SR NO. 0577

GROWTH AND DECLINE OF VEGETATION ON MINE DUMPS

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P.O. BOX 2
RANDFONTEIN, TVL.
REPUBLIC OF SOUTH AFRICA

JANUARY, 1973

TYPE II REPORT : NUMBER 1

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
P.O. Box 395
PRETORIA
REPUBLIC OF SOUTH AFRICA

1. SR No. 0577	2. Type of Report Type II	3. Recipient's Catalog No.
4. Title TYPE II REPORT : NUMBER 1		5. Report Date January, 1973
		6. Period Covered November, 1972 to January, 1973
7. Principal Investigator B.P. GILBERTSON		8. No. of Pages 21.
9. Name and Address of Principal Investigator's Organization SPECTRAL AFRICA (PTY) LIMITED P.O. BOX 2 RANDFONTEIN. Tvl. Republic of South Africa		10. Principal Investig.Rept.No. 73/3
		11. GSFC Technical Monitor MR. GEORGE ENSOR
12. Sponsoring Agency Name and Address COUNCIL FOR SCIENTIFIC & INDUSTRIAL RESEARCH P.O. BOX 395 PRETORIA Republic of South Africa		13. Key Words (Selected by Principal Investigator) Mine Dump Vegetation South African Geotectonics

14. Supplementary Notes

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15. Abstract : The main objective ~~of project SR-0577~~ is to determine the extent to which ERTS-1 imagery can be used to differentiate between mine dumps having varying degrees of vegetative cover. At this stage it is clear that the various mine dumps can be located and identified. Differences in vegetative cover can be seen and measured. Patterns of vegetative growth, some characteristic to particular dumps, can also be seen. It is therefore tentatively concluded that mine dumps can be differentiated with respect to their vegetative cover on the imagery received to date, and this is reported as a significant result. Subsequent imagery showing seasonal variations should facilitate this program.

In addition to work on the mine dumps, a photogeological project ~~entitled "A~~ on geotectonics ~~investigation~~ of South Africa has been initiated. A study of the ERTS-1 images has indicated that major structures (faults, folds and linear features) associated with the three geotectonic environments can be identified. In addition, major as well as relatively minor stratigraphic subdivisions can be recognised by their colour tones. ~~Significant results are reported~~. The results obtained to date warrant continuation of this study using colour composite prints enlarged to a scale of 1:500,000. In addition, these results have formed the basis for a proposal which has been submitted to NASA for participation in the proposed ERTS-B program.

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PREFACE

The main objective of project SR-0577 is to determine the extent to which ERTS-1 imagery can be used to differentiate between mine dumps having varying degrees of vegetative cover.

To this end, ground truth spectroradiometric data have been gathered for certain target dumps and an aircraft overflight has been carried out. Direct additive colour composites have been produced of an ERTS-1 image which includes several mine dumps. The techniques used for direct additive composite printing are described. Interpretation of the imagery has been both qualitative and quantitative; the former involved subjective observation and the latter density measurements within all spectral bands.

At this stage it is clear that the various mine dumps can be located and identified. Differences in vegetative cover can be seen and measured. Patterns of vegetative growth, some characteristic to particular dumps, can also be seen. It is therefore tentatively concluded that mine dumps can be differentiated with respect to their vegetative cover on the imagery received to date, and this is reported as a significant result. Subsequent imagery showing seasonal variations should facilitate this program.

In addition to work on the mine dumps, a photogeological project entitled "A geotectonic investigation of South Africa" has been initiated. This project will investigate the important large-scale features which characterise and therefore identify the major geotectonic environments of South Africa.

The project to date has involved the detailed study of 1:1 000 000 scale ERTS-1 colour composite prints covering portions of the 3 commonly recognized South African geological regimes viz. the ancient Kaapvaal granite-greenstone craton, the younger Namaqualand-Natal and Limpopo metamorphic mobile belts, and the cratonic sedimentory basins.

A study of the ERTS-1 images has indicated that major structures (faults, folds and linear features) associated with the three geotectonic environments can be identified. In addition, major as well as relatively minor stratigraphic subdivisions can be recognised by their colour tones. Significant results are reported. The results obtained to date warrant continuation of this study using colour composite prints enlarged to a scale of 1:500 000. In addition, these results have formed the basis for a proposal which has been submitted to NASA for participation in the proposed ERTS-B program.

1. INTRODUCTION

This report has been prepared as a "Type II report" in accordance with section 3, paragraph d, of the "Provisions for Participation in the NASA Earth Resources Technology Satellite - A (ERTS-A) Project". As such it is a record of progress made on ERTS investigation SR-0577. The two main objectives of this program are quoted below from the revised data handling plan, and are in agreement with those formulated in the original ERTS-A proposal submitted to NASA:

(a) To determine whether ERTS imagery can be used to distinguish mine dumps with vegetative cover from mine dumps without vegetative cover at 3 monthly intervals throughout the year.

(b) To ascertain whether the percentage of mine dump area that is covered by vegetation can be determined at 3 monthly intervals throughout the year. This is to be done by comparing the densities of the mine dump images in the various spectral bands.

Part B of this report describes the work which has been done towards fulfilment of these objectives.

In addition to the analysis of mine dump imagery in terms of project SR-0577, a photogeological project entitled "A geotectonic investigation of South Africa" has been initiated. This project will investigate the important large scale features which characterise and therefore identify the major geotectonic environments of South Africa. Part C of this report describes work which has been done to date on this project.

Part A of this report describes significant results which have been obtained to date.

PART A : SIGNIFICANT RESULTS

2. SIGNIFICANT RESULTS

2.1 REPORT 1

TITLE: MONITORING GROWTH OR DECLINE OF VEGETATION ON MINE DUMPS

CATEGORY: 7 N

ERTS-1 imagery is being used in an attempt to differentiate between mine dumps having varying degrees of vegetative cover. ERTS-1 images numbers 1050-07355 and 1049-07301 cover part of the main mine dump area, and have been analysed both qualitatively and quantitatively.

It has been found that the various mine dumps can be located and identified. Differences in vegetative cover can be seen and measured. Patterns of vegetative growth, some characteristic of particular dumps, can also be seen. It is therefore tentatively concluded that mine dumps can be differentiated with respect to their vegetative cover on these initial images. Subsequent imagery showing seasonal variations should facilitate the program.

2.2 REPORT 2

TITLE: A GEOTECTONIC INVESTIGATION OF SOUTH AFRICA

CATEGORY: 3 JKA

Important large scale features characterize the 3 major geotectonic environments of South Africa. These environments, viz. the ancient Kaapvaal granite-greenstone craton, the younger Namaqualand-Natal and Limpopo metamorphic mobile belts, and the cratonic sedimentary basin, are covered respectively by ERTS-1 image Nos. 1047-07184, 1056-08111 and 1050-07355.

A study of these 3 images has indicated that major structures (faults folds and linear features) associated with the three geotectonic environments could be identified. In addition, major as well as relatively minor stratigraphic subdivisions can be recognised by their colour tones.

A set of major northwest-southeast trending lineaments in the south-western sector of image No. 1047-07184 has been recognised for the first time. The emplacement of two major northwest-southeast trending layered mafic bodies (the Usushwana and Amsterdam complexes) is clearly associated with these features. This controlling factor was in existence before the deposition of the cratonic sedimentary basins and is reflected in, and to a certain extent appears to have controlled, the deposition of these basins. It is also probable that these lineaments were of importance with respect to the emplacement of the Bushveld Igneous Complex.

Major northwest-southeast trending linear structures are conspicuous features of image No. 1050-07355. These indicate the fundamental tectonic grain and in most cases take the form of faults. Some of these faults are occupied by syenite dykes belonging to the Pilansberg dyke swarm. These features could be of economic importance in that some of them appear to be associated with lead-zinc mineralization where they transect the Dolomite-Pretoria Series contact of the Transvaal System.

A number of hitherto unsuspected lineaments are conspicuous features of image No. 1056-08111. Fairly well defined major linear features which probably represent faults are encountered in the Springbok-Okiep mining district and might be of importance with respect to the copper mineralization of this area.

PART B : REPORT ON ERTS-1 PROJECT NUMBER SR-0577

3. PREPARATION OF IMAGERY

Three types of photographic imagery have been utilised in the analysis described in this part of the report. These are:

(i) 1:1 000 000 scale black and white prints of all four (MSS)* bands.

(ii) 1:500 000 scale colour composite print using bands 4, 5, and 7.

(iii) 1:160 000 scale black and white negative transparencies of all four bands.

The specific techniques utilised in the preparation of this imagery are discussed in Appendix A.

4. ACCOMPLISHMENTS DURING REPORTING PERIOD

A mobile laboratory performed in situ spectral reflectance measurements on a selected set of mine dumps. These measurements are described in report number 73/6. Aircraft overflight photography was carried out to obtain multispectral imagery and conventional 23 cm and 70 mm colour and black and white photography. An interpretative analysis involving both qualitative and quantative aspects was then performed on ERTS-image number 1049-07301. This analysis is described in section 5 below.

5. INTERPRETATION OF IMAGERY

Qualitative interpretation was performed using the colour composite shown in figure 1. The target dumps have been marked and the particular identification used refers to table 1.

* No RBV imagery of the test area is available.

TABLE 1

CLASSIFICATION OF THE VEGETATIVE COVER OF THE TARGET MINE DUMPS

Vegetation Category	Number of dump	Degree of Vegetative Cover
0	5L/29	No vegetation cover.
0	3L/5 (North Side)	No vegetation cover.
1	3L/5 (South Side)	A very small plant community constantly "farmed" by fertilizing, water spraying and "ploughing".
2	6L/20	A poor cover of plants requiring continuous attention. Extensive "soil" exposure. Soil chemistry very poor.
3	7L/1	A reasonable cover of vegetation requiring occasional attention and fertilizing with a number of "soil" exposures on small areas of high acidity.
4	1L/40, 1L/41	A good cover of vegetation, self-sustaining, with only a few "soil" exposures on small areas of locally high acidity.
5	1A/20	A self sustaining plant and tree community over 100% of the dump surface.

This classification is discussed in more detail in the "Revision of Data Analysis Plan" previously submitted.

In addition to the qualitative interpretation referred to above, quantitative densitometric measurements were also made on the imagery of the various dumps. An example of the 1:160 000 negative used for these measurements appears in figure 2.

6. RESULTS

6.1 Qualitative Interpretation

A study of figure 1 with reference to table 1 shows that there is a good qualitative relationship between the classification and the ERTS-1 imagery. In this regard, figure 3 shows a 1:43 000 colour aerial photograph covering dumps 1L/40, 1L/41 and 1A/20. The vegetation patterns visible on figure 1 are seen to be in good agreement with the ground truth of figure 3.

6.2 Quantitative Interpretation

The density readings recorded during the quantitative analysis are shown in table 2.

TABLE 2

DENSITY READINGS ON MINE DUMPS IMAGED AT 1:160 000 SCALE NEGATIVES

(The mean values for Band 4 show 95% confidence limits based on nine independent enlargements of a single 70 mm positive)

VEGETATION CATEGORY	MINE DUMP (REF)	IMAGE DENSITY			
		BAND 4	BAND 5	BAND 6	BAND 7
0	5L/29	1,13 ± 0,02	1,25	1,27	1,03
	3L/5 (North)	1,39 ± 0,05	1,51	1,61	1,28
1	3L/5 (South)	1,30 ± 0,02	1,38	1,50	1,33
2	6L/20	0,97 ± 0,01	0,82	1,10	0,97
3	7L/1	0,78 ± 0,02	0,68	1,01	0,91
4	1L/40, 41	0,54 ± 0,02	0,84	0,89	0,90
5	1A/20	0,67 ± 0,02	0,69	0,74	0,69

7. ANALYSIS

Using the vegetation categories of table 1 and the densitometry of table 2, a plot of image density versus wavelength (band number) was produced. This plot is shown in figure 4. Reflectance values resulting from the ground truth program were used to anticipate these density values for summer and winter and are also shown in figure 4.

8. DISCUSSION

The results received to date are encouraging. However, a number of apparent anomalies are seen from the comparison between anticipated and actual densities shown in figure 4.

(a) The ERTS image density values for all categories in bands 4, 5, and 6 are in accordance with relative radiance values, measured during the ground truth program. Although dumps 6/L/20 and 7/L/1 were at first thought to be anomalous (see fig. 4. investigation into the records of the Chamber of Mines Vegetation Program revealed the fact that extensive irrigation was carried out on the dumps prior to the date (10th September, 1972) that the ERTS-1 imagery was gathered. The vigorous growth of vegetation anticipated only during the summer season was hence observed.

(b) Band 5 is seen to sharply contrast the three basic vegetative units of barren slime, dry Eragrostis Curvula, and vigorous growth Eragrostis Curvula. Even the marginal case of category 1 is seen to be distinguished over barren slime in this band (for illustrative photography see report number 73/6).

(c) The reflectance data indicates that for all categories, the radiance in bands 6 and 7 should have approximately the same value. Near infrared reflectance values of vegetation and slime exposure

Image densities anticipated from 2 RDF reflectance measurements for natural winter and summer vegetation conditions on slimes dams

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Densitometric measurements of positive enlargements of ERTS images

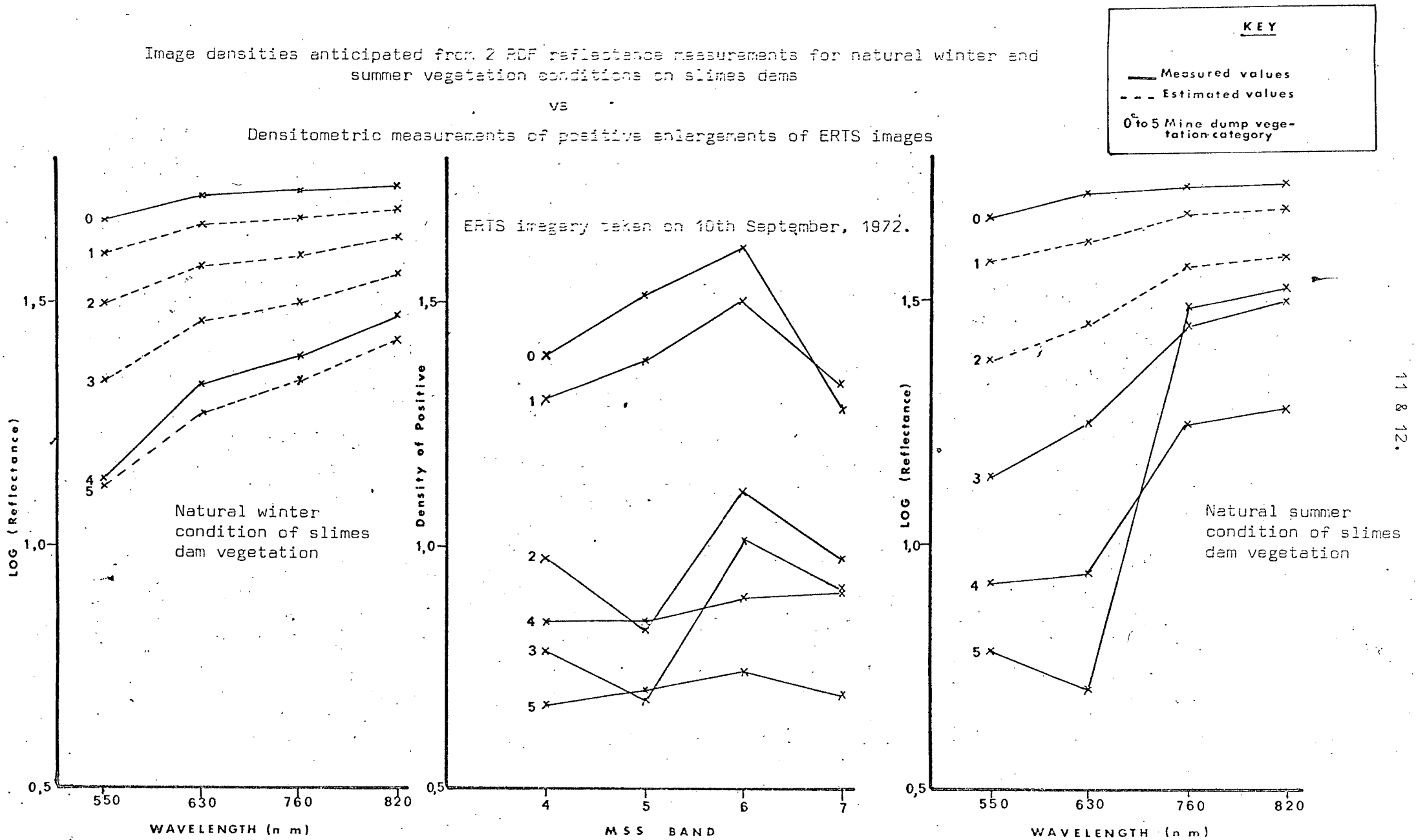


FIG. 4.

11 & 12.

have been found to have a mean deviation of less than 3% in the region 780 nm to 1 000 nm (see report 73/6), yet the densities are considerably different. This anomaly is probably due to the radiometric characteristics of the different sensors, and is being investigated.

(d) The low density readings for dump 5/L/29 are also anomalous. It is curious that the curve shape is maintained in comparison to 3/L/5. The factor of 3 difference in radiance between these two dumps could be attributed to surface wetness however. Unfortunately rainfall figures for the specific locality of 1/L/29 are not available, and irrigation of the dump was not carried out during the month of September. The possibility of smog pollution affecting the densities is being investigated.

(e) The precision of this analysis is high, as is indicated by the 95% confidence limits on the mean density readings which are based on nine independently produced enlargements from a NASA 70 mm 3rd generation positive.

9. CONCLUSIONS

Good qualitative and quantitative correlation between the vegetative status of certain target mine dumps and the corresponding ERTS-1 MSS imagery has been obtained. Significant data on the accuracy with which the vegetation categories from ground truth programs can be related to densitometric analysis of the ERTS imagery is evident and described in the above section. It is anticipated that further ERTS imagery will confirm the above observations and that it will be possible to accord to all but the smallest of the mine dumps in the Witwatersrand Complex a vegetative cover category as defined in table 1.

10. ACKNOWLEDGEMENTS

The author is grateful to Mr. W.H. Cook of the S.A. Chamber of Mines Vegetation Unit for his assistance in the above program.

PART C : REPORT ON GEOTECTONIC INVESTIGATION OF SOUTH AFRICA

11. INTRODUCTION

Tentative photogeological interpretation of the ERTS-1 imagery generated useful geological information. Consequently a geological investigation was initiated with the main objective of studying the important large scale features which characterize and therefore identify the major geotectonic environments of South Africa. Three of these geological regimes are commonly recognised viz. the ancient Kaapvaal granite-greenstone craton, the younger Namaqualand-Natal and Limpopo metamorphic mobile belts, and the cratonic sedimentary basins (with which is associated the Bushveld Igneous Complex). The project to date has involved the detailed study of ERTS imagery covering portions of all three environments.

12. IMAGERY UTILISED

The analysis described below was carried out on 1:1 000 000 scale colour composite prints of ERTS-1 imagery numbers 1047-07184, 1050-07355 and 1056-08111. These prints were prepared as described in Appendix A.

13. SUMMARY OF RESULTS OF PHOTOGEOLOGICAL INTERPRETATION

The results obtained to date have been described in detail in report number 73/5. Briefly, however, the photogeological interpretation of the ERTS-1 images has indicated that major structures (faults, folds and linear features) associated with the three geotectonic environments of South Africa could be identified. In addition, major as well as some relatively minor stratigraphic subdivisions can be recognised by their colour tones. Younger intrusive plugs of syenitic, granitic and carbonatitic material are generally clearly visible.

The fundamental differences in the tectonic style between the granite-greenstone cratons and the mobile belts is easily discerned. In this respect the arcuate schistose tongues associated with the Barberton greenstone belt are particularly diagnostic as is the flow-folding pattern of portions of the Namaqualand Metamorphic Mobile Belt.

The recognition of a set of major northwest-southeast trending lineaments in the south-western sector of image number 1047-07184 which covers the Barberton greenstone belt is of considerable significance, and the emplacement of two major northwest-southeast trending layered mafic bodies (the Usushwana and Amsterdam complexes) is clearly associated with these features. This controlling factor was in existence before the deposition of the cratonic sedimentary basins and is reflected in, and to a certain extent appears to have controlled the deposition of these basins. It is also probable that these lineaments were of importance with respect to the emplacement of the Bushveld Igneous Complex.

Major linear structures which have essentially the same direction as those described above are also conspicuous features of image number 1050-07355 which covers a portion of the cratonic sedimentary basin environment. These also indicate the fundamental tectonic grain referred to above and in most cases take the form of faults, some of which are occupied by syenite dykes belonging to the Pilansberg dyke swarm. These features could be of economic importance in that some of them appear to be associated with lead-zinc mineralization where they transect the Dolomite-Pretoria Series contact of the Transvaal System.

In a similar way a number of hitherto unsuspected lineaments are conspicuous features of image number 1056-08111, covering portion of the Namaqualand Metamorphic Mobile belt. Fairly well defined major linear features which probably represent faults are encountered in the Springbok-Okiep mining district and might be of importance with respect to the copper mineralization of this area.

14. PROBLEMS ENCOUNTERED

The images received to date have been of high quality. There appear to be no major problems as far as the interpretation of these are concerned. Patches of newly burnt grass tend to obscure important structures and lithological contacts in some areas, but this should be overcome by using images recorded at different times of the year. In the eastern portion of South Africa large areas of forestation frequently obscure important geological features, and this could also be partly overcome by using images recorded at different seasons.

15. CONCLUSIONS AND PROPOSED PROGRAM

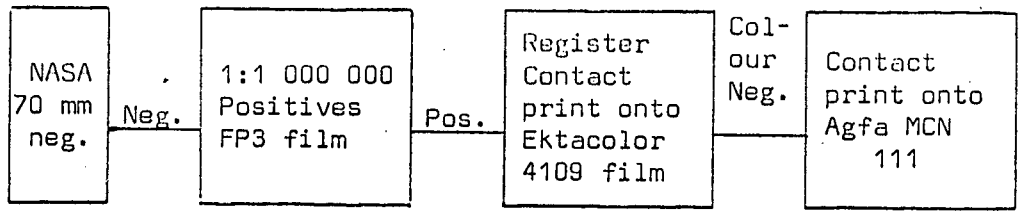
The results obtained from the preliminary investigation warrant a continuation of the project. With the study of larger areas it is believed that significant major structural patterns should emerge. It is therefore proposed to expand the present study by covering larger areas in more detail. Colour composite prints enlarged to a scale of 1:500 000 will be used for this purpose. Additionally, this enlarged study has formed the basis for a proposal to participate in the proposed ERTS-B program.

APPENDIX A

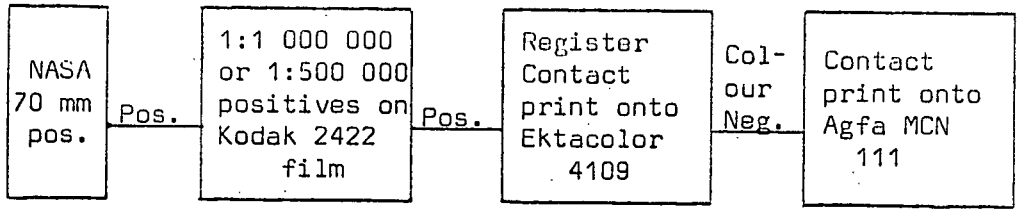
DISCUSSION OF PHOTOGRAPHIC TECHNIQUES EMPLOYED IN THE ANALYSIS OF THE ERTS-1 IMAGERY

1. Black and white enlargements to 1:1 000 000 scale were prepared in a Chromega D6 enlarger fitted with a 135 mm Rodenstock Rodagon f5,6 lens. Enlargements were made onto Agfa BW 112 grade 5 paper, processed in a Kodak Versamat 11C-L processor, using 2 developer racks at 10 fpm with type A chemistry.

2. The colour composite imagery was produced as follows:



For the densitometric analysis it was decided to work from the NASA 3rd generation positives, using the following techniques. Figure 1 was prepared in this way.



3. 1:160 000 scale black and white positives were made using a De Vere 108 A/F enlarger with an 80 mm f5,6 Rodenstock Rodagon lens. Kodak Panatomic - X 3400 aerial film was tested and found to be a suitable material for these enlargements, because of its high contrast and good frequency response over the range 0-10 cycles / mm.

The FP3, 3400 and 2422 films were processed in a Versamat 11C-L with

type A chemistry and one developer rack. The Ektacolor 4109 print film was processed in a Colenta LA-2 automatic processor using C-22 chemistry.

The Agfa MCN 111 paper was processed in the Colenta processor using Agfacolor Pa Chemistry.

The 23 cm colour photography was made with a Wild RC-10 camera, using Kodak Aerocolor negative film processed in a Versamat 1411. The contact print was made on Agfacolor MCN 111.

FIGURE 1.

1:500 000 Colour Composite of ERTS image number 1049-07301 showing the area including the mine dumps. Printing exposures have been such as to avoid underexposing the dumps; as a result the relatively low-radiance background is overexposed on the positive print.

Photographs not

Reproducible.

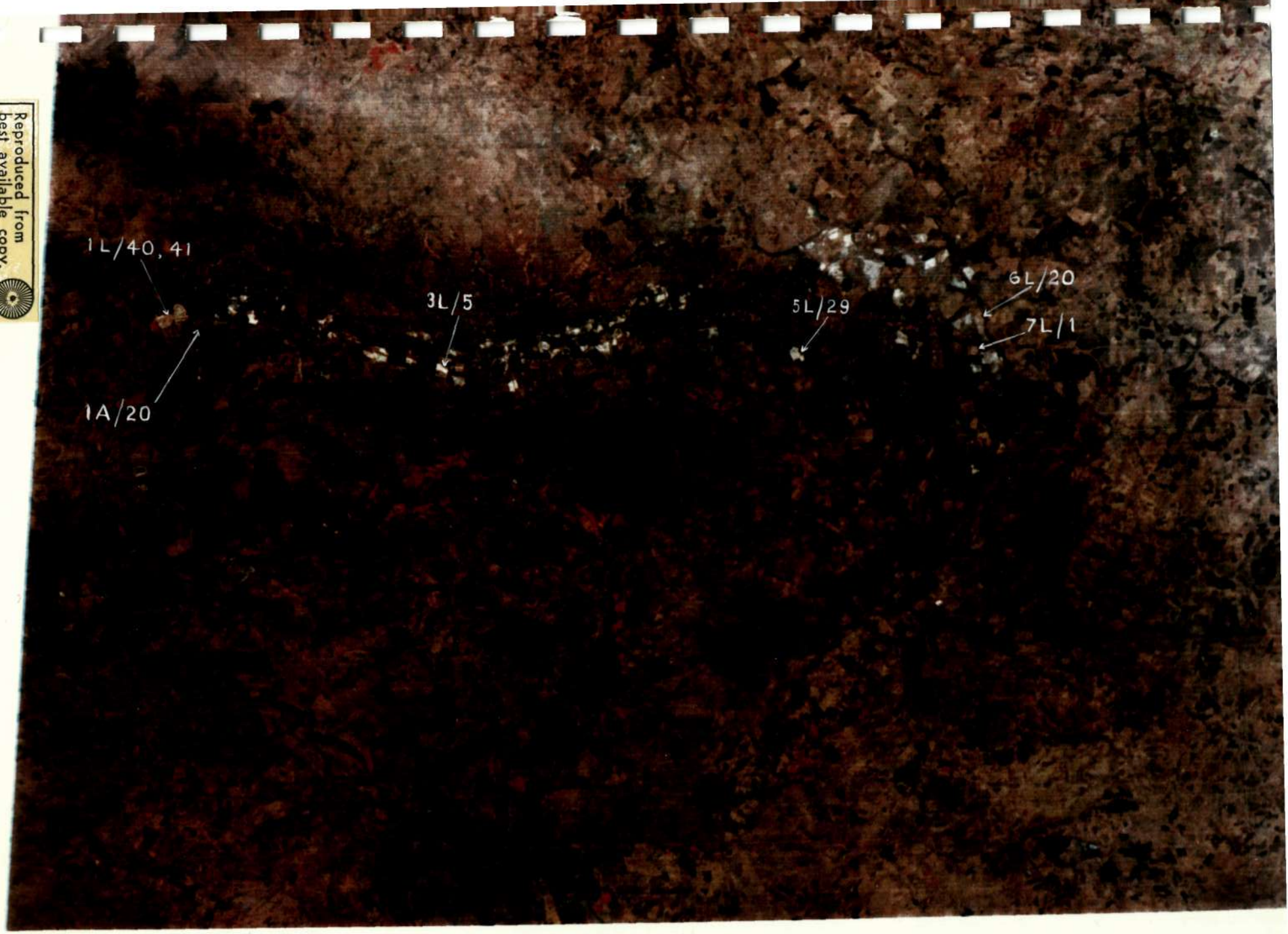


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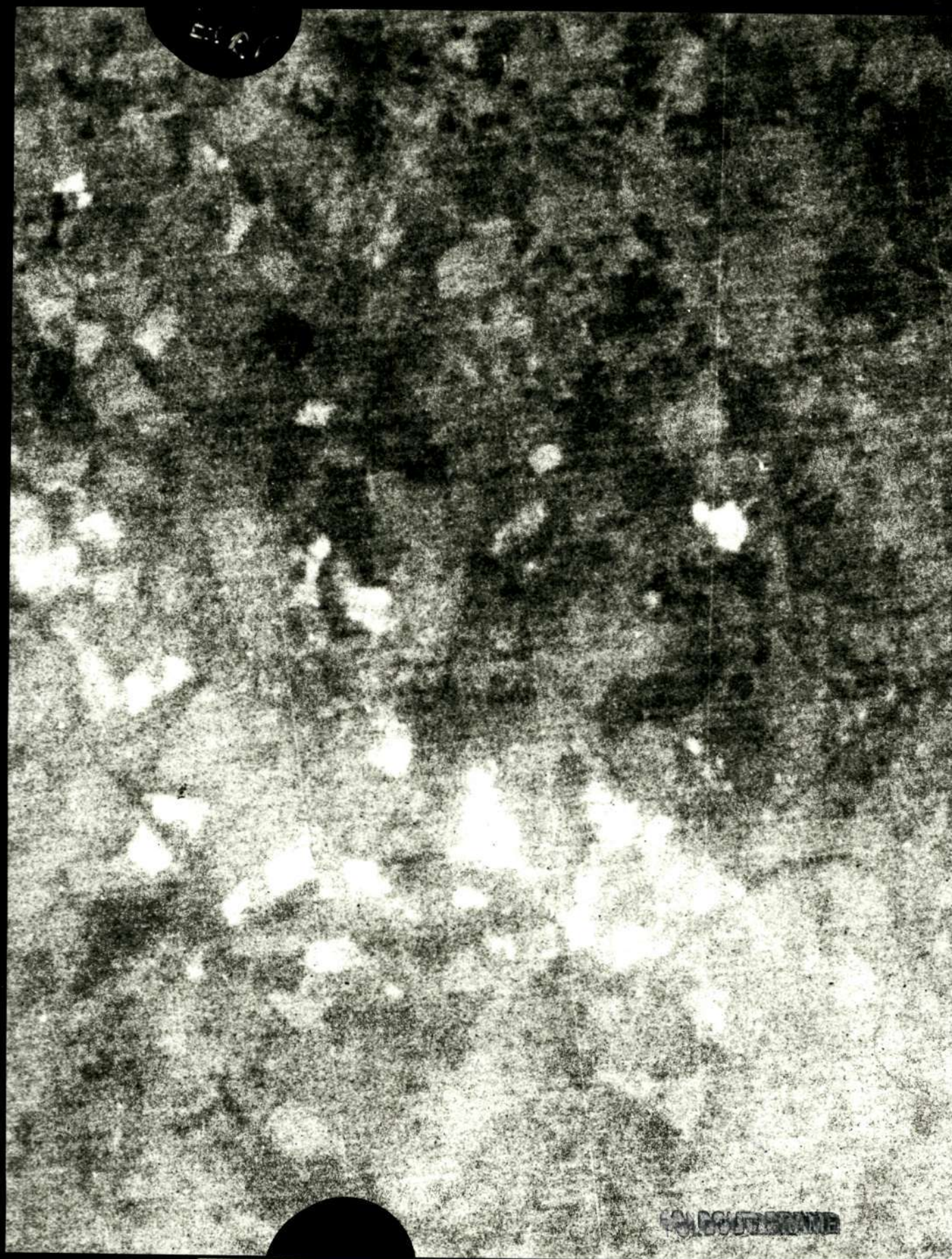
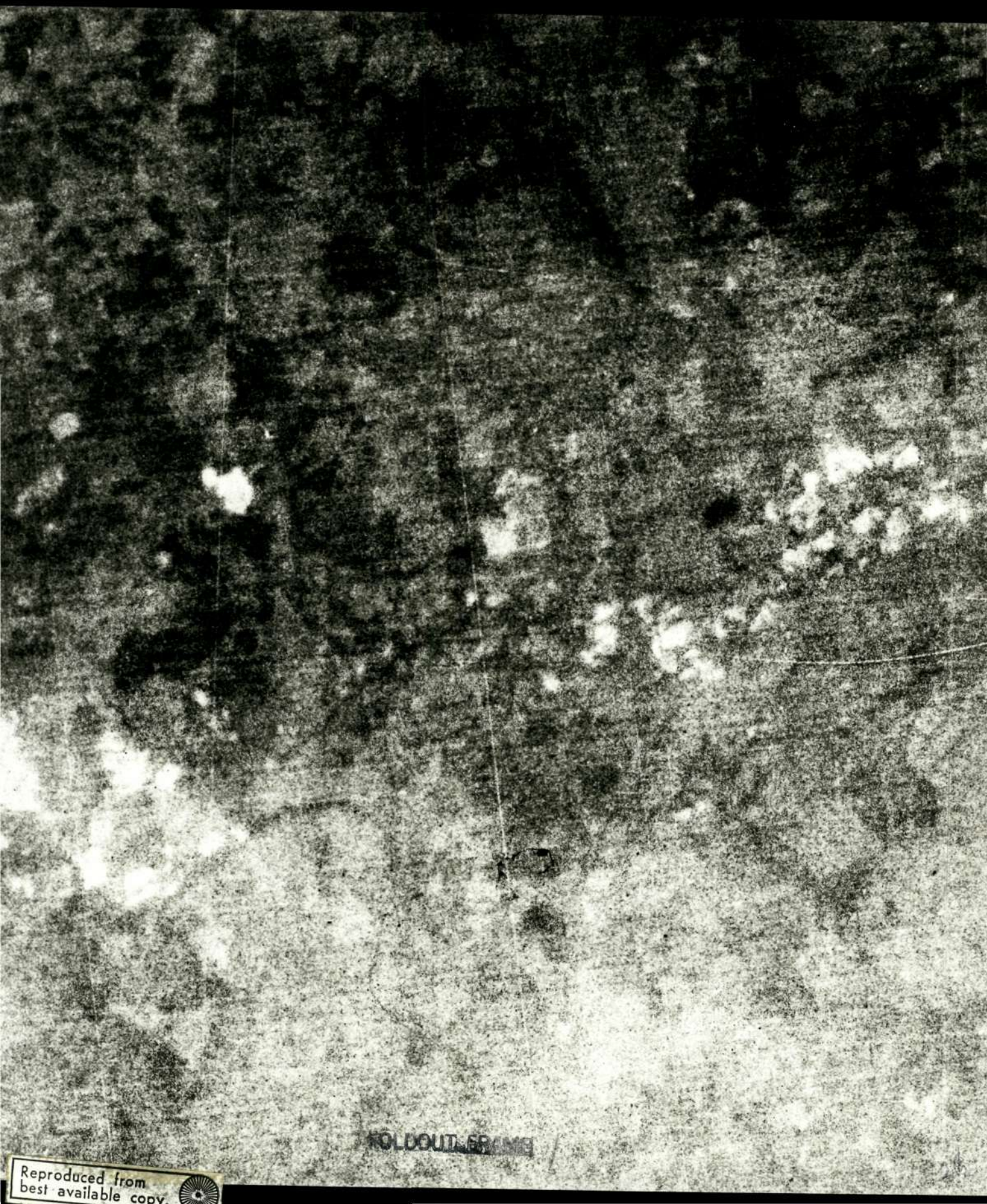
FIGURE 2.

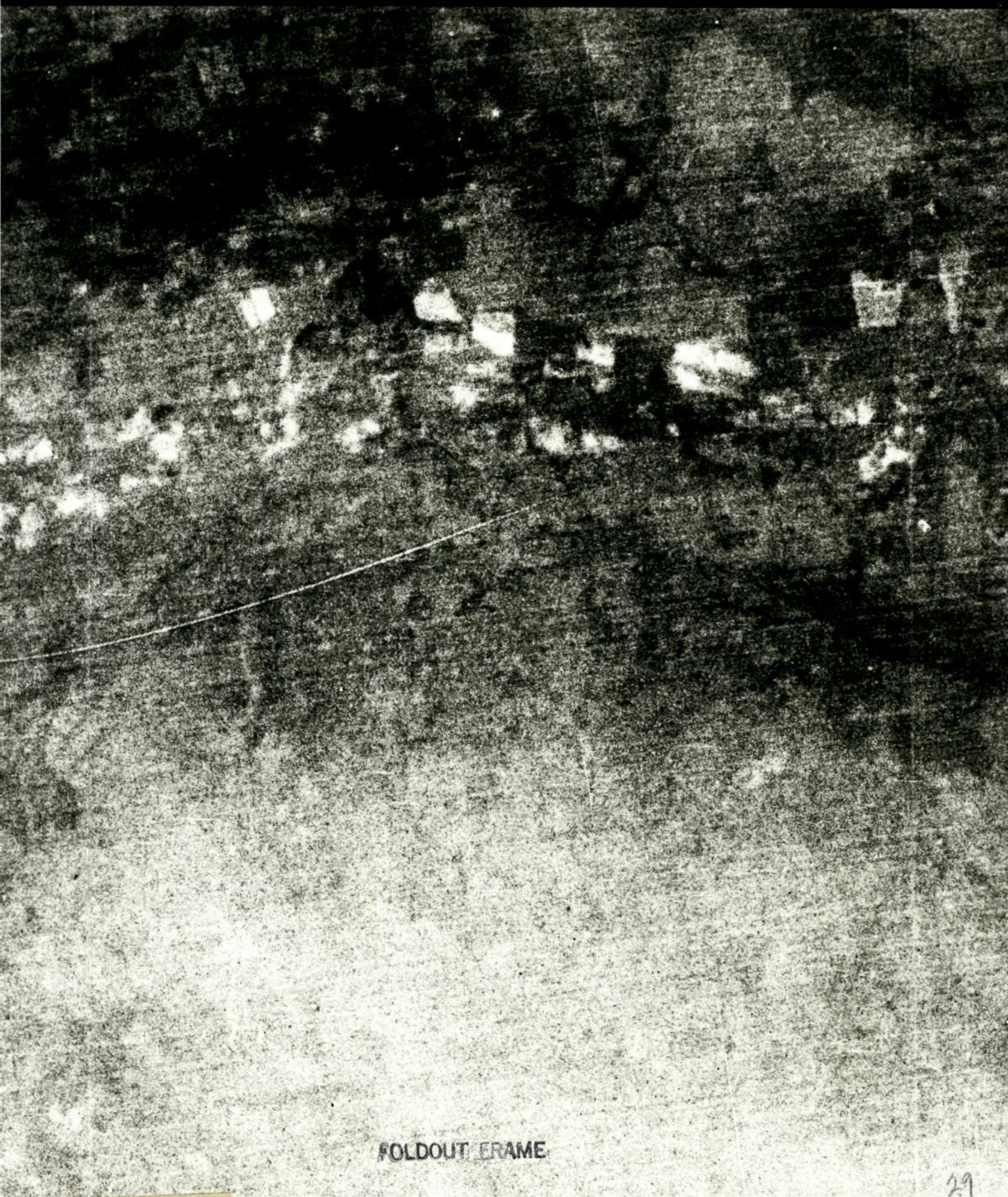
A 1:160 000 enlargement of MSS band 4 showing the target dumps.

FIGURE 3.

A 1:40 000 colour photograph showing target dumps 1L/40, 41 and 1A/20. Photography was made using a Wild RC.10 camera with a 152 mm f5,6 Super Aviogon lens on Kodak 2445 Aerocolor negative film.







FOLDOUT FRAME