Mineral Provinces

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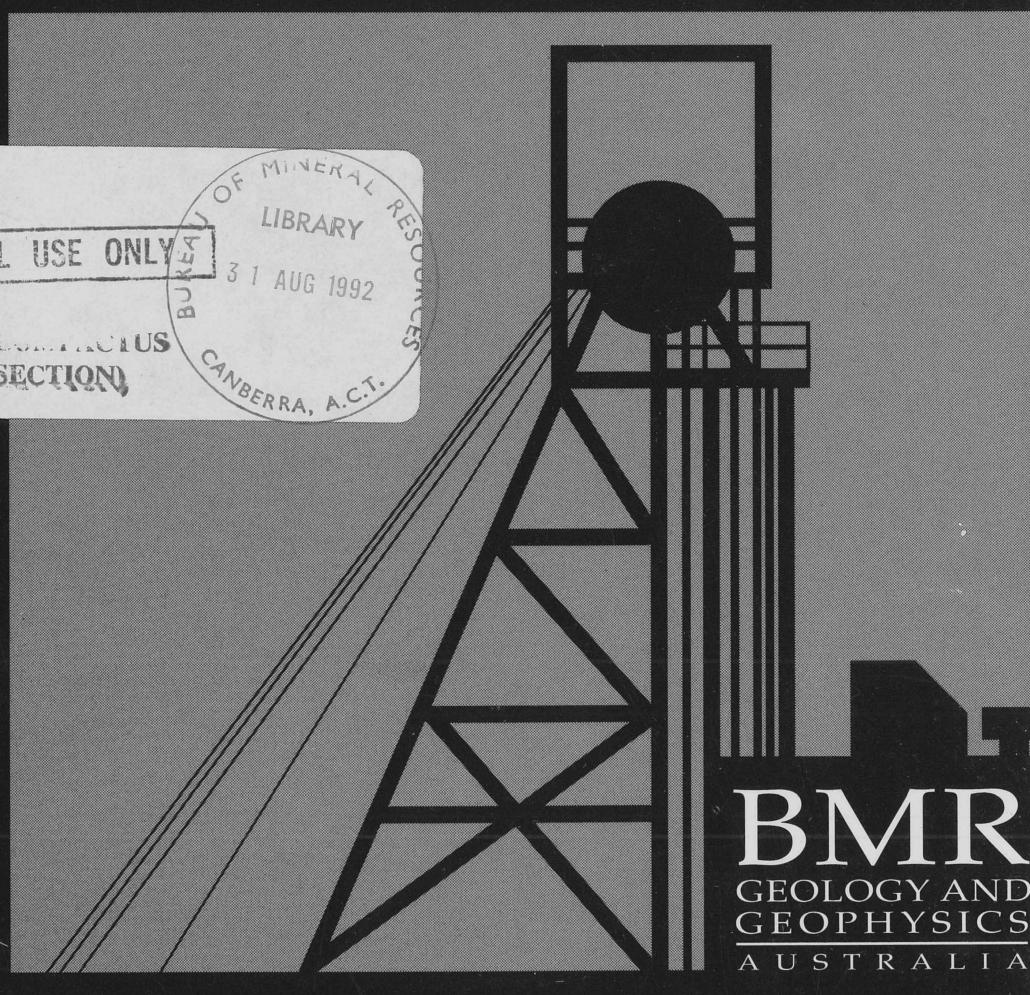
Mineral and Land Use Program's Laboratories Annual Report 1990 – 1991. Record 1992/31.



BMR
GEOLOGY AND GEOPHYSICS
AUSTRALIA

T P Mernagh, L P Black, J L Kamprad, R W Page,
J G Pyke and S–S Sun

MINERALS AND LAND USE PROGRAM
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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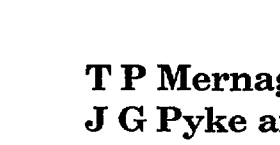

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INTRODUCTION

The primary function of the laboratories in the Minerals and Land Use Program (MLUP) is to provide high quality geochemical and geochronological data for the National Geoscience Mapping Accord (NGMA) and other MLUP projects. The NGMA is a cooperative agreement between the Bureau of Mineral Resources and State/Northern Territory Geological Surveys on projects of relevance to petroleum, mineral resources and land-use issues.

The main purpose of the National Geoscience Mapping Accord is to assist in an integrated approach to conservation and sustainable development and, in particular, to help maximise the benefits to the community from the nation's petroleum, mineral and water resources. The NGMA will substantially upgrade the current geoscientific knowledge base. MLUP's laboratories perform and important and essential role in the NGMA by providing the geochemical and geochronological data needed for the geoscience knowledge base.

MLUP's laboratories assist the NGMA and the Australian nation by providing:

- essential geoscientific data needed for the development of mineral and petroleum exploration models.

- a reliable database for the assessment of undiscovered mineral and petroleum resources.

- a geochemical database to facilitate environmental and land-use decisions.

- specialist expertise and advanced technical facilities to assist researchers from industry, universities and other government organisations.

GEOCHEMICAL LABORATORIES

Function

The geochemical laboratories provide precise and high quality data on the major and trace elements present in samples collected as part of the NGMA and other MLUP projects.

Location

X-ray Fluorescence Laboratory:	Rooms 359 & 362 BMR
Atomic Absorption and General Chemical Laboratory:	Rooms 363 & 364 BMR
Leco Laboratory:	Room 368E BMR
Rock Crushing Laboratory:	BMR Basement

Major Equipment

PHILIPS PW1450 X-ray fluorescence spectrometer
PHILIPS PW1404 X-ray fluorescence spectrometer
VARIAN AA-975 Atomic absorption spectrometer
LECO RC-412 Multiphase carbon/hydrogen/moisture determinator

Staff

J.G. Pyke (Technical Officer Grade 4)
W.Pappas (Technical Officer Grade 3)
Contract sample preparation staff as required.

Analytical Methods

Major and most trace elements were determined by X-ray fluorescence spectrometry (XRFS) on the Philips PW-1404 or PW-1450 equipment. The major elements were measured on glass fusion discs. Calibration was against international and secondary rock standards, using SiO_2 and CaO blanks. Matrix corrections, with alpha factors for the rhodium tube, were applied to all major oxides (as well as S). Na_2O was also analyzed by atomic absorption spectrophotometry (AAS) and checked against the XRFS results. Ferrous iron (FeO) was determined separately by titration with standard potassium dichromate solution, and Fe_2O_3 estimated by difference. Loss on ignition (LOI) was measured by igniting about 5 g of sample at 1050°C. Quoted LOI values are corrected for the FeO contents of the samples. Combined water (H_2O^+), moisture (H_2O^-), and total carbon (carbonate and carbon, quoted as CO_2) were determined gravimetrically until the LECO RC-412 was fully operational.

Most trace elements (Ba, Rb, Sr, Pb, Th, U, Zr, Nb, Y, La, Ce, Nd, Pr, Sc, V, Cr, Sn, Ga, As, and Cl) were analysed by XRFS on powder pellets. Molybdenum, rhodium, and gold target X-ray tubes were used to give optimum excitation for different groups of elements. Synthetic standards were employed for calibration, except for Rb (NBS-70A and MA-N), Sr (AGV-1), V (AGV-1, BCR-1, and W-1), and Cr (PCC-1 and DTS-1). Mass absorption corrections utilised the Compton scatter method for wavelengths less than 1.74 Å (Fe absorption edge), and coefficients calculated from major element compositions for longer wavelengths. Empirical interfering element corrections were made where necessary. Li, Ni, Cu, and Zn were determined with the Varian AA-975 spectrophotometer; Li being analysed by the method of standard addition. F was measured by specific ion electrode.

Estimated detection limits are given in Table 1. Detection limits for elements for which there are significant inter-element corrections (e.g. Ba, Ce, Sc, Y) may be slightly higher than the 95 percent confidence level for detection of peaks above background which was used to obtain the values given in Table 1. The precision of the XRFS technique is generally good, as the effects of all but very short-term drift in machine conditions are practically eliminated by ratioing each measurement to a monitor standard. The precision (1σ level) for trace element analyses is typically ±3 percent at the 30 to 100 ppm level. The corresponding precision for AAS analyses is between ±4 and ±6 percent. Accuracies were assessed by analysing international rock standards.

Table 1 Analytical detection limits (in percent for major oxides and ppm for trace elements)

MAJOR ELEMENTS		TRACE ELEMENTS			
SiO_2	0.006	Ba	5	Pr	3
TiO_2	0.008	Li	2	Sc	2
Al_2O_3	0.007	Rb	1	V	2
Fe_2O_3	0.005	Sr	1	Cr	2
MnO	0.004	Pb	2	Ni	2
MgO	0.006	Th	2	Cu	2
CaO	0.0014	U	0.5	Zn	1
Na_2O	0.02	Zr	2	Sn	2
K_2O	0.0004	Nb	2	Ga	1
P_2O_5	0.003	Y	1	As	0.5
		La	3	S	12
		Ce	4	F	200
		Nd	2	Cl	4

Contribution to BMR program

A total of 3035 samples haave been analysed by MLUP's Geochemical Laboratory this financial year. This work can be allocated to BMR programs as follows:

Project Code	Originator	Chemal Batch No.	No. of Samples	Preparation by Laboratory staff	XRF Major Elements	XRF Trace Elements	AAS Trace Elements	Gravimetric LOI	Volumetric Ferrous Iron
210.99	GSWA	91002	31	Yes	341	930	124	31	31
210.99	R.W. Johnson	91020	18	Yes	198	522	54	18	18
210.99	R.W. Johnson	91026	11	Yes	121			11	11
211.01	D.E. Mackenzie	90014	23	Yes	253	690	92	23	23
211.03	J. Knutson	91006	14	No	154	406	42	14	14
211.03	J. Knutson	91012	5	No	55	145	15	5	5
211.04	D. Wallace		48	No		48			
211.04	D. Hoatson	91007	2	No	22	58	6	2	2
211.05	C. Heinrich		45	No		45			
211.06	L.A.I. Wyborn	91009	18	No	198	522	54	18	18
211.06	L.A.I. Wyborn		148	No					148
211.06	L.A.I. Wyborn		498	No					498
211.08	L.A.I. Wyborn	91021	480	No	5280				
211.08	R.G. Warren	91013	57	Yes	627	1710	228	57	57
211.08	E. Jagodzinski	91010	1	Yes	11	30	4	1	1
211.08	L.A.I. Wyborn	91008	19	No	209	551	57	19	19
211.08	L.A.I. Wyborn		23	No		230			
211.08	L.A.I. Wyborn		97	No		970			
211.08	E. Jagodzinski		156	No		1560			
211.08	R. Valenta		26			390			
211.09	B.I. Cruikshank		424	No		13568	1696		
211.09	J. Knutson	91005	81	Yes	891	2430	324	81	81
211.09	J. Knutson	91025	2	No	22			2	2
211.10	M. Rattenbury	91016	25	Yes	275	750	100	25	25
211.10	M.B. Duggan	91018	51	Yes	561	1530	204	51	51
211.11	P Pieters	90015	23	Yes		713	92		
211.11	I.P. Sweet	91001	8	Yes	88	240	32	8	8
211.11	D. Heggie		313	No		6260			
211.12	R.G. Warren	91014	65	Yes	715	1950	260	65	65
211.12	R.G. Warren	91015	2	No	22	58	6	2	2
211.12	R.D. Shaw	91023	1	Yes	11			1	1

Project Code	Originator	Chemal Batch No.	No. of Samples	Preparation by Laboratory staff	XRF Major Elements	XRF Trace Elements	AAS Trace Elements	Gravimetric LOI	Volumetric Ferrous Iron
211.13	P. Stuart-Smith	91024	15	Yes	165			15	15
211.13	D. Wyborn	91017	33	Yes	363	990	132	33	33
211.13	D. Wyborn	91003	25	Yes	275	750	100	25	25
211.13	D. Wyborn		1	No	11				
211.14	S.S. Sun	91011	17	Yes	187	493	51	17	17
211.14	S.S. Sun		3			3			
241.01	R.S. Abell	90016	2	Yes	22	60	8	2	2
242.05	R. Korsch	91004	56	No	616	1680	224	56	56
CSIRO	T. Donnelly		8	No	88				

SUMMARY

Analyses

XRF major element determinations	12045 on 1095 samples
XRF trace element determinations	43672 on 1871 samples
AAS trace element determinations	4001 on 1024 samples
Gravimetric LOI determinations	606 on 606 samples
Volumetric ferrous iron determinations	1252 on 1252 samples

Sample preparation

Laboratory staff in house	346
BMR staff in field	424
Contract staff in house	270

GEOCHRONOLOGY LABORATORIES

Function

In conjunction with NGMA objectives, to elucidate age relationships and contribute to regional geological syntheses, by conducting dating programs and tracing the isotopic evolution of rocks and minerals from specifically targetted units and terranes.

Background

The dating of rock sequences and events such as igneous intrusions or metamorphism is a basic strategic aspect of all geological mapping programs. In MLUP, geochronological efforts are being directed towards:

- elucidating intrusive relationships among the Palaeozoic and possible Proterozoic batholiths of the Cape York region,
- assisting comprehensive geological syntheses in northern Australia's early to middle Proterozoic terranes, especially in the McArthur and Kimberley-Arunta NGMA areas,
- continuing geochronological work in Australia's Antarctic region (Environmental Geoscience Program),
- using isotopic tracers of Nd, Sr, and Pb to assess terrane characteristics, crustal growth patterns and the extent of crustal reworking in the generation of these crustal segments.

The time frameworks we endeavour to establish provide a cornerstone for the understanding of geological relationships in NGMA mapping programs, and can provide unique information on special problems such as the timing of mineralisation or metamorphic events. Because these tasks are conducted on project bases, they can also provide fertile ground for basic research in isotope geology.

It is the stratigraphic and tectonic applications of geochronological research which receive the most emphasis in BMR work. Being able to quantify the stratigraphic record enables a better understanding of the geological history, and more precise correlations on local, as well as regional and inter-regional scales. Inter-regional correlation is clearly of national importance, and its quantitative assessment (through current NGMA programs such as Proterozoic Metallogeny, Arnhem, and Kimberley-Arunta) is therefore a very important BMR objective.

Information relevant to a number of petrogenetic problems can also be ascertained from the isotope geochemistry of rocks, and these are important additional spin-offs from BMR's geochronological work, whether it be Rb-Sr, Sm-Nd, or U-Pb isotopic systems.

Major Equipment and its Location

The rock crushing - mineral separation laboratory is located in the basement of the BMR, and the chemical laboratory and mass spectrometers (including the SHRIMP ion microprobe) are located in the Research School of Earth Sciences, ANU. This co-operation in geochronological work dates from the early 1960's, and has been extended by the joint purchases of analytical equipment. Until 1988, BMR's major piece of analytical equipment was the Nuclide mass spectrometer, bought by BMR in 1962. This served us well, but with the advent of the ion microprobe (especially SHRIMP II, in which BMR has one-third equity), it was decided in late 1990 to sell the 28-year old Nuclide instrument.

BMR currently uses and pays daily charges on ANU's SHRIMP I ion microprobe and the Finnigan-MAT automated mass spectrometer. The SHRIMP II machine is expected to be fully operational by early 1992. At present, BMR uses 3 days per month for U-Pb zircon work on the SHRIMP I ion microprobe; in 1990/91 this analytical time was divided amongst the projects outlined below.

Staff

R.W. Page (Principal Research Scientist)	RSES, ANU
L.P. Black (Principal Research Scientist)	RSES, ANU
S-S. Sun (Principal Research Scientist)	BMR (part-time)
C. Foudoulis (Senior Technical Officer Grade 2)	RSES, ANU
L.A.C. Keast (Technical Officer)	Room B55, BMR
A.R. Watson (Technical Officer 11/4/91 - 28/6/91)	Room B55, BMR

Contribution to BMR Program

1. Project 211.01 Magmatic and tectonic setting of the gold deposits of northeast Queensland

Extensive data processing was done on U-Pb zircon ion-microprobe data collected during 1989/90. A written summary of these results and their significance was made and distributed to coworkers. Sm/Nd isotope analyses have been carried out on the same samples used for zircon dating.

2. Project 211.06 Tectonics and mineralisation of the early to middle Proterozoic of Australia

- Davenport Inlier, the Elkedra Granite and 3 units from the Hatches Creek Group (4 samples)
- Kakadu sub-project, samples from the Jim Jim Granite, Malone Creek Granite, Big Sunday porphyries, and repeat samples from the Stag Creek Volcanics and El Sherana group (6 samples).
- Pine Creek granites in and associated with the Cullen Batholith with P. G. Stuart-Smith and L. Wyborn (6 samples).
- Sybella Granite, Mount Isa, preparation of zircon samples from structurally controlled

pegmatites, with K. Connors, Monash University.

- Mount Isa Group tuff marker bed and Carters Bore Rhyolite (2 samples).
- An article based on U-Pb zircon ion-microprobe dating (with co-authors L.B. Harris and C.P. Delor of UWA) of the major tectonothermal events in the Albany Mobile Belt was completed and submitted to Precambrian Research.
- Two articles on the geochronology of the Wonga Belt and Tommy Creek Block were co-authored for the BMR Bulletin on the Mount Isa Inlier.
- An article on the age of the Broken Hill Group was co-authored.

3.Project 211.09 North Queensland Mapping Accord Project

The initial phase of Cape York dating and isotopic tracer study began with the analysis by ion microprobe of zircons from 12 granites and Sm/Nd isotopic analysis of 25 granitic and sedimentary rocks from the Coen Inlier. These comprised representatives from the Blue Mountains Adamellite, Weymouth Granite, Kintore Adamellite, Lankelly Adamellite, Twin Humps Adamellite, Morris Adamellite and Flyspeck Granodiorite. The results have so far failed to confirm the presence of Precambrian intrusives, with the dated rocks having been emplaced at either about 280 Ma or about 400 Ma. A representative of the ~400 Ma White Springs Granodiorite from the Georgetown Inlier was also analysed, to determine whether there is a precise temporal correlation between the Siluro-Devonian granitoids of the two inliers. Sm/Nd isotope systematics of granites from the Coen Inlier have many similarities with temperal equivalents in the Georgetown Inlier. The new isotopic data and their significance were presented and discussed at a MLUP seminar.

4. Project 211.11 McArthur Basin Mapping Accord Project

- U-Pb SHRIMP work on HYC tuff (Barney Creek Formation), Tanumbirini Rhyolite (probable top of Tawallah Group), and Scrutton Volcanics (3 samples).

5. Project 211.12 Kimberley-Arunta Mapping Accord Project

- U-Pb SHRIMP zircon analyses of Biscay Formation felsic lava & Sophie Downs Granite.
- Sm-Nd analyses of granites, gneisses and arkose from the Browns Range Dome, Atnarpa and Alice Spring regions.
- Modifications were made to an article with R.D. Shaw on ion-microprobe dating of felsic intrusives in the Arunta Inlier. Manuscript resubmitted to the Australian Journal of Earth Sciences.

6. Project 211.13 Lachlan-Kanmantoo Fold Belts Mapping Accord Project

An article (with co-authors R.A. Glen (NSW Survey) and R.D. Dallmeyer) based on Rb-Sr, K-Ar and Ar-Ar dating of the main deformation-forming event in the Cobar region was prepared for inclusion in the Proceedings of LFB 91 - Tectonics and Metallogenesis of the Lachlan Fold Belt.

7. Project 211.14 Musgrave Block Mapping Accord Project

- preparation of zircon concentrates and ion probe mounts for 3 gneisses and a quartzite.

- About thirty samples of felsic granulites of supracrustal volcanic and sedimentary origin, granites and mafic-ultramafic rocks of the Giles Complex have been analysed for Nd and Sr isotope compositions to define terrane characteristics, model ages and to study petrogenesis. These data will be integrated with existing geochronological, isotopic and chemical data of the Musgrave and neighbouring Blocks to assess crustal reworking and crustal growth patterns. Additional samples for zircon dating will be collected during the July-September 1991 field season.

8. Project 242.05 Antarctic Onshore Geoscience and Environment

Zircons from four locations (Mount Sones, Gage Ridge, Dallwitz Nunatak and the Field Islands) within the Archaean Napier Complex of Enderby Land were analysed by ion-microprobe, but the data are yet to be fully processed, assessed or written-up. As part of the Bureau's program in Antarctica, Peter Kinny (RSES, ANU) spent three months of the summer mapping and collecting samples for isotopic dating from localities within the northern Prince Charles Mountains (MacRobertson Land). Written contributions were made to a number of articles at various stages of preparation (see 1990/91 Publication List).

9. OZCHRON database

This year saw the continuation and near completion of data input from Australia's early to middle Proterozoic terranes. A start was made on the Archaean and Phanerozoic parts of the database. Additionally, all old and most of the recently acquired geochronolog-ical data from Antarctica were entered on the database. A file of all the Rb-Sr data for the early to middle Proterozoic terranes was released to the prime industry sponsor, and a second installment containing the U-Pb zircon data will be released to this company by June 30 1991. Some encouraging enquiries have been received from other interested companies.

LASER RAMAN AND FLUID INCLUSION LABORATORIES

Function

The laser Raman microprobe and fluid inclusion laboratories were established to provide the latest technology for ore deposit studies and also to assist with other petroleum and mineralogical studies carried out by the various branches within the BMR. Currently, there are only two laser Raman microprobes in Australia with the other one at CSIRO being devoted entirely to petroleum and coal research. The BMR's laser Raman microprobe, however, remains as a versatile general research instrument with a wide range of applications. Thus the BMR's laser Raman microprobe and associated fluid inclusion laboratories have evolved into a national research facility which allows researchers from industry, universities and other government institutions to use excess instrument time including week nights and weekends. In fact, for several weeks of the year the laser Raman microprobe runs 24 hours a day.

Location

Laser Raman Microprobe Laboratory:	Room 354	BMR
Fluid Inclusion laboratory:	Room 358B	BMR

Major Equipment

No major items of equipment were purchased for these laboratories this financial year. The following is a list of the major items of equipment currently in use in these laboratories:

DILOR Microdil 28 laser Raman microprobe spectrophotometer
SPECTRA PHYSICS 2020 5W Argon ion laser
LINKAM 600THM Heating/freezing stage
FLUID INC adapted U.S.G.S. Gas-Flow Heating/freezing system
CHAIXMECA Microthermometry apparatus
LEITZ Microscope heating stage 1350
LEITZ ORTHOPLAN-POL microscope

Staff

T.P. Mernagh (Research Scientist)

Contribution to BMR Program

The following projects were carried out as part of BMR's approved program in conjunction with the National Geoscience Mapping Accord:

Project 211.04 Mafic/ultramafic layered complexes and their mineral potential, Western Australia

A Raman microprobe study has commenced to identify similarities and differences in the Raman spectra of platinum group minerals and pyroxenes from the Munni Munni mafic/ultramafic layered complex, Western Australia.

Project 211.06 Tectonics and mineralisation of the early to middle Proterozoic of Australia

The laser Raman microprobe was used to study fluid inclusions and the nature of gold, tin and base metals mineralisation in the Pine Creek Geosyncline, Northern Territory as part of a collaborative research project with the Northern Territory Geological Survey.

Project 211.08 Regional geology and mineralisation of the South Alligator Conservation Zone

A detailed study of fluid inclusions was carried out on 52 thin sections from 65 samples of diamond drill core from Coronation Hill in the Northern Territory. An article, for submission to Economic Geology, describing the results and a suggested mechanism of mineral deposition is in preparation.

Project 211.10 Eastern Goldfields Mapping Accord Project

A detailed study of fluid inclusions and their relationship to metamorphic grade in the Eastern Goldfields, Western Australia has commenced.

Project 211.14 Musgrave Block Mapping Accord Project

A laser Raman microprobe study of feldspars and pyroxenes in pseudotachylite vein systems from the Giles Complex, Western Musgrave Block, Central Australia was completed. An article containing the results was co-authored with A.Y. Glikson and has been published in the BMR Journal.

Laser Raman Spectral Database

Another 55 mineral spectra were added to the laser Raman Spectral Database during the year. This database allows computer aided matching and identification of unknown Raman spectra using the 'Spectra Calc' software package. The database is still under development but will be available for sale at a later date.

Contribution to Cost Recovery Activities

Cost recovery activities occupied approximately 20% of available laboratory staff time and generated a total income of $10,265.00 for the 1990-1991 financial year. The current increase in external funds is attributed in part to increased marketing activity during the year which included the mailing of a promotional flyer to approximately 200 potential clients within Australia and presentations given at various conferences. The 1990-1991 list of external clients is given below:

EXTERNAL USERS OF THE LASER RAMAN MICROPROBE

	Income ($)
Australian Pulp and Paper Institute, Monash University	200
Centre for Ore Deposit and Exploration Studies, University of Tasmania	1360
CSIRO Division of Materials Science and Technology, Melbourne	1280
Department of Applied Physics, Royal Melbourne Institute of Technology	1150
Department of Chemistry, University of Tasmania	1200
Department of Electronic Materials Engineering, ANU	200
Department of Geology, Australian National University	605
Department of Geology, James Cook University of North Queensland	1320
Department of Geology and Mineralogy, University of Queensland	500
Department of Physics, Monash University	1100
Geopeko, Parkes, N.S.W.	500
Research School of Earth Sciences, Australian National University	500
School of Physics, University of New South Wales	350
Total Income	$10,265

REGOLITH / REMOTE SENSING LABORATORY

Function

The primary function of the Regolith / Remote Sensing Laboratory is to provide laboratory based support for the Mineral and Land Use Program's (MLUP) Regolith and Remote Sensing Groups. In particular the laboratory specialises in mineral identification using x-ray diffraction (XRD) techniques. However, infrared(IR), and spectroradiometric(IRIS) techniques are also used in this laboratory. The Onshore Sedimentary & Petroleum Geology Program's scanning electron microscope (SEM) is used to supplement the data obtained from the instruments in this laboratory.

As a secondary function the laboratory provides mineral identification using instrumental techniques for all BMR projects. When large numbers of samples are presented or when time consuming sample preparation is required for programs outside the MLUP, the laboratory provides training for their scientists and technicians.

Location

Regolith / Remote Sensing Laboratory: Room 248 BMR

Major Equipment

SIEMENS D500 X-Ray Diffractometer

-Siemens Diffrac-AT software using the JCPDS reference system

-Siroquant, quantitative software package

PERKIN ELMER 1330 Infrared Spectometer

IRIS Portable Spectroradiometer Unit

-jointly owned by BMR, CSIRO, NSW Dept. of Agriculture & NSW University

-this system is coming to the end of its life as a field instrument and has been in the CSIRO laboratory this year undergoing a major overhaul

-there are plans for the BMR to purchase a new unit that will cover the range of 1.1 to 2.55, when the equipment becomes available in 1993

Staff

J L Kamprad (Senior Technical Officer Grade 2)

Additional information

During 1990-1991 the laboratory was temporarily closed while all equipment was relocated from the third floor to a new laboratory in Room 248 adjacent to the Regolith and Remote Sensing work areas.

Designs for the new laboratory were completed and approved during 1989 and 1990. Work commenced with the removal of the old Flat Bed Plotter from Room 248. Then laboratory benches and cupboards were retrieved from stores where they had been since their removal from the Cores and Cutting Laboratory. Finally, the contractors commenced work in September 1990 and finished in February 1991. All laboratory instruments were recalibrated after the move.

During 1990-1991 the Technical Officer spent approximately 50% of her time on laboratory duties. The demand for detailed mineral identification is expected to increase as the NGMA projects gain momentum and process studies are undertaken in the Regolith Group.

Contribution to BMR program

MLUP was the largest user of the laboratory (53%), followed by
Groundwater (22%) who submitted sediment, clay and hydrophilic samples from the Great Artesian Basin;
Marine Geoscience & Petroleum Geology (19%) who submitted samples of rock minerals from drags of the Rig Seismic and carbonates from an exotic marine organism found off the Tasmanian coast and;
Environmental Geoscience (6%) who submitted carbonates from coastal studies.

Within MLUP total usage was as follows:

Project 211.06	Tectonics and mineralisation of the early to middle Proterozoic of Australia: Samples including whole rock mineral and clay separates from epiclastic and ignimbritic rocks of the Pul Pul Rhyolite in the South Alligator Valley	15%
Project 211.09	North Queensland Mapping Accord Project: Mineral and clay samples	6%
Project 211.10	Eastern Goldfields Mapping Accord Project: Mineral samples from the Mt. Mason area	5%
Project 211.11	McArthur Basin Mapping Accord Project: Samples of magnetically separated material	7%
Project 211.12	Kimberley-Arunta Mapping Accord Project: Whole rock mineral samples	19%
Project 211.13	Lachlan-Kanmantoo Fold Belts Mapping Accord Project: Soil nodules samples	1%

Continuing work for MLUP involves the North Queensland, Proterozoic Metallogeny, Geology of Australian National Parks and the McArthur Basin Projects.

PUBLICATIONS

by staff of the Minerals and Land Use Laboratories

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