1986/2

A FIELD EVALUATION OF THE APPLICATION OF CARR-BOYD GEOSCAN-MSS IMAGERY TO REGOLITH STUDIES FOR AN AREA SOUTHEAST OF KALGOORLIE, WESTERN AUSTRALIA

by

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C O N T E N T S

Summary

Preliminary data from early trials of the Carr-Boyd Geoscan Multi-spectral Scanner were evaluated for applicability to regolith studies. A first attempt to test the predictive value of the enhanced Geoscan MSS images failed because of initially corrupted data prior to processing. A second attempt using good data correctly processed, also showed little correlation with known expressions of surface materials. A third attempt making the best fit with the benefit of hindsight, showed better correlation, but even under these conditions the ground expression was far more variable than the image suggested. The general lack of good correlations between image pattern and ground truth may be related to lack of user skill, image pixel size and final image scale, inappropriate sensor bandpass combinations, some unknown factor, or some unknown combination of these factors.

At this stage the predictive reliability of Geoscan images for surface materials must be regarded as low in this type of country in the test area south-east of Kalgoorlie. The combinations of sensed channels used in hindsight to produce the best match are probably not those which would have been used had good data sets been available in the beginning. This limited experience suggests that careful calibration of image patterns with ground truth is essential, followed by re-enhancement of images when necessary.

Introduction

There is an ever present temptation, in the study of geological phenomena, to regard surface images produced by remote sensing techniques as being endowed with some form of mystical, often unquestioned truth. Such attitudes are often the result of the image user not being sufficiently informed about, or losing sight of, the steps involved in the production of a field version of an image.

In a strict sense the image data are generated in response to reflectance spectra of actual materials at the surface. The scanner only senses the response from an exposed surface. The reflectances are only from the top few microns of the material surface. What remains unknown to the image user is the relative proportions of what is being sensed by the scanner, and exactly how this will appear at the surface when compared with ground truth. Due regard must be paid to the way in which image data are processed and the changes in resolution which come about by the construction of a photographic print of processed scanner data. The initial pixel unit size, the presence of mixed pixel units, the ratioing techniques used in the enhancement procedures are all factors which contribute to an image being quite different from the more familiar aerial photograph. Using remote sensing images in the field requires new and different skills from those to which we are more usually accustomed and requires the user to be ever wary of the pitfalls associated with their use as simple ground pictures. An opportunity was available in Western Australia to evalute remote sensing images for their usefulness in regolith investigations.

Remote sensing imagery is availabe for a narrow NW-SE trending strip 5 km wide by 77 km long near Kalgoorlie, Western Australia. The data, of a preliminary nature, were provided for trial and evaluation by Dr. F. Honey (Geoscan Pty Ltd) to whom grateful acknowledgement is made. Data were collected (2nd February 1984, 1850 m asl.) with an aircraft-mounted Carr-Boyd Geoscan Multi-Spectral Scanner. Channel numbers and their respective bandpass widths are listed in Table 1.

The data used in this field evaluation are derived from early instrument trials. The instrument has been further modified since these early trials but not specifically for application to regolith studies.

The Carr-Boyd Geoscan MSS technique has a wide range of stated possible applications. This report serves neither to criticise instrument development nor to comment generally on the stated range of applications but rather to provide information which may assist testing and development of a methodology relating to regolith studies. Any benefits so derived may be adapted to other remote sensing systems.

Images were created using combinations of data from channels 2, 4, 6, 7, and 8. Image enhancement was done on a Comtal Vision One/20 image enhacement system at the Bureau of Mineral Resources, Canberra with advice and assistance from Mr R. F. Moore and Mr C.J. Simpson, members of the Remote Sensing Group. 5

Channel	Bandpass (micrometres)
1	0.45 - 0.50
2	0.55 - 0.60
3	0.65 - 0.70
4	0.83 - 0.87
5	0.93 - 0.97
6	1.98 - 2.08
7	2.15 - 2.25
8	2.30 - 2.40

Table. 1 Shows the channels assigned to various bandpasses used with the Carr-Boyd Geoscan system for the collection of initial test data used in this field evaluation. Extra channels have since been added to the instrument and some of the bandpasses have been altered. (Honey and Daniels, 1985, and Honey pers. comm.)

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Colour photos of enhanced images were used in a ground truth testing programme carried out by members of the Regolith Group while working in the Kalgoorlie district during May-June 1985. The degree of correlation between image-interpreted surface materials and ground truth is reported here.

Field procedures

Suitable field sites were chosen as indicated on map 1 (see map envelope at back of the record) and brief site descriptions prepared (see appendix A) bearing in mind the guidelines (see table 2) provided by the Geoscan manufacturer. Localities could not be easily plotted onto the Geoscan images because of the degree of distortion. Instead, black and white (RC9, 1:80 000) aerial photography together with topographic basemaps (Kanowna, 1:100 000 scale, sheet 3236) were used to locate field sites and for general navigation. Accurate location of site was aided by selecting sites close to access tracks, railways, and obvious landscape features. The field site locations were later transfered to the 1:30 00 Geoscan images. Field sites and associated geology extracted from the Kurnalpi 1:250 000 sheet area are shown on map 2 (see envelope).

Discussion of field results

The reliability of the first generation images used in the field was expected to be low because of uncertainty about data channel locations on the data tape. These doubts were reinforced by the almost total lack of correlation between the imagepredicted surface materials and what was observed at each locality. Table. 3 shows that predictions from the first generation images were of no real value.

The lack of correlation became obvious quite early in the ground truthing programme. A decision was made to continue collecting data in the hope that new images could be constructed from reliable data sets in Canberra, and that a better match with ground truth could be established later. In addition to data presented in the Tables it is worth noting that the roads are usually paved with a mixture of carbonate nodules with minor pisoliths and limonite-coated nodules.

Reprocessed Scanner Data

New tapes were acquired and reprocessed but the topographic distortion present in the original images remained uncorrected. However, the channels were in a known order, and the recommended channel combinations were used to provide a second generation set of images (see appendix B) to compare with the known surficial materials at visited sites. Although the scanner data were resampled prior to enhancement processing, minor imperfections are still apparent on the images as a speckled dot pattern. Table. 4 shows the images do not allow for confident predictions of surface materials. There is still considerable local variability of materials and great uncertainty about their expression in the image.

Colours Assigned	Band Combinations
Red	6/8
Green	-6/7
Blue	-4/2

Image Colour	Surface Materials
white	High Carbonate/low clay
Pink	Moderate Carbonate/low clay
Blue	Moderate Carbonate/High clay
Blue/Green	Low Carbonate/High clay
Yellow and Red	Vegetation

Table. 2 Channel combinations and Company-recommended interpretive guidelines for reliable data sets from the Carr-Boyd Geoscan system.

Dominant Image colour	Expected Surface Expression	Observed Surface Expression
White	High Carbonate Low clay	Haematite: massive (21, 25) Iron pisoliths: buckshot (27) Limonite (25) Carbonate (25)
Yellow	Vegetation	Ironstone: pisoliths (18, 19) Carbonate (18, 19) Vegetation: various forms
Blue	High clay Low Carbonate	Clay (26, 59, 61)
-Mid blue	?Moderate Carbonate/clay	Haematite (22) Quartz (22) Carbonate (22) Iron pisoliths (22)
Grey	?	Silty clay (24)

Black	Low response	Iron pisoliths: (20, 26) Carbonate: (20, 23, 27) Limonite (27) No ironstone (27)

Table 3. Image colours and recommended interpretive guidelines compared with the known surface materials. The localities (see map 1) are shown in brackets. The first generation images usedin the field showed little correlation with ground truth and were found to be generated from corrupted data files.

A third generation image enhacement was attempted to get the best correlation of image and known surface expression in hindsight. The parameters which give the most suitable results are shown in Table 5. Even in hindsight there is still considerable lack of correlation shown in Table 6, between image and ground truth.

Possible causes for lack of correlation:

1 Unskilled observers: observers may need to estimate accurately the relative proportions of various surface materials at greater than pixel dimensions to relate them better to the field images. Ground reconnaissance skills with these restrictions require time to develop because observers are presented with more ground data than can be effectively identified on an image.

2 Pixel size: the area of ground represented by a pixel is about 10 m long (along the scanline) and 12 m wide (perpendicular to the scanline). At an image scale of about 1:30 000 a pixel is represented by an area of less than the size of a pinhead. Surficial materials can be highly variable within one or two pixels. Table 6 shows the degree of correlation where channel data has been optimised to show iron, carbonate and clay. The overall colour appearing on an image does not necessarily indicate the individual colour variation within that image area, at pixel level. Observers working the Geoscan images are working with ground variablility of near pixel dimensions. They are not aware of the pixel orientation or boundary positions at the

surface. relating the overall colour indicated at one location to surficial material variablility of about a pixel size presents some difficulty for field observers.

3 Inappropriate bandpass combinations: the bandpass combinations are determined by the purpose of the images. Therefore the reflectance spectral curves of the materials being investigated may limit which channels can be selected. The way in which the data channels are combined depends upon the level of differentiation needed to highlight specific reflectances. Images with single-purpose aims would probably give the best correlation with ground truth rather than multi-purpose images.

4 Method unsuitable for this type of country: it is possible that the method might be inappropriate for this type of country where the scale of surface material variability is equal to or greater than the level of pixel resolution. Even where the scale of ground variability is less than pixel scale, there still remains the problem that the contribution of one pixel to the overall colour of a field location on the image is an unknown quantity to the general field observer of regolith.

Dominant Image colour	Expected surface Expression	Observed surface Expression
Black	Low response	Iron pisoliths: (20, 21) Carbonate: (18, 19 20, 23) Haematite (massive) (21) Quartz-angular (18) Rock fragments (18) Isolated Eucalypts (18, 20, 21, 23) Med density Eucalypts (19) Med density understory (19) Rare understory: (18, 21, 23, 24)

Table 4. Second generation image colours and Company-recommended interpretive guidelines compared with the known surface materials. The localities (see map 1) are shown in brackets.

Dominant Image colour	Expected surface Expression	Observed surface Expression
White	High Carbonate Low clay	Haematite: massive (25, 27) Iron pisoliths: buckshot (27) Limonite (25, 27) Carbonate (25, 27) Scattered Eucalypt (27) Med density shrubs (27, 25)
Blue	High clay Low Carbonate	Clay (26, 59, 61) Haematite (22, 25, 27) Quartz (22, 61) Carbonate (22, 25, 27) Iron pisoliths (22, 25a, 25b, 26 59, 61) Rock fragments (61) Limonite nodules: (25, 27)

Table 4 continued...

		Mod density Eucalypt (26)
		Mod understory: (26, 27)
		Scattered Eucalypt (27, 59, 61)
Pink	Med carbonate	Haematite (massive)
	Low clay	Limonite nodules
		Carbonate (25)

Colours Assigned	Band Combinations
Red	6/4
Blue	6/8
Green	6/7

Image Colour	Surface Materials
Green	Clays
Blues	Carbonate
Reds	Iron

Table 5. Third generation channel combinations and BMR Remote Sensing Group recommended interpretive guidelines, aided by known surface materials.

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Dominant Image colour	Expected Surface Expression	Observed Surface Expression
Yellow/orange	High iron Mod clay	Iron pisooiths: (22, 25a, 25b, 26) Carbonate (22) Quartz-angular (22) Clay (26) Haematite (22) Med density Eucalyptus (26) Med density understory (26)
White	High response	Haematite (massive) (25, 27) Carbonate (27) Scattered Eucalypts (27) Med density understory (27) Rare understory: (25)

Table 6. Image colours and BMR Remote Sensing Group recommended interpretive guidelines for third generation images compared with the known distribution of surface materials. The localities (see map 1) are shown in brackets.

Dominant Image colour	Expected Surface Expression	Observed Surface Expression
Black	Low response Low intensity	Haematite: massive (22, 27) Iron pisoliths: buckshot (20, 22, 25 61) Limonite nodules: (25, 27) Clay (61) Carbonate (20, 22, 23 25, 27) Quartz-angular (22, (61) Scattered Eucalypts (20, 23, 27, 61) Med density understory (20, 27) Rare understory: (23, 61)
Green	High clay	Iron pisoliths: buckshot (20, 22, 25 61) Haematite (massive) (21)

Table 6 continued

Dominant Image colour	Expected Surface Expression	Observed Surface Expression
		Rock fragments (18, 61)
		Scattered Eucalypts (18, 20, 21, 61)
		Med density Eucalypts (19)
		Med density understory (19, 20, 61)
		Rare understory: (18, 21, 24)
Blue	High Carbonate	Pisoliths: buckshot (18, 19, 59)
		Haematite (massive) (25)
		Limonite nodules: (27)
		Clay (59)
		Carbonate (18, 19, 27, road at 18)
		Quartz-angular (18)
		Rock fragments (18)
		Scattered Eucalypts (18, 27, 59)

Table 6 continued

		Med density Eucalypts (19, 59) Med density understory (19, 25, 27) Rare understory: (18)
Red	Iron	No dominant colour at any sample site

References

Honey, F and Daniels, J.L. 1985: Application of the Carr-Boyd Mines Limited airborne multispectral scanner to spectral discrimination of hydrothermally altered areas. 4th Thematic Conference. Remote Sensing for Exploration Geology. San Francisco, California April 1st - 4th 1985. ERIM.

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APPENDIX A

FIELD-SITE DESCRIPTIONS

GEOSCAN TEST STRIP, SOUTH-EAST KALGOORLIE

WESTERN AUSTRALIA.

23

LOCALITY NUMBER	: 18
SURFICIAL MATERIAL	: Carbonate, iron pisoliths (20%-30% 2 mm to 20 mm, angular quartz fragments, angular rock fragments
SUBSURFACE MATERIAL	: Platy and nodular carbonate at 30%
VEGETATION	: Scattered Eucalypts, rare understory
LOCALITY NUMBER	: 19
SURFICIAL MATERIAL	: Pisoliths (buckshot) 40% cover, Carbonate (reaction from drillhole sample 0 to 1 m)
SUBSURFACE MATERIAL	: Clay dark red 1 to 2 m
VEGETATION	: Medium density Eucalypts and understory
LOCALITY NUMBER	: 20
SURFICIAL MATERIAL	: Iron pisoliths (buckshot), Carbonate 0 to 2 m
SUBSURFACE MATERIAL	: Clay dark red 2 to 6 m, mottled zone 6 to 28 m, sand 28 to 34 m
VEGETATION	: Scattered Eucalypts, medium density understory, grass and lichen

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LOCALITY NUMBER : 21

SURFICIAL MATERIAL : Iron pisoliths (buckshot 80% cover), Haematite massive angular pebble and cobble sized (25 cm)

SUBSURFACE MATERIAL : platy and nodular carbonate

VEGETATION : Scattered Eucalypts and rare understory

LOCALITY NUMBER : 22

SURFICIAL MATERIAL : Iron pisoliths (buckshot) less than 80% cover. Haematite pebbles and cobbles (25 cm), angular quartz fragments. Carbonate

SUBSURFACE MATERIAL : Carbonate, greenstone fragments

VEGETATION : not recorded

LOCALITY NUMBER : 23

SURFICIAL MATERIAL : Carbonate weak acid reaction, no other materials present

SUBSURFACE MATERIAL : Clay, carbonate

VEGETATION : Scattered Eucalypts at site edges, mostly herb cover and rare understory

LOCALITY NUMBER : 24

SURFICIAL MATERIAL : Silty clay

SUBSURFACE MATERIAL : Silty clay

VEGETATION : Treeless, grasses, rare understory

LOCALITY NUMBER : 25

SURFICIAL MATERIAL : Pit: angular limonite coated iron nodules, Floor: Carbonate rich; Beyond pit: angular haematite pebbles (5 cm)

SUBSURFACE MATERIALS : Carbonates

VEGETATION : Rare understory

LOCALITY NUMBER : 26

SURFICIAL MATERIAL : Clay: leached, iron pisoliths (buckshot) in unvegetated areas

SUBSURFACE MATERIAL : Clay, rare calcareous nodules at 10 to 15 cm

VEGETATION : Medium density Eucalypts, medium understory, rare grasses

LOCALITY NUMBER : 27

SURFICIAL MATERIAL : Haematite, limonite, carbonate cover limonite and haematite on pit floor and flanks. Rare carbonate on flanks of the hill

SUBSURFACE MATERIAL : Calcrete massive below 10 cm and limonite nodules cemented by calcium skins below 40 cm to pit floor

VEGETATION : Scattered Eucalypts and rare understory

LOCALITY NUMBER : 59

SURFICIAL MATERIAL : Scattered iron pisoliths (buckshot) with intervening clay patches

SUBSURFACE MATERIAL : Red brown sandy clay loam

VEGETATION : Scattered mixed Eucalypts, rare understory with succulent shrubs.

LOCALITY NUMBER : 61

SURFICIAL MATERIAL : Ironstone nodules rare pisoliths, angular quartz and rock fragment, clay. Note: some carbonate found in shallow wash area

SUBSURFACE MATERIAL : Sandy clay, sandy clay loam

VEGETATION : Scattered Eucalypts, medium density shrubs

APPENDIX B

COLOUR IMAGES FROM GEOSCAN DATA

SOUTH-EAST KALGOORLIE, WESTERN AUSTRALIA

Note: In the field 20 cm x 20 cm colour paper prints of the images were used, but for this production 35 mm transparencies have been prepared.

10 Colour 35mm Transparencies of Images or Colour Prints (20 x 25cm) (3rd Generation) Available for Purchase from:

The Director
Bureau of Mineral Resources, Geology & Geophysics
GPO Box 378
CANBERRA ACT 2601

ATTENTION: Chief Cartographer


KALGOORLIE 5 km
Hill End
Trafalgar
Great Boulder Mine
Lakeview and Star Mine
Kamballie
Lakewood
Lakewood Mining Centre
Lakewood Lagoon Dam
Boorara
Golden Ridge Mining Centre
Golden Ridge
Trans Dam
Stoneville Siding
CLINKER HILL
MOUNT MONGER ROAD
K10-18
K10-19
K10-20
K10-59
K10-61
K9-21
K9-22
K8-23
K8-26
K8-27
K6-24
K6-25
G25-4
Six Mile Dam
Home Rule Dams
Leo Dam
Walkers Find Mining Centre
Bodgie Dam
Black Hill Mining Centre
Black Hill Dam
Majestic Mining Centre
Majestic Dam
MAJESTIC FOREST RESERVE
Woods Dam
Dingo Dam
K12
K11
K10
K9
K8
K7
K6
K5
K4
SCALE 1:50 000
1 0 1 2 3 KM

28/4514-10/1

- Geological boundary
- Differentiation of igneous body
- Bedding unmeasured
- Bedding vertical
- Foliation unmeasured
- Plunge of minor anticline
- Low scarp, breakaway

Geology from: Kurnalpi 1:250 000 geological series, 1971 edition, sheet SH51-10

CAINOZOIC

Quaternary

Recent

Qra	Alluvium — clay and silt in salt lakes, saline
Qrm	Alluvium — silt, sand and gravel in samphire flats and swamps; adjacent to salt lakes, thin veneer on planed bedrock; saline
Qrs	Eolian deposits — white to yellow quartz sand, red-brown silty sand, in sheets and dunes, saline in part
Qrc	Colluvium — pale red-brown to buff silt, sand and gravel; quartz pebble veneer
Qpk	Eolian deposits — kopi, gypsum and clay in dunes and sheets
Qpf	Alluvium — dark red to red-brown silt and sand with hardpan, contains non-saline swamps; marginal to salt lakes
Qpv	Alluvium — poorly sorted dark red clay to pebble deposits; gilgai; contains most present-day drainage
Qpl	Colluvium — dark red to red-brown clay, loam and silt; quartz, ironstone pebbles and weathered rock float; gilgai; low sloping deposits adjacent to Qpv

Pleistocene

Qqs	Alluvium — buff to pink loam and silt, sand veneer; contains kankar nodules
Qqz	Colluvium — dark red to red-brown clay, loam and sandy loam; contains sheet kankar or clay hardpan
Qqc	Colluvium — mixed angular to rounded rock fragments in loam; contains sheet kankar
Qqf	Eluvium — ironstone pebble or gravel veneer on sheet kankar; commonly mantling low hills

Tertiary

Tl	Limonite deposits — cemented ironstone gravel, and laterite
To	Deeply weathered rock; kaolinised, part subsequently ferruginised and silicified

PROTEROZOIC or ARCHAEAN

WIDGIEMOOLTHA DYKE SUITE

Ed	Quartz dolerite, gabbro, norite, granophyre, and pyroxenite

ARCHAEAN

BULONG COMPLEX

Abu	Discordant layered intrusive body; serpentinised peridotite to gabbro

CYCLE II

GUNDOCKERTA FORMATION (ASSOCIATION IV)

A2p	Acid intrusive rocks — quartz-feldspar porphyry; in sills, dykes, irregular bodies

MUGABBIE FORMATION (ASSOCIATION III)

A2d	Basic to intermediate intrusive rocks — gabbro to diorite; medium to coarse-grained
A2u	Ultramafic intrusive rocks — serpentinite and partly serpentinised peridotite; fine to medium-grained
A2e	Altered ultramafic rocks — talc-carbonate-chlorite assemblages after serpentinite, schistose
A2r	Altered ultramafic rocks — tremolite-actinolite-chlorite assemblages after pyroxenite
A2b	Basic to intermediate extrusive rocks — basalt to andesite; fine to medium-grained
A2i	Similar to A2b but with pillow structures, variolitic texture
A2k	Similar to A2b but carbonate-rich; includes some pyroclastic units
A2s	Clastic rocks — black shale, siliceous shale, mudstone, minor dolomitic shale and greywacke; in part pyroclastic; schistose

CYCLE I

GINDALBIE FORMATION (ASSOCIATION II)

A1p	Acid intrusive rocks — quartz-feldspar porphyry; in sills, dykes, irregular bodies
A1v	Oligomictic conglomerate — acid igneous clasts, derived from and marginal to A1p; in part reworked pyroclastic deposits
A1g	Interbedded shale, siltstone, conglomerate — in part reworked tuffaceous material; schistose in places

MORELANDS FORMATION (ASSOCIATION I)

A1d	Basic to intermediate intrusive rocks — gabbro to diorite; medium to coarse-grained
A1j	Layered basic sills — range in composition from pyroxenite to granophyre; medium to coarse-grained
A1b	Basic to intermediate extrusive rocks — basalt to andesite; fine to medium-grained
A1s	Clastic rocks — black shale, mudstone and minor greywacke, siliceous shale and dolomitic shale; in part pyroclastic; schistose

Regional metamorphism attains greenschist facies

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