Satellite observation of mine-dump vegetation

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SYNOPSIS

NASA's first Earth Resources Technology Satellite (ERTS-1) was launched on 23rd July, 1972, and has subsequently gathered multispectral imagery of most of Southern Africa from an orbital altitude of 900 km. Images of the Witwatersrand area have been studied 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, and differences in vegetative cover can be seen and measured. Patterns of vegetative growth, some characteristic to particular dumps, can also be seen.

SAMEVATTING

NASA se eerste Earth Resources Technology Satellite (ERTS-1) is op 23 Julie 1972 gelanseer en het sedertdien veelspektrumbeelde van die grootste deel van Suidelike Afrika vanaf 'n boonhoogte van 900 km versamel. Beelde van die Witwatersrand-gebied is bestudeer in 'n poging om tussen mynhope met 'n wisselende mate van plantebedekking te onderskei. In hierdie stadium is dit duidelik dat die verskillende mynhope opgespoor en geïdentifiseer kan word en dat verskille in die plantebedekking waargeneem en gemeet kan word. Plantegroeipatrone, waarvan sommige kenmerkend van bepaalde mynhope is, kan ook gesien word.

INTRODUCTION

ERTS-1 is the first in a planned series of Earth Resources Satellites that have been designed for extensive use throughout the world. The objective of the ERTS programme is to make possible the conducting of integrated resource and environmental surveys[1]. The need for this type of survey arises from the increasing pressure on the earth's finite natural resources, which are being called on to meet the demands of rapidly expanding populations and appetites.

We are using ERTS-1 data in a project on the detection and classification of vegetation on mine dumps along the Witwatersrand. A number of considerations motivated the choice of this project.

(1) The environmental hazard posed by mine dumps is a local problem with regional ramifications because of the effect on water quality.
(2) The state of vegetation on mine dumps appears to be a good index of their status as potential polluters.
(3) The success or failure of this project will provide a measure of the capability of ERTS-type systems in the monitoring of this type of environmental hazard.

THE ERTS-I PROJECT

ERTS-1 was launched on 23rd July, 1972, from the Western Range at Vandenberg Air Force Base. The satellite now revolves about the earth at an altitude of 900 km in a circular sun-synchronous orbit, which sweeps it down from the Arctic to the Antarctic every 103 minutes. The revolutions progress in a westerly direction, so that the distance at the equator between adjacent ground tracks on successive days is 159 km.

On board ERTS-1 are two sensing systems that acquire multispectral images of the earth's surface. The sensors used are a Return Beam Vidicon (RBV) system and a Multispectral Scanner (MSS) system.

RBV and MSS data are normally telemetered simultaneously to one of the three ground stations located at Alaska, Goldstone, and Goddard Space Flight Center (GSFC). Data gathered over locations outside the North American continent, including imagery of Southern Africa, are tape-recorded on board the satellite for later playback over one of the ground stations.

After being recorded at the ground station, the data are sent to the NASA Data Processing Facility at GSFC. This facility accepts data in the form of video tapes and converts it to film imagery, using an electron-beam recorder. The films are processed and the final products prepared for dispatch. Final photographic products consist of black-and-white and composite colour prints and transparencies. Digital computer tapes are also available for specialized investigations. The final products are dispatched throughout the world to scientists participating in the ERTS programme.

ERTS SURVEY OF MINE-DUMP VEGETATION

We are using ERTS-1 imagery in attempting to differentiate between mine dumps having varying degrees of vegetative cover, and to monitor the growth or decline of this cover on any selected dump.

Initially, we selected six mine dumps for intensive study. This selection was based on a mosaic of the Witwatersrand mine dump complex prepared from black-and-white trigonometrical survey photographs and rephotographed at a scale of 1:250 000. 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 for the classification of the mine dumps (Table I).

One 'calibration' dump of each category was selected for detailed analysis on the basis of size (as 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 I, and are identified by the numbering system developed by the Chamber of Mines of South Africa.

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TABLE I
CLASSIFICATION OF MINE DUMPS

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 'ploughing'.	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 dump surface.	1/A/20

Qualitative interpretation involved the use of 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 Plate I. Although much detail of the colour presentation has been lost, essentially all the larger mine dumps present in the aerial-photographic mosaic can be detected and identified on the ERTS-1 image. This achieves the first aim of our ERTS-1 project.

Furthermore, there is a good qualitative relation between the categories of Table I and the mine dumps appearing on the ERTS image, with the more densely vegetated dumps (i.e., those in categories 4 and 5) appearing darker than the unvegetated dumps (those in categories 0 and 1). In addition, vegetation patterns are visible on the ERTS-1 imagery that are in good agreement with ground truth, i.e., with patterns observed on aircraft-overflight photography.

This agreement between ERTS-1 imagery and ground truth[2] is encouraging, particularly since ERTS-1 image 1049-07301 was gathered in September. Later imagery, recording seasonal variation in the vegetation patterns, should enable us to refine initial interpretations of the data.

Our initial interpretation of the ERTS data has been based on ground truth gathered from the six selected mine dumps. We intend to extrapolate this interpretation to estimate the degree of vegetative cover on all the mine dumps within the Witwatersrand complex. Our

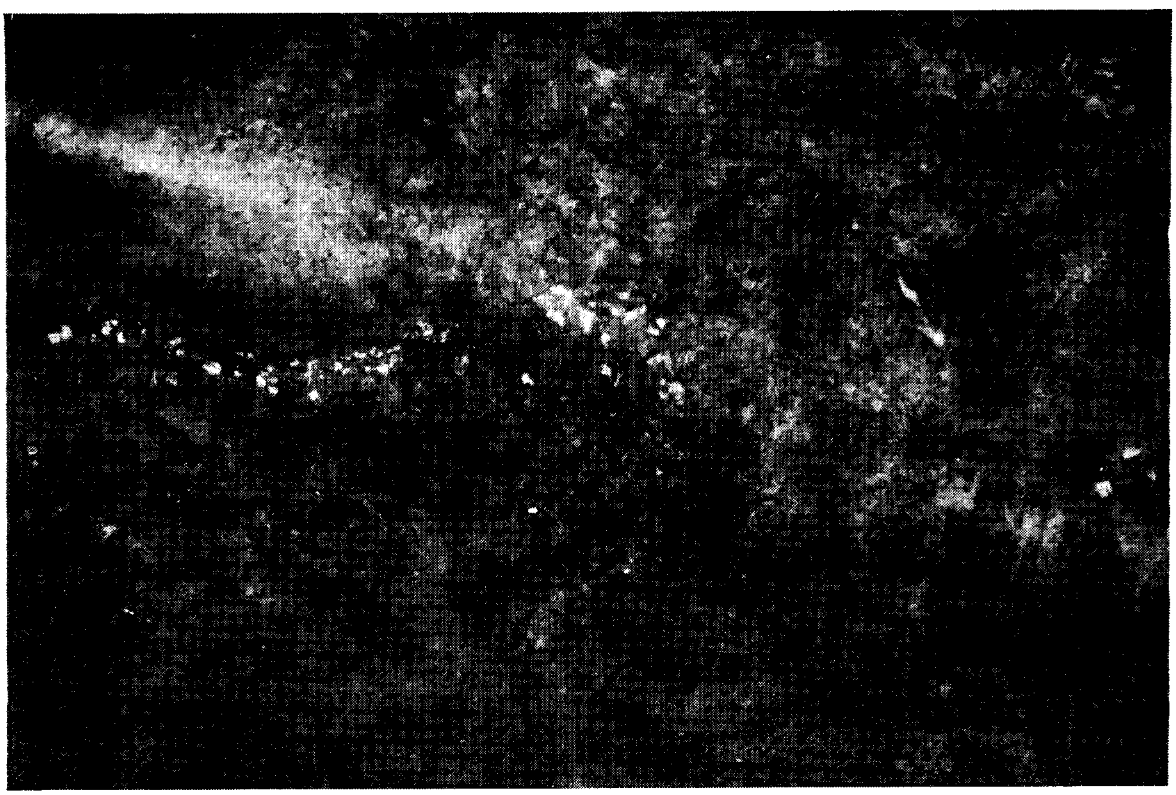

Plate I—Portion of ERTS image 1049-07301 showing mine dumps along the Witwatersrand. The image has been deliberately overexposed to enhance the contrast between the mine dumps and their background

estimate will then be compared with figures obtained by conventional means. This will provide a measure of the capability of ERTS-type systems in monitoring this type of environmental hazard.

SUMMARY AND CONCLUSIONS

Thus far we have established that mine dumps can be identified on ERTS-1 imagery and that differences in their vegetative cover can be detected. The final phase of our project is to make a quantitative comparison between ERTS-derived estimates of vegetative cover and estimates derived by conventional means.

What we have found to date leads us to conclude that there is a good possibility that an ERTS-type system could perform the function of monitoring the environmental hazard posed by mine dumps, a function at present performed by aircraft overflight or *in situ* inspection. In this way, the tasks of keeping watch on potential pollution from mine dumps could be made part of an integrated environmental monitoring system.

REFERENCES

1. Robinove, C. J. Earth resources satellites and integrated resource surveys. *Proceedings of the Symposium on Remote Sensing*, Pretoria, 1972. S. 61, pp. 47-56.
2. Gilbertson, B. P. Growth and decline of vegetation of mine dumps. NASA Earth Resources Survey Programme, *Weekly Abstracts* E73-10326.

NIM Reports

The following reports are available free of charge from the National Institute for Metallurgy, Private Bag 7, Auckland Park, Johannesburg.

Report no. 1549

Thermodynamic and related physicochemical factors pertaining to the production of ferromanganese. A literature survey.

The literature dealing with the fundamentals involved in the production of ferromanganese is examined, the objective being to assemble the available information and thus to establish what aspects require further study. It was found that fundamental knowledge on the thermodynamic properties of alloy and slag phases is incomplete, and, although the mechanism of FeO, MnO, and SiO_2 reduction by carbon dissolved in liquid iron has been established, the reduction of these oxides with solid carbon could profitably be studied further. In addition, the activities of the components in the system Fe—Mn—Si—C require further study.

Report no. 1568

A computer programme for the estimation of parameters in flotation.

The report describes a computer programme for the estimation of parameters in the model that is used to predict the performance of any flotation plant. The confidence limits for the parameter estimates are also provided by the programme. Data from an incremental batch test or from the rougher and cleaner cells in a continuous plant can be used for the estimation. A method is given for the testing of various hypotheses concerning the parameters to give the characterization of a slurry that is both adequate and significant.

Report no. 1571

The commissioning of a direct-reading spectrometer for the analysis of silicate rocks by use of the graphite-pellet technique.

A number of relevant factors concerning pellet preparation, pellet surfacing, excitation parameters, preburn time, and spark geometry were investigated and assessed, and a set of calibration graphs was prepared for a group of twenty-five standard samples. The various element lines were assessed, and, where necessary, appropriate corrections were applied for spectral interferences. The method was shown not to be as accurate as classical chemical analysis, but it requires considerably less time and is therefore less costly. The accuracy of the method is 100 ± 2 per cent. The details of the procedure are listed in an appendix.

Report no. 1582

The construction and testing of a precision calorimeter.

The design, construction, and calibration of a titration calorimeter capable of measuring ΔH for complete ($K \geqslant 10^4$) and ΔG, ΔH, and ΔS for incomplete ($10^0 \leqslant K \leqslant 10^4$) reactions in the solution phase is described. The instrument was tested by the measurement of the enthalpy change for a well-documented complete reaction—the neutralization of sodium hydroxide with hydrochloric acid. The results had a precision of 0,5 per cent and agreed with published values. The instrument and the calculation techniques for incomplete reactions were tested by measurement of the formation constants and enthalpy changes for the reactions involved in the formation of silver(I)—pyridine complexes. The results are well within the range of values published in the literature. The calorimeter, with its automated temperature-sensing ability, is more convenient to operate than the LKB 8700 calorimetry system and gives better thermogram resolution. The instrument has been operated by a technician without any difficulty.

Report no. 1587

A preliminary investigation of the flotation of copper-activated sphalerite without the use of collectors.

Although non-activated sphalerite cannot be floated without the use of collectors, it is shown that this is possible once the sphalerite has been activated with either copper or silver ions. Elemental sulphur in any of its normal allotropic forms does not play a role in this flotation.

The major factor affecting the collectorless flotation of copper-activated sphalerite is the extent of oxidation of the sphalerite both before and after activation. Oxidizing agents such as $KMnO_4$ or $K_2Cr_2O_7$ were found to be the best depressants for collectorless flotation, which does not appear to be affected by the source or composition of the sphalerite used.