Australian Institute of Nuclear Science and Engineering

Annual Report 2001

Section 1

Contents

Introduction

The Australian Institute of Nuclear Science and Engineering (AINSE) was established in 1958 to provide a mechanism for access to the special facilities at Lucas Heights by universities and other tertiary institutions and to provide a focus for cooperation in the nuclear scientific and engineering fields. Today nuclear science at the Lucas Heights Science and Technology Centre is devoted to supporting activities and research in a wide range of disciplines. These have applications in advanced technology, manufacturing, mining, agriculture, medicine and environmental protection. All are of vital importance to Australia's future.

Many of the techniques and much of the expertise at Lucas Heights cannot be found elsewhere in Australia. AINSE plays an indispensable role in facilitating university researchers with access to major scientific facilities and encouraging a national cooperative research and training effort. This has worked efficiently and cost effectively for the 37 university members and for ANSTO, by reducing the duplication of expensive items of equipment and directing Commonwealth funding towards one national organisation instead of several with sub-critical funding.

Mission

AINSE will advance research, education and training in nuclear science and engineering and their applications within Australia by being, in particular, the key link between universities, ANSTO and major nuclear science and engineering and associated facilities.

Objectives

AINSE's objectives are:

1. to provide a mechanism for users in member organisations of AINSE to have access to major nuclear science and engineering and associated facilities at ANSTO and other agreed sites for research purposes
2. to facilitate graduate and undergraduate education and training experience utilising major nuclear science and technology facilities at ANSTO and other agreed sites
3. to encourage collaboration and cooperation between member organisations of AINSE in areas primarily related to nuclear science and engineering and their applications
4. to sustain and support the development of major nuclear science and technology facilities at ANSTO and other agreed sites for shared use by member organisations of AINSE.

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Scientific Secretary
Dr Dennis Mather

President's Report

Associate Professor Ron Cooper
President, AINSE

AINSE, now in its fifth decade, welcomed the Australian Catholic University in May 2001, making it the 37th university member. Only the recently created University of the Sunshine Coast remains outside our unique nationwide collaborative research association.

The expanding membership has accompanied the spread of research areas and the traditional domains of fundamental nuclear science and allied engineering are now the stable platforms from which archaeological, biomedical, environmental and novel-materials science research projects are launched. It is significant, too, that ten years ago the areas of environmental science, Accelerator Mass Spectrometry (AMS) and radiopharmaceuticals were not part of AINSE's defined specialist areas of support. Today, these three areas constitute a major commitment of AINSE resources and are rapidly expanding areas of study.

During 2001 I visited the Northern Territory University as part of their Postgraduate Research Week and saw an AINSE-supported project which is exploring the pollution levels in flood plains around Darwin from a municipal effluent treatment plant. The project evolved from the interest stimulated in a student by AINSE's Winter school program, which led to an Honours project and then to a PhD study.

Purely as a tourist, I visited the Lake Mungo National Park in south-west New South Wales and was delighted to see evidence of the use of applied dating techniques used by a prominent AINSE award holder from the University of Sydney, Dr Mike Barbetti, who examined the area where the earliest Aboriginal remains were discovered and dated them at far greater ages than expected.

AINSE's fifth decade will see the advent of the new state of the art research reactor, which will dramatically improve the techniques available for material science, self-assembly systems, nano technology and elemental analysis techniques. The reactor will bring novel biological applications to a sharper focus. AINSE is contributing to this National Facility by involvement in neutron scattering activities and membership of the beam users group (ANBUG).

A new 2MV tandem accelerator has been ordered and will be delivered to Lucas Heights for reassembly and commissioning during 2003. It will be dedicated to ion beam analysis and ^{14}C mass analysis measurements and will significantly assist a wide range of dating applications. It is funded, in part, by a $1M Linkage Equipment and Infrastructure Fund (LEIF) grant from the Australian Research Council (ARC) which recognised the quality and track record of all AINSE members research.

To support the burgeoning demand for dating facilities, AINSE has committed resources to purchase an automatic sample preparation mass analyser system, which will dramatically increase the throughput of samples as well as their reliability.

The ARC considers that this new facility is indeed a National Facility and as such recognises AINSE as the owner of this asset. It will be on AINSE's asset register, and will be operated and maintained by ANSTO.

A combination of increasing membership together with external funding has enhanced AINSE's ability to deliver a wider range of facility access. Over the ten-year period 1991-2001 the number of awards has doubled. Over the period 1998-2001 the funding to AINSE awards has increased by more than 50 per cent. The awards are not all on-going ones; in 2000, 15 per cent of the awards were made to researchers who had never before had an AINSE award.

AINSE has acted as a peak body for external grant applications by special interest groups within AINSE. LEIF grants for neutron scattering provide for access to the world's most powerful pulsed neutron source, ISIS, at the Rutherford Laboratories in the UK, and have been highly successful. The quality of the proposals by Australian workers has resulted in access time to the facility being awarded more than double that expected purely on the grounds of subscription. In previous years, LEIF grants for the use of SIMS facilities, as well as for the development of new instrumentation on the HIFAR reactor have been obtained. These have come from the combined quality of projects and track record of teams of AINSE researchers. Such grants increase the benefit to member universities over and above that expected from membership subscriptions.

It is not insignificant to report that the output of publications from AINSE funded projects has shown a very satisfactory increase over the last few years. The increase in research funding promised by the current federal government is a resource that must be tapped by AINSE members. The strength of AINSE collaborative specialist areas is demonstrated by success in past LEIF applications and must give us confidence for the prospects for future support.

Reaching out to prospective research students AINSE successfully ran the fifth Winter School. One senior undergraduate from each of the member universities attended this four-and-a-half day intensive course held at Lucas Heights. The school gave the students lectures and hands-on experimental time on five major facilities such as the 3MV accelerator, irradiation sources, radioassay, materials science and neutron scattering. Students work in small teams and are supervised by ANSTO personnel, university workers and AINSE scholars. The latter are excellent role models and a valuable interface between the students and senior staff. The student's response is highly encouraging and most express surprise that such a wide range of science is being conducted at ANSTO especially in the non-nuclear areas of research which nevertheless derive their analytical procedures from nuclear techniques. It is pleasing to note that several honours projects have evolved from attendees at the Winter school and two, at least, has carried through to a current PhD program.

AINSE has continued to aid community collaboration with its conferences, workshops and participation in national conferences such as those of the AIP and Vacuum Society. On the international scene it is actively participating in organising major international conferences to be held in Australia. Future International meetings on Environmental Radioactivity, Radiation Research, Neutron Scattering, Plasma Physics and Radiopharmaceutical Chemistry are just some areas supported by AINSE and its members.

The future of AINSE is now one of growing areas of demand for facilities and resources. Subscriptions income will prove to be inadequate to cope with both growing demand from researchers and increasing facility costs. The science in AINSE is alive and flourishing. The task for AINSE is to satisfy the demands for access to facilities.

Ron Cooper

President

Scientific Secretary's Report

Dr Dennis Mather
Scientific Secretary AINSE

All years present their challenges and 2001 was no exception, though I feel that AINSE has been able to turn these into opportunities. I am deeply indebted to members of specialist committees and facility contact officers who have worked throughout the year to assist us in maximising the benefits flowing to university researchers through AINSE. The star performer this year is the ANSTO Neutron Scattering Group, who have developed a database that allows us to see bookings by instrument live on our internal web. Follow-up on people who do not take up time in the appointed month has significantly reduced the excess funds at the end of the year and allowed timely reallocation of these funds to other awards.

AINSE awards in 2001 were only slightly up on the previous year but expenditure on awards was significantly higher. The publication rate remained high with 289 references this year. Details can be found in section 2 of this report. First time award holders in 2001 represented 21 per cent of the cohort, which was significantly higher than the previous year's figure of 15 per cent, and another 10 per cent of the awards were made to people who had held their first award in 2000.

There were more AINSE postgraduate awards in 2001 and amongst the new postgraduate award holders was Tristan Burg, from the University of New South Wales, who first came to us for the 1998 Winter School.

Council and Committees

The Executive Committee remained unchanged from 2000, see section 2.

On the Council, changes include:

- Dr Adam Jostsons and Mr Ken Horlock, two of ANSTO's Division Directors, replaced by Dr George Collins and Mr Jack Dillich.
- Dr Neil Saintilan is Councillor for the Australian Catholic University
- the University of Auckland's Professor Ralph Cooney, replaced by Professor Tom Barnes
- the University of New England's A/Professor Matthew Fewell, replaced by A/Professor Peter Flood.
- the University of Queensland's Professor Ken Collerson, replaced by Professor John Boldeman
- the University of South Australia's Professor Roger Smart, replaced by Dr Bill Skinner.

Other changes include:

- the Engineering, Materials Science and Nuclear Technology Specialist Committee's Chairman, Professor Roger Smart, replaced by Professor Barry Muddle. Professor Brian Stone, replaced by Dr Paul Pigram and Dr Stephen Hinckley
- Dr Bill Maher retired from the Environmental Science Specialist Committee

- on the AMS Specialist Committee Dr Ewan Lawson, replaced by Dr David Fink. Professor Dan Potts and Associate Professor Mike Barbetti joined the committee.

AINSE relies on the talent and good will of people such as those mentioned above, and we are grateful for their commitment.

Finances

In 2001, income of $2,587,622 was made up of $1,253,206 from ANSTO's membership fee, $792,650 from university members, $250,292 from external grants, $276,748 from interest on investments, and $14,726 from other sources, mainly conference registrations, see figure 1.

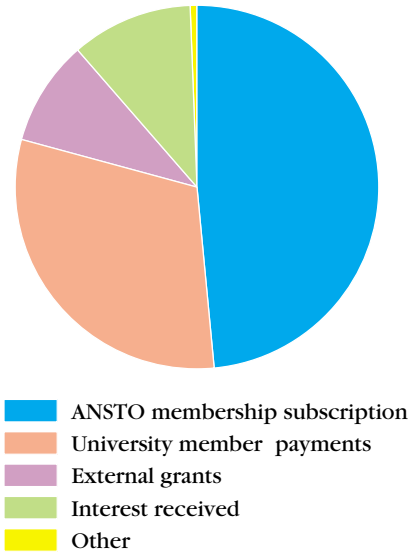


Figure 1. Operating revenue

Membership subscriptions are reviewed annually to determine AINSE support for each university. On average, for the period 1997 to 2001 inclusive, universities received research and training benefits amounting to 3.39 times their subscriptions. For more information on performance indicators see section 2, page 60.

The majority of AINSE funds are used to facilitate travel and access to Lucas Heights for university researchers and their research students, see figure 2. University projects are supported mainly through awards to cover costs associated with operating ANSTO's facilities. AINSE's operating expenses in 2001 were $2,637,832, leaving a deficit for the year of $50,210. Funds have been set aside to finance the Accelerator, and automatic AMS sample preparation/analyser, both to be commissioned in 2002/3.

The Financial Statements for the calendar year 2001 were prepared by ANSTO and audited by Gardner Escott and Co. They are presented in section 2 starting on page 9.

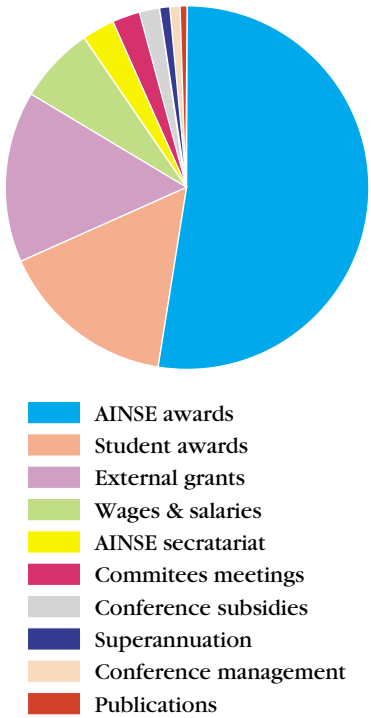


Figure 2. Operating expenses

Awards and postgraduate research awards

A total of 203 university projects were awarded in 2001. Eighty-three projects were carried over from previous years. Figure 3 shows the distribution of AINSE awards by specialist area. Highlights are given on pages 8 to 21. Full progress reports for each of the projects can be found on our Home Page.

In 2001, twelve of the thirty-four AINSE postgraduate research award holders received an award for the first time. During the year four PhD theses were received and another four are expected from students who completed their studies during the year. The AINSE postgraduate research award holders accessed the facilities for a total of 660 days. In addition, another 104 students gained access to the facilities via awards held by their supervisors for a total of 797 days.

The carry-over of awards to the value of $186,148 until the end of February 2001 was once again facilitated. This enables award holders to utilise the summer break to use ANSTO facilities.

Details of the AINSE Winter School and Conferences can be found on pages 22 to 24 of this report.

Acknowledgements

I would like to thank Irene Parker, Nerissa Phillips, Tanya Irvine and Sandy O'Connor for their calm support throughout the year. The President, Associate Professor Ron Cooper, has provided me with invaluable advice and tremendous support throughout the year. I thank

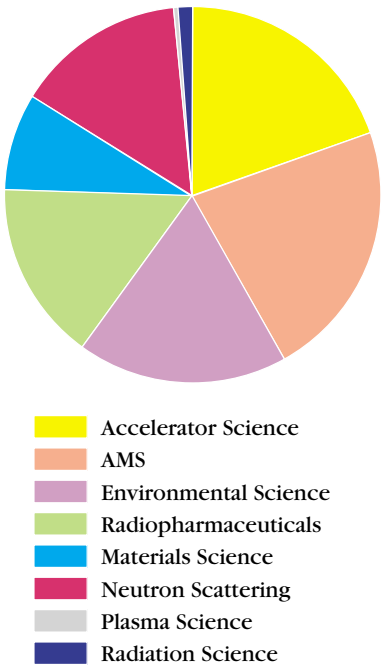


Figure 3. Awards by special area

Professor Helen Garnett, the Chief Executive Officer ANSTO, who has once again demonstrated her support and long-term commitment to AINSE. I would also like to extend my thanks to all those from the universities and ANSTO, there would be hundreds, for their help and advice throughout the year. Finally, a special thanks to the graphic designer Steven Rosevear for his artistic input, editor Jeane Balcombe for the turning so much of the text into plain English and the manager ANSTO Communications Pam Keenan for her assistance in the making of this report.

Dr Dennis Mather

Scientific Secretary, AINSE

Accelerator Science

Research Areas

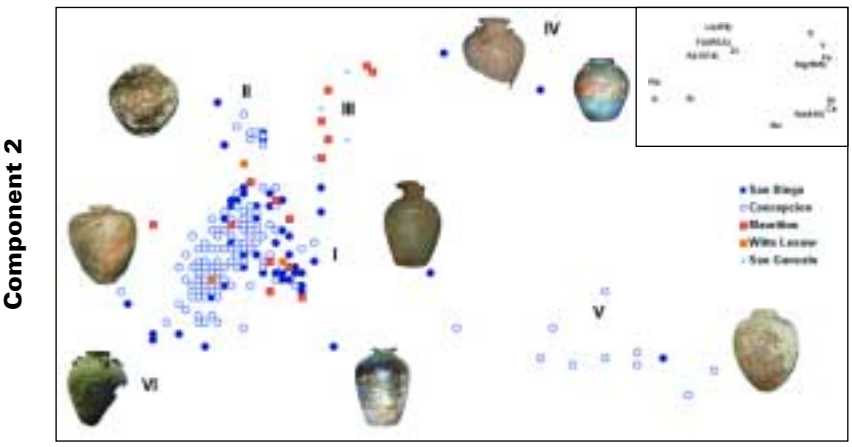
The Accelerator Science Specialist group promotes accelerator-based ion beam analysis techniques to analyse and characterise surfaces and near-surface structures. The techniques, which are non destructive and highly sensitive, are used in geological studies, characterisation of ancient ceramics and antique metal artefacts, zoological research into animal physiology, tracing and provenance of obsidian to establish former routes in the South Pacific and investigations into the detailed structure of optoelectronic materials to assist fabrication methods.

ANSTO's 3MV Van de Graaff and 10MV FN-tandem accelerators are essential instruments. The former provides beams of protons and alpha particles, while the tandem beams span a wider range of ions and energies. Most applications involve a combination of nuclear techniques. These may include proton-induced x-ray emission (PIXE) proton-induced gamma-ray emission (PIGE) Rutherford back scattering (RBS), forward recoil analysis and recoil time-of-flight spectroscopy.

Research Highlights

The Sino-European trade 1600-1800

The response of Chinese society and economy to the European trade of the Early Modern Period has been characterised as highly dynamic but little understood. Over the last two decades numerous wrecks associated with initial Sino-European trade, for example the so-called "Manila Galleons", have been excavated providing fixed chronological points for the material recovered from them.



Principal Components Scatterplot of PIXE/PIGE results for Chinese stoneware jar samples from the wrecks of the Spanish Manila Galleons San Diego (1600 AD), the Concepçion (1638 AD), the East Indiaman Mauritius (1609 AD), the Dutch East Indiaman Witte Leew (1613 AD), and the Portuguese San Goncalo (1630). Representative vessel types illustrated. Inset is the accompanying elemental distribution

Dr Peter Grave and PhD student Michael Maccheroni at the University of New England have been analysing samples of Chinese ceramic containers from several of these wrecks using the PIXE/PIGE facility at Lucas Heights to gain new insights into changes affecting production and supply.

The program of PIXE/PIGE analysis was undertaken to distinguish between jars that are obviously typologically different but also between groups of jars that appear very similar. "The results let us formulate an understanding of the changes in the pattern of supply with a greater degree of chronological precision than previously possible", said Mr Maccheroni.

"Geochemical analysis of stoneware production in South-east Asia has provided an effective means of addressing the local impacts of the transition to commodity exchange in the 17th century. For southern China, where the technology originates, the establishment of a high precision chronology will enable a detailed exploration of these issues for this core economic region", said Dr Grave.

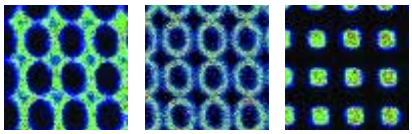
Accelerator techniques advance microdosimetry research

The Centre for Medical Radiation Physics is continuing research and development of new instrumentation for microdosimetry and radiation damage monitoring of detector systems in high-energy physics.

Microdosimetry is the most important aspect in radiation measurements for the prediction of radiobiological effects in both tissue and single event upset in microelectronics. Both phenomena are directly related to random energy deposition on a micron and submicron scale – this is similar to the size of both biological cells and sensitive nodes in high-density microelectronics chips. New instruments are needed which will be able to predict the effect of radiation treatment of cancer and identify faults in microelectronics in a radiation environment.

Professor Anatoly Rozenfeld and Iwan Cornelius from the University of Wollongong have used the heavy ion microprobe at ANSTO to study charge collection properties of silicon microdosimeters. A prototype microdosimeter based on an array of microscopic p-n junctions on a bonded silicon insulator (SOI) microdosimeter was studied using a 2 micron diameter, 20MeV scanning carbon beam. The research team has developed a new technique to adjust the size of the effective sensitive volume of single silicon cells equivalent to changing the size of biological cells.

The technique was developed by Cornelius and is based on rise time pulse shape discrimination. It will open new horizons in accurate measurements of microdosimetric spectra in a mixed LET radiation field.



a *b* *c*

Charge collection images of the silicon microdosimeter obtained with the microprobe. The results in c, show the possibility of selective charge collection from 10x10x10 micron sensitive volumes using the new technique

Hellenistic pottery fingerprints in North Syria

Dr Elizabeth Pemberton and Dr Heather Jackson of the University of Melbourne have achieved the first steps towards identifying the signature, or diagnostic fingerprint, of the clays from a Hellenistic site in Syria. Artifacts from Jebel Khalid, a Seleucid military settlement on the banks of the Euphrates in the third and second centuries BC, were analysed. This is pioneering work which will serve as a benchmark for archaeologists working not only in Syria but elsewhere.

Water jar reconstructed from sherds found at Jebel Khalid

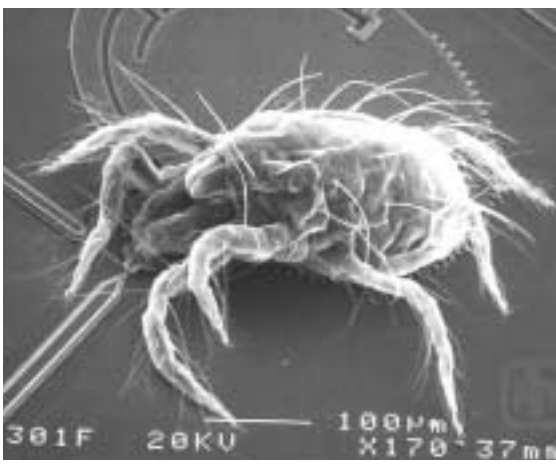
Two sequences of PIXE/PIGE analysis were put through the Van de Graaff accelerator at ANSTO. Cluster and correspondence analysis by Dr Eric Clayton from ANSTO isolated clusters of different clays from jars and local tableware of local origin. Outliers corresponded to imported lamps and figurines and other known imported wares.

Dr David Garnett at Becquerel Laboratories provided assistance with neutron activation analysis that revealed some evidence of a mafic signature: elevated levels of Cr, Co, Sc and Fe. There is also evidence of input from a granitic source, with enriched Na, Hf, Eu, Yb, Ce, Sm, Ba, K, Th, Sb, Lu, Rb and La. This result gives a start on finding the provenance of the clays and needs further work. Cooperation with Princeton University has resulted in some sherds from the ancient Syrian site of Antioch being made available for analysis. This will make an important comparandum.

Permanent magnetic films for micro machine technology

Micromachine technology is the next radical step in the silicon revolution, which has changed virtually every aspect of our lives. Its worth is estimated to be around US$100 billion/year. This is achieved by incorporating new types of silicon chip functionality enabling chips not only to think but also to sense, act and communicate as well. Such smart micromachines, which are too small to see with the naked eye, have extensive commercial applications in areas such as automotive, aerospace, defence, chemical, biological, agricultural and medical industries.

Some of the components of a micromachine can best be made with a permanent magnetic material that is capable of storing energy and delivering it at will to “actuate” with a strong force. While deposition of such a material on the required thin film form and its patterning are yet to be developed, Professor Dinesh Sood and his PhD student Mr Yunhua Wang at RMIT University are developing samarium-cobalt alloys. The main challenge is to minimise impurities such as oxygen, carbon and aluminium, and to optimise composition and magnetic anisotropy of the films. This has been successfully achieved by active research collaboration with ANSTO scientists: Dr Peter Evans using RBS, Dr Nick Dytlewski using HiERDA and Dr Ken Short with XRD and Scanning Probe Microscopy. This ongoing project is expected to open the doorway to several new nanotechnology applications in the near future.



A spider mite “caught” in a security “micro-lock” micromachine (Courtesy Sandia National Laboratories, USA)

Accelerator Mass Spectrometry

Research Areas

Accelerator mass spectrometry (AMS) is an ultrasensitive analytical technique used to identify and count selected isotopes. Isotopic concentrations at the level of 1 part in 10^{15} can be measured in long-lived radioisotopes such as carbon-14, beryllium-10, aluminium-26, calcium-41, and iodine-129.

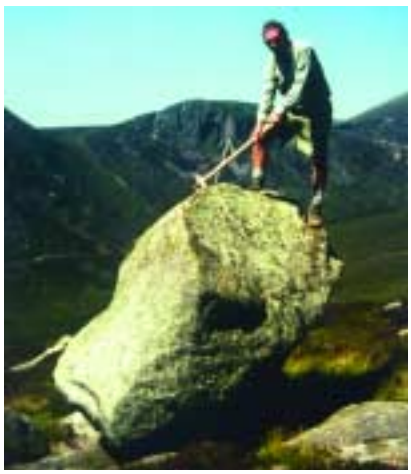
Carbon-14 analysis is probably the best known AMS technique. It is used in a wide range of disciplines including archaeology, Quaternary science, global climate change and nuclear safeguards.

Research Highlights

Irish glacial events

Ireland lies directly onshore from the North Atlantic Ocean, in which the major phases of the Last Glacial Cycle (115,000-10,000 years BP) are recorded in the deep-sea sediments as meltwater or Heinrich events. The major phases of the Last Glaciation in Ireland have not been well dated. Professor Eric Colhoun from the University of Newcastle combined cosmogenic isotope dating by Dr David Fink's AMS group at ANSTO, with optically stimulated luminescence (OSL) dating by colleagues at Oxford University to determine the ages of Irish glacial events.

Results obtained show that the last phase of mountain cirque glaciation occurred between 10,000 and 12,000 years BP, equivalent to the widespread Younger Dryas event recorded in north-western Europe and eastern North America. Earlier events that have been dated include the deposition of the end moraine that bounds the great field of oval-shaped drumlin hills in north central Ireland, which were formed 16,000 and 17,000 years BP. The South Ireland End Moraine (SIEM) that extends from south of Dublin across the southern part of the Central Plain of Ireland towards Limerick has been dated to 25,000 years BP. At this time the Irish Midland ice sheet dammed a large glacial lake, now called Lake Blessington, between the SIEM and the Wicklow Mountains. OSL dating of lake sediments has shown that this lake also existed at about 77,000 years BP during the early phases of the Last Glaciation. Phases when ice was present during the Last Glaciation have thus been identified at 10,000-12,000, 16,000-17,000, 25,000, and 77,000 years BP. These coincide with the North Atlantic Heinrich meltwater events and show the broad correlation between advances of the British and Irish sector of the north-west European ice sheet and North American glacial events.



Professor Eric Colhoun sampling a granitic moraine boulder in the Mourne Mountains for $^{10}Be/^{26}Al$ dating at Lucas Heights

Venetian reservoir effect

Following the disastrous flood of 4 November 1966 there has been intense interest by scientists and historians in finding out as much as they can about the environment of Venice before another natural disaster strikes.

In order to understand the phenomena and processes associated with the Venetian Lagoon ecosystem, Professor Alberto Albani at the University of NSW, in collaboration with Dr Ugo Zoppi from the AMS Group at ANSTO, have been investigating the ages of foraminifera. These are unicellular sea creatures which secrete a shell of calcium carbonate called a 'test'. When the organism dies the test becomes part of the sediment and presents a permanent record of environmental conditions existing during its life span.

Albani's team has been determining the magnitude of the reservoir effect of the Venetian lagoon. When organic specimens draw carbon from reservoirs other than the atmosphere, AMS analysis may yield incorrect ages. Marine shells may derive carbon from seawater, a system not in equilibrium with the atmosphere. This reservoir effect leads to apparent age differences, which have to be taken into account to obtain accurate chronologies.

Sedimentary cores were collected at the Island of S. Francesco del Deserto, north of the Basilica. Foraminifera samples were taken from a trench which also contained a Roman pipe, a laurel leaf and other plant fibres.

An apparent age difference of 1300 years was measured between the laurel leaf, measured at the Oxford Radiocarbon Accelerator in England, and the foraminifera, measured at ANSTO. Both were taken from the same depth in the lagoon sediment. This age difference is solely due to the reservoir effect and must be accounted for when determining the age of marine samples from the lagoon. Scientists may now make accurate determinations on an absolute time scale for the events that shaped the lagoon of Venice. The Roman pipe found at a depth of 2.3m probably originated during the third century AD and the laurel leaf, recovered at a depth of 2.6m, towards the end of the first century AD. All other collected samples span a period of a few millennia. The deepest sample was recovered at 4.8m and is about 5500 years old.

Bomb radiocarbon in tree rings

As a result of hundreds of atmospheric nuclear weapon detonations in the 1950s and 1960s, the concentration of ^{14}C in the atmosphere dramatically increased. By 1963-1964 it had nearly doubled in the Northern Hemisphere. Since the Nuclear Test Ban Treaty came into effect in 1963, the ^{14}C concentration in the troposphere has been decreasing due to the rapid exchange of carbon between the atmosphere, oceans and biosphere. However, no atmospheric data are available for the beginning of the nuclear age and few data sets are available for the tropics and Southern Hemisphere.

Associate Professor Mike Barbetti at the University of Sydney and Quan Hua at ANSTO have used cross-dated tree rings to examine atmospheric ^{14}C excess in the tropics and Southern Hemisphere for the period 1952-1975. The tree ring samples were taken from north-western Thailand (three-leaf pine; *Pinus kesiya*), northern New South Wales (*Pinus radiata*) and north-western Tasmania (Huon pine; *Lagarostrobos franklinii*). These tree ring sections were crossed-dated at the University of Sydney using standard dendrochronological techniques and AMS ^{14}C analyses were carried out using the ANTARES facility at ANSTO.

The AMS results, compared with previously published atmospheric and oceanic ^{14}C data, revealed some exciting features of the atmospheric circulation and the regional air-sea exchange of CO_2 for the bomb period. There were four important findings:

- a latitudinal gradient, with the ^{14}C level decreasing from north to south with a time delay of about 1.5 years
- no longitudinal gradient, implying rapid zonal mixing of the atmosphere
- atmospheric ^{14}C reached a global equilibrium distribution at the end of the 1960s and decreased exponentially, halving every 16 years and
- the time for air-sea exchange of CO_2 for the mid-southern latitudes was about 13 years.

Associate Professor Mike Barbetti (left) and Dr Peter Grave (right) with one of the tree ring samples

Environmental Science

Research Areas

AINSE's environmental science projects utilise four main areas of ANSTO facilities and expertise:

- the Cameca 5f secondary ion mass spectrometer (SIMS)
- environmental radioactivity, chiefly through lead-210 and caesium-137 dating procedures
- uranium/thorium measurements for Quaternary dating
- neutron activation analysis (NAA).

The SIMS instrument is used to solve a broad range of surface analysis, geological and biological problems. For detailed information about applications see http://home.ansto.gov.au/ainse/ug.html.

Research Highlights

Uranium on the move

Large concentrations of uranium occur in nature; if they are large enough to be mined, they are called ore deposits. The study of the formation and alteration of these deposits helps us to understand the mobility of uranium in the environment, and provides a non-intrusive way of investigating the effects of this mobility on the biosphere. This fundamental understanding can be applied to cleaning up industrial sites, or to assessing the safety of radioactive nuclear waste deposits over long periods of time.

Australia is home to some of the world's largest uranium deposits. The small deposits scattered around the Northern Flinders Ranges, South Australia, were a famous source of radium at the beginning of this century. The then recently discovered rare element, radium, was attributed quasi-magical healing qualities. The uranium deposits of the Alligator River Province, Northern Territory, are among the richest uranium deposits mined today. In both cases, uranium ores aged several hundreds of millions of years have been in contact with groundwater for extensive periods of time. As a result, the very insoluble reduced uranium minerals that constitute the ore have been partially oxidised. Part of this oxidised uranium has migrated with the groundwater. In the Flinders Ranges, this remobilised uranium was re-deposited in ancient riverbeds to form deposits that are mined nowadays. Dissolved uranium can react along the migration path with different chemical elements to form a large variety of secondary, often attractive, uranium minerals (see picture).

Uranophane rosettes ($Ca(U^{VI}O_2)2(SiO_3OH)_2 \cdot 5H_2O$) from Mt Painter Province near Arkaroola, Northern Flinders Ranges, SA. The uranophane occurs in vugs in massive uranium(IV)-bearing hematite ores. Photo Stefan Ansermet, Cheseaux, Switzerland

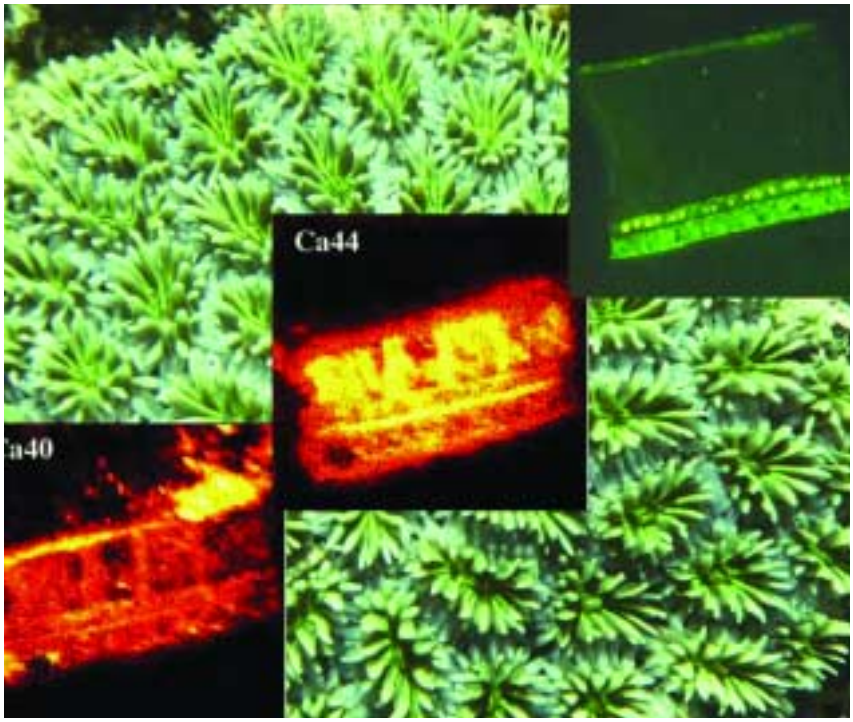
The chemical composition of secondary uranium minerals from 22 Australian localities were characterised by Dr Joel Brugger, formerly of Monash University and now at the South Australian Museum, with proton induced x-ray emission (PIXE) with assistance from Dr Peter Evans's research team. Dr Kathryn Prince's SIMS team helped determine surprisingly young ages for the formation of the minerals - all but one sample are less than 200,000 years old. Secondary uranium minerals from the Flinders Ranges and from the Alligator River have different ages. Brugger thinks that differences between climatic evolution in northern and southern Australia over the past 200,000 years have altered the uranium minerals differently in the two areas.

SIMS sees calcium in corals

Dr Alan Marshall and his research team from La Trobe University in collaboration with Rob Russell from the ANSTO SIMS team have been investigating the processes of calcium transport in corals. Calcium has to be transported across the coral epithelia to be deposited as calcium carbonate in the skeleton. In terms of cell physiology the ability to transport huge amounts of calcium very rapidly across cells is highly unusual. The quantities involved would be lethal to the majority of animal cells. In terms of coral reef biology it is important to understand coral skeletogenesis in order to understand patterns of reef growth.

The growth responses of reefs to environmental perturbations are of increasing importance in relation to global climate change and this, in turn, is of considerable concern because the world's tropical fisheries depend on the health of coral reefs.

SIMS microscopy was used to track calcium movement across coral tissues because it can differentiate between isotopes of the same element. The corals were incubated in artificial seawater in which naturally occurring ^{40}Ca had been replaced by ^{44}Ca. SIMS microscopy is able to discriminate between the two isotopes of calcium in preparations of coral tissues, thereby facilitating an understanding of the processes involved in calcium transport.



The inserts on top of the coral (Galaxea fascicularis) show a fluorescence light micrograph of tissue from this coral and SIMS images which show the different distribution of calcium isotopes. ^{44}Ca is used as a tracer to follow Ca movement across the tissue during the processes of skeleton formation

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Once a jolly swagman...

Environmental problems as diverse as increasing salinity, eutrophication and pH changes can be addressed by palaeoecological techniques. Palaeoenvironmental data for time periods and sites for which we have insufficient ecological and/or historic records are providing answers to specific river catchment management questions.

Professor Peter Kershaw and Paul Leahy from Monash University have been utilising the preserved material in sediment cores from floodplain billabongs to reconstruct changes in river and billabong ecology over the last few thousand years in the Yarra and Murray-Darling catchments. Special emphasis has been placed on establishment of pre-European settlement conditions and changes to the state of Australian rivers in the post European contact period through analysis of preserved diatoms (single celled algae). The application of ^{210}Pb dating in conjunction with Dr Henk Heijnis's team in the ANSTO radiochemistry laboratory has provided accurate chronological control on patterns and rates of change in these systems.

Early findings suggest that these sites are well suited to studying catchment change and that there have been substantial changes in many ecological parameters. The changes include early increases in pH in response to European arrival, and the late appearance of eutrophication, at least in the Yarra catchment. Dating so far has shown good comparability between ^{210}Pb derived ages and independent sediment markers. Future work will refine the accuracy of the ^{210}Pb record at a broader range of sites.

Billabongs along the Yarra

Engineering, Materials and Nuclear Technology

Research Areas

From firm foundations in ANSTO's nuclear science and technology activities, ensuring the safe and efficient operation of nuclear facilities and developing new approaches for the immobilisation and disposal of radioactive wastes, ANSTO Materials Division's expertise and facilities are directed towards enhancing the sustainability and international competitiveness of Australian industry. There are significant opportunities for collaboration with Australian universities.

Materials assessment offers an integrated service that concentrates on structural integrity, remaining life assessment, failure analysis, safety and the behaviour of industrial plant with changed operating conditions. Ceramic processing facilities enable large scale manipulation of ceramic materials ranging from crushing, grinding and milling through calcination, compaction and sintering treatments in a variety of gas atmospheres under pressures ranging from atmospheric to 200 MPa. Sol-gel technology developed for the production of wasteform precursors has been adapted to provide innovative solutions for functional ceramics in dielectric, piezoelectric, photochromic, sensor and inorganic ion-exchange applications while plasma processing techniques have been developed that modify material surfaces to enhance the value of industrial products.

State-of-the-art materials characterisation facilities include a very well-equipped metallography laboratory, x-ray diffraction, scanning and transmission electron microscopy, atomic force microscopy and solid-state nuclear magnetic resonance. A unique feature of these facilities is the operators' ability and experience in handling radioactive materials.

Research Highlights

More efficient solar cells

A program to improve the efficiency of dye sensitised solar cells (DSC) is being undertaken by Associate Professor John Bell of Queensland University of Technology and his team, who have investigated three aspects of the efficiency of these cells: the detailed characterisation of the nanostructure titania film; coverage by the sensitising dye; and developing methods for improving the interfaces between the film and the conducting substrates.

Size, shape, and distribution of the nano-structured titania particles were determined using transmission electron microscopy (TEM) with the help of Dr Kath Smith from ANSTO. The average crystallite size and phases have been determined using x-ray diffraction. The titania particles are 10-25nm, with either tetrahedral or rhombohedral shape. The film is mainly of anatase phase with a substantial amount of brookite phase. Using secondary ion mass spectrometry (SIMS), in collaboration with Dr Kathryn Prince's team at ANSTO, the penetration and coverage of dye in the film were analysed. The amount was quantified by Rutherford back scattering with the assistance of Dr David Cohen's accelerator team at ANSTO. The dye molecules percolate up to the film-substrate interface and are uniformly distributed in the porous titania film having a maximum amount of 1wt per cent of ruthenium. The penetration of the dye molecules up to the interface is necessary for an efficient flow of the injected electrons to the conducting substrate and efficient capture of light.

Commercial solar wall panel produced by Sustainable Technologies International (STI), who are providing the materials for the project

The next step of this project will be to modify the interface and isolate the back current of the injected electrons. The interface is to be characterised at ANSTO using TEM and SIMS.

Film stress control

Film stress is a very important factor in controlling film properties - especially cracking. Research by Associate Professor Michael Brungs and Young Jun Hong at the University of New South Wales, working with Dr George Collins and Dr Ken Short from ANSTO, is using crystalline titania films (anatase) intended for use in transparent solar cells. The most difficult part of this research is to prevent the film cracking if its thickness is more than 0.1μm.

Film stress can be calculated by measuring the change in curvature of the glass substrate between bare and coated surfaces. The researchers have overcome some major hurdles relating to the very small curvature difference between the film and the substrate, including the small stress generated by thin films, and how to measure at exactly same point before and after coating in order to accurately calculate stress.

AFM helps solve fouling problem for water-treatment plants

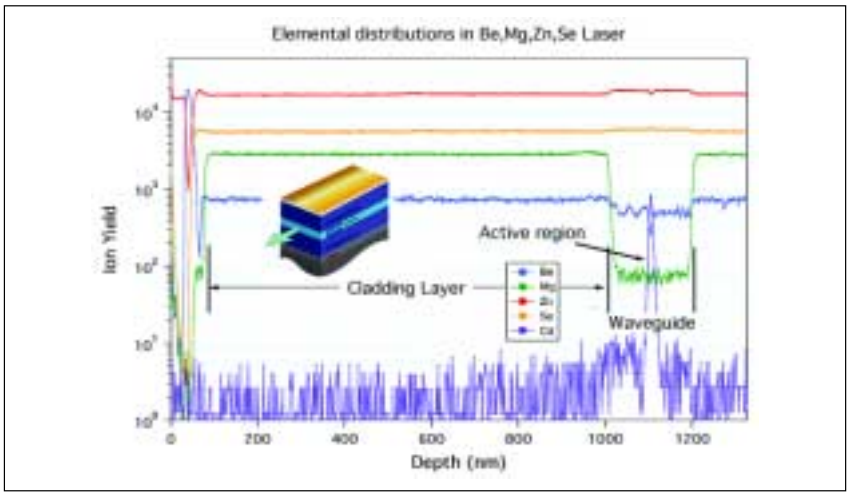
Dr Dianne Wiley of the University of New South Wales and Dr Ken Short from ANSTO are developing a technique for characterising titania coatings using atomic force microscopy (AFM).

The work is part of a collaboration with the UNESCO Centre for Membrane Science and Technology and Associate Professor Michael Brungs, School of Chemical Engineering and Industrial Chemistry, both at the University of New South Wales. Light-sensitive titania coatings are sought that could be applied to the surface of membranes to stop them fouling when they are used in applications such as the dairy industry or waste-water treatment. When a membrane is used in these applications, components in the liquid being treated attach themselves to the membrane. Once this happens they reduce the productivity of the membrane and may also change its separating properties. Some coatings have been made that will at least partially reduce and/or reverse the fouling. The researchers believe AFM techniques will increase their understanding of why the coatings work, with a view to improving their performance.

Distribution of elements in semiconductors using SIMS

Devices such as lasers and LEDs are made from semiconductor structures of many layers, each with a different composition. These layers are deposited on substrates in reactors, either using atomic beams of the required elements or by chemical reactions on the growing surface. Ideally these materials maintain their composition independent of the adjacent layers. However some elements are mobile; they diffuse into adjacent layers and change their composition and characteristics in a way that degrades the performance of the device.

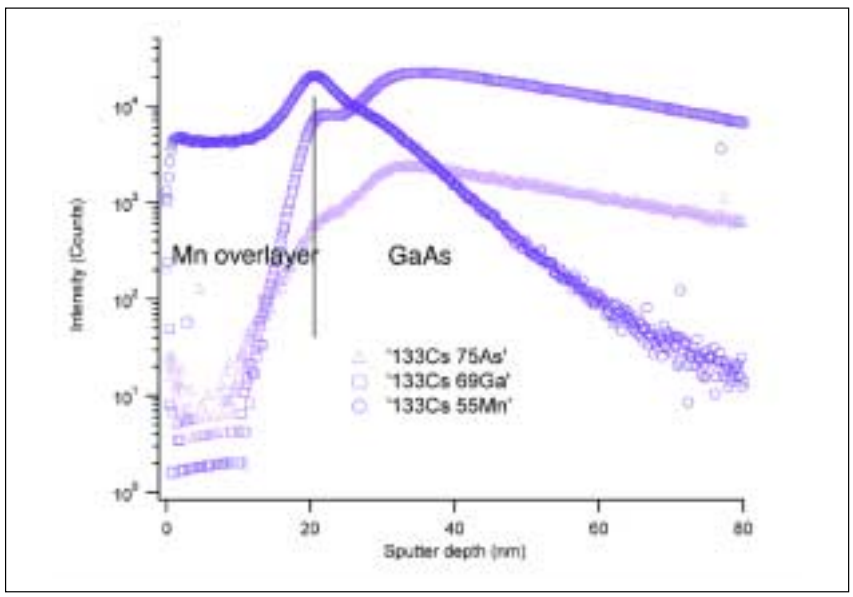
Professor John Riley and his team at La Trobe University in collaboration with Dr Kathryn Prince at ANSTO have been using SIMS to examine semiconductor structures.



The diagram above shows the usual structure of a semiconductor laser; this one, based on Be, Zn, and Mg selenides, is for operation in the blue region. The composition changes are required to set the required electrical characteristics and to fix refractive indexes so that the light is confined to the waveguide (shown by the two regions of lighter blues).

The SIMS profiles of such a device are also shown in the diagram above, in which the variation of compositions is clear.

In addition, such SIMS analyses have permitted us to determine the nitrogen concentration in InGaAsN. This information has application in communication lasers, to observe diffusion of Ga into ZnSe layers grown on GaAs substrates and the diffusion of Mn into the GaAs layers even when deposited at room temperature. Such a profile is shown below.



Neutron Scattering

Research Areas

The ANSTO neutron beam instruments include:

- high and medium resolution powder diffractometers
- high and medium resolution single crystal diffractometers
- a small angle neutron scattering instrument
- a long wavelength polarisation analysis spectrometer.

AINSE continued to manage Australia's partnership with the world's most intense pulsed neutron and muon source, ISIS, at the Appleton Rutherford Laboratories in the United Kingdom. This facility gives Australian researchers access to a wide range of techniques which are unavailable in Australia. Australian researchers were awarded 69 days of beam time for projects during 2001. Projects and publications are summarised in section 2, pages 36 and 37.

AINSE is grateful for financial assistance from the Australian Research Council's Linkage Infrastructure Equipment and Facilities funding, which contributed to the subscription to ISIS from 2000 to 2002.

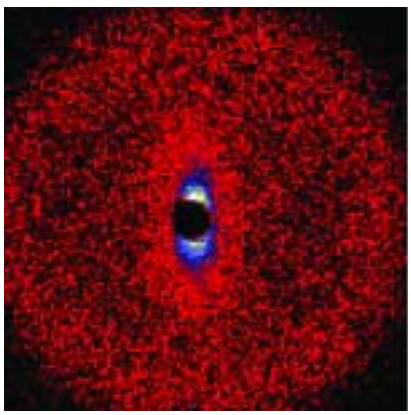
Research Highlights

Red blood cells seen with neutrons

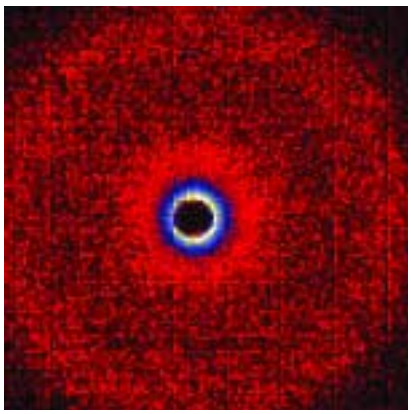
Often diffraction techniques are used as probes of atomic scale order in the solid phase of crystallised protein. At small neutron scattering angles order can also be found in living systems at much longer length scales and then related to the function of that tissue. Erythrocytes (red blood cells) are the disk-shaped cells that are used to transport exchange gases around the body. Using a beam of neutrons directed at a sample of whole living erythrocytes, Professor Philip Kuchel and Dr Chris Garvey of the University of Sydney with Dr Robert Knott from ANSTO have found a diffraction peak, indicating that there are ordered aggregates of the protein used to transport the gases.

Erythrocytes pick up oxygen in the lungs and release it where it is needed in tissue. In a similar way they also have a role to play in removing carbon dioxide from tissue and returning it to the lungs. They fulfil this role by using the iron-containing protein haemoglobin as a site to bind and release gases. All the haemoglobin in blood is found inside erythrocytes, so the shape of the cell and the distribution of the haemoglobin molecules inside the cell can play a large role in the ability of the erythrocyte to bind and release gases.

Small angle neutron scattering experiments have shown that the aggregation of haemoglobin, and presumably the affinity of the protein for the gases it must exchange, is controlled by the volume of the cell. By shearing a suspension of cells and aligning them, the team has found the aggregates are most probably lining the inside of the red blood cell membrane. Garvey is now investigating the role of known physiological regulators of the oxygen affinity of haemoglobin in the aggregation phenomenon.



SANS image of eryhthrocytes under high shear



SANS image of eryhthrocytes with no shear

Smart ceramics

Piezoelectric ceramics can sense their environment and respond to changes in it and hence are classified as smart materials. They can sense an electric field (or voltage) and generate a shape change. Alternatively they can sense a force or displacement and generate a voltage. Piezoelectric ceramics are not new. However, a new material known as PZN-PT has a piezoelectric effect ten times as great as conventional piezoelectric ceramics. They are being considered for use in a variety of applications including medical ultrasound imaging devices, shock and vibration absorbing devices and robotics.

Piezoelectric ceramics contain positively and negatively charged ions that shift relative to each other and generate a voltage when a force is applied or vice-versa. The piezoelectric effect in PZN-PT is so great that conventional ceramics would shatter under the same conditions. How PZN-PT is able to survive is the subject of considerable conjecture including several reports of electric field induced changes in the crystal structure.

Dr Erich Kisi and his team from the University of Newcastle used 2TANA at ANSTO for neutron diffraction experiments on PZN-PT single crystals under applied electric fields up to 130kV/cm. These experiments have demonstrated that some of the proposed crystal structure changes are really an artifact of the way the crystals are divided up into small regions called domains, and of the way these domains re-orient themselves under an applied electric field.

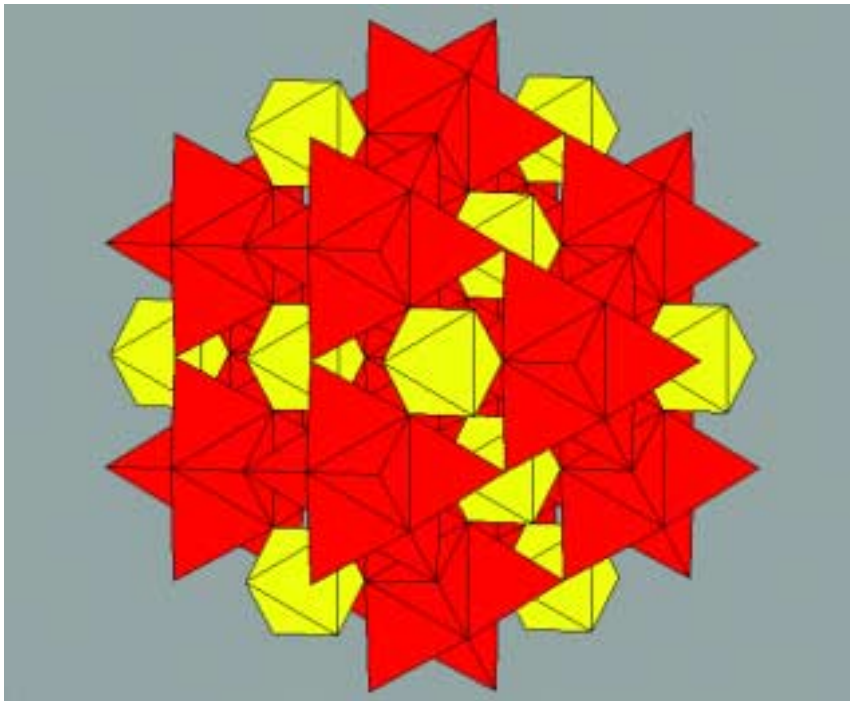
Exsolution and cation ordering in iron nickel sulfides

Geological time is usually measured in units of millions of years. Mountain ranges are built and eroded flat, sea levels rise and fall and ore-bodies are formed. Yet how fast are the reactions between minerals, which drive the ore forming processes?

Dr Allan Pring, and Barbara Etschmann from the South Australian Museum and Dr Shane Kennedy from ANSTO are trying to measure the rate at which the principal ore of nickel, pentlandite, separates from its host, a nickel-rich pyrrhotite. Above 650ºC the nickel iron sulfide exists in a single phase but at lower temperatures pentlandite $(Ni,Fe)_9S_8$ separates from the pyrrhotite $(Fe,Ni)_{1-x}S$ host. These two minerals have different crystal structures.

Powder neutron diffraction was used to measure the rate of separation (exsolution) of these minerals. Exsolution, like crystallisation, is a two-stage process. The first stage is nucleation and the second is growth or coarsening.

A series of experiments was devised to measure the rates of nucleation and coarsening, by annealing samples at different temperatures over a range of times and measuring the proportions of the two minerals pentlandite and pyrrhotite. The neutron diffraction data show that nucleation is very rapid, on a time scale of seconds or minutes in the temperature range 250ºC to 600ºC. Coarsening is also surprisingly rapid - 2μm wide lamellae of pentlandite grow in the pyrrhotite host in 24 hours at 400ºC. The amount of pentlandite exsolved is also temperature dependent and in *in situ* heating experiments we will be able to follow the extent of exsolution and re-absorption as a function of temperature. In the coming year the team hopes to be able to see whether the distribution of Fe and Ni between the minerals is temperature dependent. The results of this work have implications for understanding the processes in the formation of nickel sulfide ore bodies.



Molecular structure of pentlandite

Radiation Science

Research Areas

Research areas include chemistry, molecular biology, pharmacology, materials science, polymer science, radiotherapy and environmental science.

Facilities

Radiation science projects utilise the following facilities:

- ANSTO's gamma irradiation pond, which provides dose rates from approximately 0.1 to 3.0kGy/h
- ANSTO's small shielded gamma facility, which provides maximum dose rates of 0.2 and 0.8kGy/h
- ANSTO's deep level transient spectrometer
- a Febetron pulsed electron beam generator at Melbourne University delivering 3ns pulses of 0.2-0.6MeV electrons (variable at will); maximum beam current 7000A
- a Dynaray-4 pulsed electron Linac 0.5 to 5MeV at the University of Auckland. Pulse lengths from 200ns to 1.5ms; beam currents up to 180mA
- a Vickers 7-21MeV pulsed electron Linac at ARPANSA in Melbourne. Pulse lengths from 100ns to 4ms at repetition rates of single shot to 200pps. Dose per pulse variable up to 90Gyl.

Research Highlights

Water pollution remediation

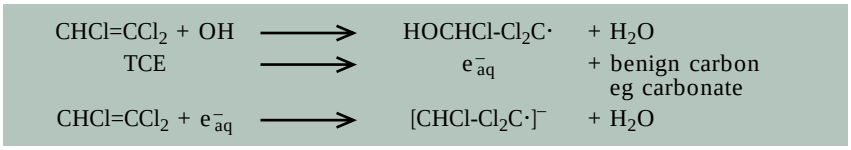
Gamma or electron irradiation of water produces the two most reactive free radicals known in water chemistry - the oxidising (OH radical), and the reducing solvated electron (e^-_{aq}).

The latter is especially useful in attacking halogen-containing molecules such as halocarbons. In recent years irradiation has been used in both sterilisation and decontamination.

Associate Professor Ron Cooper of the University of Melbourne and David Sangster, University of Sydney, have used the pulsed electron beam facility at ARPANSA in Melbourne, together with gamma radiolysis facilities at ANSTO, to probe the mechanism and efficiency of degradation of a typical industrial cleaning solvent, trichloroethylene-TCE.

The results show that attack by either of these free radicals leads to an irreversible destruction of TCE.

The initial radical attack is followed by hydrolysis of the unstable halocarbon free radical. The yields of free chloride ion are up to four times greater than expected on the basis of one molecule of TCE destroyed per initial free radical. A chain self-destruct mechanism is operative. The initial halocarbon free radical adds on to TCE, forming a new free radical but with double the halogen content. This new radical hydrolyses, releasing more chloride, or further adds on to TCE before hydrolysis. The more polluted the water (higher TCE), the more polymerisation before hydrolysis and hence the more efficient the destruction.



Electron beam experiments are able to detect the intermediate free radicals and monitor their behaviour.

Both the OH radical attack and e^-_{aq} reactions are observable over time periods up to several milliseconds.

The technique is also efficient with unsaturated chlorocarbons.

Interpenetrating polymer networks by a new route

Interpenetrating polymer networks (IPNs) are an increasingly important family of polymers as they offer the possibility of combining the special attributes of each of two or more component polymers. They are made by mixing polymers so that they will be dispersed at the microscopic level, and so that at least one polymer is cross-linked. The nano-phases need to be continuous as well. This might sound simple, but many polymers phase separate, so these IPNs can be challenging to make.

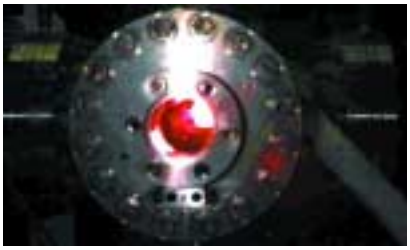
Professor Rob Burford with Bhavna Shirodkar and Martin Markotsis from the University of New South Wales have taken an oil-extended block copolymer rubber (a thermoplastic elastomer) and thermally cross-linked the flexible butadiene segments, leaving the stiff polystyrene domains alone. This is then swollen in styrene monomer containing additives, and irradiated at ANSTO. This low temperature method avoids thermal oxidation of the rubber, allowing clean products with properties ranging from those of hard rubbers to tough plastics, depending on the final polystyrene content and level of cross-linking.

They have studied the mechanical and thermal performance of these materials, and have also examined their structure by transmission electron microscopy (TEM). The stained butadiene-rich material can be resolved as a spider's web, and gives the appearance of gossamer, quite unlike that seen for IPNs using thermal methods.

These oil-free thermoplastic elastomers will be further analysed using small angle neutron scattering (SANS) to complement the TEM data to determine the structure of these materials.

Butcher throws light on LEDs

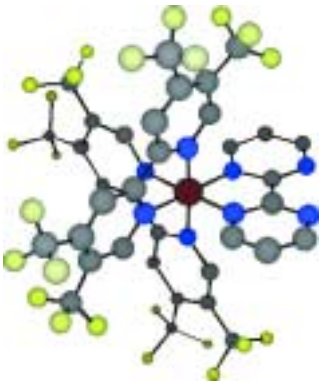
In recent years gallium nitride has been used in a broad range of applications. Most noticeably high efficiency (up to 50 per cent) gallium nitride-based white LEDs have begun to displace traditional incandescent and fluorescent light sources for some applications. One of the barriers to wider adoption of this technology is that gallium nitride is grown at temperatures of over 900°C on expensive sapphire substrates.



Remote nitrogen plasma, visible from Macquarie low temperature nitride growth system

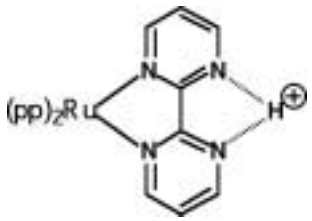
The Physics Department of Macquarie University houses one of the premier laboratories in the world for low temperature nitride film growth. One of their aims is to grow good quality gallium nitride at lower temperatures on less expensive materials. Material purity becomes more of an issue at lower growth temperatures. Oxygen incorporation in particular becomes more problematic. Dr Scott Butcher from Macquarie University has worked with Dr Kathryn Prince's SIMS team and Dr Dimitri Alexiev's DLTS facilities at ANSTO to monitor the composition and defect structure of our low temperature grown material and some related gallium compounds. With this information Butcher has been able to produce some of the best gallium nitride ever grown on glass.

Photosynthetic solar cells just a bit closer



Complexes of ruthenium and osmium based on the archetype tris(2,2'-bipyridine)ruthenium(II) $\{[Ru(bpy)_3]^{2+}\}$ are considered to be potential photosensitisers in solar energy conversion. They are chemically stable, have attractive redox properties and absorb widely over the visible spectrum. The excited state lifetime and reactivity are very suitable.

To design more efficient photosensitisers, it is important to understand the nature of these excited states. Upon light absorption, an electron is excited from the metal to a ligand so that $M\text{-}L \longrightarrow {}^{*}M^{+}\text{-}L^{-}$. For complexes of ruthenium(II) an analogy exists in the reduced species where the electron is localised on the ligand (i.e. $M\text{-}L^{-}$) and similarity (electron occupying the same area regardless of the origin) enables the reduced species to serve as useful models of the excited state.



Professor Richard Keene and Brad Patterson (an AINSE Postgraduate Scholar) of James Cook University and Dr Bob Anderson of the University of Auckland have studied the reduction of various polypyridyl ruthenium complexes in which one (or more) of the ligands has protonatable atoms.

Using the pulse radiolysis facility at the University of Auckland to initiate the reduction, they have studied the acid-base characteristics of such ligands as the identity of the other ligands {pp} in the complex was systematically changed.

The studies support the proposal that upon reduction, the electron is located on the ligand with the lowest π^{*} energy rather than being delocalised over the three ligands. There is also a demonstrable relationship between the acidity of the compounds and the nature of the other ligands coordinated to the metal centre. These general properties are consistent with observations on the same characteristics of the ligands in excited states of the same complexes. This provides useful input into the design of potential photosensitisers in improved solar energy schemes that incorporate them.

Radiopharmaceuticals and Neutron Irradiation

Research Areas

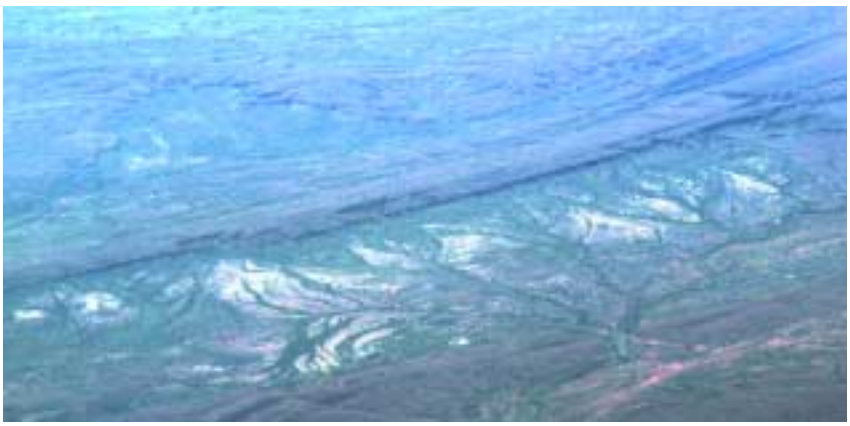
Radiopharmaceutical research focuses on the development of radionuclides and radiopharmaceuticals for diagnostic and therapeutic applications in the areas of neurology and cancer. The researchers use *in vivo* and *in vitro* evaluations of labelled compounds and carry out clinical trials with promising radiopharmaceuticals.

Radiopharmaceutical sciences consist of:

- radiopharmaceutical chemistry
- macrocycle chemistry
- short-lived positron emission tomography (PET) and single photon emission computed tomography (SPECT) radiopharmaceuticals
- molecular radiopharmaceuticals
- bio-radiopharmaceuticals
- radionuclide development and radiopharmaceutical dosimetry
- radiopharmacology
- molecular design and structure
- rapid radiochemical separations
- monoclonal antibodies
- process control for synthesis and quality control
- hot atom chemistry.

Uses for neutron irradiation vary from irradiating minerals to determine yields to irradiating tracer substances for various research, environmental, and industrial processes and applications.

Research Highlights



Oblique aerial photograph of part of the Davenport province showing the flat ridge tops referred to as the Ashburton surface

Antiquity hypothesis debunked

A decade ago it was thought that the ridge tops in the Davenport province of central Australia were remnants of an ancient land surface, the Ashburton surface, and had existed as subaerial landforms since at least the Cambrian - a period dating back some 570 million years. This would have made them the oldest persistent landforms on the continent, if not on Earth.

Apatite fission track analysis is a well-established technique with an unparalleled capacity for determining the thermal history of rocks for the temperature range characteristic of the shallow crust (less than about

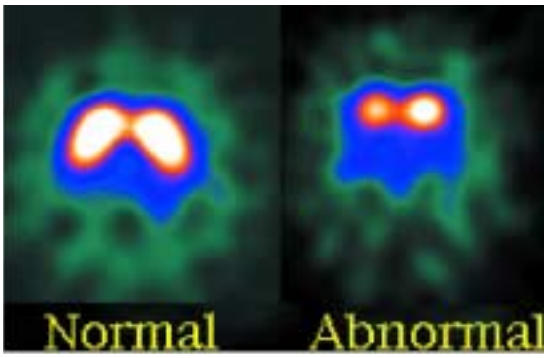
120 degrees Celsius). The technique is therefore ideal for estimating long-term denudation rates of at least several hundred metres which occurred over time scales of the order of 10^7 years. Complementing these with ^{10}Be and ^{26}Al (short-term) average erosion data with fission track analyses, Dr Barry Kohn and co-workers Dr Roderick Brown and David Belton at the University of Melbourne, and Dr David Fink at ANSTO, have estimated erosion rates that disprove the long-standing antiquity hypothesis for the Ashburton surface. These studies indicate that neither the ridge tops, nor the conglomerate surfaces within the Davenport Ranges can represent landforms that have remained subaerial since the Cambrian.

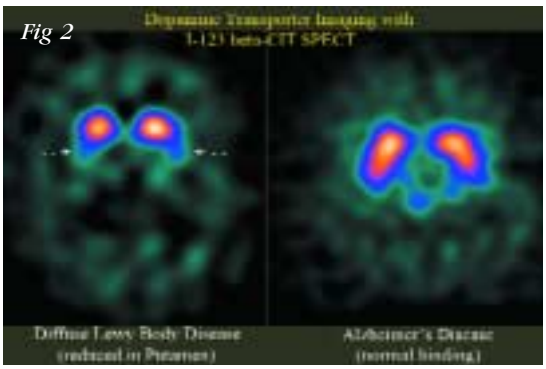
The data are not inconsistent with the suggestion that the valleys are Cambrian in age - but they do indicate a much thicker cover of sedimentary material, possibly several kilometres thick, which has since been removed by erosion. The findings support arguments that a process of burial and exhumation has contributed significantly to ensuring the subaerial preservation of ancient Australian landforms.

Radiopharmaceuticals and imaging

Over the last decade there has been increased use of radiopharmaceuticals in the imaging of disorders of the brain. Non-invasive techniques have used molecular probes to discriminate between a wider range of diseases and measure their severity. AINSE is supporting two clinical trials, one relating to the diagnosis of Parkinson's disease (PD) and the other to Diffuse Lewy Body Dementia (DLBD). Using a recently developed radioligand, clinicians hope to discriminate between these diseases and movement disorders that give similar clinical symptoms but are causally unrelated, such as Alzheimers Disease (AD). ^{123}I-beta-CIT is a radioligand which measures dopamine transporters. SPECT (Single Photon Emission Computed Tomography) is then used to image the gamma emissions of the iodine radioisotope. These transporters are present on the presynaptic terminal of the dopaminergic neurones and therefore are a marker of dopaminergic neuronal number. Substantial reduction in ^{123}I-beta-CIT binding is seen in PD compared to normal subjects; therefore the agent can be used not only to diagnose PD patients but potentially to distinguish PD from the other related disease states. The ^{123}I-beta-CIT doses are produced at ANSTO by Dr Andrew Katsifis and his team then transported overnight to hospital. The 13-hour half-life of ^{123}I makes this feasible for distribution around the country.

At the Austin and Repatriation Medical Centre, Dr Chris Rowe and his team are investigating the utility of this radiopharmaceutical in differentiating between DLBD and AD. DLBD has recently been recognised as the second most common cause of dementia after AD. DLBD patients do have mild Parkinsonian signs and the pathology is similar to Parkinson's Disease but more widespread. Recently, a small study has suggested that patients with suspected DLBD show a dramatic reduction in ^{123}I-beta-CIT binding while patients with AD have normal binding.





At Westmead Hospital in Sydney, Dr George Larcos and team are investigating PD, multiple system atrophy and progressive supranuclear palsy - the latter two diseases often clinically resemble PD and are often misdiagnosed. Additionally, it has been recognised that different forms of dementia afflict patients with PD, often resulting in dramatically different clinical consequences for the patients and their carers. Patients will be clinically examined for changes of Parkinsonism and the extent and type of cognitive impairment. Specialised scans, such as MRI and ^{123}I-beta-CIT-SPECT scans will allow detailed visualisation of brain structure and enable a differentiation of the various clinical subtypes of Parkinsonism and forms of dementia. Ultimately, this may aid in accurate diagnosis and assist in planning appropriate therapy for these patients.

So far the clinical results have indicated that ^{123}I-beta-CIT-is able to detect loss of dopamine transmitter density and that this loss can be correlated with PD type disorders (Fig 1).

This study also confirms that Diffuse Lewey Body Dementia is characterised by a marked reduction in presynaptic dopamine transporters which is not the case with Alzheimer's patients (Fig 2).

The AINSE Winter School

Joshua Combes from Griffith University unravelling crystal symmetry during the neutron scattering experiment

Nuclear Techniques Applied to Natural Processes

The fifth AINSE Winter School on nuclear techniques applied to natural processes was held from between 30 June and 4 July 2001 at the Lucas Heights Science and Technology Centre with a great deal of input from both ANSTO and university staff.

Introduction

Thirty-four students participated in the Winter School; they consisted of sixteen physics majors, eight chemistry majors, five engineering majors, two environmental science majors, one medical physics and one geology major and one student majoring in archaeology.

A background lecture and experimental session was provided for each of the following topics:

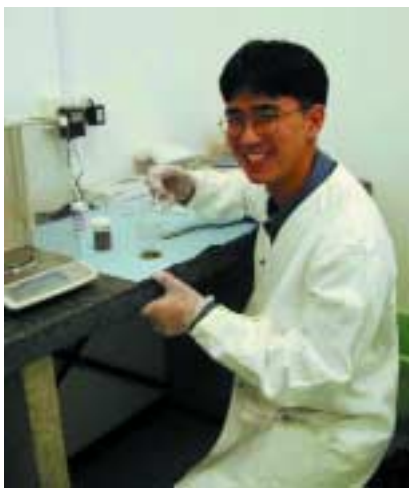
- neutron scattering
- ion beam experiments
- natural radioactivity
- radioactivity and the living world
- radiation chemistry.

On Monday 2 July Dr Julia James from the University of Sydney delivered the after dinner address on *Conflict in the World of Caves*. Dr James talked about her experiences as a speliologist and raised the major conservation issues relating to caves. The presentation sparked many questions and a lively discussion followed her presentation.

AINSE is indebted to Professor Helen Garnett, ANSTO's Executive Director, for supporting the Winter School, to the many ANSTO staff members who contributed their time and talent, to Gerald Laurence who chaired the planning committee, and to Julia James, David Sangster, Ken Doolan and Ron Cooper from the universities involved in the planning and implementation of this year's Winter School.

The Winter School targets senior undergraduates from member universities. Applications for the Winter School close in mid April, For more information see our web site or consult an AINSE Councillor.

Tanya Wiseman from Curtin University at the PIXE facility



Kwan Lee from the University of Sydney performing exacting chemical procedures during the radiation chemistry experiment

Student Comments

At the end of the Winter School students were asked to fill in a questionnaire. The final section invited them to make any other comments about their experience at the Winter School. The following is a representative selection.

"A broadening of my experience in science will help me to decide on what is available for honours using the services and equipment at ANSTO Environment."

"Found out the many uses for radiation and that there are other ANSTO facilities apart from HIFAR."

"Could we have a list of possible Honours projects and ANSTO co-supervisors?"

"I was made aware of areas in radiation chemistry I might pursue further."

"It helped me appreciate the scale of activities at ANSTO."

"Did not expect the diversity of scientific research – I now have a number of ideas for possible research."

"I was able to see our national world class facilities for research and the industry applications of nuclear techniques."

"Two out of five experiments were environment related but nevertheless interesting – particularly the mussel meter." (Physics student).

"Staff and demonstrators were more than happy to answer questions. Five very worthwhile days."

"During the experiments the staff were a great asset."

"Fantastic learning experience – a great opportunity."

"Overall atmosphere of the school was GREAT. Gerald and Dennis should be congratulated."

"Dennis provided a good welcoming committee at airport and made all feel welcome."

"Fantastic."

"I would have come even if I had had to pay for the plane ticket and food."

"Great – congratulations and thank you."

"The best 5 days I have experienced in years."

"The talk by Julia James was fantastic!"

"I had a great time. The chemistry was interesting too."

"...Thanks."

But you can't satisfy everyone

"The tours were good; the experimental sessions I found to be irrelevant, too shallow and brief. We should have been able to see the sections from all over the site and been told of the work being done in each area."

"The wide range of topics was good but a superficial treatment of all was given."

"This School could also have had High School Students (smart ones) as the level of technical knowledge is at that level." (from a Physics/Electronics student).

Melissa Sutcliffe from Northern Territory University ready for action in the natural radioactivity experiment

Shannon Whitlock from Swinburne University in front of the mussel tanks during the radioactivity in the living world experiment

Nicole Benedek from RMIT measuring breaking strain with the tensiometer for the radiation chemistry experiment

2001 Conferences and Workshops

AINSE conferences play a major part in the information exchange process for scientific and technological information, providing a forum for debate and an opportunity for young researchers to present their work. Participants from member organisations are assisted with travel and accommodation expenses and receive a discount on registration fees. There were 393 participants at conferences and 222 at workshop/symposia held in 2001.

The focus this year has been well and truly on neutron scattering techniques.

Ion Beam Analysis Conference

The 12th AINSE conference on Nuclear Techniques of Analysis was held in Cairns on 15-20 July 2001 in association with the 15th International Conference on Ion Beam Analysis. There were 230 participants, including 2 from ANSTO, 185 from overseas and 17 students; 81 papers and 205 posters were presented. The medal for best student oral presentation was awarded to Ms Tessica Weijers, Australian National University, and the best poster presentation was awarded to Mr Sergei Kucheyev, Australian National University

Environmental Science Workshop

This workshop, entitled *Archives of human impact of the last 200 years,* was held on 27-28 September 2001 at AINSE Lucas Heights Australia. There were 46 participants, including 12 from ANSTO and 15 students; 14 papers and 7 posters were presented.

ANA 2001

The Australian Nuclear Association's (ANA) 4th Conference on Nuclear Science and Engineering in Australia was held between 24-25 October 2001 at the Millennium Hotel, Sydney. There were 117 participants, including 47 from ANSTO, 3 from overseas and 7 students; 21 papers and 21 posters were presented. AINSE participated in the organisation of this conference and subsidised travel for contributors from AINSE member universities.

AINSE President Associate Professor Ron Cooper during his presentation at AN2001

Neutron Scattering Workshops

The purpose of the workshops is to demonstrate the applications of these methods to Australian industry, government and universities, and to make a start on defining specifications for the neutron scattering facilities at the Replacement Research Reactor. AINSE provided travel and accommodation subsidies for attendees from AINSE member universities.

Neutron Reflectometry

The workshop on Neutron Reflectometry at Australia's Replacement Research Reactor was held between 8-9 May 2001 at Lucas Heights. There were 49 participants including, 18 from ANSTO and six from overseas. The report on this meeting can be found at:

http://home.ansto.gov.au/ansto/neut/workshop3r_rep.html.

Neutrons in Biology

This workshop was held between 10-11 July at the University of Melbourne Australia There were 40 participants, including 10 from ANSTO, seven from overseas and three students; 10 papers and four posters were presented. The report on this meeting can be found at:

http://home.ansto.gov.au/ansto/neut/bio.pdf.

Dynamics, Excitations and Magnetism

This workshop was held between 27-28 August 2001 at Lucas Heights. There were 44 participants, including 18 from ANSTO and five from overseas. The report on this meeting can be found at: http://home.ansto.gov.au/ansto/neut/w4h.pdf.

Single-crystal Diffraction

This workshop was held between 11-12 December 2001 at Lucas Heights. There were 38 participants, including 10 from ANSTO and four from overseas.

Small-Angle Neutron Scattering

This workshop was held between 13-14 December 2001 at Lucas Heights. There were 51 participants, including 17 from ANSTO and four from overseas.