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File 64/1049, Pt. 2
Folio 9

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

RECORDS:

1964/176

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THE DEVELOPMENT OF GEOCHEMISTRY IN THE BUREAU OF MINERAL RESOURCES.

by

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RECORDS 1964/176

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Geochemical prospecting was first introduced into Australia by Dr. P. Sokoloff of the United States Geological Survey in 1947 and has been a function of the Bureau on a continuing and growing basis since that time. Present efforts in this regard cannot be compared with those of the past because staff availability and experience, techniques, instrumentation and policy have all changed: it is sufficient to say that in the Bureau, geochemistry received its first major impetus during the uranium boom, and later in prospecting for copper, lead and zinc using standard dithizone and biquinoline methods. Surveys were carried out in a number of areas including Rum Jungle, South Alligator River, Tennant Creek, Mt. Isa-Cloncurry, North Queensland, and Captains Flat.

As a result of the phosphate discovery at Rum Jungle in 1961, it became abundantly clear that the number of elements analysed needed to be expanded considerably to reduce the risk of missing deposits of minerals other than those being directly searched for; and also that provision needed to be made for a large increase in the number of samples handled per annum. About this time the Bureau changed over from largely wet to largely spectrographic analyses; and a decision was taken to reorganize and modernize the Bureau Geological Laboratory instrumentation, data processing, methods of presentation of results, co-ordination and interpretation.

This reorganization is now approaching finality and trial runs to test the sample and data handling procedures, flow of samples through various work areas, and the instrumentation are in progress. It has taken 3 years to achieve, and emphasizes spectrographic techniques; but standard wet techniques will continue to be used where applicable.

Recognizing that geochemistry is not confined to geochemical prospecting due attention has been given to other aspects e.g. silicate analyses, age determination studies, adsorption phenomena, formation of minerals etc.

There are a number of basic requirements which must be met, the main ones being:

(i) For geochemical prospecting, the facilities must be able to cope with a very large throughput of samples, and be capable of multi-element studies for orientation work. The analyses must be cheap.

(ii) The analytical scheme must be capable of high levels of accuracy where necessary, particularly where there is a petrological bias.

(iii) Data processing techniques had to be evolved to handle the expected volume of analytical information.

The basic equipment has been purchased - it was clear that different techniques were necessary to obtain the desired level of precision for different elements, and therefore a battery of equipment was necessary. Table 1 lists the equipment now installed and summarizes the main functions and capacity of each instrument. The number of samples quoted is an estimate only as much of the equipment is still being calibrated and staff training is still in progress. A major problem has been and, to some extent, still is, the acquisition of suitable standards.

Table 1

Equipment available in B.M.R. Geological Laboratory for Geochemical Studies

Automatic X-ray Spectrograph	Manual X-ray Spectrograph	Direct-Reading Optical Spectrograph	Photographic Quartz Spectrograph	Atomic Absorption Spectro-photometer	Miscellaneous- Polarograph, Flame Photometer etc.	X-ray Diffraction	Optical Equipment	12" Nuclide Mass Spectrometer	Ancillary Equipment
Capacity Samples per annum									
5000	5000	20,000	8,000	10,000	Variable	3,000		Not yet known	
Note: Some samples are duplicated on different analytical lines									
Application on present analytical scheme									
Silicate and mineral analysis for up to 15 elements. Trace and minor element analysis. Petrological and mineralogical research.	One or two element assays, Sr/Rb ratios for age determination. comprehensive qualitative analysis.	Comprehensive trace and minor element analysis for up to 33 elements per sample. Mineralogical research.	Trace element analysis for up to 10 elements. Qualitative analysis covering 50 elements. Geochemical prospecting and research.	Determination of total metal content or fractionation according to the nature of bonding. Geochemical prospecting and research.	Alkali metal determinations. Phosphate investigations. Research and miscellaneous work.	Mineral identification.	General petrological and mineragraphic equipment.	Rb/Sr K/Ar, Lead isotope determination for dating rocks and minerals.	A range of crushing and fine grinding equipment starting from 4" jaw crushers and including swing mills, roll mills, vibratory mills, mechanical mortar and pestle, balances, sizing, digesting and extraction equipment etc.

The end-product it is hoped will be an analytical facility capable of analysing silicate materials in quantity for up to 50 elements, and for the most part operated by non-professional assistants. The effective increase in staff required is negligible although a more formal status for the current structure of the laboratory organization at the non-professional level is being sought.

It is too early to estimate when the whole system will be fully operative and working on a routine basis, although the Automatic X-Ray line is now fully operational for analyses of igneous rocks (ultrabasic to acid). To shorten the working-up period an early decision was taken to obtain meaningful samples on which the trial runs could be carried out. Three main projects were therefore initiated and these were chosen to allow a full trial of the different lines, sampling procedures, and data processing system.

(i) Direct-Reading Optical Spectrograph

In co-operation with Mt. Isa Mines Ltd., more than 5000 samples were collected by auger drill on a surveyed grid over the Urquhart Shale, (the ore-bearing formation at Mt. Isa), and adjacent formations. Seventy selected samples were quantitatively analysed by a 3 metre grating spectrograph for 33 elements and these samples constitute the "standards" for the remainder. The mineralogy of the sediments is being studied by M.I.M. in an attempt to elucidate the broad trace element assemblages, and this information will be used in processing the results of the main analytical work, using a computer and auto plotter.

Most of the work of calibration and development of instrumental techniques is being carried out by Bureau officers, but we have hired consultants to assist with the direct-reading optical spectrograph; and to further develop the techniques for analysis of specific elements such as Hg and Te by atomic absorption spectrometry.

(ii) Atomic Absorption Spectrophotometer

Kalgoorlie was chosen as a suitable area for developing aspects of this technique. Work is in progress on analytical levels for Hg using single beam equipment, so far with encouraging preliminary results. Other techniques will be used or tried for other elements e.g. Ag by optical spectroscopy, As by the Gutzeit technique or by X-ray. Western Mining Corporation generously provided an excellent suite of samples for a trace element halo study at Kalgoorlie. Standards again present a problem.

(iii) Automatic X-ray Spectrograph

This equipment will be used for a variety of tasks, the first of which to be worked on is silicate analyses of rocks. These currently cost £A33 per analysis by wet methods and if the development of the W1 and G1 standards can be used as a guide, single analyses are at least suspect. It is hoped to achieve higher accuracy by X-ray and, using an internal standard, a constant check can be kept on precision levels. Samples collected for age determination are being used for the trial runs and so far these runs have been encouraging. The equipment analyses four samples at a time (three unknowns and one standard) and a complete analysis (apart from FeO which has to be done by other methods) can be carried out in an average time of 25 minutes. The operation is largely automatic and can be performed by a laboratory assistant under normal supervision; and there is therefore reason to hope that the cost of silicate analyses can be reduced to a fraction of present costs. Such analyses will then inevitably become far more common than they are at present. A computer has already been successfully used for calculating norms.

Most of the problems associated with the calibration of the new analytical lines have been identified and are being overcome and some thought is now being given to effective programming, not only of the details of handling samples and results within the system, but also **to** the types of geochemical problems which should be undertaken for study as likely to provide the most useful results.

The geochemical aspects of petrology will undoubtedly assume increasing importance; and more instrument time is now available on the manual X-ray and optical equipment, which in turn will result in increased use of these lines by mineralogists and chemists. On the age determination side, the Bureau twelve inch Nuclide machine is now operative and has added considerable additional capacity to the geochronological laboratory at the Australian National University in Canberra. Three Bureau geologists work full-time in this laboratory and a fourth geologist and two assistants in the Bureau laboratory on sample preparation, petrology, indexing etc. of age determination samples.

It is part of Bureau policy to promote and develop geochemical prospecting and other aspects of geochemistry in Australia by research into techniques and analytical procedures, giving advice and assistance to mining companies, sponsoring exploration projects, and carrying out original investigations of a detailed or regional character. Four aspects of geochemical prospecting are either under study or being considered for study.

(i) The problem of distinguishing anomalies caused by adsorbed metal ions and those caused by total metal content of stream sediment and soil samples is currently being studied. This is a very real problem in Australia, which has large arid areas, and its solution could affect the style of geochemical work carried out by mining companies, mostly in regard to analytical techniques.

(ii) Trace element halos around known orebodies. These require very precise analytical work and as previously mentioned this in itself necessitates a good deal of research particularly with the more difficult elements such as Hg, Pt, Se, As etc. This type of information is essential to the understanding of geochemical anomalies in any metalliferous province. There will never be a simple answer and each province will require a separate study.

(iii) Orientation surveys. We wish to establish a routine for this type of work. The trace element halo studies form part of orientation work.

(iv) Regional geochemical surveys. These require good geological control to be most effective e.g. the sampling interval is dependent to a marked extent on source-rock type as well as on drainage characteristics. In 1964 four groups were engaged on regional sampling - two in Queensland, one in Papua and one in Central Australia. Except for Papua the work was partly experimental. We are endeavouring to ascertain the best sampling techniques in a variety of environments, the optimum staff, best means of transport, sample registration, type of sample bag etc.. This information will allow us to estimate what average number of samples can be collected per annum; and to balance more effectively the field work against the capacity of the Transit Room and the Laboratory to handle the samples. The ultimate aim of the regional work is the production of metallogenetic and trace element distribution maps at 1:250,000 and 1:50,000 scale to complement geological and geophysical maps already being produced. No details have yet been worked out as to the form such maps will take and a suitable format cannot be devised until a good deal more work has been done.

The main task at present is to solve the problems which still remain on the analytical side. More staff training in the use of data storage retrieval and processing and sampling techniques is also necessary and in this regard a number of Bureau officers have attended IBM courses in Fortran and the 870 Document Writer system. A Record on geochemical sampling procedures has been compiled and distributed to Party Leaders. This Record is currently being reviewed to bring it up to date with changes in the Registered Number system and other aspects which have been modified as a result of the 1964 trial surveys.

Apart from research and planning and trial surveys to gear future work to the new analytical and data processing systems, the Bureau has continued with routine geochemical surveys, mainly in the Northern Territory. A six-element geochemical survey at Rum Jungle using contractors and the B.M.R. Gemco auger drill to collect samples has recently been completed. All of the prospective area within the Hundred of Goyder has now been sampled and a number of anomalies outlined. Similar surveys using 3 inch auger drills have been carried out at McArthur River and Tennant Creek in the Northern Territory; and a detailed soil sampling and regional stream sediment survey on the Port Moresby-Rigo area in Papua. With the exception of the Papuan work, these surveys followed patterns established by previous work. In previous years all of the samples were analysed in the Bureau laboratory. In 1964 all were sent to A.M.D.L., excepting those from Papua. Sample intake in 1964 is about 25,000 and the eventual intake could be as high as 40,000 involving between 400,000 and 500,000 element analyses per annum.