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

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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 Prospect.

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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<td>Silver</td>
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<tr>
<td>AGSO</td>
<td>Australian Geological Survey Organisation</td>
</tr>
<tr>
<td>Al</td>
<td>Aluminium</td>
</tr>
<tr>
<td>AIS</td>
<td>Airborne Imaging Spectrometer</td>
</tr>
<tr>
<td>ALI</td>
<td>Advanced Land Imager</td>
</tr>
<tr>
<td>AMIRA</td>
<td>Australian Mineral Industries Research Association</td>
</tr>
<tr>
<td>ARS</td>
<td>Average reflectance spectrum</td>
</tr>
<tr>
<td>ASD</td>
<td>Analytical Spectral Devices</td>
</tr>
<tr>
<td>AST</td>
<td>Denotes an ASTER sensor band</td>
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<tr>
<td>ASTER</td>
<td>Advanced Space-borne Thermal Emission and Reflection Radiometer</td>
</tr>
<tr>
<td>ATREM</td>
<td>ATmosphere REMoval</td>
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<td>Au</td>
<td>Gold</td>
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<tr>
<td>AVIRIS</td>
<td>Airborne/Visible Infrared Imaging Spectrometer</td>
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<td>BBR</td>
<td>Bad-band removal</td>
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<td>BHEI</td>
<td>Broken Hill Exploration Initiative</td>
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<td>BHD</td>
<td>Broken Hill Domain</td>
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<td>BIF</td>
<td>Banded iron formation</td>
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<td>Calcium</td>
</tr>
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<td>CASI</td>
<td>Compact Airborne Spectrographic Imager</td>
</tr>
<tr>
<td>CCD</td>
<td>Charge Couple Device</td>
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<tr>
<td>CDMA</td>
<td>Code division multiple access</td>
</tr>
<tr>
<td>CEC</td>
<td>Carpentaria Exploration Company</td>
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<tr>
<td>CFA</td>
<td>Crystal field absorption</td>
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<td>CO₂</td>
<td>Carbon dioxide</td>
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<td>Carbon monoxide</td>
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<td>CS</td>
<td>Calc-silicate suite</td>
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<td>Charge transfer shoulder</td>
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<tr>
<td>CH₄</td>
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</tr>
<tr>
<td>CNES</td>
<td>Centre National d'Etudes Spatiales</td>
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<tr>
<td>CRC LEME</td>
<td>Cooperative Research Centre Landscape Environment and Mineral Exploration (Formally known as Landscape Evolution and Mineral Exploration)</td>
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<td>CRC</td>
<td>Colour ratio composite</td>
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<td>CSIRO</td>
<td>Commonwealth Science Investigative Research Organisation</td>
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<td>DD</td>
<td>Delamerian Orogeny deformation event</td>
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<td>Digital elevation model</td>
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<td>DGPS</td>
<td>Differential GPS</td>
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<td>DPCA</td>
<td>Directed principal components analysis</td>
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<td>Digital terrain model</td>
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<td>EFFORT</td>
<td>Empirical Flat Field Optimal Reflectance Transformation</td>
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<td>EL</td>
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<tr>
<td>EM</td>
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<td>EMR</td>
<td>Electromagnetic radiation</td>
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<tr>
<td>ENVI</td>
<td>Environment for visualising images™</td>
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<td>EOS-1</td>
<td>Earth Observation Satellite</td>
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<td>ER Mapper</td>
<td>Earth Resource Mapper™</td>
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<td>ETM+</td>
<td>Enhanced Thematic Mapper Plus</td>
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<td>ERTS-1</td>
<td>Earth Resources and Technology Satellite</td>
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<td>FCC</td>
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<td>Fe</td>
<td>Iron</td>
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<tr>
<td>Fe^{2+}</td>
<td>Ferrous ion</td>
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<td>Fe^{3+}</td>
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<tr>
<td>GCP</td>
<td>Ground control points</td>
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<td>GER</td>
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<tr>
<td>GIS</td>
<td>Geographical information system</td>
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<td>Global Positioning System</td>
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<td>H_{2}O</td>
<td>Water</td>
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<td>International Atomic Energy Agency</td>
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<td>IARR</td>
<td>Internal average relative reflectance</td>
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<td>Instantaneous FOV</td>
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<td>IR</td>
<td>Infrared</td>
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<td>IRIS</td>
<td>Infrared Intelligent Spectroradiometer</td>
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<td>JPL</td>
<td>Jet Propulsion Laboratory</td>
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<tr>
<td>LEME</td>
<td>Landscape Environment and Mineral Exploration</td>
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<td></td>
<td>(Formally known as Landscape Evolution and Mineral Exploration)</td>
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<tr>
<td>LR</td>
<td>Log residuals</td>
</tr>
<tr>
<td>Ma</td>
<td>Millions of years before the present</td>
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<td>Magnesium</td>
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<td>Portable Infrared Mineral Analyser</td>
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<td>PPI</td>
<td>Pixel purity index</td>
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<td>Abbreviation</td>
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<td>ppm</td>
<td>Parts per million</td>
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<td>RLU</td>
<td>Regolith-landform unit</td>
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<td>RMN</td>
<td>Reflectance-Mean Normalisation</td>
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<td>RSI</td>
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<td>RT</td>
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<td>South Australia</td>
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<td>Visible to near-infrared</td>
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<td>XRD</td>
<td>X-ray diffraction</td>
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<td>Yellow-brown</td>
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<td>Zn</td>
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**Regolith-Landform codes**

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<tr>
<th>Code</th>
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<td>C</td>
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<td>CH</td>
<td>Sheet-flow material</td>
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<td>IS</td>
<td>Aeolian sand</td>
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<tr>
<td>SM</td>
<td>Moderately weathered saprolite</td>
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<tr>
<td>SS</td>
<td>Slightly weathered saprolite</td>
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<td>a</td>
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