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The Development of Big Slide, near Quesnel, British Columbia, between 1953 and 1982.

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Introduction

Big Slide is an extensive landslide complex on the east side of the Fraser River at the Big Bend, Moose Heights, 11.7 km north of Quesnel, British Columbia (Fig. 1). Aerial photographs dating from 1953, and field observations since 1973, show rapid landscape changes due to retrogressive slope movements. Changes are noticeable on a month to month basis and farmers in the vicinity mention the

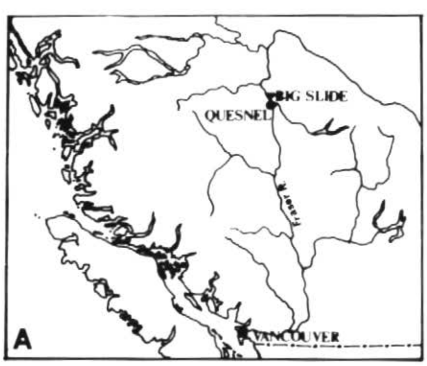
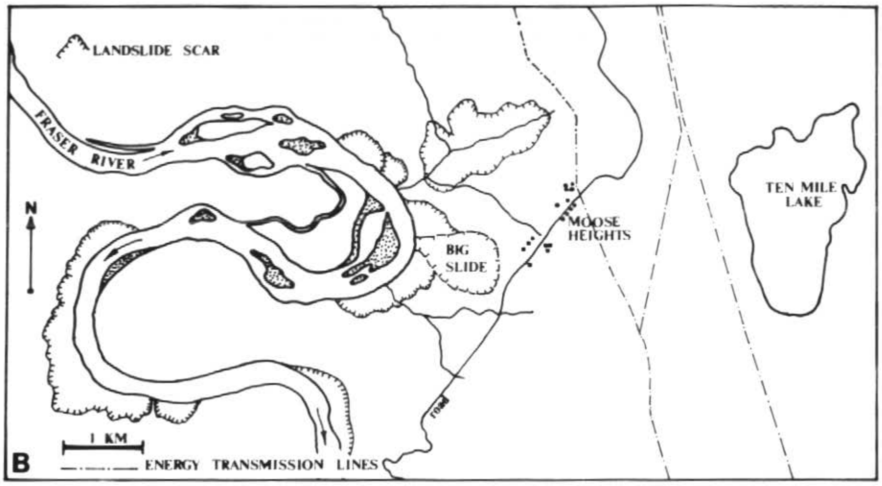


Figure 1A: *Location of Big Slide within Fraser River system.*



1B: *Location Map of Big Slide in relation to order instabilities at the Big Bend.*

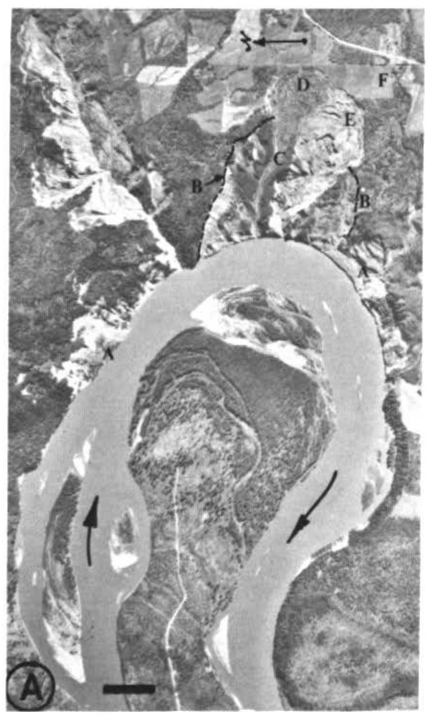
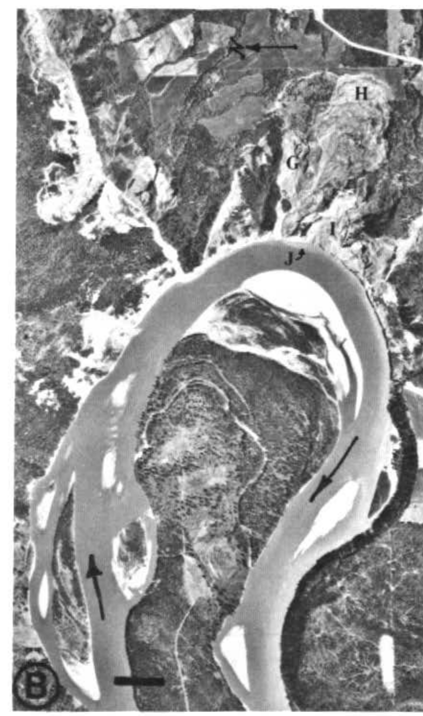


Figure 2A: *1953 Air Photograph. A = Landslides in Miocene Fraser Bend Formation related to channel erosion of Fraser River. B = Scarp of Old Landslide. C = Stabilized mudflow deposit in North Gully. D = Inactive North Bowl of Big Slide. Note grass and tree cover. E = Active South Bowl of Big Slide. Note retrogressive slide blocks. F = Field at top of the South Bowl which is the basin of area measurement in Fig. 4. Bar Scale = 300 m. Arrow denotes flow direction of Fraser River. (B.C. Air Photograph 1648-6).*



2B: *1969 Air Photograph. Note changes in channel boundary and channel pattern throughout the meander loop. Note also changes in landslides on both sides of Big Slide. G = Gully erosion of stabilized mudflow deposit in North Gully. H = Retrogression of headscarp inactive South Bowl. Note North Bowl is still inactive. I = Active movements in Miocene sediments. J = Plume of sediment in Fraser River originating from the gullies of Big Slide. (B.C. Air Photograph 5328-222).*

frequent "groaning" of the landslide complex.

The first report of a large landslide complex at Big Slide appears as "Great Slide" on Dawson's G.S.C. Map 120 dated 1875-76. The name Big Slide appears on early maps of the British Columbia Department of Lands in 1921.

Geological Setting

In the Big Slide area the channel margin of the Fraser River consists of horizontal stratified sands, gravels, silts and clays of the Miocene Fraser Bend Formation (Rouse and Mathews, 1979). Overlain by 150 m of varved Quaternary glacio-lacustrine clays and silt, these sediments have undergone mass movements at several locations around the Big Bend in response to the erosive effects of the Fraser River (Fig. 2).

The active slope movements are taking place in the upper part of the Quaternary sediments and are controlled by a basal shear surface which is exposed along the north lateral scarp of the north bowl of Big Slide at an approximate elevation of 610 m, 132 m above river level. A pronounced lip is seen at this elevation elsewhere in the complex. The nature of the geological control evident in this sharply defined shear surface is not known at present.

Geomorphology of slope movements and rates of retrogression

Big Slide consists of two bowl shaped areas between the headscarp (el. 700 m) and the lip (el. 610 m), which have been called the North and South Bowls. Leading down from the lip to the Fraser River level (el. 478 m) are two steep sided gullies in the lower part of the glacio-lacustrine deposits and the Miocene sediments. These have been called the North and South Gullies. The gullies are flanked by old landslide scars (Fig. 2), which appear to be the remnants of a large landslide (possibly Dawson's "Great Slide") and thought to have blocked the Fraser River in the recent past. Thus, Big Slide appears to have originated along an older landslide scar.

In both the North and South Bowls retrogression at the headscarp takes place by multiple rotational slumping and produces backward tilted slump blocks which move downslope and undergo progressive disintegration and remolding. The average slope of the disintegration zone is 10°. At the lip, the material has the consistency of a slurry and advances into the gully below as mudflows. The mudflows exhibit longitudinal and transverse cracks and marginal levees; along their track they leave well-marked slickensides analogous to glacial striae.

Mudflow activity in the gullies is episodic. For example, in 1973 no mudflow was present in the South Gully but in 1975 a large mudflow had almost filled it. In 1982 two large mudflow tongues were observed protruding out into the Fraser River; Big Slide mudflows constitute an important point source of sediment in this part of the Fraser system.

As in other retrogressive slope movements, headscarp retrogression is achieved when slump blocks beneath the scarp move downslope themselves, thus removing support of upslope slump blocks along the headscarp. At Big Slide the support for upslope material is removed at the lip by gully erosion, by erosion of stabilized mudflow deposits, or by mudflow processes themselves.

Groundwater is a vital factor in the mechanism of multiple retrogression, disintegration and mudflow at Big Slide. Debris in the lower part of the slump blocks is frequently very wet and sag ponds are common between upper blocks. Near the lip, mud volcanoes, indicative of artesian pressures, were noted in the slurry. Well records from farms behind the scarp indicate the existence of a perched water table two meters beneath the ground surface which discharges into the headscarp area. It is probable that in the stratified glacio-lacustrine sediments several permeable layers act as perched aquifers. It is also likely that Ten Mile Lake, located on the plateau surface approximately three kilometers east of the headscarp, contributed substantial amounts of water to the Big Slide.

The differing patterns of slope movement in the North and South Bowls have been obtained by examining aerial photographs taken at various intervals since 1953. On the 1953 aerial photographs (Fig. 2A) it can be seen that the North

Figure 3: *1981 Air Photograph. K = North Bowl re-activated completely. Note broken ground. L = Active retrogression at North Bowl headscarp into in-situ glacio-lacustrine clay. M = Active retrogression at South Bowl headscarp has almost eliminated field (F in Fig. 2A). N = Mudflow in South Gully. O = Extensive movements in landslide south of Big Slide. Note impingement of debris on Fraser River channel. Bar Scale = 100 m. Arrow denotes flow direction of Fraser River. (B.C. Air Photograph 81093-181).*

Bowl is inactive, i.e. its surface is grass- and partly tree-covered, and there are no visible cracks and broken ground. The presence of a stable mudflow tongue is noted in the North Gully. The South Bowl in contrast is very active, exhibiting disturbed ground and active retrogressive landsliding. Retrogression is taking place in in-situ glacio-lacustrine deposits and remolded debris of the North Bowl. The South Bowl movements are, therefore, partially a re-activation of previous landslide debris.

Between 1953 and 1960 there was little change in the pattern and mode of retrogression in the South Bowl headscarp. However, between 1960 and 1969 gully erosion removed the stabilized mudflow debris from the North Gully thus removing support along the foot of the North Bowl lip (Fig. 2B). In 1973 cracks appeared in the destabilized debris initiating successive retrogressive failures. By 1977 retrogressive slope failures extended to the headscarp of the North Bowl which had remained unchanged since at least 1953. In the 1981 aerial photographs (Fig. 3) the North Bowl debris is almost fully remobilized and retrogression continued. In 1982 only a narrow ridge of debris between the North and South Bowls remains unaffected by renewed movement.

Retrogression of the South Bowl, based on measurements obtained from aerial photographs taken between 1953 and 1981, is shown in Figure 4. Two measures of retrogression are given. The first is based on the decrease in area of a field (F in Fig. 2A) at the headscarp; the second is the distance of the headscarp from a point on the Moose Heights road over the period of 1953 to 1981. The decrease in the area of the field varies from a maximum of 1858 m^2/yr between 1963 and 1969 to a minimum of 464 m^2/yr. between 1953 and 1963. The rate of scarp retreat was found to vary between 6 and 12 m/yr. This rate of retrogression is very high when compared to, for example, active retrogression on coastal landslides in the United Kingdom of 0.26 - 2.15 m/yr (Hutchinson, 1973; Brunsden, 1974), on coastal landslides in till on Lake Erie of 2.0 m/yr. (Quigley and Di Nardo, 1980) and for the retrogression of the Beaver Creek landslide, Saskatoon, in glacio-lacustrine sediments of 1.2 m/yr. (Haug *et al.*, 1977).

Both curves show an increased rate of retrogression between 1963 and 1969. The reason for this is not known at present. There does not appear to be a simple correlation between total annual precipitation, measured at Quesnel Airport 6 km to the south, and the rate of retrogression (Fig. 4).

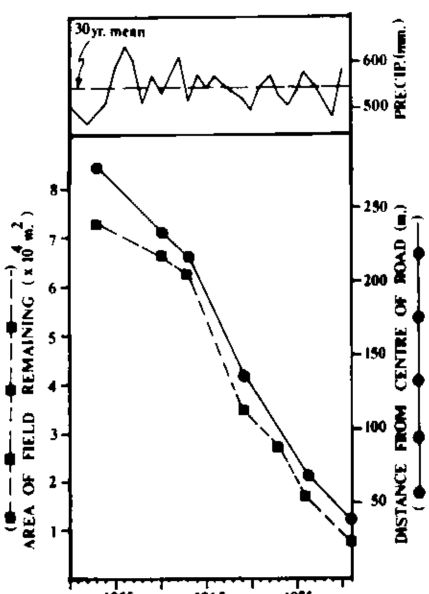


Figure 4: *Retrogressive behaviour of South Bowl, Big Slide between 1953 and 1981 in relation to the 1 year running average of total annual precipitation at Quesnel Airport. Measurements of retrogression obtained from aerial photographs.*

Conclusions

Big Slide displays exceptionally rapid retrogression over the 28 years of measurement. It may be taken as an example of the potential loss of land which may occur within the design life of homes and engineering structures as a result of slope movements in glacio-lacustrine deposits in this region of the Canadian Cordillera. The scale and rate of the movement appears to obviate any preventive measures against continued expansion of the Big Slide towards the farm buildings and Moose Heights road behind the retreating headscarp.

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