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Section 3: Engineering Geology

LANDSLIDES IN THE PALOONA DISTRICT

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Summary

The valley of Melrose Creek at Paloona has the sides mantled with a thick cover of Tertiary volcanic clay and soil, derived from the hills overlooking the valley.

Numerous landslips have occurred, due to removal of support by cuttings, or by a great increase in the weight of material due to waterlogging by heavy rains.

The slips are all of the type known as earth-flow, but some on steeper slopes resemble debris avalanches in part.

Renewed movement on old slips has occurred, and slips are to be expected even on slopes of only a few degrees.

The pipe-line must be re-located so as to avoid the sides of the valley altogether. Where it is necessary to enter the banks on the side of the river, it is recommended that the pipe-line be buried to a depth about level with the creek, to carry it beneath potential slips.

Introduction

During June, 1956, in a period of heavy rain, the pipe-line carrying the Devonport water supply was broken by a landslide which carried the pipe some distance down the hill.

At the suggestion of the Senior Geologist, the area was mapped in detail in order to determine the cause of the slippage.

General Geology

The area has been mapped recently on a regional basis, and the accompanying map is largely based on that work.

The oldest rocks are the Pre-Cambrian quartz-mica schists, forming an anticlinorium pitching north, with the axis running north-south along the Forth River at Paloona. North of Paloona township, this is overlain unconformably by the Owen conglomerate (Ordovician), forming a long strike ridge running from just north of the reservoir, in a semi-circle, finishing on a large tertiary fault at the Don River, north of Eugenana. This conglomerate is overlain by quartzites and fossiliferous shales (Caroline Creek beds) and then by the thick Gordon River limestone. The boundary of the shale and limestone is largely concealed, but underlies Paloona township and reappears further north as shown on the map, but is offset between by a fault running obliquely to the strike.

Thus all the landslides occurred over a limestone bedrock.

The overlying " colour soil " is due to tertiary volcanics, consisting of agglomerates and vitric tuffs, overlain by lava flows. The centre of vulcanism, from the grain size of the ejecta, was somewhere near Paloona, possibly on the fault mentioned.

The Pre-Basaltic Topography

The reconstruction, made on regional grounds, is that a series of streams were developed on the limestone in early Tertiary time, draining south-west to a large river which flowed north from Barrington, crossing the present Forth at Paloona, and travelling out to sea through a wide valley now buried 600 feet below Kindred. This river has been named the Paloona River. It is considered that the landslide on the pipe-line occurred on the line of an old tributary of this river, and the evidence for this is set out below. The deposits marked " stream sediments " on the map were deposited in this old tributary.

In the cutting on the railway line the stream sediments consist of rounded basalt boulders embedded in a matrix of shaley, laminated clay. The clay contains small, rounded quartzite boulders. The laminations appear to wrap around the basalt boulders. Large boulders (up to three feet diameter) of a quartzite conglomerate (well rounded, white quartzite pebbles averaging a quarter of an inch diameter, in a yellow arenaceous matrix) also occur. Boulders of this rock also occur on the river flats and where they occur next to the road carry well-developed slickensides. From the evidence of the slickensiding the conglomerate is Ordovician in age. The small quartzite pebbles found in the clay, and in the clays exposed in the landslip No. 1, are derived from this conglomerate. In addition to the basalt boulders, clay, quartzite pebbles, and conglomerate boulders, large dolerite boulders (up to several feet across) occur just above the railway cutting, and at 9197 N. 4255 E.

The distributions of these boulders of dolerite and quarzite had been noted in previous mapping, and was considered anomalous, but the most reasonable interpretation seems to be that they were included in the bed of an old stream. The basalt pebbles are considered to be volcanic lapilli dropped into muddy water, the clay originating from volcanic ash by aerial showers or erosion. No volcanic shards could be found in the clays.

Using this interpretation, contours on the base of the basalt were prepared. A key factor in locating the old lead was the discovery, at 9199 N. 4254 E., of a dip in the bedrock, at the boundary of the shale and limestone, containing basalt boulders. While such channels can develop by sub-basaltic erosion, it seems probable in this case that it represents part of the original valley, with remnants of the basalt fill remaining. This provides an accurate level on the base of the stream, which was 350 ft. S.L. at this point, dropping to about 320 ft. S.L. at the railway cutting. This gives a stream gradient of 50 ft. in 1000 yards, or 1 in 60, which is small. A large amount of water must have been carried for the stream to have transported such large boulders of dolerite and conglomerate.

Present Valley Development

Melrose Creek itself exhibits a marked change from a steep-sided valley tract to a meandering, base-levelled floodplain, where it crosses from basalt into limestone bedrock. The rock change is marked by a small waterfall. North of the No. 1 slandslide, the valley profile is asymmetric, with a steep north-eastern slope in limestone capped with basalt, and a gentle south-western slope with a very hummocky surface. The valley widening on the western side can only mean that this slope is much less stable, and the hummocky appearance suggests extensive landsliding. The instability of this slope is due to the greater depth of tertiary deposits, due to the presence of the pre-basalt valley described. Erosion on this side is essentially a process of undercutting by the stream, and removal of waste, which is replaced by landslide material. Thus landslides are an essential part of the process, and are to be expected in these tertiary deposits, as No. 5 slip, moving on a slope of only a few degrees, indicated that only very gentle slopes are stable.

Distribution and Character of Landslides

On the accompanying map, all recent landslides in the valley are shown. Except for No. 5, all have occurred over a limestone bedrock.

Slip No. 2 was initiated when the railway line was cut, as elbow bends at the base of the trees indicate movement at that time. The renewed movement this year was a combination of the types known as earthflow and debris avalanche, with a slumped arcuate head, and a bulging over-folded toe which has spilled out across the old railway track. The sides of the flow show evidence of marked transcurrent shearing, with slickensides well developed in the clays.

Slip No. 3 was also initiated by the railway cutting, and a stone embankment was built in order to stablilise the slope. However, pronounced bowing outwards of this wall indicates that movement has occurred since. The old pipe-line crosses one edge of this slip, and a resident told me that trouble was experienced with breaks in the old pipe-line due to this slip.

Slip No. 4 is a small one that moved this year, carrying the wire fence several feet downslope.

Slip No. 5 is a large earthflow moving on a very shallow slope. Examination shows that previous movement has occurred (at least several years previously) and the movement this year was renewed movement of the frontal portion of the old flow. A very large, soggy, water-laden, swelled toe has developed near the creek, resembling a solifluction lobe.

Slip No. 6 is a small earthflow that moved some years ago, breaking the pipe-line.

The other unnumbered slips are small or doubtful.

The following conclusions may be drawn:—

(1) Earthflow-debris avalanches are a feature of steep slopes in limestone mantled with basaltic soil (Nos. 2, 3, and 4) and pure earthflows occur on gentle slopes in deep basalt soil (Nos. 5 and 6).

(2) The movement is by slumping at the head, with flow at the toe. Slip surfaces are developed at the head and in intermediate zones.

(3) The instability of these slopes is a natural, unavoidable feature, which has been accentuated by the removal of the forest cover (all slips occurred in open paddocks).

(4) The direct cause of the extensive landslides in 1956 was heavy rain increasing the weight of the soil cover, together with the loss of support occasioned by man-made cuts.

(5) Renewed movement on old slips has occurred.

The Landslip on the Pipe-line (No. 1 Slip)

This slip had been extensively cut up at the time of the field work, so it was not possible to determine what type of movement had occurred, nor even its boundaries. However, I was informed that the toe developed overhanging the creek, which puts the pipe-line position at the middle or heel of the slip. Presumably it was the same type as the others investigated, namely an earth-flow, moving on a shallow slip surface.

The sole of the slip was in brown, laminated clays, and in the bottom trench white bands dipping down-hill were clearly visible. All of those bands carried slickensides indicating the top-side moved down-hill over the bottom, so almost certainly these are the slip surfaces upon which the surface material moved.

The surface material consists of red and brown clay, containing blocks of limestone and vitric tuff up to six feet diameter. The tuff has been derived from the basalt tuffs occurring further up-hill, which stand out on the hillside as a strong bank about 20 feet high; and the limestone from weathered rock. The surface clay is a mixture of weathered tuff and weathered limestone, and is quite structureless. However, the underlying clay has a laminated appearance, and contains occasional small angular quartzite pebbles up to a quarter of an inch diameter, and these clays are considered to be sedimentary deposits in an old river valley, as previously described.

Since drainage has been carried deep enough to reach this clay in most of the trenches, this clay is considered to be effectively drained, and together with the removal of much of the overburden, no further movement on this slip is likely. At the time of a second visit (7th August) much material up-hill from the drainage channels was sliding, on the clays, into the channels. This movement is due to the removal of lateral support by the cutting, and demonstrates the potential instability of the slope.

Conclusions

1. Numerous landslides occurred in 1956 as a result of increase in weight of surface soils, accentuating the instability of potentially-unstable slopes.

2. The primary instability is due to the thick cover of low-strength basaltic clays on the western bank of Melrose Creek, and the steep slope in similar clays on the eastern bank. On the eastern side, particularly, railway cuttings and tree destruction have deprived this material of much of its support.

3. The slides were all types of earthflows, moving on a shallow slip surface.

4. Renewed movement on old slips has occurred.

5. Where basaltic soils are thick, only very gentle slopes are stable.

6. The basalt cover is thickest on the western side of the valley, due to the presence of an old stream valley, and clays deposited in this valley have provided a slippery substratum that has facilitated movement.

7. Drainage measures taken on No. 1 slip should prevent renewed movement.

8. Since landsliding is an essential feature of the development of this valley, any major undertakings in the future should either avoid the valley sides altogether, or else appropriate steps should be taken to stabilise the valley side with proper drainage, especially if cuts are made. Tree planting should provide effective stabilisation on a long-term basis.

Recommendations: Relocating Pipe-line

The pipe-line will only be safe from slippage when it is relocated outside the area altogether.

Since considerations of hydraulic grade make it necessary to pass through the valley, it is desirable that the new route pass down the middle of Melrose Creek (on the belt marked as alluvium on the map), i.e., avoiding the sides of the valley.

In cross-section the river flat has steep banks overhanging it, and in all cases this is material that has migrated down-slope for distances up to 450 yards. All this material has moved to reach its present position, and as events this year have proved, needs little encouragement to move again. It is advised, therefore, that the steep banks overhanging the river flats be avoided. This particularly applies to a steep bank overhanging the western side of the creek at the northern end where the proposed new pipe-line joins the present 18-inch main.

Further south, the proposed new line is to be cut into the eastern bank of the creek, next to the road. This location (while not ideal) should be satisfactory provided the pipe-line is deeply buried, to about creek level. This should carry it beneath any potential slips.

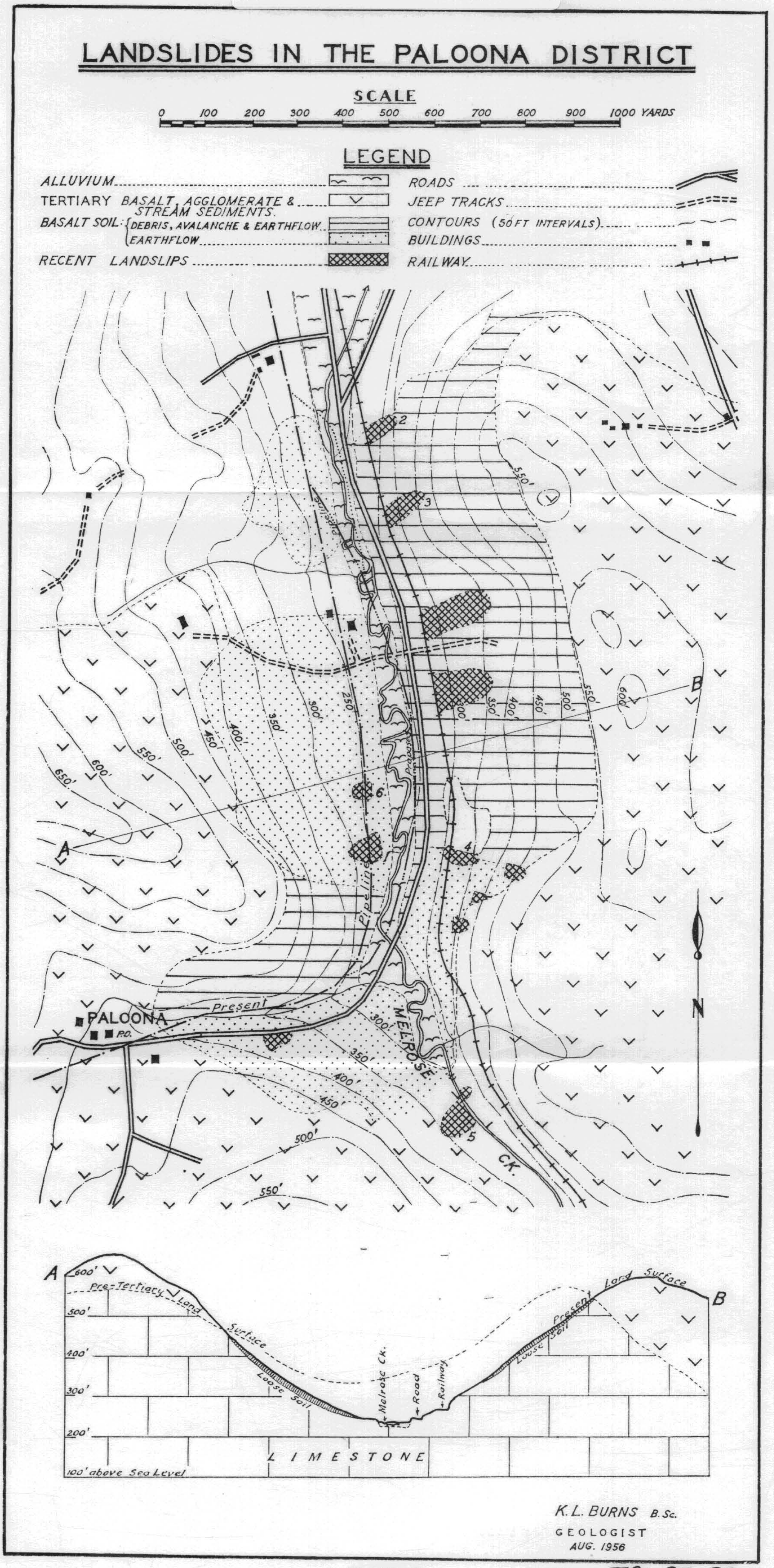

PLATE 9

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