

ANU ELECTRON MICROSCOPY UNIT

2006 Annual Report

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1. OBJECTIVES AND ORGANISATION OF THE ANUEMU

Objectives of the Unit, as set out in its establishment paper (2498/1988):

“The purpose of the unit is to provide an efficient service in scanning and transmission electron microscopy to the University community at large and to users external to the University, where appropriate. This service shall include provision for access to modern EM equipment, service for occasional users, training in EM methods for regular users and consultation on applications of EM. The Unit is encouraged to provide leadership in the development and implementation of new EM equipment and methodology. It is an objective of the University to maintain the standard of the facility at a level commensurate with the University's heavy commitment to research and to the major research objectives within the programs of the Schools and Faculties”.

As at the end of 2006: The unit is a central ANU facility administered by the Research School of Biological Sciences and mainly housed there. It provides instrumentation and technical support for light and electron microscopy and related techniques to staff and students from all areas of the ANU. It currently performs about equal amounts of biological and physical sciences work. Major equipment includes three transmission electron microscopes (TEMs), five scanning electron microscopes (SEMs), a dual beam Focused Ion Beam/SEM, confocal, deconvolution and other light microscopes, a small scanning tunneling microscope, cryo-preparation instruments and a range of ancillary equipment for specimen preparation, analysis and image processing. Two of the electron microscopes are housed in the Research School of Earth Sciences. A full description of the operation of the facility can be found through the website <http://www.anu.edu.au/EMU/index.html>.

The Facility Coordinator reports to the Director of RSBS, who has overall responsibility for the Unit's operation and chairs an advisory group concerned with provision of microscopy infrastructure at the ANU. The Advisory Committee was convened in its current form in August 2001, in an attempt to encourage a campus – wide view of all microscopy facilities. On the principle that all user groups should be represented over time, the members are appointed by invitation and have fixed terms.

Members of the ANU **Microscopy Strategic Advisory Group** (MSTAG) in 2006, as listed on <http://www.anu.edu.au/EMU/mstag.html> were:

Professor Jonathan Stone (Chair, Director RSBS) *ex officio*
Dr Sally Stowe (ANUEMU Facility Coordinator) *ex officio*
Professor Robert Elliman (RSPHYSSE, MEC Chair) to 31/12/07
Dr Ian Williams (RSES) to 31/12/06
Dr Andrew Fairbairn (RSPAS) to 31/12/07 (resigned, left ANU in 2006).
Professor Frances Shannon (JCSMR) to 31/12/06
Dr Edie Sevick (RSC, MEC Member) to 31/12/06
Professor Caryl Hill (nominee of Director JCSMR) to 31/12/07
Professor Barry Luther-Davies, (RSPHYSSE) to 31/12/06
Professor Patrick De Deckker, (Earth and Marine Sciences Dept) to 31/12/06
Professor Marilyn Ball, (RSBS) to 31/12/07
Dr Marion Stevens-Kalceff, (UNSW Electron Microscopy Unit. External Advisor) to 31/12/07

Minutes of advisory committee meetings are published at <http://anu.edu.au/EMU/MSTAG/minutes/LIST.htm>

User Input. Feedback from users comes from responses to news and queries on the users' email list, and from written surveys conducted by the Unit to canvas requirements for equipment and various organisational matters. The ANUEMU website is also used to solicit comments on a range of matters including planned major equipment purchases.

2. HIGHLIGHTS OF THE YEAR

2006 was an eventful year, with record publications using the unit's facilities, major new equipment acquired, the launch of a new national directory for shared equipment and services, and a greater range of courses and workshops offered.

Installation of New FESEM

A multipurpose analytical FESEM, the next item on the 10-year list of projected equipment replacements (<http://www.anu.edu.au/EMU/feed%20forward.html>) was bought from EM Reserve funds, and installed in August 2006. The FESEM is a Hitachi 4300 SE/N, which has a Schottky electron source to provide the high brightness and stability needed for analytical applications and extended mapping operations, combined with the highest spatial resolution currently available under analytical conditions. It is also one of the very few FESEM models, and the first in Australia, which can operate in an extended low pressure mode, making it possible to view highly hydrated samples and even liquid water for short periods. The chamber was fitted with a new top-range Oxford INCA Energy Dispersive X-ray detector, with a full suite of software including quantitative mapping and automated feature analysis. Accessories which may more easily be upgraded later have had to compromise with the restricted budget: a 10-year-old liquid nitrogen cold stage was transferred from the 4500 FESEM, an electron backscattered diffraction (EBSD) system of about the same age was transferred from an older tungsten-filament SEM, and a cathodoluminescence imaging system that could be adapted in-house to include a spectrometer was constructed for the ANU by ETP-Semra (Sydney). Smaller accessories such as a chamber camera and various specialised specimen holders are being constructed in-house.

The ensemble provides a very easy to use and versatile microscope enabling analytical work at a resolution previously impossible, as well as imaging and elemental mapping of a wide variety of samples. It provides a vehicle for the cryo X-ray mapping of biological material for which Dr Cheng Huang is an expert, and which is in high demand from RSBS, CSIRO Plant Industry and interstate users. While the 4300 extends and overlaps to some extent the functions of various other SEMs in the EMU, an important purpose is to provide a seamless transition in the replacement for the aging Cambridge 360 which is expected to be the next SEM to be decommissioned. The 4300 is housed in a room formerly occupied by a TEM, the JEOL 2000EX, which went on to a new career as part of instrumentation being constructed at the Lawrence Livermore Laboratories in the USA.

Record Publications

The record 135 publications using the facilities of the ANUEMU in 2006 easily eclipsed the previous record of 105 publications in 2005.

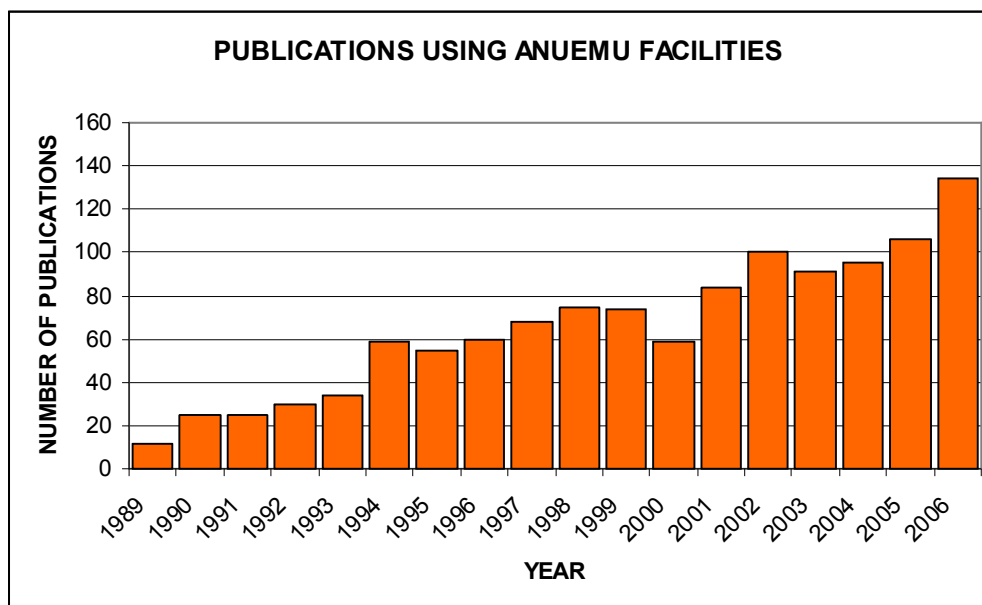


Fig. 1, Table 1 PUBLICATIONS using the ANUEMU facilities, 1990-2006
 (Not including abstracts, theses or papers in press. **NB For statistical and reporting purposes items are NOT in addition to those listed in Departmental and School reports**)
 (details in table below)

YEAR	RSBS	OTHER	TOTAL
av. 1990 - 1993	9.75	19.25	28.5
av. 1994 - 1997	10	50.5	60.5
av. 1998 - 2000	10	61	71
2001	15	69	84
2002	10	90	100
2003	8	83	91
2004	10	85	95
2005	18	88	106
2006	17	118	135

Launch of new Directory of Shared Services and Equipment for Research

DOSSER | Directory of Shared Services
and Equipment for Research

Users frequently bring problems into ANUEMU that cannot be solved with the equipment available in the unit, but it is not easy to find other shared infrastructure, even within the ANU. The problem is not peculiar to this university: a quick websearch of many others reveals the same difficulty. A solution appeared in an initiative that had been started by CSIRO, the Research Office and the JCSMR Molecular Biology Facility (Australian Cancer Research Foundation,) to make information about shared CSIRO/ANU biological resources more readily available. The RSBS IT group became enthusiastically involved, and as discussions progressed it became evident that a wide-ranging database would in fact be easier to establish and maintain than one which was restricted either geographically or thematically. The result, funded by ANUEMU, Australian Cancer Research Foundation, ANU, and the Australian Microscopy and Microanalysis Society, is DOSSER, <http://dosser.anu.edu.au/index.php> a free, web-based directory established to assist researchers from all disciplines to find scientific and research services and equipment.

Dosser has several distinguishing features, which it is hoped will lead to it become a useful national resource:

- it can be searched without registering or logging in
- it is designed on a distributed information management model, so that facilities manage their own directory details of accessible scientific services and equipment, and
- DOSSER monitors registered facilities, services, equipment, proactively requests information updates and alerts facility managers to broken links.

The database itself, searchable on equipment, location, etc, gives a brief description of equipment, contact details, booking and cost information in html format, and can be linked back to the facility website. ANU members may use their HORUS login to establish a new facility. Outside ANU, anyone may use the database freely without logging in, but must first register if they wish to include their own new facility.

Rather surprisingly, the take-up by facilities outside the ANU has been better than within it. DOSSER currently offers 70 items of equipment housed in 10 facilities and six institutions in four states. There is a bias towards microscopy at the moment - AMMS (the Australian Microscopy and Microanalysis Society) views DOSSER as a convenient partial alternative to its Directory of Australian Electron Microscopy Facilities and has contributed towards it - but it is hoped that this will change, since if DOSSER is to be successful it needs a broad database.

Light microscopy equipment.

The RSBS minor equipment fund and a number of individual contributions allowed the upgrade of the Wild Macroscope to 16Mb digital file acquisition with a SPOT Flex CCD camera, and (in 2007) a new illumination base offering excellent dark-field and Rotterman contrast illumination. This microscope is heavily used, filling an awkward gap between macro and micro photography.

New TEM Camera.

In 2006 the EMU made an unsuccessful MEC application for an updated TEM camera for the Hitachi 7100, the TEM used for most biological and almost all external work. The cost of higher resolution cameras has plummeted in the last few years, and the benefits in cost and convenience of increased resolution, sensitivity and bit depth in advancing digital image capture to more often replace film are so pressing that we decided to fund the purchase from earnings. An 11Mp bottom-mounted SIA camera was purchased after tender and is due to be installed in late 2007.

INSTRUMENT USE

The number of people using the facility (284) remained almost the same as the previous year (282). (Courses are counted as a single user)

SEM use stabilised with a slight drop (5%) to 6960 hours, after large increases of 40% over the last two years. TEM use on the RSBS instruments was constant at 787 hours compared to 758 in 2005, the CM300 in RSES dropped 21% to 952 hours, for an overall 12% drop in total TEM use to 1739 hours. Light microscopy maintained its upward trend with a 5% increase to 3190 hours, and ultramicrotome use continues to fluctuate, in 2006 increasing by 45%.

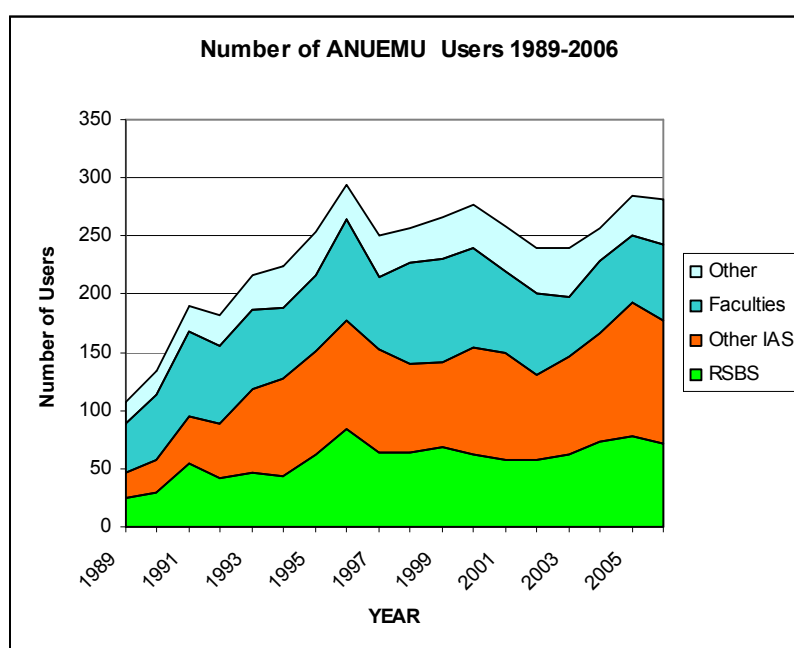


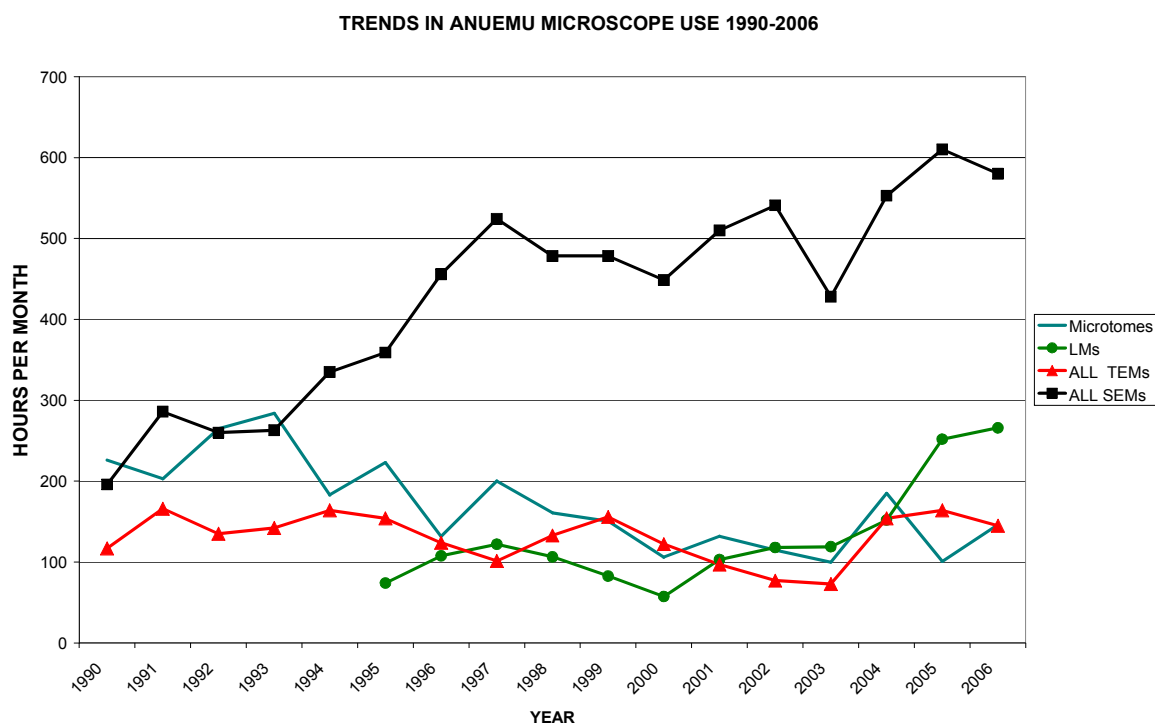
Fig 2. Numbers of ANUEMU Users 1989 to 2006. Undergraduate courses and other student groups are counted as one user. EMU staff not included.

Table 2: School and Departmental Use of the ANUEMU in 2006.

Since the pattern of use of microtomes and light microscopes has changed, with typically more users and/or more complex requirements, they have been accorded equal weight in resource requirements to electron microscopes.

Group (number of users)	CM300 TEM@RS ES	TEMs (RSBS site)	SEMs inc FIB	LMs	MICRO- TOMES	Total Hours	% use
RSBS (68)		218	149	2248	1317	3932	28.8
BOZO (8)		7	163	37.5	22	229.5	1.7
JCSMR (3)		8	10.5		12	30.5	0.2
SRES (4)			67.5	7		127	0.9
BAMBI (13)		21	14	240.5	59.5	335	2.5
RSPAS/ANH (8)		8	158.5	7		165	1.2
RSC (10)		153	81.5	62		296	2.2
Chemistry Dept (2)		3.5	14		17.5	35	0.3
RSPHysSE (40)	839	158.5	2100.9	39.5		3138	23.0
FEIT (10)		7	152	16	174	175	1.3
RSES (44)	95.5		2016	28.5		2140	15.7
EMS (23)	14	10.5	848	11		884	6.5
School of Art (1)			14	7		21	0.2
General Courses (2)		8	50.5	38.5	97	194	1.4
EMU staff and visitors (10)		101.5	527.5	323	174	1146	8.4
Total ANU (246)							
Other Universities (13)			186	26.5	28	241	1.8
GOVERNMENT (23)	3.5	92	357.5	45	27	525	3.8
COMMERCIAL (2) (38 external users)			29.5			30	0.2
TOTALS (284, 278 non-staff)	952	787	6960	3190	1754	13643	100
		(515h on 7100, 273h on Philips 430					

Figure 3: ANUEMU Microscope Use 1990 to 2006



3. STAFF

Facility Coordinator

Sally Stowe, MSc Hons (Auck), PhD

Senior Technical Officers

Frank Brink, BAppPhys (SA) MSc (LaTrobe) PhD

Cheng X. Huang, MSc (Beijing Agricultural), PhD (La Trobe)

David Llewellyn, DipEng (Bruce TAFE)

Daryl Webb, BSc (NTU), MSc (Med)(prelim) (Syd)

Technical Officers

Geoffrey Hunter

Ruolan (Lily) Shen, DipTCM (Guangzhou)

Visitors

Prof. Saeed Asgary, Shahiad Beheshti University of Medical Sciences, Iran (Jul-Aug)

A/Prof. Mohammed Jafar Eghbal, Shahiad Beheshti University of Medical Sciences, Iran (Jul-Aug)

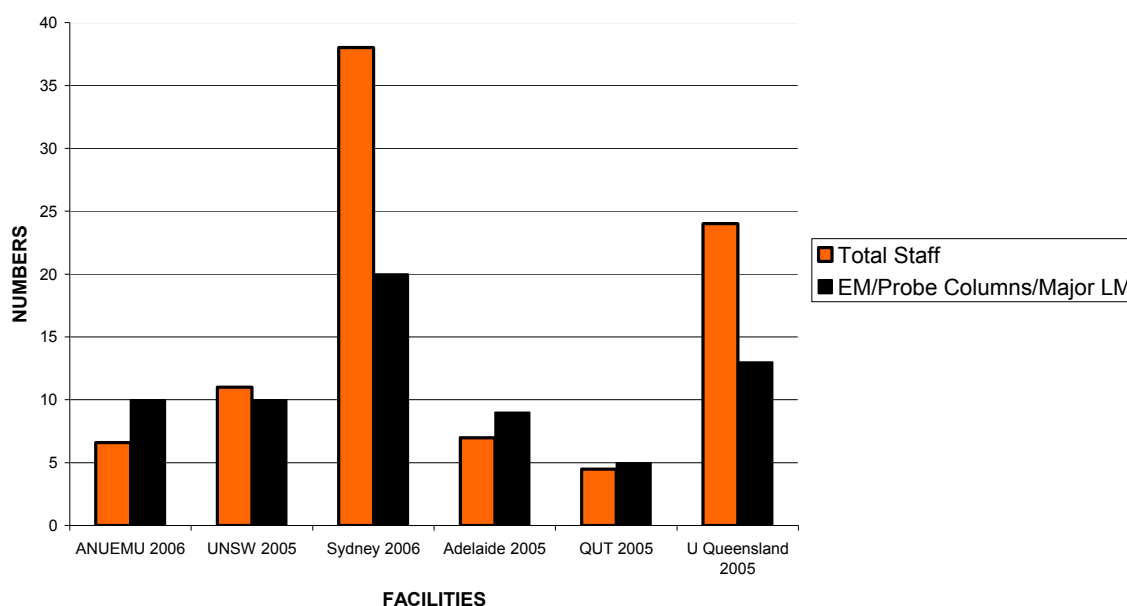
A/Prof. Jamileh Ghoddsi, Mashad University of Medical Sciences, Iran (Jul-Aug)

A/Prof. Masoud Parirokh, Kerman University of Medical Sciences, Iran (Jul-Aug)

The chart below shows a comparison of staff levels in the ANUEMU with those of the central microscopy units of some comparable Australian Universities.

Figure 4:

Comparative Staff and Major Equipment Levels in Australian EM Units



4. TEACHING

Most teaching performed by unit staff takes the form of interactions with users on an individual basis, but a number of regular and occasional workshops are also offered, depending on demand. The most extensive are the Microscopy, Imaging and Analysis series of one day workshops delivered mainly by EMU staff, and an Advanced SEM course with Steve Chapman (Protrain Ltd).

Undergraduate teaching – the ANUEMU facilities were used by BOZO and FEIT, and pilot labs with the Physics Dept lead to 1st year visits and a series of 3rd year labs in 2007

Brink FB. Presented one-day course on Energy Dispersive X-ray Microanalysis as part of the EMU Microscopy, Imaging and Microanalysis Workshops (MIA 2006), and contributed to other sessions.

Huang CX contributed to Root/Soil Biology Workshop 2006, convened by Prof. Margaret McCully, CSIRO Plant Industry, and to Microscopy Imaging and Analysis 2006.

Stowe S. Convened and lectured in the eight-day ANUEMU MIA 2006 workshop series (April-May),

lectured to Physics 1201,
co-convended two-day satellite workshop of ACMM-19 on Laser cell Capture Microscopy,
co-convended five-day Advanced SEM Workshop run by Steve Chapman of Protrain,
co-supervised two PhD students.

Webb D. Ran Light Microscopy and Advanced Fluorescence Light Microscopy sections of MIA 2006, and a one-day light microscopy course for BAMBI.

All ANUEMU staff contributed to practical sessions for MIA 2006, and for Physics 1201 and 3032.

5. COLLABORATION AND OUTREACH

Collaborations within ANU

Brink FJ, Visiting Fellow at Research School of Chemistry. Oxygen and fluorine ordering in metal oxyfluorides, with Prof. R Withers.

Visitors from other Australian and Overseas Universities

ANUEMU facilities are used by visitors to many departments of the ANU. In addition, they were used by staff and research students from Canberra Institute of Technology, Charles Sturt University, ADFA, James Cook University, University of Western Sydney, and the University of Melbourne, and from overseas, from the Universities of Otago (NZ) British Columbia(Canada), and several Iranian Universities (see below):

Collaborations with Other Institutions and Universities

Brink FJ, and Stowe SJ with Prof. Saeed Asgary, Assoc. Prof. M Parirokh and Assoc. Prof. J Eghbal, Endodontic Department, Dental School, Shahid Behesti University of Medical Sciences, Tehran, Iran and Kerman University of Medical Sciences, Kerman, Iran.
Analysis of endodontic materials and procedures.

Cheng CX with Prof. Margaret McCully, CSIRO Plant Industry. Cryo-SEM of plant-soil interactions.

Stowe S with Prof. Nicholas Strausfeld, University of Arizona, USA and Dr David Rowell, School of Botany and Zoology. Onychorphan neuroanatomy and phylogeny. Stowe S and Aung S, with Prof. D Stavenga, University of Groningen, Netherlands. Optically active microstructure of lepidopteran cuticle.

Cooperation with Government, Industry & Commerce:

The ANUEMU Facilities were used by a number of Government organisations - CSIRO Plant Industry and Entomology Divisions, the Australian Federal Police, The Canberra Hospital, GeoScience Australia, Dept of Energy and Conservation, and Australian National Botanic Gardens. Commercial users included ProSciTech, Robson Laboratories and Dyesol.

Other Activities:

Brink FJ was the ACT representative for the Australian MicroAnalytical Society (AMAS).

Stowe SJ was a member of

- the international advisory board for *Medical Electron Microscopy* (Springer)

- (from 2007) member, editorial board of *Scanning*

Reviewed manuscripts for *Measurement Science and Technology* and *Arthropod Structure and Development* and was a member of

- ANU Microscopy Strategic Advisory Committee

- CSIRO Black Mountain Microscopy Advisory Committee

- ANU Centre for the Science and Engineering of Materials Advisory Committee

- JCSMR EMU Management Committee and

- was the ACT representative on the executive committee of the Australian Microscopy and Microanalysis Society,

6. PUBLICATIONS

EMU Staff Publications 2006

1. Asgary S, Parirokh M, Eghbal M J, Ghoddusi J and Eskandarizadeh (2006) A. SEM evaluation of neodentinal bridging after direct pulp protection with mineral trioxide aggregate. *Aust Endodontic J* **32**:26-30.

2. Asgary S, Parirokh M, Eghbal J, Stowe S and Brink F. (2006) A qualitative X-ray analysis of white and grey mineral trioxide aggregate using compositional imaging. *J. of Mat. Science: Materials in Medicine*. **17**:187-191.

3. Ball MC, Canny MJ, Huang CX, Egerton JJG and Wolfe J. (2006) Freeze/thaw-induced embolism depends on nadir temperature: the heterogeneous hydration hypothesis. *Plant, Cell and Environment* **29**:729-745.

4. Brink F J, Withers R L, Cordier S and Poulain M(2006). An electron diffraction and bond valence sum investigation of oxygen/fluorine ordering in $Nb_nO_{2n-1}F_{n+2}$, $n=3$. *J. Solid State Chem* **179**:341-348.

5. Canny MJ and Huang CX. (2006) Leaf Water Content and Palisade Cell Size. *New Phytologist* **170**:75-85.

6. Johannessen B, P. Kluth, C. J. Glover, S. M. Kluth, G. J. Foran, D. J. Cookson, D. J. Llewellyn, and Ridgway MC (2006) Structural stability of Cu nanocrystals in SiO₂ exposed to high-energy ion irradiation *Nuclear Instruments and Methods in Physics Research B* **250**: 210-214

7. Norén L, Withers RL, Brink FJ, Schmid S and Ting V(2006). SnSb revisited. *J Solid State Chem* **179**:404-412.

8. Refshauge S, Watt M, McCully ME and Huang CX (2006). Frozen in time: a new method using cryo-scanning electron microscopy to visualize root-fungal interactions. *New Phytologist* **172**:369-374.

9. Reith R, Rogers SL, McPhail DC and Webb D. (2006) Biomineralization of Gold: Biofilms on Bacterioform Gold. *Science* **313**:233-236.

10. Strausfeld NJ, Strausfeld CM, Loesel R, Rowell D and Stowe S. (2006) Arthropod Phylogeny: onychophoran brain organisation suggests an archaic relationship with a chelicerate stem lineage. *Proc Roy Soc B* **273**:1857-1866.

11. Strausfeld NJ, Strausfeld CM, Stowe S, Rowell D and Loesel R. (2006) The organisation and evolutionary implications of neuropils and their neurons in the brain of the onychophoran *Euperipatoides rowelli*. *Arthropod Structure and Development* **35**:169-196.

Conferences

Hunter G, Huang CX, Shen L and Stowe SJ attended ACMM-19, the 19th Australian Conference on Microscopy and Microanalysis.

Brink FJ and Stowe SJ attended ICEM XVI, Sapporo, September 2006

Conference presentations:

Brink F, Withers R, Noren L. Structured diffuse scattering and local oxygen/fluorine ordering in transition metal oxyfluorides. ICEM XVI, International Congress on Electron Microscopy. Sapporo, September 2006

Freeman D, Luther-Davies B, Madden S, Stowe S. Real-time drift correction of a focused ion beam milling system. NSTI Nanotechnology Conference and Trade Show, Boston, May 2006

Medek, DE, M Schortemeyer, CX Huang, MJ Canny, MC Ball. Freezing and embolism in subantarctic and alpine grasses. Presented at the 91st Annual Meeting, Ecological Society of America Memphis TN August 6-11, 2006
2006 international

PUBLICATIONS that have used the facilities of the ANUEMU:

2005 not previously listed:

GLIKSON AY, VICKERS J (2005). The 3.26–3.24 Ga Barberton asteroid impact cluster: Tests of tectonic and magmatic consequences, Pilbara Craton, Western Australia. *Earth and Planetary Science Letters*, **241**:11-20.

Yu J, Chen Y, Wuherer R, Liu Z, Ringer SP (2005) In Situ Formation of BN Nanotubes during Nitriding Reactions *Chemistry of Materials* **17**:5172-5176.

2006:

1. Aleinikoff JN, Schenck WS, Plank MO, Srogi L-A, Fanning CM, Kamo SL, Bosbyshell H. (2006) Deciphering igneous and metamorphic events in high-grade rocks of the

Wilmington Complex, Delaware: Morphology, cathodoluminescence and backscattered electron zoning, and SHRIMP U-Pb geochronology of zircon and monazite, *Geological Society of America Bulletin*, **118**: 39-64.

2. Allen MB, Morton AC, Fanning CM, Ismail-Zadeh AJ, Kroonenberg SB (2006) Zircon age constraints on sediment provenance in the Caspian region, *Journal of the Geological Society, London* **163**: 647-655.
3. Anma R, Armstrong R, Danhara T, Orihashi Y, Iwano H. (2006). Zircon sensitive high mass-resolution ion microprobe U-Pb and fission-track ages for gabbros and sheeted dykes of the Taitao ophiolite, Southern Chile, and their tectonic implications. *Island Arc* **15**: 130-142.
4. Arcon D Jaglicic Z., Zorko A, Rode A V, Christy, AG, Madsen N R, Gamaly EG, Luther-Davies B *Origin of Magnetic Moments in Carbon Nanofoam*, Phys Rev B, **74**, 0114438 (1-9) (2006).
5. Armstrong RA, Lana C, Reimold WU, Gibson RL. (2006). SHRIMP zircon age constraints on Mesoarchean crustal development in the Vredefort dome, central Kaapvaal craton, South Africa, in Reimold, W.U. and Gibson, R.L., Processes on the Early Earth: Geological Society of America Special Paper **405**:233-253.
6. Asgary S, Parirokh M, Eghbal M J, Ghodduji J and Eskandarizadeh (2006) A. SEM evaluation of neodontinal bridging after direct pulp protection with mineral trioxide aggregate. *Aust Endodontic J* **32**:26-30.
7. Asgary S, Parirokh M, Eghbal J, Stowe S and Brink F. (2006) A qualitative X-ray analysis of white and grey mineral trioxide aggregate using compositional imaging. *J. of Mat. Science: Materials in Medicine*. **17**:187-191.
8. Augustsson C, Münker C, Bahlburg H, Fanning CM. (2006) Provenance of late Palaeozoic metasediments of the SW South American Gondwana margin: a combined U-Pb and Hf-isotope study of single detrital zircons, *Journal of the Geological Society, London*, **163**, 983-995.
9. Ávila JN, Chemale Jr. F, Mallman G, Kawashita K., Armstrong RA (2006). Combined stratigraphic and isotopic studies of Triassic strata, Cuyo Basin, Argentine Precordillera. *Bull. Geol. Soc. America*, **118**, 1088-1098.
10. Araujo LL, Kluth P, Azevedo G de M, Ridgway M(2006) Vibrational properties of Ge nanocrystals determined by EXAFS. *Physical Review B* **74**
11. Baker NJ, Lee HW, Littler IC, de Sterke CM, Eggleton BJ, Choi DY, Madden S, Luther-Davies B (2006) Sampled Bragg gratings in chalcogenide (As₂S₃) rib-waveguides. *Optics Express* **14**(20), 9451-9459.
12. Baldo E, Casquet C, Pankhurst RJ, Galindo C, Rapela CW, Fanning CM, Dahlquist J, Murra J (2006) Neoproterozoic A-type magmatism in the Western Sierras Pampeanas (Argentina): evidence for Rodinia break-up along a proto-Iapetus rift? *Terra Nova* **18**:388-394.

13. Ball MC, Canny MJ, Huang CX, Egerton JJG, Wolfe J (2006) Freeze/thaw-induced embolism depends on nadir temperature: the heterogeneous hydration hypothesis. *Plant, Cell and Environment* **29**:729-745.
14. Becker T, Schreiber U, Kampunzu AB, Armstrong R (2006). Mesoproterozoic rocks of Namibia and their plate tectonic setting. *Journal African Earth Sciences*, **46**, 112-140.
15. Beranek LP, Link PK, Fanning CM (2006) Miocene to Holocene landscape evolution of the western Snake River Plain region, Idaho: Using the SHRIMP detrital zircon provenance record to track eastward migration of the Yellowstone hotspot. *Geological Society of America Bulletin* **118** 1027–1050.
16. Berly TJ, Hermann J, Arculus RJ, Lapierre H (2006) Supra-Subduction Zone pyroxenites from San Jorge and Santa Isabel (Solomon Islands) *J Petrol* **47**: 1531-1555.
17. Berry R, Stange G, Olberg R, van Kleef J (2006) The mapping of visual space by identified large second-order neurons in the dragonfly median ocellus. *J Comp Physiol A* **192**:1105-1123
18. Bindi L, Petricek V, Withers RL, Zoppi M, Bonazzi P (2006) A novel high-temperature commensurate superstructure in a natural bariopyrochlore: a structural study by means of a multiphase crystal structure refinement *J Solid State Chem.* **179** 716-725.
19. Blinc R, Cevc P, Arcon D, Zalar B, Zorko A, Apih T, Milia F, Madsen N R, Christy AG, Rode A V (2006). ¹³C NMR and EPR of carbon nanofoam *Physica Status Solidi B: Basic Solid State Physics* **243**, 3069-3072
20. Boger SD, Wilson CJL, Fanning CM (2006) An Archaean province in the southern Prince Charles Mountains, East Antarctica: U–Pb zircon evidence for c. 3170 Ma granite plutonism and c. 2780 Ma partial melting and orogenesis, *Precambrian Research*, **145**: 207-228.
21. Boshoff R, Van Reenen DD, Smit CA, Perchuk LL, Kramers JD, Armstrong R (2006). Geologic History of the Central Zone of the Limpopo Complex: The West Alldays Area. *The Journal of Geology* **114**: 699–716.
22. Brink FJ, Withers RL, Cordier S, Poulain M (2006) An electron diffraction and bond valence sum investigation of oxygen/fluorine ordering in Nb_nO_{2n-1}F_{n+2}, n = 3 *Journal of Solid State Chem* **179**:341-348
23. Buick IS, Allen C, Pandi, M, Rubatto D, Herman, J (2006). The Proterozoic magmatic and metamorphic history of the Banded Gneiss Complex, central Rajasthan, India: LA-ICP-MS U-Pb zircon constraints. *Precambrian Research* **151**: 119-142.
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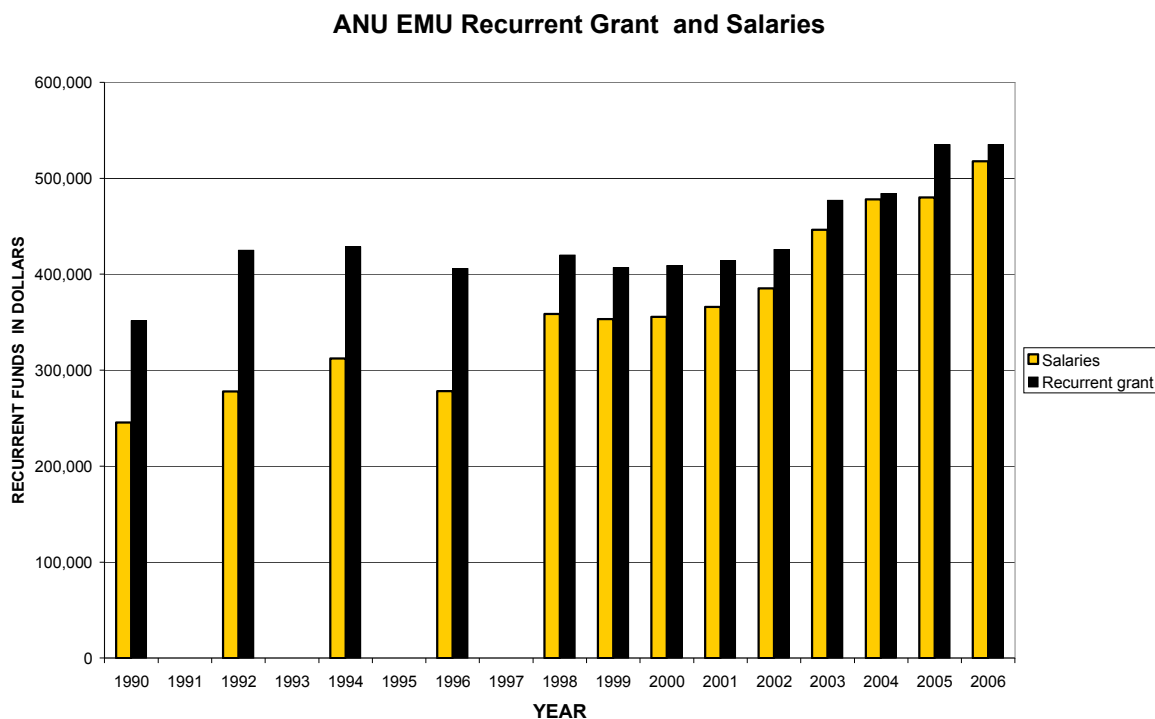
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7. FINANCE

(Formal returns are provided through RSBS, which administers the main part of ANUEMU, and RSES, which administers the account covering the use of the CM300 TEM).

Figure 5



Grants and Contributions for Equipment:

Analytical FESEM:

EM Reserve	\$658,000
Centre for Visual Sciences	\$3,000
RSES(towards transfer of EBSP)	\$5,000

Other:

RSBS (for camera upgrade)	\$12,300
RSBS (towards laser repair)	\$5,000

Operating Funds:

Recurrent funding	\$535,000	86%
Internal Cost Recoveries:	\$43092	9%
External Earnings:	\$39997	5%

Comprising:

GeoScience Australia	\$13874
CSIRO	\$8492
Australian Universities	\$1055
Overseas Universities	\$2500
Commercial	\$3700
Sales of value-added consumables	\$8890
Miscellaneous:	\$1486

TOTAL..... \$618089 100%

In addition the RSES CM300 TEM account received \$10,000 for consumables and operating expenses, from the EME department of RSPHYSSE.

Overheads such as electricity, water, and most administration costs are covered by RSBS, or RSES in the case of the CM300. RSES also provides the salary of Dr John Fitz Gerald, who manages that instrument with the assistance of an ANUEMU staff member, Mr David Llewellyn.

Charging Policy: The ANUEMU charges are given on www.anu.edu.au/EMU/costs.html. The Unit recovers major consumable costs and a proportion of operating costs from academic users with available grants, charging \$10-15 per hour in 2006. In 2007 \$15 per hour was charged as the default rate. However for some instruments with high and predictable running costs, (the confocal light microscope and FIB/SEM), all academic users are subject to a non-negotiable minimum hourly rate. Non-university government users are charged at a rate (\$50-\$75 per hour) that covers all costs apart from capital equipment. Industry users are charged at commercially competitive rates that also cover major equipment replacement costs. Non-standard applications such as cryo procedures attract a surcharge on all users.

The Unit runs extremely cheaply, with a cost per electron microscope hour equivalent (for salaries, maintenance, consumables, and small equipment, but not power, water and admin overheads), of \$26 /hr on a "Full Use" basis (ie spreading costs over a nominally full use schedule of 2000 hours (40 hours per week, 50 weeks per year), and \$61/hr calculated on the actual hours used (on average, 43% of "Full Use"). Although the hourly costs levied are often considerably lower than comparable units, as a proportion of running costs they are relatively high, because of the minimal staff levels and comparatively very low recurrent grant. As more ANU researchers have become recipients of external grants, charges have been progressively increased at a rate which has allowed users to adjust, and avoided a decrease in overall equipment use. **Earnings from all internal and external sources are projected to increase from approximately \$94,000 in 2006 to approximately \$130,000 in 2007, about 25% of the recurrent grant.**

8. THE FUTURE

All institutions must change if they are to survive, and 2007 has been a watershed year for the ANUEMU. During 2007 the ANU became involved in the establishment of a national microscopy grouping, the Australian Microscopy and Microanalysis Research Facility (AMMRF), part of the NCRIS funding scheme. There were difficulties, not least that the ANUEMU, while already delivering most outcomes required by the NCRIS scheme, does not have a level of staffing and formal administrative structure, nor of central funding, sufficient to mesh easily with the proposed new national entity. However the process has had the benefit of precipitating moves to establish a more robust structure for the ANUEMU.

The proposed shift to a less autonomous but I hope substantially better funded system brings major changes in the administrative structure of the ANUEMU, and marks a natural time for me to retire. The last 17 years of coaxing along the transition from a predominantly biological TEM unit to a very broadly based unit offering TEM, SEM, Light Microscopy and a FIB/SEM have been often frustrating, but usually rewarding and

always interesting. Overall use and output as measured by various performance indicators, most importantly publications, have approximately tripled. The most common staff qualification has climbed to PhD, although staff numbers have fallen. With the support of many people, especially the ever-resourceful EMU staff, and a succession of RSBS directors willing to go to a good deal of trouble in support of a university-wide facility, this has been achieved on a budget that has barely changed in more than a decade and is now remarkably low in comparison to the resources provided to similar units by other universities. Nonetheless the EMU's overall operating budget (recurrent funds plus internal and external earnings) has been balanced or in credit every year from 1990 to 2006.

I remain convinced that affordable and up-to-date common research resources are essential to provide the flexibility necessary for frontline research, helping ANU researchers remain competitive with often much larger and better funded teams overseas. They are particularly important for the graduate students, limited term researchers and visitors upon whom the bulk of the ANU's research output depends. Accountability, responsiveness to existing user requirements and anticipation of the future needs of a variety of users is a challenge for any central facility without an infinite budget. It is a balancing act that requires strong central support if shared facilities are not to fall prey to some form of the "tragedy of the commons."

I hope the formalisation of a new structure in 2008 will further the evolution of the ANU EMU to a provider of the highest quality imaging and analysis equipment and expertise.



Dr SJ Stowe
ANUEMU Facility Coordinator
December 2007

Front Cover

Foam-test-blue. *This image is from Victoria Cooper's exhibition Rio Vista - Aqua Vista, was created for the Palimpsest 06 Symposium and shown in the historic house, Rio Vista, at the Mildura Arts Centre. This work was constructed in the form of artists' books and was drawn together from visual site-specific research for a Doctorate in Creative Arts at James Cook University currently being undertaken by Cooper. Her research investigates current perceptions and issues pertaining to water within the context of cultural stories and scientific visual information.*

The subject of this part of the research project is the Queen Anne styled house Rio Vista and its historical connection with the Murray River, irrigation and water. The original owner of the house was William Chaffey, who with his brother George came to the region in 1886 to undertake the opening-up of land to irrigation.

Victoria Cooper wishes to acknowledge Electron Microscope Unit, -Australian National University in providing vital ongoing assistance in this project during her Artist in Residencies at the ANU School of Art during May 2006 and 2007.

Back Cover:

SEM of *Radioloaria* sp. (Roger Heady)