims for Kobes and Beaton, but in his report made no mention of physical work on the claims. They apparently prospected the claims (Dowling, 1915) but did no trenching or tunneling.

Hundreds of claims were staked by other prospectors further up the Skeena River and on to the Klappan, but they are out of the area with which this report is concerned.

It was evident to the early workers in the Groundhog coalfield that any plan for economic development was dependent upon rail access.

Malloch (1912, p.76) noted the need for a railway to the coalfield and said the shortest route would be to Stewart. He pointed out that 12 miles of railway had already been built up Bear River from Stewart, but that difficult rock work and a long tunnel would be required to get through Bear Pass. He wrote:

> "These difficulties would be avoided by building a line up the Nass from Nasoga Gulf, which offers the nearest suitable harbour."

Campbell-Johnston (1912 p.13) reported:

> "Mr. Leon Benoit ... has a charter called the 'Nass and Skeena River Railway', which is subsidized already for 100 miles by the Federal Government to $35,000 per mile, to build down to Nasoga Gulf near the mouth of the Nass River."

He also reported that in 1912 Sir Donald D. Mann, the British railroad builder, secured a charter for a railway called, "Canadian North-Eastern Railway" (1912, p. 1 and 7) which was to build from Stewart, up Bear River and Bear Pass and into Nass Valley. This railway was to ultimately reach Edmonton after traversing the Cassiar, Omineca and Peace River districts. Sir Donald Mann is reported to have secured an option on 145 sections in the coalfield in 1912.

In 1913, Lord Rhondda, a famous coal producer from Great Britain, sent a group of engineers to look into the feasibility of production from the Groundhog coalfield. They conducted preliminary reconnaissance surveys in order to locate feasible rail routes from the coalfield to tidewater. Lord Rhondda bought into the Nass and Skeena River Railway Charter which was owned by Scott and Benoit. However, all efforts to build a railway were terminated with the advent of World War I (Campbell-Johnston, 1920, pp. 3 and 4) and with Lord Rhondda's death during the war years.

The Geological Survey of Canada sent a party into the Groundhog in 1948 under the direction of A. F. Buckham, assisted by B. A. Latour.

They travelled to the coalfield by horse over the old Yukon Telegraph Trail to Damdochax (Blackwater) Lake and then up the Groundhog trail to the coalfield. The trails were in very poor condition after 37 years of disuse, and their trip was accomplished with much difficulty and hardship.

The report which resulted from their work (Buckham and Latour, 1950) summarized all known previous work and recorded detailed information on most of the known coal occurrences. However, very little was known of the structure or stratigraphy of the coalfield so that no conclusions were possible as to the number of coal seams, their thicknesses or their stratigraphic positions. Nor was it possible to correlate the various coal occurrences.

Buckham and Latour (1950) concluded:

> "In a field of this great size it is probable that areas exist where the coal is sufficiently clean and sufficiently undisturbed to be mined successfully, but it will be expensive to find such areas and to determine their size relative to that of the field as a whole. It is not considered that prospecting for such areas is advisable unless, or until transportation conditions are much more favorable than at present."

In 1966, Coastal Coal, Ltd. acquired Coal Licences on 14 surveyed lots and 10 unsurveyed sections in the Groundhog coalfield and acquired sole prospecting rights to an area of about 740 square miles.

A party of 8 geologists, assistants, and prospectors worked under the direction of R. V. Best during the summer of 1968. They used a helicopter and conducted geological mapping over a very large area, extending from Mount Jackson northwestward to the Little Klappan River and from Nass River northeastward to Buckinghorse Lake, covering an area of about 1500 square miles.

Their report was prepared by J. M. Black (1968). He concluded:

> "... The Ground Hog area and the area adjoining to the southwest do not contain minable coal seams."

In 1969 and 1970 a Joint Venture composed of Placer Development Ltd., Quintana Minerals Corp. and National Coal Corp. geologically mapped about 200 square miles and prospected about 100 square miles of the southern part of the Groundhog coalfield. The work was under the direction of Willard D. Tompson, signator of this report, assisted by geologists David M. Jenkins, Michael W. Roper and Geoffery Bird, and four geological assistants and 2 prospectors.

Six diamond drill holes were drilled late in the season of 1970.

They concluded:

"An area of about 119 square miles is underlain by rocks of the Coal Bearing Lithosome. The coal bearing rocks crop out at the surface or are covered by a thin mantle of surface deposits. Strata over much of this area display minimum folding and faulting.

"Parts of the Coal Bearing Lithosome were tested by diamond drilling during 1970, and were shown to contain coal seams which have an aggregate thickness of more than 25 feet.

"Coal reserves, based upon 25 feet of coal over 119 square miles, are on the order of four billion tons."

OTHER RESOURCES OF THE GROUNDHOG COALFIELD AREA

Fish, wildlife and water are important resources which contribute to the value of the Groundhog coalfield and the surrounding area.

David Spalding, Regional Director of B.C. Fish and Wildlife Branch, Smithers, provided an evaluation of fish and wildlife values in the area and made specific recommendations for their protection and the protection of habitat:

Wildlife

"Wildlife values should be considered as moderate within the area under study (Spatsizi is regarded as high) and includes caribou, goat, sheep, black bear, grizzly bear, moose, wolves, furbearers, and migratory waterfowl. The following account is still general and further study is required to pinpoint critical areas for protection or intensive management.

"Mountain Goat. - This species is probably found throughout the area at higher elevations, but goat or goat sign have been recorded as follows: SE side of Devil's Claw, a group of 21; Groundhog Mountain, 30 seen; Distingue Mountain, plentiful sign; McEvoy Mountain, plentiful; headwaters of Porky Creek, moderate to plentiful sign; evidence of goats has also been recorded from Mount Taylor and Mount Gordon.

"Caribou. - Small groups of caribou appear to winter and summer throughout much of the study area; summering caribou recorded in the vicinity of Nanny Goat, Otsi and Beirnes Creek; 14 - 18 caribou on Pyramid Bluff; a herd of 30 - 32 caribou in the vincinity of Panorama Lake reported by the guide; plentiful summer sign seen on

Mount Taylor, moderate-plentiful on the headwaters of Porky Creek and moderate sign in the headwaters of Jenkins Creek; caribou winter on Mount Jackson. A herd of 150-200 caribou has been reported in the Mount Beirnes area but this has not been verified.

"Stone Sheep. - An unknown number of sheep inhabit the area between Panorama Lake and the headwaters of Beirnes Creek. Further work is required to determine their numbers as well as summer and winter ranges.

"Moose. - Moose are scattered throughout most of the valley bottoms during the summer, but are abundant on Jackson Flats, while McEvoy Flats support some summer moose and is considered a Class III winter range (moderate use). Other areas below about 4,000 feet along the Skeena River support scattered wintering moose.

"Bear. - Although there have been few official sightings of both black and grizzly bear, the area is considered good for grizzlies. This assumption is supported by the fact that garbage dump bear problems developed when construction camps were built for the B.C. Railway.

"Wolves. - Scattered throughout the area with concentrations following both moose and caribou.

"Furbearers. - Abundance and distribution of furbearers within the study area are unknown, although periodic recordings of beaver dams during surveys indicate this species is found in many swampy areas.

"Waterfowl. - The only 2 species recorded are Canada geese and 'white geese' (probably snow geese). No known nesting sites are known, but lone Canadas have been sighted along the Skeena and Canadas as well as Snow geese use Kluayaz Lake as a stop-over point during the fall migration.

Wildlife Management and Protection Strategies

"Hunting. - Protection against over-hunting must be a prime consideration during both the construction and mining phases. An influx of people into the Groundhog plus improved road access will place heavy hunting pressure on all wildlife. Shortened or closed seasons as well as limited entry hunts will have to be invoked.

"Trapping. - Further study is required to determine the present level of trapping and possible effects of industrial activity on the furbearers and traplines in the area.

"Guiding. - The study area is presently covered by a Guide-Outfitter's guiding territory. As development proceeds the increased access, increased hunting pressure by members of the mining community and possible increased pressure by hunters using the B.C. Railway will have a serious, negative effect upon his operation. During 1975 the guide-outfitter took out 15 hunters, who harvested 9 moose, 4 goat, 9 caribou and 2 wolves. What proportion came from the proposed coal-block area is not known but I estimate it to be considerable.

"Garbage Disposal. - Garbage dumps must be located some distance (preferably greater than 1 mile) from the community, and the only effective method to prevent bears concentrating at the dump site is to incinerate the garbage.

"Habitat Protection. - Low elevation underground mining will have minimal effect upon wildlife habitat, although wet, marshy areas must be protected for beaver and summering moose. Additionally, the camp or townsite should be positioned so it has minimal effect upon low elevation, flat land used by moose, caribou and furbearers.

"If open-pit mining is contemplated further study is required to determine the relationships between these pits and wildlife distribution.

Fishery Values

"Our present knowledge indicates fishery values are low throughout most of the study area although some localized spots should be considered of moderate value. Dolly Varden, rainbow and steelhead trout plus coho have been found during a limited sampling program. Some of the smaller tributaries to the upper Skeena have major barriers which preclude fish movement, e.g. Duke, Telfer, Langlois, Nanny Goat, the upper Otsi, and upper Porky Creeks. Further inventory work is required if any industrial development is considered.

"Steelhead. - Several hundred (?) steelhead move into the Kluatantan each year and provide a lucrative fishery for the guide-outfitter - up to 20 steelhead are taken each year by guided fishermen and an unknown number by non-guided fishermen. This is the most important recreational fishery in the area and must not be damaged.

"Coho. - Coho fry have been found as far up the Skeena as Otsi Creek and up the Kluatantan to Kluayaz Lake and it is believed that coho move into Kluayaz Creek to spawn. The number of coho using this part of the upper Skeena is unknown at this time and further work is required.

"Rainbow Trout. - Found in conjunction with steelhead in the Kluatantan system.

"Dolly Varden. - Found in the upper Skeena to Otsi Creek and in the Kluatantan. One large Dolly (several pounds) observed at the confluence of the Skeena and Kluayaz Creek.

Fisheries Management and Habitat Protection Strategies

"Fishing. - At present, firm control of steelhead fishing must be anticipated. Undoubtedly there will be steelhead fishermen amongst both contruction workers and miners and this pressure could not only threaten the steelhead population in the system as well as the livelihood of the guide.

"Present or potential fishing pressure on other species is unknown.

"Habitat Protection. - Stream and river banks, i.e. the Skeena, Kluatantan, and Otsi Creek must be protected to protect coho, steelhead and rainbow trout habitat. Additional work in the area will indicate other areas which will require protection.

"Construction of roads and camps, movement of equipment and mining operations must be kept away from these sensitive areas of banks and stream beds.

"Storage piles of coal as well as waste material must not be allowed to enter any of the water systems within the coal block. Additionally, every effort must be made to prevent loose coal dust from blowing into free-running water or onto ice covering any of these waterbodies. If there are plans to wash coal this operation must take place well enough distant from free-flowing water so as not to pollute fish habitat. Finally, loose coal dust transported by rail must not be allowed to blow into the Skeena or any tributaries containing fish.

"Additional field work is required for fisheries and wildlife populations, as well as critical habitat, if any industrial development is anticipated."

GEOLOGY

General Geology

The Groundhog coalfield lies in the Skeena Mountains of the Central Plateau and Mountain physiographic province (Holland, 1964).

Holland states (p.55, 56)"

"The Skeena Mountains are a distinctive (physiographic) unit, being formed largely of folded sedimentary rocks of Upper Jurassic and Lower Cretaceous age. The principal rocks are black fine-grained argillite and shale, and dark greywacke. Limestone, or rocks directly of volcanic origin, are absent, igneous intrusions are few in number ... The rock structures are extremely complex, the major folds averaging about 4 per mile with many overturned and recumbent outlines. Only in parts of the Groundhog Range, Upper Skeena Valley, and Eaglenest Range do broad folds predominate ... Most of the fold axes are nearly horizontal or plunge: gently northwest."

Percentage of Outcrop. - The area is covered by dense forest below 4500 feet elevation, and by scrub spruce, deciduous brush, and grasses up to about 5000 feet elevation. Gentle slopes above 5000 feet are mostly grass covered. Steep slopes are mostly barren of vegetation.

Low-lying ground along Skeena River has a mantle of river gravels and boulders. Areas which lie adjacent to mountain fronts show evidence of considerable landslide activity and large areas appear to be covered by solifluction sheets. Diamond drilling showed that this material may be up to 120 feet thick.

Ninety to 95 percent of the map area is covered by overburden of one or more of the types described above. Rock outcrops in covered areas are most likely to occur in creek banks.

Description of Rocks. - The area is underlain by drab appearing, grey, sandstone and mudstone. The rocks are unmetamorphosed. Bedding thickness varies from less than one inch to 100 feet or more. Beds of conglomerate and thick bedded sandstone form cliffs whereas areas underlain by thin bedded sandstone and mudstone more commonly display gentle relief.

Topographic Relations. - Mountainous areas within the map area are those underlain by the most competent rocks; e.g. conglomerate beds, and thick bedded sandstones. Areas of low relief are mostly underlain by less competent rocks such as mudstones, thin bedded sandstones, carbonaceous shales, and coal beds. For example, near the head of Currier Creek at an elevation of 5500 feet, mudstone, sandstone, shale, and coal beds form an area of rather gentle relief as compared to the area around Devil's Claw Mountain which is underlain mostly by conglomerate and sandstone, and which has high relief.

Geological Age and Stratigraphic Position of Rocks. - The rocks of the Groundhog coalfield belong to the Bowser Assemblage (Souther and Armstrong, 1966) and are Upper Jurassic to Lower Cretaceous in age (Malloch, 1912, p.78, 82; Souther and Armstrong, 1966; Brew, 1967; Grove, 1969 and Eisbacher, 1973). The coalfield lies in the east-central portion of the Bowser Basin. During the Upper Jurassic, shales, greywacke and conglomerate accumulated in a marine basin which was open to the west. Uplift in the Coast Mountains during latest Upper Jurassic and Lower Cretaceous resulted in the development of an inland basin (Souther and Armstrong, 1966). Eisbacher (1973) suggests that the occurrence of coal in the Groundhog Range provides some evidence that the basin was filled in part by deltaic deposition. A slow rate of subsidence coupled with luxuriant growth of plant material and rapid burial beneath water and other vegetation in the upper delta area led to an accumulation of peat. Subsequent burial beneath other sediments and diagenesis resulted in the development of coal.

Frazier and Osanik (1969) show that in delta sequences, peat accumulates in the delta-plain facies and interfingers laterally with inorganic sedimentary rocks.

It is suggested that the coal measures in the Groundhog coalfield represent uppermost Jurassic-Lower Cretaceous alluvial fans and delta plains upon which peat accumulated during the regression of the sea.

Stratigraphy

Three stratigraphic sections were measured by Malloch (1912) during 1911 and 1912. The first section, which he called the Anthracite Creek section, was measured on the southern cirque wall at the head of Anthracite Creek.

The second stratigraphic section, which he called the Main Section of the Skeena Series, was measured on McEvoy Ridge. McEvoy Ridge is underlain by the north limb of a breached anticline, and the rocks display marked regularity in strike and dip over a length of about 3 miles. Malloch's Main Section was probably measured about one mile east of Sam Creek, north of Currier Creek.

The third stratigraphic section was measured on the southern slope of the northwest shoulder of Mount Jackson.

Malloch (1912, p. 78-81) divided the rocks in the coalfield into four groups (from youngest to oldest) and inferred correlations between the sections:

Group 1

"Thickness	
1,300 feet	Heavy conglomerate beds, hard siliceous sandstones, shaley sandstones, often with chert pebbles, usually yellow or weathering yellow, brown and black shales and coal seams.

Group 2

"1,000 feet	Essentially a succession of black, brown and purplish shales, with subordinate beds of coarse, crumbly, grey sandstones, weathering brown, a few siliceous sandstones and shaley sandstones, with chert pebbles, and numerous seams of very dirty coal.

Group 3

"700 feet	A series of yellow and brown shales and grey shaley sandstones, weathering to yellow color. These are interbedded with black shales and coal seams.

Group 4

"950 feet	Coarse, crumbly sandstones and brown, black, grey, and purplish shales, also beds of hard siliceous sandstones, conglomerates, and a few coal seams."

R. V. Best (Black, 1968) divided rocks of the Bowser assemblage into four units; (1) Lower Conglomerates (2) Lower Shale (3) Upper Shale and (4) Upper Conglomerate.

The Lower Conglomerate is composed largely of coarse clastics, mostly thick bedded sandstones and conglomerates. The conglomerates contain pebbles of black chert. Conglomerate beds are interbedded with thin bedded greywacke or sandstone, siltstone and shale. The Lower Conglomerate unit is thinner bedded and finer grained near its' top and grades into the overlying unit. Near its' top are a few minor coal seams. It is non-marine, is 1,000 to 1,500 feet thick and outcrops on the slopes above Kluatantan and Kluayetz valleys.

The Lower Shale unit includes interbedded shales, greywacke and sandstone with coal seams. The beds are mostly non-marine and appear to be lenticular and are discontinuous over great distances. Some marine sandstones, grey shales and shell coquinas occur. Rapid changes occur along strike and make correlation of coal seams and beds difficult. In some localities the beds are strongly deformed. The unit is estimated to be from 1,500 to 2,500 feet thick. It erodes readily and exposures are mostly on lower slopes or in valley bottoms.

The Upper Shales grade upward from the Lower Shales. It is a similar unit but does not contain coal seams. It has many sandstone and siltstone beds and some limy beds which contain fossil plants. The unit is completely exposed near Devil's Claw Mountain and is about 4,500 feet thick.

The Upper Conglomerate consists of conglomerate beds 50 to 200 feet thick with subangular to rounded pebbles which are black, green, yellow, brown and white. Sandstone and some shale are interbedded with the conglomerate. Sandstone beds are up to 50 feet thick. This resistant conglomerate forms the peak of Devil's Claw Mountain and has an exposure which is 1000 feet thick.

Eisbacher (1974) identified three provisional, informal rock-stratigraphic units which he termed, (1) Facies Belt A, principal outcrop area, Duti River-Slamgeesh (2) Facies Belt B, principal outcrop area, Mount Gunanoot-Groundhog Range and (3) Facies Belt C, principal outcrop area, Jenkins Creek.

Eisbacher shows that rocks of Facies Belt A do not outcrop in the Groundhog coalfield. However rocks of his Facies Belt B underlie most of the area of the coalfield and rocks of his Facies Belt C overlie the coal-bearing rocks.

During the investigation of the Groundhog coalfield in 1970 (Tompson, et.al.) the workers identified provisional, informal rock-stratigraphic units which were used in mapping. In the report from that investigation those rock-stratigraphic units were identified as, "Lithosomes" (Plates I and II):

1. Lonesome Mountain lithosome
2. Devil's Claw Conglomerate lithosome
3. Coal-Bearing lithosome
4. McEvoy Ridge lithosome

The various lithosomes are named according to the geographical location of their respective type sections, except for the Coal-Bearing lithosome which is poorly exposed. Thus it is described from its' appearance at various places throughout the coalfield. The only attempt to develop a stratigraphic section for the Coal-Bearing lithosome was at a locality where part of it is exposed north of Currier Creek at the headwaters of Dave Creek (Fig. 3). The following descriptions of these rock-stratigraphic units is largely by Jenkins (Tompson, Jenkins and Roper, 1970).

Lonesome Mountain Lithosome

This group of well indurated rocks is best exposed on Lonesome Mountain. Other good exposures occur on Distingue Mountain, Taylor Mountain and Moss Mountain. When viewed from a distance rock outcrops of this lithosome are dark brown with rare black bands. The two predominant litholigic associations of the lithosomes are sandstone-conglomeratic sandstone, and a mudstone-coal association.

Eisbacher's type section for his rock-stratigraphic unit, "Facies C" is north of Jenkins Creek. The Jenkins Creek area is shown by this writer to be underlain by rocks of the "Lonesome Mountain lithosome". Therefore it is concluded that Eisbacher's, "Facies C" rocks and the writer's "Lonesome Mountain lithosome" rocks are the same rock-stratigraphic unit.

Sandstones. - Weathered surfaces of sandstone beds range in color from tan to dark brown. Some beds which are well cemented with quartz, weather to a variety of dark grey hues.

Particle size varies between wide limits. Complete mixed gradation exists between medium grained conglomerates and fine grained sandstones. Rare beds of the coarse Devil's Claw conglomerate occur, but they are thin bedded.

Mineralogically these sandstones and conglomerates are quartz-black chert assemblages. Iron bearing heavy minerals occur in concentrations up to ten percent in some beds and less than one percent in other beds.

Bedding which is exposed in large outcrops is characteristically even. Sand body thickness is variable, and is from five feet to as much as fifty feet. Average thickness is probably 15 to 20 feet. Internal stratification consists of small scale trough and planar cross-laminae. Burrows and other evidence of bioturbation are commonly encountered.

Marine molluscan fossils occur in at least one sandstone unit of this lithosome.

Mudstone. - Rocks of this type are not well exposed in areas in which they may be easily studied. Where exposed they are sombre brown in color, sandy in texture, and 15 to 30 feet thick.

Interbedded with the mudstones are thin, discontinuous coal beds ranging up to three feet in thickness.

A crude cleavage is present in many rocks of this lithosome, and in small areas a well developed slatey cleavage occurs.

These rocks are believed to be time stratigraphic equivalents of the Devil's Claw Conglomerate lithosome. Facies change is thought to take place by pinch out and by mixed lateral gradation.

Devil's Claw Conglomerate Lithosome

Two predominant lithologic associations occur in this lithosome: (1) conglomerate-sandstone association and (2) mudstone, carbonaceous mudstone, and sandstone associations. The latter association is similar to the Coal-Bearing lithosome.

Conglomerate. - Medium to dark grey hues are characteristic of both fresh and weathered surfaces.

Grain size classes are bimodally distributed. One mode falls in the large pebble to large cobble size range. Such large particles are well rounded, exhibit good sorting, and are composed either of black chert or light green to cream colored chert. The second mode falls in the medium to coarse sand range. These grains are only moderately well sorted and are mineralogically a quartz-chert assemblage. Matrix free conglomerates occur but are rare.

Upon weathering, the pebbles are released, and where slopes are steep, the pebbles are washed into streams. On gentle slopes the pebbles accumulate on the surface and cover the ground over large areas.

Thin lenses of coal occur but are the result of local accumulations of plant detritus.

Conglomerate body accumulations range from 40 to 200 feet thick including local lenses or wedges of sandstone. Lateral facies changes yield a continuous series from conglomerate to conglomeratic sandstone to sandstone. As the proportion of sand increases, the thickness of individual sand bodies decreases. In non-conglomeratic facies the thickness of sand bodies averages 15 to 20 feet.

Mudstone. - Between the conglomerate tongues, 50 to 150 feet of mudstone, carbonaceous rocks, and sandstone occur. These strata appear to be identical to the Coal-Bearing lithosome with exception of the carbonaceous units, which are thin and discontinuous.

Coal-Bearing Lithosome

This group of poorly indurated rocks is well exposed only in the beds of high gradient streams. Elsewhere it is covered with brown colored soils. Where exposed, outcrops are various shades of dark grey-brown with black bands produced by carbonaceous beds. Clastic sediments range from fine to coarse grained and are better sorted than those of the underlying McEvoy Ridge lithosome. Muddy rocks comprise 70 to 75 percent of this lithosome; carbonaceous units, 15 to 20 percent, and sandstones about 10 percent. Strata are characteristically medium to thick bedded.

<u>Mudstones</u>. - Outcrops are medium to dark grey when fresh and various shades of grey-brown when weathered.

The texture is highly variable as in the underlying McEvoy Ridge lithosome. Between 10 and 20 percent of these muddy rocks are claystones.

Due to poor exposure, bedding characteristics are not well known. Vertical contacts are gradational where mudstone overlies sandstone and are erosional where sandstone overlies muddy rocks. Internal stratification is most commonly a lamination produced by interbedding of mineral matter and plant fragments. Bedding fissility is a common attribute of the claystones, but is only weakly developed.

Mudstones grade into carbonaceous units through an increase in the proportion of included plant debris. As a result the coal content of carbonaceous units varies widely from stratum to stratum.

<u>Sandstones</u>. - These rocks are typically medium to dark grey in color, but weathering produces a variety of sombre brown and orange hues.

Particle size varies from fine to coarse. Most sandy strata are medium grained. Sorting varies within broad limits and textural maturity ranges from mature to submature. Friability is a common attribute with only an occasional bed being well cemented with calcite or silica.

Quartz and black chert are the most abundant minerals comprising these sandstones. Ferromagnesian minerals comprize up to 15 percent of some beds. Weathering has oxidized these grains to bright orange limonitic grains.

Beds which are two to five feet thick are typically arranged in multistorey accumulations 10 to 35 feet thick. Most sand bodies are 10 to 20 feet thick. Internal stratification consists of small scale trough cross-laminae and medium sized, planar cross-laminae.

Contacts with the overlying conglomerate beds are conformable and are best placed at the bottom of the lowest coarse conglomerate tongue.

Fair exposures of the Coal-Bearing lithosome occur on Dave Creek (which was named in 1970) a tributary of Currier Creek which enters Currier Creek from the north-east near its' headwaters.

The strata here are on the south limb of a syncline whose axis strikes northwesterly. The dip is about 40 degrees northeast and the slope of the hill is about 25 degrees southwest. Thus, a fair cross section of the rocks is exposed.

The stratigraphic section of the Coal-Bearing lithosome which was measured on Dave Creek is shown on Figure 3.

McEvoy Ridge Lithosome

This lithosome is characterized by well indurated, dark colored, poorly sorted, fine to coarse grained clastic rocks. Mudstone and fine grained texturally immature sandstone are the predominant rock types. The former comprises 60 to 80 percent of this lithosome. Chert pebble conglomerate occurs only in insignificant quantities. Bedding thickness is thin to medium and even in character.

Mudstones. - The mudstones are dark grey to olive grey in color. Weathered surfaces are mottled with various shades ranging between dark greyish orange and dark greyish brown.

The texture is highly variable. The proportion of coarse clastics (silt and sand) varies continuously between 10 and 50 percent. Claystones comprise less than 5 percent of this lithosome.

The evenly bedded character of strata in this lithosome is one of its most unique attributes. Lateral and vertical contacts are typically gradational, except where mudstone is overlain by sandstone or where local erosional contacts occur. Internal stratification is not common except where delineated by included sandstone laminae. The rocks are well indurated and yield float with a poorly developed conchoidal fracture. Bedding fissility rarely occurs.

Sandstones. - McEvoy Ridge lithosome sandstones are typically dark grey to olive grey. Weathering may produce a grey colored surface mottled with shades of pale, greyish orange.

Fine to medium grain sizes are most abundant, but occasionally coarse sandstones with fine conglomerate lenses occur. In general, the finer grained rocks are poorly sorted. Textural maturity ranges from submature to immature. Friability decreases with an increase in maturity, due to the addition of silica cement.

Mineralogy as determined in hand specimens consist of quartz, black chert, and unweathered ferromagnesian minerals.

Bedding is characteristically regular in units of 2 to 5 feet. Multistorey sandbodies range up to 30 feet in thickness, but average 5 to 10 feet. Lower contacts are commonly erosional and are sharp. Upper contacts are depositional and gradational. Lateral facies changes take place by either pinch out or gradation to mudstone. Internal stratification consists of small scale trough cross lamination and micro-cross lamination.

Contact with the overlying coal bearing units is gradational, and is best placed at the first medium grey, friable, sorted, quartzose sandstone.

STRUCTURAL GEOLOGY

Contacts

Rock contact between the four lithosomes are poorly exposed and appear to be gradational. Contacts are believed to be conformable (Plates I and II).

Lonesome Mountain - Devil's Claw Lithosomes. - The contact between these rocks is drawn at the top of the uppermost of the thick conglomerate beds. However, the conglomerates apparently are discontinuous laterally, so that the position of the contact is tenuous in most instances.

However, fair exposures of the contact were observed southwest of Table Mountain in Lot 2186. Here the Lonesome Mountain sandstones are conformably underlain by conglomerate beds which conformably overlie the rocks of the Coal-Bearing lithosome.

Near the headwaters of Davis Creek, sandstone beds which are correlated with rocks of the Lonesome Mountain lithosome, conformably overlie conglomerate beds of the Devil's Claw lithosome.

About 2½ miles northwest of the junction of Leach Creek and Currier Creek the lower conglomerate bed of the Devil's Claw lithosome is conformably overlain by sandstone and thick conglomerate beds which are believed to correlate with sandstones of the Lonesome Mountain lithosome.

At Devil's Claw Mountain sandstones and conglomerates of the Devil's Claw lithosome are conformably overlain by a small remnant of sandstone which is correlated with the Lonesome Mountain sandstones.

Devil's Claw - Coal-Bearing Lithosomes. - At Table Mountain in Lots 2185 and 2186 there is a fair exposure of the contact between rocks of the Devil's Claw lithosome and the Coal-Bearing lithosome. The contact is conformable and the dips are gentle, about 15 degrees to the southwest.

A good exposure of the contact between the Devil's Claw and Coal-Bearing lithosomes occurs at grid coordinates 55,000 E and 144,000 N. The rocks here are on the north limb of a syncline whose axis plunges gently to the southeast. The contact is conformable and the beds dip 10 to 30 degrees to the southwest.

Near the headwaters of Davis Creek a section of steep dipping beds is exposed which clearly show Devil's Claw rocks conformably overlying rocks of the Coal-Bearing lithosome.

Coal-Bearing - McEvoy Ridge Lithosomes - The contact between rocks of the Coal-Bearing lithosome and McEvoy Ridge lithosome is well exposed in only one place. At approximate coordinates 93,000 E - 113,000 N there is a sharp peak which lies near the head of the east fork of Anthracite Creek. Here, the rocks dip about 40 degrees northeast and expose a conformable contact between the two rock units.

McEvoy Ridge Lithosome - Hazelton Assemblage. - Malloch (1912) reported that rocks belonging to the Hazelton group were observed on Currier Creek, Beirnes Creek, Skeena River, and Moss Mountain. However, the writer did not identify Hazelton rocks in the map area. Lithology and distribution of the Hazelton Assemblage have been revised since Malloch's work in the coalfield (Duffell and Souther, 1964; Armstrong, 1965; Souther and Armstrong, 1966 and Grove 1969) and the rocks in Bowser Basin which he called Hazelton rocks, now belong to the Bowser Assemblage.

Faults and Fault Systems

Five principal fault systems were recognized by the writer and were named according to the type of faulting involved and the geographic location of the faults (Plates I and II):

1. Groundhog thrust fault
2. Upper Currier Creek normal fault
3. Distingue Mountain thrust fault
4. Beirnes Creek high angle reverse fault
5. Duke Creek - Langlois Creek faults

The Groundhog Thrust Fault. - This is the principal fault in the area. The front of the fault lies about two miles west of Skeena River and extends from Currier Creek northwestward through the coalfield and many miles beyond. The strike of the fault is about N 50°W and the dip is unknown.

Rocks along the front of the fault display gentle dips except in the vicinity of Mount Alex where tight drag folds provide evidence for thrust faulting.

Southeast from Mount Alex the tightly folded rocks along the thrust plane are not exposed. The position of the fault is inferred from topographic expression as noted below.

Along the Groundhog thrust fault rocks of the McEvoy Ridge lithosome are commonly thrust over rocks of the Coal-Bearing lithosome. The front of the fault is serrate with many lobes of McEvoy Ridge rocks protruding over the Coal-Bearing rocks.

The position of the fault was recognized because there is a marked change of rock types on opposite sides of the fault, and by an irregular line along the front of the fault. A prominent break in topography occurs along this line and forms a narrow, flat strip of ground, commonly occupied by swamps. This feature is readily observed from the air and on aerial photographs.

Upper Currier Creek Normal Fault. - About four miles west of the Groundhog thrust fault, at the headwaters of Currier Creek, rocks of the Coal-Bearing lithosome are down faulted against rocks of the McEvoy Ridge lithosome.

The strike of the fault varies from about N. 45° W. to N. 20° W. and extends from near the junction of Currier Creek and Leach Creek to Beirnes Creek, and perhaps a mile or more north of Beirnes Creek. Dip is believed to be near vertical.

Distingue Mountain Thrust Fault. - Evidence for thrust faulting is visible in the cirques of Distingue Mountain and on the steep slopes at the head of Campbell-Johnston Creek. The fault extends from the small round mountain south of View Mountain to Mount Taylor, and on to the northwest out of the map area. Drag folding, with isoclinal folds and recumbent isoclinal folds, occurs in the hanging wall of the axial plane of the thrust fault.

Beirnes Creek Fault. - Rocks of the Coal-Bearing lithosome dip southwesterly away from Mount Alex and are in fault contact with McEvoy Ridge rocks in the valley of Beirnes Creek. The fault dips 77° SE. and is believed to be a high angle reverse fault.

Duke Creek - Langlois Creek Faults. - Subparallel faults along Duke Creek and Langlois Creek place rocks of the Coal-Bearing lithosome in fault contact with rocks of the Lonesome Mountain lithosome. Table Mountain is believed to be an erosional outlier of Lonesome Mountain rocks.

The two faults are believed to have steep dips, as they cross areas of high relief with little change in direction or topographic expression.

Apparently the block which includes Table Mountain is upthrown slightly relative to the blocks to the north of Langlois Creek and to the south of Duke Creek. Thus the Table Mountain block is a horst.

Folds

Folding is dominated by three principal synclines:

1. Syncline Creek - Devil's Claw syncline
2. Skeena River syncline
3. Distingue Mountain syncline

Some prominent anticlines were identified. Most are probably breached and occupy areas of low relief:

1. Skeena River anticlines
2. Upper Currier Creek anticline

Syncline Creek - Devil's Claw Syncline. - This syncline extends from the headwaters of Davis Creek northwestward to Syncline Creek, and is the most prominent and obvious structural feature in the Groundhog coalfield.

All rocks units along strike of the syncline display evidence of folding.

Rocks on the northern limb have relatively gentle dips, typically less than 30 degrees southwest.

However, the southern limb is folded sharply, and rocks along the entire length of the syncline have steep to near vertical dips. These steep dipping strata are well exposed near Syncline Creek, and near the headwaters of the east and west forks of Geoffrey Creek.

The axis of the syncline strikes along a creek which is a tributary of Beirnes Creek, entering from the north. This tributary was named Syncline Creek in 1970 and is shown as such on the accompanying geological map.

Skeena River Syncline. - A syncline is believed to underlie the area occupied by Skeena River. Data from widely spaced outcrops (Plate I) provide evidence for the syncline. Campbell-Johnston (1911) and Buckham and Latour (1950) also said Skeena River occupies a syncline. However Black (1968) said Skeena River occupies a breached anticline.

Distingue Mountain Syncline. - The Distingue Mountain syncline is characterized by steep dipping to vertical beds on the south limb of the fold, and recumbent, isoclinal folds on the north limb.

Steep dipping beds occur near Mount Taylor and continue southeasterly on strike to Distingue Mountain and View Mountain. Exposures along strike are good.

Overturned folds on the north limb of the syncline are well exposed on the mountain northwest of Campbell-Johnston Creek. The axes of the folds strike northwesterly and the axial planes are nearly horizontal. Other exposures occur along strike in the north face of View Mountain.

Skeena River Anticlines. - The areas on both sides of Skeena River are heavily covered by forest and overburden. However, a few scattered outcrops over a length of 10 miles provide data which suggest that anticlines occur striking parallel to the Skeena River syncline.

The amplitude of these folds is believed to be small but no measurements are possible due to lack of exposure and incomplete information regarding the stratigraphic section.

Upper Currier Creek Anticline. - A breached anticline is well exposed near the headwaters of Currier Creek. Rocks of the McEvoy Ridge lithosome are folded and form a symmetrical anticline which has a horizontal axis. The anticline is breached and a creek flows southeasterly along the axial plane for a distance of about two miles. The strata which form McEvoy Ridge underlie the north limb of the fold.

Upper Currier Creek - Upper Beirnes Creek Folds. - In the high, rolling area between upper Currier Creek and upper Beirnes Creek, rocks of the Coal-Bearing lithosome are folded into northwest-striking anticlines and synclines which vary from tight folds to more open folds.

To the west of the map area, however, for a distance of three to four miles, rocks of the Coal-Bearing lithosome are only gently warped. Several coal occurrences were noted in the high meadows between upper Beirnes Creek and upper Currier Creek and on the headwaters of Anthony Creek, a tributary of Nass River.

COAL SEAMS

Benoit Seam. - This coal seam was discovered by R. C. Campbell-Johnston and George M. Beirnes in the autumn of 1910 (Buckham and Latour, 1950) and was named for Leon Benoit who commissioned and organized the finances for Campbell-Johnston's examination of the Groundhog area. The sub-outcrop of the Benoit seam is about 130 feet southwest of the confluence of Beirnes Creek and Skeena River. In 1911 many cuts were made in river gravels of Beirnes Creek in order to expose the seam (Campbell-Johnston, 1912 a, p.13). Approximately 184 feet of trenches were dug parallel and normal to the strike of the coal seams. The main cut was:

> "....twelve feet deep at face and necessitated a great width like a railway cutting to prevent the sides falling on the men; this size also forced the removal of a large number of cubic yards with barrow ... the big cut ...(was) organized when the seam was reached in a pit ... (it) is 61 feet long from the creek. At the end the ground was too deep to stand, so a tunnel was carried in and timbered heavily for 11 feet till the floor of the coal seam was reached. Then a slope on the floor was sunk 14 feet deep to catch a solid rock roof, get normal width ... It would appear that the seam will be normally six feet thick when it finds itself."

Buckham and Latour (1950) reported that the seam was 6 feet 4 inches wide with 4 feet 6 inches of clean coal. Campbell-Johnston reported five analyses on coal from Benoit seam,

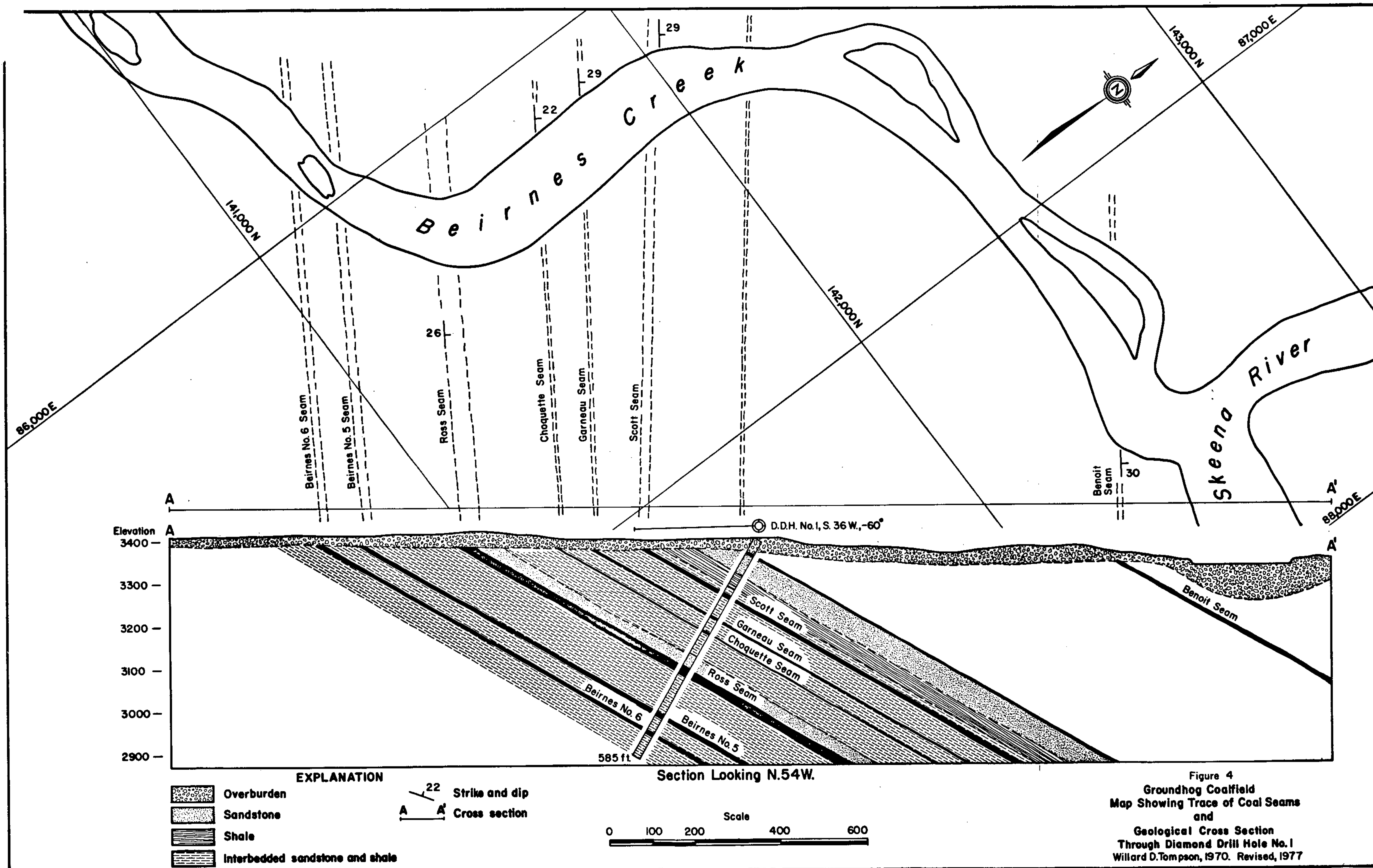


Figure 4
Groundhog Coalfield
Map Showing Trace of Coal Seams
and
Geological Cross Section
Through Diamond Drill Hole No. 1
Willard D. Tompson, 1970. Revised, 1977

which were probably cleaned by hand prior to analyses, and said (1912c, p.6) he,

> "... feels confident that screened coal here can be kept at 84 percent fixed carbon, and ash about 6 percent ..."

Analyses of Campbell-Johnston's samples are as follows:

			Clean coal bands in one face		
Moisture	3.0	4.5	4.0	4.0	4.5
Volatile matter	6.6	4.6	5.1	5.0	4.5
Fixed matter	74.6	80.1	82.6	82.0	84.0
Ash	15.0	10.0	7.5	8.0	6.0
Sulfur	0.8	0.8	1.0	1.0	1.0
	100.0	100.0	100.0	100.0	100.0
Btu					12,852

He also recorded (1911a, p.13) assays of samples taken by "other engineers" and noted that shipped coal had to be free from bone and dirt:

Moisture	N.D. %	3.0 %
Volatile matter	10.28	6.6
Fixed carbon	71.07	74.6
Ash	18.55	15.00
Sulfur	0.10	0.8
	100.00	100.00
Btu	Not recorded	

Diamond drill hole number one (Fig.4) which was drilled in August, 1970 (Tompson, et.al.) did not penetrate the Benoit seam, as the drill hole was collared in the foot wall about 400 feet stratigraphically below the seam. The distance between the Benoit seam subоutcrop and the collar of the diamond drill hole is 900 feet and the entire intervening area is extensively covered by the gravels of Beirnes Creek. Thus surface prospecting methods are of no use. Therefore the section of rocks lying between the Benoit seam and the first bedrock encountered in drill hole number one, are unexplored.

Bedding in sandstone near the Benoit seam strikes N. 55° W. and dips 37° N.E.

<u>Scott seam</u>. - The Scott seam was discovered by Campbell-Johnston and his miners in 1911 and was named for J. G. Scott of Quebec City who, with Leon Benoit, formed the B.C. Anthracite Syndicate. A cut was made on the Scott seam 14 feet wide, up to 12 feet deep and 35 feet long. At the face of the cut a double compartment tunnel was driven for 16 feet and a single tunnel was driven 26 feet more. The seam was found to be 10 feet wide and (Campbell-Johnston, 1911a, p.16) wrote:

> "It is a splendid seam to work in the future and get a high percentage of extraction of clean hard coal."

Coal analyses of the Scott seam which are shown in that 1911 report are as follows:

Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
	9.72	71.07	19.19		0.02
3.5	4.6	81.10	10.00		0.8
	11.17	75.66	13.13		0.04
4.5	4.5	77.0	13.0	12,323	1.0
4.5	6.5	78.0	10.0	12,843	1.0

The Scott seam was intersected in diamond drill hole number one (Fig.4) in 1970 (Tompson, et.al,1970) at the interval 148.8 feet to 154.5 feet. Thus in this intersection the seam is 5.7 feet wide.

	Interval	Feet
Carbonaceous, cross bedded sandstone		
Coal, vitrain predominant with thin bands of clarain	148.8-149.7	0.9
Carbonaceous shale	149.7-149.8	0.1
Coal	149.8-150.2	0.4
Coal with minor quartz veinlets	150.2-150.4	0.2
Coal	150.4-152.0	1.6
Coal with minor quartz veinlets	152.0-152.5	0.5
Coal	152.5-154.0	1.5
Coal with minor calcite veining	154.0-154.5	0.5
Black carbonaceous shale		
Total coal, including coal with minor veinlets		5.7 feet

The drill core was split with a diamond saw and half was analyzed without benefication:

Moisture	.46 %
Volatile matter	5.91
Fixed carbon	40.82
Ash	52.81
Sulfur	0.53
Btu	6,298

The other half of the core was crushed to minus 3/8 inch and subjected to float-sink tests at specific gravities; 1.40, 1.50, 1.60, 1.70, 1.75, 1.80, 1.90 and 2.00. Each gravity fraction was analyzed for percent ash and sulfur and washability tables were prepared. A composite sample was prepared from float fractions up to 1.75 and proximate analysis was made:

Volatile matter	6.62 %
Fixed carbon	78.14
Ash	15.24
Sulfur	0.47
Btu	12,143

It is readily apparent that crushing and floating the coal at 1.75 specific gravity reduced the ash to about 1/3 of that of the raw coal. This permitted an increase in the fixed carbon analysis by 50 percent and nearly doubled the calorific value. It is noted that this analysis does not vary widely from those shown by Campbell-Johnston (above) for the Scott seam.

The Scott seam was measured in outcrops and sampled during the field investigation of 1970 (Tompson, et.al.). An analysis was made on the fraction which floated at specific gravity 1.58:

Width	Inherent Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
3.8 ft.	1.21	4.87	85.58	8.34	13,772	0.47
5.9 ft.	1.43	1.80	87.17	9.60	13,747	0.52

The overlying shale bed strikes north 65 west and dips 29 degrees northeast.

Garneau Seam. - The Garneau seam is 56 feet stratigraphically below the Scott seam. Campbell-Johnston (1911a, p.17) reported that the Garneau was 115 feet below the Scott and that it was 200 feet from tunnel to tunnel. Thus there is a discrepancy between earlier figures and more recent ones. The tunnels were about 200 feet apart, but a line drawn between the tunnels is not at right angles to the strike of the beds. Thus his measurement was along an apparent dip and would need to be adjusted before calculating the stratigraphic interval.

Campbell-Johnston made a deep cut in the river gravels for 34 feet and then drove a tunnel for 24 feet. He reported,

"... *36 inches of clean coal without any clay or shale partings.*"

His sample gave the following analysis:

Moisture	4.00 %
Volatile matter	4.00
Fixed carbon	82.50
Ash	8.50
Sulfur	1.00
Btu	13,455

Another engineer, whom he did not name, took "terribly dirty samples":

Volatile matter	11.30 %
Fixed carbon	66.24
Ash	22.16
Sulfur	0.30

The Garneau seam was sampled in 1970 (Tompson, et.al.). Where exposed, the seam was 2.7 feet wide. The sample was crushed to minus 1/4 inch and the float fraction at specific gravity 1.58, was analyzed:

Inherent moisture	1.16 %
Volatile matter	2.56
Fixed carbon	87.40
Ash	8.88
Sulfur	0.44
Btu	13,997

The Garneau seam was intersected in diamond drill hole number one (Fig.4) in 1970 (Tompson, et.al., 1970) at the interval 210.5 to 212.3 feet, an intersection width of 1.8 feet.

	Interval	Feet
Coal, vitrain predominant with thin bands of clarain	210.5-211.8	1.3
Coal, with contorted quartz veining	211.8-212.0	0.2
Coal	212.0-212.2	0.2
Coal, with 5 percent pyrite	212.2-212.3	0.1
Total coal		1.8 feet

The drill core was split with a diamond saw and the raw coal analysis on half of the core is as follows:

Inherent moisture	0.64 %
Volatile matter	4.82
Fixed carbon	58.64
Ash	35.90
Sulfur	0.52
Btu	9,255

Ross Seam. - The workings on the Ross seam are about 1800 feet southeast from the junction of Beirnes Creek and Skeena River. They are caved and obscure. Campbell-Johnston (1911a, p.18) reports,

> "... a cut was put in the coal for 36 feet. Then a cut to the north for 34 feet in coal and shale alternating and at the end, a timbered tunnel for 6 feet in solid coal."

He gave one analysis of coal from this seam:

Volatile matter	9.33 %
Fixed carbon	80.94
Ash	8.96
Sulfur	0.77

The Ross seam was intersected in diamond drill hole number one (Fig.4) in 1970 (Tompson, et.al.) at the interval 347.0 to 361.5 feet. This intersection is 14 feet in width, but the interval, 354.2 to 359.0 feet, is interbedded shale with coal partings

	Interval	Feet
Fossiliferous shale with coal partings		
Coal, vitrain predominant with thin bands of clarain up to 1 inch	347.0-352.0	5.0
Coal with quartz veinlets and bands of fusain up to ¼"	352.0-354.2	2.2
Shale, carbonaceous with coal partings	354.2-359.0	
Coal, vitrain with bands of clarain	359.0-361.5	2.5
Total coal		8.7 feet

The drill core was split with a diamond saw and half was analyzed without cleaning or benefication:

Interval	Inherent Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
347.0-354.2 (7.2 feet)	0.47	5.95	58.92	34,66	9,204	0.34
359.0-361.3 (2.3 feet)	0.58	5.28	71.24	22.90	11,418	1.23

The balance of the core was crushed to minus 3/8 inch and subjected to float-sink analysis. Proximate analysis was made on the composite 1.75 specific gravity float fraction:

Interval	Ash %	Volatile Matter %	Fixed Carbon %	Btu	Sulfur %
347.0-354.2 (7.2 feet)	10.99	5.66	83.35	12,894	0.46
359.0-361.3 (2.3 feet)	11.11	6.41	82.48	13,109	0.84

A marked improvement is apparent in the cleaned coal. In one sample there is a 41 percent increase in fixed carbon, a 68 percent reduction of ash, and a 40 percent increase in calorific value. In the second interval there is a 16 percent increase in fixed carbon, a 50 percent decrease in ash, and a 14 percent increase in calorific value.

Pelletier Seam. - Campbell-Johnston, (1911a, p.19) reported on the discovery of the Pelletier seam;

> "On the west bank an open cut to catch the bedrock was driven with difficulty - above the water level for 72 feet. Then a large shaft was sunk on the coal for 40 feet.
>
> "This demonstrates a strong high class fuel, six feet thick at bottom, of clean coal, but high in ash ..."

The analyses are as follows:

Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
	8.42	64.93	24.91		1.74
4.00	4.00	71.00	20.00	11,340	1.00
4.00	7.00	60.00	28.00	10,374	1.00
4.50	3.50	83.50	7.50		1.00

The workings on the seam were obscure at the time of the work in 1970 so no samples were taken of coal from the Pelletier.

In prospecting for the Pelletier seam on the south side of Beirnes Creek, Campbell-Johnston made the following observation (1911a, p.19):

> "From the 'Ross' is seen 150 feet of sandstone, then the swamp hides 600 feet of unproven ground. There is good high class coal float in this interval so without doubt one or more seams exist and will be located later."

Diamond drill hole number one penetrated two coal seams below the Ross (Fig.4) one seam at 468.5 feet to 477.8 feet and the other at 517.0 to 521.4 feet. These seams lie at 107 feet and 155.5 feet below the Ross and above the Pelletier. They are unnamed, but in view of the fact that they are 9.3 feet (including a 2.0 foot parting) and 5.0 feet in width they are herein called, "Beirnes No.5 and Beirnes No.6" respectively.

Beirnes No.5. - This seam was intersected in diamond drill hole number one in 1970 (Tompson, et.al.) at the interval 468.5 to 477.8 feet:

	Interval	Feet
Shale, fossiliferous, with fine interbedded sandstone		
Coal, vitrain with bands of clarain, minor quartz	468.5-472.0	3.5
Shale, carbonaceous with coal partings	472.0-474.0	
Coal, Vitrain, hard, bright	474.0-474.5	.5
Shale	474.5-475.0	
Coal	475.0-477.8	2.8
Shale, fossiliferous with fine interbedded sandstone		
Total coal		6.8 feet

The core was split with a diamond saw and half was analyzed as raw coal:

Interval	Inherent Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
468.5-472.0	.43	6.61	60.03	32.93	9,560	1.87
474.0-477.8	.52	9.36	33.92	57.20	5,395	2.19

The remainder of the core from the lower interval of Beirnes No.5 was crushed to minus 3/8 inch and floated at specific gravity 1.70. The remainder of the core from the upper interval of Beirnes No.5 was misplaced so was not tested further:

Interval	Ash %	Volatile Matter %	Fixed Carbon %	Btu	Sulfur %
468.5-472.0		No assay data			
474.0-477.8	15.73	6.90	77.37	12,266	0.52

It is readily apparent from the above, that crushing the sample and floating at 1.70 specific gravity, reduced ash from 56 percent to 16 percent, increased calorific value from 5,395 Btu to 12,266 Btu and reduced sulfur from 2.19 percent to 0.52 percent.

Beirnes No.6. - The Beirnes No.6 seam lies 48 feet below Beirnes No.5 and is 4.4 feet wide. It is known only from its' intersection in drill hole number one which was drilled in 1970 (Tompson, et.al.):

	Interval	Feet
Fossiliferous shale, thin interbedded sandstone		
Coal, vitrain with bands of clarain	517.0-521.4	4.4
Carbonaceous shale and sandstone		___
Total coal		4.4 feet

The core from the intersection of Beirnes No.6 was split with a diamond saw and half was analyzed as raw coal:

Inherent moisture	.44 %
Volatile matter	5.01
Fixed carbon	N.D.
Ash	25.28
Sulfur	0.54
Btu	10,700

The remainder of the core was crushed to minus 3/8 inch and floated at specific gravity 1.70. Analysis of the float fraction is as follows:

Ash	13.05 %
Volatile matter	6.88
Fixed carbon	80.08
Btu	12,614
Sulfur	0.60

Crushing and heavy media separation in this instance reduced ash content by about 50 percent.

Four coal occurrences were found on the north side of Beirnes Creek opposite the mouth of Geoffrey Creek. These occurrences are on the west flank of a broad anticline and the seams exposed here are probably the same as those which occur on lower Beirnes Creek and which were explored by Campbell-Johnston. Exposures were poor and not completely dug out, so widths shown below are not full widths:

Width (feet)	S. G. Float	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
2.6	1.58	2.19	10.58	77.81	9.42	13,074	0.66
2.5	1.58	1.37	15.98	82.69	6.73	13,199	0.44
1.9	1.58	2.01	9.53	76.58	11.88	12,550	0.29
6.5	1.58	1.41	10.63	79.69	8.28	13,523	0.67

Lower Anthracite Creek

Three coal seams are reported to occur on lower Antracite Creek. Campbell-Johnston (1911a, p.20) recorded these, as did Dowling (1915, p.219) and Buckham and Latour (1950, p.46). A through search was made for evidence of these seams during the summer of 1970, but the seams could not be found. However, evidence of Campbell-Johnston's earlier work was discovered when numerous cut-off tree stumps were found. This suggested that mine supports had been made and intensive digging in the south bank of the creek revealed some coal fragments and decayed timbers. Campbell-Johnston reported three seams; but did not record the distance between them. The lower seam contained 4.9 feet of coal in a 7.5 foot seam; the middle had 3.0 feet of coal in a 3.0 foot seam, and the upper had 5.9 feet of coal with one 2 inch shale parting.

	Volatile Matter %	Fixed Carbon %	Ash %	Sulfur %
Top seam 5.9 feet	6.98	86.74	6.15	0.13
Middle seam 3.0 feet	6.78	73.36	19.74	0.12
Bottom seam 4.9 feet	13.51	71.76	14.57	0.16

Davis Creek

Buckham and Latour (1950, p.44) reported upon coal occurrences on Lower Davis Creek and Upper Davis Creek. At Lower Davis Creek, about 1200 feet above its' confluence with Skeena River, two seams outcrop. The upper seam measured 4.7 feet. The lower seam, which is 22.8 feet below the upper seam, measured 3.7 feet. The analyses as given by Buckham and Latour (1950, p.44 and 64) and Dowling (1915, p.217) are as follows:

	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
Upper seam	1.40	6.06	70.68	21.86	11,788	1.60
Lower seam	1.57	7.55	65.52	25.36	N.D.	N.D.

Buckham and Latour (1950, p.44) also reported on two seams at the north and south forks of upper Davis Creek, which is more than two miles west of Skeena River. These occurrences lie in the upper plate of the Groundhog thrust fault (Plate I) and have very limited extent, so are of no interest.

The Davis Creek coal seams were sampled during the summer of 1970 (Tompson, et.al.) but correlating with McEvoy's and Malloch's sampling is not certain.

	Width (feet)	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
Davis Creek	3.5	1.52	4.25	88.64	5.59	13,872	0.64
S.side Davis Creek	4.0	1.92	5.33	87.09	5.66	13,648	0.75
N.side Davis Creek	2.4	1.41	5.34	89.01	4.24	14,346	0.58

All were floated at specific gravity 1.58 prior to proximate analysis.

Discovery Creek

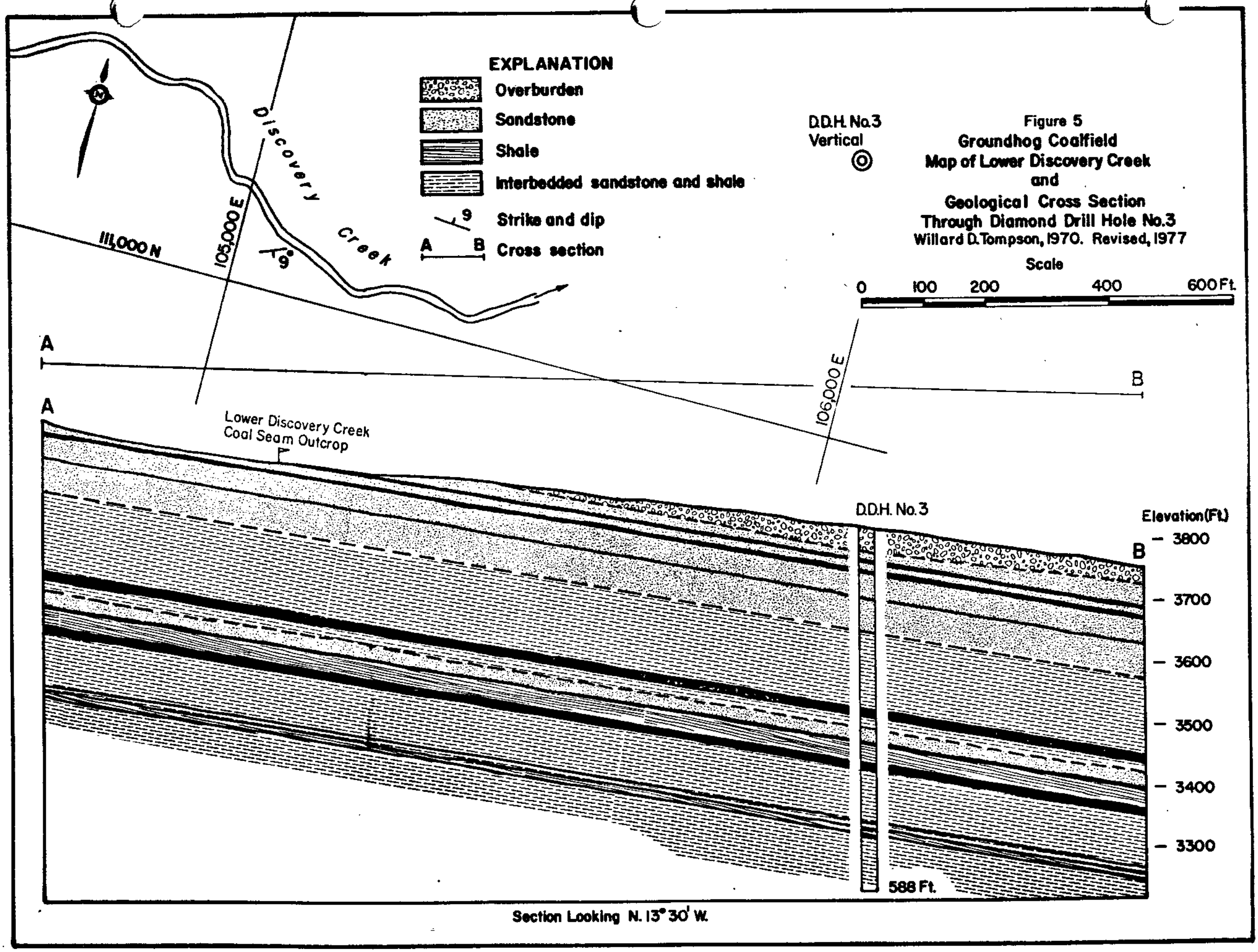
During the field work in 1970 (Tompson, et.al.) coal occurrences were noted at 10 localities along Discovery Creek. In four instances the coal forms outcrops and in 6 localities, it occurs as float in colluvium.

Lower Discovery Creek Seam. - The first work done in the Groundhog coalfield was done on the Lower Discovery Creek seam. In 1904 W. W. Leach, acting for Western Development Company stripped and tested occurrences which had been found by James McEvoy the previous year.

The seam was sampled at the face of a 16 foot drift McEvoy (1909 ?), Malloch (1912) and by Evans (1912). Buckham and Latour (1950, p.38) dug out the seam along strike from the tunnel. McEvoy recorded a width of 5.6 feet; Malloch recorded 5.8 feet, and Evans, 6.5 feet. Buckham and Latour recorded 5.9 feet.

Sampler	Width (feet)	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
McEvoy	5.6	1.17	6.54	83.37	8.92		
Malloch	5.8	2.88	7.64	78.84	10.64		
J.F. Walter	5.6	3.83	6.37	62.14	27.66		
C. Fergie	1.6	4.12	7.43	82.60	5.85	12,775	0.46
C. Fergie	3.8	3.95	8.00	84.00	4.05	12,995	0.49
McEvoy	6.2	2.62	6.96	84.49	5.93	13,814	0.57

During the field work of 1970 (Tompson, et.al.) fragments of coal were found which had been mined out during the earlier work. No coal outcrops were found. A grab sample of the "dump" material was assayed after separation at specific gravity 1.58:



EXPLANATION
Overburden
Sandstone
Shale
Interbedded sandstone and shale
Strike and dip
Cross section
D.D.H. No.3
Vertical
Figure 5
Groundhog Coalfield
Map of Lower Discovery Creek
and
Geological Cross Section
Through Diamond Drill Hole No.3
Willard D. Tompson, 1970. Revised, 1977
Scale
0 100 200 400 600 Ft.
Discovery Creek
105,000 E
106,000 E
111,000 N
A
B
Lower Discovery Creek
Coal Seam Outcrop
D.D.H. No.3
Elevation (Ft.)
3800
3700
3600
3500
3400
3300
588 Ft.
Section Looking N. 13° 30' W.

Moisture	N.D.
Volatile matter	7.81 %
Fixed carbon	84.23
Ash	3.92
Btu	14,097
Sulfur	0.50

Diamond drill hole number 3 (Fig.5) was located 930 feet, approximately east-northeast from the sub-outcrop of the Lower Discovery Creek seams. At 53.5 feet the seam was intersected. It is 6.5 feet wide and appears to be in its' normal down dip position from its' outcrop, as it strikes S. 61° E. and dips 5° to the N.E. (Dowling 1915, p.214). This coal is vitrain with thin bands of clarain up to 1/8 inch wide and contains minor quartz and calcite veining at 55.7 to 56.2 feet. About 25 percent of the coal was crushed.

The core was split and half was crushed to minus 1/4 inch. The sample was floated at specific gravity 1.65 and proximate analysis was run on the float fraction:

Moisture	0.61 %
Volatile matter	5.43
Fixed carbon	80.76
Ash	13.20
Btu	11,966
Sulfur	0.97

The remaining half of the core was tested by float-sink procedure. The core was crushed to minus 3/8 inch and float-sink tests were made on the crushed sample at specific gravities: 1.40, 1.50, 1.60, 1.65, 1.70, 1.75, 1.80, 1.90 and 2.00. Each gravity fraction was analyzed for percent ash and sulfur and washability tables were prepared. A composite sample was prepared of the 1.75 specific gravity float fraction and received proximate analysis:

Ash	17.09 %
Volatile matter	7.58
Fixed carbon	75.33
Btu	11,966
Sulfur	0.97

Coal Seam Elev. 3990. - This seam outcrops on the south bank of Discovery Creek, upstream about 550 feet from Lower Discovery Creek seam. Poor exposure and deep weathering preclude an accurate description of the seam, but it is estimated that the seam is 4 to 5 feet thick. Coal float which originates from this seam is hard and has a very bright luster. The seam was not sampled. There is no record of this seam in any of the early reports, so it apparently received no work.

The seam was intersected in diamond drill hole number 3 in 1970 (Tompson, et.al.) at 71.2 feet and is 4.8 feet wide. It is vitrain coal with thin bands of clarain and contains a few quartz veinlets at 73 feet and 75 feet. About 18 percent of the coal is crushed. It was tested in exactly the same manner as Lower Discovery Creek seam and the two analyses are recorded as follows:

	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
Crushed 1/4" x 0 Float, S.G. 1.65	0.61	4.89	81.19	13.31	13,418	0.83
Crushed 3/8" x 0 Wash. Test, Comp. 1.75 S.G.	Dry basis	6.21	80.71	13.08	12,645	0.77

Upper Discovery Creek Seam. - The Upper Discovery Creek coal seam was discovered by W. W. Leach in 1904 (Buckham and Latour, 1950, p.40). The site of the old adit was found by the writer in 1970. It is on the south bank of Discovery Creek at elevation 4470 feet and is 7800 feet west of the confluence of Discovery Creek and Skeena River.

The seam is 700 feet stratigraphically, below the Lower Discovery Creek seam. Thus, the nomenclature becomes cumbersome because the Upper Discovery Creek seam is stratigraphically below the Lower Discovery Creek seam, so the seams should be renamed after more stratigraphic information becomes available. The Upper Discovery Creek seam has been measured by several geologists; Buckham and Latour (1950, p. 40) measured a 7.2 foot seam, Leach (1904) 5.9 feet, Malloch (1912) 6.0 feet and Evans (1912) 4.8 feet. The writer measured the seam in 1970:

Carbonaceous shale	
Bright, hard coal, conchoidal fracture	2.0 feet
Carbonaceous shale	0.6
Bright, hard coal, metallic luster	3.5
Carbonaceous shale	___
Total coal	5.5 feet

Sampler	Width (feet)	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
Leach	5.9	5.75	7.34	75.26	11.65		
Leach	5.9	1.45	7.51	75.23	15.81		
Walter	5.4	4.45	8.75	79.25	7.55		
McEvoy	5.4	1.17	6.54	83.37	8.92	13,328	0.74

The writer sampled the coal seam and omitted the parting of 0.6 feet carbonaceous shale. The sample was crushed to minus 1/4 inch and floated at specific gravity 1.58. The float fraction was analyzed:

Moisture	1.64 %
Volatile matter	8.82
Fixed carbon	84.29
Ash	5.25
Btu	14,047
Sulfur	0.32

The reject portion of the sample was crushed to minus 16 mesh and floated again. Proximate analysis was made on the 1.75 specific gravity composite:

Ash	4.91 %
Volatile matter	6.20
Fixed carbon	88.89
Btu	14,012
Sulfur	0.45

The Upper Discovery Creek seam was intersected in diamond drill hole number 2 (Fig.6) at 194.6 and is 6.2 feet thick (Tompson, et.al.1970):

	Interval	Feet
Carbonaceous shale with 20 to 30 percent coal		
Coal	194.6-196.0	1.4
Carbonaceous shale	196.0-196.5	
Coal	196.5-199.8	3.3
Carbonaceous shale	199.8-200.3	
Coal	200.3-200.6	.3
Carbonaceous shale	200.6-200.8	
Carbonaceous shale with thin coal partings, fossiliferous		
Total coal		5.0 feet

The core was split with a diamond saw and half of the raw coal received proximate analysis:

Moisture	0.49 %
Volatile matter	4.21
Fixed carbon	58.42
Ash	36.88
Btu	8,966
Sulfur	0.43

The other half of the core was crushed to minus 3/8 inch and tested by float-sink procedure at specific gravities; 1.40, 1.50, 1.60, 1.65, 1.70, 1.75, 1.80, 1.90 and 2.00. Each

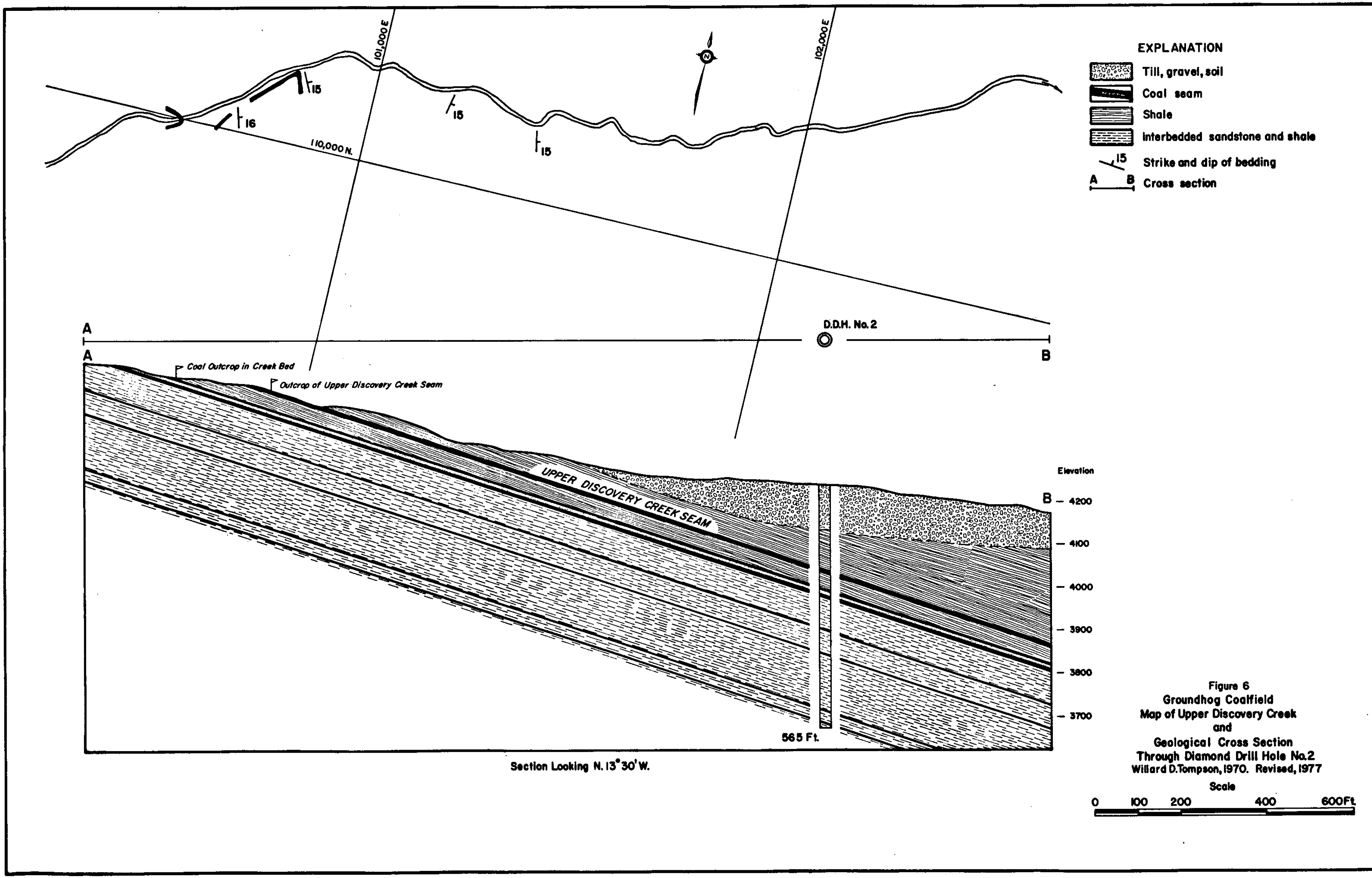


Figure 6
Groundhog Coalfield
Map of Upper Discovery Creek
and
Geological Cross Section
Through Diamond Drill Hole No. 2
Willard D. Tompson, 1970. Revised, 1977

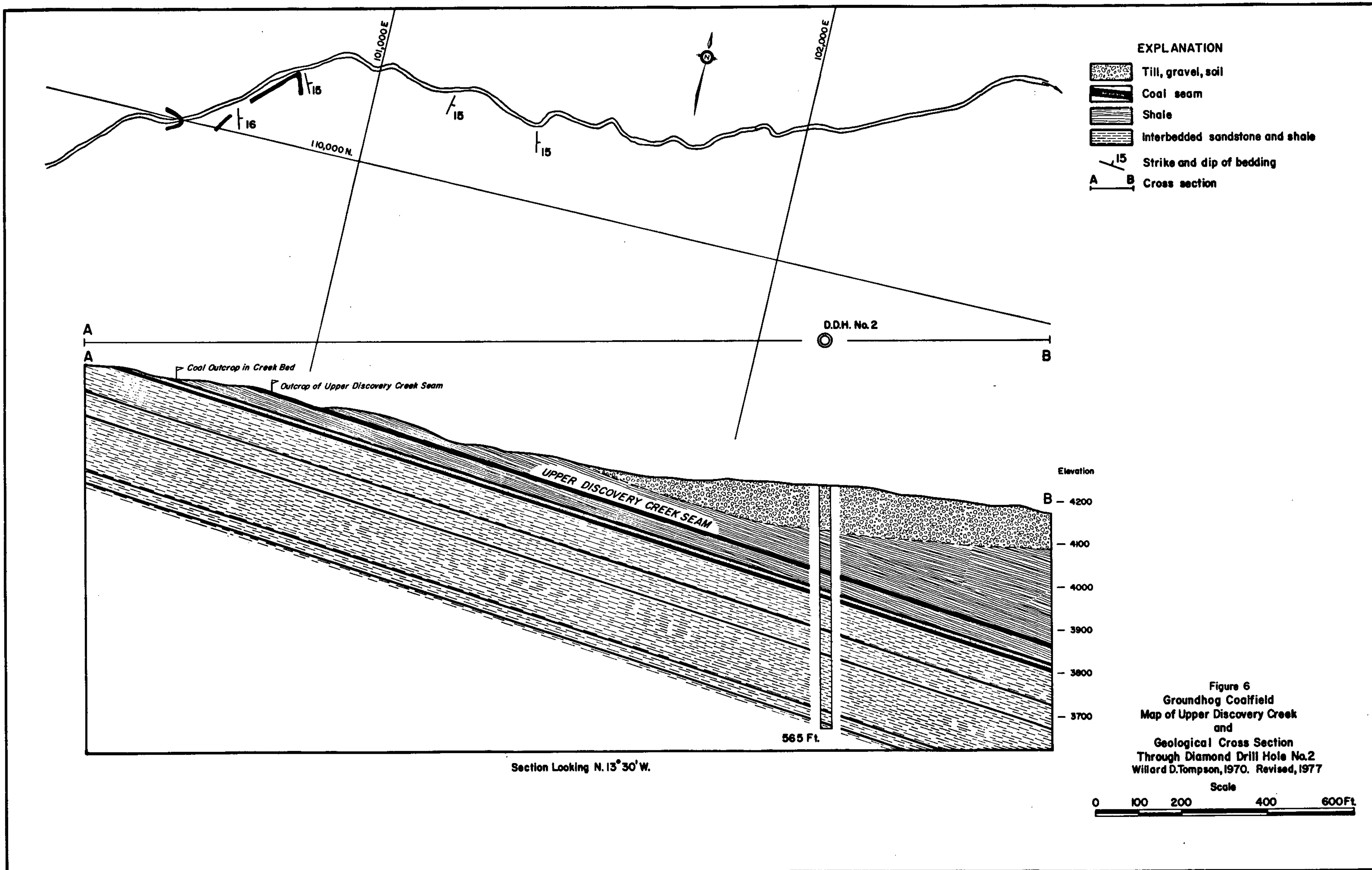


Figure 6
Groundhog Coalfield
Map of Upper Discovery Creek
and
Geological Cross Section
Through Diamond Drill Hole No. 2
Willard D. Tompson, 1970. Revised, 1977

gravity fraction was analyzed for percent ash and sulfur and washability tables were prepared. A composite of the 1.75 float fraction was analyzed:

Ash	9.43 %
Volatile matter	5.70
Fixed carbon	84.87
Btu	13,552
Sulfur	0.43

Abraham Creek

Robertson (1912) reported that,

> "Another tunnel was found on Abraham Creek, in a draw about three quarters of a mile to the northwest of Courrier creek; this tunnel had been driven in for about 20 feet on a coal seam 6 feet thick, having a strike of about east and west, dipping to north at an angle of 8 degrees and with a fairly good roof of sandy shale or sandstone."

Malloch (1912) concludes that the coal seam on Abraham Creek is the same as the Upper Discovery Creek seam. He records that the seam is 5.5 feet thick with 0.5 feet of bone near the middle. Malloch says that the seam strikes N. 54° E. and dips 16½° N., which is at considerable variation with the strike and dip recorded by Robertson.

Jenkins (Tompson, et.al.) dug on the seam in 1970 and reported it is 5.4 to 7.5 feet wide, of which 4.9 to 6.4 feet are coal. He measured the strike as east with a dip of 15° N. However he was unable to dig it out sufficiently to sample the full width, but took a 2 foot sample.

Sampler	Width (feet)	S. G. Float	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
McEvoy			1.17	6.05	76.20	16.58		
Malloch	5.5		1.04	8.39	67.89	22.68		
Robertson	6.0		2.50	8.10	62.30	27.10		
Robertson			3.0	6.6	66.0	24.4		
Jenkins	2.0	1.58	2.54	11.08	81.42	4.96	13,149	0.40

Malloch's conclusion that the Upper Discovery Creek seam and the Abraham Creek seam are the same, appears to be reasonable in that the stratigraphy of the enclosing rocks and the analyses of the seams are similar.

Diamond drill hole number 6 which was drilled in 1970 probably encountered the Abraham Creek seam. At 278.5 feet a coal seam was intersected which is 5.1 feet thick. The seam is largely vitrain coal with interbedded, carbonaceous shale. It contains quartz veinlets and minor pyrite.

The drill core was split with a diamond saw and half was crushed to minus 3/8 inch and floated at specific gravity 1.58. Proximate analysis was made on the float fraction:

Moisture	0.53 %
Volatile matter	8.37
Fixed carbon	78.14
Ash	12.96
Btu	12,899
Sulfur	0.75

The remaining half of the core was crushed to minus 3/8 inch and tested for washability at specific gravities; 1.40, 1.50, 1.60, 1.65, 1.70, 1.75, 1.80, 1.90 and 2.00. Percentage ash and sulfur were determined on each fraction. A composite sample was prepared of the 1.75 specific gravity float fraction and tested by proximate analysis:

Ash	19.76 %
Volatile matter	9.45
Fixed carbon	70.79
Btu	11,746
Sulfur	0.74

Langlois Creek

Glacial drift and alluvium obscure bedrock in the valley of Langlois Creek and on the ground above the creek.

The ground south of Langlois Creek is covered by drift and is heavily covered by spruce forest.

Abundant coal float occurs in the south bank of the creek through much of its' length, and there is much coal in the stream bed. It is inferred that prominent coal seams underlie the area south of Langlois Creek, although a large area was examined without the discovery of outcrops.

Several samples were taken from float occurrences in the banks south of the creek. They are listed in order of relative elevations from which the samples were taken.

All samples were crushed to minus 1/4 inch and were cleaned at specific gravity 1.58:

	Inherent Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
Elevation 3550 feet	N.D.	6.96	85.63	6.7	14,047	0.66
Elevation 3650 feet	N.D.	7.22	84.24	7.58	13,822	0.64
Elevation 3725 feet	N.D.	5.28	84.58	8.63	13,922	0.94
Elevation 3750 feet	1.10	6.12	84.23	8.55	13,473	0.49
Elevation 3750 feet	1.21	7.54	81.19	10.06	14,321	0.52

Telfer Creek Coal Seams

Eight coal seams are reported to occur in the upper Telfer Creek drainage. The coal seams were explored by drifts in 1911 and were reported upon by Evans (1913). None of the coal seams were observed by the writer in 1970, as the outcrops of the seams were mined out in 1911 and the workings have completely slumped. The gravel bars in the creek valley contain abundant coal float, but much of it may have come from the early mine dumps. However, at the site of each of the tunnels, buried mine timbers show where the work was done. The cabin which was constructed by B.C. Anthracite Coal, Ltd. in 1911 is in ruins, as is the shop, but much evidence of the early activity remains. The following descriptions are after Buckham and Latour (1950, p.52-55):

Coal Seam "A". - This seam is the lowest in elevation reported from Telfer Creek (Fig.7). It was exposed at an elevation of 3710 feet. It is 4.7 feet thick of which 4.6 feet are clean coal. It has a strike of N. 75° W. and a dip of 65° N.E. The analysis is as follows:

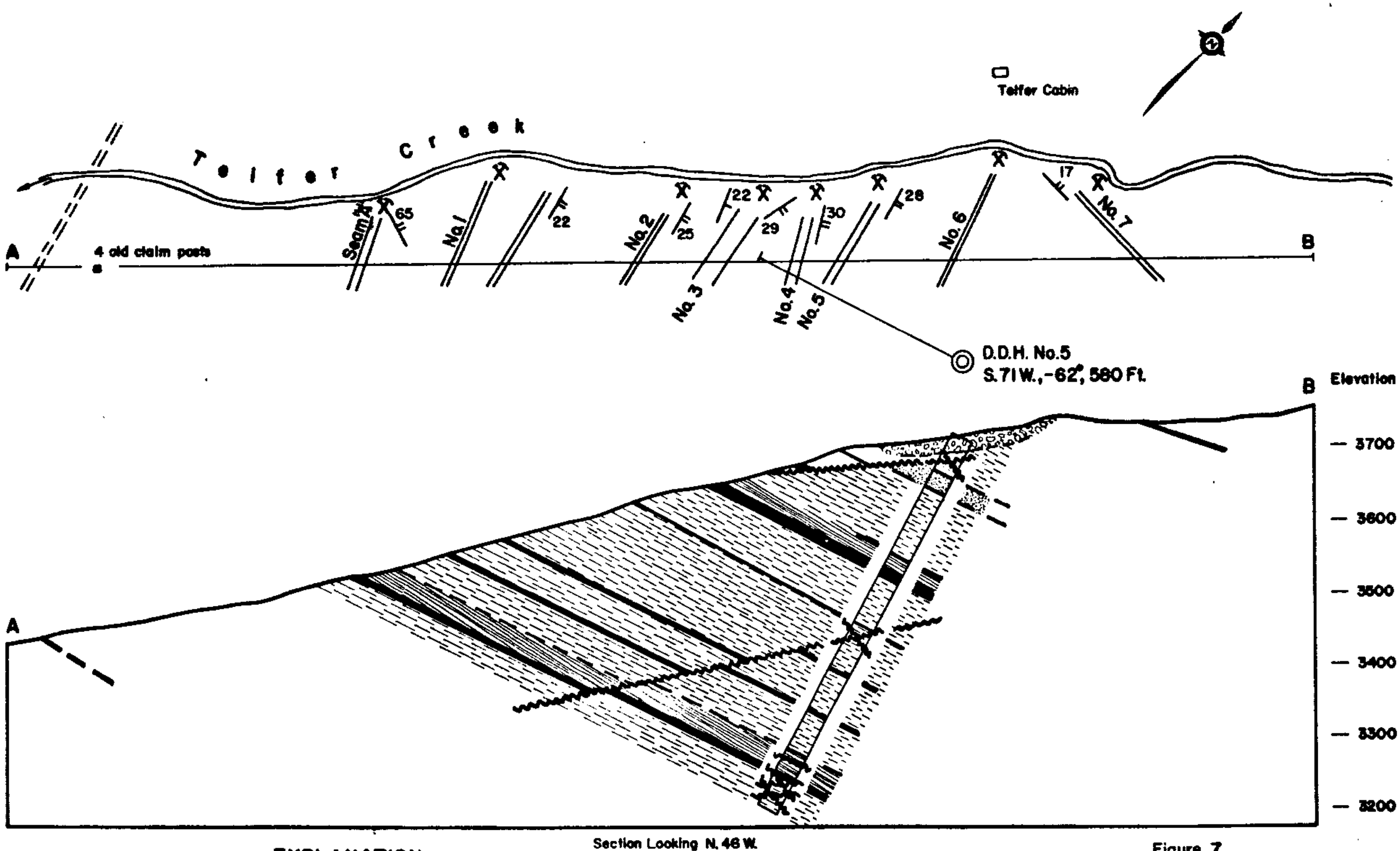
Moisture	3.55 %
Volatile matter	4.02
Fixed carbon	70.68
Ash	21.75
Btu	11,980
Sulfur	0.99

Telfer No. 1. - The Telfer No. 1 seam is about 150 feet upstream from "Telfer A". It was opened by a 20 foot drift in the steep south bank of the creek. The seam is reported to be 5 feet thick of which 3 feet are coal. No analysis is available.

Telfer No. 2. - This seam was opened with a 20 foot drift in the steep south bank of Telfer Creek. Evans measured a 5.1 foot seam, including 4.2 feet of coal. The seam strikes N. 22° W. and dips 25° N.E. The analysis is as follows:

Moisture	3.75 %
Volatile matter	5.74
Fixed carbon	56.15
Ash	34.36
Btu	9,600
Sulfur	1.57

Telfer No. 3. - The Telfer No. 3 seam was opened by a short drift which exposed 14.6 feet of stratigraphic section including 3.3 feet of coal with minor shale and 10.3 feet of mixed shale and coal. Strike is N. 9° E., dip is 29° N.E.



EXPLANATION

- Till, gravel and soil
- Coal seam
- Shale
- Sandstone
- Interbedded sandstone and shale
- Faults
- 20 Bedding strike and dip
- 20 Coal seam strike and dip
- A B Cross section
- Caved adit

Figure 7
Groundhog Coalfield
Map of Telfer Creek
and
Geological Cross Section
Through Diamond Drill Hole No.5
Willard D.Tompson, 1970. Revised, 1977
Scale
0 100 200 400 600 Ft.

Analysis of the coal is as follows:

Moisture	4.50 %
Volatile matter	6.25
Fixed carbon	47.73
Ash	41.52
Btu	7,800
Sulfur	0.99

<u>Telfer No. 4</u>. - Upstream from Telfer No. 3 a coal seam was opened by a 22 foot drift. Evans (1912) measured five feet of coal with quartz "nodules" at the face. The attitude of the seams is; strike N. 30° W., dip 30° N.E. The analysis as reported by Evans is:

Moisture	3.77 %
Volatile matter	4.27
Fixed carbon	57.75
Ash	34.21
Btu	9,580
Sulfur	0.60

<u>Telfer No. 5</u>. - This seam was opened with a 10 foot drift. The carbonaceous section comprises 6.5 feet, but includes only 1.5 feet of coal. The seam strikes N. 15° W. and dips 28° N.E. No assay information is available.

<u>Telfer No. 6</u>. - This seam was opened with a short drift. A six-foot thickness of carbonaceous shale and coal was uncovered. No estimate of the amount of coal in this bed is recorded in the literature, nor are there assays recorded.

Telfer No. 7. - A 10 foot drift on this seam exposed 3.5 feet of mixed carbonaceous shale and coal. The strike of the seam is east and the dip is 17° N. An analysis of the coal is as follows:

Moisture	5.95 %
Volatile matter	13.32
Fixed carbon	46.67
Ash	34.06
Btu	9,360
Sulfur	0.44

The analysis of this coal seam is anomalous with respect to others in the Groundhog coalfield, as the amount of volatile matter is relatively higher making it a low-volatile bituminous coal.

Drill Hole Intersections of Telfer Seams. - Diamond drill hole number 5 (Fig.7) was collared about 400 feet southeast from Telfer cabin and was designed to intersect the Telfer seams normal to their strike and dip. It was drilled at minus 62 degrees to the S. 71° W. Some faulting was recorded immediately beneath the overburden at 29 feet and the first intersection which was expected at about 90 feet was not made until 183 feet. More faulting was recorded at 300 feet, 330 feet, 385 to 400 feet and at 575 feet. Correlation of the coal seams in the drill core with the coal seams in the outcrops was not made. Six seams were intersected which had a total of 29.3 feet of coal. (It is noted that the three coal intersections between 206.1 and 217.5 feet are considered to be one seam.)

The core was split with a diamond saw and half was crushed to minus 16 mesh and separated in a solution having specific gravity 1.65.

Intersection	Feet	Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Btu	Sulfur %
183.0 - 186.8	3.8	0.90	11.07	4.77	83.26	13,473	0.31
206.1 - 209.5	3.4	0.84	11.28	5.06	82.82	13,448	0.45
212.5 - 214.3	1.8	0.52	10.30	5.22	83.96	13,698	0.70
215.0 - 217.5	2.5	0.85	11.38	4.74	83.03	13,473	0.56
291.0 - 292.2	1.2	0.52	8.84	5.28	85.36	13,972	0.70
362.0 - 366.0	4.0	0.58	4.50	4.50	90.42	14,596	0.38
429.5 - 435.5	6.0	0.55	7.74	4.78	86.93	14,022	0.74
527.0 - 533.6	6.6	0.74	8.57	4.53	86.16	13,847	0.51

The balance of the core from the first four intersections was crushed to minus 3/8 inch for washability tests. Float-sink tests were made at specific gravities; 1.40, 1.50, 1.60, 1.65, 1.70, 1.75, 1.80, 1.90 and 2.00. Each fraction was analyzed for percent sulfur and ash, and washability tables were prepared. Proximate analysis was made for the appropriate composite sample (The three intervals from 206.1 to 217.3 were combined into a single assay interval):

Intersection	Feet	Ash %	Volatile Matter %	Fixed Carbon %	Btu	Sulfur %
183.0 - 185.9	2.9	14.01	5.72	80.27	12,293	0.49
206.1 - 217.5	7.7	15.85	6.30	77.85	12,075	0.69

It is noted from the above that crushing to minus 16 and separating at 1.65 produced a superior product to that produced by crushing to minus 3/8 inch and separating at 1.70. Ash decreased from about 14 percent to 11 percent, fixed carbon increased from about 80 percent to 83 percent and calorific value increased from about 12,000 Btu to 13,500 Btu.

Duke Creek

Coal occurs in two localities on Duke Creek; three coal seams outcrop on the east bank of Duke Creek near its' confluence with Skeena River and large boulders of coal 2 to 4 feet in diameter occur at 3540 feet and 3700 feet elevation. At elevation 4650 feet two seams are partially exposed southeast of Table Mountain.

Buckham and Latour recorded a 1.9 foot seam near the mouth of Duke Creek. A sample of that seam over a width of 1.3 feet (Tompson, et.al.) gave the following analysis:

Moisture	1.39 %
Volatile matter	3.87
Fixed carbon	91.20
Ash	3.54
Btu	13,847
Sulfur	0.85

Two samples were taken by Jenkins from poorly exposed coal seams near the head of Duke Creek. The 1.58 specific gravity float fraction was analyzed:

Locality	Width	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
Upper seam	1.5	2.03	9.59	76.58	11.80	12,101	0.38
Lower seam	1.0	2.38	11.99	73.55	12.08	11,826	1.01

Trail Creek

Six coal occurrences on Trail Creek were explored by adits in 1911 and 1912 (Buckham and Latour, 1950) and were examined, mapped and sampled by Jenkins (Tompson, et.al.) in 1970 (Fig.8). The area was shown by Evans (1912) and by Jenkins to be folded and faulted and of only limited economic

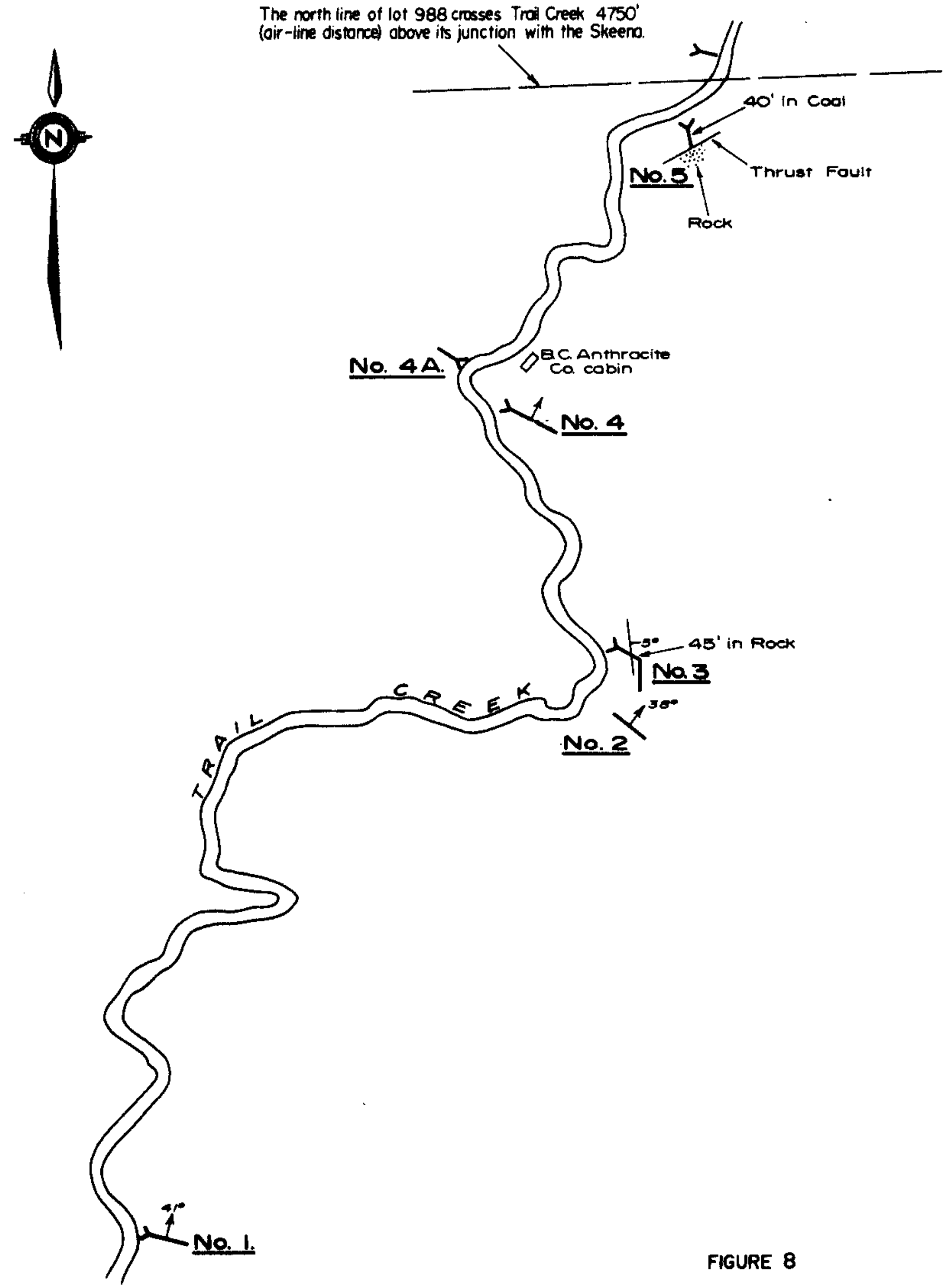


FIGURE 8

GROUNDHOG COALFIELD PROJECT

MAP SHOWING LOCATION OF COAL SEAMS & ADITS ON TRAIL CREEK

SCALE

FEET 500 250 0 500 1000 FEET

potential. Coal analyses of the various occurrences are recorded below and are referred to Evans' original locations:

Sampler, location	Width (feet)	S. G. Float	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
Evans, unnumbered tunnel	9.5							
Evans, No.2 tunnel	3.8		2.7	5.6	53.4	38.3		
Robertson, No. 2 tunnel	Spec.		2.3	5.1	71.1	21.5		
Jenkins, No. 2 tunnel	Dump	1.58	1.86	5.39	88.16	4.59	14,346	0.67
Evans, No.4 tunnel	5.4		3.20	7.02	49.43	40.35	7,860	0.99
Robertson, No. 4 tunnel	Spec.		3.4	5.4	70.8	20.4		
Jenkins, No. 3 tunnel	Dump	1.58	1.29	6.34	85.79	6.58	13,322	0.52
Jenkins, No. 1 tunnel	0.9	1.58	1.67	4.86	90.25	3.22	14,471	0.52
Leach, elev.2920	10.1							

Jackson Creek

Seven coal seams were recorded by Evans (1912) on Jackson Mountain and Jackson Creek, from near the bottom of Jackson Creek at 2990 feet elevation, to 5180 feet on the north slope of Jackson Mountain. Three of the seams were found in 1970 by Jenkins and were dug out.

2990 Feet Elevation. - This seam was dug out by Jenkins and was found to be 8.3 feet thick with 6.4 feet of coal. The strike of the coal seam is N. 5° E. and the dip is 30° S.E.

3180 Feet Elevation. - Trenching by Jenkins exposed a seam 6.4 feet thick of which 2.2 feet are coal. The seam strikes N. 25° E. and dips 37° N.E.

Jackson No. 2. - Evans described this seam as being 9.6 feet thick with 4.0 feet of clean coal and 5.6 feet of coal and shale. The strike is N. 40° W. and the dip is 74° S.W.

Jackson No. 3. - Evans records a 5.6 foot seam at the face of a 25 foot drift. The coal is interbedded with shale. The seam strikes N. 45° W. and dips 35° S.W.

Jackson No. 4. - This seam was opened by a 15 foot drift. Evans reported the seam as being 5.3 feet thick with 2.6 feet of coal. The strike is N. 56° W. and the dip is 20° N.E.

5810 Feet Elevation. - Jenkins (Tompson, et.al.,1970) dug out this seam and found it to be 3.5 feet thick. It strikes east and dips 15° N. This may be the same seam as Evans', Jackson No. 2.

The assay data on the Jackson Creek - Jackson Mountain coal occurrences are as follows:

Sampler, Location	Width (feet)	S. G. Float	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
Jenkins, 2990 ft.	8.3	1.58	2.12	11.61	79.94	6.33	10,304	0.46
Jenkins, 3180 ft.	1.4	1.58	1.80	8.72	82.31	7.17	13,723	0.49
Evans, Jackson No.1	2.3		4.01	13.08	57.71	25.20	9,600	2.42
Evans, Jackson No.2	4.0		2.45	3.86	63.96	29.73	10,280	1.93
Jenkins, 5810 ft. (Jackson No.2 ?)	3.5	1.58	3.68	8.62	80.60	7.10	12,924	0.52
Evans, Jackson No.3	4.4		2.97	5.59	65.60	25.84	11,520	1.90
Evans, Jackson No.4	2.6		2.71	6.09	67.42	23.78	12,650	3.05

It is noted that the rocks on Jackson Mountain are structurally disturbed, but details of the structures have not been solved.

Cleaning by heavy media is shown to significantly lower the ash and sulfur content, as is evident in the samples which were taken by Jenkins.

Little Creek

Three coal seams were examined by Evans on Little Creek at elevation 4100 feet and 4200 feet. Two of the seams were examined by Jenkins during the summer of 1970 (Tompson, et.al.):

Sampler Location	Width (feet)	S. G. Float	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu	Sulfur %
Evans, 4100 ft.	3.0		4.42	6.58	58.96	30.04	9,930	1.61
Jenkins, 4100 ft.	2.0	1.58	3.88	7.29	83.34	5.49	13,224	0.47
Evans, 4200 ft.	2.3		4.01	13.08	57.71	25.20	9,600	2.42

Dave Creek

Five major coal-bearing beds outcrop in the headwaters of Dave Creek. Their relative stratigraphic positions are shown in Figure 3. The strike of the sedimentary rocks is N. 44° W. and the dip is 55° S.W. Descriptions of the outcrops, from lowest elevation to highest elevation are below.

Dave No. 1. - Coal occurs interbedded with shale in a 10 foot seam. The seam is poorly exposed and is deeply weathered. It is estimated that 75 percent of the seam is coal.

Dave No. 2. - This seam was observed in outcrop about 70 feet above Dave No. 1. It is 4.9 feet thick and has 2.8 feet of coal.

Dave No. 3. - This seam occurs at elevation 5300 feet on Dave Creek. It is interbedded coal and carbonaceous shale and is 15.9 feet thick. The bed contains one coal seam which is 6 feet thick and contains 4.1 feet of coal. A sample was separated at specific gravity 1.58 and analyzed:

Moisture	1.32 %
Volatile matter	11.45
Fixed carbon	82.04
Ash	5.19
Btu	13,174
Sulfur	0.50

Dave No. 4. - The coal seam is 10.4 feet thick where exposed in outcrop and is largely interbedded carbonaceous shale with attrital coal. There are two seams of hard, bright coal each 1.5 feet thick, which are separated by a thin shale parting.

Dave No. 5. - This seam was opened by trenching and is 6.1 feet thick of which 5 feet are coal.

Beirnes Creek - Currier Creek Pass

Large quantities of coal float occur in the broad pass between Beirnes Creek and Currier Creek. Due to low topographic relief and low dips of the bedding, less than one percent outcrops occur. One coal-bearing outcrop is known. It is at elevation 4750 feet in a small northeast flowing drainage which forms the headwaters of Anthony Creek. This coal seam was found in July, 1969 by the writer and Glen Huck as a result of following float of "peacock" coal at the head of Anthony Creek. The seam was dug out by the writer in 1970, but neither the roof nor the floor were reached. The strike is N. 80° E. and the dip is 7° N. A four foot sample was cut. It was crushed to minus 1/4 inch and separated at specific gravity 1.58. Proximate analysis of the float fraction is as follows:

Moisture	N.D.
Volatile matter	5.18 %
Fixed carbon	84.81
Ash	8.25
Btu	13,847
Sulfur	0.58

About 1/4 mile south of the above location, pieces of coal float were taken from overburden. These are believed to be from a buried coal seam. The sample was prepared in the same manner as the one above.

Moisture	N.D.
Volatile matter	6.60 %
Fixed carbon	84.46
Ash	4.62
Btu	13,797
Sulfur	0.49

Coal occurs in many localities on Beirnes Creek - Currier Creek pass in the diggings of hoary marmots (Marmota caligata oxytona Hollister). In these instances sub-outcrops of the seams are believed to be within 4 or 5 feet of the surface.

Upper Currier Creek

Several coal occurrences were observed in the area north of Currier Creek where six coal seams are exposed in a small gulley. The coal seams strike northwesterly and most dips are northeast, but some are southwest as the exposures of the strata occur on both limbs of a small syncline (Plate I). The trace of these seams may be followed along the slope of the hill, as there are scattered exposures of coal in several small gullies and coal float occurs in diggings of hoary marmots.

EXPLORATION TARGETS

This writer has selected four areas as principal exploration targets. They were selected on the basis of (1) favorable geology (2) a review of data from early workers in the coalfield and (3) data from wide spaced diamond drilling. The areas are arbitrarily identified according to their geographical locations and are herein referred to as, "Target Areas, A, B, C and D" (Fig.9). The total area covered is 37,200 acres or about 58 square miles. A strip of ground 2000 feet wide along Skeena River and along major creeks is omitted from the total.

Target area "A"	23.1 square miles;	14,840 acres
Target area "B"	2.6 square miles;	1,680 acres
Target area "C"	15.9 square miles;	10,160 acres
Target area "D"	16.4 square miles;	10,520 acres
Total area,	58.0 square miles;	37,200 acres

Target Area "A"

Target area "A" (Fig.9) covers about 15,000 acres and lies in the high country at the headwaters of Beirnes Creek, Anthony Creek, Panorama Creek and Currier Creek. Elevations are from 4000 feet to 5500 feet and most of the area is above treeline.

The area is underlain by rocks of the Coal-Bearing lithosome which are traversed by northwest-striking anticlines and synclines of unknown amplitude. At least one fault transects the rocks. It strikes east and appears to truncate the fold axes. Coal occurrences in Target area "A" were described on pages 70 and 71.

Many occurrences of coal are known in this area between main tributaries of the Skeena and Nass Rivers, (pp. 70 and 71, this report) but none have received more than cursory examination, mapping and superficial digging.

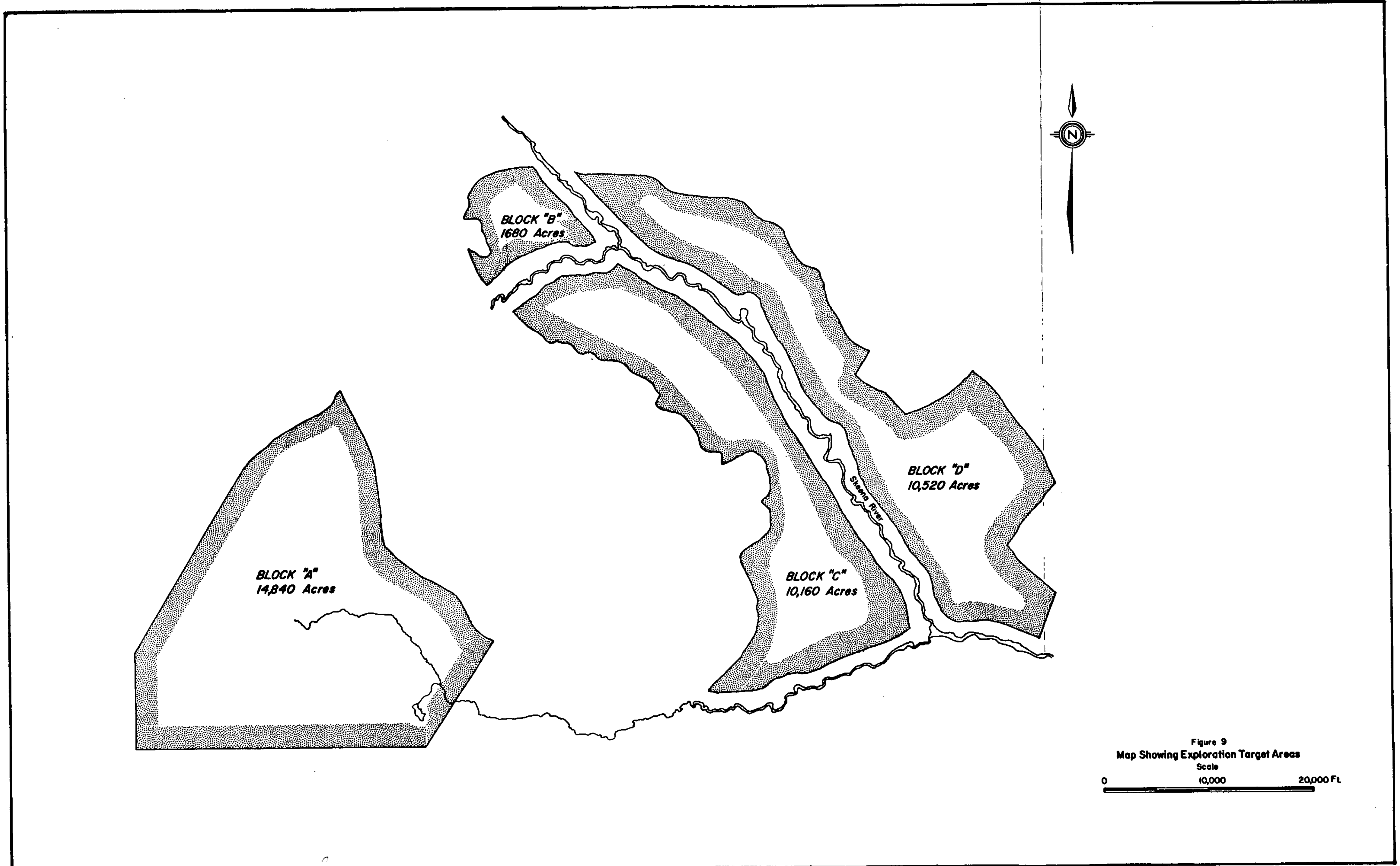


Figure 9
Map Showing Exploration Target Areas

It is reasonable to believe that the seams which outcrop on Beirnes Creek, Anthracite Creek, Davis Creek, Discovery Creek and Abraham Creek also occur in this stratigraphic section.

Target Area "B"

This area (Fig.9) covers about 1700 acres and lies north of Beirnes Creek at the apex of one of the Skeena River anticlines (p.36). The area occupies low terrain west of Skeena River and north of Beirnes Creek and is about 3500 feet to 4500 feet in elevation.

The area is underlain by rocks of the Coal-Bearing lithosome. Outcrops are few and attitudes of beds are not known except for those beds which are exposed along Beirnes Creek.

Five coal seams which occur on Beirnes Creek were tested by trenching, tunneling and diamond drilling (pp. 37 to 48, this report). The strike and dip of the seams suggests that they may underlie Target Area "B". The seams have a total width of 43 feet, and occur in about 900 feet of the stratigraphic sections of the Coal-Bearing lithosome.

Target Area "C"

Target Area "C" lies west of Skeena River, north of Currier Creek and south of Beirnes Creek (Fig.9). The area covers about 10,160 acres and is 9 miles long and from about one mile, to more than 3 miles wide. The entire area is underlain by rocks of the Coal-Bearing lithosome and many of the seams which are exposed on Beirnes Creek are believed to underlie Target Area "C" (see pp. 37 to 59, this report). The coal seams which are exposed on Davis Creek, Discovery Creek and Abraham Creek (pp. 49 to 59) also underlie the area (some of these seams may correlate with seams in the Beirnes Creek section).

Five coal seams, totalling 43 feet are known to occur in the Beirnes Creek stratigraphic section and about 600 feet of the section are still unknown and untested.

An anticline traverses Target Area "C" from Beirnes Creek southeastward to the mouth of Discovery Creek. A syncline strikes westerly from the confluence of Currier Creek with Skeena River. The amount of disturbance to the beds and to the coal seams is not known. It should be noted however, that folding and faulting are normally encountered in anthracite coal deposits.

Most of the physical work which has been done in the Groundhog coalfield was done in Target Area "C", e.g. McEvoy's and Leach's trenching and tunnelling at Discovery Creek, Abraham Creek and Davis Creek; Campbell-Johnston's trenching and tunnelling on Beirnes Creek and Anthracite Creek and diamond drilling by National Coal Joint Venture at Beirnes Creek, Discovery Creek and Abraham Creek.

Target Area "D"

This area lies east of Skeena River and northwestward from the big bend in Skeena River to about 2 miles beyond the mouth of Beirnes Creek (Fig.9). The area covers about 10,500 acres and is 11 miles long and from 1 to 3 miles wide.

Target Area "D" is underlain by rocks of the Coal-Bearing lithosome except for an erosional outlier of younger sandstones at Table Mountain. Coal occurs as abundant float in Langlois Creek, Telfer Creek and Duke Creek (pp. 59 to 65, this report) and some coal was found in other small creeks which drain southwestward from the mountains towards Skeena River. One diamond drill hole intersected 5 coal seams which total 35 feet in thickness (pp. 63 and 64). These seams probably correlate with those west of Skeena River, and thus Target Area "D" may be underlain by some of the same coal seams which outcrop at Beirnes Creek, Anthracite Creek, Davis Creek, Discovery Creek and Abraham Creek.

An anticline and syncline traverse the full length of Target Area "D", but the amount of disturbance to the beds is not known. Northeasterly-striking faults occupy the valleys of Duke Creek and Langlois Creek. However the movement on these faults is thought to be small.

EXPLORATION PROPOSAL

An exploration proposal must be directed toward identifying sufficient coal reserves to operate a thermal power generating plant for 35 years. It is suggested that a minimum of 50 million short tons of reserves must be identified, or considering that recovery may be only 50 percent if much underground mining is required, it may be necessary to identify 100 million tons of reserves.

Target Areas "B", "C" and "D" (Fig.9) contain coal seams which are from 3 feet to 11 feet in thickness and which outcrop at various places over an area of 35 square miles. Geological mapping and wide space diamond drilling show that some areas are sufficiently undisturbed to be minable. For example, diamond drill hole 3 (Target Area "C") intersected 11.3 feet in two seams which lie within 75 feet of the surface. Geological mapping and the work of the early prospectors and miners in the coalfield suggest that these seams may persist near the surface for a mile or more of width and for 2 or 3 miles or more, of length. Thus in these seams there may be 35 million to 50 million or more tons of coal readily accessible to surface mining procedures. Other seams exist in the same stratigraphic section at greater depth.

The rail grade of B.C. Railway passes through area "D" and is only across the river from areas "B" and "C". Thus there is present access to the coal seams in these large, low lying areas.

Area "A" is in alpine to sub-alpine terrain. Coal in that area should be placed in a Coal Reserve until it is needed at some time in the future.

A three year program is proposed for evaluating areas "B", "C" and "D". The estimated cost is $2,958,000.

The exploration program for the first year would entail complete, detailed geological mapping. Detailed stratigraphic studies and paleontological studies would be made of all outcrops. Several openings would be made in the coal seams in order to establish correlations of seams and to acquire large volumes of coal for washability tests, proximate analyses and ultimate analyses.

The estimated cost of the first years program is:

Geology, engineering, prospecting and coal testing	$184,000
Camp operation, various travel costs and communications	51,000
Roads and trails, fixed wing aircraft charter, helicopter contract, rail and highway travel	98,000
Administration	17,000
Total	$348,000

Diamond drilling during the second year would attempt to broadly identify coal seams which are structurally undisturbed. Two drill targets would be selected as a result of the first year's geological-geophysical exploration program and each would be tested with 10,000 feet of diamond drilling.

The estimated cost of the second year's program is as follows:

Diamond drilling, 20,000 feet	$ 330,000
All other costs	280,000
Total	$ 610,000

The third year's exploration should be directed toward outlining coal reserves in the first priority target. It is suggested that a more intensive diamond drilling program would be conducted and underground workings would be driven in order to test underground mining conditions and to get large volumes of coal for testing purposes.

A suggested cost estimate is as follows:

Diamond drilling first priority target area, 30,000 feet	$ 500,000
Underground testing	1,000,000
All other costs	500,000
Total	$2,000,000

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GEOLOGY OF THE GROUNDHOG COALFIELD
UPPER SKEENA RIVER AREA
BRITISH COLUMBIA
FOR
B. C. HYDRO AND POWER AUTHORITY

Willard D. Tompson, M.Sc.

March 25, 1977

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ABSTRACT

Semi-anthracite coal occurs in rocks of the Bowser assemblage in the upper Skeena River area, northern British Columbia. The deposits were discovered 75 years ago by surveyors who were mapping rail routes for the Federal Government.

The Groundhog coalfield lies in a realtively remote part of the Province and all early workers in the coalfield noted that rail access will be necessary for coal mine development. It is significant therefore that the northern extension of B. C. Railway passes through the coalfield and rail steel is just 20 miles from the coalfield at the time of this writing.

Fish, wildlife and water supplies are important resources of the area, and the British Columbia Fish and Wildlife Branch have made specific recommendations to minimize the effects of coal mining operations. Compliance with these recommendations is not considered to be an obstacle in the development of a mine.

Exploration work in the coalfield commenced in 1904, and preliminary studies were made of a rail route. All work ceased with the advent of World War I. No further work was done in the coalfield until 1968, when a geological survey was made by a mining company. In 1969 and 1970 a joint venture of three mining companies conducted a geological mapping program and drilled six diamond drill holes.

Four rock stratigraphic units are recognized, one of which contains seams of semi-anthracite coal which are from one foot to 11 feet or more in thickness. The coal bearing rock unit is known to occur over an area of about 119 square miles, but of that area 58 square miles contains coal seams which are believed to offer the greatest potential for economic development. An area of 35 square miles is designated as the primary target area due to its' geographical location, geological setting and coal quality.

The rocks throughout much of the coalfield are known to be folded and faulted. However certain areas exist where thick coal seams are relatively undisturbed.

Raw coal quality throughout the coalfield varies widely.

Coal which was cleaned by heavy media separation is of excellent quality and no difficulty is anticipated in cleaning coal to acceptable limits for specific uses. Coal cleaning methods will be designed to remove as much ash as specific uses demand by using heavy media, water cyclone or froth flotation.

Coal samples were cleaned at various specific gravities during the testing. The average coal quality of all seams greater than 3.0 feet in thickness, from both surface sampling and diamond drilling is summarized:

Average yields at various specific gravities from 1.58 to 1.75	38.8 %
Ash	9.8 %
Volatile matter	7.2
Moisture	.5
Fixed carbon	82.4
Sulfur	.6
Btu	13,366

The coal is a high quality thermal coal, suitable for thermal power generating stations.

It is estimated that 50 million tons of coal reserves will be required to operate a 500 megawatt thermal power generating plant for 35 years.

It may be assumed that coal production will be from open pit and underground mining operations. Normal underground mining procedures are anticipated as roof rocks are competent sandstones and shales. Early workers in the coalfield noted normal underground mining conditions. Minor gas was noted in fresh drill core. However gas commonly occurs in anthracite coal measures. Spontaneous combustion in the coal seams is not considered to be a problem.

The coalfield is in the very early stages of exploration, so therefore it is not possible to accurately calculate the coal reserves or the tonnages of recoverable clean coal. However, it is shown that the area between Evans Creek and Discovery Creek is underlain by relatively undisturbed coal seams. In the Upper Discovery Creek - Evans Creek area there are inferred about 12 million tons of open pit coal to a depth of 200 feet. In the Lower Discovery Creek area about 46 million tons of open pit coal reserves are inferred to a depth of 100 feet. An additional underground reserve of 290 million tons are inferred underlying the Discovery Creek - Evans Creek area.

A three year exploration program is proposed. The first years' work includes detailed geological studies and trenching. The cost of this work is expected to be about $348,000.

Diamond drilling, geological work and trenching during the second year of exploration would cost $610,000.

During the third year of exploration diamond drilling would be intensified and exploration adits would be driven in order to test underground mining conditions. Large coal samples would be taken for pilot plant tests. Costs of this program would be about $2,000,000.

Total estimated cost of the three year program is $2,958,000.

GEOLOGY OF THE GROUNDHOG COALFIELD
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PROPERTY AND LOCATION

The Groundhog coalfield lies in northwestern British Columbia in the Cassiar Land District and in the Omineca Mining Division (Figs. 1 and 2).

The area is shown on the northeast part of the Bowser Lake topographic map (National Topographic Series 104A, scale, 1:250,000) and on the McEvoy Flats topographic map (National Topographic Series 104A/16, scale, 1:50,000). The Groundhog coalfield continues westward and beyond the limits of the McEvoy Flats map and in that area topographic coverage is from maps which were made in 1969 and 1970 for a study of the coalfield (Tompson, Jenkins and Roper, 1970).

The coalfield occurs within the area bounded by 56°47' to 56°58' north latitude and 128°07' to 128°30' west longitude.

Three important rivers have their headwaters near the Groundhog coalfield. Skeena River (Fig.1) rises 15 miles northwest of the coalfield and flows southeasterly through the center of the coalfield. Nass River heads 3 miles west of the coalfield and flows southeasterly along its' western edge. Stikine River rises 20 miles north of the coalfield and flows northeasterly around Spatsizi Plateau.

Stewart, B.C. at the head of Observatory Inlet on Portland Canal is the nearest town and is about 95 miles southwest from the Groundhog. There is no road nor rail connection between Stewart and the coalfield.

The road between Stewart, B.C. and Dease Lake, B.C. lies about 50 miles southwest from the coalfield. However there is no connection between the coalfield and the Stewart-Dease Lake road, except along the grade of B.C. Railway.

B.C. Railway bisects the coalfield as it traverses the area westerly and northwesterly from Kluatantan Creek and along Skeena River to Beirnes Creek (Plate 1 and Fig.1). At the time of this writing the end of railway steel is at Chipmunk Creek, about 20 miles southeasterly from the Groundhog coalfield. Steel is expected to be in the coalfield by summer, 1977.

The distance by rail from the coalfield to Fort St. James is 237 miles; to Prince George, 309 miles; to Prince Rupert via B.C. Railway and C.N. Railway, 767 miles and to Vancouver, 804 miles.

Early workers in the Groundhog coalfield (Malloch, 1912 and Campbell-Johnston, 1912) wrote that a direct route to tidewater exists down Nass River to Nasoga Gulf, near the mouth of the Nass. Nasoga Gulf is 130 miles from the coalfield and offers a natural, deep water port site. The Gulf is about one mile wide and 6 miles long. It is undeveloped.

There are no Coal Licences in good standing in the Groundhog coalfield as the last Licences which were held by National Coal Corp., forfeited in December, 1974. At that time a Coal Reserve was in effect and the forfeited ground became part of the Reserve. The Reserve is still in effect at the time of this writing.

HISTORY

The earliest published record of coal occurrences in the Groundhog area was a report by Dupont (1900) for the Canadian Department of Railways and Canals. The discovery by Dupont was made near the confluence of Didene Creek and Spatsizi River, some 20 miles northwest of the area with which this report is concerned.

Malloch (1912, p.73) reported,

> "The first authentic discovery of coal in the Groundhog field was made by Mr. James McEvoy in 1903, who staked a number of claims on his discoveries".

The locality where McEvoy made his discoveries, he called Discovery Creek, a name which has endured. W. W. Leach stripped and sampled some of the seams in 1904 for Western Development Company. By 1904 Western Development Company owned 16 sections which had been acquired through prospectors in their employ or by purchase from prospectors. The 16 sections were surveyed in the summer of 1905 by A. W. Harvey and the registered owners were 16 different prospectors, including James M. McEvoy and W. W. Leach. It is noteworthy that McEvoy was the recorded owner of Lot 126 in which the Upper Discovery Creek seam occurs and Leach was the recorded owner of Lot 136 in which the Abraham Creek seam occurs. At that time the Upper Discovery Creek seam and the Abraham Creek seam were the best seams which were known in the Groundhog and were thought to be the same, although they outcrop 2½ miles apart.

In 1908 and 1909, J. Fredrick Walter and Charles Fergie worked at Discovery Creek and at Abraham Creek opening and sampling new coal seams (Malloch, 1912, p.73). This work was apparently done under an agreement with Western Development Company. Malloch notes (1912, p.73) that McEvoy was back in the field in 1911 with a large work force. However, Robertson (1912, p.k88) states that Western Development was, "quite unrepresented in the field during the season of 1912".

The sections which were owned by Western Development Company covered the area of Evans Creek, Davis Creek, Currier Creek and Abraham Creek and were comprised of Lots 126 and 141.

In 1909 Amos Godfrey and Frank A."Groundhog" Jackson staked some coal claims on Trail Creek. McEvoy and Leach, had undoubtedly ridden past the coal occurrences on Trail Creek many times, but did not stake ground here. It may be concluded therefore that they recognized that the rocks on lower Trail Creek are intensely folded and faulted and are not likely to contain workable coal seams. The claims which were staked by Godfrey and Jackson were subsequently acquired by B.C. Anthracite Coal, Ltd. who were financed by National Finance Company. They were surveyed in September, 1911 by A. P. Augustine, B.C.L.S. and by T. H. Taylor, B.C.L.S. B.C. Anthracite Coal, Ltd. ultimately owned 40 surveyed Coal Licences; Lot numbers 978 to 999 and 2179 to 2196 and 20 unsurveyed licences. These claims surrounded Western Development Company on the north, south and east.

Robertson (1912, p.k87-94) reported, that in 1912, B.C. Anthracite Coal, Ltd. established an exploration camp at Jackson Flats under the direction of H. F. Glassey. The company also established a good base camp on Trail Creek about 1¼ miles above its' confluence with Skeena River. The camp buildings were well constructed log buildings with plank floors and spruce shake roofs. The main camp buildings which were photographed by Evans (1912) are still standing (Tompson, et.al., 1970).

During the winter of 1911-1912, F. B. Chettleburgh and a party of miners drove two tunnels into coal seams on the east side of Trail Creek.

During the summer of 1912, Arthur Challoner, mine foreman for B.C. Anthracite Coal and a group of miners were actively engaged in driving 9 prospect tunnels on Trail Creek, Jackson Creek, Brewer Creek and Currier Creek. According to Robertson (1912, p.93) Challoner and 6 to 8 miners would be working at Trail Creek during the winter of 1912.

During the summer of 1911, B.C. Anthracite Coal, Ltd. had a group of miners working on 7 or 8 adits at Telfer Creek. The foreman at Telfer Creek was Seth Godfrey, who according to Robertson, would be occupied driving tunnels during the winter of 1912. This writer does not believe that either of those winter programs were actually done. A log house and shop building were constructed at Telfer Creek in much the same style as that at the Trail Creek site. The walls are still standing, but the roof is collapsed.

Another log house of similar design and construction was found by the writer near the junction of Falconer Creek and Skeena River. It probably was also built by B.C. Anthracite Coal, Ltd., but no records of prospects in that area have been found. This log building is in relatively good condition.

In the late summer of 1912, George Watkin Evans, a coal mining engineer from Seattle examined the B.C. Anthracite Coal, Ltd. properties and the Western Development Company properties (Evans, 1912). Evans had a distinct advantage in examining the coalfield at that time, as the prospects were newly dug and the miners and prospectors were actively engaged in making the cuts fresh so that Evans could make satisfactory evaluations of them. As a result, he was able to make a thorough examination of the southern half of the coalfield. He made these comments:

> "Portions of the field will prove fairly regular, while other portions are probably so severely faulted and folded as to be valueless.
>
> "There are some beds containing coal of excellent quality - the best domestic coal, in fact in the writers' knowledge, on the Pacific coast. For coal of this quality, a reasonably good market is assured. In portions of the field mining conditions admit of production at reasonable costs. In other portions costs will be prohibitive. Railway communication to tidewater is feasible, and transportation charges will, in relation to the grade of coal be moderate. Within the Skeena, Clappan and Nass watersheds will be found, it is believed, a sufficient quantity of high-grade mineable coal to warrant the building of a railway".

In June, 1910 R. C. Campbell-Johnston, a coal mining engineer formerly with the Cardiff collieries, examined some coal lands in the Kispiox Valley for J. G. Scott of Quebec and Leon Benoit, of Winnipeg. Benoit, in correspondence with Campbell-Johnston later that summer (August 5) said that he had employed George M. Beirnes to stake 20 sections of coal lands north of Groundhog Mountain. This is probably a misrepresentation of the facts, although George Beirnes did actually stake some claims, but probably for his own account, and subsequently sold them to Benoit. Benoit wanted Campbell-Johnston to examine the claims in the Groundhog, but Campbell-Johnston did not receive word of this until September. He immediately left for Hazelton by steamer, arriving on September 24. He enlisted the aid of George M. Beirnes who functioned as guide and packer.

George Beirnes was one of British Columbias' most famous packers. He lived at Hazelton and packed between Babine Lake and Telegraph Creek, supplying prospectors, miners, and telegraph operators along the Yukon telegraph line. With George Beirnes' pack string and some Indians whom Campbell-Johnston hired for backpacking, they travelled the telegraph trail from Hazelton to Blackwater (Damdochax) Lake, a distance of 135 miles.

From Blackwater Lake they planned to backpack over Groundhog Pass, where they would need to use snowshoes, then down Trail Creek to Jackson Flats on Skeena River and up the trail past McEvoy's camp to Beirnes Creek. The distance is 45 miles.

At Blackwater Lake however, the Indians refused to go further, due to the lateness of the season. Campbell-Johnston wrote (1910-2,p.4);

> "Discretion and diplomacy had to come into play to prevent the Indians deserting us and returning alone to their village at Kispiox..."

He observed that,

> "... our journey had inadvertently delayed until really too late in the fall of the year, and was commenced and undertaken against the advice of over careful old timers among the white settlers, and also the wiseacres and weather prophets among the Indians. 'Witch' Mabel with uplifted hands warned us at Blackwater of certain death for the whole packtrain and starvation for ourselves.
>
> "...A hasty start was made from Blackwater up the North Fork with three Indians and three dogs to pack full loads ..."

Campbell-Johnston, Beirnes and their packers spent 6 days examining the coal occurrences on Beirnes Creek and then backpacked out to Blackwater Lake. From a telegraph station (presumably the one at Fifth Cabin near Blackwater Lake) he wired Benoit in Winnipeg on October 24;

> "... examined coalfields finding property very much in prospect stage found one continuous unbroken commercial seam high class hard coal four feet thick am anticipating one or two more ... racing snow hoping to save packtrain".

J. G. Scott and Alexander Hardy, formed the B.C. Anthracite Syndicate in November or December, 1910 and through the Syndicate raised $150,000 for another expedition to the Groundhog in 1911.

On June 17, 1911, the newspaper "Omineca Herald" recorded as the lead column on the front page;

> "A large party, including Leon Benoit of Winnipeg and R. C. Campbell-Johnston, mining engineer of Vancouver, arrived on the Port Simpson en route to Groundhog Mountain and the coalfield of the upper Skeena".

The Herald quoted Campbell-Johnston;

> "Besides Mr. G. F. Monckton, a well known mining engineer and geologist, we have a party of seventeen men".

He further said:

> "The government has granted $3,000 for a trail along the Skeena from Fourth Cabin to enable people to get in and out later in the year ..."

The Herald noted:

> "A pack train of 58 horses had been secured for the first trip which leaves the party a little short as it had been intended to take seventy. As the train will be working all summer packing supplies, no shortage is looked for ..."

In 1920, writing to J. G. Scott, then Chairman of the British Columbia Skeena Coal Co., Ltd., Campbell-Johnston reminded him that they had a crew of 50 miners with 100 horses working the Groundhog in 1911. The variation in numbers of men can be explained in that he apparently added miners as the season progressed.

It is remarkable that from mid-June, 1911, until they departed Groundhog, probably in early October, that they prospected about 50 square miles of area, dug more than 400 feet of trenches, some up to 14 feet wide and some up to 12 feet deep, drove at least 100 feet of tunnel, and sank 55 feet of winzes, all by hand, and using wheel barrows and windlasses all of which had to be made by hand, on site. In addition, they achieved a good understanding of the geology of the area and a fairly complete understanding of the geography, which was necessary in planning for railroad access to the coalfield.

In 1911, G. S. Malloch conducted a geological evaluation of the Groundhog coalfield for the Geological Survey of Canada (Malloch, 1912). Malloch did most of his work in the area in which McEvoy and Campbell-Johnston were working and made a definite contribution to the geology of the area. He noted that the coal-bearing rocks do not occur between Groundhog basin and the Kispiox area (p.78). He produced a topographic map and geological map of the area and measured three stratigraphic sections. Unfortunately his time in the Groundhog coalfield was limited to 7 weeks.

Malloch and Campbell-Johnston had some differences of opinion regarding sampling. Malloch took continuous chip samples of the coal seams, including shale partings and bone. Campbell-Johnston said that in a product for markets, shale and bone would be removed by picking, screening, and washing and so in taking his samples he omitted shale and bone and reported as such. He wrote Benoit in December, 1911;

> "Malloch seems hopeless. He drove us distracted with his assinine propensities this summer. McEvoy and I were fondly hoping we had steered him right, but apparently not.
>
> "We have to educate people that the analysis of coal put on the market does not correspond to coal in the seam, plus shale partings, bone, roof, etc."

A large block of 145 sections was owned by Angus Beaton and Anthony Kobes. These sections lay west of Western Development Company and B.C. Anthracite Syndicate, at the headwaters of the Nass River and on Anthony Creek, Panorama Lake, Currier Creek and upper Beirnes Creek.

Several coal occurrences were observed by this writer within the area covered by the Kobes-Beaton claims, but no evidence of earlier physical work was found although old campsites were found. Campbell-Johnston (1911) examined some of the claims for Kobes and Beaton, but in his report made no mention of physical work on the claims. They apparently prospected the claims (Dowling, 1915) but did no trenching or tunneling.

Hundreds of claims were staked by other prospectors further up the Skeena River and on to the Klappan, but they are out of the area with which this report is concerned.

It was evident to the early workers in the Groundhog coalfield that any plan for economic development was dependent upon rail access.

Malloch (1912, p.76) noted the need for a railway to the coalfield and said the shortest route would be to Stewart. He pointed out that 12 miles of railway had already been built up Bear River from Stewart, but that difficult rock work and a long tunnel would be required to get through Bear Pass. He wrote:

> "These difficulties would be avoided by building a line up the Nass from Nasoga Gulf, which offers the nearest suitable harbour."

Campbell-Johnston (1912 p.13) reported:

> "Mr. Leon Benoit ... has a charter called the 'Nass and Skeena River Railway', which is subsidized already for 100 miles by the Federal Government to $35,000 per mile, to build down to Nasoga Gulf near the mouth of the Nass River."

He also reported that in 1912 Sir Donald D. Mann, the British railroad builder, secured a charter for a railway called, "Canadian North-Eastern Railway" (1912, p. 1 and 7) which was to build from Stewart, up Bear River and Bear Pass and into Nass Valley. This railway was to ultimately reach Edmonton after traversing the Cassiar, Omineca and Peace River districts. Sir Donald Mann is reported to have secured an option on 145 sections in the coalfield in 1912.

In 1913, Lord Rhondda, a famous coal producer from Great Britain, sent a group of engineers to look into feasibility of production from the Groundhog coalfield. They conducted preliminary reconnaissance surveys in order to locate feasible rail routes from the coalfield to tidewater. Lord Rhondda bought into the Nass and Skeena River Railway Charter which was owned by Scott and Benoit. However, all efforts to build a railway were terminated with the advent of World War I (Campbell-Johnston, 1920, pp. 3 and 4) and with Lord Rhondda's death during the war years.

The Geological Survey of Canada sent a party into the Groundhog in 1948 under the direction of A. F. Buckham, assisted by B. A. Latour.

They travelled to the coalfield by horse over the old Yukon Telegraph Trail to Damdochax (Blackwater) Lake and then up the Groundhog trail to the coalfield. The trails were in very poor condition after 37 years of disuse, and their trip was accomplished with much difficulty and hardship.

The report which resulted from their work (Buckham and Latour, 1950) summarized all known previous work and recorded detailed information on most of the known coal occurrences. However, very little was known of the structure or stratigraphy of the coalfield so that no conclusions were possible as to the number of coal seams, their thicknesses or their stratigraphic positions. Nor was it possible to correlate the various coal occurrences.

Buckham and Latour (1950) concluded:

> "In a field of this great size it is probable that areas exist where the coal is sufficiently clean and sufficiently undisturbed to be mined successfully, but it will be expensive to find such areas and to determine their size relative to that of the field as a whole. It is not considered that prospecting for such areas is advisable unless, or until transportation conditions are much more favorable than at present."

In 1966, Coastal Coal, Ltd. acquired Coal Licences on 14 surveyed lots and 10 unsurveyed sections in the Groundhog coalfield and acquired sole prospecting rights to an area of about 740 square miles.

A party of 8 geologists, assistants, and prospectors worked under the direction of R. V. Best during the summer of 1968. They used a helicopter and conducted geological mapping over a very large area, extending from Mount Jackson northwestward to the Little Klappan River and from Nass River northeastward to Buckinghorse Lake, covering an area of about 1500 square miles.

Their report was prepared by J. M. Black (1968). He concluded:

> "... The Ground Hog area and the area adjoining to the southwest do not contain minable coal seams."

In 1969 and 1970 a Joint Venture composed of Placer Development Ltd., Quintana Minerals Corp. and National Coal Corp. geologically mapped about 200 square miles and prospected about 100 square miles of the southern part of the Groundhog coalfield. The work was under the direction of Willard D. Tompson, signator of this report, assisted by geologists David M. Jenkins, Michael W. Roper and Geoffery Bird, and four geological assistants and 2 prospectors.

Six diamond drill holes were drilled late in the season of 1970.

They concluded:

> "An area of about 119 square miles is underlain by rocks of the Coal Bearing Lithosome. The coal bearing rocks crop out at the surface or are covered by a thin mantle of surface deposits. Strata over much of this area display minimum folding and faulting.
>
> "Parts of the Coal Bearing Lithosome were tested by diamond drilling during 1970, and were shown to contain coal seams which have an aggregate thickness of more than 25 feet.
>
> "Coal reserves, based upon 25 feet of coal over 119 square miles, are on the order of four billion tons."

OTHER RESOURCES OF THE GROUNDHOG COALFIELD AREA

Fish, wildlife and water are important resources which contribute to the value of the Groundhog coalfield and the surrounding area.

David Spalding, Regional Director of B.C. Fish and Wildlife Branch, Smithers, provided an evaluation of fish and wildlife values in the area and made specific recommendations for their protection and the protection of habitat:

Wildlife

"Wildlife values should be considered as moderate within the area under study (Spatsizi is regarded as high) and includes caribou, goat, sheep, black bear, grizzly bear, moose, wolves, furbearers, and migratory waterfowl. The following account is still general and further study is required to pinpoint critical areas for protection or intensive management.

"Mountain Goat. - This species is probably found throughout the area at higher elevations, but goat or goat sign have been recorded as follows: SE side of Devil's Claw, a group of 21; Groundhog Mountain, 30 seen; Distingue Mountain, plentiful sign; McEvoy Mountain, plentiful; headwaters of Porky Creek, moderate to plentiful sign; evidence of goats has also been recorded from Mount Taylor and Mount Gordon.

"Caribou. - Small groups of caribou appear to winter and summer throughout much of the study area; summering caribou recorded in the vicinity of Nanny Goat, Otsi and Beirnes Creek; 14 - 18 caribou on Pyramid Bluff; a herd of 30 - 32 caribou in the vincinity of Panorama Lake reported by the guide; plentiful summer sign seen on

Mount Taylor, moderate-plentiful on the headwaters of Porky Creek and moderate sign in the headwaters of Jenkins Creek; caribou winter on Mount Jackson. A herd of 150-200 caribou has been reported in the Mount Beirnes area but this has not been verified.

"Stone Sheep. - An unknown number of sheep inhabit the area between Panorama Lake and the headwaters of Beirnes Creek. Further work is required to determine their numbers as well as summer and winter ranges.

"Moose. - Moose are scattered throughout most of the valley bottoms during the summer, but are abundant on Jackson Flats, while McEvoy Flats support some summer moose and is considered a Class III winter range (moderate use). Other areas below about 4,000 feet along the Skeena River support scattered wintering moose.

"Bear. - Although there have been few official sightings of both black and grizzly bear, the area is considered good for grizzlies. This assumption is supported by the fact that garbage dump bear problems developed when construction camps were built for the B.C. Railway.

"Wolves. - Scattered throughout the area (with concentrations following both moose and caribou.)

"Furbearers. - Abundance and distribution of furbearers within the study area are unknown, although periodic recordings of beaver dams during surveys indicate this species is found in many swampy areas.

"Waterfowl. - The only 2 species recorded are Canada geese and 'white geese' (probably snow geese). No known nesting sites are known, but lone Canadas have been sighted along the Skeena and Canadas as well as Snow geese use Kluayaz Lake as a stop-over point during the fall migration.

Wildlife Management and Protection Strategies

"Hunting. - Protection against over-hunting must be a prime consideration during both the construction and mining phases. An influx of people into the Groundhog plus improved road access will place heavy hunting pressure on all wildlife. Shortened or closed seasons as well as limited entry hunts will have to be invoked.

"Trapping. - Further study is required to determine the present level of trapping and possible effects of industrial activity on the furbearers and traplines in the area.

"Guiding. - The study area is presently covered by a Guide-Outfitter's guiding territory. As development proceeds the increased access, increased hunting pressure by members of the mining community and possible increased pressure by hunters using the B.C. Railway will have a serious, negative effect upon his operation. During 1975 the guide-outfitter took out 15 hunters, who harvested 9 moose, 4 goat, 9 caribou and 2 wolves. What proportion came from the proposed coal-block area is not known but I estimate it to be considerable.

"Garbage Disposal. - Garbage dumps must be located some distance (preferably greater than 1 mile) from the community, and the only effective method to prevent bears concentrating at the dump site is to incinerate the garbage.

"Habitat Protection. - Low elevation underground mining will have minimal effect upon wildlife habitat, although wet, marshy areas must be protected for beaver and summering moose. Additionally, the camp or townsite should be positioned so it has minimal effect upon low elevation, flat land used by moose, caribou and furbearers.

"If open-pit mining is contemplated further study is required to determine the relationships between these pits and wildlife distribution.

Fishery Values

"Our present knowledge indicates fishery values are low throughout most of the study area although some localized spots should be considered of moderate value. Dolly Varden, rainbow and steelhead trout plus coho have been found during a limited sampling program. Some of the smaller tributaries to the upper Skeena have major barriers which preclude fish movement, e.g. Duke, Telfer, Langlois, Nanny Goat, the upper Otsi, and upper Porky Creeks. Further inventory work is required if any industrial development is considered.

"Steelhead. - Several hundred (?) steelhead move into the Kluatantan each year and provide a lucrative fishery for the guide-outfitter - up to 20 steelhead are taken each year by guided fishermen and an unknown number by non-guided fishermen. This is the most important recreational fishery in the area and must not be damaged.

"Coho. - Coho fry have been found as far up the Skeena as Otsi Creek and up the Kluatantan to Kluayaz Lake and it is believed that coho move into Kluayaz Creek to spawn. The number of coho using this part of the upper Skeena is unknown at this time and further work is required.

"Rainbow Trout. - Found in conjunction with steelhead in the Kluatantan system.

"Dolly Varden. - Found in the upper Skeena to Otsi Creek and in the Kluatantan. One large Dolly (several pounds) observed at the confluence of the Skeena and Kluayaz Creek.

Fisheries Management and Habitat Protection Strategies

"Fishing. - At present, firm control of steelhead fishing must be anticipated. Undoubtedly there will be steelhead fishermen amongest both contruction workers and miners and this pressure could not only threaten the steelhead population in the system as well as the livelihood of the guide.

"Present or potential fishing pressure on other species is unknown.

"Habitat Protection. - Stream and river banks, i.e. the Skeena, Kluatantan, and Otis Creek must be protected to protect coho, steelhead and rainbow trout habitat. Additional work in the area will indicate other areas which will require protection.

"Construction of roads and camps, movement of equipment and mining operations must be kept away from these sensitive areas of banks and stream beds.

"Storage piles of coal as well as waste material must not be allowed to enter any of the water systems within the coal block. Additionally, every effort must be made to prevent loose coal dust from blowing into free-running water or onto ice covering any of these waterbodies. If there are plans to wash coal this operation must take place well enough distant from free-flowing water so as not to pollute fish habitat. Finally, loose coal dust transported by rail must not be allowed to blow into the Skeena or any tributaries containing fish.

"Additional field work is required for fisheries and wildlife populations, as well as critical habitat, if any industrial development is anticipated."

GEOLOGY

General Geology

The Groundhog coalfield lies in the Skeena Mountains of the Central Plateau and Mountain physiographic province (Holland, 1964).

Holland states (p.55, 56)"

"The Skeena Mountains are a distinctive (physiographic) unit, being formed largely of folded sedimentary rocks of Upper Jurassic and Lower Cretaceous age. The principal rocks are black fine-grained argillite and shale, and dark greywacke. Limestone, or rocks directly of volcanic origin, are absent, igneous intrusions are few in number ... The rock structures are extremely complex, the major folds averaging about 4 per mile with many overturned and recumbent outlines. Only in parts of the Groundhog Range, Upper Skeena Valley, and Eaglenest Range do broad folds predominate ... Most of the fold axes are nearly horizontal or plunge: gently northwest."

Percentage of Outcrop. - The area is covered by dense forest below 4500 feet elevation, and by scrub spruce, deciduous brush, and grasses up to about 5000 feet elevation. Gentle slopes above 5000 feet are mostly grass covered. Steep slopes are mostly barren of vegetation.

Low-lying ground along Skeena River has a mantle of river gravels and boulders. Areas which lie adjacent to mountain fronts show evidence of considerable landslide activity and large areas appear to be covered by solifluction sheets. Diamond drilling showed that this material may be up to 120 feet thick.

Ninety to 95 percent of the map area is covered by overburden of one or more of the types described above. Rock outcrops in covered areas are most likely to occur in creek banks.

Description of Rocks. - The area is underlain by drab appearing, grey, sandstone and mudstone. The rocks are unmetamorphosed. Bedding thickness varies from less than one inch to 100 feet or more. Beds of conglomerate and thick bedded sandstone form cliffs whereas areas underlain by thin bedded sandstone and mudstone more commonly display gentle relief.

Topographic Relations. - Mountainous areas within the map area are those underlain by the most competent rocks; e.g. conglomerate beds, and thick bedded sandstones. Areas of low relief are mostly underlain by less competent rocks such as mudstones, thin bedded sandstones, carbonaceous shales, and coal beds. For example, near the head of Currier Creek at an elevation of 5500 feet, mudstone, sandstone, shale, and coal beds form an area of rather gentle relief as compared to the area around Devil's Claw Mountain which is underlain mostly by conglomerate and sandstone, and which has high relief.

Geological Age and Stratigraphic Position of Rocks. - The rocks of the Groundhog coalfield belong to the Bowser Assemblage (Souther and Armstrong, 1966) and are Upper Jurassic to Lower Cretaceous in age (Malloch, 1912, p.78, 82; Souther and Armstrong, 1966; Brew, 1967; Grove, 1969 and Eisbacher, 1973). The coalfield lies in the east-central portion of the Bowser Basin. During the Upper Jurassic, shales, greywacke and conglomerate accumulated in a marine basin which was open to the west. Uplift in the Coast Mountains during latest Upper Jurassic and Lower Cretaceous resulted in the development of an inland basin (Souther and Armstrong, 1966). Eisbacher (1973) suggests that the occurrence of coal in the Groundhog Range provides some evidence that the basin was filled in part by deltaic deposition. A slow rate of subsidence coupled with luxuriant growth of plant material and rapid burial beneath water and other vegetation in the upper delta area led to an accumulation of peat. Subsequent burial beneath other sediments and diagenesis resulted in the development of coal.

Frazier and Osanik (1969) show that in delta sequences, peat accumulates in the delta-plain facies and interfingers laterally with inorganic sedimentary rocks.

It is suggested that the coal measures in the Groundhog coalfield represent uppermost Jurassic-Lower Cretaceous alluvial fans and delta plains upon which peat accumulated during the regression of the sea.

Stratigraphy

Three stratigraphic sections were measured by Malloch (1912) during 1911 and 1912. The first section, which he called the Anthracite Creek section, was measured on the southern cirque wall at the head of Anthracite Creek.

The second stratigraphic section, which he called the Main Section of the Skeena Series, was measured on McEvoy Ridge. McEvoy Ridge is underlain by the north limb of a breached anticline, and the rocks display marked regularity in strike and dip over a length of about 3 miles. Malloch's Main Section was probably measured about one mile east of Sam Creek, north of Currier Creek.

The third stratigraphic section was measured on the southern slope of the northwest shoulder of Mount Jackson.

Malloch (1912, p. 78-81) divided the rocks in the coalfield into four groups (from youngest to oldest) and inferred correlations between the sections:

Group 1

"Thickness	
1,300 feet	Heavy conglomerate beds, hard siliceous sandstones, shaley sandstones, often with chert pebbles, usually yellow or weathering yellow, brown and black shales and coal seams.

Group 2

"1,000 feet	Essentially a succession of black, brown and purplish shales, with subordinate beds of coarse, crumbly, grey sandstones, weathering brown, a few siliceous sandstones and shaley sandstones, with chert pebbles, and numerous seams of very dirty coal.

Group 3

"700 feet	A series of yellow and brown shales and grey shaley sandstones, weathering to yellow color. These are interbedded with black shales and coal seams.

Group 4

"950 feet	Coarse, crumbly sandstones and brown, black, grey, and purplish shales, also beds of hard siliceous sandstones, conglomerates, and a few coal seams."

R. V. Best (Black, 1968) divided rocks of the Bowser assemblage into four units; (1) Lower Conglomerates (2) Lower Shale (3) Upper Shale and (4) Upper Conglomerate.

The Lower Conglomerate is composed largely of coarse clastics, mostly thick bedded sandstones and conglomerates. The conglomerates contain pebbles of black chert. Conglomerate beds are interbedded with thin bedded greywacke or sandstone, siltstone and shale. The Lower Conglomerate unit is thinner bedded and finer grained near its' top and grades into the overlying unit. Near its' top are a few minor coal seams. It is non-marine, is 1,000 to 1,500 feet thick and outcrops on the slopes above Kluatantan and Kluayetz valleys.

The Lower Shale unit includes interbedded shales, greywacke and sandstone with coal seams. The beds are mostly non-marine and appear to be lenticular and are discontinuous over great distances. Some marine sandstones, grey shales and shell coquinas occur. Rapid changes occur along strike and make correlation of coal seams and beds difficult. In some localities the beds are strongly deformed. The unit is estimated to be from 1,500 to 2,500 feet thick. It erodes readily and exposures are mostly on lower slopes or in valley bottoms.

The Upper Shales grade upward from the Lower Shales. It is a similar unit but does not contain coal seams. It has many sandstone and siltstone beds and some limy beds which contain fossil plants. The unit is completely exposed near Devil's Claw Mountain and is about 4,500 feet thick.

The Upper Conglomerate consists of conglomerate beds 50 to 200 feet thick with subangular to rounded pebbles which are black, green, yellow, brown and white. Sandstone and some shale are interbedded with the conglomerate. Sandstone beds are up to 50 feet thick. This resistant conglomerate forms the peak of Devil's Claw Mountain and has an exposure which is 1000 feet thick.

Eisbacher (1974) identified three provisional, informal rock-stratigraphic units which he termed, (1) Facies Belt A, principal outcrop area, Duti River-Slamgeesh (2) Facies Belt B, principal outcrop area, Mount Gunanoot-Groundhog Range and (3) Facies Belt C, principal outcrop area, Jenkins Creek.

Eisbacher shows that rocks of Facies Belt A do not outcrop in the Groundhog coalfield. However rocks of his Facies Belt B underlie most of the area of the coalfield and rocks of his Facies Belt C overlie the coal-bearing rocks.

During the investigation of the Groundhog coalfield in 1970 (Tompson, et.al.) the workers identified provisional, informal rock-stratigraphic units which were used in mapping. In the report from that investigation those rock-stratigraphic units were identified as, "Lithosomes" (Plates I and II):

1. Lonesome Mountain lithosome
2. Devil's Claw Conglomerate lithosome
3. Coal-Bearing lithosome
4. McEvoy Ridge lithosome

The various lithosomes are named according to the geographical location of their respective type sections, except for the Coal-Bearing lithosome which is poorly exposed. Thus it is described from its' appearance at various places throughout the coalfield. The only attempt to develop a stratigraphic section for the Coal-Bearing lithosome was at a locality where part of it is exposed north of Currier Creek at the headwaters of Dave Creek (Fig. 3). The following descriptions of these rock-stratigraphic units is largely by Jenkins (Tompson, Jenkins and Roper, 1970).

Lonesome Mountain Lithosome

This group of well indurated rocks is best exposed on Lonesome Mountain. Other good exposures occur on Distingue Mountain, Taylor Mountain and Moss Mountain. When viewed from a distance rock outcrops of this lithosome are dark brown with rare black bands. The two predominant litholigic associations of the lithosomes are sandstone-conglomeratic sandstone, and a mudstone-coal association.

Eisbacher's type section for his rock-stratigraphic unit, "Facies C" is north of Jenkins Creek. The Jenkins Creek area is shown by this writer to be underlain by rocks of the "Lonesome Mountain lithosome". Therefore it is concluded that Eisbacher's, "Facies C" rocks and the writer's "Lonesome Mountain lithosome" rocks are the same rock-stratigraphic unit.

Sandstones. - Weathered surfaces of sandstone beds range in color from tan to dark brown. Some beds which are well cemented with quartz, weather to a variety of dark grey hues.

Particle size varies between wide limits. Complete mixed gradation exists between medium grained conglomerates and fine grained sandstones. Rare beds of the coarse Devil's Claw conglomerate occur, but they are thin bedded.

Mineralogically these sandstones and conglomerates are quartz-black chert assemblages. Iron bearing heavy minerals occur in concentrations up to ten percent in some beds and less than one percent in other beds.

Bedding which is exposed in large outcrops is characteristically even. Sand body thickness is variable, and is from five feet to as much as fifty feet. Average thickness is probably 15 to 20 feet. Internal stratification consists of small scale trough and planar cross-laminae. Burrows and other evidence of bioturbation are commonly encountered.

Marine molluscan fossils occur in at least one sandstone unit of this lithosome.

Mudstone. - Rocks of this type are not well exposed in areas in which they may be easily studied. Where exposed they are sombre brown in color, sandy in texture, and 15 to 30 feet thick.

Interbedded with the mudstones are thin, discontinuous coal beds ranging up to three feet in thickness.

A crude cleavage is present in many rocks of this lithosome, and in small areas a well developed slatey cleavage occurs.

These rocks are believed to be time stratigraphic equivalents of the Devil's Claw Conglomerate lithosome. Facies change is thought to take place by pinch out and by mixed lateral gradation.

Devil's Claw Conglomerate Lithosome

Two predominant lithologic associations occur in this lithosome: (1) conglomerate-sandstone association and (2) mudstone, carbonaceous mudstone, and sandstone associations. The latter association is similar to the Coal-Bearing lithosome.

Conglomerate. - Medium to dark grey hues are characteristic of both fresh and weathered surfaces.

Grain size classes are bimodally distributed. One mode falls in the large pebble to large cobble size range. Such large particles are well rounded, exhibit good sorting, and are composed either of black chert or light green to cream colored chert. The second mode falls in the medium to coarse sand range. These grains are only moderately well sorted and are mineralogically a quartz-chert assemblage. Matrix free conglomerates occur but are rare.

Upon weathering, the pebbles are released, and where slopes are steep, the pebbles are washed into streams. On gentle slopes the pebbles accumulate on the surface and cover the ground over large areas.

Thin lenses of coal occur but are the result of local accumulations of plant detritus.

Conglomerate body accumulations range from 40 to 200 feet thick including local lenses or wedges of sandstone. Lateral facies changes yield a continuous series from conglomerate to conglomeratic sandstone to sandstone. As the proportion of sand increases, the thickness of individual sand bodies decreases. In non-conglomeratic facies the thickness of sand bodies averages 15 to 20 feet.

Mudstone. - Between the conglomerate tongues, 50 to 150 feet of mudstone, carbonaceous rocks, and sandstone occur. These strata appear to be identical to the Coal-Bearing lithosome with exception of the carbonaceous units, which are thin and discontinuous.

Coal-Bearing Lithosome

This group of poorly indurated rocks is well exposed only in the beds of high gradient streams. Elsewhere it is covered with brown colored soils. Where exposed, outcrops are various shades of dark grey-brown with black bands produced by carbonaceous beds. Clastic sediments range from fine to coarse grained and are better sorted than those of the underlying McEvoy Ridge lithosome. Muddy rocks comprise 70 to 75 percent of this lithosome; carbonaceous units, 15 to 20 percent, and sandstones about 10 percent. Strata are characteristically medium to thick bedded.

Mudstones. - Outcrops are medium to dark grey when fresh and various shades of grey-brown when weathered.

The texture is highly variable as in the underlying McEvoy Ridge lithosome. Between 10 and 20 percent of these muddy rocks are claystones.

Due to poor exposure, bedding characteristics are not well known. Vertical contacts are gradational where mudstone overlies sandstone and are erosional where sandstone overlies muddy rocks. Internal stratification is most commonly a lamination produced by interbedding of mineral matter and plant fragments. Bedding fissility is a common attribute of the claystones, but is only weakly developed.

Mudstones grade into carbonaceous units through an increase in the proportion of included plant debris. As a result the coal content of carbonaceous units varies widely from stratum to stratum.

Sandstones. - These rocks are typically medium to dark grey in color, but weathering produces a variety of sombre brown and orange hues.

Particle size varies from fine to coarse. Most sandy strata are medium grained. Sorting varies within broad limits and textural maturity ranges from mature to submature. Friability is a common attribute with only an occasional bed being well cemented with calcite or silica.

Quartz and black chert are the most abundant minerals comprising these sandstones. Ferromagnesian minerals comprize up to 15 percent of some beds. Weathering has oxidized these grains to bright orange limonitic grains.

Beds which are two to five feet thick are typically arranged in multistorey accumulations 10 to 35 feet thick. Most sand bodies are 10 to 20 feet thick. Internal stratification consists of small scale trough cross-laminae and medium sized, planar cross-liminae.

Contacts with the overlying conglomerate beds are conformable and are best placed at the bottom of the lowest coarse conglomerate tongue.

Fair exposures of the Coal-Bearing lithosome occur on Dave Creek (which was named in 1970) a tributary of Currier Creek which enters Currier Creek from the north-east near its' headwaters.

The strata here are on the south limb of a syncline whose axis strikes northwesterly. The dip is about 40 degrees northeast and the slope of the hill is about 25 degrees southwest. Thus, a fair cross section of the rocks is exposed.

The stratigraphic section of the Coal-Bearing lithosome which was measured on Dave Creek is shown on Figure 3.

McEvoy Ridge Lithosome

This lithosome is characterized by well indurated, dark colored, poorly sorted, fine to coarse grained clastic rocks. Mudstone and fine grained texturally immature sandstone are the predominant rock types. The former comprises 60 to 80 percent of this lithosome. Chert pebble conglomerate occurs only in insignificant quantities. Bedding thickness is thin to medium and even in character.

Mudstones. - The mudstones are dark grey to olive grey in color. Weathered surfaces are mottled with various shades ranging between dark greyish orange and dark greyish brown.

The texture is highly variable. The proportion of coarse clastics (silt and sand) varies continuously between 10 and 50 percent. Claystones comprise less than 5 percent of this lithosome.

The evenly bedded character of strata in this lithosome is one of its most unique attributes. Lateral and vertical contacts are typically gradational, except where mudstone is overlain by sandstone or where local erosional contacts occur. Internal stratification is not common except where delineated by included sandstone laminae. The rocks are well indurated and yield float with a poorly developed conchoidal fracture. Bedding fissility rarely occurs.

Sandstones. - McEvoy Ridge lithosome sandstones are typically dark grey to olive grey. Weathering may produce a grey colored surface mottled with shades of pale, greyish orange.

Fine to medium grain sizes are most abundant, but occasionally coarse sandstones with fine conglomerate lenses occur. In general, the finer grained rocks are poorly sorted. Textural maturity ranges from submature to immature. Friability decreases with an increase in maturity, due to the addition of silica cement.

Mineralogy as determined in hand specimens consist of quartz, black chert, and unweathered ferromagnesian minerals.

Bedding is characteristically regular in units of 2 to 5 feet. Multistorey sandbodies range up to 30 feet in thickness, but average 5 to 10 feet. Lower contacts are commonly erosional and are sharp. Upper contacts are depositional and gradational. Lateral facies changes take place by either pinch out or gradation to mudstone. Internal stratification consists of small scale trough cross lamination and micro-cross lamination.

Contact with the overlying coal bearing units is gradational, and is best placed at the first medium grey, griable, sorted, quartzose sandstone.

STRUCTURAL GEOLOGY

Contacts

Rock contact between the four lithosomes are poorly exposed and appear to be gradational. Contacts are believed to be conformable (Plates I and II).

Lonesome Mountain - Devil's Claw Lithosomes. - The contact between these rocks is drawn at the top of the uppermost of the thick conglomerate beds. However, the conglomerates apparently are discontinuous laterally, so that the position of the contact is tenuous in most instances.

However, fair exposures of the contact were observed southwest of Table Mountain in Lot 2186. Here the Lonesome Mountain sandstones are conformably underlain by conglomerate beds which conformably overlie the rocks of the Coal-Bearing lithosome.

Near the headwaters of Davis Creek, sandstone beds which are correlated with rocks of the Lonesome Mountain lithosome, conformably overlie conglomerate beds of the Devil's Claw lithosome.

About 2½ miles northwest of the junction of Leach Creek and Currier Creek the lower conglomerate bed of the Devil's Claw lithosome is conformably overlain by sandstone and thick conglomerate beds which are believed to correlate with sandstones of the Lonesome Mountain lithosome.

At Devil's Claw Mountain sandstones and conglomerates of the Devil's Claw lithosome are conformably overlain by a small remnant of sandstone which is correlated with the Lonesome Mountain sandstones.

Devil's Claw - Coal-Bearing Lithosomes. - At Table Mountain in Lots 2185 and 2186 there is a fair exposure of the contact between rocks of the Devil's Claw lithosome and the Coal-Bearing lithosome. The contact is conformable and the dips are gentle, about 15 degrees to the southwest.

A good exposure of the contact between the Devil's Claw and Coal-Bearing lithosomes occurs at grid coordinates 55,000 E and 144,000 N. The rocks here are on the north limb of a syncline whose axis plunges gently to the southeast. The contact is conformable and the beds dip 10 to 30 degrees to the southwest.

Near the headwaters of Davis Creek a section of steep dipping beds is exposed which clearly show Devil's Claw rocks conformably overlying rocks of the Coal-Bearing lithosome.

Coal-Bearing - McEvoy Ridge Lithosomes - The contact between rocks of the Coal-Bearing lithosome and McEvoy Ridge lithosome is well exposed in only one place. At approximate coordinates 93,000 E - 113,000 N there is a sharp peak which lies near the head of the east fork of Anthracite Creek. Here, the rocks dip about 40 degrees northeast and expose a conformable contact between the two rock units.

McEvoy Ridge Lithosome - Hazelton Assemblage. - Malloch (1912) reported that rocks belonging to the Hazelton group were observed on Currier Creek, Beirnes Creek, Skeena River, and Moss Mountain. However, the writers did not identify Hazelton rocks in the map area. Lithology and distribution of the Hazelton Assemblage have been revised since Malloch's work in the coalfield (Duffell and Souther, 1964; Armstrong, 1965; Souther and Armstrong, 1966 and Grove 1969) and the rocks in Bowser Basin which he called Hazelton rocks, now belong to the Bowser Assemblage.

Faults and Fault Systems

Five principal fault systems were recognized by the writers and were named according to the type of faulting involved and the geographic location of the faults (Plates I and II):

1. Groundhog thrust fault
2. Upper Currier Creek normal fault
3. Distingue Mountain thrust fault
4. Beirnes Creek high angle reverse fault
5. Duke Creek - Langlois Creek faults

The Groundhog Thrust Fault. - This is the principal fault in the area. The front of the fault lies about two miles west of Skeena River and extends from Currier Creek northwestward through the coalfield and many miles beyond. The strike of the fault is about N 50°W and the dip is unknown.

Rocks along the front of the fault display gentle dips except in the vicinity of Mount Alex where tight drag folds provide evidence for thrust faulting.

Southeast from Mount Alex the tightly folded rocks along the thrust plane are not exposed. The position of the fault is inferred from topographic expression as noted below.

Along the Groundhog thrust fault rocks of the McEvoy Ridge lithosome are commonly thrust over rocks of the Coal-Bearing lithosome. The front of the fault is serrate with many lobes of McEvoy Ridge rocks protruding over the Coal-Bearing rocks.

The position of the fault was recognized because there is a marked change of rock types on opposite sides of the fault, and by an irregular line along the front of the fault. A prominent break in topography occurs along this line and forms a narrow, flat strip of ground, commonly occupied by swamps. This feature is readily observed from the air and on aerial photographs.

Upper Currier Creek Normal Fault. - About four miles west of the Groundhog thrust fault, at the headwaters of Currier Creek, rocks of the Coal-Bearing lithosome are down faulted against rocks of the McEvoy Ridge lithosome.

The strike of the fault varies from about N. 45° W. to N. 20° W. and extends from near the junction of Currier Creek and Leach Creek to Beirnes Creek, and perhaps a mile or more north of Beirnes Creek. Dip is believed to be near vertical.

Distingue Mountain Thrust Fault. - Evidence for thrust faulting is visible in the cirques of Distingue Mountain and on the steep slopes at the head of Campbell-Johnston Creek. The fault extends from the small round mountain south of View Mountain to Mount Taylor, and on to the northwest out of the map area. Drag folding, with isoclinal folds and recumbent isoclinal folds, occurs in the hanging wall of the axial plane of the thrust fault.

Beirnes Creek Fault. - Rocks of the Coal-Bearing lithosome dip southwesterly away from Mount Alex and are in fault contact with McEvoy Ridge rocks in the valley of Beirnes Creek. The fault dips 77° SE. and is believed to be a high angle reverse fault.

Duke Creek - Langlois Creek Faults. - Subparallel faults along Duke Creek and Langlois Creek place rocks of the Coal-Bearing lithosome in fault contact with rocks of the Lonesome Mountain lithosome. Table Mountain is believed to be an erosional outlier of Lonesome Mountain rocks.

The two faults are believed to have steep dips, as they cross areas of high relief with little change in direction or topographic expression.

Apparently the block which includes Table Mountain is upthrown slightly relative to the blocks to the north of Langlois Creek and to the south of Duke Creek. Thus the Table Mountain block is a horst.

Folds

Folding is dominated by three principal synclines:

1. Syncline Creek - Devil's Claw syncline
2. Skeena River syncline
3. Distingue Mountain syncline

Some prominent anticlines were identified. Most are probably breached and occupy areas of low relief:

1. Skeena River anticlines
2. Upper Currier Creek anticline

Syncline Creek - Devil's Claw Syncline. - This syncline extends from the headwaters of Davis Creek northwestward to Syncline Creek, and is the most prominent and obvious structural feature in the Groundhog coalfield.

All rocks units along strike of the syncline display evidence of folding.

Rocks on the northern limb have relatively gentle dips, typically less than 30 degrees southwest.

However, the southern limb is folded sharply, and rocks along the entire length of the syncline have steep to near vertical dips. These steep dipping strata are well exposed near Syncline Creek, and near the headwaters of the east and west forks of Geoffrey Creek.

The axis of the syncline strikes along a creek which is a tributary of Beirnes Creek, entering from the north. This tributary was named Syncline Creek in 1970 and is shown as such on the accompanying geological map.

Skeena River Syncline. - A syncline is believed to underlie the area occupied by Skeena River. Data from widely spaced outcrops (Plate I) provide evidence for the syncline. Campbell-Johnston (1911) and Buckham and Latour (1950) also said Skeena River occupies a syncline. However Black (1968) said Skeena River occupies a breached anticline.

Distingue Mountain Syncline. - The Distingue Mountain syncline is characterized by steep dipping to vertical beds on the south limb of the fold, and recumbent, isoclinal folds on the north limb.

Steep dipping beds occur near Mount Taylor and continue southeasterly on strike to Distingue Mountain and View Mountain. Exposures along strike are good.

Overturned folds on the north limb of the syncline are well exposed on the mountain northwest of Campbell-Johnston Creek. The axes of the folds strike northwesterly and the axial planes are nearly horizontal. Other exposures occur along strike in the north face of View Mountain.

Skeena River Anticlines. - The areas on both sides of Skeena River are heavily covered by forest and overburden. However, a few scattered outcrops over a length of 10 miles provide data which suggest that anticlines occur striking parallel to the Skeena River syncline.

The amplitude of these folds is believed to be small but no measurements are possible due to lack of exposure and incomplete information regarding the stratigraphic section.

Upper Currier Creek Anticline. - A breached anticline is well exposed near the headwaters of Currier Creek. Rocks of the McEvoy Ridge lithosome are folded and form a symmetrical anticline which has a horizontal axis. The anticline is breached and a creek flows southeasterly along the axial plane for a distance of about two miles. The strata which form McEvoy Ridge underlie the north limb of the fold.

Estimate of Costs

It may be assumed that coal production from the Groundhog coalfield would be from open pit and underground mining operations.

However until details of the geology of the coal seams are known it is not possible to determine how the seams may be mined or what the mining costs would be.

It is estimated that approximately 1.5 million tons of coal per year will be required for a thermal power generating station. Cost of a wash plant to process that volume of coal is on the order of $14,000,000. Cost of a heavy media plant to process 1.5 million tons of coal per year is about $60,000,000.

It is estimated that in underground mining by room and pillar techniques, about 60 percent of the coal will be extracted and that up to half of the remaining pillars may be recovered from retreat.

In producing from an open pit mine about 75 to 80 percent of the coal will be recovered. Strip ratios up to 10 yards of overburden per ton of coal are probably acceptable.

It is anticipated that the yield from heavy media separation would be about 50 percent at a specific gravity somewhere between 1.60 and 1.70.

In other British Columbia coal mining operations costs are approximately as follows:

Underground mining	$20.00 per ton
Coal washing	3.00 per ton
Open pit mining, Costs vary widely, up to	12.00 per ton
Reclamation	1.00 - 2.00 per ton

Since its' discovery the principal deterrant to production from the Groundhog coalfield, has been a lack of adequate transportation. The arrival of B.C. Railway to the Groundhog relieves many of these problems. Specifically, rail transportation of mining equipment and ancillary supplies and equipment to the coalfield will be available in 1977.

CONCLUSIONS

Coal-bearing rocks occur throughout an area of more than 100 square miles in the Groundhog coalfield. Geological mapping shows that an area of about 58 square miles contains coal seams in which structural disturbance is thought to be minimal. The coal beds are folded and faulted, but certain areas exist where thick coal seams are relatively undisturbed. Coal seam thicknesses are from 2.5 feet to 11 feet. It is not known how many coal seams occur, but there are probably more than 10.

Coal exploration Target Areas are identified as areas "A", "B", "C" and "D" and are assigned a priority due to their geographical locations, geological setting and available coal quality data.

The average coal quality of all coal seams greater than 3.0 feet in thickness, from both surface sampling and from diamond drill intersections, are summarized as follows:

Average yield at various specific gravities from 1.58 to 1.75	38.8 %
Ash	9.8
Volatile matter	7.2
Moisture	.5
Fixed carbon	82.4
Sulfur	.6
Total	100.5
Btu	13,366

The coal is a high quality thermal coal, suitable for thermal power generating stations.

It is not possible to correlate coal seams due to insufficient geological information and lack of drill data. Thus it is not possible to estimate coal reserves.

Exploration Target Areas "B", "C" and "D" cover 35 square miles of low lying ground along Skeena River. These areas offer the greatest possibility for the discovery of coal seams of economic potential.

RECOMMENDATIONS

It is recommended that an agressive exploration program be conducted in order to complete the evaluation of the economic potential of the coalfield. A three year program is proposed:

First Year

1. Detailed geological mapping, stratigraphic studies and paleontological studies should be conducted throughout the four target areas so that coal seam correlation may be established.

2. Make several openings in coal seams to aid in coal seam correlations. This would also provide an opportunity to acquire samples of coal for washability tests and other analyses (these near-surface samples would be subject to oxidation and contamination by ground water movement through the coal seams).

3. Select two primary targets for diamond drilling during the second year.

Second Year

1. Diamond drilling should be conducted in each of two primary target areas. Each should be drilled for a total of 10,000 feet, recovering HQ core.

2. Establish coal seam correlations.

3. Estimate coal reserves.

4. Make preliminary assessment of probable mining methods.

5. Conduct washability tests on coal samples from drill core.

6. Establish estimates of recoverable coal in various coal seams throughout part of the coalfield.

7. Identify principal target area for further exploration. This target area should possess the greatest potential for development of 50 million tons of clean coal.

Third Year

1. An intensive diamond drilling program of 30,000 feet should be directed toward outling coal reserves in the principal target area.
2. Several exploration adits should be driven in order to test underground mining conditions.
3. Large coal samples from underground will be required for washability tests and pilot plant tests.

Estimated Cost of the Exploration Program

It was shown on page 77 that the estimated cost of conducting the three-year exploration project will be $2,958,000.

First Year		
Geology, engineering, prospecting, and coal testing	$ 184,000	
Camp operation, various travel costs and communications	49,000	
Fixed wing aircraft charter, helicopter contract, rail and highway travel	98,000	
Administration	17,000	$ 348,000
Second Year		
Diamond drilling, 20,000 feet	330,000	
All other costs	280,000	610,000
Third Year		
Diamond drilling, 30,000 feet	500,000	
Underground testing	1,000,000	
All other costs	500,000	2,000,000
Total		$2,958,000

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CERTIFICATE

I, Willard D. Tompson of Smithers, British Columbia, do hereby certify:

1. That I am a consulting geologist, residing at Van Gaalen Road, Smithers, British Columbia

2. That I have practised my profession for more than 18 years

3. That I prospected and explored in the Groundhog coalfield from June to October, 1969

3. That I managed an exploration program in the Groundhog coalfield during 1970 and was actively engaged in geological field work during the period June 1, 1970 and October 15, 1970.

Willard D. Tompson

Willard D. Tompson
March 25, 1977

Figure 1

Map Showing Location of Groundhog Coalfield

Upper Skeena River, B.C.

Scale 1:2,000,000

100

GR-GROUNDHOG 77(2) A

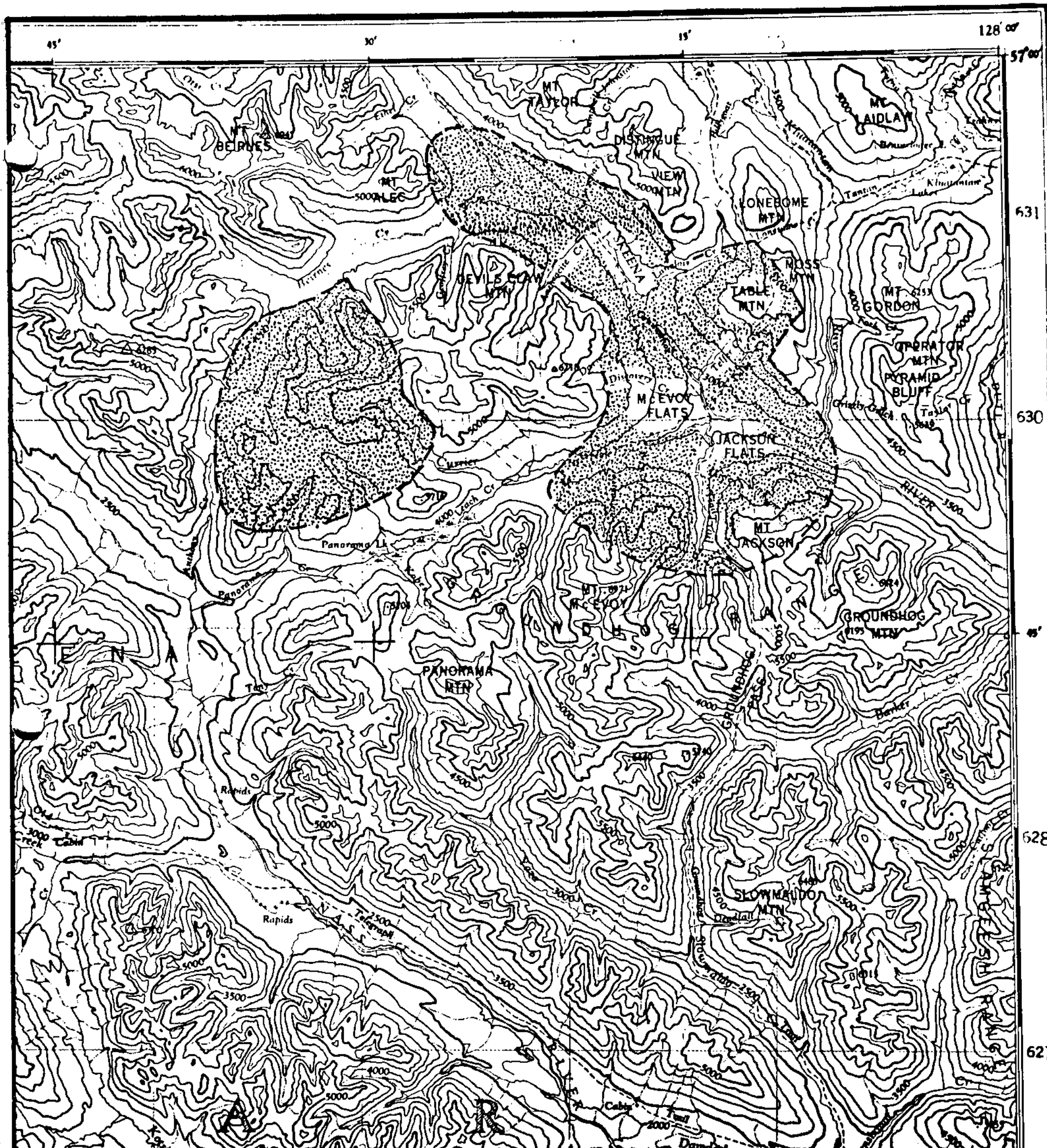


Figure 2

Topographic Map Showing
Groundhog Coalfield and Surrounding Area
Scale 1:250,000

GR-GROUNDHOG 77(2)A

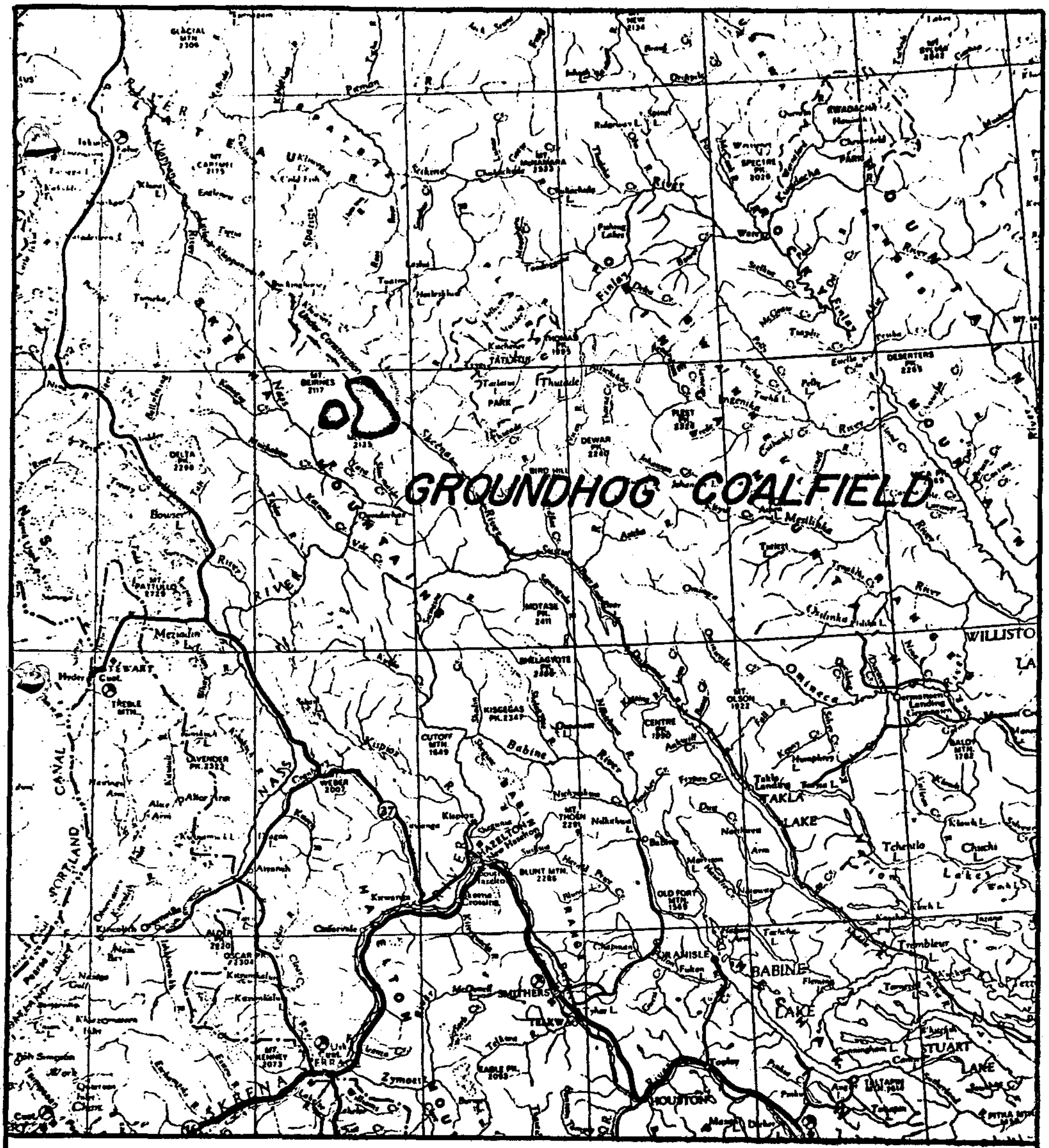


Figure I

Map Showing Location of Groundhog Coalfield
Upper Skeena River, B.C.
Scale 1:2,000,000

100

GK-GROUNDHOG 77(2)A

Figure 2

Topographic Map Showing
Groundhog Coalfield and Surrounding Area
Scale 1:250,000

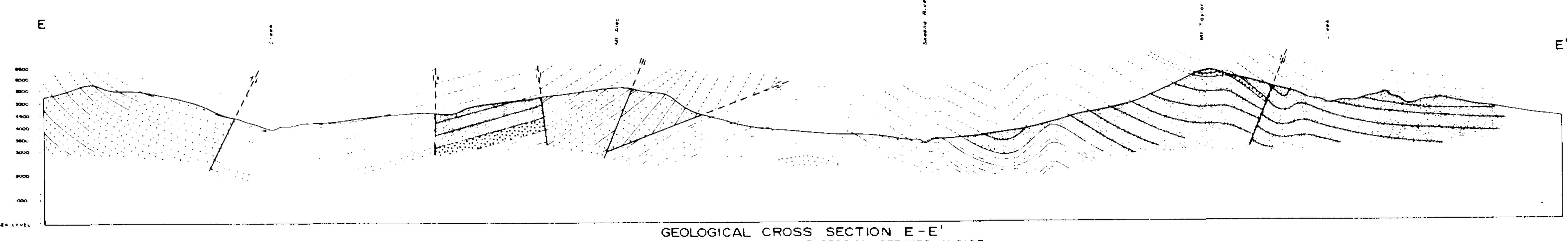
100

GR-GROUNDHOG 77(2)A

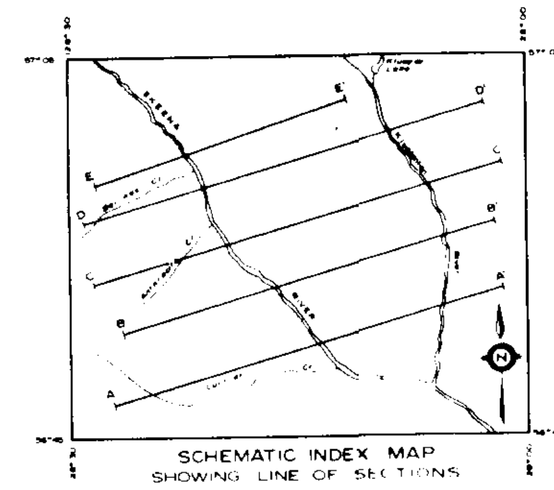
ROCKS ARE TIGHTLY FOLDED IN THIS AREA
ROCKS ARE TIGHTLY FOLDED IN THIS AREA
ROCKS ARE TIGHTLY FOLDED IN THIS AREA
ROCKS ARE TIGHTLY FOLDED IN THIS AREA
DIVISHIDE MTN
LONESOME MTN
TABLE MTN
MT LAIDLAW
MT GORDON
OPERATOR MTN
MT JACKSON
Jackson Flats
Tp 34
Tp 33
Tp 24
Tp 23
C A S S I A R
R I V E R
G R O U N D H O G   R A
EXPLANATION
LONESOME MOUNTAIN LITHOSOME – SOMBRE BROWN COLORED, WELL INDURATED, SPARSLEY FOSSILIFEROUS, CONGLOMERATIC SANDSTONES, SANDSTONES, MUDSTONES AND THIN, RARE, DISCONTINUOUS COAL BEDS.
DEVIL'S CLAW CONGLOMERATE LITHOSOME – THICK BEDDED, COARSE GRAINED, CHERT PEBBLE CONGLOMERATE INTERBEDDED WITH MUDSTONE, SANDSTONE AND MINOR COAL.
COAL BEARING LITHOSOME – SOFT, MEDIUM TO THICK BEDDED MUDSTONES (70-75 PERCENT), CARBONACEOUS UNITS, (15 TO 20 PERCENT), AND GREY SANDSTONES (10 PERCENT) WEATHER BROWN TO ORANGE.
McEVOY RIDGE LITHOSOME – DARK COLORED, WELL INDURATED MUDSTONES PREDOMINATE, WITH FINE GRAINED SANDSTONES AND SOME CARBONACEOUS MATTER. EVENLY BEDDED, 1 TO 5 FEET THICK.
STRIKE AND DIP OF COAL SEAM.
COAL IN PLACE, ATTITUDE UNKNOWN.
STRIKE AND DIP OF BEDDING; INCLINED, HORIZONTAL, VERTICAL, AND OVERTURNED.
STRIKE AND DIP OF JOINTS.
ROCK CONTACT, DASHED WHERE COVERED OR INFERRED
THRUST FAULT, "T" ON UPPER PLATE.
FAULT, DASHED WHERE INFERRED OR OBSCURED.
STRIKE AND PLUNGE OF AXIS OF ANTICLINE. DASHED WHERE INFERRED.
STRIKE AND PLUNGE OF AXIS OF SYNCLINE. DASHED WHERE INFERRED.
OVERTURNED ANTICLINE AND SYNCLINE RESPECTIVELY.
B.C. HYDRO AND POWER AUTHORITY
GROUNDHOG COALFIELD
GEOLOGICAL MAP
SKEENA RIVER AREA, BRITISH COLUMBIA
0 1 2 3 4 5,000 6 7 8 9 10,000 15,000 20,000 25,000 30,000
SCALE – 1:50,000
WILLARD D. TOMPSON, 1970
(Revised 1977)
GR-Groundhog 77(2)A.
PLATE I
57°00'
56°45'
128°00'

1101

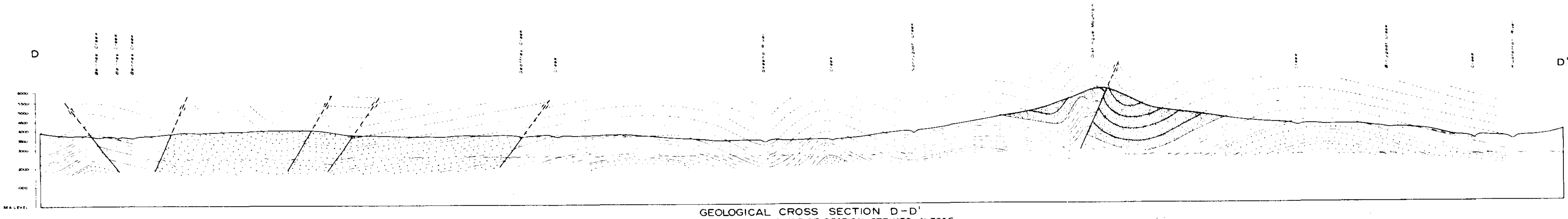
100



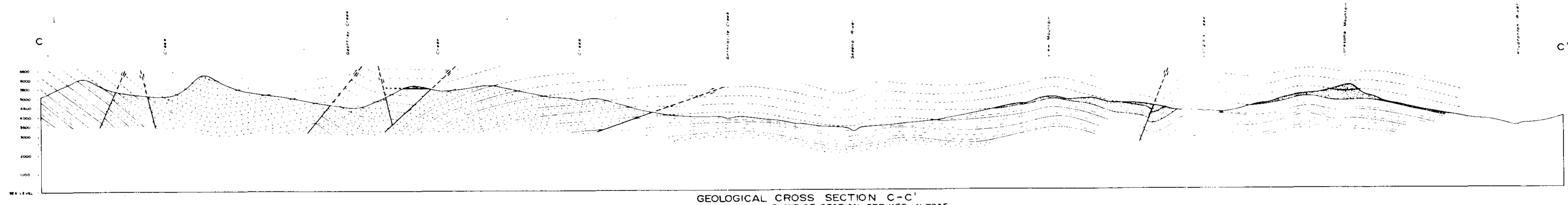
GEOLOGICAL CROSS SECTION E-E'
SECTION LOOKING NNW, PLANE OF SECTION STRIKES N 61° E



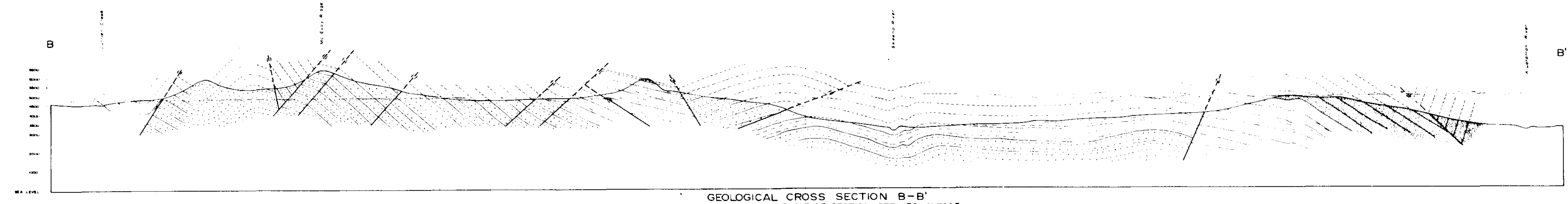
SCHEMATIC INDEX MAP
SHOWING LINE OF SECTIONS



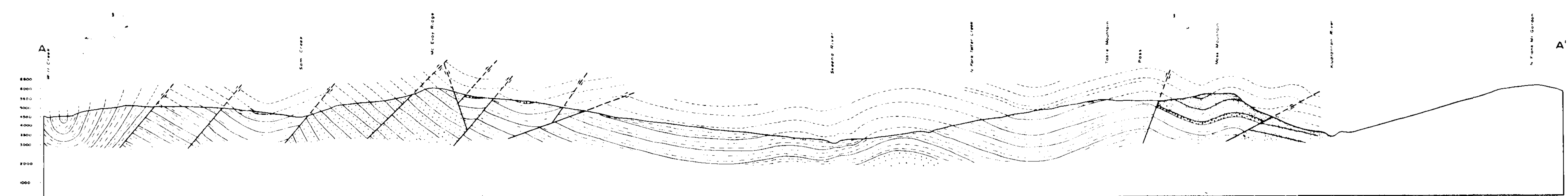
GEOLOGICAL CROSS SECTION D-D'
SECTION LOOKING NNW, PLANE OF SECTION STRIKES N 70° E



GEOLOGICAL CROSS SECTION C-C'
SECTION LOOKING NNW, PLANE OF SECTION STRIKES N 70° E



GEOLOGICAL CROSS SECTION B-B'
SECTION LOOKING NNW, PLANE OF SECTION STRIKES N 70° E



GEOLOGICAL CROSS SECTION A-A'
SECTION LOOKING NNW, PLANE OF SECTION STRIKES N 70° E

LEGEND

LONESOME MOUNTAIN LITHOSOME
Sombre brown coloured, well indurated, sparsely fossiliferous, conglomeratic sandstones, sandstones, mudstones and thin, rare, discontinuous coal beds

COAL BEARING LITHOSOME
Soft, medium to thick bedded mudstones (70-75%), carbonaceous units (15-20%), and grey sandstones (10%) which typically weather brown to orange

DEVIL'S CLAW CONGLOMERATE LITHOSOME
Thick bedded, coarse grained, chert pebble conglomerate interbedded with mudstone, sandstone, and minor coal

McEVOY RIDGE LITHOSOME
Dark coloured, well indurated mudstones predominate, with some fine grained sandstones and some carbonaceous matter. Evenly bedded, 1-5 feet thick

B.C. HYDRO AND POWER AUTORITY
GR-GR 77(2)A
M02

GROUNDHOG COALFIELD
GEOLOGICAL CROSS SECTIONS

SCALE: FEET 2000 — 0 — 2000 — 4000 — 6000 FEET

WILLARD D. TOMPSON

(11)

PLATE II