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GEOLOGY AND TERRAIN EVALUATION:
ALBERTA RESOURCES RAILWAY AND ALTERNATIVE ROUTES

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INTRODUCTION

In June, 1972, a large section of the Alberta Resources Railway was severely damaged by spring floods along the Smoky River in northwest-central Alberta. The damaged section extends northeastwards from the McIntyre Coal Ltd. mine near the northern margin of the Foothills along the deeply incised valley of the Smoky River for a distance of approximately 60 miles. Within this distance, the railway is constructed along the narrow floodplain on the north side of the Smoky River; the rail bed itself consists of local river gravel buttressed in places by large blocks of Lower Cretaceous sandstone (rip-rap) hauled in from the Foothills.

This report describes the general geology and terrain along the damaged section of the Alberta Resources Railway and in a region to the northeast (Fox Creek-Simonette area) where an alternative railway line has been suggested. Emphasis is given to the engineering aspects of these features.

SOURCES OF DATA

The bedrock geology of the area under discussion was mapped by Research Council personnel in 1969 and 1970. A summary of this work is to be published shortly in the "Proceedings: First Geological Conference on Western Canadian Coal," a copy of which is appended to the report.

The surficial (glacial) deposits and soils of the area west of 118 degrees latitude currently are being mapped by the Research Council's Geology and Soils Divisions. A surficial geology map of this area (west of 118 degrees longtitude) is being compiled on a scale of 1:250,000; however, the eastern part of the region (between Fox Creek and Simonette River) is unmapped.

PHYSIOGRAPHY

The area can be divided into three broad physiographic units which coincide largely with the composition and structure of the underlying bedrock formations (Fig. 1):

Foothills

The Foothills proper (as defined in a geologic sense) extend across the southwest portion of the region. 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 8,000 feet in the southwest to 6,000 feet along the northeast margin which merges with the sandstone and gravel-capped ridges described below.

Plateau

The hilly tableland forming the southern part of the area, between the Foothills on the southwest and the flat "plains" region to the north, is part of a dissected plateau which extends eastward to include the Swan Hills (Fig. 1). The plateau consists of a series of narrow flat-topped to gently rounded, northeast-sloping ridges separated by the wide glaciated valleys of the Kakwa, Smoky, Simonette and other rivers. The ridges are capped by gently dipping to nearly flatlying sandstones and shales of Tertiary age (Paskapoo Formation), merging to the southwest with the folded bedrock strata of the Foothills (Fig. 2). Elevations exceed 5,000 feet along the southwest margin of the plateau, gradually descending to about 3,000 feet or less along the northeast flanks.

Plains

The northern part of the area, defined approximately as that region below the 3,000-foot contour (Fig. 1), is a relatively flat to gently rolling "plain" underlain by very gently dipping Upper Cretaceous strata (sandstone, shale, coal) covered in most places by glacial deposits of various types. The "plain" is cut by the valleys of the Smoky and Wapiti

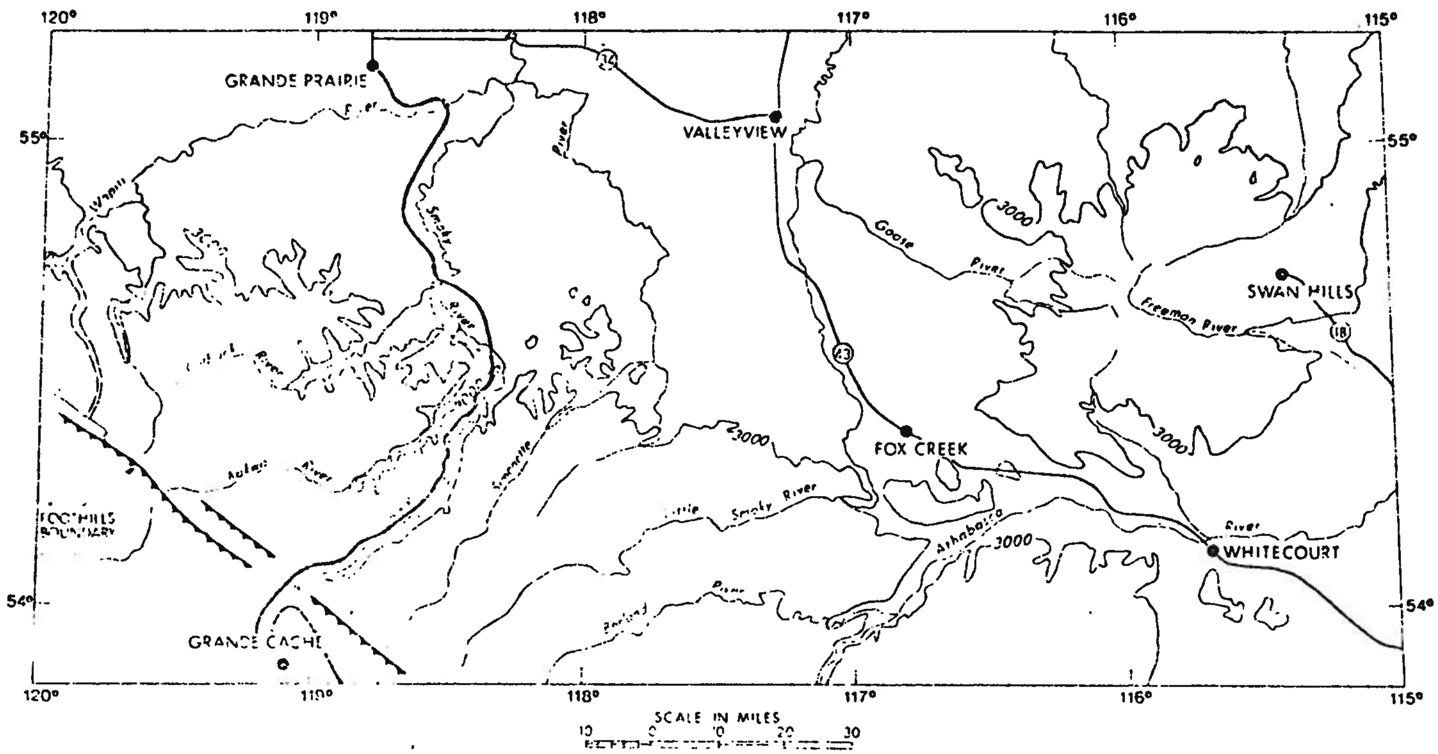

Figure 1. Major physiographic units of northwest-central Alberta. Yellow = Foothills; green = dissected plateau; white = Plains. The A. R. R. route (in red) is shown schematically.

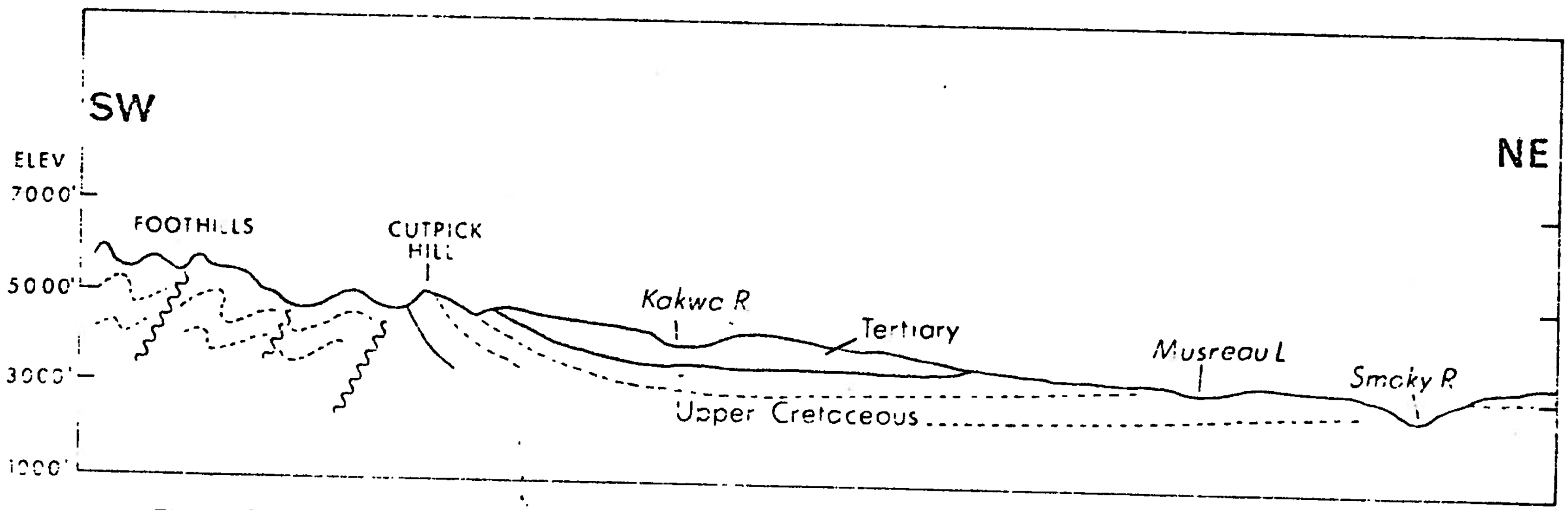

Figure 2. Schematic cross section through near-surface bedrock formations, northwest-central Alberta. Line of section is from southwest to northeast, across the regional strike of the strata.

Rivers and smaller tributary streams, which are entrenched in Cretaceous bedrock 200 to 500 feet below the level of the surrounding terrain.

GEOLOGY

Bedrock Geology

Outside of the Foothills, the area is underlain by a thick succession of interbedded sandstone, shale, and coal similar in age (Late Cretaceous and Tertiary) and composition to the bedrock formations of the Edmonton-Red Deer area in central Alberta (Fig. 3). The regional structure of these beds is that of a shallow syncline, the axis of which trends in a northwesterly direction parallel to the strike of the Foothills. 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 (see schematic cross section in Fig. 2).

The bedrock of this area can be divided into two formations grossly similar in lithology. The older beds (Wapiti Group) are latest Cretaceous in age, consisting of interbedded sandstone, siltstone, silty shale (or "claystone"), coal, and thin bentonite beds. They underlie the gently rolling plains region in the northern part of the area, dipping beneath younger Tertiary (Paskapoo) strata to the southwest. 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 claystones -- tend to be soft and bentonitic and thus relatively prone to landslides (slumping).

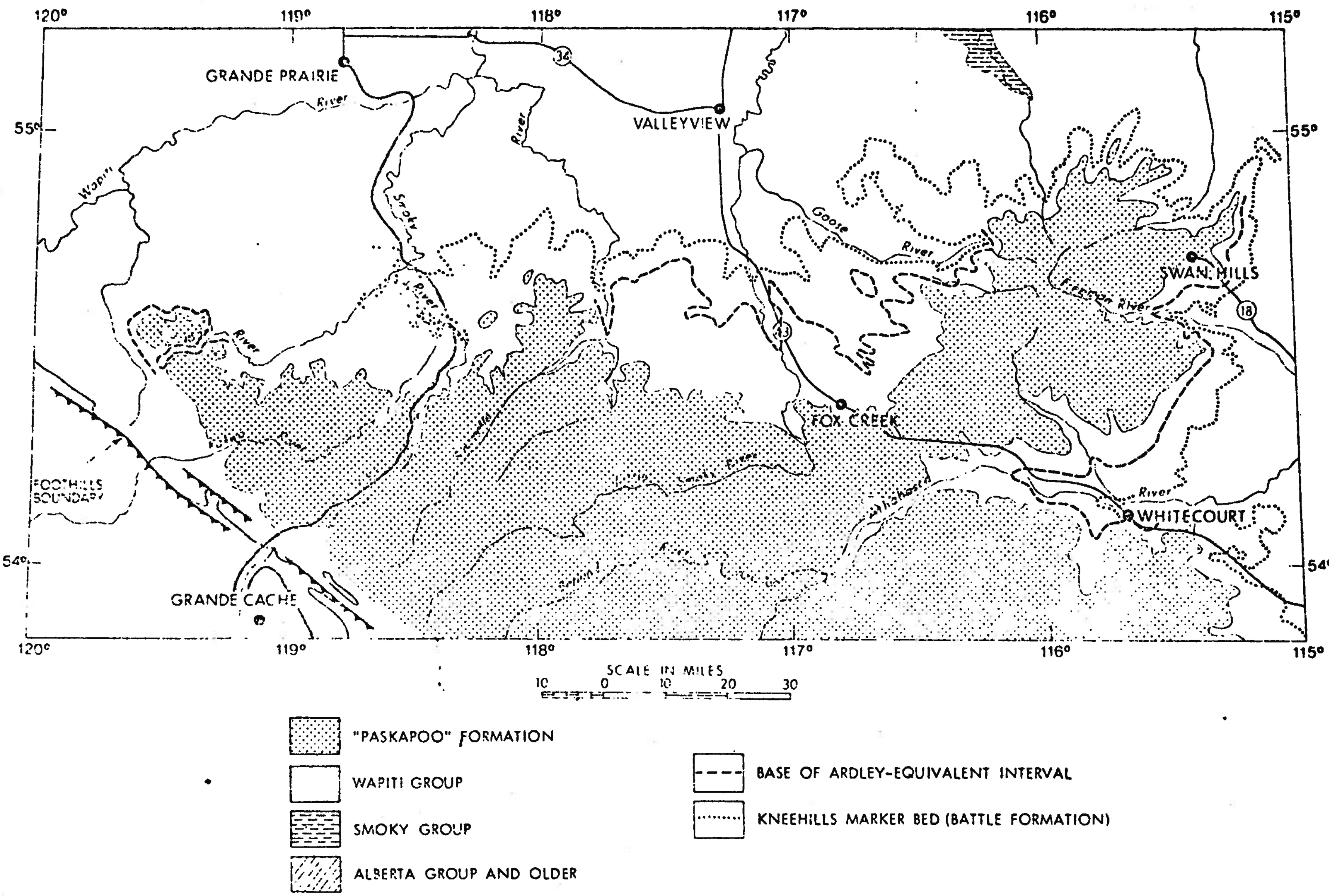

Figure 3. Major bedrock formations or groups, northwest-central Alberta. "Paskapoo" Formation = Tertiary; Wapiti Group = Upper Cretaceous coal-bearing strata. Foothills bedrock units in southwest are not differentiated.

They are associated in many outcrops in the north and northeast parts of the 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 overlie relatively soft bentonitic claystone. A typical bedrock landslide along the lower reaches of the Smoky River is shown in photo 1.

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Landslide in flat-lying, bentonitic Cretaceous bedrock; Smoky River, Tp. 64, R. 3. Slide is associated with springs or seepages rather than stream undercutting.

The younger series of beds -- shown as Paskapoo Formation in figure 3 -- overlie the Cretaceous coal-bearing strata described above and are exposed along the high ridges and incised river valleys extending out from the Foothills. They are similar in gross lithology to the Cretaceous strata, consisting of calcareous grey and buff-weathering sandstones and slightly bentonitic silty shales. 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 differences in rock composition.

Towards the margin of the Foothills, the Upper Cretaceous-Tertiary strata show a reversal in 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. These strata are harder and more indurated than the bentonitic Cretaceous beds exposed in the plains region to the northeast.

Surficial Deposits

Surficial deposits are those unconsolidated sediments (sand, silt, clay) deposited on the bedrock surface by several geologic agencies (ice, water, wind). The most important and widespread surficial deposits in the area under consideration are those of glacial origin, deposited during and shortly after the last Ice Age, in the Pleistocene epoch. These materials consist of till (unstratified sand, clay and boulders deposited directly from the glacier), glacial outwash (sand and gravel deposited in glacial streams), lake sediments (silt and clay deposited in glacial meltwater lakes), and sand dunes.

Their distribution and thickness is erratic: generally, glacial deposits (mainly till and lake sediments) are thickest in the northern part (plains) of the area, and also along many of the river and stream valleys extending out from the Foothills. They tend to be thin or absent on the higher ridges near the Foothills in the southwest, although scattered deposits of preglacial quartzite gravel are present on the upper surfaces of these ridges in the vicinity of Simonette and Smoky Rivers.

A reconnaissance map showing the distribution and different types of surficial deposits in this region (west of 118 degrees latitude) is being compiled by Geology Division personnel.

TERRAIN ANALYSIS OF THE A.R.R. AND SUGGESTED ALTERNATIVE ROUTES

The following courses of action have been suggested in repairing or otherwise rerouting the damaged section of the Alberta Resources Railway:

(1) the existing railway bed should be maintained and repaired;

(2) an alternative but essentially parallel route should be constructed along higher ground adjacent to the Smoky River;

(3) the Smoky River route should be abandoned in favor of a rail line extending west from Fox Creek to link up with the undamaged section of the A.R.R. south of Grande Prairie.

Some of the geological and engineering factors bearing on these questions are discussed below (see map fold-out at back of report = Fig. 4).

Existing A.R.R. Route

The damaged section of the A.R.R. line is approximately 60 miles in length, extending along the floodplain of the Smoky River from the northern margin of the Foothills in township 58, range 7 to where the railway first crosses the Smoky River in township 64, range 2 (map, Fig. 4). The rail bed keeps entirely to the north side of the river where it is constructed mainly on gravel bars or, where these are absent, in shallow bedrock cuts at the foot of the valley walls. The bed, which is from 10 to 15 feet above normal water levels, is composed mainly of local river gravel protected in places by sandstone rip-rap apparently hauled from the Foothills near the McIntyre mine site.

Mudslides, landslides, and rock falls appear to present only minor problems to rail bed maintenance throughout this section of the line, although the inherent instability of the bentonitic[1] Cretaceous bedrock which forms the valley walls in the lower portions of this section (from near township 62 northwards -- see Fig. 4) is readily observed on aerial photographs. An exception to this statement is found at the river crossing in township 64, range 2 where the railway line crosses to the east side of the Smoky River and climbs to the top of the valley along a large cut in bentonitic Cretaceous sandstone (photos 2 and 3, taken in 1969). This locality has been an engineering disaster area almost since the railway was constructed, and the continuing maintenance problems observed here point out the very real dangers of designing roads, railway beds, and bridge and trestle approaches in Cretaceous bedrock formations.

Apart from the situation at the river crossing described above (to which there appears to be no easy solution), the main problem involved in reconstructing or repairing the existing rail bed along the Smoky River is to ensure that proper measures are taken in protecting the bed from major floods. This means that local river gravels used to construct the main bed must be protected by an extensive barrier of coarse rip-rap, presumably sandstone hauled from the Foothills to the south or hard calcareous Tertiary sandstone exposed in places along the valley walls in the southern part of the damaged section. However, the typical bentonitic Cretaceous sandstones, which crop out extensively along the lower reaches of the damaged section, should be avoided unless field tests can demonstrate that these sandstones will stand up to normal weathering processes.

Alternative Smoky River Route

Several problems are met in designing an alternative railway route on higher ground adjacent to the Smoky River. Near the Foothills margin,

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[1] Bentonite is a clayey material used in drilling muds and for a variety of other industrial applications. It is a widespread constituent in the Cretaceous bedrock formations in many parts of the Alberta Plains and is a major cause of landslides and mudflows in these rocks.

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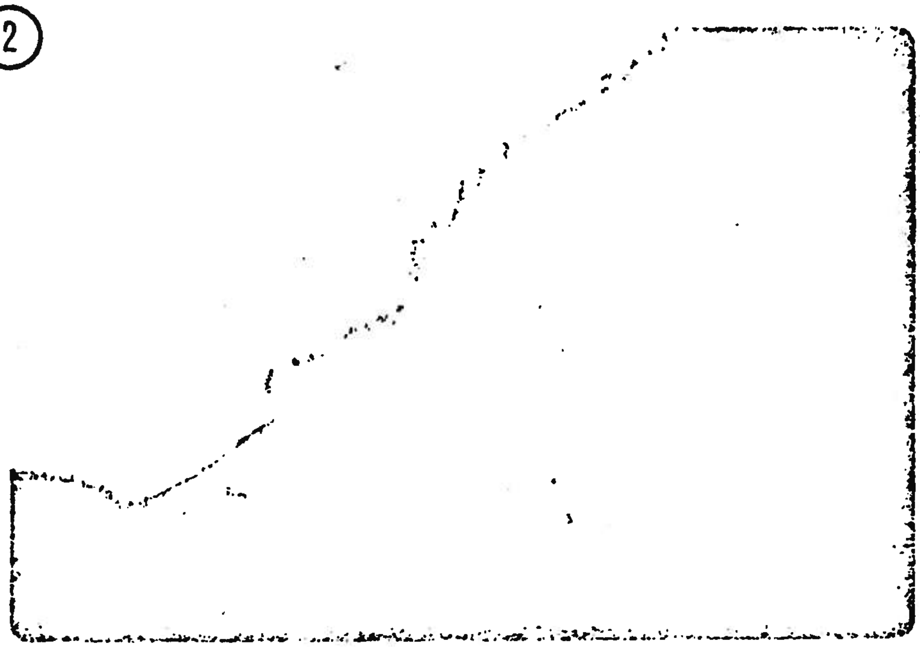

Alberta Resources Railway at Smoky River crossing near west boundary Tp. 64, R. 2. Rock cut is composed mainly of soft bentonitic Cretaceous sandstone highly susceptible to gullying and slumping. Thin coaly bed in middle of cut (arrow) provides additional instability owing to propensity of overlying rock mass to move along or "glide" over the coaly bed.

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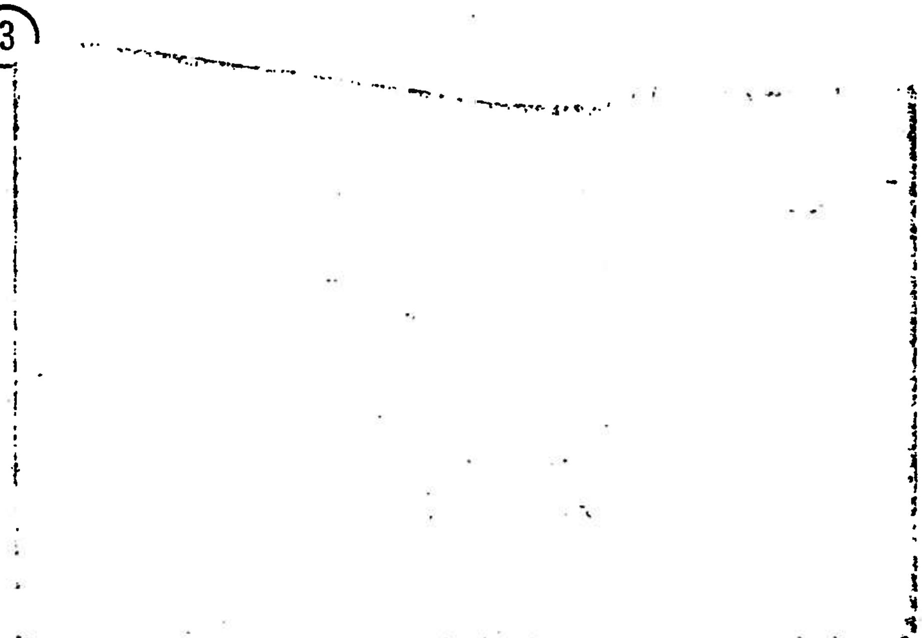

Alberta Resources Railway, same locality as above, further up the slope. Note effect of gullying and small-scale slumping in devegetated bentonitic sandstone adjacent to the trestle.

the river valley has a relief in excess of 1,500 feet, which gradually drops to about 500 or 600 feet near the northern end of the damaged section (in township 64, range 2). Moreover, the valley walls have an irregular topography characterized by numerous small stream beds and gullies, all of which would require bridging or filling. Even if the rail line were constructed along the valley walls at maximum grade to attain the top of the plateau along the north side of the river, the plateau surface itself is sufficiently irregular (with grades of 3 to 6 per cent) to require major bridge and fill work.

A possible alternative is to make use of the gravel terraces formed by glacial action along the southern stretch of the damaged rail line (see map; Fig. 4). These terraces rise several hundred feet above the present river floor (Fig. 5) and are composed of coarse glacial till and outwash now being undercut in places by the Smoky River (photo 4). The

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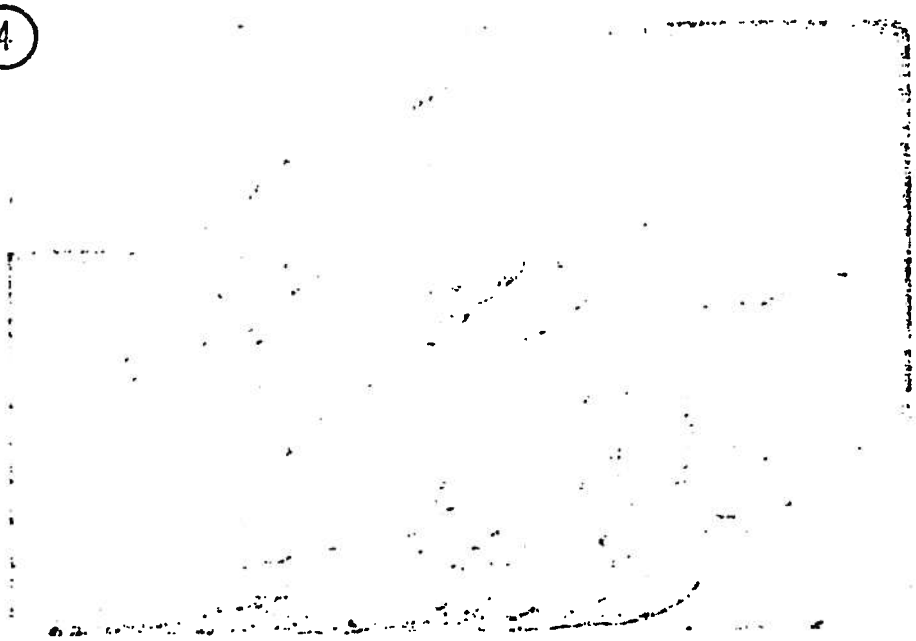
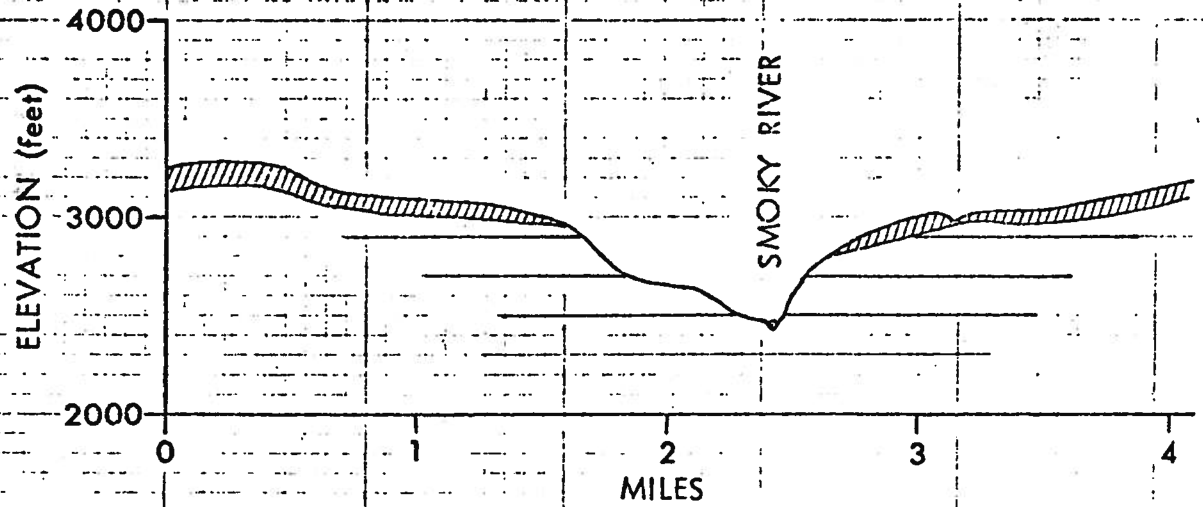
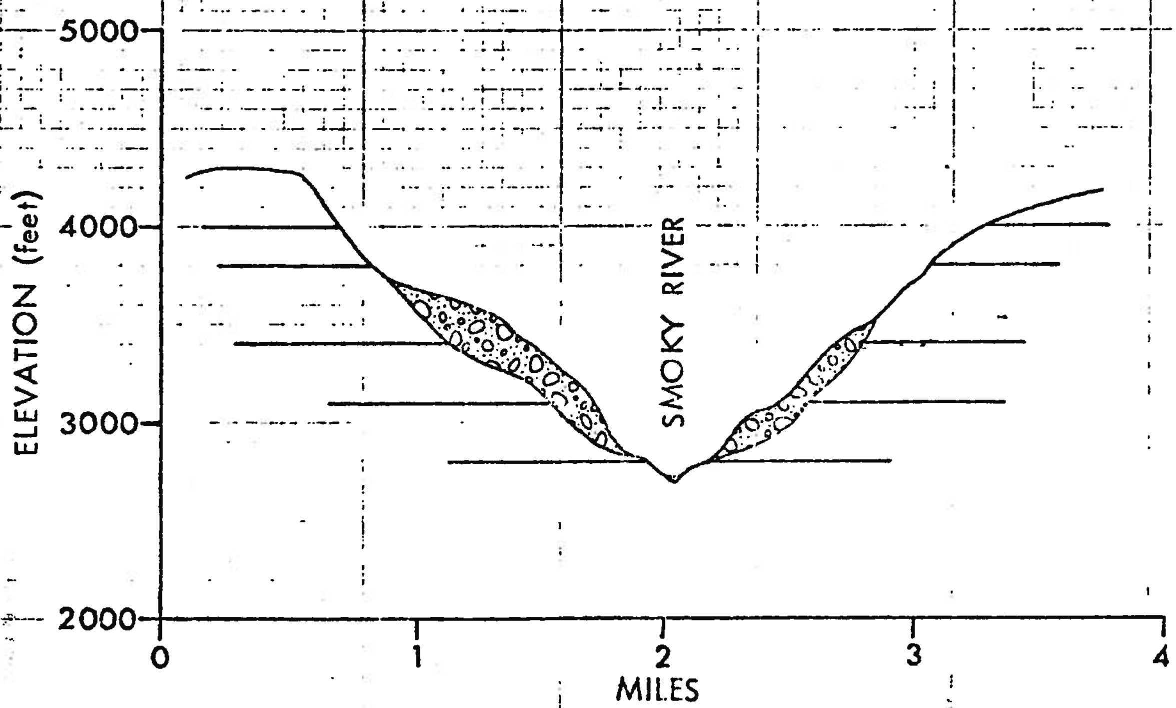


Looking up valley of Sheep River from its junction with Smoky River. Slumping in coarse alluvial gravels caused by stream undercutting. Gravels overly calcareous lacustrine clays, exposed near water level (arrow).



Tp. 63, R. 3: Thin glacial till deposits (hached) overlying Cretaceous bedrock.



Tp. 60, R. 5: Terraced Pleistocene gravels (stippled) cover Tertiary bedrock along lower valley walls.

Figure 5. Profiles of Smoky River valley. Vertical scale is exaggerated about 4 times.

terraces are dissected or absent in places and disappear altogether from the river valley near the southern boundary of township 62. North of this point, the valley is incised in Cretaceous bedrock with a thin cover of glacial till on the upper slopes, and is particularly susceptible to mudslides and landslides (photo 1). Thus, should the gravel terraces be used for the railway route, the line would have to ascend the valley walls 20 to 25 miles south of the present river crossing in township 64, or traverse the highly unstable Cretaceous bedrock terrain which forms the valley walls between the northern end of the gravel terraces and the present river crossing.

Fox Creek Route

The terrain traversed by an alternative rail line extending from the gas processing plants near Fox Creek to the existing A.R.R. line near the northern end of the damaged section (see map, Fig. 4) has much to recommend it from a geological and possibly an economic point of view. The favorable aspects can be summarized as follows:

(1) the route traverses relatively flat to gently rolling terrain with seemingly manageable grades;

(2) there are no major river crossings: The valleys of the Simonette River and Deep Valley Creek are relatively shallow and present no problems if minor bedrock slump areas are avoided;

(3) the disastrous railway crossing on the Smoky River in township 64, range 2 could be abandoned;

(4) the Simonette oilfield and gas processing plant could be serviced. Also, the thick coal seams near the junction of Simonette River and Deep Valley Creek are made accessible.

As shown on the map in figure 4, the Fox Creek route traverses a gently rolling area underlain by Cretaceous coal-bearing strata. However, glacial deposits appear relatively thick and suitable for rail bed and road construction over most of this region, although sand and gravel may be scarce locally (the surficial deposits are unmapped east of 118 degrees latitude). In this respect, the terrain closely resembles the "plains" region traversed by the A.R.R. south of Grande Prairie which has to the writers' knowledge presented few maintenance problems north of the area where the railway leaves the valley of the Smoky River.