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GEOLOGIC FEATURES AND MINERAL RESOURCES OF THE WAPITI-GRANDE CACHE REGION, NORTHWESTERN ALBERTA, AS RELATED TO HIGHWAY ENGINEERING

by

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GEOLOGIC FEATURES AND MINERAL RESOURCES OF THE WAPITI-GRANDE CACHE REGION

Introduction

This report describes the geology of an area in northwestern Alberta contained largely within N.T.S. Sheet 83L (Wapiti) and the northeast portion of N.T.S. Sheet 83E (Mount Robson). The region is traversed by three alternative routes for a proposed multipurpose highway connecting the City of Grande Prairie on the northern margin of the map-area and the town of Grande Cache in the Foothills to the southwest. The report is written with particular reference to the geological factors associated with the siting of this highway, as requested by the Department of Highways and Transport.

Source of Data

Most of the data on the bedrock geology of the area, except the Foothills in the southwest, was obtained from helicopter surveys conducted by Research Council Geology Division personnel in 1969 and 1970. This material is supplemented by information in reports by Allan and Carr (1946), Greiner (1955), and Irish (1965), and by examination of air photos.

The surficial deposits of the area have not been mapped, although some data are available in a reconnaissance soils survey report by Lindsay *et al*. (1963). Air photo examination and observations of surficial deposits made during bedrock geology surveys also have proved helpful.

Physiography

The map-area is divisible into three broad physiographic units which largely coincide with variations in bedrock and surficial geology. These units are:

(1) A relatively flat plain developed on glacial lake sediments (sand, silt, and clay) extending across the northern margin of the map-area. The plain (or "prairie") is cut by the valleys of the Wapiti River and several smaller tributary streams, which are entrenched in Cretaceous bedrock 200 to 500 feet below "prairie" level.

(2) A dissected tableland consisting of a series of narrow flat-topped to gently rounded, northeast-sloping ridges separated by the valleys of the Cutbank, Kakwa, Smoky and Simonette Rivers. The ridges are underlain by gently dipping to nearly flatlying Cretaceous and Tertiary bedrock, merging to the southwest with the folded bedrock strata of the Foothills.

(3) The Foothills proper (as defined in a geologic sense) extend across the southwest portion of the map-area. They consist of a series of northwest-trending ridges composed of complexly folded and faulted strata of Triassic, Jurassic, and Cretaceous ages. Elevations range from approximately 8000 feet in the southwest to 6000 feet along the northeast margin which is drawn arbitrarily along the series of cuesta-like ridges called Hat Mountain, Copton Ridge, and Cutpick Hill on the accompanying map (Fig. 1).

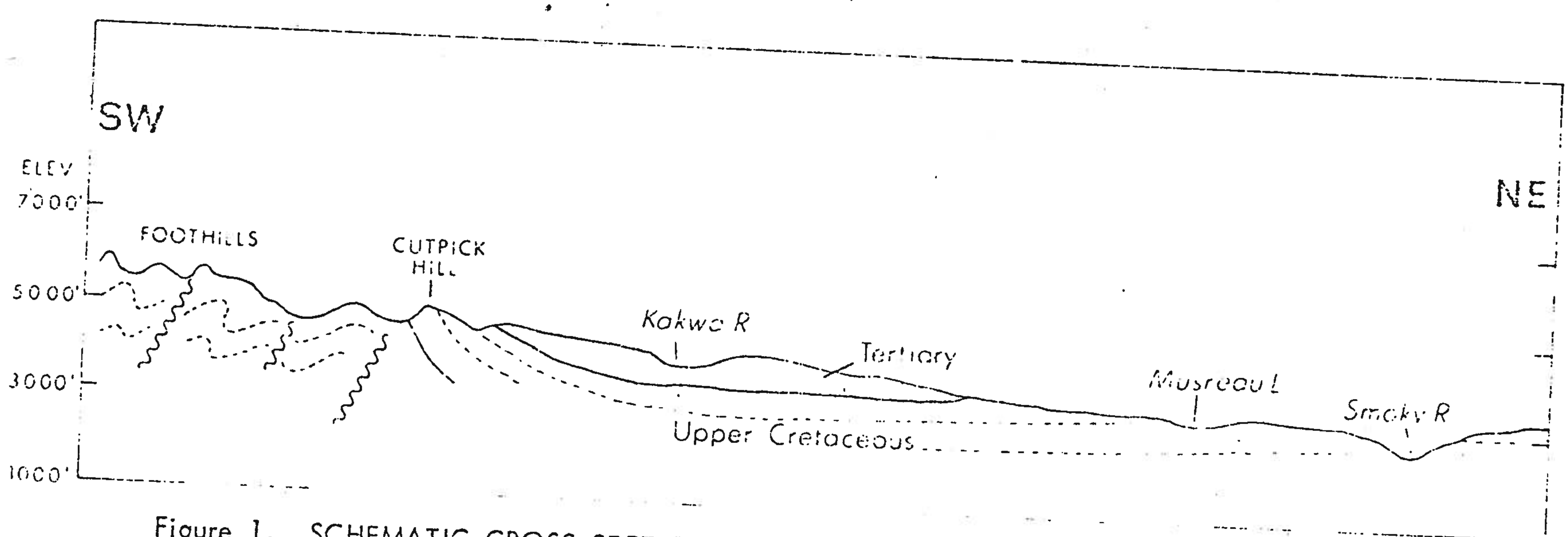

Figure 1. SCHEMATIC CROSS SECTION THROUGH NEAR-SURFACE BEDROCK STRATA, WAPITI MAP-AREA.

Bedrock Geology

Outside of the Foothills, as defined above, the map-area is underlain by a thick succession of interbedded sandstone, silty mudstone, and coal similar in age (late Cretaceous and early Tertiary) and composition to the bedrock formations of the Edmonton-Red Deer area in central Alberta. The regional structure of these beds is that of a shallow syncline, the axis of which trends in a northwesterly direction parallel to but out from the margin of the Foothills (see attached cross section). Strata on the northeast limb of the syncline dip gently to the southwest (3 degrees or less), exposing successively older beds towards the northeast. On the southwest limb of the syncline, the strata dip to the northeast with increasing steepness (5 degrees to 15 degrees), abutting against the complexly folded and faulted Cretaceous beds that mark the northeast margin of the Foothills.

The bedrock of this area can be divided into two units grossly similar in lithology. The older beds are latest Cretaceous in age, consisting of interbedded sandstone, siltstone, silty mudstone (or "claystone"), coal, and thin bentonite beds. The sandstones are buff- to grey-weathering, relatively soft, bentonitic rocks with harder carbonate-cemented, brown-weathering concretionary beds. They range in thickness from 1 to 50 or more feet but are extremely lenticular in nature, grading laterally into finer-grained siltstones and mudstones within very short distances. Thus, correlation or projection of individual beds between adjacent outcrops is difficult or impractical in many cases.

The finer-grained beds -- siltstones and silty mudstones -- tend to be soft and bentonitic and thus relatively prone to failure (slumping). They are associated in many outcrops in the north and northeast parts of the map-area with coal beds ranging in thickness from less than a foot to 15 or more feet. The coal beds in turn almost invariably contain thin bentonite beds 1 to 18 inches thick, and usually overly relatively soft bentonitic mudstone. The coal deposits are described in greater detail in the section on "Mineral Resources".

The younger series of beds -- early Tertiary in age -- overlying the Cretaceous coal-bearing strata described above are exposed along the axis of the shallow synclinal structure paralleling the Foothills boundary. They are similar in gross lithology to the Cretaceous strata, consisting of lenticular grey and buff-weathering sandstones and slightly bentonitic silty mudstones. The main distinctions between the two sets of strata are:

(1) the Tertiary sandstones are more calcareous and hence harder than the underlying Cretaceous sandstones;

(2) the Tertiary beds contain little or no coal, except for scattered thin seams a few inches thick. The general impression is that the Tertiary beds are less prone to failure than the more bentonitic Cretaceous succession, in part owing to rather subtle differences in rock composition.

Towards the margin of the Foothills, the Upper Cretaceous-Tertiary succession reverses dip (from very low southwesterly dips to 10 to 15 degrees northeast), exposing the uppermost Cretaceous strata along a series of cuesta-like ridges or hills that mark the edge of the folded belt. The bedrock geology of the Foothills proper is quite complex: in general, a series of northwest-striking folded thrust sheets expose a successively older series of strata towards the Front Ranges of the Rocky Mountains to the southwest. These beds contain the bituminous (coking) coal deposits of Early Cretaceous age being mined near Grande Cache; a good summary of the geology of this region is given by Irish (1965).

Surficial Geology

The surficial deposits in the area (defined as all materials overlying bedrock) consist of preglacial gravels and sands, glacial deposits, and recent deposits; their distribution along the proposed highway routes is indicated on the accompanying map.

The preglacial gravels and sands, deposited by rivers flowing from the mountains to the plains prior to disruption of regional drainage by the Pleistocene ice sheets, directly overlie bedrock on many portions of the dissected tableland between the Foothills proper and the lake plain area in the northern part of the map sheet. They probably also occur in buried valleys below considerable thicknesses of valley fill; however, this has not been documented by field investigation.

During the Pleistocene epoch, glaciers advanced into the area from the mountains to the southwest and from the Canadian Shield to the northeast. The number and age of ice advances from the two sources is unknown; however, the net effect of these glaciations is a complex of glacial deposits overlying bedrock and/or preglacial gravels and sands in most of the area.

Glacial materials consist of:

(1) glacial till, which is non-sorted, non-stratified sediments deposited by a glacier. It contains material in the size range from boulders to clay.

(2) lacustrine sediments composed of sand, silt and clay which were deposited in lakes formed in front of the glaciers.

(3) glacial gravels and sands deposited by streams flowing from the glaciers as they melted.

Recent deposits include alluvial sediments, consisting of gravel, sand, silt, and clay, which are confined to valleys occupied by present-day streams and sand dunes which are relatively common in the northeast portion of the area.

Mineral Deposits

Oil and Gas

No major oil or gas fields have been discovered within the map-area, although the region (especially the southwest part) is relatively unexplored. This is because access is generally difficult and the depths to potential oil- or gas-producing formations are great. However, it is considered that the oil and gas potential of the area is good -- especially the potential for "sour" gas -- and it appears likely that exploration activity will continue at a high rate for some time to come.

Needless to say, it is impractical at this stage to attempt to predict the locations, even in a general way, of possible oil or gas fields.

Coal

Two general types of coal are abundant in the map-area: bituminous (coking) coal and subbituminous coal.

Bituminous coal is confined to the Lower Cretaceous strata of the "inner" Foothills, in the extreme southwest corner of the map-area. Large reserves apparently are present in a zone that continues north from the present site of the McIntyre-Porcupine operation on Smoky River, across the Kakwa River into British Columbia (see accompanying bedrock geology map).

Subbituminous coal is widespread in Upper Cretaceous strata in the west-central and northern parts of the map-area. Known outcrops of major Upper Cretaceous coal seams are marked (in red) on the accompanying bedrock geology map. The thickest deposits apparently extend about the southeast margin of Nose Mountain (near the headwaters of Cutbank River) and on the Kakwa and Smoky Rivers near the junctions of the two rivers.

These coals are non-coking in quality and, although widespread, are unlikely to be mined (for thermal power-generating plants) in the near future.

Metallic Minerals

No known deposits of metallic minerals are present in the map-area, and it is unlikely that such deposits (iron, lead, zinc, gold, etc.) will be found. The possible exception is uranium, for which some prospecting has been done in recent years.[1] However, to date no bona fide uranium showings have been confirmed, and present knowledge suggests that discovery of a major uranium deposit within the area is unlikely, if not improbable.

Industrial Minerals

Industrial minerals include such commodities as limestone, gypsum, salt, phosphate rock, glass sand, bentonite, clay and shale, road aggregate, and so on. Of these materials, only sand and gravel, bentonite, and possibly certain types of clays and shales are known to be present within reasonable proximity of the proposed highway sites. However, none of these deposits has any real commercial value at the present time, owing to the distance from markets and the widespread distribution of similar deposits in other parts of the province.

The exception to this statement is found in the sand and gravel deposits, the distribution of which has a direct economic bearing on the costs of highway construction. These materials are discussed elsewhere in more detail.

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1 There is a gross similarity between the Upper Cretaceous and Tertiary rocks of the area and the uranium-bearing sedimentary strata of the Colorado Plateau.

Geologic Factors Related to Highway Location

Several factors related to the geology of the area will have direct bearing on highway construction; these include groundwater conditions, stream erosion and gullying, sources of aggregate, engineering properties of the geologic materials, and landslides.

Groundwater Conditions

Groundwater conditions have not been investigated in the map-area, with the result that only the following brief statements can be made. In general groundwater flows from high areas (recharge areas) to low areas (discharge areas) along arcuate flow paths. In the map-area, major recharge areas will be most abundant in the Foothills proper and the adjacent dissected tableland, and major discharge areas will be found in lakes and bogs, and along the banks of streams where they may discharge in the form of springs. A high groundwater table along stream banks and road grades will make the slopes unstable and prone to landslides and gullying.

A road constructed near discharge areas such as lakes and bogs or along the lower slopes of the numerous valleys in the region may require adequate drainage to ensure stability of the road grade. In addition the groundwater in discharge areas may contain a high percentage of sulfates which would create corrosion problems for concrete structures.

Stream Erosion and Gullying

Active lateral erosion and redeposition of materials are occurring wherever streams meander in the map-area. Any road crossing located in the stream valleys should be constructed on the inside of meander wherever possible to minimize detrimental effects due to erosion.

Active gullying is occurring in bedrock and surficial deposits along many of the deeper valleys. It can be delineated on areal photographs, for the slopes are generally quite steep and sparsely vegetated. These areas should be avoided where possible because of their inherent instability. Removal of vegetation from any of the steep slopes during road construction will also result in active gullying; therefore this practice should be kept to a minimum (see photograph of A.R.R. crossing on Smoky River for effects of gullying on devegetated Cretaceous bedrock).

Sources of Aggregate

Sources of aggregate in the area include preglacial sands and gravels, glacial sands and gravels (outwash), and alluvial materials along present streams. Preglacial gravels are found on the upper slopes of the high ridges that form the dissected tableland in the central and southeast portion of the map-area, where they may be overlain by a veneer of glacial deposits. Glacial sands and gravels undoubtedly occur at or near the surface in many parts of the area, but field investigation will be required to locate them. Alluvial sands and gravels can be delinated on areal photographs because they are found as bars and terraces along the major rivers and streams. Possible aggregate sources of this type are indicated in the section beginning on p. 14.

The quality and quantity of aggregate present at any particular locality can only be determined by field investigations.

Engineering Properties of the Geologic Materials

Engineering properties of the geologic materials determine their suitability for road base material as well as their potential for slumping (landslides).

A comparison of Atterberg limits, clay contents and derived indices from both Tertiary and Cretaceous fine-grained strata (silty mudstones) in various parts of the area (Table 1) shows no distinct stratigraphic or areal variation in these attributes. Average values for each property for each series of strata are (from Table 1):

	L_W	P_W	I_p	% clay	Activity
Tertiary (5 samples)	40.8	22.9	17.9	44.3	0.39
Upper Cretaceous (15 samples)	37.6	24.5	13.1	32.5	0.38

The main distinction is that the Tertiary mudstones contain more clay and hence have a slightly higher liquid limit than the Cretaceous rocks. However, the Cretaceous mudstones appear to be more bentonitic than the Tertiary rocks (i.e. contain more montmorillonite in the clay size fraction), and therefore are more "active" or prone to failure than the Tertiary mudstones.

No data are available for the engineering properties of the surficial materials in the area, although data obtained on similar materials in other areas suggest that the properties of these materials should be within the following ranges:

	L_w	P_w	I_p
preglacial gravels and sands		variable	
glacial till	30-50	10-20	20-30
lacustrine sediments	40-70	20-30	20-40
alluvial deposits		extremely variable	

Landslides

Several factors may contribute to a landslide such as a high groundwater table, undercutting or oversteepening of a slope by stream erosion or by man, removal of vegetative cover, and the inherent characteristics of the geologic materials. Widespread slumping (landslides), almost all of which appears to be bedrock-controlled, occurs along the valleys of the Smoky, Kakwa. Cutbank, and Wapiti Rivers and some of the larger tributary streams. A plot of the major landslides - based on field observations and air photo examination - is shown on the accompanying map, from which the following general observation can be made. Large-scale bedrock slumping is confined mainly to the north and northeast portions of the map-area in strata mapped as Upper Cretaceous. Probably, this is in part due to the higher bentonite content of the Cretaceous beds, which makes them more prone to failure than the Tertiary mudstones.

Two basic types of landslides are found in the bedrock formations of the map-area. The most common is a "step"-type slide, observed in many

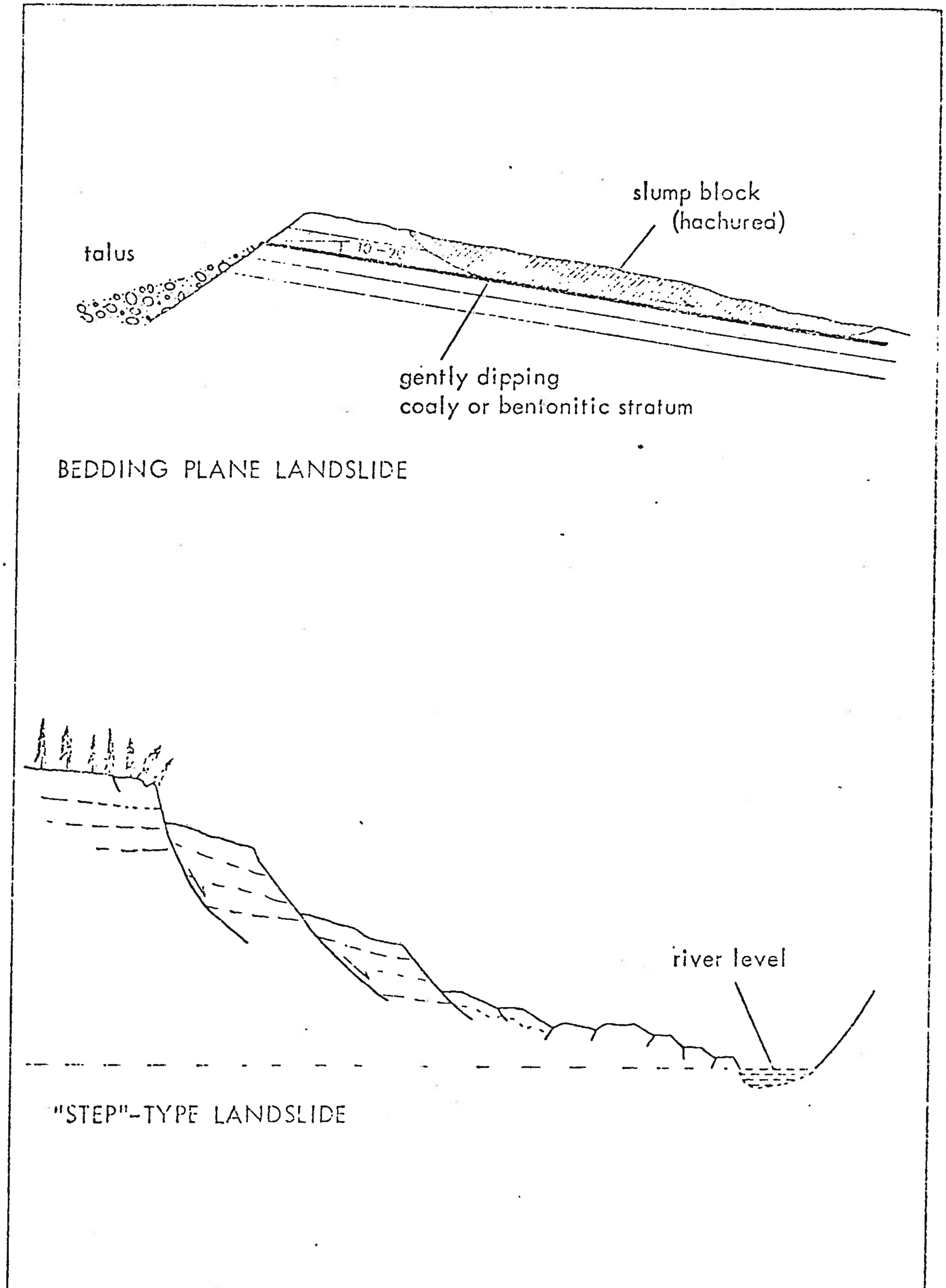

Figure 2. TYPES OF LANDSLIDES, WAPITI MAP-AREA

places along the major river valleys, which are entrenched in bentonitic, coal-bearing Cretaceous bedrock. These take the form of a series of downfaulted slump blocks that appear to cut across the bedding of nearly flatlying strata, producing a series of step-like terraces that extend from near the top of the adjacent valley wall to river level (Fig. 2). Most if not all of these large-scale bedrock slump blocks are associated with groundwater seepages, and many grade into jumbled rock- and mudflows, especially near the base of the slide.

The other type of landslide can be observed on the dip slope of a high bedrock ridge near the western edge of township 60, range 8, west of 6th meridian. Although this locality has not been examined on the ground by the writers, it seems apparent from a general knowledge of the bedrock geology of nearby areas and from air photos that the slide has taken place in gently northeast-dipping (10 degrees to 20 degrees) interbedded sandstones and shales in the Upper Cretaceous or basal Tertiary succession. The interpretation is that a failure plane developed along a coal seam or bentonitic bed causing a large elliptical-shaped bedrock mass to slip down the dip plane away from the scarp face (Fig. 2). In this connection, it should be noted that coal seams in the Upper Cretaceous strata of the map-area almost invariably contain thin bentonite beds 1 inch to 24 inches thick, thereby serving as ideal "zones of lubrication" along which failure planes may develop. Thus, the series of cuesta-like bedrock ridges extending from Nose Mountain southeastward to the Smoky River, paralleling the Foothills front, should be considered especially prone to bedding plane landslides, like that in township 60, range 8.

Description of Geologic Conditions Along Proposed Highway Routes

The three proposed highway routes have been designated on the accompanying map as Route No. 1 (eastern), Route No. 2 (central), and Route No. 3 (western), respectively. Each route has been subdivided into segments marked by letters (A to O) to allow the following descriptions of geologic conditions along each of the proposed routes:

Route No. 1

A - B

(1) surficial deposits: lacustrine sediments except for alluvial deposits along Bald Mountain Creek.

(2) bedrock: Cretaceous, virtually flat-lying.

(3) groundwater conditions: avoid bogs where possible.

(4) landslides: none apparent.

(5) stream erosion and gullying: not significant.

(6) aggregate sources: none apparent, requires field investigation.

Comments: no obvious geological problems at crossing B.

B - C

(1) surficial deposits: lacustrine sediments and glacial till except for recent alluvium along Cutbank River.

(2) bedrock: Cretaceous, virtually flat-lying.

(3) groundwater conditions: avoid bogs where possible; springs may contribute to landslides along Cutbank River.

(4) landslides: prevalent along Cutbank River at proposed river crossing at C. The crossing could be moved to the east as indicated by a dashed line to avoid obvious slumping.

(5) stream erosion and gullying: may be a factor in the area that is crosshatched. The stream courses are controlled by glacial flutings or faults in the bedrock and some gullying is apparent. This area may be unstable and should be avoided or undergo detailed geological investigation before road construction.

(6) aggregate sources: several bars and terraces are present along the Cutbank River (quality unknown). Possible aggregate present on surface southwest of crosshatched area.

C - D

(1) surficial deposits: uncertain, probably till except for lacustrine deposits adjacent to Musreau Lake and alluvium along the Kakwa River.

(2) bedrock: Cretaceous, virtually flat-lying.

(3) groundwater conditions: avoid bogs and possible springs along stream banks.

(4) landslides: no apparent problems.

(5) stream erosion and gullying: fairly common along minor streams in the area.

(6) aggregate sources: bars and terraces along the Kakwa River (quality unknown).

Comments: the crosshatched area contains glacial flutings or is faulted. Field investigation required to indicate if area is suitable for road construction.

D - E

(1) surficial deposits: probably till except for alluvial deposits along the Smoky River and other minor streams.

(2) bedrock: Tertiary, nearly flat-lying.

(3) groundwater conditions: probably numerous springs along stream courses.

(4) landslides: no apparent problems.

(5) stream erosion and gullying: fairly common along many of the streams.

(6) aggregate sources: well-developed terraces and bars along the Smoky River (quality unknown).

E - lat. 54°

(1) surficial deposits: unknown, probably a complex of glacial till and alluvial sand and gravel along Bolton Creek.

(2) bedrock: Tertiary, nearly flat-lying to gently northeast-dipping at south end of map-area (lat. 54 degrees).

(3) groundwater conditions: springs along the banks of Bolton Creek may make road cuts unstable.

(4) landslides: none apparent.

(5) stream erosion and gullying: may be a problem if vegetation is removed from the banks of Bolton Creek.

(6) aggregate sources: gravel deposits (outwash?) observed from helicopter but quality and distribution unknown.

Comments: glacial and alluvial sediments along Bolton Creek may be prone to erosion and slumping, especially during flood stages.

Route No. 2

A - F

(1) surficial deposits: lacustrine sediments except for alluvial deposits along Bald Mountain Creek.

(2) bedrock: Cretaceous, virtually flat-lying.

(3) groundwater conditions: avoid bogs where possible.

(4) landslides: several occur along Mountain Creek. The road could be rerouted to the west to avoid them.

(5) stream erosion and gullying: not a major problem.

(6) aggregate sources: none apparent, would require field investigation.

F - G

(1) surficial deposits: lacustrine sediments except for alluvial deposits along Big Mountain Creek.

(2) bedrock: Cretaceous, virtually flat-lying.

(3) groundwater conditions: avoid bogs where possible.

(4) landslides: present along Big Mountain Creek, could be avoided by rerouting the road to the west.

(5) stream erosion and gullying: not a major problem.

(6) aggregate sources: none apparent, would require field investigation.

G - H

(1) surficial deposits: lacustrine sediments, glacial till, and recent alluvium along the Cutbank River.

(2) bedrock: Cretaceous, virtually flat-lying.

(3) groundwater conditions: springs may contribute to landslides along Cutbank River.

(4) landslides: present all along banks at H; no alternate site obviously suitable for considerable distance on either side of the proposed site.

(5) stream erosion and gullying: may be prevalent along the Cutbank River.

(6) aggregate sources: bars present along Cutbank River (quality unknown).

H - I

(1) surficial deposits: primarily glacial till except for recent alluvial deposits along the Kakwa River.

(2) bedrock: Cretaceous and Tertiary, virtually flat-lying.

(3) groundwater conditions: discharge from springs along stream could present problems.

(4) landslides: none apparent.

(5) stream erosion and gullying: problem can be avoided by putting road on point bar on southeast side of the Kakwa River at locality shown on map.

(6) aggregate sources: some bars present along the Kakwa River.

I - J

(1) surficial deposits: primarily glacial till with recent alluvium along Smoky River.

(2) bedrock: Tertiary, flat-lying to gently northeast-dipping towards the south.

(3) groundwater conditions: problems with springs may occur along the Smoky River and Prairie Creek.

(4) landslides: none apparent.

(5) stream erosion and gullying: can be minimized by placing the crossing over the Smoky River where point bars occur on either side of the river.

(6) aggregate sources: bars and terraces are present along the Smoky River (quality unknown).

Comments: crosshatched area has a north-south lineation which is either flutings or faulting in bedrock. Requires field examination to determine if potential construction problems exist.

J - lat. 54°

(1) surficial deposits: unknown; may be complex.

(2) bedrock: moderate to steeply northeast-dipping Cretaceous sandstone, shale, and coal.

(3) groundwater conditions: springs may be a problem along Wanyandie Creek.

(4) landslides: none apparent.

(5) stream erosion and gullying: gullying may be a problem if slopes devegetated.

(6) aggregate sources: unknown.

Comments: problems encountered in road construction along Wanyandie Creek may be similar to those postulated for Bolton Creek depending to a large extent on the nature and distribution of surficial deposits.

Route No. 3

A - K

(1) surficial deposits: lacustrine deposits except for alluvial deposits along Campbell and Bald Mountain Creeks.

(2) bedrock: Cretaceous, virtually flat-lying.

(3) groundwater condtions: avoid bogs and springs along Campbell Creek and Bald Mountain Creek.

(4) landslides: none apparent.

(5) stream erosion and gullying: not a major problem.

(6) aggregate sources: Campbell and Wilson Creeks may flow in abandoned glacial meltwater channels which could contain sand and gravel buried by lacustrine sediments.

Comments: keep road away from edge of Bald Mountain Creek except where crossing occurs because of potential bank instability.

K - L

(1) surficial deposits: lacustrine sediments and glacial till.

(2) bedrock: Cretaceous, virtually flat-lying.

(3) groundwater conditions: avoid bogs where possible.

(4) landslides: none apparent.

(5) stream erosion and gullying: no major problems evident.

(6) aggregate sources: none apparent.

L - M

(1) surficial deposits: till except for alluvium along the Cutbank River.

(2) bedrock: Cretaceous, virtually flat-lying.

(3) groundwater conditions: springs may present problems along Cutbank River.

(4) landslides: none apparent.

(5) stream erosion and gullying: not a serious problem.

(6) aggregate sources: bars along the Cutbank River (quality unknown).

M - N

(1) surficial deposits: probably glacial till with recent alluvium along the Kakwa River.

(2) bedrock: Cretaceous and Tertiary, virtually flat-lying to gentle northeast dips near N.

(3) groundwater conditions: springs may be a factor along the Kakwa River.

(4) landslides: none apparent; possibility of bedding plane slides.

(5) stream erosion and gullying: may be a problem but can be minimized by crossing the river where two point bars occur on opposite sides of the river.

(6) aggregate sources: well-developed bars and terraces along the Kakwa River (quality unknown).

N - O

(1) surficial deposits: unknown but probably complex; require field investigations to work out details.

(2) bedrock: Cretaceous and Tertiary, gently to steeply northeast dipping; complexly folded and faulted near Foothills margin.

(3) groundwater conditions: springs along the numerous streams may present stability problems.

(4) landslides: bedding plane slides present in Tp. 60, R. 8, and possible slides in surficial deposits along Sheep and Smoky Rivers valleys (see accompanying photograph).

(5) stream erosion and gullying: may present some problems especially along the lower slopes of Sheep and Smoky Rivers valleys.

(6) aggregate sources: gravel bars and terraces present along the Sheep and Smoky Rivers (quality unknown).

Comments: A series of gravel terraces extend along the Smoky River between the Foothills front to beyond point J. They also extend up the valleys of the Sheep and Muskeg Rivers for unknown distances. At point O (junction of the Sheep and Smoky Rivers) the gravels overly plastic calcareous lacustrine clays (see accompanying photographs) near water level, or glacial till further up the Smoky River, towards the McIntyre-Porcupine coal treatment plant. Although susceptible to erosion and slumping in places (by stream undercutting), they may be wide enough elsewhere to provide a suitable highway bed.

O - Grande Cache

Comments: From point O, Route No. 3 provides two alternative routes. The first, along the north bank of the Smoky River, links up with the existing road between Grande Cache and the McIntyre-Porcupine coal treatment plant. That portion of the route between the coal plant and point O would have to be built along a series of partly dissected gravel terraces, overlying to variable depths glacial lake clay, glacial till, and hard, steeply dipping sandstone and shale bedrock formations. South of the coal plant, the existing road extends along a wide alluvial valley and presumably could be upgraded to highway specifications without encountering serious geologic problems.

The alternative route proceeds from point O across the Smoky River, up the valley of the Muskeg River to join the existing Grande Cache-Muskeg Cabins road. The same type of gravel terraces present along the Smoky River at point O extend up the valley of the Muskeg for an unknown distance; thus, this route provides much the same type of terrain for road construction as that described above, although detailed field examination of the two routes might provide a basis for a preference.

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Summary of Geologic and Environmental Factors Related to Highway Planning in the Wapiti - Grande Cache Area

An overall assessment of the geologic and environmental factors related to selection of a multipurpose highway route between Grande Prairie and Grande Cache indicates a preference for the western route (No. 3 on the accompanying map). This preference is based on the following considerations:

(1) Geologic (terrain) Factors

Undoubtedly, some engineering problems will be encountered along the two eastern routes (Nos. 1 and 2), where the roads descend into and cross the valleys of Mountain and Big Mountains Creeks, and the Cutbank, Kakwa, and Smoky Rivers. The Upper Cretaceous bedrock in this area appears to be extremely unstable, and the propensity for valley walls to slump and gully is apparent from both field observations and examination of air photographs. Possibly detailed field investigations of these routes, especially adjacent to the major river valleys, would help avoid some of the more obvious unstable areas, but even those portions of the valley walls not presently associated with landslides, can be activated by construction procedures, including devegetation.

Also some serious problems in roadbed construction and maintenance may be met in routes No. 1 and 2, where they proceed up the valleys of Bolton and Prairie Creeks, respectively. The thickness and composition of the surficial deposits along the creek valleys is unknown, although they likely are quite thick in places. Thus, the suitability of these deposits as roadbed materials and their susceptibility to erosion when disturbed should be considered.

The western route (No. 3) largely avoids the obviously unstable landslide areas along the major river valleys, except possibly the crossing on Cutbank River. It parallels and crosses the Kakwa River along a series of low alluvial terraces that from present knowledge appear to be stable and therefore suitable for roadbed construction. Some problems are liable to be encountered south of the Kakwa River towards the Foothills, but detailed field examination of the proposed route should help avoid areas prone to bedding-plane landslides or terrace slumping and erosion.

(2) Mineral Resources

No really distinct basis exists at present for selecting among the three routes with respect to potential mineral resources development. Oil and especially "sour" gas are likely to be found in any part of the area, including the outer part of the Foothills, and coal is widespread throughout the region (except the southeast area underlain by Tertiary strata), although it is unlikely that the sub-bituminous Upper Cretaceous coal deposits will be utilized in the foreseeable future.

Perhaps the only comment, therefore, that has some immediate bearing on this matter concerns the distribution of bituminous (coking) Lower Cretaceous coal of the Foothills, which deposits are closest to the western route (No. 3). Large deposits of bituminous coal are known to exist adjacent to the Kakwa River, in a belt of folded strata that extends in a northwest direction from the McIntyre Porcupine deposit on Smoky River. Obvious access to these deposits is via a road along the Kakwa River from the east, or along Copton Creek which enters the Kakwa at the proposed crossing site of route No. 3. The two easterly routes

(Nos. 1 and 2) do not provide any feasible access to the bituminous coal deposits adjacent to the Kakwa River.

Environmental Considerations

Among the various environmental and cultural factors associated with highway planning are the potential scenic and recreational aspects of the proposed routes, summarized in very general terms below:

Route No. 1 (eastern route): access to prime recreational areas of the Foothills is limited to the southern terminus of this route. Also, it traverses heavily forested terrain, following creek and river valleys south of the Kakwa crossing. Therefore, the scenic potential of the route is low, providing few if any good panoramic views of the area. However, the proximity to Musreau Lake north of the Kakwa crossing may be of some benefit to the residents of the Grande Prairie district for boating and possibly fishing.

Route No. 2 (central route): almost identical to route No. 1 from a scenic and recreational point of view. Both routes provide some access to sport fishing and big game hunting areas, but otherwise contain little appeal for the average tourist.

Route No. 3 (western route): provides much better access to Foothills-type scenery and terrain along the southern part (south of Kakwa crossing). That part of the Kakwa River valley adjacent to the proposed crossing site contains some very scenic meadows developed on low alluvial terraces, ideally suited to camping and picnicing. Moreover, the road puts the upper reaches of the Kakwa River (including Kakwa Falls) and the scenic valley of Copton Creek within striking distance of sportsmen and other outdoors-oriented travellers. Thus, even if coal-development adjacent to the Kakwa

River valley should be held in abeyance for one reason or another, the scenic attractions of this area would still require some access from the northeast, if they are to be enjoyed by citizens of and visitors to Alberta.