Section 1
Contents

President's Report

The Australian Institute of Nuclear Science and Engineering is a national organisation with a 45 year track record of collaboration and facilitating the interaction of universities and one of the major Publicly Funded Research Agencies, ANSTO. AINSE currently has 37 university members and has grown with the university sector since its inception in 1958. The AINSE collaborations at ANSTO have produced 135 PhD theses and since 1990 (when computer records were kept) the AINSE collaborations have produced an average of 230 research publications per annum. There are currently 409 University researchers who are active award holders.

AINSE provides research grants to support projects requiring access to the facilities at ANSTO and other AINSE associated facilities. AINSE also facilitates interactions and collaborations between university researchers and ANSTO scientists and technical personnel. AINSE also provides support for Postgraduate students in the form of Postgraduate Research Awards. In addition we continue to run the highly successful AINSE Winter School for senior undergraduate students.

AINSE recently restructured its specialist review committees to reflect changes in the major foci of research undertaken by the researchers who utilize the ANSTO facilities from its member universities. Five major research areas were identified and specialised panels were established to review grant applications and advise AINSE on relevant matters. The five areas are: Environmental Sciences; Materials - Properties and Engineering; Materials - Structures and Dynamics; Archaeology and Geosciences; and Biomedical Science and Biotechnology. The specialized committees provide peer review for grants to access the ANSTO facilities.

Another role of AINSE concerns the organisation of conferences and in assisting Australian institutions in organising International Congresses. In 2003 this included the organisation of the 12th International Congress of Radiation Research of the International Association of Radiation Research (held in Brisbane in August 2003), as well as supporting the 15th International Symposium of Radiopharmaceutical Chemistry in Sydney.

The new Tandem accelerator which was purchased by AINSE with financial assistance of a LIEF grant and by ANSTO is now installed in a completely refurbished facility building. One of the major applications of the accelerator will be for accelerator mass spectrometry for sample dating as well as analysis using ion beam analysis techniques. Some problems encountered by the manufacturers (HVE, Netherlands) have held up final commissioning of the accelerator but our aim is to have the remaining problems ironed out by mid year. AINSE has also purchased an automatic element analyser, isotope ratio mass spectrometer, which also prepares samples for analysis. It is expected to speed up sample preparation and substantially increase sample throughput on the new accelerator when it comes on-line.

The construction of the replacement research reactor (RRR) is proceeding well and this facility will provide a world class neutron source that will greatly enhance the research capability for AINSE supported projects. ANSTO is currently developing a facility access program in consultation with AINSE to stimulate the growth of research programs of excellence once the neutron beams are on-line.

Professor Hans Coster, President

Scientific Secretary's Report

Two thousand and three has been a year of change for AINSE in two significant ways: the development of a new strategic plan for AINSE as described in the President's report; and changes in staff at the secretariat. Both Nerissa Phillips and Tanya Irvine took extended maternity leave covering most of the year. Tanya decided to be a full time mother while Nerissa has returned to work two days a week. Andrew Henriksen left in August once he had completed his certificate III, and Irene Parker decided it was time for a change in September. I have engaged a young science graduate, Ben Thompson who commenced two days before the NTA Conference in November.

My thanks go to both the incoming and outing councillor for the University of Western Australia for their assistance with the organisation of the December Council meeting held at St Catherine's College. Once again the postgraduate students provided an interesting afternoon of presentations on their research topics. At the meeting Gerald Laurence was presented with an honorary fellowship in recognition of his contribution to AINSE over many decades. Gerald's association with AINSE goes back more than 40 years.

Neutron scattering workshops continued during 2003. These workshops have significantly increased the general awareness of the potential for using neutrons as a tool for better understanding the structure of matter. The workshops were conceived and designed to disseminate information on the potential capability of ANSTO's Replacement Research Reactor and to gather feedback on the selection of instruments. I believe we will have an increasing number of new applicants over the next few years, many of whom will have attended these workshops.

The 12th International Congress of Radiation Research in Brisbane 17 - 22 August was a big success. It is probably the largest meeting ever organised by AINSE and as planning moved into high gear in September 2002 the world was rocked by the terrorist attacks in the US, then by the outbreak of SARS and more bombings in Indonesia. Finally, the USA declared war on Iraq in early 2003. In response to a drastically reduced forecast of registrations, we cut expense items from the budget but as late as one month before the Congress we were forecasting a deficit of about $20,000. On the day, though, it became clear that people had not cancelled their plans to attend - they just left registration to the last minute. We finally had over 900 full delegates and with day registrations the count increased to just over 1100.

Council and Committees

While 2002 was the final year for Ron Cooper as President the Executive Committee voted for his continued involvement in 2003 as immediate Past President, in recognition of the significant contribution he has made to the running of AINSE. On AINSE Council, changes include:

- Macquarie University's Professor Peter Bergquist, replaced by Professor Jim Piper
- The University of Melbourne's A/Professor Ron Cooper, replaced by Professor Jim Camakaris
- The University of Queensland's Professor John Boldeman, replaced by Dr Paul Meredith
- RMIT University's Professor Dinesh Sood, replaced by Professor Peter Johnston
- The University of South Australia's Dr Bill Skinner, replaced by Dr Namita Choudhury
- Swinburne University of Technology's Dr Peter Alabaster, replaced by Dr Anthony Bartel The University of Sydney's Professor Len Lindoy, replaced by A/Professor Brendan Kennedy
- The University of Wollongong's Professor Anatoly Rozenfeld, replaced by Professor Allan Chivas
- The University of Western Australia's Brian Stone, replaced by Dr Jasmine Henry.

Dennis Mather, Scientific Secretary

Of particular note are Professors Bergquist, Boldeman and Stone, each of whom has been on AINSE Council for many decades.

Professor Helen Garnett left ANSTO in September and over the seven years as Executive Director of ANSTO has shown strong and continuous support for AINSE.

The commitment to refresh membership of the specialist committees has resulted in many changes on these committees. See page 4 of Section 2 of this report.

AINSE is grateful for the dedication and generosity of all those who contributed to the various committees and Council. Without their input the organisation would not be able to move forward with such surety.

With considerable sadness I record the sudden death of John Head, University of Wollongong, who participated as a reviewer of AMS based applications for many years.

Finances

In 2003, income of $3,517,582 was made up of $1,405,174 from ANSTO's membership fee, $734,115 from universities, $929,206 from conference sponsorships and registrations, the majority of which is related to the 12th International Congress of Radiation Research, $306,691 from external grants, $136,920 from interest, and $5,476 from other sources.

Membership subscriptions are reviewed annually to determine AINSE support for each university. On average, for the period 1999 to 2003 inclusive, universities received research and training benefits amounting to 2.99 times their subscriptions. This is just about on the target of 3, for more information on performance indicators, see section 2, page 67.

AINSE's operating expenses in 2003 were $3,612,657, leaving a deficit for the year of $95,075, see figure 2, this was less than the plan. The majority of AINSE funds are used to facilitate travel and access to Lucas Heights for university researchers and their research students and while the budget for 2003 Awards was $1,567,399 which was much the same as last year uptake was significantly down at $1,256,888 and is explained by reduced accelerator activity because of the need to partly decommission the old 3MV van de Graaff while the new Tandetron was being assembled. There were also significant disruptions to supply of radioisotope products during the year. The issues are resolved and many of these awards have been carried over into the new year.

Funds have been set aside for the final payments for Tandetron accelerator, and automatic AMS sample preparation/analyser, both to be commissioned in 2004

The 'Other Expenses' category has two very large extraordinary items; conference management, $782,402, most of which is associated with the 12th International Congress of Radiation Research, and $239,802 towards the cost of the EA/IRMS.

The Financial Statements for the calendar year 2003 are in section 2 of this report starting on page 6 and were prepared by ANSTO Finance and audited by Escott Aston and Co.

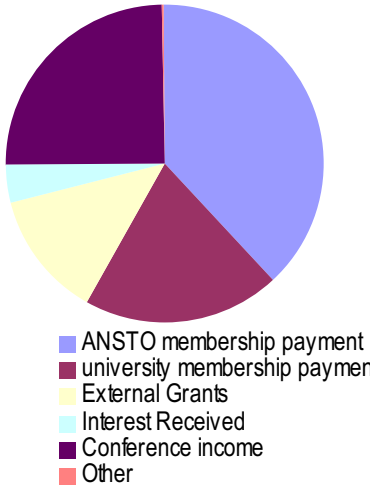


Figure 1 Operating Revenue

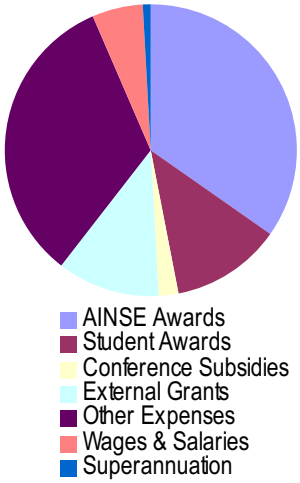


Figure 2 Operating Expenses

Awards and postgraduate research awards

A total of 186 Awards were made in 2003 and another 66 were carried over from previous years. Figure 3 shows the distribution of AINSE awards by specialist area. Research highlights are given on pages 6 to 15. Progress reports for each of the projects can be found on our home page.

In 2003 fifteen of the forty-one AINSE postgraduate research award holders received an award for the first time. During the year seven PhD theses were received. The AINSE postgraduate research award holders accessed the facilities for a total of 554 days. In addition, another 82 students gained access to the facilities via awards held by their supervisors for a total of 536 days.

Our publication rate remained high with 372 publications notified this year. Details can be found in section 2 of this report. First time award holders in 2003 represented 25 per cent of the cohort, which is slightly higher than last year's figure of 23 per cent. I attribute this, in part, to the diligence of our Councillors and to my university visit program; in 2003 I spoke with researchers and students at 25 member universities. My thanks go to the Councillors without whom these visits would be much more difficult to organise and not nearly as effective.

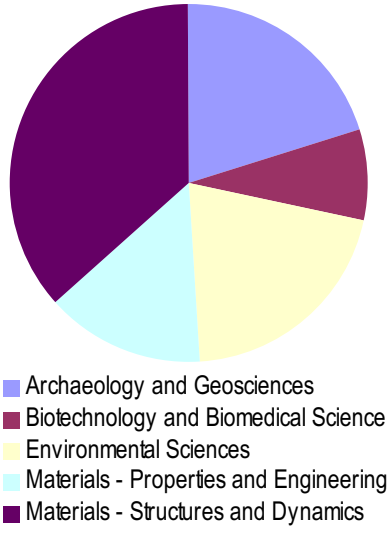


Figure 3 Expenditure by Specialist Area

Acknowledgements

The President, Professor Hans Coster and immediate Past President Associate Professor Ron Cooper, have provided me with invaluable advice and tremendous support throughout the year. I thank Professor Helen Garnett, for the last time as Chief Executive Officer ANSTO, who never failed to demonstrate support and long-term commitment to AINSE. I wish her every success as vice chancellor of Charles Darwin University. The AINSE executive committee has been the most effective since my arrival at AINSE and I look forward to exciting years ahead. I also extend my thanks to all those from the universities and ANSTO, there would be hundreds, for their help and advice throughout the year.

I thank Irene Parker for her loyalty to AINSE over more than a decade; Rachael Bell who laboured on valiantly for most of the year; Ben Thompson for his energy and enthusiasm and Sandy O'Connor for her support with the book keeping.

Finally, a special thanks to Peter Thompson who negotiated the final wording with the contributors and compiled the research highlights sections.

In the meantime ANSTO is proceeding with the development of a neutron reflectometer that will be of great interest to researchers working on molecular films, colloids and surface structures. This instrument will be used with HIFAR before being transferred to the new facilities of the RRR.

AINSE researchers have also continued to bid successfully for time on the neutron spallation source (pulsed neutron source) (ISIS) in Oxford (UK). Access is determined by peer review of the projects and the subscription for access is underwritten by AINSE and an ARC LIEF grant.

Recently the federal government set up taskforces to review the national research infrastructure and a review of collaboration between universities and major nationally funded research institutions. AINSE made submissions to both taskforces. What emerged from the presentations made and the subsequent discussions and reports, was that AINSE represents an excellent model for facilitating collaboration and access of Universities researchers to major publicly funded research institutions such as ANSTO and thereby contributes significantly to the effectiveness of the national research infrastructure. It was most pleasing that the value of the AINSE model was recognized in these reviews.

A decision was made by Council in last year to initiate the development of a strategic plan for AINSE and much effort was devoted in 2003 by the Executive to this task. AINSE is particularly indebted to Dr. Stephen Thurgate, the Councillor for Murdoch University, for providing a major input into this process. The new Strategic Plan was debated and adopted at the Council meeting held in Perth at the end of 2003. Details of the Strategic Plan can be seen on the AINSE website. In essence it:

- allows for a wider scope for membership of AINSE by institutions other than Universities such as Museums, Hospital and other Research establishments, including CSIRO.
- provides for the inclusion of additional research facilities (other than those at ANSTO) to come into the AINSE portfolio.
- sets targets for increasing the quantity and quality of AINSE supported research and to provide indicators to monitor the research outcomes.

Implementation of the Strategic plan will have profound impacts on the very nature of AINSE and the way it operates. I am confident, however, that the enlarged scope provided for in the Strategic Plan will allow the highly successful AINSE model to be extended into new areas. It will open up new opportunities for AINSE to provide the vital link between researchers and institutions using nuclear techniques and instrumentation in a wide range of disciplines. In particular, the construction of the Australian Synchrotron in Victoria is of special interest to AINSE and its member researchers. To this end AINSE has already initiated discussions both to explore access to this future facility for AINSE researchers as well as to support the development of beam line instrumentation.

The past year has been a very busy one for AINSE. I would like to thank the members of the Executive for their valuable input and collegiate support. AINSE is now set to move forward and the year 2004 should prove an interesting one.

Research Highlights

Archaeology and Geosciences

Lake Carpentaria

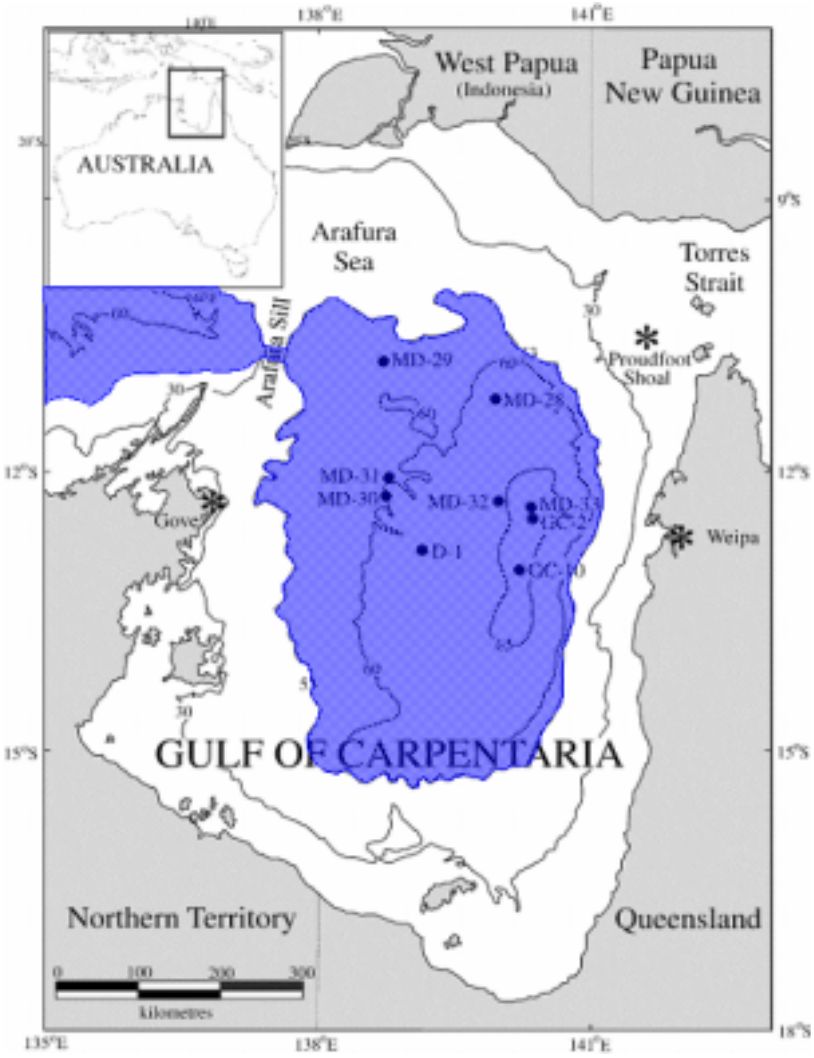
The Gulf of Carpentaria in northern Australia is today a large embayment connecting the Indian and Pacific Oceans. Throughout much of the past two million years, when sea-levels were commonly lower than that of today, the Gulf was a lake, bordered by land bridges between Australia and New Guinea at Torres Strait in the east, and the Arafura Sill in the west. At times, the lake was very large, encompassing an area substantially larger than Tasmania.

A study of the sediment cores recovered from the floor of the present Gulf has been used to identify the timing of the lake's most recent filling and helping to pinpoint past variations in monsoonal rains which maintained water in the lake. The land bridges around the lake are the likely sites of human migrations into Australia.

A group at the University of Wollongong including Professor Allan Chivas, Drs Adriana Garcia and Dioni Cendon, together with PhD students Jessica Reeves, Sabine Holt and Martine Couapel, has provided a record of the lake's history for the past 130,000 years using a variety of chemical and dating techniques and a detailed examination of the organisms preserved in the sediments.

Collaborative research with Dr David Fink, at ANSTO, using Accelerator Mass Spectrometry (AMS) carbon-14 dating, provided detail of the lake's more recent history by dating small shells including molluscs and ostracods. Twenty thousand years ago, at the last glacial maximum, Carpentaria was a nearly-dry lake basin with negligible monsoonal rain. By about 15,000 years ago, the monsoon became more intense and the lake began to fill fairly rapidly. By 12,000 years ago, freshwater from the lake was overflowing with into the Arafura Sea to the west.

At about this time the sea-level had risen sufficiently to flood back into the lake, also from the west, and converted the area into a large embayment of the sea. About 7,500 years ago, with sea-level rising further, the land bridge at Torres Strait was breached to form a seaway between Australia and New Guinea, a position maintained until today.



Map of the shorelines of Lake Carpentaria (darker blue) and its connection to the ocean at about 12, 000 years ago. The pale blue pattern indicates the current shorelines and the contours are the present water depths.

The sample points in the central area of the Gulf mark the sites of drill cores

Thailand abandoned for centuries

Bronze and Iron Age settlement mounds from approximately 500 BC – 1300 AD in north east Thailand are among the most significant sites in south east Asia. Study of these sites is critical as it provides key evidence of the relationship between human behaviour and environmental process during a period of increasing cultural complexity in this region.

AINSE Postgraduate Scholar Jeremy Habberfield-Short, from Southern Cross University, has been dating the accumulated occupation debris that make up these important archaeological sites using ANSTO's Accelerator Mass Spectrometer (AMS). He has been addressing two major questions.

First, the archaeological evidence suggests long-term intensive settlement; was this really so? Secondly, how much did environment influence social and cultural development?

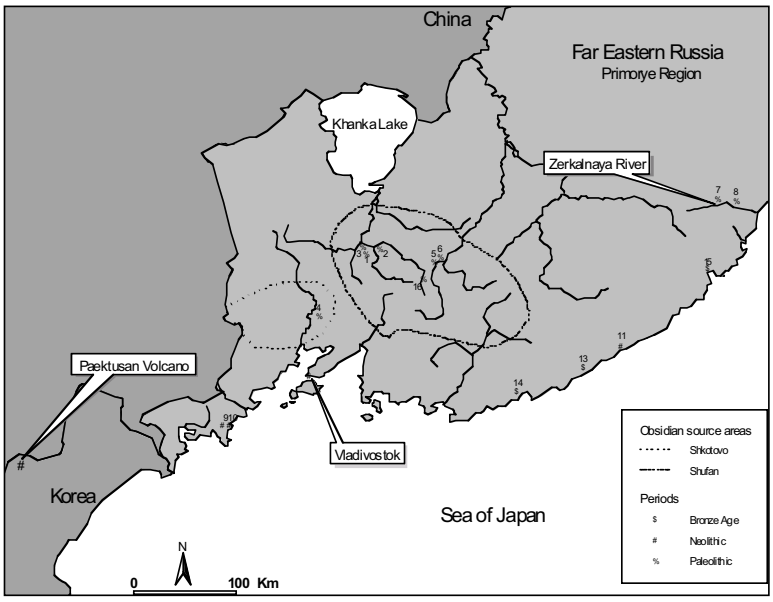
By defining the palaeoenvironmental conditions under which these sites formed, and their sedimentary histories, Jeremy has been able to identify site formation histories more complex than hitherto thought, linking environmental change with social change and cultural development. Jeremy's chronologies describe a history of periodic occupation, rather than the previously presumed continuous occupation, on individual sites, related to the construction of surrounding drainage earthworks. Periods of abandonment, lasting several centuries, are typical of this occupation history, and may be related to fluctuations in environmental conditions.

Left: Archaeological excavation at Ban Non Wat. Jeremy, central back, records sediment sections, while the project's villager employees assist. The excavation in the foreground is through late Iron Age sediments, while the ladder in the background stretches down to Bronze Age horizons (Photo: Steve Abbott)

Path-breaking Trading Networks

The presence of obsidian and basaltic glass artefacts in the Primorye region in Far East Russia represents a very early and important example of overland transport. The geological source region of these Palaeolithic artefacts was determined by comparing their elemental compositions with those from samples collected at outcrops that may have been used.

A collaboration between Dr Robin Torrence of The University of Sydney and the Australian Museum, Trudy Doelman of the University of Sydney, and Nina Kononenko of the Institute of History, Archaeology and Ethnography of the Peoples of the Far East Vladivostok, Russia has used Proton-induced X-ray Emission (PIXE) and Proton-induced Gamma-ray Emission (PIGME) studies in the comparative analysis of the chemical composition of obsidian and basaltic glass from the archaeological sites with that of samples collected at specific outcrops.



Above: Basaltic glass artefacts possibly dating to the Pleistocene found near the quarries in Far East Russia

The PIXE-PIGME results demonstrate that as early as 12,000 years ago, obsidian from the Paektusan volcano, located on the border between China and Korea, was moved as much as 200 km to the basaltic plateau in central Primorye. At the same time basaltic glass was also being used in the vicinity of the sources. Later, obsidian and basaltic glass from three source regions were transported up to 700 km to coastal sites. The results indicate that exchange of these raw materials was used to create social links among groups with access to resources in other areas. This may have been important during a time of climatic change.

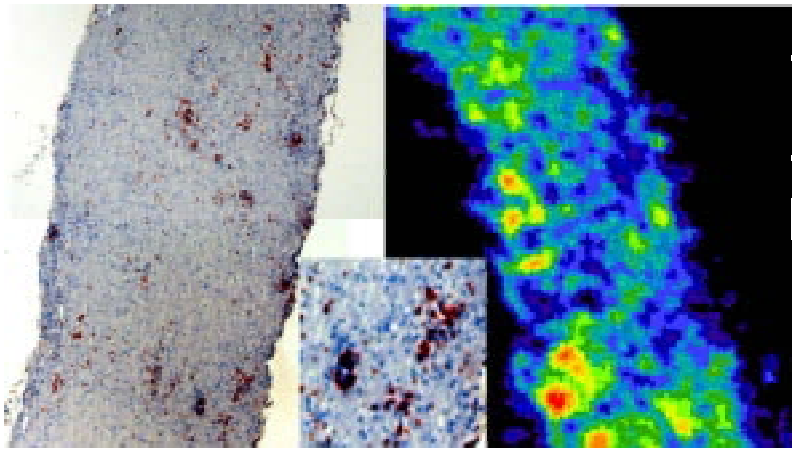
Left: Map showing the region where the basaltic glass artefacts were found

Research Highlights

Biomedical Science and Biotechnology

Imaging multiple sclerosis

One of the hallmarks of multiple sclerosis (MS), as well as some neurodegenerative diseases, is the infiltration of blood leukocytes and macrophages into the brain and spinal cord. This is accompanied by activation of resident cells in the brain called microglia. This, first causes a loss of myelin insulating the nerve, and then loss of the nerve itself leading to permanent functional deficits. Since these non-specific inflammatory cells (macrophages and microglia) appear to be the main cause of tissue damage, direct visualisation of their accumulation and/or activation in the central nervous system (CNS) is of considerable interest.



Comparison of positron emission tomography (PET) scans with tissue sections shows that the radiolabel binds to the inflammatory cells

Peripheral benzodiazepine receptors (PBRs) are present in significantly greater quantity in the inflammatory cells mentioned above than in the normal central nervous system. Therefore, the appearance of PBRs in the CNS is a sign of neural inflammation and damage.

A team comprising Dr David Willenborg and Dr Maria Stakykova at the Neurosciences Research Unit, ANU Medical School, and Filomena Mattner, Dr Andrew Katsifis, Patrice Ballantyne and Jeanette Chapman from ANSTO Radiopharmaceuticals have developed a small molecule that attaches only to the PBRs. By radiolabelling this molecule they can detect neural inflammation.

In an animal model of MS they have shown that the labelled molecule enters the CNS where it binds very tightly to the PBRs. An interesting development is that the molecule used in this research may also act in destroying the inflammatory cells thus being a possible therapeutic agent for CNS inflammatory diseases.

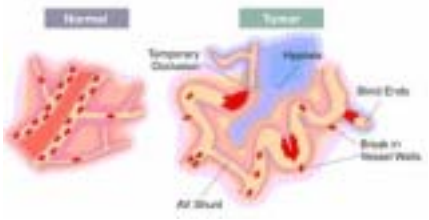
Radiotherapy – the next step

Radiotherapy fails to eradicate solid tumours in part because of the presence of a small fraction of cells that do not have enough oxygen. These hypoxic cells which are a consequence of the chaotic blood supply in the growing tumour - see the figure below - may survive radiotherapy treatment to repopulate the tumour and cause relapse for the patient.

Dr Michael Hay and collaborators at the Auckland Cancer Society Research Centre and Stanford University have been developing potential drugs that selectively target the hypoxic fraction of solid tumours. These hypoxia-selective drugs are not toxic to normal oxygenated tissues, but undergo activation in the absence of oxygen to a cytotoxin capable of killing cancer cells. These drugs have to be inert in normal tissue and able to diffuse through oxygenated regions of the tumour until they encounter cells with low oxygen levels which are resistant to radiotherapy. The drugs are then activated by enzymes present in the cells and kill the cells.

One important parameter to optimise in the design of these hypoxia-selective drugs is the reduction potential of the drug. This parameter influences the ability of the drug to reach the target cell population and to be activated when it reaches that target population. Associate Professor Robert Anderson is measuring the reduction potential using the University of Auckland/AINSE Linear Accelerator/Pulse Radiolysis facility.

The team identified a range of compounds with excellent *in vitro* properties and are currently developing several leads *in vivo*, against mouse tumours, in combination with radiation.



Tumor hypoxia results from differences in the vasculature between tumor and normal tissues

Potential tumour imaging agent

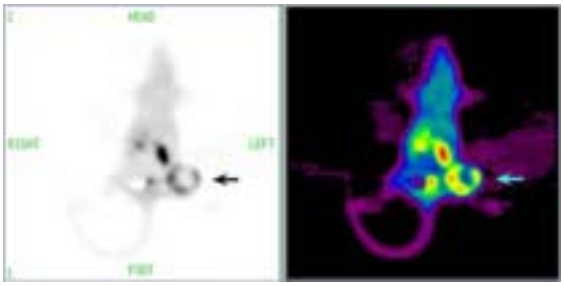
Positron Emission Tomography (PET) allows the rapid and repeated non-invasive assessment of the many biological processes implicated in cancer. Short-lived positron emitting radionuclides such as fluorine-18 and carbon-11 allow visualisation of these biological processes at the molecular level.

One such process that has been exploited to assess tumours has been the visualisation of glucose metabolism using fluorine-18 fluorodeoxyglucose (FDG).

While FDG is highly sensitivity for most tumour types it is relatively insensitive for detecting tumours in the brain due to high levels of glycolytic metabolism in normal brain tissue. Also, it has an imperfect specificity for whole body imaging due to uptake of FDG in various benign conditions, including infection and inflammation.

Professor Rod Hicks, Dr Peter Roselt and Peter Eu, at the Peter MacCallum Cancer Centre in collaboration with GE Medical Systems and Dr Andrew Katsifis and his research group at ANSTO Radiopharmaceuticals have embarked on the development of the amino acid metabolism imaging agent fluorine-18 fluoroethyltyrosine (FET). Early results show great promise for imaging brain tumours. Unlike FDG, FET is not influenced by glucose levels, and should therefore provide better cancer detection in diabetic patients.

With the aid of a newly acquired small animal PET system scientists at the Centre are also providing stark evidence for the localisation of FET in tumours using murine tumour models (see figure). As a direct result of this research, clinical trials have been scheduled in patients suffering from primary and secondary brain tumours in the hope that FET PET can provide complementary information to FDG PET regarding the presence and grade of tumour.



Small animal PET image of a squamous cell carcinoma deposit in the left hind limb of a mouse that has been injected with FET. The tumour pointed out by the arrows displays heterogeneous FET uptake with greatest avidity at its periphery. Reduced FET uptake in the centre of the tumour is indicative of cellular necrosis.

DNA damage by ^{123}I decay

Iodine-123 is a member of a special class of radioactive isotopes characterised by the emission of very low energy electrons known as Auger electrons.

The consequent short range of these electrons means that Auger-emitting radioisotopes produce an intense focus of radiochemical damage. The most studied example is ^{125}I. When a decay event occurs, on or close to a DNA molecule, it induces a cluster of breaks in the DNA strands, resulting in a double-strand scission. For DNA in cells, 50-100 such decays is sufficient to kill the cell.

While ^{125}I-labelled precursors, or “building blocks”, of DNA can be used to incorporate the isotope into the DNA of cancer cells, the discovery that DNA-binding drugs labelled with Auger emitters bring the isotope close enough to DNA to produce equivalent damage has increased the scope for exploitation of such isotopes for treatment.

With radioprotection in mind, the relatively long 60 day half-life of ^{125}I is troublesome in clinical application. Accordingly there is interest in ^{123}I with its half-life of only 13.2 hours. However, the ^{123}I decay event is not as intense as that of the ^{125}I counterpart.

AINSE funded this project led by Associate Profession Roger Martin from the University of Melbourne to investigate the efficiency of DNA double-stranded breakage induction by a DNA ligand labelled with ^{123}I.

The results show that the relative DNA breakage efficiency for ^{123}I versus ^{125}I is 0.6. Although this reduction of efficacy is significant, this compromise is probably out-weighed by the advantages of the much shorter half-life and its implication for radioprotection.

Research Highlights

Environmental Science

Honey-powered Possums!

The tiny marsupial honey possum, weighing in at only 9-10g, is unique in relying for its survival entirely on a diet of nectar and pollen gleaned from Banksia blossoms in the southwest of WA. Although not yet declared endangered, its future is insecure owing to a drastic reduction in its range caused by land clearing and urban development.

Honey possums have relatively low rates of reproduction when compared with similar-sized possums that do not subsist on high carbohydrate diets such as nectar, and it is thought that their highly unusual diet may be deficient in digestible protein and essential amino acids.

An AINSE-funded research program by Professor Don Bradshaw and Ms Felicity Bradshaw at the University of Western Australia is focusing on measuring rates of nectar and pollen intake in free-ranging individuals (using the isotopes ^{3}H, ^{18}O and ^{22}Na) and determining levels of protein turnover with ^{15}N.

ANSTO's linear accelerator is used to measure enrichment levels of ^{18}O in the tiny blood samples that can be taken from this animal without harm. Excretion rates of injected glycine-^{15}N are used to estimate rates of protein turnover.

Preliminary results suggest that the possums ingest approximately 1g of pollen per day, which is more than adequate to maintain nitrogen balance, but perhaps limiting when young are being fed and growing.

Honey possums feeding on a banksia blossom

The importance of history

"The 2002 drought was the largest on record …", "The Murray River has never been this salty ...", "The Snowy River is well on its path to recovery …". These are some of the claims made via the media in the last year.

An historical dimension must be sought to determine the strength of such claims.

A research group at the University of Adelaide is focussing directly on that historical context to explore the degree to which recent human activities have impacted on natural waterways. In association with several AINSE Awards, Drs Peter Gell, John Tibby, Jennie Fluin and co-workers are utilising the siliceous remains of fossil diatoms in lake sediments to examine changing water quality, and in some instances, changing climate. Fine resolution analysis of 100-500 year old sediment sequences, supported by caesium and lead chronologies, measured at ANSTO, are providing the temporal context critical to an understanding of our present environmental plight.

There are three contrasting stories of salinity and lake water change.

One billabong on the Murray shows wetlands going saline in the 19th century. Another on the Snowy is as much as fifty times more saline than a century ago when it received its full entitlement water from the Snowy. By contrast a lake managed today as a freshwater system was in fact naturally brackish until the early 20th century.

Expansion of range of toxic dinoflagellate

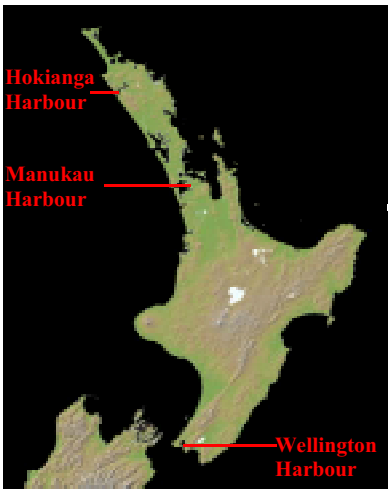
Consumption of oysters infected with *Gymnodinium catenatum* leads to paralytic shellfish poisoning (PSP) and possibly death. *G catenatum* is a toxic dinoflagellate that has now naturalised in coastal waters of many areas in southern Australia. It was first noticed in Australia in Tasmania in the Derwent estuary in 1986, it is now responsible for the regular closure of shellfish farms.

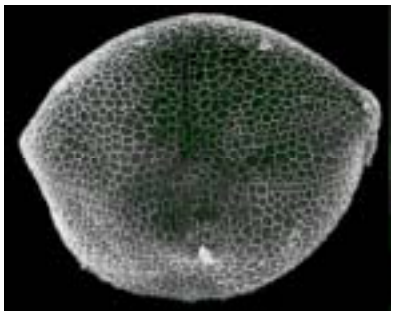
After its initial recognition in Tasmania, *G catenatum* spread to other areas, including Port Phillip Bay and Port Lincoln. The main vector of spreading is thought to be ballast water transport.

In May 2000, PSP toxins were detected near Manukau Harbour, North Island, New Zealand. It subsequently spread north and south to cover 1500 km of coastline and did not decline until February 2001. *G. catenatum* had not previously been reported in New Zealand.

To address speculation that the organism is a recent introduction into New Zealand Dr Andrew McMinn, Dr Gustaaf Hallengraeff and Amy Lovell from the University of Tasmania, took sediment cores from Manakau in the north to Wellington in the south. The chronology of the cores was established using Pb-210 dating.

These cores established that *G. catenatum* has been present in northern North Island since at least 1980 despite not being noticed previously. However, it has only been present in Wellington Harbour since 2000, and this reflects a significant expansion of its range and consequent threat to the New Zealand shellfish industry





Colony of living Gymnodinium catenatum

Left: a cyst of Gymnodinium catenatum, which survive for many years in sediments and are capable of being transported around the world in ballast water.

New markers for studying land erosion

Soil erosion and degradation continues to be a major issue in the management of land resources in Australia and other parts of the world. For some time, the unique signature of caesium-137 (^{137}Cs) – from atmospheric nuclear tests has enabled estimates of land erosion and soil redistribution.

The role of ^{137}Cs in land erosion studies is decreasing for a number of reasons: an end to above-ground nuclear testing; the natural transport of material downward in the soil profile; and ^{137}Cs is not suitable for use in marine and estuarine environments or areas where the soil is salty.

An AINSE supported study to investigate the suitability of ^{210}Pb and ^{7}Be for use in soil erosion and redistribution studies, compares the spatial and vertical variations in ^{210}Pb and ^{7}Be with the corresponding values of ^{137}Cs obtained for the same set of samples.

Dr Lidia Morawska and co-workers from Queensland University of Technology examined soil samples from south east Queensland with gamma ray spectroscopy using a Compton suppression system was used to measure ^{210}Pb, ^{226}Ra, ^{7}Be and ^{137}Cs radioactivity.

Results show that excess ^{210}Pb inventory increases with soil depth but with a decreasing contribution from the layers underneath. This trend is promising for its potential use as a surface soil marker for redistribution studies.

^{7}Be radioactivity remains predominantly in the surface 0-1cm with no signal below 2cm of soil. The short half life of ^{7}Be is probably responsible for this behaviour; it disintegrates before it disperses to the lower layers of the soil. Measurement of ^{7}Be inventories may be useful for rapid soil movement estimates and redistribution over the scale of a few months.

A small sample like this carries information about erosion and redistribution of soil when measured using nuclear techniques

Research Highlights

Materials – Properties and Engineering

Functionally-graded Ti_3SiC_2–TiC composites

Ti_3SiC_2 is a ternary carbide with a micro-layered microstructure which displays a unique combination of properties not normally found in ceramics, see figure 1. It is a better thermal and electrical conductor than titanium metal, is resistant to thermal shock, and is relatively light. However, unlike traditional binary carbides like WC, SiC and TiC, which are among some of the hardest, stiffest, and most refractory materials known, Ti_3SiC_2 is relatively soft and not wear resistant.

To overcome this problem Associate Professor Jim Low, David Lawrence and Zeya Oo at Curtin University used a controlled high-temperature heat-treatment of Ti_3SiC_2 in vacuum to deposit a surface graded layer of hard-wearing TiC see figure 2.

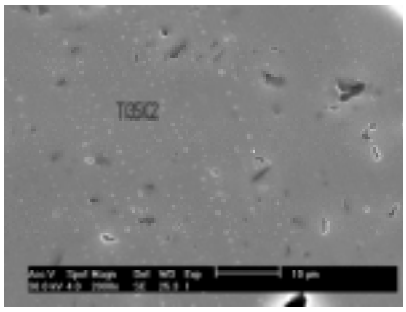
The phase evolution and the graded nature of this system have been characterised by x-ray diffraction at Curtin University, neutron diffraction at ISIS, UK and ANSTO and grazing-incidence synchrotron radiation diffraction at the Photon Factory in Tsukuba, Japan.

Results show that a TiC layer commenced to form near the surface of Ti_3SiC_2 at 1200∀C in vacuum or in argon and grew rapidly in thickness with rising temperature to 1500∀C.

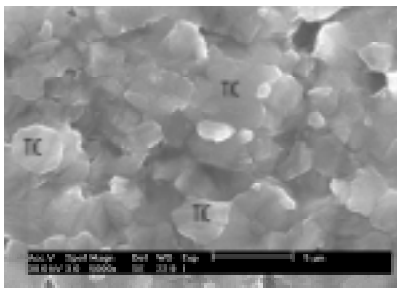
Such a hybrid system of $Ti_3SiC_2$4TiC is expected to display superior properties in applications where resistance to damage, wear and heat is essential, notably in wear-resistant components such as cutting-tools. Other potential uses include automobile and aircraft engine components, rocket engine nozzles, aircraft brakes, and racing car brake pads and discs.

Figure 1

SEM photo of a typical microstructure of polished and chemically-etched Ti_3SiC_2.



(a)



(b)

Figure 2

SEM photos of a polished Ti_3SiC_2 sample showing the microstructure (a) before and (b) after the vacuum heat-treatment at 1500 ∀C for 6 h.

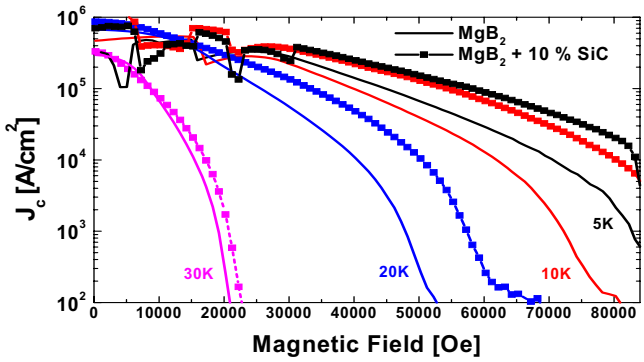
Newly discovered MgB_2 superconductors

In January 2001, a totally new superconductor was discovered. magnesium diboride (MgB_2) has a surprising high critical temperature of 39K. Previously the highest temperature for a metallic superconductor - niobium tin - was 20 K. The new superconductor could be cooled using conventional electrical refrigerators.

For practical applications, the new compound needs to carry large superconducting critical current in high magnetic fields and high temperatures.

In collaboration with ANSTO the team at the Institute for Superconducting and Electronic Material, University of Wollongong significantly improved the superconducting performance of the MgB_2 compound through nano-SiC chemical doping and hot isostatic pressure technique. The samples they made can carry world-record high super-current at high temperatures and in high magnetic fields, reaching the level for practical applications.

Since magnesium and boron are both cheap and abundant, practical long-length conductors made with the doped MgB_2 may eventually replace conventional niobium-based low temperature superconductor and sterling silver-clad copper oxide based high temperature superconductor.



Super-current vs magnetic field for pure and 10 wt % nano-SiC doped MgB_2 made by hot isostatic pressure technique.

Ceramic filters

ANU post-graduate student Tony Flynn and his supervisor Dr Zbigniew Stachurski are developing a strong, sintered, porous ceramic material that includes a three-dimensional network of interconnected pores within its structure. The ceramic comprises inexpensive, readily available materials and has potential uses in selective filtration and fraction recovery from gases and fluids; catalysis; slow release mechanisms; and in basic insulating and structural applications.

Flynn and Stachurski want the structure to be capable of allowing passage of gases and fluids at a range of pressures and ideally to be a structure that could be formed by fusing solids at temperatures between 1000-1500°C.

In order to determine conditions for the formation of a structure with optimal strength and capacity, a range of samples of varying composition were fused at a number of temperatures between 1000-1500°C. Shrinkage of the pores as the samples fused was measured in a laser dilatometer furnace at ANSTO Materials and Engineering Science. Results obtained at this facility were not obtainable for any other source available to the researchers.

These results have permitted the achieving of precise firing cycles that permit both maximisation of strength and articulated porosity in samples.

Research Highlights

Materials – Structures and Dynamics

Developing a sensor for free iron in seawater

Iron is a limiting trace metal nutrient regulating the growth of primary food sources such as phytoplankton. Free iron in seawater regulates the uptake of iron by marine biota. Being able to monitor the free iron allows assessment of the environmental impact of it on the marine ecosystem.

Existing techniques are not capable of monitoring free iron in seawater. This work by Associate Professor Roland De Marco, Associate Professor Craig Buckley, Dr Alberto Zirino, Professor J Ross Macdonald, and Mr Bobby Pejcic at Curtin University and Professor Stephen Thurgate from Murdoch University, aims to develop a sensor which can monitor the free iron in seawater.

The major source of iron is through deposition of material from land. Isolation from land limits this important nutrient as can be seen in figure . This SeaWiFS satellite image shows a “doughnut”-shaped phytoplankton “bloom” in the Southern Ocean resulting from iron fertilization of a selected oceanic site.

The nanochemistry of the iron sensor is being investigated using small angle neutron scattering, with a view to developing improved sensor materials. Work to date has revealed the necessity to strike a delicate balance between the electron transfer and ion-exchange in the nanostructured network of the sensor if a functional sensor is to be obtained.

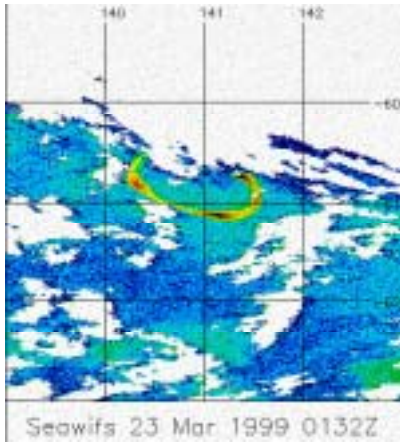


Figure 1. This image appeared on the cover page of the 12 October 2000 issue of Nature as a result of the seminal paper by Abraham et al. (Nature, Vol. 407, pp. 727-730, 2000).Courtesy of CSIRO Marine Research - NASA SeaWiFS Project and Orbimage.

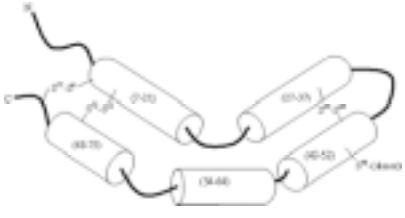
Lung surfactant ‘squeeze out’

In humans and other mammals the fluid that forms the interface between lung tissue and the atmosphere is an aqueous mixture of phospholipids, known as natural lung surfactant. A lack of natural lung surfactant leads to a condition known as Respiratory Distress Syndrome (RDS), which is one of the major causes of mortality and morbidity in premature infants. Current treatments are not as effective as desired, and use materials derived from animal sources which can have undesirable consequences.

The structure and properties of the surfactant lipids are altered by surfactant-associated proteins. It is known that absence or mutations of one of these, SP—B, leads to severe respiratory problems. SP—B is believed to mediate the transfer of lipids between the monolayer and air-water interface and various structures in the alveolar fluid but the mechanism for this is poorly understood.

In this work Dr Wilfred Fullagar and Associate Professor Ian Gentle from the University of Queensland and Dr Stephen Holt from the Rutherford Appleton Laboratory in the UK used x-ray and neutron reflectometry to study the interfacial structure of SP—B as a function of surface pressure and to study mixtures of SP—B and the predominant phospholipid, dipalmitoylphosphatidylcholine (DPPC), at the air-water interface as a function of surface pressure.

Results show that when the SP—B is mixed with DPPC the system responds much more readily to compression. Initial interpretations advance the understanding of the mechanism affecting the solubility SP—B. Improving the understanding of the role of lung surfactant proteins is necessary to the long term goal of developing a totally synthetic therapeutic preparation for RDS.



Possible unfolded state of the protein at the interface, where the barrels represent alpha helices, indicating retention of secondary structure

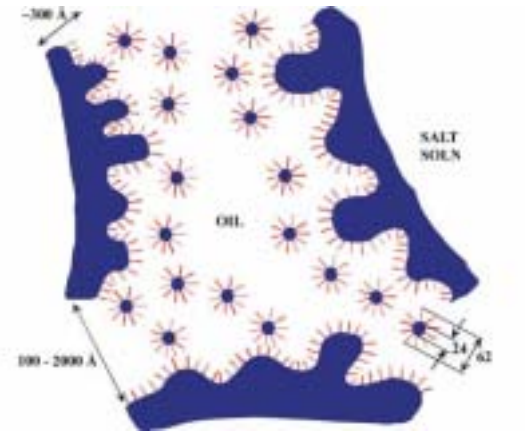
Inorganic films, protein solutions, and emulsions

At the ANU Research School of Chemistry Professor John White, Dr Philip Reynolds, Dr Mark Henderson, Dr Rama Heidari, Dr Johann Zank, Mr Adam Perriman and Mr Krisztian Baranyai utilised the uniquely valuable surface neutron reflectometry instruments at ISIS, in the UK, to investigate the growth of highly crystalline inorganic films.

White's team has discovered that thin silicate films grown at the air/water interface using surfactant templates are highly oriented and have cylindrical micellar structures parallel to the surface. Investigation of the mechanisms by which these structures form at the air-water and solid interfaces is allowing the making of new inorganic materials.

In a world-first, the team has found the thermodynamics of thermal denaturation of protein solutions. They are examining how to control the level of denaturation to reach metastable states. As many biological structures form at interfaces, these studies may prove valuable for understanding and possibly treating diseases where partial or full protein denaturation occurs, for example Alzheimer's disease. The ability to measure at temperatures up to 80C has been of key importance in this work.

Neutron contrast variation is allowing the team to investigate the structure and stability of emulsions to gain "images" of the core, the surfactant coating and the exterior of emulsion droplets. New structures at the nanoscale have been discovered as well as how they influence emulsion properties. The team is using mixtures of surfactants to stabilise emulsions and produce desirable properties. Currently they are focusing on oil/water emulsions and the milk fat membrane.



Cartoon of a typical emulsion at nanoscale resolution

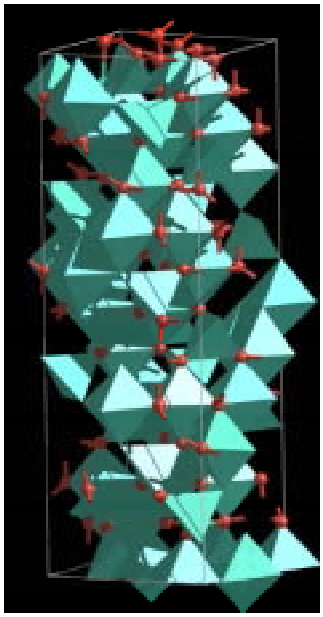
A universal structural model of ν-alumina

ν-Alumina is an industrially important material, with applications in the automotive, petroleum and pharmaceutical industries, in wear ceramics, in structural composites in the aerospace industry, and in miniature power supplies. Nanocrystalline ν-alumina has recently been shown to be thermodynamically stable and this paves the way for a wide range of other applications.

Despite the wide use of ν-alumina there is still disagreement over the nature of its structure. Greater knowledge of its structure will greatly assist in processing and developing new applications.

AINSE postgraduate scholar Gianluca Paglia, at Curtin University of Technology, has performed a comprehensive study on the structure of ν-alumina, under supervisors Associate Professor Craig Buckley and Associate Professor Andrew Rohl from Curtin University of Technology and Dr Brett Hunter from ANSTO. From analysis of neutron diffraction data obtained using from the facilities at ANSTO, and cross-checked with nuclear magnetic resonance and electron diffraction data, Paglia derived a new structural model for the structure of boehmite-derived ν-alumina. Paglia conducted the most comprehensive computational investigation to date of possible structures of ν-alumina, in the order of 1.5 billion, using interatomic potentials and density functional theory. Computational models were compared with the experimental findings.

In addition to providing a more realistic representation of the structure, this research has also served to advance knowledge of the evolution of the crystal structure with changing temperature and makes new insights into the location of hydrogen in ν-Al_2O_3.



Example ν-alumina structure after optimisation of a possible structural configuration

The AINSE Winter School

Nuclear techniques applied to natural processes

The seventh AINSE Winter School on nuclear techniques applied to natural processes was held at the Lucas Heights Science and Technology Centre from Saturday 5 July to Wednesday 9 July 2003 with a great deal of input from ANSTO and university staff.

Thirty-six students participated in the Winter School; their academic interests were declared as follows: physics 10, chemistry 9, biology 6, biomedical science 3, biochemistry and molecular, geoscience 3, nuclear medicine 2, engineering 2, archaeology 1.

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

• neutron scattering

• natural radioactivity

• radioactivity and the living world

• radiation chemistry

On the Saturday Dr Kirsten Benkendorff, from Flinders University spoke on her research *Molluscan Medicines: Research at the interface of biology and chemistry* Dr Benkendorff received NSW Young Australian of the Year Award for the Environment in 2001.

On the Monday A/Prof David Jamieson's, presentation was entitled *The rediscovery of Australia: an unfinished tale of mystery, conspiracy and intrigue.* A/Prof Jamieson's is Director of the Microanalytical Research Centre and Program Manager of the Centre for Quantum Computer Technology at The University of Melbourne.

Matthew Shaw, The University of Canberra not spilling a drop

Thanks

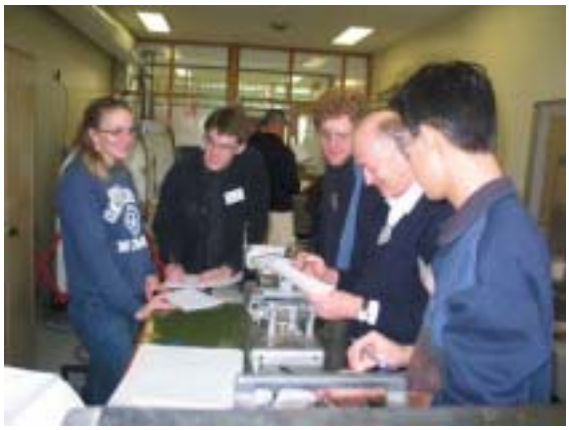
AINSE is indebted to Professor Helen Garnett, ANSTO's Executive Director, for supporting the Winter School, to the many ANSTO staff members who contributed their time and talent, to Gerald Laurence, Julia James, David Sangster and Ken Doolan from the universities involved in the planning and implementation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

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

Rishni Ratnam, The University of Newcastle demonstrating skill with a pipette

Right: Sarah Beavan Queensland University of Technology and, demonstrator Till Böcking UNSW

Above April Morton from Central Queensland University in a pensive moment



Above: Joanna Graaf The University of Auckland, Adam Palmer The University of Adelaide, Morgan Hedges The University of Wollongong, Dr Ken Doolan University of Western Sydney and Lyndon Jee Curtin University of Technology at work on the radiation experiment

Right: Suyog Belbase from the Australian Catholic University, Sara Khor from Monash University and Rishni Ratnam from The University of Newcastle

2003 Conferences & 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.

15th International Symposium of Radiopharmaceutical Chemistry

The 15th International Symposium of Radiopharmaceutical Chemistry was held on 11 -14 August 2003 at the Sheraton on the Park Sydney. It was sponsored by ANSTO and AINSE provided travel and accommodation support to student contributors from member universities. There were 440 participants including , including 380 foreigners from thirty seven countries, plus twenty sponsors and exhibitors attended the symposium.

The symposium consisted of six keynote Plenary Lectures, 101 oral presentations, 300 posters and two workshops. The keynote speakers included Prof Alex Levitzki, who spoke on Signal Transduction in Cancer, Prof Ronald Hubner, Prof Roger Uren, Prof Mark Wilkins who spoke on proteomics, Prof Yasushuiha Fijibayyashi who spoke on gene therapy and Prof Curt Freed who spoke on stem cell research.

12th International Congress of Radiation Research

The 12th International Congress of Radiation Research was held on 17 - 22 August 2003 at the Brisbane Convention Centre. The Congress incorporated the annual scientific meeting of the Faculty of Radiation Oncology of the Royal Australian and New Zealand College of Radiologists, and the AINSE Radiation Science Conference. There were 1087 participants including 251 from Australia, the remainder came from thirty eight other countries. AINSE supported travel and accommodation for fifteen students and twelve academics from member universities who presented papers.

The program covered all of the major disciplines of radiation science, namely from physics, chemistry, biology and medicine. It included 9 congress and 8 plenary lectures, 267 papers and 650 posters.

The Congress was supported by 26 sponsors and exhibitors.

3rd Quaternary Dating Workshop

The 3rd Quaternary Dating Workshop conference was held on 1-2 October 2003 at Lucas Heights. This series of workshops is designed to showcase dating methods and new developments in the instrumental techniques which are available. The target audience is research students and young career researchers. This year there were 58 participants including twenty six students. Participants came from 13 organisations. Fourteen papers and seven posters were presented.

13th Nuclear Techniques of Analysis & 8th Vacuum Society of Australia Congress

The 13th Nuclear Techniques of Analysis & 8th Vacuum Society of Australia Congress was held on 26-28 November 2003 at Lucas Heights. There were 107 participants including 25 from ANSTO, 12 sponsor/exhibitors and 35 students. 33 papers and 57 posters were presented. Nineteen universities were represented.

2nd AINSE Symposium on Small-Angle Scattering and Reflectometry

The 2nd AINSE Symposium on Small-Angle Scattering and Reflectometry conference was held on 25-26 June 2003 at Lucas Heights. There were 69 participants from twelve universities and ANSTO Twenty three students attended. Twenty eight papers and twenty one posters were presented.