CSEM's
Materials Monthly
December 2003
Making materials matter

Materials maketh the (Ice)man

When a dried out human corpse was found on the mountainous border between Italy and Austria by German mountaineers in 1991, authorities thought they'd simply found the remains of an unlucky hiker who'd been caught out in the elements.

▲▲ We know where he died, but where did Oetzi live?

On closer examination, however, it was realised that this was no ordinary modern-day hiker. Radiocarbon dating revealed the body was between 5350 and 5100 years old. The mummified body, which quickly became known as the Iceman, is one of the key scientific discoveries of the 20th century.

An enormous amount has been learned about the Iceman since then. Ötzi, named after the Ötz valley/mountains where he was found, provides us with a unique window into the world of the late Neolithic (New Stone Age). However, while it was known when and where Ötzi died, where he actually lived throughout his entire life has remained a mystery. Now, innovative research by materials scientists at the Research School of Earth Sciences has revealed precious new details on the Iceman's life.

Interrogating a 5000 year old corpse

The question on where Ötzi came from is far from academic. As the scientific value of the Iceman grew, so did his celebrity status and it wasn't long before Italy and Austria were fighting over who had the rights to the remains. It was first believed that the corpse was found on the Austrian side of the border but a detailed survey revealed he lay 93 m on the Italian side.

"Actually, I'd have been happy wherever Ötzi grew up," says Dr Wolfgang Müller, a geochemist at RSES. "Modern-day borders are irrelevant to the true value of the discovery. The iceman is a gift to all of us, to anyone interested in prehistory.

"From a research point of view, however, it's very important to know where Ötzi may have grown up," says Wolfgang, who's Austrian himself. "It sheds light on where people lived, how far they moved over a lifetime and provides information on the society back then."

So, how do you make a 5,000 year old corpse reveal where it originally came from. Surely, this is a question beyond the forensic skills of the best pathologist? A pathologist may be, but this type of challenge is often taken on by earth scientists, who are frequently attempting work out where a rock may have originated. The answer is usually found by matching some unique geological signature locked in the rock with an area where that signature is also present. That signature might be microfossils, a unique geological structure or the specific isotopic composition of an element.

Geochemist turns sleuth

For many years Wolfgang Müller has been using isotopic ratios to date rocks in order to better understand deformation processes in the Earth's crust. By looking outside of the traditional sphere of earth sciences, he suspected that his ability to analyse very small samples might shed some light on where the Iceman was born, and made a request to Ötzi's keepers (the South Tyrol Museum of Archaelogy, Bolzano, Italy;) for minute tooth and bone samples. At the time, Wolfgang was based at the Swiss Federal Institute of Tech in Zürich.

"Access to Ötzi is incredibly limited," says Wolfgang, "so I was very happy when they acceded to my wishes two years later, and I was allowed to take micro- to milligram-sized tooth, bone and intestinal samples for isotopic analysis."

With the help of colleagues in the United States and Switzerland, and using the sophisticated technology available at RSES where Wolfgang was now working as a postdoc, the samples were analysed for the isotopic composition of strontium (the decay product of rubidium), lead (the decay product of uranium and thorium), and oxygen (oxygen 16 and oxygen 18) using a variety of mass spectrometers .

"If you can measure these isotopes with sufficient precision, and you understand the proc-

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esses by which isotopic variation occurs in the landscape and are taken up in our body's tissues," says Wolfgang, "then you have a powerful tool for mapping where an individual like Ötzi may have come from."

Reading the bones

This is where a little biology helps with the investigation. Our teeth mineralize when we're very young (even our adult teeth that haven't come through yet). The enamel of our teeth, therefore, reveal something of our childhood.

Our bones, however, are constantly re-mineralizing throughout our life meaning that their constituent atoms are always being exchanged with the surrounding environment. Bones thus are an archive of the last 10-20 years of an individuals life.

Wolfgang's analysis revealed that Ötzi's teeth could only be reconciled with southern waters, and that they had more of the heavier oxygen isotope than his bone, suggesting that he spent his early years at a slightly lower altitude before migrating to higher ground.

The analysis for strontium and lead from Ötzi's teeth and bones provide additional information on where the Iceman had lived. The Alpine mountains around the Iceman are geologically complex that they include at least four different rock types, each of which has a distinct ratio of radiogenic isotopes of strontium and lead in the rock and overlying soil. Food reflects the isotopic composition of the soil in which it is grown, so Wolfgang and his colleagues could narrow down Ötzi's childhood origins down to several southern valleys.

The pastures of his youth

By linking this information to the oxygen/altitude findings the researchers believe that Ötzi's childhood likely was spent in the Eisack Valley with known contemporaneous archaeological sites, some 50 km south east of his final resting place, and well inside Italy (thereby strengthening Italy's claim to the Iceman's remains).

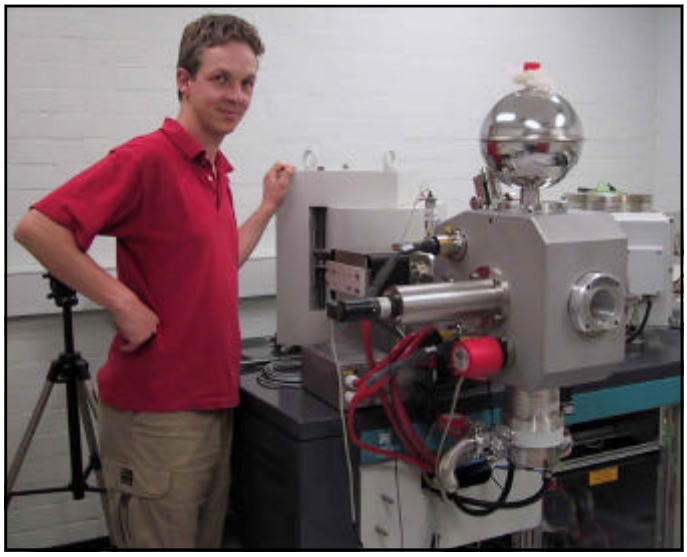
Another piece of sleuthing appears to corroborate this finding. Twelve tiny pieces of white mica that are a perfect capsule of geological age information were found in Ötzi's stomach. It's believed these came from the grind stone that processed the wheat and barley that he ate shortly before his death. The geological age of the mica is consistent with rocks found in a small area to the west of the Eisack Valley.

Thus, the researchers have concluded that Ötzi likely grew up in the Eisack Valley, then as an adult spent time in the upper Etsch valley before setting off on his final journey to the north.

Ötzi is now housed in a glass fridge where he is kept at minus 6 degrees centigrade and 98% humidity in the South Tyrol Museum of Archaeology, Bolzano, Italy.

Wolfgang's research has recently appeared in *Science* magazine, and has been hailed as setting new standards for isotopic life history reconstruction. His approach has been praised for its multi disciplinary nature and use of diverse evidence.

"Our results have revealed important details about Ötzi's life and times, and by inference, a richer understanding of his culture," says Wolfgang. "However, the finer details of his life, such as his occupation, life style and why he met with a violent death, are still a mystery. Ötzi's full story is yet to be told."



▲▲ Wolfgang with one of the RSES mass spectrometers used in tracking the Iceman's life history.

More information: Wolfgang.Mueller@anu.edu.au

More information on Ötzi can be found at www.iceman.it

What else do we know about Ötzi?

Since his discovery, Ötzi has been prodded, imaged, sampled and probed from every angle. Here's what other research has revealed about the Iceman.

- he died aged 46
- he was probably killed by an arrow that penetrated his left shoulder (suggesting he might have been on the run from enemies)
- tree pollen in his gut suggests he died in early summer
- there are 15 groups of simple tattoos on his back and legs that coincide with acupuncture points
- he suffered acute arthritis, worms and diarrhoea
- his culture knew how to use a variety of materials, particularly different types of wood: he was carrying an axe with a wooden handle, a blade made of pure copper, a large bow with 14 arrows made of viburnum and dogwood stored in a fur quiver; a flint knife; and a two containers made of birch bark
- DNA analysis indicates Ötzi is most closely related to central and northern Europeans, including those living in the Alps.
- Analysis of his gut contents revealed he had eaten domesticated cereals – wheat and barley – shortly before his death.

The Glass Workshop

The Glass Workshop at the School of Arts (National Institute of the Arts) provides courses and facilities comparable with the world's best. Courses aim to prepare students for a career in the visual arts and are offered at both graduate and undergraduate levels. With the expertise of its academic staff, advanced technical facilities, and location close to Australia's national collecting institutions, the Glass Workshop provides an excellent environment for study and research.

Facilities & staff

The facilities offered by the Glass Workshop rank among the best in the world. The Workshop includes:

- **a fully equipped hot shop with:**
  - tank furnace,
  - colour pot furnace,
  - glory holes and 4 annealing kilns;
- **kiln forming area with 9 kilns;**
- **cutting and cold working areas with:**
  - stone and diamond cutting lathes,
  - belt sanding machine,
  - core drill,
  - grinding machines,
  - diamond cut off saw,
  - engraving room,
  - polishing area,
  - sandblasting area.

The Glass Workshop also contains a seminar and exhibition room. In addition, there is a purpose-built studio for architectural glass work, and within the Workshop each student is allocated an individual work space. The Glass Workshop has established a glass data base available on the World Wide Web to assist in the exchange of current information and practice.

In addition to Workshop facilities, through the Complementary Studies Program, students can access the resources of other Workshops within the School and University, including the three dimensional modelling and design facilities offered by the School's Computer Art Studio and the NITA Macintosh laboratories.

Workshop staff are all practising professional artists who have national and international reputations and actively maintain contact with other institutions, arts organisations and practitioners. They specialise in a diverse range of glass applications, from design and production to conceptually based glass work, including blown glass, kiln-formed glass, engraving and lamp working.

mould making for glass casting

glass blowing

International & industry links

Students have access to the many major events regularly hosted by the Workshop. These events allow students to develop professional connections which will be of great value in their future practise. The ongoing Latitudes workshop and exhibition series hosted by the Glass Workshop (and undertaken in collaboration with the Bullseye Glass Company, USA) have also attracted world-wide attention.

The Workshop has developed strong links with industry which enrich the study program for students. An example of these links is the Latitudes workshop and exhibition series undertaken in collaboration with the Bullseye Glass Company, USA, and hosted by the Glass Workshop. The Latitudes project, initiated by Klaus Moje and developed to its current form by Kirstie Rea, demonstrates the enthusiasm and drive within the Workshop. An exhibition resulting from the Latitudes project was shown at Seto during the 1999 GAS Conference and also at the Bullseye Gallery in Portland, USA.

Ubique by Jacqueline Gropp

The Workshop has developed professional contacts with university glass departments in Europe, Japan and the USA which students can visit as part of the CSA's study exchange program.

The Head of the Workshop is Richard Whiteley.

More information:

Web: www.anu.edu.au/ITA/CSA/glass/index.html

Phone: 6125 5829

Email: Richard.Whiteley@anu.edu.au

For general enquiries regarding studying at the School of Arts, contact NITA Student Services by telephoning 6125 5711.

Opportunities

The Network Rules

ARC Research Networks is a new program designed to encourage collaborative approaches to research in inter-disciplinary settings. ARC Research Networks are platforms for generating new knowledge in areas that span traditional disciplinary boundaries. Networks link researchers, research groups and others involved in innovation; nationally and internationally.

The funding rules for ARC Research Networks have been approved by the Minister for Education, Science and Training. They may be downloaded from the ARC website. Application forms for Research Networks grants will be released in the ARC's on-line Grant Application Management System (GAMS) this month. Instructions to applicants will released at the same time.

Research Office (RO) Deadlines

1st Deadline: 23 February 2004
Draft applications submitted by this deadline will be checked by the RO against the technical rules and selection criteria. The RO will provide feedback that can strengthen your application. (It is not necessary to submit all the participant signatures at this stage.)

Final deadline: 8 March 2004
COMPLETE and FINAL applications need to be submitted to the RO by this deadline. Applications would need to be fully reviewed and checked in the local areas and locally submitted on GAMS prior to submission to the RO. Only a basic technical check of applications will be conducted by the RO at this stage. Signatures of all applicants must be provided by this deadline.

More information:
www.arc.gov.au/grant_programs/centres_networks/research_networks.htm

www.arc.gov.au/pdf/RN_funding_rules.pdf

NSWk Project Grants for 2004

Science Minister Peter McGauran has announced the availability of $400,000 funding for National Science Week Project Grants in 2004.

“National Science Week aims to encourage young people to study science; to promote science-based careers; and inform businesses of the importance of innovation to their long-term success,” said Mr McGauran. “This hands-on celebration is one of the key ways in which we can join with the community in emphasising the importance of science and innovation to Australia’s future.”

Individuals or groups are encouraged to apply for grants in order to showcase their capabilities during National Science Week 2004.

The closing date for applications is Friday 23 January 2004. It is expected that successful projects will be announced in March-April 2004.

More info: www.dest.gov.au/nias/grants.htm

Diary: conferences and seminars

◀◀✧▶▶ **Photons@work** — **27 Jan—5 Feb 2004**
Australian Synchrotron Summer School, ANU, http://wwwrsphysse.anu.edu.au/sync.school/

◀◀✧▶▶ **ACMM-18** — **2-6 Feb 2004**
Aust Conference on Microscopy and Microanalysis 18
Geelong, http://www.deakin.edu.au/events/acmm18/

◀◀✧▶▶ **28th Annual Condensed Matter and Materials Meeting** — **3-6 Feb 2004**
Charles Sturt Uni, Wagga Wagga, http://www.tip.csiro.au/wagga/

◀◀✧▶▶ **Planetary timescales: from stardust to continents** — **16-19 Feb 2004**
Elizabeth and Fred White Conference
Australian Academy of Science, Shine Dome, http://www.mso.anu.edu.au/PSI/white_conference.html

◀◀✧▶▶ **AMAS 7** — **18-20 Feb 2004**
The 7th Biennial Symposium of the Australian Microbeam Analysis Society,
Uni of Melbourne, http://www.microscopy.org.au/amas/AMASVII/Symposium_HomePage.html

◀◀✧▶▶ **7th World Biomaterials Congress** — **17-21 May 2004**
Sydney, http://www.tourhosts.com.au/biomaterials/

◀◀✧▶▶ **ICSM 2004** — **28 June—2 July 2004**
International Conference on the Science and Technology of Synthetic Metals,
Uni of Wollongong, http://icsm2004.uow.edu.au/

◀◀✧▶▶ **12AEC** — **4-8 July 2004**
12th Australasian Electrochemistry Conference (in conjunction with INTERACT 2004)
Gold Coast, Qld, http://www.edaq.com/EDRACI/meetings.html

◀◀✧▶▶ **VUV 14** — **19-23 July 2004**
14th International Conference on Vacuum Ultraviolet Radiation Physics,
Cairns, Qld, http://vuv14.anu.edu.au/

◀◀✧▶▶ **SIF2004** — **26-29 Sept 2004**
International Conference on Structural Integrity and Fracture,
Brisbane, Qld, http://www.cat.csiro.au/SIF2004/

Materials innovation in the ACT

It's as easy as scissor, rock, paper

Launching the ACT Node of the AMTN

The end of November saw the official launch of the ACT Node of the Australian Materials Technology Network (AMTN) at the National Convention Centre. The launch was held at the second Industry Forum run by the ANU Engineering Alliance.

A strong band of materials loyalists from ANU together with a smattering of industry and government representatives turned up to see Peter Gordon, the Executive Director of ACT Office of Business and Tourism, launch the Node by cutting a kevlar ribbon with a pair of tungsten carbide scissors. The kevlar was a bit tougher than expected, but with a display of true grit Peter Gordon sliced through the ribbon on the second attempt.

▲▲ The guest speakers: Ray Roberts with fibre board, Tim Senden with scissors and Len Kosharek with a diamond composite.

The ANU has played a leading role in the establishment of the Network. It was the brainchild of Professor Jim Williams, Director of the Research School of Physical Sciences and Engineering.

The ACT Node is being supported by the ANU, Business ACT and the Commonwealth Government's Backing Innovation Access Program. The Node is being hosted by CSEM.

Ray talks about problems with paper. ▶▶

"For many years CSEM has been providing a valuable boost to materials science and engineering at the ANU," says CSEM's Director, Dr Zbigniew Stachurski. "Now, with the ACT Node of the AMTN joining us we're hoping to build bridges between the research community on campus and local industry. I'm hoping we can build some exciting collobora-tions."

▲▲ Peter Gordon discovers Kevlar tape is tougher than it looks.

To underscore the value that materials science and technology can add to industry and manufacturing, three presentations on ANU related materials science and innovation were made following the ribbon cutting.

u Mr Len Kosharek, Chief Executive of Ringwood Superabrasives, spoke about his company's efforts to commercialise ultra-hard cutting materials (**scissor**) that were developed by the late Professor Ted Ringwood (RSES);

u Dr Tim Senden then demonstrated how 3D models of rocks could be generated by X-ray computer tomography (**rock**) allowing for improved oil extraction; and

u Mr Ray Roberts then discussed how his materials science is revolutionising our understanding of paper (**paper**) and fibre board manufacture.

Following the talks champagne and canapés were served to celebrate the launch of the node.

CSEM would like to the thank the ANU Engineering Alliance, the National Institute of Physical Sciences and Business ACT for sponsoring and assisting with the coordinating of the event.

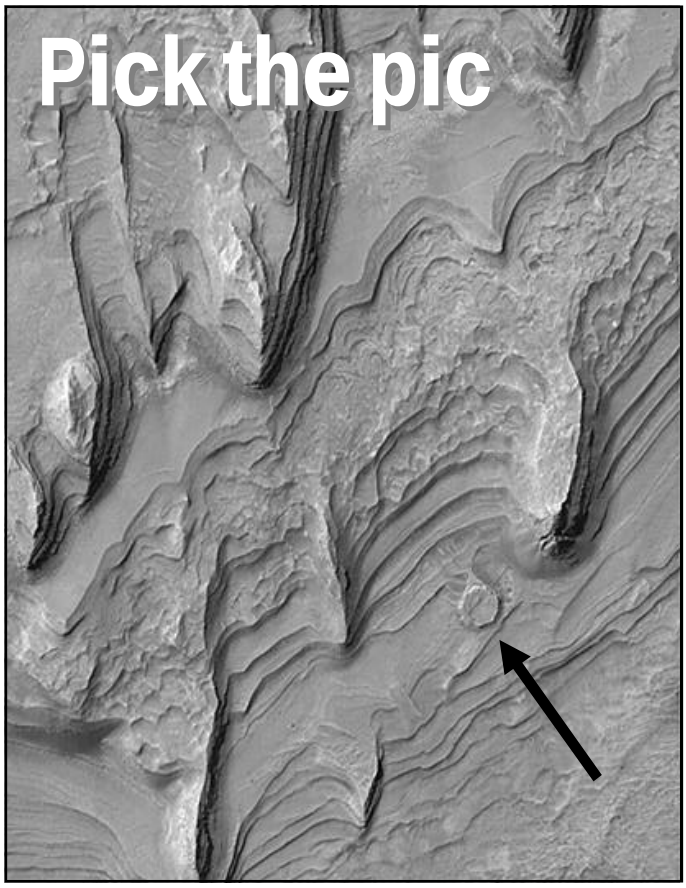
For more info on the AMTN, please see the May 2003 issue of Materials Monthly. For more information on Ringwood Superabrasives, please see June, 2003; X-ray computer tomography: April 2002; and smarter paper: November, 2003. All issues of Materials Monthly can be found at **http://www.anu.edu.au/CSEM/newsletter.htm**

the backpage

MM webspotting

Just for fun (it's Xmas)

- **Insultingly stupid movie physics**
  http://www.intuitor.com/moviephysics/
- **Optical illusions to spin your brain**
  http://www.ritsumei.ac.jp/~akitaoka/saishin-e.html
- **Online encyclopedia of works of structural engineering**
  http://www.structurae.info/en/
- **Home of long range weather**
  http://www.predictweather.com
- **How everyday things are made**
  http://manufacturing.stanford.edu/
- **Autopsy report (the experiences of a medical examiner)**
  http://www.autopsyreport.netfirms.com
- **Your world clock meeting planner**
  http://www.timeanddate.com



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Faculties
Department of Chemistry (Faculty of Science)
Depart of Engineering (Faculty of Engineering and Information Technology)
Department of Geology (Faculty of Science)
Department of Physics (Faculty of Science)

National Institute of the Arts
Materials Workshops

The bones of Mars

Pictured are wind-ravaged sedimentary rocks lying in Gale Crater in the Aeolis region of Mars. The small circular feature in the lower right quarter of the picture (with the arrow pointing at it) is a mesa that was once a small meteor impact crater that was filled, buried, then exhumed from within the sedimentary rock layers exposed here. Gale Crater contains a mound of layered sedimentary rock that stands higher than the rim of the crater. This giant mound suggests that the entire crater was not only once filled with sediment, it was also buried beneath sediment.

You can see this image and countless other weird Martian landforms (well, not countless but more than 134,000 images) at the **Mars Global Surveyor Mars Orbiter Camera website at http://www.msss.com/moc_gallery/**

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www.anu.edu.au/CSEM