BASEMENT AQUIFER PROJECT

Preliminary account of the profile in BH2, Chikobwe Dambo

R L F Kay & M J McFarlane

BASEMENT AQUIFER PROJECT: preliminary account of the profile in borehole BH2, the Chikobwe Dambo

R.L.F. Kay and M.J. McFarlane

Introduction

Preliminary studies have been made of the first core to be sampled largely intact. This is boreehole BH2, the location of which is a mid-slope position some 250 m west of the margin of the Chikobwe Dambo (Dowa West Project area, Malawi) and some 11 m above it (fig. 1). This is equivalent to location type C of McFarlane et al. (see accompanying report).

Profile characteristics are summarised in figure 2 and are interpreted thus. A thin colluvial mantle comprises the upper 2m. This has overrun a yellow, more sandy and quartz-rich material extending down to a stone line at 10m depth, which in turn overlies saprolite (weathered rock).

The material underlying the colluvium and above the stone line is evidently very extensively leached and is believed to represent a former clay and sand mix of dambo-infill which has been modified by leaching after emergence above a declining water table. It is thus proposed that material of this type, occurring at the described stratigraphic position in profiles peripheral to the present-day dambos, be termed palaeodambo material.

Experimental methods

Preliminary characterisation of the mineralogy of the main components is shown in figure 3 by means of the X-ray diffractometer traces. These were all obtained using the BGS/IOH equipment at Wallingford (a Harwell designed BPEX X-ray diffractometer with carbon monochromator) under identical copper Kα tube conditions (34 kV and 28 mA). Note that the intensity scaler (full scale signal) is not the same for each trace.

Samples were finely ground in acetone using a microniser mill containing alumina discs. A small amount of the crushed material was then further ground using an agate mortar and pestle and a fairly viscous acetone slurry was then evaporated on glass slides ready for X-ray diffractometry.

Evaporation from an acetone slurry was found to provide a sample containing a low degree of preferred orientation which is essential for estimation of the relative proportions of the constituent minerals. For the purposes of estimation of modal contents of kaolinite and montmorillonite peak heights at $6.3^\circ\theta$ and $3^\circ\theta$ respectively were compared with the peak height intensity of quartz at $13.3^\circ\theta$ (see fig. 3). The selected peaks gave more consistent intensity ratios than possible alternatives. The large difference between the intensities of quartz and clay mineral peaks resulting from the disparity in their modal abundances normally required estimation of peak heights on separate X-ray diffraction runs.

It is recognised that more precise XRD estimation of modal composition can be be made using peak areas rather than heights. At the time of writing the Wallingford equipment does not routinely produce data in a digital form which would facilitate this operation but steps will be taken to rectify this.

Standard mixtures with 50, 25, 10, 5 and 2.5 % by weight of kaolinite with quartz produced a systematic variation in intensity ratios from which a calibration curve was drawn. A Fuller's Earth sample was used to test the response for a mixture containing 10% montmorillonite with quartz and one containing 5% montmorillonite, + 5% kaolinite + 90% quartz. This produced good results. In natural materials, however, montmorillonite presents greater problems because the range of chemical composition and degree of disorder cause variations in peak position and peak shape. It seems probable that it will be necessary to perform surface area measurements (probably at BGS Gray's Inn Road) in order to determine modal compositions of samples shown by preliminary examoination to contain montmorillonite.

Discussion

The upper two examples of figure 3 are very extensively leached. Poorly crystalline kaolinite is present at about 3% in the sample from 4.0 m but at some 10% in the 2.0 m sample. This is believed to result from mixing with the colluvium which is expected to contain relatively more kaolinite, although XRD data are awaited.

Studies from the vermiform laterite immediately above the stone line proved particularly informative concerning the verification of the nature of the sub-colluvial palaeodambo material. It was observed in the field that the vermiform cavities of dambo-peripheral laterites contain a conspicuously dark grey clay, very reminiscent of dambo clay. In the core from borehole BH2, the clay was similarly grey. One nest of vermiform cavities (sketched in fig. 4) showed what appeared to be a sequence with dark grey clay in one area (labelled A), paler grey 'oolitic' clay (B) occurring as small spherules like cod's roe adjacent to this (B), with a strikingly white clay (C) beside that. XRD traces of these three clays are reproduced in fig. 4 and show a leaching sequence from smectite to kaolinite. (The large peak labelled K/S on the XRD trace B was originally interpreted to represent an intermediate kaolinite/smectite interlayer mineral. The sharpness of this peak and lack of confirmatory peaks have thrown some doubt on this interpretation and this mineral awaits identification.) XRD of the interpipe area (D) and also the iron-enriched area near the pipe (E) showed quartz, kaolinite and goethite to be dominant, with goethite more concentrated near the pipe.

Although pisolithic laterite is well known for its ability to preserve from subsequent weathering some of the material in which it formed, such that pisoliths may contain material which is less weathered than the matrix, no previous studies have reported comparable preservation of minerals associated with the vermiform laterite textures. This study of the individual textural components indicates that the vermiform laterite formed in smectitic clay which is partly preserved in the vermiform cavities. It also shows that even in this protected position the smectite is being leached to kaolinite. Interestingly, it is the interpipe areas which are most extensively leached to kaolinite (contrary to the popular belief that the vermiform cavities are the preferred passages for water movement).

XRD examination of saprolite samples at 12.7 and 29.0 m (fig. 3) shows a chloritic mineral to be present, probably in addition to kaolinite. (Kaolinite's principal peaks occur on the XRD traces at similar θ angles to some of those attributable to chlorite; chlorite can be removed using hydrochloric acid and the presence of kaolinite then confirmed by further XRD but this remains to be done). The chlorite represents an earlier stage of alteration and it is also possible that both chlorite and kaolinite at these depths could be of hydrothermal rather than weathering origin. The location of the water table has yet to be established but it is likely that it lies above both these samples. This is of interest in view of the general assumption that, under ambient conditions, kaolinisation occurs only above the water table. Earlier work (McFarlane 1983) has shown that kaolinisation may occur below the water table in a watershed situation where there is good renewal of groundwater. If there is kaolinite below the water table, and it is not of hydrothermal origin, it would have to be deduced that water is moving rather freely through this profile.

Further studies of this and the other presently available profiles are planned or in progress.

Reference

McFarlane, M.J. 1983 A low level laterite profile from Uganda and its relevance to the question of parent material influence on the chemical composition of laterites. In Wilson, R.C.L. (ed.) Residual deposits: surface related weathering processes and materials. Blackwell, Oxford. pp. 69-76.

Acknowledgements

We thank Drs. E.P. Wright and D.J. Morgan for their critical reading of this report.

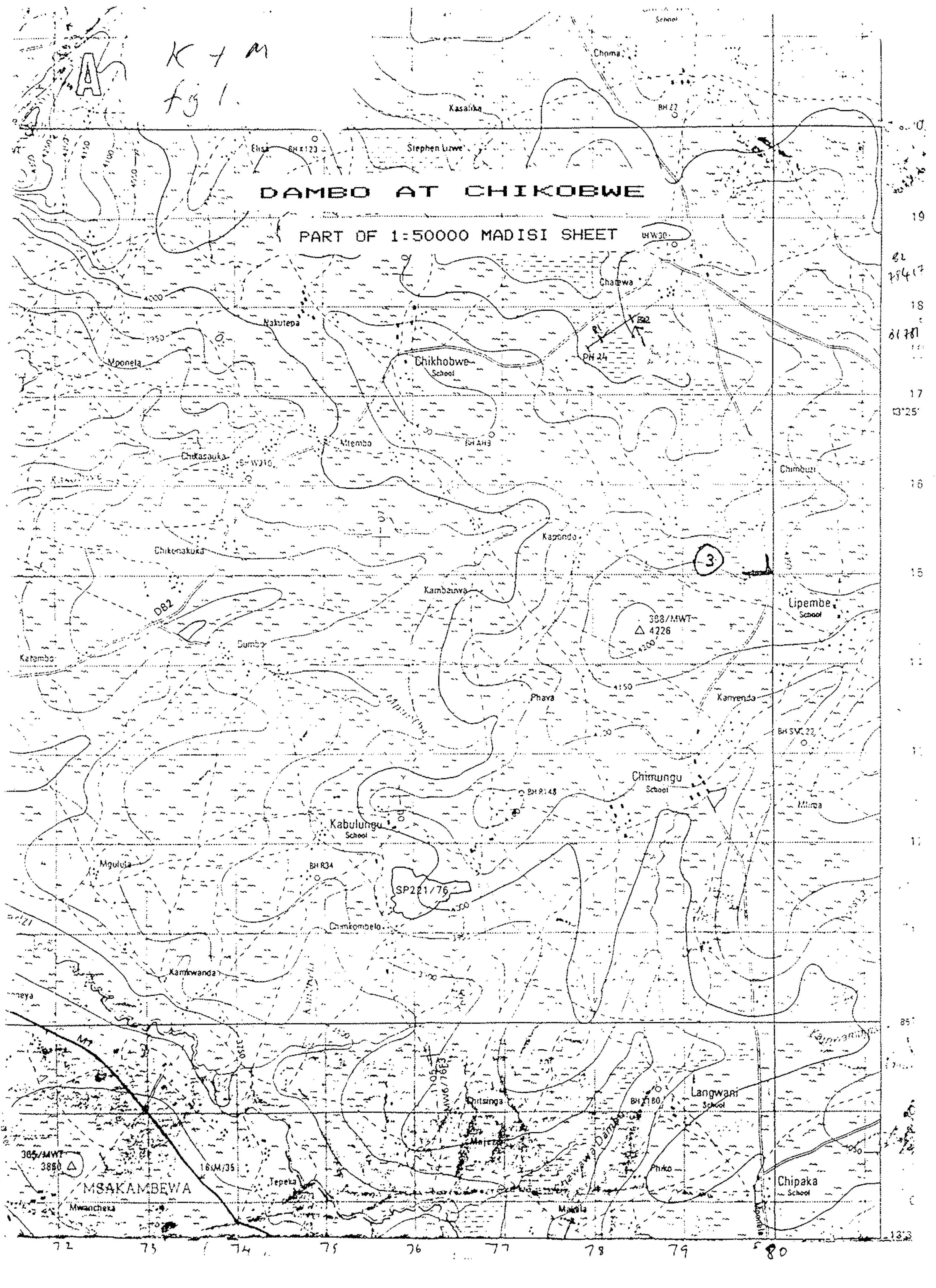
Figure Captions

Figure 1 Part of the 1:50000 Madisi Sheet, Malawi, showing the Chikobwe Dambo and the location of the borehole BH2.

Figure 2 Lithological log of borehole BH2.

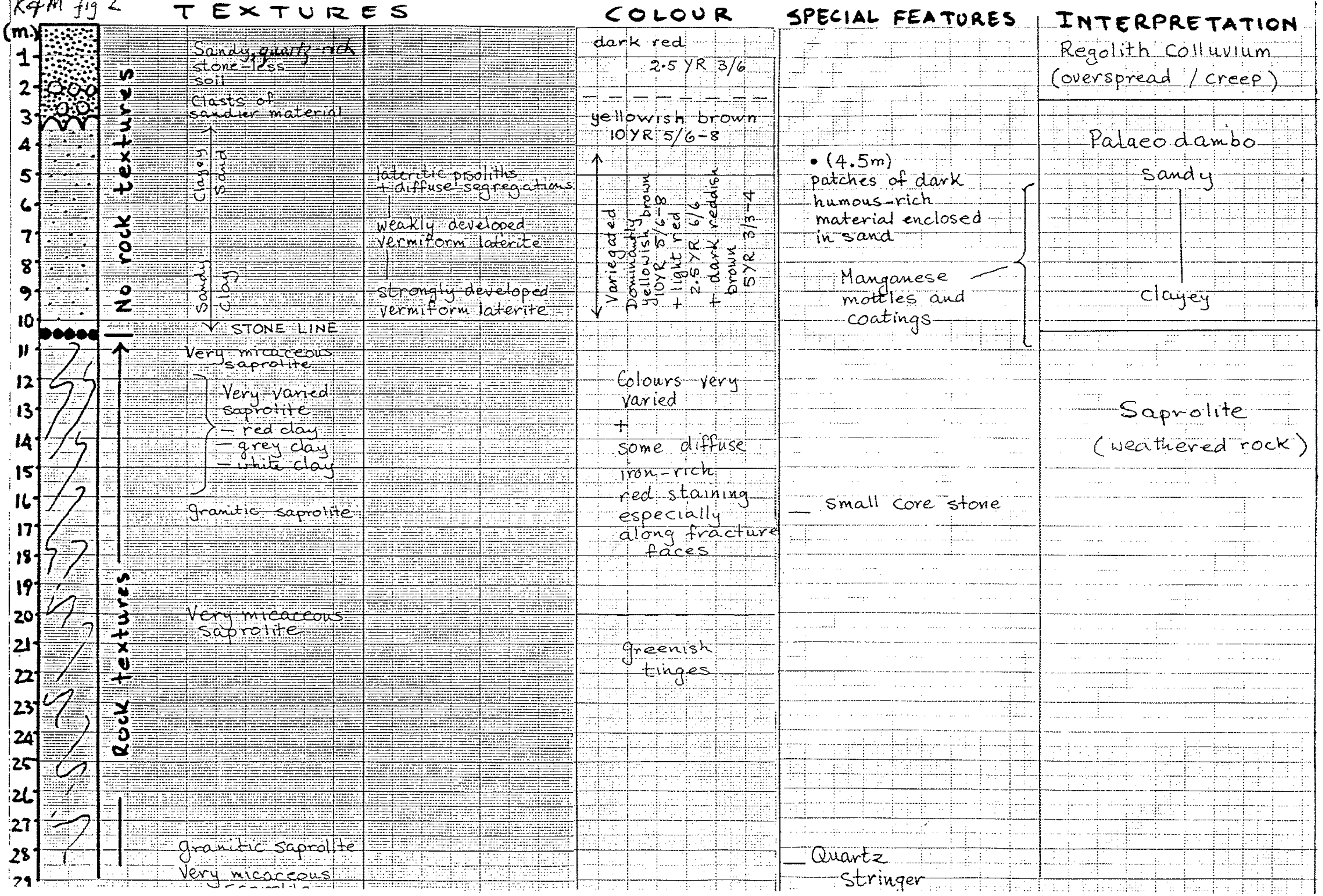
Figure 3 X-ray Diffractometer traces for four samples from borehole BH2 shown in relation to their position in the profile.

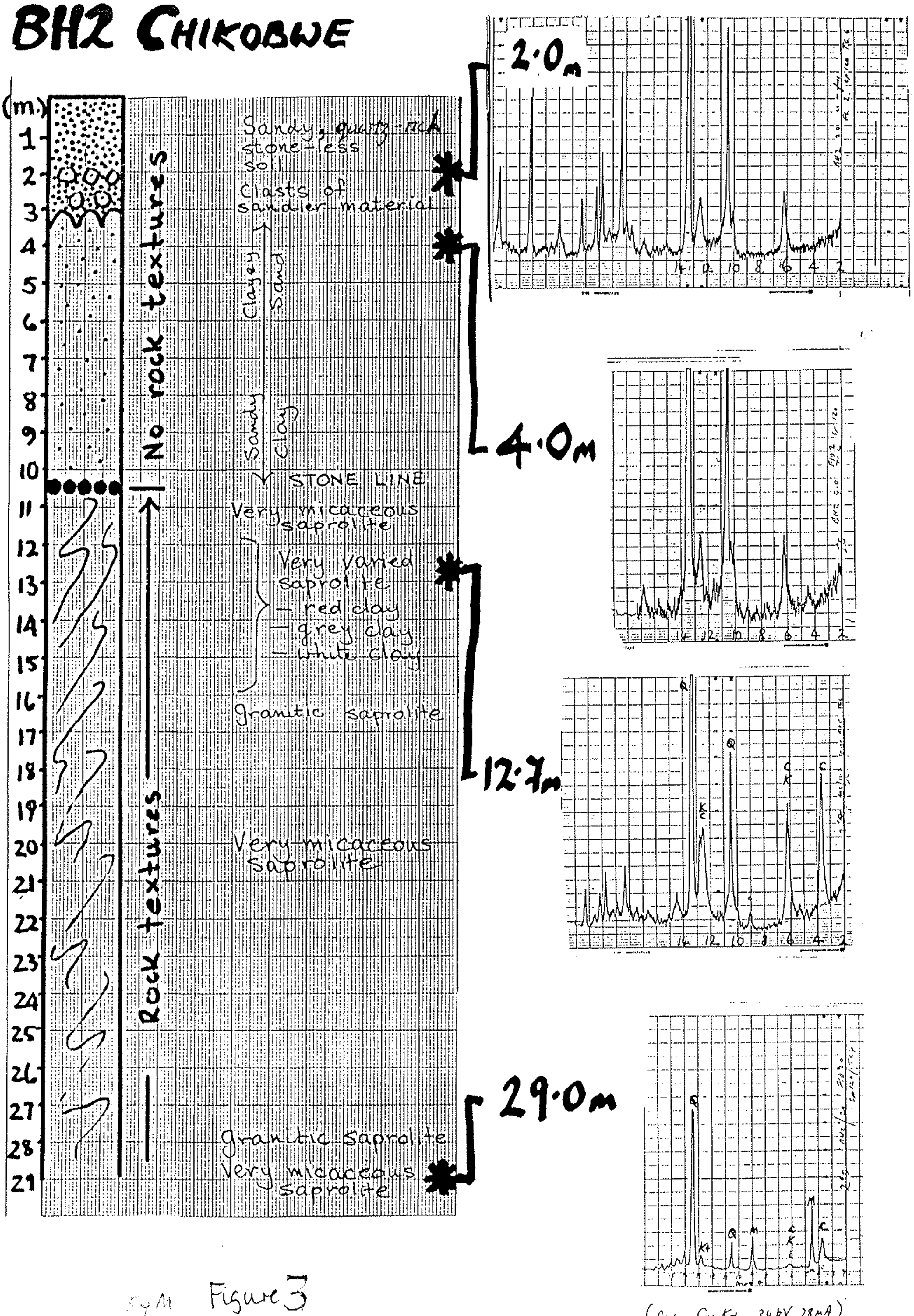
Figure 4 Interpretive sketch and XRD results of a nest of vermiform cavities occurring at 10m depth in BH2. The various illustrated features are described in the text.



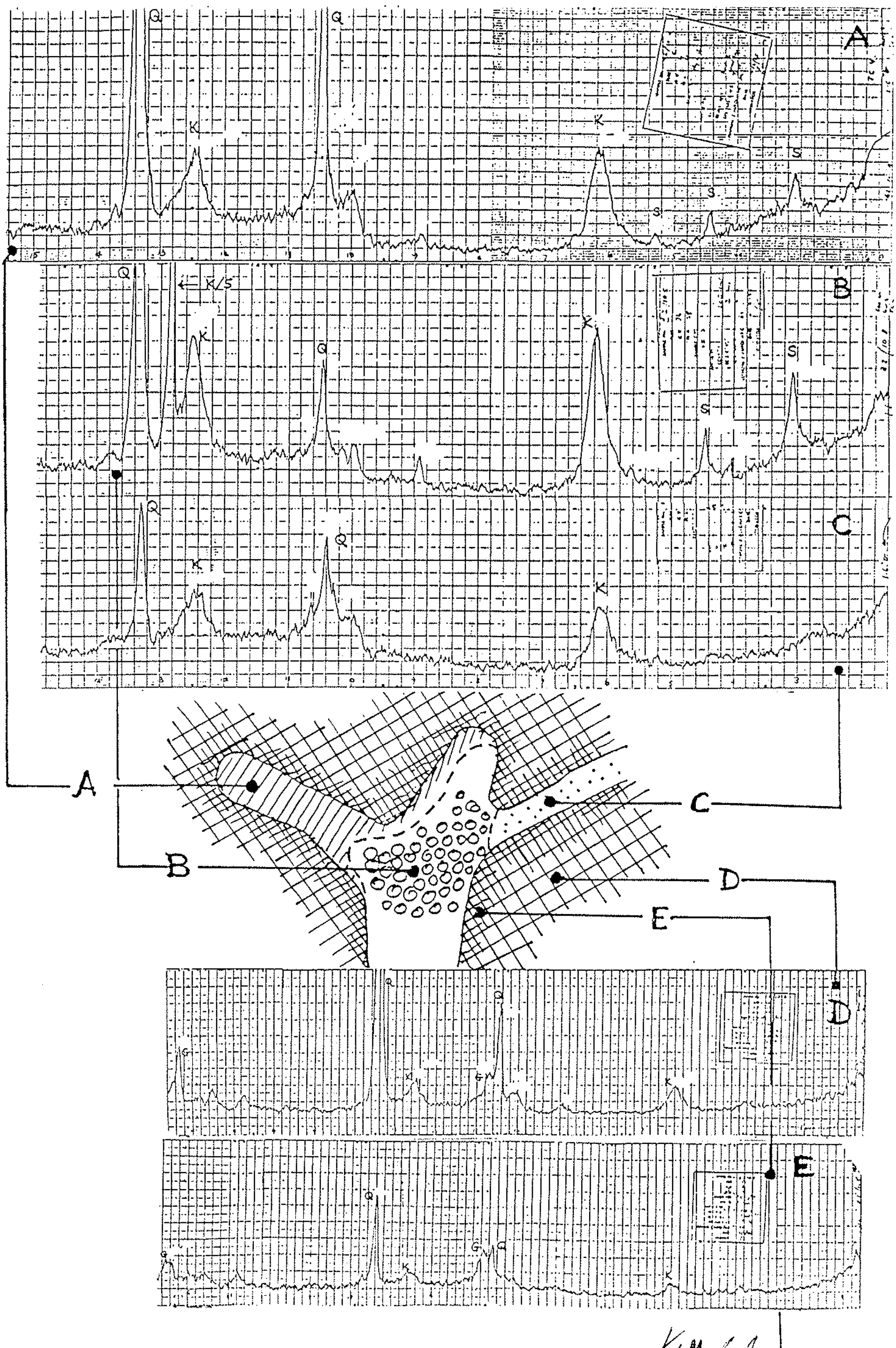
K + M
fig 1.
A
DAMBO AT CHIKOBWE
PART OF 1:50000 MADISI SHEET
Choma
Kasalika
Elisa
Stephen Lizwe
Chatewa
Nakutepa
Mponela
Chikhobwe
School
Mtembo
Chikasauka
Chikonakuka
Kaponda
Kambauwa
D82
Katembo
Dumbo
388/MWT
4226
Lipembe
School
Chimbuzi
Phava
Kanyenda
Chimungu
School
Mlimba
Kabulungu
School
Mgulula
SP221/76
Chimkombelo
Kamkwanda
Langwani
School
Chitsinga
Majeza
365/MWT
3880
MSAKAMBEWA
Tepeka
Mwancheka
Mawala
Phiko
Chipaka
School
13°25'
72
73
74
75
76
77
78
79
80

K4M fig 2


(m)
TEXTURES
COLOUR
SPECIAL FEATURES
INTERPRETATION
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
No rock textures
Rock textures
Sandy, quartz-rich stone-less soil
Clasts of sandier material
Clayey Sand
Sandy Clay
STONE LINE
lateritic pisoliths + diffuse segregations
weakly developed vermiform laterite
strongly developed vermiform laterite
Very micaceous saprolite
Very varied saprolite
— red clay
— grey clay
— white clay
granitic saprolite
Very micaceous saprolite
granitic saprolite
Very micaceous
dark red
2·5 YR 3/6
yellowish brown
10YR 5/6–8
Variegated
Dominantly yellowish brown 10YR 5/6–8
+ light red 2·5YR 6/6
+ dark reddish brown 5YR 3/3–4
Colours very varied
+
some diffuse iron-rich red staining especially along fracture faces
greenish tinges
• (4.5m) patches of dark humous-rich material enclosed in sand
Manganese mottles and coatings
Small core stone
Quartz stringer
Regolith Colluvium
(overspread / creep)
Palaeo dambo
Sandy
Clayey
Saprolite
(weathered rock)


BH2 CHIKOBWE
(m.)
Sandy, quartz-rich stone-less soil
Clasts of sandier material
Clayey Sand
Sandy Clay
No rock textures
STONE LINE
Very micaceous saprolite
Very varied saprolite
– red clay
– grey clay
– white clay
Granitic saprolite
Very micaceous saprolite
Rock textures
Granitic saprolite
Very micaceous saprolite
2·0m
4·0m
12·7m
29·0m
Q
K
C
M
(All Cu Kα 34kV 28mA)

SyM Figure 3



KdM fig 4