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AUSTRALIAN GEODYNAMICS COOPERATIVE RESEARCH CENTRE

AMIRA
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OPEN FILE REPORT SERIES

REGOLITH-LANDFORMS OF THE MT ISA GEODYNAMIC TRANSECT

M.R. Dell

CRC LEME OPEN FILE REPORT 138

April 2002

(CSIRO Exploration and Mining Report 451R / CRC LEME Report 67R / CRC AMET Report, 1998.
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CRC LEME is an unincorporated joint venture between CSIRO-Exploration & Mining, and Land & Water, The Australian National University, Curtin University of Technology, University of Adelaide, University of Canberra, Geoscience Australia, Bureau of Rural Sciences, Primary Industries and Resources SA, NSW Department of Mineral Resources-Geological Survey and Minerals Council of Australia.
Headquarters: CRC LEME c/o CSIRO Exploration and Mining, PO Box 1130, Bentley WA 6102, Australia

CSIRO/CRC LEME/AMIRA PROJECT P417
GEOCHEMICAL EXPLORATION IN REGOLITH-DOMINATED TERRAIN, NORTH QUEENSLAND 1994-1997

In 1994, CSIRO commenced a multi-client research project in regolith geology and geochemistry in North Queensland, supported by 11 mining companies, through the Australian Mineral Industries Research Association Limited (AMIRA). This research project, "Geochemical Exploration in Regolith-Dominated Terrain, North Queensland" had the aim of substantially improving geochemical methods of exploring for base metals and gold deposits under cover or obscured by deep weathering in selected areas within (a) the Mt Isa region and (b) the Charters Towers - North Drummond Basin region.

In July 1995, this project was incorporated into the research programs of CRC LEME, which provided an expanded staffing, not only from CSIRO but also from the Australian Geological Survey Organisation, University of Queensland and the Queensland Department of Minerals and Energy. The project, operated from nodes in Perth, Brisbane, Canberra and Sydney, was led by Dr R.R. Anand. It was commenced on 1st April 1994 and concluded in December 1997. The project involved regional mapping (three areas), district scale mapping (seven areas), local scale mapping (six areas), geochemical dispersion studies (fifteen sites) and geochronological studies (eleven sites). It carried the experience gained from the Yilgarn (see CRC LEME Open File Reports 1-75 and 86-112) across the continent and expanded upon it.

Although the confidentiality period of Project P417 expired in mid 2000, the reports have not been released previously. CRC LEME acknowledges the Australian Mineral Industries Research Association and CSIRO Division of Exploration and Mining for authority 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.

The Mt Isa Geodynamics Transect was a collaborative seismic project by the Australian Geological Survey Organisation and the Australian Geodynamics CRC. The survey resulted in drilling some 1200 seismic shot holes which presented a unique opportunity to study the nature of the regolith along this transect. This particular report presents collaborative research between CRC LEME, CRC AMET and the Australian Geodynamics CRC and is published courtesy of CRC AMET.

This report (CRC LEME Open File Report 138) is a second impression (second printing) of CSIRO, Division of Exploration and Mining Restricted Report 451R, first issued in 1998, which formed part of the CSIRO/AMIRA Project P417.
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PREFACE

In March 1994 the Australian Geodynamics CRC (AGCRC) and the Australian Geological Survey Organisation (AGSO) conducted a seismic survey across the Proterozoic Mt Isa Inlier in Northern Queensland. The objectives of that study were to determine the regional and local structure of the Mt Isa region, particularly the nature of its boundaries and internal structure. The survey resulted in some 1200 seismic shot holes being drilled along the full extent of the transect. Coincident with this study, the CRC for Landscape Evolution and Mineral Exploration (CRCLEME) in collaboration with the CRC for Australian Mineral Exploration Technologies (CRCAMET), initiated an AMIRA Project (P417) which was concerned with developing our understanding of the nature and evolution of the regolith and landscape of the Mt Isa region.

The large number of seismic shot holes along the seismic transect presented a unique opportunity to study the nature of regolith materials and regolith stratigraphy associated with the principal lithologies and tectonic units of the Inlier and adjoining basins. To that end, the three CRCs entered into a collaborative arrangement whereby the lifts from each shot hole were logged from a regolith perspective. The observed regolith stratigraphic relationships were placed in context by mapping the regolith landforms along a 5 km swath for the length of the transect. This report presents the results from this study and represents a successful outcome from that collaboration.

Tim Munday (CRCAMET)
Program Manager – Airborne EM Mapping.

Ravi Anand .(CRCLEME)
Project Leader -AMIRA P417.

ACKNOWLEDGMENTS

Firstly I would like to thank Dr Tim Munday for giving me the opportunity to carry out this project, he and the whole CRCAMET (Cooperative Research Centre for Australian Mineral Exploration Technologies) team have made this project possible. Don Hunter for his hours of dedicated computer instruction and help with the GIS construction. This project would not have been possible without the support and cooperation of the Australian Geodynamics Cooperative Reasearch Centre (AGCRC), and in particular Bruce Goleby at the Australian Geological Survey Organisation (AGSO) and all the members of the AGSO field crew. Thanks are also due to Dr Ravi Anand of the Cooperative Research Centre for Landform Evolution and Mineral Exploration (CRCLEME) for reviewing this paper and assistance in the geochemical and mineralogical analysis of select samples from the Geodynamic Transect. Thanks to Lisa Worrall, Bob Gozzard, Col Steel and Angelo Vartesi for their helpful input. The assistance of Matt Killick in reviewing this document is also appreciated. Finally I would like to thank my family who have given me the support to see this project to conclusion.

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1. INTRODUCTION

1.1 Background

The observations made within this report are the result of a detailed study concerning regolith-landforms along the Mt Isa Geodynamic Transect undertaken by the AGCRC and AGSO during 1994 (Goleby *et. al.*. 1996). The goals of the Geodynamic Transect where to study the crustal structure of the Mt Isa Inlier in northwestern Queensland through a seismic survey with supplementary stratigraphic, structural and regolith information gathered from the drill spoil and surficial observations. The Geodynamic Transect consisted of 1200 drillholes spaced at 240 metre intervals along the entire length of the 260 km long transect. Access to the drill cuttings from the seismic shotholes provided a unique opportunity to investigate the nature of regolith materials and boundary relationships across a highly prospective and economically significant area of Australia.

1.2 Objectives

The aim of this study was to document the nature and variability of regolith-landforms across the Mt Isa Inlier and onto the adjacent Georgina and Eromonga basins with specific attention given to the Geodynamic Transect and adjacent areas. This information was supplemented by regolith stratigraphic information recovered from drill spoil while drilling holes for the seismic charges. The study aims to further our understanding of regolith-landforms across the main stratigraphic units of the inlier, thereby providing a basis for defining regolith structure more widely over an area important to exploration.

The specific objectives of the study were to:

a) document the regolith-stratigraphic relationships along the transect.

b) generate a regolith-landforms materials map along the transect and adjacent areas.

1.3 Location

The 260 kilometre long Geodynamic Transect is oriented approximately east to west, and lies to the south of both Cloncurry and Mt Isa in northwestern Queensland. The study traverses the relatively high relief of the Proterozoic assemblages of the Mount Isa block while overlapping in the east and west onto the Mesozoic sediments of the Eromonga and Georgina basins (Figure 1).

1.4 Climate

The climate across the Mt Isa Inlier is sub-tropical to arid, receiving some 300 mm rain per year. Most rain is received as summer storms between November and April (Ryburn *et. al.*. 1988). Annual maximum daily temperatures average 32° C, with a minimum being 17° C.

1.5 Vegetation

Three main geomorphic vegetative domains are evident across the study area. The flat or gently undulating plains of the Eromanga and Georgina basins support numerous native grasses and sparse stands of eucalyptus, rare gidgee (*Casuarina spp.*), while spinifex is present in more sandy iron-rich soils. Over the Proterozoic rocks of the Inlier the thin skeletal soils support sparse open *Eucalyptus spp.* with very abundant spinifex (*Troidia spp.*). Low trees and shrubs of *Acacia, Grevillea, Melaleuca,* and *Brachychiton spp,* are also sparsely distributed across the inlier. Alluvial

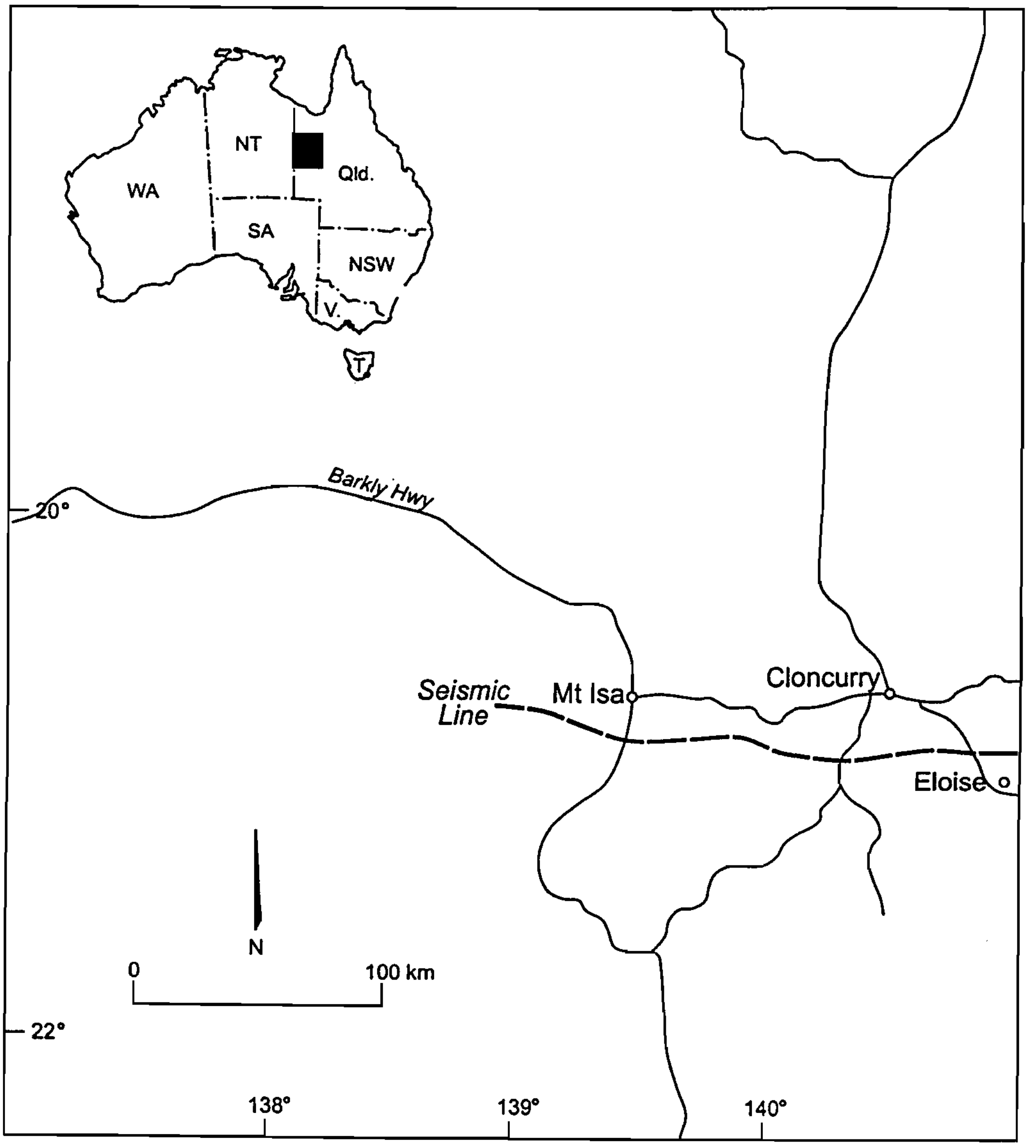


Figure 1. Location of the AGSO/AGCRC Mount Isa Geodynamic Transect.

floodplains, riverbanks, anastomosing stream systems and drainage gullies support the densest vegetation, usually stands of gidgee, eucalypts and abundant native grasses (Ryburn *et. al.*. 1988).

Dominant vegetation types and their densities were recorded along with regolith-landform information at each drill site. This information indicated a strong relationship between vegetation and soil type. The more clay-rich and calcareous soils support abundant grasses and gidgee. These soils are generally located in flatter areas, alluvial floodplains or other shallow drainage depressions. Skeletal calcareous soils formed over the calcareous metasedimentary units, support abundant native grasses with spinifex being absent. The more iron-rich soils developed over closely subcropping or outcropping bedrock support a very abundant cover of *spinifex* with sparse *eucalypt, acacia* and *grevillea.*

1.6 Geology

The Mount Isa Inlier comprises a series of outcropping Early to Middle Proterozoic Rocks covering more than 50,000 square kilometres in northwest Queensland (Blake 1987). The Inlier is bounded to the northwest by the Proterozoic south Nicholson Basin, to the west and south by the Palaeozoic Georgina Basin, to the south and southeast by the Mesozoic Eromonga Basin, and to the northeast by the Mesozoic Carpentaria Basin (Figure 2).

The Geodynamic Transect traversed the sedimentary successions from Eromonga Basin in the east across the Proterozoic rocks of the Inlier to the to the Georgina basinal sediments in the west. Blake (1987) divides the inlier into 3 distinct tectonic zones, the Eastern Fold belt, the Kalkadoon-Liechhardt Belt and Western Fold Belt (Figure 2). For the purpose of this report regolith-landform unit descriptions in Appendix II have been grouped in the same way. For ease of reference the three main tectonic divisions within the inlier have been further divided into the main rock groups. These divisions and the stratigraphic framework are outlined in Figure 3.

1.7 Geomorphology

Two separate maps detailing the distribution of major geomorphic or physiographic zones and landforms observed along the Geodynamic Transect are attached as part of Appendix 1.

The study area traversed three main geomorphic regions. These are:

1. The planar areas prominent in the west and eastern extremities of the survey area represented by the Eromonga and Georgina basins. Areas of low relief are also present adjacent to major rivers, as valley fill or as remnant plains and elevated plateaux of valley fill material within the inlier. These environments are dominated by sheetwash and overbank sediment movement during significant flood events.

2. Gently undulating plains and low hills, which are the most common landform elements within the Inlier. Sheetflow predominates in these regions.

3. High hills and hill belts trending NNW – SSE are present through the middle of the inlier, which are generally contained to the more siliceous metasediments and felsic volcanic units. Downslope creep and gullying predominate in these environments.

The landform divisions map (Appendix I) has been derived from the landform attributes attached to the regolith materials map polygons. These landform divisions are based on the RTMAP divisions of Pain *et. al.* (1991). RTMAP is a regolith and landform classification and coding scheme developed at AGSO in Canberra.

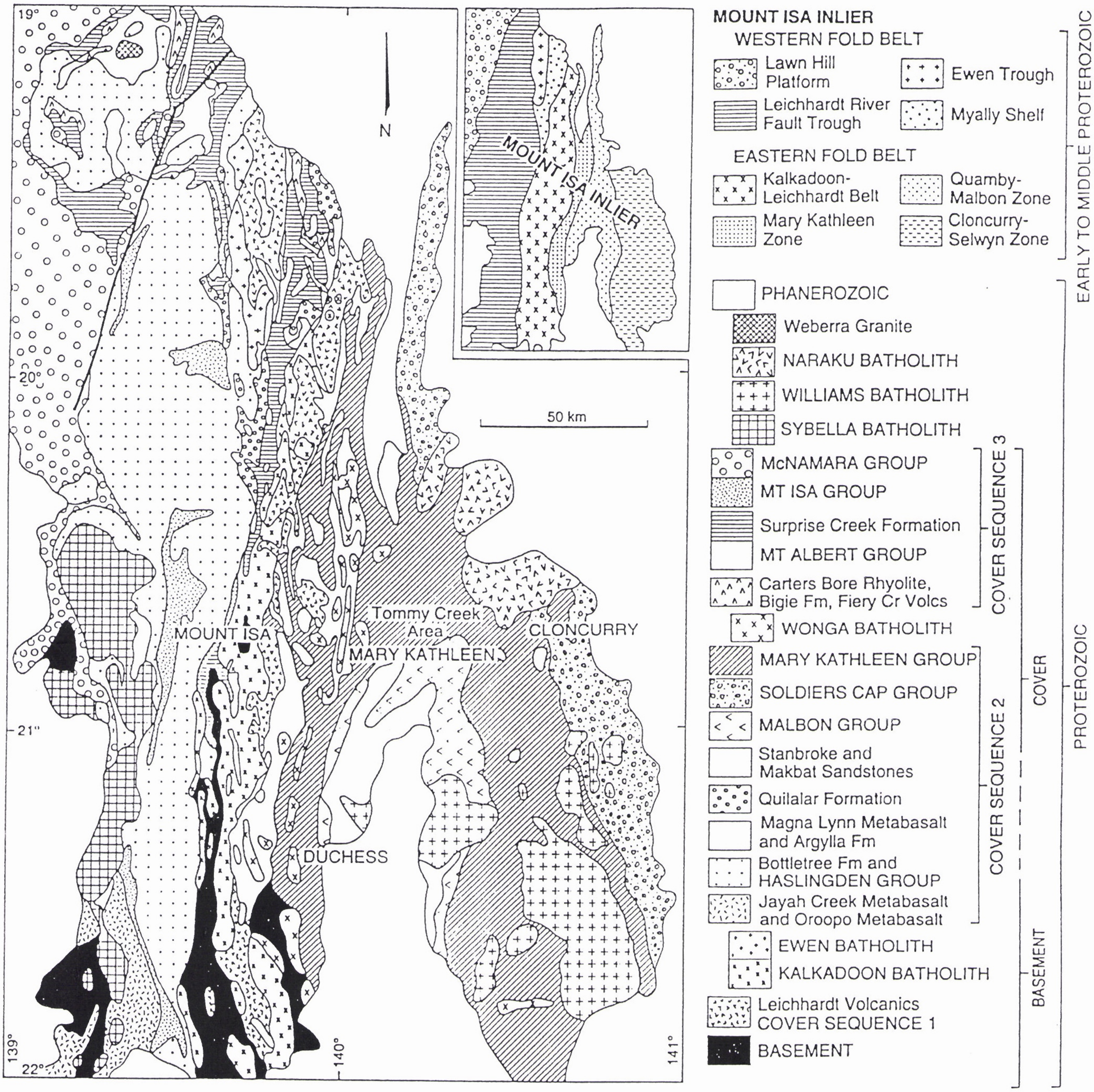


Figure 2. Geology and tectonic zones of the Mount Isa Inlier (after Blake 1987)

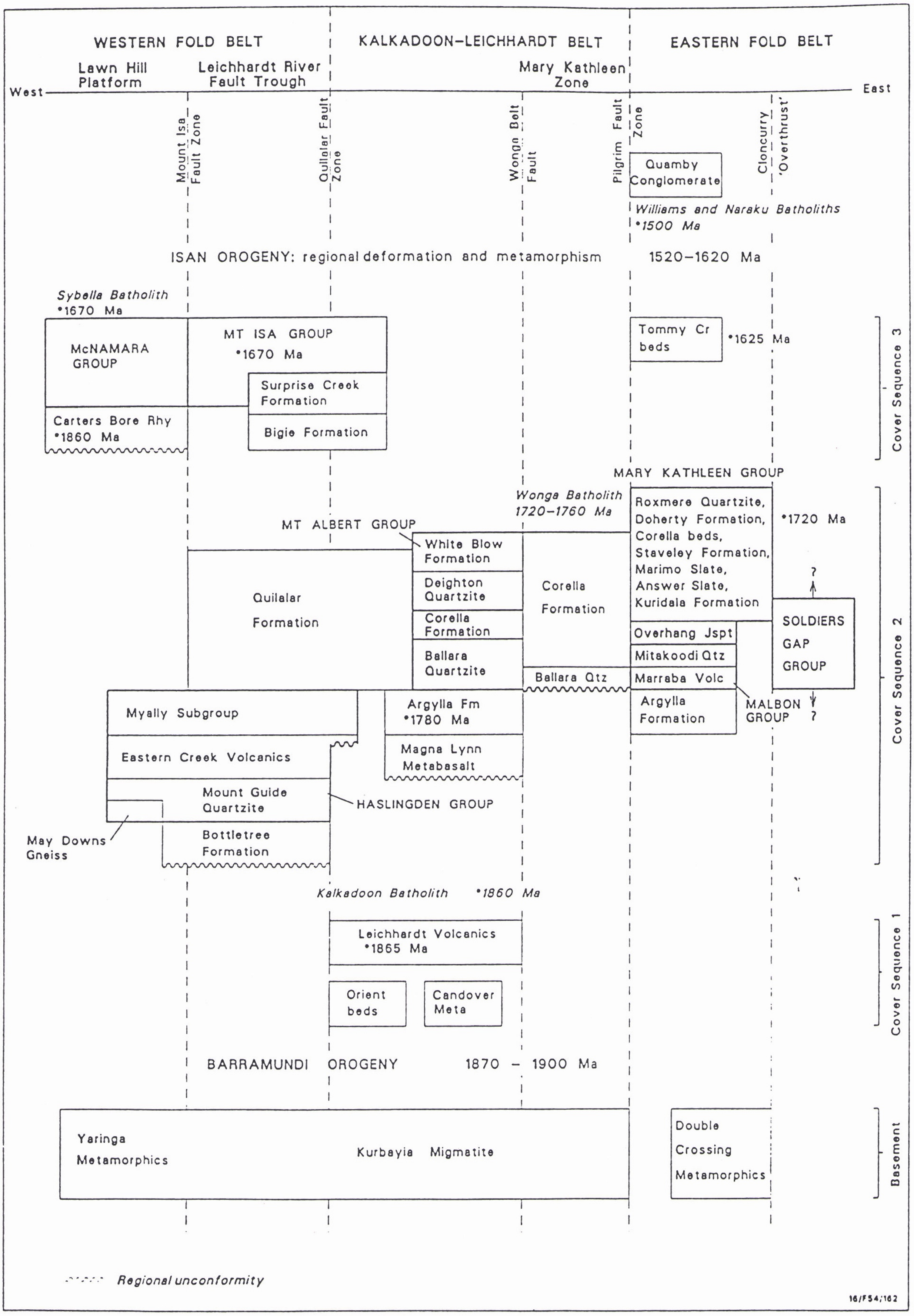


Figure 3. Stratigraphic framework of the Mount Isa Inlier (Blake 1987)

Southeast of Cloncurry just to the south of the Geodynamic Transect a group of planated mesa sequences unconformably overlies Proterozoic successions (Figure 4). The basal contacts of these Mesozoic successions reveal that the paleo-landscape at the time of their deposition had considerable relief, at least comparable to the relief observed in the inlier today. The unconformity surface between the Proterozoic basement and the Mesozoic sedimentary successions has an observed local relief of up to 50 metres. Variation in the height of the mesa surfaces suggests the sediments were deposited as valley fill material within a now eroded land surface.

1.7 Mineralisation

Gold and copper were first discovered at Cloncurry in the 1860's. Today the Mt Isa Inlier is a major producer of copper, lead, zinc and silver (Blake 1987). Fresh disseminated sulphides including pyrites and chalcopyrites crystals and ex-sulphide weathering voids are present within drill spoil at numerous locations along the Geodynamic Transect. The sulphides were observed in the full spectrum of rock types and geological settings but preferentially within schistose rocks and proximal to major geological boundaries.

Multi-element geochemistry and mineralogical analysis have been completed for 9 representative type sections across the Geodynamic Transect. These results are described in Chapter 2.3. Bottom of hole geochemical results for each of the 1200 drill holes have been collected by AGSO for inclusion in their Rockchem database.

Figure 4. Ferruginised and silicified Mesozoic sediments south east Cloncurry sheet looking north west from 459251 mE 7684119 mN.

2. REGOLITH AND LANDFORMS

2.1 Methodology

Descriptions of the regolith materials, geomorphic setting, landform units, drainage development, vegetation species and density, depth of weathering and surficial soil components were recorded on a data sheet at each seismic shot hole along the transect. The shot holes were drilled to RAB refusal or 40 metres which ever occurred first. The regolith materials and underlying fresh bedrock were logged from 2 metre bulk sample lifts using the RTMAP scheme (Pain *et. al.*. 1991).

A regolith-landform map was produced from numerous surficial observations along and proximal to the Geodynamic Transect and compiled in the field on 1:20 000 scale aerial photos. Landsat TM imagery was used as a basemap for the final map compilation. The landform and vegetation observations for each of the sites were collected to aid the interpretation of the regolith-landform mapping units and for the compilation of the landforms and geomorphic domain maps. Mapping covers the 260 km length of the Geodynamic Transect and was extended out from the line by 5 kilometres North and South. This gives an approximate study area of 2 600 square kilometres.

The regolith-landform map forms part of a comprehensive GIS containing information on regolith stratigraphy, landforms, geomorphology, vegetation, samples, site photographs, and geochemical and mineralogical data.

Representative regolith stratigraphic sections have been compiled over each of the primary rock types along with descriptions of the primary weathering trends. These sections along with photographic documentation of the surficial materials and landscape along the section have been included in Appendix II.

2.2 Overview

The information contained within this section is derived largely from an interpretation of the drillhole logs combined site descriptions collected along the Geodynamic Transect. This information has been summarised from full descriptions of regolith developed over specific geological units, which are detailed in Appendix III. Typical hole profile numbers are included as 4 figure numbers for cross reference with the drill logs database provided on the enclosed CD (Appendix IV).

The nature of surficial regolith materials, regolith stratigraphy and regolith-landform relationships across the Geodynamic Transect show a strong litho-dependency. Table 1 provides a synopsis of rock types, associated landforms, weathering processes and regolith development. For convenience, variations in landforms and their associated regolith materials are is discussed with respect to the major lithologies found along the Geodynamic Transect.

2.2.1 Mafic Volcanics

Mafic volcanic rocks are observed within the Soldiers Cap Group, the Marraba Volcanics, Magda Lynn Basalts and Eastern Creek Volcanics. The landforms developed over these lithologies are principally low-angle erosional plains or gently undulating low hills. The metabasalts, metadolerites and amphibolites are characterised by a thin, iron-rich, regolith supporting common spinifex and native grasses with sparse eucalypt, acacia and grevillea species. The upper part of the profile may comprise orange sandy to silty clay soils (0.1 – 0.3 metres thick) with an iron-rich lag, which commonly includes ferruginous granules and fragments. Fragments of ferruginous saprolite and weakly oxidised bedrock are also present as lag material and within the soil profile (see photos for site 3340 on Section 3/Appendix II). Fe-saprolites extend to between 2 and 4 metres. The iron in the profile is sourced from the weathering of ferromagnesium minerals.

Deeper regolith profiles are present where iron-rich alluvium and Tertiary sediments mantle the mafic units. Figures 5 and 6 show quartz-rich alluvium and colluvium unconformably overlying saprolite within the Marraba Volcanic Group. Ferruginous segregations representing mottle development is observed within drill spoil for some profiles. They are also exposed *in situ* within a creek cutting adjacent to hole number 5482 (as seen on Section 2/Appendix II). Late stage pedogenic carbonates in the form of calcareous veining, nodule development and pervasive calcification is present within saprolite and the saprock and is unevenly distributed within all mafic units.

Massive more silicic mafic volcanic units appear to be relatively resistant to weathering and adjacent units commonly exhibit an accentuated weathering profile development. One possible reason for this may be due to damming of groundwaters by the mafic units. This phenomenum is well illustrated between holes 5584-5589 and 5506-5508 (see Section 2/Appendix II.).

2.2.2 Felsic Volcanics

The porphyrys, rhyolites and rhyodacites of the Argylla Group and the Corella Beds are present through the centre of Mount Isa Inlier as high to low hill belts and on the adjacent gently undulating plains and low hills. Felsic volcanics exhibit a variable regolith as seen on Sections 3 and 5/Appendix II. Typically thin, quartz-rich, sandy-clay skeletal soils or a quartz rich colluvial veneer of oxidised bedrock fragments, vein quartz and ferruginous granules overlie saprock or siliceous bedrock (see Section 5/Appendix II, and photos for drill hole 4444). Rarely saprolite is developed to a depth of 10 metres.

Iron staining and fine ferruginous veining is common within the upper saprolite or saprock horizons and may persist to depths of 2 to 4 metres. Calcrete, calcareous veining, calcareous nodules and pervasive calcareous infiltration are present as fragments on the surface and developed within the saprolite, saprock and underlying bedrock.

2.2.3 Granites and Gneiss

The granitic rocks of the Kalkadoon Granites and the Sybella Formation are present in the western half of the Mount Isa Geodynamic Transect. Landforms associated with these rocks are low hills and rises dissected by small ephemeral creeks and streams. A sparse to moderate cover of spinifex with lesser eucalypts and acacia is present over much of the granite country. Regolith developed over granites is generally thin, characterised by a veneer of coarse angular sheetwash or colluvial granitic gravels, which overlie a thin (0.2 to 2 metre), moderately oxidised, iron stained saprolite horizon (as seen on Section 2). Fresh bedrock below crops out as tors and low barren rises. Pedogenic carbonates and weakly calcareous saprolites are unevenly distributed over the granitic units.

There is limited evidence for deep regolith development over granitic rocks close to the contact of the Kalkadoon Granites and the gneissic rocks of the May Downs Group (330427 mE 7689549 mN). Here a series of 60 metre high mesas rise above the surrounding undulating plains (Figure 7). The Mesas are capped by 10-15 metres of silicified, iron-rich, collapsed mottled zone and ferruginous saprolite. Beneath the siliceous cap a 10 metre thick zone of bleached and mottled silicified saprolitic clays is exposed above a steep debris slope of ferruginous saprolite and fragments of mottled granitic saprolite (see Figure 8). This is the only location along the whole Geodynamic Transect where a substantial regolith profile is preserved over granitic rocks.

The gneissic rocks of the Yaringa and May Downs Group are present within undulating plains and low rises on the western extent of the Geodynamic Tansect. Usually a thin silty to sandy soil or veneer of alluvium and colluvium overlies 0.5 to 4 metres of calcareous saprolite beneath which fresh bedrock is encountered. This is However close to the contact of the Yaringa Group and the McNamara Group sediments saprolite development extends to up to 12 metres in depth (see on Section 1/Appendix II). The regolith profiles of the gneissic rocks are considerably more calcareous

Figure 5. Section through the colluvial plains at 427963 mE 7684194mN. Coarse angular polymictic colluvium over the saprolitic metasediments and metavolcanics of the Marraba Volcanic Group.

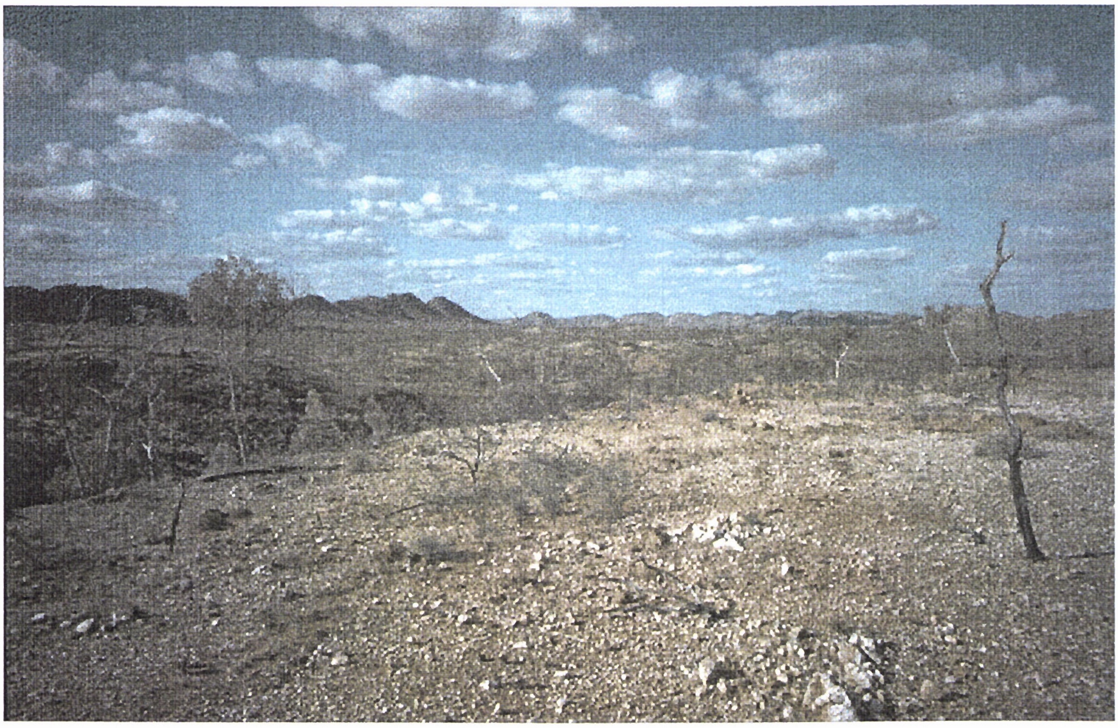


Figure 6. The edge of the quartz rich colluvium present over the Marraba Volcanics at location 402860 mE 6787148 mN. Active backslope retreat from the north or top of the photo is removing the colluvial material.

Figure 7. (1364/60). Mesa within the rocks of the Sybella Granite. Location 333248 mE 7690944 Mn

Figure 8. Mottle development within a mesa profile from a silicified saprolitic granitoid within the Sybella Granites. Location 330427 mE 7689549 mN

than the surrounding granitic and sedimentary units with pedogenic carbonates present within all profiles.

Rock Type	Landform	Weathering processes/ Profile development	Soils
Granites/Gneiss	Low hills and undulating plains. Mesas in zones of metamorphic/structural deformation	Exfoliation. Mass wasting. Common sheet-flow deposits of quartz/feldspar gravels. Generally shallow weathering (0-2 m).	Sands and gravels. Variable ferruginisation and minor calcareous induration.
Porphyrys/Felsic volcanics	Moderate to high hills	Gullying, exfoliation. Poor profile development and generally shallow weathering (0-2m).	Silts and sands and siliceous weathered bedrock fragments.
Calcareous metasediments, Limestones	Plains/low hills to hills	Chemical weathering. Gullying. Moderate profile development (2-6m).	Calcareous silty to sandy soils. Common surficial calcite and calcareous veining and infultration at or near surface.
Quartzites and Sandstones	Moderate to high hills. Elevated in respect to surrounding environs	Exfoliation. Gullying is present along shears/strain zones or associated with finer sediments. Common siliceous capping. Shallow to moderate profile development (0-8m).	Silty to sandy with common angular bedrock fragments minor ferruginisation on higher hills.
Siltstones, Mudstones, slates and shales	Moderate hills/plains	Gullying/sheet-wash Generally deeper profile development and increased weathering depths in plainar and upright sedimentary successions (0-40m).	Uncommon ferruginisation, mottled zone development and surficial ferruginous lags.
Basalts & Dolerites	Moderate-low hills and plains	Gullying/sheet-wash. Moderate profile development. Variable profile development depending on the degree of silicification and foliation (0-4m).	Orange-brown clays. Common ferruginous granules and nodules minor mottling.
Schists	Moderate to low hills, plains, gullies, streams and valley floors.	Commonly deep weathering. Variable profile development depending on silicification (1-30m).	Micaceous silty iron-rich soils. Common calcareous induration.

Table 1. Generalised relationships between bedrock geology, landform, soils and weathering along the Geodynamic Transect.

2.2.4 Schists

Schists and schistose bedrock are contained within all major tectono-stratigraphic units. Schistose packages are preferentially distributed along contacts (see Section 5/Appendix II, Hole 4435) and fault zones. They are picked out as gullies, valleys, streams or depressions within the landscape (see Section 4, Holes 2518, 2479). Schists commonly support thin (0.1 to 1 metres), variably calcareous, fine, sandy to silty, micaceous, iron-rich soils. Beneath the soil strongly foliated and occasionally crenulated iron stained and variably calcareous saprolite extends to depths of between 1 and 30 metres. The saprolite commonly contains fine quartz veining, disseminated sulphides and calcareous veining and nodules. The regolith profile is commonly enriched in iron with hematitic iron segregations and pervasive iron staining present within the saprolite and saprock and extending into the bedrock below. Many of the schistose weathering profiles are calcareous with common calcareous veining, nodules and massive or fragmental calcrete.

In rare cases a schist capped by calcrete, silcrete, ferruginous saprolite or some other resistant material may actually sit above surrounding units (as seen at hole 4348 on section 5/ Appendix II). For the most part schistose rocks usually develop deeper regolith profiles, and sit in the lower parts of the landscape.

2.2.5 Calcareous Metasediments – Calc Silicates

The rocks of the Corella Beds and the Corella Formation are a series of calcareous and variably siliceous pelitic metasediments, limestones, siltstones and schistose metasediments or their brecciated equivalents. The complex internal structure of the calcareous units result in little continuity in observed weathering characteristics. This is well illustrated on Section 4 between holes 2387 and 2470. The more siliceous and commonly brecciated equivalents of these metasediments outcrop as a series of low undulating hills and as rises through colluvial and alluvial sheetwash plains (see photo for site 2464 on Section 4/Appendix II). Their soils support a moderate cover of spinifex and native grasses with sparse eucalypt and acacia species. Regolith profiles commonly show between 5-50 cm of fine clayey-silty, calcareous, soils. Surficial calcite crystals, calcareous nodules, quartz fragments and abundant ferruginous and calcareous bedrock fragments are common. Saprolitic clays extend to depths of between 2-6 metres.

Limestones and schistose metasedimentary units, which occur between the silicic breccias and pelitic sediments generally occupy the low areas in the landscape. The limestones have developed a fine grey silty soil, between 0.1 – 0.3 metres thick. Outcropping bedrock and surficial weathered bedrock fragments are common. Calcite crystals formed by contemporary pedogenic processes are commonly observed on the surface and within the soil and weathering profiles (see photos for hole 2487 on Section 4/Appendix II). Native grasses and eucalypts predominate with uncommon acacia spp. These thin soils may overlie 2 to 4 metres of saprolite, or lie directly above unweathered limestones. Hole 2405 represents the typical deep profile, 2410 is typical of a shallow profile.

The coarse metasandstone units and mafic volcanic units present within the Corella Formation are generally less susceptible to weathering than the surrounding calcareous metasediments. The latter are characterised by thin, silty to sandy, calcareous soils and colluvium, which in turn overlie up to 0.5 to 2 metres of calcareous saprolite.

The more schistose units within the predominantly massive units are characterised by thin, iron-rich, silty to sandy soils, which support eucalypt, acacia and spinifex species. The saprolitic clays commonly extend past 10 metres (see hole numbers 2479 and 2518 on Section 4/Appendix II), contain calcareous fragments and are usually pervasively stained with iron.

2.2.6 Siltstones, mudstones and slates

Siltstones, mudstones and slates are present within the Corella Beds, Marimo slates, Quilalar Formation, McNamara Group and as poorly consolidated units within the Eromonga and Georgina basins, as described in Chapter 2.2.8. These rocks are commonly interbedded with sandstone and quartzitic units. Rocks of this type are associated with low hills, rises and plains and support a vegetation regime dominated by spinifex with native grasses and eucalypts. Casuarina spp are present within areas of subdued relief.

Fine silty to micaceous and variably sandy soils some 0.05 to 0.5 metres thick have developed over these rock types. Oxidised or weakly iron-stained saprock or siliceous bedrock fragments are also common at the surface. Below the soil, a variably calcareous and ferruginous upper saprolite developed to depths of between 2 and 20 metres grades through 5 to 20 metres of saprolite. Thicker saprolite profiles are observed within the mudstones and siltstones units of the Quilalar Formation and the McNamara group rocks. Here the saprolite is commonly in excess of 40 metres. Silicification within the upper profile is common and is particularly well developed on the basin margins between the outcropping McNamara group rocks (see Section 1/Appendix II between holes 6640-6658 and 6724 and 6736).

Within the rocks of the Marimo slates a thin surficial cover of ferruginised colluvial bedrock fragments and thin silty soils usually overlie between 10 and 20 metres of purple to pale brown, iron stained, saprolite and saprock (see Figures 9 and 10). Ferruginous and quartz veining is common.

Figure 9. Outcropping low hills of the Marraba Group at Location 402860 mE 6787148 mN

Figure 10. Surficial colluvium and oxidised slatey and schistose bedrock fragments developed over the Marimo slates. Location 441285 mE 7685436 mN.

2.2.7 Sandstone and quartzites

Sandstones and quartzites are observed within the McNamara Group, Mt Isa Group, Overhang Jaspilites, Mitakoodie Quartzite, Quilalar Formation as well as within the sedimentary basins flanking the inlier. The basinal successions are described in chapter 2.2.8. The sandstones and quartzites found within the Mt Isa Inlier typically form the higher elements of the landscape, either as hills or high hills. This may be related to the siliceous nature of the sediments and the characteristic siliceous and sometimes weakly ferruginous upper weathering profile they develop, which acts as a protective cap. These rocks generally support thin, sandy to silty soils. Weakly ferruginous and siliceous bedrock fragments are common. These soils support a medium cover of spinifex and eucalypts.

The quartzites of the Inlier are characterised by thin regolith profile development (see Section 3/Appendix II). A thin skeletal or colluvial soil mantle may overlie up to 4 metres of variably ferruginous saprolite, which develops on hard siliceous unoxidised bedrock. Minor iron staining is common within the upper profile but this rarely persists past 6 metres in depth.

The sandstones and metasandstone units observed within the Inlier are either outcropping, have a thin sandy to silty soils on moderate slopes or are concealed beneath up to 4 metres of colluvium comprised of weakly oxidised bedrock. The upper sandstone profile is hard, highly siliceous, variably ferruginous and rarely calcareous Commonly this part of the profile and is between 2-10 metres thick. Below, saprolite may extend below 40 metres but more commonly a thin saprolite and saprock horizon up to 10 metres thick overlies unoxidised hard bedrock.

2.2.8 Basinal Sediments

Poorly consolidated sediments were observed within the Eromonga Basin at the eastern end of the Geodynamic Transect and within the Georgina Basin on the western extent of the Transect. At several locations along the western margin of the Eromonga basin, older coarse polymictic gravels and pebbles and overlying black soil units onlap onto the Proterozoic rocks of the Soldiers Cap Group (Figure 11). These units are being removed by backslope denudation and are most likely the remnants of older exhumed Tertiary or Mesozoic colluvium and alluvium.

The flat open black soil plains of the Eromonga Basin support abundant native grasses while the low rises of ferruginised polymict gravels and alluvium with their more iron-rich soils support a mix of spinifex, native grasses and eucalypts.

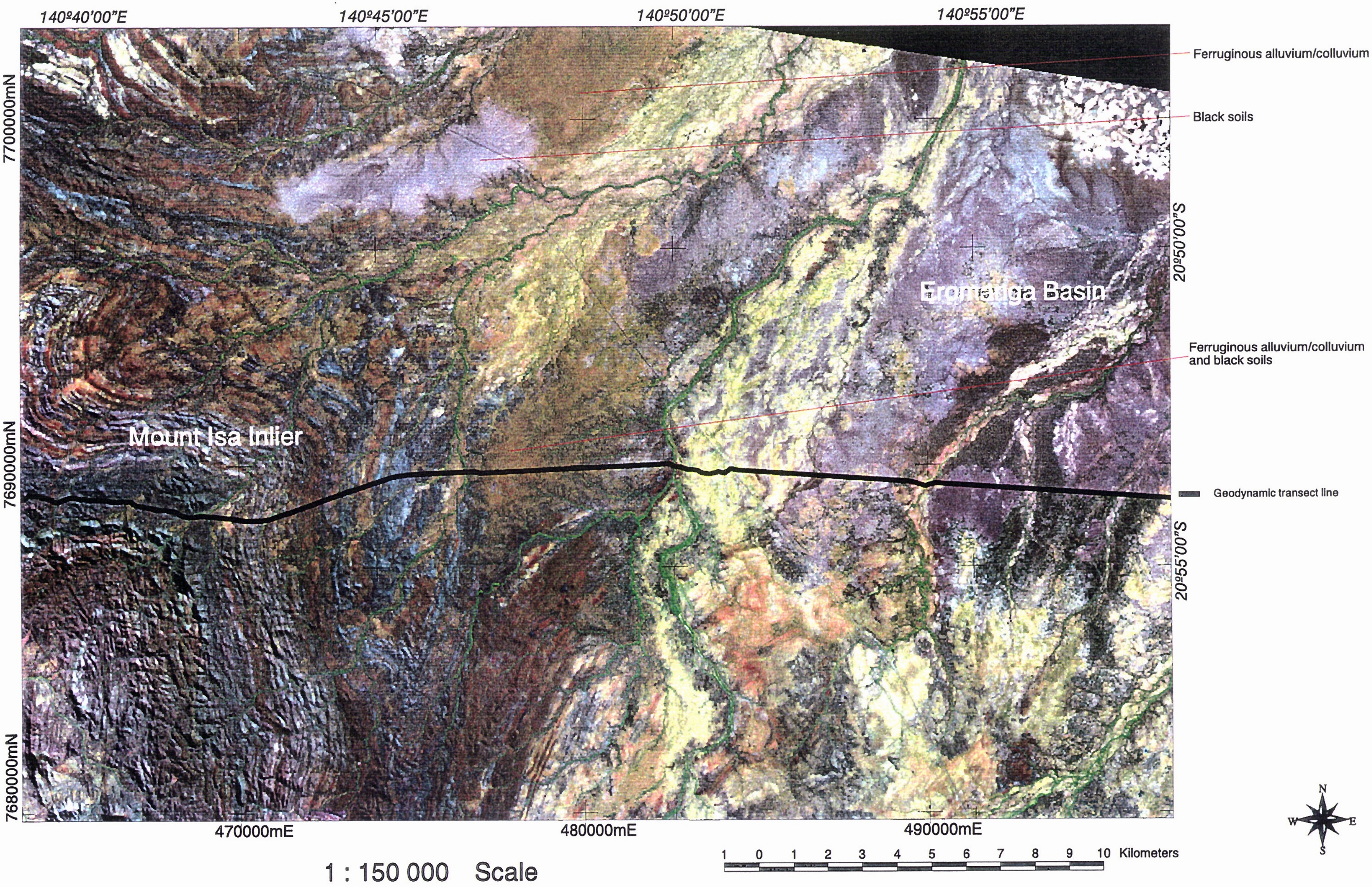
The generalised stratigraphy of the plains sees a 1 to 4 metre thick layer light grey smectitic 'black soils' overlying 2 to 20 metres of medium to very coarse silty-sandy alluvium with common sub-angular to well rounded polymict alluvial pebbles and boulders (Figure 12). Below are a succession of saprolitic sandstones, siltstones and mudstones with uncommon conglomeratic lenses and limestone sequences.

To the south of the exposed in section at the Eloise mine the poorly consolidated siltstones and mudstones are observed, they are strongly fractured and show abundant soft sediment deformation features (slicken sides and slumping). They also exhibit variably calcareous and minor iron concentrations the latter case representing early stage mottling within the upper 1 to 2 metres. The mudstone and siltstone successions are underlain by a coarse basal conglomerate-breccia unit, which directly overlies the Proterozoic amphibolite basement rocks. An analogous basal conglomerate and breccia unit is also observed directly overlying the Proterozoic basement rocks of the Soldiers Cap group within sedimentary mesa successions outcropping at Davis Hill.

The sediments and black soil plains of the Georgina Basin were observed on the western most extent of the Geodynamic Transect, immediately to the west of the of outcropping low hills of sandstones, mudstones, dolomites and siltstones of the McNamara Group. The McNamara Group sediments and

Mt Isa Inlier - Eromonga Basin

Figure 11. Older alluvium/colluvium and black soil units overlying Proterozoic assemblages on the basinal margin.



the associated overlying lags, ferruginised saprolites, bedrock fragments and iron segregations, are the source of the abundant ferruginous granules and oxidised bedrock fragments present on the colluvial slopes covering the plain margins and within buried alluvium in the plains.

The black soils present over the flat open plains support abundant native grasses, while the exposed iron-rich sandy alluvium present within the black soils supports abundant spinifex and sparse stands of eucalypt, gidgee and casuarina.

The stratigraphy of the plains within the Georgina Basin plains is a 2 to 6 metre thick layer of black soils overlies alluvial units. These silty-clay loams contain common alluvial pebbles comprising mainly quartz with rarer Cambrian pebbles containing fossil trilobites. The alternating alluvial gravels and sandy alluvial clays extend to a depth of between 15-25 metres. These gravels comprise predominantly quartz, chert and Cambrian cobbles with rare fine ferruginous granules. Thin bands of laminar grey chert are present within these sediments.

The alluvial units present within the Georgina Basin in part contain and are underlain by 2 to 6 metres of variably silicified and ferruginised saprolitic siltstone and sandstone units. These units contain common fine quartz granules, and rarer ferruginous granules and persistent chert fragments. The sediments show weak and inconsistent purple through to pale yellow haematite and limonitic iron staining and uncommon sub-metallic iron accumulations that commonly represent early mottle development.

The lowermost units extending past depths of 40 metres are a series of bleached, white, variably silicified saprolitic siltstones and sandstones. These units contain fine quartz gravels and common grey chert bands.

Poorly consolidated surficial sediments are also encountered across the Mt Isa Inlier, contained within or adjacent to drainage depressions and plateaux. These sediments are exposed to similar groundwater processes as the near surface basinal sediments, and are commonly weakly ferruginised and calcareous.

Figure 12. Pit section at the Eloise mine. Brown-Black soils overlying yellowy orange alluvium and white siltstones and mudstones. Location 498512 mE 7689161 mN

2.3 Mineralogy and Geochemistry

Mineralogical and geochemical analysis were carried out on nine representative rock types across Geodynamic Transect (Figures 13 and 14).

Overlying the mudstone, siltstone and sandstone successions of the Eromonga and Georgina basin sequences are a series of black soils and alluvium. Both the sediments and overlying material have high concentrations of quartz and feldspars within smectitic and kaolinitic clay matrix. Weakly mottled or Iron stained quartz, kaolinite and goethite-rich saprolitic clays after mudstones, siltstones and sandstones extend to depths of 20 metres. Geochemically, the lower mottled zone shows elevated levels of iron, copper, lead, zinc and nickel. The weathered and bleached saprolites are primarily quartz, kaolinite and mica with variable amounts of mica. Silicification of saprolites is common particularly within the more quartz rich sandstone lithologies (see figures 13-14 sections G,H & I).

The calc-silicate rocks of the Inlier show well developed pedogenic carbonates as calcite crystals, calcareous veining, staining and infiltration. The soil and upper saprolite comprise primarily quartz, feldspar, calcite, smectites and kaolinite. The thin surficial soils and upper saprolite are underlain by a carbonatedd veined and indurated saprolite. The saprolite consists principally of calcite, quartz, mica, felspar and smectities and kaolinite. Feldspar, quartz, smectites and kaolinites are the main mineralogical components in fresh bedrock. (see Figure 13-14 sections B & E)

The mafic metabasalts and schistose rocks are characterised by their high iron content. Soils, clays and iron-rich lag comprised of feldspar, quartz, kaolinite, amphiboles and hematite overlie outcropping ferruginised and saprolitic mafic units. These rocks commonly show high concentrations of calcite and dolomite as calcareous veining and calcrete within the soils and upper saprolite. In the lower saprolites feldspars, quartz, smectites, multi-layer minerals, kaolinite and amphiboles dominate. The smectites and multi-layer minerals are weathering products of the amphiboles. (see Figures 13-14 sections A,C & D)

The granitic rocks observed across the inlier generally exhibit shallow weathering profile with the thin colluvial or skeletal soils comprising quartz, feldspar, smectite, kaolinite and mica. The granites do show a degree of calcareous enrichment and cementation this is expressed in the mineralogy and geochemistry with elevated dolomite and high calcareous content. Generally though calcretes and dolomite is absent from the granitic profile (see Figure 13-14 section F).

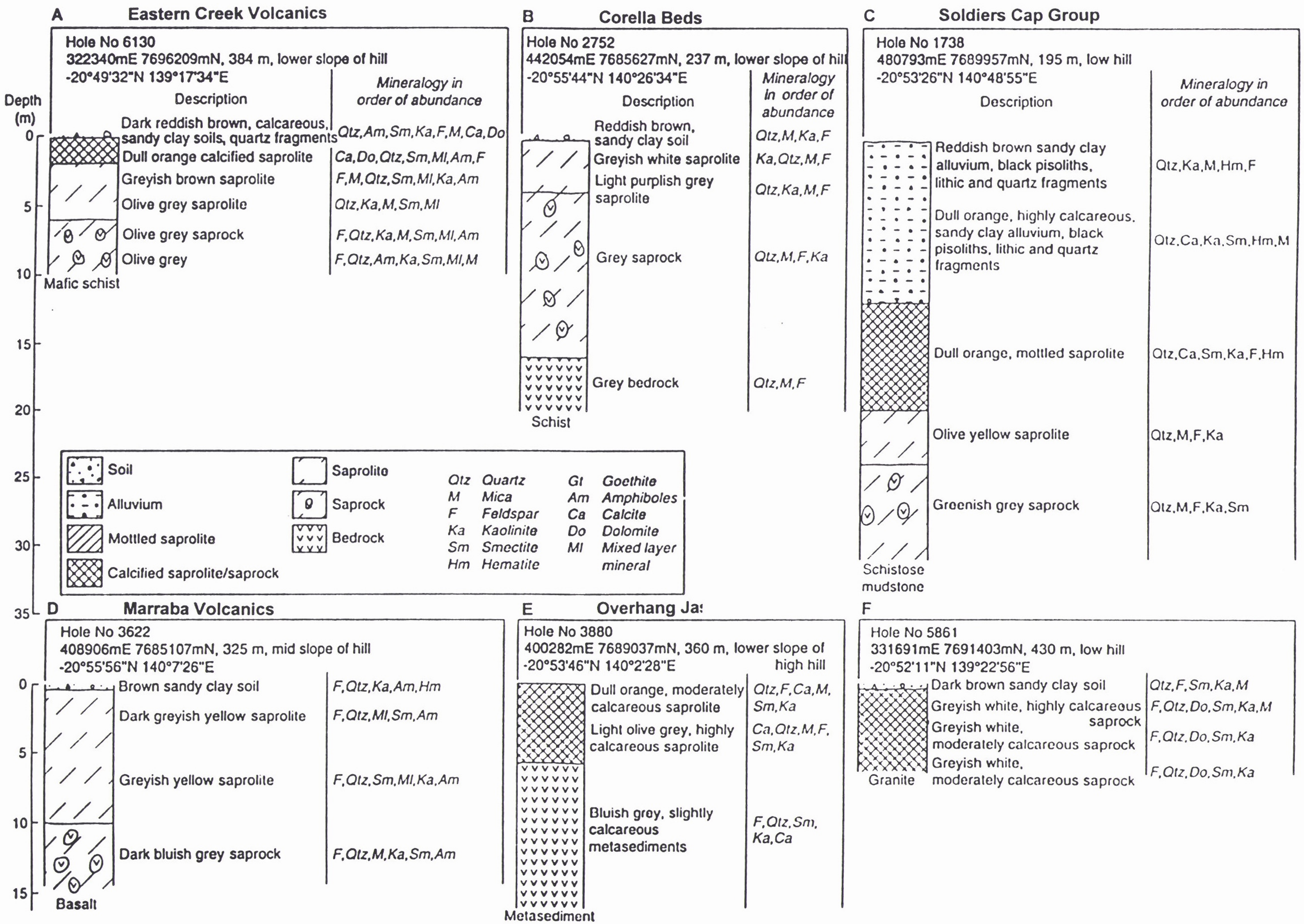


Figure 13. Stratigraphy and mineralogy for selected rock types along the Geodynamic Transect.

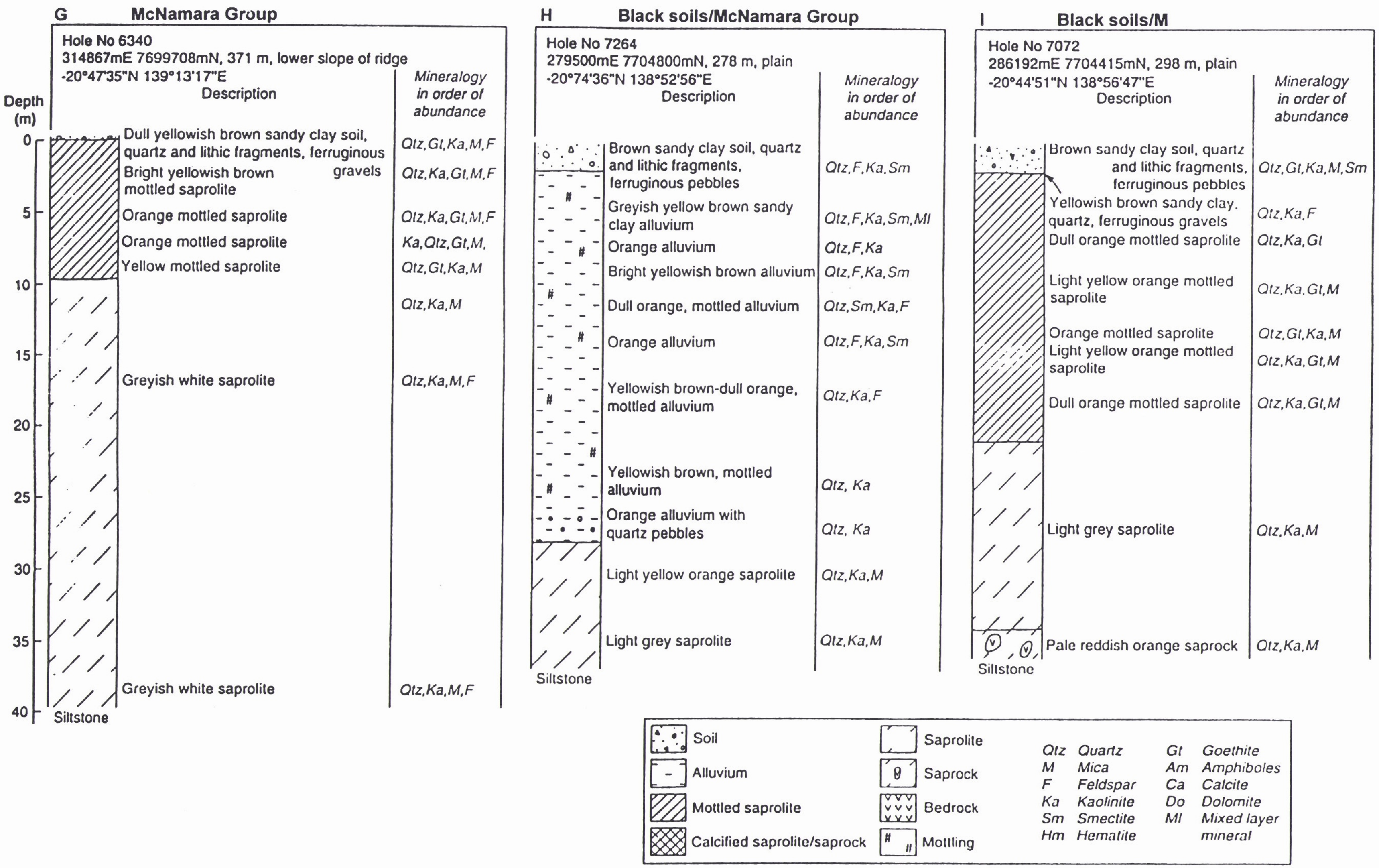


Figure 13. Stratigraphy and mineralogy for selected rock types along the Geodynamic Transect.

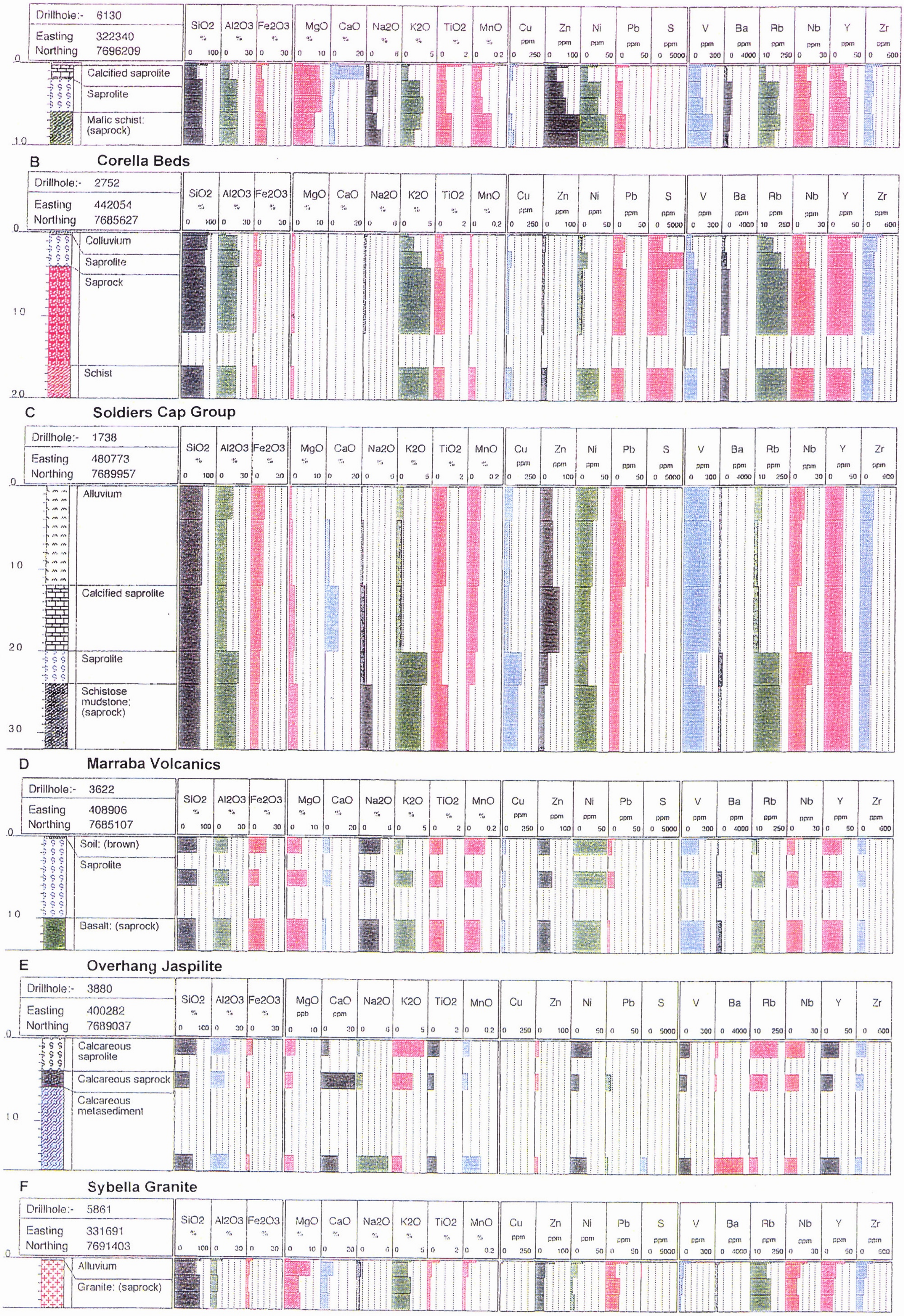


Figure 14. Geochemical characteristics for selected rock types along the Geodynamic Transect

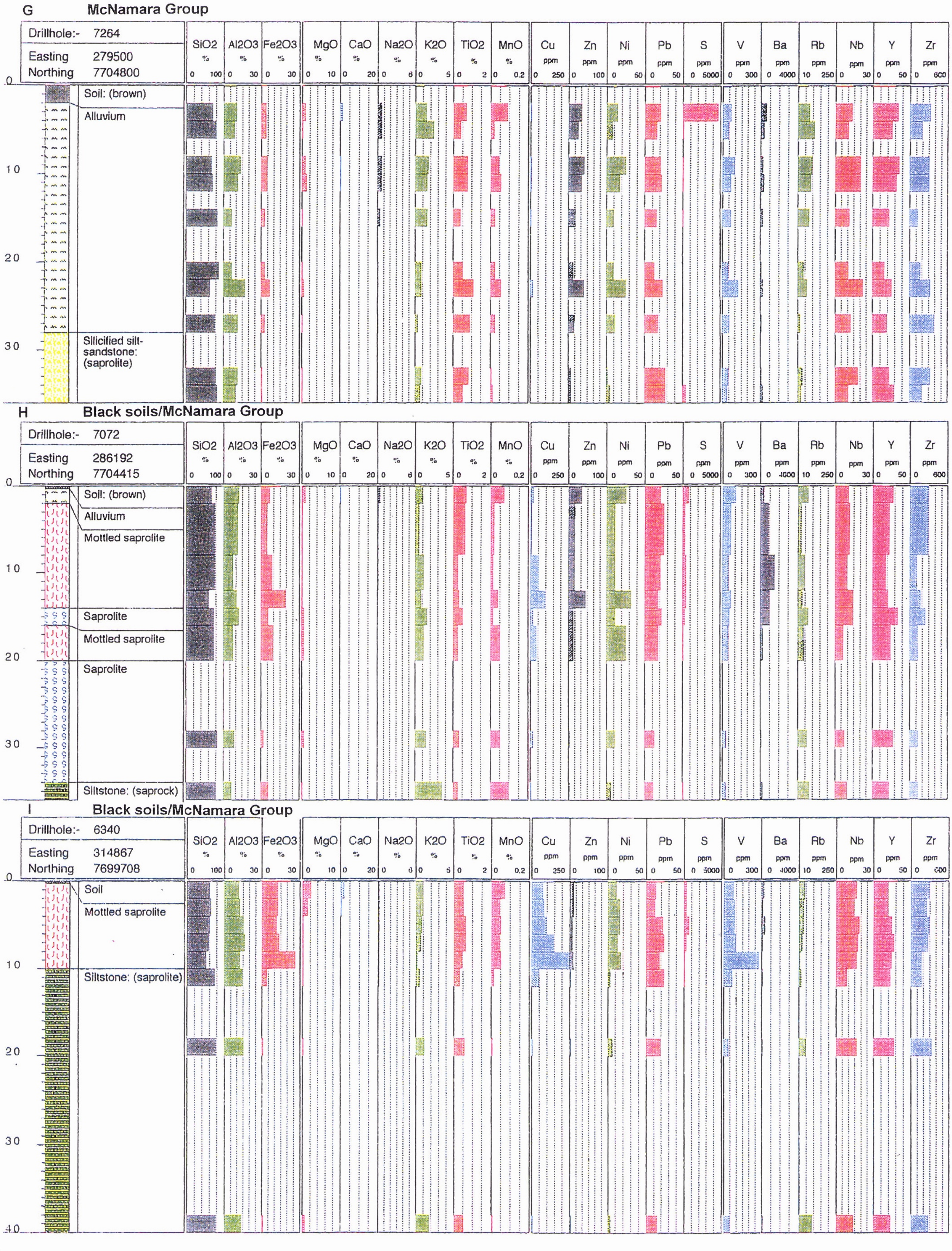


Figure 14. Geochemical characteristics for selected rock types along the Geodynamic Transect

3. DISCUSSION

3.1 Weathering Characteristics

The complex geology observed within the drill spoil along the Geodynamic Transect is reflected in the development of a highly variable, complex regolith profile. The observed complexities are related to a varied tectonic history, complex boundary relationships, sudden changes in lithology the steep dip and gradational metamorphic grade.

The rocks observed along the Geodynamic Transect and in particular across the Inlier itself are characterised by relatively thin regolith profiles. The nature of the present-day regolith and more notably the thin profiles can be attributed to the present erosive geomorphic phase, which has persisted through the late Tertiary and Quaternary (Blake 1987). This regime coupled with the present climate in the study area is not favourable for deep (>50 metres) regolith development or the preservation of older weathering profiles.

The removal of the regolith mantle is facilitated by the relatively high relief of the inlier, coupled with heavy seasonal rains which act to prevent the 'blanket' lateritic profiles which have developed within similar aged rocks in areas of western and south-eastern Australia.

Remnant mantles of black soils and patches of ferruginous alluvium and colluvium elevated above the present basin and are interpreted as being indicative of past stable landscapes are observed being actively eroded from the Proterozoic rocks of the inlier (see Figure 14 and Appendix II). The removal of this material is aided by the development of active new drainage networks, which have captured older drainage systems.

Evidence for past deep weathering episodes are preserved within mesa structures (Figure 4), developed over Proterozoic and Mesozoic rocks and within the basinal sedimentary assemblages present within the Eromonga and Georgina basins. Other more fragmental evidence for past deep weathering events is present beneath isolated siliceous, ferruginous caps, Tertiary sediments or alluvial soil profiles along the Geodynamic Transect. Examples of this are illustrated in Appendix II see Section 1 between holes 6766 and 6809 and Section 4 between holes 2518 and 2512 and between holes 2446 and 2428). At these locations the relatively resistant materials have preserved a more complete weathering profile with deeper saprolite development than surrounding rock units and the development of mottling, strong iron staining and silicification of the upper profile.

Thick regolith profiles are generally restricted to areas of subdued relief; unconsolidated or poorly consolidated sediments; where shearing or faulting is present or where significant permeability contrasts along bedrock contacts are present. In these situations regolith thickness exceeds 40 metres.

3.2 Silicification

Silicification is observed in numerous locations and geomorphic settings along the Geodynamic Transect. It occurs as laterally extensive siliceous duricrusts capping Mesozoic sedimentary successions and Proterozoic basement, and as variably silicified horizons within saprolite, saprock, bedrock, alluvial or colluvial profiles. The silicification of the rocks observed within the inlier can be attributed to intrusion of igneous bodies and associated contact metamorphosism and metasomatic fluids, regional scale metamorphism and to groundwater and weathering processes. Silicification resulting from groundwater and weathering processes is commonly spatially related to ferruginisation. Silicic horizons are both overlain, or in places underlain by iron enriched or cemented material. The spatial relationship of ferruginisation and silicification suggests that siliceous and ferruginous duricrusts can form in similar settings.

In areas where there has been considerable stripping of weathered material these siliceous mantles are elevated in respect to the rest of the landscape. This phenomena is best illustrated by the mesas to the south east of Cloncurry and by the silicic capped metasedimentary successions south east of Mt Isa which rise up to 200 metres above the undulating granitic and porphyritic plains below.

Siliceous mantles are observed within the poorly consolidated sediments of the Georgina Basin. These silicified saprolitic sandstones and siltstones and silicified and ferruginised alluvium are observed continuously for over 1 km at thicknesses up to 10 metres beneath a thin cover of saprolitic clays, iron-rich colluvium and black soils. As seen on Section 1/Appendix II these inclined siliceous mantles sit within the saprolite below the lower slope of a low hill. This setting has been suggested as being a favourable sight for the formation of both siliceous and ferruginous duricrusts (Ollier & Pain 1996).

3.3 Ferruginisation

Ferruginisation or more particularly the development of iron-rich regolith profiles is greatest within the more mafic volcanic, and schistose and iron-rich sedimentary lithologies. However, some degree of ferruginisation in the form of iron staining or iron-rich veining is observed within all rock types. Ferruginisation occurs as pervasive staining, micro and large-scale veining and spotting and in more concentrated forms as goethitic and hematite rich ferruginised saprolites and mottled zones and iron cemented alluvium. Sub-metallic hematitic accumulations and segregations as early stage mottling were observed within metasedimentary units and less frequently within metabasalts, mafic schists. Within the Sybella granites a very well developed mottled zone up to 10 metres thick is preserved beneath a hard resistant cap of silicified and ferruginised saprolites.

Iron-rich lags of ferruginous granules, pisoliths, ironstone fragments and ferruginised bedrock fragments are common over mafic lithologies and where ferruginous saprolites are exposed at surface. Iron cemented bedrock fragments and lag occur within drainage depressions or depositional slopes adjacent to iron-rich litholgies or ferruginous weathering mantles.

The lack of extensive iron-rich lithologies and ultramafic units across the inlier has restricted the formation of the deeply weathered lateritic profiles capped by a hardened ferruginous mantle or 'duricrust', underlain by mottled saprolitic clays, pallid zone, saprock and bedrock which are observed in Western and South Eastern Australia.

3.4 Calcification

Calcification and the calcareous enrichment of the regolith profile and underlying rocks is observed as late stage pedogenic calcretes, calcareous nodules and as pervasive calcareous veining and coatings. Calcretes are preferentially developed within the calc-silicate units of the Corella Formation and Corella Group rocks. Pedogenic carbonates are also observed adjacent to creeks, rivers and other drainage depressions or poorly drained areas of the landscape. Contemporary processes have led to the development of calcareous root casts. These have developed beneath native grasses and are observed within recent unconsolidated sediments at station 3532. Gypsiferous crystals and calcification of the upper profile within sediments of the Eromonga Basin is attributed to present groundwater processes.

3.5 Implications for Exploration

Geochemical exploration strategies over much of the Mt Isa Block are relatively simple due to the extensive outcrop of unweathered or partially weathered bedrock and skeletal soils. Soil and stream sediment sampling strategies can be employed over these areas, with numerous ephemeral streams and creeks providing fresh sample media after each wet season. Care must be taken to identify colluvial and alluvial materials, which will dilute or mask the geochemical signal of the underlying rocks. The Geomorphic domains map as part of Appendix 1 shows the distribution of Skeletal soils, colluvim and alluvium across the study area.

Regional studies undertaken by the CSIRO within the Yilgarn Craton and the Mt Isa Block and localised studies of the Lady Loretta and Python Prospects have found that Ferruginous upper profiles, mottled zone and calcretes provide favourable sampling media for metalliferous mineral exploration. (Anand *et. al.* 1997, Dell 1992, Lintern & Butt 1997 and Smith *et. al.* 1992). Both these media would be effective tools for mineral exploration within Inlier.

The historically economically important sedimentary and metasedimentary units of the Urqhart Shales and Mt Isa group rocks show strong bleaching and deep saprolite development to depths in excess of 40 metres. In these areas deep drilling below the bleaching is recommended as weathering may have leached the pathfinder elements. Iron-rich sedimentary sequences within these units are expressed surficially by the presence of iron-rich segregations, granules, ferruginous duricrusts or gossan like features. These massive iron accumulations effectively scavenge ore related elements and provide a very useful sampling medium.

The sedimentary dominated areas at the Eastern and Western Extents of the study area provide the most difficult exploration environments. Geophysical technologies are proving the most useful tools in these environments, with supplementary redox front or ferruginous interface zone sampling. Further work is required on the definitions and development of effective geochemical strategies in these environments.

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APPENDIX I

Regolith-Landform Maps

These maps are not supplied in the Open File version as they are available in digital form. See the CD in this report and the CDs in the Final Report - Open File Report 120.

APPENDIX II

Regolith Sections

These maps are not supplied in the Open File version as they are available in digital form. See the CD in this report and the CDs in the Final Report - Open File Report 120.

APPENDIX III

Regolith Geology by Rock Type

APPENDIX III

INTRODUCTION

The regolith observed along the Geodynamic Transect showed a very strong litho-dependency. This appendix has been included to provide a more comprehensive description of the regolith observed over specifically defined rock units as discussed by Blake (1987) see (Figure 3). These descriptions contain observations made by Blake (1987), Grimes (1979), Ryburn *et. al.* (1988), Smart *et. al.* (1980) and Steward & Blake (1992).

EROMONGA BASIN

The eastern most end of the Geodynamic Transect profiled the sediments of the Cloncurry and Julia Plain physiographic divisions which are contained within the Eromonga Basin. These Cainozoic and Mesozoic sediments are the remnants of a once extensive cover over the Proterozoic basement. The landscape comprises a series of flat open black soil plains where native grasses dominate. Gently sloping low hills supporting a mix of spinifex, native grasses and sparse eucalypts.

At several locations along the western margin of the Eromonga basin, coarse polymictic gravels and pebbles and overlying black soil units onlap onto the Proterozoic rocks of the Soldiers Cap Group (Figure 4). These units are being removed by backslope denudation and are interpreted as the remnants of older exhumed Tertiary or Mesozoic colluvium and alluvium.

Drill cuttings along the Geodynamic Transect show a 2-4 metre thick layer of light grey, smectitic, silty cracking clays which in turn overlie 10-20 metres of variably silty-sandy sediments made up of 10-20% fine gravels and polymict pebbles of an alluvial origin. Large pebbles and boulders up to 25 centimetres in diameter suggest a high-energy environment for the mode of deposition. This coarse alluvium depicted as the pale yellow areas on Figure 4 are very similar to those observed within presently active ephemeral, anastomosing streams in the Georgina Basin. In section, these creeks and streams in the Georgina Basin show the transported nature alluvium within which the surficial sandy-clay loam soils are developed. The units are variably 1 to 5 metres thick and are underlain by the coarser more iron-rich alluvial material to depths of between 2 and 15 metres.

Underlying the coarser alluvium is a sequence of variably weathered sandstones, siltstones and mudstones with minor conglomeratic lenses and limestone successions. Mottled horizons are developed within the alluvium and upper saprolites experienced as hematitic staining and sub-metallic accumulations extending to depths of between 5 and 20 metres. Saprolitic clays exist to depths in excess of 40 metres.

The stratigraphy of the black soil plains is well-exposed in dams, test pits and engineering holes at the Eloise mine, 11 km south of the Geodynamic Transect. Here a variable 1 to 5 metre thick grey sandy-silty-clay loam soil unit overlies a 2-15 metre thick, reddish-brown to greyish brown variably cemented, gravelly-sand alluvial unit (Figure 5). This alluvial material unconformably overlies between 50-80 metres of strongly to moderately weathered Mesozoic siltstone and mudstones. These siltstones and mudstones are poorly consolidated, strongly fractured and show abundant soft sediment deformation features (slicken sides and slumping). They are variably calcareous and show minor iron concentrations as early stage mottling within the upper 1 to 2 metres. The mudstones and siltstones present in the basin are underlain by a coarse basal conglomerate-breccia directly overlying the Proterozoic amphibolite basement rocks. An analogous basal conglomerate and breccia unit is also observed directly overlying the Proterozoic basement rocks of the Soldiers Cap group within sedimentary mesa successions.

Close to the Arolla homestead are limestones, calcareous sandstones and siltstones of the Toolbec Formation. The calcareous sediments contain abundant fossil and casts of bi-valves and snails. Well preserved plant fragments, pyritic pseudomorphs, both in cubic form and as framboidal pebbles, and ferruginous granules are common. This unit conformably overlies the basinal mudstone and siltstone successions.

Extensive black soil plains and grasslands extend past the eastern extent of the Geodynamic Transect. As observed at location 549040E 7686807N, between 2 to 4 metres of dark brown cracking clays 'black soils' are underlain by 2-4 metres of alluvial sands, silts and gravels, with minor crystalline gypsum. The alluvium is underlain by a 15 to 25 metre thick sequence of weakly mottled and orange iron stained saprolitic clays after mudstones and siltstones. This mottled zone is underlain by 30-40 metres of saprolitic/saprock, weakly silicified mudstones and interstitial mudstone and sandstone sequences.

EASTERN FOLD BELT

Unconformably overlying the Proterozoic rocks of the Eastern Fold Belt consolidated Mesozoic sediments form a series of mesas and buttes which rise up to 200 metres above the low undulating plains of the Proterozoic basement rocks (Figure 4). The basal unit of these sediments is a coarse silicified conglomeratic unit up to 5 metres thick consisting of pebbles and sub-angular rock fragments of slate, pumice, other vesicular pebbles and quartzite fragments in a coarse sandy matrix. There are abundant plant leaf, bark and stick casts on the upper surface of the conglomerate unit. The conglomerate unit grades upward through silicified coarse cross-bedded sandstones with common coarse quartz pebbles, through finer sandstone, siltstone and mudstone sequences. The tops of the mesas consist of up to 10 metres of highly silicified and mottled and ferruginised sandy to silty saprolitic sediments. The ferruginous and silicified saprolite comprising the upper weathering surface of planated mesas are covered by abundant ferruginous granules, silicified mottle fragments, fragments of ferruginous saprolite with patches of finer ironstone granules and pisolitic gravels. This surface supports abundant spinifex with a sparse to very sparse cover of eucalypt and *grevillea spp.*

These sediments contain evidence for prolonged deep weathering events, with the upper ferruginised and silicified saprolite exhibiting well-developed mottled zone formation. This weathering profile forms part of the Aurukun planation surface and is documented to have developed during the Oligocene.

Soldiers Cap Group

The amphibolites, metadolerites, metabasalts, and quartzitic and schistose metasediments and metavolcanics of the Soldiers Cap Group are exposed in an environment dominated by series of low undulating hills and plains dissected by a number of small ephemeral creeks. The Mt Norna Quartzite group is the most dominant geomorphological feature in the Cloncurry area forming a range of higher hills rising over to 300 metres above the rest of the landscape. This unit is economically significant as the Mt Norna Copper mine is hosted by the Soldiers Cap Group. The soils are generally thin developed over saprock or outcropping fresh bedrock and support a moderate cover of spinifex and sparse eucalypts. Lesser stands of acacia appear to occur mainly on outcropping or closely subcropping bedrock and on more iron-rich profiles.

Quartzites and silicified mafic volcanics typically show little to no signs of weathering, being oxidised to depths of between 0.1 to 2 metres. Where encountered these units form the higher hills or the undulating areas of elevated relief.

The amphibolites, metabasalts and metadolerites show shallow regolith profile development with moderately to strongly oxidised bedrock outcropping at the surface. The soils were present are generally thin (between 5 and 10 cm thick) and generally comprise iron-rich sandy-clays. A lag of ferruginous granules and oxidised bedrock fragments is present where mafic oxidised bedrock outcrops or closely sub-crops. Saprolite development is thin to absent except where weakly indurated ferruginous sediments and black soils overlie the Proterozoic units, within sheared and foliated units, or where Cainozoic or Quaternary alluvium mantles the mafic units. In these situations iron stained and weakly calcareous saprolite develops to depths of up to 12 metres. Saprock development is thin up to 4 metres deep, with fresh or weakly iron stained bedrock below.

On the western margin of the Soldiers Cap Group, an area of subdued relief with more silty soils supporting sparse eucalypt and spinifex marks the location of the Cloncurry Overthrust. Weathering profiles within the upright micaceous schistose metasedimentary units are strongly developed, with common iron stained saprolite and saprock development to depths of between 2 to 8 metres. Quartz veining, calcareous nodules, bands of calcareous saprolite/saprock and calcrete commonly occur in association with the profile development.

Corella Beds

Located between holes 2296 to 2518 the rocks of the Corella Beds are a series of calcareous and variably siliceous pelitic metasediments, limestones, siltstones and schistose metasediments or thin brecciated equivalents. The more siliceous and commonly brecciated equivalents of these metasediments outcrop as a series of low undulating hills and as rises through colluvial and alluvial sheetwash plains. These soils support a moderate cover of spinifex and native grasses with sparse eucalypt and acacia species. The profiles show between 5-50 cm of fine clayey-silty calcareous skeletal soils with common surficial calcite crystals, calcareous nodules, quartz fragments and abundant ferruginous and calcareous bedrock fragments. Moderately to strongly weathered saprolitic clays and saprock extends to depths of 2-6 metres beneath which fresh bedrock is encountered.

Limestones and schistose metasedimentary units within the silicic breccias and pelitic sediments generally occupy the low areas in the landscape such as the creeks, streams, gullies or valley floors. Limestones support a fine grey silty soil 0.1 – 0.3 metres thick. Outcropping bedrock and surficial weathered bedrock fragments. Calcite crystals formed by contemporary pedogenic processes are commonly observed on the surface and within the soil and weathering profiles. Native grasses and eucalypts predominate with uncommon acacia spp. These thin soils may overlie 2 to 4 metres of saprolitic weathered bedrock, or lie directly above unweathered silicic limestones. Hole 2405 is a typical deep profile, and hole 2410 is a typical shallow profile.

The schistose rocks contained within the Corella Beds support thin iron-rich silty to sandy soils supporting eucalypt, acacia and spinifex species. Saprolitic clays extend past 10 metres (eg 2479, 2518), contain common calcareous fragments and are pervasively stained with iron. Hole 2296 contains common fine calcite veining and fresh silver to yellow disseminated sulphides.

Marimo Slates

In the vacinity the Cloncurry river the slates, phyllites, metasiltstones, and fine metasandstones of the Marimo Slates are exposed as a series of resistant hills. They are also observed beneath cover in low depositional plains and valley fills.

The plains, floodplains and valley floors support common native grasses and gidgee with lesser eucalypts. Calcareous silty-sands, gravelly and cobbley alluvium is developed to between 0.5-15 metres deep. On the west bank of the river a thick layer of fine aeolian silts mantle a coarser alluvium and the bedrock. Beneath the alluvium, saprolite is encountered within the slates, schists (some graphitic) and variably schistose metamudstones and siltstones, extending below 40 metres in depth. Typically these saprolitic sediments show minor iron staining veining or spotting and infrequent quartz veining.

Through the hill belts, a thin veneer of ferruginous colluvial detritus up to 4 metres deep overlies 4-10 metres of saprolitic clays or saprock developed within the slates and schists. The saprolite is variably calcareous with calcrete bands and common ferruginous staining. This weathered zone is usually underlain by siliceous bedrock. The vegetation changes to open woodland dominated by eucalypts as seen in Figure 6. Typical profiles include holes (2833 - 2822 - 2791- 2767).

Overhang Jaspilite

The jaspilities, cherts, limestones and siltstones of the Overhang Jaspilites bound the western-most extent of the Corella Beds and the Marraba Volcanics. The siltstones and limestones show similar weathering characteristics to the Corella beds and Marimo Slates. The iron-rich siliceous chert and jaspilite members outcrop as 20-30 metre high ridges above the low undulating plains. Weathering profiles are poorly developed with weakly oxidised siliceous bedrock underlying a thin surficial veneer of colluvium.

Mitakoodi Quartzite

The hard siliceous quartzites and sandstones of the Mitakoodi Quartzite member form a range of low but steep resistant hills. The thin skeletal soils support a moderate cover of spinifex, eucalypts and acacia. Typically bedrock outcrops or fine silty to sandy skeletal soils with abundant coarse angular quartzite fragments overlie 1–2 metres of moderately weathered saprock or quartzite bedrock. Iron staining persists within the saprolite and bedrock to depths of up to 8 metres.

Marraba Volcanics

West of the Mitakoodi quartzites, the mafic rocks of the Marraba Volcanics outcrop through low angle colluvial plains and as a series of low undulating hills. The landscape is sparsely vegetated with spinifex, acacia, eucalypt, casuarina and grevillea species. Between stations 3100-3450 and 3665-3796, a 1-5 metre thick mantle of sandy-silty quartz rich alluvium and colluvial soils with a lag of ferruginous lithic fragments blanket the Proterozoic metabasalts, amphibolites, schists, slates, felsic volcanics and metasandstones and siltstones. Figure 7 shows this polymictic angular colluvial detritus unconformably overlying upright saprolitic metasediments. The colluvial material is now being removed by a more recent northward trending drainage system that is capturing the earlier southeast trending system. Up to 0.8 metres of alluvial or colluvial soils comprising quartz and oxidised bedrock fragments, calcareous and ferruginous nodules overlie 2-4 metres of iron-stained saprolitic bedrock. The saprolites show strong clay replacement and common goethitic and hematitc staining. Fresh or moderately weathered saprock extends to depths of between 15-25 metres. The bedrock contains rare calcite veining and disseminated sulphides.

Argylla Formation

The porphyritic rocks of the Argylla group observed within and adjacent to the Marraba Volcanics succession form an undulating landscape of low to medium hills. The thin soils support sparse eucalypts, spinifex, acacia, grevillea and grasses. Typically 0.3 metres of skeletal soils and gravels characterise these rocks comprised chiefly of oxidised bedrock and quartz fragments and rare ironstone granules. The soils are underlain by up to 2-3 metres of variably calcareous saprolitic clays and saprock exhibiting minor quartz veining and goethitic staining under which fresh bedrock occurs.

KALKADOON-LEICHHARDT BELT

This belt is characterised by very thin absent weathering profiles and skeletal soils developed over outcropping siliceous mafic and felsic volcanics and metasedimentary units. However, the calcareous metasedimentary units of the Corella Formation observed within the Mary Kathleen Zone commonly show a thicker profile development.

Corella Formation

The Corella Formation contains similar rock units and exhibits similar weathering characteristics to the Corella Beds of the Eastern Fold Belt, but contains coarser metasandstone units and mafic volcanics that are generally less susceptible to weathering. Thin silty to sandy calcareous soils and colluvium overlie up to 10 metres of calcareous saprolitic bedrock with 50-80% replacement of primary minerals by clay.

Kalkadoon Granites-Leichhardt Volcanics-Magda Lynn Basalts

The landscape developed over the rocks of the Kalkadoon Granites, Leichhardt Volcanics and Magda Lynn Basalts is typified by a series of low hills and undulating plains. Spinifex and native grasses dominate with sparse acacia and eucalypt species. Thin regolith profiles are observed. Commonly, skeletal soils with oxidised bedrock and quartz fragments cover closely subcropping or outcropping oxidised bedrock. Calcrete and calcareous veining occur unevenly distributed within all units. Saprolite development is uncommon but iron stained saprock may extend to depths of between 1-8 metres.

Quilalar Formation

The Quilalar Formation is a series of siltstones, mudstones and sandstone hills rising 150 to 200 metres above the low and undulating hills of the granites and metavolcanics of the Kalkadoon Leichhardt Belt. The siliceous capped hills of sandstones and metasandstone units of the Quilalar Formation form the highest ridges within the hill belt. The siliceous and weakly ferruginised cap is up to 10 metres thick with primary bedding structures, cross bedding and ripple marks preserved. The flat surface formed by the siliceous mantle is concordant with similar features through many of the hills surrounding Mt Isa.

Drillholes through the Quilalar formation are restricted to the valleys, which dissect the range of higher hills. Here, coarse angular colluvium up to 1 metre thick consists of silicified and weakly ferruginised saprolitic sandstones, siltstones, mudstones and quartzites. This colluvium overlies weakly iron stained saprolitic clays, unoxidised saprolitic quartzite, silicified coarse sandstone and siltstone extending to greater than 40 metres in depth.

WESTERN FOLD BELT

Mount Guide Quartzite

The coarse arkosic sandstones, sandstones and conglomeratic units form a series of low hills and undulating plains where thin skeletal clay soils, colluvium or outcropping saprolite overlie up to 2 metres of strongly iron-stained saprolitic sediments with up to 80% clay replacement of primary minerals. Beneath saprock and weakly oxidised bedrock extend to 12 metres.

Eastern Creek Volcanics

The metabasalts and volcanics show a similar weathering pattern to the Mount Guide Quartzites and outcrop in creek cuttings and gullies within gently undulating colluvial plains. A surficial iron-rich lag of oxidised bedrock, ironstone fragments and granules with rare calcrete fragments and orange sandy-clay soils overlies two metres of iron-stained calcareous saprolitic clays and saprock. Hematitic nodules are present within iron segregations in saprolite exposed in a creek cutting near hole 5482. This is the only exposed evidence for mottle formation within mafic volcanic units noted along the transect. Within the drill spoil, fresh volcanic bedrock shows persistent calcareous veining to depths of 10 metres.

McNamara Group

The felspathic and micaceous siltstones and sandstones of the McNamara Group crop out in as a series of 20-30 metre high hills and are present in low angle plains under a thin veneer of colluvium or black soils. Iron-rich lags of ferruginous saprolite, ferruginous lithic fragments with common ironstone fragments and ferruginous granules are present at surface where the more iron-rich members of the McNamara Group outcrop. In places, iron-rich fossilised stromatolites sit exposed on the surface within iron-rich siltstone beds. More typically, up to four metres of black soils or a thin 0.2-1 metre surficial veneer of colluvium and sheetwash is underlain by 10-30 metres of mottled or variably iron stained saprolitic clays. At depth these grade into saprock or bedrock. Silicification of the upper saprolitic profile is common, with siliceous horizons up to 10 metres thick being observed in places.

Sybella Formation

To the west of the Barkley Highway the granites of the Sybella Formation are observed as a series of low undulating plains. The thin soils support a sparse cover of spinifex, eucalypts and acacia with grevillea species present in gullies and drainages. The granites within the plains show very little regolith profile development. A thin surficial colluvial cover is present over much of the unit. Between 5-30cm thick of quartz, feldspar, smectite, kaolinitic and mica rich granitic gravels, or thin skeletal soils overlie moderately to weakly oxidised granitic saprock/bedrock which extends up to 2-4 metres. Mineralogically the granitic saprock retains the felsdpars quartz, smectites and kaolinites. The calcareous nature of the saprock is probably due to the presence of dolomite. Fresh granitic bedrock with rare mafic intrusions /inclusions extend to 10-15 metres.

Deeper granitic regolith profile development is observed within a group of mesas close to the contact with the gneissic rocks of the Mt Guide Quartzite and May Downs Gneiss Groups. Here, silicified granitic saprolites and saprock rise as mesas 30-60 metres above the gently undulating plains below. The mesa surfaces are capped by a 5 to 10 metres of silicified and ferruginised saprolite or collapsed ferruginised mottled zone. The resistant cap is underlain by bleached silicified saprolite after granite within which a zone containing hematite-rich silicified mottles up to 60 centimetres long. These features are illustrated in Figure 8.

Judenan Beds

The Judenan Beds are a series of quartzitic and schistose mafic volcanic units. The quartzites show thin skeletal soils over 1 to 3 metres deep of siliceous saprolite or saprock, or more commonly fresh bedrock. The mafic volcanic units show similar weathering characteristics to the rocks of the Eastern Creek Volcanics.

Yaringa Group

These gneissic rocks show fairly shallow profile development except close to the postulated fault contact with the McNamara Group. Here deeply weathered strongly foliated rocks extend to 12 metres deep. More typically a thin surficial layer of colluvium/alluvium overlies up to two metres of saprolitic clays with moderately weathered and oxidised saprock extending to a depth of 4 metres where unweathered bedrock is encountered.

GEORGINA BASIN

The sediments beneath the black soils of the Georgina basin were observed immediately to the West of outcropping low hills of sandstones, mudstones, dolomites and siltstones of the McNamara Group.

The McNamara Group sediments and the associated overlying lags, ferruginised saprolites, bedrock fragments and iron segregations are the source of the abundant ferruginous granules and oxidised bedrock fragments present on the colluvial slopes covering the plain margins and within buried alluvium in the plains.

The black soils present within the flat open plains support abundant native grasses, while the exposed iron-rich sandy alluvium present within the black soils supports abundant spinifex and sparse stands of eucalypt, gidgee and casuarina.

Within the plains a 2 to 6 metre thick layer of black soils overlies alluvial units. These silty-clay loams contain common alluvial pebbles comprising mainly quartz with rarer Cambrian pebbles containing fossil trilobites. The alternating alluvial gravels and sandy alluvial clays extend to a depth of between 15-25 metres. These gravels comprise predominantly quartz, chert, fossiliferous Cambrian cobbles with rare fine ferruginous granules. Thin bands of laminar grey chert are present within these deposits.

The alluvial units in part contain and are underlain by 2 to 6 metres of variably silicified and ferruginised siltstone and sandstone units. These units contain common fine quartz granules, and rarer ferruginous granules and persistent chert fragments. The sediments show weak and inconsistent haematite staining and sub-metallic iron segregations, which are interpreted to represent early mottle development.

The lowermost units extend to depths of greater than 40 metres and comprise a series of bleached/white, variably silicified saprolitic siltstones and sandstones. These units contain fine quartz gravels and common grey chert bands.

APPENDIX IV

GIS/Data Structure

APPENDIX IV

SEE ENCLOSED CD

GIS STRUCTURE/EXPORT FILES

All of the information collected and compiled within the scope of this study has been incorporated into tables, maps, photographs and images and have been generated as, or attached to a coverage with the Arcview GIS package. All the data has been assembled in this manner to allow users too interactively explore and interrogate the area to access the information relevant to their needs. The data is also provided as arcview export files <.e00> and .txt files.

All coverages and related data tables are found within the Isa_seis Folder on the CD contained within this report. To start the GIS you will have to first insert the CDROM into the CDROM Drive and start the Arcview GIS package on your computer. To load the Isa_seis GIS you go to the <PROJECT> menu and select (Open Project). You should see two project files in the Dialogue Box one named isa.apr and one called isabackup.apr. Select isa.apr and press (OPEN). Occasionally, depending on your CDROM address the .apr file will not be able to find the correct directiory path to the files. Arcview provides a path route to find the file it is looking for. This process is laborious at first taking around 30 minutes. However if you save the project under a new .apr or project name on your system you will not have to go through this process again.

This .apr file is set so that most information is displayed on the screen either as themes within one of the four 'views' or as indexed tables which are attatched to themes within these 'views' and are highlighted when the relevant locations are selected.

Below are listed all the folders contained within the Isa_seis directory and a description of their contents in the context of the GIS.

isa.apr

project file - select to open the Mt Isa GIS

isabackup.apr

backup project file – essential if isa.apr gets corrupted

drilling <dir>

drill_sites (point coverage)

This point coverage was generated form the differential GPS co-ordinates collected for every fiducial along the Geodynamic Transect. This coverage contains the northing and easting for every drillhole logged along the Geodynamic Transect between stations 1558 and 7388. Attached to this coverage are text files of the Regolith drill logs and the Landform descriptions.

logging <dir>

logging (text file)

This is a text file generated from a spreadsheet and contains all the downhole drill log descriptions in both RTMAP format and longhand format. This file has a one-to-many relationship with the drill_sites point coverage.

Regolith codes (text file, csv file)

This file contains all the RTMAP codes used within the scope of the project for interpretation of the logging.txt, samples.txt, landforms.txt and geochemistry.txt files.

geochemistry <dir>

geochemistry (point coverage)

This point coverage was generated from the differential GPS co-ordinates and marks the location of a select number sites where geochemical analysis of the drill spoil where undertaken.

geochemistry (text file)

This small data set is a text file of a spreadsheet and contains geochemical analysis for a select group of type sections along the Geodynamic Transect. This file shares a one-to-many relationship with the geochemistry point coverage. This table can be viewed in the 'Attributes of geochemistry.txt' table.

images <dir>

tm742 (image file)

This image file is a ratioed image using bands 7/4/2 of a clipped Landsat Thematic Mapper Image of the Cloncurry and Mt Isa scenes. To view an image within the image folder you must choose an image data source from the <THEMES> menu. This rectified satellite image was used as a basemap for the construction of the regolith landform maps contained within the regolith_map folder.

This image was used for much of the surficial regolith map intepretation on this image the various colours represent:

Red: Iron-rich lithologies usually metabasalts or amphibolites.
Green: Vegetation along drainage systems.
White: White may represent either quartz rich aluvium or colluvium or outcropping quartz rich sandy limestones such as the Toolbec formation which is observed around 50000mE on the image.
Greeny Blue: Quartz rich siliceous bedock such as quartzites at around 43000 mE, or siliceous porphyrys.
Grey: Clay rich black soil plains.
Light Brown-Yellow Brown: Sandy alluvium and colluvium.
Purpley-pink: Granitic Bedrock or iron-rich porphyrys.

landforms <dir>

landforms (text file)

This text file contains site description information for each of the drill_site locations. The file contains descriptions of the observed regolith mapping unit, landform, landform element, drainage network development, vegetation and the dominant geomorphic process acting at the site. This file shares a one to one relationship with the drill_sites point coverage. This text file can be viewed as the 'Attributes of landform.txt' table

legends <dir>

.avl (legend files)

This folder contains a series of legends for the maps contained within the regolith_map folder. To select or change a legend you must first select a polygon coverage within the theme window beside the view. By selecting edit legend in the <THEME> menu you select the the legend editor which allows you to load relevant legends or edit the colours and patterns of the existing legends. You must click on the apply button to apply your changes to the themes legend.

There are three different legends for each of the three main maps the original coloured legend (eg. Geomorphic.avl), a pastel colour legend (eg geomorphicpas.avl), and a uncoloured polygon coverage (eg. Geomorphicpoly.avl).

regokey.txt (formatted text file)

This is a formatted text file of the legend for the regolith map.

master <dir>

buffer (arc coverage)

This is an arc generated cover marking the extent of the study area. It was generated by using a 10 km buffer based along the fiducials of the Geodynamic Transect

drillsites (arc coverage)

This is the point coverage generated for each of the logged drilholes along the Geodynamic Transect.

grid (arc coverage)

This is an arc generated AMG co-ordinate based grid.

master (arc coverage)

master_sngl (arc coverage)

sample_sites (arc coverage)

photos <dir>

photo (combined point/text coverage)

This coverage contains the GPS locations and descriptions of 150 digital pictures of surficial and oblique features along the Geodynamic Transect. The photo coverage is first selected by clicking on the photo coverage in the active theme window until a small tick appears. This will plot the location of the photo sites on the view. This coverage needs to be selected again by clicking on the actual word 'photo' to make it the active theme. This will generate a small raised box around the theme. To view the photos for a given site you must first select the <HOT LINKS> button (lightning bolt symbol). Then move the cursor (which should now look like a lightning bolt and click on one of the photo site symbols. If at this stage you receive an error message saying cannot locate (photoname).giff you are in the incorrect working directory. You can easily correct this be selecting <ADD THEME> from the menu and highlighting isa_seis by clicking on it. Select cancel and you should be right to continue. At most photo sites more than one photo has been taken to view the other photos you must drag the top photo off to the side. A description of each photo can be viewed in the 'Attributes of photo' table.

.gif files are digitised slides

.tif files are scanned photographs

regolith_map <dir>

geomorphic (dissolved polygon coverage)

This coverage displays the three main geomorphic domains present within the study area.

landforms (dissolved polygon coverage)

This map shows the main landform divisions present within the study area. The divisions are based on the landform divisions outlined by AGSO in their RTMAP site location descriptions.

regolith (dissolved polygon coverage)

This map shows the surficial regolith materials present within the study area.

regolith_map (original full polygon coverage)

This coverage is the original full line copy of the map which was generated to display all the characteristics and divisions of the other three maps/coverages.

These maps have been compiled from site descriptions and observations at each drillsite along the Geodynamic Transect and from scattered 'off Transect' site observations. These maps are designed to be a base for further studies and can be altered fairly easily within ARCTOOLS . One can simply load up the existing coverage and add, remove or change the polygon or line structure of the coverage. You will then need to load up arc and build the coverage as a polygon coverage. To attribute the coverage you load it up on ARCVIEW and open the attribute table for the edited coverage and select edit table and proceed to attribute the polygon for each of the three field attributes (regolith type, landforms and geomorphic). One can update the new coverage to a dissolved polygon coverage by opening up arc and using the dissolve function on the edited coverage.

samples <dir>

samples (point coverage)

This point coverage was generated from the differential GPS co-ordinates and marks the location of a select number sites where samples of the drill spoil where taken.

samples.txt (text file)

This text file is a spreadsheet containing all information on collect samples along the Geodynamic Transect. These samples have been retained at the CSIRO in Perth as reference samples. The samples reference number is recorded in the CSIRO no column of the 'Attributes of samples' spreadsheet.

Sampoint.csv (text file)

This is the import file used for the generation of the AMG coordinated for point coverage generation.

Sampoint.txt (text file)

This is the text file used for the generation of the AMG coordinated for point coverage generation within arc.

LOGGING TABLE

REGOLITH TYPES - CODE,DEFINITION

UOC00	clay
UOM00	weathered material (unknown origin)
UOS00	sand (unknown origin)
SDT00	terrestrial sediments
SDE01	aeolian sand
SDE00	aeolian sediments
SDA00	alluvial sediments
SDA20	overbank deposits
SDC00	colluvial sediments
SDC01	scree
SDC05	sheet flow deposit
WIR00	in situ weathered rock
WIR10	saprolite
WIR11	slightly weathered saprolite
WIR12	moderately weathered saprolite
WIR13	highly weathered saprolite
WIR14	very highly weathered saprolite
WIR15	completely weathered in situ rock
WIR15.1	mottled zone
WIR15.2	pallid zone
WIR20	residual material
WIR21	lag
WIR24	soil on bedrock
WIR25	soils on saprolite
WIS00	shallow soil on fresh bedrock
BU00	unweathered bedrock

BEDROCK

AMP M	amphibolite
ARKS S	arkose
ARNT S	arenite
BLT I	basalt
DOL M	dolomite
GFL M	granofels
GNS I	gniess
GRD I	granodiorite
GRT I	granite
HFL M	hornfels
JASPILITE	jaspilite
LMST S	limestone
MDST S	mudstone
METB M	metabasite
METS M	metasediment
MYL M	mylonite
PHY I	porphyry
QTZ M	quartzite
RHY I	rhyolite
SCHT M	schist
SDST S	sandstone
SED H/MET CALC	calcareous metasediment/calc-silicate
SHLE S	shale
SLA M	slate
SLST S	siltstone

COLOUR

BK	black
BL	blue
BR	brown
BU	buff
CH	chocolate
CR	cream
FA	fawn
GR	green
GY	grey
IR	iridescent
KH	khaki
MA	maroon
MO	mottled
OL	olive
OR	orange
PU	purple
PI	pink
RE	red
VC	varicoloured
VG	variegated
VI	violet
WH	white
YE	yellow

Where more than one colour is present the different colours are seperated by a / eg a blue and green rock is bl/gr and where tonal colours are present ie a greeny-blue and reddy brown rock is gr-bl/re-br.

MATRIX

CA	Calcareous
CY	Clay
SI	Siliceous
MI	Micaceous
FE	Ferruginous
SA	Sandy
GPT	Graphitic
GV	Gravel
SLT	Silt

GRAINSIZE

MUD	clay/mud (<0.002mm)
C	coarse
CS	coarse sand (0.5-1mm)
CB	cobble (64-256mm)
F	fine
FS	fine sand (0.125-0.5mm)
GL	granule (2-4mm)
GV	gravel (2-60mm)
M	medium
MS	medium sand (0.25-0.5mm)
PB	pebble (4-64mm)
SA	sand (0.062-2mm)
SLT	silt (0.002-0.062mm)
ST	stone
VC	very coarse
VCS	very coarse sand (1-2mm)
VF	very fine

OXIDATION

B	bleached
UO	un oxidised
WO	weakly oxidised
MO	moderately oxidised
SO	strongly oxidised
CO	completely oxidised

WEATHERING

0	unknown
1	fresh
2	slightly weathered
3	moderately weathered
4	highly weathered
5	very highly weathered
6	completely weathered

INDURATION

DC20	calcrete
IK00	calcareous induration
IF00	ferruginous induration
N020	calcareous nodules
IN00	indurated materials
IS00	siliceous induration
DC60	silcrete
CV	calcite veining
CC	calcite crystals
W	DENOTES WEAK

SAMPLE TABLE

SAMPLE TYPE

CUTTI	cutting
FLOAT	float
SOIL	soil

COHERENCE

CP	compact
CON	consolidated
FI	fissle
FR	friable
HD	hard
IN	indurated
PO	porus
UN	unconsolidated

SORTING

B	bimodally sorted
M	moderately sorted
N	not applicable
P	poorly sorted
U	insorted
VW	very well sorted
W	well sorted

MOTTLE/SEGREGATION ABUNDANCE

0	none
1	very few (<2%)
2	few (2-10%)
3	common (10-20%)
4	many (20-50%)
5	very many (>50%)

SEGREGATION TYPE

F	fragments
N	nodules

SEGREGATION COMPOSITION

F	ferruginous
K	calcareous

SEGREGATION SIZE

CSE	coarse (6-20mm)
FIN	fine (<2mm)
MED	medium (2-6mm)
VCS	very coarse (20-60mm)

LANDFORM TABLE

LANDFORM

AL00	alluvial landforms
AL10	alluvial plain
AL11	flood plain
ER00	erosional landforms
ER10	erosional plain
ER20	rises (9-30 metres relief)
ER30	low hills (30-90 metres relief)
ER40	hills (90-300 metres relief)
ER80	drainage depression
FA02	colluvial fan/footslope
PL00	plain
PL01	depositional plain

LANDFORM ELEMENT

BAN	bank
CRE	crest
DDE	drainiage depression
GUL	gully
HCR	hillcrest
HSL	hillslope
LSL	lower slope
MSL	mid slope
PED	pediment
PLA	plain
STB	stream bed
STC	stream channel
USL	upper slope
VLF	valley floor

GEOMORPHIC PROCESSES

GR00	gravity
GR01	verticle collapse
GR02	particle fall
GR03	creep
WI00	wind
WT00	water
WT01	channeled stream flow
WT02	over-bank stream flow
WT03	sheet flow, sheet or surface wash
WT07	rilling/gullying