1983-16

STRUCTURAL AND SEDIMENTOLOGICAL FRAMEWORK OF LOWER CRETACEOUS COAL-BEARING ROCKS IN THE GRANDE CACHE AREA, ALBERTA

EDMONTON GEOLOGICAL SOCIETY

FIELD TRIP 1983

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INTRODUCTION

The objective of this field trip is to examine Lower Cretaceous coal-bearing strata of the Rocky Mountain Foothills in the Grande Cache area of central Alberta. Participants will have an opportunity to observe at first hand the lithology and complex structural relationships of the rock succession. Examples of lithofacies related to shallow marine, coastal plain, swamp, alluvial flood plain and alluvial channel environments can be observed.

The Grande Cache area is situated 350 km west of Edmonton in the inner Foothills (Fig. 1). The area consists mainly of forested mountains, with some reaching altitudes over 1800 m which are bare-topped and rocky. Topographic relief is greatest and bedrock exposure best on mountain slopes adjacent to the Smoky River, an antecedent river flowing northeastward. Additional outcrops can be found on the rocky, bare-topped ridges, along tributary streams of the Smoky River, and in excavations made for coal exploitation.

The presence of coal in the area was likely known to the earliest travellers of the Smoky River since outcrops of thick coal seams are evident at many localities. The first documented investigation occurred in 1916 after a number of claims had been staked (see Irish, 1965). By 1926 two subsidiary companies of McIntyre Porcupine Mines Ltd. held most of the claims. In 1959, under an option agreement, United States Steel Corporation began a four year exploration program (Landes, 1963). McIntyre Mines conducted detailed economic studies after opening discussions with Japanese interests in 1964, and in August 1970 the first shipment of clean metallurgical coal left the newly constructed mine plant.

GEOLOGIC SETTING

The inner Foothills in this area are bounded in the southwest by the Rocky Pass Thrust and in the northeast by the Muskeg Thrust (Fig. 1). Because of a general northwestern plunge of Paleozoic carbonate rocks, the inner Foothills are much wider along the Smoky River than along the Athabasca River. The Cowlick Thrust is an extension of the Boule Thrust, which is the thrust marking the boundary between Foothills and Front Ranges along the Athbasca River.

The inner Foothills in the Grande Cache area are characterized by Cretaceous (probably also minor Upper Jurassic) clastic rocks. On Figure 2 the Mesozoic and Paleocene formations in the Foothills of central Alberta and northeastern British Columbia are shown. These rocks belong to two molasse sequences (Eisbacher <u>et al</u>., 1974).

Regionally, geological mapping on a reconnaissance scale has been undertaken by the Geological Survey of Canada (Irish, 1965; Price <u>et al</u>., 1977; Mountjoy, 1978; McMechan, in prep.). More detailed mapping was done by Wrightson (1979) along the Smoky River between the Cowlick and Syncline Hills Thrusts (see Figs. 1 and 4). The Alberta Geological Survey is presently mapping in detail the area along the Smoky River between the

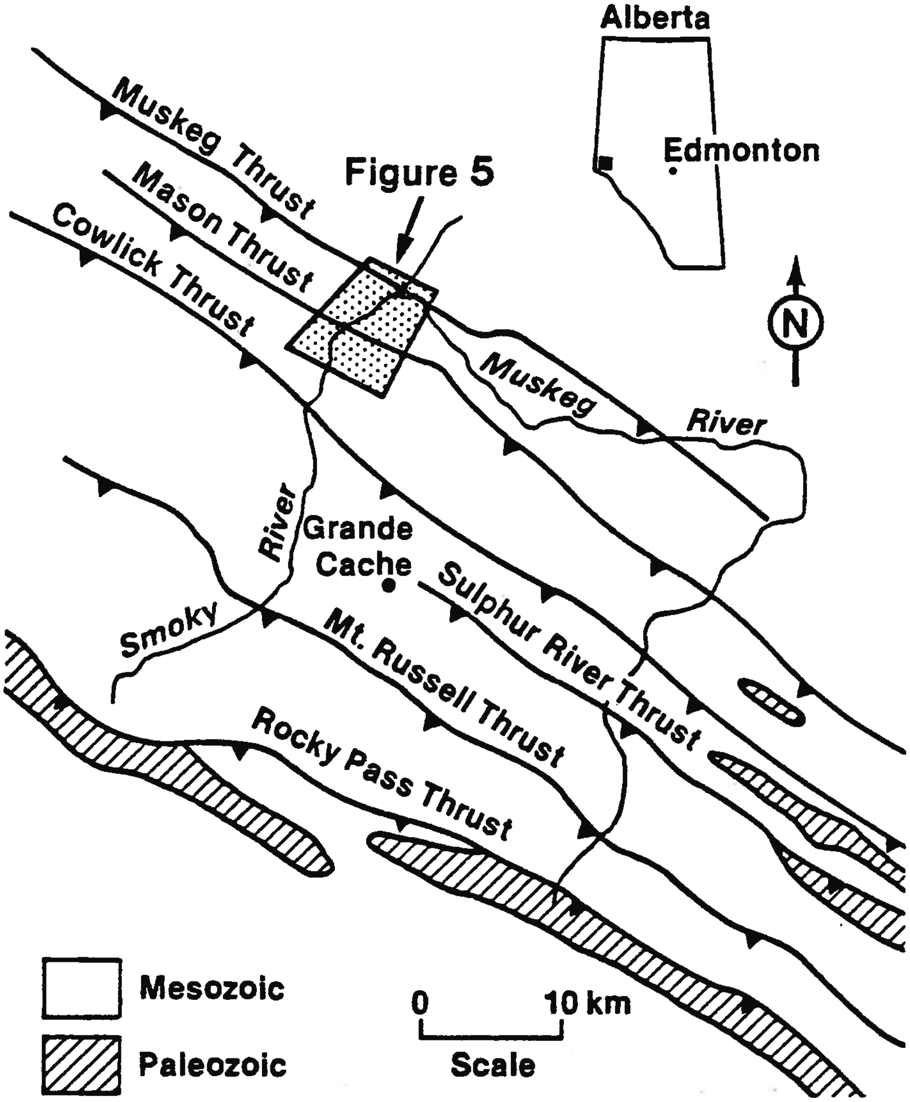

Figure 1. Location map of the Grande Cache area.

Age		Northeastern British Columbia	Grande Cache Area	Athabasca River, Coalspur Area
Paleocene	Upper molasse sequence	?	Paskapoo Fm.	Paskapoo Fm.
Maastrichtian		Wapiti Fm.		Coalspur Beds
			Brazeau Fm.	Brazeau Fm.
Campanian		Puskwaskau Fm.	Wapiabi Fm.	Wapiabi Fm.
Santonian		Bad Heart Fm.		
Coniacian		Muskiki Fm.		
Turonian		Cardium Fm.	Cardium Fm.	Cardium Fm.
Cenomanian		Kaskapau Fm.	Kaskapau Fm.	Blackstone Fm.
		Dunvegan Fm.	Dunvegan Fm.	
		Shaftesbury Fm.	Shaftesbury Fm.	
Albian	Lower molasse sequence	Boulder Creek Fm.		
		Hulcross Fm.		
		Gates Fm.	Gates Fm.	Gates Fm.
		Moosebar Fm.	Moosebar Fm.	Moosebar Fm.
		Gething Fm.	Gladstone Fm.	Gladstone Fm.
		Cadomin Fm.	Cadomin Fm.	Cadomin Fm.
Aptian				
Valangian		Minnes Group	Nikanassin Fm.	Nikanassin Fm.

Figure 2. Mesozoic and Paleocene formations in the Foothills of Central Alberta and northeastern British Columbia.

Cowlick and Muskeg Thrusts (Langenberg, 1982). Recent lithostratigraphic work on the Lower Cretaceous along the Foothills was performed by McLean (1977, 1982).

STRATIGRAPHY AND SEDIMENTARY ENVIRONMENT

Some 1200 m of marine and non-marine clastic sediments ranging in age from Jurassic to Late Cretaceous are present. For mapping purposes of the Alberta Geological Survey a modified stratigraphic nomenclature was adopted based on the work of McLean (1982) and Stott (1982), and is shown in Figure 3. This modified nomenclature is presented here to facilitate discussion and recognition of mappable units. The nomenclature and suggested changes from earlier proposals (McLean, 1982) will be formally introduced in a forthcoming publication by Langenberg, according to the rules by Hedberg (1976).

<table>
<tr><th colspan="2">Irish, 1965</th><th colspan="2">McLean, 1982</th><th colspan="2">Langenberg, proposed in this paper</th></tr>
<tr><td colspan="2">Shaftesbury Fm.</td><td colspan="2">Shaftesbury Fm.</td><td colspan="2">Shaftesbury Fm.</td></tr>
<tr><td rowspan="6">Blairmore Group</td><td rowspan="5">Luscar Fm.</td><td colspan="2">Mountain Park Fm.</td><td rowspan="3">Gates Fm.</td><td>Mountain Park Member</td></tr>
<tr><td rowspan="3">Malcolm Creek Fm.</td><td>Grande Cache Member</td><td>Grande Cache Member</td></tr>
<tr><td>Torrens Member</td><td>Torrens Member</td></tr>
<tr><td>Moosebar Member</td><td colspan="2">Moosebar Fm.</td></tr>
<tr><td colspan="2">Gladstone Fm.</td><td colspan="2">Gladstone Fm.</td></tr>
<tr><td>Cadomin Fm.</td><td colspan="2">Cadomin Fm.</td><td colspan="2">Cadomin Fm.</td></tr>
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Figure 3. Stratigraphic nomenclature of the Grande Cache area.

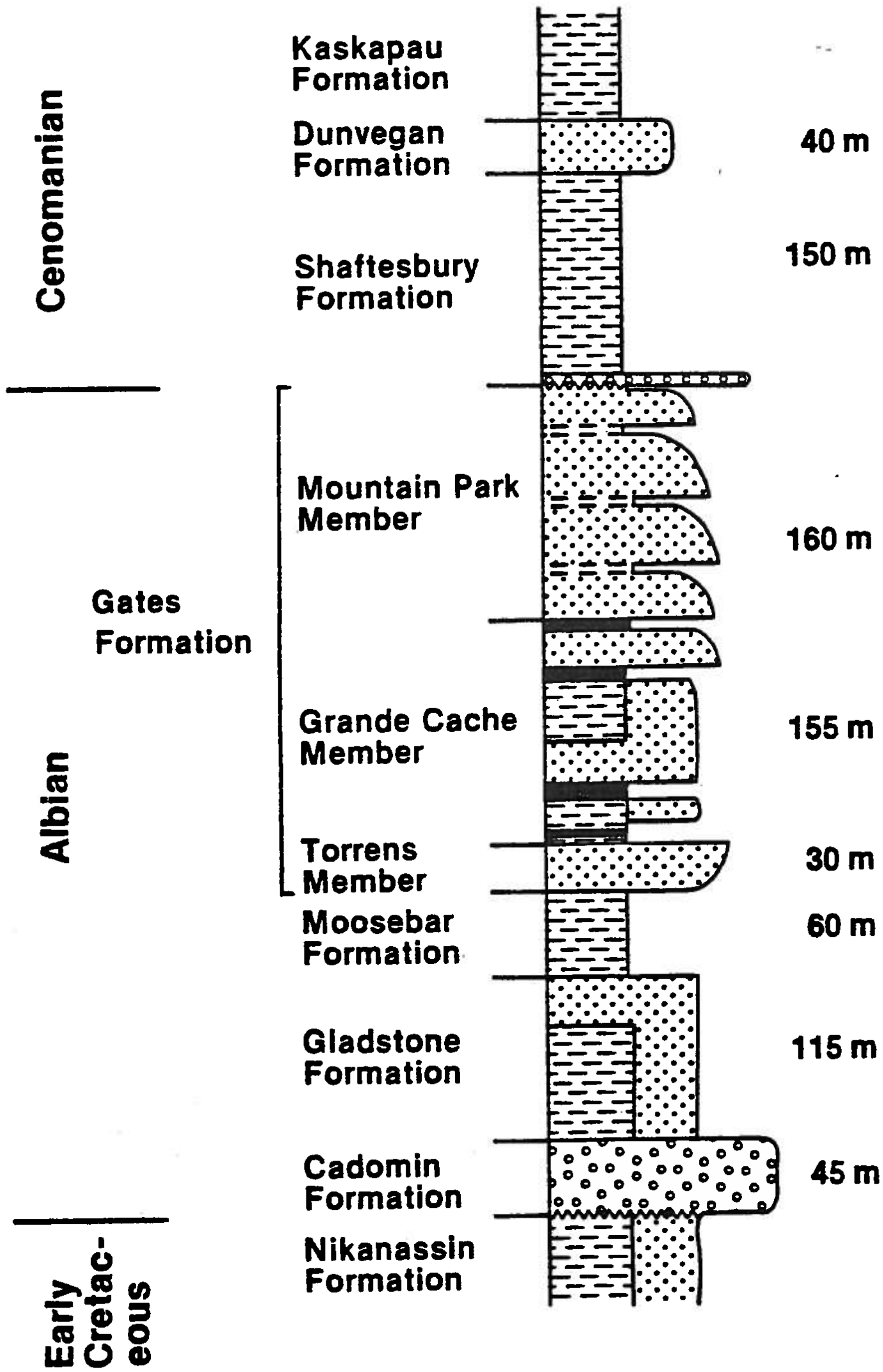


Figure 4. Simplified columnar stratigraphic section of the Grande Cache area.

The rationale for adopting a modified nomenclature is as follows. Recent mapping by both the Alberta Geological Survey and the Geological Survey of Canada (Langenberg, 1982; McMechan, in prep.) has shown that the Moosebar Member of McLean (1982) is a readily mappable unit on a 1:50,000 scale and should therefore have formation status. The boundary between the Mountain Park Formation and the Malcolm Creek Formation has been placed by McLean (1982) at the base of the first massive sandstone above the highest major coal seam (McLean, 1982, p. 3). This boundary is not regionally mappable and it is suggested therefore that the Mountain Park Formation be designated as a member. Accordingly, the Torrens Member, Grande Cache Member and Mountain Park Member would comprise a single formation. This interval was mapped in northestern British Columbia by Stott (1982) as the Gates, Hulcross and Boulder Creek Formations (Fig. 2). The Hulcross and Boulder Creek Formations cannot be mapped in the Grande Cache area, and it seems unlikely that the Mountain Park Member extends much higher than the top of the Gates Formation. Consequently, it is proposed that the formation formed by the Torrens, Grande Cache, and Mountain Park Members be called the Gates Formation. The Malcolm Creek Formation as defined by McLean (1982) could possibly be dropped. The Cadomin, Gladstone, Moosebar and Gates Formations together are equivalent to the Blairmore Group as defined by Mellon (1967). There are arguments that can be presented to change the name of this group from Blairmore to Luscar Group in areas where economic coal seams occur.

Figure 4 shows a simplified columnar stratigraphic section of the Grande Cache area. Many of these lithostratigraphic units are mappable. A geological map and cross section of the area to be visited by the field trip participants is shown in Figure 5. This map only shows formations, but the members also form mappable units.

Nikanassin Formation

Some 365 m of Nikanassin sandstone and shale are exposed in the Syncline Hills Thrust sheet. Its lower part is marine as shown by marine trace fossils and the occurrence of crinoids (Pentacrinus). The upper part contains carbonaceous shale, plant remains and thin lenticular coal seams indicative of non-marine sedimentation. Pentacrinus suggests a Jurassic age for the lower part of the formation. Irish (1965) reports lower Cretaceous plants from the upper part of the formation. An unconformity exists between the Nikanassin and the overlying Cadomin Formation.

Cadomin Formation

The conglomerates of the Cadomin Formation are one of the most useful stratigraphic markers in the Foothills (Stop 1, Fig. 5). McLean (1977) did a regional study on the Cadomin Formation. He concludes that a long period of pedimentation accompanied the formation of these sediments. Extensive areas covered by a single thin bed of conglomerate are remnants of the pediment surface, whereas thicker conglomerate and sandstone sequences are of alluvial fan and fluvial origin. In the field trip area the Cadomin Formation is 45 m thick and forms part of the Smoky River alluvial fan. The age of sedimentation is estimated at Aptian-Albian.

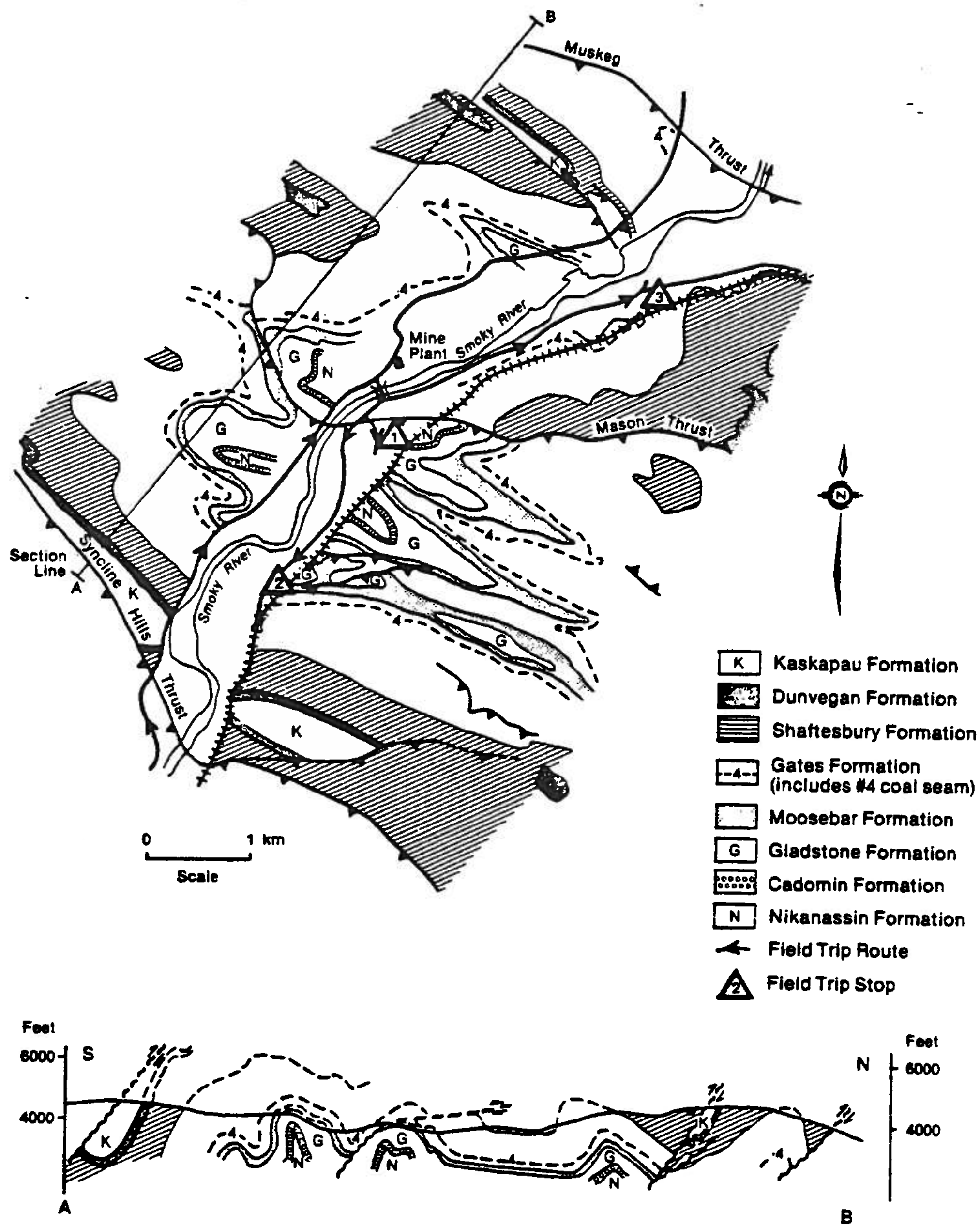


Figure 5. Geological map and cross-section of the area visited by the field trip. The cross-section is a composite of down-plunge projections performed in several cylindrical domains and is based on a computer-plot.

Gladstone Formation

The Gladstone Formation is represented by 115 m of generally fining upward sequences of sandstone, shale and minor coal seams (Stop 1, Fig. 5). The lower part of the formation has well defined fining upward sandstones deposited on an alluvial plain on which braided rivers flowed. The upper part of the formation contains shallow marine pelecypods (Protocardium), marine trace fossils, and possibly slightly brackish water foraminifera. These observations agree with the estuarine environment proposed by McLean and Wall (1981) for the upper Gladstone Formation north of the North Saskatchewan River. The age of sedimentation is estimated to be early Albian based on microfossils (McLean and Wall, 1981).

Moosebar Formation

The dominant lithology of the Moosebar Formation is dark-gray shale. In the field trip area the formation is 60 m thick (Stop 2, Fig. 5). Interbedded layers of generally fine grained sandstone occur in the middle and upper part of the section. They define coarsening upward sequences. These sandstones often show hummocky cross-stratification. These sandstones also contain burrows and traces of a marine deposit feeding fauna (G. Pemberton, pers. comm., 1982). The presence of a marine fauna (foraminifera) and a marine type of bioturbation indicates a shallow shelf setting (McLean and Wall, 1981). This is also indicated by the hummocky cross-beds that indicate storm wave activity in shallow marine environment below average wave base. Based on the foraminifera an age of early Albian can be established for this formation.

Torrens Member

The type section of the Torrens Member is near Mount Torrens which is close to the border of Alberta and British Columbia (McLean, 1982). The boundary between the Moosebar Formation and the Torrens Member of the Gates Formation is gradational and is placed at the base of the first massive sandstone bed above which few, or no shales, occur. It forms the upper part of the highest coarsening upward sequence of the Moosebar Formation. At Stop 2 the Moosebar and Torrens represent two coarsening upward sequences. The Torrens Member is about 30 m thick. It consists of fine-grained sandstones that often show parallel laminations, but there is some cross-bedding. Pebble conglomerate beds are also present in minor amounts. Burrows of a marine suspension feeding fauna are present in distinct layers and one outcrop contains a bed of oyster (Ostrea sp.) shells.

The Torrens Member represents a relatively high energy shoreline environment from wave base to slightly above sea level. Consequently, the coarsening upward sequence is caused by a prograding beach complex. No fossils useful for age determinations were found, however, the gradational contact with the Moosebar Formation suggests a probable early Albian age.

Grande Cache Member

The type section of the Grande Cache Member is a bulldozer cut in the Cowlick Thrust sheet near the town of Grande Cache (McLean, 1982). Recently, some reclamation has been performed in this artificial cut, which has deteriorated the exposure. This field trip will visit another good section of the Grande Cache Member (Stop 3, Fig. 5).

This member is characterized by thick, economic coal seams. All Lower Cretaceous coal mined in the central Alberta Foothills (both at present and in the past) comes from the Grande Cache Member. In the field trip area the member has a thickness of 155 m. Shale and fine-grained sandstone are the main constituents of this member, besides coal. The sandstone above the No. 4 coal seam (known as 'Super 4 Sandstone') changes facies laterally and locally, shales occur in this interval. The numbering of coal seams is according to Landes (1963). Higher up in the section fine to medium grained channel sandstones occur, especially in the interval between the No. 10 and No. 11 seams. The No. 4 and No. 10 coal seams are the only laterally continuous seams in the area visited by this field trip. The No. 3 seam which occurs immediately above the Torrens Member in the Syncline Hills Thrust sheet is not present in the Mason and Muskeg Thrust sheets (Fig. 5). Some pelecypod-shell layers immediately above this coal seam are laterally continuous and overlie carbonaceous shales where the coal seam is absent. Pelecypods from these layers include Unio douglassi and Murraia naiadiformis (C.R. Stelck, pers. comm., 1982). The latter pelecypod is indicative of brackish water conditions. These shallow, brackish marine conditions are also indicated by microfossils from the shales associated with the shell layers (J.H. Wall, pers. comm., 1982). Microfossils indicative of shallow, brackish marine conditions are also found in shales above the No. 4 and No. 10 seams. Coal associated with a shallow, brackish marine fauna points to a low energy coastal or delta plain environment behind shoreline deposits. The trough cross-bedded sandstones in the upper part of the member are indicative of the presence of fluvial channel deposits.

From the occurrence of ostracods the age of the Grande Cache Member is estimated to be early Albian (J.H. Wall, pers. comm., 1982).

Mountain Park Member

This lithostratigraphic unit was introduced by MacKay (1929a, b) in the Mountain Park area. Its mappability has been a problem in certain areas. For that reason it is suggested that it be reduced from a formation to a member. McLean (1982) designated a reference section along Malcolm Creek near Grande Cache, however, access to this section is difficult. A more accessible section occurs along the railroad at Stop 3 (Fig. 5). In this section there is continuous exposure from the top of the Torrens Member to the base of the Shaftesbury Formation.

The Mountain Park Member is characterized by very fine to medium grained sandstones. They occur in thick to massive beds, with abrupt bases and decrease in grain size upward. A scour surface often occurs at the base. In between the sandstones are units of shale, or interbedded shale and sandstone that contain minor thin coal seams. In most sections four fining-upward sequences can be distinguished, but in Stop 3 five fining-upward sequences may be present.

Thick, fining-upward sandstones are interpreted as fluvial channel deposits laid down by meandering streams. The finer grained sediments between are considered flood plain deposits. Near the top of the formation some marine trace fossils are found, together with possibly brackish pelecypod fossils. This may indicate an estuarine environment, signalling the advance of the Boreal Sea.

Some palynomorphs were recovered from the upper 50 m of the member at Malcolm Creek (A.R. Sweet, pers. comm., 1982), which indicate a middle Albian age.

Shaftesbury Formation

About 150 m of dark gray marine shale belonging to the Shaftesbury Formation (Stott, 1982) are present in the field trip area. The base of the formation is marked by a pebble conglomerate bed, that often shows large wave ripples. The age of the formation is Albian and Cenomanian.

Dunvegan Formation

Brown to reddish weathering quartzitic sandstone above the Shaftesbury shales forms an easy mappable rock unit, which belongs to the Dunvegan Formation (Stott, 1982). It is about 40 m thick. Specimens of *Inoceramus athabaskensis* have been recovered from the formation, which age is Cenomanian.

Kaskapau Formation

Dark gray marine shales above the Dunvegan Formation belong to the Kaskapau Formation (Irish, 1965). Only the lower part of the formation is present in the field trip area. The lower part of the formation, in which a specimen of *Dunveganoceras* was found, is Cenomanian in age.

STRUCTURAL GEOLOGY

Compressive stresses have deformed the region from the southwest. As a result the strata are folded and cut by numerous thrust faults. The main deformation took place between early Campanian and late Eocene time (Bally *et al*., 1966; Price, 1981).

The geological map and cross-section of Figure 5 were constructed from plots obtained by a computer-based storage and display system (Kilby and Charlesworth, 1980; Langenberg, 1982). Cylindrical domains were established and the cross-section was then obtained by the method of down-plunge projection.

Several thrust sheets can be recognized in the study area (Fig. 5). Stops 1 and 2 are situated in the Mason Thrust sheet, Stop 3 in the Muskeg Thrust sheet. The thrust faults are southwest dipping. Some northeast dipping faults occur. Folds are chevron folds, which are caused by layer parallel shortening.

DAY 1: ROAD LOG

Hinton - Grande Cache

For location of stops see Figure 5.

Road log starts 7 km west of Hinton at junction of Highways 16 and 40.

Kms	
0	
3.5	Turnoff to Entrance. Good outcrop of Entrance Conglomerate along railroad, 1 km west of Entrance.
4.8	West dipping greenish, cross-bedded sandstones and shales of the Brazeau Formation.
11.0	Glaciated outcrops of green medium grained sandstones and pebble conglomerates of the Brazeau Formation.
12.9	Entrance Conglomerate.
38.2	Wild Hay River.
67.3	Little Berland River.
79.6	Orange-weathering sandstones, grey shales and coal (probably equivalent to the Coalspur Beds). A mammal jaw-bone, fish bones and fish scales have been found in this possibly Paleocene outcrop (M.V.H. Wilson, pers. comm., 1982).
80.5	Berland River.
82.8	Cabin Creek. Cross-bedded channel sandstone on top of coal (probably equivalent to the Coalspur Beds).
113.0	Junction with Forestry Trunk Road to Grande Prairie.
115.2	Cross-bedded sandstone and pebble conglomerates of the Brazeau Formation. View of Lower Cretaceous sections on Flood Mountain and Mount Hamell.
118.1	Wapiabi shales with minor sandstone.

Kms

119.7 Cross-bedded sandstones (with pebble conglomerate horizons) and shales of the Brazeau Formation.

123.3 Muskeg River. Sandstones of the Chungo Member of the Wapiabi Formation.

129.0 Marine shales of the Kaskapau Formation overlain by rippled sandstones of the Cardium Formation. Minor granule conglomerate and coal. Marine trace fossils. Towards the northwest view of Flood Mountain and Cutpick Hill. Cutpick Hill has a well exposed section from the Kaskapau Formation to the Brazeau Formation.

132.1 Kaskapau shales; folded in west part of exposure.

134.3 Sandstones and shales of the lower Nikanassin Formation in the southwest limb of the Susa Creek Anticline.
View of exploration roads and trenches on Grande Mountain (No. 3, 4 and 10 coal seams) straight ahead.

135.3 Railway overpass.
Section of Nikanassin, Cadomin and Gladstone Formations along the railroad.

137.3 Channel sandstones of the Mountain Park Member.

141.1 Grande Cache Lake.
Cadomin Conglomerate.

142.4 Cadomin Conglomerate.

144.1 Victor Lake section.
Section of the Moosebar and Gates Formations from near the base of the Moosebar to 10 m above No. 4 coal seam.
Mountain Park Member channel sandstones are exposed 150 m to the southwest.

144.9 Shales of the Shaftesbury Formation.

145.4 Sandstones of the Dunvegan Formation.

146.1 Shales of the Kaskapau Formation.

146.4 Grande Cache townsite.
Continue on road towards Smoky River and mine plant of Smoky River Coal Ltd.

151.4 Sandstones of the Dunvegan Formation in contact with Shaftesbury shales.

152.3 Smoky River Bridge.

Kms

154.6 Malcolm Creek.
The type section of the Malcolm Creek Formation is upstream along this creek (McLean, 1982). This formation name could possibly be abandoned.

161.1 Thinly bedded sandstones and minor shales of the lower Nikanassin Formation containing a marine trace fossil assemblage.

162.0 View across the river of a section from the Nikanassin Formation to the No. 3 seam of the Grande Cache Member.

162.8 Close to the trace of the Syncline Hills Thrust, which is well exposed along the railroad across the river.

165.1 Tectonically disturbed section from the Torrens to the Mountain Park Member.

167.5 View of Stop 2 (Gladstone - Moosebar - Torrens) across the river.

168.9 Cadomin Conglomerate in contact with sandstones of the Gladstone Formation.

169.4 Mine plant of Smoky River Coal Ltd.; turn right and cross river. Across bridge turn right.

169.9 Turn left.

170.3 Park at culvert and walk to Stop 1 (Cadomin - Gladstone) along the railroad.

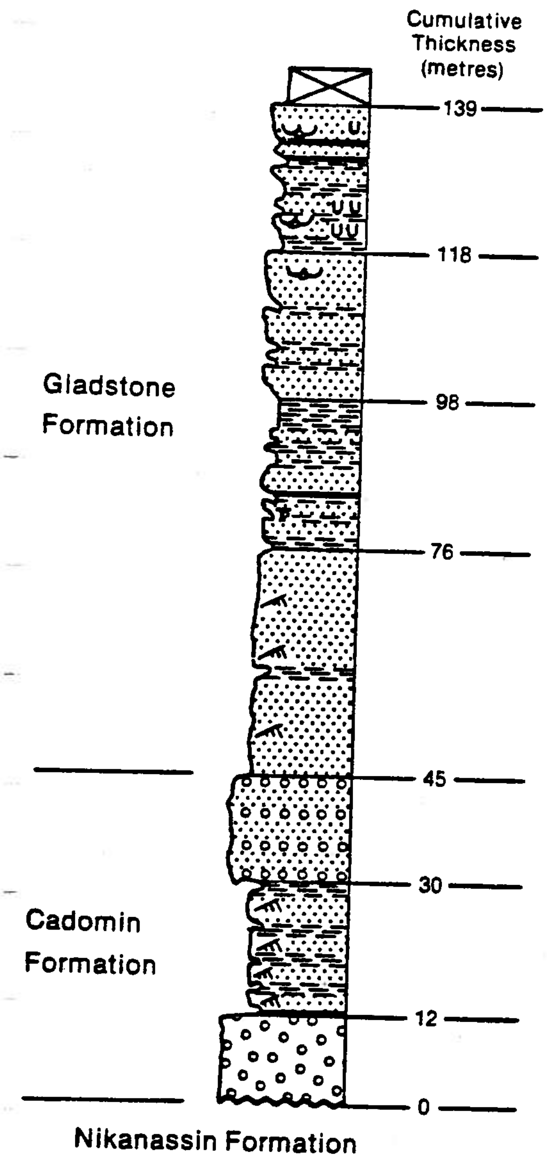
STOP 1

The section of Stop 1 is shown in Figure 6. An overview of the section is presented in Figure 7. The base of the Cadomin Formation scours into shales of the Nikanassin Formation. Although an angle of 8° was measured between the strata on both sides of the contact, a statistical test shows that this difference is insigificant. It is concluded that the contact is a disconformity.

Notice a coal seam at 12 m from the base of the section, as well as several thin seams higher up in the section. A rotated thrust fault at 111 m repeats 7 m of section (see Fig. 7).

At 122 m from the base of the section a bioturbated sandstone contains the trace fossils Arenicolites and Diplocriterion (Fig. 8). At 126 m there is a layer with Protocardium fossils.

The stream bed of the Smoky River can be seen from this locality, and appears to be braided. This river is a present day analogue for parts of the Cretaceous section in this stop.



Unit	Thickness (metres)	Description
7	21	Interbedded very fine to fine grained sandstones and shales. Trough cross bedding. some extensively burrowed layers. Two 30 cm thick coal seams. A 5 cm thick chert pebble conglomerate.
6	20	Fine grained sandstones, grayish orange weathering. Trough cross bedded. Some minor shale. At 13 m from the base of this unit there is a fault, which repeats 7 m of section.
5	22	Interbedded fine grained sandstones and shales. Sandstone pale reddish brown weathering. Two minor coal seams, the lower one 20 cm thick.
4	31	Fine grained, ripple cross-stratified sandstone. Light brown to moderate reddish brown weathering. Some minor shale.
3	15	Interbedded pebble conglomerate and medium grained sandstone, cross bedded.
2	18	Fine grained sandstone, cross bedded. Minor shale. A 40 cm thick coal seam at bottom.
1	12	Pebble and cobble conglomerate. Very thick bedded.

Figure 6. Columnar stratigraphic section of the Cadomin and Gladstone Formation in Stop 1.

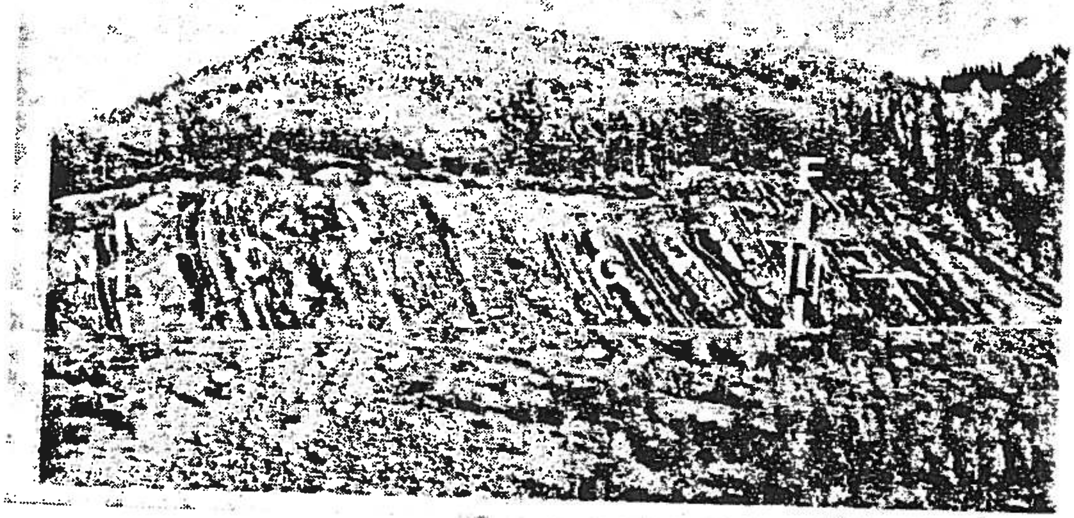


Figure 7. Overview of the section of Stop 1. N = Nikanassin Formation, C = Cadomin Formation, G = Gladstone Formation, F = Fault.

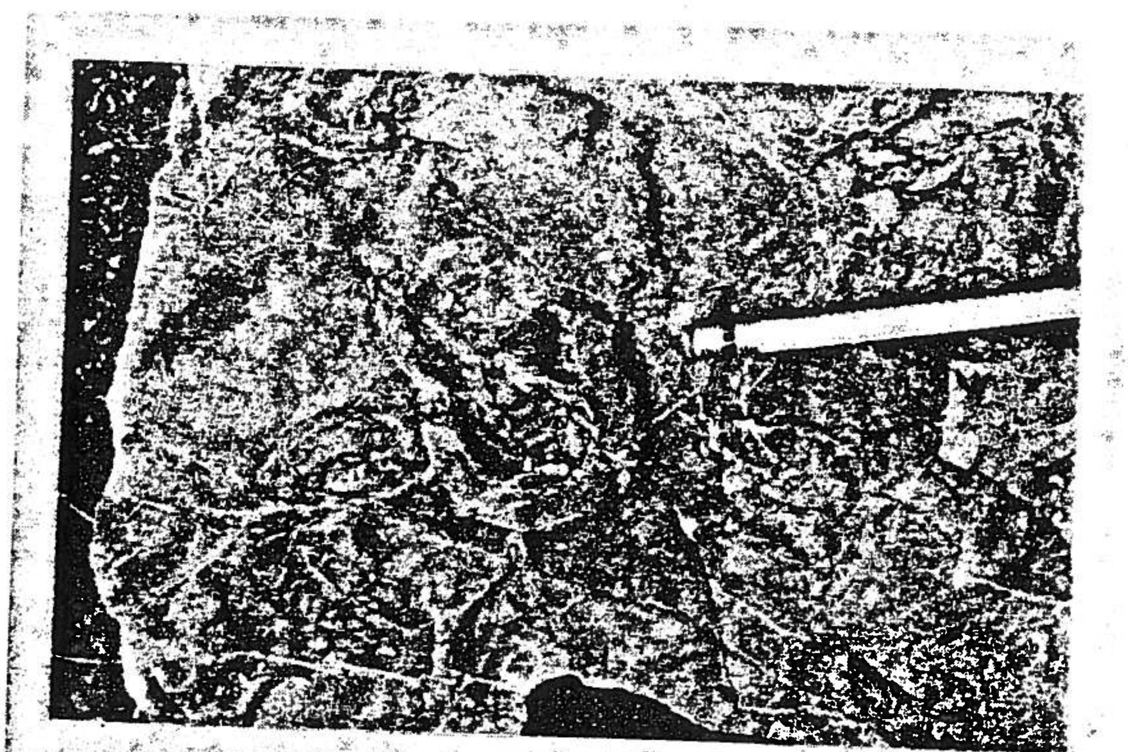
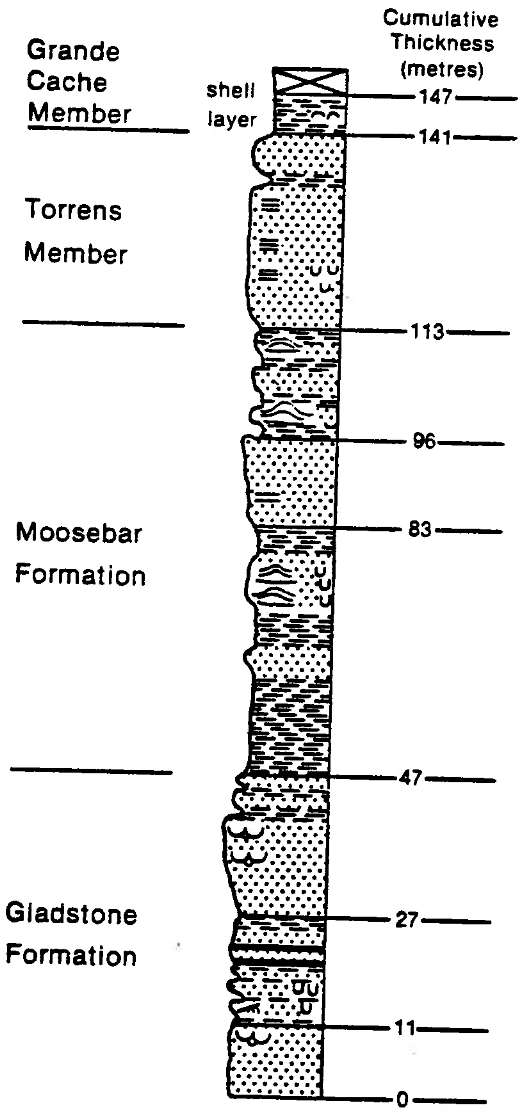


Figure 8. The trace fossil Diplocriterion in the upper Gladstone Formation of Stop 1.



Unit	Thickness (metres)	Description
8	6	Carbonaceous shales, dark gray with minor ironstone layers. Some conspicuous layers with pelecypod-shells.
7	28	Fine grained sandstone, grayish orange weathering. very thick bedded with parallel laminations. In lower part some burrowed layers, indicative of a suspension feeding fauna.
6	17	Interbedded very fine grained sandstone and shales. Sandstones show hummocky cross-stratification. Some burrows.
5	13	Coarsening upwards succession with medium grained sandstone on top; lower down very fine grained sandstones with minor shale. Some parallel laminations.
4	36	Dark gray shale, some ironstone layers. Towards top interbedded very fine-grained sandstone and shale. Sandstones show hummocky cross-stratification. Burrows that are indicative of a deposit feeding fauna.
3	20	Sandstones, very fine to medium grained, grayish orange weathering. Trough cross bedded. At the top some shales and at the very top a 10 cm thick coal seam.
2	16	Interbedded fine grained sandstones and shales. Burrowed. Ripple cross-stratification. Two thin coal seams; the upper one 20 cm thick.
1	11	Fine grained sandstone, moderate reddish brown weathering. Thick to very thick bedded. Some shale interlayers. Some minor coal seams and a 10 cm thick chert conglomerate layer.

Figure 9. Columnar stratigraphic section of Gladstone Formation, Moosebar Formation and Torrens Member in Stop 2.

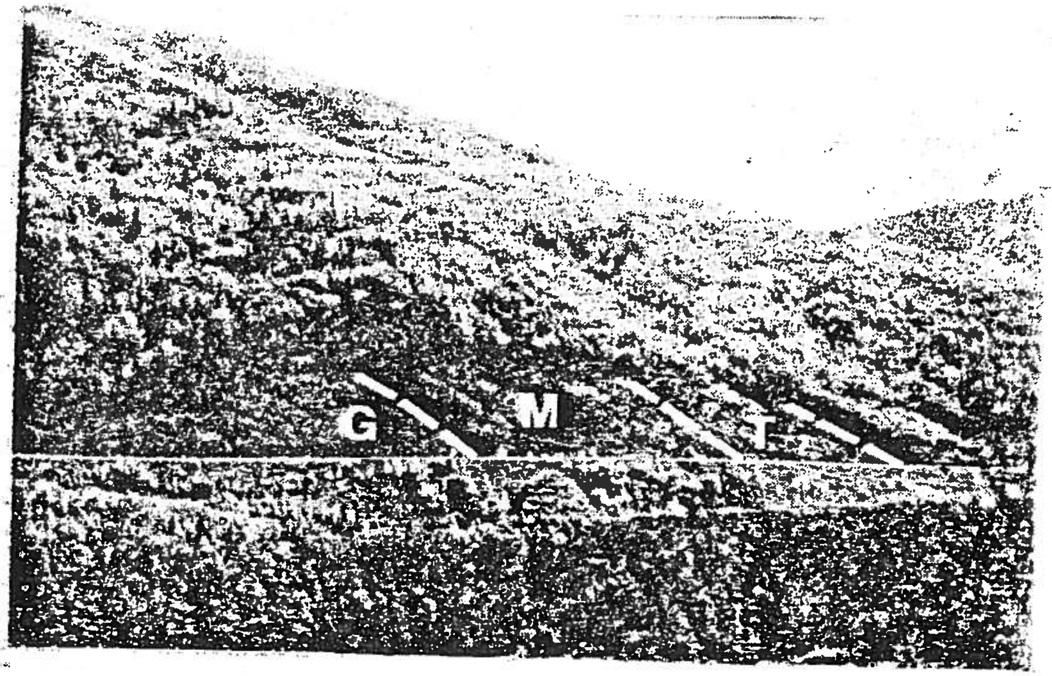


Figure 10. Overview of the section of Stop 2. Gladstone Formation (G) at the bottom, Moosebar Formation (M) in middle and Torrens Member (T) at the top.

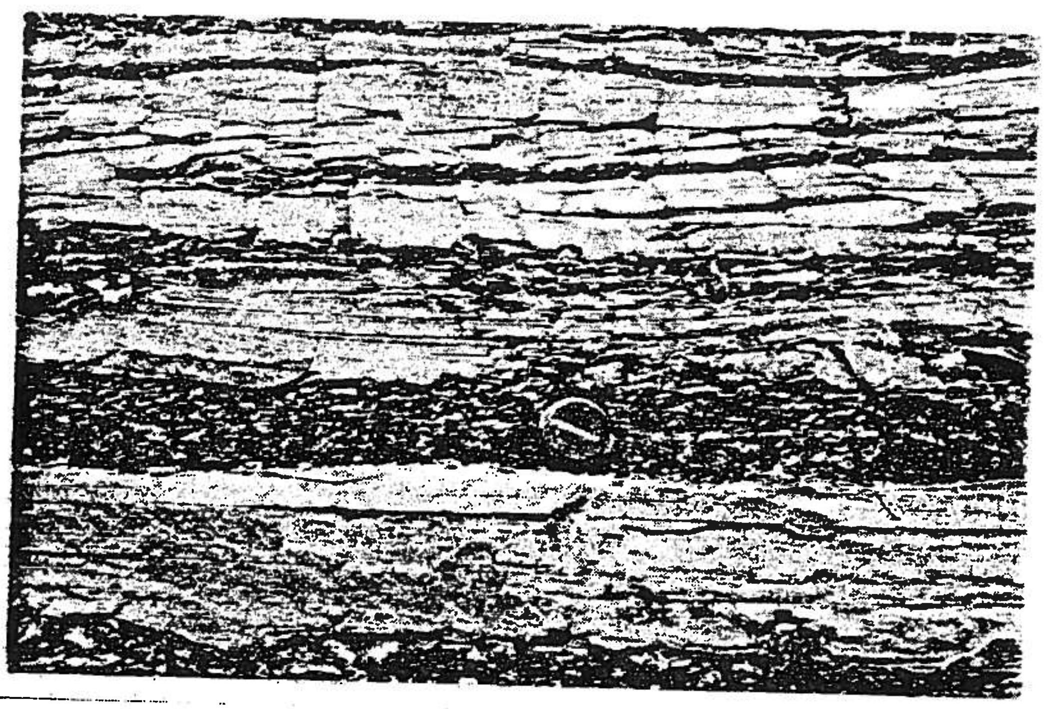


Figure 11. Hummocky cross-beds in the upper part of the Moosebar Formation of Stop 2.

Walk 1.5 km along the railroad in a southwesterly direction. The start of the section of Stop 2 is in the core of an anticline in the Gladstone Formation.

STOP 2

The section of Stop 2 is presented in Figure 9. An overview of the section is shown in Figure 10. A pebble conglomerate layer at 12 m from the base of the section and two thin coal seams at 21 m can be correlated with strata in the top of the section of Stop 1. The 10 cm thick coal seam at the top of the Gladstone Formation is in the same stratigraphic postion as the 2 m thick No. 2 coal seam in the Cowlick Thrust sheet.

Notice hummocky cross-beds at 75 m, as well as the trace fossils Planolites and Arenicolites. More hummocky cross-beds occur in Unit 6 (from 96-113 m), as shown in Figure 11.

Unit 7 (from 113-141) represents the Torrens Member. Notice the parallel laminations and also some bioturbated layers (at 120 m) with the trace fossils Arenicolites and Diplocriterion.

In Unit 8 there are some pelecypod-shell layers in carbonaceous shales. The shales below the shell layers are in the same stratigraphic position as the No. 3 coal seam of the Cowlick and Syncline Hills Thrust sheets.

Return to the vehicle, drive back to the bridge over the Smoky River and continue for 2.1 km in northeasterly direction (Fig. 5). Park and walk along the creek to the railroad. The start of the section of Stop 3 is 700 m east along the railroad.

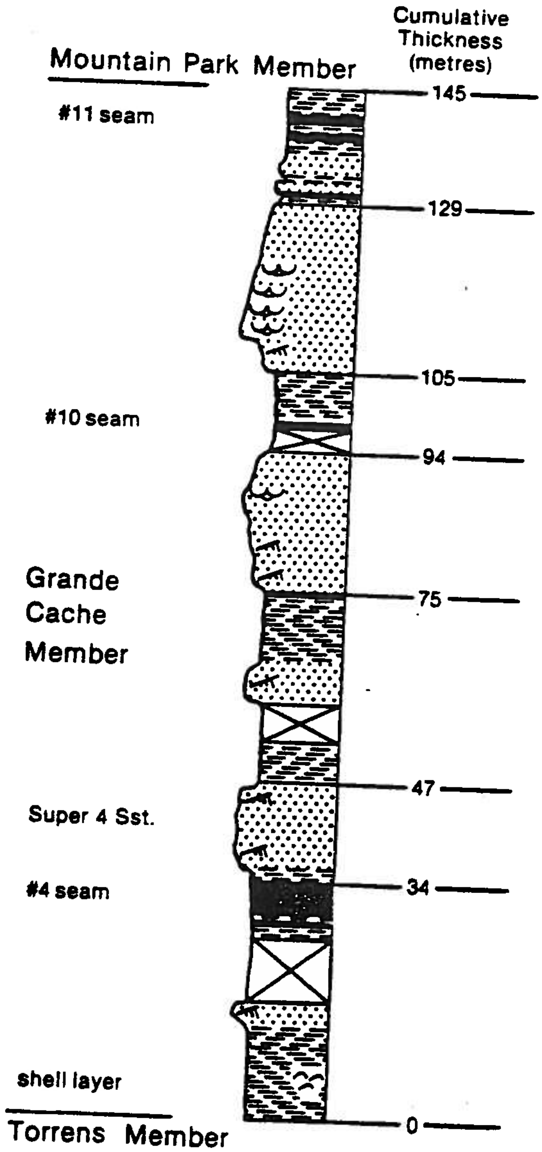
STOP 3

At this stop a continuous section of the Grande Cache and Mountain Park Members is exposed. A description of the section through the Grande Cache Member is given in Figure 12; the section through the Mountain Park Member is shown in Figure 13.

Notice the pelecypod-shell layers at 5 m from the base of the section. The 5 m thick coal seam at 30 m is the No. 4 seam. This is the major economic coal seam of the area, which is mined both underground and in open pits.

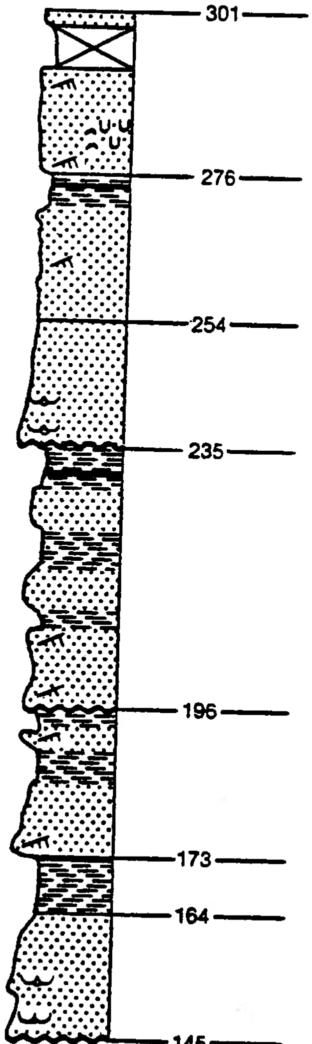
At 97 m the No. 10 coal seam is partly exposed. Unit 6 (from 105-129 m) is a prominent fining upward sandstone body with trough cross-beds. Coal seam No. 11 occurs in Unit 7.

Unit 8 (Fig. 13) is a prominent fining upward sandstone which forms the base of the Mountain Park Member. It scours into Unit 7 (Fig. 12) of the Grande Cache Member (Fig. 14). Another fining upward sandstone is formed by Unit 12.



Unit	Thickness (metres)	Description
7	16	Shales and coal, minor very fine grained sandstone. Composite thickness of coal 4.5 m (#11 seam).
6	24	Fine to medium grained sandstone, trough cross bedded. Pale brown weathering. Rip up clasts and ripple cross stratification in lower part.
5	11	Shales and 1.5 m thick exposed coal (#10 seam).
4	19	Fine grained shaley sandstone, minor medium grained sandstone. Yellowish gray weathering. Ripple cross stratification.
3	28	Gray shales, some fine grained rippled sandstone. A 40 cm thick coal seam at top.
2	13	Fine grained sandstone, moderate yellowish brown weathering. Ripple cross stratified, known as 'Super 4 Sandstone'.
1	34	Dark gray carbonaceous shale and coal. 5 m thick coal bed (#4 seam). At 5 m from base conspicuous pelecypods layers.

Figure 12. Columnar stratigraphic section of the Grande Cache Member in Stop 3.



Unit	Thickness (metres)	Description
14	25	Fine grained sandstone, ripple cross stratified. Reddish brown weathering. Some burrowing in a zone with gastropod and pelecypod fossils.
13	22	Interbedded fine grained sandstone and shale. Sandstone ripple cross stratified. At top shale and minor coal (coal up to 20 cm thick).
12	19	Fine to medium grained sandstone. Grayish orange weathering. Trough cross bedding. Scour surface at bottom.
11	39	Fine grained sandstone, shaley sandstone and shale. Sandstone show ripple cross stratification. Light olive gray weathering. Scour surface at bottom. Near top 1 m thick coal and shaley coal.
10	23	Medium to fine grained sandstone and shale. Sandstone ripple cross stratified and grayish orange weathering.
9	9	Shale and minor sandstone. A 40 cm thick coal seam at the top.
8	19	Fine to medium grained sandstone. Trough cross bedded. Moderate brown weathering. Scouring into Grande Cache Member at bottom.

Figure 13. Columnar stratigraphic section of the Mountain Park Member in Stop 3.

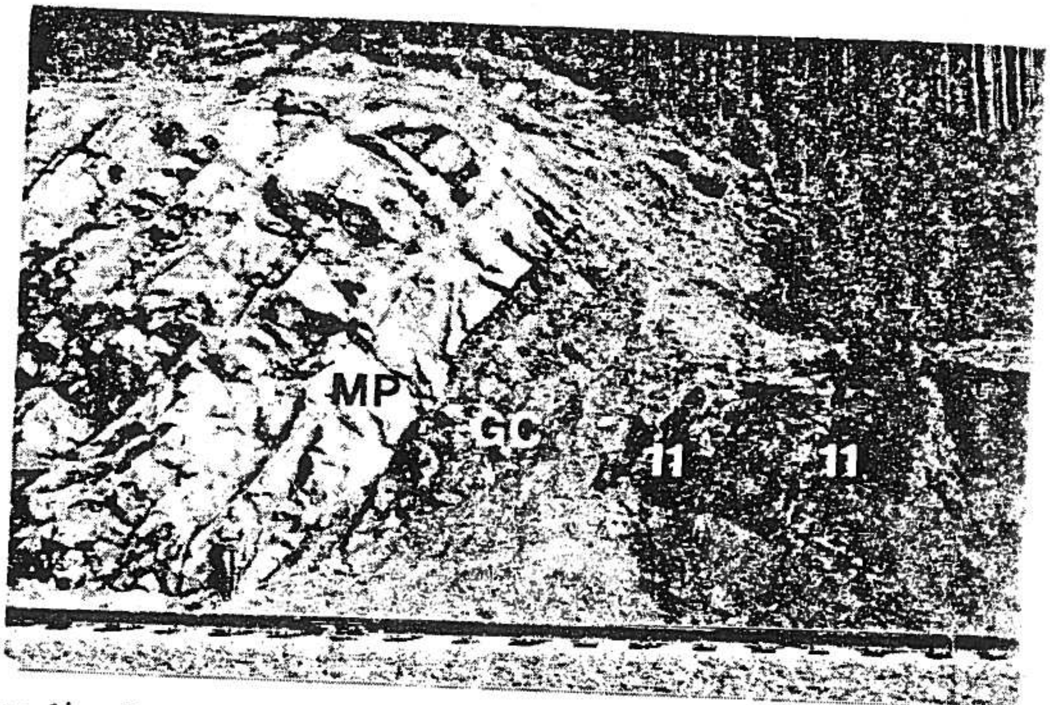


Figure 14. Base of the Mountain Park Member (MP) scouring into Grande Cache Member (GC) with No. 11 coal seam (11).

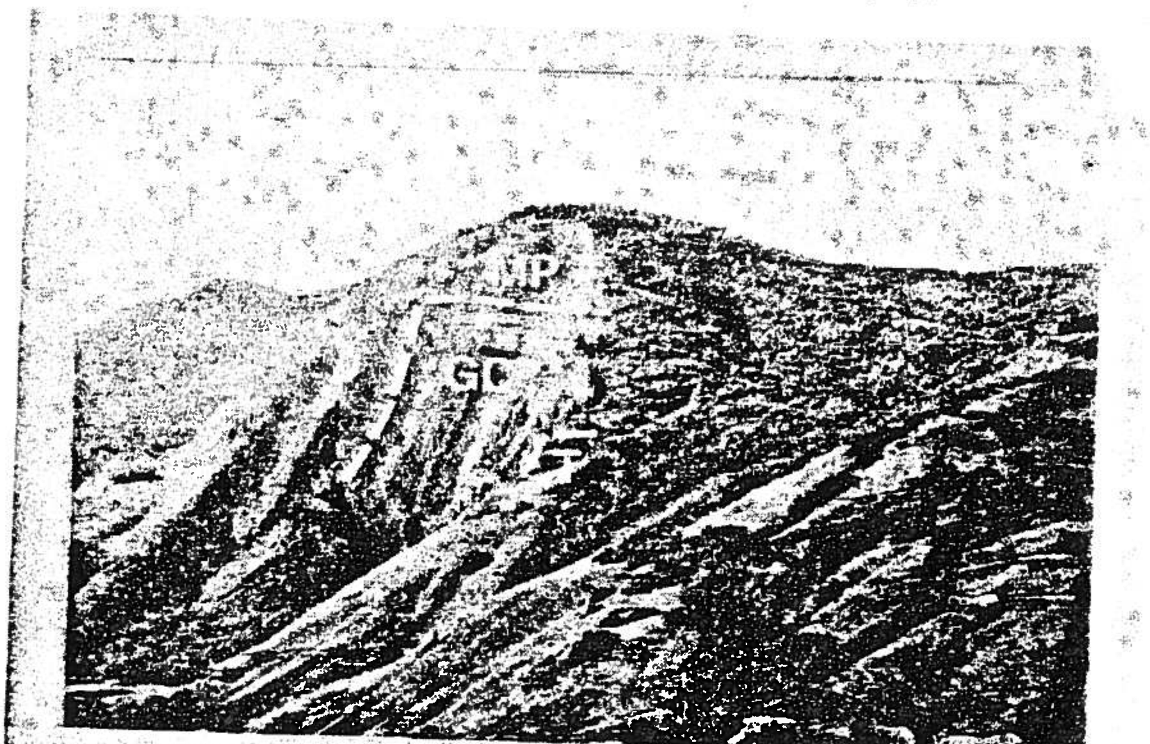


Figure 15. Chevron fold across the Smoky River from Stop 3. T = Torrens Member, GC = Grande Cache Member, MP = Mountain Park Member.

Notice minor thin coal seams in Units 9, 11 and 13. The fine-grained sandstone of Unit 14 is bioturbated as shown by the trace fossils Diplocriterion and Skolithos at 282 m. Gastropod and pelecypod fossils occur in the same zone.

Notice the (poorly exposed) pebble conglomerate that marks the base of the Shaftesbury Formation.

A better exposure of the contact between the Mountain Park Member and the Shaftesbury Formation is present 300 m east along the railroad. Across the Smoky River a large scale chevron fold in the Torrens, Grande Cache and Mountain Park Members can be observed from Stop 3 (Fig. 15).

DAY 2:

Smoky River Coal Mine

The mining operations of Smoky River Coal Ltd. (a subsidiary of McIntyre Mines) will be visited. In 1981 Smoky River Coal Ltd. produced 2.1 million long tons of clean coal from surface and underground operations. The coal is of medium to low volatile bituminous rank with a mean maximum reflectance of vitrinite in oil of 1.5% (Haquebard and Donaldson, 1974). Consequently, it is one of the highest ranked coking coals of the Rocky Mountains. It belongs to the Keystone Group as defined by Pearson (1980).

An overview of the active No. 9 surface mine will be given from the reclaimed area of the abandoned No. 8 surface mine (Fig. 16). The entrances of underground mines can also be observed. The structure is a large scale anticline (called the McEvoy Anticline), with several subsidiary chevron folds in its northeast limb.

The No. 4 seam, which is about 6 m thick, is both mined in the No. 9 surface mine and in the underground mines (Mines 9A-4 and 9G-4). Coal from the No. 10 seam is recovered in the surface mine during overburden removal.

STOP 4

After the overview the active No. 9 surface mine will be entered. On the northwest wall of the open pit a section of the Grande Cache Member from the No. 4 to No. 10 coals seams will be studied. In 1981 overburden was removed at a ratio of 9.5 cubic metres of rock for every long ton of raw coal (a stripping ratio of 9.5 to 1). This makes the coal expensive to produce. Exploration is aiming at developing surface mines with stripping ratios of less than 8 to 1.

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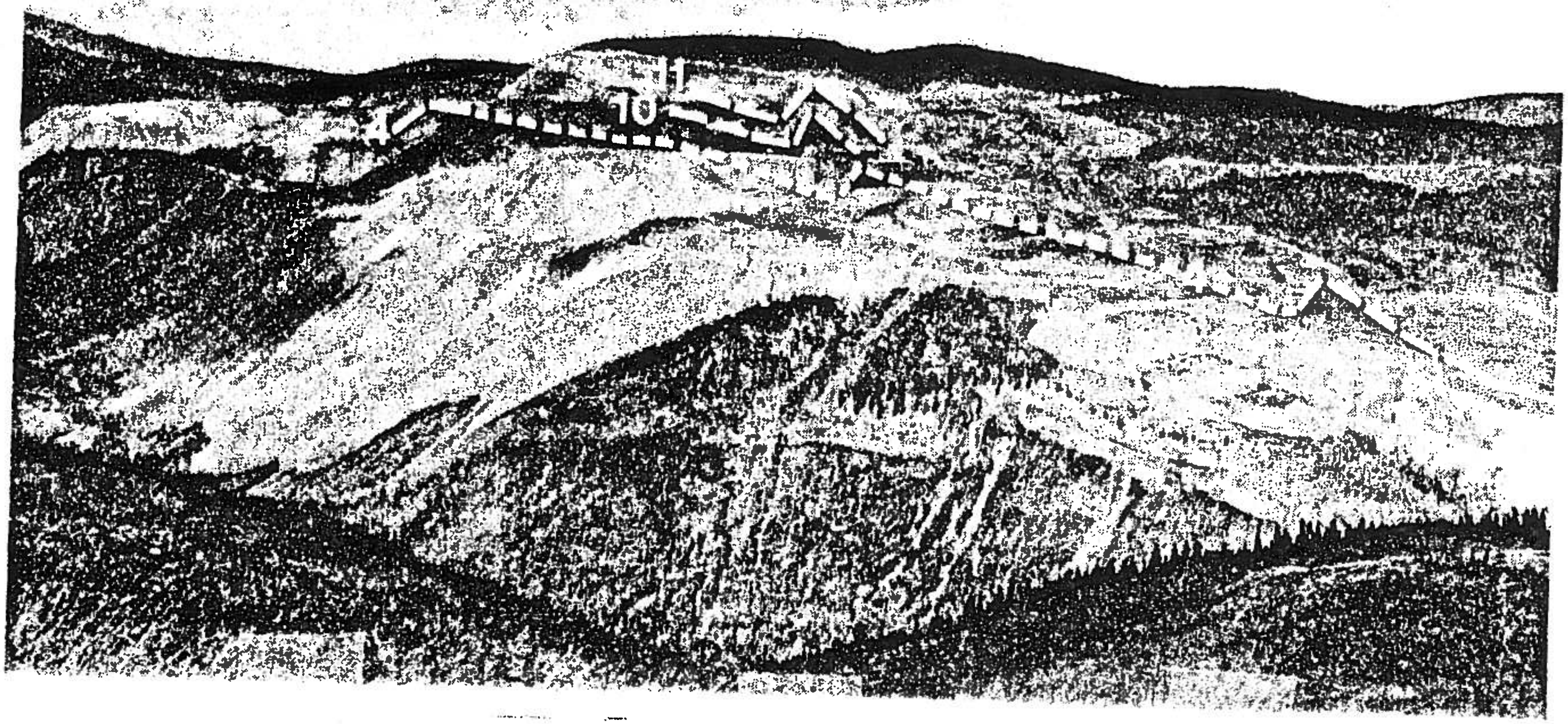

Figure 16. Overview of the active No. 9 surface mine from No. 8 mine. C = Cadomin Formation. The traces of the major coal seams (No. 4, 10 and 11) are also indicated.

thanked for discussions concerning the stratigraphic nomenclature. Sheila Binda typed the manuscript.

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