

## Industry-student interaction a triumph for student interest and education



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The seismic services contractor Terrex Seismic recently hosted an education day and tour of their facilities for students from the Queensland ASEG branch and the QUT students' Natural Resources Society.

On 26 March a bus with 20 or so students arrived at Terrex's Banyo facility, to be met by Richard Barnwell, Senior Geophysicist at Terrex Seismic, with local ASEG representatives Lindsay Horn and myself.

The wonderful crew at Terrex Seismic showed us around their workshop and warehouse where they demonstrated their seismic vibrators, their geophones and showed examples of how that seismic data is recorded. After an enlightening presentation of seismic geophysics by Richard, helped out by Lindsay's experienced insight, we had a great, albeit loud, demonstration. The crew brought out one of their IVI Envirovibes and, without actually vibrating the plates, turned it on and showed us how this machine operated. We split up in groups and then took a tour through their Banyo facilities. Amongst the large fleet of vehicles and stockroom of equipment the tour came to a gravity meter demo. This was actually the first time a lot of the students have had the chance to see a gravity meter in action and with tutelage learn how to use it. After the gravity meter lesson we had a chance to view the survey equipment and understand the importance of accurate placement that finally ended with data acquisition and the recording processes. Their recording trucks in real-time detailed any seismic impulses and, when the sensitivity was increased for demonstration, it was especially interesting and educational to see a visible response from the receivers on-screen.

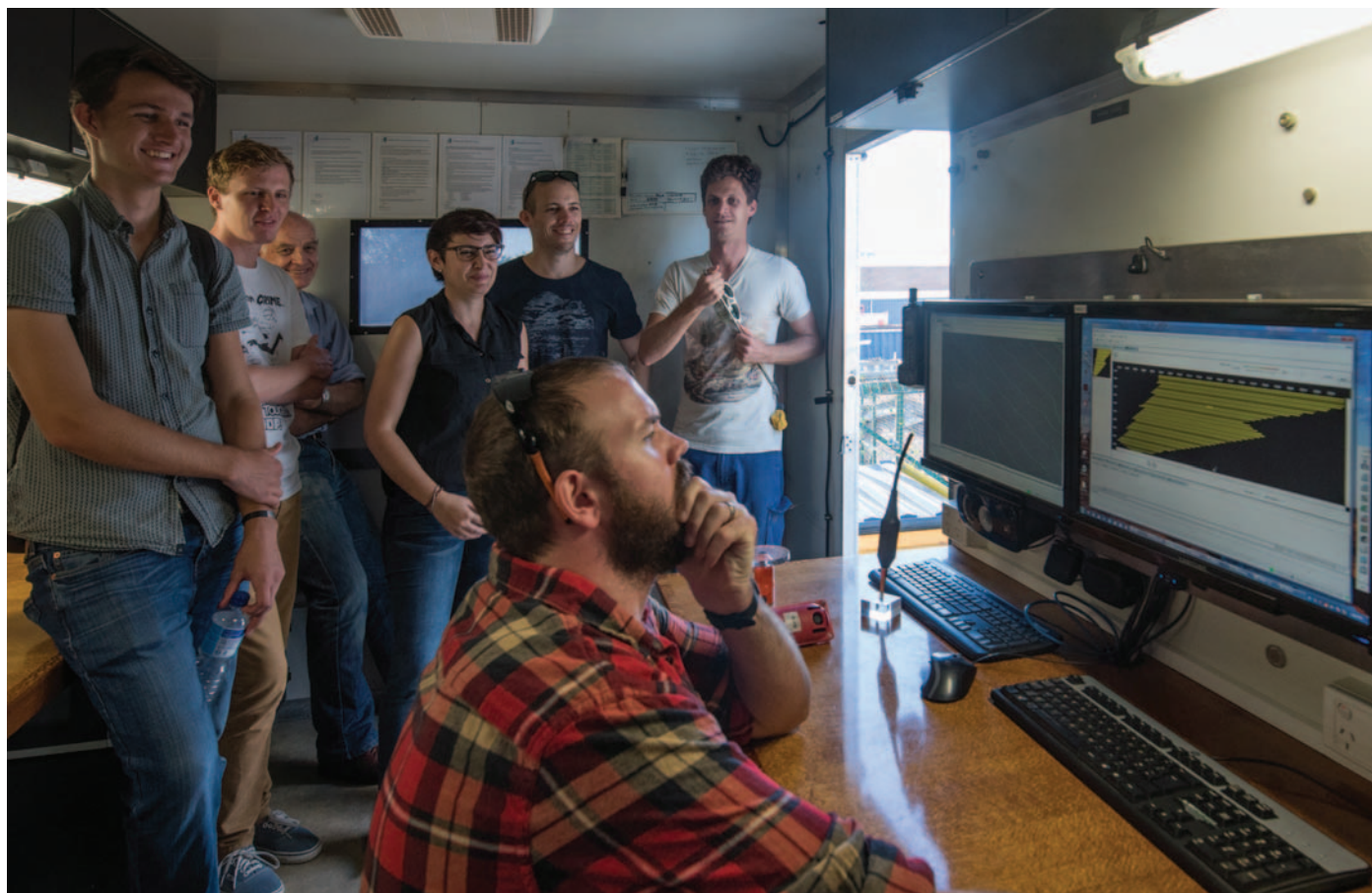
Overall the demonstrations were an eye-opener especially in regards to geophysics, seismic planning and acquisition, and how the data is recorded and processed. For most of the students it was their first time seeing the work that goes into acquiring seismic data, and I believe it firmly planted in us the idea of an industry that is crucial to exploration, energy and the resource industry.

The day was an excellent outcome flowing from opportunities generated when Kat Gioseffi (a second year student at QUT) and I (a then honours student at QUT) were awarded student bursaries to attend the ASEG-PESA Perth Conference last February, where we met up with Richard Barnwell at the Terrex Exhibition booth. This contact proved to be a highlight of our conference and led to opportunities to make some real connections in the geophysics and geoscience industry. The resulting students' day at Banyo, Brisbane, was the first time Terrex Seismic have done something like this, and with the help of ASEG we had a great opportunity in small partnership to introduce geophysics to the students and for them to make some contacts and actually see what it is our industry entails.

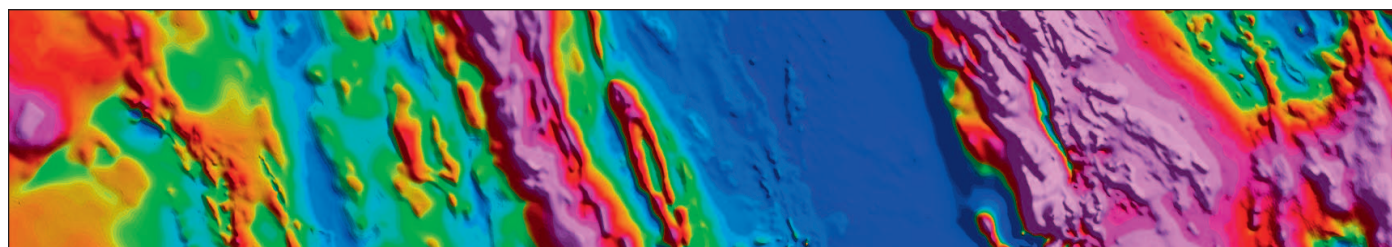


Students from QUT at the Terrex Seismic facility, Banyo, Brisbane.





Shaun Anderson of QUT monitors the truck-mounted seismic survey control centre, with students (from left) Matt Walker, Stephen Price, Katherine Gioseffi, Cameron McColl and Jimmy Recard learning about the operations. At back is local ASEG Branch representative Lindsay Horn overseeing operations.



## Exploration Geophysics

The Journal of the Australian Society of Exploration Geophysicists

## Preview

The Magazine of the Australian Society of Exploration Geophysicists

## Stay informed

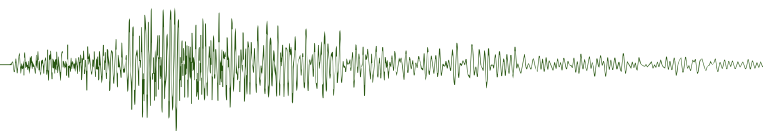
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## Forthcoming lecture tours for professional development and continuing education

We have distinguished lecturers from both the SEG and the EAGE visiting Australia later this year. Check the ASEG Calendar, contact your local branch or Wendy Watkins ([WWatkins@agl.com.au](mailto:WWatkins@agl.com.au)) on the ASEG Federal Executive for details.

**Hansreudi Maurer**, Professor of ETH Exploration and Engineering Geophysics at ETH Zürich, Switzerland, is the SEG's 2015 Near Surface Honorary Lecturer. His topic is *The curse of dimensionality in exploring the subsurface*, with particular application to tomographic inversions of 2D and 3D seismic data.

Professor Maurer writes:

'The term 'curse of dimensionality' refers to increases in the dimensionality of model spaces that result in undesirable increases in data sparsity, such that model parameters are no longer sufficiently constrained by the data. Although the term is usually employed in combinatorics, machine learning, and data mining, it is also directly relevant for many problems in exploration geophysics. The most obvious applications are 3D tomographic inversions, which typically include very large numbers of unknowns.

There is a further 'curse of dimensionality' and related data sparsity that may impede many geophysical investigations: 3D surveys typically involve the acquisition of data using only a 2D array of sensors distributed across the Earth's surface. As a consequence, procedures for imaging the subsurface are missing data recorded in the third dimension, depth. Similar problems affect 2D inversions of (1D) profile data.

Computational problems that need to be overcome in large-scale tomographic inversions are additional issues associated with the 'curse of dimensionality'. In particular, the rapidly emerging field of realistic 3D full-waveform inversions of elastic and anisotropic data is hitting the limits of current computer facilities.

Seemingly ever increasing computing power will undoubtedly be beneficial for such endeavours. Nevertheless, suitable model parameterisations that offer appropriate spatial resolution while keeping the inversion problem computationally tractable will continue to be critical elements of any high dimension inversion endeavour.

Because of the large computational costs and the difficulties to cover extensive areas with geophysical sensors in complicated terrain, many land surveys continue to involve data acquisition along profiles. Such surveys will play a significant role for the foreseeable future. When solving the associated 2D inversion problems, the 'curse of dimensionality' strikes again. The underlying 2D assumption that subsurface properties and topography do not change in the third dimension, that is, perpendicular to the tomographic plane, is often unjustified.

The problem of data sparsity can be partially alleviated by employing optimised experimental design and optimised data parameterisation approaches. These techniques identify experimental configurations and data representations that optimise data information content and resultant models in a cost-effective manner.

In this lecture, I will illustrate the 'curse of dimensionality' by means of several examples from near-surface geophysics. I will present a variety of options for addressing the related problems, including experimental design techniques and optimised model parameterisation strategies. I will also discuss problems and remedies related to out-of-plane features in 2D elastic full-waveform inversions.'

**Alessandro Ferretti**, CEO of Tele-Rilevamento Europa, Milan, Italy, is the EAGE's visiting lecturer in its international continuing education and training program. His topic is *Satellite InSAR Data: Reservoir Monitoring from*

*Space*, a one-day seminar in radar interferometry (InSAR).

Mr Ferretti has this to say about the course: 'Satellite radar interferometry (InSAR) is becoming a standard tool for monitoring surface deformation phenomena, but just a few people know the basic principles behind InSAR measurements. This EET course is intended as a guided tour of InSAR and its applications. It is *not* a course for radar specialists. It is an introduction for people who have a limited background in remote sensing, but who are interested in new technologies and in their applications. InSAR data can be used for subsidence monitoring, fault characterisation and calibration of geo-mechanical models in the oil and gas sector, for monitoring landslides, volcanoes and seismic faults and even for monitoring the stability of individual buildings. The number of applications of InSAR data is growing steadily. Therefore, it is worth spending some time to get to know what is actually behind the 'magic of InSAR', a technology capable of measuring displacements of just one millimeter on the ground from satellites orbiting the earth hundreds of kilometres above us.'

Registration for this course is via the EAGE website <http://lg.eage.org/?evp=10266>

The ASEG OzSTEP Courses for 2015 have been finalised. These are:

- Reservoir Monitoring/4D Seismic. Instructor Professor David Lumley, UWA (October 2015).
- Potential fields: a (re)introduction for geophysicists and geologists Instructor Dr Bob Musgrave, GSNSW (October 2015).
- AVO and Inversion. Instructor Brian Russell (November 2015).

Check the ASEG Calendar, contact your local branch or Wendy Watkins ([WWatkins@agl.com.au](mailto:WWatkins@agl.com.au)) for details.





Australian Society of  
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## Australian Specialist's Travelling Education Programme (OzSTEP)

### ***4D Seismic Reservoir Monitoring***

**Date:** October 2015

**Who Should Attend:** Managers and staff on development and production asset teams; geophysicists, geologists, and reservoir engineers; any others with a science or engineering background, including university students, who are interested in time-lapse techniques to monitor fluid flow in the earth.

#### **Instructor: Prof David Lumley, UWA**

David Lumley is a Winthrop Professor and Chair in Geophysics, jointly appointed to the School of Physics, and School of Earth & Environment, at the University of Western Australia (UWA). He is also the founding Director of the UWA Centre for Energy Geoscience research. Prof. Lumley has published 150+ refereed journal papers and expanded abstracts, and is the lead or senior Chief Investigator for over \$130 Million in competitive research grants. He is a physicist with a focus on geophysical energy and environment applications, with prior research and operations roles in industry (including Chevron Research), and academic institutions (including Stanford University, PhD '95, and the University of Southern California). David has significant business owner experience as the Founder and Chief Scientist of 4th Wave Imaging Corp., a 4D seismic technology company purchased by Fugro in 2007. Prof. Lumley actively participates with international scientific societies such as ASEG, SEG and AGU, where he has served as a chairman and organizer of various scientific committees and workshops, and was elected as First Vice President of the SEG (2009-10) representing 35,000 members worldwide. David has served as an international Distinguished Lecturer for the SEG, SPE and AAPG societies, and has received several scientific honors including the first SEG Karcher Award for his "pioneering work in developing time-lapse 4D seismology" to image subsurface fluid flow. Prof. Lumley serves as an expert adviser to industry and government organizations, including the Western Australia state government for regional exploration and development of hydrocarbons, geothermal energy and CO<sub>2</sub> storage, and the US National Academy of Sciences.

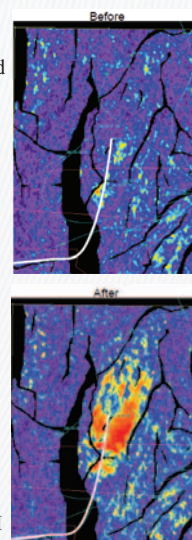


#### **Course Outline:**

This 1-day course is a practical overview of the most important theory, concepts and methods used in the modeling, design, acquisition, processing and quantitative interpretation of time-lapse 4D seismic data. Lecture topics include:

- 4D Rock and Fluid Physics, and various approaches to time-lapse 1D/2D/3D Seismic Modeling, to quantify how physical changes in the reservoir respond as changes in seismic data. This is useful for predicting the strength of the 4D signal, designing 4D seismic surveys and processing flows to enhance 4D signal and reduce 4D noise, and quantitatively interpreting 4D seismic data in order to estimate changes in reservoir properties such as fluid saturation and pore pressure.
- 4D Seismic Acquisition and 4D Processing techniques, to quantify non-repeatable 4D noise and suppress it, and to enhance real 4D seismic signal in the reservoir.
- 4D Quantitative Interpretation techniques to detect and analyze reservoir fluid flow anomalies, and to quantify them in terms of changes in pressure/saturation and other reservoir properties, using both qualitative and quantitative methods, including inversion.
- Monitoring aquifer drive and injected fluids such as water, gas, steam and CO<sub>2</sub>, locating bypassed hydrocarbons, identifying reservoir compartmentalization, and quantifying the hydraulic properties of faults (seals, leaks, baffles).
- Integration of 4D seismic information with geologic and engineering data to update the reservoir fluid flow model so that predictions of hydrocarbon recovery and fluid injection match the actual production data better ("4D seismic history matching").
- Time permitting... advanced 4D seismic topics including compaction, geomechanical stress, anisotropy, 4D FWI (full waveform inversion), passive and ambient noise seismology, 4D gravity.
- Many case study examples from around the world, both onshore and offshore, including primary depletion, water or gas injection, steam flood, and CO<sub>2</sub> storage.

**4D Seismic  
Pressure Anomaly**





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## Australian Specialist's Travelling Education Programme (OzSTEP)

### ***Potential fields: a (re)introduction for geophysicists and geologists***

**Date:** October 2015

**Who Should Attend:** geophysicists who wish to update/expand their appreciation of the use of potential field techniques; geologists who use gravity and/or magnetic data in mapping, exploration or interpretation (or who should do so!).

**Instructor:** Bob Musgrave, Geological Survey of New South Wales

Bob Musgrave is the Research Geophysicist with the Geological Survey of NSW. Bob graduated with a BSc (Hons) from the University of Sydney in 1981, majoring in geology and geophysics. Bob went on to complete a PhD (1987) at the University of Sydney in palaeomagnetism. Bob's interests in tectonics, palaeomagnetism and magnetic petrophysics led him through post-doctoral fellowships at Victoria University of Wellington (1987), the Australian National University (1988-89), and the University of Tasmania (1989-91). Bob went on to join the Ocean Drilling Program, based at Texas A&M University (1991-93), and to date has sailed on 5 ODP/IODP expeditions, the most recent in 2014. Returning to Australia, Bob was a Senior Lecturer in geophysics at La Trobe University until 2003. Bob was then a Senior Research Fellow at Macquarie University, before joining the Geological Survey of NSW in 2005. Bob is currently also a Conjoint Senior Lecturer at the University of Newcastle and an Honorary Associate of the University of Sydney. Bob's initial interest in palaeomagnetism has broadened over the years into a diverse range of applications, from magnetostratigraphic dating and tectonics, to magnetic petrophysics studies of hydrocarbon migration, gas hydrate accumulation, and the relationship of mineralisation processes to remanence-dominated magnetic anomalies. His work with GSNSW has emphasized applications of magnetic and gravity studies, including novel data filtering and presentation, long-wavelength interpretation and integration with passive seismic datasets, and joint magnetic and gravity inversion of complex tectonic settings. His research has yielded more than 50 peer-reviewed publications.



#### **Course Outline:**

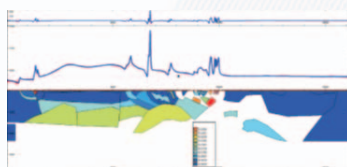
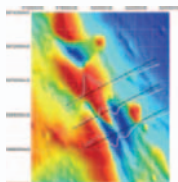
Prerequisites: basic geology. No prior geophysical training is necessary, and the maths will be kept "light", so the course should be accessible to all geoscientists – but there will be the opportunity for more sophisticated discussion for those with established skills in geophysics.

##### **Session 1 - Basics:**

- Course overview and scope
- Basic form of potential field anomalies
- Data acquisition
- Scalar, gradient and tensor data. Earth's gravity and magnetic fields

##### **Session 2 - Physical properties :**

- Density and magnetic susceptibility
- Remanence
- Magnetic properties and mineralisation
- Microbes and magnetic diagenesis

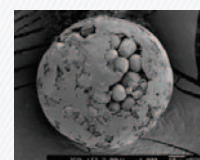


##### **Session 3 - Data presentation and filtering :**

- Derivative filters; phase filters and the tilt filter.
- Edge analysis ("worming").
- Euler depths; spectral depths. Curie depth.
- Isostatic correction.
- Tensor and gradient data interpretation.

##### **Session 4 - Potential field inversion :**

- Source mapping; derivative maps; inferring lithology.
- Direct inversion, and its limitations.
- Geologically constrained inversion.
- Remanence and inversion.
- Case studies.







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## Australian Specialist's Travelling Education Programme (OzSTEP)

### ***AVO and Inversion Methods in Exploration Seismology***

**Dates:** 2nd Nov (Perth), 4th Nov (Brisbane) and 6th Nov (Melbourne)

**Who Should Attend:** Geoscientists with a solid background in exploration seismology who wish to broaden their knowledge of AVO and inversion methods and their applications.

#### **Instructor: Dr Brian Russell**

Brian Russell graduated from the University of Saskatchewan (BSc) in 1973 with a major in physics, and received a BSc (Hons) (1975) at the same university, a MSc in geophysics from Durham University (1978), U.K., and a Ph.D. from the University of Calgary (2004), all in exploration geophysics. He joined Chevron as an exploration geophysicist in 1976 and subsequently worked for Teknica and Veritas before co-founding Hampson-Russell Software with Dan Hampson in 1987. Hampson-Russell is now a subsidiary of CGG, where Brian is Vice President, GeoSoftware and a CGG Fellow. Brian is involved in the development of new AVO, rock physics, inversion and seismic attribute techniques as well as presenting courses throughout the world. He is a past-President of both the SEG and Canadian SEG (CSEG) and has received Honorary Membership from both societies, the CSEG Medal and the Cecil Green Enterprise Award from SEG. He is currently Chairman of the Board of the Pacific Institute for the Mathematical Sciences (PIMS), an Adjunct Professor in the Department of Geoscience at the University of Calgary and at the School of Energy Resources at the University of Wyoming, and is registered as a Professional Geophysicist (P.Geoph.) in the Province of Alberta.



#### **Course Outline:**

- Part 1: The rock physics basis of AVO and inversion
- Part 2: Post-stack seismic inversion and wavelet analysis
- Part 3: Pre-stack inversion and AVO methods and case studies.
- Part 4: Azimuthal amplitude and velocity analysis for fracture determination.
- Part 5: Stochastic inversion methods.
- Part 6: Applications to unconventional plays.