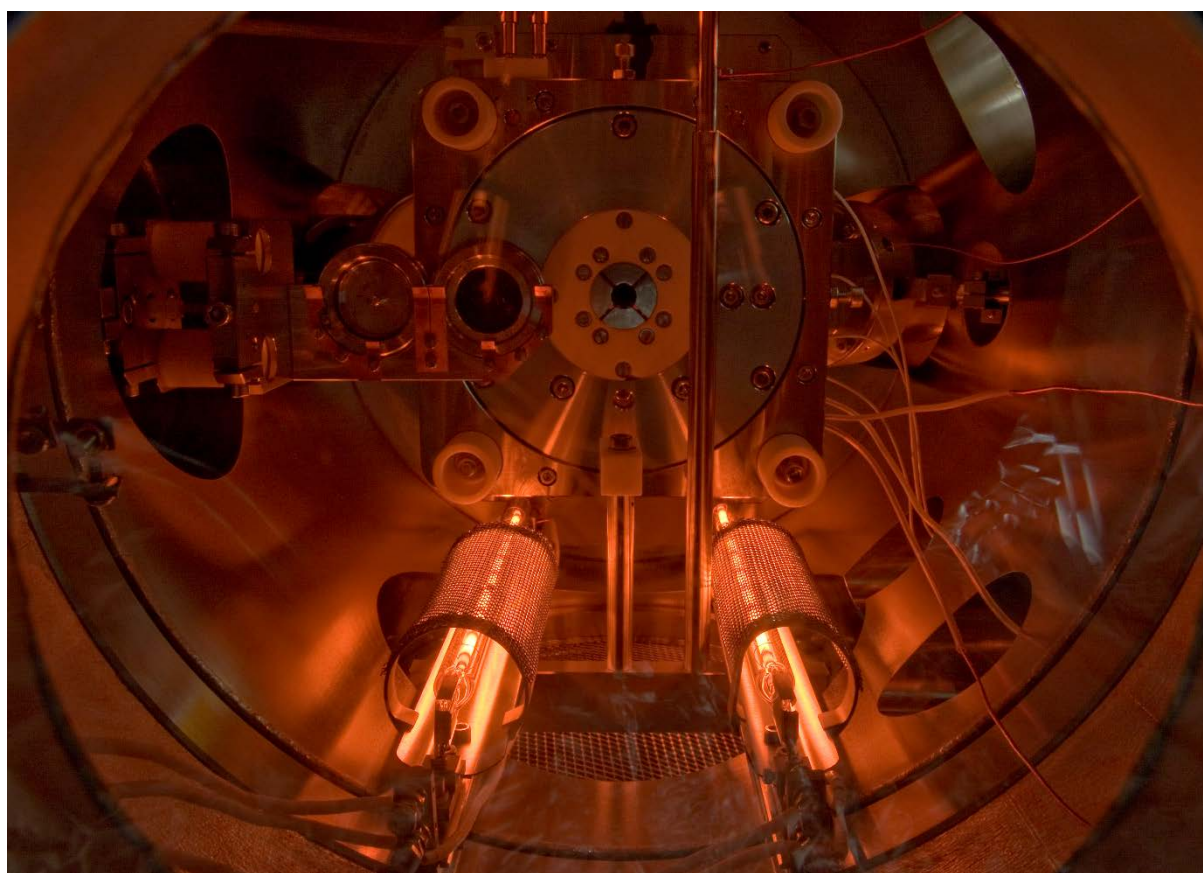


# Research School of Earth Sciences Annual Report 2017



*Infra-red heating of the source chamber prior to the successful installation of SHRIMP-SI, RSES' dedicated Stable Isotope capability for in situ micro analysis.*

*Photo credit: Peter Lanc*



Australian  
National  
University

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## **DIRECTOR'S REVIEW OF 2017**

2017 has been a year of constructive change in response to the School review undertaken in November 2016, and the release of the ANU's new strategic plan, which has articulated a renewed and invigorated vision for the University in fulfilling its role as Australia's national university.

The School review highlighted shortcomings in the School's governance and strategic planning processes. This triggered a complete overhaul of the School's governance structure, replacing the School's previous cluster and disparate research group structure with seven similar sized and coherent research groups: Biogeochemistry, Climate and Fluid Physics, Earth Dynamics, Experimental Petrology, Geochemistry and Cosmochemistry, Palaeoenvironments, and Seismology and Mathematical Geophysics. Three new portfolios were created: Research, Engagement and Experience, alongside the existing Education and Higher Degree Research portfolios, with each headed by an Associate Director representing the portfolio on the School's Executive.

The long-running review of the School undergraduate education curriculum has continued as have efforts to grow the new Masters of Earth Science (Advanced) program. At the same time the School has worked hard to create new professional development opportunities for both its academic and professional staff, and to implement a range of strategies to address equity issues and thereby enhance our ability to recruit and retain the best possible staff. The full review of the School undertaken in late 2016 allowed us to gain an external assessment on the School's current performance and operations and to seek feedback on the planned future directions of the School.

2017 turned out to be a disappointing year for Australian Research Council (ARC) funding, with only three funded ARC Discovery grants to Dr Mark Kendrick, Prof. Vickie Bennett and A/Prof. Michael Gagan as lead CIs, and a large proportion of grant applications falling in the top 10% and 25% of unfunded proposals. This was offset by ARC DECRA (early career) fellowships awarded to Dr Callum Shakespeare and Dr Andrew Valentine, and a prestigious Robert J. Hawke Fellowship to Dr Bishakhdatta Gayen.

The School welcomed Dr Rhodri Davies to the continuing academic faculty late in 2017. Associate Professor Leanne Armand also joined the School as the new ANZIC (Australian and New Zealand International Ocean Discovery Program Consortium) Program Scientist, taking over the role from Prof. Neville Exon who retired in September.

Professor Ian Williams and Associate Professors Michael Gagan, Masahiko Honda, and Ross Kerr took advantage of the ANU's voluntary early retirement scheme at the end of 2017, as did professional staff Maree Coldrick, Joan Cowley, Les Kinsley, Harri Kokkonen, Linda McMorrow, Robyn Petch, Robert Rapp, and Heather Scott-Gagan. In addition, professional staff members Mary Anne King and Joy McDermid took up positions elsewhere in the University during 2017. Collectively these staff members

have contributed over 300 years of highly committed service to the ANU and the School. Their skills, expertise and dedication will be sorely missed and difficult, if not impossible, to replace.

Research highlights for the year were many and include among other high profile publications and developments:

- PhD student Tim Jones and Dr Rhodri Davies's solution, published in *Nature*, to the long-standing (150-year) question about the origin of double-track volcanism at Hawaii.
- A/Prof. Jochen Brocks and postgraduate students Amber Jarrett and Tharike Liyanages' publication, also in *Nature*, of a molecular fossil record showing increased steroid diversity and abundance between 659 and 645 million years ago, which marks the rise of marine planktonic algae between successive 'snowball Earth' glaciation events.

The School hosted Dr Valerie Masson-Delmotte who presented the 19<sup>th</sup> Jaeger-Hales Lecture "From water molecules to climate, making sense of Greenland and Antarctic ice core records". Dr Masson-Delmotte is one of the world's preeminent climate scientists and co-chair of the Intergovernmental Panel on Climate Change (IPCC) Working Group I (the physical scientific basis of the climate system and climate change) for the 6<sup>th</sup> IPCC assessment cycle.

A number of RSES academics were awarded significant national and international honours. Emeritus Professor Brian L.N. Kennett was awarded the Inge Lehmann Medal by the American Geophysical Union, Professor Eelco Rohling was made a Fellow of the American Geophysical Union and Dr Rhodri Davies was awarded the Anton Hales Medal by the Australian Academy of Science.

The School graduated sixteen PhD students, four Master of Earth Science (Advanced) students and seven Honours (4th year) students.

A major review of the School's Education program has continued under the direction of A/Prof. David Heslop and Prof. Mike Roderick, with significant progress in developing Geophysics as a new core subject within the Earth Science major. The new Masters of Earth Science (Advanced) program has continued to grow to the extent that it is approaching a sustainable footing and represents a very significant part of the School's education offerings.

As in previous years the success of the School across its research, education, research training, and engagement activities has been supported by the extraordinary commitment and expertise of its professional staff. These staff, along with all of our students and academic staff, are thanked for their ongoing dedication to the School and its goal to remain among the top-ranked university geoscience programs in the world.

## STAFF AND STUDENT LISTS

### ACADEMIC STAFF

#### Director

S.M. Eggins, BSc UNSW, PhD Tasmania

#### Associate Directors

<b>Geochemistry</b>	G.M. Yaxley, BSc PhD Tasmania (to 30/06/17)
<b>Geophysics</b>	P. Tregoning, BSurv PhD UNSW (to 30/06/17)
<b>Ocean &amp; Climate Geoscience</b>	E. Rohling, BSc, MSc, PhD Utrecht (to 30/06/17)
<b>Research</b>	E. Rohling, BSc, MSc, PhD Utrecht (from 1/07/17)
<b>Higher Degree Research</b>	J.J. Brocks, Dip Freiburg, PhD Sydney
<b>Education</b>	D. Heslop, BSc Durham, PhD Liverpool, Dr habil. Bremen
<b>Engagement</b>	P.L. King, BSc (Hons) ANU, PhD Arizona State (1/07/17 to 30/11/17) M.S. Miller, BA Whittier, MSc Columbia, MEng Cornell, PhD ANU (from 1/12/17)
<b>Experience</b>	G.M. Yaxley, BSc PhD Tasmania (from 1/07/17)
<b>Projects</b>	V.C. Bennett, BSc PhD UCLA (to 30/06/17) P. Tregoning, BSurv PhD UNSW (from 1/07/17)
<b>Benchmarking</b>	V.C. Bennett, BSc PhD UCLA (from 1/07/17)

#### Distinguished Professors

H.St.C. O'Neill, BA Oxford, PhD Manchester, FAA, FRS

#### Professors

V.C. Bennett, BSc PhD UCLA

I.H. Campbell, BSc UWA, PhD DIC London

S.F. Cox, BSc Tasmania, PhD Monash

P.R. Cummins, BA Physics, PhD UC Berkeley

S.M. Eggins, BSc UNSW, PhD Tasmania

N.F. Exon, BSc (Hons) NSW, PhD Kiel (to 30/09/17)

T.R. Ireland, BSc Otago, PhD ANU  
G.S. Lister, BSc Qld, BSc (Hons) James Cook, PhD ANU  
B.J. Pillans, BSc PhD ANU, HonFRSNZ  
A.P. Roberts, BSc Massey, BSc (Hons) PhD DS Victoria (Wellington)  
M.L. Roderick, BAppSc QUT, PGDipGIS Qld, PhD Curtin  
E. Rohling, BSc, MSc, PhD Utrecht  
M.S. Sambridge, BSc Loughborough, PhD ANU, FAA, FRAS  
I.S. Williams, BSc PhD ANU  
G.M. Yaxley, BSc PhD Tasmania

### **Senior Fellows**

N.J. Abram, BSc Advanced (Hons) Sydney, PhD ANU  
Y. Amelin, MSc PhD Leningrad State  
L.K. Armand, BSc (Flinders), BSc(Hons) PhD ANU  
A.J. Berry, BSc (Hons) Sydney, DPhil Oxford  
J.J. Brocks, Dip Freiburg, PhD Sydney  
M.J. Ellwood, BSc (Hons) PhD Otago  
S.J. Fallon, BA MS San Diego, PhD ANU  
M.K. Gagan, BA UC Santa Barbara, PhD James Cook  
D.C. Heslop, BSc Durham, PhD Liverpool, Dr habil Bremen  
A.M. Hogg, BSc ANU, PhD UWA  
M. Honda, MSc PhD Tokyo  
R.C. Kerr, BSc Qld, PhD Cambridge, FAIP  
P.L. King, BSc (Hons) ANU, PhD Arizona State  
J.A. Mavrogenes, BS Beloit, MS Missouri-Rolla, PhD Virginia Tech  
S.C. McClusky, BSurv PhD UNSW  
M.S. Miller, BA Whittier, MSc Columbia, MEng Cornell, PhD ANU  
H. Tkalčić, Dip Engineering in Physics, Zagreb, PhD California Berkley  
P. Tregoning, BSurv PhD UNSW  
J. Yu, BSc MSc Nanjing University, PhD Cambridge

### **Fellows**

D.R. Davies, MSci PhD Cardiff, UK

M.A. Forster, BSc MSc PhD Monash  
M.A. Kendrick, BSc Edinburgh, PhD Manchester  
B.N. Opdyke, AB Columbia, MS PhD Michigan  
A. Valentine, BA MSc Cambridge, DPhil Oxford

### **Research Fellows**

J. Avila, BSc MSc UFRGS, PhD ANU  
O. Branson, BSc (Hons) Bristol, MSc Southampton, PhD Cambridge  
A. Burnham, MSci MA Cambridge, PhD Imperial College London  
C. Eakin, MSc Imperial College London, PhD Yale  
B. Gayen, PhD UC San Diego, USA  
A. Kiss, (from 14/08/17)  
C. Le Losq, MSc, PhD IPGP, France  
G. Mallmann, BSc MSc UFRGS, Brazil, PhD ANU  
A. Morrison, BSc (Hons) ANU, GradDipEd Canberra, PhD ANU (from 14/03/17)  
J. Pownall, MEarthSci Oxford, PhD Royal Holloway University of London  
A. Purcell, BSc (Hons), PhD ANU  
C. Shakespeare, BSc (Hons) ANU, PhD Cambridge  
K. Stewart, BSc (Hons), PhD ANU  
R. Wood, BSc (Hons) Durham, MSc DPhil Oxford

### **Postdoctoral Fellows**

S. Allgeyer, PhD Paris Diderot, France  
K. Grant, BSc Southampton, MSc JCU, PhD Southampton  
B. Hejrani, BSc Kurdistan, MSc Tehran, PhD Aarhus, Denmark  
F. Hibbert, PhD St Andrews, UK  
A. Koulali, PhD Rabat Agdal, Morocco  
J. Mallela, BSc (Hons) Leeds, MSc Heriot-Watt, PhD West Indies  
G. Marino, MSc (cum laude) 'Federico II' of Naples; PhD Utrecht  
M. Mustac, PhD ANU (from 3/3/17)  
J. Pfeffer, MSc Joseph Fourier, Grenoble, France, PhD Strasbourg  
L. Waszek, BA (Hons) MSci PhD Cantab (from 17/5/17)  
D. Yin, PhD Tsinghua, Beijing

### **Emeritus Academics**

R.J. Arculus, BSc PhD Durham, FAIMM  
K.S.W. Campbell, MSc PhD Queensland, FAA  
J.M.A Chappell, BSc MSc Auckland, PhD ANU, FAA, HonFRSNZ  
W. Compston, BSc PhD DSc (Hon) WAust, FAA, FRS  
P. DeDeckker, BA MSc (Hons) Macquarie, PhD DSc Adelaide  
R.A. Eggleton, BSc (Hons) Adelaide, PhD Wisconsin, DSc Adelaide  
D.J. Ellis, MSc Melbourne, PhD Tasmania  
N.F. Exon, BSc (Hons) NSW, PhD Kiel (from 30/09/17)  
J.D. Fitzgerald, BSc James Cook, PhD Monash  
D.H. Green, BSc MSc DSc DLitt (Hon) Tasmania, PhD Cambridge, FAA, FRS  
R.W. Griffiths, BSc PhD ANU, FAIP, FAA  
I.N.S. Jackson, BSc Qld, PhD ANU, FAA  
B.L.N. Kennett, MA PhD ScD Cambridge, FAA, FRS  
K. Lambeck, BSurv NSW, DPhil DSc Oxford, FAA, FRS  
I. McDougall, BSc Tasmania, PhD ANU, FAA  
D.C. McPhail (dec 12/3/17), BSc. (Hons) MSc British Columbia, PhD Princeton  
M.D. Norman, MSc Tennessee, PhD Rice  
M.S. Paterson, BSc Adelaide, PhD Cambridge, FAA  
R.W.R. Rutland, BSc PhD London, FTSE  
S.R. Taylor, BSc (Hons) MSc New Zealand, PhD Indiana, MA DSc Oxford, HonAC  
J.S. Turner, MSc Sydney, PhD Cambridge, FIP, FAIP, FAA, FRS

### **Honorary Academics**

R.A. Armstrong, BSc MSc Natal, PhD Witwatersrand (from 19/11/16)  
C.M. Fanning, BSc Adelaide (from 5/11/16)  
C.B. Foster, BSc (Hons) Adelaide, PhD Queensland (from 17/3/17)  
D. Rubatto, BSc MSc Turin, PhD ETH Zürich (from 1/8/17)  
A. Gerson, PhD Strathclyde, Scotland (from 1/02/2016)  
N. Williams, BSc (Hons) ANU, MPhil PhD Yale (from 1/7/17)

### **Adjunct Academics**

J. Hermann, Dip PhD ETH Zürich (to 31/7/17)  
D. Rubatto, BSc MSc Turin, PhD ETH Zürich (to 31/7/17)



## **Visiting Fellows**

A. Acosta-Vigil, PhD Granada  
C. Alibert, MS Paris VII, first thesis ENS Paris, State thesis, CRPG, Nancy  
R.V. Burne, BSc Wales, DPhil Oxford  
L. Chang, BSc Peking, PhD Southampton (to 26/10/17)  
G.F. Davies, MSc Monash, PhD CalTech  
P. de Caritat de Peruzzis, PhD ANU  
X. Duan, PhD Inst Geology & Geophysics, Chinese Academy of Sciences  
G.M. Gibson, BSc Edinburgh, PhD Otago  
R. Grün, Diplo Geol, Dr.rer.nat.habil Köln, DSc ANU, FAAH  
R. Henley, BSc (Hons) London, PhD Manchester  
W. Howard, BA, PhD Brown University  
A.L. Jacques, BSc (Hons) Western Australia, PhD Tasmania  
T.P. Mernagh, PhD Newcastle  
B. Montaron, PhD Pierre et Marie Curie, France (to 22/05/2017)

## **PROFESSIONAL STAFF**

### **School Manager**

G.F.M. Pearson, BA, BTh, MBA, FAIM

### **Executive Assistant to the Director and the School Manager**

M. Farrer

### **Philanthropic Development Manager**

M. King, DipTeach ACU, BA Deakin, GradDipRE ACU, MEd UNSW (to 30/6/17)

### **Senior Administration Officer**

B.J. Armstrong, BSc UNISA (South Africa)

### **Building and Facilities Officer**

E. Ward, Cert V Frontline Management, Quest/ANU

### **Student Administrator HDR**

M. Coldrick

### **Student Administrator Coursework**

J. McDermid, BCom Victoria University (Wellington), MAppSc (Lib&InfoMgt) CSU (to 30/6/17)

T. Asher (from 10/7/17)

### **Education Officer**

B. Harrold, BSc ANU

### **Receptionist**

T. Asher

### **Research Group Administrators**

E. Arnold – Earth Dynamics; Seismology & Mathematical Geophysics

J. Magro – Experimental Petrology; Geochemistry & Cosmochemistry

R. Petch – Biogeochemistry; Climate & Fluid Physics; Palaeoenvironments

### **IODP Administrator**

C. Beasley, BA (Sustainable Systems) ANU

### **Centre Administrator for Centre of Excellence Climate System Science and Centre of Excellence Climate Extremes**

A. Bryleva, BPublicAdmin Lomonosov Moscow State, Cert III Bus Adm CIT (from 1/08/17)

### **Electronics Group Manager**

A. Latimore, BEng University of Canberra

### **Electronics Group**

D. Cassar, AdvDipEng CIT

D. Cummins, AdvDipEng CIT

T. Redman, AssocDip(Elect Eng) CIT

H. Sasaki, AssocDip CIT

### **Mechanical Engineering Workshop Manager**

A. Wilson, AssocDipMechEng CIT, Cert III Engineering (Mechanical) Trade

### **Mechanical Engineering Workshop**

B. Butler, Cert III Mechanical Engineering Sydney Institute, Cert III Engineering-Mechanical Trade (Toolmaking)

C. Were, AdDipMechEng CIT, Cert III Engineering (Mechanical) Trade

G. Woodward, Cert-Fitting and Machining Trade

### **School Laboratory Manager**

D. Cassar, AdvDipEng CIT

### **Research Officers**

A. Arcidiaco, BAppSc GradDip SAInst

J. Byrne, BSc (Hons) ANU, PhD Monash  
A. Heerdegen, BSc (Hons) Massey, PhD ANU  
P. Holden, BSc Lancaster, PhD St. Andrews  
G. Luton, BSurv UNSW  
H.W.S. McQueen, BSc Qld, MSc York, PhD ANU  
S. Mousavi, BSc, MSc, Tehran University, PhD Leipzig  
R. Rapp, BA State University of New York, PhD Rensselaer Polytechnic Institute  
L. Rodriguez Sanz, BSc Venezuela, MEnvStudies, PhD Autonomous (Barcelona)  
M. Salmon, BSc (Hons) PhD Victoria (Wellington)

### **Technical Officers**

J. Cali, BAppSc QIT  
D. Clark, Cert III Metal Fabrication AdvDipEng CIT  
J. Cowley, BSc ANU  
R. Erigela, (from 1/5/17)  
R. Esmay, BSc (Sr Thesis) SUNY Purchase  
B. Fu, BSc Chungchun, MSc Nanjing, PhD Vrije  
J. Hope, BSc JCUNO  
L. Kinsley, BSc GradDipSc ANU  
H. Kokkonen, Certificate in Lapidary ACT TAFE, BAppSc Canberra College of Advanced Education  
P. Lanc, AssocDip Bus (Applied Computing) CIT  
Q. Li, BEng Beijing Electronic Science and Technology Institute, MEng UNISA  
L. McMorrow, AssocDipSc NTU  
H. Miller, AdDipMechEng CIT  
G. Nash, BSc Hons ANU  
S. Paxton, AssocDip AppliedGeoscience CIT, FGAA  
A. Purelli, (from 20/04/2015)  
S. Rayapaty, BEng Jawaharlal Nehru Technological University, MIT University of Canberra  
A. Rummery, Cert III CIT (x3)  
D. Scott, AssocDipMechEng CIT  
H. Scott-Gagan, BSc Sydney  
D. Thomson, Cert-Fitting and Machining Trade  
B. Tranter, Cert II Auto Radiator Services John Batman Institute TAFE, Auto Climate Control/Air conditioning Casey Institute of TAFE (to 10/03/2016)

U. Troitzsch, Diplom Technische Universität Darmstadt, PhD ANU  
D. Vasegh, AssocDeg Khajeh Nasireddin Toosi University of Technology (Iran)  
J. Zhang,  
X. Zhang, PhD LaTrobe  
X. Zhao, BSc Jilin University, PhD Southampton  
S. Zink, BSc Hanover, Diploma (MSc) Hanover

## POST-GRADUATE STUDENTS

### PhD Candidates

Amies, Jessica	Hoffmann, Janosch	Penny, Tiah
Andrew, Sarah	Holland, Katherine	Pham, Thanh
Anenburg, Michael	Hu, Yuzhi (Daisy)	Pranantyo, Ignatius
Baruleva, Olga	James, Hannah	Prichard, Jennifer
Bean, Lynne	Jones, Timothy	Qian, Yao
Bobrovskiy, Ilya	Kallenberg, Bianca	Rajabi, Sareh
Bonning, Geoffrey	Kimbrough, Alena	Renggli, Christian
Cajal Contreras, Yamila	Kirby, Rachel	Samanta, Moneesha
Carr, Patrick	Koefoed, Piers	Schoneveld, Louise
Castillo Gonzalez, Paula	Koudashev, Oleg	Scicchitano, Maria
Chen, Bei	Krestianinov, Evgenii	Sebastian, Nita
Chen, Mimi	Lakey, Shayne	Short, Michael
Chopping, Richard	Li, Yuwei	Sieber, Melanie
Cipta, Athanasius	Liu, Li	Skelton, Richard
Cline II, Christopher	Loiselle, Liane	Smith, Tegan
Cocker, Helen	Long, Kelsie	Sohail, Taimoor
Connolly, Clare	Lowczak, Jessica	Sommer, Johanna
Contro De Godoy, Bruna	Manceau, Rose	Stephenson, Joanne
Crisp, Laura	Mare, Eleanor	Tambiah, Charles
Dai, Yuhao	Martin, Hayden	Tian, Siyuan
De Leon, Andrea	Martinez Moreno, Josue	Timmerman, Suzette
Ducommun-Dit-Verron, Joelle	Masoumi, Salim	Tolley, James
Duvernay, Thomas	Mathews, Christopher	Tyler, Perinne
Ellis, Bethany	McConachie, Shannon	Tynan, Sarah
Emetc, Veronika	McConnochie, Craig	Valetich, Matthew
Fang, Fang	Miller, Laura	Vinnichenko, Galina
Farmer, Nicholas	Misztela, Monika	Vreugdenhil, Catherine
Gauthiez-Putallaz, Laure	Mondal, Mainak	Ward, Josephine
Gibson, Angus	Mustac, Marija	Whan, Tarun
Goodarzi, Patrick	Naguit, Muriel	Williams, Morgan
Gray, Sharon	Nand, Vikashni	Wu, Jiade
Haber, Thomas	Nash, Graham	Wu, Yang
Hao, Hongda	Nettersheim(Bruisten), Benjamin	Wurtzel, Jennifer
Harazin, Kathleen	Ogunsami, Abdulwaheed	Zannat, Umma
Hawkins, Rhys Peter	O'Neill, Cameron	Zheng, Siru
Haynes, Marcus	Owens, Ryan	Zhou, Yifei
Hayward, Kathryn	Pejic, Tanja	Zhu, Ziyi

Eriks, Nicole (withdrew April 2017)

Johnson, Emma (withdrew November 2017)

Stone, Laura (withdrew November 2017)

## MPhil Candidates

Baeza, Leonardo  
Carrasco Godoy, Carlos  
Creighton, Reuben  
Leonard, Yosafat  
Muston, Jack  
Qu, Tongzhang  
Sohail, Taimoor (Transfer to PhD November 2017)  
Yuguru, Samuel

## Master of Earth Sciences (Advanced)

Agrawal, Shubham  
Chen, Xiaoyu  
Flanigan, Michaela (completed)  
He, Nini  
Hu, Shangyu  
Lin, Yucheng  
Marais-Van Vuuren, Christo  
Marris, Kristen  
Merriman, Prudence  
Naina  
Palm, Andrew  
Rozenbaks, Peteris  
Shi, Lin (completed)  
Song, Cheng  
Su, Xiaoyu  
Tuveng, Karina (completed)  
Wang, Chuang  
Yin, Fan (completed)  
Zhang, Yuejiao  
Zhao, Siyuan  
Zhou, Qianhui  
Zhou, Jin

## UNDERGRADUATE EDUCATION

### Honours completions

Bardwell, William  
Chen, Fangqin  
Hargreaves, Jessica  
Holder, Liam  
Laker, Darren  
Pasic, Bozana  
Perera, Rushi

### Earth & Marine Science Programme

Semester 1	Course description	Convenor, Teaching staff	Number of students
EMSC1006/4006/6107	Blue Planet	<b>B. Hanger</b> , P. King, S. Eggins	158
EMSC2012/4012/6031	Introduction to Structural & Field Geology	<b>S. Cox</b> , K. Hayward	16
EMSC2014/4014/6014	Sedimentology & Stratigraphy	<b>B. Opdyke</b> , B. Pillans	31
EMSC2017/4017/6017	Rocks and Minerals	<b>G. Yaxley</b> , B. Hanger, G. Mallmann, J. Avila	32

EMSC3002/4002/6030	Structural Geology & Tectonics	<b>S. Cox</b> , G. Lister	14
EMSC3023/4023/6023	Marine Biogeochemistry	<b>M. Ellwood</b> , S. Fallon, O. Branson	21
EMSC3024/4024/6024	Magmatism & Metamorphism	<b>G. Lister</b> , I. Williams, G. Mallmann, J. Pownall	13
EMSC3032/4032/6032	Melting Polar Ice Sheets	<b>P. Tregoning</b> , S. Allgeyer, J. Pfeffer	9
EMSC4017/8017	Research Methods and Proposal	<b>M. Forster</b>	12
EMSC4018/8018	Advanced Water and Marine Geosciences	<b>M. Ellwood</b> , S. Fallon, O. Branson	5
EMSC4121/8021	Advanced Geochemistry, Petrology and Tectonics	<b>A. Burnham</b> , H. O'Neill, V. Bennett, M. Kendrick, A.L. Jaques	2
EMSC4122/8022	Analytical Techniques	<b>V. Bennett</b> , Y. Amelin	4
EMSC4123/8023	Data Analysis	<b>D. Heslop</b>	6
EMSC4706/8706	Natural Hazards	<b>P. Cummins</b>	11
<b>Winter</b>			
EMSC3001	Field Geology	Run by University of Queensland	5
<b>Semester 2</b>			
EMSC1008/6008	Earth	<b>A. Berry</b> , M. Gagan, C. Eakin	71
EMSC2015/4015/6015	Chemistry of the Earth	<b>M. Kendrick</b> , I. Williams	29
EMSC2019/4019/6019	Geobiology & Evolution of Life on Earth	<b>J. Brocks</b> , L. Bean	34
EMSC2021/4021/6021	Climate System Science	<b>M. Roderick</b> , A. Hogg, C. Shakespeare	29
EMSC3007/6007	Economic Geology	<b>J. Mavrogenes</b>	17
EMSC3022/6022	Planetary Science	<b>C. Lineweaver</b> , T. Ireland	43
EMSC3025/4025/6025	Groundwater	<b>D. Heslop</b> , P. King, B. Opdyke	16
EMSC3027/4027/6027	Palaeoclimatology & Climate Change	<b>J. Yu</b> , N. Abram, K. Grant	18

EMSC4123/8023	Data Analysis	<b>D. Heslop</b> , M. Sambridge	8
EMSC4190/8109	Advanced Earth Physics	<b>S. McClusky</b> , H. Tkalčić, I. Jackson, B. Tauzin	3
<b>Spring</b>			
EMSC3019/6119	Coral Reef Field Studies	<b>M. Ellwood, S. Fallon</b>	28
EMSC3050	NCP Field trip (Japan)	D. Heslop, P. Cummins, S. Mousavi	15
<b>Special topics</b> EMSC3050/4050/ 6805/8014	Research project (6 units)	Y. Amelin, A. Berry, M. Ellwood, S. Fallon, M. Forster, D. Heslop, G. Lister, J. Mavrogenes, H. Tkalčić, I. Williams, P. Tregoning, R. Wood	21

### Physics Programme

	Course description	Convenor, Teaching staff	Number of students
PHYS2017	Waves and Optics	A. Hogg	62
PHYS3034/4034	Physics of Fluid Flows	<b>R. Kerr</b> , A. Hogg, B. Gayen, K. Stewart	21
PHYS3070	Physics of the Earth	<b>H. Tkalčić</b> , D.R. Davies, A. Valentine	17

### Archaeology Programme

	Course description	Convenor, Teaching staff	Number of students
ARCH1111	Archaeology Uncovered	Duncan Wright (RSHA), incl. <b>R. Wood</b>	50
ARCH8032	Introduction to Archaeological Science	Philip Piper (RSHA), incl. <b>R. Wood</b>	10



## THESES AND AWARDS

### PhD theses completed (Supervisor in parentheses)

Castillo Gonzalez, Paula "Evolution of the Patagonian-West Antarctica margin of Gondwana in the Palaeozoic Early Mesozoic: new models constrained by zircon U-Pb ages, and O and Hf isotopic compositions" (C. Mark Fanning)

Cocker, Helen "Platinum group elements: Indicators of sulfide saturation in intermediate to felsic magmatic systems and implications for porphyry deposit formation" (Ian Campbell)

De Leon, Andrea "The boron geochemistry of biogenic silica: insights from marine sponges and diatoms" (Stephen Eggins)

Haber, Thomas "Constraining the bombardment history of the moon with a set of Apollo 14, 16 and 17 impact melts rocks" (Victoria Bennett)

Hoffmann, Janosch "Ice height change in east Antarctica derived from satellite laser altimetry" (Paul Tregoning)

Holland, Katherine "Distinguishing biological from environmental controls on the chemistry of planktic foraminifer shells" (Michael Ellwood)

Kallenberg, Bianca "Comparison of observations and modelling of surface mass balance variations in east Antarctica" (Paul Tregoning)

Kimbrough, Alena "The glacial-interglacial monsoon recorded by stalagmites from southwest Sulawesi, Indonesia" (Michael Gagan)

Koefoed, Piers "Sequencing planetary accretion using chronology of ungrouped achondrites" (Yuri Amelin)

McConnochie, Craig "Experiments on the interaction of ice sheets with the polar oceans" (Ross Kerr)

Mustac, Marija "Hierarchical Bayesian inversion for the point source moment tensor: method and applications" (Hrvoje Tkalčić)

Naguit, Muriel "Towards earthquake-resilient buildings: rupture process and exposure/damage analysis of the 2013 Mw7.1 Bohol Philippines earthquake" (Phil Cummins)

Nettersheim (Bruisten), Benjamin "Reconstructing earth's alien, ancient ecology - A multiproxy study of the 1.64 billion years old Barney Creek Formation, Northern Australia" (John Mavrogenes)

Pejic, Tanja "Attenuation tomography of the upper inner core" (Phil Cummins)

Short, Michael "Tracing terrestrial salt cycling using chlorine and bromine" (Bear McPhail)

Vreugdenhil, Catherine "Geostrophic convective circulation in a rotating rectangular basin" (Bishakhdat Gayen)

## STAFF HONOURS & AWARDS

	AWARD	AWARDING BODY
<b>Dr D.R. Davies</b>	Anton Hales Medal	Australian Academy of Science
<b>Dr B. Gayen</b>	RJL Hawke Fellowship	Australian Antarctic Division
<b>Em.Prof. Griffiths</b> <b>R.W.</b>	Visiting Professorship award	Universite Grenoble-Alpe, France
	2017 John Conrad Jaeger Medal	Australian Academy of Science
<b>Prof T.R. Ireland</b>	Fellow	American Geophysical Union
<b>Dr M.A. Kendrick</b>	Fellow	Higher Education Academy
<b>Em.Prof. B.L.N. Kennett</b>	Inge Lehmann Medal	American Geophysical Union
<b>Dr P.L. King</b>	Senior Fellow	Higher Education Academy
	Clare Burton Award for Equity & Diversity	ANU Vice-Chancellor's staff excellence & service award
<b>Dr G. Marino</b>	University of Vigo programme to attract excellent research talent	University of Vigo (Spain)
<b>Prof E. Rohling</b>	Fellow	American Geophysical Union



A/Prof. Penny King receiving the Clare Burton Award for Excellence in Equity and Diversity from the Vice Chancellor, Prof. Brian Schmidt.

## STUDENT HONOURS & AWARDS

<b>Higher Degree Research</b>	
AGU Study of the Earth's Deep Interior Graduate Research Award	Timothy Jones
34th International Geological Congress Travel Grant for Early Career Geoscientists, awarded by the Geological Society of Australia	Kathryn Hayward
KSW Campbell Award for Teaching Excellence	Kathryn Hayward
DA Brown Travel Fellowship 2016	Bethany Ellis
DA Brown Travel Fellowship 2017	Perinne Tyler
Jaeger Scholarship	Tharika Liyanage
Mervyn & Katalin Paterson Fellowship 2016	Kathryn Hayward, Suzette Timmerman, Sarah Andrew & Lynne Bean
Mervyn & Katalin Paterson Fellowship 2017	Ilya Bobrovskiy & Rose Manceau
Ringwood Scholarship	Galina Vinnichenko
Robert Hill Memorial Prize	Jennifer Wurtzel
Sue Kesson Scholarship	Patrick Goodarzi
<b>Coursework</b>	
A L Hales Honours Scholarship	Jessica Hargreaves
ARC Centre of Excellence Climate System Science Scholarship	Jessica Hargreaves & Liam Holder
John and Kerry Lovering Scholarship	Andrew Palm
Scholarship in Regolith Science	Prudence Merriman

## **RESEARCH ACTIVITIES**

### **BIOGEOCHEMISTRY**

Group leader: Michael Ellwood

Academic members: L. Armand, O. Branson, J. Brocks, S. Eggins, S. Fallon, R. Wood

The biogeochemistry group at RSES has had a dynamic year. The group continues to focus on its research strengths to answer key research problems in marine and terrestrial science. These questions include

What is the role the oceans in regulating global climate?

How do changes in the bioavailability of trace metals shape the microbial community in the ocean?

How do foraminifer and corals calcify?

What was the physical and chemical state of the ocean during the last glacial period?

What was the tempo and mode of evolution of complex life on Earth and can they be traced using biological information from the structure and isotopic composition of molecular fossils along with data from sedimentology, microfossils and inorganic geochemical proxies to reconstruct ancient microbial ecosystems?

We welcomed a new recruit to the biogeochemistry group: A/Prof. Leanne Armand. Leanne is the new ANZIC (Australian and New Zealand International Ocean Discovery Program Consortium) Program Scientist. She is an expert in Southern Ocean diatom taxonomy (the identification of marine microscopic phytoplankton). She has a strong interest in the distribution of individual species related to the physical oceanic environment, and the subsequent preservation of this environmental relationship in the fossil record.

The group continued to publish high impacting papers with notable additions to the following top-ranking journals: Nature, Nature Communications, Nature Geoscience, PLOS ONE, Geochimica et Cosmochimica Acta, Journal of Human Evolution, Earth and Planetary Science Letters.

In 2017 group members continue to contribute to the undergraduate teaching program within RSES. Courses taught by academic group members include: Marine biogeochemistry, Palaeoclimatology and Climate Change, Coral Reef Field Studies, Sedimentology and Stratigraphy and The Blue Planet.

## **CLIMATE & FLUID PHYSICS**

Group Leader: Andy Hogg

Academic members: B. Gayen, A. Hogg, R. Kerr, A. Kiss, A. Morrison, M. Roderick, C. Shakespeare, K. Stewart, D. Yin

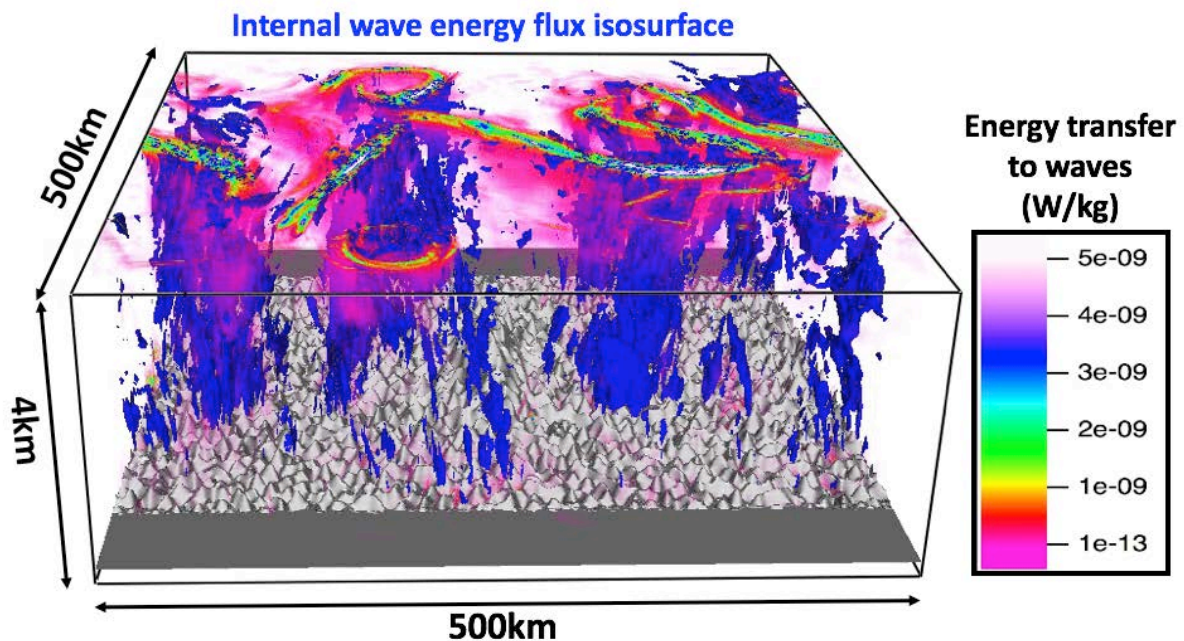
The Climate & Fluid Physics group conducts research into fluid physics and thermodynamic processes that are relevant to the Earth system. Our current research priorities include oceanic convection, ice-ocean interactions, the energy balance of the land surface and the large-scale circulation of the ocean. In 2017 we changed our name (formerly Geophysical Fluid Dynamics) to better represent the breadth of research we undertake. 2017 was also the first year of the recently funded ARC Centre of Excellence for Climate Extremes, which follows on from the ARC Centre of Excellence for Climate System Science and supports the research of many in the group.

This year saw the first full year of the Consortium for Ocean-Sea Ice Modelling in Australia (COSIMA; see [cosima.org.au](http://cosima.org.au)), led by this group. We built a new version of ACCESS-OM2 (the ocean-sea ice component of Australia's ACCESS climate model) which is currently in the final stages of pre-release. ACCESS-OM2 will be released at 3 different resolutions ( $1^\circ$ ,  $0.25^\circ$  and  $0.1^\circ$ ) with a consistent set of parameters. We have finalised a new topography dataset with upgraded vertical resolution for the  $0.1^\circ$  version (Stewart et al. 2017) and will complete a full spinup of the model in early 2018.

While developing ACCESS-OM2, we have continued to make scientific progress with our previous modelling suite. We published a significant paper on the energetics of upwelling in the Southern Ocean (Hogg et al. 2017), showing the mechanism by which winds in the Southern Ocean influence northern hemisphere ocean circulation. We have continued our work on the interaction of the ocean with the Antarctic continent, using models to show how variations in wind stress control the flow of warm water onto the coastal fringes of Antarctica, potentially controlling the rate of ice sheet melting (Spence et al. 2017). This landmark study was published in Nature Climate Change and has received significant attention.

Work on the Californian drought with ETH-Zurich scientists has led to a new understanding of the relation between drought and long-term climate warming. In particular, the warming experienced during drought has a different heating source from the warming expected because of climate change. This has opened the possibility of using new ways to separate observed changes in temperature due to changes in the long-term mean from changes in extremes. Work with another group from ETH-Zurich has also led to a re-evaluation of projections about changes in aridity over land with warming. In particular, an analysis of direct climate model output from the last glacial maximum to the year 2100 has shown that the warmer conditions associated with high  $\text{CO}_2$  are also generally associated with greening as has been observed over the last century.

At the fundamental level, we conducted groundbreaking new "internal wave resolving" ocean model simulations (Shakespeare & Hogg 2017a,b). Results from ultra-high resolution numerical modelling reveal a new source of internal wave energy in the ocean. Internal waves are thought to be responsible for mixing the deep ocean and thereby maintaining the ocean overturning circulation. Our model illustrates the process of "spontaneous generation" where waves emerge from the mean flow due to a breakdown of balanced dynamics, without any direct forcing. The figure shows how these surface generated waves propagate to the ocean bottom, potentially providing an energy source for mixing in the abyss.

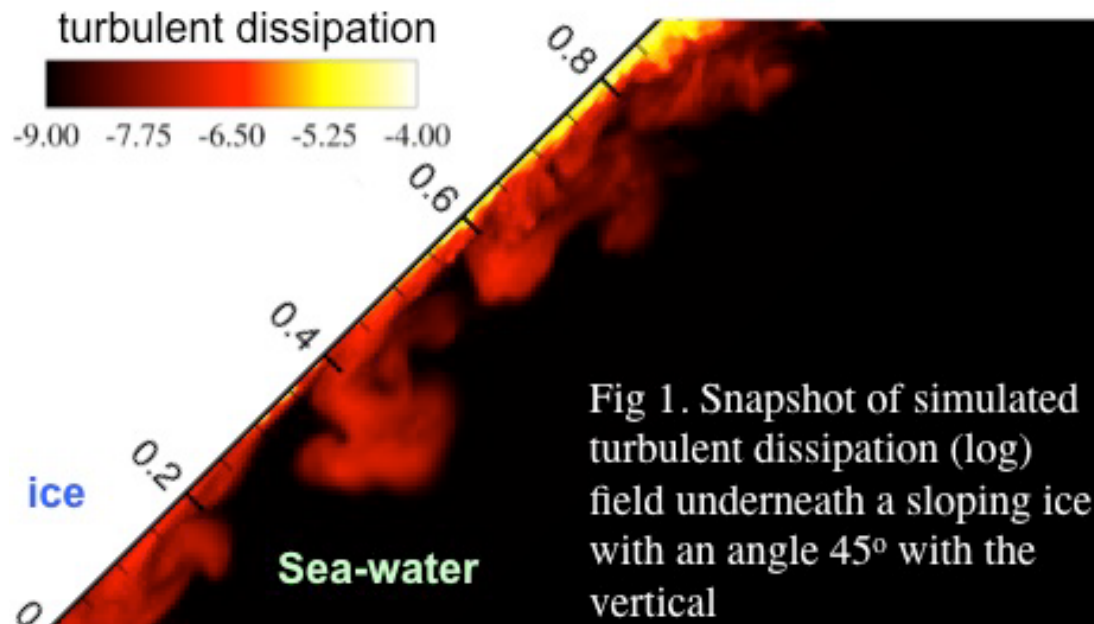


Ultra-high resolution numerical model showing the spontaneous generation of internal waves from fronts and jets near the ocean surface. Colours show the energy transfer into the downward wave field from the mean flow. The downward propagating waves are visualised by an isosurface of the vertical wave energy flux.

This year, we continued our quantitative modelling of the convective dissolution of ice in the polar oceans, using a combination of theory, laboratory experiments and direct numerical simulations. The complex boundary layer dynamics beneath Antarctic ice shelves was examined to reveal the parameter dependence of melting rate at sloping ice faces under natural convection. The effect of subglacial freshwater discharges on tidewater glaciers was quantified and compared with a common ice-ocean parameterization (McConnochie & Kerr 2017a,b). For a sloping ice face the vertical component of the salinity gradient produces stabilizing density stratification within the boundary layer adjacent to the ice face thereby reducing turbulent transport (McConnochie & Kerr 2018). We have also developed theoretical scaling solutions for the convective flow that compare well with the DNS results (Mondal et al. 2018).

During 2017, we also examined the role of convection in maintaining the circulation relevant to the North Atlantic basin. Our DNS results show for the first time that surface buoyancy forcing alone can drive substantial basin-scale sub-tropical and sub-

polar gyres, along with full-depth overturning circulation. The results also show that mass transport and heat throughput are governed by horizontal geostrophic flow in the thermal boundary layer. Vertical heat transport from the surface layer into the deep interior mostly occurs in open-ocean chimney convection within the sub-polar gyre, whereas vertical mass transport is accommodated mostly against the side boundaries (Vreugdenhil et al. 2017).



### Staff news

Bishakhdatta Gayen was promoted to Level C.

Adele Morrison joined the group to take up her DECRA Fellowship.

Andrew Kiss joined the group as a Research Fellow.

### Student news

Catherine Vreugdenhil graduated from her PhD and took up a Postdoctoral Fellowship at Cambridge University.

Craig McConnochie graduated from his PhD and took up a Postdoctoral Fellowship at Woods Hole Oceanographic Institution.

Alice Barthel graduated from her PhD and took up a Postdoctoral Fellowship at Los Alamos National Laboratory.

Josué Martínez-Moreno joined the group as a PhD student, working on Southern ocean eddies with Andy Hogg.

### Emeritus, Honorary staff and Visitors

Dr James Munroe visited the group for the duration of 2017 from Memorial University, and built a new framework to analyse ocean model output.

Dr Fanghua Wu visited from the Chinese Meteorological Agency to work on high-resolution ocean model development.

Dr Claire Carouge remains as a long-term visitor from UNSW, heading the Computational Modelling Support team for the ARC Centre of Excellence for Climate Extremes.

## **EARTH DYNAMICS**

Group Leader: Dr Paul Tregoning

Academic members: S. Allgeyer, S. Cox, M. Forster, A. Koulali, G. Lister, S. McClusky, J. Pfeffer, J. Pownall, A. Purcell

The Earth Dynamics group is a newly formed amalgamation of the Geodynamics, Rock Physics and Structural Geology and Tectonics groups at RSES. Research in the *Earth Dynamics* group involves the integration of data and concepts from several fields to better understand Earth Dynamics on a wide range of temporal and spatial scales. We are interested in how earthquakes nucleate and propagate, how (and how fast) fluids and magmas move through deforming rock, why, when and where large ore deposits form, and how the planet surface responds to the waxing and waning of ice sheets. Through the integration of these many different disciplines we address the overarching goal of understanding our planet so that we may benefit from the natural resources it produces, better guard ourselves against the natural hazards it poses and to understand how Earth is responding to our changing climate.

Highlights in 2017 include new results of crustal deformation in Java (Koulali et al., 2017a), earthquakes and slow-slip events on the Hikurangi subduction zone in New Zealand (Koulali et al., 2017b), separating different components of vertical land motion at tide gauges (Pfeffer et al., 2017) and a new ice sheet model for the North American continent (Lambeck et al., 2017). Several PhD student papers were published, covering topics of mass balance in Antarctica (Kallenberg et al., 2017), the theory and application of estimating biases in geocentre motion (Zannat and Tregoning, 2017a,b), modelling of tropospheric gradients using GPS data (Massoumi et al., 2017) and new outputs of hydrological models after the assimilation of total water storage and soil moisture information from the GRACE and SMOS satellite missions (Tian et al, 2017). New results of temporal gravity field estimates from GRACE data using our software were presented at the GRACE Science Team Meeting in Austin, Texas, in October.

Laboratory studies in rock deformation continued to focus on using high P, T experiments to develop understanding of wear processes and evolution of friction in the first milliseconds of earthquake slip. The new laser interferometry technique was used to record slip velocities on microsecond timescales during fast slip events was supported by microstructural analysis using electron microscopy. The results are



applied to understanding (1) the dynamics of ore formation in active faults, and (2) factors controlling where highest fluid fluxes occur in faults. The 50th anniversary of the commissioning of Rig 1 in the Rock Deformation laboratory was celebrated at RSES in November with a 1-day colloquium during which many alumni of the rock deformation laboratory gave scientific presentations.

### **Student news**

Bianca Kallenberg and Sareh Rajabi submitted their PhD theses, which were subsequently accepted. Salim Masoumi submitted his PhD thesis and is currently making corrections necessary for completion.

Siru Zheng commenced her PhD. Her work will focus on using a Kalman filter to analyse global and regional sea level change, assimilating tide gauge observations with satellite altimetry measurements of sea surface heights.

### **Emeritus, Honorary staff and Visitors**

Anne Kockmeyer visited the group as an intern as part of her Masters degree at the University of Bonne, Germany. Anne worked on developing models for extracting steric sea level signals from tide gauge records. We also hosted two undergraduates, Ben Schiffer and Erin Gray, for 8 weeks as part of the Princeton International Internship Program. Erin worked on improving the modelling of GRACE satellite orbits using our in-house software while Ben worked on estimating geocentre motion on Earth from global GPS data.

### **Extended travel and outcomes**

As part of her PhD research, **Ms K Hayward** had extended collaborative visits to labs at the University of Manchester, Ecole Normale Supérieure (Paris) and INGV (Rome) to conduct experiments and learn techniques for measuring rapid elastic unloading of rock samples during fast shear failure events.

### **Outreach activities & Service roles external to ANU**

Prof S F Cox provided a 2-day course on "Deformation processes and structural analysis on fracture-controlled hydrothermal ore systems" as part of the Society of Economic Geologists Annual Conference (SEG2017) at the China University of Geosciences, Beijing. He also presented a 1-day course at the University of Tasmania as part of the CODES Masters program. Cox also provided an evening lecture and demonstration of the deformation sandbox to a Canberra Rotary group.

Dr Paul Tregoning gave a presentation to Year 11 and 12 students at Narrabundah College on 21 February to highlight the need and usage of mathematics and computer programming in climate science studies.

## EXPERIMENTAL PETROLOGY

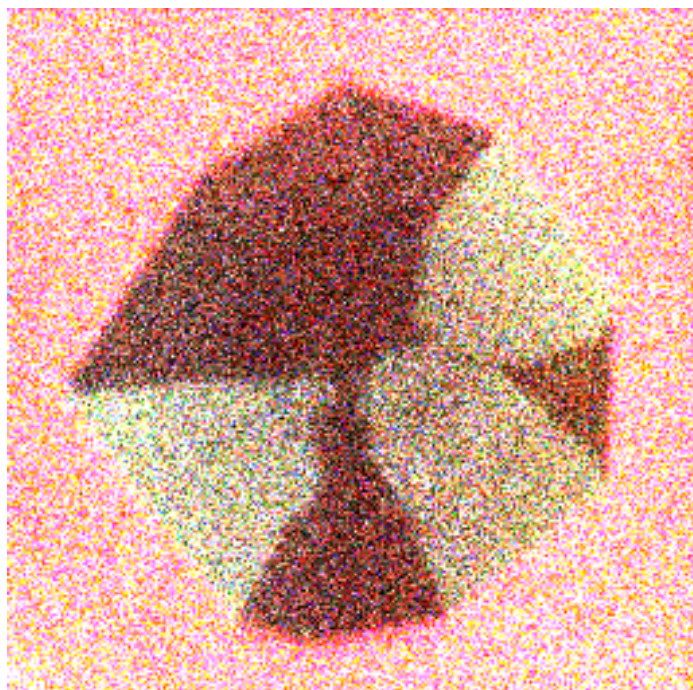
Group leader: Andrew Berry

Academic members: A. Burnham, I. Campbell, C. Le Losq, G. Mallmann, J. Mavrogenes, H. O'Neill, G. Yaxley

In 2017 the experimental petrology group comprised five members of continuing academic staff (Andrew Berry, Ian Campbell, John Mavrogenes, Hugh O'Neill, and Greg Yaxley), five postdoctoral fellows (Antonio Acosta-Vigil (visiting), Antony Burnham, Xianzhe Duan (visiting), Charles Le Losq, and Guil Mallmann), three technical staff, and 18 PhD students. Eleanor Mare and Louise Schoneveld submitted their PhD theses during the year, with Eleanor taking up a postdoc at the University of St Andrews and Louise moving to a position at CSIRO in Perth.

Two new fully automated piston-cylinders were commissioned in 2017, bringing the total number of operational piston-cylinders to 11. We also took delivery of a JEOL JXA-8530F HyperProbe, funded by an ARC LIEF grant led by Greg Yaxley, which has been installed in the Centre for Advanced Microscopy. The new microprobe, which has a field-emission electron gun, is producing excellent data.

The research highlight of the year was a paper in Nature Geoscience by Antony Burnham and Andrew Berry describing geochemical ways of distinguishing detrital zircons from different types of granites with implications for the Earth's crust in the Hadean ("Formation of Hadean granites by melting of igneous crust", Nature Geoscience, 10, 457-461, 2017). The paper was reported by 29 news outlets and Antony was interviewed live on ABC TV.



Sector zoning of REE in a 40 µm crystal of synthetic zircon imaged by PhD student Laura Crisp using the Cameca nanoSIMS 50L at the University of Western Australia.

## GEOCHEMISTRY AND COSMOCHEMISTRY

Group Leader: Trevor Ireland

Academic members: Y. Amelin, J. Avila, V. Bennett, M. Honda, M. Kendrick, P. King, I. Williams

The Geochemistry and Cosmochemistry Group uses experimental and analytical equipment to characterise Earth materials throughout geologic history in order to understand the processes that have been active in making a habitable planet. Much of our work is based around laboratories and facilities, particularly related to analytical mass spectrometers (Noble Gas, SHRIMP, TIMS), but we also carry out experiments including the SPEC-E lab.

G&C has a close association with the 'Origins: Stars, Planets and Life' research theme, where much of our work is applied. The origin and evolution of Earth as a planet is a key element of our research, and much of that research is based on the measurements we can make.

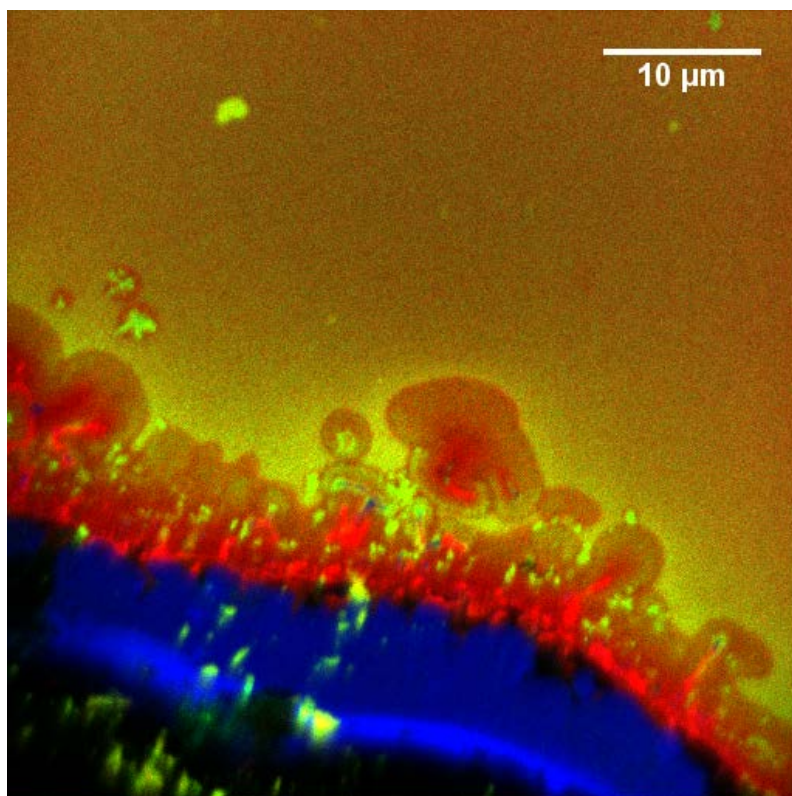
This year has seen developments in all the laboratories. The SHRIMP Facility continues to improve in the measurement of minor stable isotopes and particularly in the abundances of  $^{17}\text{O}$ ,  $^{33}\text{S}$ , and  $^{36}\text{S}$ . In the PhD work of Liane Loiseau, resolution in  $^{17}\text{O}$  has been demonstrated at the 0.1 permil level for Martian meteorites. Techniques have been developed for the precise analysis of O isotopes in 40 mm thin sections of biophosphate. In a collaborative study with representatives from the Chinese National Institute of Metrology, as a contribution to the Avogadro Project, the isotopic composition of enriched Si has been measured in both negative and positive ion mode, achieving sub-percent precision on isotopic ratios as small as  $3 \times 10^{-7}$ .

The SPIDE<sup>2</sup>R lab (isotope geochemistry clean laboratory and Triton plus and MAT 261 mass spectrometers) continues in full production. A sampling of the highlights for 2017 include: improvements on our Triton plus enabling measurement of high precision isotope ratios of extinct nuclides ( $^{142}\text{Nd}$ ) to  $\pm 5$  ppm (2 SD). PhD student Pat Carr, as part of his research, developed protocols for measurement of Nd isotopic compositions of low Nd concentration tourmalines for fluid tracing associated with mineralisation. New chemical procedures have been developed enabling the first high precision ID-TIMS U-Pb dating of the mineral cassiterite. Collaborative work with our visitors Mingxing Ling and Weidong Sun, Chinese Academy of Sciences, has led to refined age estimates of the Ordovician-Silurian boundary using single zircon ID-TIMS U-Pb dating. Continued high precision U-Pb age determinations and initial Sr isotope accretion chronology of the oldest achondrite meteorites are leading to a refined chronology of early solar system processes and planetary differentiation timescales.

In the Noble Gas lab, Helix-MC *Plus* multi-collector noble gas mass spectrometer functions well. During the year, in collaboration with Thermo-Fisher Scientific, we developed a collector automation kit for the mass spectrometer, which is now commercially available. The first one was sold to the University of Oxford. Utilising the mass spectrometer, a post-graduate student, Ms Suzette Timmerman produces high quality noble gas data from minute amounts of well-characterised diamonds. These

results are useful to constrain the structure of the mantle and how it has changed since Earth's formation.

The SPEC-E (Spectroscopy, Characterization and Experiments) Laboratory saw the installation of thermogravimetric analysis, differential scanning calorimeter and differential thermal analysis equipment. The infrared spectrometer with microscope and environmental chambers, plus the handheld infrared spectrometer continue to operate well. New approaches with X-ray diffraction are being pioneered at the Australian Synchrotron and Advanced Light Source.



Cross-section of a basaltic glass reacted with SO<sub>2</sub> at 800 °C created by Christian Renggli (PhD working with Penny King). Brown- silicate glass, red – silicate phases, blue – calcium sulfate, green – magnesium sulfate.

### Staff news

Congratulations to Vickie Bennett on her promotion to Professor (Level E1) in 2017. An honour well deserved for her tireless efforts in leadership and promoting Earth Chemistry and G&C.

Congratulations also to Prof. Ian Williams and Dr Masahiko Honda for deciding to take on retirement. Ian and Honda have been stalwarts of developing the capabilities of mass spectrometers – Ian with SHRIMP, Honda with the Noble Gas Lab. While they aren't going anywhere, this is a significant event for them and for us and we wish to thank them for all they have done, congratulate them on a career well served, but also look forward to working on with them into the future.

### Student news

We congratulate completing students who have fought and persevered through their programs of endeavour:

Thomas Haber was awarded the PhD degree and is now a postdoctoral fellow at the University of Münster, continuing his research on lunar and meteorite samples.

Piers Koefoed has completed his PhD degree and is heading to Washington University in St Louis for a post doc position.

Darren Laker was awarded a first class Honours degree for his thesis "Source Material of the Fractionated Mole Granite: Whole Rock and Zircon Analysis" (supervisors Prof. V. Bennett and Dr. M. Norman).

Geoff Bonning was awarded a first class Honours degree for his thesis "Oxygen isotope compositions of chondrules from carbonaceous chondrites" (supervisor Prof. T. Ireland). Geoff has commenced PhD studies with us.

Callum MacFarlane was awarded a first class Honours degree for his thesis titled "Biogenic Sulfur isotopic Fractionation on SHRIMP SI" (supervisor Prof. T. Ireland). Callum has taken a position with an Australian Government Department.

This year saw the start of research programs for the following new students:

Geoff Bonning (PhD with supervisor Prof. T. Ireland): Experimental cosmochemistry and the origin of high temperature fractionations in the early solar system.

Evgenii Krestianinov (PhD with supervisor Dr Y. Amelin) will study chronology of accretion and differentiation of asteroids using isotope systematics of ungrouped achondrites.

### **Emeritus, Honorary staff and Visitors**

Dr Marc Norman continues his research on the bombardment history of the Earth and Moon.

Dr George Gibson led a 6-day post-conference field excursion in the Mount Isa region as part of Rodinia 2017, one of two major meetings for IGCP 648: Supercontinent cycle and global geodynamics.

### **Extended travel and outcomes**

Prof. Vickie Bennett spent 3 weeks in the Isua region, southwest Greenland as part of ARC funded fieldwork to investigate the origins of habitability as preserved in the oldest (>3,600 million year old) rock record.

Dr M. Honda attended a Geochronology Workshop held at New Mexico Tech, Socorro in June.

Prof. Trevor Ireland visited Prof. Weidong Sun at the Qingdao Institute of Oceanology for 3 weeks and attended 2 conferences: 3<sup>rd</sup> Beijing International Forum on Lunar and Deep Space Exploration, and the Meteorites in China Symposium in Kunshan.

Prof. Ian Williams spent 2 weeks collecting zircon samples in the Galapagos Islands. During 2 weeks in China he visited geological sites in Yunnan and worked in the Beijing SHRIMP Laboratory. He was a guest speaker at the Granites2017@benalla conference.

Dr Penny King spent time at Tokyo Institute of Technology as an invited speaker and guest of the ELSI Origins Network, Cosmic Perspectives of Earth workshop series.

### **Outreach activities**

Prof. Ian Williams, continuing his work with Australian Scientific Instruments, spent a week in India progressing the purchase of a SHRIMP by the Geological Survey of India, and four weeks in Russia helping to upgrade the St Petersburg SHRIMP. He also spent two weeks at IIT Roorkee, where he presented the entire second semester isotope geochemistry course in one week to a group of HDR students selected from top Indian universities.

## **PALAEOENVIRONMENTS**

Group Leaders: Bradley Opdyke & Jimin Yu

Academic members: N. Abram, M. Gagan, K. Grant, D. Heslop, F. Hibbert, G. Marino, B. Pillans, A. Roberts, E. Rohling

The Palaeoenvironment Group uses geochemical proxies to reconstruct past environmental changes across the surface of the planet. While much of our work is marine based, palaeoenvironmental reconstructions include geochemical and palaeontological proxies from cave deposits and lake sediments. The backbone of our work is based on our stable isotope laboratories, but substantial work is also done on magnetometers, ICP-AES, ICPMS and XRF instruments.

Our team has a large group working on highly detailed global sea level records for the late Pleistocene, but also looking further back in time. Times when global temperatures were substantially warmer than the past million years. We also have a number of scientists using boron contents in foraminifers to reconstruct changes in the pH of the ocean during the late Pleistocene. Reconstructing ocean temperatures going back in time using organic molecules as well as Mg/Ca contents of carbonates are powerful tools that are being employed by the Group to reconstruct past climates.

Members of the group spent significant time at sea this past year, with long voyages to the Bay of Bengal and the Western Pacific Warm Pool (with the IODP) and the Antarctic margin (on the RV Investigator) playing prominent roles.

### **Workshops/conferences attended:**

- Antarctic Variability meeting, Hobart, July (invited speaker), Rohling
- Palaeoclimate modelling intercomparison project (PMIP) meeting, Stockholm, September (keynote), Rohling
- AGU Fall Meeting, New Orleans, December, Rohling (editor functions), Hibbert
- Attended the PALSEA2 conference, Mexico, November, Hibbert
- Invited speaker at 2 workshops in Hobart ('Antarctic Frontiers' in September & 'Future sea levels & coastal impacts' in November), Hibbert, Grant, Rohling
- Invited speaker at the 'XRF Taiwan' conference, March, Grant

- Attended PAGES open science meeting, Zaragoza (Spain), May, Grant
- IODP planning workshop, Sydney, June, Opdyke
- Presented a paper at the CBEP (Climatic and Biotic Events of the Paleogene 2017), Snowbird (Utah), September, Opdyke
- Bipolar seesaw, ocean circulation, and Antarctic ice-sheet melting at the end of an ice age. The Antarctic frontier symposium. Hobart, September, Marino

### **Outreach, meetings/interviews:**

- Taught at the Urbino Summerschool in Palaeoclimatology, July-August 2017, Rohling
- Sailed of the RV Investigator January – March 2017. Voyage 01 to the Sabrina Shelf of the Antarctic margin. Opdyke
- Public lecture (invited) at Music for a Warmer World festival with Climate Tasmania, Hobart, February 2017. Rohling
- Invited lecture and panel membership, Hobart high-schools event with Climate Tasmania, Hobart August 2017. Rohling
- Sky News Live TV interview on Conversation article, 24 April 2017. (<http://www.highstand.org/erohling/Rohling-papers/Sky%20News%20Interview%2024-04-2017.mov>). Rohling
- ABC Radio Live interview on fast CO<sub>2</sub> rise, June 2017. (<http://www.abc.net.au/radionational/programs/drive/story-2/8655512>) Rohling

### **Outreach-related publications:**

- Authored article: The Conversation, 20 April 2017 (<https://theconversation.com/we-need-to-get-rid-of-carbon-in-the-atmosphere-not-just-reduce-emissions-72573>) Rohling
- Public-science book: Rohling, E.J., The oceans: a deep history. Princeton University Press, 2017. ISBN 9780691168913.
- Henley, B, Abram, N.J. (2017). The three-minute story of 800,000 years of climate change with a sting in the tail. The Conversation.



## **SEISMOLOGY & MATHEMATICAL GEOPHYSICS**

Group Leader: Hrvoje Tkalčić

Academic members: P. Cummins, D.R. Davies, C. Eakin, B. Hejrani, M. Miller, M. Mustac, M. Sambridge, B. Tauzin, A. Valentine, L. Waszek

Significant research highlights start with a publication of pioneering inter-disciplinary research on intra-plate volcanism within the Pacific domain in *Nature*. This work was led by PhD student Tim Jones and Dr Rhodri Davies, and solves a long-standing (150-year) question about the origin of double-track volcanism at Hawaii (and elsewhere). In seismology, the focus has been in both imaging and seismic source studies developing and applying novel techniques with notable achievements on both fronts. The publications on Earth structure ranged from those on the Australian cratons, lithosphere of Northeast Asia, Western USA, Africa, the mid mantle structure and discontinuities (a paper just accepted by *Nature Communications*), to the attenuation structure of the inner core. The publications on the earthquake sources included methodological improvements within the Bayesian framework with the application to the volcanic and geothermal areas and the inclusion of the effects of heterogeneous Earth structure and application to the Australasian region. A significant breakthrough and a new direction of research in seismology is the Earth's correlation wavefield, the main PhD thesis topic of Son Pham (to be submitted to *Nature*).

In mathematical geophysics the focus has been in several areas, especially in understanding how to exploit concepts of sparsity in ill-constrained inverse problems; and in utilizing machine learning algorithms more generally. A particular effort has been made to understand the relationship between Gaussian processes and geophysical inversion.

Members of the group have been active participants in the newly formed Data Science Frontier research theme. In addition to stimulating data science focus across the school, a new project has been initiated in collaboration with Geoscience Australia on 'Data Analytics in solid Earth geophysics', which will focus on translating probabilistic inversion algorithms, developed within the group in recent years, to an operational environment, largely through development of flexible software packages.

AuScope operations and maintenance funding was approved for next two years to continue our national passive seismic imaging program. We entered a new round of negotiations on the WRA station maintenance and operation with the UN in Vienna, and we are anticipating an outcome of the Marine National Facility proposal to use RV Investigator for a deployment of OBS and island seismometers in the Southern Ocean, which would present a new research direction for the Group.

### **Staff news**

A/Prof. Meghan Miller and Dr Lauren Waszek (ARC DECRA Fellow) arrived in RSES early this year.

Dr Rhodri Davies received his tenure in December 2017.



Dr Benoit Tauzin joined the group as a Research Fellow, Dr Marija Mustačić joined the group as a Postdoctoral Fellow and Dr Sima Mousavi joined the group as a Researcher.

Mr Qi Li resigned from his position as a technical officer to accept a new position in the automobile industry.

Mr Sam Rayapaty left his post as the Operations Manager in Warramunga and joined the group in Canberra as a technical officer.

Mr Joel Tatapudi joined the group as the Operations Manager in Warramunga and Mr Rajesh Erigela joined the group as the Technical Assistant in Warramunga.

### **Student news**

Chris Mathews and Thomas Duvernay started as PhD students and are supervised by Rhodri Davies.

Yuwei Li started as a PhD student and is supervised by A/Prof Meghan Miller.

Shubham Argrawal is a new MSc student supervised by Dr Caroline Eakin.

Marija Mustačić received her PhD in March and accepted a postdoctoral position in the group. She is actively searching for academic opportunities in Europe.

Muriel Naguit received her PhD in June and resumed a position in Philippines.

Tanja Pejić received her PhD in November and accepted a continuing position in Geoscience Australia.

Rhys Hawkins (supervisor Prof. M. Sambridge) submitted his PhD thesis in August.

Athanasius Cipta (supervisor Prof. P. Cummins) submitted his PhD thesis in November.

Tim Jones (supervisor Dr D.R. Davies) is about to submit his PhD thesis.

### **Emeritus, Honorary staff and Visitors** in the group and their contributions

Emeritus Professor Brian L.N. Kennett continues with strong international presence and high publication output.

The group hosted Dr David Al-Attar (University of Cambridge) in July, while he worked with Dr Andrew Valentine on aspects of normal mode seismology.

The group hosted the intern Claire Richardson sponsored by Incorporated Research Institutions of Seismology (USA) for three months, while she worked with A/Prof Tkalčić and Dr Mousavi on imaging of the lowermost mantle. A poster was presented at the AGU Meeting.

The group hosted Dr Stefanie Donner (University of La Munich) in September, while she worked with A/Prof Tkalčić, Dr Mustačić and Dr Hejrani on aspects of earthquake source physics involving rotational seismology.

The group hosted A/Prof Fabrice Fontaine (University of La Reunion) in October, while he worked with A/Prof Tkalčić and Dr Hejrani on aspects of volcano seismology.

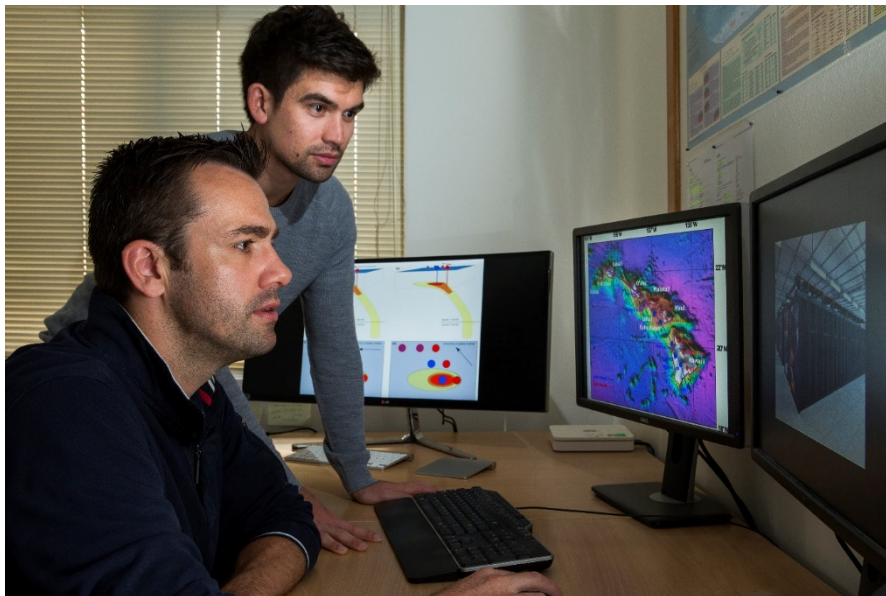
Dr Endra Gunawan and Dr Mohammad Asrurifak (Bandung Institute of Technology) visited the Group in March to finalise contributions to the 2017 revision of the Indonesian national earthquake hazard map with Prof Cummins.

Mr Mudrik Daryono and Ms Shindy Rosalia (Bandung Institute of Technology) visited the group in November-December to undertake research on active faults in Indonesia and seismic ambient noise tomography of western Java, respectively, in collaboration with Prof Cummins.

### **Outreach activities**

The Group continues to maintain and operate the Warramunga Seismic and Infrasonic Station in Northern Territory on behalf of the Comprehensive Nuclear Test Ban Treaty Organisation at the United Nations to fulfil Australia's international obligations.

Outreach highlights this year include the Group's first recordings in Canberra of "footyquake" during the Raiders game in August and "jetquake" during the SkyFire event and Super Hornet flyover back in March. The work on "footyquake" by Salmon, Eakin and Sambridge was nominated the ANU media & outreach awards.



Dr Rhodri Davies and Mr Tim Jones discussing the emergence of double volcanic tracks in Hawaii.

## **AUSTRALIAN AND NEW ZEALAND IODP CONSORTIUM (ANZIC) OFFICE**

Group Leader: A/Prof. Leanne Armand (Program Scientist).

The Australian and New Zealand International Ocean Discovery Program Consortium (ANZIC) office, hosted in RSES at ANU, had a substantially active and productive 2017. ANZIC scientists participated on seven expeditions around the world's oceans, but notably three expeditions occurred in the Australian and New Zealand region (Exp. 371 – Tasman Frontier Subduction Initiation and Paleogene Climate; Exp. 369 – Australian Cretaceous Climate and Tectonics and Exp. 372 Creeping Gas Hydrate Slides and Hikurangi logging while drilling). ANZIC were able to sail a total of 16 scientists, inclusive of three Co-Chiefs, and an additional two Education and Outreach Officers, across the seven expeditions, a tremendous outcome for ANZIC. The three regional voyages also enabled the ANZIC Office to showcase the RV JOIDES Resolution to politicians, scientists, students, science educators and industry personnel whilst in Australian ports (Townsville, Hobart and Fremantle). On average 100-150 visitors were guided through the general and scientific laboratories of the ship. Media agencies covered each port visit.

The Australasian IODP regional planning workshop was organised and successfully run by the ANZIC Office at the University of Sydney in June this year. There were 100 participants from around the world who discussed and put to paper pre-proposals that were encapsulated into a final report. A summary report on the workshop and its outcomes will soon appear in the IODP journal 'Scientific Drilling'.

Another highlight was the December launch, at the National Library of Australia, of the ANZIC legacy book, edited by Neville Exon, celebrating the achievements of the Australian and New Zealand participants in the Integrated Ocean Drilling Program (2008-2013). The book is now available for free download via: <https://press.anu.edu.au/publications/exploring-earth-under-sea>.

2017 saw a changing of the guard in the ANZIC Office, with Prof. Neville Exon retiring from the Program Scientist's role at the end of September after nine years (under ARC funding). His beyond-the-call-of-duty stewardship of the ANZIC Office over this time has seen it grow into a mature and highly acclaimed research entity in the Australasian geoscience community. A/Prof. Leanne Armand was recruited from Macquarie University to take up the role of Program Scientist, overlapping with Prof. Exon during his final month. Dr Ian Poiner is another new presence in ANZIC's line up - as the new Chair of the ANZIC Governing Council. He replaced the out-going Chair, Dr Geoff Garrett AO, at the end of 2016.

### **Extended travel and outcomes**

The ANZIC Program scientists travelled extensively because of the significant increase in activities due to port visits to Australia during 2017 and in the normal role of meeting attendance and representation. Prof. Exon attended the ANZIC Governing Council meeting and the Australasian IODP regional planning workshop in Sydney (UNSW and USyd, respectively) and led the port calls in Townsville and Hobart. A/Prof. Leanne

Armand attended the IODP Forum in Tongji University China, the European Consortium for Ocean Research Drilling (ECORD) Facility board meeting in Southampton, U.K., the Australasian IODP regional planning workshop in Sydney and the JR port calls in both Hobart and Fremantle.



Hobart port call of the RV JOIDES Resolution: members of ANZIC and JOIDES Resolution Science Operator alongside. L-R: Brad Clement (JRSO), Richard Arculus (ANU, Lead CI ARC LIEF), Neville Exon (Outgoing ANZIC Program Scientist), Trevor Falloon (UTas, previous ANZIC expeditioner), Leanne Armand (Incoming ANZIC Program Scientist) and Ian Poiner (Chair ANZIC Governing Council).

Photo Credit: Catherine Beasley

ANZIC members undertake travel to represent ANZIC interests, provide advice and participate in IODP reporting and assessment activities across the three IODP platforms (US, Japanese and European consortia). ANZIC was represented at the

JOIDES Resolution Facility Board (JRFB) meetings by Prof. Mike Coffin (UTas), the Japanese Chikyu Facility Board (CIB) meetings by Dr Andrew Heap (Geoscience Australia) and the ECORD Facility Board by A. Prof. Leanne Armand (ANU). Prof. Stephen Gallagher (UMelb) also attended the ECORD Facility Board meetings as the Asian-Oceanian representative on the ECORD facility board. David Campin (UQld) was ANZIC's representative on the Environmental Protection & Safety Panel (EPSP), whilst Prof. Tim Naish and Dr Rob McKay (both UVictoria, N.Z.) were on the Science Evaluation Panel (SEP).

### **Outreach activities**

Specific outreach activities for the ANZIC Office in 2017 included representation at the Science meets Parliament by David Heslop (ANU) and Jonathan Aitchison (UQld) in

February. Our representatives meet with Liberal and One Nation MPs and senior senator staffers to discuss and celebrate the achievements of IODP and ANZIC.

To wrap up Australia's National Science Week, both Prof. Neville Exon and Ms Catherine Beasley from the ANZIC Office, Ron Hackney and Andrew Heap from Geoscience Australia and Dr Nobu Eguchi from Japan-IODP, presented material from IODP to the public and assisted with a live link-up to the RV JOIDES Resolution during Exp 371, at Geoscience Australia's Open Day.

As reported elsewhere three major Australian port call visits by the RV JOIDES Resolution were made opportunity of, thus enabling rare guided scientific visits to a wide variety of VIP, scientific, industry and political personnel. These were very successful on many levels.

ANZIC was invited to hold a seat on the National Marine Science Committee (NMSC) chaired by Mr Tim Moltmann. Em.Prof. Patrick DeDecker (ANU) and A/Prof. Leanne Armand represented and reported on ANZIC activities to the Committee meetings held in Canberra through 2017.

The Governing Council Chair, Ian Poiner, and out-going ANZIC Program Scientist, Neville Exon, represented ANZIC's interests and future aspirations in solicited requests for additional information to the next stage of development of the Australian infrastructure roadmap process.

Finally, ANZIC was successful in placing an Education and Outreach Officer, Ms Debra Beamish, from Corinda State High School (Brisbane, Qld) on to IODP Exp. 371. She represented ANZIC exceedingly well, conducting many live video sessions from the ship to schools globally. An article for the Conversation was also a product of this voyage, produced by ANZIC co-chief Prof. Rupert Sutherland (VUW, NZ) (<http://theconversation.com/explorers-probe-hidden-continent-of-zealandia-83406>). Expedition 371 received global media attention due to the seventh continent find interest. The full list of media coverage from this voyage can be accessed via the IODP website: [http://iodp.tamu.edu/outreach/tasman\\_frontier.html](http://iodp.tamu.edu/outreach/tasman_frontier.html).

# RESEARCH SUPPORT

## ELECTRONICS GROUP

Andrew Latimore, Tristan Redman, Daniel Cummins, David Cassar, Hideo Sasaki.

### Introduction

The Electronics Group provides technical support to the Research School of Earth Sciences and wider ANU academic research. The Group consists of one engineer and four technical officers. The Group holds the responsibility for maintaining and servicing electronic systems within the Research School of Earth Sciences and provides a development facility able to design and fabricate state of the art electronic systems. The Group operates an automated component placing machine for fast production of multiple circuits with a high component capacity. The facility also includes advanced optical inspection systems that enable the detection of microscopic faults and allows the Group to produce reliable, high quality, circuit designs. These services have been recognised and utilised by areas external to the Research School of Earth Science, successfully sharing our technical expertise and ability with the ANU community. During this year the Electronics Group has given support to the school with David Cassar working part time as Laboratory Manager, also Daniel Cummins and Andrew Latimore are Work Health and Safety committee members.

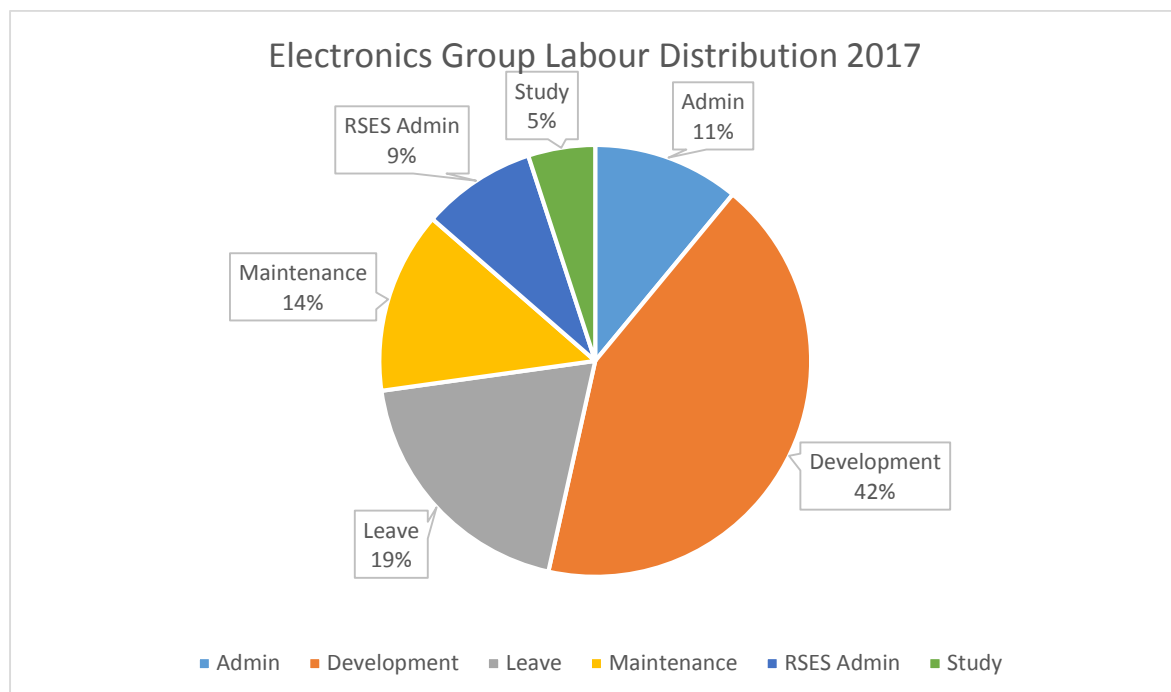


Fig 1. Electronics Group time distribution (5 FTE)

### 2017 Highlights

During 2017 the Electronics Group utilized 42% of available resources on development tasks, signifying the Research School of Earth Sciences demand for electronic engineering and assembly. The Group also utilised 14% of labour resources on

maintenance tasks and 11% on administrative tasks. Fig 1 displays the distribution of the Electronics Group's labour resources for 2017. The major development projects are summarised in the following sections.

### **Wide Dynamic Range, Vibrating Reed Electrometer**

The wide dynamic range Electrometer project currently undertaken by RSES Electronics Group involves the engineering and assembly of electronics and mechanical designs required for amplification of ion current arriving on a Faraday cup. During 2017 the Electronics Group has been developing an Electrometer with an extremely low input bias current using alternating current synchronous amplification techniques. To achieve this the circuit utilises a mechanically vibrating reed to create a time-varying capacitor which is used to collect charge. This configuration creates an amplifier with ultra-high input impedance and thus very low input bias currents. With sufficiently low bias current, the amplifier can detect low input current signals from the Faraday cup. The amplifier can operate in two formats, one using a standard resistive feedback component to develop a voltage proportional to input current, or open loop charge mode where charge is collected on the input capacitor and current is measured as the differential voltage increase over time.



Fig 2. RSES-built vibrating reed, vacuum gap, variable capacitor

### ***TerraSAWR* Seismic Recorder**

The TerraSAWR project builds on the success of the Electronics Group's first digital seismic recorder design and enhances several aspects including reducing the size of the unit and providing satellite communications. This device digitally records three channels, sampling up to 1000 samples per second at a resolution of 24-bits. The Electronics Group has been directly involved with the installation and recovery of the seismic sensors and recorders over several of years, from this experience the Electronics Group has developed a more robust and easier to construct unit with the same resolution and timing specifications. Due to the recent restrictions imposed on

the transportation of Lithium batteries, the new design employs a solar panel as the primary power source and only requires a small SLA battery. The new power arrangements provide an indefinite runtime, allowing the units to record for longer periods between servicing and also with the new satellite data transmission feature the client is able to monitor the health of the unit in real time, deployed anywhere in the world. The circuit design operates on ultra-low power to minimise the solar power requirements, and this allows easy installation of the system.

In addition to the battery change, the power supply has been made to be more robust, increasing the maximum input voltage to 25V from 14V, as well as adding an option to include a hot-swappable external power source should a larger power source be required. There is also an inbuilt MMPT solar charging circuit to provide an efficient charging source for the internal battery.

Other improvements include:

- Digital control over the onboard clock to significantly reduce the overall timing drift over the life of a record.
- Internal GPS antenna which can be used in areas where there is a risk of damage to external ones or as a backup if the external antenna is damaged.
- Optional satellite telemetry which provides a state of health transmission once per day if the unit is functioning correctly. This can be used to evaluate which units are working to plan service runs potentially reducing the need for scheduled service runs, significantly reducing operational costs.
- Improved panel design to include dust protection to reduce failures of the SD card and reprogramming ports.

Finally, the unit was designed with an emphasis on manufacturability to accommodate the interest in commercialisation. The handling and production time has been significantly reduced from the previous generation, meaning we can both cost effectively and time efficiently produce the units, in either small or large quantities.



Fig 3. TerraSAWR seismic recording system with solar array and seismograph sensor



## **Micro-mill automation system**

The Micro mill automation project involved the design, programming and construction of a three axis, plus spindle motor, control system to operate a micron precision milling stage. The Micro mill can function autonomously and can be programmed to run tool paths generated from Labview. The user software, developed by Peter Lanc of RSES Earth Chemistry, enables the operator to map cutting paths on sample images and then observe the milling process on live video.

## **8 Channel cold seal furnace**

The 8 Channel Cold Seal Furnace project provides a new experimental facility capable of running 8 furnaces using a computer interface for automated control of sample heating. Data logging will enable viewing and storing of experiment parameters. The project involves programming of proportional, integral, differential (PID) controllers accurately manipulating phase angle firing units to regulate furnace power. The system includes a computer interface and LabVIEW user screen easily giving the client access to all system parameters and historical temperature trends. Electronics and software were developed by the Electronics Group and installed on the apparatus designed and assembled by Earth Materials. During 2017 the Electronics Group completed installation and implemented the system and carried out extensive testing.

## **Helix MC Motor controller**

The RSES Electronics Group and Mechanical Workshop have developed an upgrade package to automate the transverse collector position of the Helix MC noble gas mass spectrometer. The project involved designing electronics to interface and control multiple stepping motor actuators that manipulate the mass spectrometer's Faraday cup collector position in a perpendicular direction to the beam path by the host computer. The upgrade has been installed onto RSES Noble Gas group's Helix MC machine with great success. This success has created interest abroad for the upgrade and the Electronics group with the Mechanical workshop have assembled a system for the University of Oxford, UK. The assembly of the Oxford upgrade occurred during 2017.

## **Other projects include:**

- Cryogenic pump regeneration heater controller.
- 200T software development.
- J1 process cooling hardware upgrade.
- Rig 1 Laser interferometer.
- 8 channel cold seal furnace assembly and testing.
- pH meter /CO<sub>2</sub> sensor acquisition.
- Sea water sensor enclosures design and fabrication.
- Strip heater pyrometer controller.
- GFD temperature isolation lab HVAC control update.
- SHRIMP SI Source motor controller upgrade.

## Maintenance and improvements

During 2017 the Electronics Group has been significantly involved with maintaining RSES's scientific instrumentation. The complexity of the Research School's equipment often leads to unexpected failures to electronic and electro-mechanical systems causing instrument downtime. The Electronics Group endeavours to keep the School's equipment running offering immediate service and expert fault-finding skills that save lengthy instrument stoppages and saves expensive external technical service calls. Some repairs take a considerable amount of time to diagnose and implement. This support is a major part of the Electronics Group's time, a 2017 summary can be found below for various RSES facilities.

### Neptune, and Neptune plus - ICPMS

- Fixed magnet control system, field programmable gate array failure.
- Fixed magnet Digital to Analogue converter missing bit glitch.
- Fixed Amplifier housing heater controller circuit.
- Amplifier boards replacement
- I2000 RF generator power supply repair
- Chiller relay replacement
- Apex IR temperature
- Faraday cup motor drive failure fault repair

### Varian MS

- High voltage repairs

### Triton MS

- Fixed High voltage breakdown problem, diagnosed fault to design problem of HV isolation transformer. New improved transformers were made by hand and successfully installed.

### Mat 251 MS

- Liquid nitrogen trap repairs
- Power circuit breaker replaced

### Noble Gas VG5400

- Fixed High Voltage power supply
- Ion Gauge repair
- High voltage conditioning
- Magnet pole piece motor repair
- High voltage switching relay repair

### SHRIMP RG, 2, SI

- Duoplasmatron power supply repair SHRIMP RG, SHRIMP 2
- Electrometer amplifier cVar fault detecting
- High voltage breakdown issues SHRIMP SI, SHRIMP 2, SHRIMP RG
- Beam monitor repairs SHRIMP 2
- Motor controller tuning and resolution improvement, SHRIMP RG

- Distributed Vacuum Management source code update
- Ion pulse counting system repair- SHRIMP 2
- Electron suppressor repair – SHRIMP 2
- UPS failure, battery replacement
- Electrometer drift fault detecting
- Beam current leakage fault detecting

#### Earth Materials press maintenance

- Water leakage repairs
- Recalibration of bleed valves

#### Attenuation apparatus

- Linear variable differential transformer repair
- Pressure gauge replacement
- Pressure calibration

#### Rig 1 High pressure apparatus

- Laser interferometer support

### External projects

The facilities and expertise at RSES Electronics Group are available for the ANU community. During this year several projects were undertaken for clients external to RSES. These projects are a demonstration of the reputation RSES Electronics Group has achieved with the ANU research community. Recent external projects include:

- **Liquid Instruments** – Continued to provide design and construction support for their line of MOKU instruments
- **Bram Slagmolen, Department of Quantum Physics** – Provided construction and design support on a range of projects including the niceBBPD photodetector and the T240 Chassis Interface.
- **Jie Zhao, Department of Quantum Physics** - Provided construction and design support on a photodetector project and high voltage amplifiers.
- **Penten** - Provided construction services for locally based technology company.

## ENGINEERING WORKSHOP

Andrew Wilson, Carl Were, Brent Butler, Geoff Woodward, Hayden Miller (1/2 time share with Rock Physics)

4.5 FTE Staff.

### Activities

Mechanical requests from within RSES decreased reasonably significantly this year. External work, mostly from other areas of ANU doubled compared to recent years.

Internal charge rate for 2017: \$45/hour + materials, consumables and running costs.

Turnaround time for engineering workshop requests for 2017 was short.

The core work undertaken in 2017 included:

Pick and Place Stage for Palaeomagnetism Lab, Dr Xiang Zhao

SHRIMP Maintenance and Development, Including the commencement of a new Multi-Collector for SHRIMP SI- Prof Trevor Ireland.

Rotary Mechanism Test Rig, Dr James Gilbert, Mr Gaston Gausachs, Mr Nick Herral of RSAA

Mechanicals for TerraSAWR compact seismic data recorders, Dr Michelle Salmon

Various components for the ANU Solar Car student project for CECS ANU

<b>RSES Engineering Workshop Resource Distribution</b>		
<b>Labour Totals</b>	<b>Hours</b>	
Uncharged Work	1501	27%
Charged Work	4069	73%
Total logged hours	5570	
<b>Charged Distribution (Internal RSES/External)</b>		
Research Support RSES	2800	50%
External Work	1269	23%
Total charged hours	4069	
<b>Uncharged Distribution</b>		

Training	295	20%
Administration	768	51%
Workshop Equipment, Servicing and Repairs	376	25%
Other	62	4%
Total uncharged hours	1501	

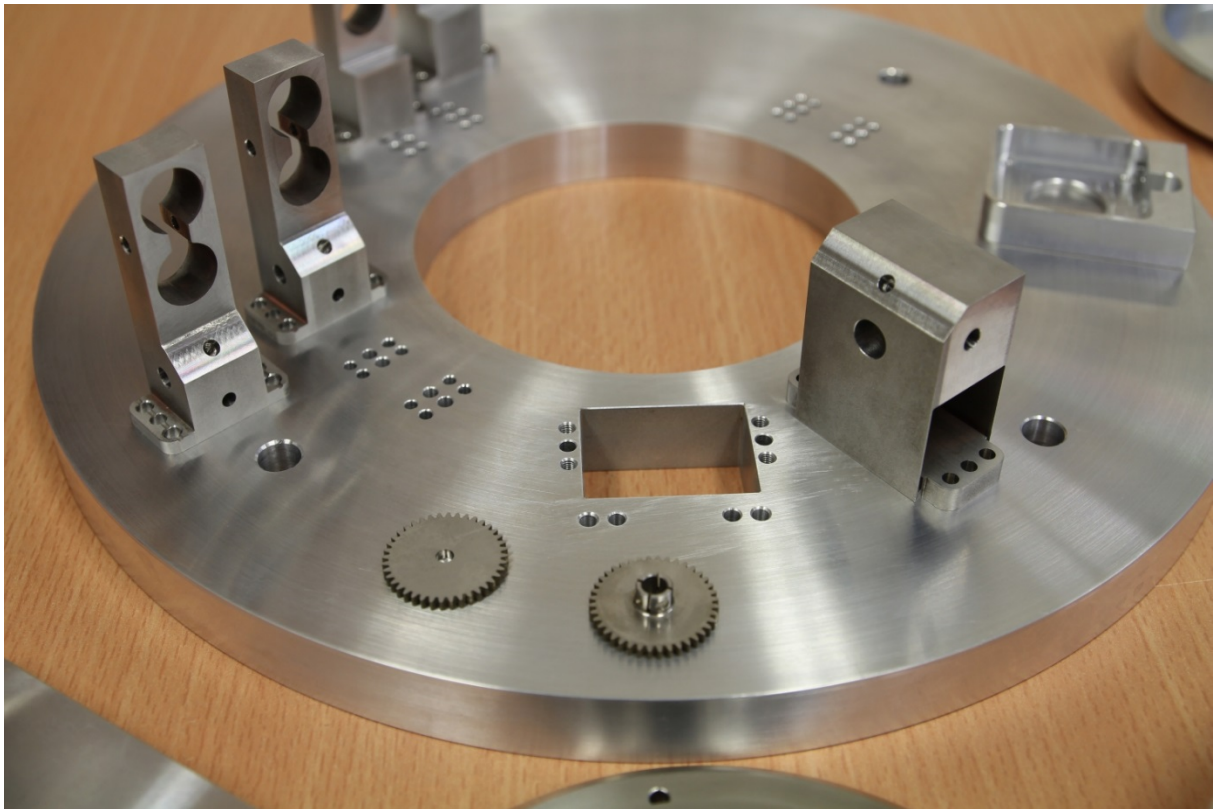


Fig 1. Parts for Rotary Test Mechanism, RSAA

## ALUMNI RELATIONS AND PHILANTHROPY

Mary Anne King

In 2017 the Vice Chancellor launched the Australian National University (ANU) 2017 - 2021 strategic plan, which sets out how we will ensure that our great national university delivers innovation in research, teaching and learning that will continue to serve Australia and be a valuable global resource. 'Building a culture of collegiality and engagement –across and beyond ANU' is one of the key initiatives that will, over the next five years, change the ANU and create opportunities for the wider community to make philanthropic contributions to our university that have an enduring impact.

At a school level there have been some good examples of engagement throughout the year. Meetings with alumni, business and government departments in Perth, Sydney and Melbourne resulted in financial support for students, guest speakers for seminars and research collaborations for post docs. A collaboration between academics in Art and Science resulted in an exquisite textile piece being kindly donated by the artist, Dr Jennifer Robertson.

Several donations were made to support a new equity scholarship for undergraduate students. This will commence in 2018. Thanks to one of our former geology graduates, RSES students were offered vacation work in the mining sector which added value to their course work and also resulted in offers of future employment. A \$50,000 donation to support a PhD student was generously matched by the School to provide an opportunity for a student to experience an ANU education and reach their potential. Donations were given to support students taking part in field trips to Greece and to assist Chinese students at Peking University to work on projects at RSES.

In July 2017, a new Science Advancement Office was introduced to improve the way philanthropic and alumni relations functions and activities are delivered in the Joint Colleges of Science. Alumni and friends events in Canberra, Singapore, Indonesia, Sydney and Melbourne have been well attended. The Director of RSES and the Dean of Science have been able to strengthen relationships with graduates and share some of the current science research with a wider network.



Jennifer Robertson generously donated *Crystal Imperfections as Agents of Deformation* to RSES. It is displayed in the J1 Seminar Room.

## RESEARCH GRANTS AWARDED DURING 2017

Dr T. Vance, **A/Prof. N.J. Abram**, Dr M. Curran, Dr A. Gallant, Dr A. Moy, Dr J. Roberts, A/Prof. P. Vallenga, Mr C. Plummer, Dr V. Favier 'AAS project no. 4414: IPICS 2k ice core array: Filling the climatological gap of the Indian Ocean sector from Wilhelm II Land'; Australian Antarctic Science Program; 2017-2021; \$1,094,500.

**A/Prof. Y. Amelin, Prof. T. Ireland, Prof. V. Bennett, Dr T. Esat** 'Electrometers with wide dynamic range for isotope ratio mass spectrometry'; ANU Major Equipment Committee; 2017; \$92,000.

**Prof. V. Bennett**, Prof. A. Nutman and Dr D. Tanner 'Revealing the deep Earth in deep time'; ARC Discovery Project; 2018-2020; \$333,357.

**A/Prof. A.J. Berry, Miss L.A. Miller** 'The redox state of pre-shield stage magmas at Hawaii'; Australian Synchrotron International Access Program; 2017; \$6,400.

**A/Prof. A.J. Berry, Prof. G.M. Yaxley**, Dr J. Wykes, **Miss L.A. Miller** 'The coordination of niobium in carbonatite melts'; Australian Synchrotron Access Program; 2017; 4 days beam time + \$1720 travel grant .

**A/Prof. A.J. Berry, Prof. G.M. Yaxley, Mr P. Goodarzi** 'The oxygen fugacity of the lithospheric mantle sampled by non-diamondiferous kimberlites'; Advanced Photon Source; 2017; 3 days beam time.

**Dr A. Burnham** 'The effect of Fe oxidation state on the solubility of Zr in silicate melts'; Australian Synchrotron; 2017; \$1,220.

**Dr A. Burnham, Dr C. Le Losq**, Dr J. Wykes 'Structural environment of trace elements in silicate melts as a function of pressure'; Australian Synchrotron; 2017; \$1,720.

**Prof. P. Cummins, A/Prof. S. McClusky, A/Prof. M. Miller** 'Australia-Indonesia Tectonics Observatory (AITO)'; ANU MEC; 2017; \$255,000.

**Dr D.R. Davies** 'Fluidity: the next frontier'; AuScope; 2017; \$10,000.

**Dr C.M. Eakin**, Dr K. O'Farrell 'Tracing plumes from source to surface'; Cooperative Institute for Dynamic Earth Research (CIDER); 2017; US\$3,190.

**A/Prof. M.J. Ellwood**, Prof. P. W. Boyd, A/Prof. Z. Chase, Dr A. Abbott, A/Prof. A. Bowie 'Constraining external iron inputs and cycling in the southern extension of the East Australian Current'; Marine National Facility, Granted Voyages; 2018; \$3,400,000.

**A/Prof. M.J. Ellwood, Prof. S. M. Eggins, A/Prof. S. Fallon, Dr J. Yu** 'Upgrade of an aging Multi-Collector Inductively Coupled Plasma Mass Spectrometer'; Major Equipment Committee; 2017; \$111,000.

Dr H. Neil, Dr D. Sinclair, **A/Prof. S. Fallon** 'Corals, currents and phytoplankton: Reconstructing 3000 years of circulation and marine productivity in the world's largest ocean gyre'; Royal Society of New Zealand Marsden Fund; 2017-2019; \$850,000.

**A/Prof. M. Gagan** 'Exploring past climates, volcanic disasters and earthquakes in Australasia'; ARC Discovery Project; 2018-2020; \$458,418.

**Dr A.McC. Hogg, Dr B. Gayen** 'A new approach to ice melting rates: direct numerical simulation'; Australian Antarctic Division; 2017; \$192,000.

**Dr M.A. Kendrick, A/Prof. O. Nebel** 'Mantle evolution and the origin of Earth's atmosphere'; Australian Research Council Discovery Program; 2018-2020; \$416,000.

Dr Y.C. Liu, Dr M.J. Liang, Dr L.M. Zhou, **Dr M.A. Kendrick**, Mr M. Fard, Mr W. Ma, Mr M.L. Zhou 'The metallogenesis of quartz-rich carbonate-hosted Pb-Zn deposits in the thrust-fold belt: A case study of the Malayer-Esfahan Pb-Zn metallogenic belt in Iran'; China MNSF; 2018-2020; \$185,000.

**Dr P.L. King** 'Elizabeth & Frederick White Conference on Gas-Solid Interactions in Earth Sciences & Astronomy'; Australian Academy Science, ANU Schools and Institutes; 2017-2018; \$27, 000.

**Dr P.L. King** 'Short Course on High Temperature Gas-Solid Reactions in Earth and Planetary Processes'; Geochemical Society; 2018; \$2,000.

**Dr P.L. King** 'Short Course on High Temperature Gas-Solid Reactions in Earth and Planetary Processes'; Mineralogical Association of Canada; 2018; \$1,000.

**Dr P.L. King, T. Jones** 'Radiocarbon dating of calcium oxalate mineral crusts in association with western Arnhem Land rock art'; Australian Institute of Nuclear Science & Engineering; 2017; \$19,400.

**Dr P.L. King, Dr U. Troitzsch** 'Crystal structure characterization of carbonates in coralline algae with microdiffraction'; Advanced Lightsource, Berkeley Labs; 2017; 2 days beam time.

**Dr P.L. King, Dr U. Troitzsch** 'Crystal structure characterization of carbonates in coralline algae with microdiffraction'; Advanced Lightsource, Berkeley Labs; 2017; 2 days beam time.

**Dr P.L. King, Dr U. Troitzsch** 'Kinetics of Gas-Solid Reactions Relevant to Earth and Planetary Sciences'; Australian Synchrotron ; 2017; 2 days beam time + \$1,440 travel grant.

**Dr P.L. King, Dr U. Troitzsch** 'Monitoring Gas-Solid Reactions In-situ Relevant to Earth and Planetary Systems and Past Environments'; Australian Synchrotron ; 2017; 3 days beam time + \$1,243 travel grant.

**Dr G. Mallmann**, Dr J. Wykes, A/Prof. T. Rushmer 'An in-situ high-pressure and high-temperature study of the speciation of U and Th in silicate magmas'; Australian Synchrotron; 2017; \$1,600.

A/Prof. S. Micklethwaite, Prof. J. Walker, **Dr S. McClusky**, Dr R. Clarke, Dr P. Dahlhaus, Dr T. Drummond, Dr S. Florentine, DR G. Lu, DR M. Murshed, Dr I.



Popstefanija, Dr T. Rawling, DR L. Sullivan, Dr N. Tapper 'UAV Sensing and Data Discovery for a Changing Planet'; ARC LIEF; 2018; \$1,275,000.

Dr S. Meffre, Dr J. Whittaker, **Dr M. Norman**, Dr M. Cracknell, Dr E. Belousova, Prof. W. Collins, Mr M. Arundell, Prof. D. Cooke, Dr R. Maas, Dr D. Huston, Dr R. Musgrave, Dr J. Greenfield (Partner Investigator) 'Ore deposits and tectonic evolution of the Lachlan Orogen, SE Australia'; ARC Linkage Project; 2017-2019; \$419,000.

Prof. G. Foster, Dr M. Hain, Prof. P. Wilson, **Prof. E. Rohling**, Dr J. Milton 'What caused the Mid Pleistocene Transition? Insights from a new high resolution CO2 record'; NERC, UK; 2017; £495,966.

**Prof. M. Sambridge, Dr A. Valentine** 'Inversion and Data analytics in Solid Earth Geophysics'; Geoscience Australia; 2017-2020; \$300,000.

**Prof. M. Sambridge, Dr M. Salmon** 'AuScope NCRIS Project Plan 2017-2018: Earth Imaging – National data infrastructure'; NCRIS – AuScope Ltd.; 2017-2018; \$750,000.

**Prof. M. Sambridge, Dr M. Salmon** 'AuScope NCRIS Project Plan 2017-2018: Earth Imaging – Seismometers in Schools'; NCRIS – AuScope Ltd.; 2017-2018; \$200,000.

**Dr C.J. Shakespeare** 'Internal wave breaking and mixing in the ocean'; DECRA; 2017; \$328,075.

Dr R. Fleddermann, A/Prof. A. Sheppard, Dr A. Kingston, A/Prof. R. Arknell, Dr M. Rug, **Dr U. Troitzsch** 'Establishment of a Custom Optical Projection Tomography Facility'; Australian National University, Major Equipment Committee; 2018; \$66,000.

**Dr A. Valentine** 'Enabling next-generation earthquake and tsunami early warning'; ARC Discovery Early Career Research Award (DECRA); 2018-2020; \$337,300.

A/Prof. P. Piper, Dr J. Fenner, **Dr R. Wood**, Dr H. Stuart-Williams 'Avruga and the Mongol Empire of Genghis Khan: An archaeological science approach to determining chronology, diet and environment'; RSHA Interdisciplinary/Cross-College Collaborative Research Scheme (ANU); 2017; \$15,000.

**Dr J. Yu**, Dr X. Xie, Dr X. Ma, Dr J. Du 'Investigating the deep North Pacific's role in atmospheric CO2 changes since the Last Glacial Maximum'; National Science Foundation of China; 2017; ¥740,000, (equivalent \$150,000).

## PEER-REVIEWED PUBLICATIONS

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<b>Dr P.L. King</b>	Chair	Mineralogical Society of America Short Course Committee
	Past-Chair and Advisory Board Member	Australasian University Geoscience Educators' Network
	Member	Geochemical Society – European Association of Geochemistry Fellows Awards Committee
	Member	American Geophysical Union Education Pilot Task Force
	Contributing Editor	Elements magazine "A life in Science" column.
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	Member	Organizing Committee, International Conference on Rock Magnetism, Utrecht, The Netherlands
	Member, Panel Chair	College of Experts, Australian Research Council
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<b>Dr J. Rogers</b>	Chair	Geological Society of Australia (ACT Division)
	Convenor	Cenozoic/Recent Working Group, InterRad
	Member	Scientific Committee, InterRad
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