THE USE OF ERTS/LANDSAT IMAGERY IN RELATION TO AIRBORNE REMOTE SENSING FOR TERRAIN ANALYSIS IN WESTERN QUEENSLAND, AUSTRALIA

ERTS FOLLOW-ON PROGRAMME STUDY NO. 2692B
(29650)

QUARTERLY REPORT

by

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I Introduction

The investigations cover the Gregory River - Mt Isa - Cloncurry - Dobbyn area of western Queensland, Australia.

The aim is an evaluation of ERTS/LANDSAT I and II imagery taken at different seasons of the year, namely March, July, September and December, for analyses of features of the natural terrain with particular reference to geological mapping and mineral exploration. The imagery is being evaluated in relation to airborne imagery of selected areas and interpretation is being verified by the ground truth investigations.

II Techniques

As a first step the negatives of the individual MSS bands of whole NASA frames have been used to produce photographic positive plates which have then been projected through appropriate filters, both individually and in combination to give colour compositives. Overlays of the spectral signatures displayed at the 1:250,000 scale have been prepared and these in turn have been interpreted with reference to structural features, superficial and bedrock geology, vegetation, soils, and other relevant ground truth information.

As a second step grids have been established over the whole NASA frames and photographic positive plates have been prepared from each MSS band for each grid section chosen for detailed study. These plates have been displayed through appropriate

filters both individually and in combination at the 1:50,000 scale and overlays of the spectral signatures displayed have been prepared and interpreted with reference to the same environmental parameters as for the whole frames.

Colour transparencies have been produced of the individual MSS bands and of the colour composites produced by combinations of them, both for the whole NASA frame and for the individual grid sections of those frames.

Overlay maps of the spectral signatures recognised on the whole frames and on the grid sections are being drafted. Additionally further overlay maps showing (a) spectral tone and (b) spectral colour are being drafted in such a way that they can be reproduced in black and white both individually and also in combination to portray the identified spectral signatures.

In the previous report reference was made to the colour composite of frame ID2039-23555 obtained by the addition of bands 4, 5 and 7. This had been scanned and digitized with a Joyce-Loebl 3 CS microdensitometer and the data procured. It was subsequently found however that the data was contaminated by spurious faults generated in the scanning process. These were of a random nature and proved difficult to identify, but it is now believed that the source of the trouble has been traced. Consequently scanning of further colour composites and a repeat scan of the above composite will now proceed forthwith.

Preliminary work on digital data

As part of the preliminary work in handling the digital data one tape of a LANDSAT I image of south-east England has been studied. A number of programmes have been written for this purpose and these are summarized in the Program Library (Appendix 1). As examples of the type of output which it is hoped to generate for the LANDSAT II data two diagrams are enclosed. Figure 1 shows an equal population density sliced into 11 groups, while Figure 2 shows the effect of ratioing Bands 5 and 7. Both diagrams have been generated on a Calcomp microfilm plotter.

For the interpretation of the NASA imagery an additive viewing system built at Bedford College is being used. The results obtained are being compared with those from multi-spectral photography acquired at scales of 1:15,000 and 1:5,000. The aerial photography is being studied using 9 x 9 inch black and white prints and a Hilger and Watts stereoscope, and infra-red and true colour films viewed stereoscopically on light tables and also projected at a suitable scale on a screen.

III Accomplishments

The interpretation procedures described in section II have been completed only in respect of the whole NASA frames designated as Cloncurry - Dobbyn flown on 22.12.1972 and 2.3.1975, for all grid sections of the first named frame and for grid section 21 covering the Dugald River area of the second. They have also been completed for grid section 23 covering the Lady Annie area of the Gregory River - Mt Isa frame flown on 15.2.1973 and on 22.3.1975. Ground truth information for representative parts of the areas covered by those frames and grid sections was obtained in 1971, 1972, 1974 and 1975. The ground survey data was acquired before any imagery under the NASA contract was received.

The LANDSAT imagery so far examined has provided a considerable amount of new data. This may be summarized with respect to specific kinds of information and with respect to specific areas.

With regard to the recognition and delineation of geological structures, combinations of the individual MSS bands of the LANDSAT I pictures taken on 22.12.1972 and the LANDSAT II pictures taken on 2.3.1975 of the Mt Isa - Cloncurry - Dobbyn area when projected through appropriate filters to produce colour composites at a 1:250,000 scale display the major structural features and distinguish between contrasting lithological/stratigraphical units within the major geological formations and discriminate iron rich zones which may be associated with base metal deposits.

In the centre of the frame the nature of the contrast between the Precambrian shield and the sedimentary basin to the east is outlined. Within each of these major units structural features not appreciated hitherto are revealed. Of particular interest are the continuity of a major lineament extending from the vicinity of Kajabbi south-south-eastwards through and on beyond the vicinity of the old Great Australia mine and also the apparent intersection of this with a number of north-east - south-west trending structures which are concealed beneath Mesozoic and later cover. Ore deposits are associated with some of these structures.

In the west of the frame the area underlain by the rocks of the Kalkadoon - Leichardt basement, mostly Leichardt metamorphics and Kalkadoon granite, is clearly distinguished from the areas of the western and eastern sedimentary successions respectively, with the bounding faults, particularly the Mt Remarkable fault, being clearly displayed. This is due to the discordance of spectral signature boundaries on either side of the fault which is apparent at both seasons of the year. To the south-east of the Mt Remarkable fault, the Wonga fault is also very clearly delineated on the LANDSAT imagery, persisting as a clearly defined lineament beyond the limits shown on the published geological maps.

South-east of Mary Kathleen the anticlinorium which comprises the north-east plunging Duck Creek and Bulonga anticlines and the Wakeful syncline involving rocks of Proterozoic age is clearly

displayed on both the LANDSAT I December 1972 and the LANDSAT II March 1975 imagery. This is due largely to the sharp tonal contrasts apparent at both seasons between the Overhang jasperlite (7 and 6) and Mitakoodi quartzite (3 and 4) which it caps around the periphery of the feature and between the latter and the Marraba volcanics (5, 6 and 7) towards the centre. East of the anticlinorium a series of contrasting spectral signatures trending approximately north - south to north-north-west/south-south-east occur within the Proterozoic Corella formation. Some are associated with faults while one dark signature appears to be related to the mineralized zone which includes the Mt MacNamara mine.

When sections of the LANDSAT I December 1972 imagery are enlarged to a 1:50,000 scale more detailed information is revealed. Within the areas underlain by the Kalkadoon - Leichardt basement and the western and eastern sedimentary successions contrasting spectral signatures distinguish individual lithological units with that of light tones of green distinguishing dolerite horizons from Leichardt metamorphic rocks which produce a predominantly yellow signature and those of dark tones of green differentiating calcareous horizons from other lithologies within the Corella formation and from the Deighton quartzite which has lighter signatures containing a yellow component.

At the 1:50,000 scale distinctive spectral signatures on the LANDSAT I December 1972 imagery of the Dugald River area distinguish the different lithological units in the Proterozoic sequence. The Knapdale quartzite, which forms a prominent ridge, is differentiated by a relatively light signature which however, is darker than that of the plains where soil, residual and transported cover masks bedrock. East and south of the quartzite range very dark signatures distinguish the Dugald River lead zinc Lode and the Lady Clayre copper deposit but some doubt exists as to whether they are produced by the ore horizons or by nearby outcrops of bedded limestones. Elsewhere similar bedded limestones also produce dark signatures.

Preliminary interpretations of the LANDSAT II March 1975 imagery of the Dugald River area confirm the detailed geology interpreted from the LANDSAT I December 1972 imagery. Major and minor fault features are discernible and some of them may have some significance with regard to mineral deposits within the area.

The LANDSAT I and the LANDSAT II imagery of the Lady Annie area which is contained on the frames covering the Gregory River - Mt Isa pictures has been interpreted at a scale of 1:48,000. Preliminary studies of this have shown that the lithological units are very clearly delineated and have revealed a number of important structural features, hitherto not known, and including the possible continuation of the Carleton fault with which the

Lady Loretta lead zinc deposit is associated, beneath cover of Cambrian rocks to the east. Some ground truth information for this area was obtained in August 1972 and in August 1975 but additional information is now required to check on detailed interpretation of the imagery.

On the extensive level plains north of Cloncurry intricate patterns of spectral signatures are displayed by a combination of the MSS bands 4, 5 and 7 of imagery flown on 22.12 1972 and on 2.3.1975. The spectral signatures are produced by a combination of the reflectances from the plant cover, the soils and the superficial deposits from which the latter are derived. Comparison of the patterns of spectral signatures for the two dates show that the contributions of the reflectances of the environmental components vary with the season.

The channels of the Williams and Cloncurry rivers show up very strongly and very distinctly from the surrounding plains on both the LANDSAT I December 1972 and the LANDSAT II March 1975 imagery, this being due largely to the stronger reflectances of the trees which occupy their beds than that of the vegetation over the surrounding terrain. Differences of spectral signature are evident both within the beds of the rivers and along their banks, these being most marked on the March imagery when reflectances were stronger, the contrast of reflectances between tree cover and bare sediment was greatest and the influence of flooding widespread. For both months evidence of old channels is accorded by

transgressive spectral signatures, these being of darker tone than the surrounding signatures in December and of lighter tone than the surrounding ones in March.

The imagery for both dates shows large areas of relatively light toned signatures over the central part of the plains between the Cloncurry and Williams rivers, finger like areas of darker tone producing more complex patterns following the creeks tributary to the Williams river and a mosaic of smaller areas of variable tone and colour between the two. This pattern suggested possible contrasts between an open grassland over the central part of the plains, belts with tree growth along the creeks and grasslands with varying numbers of trees between the two. Much of the country is inaccessible but an examination of the air photos covering a strip of country chosen for air survey on the basis of an first interpretation of the LANDSAT I coverage of this area for 22.12.1972 indicates that this interpretation is correct. Plant specimens have been collected and identified from representative areas. It is anticipated that after further ground truth studies, planned for later this year have been undertaken, a map of the plant communities over large areas of the plains to the north and east of Cloncurry, and including the areas imaged on the NASA frames designated Julia Creed - MacKinlay may be possible.

Comparison of the overlay of spectral signatures for the imagery obtained on 22.12.1972 with a map showing the superficial

deposits and bedrock geology prepared by the Australian Bureau of Mineral Resources for the Cloncurry 1:250,000 sheet area in 1970 and covering part of the plains west of the Williams river shows a remarkable coincidence of boundaries. There is less coincidence of boundaries between the spectral signatures for the imagery obtained on 2.3.1975 and the superficial deposits, doubtless because of the greater vegetation cover following rains at this period. Certain boundaries however, are common to both periods.

A major spectral boundary running approximately north - south from Gipsy Plains to Mt Margaret is apparent on both the LANDSAT I December 1972 imagery and the LANDSAT II March 1975 imagery. This boundary coincides with that delineating areas underlain by older alluvium, grey clay and silt to the west from that covered by alluvial sand and gravel with minor areas of older alluvium, and Allaru mudstone to the east. In December 1972 the area underlain by older alluvium was characterized by spectral signatures of light tone (3 or 2) and green and yellow hue on the LANDSAT I imagery whereas that covered by colluvium had spectral signatures of light tone and mainly red hue. In the March 1975 imagery of LANDSAT II however, the former area was characterized by spectral signatures of darker tone (mainly 4, 5 and 6) and dominantly crimson red hue whereas the latter had spectral signatures of medium tone (4 and 3) and dominantly green and blue hue. Ground truth investigations

carried out in the period June to September 1974 showed that the plant cover over the older alluvium on the western part of the plain comprised a savanna grassland composed mainly of perennial Astrebla and annual Iseilima species associated with Cenchrus ciliaris and Chrysopogon fallax whereas that over the colluvial sand and gravel to the east comprised a sparse grass cover of annual Aristida contorta and Sporobolus australasicus associated with Cenchrus ciliaris and Chrysopogon fallax with some Triodia pungens (the harsh spinifex grass) and scattered Carissa lanceolata bushes and small Eucalyptus pruinosa trees. The soils were respectively characteristically yellowish brown 10 YR 5/4 clays drying to a grey colour at surface and reddish brown 5 YR 4/8 soils of lighter texture. The presence of the well defined major boundary at both seasons is believed to emanate from the contrasts of plant cover, soils and superficial deposits. The change of hue in the spectral signatures at the different seasons is believed to be due to the fact that at the end of the dry season in December the soft grasses growing on the older alluvium were brown in colour and in a very dry state thereby producing a poor reflectance whereas the trees and bushes and the harsh Triodia pungens grass over the colluvial sand and gravel were still green, had retained some moisture and were reflecting sufficiently strongly to give a light red component to the spectral signature. In March, however, the position had been reversed, the soft perennial grasses had put on new green growth in response to the incidence of rainfall and

were reflecting strongly to give the crimson hues to the spectral signatures. Over the areas of colluvial sand and gravel, however, there was probably much bare ground producing green and blue signatures, the annual grasses were probably sparse and the Triodia pungens grass and the scattered bushes and trees gave only weak reflectances.

Within the area of older alluvium west of the line from Gipsy Plains to Mt Margaret the spectral signatures are relatively uniform on both the LANDSAT I December 1972 and the LANDSAT II March 1975 imagery. Minor variations within the relative proportions of the colour components in the signatures in December and in the tone of the signatures in March were probably caused by minor differences in the relative abundances of the major grass species or in moisture conditions. Within the area east of the line from the Gipsy Plains to Mt Margaret, however, a mosaic of spectral signatures contrasting in both tone and hue is evident at both seasons. Here the distributional pattern of the signatures on the LANDSAT I imagery for December 1972 suggests a close relationship with the nature of the superficial deposits and bedrock geology, influenced at least in part by the nature of the soils and the composition of the vegetation. These spectral signatures of dark tone (5) and violet and red hue occur over areas underlain by the Lower Cretaceous Allaru mudstone and adjacent areas of modern alluvium along the creeks. These areas are inacessible for ground survey but studies of the aircraft

imagery indicate that they carry open woodland characterized by Acacia cambagei or other Acacia and Eucalyptus species. On the March 1975 LANDSAT II imagery spectral signatures of medium to dark tone (4 and 5) and blue, green and violet or crimson hue occur over the same areas but extend also over adjacent areas of older and modern alluvium, where on the evidence of ground survey in other parts of the region, it is likely that fresh green growth of the grass species Cenchrus pennisetiformis, may be contributing the crimson colour to the signature.

Generally speaking, the March 1975 LANDSAT II imagery of the area east of the Gipsy Plains - Mt Margaret line shows a mosaic of spectral signatures which appear to bear little relationship to geology. At this season it is believed that the plant cover largely determines the spectral signatures, a suggestion borne out by the fact that certain spectral boundaries coincide with fence lines which may be delineated because differences of grazing practice on either side of them has caused differences of plant composition, in turn giving different spectral responses. The straight line of the spectral boundaries following fence lines contrasts with the more diffuse boundaries elsewhere.

IV Significant Results

The following significant results have been obtained:-

1. The LANDSAT I December 1972 and the LANDSAT II March 1975 imagery contrast the geology of the Cloncurry - Dobbyn and

the Gregory River - Mt Isa areas very clearly. The known major structural features and lithological units are clearly displayed while additionally, hitherto unknown lineaments have been revealed. Of particular significance are those at the eastern edge of the Precambrian shield, and those which appear to occur in the basement below cover of Cambrian and later rocks. Mineralization is associated with some of the features identified.

2. Throughout the Gregory River - Mt Isa - Cloncurry - Dobbyn area similar rock types produce similar spectral signatures e.g. quartzites produce light signatures, iron rich rocks produce dark signatures. The hues, however, vary with the geological formation, the Megally quartzites in the Lady Annie area producing signatures of yellow hue and the Knapdale quartzite in the Dugald River area one of predominantly green hue.

3. Appreciably more geological information is discernible at the 1:50,000 scale than on the 1: 250,000 scale.

4. Ore horizons may be identified at the 1:50,000 scale, particularly where they are associated with iron rich rocks.

5. On the level plains north of Cloncurry distinctive spectral signatures produced by the combined reflectances of plant cover, soils and geology, distinguish different types of superficial deposit. The latter are more clearly discriminated by the LANDSAT I December 1972 imagery than by the LANDSAT II March 1975 imagery.

6. Existing and former channels of the Cloncurry and Williams rivers are distinguished at the 1:50,000 scale on both the LANDSAT I December imagery and the LANDSAT II March imagery.

7. On the Cloncurry Plains fence lines are discernible on the 1:50,000 LANDSAT II March 1975 imagery. This is believed to be due to cut lines along the fences giving a different spectral signature from the grasslands on either side and also to differences of grazing practices on either side of the fences.

V Publications

Papers are in preparation but none have been published during the period covered by this report.

VI Problems

Technical problems have been experienced in digitizing the colour composites and are referred to in Section II on Techniques.

VII Data quality and delivery

Long delays over the supply of imagery are impeding progress. The position regarding the receipt and handling of the MSS negatives is given in Table 1 (appended). Repetitive imagery for part of the area for which it was requested has not been received. In particular imagery for September and November/December has not been received for the Cloncurry - Dobbyn area and imagery for July has

not been received for the Gregory River - Mt Isa area.

A request for a LANDSAT II computer compatible tape, ID - 2039-23555, was submitted on 5th January and the tape was received from the EROS Data Centre on 19th March. We are now in the process of studying it but have not as yet obtained any results.

VIII Recommendations

There are no recommendations at this stage.

IX Conclusions

Our only conclusions at this stage are:

1. Confirmation of the value of the imagery for geological mapping, for the delineation of structural features and identification of mineralized zones.
2. Indications that for (1) above imagery at different seasons of the year provides complementary information.
3. Interpretations at the 1:50,000 scale yield more information than interpretations at the 1:250,000 scale.
4. The discrimination of distinctive plant communities within the natural vegetation is possible.
5. Areas of differing superficial deposits may be identified where they carry distinctive plant communities.
6. Recently burnt areas can be identified.

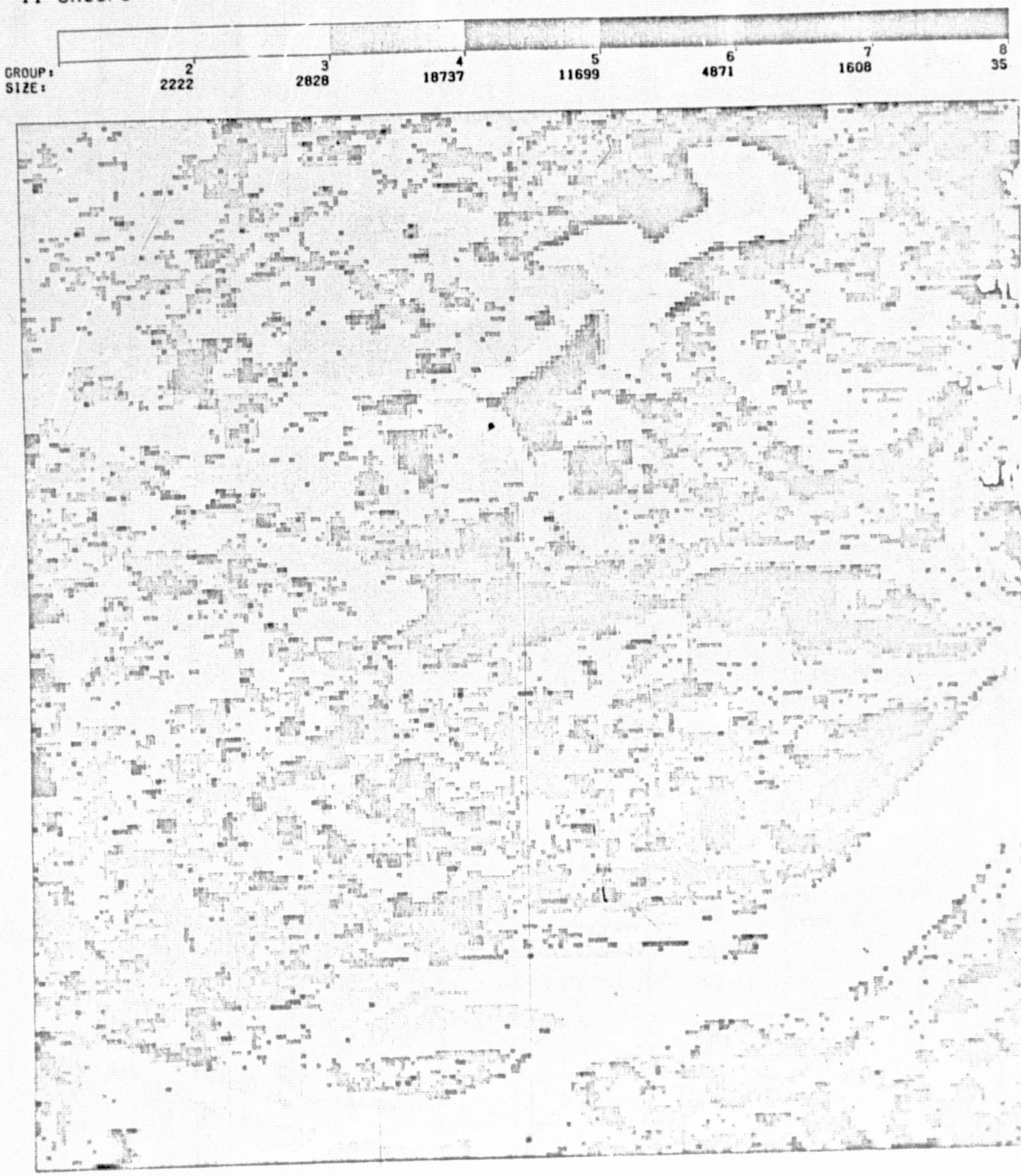

Fig. 1. Level slice of Band 6 into 11 groups.

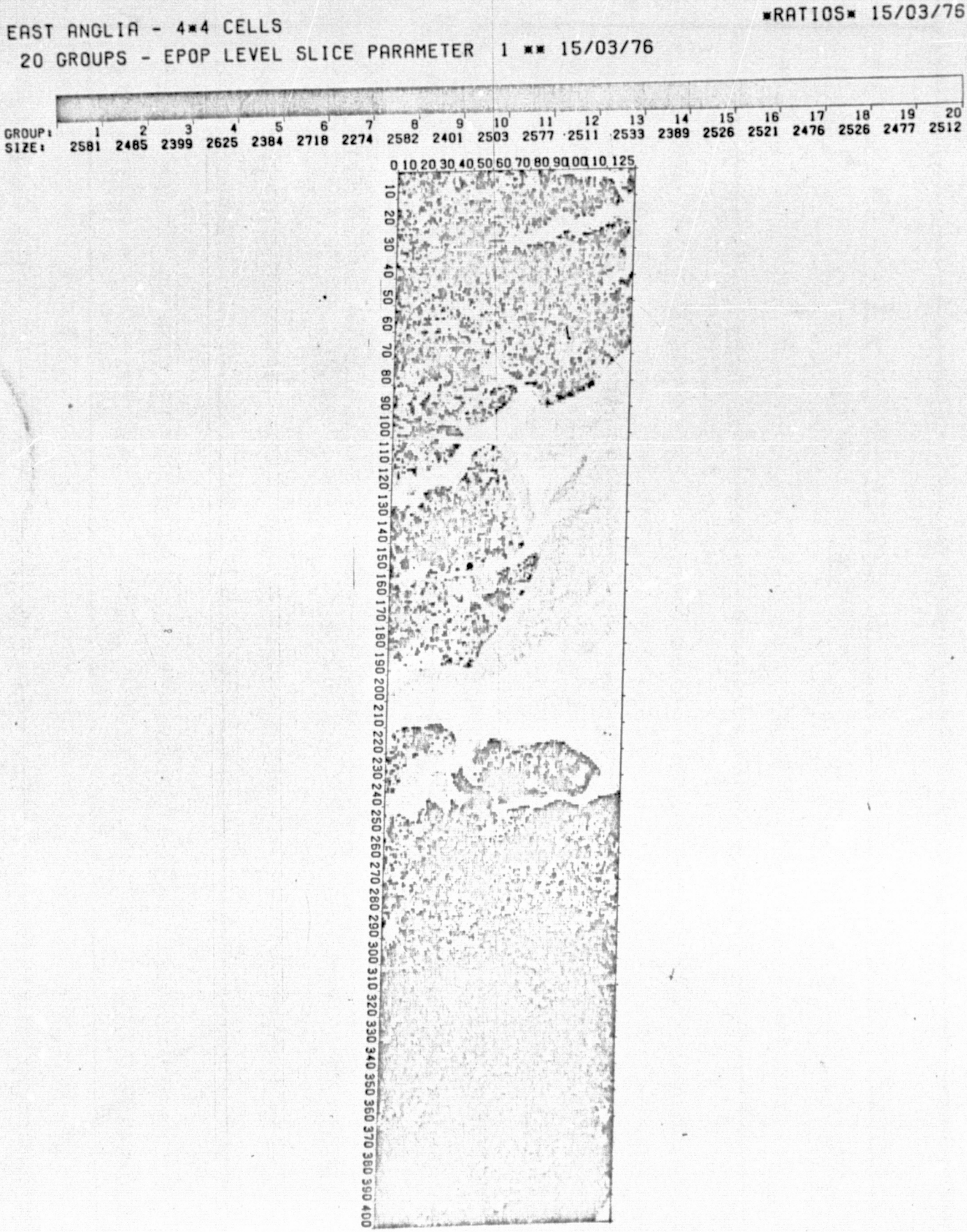

Fig. 2. Equal population (EPOP) density slice into 20 groups for the ratio of Band 5 to Band 7.

Table 1. ERTS/LANDSAT imagery of western Queensland received and processed for interpretation during the period 1st April 1975 - 2nd February 1976.

Name of Area	No of Frame NASA 1D Ref. No	Date of Imagery	Date of Receipt of Imagery	Date of completion of Plates of which frame for additive viewing	Date of completion of plates of grid sections of frame for additive viewing
Cloncurry - Dobbyn	2039 - 23555	2. 3. 1975	18. 8. 1975	3. 9. 1975	30. 1. 1976 [GS 16 Mitakoodi fold GS 21 Dugald River GS 22 Cloncurry Plains GS 23 Mt Isa GS 24 Mary Kathleen]
Cloncurry - Duchess	2039 - 23562	2. 3. 1975	18. 8. 1975	3. 9. 1975	30. 1. 1976 [GS 22 Kuridala only]
Gregory River - Mt Isa	2041 - 00013	4. 3. 1975	18. 8. 1975	3. 9. 1975	30. 1. 1976 [GS 23 Lady Annie and GS 28 Yelvertoft - Barkley Downs only]
Georgina River	2041 - 00020	4. 3. 1975	18. 8. 1975	3. 9. 1975	-
Julia Creek - McKinlay	2083 - 23503	1. 3. 1975	18. 8. 1975	3. 9. 1975	-
Gregory River - Mt Isa	2059 - 00012	22. 3. 1975	3. 11. 1975	24. 11. 1975	30. 1. 1976 [GS 23 Lady Annie GS 28 Yelvertoft - Barkley Downs only]
Georgina River	2059 - 00015	22. 3. 1975	3. 11. 1975	24. 11. 1975	-
Julia Creek - McKinlay	2128 - 23503	30. 5. 1975	3. 11. 1975	24. 11. 1975	-
Cloncurry - Dobbyn	2183 - 23552	24. 7. 1975	11. 12. 1975	7. 1. 1976	30. 1. 1976 [GS 16 Mitakoodi fold GS 21 Dugald River GS 22 Cloncurry Plains GS 23 Mt Isa GS 24 Mary Kathleen]
Julia Creek - McKinlay	2183 - 23554	24. 7. 1975	11. 12. 1975	7. 1. 1976	-
Gregory River - Mt Isa	2239 - 00001	18. 9. 1975	2. 2. 1976		
Georgina River	2239 - 00003	18. 9. 1975	2. 2. 1976		
Julia Creek - McKinlay	2236 - 23491	1. 9. 1975	2. 2. 1976		

APPENDIX I.
PROGRAM LIBRARY

STRUCTURE.

The programs are listed in the following five sections. A pragmatic distinction is made between two types of data object. The first, called DATA, is a three-dimensional array of real values. It normally represents a multi-spectral set of values for each point, and referred to as parameters, in a two-dimensional picture array. The second data type is called MAPS, viz: after any form of classification process each pixel is associated with some small integral group number and a MAPS data set contains one or more "maps" or arrays of these group numbers. Both types of data set have self-contained formats, including titles and annotation information, which are preserved through all the programs. The parameters after program names are the (dummy) names of files used by the program.

1. DATA Input Routines.

CHURN (PTAPE, DATA)

Extra information required: title
forms "input" file.

Inputs paper tape in standard microdensitometer format and constructs DATA file.

LANDSAT (MTAPE, DATA)

From "input": title, position specification.

Inputs LANDSAT magnetic tape and constructs DATA file using specified portion of the quarter-frame area and averages over specified pixel field.

2. DATA operations.

DCHOP (DATA 1, DATA 2) .....

From "input": number of columns left and right and rows top and bottom to be removed.

From DATA 1 constructs new file DATA 2 containing a subset of the data, by "chopping" specified numbers of rows and columns from the edges.

DHIST (DATA)

From "input": number of steps (may be blank)
optionally - range settings and extra title.

Draws hist-ograms of the DATA, parameter by parameter, on the lineprinter.

PSLAP (DATA 1, DATA 2)

Applies the pseudo-Laplace boundary transformation to DATA 1 and produces new file DATA 2.

PSOB (DATA 1, DATA 2)

Applies the boundary transformation suggested by Sobell (Duda & Hart).

RATIOS (DATA 1, DATA 2)

From "input": parameters to be ratioed.

Produces new data set whose parameters are the values of the ratios of the specified pairs of parameters from the original data.

3. DATA-MAPS Operations.

EPOP (DATA, MAPS)

From "input": no. of groups in slice.

Constructs one equal-population density slice from DATA and produces set of MAPS, one map for each parameter.

EXTRACT (DATA, MAPS, TDATA, TMAPS)

From "input": map select instruction.
group numbers to be extracted.

From DATA and selected map constructs training set of TDATA and TMAPS (for use with SOUP) by extracting all points in the selected groups.

POLYDIV (DATA, MAPS)

From "input": level up to which splitting is to be carried out.

On the DATA set performs polythetic division cluster analysis (Lance) producing a set of MAPS, one for each successive split.

SLICE (DATA, MAPS)

From "input": no. of groups in slice.

Constructs an equal interval density slice similar to that produced by EPOP.

SOUP (TDATA, TMAPS, DATA, MAPS)

From "input": map select from TMAPS instruction, threshold instruction.

From training set TDATA and TMAPS performs supervised classification on DATA and produces single map set MAPS using the quadratic rule with or without a "bin" according to the required threshhold.

TSETS (DATA, TDATA, TMAPS)

From "input": coordinates of training set areas with corresponding group numbers.

From DATA extracts rectangular areas and constructs training set TDATA and TMAPS for SOUP.

4. MAP-MAP TRANSFORMS.

MCHOP (MAPS 1, MAPS 2)

From "input": number of columns left and right and rows top and bottom to be removed.

Performs the same function as DCHOP but for MAPS.

MERGE (MAPS1, MAPS2, MAPS3)

Concatenates two compatible map sets MAPS1, MAPS2 to form MAPS3.

ROTATE (MAPS1, MAPS2)

Rotates MAPS1 through 90° to form MAPS2. Rotation is clockwise unless the maps have already rotated, in which case it is anti-clockwise.

SELECT (MAPS1, MAPS2)

Selects specified maps from MAPS1 and forms new set MAPS2.

SMOOTH (MAPS1, MAPS 2)

From "input": smoothing parameters.

Performs simple smoothing operation on 3 x 3 pixel arrays removing more or less isolated points to surrounding groups.

TSMJOIN (TMAPS1, TMAPS2, TMAPS3)

As TSDJOIN but merges training set maps.

5. MAP Output.

GLIMP (MAPS)

From "input": GLIMP instructions.

Produces a Grey Level IMage Plot on microfilm. Glimp instructions allow setting (a) a geometric 'distortion' - i.e. squash pixels to rectangles; (b) "*skew" - i.e. for Landsat pictures; (c) "*tick" - switch on tickmarks and pixel numbers along the edges; (d) "*neg" - reverse image so that higher groups are less shaded; (e) "*gps" directive selects range of groups to be assigned grey levels and optional "*map" directive to draw only selected maps.

MICPLOT (MAPS)

From "input": optional directives, shading list.

Produces on microfilm a plot with symbolic shadings for each group. Optional *directives as for glimp (except no * neg, *skew, *gyps) plus "*SEP" (shading) which draws each map once for each group with only that group shaded.

PAPLOT (MAPS)

From "input": map select instructions.

Prints maps on the lineprinter printing either a letter for each group or overprinting grey levels.