ADVANCED SEISMIC DATA PROCESSING AND INTERPRETATION

7 – 11 DECEMBER 2014 | ABU DHABI | UAE
Course Description
With the presence of new data acquisition techniques, like e.g. VSP, hole-to-hole, multi-component, and ocean bottom cable, also new processing methods have to be developed.

New developments in data acquisition offer also new challenges in processing and new possibilities in interpretation. Such developments are a.o. longer offsets, multi-azimuth for marine data, broadband acquisition, multi-component streamer, passive seismic (seismic interferometry) and simultaneous shooting (blended seismic).

Existing and new data sets will be exploited for optimal information retrieval: in addition to the conventional P-waves also the S-waves will be investigated and in addition to the kinematic properties, i.e. travel times, for velocity and structural determination also the dynamic properties, i.e. phase and amplitudes, for lithology and/or direct hydrocarbon indication will be investigated. Anisotropy, where present, should be taken into account and can be exploited for a.o. fracture orientation and density and time-to-depth conversion. The availability of other types of data like geological data and well data, in a production environment, should be properly integrated in inversion studies to initialize and constrain the results.

This course deals with the advanced processing methods that are often carried out as part of a special study and may involve the integration of data acquisition, processing and interpretation as well as petrophysics, production geology and reservoir engineering. The topics that will discussed cover the whole spectrum of what has become feasible nowadays. This includes a discussion of the new developments in acquisition as these have matured over the last couple of years.

Course Objectives
At the end of this course the participants will have a working knowledge of the full range of representative advanced/special processing methods, which he or she may carry out him-/herself and/or supervise. He or she is fully capable to account for the geophysical input in multi-disciplinary teams.

The following topics will be discussed:
1. Developments in acquisition geometries and hardware
2. Stress-strain relationships and elastic constants
3. The wave equation, wave phenomena, rock physics and the Gassmann equation
4. Overview of seismic data processing
5. Migration or imaging
6. Velocity model building
7. Multi-component seismic and OBC/OBN seismic
8. Anisotropy
9. Borehole seismic – VSP
10. AVO/AVA
11. Seismic inversion
12. 4D seismic
13. Seismic attributes

Learning methods and tools:
This course includes theory, exercises and examples; a handout that covers all course material will be made available.
5-Day Course Outline

1. Developments in acquisition geometries and hardware
   - Acquisition geometries
   - Acquisition parameters
   - Spatial sampling
   - Arrays and point receivers
   - Data partitioning and offset vector tiling (OVT)
   - New developments in receivers:
     - MEMS (micro electro-mechanical system) devices
     - Dual-sensor cables - Geostreamer (PGS)
     - Variable depth streamer – Broadseis (CGGVeritas)
     - ObliQ – sliding notch acquisition (Schlumberger)
     - UniQ – point receivers (WesternGeco)
     - Isometrix – multi-sensor towed streamer (WesternGeco)
   - New developments in sources:
     - Low-frequency and high-frequency vibrators
     - Productivity enhancement for vibrator seismic (e.g. Slip sweep)
     - Time and depth distributed source – geosource (pgs)
     - Low frequency sources
     - Simultaneous sources (blended seismic)
   - New developments in acquisition geometries:
     - Multi-azimuth (MAZ) and full-azimuth (FAZ) marine seismic
     - Coil shooting
     - Long offsets

2. Stress-strain relationships and elastic constants
   - Deformation and the strain tensor
   - Traction and the stress tensor
   - Stress-strain relations: Hooke’s law
   - The equation of motion
   - Symmetry properties of the strain tensor, stress tensor and stress-strain tensor
   - Definitions of elastic constants
   - Relationships between elastic constants

3. The wave equation, wave phenomena, rock physics and the Gassmann equation
   - The acoustic wave equation
   - The elastic wave equation
   - P-waves and S-waves
   - The boundary conditions
   - Rock properties
   - The Gassmann equation to calculate effects of fluid substitution

4. Overview of seismic data processing
   - The processing sequence
   - Various types of velocities: definition and way of measurement
   - Stacking velocities: behaviour and determination
   - Signal properties and deconvolution
   - Principles of blended data processing

5. Migration or imaging
   - Migration, modelling and inversion
   - Geometric approach to migration
   - Examples
   - Resolution before and after migration
   - Aliasing
   - Ray definitions
   - The Dix equations
   - Definition of time migration and depth migration
   - The acoustic wave equation
   - Factorization of the wave equation
   - Forward and inverse waveform extrapolation in depth
   - Migration of various data sets:
     - Shot profile migration and imaging conditions
     - Survey sinking or redatuming and imaging conditions
     - Zero-offset data migration and imaging conditions
   - Migration algorithms:
     - (k,f)-migration (Stolt)
     - Phase-shift migration (Gazdag)
     - Phase-shift-plus-interpolation (PSPI) migration
     - Split-step-Fourier (SSF) migration
     - Extended split-step Fourier (ESSF) migration
   - The Kirchhoff integral, the Rayleigh integral and Green’s functions
   - Kirchhoff (= summation or diffraction stack) migration
   - Wavefield extrapolation in time, forward and reverse
   - Reverse time migration – RTM
   - Migration and demigration

6. Velocity model building
   - Minimal data sets and common image gathers – CIG’s
   - Iterative velocity model building with CIG’s
   - The migration conditions
   - Migration and traveltime inversion
   - Migration and demigration
   - Normal incidence wavefront curvature and stacking velocity
   - Velocity model parameterization
   - Velocity model building methods:
     - Coherency inversion or model based stack
     - Map migration
     - Dynamic map migration (dmm) or curvature inversion
     - Stereotomography
     - Traveltime inversion (tti)
     - Tomographic velocity model building
     - Full waveform inversion (fwi)
7. **Multi-component seismic and OBC/OBN seismic**
   - The data matrix
   - The hodogram and polarization analysis of 3C (three-component) data
   - Polarization filtering
   - Rotation of sources and receivers
   - Characteristics of P-, SV-, and SH waves
   - Displacement components of geophones at the free surface
   - Radiation characteristics of a vertical and horizontal vibrator
   - P/S-wavefield separation:
     - VSP data
     - Surface seismic data
   - Elastic wavefield decomposition
   - OBC (ocean bottom cable) and OBN (ocean bottom node) 4C features
   - Technical advantages of wide-azimuth ocean-bottom seismic
   - Generation of P-to-S converted waves
   - Acquisition geometries for ocean-bottom seismic
   - Determination of receiver locations at the ocean bottom
   - Calibration of the various receivers
   - Processing of OBC data – PS converted data
   - Wavefield decomposition with various combinations of receivers
   - Hydrophone and vertical geophone summation for deghosting and dereverberation

8. **Anisotropy**
   - Introduction and definition of anisotropy
   - The stress tensor, the Voigt annotation and symmetries
   - Plane wave solutions and the Christoffel equations
   - Phase velocity and group velocity
   - Relationship between Wave surface and Slowness surface
   - Measurement of group velocity and phase velocity
   - Raytracing, the eiconal equation and the transport equation
   - Shear-wave splitting
   - Definitions pertaining to anisotropy
   - Transverse isotropy (TI):
     - Angle dependent velocity in VTI (Vertical TI) media
     - Thomsen’s notation for weakly anisotropic media
     - VTI parameters for finely layered media (Backus averaging)
   - Angle dependent reflection and transmission coefficients
   - HTI (Horizontal TI) and TTI (Tilted TI) media and azimuthal anisotropy
   - Crack and fracture properties
   - Anisotropy from seismic survey design and processing

9. **Borehole seismic – VSP**
   - VSP acquisition geometries and multi-component datasets
   - The processing sequence for VSP data:
     - Wavefield decomposition
     - Deconvolution
     - Migration
   - VSP data matching with surface seismic and with well data

10. **AVO/AVA**
    - Factors affecting amplitudes
    - The boundary conditions
    - The Zoeppritz equations for reflection and transmission coefficients
    - Approximate expressions for the reflection coefficients
    - Rock properties, fluid substitution algorithms and Vp-Vs relationships
    - AVO modelling
    - Processing for AVO analysis
    - Estimation of AVO parameters
    - Modelling of tuning effects and wavelet stretch
    - Calculation and interpretation of AVO attributes
    - Crossplotting of AVO attributes and AVO classification
    - Elastic inversion based on AVO behaviour
    - Angle stacks and Elastic impedance with its application

11. **Seismic inversion**
    - From reflectivity to acoustic impedance
    - Least-squares estimation methodology
    - Singular value decomposition (SVD)
    - Resolution matrix and Covariance matrix
    - AVO inversion or elastic inversion
    - Probability theory and Bayesian approach to inversion
    - Deterministic inversion and stochastic inversion

12. **4D seismic**
    - Objectives and feasibility analysis
    - Rock physics
    - Fluid substitution with the Gassmann equation
    - Measurement of traveltime differences and amplitude differences
    - Quantification of repeatability of acquisition and processing
    - Methods to assess the comparison of different datasets
    - Methods for cross-equalization of two datasets
    - 4D modelling of different scenarios
    - The 4D workflow

13. **Seismic attributes**
    - Introduction to attributes, definitions and historical overview
    - Analytic traces: instantaneous amplitude, - phase, and – frequency
    - Attribute classification
    - The geometric attributes dip and azimuth
    - The coherency attribute
    - Curvature and reflector shape
    - Spectral decomposition and its applications
petroEDGE® delivers energy industry skills-based training courses in major cities around Asia, catering for every stage of your organisation’s development path. Since our inception, we have provided wide range of management development training, business strategy and technical skills training courses to over 100 leading international corporations and government establishments.

Our growing client profile:
- Almansoori Wireline Services (Thailand)
- Arabian Bridge Company for Oil Services
- Asetanian Marine Pte
- Bangladesh Oil, Gas & Mineral Corp
- Bergen Group ASA
- BG Exploration and Production India
- BJ Services Company Middle East
- BP Exploration & Operating Vietnam
- BP Exploration Operating Company
- BP Indonesia / Singapore & Vietnam
- Brunei LNG
- Brunei Petroleum
- Brunei Shell Petroleum Co
- Cairn Energy India Pty
- Carigali Hess Operating Co.
- Carigali PTTEPI Operating Company
- CGG Veritas (M)
- Charnavon Petroleum
- Chevron Asia South
- Chevron Thailand E & P
- CNOOC
- Cuulong Joint Operating Company
- Det Norske Veritas (DNV) As
- Det Norske Veritas Pte
- Dof Subsea Australia Pty
- DPS Bristol (M)
- Esso Malaysia Berhad
- ExxonMobil E & P Malaysia Inc.
- First Gas Power Corporation
- Genting Oil & Gas
- Geomechanics International
- Greatwall Drilling Company
- Halliburton Energy Services, Inc.
- Hercules Tanjung Asia
- Hess (Thailand) Limited
- Hoang Long Hoan Vu JOC
- Intisari Oilfield Service
- Intra Oil & Services Bhd
- Japan Vietnam Petroleum Company
- Kavim Engineering & Svs Pte
- Kebabangan Petroleum Operating Co.
- KUFPEC Regional Ventures (Indonesia)
- Lam Son JOC
- Lion Rig Builder Pte
- Lundin Malaysia B.V.
- Maersk Drilling
- Maersk Oil Qatar
- Malakoff Corporation Berhad
- Malaysia LNG
- Malaysia Marine & Heavy Engineering
- Malaysia-Thailand Joint Authority
- Media Chinese International
- Mid-Continent Equipment Group Pte
- MISC Berhad
- Mitsui Oil Exploration Co.
- MMS (Insurance Brokers)
- Murphy Oil Corporation
- National Healthcare Group
- Nations Petroleum (SE Asia)
- Newfield Peninsula Malaysia Inc.
- Nipon Oil Exploration (Malaysia)
- Oceaneering International
- Offshore Geo-Surveys
- Optimal Chemicals (M)
- Optimal Olefins (M)
- PC Vietnam
- PCPP Operating Company
- Pearl Energy (Nam Conson)
- PERMATA
- Permata - PMTSB
- Pertamina Learning Center
- PetroEnergy Resources Corp.
- Petrofac Malaysia Limited
- Petroleum Insitute of Thailand
- Petroleum Well Logging Co.
- Petrolux
- PETRONAS Holdings
- PETRONAS Carigali
- PETRONAS Carigali Vietnam Limited
- PETRONAS Dagangan Berhad
- PETRONAS Gas
- PETRONAS Methanol (Labuan)
- PETRONAS Penapisan (Melaka)
- Petrousaha Engineering Services
- Petrovietnam Drilling & Well Services
- Powertium Marine
- Premier Oil Indonesia
- PT Halliburton Indonesia
- PT Medco E&P Indonesia
- PT Pertamina (Persero) Head Office
- PT Perusahaan Gas Negara
- PT PLN (Persero) Kantor Pusat
- PTT Exploration & Production
- PTTEP International Limited
- PTTEP Iran Company Limited
- PTTEP Oman Company
- PVD Offshore Services Co.
- Ranhill Engineers & Constructors
- Rhodia Asia Pacific Pte
- Repsol
- Royal Norwegian Embassy
- Sabah Shell Petroleum Co
- Sapura Energy
- Sapuracrest Petroleum Berhad
- Sarawak Shell Berhad
- Saudi Arabian Oil Company
- Saudi Basic Industries Corp
- Schlumberger Oilfield (S) Pte
- Scomi Oiltools
- Shell Eastern Petroleum
- Shell MDS (Malaysia)
- Shell Saudi
- Sime Darby Plantation Sdn Bhd
- Singapore Petroleum Co.
- SN Aboitiz Power
- S-Oil Corporation
- Talisman Malaysia
- Tately N.V.
- Technip Geoproduction (M)
- Teknik Janakuasa
- Temasek Holdings Pte
- Tenaga Nasional Berhad
- Thang Long JOC
- TL Offshore
- Total (China) Investment Co. .
- TOTAL E&P Indonesia
- Trans Thai Malaysia
- Transwater API
- Tri-M Technologies (S)
- Truong Son JOC
- UMW Standard Drilling
- University New South Wales
- Vastalux
- Vinyl Chloride (Malaysia)
- YTL Power International Berhad

Train Your Whole Team At A Convenient Time And Location Through In-House Training.

Call us at +65 6741 9927 to enquire or email your query to info@asiaedge.net. Visit us at www.petroedgeasia.net for more information.
IN-HOUSE TRAINING SOLUTIONS

petroEDGE® focuses on skills development in 3 main areas – Engineering, Management and Strategy for Upstream Exploration and Production Business.

Our In-House Training Solutions Team offer a full spectrum of short courses, curricular competency based solutions that can be customised to your long term and short term business needs.

Types of In-House Programmes offered

FUNDAMENTAL PROGRAMMES
Introduction to Exploration & Production • Drilling Essentials • LNG Fundamentals
Introduction to FPSO • CBM & Shale Gas Technical Fundamentals

TECHNICAL PROGRAMMES
Operations Geology (Level 2) • Basin Analysis (Level 2) • HPHT Well Engineering
Deepwater Well Engineering • Deepwater Well Operations • Well Intervention
Well Integrity Management (Drilling & Production) • HAZOP Assessment & Leadership
HPHT Completions Techniques • Well Operations and Maintenance • Stuck Pipe Prevention & Fishing
Train-the-Trainer: Gas Processing Level 1 • Train-the-Trainer: Gas Processing Level 2

MANAGEMENT & SOFTSKILLS PROGRAMMES
Technical Report Writing & Presentation Skills • Writing Standard Operating Procedures
EPCIC Contract Management Techniques • Advanced Budgeting & Forecasting in Oil & Gas
E & P Accounting • Finance for Non-Finance • Leadership & Team Dynamics

“TRAIN-THE-TRAINER” PROGRAMME
The "Train-the-Trainer" program has proven to be one of the most cost effective methods for embedding the process of delivering and facilitating crucial training programmes within your organisation in terms for sustainable skills and knowledge development.

“Train the Trainer” programme and its specific deliverables provide in-depth concept knowledge, instructor training, and facilitation skills. This experience prepares select employees to become internal Program Leaders, licensed to teach internally. The internal trainer can play a critical role in developing and implementing programs that align the organization for success.

This programme will be a carefully designed approach for sustainable and effective organisational improvement. The role-out will reflect the immediate on and on-going challenges faced within your organisation.

CURRICULUM DEVELOPMENT PROGRAMME SERVICES

With the constant changing of business environment and volatile economy, every company, big or small, needs to stay abreast of the rapidly evolving developments and acquire new competencies in order to stay competitive. Our key pool of trainers, industry experts and consultants are available to develop a Curriculum Development training programme to help you attain relevant competencies in the area that is most needed.

To learn more, call us at +65 6741 9927 or email info@asiaedge.net

Train Your Whole Team At A Convenient Time And Location Through In-House Training.
Call us at +65 6741 9927 to enquire or email your query to info@asiaedge.net. Visit us at www.petroedgeasia.net for more information.
petroEDGE® boasts an unrivalled teaching faculty. All of our partners and consultants have extensive management and technology experience coupled with a track record in delivering high quality courses to professionals in leading oil majors globally.

In addition to individual consultants and trainers, petroEDGE® also works closely with 2 major training partners, namely: -

PETRONAS LEADERSHIP CENTRE

PETRONAS Leadership Centre (PLC), started as an internal training department in 1979. Over the years, we have established ourselves as a top corporate learning hub for industry leaders, serving the Oil & Gas sector in Malaysia and beyond. Backed by over 30 years of experience and our deep passion for excellence, PLC has robust tools and Learning and Development know-how to help leaders transform and enhance their leadership skills. This is supported by the resources of PETRONAS and its firm belief in the importance of human capital development. For further information on PLC, visit www.petronasleadershipcentre.com.my.

ROBERTSON CCG

The Robertson Training Centre was established in 1990 to provide a comprehensive range of upstream training programmes for the international petroleum industry. With a portfolio of over 70 courses, training has been given to personnel from over 120 companies and delivered in more than 45 countries. The Centre has now gained a reputation for the quality of its product. Robertson is unique in the oil and gas training field in that by using our in-house experts, we can design and present training programmes of any length in virtually any global location. In addition to five day short courses, the Centre’s most effective training programmes, delivering real skills transfer, are in-company workshops using client data. Given over 6-12 weeks, these workshops teach technical skills in exploration, development and production, project planning and management, teamwork and presentation skills. Long term training on a one-to-one basis is also offered for periods of up to 6 months.

petroEDGE® are members of the esteemed Energy Institute and the CPD Certification Service. We also proud to have been inducted as an approved training provider of Institute of Leadership & Management for 4 of our training programmes. This highlights the confidence given to the quality of our trainings courses.

The CPD Certification Service helps organisation provide certified CPD and acts as a point of contact for those seeking to obtain certified CPD material. It supports further learning initiatives being undertaken by Government, professional institutions, trade associations, individual organisations, training providers, suppliers and so on.

For more information, visit www.cpd.co.uk.

The Energy Institute (EI) is the professional body for the energy industry, delivery good practice and professionalism across the depth and breadth of the sector. The purpose of the EI is to develop and disseminate knowledge, skills and good practice towards a safer, more secure and sustainable energy system.

In fulfilling this purpose the EI addresses the depth and breadth of energy and the energy system, from upstream and downstream hydrocarbons and other primary fuels and renewables, to power generation, transmission and distribution to sustainable development, demand side management and energy efficiency. A Royal Charter membership organisation, the Energy Institute provides a wealth of expertise in energy matters, serving as a home for energy professionals and a scientific and technical reservoir for industry. It is licensed by the Engineering Council to offer Chartered, Incorporated and Engineering Technician status to engineers and also by the Science Council and Society for the Environment to offer registration as Chartered Scientist and Chartered Environmentalist.

The EI is an international organisation serving its members in around 80 countries. For more information, visit www.energynst.org.

The Institute of Leadership and Management (ILM) is Europe’s foremost leadership and management body. At ILM, we are passionate about the power of leadership and management to transform people and businesses. We believe that good leadership and management creates effective organisations, which builds social and economic prosperity. ILM work with organisations in all sectors to help them define, develop and embed the leadership and management capability they need to succeed. ILM provides qualifications in leadership and management, coaching and mentoring and specialist areas such as social enterprise. For more information, please visit https://www.i-l-m.com.

Our programmes approved by ILM are: International Oil & Gas Executive Development Program 2013, Human Competency & Capability Development, Leadership Team Dynamics in Oil & Gas and Technical Report Writing & Presentation Skill for Oil & Gas Professionals.

Visit us at www.petroedgeasia.net or contact us directly at +65 6741 9927 or email to info@asiaedge.net for more information.
**ADVANCED SEISMIC DATA PROCESSING AND INTERPRETATION**

**REGISTRATION FORM**

<table>
<thead>
<tr>
<th>AB DHABI</th>
<th>UAE</th>
<th>7 – 11 December 2014</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>EARLY BIRD</th>
<th>NORMAL</th>
<th>TEAM DISCOUNTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD 3,899</td>
<td>USD 4,099</td>
<td>petroEDGE recognises the value of learning in teams.</td>
</tr>
</tbody>
</table>

petroEDGE In-house Training

- Yes, I would like to organise this training on-site and save on total course fees! For further information about On-site Solutions, please call +65 67419927 or email info@asiaedge.net

---

**DELEGATE DETAILS**

Please note:
- Indicate if you have already registered by Phone + Fax + Email + Web
- If you have not received an acknowledgement before the training course, please call us to confirm your booking.
- Photocopy this form to register multiple delegates.

### Delegate 1

- **Name:**
- **Job Title:**
- **Department:**
- **Telephone No.:**
- **Email:**

### Delegate 2

- **Name:**
- **Job Title:**
- **Department:**
- **Telephone No.:**
- **Email:**

### PAYMENT METHODS

- **By Cheque/ Bank Draft:** Make Payable to Asia Edge Pte. Ltd.
- **By Direct Transfer:**
- **Swift Code:** OCBCSGSG

All bank charges to be borne by payer. Please ensure that Asia Edge Pte Ltd receives the full invoiced amount.

### PAYMENT POLICY

Payment is due in full at the time of registration. Full payment is mandatory for event attendance. By submitting this registration form, you have agreed to Asia Edge Pte Ltd’s payment terms.

### CANCELLATIONS & SUBSTITUTIONS

- You may substitute delegates at any time. ASIA EDGE PTE LTD does not provide refunds for cancellations. For cancellations received in writing more than seven (7) days prior to the training course you will receive a 100% credit to be used at another ASIA EDGE PTE LTD training course for up to one year from the date of issuance. For cancellations received seven (7) days or less prior to an event (including day 7), no credits will be issued. In the event that ASIA EDGE PTE LTD cancels an event, delegate payments at the date of cancellation will be credited to a future ASIA EDGE PTE LTD event. This credit will be available for up to one year from the date of issuance. In the event that ASIA EDGE PTE LTD postpones an event, delegate payments at the postponement date will be credited towards the rescheduled date. If the delegate is unable to attend the rescheduled event, the delegate will receive a 100% credit representing payments made towards a future ASIA EDGE PTE LTD event.

No refunds will be available for cancellations or postponements.

- ASIA EDGE PTE LTD is not responsible for any loss or damage as a result of a substitution, alteration or cancellation/postponement of an event. ASIA EDGE PTE LTD shall assume no liability whatsoever in the event this training course is cancelled, rescheduled or postponed due to a fortuitous event, Act of God, unforeseen occurrence or any other event that renders performance of this training course impracticable or impossible. For purposes of this clause, a fortuitous event shall include, but not be limited to: war, fire, labor strike, extreme weather or other emergency.

### PROGRAM CHANGE POLICY

Please note that speakers and topics were confirmed at the time of publishing; however, circumstances beyond the control of the organizers may necessitate substitutions, alterations or cancellations of the speakers and/or topics. As such, ASIA EDGE PTE LTD reserves the right to alter or modify the advertised speakers and/or topics if necessary. Any substitutions or alterations will be updated on our website as soon as possible.

This brochure may not be copied, photocopied, reproduced, translated, or converted to any electronic or machine-readable form in whole or in part without prior written approval of ASIA EDGE PTE LTD.

---

**4 EASY WAYS TO REGISTER**

- **Online:** www.petroedgeasia.net
- **Email:** info@asiaedge.net
- **Phone:** +65 6741 9927
- **Fax:** +65 6747 8737

---

Train Your Whole Team At A Convenient Time And Location Through In-House Training.

Call us at +65 6741 9927 to enquire or email your query to info@asiaedge.net. Visit us at www.petroedgeasia.net for more information.