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# LATERITE GEOLOGY AND JARRAH DIEBACK: MAPPING METHOD AND PRELIMINARY FINDINGS

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SUMMARY:

Geological observations made at dieback investigation sites indicate that the geology of upland sites can form a useful basis for dieback monitoring and research. A method is recommended which has a terminology and approach to standardise any future examination of the lateritic caprock horizon. The work reported is preparatory and additional, more co-ordinated studies are required to test the relationships between geology, hydrology and dieback.

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# LATERITE GEOLOGY AND JARRAH DIEBACK:

# MAPPING METHOD AND PRELIMINARY FINDINGS

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# LATERITE GEOLOGY AND JARRAH DIEBACK

## 1. INTRODUCTION

*Phytophthora cinnamoni*, the jarrah dieback fungus is a water borne pathogen that can kill jarrah (*Eucalyptus marginata*) and many species in the understorey. *Banksia grandis*, which can be a major component of the understorey, is very susceptible to *P. cinnamoni* and can be killed within months after infection. The death of banksia is usually very rapid. The response of jarrah to the fungus is variable: it can be gradual with the trees taking several years - if not a decade - to decline and die; or sizable areas of forest can decline and die in a matter of five to six weeks.

Of the many tasks facing the dieback researcher none is more troublesome than the early differentiation of those forest areas which are protectable from those which are highly susceptible to jarrah dieback. Dieback research requires a holistic approach: all components of the system from the pathogen, through the components of the natural landscape, to the host plants themselves have to be studied (See Table 7 page 24).

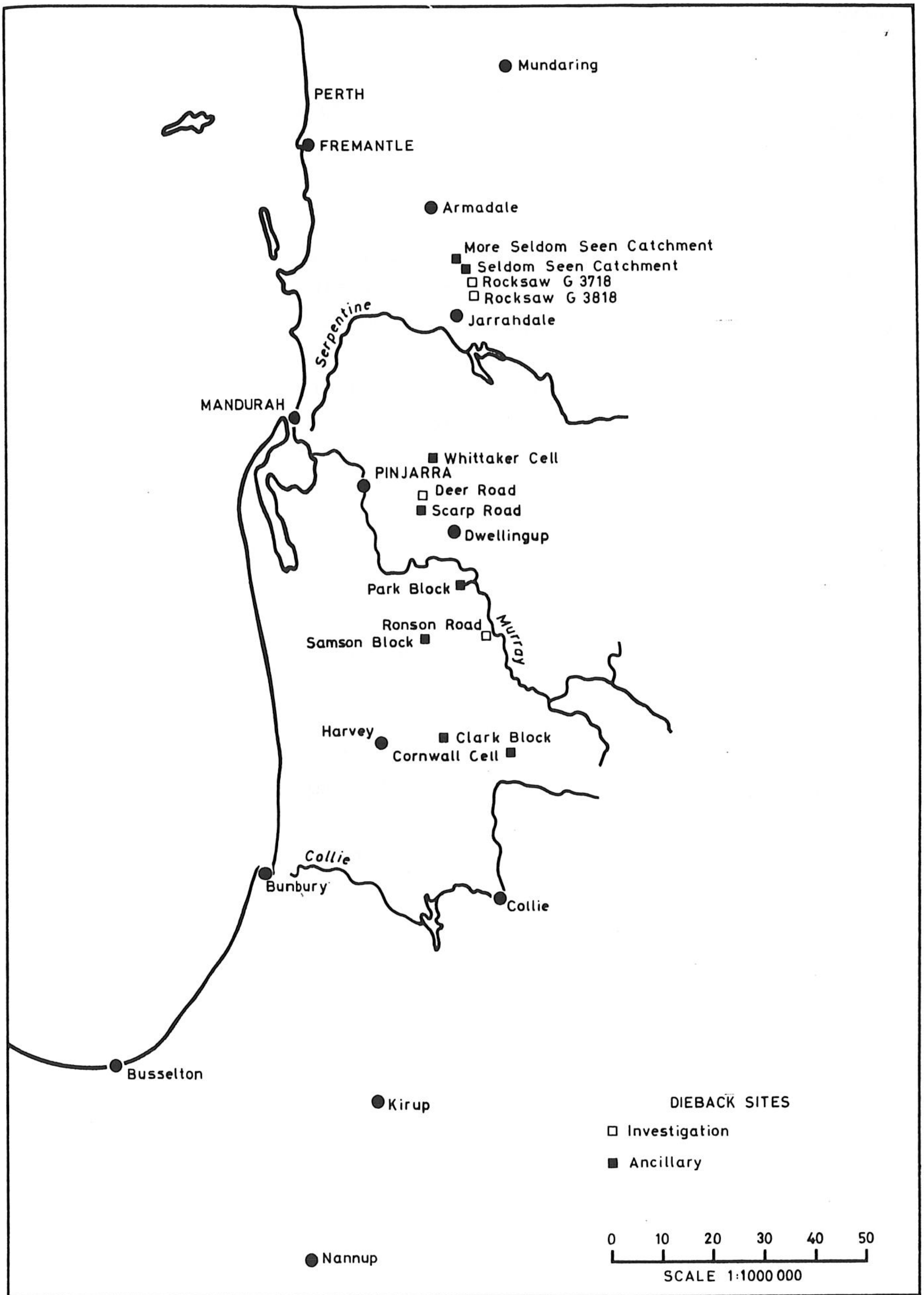
This jointly authored report examines the apparent relationship between laterite geology and jarrah dieback. Two sources of information are used:

(i) Observations from dieback investigation sites (Section 4).

(ii) Observations from sites elsewhere in the Jarrahdale-Harvey region (Section 5).

A total of 14 sites is involved. Figure 1 shows their location.

The report also explains of the mapping method used in the present investigation and suggests further studies in this area (Section 3).

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SITE LOCATION

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FIGURE 1

To accompany Laterite Geology and Jarrah Dieback Report.

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It should be remembered that many of the conclusions reached in the report are speculative. In some instances they amount to little more than intelligent guesses. This is in keeping with the stage reached in this part of the dieback research programme.

## 2. BACKGROUND

The development and spread of dieback at the Deer Road dieback research area, northwest of Dwellingup has been recorded for over twelve years. Not only areas of long established dieback have been studied but also stands of healthy jarrah. Some of the latter have been inoculated with the jarrah fungus as part of a controlled experiment to monitor the effects of the disease. The response of the jarrah to the disease has been variable. The disease pattern was difficult to explain until further more detailed sampling was carried out over individual test plots in severely-affected forest.

In May 1982, Dr Shea, discovered the Pc (Phytophthora cinnamoni) zoospores were very abundant, deep in the soil layer just above the lateritic caprock. This concentration was in contrast with the absence of zoospores in the upper soil layers (See Figure 16). Further experiments with introduced zoospores revealed that movement of water over the surface of the caprock played a major part in the subsurface lateral spread of the zoospores. The pattern of clefts and depressions in the surface of the caprock offered clues to the behaviour of Pc in upland sites. Furthermore it was discovered that zoospores were able to attack the vertical root system of the jarrah. The habitual presence of a hard, sheet-like caprock layer in such dieback affected sites looked to be promising for use as a broad indicator of dieback susceptibility.

The results of the preliminary investigation will be published (Shea et al 1983). Additional areas of lateritic caprock were exposed at Deer Road. The work was then extended to an area of massive and sudden decline and death of jarrah at Ronson Road. There, too, the lateritic caprock layer was found to be associated with severely affected jarrah. Additional areas of caprock were examined at two sites at Jarrahdale making use of a rocksaw machine under trial for Alcoa. At this stage the Forests Department contacted the Geological Survey for advice and assistance.

## 3. METHOD

Darling Range laterite is derived from the in situ weathering of granitic rocks (e.g. granite, granitic gneiss, migmatite) and basic rocks (e.g. dolerite, amphibolite, metabasalt). The lateritic caprock preserves enough of the relict texture of the original rock to serve as a reliable guide to the underlying bedrock geology. Also laterite weathered from granitic rocks is high (e.g. 20%) in quartz content while the weathered derivatives of basic rocks are largely devoid of quartz.

Geologists mapping the geology of the Darling Range have been able to make use of lateritic caprock exposures to locate the boundaries of lateritised rocks. Dolerite dykes in particular need to be delineated because these affect chemical grades of bauxite pits and they are the sites of deep weathering and potential seepage. Depending on their size and occurrence in the landscape, dolerite dykes - both fresh and lateritised - have effects on groundwater hydrology. Therefore it is important to include the delineation of dolerite dykes in any type of site investigation.

Table 1 summarises the method. It incorporates material used since 1958 together with additional information gathered as part of the present assignment.

TABLE 1

MAPPING THE GEOLOGY OF FOREST AREAS

1. Study area defined by catchment boundaries.

2. Traverse from interfluve (crest) to lower slope and stream.

3. Make initial observations at 30 m intervals and increase density of observations at changes in slope.

4. At each observation point record:

    (a) SOIL

    Clay Sand Loam Gravel
    - Subdivided gravel into fine, medium, coarse
    - Note predominance of ferruginous gravel
    - Note presence of rock floaters at base of large trees
    - Caution with regard to soil creep
    - Note surface processes e.g. erosion deposition, evidence of overland flow.

    (b) ROCK

    Bedrock - granite
    - dolerite

    Laterite
    - Ferruginous pisolitic in situ or recemented
    - Fragmental quartz rich: lateritised granite
    - Fragmental and iron rich: lateritised dolerite
    - Shape of outcrop: blocky, flat/tabular
    - Surface of outcrop: broken, smooth; differentially weathered; or endurated

5. Make connection traverses to map more significant areas.

A preliminary terminology for the other features of the lateritic caprock exposure is suggested. The removal of overlying soil layers has revealed a previously overlooked pattern of alternating surfaces, depressions and accumulations. Another dimension has been added to the mapping of laterite. More work on the terminology is obviously needed. However at this stage all that is necessary of the observer is to record his first impressions. Later on some details will be discarded or new terms coined.

Three elements are clearly important: the morphology (or form) of the caprock; the presence or absence of pisolitic ferruginous caprock; and the origin of the caprock exposure (e.g. in situ granitic or doleritic rocks; or transported). All three elements can be understood in relation to the catena (Latin for chain). Using the catena the relationships between slope components can be translated to the catchment.

The first set of observations made for each caprock exposure (e.g. outcrop, boulder, floater) is about its texture and mineralogy. Table 2 provides a code for these observations.

TABLE 2

CAPROCK TEXTURE AND MINERALOGY

| | MINERALOGY | | | |
|---|---|---|---|---|
| | Gibbsitic | Ferruginous | Clayish | Earthy |
| TEXTURE | | | | |
| Pisolitic | Pg | Pf | Pc | Pe |
| Fragmental | Fg | Ff | Fc | Fe |
| Massive | Mg | Mf | Mc | Me |
| Tubular | Tg | Tf | Tc | Te |

Abundant quartz: Q

Not all of these types will be found at any one location. In time, with practice, it is possible to reduce the series into three fundamental types:

(i) Laterite from granitic rocks
(quartz common or abundant)

(ii) Laterite from doleritic rocks
(quartz rare)

(iii) Pisolitic ferruginous laterite
(quartz may be present)

This has been the approach taken in the figures prepared as part of the description of the investigation and ancilliary sites (e.g. Sections 4 and 5). That is, the geology has been simplified to focus the reader's attention on the main issues.

For example, the distribution of pisolitic ferruginous laterite vis a vis other caprock types in the catena could mean that the drainage at a particular point in the slope is predominantly lateral because the vertical channels have been closed off. The observer has to be alert for sizable areas of Pf (pisolitic ferruginous) (or the "spotted dog" of Dr Shea's terminology).

Iron is the main cementing medium for all types of lateritic caprock. It is the maghemite phase of iron that is of immediate interest. It is mobile and probably represents one of the closing stages of iron deposition and, hence, laterite formation.

Where the caprock is mixed the observer simply records the relative amounts. Usually it is sufficient just to state P/Fg for a mixed Pisolitic and Fragmental Gibbsitic caprock. The observer has always to make intelligent decisions as to the principal features of the exposure. The objective is to gain an insight into the important elements and not to become overwhelmed with detail. The code is there as a shorthand to aid in communication. If the exposure defies an initial attempt to codify it then the description is written in full; and, for really unusual examples, a specimen is collected for later verification.

The observer then takes stock of the other features of the caprock. Removal of the soil as part of a site investigation should not remove from the observer's mind the indisputable fact that, eventually, the same insight into laterite geology has to be gained from viewing forested areas. In other words, there has to be a continual interplay between what can be seen at the washed down slot and the adjoining undisturbed forest with its meagre display of laterite. The challenge is to find diagnostic features which are observable under natural conditions.

Table 3 provides a general list of points to be observed in addition to texture and mineralogy. It is not exhaustive. More work will find new features and discard non-essential elements.

TABLE 3

OTHER CAPROCK FEATURES

| | |
|---|---|
| EXPOSURE: | Outcrop, disturbed outcrop, boulder, floater (e.g. small boulder) |
| SURFACE: | rough, smooth, differential weathering |
| HARDNESS: | endurated, friable, soft |
| DEPRESSIONS: | shallow, deep; pot hole, basin, root hole; parallel, transverse, braided |
| COMPOSITION: | uniform, mixed (or heterogeneous) recemented |
| OUTCROP: | blocky, flat |

Ideally these geological observations will be matched with notes on man's effect on the site (e.g. logging, fire, tracks) understorey and overstorey vegetation (its health or mortality) soil types and slope gradient. Once again these data are related to the catena and from the catenas to the catchment. This sequence is required in order to extrapolate site specific results into other geologically comparable areas. It also goes a long way in explaining the role of geomorphological processes. These, with or without man's interference, determine the environmental geology of the site and consequently the site's capability to promote or hinder the spread of jarrah dieback. Viewed in this way laterite geology can act as a broad indicator of what to expect and, as a consequence, where to locate hydrological bores and dieback test plots. Ultimately it could be instrumental in determining how to manage the forest in a specific area.

The vegetation mapping system of Havel has a substantial substantial geomorphic base. It may be possible to subdivide the P and S units of that system on the form of the hillslope. For example the presence of a depositional mantle at the base of laterite slopes is an indication of hillslope stability. Conversely a breakaway or bedrock exposure would indicate erosion.

Connacher and Dalrymple (1977) have developed a nine unit land surface model. Each component of the hillslope from crest (or interfluve) to stream line is given an identifying number. The model embraces both form and process. Table 4 provides abbreviated definitions of the component units. Figure 2 illustrates the spatial pattern implied by the model.

An average slope on the western Darling Range would have components 1, 2, 5, 6, 7 while in the extreme east the slope components could be 1, 4, 5, 6, 7 i.e. surface wash and rock fall are dominant. This model could be applied to the investigation and allied to Havel's system to provide a means of extrapolating data.

This is only a suggestion. In Section 4 the hillslope has been divided into a series of zones rather than landsurface units. Additional on site work is required before the zones can be classified into land surface units.

TABLE 4
NINE UNIT LAND SURFACE MODEL

| Land surface Unit | Abbreviated Definition |
|---|---|
| 1 | Interfluve, with predominant pedo-geomorphic processes being those resulting from vertical (both up and down) soil-water movements |
| 2 | Responses to mechanical and chemical eluviation by lateral subsurface soil-water movements either predominate or serve to distinguish this unit from other units on the catena |
| 3 | Convex slope element where soil creep is the predominant process producing lateral movement of soil materials |
| 4 | Slope greater than 45$^{o}$ characterised by the processes of fall and rockslide |
| 5 | Response to the transportation of a large amount of materials downslope, relative to other units, by flow, slump, slide, raindrop impact, surface, wash, and man's cultivation practices |
| 6 | Response to colluvial redeposition from upslope |
| 7 | Response to redeposition from upvalley of alluvial materials |
| 8 | Channel wall, distinguish by laterial corrasion by stream action |
| 9 | Stream channel bed, with transportation of materials downvalley by stream action being the predominant process |

From Conacher and Dalrymple (1977)

# NINE UNIT LANDSURFACE MODEL AND THE CATENA

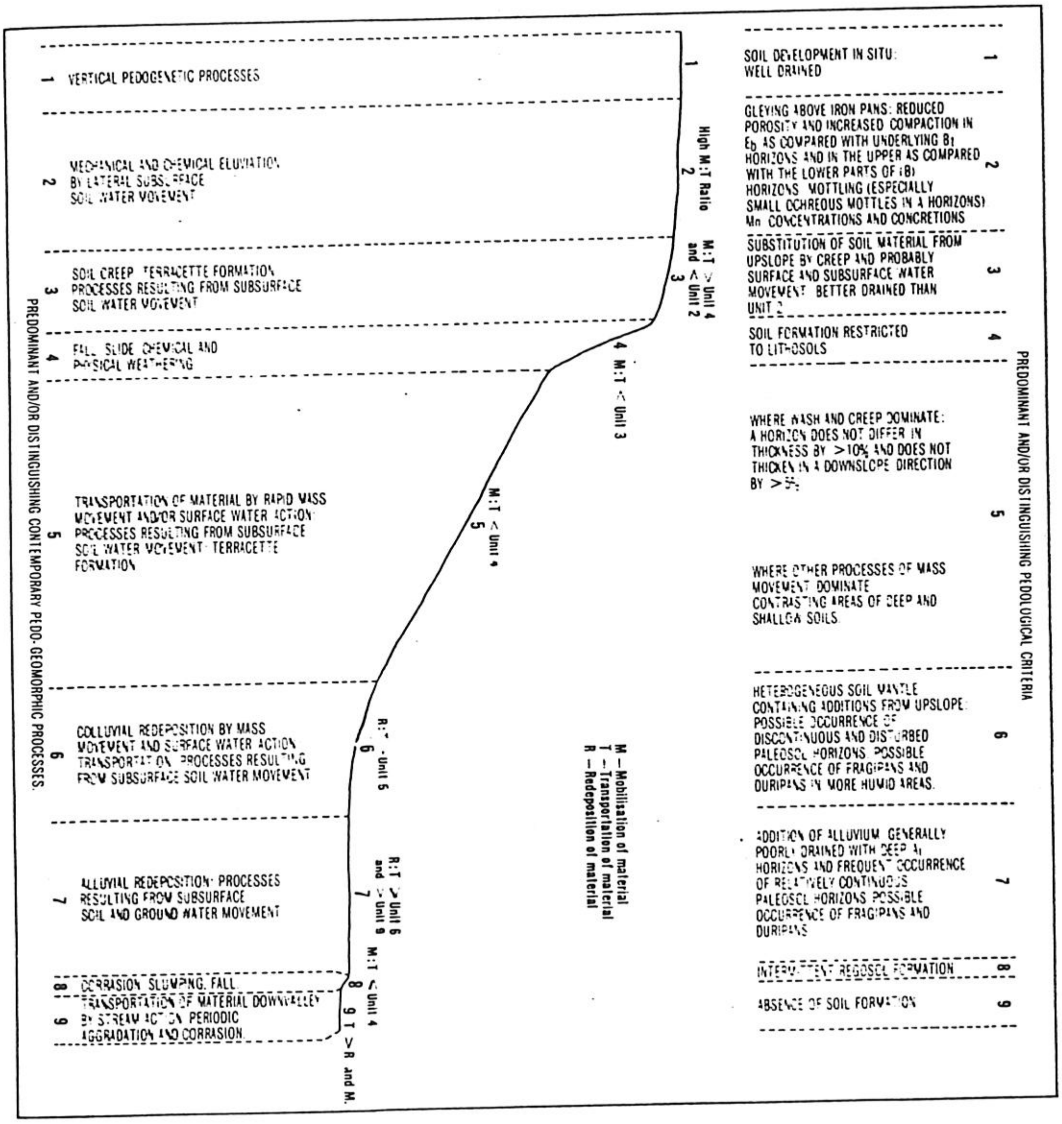



Figure 2

## 4. INVESTIGATION SITES

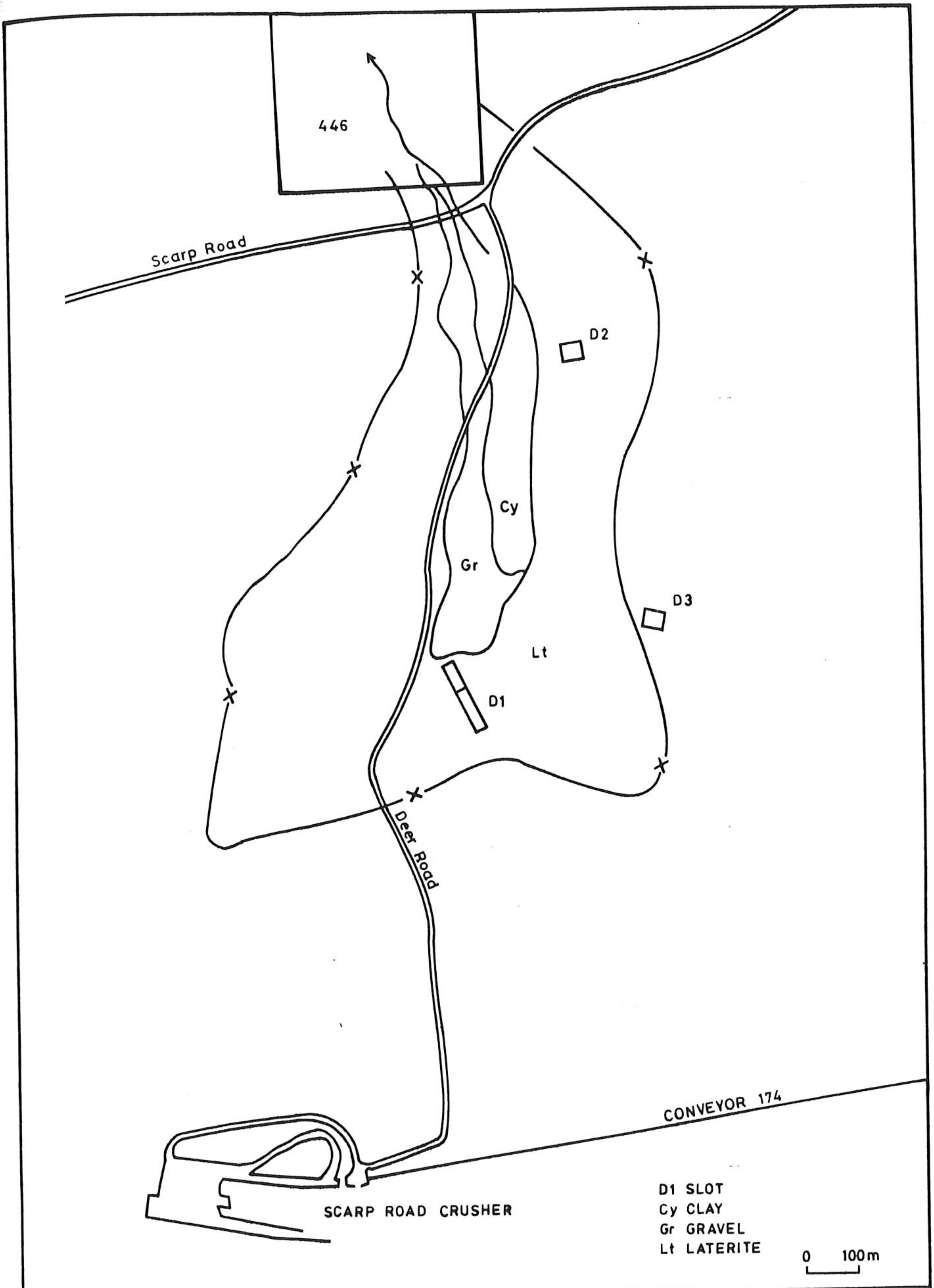
Data from four sites is presented. Two sites (e.g. Deer and Ronson Road) have shallow backhoe trenches and wash down slots; two have deeper trenches cut by a rocksaw machine (hence the designation Rocksaw G3718 and G3818). In each case the main features of the laterite geology and forest are given.

### 4.1 DEER ROAD

The Deer Road dieback research area is a small, west facing catchment 8 kilometres (km) northwest of Dwellingup. It is located just above the Darling Scarp. Dieback has been present in the valley for decades. The forest on parts of the ridge has been purposefully infected by Pc (Phytothora cinnamoni) with variable results. As mentioned in the background section the area has been studied for years and finally yielded another clue to understanding and combating jarrah dieback, namely the part played by lateritic caprock.

Three plots (e.g. D1-D3) have had their soil layers removed. It was at D3 that the discovery was made that the spread of Pc - both laterally and vertical - is controlled by the presence and nature of the lateritic caprock horizon. D1 is located in healthy jarrah forest; D2 in forest innoculated by Pc; D3 in severely dieback affected forest.

All three sites occur in the middle to upper slopes of the laterite ridge. Figure 3 shows their location and the general geology of the catchment. Ferruginous laterite and laterite weathered from dolerite predominates on the western and southern slopes and pases abruptly into the bauxitic laterite of the northern and eastern slopes. This is fairly typical of areas close to the escarpment.

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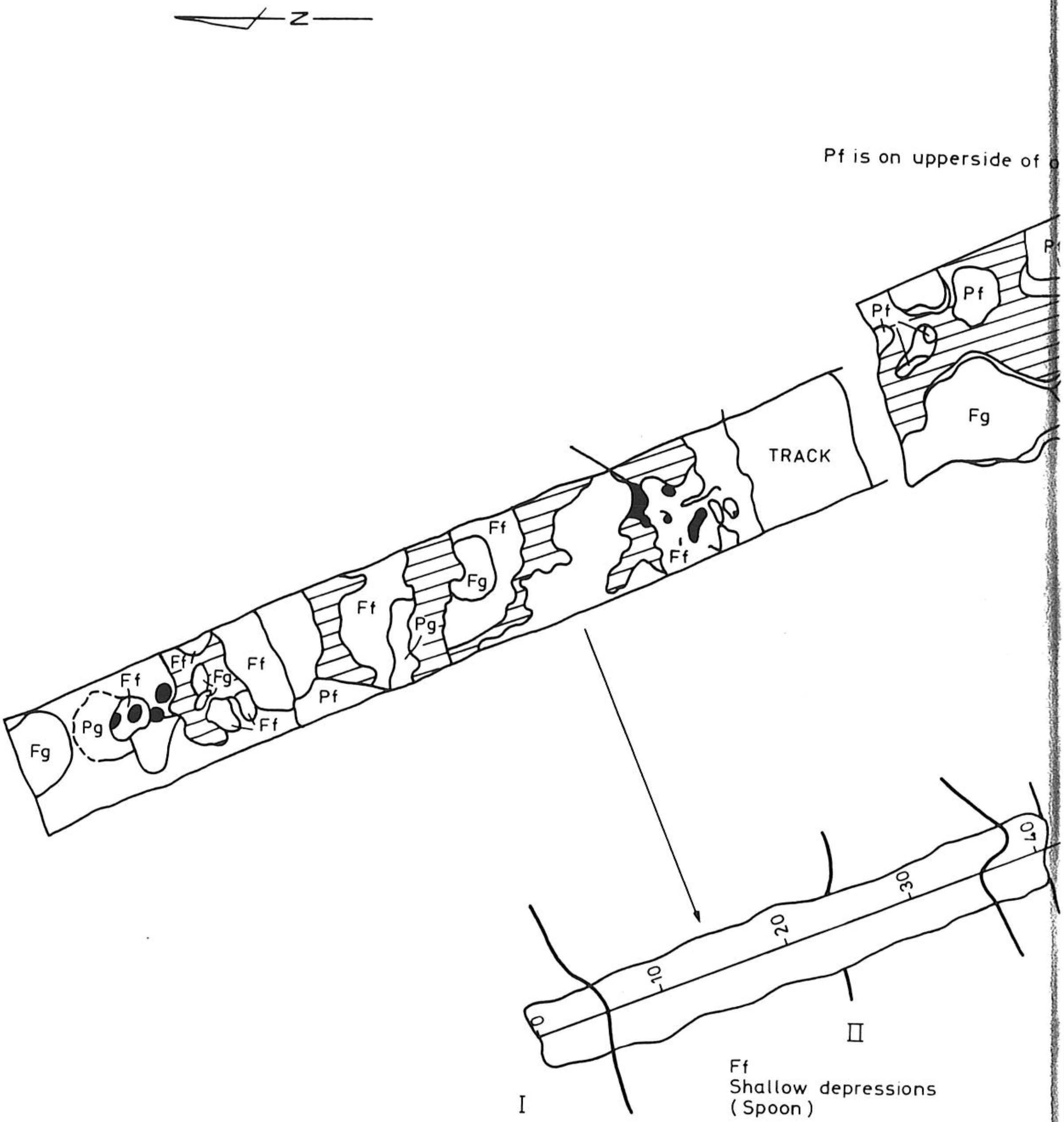
| DRAWN | MK | NOV 83 | | |
| CHKD | AJS | NOV 83 | | FIGURE 3 |
| APVD | AJS | NOV 83 | To accompany Laterite Geology and Jarrah Dieback Report | 21 101 |

Figure 4 is a plan view of Dl. The top end of the slot adjoins one of Alcoa's bauxite pits (e.g. D4723) while its lower end grades into pisolitic laterite and gravelly loam. Altogether an area of 8 by 120 metres has been laid bare.

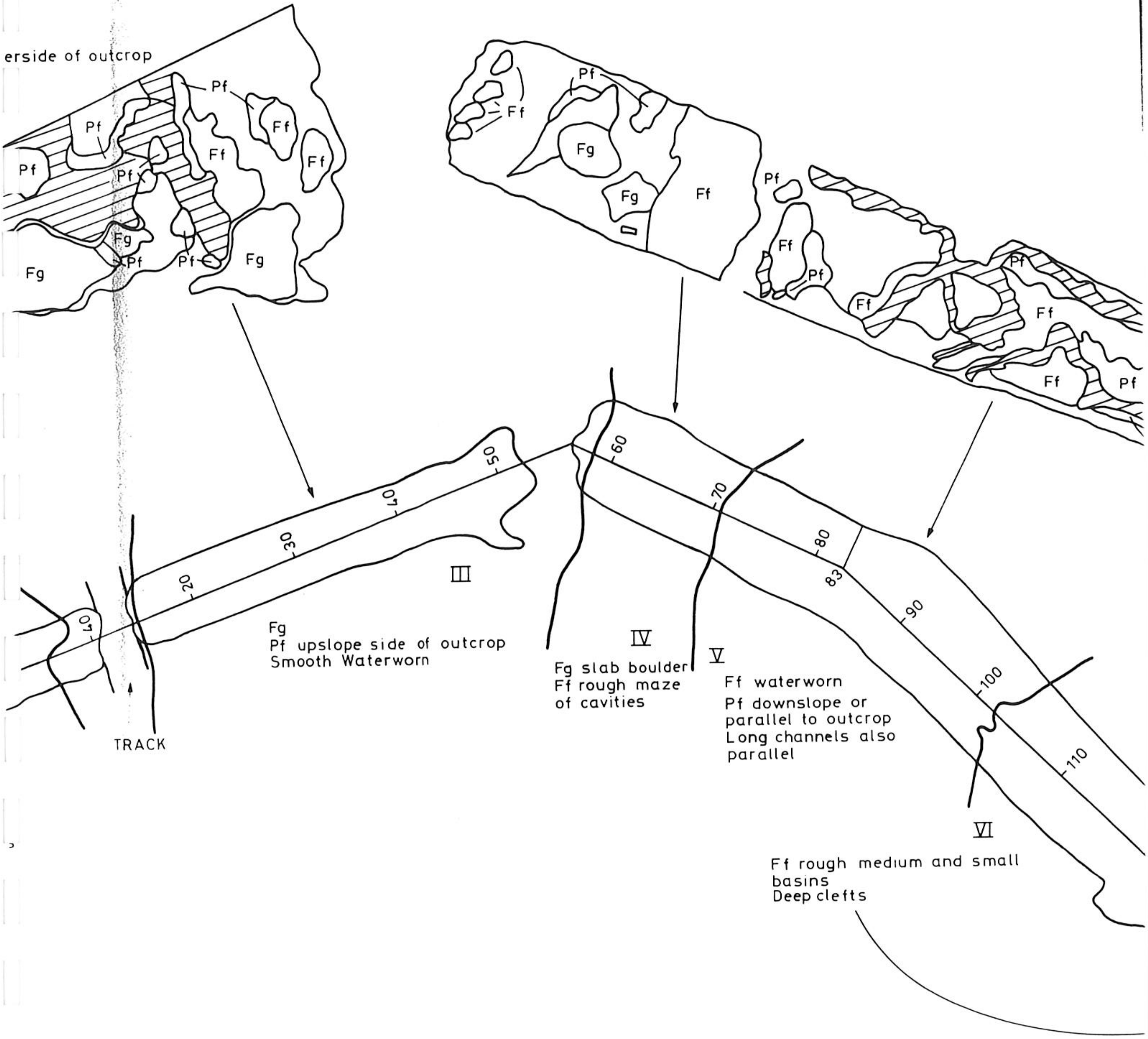
The lateritic caprock of Dl is derived from dolerite. There are only two small areas of laterite of granitic origin (e.g. at 7 m and 85 m). The main features of the slot is the occurrence of pisolitic ferruginous caprock (e.g. Pf), the caprock surface and depressions. Using these parameters it has been possible to divide the slot up into 6 zones (see Figure 4) and then to postrate the behaviour of water moving through the soil, over and into the upper part of the lateritic profile.

The caprock of Zone I has deep (e.g. 0.25 m) clefts and a rough surface water would readily penetrate through the clefts and would not be retained very long. Zone II's caprock has shallow "spoon shaped" cavities which are partially plugged by accumulations of Pf (pisolitic ferruginous caprock). The orientation of the root cavities is across the slope and they appear to connect with a cluster of verical root holes. An interesting feature is the deposition of iron around the collars of the root holes. This is mainly maghemite as evidenced by its mild magnetism. It appears likely that water could be held for a few days then flow across slope until encountering one of the vertical root holes. Some water probably flows down the slope around the 35 m mark and this penetrates the caprock just above the track. (Bulldozing of the track may have disrupted the surface and obscured the true nature of events.)

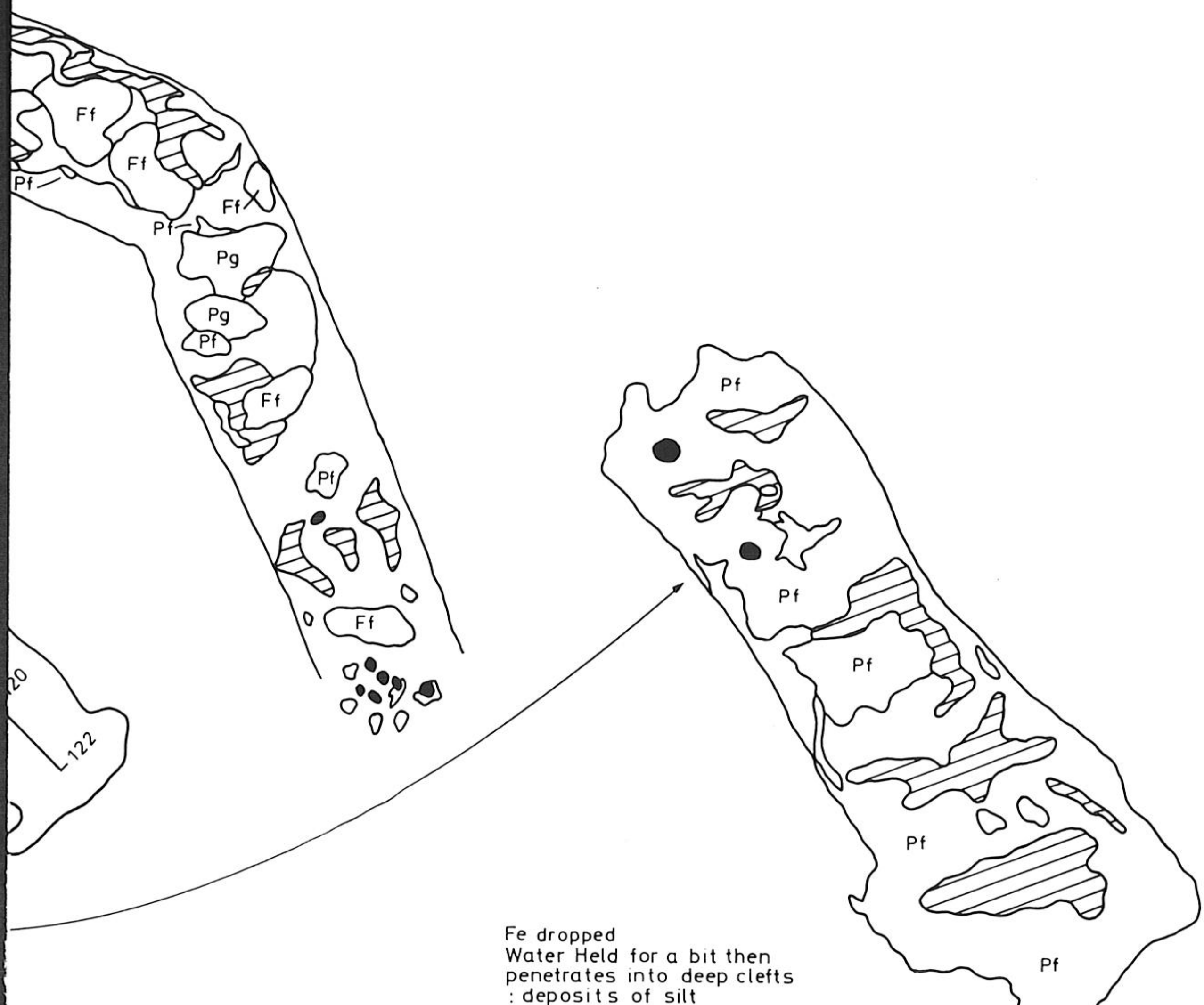
Zone III is characterised by caprock which has less iron (e.g. Fg) and a smooth (waterworn?) surface. Pf is present and occurs mainly on the upslope side of the caprock i.e. in the very position one would expect deposition of iron to occur as the result of water action. Leached iron



N
Pf is on upperside of o
Pf
Pf
Fg
TRACK
Ff
Ff
Fg
Ff
Pg
Ff
Ff
Fg
Ff
Pf
Ff
Pg
Fg
0
10
20
30
40
I
II
Ff
Shallow depressions
(Spoon)



erside of outcrop
Pf
Ff
Fg
III
Fg
Pf upslope side of outcrop
Smooth Waterworn
TRACK
IV
Fg slab boulder
Ff rough maze
of cavities
V
Ff waterworn
Pf downslope or
parallel to outcrop
Long channels also
parallel
VI
Ff rough medium and small
basins
Deep clefts




Comp
Drawn
Chkd
Apvd

| | GIBBSITIC | FERRUGINOUS | CLAYISH |
|---|---|---|---|
| PISOLITIC: | Pg | Pf | – |
| FRAGMENTAL: | Fg | Ff | – |

ENDURATED:

ROOTHOLE:

ROOTCHANNEL:

DEPRESSION:

0 10m

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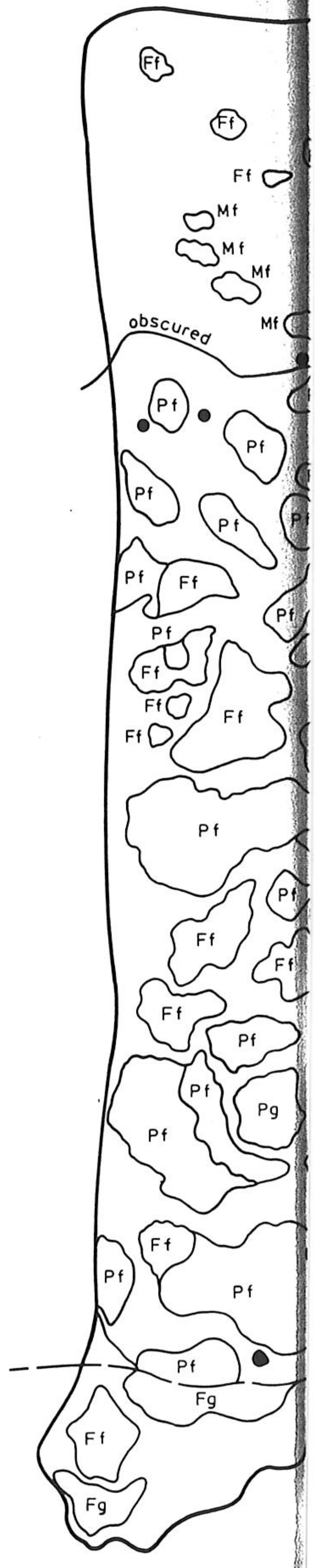
| Drawn | LJ | Nov 83 | SLOT D1 | |
| Chkd | AJS | Nov 83 | | FIGURE 4 |
| Apvd | AJS | Nov 83 | To Accompany Laterite Geology and Jarrah Dieback Report | 21102 |




| | GIBBSITIC | FERRUGINOUS | CLAYISH |
|---|---|---|---|
| PISOLITIC | Pg | Pf | - |
| FRAGMENTAL | Fg | Ff | - |
| MASSIVE | - | Mf | Mc |
| ROOTHOLE | ● | | |

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| Apvd | AJS | Nov 83 |

DEER ROAD
SLOT D2

To Accompany Laterite Geology and Jarrah Dieback Report

Map Index

FIGURE 5

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would be the cementing agent and iron pisolites would loose from above would form the nuclei. The boundary between Zone III and IV is sharp. In Zone IV Ff (Fragmental ferruginous) predominates and the surface of the caprock is rough and strewn by a maze of cavities. It is highly probable that the subsurface water penetrates the caprock.

Zone V has a smooth surface but this time the Pf is on the downslope side of the laterite blocks or occurs parallel to the orientation of the slot. Surface depressions occur as long channels and they are parallel to the slot.

Thus the association between channels and Pf deposition is still apparent; but is the converse to that found at Zone III. Zone VI - in relative terms - is the more dramatic. The caprock has a rough surface characterised by small and medium basins, and deep clefts. The site is depositional. Iron rich solutions mobilised from upslope are brought to the soil/caprock interface by water flow across the caprock surface (and possibly by water welling up from deeper in the profile?) and is held briefly before penetrating the caprock by way of the deep clefts.

D2 occupies a middle to lower position in the landscape. Figure 5 illustrates the geology of the slot. Once again it predominantly derived from the lateritisation of dolerite. The jarrah shows little response to the presence of Pc while the banksia has been eliminated. The central portion of the slot is a series of Pf (Pisolitic ferrunginous) and Ff (Fragmental ferruginous) caprock. Each exposure is separated from its neighbour by cavities.

The Pf occurs as mushroom shaped plugs (or accumulations) in its own right or as a veneer over Ff. The lower part of this middle zone is heterogeneous which indicates some secondary mobilization and deposition of maghemite. The plugs present an impervious surface probably diverting water into the clefts. The Ff caprock presents a rough, clefted and endurated surface.

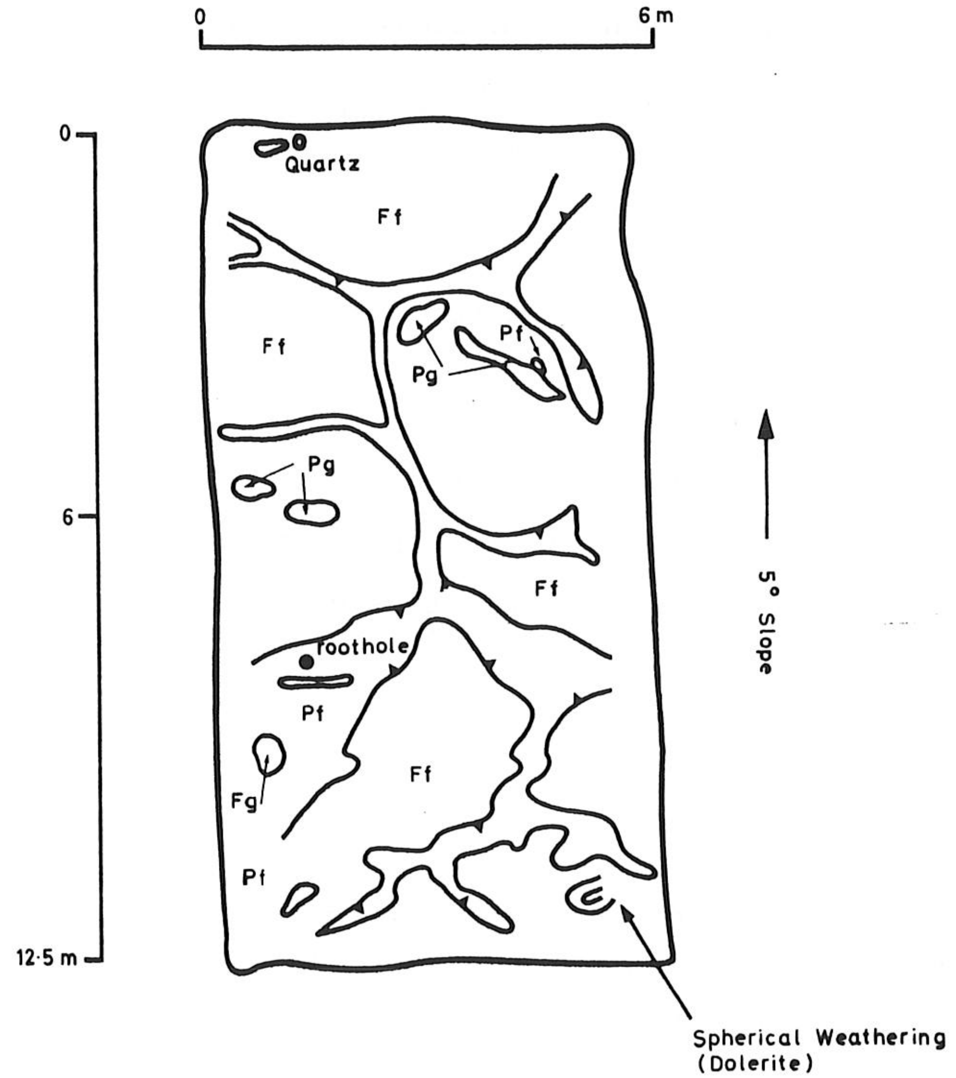
Upslope from the central portion (e.g. Zone II) the caprock is earthy and the general impression is that deep clefts are also present. Downslope the Pf gives way to Ff.

The interpretation of these observations is that D2 is a quickly drained site. Water can readily infiltrate through the cavities separating the exposures and the deep clefts within the Ff caprock. In many ways D2's Zone II has similarities to Zone VI of D1. Both have an abundance of Pf. It could be postulated that the introduction of Pc zoospores to D1 would also result in the death of banksias, but would leave the jarrah relatively untouched.

D3 slot has a stock work of interconnecting depressions and root channels. (See Figure 6) The caprock is predominalty Ff (Fragmental ferruginous) with discrete areas of Fg (Fragmental gibbsitic) caprock. Each exposure is separated by deep clefts: these accumulate water and then allow it to penetrate. Ff caprock predominates and it is endurated and show some signs of water action. Spheroidal weathering is present which confirms the doleritic origin of the caprock.

The deep clefts are, at present, ladened with fine soil; but, during washing operations, it was observed that they narrowed with increasing depth. It is interpreted that, under natural conditions, the water moving through the soil is held for a few days then slowly escapes down through the clefts.

In summary: of the three sites at Deer Road: D1 and D2 exhibit quick drainage characteristics, while D3 is a slow draining site. Table summarises the main features observed at each site.




| | GIBBSITIC | FERRUGINOUS | CLAYISH |
|---|---|---|---|
| PISOLITIC | Pg | Pf | - |
| FRAGMENTAL | Fg | Ff | - |
| MASSIVE | - | Mf | Mc |

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DEER ROAD

SLOT D3

Map Index

FIGURE 6

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To accompany Laterite Geology and Jarrah Dieback Report.

TABLE 5
MAIN FEATURES OF DEER ROAD SITES

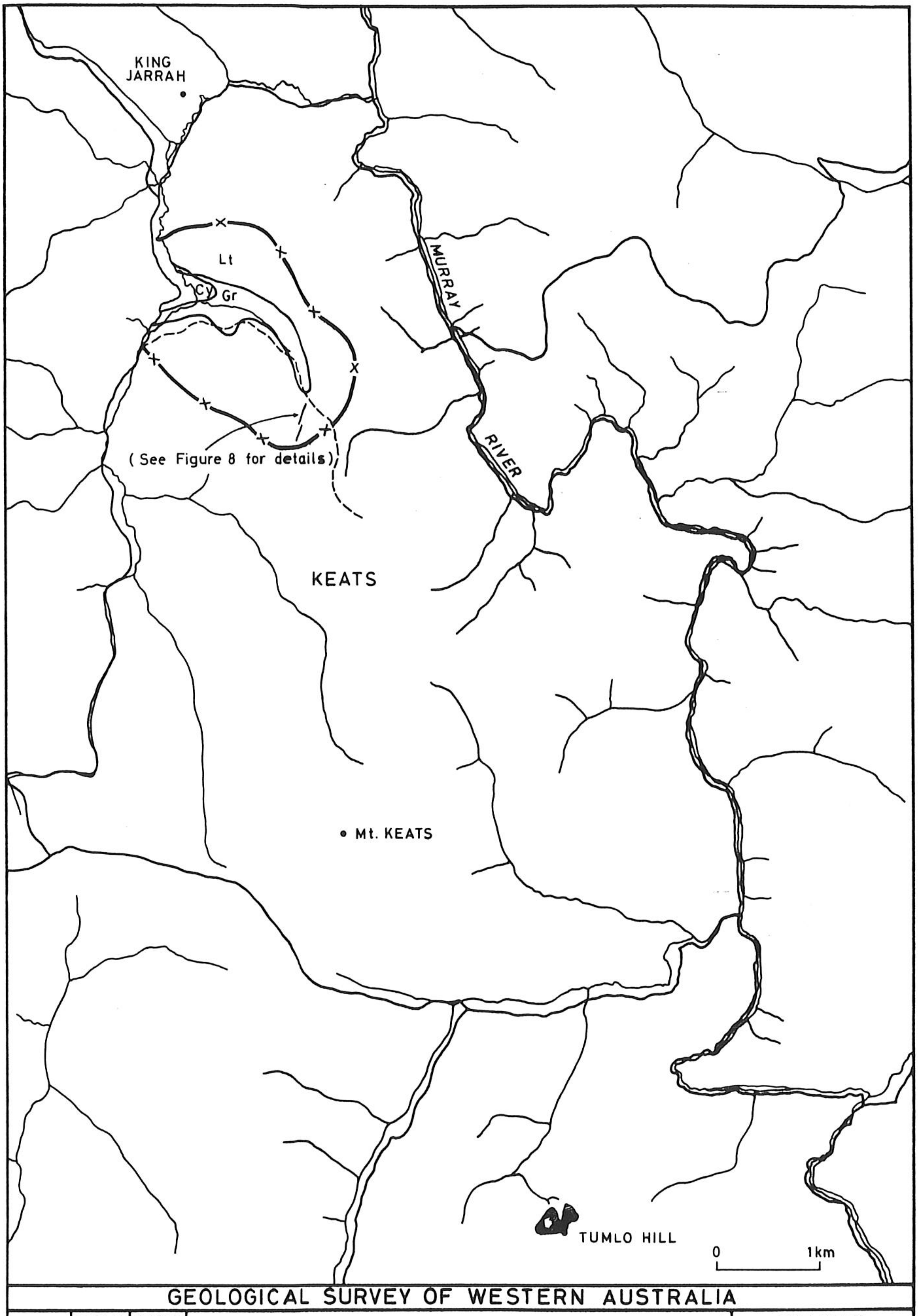
| SLOT | ZONE | CAPROCK TYPE | SURFACE | CLEFTS | ROOT HOLES | FLOW |
|---|---|---|---|---|---|---|
| D1 | I | Fg | Rough | Deep | - | Vertical |
| | II | Ff & Pf | Rough | Shallow, extensive | Common | (Lateral) Vertical |
| | III | Fg & Pf | Smooth | Shallow, localised | Rare | Lateral |
| | IV | Fg & Ff | Rough | Many cavities | Rare | Lateral |
| | V | Ff & Pf | Smooth | Long channels | Common | Vertical |
| | VI | Ff & Pf | Rough | Deep | Common | (Lateral) Vertical |
| D2 | I | Ff & Fe | Rough | Deep | - | Lateral? |
| | II | Ff & Pf | Rough | Deep | Common | (Lateral) Vertical |
| | III | Ff & Fg | Rough | Deep | - | Vertical |
| D3 | I | Ff | Smooth | Deep | Rare | Vertical |

Note: Pf (pisolitic ferruginous) caprock - the important characteristic to note is whether it show signs of reworking and recementation. If so it is possible that cracks in the caprock have been closed off.

## 4.2 RONSON ROAD

The Ronson Road study area is located 20 km southeast of Dwellingup. The area was selected for investigation because of the spread upslope of dieback and the rapid decline and death of jarrah. Two trenches were cut by backhoe: these trenches run from the crest of the ridge down to the slower slope. Three washdown slots were then established to expose the surface of the lateritic caprock occurring in the middle and middle to lower slope. Slope gradients range from 5 to 8 degrees.

Figures 7 to 10 show the general geology, site geology and catena respectively. The geology of Ronson Road can be divided into five zones. Table 6 summarises the main features.

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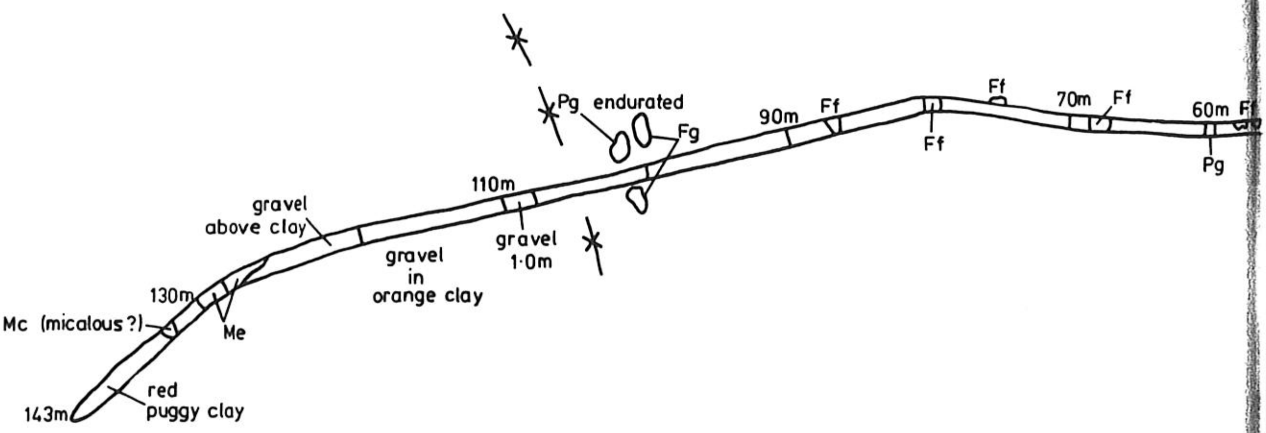
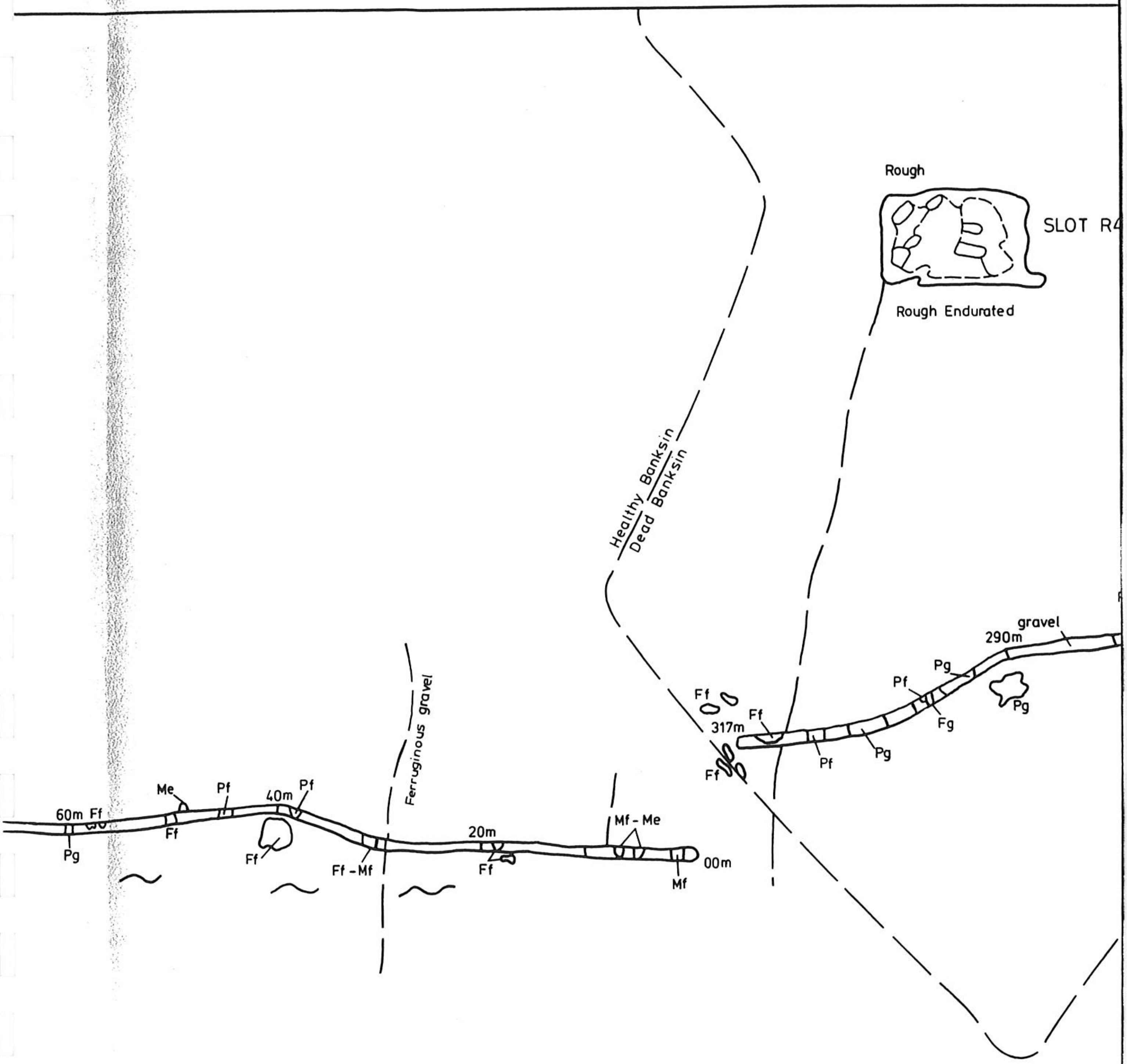
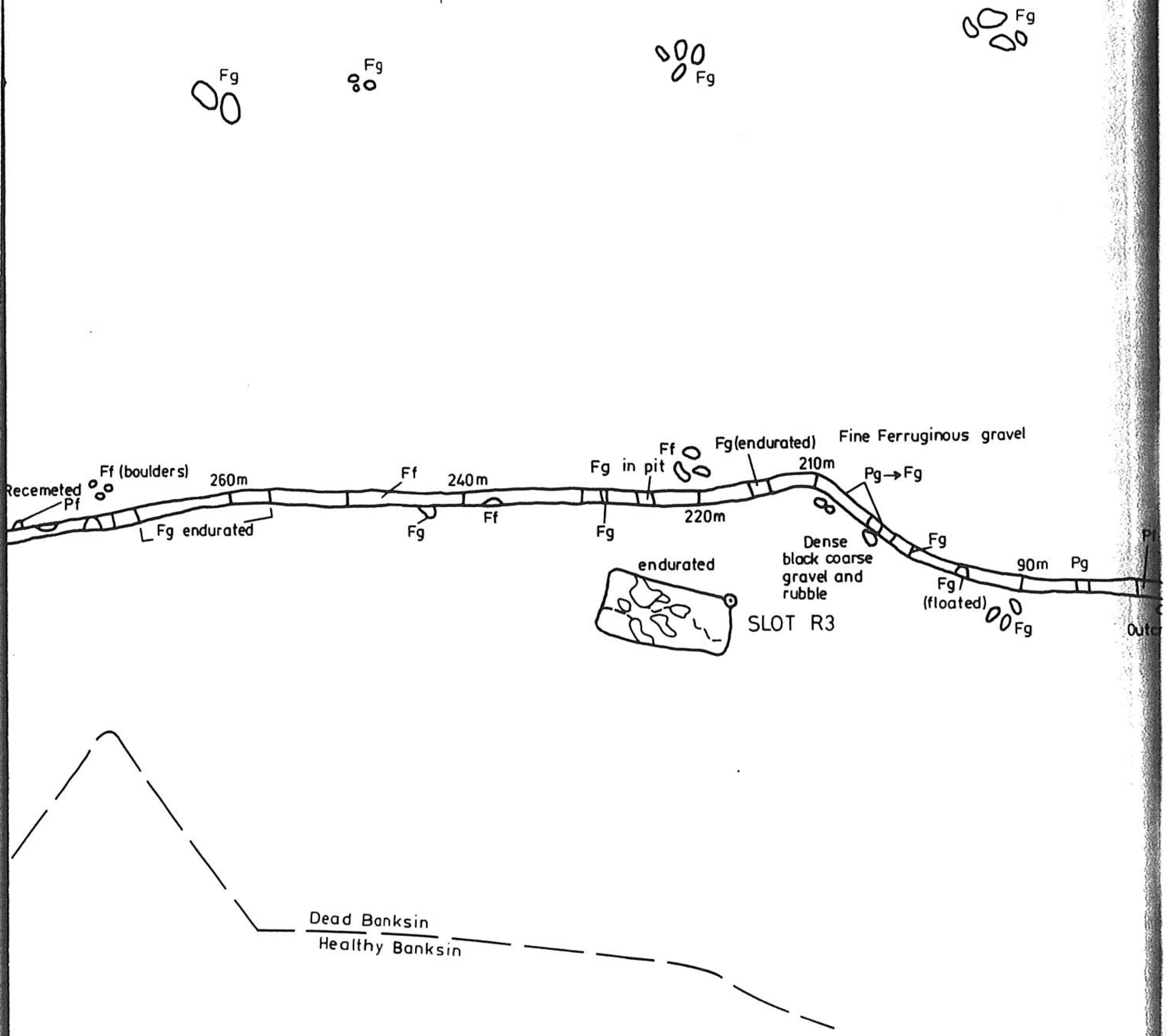
| DRAWN | LJ | NOV 83 | | |
| CHKD | AJS | NOV 83 | | FIGURE 7 |
| APVD | AJS | NOV 83 | To Accompany Laterite Geology and Jarrah Dieback Report | 21107 |



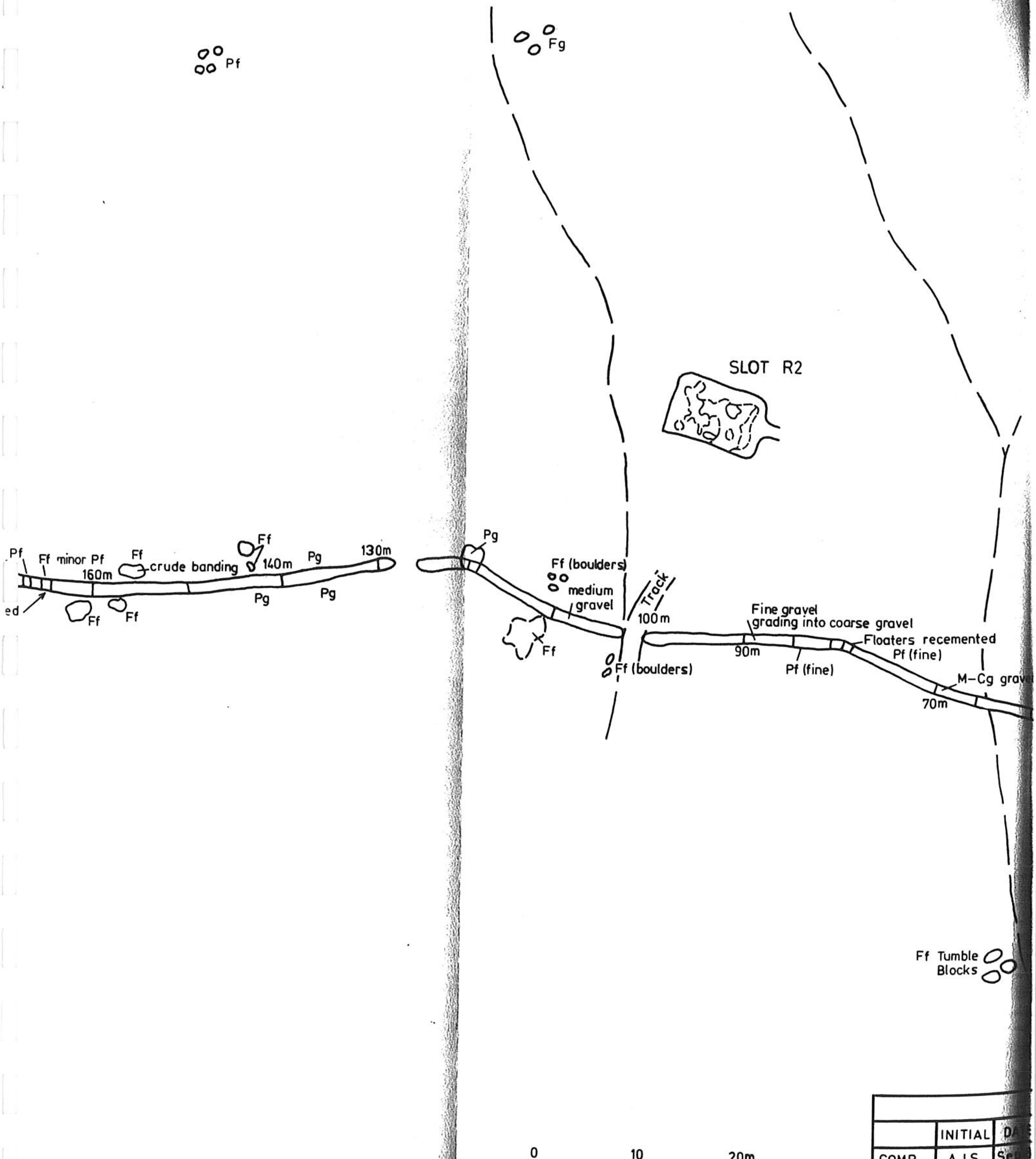
Pg endurated
Fg
90m
Ff
Ff
Ff
70m
Ff
60m
Ff
Pg
110m
gravel
above clay
gravel
1·0m
gravel
in
orange clay
130m
Mc (micalous?)
Me
red
puggy clay
143m



Rough
SLOT R4
Rough Endurated
Healthy Banksin
Dead Banksin
Ferruginous gravel
gravel
290m
Pg
Pf
Fg
Pg
Ff
Ff
317m
Pf
Pg
Ff
60m Ff
Pg
Me
Ff
Pf
40m
Pf
Ff
Ff - Mf
20m
Ff
Mf - Me
00m
Mf




| | GIBBSITIC | FERRUGINOUS | CLAYISH |
|---|---|---|---|
| PISOLITIC | Pg | Pf | — |
| FRAGMENTAL | Fg | Ff | — |
| MASSIVE | — | Mf | Mc |




| | INITIAL | DA |
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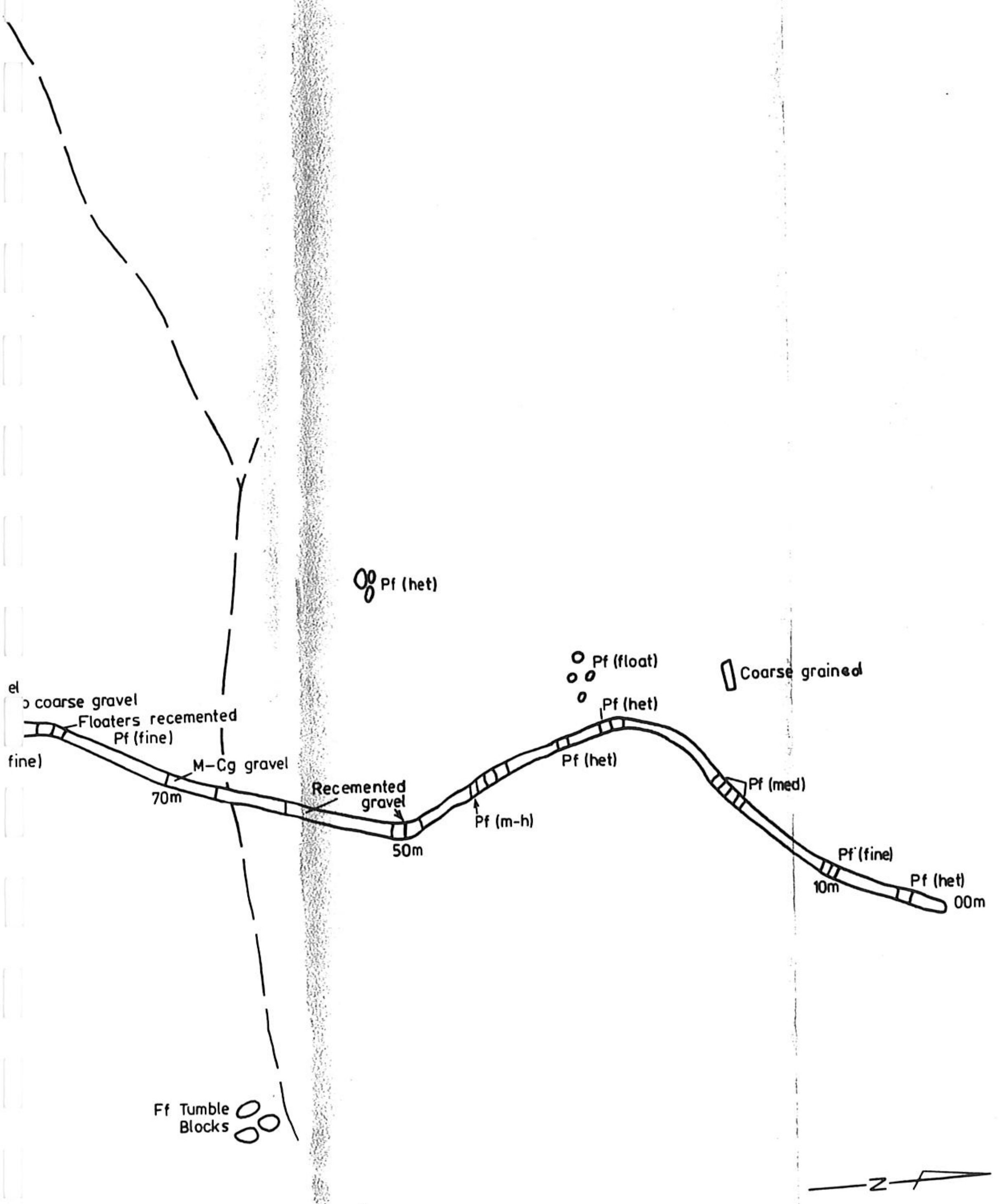
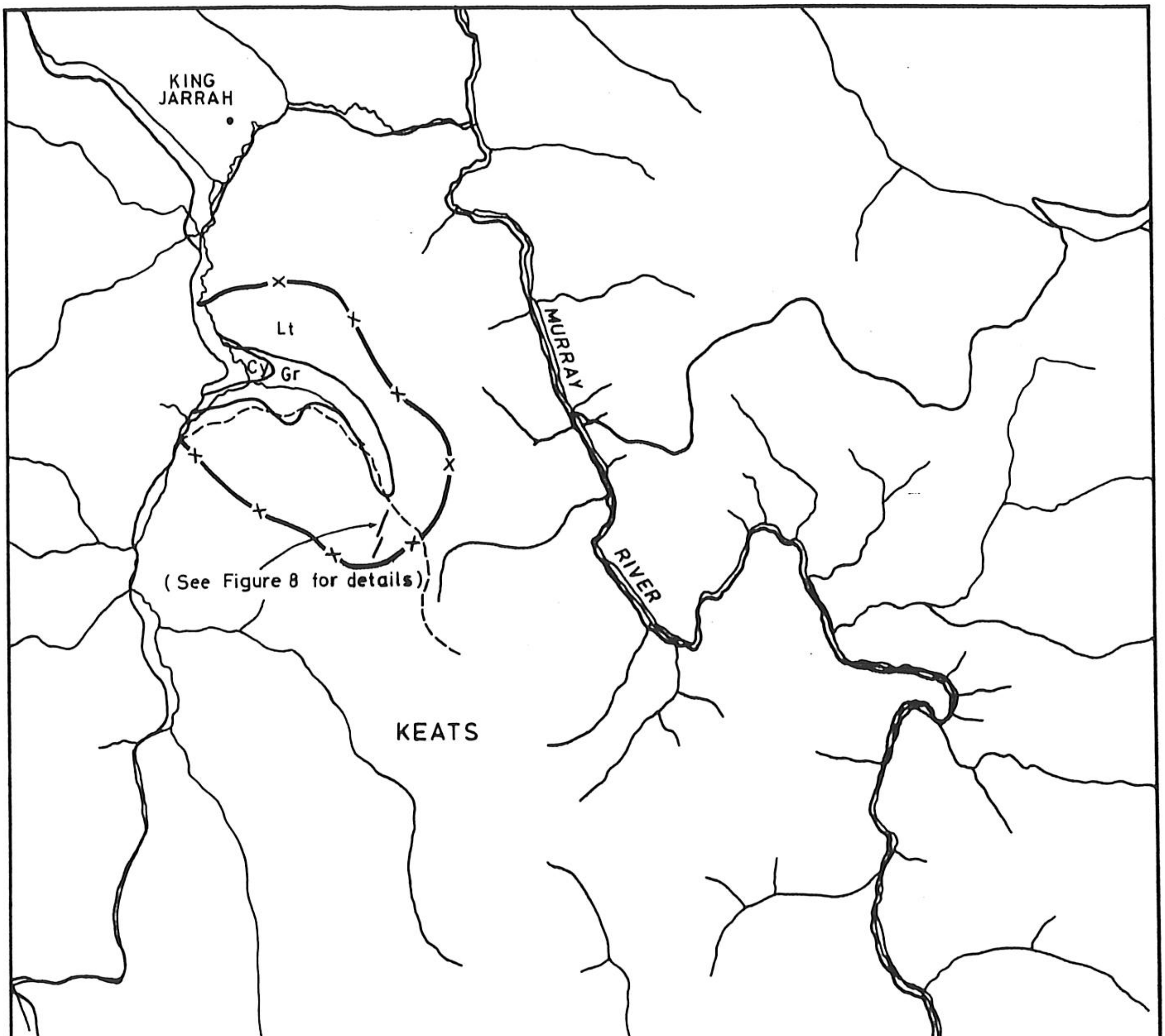
| COMP | A J S | Se |
| DRAWN | L J | Oct |
| CHKD | A J S | Nov |
| APVD | A J S | Nov |



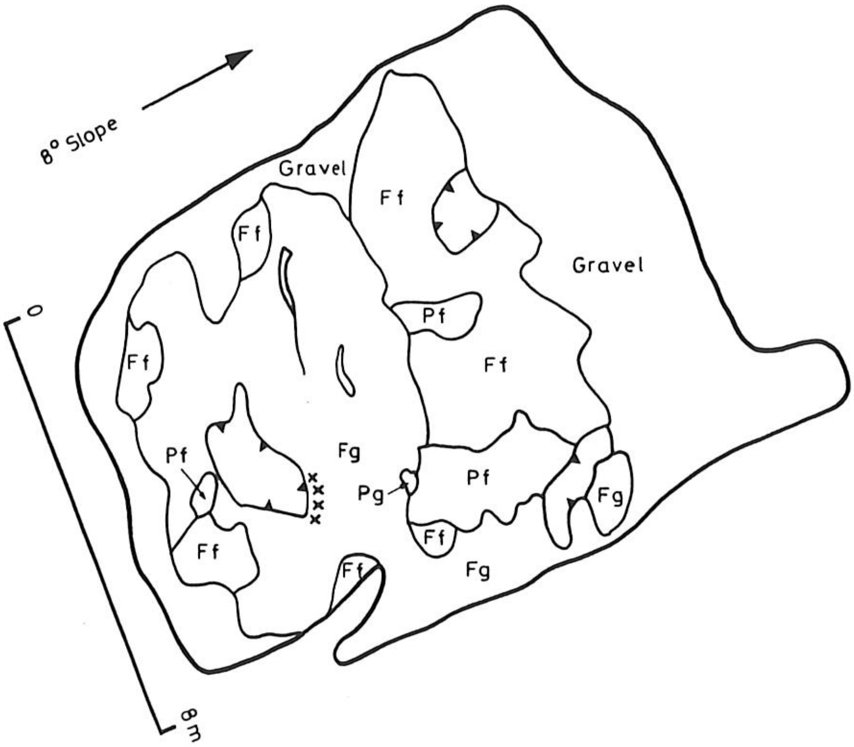

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

| | INITIAL | DATE | | |
|---|---|---|---|---|
| COMP | AJS | Sep 83 | GEOLOGY | MAP INDEX |
| DRAWN | LJ | Oct 83 | RONSON ROAD | FIGURE 8 |
| CHKD | AJS | Nov 83 | | 21106 |
| APVD | AJS | Nov 83 | TO ACCOMPANY Laterite Geology and Jarrah Dieback | |

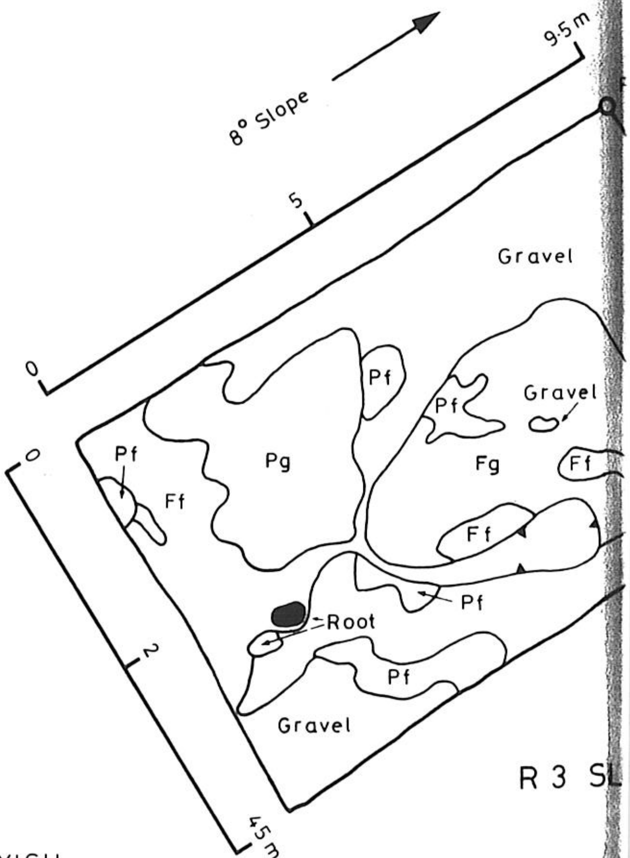



GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

| | INITIAL | DATE | | |
|---|---|---|---|---|
| COMP | AJS | SEP 83 | RONSON ROAD | MAP INDEX |
| DRAWN | LJ | NOV 83 | | FIGURE 7 |
| CHKD | AJS | NOV 83 | | |
| APVD | AJS | NOV 83 | To Accompany Laterite Geology and Jarrah Dieback Report | 21107 |

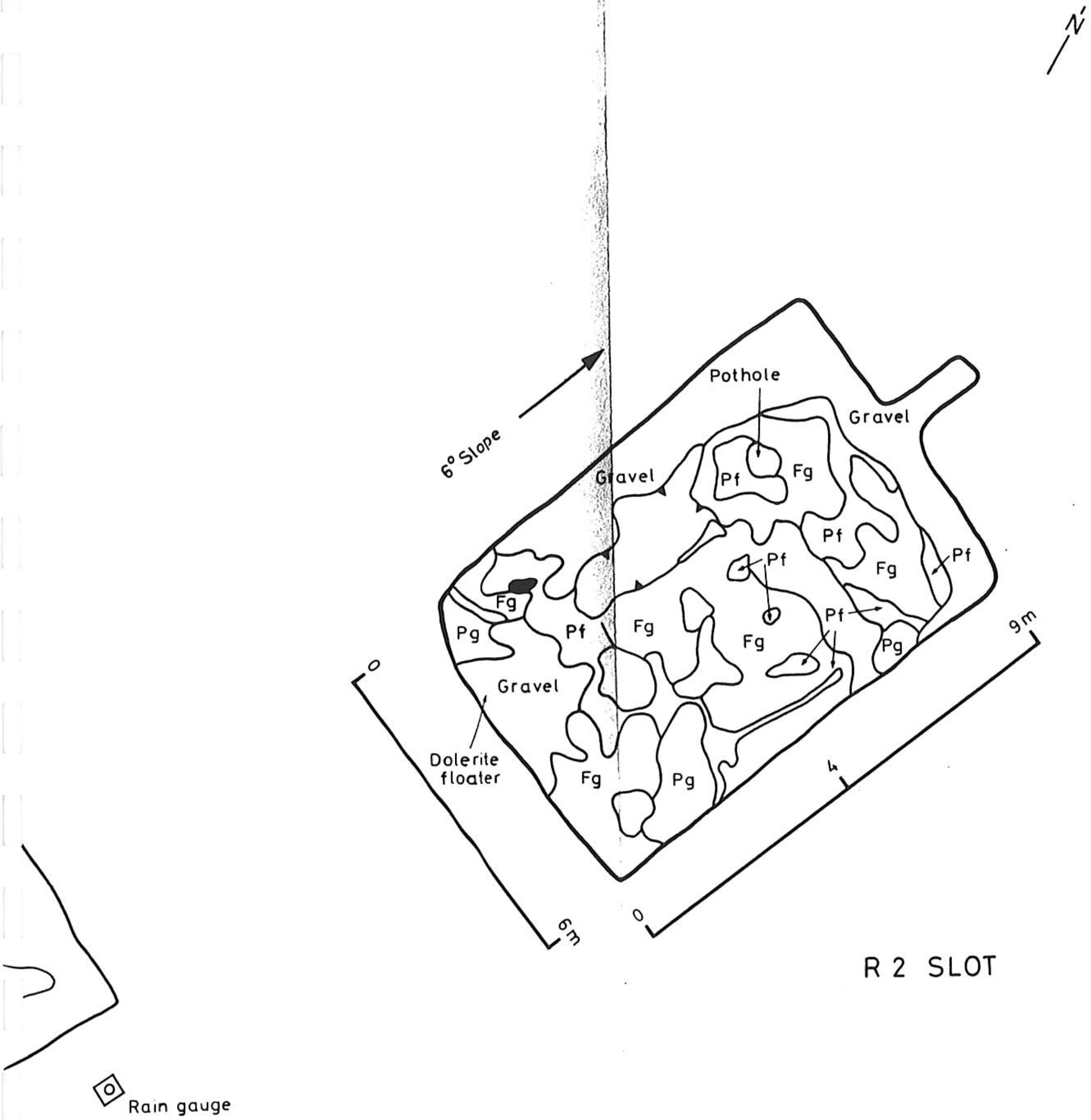



R 4 SLOT




R 3 SL

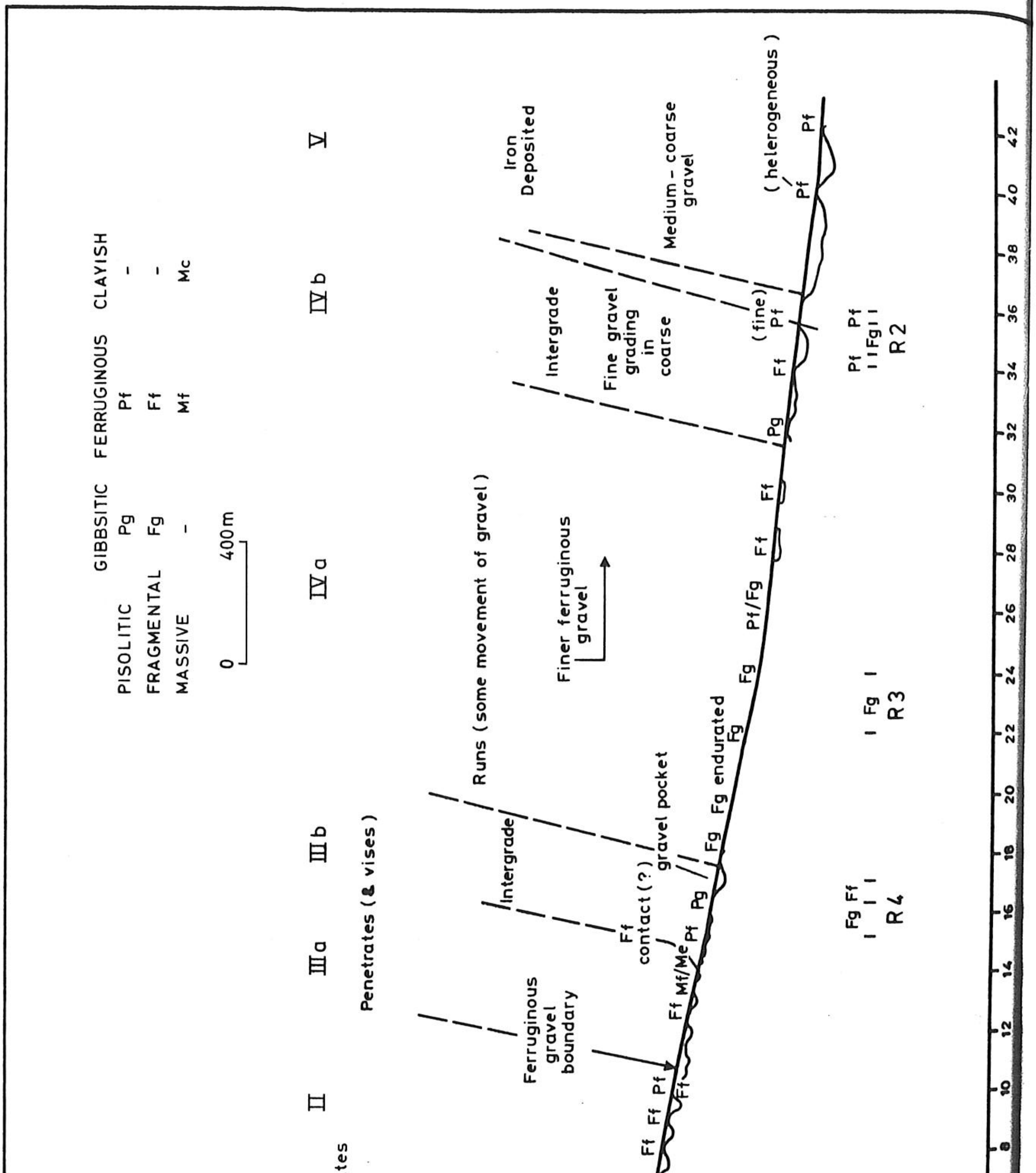
| | GIBBSITIC | FERRUGINOUS | CLAYISH |
|---|---|---|---|
| PISOLITIC | Pg | Pf | – |
| FRAGMENTAL | Fg | Ff | – |
| MASSIVE | – | Mf | Mc |




R 2 SLOT

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

| | Initial | Date | RONSON ROAD SLOTS R2-4 | Map Index FIGURE 9 |
|---|---|---|---|---|
| Comp | AJS | SEP83 | | |
| Drawn | AJS | SEP83 | | |
| Chkd | AJS | Nov83 | | 21107 |
| Apvd | AJS | Nov83 | To accompany Laterite Geology and Jarrah Dieback Report. | |




# GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

| | INITIAL | DATE |
|---|---|---|
| COMP | AJS | SEP 83 |
| DRAWN | LJ | NOV 83 |
| CHKD | AJS | NOV 83 |
| APVD | AJS | NOV 83 |

## RONSON ROAD CATENA

To Accompany Laterite Geology and Jarrah Dieback Report

MAP INDEX

FIGURE 10

21109

TABLE 6
MAIN FEATURES OF RONSON ROAD SITES

| TOPOGRAPHIC POSITION | ZONE TYPE | CAPROCK | SURFACE | CLEFTS | ROOT HOLES | FLOW |
|---|---|---|---|---|---|---|
| Crest | I | Me, Fg | Rough | Deep | - | Vertical |
| Upper slope | II | Ff | Rough | Deep | - | Vertical |
| Upper to Middle slope | IIIa | Ff, Mf/Me | Rough | Deep | Rare | Vertical, lateral |
| " | IIIb | Pf, Pg | Rough | Deep | - | Vertical |
| Middle slope | IVa | Fg, Ff | Smooth | Shallow | Rare | Latral |
| " | IVb | Pg, Ff, Pf | Rough | Shallow | Common | Vertical, lateral |
| Lower slope | V | Pf | Rough | Deep | - | Lateral |

The lateritic caprock at the crest (Zone I) is friable and pale brown in colour. It is weakly cemented and appears to be thin. This poor development is a common characteristic of catchment interfluves. Zone II has more extensive laterite cropping out in pockets of deep gravel. The surface of the caprock is undulating and exhibits a general "roller coaster" morphology. Water would readily enter the overlying soil and penetrate the laterite profile.

The boundary between Zones II and III is made on the basis of the ferruginous gravel. There are indications that iron pisolitics are being eroded from the gravel pockets of Zone II and are being transported and then deposited at Zone III(b). This transportation may be a combination of limited overland flow and subsurface interflow. (Water may rise to the surface at Zone III(b)?).

Zone IV(a) is the more interesting section of the Ronson Road catenas. The caprock is endurated and the movement of fine gravel and the mode of occurrence of Pf (pisolitic ferruginous) caprock at slots R2-R4 support the interpretation that the water is retained then shed with little vertical penetration. Water may be retained only for a few days but sufficiently long enough to trigger an outbreak of Pc and assist in its spread upslope.

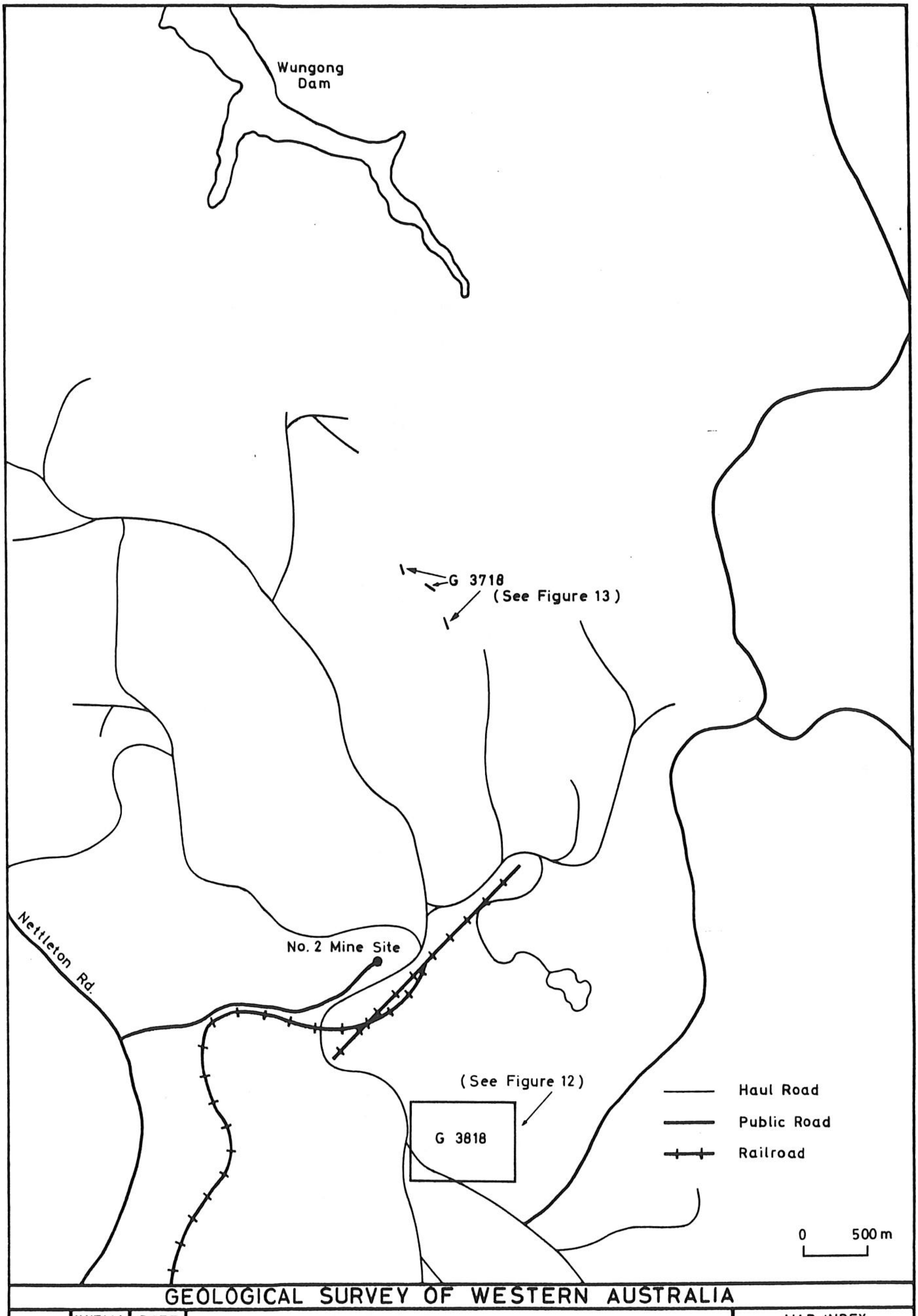
Zone IV(b) is an intergrade: here fine gravels merge into medium to coarse gravel. The caprock of Zone V is exclusively Pf. The heterogeneous nature of the caprock indicates re-working of the material possibly from upslope and across slope.

The Ronson Road study area has a predominance of laterite weathered from dolerite. There are only a few granite derived exposures.

In summary it appears probably that the sheet like laterite surface of the midslope (e.g. Zone IV(a)) retains the water in its overlying soil layers and that the water is subsequently shed laterally. The distribution of Pc needed to be sampled in order to confirm the relationship between the processes acting in this zone and the intensity of jarrah dieback. The type and thickness of the surface soils should also be determined.

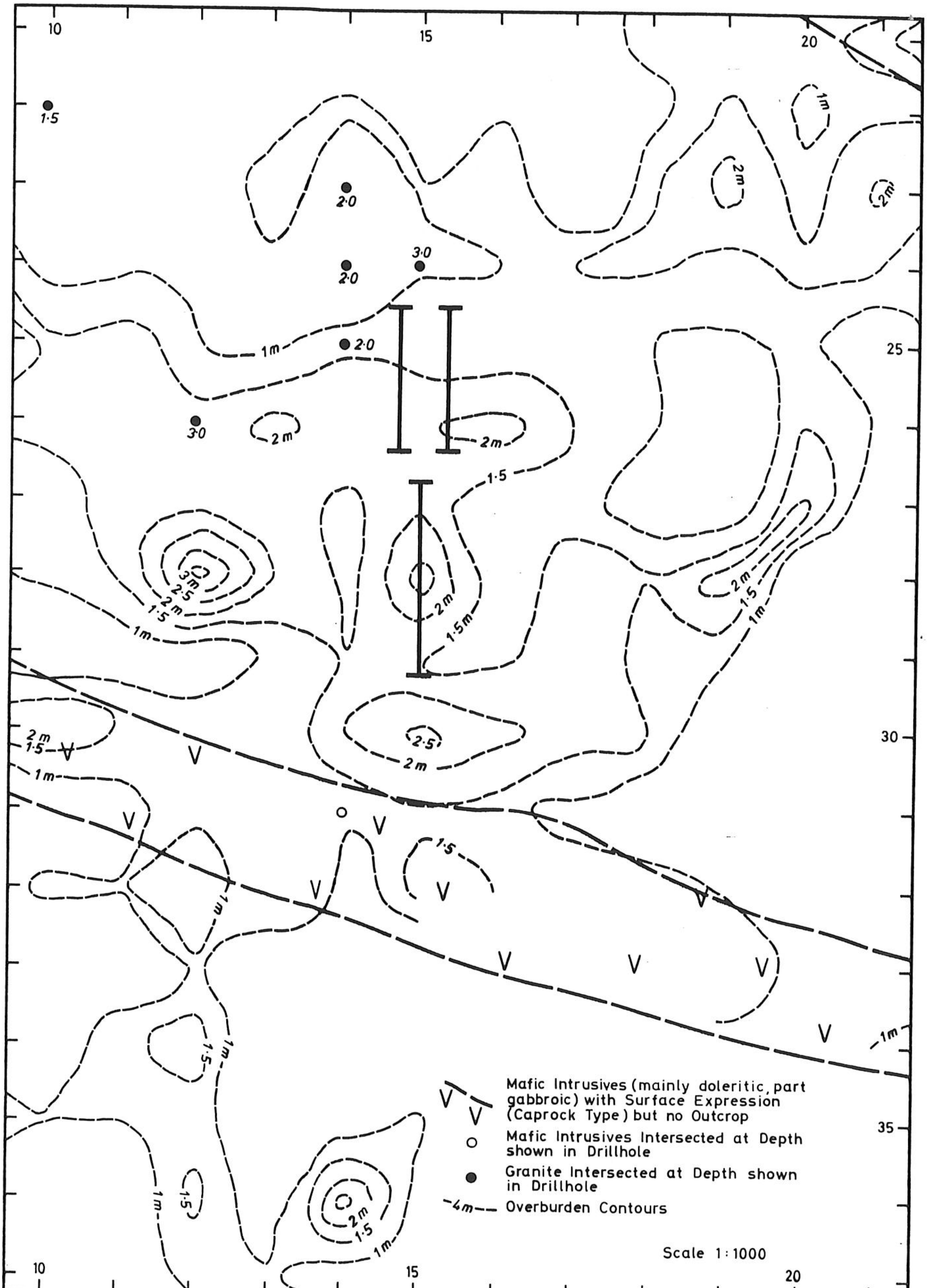
## 4.3 ROCKSAW TRENCHES

Alcoa of Australia Limited has been experimenting with various machines to cut down on the amount of blasting required adjacent to private properties. Late in December 1982 the company was testing a rocksaw machine at Jarrahdale No 2 Mine Site. Tests were carried out at bauxite pit (e.g. G3818) and upslope from a water point (e.g. G3718). Trenches were cut in the lateritic caprock. Dr Shea seized this opportunity to inspect these caprock exposures. Figure 12 shows their location and the general geology of the area.




GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

| | INITIAL | DATE | | |
|---|---|---|---|---|
| Comp | AJS | SEP 83 | JARRADALE No. 2 SITE | MAP INDEX |
| Drawn | LJ | OCT 83 | | |
| Chkd | AJS | NOV 83 | | FIGURE 11 |
| Apvd | AJS | NOV 83 | To accompany Laterite Geology and Jarrah Dieback | 21009 |




## GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

| | INITIAL | DATE |
|---|---|---|
| COMP | ALCOA | SEP 83 |
| DRAWN | LJ | NOV 83 |
| CHKD | AJS | NOV 83 |
| APVD | AJS | NOV 83 |

# ROCKSAW TRENCHES AT G 3818

MAP INDEX

FIGURE 12

To Accompany Laterite Geology and Jarrah Dieback Report.

21010

#### 4.3.1 Rocksaw G3818

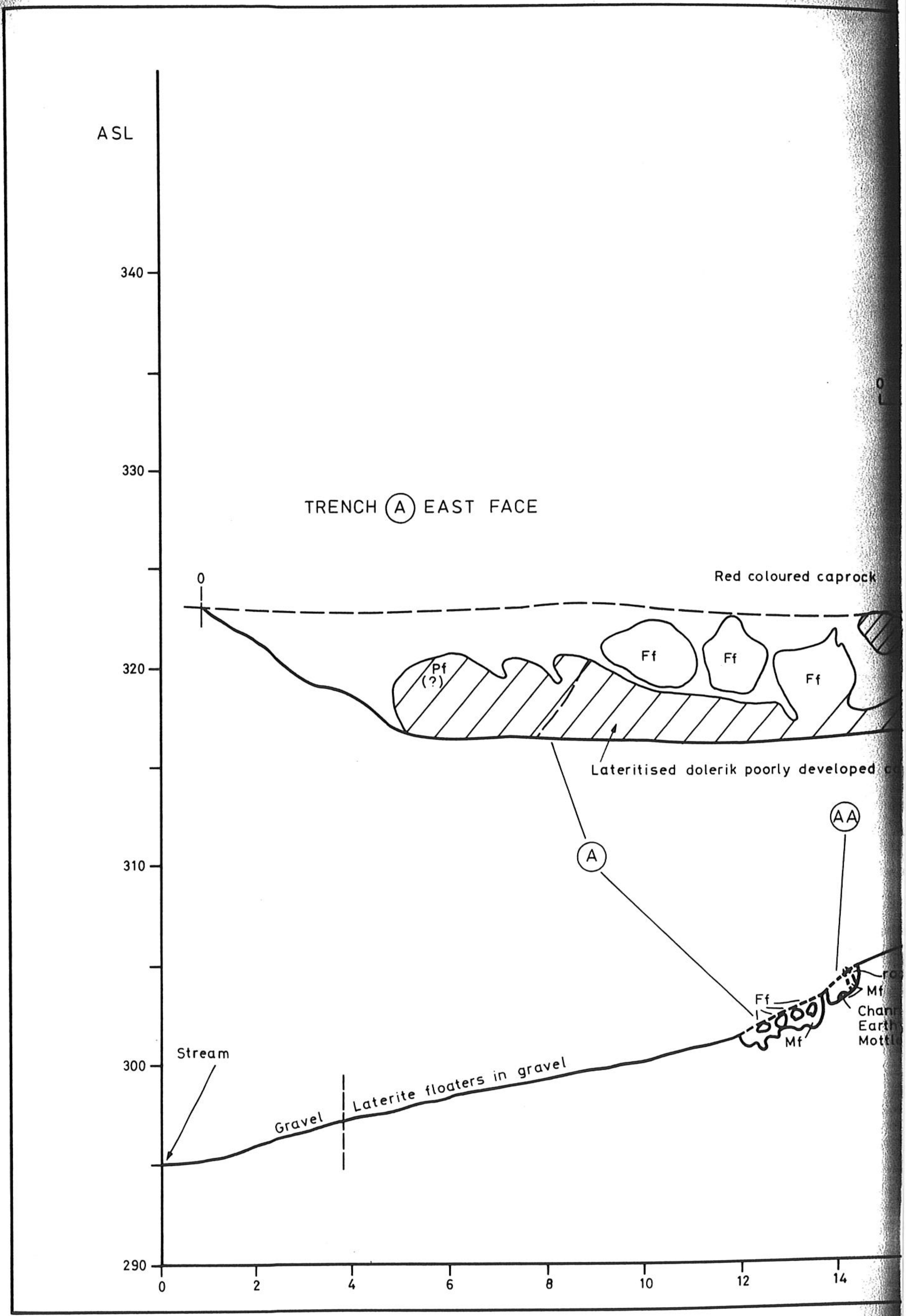
Three trenches were mapped of the nine which were cut by the rocksaw. (See Figure 13). The site selected for the trial has only an incipient caprock developed. The caprock is of granitic origin. Drilling for bauxite by Alcoa intersected areas of near surface granite. The site occurs in deep (e.g. 1.0-2.5 m) grey gravel overlying a poorly developed caprock.

Pf occurs as a thin rind and may act as a sealing medium. The iron concretions are coarse and heterogeneous and this indicates that the site is depositional. The trenches have cut several cross channels which probably act as preferred pathways for the water which is flowing through the coarse textures soils to enter the laterite profile.

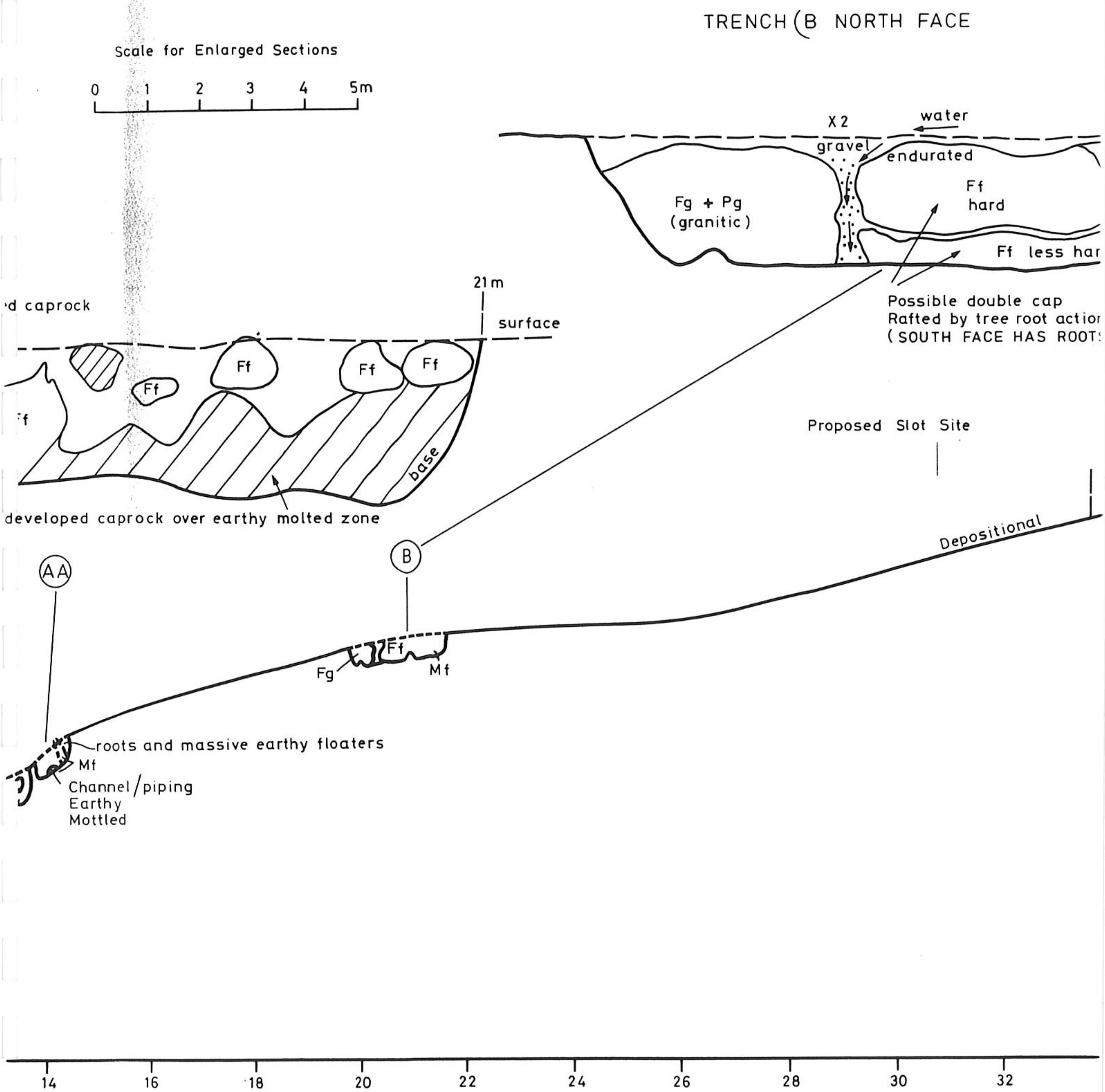
The site is not typical of a bauxitic laterite pit. The main value of the investigation is that it demonstrates the mobility of iron even in a predominantly granitic area. The iron has been deposited and probably the Pf (maghemite rich) rind transfers accumulated water laterally until it can penetrate the profile by way of the cross channels. Otherwise the site appears to be a well drained site with water moving rapidly down the profile. The relationship between the site's geology and dieback is not known. In geological terms the site is similar to that studied by the CSIRO (Johnson et al 1983) at Del Park Area "C".

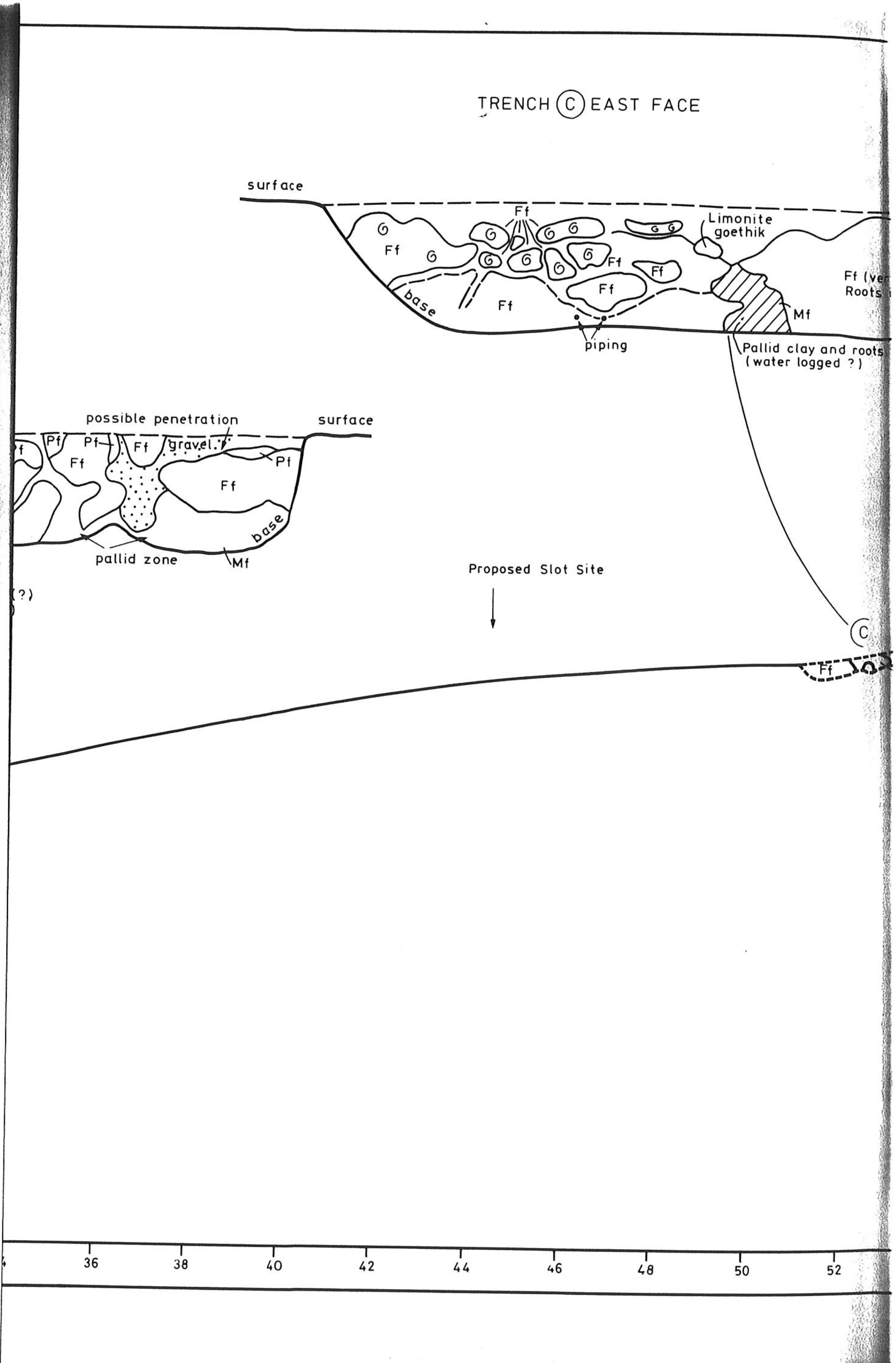
#### 4.3.2 Rocksaw G3718

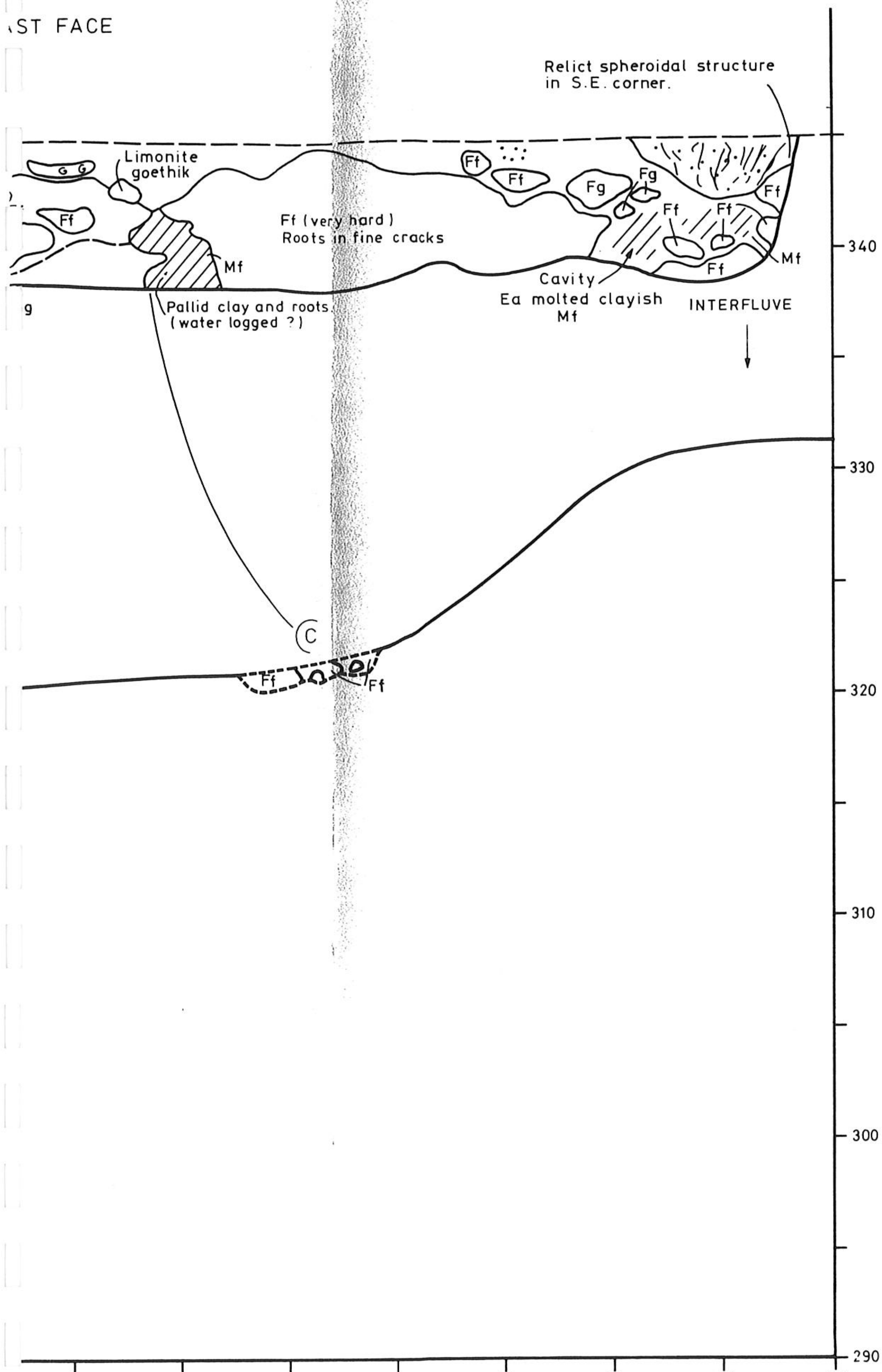
The study area is situated in the southern end of the Seldom Seen Catchment, Jarrahdale. Dieback has been in this catchment since 1940. The investigation sites was positioned to examine the type of caprock lying beneath the surface soils. Four trenches were cut by the rocksaw machine. Figure 14 illustrates the catena relationship.



ASL
340
330
320
310
300
290
TRENCH (A) EAST FACE
0
Red coloured caprock
Pf
(?)
Ff
Ff
Ff
Lateritised dolerik poorly developed
A
AA
Ff
Mf
Mf
Stream
Gravel
Laterite floaters in gravel
0
2
4
6
8
10
12
14

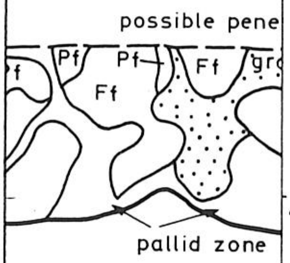

TRENCH (B NORTH FACE
Scale for Enlarged Sections
0 1 2 3 4 5m
X 2
water
gravel
endurated
Ff
hard
Fg + Pg
(granitic)
Ff less har
Possible double cap
Rafted by tree root actio
( SOUTH FACE HAS ROOT
'd caprock
21m
surface
Ff
Ff
Ff
Ff
'f
base
developed caprock over earthy molted zone
Proposed Slot Site
Depositional
AA
B
Ff
Fg
Mf
roots and massive earthy floaters
Mf
Channel / piping
Earthy
Mottled
14
16
18
20
22
24
26
28
30
32


TRENCH (C) EAST FACE
surface
Ff
Limonite goethik
Ff (ver
Roots
base
Mf
piping
Pallid clay and roots
(water logged ?)
possible penetration
surface
Pf
gravel
Ff
pallid zone
base
Mf
(?)
Proposed Slot Site
C
36
38
40
42
44
46
48
50
52




PISOLITIC
FRAGMEN
MASSIVE
SPHEROID
PIPING A
TREE RO
GRAVEL :

| | Initial | D |
|---|---|---|
| Comp | AJS | O |
| Drawn | LJ | N |
| Chkd | AJS | N |
| Apvd | AJS | N |




| | GIBBSITIC | FERRUGINOUS | CLAYISH |
|---|---|---|---|
| | Pg | Pf | - |
| TAL : | Fg | Ff | - |
| | - | Mf | Mc |

(?)

L STRUCTURES : ⑥

D CAVITIES : ////

TS : ///

36

EOLOGICAL SURVEY OF WESTERN AUSTRALIA

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83

83

83

83

G 3718 ROCKSAW TRENCHES
JARRAHDALE

To accompany Laterite Geology and Jarrah Dieback Report

Map Index

FIGURE 13

21011

Trench C has been cut into lateritised dolerite. There is extensive iron: mainly goethite and haematite with minor limonite. Pf (pisolitic ferruginous) is absent. Spheroidal structures are abundant. Tree roots have forced their way into vertical and curvilinear cracks and crevices in the caprock. There are cavities in the centre wall and upper end of the trench. The caprock is thin. Pallid zone clay (or saprolite) occurs close to the surface. There is some gleying at the base of the central cavity. The forest is healthy with a vigorous understorey of banksias and black boys.

This evidence supports the deduction that the site is quickly drained. Although at certain times the pallid zone clay may be saturated. The cracked sequence is very similar to Zone 1 of Ronson Road.

Trench B has a contact between granitic and doleritic derived laterite. Once again the caprock passes abruptly into pallid zone. There are several large channels and cracks which have been utilised by tree roots. Pf occurs on the upper side of the caprock exposures. This site appers to be a combination of rapid penetration (i.e. around the Ff exposures) and water shedding (i.e. around the Fg exposures).

Trench AA has only incipient caprock. Its sheer walls made access impossible. There are some arched structures which could be caused by piping. Pallid zone clay underlies the poorly developed caprock. Trench A has laterite blocks lying above earthy mottled and pallid zone clay. Pg is absent. It appears likely that the site occupied by the two trenches is quickly drained.

Two more exposures need to be made at G3718 between trenches B and C. It is in this midslope position that areas of water shedding that laterite can be expected to occur. The attempt at tracing water flow at trench C by using dye needs to be repeated.

## 5. ANCILLARY SITES

Geological observations at a reconnaissance level have been made at other sites in the Dwellingup region (e.g. Scarp Road, Whittaker) as part of the current investigation. Also geological observations were made during forest mapping on other occasions (e.g. 1978-1981). These two sets of observations have been used to extend the geographical distribution of the phenomena described at the main sites (e.g. Deer, Ronson, and Rocksaw). Figure 1 shows their location.

### 5.1 JARRAHDALE DIVISION

#### 5.1.1 Seldom Seen Catchment

Jarrah dieback has been established in the catchment since the early 1940s. Alcoa and the Forests Department have planted trees on the old dieback areas. Caprock mapping for that project and to delineate sites for bauxite drilling outlined areas of Pf caprock and ferruginous gravel. These occurred on the lower to middle slopes (northern and western) of the catchment and were almost co-incident with the boundary between dieback and suspected dieback.

#### 5.1.2 More Seldom Seen Catchment

While mapping the Coronation Road Catena as part of a pedogeomorphic investigation (Iraci and Smurthwaite (1978) unpublished) the association of coarse gravels, Pf caprock and dieback was noted. The contrast between healthy and dieback affected forest was most pronounced. Observations were made of soils and surface processes. The depositional zone of the catena seemed to act as a buttress to the slope. The sudden,but short lived,rise of subsurface water during a storm can now, in hindsight, be attributed to the water shedding properties of the midslope lateritic caprock.

## 5.2 DWELLINGUP DIVISION

### 5.2.1 Whittaker Cell

Ferruginous gravel and Pf and Ff caprock mark the location of severely affected forest or forest with a high impact potential. Little overland flow was observed but the surface of the caprock and distribution of exposures in the hillslope provide indications that the caprock could cause the lateral flow of subsurface water. Eight sites were briefly visited;of these,six had either ferruginous gravel and Pf,or had laterite of doleritic origin.

### 5.2.2 Scarp Road

Caprock of granitic origin was inspected at a small bauxite pit. The endurated surface had shallow depressions and many root holes. A thin veneer of Pf was observed but no sizable accumulations of recemented material. The caprock surface was broken and deep clefts separated each exposure. Vertical rather than lateral water flow was interpreted.

### 5.2.3 Park Block

Pf caprock has been exposed on a small trench. It lies just upslope from dieback. Upslope the forest is healthy and the caprock outcrops are bounded by broken edges. Mapping carried out in 1973 further to the west revealed large dolerite (almost gabbroic) dykes which are lateritised. The ferruginous gravel can be attributed to the subsequent denudation of these lateritised dykes.

## 5.3 HARVEY DIVISION

### 5.3.1 Cornwall Cell

During a dieback mapping workshop constructed by the Forests Department in November 1980 geological observations were made at 11 investigation sites. A review of these observations shows that positive (i.e. laboratory tested) dieback was found at 8 sites: of these 5 have ferruginous gravel or iron rich laterite exposures. This means that geological factors as well as the mortality of indicator species should be taken into account. It would be interesting to map the geology of the area using the 70 mm photography.

### 5.3.2 Samson and Clarke Blocks

Mapping the distribution of dieback during 1979 revealed a series of healthy forest areas surrounded by dieback. Each healthy area occurred on the middle to upper slopes of the ridge. Exact details of the geology are recorded on the files at Alcoa; however, iron rich laterite - whether Pf or doleritic - is associated with dieback. The steep slopes of Mount William provide an excellent transect which passes through healthy to dieback affected forest.

Clarke Block has extensive areas of ferruginous laterite. An interesting feature of the area is the series of east-west valleys and ridges which are strongly influenced by the orientation of dolerite dykes.

## 6. CONCLUSION

There is strong correlation between the morphology of the lateritic caprock horizon and the intensity of jarrah dieback infestation. Of particular interest is the interplay between slope position, caprock type and its surface. Pf (pisolitic ferruginous) material appears to have the role of filling the channels and crevices in and between the caprock exposures. The result is to re-direct the water which is moving through the surface soil. This diversion commonly causes the subsurface water to move laterally across the slope until it finds a root hole, or until it finds a depression.

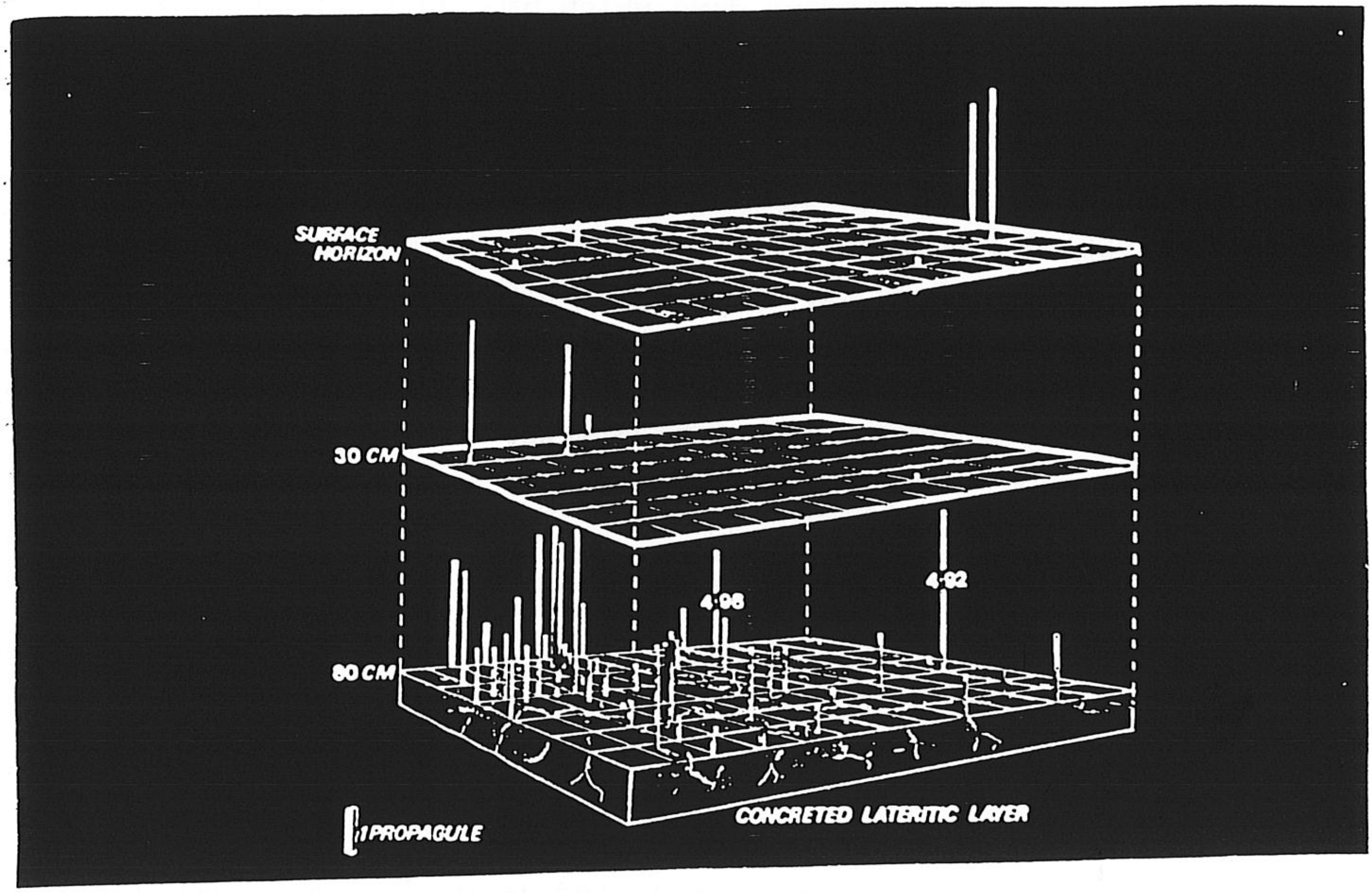


Figure 14 On a severely diseased site most inoculum of P. cinnamoni occurred in soil at depth above a concreted lateritic layer (vertical bars represent propagule numbers per gram oven dry weight).

The root holes which jarrah has bored through the caprock are the pathways down which banksia roots and water can pass into the upper levels of the laterite profile. Depressions, on the other hand, act as a holding area in which the subsurface water is retained. The retention may be only a matter of days but this is sufficient time in which to activate any Pc which may be present. These shallow holding areas or basins act as reservoirs which are connected in turn to the vertical holes and cracks in the caprock by a series of channels. This broad picture has emerged but there is a considerable amount of painstaking work to be done before one can be certain of the exact nature of the key indicators shown in Table 7.

The majority of the sites mapped to date have two things in common: (i) the laterite is weathered from dolerite and (ii) the Pf material can act as a sealing medium for lateral channels and, in some instances, for vertical cracks in the caprock. The problem is that insufficient work of a co-ordinated nature has been done to date to be absolutely positive that these two phenomena can be used as reliable site indicators.

Some 40 per cent of the lateritic landscape of the western regions of the Darling Range is of doleritic origin. Pf caprock occurs on the middle to lower slopes of most laterite slopes. In other words what is so special about the geology of the areas studied? What is not known at this stage is whether there is a unique combination of lateritised dolerite dykes, Pf caprock and hill slope creates the right hydrological setting for the proliferation and spread of the jarrah dieback fungus. Also whether this pattern is a rare occurrence or is sufficiently common to serve as a research and management tool.

What can be definitely stated is that lateritic caprock does influence the movement of subsurface water: an ephermal aquifer can be produced and this needs to be quantified as part of the general investigation into the hydrology of hillslopes.

Table 7 Major areas of research on the *Phytophthora cinnamoni* x host x environment interactions within the Forests Department of Western Australia supervised by Drs B. Shearer and J. Tippett

| 1. PATHOGEN EPIDEMIOLOGY | 2. SITE IMPACT IDENTIFICATION | 3. DISEASE ASSESSMENT | 4. HOST RESPONSE |
|---|---|---|---|
| What are the differences between sites that affect development of the pathogen at depth in the soil profile?<br>- Comparison of environmental factors - moisture, temperature, water movement (hillslope hydrology).<br>- Comparison of pathogen behaviour (survival sporulation, dispersal).<br>- Host infection<br>- Effects of disturbance | How can factors affecting impact be recognized? Identification of key indicators:<br>- Geology<br>- Soil<br>- Landscape<br>- Vegetation | What is the damage from infection on different sites? | Why does jarrah respond the way it does?<br>- mechanism of resistance<br>- phloem physiology<br>- interactions with environment<br>- genetic attributes |

## 7. RECOMMENDATIONS

1. That the method outlined in the report should be followed - initially at Deer Road and then at subsequent sites.

2. That undisturbed slopes should be examined first before the ground is affected by washing down or by backhoe excavation. The sequence of events should be along these lines.

   (i) the undisturbed catena is mapped (e.g. geology, flora, dieback),
   (ii) related to hydrology (e.g. surface and ground waters; observed and measured),
   (iii) representative sites have their surface soil dyed, progressively removed and sampled for Pc,
   (iv) the surface of the caprock is mapped and the observations compared with those found under natural conditions.

3. That the catena - catchment method should be related to the vegetation mapping system of Havel and a review made of the utility of the NULM (Nine Unit Landsurface Model) of Conacher and Dalrymple.

4. That the following areas should be mapped:

   (i) Deer Road: additional mapping of dieback plots
   (ii) Ronson Road: dieback mapping of catena
   (iii) Rocksaw G3718: dieback mapping of catena; two more slots required
   (iv) Whittaker Cell: using 70 mm photography and dieback maps
   (v) Cornwall Cell: using 70 mm photography and dieback maps
   (vi) Dieback spread monitoring sites: map exposures and catena.

5. That Alcoa's Five Year Mine Plans should be examined to select areas for mapping of dieback and geology ahead of logging and cleansing (e.g. Huntly Crusher Site 4; Del Park Area "C"). Use can then be made of the detailed geological mapping, drilling and subsequent mining excavations.

## 8. ACKNOWLEDGEMENTS

The assistance of Mr Bureherig and Mr Dillon of the Forests Department in mapping Deer and Ronson Road sites is gratefully acknowledged. Also the authors wish to thank Mr Day and Mr Sadlier of Alcoa for the maps and topographical survey data for the Rocksaw Trenches at Jarrahdale No 2 Mine Site.

## 9. REFERENCES

Connacher, A.J. and Dalrymple, J.B., 1977, The nine unit landsurface model: an approach to pedo-geomorphic research Geoderma 18, 1-147.

Iraci, C., and Smurthwaite, A.J., Oct-Nov 1978, Landscape Catena description in the central Jarrahdale region. Applied Pedo-geomorphology Project Report. Geography Department, University of W.A.

Johnson, C.D., Hurle, D.H., Hudson, D.R., and Height, M.I., 1983, Water Movement Through Preferred Paths in Lateritic Profiles of the Darling Plateau, Western Australia C.S.I.R.O. Groundwater Research Technical Paper No. 1.

Shea, S.R., Shearer, B.L., Tippett, J.T., Deegan, P.M., 1983 Distribution, Reproduction and Movement of Phytophtora cinnamoni at various depths of soil on sites highly conducive to Jarrah Dieback in South Western Australia Plant Disease (in press).