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CSIRO
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LAWLERS ORIENTATION STUDY
Contribution to Field Guide, Eastern Goldfields Trip, 1-2 November 1990

R.R. Anand, R.E. Smith, H.M. Churchward and J.L. Perdrix

CRC LEME OPEN FILE REPORT 37

February 1999

(CSIRO Division of Exploration Geoscience, unnumbered report, 1990.
Second impression 1999)

CRC LEME is an unincorporated joint venture between The Australian National University, University of Canberra, Australian Geological Survey Organisation and CSIRO Exploration and Mining, established and supported under the Australian Government's Cooperative Research Centres Program.

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Headquarters: CRC LEME c/o CSIRO Exploration and Mining, Private Bag, PO Wembley, Western Australia, 6014

RESEARCH ARISING FROM CSIRO/AMIRA REGOLITH GEOCHEMISTRY PROJECTS 1987-1993

In 1987, CSIRO commenced a series of multi-client research projects in regolith geology and geochemistry which were sponsored by companies in the Australian mining industry, through the Australian Mineral Industries Research Association Limited (AMIRA). The initial research program, "Exploration for concealed gold deposits, Yilgarn Block, Western Australia" (1987-1993) had the aim of developing improved geological, geochemical and geophysical methods for mineral exploration that would facilitate the location of blind, buried or deeply weathered gold deposits. The program included the following projects:

P240: Laterite geochemistry for detecting concealed mineral deposits (1987-1991). Leader: Dr R.E. Smith.
Its scope was development of methods for sampling and interpretation of multi-element laterite geochemistry data and application of multi-element techniques to gold and polymetallic mineral exploration in weathered terrain. The project emphasised viewing laterite geochemical dispersion patterns in their regolith-landform context at local and district scales. It was supported by 30 companies.

P241: Gold and associated elements in the regolith - dispersion processes and implications for exploration (1987-1991). Leader: Dr C.R.M. Butt.
The project investigated the distribution of ore and indicator elements in the regolith. It included studies of the mineralogical and geochemical characteristics of weathered ore deposits and wall rocks, and the chemical controls on element dispersion and concentration during regolith evolution. This was to increase the effectiveness of geochemical exploration in weathered terrain through improved understanding of weathering processes. It was supported by 26 companies.

These projects represented "an opportunity for the mineral industry to participate in a multi-disciplinary program of geoscience research aimed at developing new geological, geochemical and geophysical methods for exploration in deeply weathered Archaean terrains". This initiative recognised the unique opportunities, created by exploration and open-cut mining, to conduct detailed studies of the weathered zone, with particular emphasis on the near-surface expression of gold mineralisation. The skills of existing and specially recruited research staff from the Floreat Park and North Ryde laboratories (of the then Divisions of Minerals and Geochemistry, and Mineral Physics and Mineralogy, subsequently Exploration Geoscience and later Exploration and Mining) were integrated to form a task force with expertise in geology, mineralogy, geochemistry and geophysics. Several staff participated in more than one project. Following completion of the original projects, two continuation projects were developed.

P240A: Geochemical exploration in complex lateritic environments of the Yilgarn Craton, Western Australia (1991-1993). Leaders: Drs R.E. Smith and R.R. Anand.
The approach of viewing geochemical dispersion within a well-controlled and well-understood regolith-landform and bedrock framework at detailed and district scales continued. In this extension, focus was particularly on areas of transported cover and on more complex lateritic environments typified by the Kalgoorlie regional study. This was supported by 17 companies.

P241A: Gold and associated elements in the regolith - dispersion processes and implications for exploration. Leader: Dr. C.R.M. Butt.
The significance of gold mobilisation under present-day conditions, particularly the important relationship with pedogenic carbonate, was investigated further. In addition, attention was focussed on the recognition of primary lithologies from their weathered equivalents. This project was supported by 14 companies.

Although the confidentiality periods of the research reports have expired, the last in December 1994, they have not been made public until now. Publishing the reports through the CRC LEME Report Series is seen as an appropriate means of doing this. By making available the results of the research and the authors' interpretations, it is hoped that the reports will provide source data for future research and be useful for teaching. CRC LEME acknowledges the Australian Mineral Industries Research Association and CSIRO Division of Exploration and Mining for authorisation to publish these reports. It is intended that publication of the reports will be a substantial additional factor in transferring technology to aid the Australian Mineral Industry.

This report (CRC LEME Open File Report 37) is a Second impression (second printing) of CSIRO, Division of Exploration Geoscience Restricted Report Unnumbered, first issued in 1990/11, which formed part of the CSIRO/AMIRA Projects P240 and P241.

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LAWLERS FIELD STOPS

1 and 2 November 1990

10.00 AM

STOP 1 Brilliant area

An example of regolith in an erosional regime (Unit 2)
- low stony hills
- stripping of the lateritic profile
- lag of ferruginous cobbles (iron segregations)
- red clay soil
- pedogenic carbonate
- pockets of saprolite/bedrock

The ferruginous cobbles occur largely on erosional areas in the Lawlers district and appear to have been derived from the breakdown of iron segregation bodies. The iron segregations, several metres across, commonly occur within the ferruginous saprolite/saprolite horizons in a weathering profile. Ferruginous cobbles are black, generally non-magnetic and many of them are dominated by low Al-substituted goethite and hematite. The internal surfaces of many of the ferruginous cobbles show the goethite pseudomorphs after pyrite. Ferruginous cobbles are high in Fe (71% Fe_2O_3), Mn (3000 ppm), Zn (380 ppm), Cu (157 ppm), and Co (91 ppm) – mean values of 33 samples.

STOP 2 Agnew-McCaffery area

Comparison of the regolith between erosional (Unit 2) and residual regimes (Unit 1) of the Agnew - McCaffery area. The location comprises two minor valleys.

Residual regime - broad crest, backslope, valley floor (Northern Valley).

- Gravelly sandy loam to sandy clay loam soil over lateritic residuum.
- Lateritic gravels with yellowish brown cutans on broad crest and become finer downslope.
- Downslope, the gravels with dark brown to brownish black surfaces become increasingly more common.
- Hematite and maghemite are more abundant in lateritic lag gravels on broad crest. This suite of minerals also dominates the backslope and valley floor.
- Fe_2O_3 is the most abundant constituent with values greater than 75% in lateritic gravels. The small amounts of Al_2O_3 and SiO_2 are mainly present as kaolinite.
- The trace elements V, Mn, Cr, As, Pb, and Ga are more abundant in the lateritic gravels than in lag of ferruginous saprolite.
- Goethites are highly Al-substituted (up to 30 mole %).

Erosional regime - breakaway, pediment slope, valley floor (Southern Valley).

- Gravelly sandy clay loam soil over saprolite.
- Subcropping saprolite/ferruginous saprolite (Unit 2) on the breakaway and upper pediments and alluvium/colluvium dominating the valley floor.
- The pediments below the breakaway are mantled by a coarse lag containing yellowish brown ferruginous saprolite/mottled saprolite.
- These lags become finer downslope, they are mixture of clasts with yellowish brown surfaces and others that are black. Cutans are generally not present.

- Goethite is the dominant mineral. Al-substitution in the goethite from the lags of the erosional regime is systematically lower (13-18 mole %) than goethites from the residual regime. Kaolinite is relatively more abundant in ferruginous saprolite than in lateritic gravels.
- Fe_2O_3 averages about 55% in lag of ferruginous saprolite/mottled saprolite.
- Cu and Ni are more abundant in lag of ferruginous saprolite/mottled saprolite than in lateritic gravels.

LUNCH 12.45 PM

2.00 PM

STOP 3 Turrett Pit

Colluvial outwash plain (Unit 6), colluvium on lateritic residuum.

Laterite relationships and regolith stratigraphy from mine pit walls.

Units of the weathering profile (Southern half of the Western wall).

Top

- Gravelly colluvium (hardpanized and containing lateritic detritus).
- Lateritic residuum with iron segregations.
- Massive iron segregation bodies (note breakdown of iron segregations into small 5 to 10-mm nodules); many iron segregations and nodules show goethite pseudomorphs after pyrite).
- Ferruginous saprolite/collapsed ferruginous saprolite.
- Saprolite, saprock.

Bottom

Also (northern half)
- Colluvium on packed duricrust (black pisoliths in sandy matrix).
- Colluvium on red clay (some hardpanized).

STOP 4 Agnew gravel pit

Residual regime - backslopes, crest

- Lateritic nodules, pisoliths.
- Nodular/pisolitic duricrust (some hardpanized).
- Pockets of Fe-rich pebbly duricrust.

Erosional regime - breakaway, pediment slopes.

- Lag of ferruginous saprolite/mottled saprolite, iron segregations.

Lateritic duricrust and lateritic gravels are dominated by hematite, goethite, and maghemite with small amounts of kaolinite, gibbsite, quartz and, anatase. By contrast, iron segregations are dominated by goethite with small amounts of hematite.

5.00 PM

BARBECUE AT 5.45 PM

8.00 AM

STOP 5 Waroonga Pit

Colluvial outwash plain (Unit 6); thick colluvium on lateritic residuum.

Top

- Red colluvium.
- Hardpanized red colluvium containing lateritic detritus, with abundant partings (Si-rich) and Mn staining.
- Red clay with some ferruginous granules (note the sharp contact between hardpanized colluvium and red clay).
- Nodular duricrust (hematite rich-red nodules in a kaolinite-rich matrix).

Bottom

STOP 6 Brilliant area

- Fe-rich nodular/oolitic duricrust on crest and breakaway face.
- Ferruginous cobbles (iron segregations) on pediments.
- Local pockets of pedogenic carbonates.
- Saprolite.

Iron-rich duricrusts are sporadically distributed throughout the Lawlers district and commonly occur on topographically-elevated areas. The most characteristic features of Fe-rich duricrusts are :

- the boundaries between nodules/ooliths and matrix are not well developed in sliced surfaces, despite the pebbly appearance of weathered surfaces;
- the matrix and nodule compositions are not significantly different and both are Fe-rich;
- the volume of matrix between the nodules is small;
- nodules generally lack cutans;
- weathered ilmenite grains and slightly-ferruginized charcoal fragments occur within pisoliths;
- charactarized by high concentration of Fe and very low concentration of Si and Al;
- dominated by hematite, goethite, and maghemite;
- large range in values on Mn, Cr, V, Zn, Ni, Co, As, and Ga.

11.00 AM DEPART LAWLERS FOR KALGOORLIE.

LUNCH AT LEONORA

RETURN TO KALGOORLIE BY BUS.

PROJECT LEADER'S PREFACE
R. E. Smith
26 October 1990

Regolith relationships and the challenges to geochemical exploration in the Lawlers district represented a logical progression from the experiences which had arisen from the Mt. Gibson and Bottle Creek orientation studies, moving towards more complicated settings, namely those involving deep burial of laterite profiles. Thus, because of its scientific merit, the Lawlers district became one of the Laterite Geochemistry Project's four substantial district-scale orientation studies.

The research activities at Lawlers have been part of a three-way collaborative study: Forsayth Mining Ltd., the tenement holders, providing geological control and funds for research, GEOCHEMEX Australia carrying out the exploration geochemistry applications for Forsayth, and the Laterite Geochemistry Group providing the research component. Under the terms of the agreement, the flow of research results from this activity to the CSIRO/AMIRA Laterite Geochemistry Project P240 has been subject to a three-months period of confidentiality. The GEOCHEMEX laterite-based geochemical programme commenced in mid-1988 and the CSIRO research study in November 1988.

In mid-1989, scientists of the CSIRO WA Remote Sensing Group were invited to commence collaborative research with the Laterite Geochemistry Group on testing the application of remote sensing to regolith mapping within the Lawlers district. This collaboration is in full flight.

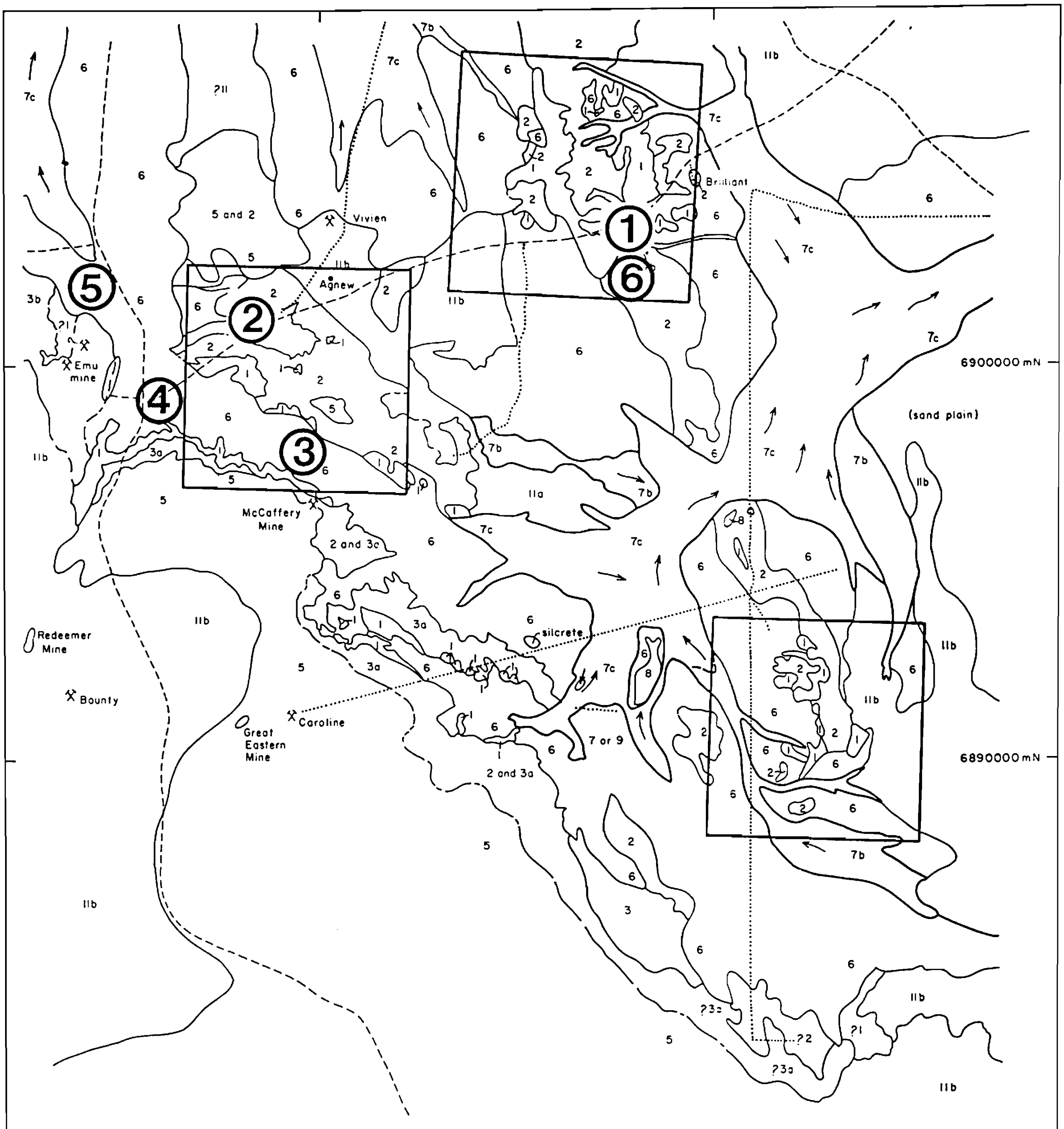
The attributes of the Lawlers district pertinent to geochemical exploration are listed below, as well as the components of the research study.

ATTRIBUTES OF THE LAWLERS DISTRICT

- Typifies important exploration problems, Norseman-Wiluna
- Mafic/ultramafic sequences
- Buried laterite profiles
- Orientation on concealed ore
- Opportunity for state-of-art geochemical exploration
- Substantial exploration regolith framework
- Rapidly-growing bedrock control

RESEARCH COMPONENTS, LAWLERS

- District-scale regolith framework
- Orientation, Au beneath +10 m lateritic hardpan
- Type study of iron segregations, etc.
- Feasibility of drilling for lateritic geochemistry
- Bedrock versus laterite composition (mafic and ultramafic sequence)
- Further classification of laterites



PROVISIONAL MAP SHOWING THE SURFACE DISTRIBUTION
OF REGOLITH UNITS, LAWLERS DISTRICT

Generalised from mapping by
I.K. Butler, R.E Smith, R.R Anand and H.M. Churchward

Note: The map uses an uncontrolled photomosaic as its base;
some minor distortion occurs.

(Refer also to Appendix III of Butler et al. 1989)

N

0 km 1

Depositional units

Note: Alluvium in upper tributaries is omitted

Alluvium — 7b Alluvium in lower tributaries

7c Alluvium in braided-wash valleys

Colluvium — 6 Colluvium as sheetwash

Calcrete — 8 Interpreted as valley-form calcrete

Residual units

Lateritic residuum — 1 Loose lateritic pisoliths and nodules; Nodular lateritic duricrust

Truncational units, Mottled zone — 3a Contains outcrop and scree of mottled zone and saprolite after mafic rocks

3b Mottled zone and saprolite after felsic rocks

Saprolite — 11 Saprolitic outcrops and segments, a mafic, b felsic

Outcrop, rubble, lithosols — 5 Bedrock lithologies exposed or beneath veneer of regolith

Stony soil — 2 Red-brown soil, ironstone lag and saprolite after mafics. Pedogenic calcrete

Areas of detailed mapping

Road

Track

260000mE

270000mE

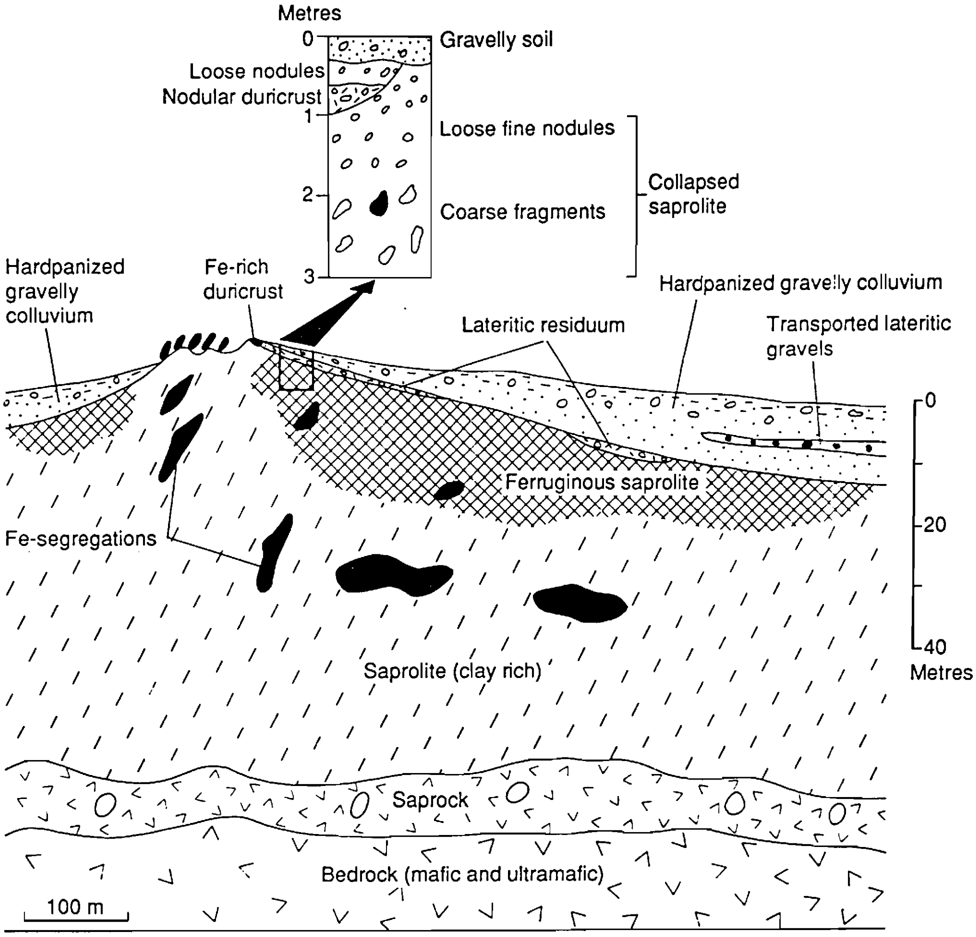
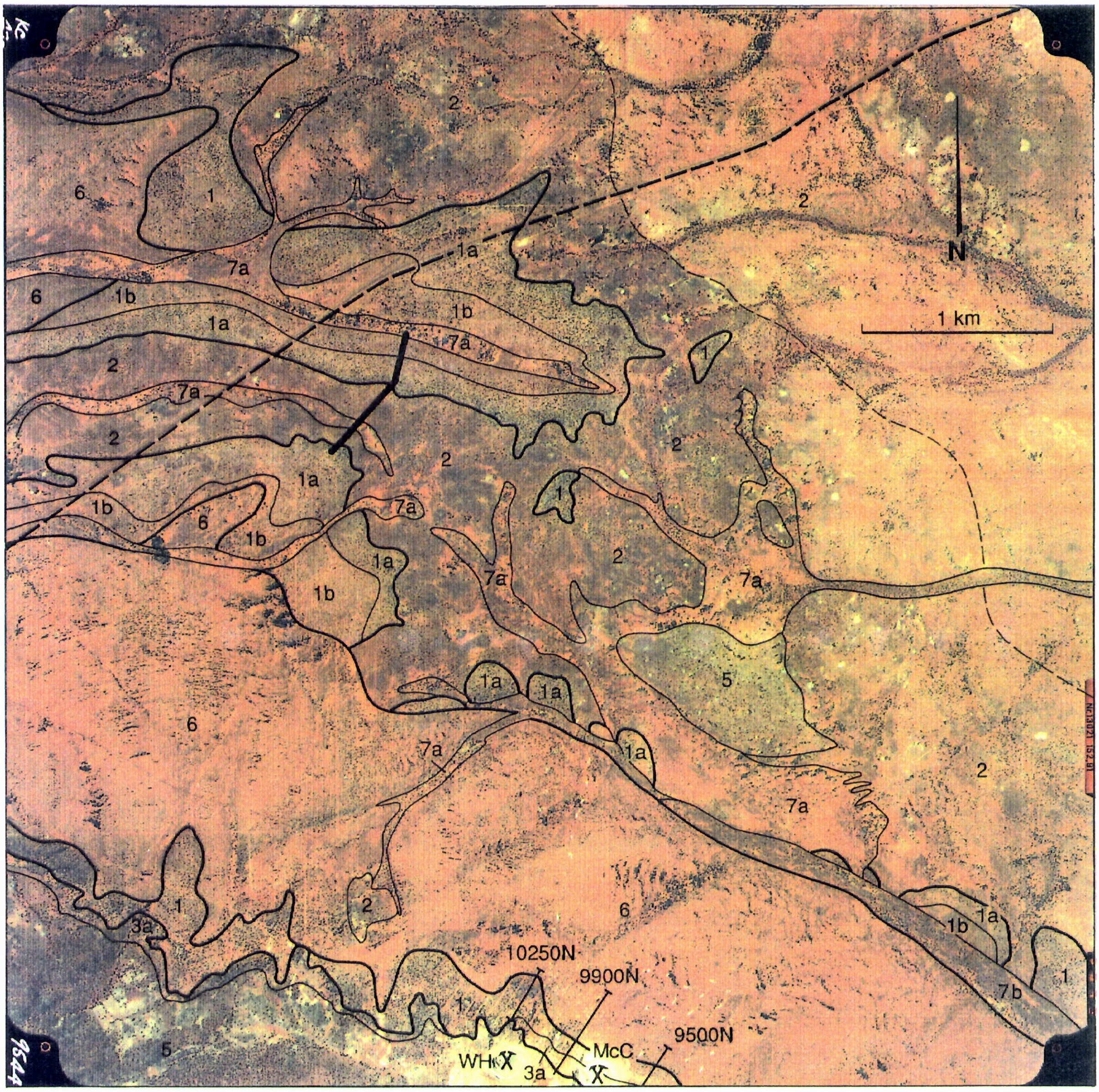


Fig. MM. Generalized composite section for Lawlers district showing regolith/landform relationships and distribution (vertical and lateral) of lateritic units and associated ferruginous materials.

CHARACTERISTICS OF REGOLITH UNITS : LAWLERS DISTRICT

TYPE OF REGIME	EROSIONAL REGIMES						RESIDUAL REGIME	DEPOSITIONAL REGIMES					
REGOLITH UNIT AT SURFACE	2	3a	3b	5	11a	11b	1	6	7a	7b	7c	8	9
LANDFORM	Low hills	Breakaway and pediment slopes		Convex hills	Pediplain		Undulating upland (crests with back slopes)	Long very gentle slopes	Floors of minor tributaries	Broad wash features of major tributaries	Broad alluvial floors - braided of rainage	Calcreted drainage lines	Local drainage sumps
VEGETATION	Mulga	Mulga		Mulga	Mulga		Mulga	Mulga, Eremophila shrubs	Mulga			Mulga, Eucalyptus	Mulga
LAG	Coarse iron segregations, vein quartz	Lag of ferruginous saprolite, mottled saprolite, iron segregations	Fine quartz, feldspar grit	Lags not common, rock outcrops	Lags not common, saprolite outcrops	Quartz, saprolite outcrops	Lateritic nodules, pisoliths, fragments of Fe-rich duricrust	Fine grained lag (<10mm)	Medium ferruginous lag (30-50mm)	Medium - fine ferruginous lag (10-30mm)	Fine grained lag (<10mm)	Lags not common	Lags not common
SOILS	Red sandy light clays	Red sandy clay loam	Clayey sand	Stony clay loam	Red sandy clay	Clayey/loamy sand	Brown fine sandy loam to fine sandy light clays	Red fine sandy clay loam to fine sandy light clays	Red sandy clay loam to light clays			Calcarous red light clays	Red clay (Smectitic)
ALLUVIUM	-	——		-	——		-	Some at depth	Extensive alluvium Thickness not known			Extensive alluvium	Extensive alluvium
COLLUVIUM	Shallow stony clay loam (1-2m)	Shallow clay loam with abundant lateritic debris (0.5-4m)		Minor	——		Minor	Sands, white grey clays with lateritic debris (2-22m)	-	-	-	-	-
HARDPAN (developed in colluvium/alluvium)	-	Minor		-	——		-	Hardpan can be present at 0.5-10m	Hardpan can be present				-
CALCRETE	Pedogenic calcrete	——		-	——		-	-	-			Abundant calcrete	-
LATERITIC RESIDUUM	-	——		Some duricrust on crests	——		Lateritic pisoliths, nodules, nodular duricrust (1-8m). Duricrust can be Fe-rich	May be present beneath colluvium at 2-20m thickness 0.5-8m	May be present beneath alluvium			-	-
FERRUGINOUS SAPROLITE/MOTTLED SAPROLITE	-	Present	-	-	——		Present with iron segregations	Present with iron segregations (8-30m)	Present with iron segregations			-	-
SAPROLITE	Multicoloured clay rich saprolite with iron segregations, variable thickness		Granitic/felsic saprolite	-	Mafic saprolite	Felsic saprolite	Clay rich saprolite with iron segregations, variable thickness					?	?
BEDROCK	Mafic, ultramafics		Granitic/ felsic rocks	Mafic, Ultramafics	Mafic	Felsic	Mafic, ultramafics		Mafic, ultramafics				



EROSIONAL REGIMES

2	Soil, lag, on saprolite
3a	Mottled zone saprolite
5	Subcrop of bedrock

RESIDUAL REGIMES

1	Lateritic residuum
1a	duricrust
1b	gravel

Gradational subdivision within Unit 2

DEPOSITIONAL REGIMES

7	Alluvium
7a	in minor tributaries
7b	in major tributaries
6	Colluvium as sheet wash

Traverse

Regolith cross sections from Anand et al (1989)

McCaffery and Weight Hill mine pits

Agnew-Leinster road

Fig 22. Map showing the surface distribution of regolith units and vegetation for the Agnew-McCaffery area (Photo 4/9544, 6.12.1988). Bedrock lithologies are mafic and ultramafic. Reproduced from 106R. Airphotograph taken by Kevron Aerial Surveys, published with permission of Homestake Gold of Australia Limited.

A

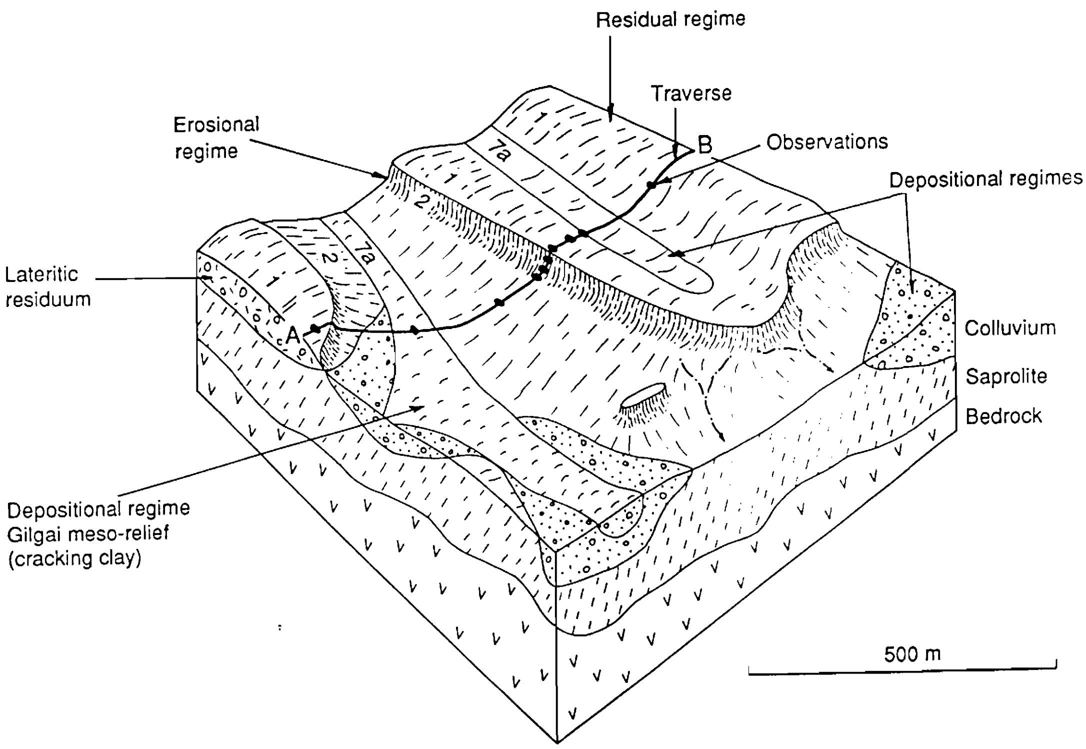


Fig. 23A. Generalized regolith/landform model based upon the Agnew-McCaffery study area. Reproduced from 106R.

B

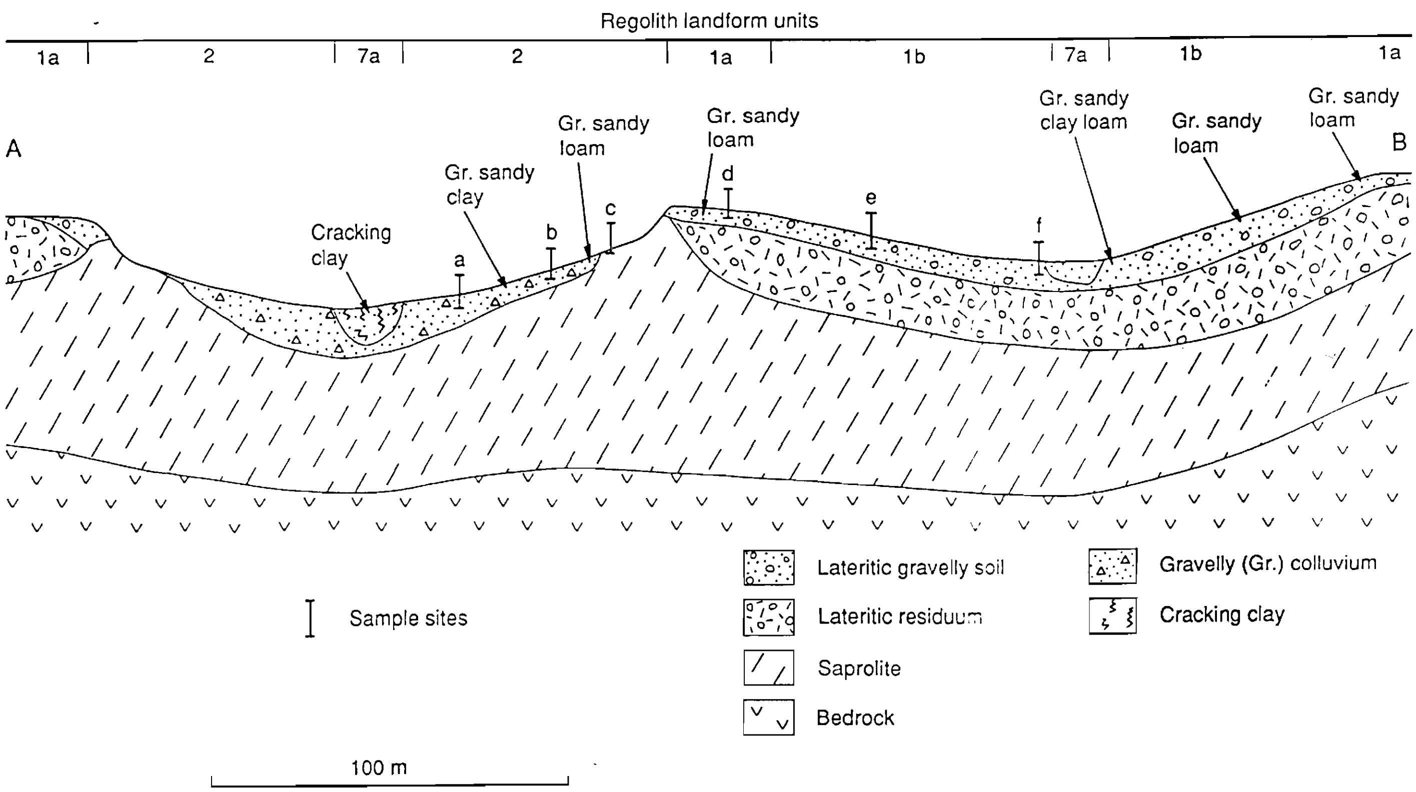


Fig. 23B. Schematic regolith cross-section showing trends in soil and regolith stratigraphy for the traverse shown in Fig. 23A. Reproduced from 106R.

Table 7. Regolith characteristics, Agnew-McCaffery Area

SAMPLE SITES (See Fig. 23B)	a	b	c	d	e	f
REGOLITH UNIT AT SURFACE	2	2	2	1a	1b	1b
TYPE OF REGIME	Erosional			Residual		
LANDFORM	Valley floor	Upper pediment	Breakaway scarp	Broad smooth crest	Smooth gentle slopes "back slopes"	Valley floor
LAG	Lag of mixed origin (ferruginous pebbles/ granules, lateritic nodules)	Lateritic lithic fragments	Lateritic lithic fragments	Lateritic lag	Lateritic lag	Lateritic lag
SOILS	Gravelly red fine sandy clay	Reddish-brown gravelly fine sandy loam	-	Gravelly reddish brown fine sandy loam	Gravelly reddish brown fine sandy loam	Gravelly brown fine sandy clay loam
COLLUVIUM	Gravelly colluvium	Gravelly colluvium		-	-	Gravelly colluvium
HARDPAN	Present within a metre	Present within a metre	-	-	Some	Some
LATERITIC RESIDUUM	-	-	-	Nodular duricrust	Nodular duricrust (?)	Nodular duricrust (?)
SAPROLITE	Ferruginous and clay-rich saprolite (?)	Ferruginous and clay-rich saprolite	Ferruginous and clay-rich saprolite	Ferruginous and clay-rich saprolite (?)	Ferruginous and clay-rich saprolite (?)	Ferruginous and clay-rich saprolite (?)

Reproduced from 106R.

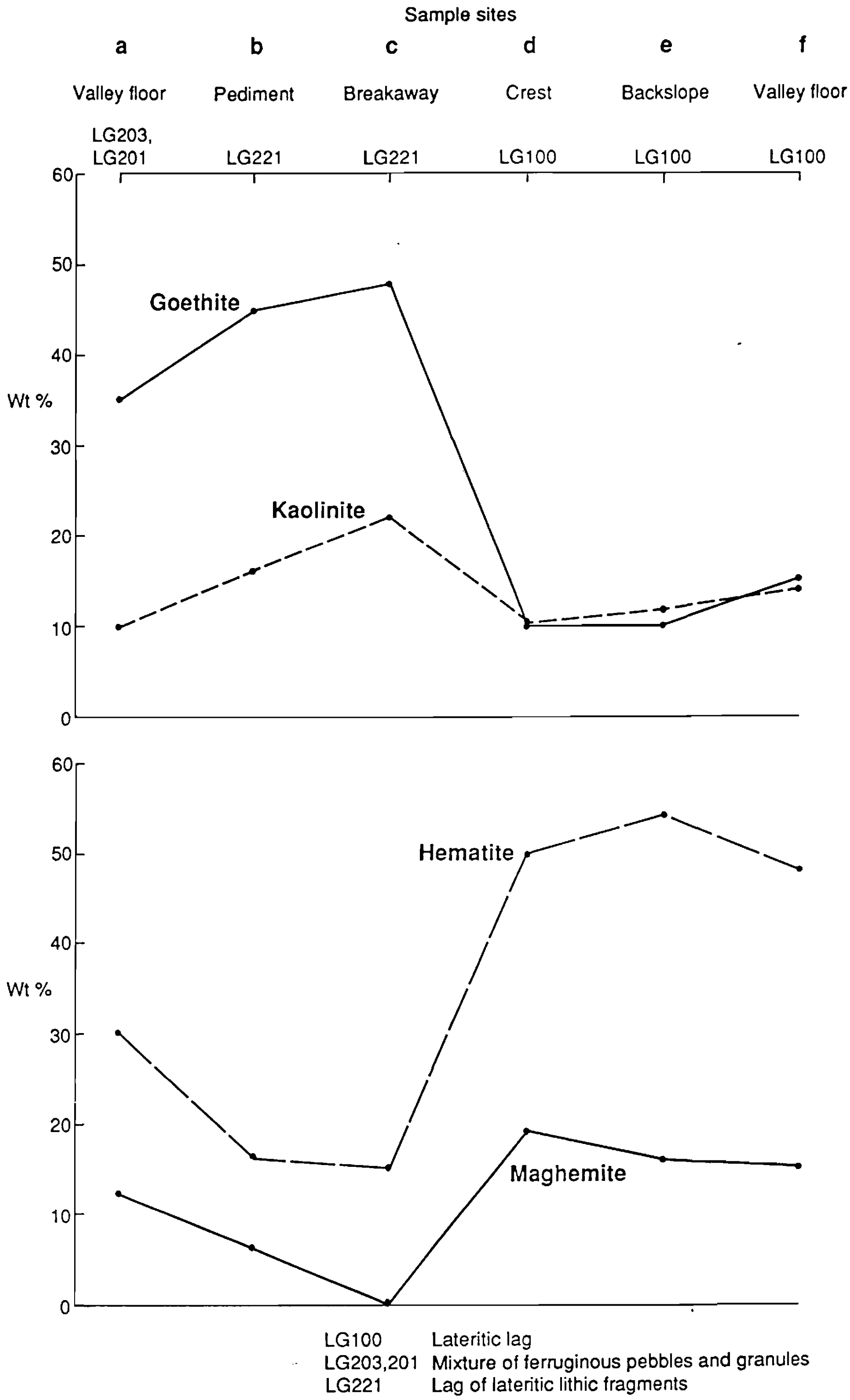


Fig. 25. Distribution of goethite, hematite, maghemite, and kaolinite in lag gravels for the sample sites shown in Fig. 23B. Reproduced from 106R.

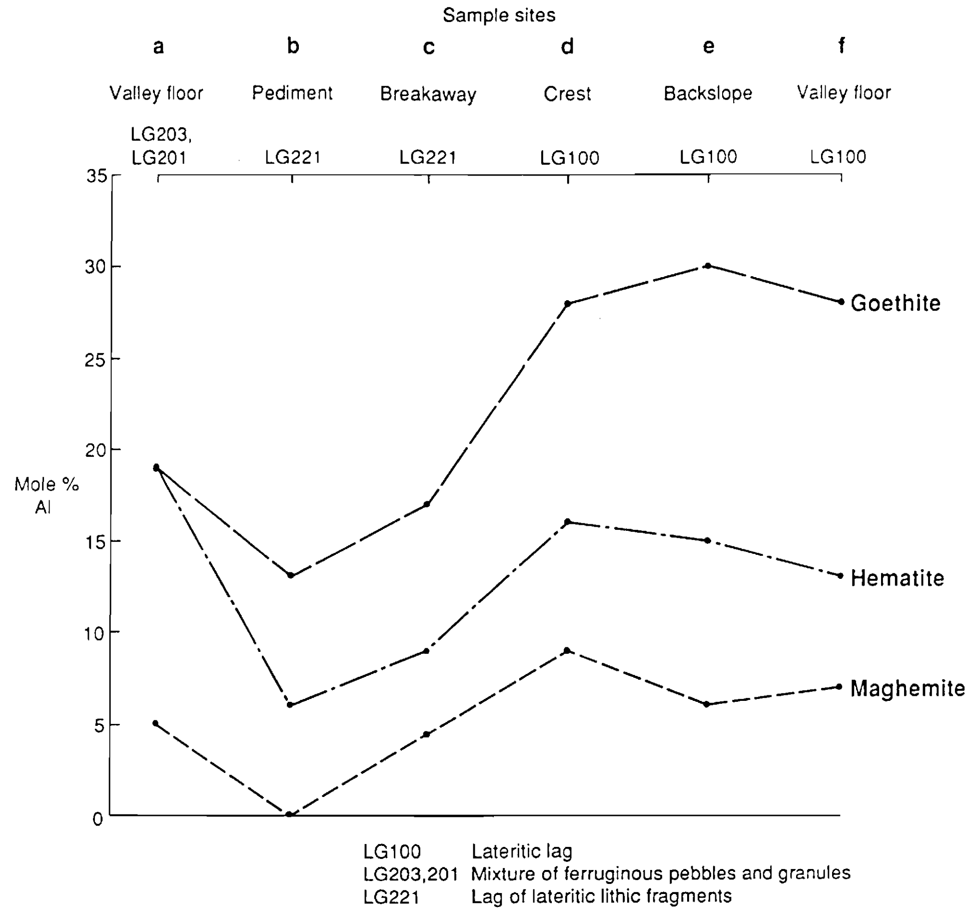


Fig. 26. Distribution of Al-substitution in goethite,hematite,and maghemite in lag gravels for the sample sites shown in Fig. 23B. Reproduced from 106R.

Table XX. The types of laycr-silicate minerals present for the different regolith/landform situations along the studied traverse of Figs 23A and B in the Agnew-McCaffffery study area.

	Truncational regime			Residual regime	
Regolith/ landform unit:	7a	2	2(in part)	1a	1b
Location:	Cracking clay	a	c	d	f
Landform setting:	Central drainage with gilgai meso-relief	Valley floor	Breakaway	Crest	Valley floor
Kaolinite:	+	+ +	+ + +	+ + +	+ + +
Smectite:	+ + +	+ +	+	? +	+ +
Chlorite:	+ +	+ +			
Inter-stratified:	+		+ +		
Illite:		+			

Codes for abundances:
Dominant + + +
Sub-dominant + +
Minor +

Modified from Table 8 in 106R.

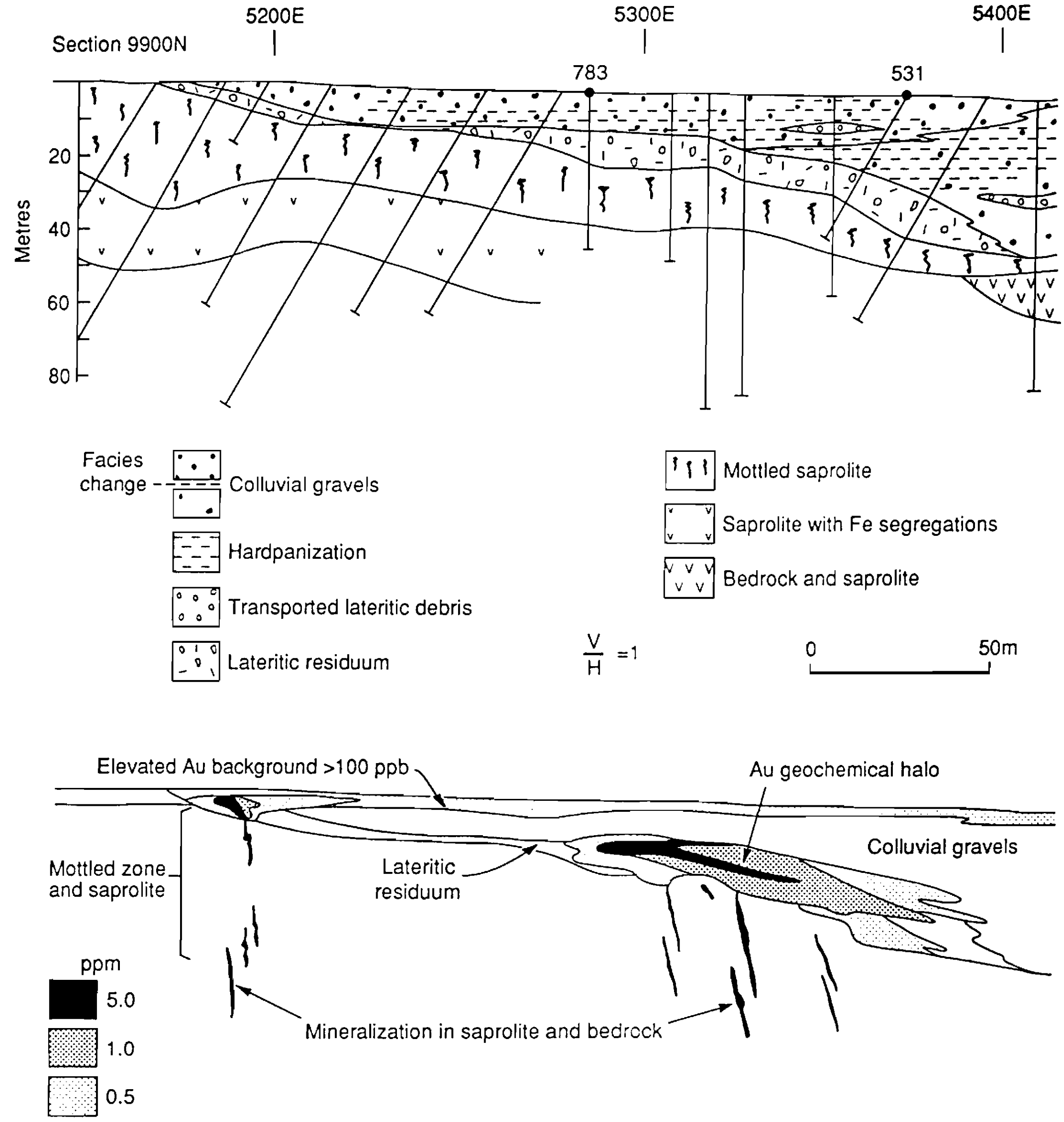
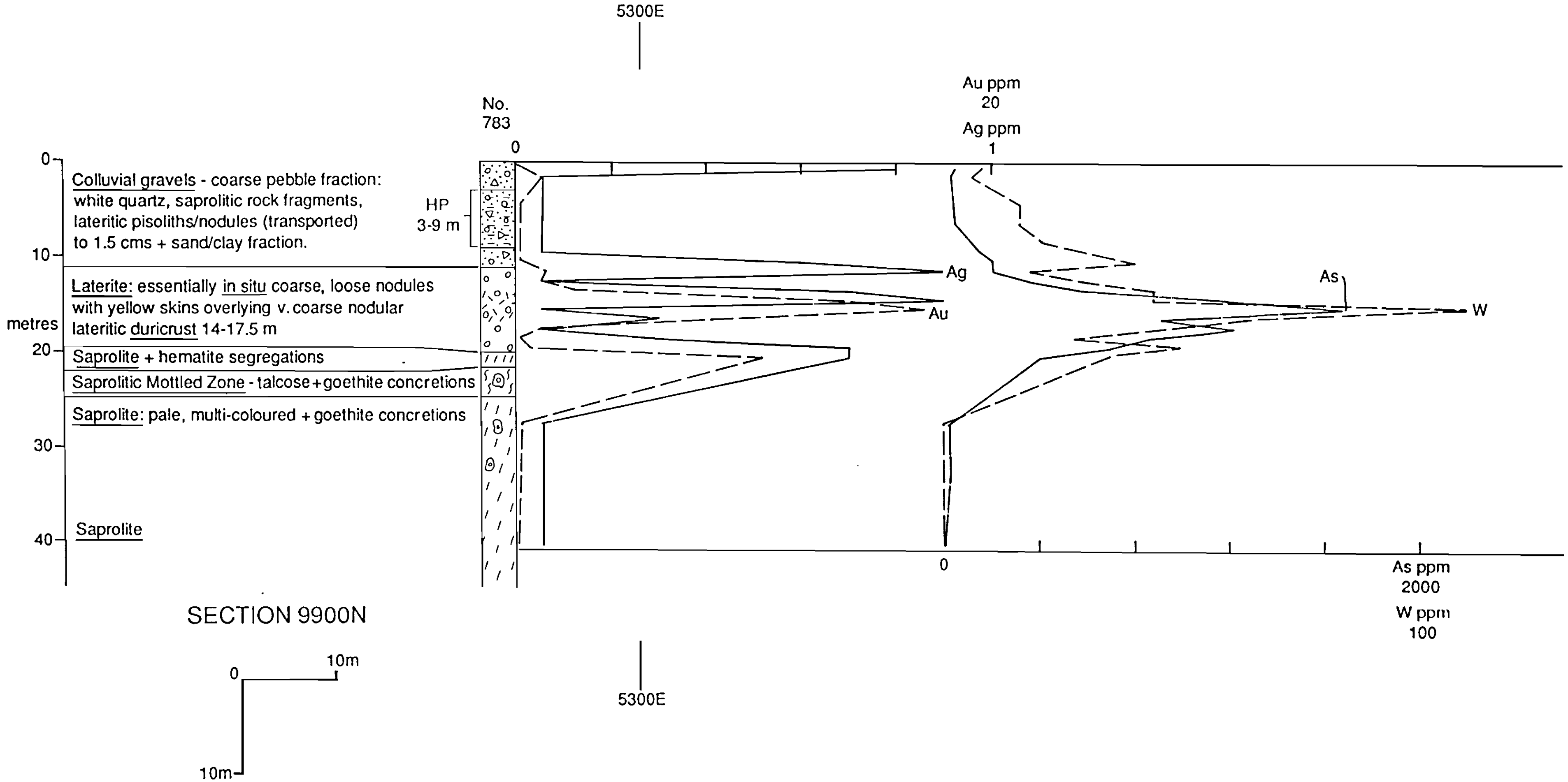


Fig. PP. Diagrammatic cross-section along line 9900N in the North Pit study area showing relationships for the regolith and dispersion of Au in lateritic residuum.

Reproduced from 22R.



Fig, 16. Geochemical data for regolith units intersected in drill hole 783, North Pit area. Au, Ag, As, and W.

INTERIM

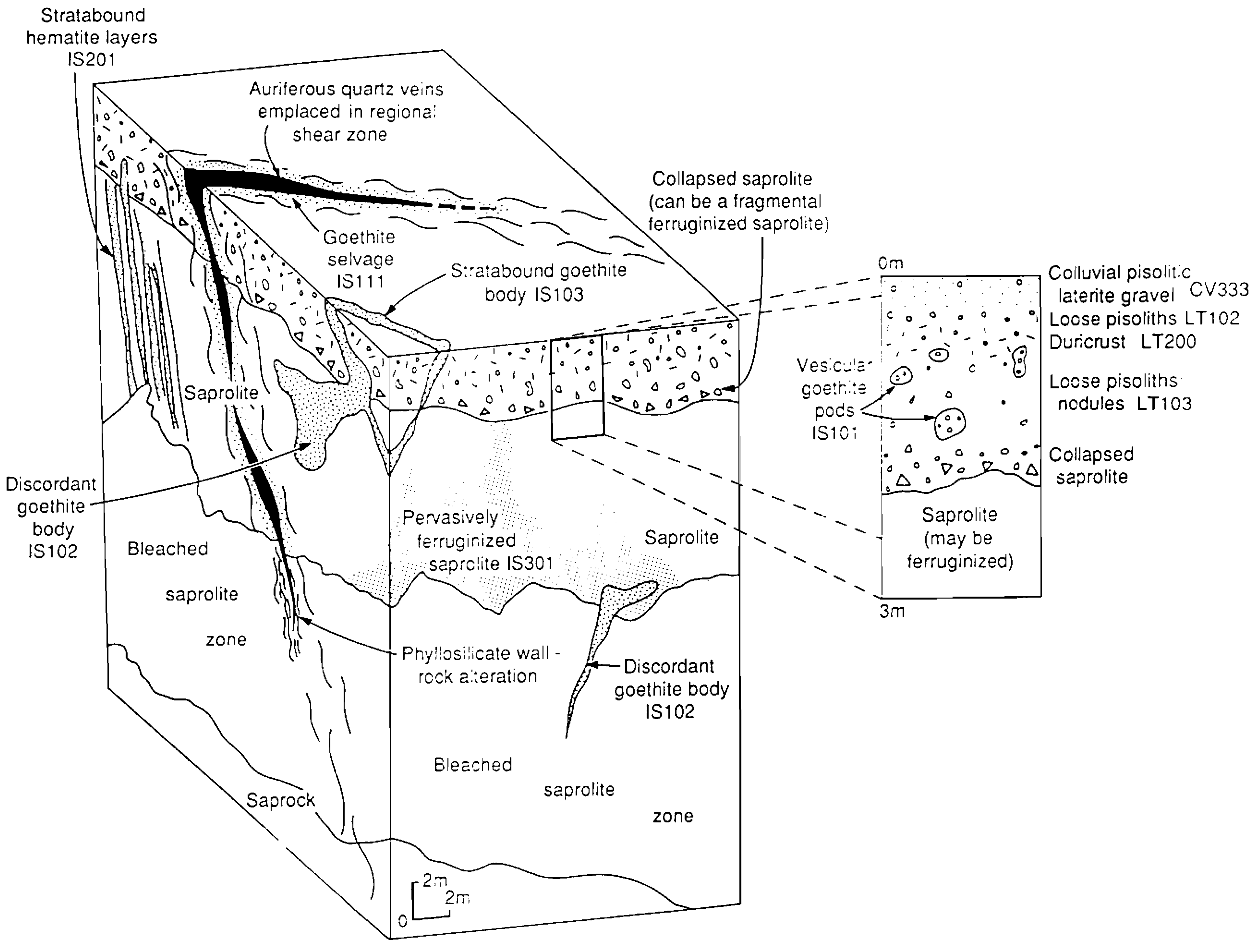
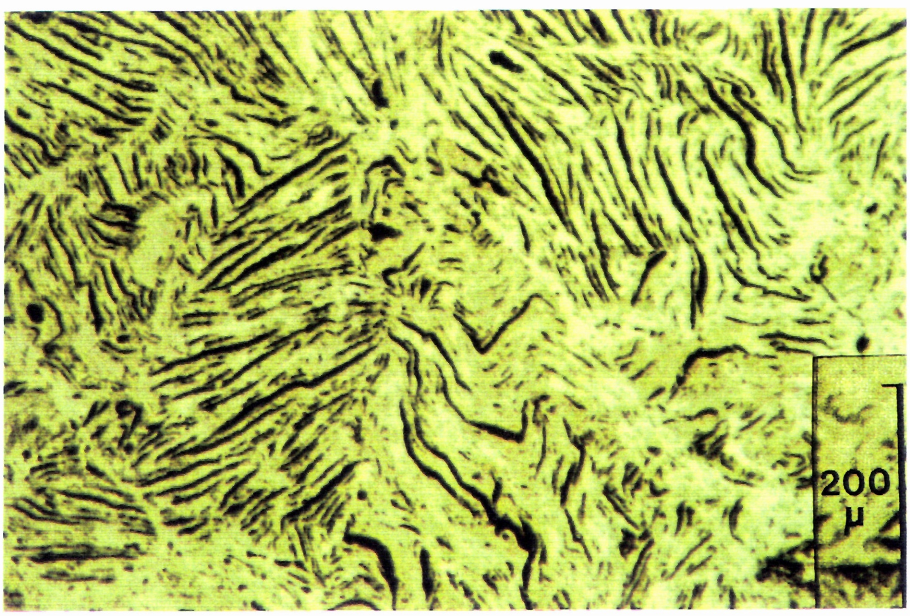


Fig. 4.3/4.X. Detail block diagram showing field relationships and classification codes for several categories of lateritic materials and iron segregations. Reproduced from 60R.

Iron segregation.



Photomicrograph of polished section of iron segregation
showing goethite pseudomorph after pyrrhotite.

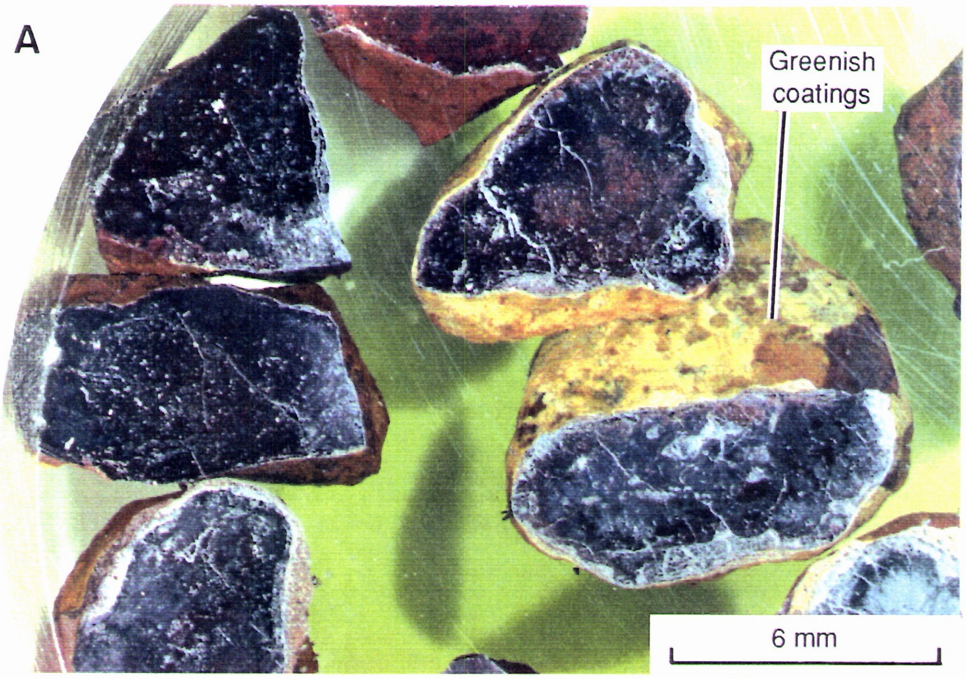
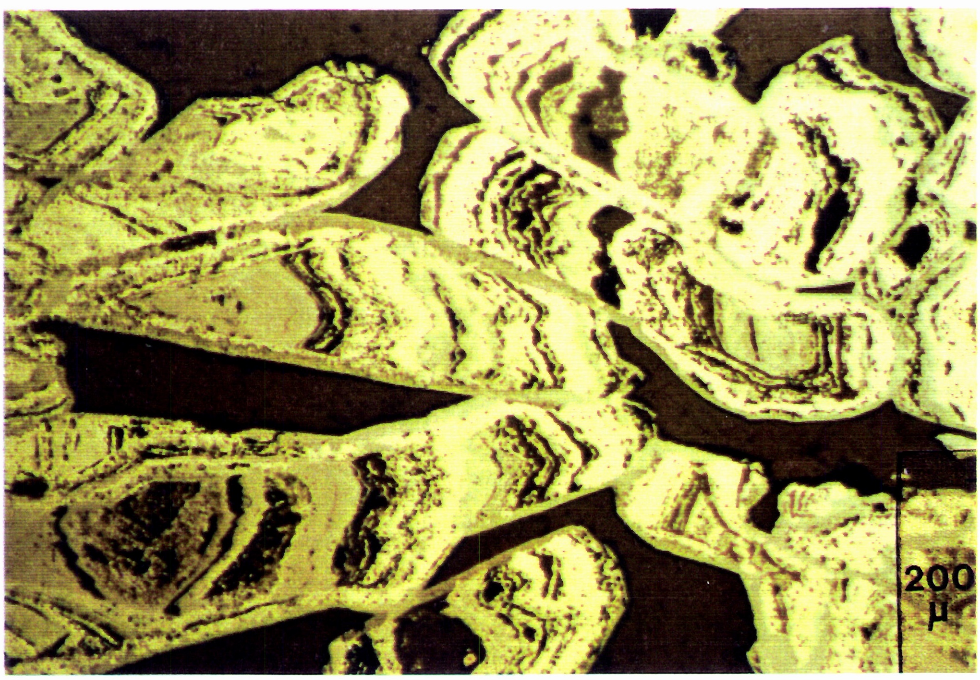


Fig. 11a. Lateritic nodules and pisoliths from residual laterite (Hole 729, sample 07-0838). Reproduced from 22R.



Photomicrograph of polished section of lateritic nodule showing relict talc in goethite-rich matrix.

Identification of regolith units in drill spoil/open pit

The following criteria, taken conjointly, are believed sufficient to establish the characteristics of residual and transported regolith in a field situation, although ambiguous situations can arise.

Hardpanized colluvium/colluvium

- Red-brown, non-hardpanized colluvium may have variable colours
- Hard, brittle, irregular dull fracture faces, very fine porosity
- Abundant Mn staining
- Glassy, botryoidal opal in pores or along partings
- Soft carbonates along partings
- Exhibit coarse subhorizontal lamination
- Presence of large amounts of sandy/gritty clays
- Presence of polymictic gravels - exotic lithorelics, lateritic gravels without cutans

Lateritic residuum

- The nodules and pisoliths with yellowish brown/olive green cutans
- Presence of small fragments of lateritic duricrust in drill spoil

Transported laterite

- Large proportion of nodules/pisoliths which are fractured or the abundance of chipped cutans.
- Layers of well sorted and well rounded lateritic gravel
- Presence of cyclic bands of packed lateritic debris alternating with layers of colluvium/alluvium

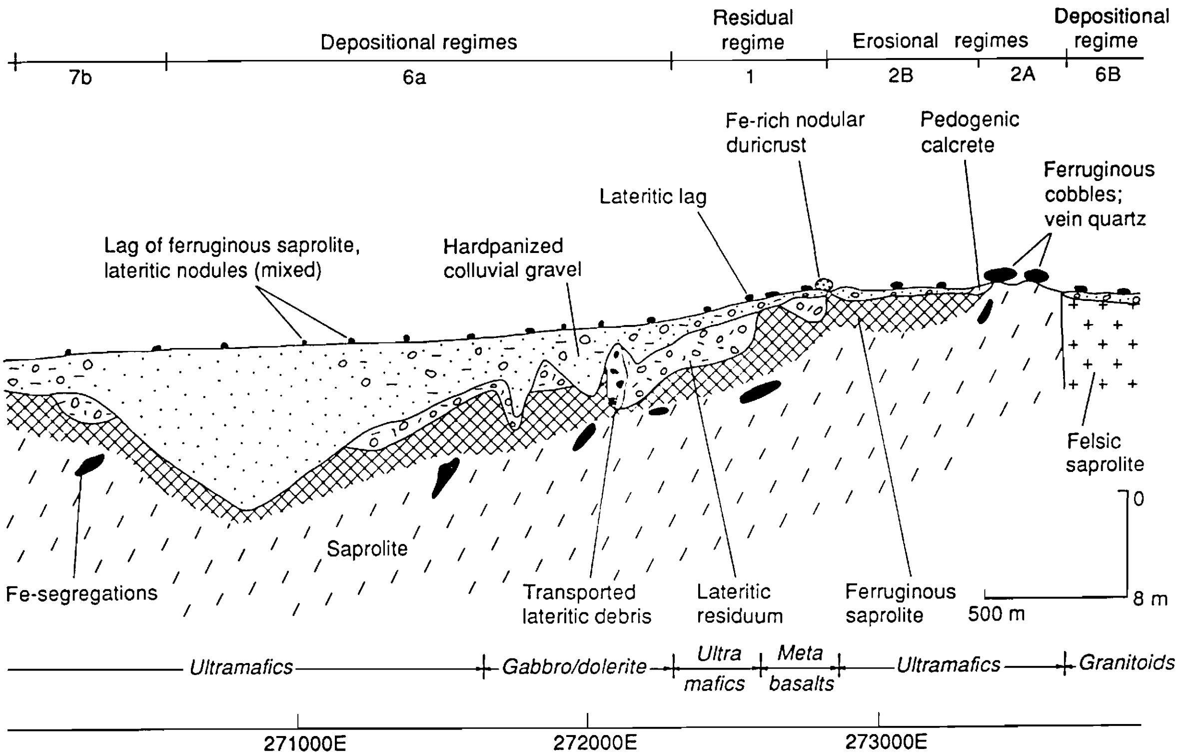


Fig. NN. Diagrammatic cross-section along line 6 891 600N in the Meatoa Study area showing relationships for the regolith.

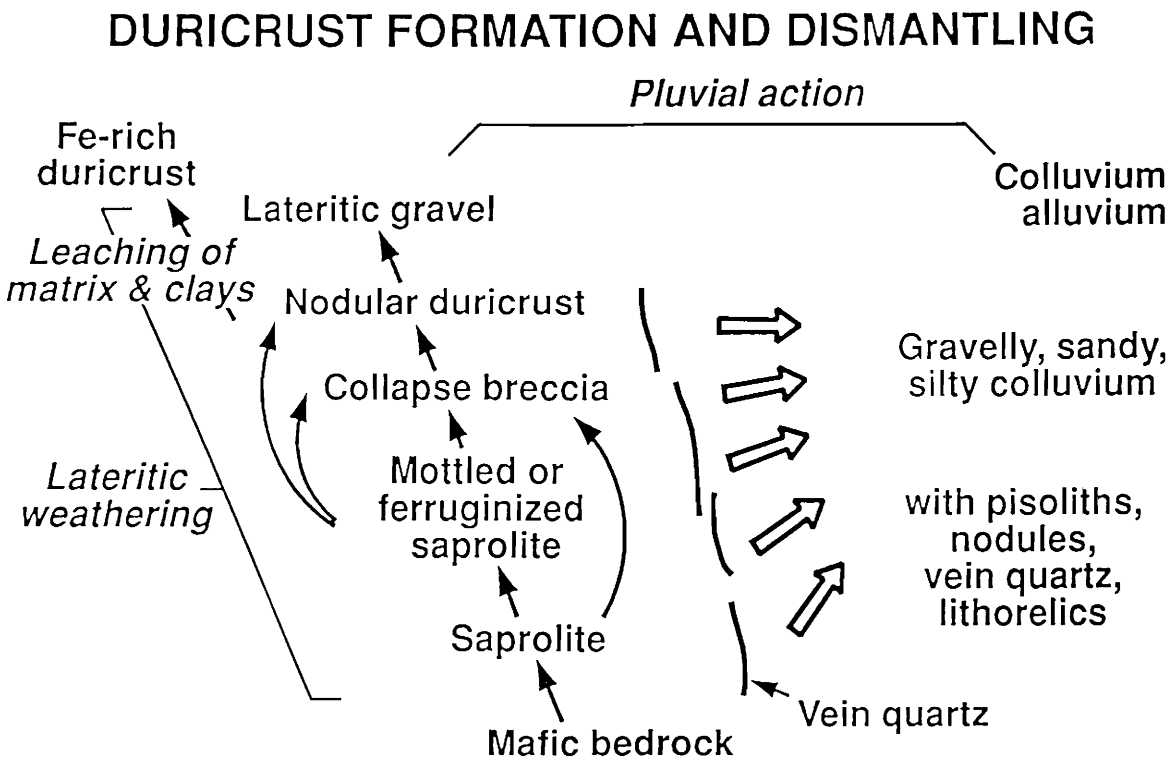


Fig. XX. Schematic facies relationship diagram for the formation of the lateritic weathering mantle at Lawlers and its subsequent dismantling. (Other possible origins for Fe-rich duricrust are being researched.)

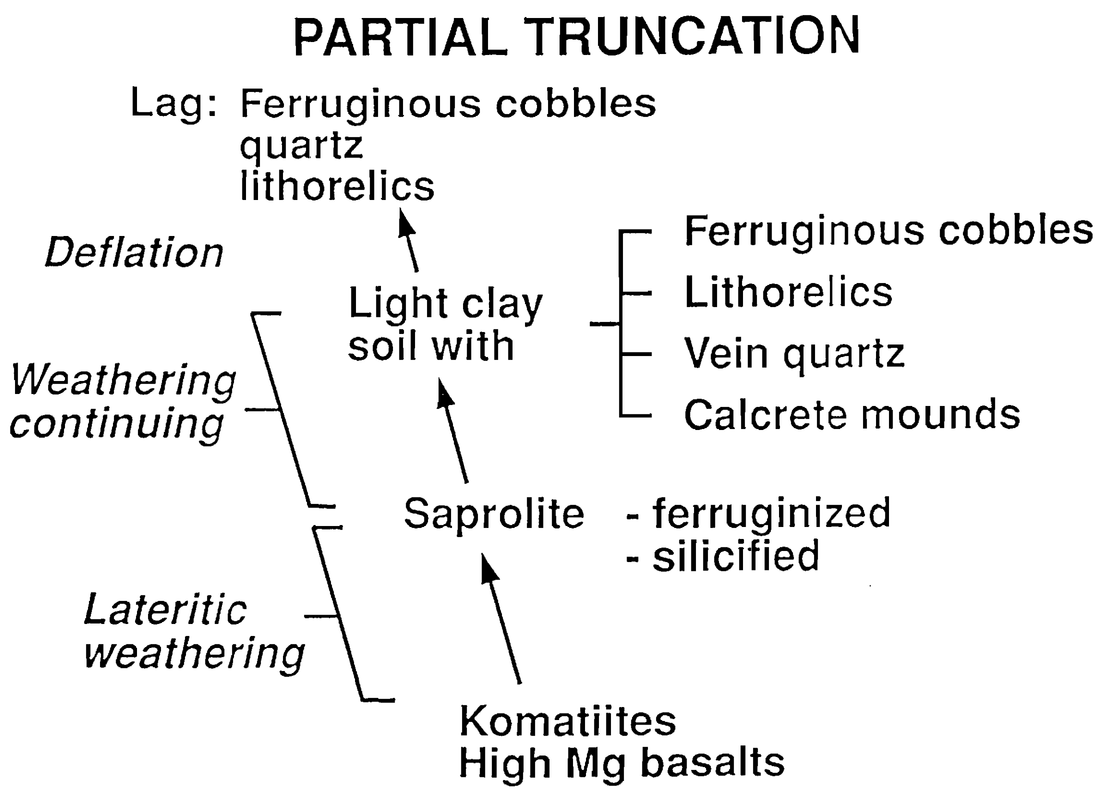


Fig.YY. Schematic facies relationship diagram for the periods of erosion with post-lateritic weathering.

REGOLITH	BODDINGTON	Mt. GIBSON	BOTTLE CREEK	LAWLERS
Hardpan	-	*Deep, discontinuous*	*Deep, continuous*	*Shallow, discontinuous*
Calcareous clays	-	*Common*	*Trace*	*Trace*
Lateritic gravels	*Extensive, discontinuous*	*Extensive, discontinuous*	*Extensive, discontinuous*	*Extensive, discontinuous*
Lateritic duricrust	*Extensive, discontinuous*	*Extensive, discontinuous*	*Patchy*	*Patchy*
Mottled zone	*Extensive*	*Extensive*	*Extensive*	*Very patchy*
Ferruginous saprolite	-	-	*Common*	*Extensive*
Fe-rich duricrust	*Very patchy*	*Patchy*	*Patchy*	*Patchy*
Fe-segregations	-	*Few*	*Moderate*	*Abundant*
Gossans	-	*Trace*	*Present*	*Present*

Fig. LL. Comparison of the regolith between the four orientation study areas.

Acknowledgements

A number of the Tables and Figures in this Field Guide have been reproduced from CSIRO Restricted Reports, and abbreviated notations are used as follows:-

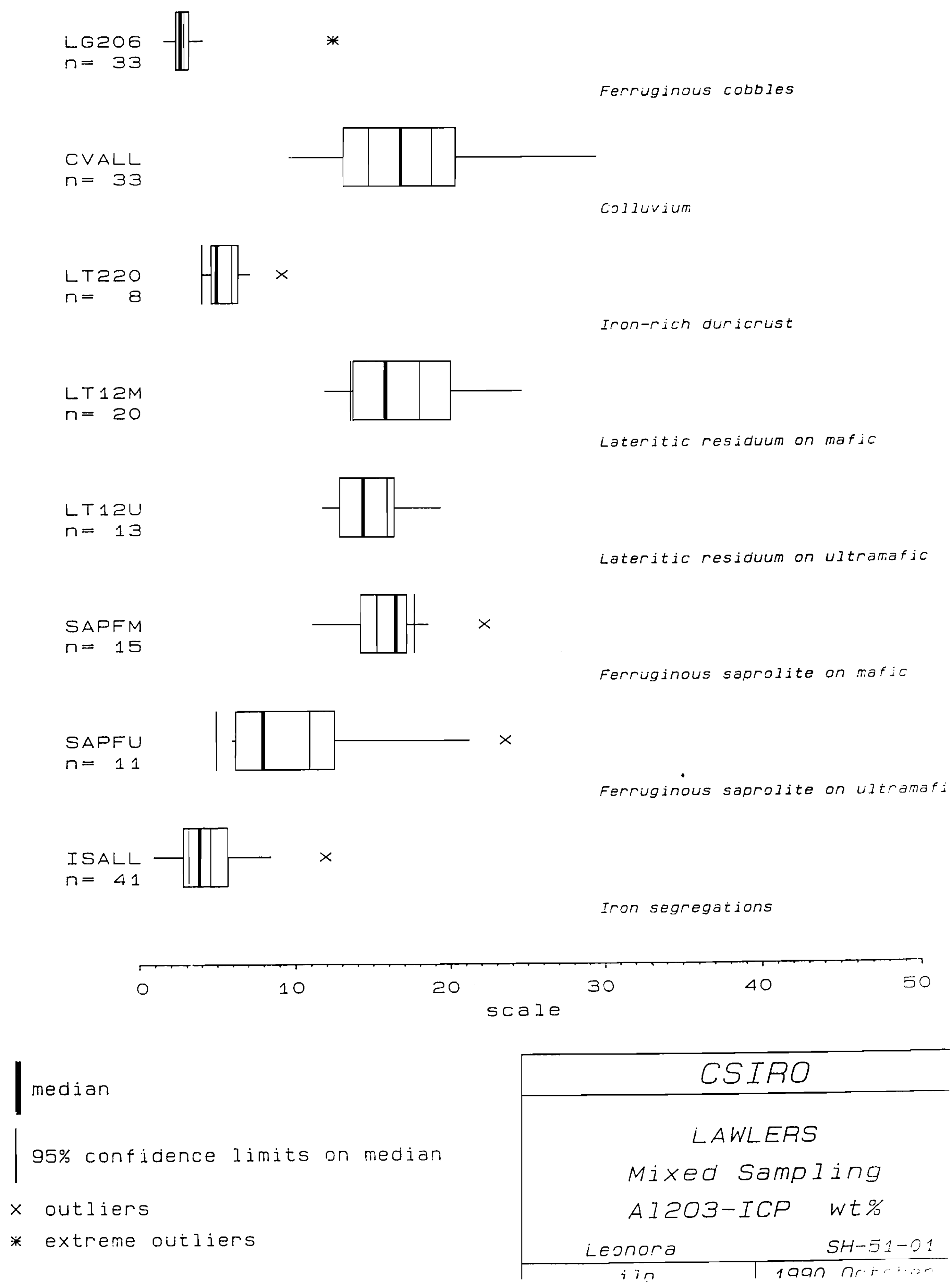
22R = CSIRO Division of Exploration Geoscience Restricted Report 22R, *Research into Laterite Geochemistry Lawlers District, Western Australia* (Progress Report to Geochemex Australia and Forsayth Mining Ltd) by RR Anand, J Innes and RE Smith, 28 April, 1989, 42 + A12 pp.

60R = CSIRO Division of Exploration Geoscience Restricted Report 60R, Laterite Types and Associated Ferruginous Materials, Yilgarn Block, WA, terminology, classification, and atlas, by RR Anand, RE Smith, J Innes, HM Churchward, JL Perdrix and EC Grunsky, August 1989. This forms Chapter 3 of the Manual under preparation *Laterite Geochemistry for Mineral Exploration*, Compilers and Editors RE Smith and RR Anand.

106R = CSIRO Division of Exploration Geoscience Restricted Report 106R, *Regolith/landform relationships and the Petrological, Mineralogical and Geochemical Characteristics of Lags, Lawlers District, Western Australia* (Progress report to Forsayth Mining Ltd and Geochemex Australia) by RR Anand, HM Churchward and RE Smith, April 1990, 105 pp.

The Project Leader and scientists within the Laterite Geochemistry Group acknowledge the substantial sponsorship by mining and exploration companies, through AMIRA, which has made possible this multidisiplinary approach to exploration research.

BOX PLOT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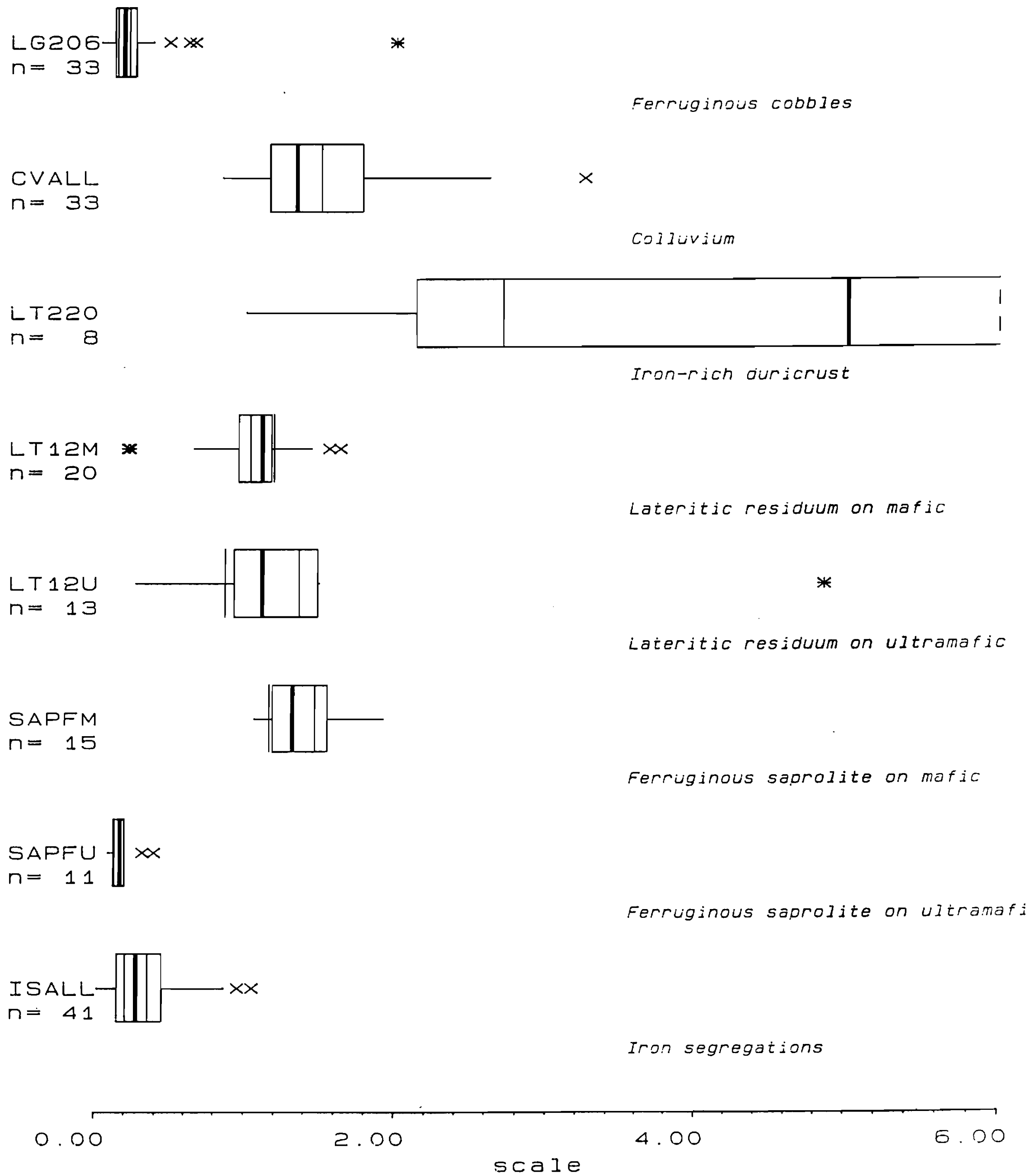
n= 33
Ferruginous cobbles
CVALL
n= 33
Colluvium
LT220
n= 8
Iron-rich duricrust
LT12M
n= 20
Lateritic residuum on mafic
LT12U
n= 13
Lateritic residuum on ultramafic
SAPFM
n= 15
Ferruginous saprolite on mafic
SAPFU
n= 11
Ferruginous saprolite on ultramafi
ISALL
n= 41
Iron segregations
0
10
20
30
40
50
scale
median
95% confidence limits on median
× outliers
* extreme outliers
CSIRO
LAWLERS
Mixed Sampling
Al2O3-ICP wt%
Leonora
SH-51-01

BOX PLOT



median

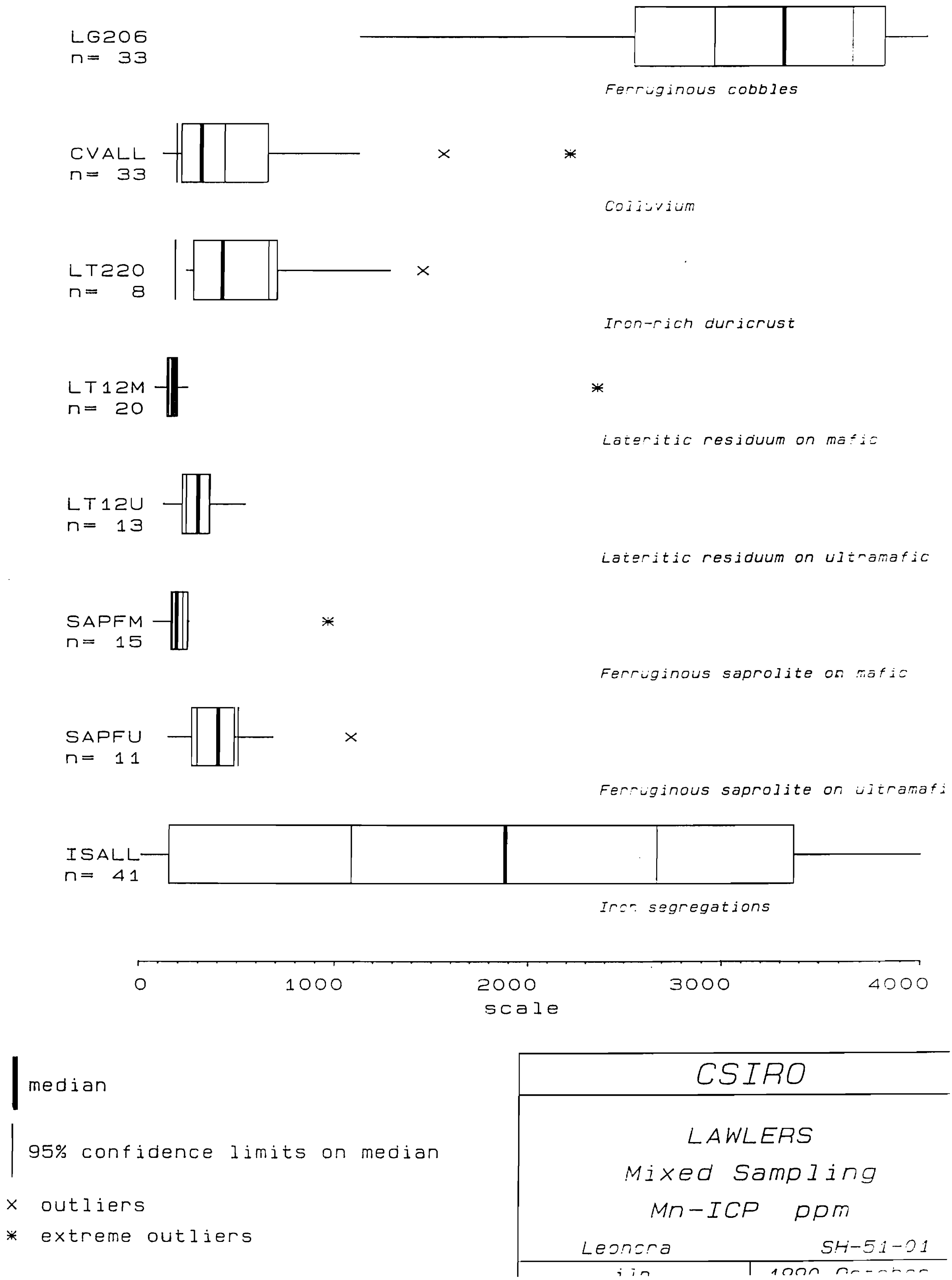
95% confidence limits on median

× outliers

* extreme outliers

CSIRO
LAWLERS Mixed Sampling TiO2-ICP wt%
Leonora SH-51-01

BOX PLOT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Colluvium
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Lateritic residuum on mafic
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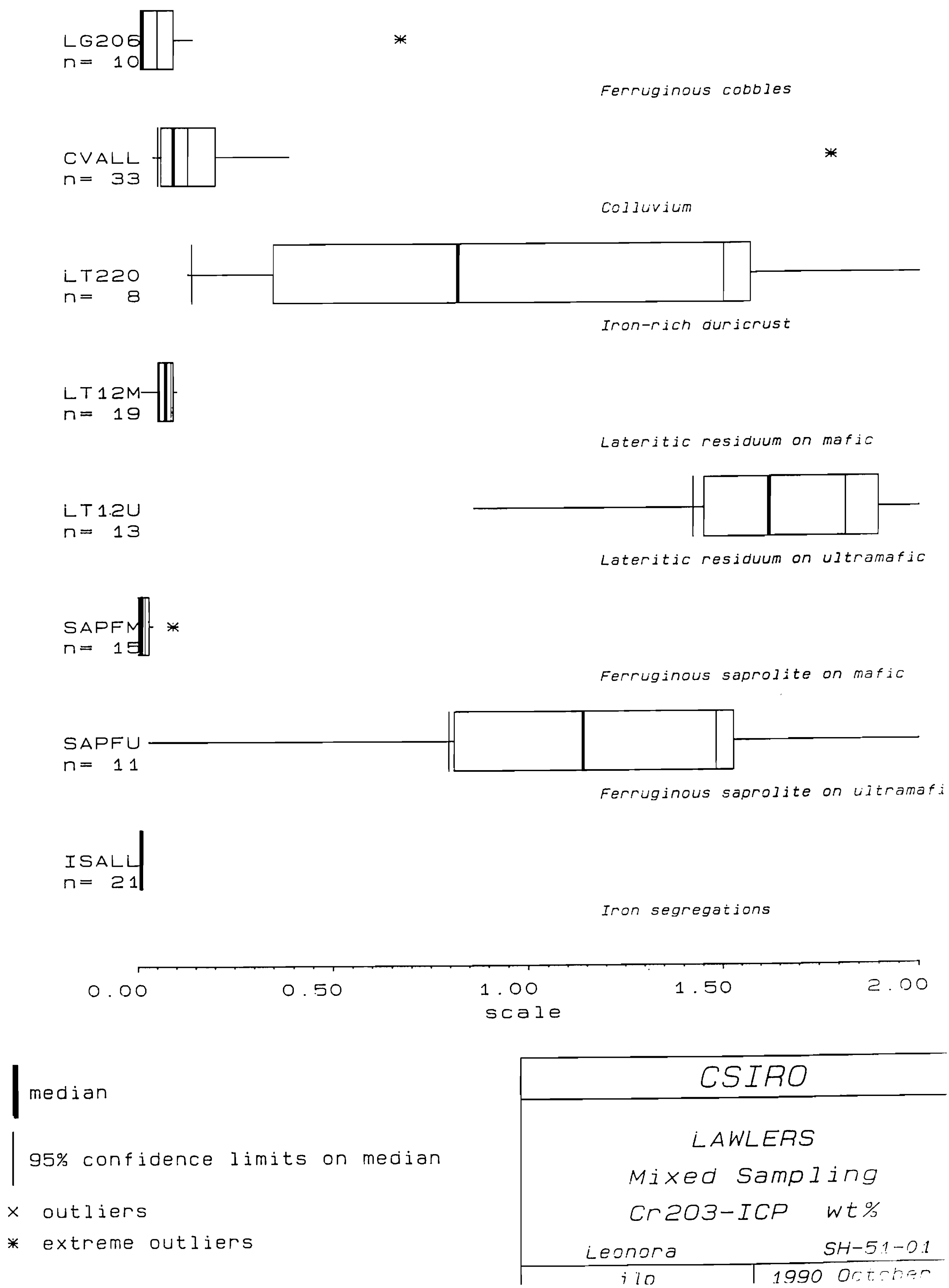
n= 13
Lateritic residuum on ultramafic
SAPFM
n= 15
Ferruginous saprolite on mafic
SAPFU
n= 11
Ferruginous saprolite on ultramafi
ISALL
n= 41
Iron segregations
0
1000
2000
3000
4000
scale
median
95% confidence limits on median
× outliers
* extreme outliers
CSIRO
LAWLERS
Mixed Sampling
Mn-ICP ppm
Leonora
SH-51-01

BOX PLOT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Colluvium
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Iron-rich duricrust
LT12M
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Lateritic residuum on mafic
LT12U
n= 13
Lateritic residuum on ultramafic
SAPFM
n= 15
Ferruginous saprolite on mafic
SAPFU
n= 11
Ferruginous saprolite on ultramafi
ISALL
n= 21
Iron segregations
0.00
0.50
1.00
1.50
2.00
scale
median
95% confidence limits on median
× outliers
✳ extreme outliers
CSIRO
LAWLERS
Mixed Sampling
Cr2O3-ICP wt%
Leonora
SH-51-01
1990 October