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STABILITY OF THE WESTERN SIDE OF HEAVITREE GAP, ALICE SPRINGS, N.T., MAY 1962.

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CONTENTS

	Page
SUMMARY	1
INTRODUCTION	1
GEOLOGY	2
TOPOGRAPHY	2
STABILITY OF SLOPES	4
DESCRIPTION OF SUBDIVISIONS	4
ADDITIONAL OR ALTERNATIVE SAFETY MEASURES	7
CONCLUSIONS	7

TABLES

Table 1: Summary of features of topographic subdivisions

PLATES

Plate 1: Photo mosaic of western side of Heavitree Gap

Plate 2: Surface contours on the western side of Heavitree Gap

Plate 3: Topographic subdivisions

Plate 4 - 7: Photographs of topographic subdivisions

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SUMMARY

The western side of Heavitree Gap (through which the Central Australian railway passes) consists of bare faces of well-bedded and jointed quartzite, sandstone and shale. Rock falls in the past have caused minor damage to the railway line. The western side of the gap has been divided into 14 units on the basis of the type of surface, in order to estimate the amount of potentially dangerous loose material. Loose material is present in several of the subdivisions, and rock falls from these areas could be triggered by vibrations from passing trains.

Risk of rock falls onto the line could be considerably reduced by removing 7000 cubic yards of rock, and by constructing a steel barrier fence 1300 feet long on the western side of the railway. An earth trench and earth wall would be preferable to the steel barrier but there is insufficient space between the rock outcrop and the railway for a trench and wall over the whole of the dangerous interval.

INTRODUCTION

At the request of the Secretary, Commonwealth Railways, the western side of Heavitree Gap was inspected, and an estimate was made of the amount of rock which would have to be removed to reduce the possibility of a rock fall obstructing the Central Australian railway line which passes through the Gap. Heavitree Gap is three miles south of Alice Springs township, and besides the railway, the main southern access road, telegraph and power lines pass through it. Most of the floor of the Gap is occupied by the bed of the Todd River.

Falls of rock have occurred at infrequent intervals, and damage to the railway line has sometimes resulted. In one instance, steel girders supporting a small culvert were considerably bent by a fall originating from the northern escarpment of the western side of the Gap.

GEOLOGY

Precambrian Granite (Older than Upper Proterozoic)

Granite of Precambrian age occurs along the northern flank of Heavitree Range, and is exposed in a small excavation at the northern end of the Gap. Apart from this exposure, the granite is obscured by scree. No granite is likely to fall on the railway line.

Upper Proterozoic - Heavitree Quartzite

The Heavitree Quartzite overlies the Precambrian granite with a major unconformity. It consists of medium to thick-bedded sandstone and quartzite, with about 20 feet of shale at the base, and a few thin shale beds interbedded with the sandstone and quartzite. The beds strike 090° and dip 50° south. They are well jointed, and the major joint set strikes 210° and dips 70° west. A minor set strikes 160° and dips 60° east. Two lesser sets strike 240° with a dip of 20° west, and 130° with a dip of 30° east.

Below the zone of surface weathering, the joint planes and bedding planes are planes of weakness. Insolation in the arid climate with extremes of temperature causes fissures to develop along these planes of weakness. At the base of the zone of surface weathering they are 'hairline fractures'; near the top of the profile, where the effects of insolation are greater, and confining pressures are smaller, movement occurs in a direction at right angles to the joint planes. In this way joint planes and bedding planes are 'opened', and sub-rectangular blocks of Heavitree Quartzite are broken out from the outcrop.

The thickness of the zone of surface weathering is approximately 20 feet, as indicated by -

(a) about 20 to 25 feet of rock appears to have been removed in places when the railway was constructed and openings along bedding planes in the exposed rock are small.

(b) on one of the scarp faces, solid rock is exposed where a thickness of approximately 20 feet of open jointed material has fallen away.

TOPOGRAPHY

The topography of the western face of Heavitree Gap is illustrated in Plates 1 and 2. Plate 2 is a contour plan of the area (at a scale of 1 inch : 80 feet) prepared by triangulation and using an Abney level. Plate 1 is a photo mosaic of the western side of the Gap. There are two main strike ridges and each has a north-facing escarpment; a steep valley separates them, and scree-covered slopes extend to the north and south.

The western face has been subdivided into 14 areas, based on the type of surface represented. The areas are shown on Plate 3, and are listed in Table 1 together with their estimated surface area and maximum gradient.

TABLE 1

SUMMARY OF FEATURES OF TOPOGRAPHIC SUBDIVISIONS

Topographic Subdivision		Area (Square Yards)	Maximum Gradient (Expressed as the tangent of the base angle)	Overall Gradient	Direction of overall gradient
Northern scree slope		4,800	1 in 2	1 in 2	080°
Northern escarpment		15,000	Vertical	2 in 1 to 3 in 1	050°
Northern strike ridge		2,000	1 in 1	1 in 1	110°
Northern dip slope		2,500	1 in 1	1 in 1.2	175°
Central strike ridge		2,720	1 in 1	1 in 1.4	150°
Northern escarpment		3,600	Vertical	3 in 1 to 2 in 1	070°
Northern strike ridge		*	2 in 1	1 in 1.3	175°
Northern scree slope		*	2 in 1	1 in 2.2	150°
Pediment outcrop	(a)	2,600	5 in 1	2.2 in 1	105°
	(b)	1,260	3 in 1	2 in 1	110°
	(c)	1,100	Vertical	1 in 1	140°
	(d)	1,100	Vertical	1 in 1	140°
Pediment scree	(a)	5,100	2 in 1	1 in 1.3	130°
	(b)	1,570	1 in 1	1 in 1.3	140°

* Not calculated, since the feature does not constitute a hazard to the railway.

STABILITY OF SLOPES

The slopes under consideration fall into three classes, which are discussed below:

Escarpment and "pediment outcrop" areas

The gradient in these areas is greater than the angle of rest, so that any blocks which break loose will fall to the base of the escarpment, although they may be reduced in size by collision with projecting ledges. The stability of these slopes is thus dependent on the degree to which blocks have become detached from the surfaces. Where a block is separated from solid outcrop by open joint and bedding planes it must be regarded as unstable. However, the bedding planes dip steeply away from the escarpment, so that many loose blocks rest in a V-shaped depression and are unlikely to fall.

Scree-covered slopes

The stability of this type of slope is dependent on the gradient, the lithology and texture of the scree and the amount of vegetation covering the slope. If the gradient of the slope is greater than the angle of rest the slope is unstable and movement of scree could be triggered by the vibration set up by a train moving through the gap. From observations on the Pediment Scree (a) (see Plate 3), the angle of rest of such a slope is estimated to be 37 degrees (a gradient of 1 in 1.3). The rubble on this slope ranges in size from 3 inches to 1 foot, and the slope is not vegetated. Where there is a considerable amount of soil in a scree slope its stability would be decreased when saturated by rain. This effect would be most serious where there is no vegetation.

Slopes having small areas of scree separated by subdued outcrop

The stability of these slopes is determined largely by the configuration of the outcrop areas, but the overall gradient and the size of the scree areas also have an effect. In the Heavitree Gap area the only slope that fits into this category is Pediment Scree (a). On this slope, the individual areas of scree are less than twenty square yards in area, and many of them are less than 10 square yards. Many of them appear to have a gradient close to the angle of rest. The outcrops in this area are generally low, long and narrow and act as small retaining walls, from one to three feet high. The movement of rubble is inhibited by these walls.

DESCRIPTION OF SUBDIVISIONS

Northern Scree (Plate 4).

The maximum gradient on this slope is 1 in 2, which is considered to be less than the angle of rest. It is covered by a vigorous growth of spinifex, which adds considerably to its stability. It is most unlikely that any material already on this slope will move. If the slope were cleaned, it would become a less efficient buffer to material falling from the scarp above it, and the angle of rest would be reduced, i.e. new material accumulating on the slope would be unstable.

Northern Escarpment (Plates 4 and 5).

There are many blocks in this area which are separated from solid rock by open joints. A count of these blocks in a representative area indicated a density of 3 cubic yards per 50 square yards. The total area of the escarpment is 15,000 square yards, and the total volume of loose material is estimated to be 900 cubic yards. Some of it could be removed with a crowbar, but a considerable amount could only be moved by the use of explosives.

There is a small overhang at the top of the eastern end of the escarpment. This could become unstable, although there do not appear to be sufficient open strike joints to cause immediate danger. The volume of this overhang is estimated at 1,500 cubic yards.

Most of the material within the zone of surface weathering on this escarpment appears to have already fallen, but a thin veneer remains in places. It is estimated that an average thickness of 3 feet of potentially dangerous material remains on this face, so that a total of about 15,000 cubic yards would need to be moved to clean the escarpment back to solid rock.

Northern Strike Ridge (Plate 5).

This area is underlain by outcrops with numerous large loose blocks. The surfaces involved are small, and slope at less than the angle of rest. The area is stabilised by spinifex and scrubby vegetation. No serious rock falls from this area are likely.

Northern Dip Slope (Plate 5).

This area is on the southern flank of the northern strike ridge. Bedding planes and the major set of joints appear to be open to a depth of 20 feet, but the minor sets of joint planes do not appear to have been opened. The likelihood of rock falls from this area is therefore low, but any blocks which did break loose would probably be very large and would probably fall to ground level. Approximately 17,000 cubic yards would have to be shifted to remove the zone of open joint and bedding planes.

Central Strike Ridge (Plate 6).

This ridge occurs at the head of the valley between the two main strike ridges. The joint planes and bedding planes appear to have been opened throughout the ridge. Blocks with a volume of one cubic yard or more are likely to become dislodged from the ridge, and some of these would probably reach level ground. The volume of rock in the ridge is about 4,000 cubic yards, and the complete removal of this material is considered desirable.

Southern Escarpment (Plates 6 and 7).

The thickness of the zone of surface weathering on this escarpment appears to be about 20 feet. In one area the material within the zone has fallen, leaving apparently solid rock on the face of the escarpment. On the assumption that the density of existing loose blocks is similar to that on the northern escarpment, the volume of loose material on this escarpment would be about 250 cubic yards. To clean the escarpment back to solid rock would require the removal of about 25,000 cubic yards.

Southern Strike Ridge

Most of this area is underlain by solid outcrop, and the gradient over much of it is less than the angle of rest. There is very little danger of significant rock falls from this area. The steepest part has a stable dip slope below it.

Southern Scree Slope

The maximum gradient in this area is 1 in 2, which is well below the angle of rest. It is stabilised by spinifex, and the base of the scree slope is 30 feet from the railway line in the north and 200 feet from it at the southern end. The danger of serious rocks falls from this area is negligible.

Pediment Outcrop (Plates 5 and 7)

These areas include the exposed ends of the strike ridges. They are faces which are roughly perpendicular to the strike, and the overall gradient on them is greater than the angle of rest. In detail these surfaces are quite irregular, except where they have been modified by the railway cuttings. Four areas of this type are discussed below:-

(a) The exposed end of the northern strike ridge, on which the overall gradient varies from 2 in 1 to almost vertical. Loose material falling from the top would probably reach level ground, but may be caught in a projecting ledge on the irregular surface. A count of loose material in a sample area indicated a density of 2 cubic yards per 80 square yards. The total area involved is 2,600 square yards, so that the removal of 65 cubic yards would be required to clean this face of loose material.

Part of this area includes the cutting made when the railway was constructed; in this part fairly solid rock is present. In the remainder, open joint and bedding planes probably persist to a depth of 20 feet; 18,000 cubic yards would therefore have to be moved to clean the face back to solid rock.

(b) The exposed end of part of the southern strike ridge, is similar to (a). The total area is 1,260 square yards, and it contains an estimated 50 cubic yards of loose material.

(c) and (d) These areas consist of small dip slopes and vertical exposed faces, with very minor amounts of scree. The outcrop appears to be fairly solid, but a few loose blocks are present. These areas could be cleaned of dangerous loose blocks by the removal of about 40 to 50 cubic yards.

Pediment Screes (Plates 6 and 7)

These areas represent the ends of the strike ridges where the gradient is close to the angle of rest; they are partially covered by scree material. Two areas have been delineated, as described below:-

(a) The major part of this area is a mixed "scree with low outcrop" slope, which is thought to be safe because of the irregular surface, and the interference given to falling material by the outcrop areas.

However, the southern part of this area is occupied by a scree slope, the gradient of which (1 in 1.3) appears to be close to the angle of rest, as a minor disturbance results in considerable movement of material. The angular blocks which form the scree range from a few inches to one foot long; around the margins, there are several much larger boulders (up to a cubic yard). There is no vegetation on the slope. Assuming an average depth of 3 feet, the total volume of the scree material is 1,700 cubic yards, and all of this should be removed. This could exaggerate the effect of falls from the eastern end of the southern escarpment. Additional safety could be provided by cutting a series of benches in the outcropping rock after removal of the scree. Six benches, each 30 feet wide, could be constructed, involving the removal of 8,500 cubic yards.

(b) The area at the end of the southern strike ridge is a scree slope with a few low outcrops. The maximum gradient is 1 in 1, but over most of the slope the gradient is 1 in 2 or less. There is a considerable growth of spinfex on the slope, and there is little risk of serious rock falls from this area.

ADDITIONAL OR ALTERNATIVE SAFETY MEASURES

A steel barrier fence, 3 feet high and 1,300 feet long, in the position shown on Plate 3, would prevent material from minor rock falls on the western side of the Gap from reaching the railway line. However, this is unlikely to give complete protection, unless it could be designed to withstand an impact from a boulder of 1½ cubic yards after it had rolled down an almost vertical slope from a height of 200 feet.

A cheaper and more effective trap for rock falls would be a trench, with an earth wall. There is only enough space for this along the northernmost 400 feet of the section of the railway line which is liable to damage from rock falls.

A limited programme of rock bolting could be useful in increasing the stability in some areas, particularly the northern dip slope and the central strike ridge.

CONCLUSIONS

Several degrees of safety may be obtained by removing increasing volumes of rock. These are listed below, in order of urgency, together with the estimated volume which would have to be removed at each stage.

Stage 1.	Removal of loose material from –		
	(a) Northern escarpment	...	900 cu. yards
	(b) Southern escarpment	...	250 " "
	(c) Pediment outcrop areas	...	160 " "
	Removal total volume of central strike ridge	...	4,000 " "
	Removal total volume of scree in southern part of pediment scree area (a)	...	1,700 " "
		Total :	7,010 " "
Stage 2.	Benching under the scree in the southern part of pediment scree area (a)	...	8,500 " "
		Total :	8,500 " "

Stage 3.	Removal of overhang on northern scarp	...	1,500 cu. yards.
	Total :		1,500 " "
Stage 4.	Removing zone of open joints on:		
	(a) northern escarpment to a depth of 3 feet	...	15,000 " "
	(b) southern escarpment to a depth of 20 feet	...	25,000 " "
	(c) northern dip slope to a depth of 20 feet	...	17,000 " "
	(d) Pediment outcrop (a) to a depth of 20 feet	...	18,000 " "
	Total :		75,000 " "

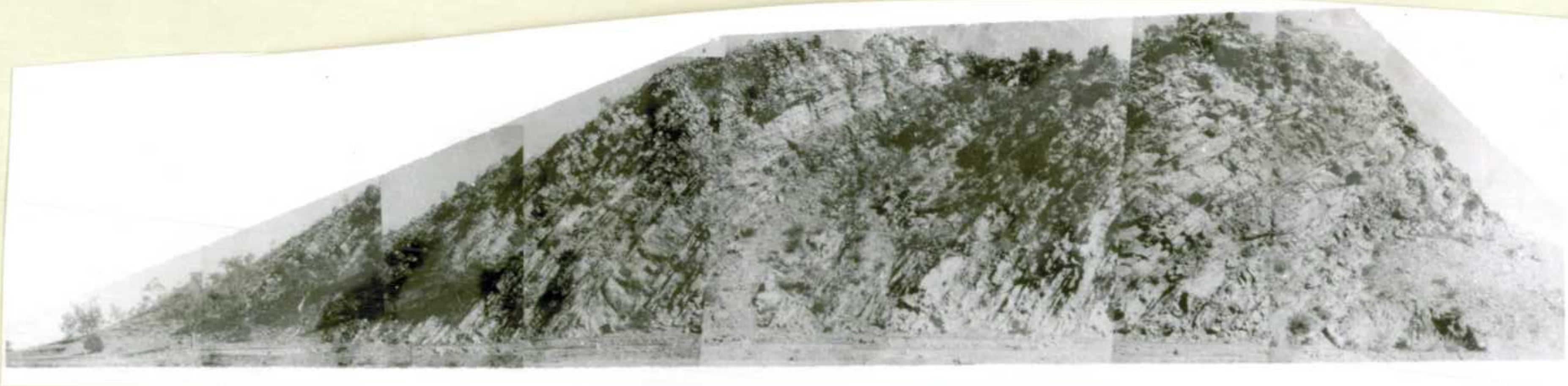

PLATE 1 Photo mosaic showing panoramic view of western side of Heavitree Gap

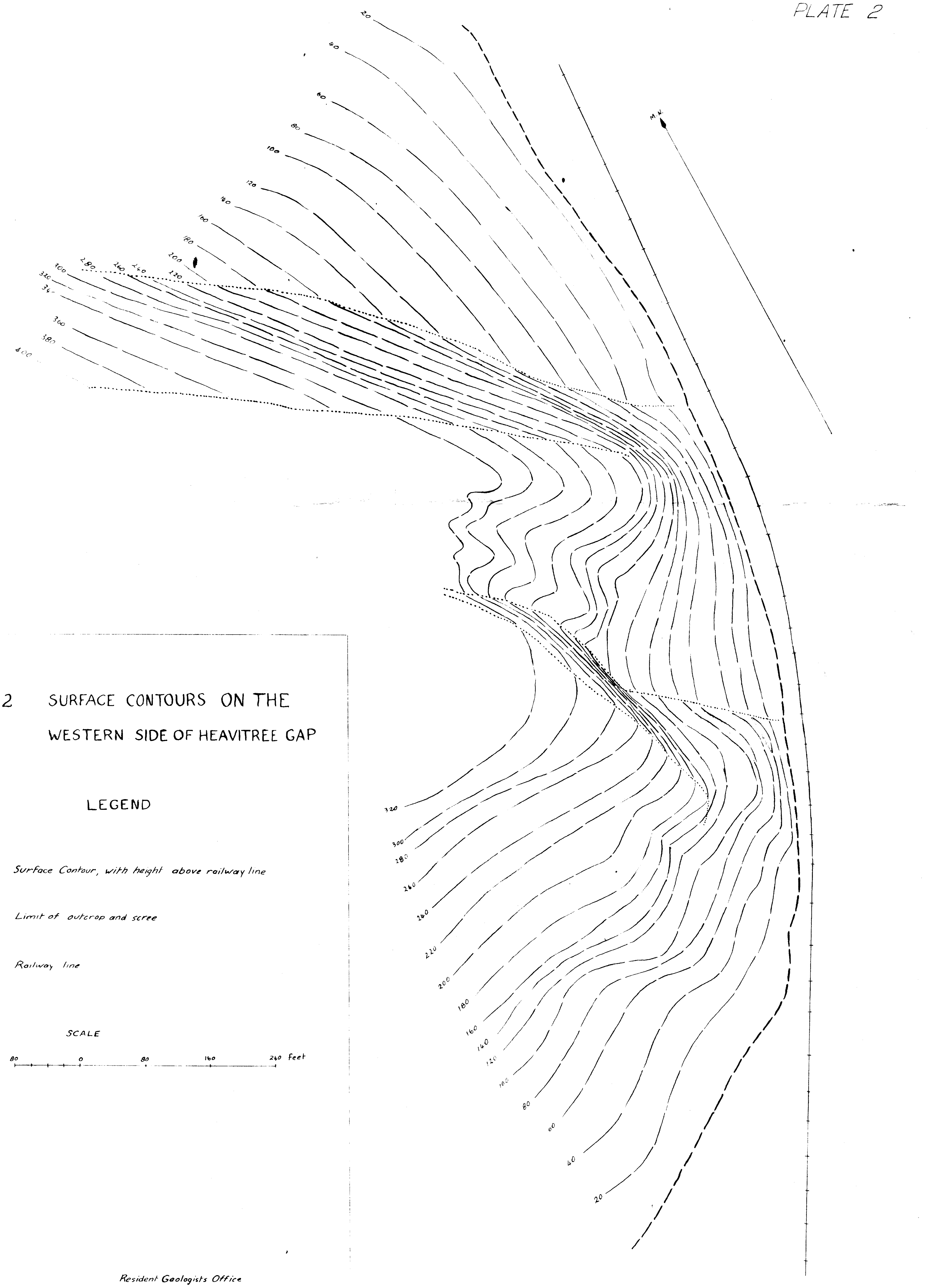

PLATE 2 SURFACE CONTOURS ON THE WESTERN SIDE OF HEAVITREE GAP

LEGEND

220 —— *Surface Contour, with height above railway line*

— — — *Limit of outcrop and scree*

+—+—+ *Railway line*

SCALE

80 0 80 160 240 feet

Resident Geologists Office
Alice Springs May 1962

To accompany Records 1962/147

F53/14/19

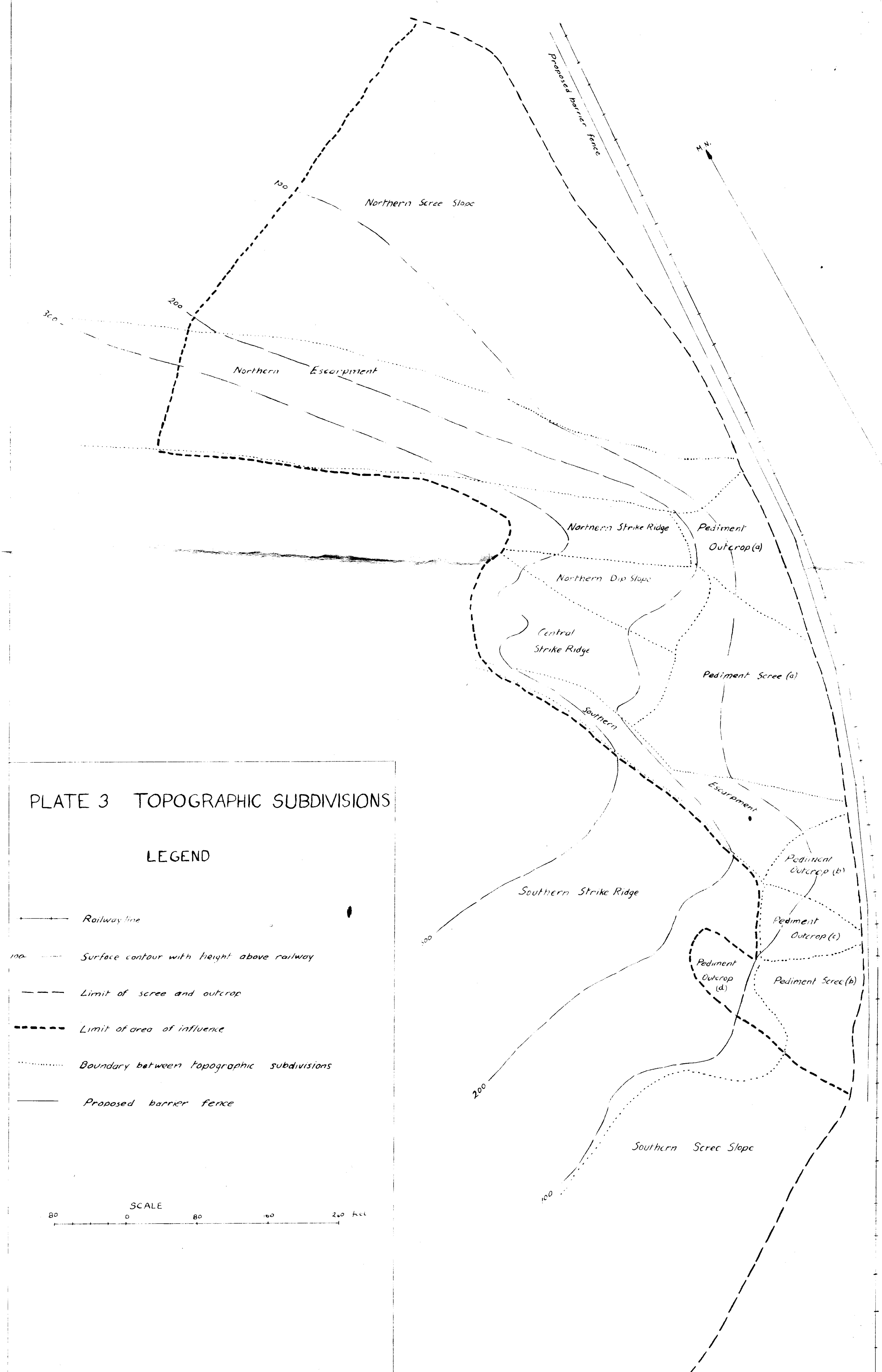

PLATE 3 TOPOGRAPHIC SUBDIVISIONS

LEGEND

- Railway line
- 100 Surface contour with height above railway
- Limit of scree and outcrop
- Limit of area of influence
- Boundary between topographic subdivisions
- Proposed barrier fence

SCALE

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Alice Springs May 1962

To accompany Records 1962/147

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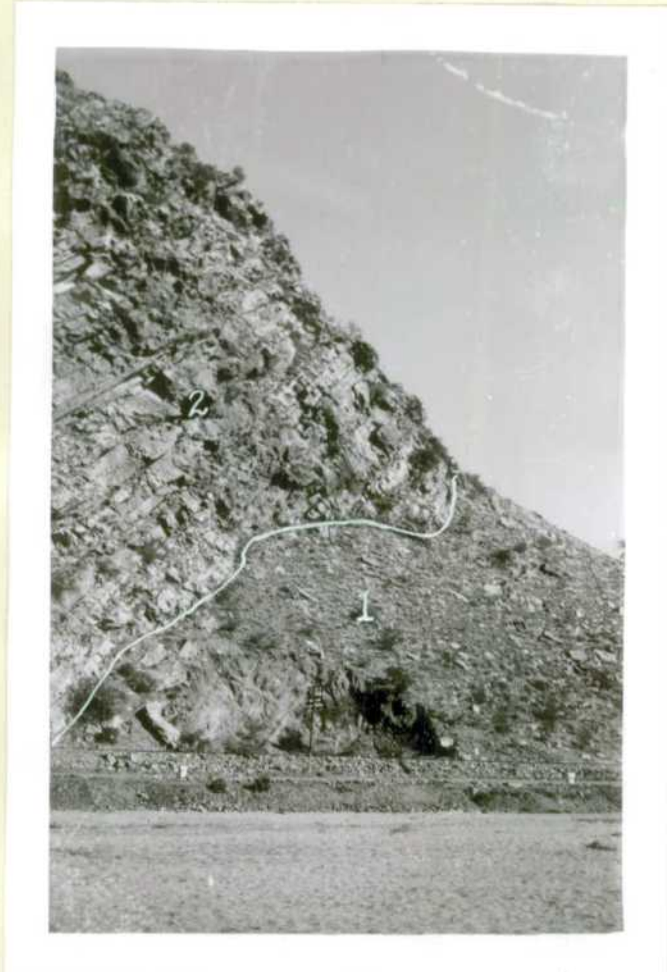

PLATE 4

1. Northern scree
2. Northern escarpment

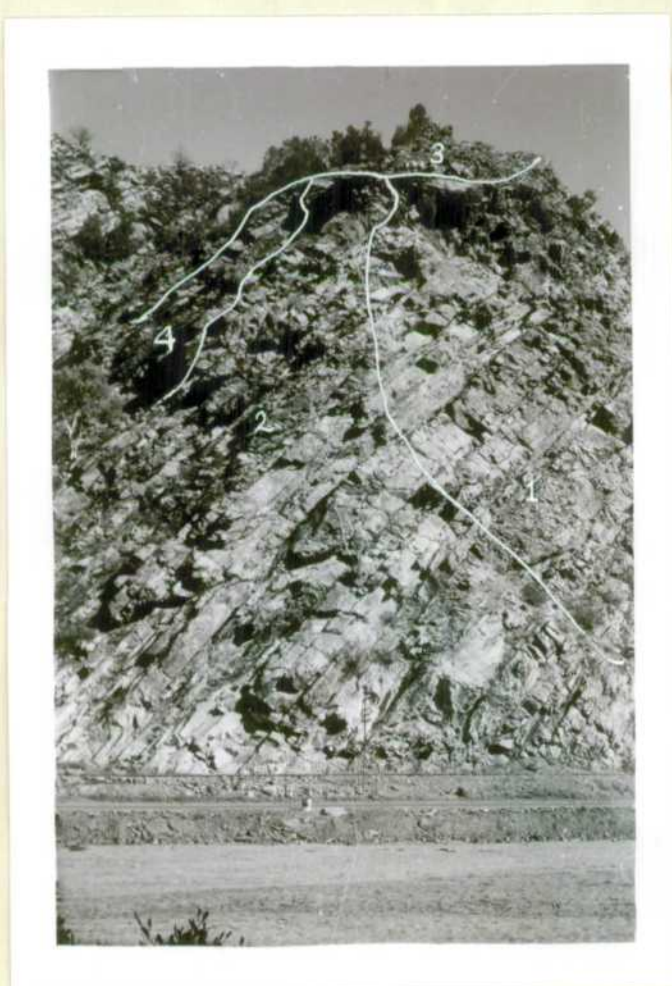

PLATE 5

1. Northern escarpment
2. Pediment outcrop (a)
3. Northern strike ridge
4. Northern dip slope

PLATE 6

1. Pediment scree (a)
2. Central strike ridge
3. Southern escarpment
4. Northern dip slope

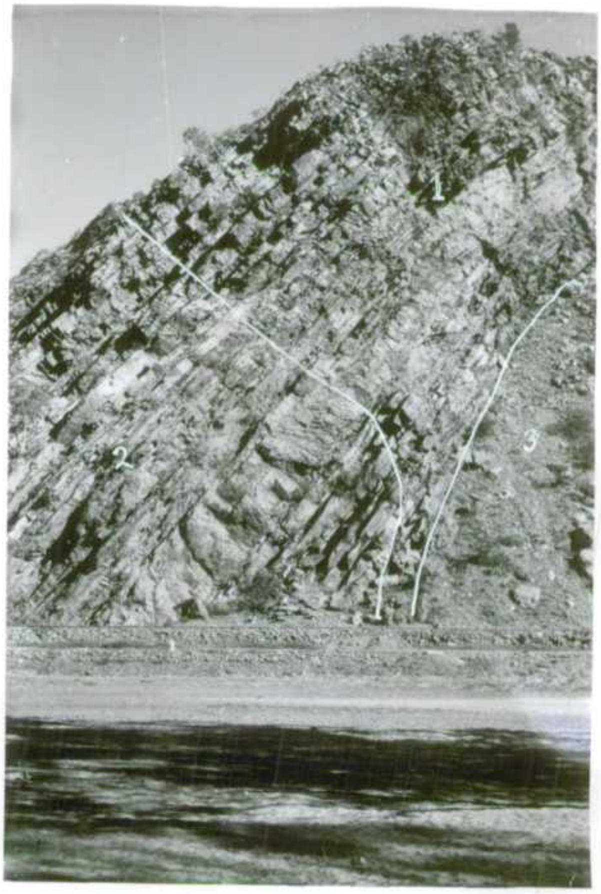

PLATE 7

1. Southern escarpment
2. Pediment outcrop (b)
3. Pediment scree (a)