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Paper E 4

MONITORING VEGETATION COVER ON MINE DUMPS WITH ERTS-1 IMAGERY: SOME INITIAL RESULTS

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ABSTRACT

ERTS-1 imagery is being used in an attempt 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. Subsequent imagery showing seasonal variations should facilitate this program.

1. INTRODUCTION

For many years the economy of South Africa was heavily dependant upon mining activities. One of the aftermaths of such activities has been the development and growth of mine tailings dumps. These dumps can be divided into two broad categories, namely sands dumps and slimes dams.

Sands dumps are mounds of crushed rock material. In time the minerals are leached out, leaving no binding properties. The resultant substance becomes similar to river sand, with no nutrient value and is left as an inert and inhospitable medium for plant growth. "Slime" residues consist of a very finely ground silicious rock. From a botanical point of view, cyanided slimes are initially noxious, but with weathering, noxious properties disappear from the dams. The ores from which these tailings are derived contain pyrite, which with weathering continuously tend to maintain acid conditions on the dump.

In recent times, attention has been directed towards mine dumps as being detrimental to the environment. For example, the Witwatersrand derives its water from one major river, the Vaal. Pollution of streams in the Witwatersrand system from mine dumps affects the Vaal because the mines are largely situated in its catchment area.

The growing concern over the problem of pollution is expressed in the Atmospheric Pollution Prevention Act (Act No. 45 of 1965). Section 32 of the act applies specifically to the mining industry. The air and

water pollution from the dumps may be largely prevented by ensuring that a vegetative growth covers the entire mine dump. In the years following the promulgation of the act, the annual expenses incurred by the Chamber of Mines of South Africa in promoting the growth of vegetation on mine dumps have grown steadily and totalled $1M for the year 1969. This amount does not include expenditures by mines which are not members of the Chamber.

The growth or decline of vegetative cover on mine dumps has to date been monitored by both aerial photography and site visits. The latter is usually preferred because of the expense of the former and the greater accuracy of the latter. On the other hand, because of the geographic separation of the mine dumps (see figure 1) site visits are inconvenient and difficult to co-ordinate.

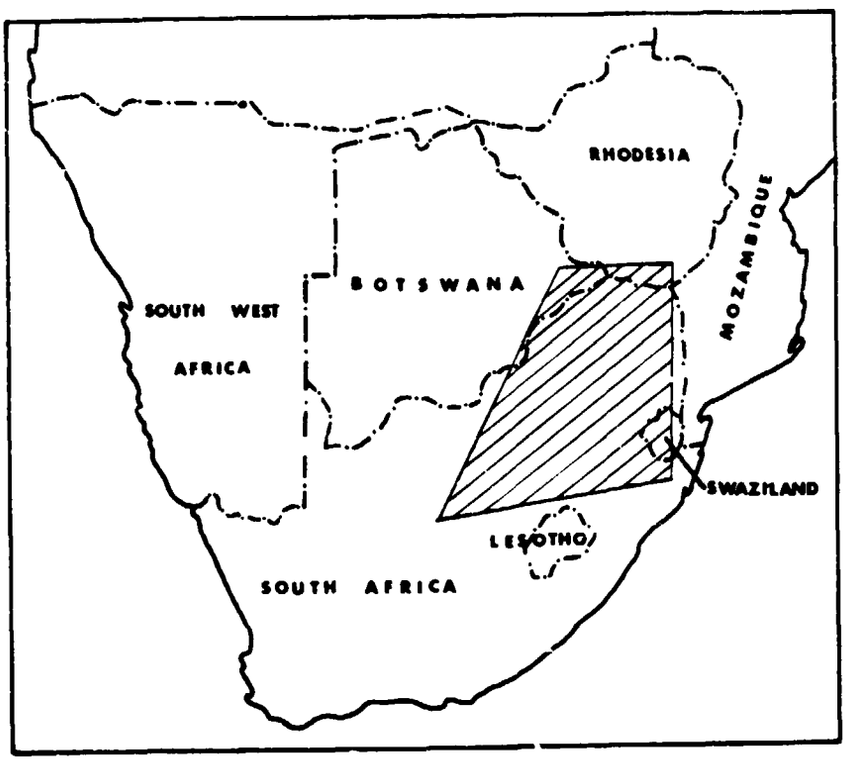

FIGURE 1

Geographical distribution of majority of mine dumps in South Africa

ERTS-1 imagery is being used in an attempt firstly to differentiate between mine dumps having varying degrees of vegetative cover, and secondly to monitor the growth or decline of this cover on any selected dump. Two ERTS-1 images (1049-07301 and 1050-07355) that include part of the main mine dump area have been received to date, and have been analysed both qualitatively and quantitatively. The results are described below.

2. CLASSIFICATION OF VEGETATIVE COVER ON MINE DUMPS

Six mine dumps were selected for intensive study. This selection was done by preparing a mosaic of the Witwatersrand Mine Dump Complex from black and white Trigonometrical Survey photography and rephotographing at a scale of 1:250 000. Part of this mosaic is shown in figure 2. A short list of dumps expected to be well resolved on the ERTS-1 imagery was compiled from this reduced mosaic. Ground observation of a selection of these dumps was then undertaken and the vegetation cover investigated.

A vegetation scale was compiled in order to classify the mine dumps into categories. This classification is shown in table 1. One "calibration" dump of each category was selected for detailed analysis on the basis of size (large as possible), homogeneity (uniformity of vegetation distribution over the top surface), and contrast (with respect to the adjacent environment). The dumps selected are listed in the last column of table 1, and are identified using the numbering system developed by the Chamber of Mines.

3. QUALITATIVE ANALYSIS

Qualitative interpretation was performed using a colour composite print prepared of image 1049-07301 with MSS bands 4,5 and 7 shown in blue, green and red respectively. A black and white positive image prepared from this colour composite is shown in figure 3. Although much detail of the colour presentation has been lost it can be seen that essentially all of the larger mine dumps present in the aerial photography mosaic of figure 2 can be detected and identified on the ERTS-1 image. This achieves the first aim of ERTS-1 proposal SR-057.

Furthermore, there is a good qualitative relationship between the categories of table 1 and the mine dumps imaged in figure 2, with the more densely vegetated dumps (i.e. those falling in categories 4 and 5) appearing darker than the unvegetated dumps (those falling in categories 0 and 1). In addition, vegetation patterns are visible on the ERTS-1 imagery which are in good agreement with ground truth, i.e. with patterns observed on aircraft overflight photography. This can be seen by comparing figures 3 and 4.

This agreement between ERTS-1 imagery and ground truth is encouraging, particularly since ERTS-1 image 1049-07301, was gathered in

FIG. 2 : Aerial photography mosaic of West Witwatersrand area

FIG. 3 : Part of ERTS-1 image No. 1049-07301

Mine dump 1/L/38,39

Mine dump 3/L/5,6

FIGURE 4

TABLE 1

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

September when the mine dump vegetation is, generally speaking, in poor condition. Even better agreement is anticipated for imagery gathered during the spring and summer months.

4. QUANTITATIVE ANALYSIS

Densitometric measurements were made on black and white negatives enlarged to 1:160 000 scale of various mine dumps on the ERTS-1 image. The density readings are recorded in table 2. The 95% confidence limits on the mean density readings indicate the precision of the analysis.

TABLE 2

Density readings on mine dumps imaged on 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	Image Density			
		Band 4	Band 5	Band 6	Band 7
0	5/L/29	1,13 ± 0,02	1,25	1,27	1,03
	3/L/5 (East)	1,39 ± 0,05	1,51	1,61	1,28
1	3/L/5 (West)	1,30 ± 0,02	1,38	1,50	1,33
2	6/L/20	0,97 ± 0,01	0,82	1,10	0,97
3	7/L/1	0,76 ± 0,02	0,68	1,01	0,91
4	1/L/40, 41	0,84 ± 0,02	0,84	0,89	0,90
5	1/A/20	0,67 ± 0,02	0,69	0,74	0,69

Plots of image density versus wavelength (ERTS-1 band number) were prepared using the vegetation categories of table 1 and the densitometry of table 2. These plots are shown in figures 5 and 6.

Figure 5 shows a good separation between the density readings for vegetation categories 0, 1, 4 and 5. Consequently it is anticipated that mine dumps falling into these categories should be identifiable. However, a number of anomalies require further study. For example, the density readings for dump 5/L/29 (see table 2) are low compared to those for dump 3/L/5 which falls in the same vegetation category. Although this anomaly is being investigated no satisfactory explanation has yet been found.

The density readings obtained for vegetation categories 2 and 3 were at first thought to be anomalous, since their plots, which are shown in figure 6, differ considerably in shape from those of figure 5. However, investigation into the records of the Chamber of Mines Vegetation Program revealed that irrigation had been carried out on these

Density vs Band Number
(Vegetation Categories
0,1,4 and 5)

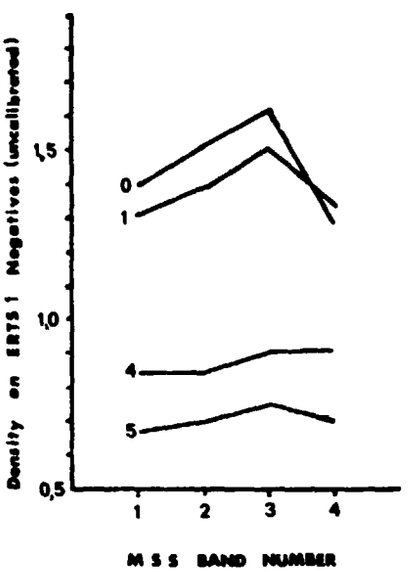

Fig. 5

Density vs Band Number
(Vegetation Categories
2 and 3)

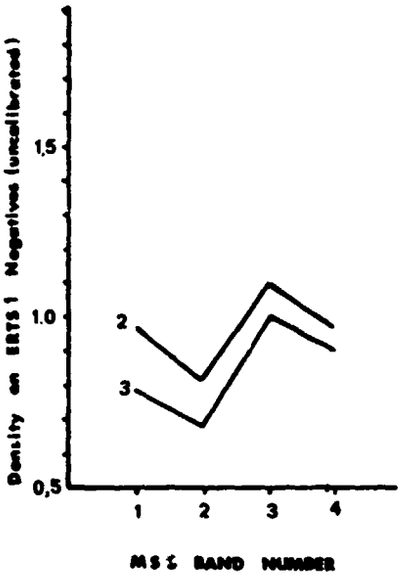

Fig. 6

dumps prior to the date on which the ERTS-1 imager, was gathered. The reflectance properties of these dumps were consequently changed quite markedly by the resulting vigorous growth of vegetation. Clearly cognisance will have to be taken of such husbandry practices during image interpretation.

A further aspect which requires investigation is the change in spectral properties of any selected mine dump with season and time. As more ERTS-1 images gathered at different times of the year become available, it may be possible to establish "signatures" which will allow the monitoring of growth or decline of vegetation on a given mine dump.

5. CONCLUSIONS

It has been found that various mine dumps can be located and identified. Patterns of vegetative growth, some characteristic of particular dumps, can also be seen. Although a number of anomalous features require further investigation, good correlation between the vegetative status of certain target mine dumps and the corresponding ERTS-1 MSS imagery has been observed.

It is therefore tentatively concluded that mine dumps can be differentiated with respect to their vegetative cover on these initial images. It is hoped 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. Subsequent imagery showing seasonal variations should facilitate the program.

7. ACKNOWLEDGEMENTS

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