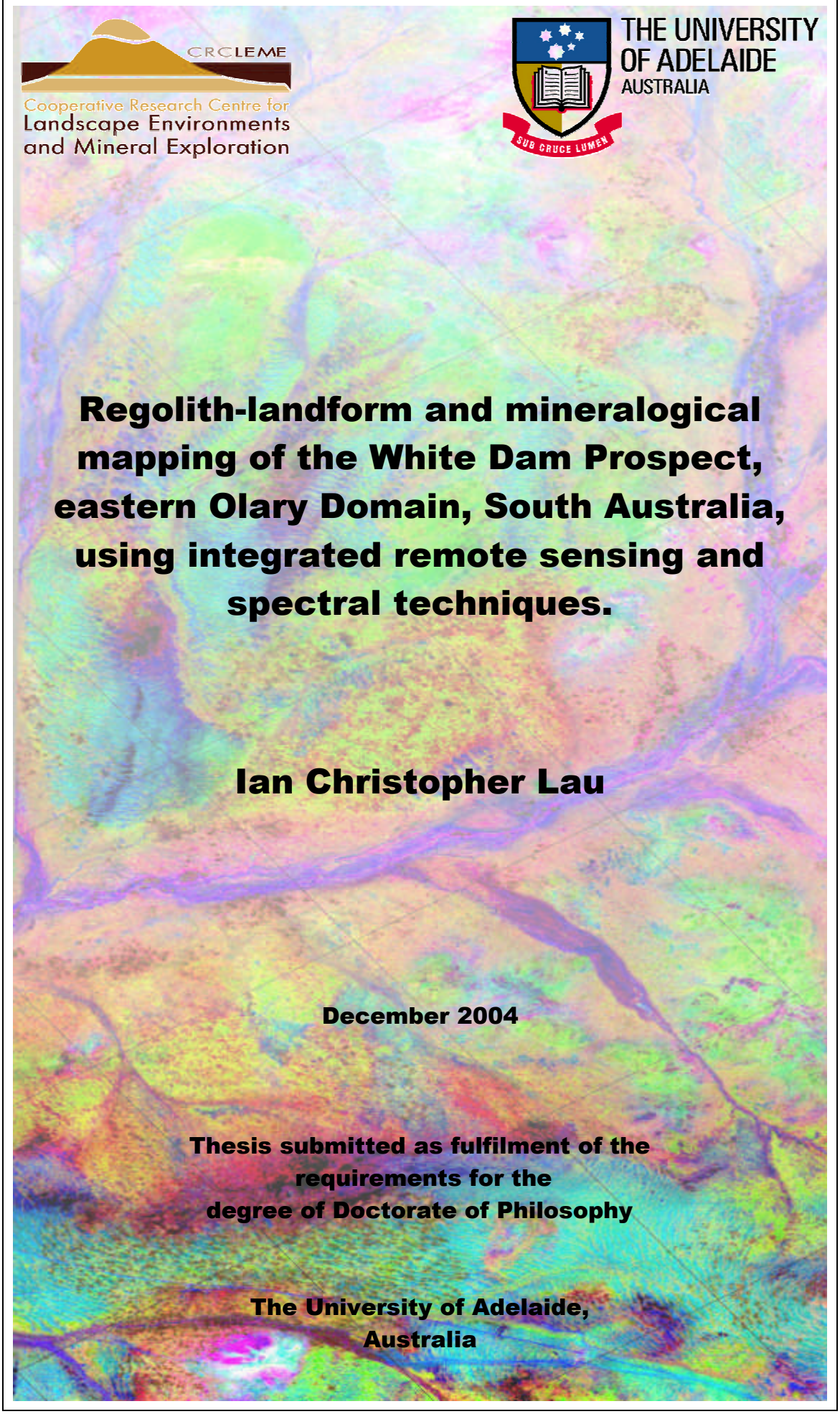

Regolith-landform and mineralogical mapping of the White Dam Prospect, eastern Olary Domain, South Australia, using integrated remote sensing and spectral techniques.

Ian Christopher Lau

December 2004

Thesis submitted as fulfilment of the requirements for the degree of Doctorate of Philosophy

The University of Adelaide, Australia

Certificate of Originality

I hereby declare that this submission is of my own work and that, to the best of my knowledge and belief, contains no material previously published or written by another person, unless it has been acknowledged accordingly. I have endeavoured to perform the research encapsulated in this document from my own ideas and investigations. I give consent for this thesis to be loaned or photocopied, However, ask for acknowledgement when the original ideas, data or figures contained within this thesis are used.

Ian Christopher Lau, December 2004

Abstract

The research contained within this thesis was directed at examining the spectral properties of regolith-dominated terrains using airborne and proximal hyperspectral instruments. The focus of the investigation was to identify the mineralogy of the regolith and determine if surficial materials were indicative of the underlying bedrock in the regolith-dominated terrain of the eastern Olary Domain, South Australia. The research area was constrained to a 250 km^2 area around the Cu-Au mineralisation of the White Dam Prosect.

Integrated remote sensing, using airborne hyperspectral datasets (HyMap), Landsat imagery and gamma-ray spectroscopy data, was performed to map regolith-landforms and extract information on surficial materials. Detailed calibration of the HyMap dataset, using a modified model-based/empirical line calibration technique, was required prior to information extraction.

The White Dam area was able to be divided into: alluvial regolith-dominated; *in situ* regolith-dominated; and bedrock-dominated terrains, based on mineralogical interpretations of the regolith, using the remotely sensed hyperspectral data. Alluvial regions were characterised by large abundances of vegetation and soils with a hematite-rich mineralogy. Highly weathered areas of *in situ* material were discriminated by the presence of goethite and kaolinite of various crystallinities, whereas the bedrock-dominated regions displayed white mica-/muscovite-rich mineralogy. Areas flanking bedrock exposures commonly consisted of shallow muscovite-rich soils containing regolith carbonate accumulations.

Traditional mineral mapping processes were performed on the HyMap data and were able to extract endmembers of regolith and other surficial materials. The Mixture Tuned Matched Filter un-mixing process was successful at classifying regolith materials and minerals. Spectral indices performed on masked data were effective at identifying the key regolith mineralogical features of the HyMap imagery and proved less time consuming than un-mixing processes. Processed HyMap imagery was able to identify weathering halos, highlighted in mineralogical changes, around bedrock exposures.

Proximal spectral measurements and XRD analyses of samples collected from the White Dam Prospect were used to create detailed mineralogical dispersion maps of the surface and costean sections. Regolith materials of the logged sections were found to correlate with the spectrally-derived mineral dispersion profiles. The HyLogger drill core scanning instrument was used to examine the mineralogy of the fresh bedrock, which contrasted with the weathering-derived near-surface regolith materials. The overall outcomes of the thesis showed that hyperspectral techniques were useful for charactering the mineralogy of surficial materials and mapping regolith-landforms.

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Definition of Terms and Acronyms used:

Ag	Silver
AGSO	Australian Geological Survey Organisation
Al	Aluminium
AIS	Airborne Imaging Spectrometer
ALI	Advanced Land Imager
AMIRA	Australian Mineral Industries Research Association
ARS	Average reflectance spectrum
ASD	Analytical Spectral Devices
AST	Denotes an ASTER sensor band
ASTER	Advanced Space-borne Thermal Emission and Reflection Radiometer
ATREM	ATmosphere REMoval
Au	Gold
AVIRIS	Airborne/Visible Infrared Imaging Spectrometer
BBR	Bad-band removal
BHEI	Broken Hill Exploration Initiative
BHD	Broken Hill Domain
BIF	Banded iron formation
Ca	Calcium
CASI	Compact Airborne Spectrographic Imager
CCD	Charge Couple Device
CDMA	Code division multiple access
CEC	Carpentaria Exploration Company
CFA	Crystal field absorption
CO_2,	Carbon dioxide
CO	Carbon monoxide
CS	Calc-silicate suite
CTA	Charge transfer absorption
CTS	Charge transfer shoulder
Cu	Copper
CH_4	Methane
CNES	Centre National d'Etudes Spatiales
CRC LEME	Cooperative Research Centre Landscape Environment and Mineral Exploration (Formally known as Landscape Evolution and Mineral Exploration)
CRC	Colour ratio composite
CSIRO	Commonwealth Science Investigative Research Organisation
DD	Delamerian Orogeny deformation event
DEM	Digital elevation model
DGPS	Differential GPS
DN	Digital number
DPCA	Directed principal components analysis
DTM	Digital terrain model
EFFORT	Empirical Flat Field Optimal Reflectance Transformation
EL	Empirical Line
EM	Electromagnetic
EMR	Electromagnetic radiation
ENVI	Environment for visualising images™
EOS-1	Earth Observation Satellite
ER Mapper	Earth Resource Mapper™

ETM+	Enhanced Thematic Mapper Plus
ERTS-1	Earth Resources and Technology Satellite
FCC	False colour composite
Fe	Iron
Fe^{2+}	Ferrous ion
Fe^{3+}	Ferric ion
FF	Flat field
FOV	Field of view
FWHM	Full width half maximum
GA	Geoscience Australia
GCP	Ground control points
GER	Geophysical Environmental Research
GIS	Geographical information system
GPS	Global Positioning System
H_2O	Water
HyCorr	Hyperspectral Correction
HYDICE	Hyperspectral Digital Imagery Collection Experiment
HyLogger	Hyperspectral Core-Logger
HyMap	Hyperspectral Mapper
IAEA	International Atomic Energy Agency
IARR	Internal average relative reflectance
IFOV	Instantaneous FOV
IR	Infrared
IRIS	Infrared Intelligent Spectroradiometer
JPL	Jet Propulsion Laboratory
LEME	Landscape Environment and Mineral Exploration (Formally known as Landscape Evolution and Mineral Exploration)
LR	Log residuals
Ma	Millions of years before the present
Mg	Magnesium
MIMEX	Mount Isa Mines Exploration Pty. Ltd
MIR	Mid infrared
MMTG	Mineral Mapping Technologies Group
MNF	Minimum Noise Fraction
Mo	Molybendinite
MSS	Multispectral scanner
Na	Sodium
NDVI	Normalised difference vegetation index
NH_4	Ammonia
NIR	Near infrared
N_2O	Nitrous Oxide
nm	Nanometres
OARS	Operational Airborne Research Spectrometer
OlD	Olary Domain
OD	Olarian Orogeny related deformation event
O_2	Oxygen
O_3	Ozone
-OH	Hydroxyl group
Pb	Lead
PCA	Principal components analysis
PIMA	Portable Infrared Mineral Analyser
PPI	Pixel purity index

ppm	Parts per million
PSA	Post settlement alluvium
QFS	Quartzo-feldspathic gneiss suite
RB	Red-brown
RC	Reverse circulation
RCA	Regolith carbonate accumulation
REDOX	Reduction-Oxidation
RGB	Red-green-blue
RLU	Regolith-landform unit
RMN	Reflectance-Mean Normalisation
ROI	Region of interest
RSI	Research Systems Incorporated
RT	Radiative Transfer
S.A.	South Australia
SEDEX	Sedimentary exhalative
SPOT	Systeme Probatoire d'Observation de la Terre
SWIR	Shortwave infrared
TC	Total count radiometric channel
TCC	True colour composite
TIR	Thermal infrared
TM	Thematic Mapper
TSA	The Spectral Assistant
TSG	The Spectral Geologist
µm	Micrometers
U	Uranium
USGS	United States Geological Survey
UV	Ultraviolet
VIS	Visible
VNIR	Visible to near-infrared
XRD	X-ray diffraction
YB	Yellow-brown
Zn	Zinc
3D	Three-dimensional

Regolith-Landform codes

A	Alluvial material
AC	Alluvial channel
C	Colluvial material
CH	Sheet-flow material
IS	Aeolian sand
SM	Moderately weathered saprolite
SS	Slightly weathered saprolite
a	Alluvial landform
ap	Alluvial plain
aw	alluvial swamp
el	Low erosional hill
ep	Erosional plain
er	Erosional rise
fa	alluvial fan
fc	colluvial/sheetflood fan
pd	Depositional plain
ps	sand plain