COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF
NATIONAL DEVELOPMENT

BUREAU OF MINERAL
RESOURCES, GEOLOGY
AND GEOPHYSICS

Record 1972/47

CAINOZOIC LATERITE AND SEDIMENTS IN THE ALCOOTA SHEET AREA, NORTHERN TERRITORY

by

B.R. Senior

Record No. 1972/47

CAINOZOIC LATERITE AND SEDIMENTS IN THE ALCOOTA SHEET AREA, NORTHERN TERRITORY

by

B.R. Senior

CONTENTS

SUMMARY

Laterite developed on Archaean to Proterozoic Arunta Complex rocks is characterized by a basal silica and alumina-rich kaolinite zone, grading to a middle mottled zone and an upper ferruginous zone. The laterite was probably formed in early Tertiary or late Cretaceous times and was subsequently eroded or truncated prior to widespread sedimentation which began before the late Miocene. These sediments, the Alcoota Beds, are at least 190 m thick and include the fossiliferous late Miocene to early Pliocene Waite Formation. The sediments are most probably derived from basement and were deposited by rivers and in lakes. Their varicoloured nature suggests the presence of both oxidizing and reducing environments favourable to the formation of sedimentary uranium; radioactive anomalies in gamma-ray logs are present in a drill hole and a water bore.

INTRODUCTION

Cainozoic rocks of the Alcoota Sheet include laterite developed on igneous and metamorphic rocks of the Arunta Complex, and younger lacustrine and fluviatile Tertiary sediments (Alcoota Beds). In situ deep chemical weathering which formed the typical tri-zonal arrangement of the laterite profile preceded the deposition of the Tertiary sediments. Cainozoic rocks are widely distributed in the Alcoota Sheet and the generalized distribution is given in Figure 1. Most of the observable outcropping laterite and Tertiary sediments are restricted to a dissected area in the southeast quadrant. In this area an east-west depression bounded to the south by the Harts Range contains up to 180 m of Tertiary sediments. This depression is called the Waite Basin and the outcropping sediments the Waite Formation (Woodburne, 1967).

Similar sediments to those in the Waite Basin occur in the central and central-western part of the Sheet area. However, outcrop in this area is limited to low, sandy, soil-mantled rises, and most of the sediments are known only from one BMR drill hole and from drillers' lithological logs of water bores. Sediments have not been uplifted and dissected like those in the Waite Basin and include additional younger rocks. For this reason they have been arbitrarily separated for mapping purposes.

CAINOZOIC ROCK UNITS

(1) Laterite (Cz)

Deep chemical weathering, which is inferred to have occurred in early Tertiary or possibly late Cretaceous time, altered the upper 40 m of exposed Archaean rocks to laterite. The laterite has a typical tri-zonal arrangement of zones of varying mineralogical and chemical composition comprising a lowermost leached zone, an intermediate mottled zone, and a ferruginous top.

In the Alcoota Sheet area a widespread terrain of laterite had developed prior to Miocene time. This age limit is based on the assumption proposed originally by Woolnough (1972) that these laterites formed during a continent-wide phase of chemical weathering. Stratigraphic evidence for thick deep weathering profiles in western Queensland indicate a late Cretaceous or early Tertiary age (Senior et al., 1968, 1969) and basalts which overlie the deep weathering profile in the Surat Basin were isotopically dated as early Miocene by Exon et al. (1970).

A subsequent period of erosion stripped the laterite from most of the area, and some of the detritus was incorporated in the Waite Formation, which now covers the wholly or partly eroded surface. In some depressions in the original laterite surface, an almost complete profile is preserved below Waite Formation in the southeast part of the Sheet.

The leached or clay-rich zone of the laterite grades from relatively unweathered parent rock at the base into a zone dominated by white kaolinitic clay minerals. It is generally possible to identify the gross lithology of the parent rock in the basal to middle part of this zone, and textural features of the host rock, together with quartz veins and remnants of large phenocrysts such as quartz and muscovite, are preserved.

The leached zone grades up into a variegated or mottled zone. This zone, which is up to 10 m thick, contains patches, stained pink, purple, brown or yellow by iron oxides, which contrast markedly with the white clay-rich matrix. Individual stained patches or mottles vary in size, and range from small nodular shapes to structureless masses (Fig. 2). Iron oxide staining and enrichment of iron oxide increases upwards through the mottled zone. Kaolinite and quartz are dominant, with subordinate amounts of hematite and goethite (Table 1). The texture of the parent rock cannot be recognized at the top of the mottled zone.

Overlying the mottled zone is a ferruginous zone up to 8 m thick. This is the most strongly indurated part of the laterite profile and forms prominent vertical escarpments generally with a columnar structure. Goethite and hematite are the dominant iron minerals. In detail the rock is generally fine-grained, rather massive and structureless, although it is cut by an irregular mosaic of fine fractures. Numerous vertical and subhorizontal joints give the zone a pronounced columnar structure, similar to that developed in some soil profiles as a result of volume changes. In places the upper 3 or 4 m of the ferruginous zone is reworked by pedogenic processes and consists of a re-cemented fragmentary layer, with a nodular structure in part, containing numerous iron pisolites. The pisolites range up to 1 cm in diameter and have a simple layer structure of concentric shells of contrastingly coloured iron oxides. This material slumps by solifluxion into the underlying ferruginous zone down vertical fractures, commonly forming 'pipe-like'infillings.

<u>Geochemistry of the Alcoota laterite</u>

Twelve samples of laterite collected from the leached, mottled, and ferruginous zones, and including one sample of unaltered parent rock for comparison, were analysed by x-ray diffraction and x-ray fluorescence. The results are given in Tables 1 & 2, and the average analysis for each part of the profiles are illustrated by histograms in Figure 3.

The results show that the formation of laterite involves rock decomposition, liberation of alkali and alkaline earth metals (K, Na, Ca, Mg) and of silica, and the concentration of iron and aluminium oxides and hydroxides. In general, iron oxide concentrations increase upward in the laterite profile, reaching 40% or more in the ferruginous zone. The abundance of SiO_2 is similar in both the leached and mottled zones, but in the ferruginous zone, where Fe_2O_3 concentrations are high, the SiO_2 content is markedly reduced.

Lukashev (1958) gives examples of laterites developed over mafic and ultramafic rocks which have concentrations of between 60 and 80% iron oxide, and points out that they may contain significant amounts of Ni, Co, Mn, Ag, Au, and Cr.

Only one sample, No. 70091110 (Grid. ref. 253143) was collected from a laterite developed on mafic igneous rock. X-ray analysis indicated that this sample appeared to contain some silver, but further work failed to confirm the presence of the metal.

(2) <u>The Alcoota Beds</u> (Map units Ta, Waite Formation Tw, and TQt)

The thickness of Tertiary sediment which crops out in the Alcoota Sheet is small and amounts to approximately 15% of the total. The Alcoota Beds have a composite thickness of approximately 250 m, as inferred from drill holes (BMR Alcoota Nos 1, 2, & 3). Of this total the basal mudstone and siltstone sequence (unit Ta) is represented by less than 5 m of outcrop along the Plenty River valley. In contrast, the Waite Formation (unit Tw) crops out extensively in mesa escarpments in a belt roughly peripheral to the margins of the Waite Basin (Woodburne, 1967) in the south-east quadrant of the Alcoota Sheet area. In most places the Waite Formation unconformably overlies a partly truncated laterite developed in Archaean rock (Fig. 4). The youngest sediments in the Alcoota Beds (unit TQt) are represented at the surface by only a few metres of quartzose sand and chalcedonized chemical and clastic sediments (Fig. 1).

In subcrop the Tertiary to Quaternary lithology differs appreciably from the majority of outcrops, and for this reason it is proposed to use the name Alcoota Beds informally for the entire sequence. The formally defined Waite Formation (Woodburne, op. cit.) becomes the middle unit within this framework. The lower limit of the Alcoota Beds is unknown; two drill holes in it failed to reach basement.

The lithology and possible correlation between units in the Alcoota Beds is shown in Figure 5. The coarse sediments in BMR Alcoota 3 are thought to be a facies equivalent of the Waite Formation, the clastics having been locally derived from the nearby Harts Range, which forms the southern boundary of the Waite Basin.

An improtant result of the drilling is the discovery of relatively thick Tertiary sediments in the Alcoota Sheet area. These sediments may well have a sedimentary uranium potential as:

(a) The sediments are derived from nearby Archaean basement which has abundant acid plutonic potential source rocks.

(b) The alternating coarse and fine-grained Tertiary sediments appear to have been deposited under fluviatile and lacustrine conditions.

(c) The sediments have a variety of red, white, and green zones, the result of differentiation under oxidizing and reducing conditions. Uranium is in places elsewhere associated with the junction of oxidizing and reducing zones.

Unfortunately, not all of the BMR stratigraphic holes were gamma-ray logged. However, logs were run in BMR Alcoota 2 and in three abandoned water bores on Woodgreen station. In two of the holes logged there are two small but apparently anomalous zones of relatively high radioactivity. In Alcoota 2 a small anomaly was recorded from a sandy conglomerate bed in the interval 90 to 100 m, which is possibly due to a very low concentration of uranium in groundwater (Fig. 6). The second anomaly, obtained in an abandoned waterbore (Woodgreen No. 1), is 10.5 m thick and according to the driller's log given by the property owner of Woodgreen station it lies in a median position between a red miaceous sandstone and a green and grey medium-grained sandstone (Fig. 7).

Unit Ta

BMR Alcoota 1 and 2 drill holes penetrated a massive mudstone and siltstone sequence below the Waite Formation to total depth (Fig. 5). The upper part of these argillaceous sediments is weathered and mottled and stained by red oxide. The red coloration is especially evident in BMR Alcoota 1. However, in the sequence in both holes there is a zone of slightly leached white mudstone and siltstone, which in BMR Alcoota 2 graded into a basal sequence of green and grey, unaltered, pyritic mudstone. The sediments are almost devoid of bedding except for a few faint laminations. Apparently they were deposited in a lacustrine environment, in very quiet water, under reducing conditions.

Waite Formation (Tw)

About 40 m of the upper part of the Tertiary Waite Formation crops out in the Alcoota Sheet area; the full thickness is nowhere exposed. BMR Alcoota 3, 500 m east of Harts Range police station, drilled 130 m of sandstone, siltstone, and mudstone (Yeates, 1971), and is equated with the Waite Formation (Fig. 5).

In outcrop the Waite Formation consists of interbedded chalcedonic limestone, sandstone, siltstone, and minor sandy conglomerate. Beds of cream or white chalcedony form hard resistant summit caps to many low plateaux and mesas. The multiplicity and lack of clastic detritus in the chalcedonic beds indicate that they formed by direct precipitation of silica and are contemporaneous with interbedded clastic deposits of the Waite Formation. Some beds have the appearance of limestone, and secondary replacement of clacium by silica may have played a part in altering the composition of the original chemical sediments. A sample of chalcedonic limestone (No. 70091113) analysed by x-ray fluorescence consisted dominantly of SiO_2 (96.7%) with minor iron oxide (0.77%), calcium oxide (0.35%), and phosphorous pentoxide (0.25%).

In most outcrops the sediments increase in grainsize upwards, and in the Alcoota Sheet area Woodburne (1967) attributed this to a change from a lacustrine to a fluviatile environment of deposition. BMR Alcoota No. 1 tends to confirm this, because the subsurface sediments are dominantly argillaceous and include abundant mudstone, siltstone, and claystone.

Vertebrate fossils in the outcropping lacustrine part of the sequence are late Miocene or early Pliocene (Woodburne, op. cit.). The fine grainsize of the sediments, and prolific iron staining observed in the cores recovered in BMR Alcoota No. 1, (the result of contemporaneous weathering,) suggest that an early Tertiary age might be appropriate for this part of the sequence. Sediments from cuttings in the interval 102 to 105 m in BMR Alcoota No. 1 (unit Tc) proved to be palynologically barren.

The distribution of Tertiary sediments (Fig. 1) shows two north-trending extensions of the Waite Basin. At a point 10 km south of Utopia homestead, on the westernmost extension, coarse-grained sediments occur with pebble to small boulder sized clasts. The linearity and coarseness of these deposits, and the probable decrease in grainsize southwards, indicate a northerly source of detritus with drainage flowing southward into the Waite Basin. This is a reversal of the present-day drainage direction. As late Miocene to early Pliocene vertebrate fossils are present in the upper part of the Waite Formation, the Waite Basin was uplifted and dissected after the early Pliocene.

(3) Undifferentiated Tertiary sediments (TQt)

Figure 1 shows a broad area of Tertiary sediments in the centre and central-west part of Alcoota Sheet area, which extend into the neighbouring Napperby Sheet. They are largely unknown as they outcrop poorly and are mantled with Quaternary red sandy soils. Only 11 of approximately 50 drillers' logs of water bores in this area record lithological information. However, these sediments are in the order of 100 m thick as intersected in BMR Alcoota 2. Surface outcrops consist of silty sandstone overlying beds of travertine, limestone, and chalcedony. In subcrop the sediments consist of poorly sorted quartzose sandstone and pebble conglomerate with some siltstone and mudstone beds. The coarser-grained beds are a source of groundwater.

No fossils have been recorded from the sequence and the age of the sediments is unknown. These rocks, unlike the Waite Formation in the Waite Basin, are not dissected, and are probably younger, the upper part being possibly younger than early Pliocene.

REFERENCES

EXON, N.F., LANGFORD-SMITH, T., and McDOUGALL, I., 1970 - The age and geomorphic correlations of deep-weathering profiles, silcrete, and basalt in the Roma-Amby region, Queensland. J. geol. Soc. Aust., 17(1), 21-30.

LUKASHEV, K.I., 1958 - Lithology and geochemistry of the weathering crust. Translated from Russian 1970. Israel Programme for scientific translation.

SENIOR, B.R., GALLOWAY, M.C., INGRAM, J.A., and SENIOR, DANIELE, 1968 - The geology of the Barrolka, Eromanga, Durham Downs, Thargomindah, Tickalara and Bulloo 1:250,000 Sheet areas, Queensland. Bur. Miner. Resour. Aust. Rec. 1968/35 (unpubl.).

SENIOR, B.R., INGRAM, J.A., THOMAS, B.M., and SENIOR, DANIELE, 1969 - The geology of the Quilpie, Charleville, Toompine, Wyandra, Eulo and Cunnamulla 1:250,000 Sheet Areas, Queensland. Bur. Miner. Resour. Aust. Rec. 1969/13 (unpubl.).

WOODBURNE, M.O., 1967 - The Alcoota Fauna, central Australia. Bur. Miner. Resour. Aust. Bull. 87.

WOOLNOUGH, W.G., 1927 - Presidential address. Part 1 - The chemical criteria of peneplanation; Part 2 - The duricrust of Australia. J. Roy. Soc. N.S.W., 61, 17-53.

YEATES, T., 1971 - Shallow stratigraphic drilling, western Eromanga Basin and Alcoota area, Northern Territory. Bur. Miner. Resour. Aust. Rec. 1971/120 (unpubl.).

TABLE 1

Minerals identified by X-ray diffraction in order of relative intensities (1-3) and grouped according to their position in the laterite profile

G.E. Berryman analyst, BMR laboratories.

Sample No.	Muscovite	Kaolinite	Quartz	Goethite	Haematite	Grid Ref.
			Ferruginous Zone			
70091101	-	2	1	-	3	253158
" 1106	-	2	1	-	-	268173
" 1111	-	2	1	-	3	249145
			Mottled Zone			
" 1102	-	1	2	3	-	253158
" 1112	-	2	1	-	3	249145
" 1115	-	2	1	3	-	212157
" 1120	-	2	1	-	-	264186
			Leached Zone			
" 1103	-	1	2	-	-	253158
" 1105	-	2	1	-	-	268173
" 1119	1	3	2	-	-	255184

TABLE 2

X-Ray fluorescence analyses of laterites, grouped according to their position in the laterite profile

J.W. Sheraton analyst, BMR Laboratories

(For data retrieval at the BMR each sample number is prefixed 7009)

Ferruginous zone

Sample No.	1101	1106	1111	1110
SiO_2	34.74	47.05	73.78	65.93
TiO_2	1.31	0.12	1.54	2.60
Al_2O_3	19.65	11.53	15.51	0.64
*Fe_2O_3	42.74	41.42	8.24	30.86
MnO	0.04	0.04	0.01	0.03
MgO	0.48	0.29	0.16	0.22
CaO	0.38	0.16	0.05	0.01
Na_2O	0.00	0.02	0.04	0.06
K_2O	0.07	0.02	0.06	0.00
P_2O_5	0.05	0.05	0.07	0.06
Total	99.46	100.69	99.45	100.41
Loss on Ignition	9.60	7.34	7.10	3.67

Mottled zone

Sample No.	1102	1112	1115	1120
SiO_2	68.94	84.41	79.92	75.77
TiO_2	0.67	0.90	1.55	1.04
Al_2O_3	19.27	11.51	12.74	21.41
*Fe_2O_3	9.84	5.72	4.18	1.68
MnO	0.00	0.00	0.00	0.00
MgO	0.65	0.19	0.21	0.13
CaO	0.31	0.06	0.04	0.08
Na_2O	0.00	0.03	0.25	0.04
K_2O	0.09	0.02	0.02	0.08
P_2O_5	0.04	0.03	0.05	0.06
Total	99.82	99.87	98.95	100.29
Loss on Ignition	8.37	5.16	6.24	9.07

Table 2 (cont.)

Leached zone

Sample No.	1103	1105	1119
SiO_2	69.61	76.12	89.15
TiO_2	1.23	0.02	0.48
Al_2O_3	22.81	21.09	8.19
*Fe_2O_3	1.10	1.54	0.66
MnO	0.00	0.00	0.00
MgO	0.64	0.27	0.48
CaO	2.70	0.20	0.08
Na_2O	0.05	0.06	0.05
K_2O	0.13	0.18	2.16
P_2O_5	0.02	0.03	0.02
Total	98.29	99.52	101.27
Loss on Ignition	11.17	8.89	1.72

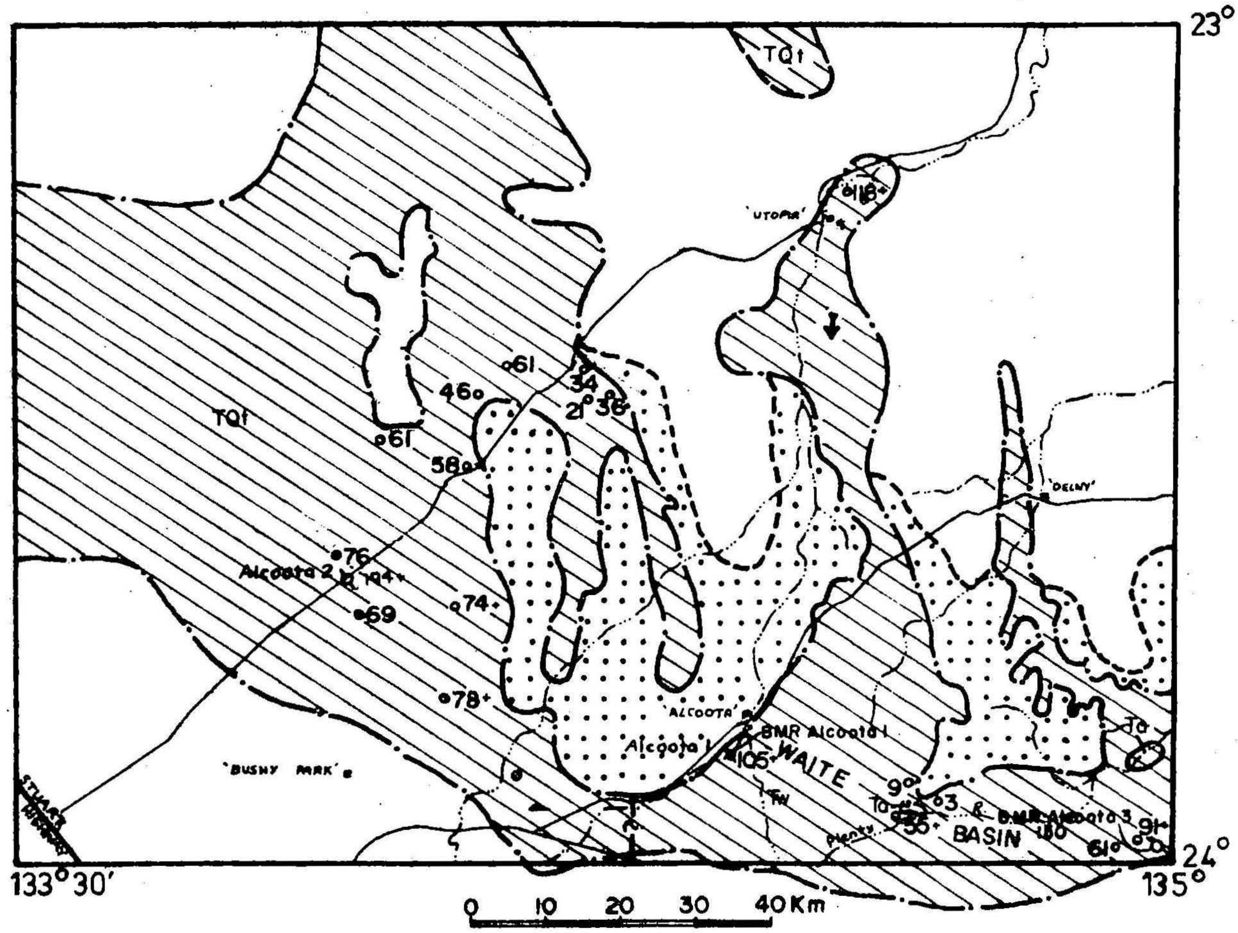
Biotite-quartz-feldspar-gneiss (parent rock)

Sample No.	1104
SiO_2	75.30
TiO_2	0.11
Al_2O_3	13.45
*Fe_2O_3	0.97
MnO	0.00
MgO	0.22
CaO	0.99
Na_2O	2.90
K_2O	5.91
P_2O_5	0.05
Total	99.90
Loss on Ignition	0.52

ALCOOTA

FIGURE 1

DISTRIBUTION OF LATERITE AND CAINOZOIC SEDIMENTS



- Generalized distribution of Tertiary sediments (units Ta, Tw and TQt).
- Areas of laterite developed in Archaean rocks which probably were covered in late Miocene time by Tertiary sediments
- PreCambrian & Palaeozoic rocks
- Direction of transport of Tertiary fluviatile sediment
- o Water bore
- BMR scout hole

(Water bore and BMR scout hole:) with thickness in metres of Tertiary sediments
+ indicates full thickness of sediments not penetrated

To accompany Record 1972/47

F53/A10/15

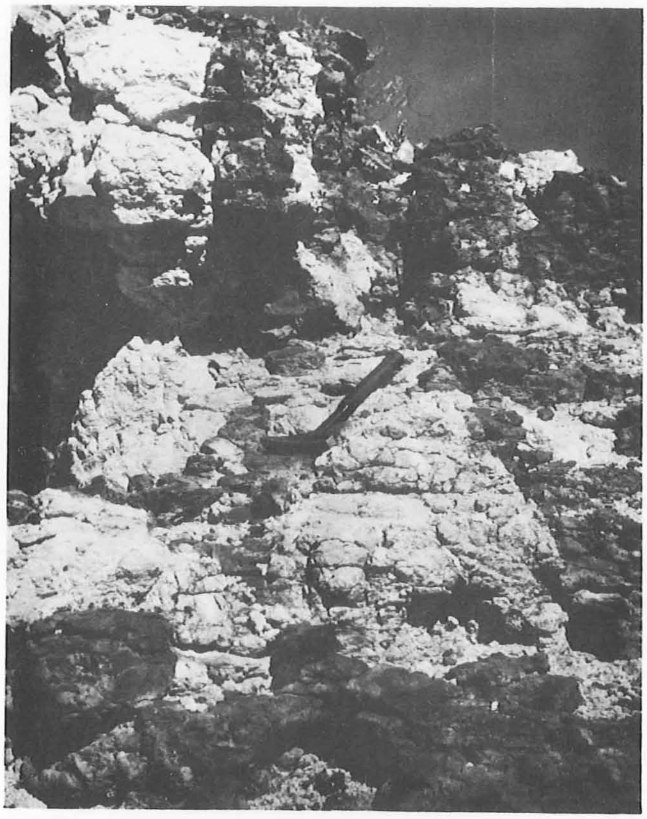


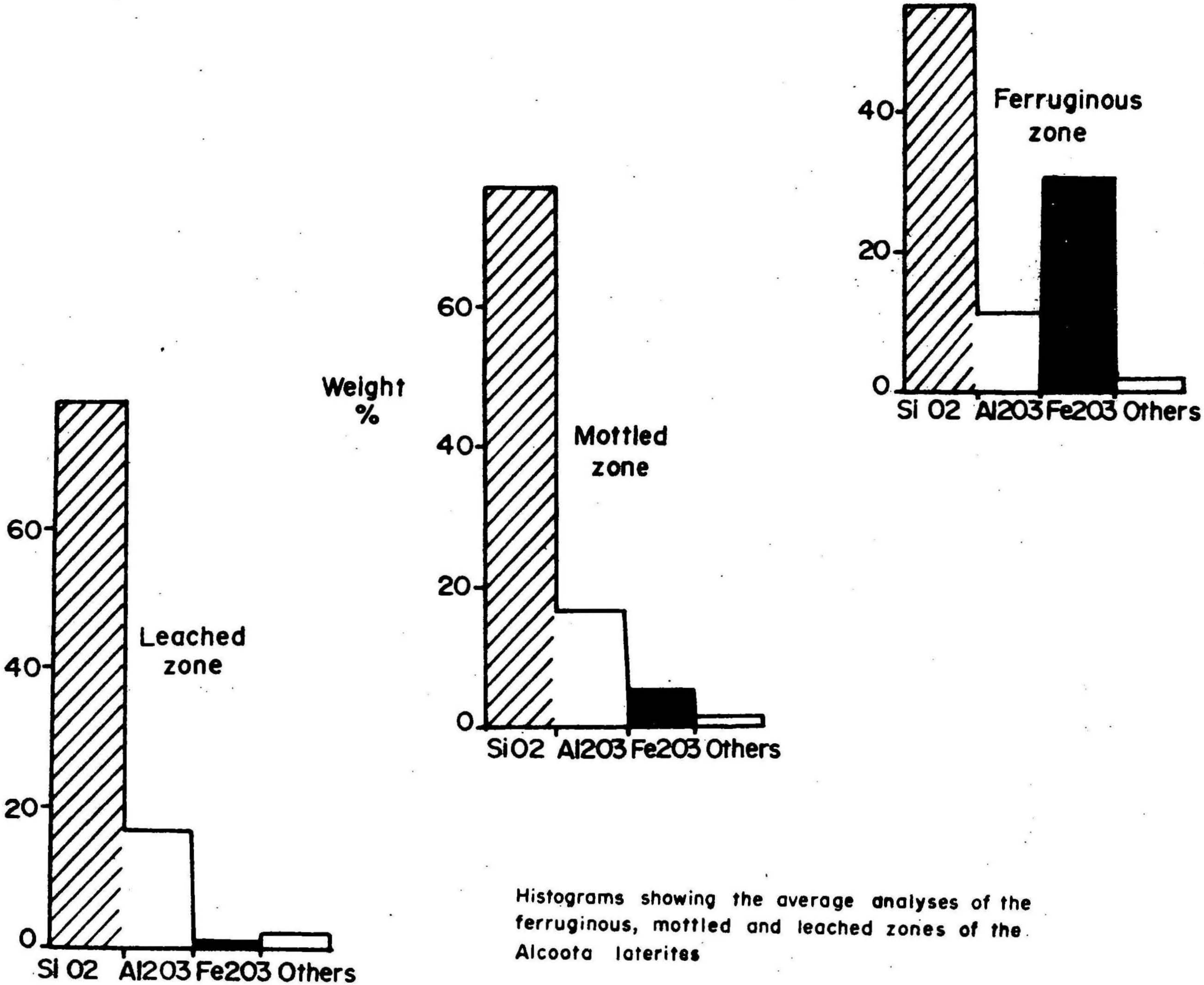
Fig. 2: A typical mottled zone in a laterite profile showing highly irregular zones of slight iron-enrichment contrasting with iron-leached kaolinitic rock.
Neg.No.CA/4661.

Fig. 4: Tertiary Waite Formation sediments (light grey) overlying a gently undulating surface of laterite (dark tones). A bed of chalcedony in the Waite Formation forms a concordant mesa capping. (Grid. Ref. 240145). Neg.No. CA/4663.

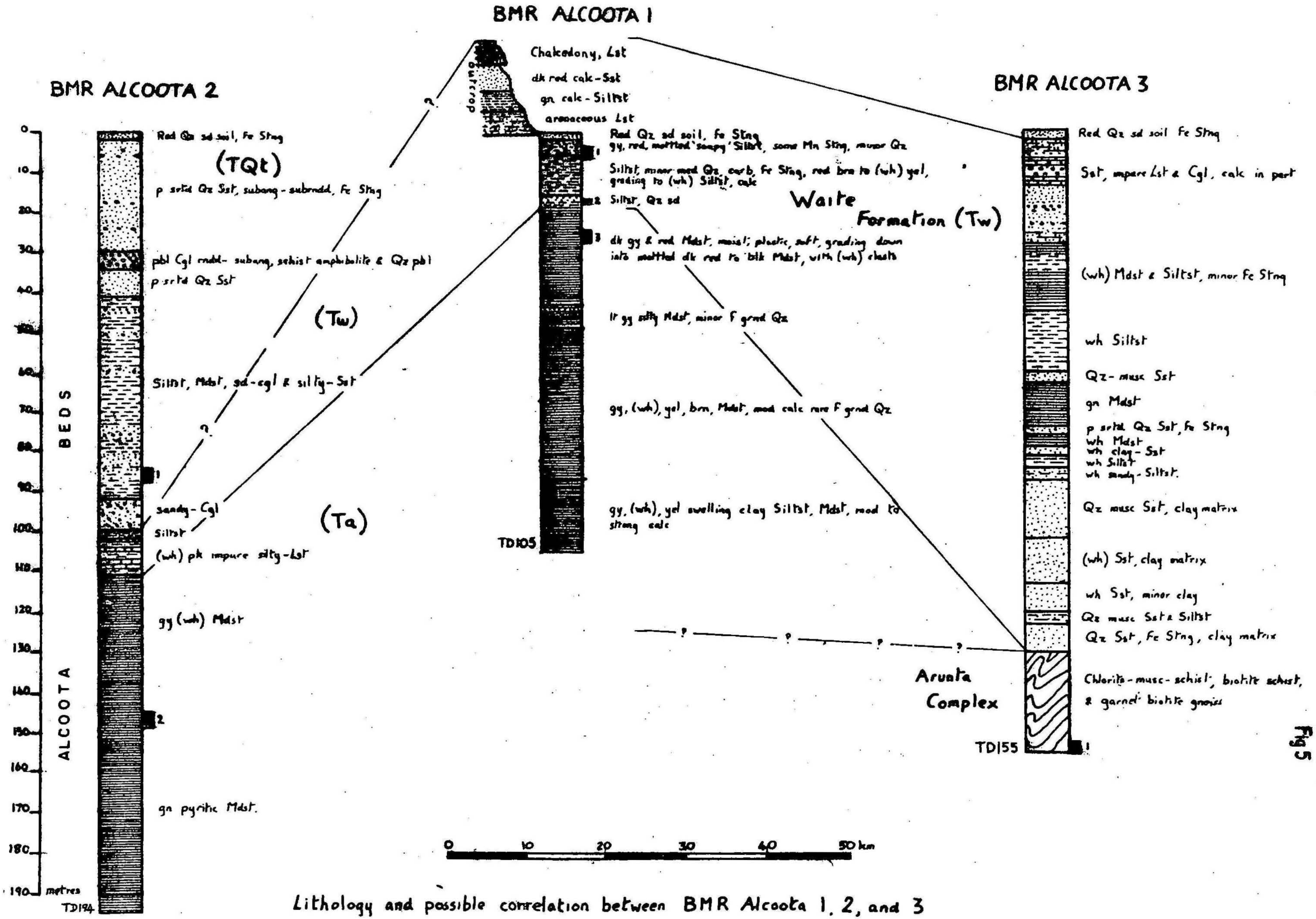
To accompany Record 1972/47

F53/A10/21

FIGURE 3



Histograms showing the average analyses of the ferruginous, mottled and leached zones of the Alcoota laterites



Lithology and possible correlation between BMR Alcoota 1, 2, and 3

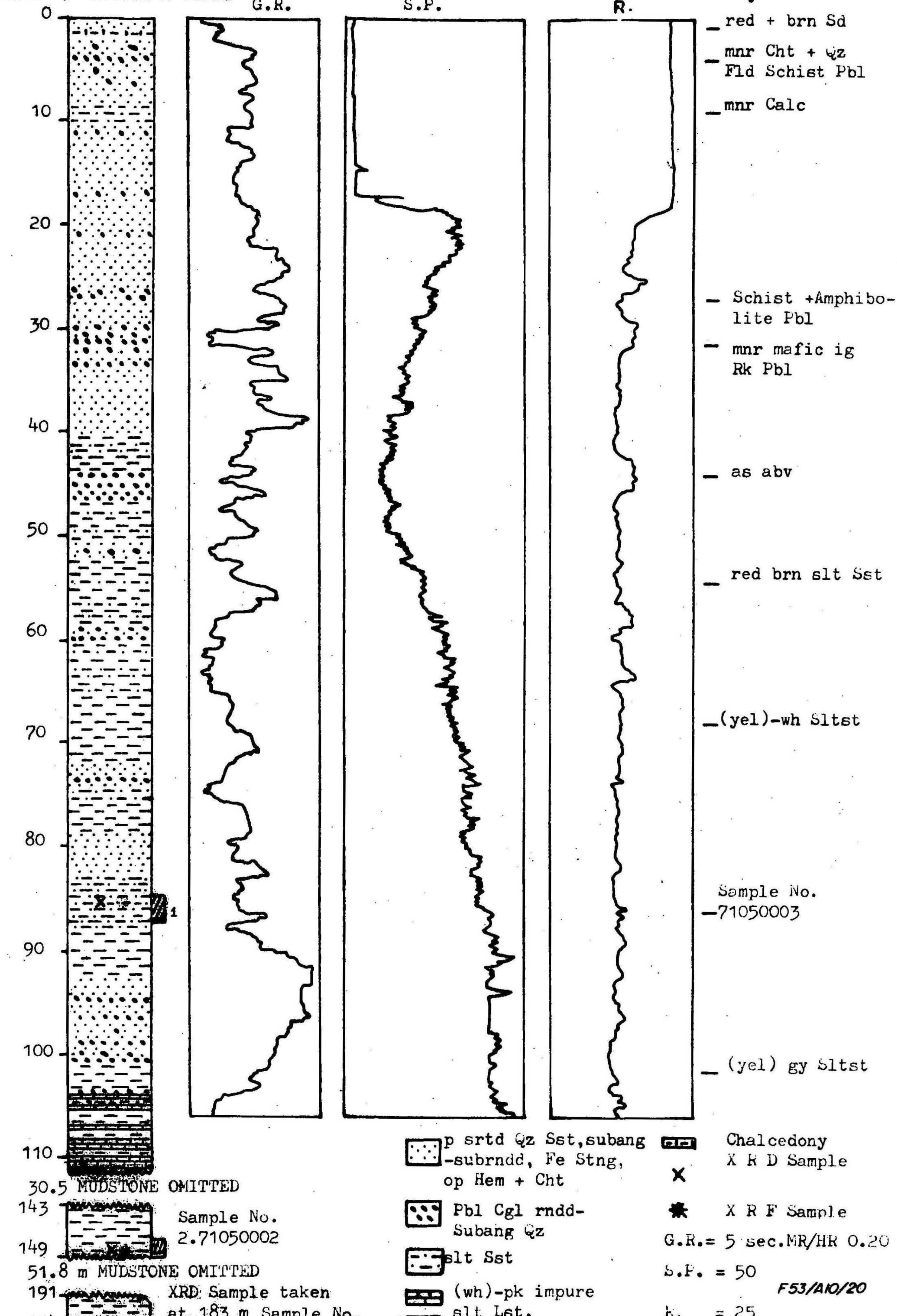
To accompany Record 1972/47

F53/A10/19

Fig 5

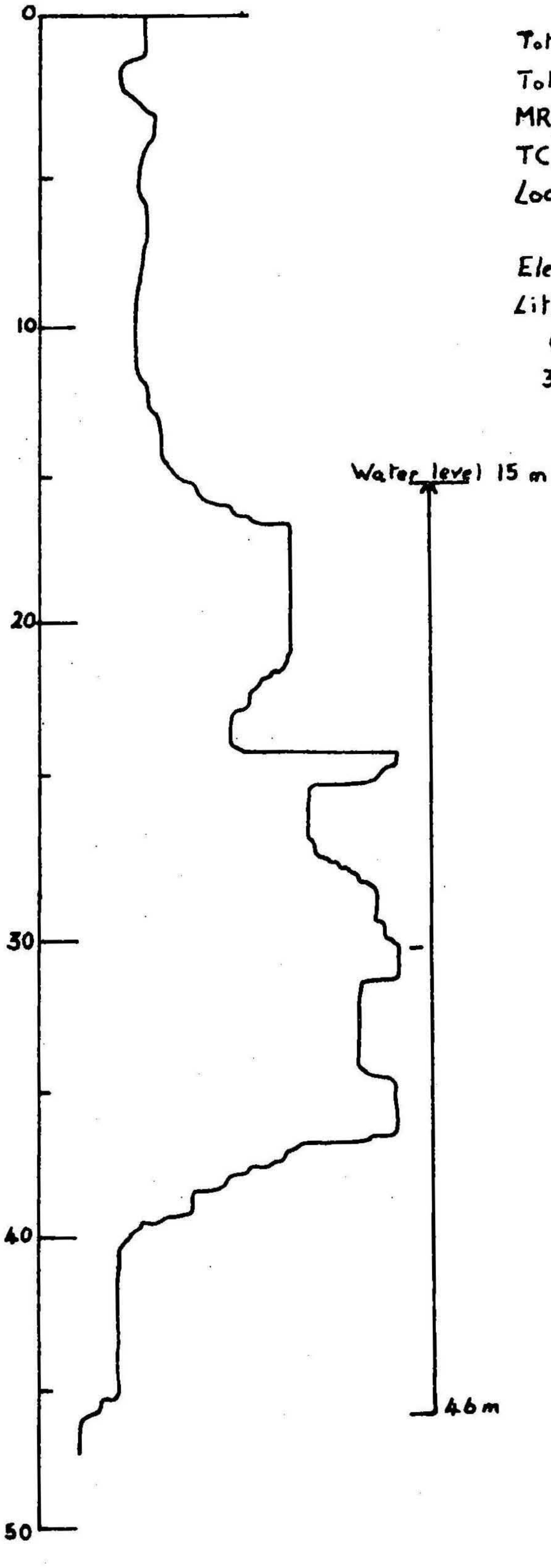
B.M.R. ALCOOTA No.2.
T.D. 194 metres 2 Cores

Fig 6



To accompany Record 1972/47

GAMMA-RAY LOG OF WOODGREEN 1 (Reg. No.56)



Total depth driller 55 m
Total depth logger 48 m
MR/HR ·020
TC Secs 16
Location Lat 22°31'S
Long 134° 17'E
Elevation 580 m (approx)
Lithology
0 - 30 Red micaceous sandstone.
30 - 55 Green sandstone.