DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1973/7

REMOTE SENSING IN GEOLOGY AT B.M.R. 1965-1972

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SUMMARY

Eight examples of remote sensing work done by BMR from 1965 to 1972 are briefly described. They include the use of: panchromatic photography, black and white infrared photography, colour aerial photography, colour infrared photography, side-looking radar imagery and infrared imagery.

REMOTE SENSING IN GEOLOGY AT BMR, TO 1972*

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Introduction

The substance of this record was presented at an informal symposium on remote sensing at the CSIRO Division of Mineral Physics, Sydney, September 20-23, 1972.

The term "Remote Sensing" refers here to the use of instruments operating at certain wavelength bands of the electromagnetic spectrum (Fig. 1) from the ultra-violet to the microwave, to acquire data about objects although not in contact with them. The various electrical and radioactivity methods of geophysical prospecting, and the sensing of the earth's natural fields of gravity and magnetism are excluded; however, the combination of some of these methods with remote sensing techniques (in the restricted sense) can provide useful information.

At BMR nearly all the work in the field of remote sensing has been, and still is, concerned with the application of panchromatic aerial photographs to geological mapping, and in this sense BMR, since its inception, has been concerned with remote sensing.

One of the principal functions of BMR is the gathering of basic geological information required for the evaluation of the country's mineral resources. This information is recorded on regional geological maps at 1:250 000 and larger scales, and since 1946, overlapping vertical black and white aerial photographs have been used in the preparation of these maps.

During the last six years however, BMR has applied some of the newer techniques in geological situations, and it is the purpose of this record to review briefly the results achieved, and to refer also to an example of our routine photogeological work.

Equipment

Both pocket and mirror stereoscopes are used. The latter are high quality instruments equipped with 3 X binoculars and a few are mounted on parallel guidance devices. Field geologists carry pocket stereoscopes on traverse, and in the field camp they usually have one or more mirror

* Read at the CSIRO Remote Sensing Symposium, North Ryde, September 20-23, 1972.

stereoscopes. The Photogeology Group has a pair of optically scanning stereoscopes with which two people can study the same pair of photographs simultaneously; these are used for training purposes. A special stereoscope has been devised for viewing 70 mm film in roll form; it has 4 X magnification, and can be mounted on a parallel guidance device. Equipment for compilation includes a Grant projector, Map-o-Graph, two optical pantographs (Omnigraph Fotokopist), Sketchmasters and a Radial Line Plotter. Another piece of equipment that has been used, in fracture studies, is the laser scan.

Examples of work done

1. Photogeology prior to regional geological mapping.

Prior to the geological mapping of the Kimberley Plateau in 1965 two photogeologists examined about 3500 aerial photographs at 1:50 000 scale and produced six 1:250 000 scale photogeological maps that provided the basis for the planning of the subsequent field work (Perry & Richard, 1965).

A combined BMR - Geological Survey of Western Australia (GSWA) party of 9 geologists mapped the area in 9 weeks, aided by two helicopters, which together flew a total of 300 hours. The principal value of the photogeological maps was in the planning of helicopter traverses. The areal distribution of formations on the maps determined the location and spacing of traverses, which were plotted on photo-scale mosaics and then transferred to individual photos. The photos themselves were used for navigation in the air. Besides the helicopter operations, numerous ground traverses were made, and the photogeological maps were also used for planning these.

Similar photogeological work is still being done in support of the regional geological mapping program, the main purpose of course, being to enable more effective use to be made of geologists' time in the field.

2. Experimental black and white infrared aerial photography.

In 1966, two members of the Geophysical Branch of the Bureau experimented with black and white infrared aerial photography of an area near Brisbane (Polak & Wiebenga, 1968).

They used 2 F24 cameras, one with panchromatic film, the other with IR. This demonstrated that streams and water bodies appeared black on pan IR photographs except where they were less than 0.3 m deep. Water with suspended sediment appeared lighter in some shade of grey depending on the concentration of suspended matter. Vegetation inundated by salt water showed a lower reflectance of IR than well-drained vegetation.

3. Experimental 70 mm colour aerial photography, N.T., 1967.

During the winter of 1967 the Airborne Group of the Geophysical Branch was engaged in aeromagnetic work in the N.T. with the Bureau Cessna VH-GEO, which was equipped with a single Vinten 70 mm camera. Several areas were flown with colour film (MS Ektachrome, typical exposure 1/500 sec at f.7-8) at various altitudes, both with a 76 mm (3 inch) focal length lens and with a 44 mm (1 3/4 inch) lens, and at one locality in the Ngalia Basin a single run of panchromatic film was exposed for comparison. It was found that some sedimentary rock types could be readily differentiated on the colour film but not on the panchromatic (Wells & Perry, 1971).

4. Colour aerial photography for detailed geological mapping.

Possibly partly as a result of some of the officers of the Geological Survey of Queensland (GSQ) having seen examples of the experimental 70 mm colour aerial photography, the Survey decided in 1968 to fly two 100 000 Sheet areas in the Cloncurry region in colour at 1:20 000 scale. This photography was used in a joint program of detailed geological mapping by GSQ and BMR begun in 1969. The following comments are quoted from the field party annual report for 1969 -

> "The quality of the colour photographs appeared superior to all existing B & W photography covering the area at various scales; the colour tonings, though slightly exaggerated in places, were quite realistic. Accurate navigation, especially in difficult granitic terrain, was made simple using colour photographs. Amphibolite bands and dark-toned sedimentary units were readily distinguishable from each other, and certain parts of the Corella Formation showed a characteristic blue colour.
>
> "Small (3 to 5 ft) veins (especially calcite veins in amphibolite), mines, gossans, and soil-covered gossan extensions were particularly obvious in colour. In general, photo-interpretation from colour photos was more accurate and detailed than that possible from black and white photos; in particular, intricate folding was much more evident in colour".

The party recommended that further areas be flown in colour despite the high cost of colour prints relative to panchromatic. BMR has followed this recommendation for other areas being mapped in detail, by letting contracts through the Division of National Mapping for colour photography specifically for geological work.

5. Colour and colour IR aerial photography.

Early in 1970, at the request of the Victorian State Rivers and Water Supply Commission, the Airborne Group of the Geophysical Branch flew simultaneous colour and colour infrared 70 mm vertical aerial photography over three areas in northern Victoria. These were the East Goulburn Main Channel, the Waranga Western Channel and the Kerang-Kow Swamp area, and the main purpose was to locate zones of seepage from channels. Vinten cameras with 44 mm (1 3/4 inch) lenses were used at an altitude of 1370 m (4500 feet) above ground level, resulting in photographs with a nominal scale of 1:30 000. Films used were Kodak Ektachrome Infrared type 8443 with a Wratten 12 filter, and Ektachrome Aero Colour type 2448, without filter.

Both films were processed to the negative, and contact prints made from all negatives. For ease of handling, both for the field and in the office, prints of several runs were stuck to cardboard sheets of convenient size, colour prints on one sheet and colour infrared prints of the same area on another. This arrangement made it easy to follow features such as channels from one run to neighbouring runs, and also allowed comparison between film types to be made easily.

It was found that prints could be viewed in their strips with a pocket stereoscope, the magnification naturally enabling details to be resolved more easily than with the unaided eye; as well, the stereoscopic view provided a blending of hues in those frames in which the hues in one frame did not exactly match the hues of the same point of detail in the adjoining frame. However, for most of the interpretation the stereoscopic view was found to be unnecessary.

The photographs were very useful for locating seepages, tracing old stream channels, identifying the sites of former lakes, and delineating water-logged areas and areas of high salinity. Currey (1971) reports that details of vegetation types and yield per acre can be obtained from the photography. Although natural boundaries showed better on the colour infrared photography than on the normal colour, because of the greater contrast, it was found that with experience the same boundaries could be determined just as well on the normal colour photographs.

6. Radar-Papua New Guinea.

In 1970 the Department of Army let a contract for side-looking radar imagery of several areas in Papua New Guinea that it had not been possible to photograph because of persistent cloud cover, and in 1971 a BMR field party mapping the geology of the western central ranges used some of this radar imagery for base map compilation and geological interpretation (Davies & White, 1972).

The radar was a Westinghouse AN-APQ97 unit (Ka band, wavelength .86 cm) mounted in a DC6B aircraft which flew at an altitude of 6000 m above sea level; the original radar strips were at scales ranging from 1:210 000 to 1:223 000, and adjacent strips were acquired with the radar looking in opposite directions. From these the contractor produced mosaics which had certain shortcomings because of this manner of data acquisition, e.g. the same feature imaged in adjoining runs looked different, in some places markedly so; at some joins, features were repeated; at others, missed out altogether. Thus it was found to be more satisfactory to use photographic enlargements of the original radar strips.

The imagery had the usual advantages claimed for radar, namely its synoptic presentation of data and its day-night all-weather capability (except for very heavy rain). It was found to be good for the mapping of major lineaments and faults, and satisfactory for distinguishing some rock types, particularly ultrabasic rocks by their smooth texture (probably because of different vegetation from that on surrounding rocks and its sparser growth), and limestones because of karst weathering features. Edges of beds and cliffs facing the radar were emphasized because of the strong return of signal by these features. In general however, interpretation of rock types was more difficult than on aerial photography, partly due to the lack of the stereoscopic view.

Because of the high relief and steep terrain of the central highlands the radar imagery exhibited the disadvantage known as layover. This is an apparent oversteepening or over turning of terrain in the near range, caused by the radar pulses close to the aircraft, where the depression angle is relatively great, impinging on the tops of hills either before or at about the same time as pulses reaching the valleys that are actually closer to the aircraft. The consequence is that these geographical features though in fact separated, appear on the imagery to be in about the same place.

7. Infrared Linescan.

In March 1971 Canadian Aero Service obtained, at their expense, infrared imagery over several sites in the Canberra area to demonstrate the potential of the technique to BMR, the Forestry Research Institute and the Division of Land Research of CSIRO. Their scanner detector was sensitive to wavelengths from 1 to 5.5 micrometres (1 micrometre = 1/1000 mm), and the incoming radiation could be filtered so that the detector received either principally reflected infrared (1 to 3.5 micrometres) or principally emitted infrared (3.5 to 5.5 micrometres). Details have been reported by Simpson (1971) who concluded that in areas of good exposure thermal infrared could be used for differentiating between rock types, provided their thermal properties differed sufficiently. He also commented on the difficulty of interpreting the imagery. It is desirable to have both ground data and recent aerial photographs of the studied area to carry out a satisfactory interpretation of infrared imagery.

Another experiment with infrared linescan was carried out over the Hail Creek Syncline in the Bowen Basin where Upper Permian coal measures crop out. A scanner sensitive to the 8 to 14 micrometre band was flown over the area three times (at 8 pm, 4 am, and 11 am) within a 24-hour period, and during the 11 am run, vertical panchromatic aerial photographs were also taken. The data are still being evaluated, but preliminary results indicate that cool anomalies in the post-sunset imagery are related to linear grass-covered strips that occupy positions at which shallow coal seams come to the surface. The cool strips are apparently due to the presence of grass. The simultaneous aerial photography is proving extremely valuable in the interpretation of the imagery.

8. Remote sensing project W.A., 1971.

In this experiment an interpretation of the geology of two areas near Kalgoorlie was made by considering the information from detailed aeromagnetic, 4-channel gamma ray spectrometer, and multispectral photographic data (Shelley & Simpson, 1972). More geological information was extracted from this combination of techniques than could be obtained from any one of them considered singly. Conventional colour photographs proved to contain more information than colour infrared photographs, or than photographs produced on panchromatic film through various Wratten filters. Only a duel camera system was available at the time, and this was unsatisfactory for multispectral photography using a single film type. Interpretation of large numbers of prints from separate spectral bands resulting from photography with a multilens camera is considered impractical because of the time consuming nature of the task.

9. Radar - Mt. Isa-Cloncurry area, Queensland

During the Autumn of 1972 a Caravelle jet belonging to Aero Service Corporation fitted with a Goodyear Aerospace Corporation GEMS 1 000 side-looking radar system was engaged in survey work in Indonesia.

The location of the aircraft relatively close to Australia presented an opportunity of bringing it to this country at a much reduced positioning charge compared with the fee that would be charged for commissioning the plane from its home base at Philadelphia, U.S.A. The Australian Committee for ERTS supported the proposal to acquire radar imagery of one of the ERTS test sites, and subsequently a contract, funded jointly by the Division of National Mapping and BMR, was let for coverage of a 100 km by 30 km area in the Mt Isa-Cloncurry region.

The survey flights took place in mid-June, 1972, and the area imaged lies between latitudes 20°20' & 2112"' South, and longitudes 139°10' & 140°30' East, and stereoscopic coverage was obtained for the greater part of this. The contractor produced four mosaics and five radar strips at 1:100 000 scale.

The BMR study of the radar was in progress when this record was being written and the final results will be reported elsewhere. Only preliminary results can be given here: i) for the appreciation of regional topographic expression, and thus to a large extent, of regional geological structure, the radar mosaics are superior to photo-mosaics at the same scale prepared from 1:85 000 scale air photographs; ii) lithological units that differ in respect of topographic expression, fracture pattern, in drainage pattern, can be readily delineated.

Future Work

It is expected that BMR will continue to use photogeology as a preliminary to regional mapping, and to an increasing extent, to detailed mapping as well. Work will also continue on the application of new forms of remote sensing, including satellite imagery, to geological problems under Australian conditions, some of it perhaps in collaboration with other agencies interested in remote sensing.

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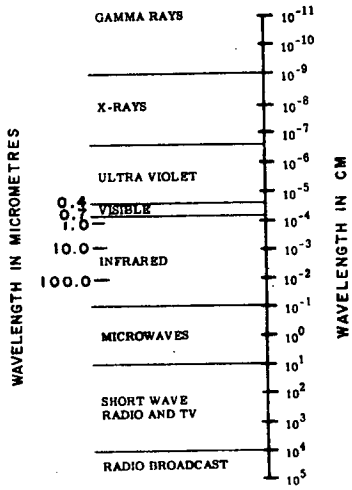

FIGURE I. THE ELECTROMAGNETIC SPECTRUM

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