1980/6. Savage River Mines open-cut: notes for the guidance of Inspectors of Mines.

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Abstract

A geological investigation of the Savage River Mines open-cut was made on 10-12 December 1979 with the object of providing guidance for the Department's Inspectors of Mines.

The area is one of complex geology with rock types having a wide range of geotechnical properties.

The main areas of immediate concern are the inter-related problems of drainage, slope stability and blasting technique. In the long term the safe disposal of rock-waste and tailings will present a serious problem because of the lack of suitable sites in the vicinity of the open-cut.

GEOLOGICAL SUMMARY

The open pit at Savage River is situated in an area of complex geology. A sequence of meta-sediments of Precambrian age comprising a succession of actinolite and chlorite schists is intruded by ultrabasic rocks, dolerite, gabbro and basalt. Both the schistosity and the contacts in this sequence are near-vertical. By nature of their composition many of these rocks are weak and incompetent and when sheared and weathered become so incompetent that they possess the strength and properties of a soil. The orebody is elongate with overshoots that appear to follow some of the major discontinuities.

Both the east and west walls are deeply weathered in the upper benches, and two very deep zones of Tertiary weathering occur at the northern and southern ends of the pit (fig. 1, plate 1). The weathering at the southern end of the pit is associated with basalt which caps the ridge. The basalt appears completely decomposed for its entire thickness and the underlying metamorphic rocks are weathered to a considerable depth. The weathering at the northern end appears to be associated with a Tertiary valley and continues down to the existing floor level of the pit, and could continue to its proposed depth (plate 3).

A set of ESE-WNW faults appear on the east wall of the pit. These faults are frequently associated with wide crush zones and intensive jointing (plate 2). The fault crush and gouge is frequently completely mylonized to a soft clay and is invariably moist (plate 4). Numerous landslides and rock falls have been associated with these faults in the past (plate 5).

Another set of faults (ENE-WSW) are visible at the southern and northern ends of the pit. The extent of both sets of faults from the east wall to the west wall is difficult to trace because of a widespread cover of spoil from side casting in this area which covers the benches, and because of existing slips (plate 6). The extent of these faults outside the quarry, particularly to the east is unknown. Three major sets and joints have been identified by McMahon* and Piteau, 1979*, and are readily identifiable in the pit. Shear polish and thin clay layers are seen on these joint faces.

* Consultants reports to Savage River Mines

The intersection of steeper joints or an intersection of a joint with a fault or a plane of schistosity has resulted in numerous very large wedge failures in which several benches have fallen (plates 6, 7). Large planar failures appear to be more associated with weakness along the schistosity between competent and incompetent layers. Toppling failures along the schistosity and low angle planes dipping into the pit are widespread along the west wall and appear to have occurred at most levels at the northern end of the west wall (plates 8, 9).

This brief summary of the geology indicates that the Savage River open-cut is in an area of complex geology comprising rocks with a wide range of strengths (from massive competent dolerite to very incompetent clays) in an area of high and intensive rain. Under these conditions any design for deepening the pit to the depths proposed by the company (see later) that does not take into account the variability of the geology and sensitivity of the rocks is one of great danger (plate 10).

PROBLEMS AND PROCEDURES

Introduction

As mentioned in the previous section the Savage River open-cut is in an area of complex geology, with a wide range of rocks of differing strengths. The impression gained from the recent visit is that to date the pit has been operated like a quarry in a uniform rock type. Inflexible equipment and set mining procedures are followed with emphasis on production without regard to the nature of the geology.

Numerous rock falls and landslides have occurred in the open-cut in the past, fortunately with no loss of life and with no great interruption to production. This record may not continue as the pit is now entering a crucial stage in which it is being deepened by approximately one-third to one half of its existing depth. If the pit is to reach its planned depth of 25 levels (it is at present at level 16) many of these past practices need to be modified. Decisions such as overall design slope angle will have to be taken soon.

In order to make the correct decision many of the questions asked by McMahon in 1974 and restated by Piteau in 1979 must be answered, for example, is the design for a dry slope angle or a wet slope angle? Also the practices recommended by Piteau for example 'the control blasting', which clearly means geological control blasting, on the benches should be initiated. Evidence for a change in the approach of the mine procedures can be seen in the existing work of widening bench 9 into a berm, the groundwater investigation by Australian Groundwater Consultants being undertaken at present, and a marked increase in the geological section's staff at the mine since the previous visit in 1977.

The question is what part can the Department of Mines play in promoting this new approach. Clearly it must be one of persuasion backed by an adequate knowledge of the pit and its problems by the Inspectors of Mines. The first pre-requisite is for the Department to have a copy of Piteau's report at Burnie and this report to be understood fully by the officers at that office. They should also be conversant with the preceding reports by McMahon and any future reports, e.g. the Australian Groundwater Consultants' report. As the Piteau report is going to be the design manual for the pit to level 25, the accuracy of its predictions needs to be monitored independently by our officers. Equally important is a full appreciation by the field officers of the problems of the mine which are summarised below. These may be grouped under three headings:

(1) Water - surface water and groundwater

(2) Slope stability of the pit

(3) Lack of suitable areas for waste disposal

Water

Surface Water

Clearly the aim here is to keep as much surface water out of the pit as possible and ensure that what gets into the pit is drained out as quickly as possible. The mine inspectors should note that:

(1) all drains inside and outside the pit are working;

(2) roadside gutters and benches are drained and no large ponds allowed to accumulate, especially on the benches;

(3) dumps have drains around them which should flow away from the pit;

(4) the quarry floor is drained adequately.

The amount of water coming out of the pit should be estimated and an attempt made to correlate this with a given period of intensive rain. As the rate of evaporation in this climate, particularly in winter, is very low some idea of the amount of soakage or recharge of the groundwater could be made. This is particularly important as it is known that the water table responds quickly and rises very rapidly. This has been proved by observations made by Australian Groundwater Consultants.

Groundwater

There is not much the Department of Mines can do in this field apart from making routine checks of any drainage pipes to see that they continue to flow.

An independant check of the levels as well as the records of any observation bores to measure groundwater movements could be done at the pit. Also, Inspectors could see that the observation bores remained capped and monitored, while they remain in existence. It is important that the results of the present groundwater investigation by Australian Groundwater Consultants and their conclusions as to the possibility of draining the pit be known. A copy of this groundwater report will be required by the Burnie office.

Slope Stability

Piteau has subdivided the existing pit and its proposed extension to level 25 into a dozen or more small areas. A wet and dry slope angle have been calculated for each of these areas. These slope angle calculations or predictions are based on a statistical analysis of the discontinuities, the rock type and the type of failures present in the area. These are all modelled by computer to give a predicted design wet and dry slope angle for the particular area. The major concern is the lack of available readings in critical areas. A dry face may not be practical in such a complex groundwater regime as clearly must exist at Savage River.

It is therefore important that the Inspectors of Mines be familiar with Piteau's subdivisions and the data on which his predictions for each are based. This will take some time: it was only on the third day in the pit that some familiarity with Piteau's individual areas was being achieved on the present visit.

The east wall of the pit can be subdivided into three sections: the northern section, the middle section and the southern section - south of the haul road fault. Because of the depth of weathering the northern section is dominated by earth slides with the possibility of some flows, the centre section contains rock falls and slides below the weathered horizon and the southern section appears to contain a mixture of both rock and earth slides.

The northern section of the west wall is dominated by toppling failures, the cause of which appear to be overblasting, as the result of the choke blasting technique. Some method of pre-splitting appears to be required to protect these benches. The southern section is poorly exposed and it is impossible to determine its slope stability because of the debris which covers the benches. At present the benches become obliterated very quickly.

Our inspectors should monitor a few key slide and rock movements. The present monitoring of old bench failures by the company appears to be haphazard or non-existent. No plots or graphs of any of the movements of the previous slides were seen. Such monitored slides would be invaluable both in the softer and the hard rock regimes of the open-cut.

An effort should be made to clean up the existing benches and to make every second bench a reasonably wide berm, as is planned below level 9. This allows easy access to check for movements and for machinery to clean up small rock falls and allow spalling of dangerous areas before they fall.

The blasting technique used appears to the writers to be the problem. No differentiation between bench or berm wall cutting and production blasting is made in the pit. The use of angle drill holes and pre-splitting techniques to make berm walls safe should be a high priority for future safety. The amount of overbreak and damage to existing benches by production blasting is, to say the least, alarming. Evidence for overblasting is present on most benches.

Piteau's 'control blasting' or geological control blasting for the berms and benches should be given high priority. Some seismic shock monitoring of the production choke blasting on the nearby benches may be very illuminating.

Clearly if this choke method of production blasting is to be continued there must be some reduction of the number of charges and holes in sensitive geological areas so as to control the amount of overbreak into the future berms. There is little sense in designing for a wide berm when at least half of it falls as the result of overblasting or is dug out because it contains ore.

Waste Disposal

Mine Dumps

The problem of waste disposal at the Savage River Mines appears to be a major one and will become more severe in the near future because the waste to ore ratio is 2:1 at the mine. Obviously large high dumps should not be placed close to the edge of any deep pit. At Savage River, the high and intensive rainfall, zones of deep weathering, rapid rise of the water table following rain, make this extra loading even more dangerous. All of this is obvious and known to the staff at Savage River Mines. The topography of the mine area is one of narrow ridges and steep sided deep valleys. In such deeply dissected country large dumps placed on narrow ridges will spill over into the steep sided and deep valleys, and will always have a great potential to slide. There appears to be no alternative and it is a risk which must be accepted unless some very costly alternative major engineering project is built to dump outside the present area.

All the Inspectors of Mines can hope to achieve is that the spill over into the valleys is minimised. Checks of the angle of repose of the dumps should be routinely carried out, and the dumps should be as free draining as possible with drains around them to lead the water away from the pit.

Tailings Dam

The new site for this dam is in a steep valley and with such a high dam it needs to be investigated by a competent consulting geotechnical engineering firm whose investigation should be checked by the officers of this department.

SUMMARY OF THE MAIN RECOMMENDATIONS

The Inspector of Mines should:

(1) *Literature*

Critically read consultants reports past, present and future

(2) *Surface water*

Note: The two objectives are to

(a) keep as much surface water out of the pit, and

(b) get water entering the pit drained out as quickly as possible

(*a*) check that all drains (inside and outside of the pit) are working

(*b*) check that all roads and benches are drained - do not allow ponding

(*c*) check that dumps have drains around them flowing away from the pit

(*d*) check that the quarry floor is drained (*e*) estimate outflow of water from pit to help work out the hydrology

(3) *Groundwater*

(*a*) check the flows from drainage pipes

(*b*) check the records from observation bores

(*c*) observe springs and seepages

(*d*) encourage the preservation of observation bores for as long as possible

(*e*) review Australian Groundwater Consultants report

(4) *Slopes*

(*a*) become familiar with Piteau's slope segments

(*b*) check new faces for joints, faults and failure modes. Compare with Piteau's data for the corresponding segment. Report significant or unusual features

(*c*) monitor selected slopes for movement by survey and by photography

(5) *Blasting*

(*a*) check for excessive blast damage and overbreak

(*b*) report cases where excessive blast damage has caused slope failure (*e.g.* toppling failure)

(*c*) encourage the use of 'geological control blasting' even in production holes *i.e.* blasting technique should be varied according to the geology.

(*d*) present choke blasting techniques using large diameter vertical holes are not suitable for the development of the final face. This technique should be replaced by the use of angle holes and pre-splitting techniques which would result in steeper but more stable slopes.

(6) *Mine dumps*

Check location and drainage

(7) *Tailings dam*

The dam should be investigated and designed by competent geotechnical engineer

[3 January 1980]

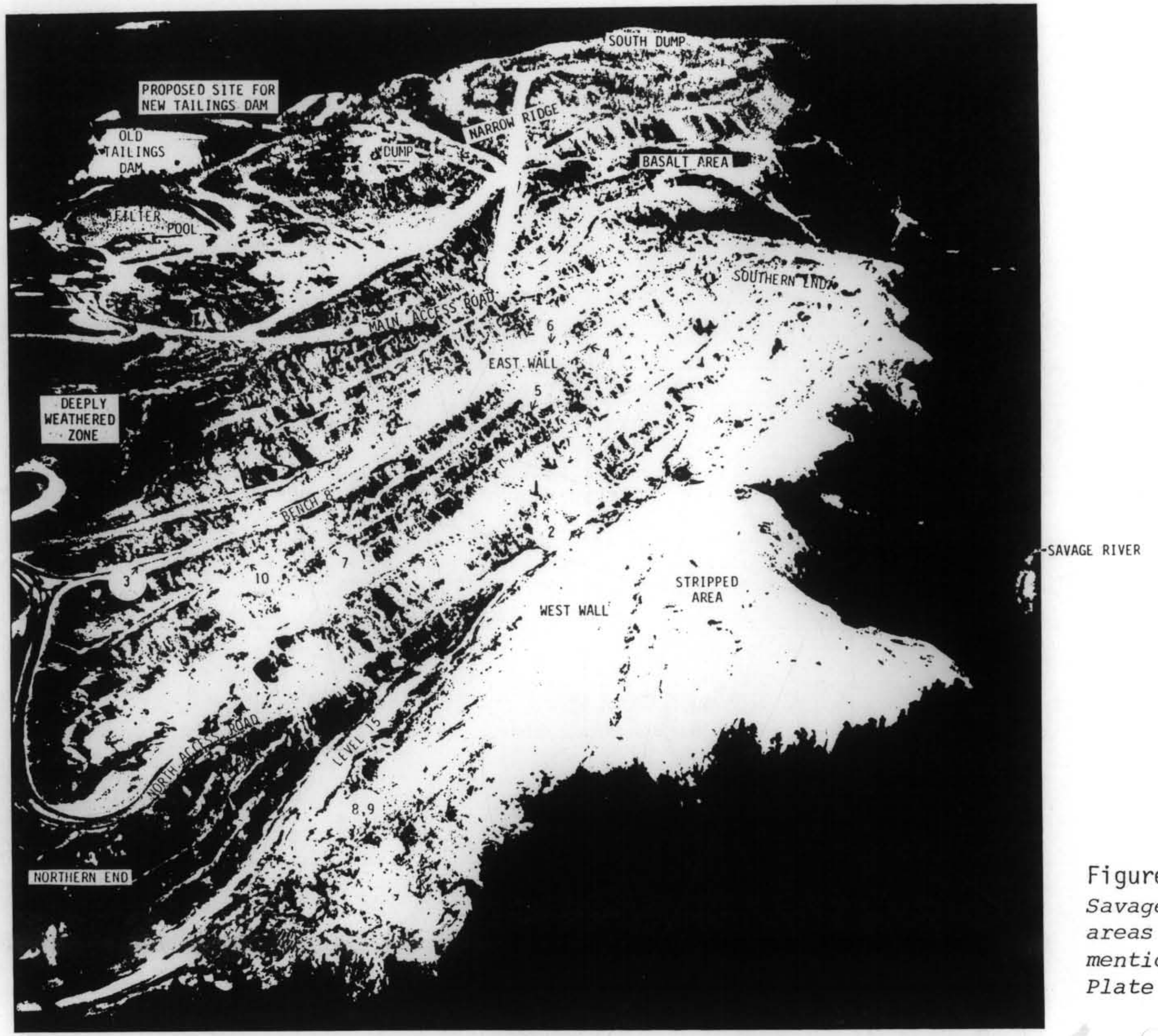

Figure 1. *Aerial view of Savage River open-cut, showing areas and positions of photographs mentioned in the text. See also Plate 1.*

5 cm

Plate 1. *Aerial view of Savage River open-cut (for explanation see Figure 1).*

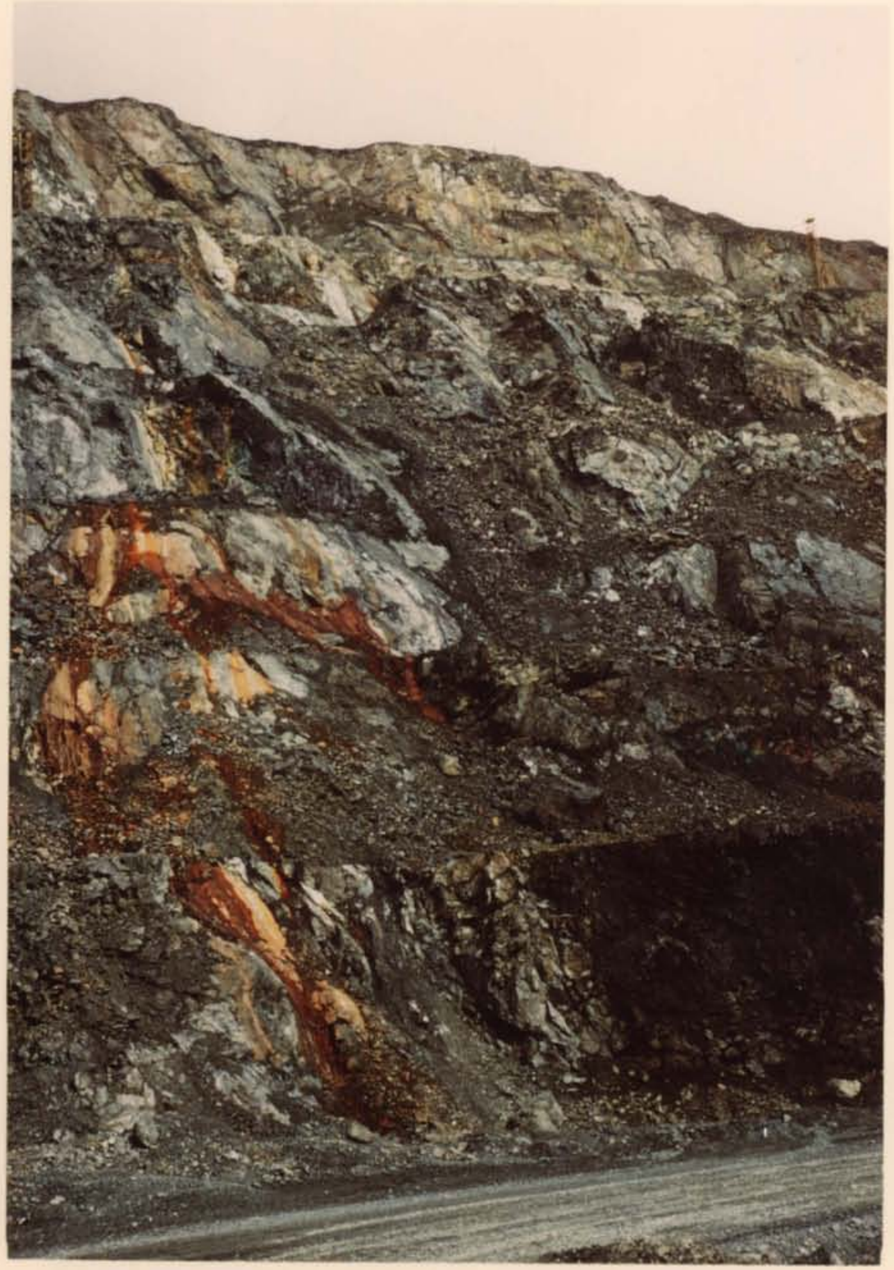

Plate 2. *Central part of east wall. Zone of WNW-ESE faults, and failures.*

5 cm

Plate 3. *North end of east wall. Zone of Tertiary weathering and landslides.*

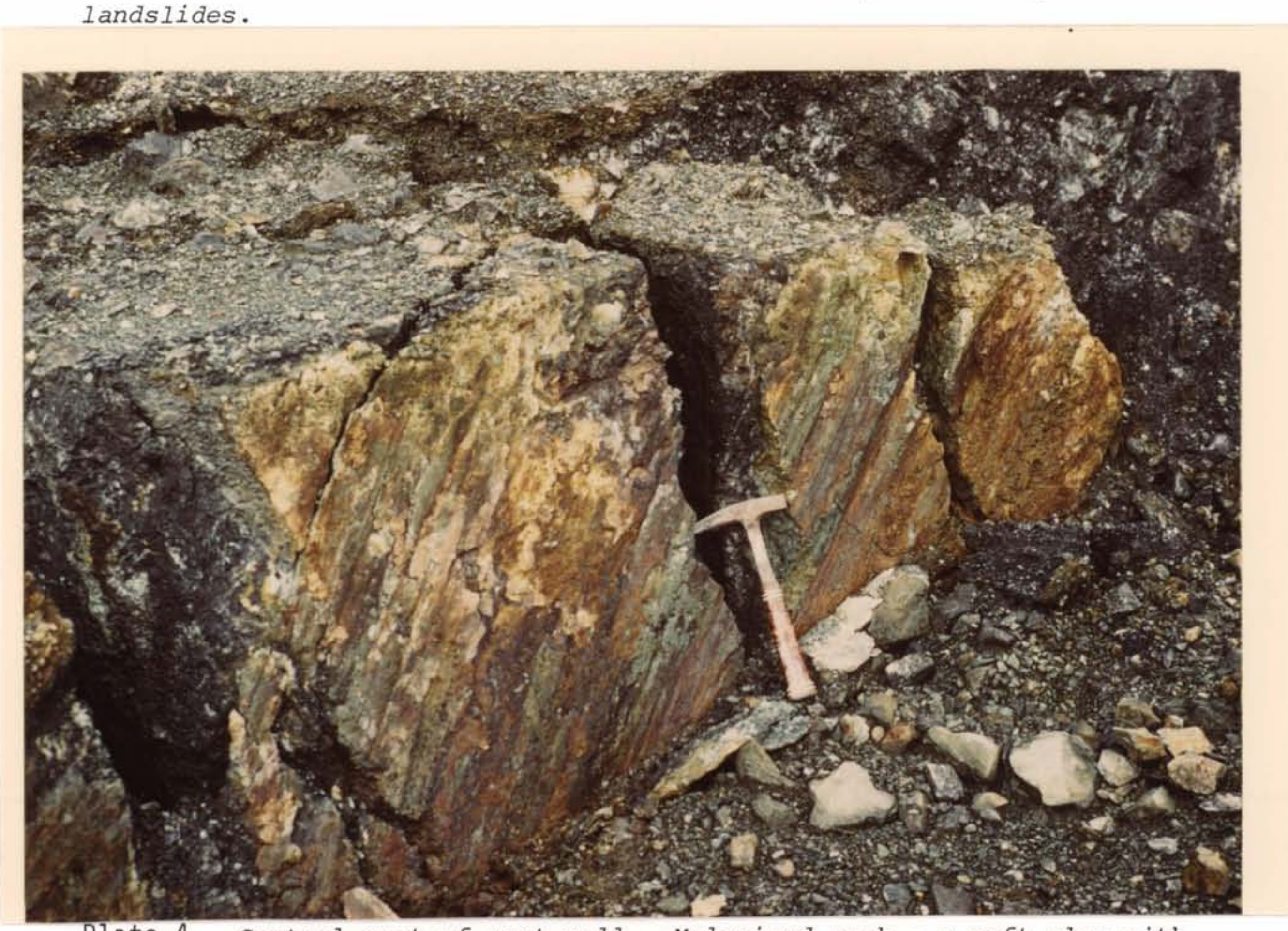

Plate 4. *Central part of east wall. Mylonised rock - a soft clay with slickensides on face.*

5 cm

Plate 5. *Central part of east wall. Rotational wedge failure, Bench 9.*

Plate 6. *Central part of east wall, looking across to west wall. Bench failure on east wall. Side casting on west wall.*

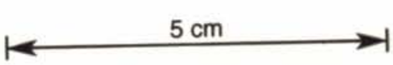

Plate 7. *Central part of east wall. Movement caused by rotational wedge failure.*

Plate 8. *Northern end of west wall. Progressive toppling failure. Original attitude and schistocity are seen below upper tree.*

5 cm

Plate 9. *Northern end of west wall. Failure probably due to overblasting by choke blasting technique.*

5 cm

Plate 10. *Central part of west wall. Damage to a competent rock caused by overblasting.*

5 cm