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INTERNATIONAL COOPERATION

Right to left: Prof. Simon Ringer addressing Commissioner Geoghegan-Quinn, Dr Don Russell, Secretary of DIISRTE and Mr David Harmon, EU Cabinet official.

European Commissioner visits the AMMRF

In March this year Ms Máire Geoghegan-Quinn, European Union Commissioner for Research, Innovation and Science visited the headquarters of the AMMRF at the University of Sydney with a delegation of several European advisors. The aim of the visit was to establish a bilateral relationship with Australia and to learn from Australia's successful strategy in the provision of research infrastructure.

The AMMRF, the Australian National Fabrication Facility (ANFF) and the Integrated Marine Observing System had been selected by the Commonwealth Department of Innovation, Industry, Science, Research & Tertiary Education (DIISRTE) to showcase the achievements of highly successful Australian collaborative research infrastructure.

The AMMRF was Ms Geoghegan-Quinn's first port of call during her three-day visit to Australia. She listened to presentations by Prof. Simon Ringer, Executive Director and CEO of the AMMRF and Ms Rosie Hicks, CEO of ANFF, on the nature of the infrastructure and the breadth of research that our organisations can enable. She engaged in a wide-ranging round-table discussion session with AMMRF and ANFF staff and DIISRTE officials. Ms Geoghegan-Quinn clearly recognises that the distributed collaborative network, that is so effective in Australia, is an excellent model for the EU research environment. Later, during an innovation and commercialisation showcase she met leading Australian researchers, including several high-profile AMMRF users. She also met for discussions with the Minister and Australia's Chief Scientist.

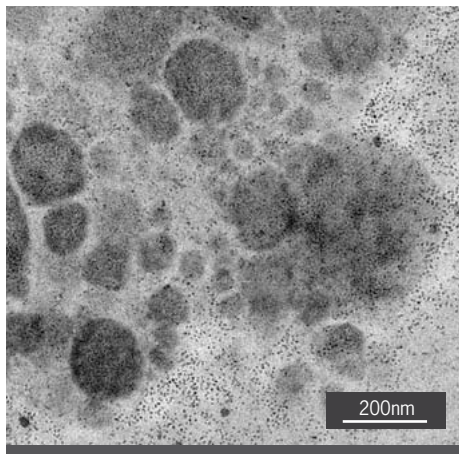
The AMMRF is also engaging directly with the European research community through the recent formalisation of a Collaborative Framework with EuroBioImaging.

Of the meeting Ms Geoghegan-Quinn said, "The work that is being undertaken here at the AMMRF is an excellent example of the importance of creating critical mass in key technologies, which is crucial to enable us to respond globally to the grand challenges facing the planet."

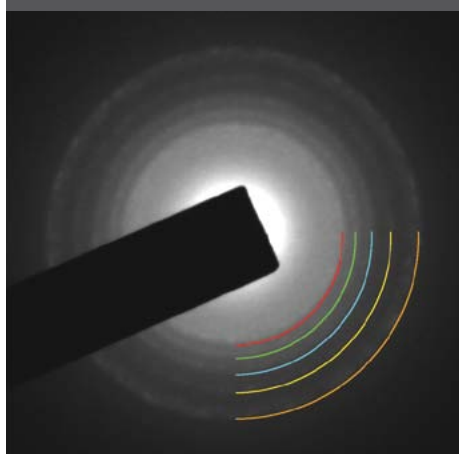
Prof. Simon Ringer said "We were very pleased that the Commissioner was able to visit the AMMRF. We have a vision to develop collaborative links with EU infrastructure that will be beneficial for both Australian and European researchers. The visit brings us significantly closer to realising this vision." ■

His Excellency Mr David Daly, Australian Ambassador to the EU, Commissioner Geoghegan-Quinn, Prof. Simon Ringer, AMMRF and Ms Rosie Hicks, ANFF.

RESEARCH



Transmission electron micrograph of the respiratory epithelium from a pigeon beak. The very small black dots in the above image are the iron cores of ferritin. The selected area diffraction pattern below was taken from a similar region and is characteristic of ferrihydrite.



Pigeon navigation does a U-turn

UWA

Pigeons are famous for their navigational abilities but the means by which they harness environmental cues to find their way around, often in conditions with minimal visual information, were a mystery for many years. Experimental evidence implicated magnetism as the main guiding factor but the nature of the sensory organs that detect the magnetic fields remains speculative. A logical candidate for a magnetoreceptor would be a cell containing the highly magnetic, crystalline, iron-containing mineral magnetite. The other requirement for such a sense organ is that it be part of the nervous system or intimately connecting with it so the information detected can be transmitted directly to the brain.

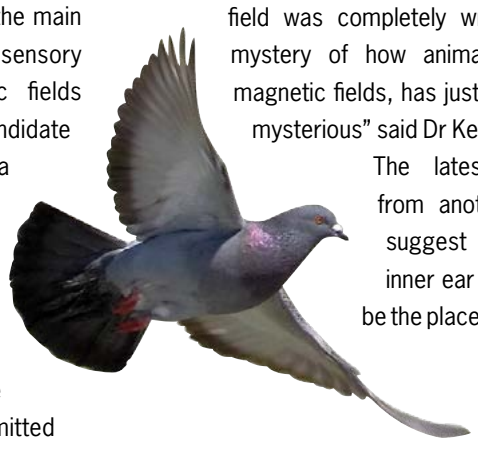
A report in 2003, that rapidly become dogma, suggested that iron-containing cells found in the upper beaks of pigeons were the proposed receptors. However, a new study published this April in *Nature*, caused quite a stir when it showed conclusively that this is not the case and the search for the elusive magnetoreceptors must go on.

The international team lead by Australian Dr David Keays at the Institute of Molecular Pathology in Vienna included Dr Jeremy Shaw and Prof. Martin Saunders from the AMMRF at the University of Western Australia (UWA).

Microscopy demonstrated that the iron-containing cells seen in the beaks are in fact macrophages (a type of immune cell) and not the nerve cells that magnetoreceptors would need to be if they are to function as a sensory receptor. By using sophisticated microanalysis in the AMMRF at UWA Dr Shaw and Prof. Saunders showed that the iron inside the cells was actually in the form of ferrihydrite inside iron-storage proteins. Macrophages all over the body contain iron in this form from the breakdown of old red blood cells. The macrophage cells in the beak are no different.

"Our contribution confirmed that the iron in the pigeon beak macrophage cells was just normal cellular iron, composed primarily of ferrihydrite, similar to that found in many other animals. Magnetite is the likely candidate for the magnetic material in a sensory organ because it is the only form of iron that is magnetic enough to respond to tiny differences in the Earth's relatively weak magnetic fields," Dr Shaw said.

"It took a team of Australians and Austrians to show that the established dogma in the field was completely wrong. The mystery of how animals detect magnetic fields, has just got more mysterious" said Dr Keays.



The latest results from another team suggest that the inner ear might just be the place to look. ■

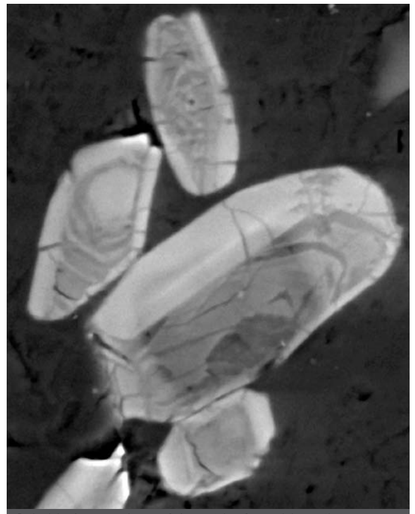
RESEARCH

Mysterious iron deposits explained

There is an enduring enigma around the formation of some of the Earth's iron formations. Most were deposited in the oceans before free oxygen first accumulated in the atmosphere about 2.4 billion years ago. However there are a few major formations in Australia and North America that formed somewhat later, around 1.9–1.8 billion years ago. During this period the Earth's atmosphere contained enough oxygen to have prevented these iron formations from occurring.

A group of scientists led by Prof. Birger Rasmussen from Curtin University and including Dr Janet Muhling from the AMMRF at the University of Western Australia (UWA) has solved the puzzle and reported their findings and ideas in *Nature* on April 26.

Firstly, the researchers found layers of volcanic ash within the Australian iron formation, and examination of those layers with a polarising-light microscope revealed the presence of zircon. Then, by using sensitive high-resolution ion microprobe analysis in the AMMRF Linked Lab at Curtin University they were able to date the zircon and show that the Australian and the North American deposits are definitely the same age (1.88 billion years old). The co-incidence of these two deposition events led the researchers to suggest that processes deep within the Earth radically changed the chemistry of the global ocean to allow the iron to be deposited.



Cathodoluminescence image of zircons taken from ash layers that were analysed to date the Australian iron formation. The alternating dark and light bands were formed by crystallisation from magma, indicating volcanic eruptions during formation.

It is known that at this time there was voluminous igneous activity with large regions of new crust being formed and noticeable amounts of mantle depletion (melting). This ties in with the evidence that giant volcanoes erupted both on land and on the sea floor, releasing large amounts of iron from the mantle. The supply of oxygen from all but the shallowest layers of the ocean would have been overwhelmed by the sudden influx of iron. This promoted the deposition of the anomalous iron formations in Australia and North America. Free oxygen remained in the atmosphere due to the burgeoning microbial life.

The equally dramatic disappearance of iron formations some 40 million years later can be explained as a consequence of rapidly waning igneous activity that allowed the ocean to become dominated by seawater oxidants once more.

The team's findings not only explain the sudden appearance and disappearance of iron formations around 1.9 billion years ago, but also explain the preservation of an oxygen-rich atmosphere above an oxygen-poor ocean. Understanding relationships between the chemistry of the hydrosphere and atmosphere, and deep Earth processes provides insights into the formation of the Earth.

COMMUNITY

Cooperation between AMMRF and EMBL Australia formalised

A Memorandum of Understanding (MoU) was recently signed by Prof. Simon Ringer, AMMRF Executive Director & CEO and Prof. Nadia Rosenthal, Scientific Head of EMBL Australia. The AMMRF and the European Molecular Biology Laboratory (EMBL) Australia are now formally cooperating to establish programs of research collaboration underpinned by the capabilities of the AMMRF. These programs will bring significant benefits to the communities served by both institutions.

Understanding *E. coli* infections

E. coli is the most common cause of urinary tract infections such as cystitis. Some people have an underlying genetic susceptibility to these infections and an understanding of the complete immunological response to these bacteria would be extremely valuable. Dr Glen Ulett and his group at Griffith University has examined the response of bladder tissue to *E. coli* infection in a mouse model and his recently published work reports that the activity of 1564 genes was altered on infection.

Scanning electron microscopy of infected bladders carried out in the AMMRF at the University of Queensland allowed Dr Ulett and his team to see the extent and nature of the bladder tissue damage caused by the bacterial infection. Armed with that knowledge he was able to correlate his observations with the extensive bank of genetic data. This work has generated a great deal of new information on which to base future studies into the variability of human responses to *E. coli* infection and to pinpoint more accurately potential targets for immune therapies in order to treat these infections. The research was published in the *Journal of Immunology* with a striking scanning electron micrograph from the study used on the journal's cover.

EXECUTIVE DIRECTOR'S COLUMN

I have often been heard to say that the AMMRF Operational Group meetings are the best of all the meetings I have to attend. Held every two months in rotating locations across the AMMRF nodes, the meeting brings together all the node directors and key AMMRF administrative staff. This is where strategic plans are hatched, equipment purchases discussed and importantly, it provides an opportunity for like-minded people to discuss the challenges of running centres of microscopy and microanalysis.

There is always an air of competition with directors given the chance to show off their latest achievements and successes as we deliver 'Round the Nodes' reports. In the last meeting, I have to say that Prof. David Sampson stole the show with his reporting of two *Nature* papers as a direct result of work at the node in Western Australia. Both of these papers are reported in this issue of the *News*. The work by Dr Jeremy Shaw and Prof. Martin Saunders on the pigeon navigation paper was picked up by Robin Williams of the *ABC Science Show* and featured on national radio. This type of success reflects the AMMRF's importance in Australian scientific achievement, highlighting the value of having quality collaborative characterisation instrumentation run by experienced practitioners.

We are continuing to build collaboration nationally and internationally with other microscopy-focused groups and organisations. Not only do these links reflect the esteem in which the AMMRF is held in research and infrastructure circles, they are vitally important networks that must nurtured as we look forward to building a sound future based on best-practice in the field.

Looking ahead, the Sunshine Coast in Queensland will host 90 delegates from round the nodes at the upcoming AMMRF Strategic Planning Workshop. I look forward to your contribution to debates, talks and activities that will strengthen our team and inform the direction of our organisation going forward.

I look forward catching up with people at the workshop.

Prof. John Drennan
AMMRF Scientific Director

Prof. Simon Ringer, our Executive Director, was on leave during preparation of this issue of the News.

INTERNATIONAL COOPERATION

Advanced Microscopy in Saudi Arabia

On March 3 2012 the Australian Ambassador to Saudi Arabia attended the signing of a Memorandum of Understanding (MoU) at the National Guard Health Affairs office in Riyadh, Saudi Arabia, by Prof. Aidan Byrne, Dean of Science at the Australian National University (ANU) and Dr Bandar Al Knawy, CEO of the National Guard Health Affairs (NGHA).

The MoU formally supported the existing relationship in which the Centre for Advanced Microscopy (CAM) the AMMRF node at ANU will develop and deliver a new online Master of Microscopy program in biology. The program begins in the second semester of 2012 with students from Saudi Arabia taking part.

ANU academics gave presentations on their field of expertise and Prof. Tim White, Director of CAM, introduced e-learning and online microscopy resources, using the AMMRF Technique Finder as an example.

The MoU brings benefits to both parties. NGHA is rapidly expanding its facilities and is looking to give their students access to an intensive practical qualification, which the ANU Master of Microscopy is uniquely designed to do. For CAM it supported the development of a series of academic programs from undergraduate through to PhD level by a team of highly skilled academic and technical experts who are actively seeking new ways to deliver microscopy education to local and international students both traditionally and online.

There are plans for another delegation of physical scientists from CAM to travel to Riyadh and Jeddah later this year.

MOU signing ceremony in Riyadh. The Australian Ambassador to Saudi Arabia, Mr Neil Hawkins is at the back, on the left.

TECHNIQUE

Atomic-scale 3-D orientation mapping

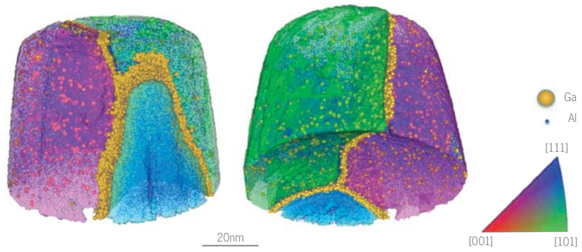
Researchers at the University of Sydney have demonstrated for the first time a powerful and completely new technique to measure and map the orientation of the crystalline structure of matter at the nanoscale in three dimensions. It was published in *Scripta Materialia* in June this year (vol. 66, p 835). The method can be applied to provide new and detailed insight into atomic-scale features that strongly influence the electrical, optical, magnetic and mechanical properties of nearly all materials. Characterisation of precipitates, grain boundaries or crystalline defects aids in the control of properties through the manipulation of microstructure at the finest length scales.

The method utilises atom probe microscopy, which is well known as a powerful technique for 3-D atomic mapping, but hitherto has not conventionally been viewed as a tool that can provide information of crystal orientation. It has long been recognised that the spatial resolution is sufficient to visualise crystallographic planes oriented perpendicular to the direction in which the analysis is performed, yet the lower spatial resolution along other orientations due to aberrations has made crystallographic analyses difficult, or impossible. Modern wide field-of-view detectors now make it possible to identify and distinguish at least three crystallographic directions, or three sets of planes, due to density variations in atom probe data. This is sufficient information to determine the orientation of the grain. For this work 3-D Hough transforms coupled with fast Fourier transforms have been used to obtain crystallographic plane orientations. The technique is highly automated and has the potential to be used to examine large datasets rapidly.

The capabilities of this new method are best described by the images it generates: the image on the right shows a reconstructed volume of a nanocrystalline aluminium sample with gallium atoms (gold spheres) segregated to the interfaces. The colours of the grains represent the crystal orientation according to the pole figure provided. Significant advantages over more conventional beam-based techniques such as transmission electron microscopy include the 3-D nature of the data, which overcomes issues involved with the study of features less than the specimen thickness (50–100 nm) and the ability to study all elements in the periodic table, including lithium and hydrogen.

The real advantage of this new method is the unprecedented combination of quantitative 3-D measurement of composition with the new ability to determine crystal orientation in 3-D, and to do both at the atomic scale.

For further information contact A/Prof. Julie Cairney on julie.cairney@sydney.edu.au or (02) 9351 4523



COMMUNITY

Users fly high in Innovation Awards

Two of our high-profile AMMRF users were recent winners in *The Australian* Innovation Awards. Prof. Mark Kendall was the overall winner for his work developing the vaccine Nanopatch. Members of his team use the AMMRF at the University of Queensland in the development and testing of their patches as reported in our September 2011 *News* and in our 2011 *Profile*.

The winner in the health category was Prof. Marcela Bilek (shown above) and her colleagues, Profs David MacKenzie, Cristobal dos Remedios and Tony Weiss for their work on plasma-induced ion implantation to activate surfaces of medical devices. The treated surfaces readily bind the patient's own proteins, cloaking the coated devices from the body's defence systems and minimising rejection reactions. Alternatively, surfaces can be coated with other proteins and small molecules before implantation, to encourage specific biological responses. As reported in our 2011 *Profile*, the work of Prof. Bilek's team was enabled by scanning electron microscopy at the AMMRF at the University of Sydney.

Prof. Tanya Monro, a regular user of the AMMRF at the University of Adelaide, was a finalist in the Health category with her VESPR, a new and highly sensitive biosensor.

International advisor visits the AMMRF

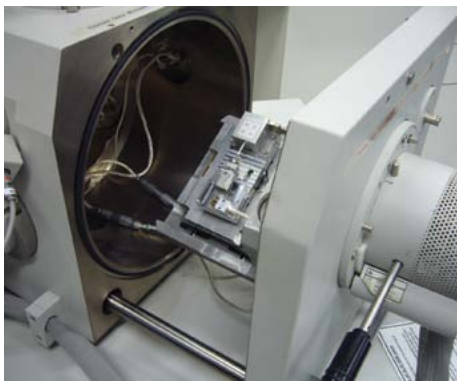
Prof. Roger Wepf, Director of the microscopy unit, EMEZ, at the university ETH Zurich, and member of the AMMRF International Technical & User Advisory Group (ITUAG) visited our facilities recently. During his first stop in Adelaide, Prof. Wepf caught up with Prof. Hans Griesser and Dr John Denman to review our flagship ToF SIMS capability located in the AMMRF at the University of South Australia. Hans and John were able to provide a detailed overview of what is required to run a complex instrument such as the PHI TRIFT V nanoToF.

Prof. Wepf also visited the Sydney node, headquarters of the AMMRF. Here he gave a comprehensive presentation about EMEZ and technique developments in correlative microscopy, cryo specimen preparation, focused ion beam techniques and atom probe tomography.

Similarities between EMEZ and the AMMRF nodes provided fertile material for discussion. However, a culture of collaborative research infrastructure does not exist in Switzerland. Prof. Wepf deepened his understanding of how the AMMRF is organised, how it operates and what benefits flow from our collaborative structure. Even in such a small country he sees much potential for Swiss institutions to be more strategic and collaborative with their approach to research infrastructure and intends to share the AMMRF story with colleagues when he returns to Zurich.

CAPABILITY

Boost to instrumentation



The AMMRF Linked Lab at RMIT University has recently installed a Hysitron Model PI 85 Pico-indenter (above) making it possible to measure the hardness of thin films and other nano-sized devices while they are being observed in a scanning electron microscope (SEM). This is the first in Australia to allow site-specific hardness measurements inside the SEM (left). This instrument also has a conductive diamond tip that allows electrical conductance and resistance tests to be carried out during imaging. This is a huge leap forward for the analysis of piezo-electric thin films specifically and more generally in the development of novel electronic devices. Contact Phil Francis, phil.francis@rmit.edu.au for access and training.

In late February 2012, a new Bruker Dimension Icon Atomic Force Microscope (AFM) was installed in the AMMRF at the University of New South Wales. It was funded through the University's Major Research Equipment and Infrastructure Initiative.

In contrast to other AFMs in the facility, the new instrument is configured as a large platform AFM. Its low drift and low noise allows users to achieve artifact-free images. With the new ScanAsyst automatic image optimisation technology these are collected faster and with more consistent results. This system also allows the recording and analysis of tip-sample interactions enabling projects such as coating characterisation, as well as graphene and polymer analysis.

The University of Queensland node has recently installed a JEOL JSM-7800f Thermal Field Emission SEM, the first of its type in Australia. It incorporates the latest in-lens technology allowing the instrument to maintain resolution even at very low accelerating voltages. Immediate application is found in polymer chemistry where it is now possible to distinguish between different polymers with similar atomic number distributions. A range of new equipment has also been installed at the AMMRF Linked Lab at Queensland University of Technology. Three bench-top scanning electron microscopes are now variously installed in a PC2 lab, a quarantine lab and at the university's pilot-plant facility. The central facility is also getting a boost with a LIEF–funded JEOL 7001F SEM currently being commissioned.

In March, a BMT Multiscan AFM was installed, supporting research in a wide range of surface analysis applications. The system incorporates massive piezo stacks, in contrast to the conventional tube-scanner design, giving a highly linear performance and a world-beating 800 x 800 µm scan field. "It is exciting to be second only to Mercedes Benz in adopting this technology", said Dr Peter Hines. ■

COMMUNITY

On tour with *Incredible Inner Space*

Dr Jeremy Shaw and Asst/Prof. Lecia Khor at Scitech

After its successful three-month display at Questacon, where over 92,000 people saw it, *Incredible Inner Space* has now wowed more than 40,000 visitors at Scitech in Perth. Ms Alison Fowler, Scitech's Science Programs Coordinator, has organised several Meet the Scientist events with AMMRF staff. She says, "the events are an opportunity for visitors to meet and chat to a real scientist in an informal environment, contributing to their positive attitude towards science and scientists. Hands-on activities are a great conversation starter, allowing scientists to engage Western Australians with cutting-edge science relevant to their lives. *Incredible Inner Space* is a great opportunity for this." ■

STAFF NEWS

ANU **Dr Melanie Rug** has taken up the role of Deputy Director (Programs) at the Centre for Advanced Microscopy. She received her PhD from Ruprecht-Karls University of Heidelberg in 1999 for her work on schistosomes. She then moved to Australia to work on malaria, firstly at La Trobe University and then at the Walter and Eliza Hall Institute. Melanie is a cell biologist with extensive experience in the application of a wide range of microscopy techniques including confocal, TEM, SEM and AFM.

UNSW **Dr Rhiannon Kuchel** has joined the Electron Microscope Unit as a Technical Officer. She holds a PhD in cell biology and has a Bachelor of Marine Science from Macquarie University. Rhiannon brings over four years' experience in research and laboratory maintenance. Her research focused on pearl oyster immunology, specifically the effects of environmental fluctuations on key immunological parameters. Rhiannon did the majority of her research at Macquarie University and the Sydney Institute of Marine Science.

Hypersonic travels

University of Queensland (UQ) node director, Prof. John Drennan accompanied Prof. Michael Smart, Chair of Hypersonic Propulsion and Head of the Hyshot Group at the School of Mechanical and Mining Engineering at UQ, on a visit to the Wright Patterson Air Force Base in Ohio, USA early this month.

The Base is the home of the Materials Directorate, which is developing materials for the extreme conditions associated with new developments in aircraft design. The Base has extensive microscopy facilities and researchers are developing new techniques in both in-situ microscopy and in the sectioning of hard materials to build up 3-D information on alloys and ceramics. Profs Drennan and Smart were invited to present their ideas on developing materials to protect surfaces on hypersonic aircraft. This is an area dear to Prof. Drennan's heart and the visit was extremely productive. ■

MyScope update

Scanning probe module now live. ■

ammrf.org.au/myscope

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