Department of
MINERAL RESOURCES
New South Wales

S.M.E.D.G.

EXPLORATION TOWARDS 2000

A seminar to be held at the Masonic Centre, Castlereagh St.,

on 20th September, 1985.

Sponsored by:

New South Wales Department of Mineral Resources
Sydney Mineral Exploration Discussion Group

PROGRAMME

8:30 - 8:40	Welcome and Introduction
8:40 - 9:20	Dr. D. Mackenzie (CRA Exploration Pty. Ltd.) Exploration Towards 2000 - Survival of the Fittest?
9:20 - 10:00	Dr. R. Large (Department of Geology, University of Tasmania) Ore Deposit Models for the Future.
10:00 - 10:30	Morning Tea
10:30 - 11:00	Mr. N.J. Marshall (Exploration Consultant) Alternative Sampling Media in Reconnaissance Geochemical Exploration.
11:00 - 11:30	Dr. G.F. Taylor (CSIRO, Division of Mineral Physics and Mineralogy) Primary Haloes and Secondary Dispersion in Search for Concealed Mineralisation.
11:30 - 12:00	Dr. Soey Sie (CSIRO, Division of Mineral Physics and Mineralogy) Microbeam Techniques - Analysis for the Future.
12:00 - 2:00	Lunch
2:00 - 2:30	Mr. R.N. Walker (Image Processing Services) The Display and Interpretation of Geophysical Data Using Image Processing Techniques.
2:30 - 3:00	K. Vozoff, K. Lebrocq, K. McAllister and D. Moss (Macquarie University) Deep Exploration and Development by New Electromagnetic Techniques.
3:00 - 3:30	Dr. J.R. Bishop (Mitre Geophysics Pty. Ltd.) Dr. R.J.G. Lewis (Department of Geology, University of Tasmania) The Piezoelectric Exploration Method
3:30 - 4:00	Afternoon Tea
4:00 - 4:30	Mr. J.G. Wilson (Australian Photogeological Consultants) Exploration Remote Sensing Towards 2000.
4:30 - 5:00	Dr. A. Green (CSIRO, Division of Mineral Physics and Mineralogy) Advanced Remote Sensing for Mineral Identification.

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EXPLORATION TOWARDS 2000 -

SURVIVAL OF THE FITTEST

D.H. Mackenzie

Factors which influence current exploration practice and strategy are mainly non-geological in nature. They include the end of the post-WWII growth cycle with decline in growth of metal usage through substitution and greater recycling; over supply of most commodities when viewed world-wide; Australia's weak cost position in world markets; the natural cyclicity of discoveries and inadequate understanding of the geological make-up of the continent especially in concealed areas; and cultural factors which deter exploration in significant areas of the country.

These factors have led to a focus of exploration either for specific commodities like precious metals and petroleum which may give quick cash flows or for the very largest targets in favourable locations which might rank high in the world league or on relatively easier targets near existing mines. The industry is applying sophisticated technology in drilling, geophysics and to a lesser extent geochemistry and remote sensing but has fallen behind in the methods to manipulate the large volumes of historical and current complex data so generated and put them into a coherent geological framework for exploration needs.

How is this likely to change between 1985 and the year 2000? Recent discoveries and encouraging intersections near Kalgoorlie, Mt. Isa, Cobar, Que River and Broken Hill indicate that companies with existing mines would do well to look with new vision in their own backyard even though the fields have been going for a century or more. In grassroots exploration we need to focus on the very best types of target. Some of these will lie in concealed ground therefore fitting together the subsurface geology of the continent is going to be necessary to conceptualise these targets. To carry out the search will require the use of some sophisticated tools. We need to face the cost of researching and developing these tools, like scanners and down hole geophysical instruments as an integral cost of exploration. But they will not be nearly so useful if they are not matched with much better geological focus on what makes ore. To achieve this means a much greater applied input from our academic colleagues than has been the case in the past. The amount of data generated will not decrease so better and faster handling of the data which fuels thinking will be required of geotechnical computing systems. As we move to more concealed areas the type of analysis and targetting applied in the oil industry must be applied to mineral exploration.

The survivors of the difficult times ahead will be these who fit and adapt themselves best to the type of circumstances indicated above.

ORE DEPOSIT MODELS FOR THE FUTURE

Ross R. Large

University of Tasmania

Probably the most significant recent advance in mineral exploration has been the development of multidiscipline ore deposit models based on conceptional genetic studies combined with technique oriented target definition. It is difficult to isolate which single technique has made the most impact on exploration procedures over the period 1970-85. A list of the most important is given below.

Geophysical - Deep penetration transient E.M.
- Image processing for airborne surveys.
- down hole E.M., magnetics.
- Advanced computer interpretation.

Geochemical - rapid, low level, analytical techniques - especially for gold.

Geological - wall rock alteration models
- ore deposit environment models
- landsat interpretation.

These techniques are continuing to develop and will probably form the nucleus of further advances in the next 15 years. However, two other rapidly developing fields which will greatly enhance the formulation of new ore deposit models are isotopes geochemistry and fluid inclusion studies.

Pb isotopes: the practical application of lead isotopes to exploration has been successfully demonstrated by CSIRO research.

O/H isotopes: the potential of oxygen and hydrogen isotopes remains considerably underdeveloped in Australia, while recent overseas studies indicate this technique offers great promise.

S isotopes: are useful in detailed genetic studies but generally have limited application to exploration.

Fluid Inclusions: recent developments of the Laser Raman Microprobe allow more detailed assessment of fluid inclusion compositions which can be directly related to favourable ore deposit environments.

A range of information is available by the combination of isotopic and fluid inclusion studies (see Table 1) which when placed in the correct geological context can provide a tightly constrained exploration model. The promising development of coupled I.C.P. - mass spectrometer facilities in the last two years suggest that it will soon become possible to obtain low level geochemical analyses plus isotope analyses on the same sample on a routine basis with rapid turn around and at relatively low cost. This will lead to a revolution in the use of isotope geochemistry in the development of exploration models.

Table 1: Potential information available from isotope and fluid inclusion studies in exploration

Technique	Source Rock	Source Solution	Age	Drill Target Signature	Halo Indicator	Formation Temperature	pH/fO_2
Lead isotopes	Yes	No	Yes	Yes	No	No	No
Oxygen/Hydrogen Isotopes	No	Yes	No	Yes	Yes	Maybe	No
Sulphur Isotopes	Maybe	Maybe	No	No	No?	Maybe	Yes
Fluid Inclusions	No	Maybe	No	Maybe	?	Yes	Yes

ALTERNATIVE SAMPLING MEDIA IN RECONNAISSANCE GEOCHEMICAL EXPLORATION

N.J. Marshall

Exploration Consultant

Reconnaissance exploration has fallen into disfavor in recent years, because of the widely held belief that such "grass-roots" programs are disproportionately expensive compared to more detailed assessments on historically known mineralization - "advanced prospects".

Yet some of the most exciting discoveries have been made through a combination of imaginative conceptual thinking, cost-effective reconnaissance exploration, and of course luck - Telfer, Lihir Island, Olympic Dam, Pajingo, and a host of "Carlin type" deposits in the south-west USA.

In geochemistry, cost-effective exploration translates to maximizing sampling intervals (which in themselves should be a dynamic function of geology and geochemical landscape), and hence minimizing field and analytical costs, without sacrificing "findability". Thus funds are conserved for other plays, and should mineralization be present, "advanced prospect" status should quickly be reached at the low end of the cost curve. Regrettably this attitude seems not to be encouraged by government regulations for expenditure requirements, perpetrated by some joint ventures, and publicized in the trade media, where a measure of exploration effectiveness is made to sound directly proportional to expenditure.

There is a real need to recognize expenditure requirements in terms of exploration risk, i.e. presence or absence of significant mineralization on strike, local landscape, and a properly tailored (rather than ritualistic) exploration program - these influence "findability".

Australia, with its deeply weathered, often lateritized landscape with subsequent mechanical dispersion and dilution, presents problems in geochemical dispersion which can be turned to advantage for first phase exploration, rather than combated by closer spaced sampling, including collecting samples at depth (where secondary dispersion is often more limited).

This involves a consideration of "what" causes a secondary geochemical anomaly - that is, what is the active component where the metals are found, how is it dispersed, how can the active component be highlighted, and what sample residence site will have the greatest directional zone of influence.

To be useful for a survey, the sampling medium must be ubiquitous, readily available, simple to collect, transport, and analyze, be consistent, and be able to contain elements which are diagnostic for the styles of mineralization sought.

Clearly, heavy mineral panned concentrates and RAB cuttings of weathered bedrock do not meet all these criteria, although the latter may be necessary in the more detailed and necessarily higher cost, rather than earlier (as is often done) phase of exploration.

In practice, combinations of several sampling media are often necessary to avoid large gaps in prospective terrain.

This is best done by planning surveys through a combination of stereo photo analysis of the landscape, formulation of conceptual models appropriate to the geology, budget/time restrictions, and on-site training of the sampling crew. Experience is an important factor, as one does not often have the luxury of orientation sites appropriate to the mineralization type sought, within the exploration tenement.

For example, a typical survey in the Lachlan Fold Belt may involve a combination of stream sediments, gully soils, base of slope soils and surface soils from micro-depressions, located on air photos, rather than on a controlled, closer spaced grid.

"B horizon" samples taken at depth are considerably more time-consuming, and therefore costly to collect, than A horizon soils which may give an adequate, (if more subdued) response. Many parts of Australia have only a skeletal soil development and soil sampling depth is irrelevant.

In wide humic acid laden streams in Tasmanian rain forests, manganese coatings deposit on stream pebbles at the air-water interface with a change to oxidizing conditions. Base metals coprecipitated with the MnO_2 give a superior anomaly contrast, and hence dispersion train, to conventional stream sediments where the geochemically active components are rapidly diluted by barren silt, clay and sand of low surface adsorption activity - i.e. "scavenging" occurs, but this is relative to source concentration.

Direct sampling of ferricrete, containing iron oxide immobilized elements on thin residual laterite profiles in many parts of Australia is very effective in showing broad high contrast dispersions from narrow mineralized sources. By comparison, thin residual soils over laterite tend to be ineffective, due to fixation of metals in the ferricrete component, which can be regarded as a lithified fossil B horizon soil. In flat lying, deflated areas, the former laterite profile has been stripped leaving a lag of pisolitic ironstone gravel among a sea of wind-blown silt and alluvium. These ironstones can disperse mechanically for several hundred metres down slope, to accumulate parallel to greenstone ridges. Selective sampling of this often ubiquitous surface medium can give displaced high contrast anomalies.

Thus these sampling media, readily available at surface, show superior dispersion to fresh and weathered bedrock, which must be penetrated at fairly close grid intervals by RAB drilling to locate the anomaly. That process belongs more properly to the next follow-up stage of exploration, using an affordable close grid over the previously defined anomaly zone or its up-slope projection.

Gossanous iron oxides containing "fixed" or immobilized heavy metal ions recrystallize through dehydration of goethite and lepidocrocite (in "limonite") components, to form hematite and maghemite, which disperse into stream sediments.

Maghemite, being ferro-magnetic, can be readily recovered from arid zone stream sediments to give an anomaly concentrate with superior contrast and dispersion to the sieved whole sediment. In fact this iron oxide component with its coprecipitated anomalous metal is often the predominent active ingredient of a stream sediment anomaly, where mechanical dispersion and thus high dilution by barren detritus predominates. In such circumstances, conventional stream sediment sampling requires close sampling of minor creeks. Magnetic concentrate sampling of major creeks is a more cost-effective technique for low density first phase coverage to isolate sub-areas for closer, conventional sampling.

Experience gained with these alternative sampling media on numerous case histories over the last seven years has demonstrated their strengths and limitations. Background values for certain elements are strongly enhanced in iron and manganese oxide concentrates, requiring a familiarization as to threshold.

Other techniques, still confidential, have been developed where these media are lacking in some desert terrains, and successfully demonstrated blind mineralization previously only expressed through geophysics.

In many cases, exploration expenditure incurred on more traditional work could have been substantially reduced by designing reconnaissance surveys to focus progressively onto target zones. This approach needs to be recognized and encouraged in funding exploration budgets, perhaps by more innovative government expenditure requirements and more innovative joint venture arrangements, to encourage grass roots exploration as a source of future "advanced prospects".

A future trend would be to refine existing instrumentation to allow mobile laboratory field detection given the problems of high iron matrix, and surface analysis of small samples. In this regard, recent advances in small X-ray tube sources, coupled with energy dispersive detector systems are pertinent. Utilization of laser ablation and similar techniques for analysis of targeted microsurfaces as seen by binocular microscope, is a promising research area in applied "phase analysis" of geochemically active components, such as non-magnetic iron oxide coatings.

PRIMARY HALOES AND SECONDARY DISPERSION IN THE SEARCH FOR CONCEALED MINERALIZATION

Graham F. Taylor
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Mineral exploration in Australia has to face three major obstacles:

- economics of mineral production
- a greater emphasis on concealed mineralization, and
- deep weathering and transported overburden.

It is doubtful whether scientific research can overcome the first but continued efforts within industry, tertiary institutions, BMR, CSIRO and the State surveys are already leading to better concepts and cost-effective techniques in exploration for concealed mineralization. This paper outlines some significant advances in geochemistry.

Advances in analytical techniques leading to less expensive, more rapid determinations of a wider range of elements at lower concentrations has moved trace multi-element geochemistry into the range of most companies. Many micro-computers are now capable of handling the vast amount of data produced.

Prior to the recognition of primary haloes it is essential to characterize the fresh rock. Metamorphism, alteration and intense weathering often make this extremely difficult on mineralogical and textural evidence. The immobile elements Ti, Zr, Cr, Y and Nb may be used to characterize weathered rocks and the REE, metamorphosed and altered rocks.

Primary haloes whether mineralogical or geochemical, narrow or extensive, subtle or intense are associated with most styles of mineralization. In areas of high relief and high rain fall (e.g. west coast of Tasmania) it may be possible to use such haloes directly in the search for concealed mineralization. However, over much of Australia, fresh rock occurs below a deeply weathered crust and we must learn to recognize the manifestations of primary haloes in this weathered material. The concept of 'zonality' as proposed by the Russians has not yet received necessary testing in Australia and needs more than an empirical basis to be successful.

We have been reasonably successful in the use of surficial material in discovering outcropping and near-surface mineralization. Can we use such material in the search for concealed mineralization? Evidence to date is conflicting and additional research is needed to determine factors controlling secondary dispersion. Recent work in W.A. has shown that there is sufficient dispersion into lateritic overburden to give recognizable anomalies above concealed mineralization.

Saline groundwaters with their potentially high leaching capacity offer significant opportunities for detection of a wide variety of commodities. Techniques successful in uranium exploration are presently being adapted to the search for base metals, gold and diamonds.

MICROBEAM TECHNIQUES - ANALYSIS FOR THE FUTURE

S.H. Sie

CSIRO - Division of Mineral Physics and Mineralogy

The tools of the earth scientists have progressed considerably from mallets, crucibles and microscopes. One instrument introduced some two decades ago, namely the electron microprobe, has been responsible for much of the progress in mineralogy and petrology. The information made available by multi-element analysis, combined with in-situ, non-destructive features, delineates features of complex mineral assemblages. The microbeam is essential considering the typical size of mineral phases is of the order of 10-50 pm. The advent of modern high resolution energy dispersive spectrometers (EDS) added convenience in the analysis, although with less sensitivity than wavelength dispersive spectrometers (WDS) due to poorer resolution. The detection limits are determined by the continuum radiation background inherent in electron induced excitations, and range from about 100 to 500 ppm, with the lower ranges obtained with WDS.

The desirability of extending the limits of detection to trace levels (PPM) is warranted by the importance of such information in a wide range of applications. Foremost amongst them are studies of mineralized primary and secondary haloes of concealed deposits with implications in geochemical methods of exploration as well as the ore genesis process itself. Another is the study of partitioning of certain trace elements, e.g. rare-earth elements (REE) between coexisting phases, which can provide key data in the study of rock genesis and metamorphosis. More relevant to the mineral processing would be to locate traces of noble metals in hosts of base metal ores.

Trace elements are conventionally detected by optical spectrometric techniques and by neutron activation. Invariably, these techniques do not show uniform sensitivity to all elements, and more seriously they are destructive techniques that can be problematic when samples are scarce.

Particle induced X-ray emission (PIXE) when characteristic X-rays are induced by particles such as protons from accelerators provides the in-situ trace detection capability. Its enhanced sensitivity (typically 1-10 ppm) over that of electron microprobes is due to its much higher relative ratio of characteristic X-ray to the continuum background. With EDS, detection is limited to elements heavier than Na because of a rather thick absorber is needed to protect the detector from scattered beam. The lighter elements can be detected by a number of other ion-beam techniques.

A much higher sensitivity in in-situ detection of trace elements can be achieved by ion-microprobes. A microbeam of low energy primary ions (few tens of KeV energy) such as O, Ar, Ga are used to sputter the sample. A fraction of the sputtered material is ionized (secondary ions) and can be analyzed using mass spectrometers. Quantitative analysis however is beset by problems of the uncertainty in the sputtering yield due to matrix affects. With high resolution spectrometers, isotopic analysis can be performed in some favourable cases. However, in most cases molecular interferences hamper the analysis.

This interference problem can be eliminated by accelerating the secondary ions to MeV energies, in a new technique known as accelerator mass spectrometry (AMS). At MeV energies, molecules dissociate into their elemental ions, which can be further analyzed by nuclear particle identification techniques. The resultant high isotopic sensitivity has opened up a number of new fields, particularly in the application of rare cosmogenic radio nuclides as clocks and tracers. Preliminary applications to detection of ehavy isotopes appear to be promising.

Applications of AMS to date has been with ion-sources without microprobing capability. A development of an AMS system and such a source are currently being undertaken by the CSIRO at the Heavy Ion Analytical Facility (HIAF) laboratory at North Ryde. Current facility includes a proton microprobe with spatial resolution of 5 pm, equipped with EDS.

DISPLAY AND INTERPRETATION OF AIRBORNE GEOPHYSICAL DATA USING IMAGE PROCESSING TECHNIQUES

R.N. Walker

Image Processing Services

The development of image processing has introduced a new dimension to the interpretation of airborne geophysical data and other large geophysical data sets. It is now possible to view a data set in colour and to interactively vary hues, contrasts and other characteristics in the search for unusual or anomalous patterns which may have significance in the exploration process. It is also possible to readily compare and integrate different data sets and to relate these to known or interpreted geology.

It is now much easier to go beyond the search for simple anomalies, such as discrete intensity highs, and to concentrate on more subtle features such as inflexions, trends, composite anomalies and lithological signatures.

Geophysical data are usually entered into the image processor as a "gridded file" which is produced at an intermediate stage in the preparation of a contoured plan. For display purposes the lowest intensity value is set to black and the highest value is set to white with intermediate values scaled linearly between these extremes to give a "grey scale intensity image". The data can then be manipulated using normal image processing techniques.

The advantages of image processing are:-

* contrast changes can be made rapidly to maximize detail either in a part or all of an image.

* mathematical processings (e.g. derivatives and ratios) are easily performed.

* scales can be changed rapidly.

* data sets are easily compared using colour composites and split screens.

* profiles and coloured contour maps are easily superimposed on images.

Image processing by its very nature is a highly visual technique and this will be obvious during the presentation where various examples of processing will be shown.

An example of the use of magnetics in a structural reinterpretation of the McArthur River Pb-Zn-Ag deposit will be presented.

DEEP EXPLORATION AND DEVELOPMENT BY NEW ELECTROMAGNETIC TECHNIQUES

K. Vozoff[1], K. LeBrocq[1], K. McAllister[1], D. Moss[2]

The Centre for Geophysical Exploration Research, Macquarie University, is involved in the demonstration and evaluation of a new transient electromagnetic method, initially developed in the United States.

This method, LOTEM (Long Offset Transient Electromagnetics) is particularly directed towards petroleum exploration, where deep soundings are required.

The method, as developed by Kaufman and his predecessors, is described in Kaufman & Keller (1983). There, a large amplitude square wave or similar current is driven through the earth via a 1-2 kilometre long cable grounded at its ends. The vertical component of the resulting transient magnetic fields are recorded at offsets of 3 to 20 kilometres or so, and interpreted by fitting to horizontally-layered models. This detects features at maximum depths of $1\frac{1}{2}$ to 4 kilometres, depending on the electrical conductivities in the section.

Fieldwork and theory have established that this measurement responds most strongly to the presence and parameters of conductive features, i.e. zones of high porosity/salinity. Resistive zones, and especially their resistivity values, are not resolved unless their depth is small in comparison to their thickness (Strack, 1983, 1984; Vozoff et al., 1984).

Eadie (1980) shows that the transient electric field (E) is sensitive to resistive zones, and their resistivity, in a manner which is complementary to the magnetic field (H). Thus the inclusion of E-field measurements into the LOTEM system allows the geological section to be derived with more certainty.

In particular, if we consider the variation of the resistivity within a potential reservoir unit, it is found that quite marked differences occur due to the porosity and type of pore fluid contained. Where the reservoir contains hydrocarbons it may be considerably more resistive than at other regions within the same reservoir unit.

It is therefore suggested, when the LOTEM measurements (inclusive of E-field data) are used in conjunction with well hole and seismic data, that the LOTEM method may be utilised in development of a prospect by mapping the 'porosity' trends within a potential (or known) reservoir.

[1] Centre for Geophysical Exploration Research, Macquarie University, North Ryde, NSW 2113.

[2] Esso Australia Limited, GPO Box 4047, Sydney, NSW 2001.

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THE PIEZOELECTRIC EXPLORATION METHOD

J.R. Bishop & R.J.G. Lewis

(Mitre Geophysics) (University of Tasmania)

Piezoelectric materials produce electric charges upon their surfaces when stressed. Several naturally occurring substances are piezoelectric; among the strongest are quartz and sphalerite. Deposits containing these minerals can be detected using the piezoelectric exploration method. (With the exception of the gravity method for sphalerite, neither of these minerals can be detected by any other geophysical technique.)

The method was pioneered by the Russians and consists of applying a stress to the ground (usually by a seismic source) and measuring any resultant electric or magnetic field (dipoles are used for the former; coils for the latter). The location of the deposit is determined as follows: The elapsed time between onset of the seismic source and the arrival of a signal at the receiver is recorded. Since the time taken for the signal to travel from the target to the receiver is effectively zero (the electromagnetic wave travels at the speed of light), the elapsed time is the time taken for the seismic wave to reach the target from the shotpoint. If the seismic velocity of the surrounding rock is known, then the distance from the shotpoint to the target may be calculated. Recordings using several shotpoints in different positions will locate the target. Case histories indicate that shot to target distances of 20m to 30m are possible on the surface, with over 100m obtainable in underground or borehole applications.

In Russia, the method has been used for several years; mostly for locating quartz veins in operating gold mines, but also in "grass-roots" exploration for gold, tin, tungsten and other economic minerals which may occur with quartz. The method's application in the search for massive sulphides is apparently not yet routine. Until recently, the technique attracted little attention in the western world. Some research is now being done in Canada (in 1983, Russian scientists successfully demonstrated the technique in two Canadian mines) and some tests have been tried in Sweden (with equivocal results). Our experiments have confirmed that signal levels are low and that there are several sources of electrical noise to be minimised. Nevertheless, encouraging results have been obtained from tests over quartz veins.

REMOTE SENSING TOWARDS 2000

J.G. (Tim) Wilson

Australian Photogeological Consultants, Canberra

Technological aspects of remote sensing in the last 10 - 15 years are highly impressive and the giant strides look like being maintained in regard to the reception and processing of remotely sensed data. In the exploration for minerals and hydrocarbons, however, the huge advances in technology have not been matched by resultant new discoveries around the world, and Australia is no exception. Disappointment attended the "direct" approach to remote sensing in exploration using, since 1972, the spectral bands on Landsats 1,2,3 and 4 in the attempt to locate mineralised targets on the basis of their spectral properties. It is against this background that remote sensing towards 2000 should be seen, and although the previous technological push will continue to be exerted, it is apparent that the approach to operational remote sensing involvement by exploration companies is undergoing fundamental attitudinal changes. In fact remote sensing for exploration has reached a cross-road. In Australia and elsewhere this is due to renewed critical examination of the role of spectral remote sensing, and to financial constraints in the Industry. In the few exploration company in-house remote-sensing divisions that are in Australia, operational changes are already manifest. In general, these changes reflect the need, and ability, to provide greater exploration cost-effectiveness than has hitherto been the case. The current changes and attitudes set the scene for the period ahead, and a possible scenario is discussed. Before doing so, however, it is necessary to comment on the status of multispectral (visible and infrared) remote sensing for exploration.

Although the basic objective was, and remains, the direct spectral detection of mineralogical targets, it has been known for years that to achieve this objective, i.e., mineral identification, from airborne or space platforms, much more spectral information is and will be necessary than has been provided by resource satellites to date, including Landsat TM. Subscription to the philosophy of spectral targeting for exploration therefore prescribed the development of a new capability in spectral remote sensing, namely, imaging

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A realist may suggest that the assiduous attention that has been devoted continuously during the last 10 - 12 years to refinement of the abovementioned approach by the scientific and research community, will reach its peak, and wane, before the year 2000. This will surely be so as far as application for exploration in Australia is concerned. Not only will local exploration groups be hard-pressed to manipulate the potentially huge amounts of imaging spectrometry data in a meaningful, affordable, expedient, and cost effective way, but it will at last be realised , widely, that the continent of Australia has an unusual geomorphic and weathering history, extending back to the Permian, that militates against the hoped-for benefits from these technological refinements.

The spectral approach to remote sensing, confined as it is to the outermost few microns ("skin") of the materials on the "face" of the earth, is what the writer has termed the "geodermatological" approach to remote sensing. A different approach is the "geomorphological"* approach to the use of remotely sensed data for exploration, using images. In the next decade or so the "geomorphological" protagonists could receive a filip when, and if, images or photographs from experimental or conceptual systems like SPOT, LFC, stereo-MOMS, SIR, Mapsat, and Radarsat (to name but a few) become freely available.

It can be argued that the geomorphological approach to exploration remote sensing is and will continue to be the realm of the photogeologist; and the geodermatological approach, being akin to "remote geochemistry/mineralogy", is really the realm of the geochemist. In similar vein there is a third category of remote sensing techniques for exploration that overlaps with an established earth science. These are the remote-sensing techniques that seek to penetrate the surface, and they have definite geophysical overtones. The

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* The term is here intended to cover interpretation of the overall distribution and morphology of lithotypes, including 3 dimensional structure, by photogeological techniques.

writer suggests that remote sensing for exploration between now and 2000 will be acknowledged to fall largely, if not entirely, within the professional domain of these 3 groups of geoscientists, viz. geophysicists, geochemists/mineralogists, and image interpreters (photogeologists), and the "pure" remote-sensing explorationist will be an anachronism. IN the heady days of optimism and one-up-manship (1972 - 78?) remote sensing was defined in such a way to completely exclude geophysics, and image interpretation was incidental. Times have changed - so much in fact, that the remote sensing divisions within most exploration companies will almost certainly cease to retain their former identities, because the work will change.

Already the most useful (incredibly useful) spin-off to exploration in Australia from mining industry involvement with remote sensing has been the ability to integrate various digital data sets; based on what was learnt from Landsat data processing. These data sets include, particularly, geophysical data, as well as digital terrain and thematic information. In-house remote sensing centres will evolve into comprehensive "Digital Data Integration and Geographic Data Base centres". Such facilities will continue to exist of their own volition - they will become indispensible in exploration - but it warrants mention that should commercialisation of remote sensing go the way it might, the far higher purchase prices of the remotely sensed data may ensure their minimal usage in the next decade, by what used to be called Remote Sensing divisions.

ADVANCED REMOTE SENSING FOR MINERAL IDENTIFICATION

A. Green

CSIRO - Division of Mineral Physics and Mineralogy

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