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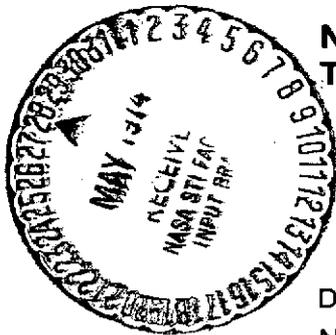
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SR No. 9616

**TO ASSESS THE VALUE OF SATELLITE IMAGERY  
IN RESOURCE EVALUATION ON A NATIONAL  
SCALE**

November 1973

Type III Report for Period July 1972 to November 1973



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COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

I

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14. Supplementary Notes: The analyses in this report were performed in collaboration with:  <table border="0"> <tr> <td>Dr C.N. MacVicar</td> <td>Soil and Irrigation Research Institute</td> </tr> <tr> <td>Dr D. Edwards</td> <td>Botanical Research Institute</td> </tr> <tr> <td>Dr B.N. Temperley</td> <td>Geological Survey</td> </tr> <tr> <td>Mr L. Claassen</td> <td>Dept. of Planning &amp; Environment</td> </tr> <tr> <td>Mr W. Kirchoff</td> <td>Aircraft Operating Co. (Pty) Ltd</td> </tr> </table>			Dr C.N. MacVicar	Soil and Irrigation Research Institute	Dr D. Edwards	Botanical Research Institute	Dr B.N. Temperley	Geological Survey	Mr L. Claassen	Dept. of Planning & Environment	Mr W. Kirchoff	Aircraft Operating Co. (Pty) Ltd
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Dr B.N. Temperley	Geological Survey											
Mr L. Claassen	Dept. of Planning & Environment											
Mr W. Kirchoff	Aircraft Operating Co. (Pty) Ltd											
15. Abstract  <p>It has been shown that ERTS Imagery, particularly in the form of 1:500 000 scale false colour photolithographic prints, can contribute very significantly towards facilitating and accelerating (dramatically, in the case of vegetation) resource surveys and geologic mapping. Fire mapping on a national scale becomes a feasibility, numerous new geologic features, particularly lineaments, have been discovered, land-use can be mapped efficiently on a regional scale and degraded areas identified.</p> <p>The first detailed tectonic and geomorphological maps of the Republic of South Africa will be published in the near future mainly owing to the availability of ERTS Images.</p>												

P R E F A C E

This is the final report of the ERTS participation project SR 9616\*.

Following a summary of significant results, this report is divided into seven sections:

Section I describes the history of the project as well as data utilization and consequences of the study approach.

Section II deals with soil and terrain mapping and agricultural inventorization.

Section III describes how a number of successful vegetation surveys could be undertaken with minimal effort and the potential of ERTS for mapping fire and degraded vegetation.

In Section IV the discovery of numerous previously unknown geologic features, particularly lineaments, is reported.

Section V indicates the value of ERTS imagery for land-use surveys, particularly on a regional scale, as well as for detecting wind erosion.

Finally Sections VI and VII deal briefly respectively with the cartographic quality and educational value of ERTS Images.

\*Incorporating the sixmonthly Type II reports:

C S I R FIS 38 for July 1972 - January 1973, NASA-CR-130012

C S I R FIS 40 for February - July 1973, NASA-CR-133589.

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## SUMMARY OF SIGNIFICANT RESULTS

### IMAGE REPRODUCTION: DISCIPLINE 8G

An ERTS image product, 1:500 000 false colour photolithographic prints, with maximal pictorial information content can be mass produced by conventional commercial processes in consistent quality and at reasonable cost (about US \$200 per scene for 500 copies or less). This product is easy to handle and can be interpreted with ease after a limited familiarisation period by users with some experience of conventional photo-interpretation techniques.

### NATIONAL RESOURCE SURVEY: DISCIPLINE 10A

The significant results for national resource survey purposes are:

- (1) ERTS imagery can be phased into the current programmes of survey agencies as an additional data base without major problems. After initial negative response because of lower resolution than conventional images, it was soon realized that conventional interpretation techniques are applicable but that a new perspective, ideally commensurate with small scale mapping, is acquired.
- (2) ERTS imagery can contribute very significantly in reducing the time and cost of resource surveys. In specific cases the time needed for surveys of comparative reliability can be reduced from years to a matter of weeks and the amount of field work required drastically reduced.

Numerous new geologic features were discovered.

Locally those national survey agencies most familiar with ERTS imagery are already routinely using it in current survey programmes.

ERTS imagery has provided a major data base and/or impetus for at least two projects: the first detailed tectonic and geomorphological maps of the Republic of South Africa.

- (3) Resource Management : Although resource management has not been an objective of this study, a number of significant results in this

respect have been achieved of which outstanding is the efficiency with which position extent and time of fires can be monitored on a national scale including both fires in grassland, burnt annually (in cycles of 18 days and less) and in fynbos (macchia), burnt at intervals of several years (in cycles of up to decades).

SOIL AND TERRAIN MAPPING FOR AGRICULTURAL  
INVENTORIZAZION AND PLANNING : DISCIPLINE 1D

Evaluation of the results obtained show that, with some limitations, ERTS imagery can be a valuable aid in the current South African small scale soil and terrain morphological inventorization programme which is being undertaken with the aim of planning optimal land usage. This applies particularly to the 1:500 000 false colour reproductions of which a limited number were investigated.

The following significant results can be reported:

- (1) This study showed clearly that identification of soil types is only possible where a close correlation exists between soil type, vegetation, terrain morphology, geology, climate or land-use.

It was possible for example to identify soil landscapes in arid and semi-arid regions. In the more vegetated humid regions, however, attempts at small scale soil mapping were less successful. Differences in vegetation on the Makatini Flats make it possible to distinguish between the Makatini/Shortlands association and other sandier associations. Land-use patterns, for example, make it possible to delimitate the brack clay soil of the northwestern Orange Free State.

- (2) Terrain morphological type boundaries are readily identified and in several cases it has been possible to trace these with greater accuracy and ease than has been the case with conventional methods. Individual geomorphological features could be recognized consistently. These include mountains, ridges, river valley systems and associated alluvium, footslopes, various kinds of lineaments, plateaux, pans, dunes, canyons, colluvial and aeolian deposits, lagoons and structural watergaps.

- (3) The first detailed 1:500 000 geomorphological map of the Republic of South Africa will be taken from its present second approximation to the final publication edition as a result solely of ERTS-1 imagery.
- (4) Various other agricultural features such as cultivated land natural grazing land and irrigation schemes could be distinguished. In some cases dry land and irrigation farming of the same crop and natural and artificial pasture could be separated. Mis-managed and burnt areas are clearly identifiable.
- (5) Homogeneous agricultural regions can be identified for the purpose of planning optimal land utilization.

#### PLANT ECOLOGICAL SURVEYS: DISCIPLINE 1C

The following significant results were obtained in evaluations of the ERTS imagery for representatives of nearly all the main types of vegetation occurring in South Africa with the exception of the arid Karoo:

- (1) A significant finding was that major veld types, physiognomic-structural and ecological classes of vegetation could be mapped with at least a fair degree of accuracy and most often with a generally high degree of accuracy by various investigators within a matter of weeks on the basis of existing knowledge and with only a minimum of ground control. By conventional methods an equivalent degree of accuracy would, conservatively estimated, have been obtained by at least six months to eighteen months. These results were obtained in spite of the fact that in many cases the available imagery were acquired at dates when differentiation is a minimum. When used with good ground truth knowledge of the vegetation the ERTS imagery provides an early perspective to a more effective synthesis of information. Thus the ERTS image provided almost immediately the extent of dense scrub vegetation in inaccessible areas of the Tugela River Valley that took several years by ground methods and which on a broad basis could have been more effectively delineated with the aid of the satellite imagery. Similarly, on

relatively little prior knowledge a preliminary test survey delineating the main physiognomic-structural vegetation types over roughly 500 000 km<sup>2</sup> of the Eastern Cape Province could be carried out within a month and shown to be reasonably accurate by reference to limited ground control, reference to medium scale panchromatic air photography, existing knowledge and 1:125 000 scale mapping.

Cursory examination of a few of arid Karoo areas revealed little vegetation detail with only recognizable vegetation boundaries corresponding to topographic and geological boundaries.

- (2) ERTS imagery provides maximal effective differentiation of dense wooded forest and scrub vegetation as well as for sparse vegetation cover types, which is commonly the result of overgrazing and erosion in mesic areas. This information is important for land use quality surveys and management planning.
- (3) For monitoring fire and establishing the ecological and possible socio-economic relationships of fire the ERTS imagery proved outstandingly useful if consecutive imagery is available because burnt areas are clearly identifiable. The monitoring of fire on a national scale would be impossible by conventional means in view of the cost of acquiring the data base and the manpower involved in interpretation.
- (4) The most serious failure of present methods of analysis of the ERTS imagery for vegetation survey was its general inability to resolve boundaries between open savannas and grasslands, between natural forests and exotic tree plantations and to a lesser degree with scrub. In general, however, the ERTS imagery on a variety of tests in a number of situations proved an invaluable technical aid whose potential has still not been fully utilized. Work is still proceeding on the use of the images.

GEOLOGY : DISCIPLINE 3K

Unfortunately the original list of objectives to which the use of

ERTS images could be applied has proved to be too ambitious and, owing to previous commitments, the limited staff of the Geological Survey has been unable to devote the necessary time within the reporting period to achieve significant results. The main exception to this has been the observation of lineaments, not previously recorded, which may be of regional structural importance or connected with the distribution of mineral deposits. These lineaments include:

- (1) Lineaments in the granite near Pietersburg, Transvaal, on which known gold and copper deposits are situated.
- (2) A lineament hundreds of kilometres in length that crosses the Transvaal from Botswana to Swaziland, and on which lie numerous volcanic pipes.
- (3) Two long north-south lineaments near Thabazimbi in the Transvaal, discovered just in time to be added to a map ready for publication.
- (4) Revision of the fault pattern in the Soutpansberg area, Transvaal.
- (5) Subsidiary faults associated with the Tugela fault in Natal.

These and many other newly discovered lineaments have not yet been visited in the field so that their identity and significance are still largely unknown.

ERTS Images have proved to be so informative that it has become routine practice in the Geological Survey, to use these images for the following purposes:

- (1) Reconnaissance in the case of the few areas left that have not yet been mapped on a scale greater than 1:1 million.
- (2) Revision of maps that is carried out from time to time as new data becomes available.
- (3) Checking new maps prior to publication.
- (4) As a basis for a tectonic map of the Republic of South Africa. This project, which will commence in 1974, has ERTS imagery as its main impetus and data base.
- (5) As a basis of any map required on a scale of 1:1 million or

1:500 000 in which structural features are more important than stratigraphical.

- (6) For making a structural synthesis of any area after mapping has been completed.
- (7) For tracing the extension of known mineral deposits and in locating promising areas for further exploration.
- (8) For tracing faults and fracture zones that may be aquifers.

In general the value of the maps published by the Geological Survey will be enhanced by the availability of ERTS images. Not only will they be more accurate but they will include structural data, not apparent either in the field or on aerial photographs, that will be of value to the private sector, especially to the civil and hydraulic engineer and to the economic geologist.

#### URBAN AND REGIONAL LAND-USE SURVEY : DISCIPLINE 2A

- (1) From the study of ERTS-A imagery the Department of Planning and the Environment has come to the conclusion that greatest advantage which can be derived from the imagery is by undertaking land-use analyses on a macro-scale, which can be useful mainly in the field of planning at a sub-national, regional and sub-regional scale. The images could be used very usefully in preparing an inventory of land-use on a national scale.

ERTS images can most profitably be used in the reconnaissance stages of an investigation, where a problem area can be identified very quickly and examined in more detail at a later stage. In some cases in studying an area from satellite images, features may be revealed that are not readily apparent from large scale photographs.

- (2) The delimitation of the country into regions may be tested by examining ERTS images in order to locate regional boundaries. The boundaries drawn from false colour images correspond well with those obtained by using the sift method.

- (3) In spite of the fact that details of cultivation, for example the difference between orchards and vineyards, cannot be clearly distinguished from the ERTS images, the pattern of land-use derived from a study of the ERTS images compares very favourably with those obtained from detailed studies of the Gamtoos River Valley and the Breë River Valley. Thus for preparing small scale land-use maps ERTS images appear to be ideal.

The advantage of the ERTS images is that they enable broad generalized maps of land-use to be compiled in a relatively short time. By contrast the use of conventional photographs at a relatively large scale makes the mapping of land-use a protracted process for national and sub-regional purposes.

The monochrome and false colour images do not lend themselves to detailed studies of land-use and are therefore not a substitute for conventional photographs at larger scales. Furthermore, it is necessary to have a knowledge of the area in question in order to derive the most benefit from the use of the satellite images.

- (4) If photographs are taken at different seasons and over a lapse of a few years such features as the changing crop cycle can be plotted as well as urban expansion, changes in land-use and cultivation practices, and desert encroachment.

#### CARTOGRAPHY : DISCIPLINE 2B

A cartographic study based on identification of known detail points revealed a scale discrepancy of up to 1%, a displacement of up to 5 km in latitude and a displacement of up to 3.5 km in longitude of the geographic tick marks on system corrected MSS imagery. These variations also include an azimuth swing of 2 degrees. After correction of these errors, all measured points were within 500 m of their true positions.

The cartographic quality seems to have suffered from deficiencies in the photographic reproduction equipment.

Because of its educational value, a local ERTS image will be included in a South African school atlas being produced.



The following individuals have served on this Committee:

Chairman : Dr O.G. Malan, CSIR

Secretary : Dr P.leR. Malherbe, CSIR

Soil and Irrigation Research Institute:

Dr J.M. de Villiers

Dr C.N. Mac Vicar

Mr G.P. Kruger

Mr H. van Vliet

Botanical Research Institute:

Dr D. Edwards

Mr N.G. Jarman

Mr J.C. Scheepers

Geological Survey:

Dr W.L. van Wyk

Dr B.N. Temperley

Mr L.N.J. Engelbrecht

Mr J.R. Vegter

Department of Planning:

Mr J.J. la Grange

Mr L. Claassen

Mr J.G. van Zyl

Dr F.B. Chmelik

Trigonometrical Survey Office:

Mr W.C. Watson

Mr D. Struwig

Mr J.P. Greyling

South African Air Force:

Cdt. N.J. Swardt

Cdt. E.B. White

Maj. C.G. Wells

Spectral Africa (Pty) Ltd:

Mr B. Gilbertson

Mr M. Kreitzer

Mr T.G. Longshaw

### 1.3 Support Facilities

The ERTS Investigator's Committee was instrumental in obtaining the following support facilities:

#### 1.3.1 Additive Colour Viewer

Funds were obtained for the acquisition of an "International Imaging Systems Mini Addcol Model 6020", which was housed at the Botanical Research Institute and utilized mainly by members of this institute.

#### 1.3.2 Photographic Reproduction Facilities

Black and White 1:10<sup>6</sup> enlargements of ERTS imagery were produced by the Trigonometrical Survey Office, the national agency for aerial photographic coverage.

#### 1.3.3 Photolithographic False Colour Prints

By means of subscriptions, sufficient funds were obtained to commence with the production of a set of 70 to 80 false colour images (consisting of MSS bands 4, 5 and 7) giving complete coverage of the Republic of South Africa (covering also Swaziland and Lesotho) at a scale of 1:500 000.

Due to delays in delivery of originals ordered from NDPP, this set has only been partially completed.

#### 1.3.4 Aircraft Underflights

Aircraft underflights were arranged with the cooperation of the South African Air Force of a strip between Ventersdorp and Vaalwater (a distance of about 250 km). Black and white infrared, colour and colour infrared film was utilized at scales up to 1:150 000. Attempts to arrange these flights coincident with ERTS photography proved to be difficult because of weather conditions and technical problems.

Although no specific reference is made in the report to utilization of these underflight results, the material proved to be very valuable in training personnel to become accustomed to small scale and false colour photography of which little experience was available prior to the ERTS programme.

#### 1.4 Personnel Changes

The following changes in co-investigators as originally set out in the proposal took place during the report period:

##### Soil and Agricultural Land Use Inventory:

Dr J.M. de Villiers succeeded by Dr C.N. Mac Vicar  
April 1973

##### Geology

Dr W.L. van Wyk succeeded by Dr L.E. Kent  
October 1973

##### Land Use

Mr J.J. la Grange succeeded by Mr L. Claassen  
April 1973

## 2. DATA COVERAGE

During the report period copies of about 500 scenes were received from NDPF.

Of those covering the Republic of South Africa all, except six RBV frames, were MSS products. These images cover the period 2 August 1972 to 28 March 1973. Consequently no images covering the autumn-winter months April, May, June and July were obtained.

This is unfortunate for two reasons:

- (i) No imagery with the lowest sun angles, which reveals topographic features best, is available. This could have facilitated geologic interpretation.
- (ii) The possibility of detection of air pollution, which is most pronounced in the northern urban areas during mid-winter mornings owing to inversion conditions, could not be evaluated.

Of the 77 scene positions covering the Republic, only 7 were not imaged with less than 10 % cloud cover at least once. The rest were imaged with less than 5 % cloud cover between one and seven times (see Fig. 1). Unfortunately these were not always well distributed temporally. For example, all imagery of the ground track running across the eastern

# ERTS Coverage of South Africa

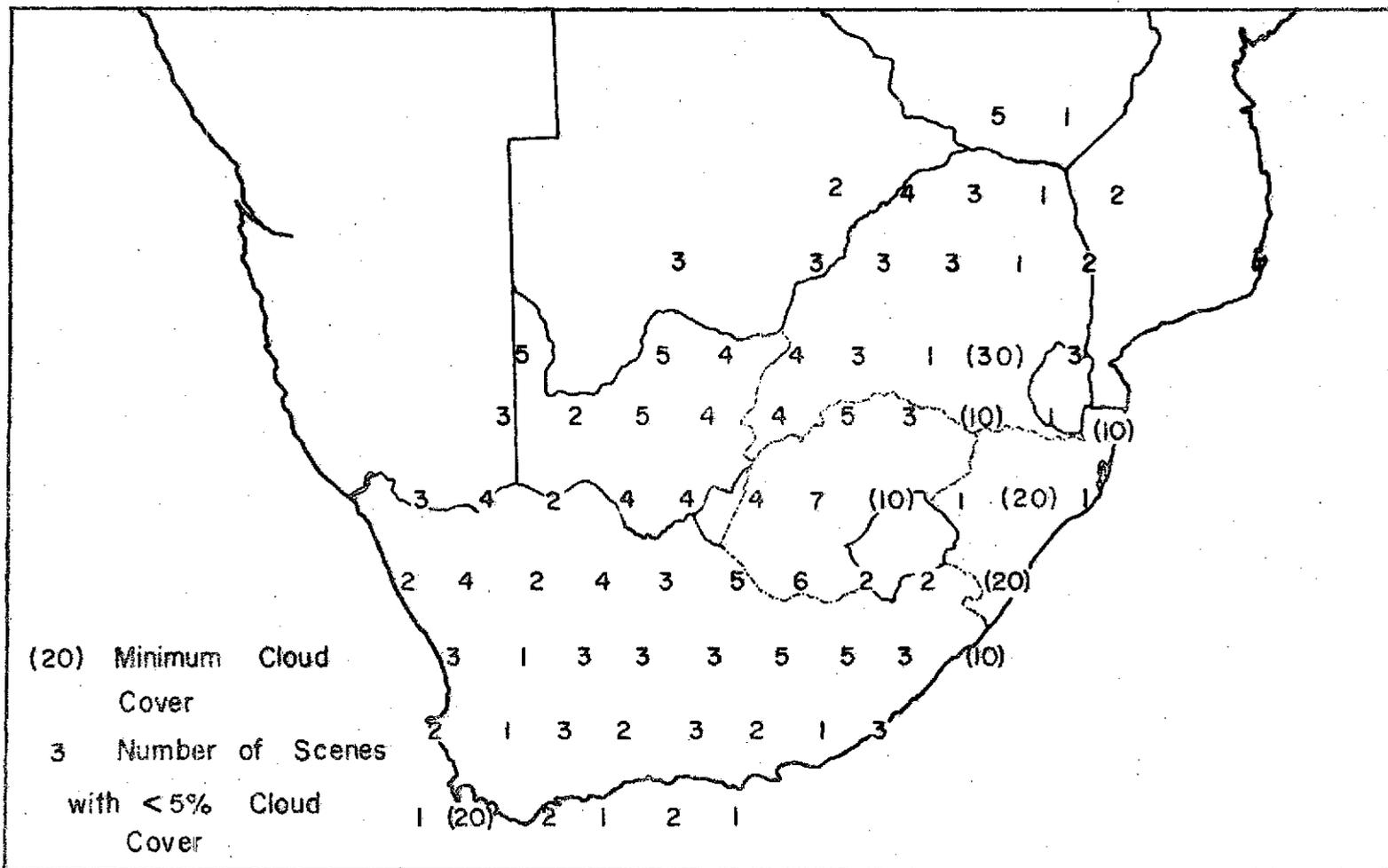


FIG. 1

borders of the Orange Free State and Lesotho were obtained during September to December 1972.

### 3. DATA QUALITY

Three product types were obtained from NDPF: Initially 70 mm positives and negatives were received. Of selected scenes also 9½ inch B/W positives were ordered.

#### 3.1 Negatives, 70 mm

The 70 mm negatives proved to be much denser than expected and could not be utilized in the reproduction facilities at our disposal.

#### 3.2 Positives, 70 mm

Most 70 mm positives received were of good quality. Unfortunately data in which the quality was degraded were also received.

Newton rings, which appeared fairly regularly initially were completely absent during later shipments.

Flaws caused by lint, fibres, etc. appeared regularly on 70 mm products. These objects seem to be situated in the reproduction apparatus since they usually reappear at different positions on all four bands of a particular scene. Fortunately these flaws usually do not interfere seriously with interpretation.

The most troublesome defect is that definition was lost due to unsharpness, presumably in the photographic reproduction process. This can readily be observed by inspecting the diagonals of the alphanumeric symbols Ø, N, Z, 2, etc. in the image annotation or geographic tick marks. In sharply reproduced images the steps in the diagonal - including the consistent error near the base of the symbol N- are sharply defined. Some products received were uniformly unsharp and in many others the annotation quality varied from sharp to unsharp over the image (unsharpness was observed to be distributed randomly and not restricted to corners or edges.)

Assuming that the transfer characteristics from EBR onto the first generation positive is constant, the definition of the alphanumeric symbols gives a convenient criterium for the quality of the photographic processing process, independent of scene, data acquisition or data transmission characteristics. For this purpose additional special resolution test patterns, generated by the EBR and inserted between tick marks on the image border, might be useful - also in subsequent photographic reproduction by users.

### 3.3 Positives, 9½ inch

For the purpose of producing 1:500 000 scale false colour photolithographic prints, 9½ inch positives of selected scenes were ordered from NDPF.

These positives are uniformly of good quality. They are more contrasty in the lighter tones whereas the 70 mm positives have their highest contrast in the darker tones. The relative advantages of these differences depend on the scene and application.

### 3.4 RBV Products

The copies of the few RBV frames available contain large radiometric anomalies which, according to NDPF, are due to initial processing problems.

Reprocessing of the original tapes was requested for the purpose of a more valid comparison between MSS and RBV products. These reproduced products have, however, not been received yet.

## 4. PRODUCT UTILIZATION

### 4.1 Photographic Processing

Owing to the fact that the 70 mm negative transparencies were much denser than expected, the planned photo-reproduction procedures had to be rearranged.

A standard procedure for reproduction of 1:10<sup>6</sup> scale B/W paper prints was followed:

From the NDPF 70 mm positive transparency a 1:10<sup>6</sup> scale negative is produced which is then used by the Trigonometric Survey Office in Pretoria to produce 1:10<sup>6</sup> scale B/W prints. This office routinely produces contact copies of the rational airphoto coverage and 1:10<sup>6</sup> scale ERTS prints could therefore be handled in a similar way.

Selected scenes have been enlarged to 1:500 000 and 1:250 000 scale by the same agency for user evaluation.

#### 4.2 Photolithographic Printing

The most useful product type which could be produced in large numbers at a reasonable cost proved to be 1:500 000 false colour composites of MSS bands 4,5 and 7.

This scale proved to be much more convenient for annotation and the colour composite eliminated the tedium of comparing two or more copies for the purpose of identifying features. Subtle tone differences are also revealed much clearer in the colour composite.

Initially 70 mm positives were employed. It soon became clear that in some cases the quality of the final product was unsatisfactory owing to unsharpness of the original positive.

Consequently 9½ inch positives were ordered from NDPF for this purpose.

In order to obtain a final scale as closely as possible to 1:500 000, a cartographic analysis (described later in this report) was undertaken. This indicated that a cross track registration mark separation of on the average 397 mm (compared with 2 x 197.5 mm indicated on page 3 to 5 of the ERTS Data Users Handbook) was required.

In one step the NDPF 9½ inch positive was enlarged to a negative screen of this scale. A screen of 175 screen points per inch was chosen (giving 6.5 million screen points per colour compared with 7.5 million theoretical data points per band). Simultaneously the contrast was also increased by processing step 5 and step 14 of the grey scale, respectively, to 0 % and 100 % transmission (in the negative screen). Densitometry on a few selected scenes have indicated that very little information is

lost by sacrificing the extreme ends of the grey scale in favour of increased contrast.

MSS bands, 4, 5 and 7 were then printed in a set of trichromatic colours, respectively yellow, magenta and cyan.

Selected examples of prints are appended to this report.

It is gratifying to note, as indicated by the example of the street pattern of Paulpietersburg situated at approximately  $30^{\circ} 50' E$   $27^{\circ} 25' S$  in scene 1047-07191 that the "resolution" has actually improved through the three additional generations after the NDPF product (See Fig. 2).

No explanation can be given at this stage why this particular street pattern is visible compared to other towns in the same scene where this is not the case.

The local cost of this process is approximately US\$200 per scene per first 100 copies, rising US\$7 per additional 100.

#### 4.3 Additive Colour Viewing

The additive colour viewer was also utilized for analysis in some cases. It is inconvenient to use for annotation because of problems with parallax in addition to the small scale of  $1:10^6$ . Its advantages are quicker access to colour composites (also for change detection in repetitive coverage) and greater flexibility in choice of colour and colour balance, which sometimes facilitates discrimination between similar features.

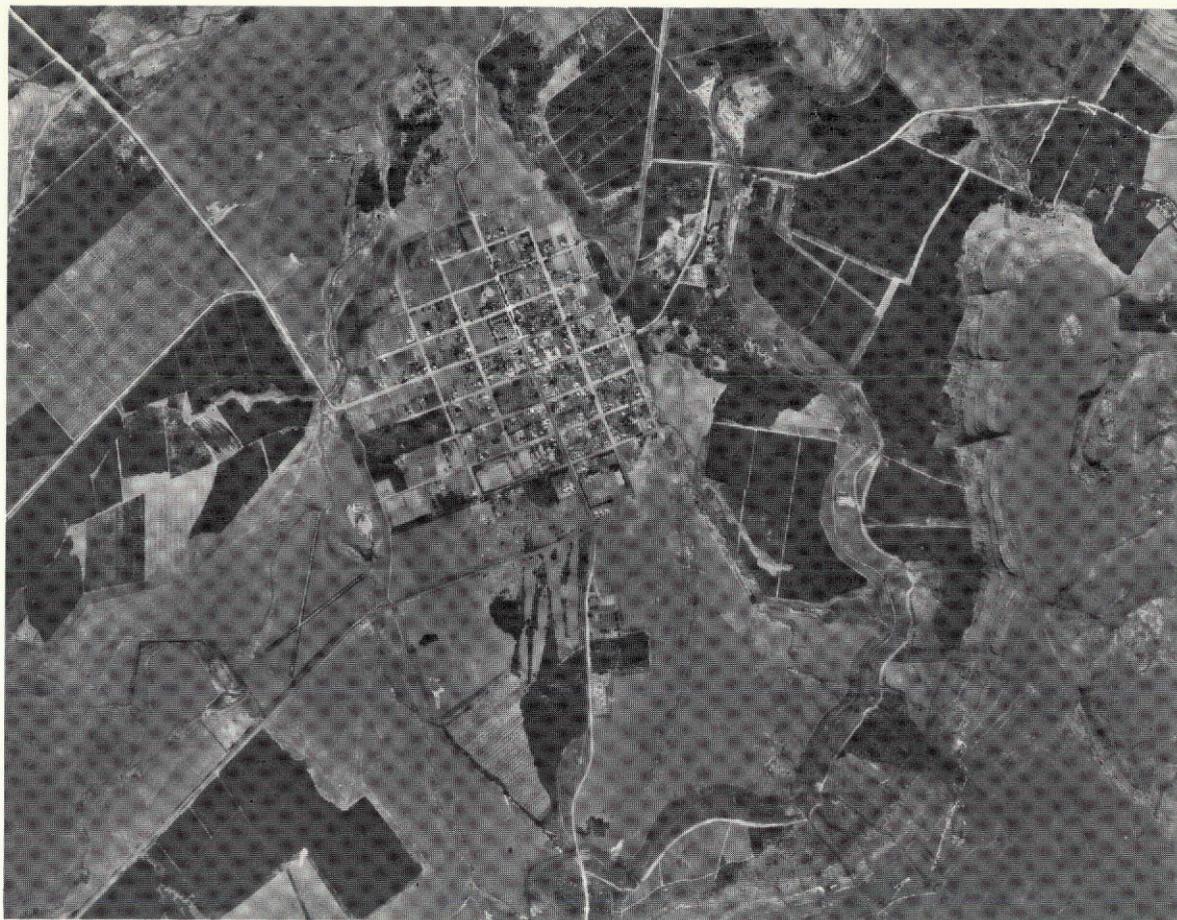
#### 4.4 Computer Compatible Tapes

CCT's for scene 1190-07143 were received a few days before drafting of this report. Promising-looking images were obtained by processing these on a hybrid computer system with low quality photo-fase outputs, but no conclusive results can be reported at this stage.

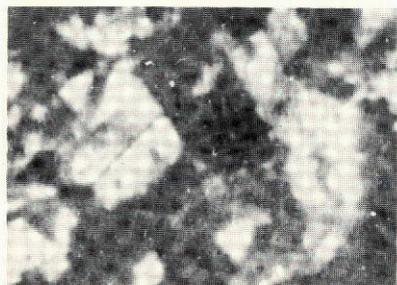
This investigation will be continued.

### 5. CONSEQUENCES OF STUDY APPROACH

The general approach in this study was to attempt to integrate



(a) Aerial Photograph 1:36 000 scale



(b) Band 5  
Black and white enlargement  
Negative print 1:150 000



(c) 1:500 000 scale  
False Colour photolitho  
print

Fig. 2 Comparative resolution of street pattern of Paulpietersburg on image 1047-07191

ERTS results on a broad scale into current survey programmes, rather than to create an intensive new research project.

The advantage of this approach was that it was possible to draw on the experience of a larger number individuals from a variety of agencies representing mainly "end users" confronted with practical resource survey and management problems rather than purely academic issues.

Also use could thus be made of existing organisational structures facilities and field personnel.

A disadvantage was that because of other priorities in current programmes of the agencies involved, progress sometimes was slower than expected and all objectives could not be achieved before the deadlines imposed by NASA. For this reason the project will be continued on a unilateral basis and a more comprehensive report will be completed probably within about six to nine months.

Furthermore, because the priorities of different agencies do not coincide geographically, a truly multidisciplinary investigation has not been achieved. Such an approach will most probably yield considerably more information than the sum of the separate investigations and might profitably be applied at some future opportunity.

## II. EVALUATION OF ERTS-1 IMAGERY FOR AGRICULTURAL INVENTORIZATION

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### A. SMALL SCALE SOIL AND TERRAIN MAPPING

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 Services  
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#### 1. OBJECTIVES

The object of the project is to evaluate the application of earth satellite imagery to small-scale soil and terrain mapping.

#### 2. SCOPE OF ACTIVITY

Field staff throughout the Republic are engaged in demarcating natural regions on the basis of homogeneity of soil pattern (associations) and terrain type (using a modified and expanded Hammond Procedure). These two factors (soil associations and terrain morphology) define the basic mapping unit, which has been called the pedosystem : significant changes in either or both of the factors define a pedosystem boundary. This mapping unit is proving to have very great practical significance and is appropriate for small-scale (1:250 000 and smaller) mapping. Satellite imagery was introduced into this program in an attempt to accelerate field operations, (to see if it really accelerated the field research or not) to confirm and refine boundaries obtained by field plotting or other conventional methods (1:50 000 Topographic maps) and possibly to reveal boundaries overlooked during the field survey. A further phase of the investigation was to investigate the extent to which individual characteristics within these patterns could be identified.

### 3. PROCEDURE

The general procedure followed in the field (during the mapping of soil associations) was to view the images with the aid of a hand lens. The technique employed during the investigation of images for terrain morphological and geomorphological purposes consisted of examining the images under magnification of a mirror stereoscope. The enlargement and an "apparent" slight stereoscopic effect improved the image. Terrain-morphological patterns and individual geomorphological elements were marked on maps. Selected information (Boundary areas) was compared with aerial photographs and 1:50 000 topographic maps.

### 4. ANALYSES AND FINDINGS

#### 4.1 Soil Mapping

The general trend of the reports submitted by the field personnel varies from negative to neutral for most of the Republic to slightly positive for limited areas.

It is clear, however, that identification of soil types is possible only where a close correlation exists between soil type, vegetation, terrain morphology, geology, climate or land-use.

The following examples serve to illustrate the application of satellite imagery for the mapping of soils. With the aid of these examples, an attempt will be made to indicate the positive contribution as well as the limitations of this technique for small scale soil mapping.

4.1.1 On the Makatini plain in North Eastern Natal (Image 1010-07131) it was possible, for example, to distinguish between soils of the Makatini/Shortlands association, which is under a bushveld- savanna vegetation, and very sandy soils covered by forests.

4.1.2 In the north-western Orange Free State (Image 1050-07362) it was possible to identify sandy soils on account of the light shade of ploughed lands.

4.1.3 Black clay soils of the northern Orange Free State and south eastern Transvaal are shown by the darker shade of ploughed lands

(1049-07301, 1048-07245). These soils can be delimited exceptionally accurately on satellite images as the transition from the surrounding areas is very sharply defined.

4.1.4 The black and red clay soils of the Springbokflats are differentiated clearly by the darker shade and land-use pattern.

4.1.5 The delimitation of yellow/grey acid sandy latosols (Plinthic) which occur on the granite between Johannesburg and Pretoria (1049-07301) present no problem. These soils can be identified as result of their lighter shade in comparison to the surrounding areas.

4.1.6 Similarly the red neutral sandy loam soils of the area south of Pretoria (1049-07301) as well as north western Transvaal (1050-07355) can be recognized by their darker shade.

4.1.7 The specific texture (drainage pattern) and darker shade make it possible to delimitate the black clay soils and lithosols on basalts of the Drakensberg etage (1049-07313).

4.1.8 In Natal, Transkei and Eastern Cape where a humid climate exists and the terrain morphology consists mainly of mountains and hills with a dense plant cover, no significant soil boundaries could be identified (1047-07181, 07193-07200). For mapping soil in these areas satellite images have restricted use.

4.1.9 The weakly developed soils on rock (A-B : argillic - C/R profiles) of the Western Cape in the vicinity of Bredasdorp and Swellendam (1143-07563, 1180-0812), can be mapped according to the land-use pattern.

4.1.10 Lithosols associated with mountains and hilly lands could be identified where the mountains and hills were clearly perceptible. For example, the Waterberge (1068-07363), Soutpansberge (1049-07292), Drakensberge (1048-07243), and the folded mountain systems of the Cape.

4.1.11 This study has shown that some regional soil boundaries, which are accentuated by one or more of the soil forming factors and/or land-use can clearly be seen on the satellite images. It was, however,

not possible to divide the abovementioned mappable areas into smaller areas by using the images. For example, it was not possible to distinguish the black clay soils of the northern Orange Free State and south eastern Transvaal into areas of black clay (south eastern Transvaal) and areas of solonchic clay soils (northern Orange Free State). Some soil boundaries expected to be very clear, could not be seen on the images. It was, for example, not possible to see any difference between the acid yellow/grey sandy soils of the Sheepmore flats and the acid, red, clays around Ermelo and the non-humic, red and yellow latosols (freely drained) around Paulpietersburg (1048-07245).

#### 4.2 Erosion

It was impossible to delimitate areas having widespread erosion. The reason for this may be the fact that these are found mainly in narrow strips along rivers and that their tone and texture are very similar to that of the deposits in which they occur.

#### 4.3 Agricultural land-use

It was possible to distinguish cultivated land, natural grazing land and irrigation schemes, but was not possible to subdivide further.

4.3.1 Areas under dryland cultivation have a characteristic chequer-board pattern, and the intensity of the use can be gathered from the general size of the squares. For example: The Malmesbury-Piketberg (1055-08064) and Bredasdorp-Swellendam (1143-07563) wheat growing areas. The north west Orange Free State maize growing area (1050-07364) and the cultivated lands of the south eastern Transvaal (1048-07243).

4.3.2 Grazing areas contain few features caused by human exploitation with the result that it has a more natural pattern with gradual transitions. Examples of the typical pattern of grazing areas are the western parts of Northern Transvaal (1050-07350) and Northern Natal (1047-07191).

4.3.3 Areas under irrigation can easily be identified by the small chequerboard pattern and their position next to a river. Examples of such irrigation schemes are Vaalharts (1069-07423), Breërivier in the Western Province (1180-08012), the Loskop irrigation scheme along the

Olifants River (1049-07295), the Sundays River and Fish River irrigation schemes (1176-07382) and the Pongola irrigation area in Northern Natal (1047-08191).

#### 4.4 General land-use

The objective of this section is to give a general evaluation of the satellite images for the study of land-use patterns (non-agricultural).

4.4.1 The 1:10<sup>6</sup> scale black and white prints made available are not suitable for land-use studies. Image quality is too low and variable and the scale too small for the extraction of consistently useful information. Use patterns can be distinguished to some extent but much of the required detail remains below the threshold of satisfactory identification.

Scenes that have been processed to 1:500 000 false colour form give excellent results, overcoming to a considerable degree the handicap of scale inherent in the 1:10<sup>6</sup> black and white prints. However, these are largely unavailable at the present time.

4.4.2 Roads can be located depending upon the degree of contrast between the road and adjacent land. Although streets in urban areas are most frequently invisible (for instance Johannesburg, Pretoria, Bloemfontein), streets in small towns such as Paulpietersburg (1047-07191) are sometimes visible.

Although tarred throughways such as the Ben Schoeman highway between Johannesburg and Pretoria and sections of the Pretoria-Witbank highway are not visible, minor roads in the Kalahari (1052-07472) and other localities with a dust, stone or calcrete surface, could be clearly seen as result of natural contrast and linear continuity. The main railway line between Cape Town and Johannesburg via Kimberley and Bloemfontein could be followed for nearly the entire distance as a result of cultural patterns along the line.

4.4.3 Dams of different sizes, from small farm dams to large reservoirs such as the Hendrik Verwoerd dam can be clearly seen. The ability

of satellite images to record farm dams in the vicinity of Burgersdorp is well illustrated on image 1140-07380.

4.4.4 Major political boundaries such as the South Africa/Swaziland and South Africa/Lesotho borders can be seen chiefly because of differentials in intensity of grazing and land-utilization. High contrast and lineal extent tend to overcome the limited resolution of the imagery. The border between the National Kalahari Gemsbok park and South West Africa, (20°E longitude) is, also exceptionally clear. (1055-08044).

#### 4.5 Geomorphology

Terrain morphological type boundaries are readily identified and in several cases it has been possible to trace such boundaries with greater accuracy and ease than is the case with conventional methods. However, in some instances boundaries could not be identified with the help of this aid. Individual geomorphological features could be identified reasonably consistently - these include mountains, ridges, river valley systems, footslopes, various kinds of lineaments, plateaux, pans, dunes, canyons, alluvial, colluvial and aeolean deposits, lagoons and structural watergaps.

##### 4.5.1 Terrain Morphology

The boundaries of each broad terrain morphological pattern were clear as long as there was a marked contrast with the adjoining pattern. It was observed that boundaries tend to become indistinct as the climate becomes humid (Natal Transkei, South eastern Transvaal, and eastern Cape).

The sharpest and clearest boundaries between patterns and individual components of a pattern were observed in semi-arid and arid areas. (See figure 1 and images 1055-08053, 1053-07533).

4.5.1.1 Large flat low lands, which display a fine texture and light tone on the images, form a considerable part of the Republic of South Africa, for example: Bushmanland (figure 1, 1055-05053), the Kalahari (1050-07350). In some instances these lowlands are featureless while

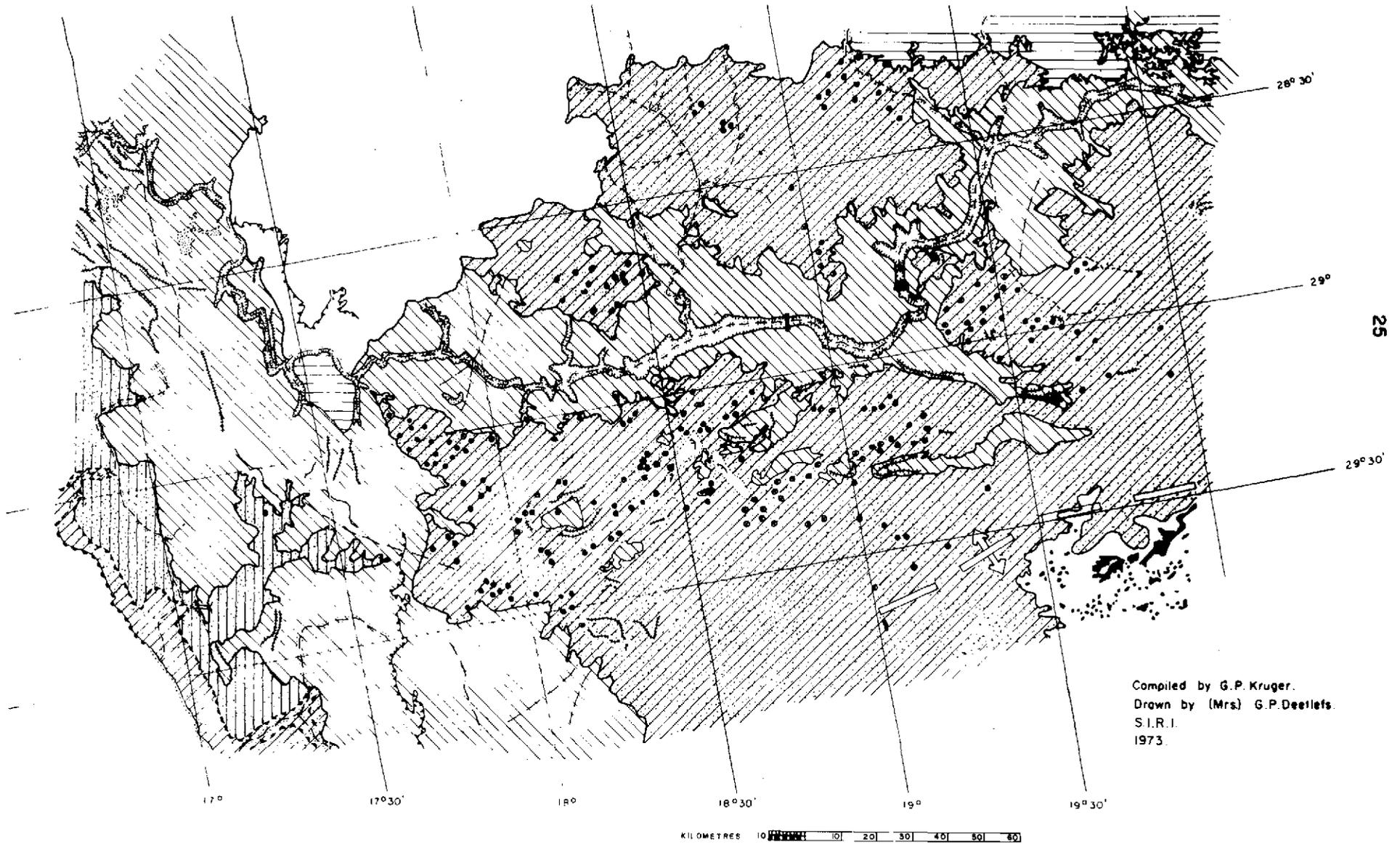


FIG 1

A RECONNAISSANCE GENERAL GEOMORPHOLOGICAL MAP OF THE WESTERN BUSHMANLAND AND NAMAQUALAND

GEOMORPHOLOGICAL MAP LEGEND FOR FIGURE 2A. FORM COMPLEXES (RELIEF CLASSES)

Flat low lands



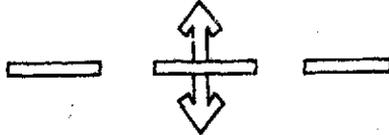
Undulating low lands



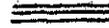
Hilly and mountainous areas

B. SPECIAL RELIEF FORMS

(1) Neotectonic cymatogenic anticlinal axis



(2) Joints

(3) Fragments of destructional land surfaces  
(Plateaus etc.)

(4) Isolated residuals (monadnock, butte)



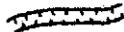
(5) Cuestas



(6) Hogbacks

(7) Ridges resulting from the intersection of  
valley slopes

(8) Edges of deep incised valleys and canyons



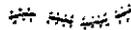
(9) Large waterfalls



(10) River channel



(11) Large accumulation flood plains and terraces



(12) Deflation depressions (Pans, Playas)



(13) Areas of drift sand



(14) Areas of transversal dunes



(15) Abrasion cliffs in rock



(16) Older abrasion cliffs in rock



(17) Beaches



in other cases they are dotted by isolated residuals. These residuals were easily identified on the satellite images by their darker tone.

4.5.1.2 Mountainous areas could usually be recognised easily (figure 1). Foothills were often confused with piedmont plains. The identification of highlands is feasible because of their specific coarse texture, pattern (for example Cape folded mountains) and darker shades. Sometimes it was possible to identify the lithology of the highlands. For example, it was possible to recognise dolerite ridges. These highlands are usually circular in form and have a dark shade. In the vicinity of Middelburg (Cape) (1140-07383) exceptionally good examples of this phenomenon were encountered. The crests of the highlands in this area, which consists of sedimentary rocks, have a light shade and show a dendritic pattern.

Highlands underlain by granite could also be easily identified, because the genetic tendencies of these areas are dictated by joint systems which contribute to a characteristic pattern. A typical example of a granite highland area is in the vicinity of O'Kiep (1055-08055).

4.5.1.3 Detailed morphometric characteristics which define morphological patterns must, however, still be derived from high resolution sources such as photographs and 1:50 000 topographic maps. It is not possible to deduce the slope form (convex, concave, straight) or to distinguish between high and low mountains and hills. It is, however, feasible, by estimating the area of highlands, to make a reasonably accurate assesment of the percentage steep land in a specific areas.

#### 4.5.2 Constructional landforms

These landforms can be identified by means of their position, shade, texture, and general morphology. Identification and delimitation of these landforms is made easier by a prior knowledge of their existence.

##### 4.5.2.1 Aeolean Landforms

Some dunes are not always distinguishable. In the Koa Valley two areas covered by transverse river sand dunes can be seen on the satellite images (figure 1, 1055-08053). It is, however, not possible

to identify the bulk of the sand dunes in this area. The same problem is experienced in the northern parts of the Kalahari Gemsbok National Park. The sand dunes in this area are probably concealed by vegetation (1055-08044).

The north-west, south-east strike of the dunes in the Kalahari north of Upington (1072-07592), as well as the north-south strike of transverse dunes west of the Langberge (1053-07533), and the dunes north of Kenhardt is clearly visible.

Active dunefields, which are not stabilised by vegetation, can be found along the south coast at various places. These dunefields with an exceptionally light shade are found near Hermanus (1180-08015), Bredasdorp (1143-07563), and Port Elizabeth (1049-07322). The identification of these dune fields present no problems.

Areas covered by aeolian sands, for example, Bushmanland (1055-08053), the west coast (1056-08114), (1055-08062), the Knersvlakte (1055-08062), north-western Orange Free State (1050-07362) and the coast of Zululand (1010-07134) can be recognised by the fine texture, light shades and sometimes by land-use patterns.

#### 4.5.2.2 Fluvial landforms

Only the larger accumulations of fluvial and colluvial deposits could be clearly identified. These landforms usually have a very light shade and fine texture. The fluvial forms are situated along rivers with the result that it sometimes shows the same pattern as the river systems.

Large alluvial deposits are encountered in the following areas:

- (i) Beaufort West along the Sout River (1059-07434).
- (ii) In the vicinity of Leeugamka along the Gamkariver (1142-07502).
- (iii) Along the Sak River and Verneukpan. (1198-08005)
- (iv) Along the Vaal River west of Kimberley (1142-07490).
- (v) Along the Orange River between Douglas and Prieska (1142-07490).

- (vi) Along the Doring River west of the Roggeveld ranges (1180-08012).
- (vii) Along the Limpopo River in the vicinity of Pafuri (1138-07240).

On the northern side of the Outeniqua ranges Tertiary high level gravels, which are remnants of old depositional surfaces, could be identified (1069-07434). The recognition of these surfaces is made possible by the land-use.

#### 4.5.2.3 Colluvial landforms

Large areas covered by colluvial deposits occur in the Republic. For example:

- (i) On the Piedmontslopes of the Cape folded mountains (Little Karoo, 1143-07560), colluvial areas, which have a lighter shade than the surrounding areas, are found.
- (ii) In the vicinity of Gamspoort and Soetvelde in Northern Transvaal (1138-07245) a second area of large colluvial deposits is found. On the 1:500 000 false colour images, these deposits are light yellow in colour.

#### 4.5.2.3 Lagoons, lakes and pans

The lagoons near Hermanus (1143-07563), Knysna (1142-07504), Durban (1047-07200), St. Lucia (1010-07131) and Saldanha (1055-08064) are clearly visible on the images. In some cases (Saldanha) deltas of rivers which flow into the lagoons could be seen.

Lake Chrissie and other smaller lakes near Ermelo (1048-07243) and Barberspan (1069-07414) can easily be identified in the images.

Pans which occur over the whole central plateau of the sub-continent are readily identified when they are lighter in shade against a dark background. These pans were easily identified in arid and semi-arid areas on sediments of the Karoo systems. In areas (for example Alexandria) (1049-07322) where the pans are very small (less than 50 metre in diameter), and are covered by thick vegetation, it was impossible to recognise them. Pans are mainly identified by their morphology (circular shape) and light shades.

Several lines of pans, which indicate fossil river beds, could be seen in the Kalahari (1053-07531) north western Free State (1050-07362), and Barberspan (1069-07420). These fossil river beds are of economic importance because of the large amount of underground water they contain.

#### 4.5.3 Destructional landforms

The surface of the Republic consists mainly of destructional landforms.

With the aid of the satellite images it was feasible to identify structural water gaps through the Magaliesberg (1049-07301), the Steelpoort Mountains (1138-07245), the Vredefort Dome (1050-07362) and the large number of gaps through the Cape folded ranges (1069-07434), 1142-07502), 1180-08012). The positions of structural water gaps through the Lebombo Ranges (1047-07182, 1047-07175) could also be determined by means of these images.

Several plateaux which are the result of resistant horizontal or near horizontal sedimentary layers are present in the Republic. Most of these plateaux and associated canyons and escarpments can be identified on satellite images. For example:

- (i) The Ghaapse (1052-07475, 1142-0749) and Ventersdorp (1050-07355), plateaux which are underlain by dolomite. The escarpment of the Ghaapse Plateau is especially recognisable.
- (ii) Quartzites of the Nama System gave rise to a number of plateaux for example the Blydeverwachtplateau near Karasburg which also occurs north of the Augrabies Waterfalls (1055-08053) and the Nababiep plateau west of Vioolsdrift (figure 1, 1056-071117).
- (iii) The plateau on which Nieuwoudsville (1055-08062) is situated is underlain by Quartzites of the Cape system. The Doring- Kobe- and Soutriviers incised deep canyons in this area into the sediments of the Cape System. Near Port Edward (1045-07200) the Mtamvunariver has deeply

incised the quartzites of the Cape System forming the Oribi Gorge which is clearly visible on the satellite images. Other canyons and plateaux along the east and south coast of the Republic incised in the Tertiary marine surfaces, are easily recognised as result of the unique vegetation on the plateaux and in the canyons.

Contrast again is the key to the location of river and stream channels. Dry sandy creeks are quite visible; rivers with numerous sand-bars highly visible; sections of broad rivers with well vegetated banks invisible. The Rio Save appearing on 1045-07173 demonstrates this clearly. Here the braided channels sections are in marked contrast to adjacent banks, and the waterfilled channel also provides strong contrast with the very dry sandy stream bed. On the contrary, in 1049-07364 (Bloemfontein) the streams leading to the Rustfontein, Tierpoort, Krugersdrif, Erfenis and Allemanskraal reservoirs are indistinct to invisible when dissociated from the typical reservoir image. Drainage lines cannot be followed in most instances. For example, the Tugela River is not visible in its lower course. The above details are needed for reference in land-use and soil studies. (Each soil landscape exhibits a characteristic surface geometry that is influenced by the stream pattern density).

## 5. CONCLUSIONS

The limitations of the satellite imagery accepted, there remain sufficient grounds for optimism that the material, particularly 1:500 000 false colour reproductions, will provide valuable aid in the soil and terrain morphological inventorization program currently being undertaken in South Africa.

### 5.1 Soil Mapping

In the case of soil mapping these images contribute very little new information as the differences they show are already known. However, the images allowed the personnel concerned to determine some of the known boundaries more accurately and quicker. This was mainly possible on the 1:500 000 false colour images.

The main value of these images for soil mapping is possibly the fact that it makes one aware of differences within specific areas, especially those where there is a lack of relevant information.

## 5.2 Geomorphological Mapping

The possibilities for small-scale geomorphological mapping are very promising. This was especially helpful in dry areas when mapping various geomorphological phenomena.

Application of ERTS imagery to the final preparation of the first detailed small-scale (1:1 500 000) terrain-type map of the Republic of South Africa revealed its potential usefulness and value with respect to the following:

- (i) The imagery is capable of providing a primary information base which is adequate and in many respects superior to other, more conventional sources of data on broad-scale terrain patterns, mainly because the latter (e.g. air-photos, topographic maps) are too detailed, too voluminous and non-synoptic).
- (ii) The imagery is particularly valuable in the case of areas for which there may be no conventional airphotographic or topographic coverage.
- (iii) Costly outlay in acquiring all available airphotography and topographic coverage is eliminated. With the satellite imagery as the primary and continuous base, it has become necessary only to acquire and study conventional coverage of preselected control sections or test areas.
- (iv) The practical problems and drudgery associated with the analyses and sorting of massive volumes of large-scale photographs and maps in a small-scale study such as this, are eliminated. In other words, the scale of the latter is inappropriate to a study such as this, whereas that of the satellite imagery is tailor-made. The savings in capital outlay, time and fatigue are difficult to assess quantitatively at this stage but they are believed to be considerable.

B. EVALUATION OF ERTS IMAGERY FOR SMALL-SCALE MAPPING OF  
GENERAL AGRICULTURAL INFORMATION

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1. OBJECTIVES

The purpose of this project was to evaluate the application of satellite imagery to small-scale general agricultural inventorization.

2. FINDINGS

2.1 Subdivision into agricultural regions

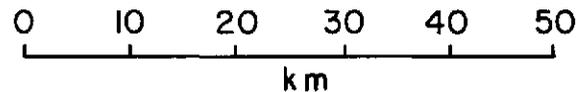
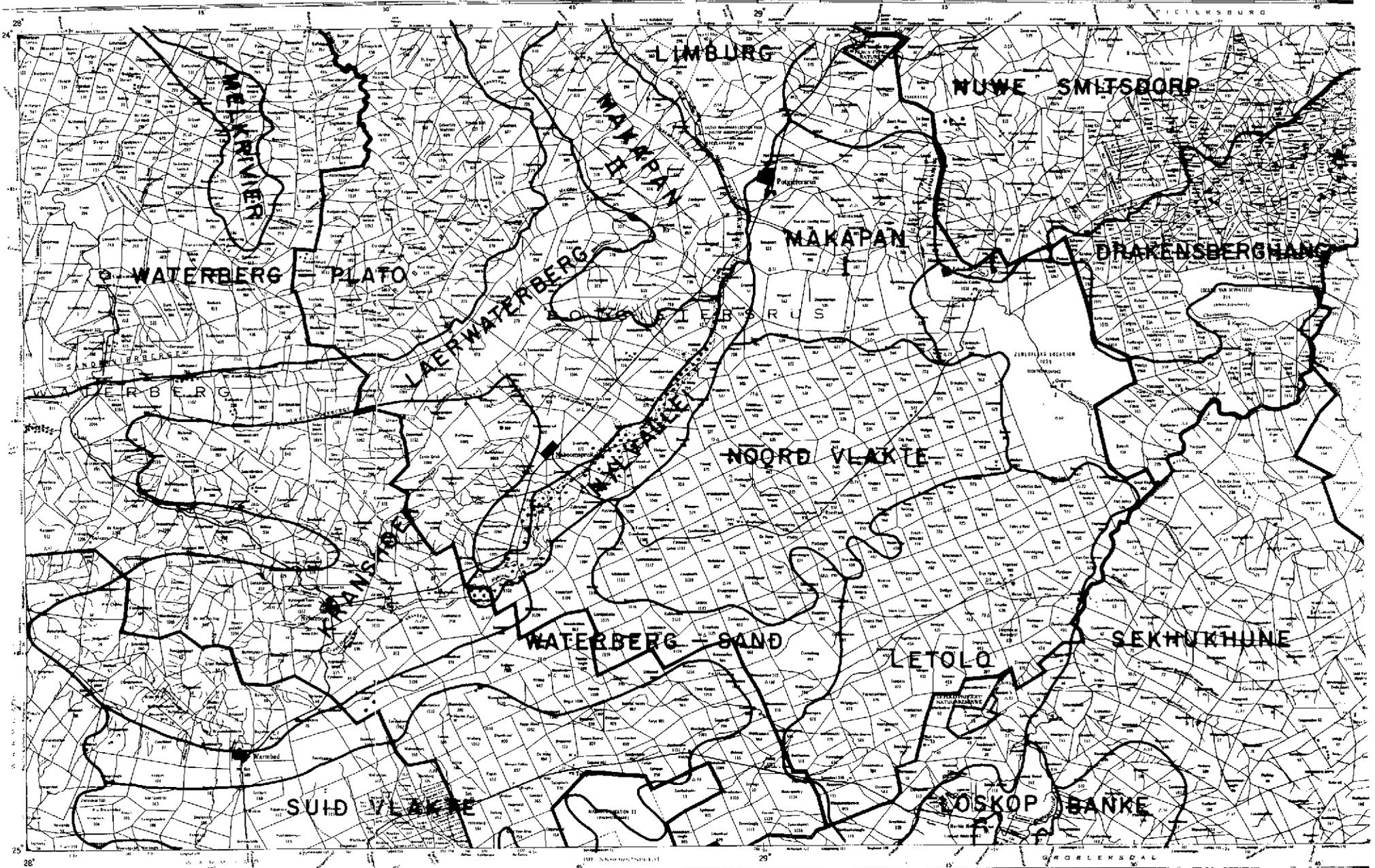
Homogeneous agricultural regions can be delimited as result of drainage patterns and colour shades. The study area on image 1049-07295 in the form of 1:500 000 false colour was divided into broad regional units with regard to the above mentioned norms.

Figure 2 superimposed on a 1:500 000 scale topocadastral map of the area, illustrates these agricultural regions. No further subdivision was possible.

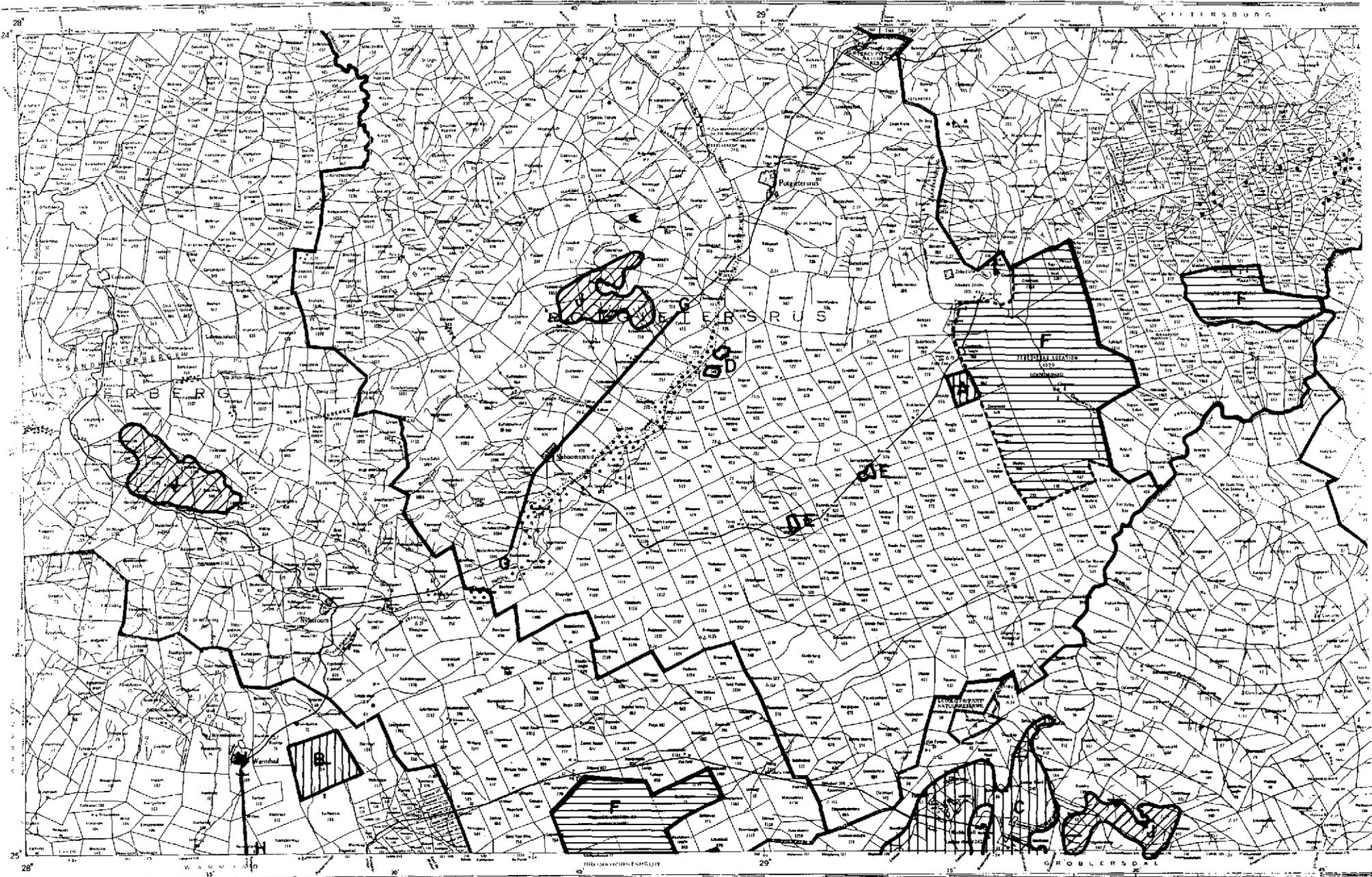
2.2 Agricultural features and land-use

It is possible to differentiate between dry land farming, irrigation and between natural pasture and artificial pasture and identify their features:

1. There is a difference of colour shading between the farms Grasplaats (A figure 3) and Tweefontein (B figure 3). It was found that the farm Grasplaats is covered by artificial pasture (*Cenchrus Ciliaris*) while Tweefontein is covered by natural vegetation.
2. A difference could also be seen between dry land, winter wheat and winter wheat under irrigation. Areas C and D, marked on



BROAD AGRICULTURAL REGIONS  
BASED ON E 1049-07295



35

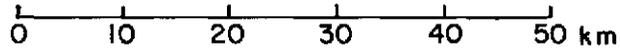


FIG. 3

GENERAL AGRICULTURAL INFORMATION

BASED ON E 1049-07295

figure 2 are covered by winter wheat under irrigation. The areas marked E on figure 2 are planted with winter wheat under dry land conditions. A clear difference in shade could be seen between these areas.

3. Bantu areas could be identified as result of the exploitation of vegetation and are shown on figure 2 by symbol F.
4. Areas damaged by veldfires during the winter months of 1972 are clearly visible on image 1049-07295. These areas are hardly visible on image 1085-07303 taken later during the mentioned period which partly overlaps with 1049-07295. This proves that the vegetation improved. Some of the areas are shown (on figure 3) by the symbol J.

### 3. CONCLUSIONS

This preliminary investigation has shown clearly that these images have great potential in evaluating homogeneous agricultural areas for the purpose of planning for optimal land utilization. It is however, impossible to elaborate on this subject as there is a need for more information. Further investigation should prove a valuable prospect for agricultural planning and land utilization in the Transvaal Region.

### III. PLANT ECOLOGICAL SURVEYS

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#### PROBLEMS

1. There were a number of problems that had to be rectified on receipt of the ERTS imagery. Preliminary tests by a number of botanical survey officers using panchromatic enlargements at a scale of 1:1 000 000, with each band printed separately, evoked a poor reaction as at that scale only the most gross boundaries showed. Panchromatic enlargements to 1:500 000 and 1:250 000 provided more information but did not very greatly enhance interpretation and required more experience of normal photo interpretation than some workers had.

The production of photolithoprints at a scale of 1:500 000 in a false colour form proved to be a major advance, providing an additional dimension that enabled many features, indistinguishable on the panchromatic prints, to be recognised. The litho prints were not without drawbacks as different processing conditions could accentuate or under emphasize vegetation differences. Nevertheless, this medium was considered the most useful product.

2. Throughout these assessments a colour additive multispectral viewer was available and used for certain aspects, but although a variety of useful colour variations could be obtained, the small 1:1 000 000 scale was inhibitory and the parallax effect distorted patterns and even affected colour variation. It is with interest that the arrival of computer compatible tapes is awaited for their potential application to a variety of cartographic as well as interpretative problems.

3. Another major problem was the periods for which the imagery was available. Most images received were for the months of August 1972 to January 1973. The early months show little differentiation of the vegetation during the winter dry season when up to September most trees are leafless and the grass cover is bleached. December and January represent a summer period when both grass and trees are green. Many vegetation types are visible, but experiments with air photos suggest

that for maximum grass and tree vegetation contrasts March and April imagery would be best as the trees and grasses assume different colourings. In attempting to monitor fires, the irregular receipt of coverage made a detailed analysis impossible, though even from the available images good conclusions could be drawn, including the surprising revelation that on September 8 85% of one small veld type in Natal showed evidence of veld burning.

A. AN ASSESSMENT OF ERTS-1 IMAGERY FOR DETECTING VEGETATION PATTERNS IN THE CENTRAL TUGELA RIVER CATCHMENT AREA OF NATAL, SOUTH AFRICA

Investigator

D. Edwards

1. OBJECTIVES

To assess the value of 1:500 000 False Colour representation of ERTS-1 image 1047-07193 of 8 September 1972 for detecting vegetation patterns in the Central Tugela River Catchment Area of Natal, an area which was previously extensively surveyed. Specific objectives were to ascertain what kinds of vegetational and ecological features were differentiated on the ERTS image taken at the end of the dry season, and especially of important ecological interfaces such as invading Acacia Thornveld-grassland contact.

2. METHODS

A false colour representation of ERTS-1 image 1047-07193 of 8 September 1972 at a scale of 1:500 000 was compared after annotation mainly on hue and physiographic characteristics with the relevant part of the 1:250 000 vegetation map of the Tugela Catchment Area published by Edwards (1967). A Zeiss Sketchmaster was used to check the accuracy of the presumed vegetation boundaries drawn from the ERTS image with that of the 1:250 000 vegetation map. Knowledge of the vegetation and characteristics of the area were then used to evaluate the features shown on the ERTS image. Use was also made of an Additive Colour Viewer to examine and compare at a screen scale of 1:1 000 000 this and a subsequent December 7th image 1137-07202.

It is appropriate here to point out that vegetation mapping, particularly in an area of great physiographic and ecological diversity such as the present one chosen for evaluating the ERTS imagery, is subject to considerable generalization and compromise appropriate to the final scale of mapping used. These aspects were appreciated and taken into account when assessing the "recognition ability" of the false colour ERTS image. The evaluation was intended primarily to determine to what extent the ERTS image differentiated the various kinds of vegetation entities present in the area and of the nature of the entities differentiated, rather than to use the ERTS image for broad sweeping generalizations of the vegetation landscape which are usually evident on the images.

### 3. DESCRIPTION OF THE STUDY AREA

A detailed account of the study area is given by Edwards (1967)<sup>1</sup> of the 29 000 km<sup>2</sup> catchment area of the Tugela River in the central part of the province of Natal. The central part of this catchment shown on ERTS image 1047-07193 is one of major ecological diversity with a wide range of ecological types. As such it is of singular interest for assessing what can be detected of the various ecological and vegetational features on satellite imagery.

Briefly, the five ecological regions represented on the Tugela catchment area of the ERTS image are:

3.1 The Tugela Valley, a Region of marked topographic variation with an altitudinal range from approximately 170 m to 1400 m. The warmer eastern semi-coast part of the Valley below 250 m has been excluded because of cloud cover. The Valley Region is dry with a mean annual rainfall between 600 mm and 900 mm on the area covered by the ERTS image. Temperatures range from minima of -6,7 °C in the coldest interior part around Weenen to extreme maxima generally of 45 °C. The

<sup>1</sup> Edwards, D. (1967). A Plant Ecological Survey of the Tugela River Basin. Mem. Bot. Surv. South Africa No. 36. Pietermaritzburg : Natal Town and Regional Planning Commission.

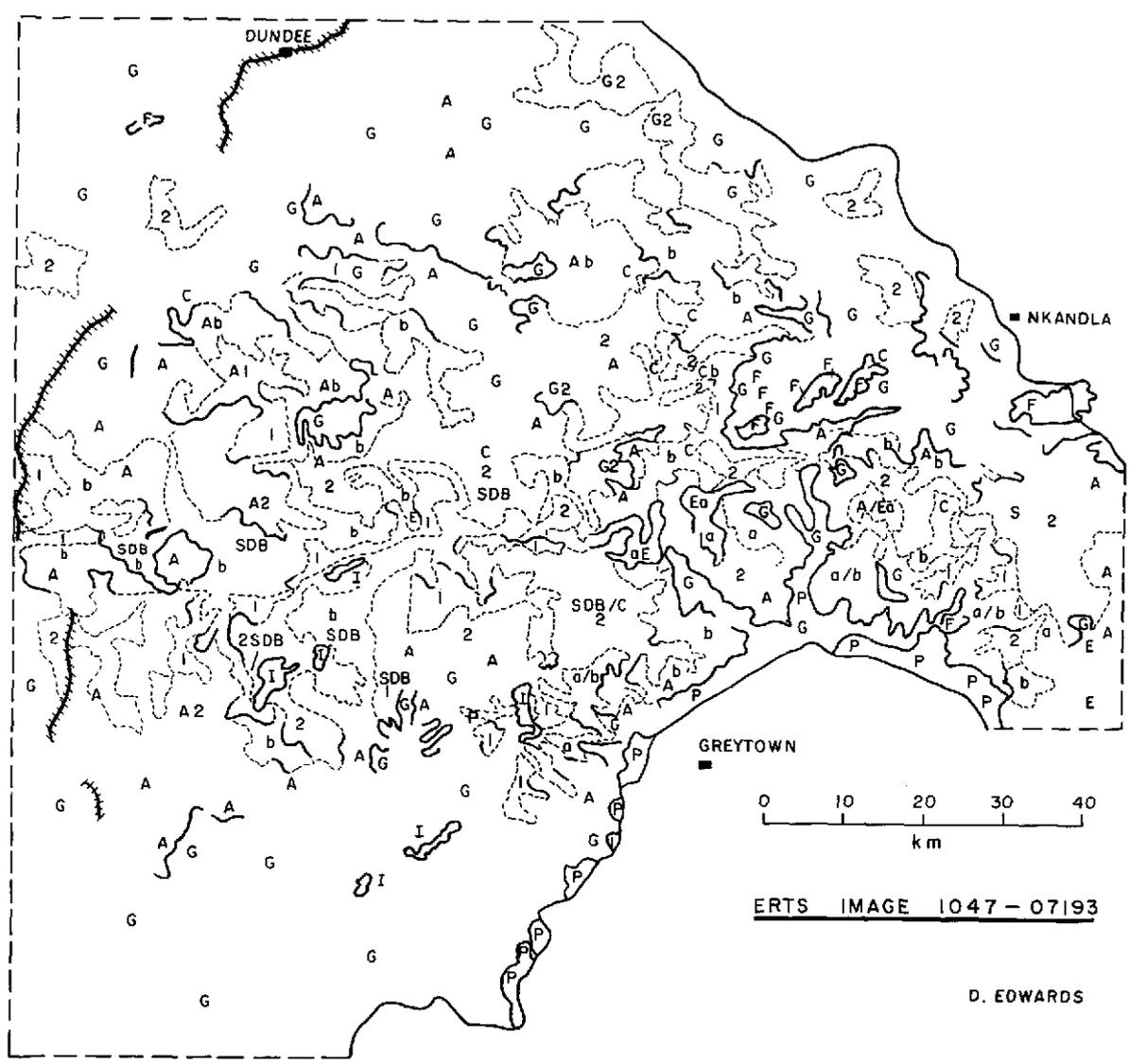
vegetation ranges from open to closed tree or shrub dominated succulent Euphorbia and Aloe scrub, to deciduous, evergreen and mixed deciduous-evergreen scrub and savanna, including extensive microphyllous deciduous Acacia thorn tree dominated types. The Region is severely overgrazed and extensively eroded in the vicinity of heavy populations of the Bantu people, but in other less accessible areas and where white farmers have selectively grazed the veld, scrub development and scrub encroachment into former grassland is extensive. The Region was mapped by Edwards (1967) into 8 main vegetation types.

3.2 The Interior Basins Region inland of the Tugela Valley is a region of uniform topography with little relief apart from low hills and ridges mainly of dolerite intrusions. Mean annual rainfall ranges from 600 mm to 1000 mm and extreme temperatures from  $-5,6^{\circ}\text{C}$  to  $41^{\circ}\text{C}$  with severe frosts during winter. The Region was mapped by Edwards (1967) into four main grassland types with, in addition, Acacia Thorn outliers of the Valley Region locally on the dolerite hills and ridges and extensively on the acetone between the Interior Basins and Valley Regions where they are of secondary origin as a result of past veld mismanagement on erodible solodized-solonetzic clay pan soils.

3.3 The Coast Hinterland, Midland Mistbelt and Highlands Regions are moist, misty regions that become progressively cooler from 500 m near the coast to 2100 m in the interior. On the part of the ERTS image studies they are along the catchment boundary and form the summits of high hills and mountains. In the interior Highlands Region severe frosts occur, but only light frosts occur in Coast Hinterland Region. The mean annual rainfall is between 800 mm and 1500 mm. The three regions were mapped by Edwards into 4 main grassland and three evergreen forest types. Extensive exotic pine, eucalyptus and wattle plantations occur in the regions.

3.4 The Coast Lowlands Region with its subtropical character and extensive sugar cultivation is, insofar as the Tugela River catchment is concerned, completely cloud covered on the ERTS image and has thus been excluded from this study. South of the Tugela River estuary to Durban in the extreme southeast corner of the ERTS image, the Coast

COMPARATIVE ANNOTATION OF MAIN VEGETATION  
PATTERNS OF CENTRAL TUGELA RIVER CATCHMENT  
AREA



— CONFIRMED BOUNDARIES FROM ERTS IMAGE AND PREVIOUS SURVEY

----- VEGETATION BOUNDARIES FROM ERTS IMAGE ONLY, CORRESPONDING TO VALID BOUNDARIES NOT PREVIOUSLY MAPPED AS SUCH.

+++++ RAILWAY

FIG. 1

LEGEND : FIGURE 1

- A  
G      Confirmed boundaries from ERTS image and previous survey
- A      Acacia karroo-A.nilotica Thornveld  
C      Combretum apiculatum Tree Veld  
E      Euphorbia tirucalli Succulent Scrub  
S      Sclerocarya-Acacia Tree Veld  
SDB    Semi-deciduous Bush (Acacia-Boscia-Olea-Schotia Scrub)  
G      Grasslands (of various types, seldom distinguishable)  
F      Evergreen Forests (of various types, not distinguishable)  
P      Exotic tree plantations  
I      Irrigated croplands
- Vegetation boundaries from ERTS only, corresponding to valid boundaries not previously mapped as such
- a      Dense Succulent or Evergreen or Semi-deciduous Scrub  
b      Moderately Dense Succulent or Evergreen Scrub or Dense Semi-deciduous Scrub  
1      Extensive Sparse Vegetation, mainly Severely Eroded and Overgrazed Land  
2      Moderately Sparse Vegetation, mainly Moderately to Locally Severely Eroded and Overgrazed
- Noté: Many of the boundaries between the open deciduous microphyllous savanna form of Acacia karroo-A.nilotica Thornveld and Grassland cannot be distinguished on ERTS image 1047-07193 of 8 September 1972, the end of the dry season.
- +++++ Railway

Lowlands are characterized by a distinctive colour patchwork of sugar cultivation occasionally interspersed by darker hued Evergreen Coast Lowlands Forest and with a line of Coast Dune Forest and Scrub.

#### 4. RESULTS (See map, Fig. 1)

For evaluating the vegetational and ecological differentiation apparent on the false colour representation of ERTS image 1047-07193, the time of year at which the imagery was recorded appears to have been critical. The date of photography, 8 September 1972, is at the end of the dry winter season immediately prior to the spring rains that occur later in the month and even in the following month in some of the driest areas. Thus, apart from evergreen plant communities, such as the indigenous evergreen forests, evergreen succulent and semi-deciduous scrub types, exotic plantations of trees such as Pinus spp., Eucalytus spp. and Black Wattle (Acacia mearnsii), and irrigated crop land and sugar farms, most of the image shows a general absence of infrared reflectance (red tones) that is typical of the end of dry season. There is also an abundance of freshly burnt grassland that is also typical of the end of the dry season. There is evidence of a slight infrared reflectance from the vegetation of the moister higher areas, and increasingly so towards the coast where higher temperatures and milder winters stimulate earlier vegetation growth than in the colder inland areas and in the dry Valley Region. The general drabness of the false colour representation of 1047-07193 of 8 September 1972 is evident by comparison with the partly cloud covered image 1137-07202 of 7 December 1972, which shows an overall considerably higher infrared reflection from the early summer growth of grass and deciduous tree and shrub vegetation.

A minor point also brought out in the comparison of the September and December images was the lower incidence of long shadows in the rugged topography in the summer photography, a feature assisting local interpretation.

With the exception of extensive evergreen forests, dense evergreen scrub, exotic tree plantations, irrigated croplands, sugar fields, and severely eroded and overgrazed vegetation, no vegetation types/plant

communities as mapped and surveyed by Edwards (1967) could be consistently and unambiguously delineated over the extent of their distributions. A major disappointment was the inability to detect, except over short distances and especially negatively discernable in the important Estcourt to Dundee area, the important grassland-Acacia Thornveld interface that separates the Dry Valley Scrub and Savanna from the Interior Basins Grasslands. All of the following 17 vegetation types that were mapped by Edwards (1967) for the area covered by the ERTS image could sometimes be distinguished from neighbouring types in different parts of their distribution ranges:

- (1) Semi-coast Secondary Aristida junciformis Grassland.
- (2) Mistbelt Secondary Aristida junciformis Grassland.
- (3) Themeda-Trachypogon Highlands Grassland.
- (4) Themeda-Hyparrhenia Grassland.
- (5) Moist Transitional Themeda-Hyparrhenia Grassland.
- (6) Tristachya-Digitaria Grassland.
- (7) Transitional Tristachya-Digitaria Grassland.
- (8) Semi-coast Forest.
- (9) Mistbelt Mixed Podocarpus Forest.
- (10) Mountain Podocarpus Forest.
- (11) Spirostachys Valley Woodland.
- (12) Euphorbia tirucalli Succulent Scrub.
- (13) Combretum apiculatum Tree Veld.
- (14) Semi-deciduous Bush (Acacia-Boscia-Olea-Schotia Scrub).
- (15) Sclerocarya-Acacia Tree Veld.
- (16) Dry Coast Acacia karroo-A.nilotica Thornveld.
- (17) Interior Acacia karroo-A.nilotica Thornveld.

Study of the ERTS image showed that the following vegetational features are well and consistently shown:

- (i) Evergreen forests and exotic tree plantations, often differentiated.
- (ii) Dense evergreen succulent, evergreen and semi-evergreen scrub.
- (iii) Dense deciduous and relatively dense semi-deciduous scrub.
- (iv) Heavily overgrazed and extensively eroded areas.
- (v) Less completely severely overgrazed and eroded areas.
- (vi) Burnt areas (see separate report by M.L. Jarman).
- (vii) Cultivated and irrigated crop lands.

These are all essentially extreme physiognomic-structural classes of vegetation which often cut across the finer ecological and floristically based classification of Edwards (1967), but which are also sometimes coincident with his classification in certain situations, especially where there are sharp physiographic and hence vegetational discontinuities, or where a certain land-use is associated with a particular ecological-floristic class of vegetation. For instance, Euphorbia tirucalli Succulent Scrub was mapped by Edwards (1967) to include both dense and open phases. On steep hillsides in the Tugela Valley the dense phase of E. tirucalli Succulent Scrub often forms a distinctive zone of vegetation that can be discerned on the ERTS image by its high infrared reflectance from surrounding open, lower infrared reflecting vegetation. However, there are a number of situations where such E. tirucalli Succulent Scrub is contiguous with dense mixed mesophytic Acacia Thorn Scrub, dense scrub forms of Combretum apiculatum Tree Veld, or undisturbed Spirostachys Valley Woodland that have similar high infrared reflectance and textural image characteristics. On the other hand, much of the Spirostachys Valley Woodland on the valley floor has been uniformly destroyed and overgrazed and can be discerned on the ERTS image.

As previously mentioned, it was disappointing that on this dry season imagery there were few instances that could be found of differential reflectance between the two important and extensive physiognomic-structural classes of grassland and deciduous open microphyllous Acacia

Thorn savanna. Even on the early summer December imagery with its generally high infrared reflectance from the summer growth no clear differentiation could be found of these two vegetation classes.

## 5. CONCLUSIONS

5.1 The dry season 1:500 000 false colour ERTS imagery was effective in differentiating the extreme sparse cover and dense tree and shrub (forest and scrub) physiognomic-structural classes of vegetation even when these are not always readily mappable owing to their small fragmentary nature and the small scale of the imagery. The imagery was generally not successful in differentiating intermediate deciduous savanna and grassland physiognomic-structural classes of vegetation, a feature that is almost certainly due to characteristics of the vegetation during the dry season and early summer periods when the imagery was recorded. General experience suggests that late summer and early autumn imagery would have been more successful.

5.2 Despite the intensive experience gained over a number of years during a previous survey of the Tugela River catchment area, the ERTS imagery provided an overall and more balanced view of several aspects of this ecologically complex area. The ERTS view suggests that greater emphasis could have been laid upon the mapping of various types of dense tree and shrub vegetation on the one hand, and of open severely degraded vegetation on the other, both aspects having been underestimated in mapping for their land-use significance to the region. The ERTS image suggests a simple and logical map classification of major degradation stages in the vegetation that is consistent even for the summer growth of vegetation shown on the December image.

5.3 The recent availability of false colour litho prints at 1:500 000 scale of the ERTS imagery greatly facilitated interpretation. Previous attempts at interpreting 1:1 000 000 B/W prints and positives were extremely frustrating and difficult unless only the grossest features were to be delineated. Imagery scale enlargement to 1:250 000 would give greater clarity and definition and give better

interpretation facility than at 1:500 000.

5.4 This evaluation for a well known but ecologically complex region confirms that ERTS imagery is one of the most efficient and valuable technological aids available for reconnaissance and small scale ecological and vegetation surveys. Not only can it facilitate ground work, but it also assists in providing a better overall synthesis. An improvement in resolution would make the imagery even more valuable.

B. NATURAL VEGETATION BOUNDARIES OF THE SOUTH WESTERN CAPE PROVINCE (TEST SITE B.) FROM ERTS-1 IMAGERY

Assistant Investigators : H.C. Taylor  
C. Boucher

1. OBJECTIVES

To investigate the potential of ERTS-1 imagery at a scale of 1:500 000 in false colour photolithoprint form in recognising and mapping vegetation and cultural boundaries.

2. METHOD

ERTS images, 1055-08064 of the 16th September 1972 and 1180-08015 of 19 January 1973 were reproduced in the form of 1:500 000 scale false colour photolitho prints comprising MSS bands 4, 5 and 7.

The various patterns visible on these scenes were interpreted in the light of present knowledge and ground checks through parts of the area.

3. DESCRIPTION OF STUDY AREA

The South Western Cape, Test Site B, has been covered by two ERTS scenes; 1055-08064 (16 September 1972) covering the northern sector, and 1180-08015 (19 January 1973), the eastern portion.

This area forms the South West corner of South Africa with the port of Cape Town being the major urban centre.

There are two major topographical regions, the mountains and the

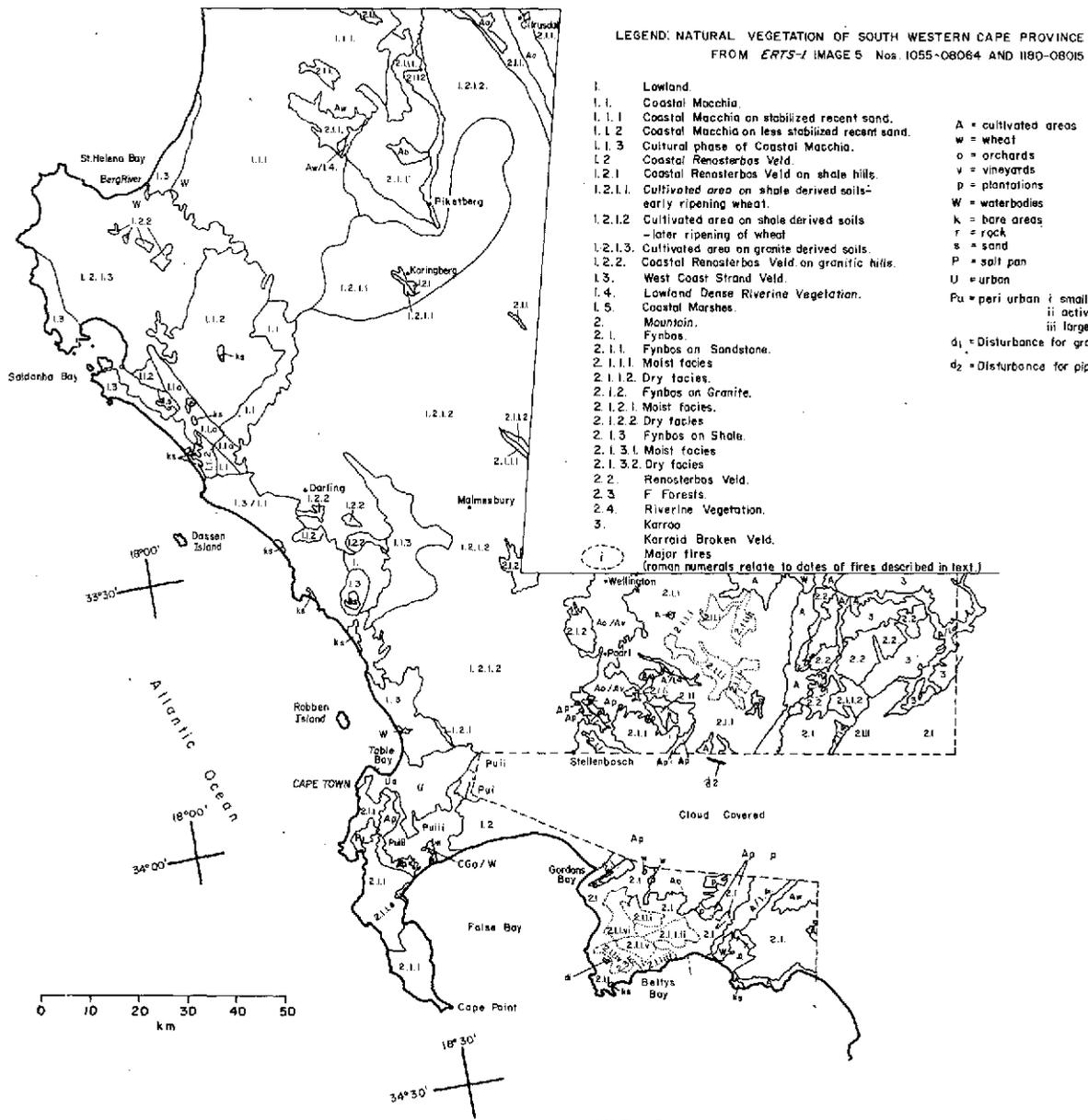


FIG. 2

lowlands. Most of the mountains are of sandstone with strong linear patterns that in the past have been extensively folded and faulted and weathered to a rugged landscape. The steep topography may be seen on the imagery.

The lowlands comprise undulating topography of recent sands and shales. Granite hills protrude from the lowland plain. The weathering pattern of these granites contrasts with that of the rugged sandstone areas, the granite hills having a smooth, rounded appearance.

The climate of the Western Cape may be classified as of the mediterranean type, the rainfall occurring largely in winter.

The natural vegetation resembles somewhat in physiognomy the vegetation of other mediterranean regions. The local term for this vegetation is 'fynbos', and it sometimes referred to as Macchia. It is a mixture of ericoid and broad leaved sclerophyllous shrubs with grass-like herbs of the family Restionaceae. Fynbos may be tall ( 3 metres +), medium (1,0 - 3,0 m) or low (0,1 - 1,0 m) depending on habitat. The vegetation has been mapped into several Veld Types by Acocks (1953).

In drier areas, in the rain-shadow of the Westerlies, semi-desert dwarf shrub vegetation occurs, which is known locally as Karoo.

Fynbos on the lowlands has been largely destroyed for intensive agriculture. This area produces a considerable amount of wheat and virtually all of South Africa's grapes from which wine is made.

#### 4. RESULTS (See map, Fig. 2)

##### 4.1 Coast Lowland Areas (map legend 1)

The West Coast belt depicted on ERTS image 1055-08064 consists mainly of flattish, undulating and rolling topography comprising Veld Types 34 (West Coast Strandveld) and 47 (Coastal Macchia) on Recent sands and Veld Type 46 (Coastal Renosterbosveld) on shale and granite. In the extreme north and south of the scene the steep relief of the Table Mountain Sandstone stands out clearly.

In the lowlands, some general patterns and impressions which are not shown on maps and cannot be readily discerned during ground

reconnaissance, stand out plainly. Examples of these are the 'dark smudge' of Coastal Macchia (map legend 1.1.2) east of Langebaan Lagoon, the lighter mosaic of early-ripening wheatlands in the Piketberg District (map legend 1.2.1.1) and the lowland drainage system between Darling and Malmesbury (map legend 1.1.3). These features may be of value in determining agricultural potential and this is important in planning.

#### 4.1.1 Coastal Macchia - Veld Type 47 - (map legend 1.1)

The boundaries of this Type depicted on ERTS scene 1055-08064 agree closely with those mapped by Acocks (1953) except in area 1.1a (see map) where Acocks shows a narrow tongue of Coastal Renosterbosveld (Veld Type 46) extending from the Darling area north-west to the eastern shores of Langebaan Lagoon. On a rather superficial knowledge of this area and from the lack of differentiation on the ERTS image it would seem that Acocks' boundary is faulty here.

##### 4.1.1.1 Coastal Macchia on stabilized recent sand (map legend 1.1.1)

On these relatively stable sands the topography is flat or very gently undulating. There is some cultivation of wheat but due to the low rainfall crops are poor and many fields are fallow. The natural vegetation consists of a markedly restioid fynbos appearing dark brown in the field. The ERTS scene shows a mosaic of white (fallow), pink (wheatfields in leaf) and irregular patches of grey (restioid fynbos).

##### 4.1.1.2 Coastal Macchia on less stabilized recent sand (map legend 1.1.2)

This is an area of recent dunes, of white sand, poor in nutrients and sharply undulating. Because of the poor and unstable substratum, no cultivation is practised, the area being devoted to extensive grazing. The natural vegetation, though degraded in places, is still intact, hence the comparatively uniform smudged blue-pink appearance on the imagery.

The lighter tone delimited by the dotted boundary in 1.3 on the map, depicts recent burns where the white sand shows through burnt stubble. Open dunes show up white ( $K_s$ ).

4.1.1.3 The Lowland cultural phase of Coastal Macchia (map legend 1.1.3)

This lowland area of Coastal Macchia on Recent sands consists partly of artificial pastures in various stages of establishment (white to pink) and partly of remnant restioid Coastal Macchia patches (dark blue-grey). The area forms the catchment of a stream: its drainage line continuing in a north-westerly direction can be clearly seen.

4.1.2 Coastal Renosterbosveld - Veld Type 46 - (map legend 1.2)

This type occurs inland of Coastal Macchia, on undulating and rolling terrain on soils derived mainly from the Malmesbury geological series of shales and quartzites, or in the west and south, from Cape Granite. Most of the natural vegetation has been removed to allow for cultivation.

4.1.2.1 Coastal Renosterbos on shales (map legend 1.2.1)

An example of the remaining natural vegetation on shale soil from the Malmesbury series north of the village of Koringberg is indicated by the blue-grey image hue (map legend 1.2.1).

Intensively cultivated wheatlands (map legend 1.2.1.1) on shale soils derived from the Malmesbury series in the Piketberg District are easily identified by their red hue, though of a paler red hue than the wheatlands further south (map legend 1.2.1.2). In the vicinity of Piketberg the wheat ripens early, probably due to higher spring temperatures and a lower local rainfall. The intensively cultivated wheatlands (map legend 1.2.1.2) on soils similar to those at Piketberg but where the vegetation remains greener (unripened wheat with a mixture of other grains and of lupins) until the end of October, are shown in the ERTS scene as a much redder mosaic.

Wheatlands on soils derived from granite in the Saldanha area (map legend 1.2.1.3) show a somewhat bluer tint in the mosaic, probably due to more old fallow lands with ruderal vegetation.

4.1.2.2 Coastal Renosterbosveld on granite hills (map legend 1.2.2)

Remnants of this type of vegetation on granite hills of this area are of a lighter hue on the ERTS scene than that for natural

vegetation on Malmesbury shale soils (map legend 1.2.1).

#### 4.1.3 West Coast Strandveld - Veld Type 34 - (map legend 1.3)

This is a low, open, semi-succulent scrub seen as a smudgy greyish-pink hue on the ERTS image. Further south on the West coast it becomes difficult to distinguish this Veld Type from Coastal Macchia (map legend 1.1).

#### 4.1.4 Lowland riverine vegetation (map legend 1.4)

Rare on image, can only be distinguished from valley cultivation (map legend (Aw) ) by its narrow extent within mountainous areas and by local knowledge of the terrain.

#### 4.1.5 Coastal Marshes (map legend 1.5)

A distinctive lilac colour, in the south-eastern part of Langebaan Lagoon depicts marshes with vegetation of Phragmites - Senecio halimifolius, Chenopod - Juncus and other halophytic communities.

#### 4.2 Mountainous areas (map legend 2)

The delineation of Table Mountain Sandstone Mountains bearing Veld Type 69 (Fynbos or Macchia) is generally very clear. Although the amount of Veld Type 69 Fynbos on this scene is too small to determine whether sub-types can be distinguished on ERTS images, the boundary of the Veld Type as a whole can nevertheless be accurately drawn from the ERTS imagery and the extent of Mountain Fynbos thus readily calculated.

#### 4.2.1 Fynbos (map legend 2.1)

This is the vegetation called Macchia by Acocks (1953) and listed under his category of sclerophyllous bush types (Veld Type 69).

#### 4.2.1.1 Fynbos (Veld Type 69) on Table Mountain Sandstone (map legend 2.1.1.)

This Veld Type is readily distinguished on the ERTS scene by its dark hue, clearly marked boundaries and the ribbed effect given by the steep slopes, sharp ridges and deep valleys characteristic of the Table Mountain Sandstone geomorphology.

The dark colour of the moist facies (2.1.1.1) on south-west

facing slopes is accentuated on the ERTS scene by shadows cast in the early morning when the image was taken. Conversely, the dry facies (map legend 2.1.1.2) appear lighter in hue due both to sparser vegetation and to direct illumination.

#### Fire patterns in Mountain Fynbos

The determination of broad vegetation age groups or stages of regeneration after fires can possibly be determined by comparison with known regeneration stages. The fire pattern in the mountains has been well recorded as most of these areas are controlled by the Department of Forestry. The area on the east peninsula of False Bay, the Kogelberg, is well known to the investigators. The infrared reflectance associated with longer unburnt vegetation can be related to the time that has elapsed since the burning. Approximately 60 km north of the Kogelberg, another area which showed possible fire damage was checked against records, confirming that these fires occurred from the 11th to 18th March 1971. These fires were correctly forecast as falling into class (i), or fires 1 to 2 years old.

The vegetation occurring in the areas marked 2.1.1 (i) - (vi) have the following known regeneration periods:

- 2.1.1 (i) -  $1\frac{1}{2}$  years between burning and photography - grouped as 1 - 2 years.
- (ii) -  $2\frac{3}{4}$  years between burning and photography - grouped as 2 - 3 years.
- (iii) - 3 years between burning and photography - grouped as 2 - 3 years.
- (iv) -  $3\frac{3}{4}$  years between burning and photography - grouped as 3 - 5 years.
- (v) -  $4\frac{3}{4}$  years between burning and photography - grouped as 3 - 5 years.
- (vi) - 28 years between burning and photography.

#### 4.2.1.2 Fynbos on Granite (map legend 2.1.2)

Granitic mountains having fynbos vegetation (map legend 2.1.2) can be distinguished from the sandstone areas because of the less rugged relief. The distinctiveness, if any, of fynbos on granite from that on sandstone has yet to be determined.

In the area annotated 2.1 vi a circular exposure of a shale band in the Table Mountain geological series can be distinguished. A tall dense moist Fynbos occurs there.

#### 4.2.2 Mountain Renosterbosveld (map legend 2.2)

On ERTS image 1180-08015 this veld type, which is a less dense vegetation grazed because of its grass component, has a lighter grey hue than the Mountain Fynbos that has little grass and a more harsh topography.

This Veld Type, dominated by low grey shrubs of Elytropappus rhinocerotis, has a lower infrared reflectance than the Mountain Fynbos Vegetation.

#### 4.2.3 Forests (map legend 2.3F)

Indigenous evergreen forest patches are not distinguishable on the imagery because they occur in mountain gorges, are not extensive, and often merge into riverine vegetation.

Platbos Forest, (map legend 2.3F) was surrounded by burnt fynbos that has a light colour on the image and is therefore clearly visible.

#### 4.2.4 Mountain riverine vegetation (map legend 2.4)

The riverine vegetation in the mountainous areas is often indistinguishable from the tall dense moist fynbos surrounding it. This vegetation is only well developed where deeper soils can develop on the flats and river valleys (confer 4.1.4).

#### 4.3 Karoo (map legend 3)

A portion of the large semi-desert region with dwarf shrubs and often with succulent plants, known as Karoo in South Africa, appears on ERTS-image 1180-08015. The small area represented on this image is Karroid Broken Veld (Veld Type 26, map legend 3), which has an even more open nature and is generally well grazed and has lighter tone on the imagery than Mountain Renosterbosveld.

#### 4.4 Tree plantations

In certain areas aggregations of introduced Pinus species can be

distinguished by the darker red lines (indicated by P on the map). The plantations of pines on the east slopes of Table Mountain and Constantiaberg are distinguished as a darker pink. The mapping of all but the largest plantations and pine invasions is hindered by the rugged terrain, shadows cast by the mountains, small scale of the imagery and because of colour similarities with riverine vegetation.

#### 4.5 Urban Areas (see map)

Densely built up areas appear slatey-grey as at Cape Town city centre (map legend Ua) and its suburban extensions along the main roads and railways east and south.

Peri-urban areas appear either as purplish-pink market garden smallholdings or as whitish patches where urban development is actively in progress (the sandy soils being exposed by earth moving equipment), or as light pink smudges which depict the large residential holdings with leafy trees, green lawns and small vineyards, as at Constantia (see map).

### 5. CONCLUSIONS

5.1 The synoptic view provided by the ERTS images facilitates recognition of major physiographic divisions of coastal lowlands and mountains. The natural vegetation and cultural patterns confirm most Veld Type boundaries mapped by Acocks (1953), these boundaries being particularly obvious where physiographic and vegetation boundaries coincide. One discrepancy involving natural vegetation boundaries is the inclusion by Acocks of a tongue of Coastal Renosterbosveld traversing the Coastal Macchia on the east coast of Saldanha Bay, whereas ERTS imagery does not reflect any difference and the authors too have tentatively not been able to substantiate Acocks' boundary (see text, 4.1.1).

5.2 Initially ERTS imagery was supplied in a 9" x 9", 1:1000 000 scale format in black and white, each band being separately printed. The detail visible was disappointing and interpretation often difficult. The development of photolitho prints at a scale of 1:500 000 has made this present study possible. Scale is the most significant advantage though

the colour representation allows for faster and more positive identification of vegetation. Minor problems of colour registration and colour rendition were experienced but the advantages of this medium outweigh the disadvantages.

5.3 The natural vegetation of the coastal lowland has been reduced to isolated pockets as most of the land is arable and is used for cultivation of wheat. Unploughed areas are of interest to botanists for conservation reasons and ERTS imagery helps identify and locate such areas. A similar result could have been obtained using air photos, but the number of photos would have been so large as to make the task inhibitive. A parallel situation occurs with the plotting of indigenous forests, which occur in the moist mountainous areas.

5.4 The use of fire as a management tool in the mountain fynbos is already established and an operational ERTS system would be useful for fire monitoring and management planning.

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#### Footnote

Interesting confirmation of some of these interpretations was obtained from an oblique aerial photograph of the Saldanha Bay area appearing in African Wildlife 27 (4) p. 162 (1973). The following features were visible in the photograph:

#### 4.1.3 West Coast Strandveld

Granite hills bearing this vegetation are visible in the left foreground (shown as a smudgey greyish-pink hue on the ERTS image).

4.1.2.1.3 Coastal Renosterbosveld on granite in the Saldanha area (beyond the West Coast Strandveld on the photograph), showing a somewhat bluer tint on the ERTS image. The higher proportion of old fallow lands with ruderal vegetation can be seen on the photograph as darker patches. The larger of these can actually be matched with those on the ERTS image.

4.1.1.2 Coastal Macchia on less stabilized recent sand is clearly visible on the photograph as a dark blue-green smudge beyond and to the right of the Coastal Renosterveld on granite. The road to Saldanha can just be discerned as a thin, faint, whitish line; this is also discernible on the ERTS image.

4.1.2.1 Coastal Renosterbosveld on shales

Koringberg (map legend 1.2.1) can be seen on the photograph as two low grey-blue humps beyond the Coastal Macchia.

4.2.1.1 Fynbos on Table Mountain Sandstone

The mountains of Piketberg (left) and of the Koue Bokkeveld-Cedarberg complex are visible in the distance.

Acocks, J.P.H., 1953. Veld Types of South Africa. Bot. Surv. Mem. S. Afr. No. 28, pp. 192, Govt. Printer : Pretoria.

C. INVESTIGATION OF APPLICABILITY OF SATELLITE IMAGERY TO VEGETATION MAPPING AT 1:500 000 SCALE IN THE EASTERN-TRANSSVAAL ESCARPMENT AREA

Assistant Investigator : J.C. Scheepers

1. OBJECTIVE

To assess the potential usefulness of 1:500 000 false colour photolitho prints of ERTS-1 image 1138-07245 to assist in mapping vegetation in the Eastern Transvaal Escarpment area.

2. RESULTS

The rendering of the satellite imagery in colour and the 1:500 000 scale facilitated orientation in comparison with black and white 1:10<sup>6</sup> scale imagery. This may be influenced by greater familiarity with the

imagery, but the investigator is of the opinion that easier orientation is an intrinsic attribute of the imagery in colour.

Recognition of landscape classes was likewise easier with the coloured prints than with the black and white imagery. Major streams and rivers (including ravines and canyons) are recognizable over the greater part of their length. This appears to be a combined landscape-vegetation feature (e.g. gallery forest along streams in Lowveld savanna vegetation). Pure landscape or macrorelief features that could be recognized without difficulty are the following (indicated by integers on the map (Fig. 3)).

0. Water bodies.
1. Lowveld.
2. Foothill.
3. Montane.

Vegetation per se gave rise to many difficulties in attempts to interpret recognizable patterns of hue and tone. To some extent vegetational landscape features can be interpreted by inference but this is not as easy as it appears at first sight. A critical re-evaluation of first attempts revealed errors of interpretation which are difficult to improve on, e.g. discrimination between timber plantation and forest. In this respect, the colour prints appeared to be less useful for discrimination between vegetation classes per se than black and white imagery at different wavelengths used in conjunction. This may be due to the different contrast ranges employed in the reproduction processes of the two types. In other respects the experience with the colour prints was similar to that with black and white imagery.

Plantations, forest, scrub-forest, scrub, woodland and dense orchards were difficult to consistently separate from one another except, on occasion, by inference. These dense-woody vegetation classes can, however, be separated from sparse-woody and grassland vegetation classes. Sparse-woody and grassland vegetation classes, namely savanna, parkland and grassveld, also proved difficult or impossible to distinguish internally except by inference. An attempt was made to distinguish the following vegetation classes (indicated by decimals on the map). The

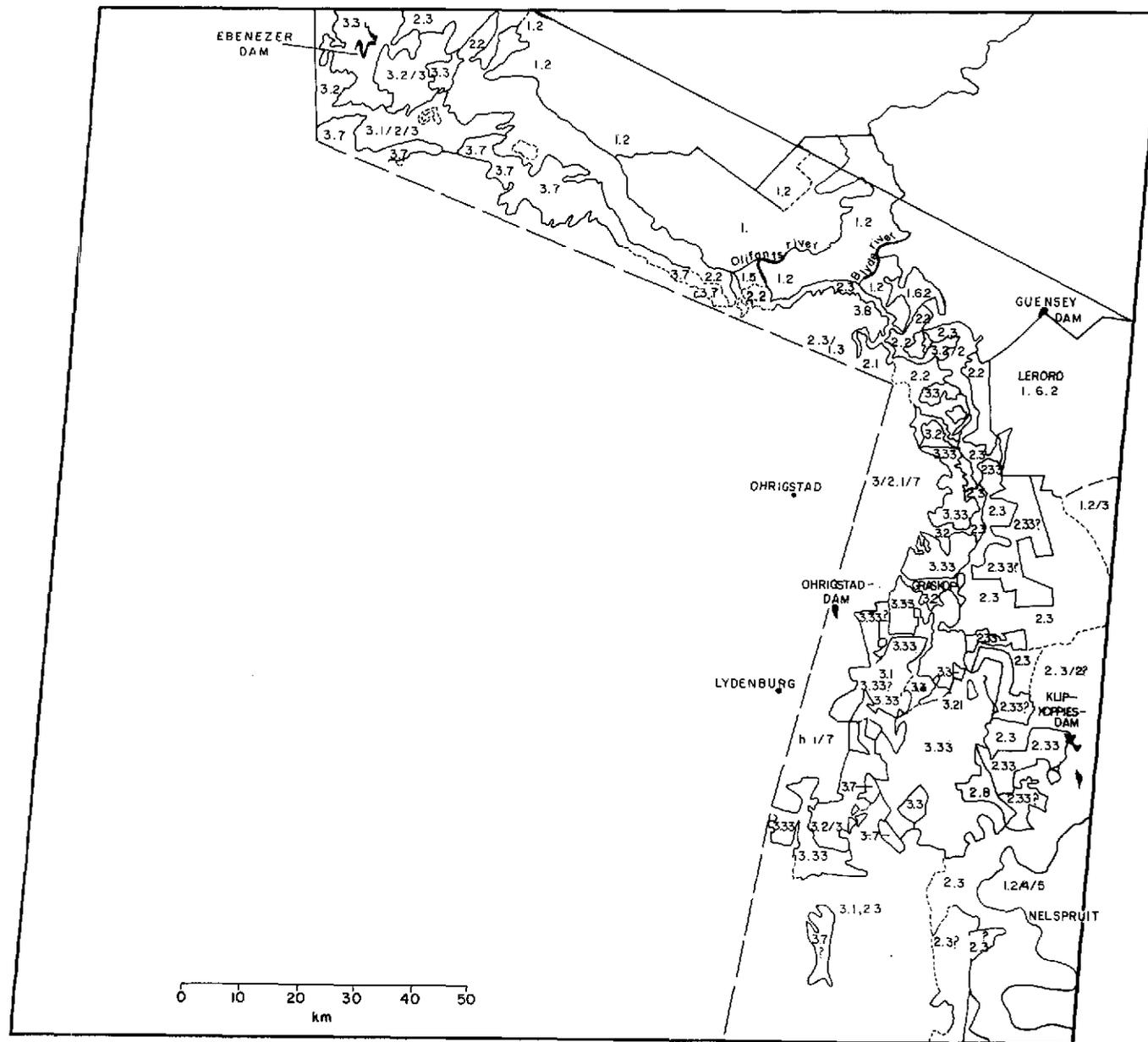


FIG. 3  
Vegetation map of the Eastern Transvaal Escarpment based on 1138-07245 1:500000 false colour print

limited success achieved can be seen by consulting the map:

- .1 Grassveld.
- .2 Savanna and Parkland (Tree-grass Mosaic).
- .3 Closed woody formations.
  - .31 Scrub.
  - .32 Scrub Forest and High Forest.
    - .321 Scrub Forest.
    - .322 High Forest.
  - .33 Plantation.
    - .331 Eucalypt.
    - .332 Pine.
- .4 Orchards etc. (under irrigation).
- .5 Cultivated lands.
- .6 Overgrazed, ± denuded to eroded pasture.
  - .61 Bantu Homelands.
  - .62 White Areas.
- .7 Sparsely vegetated to bare rock.
- .8 Very sparsely vegetated to bare rock. Extremely eroded subsoil (and soil).  
(? indicates tentative assignment)

### 3. CONCLUSIONS

Although much vegetation mapping can be done by inference, the results of attempts to map vegetation by direct recognition of hue, tone and texture were disappointing in the broader intermediate vegetation classes between sparse and dense woody cover. With extensive ground control, however, the full potential of these colour prints could be realized. Unfortunately, it was not possible to investigate in the field further the many baffling features.

D. AN INVESTIGATION INTO THE BOUNDARIES OF THE EVERGREEN FORESTS  
AND OTHER VEGETATION TYPES OF THE EASTERN CAPE

Assistant Investigator : N.G. Jarman

1. OBJECTIVES

- (a) To investigate the potential of false colour photolitho prints of ERTS-1 imagery at a scale of 1:500 000 for vegetation mapping.
- (b) To establish the position and boundaries of evergreen forests and other vegetation patterns in a portion of the Eastern Cape Region of South Africa.

2. METHOD

The scene 1084-07265 (15 October 1972), in the form of a 1:500 000 scale false colour photolitho print of MSS bands 4, 5 and 7 was examined.

Units on the imagery based on hue and texture were identified, related to cultural and vegetation patterns established by Board (1962) in a survey of this area.

This area was visited by the Assistant Investigator, and is known to the Co-investigator.

Checks were made on some of the interpretations by comparing annotated units with standard aerial photography at a scale of 1:36000.

3. DESCRIPTION OF THE STUDY AREA

The area covered, a portion of the coast around East London, has been divided by Acocks (1953) into a number of different major vegetation types, delineated on the map by dotted lines. Major vegetation types discussed here are:

3.1 Coast dune scrub and forest

On and immediately behind the coastal sand dunes, is a coast dune

scrub and forest vegetation with a smooth, salt and wind pruned canopy, which shows up on the lithoprint as a thin dark red line along the coast. Where the vegetation is protected from exploitation it spreads further inland.

### 3.2 Coast forest and Thornveld (map legend 1)

In the east, running parallel to the coast, is an approximately 25 km wide vegetation belt rising to the 500 m contour which is termed 'Coast Forest and Thornveld' (Acocks Veld Type 1). This type is characterised by relic forests in river valleys, where they are protected from exploitation and adverse microclimatic changes separated by grassed areas on the interfluves. This grassland has a strong woody element and, if completely protected, especially from fire, will revert rapidly to forest. This type can be recognised by its pink tinge on the image.

### 3.3 Eastern Province Thornveld (map legend 7)

Between the 500 m and 700 m contour is an undulating plain, approximately 35 km wide, termed the 'Eastern Province Thornveld' (Acocks Veld Type 7). This area supports an Acacia karroo and grass vegetation with a complete physiognomic range from closed Acacia karroo tree and shrub communities, through more open types to pure grassland. On the imagery in the north-eastern portion a deep pink expresses the tendency for Acacia karroo trees to be dominant while in the south-west of the image the lighter hues suggest the presence of more open communities.

### 3.4 Dohne Sourveld (map legend 44)

Above the 700 m contour lies Acocks 'Dohne Sourveld' (Acocks Veld Type 44b) with a cooler wetter climate than the previous types and supporting extensive forests, tree plantations and grassed areas. The bright red hue representing forests on the lithoprint are the most noticeable vegetational feature. The accompanying grassland which has good cover and is generally well conserved, is clearly distinguishable by its orange hue.

### 3.5 Valley Bushveld

The four major vegetation belts previously mentioned are dissected by incised valleys

formed by rivers such as the Buffalo, Keiskamma, Chalumna and Kei. These valleys receive a less effective rainfall than the surrounding ridges and plains and have a Valley Bushveld vegetation (Acocks Veld Type 23) characterised by small trees and shrubs with many thorny scramblers and a less dense field layer. The north-facing slopes carry xeric plant communities while some of the south-facing slopes support a mesic vegetation or may even develop narrow strips of short dense 'forest'. These small forest patches with bush margins can be easily picked out on the lithoprints by their dark red colour although they are so small. Accurate mapping of many of their boundaries is impossible.

The vegetation in this area has been profoundly modified by man, firstly by the Bantu pastoralists and, to a greater extent, by the more-intensive exploitation by Bantu and European settlers.

#### 4. RESULTS : VEGETATION AND LAND-USE (See map, Fig. 4)

The red hue on the photolitho prints represents high infrared reflectance (Blythe & Kurath, 1968). The more dense the vegetation, the more saturated the red hue. Forests and thick bush with heavy canopies show up in deep red hues, savannas which have an almost closed tree canopy show up in lighter red hues, savannas with an open tree canopy show up even less red, while grassland is depicted as a pale yellow/orange hue.

#### 4.1 Area between the Keiskamma and Buffalo Rivers

##### 4.1.1 The Coastal Region

(i.e. 'Coast Forest and Thornveld' Acocks, 1953).

##### 4.1.1.1 The beaches and estuaries

Sandy beaches, in places up to 3 km wide, run the entire length of the coastline, being broken only by river mouths and occasional rocky stretches.

The river mouths tend to widen into estuaries, as is well demonstrated by the Buffalo, Keiskamma and Gonubie Rivers.

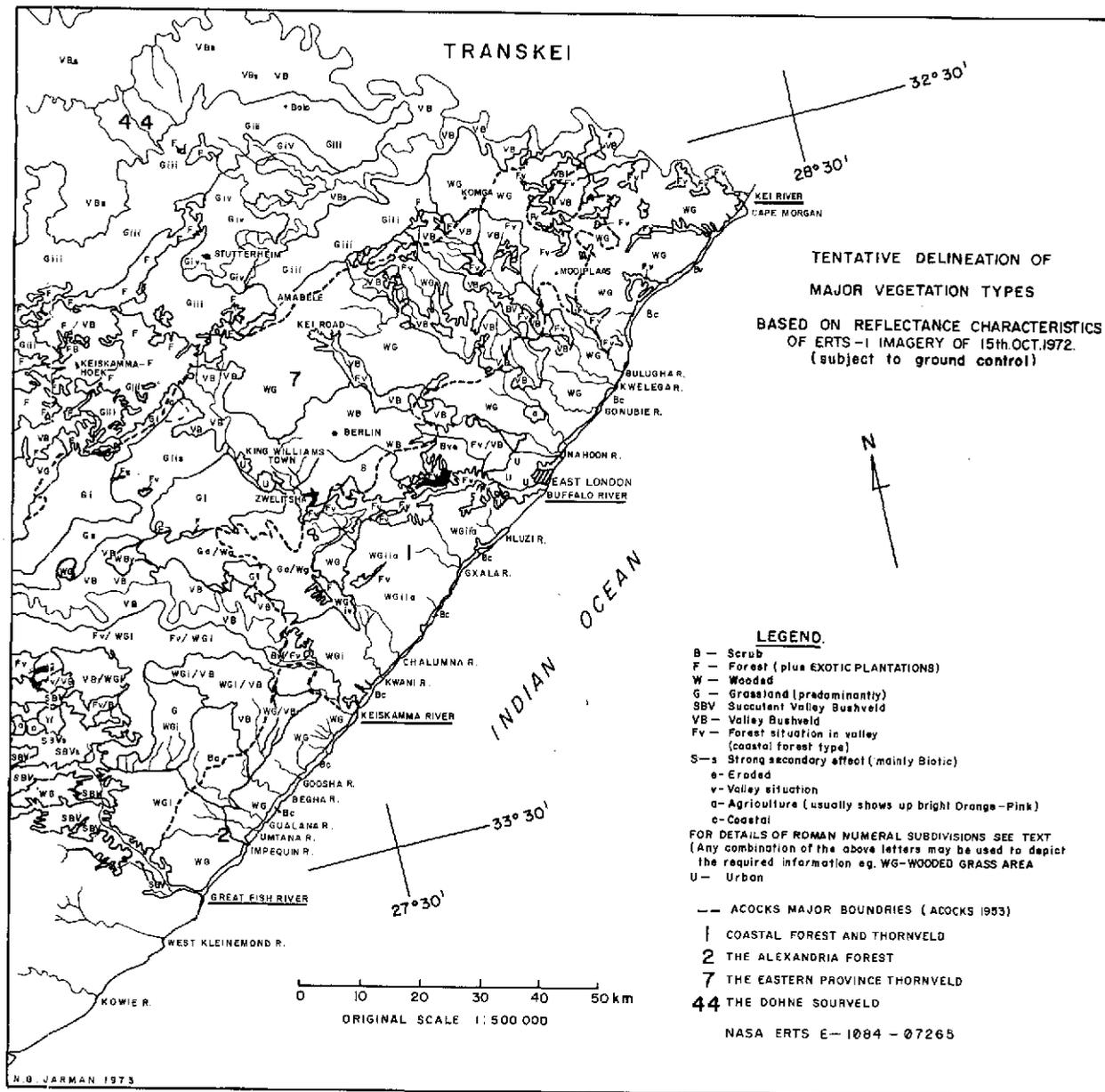


FIG. 4

#### 4.1.1.2 Coast dune scrub and forest (map legend Bc)

This vegetation type lies on and behind the dunes but seldom reaches a width of more than five hundred metres, except where specially protected. It runs the entire length of the coast being broken only by rivers and urban development. Vegetation is primarily a dense scrub type, but in some areas its successional development may reach the forest climax, though this has largely disappeared as a result of past commercial exploitation and clearing for development. The deep red signature on the photolitho print for this type indicates the dense nature of the canopy and is denoted by Bc or Coastal Bush in the annotation.

#### 4.1.1.3 Coast lowland forest and Thornveld (map legend WGi and WGiia)

In an area between the Keiskamma and the Buffalo Rivers in a belt approximately 15 km wide, lies an important agricultural area, with a natural vegetation of grass and small trees, usually Acacia karroo, on the interfluves. The physiognomic status of this type varies from thorn woodland (closed trees) through thorn savannas (trees open) to grassland (trees absent). This area is characterised by a reddish hue on the image suggesting that trees are generally present though not providing a completely closed canopy. There are certain pattern differences between WGi and WGiia, although they are classed here together. This difference is caused by a land-use pattern; WGi is a Bantu area under a strict betterment management programme (Board, 1962) with limited agriculture to prevent erosion, while WGiia is a European area with more agricultural diversity. In this latter area the light pink hues show areas of cultivation, probably pineapples.

In many protected valleys there are signs of natural evergreen forest development which may be recognised on the photolitho prints by their strong red hue (map legend Fv).

The northern boundary of this type on the image may be taken as the Buffalo River where there is a hue change to a slightly darker red at that point.

#### 4.1.2 Eastern Province Thornveld (map legend WG, G, Gi, Gii)

To the west of the Coast Forest and Thornveld above the 500 m

contour is a physiographically separated area showing marked topographic dissection.

In the major river valleys a scrub and scrub-forest occur, which will be discussed later (4.1.4).

On the dissected topography thorn trees occur abundantly in valleys but grass is dominant on the interfluves. Agriculture has replaced many of these grassy patches. The presence of the trees can be detected on the image by a red tinge and undulating texture (map legend Ga/WG). This area contrasts with the adjacent less dissected type east of Zwelitsha, a grassed area (map legend Gi) which has a smooth texture and an orange-red hue, suggesting grass cover. The adjacent grassed area (map legend Gii) appears to be similar in all respects, but the land-use pattern (heavy grazing suspected) produces a grey-orange hue on the image, contrasted to the orange hue of the first grassed area.

#### 4.1.3 Dohne Highland Sourveld (map legend F and Giii)

This area, is higher in altitude (over 700 m elevation) than the other areas having a cooler, wetter climate. This climate supports an evergreen forest climax (map legend F). In many areas the climax is realised, but where environmental and biotic factors prevent this a good cover of grass is usually present (map legend Giii).

#### 4.1.4 Valley Bushveld and Coast Lowlands Forests (map legend VB and Fv)

The rivers in this area, have steep valleys which are considered here to have two phases of a vegetation type referred to as Valley Bushveld by Acocks (1953). On mesic slopes a dense tree or shrub vegetation with some succulent components is found. The canopy is also dense with a high infrared reflectance that shows deep red on the imagery. If the site is both mesic and protected, forest may develop. The subtle changes between dense scrub and forest canopies cannot be recognised on this imagery. Many of these forest and dense bush patches can be clearly seen as dark red on the photolithoprints (map legend Fv), but because of their small size they have not all been annotated. On the xeric slopes, a drier microphyllous vegetation of trees predominates, usually of *Acacia* spp. with a grassed ground layer where not removed by man, often

associated on the photolithoprint with a grey-blue colour. This phase of the Valley Bushveld is very well adapted to the climate and if correct farm management is not applied on the grassy interfluves the bush rapidly invades the grassed areas.

#### 4.2 Area between the Buffalo and Kei Rivers

This area is dissected by a number of rivers, as can be seen on the imagery. This dissection has resulted in a complex geomorphological pattern that in turn supports a very varied vegetation, which has been modified over the past three hundred years by biotic influences.

##### 4.2.1 Coastal Forest and Thornveld and Eastern Province Thornveld

These two Veld Types (Acocks, 1953) cannot be separated on the ERTS imagery as the physiognomy is similar but some sub-divisions can be made on hue, texture and local knowledge.

##### 4.2.1.1 Coast dune scrub and forest (Bc)

This type, north of the Buffalo, is very prominent as the forests appears less disturbed than further south. A maximum width is reached at Cape Morgan.

##### 4.2.1.2 Coast Lowlands Forest (map legend Fv)

Coast Lowlands Forest was undoubtedly more extensive prior to the arrival of man. These forests are now only remnants, but examples may be seen along the Kei River and in many small patches along water courses. The grassland in this coast area, if protected, soon reverts to scrub that in turn will develop into forest. They are not pure grassland, having a Thornveld component except where management prevents shrub encroachment. Different land management practices are used to control shrub encroachment, and a wide range of physiognomic types are obvious from the varying hues on the photolithoprint. Coast forests occur only in the protection of steep-sided river valleys.

##### 4.2.1.3 Coastal Thornveld and Eastern Province Thornveld (map legend WG)

Acocks recognizes two main vegetation types on a floristic

basis but these two vegetation types are indistinguishable on the satellite imagery, which is understandable as they both appear as wooded grassland types. They occur on the interfluves and reflect biotic variations. The area north of the Buffalo River has a strong red tinge suggesting a more dense tree cover.

#### 4.2.2 Valley Bushveld (map legend VB)

The river valleys of the northern sector of the image have a similar species composition to those in the south, but the valleys are often deeper, in places providing a more suitable habitat for dense mesic vegetation and forest development, and a reduction in the xeric types.

The main line of thorn tree encroachment does not occur on the coastal belt, but in the drier western parts where the Great Kei River has provided a corridor for the invasion of Acacia karroo into the grassland areas.

#### 4.2.3 Sweet Veld (map legend Giv)

In the drier valleys around Stutterheim is an area with highly palatable grass cover. This area is predominantly grassed but susceptible to invasion by thorn trees if overgrazed as demonstrated by the tongues of the thorn tree element of the valley bushveld which has already invaded part of the valley.

#### 4.2.4 Dohne Sourveld

This type can again be divided into two components:

##### 4.2.4.1 Midland Forest (map legend F)

Forests cover a considerably smaller area here than south of the Buffalo River, but are easily recognised by their bright red hue. The forests that grow here have been protected by the individual farmers on whose land they occur.

##### 4.2.4.2 The grass phase (map legend Giii)

This is more extensive than in the south and may be recognised by its orangey hue. It is interesting to note that at present it is

confined to the main ridges, while the valleys of the tributaries of the Kei provide a passage for invasion of the grass by microphyllous thorn tree elements of the Valley Bushveld. Greyish areas following river valleys towards Stutterheim show the extent of the Valley Bushveld invasion.

#### 4.3 Area between the Keiskamma and Fish Rivers

##### 4.3.1 Coastal belt

##### 4.3.1.1 Coast Dune Scrub and Forest (map legend Bc)

This type is similar to the Coast Dune Scrub and Forest of the other areas described.

##### 4.3.1.2 Coast Belt (map legend WG)

The coast belt has become a woody, grassed area, although the climax would be forest if the vegetation were left undisturbed. Acocks (1953) notes that this forest would be of a different type to those described in 1.1.2 and 2.1.2, being more xeric in nature, though this is not evident from the satellite imagery.

##### 4.3.2 Valley Bushveld (map legend VB)

This vegetation type tends to dominate in this sector, where both the Fish and Keiskamma Rivers have extensive valleys.

##### 4.3.2.1 Keiskamma River Valley (map legend VB)

The vegetation appears similar to the other Valley Bushveld areas, with a certain amount of coast forest development in the valleys. In the catchment area a considerable amount of secondary disturbance has taken place denoted by an 's' on the map annotation. It is interesting to note that there appears to be a greater occurrence of forests in the tributaries on the south bank of the river than the north. This may be natural, but it is possible that there is a biotic influence here, with the timber having been used for domestic purposes.

##### 4.3.2.2 The valleys of the Begha and Gualana (map legend SBV)

The valleys of these rivers are evident as they are associated

with a succulent Valley Bushveld Type vegetation (SBV). This vegetation type may be recognised by its dull red hue, as against the brighter red of the forests. The light orangey-red patches which also occur in the valleys represent agriculture, possibly pineapples, which are a perennial crop and will have a strong reflectivity, even at the beginning of summer when other annual crops have not developed.

Nearer the coast, approximately 20 km from the sea, the river valleys narrow and the Bushveld vegetation decreases.

#### 4.3.2.3 The Fish River Valley (map legend SBV)

This particular valley is well known for its succulent bush vegetation and shows up well on the imagery in the same dark red hue as in the Begha and Gualana River valleys.

The river has cut a steep straight valley for approximately twenty kilometres from the sea, then it broadens into a wide valley which on the imagery is obvious from its dark grey colour. This dark grey corresponds to a succulent shrub vegetation. However, it is probably reflectivity from the rock type, a slate, which results in this particular photo hue. The hills and side valleys surrounding the major valley support a succulent scrub vegetation.

#### 4.3.2.4 Invasive Valley Bushveld (map legend VB - this type is mixed with the Wooded Grassland WGi)

Directly north of the broad Fish River Valley, above the 300 m contour, are two areas which are light grey in colour and which probably represent an area previously grassed and now denuded by management malpractices and invaded by microphyllous Acacia karroo trees and shrubs.

#### 4.3.3 Wooded Grasslands (map legend WGi)

The remaining area may be divided into two different types of wooded grassland. In the west, on the south bank of the Keiskamma River, is a well-covered area with dense vegetation development. In the east, however, forming a semicircle around the Gualana, Begha catchment areas, is a somewhat denuded wooded grassed area.

#### 4.4 Urban development (map legend U)

The area depicted in this image is the Border Region, centered on

the port of East London on the estuary of the Buffalo River.

Urban development associated with East London stretches from the south bank of the Buffalo River to the mouth of the Gonubie River.

Two dams are situated along the Buffalo River to provide water for East London industry and human consumption. The line of rail can be followed from East London towards the interior to Zwelitsha and King Williams Town via Berlin.

Stutterheim, Berlin and Komga, small market towns on the railway line, are also recognizable.

## 5. CONCLUSIONS

5.1 From an entirely vegetational aspect, ERTS imagery cannot be used to give definite boundaries, but is a useful tool to formulate ideas about the vegetation and to assist considerably in the boundary mapping of pre-investigated areas of sizes approximately 20 000 hectares in extent.

5.2 This particular image gives a synoptic view of an area, a portion of which has, in the past, been mapped in detail (Board, 1962), and which has been studied briefly by the investigator. This portion acted as truth site information, and from there it was possible to extrapolate certain hue characteristics and interpret them in terms of vegetation, these where checked on airphotos at a 1:36000 scale.

5.3 Extrapolation was found to be difficult as the physiognomic variation of most of the area is limited, being of a thorn savanna type with varying degrees of trees and shrub. This resulted in comparatively few categories. However, on a regional basis it is important that this large area, termed 'Wooded Grassland' or Grassy Woodland, can be recognised and separated from predominantly grassland and dense vegetation such as Forest and Scrub.

5.4 The locality of the major forests has been known, but their boundaries have never been accurately mapped at a regional level. This was done with comparative ease.

5.5 The boundary between pure, well-managed grass and the savanna types is clear, in the case of the 'Dohne Sourveld' grass phase and the major invading savanna types of Valley Bushveld, but the boundaries between grassveld and the thornveld in different circumstances, as in the area west of King Williams Town are somewhat arbitrary. Extrapolation by using ERTS imagery alone is not reliable.

5.6 The separation of succulent shrub types and forests due to their different hue saturations is useful and some confidence can be placed on the interpretation.

5.7 An unsolved problem was the separation of natural evergreen forest from planted exotic forest plantations.

5.8 This image highlights the problems of land utilization in the area with the encroachment of Valley Bushveld into mismanaged areas, which may vary according to the demographic patterns involved. Many hue variations reflect agricultural practices.

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Acocks, J.P.H., 1953. Veld Types of South Africa. Bot. Surv. Mem. 28, pp. 192.

Board, C., 1962. The Border Region. Natural Environment and Land-Use in the Eastern Cape. Cape Town: Oxford University Press, p. 238.

Blythe, R. and Kurath, E., 1968. Infrared images of natural subjects. Applied Optics 7(9), 1769-1777.

E. PRELIMINARY ASSESSMENT OF VELD BURNING PATTERNS IN NATAL FROM ERTS-1 IMAGERY

Assistant Investigator : M.L. Jarman

1. OBJECTIVES

To make a preliminary assessment from available ERTS imagery of the veld burning in Natal in relation to Veld Type and the time of occurrence of burning.

## 2. METHOD

Positive identification of burnt areas was carried out using 70 mm ERTS positive images of the green, red and infrared bands in an Additive Colour Viewer. The information was then transferred onto black and white 1:1 000 000 prints of the ERTS-1 imagery, each burnt area being marked on band 7 of the black and white prints, with arrows and numbering according to the grey scale found at the bottom of each particular print. This scale was assigned numbers from 1 to 10 from white through the grey shades to black.

For fires of less than 1 mm diameter (less than 100 ha) an X was used, and where possible a corresponding grey-scale value was assigned to them.

Along the margin of each print the categories of burn age were indicated according to their grey scale numbers as follows:

Freshly burnt - grey scale 9-10

Recently burnt - grey scale 7-8.

Old burns - grey scale 4-6.

Each print was treated separately to categorise

- (i) The number of burns per grey scale category per quarter degree square of latitude and longitude per Veld Type.
- (ii) The area in ha of burns per grey scale category per quarter degree square per Veld Type, using a fine (1 mm) dot grid.
- (iii) The percentage of area burnt per quarter degree square per grey scale category per Veld Type.

All available ERTS-1 images for assessing veld-burning patterns in Natal are given in Table 1.

## 3. RESULTS

Of the 8 images needed to give complete coverage of Natal, 6 of those available were taken on the 8th and 9th of September 1972. These 6 were used to give an assessment of the total percentage of each Veld Type burnt at that time. This included, fresh, recent and old burns from winter into early spring. The period of persistence of a winter burn on the ERTS imagery is unknown. It is not therefore known whether autumn and very early winter burning is reflected in the results or not.

Table 1. Imagery used in preliminary assessment of veld burning

Ubombo	Mtubatuba	Vryheid	Dundee	Port Shepstone	Volkswest	Harrismith	Matatiele
nil	1010-07134	1011-07190	1047-07193	1047-07200	1048-07245	1048-07252	1048-07254
	1190-07143	1047-07191	1137-07202		1066-07245	1084-07253	1084-07260
		1137-07200			1120-07254	1120-07260	
					*1138-07254		
<u>Dates of imagery</u>							
	2 Aug 1972	3 Aug 1972	8 Sep 1972	8 Sep 1972	9 Sep 1972	9 Sep 1972	9 Sep 1972
	29 Jan 1973	8 Sep 1972	7 Dec 1972		27 Sep 1972	15 Oct 1972	15 Oct 1972
		7 Dec 1972			20 Nov 1972	20 Nov 1972	
					8 Dec 1972		

\* Completely cloud covered.

Table 2. Areas and percentages of Veld Types in Natal (excluding Ubombo and Mtubatuba images) showing evidence of burning on the 8th and 9th September 1972

No. Veld Type	Total area burnt (Ha)	Total area Veld Type covered (Ha)	% of each Veld Type burnt at that date
1. Coastal Forest and Thornveld	3604	171250	2,1 %
5. Ngongoni Veld	28832	445000	6,5 %
6. Zululand Thornveld	1908	244250	0,8 %
8. North Eastern Mountain Sourveld	8056	51250	15,7 %
10. Lowveld	8480	661250	1,3 %
11. Arid Lowveld	3710	41250	9,0 %
23. Valley Bushveld	31270	350000	8,9 %
44. Highland Sourveld	313660	1198750	24,5 %
45. Ngongoni Veld of the Natal Mistbelt	36464	330000	11,1 %
54. <u>Themeda</u> Veld to Highland Sourveld Transition	2756	10000	27,6 %
57. North Eastern Sandy Highveld	46004	53750	85,6 %
58. <u>Themeda-Festuca</u> Alpine Veld	8268	33750	24,5 %
63. Piet Retief Sourveld	37418	107500	34,8 %
64. Northern Tall Grassveld	48760	43750	11,2 %
65. Southern Tall Grassveld	101866	891500	11,4 %
66. Natal Sour Sandveld	89756	675000	13,3 %
TOTAL	800810	5700250	14,1 %

The results are given in Table 2.

A preliminary assessment of the burn data for the Vryheid images 1011-07190, 1047-07191 and 1137-07200 taken, respectively, on the 3rd August, 8th September and 7th December 1972, reveals several features.

3.1 There were 64 fresh burns on the August image and 195 recent burns on the September image. If one assumes that fresh burns on the August image become recent burns on the September image, there is a discrepancy of 131 burns in this category, which could only have occurred very soon after the August imagery was taken. This feature is consistent for all the Veld Types and quarter degree squares examined in this assessment.

3.2 The number of burns and the area of each burn should give some indication of the burning practice. Depending on the area involved, a large number of small burns arranged in a rather regular pattern, would appear to indicate organised burning, rather than accidental burns. The August image totalled 134 burns of 61162 Ha in extent, averaging 456 Ha per burn, whereas the September image totalled 280 burns averaging 725 Ha in extent. This increased area of burn over a period of 5 weeks, together with the evidence of 131 burns soon after the 3rd August, appears to indicate dry inflammable conditions, accompanied by some accidental big fires and extensive burning prior to the spring rains.

3.3 If consecutive images for each quarter degree square are compared, it is possible to monitor the amount of burning which takes place over a given period of time, taking into account the age of the burn. For example, the quarter degree square 2730AC, Veld Type 57, on the 3rd of August showed 2 fresh burns of area 2968 Ha. On the 8th of September the same area and Veld Type recorded four recent burns of total area 6572 Ha. From examining the imagery these are obviously the 2 burns of the August 3rd image plus an additional two burns soon after the 3rd of August, of area 3604 Ha. There was no difficulty in determining such information from the imagery.

#### 4. CONCLUSIONS

This preliminary assessment has definitely proved the usefulness

of ERTS imagery in investigating precisely the location, extent and time of burning in relation to vegetation type and management. The results have proved conclusively that monitoring of the burning pattern is a practical feasibility, provided suitable consecutive imagery is available.

As far as detecting burn areas on the imagery is concerned, small fires are more difficult to detect than large fires on the 1:1 000 000 black and white prints, but the Additive Colour Viewer removed the difficulty of differentiating between fires and water-bodies in band 7 and positively identified burn age whereas this feature on the prints was sometimes difficult to assess.

The 1:500 000 false colour photolithoprints are very suitable for burning inventory work.

It must be stressed that this is a preliminary assessment. Nevertheless, the data that have been collected for this investigation, together with that obtained from a future operational satellite, will be invaluable for detailed investigations of burning practice which is a very important range management method.

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Acocks, J.P.H., 1953. Veld Types of South Africa. Bot. Surv. S. Afr. Mem. No. 28, Government Printer: Pretoria.

F. THE IDENTIFICATION AND MAPPING OF EXTENSIVE SECONDARY INVASIVE AND DEGRADED ECOLOGICAL TYPES (TEST SITE D)

Assistant Investigators : N. Jarman  
O. Bosch

1. OBJECTIVES

To attempt to recognise areas which have been degraded over the last twenty years.

2. METHOD

Black and white prints of MSS bands 5 and 7 at a scale of 1:1 000 000 were, in conjunction with an additive colour viewer, used to draw vegetation boundaries.

These boundaries were then superimposed on the standard vegetation map of South Africa drawn by Acocks in 1953 to attempt to assess any

major vegetation changes that had occurred in the past twenty years.

### 3. BACKGROUND

In Veld Types of South Africa by Acocks (1953) it was predicted that a dwarf shrub vegetation type, the False Upper Karoo, Veld Type 36, would invade grassland.

Imagery was studied in an area known to have been invaded by dwarf shrub vegetation and for which a map was available (Bosch, Herbst, 1971).

The area chosen was the Caledon River Valley, which forms part of a present survey project being undertaken by O. Bosch.

Much of this area has good grass cover, with few dwarf shrubs, but evaluated as a whole at 1:1000 000 scale this area may be considered as False Upper Karoo.

### 4. RESULTS (See map, Fig. 5)

On the ERTS imagery (1049-07313) of 10 September 1972 and 1121-07321 on the 21st November 1972 certain patterns in the vegetation, accentuated by topography, suggested that the boundary of the False Upper Karoo, a dwarf shrub type of vegetation, was no longer in the same position as plotted by Acocks in 1953. A map of the newly degraded area was drawn from the ERTS imagery and superimposed on Acock's Veld Type Map and the boundary of the False Upper Karoo appeared to have moved in a northerly and westerly direction, a maximum of 70 km and a conservative measurement of 43 km invading grassland (see map).

Brief excursions in the field and corroboration with the vegetation map of Bosch and Herbst (1971) confirmed the movement.

This boundary has been recognised over a limited front, and unsuccessful attempts have been made to extrapolate over the more extensive boundary. A number of possibilities were established, but fieldwork was not carried out as no project is at present underway in these areas.

### 5. CONCLUSIONS

5.1 It was encouraging that vegetation boundaries associated with degradation, especially with such fine physiognomy, could be identified

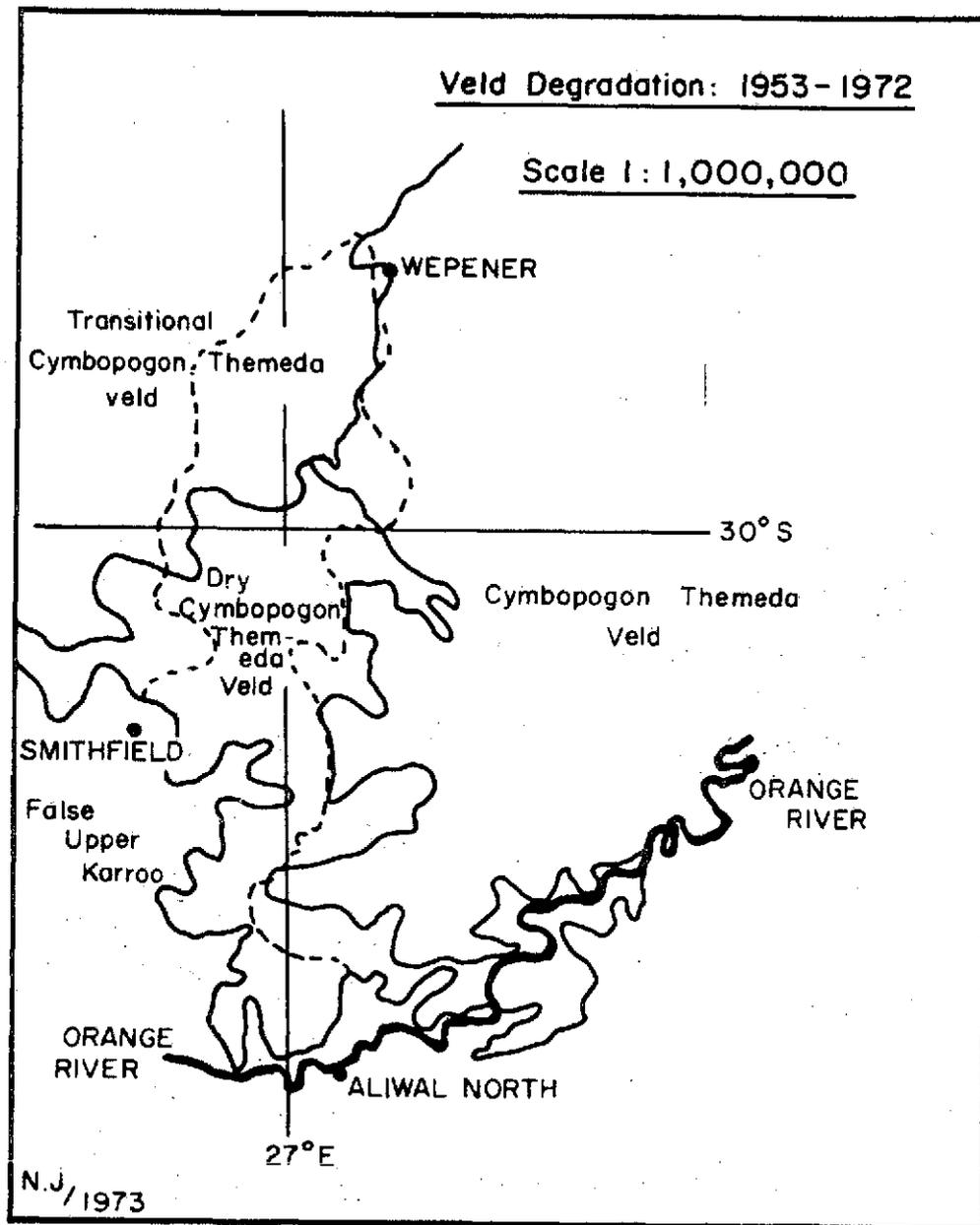


Fig. 5 Invasion of Karoo into Grassland  
 Dotted boundary delimits grassed area (Dry Cymbopogon-Themeda Veld) which has been invaded by dwarf scrub communities (False Upper Karroo)

if sufficient fieldwork and ground control are done. The area showing positive identification was associated with a distinct topography which probably aided identification. Extrapolation, with sufficient ground control, is expected to be positive but at present the complete picture cannot be obtained.

This research has been reviewed by a number of research workers and the popular press. There is some disagreement over the exact boundary drawn although the invasionary trend is agreed by all. This problem will be settled with the completion of the present project in 1974.

5.2 Although agriculturalists were aware of this vegetation change ERTS imagery has high-lighted the problem. An evaluation of revenue lost and the amount of money it will cost to prevent encroachment cannot be readily estimated, but if degradation carries on at its present rate the revenue loss will be maximal. It is only from a synoptic view of these threatened areas as given by ERTS that the vegetation patterns can be readily observed and brought to the notice of Agricultural Planners. Infrared coloured lithoprints are not available for this area yet, but evidence of degraded areas in the Tugela River Valley suggests that this medium may help in identifying this boundary more positively.

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Acocks, J.P.H., 1953. Veld Types of South Africa. Mem. Bot. Surv. S. Afr. 28, Govt. Printer : Pretoria.

Bosch, O.J., Herbst, S.N., 1971. Provisional Plant Ecological Regions in the Upper Orange River Catchment Area, Orange Free State Region. Unpublished manuscript.

## G. OTHER PRELIMINARY STUDIES ON ERTS-IMAGERY

### 1. INTRODUCTION

A number of preliminary investigations were carried out when ERTS imagery first became available. Imagery at that time was supplied as black and white prints at a scale of 1:1 000 000, each band being produced separately. Detailed reports were supplied in two previous Type II reports. These studies have as yet not been continued due to lack of suitable imagery products, or where the investigation was linked to an on going project that has not yet been completed and for which final

conclusions regarding the vegetation are not yet resolved.

## 2. RESULTS

The following is a short resumé of findings from these reports (for further details the required reports should be consulted):

### 2.1 Central Highveld

Surveys by Scheepers and Jarman (1973) and Morris (1973) were of a major part of the central Highveld Plateau of South Africa, using scenes 1049-07304, 1049-07310, 1050-07362 of the 10th and 11th September 1972 and 1068-07355, 1068-07362, 1069-07414 and 1069-07420 of 29 and 30 September 1972. These images were thus taken at the end of the dry winter season, which is one of the worst times for recording differences in vegetation. This area has been intensively cultivated and much of the original grassland has been removed. Agricultural interference has destroyed many natural vegetation boundaries, though some may be recognised by changes in land-use.

Some conclusions regarding the extent of natural vegetation and its major interfaces could be made but few definite conclusions were drawn. Where vegetation boundaries could be detected they were found to be very accurate and due to the larger scale of the 1:1000 000 ERTS imagery gave more precise boundaries than the available 1:1500 000 Acocks Veld Types Map.

Of major ecological and land-use interest was the identification of thorn tree (Acacia karoo) encroachment into grassland in the Kroonstad area. This will be published on completion of the Highveld Survey.

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Scheepers, J.C., and Jarman, N.G. The identification and mapping of regional habitat/ecological types in the Highveld Grassland. (Test Site D) Type II report, February 1973, p. 14-19.

Morris, J.W. Land-use and vegetational patterns in the South Western Transvaal. Type II report, August 1973, p. 9-10.

### 2.2 The Northern Transvaal

Coetzee (1973) carried out a number of investigations using ERTS images 1085-07303 and 1050-07355. Available for this area were a number of aerial photographs at a scale of 1:150 000 taken specifically as ERTS

underflights. The area has a complex vegetation structure and physiognomy, varying from grass through savannas with trees and shrubs, dense trees and shrubland with grass to scrub and woodland. It was hoped that ERTS imagery would be able to separate these major physiognomic types, but distinctions could only be made between densely wooded areas of forest and woodland and areas with less dense vegetation such as grass and grass with trees. No distinction could be made between pure stands of grass and grass with trees. This result was disappointing but it is possible that, at a different season, with greater contrast and different image products and especially a larger scale, these complex patterns will become evident. The underflight aerial photography showed that at that scale patterns could be recognised.

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Coetzee, B.J. Evaluation of ERTS-1 data for a plant ecological survey of the Northern Transvaal Bushveld. (Test Site A). Type II report, February 1973, p. 19-25 and Type II report, August 1973, p. 13-14.

### 2.3 Kelp Survey

The kelp survey by Jarman (1973) was investigated to attempt to map the extent of kelp off the South West coast of South Africa. Scenes examined were 1055-08064 and 1145-08073. These images were re-processed photographically for maximum contrast in the sea, but no kelp beds were visible. Failure to identify kelp could be for a number of reasons. All images were taken at high tide when much of the kelp is inundated. The kelp beds are not very wide and occur where vigorous wave action may detract from the kelp images. Finally, the interpreters were not familiar with the complete situation and inexperience may have accounted for the failure of this investigation.

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Jarman, N.G. An investigation into the mapping of kelp beds off the west coast of South Africa using ERTS-1 imagery. Type II report, August 1973, p. 24-25.

IV. GEOLOGIC INTERPRETATION OF ERTS-1 IMAGERY

Co-investigator : Dr W.L. van Wyk (to July 1973)  
: Dr B.N. Temperley  
Geological Survey, Pretoria

A. GENERAL OBSERVATIONS

1. OBSERVATIONS ON EIGHT B/W 1:1 MILLION ERTS IMAGES OF  
THE NORTHERN TRANSVAAL (SEE FIG. 1)

Assistant Investigator : Mr S.B. de Villiers  
Geological Survey Regional Office,  
Pietersburg

1.1 Lithology

1.1.1 Quartzites

Where strongly inclined and alternating with more rapidly weathering rock types these are generally recognisable.

1.1.1.1 Quartzites of the Archaean craton

The folded magnetic quartzites of the Swaziland System (S)\* crossed by the Sand River south of Matoks, which lie in a field of Archaean granite (AG2), form rugged country which shows up darker on image Eb (Louis Trichardt) than the surrounding smoother granitic area.

1.1.1.2 Quartzites of the Limpopo Mobile Belt

Alternating quartzites (S) and stratiform metabasic rocks (AN1) lying with sinuous outcrops in a field of gneissic granite (AG4) show up clearly on images Ea (Messina), Eb (Louis Trichardt) and Fb (Beauty) because the quartzites form rugged ridges that are darker than the lower smooth ground formed by the interbedded metabasic rocks and the surrounding granite.

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\*The letters and figures in brackets after stratigraphical names are the reference letters printed on the published 1:1 million map entitled Geological Map of the Republic of South Africa, 1971 edition.

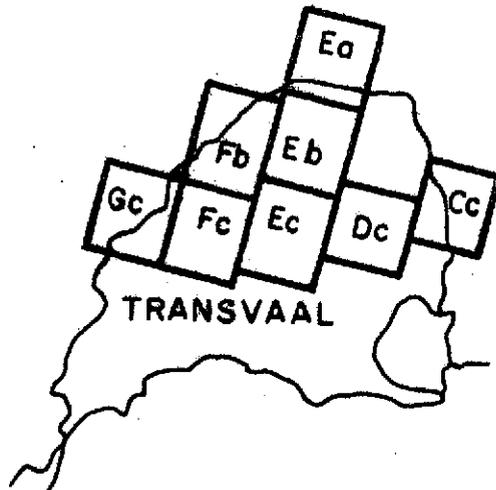


FIG. 1. Distribution of Images used in the northern Transvaal Survey

<u>Locality Symbol</u>	<u>Centered Near</u>	<u>ERTS ID No.</u>
Cc	Skukuza	1047-07182-5
Dc	Penge	1048-07240-5
Ea	Messina	1049-07290-5
Eb	Louis Trichardt	1049-07292-5
Ec	Naboomspruit	1049-07295-5
Fb	Beauty	1050-07350-7
Fc	Thabazimbi	1050-07353-5
Gc	Derdepoort	1069-07411-5

#### 1.1.1.3 Quartzites of the Dominion Reef System (Dr)

These quartzites, alternating with more rapidly weathering rocks, form dark faintly seen ridges, with smoother lighter strips between, near the Palala River on image Fb (Beauty) where they lie unconformably on the granite (AG4) of the Limpopo mobile belt. The same quartzites form conspicuous dark rugged ridges on the Moses River west of Groblersdal on image Ec (Naboomspruit) where they form part of a roof remnant of the Bushveld Igneous Complex. Dominion Reef quartzites, however, do not show up well north of the Dwarsberg on image Gc (Derdepoort).

#### 1.1.1.4 Quartzites of the Transvaal System

Quartzites of the Black Reef (T1) and the Pretoria (T3) Series, which alternate with more rapidly weathering rocks including dolomite (T2), shale, diabase sills, etc., form dark rugged ridges that surround the Bushveld Igneous Complex and occur locally as roof remnants lying upon it. The most conspicuous parts of the encircling outcrops are:

- (a) On image Gc (Derdepoort) at the western end of the Complex contortion by folds and displacement by faults is revealed by the pattern of light and dark bands.
- (b) On image Fc (Thabazimbi) the quartzites form an E-W belt passing immediately south of Thabazimbi.
- (c) On images Ec (Naboomspruit) and Fc (Thabazimbi) the quartzites occur on the south-western side of the Nylstroom syncline, and
- (d) On images Dc (Penge) and Ec (Naboomspruit) they form the Strydpoort-Wolkberg range at the northeastern corner of the Complex.

The same quartzites forming roof remnants are clearly seen at the following localities:

- (a) On image Ec (Naboomspruit) south east of Groblersdal these quartzites along with those of the Dominion Reef System form conspicuous arcuate ridges.

- (b) On image Fc (Thabazimbi) between the Nylstroom syncline and the Crocodile River they occur with felsite (Lf) and granophyre (gr) of the Complex. Together these formations form an area of rough country but, without pre-knowledge, their outcrops cannot be separately distinguished.
- (c) At the western end of the Complex in the Nietverdiend and Swartfontein area on image Gc (Derdepoort) Magaliesberg Stage rocks (T3m) are intimately associated with the basic portion of the Complex (AN3). These formations show up together but cannot be distinguished from one another.

#### 1.1.2 Sandstones

Where massive, well jointed and well exposed sandstones show up well.

##### 1.1.2.1 Sandstones of the Waterberg System

Sandstones of the Kransberg Series (W2), the upper series of the system, lying nearly horizontally form the Waterberg Plateau, which shows up as a dark rugged area on images Ec (Naboomspruit) and Fc (Thabazimbi). The plateau is bounded by a conspicuous escarpment on its eastern, western and southern sides.

The sandstones of the Nylstroom Series (W1), the lower series of the System, form rather less rugged and lighter toned ranges on image Eb (Louis Trichardt), the Mokgabens, the Blauberg and the Soutpansberg. The light E-W bands that cut the Soutpansberg at the eastern edge of this image are downfaulted strips of Karoo rocks.

Some outliers of the Kransberg on the Nylstroom Series show up as dark areas on lighter around the Glen Alpine dam on the Mogalakwena River on images Eb (Louis Trichardt) and Fb (Beauty).

##### 1.1.2.2 Sandstones of the Karoo System

The Bushveld sandstones of the Stormberg Series (K4), the uppermost sedimentary rocks of the Karoo System, where they are crossed by the Mogol River on Image Fb (Beauty), show up with a dark tone like that of the Nylstroom Series sandstones from which they cannot be separated without pre-knowledge of the area.

### 1.1.3 Lavas

The lavas of the Stormberg Series (K4v) of the Karoo, mainly basalt and rhyolite, which form the Lebombo range, show up very clearly on image Cc (Skukuza) because of the linear pattern of light and shade produced by their topographical relief.

### 1.1.4 Gneisses and granites

#### 1.1.4.1 Archaean cratonic gneiss (AG2)

In the very flat country between Thabazimbi and the Marico River on image Gc (Derdepoort) this rock gives a fairly uniform grey tone but on image Eb (Louis Trichardt) the Archaean granite of the Pietersburg Plateau is mottled with white patches, presumably due to areas of sandy soil (see below) which accumulate in the lower ground in this region of greater relief.

The younger plutons (AG3) of Matala and Uitloop show up dark on image Ec (Naboomspruit) due to their ruggedness, but the less resistant plutons of Molatsi and Matoks do not show up well nor does the one north of the Dwarsberg on image Gc (Derdepoort).

#### 1.1.4.2 Gneissic granite of the Limpopo mobile belt (AG4)

This has a mottled white-on-grey appearance on image Eb (Louis Trichardt) and the younger Bulai and Singleton plutons (AG6) west of Messina on image Ea (Messina) cannot be distinguished.

#### 1.1.4.3 Granite of the Bushveld Igneous Complex (AG5)

At the middle of the southern and eastern edges of image Ec (Naboomspruit) and in the eastern part of image Dc (Penge) this granite, along with some granophyre and felsite, forms areas of rather light tone mottled with darker patches which are rugged tors (Koppies); but the same formations in the Makapansberg northwest of Potgietersrus on image Ec (Naboomspruit) appear as a more uniformly dark area.

### 1.1.5 Basic and ultrabasic rocks

#### 1.1.5.1 Basic rocks of the Jamestown Igneous Complex (AN1)

These rocks, folded into the cratonic Archaean granite (AG2)

northeast of Barberton, form a rugged area at the southern edge of image Cc (Skukuza) but the same rocks east of Pietersburg on image Eb (Louis Trichardt) are indistinguishable from the granite.

#### 1.1.5.2 Gabbro and norite of the Bushveld Igneous Complex (AN3)

The Bushveld Gabbro and norite form rugged country that shows up dark and rough at the eastern edge of image Ec (Naboomspruit and in the southwestern part of image Dc (Penge).

#### 1.1.6 Syenites and carbonatites

The Phalaborwa Complex (AS1) with carbonatite shows up as dark concentric semicircles at the northwest corner of image Cc (Skukuza). The Pilansberg alkaline complex (AS2) appears as a rugged circular area at the southern edge of image Fc (Thabazimbi), but is much confused by black burned veld areas. The carbonatite complex (AS2C) at Glenover can be seen as a faint ring near the northwestern corner of image Fc (Thabazimbi) but the carbonatite plugs west of the Klipriver dam on the same image do not show up, nor does that of Nietverdiend on image Gc (Derdepoort). The Spitskop Complex east-northeast of Groblersdal appears as a dark ring of rugged ground on image Dc (Penge).

#### 1.1.7 Soils

##### 1.1.7.1 Sandy soils on unexposed or poorly exposed sandstones

The Kransberg Series sandstones on the Waterberg Plateau and the Nylstroom Series sandstones round its southern edge on images Ec (Naboomspruit) and Fc (Thabazimbi) give pale patches due to sandy soil on the lower slopes.

The sandstones of the Eccca Series (K2) and of the Waterberg Series (K4) of the Karoo in the Springbok Flats on image Ec (Naboomspruit), the Eccca rocks that are faulted down into the Soutpansberg, and the Eccca north of Angelina on image Eb (Louis Trichardt) are largely or entirely sand covered and show up as light toned patches.

The sandy soil that produces the pale element in the mottling of certain granite areas has already been mentioned.

##### 1.1.7.2 Grey-black (turf) soil with calcrete

Southwest of Makoffa on image Fc (Thabazimbi) this type of soil

C-2

shows up as a circular white patch.

#### 1.1.8 Mine dumps, salt pans and lime works

All these show up as white dots. Mine dumps are seen at Messina, image Ea (Messina), and at Phalaborwa, image Gc (Derdepoort); a salt pan occurs at the northwest corner of the Soutpansberg on image Eb (Louis Trichardt); and a lime works can be seen at Immerpan Station on the Springbok Flats on image Ec (Naboomspruit).

### 1.2 Structures

#### 1.2.1 Folds

Contorted outcrops of the quartzites and metabasic rocks in the greisses of the Limpopo mobile belt can be seen clearly on images Ea (Messina) and Fb (Beauty) indicate strong folding.

The Pretoria Series of the Transvaal System is folded near the Botswana border on Image Gc (Derdepoort). It is also involved in anticlinal structures between the Wonderkop Fault and the Olifants River and in synclinal structures in the Leole Mountains east of that river as seen near the northeastern corner of image Ec (Naboomspruit) and in the northwestern corner of image Dc (Penge).

Apart from the enormous and very deep synclinal basin of the Transvaal System and Bushveld Igneous Complex, the northern part of which is covered by images Dc (Penge), Ec (Naboomspruit), Fc (Thabazimbi) and Gc (Derdepoort), and the shallower Waterberg basin that appears on images Ec (Naboomspruit) and Fc (Thabazimbi), there is a pear-shaped basin of lesser magnitude known as the Nylstroom syncline which is very well displayed on image Ec (Naboomspruit). Its inner concentric ridges are outcrops of sandstones of the Nylstroom Series of the Waterberg System and its outer ones outcrops of the underlying felsite, granophyre and granite of the Bushveld Complex.

Immediately to the north of this basin is a westward pitching anticline involving outcrops of the same formations and in the extreme southeastern corner of the same image there appears a small part of the northern edge of the Cullinan-Middelburg synclinal basin consisting of

the Nylstroom Series lying unconformably on the Bushveld Complex.

### 1.2.2 Faults, joints and dykes

#### 1.2.2.1 Faults

Some lineaments can be identified as faults because they either offset or truncate outcrops or they separate areas of different tone or texture.

The principal faults identified by offset or truncated outcrops are the following:

- (a) Wonderkop fault at the northeast corner of image Ec (Naboomspruit) and the western edge of image Dc (Penge).
- (b) Ysterberg fault northeast of Potgietersrus on image Ec (Naboomspruit).
- (c) Steelpoort and several associated faults at the centre of image Dc (Penge).
- (d) Faults near the Botswana border on image Gc (Derdepoort), and the
- (e) Dwarsberg fault on image Fc (Thabazimbi).

Faults identified by tonal differences include:

- (a) Soutpansberg faults on image Eb (Louis Trichardt) that throw Karoo down against Waterberg and
- (b) Vaalwater-Bulge river fault in the northern part of image Fc (Thabazimbi) which separates different formations of the Kransberg Series of the Waterberg System.

Dark lineaments coincide with major faults in the southern corner of image Ea (Messina) and near the centre of image Fb (Beauty) but the cause of the dark tone is not apparent. Not all major faults show up on the images. The two that cut the Crocodile River Basement Complex roof remnant are not apparent on image Fc (Thabazimbi) and the Welgevonden fault with its thermal springs cannot be detected at all on image Ec (Naboomspruit) presumably because the same formations occur on both sides of it.

#### 1.2.2.2 Joints

Joint systems are particularly well developed in the Waterberg System and especially on the Waterberg plateau where they are revealed by rectilinear valleys in deeply dissected country on images Ec (Naboomspruit) and Fc (Thabazimbi).

Unidentified lineaments in the form of un-naturally straight valleys must be provisionally attributed to joints. These are numerous in the basic part of the Bushveld Complex on image Dc (Penge).

#### 1.2.2.3 Dykes

On the scale of 1:1 million even the widest dykes appear so narrow that they are best classified as structures.

Where dykes occupy some of the joints of a joint system, as on the Waterberg plateau those joints that contain dykes cannot be distinguished from those that do not.

Dykes striking NE and SE that cut granite east of Matoks on the Sand River show up as faint dark lineaments on image Eb (Louis Trichardt). Two E-W lineaments in the Archaean granite east of the Bushveld Complex appear in the western part of image Cc (Skukuza). The southern is a very prominent dolerite dyke north of Bosbokrand and though the northern is probably a dyke it has not yet been identified as such with certainty.

### 1.3 Conclusions

As in the case of ordinary air photographs, geological units are recognised more by their shape and topographical relief than by their tone. The main difference between ERTS images and air photos is that the topographical relief on the images is indicated by the tonal pattern instead of by stereoscopic vision. In general the higher the relief the darker the tone for two reasons (a) deep valleys are less reflective than level ground and (b) rock exposures are less reflective than vegetation.

The main distinguishable categories of geological units are:

- (1) Stratiform bodies, the high dip of which gives them rectilinear or curvilinear outcrops, are most obvious where thick resistant and thick easily erodible layers alternate. Such units include sedimentary and meta-sedimentary rocks, lavas and (in other areas) sills.
- (2) Massive but well-jointed stratiform bodies that are more or less horizontal and so form rugged plateaus bounded by high escarpments. These include dominantly arenaceous series and (in other areas) dolerite sills.
- (3) Ring complexes, especially those that include concentric outcrops of rock types that differ from one another and from the country rock in resistance to erosion. In this area these are mainly syenites.
- (4) Granites and gabbros that are characterised by the tor (koppie) type of physiography.
- (5) Alluvium because of its smooth surface and its narrow branching disposition coincident with parts of drainage systems...

Lithological distinction of rock types within these categories is rarely possible except by pre-knowledge of which formations are actually present and even then distinction is not always possible. The type of landscape produced is more distinctive on the images than the type of rock from which it is etched, e.g. tors may be of granite or gabbro, and the same rock at localities in different stages of peneplanation and under different climatic conditions develops different surface features.

Tone or tone pattern, where independent of shape and relief, seems to be significant only in distinguishing sandy soil, which gives light tones, cultivation, which gives a patchwork of rectangles, and burned veld, which gives irregular black areas.

The delineation of light and dark or rough and smooth areas by tracing from images does not build up a complete geological map, even if the lithological identity of the rock bodies is known. This is

because outcrop boundaries as distinct from exposure boundaries cannot be drawn except in cases where the characteristic form and tone of a formation is known to extend right up to the limit of its outcrop. In this respect ERTS images do not differ from ordinary air photographs. Tracings such as can be drawn would have been useful in the reconnaissance stage of geological mapping but, in most parts of South Africa, this stage has long been passed.

2. OBSERVATIONS ON FIVE B/W 1:1 MILLION IMAGES OF SOUTHERN TRANSVAAL (SEE FIG. 2)

Assistant Investigator : Mr F. Walraven  
Geological Survey

In general the number of lineaments on the images far exceeds those that can be accounted for as known faults.

Image Fd (Rustenburg), displays exceptionally good resolution and tone contrast and the information on it exceeds that shown on the 1:1 million geological map. The Black Reef Series can be followed with reasonable accuracy on this image and the contact between the Dolomite Series and the Pretoria Series is visible but only moderately accurately in places. The contact between the Timeball Hill, Daspoort and Magaliesberg Stages are very clearly visible and the outcrops of the constituent shales and quartzites are very obvious. The contacts between the Pretoria Series and the Bushveld Complex are clear, as are those between the acid and basic portions of the Complex, and the Pilansberg Complex is also very clear on this image. All the faults that have been shown on the 1:1 million map can be seen on the image as well as many other lineaments.

3. A STATISTICAL STUDY OF THE LINEAMENTS OF THE WATERBERG PLATEAU

Assistant Investigator : Dr R.C. Rhodes  
Geological Survey, Pretoria  
(to June 1973)

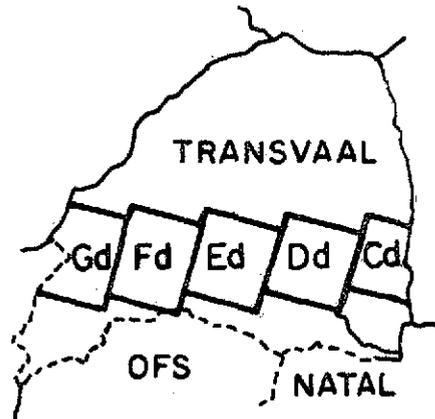


FIG. 2 Distribution of Images used  
in Southern Transvaal Survey

<u>Locality Symbol</u>	<u>Centered Near</u>	<u>ERTS ID No.</u>
Cd	Barberton	1047-07184
Dd	Carolina	1048-07243
Ed	Pretoria	1049-07301
Fd	Rustenburg	1230-07370
Gd	Mafeking	1069-07414

A detailed study of the Waterberg Plateau in the northwestern Transvaal on images Ec (Naboomspruit) and Fc (Thabazimbi) showed a complex lineament pattern. Individual lineaments here can be followed for several tens of kilometres and in some places the spacing of the lineaments is so close as to exceed the resolution of the images. A statistical analysis of these lineament orientations on the images was compared with one of the same lineaments as mapped by conventional means and shown on recent unpublished Geological Survey maps. Both sets of data show an identical, very strong northwesterly orientation, with a weaker trend at right angles. The orientation and relative strengths of these peaks coincide closely between the satellite and ground data, indicating that satellite imagery is reliable for studies of this type. Analysis of ERTS-1 images provides a rapid and inexpensive method of regional tectonic synthesis.

#### 4. OBSERVATIONS ON THREE B/W 1:1 MILLION IMAGES OF EASTERN CAPE PROVINCE (SEE FIG. 3)

Assistant Investigator : B.E. Lock.  
Rhodes University, Grahamstown

##### 4.1 Physiography

The Drakensberg escarpment is clearly seen on image Dg (Kokstad-W).

##### 4.2 Lithological differences and outcrop boundaries

The Karoo basaltic volcanic rocks around Barkly East, image Eg (Zastron) and Eh (Queenstown), which are veld covered, display a darker tone than the underlying sedimentary rocks, which carry cultivation, but this distinction is partly obscured by geomorphological factors. At Barkly East itself the lava forms flat, fertile country utilized for cultivation so that here there is little tonal distinction between the lava outcrop and that of the slightly lighter Cave Sandstone.

The outcrop boundaries between the sedimentary rocks of the Beaufort Series (darker) and Molteno Beds of the Sormberg Series (lighter) of the Karoo System and that between the Cave Sandstone and

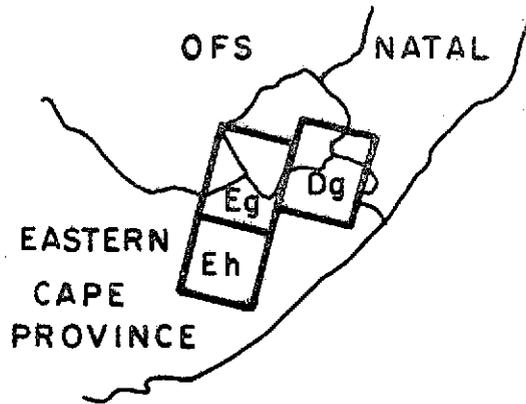


FIG. 3 Distribution of images used in Eastern Cape Province Survey

<u>Locality Symbol</u>	<u>Centred Near</u>	<u>ERTS ID No.</u>
Dg	Kokstad	1084-07260
Eg	Zastron	1139-07322
Eh	Queenstown	1049-07315

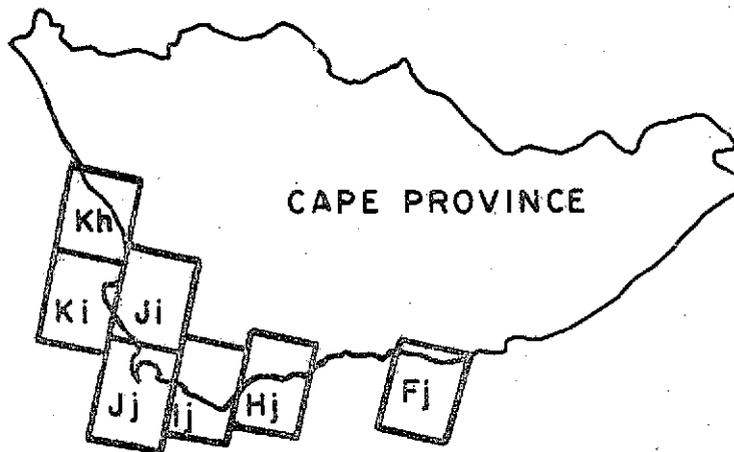


FIG. 4 Distribution of images used in South Western Cape Survey

<u>Locality Symbol</u>	<u>Centred Near</u>	<u>ERTS ID No.</u>
Fj	Port Elizabeth	1176-07334
Hj	Mossel Bay	1142-07504
Ij	Bredasdorp	1143-07563
Ji	Porterville	1180-08012
Jj	Hermanus	1180-08015
Kh	Vanrhynsdorp	1181-08065
Ki	Saldanha	1055-08064

the basaltic lavas of the Stormberg Series are clearly seen on image Dg (Kokstad-W).

The circular basic intrusions in the Karoo in the vicinity of Queenstown are clearly seen on image Eh (Queenstown) and the Mount Arthur complex on image Dg (Kokstad-W).

#### 4.3 Dykes

A number of lineaments, conspicuous on image Eg (Zastron) are probably dykes rather than faults. A dyke that is shown on Stockley's map (Report on the Geology of Basutoland, 1947) is particularly prominent: it follows the Free State-Lesotho border where this runs E-W east-northeast of Zastron on image Eg (Zastron). An E-W system of dykes that cross the Lesotho border at Qacha's Nek appears as lineaments on image Dg (Kokstad-W).

### 5. OBSERVATIONS ON SEVEN 1:500 000 FALSE COLOUR COMPOSITE ENLARGEMENTS OF THE WESTERN AND SOUTHERN CAPE PROVINCE (SEE FIG. 4)

Assistant Investigator : Mr J.N. Theron  
Geological Survey, Regional Office,  
Cape Town

#### 5.1 Lithology and outcrop boundaries

The Paarl, Paardeberg and Darling granite batholiths (AG9) can be discerned on image Ji (Porterville), but actual delimitation of the granite-metasediment contacts is impossible. The extensive cultivation is probably the reason for this. There is also no tonal difference between the granite, the Bokkeveld Series (mainly shale) of the Cape System, and the Cretaceous Enon Beds (pink and red sandstone and conglomerate) on image Hj (Mossel Bay).

The best image for geological interpretation is Ji (Porterville). Outcrop boundaries can be located most exactly where they coincide with lithological changes from dominantly arenaceous to dominantly argillaceous formations, e.g. the Bokkeveld sequence (alternate shale and quartzite) of the Cape System between Cold Bokkeveld and Wuppertal, and the Upper Shale Band in the Table Mountain Sandstone (T.M.S.) of the

same system. Otherwise boundaries can be located only approximately, as between the T.M.S. and the Nama (formerly Malmesbury) System rocks or between the T.M.S. and the Dwyka of the Karoo System. But the T.M.S. of the Piketberg on image Ki (Saldanha) stands out well against the Nama.

The T.M.S.-Bokkeveld boundary on image Kh (Vanrhynsdorp) can be followed only with fair certainty, but the small Bokkeveld outliers close to the confluence of the Kobe and Doring rivers are again very clearly displayed by a tonal colour difference. The Bokkeveld sequence north of the Langberg on image Hi (Mossel Bay) shows the traces of the major bedding planes, but there is no tonal difference between the granite (AG9), Bokkeveld or Enon beds near Mossel Bay.

Delineation of the White Band (carbonaceous shale) in the Dwyka on image Ki (Saldanha) is fairly clear.

The marked dark patch just east of Swellendam on image Ij (Bredasdorp) coincides with an outcrop of the Enon conglomerate of the Cretaceous. This is rather strange in view of the fact that west of Worcester on image Ji (Porterville) and eastwards towards Riversdale the outcrop of this formation cannot be distinguished. This anomaly may have a vegetational or agricultural explanation. The Cretaceous rocks cannot be clearly delineated from the pre-Cambrian along the Sunday's River on image Fj (Port Elizabeth).

The Alexandria Formation of the Tertiary, a white limestone, displays on image Ij (Bredasdorp) a darker colouration east and west of the Potberg (Breede River estuary) than near Bredasdorp, a difference attributed to this formation having a greater thickness in the two basins in the Potberg vicinity.

The various major Tertiary to Recent deposits of sand (Cape Flats, Saldanha, Mamre) can be recognised on image Ki (Saldanha) but accurate delimitation from the older formations is not possible. The dark patch just east of Saldanha Lagoon coincides with part of the Tertiary to Quarternary Langebaan limestone where depth to bedrock is in excess of 30 metres. The area may perhaps be worth investigating for its ground-water potential. The contacts between sand-covered areas and bedrock are very clearly displayed on image Kh (Vanrhynsdorp).

## 5.2 Dykes, sheets and plugs

The northwest-trending dolerite dyke near the confluence of the Kobe and Doring Rivers on image Kh (Vanrhynsdorp) is traceable but virtually nothing can be discerned of the various dolerite sheets and dykes that occur in the area covered by image Ji (Porterville). This applies also to the varied "plug-like" features just north of the Tanqua River.

## 5.3 Folds

The synclinal structure of the Bokkeveld beds along the Elands River on image Fj (Port Elizabeth) as well as those that extend from Humansdorp to the Langkleof are easily discerned, but the southern synclinal structure from Storms River to Nature's Valley is not easily visible, probably as the result of thick vegetation and bush.

The anticlinal structure in the T.M.S. just south of Albertina on image Hj (Mossel Bay) is barely discernable.

In the northeast corner of the B/W 1:1 million image Kh (Vanrhynsdorp) two small domal structures appear. Both were visited in the field and proved to have existence in fact, i.e. the Nama beds dip away from the centre of the structures and from the meagre amount of data available no solid rock has yet been encountered in their centres. A borehole, in one instance only, penetrated soil and rubble to over 30 metres. These structures are not visible on the false colour composite enlargement of the same scene.

## 5.4 Faults

The major Clanwilliam fault as well as some of the other faults can be recognised on image Kh (Vanrhynsdorp), but cannot be traced with certainty in areas where mapping has not actually been done. Some faults including those in the Bainskloof Mountains and those causing the graben structures north of Gydo Mountain are clearly visible, but the Worcester and Ceres faults and some other major dislocations do not show up as marked linear features.

The faults across the Peninsula south of Simonstown and that striking from Rooi-Els to Houw-Hoek on the other side of False Bay are

visible as lineaments on image Jj (Hermanus), but the major faults on images Fj (Port Elizabeth) and Hi (Mossel Bay) cannot be recognised.

#### 5.5 Overthrust or gravity slide

The effect of the overthrust/gravity slide as represented in the Baviaanskloof Range where it transects the regular Bokkeveld succession is well displayed on image Fj (Port Elizabeth).

#### 5.6 Joints

The dominance of northwest joint systems shows up very clearly on image Kh (Vanrhynsdorp) with other systems variously orientated.

#### 5.7 Geomorphological features

The effect of the Mio-Pliocene east-west trending warping axis which influenced and controlled the drainage development of the Duivenhoks, Kafferkuils and Gourits Rivers between Heidelberg and Mossel Bay is clearly visible on image Ij (Bredasdorp). North of the warping axis rivers meander, numerous tributaries occur, etc., whereas to the south their courses are straighter and directly seawards.

Curved lineaments approximately parallel with the coast line seen on image Ij (Bredasdorp) may represent either successive coast lines or fossil dunes. The former southern limit of the Saldanha Lagoon is visible on image Ki (Saldanha) and just north of Laaiplek and south of Dwarskersbos the otherwise smooth concave coast line exhibits a hump/bulge which may perhaps be the result of bedrock at relatively shallow depth.

#### 5.8 Problems

A marked tonal difference occurs northeast and southwest of a NW-SE line situated north of Vanrhynsdorp on image Kh. The dividing line more or less follows a previously assumed fault between the Nama (formerly Malmesbury) System rocks and gneiss to the west and the Nama to the east. The existence of this fault has been repeatedly questioned and it is not shown on the 1970 edition of the 1:1 million geological map.

The marked linear yellow colour change striking SW-NE just north

of Vanrhynsdorp on image Kh cannot be explained. It is not the main road nor any known geological feature.

#### 5.9 Conclusions from study of SW Cape Province false colour composite enlargements

In this already well mapped region nothing new of any significance has been found as a result of the study of the ERTS-1 imagery. However, the false colour composite enlargements exhibit most of the major elements of the geological structure on a very convenient scale for regional representation. Some features, such as joint systems and major bedding planes within stratigraphical units, are better displayed on the enlargements than on the 1:1 million geological map.

### B. PROGRESS IN THE USE OF ERTS-1 IMAGERY IN THE PERSUANCE OF THE PARTICULAR GEOLOGICAL OBJECTIVES IN THE TEST SITE AREAS SPECIFIED IN THE PARTICIPATION AGREEMENT

#### 1. TEST SITE A : TRANSVAAL

##### Co-investigators

: Dr F.J. Coertze,  
Geological Survey, Pretoria  
Dr H. Jansen  
Geological Survey, Pretoria  
Mr F. Walraven,  
Geological Survey, Pretoria  
Mr G. Andrews,  
Geological Survey, Pretoria  
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Geological Survey, Regional Office,  
Pietersburg  
Prof. W.J. van Biljon,  
Rand Afrikaans University,  
Johannesburg.

#### 1.1 Objective (a). Regional geological structure of the Bushveld Igneous Complex (See Fig. 5)

##### Results

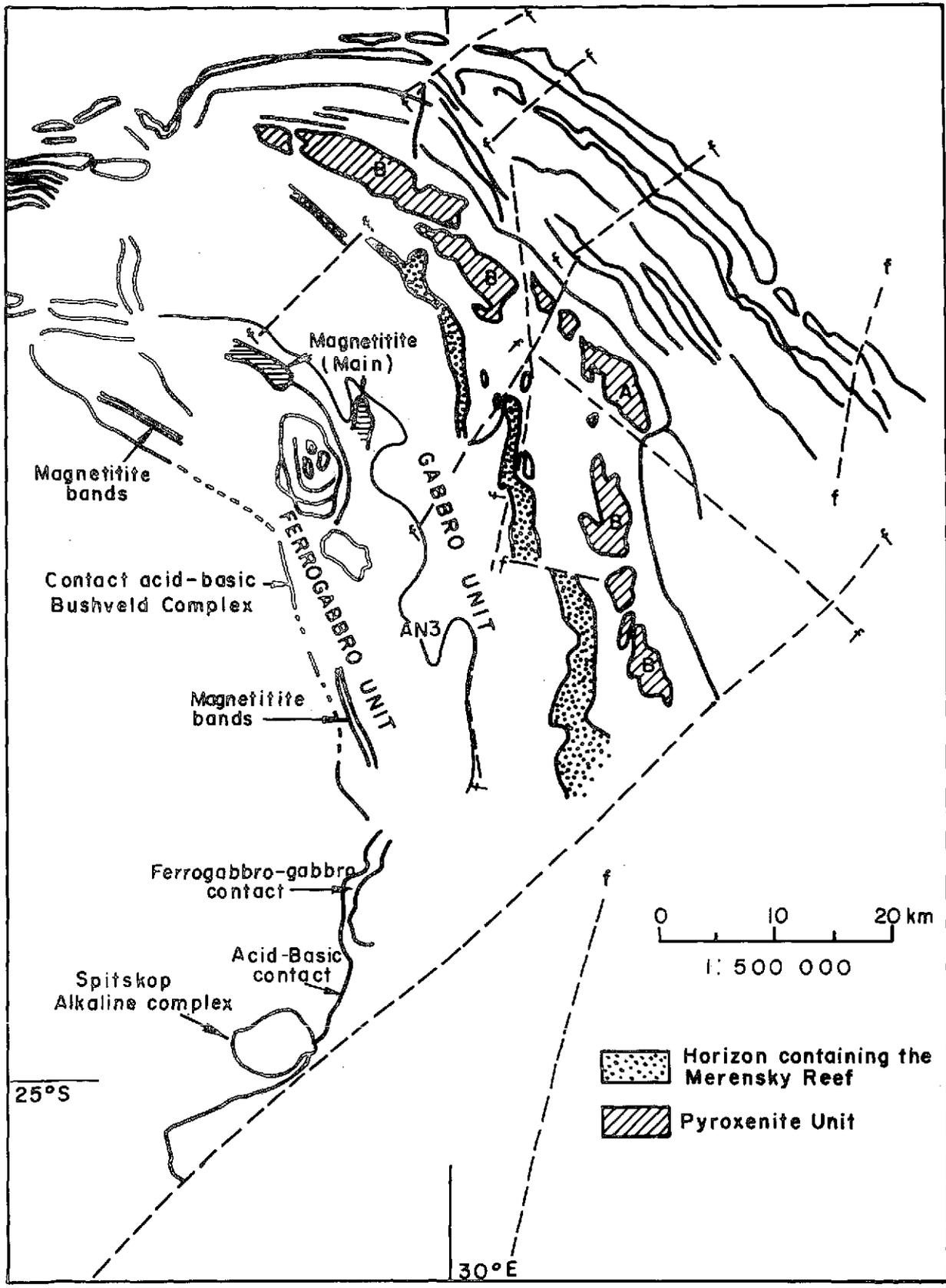


FIG. 5 Northeastern part of the Bushveld Igneous Complex and underlying sedimentary rocks of the Transvaal System. Interpretation of part of false colour composite ERTS-1 enlargement E-1138-07245, De (Penge) by F. Walraven

- 1.1.1 Contact between gabbro and ferrogabbro and distribution of magnetite bands. False colour composite enlargement Dc (Penge) and figure 5.

This image includes part of the outcrop of the basic portion of the Bushveld Igneous Complex. The upper part of this basic portion consists of a unit referred to as ferrogabbro and this is immediately underlain by a much thicker unit referred to simply as gabbro. Although the ferrogabbro is not exposed, the soil upon it has a different shade of green on the false colour composite enlargement from that of the soil developed on the gabbro, the former being olive green and the latter blue-green. The magnetite bands that form part of the ferrogabbro unit can be seen very clearly.

- 1.1.2 Distribution of chromitite bands. Same false colour composite enlargement as above.

The pyroxenite containing chromitite bands, which underlies the gabbro, forms hills recognisable on this image as rows of brown patches in a field of blue-green. As the hills marked A in figure 5 resemble those marked B it is to be expected that they are formed of the same rock type and contain chromitite. They are indeed made of the same rock, though in hills A the chromitite concentrations are insignificant.

- 1.1.3 Carbonatite-bearing alkaline complex at Spitskop. Same false colour composite as above.

This complex can be seen quite clearly in contrast to the black and white images.

- 1.1.4 Tin-bearing Bobbejaankop granite. False colour composite enlargement E-1049-07295, Ec (Naboomspruit).

An attempt was made to locate this tin-bearing granite, which is a phase of the acid portion of the Complex, but without success. No distinction can be seen between this granite and either the surrounding main granite or the sedimentary rocks of the Transvaal System in its vicinity.

### 1.1.5 Comparison of different prints of the same image

Final printing plays a large part in the clarity with which certain features are shown on ERTS images, whether black and white or colour composite. Different prints of the same image using the same parts of the spectrum show widely different details due to variable balance between the parts of the spectrum and the intensity and contrast of each.

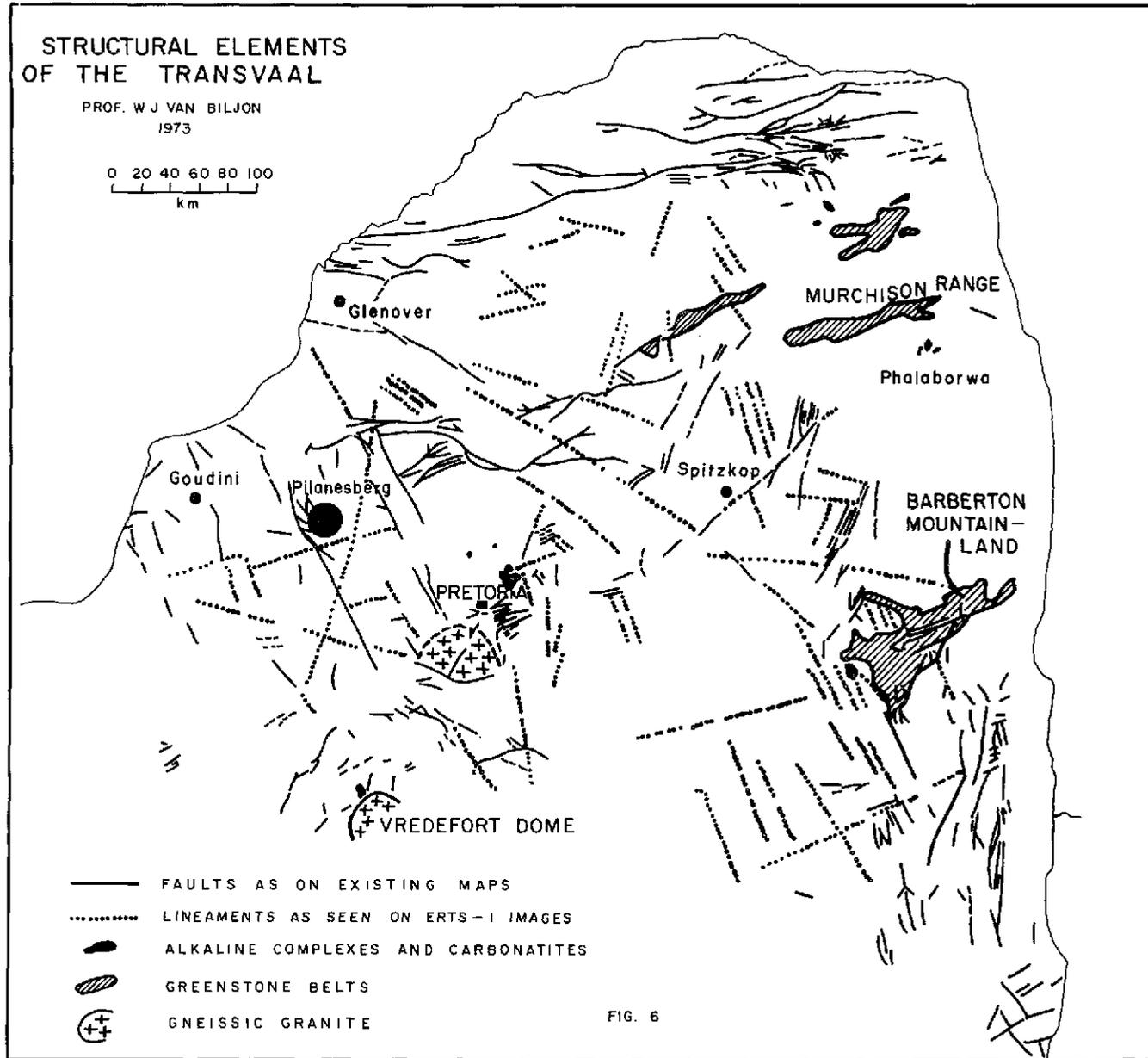
### 1.2 Objective (b). Lineaments that could be mineralized or cast light on possible petrographic and mineralogenic provinces

#### Results

#### 1.2.1 Major lineaments in the Transvaal

A mosaic of ERTS-1 images covering the Transvaal reveals that some large-scale structural features can be observed. (See Fig. 6). In particular some faults can be seen lying on major lineaments, not recognised before. One such lineament running for nearly 600 km across the Transvaal begins in Swaziland and runs in a north-westerly direction through the Bushveld Complex into Botswana. It was also noticed that the south-western edge of the Barberton Mountainland is bounded by this lineament, that the triangular patch of felsite protruding through Waterberg sandstones has one side parallel to the same lineament, and that both the alkaline rocks near Badplaas and the carbonatite at Glenover lie on this line. It was further noted that north-west trending faults in the western Bushveld Complex are continuous for much longer distances than indicated on the geological maps and that a large number of pipe-like bodies (volcanic vents) lie on these lineaments, e.g. carbonatites at Goudini, Tweerivier, Bulhoekkop, Nooitgedacht and Kruidfontein, alkaline rocks at the Vredefort Dome, and the copper-bearing volcanic plug at Roodewal south-east of Potchefstroom.

A number of east-northeast trending lineaments were also noted in the same area. These are not shown on any geological maps except that the fault skirting the southern side of the Pilansberg is parallel



to this direction. The direction also coincides with some kimberlite fissures occurring north of Swartruggens.

It is concluded that many of the geological features of the Transvaal, including sedimentary basins, granite plutons and volcanic plugs are controlled by fundamental crustal fractures which have been active since the earliest geological history and may be active even to the present.

#### 1.2.2 The Louis Trichardt - Pietersburg area

In an area of Archaean granite between Louis Trichardt and Pietersburg (See Fig. 7) three lineaments not previously noted have been recognised on image E-1049-07292 Eb (Louis Trichardt). A faint lineament striking NE coincides with occurrences of gold and copper at and near the old Harlequin Mine on Goedgenoeg 185 LS, the minor copper occurrences near Bandelierkop, and the phosphate (apatite/vermiculite) deposits NE of Bandelierkop. This lineament may therefore represent a zone of mineralization probably related to a shear or fracture zone although the apatite deposits are associated with pegmatites. A shear zone striking more or less in the same direction has been reported to occur in this apatite-bearing area. Two lineaments striking NW are probably also fractures or fault zones but as yet no mineralization has been found on them.

#### 1.2.3 Thabazimbi

Two long N-S lineaments near Thabazimbi on image E-1050-07353-7 Fc (Thabazimbi) had not been observed before (Fig. 8). Their identity has not yet been established in the field.

### 1.3 Objective (c). The complicated fault system in the Soutpansberg area

The fault pattern as indicated by lineaments on image E-1211-07302-7 Eb (Louis Trichardt) (fig. 7) and also by provisional field data, differs from that on the 1970 edition of the 1:1 million geological map. For instance, a fault seems to bound the northeastern spur of Blauberg on the south. It strikes through the flats north of Vivo along

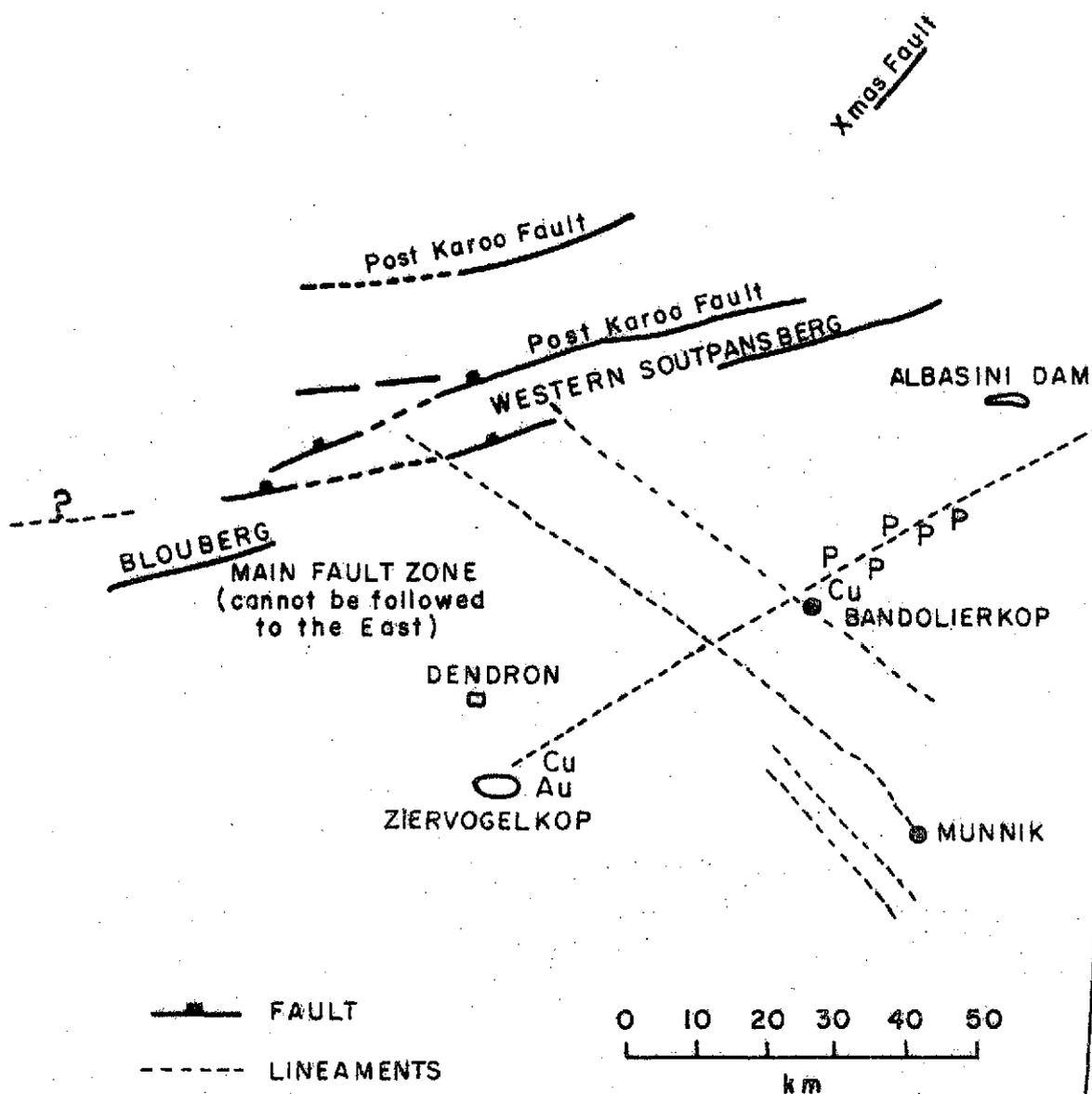


FIG. 7 Lineaments in granite which may reveal loci of ore deposition south of the Soutpansberg on image E-1049-07292-7 Eb (Louis Trichardt) traced by S.B. de Villiers; and probable links between major fault-zones in the western Soutpansberg and Blauberg as indicated by lineaments in the same area on image 1211-07302 traced by H. Jansen.

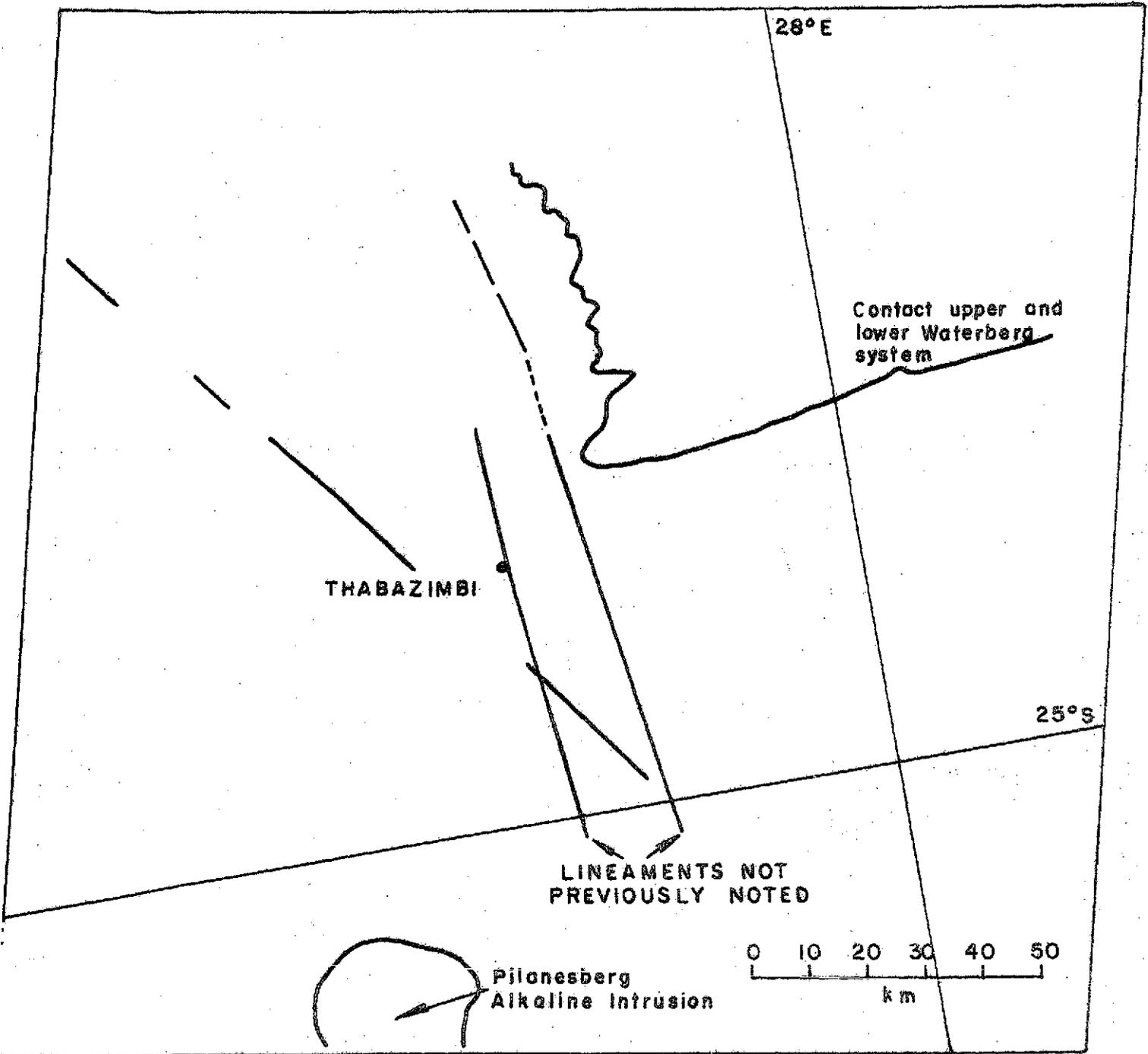


FIG. 8 Two north-south lineaments not previously observed found on image E-1050-07353-7 Fc (Thabazimbi) by F. Walraven

the northern slope of the Soutpansberg.

## 2. TEST SITE B - WESTERN CAPE PROVINCE

Co-investigators : Mr J.N. Theron,  
Cape Town Regional Office of the  
Geological Survey

### Objectives:

- (a) Geological structure of the Cape Folded Belt and pre-Cambrian rocks to the north.
- (b) Extension and ramifications of the Worcester fault with which the disastrous Ceres earthquake of September 1969 was believed to be associated.
- (c) Structural features that could control the occurrence of Kimberlite pipes and lead to the discovery of hitherto unknown pipes.
- (d) Geomorphological features that could assist in the prospecting and discovery of marine- and old river terraces that are diamond-bearing.
- (e) The detection of underground water flows from the dry sand-covered areas into the Atlantic Ocean.

### Results:

Apart from the detailed account under section 2 of this report on what known geological features can and cannot be seen on the images, no significant advance in the pursuance of the specified objectives was made during the reporting period. The following observation, previously referred to applies to Objective (b).

The fault to which the Ceres earthquake was evidently related cannot be recognised with certainty. The Worcester fault and some of the other major dislocations do not show as marked linear features. Their positions can be deduced, but their exact locations are not visible on the false colour composite enlargement E-1180-08012 Ji (Porterville).

### 3. TEST SITE C - NATAL

#### Co-investigators

: Dr J.W. du Preez,  
Geological Survey Regional Office,  
Pietermaritzburg  
Mr C.J. van Vuuren  
Geological Survey Regional Office,  
Pietermaritzburg.

#### 3.1 Objective (a). The regional geological structure of the Lebombo monocline and of the pre-Cambrian rocks in the Nkandla area

##### Results

The use of ERTS-1 images false colour composites enlargements E-1047-07191, Ce (Vryheid) and E-1047-07193, Cf (Pietermaritzburg) has not lead to any significant advances in the persuances of this objective. This area has already been mapped in great detail and although some of the main features show up on the images, others do not. The complex Bumbeni volcanism on the eastern slope of the Lebombo range is hardly recognisable, but with better photographic definition this complex assemblage of acid and basic lavas might have been demarcated.

The large Tugela fault is shown clearly as a multiple fracture (fig. 9), but poor definition prevented detailed structural analysis of the pre-Cambrian rocks of the Nkandla area.

#### 3.2 Objective (b). Lineaments and structures in the Nkandla area with special reference to the possibility of minaralization

##### Results

Poor photographic definition excluded accurate identification of structures on the images in the Nkandla area. Between Pongola and Piet Retief a series of parallel lineaments is, however, clearly shown, which probably represents a swarm of diabase dykes. In addition image Ce (Vryheid) shows a lineament some 80 km long, running NW-SE between Paulpietersburg and Piet Retief. This prominent feature has not been recorded on Geological Sheet 68 (Piet Retief) and therefore warrants

TRACING FROM ERTS FALSE COLOUR COMPOSITE ENLARGEMENT  
(Cf PIETERMARITZBURG) E-1047-07193 SHOWING TUGELA FAULT SYSTEM

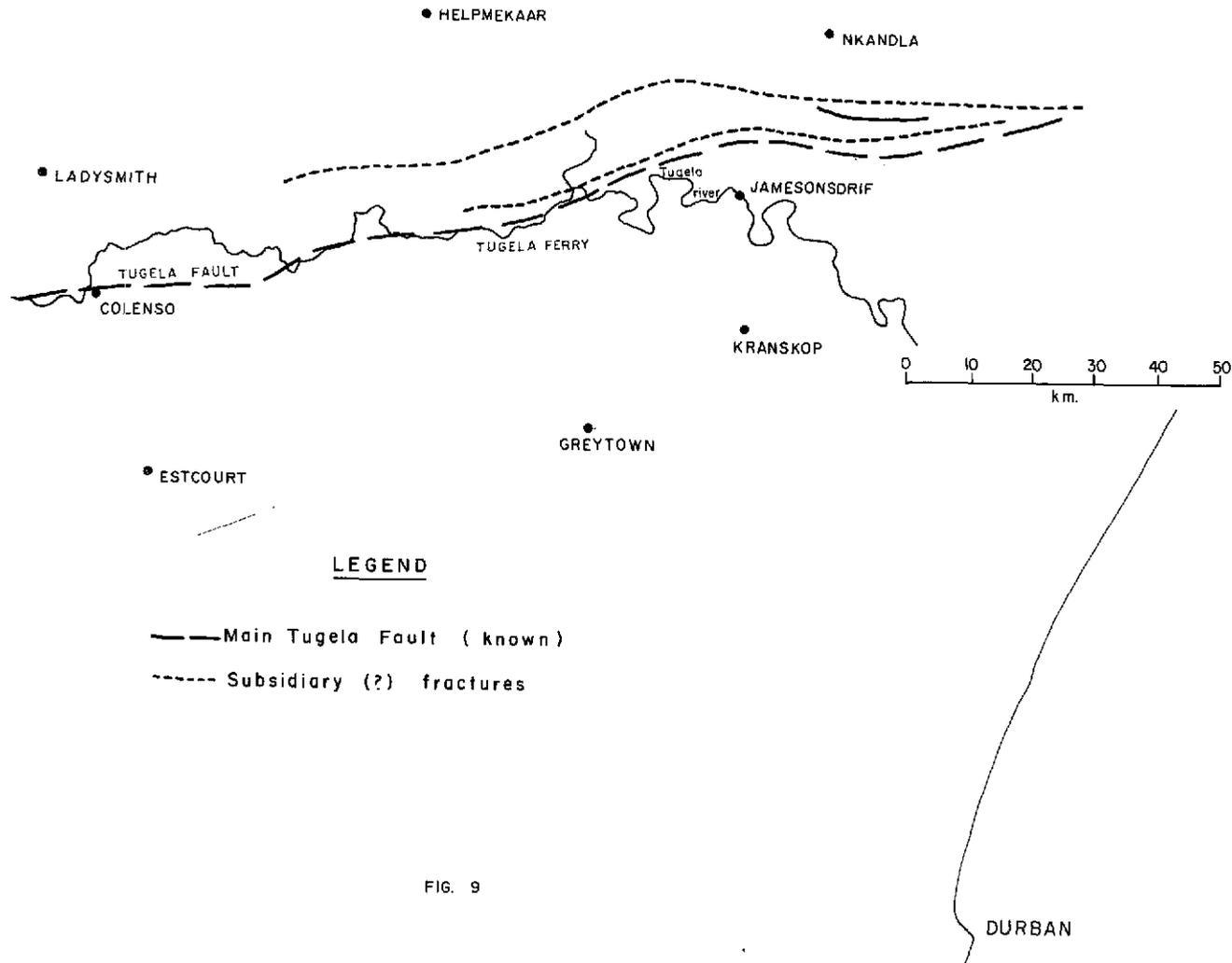


FIG. 9

close examination on the ground. Although no mineralization is known to be associated with the swarms of basic dykes illustrated on Sheet 68, a re-examination of this possibility appears justified.

3.3 Objective (c). Large-scale structural features in the Karoo rocks which could be useful in the oil exploration programme now being carried out

Results

A light coloured zone striking roughly NW-SE occurs on image Ce (Vryheid) some 15 km south of Vryheid (fig. 10). It is known that this area is underlaid by the Ecca series of the Karoo System and that indications of oil occur in the Middle Stage of this Series in the Dannhauser area. The reason for the light colour is not known but it may be due to agricultural practises or to some geomorphological factor.

C. USES OF ERTS-1 IMAGERY

1. Reconnaissance

Because geological mapping in South Africa is now beyond the reconnaissance stage ERTS imagery is not as useful now as it would have been had it been available earlier. With regard to mineral prospecting, in a brief report entitled "A structural interpretation of the gravity field over the Gordonia-Carnavon region of northern Cape Province", Prof. D.A. Pretorius, Director of the Economic Geology Research Unit, University of the Witwatersrand, in a paper presented at the 1973 Congress of the Geological Society of South Africa stated:

"Had the imagery become available three or four years earlier, it would not have required the reprocessing of the gravity field to delineate one of the major structural features of South Africa. The images would also have been of appreciable value in the initial stages of the current prospecting programmes for base metals in the Prieska-Uppington area. The Brakbos lineament can now be seen to represent the locus of known mineralization at Copperton and Areachap. An extensive tract of country between

TRACING FROM ERTS FALSE COLOUR COMPOSITE  
ENLARGEMENT E-1047-07191 (Ce, VRYHEID)  
SHOWING LINEAMENT BETWEEN PIET RETIEF  
AND PAUL PIETERSBURG AND LIGHT-COLOURED  
ZONE BETWEEN VRYHEID AND DUNDEE.

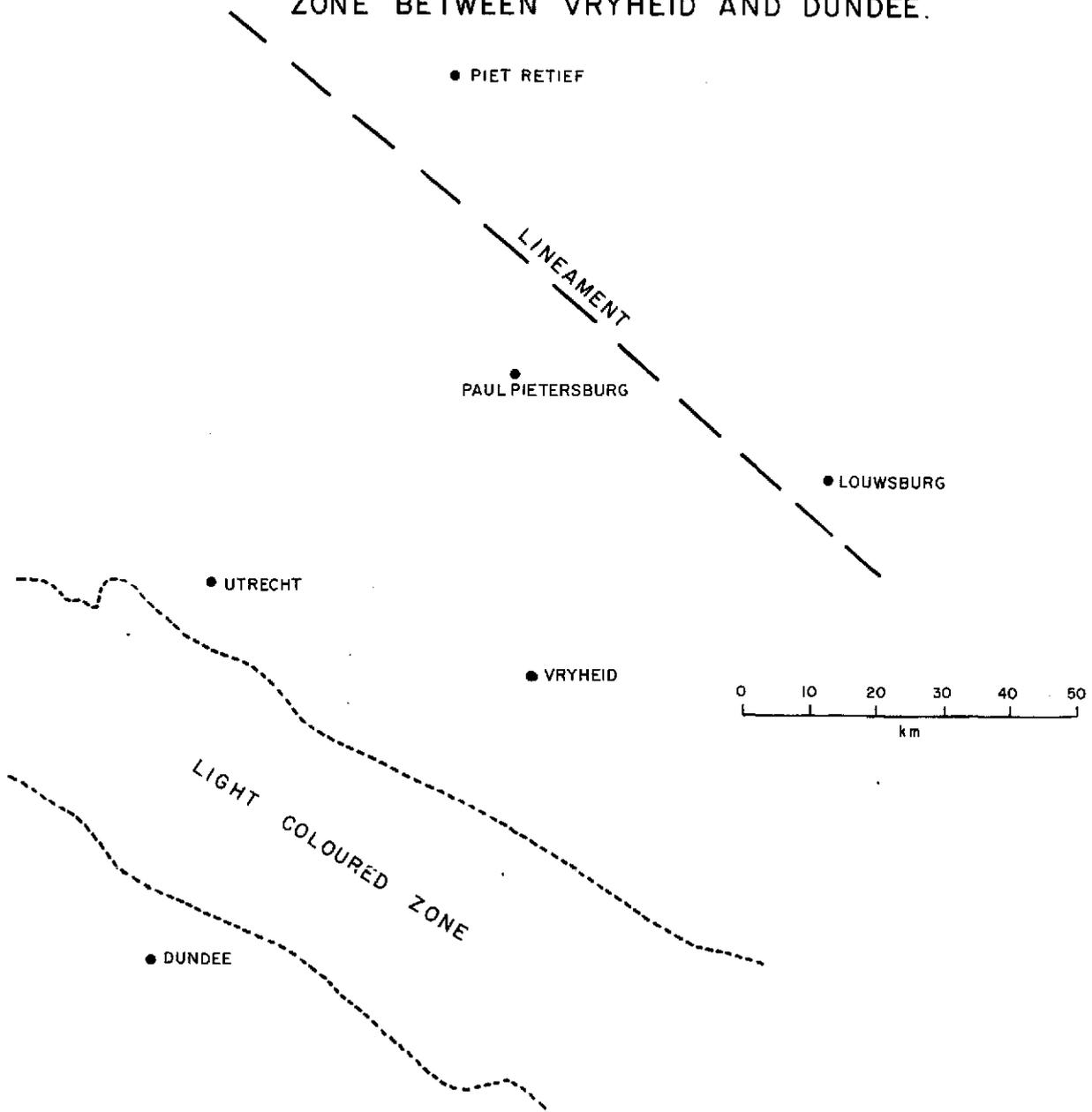


FIG. 10

these two localities can be seen, on ERTS-1 imagery to be underlain by potentially favourable loci for further mineralization".

## 2. Geological map revision

### 2.1 Topographical base

The existing 1:1 million geological map of South Africa has been compiled by scale reduction from innumerable earlier maps the topographical basis of which was, in many cases, surveyed before the days of aerial photographs. Comparison of parts of the 1:1 million map with ERTS images shows that the topographical base, in particular the details of the drainage pattern, in the next edition of the 1:1 million map, can be greatly improved by the use of the images.

### 2.2 Geology

There are still areas in South Africa that are being or will be mapped on a larger scale than the existing maps and others of which the existing maps are from time to time revised, and in future it will be routine practise for geologists to use ERTS images in this work. The main elements in the geology that can be revised by the use of ERTS imagery are those revealed as lineaments on the images. The lineaments show that many known faults and dykes are very much longer than indicated on the existing maps. Further, it is usual practise when mapping to omit lineaments seen on aerial photographs unless they can be proved to be dykes or faults, or to be joints of known hydrogeological or mineralogical significance. Inspection of the images and comparison of them with existing geological maps shows that there are, in many parts of the country, innumerable lineaments that are not shown on any geological map. While most of the shorter of these may be joints of only collective importance as members of systems, the longer ones that are revealed as strong negative or positive topographical features are likely to be of structural, petrogenic or metalliferous significance. The ERTS images draw attention to these longer lineaments much more effectively than can ordinary aerial photographs. If such lineaments have not already been identified in the field, this should be done at the first opportunity.

### 3. Structural synthesis

Apart from the notes and map by Prof. Van Biljon provided on page 104 of this report, no detailed structural synthesis of an area has yet been made in South Africa with the help of ERTS imagery. It is, however, obvious that in areas of good rock exposure images of sharp contrast and high resolution can be of great assistance in this process and such use will undoubtedly be made of them in the future.

### 4. Tectonic map of South Africa

One of the most important projects that will be greatly assisted by the use of ERTS imagery is the compilation of a tectonic map of South Africa. This project will commence in 1974 as a result of the availability of ERTS imagery which has provided not only the impetus to start the work but the very basis of the compilation.

### 5. Use of the 1:500 000 enlargements

The main advantage of enlargements, whether black and white or false colour composite, is that it is very much easier to make tracings of detail from them than it is from the original 1:1 million images. This is a very important advantage because it often determines whether it is worthwhile making a tracing or not.

### 6. Use of false colour composite enlargements

The use of false colour composites introduces a new factor into image interpretation. As this is one in which most geologists have had no experience at all, it will take some time before they develop sufficient expertise to derive full benefit from this refinement. Geologists need some instruction in false colour interpretation which might well take the form of examples of interpretation in other disciplines. The geologist must know how to distinguish colours that are due to different types of vegetation and soil so that he can eliminate these from the available geological evidence or take them into account correctly so that true geological inferences can be made from them.

### D. DIFFICULTIES

Apart from difficulties that arise from poor definition or tone

contrast in some images, from poor rock exposures in some parts of the country, and from lack of knowledge in the full interpretation of false colour composites, the main difficulty experienced is to find the exact location of observed detail with reference to its topocadastral setting. This arises from the frequent lack of registration on the images of roads, railways and towns, and the difficulty is most acute in areas of low topographical relief in which the lesser drainage lines are invisible.

This difficulty is being overcome, as far as the 1:500 000 enlargements are concerned, by the use of transparent overlays which are being printed from the 21 published topocadastral maps of that scale which cover the country. These overlays show main roads, railways, the main rivers and a light cover of place names and are very satisfactory for the purpose.

V. EVALUATION OF ERTS-1 IMAGERY FOR URBAN AND REGIONAL  
LAND-USE SURVEYS

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1. OBJECTIVES

In South Africa land-use surveys form an important element of regional study. The lack of adequate, up-to-date maps and the extensive nature of development regions make the undertaking of land-use surveys on a regional scale a lengthy and tedious undertaking. ERTS images were, therefore, examined to determine whether they can be used to overcome this problem, and, if so, the extent of the knowledge which can be derived. To assist the Department in this evaluation, the Department of Forestry, the Natal Provincial Administration and a number of universities have been involved in the work. Only the Natal Provincial Administration and the University of Cape Town provided detailed comments on the use of the images.

2. METHODS

Most investigators did not appear to use optical apparatus, although a few used a lens and/or a stereoscope. Areas for which land-use surveys were available or which were known to the investigators were chosen for study.

Two sets of prints were used. In the early stages of investigation only monochrome prints at a scale of  $1:10^6$  were available. These were found to be rather unsatisfactory in some cases since certain features were not as clearly defined as those shown in other satellite photographs. Evaluation could therefore be facilitated if better prints were available.

False colour prints at a scale of  $1:5 \times 10^5$  became available at a later stage and this considerably altered the attitude of the investigators since these prints enabled better identification of land-use. It is thought that even persons not well versed in photo interpretation could profit by having such prints made available.

### 3. RESULTS

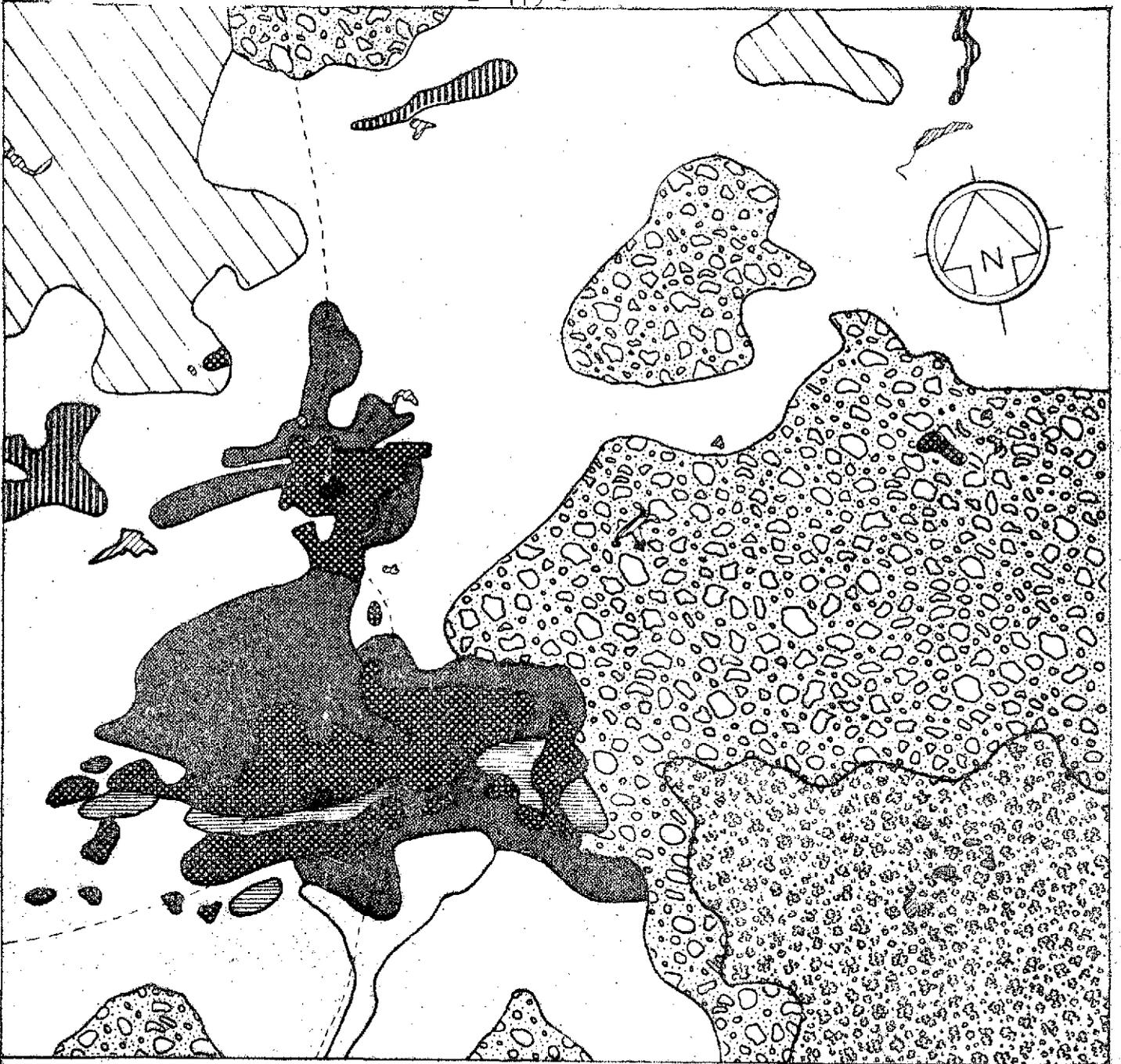
#### 3.1 Land-use analysis of urban and metropolitan areas

##### 3.1.1 The Southern Transvaal

This is the most urbanised area in the Republic and its environs contain most land-uses; it is, in addition, known to the researchers.

The following urban land-uses, shown on Map 1 were identified on the monochrome prints:

- (i) The extent (or boundary) of urban areas is clearly visible. It appears that newer residential areas have a lighter tone than the older suburbs, probably due, inter alia, to the difference in planting.
- (ii) The central business district is noticeably darker than other built-up areas of the city.
- (iii) The main railway network can be easily identified in urban areas, especially where two or more tracks occur, or where a railway is adjacent to a road. The most important skunting yards in the two large urban complexes can also be distinguished.
- (iv) Tarred roads are not so conspicuous. Where the freeway



REFERENCE

SCALE 1:100,000

A. URBAN LAND USE

-  C.B.D.
-  Urban development (Built-up areas)
-  Urban fringe (small holdings)

B. RURAL LAND USE

-  Storage Dams
  -  Irrigation farming
  -  Intensive Cultivated areas
  -  Extensive Cultivated areas
  -  Exhausted Agricultural Land
- } Drylands

C. OTHER LAND USE

-  International Airport.
-  Mining Areas
-  Main Transportation Corridors.

MAP

LAND USES AS IDENTIFIED FROM E.R.T.S.-A IMAGES

PRETORIA - WITWATERSRAND AREA

is still under construction, its route is clearly discernible.

- (v) Large open areas in the city, for example golf courses, are conspicuous because of their contrast with the surrounding built-up area.
- (vi) An international airport is easily identifiable by the main runway, which is visible without the use of the stereoscope.
- (vii) The so-called "urban fringe", a transition area of small holdings between town and country, is also distinguishable, because of its characteristic intensity of land-use.

#### Conclusion

Only the very broad and large-scale components of a metropolitan area can be identified from the ERTS images. For land-uses in an urban area the photo-scale is too small to provide worthwhile results.

### 3.2 Land-use analysis of national and regional areas

#### 3.2.1 The Southern Transvaal

In 3.1.1 the urban land-uses of the Southern Transvaal were discussed. In this section the rural elements of the region, identified from monochrome prints, are discussed.

- (i) The gold mining areas stand out very clearly.
- (ii) The type of agriculture and the intensity of cultivation is very clearly discernible. It was possible to identify irrigated areas, also intensive and extensive dryland cultivation.

In two cases, land which has been overworked by wrong farming methods can also be identified, by its contrasting lighter tone to its surrounding agricultural areas.

#### Conclusion

It is clear that the photographs can be an important source of

information in rural land-use studies of South Africa where broad patterns of agriculture can be identified rapidly.

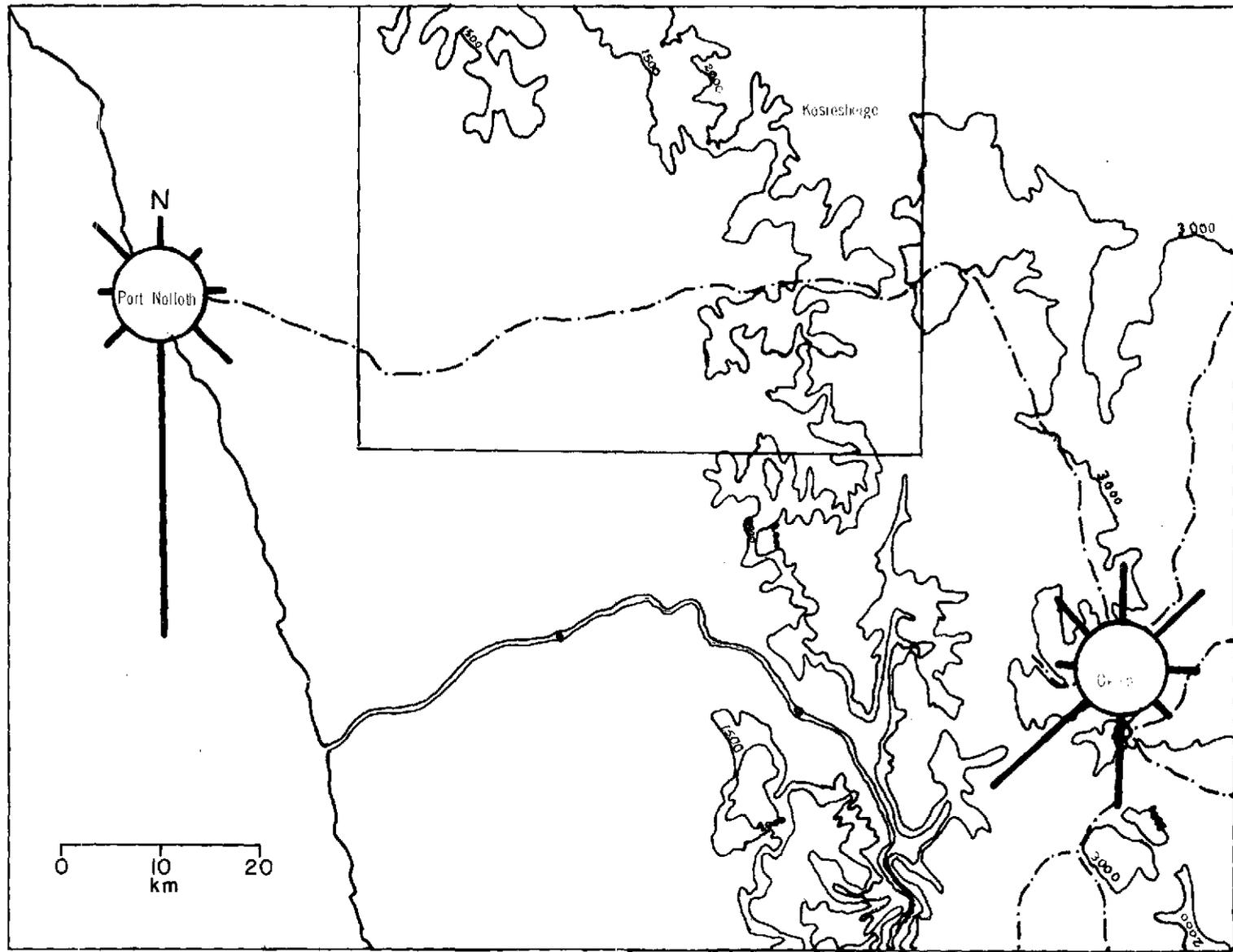
### 3.2.2 Namaqualand, Cape Province

This area, like that of the Southern Transvaal, was studied from monochrome prints. The area is to the east of Port Nolloth on the Atalantic coast (see map 2 ).

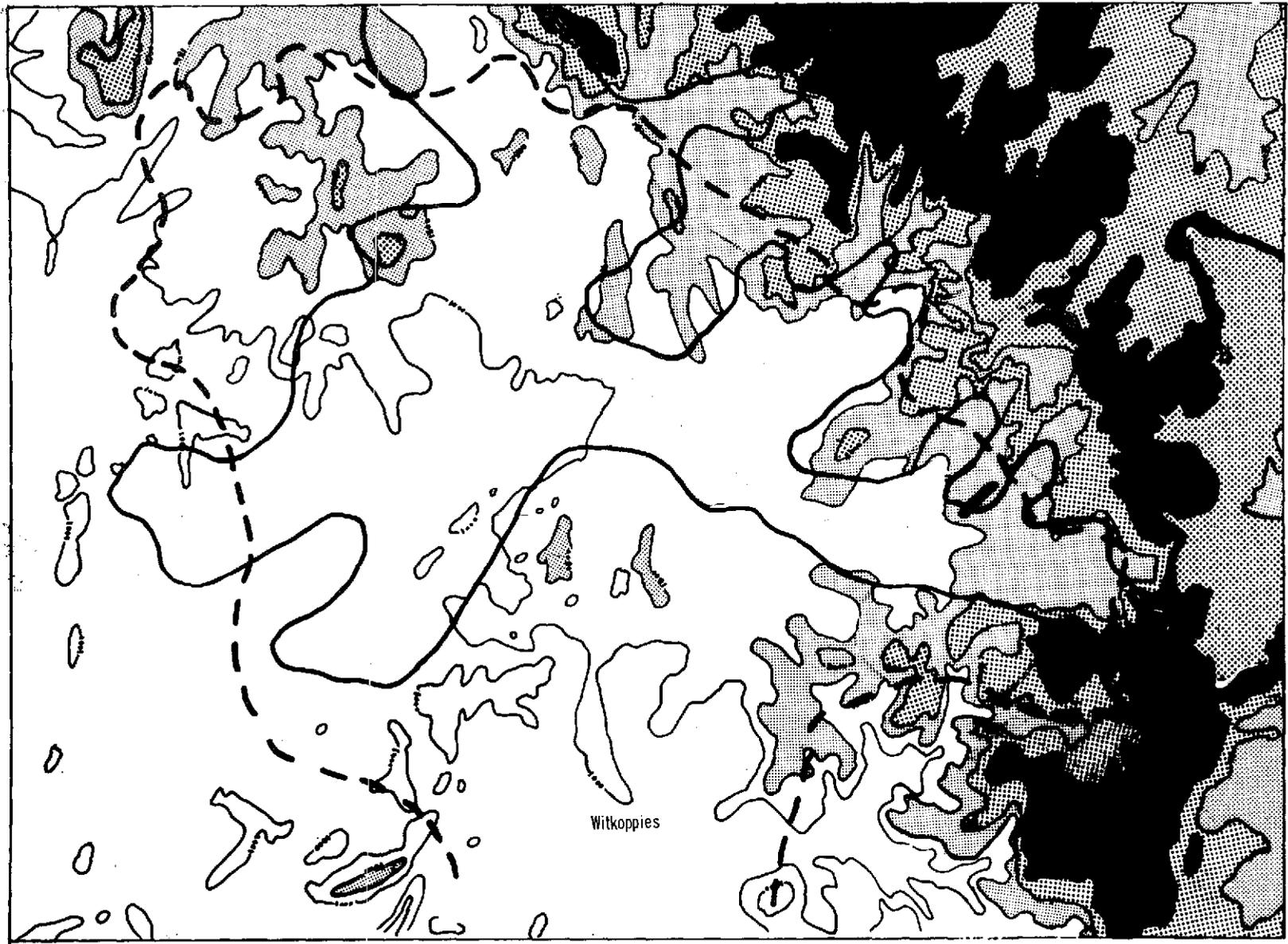
The region is desolate and is generally inaccessible by normal means of communication, there being no roads or bridges in the area (it is marked on map 2 and enlarged on map 3 ). The rainfall is low, of less than 250 mm (10 in) a year, and is very low along the coast, being about 75 mm a year at Port Nolloth. The rainfall, moreover, is subject to considerable variation. Evaporation from a free water surface is of the order of 2500 mm (100 in) a year. The region is, thus, semi-desert and human settlement is on very large farms of 4 000 ha and more. The main economic activity is sheep farming.

The area was brought to the Government's attention because it was known that sand erosion was becoming a problem in this part of Namaqualand. The Government wished to control land-use there as farms were being badly encroached on by wind-blown sand. An Interdepartmental Committee on Land Conservation Problems of Farms in Namaqualand was established to investigate the matter and the Department of Planning and the Environment was represented on this Committee.

A survey of the area affected to the west of the Kosiesberge was made. The sand appeared to drift from the Kosiesberge and the surrounding topography appeared to have a funnelling effect on the wind. The extent of the problem could not be gauged in the field nor could it be readily identified from large scale photographs since a large number of these would have to be spread out to cover the area concerned. Instead, by examining an ERTS print with a handlens, the approximate extent of the sand could be seen immediately. Furthermore, the approximate direction of the drift of the sand could also be seen, namely north-east. The approximate area of the sand is shown on map 3 as Boundary A. A study of wind directions at two stations nearest to the area was made at Port Nolloth and Okiep (map 2 ). The wind has



MAP 2. WIND FREQUENCY PORT NOLLOTH AND OKIEP(NAMAQUALAND)



REFERENCE

Over 2500 ft.	
2000 2500	
1500 2000	
Less than 1500	
Boundary A	
Boundary B	

NASA ERTS E 1056 081111 5

SCALE: 1: 250 000

MAP 3 EROSION AREA NAMQUALAND SOUTH AFRICA

a predominantly southerly component in this region although a fair percentage of wind frequency is north-easterly at Okiep.

After demarcating the erosion on an ERTS image, photographs on a scale of 1:40 000 were studied and the critical areas determined more closely. By chance a strong wind was blowing at the time that the flight was being made and it was clear that the wind was coming from the north-east. Thus the published climatic data is inapplicable to the area.

The sand appears to be picked up by the wind and borne over the mountains; it loses speed as it comes into contact with minor topographic features to the west and drops its sand load. Near the hills the sand appears to have stabilised itself although the dunes just east thereof appear to be unstable and are aligned in an east-west direction.

Boundary A (map 3) is the extent of the area of erosion as determined independently by the Interdepartmental Committee referred to earlier. It is thus apparent that it corresponds fairly well with that obtained from the ERTS print.

#### Conclusion

The pattern and direction of wind erosion can be readily identified and plotted on a scale of 1:1 000 000. It would be a considerably more onerous task to locate the extent of the area affected by the sand on large-scale photographs. The use of ERTS images reduces the time taken to identify the area to a fraction of what it would otherwise be.

Without the availability of small scale ERTS prints the problem may not be tackled or it may take much longer to discover the nature of the problem.

The satellite images are therefore a valuable tool in the reconnaissance stages: the problem area can be identified quickly and examined in more detail thereafter.

It is known that sand dunes shift their positions with time and therefore a number of ERTS images, taken over a period of years,

would be useful in helping to determine changes that may have occurred.

### 3.2.3 Regional land-use in the Gamtoos River Valley and the Port Elizabeth/Uitenhage Metropolitan area

The region shown in Map 4 is an example of a detailed land-use survey of the Gamtoos Valley which was mapped from conventional air photographs, all-in-all some 50 different photographs were used in the compilation.

This type of land-use analysis is not possible from satellite images. In land-use surveys for detailed planning on a local level, therefore, conventional photographs will be more suitable, although they are more time-consuming.

Map 5 shows the land-use in the Gamtoos River Valley in its broad regional setting in relation to the Port Elizabeth/Uitenhage Metropolitan Area. The false colour images show clearly the broad pattern of irrigation in the valley. These details are satisfactory if the broad regional land-use pattern were to be analysed. The photograph also shows the other broad regional land-uses, such as extensive mixed farming and extensive pastoral areas.

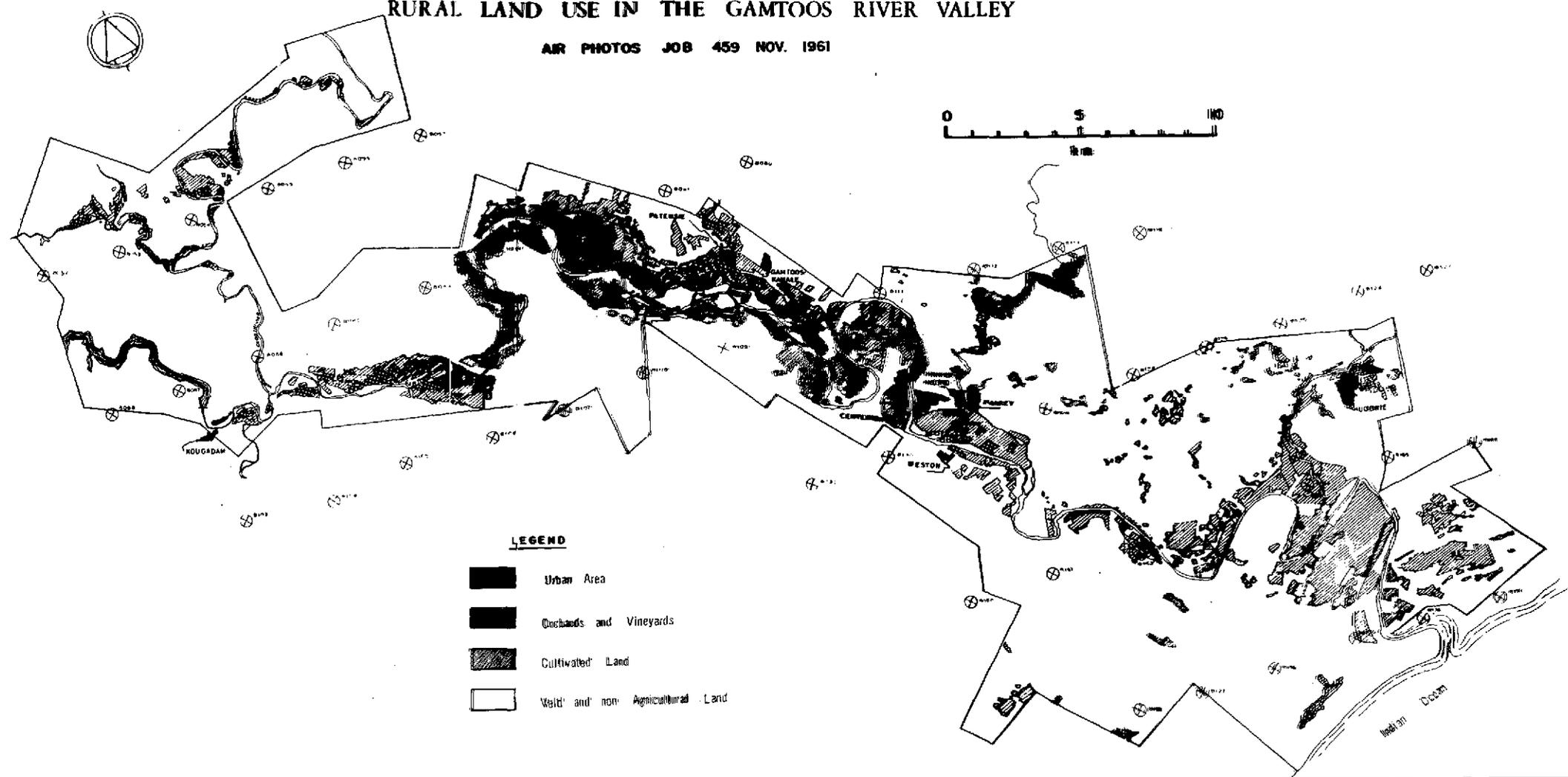
Needless to say, a personal knowledge of the broad economic land-use activities is important for this type of analysis. The time spent in this type of mapping, particularly when false colour images at a scale of 1:500 000 are available, is minimal when compared to mapping from conventional photographs. In the study of macro-areas, the differences in accuracy between maps produced from conventional and from ERTS images are negligible, especially since detail cannot, in any case, be shown on small scale land-use maps.

### Conclusion

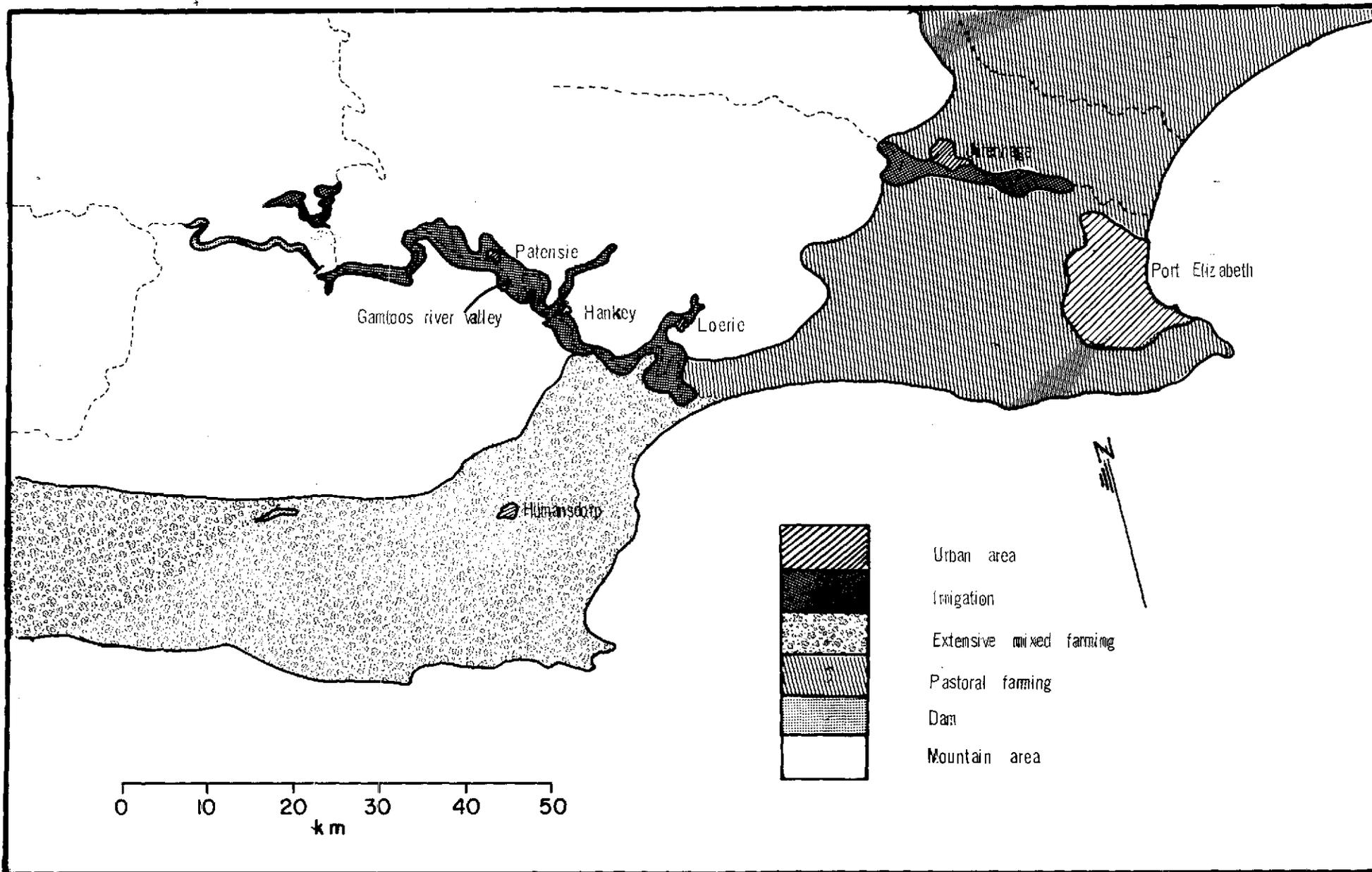
A comparison of the Gamtoos Valley as shown on Maps 4 and 5 brings out the fact that the broad land-use patterns compare very well and the mapping shown on Map 5 is satisfactory for purposes of regional planning.

# RURAL LAND USE IN THE GAMTOOS RIVER VALLEY

AIR PHOTOS JOB 459 NOV. 1961



MAP 4



NASA ERTS E 1176 07384

MAP 5. REGIONAL LANDUSE PATTERN GAMTOOS / PORT ELIZABETH METROPOLITAN AREA

### 3.2.4 The South Western Cape Province

One of the purposes for which ERTS images could be used is to test the validity of regional boundaries.

Planning regions for development purposes have been determined on the basis of four basic factors, namely the existence of a nodal point, population distribution, the network of infrastructure and the existence of physical boundaries. After these four aspects had been considered, the regional boundaries were adjusted so as to conform to magisterial district boundaries since the statistics are published on this basis.

The subdivision of the South West Cape into regions was tested with the aid of ERTS images. An exceptionally good correlation was found between the original regional subdivision, before the boundaries were adjusted to conform to those of the magisterial district, and the regions as these appear on the images.

The town of Bonnievale in the Swellendam District may be mentioned as an example. In the regional subdivision the sift method was employed and it was apparent that the town did not form part of the intensive winter grain area in the Swellendam/Bredasdorp/Caledon region but of the fruit growing area of the Robertson/Worcester/Ceres region. Due to the administrative structure it was, however, necessary to incorporate the town into the former region.

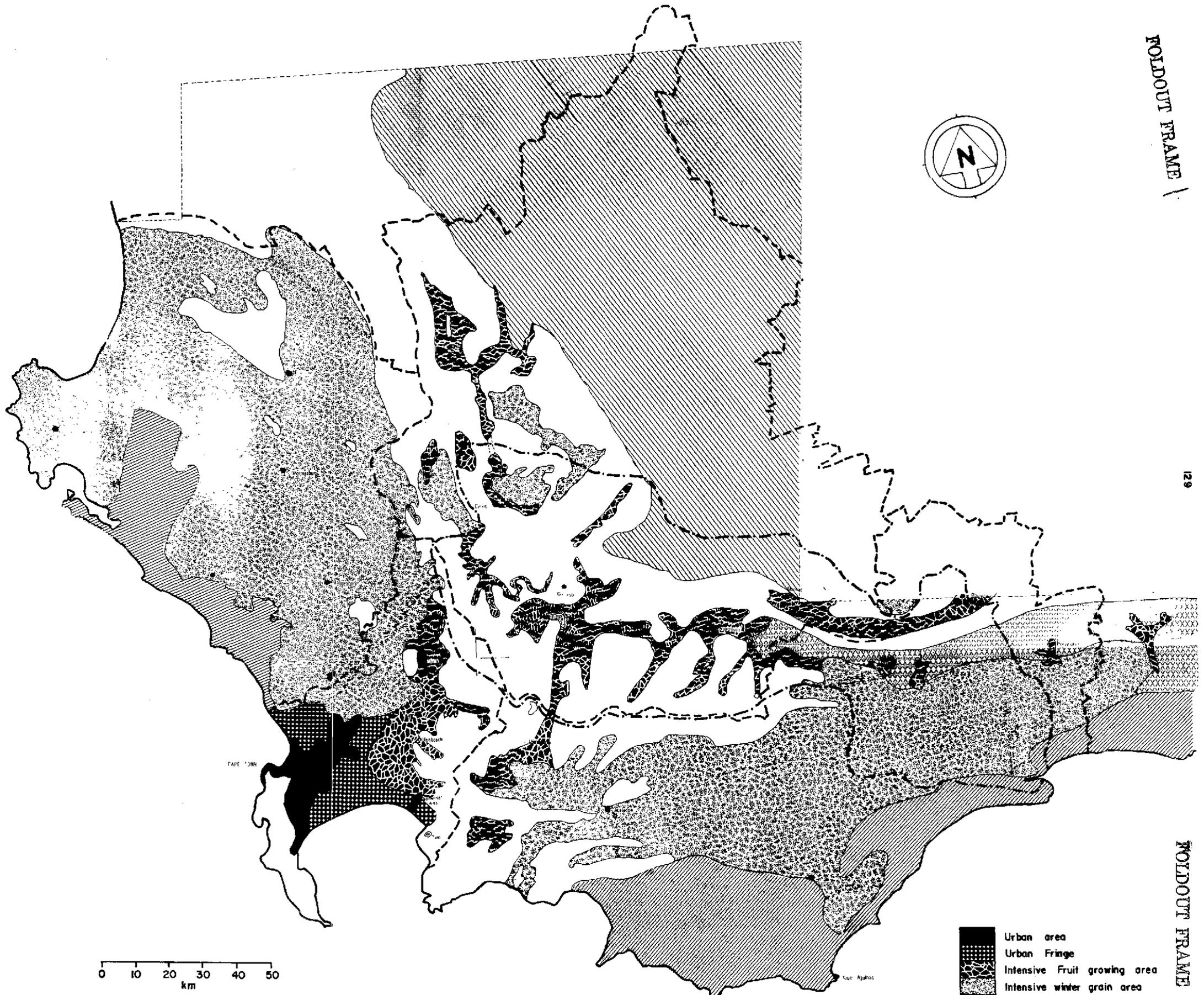
Further confirmation of the use of the ERTS false colour images was obtained by comparing a land-use map compiled from field surveys in the Breë River (map 7). The coincidence of the broad pattern of land-uses is very good (compare Maps 6 and 7).

With the aid of future ERTS images which periodically become available, it will be possible to identify changes in the broad land-use pattern. This finding would likewise apply to encroachment of desert areas, which was discussed in 3.2.2.

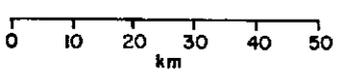
The Geography Department at the University of Cape Town found the 1:500 000 scale enlargements in False Colour invaluable supplementary aids to the preparation of a generalized map of land-use, verdant areas such as vineyards, orchards and lucerne fields being rendered clearly apparent in red. However, it is not possible to identify the crops with certainty by tone, e.g. in some instances vine-

FOLDDOUT FRAME

129



FOLDDOUT FRAME



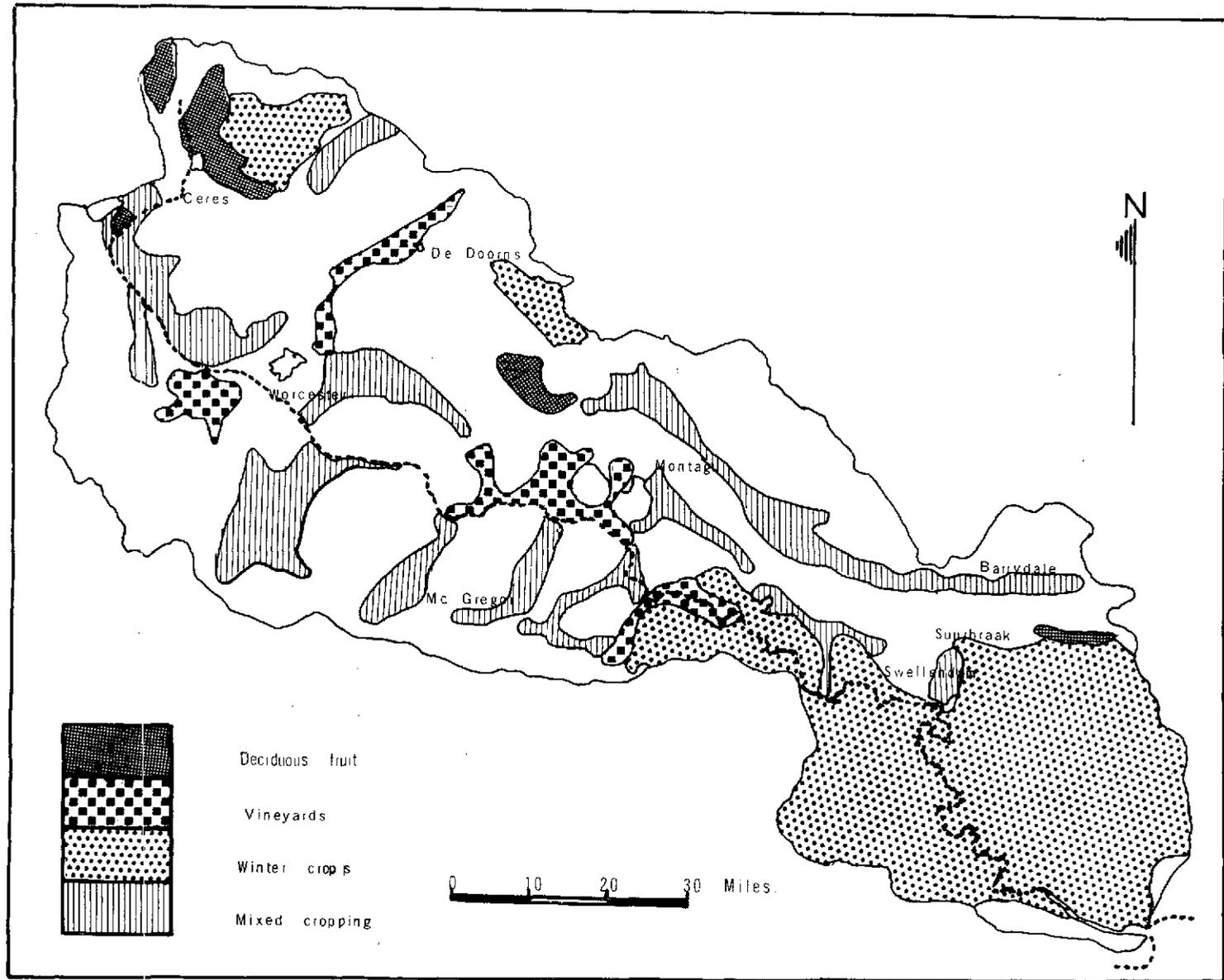
-  Urban area
-  Urban Fringe
-  Intensive Fruit growing area
-  Intensive winter grain area
-  Sandy coastal area with extensive winter grain.
-  Mixed Farming (Transitional zone)
-  Extensive pastoral farming
-  Extensive pastoral farming Mountain
-  Dams
-  Boundary of Development Region
-  Breë River Catchment area

SOURCE:-(a) NASA ERTS - 1180 - 08012  
 False Colour 1189 - 08015  
 1:500 000 1055 - 08064  
 1143 - 07563

(b) S.A. 1:500 000 Sheet Cape Town SE  
 35 / 17 1/2 Administrative Edition

**REGIONAL LAND USE IN THE SOUTH WESTERN CAPE**

MAP 6



MAP 7

Land use in the 3reë River Catchment area

yards, orchards and lucerne fields appear similar. In other cases vineyards appear in either a lighter or a darker tone of red than neighbouring orchards.

The false colour also facilitates recognition of well vegetated areas, e.g. the Tsitsikama forest, which is clearly distinguishable in the monochrome images. Furthermore, areas of dark vegetation such as the renosterveld are clearly distinguished from areas of inland water, while tree growth, such as the plantations east of Voëlvlei is readily distinguishable from indigenous bush.

The Department of Planning and the Environment found that it was possible to identify the following basic types of land-use in the South West Cape (see Map 6):

- (i) Urban areas and the urban fringe.
- (ii) Fruit growing areas.
- (iii) Intensive winter grain areas.
- (iv) Sandy coastal areas with extensive winter grain.
- (v) Mixed farming (transitional Zone).
- (vi) Extensive pastoral farming.
- (vii) Mountains.
- (viii) Dams.
- (ix) Rivers.

#### Conclusion

Thus, in testing the validity of the regional boundaries with the aid of ERTS images, the difference in land-use between the Bonnievale area and the intensive winter grain region could be clearly seen. Along the South West Cape coast a good correspondence was found between the use of the sift method and the delimitation of regions with the aid of ERTS images.

This means that if the method is extended to the whole of the Republic a rapid inventory of land-use on a broad scale can be made, a task which would otherwise be well-nigh impossible.

## VI. CARTOGRAPHIC QUALITY OF NDPF MSS PHOTOGRAPHIC PRODUCTS

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### 1. OBJECTIVE

To establish the cartographic quality and precise dimensional properties of system corrected multi-spectral scanner imagery for exact determinations of scale and enlargement factor from NASA Data Processing Facility 9 inch Positive Transparencies.

### 2. METHODS

#### 2.1 Cartographic Qualities

The 1:500 000 false colour copies of scenes 1049-07295 and 1085-07303, produced from NDPF 70 mm positives which were scaled according to the nominal cross track registration separation on page 3-5 of the ERTS Data Users Handbook, were analysed.

By identifying 9 points of details on each ERTS image and on up to date Trigonometrical Survey 1:50 000 topographical series maps, the South African Coordinate System coordinates of these points were obtained.

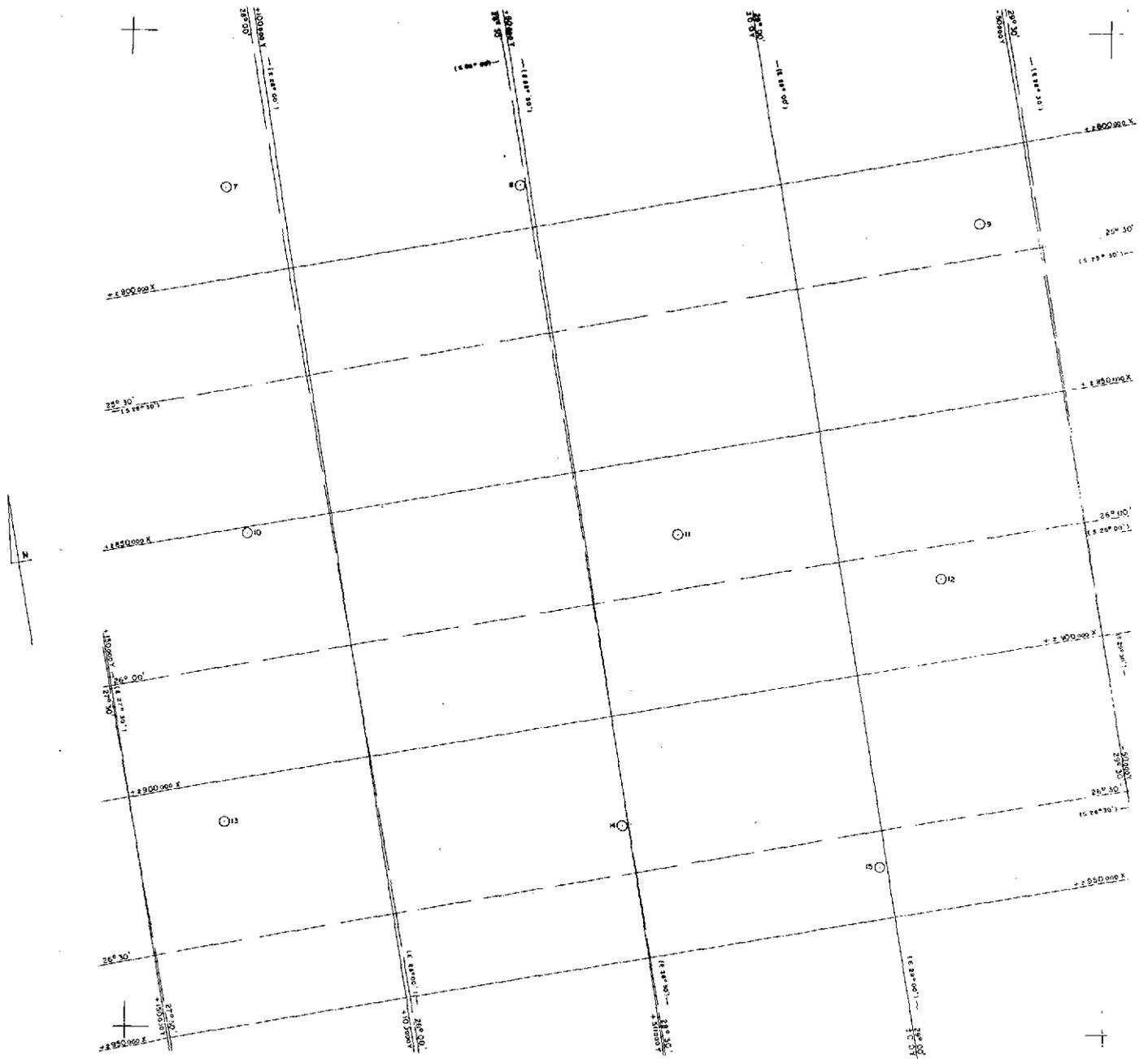
By comparing 'calculated' distances i.e. coordinate 'joins' with scaled lengths from the photos, 6 scale factors could be obtained between the outer points on each image.

Having the coordinates for the detail points, the South African Coordinate Grid could be superimposed on the images by plotting the intercepts from the detail points. See Figs.1 and 2 reduced from the originals.

#### 2.2 Scale and Enlargement Factors

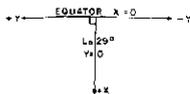
Eight sample 9 inch NDPF positive transparencies in band 6 were measured on a high precision aerial photography stereo-comparator. (Wild Stereo Comparator StK 1118, with scale recording accuracies of 1 micron).





GRID OVERLAY FOR "ERTS" PHOTO  
E-1085-07303 16 OCT 72

SOUTH AFRICAN CO-ORDINATE SYSTEM  
TRANSVERSE MERCATOR PROJECTION GRID  
CENTRAL MERIDIAN L<sub>0</sub> 29° EAST



CO-ORDINATES L<sub>0</sub> 20° METRES

	X	Y
7	+ 11 403	+ 2 761 275
8	+ 52 917	+ 2 790 652
9	- 30 456	+ 2 814 498
10	+ 17 490	+ 2 851 196
11	+ 31 242	+ 2 865 734
12	- 19 568	+ 2 882 585
13	+ 131 455	+ 2 908 975
14	+ 51 541	+ 2 922 549
15	+ 1 025	+ 2 939 146

SCALES

7 - 9	1:504 000
9 - 15	1:500 000
15 - 13	1:502 100
13 - 7	1:509 000
7 - 15	1:503 600
13 - 9	1:500 500

PROJECTION GRID OVERLAY POSITIONED  
FROM IDENTIFIED AND CO-ORDINATED  
DETAIL  
GEOGRAPHICALS FROM GRID CONVERSIONS  
BY—  
AIRCRAFT OPERATING CO (PTY) LTD.

AUGUST 1973

*D. Kinkhoff*  
LAND SURVEYOR

FIG. 2

Measurement comprised single plate x and y determinations on each photo of four or more ground detail points near the photo extremities as well as the four corner graticule crosses on every diapositive. (actual reading repeatability averaged 20 microns).

South African Transverse Mercator coordinates of the ground detail points were scaled from the Trigonometric Survey 1:50 000 topographical map series to an equivalent accuracy (20 x 20 microns). Plate distances between detail points were then compared with the equivalent map or ground distances.

The dimensions and angles between the graticule crosses were also calculated from the comparator x y measurements.

### 3. RESULTS

#### 3.1 Cartographic Evaluation

The mean of the six scale values were respectively 1:502 300 and 1:502 100 for images 1049-07295 and 1085-07303.

It was found that the overlay grid is square to within normal scaling errors and that the expected oblique stereographic projection of the photos transforms with undetectable distortion into the orthomorphic South African Transverse Mercator Projection.

The geographic tick marks supplied by NASA on these system corrected MSS images, prove to be in error with up to 5 km shift in latitude and 3,5 km in longitude, including an azimuthal swing of about 2 degrees.

#### 3.2 Scale Factors and dimensional accuracies

Actual scale factors grouped themselves into two main groups of 1:997 300 and 1:991 800m the latter being nearly 1 % in error from the nominal 1:1,000 000 scale.

The precision measurements of the graticule crosses showed large variations from the nominal given dimensions. The variations were from 2,0 mm to 2,8 mm larger than nominal.

The angles also showed that the graticule crosses were out of

square by 0,1 to 0,13 degrees. Dimensions are also unevenly increased on individual diapositive with a 1 % variation comparing N-S with E-W graticule distances.

#### 4. CONCLUSIONS

##### 4.1 Cartographic

Scaling factors and geographic graticules or coordinate grid overlays can be produced through the identification of ground detail. Such overlays would improve the location of position to within  $\pm 500$  m rather than the  $\pm 5$  km accuracy based on NASA supplied geographic tick marks.

##### 4.2 Enlargement and dimensional consistency

The tremendous cartographic potential of the ERTS imagery can be further increased if the optical and dimensional characteristics of the photographic reproduction process were more precisely determined and controlled. It would appear that the lenses used in the reproduction of the diapositives require re-calibration to reduce the + 1 % enlargement error.

VII. USE OF ERTS IMAGES FOR EDUCATIONAL PURPOSES;  
IN A SCHOOL ATLAS

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 University of South Africa  
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 Department of Geography  
 Rand Afrikaans University  
 Johannesburg

1. BACKGROUND

The new geography syllabi of South African schools (of all provinces and departments) emphasize map and aerial photo interpretation. The material for this purpose is lacking in school atlases presently being used. One publishing firm has made ample provision for vertical and oblique photographs taken from aircraft and manned satellites (Gemini and Apollo). However, until the availability of ERTS imagery, coverage of Southern Africa from space attitudes was inadequate.

2. ADVANTAGES OF ERTS IMAGERY

Physical features and cultural activities are clearly revealed on ERTS images. Although no studies of details can be undertaken without the aid of sophisticated equipment, their prime value (particularly at school level) is that these images provide a clear and informative overall view of a relatively large area.

The similarity of scale between ERTS images and existing topographic, topocadastral and various thematic maps (1:250 000 - 1:1 500 000) facilitates visual orientation and comparison.

Available aerial photographs in black and white are less easy to interpret than full colour images. The false colour representation further facilitates interpretation and transition to symbolization. Colour also stimulates student interest and has more aesthetic value in an atlas than black and white.

Loss of detail on maps due to symbolization and generalization confuses map readers. Aerial and space photographs provide a two step

bridge between reality and map representation, thereby enabling students to master the art of correlating reality with symbols on the map.

3. CONCLUSIONS

In view of the advantages it is proposed to include a false colour representation of ERTS image 1180-08012 at a scale of 1: 500 000 and an explanatory map of the same area in an atlas for local use, to be published early in 1974.