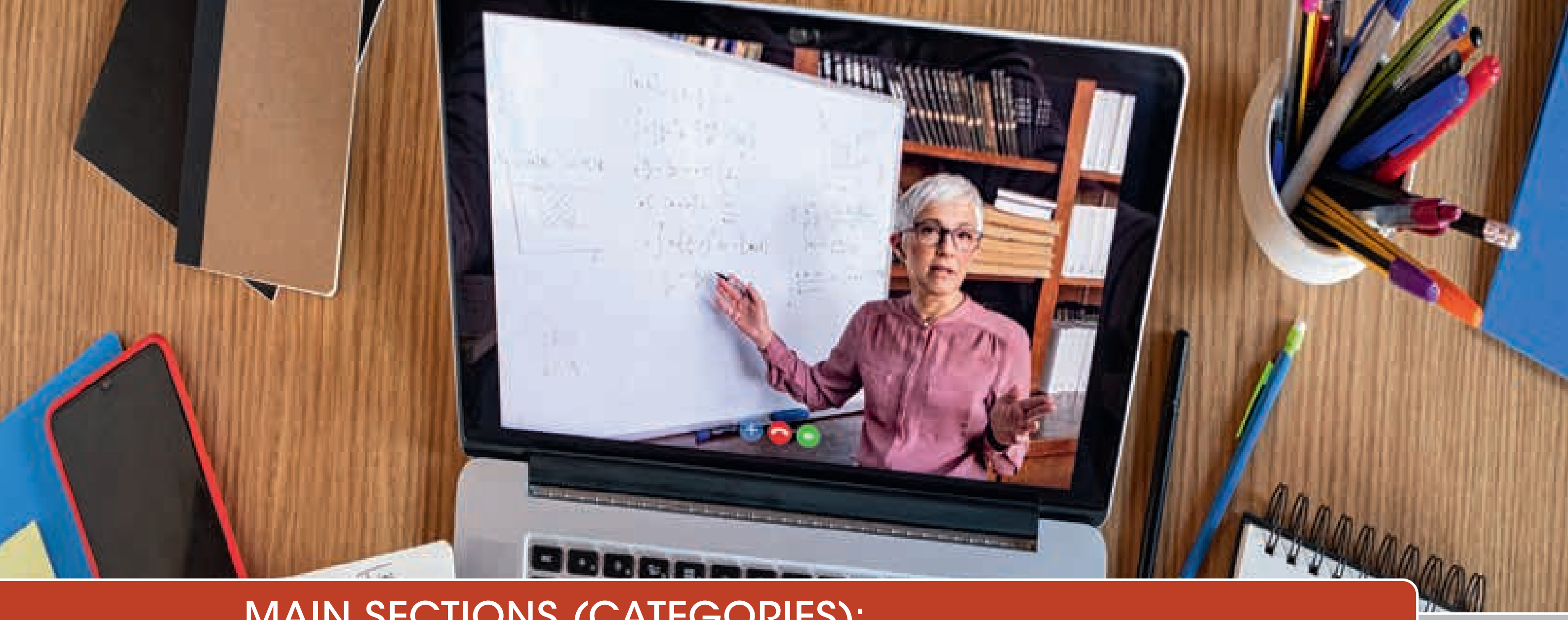
EAGE

SHORT COURSE CATALOGUE

www.learninggeoscience.org

learning geoscience



MAIN SECTIONS (CATEGORIES):

Data Science
- Machine Learning

Energy Transition

Engineering
- Petroleum Engineering
- Reservoir Management
- EOR/IOR

Geology
- Structural Geology
- Carbonate Geology
- Stratigraphy
- Geological Modelling

Geophysics
- Seismic Acquisition
- Seismic Processing
- Surface Imaging
- Integrated Geophysics
- Mineral Exploration
- Reservoir Characterization

Near Surface
- Environmental Geophysics
- Non-Seismic Methods

Reservoir Characterization
- Rock Physics
- Geomechanics
- Geochemistry

Training and Development
- Human Resources

ICONS

Book
This course has a dedicated book available at the EAGE Bookshop

EAGE Education Tour (EET)
This course is part of the EET programme supported by the EAGE Education Fund.

E-Lecture
This course comes with an EAGE E-Lecture that you can watch on Learning Geoscience

Energy Transition
This course covers topics and skills that can be applied within the energy transition

In-House
This course can be requested for in-house training (subject to instructor's availability)

New
New course

EAGE commits to constantly expand, improve and tailor our education programmes to meet the demand for innovation and participation.

Welcome Words

The European Association of Geoscientists and Engineers (EAGE) recognizes the necessity for high-quality training and education throughout the lifetime of the industry professional. Indeed, we see educational tools as a key deliverable to our membership, especially relevant in our rapidly changing industry. To this end, I would like to introduce the EAGE Short Course Catalogue in which you will find an overview of over ninety short courses, delivered by a range of experienced instructors from industry and academia. We have carefully selected these courses to be multidisciplinary, in keeping with our Association's ethos, and to keep abreast of the latest trends in geoscience and engineering. Most of our courses are designed to be easily digested in bites of one to four days in-person or two to five half days online.

EAGE offers a broad range of education opportunities in a variety of formats, both public and in-house, with the current focus on online education:

- Interactive Online Short Courses
- Interactive Online EAGE Education Tours
- Extensive Online Courses with interactive elements
- Self-paced Online Courses
- Distinguished Lecturer Webinars
- E-Lecture Webinars
- E-Lectures
- Online in-house training

I strongly encourage you to discover our education offerings on our new online learning platform - Learning Geoscience, and participate in our short courses, which I am sure that you will find both high quality and professional in nature.

Do not forget to check on the Education Packages, the package includes all our online courses and is available with 3, 5 or 10 credits at LearningGeoscience.org. Save up to 50% on registration fees compared to individual courses.

Finally, I should add that the EAGE is continually refreshing the catalogue to ensure it keeps pace with, and is relevant to, current industry developments. I am pleased to inform you that the Energy Transition is added to the catalogue as a new category. In addition to that, we have also marked courses relevant to the Energy Transition with a specific icon. Should you have any suggestions or proposals for new courses please let me know.

I wish you an enjoyable and informative learning experience!

Colin MacBeth I Education Officer (EAGE Board)

About EAGE and Learning Geoscience

EAGE is a professional association for geoscientists and engineers. Founded in 1951, it is a non-profit organization with a worldwide membership providing a global network of commercial and academic professionals. The Association is truly multi-disciplinary and international in form and pursuits. EAGE believes that it is vitally important for all geoscientists to keep up-to-date on the latest developments in their field. For this reason the Association actively develops and delivers education programmes for different audiences.

Learning Geoscience, the online education platform of EAGE, is the focal point for all online education activities organized by the Association. Online training can overcome limitations of time, distance and financial resources. It is a flexible format that allows participants, from students to professionals, to attend lectures from anywhere in the world and at the time that is convenient for them. The Learning Geoscience platform offers an integrated set of interactive, or self-paced, online courses of experienced instructors from industry and academia which give participants the possibility to follow the latest education in geoscience and engineering remotely. It also offers free learning resources, such as E-Lectures and webinars from our Distinguished Lecturer Programme.

EAGE Education Tours (EET)

Since 2006, the popular EAGE Education Tours (EET) have already attracted thousands of participants. An Education Tour on current Geoscience topics consists of a one day classroom or 2 half days online course, presented by an acknowledged industry expert/academic who visits various locations worldwide. The courses presented in this programme are specifically designed with an appeal to a wide audience, as opposed to some of the more specialized short courses in this catalogue, and aim to fulfil EAGE's mission of providing members with access to the latest developments in Geoscience at an affordable price.

In this catalogue the EET courses have been identified with a red icon.

A selection of courses from the EET programme are currently being offered online in order to give participants the possibility to follow the latest education in geoscience and engineering remotely. Online EETs are delivered in two half-day sessions and participants have the possibility to interact live with the instructors, ask questions and conduct practical exercises. Scheduled EETs can be found in the education calendar at www.LearningGeoscience.org.

Customized in-house training

Most of the short courses are also available as in-house training, which can be organized on a company's premises or online and customized to better fit with specific needs. In-house courses are suited for groups of 10–20 participants, although sessions for larger audiences can be arranged as well. In-house courses can be complemented with a consultation session, if needed. Many instructors are flexible to customize the curriculum with individual preferences and training needs. If your company has a specific interest, do not hesitate to contact us for a personalized proposal.

In-house training is a flexible and cost-effective option for the continuous professional development of your company. Engaging in training as a group and undertaking activities and discussions together can also serve as a team-building exercise, strengthen the bonds between colleagues, refresh team skills and boost confidence.

EurGeol Accreditation

Since 2013 EAGE has been an official Continuing Professional Development (CPD) Provider for the 'European Geologist' title, which is a globally recognized professional accreditation established by the European Federation of Geologists (EFG). In order to obtain and maintain this title, the holder must provide a record of high-quality CPD activities, which include short courses such as the ones presented in this catalogue. For more information about this accreditation system and corresponding EAGE learning activities please visit www.eage.org/education/eurgeol-title.

Find education opportunities for you

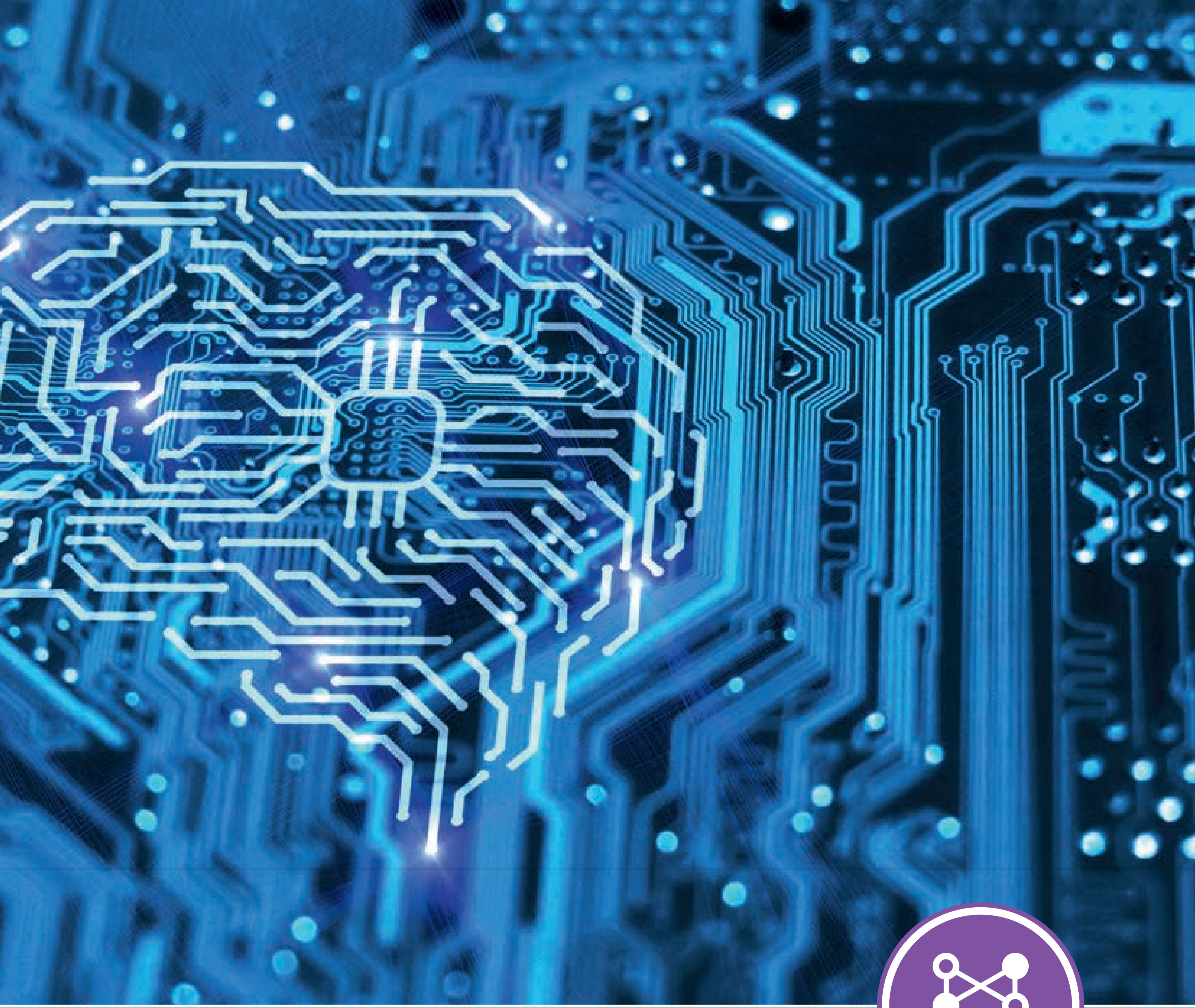
The courses presented in this catalogue are scheduled throughout the year. Visit our online education platform www.LearningGeoscience.org to see the latest schedule. Interested in a course that is not scheduled? No problem! You can request it as in-house training. For personalized proposals and more information about programmed activities, contact us at CorporateRelations@eage.org.

Online Course formats

Self-Paced Courses
Pre-recorded online courses with self-paced study materials, quizzes and exercises that you can complete with your own schedule over a set period.

Extensive Online Courses with Interactive Elements
Deep-dive experience, with extensive self-paced online materials complemented with regular interactive sessions with the instructor.

Interactive Online Short Courses (IOSC)
Real-time instructor-led online courses of two to four days with the possibility to interact with the instructor and ask questions.



Data Science

MACHINE LEARNING •

DATA SCIENCE • MACHINE LEARNING

Cloud Basics for Geosciences

CLOUD | HIGH PERFORMANCE COMPUTING | IOT | DATA MANAGEMENT | DATA PROCESSING

Instructor:	Guy Holmes (TapeArk, Australia)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

1. What is the cloud?

A summary of what the cloud is including an introduction to the three most popular clouds in use today in the industry. The summary will include a breakdown of the tools available to cloud users and some basic concepts about cost, and a few examples of workloads that you should consider using the cloud for.

2. The difference between Public Clouds and Private Clouds.

There are fundamental differences between clouds that are Private and Public, and numerous misconceptions about which is best, more secure, and the most scalable. Included a few real work examples of systems that are Private and Public and why one should consider the options carefully.

3. What does the cloud enable – why use it?

The cloud is such an important part of our ecosystem now and will continue to be in the future. The key reasons why it should be used will include scalability, security, evergreening, reliability, cost, and the tools enabled by the cloud systems such as AI and ML.

4. Cloud Security Awareness

There are a lot of misconceptions about cloud security. We will look at a few security breaches, why they occurred, how to prevent them, and the additional security features available to cloud users to help protect their data.

5. The movement to Geophysics in "real time" in the Cloud

With the advance of the SpaceX constellation, real time data streaming in remote areas – even high volume low latency – will become possible. This is going to mean survey data can be looked at, QC'ed, and used essentially in real time as it arrives in a cloud account. This is going to move the Geo closer to the data flows, and create a more dynamic exploration system that can make decision while the survey is still being recorded, rather than far later.

6. The movement to "Big Data" from "Small Data"

The oil sector has never in its history had the opportunity to have access to all of their data, all of the time. Using small sample data sets, subsets of surveys, to explore will no longer be necessary as the cloud continues to grow. This change needs a change of mindset in the industry to both understand why this is valuable, and how to take advantage of it.

Course Objective

In this course, you will learn to:

- Describe the major public and private cloud providers and their relative strengths
- Understand the difference between public and private clouds
- Describe the basic global infrastructure of the cloud
- Compare and contrast conventional on-premise infrastructure to that on offer in the cloud
- Be better prepared to think about problem solving in a new way - with the use cloud technology

Course Outline

1. What is the cloud?
2. The difference between Public Clouds and Private Clouds.
3. What does the cloud enable – why use it?
4. Fundamental concepts of cloud based compute, storage, database, and networking
5. Cloud Security Awareness
6. The movement to Geophysics in "real time" in the cloud
7. The movement to "Big Data" from "Small Data"
8. The concepts behind Big Data

Participants' Profile

Geoscientists of all skill levels that are seeking to better understand why the cloud is changing the industry and how the cloud can be used in their roles to improve project outcomes.

Prerequisites

Participants should have casual familiarity with linear algebra and calculus.

About the Instructor

Guy is a graduate of Geophysics from Macquarie University in Sydney, and has completed a Masters of Business Administration (Technology Management) from Deakin University in Melbourne and is a graduate of the Australian Institute of Company Directors.

Guy is a successful leader with a proven track record in the growth of start up and turn around businesses in the IT, medical and information management sectors.

DATA SCIENCE • MACHINE LEARNING

Machine Learning in Geosciences

CONVOLUTIONAL NEURAL NETWORKS | MACHINE LEARNING | NEURAL NETWORKS | OIL AND GAS | SEMBLANCE GATHERS | SUPPORT VECTOR MACHINE

Instructor:	Gerard Schuster (King Abdullah University of Science and Technology, Saudi Arabia)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

Participants will learn the high-level principles of several important topics in machine learning: neural networks, convolutional neural networks, and support vector machine. They will practice the execution of these methods on MATLAB codes (free for 30 days after downloading it from the MATLAB site) and Python-related codes (can be uploaded during the course). Applications include fracture detection in photos, fault delineation in seismic images and picking NMO velocities in semblance gathers.

Course Outline

About 66% of the time will be for 50-minute lectures and the remaining time will be devoted to lab exercises.

Participants' Profile

The course is designed for geoscientists who have heard about Machine Learning and might know some details, but lack enough knowledge to test ideas or make the next step in understanding. This limitation will be mitigated after a day of diligent attendance and effort. A selective overview of important ML topics is provided and their practical understanding comes from MATLAB and Python-related exercises applied to geoscience problems.

Prerequisites

Participants should have casual familiarity with linear algebra and calculus.

About the Instructor

Gerard T. Schuster received his M.Sc. in 1982 and his Ph.D in 1984 from Columbia University, both in Geophysics. From 1984-1985 he was a postdoctoral fellow at Columbia University, after which he assumed a faculty position in Geophysics at University of Utah from 1985 to 2009. In that time he won several teaching and research awards, founded and directed the UTAM consortium, was chief editor of Geophysics for several years, and supervised more than fifty students to their graduate degrees. He was given EAGE's Eotvos award in 2007, awarded SEG's Kauffman gold medal in 2010, and is the 2013 SEG Distinguished Lecturer for spring 2013. In the summer of 2009 he moved to KAUST (King Abdullah University of Science and Technology) as a Professor of Earth Science just north of Jeddah. He holds a joint appointment with both Universities, except he is now an adjunct Professor of Geophysics at University of Utah. His primary interests are in seismic migration and modeling, interferometry, waveform inversion, and a fondness for solving geological problems with modest-sized seismic experiments. Since 2018, he also also been teaching courses on machine learning.

New Applications of Machine Learning to Oil & Gas Exploration and Production

DEEP NEURAL NETWORKS (DNN) | EXPLORATION | MACHINE LEARNING | OIL AND GAS

Instructor:	Dr Bernard Montaron (Fraimwork SAS, Malaysia)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

The course introduction will attempt to answer the question: How will A.I. change the way we work in the Oil and Gas industry in the coming years? Looking at what is underway in other industries and guessing what type of projects are under development in R&D departments in our industry will help answer that question.

Oil and Gas examples will be presented corresponding to each of the terms A.I., Machine Learning, and Deep Learning, allowing participants to reach a clear understanding on how they differ.

The course will then focus on Deep Learning (DL) and address all key aspects of developing and applying the technology to Oil and Gas projects.

- What is DL and how different is it from traditional neural networks?
- A peek at the mathematics behind Deep Neural Networks (DNN)
- Typical workflow to design and develop a deep learning application in an E&P project
- Common challenges, difficulties, and pitfalls in deep learning projects
- Software tools and hardware required + Cloud computing vs in-house solutions.

This will be followed by live demonstrations of two DNN-based applications specific to Oil and Gas upstream domains.

First, we'll run software performing automatic fault identification on released seismic data from New Zealand basins to demonstrate how a DNN recognizes faults and how it differs from other algorithms such as ant tracking. Starting from default training, the DNN can gradually learn to recognize faults like the Geophysicist or Structural Geologist. The training set constantly evolves incorporating feedback from human experts.

Second, the identification of resource opportunities in very large repositories of text and image documents will be demonstrated. This will be done with a deep learning application that performs contextual search and linguistic analysis. Unlike keyword search, contextual search extracts information based on its context, just like humans do. And then linguistic analysis is run on the extracted information to identify actionable opportunities. This list of opportunities can then be further evaluated by human experts.

Finally, the course conclusion will summarize key learnings and answer any additional questions/queries from participants.

Course Objectives

Upon completion of the course, participants will have acquired detailed knowledge of what deep learning is exactly, how it works, and in which way it differs from traditional neural networks that have been used in the industry during the last 30 years. They will understand which domains this can be applied to and for what type of applications. And they will also understand what are the main challenges, difficulties, and pitfalls when developing new applications. Finally, they will have seen demonstrations of deep neural networks applied to Exploration and Production disciplines and will be able to evaluate how useful the technology could be for their own domain.

Course Outline

Morning session: 3 hours + breaks. Lunch break. Afternoon session: 3 hours + breaks

- Introduction to the new A.I. world: What's currently underway in R&D departments?
- Artificial Intelligence, Machine Learning, and Deep Learning: how do they differ and examples of O&G applications
- A closer look at Deep Learning:
- What is it and how different is it from traditional neural networks?
- A peek at the mathematics behind Deep Neural Networks (DNN)
- Typical workflow to design and develop a deep learning application in an E&P project
- Common challenges, difficulties, and pitfalls in deep learning projects
- Software tools and hardware required + Cloud computing vs in-house solutions.
- Application to Geophysics and Geology: automatic fault identification with a DNN (live)
- Application to Production Engineering: detecting oil & gas opportunities with a DNN (live)
- Conclusion - Key learnings

Participants' Profile

The course is designed for geoscientists, petroleum engineers, and petrophysicists from new ventures/basin, exploration, and development & production disciplines - from early career to senior, working in oil & gas companies or service companies.

About the Instructor

Dr. Bernard Montaron is CEO of Fraimwork SAS, Paris, France, and CTO of Cenozai Sdn Bhd, Kuala Lumpur, Malaysia. Two startups created in 2017 that are specialized in the application of AI to various domains, and provide services to oil and gas companies for exploration and production. In 2015-2017 he was Chief Geoscientist of Beicip Tecsol in Kuala Lumpur. Prior to this, Bernard Montaron worked 30 years for Schlumberger where he held a number of positions in R&D and Marketing. He has worked for the oil and gas industry in Europe, in the US, in the Middle East, in China, and Malaysia. Bernard was General Manager of the Schlumberger Riboud Product Center in Paris – Clamart, France (2002-2003) and he was VP Marketing of Schlumberger Middle East and Europe-Africa-Russia regions (2000-2001). Bernard holds a MSc degree in physics from ESPCI, Paris, and a PhD in Mathematics from University Pierre et Marie Curie, Paris. He has a Machine Learning certificate from Andrew Ng's course (Stanford Univ./Coursera). Bernard received the best oral presentation award at the APGCE 2017 conference for his paper on "Deep Learning Technology for Pattern Recognition in Seismic Data – A Practical Approach".

Developing Deep Learning Applications for the Oilfield: From Theory to Real World Projects

DEEP NEURAL NETWORKS (DNN) | EXPLORATION | MACHINE LEARNING | OIL AND GAS

Instructor:	Dr Bernard Montaron (Fraimwork SAS, Malaysia)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: Extensive Course - self-paced study + 4 live sessions of 1 hour	CPD Points: 10
	Online: IOSC - 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

This course starts with the story of AI from the 1950s to the AI revolution of the 2010s. Today's AI business landscape and what's happening in the oil and gas are reviewed. The basic concepts of Machine Learning are introduced, followed by a detailed presentation of neural networks (NN). NN used 25 years ago in the oilfield are discussed, then participants experiment a NN trained in 12 seconds to read handwritten digits. Deep convolutional NNs (DNN) are then studied and applications to salt mapping and fault detection in seismic data discussed and demo'ed. Finally, participant teams are asked to design DNNs and to define how to create the data sets for two oilfield projects: sweet spot detection in Bakken field, USA, and GWC prediction in seismic data of undrilled carbonate pinnacles offshore Central Luconia, Malaysia.

Course Objectives

Upon completion of the course, participants will have acquired detailed knowledge of what deep learning is exactly, how it works, and in which way it differs from traditional neural networks that have been used in the industry during the last 30 years. They will understand which domains this can be applied to and for what type of applications. And they will also understand what are the main challenges, difficulties, and pitfalls when developing new applications. Finally, they will have seen demonstrations of deep neural networks applied to Exploration and Production disciplines and will be able to evaluate how useful the technology could be for their own domain.

Course Outline

Part 1:
- A little history of artificial intelligence (A.I.)
- The AI revolution in the last ten years
- Today's AI business landscape
- GAFAMs and free online AI software development tools
- What's happening with AI in the Oil & Gas business?
- Linear Regression as an introduction to Machine Learning

Part 2:
- A little more on linear regression
- Neural Network basics
- Logic gates (NOT, OR, AND) as neural networks… and implications
- Understanding ML buzz words: gradient descent, backpropagation, generalization, etc.
- The mathematics of NNs and ML (linear algebra)
- Image classification/pattern recognition with a neural network (NN-DIGITS)
- NN-DIGITS training demo

Part 3:
- Discussion on NN from the past in the oilfield industry, and handwritten digit classification
- The Deep Learning revolution: how did it happen?
- A very complex NN: the human eye and the visual cortex
- Introduction to deep convolutional NNs (CNNs)
- How CNNs make it possible to develop a micro-paleontology ML software
- Free download AI tools (ATOM, Keras, TensorFlow) running on a gamer laptop PC
- NN/CNN demos with these tools using an online data set from Kaggle

Part 4:
- Discussion on self-driving cars ML software, and adversarial attacks
- Adversarial examples for the human brain: optical illusions and perception errors
- Discussion on the salt classification paper
- Important considerations on accuracy metric
- Review of a CNN-based system for picking faults in seismic data
- Software demo of "MyFault"
- Introduction to part-5 teamwork exercises: do your own ML project

Part 5:
- Team exercises and presentations

Participants' Profile

This course is intended for technical staff and managers interested to understand what Deep Learning is and how it can be applied to oilfield projects (all disciplines).

About the Instructor

Dr. Bernard Montaron is CEO of Fraimwork SAS, Paris, France, and CTO of Cenozai Sdn Bhd, Kuala Lumpur, Malaysia. Two startups created in 2017 that are specialized in the application of AI to various domains, and provide services to oil and gas companies for exploration and production. In 2015-2017 he was Chief Geoscientist of Beicip Tecsol in Kuala Lumpur. Prior to this, Bernard Montaron worked 30 years for Schlumberger where he held a number of positions in R&D and Marketing. He has worked for the oil and gas industry in Europe, in the US, in the Middle East, in China, and Malaysia. Bernard was General Manager of the Schlumberger Riboud Product Center in Paris – Clamart, France (2002-2003) and he was VP Marketing of Schlumberger Middle East and Europe-Africa-Russia regions (2000-2001). Bernard holds a MSc degree in physics from ESPCI, Paris, and a PhD in Mathematics from University Pierre et Marie Curie, Paris. He has a Machine Learning certificate from Andrew Ng's course (Stanford Univ./Coursera). Bernard received the best oral presentation award at the APGCE 2017 conference for his paper on "Deep Learning Technology for Pattern Recognition in Seismic Data – A Practical Approach".

DATA SCIENCE • MACHINE LEARNING

Data Science for Geoscience

CASE STUDY | CLIMATE | CORRELATION | CROSS-PLOTTING | DECOMPOSITION | DEPOSITS | EARTHQUAKE | ENVIRONMENTAL | EXTRAPOLATION | FACIES | FLOODING | FOURIER | GEOSTATISTICS | GROUNDWATER | MODELING | UNCERTAINTY

Instructor:	Prof. Dr Jef Caers (Stanford University, United States)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: Extensive Course - self-paced study + 4 live sessions of 1 hour	CPD Points: 10
	Online: IOSC - 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

This course provides an overview of the most relevant areas of data science to address geoscientific challenges and questions as they pertain to the environment, earth resources & hazards. The focus lies on the methods that treat common characters of geoscientific data: multivariate, multi-scale, compositional, geospatial and space-time. In addition, the course will treat those statistical method that allow a quantification of the "human dimension" by looking at quantifying impact on humans (e.g. hazards, contamination) and how humans impact the environment (e.g. contamination, land use). The course focuses on developing skills that are not covered in traditional statistics and machine learning courses.
The material aims at exposure and application over in-depth methodological or theoretical development. Data science areas covered are: extreme value statistics, multi-variate analysis, factor analysis, compositional data analysis, spatial information aggregation, spatial analysis and estimation, geostatistics and spatial uncertainty, treating data of different scales of observation, spatio-temporal modeling. The focus lies on developing practical skills on real data sets, executing software and interpreting results.

Course Objectives

The objectives of this course are to:
- Discover fields of data science typically not covered in traditional courses
- Identify a combination of data science methods to address a specific geoscientific question or challenge whether related to the environment, earth resources or hazard, and its impact on humans
- Use statistical software on real datasets and communicate the results to a non-expert audience

Course Outline

Part I: Extremes
- Statistical analysis of skew data
- Extreme value statistics
- Applications: size and magnitude distributions (volcanoes, diamonds, earthquakes), extreme flooding, weather, climate.

Part II Compositions
- Compositional data analysis
- Applications: geochemical data in Earth Resources

Part III Causality
- Multivariate analysis of compositional data
- Application: pollution, water quality, anomaly detection, Earth Resources prospecting.

Part IV Geospatial analysis
- Bayesian Aggregation of geospatial information
- Weights of Evidence method
- Logistic regression

Part V spatial uncertainty
- Spatial analysis, geostatistics & spatial uncertainty
- Application: interpolating remote sensing data, pollution data, groundwater/reservoir modeling
- Variogram Analysis
- Kriging
- Multiple-point geostatistics

Participants' Profile

Geoscientists and geo-engineers who wish to expand their knowledge on data scientific methods specifcally applicable to earth science type data sets: skew data, compositional/multivariate, spatio-temporal.

Biography

Jef Caers received both an MSc ('93) in mining engineering / geophysics and a PhD ('97) in engineering from the Katholieke Universiteit Leuven, Belgium. Currently, he is Professor of Geological Sciences (since 2015) and previously Professor of Energy Resources Engineering at Stanford University, California, USA. He is also director of the Stanford Center for Earth Resources Forecasting, an industrial affiliates program in decision making under uncertainty with ~20 partners from the Earth Resources Industry. Dr. Caers' research interests are quantifying uncertainty and risk in the exploration and exploitation of Earth Resources. Jef Caers has published in a diverse range of journals covering Mathematics, Statistics, Geological Sciences, Geophysics, Engineering and Computer Science. Dr. Caers has written four books entitled "Petroleum Geostatistics" (SPE, 2005) "Modeling Uncertainty in the Earth Sciences" (Wiley-Blackwell, 2011), "Multiple-point Geostatistics: stochastic modeling with training images" (Wiley-Blackwell, 2015) and "Quantifying Uncertainty in Subsurface Systems (Wiley-Blackwell, 2018).

Recommended Reading

Coles, S., Bawa, J., Trenner, L., & Dorazio, P. (2001). An introduction to statistical modeling of extreme values (Vol. 208). London: Springer.
Pawlowsky-Glahn, V., & Buccianti, A. (2011). Compositional data analysis: Theory and applications. John Wiley & Sons.
Härdle, W., & Simar, L. (2003). Applied multivariate statistical analysis. Berlin: Springer.
James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). An introduction to statistical learning. New York: Springer.

About the Instructor

Jef Caers received both an MSc ('93) in mining engineering / geophysics and a PhD ('97) in engineering from the Katholieke Universiteit Leuven, Belgium. Currently, he is Professor of Geological Sciences (since 2015) and previously Professor of Energy Resources Engineering at Stanford University, California, USA. He is also director of the Stanford Center for Earth Resources Forecasting, an industrial affiliates program in decision making under uncertainty with ~20 partners from the Earth Resources Industry. Dr. Caers' research interests are quantifying uncertainty and risk in the exploration and exploitation of Earth Resources. Jef Caers has published in a diverse range of journals covering Mathematics, Statistics, Geological Sciences, Geophysics, Engineering and Computer Science. He was awarded the Vistelius award by the IAMG in 2001, was Editor-in-Chief of Computers and Geosciences (2010-2015). Dr. Caers has received several best paper awards and written four books entitled "Petroleum Geostatistics" (SPE, 2005) "Modeling Uncertainty in the Earth Sciences" (Wiley-Blackwell, 2011), "Multiple-point Geostatistics: stochastic modeling with training images" (Wiley-Blackwell, 2015) and "Quantifying Uncertainty in Subsurface Systems (Wiley-Blackwell, 2018). Dr. Caers was awarded the 2014 Krumbein Medal of the IAMG for his career achievement.

Geophysical Data Analysis in Julia, including Machine Learning

MACHINE LEARNING | JULIA | OPEN SOURCE | GEOPHYSICS | IMAGING | INVERSION | PRE-PROCESSING | DENOISING | DATA VISULALIZATION | QUALITY CONTROL

Instructor:	Dr Rajiv Kumar (Schlumberger, United Kingdom)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

The main objective of this course is to bridge the gap between R&E and non-R&E people working in the industry together by providing a learning platform to non-R&E people where they can understand and develop their own research ideas and give them life. Even R&E people can learn the power of open source languages such as JULIA in testing and writing small prototypes while utilizing parallel computing capabilities. The audience will learn and develop small research prototypes on seismic data processing concepts such as denoising, interpolation, modelling and inversion. The second objective is to demonstrate to the audience that they can further explore the world of machine learning in JULIA while connecting the conventional and ML techniques to stay up-to-date with the advancements in the field of signal processing.

Course Objectives

Upon completion of the course, participants will learn:

- how to build and test small research prototypes in JULIA for day-to-day task
- to use and understand signal processing tools available in open source and how to adapt these tools as per the research require-ments
- to perform parallel computing in JULIA to scale small research prototypes to a large-scale problem

Course Outline

The course is completely hands-on delivered through various jupyter notebooks with a couple of presentations in between.

- Introduction to JULIA
  - loading JULIA, IDE and various other environments
  - introduction to variables, types, functions, data structure, control flow
  - introduction to parallel computing in JULIA
- Various data preprocessing tasks such as
  - loading LAS, Excel, text, SEGY format in JULIA,
  - organizing the data
  - cleaning and visualization
- Tutorial on designing different seismic preprocessing tools such as
  - denoising
  - interpolation
  - deconvolution
- Using Synthetic VSP dataset, setup and perform
  - full-waveform inversion
  - reverse time-migration
- Building machine learning model to perform denoising on VSP datasets

Participants' Profile

Geoscientists who are interested to create, design and learn programming to develop their ideas from imagination to real-world solutions. This course will demonstrate to them the power of open source programming languages such as JULIA, and enable them to use it in there day to day tasks while testing it in real-time to further extend it to be ready to deploy on the production scale.

Prerequisites

The audience is expected to have prior knowledge of basic signal processing concepts such as correlation, deconvolution and Fourier transforms and seismic processing background.

Recommended Reading

1. https://www.youtube.com/user/JuliaLanguage/playlists
2. https://juliaacademy.com/courses?preview=logged_out
3. https://julialang.org/learning/tutorials/

About the instructor

Dr. Rajiv Kumar received his M.Sc. degree in Applied Geophysics in 2008 from the Indian Institute of Technology, Bombay. He worked as a Borehole Geophysicist in Schlumberger from 2008-2011. He completed his Ph.D. in 2017 from the University of British Columbia, Canada, in Computational Geophysics. From 2017-2018 he was a Postdoctoral Fellow at the University of British Columbia, Canada and Georgia Institute of Technology, USA. He joined DownUnder Geosolutions as a Research Scientist in 2019 based in Perth, Australia. Since 2020, He is working as a Senior Research Sci-entist in Schlumberger Geophysics Technology Centre, Gatwick, UK. His main interests are signal processing, modelling, inversion, and bridging the gap between machine learning and classical processing techniques in Geophysics. He is a member of EAGE and SEG.

Machine Learning for Geoscientists with Hands-on Coding

CASE STUDY | DATA SCIENCE | FACIES CLASSIFICATION | FAULT DETECTION | MACHINE LEARNING | ROCK PHYSICS | WELLS

Instructor:	Dr Ehsan Naeini (United Kingdom)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

Machine learning has been around for decades or, depending on your view, centuries. By applying machine learning to our workflows, e.g. petrophysics, rock physics, seismic processing and reservoir characterization, we can bring speed, efficiency and consistency over traditional methods of data analysis. In addition, we can implement a range of machine learning techniques together with optimization algorithms and statistics to identify new patterns and relationships in multi-dimensional datasets. This has the potential to enhance our quantification and strengthen our interpretation of the subsurface; ultimately leading to a more accurate predictive outcome.

In this course we attempt to layout the reality of artificial intelligence, machine learning, deep learning and big data. We cover the basic principles of machine learning and some of the most widely used algorithms. We continue by explaining a workflow for implementing a typical machine learning application in practice and to quality control and interpret the outcomes. Following this we shift focus to Geoscience and show various examples in which machine learning algorithms have been implemented for well- and/or seismic-based applications. Given the hands-on coding nature of this course, trainees will code up a classification and a regression algorithm for lithology/facies and well log prediction correspondingly. Throughout these exercises the trainees will become familiar with the flexibility of coding machine learning in Python (although we do not intend to teach Python in details in this course) as well as familiarization with publicly available python libraries for machine learning and analytics. The course is for entry level practitioners and involves hands-on coding, hence having some Python skills is an advantage but not essential.

Course Objectives

1. Use python;
2. Understand various machine learning algorithms, concepts and terminologies;
3. Learn how to analyse data in big scales;
4. QC for machine learning applications;
5. Extend their newly learned knowledge to their day to day practice and implement their own ideas.

Course Outline

1. Introduction;
2. Machine Learning Principles;
3. Machine Learning in Practice;
4. Exercise 1: ML for classification;
5. Exercise 2: ML for regression.
6. Exercise 3: Application of ML on seismic data

Participants' Profile

The course is designed for basically everyone, however, an introductory level of analytics expertise is useful.

Prerequisites

There are no prerequisites, but basic Python knowledge can be useful.

About the Instructor

Ehsan Naeini is a Geoscience researcher and practitioner with more than 16 years' industry experience, particularly in seismic inversion, processing, computational and data science.

He has an MSc and PhD in Geophysics (Exploration Seismology) from the University of Tehran and a BSc in Physics from the University of Isfahan. Whilst studying for his PhD, Ehsan was a lecturer in Geophysics at the University of Isfahan.

Ehsan has held Chief Product Officer, VP R&D and lead positions in software technology companies while working at the intersection of sales, marketing, client support and service project execution. He also has been invited as Visiting Scholar at Colorado School of Mines. He has taught ML courses to various groupings sponsored by EAGE, AAPG, SEG, Royal Geological Society and at Mines.

Introduction to Machine Learning (ML) for Geophysical Applications

ARTIFICIAL INTELLIGENCE | CLASSIFICATION | CLUSTERING | DEEP LEARNING | MACHINE LEARNING | NON-LINEAR REGRESSION

Instructor:	Dr Jaap C. Mondt (Breakaway, Netherlands)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: Extensive course - self-paced study + 5 live sessions of 1 hour	CPD Points: 10
	Online: IOSC - 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

Business context

More and more Machine Learning (ML) will play a role not only in society in general but also in the geosciences. ML resorts under the overall heading of Artificial Intelligence. In this domain often the word "Algorithms" is used to indicate that computer algorithms are used to obtain results. Also, "Big Data" is often mentioned, indicating that these algorithms need an enormous amount of input data to produce useful results.

Many scientists mention "Let the data speak for itself" when referring to machine learning, indicating that hidden or latent relationships between observations and classes of (desired) outcomes can be derived using these algorithms. A clear example is in the field of Quantitative Interpretation. For clastics we have a reasonable understanding in which cases known rock properties expressed in equations can be used to predict say pore fluids. But for carbonates it is often an enigma and we have to resort to statistical relationships. Then ML enters into the game. If we have many wells with known drilling results, the algorithms can derive non-linear relationships between seismic observations and the known well results (supervised learning). But sometimes it is already useful if an algorithm can define separate classes (say seismic facies), which then still need to be interpreted (unsupervised learning).

The course

The aim of this 1-day course is to introduce how Machine Learning (ML) is used in geophysical applications. It will give an understanding of the "workflows" used in ML. The used algorithms can be studied separately using references. Power-point presentations will introduce various aspects of ML, but the emphasis is on computer-based exercises using open-source software. The course concerns a genuine geophysical issue: predicting lithology and pore fluids, including fluid saturations. The input data are Acoustic and Shear Impedances, Vp/Vs ratios and AVA Intercept and Gradients. The exercises deal with preconditioning the datasets (balancing the input classes, standardization & normalization of data) and applying several methods to classify the data: Bayes, Logistic, Multilayer Perceptron, Support Vector, Nearest Neighbour, AdaBoost, Trees. This for supervised as well as unsupervised applications. Non-linear Regression is used to predict fluid saturations.

Course Objectives

The objectives of this course are to:

1. Have a good understanding on how and when MLcan be applied effectively in the geosciences;
2. Realize the workflows that can be used in ML;
3. Solve the main issue of ML, namely choosing the appropriate algorithm and its parameters.

Participants' Profile

This course is meant for all those who are interested in understanding the impact Machine Learning will have on the Geosciences and then specifically the impact on seismic and non-seismic data acquisition, processing and interpretation. Hence, geologists, geophysicists and petroleum and reservoir engineers, involved in exploration and development of hydrocarbon fields, but also those working in shallow-surface geophysics.

About the Instructor

Jaap Mondt has a Bachelor's degree in Geology (University of Leiden) and a Master's degree in Geophysics (University of Utrecht), PhD in Utrecht on "Full wave theory and the structure of the lower mantle". He then joined Shell Research to develop methods for Quantitative Interpretation. Subsequently worked in Shell Expro in London where he was actively involved in acquiring, processing and interpreting Offshore Well Seismic data. After his return to The Netherlands he headed a team for the development of 3D interpretation methods using multi-attribute statistical and pattern recognition methods. After a period of Quality Assurance of "Contractor" software for seismic processing, he became responsible for Geophysics in the Shell Learning Centre. During that time, Mondt was also part-time professor in Applied Geophysics at the University of Utrecht. From 2001 till 2005 worked on the development of Potential Field Methods (Gravity, Magnetics) for detecting oil and gas. Finally, became a champion on the use of EM methods and became involved in designing acquisition, processing and interpretation methods for Marine Controlled Source EM (CSEM). After retirement he founded Breakaway, providing courses on acquisition, processing and interpretation of geophysical data (seismic, gravity, magnetic and electromagnetic data).

In the last couple of years, he developed a keen interest in the use of Machine Learning for Geophysical Applications and developed a practical Machine Learning course for Geophysicists and Interpreters.

Energy Transition

ENERGY TRANSITION

Geophysical Monitoring of CO_2 Storage

4D | ACOUSTIC | ELECTROMAGNETISM | FLOODING | GRAVITY | INVERSION | MAPPING | ROCK PHYSICS | SATURATION | TIME-LAPSE

Instructor:	Prof. Martin Landrø (Norwegian University of Science & Technology, Norway)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

The course discusses various methods for monitoring subsurface injection of CO_2. Specifically, the following topics will be covered:

- Rock physics related to injection of CO_2 into porous rock
- Time-lapse seismic methods
- Gravity and electromagnetic methods
- Saturation and pressure effects
- Early detection of leakage
- Mapping overburden geology and identification of potential weakness zones
- Field examples
- Well integrity issues
- Using gas leakage as a proxy to study potential leakage of CO_2
- Laboratory experiments of CO_2 flooding including acoustic measurements

Course Objectives

Upon completion of the course, participants will be able to understand possibilities and challenges related to geophysical monitoring of a CO_2 injection process.

Participants' Profile

The course is designed for geoscientists working in oil companies, service companies and research organizations.

Prerequisites

Participants should have knowledge of basic geophysics and some geology.

About the Instructor

Prof. Dr Martin Landrø received an M.S. (1983) and Ph.D. (1986) in physics from the Norwegian University of Science and Technology. From 1986 to 1989, he worked at SERES. From 1989 to 1996, he was employed at IKU Petroleum Research as a research geophysicist and manager. From 1996 to 1998, he worked as a specialist at Equinor's research center in Trondheim. Since 1998, Landrø has been a professor at the Norwegian University of Science and Technology, Department of Petroleum Engineering and Applied Geophysics. He received the Norman Falcon award from EAGE in 2000 and the award for best paper in GEOPHYSICS in 2001. In 2004 he received the Norwegian Geophysical award, and in 2007 Equinor's researcher prize. He received the SINTEF award for outstanding pedagogical activity in 2009. In 2010 he received the Louis Cagniard award from EAGE and in 2011 the Eni award (New Frontiers in Hydrocarbons). In 2012 Landrø received the Conrad Schlumberger award from EAGE. Landrø's research interests include seismic inversion, marine seismic acquisition, and 4D and 4C seismic. In 2012 Land røreceived the IOR award from the Norwegian Petroleum Directorate. He is a member of EAGE, SEG, The Norwegian Academy of Technological Sciences and The Royal Norwegian Society of Sciences and Letters.

ENERGY TRANSITION

An Introduction to Offshore Wind

OFFSHORE WIND | ENERGY TRANSITION | GEOSCIENCE | RENEWABLES | OFFSHORE

Instructor:	Jeroen Godtschalk (BLIX Consultancy BV, Netherlands)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 3 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

The purpose of this course, is to provide the participants with a comprehensive introduction into offshore wind, it's development and the role of the geoscientist in this process.

During the course, the participants are taken through all the basic building blocks of the offshore wind development. We start the course with an introduction into the various options for renewable energy and why offshore wind is often the preferred option. We conclude this course by discussing the installation issues for offshore wind farms, but also touch upon maintenance issues. In between we cover all the basic steps of development, with a slight focus on the more geoscience related work such as site investigation work, setting the correct parameters for the offshore campaign and foundation selection.

After having completed the course, the participants should have a better understanding of how offshore wind farms are being developed and what factors are influencing the design and the business case of such farms. The participant should than also have a clear idea on what the role of the geoscientist in this process is. This should give him/her also some possible guidance on the career opportunities in this field, should he/she decided to move away from oil & gas and pursue a career in offshore wind.

In order to participate in this course, no real knowledge of offshore wind is mandatory. A basic understanding of geophysical and geotechnical methods will help, but the course can also easily be followed with limited knowledge of these subjects.

If required the course can be tailored to suit the needs of the group, with either more or less detailed presentations. We are happy to discuss any preferences upfront.

Course Objectives

Upon completion of the course, the participants will be able to:

1. Better understand the process and the steps of an offshore wind farm development.
2. Have a clear understanding of the role of the geoscientist in this proces.
3. Understand what factors are determining the final design and layout of an offshore wind farm.
4. Have a good overall idea of offshore wind

Course Outline

1. Offshore wind basics
- Overview of renewable energies
- Why offshore wind
- The physics behind offshore wind
- What is needed for an offshore wind farm (how to decide on a suitable site)
- Required permits

2. Site selection
- What stakeholders do we have before site selection
- Seabed occupation/UXO
- Grid connection to shore
- Ports/logistics hub
- Geospatial issues
- Desktop studies on geology, archaeology, morphodynamics

3. Data collection
- MetOcean Data – wind, waves and current
  - o Methodology
  - o Why needed and how is it used
- Geophysical data – seabed and below seabaed
  - o Methodology
  - o Why needed and how is it used
- Geotechnical data – seabed and below seabed
  - o Methodology
  - o Why needed and how is it used
- Morphodynamics
- Integration into a ground model

4. Foundation types
- Different types of foundation
- Which foundation suits which project and why
- Pro's and Con's for each foundation

5. Transport & Installation
- Installation of different foundations
- Cable installation
- Typical issues for installation
- Maintenance

Participants' Profile

The course is designed for anybody who wants to learn more about offshore wind development and who is keen to learn to understand the basic building blocks of offshore wind.

Prerequisites

A basic understanding of geophysical and geotechnical methods will help, but the course can also easily be followed with limited knowledge of these subjects. In addition, basic understanding of physics will help to understand the overall idea of wind energy and its associated issues.

About the Instructor

Jeroen Godtschalk has a MSc in geophysics from the University of Utrecht in The Netherlands. Following his graduation, he joined the oil & gas industry and worked for 10 years with Bluewater Energy Services B.V. in The Netherlands. In the first years of his career he was involved in numerous site investigations (both geophysical and geotechnical) related to foundation design for Bluewater's FPSO's. Following the results of the site investigations, he also performed the foundation design, such as anchor piles or drag anchors.
Later in his career he moved to more operational roles, where he was operations manager for one of the installation vessels of Heerema Marine Contractors. During this time, he learned the importance of offshore operations and all the factors that influence this.
Ahead of the downturn in the oil and gas he moved to a sand mining/dredging company as Director of Production, where he was responsible for the whole production of the company in both The Netherlands and France. During this time, he was, again, involved in prospecting new locations for sand extraction where sand volumes had to be estimated based on site investigation work.
Since more than 2 years, he is now working for BLIX Consultancy in The Netherlands as a Sr Consultant/Project Manager. During his time with BLIX, he has mainly worked as a project manager for site investigation related work, most notably the Hollandse Kust West (1.4GW) and IJmuiden Ver (4GW) offshore wind farms offshore The Netherlands. In parallel, he co-created and is currently lecturer of the course "Offshore Wind Project Development Course" (created together with the DOB-Acadamy), where he is responsible for the part of "Site Selection & Permitting" for this course.

Geological History of CO_2: Carbon Cycle and Natural Sequestration of CO_2

CARBONATES CLIMATE ENVIRONMENTAL GEOCHEMISTRY GEOMORPHOLOGY PALEOCLIMATE SEDIMENT WEATHERING

Instructor:	Dr Alain-Yves Huc (UPMC - Paris VI University, France)	
Language:	English, French	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

With respect to the current genuine public concern regarding the anthropogenic increase of Green-House gases, intensive research and technology development focus on the capture and underground storage of industrial quantities of CO_2 concentrated in emissions from combustion sources. At the global scale, the withdrawal of the CO_2 diluted in the atmosphere relies essentially on natural bio-geological processes. As a complement to the study of the involved factors in the modern terrestrial eco-system, the geological perspective provides the opportunity to investigate these processes and their consequences at different time scales.

During Earth's history the atmospheric CO_2 has been subjected to extensive changes in term of absolute quantity and relative concentration. From a geological perspective, the current anthropogenic driven alteration of the Earth's atmosphere actually occurs during a period of low atmospheric CO_2 (Ice-House). A large part of the remaining time intervals of the Phanerozoic were apparently dominated by Green-House conditions. The latter situation resulting from the high concentration of atmospheric CO_2, due to volcanic and metamorphic degassing associated with the long term tectonic activity of Phanerozoic megacycles. The subsequent decrease of atmospheric CO_2 at the end of the megacycles is interpreted by a negative feedback involving the CO_2 driven silicate weathering which consumes CO_2.Based on the CO_2 sourcing (tectonic degassing) and CO_2 sinking (sedimentation of carbonates and organic matter), the most popular model depicting the change of atmospheric CO_2 during the Phanerozoic are based on the Berner's GEOCARBSULF approach. The resulting curve which exhibits the long-term change is, to some extent, comforted by the comparison with the estimates of past PCO2 values provided by different indicative proxies.

However some available data depart from the model and high resolution series of proxies suggest that high amplitude and high frequency changes in atmospheric CO_2 were occurring at a much lower time scale. Implications include the possibility to better explain short term climatic events such as the Late Ordovician continental-wide glaciation, to reconsider the significance of brutal events of injection of CO_2 in the atmosphere as a result of intra-plate volcanism and their environmental responses and geochemical record in oceanic sediments (e.g.the Permo-Trias Siberian traps), to revisit the so-called climatic optima such as the Late Palaeocene and Early Eocene, and the necessity to improve our assessment of the kinetics of the retroaction loops controlling the level of CO_2 in the atmosphere.

The main reservoir of carbon is the Mantle. It is the likely repository of a large part of the CO_2 which was initially present in the primitive atmosphere of the Earth, following accretion and degassing, and from which it was probably progressively withdrawn through the process of subduction. The two other major reservoirs of carbon are the sedimentary carbonates and organic matter. The progressive build up of these reservoirs correspond to a long-term sink for around 80 bar of atmospheric CO_2. It should be noted that for both of them the processes involved in the transformation of CO_2 into carbonates and kerogen are biologically driven and that the efficiency of these processes tends to increase as biological evolution proceeds

Course Objectives

Upon completion of the course, participants will be able to:

- Place the current atmospheric CO_2 concentration in a geological perspective;
- Provide an overview of the methods used to approach the value of the past atmospheric CO_2 content;
- Review the change in the carbon cycle throughout geological time: Evolution of source and sink.

Course Outline

- Tools for monitoring changes in atmospheric CO_2 throughout time.
- The carbon cycle.
- Processes of natural sequestration of atmospheric CO_2: the carbon sinks.
- Atmospheric CO_2 change on planet Earth:
  - from Precambrian to Phanerozoic;
  - the Cenozoic;
  - the Pleistocene ice house an inaccurate analogue for the current CO_2 depar -ture from natural values.
- Evolution of carbon sinks, the instrumental role of biology.

Participants' Profile

Anyone interested in the current atmospheric CO_2 concern and the evolution of the biogeochemistry of the Earth's system.

Prerequisites

Basics geology and chemistry (biology).

About the Instructor

Alain-Yves Huc
PhD Strasbourg University, France (1978)
Post doc Woods Hole Oceanographic Institution, USA (1978-1979)
Research Associate at the Applied Geology Department, Orleans University (1979-1981) then at IFP New Energies
Head of the Geochemistry Department, IFP New energies, France (1990-2000)
Director of the Exploration Department at IFP School (2000-2004)
Director of the Exploration Department at IFP School (2000-2004)
Expert Director at IFP New energies (2004-2013)
Research Director Emeritus at UPMC (2013-)

Geological CO2 Storage

CARBONATES CLIMATE ENVIRONMENTAL GEOCHEMISTRY GEOMORPHOLOGY PALEOCLIMATE SEDIMENT WEATHERING

Instructors:	Andreas Busch*, Eric Mackay*, Florian Doster*, (*Heriot-Watt University, United Kingdom) Martin Landrø (NTNU, Norway), Philip Ringrose (Equinor & NTNU, Norway)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: Extensive Course - self-paced study + 7 live sessions of 1 hour	CPD Points: 15

NEW

Course Outline

Module 1: Introduction
- Introduction to CCS
- Introduction to saline aquifer storage
- CO2 storage project design

Module 2: Reservoir concepts and storage requirements
- Reservoir/seal systems for pore space storage
- Storage capacity
- CO2 PVT

Module 3: Flow mechanics (part I)
- Single phase flow in porous media - Darcy
- Single phase flow in porous media - Mass conservation
- Two-phase transport - Pore scale processes

Module 4: Flow mechanics (part II)
- Two-phase transport: Introduction to relative permeability, capillary pressure
- Two phase transport: Non-linear processes
- Link to dynamic reservoir modelling/simulation

Module 5: Storage risks: Seals, assessment, geomechanics and geochemistry
- Geochemical requirements to safely store CO2
- Geomechanical requirements to safely store CO2
- Seal integrity

Module 6: CCS monitoring and risk assessment
- Well integrity and subsurface monitoring
- Seabed/shallow subsurface monitoring
- (Near) Surface and Marine monitoring

Module 7: Public perception, policy and emerging/niche CO2 storage options
- CO2 for enhanced oil production
- Emerging/niche options to store CO2
- Public perception and policy

Participants' Profile

All those interested in the geoscience and engineering aspects or carbon capture and storage.

About the Instructors

Andreas Busch (Heriot-Watt University)
Prof. Andreas Busch is Professor in Earth Sciences. He is currently the Director of the Institute of GeoEnergy Engineering and Head of the GeoEnergy Research Group in the Lyell Centre, both at Heriot-Watt University. His research is focusing on topics associated with the Energy Transition, working with a diverse group of researchers composed of geologists, geomechanists, petroleum engineers, hydrologists and geochemists. The group aims at an improved understanding of the coupled thermo-hydro-chemical-mechanical aspects related to carbon capture and storage (CCS), geothermal heat, hydrogen storage and natural gas production on the laboratory, field, and modelled reservoir scale.

Eric Mackay (Heriot-Watt University)
Eric Mackay holds the Energi Simulation Chair in CCUS and Reactive Flow Simulation in the Institute of GeoEnergy Engineering at Heriot-Watt University, where he has worked since 1990. His research interests include the study of fluid flow in porous media, such as the flow of oil, gas and water in subsurface geological formations. He has over 100 publications related primarily to maintaining oil production when faced with mineral scale deposition, but since 2005 he has also worked on Carbon Capture and Storage. He is involved in projects identifying methods for calculating secure CO2 storage potential in saline formations and depleted hydrocarbon reservoirs.

Florian Doster (Heriot-Watt University)
Professor Florian Doster [PhD, Stuttgart University, 2011] is Professor for Multi-Scale Multi-Phase Flow Modelling in the Institute of GeoEnergy Engineering at Heriot-Watt University and Program Director for Subsurface Energy Systems. His research interests include the study of multi-physics multi-phase flow phenomena in porous media and their appropriate physical and mathematical description across length and time scales. He focuses on phenomena related to CO2 storage, flow in fractured porous media and hysteretic phenomena such as trapping. His research is funded by the ACT(BEIS), European Commission, US Department of Energy, the Scottish Energy Technology Partnership, Norwegian Research Council, Foundation CMG, Total, BP and Petronas.

Martin Landro (NTNU)
Prof. Dr Martin Landrø received an M.S. (1983) and Ph.D. (1986) in physics from the Norwegian University of Science and Technology. From 1986 to 1989, he worked at SERES. From 1989 to 1996, he

was employed at IKU Petroleum Research as a research geophysicist and manager. From 1996 to 1998, he worked as a specialist at Equinor's research center in Trondheim. Since 1998, Landrø has been a professor at the Norwegian University of Science and Technology, Department of Petroleum Engineering and Applied Geophysics. Landrø's research interests include seismic inversion, marine seismic acquisition, and 4D and 4C seismic. Recognitions received: EAGE Norman Falcon award (2000), best paper in GEOPHYSICS (2001), Norwegian Geophysical award (2004), Equinor's researcher prize (2007), SINTEF award for outstanding pedagogical activity (2009), EAGE Louis Cagniard award (2010), Eni award - New Frontiers in Hydrocarbons (2011), EAGE Conrad Schlumberger award (2012), IOR award from the Norwegian Petroleum Directorate (2012).

Philip Ringrose (Equinor, NTNU)
Philip Ringrose is a Specialist in Petroleum Geoscience at Equinor. He has over 30 years of experience in reservoir modelling and field development projects. He is also Adjunct Professor in CO2 storage at the Norwegian University of Science and Technology (NTNU) in Trondheim, Norway. He has published widely on geology and flow in rock media and is Co-Editor of Petroleum Geoscience. Philip was elected as EAGE President in 2014/2015 and is active in the global development of applied geoscience and low-carbon energy solutions.

Value of Information in the Earth Sciences

DECISION MAKING | GEOSTATICS | INVERSION | MODELING | MONITORING | NOISE | RESERVOIR CHARACTERIZATION | ROCK PHYSICS | SEISMIC ATTRIBUTES | SENSORS | SIGNAL PROCESSING | UNCERTAINTY

Instructor:	Prof. Jo Eidsvik (Norwegian University of Science and Technology, Norway)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 to 4 live sessions of 4 hours	CPD Points: 4 to 8
	Classroom: 1 to 2 days	CPD Points: 5 to 10

NEW

Course Description

We constantly use information to make decisions about utilizing and managing natural resources. How can we quantitatively analyze and evaluate different information sources in the Earth sciences? What is the value of data and how much data is enough?

The purpose of the course is to give participants an understanding of the multidisciplinary concepts required for conducting value of information analysis in the Earth sciences. The value of information is computed before purchasing data. It is used to check if data is worth its price, and for comparing various experiments.

The course will outline multivariate and spatial statistical models and methods (Bayesian networks, Markov models, Gaussian processes, Multiple point geostatistics), and concepts from decision analysis (decision trees, influence diagrams), and then integrate spatial statistical modeling, geomodeling and decision analysis for the evaluation of spatial information gathering schemes.

Unlike the traditional value of information analysis, this course focuses on the spatial elements in alternatives, uncertainties and data. A coherent approach must account for these spatial elements, and clearly frame the decision situation - we demonstrate a workflow for consistent integration and apply this in a series of examples. In this course we discuss and show examples of the value of imperfect versus perfect information, where the likelihood model of geophysical measurements is less accurate. We also discuss the value of total versus partial information, where only a subset of the data are acquired.

Course Objectives

Upon completion of the course, participants will be able to:
- Frame a spatial decision situation with alternatives, experiments and spatial geomodelling;
- Use a workflow to conduct value of information analysis in spatial situations;
- Interpret and compare the value of information of different spatial experiments.

Course Outline

- Motivation for value of information analysis in the Earth sciences;
- Decision analysis and the value of information;
  - decision making under uncertainty, value functions, utility, decision trees, influence diagrams, value of perfect information, value of imperfect information
  - run simple demo example / project on computer
- Statistical modeling and spatial modeling;
  - Bayesian networks, Markov models, Gaussian processes, non-Gaussian spatial processes. An important element here is conditioning to data (Bayes rule) and the spatial design of experiments, which will be important for the value of information analysis later
  - run demo / project on computer
- Value of information analysis for spatial models;
  - Framing of spatial decision situations and opportunities for spatial data gathering
  - Partial and total spatial information / imperfect and perfect spatial information
  - Coupled or decoupled spatial value function
  - Develop a workflow for value of information analysis in spatial applications
  - run demo / projects on computer
- Examples of value of information analysis in various energy transition applications: petroleum, mining, CO2 sequestration, hydrology, groundwater and wind energy production;
  - Description of decision situations, statistical modeling, data gathering opportunities
  - Run demo / project on computer

Participants' Profile

The course is designed for students, researchers and industry professionals in the Earth and enviromental sciences who has interests in applied statistics and /or decision analysis techniques, and in particular to those working in petroleum, mining or environmental geoscience applications.

Participants should have knowledge of basic probability and statistics, and mathematical calculus. Although it is not essential, it helps to know basic multivariate analysis and decision analysis or optimization. The participant must be willing learn statistical topics and earth science applications, and appreciate the multidisciplinary approach to solving quantitative challenges.

About the Instructor

Jo Eidsvik is Professor of Statistics at the Norwegian University of Science and Technology (NTNU), Norway. He has a MSc in applied mathematics from the University of Oslo (1997) and a PhD in Statistics from NTNU (2003). He has industry work experience from the Norwegian Defense Research Establishment (1998-1999) and from

Equinor (2003-2006). He has been a visiting professor at the Statistics and applied mathematical sciences institute (SAMSI) in 2009-2010 and at Stanford University in 2014-2015.
Eidsvik has teaching experience in a variety of statistics courses at the university level, including Statistics, Probability, Applied regression analysis, Stochastic processes, Spatial statistics, Computational statistics.

He has been head of the graduate study program in Industrial Mathematics (~50 students every year) and the undergratuate program in physics and mathematics (~100 students every year) at NTNU. He has supervised 45 MSc students and 7 PhD students. He has written about 50 papers in statistical and earth sciences journals.

ENERGY TRANSITION

Medium and Low-Grade Geothermal Energy: Geoscience and Geomechanics

ENERGY | CLIMATE CHANGE | CARBON NEUTRALITY | BASIN ANALYSIS | CLIMATE | CONTINENTAL MARGIN | ENVIRONMENTAL | GEOMECHANICS | GEOTHERMAL | GROUNDWATER | SALT | SEQUENCE STRATIGRAPHY

Instructors:	Grant Wach (Dalhousie University, Canada), Maurice Dusseault (University of Waterloo, Canada)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

EET

Course Description

Globally, countries are striving to gain control of the climate crisis by achieving carbon neutrality through significant and sustained reduction of fossil fuel based energy production. Access to energy remains vital however, so the importance of developing renewable energy technologies is paramount. Geothermal energy is a key opportunity to achieving the energy transition due to low carbon emissions, reliable energy production and relatively low operating costs. Determining the economic viability of geothermal energy is controlled by geographical and geological constraints, so thorough investigation of the subsurface geology is necessary in the evaluation of geothermal energy potential.

Steam-based geothermal systems have been well-studied and developed since the first small successes in Lardarello in 1911. However, geothermal steam for direct power generation is a rarity around the world, and extremely site-specific. The Iceland successes are well-known, as are fields such as Cerro Prieto and the Geysers, but >98% of the land mass of the world does not have High-T (steam) systems. In this course, we will discuss global energy challenges and the energy transition, geological influences on geothermal energy sources, and focus on medium and low-grade systems in permeable reservoirs, and in hot dry rock at depth. We will also discuss geothermal energy storage, geothermal fluids, HOR stimulation, and related topics. Our intent is to leave you with a broad understanding of the thermal energy beneath our feet, how we might exploit it, and how we might even store heat in a "Thermal Battery" for power generation, or for habitat heating. Geothermal energy may fit comfortably with renewable energy sources (hydro, wind, sun) but integrating different combustion-free energy sources required careful planning and good geological and mechanical engineering.

Course Objectives

1) Understand basic geological concepts with influence geothermal energy systems
2) Discuss the viability of developing a geothermal energy system in a given area (exercise)
3) Discuss the different types of geothermal systems
4) Consider basic risks of geothermal system development in a given area
5) Understand basic geomechanical/engineering considerations of geothermal energy systems

Course Outline

1. Introduction:
   a. Geothermal systems (petroleum system elements format): i. High-T Steam systems - dry steam, wet steam ii. SedHeat systems - hot aqueous fluids in porous permeable strata iii. HOR systems - Hot (& warm) Dry Rock systems with minimal permeability
   b. Low energy, high energy systems: i. Lowest energy systems are geothermal gradient systems ii. Highest energy systems are supercritical water systems at moderate depth iii. Intermediate energy systems in hot areas of sedimentary basins
   c. Temperate and Northern climates: i. Extreme need for heat in sub-arctic and artic climate zones ii. Use of heat for power, habitats, agriculture
   d. Tropical and Arid Environments: i. Extreme need for cooling in hot-dry and hot-humid climates ii. Combining geothermal and other renewable energy sources for cooling
2. Clastic Reservoirs:
   a. Typical petrophysical properties (e.g. geopressured aquifers in the GOM)
   b. Adequate flow and energy flux
3. Carbonate Reservoirs:
   a. Carbonate systems, naturally fractured strata (dual porosity systems)
   b. Hot fluids from oil production
4. HOR - Hot Dry Rock:
   a. EGS - Enhanced Geothermal Systems
   b. Naturally fractured systems and stimulation
   c. Advective and conductive heat flux
5. Saline Aquifers and Salt
6. Data collection and requirements
   a. Thermal information: T (z, t...), specific heats, porosities, thermal conductivities, etc.
   b. Fluid flux information: reservoir characteristics, well stimulation effects
   c. Geochemistry of fluids and scale potential in SedHeat and High-T systems
   d. Microseismic surveillance, Deformation monitoring, Pressures...
7. Geotechnical Constraints and Hazards
   a. Fluids management
   b. Hydraulic fracture stimulation
   c. Induced seismicity -11 T, b.p effects

8. Energy Storage
   a. Heat storage in shallow geo-repositories (<1000 m)
   b. Heat storage in deep geothermal heat reservoirs
   c. Integrating geothermal energy with compressed air energy storage

Participants' Profile

This course is designed for students and professionals in the geological and engineering fields who are interested in learning about the fundamentals of geothermal energy systems and modern energy challenges.

Prerequisites

Participants should have prior knowlegde of basic geology and/or geomechanics.

About the Instructor

Grant Wach began his career advising worldwide for multinational companies. He still works with the energy sector but now as Professor of Geoscience at Dalhousie University he serves as a mentor, helping students become successful geoscientists. Wach's research goal is to understand the reservoir component of CCUS and Geothermal systems; understanding the internal complexity of the reservoir is not easy but part of the path to Energy Sustainability, and Carbon Neutrality. These steps are part of the Energy Transition the World is now undergoing.
Professor Wach is an expert advisor to the Energy Sustainability Committee of the UNECE. The committee just released their technology brief on CCUS CCUS brochure_EN_final.pdf (unece.org). He has advised the Nova Scotia government on Carbon Storage and Sequestration and completed the first evaluation of basins in the Maritimes for Carbon Storage. He was principal Investigator of the Gas Seepage Project (GaSP) evaluating methane (CH4) emissions from coal and oil and gas extraction sites in Atlantic Canada. Wach is a member of Geothermal Canada, and has recently presented invited lectures on Geothermal Technology in Canada (Future Pathways- Geothermal Technology 2020) and at KAUST in Saudi Arabia.
Professor Wach completed his doctorate in Geology at the University of Oxford (D.Phil. Geology). He was the first recipient of the AAPG Foundation Professor of the Year Award in 2012 and received the CSPG Stanley Slipper Gold Medal 2018 for outstanding contributions to exploration and development, teaching and mentorship.

Maurice Dusseault is a Professional Engineer and Professor of Geological Engineering at the University of Waterloo, where he has taught and carried out geomechanics research since 1982. His research is focused on deep subsurface engineering issues including oil production, hydraulic fracturing, energy storage, geothermal energy, carbon sequestration, and deep injection disposal of granular solids and liquid wastes. He holds over 90 international patents and has about 600 full-text papers published in journals and conferences. Maurice is a well-known educator and consultant, an advisor to companies and governments on matters relating to energy development, hydraulic fracturing, energy geostorage, wellbore integrity, technology and innovation. Maurice is deeply interested in energy technologies that can be scaled to community levels to provide robust and reliable heat and power. These include integrating natural gas, hydrogen, compressed air energy storage, and heat geo-storage. Another important component of his research is environmental geomechanics: safe and permanent sequestration of carbon (CO2, petcoke, biosolids...), particulate solid slurries, and waste fluids through injection deep into sedimentary strata.

ENERGY TRANSITION

Geology and Engineering of Carbon Capture and Storage

CCS | CARBON | RESERVOIR | STORAGE | CO2 | ENERGY | CLIMATE | CHANGE | CARBON NEUTRALITY | ENERGY TRANSITION | BASIN ANALYSIS | CLIMATE | ENVIRONMENTAL, GEOMECHANICS | ENGINEERING

Instructors:	Grant Wach (Dalhousie University, Canada), Maurice Dusseault (University of Waterloo, Canada)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

EET

Course Description

Global leaders and decision-makers are well aware of the climate crisis and many are taking action to mitigate the effects of climate change by reducing CO2 emissions. However, the demand for energy remains high, especially in areas that require heating and cooling, and currently much of the world's energy is derived from hydrocarbons. Discussion of the 'Energy Transition', which is the shift from fossil-fuel based energy to renewable sources, seems ubiquitous in recent years, the transition is not as simple as that. Ensuring reliable access to energy in all jurisdictions is crucial, as are economic considerations. Combining a switch to renewables with an
emission-reduction measures such as Carbon Capture and Storage is necessary in the path to carbon neutrality.
Carbon Capture and Storage (CCS) refers to the capture of emitted CO2 from the atmosphere, transport, and eventual storage in geological structures. The basic concept is simple, but the execution is complex; it requires the identification of high-emission sites, detailed basin analysis to determine suitability and safety for carbon storage, engineering, economic analysis, and risk analysis before an informed decision to develop a CCS site can be made. This course will overview current energy challenges (the WHY), and geological and engineering basics of CCS (the HOW). Students will leave with a better understanding of this mitigation opportunity and how decisions can be made to pursue CCS in a given area.

Course Objectives

Upon completion of this course, participants will be able to:
1) Understand the need to reduce atmospheric CO2 and the effects of climate change to the global climate system
2) Understand the basic concepts involved in reservoir characterization
3) Discuss suitability of developing CCS sites, considering proximity to emission source, geology and engineering
4) Discuss social and economic considerations of CCS
5) Discuss case studies of existing CCS operations

Course Outline

PART 1: Geoscience
1. Introduction: Anthropogenic Atmospheric CO2 and the Need to Reduce Emissions
   a. Radiative Forcing of CO2 & Climate Change
   b. Energy Challenges and the Energy Transition
   c. Carbon Capture and Storage (CCS): Concept Intro
   d. The role of CCS in the path to Carbon Neutrality
2. Geological Considerations: Basin Suitability
   a. Seismicity
   b. Depth
   c. Fault intensity
   d. Geothermal regimes
   e. On vs. Offshore Basins
   f. Accessibility
   g. Existing Petroleum/ Coal Resources
   h. Industry Maturity
3. Identifying a Prospective Site
   a. Reservoir/Seal Criteria
4. Detailed Site Characterization
   a. Structural and Stratigraphic Models
   b. Injectivity
   c. Containment
   d. Capacity
5. Economic Evaluations
6. Risk
7. Monitoring
8. Decision to Develop
9. Types of CCS Facilities
   a. Case Study of operational CCS sites
10. Wrap-Up and Exercises

PART 2: Engineering
1. Introduction: The Engineering Context for CCS
   a. Sequestration Options: Carbon or CO2?
   b. The Behavior of CO2
   c. Capacity Estimation
   d. Injection Strategies
   e. Reservoir integrity Issues
   f. Monitoring and Optimization
2. Sequestration Options
   a. The Various Storage and Sequestration Mechanisms
   b. The Need for Interim Storage – Salt Caverns, other…
   c. CO2 as a Sequestration Medium
   d. Direct Injection of Carbon-rich Solids – CH4 Harvesting
3. The Behavior of CO2
   a. The Various Phases of CO2 with Pressure and Temperature
   b. Properties of CO2: Density, Viscosity, Solubility in H2O

   c. Impure CO_2 impacts
4. Capacity Estimates
   a. Pore Volume Access Concepts
   b. Porous Media Flow Instabilities

Gravity instability, Capillary instability, Viscous fingering, Channelling

5. Injection Strategies – Water-saturated Assumptions
   a. Vertical Well and Horizontal Well Options
   b. Down dip or Up-dip injection? Gravity Effects
   c. Pure? Pre-Mixed? Cyclic Water/CO_2 Injection?
6. Reservoir Integrity – Wellbores, Abandoned Wells
   a. Leakage Mechanisms, Corrosion…
7. Monitoring and Optimization
   a. PVT & Q monitoring
   b. Deformation Monitoring – InSAR, Tilt, Others
   c. Microseismic Monitoring

Participants' Profile

This course is designed for students and professionals in the geological and engineering fields who are interested in learning about the fundamentals of carbon capture and storage and modern energy challenges.

Prerequisites

Participants should have prior knowledge of basic principles of geology and/or engineering.

About the Instructor

Grant Wach began his career advising worldwide for multinational companies. He still works with the energy sector but now as Professor of Geoscience at Dalhousie University he serves as a mentor, helping students become successful geoscientists. Wach's research goal is to understand the reservoir component of CCUS and Geothermal systems; understanding the internal complexity of the reservoir is not easy but part of the path to Energy Sustainability, and Carbon Neutrality. These steps are part of the Energy Transition the World is now undergoing.

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ENERGY TRANSITION

Rock Physics, Geomechanics and Hazard of Fluid-Induced Seismicity

EARTHQUAKE | ELASTICITY | GEOTHERMAL | INDUCED SEISMICITY | MECHANICS | MONITORING | PORE PRESSURE | SEDIMENT

Instructor:	Prof. Serge Shapiro (Freie Universitaet Berlin, Germany)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 to 4 live sessions of 4 hours	CPD Points: 4 to 8
	Classroom: 1 to 2 days	CPD Points: 5 to 10

NEW

Course Description

Part 1 (20% of the course) includes: Rock physical and poroelastic fundamentals of fluid-induced seismicity (including microseosmicity): Elastic waves, Elastic Anisotropy, Poroelastic waves, Slow wave and diffusion, Fluid flow in rocks, Seismic attenuation, Reservoir properties: permeability, porosity, fluid viscosity, fluid elasticity, rock elasticity.
Part 2 (20% of the course) includes: Geomechanics and physics of faulting and earthquakes and principles of the microsiesmic monitoring method: faulting types, faulting criteria, tectonic stresses, rock criticality, detection, location, earthquake mechanisims, moment tensors and magnitudes of earthquakes, microseismic common receiver gathers, microseismic reflection imaging.
Part 3 (40% of the course) includes: Various types of induced seismicity: production-induced earthquakes, injection induced earthquakes, geothermal systems, hydraulic fracturing, waste water injection and carbon sequestration; interpretation of microseismic data for reservoir stimulation and hydraulic fracturing: types of induced seismicity, pressure diffusion, rt-plots, triggering fronts, back fronts, hydraulic diffusivity, event density, event rate, hydraulic anisotropy, hydraulic non-linearity, hydraulic fracturing, fracture propagation, volume balance, fluid loss, stimulated volume, correlations with hydrocarbon production, data quality control, estimation of hydraulic properties of rocks, fracture efficiency, enhanced permeability, permeability of fracture, permeability of rocks.
Part 4 (20% of the course) includes: Fundamentals of assessment of induced-seismicity hazard (injection, post-injection and disposal operations): Seismicty statistics, Gutenberg-Richter law, Interevent times, Seismogenic index, Rupture propagation, Bounds of magnitude frequencies, Maximum expected magnitude, triggered and induced earthquakes, factors controlling hazard and requirements for microseismic monitoring; Hazard of various types of induced seismicity: hydraulic fracturing, geothermal systems, waste water injection and carbon sequestration, hydrocarbon production, water reservoirs.

Course Objectives

- Rock physics and geomechanics of induced seismicity:
  Poroelastic phenomena and seismic waves
  Stress, pore pressure and rock failure
  Geomechanics of tectonic and induced earthquakes

- The method of microseismic monitoring:
  Observation systems, detection and location of (micro)earthquakes
  Microseismic wavefields and imaging

- Seismicity, pressure diffusion and hydraulic fracturing:
  Various types of induced seismicity
  Modeling of fluid-induced seismicity
  Seismicity during a fluid injection
  Seismicity after a termination of a fluid injection
  Hydraulic properties of reservoirs and induced seismicity
  Hydraulic fracturing of hydrocarbon reservoirs
  Seismicity induced by hydraulic fracturing
  Non-linear diffusion and seismicity in unconventional reservoirs

- Hazard of induced seismicity:
  Rates and magnitudes of fluid-induced earthquakes
  Seismogenic index
  Statistics of large magnitudes
  Hazard of various types of induced seismicity

Participants' Profile

The course is targeted to Geophysicists, Geologists, Petrophysicits, Reservoir Engineers, Graduate and Postgraduate Students, Researchers, Interpreters.

Prerequisites

Graduated (bachelor level) in geology, or geophysics, or physics, or mathematics, or petroleum engineering, or geosciences.
Recommended Reading
S.A. Shapiro, 2015, Fluid-Induced Seismicity, Cambridge (U.K.): Cambridge University Press, pp 289., ISBN: 9780521884570

About the Instructor

Serge A. Shapiro has been Professor of Geophysics at the Freie Universität Berlin, Germany since 1999, and since 2004, Director of the PHASE (PHysics and Application of Seismic Emission) university consortium project. From 2001 till 2008 he was one of Coordinator of the German Continental Deep Drilling Program (KTB). He was one of PIs of the 3rd KTB long-term fluid-induced seismicity experiment. His research interests include seismogenic processes, wave phenomena, exploration seismology, and rock physics. He received the SEG Virgil Kauffman Gold Medal in 2013 for his pioneering research on fluid-induced seismicity and rock physics, and in 2004 was elected a Fellow of The Institute of Physics (UK).

Engineering

PETROLEUM ENGINEERING •
RESERVOIR MANAGEMENT •
EOR/IOR •

Basic Well Test Analysis

BASIN ANALYSIS | CASE STUDY | CLAY | CORE | CORRELATION | CROSS-PLOTTING | DECISION MAKING | DECONVOLUTION | FRACTURES | HORIZONTAL WELLS | HYDRATES | INJECTION | PERMEABILITY | PRODUCTION | WORKFLOWS

Instructor:	Saad Ibrahim (Petro Management Group Ltd., Canada)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

Well testing of oil, gas, and water wells is the technology that has been effectively used since the start of the oil business over century ago. Well test analysis/interpretation is considered one of the most effective reservoir management tool to help in maximizing well prodivity, enhance the expected ultimate recovery of hydrocarbons, and also in devicing the fileds development plans. This courses offers the foundation of this techniques which covers the theory in a concise fashion and the emphases is on the practical applications using numerious actual well tests data and the application of the analysis results (using commercial software) for field development.

Course Objectives

1. Provide good understanding of what goes on inside the black box (software) before starting well testing.
2. Provide appreciation of well test design before commencing with testing to ensure conclusive results are ontained.
3. Offering step-by-step on how to analyze various types of well testing with emphasis on understanding data quality
4. Well test analysis is a mix of science and art which is foundation of well test interpretation

Course Outline

- Review of the flow equations: Equation of state, Darcy and continuity equation; Common flow geometry
- Dimensionless parameters: definitions and Type Curve use/applications
- Boundary conditions: infinite, Pseudo- steady state and steady state
- Solution of the diffusivity equation: (class problem)
- Build-up test analysis: Principle of Superposition, Horner Plot; average reservoir pressure (MBH) method (class problem); Reservoir boundaries and channel analysis
- Wellbore skin factor and partial penetration (class problem)
- Wellbore storage: use of type curves and (class problem)
- Draw-down testing: Application and test analysis and equivalent time; Reservoir Limit Testing (case study - fractured basement)
- Hydraulically fractured wells
- Fracture characterization (frac. Half-length, conductivity and orientation)

Participants' Profile

Engineers and geologists who are or will get involved in well testing and its applications for field development. All levels are welcome

Prerequisites

Some background in reservoir and production engineering will be helpful.

About the Instructor

Saad Ibrahim, P.Eng., an independent consultant and president of Petro Management Group Ltd., established in Calgary (1994). Graduated from the University of Alexandria (Egypt) with B.Sc. in Mechanical Engineering in 1973. He also completed a post-graduate program with the University of Calgary, Canada, in Chemical and petroleum engineering in 1983.

He has over 35 years of reservoir/production engineering experience in Western Canada (with Amoco, BP and Husky) and internationally in Yemen (with Nexen Petroleum International Ltd.), Algeria, Libya, Tanzania, Iraq, Egypt, Turkey, Venezuela, Argentina, Ecuador, Peru, Kazakhstan and Uzbekistan. The focus of his experience lies in the area of reservoir management and well-test planning/analysis.

Saad Ibrahim has lectured regularly for the Society of Petroleum Engineers (SPE), in Calgary, Moscow and Muscat (Oman). He also offered numerous public and in-house training course worldwide and published recently a technical paper titled "Performance Evaluation of Multi-stage Frac of Horizontal Wells MFHW's", for the Oil and Gas Expo & Conference in Calgary. He was further on the Reserve Panel of the 4th International Conference in Calgary on Horizontal Well Technology. He is a member with the APEGA and SPE.

Introduction to Heavy Oil: Genesis, Properties, Distribution, Recovery Technologies and Upgrading

GEOMECHANICS | HEAVY OIL | OFFSHORE | VISCOUS OIL

Instructor:	Dr Ali Shafiei (Nazarbayev University, Kazakhstan)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

The course explores heavy oil, extra heavy oil, and bitumen, also known as viscous oil (VO), resource development including its genesis, physical and chemical properties, resources, reserves, geographical distribution, production, transport, upgrading, refining, future technology developments, and environmental impacts. There are over 9 trillion barrels of heavy oil, extra heavy oil, and bitumen oil known to exist in the world. By comparison, originally there were about 4.7 trillion barrels of conventional oil of which almost 1.2 trillion barrels have been processed to date. Canada and Venezuela alone possess over 30% of the world endowment. Since 1990 the VO in situ production industry has seen a number of startling advances. New production technologies, combined with developments in waste management, upgrading, monitoring and transportation have changed expectations. Now, it is a widely held view that 15-20% of the world's VO resource base can be profitably produced with current technology; this ratio will rise as further technological advances are implemented. By 2030, VO's contribution to the daily oil production will be about 17%. These figures show the importance of VO developments in the near future to fulfill a major part of the growing global demand for fossil fuels.

A summary of the main topics along with a brief description of the viscous oil resource, its size, production technology advances during the last few decades and environmental issues related to development of this vast resource. The terminology used herein, including terms alluding to VO physical properties (e.g. tar sands, heavy oil, extra-heavy oil, bitumen) and terms used to classify VO into categories such as known or assumed resources (OOIP), technical reserves, and proven, probable or possible reserves are defined. Chemical composition and physical properties play crucial roles in production technology selection as well as upgrading and refining technology selection. Chemical and physical properties of some VO's are presented and the differences are discussed. Some of the proposed mechanisms for VO emplacement, followed by the genesis, physical and chemical properties and reservoir characteristics of the some major VO fields in several countries are outlined. The nature and development of different in situ production technologies including scientific and engineering challenges such as understanding geomechanics impacts on production or finding other heat sources for steam generation are addressed. Upgrading, refining techniques and transportation used in the VO industry is also highlighted. The environmental sustainability of VO development is also discussed.

Course Objectives

Upon successful completion of the course the attendants will be able to:

- Describe genesis, physical, and chemical characteristics, and geographical distribution of heavy oil resources around the world;
- Explain the major commercialized and emerging heavy oil recovery technologies;
- Recall some examples of heavy oil recovery operations;
- Describe major heavy oil upgrading technologies.

Course Outline

This course deals with:

- Genesis, physical, and chemical characteristics;
- Geographical distribution of heavy oil resources around the world;
- Major heavy oil recovery technologies and recovery mechanisms;
- Geomechanics effects;
- Examples of heavy oil recovery operations;
- Heavy oil upgrading technologies;
- Environmental issues;
- Technological challenges.

The course has foundation level, but is comprehensive. A more detailed outline can be provided on request (depending on level and duration of the course and also background of the course participants). The course can be delivered in 1-2 days or in 4-7 days with more details including problem solving sessions.

Participants' Profile

The course is intended for engineers, geoscientists, and technologists active in E&P industry involved in exploration, production, transportation, upgrading and environmental management.

Prerequisites

Knowledge of the oil industry and a good sense of physics and chemistry will be valuable.

About the Instructor

Dr Ali Shafiei is currently an Assistant Professor of Petroleum Engineering in Nazarbayev University, Astana, Kazakhstan. He obtained his PhD (March 2013) in "Thermal Heavy Oil Recovery and Petroleum Reservoir Geomechanics" from the University of Waterloo in Canada with a dissertation on: "Mathematical and Statistical Investigation of Steamflooding in Naturally Fractured Carbonate Heavy Oil Reservoirs". The focus of his PhD research project was on developing mathematical and statistical tools to predict performance of steamflooding in naturally fractured heavy oil reservoirs as one of the very challenging classes of reservoirs in terms of reservoir behavior considering the complex production mechanisms involved and the interaction between the rock matrix and the fracture network. Shafiei is a specialist in reservoir characterization and formation evaluation, heavy oil recovery from complex reservoir systems, EOR, and petroleum geomechanics. Shafiei has over a decade of Canadian and international research, graduate supervision, teaching, training, and consulting/industry experience in the E&P industry. He was a scientific adviser to the Alberta Department of Energy (Alberta, Canada) in 2014 served as a member of the Innovative Energy Technology Program (IETP 2014) to review progress reports on various full field scale trials that the Alberta DoE was involved with various oil and gas companies in Canada on heavy oil recovery and geological CO_2 sequestration. He is also a long time active member of the EAGE, SPE, and AAPG. As of today, Shafiei's professional and academic experience has resulted in over 40 refereed journal papers, vetted conference proceedings, chapters in books and monographs in petroleum geosciences and engineering and reservoir geomechanics.

Petroleum Engineering for Non-engineers

2D, 3D AND 4D | CASE STUDY | DECISION MAKING | DRILLING | ECONOMICS | FAULTS | FLOODING | FLUID | GEOPHONES | HORIZONTAL WELLS | INJECTION | LITHOLOGY | MARINE SEISMIC | MONITORING | MWD | OFFSHORE | OIL AND GAS | RESERVOIR CHARACTERIZATION | RESERVOIR ENGINEERING | RESERVOIR MODELING | SANDSTONE | SHALE | TIME-LAPSE

Instructor:	Mr Saad Ibrahim (Petro Management Group Ltd., Canada)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

This course is designed to provide non-engineering petroleum industry technical professionals with a thorough overview of most key aspects of petroleum engineering technology and its applications for upstream, midstream, and downstream stages. surprisingly, nearly 70% of the staff of the oil companies are non-engineers (support staff) that have limited knowledge of what goes on the operation of exploration, development, and production. The course will allow the support staff to understand the tasks performed by the engineers and how to improve cooperation and efficiency of the operation.

The course addresses engineering issues ranging from initial involvement with explorationists, discovery evaluation and field development, production optimization, and all the aspects of well drilling. The use of seismic survey in the exploration stage will be explained how to locate oil and gas prospects and estimate expected reserves. The step-by-step process of drilling a well is discussed for onshore and offshore operations. The sessions will focus on relevant and practical issues; including real case studies and presenting video clips to illustrate the process of decision making and the risks involved in each operational step. The impact of drilling for oil and gas and hydraulic fracturing on the environment and to mitigate risks will be discussed, which has been a concern in many parts of the world. A group discussion on this subject is usually of great interest to the attendees. During the production history of oil and gas fields, operational problems are frequently expected. It is the responsibility of the engineers to use proper diagnostic tools to define the cause of the problems and to device the remedial actions. The application of horizontal wells including Multi-stage Fracturing and the latest industry techniques of applications will be illustrated. Another tool to maximize production is the use of artificial lift (down-hole pumps). A review of the different methods of artificial methods and applications will be discussed. Also, the techniques of Enhanced Oil Recovery (EOR) will discussed, including the screening of various EOR schemes and how it will be executed. The cost and benefits for EOR applications will be discussed. Well and field decommissioning, when operation is no longer profitable and described for onshore and offshore. It is critical that no negative impact on the environment as a result of decommissioning. Finally, the process of economic evaluation is discussed including related risks (technical, economical, and political) and uncertainty for various projects.

Course Objectives

Upon successful completion of the course the attendants will have learned:

- About an overview of the industry and how the roles of different professional disciplines are integrated to generate development plans
- How a well is drilled and completed to have save operation and well control
- About production problems; diagnoses and remedy
- About economic evaluation to justify field development

Course Outline

Day 1:

- Overview; role of petroleum engineers and the main components of field development
- Reservoir Geology
  - Types of reservoir rocks
  - Main elements of petroleum reservoirs
- The Drilling Rig; equipment and operation (onshore and offshore) Video clip
- Well completion techniques including Hz wells
- Formation evaluation techniques
  - Mud logging, coring, and open hole logging
  - Rock and fluid properties

Day 2:

- Porosity and permeability definitions & measurements and fluid sampling
- Oil and gas reserves determination
  - Volumetric and material balance methods
  - Decline analysis and empirical methods
- Reservoir delineation & development
  - Field development considerations (case study)
  - Types and applications of artificial lift
  - Horizontal well applications
- Production operations and optimization
  - Well performance and well testing (video clips)
  - Operational problems; diagnoses and remedy
- Enhanced Recovery Mechanism
  - Types of EOR schemes (video clips)
  - Planning and designing of waterflood projects
- Unconventional Oil and Gas

- Tight formations and the application of Multi-stage Frac of Hz Wells (MFHW's) – video clips

- Decommissioning and Related Environmental Matters
- How wells are abandoned; on-offer and off-shore
- Case studies/video clips

- Economic evaluation
- Input data for economic analysis; risks and uncertainty

Participants' Profile

This course is aimed at non-engineering professionals and most support staff involved in the oil industry and also for junior exploitation engineers/technologists, and geologists.

Prerequisites

No prerequisites are required.

About the Instructor

Mr. Saad Ibrahim, P.Eng., an independent consultant and president of Petro Management Group Ltd., established in Calgary (1994). Graduated from the University of Alexandria (Egypt) with B.Sc. in Mechanical Engineering in 1973. He also completed a post-graduate program with the University of Calgary, Canada, in Chemical and petroleum engineering in 1983.

Mr. Ibrahim has over 35 years of reservoir/production engineering experience in Western Canada (with Amoco, BP and Husky) and internationally in Yemen (with Nexen Petroleum International Ltd.), Algeria, Libya, Tanzania, Iraq, Egypt, Turkey, Venezuela, Argentina, Ecuador, Peru, Kazakhstan and Uzbekistan. The focus of Mr. Ibrahim's experience lies in the area of reservoir management and well-test planning/analysis.

Mr. Ibrahim has lectured regularly for the Society of Petroleum Engineers (SPE), in Calgary, Moscow and Muscat (Oman). Also Mr. Ibrahim has offered numerous public and in-house training course worldwide. Mr. Ibrahim published recently a technical paper titled "Performance Evaluation of Multi-stage Frac of Horizontal Wells MFHW's", for the Oil and Gas Expo & Conference in Calgary – June 2011. Mr. Ibrahim was on the Reserve Panel of the 4th International Conference in Calgary on Horizontal Well Technology. Mr. Ibrahim is a member with the APEGA and SPE.

Uncertainty in Reservoir Management

ALGORITHM | PRODUCTION | RESERVOIR | RESERVOIR MODELING | SAND | UNCERTAINTY

Instructor:	Prof. Peter King (Imperial College London, United Kingdom)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

The course will provide an introduction into many of the concepts behind uncertainty in reservoir modelling. It will start with a description of the origins of uncertainty with a mixture of heuristic treatments and more formal mathematical approaches. It will then develop the appropriate mathematical ideas and tools for estimating uncertainty in practical reservoir modelling. Finally, some ideas for how uncertainty can be managed will be explored.

Course Objectives

The aim of this course is to provide some of the basic statistical tools for quantifying uncertainty and some simple strategies for dealing with it.

Course Outline

The course will be given by formal lectures and some simple exercises.

Participants' Profile

The course is primarily addressed to reservoir engineers involved in building reservoir models but could also be of interest to production engineers who have to deal with the consequences of uncertainty in reservoir performance.

About the Instructor

After completing a PhD in theoretical statistical physics from Cambridge University in 1982 Professor Peter King spent 17 years with BP at their technology centre in Sunbury-on-Thames where he worked on a wide variety of subjects applying methods of mathematical physics to reservoir characterisation and modelling. In particular he developed a real space renormalisation approach to both single and two phase upscaling. In collaboration with the members of the Department of Physics at Boston University he has used percolation theory to estimate connectivity of sands as well as uncertainties in production from low to intermediate net-to-gross systems. He had also developed network models of pore scale flow and viscous fingering, object based methods for characterising reservoir heterogeneities. Again in conjunction with Boston University he worked on segregation in avalanches in granular materials as an explanation for the formation of crossbeds in Aeolian systems. Recently he has worked on applying stochastic search algorithms (simulated annealing and genetic algorithms) to optimising business decisions with particular interest to decision making in the presence of uncertainty. He joined the Department of Earth Science & Engineering at Imperial College in 2000. Professor King is a Fellow of both the Institute of Physics and the Institute of Mathematics and its Applications (having served on its Governing Council from 1991-1994).

Reservoir Management for Unconventional Oil and Gas Resources

ANISOTROPY | FRACTURES | GEOCHEMISTRY | RESERVOIR MODELING | SHALE | UNCONVENTIONAL

Instructor:	Prof. I. Yucel Akkutlu (Texas A&M University United States)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

The field of reservoir characterization and engineering has been evolving quite fast during the last 10 years. This has been due to increasing interest in the unconventional resources in North America. New tools and analysis techniques have been developed. This course introduces unconventional oil and gas resources as a reservoir to the practicing engineers. The emphasis is on the tight gas/oil formations and organic-rich source rocks, in particular shale.

The course provides in-depth discussions on fluids storage, phase change, and transport for reservoir evaluation and development. New discussions related to nano-confined fluids will be included, new reservoir storage mechanisms as sorbed gas and capillary-condensed fluids will be introduced. Hydrocarbon in-place calculations are presented, including new-pore-scale considerations. A new method is introduced to assess the liquid potential of the source rocks.

Laboratory techniques are discussed for the characterization of unconventional formations. The course will help engineers understand transient flow regimes associated with horizontal wells completed with hydraulic fractures, and analyze the production data using various analytical and simulation methods.

A new production history-matching and optimization method will be introduced using a real shale gas well production data. Field case studies will be introduced to discuss the field development including economic and environmental evaluation of horizontal wells with multi-stage fracturing.

Environmental considerations during the development of an unconventional field will be discussed including issues related to groundwater protection. The need for the utilization of large volumes of water for drilling and hydraulic fracturing will be discussed. Waste water disposal operations in USA and the induced seismicity will be discussed.

The course helps students understand the unconventional reservoir physics and improve their business performance by developing more accurate reservoir models.

Course Objectives

The aim of this course is to:

1. Assess, characterize and classify unconventional resources;
2. Predict the petro-physical and geochemical quantities relevant to unconventional resources assessment;
3. Predict hydrocarbon in-place including gas, wet-gas, condensate and oil windows;
4. Evaluate the relative accuracies of unconventional reserve estimates;
5. Perform rate-transient and pressure transient analysis for horizontal wells with hydraulic fractures and predict effective fracture dimensions contributing to production;
6. Formulate a field development plan for an unconventional resources.

Course Outline

Introduction

- Unconventional oil and gas resources: Tight gas/oil and source rock (CBM, organic-rich shale) characteristics;
- Unconventional resources in North America, their oil/gas production trends and reserves;
- What is shale, and what makes shale a hydrocarbon resource?;
- Resource-reservoir duality and the concept of reservoir creation.

Fundamentals

- Source rock burial, diagenesis, catagenesis;
- Multi-scale pore structure development in source rocks;
- Effective porosity in unconventional resources;
- Multi-scale oil/gas storage mechanisms in shale;
- Occurrences of hydrocarbons in organic and inorganic pore networks in source rocks;
- Phase change and capillarity in organic nanopores;
- Volumetric calculations for shale: gas, wet-gas, condensate and oil;
- Material balance calculations for source rocks;
- Flow and other mass transport mechanisms for shale gas and oil reservoirs;
- Stress-dependent shale permeability and its modeling;
- Flow calculations for shale using Wasaki's permeability model for organic-rich shale;
- Multi-phase flow considerations in source rocks.

Reservoir Evaluation and Characterization for Unconventional Resources

- Routine core analysis;
- Special core analysis;
- Organic matter classification: bitumen vs. kerogen;
- Kerogen type and maturity;
- Hydrocarbons recovery potential from kerogen;
- Integration of core-data and log-data
  - TOC estimation
  - Free and sorbed-phase fraction analysis;
- Examples on shale core measurement data and analysis;
- Exercise on predicting shale gas and shale oil permeability;

Pre-frac Injection Test

- Pressure fall-off (or DFIT) Test Analysis and Interpretation;
  - Typical pressure transient and its signatures;
  - Breakdown pressure, instantaneous shut-in pressure, fracture closure pressure;
  - Analysis of the pressure fall-off data for flow capacity, leak-off type and presence of fractures;
- Example calculation of the breakdown pressure;
- Example calculation of the overburden stress using Eaton's equation.

Geomechanics

- Fracture evolution in ductile and brittle formations;
- Griffith's theory of brittle rock failure;
- Laboratory measurements;
- Stress-strain diagrams;
- Popular geo-mechanical concepts for stimulation decisions;
- Example decision making on vertical locations for perforations in cased-cemented hole;
- Exercise calculation of the four elastic moduli using uniaxial test data.

Transient Flow Regimes and Production Analysis

- Reservoir flow regimes and flow patterns;
- Pressure evolution during transient flow;
- Production rate transient signatures in flow patterns:
  - Vertical wells with hydraulic fracture
  - Horizontal wells with and without hydraulic fracture
  - Horizontal well with multiple hydraulic fractures;
- Production rate transient analysis (RTA) methods

Type-curves

- Straight line methods, A√k method
- Flow simulation requirements for the unconventional reservoirs
- Empirical methods, e.g., Arps, Duong, stretched exponential decline;

- Total fracture surface area calculation using RTA with dynamic matrix permeability;
- Workflow for engineering analysis of horizontal wells with hydraulic fractures;
- Example type-curve analysis.

Unconventional Field Case Studies

- Single-well fracture interference study using Barnett data;
- Single well fracture surface area calculations using RTA;
- History-matching Marcellus shale gas well
  - Impact of the number of transverse fractures on future recovery;
- History-matching Eagle Ford shale gas well;
- History-matching Bakken shale oil well;
- A shale gas well completion optimization
  - Procedure of calculating hydraulic fracture economics: NPV, IRR, DROI
  - Number of fracture stages/clusters
  - Transverse fracture spacing
  - Fracture propped-length;
- A tight gas field case study in Canada.

Participants' Profile

The course is designed for reservoir engineers and earth scientists who would like to learn the unconventional reservoir engineering concepts, terminology and analysis tools.
Participants should have a geology, geophysics, or petroleum engineering background.

About the Instructor

Yucel Akkutlu is Rob L. Adams '40 Professor in Petroleum Engineering and William Keeler faculty fellow at Texas A&M University in USA. He is a chemical engineer and received Ph.D. in petroleum engineering from the University of Southern California. He teaches undergraduate and graduate courses in reservoir engineering and petrophysics, and has chaired more than 40 graduate-level committees. His research focuses on characterization and exploitation of unconventional oil and gas resources and on oilfield chemistry with application on IOR/EOR. He has written more than 100 peer-reviewed journal articles and conference proceedings, six book chapters, and has three patents. He is the author of "Nano-confined Petroleum Recovery from Source Rocks," which will be published in 2020. He has received over $3 million in external research funding from sources such as the Department of Energy and unconventional oil and gas industry. He is a distinguished member of the Society of Petroleum Engineers (SPE). He was executive editor of the SPE Journal 2013-2016. He was 2014-15 SPE distinguished lecturer. He has received 2017 TAMU-Association of Former Students teaching award, 2016 TAMU-Association of Former Students distinguished achievement award, and 2015 AIME Rossiter W. Raymond memorial award. Akkutlu served in various SPE, EAGE, and NSERC (Canada) committees.

Fundamentals of Petroleum Reserves under PRMS 2018

ANALOGY | DECISION MAKING | DECLINE CURVE ANALYSIS | EUR | MATERIAL BALANCE | RESERVES | RESOURCES

Instructor:	Victor Alexei Huerta Quiñones (Universidad Nacional de Ingeniería, Peru)	
Language:	English, Spanish	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

This course allows an in-depth look at the framework, classifications, categorization and applications of Petroleum Resources Management System (PRMS). Participants will gain a solid understanding of this valuable resources management tool, including insight into the latest updated version (PRMS 2018), as well as, the use of some indicators to reserves management.

In addition, this course will provide training in production forecasting and reserves estimation for conventional and unconventional reservoirs, by diverse methods such as field and reservoir analogy, volumetric estimations, material balance equation and rapidly applied decline models favored by the industry for routine forecasting.

Recommended methodology will be based on the resolution and discussion of some case studies to illustrate and clarify definitions.

Course Objectives

The aim of this course is to:

1. Enhance background, criteria and technical skills of participants to classify, categorize and estimate reserves and resources in oil and gas assets;
2. Make a brief and concise review and keep up with the latest definitions and regulations of reserves and resources definitions;
3. Provide some guidelines and "rules of thumb" for a quick assessment of an oil and gas assets;
4. Show that PRMS is a powerful management tool that is widely used in the industry.

Course Outline

Part I: PRMS Project Framework

- PRMS project background
- Major principles and key guidelines in PRMS
- How PRMS captures risk and uncertainty
- Assessing and reporting unconventional resources

Part II: Classification and Categorization of Reserves and Resources

- 2018 Petroleum Resources Management System (PRMS)
- Comparison of SEC and PRMS guidelines
- Definitions of Prospective and Contingent Resources
- Reserves Categories: Proved, Probable y Possible
- Incremental vs. cumulative approach
- Indicators of Reserves Management

PART III: Overview of Reserves and Resources Estimates in Conventional and Unconventional Reservoirs

- Well / Field Analogy Applications
- Volumetric Estimations
- Material Balance Applications
- Forecasting performance with traditional decline-curve analysis (DCA) and allied tools (Numerical Reservoir Simulation) and understand their relative strengths
- Empirical and semi-theoretical decline models including Arps, Fetkovich's, Stretched Exponential, Power-Law, Transient Linear Flow, and Duong.

Part IV: Production Forecasts and Reserves Estimates in Unconventional Reservoirs

- Traditional vs Modern Decline Curve Analysis
- Empirical and semi-theoretical decline models including Arps, Fetkovich's, Stretched Exponential, Power-Law, Transient Linear Flow, and Duong
- Diagnostic plots for flow regime identification, pressure normalization of rate data, recommended workflow for pressure-rate-time production data analysis
- Developing Probabilistic Production Type Well curves
- Applications for tight oil and gas reservoirs

Part V: Oil and Gas Assets Value and Decision Analysis

- Traditional Deterministic Cash Flow Analysis: NPV, IRR, Pay Out, PIR
- Decision trees concepts and calculation of expected monetary value (EMV)
- Monte Carlo simulation in estimating profitability indicators: Expected NPV and Financial Risk estimation

Participants' Profile

This course is intended for technical staff, including managers, who are or will be responsible for reserve/resource estimation, or who will be responsible for the reporting of reserves and other resources to senior levels within the company or externally. Technical disciplines may include:

- Reservoir Engineers
- Geoscientists
- Production Engineers

Prerequisites

Participants should have a prior knowledge of basic concept of reservoir engineering, reservoir characterization and reservoir management.

Recommended reading

1. J. Lee. Notes Course PETE 652: Deterministic Reserves Evaluation.
2. John D. Wright. Oil and Gas Property Evaluation, John D. Wright, Thompson-Wright, LLC, August 2015
3. R. Weijermars. Notes Course PETE 664: Petroleum Project Evaluation and Management.
4. C. Cronquist. Estimation and Classification of Reserves of Crude Oil, Natural Gas and Condensate.
5. J. Lee. Oil and Gas Reserves: The New SEC Reporting Rules
6. J. Etherington & R. Seager. Managing your Business using PRMS and SEC Standards
7. Securities and Exchange Commission: Modernization of Oil and Gas Reporting; Final Rule
8. Oil and Gas Reserves Committee SPE. 2018 Petroleum Resources Management System (PRMS)
9. SPE/WPC/AAPG. Guidelines for the Evaluation of Petroleum Reserves and Resources
10. T. Ahmed. Reservoir Engineering Handbook
11. G. Rojas. Ingeniería de Gas y Gas Condensado
12. C. Smith, G. Tracy & R. Farrar. Applied Reservoir Engineering, Vol. I y II
13. L. Dake. The practice of Reservoir Engineering
14. B. Craft & M. Hawkins. Applied Petroleum Reservoir Engineering
15. M. Economides. Petroleum Production Systems
16. M. Carlson. Practical Reservoir Simulation
17. R. Lee & D. Katz. Natural Gas Engineering: Production and Storage
18. H. Beggs. Gas Production Operations

About the Instructor

Victor Alexei Huerta Quiñones is Technical Manager for Reservoir Management Consulting (RMC), a consulting company specialized in managing oil and gas fields, as well as, their reserves and resources.

Petroleum Engineer, graduated from the National University of Engineering, Lima - Peru, and Master of Science in Energy and The Environment from the University of Calgary, Canada. He has 19 years of experience as reservoir engineer for oil and gas fields.

He worked as Senior Numerical Simulation Engineer and Development Head at SAVIA PERÚ, working for subsurface projects of oil and gas fields, Blocks Z-2B and Z-6. He was also head of the Development and Production Department of PETROPERU in charge of the follow-up of the Development of Situche Central field, Block 64. He also worked for Repsol Peru as technical leader in the Development of Block 57 and for Pluspetrol Norte, in the surveillance of the heavy oil fields of Block 1AB

Part-time Associate Professor of undergraduate and postgraduate Petroleum and Natural Gas engineering school at UNI for the courses "Applied Reservoir Engineering", "Natural Gas Engineering", "Enhanced Oil Recovery" and "Numerical Reservoir Simulation". He was chairman of the Society of Petroleum Engineers (SPE) Lima Section during 2014-2015. He has published more than 20 technical papers in international conferences organized by SPE.

Upscaling and artificial intelligence based proxies for uncertainty assessment of reservoir production

3D ANISOTROPY | CAPILLARY PRESSURE | CARBONATES | CASE STUDY | FACIES | FLOODING | FLUID | FRACTURES | GEOCELLULAR | GEOSTATISTICS | GROUNDWATER | HISTORY-MATCHING | OIL AND GAS | PERMEABILITY | RESERVOIR CHARACTERIZATION | RESERVOIR ENGINEERING | RESERVOIR MODELING | UNCERTAINTY | WORKFLOWS

Instructor:	Prof. Dr Dominique Guérillot (Texas A&M University, Qatar)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

The aim of the course is to recap main techniques required to build an integrated reservoir model and to explain different potential workflows for field development and/or history matching processes. This course will include explanations of upscaling techniques and the use of proxies for uncertainty assessment of production forecasts. All these methods will be illustrated and applied to the Brugge case.

Course Objectives

Upon completion of the course, participants will be able to:

- Understand the fundamentals of Geostatistics and Spatial Modeling
- Calculate a variogram
- Know what are the principal of Kriging
- Know the main methods of Geostatistical Simulations for modeling heterogenous and fractured reservoirs
- Be familiar with the main Upscaling technics used in reservoir simulators
- Know how to use proxy models for assessing Uncertainty in Production Forecasts
- Application to the Brugge field will be given to illustrate the methodology.

Course Outline

Integrated Geological Modeling and Reservoir Simulation
Geostatistics and Spatial Modeling
Variogram
Kriging
History Matching Principles

Geostatistical Simulations
Limitations of Kriging
Geostatistical Simulation
What do we want from a simulation?
Principles of stochastic modeling
Pixel based model
Object based model
Sequential Gaussian Simulation (SGS)
Random Character
Properties of SGS
Scale
Cell Sizes & Ranges
Indicator Formalism
Sequential Indicator Simulation

Upscaling
Why Upscaling is Needed?
Orders of magnitudes for the Geological Model and the Reservoir Simulators
Is it necessary to take into account all heterogeneities ?
Impact on CPU cost
Can we replace heterogeneities by homogeneity?
Is it right to call "equivalent" the upscaled permeabilities?
The upscaling problems considered here
Upscaled Values Depends on Flow
Upscaling of Geo-cellular Models
Upscaling in Integrated Studies
Upscaling of porosity
Upscaling of absolute permeability
Differences between additive and non additive variables
Single phase
Darcy's law
Single Phase Flow around Wells
What happenS in 1 D?
Arithmetic Average
Harmonic Average
Geometric Average
Weighted Arithmetic Average
Weighted Harmonic Average
What happens for a layer cake model?
Upscaling generates anisotropy
How to handle barriers & faults?
How to handle fractures?

Uncertainty Assessment in Production Forecast
Intuitive Workflow
Recommended Workflow
Artificial Neural Network as Proxy
Applications on case studies
Application to Brugge field

Participants' Profile

The course is primarily addressed to reservoir geologists and reservoir engineers involved in building reservoir models but could also be of interest to production engineers who have to deal with the consequences of uncertainty in reservoir performance.

Prerequisites

Darcy's law, basic probability and statistics.

Recommended Reading

- Corvi P., Heffer K., King P., Tyson S., Verly G., Ehlig-Economides C., Le Nir I., Ronen S., Schultz P., Corbett P., Lewis J., Pickup G., Ringrose P., Guérillot D., Montadert L., Ravenne C., Haldorsen H., Hewett T. 1992. Reservoir characterization using expert knowledge, data and statistics. Oilfield Review 4(1):25-31.
- Guérillot, D. and Bruyelle, J. 2014. A fast and accurate upscaling of transmissivities for field scale reservoir simulation. In ECMOR XIV-14th European Conference on the Mathematics of Oil Recovery.
- Bruyelle, J., & Guérillot, D. (2019, October 21). Proxy Model Based on Artificial Intelligence Technique for History Matching - Application to Brugge Field. Society of Petroleum Engineers. doi:10.2118/198635-MS
- Bruyelle, J., & Guérillot, D. (2019, September 17). Optimization of Waterflooding Strategy Using Artificial Neural Networks. Society of Petroleum Engineers. doi:10.2118/196643-MS
- Bruyelle, J., & Guérillot, D. (2019, October 21). Well Placement Optimization with an Artificial Intelligence Method Applied to Brugge Field. Society of Petroleum Engineers. doi:10.2118/198656-MS

About the Instructor

Former member of the Executive Committee of IFP and Program Director for the Upstream R&D of Saudi Aramco, he is focusing in Oil and Gas Exploration and Production including Unconventional, CO_2 EOR and Carbon storage. After a PhD in Applied Mathematics, he joined IFP in 1982 in the Reservoir Engineering Dpt. He started his career in the Exploration and Production sector developing Expert system for selecting EOR methods and Advanced Compositional Reservoir Simulators for EOR (CO_2 and thermal methods).

In 1985, he began cooperating with geologists and he invented with the Paris School of Mines the first software package integrating reservoir characterization and flow simulations in porous media proposing innovative methods for upscaling absolute permeabilities.

After being the Director of the Geology and Geochemistry (95-01, in 2001, he became member of the Executive Committee of IFP and Managing Director of Exploration and Reservoir Engineering Centre with a total budget of 30 Millions of Euros. Consequently, IFP nominated him as board member of several Exploration and Production subsidiaries of IFP: Beicip-Franlab and RSI in France, IFP MEC in Bahrain, etc. He developed new strategic orientations for the business unit he was in charge modifying its business model to generate revenues based on royalties through the development of several strategic marketed software for IFP. In 2009, he created a Young Innovative Company (YIC), Terra 3E, in Energy and Environment: http://www.Terra3E.com developing innovative plug-ins in Petrel software among which the first tool for accurate calculations of fluids in place for gas and oil shales and upscaling transmissivities. From 2010 to 2013, he was senior expert for Petrobras, Brazil. In 2012, he served the European Commission for selecting R&D projects on CO_2 Storage.

In 2013, Qatar Petroleum called Dominique Guérillot for developing their R&D Centre at the Qatar Sciences and Technology park in Doha, Qatar. He is currently full professor at Texas A&M University in their campus of Qatar.

He published more than 50 full and refereed papers, holds 5 patents, is member of the IJOGCT editorial team, the SPE and EAGE associations, is referee of the Oil & Gas Science and Technology (OGST), and member of the editorial board of the Petroleum Geoscience journal of the Geological Society.

Introduction to Waterflood Management

EOR | RESERVOIR CHARACTERIZATION | ROCK WETTABILITY | BUBBLE POINT PRESSURE | RESERVOIR DRIVES | INJECTION REQUIREMENTS | WATERFLOOD STAGES | RCOVERY FACTOR | SWEEP EFFICIENCY | NUMERICAL MODELING

Instructor:	Ibrahim Saad (Petro Management Group Ltd., Canada)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

This course provides a complete review of all aspects of waterflood schemes being the most proven, lowest cost, and applicable to various types of reservoirs to EOR. A group exercise will be offered Class problems which will be offered to the course attendees to emphasize the technical concepts taught.

Course Objectives

Upon completion, participants will be able to:

1. Understand data acquisition required to properly evaluate waterflood potential
2. Evaluate geological and engineering risks to implement waterflood projects
3. Establish the knowledge to present the cost and the benefit of the waterflood project to obtain managerial and regulatory agencies
4. Learn how to estimate the Expected Ultimate Recovery (EUR) of the waterflood project and prepare production forecast

Course Outline

1: Introduction to Waterflooding and E.O.R
2: Reservoir Characterization
3: Reservoir Drives and Reserves Estimate
4: Waterflood planning and Design

Participants' Profile

Engineers and geologists who are or will get involved in designing and monitoring waterflood projects. Technical level from junior and senior staff.

Prerequisites

Some background in reservoir engineering will be helpful.

About the Instructor

Saad Ibrahim, P.Eng., an independent consultant and president of Petro Management Group Ltd., established in Calgary (1994). Graduated from the University of Alexandria (Egypt) with B.Sc. in Mechanical Engineering in 1973. He also completed a post-graduate program with the University of Calgary, Canada, in Chemical and Petroleum Engineering in 1983.

Mr. Ibrahim has over 40 years of reservoir/production engineering experience in Western Canada (with Amoco, BP and Husky) and internationally in Yemen (with Nexen Petroleum International Ltd.), Algeria, Libya, Tanzania, Iraq, Egypt, Turkey, Venezuela, Argentina, Ecuador, Peru, Kazakhstan and Uzbekistan. The focus of Mr. Ibrahim's experience lies in the area of reservoir management and well-test planning/analysis.

Geology

STRUCTURAL GEOLOGY •
CARBONATE GEOLOGY •
STRATIGRAPHY •
GEOLOGICAL MODELLING •

An Overview of Carbonate Diagenesis: The Good, The Bad, and The Ugly of Carbonate Reservoir Quality

CARBONATES CASE STUDY DIAGENESIS INTEGRATION INTERPRETATION LITHOLOGY PERMEABILITY RESERVOIR CHARACTERIZATION SEQUENCE STRATIGRAPHY THIN SECTION

Instructor:	Dr Dave L. Cantrell (Cantrell GeoLogic and Stanford University, United States)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

Diagenesis includes all chemical, physical and biological changes, modifications or transformations undergone by a sediment after its deposition and during and after its lithification (AGI Glossary of Geology), exclusive of metamorphism. Carbonate rocks and sediments are especially susceptible to post-depositional modifications because of the high chemical reactivity of carbonate minerals; these carbonate minerals react quickly with natural waters in order to bring the water into equilibrium with the host carbonate sediments and rocks (Moore 1989). These rock-water interactions can have a dramatic effect on the original (depositional) reservoir quality framework of a sediment, and can either create, modify, or completely destroy reservoir quality. Given that these alterations can occur at any time during the history of the sediment, understanding and predicting carbonate diagenesis and its impact on reservoir quality can be a very challenging - and at times frustrating! - process.

While the full gamut of carbonate diagenetic processes is extensive, a simplified list of the most commonly encountered processes includes: cementation, dissolution, dolomitization, compaction (including pressure solution and stylolitization), fracturing, and the in situ growth of other minerals in the sediment. These processes can be considered within a context of diagenetic environments, including the marine environment, the mixing zone, the meteoric environment, and the burial environment. A consideration of the typical conditions, processes and products for each of these diagenetic environments provides a method for both understanding and predicting carbonate diagenesis.

The relationship between reservoir quality and diagenesis is complex and variable, and at times the various diagenetic processes work in complementary and overlapping ways. For example, movement of undersaturated water through a sediment may partially dissolve the sediment to create or enhance porosity; as dissolution continues, however, waters may become saturated to the point where they cement porosity in adjacent sediments, to produce a tightly cemented carbonate rock with abundant moldic porosity but little permeability. Likewise dolomitization may occlude, redistribute, create or enhance porosity, based on a number of different factors.

This workshop provides an in-depth overview of the nature and extent of common diagenetic alterations in carbonates and their impact on reservoir quality; it then uses a series of case studies to illustrate how the principles described in this workshop can be applied to understand and predict reservoir quality in several outcrop and subsurface examples.

Course Objectives

Upon completion of the course, participants will be able to:

- identify common diagenetic products in carbonate rocks and sediments
- understand the processes that gave rise to these products
- predict the likely location and effect of diagenesis in the subsurface
- appreciate the role that diagenesis plays in producing final reservoir quality

Course Outline

Introduction

Diagenesis in Carbonate Rocks and Sediments – what is it, and why should you care?

Aspects of Diagenesis: Recognition of Processes and Products

- Cementation
- Dissolution
- Dolomitization
- Compaction and Pressure Solution
- Fracturing and Others

Organizing Principles

Diagenesis in Time and Space - the Importance of Diagenetic Environments

Implications for Reservoir Quality

Case History #1: Dolomitization in Middle Eastern Carbonate Rocks

Case History #2: Introduction to Karst Systems and Reservoirs

Case History #3: An Introduction to Microporosity in Middle Eastern Carbonate Rocks

Conclusions

Participants' Profile

The course is designed for geoscientists and engineers looking to enhance their understanding of and ability to predict carbonate diagenesis.

Prerequisites

Some knowledge of carbonates and the main challenges of reservoir quality prediction and modeling in carbonates would be helpful.

Recommended Reading

Longman, M. W., 1980, Carbonate diagenetic textures from near-surface diagenetic environments: Amer. Assoc. Petroleum Geologists Bull., v. 64, p. 461-487.

Tucker, M. E. and Wright, V. P., 1990, Carbonate sedimentology: Blackwell Scientific, Oxford, 482pp.

About the Instructor

Dave L. Cantrell has over 35 years of worldwide geologic industrial and academic experience. He graduated from the University of Tennessee with an MSc in Geology in 1982, and from the University of Manchester with a PhD in Geology in 2004. Dave began his industry career in 1982 with Exxon where he conducted numerous reservoir characterization and geological modeling studies on reservoirs in the Middle East; the Permian, Powder River, Williston, and Gulf of Mexico Basins of the USA; and the Maracaibo and Barinas Basins of Venezuela; among others. After moving to Saudi Arabia in 1997, he conducted studies on several large carbonate fields there, and lead geologic R&D for Saudi Aramco from 2000-2008; he also served as a professor and Associate Director for the College of Petroleum Engineering & Geosciences at King Fahd Petroleum & Minerals (KFUPM) from 2015-2017. He is an AAPG Certified Petroleum Geologist, a Fellow of the Geological Society of London, and an adjunct professor at Stanford University; he has published over 40 articles in peer-reviewed journals, and holds one patent.

Sedimentological Characterization of Carbonate Rocks

CARBONATES | RESERVOIR CHARACTERIZATION | SEDIMENTOLOGY | STRATIGRAPHY

Instructor:	Laura Galluccio, Catherine Breislin (Badley Ashton, United Kingdom)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

More than 60% of the world's oil and 40% of the world's gas reserves are held within carbonate rocks. An understanding of these will ultimately help improve sedimentological facies and reservoir quality prediction while reducing uncertainties with respect to reserve estimates and potential oil/gas recovery. The first part of this course provides an understanding of the fundamentals of carbonate sedimentology, together with the skills required to characterize and interpret carbonate rocks, in order to establish an understanding of their depositional environment and implications for reservoir geometry and extents. In detail, the course offers an insight into the environmental, biological, physical, chemical and climatic controls on the carbonate factory, enabling facies analysis. In addition, sequence stratigraphical methods and their application will be covered in the second part of the course to provide all the tools needed to reconstruct the sedimentological architecture at the field scale. These factors help reduce uncertainties associated with the prediction of geometries and lateral heterogeneity within carbonate reservoirs.

Part A: in order to appreciate the evolution and development of carbonate sediments, a basic understanding of the chemical, biological and physical processes involved in their formation is essential. The first part of this course outlines the controls on carbonate production (the carbonate factory), and the impact of carbonate producers on carbonate accumulation and hence implications for carbonate body geometries. It considers the key textural (Dunham classification), mineralogical, compositional and fabric/sedimentary structure observations necessary to help evaluate and interpret carbonate rocks. Carbonate deposition is controlled by a wide range of internal and external factors, including the light, temperature, energy levels, salinity and nutrient availability. Understanding these factors provides a better perspective on the nature and distribution of carbonate sediments, and thus, enhances reservoir description and the subsequent construction of more robust depositional models. The effects of the environmental controls on carbonate production, wherever possible, will be illustrated with observations from modern day analogues.

Part B: To fully understand carbonate systems, it is necessary to appreciate the larger scale depositional settings within which they develop. An understanding of the tectonic setting and the depositional geometry of a carbonate platform is vital in developing accurate depositional models. These aspects, together with the types of carbonate accumulations and their applications, will be fully addressed in this course. Finally, the principles of sequence stratigraphy, its importance in subsurface carbonate reservoir characterisation and the tools and techniques required for the application of sequence stratigraphy will all be covered. Overall, these factors aid in the prediction of the sedimentological heterogeneity expected at the large-scale, and hence, the interpretation of the reservoir architecture.

Course Objectives

Upon completion of the course, participants will have:

- A good understanding of a carbonate system, including the major controls on carbonate production;
- An appreciation of the heterogeneous nature of carbonate sediments and how this may impact predictability variations within the subsurface;
- An understanding of the techniques used to apply a sequence stratigraphic framework in a typical carbonate succession, and hence the impact on reservoir quality prediction.

Course Outline

The course will be organised into two sessions:

Part A: The carbonate system - "Carbonates are born not made"

- The mineralogy of carbonates;
- The composition of carbonate rocks: skeletal vs non-skeletal allochems;
- Classification of carbonate rocks;
- The controls on carbonate production;
- The carbonate factory - the impact of carbonate producers on the carbonate accumulation geometry;
- Types of carbonate accumulations;
- Applied carbonate facies analysis;
- Typical carbonate facies observed in core and thin-sections;
- The key to identifying carbonate depositional environments.

Part B: Sequence stratigraphy applied to carbonate reservoirs

- Introduction to the basic concepts of sequence stratigraphy;
- Carbonate record and sea level;
- Methods used to establish a sequence stratigraphic framework;
- Prediction of the sedimentological heterogeneity and interpretation of the sedimentological reservoir architecture.

Each section will be accompanied by example case histories and exercises.

Participants' Profile

This course is designed for petroleum geologists, geoscientists, petrophysicists and engineers involved in exploration and production of carbonate plays.

Prerequisites

Although previous knowledge on carbonate sedimentology is not necessarily required, participants should have some knowledge of geology.

About the Instructor

Laura Galluccio (Ph.D) is one of Badley Ashton's UK-based senior carbonate reservoir geologists with an interest in carbonate petrography and sedimentology. She specialises in sedimentology, diagenesis and reservoir quality characterization of limestones and dolomites in both conventional and unconventional reservoirs. She has wide experience in the Middle East, the USA, Europe and Africa. The projects she has been involved in cover a wide range of depositional environments from shallow to deeper water carbonates. Laura received his BSc, MSc and PhD at the University of Naples (Italy), with her PhD conducted in conjunction with Shell Italy. As an effective communicator and with a proven track record of excellent client care, past roles include Team Leader of the Carbonate Group, and local Business Manager and Consultant Geologist based in PDO's offices, Muscat. Since her appointment as Regional Manager in August 2017, Laura oversees business activity in the Middle East, Africa and Asia, supported by regional Operations and Portfolio Managers. Laura's other research interests include sedimentology and sequence stratigraphy of ancient and recent carbonate platforms and the characterization of diagenetic processes affecting carbonate sediments with integration into the regional framework and influence on the pore system. She is currently involved in research on the diagenesis and pore volume assessment of Hyamm Formation in Oman in collaboration with the Ferrara University and Sultan Quaboos University, as well as a project focused on the role of hydrocarbons emplacement for calcite precipitation, in collaboration with Newcastle University. Laura has undertaken teaching of geological mapping, petroleum geology and reservoir quality evaluation at both BSc and MSc levels, while co-supervising a variety of BSc and MSc carbonate research projects.

Catherine Breislin (Ph.D) is a Reservoir Geologist working in Badley Ashton's UK-based Carbonate Team. She specialises in carbonate sedimentology, diagenesis and reservoir quality analysis using a range of techniques in both conventional and unconventional reservoirs. Her work to date has focused on investigating the controls of depositional facies, platform architecture, and structural development on basin-scale diagenetic fluid flow and its impact on reservoir quality. Her project work has covered a wide range of depositional environments from shallow to deeper water carbonates.

Catherine received her MESci at the University of Liverpool (UK), and PhD at the University of Manchester (UK), with her PhD conducted in conjunction with Shell and the British Geological Survey. Catherine has a strong background in field geology, core-logging, carbonate sedimentology and geochemistry, and is proficient in conducting spatial integration of multiple data sets. She also has experience in lab-based mineral identification analyses, where she has developed best practice methodologies and workflows. While co-supervising an MSc carbonate research project at Manchester University, Catherine has undertaken teaching of carbonate sedimentology, geological mapping, petroleum geology and reservoir quality evaluation at both BSc and MSc levels.

Carbonate Reservoir Characterization

CARBONATES RESERVOIR CHARACTERIZATION SEDIMENTOLOGY STRATIGRAPHY

Instructor:	Laura Galluccio, Catherine Breislin (Badley Ashton, United Kingdom)	
Language:	English, Italian	
Level:	Foundation	
Duration and formats:	Online: Self-paced course - 7 hours recorded material	CPD Points: 3
	Online: IOSC - 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

This carbonate reservoir characterization course focuses on the analysis of carbonate depositional textures and the subsequent diagenetic modifications as the main controls on the pore system evolution, heterogeneity and complexity. The intricate inter-relationship of the depositional and burial history can be unravelled to allow the prediction of reservoir facies, and hence, aid reconstruction and development of three-dimensional reservoir models. This course demonstrates the value of understanding pore system evolution as a part of large-scale volumetric assessments and the development of carbonate reservoirs.

Reservoir quality in carbonate successions is often defined by the storage capacity, flow potential (ie. porosity and permeability respectively, measurements that are often acquired during conventional core analysis) and connectivity of pores (recorded as the pore-throat radius distributions during special core analysis). The interplay between these quantifiable factors (including sample-scale heterogeneities) is inevitably linked to the original depositional characteristics of the carbonate sediments, together with their susceptibility to post-depositional diagenetic alteration, which results in the ultimately complex pore system. Therefore, the classification of individual pore types will be detailed in this course, with their primary depositional or secondary diagenetic origin being discussed in context with sedimentological and stratigraphic models in order to underpin their spatial relationships and potential connectivity. In addition, the characterization of micrite textures will be discussed to illustrate their impact on the microporosity, factors that are particularly important to consider in tight unconventional reservoirs.

The depositional controls on reservoir properties that will be taken into consideration in this course include the texture, grain size, clay and matrix content as well as the type and quantity of allochems. The relationship between dissolution processes that result in an enhancement of the pore system, cementation processes that reduce the pore volume and the resultant connectivity and fluid flow pathways will be assessed to constrain the dominant diagenetic controls on the reservoir properties. In addition to this, the process of dolomitisation will be scrutinised in order to determine if and how this process enhances and/or reduces reservoir properties.

Integrating the key controls on reservoir quality within the sedimentological framework enables the establishment of a conceptual reservoir architecture model, which can be used to assess and predict the vertical and lateral variations in porosity and permeability at the reservoir and/or field scale. This course outlines how to conceptually build a reservoir architecture model, which in turn can be used to aid reservoir modelling.

This course will be accompanied by a series of in-class exercises, which will emphasize the integration of the various datasets, providing participants with experience in carbonate reservoir characterization.

Course Objectives

Upon completion of the course, participants will be able to:

- Identify the different pore types, their interconnectivity and hence the impact on permeability;
- Determine how specific sedimentological parameters and diagenetic process impact reservoir quality;
- Understand sample heterogeneity and its impact on reservoir quality data;
- Upscaling of reservoir quality data to aid prediction at the field scale.

Course Outline

The course will be organised into three sessions:

Part A: Reservoir quality analysis - What it is and how to approach it

- Definition of reservoir quality;
- How to characterise reservoirs.

Part B: Pore types and connectivity

- Concepts and definitions;
- The carbonate pore type classification(s);
- Permeability and pore-throat radius distributions;
- Manipulating reservoir quality data;
- Introduction to advanced reservoir quality tools.

Part C: Controls on reservoir quality

- Sample heterogeneity;
- Sedimentological controls;
- Diagenetic controls;
- Reservoir architecture construction.

Each section will be accompanied by examples from case history exercises.

Participants' Profile

This course is designed for petroleum geologists, geoscientists, petrophysicists and engineers involved in exploration and production of carbonate plays.

Prerequisites

Although previous knowledge on carbonate sedimentology is not necessarily required, participants should have some knowledge of geology.

About the Instructor

Laura Galluccio (Ph.D.) is one of Badley Ashton's UK-based senior carbonate reservoir geologists with an interest in carbonate petrography and sedimentology. She specialises in sedimentology, diagenesis and reservoir quality characterization of limestones and dolomites in both conventional and unconventional reservoirs. She has wide experience in the Middle East, the USA, Europe and Africa. The projects she has been involved in cover a wide range of depositional environments from shallow to deeper water carbonates. Laura received his BSc, MSc and PhD at the University of Naples (Italy), with her PhD conducted in conjunction with Shell Italy. As an effective communicator and with a proven track record of excellent client care, past roles include Team Leader of the Carbonate Group, and local Business Manager and Consultant Geologist based in PDO's offices, Muscat. Since her appointment as Regional Manager in August 2017, Laura oversees business activity in the Middle East, Africa and Asia, supported by regional Operations and Portfolio Managers. Laura's other research interests include sedimentology and sequence stratigraphy of ancient and recent carbonate platforms and the characterization of diagenetic processes affecting carbonate sediments with integration into the regional framework and influence on the pore system. She is currently involved in research on the diagenesis and pore volume assessment of Hyamm Formation in Oman in collaboration with the Ferrara University and Sultan Quaboos University, as well as a project focused on the role of hydrocarbons emplacement for calcite precipitation, in collaboration with Newcastle University. Laura has undertaken teaching of geological mapping, petroleum geology and reservoir quality evaluation at both BSc and MSc levels, while co-supervising a variety of BSc and MSc carbonate research projects.

Catherine Breislin (Ph.D) is a Reservoir Geologist working in Badley Ashton's UK-based Carbonate Team. She specialises in carbonate sedimentology, diagenesis and reservoir quality analysis using a range of techniques in both conventional and unconventional reservoirs. Her work to date has focused on investigating the controls of depositional facies, platform architecture, and structural development on basin-scale diagenetic fluid flow and its impact on reservoir quality. Her project work has covered a wide range of depositional environments from shallow to deeper water carbonates.

Catherine received her MESci at the University of Liverpool (UK), and PhD at the University of Manchester (UK), with her PhD conducted in conjunction with Shell and the British Geological Survey. Catherine has a strong background in field geology, core-logging, carbonate sedimentology and geochemistry, and is proficient in conducting spatial integration of multiple data sets. She also has experience in lab-based mineral identification analyses, where she has developed best practice methodologies and workflows. While co-supervising an MSc carbonate research project at Manchester University, Catherine has undertaken teaching of carbonate sedimentology, geological mapping, petroleum geology and reservoir quality evaluation at both BSc and MSc levels.

Carbonate Reservoirs - Sedimentology, Diagenesis and Reservoir Quality Evaluation

CARBONATES | RESERVOIR CHARACTERIZATION | SEDIMENTOLOGY | STRATIGRAPHY

Instructor:	Laura Galluccio, Catherine Breislin (Badley Ashton, United Kingdom)	
Language:	English, Italian	
Level:	Foundation	
Duration and formats:	Classroom: 5 days	CPD Points: 25

NEW

Course Description

An understanding of the depositional origin, together with the post-depositional modifications, is imperative to the successful exploration and production of carbonate sediments, which hold more than 60% of the world's oil and 40% of the world's gas reserves. Although carbonate rocks present complexity, this course is designed to understand the basic principles of carbonate sedimentology, diagenesis and reservoir characterization while making it straightforward to grasp and integrate the information.

The first part of this course is designed to develop skills in characterizing carbonate rocks and identifying and interpreting their depositional settings. This includes an insight into the controls on the carbonate factory (such as environmental, biological, physical, chemical and climatic controls), an in-depth examination of the classification of carbonate textures and gives an understanding of the larger scale tectonic setting and depositional geometry of carbonate platforms. The principles of sequence stratigraphy and its importance in the subsurface characterization of carbonate reservoirs will also be discussed. All these factors are crucial in predicting the geometry of carbonate reservoirs in the subsurface and developing accurate depositional models, which in turn will have an impact on the prediction of the reservoir architecture.

The second session of the course will focus on the diagenetic processes and products that have an impact on carbonate reservoirs. This will encompass the identification of the products and processes involved within meteoric, marine and burial diagenetic environments, using both petrographical and geochemical analytical techniques, while taking into consideration their implications on the resultant reservoir properties. In addition to this, the process of dolomitisation and the proposed models of dolomite formation (including expected body geometries) will be discussed, illustrating whether this process benefits or hinders reservoir quality. This section will also review the various analytical techniques utilised in identifying the origin of the diagenetic phases and thereby aiding the prediction of their potential vertical and lateral extent.

The third and final part of the course will analyse the pore system evolution, integrating the intricate link between sedimentology and diagenesis to aid prediction of reservoir properties at the field scale. The classification of pore types will be discussed, with their primary depositional or secondary diagenetic origin being determined in order to understand their spatial relationships relative to the sedimentological framework and hence their potential connectivity. The characterization of micrite textures will also be discussed to illustrate their impact on microporosity, an important factor to consider when characterizing unconventional tight reservoirs. This course outlines how to conceptually build a reservoir architecture model by integrating the key controls on reservoir quality within the sedimentological framework, which in turn can be used to assess and predict the lateral and vertical variations in porosity and permeability at the large scale.

This course will be accompanied by a series of in-class exercises, which will emphasize the integration of the various datasets, providing participants with experience in carbonate reservoir characterization.

Course Objectives

Upon completion of the course, participants will be able to:

- Understand a carbonate system, including the major controls on carbonate production, describe carbonate sediments and their associated heterogeneity, and understand the techniques used to apply a sequence stratigraphic framework in a typical carbonate succession;
- Understand the various diagenetic processes that carbonate sediments are predisposed to and how to identify the origin of resultant products and hence their impact on reservoir quality. Knowledge on the analytical techniques used to characterize diagenetic products will also be gained;
- Determine how sedimentological parameters and diagenetic process impact reservoir quality in order to aid prediction at the field scale.

Course Outline

Sedimentology and sequence stratigraphy - Days 1-2

Part A: The carbonate system - "Carbonates are born not made"

- Mineralogy, composition and classification of carbonate rocks;
- The carbonate factory and controls on carbonate production;
- Applied carbonate facies analysis with core-based and thin-section examples;
- The key to identifying carbonate depositional environments;

Part B: Sequence stratigraphy applied to carbonate reservoirs

- Introduction to the basic concepts of sequence stratigraphy;
- The carbonate record and sea level variations;
- How to establish a sequence stratigraphic framework;
- Prediction of the sedimentological heterogeneity and interpretation of the sedimentological architecture.

Diagenesis - Day 3

Part A: The diagenetic realm

- Introduction to diagenetic processes;
- Diagenetic environments;

- Dolomites and evaporites;
- Building a paragenetic sequence;

Part B: Analytical techniques
- Advanced microscopy analyses including cathodoluminescence and scanning electron microscopy;
- Geochemical analyses such as trace elements, stable isotopes and fluid inclusion thermometry.

Reservoir quality assessment - Days 4-5

Part A: Reservoir quality analysis - what it is and how to approach it
- Definition of reservoir quality;
- How to characterize reservoirs.

Part B: Pore types and connectivity
- Concepts and definitions;
- The carbonate pore type classification(s);
- Permeability and pore-throat radius distributions;
- Manipulating reservoir quality data.

Participants' Profile

The course is targeted at all geoscientists, including petroleum geologists, petrophysicists and petroleum engineers involved in exploration and production of carbonate plays.

Prerequisites

Although previous knowledge on carbonate sedimentology is not necessarily required, participants should have some knowledge of geology.

About the Instructor

Laura Galluccio (Ph.D.)is one of Badley Ashton's UK-based senior carbonate reservoir geologists with an interest in carbonate petrography and sedimentology. She specialises in sedimentology, diagenesis and reservoir quality characterization of limestones and dolomites in both conventional and unconventional reservoirs. She has wide experience in the Middle East, the USA, Europe and Africa. The projects she has been involved in cover a wide range of depositional environments from shallow to deeper water carbonates. Laura received his BSc, MSc and PhD at the University of Naples (Italy), with her PhD conducted in conjunction with Shell Italy. As an effective communicator and with a proven track record of excellent client care, past roles include Team Leader of the Carbonate Group, and local Business Manager and Consultant Geologist based in PDO's offices, Muscat. Since her appointment as Regional Manager in August 2017, Laura oversees business activity in the Middle East, Africa and Asia, supported by regional Operations and Portfolio Managers. Laura's other research interests include sedimentology and sequence stratigraphy of ancient and recent carbonate platforms and the characterization of diagenetic processes affecting carbonate sediments with integration into the regional framework and influence on the pore system. She is currently involved in research on the diagenesis and pore volume assessment of Hyamm Formation in Oman in collaboration with the Ferrara University and Sultan Quaboos University, as well as a project focused on the role of hydrocarbons emplacement for calcite precipitation, in collaboration with Newcastle University. Laura has undertaken teaching of geological mapping, petroleum geology and reservoir quality evaluation at both BSc and MSc levels, while co-supervising a variety of BSc and MSc carbonate research projects.

Catherine Breislin (Ph.D) is a Reservoir Geologist working in Badley Ashton's UK-based Carbonate Team. She specialises in carbonate sedimentology, diagenesis and reservoir quality analysis using a range of techniques in both conventional and unconventional reservoirs. Her work to date has focused on investigating the controls of depositional facies, platform architecture, and structural development on basin-scale diagenetic fluid flow and its impact on reservoir quality. Her project work has covered a wide range of depositional environments from shallow to deeper water carbonates.

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GEOLOGY • STRATIGRAPHY

Integrated Methods for Deep-Water Reservoir Characterization

DEPOSITS FACIES GRAVITY MARINE OUTCROP SEDIMENTOLOGY SEQUENCE STRATIGRAPHY SHALLOW

Instructor:	Dr Jon R. Rotzien (Basin Dynamics, LLC, United States)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

Deep-water depositional systems form some of the largest petroleum reservoirs on Earth and represent the frontier of oil and gas exploration. However, deep-water depositional systems remain the least well understood because sediment gravity flows, including turbidity currents and hybrid and debris flows, are both infrequent and difficult to predict and monitor, setting them apart from sediment transport processes occurring on mountain tops and shallow marine settings. Therefore, modern seismic data and, in particular, deep-water outcrops provide prime sources of stratigraphic data used to risk drilling targets and build reservoir models at every phase in the upstream exploration and production process. This course focuses on sub-bed-scale and field-scale architectural elements in deep-water depositional systems and how they affect the main risks in deep-water E&P across the value chain: reservoir presence, deliverability, seal and trap. The course has three main themes:

- Sediment gravity flows, sedimentation mechanics and resulting bed configuration.
- Depositional elements in the core, outcrop, and seismic scale.
- Application and interpretation of risk and uncertainty from new ventures to field development and EOR.

The impact of deep-water reservoir architecture on field success will be investigated through modeling theory, to derive strategies for optimal outcomes over a range of uncertainty. Case studies will be used to illustrate each topic and determine appealing workflows. This course will alternate between inclusive lectures, hands-on technical demonstrations, and collaborative exercises involving practical application of cores, outcrops, logs, and seismic data. The course starts with an overview of how sediment is transported and deposited from shelf to bathyal depths and focuses on the broad range of sedimentary processes and depositional environments. Individual and team exercises involving core and outcrop samples allow participants to describe samples and interpret their mechanism of deposition and their range of possible depositional environments. Next, a deeper dive into depositional environments illustrates the types of facies, as well as depositional and stratigraphic architecture, likely to be found along the deep-water depositional system from submarine canyon to basin plain. Collaborative exercises using core, outcrop, and seismic examples highlight the range of deep-water depositional environments and their effect on reservoir architecture and development. The skills of core description and integration, reservoir characterization, and sequence stratigraphy are emphasized. Core-log-seismic exercises will show modern techniques on how to predict variations in reservoir architecture in deep-water depositional systems. This course will conclude with a discussion summarizing modern advancements in the prediction of sedimentary deposits, facies, and reservoir development in a variety of different settings.

Course Objectives

This course will give participants an understanding of the broad scope of marine siliciclastic depositional systems. Upon completion of the course, participants will be able to:

- Describe transport and depositional processes of deep-water strata including turbidites, debrites, and transitional to hybrid flow type deposits
- Understand the different types of marine depositional environments (deltaic and outer shelf environments and those of submarine fans — canyon, channel, levee, splay, overbank) and their implications to petroleum reservoir architecture and reservoir quality
- Understand and interpret modern and ancient marine depositional systems
- Characterize marine stratigraphy and build relationships with depositional environments using outcrop, core, and other oil and gas industry data
- Use lithofacies and stratigraphic architecture to understand variations in deep-water reservoir properties pertaining to petroleum reservoir presence, quality, and seal presence
- Conceptualize and apply source-to-sink transport and sequence stratigraphic methods to marine and deep-water sediment delivery
- Apply skills in seismic interpretation, reservoir characterization, core analysis, geophysical log interpretation, sequence stratigraphy, play fairway mapping, risk and uncertainty analysis, gross depositional environment mapping, and oil and gas exploration methods

Course Outline

1. Introduction to marine depositional systems with a focus on deep-water depositional systems

- Significance of deep-water petroleum reservoirs to the global oil and gas industry
- Scientific and economic drivers for understanding sediment gravity flows and their deposits
- Sediment gravity flows in action - historic sediment gravity flows from Canada, France, Norway, and United States

2. Reservoir prediction: Transport and sedimentation processes of sediment gravity flows

- Types of mass movement and deep-water deposits
- Physics of sediment gravity flows and rheology, and steady vs uniform flows
- Predictive attributes of deep-water sedimentation to reservoir and seal presence, and reservoir quality

3. Basic building blocks of clastic petroleum reservoirs: The range and variability of deep-water sedimentation units

- High- and low-density turbidity currents and their impacts on petroleum reservoir development

- Bouma and Lowe turbidite models and their application to reservoir characterization
- Debris flows and their impact on submarine fan sedimentation
- Transitional flows, slurry flows, and hybrid events and their classifications - M & H divisions and their impact on reservoir quality
- Mass-transport deposits (MTD) and review of other sediment remobilization processes, including contour currents and contourite deposits

4. Source-to-sink concepts and impact on reservoir quality
- Source-to-sink method application to oil and gas exploration and production
- Paralic and shallow-marine processes of sedimentation
- Facies models and reservoir characterization for shallow-marine environments
- River-, tide-, and wave-dominated deltas, and fan deltas
- What are the different types of clinoforms observed in seismic data, and what is their role in sediment delivery to deep-water basins?
- Incised valleys as prospective oil and gas targets
- Ichnofacies of terrigenous, shallow-marine, and deep-marine depositional environments

5. The five main deep-water depositional environments according to
- 2D and 3D seismic, outcrop, core, and log data
- Canyons
- Channels
- Levees
- Lobes (splays), with an introduction to deep-water braided channel and lobe systems
- Overbank

6. Scales of petroleum reservoir heterogeneity: Architectural elements
- What are the various methods of stratigraphic interpretation and genetic element classification in reservoir characterization?
- Sub-bed scale architecture and Turbidite Ratios

7. Active margins vs. passive margins: Deep-water sedimentary basins and their facies models
- What are the effects of tectonic setting, shelf geometry, climate, and other critical factors on deep-water sedimentation?
- Rifts
- Range and variability in passive margin facies models
- Salt and its effects on sediment transport and deposition
- What are typical facies models for active margins? Discuss strike-slip and convergent margins, and hybrid basins associated with active margins
- Intracratonic basins
- Foreland basins
- Forearc and hybrid basins

8. Large-scale drivers of continental margin sedimentation and application of sequence stratigraphic methods to exploration and appraisal
- How was sequence stratigraphy developed by Grabau, Sloss, Mitchum, Vail, Thompson, Hubbard, Van Wagoner, and others? How is it applied? What are the strengths and limitations of a sequence stratigraphic approach?
- AIGR model
- Provenance and source-to-sink methods to understand sediment transfer and application to reservoir presence and reservoir quality
- How do you know you're in a deep-water depositional system? A review of key similarities and differences with deep-water systems and other systems including fluvial and shallow-marine environments
- Conclusions and recent advancements in deep-water petroleum reservoirs

Participants' Profile

The course is designed for employees of natural resource companies in technical and management positions. Industry professionals will receive an understanding of deep-water sedimentary transport processes and depositional products, as well as knowledgeable insight into the scale and architecture of the wide range of deep-water reservoirs. This course draws from materials presented in Basin Dynamics, LLC field trips of major deep-water sedimentary outcrops worldwide.

Prerequisites

Participants should have knowledge of basic reservoir and exploration and development concepts, as well as experience with common geological, geophysical and engineering data.

Recommended Reading

- Beaubouef, R.T., Rossen, C.R., Zelt, F.B., Sullivan, M.D., Mohrig, D.C., Jennette, D.C., Bellian, J.A., Friedman, S.J., Lovell, R.W., Shannon, D.S., 1999. Deep-water sandstones, Brushy Canyon Formation, West Texas: American Association of Petroleum Geologists, Bulletin, Continuing Education Course Note Series #40, 48 p.
- Haughton, P., Davis, C., McCaffrey, W., Barker, S., 2009. Hybrid sediment gravity flow deposits — Classification, origin and significance: Marine and Petroleum Geology, v. 26, p. 1900-1918.
- Lowe, D.R., 1982. Sediment gravity flows: II. Depositional models with special reference to the deposits of high-density turbidity currents: Journal of Sedimentary Petrology, v. 52, p. 279-297.
- Marchand, A.M., Apps, G., Li, W., Rotzien, J.R., 2015. Depositional processes and impact on reservoir quality in deepwater Paleogene reservoirs, US Gulf of Mexico: American Association of Petroleum Geologists, Bulletin. DOI: 10.1306/04091514189
- Morris, E.A., Hodgson, D.M., Brunt, R.L., Flint, S.S., 2014. Origin, evolution and anatomy of silt-prone submarine external levees: Sedimentology, v. 61, p. 1734-1763.

About the Instructor

Dr. Jon R. Rotzien is President of Basin Dynamics, LLC and Adjunct Professor at University of Houston. His expertise is the sedimentology and stratigraphy of deep-water depositional systems, source-to-sink sediment transfer, and basin analysis. Jon addresses global challenges in the exploration and production of petroleum, including reservoir presence and quality forecasting in frontier to mature basins, and reservoir connectivity and deliverability. Prior to his present position at Basin Dynamics, he was an exploration and appraisal geoscientist at BP. He has published peer-reviewed research papers and scientific conference proceedings pertaining to petroleum geology, reservoir quality, reservoir characterization, sequence stratigraphy, process sedimentology, basin analysis, and geophysics, and he teaches petroleum reservoir courses in North America, South America, Europe and Asia-Pacific. He is a Distinguished Award winner of GCSSEPM (2018), associate editor of the Bulletin of Canadian Petroleum Geology and co-founder of the Houston Explorers Club. Mr. Rotzien received a Ph.D. in Geological and Environmental Sciences from Stanford University and a B.A. degree in Geology from Colorado College.

Petroleum Exploration Strategy

BLOCK CONTRACT ECONOMY ENVIRONMENTAL EXPLORATION EXTRAPOLATION LICENSE OIL AND GAS PS RESOURCES RISK SEC UNCERTAINTY

Instructor:	Jean-Jacques Biteau (Total Energies Professor Associate, France)	
Language:	English, French	
Level:	Advanced	
Duration and formats:	Online: 2 to 4 live sessions of 4 hours	CPD Points: 4 to 8
	Classroom: 1 to 2 days	CPD Points: 5 to 10

NEW

Course Description

This course is set up as follows:
Chapter 1: Introduction;

Chapter 2: Definitions, elements of strategy, partnerships
- Reserves and costs
- Upstream actions, elements of strategy and petroleum partnership

Chapter 3: Evaluation of Exploration projects;
- 3a Working sequence and costs
- 3b The prospect Evaluation sheet or 'Fiche Objective'
- 3c Economic criteria
- 3d Economic studies in exploration / appraisal

Chapter 4: Partnerships, Contracts and mining acreage;
- 4a Partnerships
- 4b The main petroleum contract types

Chapter 5: Missions and role of the Geoscience / Exploration Manager in affiliates / Manager Career, a mixt of experiences;

Chapter 6: Practical case study.

Course Objectives

Upon completion of the course, participants will be able to:
- identify the pillars of exploration;
- understand resources, risk, uncertainty and value.

Participants' Profile

The course is designed for professionals with a geoscience background. Students should have at least Master's degree.

About the Instructor

Jean-Jacques Biteau graduated in 1977 from ENSG, i.e Nancy Geology School. Since 1977, he has worked in a large variety of positions for Algerian Government (his first professional assignment as hydrogeologist) and then for Total (appointed in 1979 as Geological engineer) in headquarters and affiliates: Netherlands, Angola, France, as well short durations stays in Gabon, Congo.... His last active position was Vice President Coordination & Portfolio Management. He started for Total a phase of preretirement period in 2016.
He is currently Professor at ENSG School, IFP School and also teaches with Total Professor Associates classes covering "Pressures, Seals and Traps". He was President of the EAGE Board from June 2017 to June 2019. He retired in April 2019 and now continues to serve as a teacher.

Volumes and Risks Assessment for Conventional and Unconventional Plays and Prospects

CBM COAL OIL AND GAS PETROLEUM EXPLORATION RISK SHALE UNCERTAINTY UNCONVENTIONAL VOLUMES

Instructor:	Prof. Dr Alexei Milkov (Colorado School of Mines, United States)	
Language:	English, Russian	
Level:	Intermediate	
Duration and formats:	Online: 6 live sessions of 4 hours	CPD Points: 12
	Classroom: 3 days	CPD Points: 15

NEW

Course Description

The course enables participants to transform qualitative geological descriptions of plays and prospects into technically robust quantitative success-case and risked volumetric models. Obtained learnings will help participants to evaluate probabilities of success (PoS) for exploration plays, segments, prospects, wells and portfolios and to assess the range of petroleum volumes in exploration projects. Examples and case studies come from both conventional and unconventional plays, prospects and wells around the world. The learning objectives are achieved through well-illustrated lectures, numerous hands-on exercises and active class discussions.

We will cover the following topics:

- Play-based exploration;
- Assessment of success-case volumes for plays (conventional and unconventional), segments, prospects, wells and portfolios;
- Assessment of exploration risks and probabilities of success;
- Biases and logical fallacies in;
- Post-mortem analysis.

Course Objectives

Upon completion of the course, participants will be able to:

- Use play-based exploration approach and tools (e.g., Common Risk Segment mapping, Field Size Distribution analysis, Creaming Curves etc.) to locate sweet spots in conventional and unconventional plays and assess remaining play/basin potential;
- Calculate deterministic potential (success-case) petroleum resources in conventional prospects and in unconventional plays. Assess and justify the range and probabilistic distribution of input parameters used in volumetric calculations;
- Assess geological risks and PoS for conventional and unconventional exploration, appraisal and development segments;
- Use industry-standard software (GeoX, REP or both) and run Monte-Carlo simulations to estimate unrisked and risked probabilistic volumes for plays, segments, prospects and wells;
- Recognize biases and logical fallacies common in exploration assessments and know how to correct them;
- Aggregate segments into a prospect and use risk and volumes dependencies between segments to estimate PoS and volumes for the prospect. Calculate PoS for wells;
- Aggregate prospects and wells into exploration portfolio. Predict the outcomes of portfolio drill-out;
- Evaluate drilling results to establish main reason(s) for well failure.

Course Outline

Day 1. Big picture trends in petroleum exploration. Play-based exploration. Fundamentals of volumetric and risk assessment for prospective segments.

The first day introduces the participants to global exploration trends and the concepts of Exploration Triangle and Play Based Exploration. You will learn the fundamentals of volumetric and risk assessment, the main definitions and the commonly used assessment tools (software).

- Welcome and introductions;
- Global trends in petroleum exploration since 1900;
- Play-based exploration;
- Common Risk Segment (CRS) maps;
- Field size distributions;
- Creaming curves;
- Yet-to-Find resources;
- Risk versus uncertainty;
- Deterministic and probabilistic volumes;
- Success-case and risked volumes;
- Software tools used in the assessment of prospective resources.

Day 1 exercises:

- Evaluate the play fairway, make CRS maps, locate sweet spots in the play;
- Build and evaluate field size distributions and creaming curves, define remaining play/basin potential.

Day 2. Basics of statistics, distributions and probabilities. Biases and fallacies in exploration. Volumetrics and risking for a segment of conventional petroleum resources.

The second day starts with the discussion of statistical parameters, distributions and probabilities. Participants will use real-world data (area, thickness, Net/Gross, porosity, saturation, Formation Volume Factor, Recovery Factor) to build distributions as inputs into volumetric models. This will be followed by the discussion of biases and fallacies in petroleum assessments and the tools that help reduce them. We will finish the day by doing hands-on assessment of volumes and risk for a conventional prospect.

- Meaning of basic statistical parameters (Mean, Mode, P10 etc.);
- Distributions appropriate to use in petroleum exploration projects;
- Where and how to get data to build distributions;
- Main biases and logical fallacies common in petroleum exploration;
- Techniques to reduce biases (Risk Tables, assurance teams);
- Assessment of volumes and geological PoS for a segment;

- Using information on Direct Hydrocarbon Indicators (DHIs) to update geological PoS;
- Assessment of geological risks for appraisal and development wells.

Day 2 exercises:
- Build porosity distribution for a segment;
- Calculate volumes and evaluate sensitivities to various inputs for a conventional oil segment.;
- Assess success-case volumes, geological PoS and risked volumes for a conventional oil segment (real prospect from offshore West Africa).

Day 3. Volumetrics and risking for unconventional plays. Aggregation of segments into prospect. Portfolio analysis. Post-drilling analysis.
The third day will start with the discussion of volumes and risk assessments for unconventional oil and gas plays (tight, shale, CBM). After that, we will discuss aggregation of segments into prospects and prospects into a portfolio. We will finish the course by studying how to do post-mortem analysis, learn from exploration successes and failures and become better explorers.
- Assessment of volumes and risks for unconventional plays;
- Aggregation of segments into prospect, with risk and volume dependencies;
- Calculation of PoS for prospects and wells;
- Aggregation of prospects into portfolio;
- Learnings from discovery wells;
- Learnings from dry holes;
- Full Cycle Economics evaluation.

Day 3 exercises:
- Assess in-place and recoverable volumes in unconventional shale gas and shale oil plays (real plays onshore Australia);
- Assess recoverable volumes for small(ish) acreage of unconventional tight oil in the USA (real play in the Powder River basin);
- Aggregate segments into a prospect, calculate values of PoS for the prospect and for the well;
- Evaluate a dry hole, determine the reason for well failure.

Participants' Profile

The course is designed for geoscientists, engineers and managers who work on exploration projects and require competency in the assessment of risks and volumes.

About the Instructor

Alexei V. Milkov is Full Professor and Director of Potential Gas Agency at Colorado School of Mines and a consultant to oil and gas industry. After receiving PhD from Texas A&M University, Dr. Milkov worked for BP, Sasol and Murphy Oil as geoscientist and senior manager. He explored for conventional and unconventional oil and gas in over 30 basins on six continents and participated in the discovery of more than 4 Billion BOE of petroleum resources. He also worked on several appraisal and production projects. Dr. Milkov has deep expertise in oil and gas geochemistry, petroleum systems modeling, exploration risk analysis, resource assessments and portfolio management. He published 50 peer-reviewed articles. Dr. Milkov received several industry awards including J.C. "Cam" Sproule Memorial Award from the American Association of Petroleum Geologists (AAPG) for the best contribution to petroleum geology and Pieter Schenck Award from the European Association of Organic Geochemists (EAOG) for a major contribution to organic geochemistry.

3D Reservoir Modeling of Naturally Fractured Reservoirs

DENSITY | FRACTURES | GEOCELLULAR | INTEGRATION | POROSITY | PRODUCTION | RESERVOIR CHARACTERIZATION | WELLS | WORKFLOWS

Instructor:	Dr Tim Wynn (TRACS International Ltd, United Kingdom)	
Language:	English	
Level:	Advanced	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

Reservoir modeling for field development planning is a well-accepted process but its application to fractured reservoirs requires specific considerations that are less commonly known. This course describes a practical methodology for building 3D static ('geocellular') reservoir models for naturally fractured reservoirs using standard modeling software, covering such considerations.

The issues addressed include the integration of log, core and seismic data, the process of defining and building the static reservoir model itself and the creation of output in a form appropriate for dynamic modeling using dual porosity reservoir simulators where appropriate. More complex workflows using discrete fracture networks will also be summarized, as will general issues of fracture description, uncertainty-handling and developing and managing fractured reservoirs.

Course Objectives

Upon completion of the course, participants will:

- Be aware of practical workflows for modelling naturally fractured reservoirs using standard industry software;
- Understand the data-gathering requirements and methodology for characterizing fractured reservoirs;
- Appreciate the special distinction of naturally fractured reservoir models compared to standard single-porosity models.

Course Outline

- Origins and distributions of natural fracturing
- Describing and quantifying fractures from well data
- Estimating fracture system characteristics away from wells
- Geological model building workflow for implicit fracture representation
- Brief introduction to discrete fracture networks
- Basic fractured reservoir simulation model construction
- Fractured reservoir development and management considerations

Participants' Profile

Geoscientists and petroleum engineers newly working in naturally fractured reservoirs where they need to provide or receive output from fractured reservoir models.

Prerequisites

Participants should have and in depth understanding of the oil business and a good understanding of conventional reservoir characterization and modelling techniques. No software will be used interactively during the day and no hands-on modelling experience is therefore required. However, it would be beneficial.

About the Instructor

Dr Tim Wynn is a Reservoir Geologist with 27 years' experience in reservoir development and reserves evaluation studies with a focus on the geological and geomechanical aspects of naturally fractured reservoir characterisation and modelling. With a PhD in structural geology from Imperial College, London he joined GeoScience Limited in 1994 and spent 6 years working on fractured reservoir characterisation projects for the nuclear and oil industries. He then joined ICE Energy working on wellbore stability problems until the merger of ICE Energy with TRACS International in 2001. During his career, Tim has worked on a wide variety of international consultancy projects and delivered many training courses.

This broad experience over many years has enabled Dr Wynn to understand the key issues for people working in naturally fractured reservoirs including biases in interpretation, inappropriate modelling techniques and understanding potential mitigations during the development and management of naturally fractured reservoirs. Tim is a member of the EAGE, SPE, Geological Society, London and PESGB and has published a number of papers since 1995 on structural geology, naturally fractured reservoirs and geomechanics. He is also a technical peer reviewer for the EAGE and SPE.

Deepwater Reservoirs: Exploration and Production Concepts

CONTINENTAL MARGIN | DRILLING | FACIES | MARINE | SAND | SANDSTONE | SEQUENCE STRATIGRAPHY | SHALE | TURBIDITE

Instructor:	Prof. Dorrik Stow (Heriot-Watt University, United Kingdom)	
Language:	English	
Level:	Advanced	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

Sandstones deposited in deep marine environments form important hydrocarbon reservoirs in many basins around the world. Interbedded mudstones can be important as source rocks, as well as acting as barriers, baffles and seals. Deepwater reservoirs are currently the principal target for oil and gas exploration, with over 1600 existing turbidite fields and plays. Driven by technological advances and much improved scientific understanding, the pace of exploration and discovery in this realm is fast accelerating. Keeping pace with these developments and with the new knowledge base is essential for all those involved in deepwater systems. What began as the turbidite reservoir has matured into the more varied deepwater play of the 21st century that no company can afford to ignore.

This course is designed to provide the participant with a state-of-the-art review and update, thereby providing an overall understanding of the complexity of the deep marine system. It will outline the processes and facies and how they evolve on the slope and in the open ocean; discuss how these facies build into distinctive architectural elements and how they can be recognized in the subsurface. The course also covers analysis and interpretation of seismic records, sea floor images, well logs (including borehole image logs), core materials and outcrop characteristics of the component elements of deepwater reservoirs, emphasizing internal architecture as related to reservoir performance. Examples from different deepwater plays around the world will be used to further illustrate their exploration, appraisal, development and reservoir management.

Course Outline

Day 1 : Deepwater Overview, Building Blocks & Architecture

GLOBAL OVERVIEW
- Global and historical perspectives, technologies and current trends
- Deepwater systems with hydrocarbons or hydrocarbon potential
- Ancient and modern analogues of deepwater systems
- Process-facies overview and state-of-the-art

DOWNSLOPE SYSTEMS
- Mass transport processes and facies: slides, slumps, debris flows
- Turbidity currents: massive sands and thin-bedded turbidites
- Hyperpycnal flows: new deepwater models
- Subsurface recognition, examples and reservoir characteristics

ALONGSLOPE SYSTEMS
- Contour (bottom) currents: processes and facies
- Deepwater tides, waves and other bottom currents
- Subsurface recognition, examples and reservoir characteristics

OPEN-OCEAN SYSTEMS
- Pelagic-hemipelagic processes and facies
- Deepwater black shales: nature, occurrence and examples
- Petroleum perspective: barriers, baffles and source rocks

ARCHITECTURE: CHANNEL STYLE AND GEOMETRY
- Overview of deepwater architectural elements
- Channel style, geometry fill characteristics
- Mass transport complexes in channels and basins
- Subsurface wireline logs and reservoir examples

ARCHITECTURE: LOBES, MOUNDS AND SHEETS
- Turbidite lobes and sheets
- Contourite drifts and sheets
- Subsurface wireline logs and reservoir examples

Day 2 : Seismic/Sequence Stratigraphy and Deepwater Plays

SUBSURFACE MODELS
- Synthesis of deepwater models and their features
- Seismic characteristics of deepwater elements and systems
- Wireline log characteristics and borehole image logs
- Sea-level, tectonic, sediment supply and other controls
- Sequence stratigraphy and depositional models

DEEPWATER MASSIVE SANDS
- Case studies: modern, ancient and subsurface examples
- Reservoir size, homogeneity and connectivity
- Deliberate search for the perfect deepwater reservoir

THIN-BEDDED TURBIDITES
- Case studies: modern, ancient and subsurface examples
- Reservoir potential and development issues
- The problem of shales and shale dimensions

DEEPWATER DRILLING
- Special issues for drilling in deepwater
- Slope instability and hazard mapping
- Turbidity currents and bottom currents: potential hazard

DEEPWATER PLAYS WORKSHOP
- Lessons from established turbidite plays: North Sea, California, Bohai and others
- Lessons from current deepwater provinces: Gulf of Mexico, West Africa, NW UK Continental Margin, Brazil, North Slope Alaska, Nile Delta and others

- Interactive discussion session to consider implications for exploration, appraisal, development and reservoir management; to share and discuss individual datasets, experience, questions and problems
- The new frontiers…current targets and expectation
- Course summary and take-home lessons

Participants' Profile

All geologists, geophysicists and petroleum engineers involved in exploration and development of the deepwater play. Project managers for deepwater plays and reservoir production.

Prerequisites

Participants should have basic knowledge of stratigraphy and sedimentology.

About the Instructor

Professor Stow is a leading specialist and internationally renowned expert in deepwater sedimentary systems, with 40 years experience in modern, ancient and subsurface sediments. He has a particular interest in deepwater hydrocarbons, including numerous joint research projects with industry, individual consultancies, short course and field course organisation. His extensive record of scientific publications includes over 250 scientific papers and reports, numerous books and edited volumes. He is currently engaged on a major research initiative with the Integrated Ocean Drilling Program that drilled west of the Gibraltar gateway in the Atlantic Ocean, and writing a book on Deepwater Sedimentary Systems.

Professor Stow is a lively, interesting and highly informed instructor. He is a seasoned presenter to audiences large and small, specialist and generalist. He is able to draw upon a great wealth of experience and examples to fully illustrate his presentations, and utilizes short course exercises for further instruction. His teaching and instruction has been highly acclaimed at all levels.

His recent text Sedimentary Rocks in the Field (Manson, 2005) is a must-have for students and professional geologists alike, while Oceans: An Illustrated Reference (Oxford University Press and University of Chicago Press, 2004) and Vanished Ocean (OUP 2010) represent a venture into popular science. He is currently Head of the Institute of Petroleum Engineering and Professor of Petroleum Geoscience at Heriot Watt University (Edinburgh, UK). Professor Stow has been an enthusiastic lecturer and speaker throughout the world, on everything from deep-sea turbidites to the Lost Tethys Ocean.

He has worked with many different oil and gas companies in the provision of in-house or collective courses, field and core workshops, and in collaborative research projects. Companies have included: Anadarko, AGACO, BP, Britoil, Chevron, Elf, ETAP, Maersk, Mobil, NExT Schlumberger, Nexen, Petrobras, Petronas, Repsol, Shell, and UNI.

New Tools and Approaches in Reservoir Quality Prediction

BASIN ANALYSIS | CASE STUDY | DEPOSITS | DIAGENESIS | FACIES | INTEGRATION | MAPPING | POROSITY | RESERVOIR CHARACTERIZATION | RESERVOIR MODELING | SEDIMENT | SEQUENCE STRATIGRAPHY | SPARSE DATA

Instructor:	Dr Dave L. Cantrell (Cantrell GeoLogic and Stanford University, United States)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 to 4 live sessions of 4 hours	CPD Points: 4 to 8
	Classroom: 1 to 2 days	CPD Points: 5 to 10

NEW

Course Description

Reservoir quality prediction has historically been the "holy grail" of reservoir geologists, yet few have been completely successful at achieving this in a truly quantitative fashion. Most oil companies have traditionally based their reservoir quality prediction efforts on geostatistical models that are primarily driven by well and seismic data, usually with some input from qualitative studies of outcrop and observations of modern sedimentary processes. Prediction results from such studies are often less than optimal, especially in areas where data quality is poor and/or data coverage is sparse.

The sheer complexity of factors controlling reservoir quality in the subsurface makes prediction challenging, especially in carbonates. These factors include primary depositional texture and composition, as well as a wide variety of post-depositional modifications that occur to the sediment during and after burial. Developing quantitative tools that allow the prediction of reservoir quality ahead of the bit, and ideally pre-drill, can provide enormous benefits for both exploration and development drilling by reducing the risk associated with exploitation of heterogeneous intervals.

Reservoir quality prediction means different things to different people; this workshop outlines an approach that's based on an understanding of the geological processes that control reservoir quality, and which allows the quantitative prediction of reservoir quality (porosity and permeability) ahead of the bit. To accomplish this, this workshop first provides an overview of the main controls on reservoir quality in both clastic and carbonate rocks, and then presents a new approach to pre-drill reservoir quality prediction that involves the integration of a variety of modelling techniques to understand, quantify and predict the geological processes that control reservoir quality. Since the initial reservoir quality framework is established at the time of deposition by a variety of depositional controls, this workflow uses numerical process models to predict initial reservoir quality; results from these models are then modified via a series of other modeling technologies (compaction models, kinetic cementation models, reaction transport models, etc.) to quantify and predict various diagenetic modifications that have significantly affected reservoir quality in the interval of interest. This approach successfully integrates these two different technologies into one workflow that holistically predicts reservoir quality. Several case histories will be shown in which this approach has been successfully applied.

Course Objectives

Upon completion of the course, participants will be able to understand:

- the main controls on reservoir quality, for both clastics and carbonates
- the main principals behind a geologically process-based approach to reservoir quality prediction
- the quality and power of geologically based predictions, as well as some of the inherent limitations
- how geological process models can be used to assess uncertainty in prediction results.

Course Outline

Introduction to reservoir quality
- Controls on reservoir quality in clastic and in carbonate rocks

Introduction to geological process based modeling
- What is process modeling and how does it work?
- How process based modeling fits into an overall reservoir quality prediction framework
- What differentiates process modeling from other types of geological modeling
- Key input parameters in process modeling

Overview of process modeling in siliciclastics

Case History #1 : Modeling a Paleozoic sandstone reservoirs in the Middle East

Overview of process modeling in carbonates
- Distinctive aspects of carbonates

Case History #2 : Modeling a carbonate reservoir in the Middle East

Conclusions

Participants' Profile

The course is designed for geologists, reservoir engineers and technical managers - and for all others looking to enhance their understanding and ability to predict reservoir quality.

Prerequisites

Some knowledge of geology, geological processes, and the main challenges of reservoir quality prediction would be helpful.

Recommended Reading

Cantrell, D. L., Griffiths, C. M. and Hughes, G. W., 2015, New tools and approaches in carbonate reservoir quality prediction: a case history from the Shu'aiba Formation, Saudi Arabia: Geological Society, London, Special Publications, v. 406, p. 401-425.

About the Instructor

Dave L. Cantrell has over 35 years of worldwide geologic industrial and academic experience. He graduated from the University of Tennessee with an MSc in Geology in 1982, and from the University of Manchester with a PhD in Geology in 2004. Dave began his industry career in 1982 with Exxon where he conducted numerous reservoir characterization and geological modeling studies on reservoirs in the Middle East; the Permian, Powder River, Williston, and Gulf of Mexico Basins of the USA; and the Maracaibo and Barinas Basins of Venezuela; among others. After moving to Saudi Arabia in 1997, he conducted studies on several large carbonate fields there, and lead geologic R&D for Saudi Aramco from 2000-2008; he also served as a professor and Associate Director for the College of Petroleum Engineering & Geosciences at King Fahd Petroleum & Minerals (KFUPM) from 2015-2017. He is an AAPG Certified Petroleum Geologist, a Fellow of the Geological Society of London, and an adjunct professor at Stanford University; he has published over 40 articles in peer-reviewed journals, and holds one patent.

Well Logs and Borehole Image

CROSS-PLOTTING DENSITY INTERPRETATION OIL AND GAS RESISTIVITY SONIC WATER WELL LOG WELLS

Instructor:	Prof. Dr Michael Poppelreiter (Shell, Kuwait)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 6 live sessions of 4 hours	CPD Points: 12
	Classroom: 3 days	CPD Points: 15

NEW

Course Description

The most universal, comprehensive and concise descriptive documents on oil and gas wells are well logs. They impact the work of almost every oil field group from geologists to roustabouts to bankers. Familiarity with the applications of well logs is therefore essential for people forging their careers in the oil business.

The instructor uses a core-based approach to help participants develop a good grounding in understanding and applying well logging techniques. General principles of physics are presented to explain the functioning of modern logging tools. Wherever possible, the physics of logging measurements is related to everyday tools and applications. Cross-plotting and reconnaissance techniques quickly and efficiently discriminate between water, oil and gas. Error minimization techniques, applicable only to computerized log analysis, produce optimal results. Participants benefit from realistic experience by working in teams on a comprehensive log interpretation exercise.

Course Objectives

Upon completion of the course, participants will be able to:

- Understand geological application of the most commonly run well logs, i.e., caliper, gamma ray, sonic (velocity), resistivity, density, neutron, photoelectric factor, borehole images;
- Read log headers to understand which tool was run in which borehole environment;
- Quality control the logs;
- Block logs in geologically meaningful intervals;
- Identify lithologies using various techniques such as common cross-plots;
- Calculate net-to-gross ratio and identify pay zones;
- Interpret the depositional environment.

Participants' Profile

The course is designed for geologists, petrophysicists and stratigraphers.

Prerequisites

Basic understanding of geology and petrophysics is desirable, along with knowledge of the principles of geoscientific data management.

About the Instructor

Prof. Dr Michael C. Poppelreiter, Director of the South East Asian Carbonate Research Lab (SEACaRL), Shell Chair in Petroleum Geology at the Department of Geosciences, Universiti Teknologi PETRONAS (UTP). From October 2019 he has been working for Shell Kuwait.

Area of expertise: Shell Subject Matter Expert for carbonate geology, Outcrop and Regional Geological Studies (focus Middle East), Conceptual Modelling, Reservoir Modelling and 3D Digital Modelling, Project management, CO_2 in carbonate, Technical Assurance & Capability (TA-2), 25 publications and 2 books on borehole image logs and reservoir geology.

Reservoir Model Design: How to Build Good Reservoir Models

3D | CARBONATES | DEPOSITIONAL SYSTEM | GEOSTATISTICS | INTEGRATION | PERMEABILITY | ROCK PHYSICS | SEDIMENT

Instructors:	Dr Mark Bentley (AGR TRACS International, United Kingdom) and Prof. Philip Ringrose (Equinor and NTNU, Norway)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

This short course will provide an introduction to reservoir model design, covering the following main design elements:

- Model purpose;
- The rock model;
- The property model;
- Model scaling;
- Handling uncertainty.

In this course, Mark Bentley and Philip Ringrose share their insights into building geological reservoir models, covering clastic and carbonate sedimentary depositional systems, as well as fractured reservoirs. The connection between geology and fluid flow is developed with a focus on designing fit-for-purpose models with the consideration of implications for single-phase and multiphase flow and with examples of application to oil and gas reservoirs and to CO_2 storage. Integration of seismic data, well data and dynamic data with associated uncertainties are integral to the workflows and methods discussed. This is a shorter version of a 5-day course and so is intended as an introduction to the main concepts.

Course Objectives

Know how to approach a reservoir modelling task and assess the key design elements – distinguish between 'good' and 'bad'.

Course Outline

1. Introduction: Model Purpose (45 mins);
2. Designing the Rock Model (60 mins);
3. Property Model issues, Permeability and NTG vs TPM (90 mins);
4. Model Scaling (45 mins);
5. Handling Uncertainty (45 mins);
6. Summing up: the Design Template.

Participants' Profile

Geologists, geophysicists, petrophysicists, or reservoir engineers who have or wish to work in multi-disciplinary teams on reservoir development projects.

Prerequisites

Participants should have good knowledge of at least one component of multi-disciplinary reservoir modeling: e.g., geological modeling, geostatistics, petrophysics, rock physics, or reservoir simulation.

About the Instructors

Mark Bentley has spent most of his career working in or leading integrated study teams, initially with Shell and subsequently with TRACS (now part of AGR) where he currently designs and runs courses and directs the TRACS Training programme. His specialist fields of expertise are 3D reservoir modelling and scenario-based approaches to handling subsurface uncertainty and risk. Mark has served as a distinguished lecturer for the SPE and the EAGE, and has delivered training courses on every continent, except Antarctica.

Philip Ringrose is a Specialist in Petroleum Geoscience at Equinor. He has over 30 years of experience in reservoir modelling and field development projects. He is also Adjunct Professor in CO_2 storage at the Norwegian University of Science and Technology (NTNU) in Trondheim, Norway. He has published widely on geology and flow in rock media and is Co-Editor of Petroleum Geoscience. Philip was elected as EAGE President in 2014/2015 and is active in the global development of applied geoscience and low-carbon energy solutions.

Challenges and Solutions in Stochastic Reservoir Modelling - Geostatistics, Machine Learning, Uncertainty Prediction

GEOLOGY | GEOLOGICAL MODELLING | CROSS DISCIPLINE | RESERVOIR CHARACTERIZATION | RESERVOIR MANAGEMENT

Instructor:	Prof. Vasily Demyanov (Heriot-Watt University, United Kingdom)	
Language:	English, Russian	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW EET

Course Description

Reservoir prediction modelling is subject to many uncertainties associated with the knowledge about the reservoir and the way they are incorporated into the model. Modern reservoir modelling workflows, which are commonly based on geostatistical algorithms, aim to support development decisions by providing adequate reservoir description and predict its performance. Uncertainty about reservoir description needs to be accounted for in modelling workflows to quantify the spread of reservoir predictions and its impact development decisions.

The course aims to build awareness of the impact the modelling choices on the reservoir predictions and their relation to the way uncertainty is incorporated into reservoir modelling workflows. The course addresses the problem of tying the workflow with the expected geological vision of a reservoir subject to uncertainty. This is associated with one of the common issues, when standard assumptions of a workflow are not consistent with the model geology or do not reflect possible variations due to existing uncertainty.

The course demonstrates the implementation of geostatistical concepts and algorithms in geomodelling workflows and the ways uncertainty is accounted for in reservoir description and predictions. The course includes an overview of the state-of-the art conventional techniques and some more novel approaches, in particular machine learning for reservoir description.

Machine learning provides new opportunities in data integration and the model control to tackle the modelling challenges related to non-stationary multi-scale correlation structure and complex connectivity patterns in reservoirs. Novel machine learning techniques are good at capturing dependencies from data, when their parametric description is difficult; and controlling the impact of noisy and ad-hoc data.

Course Objectives

The objectives of the course are:

- Provide a practical overview of geostatistical concepts used in modelling workflows and their impact on reservoir models.
- Explain how uncertainty is accounted for and propagated through geomodelling workflows.
- Introduce some machine learning approaches in geomodelling through a series of case studies.
- Demonstrate integration of geomodelling techniques for uncertainty quantification of reservoir predictions.

The outcome of the course is the practical understanding the key geostatistical concepts, their implementation in reservoir modelling, principles of machine learning and its application in reservoir modelling. The course participants will get familiar with a variety of conventional and advanced stochastic modelling algorithms and become aware of the impact from different modelling assumptions.

Course Outline

- Concepts and assumptions of geostatistics
- Stochastic simulation vs interpolation
- Uncertainty quantification workflow for reservoir predication
- Machine learning techniques for spatial reservoir modelling
  - Classification - lithofacies
  - Regression – ML geomodelling
  - Dynamic model update through learning from data
- Data driven integration of relevant data and knowledge

Participants' Profile

The course is designed for a wide audience of reservoir modellers, geologists and engineers with range of experience from novices to experienced practitioners.

Prerequisites
Participants should have a basic knowledge of reservoir modelling and numerical analysis.

About the Instructors
Prof. Vasily Demyanov of Institute of Petroleum Engineering, Heriot-Watt University (Edinburgh), lectures geostatistics and leads industry and government funded research in Geo Data Science and uncertainty quantification for reservoir prediction modelling. He has over 20 years of experience in geostatistics and has published over 100 publications. Vasily has co-authored a number books: Challenges and Solutions in Stochastic Reservoir Modelling – Geostatistics, Machine Learning, and Uncertainty Predictions with EAGE (2018); Geostatistics: Theory and Practice (Nauka, 2010, in Russian). Vasily Demyanov is an Associate editor for Computers and Geosciences Elsevier journal and a guest editor for Mathematical Geosciences Springer Journal special issue on Data Science in Geoscience due in 2019.

Vasily's research interests lie broadly across spatial statistics, machine learning and uncertainty. In particular his research is focused on uncertainty quantification in prediction modelling, inverse modelling for history matching, stochastic optimisation, Bayesian inference, and the problem of integration of reservoir knowledge and relevant data into statistical modelling workflows with machine learning and data analytics approaches.

Vasily Demyanov obtained the first degree in physics from Moscow State University (1994) and a PhD in physics and mathematics from Russian Academy of Sciences (1998) with a thesis on radioactive pollution modelling with geostatistics and artificial neural networks. Prior to joining Heriot-Watt in 2003 he worked with the University of St. Andrews (2000-2002) and Nuclear Safety Institute, Moscow (1994-2000).

Construction of Fractured Reservoir Models for Flow Simulation Incorporating Geology, Geophysics, and Geomechanics

ANISOTROPY | FLOW SIMULATION | FRACTURES | GEOMECHANICS | HISTORY-MATCHING | INVERSION | OUTCROP | RESERVOIR CHARACTERIZATION | RESERVOIR ENGINEERING | RESERVOIR MODELING | UNCONVENTIONAL

Instructors:	Reinaldo Michelena (SeisPetro Geoconsulting, United States), Chris Zahm (UT Austin, United States), James Gilman (iReservoir, United States)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

Flow models have the purpose of explaining and forecasting reservoir performance that can help plan the development and exploitation of the resource. This class explains the steps needed to build fractured reservoir models using sound stratigraphic and structural frameworks, calibrated 3D seismic attributes, and geomechanical information. Models and concepts are examined in the context of how they impact fluid flow, reservoir simulation results, field production, and forecast in conventional and unconventional reservoirs. This 2-day course presents workflows along with conceptual and spreadsheet-based exercises to solidify concepts. The course provides in-depth presentations and discussions of the models presented.

Course Objectives

- Highlight geologic concepts that control natural fracture development in conventional and unconventional reservoirs.
- Value characterization methods that incorporate the use of 3D seismic data for improved mapping of mechanical facies and fracture properties
- Discuss workflows that combine geologic and geomechanics concepts, petrophysical properties, and seismic attributes within geological models in preparation for reservoir simulation.
- Quantify the combined effect of fracture properties and geomechanical properties in effective flow properties of simple fracture scenarios.
- Understand the need of combining multiple disciplines and data sources to develop an adequate flow model.
- Understand that fracture models are not platform- or software-specific, but utilize and blend all available data and relevant analogs.
- Understand that consistently developed continuum and discrete fracture models can yield very similar results.
- Model effective fracture permeabilities in a cell of a geologic model and understand the parameters that control such permeability.

Course Outline

Session 1

- Natural fractured reservoirs: overview and concepts
- Impact of natural fractures on reservoir performance: overview
- Tight unconventional reservoirs: mechanical stratigraphy in core, well logs, and seismic
- Tight unconventional reservoirs: use and value of outcrop analogs
- Tight carbonate mechanical stratigraphy interpretation
- Reservoir engineering data for of naturally fractured reservoirs

Session 2

- Tight unconventional reservoirs: seismic properties for fracture characterization
- Discrete vs continuum natural fracture descriptions for simulation in fractured reservoirs
- Tight unconventional reservoirs: geomechanics review
- Effective fracture permeability·

Session 3

- Tight unconventional reservoirs: modeling perm of reactivated fractures
- Pressure transient response time
- Conventional fractured reservoirs: overview and concepts
- Conceptual integrated fault damage zone model
- Value of outcrop analogs in fracture modeling
- Conventional fractured reservoirs: facies, rock properties in core and well logs

Session 4

- Conventional fractured reservoirs: rock properties from 3D seismic
- Calibration of effective fracture permeabilities
- Special considerations for flow simulation in fractured reservoirs
- Putting it all together: Integration of outcrop, core, well logs, and seismic for improved reservoir models

Participants' Profile

Due to its multidisciplinary nature, this class is designed for all levels from entry to advanced.

Prerequisites

None

About the Instructors

Reinaldo J Michelena is reservoir characterization and geophysical advisor. He has a Ph.D. in geophysics from Stanford University and a B.S. in physics from Universidad Simón Bolívar (Venezuela). He has over 35 years of experience in research, development, and application of seismic methods to help reservoir delineation and characterization, from prototyping, programming and testing of algorithms to integrated interpretation of field data results.

Chris Zahm is a Research Geologist at the Bureau of Economic Geology at the University of Texas at Austin. He received his Ph.D. in 2002 from the Colorado School of Mines as a structural geologist and has M.Sc. degree from the University of Texas at Austin in Hydrogeology and B.S. in Geology from the University of Wisconsin-Madison. With more than 25 years of experience working fractured reservoir systems in both industry and academia, Chris has focused on characterizing and modeling natural fracture systems in subsurface reservoirs from around the world including onshore US, Norwegian North Sea, Indonesia, offshore Brazil, Bolivia, and the Middle East.

James Gilman provides reservoir engineering and flow simulation consultation with more than 40 years of experience. His expertise includes specialization in the area of application and development of numerical simulators for fluid flow in petroleum reservoirs. He has been involved in development of 3-phase simulators for naturally fractured reservoirs. He is actively involved consultation in the areas of reservoir engineering, reservoir simulation, naturally fractured reservoirs, and unconventional reservoirs. He has extensive training experience in these areas through Marathon, iReservoir and Nautilus.

Sedimentary Rocks and Depositional Environments

BASIN ANALYSIS | CONTINENTAL MARGIN | CORES | LITHOLOGY | OUTCROP | RESERVOIR CHARACTERIZATION | SANDSTONE | SEDIMENTS | SHALE | THIN SECTION | TURBIDITE

Instructor:	Prof. Dorrik Stow (Heriot Watt University, United Kingdom)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 3 live sessions of 4 hours	CPD Points: 6
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

Sedimentary rocks and their depositional environments are fundamental to all aspects of petroleum geoscience, including evaluation of the petroleum system, exploration, field appraisal, reservoir characterisation and development, and solving production issues. Equally, they are fundamental to the study of stratigraphy, mineral resources, water resources and global environmental change.

Sediments deposited in rivers and deserts, deltas and deep-sea fans, coasts, shelves and contourite drifts, bioherms and carbonate platforms, all differ significantly in their rock properties, diagenetic character, heterogeneity and architecture. Such differences are key to understanding their behaviour as source rocks, migration pathways, reservoir rocks and seals, in both conventional and unconventional hydrocarbon systems.

This course is designed to give the participant a succinct, state-of-the-art, overview of sediments, sedimentary rocks and their principal characteristics, thereby providing a broad understanding of the range of sedimentary environments and the rocks they comprise. It covers clastic, carbonate, evaporite and volcaniclastic sediments, and the full range of settings in which they are deposited – including continental, shallow marine and deepwater depositional environments. Careful consideration is given to the principal diagnostic features of sediments from the main environments – in the field, in cores/boreholes, and in modern systems. Rock features include sedimentary structures, ichnofacies, textures, composition, petrophysical characteristics, and biogenic/organic content. For each environment, selected wireline logs will be examined, and the overall rock geometry or architectural elements discussed. A series of case studies will illustrate a range of hydrocarbon fields and plays from each of the main depositional environments.

The presentations are fully illustrated with high quality colour images of sediments and sedimentary rocks from a wide range of modern, ancient and subsurface examples. Where possible the course can be run in conjunction with examination of cores in the lab, and/or with field work, in order to better illustrate key features.

The course will build on the handbook Sedimentary Rocks in the Field (Stow, 2005) and the new edition in preparation, Sedimentary Rocks in the Field and Core (Stow and Gerard, 2021). Each participant will receive a copy of the latest revised edition of this book as well as a full set of the PowerPoint presentations.

Course Objectives

Upon completion of the course, participants will be able to:

- UNDERSTAND the economic and environmental significance of sedimentary rocks
- APPRECIATE the full range of sedimentary rocks and their key differences
- RECOGNISE the nature and origin of the principal sediment characteristics
- DISTINGUISH between types of sedimentary rocks – modern, ancient and subsurface
- EVALUATE sediments in terms of the processes and environments of deposition
- ASSESS and interpret facies associations, sequences and architectural elements
- FOCUS on source, reservoir and seal properties of different sediment types
- RESOLVE clearly and simply between different depositional environments in the subsurface
- GAIN an astute understanding of what questions to ask and what analyses to make
- BECOME a better 21st century sedimentologist

Course Outline

Unit 1: Introduction and Overview.

- Course aims and content
- Classification and properties of sedimentary rocks
- Interpretation of depositional environments
- Methods of study: field, core and laboratory
- Significance: resources, water and the environmental record

Unit 2: Principal characteristics of sedimentary rocks.

- Introduction and facies concept
- Bedding and lamination
- Primary structures: erosional and depositional
- Secondary structures: post-depositional deformation & dewatering
- Biogenic structures: trace fossils, bioturbation, ichnofabrics and ichnofacies
- Chemogenic sedimentary structures
- Sediment texture and fabric: grain size, sorting, grain fabric
- Sediment composition and colour
- Principal diagenetic changes: physical and chemical

Unit 3: Siliciclastic sedimentary rocks
- Conglomerates: definition, types, characteristics, classification, occurrence
- Sandstones: definition, types, characteristics, classification, occurrence
- Mudrocks: definition, types, characteristics, classification, occurrence
- Hydrocarbon significance: source, reservoir and seal

Unit 4: Biogenic sedimentary rocks
- Carbonate rocks: definition, types, characteristics, classification, occurrence
- Cherts and siliceous sediments: definition, types, characteristics, classification, occurrence
- Phosphorites: definition, types, characteristics, classification, occurrence
- Coal: definition, types, characteristics, classification, occurrence
- Hydrocarbon significance: source, reservoir and seal

Unit 5: Chemogenic sedimentary rocks
- Evaporites: definition, types, characteristics, classification, occurrence
- Ironstones: definition, types, characteristics, classification, occurrence
- Soils, paleosols and duricrusts: definition, types, characteristics, classification, occurrence

Unit 6: Volcaniclastic sedimentary rocks
- Definition, range of types and classification
- Principal sedimentary characteristics and occurrence
- Hydrocarbon significance: source, reservoir, seal and correlation

Unit 7: Interpretations and depositional environments
- Building blocks: facies characteristics and models
- Vertical sequences and cycles, wireline log characteristics
- Lateral trends and geometry
- Architectural elements and facies associations
- Sequence stratigraphy and bounding surfaces
- Controls, rates and preservation

Unit 8: Depositional environments summary
- Principal characteristics of each of the main depositional environments
- Hydrocarbon case studies from each of the main depositional environments
- Case studies and exercises throughout course
- Optional special topics – to be discussed in advance
- Potentila for core session in core lab and/or for complementary field work
- Each participant will receive a full set of the PowerPoint presentations
- Each participant will receive a copy of the latest revised edition of the instructor's book:
  - Stow, 2005, Sedimentary Rocks in the Field, CRC Taylor & Francis Group

Participants' Profile

The course is designed for all geologists, geophysicists and petroleum engineers involved in exploration and development. Project managers and senior management would also benefit from such a course as a refresher.

Recommended reading

- Boggs S, 2009 (Second edition). Petrology of Sedimentary Rocks, Prentice Hall
- Leeder MR, 2011 (Second edition). Sedimentology and Sedimentary Basins: From Turbulence to Tectonics, Blackwell Science
- Maynard JB, Potter PE, Depetris PJ, 2005. Mud and Mudstones: Introduction and Overview, Springer
- Reading HG, editor, 1996 (3rd edition) Sedimentary Environments and Facies, Blackwell
- Selley RC, 2000. Applied Sedimentology, Academic Press, San Diego.
- Stow DAV, 2005. Sedimentary Rocks in the Field, CRC Taylor & Francis Group

About the Instructor

Professor Dorrik Stow FRSE is a leading specialist and internationally renowned expert in sedimentary systems, with over 40 years experience in modern, ancient and subsurface sediments. He has a particular interest in deepwater hydrocarbons, including numerous joint research projects with industry, individual consultancies, short course and field course organisation. His extensive record of scientific publications includes over 300 scientific papers and reports, numerous books and edited volumes. He has also worked closely on continental, shallow water, deltaic and carbonate systems from across the world.

Professor Stow is a lively, interesting and highly informed instructor. He is a seasoned presenter to audiences large and small, specialist and generalist. He is able to draw upon a great wealth of experience and examples to fully illustrate his presentations, and utilizes short course exercises for further instruction. His teaching and instruction has been highly acclaimed at all levels. He has worked with many different oil and gas companies in the provision of in-house or collective courses, field and core workshops, and in collaborative research projects.

His recent text Sedimentary Rocks in the Field (Manson, 2005) is a must-have for students and professional geologists alike, while Oceans: An Illustrated Reference (Oxford University Press and University of Chicago Press, 2004) and, more recently, Vanished Ocean (Oxford University Press, 2010) are written as popular science. He has worked both in industry and university and is currently Emeritus Professor (Petroleum Geoscience) at Heriot Watt University (Edinburgh, UK), Distinguished Professor at the China University of Geoscience (Wuhan, China), and Leverhulme Emeritus fellow. Professor Stow has been an enthusiastic lecturer and speaker throughout the world, on everything from deep-sea turbidites to the Lost Tethys Ocean.

Geophysics

- SEISMIC ACQUISITION •
- SEISMIC PROCESSING •
- SURFACE IMAGING •
- INTEGRATED GEOPHYSICS •
- MINERAL EXLORATION •
- RESERVOIR CHARACTERIZATION •

Advanced Marine Seismic Acquisition Techniques

3D | OBC | P-WAVE | PRM | RESERVOIR ENGINEERING | SIMULTANEOUS SOURCE | WIDE AZIMUTH

Instructor:	Dr Mike Branston (WesternGeco, United Kingdom)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 to 4 live sessions of 4 hours	CPD Points: 4 to 8
	Classroom: 1 to 2 days	CPD Points: 5 to 10

NEW

Course Description

The course is designed to familiarize the student with the latest developments in Marine Seismic Acquisition including Wide-Azimuth with its many geometry variants, Broadband techniques (boosting the high and low frequencies), seabed receivers for both P-wave and Converted-wave recording, simultaneous source acquisition, and methodologies to improve efficiency. The course starts with an overview of conventional 3D towed streamer seismic acquisition and then concentrates on recent advances that have enabled dramatic improvements in seismic data quality and interpretability. While the development of 3D marine seismic acquisition since the 1980s has been arguably the single most effective technique in improved drilling success, the recent addition of "true 3D" or "wide-azimuth" techniques has led to improved sub-surface illumination and imaging. In addition to improved imaging, improved resolution has been achieved through so-called broadband techniques achieved through novel source and streamer geometries and multi-component receivers. The course compares wide-azimuth towed streamer seismic acquisition as well as sea-bed seismic acquisition, ocean bottom cable (OBC) and ocean bottom node (OBN). Design and practical implementation considerations are reviewed; together with relative cost-benefits. In the case of sea-bed seismic, the value of multi-component recording is reviewed. Broadband seismic techniques are explained in terms of source and receiver design, practical implementation and interpretational benefits. The course reviews the latest developments in simultaneous source technology, which are attempting to improve the data density and / or operational efficiency of seismic acquisition. Finally the course reviews the other operational methodologies and designs that have been developed to improve acquisition efficiency.

Course Objectives

A practical approach is adopted and is designed to provide the student with an up-to-date understanding of recent developments in marine seismic acquisition technology. At the end of the course the student will be able to understand why and where these new technologies are applicable, understand what studies are required to design new surveys and understand the relative costs of acquiring and processing the seismic data compared to conventional acquisition.

Participants' Profile

The course is designed for geophysicists and explorationists who wish to gain an overview of recent developments in 3D marine seismic acquisition. Participants are assumed to have a working knowledge of conventional seismic acquisition techniques and their use in exploration and development of hydrocarbon resources.

Prerequisites

Participants should have a working knowledge of conventional seismic acquisition techniques and their use in exploration and development of hydrocarbon resources.

About the Instructor

Mike Branston manages WestenGeco's Solution Design and Modeling activities across the Eastern Hemisphere. He has been based in Norway, Malaysia and the UK. Mike holds both a BSc and a PhD in geophysics and was awarded Chartered Geologist status by the Geological Society of London in 2006.

Since 2014 he has volunteered his time and expertise to assist the PESGB (Petroleum Society of Great Britain) in the organisation of their biannual petroleum exploration conference (PETEX); initially as a member of the technical committee and more recently as chairman of that committee.

The Benefit of Broadband Technology for Reservoir Characterization and Imaging – the End-User Value

APPRAISAL | BROADBAND | CASE STUDY | INTERPRETATION | INVERSION | MARINE ACQUISITION | OFFSHORE | RESERVOIR | SEDIMENT

Instructor:	Dr Cyrille Reiser (Petroleum Geo-Services, United Kingdom)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

The main aim of this course is to provide a very accessible overview of the many concepts behind broadband seismic (primarily offshore) and its implication for the reservoir focused asset based geoscientist. This will be done through the a very comprehensive set of case study material from all regions of the world and for various stages of the exploration, appraisal and development asset life cycle. The course aims to objectively discuss the various broadband seismic technologies and commercial offerings available today and their respective merits with regards to quantitative reservoir characterization and reservoir imaging using real world application examples. The course will further attempt to identify possible pitfalls and issues with regards to the treatment of broadband data that might lead to flawed or erroneous QI.

Course Objectives

Upon completion of the course, participants will be able to understand the value of broader bandwidth seismic data in general and for quantitative reservoir analysis from interpretation to rock property estimation in particular. The course is intended to be very applied and hands on and will only review the very basic concepts of inversion based rock property analysis and quantitative interpretation but will otherwise focus on examples to illustrate the benefit of extended bandwidth seismic.

Course Outline

Course schedule:

- What is broadband seismic?
- Potential benefits
- Exploration case studies
- Appraisal development case studies
- What next?

Participants' Profile

The course is designed for geoscientists with a basic level of geophysical knowledge, including a general knowledge of towed streamer acquisition and processing methods but the content is designed to be accessible for most geoscientists working with or interested in using broadband seismic in their day-to-day working life. In other words, definitely no requirement for expert knowledge.

About the Instructor

Dr Cyrille Reiser holds a Ph.D in 1998 from Lyon's Ecole Normale with the title "Automatic recognition of genetic sequence and sedimentary bodies by wireline log shape analysis". He worked for 10 years with CGG prior to join and develop in end of 2008, the Reservoir Characterisation Group in PGS Reservoir. He is presently the Reservoir Characterisation Director for PGS Reservoir.

Time-Lapse Seismic: A Multidisciplinary Tool for Effective Reservoir Management

4D | FLUID | GRM | INJECTION | MONITORING | OIL AND GAS | PRM | PRODUCTION | WORKFLOWS

Instructor:	Cedric Fayemendy (Equinor, Norway)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

Geophysical Reservoir Monitoring (GRM) of reservoirs relies on frequent time-lapse observations with high-survey repeatability. This technology is a key enabler for maximizing the oil recovery of oil and gas fields. The GRM technology aims at understanding and updating the knowledge of producing reservoirs. This is achieved through mapping the movement of fluid and pressure fronts and fluid contacts during production and injection. The combination of production monitoring with repeated seismic acquisition and geological and reservoir information provides reliable estimates of static and dynamic reservoir parameters. The lecture will first review the geophysical reservoir monitoring history at Equinor. We will share our experience with 4D processes, resources allocation and the overall monitoring strategy. The lecture will also cover challenges in understanding the 4D responses and value creation. Finally, we will look at how we push the GRM technology towards higher use of quantitative results.

Course Objectives

The purpose of this course is to provide an overview of the importance and the benefit of time-lapse seismic.

Course Outline

- Theory of time lapse monitoring
- How do we plan for time lapse seismic?
- The value of acquiring time lapse data.
- How are time-lapse data managed by the asset and integrated in the reservoir management process.
- An overview of the latest developments in time-lapse monitoring in Equinor including PRM.

Participants' Profile

This course should be of interest to managers, geoscientists, reservoir and petroleum engineers with an interest in reservoir management and monitoring using time-lapse seismic.

About the Instructor

Cedric Fayemendy is currently working with in Equinor with reservoir monitoring. He holds a master degree in Geophysics (1998) from University of Paris VI. He joined Equinor in 2010 after spending 12 years in the oil industry working with Schlumberger and ConocoPhillips.

Land Seismic on New Technological Level

3D BROADBAND FULL AZIMUTH MULTICOMPONENT REFRACTION
RESERVOIR CHARACTERIZATION STATICS SURVEY DESIGN VIBROSEIS

Instructor:	Dr Anatoly Cherepovskiy (Independent Consultant, Russia)	
Language:	English, Russian	
Level:	Foundation	
Duration and formats:	Online: 2 to 4 live sessions of 4 hours	CPD Points: 4 to 8
	Classroom: 1 to 2 days	CPD Points: 5 to 10

NEW

Course Description

This course will provide information related to recent trends and advances in land seismic data acquisition technology, equipment and the methodologies that are being utilized to improve seismic imaging quality and productivity of 3D acquisition with an emphasize on the high-end surveys as performed in open areas. The course will not cover the fundamentals of 3D and multicomponent seismic survey design, although there will be a section that will give a review of recent survey design approaches and principles.

Course Objectives

The purpose of this course is to:
- provide an overview of trends in 3D land seismic and achievements;
- understand trade-offs in modern field technologies;
- understand the ways to improve seismic imaging and data conditioning for better reservoir characterization.

Course Outline

1. Introduction
2. The revolutions and trends in 3D land seismic and evolution in survey design, field equipment, and acquisition techniques. The criteria of field data quality. The role of global positioning systems. Arrays versus point receivers and point sources Intra-array statics (synthetic and field-data examples), non-vertical ray emergence, and other factors degrading high-frequency content of acquired data and distorting amplitudes and AVO effects. Is there a compromise between high-frequency preservation and S/N ratio improvement? Digital array forming.
3. Wide-azimuth and high-density surveys
   Breakthrough in seismic imaging with HD and WAZ data. More receivers or more sources? New types of attributes extracted from HD and WAZ data to better characterize complex and fractured reservoirs.
4. Excitation and recording of wideband seismic signals
   Why do we need broadband signals? Types of velocimeters and accelerometers. Low-dwell and other nonlinear sweeps. Field data examples.
5. 3C sensors and multi-component seismic
   Advantages of 3C single sensors from operational and geophysical points of view. Multicomponent seismic with MEMS accelerometers: expectations and practical achievements. Ray-tracing and finite-difference modeling studies.
6. Multiple-fleet and high-productivity vibroseis techniques
   New paradigm in seismic exploration: better sampling of noise and signal. The issues of data and equipment QC in high-productivity vibroseis.
7. Diversity stack in noisy areas
8. Cableless recording systems
   Innovative technologies enabling a new generation of recording systems without cables and radio: the importance of GPS in the evolution of land seismic acquisition techniques. Where cableless systems are applicable? Full cableless and infill modes. Testing of autonomous (nodal) and real-time recording systems in Russia.
9. Conclusions
   Not all acquisition techniques are equal (status in Russia vs. Middle East and North America)
   What will be high-end land 3D surveys in the future: point 3C acquisition? A mix of cable and cableless, very dense and very noisy data?

Participants' Profile

The course is appropriate not only for geophysicists involved in land survey design, acquisition, and modeling, but also for those involved in data processing and interpretation who wish to better understand the potential improvements that can be made.

Prerequisites

The course assumes familiarity with basic seismic acquisition techniques and equipment. No mathematical background is required, since physical concepts are graphically illustrated. A comprehensive list of references is given in the book.

Recommended Reading

Meunier, J., 2011, Seismic acquisition from yesterday to tomorrow: Distinguished Instructor Short Course, SEG / EAGE, Tulsa, OK USA.

About the Instructor

Anatoly Cherepovski received an MSc in Geophysics from Moscow State University in 1980. He joined OZGEO overseas geological exploration company (Moscow) and carried out seismic data processing including almost two years at the field data processing centre in Yemen. In 1991 he obtained a PhD at VNIIGeofizika Research Institute (Moscow) with a dissertation titled fImproving efficiency of vibroseis investigations in frontier areasf.
In 1995 he joined Petrosystems division of CGG (Moscow) as a project manager. From 1998 to 2004 he worked for Green Mountain Geophysics (GMG), later I/O GMG, where he was involved in 3D survey design, refraction statics determination, and benchmark data processing. He presented courses on seismic survey design and refraction statics to numerous companies in Russia and CIS. In 2004 he joined I/O full-wave team and was involved in 3D/3C model-based survey design, ray-trace and finite-difference modeling. From 2008 to 2016 he served as regional geophysicist for Sercel, Moscow office, and provided consultancy on multicomponent equipment and survey design, high-density single-sensor and single-source seismic, broadband seismic, and high-productivity vibroseis techniques. From 2017 he works as seismic expert for NewTech Services company, Moscow office, and provides consultancy on cableless recording systems and high-density 3D surveys.
Anatoly is a member of EAGE, SEG, and EAGS (EurAsian Geophysical Society). He is the author of English-Russian and Russian-English Dictionary of Exploration Geophysics, EAGE, 2008.

Land Seismic Survey Design

3D BROADBAND IMAGING INTEGRATION INVERSION LAND SEISMIC MODELING NOISE SENSORS SIGNAL PROCESSING SIMULTANEOUS SOURCE VIBROSEIS WIDE AZIMUTH

Instructor:	Paul Ras (SD2I Geophysical Consulting, Netherlands)	
Language:	English, Dutch	
Level:	Intermediate	
Duration and formats:	Online: 3 live sessions of 4 hours	CPD Points: 6
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

This course presents an integrated approach to modern land 3D seismic survey design as it has a key role in the seismic value chain going from acquisition to processing, imaging and inversion & characterization. It will describe the main technology advances in land seismic acquisition: high-channel count single sensor (point receiver), simultaneous source high-productivity vibroseis, broadband and wireless nodal systems. New acquisition technology has in turn inspired progress in processing, imaging and inversion & characterization. Seismic survey designs have changed accordingly, wide azimuth high-density surveys are now the norm in many environments. And the survey design workflow now includes single sensor, single source, simultaneous source, broadband, symmetric sampling, cross-spreads, spatial continuity and more powerful 5D interpolation methods. It has also become more integrated, with requirements from processing, imaging and inversion & characterization feeding back to the design and hence acquisition.

Course Objectives

The purpose of this course is to understand:

- The main parameters related to land survey design;
- The generic land seismic survey design workflow;
- The impact of the new acquisition technology on survey design;
- How design and acquisition affects processing, imaging and inversion and characterization.

Course Outline

1. Introduction: setting the stage discussing the survey design process as part of the seismic value chain and from the perspective of integrated project design;
2. Survey design workflow: generic survey design workflow introducing the basic design parameters and explaining how they are estimated. Among other things this involves survey objectives, resolution, signal and noise. In the next sections, we will show the impact of the new technologies;
3. The advent of high-channel count systems has enabled single sensor (or point receiver) recording. This can provide unaliased sampling of signal and noise enabling easy removal of in particular near surface source generated noise;
4. Simultaneous source hi-productivity vibroseis: acquiring data from multiple (groups or single) vibrators simultaneously from different source locations, which can improve spatial sampling and reduce cost by increasing productivity;
5. Broadband: driven by imaging and inversion requirements, there has been a major technology effort to increase bandwidth, mostly on the low but also on the high frequency side of the spectrum;
6. Wireless nodal systems significantly improve operational flexibility in restricted areas; increasingly being used with single sensors. Nodal technology is developing fast with higher channel counts while improving Wifi & Bluetooth technology enables better QC;
7. The impact of survey design at the data processing stage includes receiver sampling for adequate noise suppression, improved source sampling for well sampled gathers (cross-spread, source, receiver) and fold (trace density). When we design the survey, we can for instance ensure well interpolated & regularized input to imaging, understanding of multiple behaviour, and enable good surface wave inversion for near surface modeling;
8. At the imaging stage we should ensure spatial continuity, good spatial sampling (CMP bin), trace density, azimuth/offset sampling for azimuth preserving OVT migration, sufficient migration aperture and bandwidth. We can model for good illumination;
9. To ensure optimum inversion – in particular pre-stack and AVOAz – and reservoir characterization, wide azimuth, high-density survey designs can provide good azimuth/offset sampling and S/N. Low frequency data (broadband) will reduce the dependency on well data, high frequency data and good spatial sampling will optimize resolution;
10. Finally, there will be a quick look at some future developments like ongoing research efforts in the area of vibroseis sources, simultaneous sources and wavefield interpolation.

Participants' Profile

Acquisition geophysicists who are naturally involved in survey design but also processing geophysicists and interpreters who wish to understand how acquisition programmes can be tailored to tackle their problems. The course may also be beneficial to geoscience (geophysics and geology) students.

Prerequisites

Participants are assumed to have basic knowledge of seismic acquisition and processing techniques.

About the Instructor

With more than 20 years industry experience principally with Schlumberger, Paul Ras has worked in land seismic acquisition, survey evaluation & design, data processing, inversion & reservoir characterization. He is currently a geophysical consultant based in the Netherlands, teaching and consulting for Schlumberger NExT and working with geophysics startups. Paul began his career at TNO Institute of Applied Geoscience and Delft Geophysical in the Netherlands, working in software development and as a seismologist on field crews. He then worked in various roles for Geco-Prakla, on crews and in the survey evaluation and design group. After a three year secondment at Saudi Aramco followed by starting up WesternGeco's data processing center in Saudi Arabia, he moved to inversion and reservoir services working for Schlumberger's DCS segment based in Cairo. Then came various technical and project management roles mainly involving new technology like the land UniQ acquisition system, land demultiple processing and seismic guided drilling. From 2013 until 2015 he worked as a land area geophysicist for WesternGeco based in the UK. Paul is a graduate in Applied Geophysics from Delft University of Technology in the Netherlands.

Integrated Seismic Acquisition and Processing

3D DENSE SURVEYS DYNAMITE IMAGING INTERPRETATION LAND SEISMIC MAPPING MIGRATION NEAR SURFACE OBC OFFSHORE ONSHORE SAND SENSORS SPARSE DATA SURVEY DESIGN VIBROSEIS WAVE PROPAGATION

Instructor:	Jack Bouska (Independent Consultant, Canada)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 to 4 live sessions of 4 hours	CPD Points: 4 to 8
	Classroom: 1 to 2 days	CPD Points: 5 to 10

NEW

Course Description

A significant transformation is sweeping the seismic industry. The maturing of simultaneous source shooting, the introduction of ultra-small-lightweight autonomous recorders, along with the complimentary development of a new generation of highly portable, miniaturized impulsive seismic sources, all represent a true revolution in seismic acquisition technology. These new inventions are not only reducing the cost of conventional seismic, but are enabling ultra high-quality 3D's with mega-dense spatial sampling, in ways that were unimaginable only a decade ago. To truly take full advantage of these recent innovations in source and recording technology requires abandoning some outdated survey design and data processing practices in favor of more appropriate methods tailored to modern seismic surveys. This course covers the full breadth of knowledge and tools required to select and adjust survey design parameters for optimum imaging of the subsurface target, while honoring equipment limits and surface constraints. Students will learn a practical set of survey design techniques, using a combination of both presentations and in-class exercises, which are reinforced using specific examples of cutting-edge seismic acquisition projects from around the globe.

Course Objectives

Each participant will gain exposure to the core principals of seismic 3D survey design, along with practice in selecting a balanced set of 3D acquisition geometry parameters for both optimum field implementation and competent data processing. Students will also learn how those parameter choices directly affect acquisition operations, data processing and the quality of the final image volume.

Course Outline

- Foundations of seismic system integration and subsurface mapping;
- Methods of acquiring seismic data, to image the subsurface;
- Optimum processing of wide azimuth seismic data, to image the subsurface;
- Introduction to the survey design study, a data driven investigation into survey objectives, mapping requirements and geographic constraints;
- The survey design procedure, techniques for selecting a balanced set of 3D geometry parameters;
- Offshore Ocean Bottom Seismic 3D survey design, with worked examples;
- Onshore 3D seismic surveys using explosive sources, with worked examples;
- Onshore 3D seismic surveys using Vibroseis sources, with Simultaneous Source examples.

Participants' Profile

The course is designed for:

1. Seismic acquisition specialists who wish to learn more about designing cost-effective acquisition programmes, that are well matched to state-of-the-art processing and imaging techniques, along with strategies to exploit the future of high channel count crews in order to create ultra-high quality images;
2. Seismic processing specialists who wish to learn about how acquisition geometry parameter choice directly affects the ability to attenuate noise, and image the subsurface, in the context of a modern processing scheme
3. Seismic interpreters with a desire to know more about both of the above.

Prerequisites

Participants are assumed to possess a working knowledge of the reflection seismic method and its use in exploration and reservoir management.

About the Instructor

Jack Bouska graduated with a Geophysics degree from the University of Alberta (1980), and started working at Seiscom-Delta (1981) then moved to Western Geophysical (1983), before joining Dome Petroleum in 1985, persevering through the Dome-Amoco-BP mergers of 1988 & 1998. His career included residence in; London U.K., Muscat Oman, and Calgary Alberta, while tackling a wide variety of projects spanning across five continents. Initial projects included revitalizing cost effective exploration for Amoco Canada using his invention of Sparse-3D, later expanding into the S. American Andes, designing and acquiring some of the world's largest Heli-portable 3D's. His innovation at BP continued with novel acquisition techniques for Seabed OBC-3D's in the North Sea, Caspian Sea, Gulf of Suez, Abu Dhabi, Indonesia and West of Shetlands. While in the UK, Jack also acted as team Leader for the upstream technology Reservoir Management team, prior to moving to Oman as the Middle East region Seismic Delivery Manager, where he instigated several ultra-high speed Vibroseis surveys made possible by his invention of Distance Separated Simultaneous Sweeping (DS3). While in Oman, he also invented a new type of seismic sensor and autonomous node recorder, resulting in several patents (as inventor) and a commercial implementation (the BP-Schlumberger-Rosneft Nimble Node). In 2013 he moved back to Calgary as regional seismic delivery manager for BP's Oil Sands and Canadian offshore seismic programs, before retiring in 2015, and turning his attention to industry training and consultation. As an author of more than 50 industry papers and technical presentations, Jack's innovations in seismic acquisition design and processing have been recognized by numerous geophysical societies; including the CSEG with the Best Theme Paper award in 1995, Best of Session papers in 1997 & 98 and best technical luncheon talk of 2014. The SEG also awarded Jack the Best Paper in the Leading Edge 2005, and Honourable Mention in Best Paper category, 2005 National convention. Jack has served as an EAGE Distinguished Lecturer for 2007-2008 and in 2009, the Society of Exploration Geophysicists selected him as the spring SEG Distinguished Lecturer in Geophysics. Jack is an active member of the EAGE, SEG, CSEG, and APEGA.

Seismic Acquisition Project Essentials: from Concept to Completion and Beyond

FINANCE | HSE | PROCUREMENT | PROJECT MANAGEMENT | SCOUTING | SEISMIC SURVEY

Instructor:	Jan de Bruin (Independent Consultant)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 2 to 4 days	CPD Points: 10 to 20

NEW

Course Description

Existing courses and books with the title 'seismic acquisition' typically deal with designing seismic surveys, and sometimes also with processing and evaluation of the acquired data.

Design : Although I treat design in a somewhat less conventional way, it is an important part of this course too, but other equally important subjects receive equal attention. These are: Clients : We need to know who our clients are and understand what they want and why they want it. Without them and their support we won't have a project, and there will be no point designing a seismic survey.

Finance : It would be unfortunate to have the best possible design in the world that will achieve your clients' objectives and find out that it is too expensive and the company will not set a budget aside for it.

Procurement : A seismic survey is usually not bought "off the shelf". We need to identify companies that can carry out the seismic survey according to our design and our HSE requirements. We need to sign a contract with the company that we select to do the work. The course will also look at this from the perspective of seismic companies.

Scouting : In order to come up with a good design that is not too expensive it is essential to scout the area where seismic data is to be acquired. Scouting costs relatively little and helps to avoid unpleasant and expensive surprises during execution.

Communities : For the duration of the survey, and in case of success for many years thereafter, we will be co-habitants of the area together with the people who have lived there for generations. Those people can and often will have a significant influence on the project and can make it impossible to complete it.

Execution : Even with good preparation, unexpected things will happen when the work in the field starts, making life more complex and more interesting. When a crew of 1000 people is at work or a 10 streamer vessel is acquiring data there is little room for mistakes and not much time to decide what to do.

Equipment : Equipment changes faster than any of the other elements in this course. Ever since the beginning of seismic acquisition these changes have been towards larger quantities, better quality and lower prices for seismic sources and receivers. This process is expected to continue and the equipment used today may be very different from equipment that will be used in the seismic industry 10 years from now.

Project management and Safety : These are the two pillars on which any good project rests. Good project management includes good safety management. One could even argue that the two are largely the same. Seismic acquisition is an industry where significant hazards exist and serious accidents still happen. These can and must be avoided.

Course Objectives

To make seismic acquisition projects more successful.
This is done by:

- better understanding the goals of clients of seismic surveys
- better preparing for a seismic survey, through scouting
- making a better design of the survey (design is also covered in other courses)
- learning how to improve relations with people living in the area of the seismic survey
- better managing the financial aspects of a seismic survey

Course Outline

1. Introduction
2. Clients
3. Scouting
4. Design
5. Procurement
6. Safety
7. Communities
8. Execution
9. Finance
10. Equipment
11. Project management
12. Outro

Participants' Profile

This course suits professionals who want to understand why their last seismic survey was not as successful as they expected.

If you are either a client of seismic survey, in procurement, providing finance support or in an HSE supporting or policing role related to seismic acquisition, then this course will be of interest to you.

This course will be of interest for employees of seismic companies who want to have a better understanding of how seismic surveys are conceived, initiated and managed in oil companies. More detail about the exact reasons why oil companies want to acquire seismic data and how they go about this will also be a focus.

If you live in an area where a seismic survey will be conducted or if you are with an NGO in need of understanding more about seismic acquisition, then this course is for you.

Prerequisites

This course is essential for Geophysicists and staff in other disciplines who are or will be involved in planning and executing seismic surveys. The course also contains important knowledge for those who are providing support during the planning and execution of these surveys such as people in HSE, Procurement, and Finance. The course will be beneficial for those whose task it is to get the highest possible value out of the data delivered by seismic surveys, for example Geologists and Reservoir Engineers. It is only in the section about design that some geophysical background will be helpful but this should not stop anyone subscribing. Regardless of their experience and education, those whose main task is to make important contributions to the success of seismic surveys will benefit from this course. Partially this is because the project (the seismic survey) will benefit when all those involved have a good understanding of what the others are doing

About the Instructor

Jan de Bruin has 29 years experience as a geophysicist with Shell and has covered the full range of geophysical jobs from new recruit to Chief Geophysicist, and from software development to processing to quantitative interpretation to seismic acquisition. From 1999 until 2015 he has been accountable for the successful initiation and completion of many geophysical surveys.

Jan de Bruin has a MSc Physics degree from Delft University in the Netherlands. He has also completed the Henley MBA. He joined Shell in 1986 and has worked for Shell in 9 different countries. He left Shell in 2015 when the opportunity arose to make a change, helped by the drop in oil price, and has used 2016 and part of 2017 to develop this course and to become involved in several interesting projects.

Basic Geophysical Data Acquisition and Processing

2D, 3D, 4D SEISMIC | ELECTRICAL SURVEYING | GPR | GRAVITY SURVEYING | IMAGING | MAGNETICS SURVEYING | RESULT IN DEPTH | ROCK PROPERTIES | SHALLOW RETRACTION | SIGNAL-TO-NOISE RATIO | VALUE OF INFORMATION | WAVE PROPAGATION

Instructor:	Dr Jaap C. Mondt (Breakaway, Netherlands)	
Language:	English, Dutch	
Level:	Foundation	
Duration and formats:	Classroom: 5 days	CPD Points: 25

NEW

Course Description

This course treats various geophysical methods, from gravity to magnetics, electrical, electro-magnetic, refraction and reflection seismic. It will be taught not only by explaining and discussing the methods, but above all by applying the theory in mainly Excel based assignments.

Various kinds of geophysical data are available. They are usually separated into Non-seismic and Seismic data. Non-seismic data (gravity, magnetics, electrical, electromagnetics, spectral, etc.) is the main data used in shallow subsurface applications (engineering, mapping pollution, archaeology, etc.) and at the early exploration stage in the search for oil, gas or minerals. Seismic is the main subsurface evaluation tool for the EP industry, but it has its limitations. Therefore, non-seismic methods are used successfully as complementary tools at the more mature exploration stages and even for production.

In combination with seismic data they can significantly reduce the uncertainty of subsurface models as they measure different physical properties of the subsurface. Controlled Source EM, for example, responds to reservoir resistivity and can thus be used to differentiate between hydrocarbons and brine in a geological structure mapped by seismic.

The main topics covered by the programme are:

- Gravity surveying
- Magnetics surveying
- Electrical surveying
- Electro-Magnetic surveying, including Ground Penetrating Radar
- Acquisition of shallow refraction seismic data
- Acquisition of reflection seismic data
- When to use 2D, 3D and 4D seismic / non-seismic
- Principles of wave propagation
- Basic designs of 2D and 3D seismic acquisition
- Processing of seismic and GPR data with the objectives of improving signal-to-noise ratio, vertical and lateral resolution
- From simple migration to Imaging
- Result in depth (Time-to-Depth conversion)
- What to spend on a new survey, be-it a new survey or a reprocessing or re-interpretation project. Hence, to determine whether the expected reward (increase in value) is higher than the cost of the project. In short, what is the value of the new information obtained (VOI: Value Of Information)

Course Objectives

At the end of the course, participants will have a good understanding of what information various geophysical data can give and for what purposes it can be used. This will enable them to specify the requirements for a survey or a reprocessing or interpretation project, either done in-house or by a specialised service provider.

Other benefits include:

- Place and value geophysical activities in a multi-disciplinary context
- Judge the merits of various geophysical techniques
- Better liaise and collaborate with staff in related disciplines
- Recognise artefacts and direct hydrocarbon indications on seismic
- Value novel developments such as time lapse methods for hydrocarbon reservoir monitoring or pollution control.

Course Outline

- Part 1: The principles and limitations of Geophysical methods
- Part 2: Gravity surveying, Magnetic surveying, Electrical surveying
- Part 3: Electro-Magnetic surveying
- Part 4: Seismic Refraction surveying
- Part 5: Seismic Reflection surveying
- Part 6: Value of undertaking a new project (VOI)

Participants' Profile

The course is designed for Geologists, Geophysicists and Petroleum Engineers involved in exploration and development of oil and gas fields and for those involved in projects related to the shallow subsurface (monitoring pollution). In addition, it would be useful for those dealing with the effects of production of a field (subsidence, earth tremors).

Prerequisites

A reasonable level of understanding of mathematics and physics is assumed.

Recommended Reading

An Introduction to Geophysical Exploration, Kearey, Brooks, Hill, ISBNB0-632-04929

About the Instructor

Dr Jaap C. Mondt obtained a Bachelors degree in Geology at the University of Leiden followed by a Masters degree in Theoretical Geophysics and a PhD on "Full wave theory and the structure of the lower mantle" at the University of Utrecht. Dr Mondt then joined Shell Research in The Netherlands to develop methods to predict lithology and pore-fluid based on seismic, petrophysical and geological data. Subsequently he worked at Shell Expro in London to interpret seismic data from the Central North Sea Graben. After his return to The Netherlands, he headed a team for the development of 3D interpretation methods using multi-attribute statistical and pattern recognition analysis on workstations. After a period of Quality Assurance of "Contractor" software for seismic processing, he became responsible for Geophysics in the Shell Learning Centre. During that time he was in addition part-time professor in Applied Geophysics at the University of Utrecht. From 2001 till 2005 he worked on the development of Potential Field Methods (Gravity, Magnetics) and EM methods (CSEM) for detecting oil and gas. After his retirement from Shell, he founded his own company (Breakaway), specialised in courses on acquisition, processing and interpretation of geophysical data (seismic, gravity, magnetic and electromagnetic data). In addition to providing support to the Shell Learning Centre, he gives his own courses to International as well as National energy companies.

Advanced Seismic Data Acquisition and Processing

ACQUISITION STRATEGY | MIGRATION | NMO CORRECTION | NOISE SPREAD | PERMEABILITY | POROSITY | PROCESSING STRATEGY | RESERVOIR ROCKS | ROCK PROPERTIES | SIGNAL PROCESSING | SOURCE ROCKS | SPACIAL ALIASING | SYMMETRIC SAMPLING | TIME-TO-DEPTH CONVERSION | VALUE OF INFORMATION | VELOCITY MODEL

Instructor:	Dr Jaap C. Mondt (Breakaway, Netherlands)	
Language:	English, Dutch	
Level:	Advanced	
Duration and formats:	Classroom: 5 days	CPD Points: 25

NEW

Course Description

The course deals with advanced methods of seismic acquisition and processing. It will be taught not only by explaining the methods, but above all by applying the theory in mainly Excel based assignments.

Seismic data is one of the main sources of information on the subsurface. We not only need to obtain the structure that could contain hydrocarbons, but also the rock properties so we can decide on whether we are dealing with reservoir rocks (sandstone, carbonates, even shales), sealing rocks (shales, salt) or source rocks (shales, coal). It is not only important to know what type of rock is present, but also what its porosity and permeability is: how easy do the hydrocarbons flow through the rocks. To obtain the best image of the subsurface we first need optimum acquisition. Optimum means fit for purpose. There are several criteria that need to be satisfied. First of all, the area covered during acquisition should be the prospect area extended sufficiently to provide fold-fold and fully migrated data. An acquisition principle that should be adhered to as much as possible is symmetric sampling, which means equal shot and receiver spacing and equal in-line and cross-line distances (for a 3D). A noise spread (trial acquisition with closely spaced receivers and shots) is acquired in each new area to determine the needed shot and receiver intervals, the bandwidth, etc. The shot and receiver station spacing should be such that no spatial aliasing of the data occurs. Surface and subsurface diagrams are useful to see what CMP spacing and offsets in each CMP gather result from the surface geometry of shots and receivers. The data recorded is the ground motion which gives a continuous (analogue) signal in time which needs to be digitized for the processing. This digitization needs to be done so that neither temporal nor spatial aliasing occurs. Namely, by aliasing information will be lost. Hence, the complete wave-field which arrives at the surface must be faithfully represented by the discrete/digital data.

Although all the information is present in the so-called shot or field records, processing is needed to make them accessible for interpretation. In interpretation, we try to obtain a true image of the "geology" of the subsurface. Processing can be divided into a) signal processing steps and b) wave propagation based processing steps. Signal processing steps are, for example, static corrections, removal of shot-generated noise by velocity filtering, shortening of the wavelet by de-convolution, NMO correction, etc. The wave-propagation part consists of migration or imaging. For wave propagation we need, in principle, to use equations describing full elastic wave propagation in an inhomogeneous, anisotropic, visco-elastic earth (as that is what really happens in the subsurface). However, these equations would lead to very complicated and computer intensive processing algorithms. So, we usually simplify our description of the wave propagation. What we do is to use, as phrased by Ian Jones and others, "appropriate approximations". The one most commonly used is the one-way acoustic wave equation which describes only a single reflection per reflection ray-path and ignores density. It only uses a velocity depth model and only considers P-wave propagation. This will provide us, for example, with migration algorithms/operators (for time- as well as depth migration) that will still do a reasonably correct summation of acquired data. It will give a migration output that still shows, maybe not correctly, the results of anisotropy, attenuation, wave conversions, shear velocities, etc. Despite the use of this acoustic approximation in our processing, amplitudes can be used (can they?) to determine pore-fluids and pre-stack migrated data that can be used in AVA analysis for deriving shear wave properties. But note that if we model, as in inversion, a synthetic geophysical quantity, say related to amplitudes, such as the reflection coefficient we need (do we?) to include densities across the interface and for AVA we need to include density and shear velocity to interpret the pre-stack seismic amplitudes (as the effect of these properties is contained in the observed data).

All of this will be treated in this course.

Course Objectives

At the end of the course participants will have a good understanding of what information seismic data can give and for what purposes in Exploration and Production it can be used. This will enable them to specify the requirements for a survey, either done by themselves of by a special service provider.

Other benefits include:

- Place and value geophysical activities in a multi-disciplinary context
- Judge the merits of various seismic geophysical techniques
- Better liaise and collaborate with staff in related disciplines
- Recognise artefacts and direct hydrocarbon indications on seismic
- Value novel developments such as time lapse methods for hydrocarbon reservoir monitoring

Course Outline

- Part 1: The role of seismic in the Exploration and Production of Hydrocarbons
- Part 2: Seismic Acquisition Strategies
- Part 3: Seismic processing Strategies
- Part 4: Time-to-Depth conversion, Direct Hydrocarbon Indicators
- Part 5: Value of Information: How much to spend on new acquisition and/or new processing

Participants' Profile

The course is designed for geophysicists involved in designing and supervising seismic acquisition and processing, and for those involved in specifying/supervising the acquisition and processing done by service companies.

Prerequisites

Participants should have a basic understanding of seismic acquisition and processing and general knowledge of the role of seismic in exploration and production of hydrocarbons.

Recommended Reading

- An Introduction to Geophysical Exploration, Keary, Brooks & Hill, ISBN-0-632-04929-4
- Looking into the Earth, Mussett & Aftab Khan, ISBN-0-521-78574-X
- Fundamentals of Geophysics, Lowrie, ISBN-978-0-521-67596-3
- The Art of Being a Scientist, Snieder & Larner, ISBN-978-0-521-74352-5
- 52 Things you should know about Geophysics, Hall & Bianco, ISBN-978-0-9879594-0-9

About the Instructor

Dr Jaap C. Mondt obtained a Bachelors degree in Geology at the University of Leiden followed by a Masters degree in Theoretical Geophysics and a PhD on "Full wave theory and the structure of the lower mantle" at the University of Utrecht. Dr Mondt then joined Shell Research in The Netherlands to develop methods to predict lithology and pore-fluid based on seismic, petrophysical and geological data. Subsequently he worked at Shell Expro in London to interpret seismic data from the Central North Sea Graben. After his return to The Netherlands, he headed a team for the development of 3D interpretation methods using multi-attribute statistical and pattern recognition analysis on workstations. After a period of Quality Assurance of "Contractor" software for seismic processing, he became responsible for Geophysics in the Shell Learning Centre. During that time he was in addition part-time professor in Applied Geophysics at the University of Utrecht. From 2001 till 2005 he worked on the development of Potential Field Methods (Gravity, Magnetics) and EM methods (CSEM) for detecting oil and gas. After his retirement from Shell, he founded his own company (Breakaway), specialised in courses on acquisition, processing and interpretation of geophysical data (seismic, gravity, magnetic and electromagnetic data). In addition to providing support to the Shell Learning Centre, he gives his own courses to International as well as National energy companies.

Introduction to Data Analysis: Concepts and Examples

4D | AVO | DEPTH MIGRATION | FRACTURES | IMAGING | IMPEDANCE | REFLECTION | RESERVOIR CHARACTERIZATION | ROCK PHYSICS | SIGNAL PROCESSING | TIME LAPSE | TOMOGRAPHY

Instructor:	Dr Robert Godfrey (Robert Godfrey Geophysics Inc., Canada)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

The course covers a range of advanced data analysis topics including novel signal processing techniques, pre-stack depth migration, reservoir characterization, time lapse analysis and the road ahead.

The free on-line books by Jon F. Claerbout, material from SEG Wiki and papers published in Geophysics, The Leading Edge and SEG Expanded Abstracts are used to provide technical background for the course topics.

Course Objectives

1. Suggest acquisition strategies to
   a. broaden spectrum (both low and high)
   b. reduce acquisition cost where appropriate
   c. provide superior illumination and
   d. improve conventional wave imaging using shear waves to highlight faults/fractures, low compressional wave impedance contrasts and gas-effected areas.
2. Advise and recommend key steps in data processing workflows.
3. Choose appropriate pre-stack depth migration algorithms to image expected dip range (e.g. Kirchhoff, Beam, RTM).
4. Advise on velocity-depth model building workflows (e.g. Grid Tomography or FWI).
5. Decide on the applicability of applying AVO and what elastic attributes to estimate.
6. Define optimal petrophysical parameters to be estimated using elastic attributes and an associated workflow including probability analysis if appropriate.

Course Outline

1. Signal Processing
2. Novel Seismic Acquisition
3. Multiple Attenuation
4. Pre-Stack Depth Migration
5. AVO & Rock Physics
6. Quantitative Interpretation
7. Time-Lapse Seismic
8. The Road Ahead

Participants' Profile

The intended audiences for this course are geoscientists-in-training, seismic data processors, petroleum geologists, seismic interpreters and operational geophysicists who are seeking to expand their knowledge base on modern concepts in geophysical data analysis.

Prerequisites

Participants are expected to have a basic knowledge of the fundamentals of data processing and some experience in interpretation.

About the Instructor

Robert J. Godfrey received a Bachelor of Applied Science degree in geological engineering from UBC in 1975 followed by a Ph.D. in geophysics in 1979 from Stanford University. He was a member of the Stanford Exploration Project founded by Jon Claerbout.

Following his graduation, he began his career with Mobil Field Research Lab in Dallas and then joined Digicon in London for 8 years where he worked in research and development. This was followed by a 25-year stint with Schlumberger where he worked in Calgary, Austin, London and Cairo, primarily in the fields of reservoir characterization and later in seismic monitoring. In 2015, he established Robert Godfrey Geophysics Inc., and is currently working as a geophysical consultant in seismic technology, geophysical education, and undertakes short-term assignments. He is a member emeritus of the SEG.

Velocities, Imaging, and Waveform Inversion - The Evolution of Characterizing the Earth's Subsurface

4D | AVO | DECONVOLUTION | INVERSION | MIGRATION | MULTIPLE ELIMINATION | NOISE CANCELLATION | SIGNAL PROCESSING | STATIC CORRECTIONS | VELOCITY ANALYSIS

Instructor:	Dr Ian Jones (Brightskies Geoscience, United Kingdom)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Online: Self-paced course - 7 hours recorded material	CPD Points: 3
	Classroom: 1 day	CPD Points: 5

NEW EET

Course Description

In using sound waves to characterise the Earth's subsurface, we can employ ray-theory and/or wave-theory, and both migration algorithms and velocity estimation schemes employ one or other of these theoretical descriptions. In this course, we'll review the evolution of the industry's approaches to building earth models via velocity estimation and imaging, outlining the evolution from ray tomography to full waveform inversion, and look towards the emerging possibilities for replacing imaging techniques with direct subsurface parameter inversion methods.

The approach will be non-mathematical, concentrating on an intuitive understanding of the principles, demonstrating them via case histories.

The course will commence with a brief overview of different migration schemes, and cover the motivations for building detailed velocity models, and briefly discuss the inherent limitations on our ability to build a detailed model. Current-day practice will be covered, exemplified via several case-studies, and we will then discuss the newer techniques such as waveform inversion and least-squares migration. The approach will not be mathematical, but rather will try to concentrate on an intuitive understanding of the principles, and demonstrate them via case histories. The course schedule will be divided into the following sections:

- Why do we need a detailed velocity model? Including a brief review of migration schemes.
- How accurate can we make an image and how detailed can we get? We'll discus the sources of uncertainty, non-uniqueness and ambiguity, as well as the intrinsic limits on resolution
- Current industrial practice: Iterative model update with both ray-based tomography and waveform methods in order to achieve 'true amplitude' subsurface information.
- What might come next? Discussing direct inversion of subsurface parameters as an alternative to simply migrating data.

Following this course, participants should ideally understand how migration works, in terms of the approximations involved, and how this relates to the geology to be imaged. They should appreciate the limitations of current and future imaging and velocity estimation technology, so as to be able to decide what model building technique should be employed to image a given geological objective. And finally, to appreciate the potential for a radical change in current industrial practise, moving from a sequential imaging route (via migrated images) to a closed-loop inversion route (directly delivering subsurface attributes).

Course Objectives

Upon completion of the course, participants will be able to:

- understand how migration works, in terms of the approximations involved, and how this relates to the geology to be imaged.
- appreciate the limitations of current and future imaging and velocity estimation technology, so as to be able to decide what model building technique should be employed to image a given geological objective.
- appreciate the potential for a radical change in current industrial practise, moving from and imaging route (via migrated images) to an inversions route (delivering subsurface attributes)

Course Outline

The course will cover the building detailed velocity models for imaging, and briefly discuss the inherent limitations on our ability to build a detailed model. Current-day practice will be covered, exemplified via case-studies, and we will then discuss the newer techniques such as waveform inversion and least-squares migration. The approach will not be mathematical, but rather will concentrate on an intuitive understanding of the principles, demonstrated via case histories.

The schedule includes:

- Why do we need a detailed velocity model?
  (Review of migration schemes)
- How accurate does an image need to be and how detailed can we get?
  (Sources of uncertainty, non-uniqueness and ambiguity, limits on resolution)
- Current industrial practice: Iterative model update
  (ray-based tomography and waveform inversion methods)
- What might come next?
  (direct inversion of subsurface parameters)

Participants' Profile

The course is designed for:
practising geoscientists who desire to better understand the principles and limitations of both current and emerging technologies involved in subsurface parameter estimation and imaging, and geoscience students.

Prerequisites
A general knowledge of geophysics.

Recommended Reading
- Jones, I.F., 2015, Estimating subsurface parameter fields for seismic migration: velocity model building, in: Encyclopedia of Exploration Geophysics. SEG, pp. U1-1-U1-24. Editors: Vladimir Grechka and Kees Wapenaar. http://library.seg.org/doi/pdf/10.1190/1.9781560803027.entry3
- Jones, I.F, 2014, Tutorial: migration imaging conditions. First Break, 32, no.12, 45-55.
- Brittan, J., J. Bai, H. Delome, C. Wang, and D. Yingst, 2013, Full waveform inversion — The state of the art: First Break, 31, 75–81.
- Jones, I.F, 2012, Tutorial: Incorporating near-surface velocity anomalies in pre-stack depth migration models. First Break, 30, no.3, 47-58.
- Jones, I.F, 2010, Tutorial: ray-based tomography. First Break, 28, no.2, 45-52
- Jones, I.F., 2010, An introduction to velocity model building, EAGE, ISBN 978-90-73781-84-9, 296 pages.

About the Instructor
Ian Jones received a joint honours BSc in Physics with Geology from the University of Manchester, UK, in 1977, an MSc in Seismology from the University of Western Ontario, Canada, and a PhD in Geophysical Signal Processing from the University of British Columbia, Canada.
After working for 'Inverse Theory & Applications Inc.' in Canada for two years, he joined CGG, where for 15 years he was involved in R&D in the London and Paris offices, latterly as manager of the depth imaging research group. In 2000 he joined ION GX Technology, as a Senior Geophysical Advisor in their London office. In 2021 he joined BrightSkies Geoscience as Senior Geophysical Advisor.
His interests include velocity model building and migration, and his most recent activity includes writing the text books: '*Velocities, Imaging, and Waveform Inversion: the evolution of characterising the Earth's subsurface*' published by the EAGE in 2018; '*An Introduction to Velocity Model Building*' published by the EAGE in 2010; and co-editing the SEG Geophysics Reprints series volumes '*Classics of Elastic Wave Theory*' and also '*Pre-Stack Depth Migration and Velocity Model Building*', as well as contributing the chapter on model building to the new SEG online encyclopaedia.
He has served as an associate editor for the journals '*Geophysics*' and '*Geophysical Prospecting*', and teaches the SEG/EAGE/PESGB continuing education course on '*Velocity Model Building*' and was an external lecturer at the University of Leeds and Imperial College London. Ian was awarded the EAGE's Anstey Medal in 2003 for "*contributions to the depth imaging literature*", made the SEG European Honorary Lecturer in 2012 for "*contributions to advancing the science and technology of geophysics*", conducted the 2018-2019 EAGE International Education Tour, and was made an *Honorary Life Member* by the EAGE in 2018, and received the best paper award for his 2019 First Break tutorial on FWI.

A Comprehensive Overview of Seismic Data Processing Steps

4D | AVO | DECONVOLUTION | INVERSION | MIGRATION | MULTIPLE ELIMINATION | NOISE CANCELLATION | SIGNAL PROCESSING | STATIC CORRECTIONS | VELOCITY ANALYSIS

Instructor:	Piet Gerritsma (Gerritsma Geophysical Training and Consultancy, Netherlands)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

Seismic data processing can be characterized by the application of a sequence of processes, where for each of these processes there are a number of different approaches. This course provides a comprehensive overview of the steps that are commonly applied in seismic data processing and discusses for each step the alternative implementations together with their inherent assumptions and strengths and weaknesses. This course provides the participants with a working knowledge of the different processing methods and enables them to assess the quality of a processing result. It can serve as a starting point for further study and/or enable them to be a member of a processing and/or multidisciplinary team.

Course Objectives

At the end of the course the participants will have obtained an understanding and appreciation of the many alternative processing approaches that are representative for the practice of current seismic data processing. The course emphasizes for each process the various existing underlying geophysical models. Many examples will be shown to illustrate the material; theory with references will be included; a handout that covers all course material will be made available.

Course Outline

The following steps in seismic data processing will be discussed:

1. Introduction to data acquisition practises
2. Static corrections
3. Velocity analysis
4. Deconvolution
5. Signal-to-noise enhancement techniques
6. Multiple elimination
7. Stacking
8. Migration: time migration and depth migration
9. Velocity model building
10. Introduction to AVO, 4D Seismic, and Seismic Inversion

Participants' Profile

Students, starting geophysicists, interpreters and geologists, petrophysicists and reservoir engineers who wish to understand seismic data processing either as an introduction for further study and/or as a knowledgeable member of a multidisciplinary team.

Prerequisites

Course participants should be interested in seismic data processing; a background in science will be sufficient.

About the Instructor

Piet Gerritsma (1942) graduated in physics at the University of Groningen. He joined Shell in 1969 as a research geophysicist in Rijswijk (The Netherlands) and Houston (USA). He was actively involved in the development of programs for statics, velocity analysis, synthetic seismograms and raytracing, deconvolution, multi-component seismic, shear waves and anisotropy, AVO and migration. He acquired operational experience as processing and special studies geophysicist in Brunei and in Canada. He was Shell"s representative in international research consortia: SEP (Stanford), DELPHI (Delft University of Technology) and IFP (Institut Francais du Petrole); he also served as associate editor of Geophysical Prospecting on Migration, Modeling and Inversion. During his Shell career he has always lectured at both basic as well as advanced level covering a broad range of topics. He left Shell in 1999 after 30 years of service. Since that time he is a lecturer at CTG (Center for Technical Geoscience) at the Delft University of Technology. He also teaches regularly courses for national and international oil companies and service companies, both as an independent teacher as well as on behalf of geoscience training alliances. He has presented this course several times on behalf of the EAGE and CSEG.

An Introduction to Velocity Model Building

3D | ANISOTROPY | DEPTH MIGRATION | IMAGING | INVERSION | RTM | TIME MIGRATION | TOMOGRAPHY | VSP

Instructor:	Dr Ian Jones (BrightSkies Geoscience, United Kingdom)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 to 4 live sessions of 4 hours	CPD Points: 4 to 8
	Classroom: 1 to 5 days	CPD Points: 5 to 25

NEW

Course Description

The course will commence with an overview of different migration schemes, and cover the motivations for building detailed velocity models, and briefly discuss the inherent limitations on our ability to build a detailed model.

Current-day practice will be covered, exemplified via many case-studies, and we will briefly discuss the less well known and emerging techniques. The approach will mostly be non-mathematical, and will rather try to concentrate on an intuitive understanding of the principles, and demonstrate them via case histories. The bias in this course is towards those techniques that have seen widespread industrial use over the past 40 years. Unfortunately, some topics will not be covered, in-part due to the time constraints: these omissions will include consideration of VSP and multi-component data, and Marchenko imaging.

Course Objectives

The course objective is to provide the participants a firm understanding of the processes and assumptions involved in building velocity-depth models and of the limitations of various migration algorithms

Course Outline

For the topics listed below, real data examples will be used to demonstrate the application and limitation of each technique.

Why do we need a detailed velocity model?
- Review of migration schemes
- The limitations of time migration and benefits of depth migration
- Snell's law and how to ignore it
- How does depth migration differ from time migration?
- Is depth migration always necessary?
- Migration using ray methods (Kirchhoff, beam, CRAM, etc.)
- Migrating using wavefield extrapolation methods (WEM, RTM, etc.)
- One-way versus two-way propagation
- Creating gathers in wavefield extrapolation methods
- Pre-processing considerations for RTM

How detailed can we get?
- Sources of uncertainty
- Non-uniqueness and ambiguity
- Limits on resolution

Resolving short-scale-length velocity anomalies:
- Anisotropy versus heterogeneity (and other higher order moveout effects)
- The mechanics of tomographic inversion with ray theory
- Parametric versus non-parametric picking of residual moveout
- Structural constraints, MAZ, OVT, and Q tomography
- The mechanics of tomographic inversion with wavefield extrapolation theory (FWI)

Examples of current industrial practice for various geological settings (time permitting):
- Resolving near-surface velocity anomalies
- Seismic response to strong vertical velocity change (e.g. chalk, basalt, salt)
- Seismic response to strong lateral velocity change (e.g. salt walls, lateral terminations)
- Comparisons of ray tomographic and FWI models for specific case studies

The Future: emerging R&D directions (time permitting)
- Waveform inversion developments
- Least squares migration
- Migrating multiples
- Full wavefield imaging
- Scattered wavefield imaging
- 'Adaptive optical imaging'
- Bayesian uncertainty estimation (putting error bars on images)

Participants' Profile

Geophysicists with an interest in migration and velocity model building and geologists (with a basic knowledge of data processing) who wish to understand a bit more about how the images they look at are created.

Prerequisites

The course is designed to be followed by anyone with a broad geoscience background: no specific detailed foreknowledge is required, although a familiarity with geophysical terminology will be useful.

Recommended Reading

- Jones, I.F, 2014, Tutorial: migration imaging conditions. First Break, accepted.
- Jones, I.F, and Davison, I., 2014, Seismic imaging in and around salt bodies. SEG Interpretation, 2, no.4, SL1-SL20.
- Jones, I.F, 2013, Tutorial: The seismic response to strong vertical velocity change. First Break, 31, no.6., 43-54.
- Jones, I.F, 2013, Tutorial: Transforms, orthogonality, eigenvectors, and eigenvalues. First Break, 31, no.1., 51-61.
- Jones, I.F, 2012, Tutorial: Incorporating near-surface velocity anomalies in pre-stack depth migration models. First Break, 30, no.3,
- Jones, I.F, 2010, Tutorial: ray-based tomography. First Break, 28, no.2, 45-52
- Jones, I. F., 2008, A modeling study of pre-processing considerations for reverse-time migration: Geophysics,. 73, NO. 6; T99—T106.
- Fruehn, J.K., I. F. Jones, V. Valler, P. Sangvai, A. Biswal, & M. Mathur, 2008, Resolving Near-Seabed Velocity Anomalies: Deep Water Offshore Eastern India: Geophysics, 73, No.5, VE235-VE241..
- Jones, I. F., 2008, Effects of pre-processing on reverse time migration — a North Sea study: First Break, 26, no.6, 73-80.
- Jones, I.F., Sugrue, M.J., Hardy, P.B., 2007, Hybrid Gridded Tomography. First Break, 25, no.4, 15-21.
- Farmer, P., Jones, I.F., Zhou, H., Bloor, R., Goodwin, M.C., 2006, Application of Reverse Time Migration to Complex Imaging Problems. First Break, 24, no.9, 65-73.
- Jones, I.F., 2003, A review of 3D preSDM velocity model building techniques First Break, 21, no.3, 45-58.
- Jones, I.F., Fruehn, J., 2003, Factors affecting frequency content in 3D preSDM imaging, : The Leading Edge, 22, no.2,.128-134.

Learner Outcome

Upon completion of this course, the participants should be able to:

1. Describe how migration works, in terms of the underlying physics and the associated approximations involved
2. Classify model building and migration schemes in terms of the theory on which they are based (waves versus rays)
3. Decide which migration and model building scheme are appropriate for imaging a given geological environment
4. Characterize the limitations of model building and migration schemes, in terms of imaging artifacts
5. Differentiate between the current state-of-the art and future imaging and parameter estimation technologies

About the Instructor

Ian Jones received a joint honours BSc in Physics with Geology from the University of Manchester, UK, in 1977, an MSc in Seismology from the University of Western Ontario, Canada, and a PhD in Geophysical Signal Processing from the University of British Columbia, Canada.

After working for 'Inverse Theory & Applications Inc.' in Canada for two years, he joined CGG, where for 15 years he was involved in R&D in the London and Paris offices, latterly as manager of the depth imaging research group. In 2000 he joined ION GX Technology, as a Senior Geophysical Advisor in their London office. In 2021 he joined BrightSkies Geoscience as Senior Geophysical Advisor.

His interests include velocity model building and migration, and his most recent activity includes writing the text books: '*Velocities, Imaging, and Waveform Inversion: the evolution of characterising the Earth's subsurface*' published by the EAGE in 2018; '*An Introduction to Velocity Model Building*' published by the EAGE in 2010; and co-editing the SEG Geophysics Reprints series volumes '*Classics of Elastic Wave Theory*' and also '*Pre-Stack Depth Migration and Velocity Model Building*', as well as contributing the chapter on model building to the new SEG online encyclopaedia.

He has served as an associate editor for the journals '*Geophysics*' and '*Geophysical Prospecting*', and teaches the SEG/EAGE/PESGB continuing education course on '*Velocity Model Building*' and was an external lecturer at the University of Leeds and Imperial College London. Ian was awarded the EAGE's Anstey Medal in 2003 for "*contributions to the depth imaging literature*", made the SEG European Honorary Lecturer in 2012 for "*contributions to advancing the science and technology of geophysics*", conducted the 2018-2019 EAGE International Education Tour, and was made an *Honorary Life Member* by the EAGE in 2018, and received the best paper award for his 2019 First Break tutorial on FWI.

Seismic Multiple Removal Techniques: Past, Present and Future

3D DECONVOLUTION EXTRAPOLATION FILTERING FOURIER IMAGING INTERPOLATION INVERSION MIGRATION RADON TRANSFORM

Instructor:	Dr Eric Verschuur (Delft University of Technology, Netherlands)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 3 live sessions of 4 hours	CPD Points: 6
	Classroom: 1 to 2 days	CPD Points: 5 to 10

EET

Course Description

The main objective of this course is to provide the audience with an overview of the techniques in seismic multiple removal, starting with the deconvolution-based methods from the 1960s, via the move-out discrimination techniques of the 1980s and ending up with wave-equation based methods from the 1990s and their 3D extensions as developed in the 2000s. Furthermore, the current challenges in multiple removal and their relation with seismic imaging and inversion are treated. A secondary objective is to discuss more general processing concepts such as high-resolution seismic data transforms (Fourier, Radon), adaptive filtering techniques, wave-equation based forward and inverse wave propagation and the processing of seismic data in different transform domains. For each method some brief description of the theory in terms of mathematics is given. However, the emphasis in this course is not to thoroughly treat the mathematics but to present some understanding of the workings of each method.

Course Outline

At the end of each lecture, a list of relevant articles in the open literature will be specified. The course is subdivided in 10 lectures, each of them being approximately 30-45 minutes. Within each lecture, examples of the described concepts on synthetic and field data will play an important role.

Lecture 1: Multiples ... what's the problem?
- Classification of multiple reflections
- Characteristics of multiples
- Impact on seismic imaging and interpretation
- Categories of multiple removal methods

Lecture 2: Multiple removal based on move-out and dip discrimination
- Principle of multiple removal by move-out discrimination
- F-K and Radon transforms
- Multiple removal by filtering in the FK or Radon domain
- Towards high-resolution Radon transforms
- Limitations of multiple removal by move-out discrimination
- Multiple removal by target-oriented dip filtering

Lecture 3: Predictive deconvolution
- Convolution and correlation concept
- Designing adaptive filters by least-squares optimisation
- Predictive deconvolution basics
- Extending the predictive deconvolution concept

Lecture 4: Multiple removal by wave field extrapolation
- Forward and inverse wave field extrapolation
- Multiple prediction by wave field extrapolation
- Application in the wave number and linear Radon domain

Lecture 5: Principles of surface-related multiple elimination
- Derivation of SRME for the 1D situation
- Including the source characteristics
- Iterative implementation of SRME
- Formulation of SRME for the 2D and 3D situation
- Relation between multiple prediction and subtraction methods

Lecture 6: Practical considerations for surface-related multiple elimination
- Effect of missing data on SRME
- Interpolation of missing near offsets
- Application of SRME in different data domains
- Shallow water multiple removal strategy

Lecture 7: Adaptive subtraction of predicted multiples
- Least squares and L1-norm subtraction
- Pattern recognition and other multiple subtraction techniques

Lecture 8: Towards 3D multiple removal
- Multiples in complex 3D environments
- 3D SRME: theory and practice
- 3D SRME: solutions via data interpolation

Lecture 9: Internal multiple removal
- Internal multiple removal by move-out discrimination
- Extending the SRME concept to internal multiples
- Internal multiple removal by inverse scattering

Lecture 10: Removing or using multiples?
- Transforming multiple into primaries
- Estimation of primaries by sparse inversion
- Including multiples in the migration process
- Including multiples in the inversion process

For the 2-days course , especially the second part of the course, will be more elaborated with extra topics being:
- more elaborate discussion on adaptive subtraction techniques (Lecture 7)
- more extensive explanation on internal multiple removal (Lecture 9)

- including the recently developed EPSI (Estimation of Primaries by Spares Inversion) methodology (Lecture 10)
- including an extensive discussion on using surface multiples in Imaging (Lecture 10)

Participants' Profile

The target audience is composed of people involved in seismic processing, imaging and inversion. The mathematical content is kept to a minimum level with a strong link to the involved physical concepts, amplified by graphical illustrations. The audience is expected to have prior knowledge at a B.Sc./M.Sc. level on processing concepts such as convolution, correlation and Fourier transforms and some basic knowledge on wave theory.

Prerequisites

Participants should have a basic knowledge of:

- Basic signal processing (convolution, correlation, Fourier transform);
- Basic seismic processing (preprocessing, imaging);
- Basic knowledge on the acoustic wave equation and wave propagation.

About the Instructor

Dirk J. (Eric) Verschuur received his M.Sc. degree in 1986 and his Ph. D degree (honors) in 1991 from the Delft University of Technology (DUT), both in applied physics. From 1992 - 1997 he worked under a senior research fellowship from the Royal Dutch Academy of Art and Sciences (KNAW). In 1997 he became assistant professor and since 1999 he is an associate professor at the DUT at the laboratory of Acoustical Imaging and Sound Control. He is the project leader of the DELPHI research consortium in the area of Multiple Removal and Structural Imaging. His main interests are seismic modeling, processing and migration techniques. In 1997 he received SEG's J. Clarence Karcher award. He is a member of SEG and EAGE.

Understanding Seismic Anisotropy in Exploration and Exploitation: Hands On

AVO | DEPTH CONVERSION | FRACTURES | IMAGING | MULTICOMPONENT | P-WAVE | PORE PRESSURE | RECIPROCITY | RESERVOIR CHARACTERIZATION | ROCK PHYSICS | S-WAVE | WIDE AZIMUTH

Instructor:	Dr Leon Thomsen (Delta Geophysics, United States)	
Language:	English	
Level:	Advanced	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

This course covers all areas of applied seismic anisotropy, with class exercises and ample time for full discussion. Because anisotropy is such a fundamental concept, it covers topics in seismic acquisition, processing, imaging and interpretation, all based on seismic rock physics.

Course Objectives

This is not a "methods course" but rather a "concept course", familiarizing the students with essential concepts, enabling them to ask the right questions in future conversations, rather than to operate particular software packages.

Course Outline

1. Physical principles
2. P-waves: imaging
3. P-waves: characterization
4. S-waves
5. C-waves
6. Epilogue

Participants' Profile

Geophysicists should attend who have a working knowledge of conventional exploration geophysics and wonder how it can be that we use isotropic concepts to acquire and analyze data that come from rocks that, after only brief thoughtful consideration, must clearly be anisotropic.

Recommended Reading

Before attending the course participants are recommended to read the following paper:

- Thomsen, L., Weak Elastic Anisotropy,Geophysics, 51(10), 1954-1966,1986.

About the Instructor

Leon Thomsen holds titles of Chief Scientist at Delta Geophysics, Research Professor at the University of Houston, and Visiting Scientist at Lawrence Berkeley National Laboratory. He holds a B.S. in geophysics from California Institute of Technology (Pasadena), and a Ph.D. in geophysics from Columbia University (New York). He held postdoctoral positions at Centre Nationale de la Recherche Scientifique (Paris), International Business Machines (Palo Alto), and Caltech. He was Assistant, then Associate Professor at the State University of New York (Binghamton), with sabbatical positions at Goddard Institute for Space Studies (New York) and the Australian National University (Canberra).

Leon"s industrial career began in 1980, at Amoco"s famous research center in Tulsa, where he was the Amoco inventor of what we now call seismic AVO. He led significant revisions to the exploration seismic paradigm, helping to establish the basic ideas of polar anisotropy and azimuthal anisotropy. His 1986 paper, establishing the modern field of seismic anisotropy, is the single-most-cited paper in the history of Geophysics; a Google search of the term ˝Thomsen parameter" returns over 300,000 hits. In 1995, he moved to Amoco"s Worldwide Exploration Group in Houston, where his 1997 paper established the modern field of converted-wave exploration, defining such concepts as fC-wavesf, fregistrationf, fgamma effectivef, fdiodic velocityf, etc. In 2008, Leon retired from BP, and established the consultancy Delta Geophysics (cf.deltageophysics.net).

Leon has served the Society of Exploration Geophysics as Distinguished Lecturer, Vice-President, President (2006-07), and Chairman of the Board of SEAM. He served as SEG/EAGE DISC Instructor in 2002. He holds the SEG"s Fessenden Award, and the Russian Academy of Natural Sciences" Kapitsa Medal. He is an Honorary Member of the Geophysical Society of Houston, and of the EAGE, and is a Foreign Member of the Russian Academy of Natural Sciences.

Borehole Seismic Fundamentals and Introduction to Advanced Techniques

2D 3D 4D ANISOTROPY ATTENUATION AVO BOREHOLE GEOPHYSICS CASE STUDY FRACTURES FULL WAVEFIELD IMAGING KIRCHHOFF LAND SEISMIC MARINE SEISMIC OFFSHORE OIL AND GAS RTM TIME-LAPSE TOMOGRAPHY TRAVELTIME VELOCITIES VSP VTI

Instructor:	Allan Campbell (VSP Consultants LLC, United States)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW EET

Course Description

This course has 6 sections. The course moves from giving a basic understanding of the most common surveys towards the newest techniques being developed to solve modern problems.

1. Introduction to Vertical Seismic Profiling

The VSP techniques used in industry are introduced. Basics of wireline acquisition, and an introduction to fiber based acquisition are covered. This section gives a brief overview of the value of all the commonly used borehole seismic techniques, from checkshot through to 3D VSP.

2. The Basics

Checkshot (velocity survey) and zero-offset VSPs are widely used, are simple to acquire and process, and have huge value. This section will describe acquisition, processing and interpretation of these basic, but possibly the most important, surveys.

3. 2D and 3D Imaging

This section will focus on designing and interpreting walkaway VSP and 3D VSP surveys. Down-hole receivers create the opportunity for higher resolution images than surface seismic can provide, and can provide images in poor seismic imaging areas, or images where surface access is difficult. Advanced processing techniques will be discussed. Specifics of survey planning and acquisition will be covered.

4. Anisotropy and More

The anisotropy module will focus on extracting VTI and HTI anisotropy parameters from walkaway VSP and 3D VSP surveys. Seismic may be improperly imaged due to poor anisotropy assumptions. Stress and fracturing information may be deduced from seismic and validated with VSP. Having receivers down-hole and sources at the surface creates an ideal opportunity to measure anisotropy in-situ. Ground truth measurement of AVO can be made with receivers downhole, this section describes the various VSP AVO techniques in common use. Downhole arrays are also ideal for locating multiple generators and measuring Q which we cover in this section.

5. Reservoir Monitoring and Reservoir Properties

This section focuses on time-lapse 3D VSP, which can observe reservoir changes with a greater precision than is possible with surface seismic. There is an overview of fracture detection and orientation with VSPs. Elastic FWI is being developed to measure the reservoir's elastic properties, and will be briefly covered. A discussion on very high resolution imaging and tomography with Crosswell seismic finishes the module.

6. Advanced Acquisition

Technology marches forward as limitations are reached in wireline acquisition. Putting the receivers in the drill string to get real-time VSPs (while drilling) is becoming routine. Optical fiber (DAS) recording is an emerging technology which enables efficient, fit-for-purpose VSP surveys with cost benefits over traditional wireline technology.

Course Objectives

Upon completion of the course, participants will know the basics of acquiring and processing borehole seismic data. They will also be familiar with the latest borehole seismic techniques in:

- High resolution imaging using 2D and 3D VSP surveys;
- Anisotropy determination and fracture analysis;
- Reservoir monitoring using time lapse VSP and crosswell seismic;
- Alternative acquisition schemes such as SWD and DAS.

Participants will have a better understanding of the role of borehole seismic techniques in hydrocarbon exploration and production. They will be able to more knowledgeably participate in the design, planning and execution of advanced surveys and be comfortable with the interpretation of these surveys.

Course Outline

The course will contain the following modules:

1. Introduction to Vertical Seismic Profiling (1.5hrs)
2. The Basics (2 hrs)
   a. Checkshot VSP
   b. Zero Offset VSP
3. VSP Imaging: 2D and 3D Techniques (2 hrs)
   a. Survey design and modeling
   b. Processing
      - model building, tomography, imaging techniques (Kirchhoff, RTM)
   c. 2D imaging
      - Offset VSP, Walkaway VSP
   d. 3D imaging

4. Anisotropy and More (3 hrs)
   a. Measuring anisotropy with walkaway and 3D VSPs
      -VTI and HTI, fractures
   b. AVO Analysis
   c. Techniques to locate multiple generators with VSP data
   d. Q estimation and Q compensation with VSP data
5. Reservoir Monitoring and Reservoir Properties (1.5 hrs)
   a. Time Lapse 3D VSP for reservoir monitoring
   b. Elastic FWI (VSP Inversion)
6. Advanced Acquisition (1.5hrs)
   a. Seismic while drilling
   b. Distributed Acoustic Sensing

Timing of sections may change.

Participants' Profile

The course is targeted toward those who have a basic understanding of surface seismic acquisition and processing, but only limited knowledge of borehole seismic. The course is designed to help participants identify borehole seismic solutions to common seismic interpretation problems. It is also be useful for those geophysicists needing higher resolution images than surface seismic can provide, and those geophysicists who need to validate seismic processing parameters and imaging models using borehole seismic. Lastly, the course is relevant for geophysicists wanting to learn how to use borehole seismic as a cost-effective reservoir monitoring tool.

Prerequisites

Participants are assumed to have knowledge of seismic response to earth reflectivity. Participants should be aware of common well logging services.

About the Instructor

Allan Campbell graduated in 1984 from the Northern Alberta Institute of Technology in Edmonton with a diploma in Earth Resources Technology and, after a spell in Dresser Atlas, graduated in 1990 from the University of Calgary with a BSc., majoring in Geophysics. In 1990, he started his 25-year career at Schlumberger in Calgary. Skills were developed in borehole seismic processing starting from basic check-shots up to the most complex 3D VSPs. In 1997, he moved to Houston Texas, to open a new borehole seismic processing center. The center rapidly evolved into a global center of excellence for VSP processing. Campbell helped Schlumberger fully develop 3D VSP processing capabilities.

2010 to 2015 saw the development of many innovative techniques. The integration of borehole seismic data into the processing of surface seismic, to improve the resolution and depth control in seismic images, was finally realized. VSP is now routinely used to detect and characterize fractures, to estimation of the elastic properties of rocks, and to monitor the changes in reservoirs due to both enhanced recovery methods and storage of CO_2.

From 2016 to the present, Campbell has been working as a geophysical consultant with VSP Consultants LLC. Projects have included work for major operators and service companies, supervising VSP processing projects. Interesting work is also being done on drill bit seismic in hard rock mining environments. VSP Consultants is also offering borehole seismic training courses to the oil and gas industry.

Full-Waveform Inversion: Where are the Anisotropic Parameters Hiding?

ANISOTROPY | IMAGING | ISOTROPY | MIGRATION | MINERALS | OIL AND GAS | VELOCITIES | WAVE EQUATION | WAVE PROPAGATION

Instructor:	Prof. Tariq Alkhalifah (KAUST, Saudi Arabia)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW EET

Course Description

The course starts by introducing the fundamentals of full-waveform inversion (FWI) starting from its basic definition. It focuses on the model update issues and provides analysis of its probable success in converging to a plausible model. In the course we will discuss the many challenges we face in applying FWI on seismic data and introduce modern day proposed solutions to these challenges. The focus of the course will be on FWI applied to anisotropic media. As a result, the course will also introduce anisotropy, its optimal parametrization and wavefield simulation in such media. Practical multi-parameter inversion for anisotropic parameters requires an optimal FWI setup. We will discuss such a setup, which includes the proper parametrization of the medium and data access scheme necessary for a potential convergence to a plausible anisotropic model.

Course Objectives

Upon completion of the course, participants will be able to understand:

- The scientific foundation behind full-waveform inversion;
- FWI challenges;
- Wave propagation in anisotropic media;
- Anisotropy + migration velocity analysis;
- Anisotropy + FWI.

Course Outline

I - Introduction to seismic inversion:
1. What is inversion?
2. What do we mean by full waveform inversion?
3. The Algorithm.

II - The elements of seismic waveform inversion:
1. Model and data.
2. The objective function.
3. The update.
4. The sensitivity kernel.
5. The non-linear issue.
6. Examples.

III - Seismic anisotropy:
1. Definition and parameters.
2. The acoustic anisotropic wave equation.
3. Fundamental issues.

IV - FWI and anisotropy:
1. Multi-parameter inversion.
2. The right set of parameters.
3. The anisotropic sensitivity kernels.
4. Getting an initial model.
5. Anisotropy and MVA.

Participants' Profile

The course is designed for geophysics, mathematicians and physicists working on problems related to seismic imaging of the Earth and building the necessary velocity models to do so.

Prerequisites

Participants should have some knowledge on the physics of seismic wave propagation.

About the Instructor

Tariq A. Alkhalifah is a professor of geophysics in the division of Physical Sciences and Engineering at King Abdullah University for Science and Technology (KAUST). He assumed his duties there in June 2009. Prior to joining KAUST, Tariq was a research professor and director of the Oil and Gas Research Institute at King Abdulaziz City for Science & Technology (KACST). He has also been associate research professor, assistant research professor and research assistant at KACST. From 1996 to 1998, Tariq served as a postdoctoral researcher for the Stanford Exploration Project at Stanford University, USA. He received the J. Clarence Karcher Award from the Society of Exploration Geophysicists (SEG) in 1998 and the Conrad Schlumberger Award from the European Association for Geoscientists and Engineers (EAGE) in 2003. He is a member of SEG and EAGE. Tariq received his doctoral degree in geophysics (1997) and master's degree (1993) in geophysical engineering from the Colorado School of Mines, USA. He holds a bachelor's degree (1988) in geophysics from King Fahd University of Petroleum and Minerals, Saudi Arabia.

Applied Depth Imaging

3D | ANISOTROPY | DEPTH MIGRATION | FULL WAVEFIELD | INTERPRETATION | MODELING | NEAR SURFACE | RTM | SALT | SHALE | TRAVELTIME | WATER | WIDE AZIMUTH

Instructor:	Dr Ruben Martinez (Reservoir Geoscience, United States)	
Language:	English, Spanish	
Level:	Intermediate	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

Hydrocarbons are increasingly more difficult to find because reservoirs are often located in geologically complex areas. This geological complexity has motivated a significant paradigm shift from time imaging towards the extensive use of seismic depth imaging. Depth imaging improves the definition of the structural and stratigraphic frameworks and provides a better assessment and mitigation of risk in E&P.

The goal of this course is for the participant to gain an understanding of the basic concepts and practical aspects used in building velocity models and seismic images in the depth domain in an intuitive manner. The participant will also be exposed to depth imaging practices currently in use by geophysicists and geoscientists through the description of workflows illustrated with synthetic and field data examples. The practical aspects are emphasized throughout the course.

At the end of the course, the emerging depth imaging technologies are reviewed for the participant to make informed decisions about what technology to use in future E&P projects.

Course Objectives

The aim of this course is focused on depth imaging concepts and applications for complex geology areas. At the end of the course, the participant will be able to:

1. Understand the fundamentals of seismic migration;
2. Explain the pitfalls of time imaging;
3. Describe the differences between time and depth seismic imaging for simple and complex geological structures and stratigraphy;
4. Discuss basic seismic acquisition parameters influencing the quality of the seismic images in complex geology areas;
5. Understand the strengths and weaknesses of the most popular prestack depth migration methods;
6. Recognize the limitations of the seismic data to produce optimum seismic images for complex structural and stratigraphic frameworks;
7. Describe velocity estimation methods required for specific exploration and field development scenarios;
8. Explain the impact of velocity anisotropy on the quality of depth images and its effect on the spatial positioning of geological structures and well ties;
9. Define and/ or choose depth imaging workflows for specific E&P scenarios such as sub-salt, pre-salt, thrust belt, sub-basalt, complex carbonates and clastics;
10. Judge the quality of seismic depth images for a geologic interpretation;
11. Interpret depth-imaged data;
12. Make informed decisions to choose depth imaging workflows and technologies to be used in a given exploration or field development project;
13. Effectively communicate about emerging depth imaging methods and technology.

Course Outline

1. Introduction to the course.
2. Seismic migration fundamentals.
3. Understanding seismic velocities.
4. Practical understanding of velocity anisotropy.
5. Review of velocity estimation methods used for depth imaging.
6. Seismic data conditioning for depth imaging.
7. Isotropic and anisotropic velocity model building and imaging in practice.
8. Optimization of seismic images for a more reliable geologic interpretation.
9. Overview of emerging velocity model building and imaging methods.

Participants' Profile

This course is designed for geophysicists, geoscientists and time processing and interpretation specialists seeking a practical understanding of depth velocity model building and imaging.

Prerequisites

It is desirable that the participants have a basic knowledge about seismic acquisition, processing and interpretation. Some basics of structural geology, stratigraphy and well logging are also desirable but not required.

Recommended Reading

Any general technical reading on basic seismic acquisition, seismic processing, time imaging, seismic interpretation, structural geology and/or salt tectonics will help to maximize the learning experience of the participant.

About the Instructor

Ruben D. Martinez is a Petroleum Geoscience Consultant and instructor with Reservoir Geoscience, LLC. He has been active in the seismic industry for 40 years.

Martinez was associated with Geophysical Service Inc. (GSI) as R&D Reservoir Geophysicist, Halliburton Geophysical Services (HGS) and Western Geophysical as Senior Research Geophysicist, AGI as director of Seismic Reservoir Characterization and Petroleum GeoServices

(PGS) as Manager Signal Processing R&D, VP Processing R&D, VP Seismic Processing Technology, Global Chief Geophysicist I&E and Chief Geophysicist I&E NSA. His responsibilities in PGS included directing global R&D and software commercialization of processing and imaging technologies. As Chief Geophysicist, he was responsible for the supervision and quality assurance of depth imaging projects, customer liaison, the promotion of best practices and the commercialization and use of high-end technology. Martinez is author and co-author of more than 70 technical papers published and/or presented at international conferences and 12 patents on seismic data acquisition, processing and imaging. He has also made numerous technical presentations at international conferences and has taught numerous courses and conducted seminars and workshops on seismic processing and imaging.

In 2005, he was invited to present the annual Milton B. Dobrin lecture at the University of Houston. He is currently an instructor of the Continuing Education Program of the Society of Exploration Geophysicists (SEG) and the European Association of Geoscientists and Engineers (EAGE). He is a member of the SEG Board of Directors as Director at Large. Martinez was the recipient of the 2014 Mexican Association of Exploration Geophysicists (AMGE) geophysics award for life-long achievements to geophysics.

He earned a BSc in Geophysics from the Instituto Politecnico Nacional (Mexico), MSc in Geophysics from the Colorado School of Mines and a PhD in Geosciences from the University of Texas at Dallas.
He is a member of the Society of Exploration Geophyscists (SEG), European Association of Geoscientists and Engineers (EAGE), Geophysical Society of Houston (GSH), American Association of Petroleum Geologists (AAPG) and Asociacion Mexicana de Geofisicos de Exploracion (AMGE).

Beyond Conventional Seismic Imaging

DEPTH MIGRATION | DIFFRACTION | FAULTS | FRACTURES | FULL WAVEFIELD | IMAGING | INVERSION | STACKING | TIME MIGRATION | TRAVELTIME | UNCERTAINTY | UNCONVENTIONAL | VELOCITIES | WAVE PROPAGATION

Instructor:	Prof. Evgeny Landa (Tel Aviv University, Israel)	
Language:	English, Russian	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW EET

Course Description

I. Wavefield Data Analysis

Time images usually provide sufficient information for a variety of subsurface models of moderate complexity and facilitate the estimation of the model for depth migration. Improving the quality of time sections remains the focus of intensive research. In particular, a lot of efforts are directed towards improving the accuracy of moveout correction. The proposed course discusses time imaging procedures such as Multifocusing and Common Reflection Surface when each image trace is constructed by stacking traces which need not belong to the same CMP gather. In this case a new and more general moveout correction is requested. These new methods open a way for reliable wavefield analysis and wavefront parameters estimation. The latest represents a basis for different applications including signal enhancement, velocity model building, statics correction, AVO analysis.

II. Seismic Diffraction

Currently applied seismic processing and imaging are almost exclusively based on seismic reflection. The latest is the response to continuity in the subsurface. At the same time accurate and reliable imaging of small scale geological elements and discontinuities of the subsurface such as faults, unconformity, fractures etc. are a key to improve seismic resolution. In unconventional reservoirs the main objective is detection of fracture corridors. Small scale objects give rise to a diffraction response. Use of seismic diffraction is a rapidly emerging technology which has tremendous potential to reduce exploration and production risks and increase oil and gas recovery.
The course integrates elements of the theory of wave propagation, diffraction modeling and imaging, and interpretation. The main objectives are: understanding the role of small and medium scale subsurface objects and elements in forming the total seismic wavefield and using diffraction for imaging.

III. Imaging without precise knowledge of the subsurface velocity model

In the proposed course I introduce a way to look at model-independent seismic imaging using the quantum mechanics concept. Can Feynman's path-integral idea be used for seismic imaging? We can construct the seismic image by summation over the contributions of elementary signals propagated along a representative sample of possible paths between the source and receiver points. When the velocity model is estimated with uncertainties, a single stationary path does not produce a correctly focused subsurface image. In contrary, quantum imaging uses all possible trajectories accounts for multiple stationary paths and takes into account model uncertainties.

IV. Pitfalls and challenges of seismic inversion

Proposed solutions are usually based on the criterion of the best fit between calculated and observed data. But it is well understood that by itself, a good fit does not guarantee that an inverted model is correct. Seismic inversion may lead to construction of several subsurface models with significantly different geological meaning, all of which fit the observed data equally well. The ill-posedness of seismic inverse problems is fundamental and does not depend on a particular type of algorithm or on the approach underlying the algorithms. In this course, I formulate a number of fundamental questions which should be addressed to make the inverse problems a mature science rather than a set of recipes.

V. Time Reversal in Seismic

Time Reversal (TR) plays an important role in seismic. It is directly connected to reverse time migration, interferometry and virtual source methods. Recently time reversal is proposed to localize subsurface sources in passive seismic and scatterers in active seismic surveys. Unlike in conventional migration, time reversal approach, in principle, does not require application of imaging condition. Numerical implementation of the time reversal method uses back propagation of the time-reversed recorded wavefield followed by an analysis of its obtained focusing. The physical implementation of TR, called Time Reversal Mirror (TRM), is used in various applications: underwater acoustics, telecommunication, cancer therapy, lithotripsy, nondestructive testing, etc. I demonstrate physical implementation of the TRM in seismic. Results of the field experiment show very promising results. I discuss possible applications of the method in seismic exploration and production.

Course Objectives

Upon completion of the course, participants will be able to:

1. Understand the role of time and depth imaging withing the general exploration work-flow.
2. Understand the differences between several prestack data analysis approaches, in particular CMP, CRS andincrease MF.
3. Appreciate importance and potential of seismic diffraction for increase resolution and reliability of seismic imaging.
4. Understand the uncertain nature of seismic velocity model and acquaintance to a way of taking the uncertainties into account.
5. Understand and admit fundamental problems of seismic inversion including FWI.

Course Outline

Introduction

- From statistics to determinism
- Overcoming uncertainties

I. Non CMP-based methods for data analysis and imaging

- Time versus depth imaging
- Why CMP method works?
- Non-hyperbolic moveout
- Why CMP method fails?
- Non-CMP based moveout: principles
- Wavefront parameter estimation: Multifocusing and Common Reflection Stack
- Applications: signal enhancement, statics correction, multiple attenuation, stack, migration

II. Seismic Diffraction

- Reflections versus difraction
- History
- Modeling
- Diffraction imaging
- Wavefield separation
- Case studies

III. Imaging without precise velocity model: Quantum seismic imaging

- Feynman “path-summation” picture of the world
- Path-summation seismic imaging

IV. Pitfalls and challenges of seismic inversion

- Inversion – thinking backward
- Non-uniqueness of geophysical inversion
- FWI: the present status

V. Time Reversal in Seismic

Participants' Profile

Participants should have a basic knowledge of seismic data acquisition and processing, static correction, CMP stacking for zero-offset approximation, normal moveout (NMO) correction, velocity analysis, semblance coherency measure, ray theory.

Prerequisites

Basic knowledge of seismic data acquisition and processing. static correction, CMP stacking for zero-offset approximation, normal moveout (NMO) correction, velocity analysis, semblance coherency measure, dip moveout. Basic knowledge in ray theory.

Recommended Reading

Participants are recommended to read the following articles before attending the course:

- Peter Hubral, 2001. The hidden roots of human discovery and creativity. First break, Volume 19.11 November 2001
- Richard Feynman, 1985. Surely You're Joking, Mr. Feynman!: Adventures of a Curious Character, Edward Hutchings (editor), W. W. Norton

About the Instructor

Evgeny Landa obtained his MSc degree in geophysics at Novosibirsk University (1972) and PhD degree in geophysics at Tel Aviv University (1986). He started his carrier in the former Soviet Union, Novosibirsk as a researcher, and senior geophysicist at the Siberian Geophysical Expedition. After immigrating to Israel, he worked at the Geophysical Institute of Israel as a researcher, Head of the R&D group and Head of the Seismic Department (1981—2002). During 2002-2014 he worked as Director of OPERA (Applied Geophysical Research Group) in Pau (France) where he was involved in different aspects of seismic data processing, velocity model building and time and depth imaging. His work on velocity model building by coherency inversion has had a strong impact on today's seismic depth imaging workflows and forms an important part of the GeoDepth (Paradigm) software package. Recently he is a professor of Tell Aviv University. His research interest involves using non-reflecting energy for increasing seismic resolution and imaging without precise velocity information. He has published more than 60 papers in international journals and his book 'Beyond Conventional Seismic Imaging'. He is a member of EAGE and SEG, from which he received the Awards of Best Paper (SEG, Honorary Mentioned, 2005) and the EAGE Eotvos Award (2007 and 2009)

Full-Waveform Inversion for High-Resolution Reservoir Characterization

AVO | ELASTICITY | FOURIER | INTERPRETATION | KIRCHHOFF | RADON TRANSFORM | REFLECTION | SCATTERING | WAVE EQUATION | WAVELET

Instructor:	Prof. Dr Dries Gisolf (Delft Inversion, Netherlands)	
Language:	English	
Level:	Advanced	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

The purpose of this course is to teach participants the fundamentals of extracting quantitative property information from seismic data. In the end this leads to an inversion process, which is called linear if the data are supposed to consist in primaries only and is non-linear if all multiple scattering and multiple mode conversion over a target interval (typically 500 m around the reservoir) is taken into account. Non-linear inversion leads to a higher resolution than obtained from conventional linear inversion techniques.

All steps required in these processes are based on wave equations and it is important, therefore, to have a good understanding of acoustic and elastic wave equations. In linear (AVO) inversion, first the reflection coefficients are derived from the data and subsequently the rock properties are derived from the reflection coefficients. In non-linear inversion, the properties are directly derived from the data. Non-linear inversion is an iterative process of which the first iteration (the Born approximation) represents the linear inversion result. The method is based on an integral representation of the wave equation. An important aspect of reservoir oriented full-waveform inversion (FWI-res) is that the surface recorded data are localized (focused) to the target area. This can be achieved by redatuming or by local demigration of migrated data.

Both the linear AVO data model in terms of reflection coefficients and the non-linear data model in terms of property contrasts against backgrounds are presented. Inversion, linear, or non-linear, requires regularization. Several regularization options are presented.

Finally, linear and non-linear inversions at the reservoir scale are demonstrated by highly realistic synthetic reservoir models and real data case studies. The real data case studies include the extraction of low-frequency models (backgrounds) from well data and the extraction of angle dependent wavelets from the seismic-to-well match.

Course Objectives

Upon completion of the course, participants will be able to:

- Understand what quantitative property information is contained in seismic data and how to extract it.
- Make better judgements as to what inversion method to apply to what problem.
- Adopt a more quantitative approach to seismic-to-well matching and low frequency background model extraction
- Further the role of reservoir geophysics in multidisciplinary projects.

Course Outline

- Introduction
- Short recap on complex integral transforms (Fourier, Laplace, F/K and linear Radon)
- The acoustic wave equation in inhomogeneous media
- Integral representations of the acoustic wave equation; Kirchhoff-Rayleigh and the Scattering Integral (Lippmann-Schwinger)
- The AVO data model; Zoeppritz reflection coefficients
- Linear inversion of AVO data including regularisation; synthetic and real data examples
- The non-linear data model for inversion; data equation and object equation; iterative, multiplicatively regularised inversion
- Applications based on an elastic full wavefield non-linear data model; realistic synthetic reservoir study, real data case studies including low- frequency model extraction and seismic-to-well matching. Synthetic time-lapse example.

Participants' Profile

This course is designed for geophysicists active in reservoirs and/or quantitative interpretation and processing geophysicists who would like to become involved in quantitative interpretation.

Prerequisites

Participants should have a basic training in geophysics and mathematics, particularly complex numbers and integrals.

About the Instructor

Prof. Dr Dries Gisolf graduated from the Delft University of Technology in 1971 and obtained his PhD at the University of Utrecht in 1975. In 1976 he joined Shell International Research Co. in Rijswijk, The Netherlands, as a seismic data processing geophysicist. Between 1980-2000 he held various positions for Shell in Oman, The Netherlands, Australia, Malaysia and Nigeria. Throughout his career with Shell he was involved in acquisition, processing and interpretation of seismic data, with an emphasis on quantitative prediction of reservoir properties. In September 2000 he was nominated as Professor of Acoustical Imaging and Sound Control at the Faculty of Applied Sciences at the Delft University of Technology. After retiring from TU Delft in 2010, he co-founded Delft Inversion in 2012, a service company providing high-resolution reservoir oriented inversion services to the oil and gas industry.

Migration and Velocity Model Building

DEPTH MIGRATION | IMAGING | INVERSION
TIME MIGRATION | TOMOGRAPHY | TRAVELTIME | VELOCITIES | WAVE EQUATION

Instructor:	Piet Gerritsma (Gerritsma Geophysical Training and Consultancy, Netherlands)	
Language:	English	
Level:	Advanced	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

The process of migration, whereby a proper image in time or depth of the subsurface is obtained, is directly related with the velocity model that both serves as input for the migration process as well as is the result of such a migration. Therefore migration and velocity model building are intimately related processes. The implementation of migration is characterized by a multitude of methods and algorithms; there is also a great variety of methods to build a velocity model. This course provides an overview of the migration principles, methods and algorithms and an overview of velocity model building principles and methods and algorithms. Examples and case studies will conclude this course.

Course Objectives

At the end of the course the participants will have obtained a complete overview and thorough understanding of the many alternative methods and algorithms that are currently in use in imaging and velocity model building.
The course emphasizes for each method the underlying geophysical model together with its assumptions and strengths and weaknesses; many examples will be shown to illustrate the material; theory with references will be included; a handout that covers all course material will be made available.

Course Outline

The following steps in Migration, DMO and Velocity Model Building will be discussed:

1. 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 wavefield extrapolation in depth
- Migration principles; the imaging conditions
- Migration of various data sets:
  - Shot profile migration
  - Survey sinking or redatuming
  - Zero-offset data migration
- Extended imaging conditions (time-shift and/or space-shift)
- 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
- Migration by double focused array synthesis
- Gaussian beam migration
- Reverse time migration — RTM
- Migration and demigration

2. 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)
  - traveltime inversion in the migrated domain (TIMD)
  - common focus panel (CFP) analysis
  - tomographic velocity model building
  - depth focusing analysis (DFA)
  - WEMVA: wave-equation migration velocity analysis
  - differential semblance optimization (DSO)
  - full waveform inversion (FWI)

4. Case studies — Examples
- Tomography
- Full Wave Inversion
- Velocity Model Building
- Parametric Velocity Estimation

Participants' Profile

ocessing and interpretation ` geologists and petrophysicists who wish to understand how the various types of velocity information can be derived from seismic data and who wish to understand how subsurface images are generated.

As the material covers the theory and practical implementations of present day practices, this course is relevant for those who are fresh from university as well as for those who wish to be updated on the newest developments. Participants should have a basic understanding of seismic acquisition and processing practices.

Prerequisites

Course participants should have a basic understanding of seismic acquisition and processing practices.

About the Instructor

Piet Gerritsma (1942) graduated in physics at the University of Groningen. He joined Shell in 1969 as a research geophysicist in Rijswijk (The Netherlands) and Houston (USA). He was actively involved in the development of programs for statics, velocity analysis, synthetic seismograms and raytracing, deconvolution, multi-component seismic, shear waves and anisotropy, AVO and migration. He acquired operational experience as processing and special studies geophysicist in Brunei and in Canada. He was Shell"s representative in international research consortia: SEP (Stanford), DELPHI (Delft University of Technology) and IFP (Institut Francais du Petrole); he also served as associate editor of Geophysical Prospecting on Migration, Modelling and Inversion. During his Shell career he has always lectured at both basic as well as advanced level covering a broad range of topics. He left Shell in 1999 after 30 years of service. Since that time he is a lecturer at CTG (Center for Technical Geoscience) at the Delft University of Technology. He also teaches regularly courses for national and international oil companies and service companies, both as an independent teacher as well as on behalf of geoscience training alliances. He has presented this course several times on behalf of the EAGE and CSEG.

Seismic Diffraction – Modeling, Imaging and Applications

DIFFRACTION | HIGH-RESOLUTION IMAGING | FULL ILLUMINATION | STRUCTURAL AND STRATIGRAPHIC INTERPRETATION | CHANNELS | FLUID-ESCAPE PIPES | FAULTS | FRACTURES | CARBONATES | WELL PLANNING | CASE STUDY

Instructor:	Dr Tijmen Jan Moser (Moser Geophysical Services, Netherlands)	
Language:	English, Dutch	
Level:	Intermediate	
Duration and formats:	Online: 3 live sessions of 4 hours	CPD Points: 6
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

The application of seismic diffraction imaging (DI) in the E&P industry has rapidly accelerated in recent years and is now positioned to make a major impact as a routine method combined with PSTM and PSDM. This is because the uplift in resolution and detectability of small scale features offered through the imaging of the diffracted wavefield is fundamentally superior to attributes derived from post-processing of the reflection image. Applications cover a very wide range of objectives such as faults, fractures, karsts, stratigraphic edges, channels, fluid escape pipes, volcanic pipes, injectites.

This course covers both the forward and inverse problem of seismic diffraction. The coverage of the forward problem extends from the discovery of the phenomenon of diffraction and the basic formulations of Fresnel and Kirchhoff to the evolution of modern seismic diffraction modeling. Diffraction imaging will be covered from the early works in the 1970s up to the present state of the art. Case studies will be presented covering examples for both structural and stratigraphic targets.

The course will put emphasis on key components for successful DI case studies:

- full integration of all available data, such as well data, legacy seismic, prior interpretation
- optimal focusing during pre-processing, model building and migration
- calibration of DI by Fresnel zone sampling to identify different components of the wavefield offering different interpretation perspectives
- validation of DI by forward modeling exercises at various scales (elementary conceptual models, bespoke models, full-detail scenarios)
- customization to interpretation throughout the workflow

Course Objectives

Upon completion of this course, the participants will:

- Have a detailed and up-to-date understanding of the physics of diffraction, diffraction modeling and imaging
- Be able to effectively communicate the key aspects of diffraction technology with other professionals
- Have a good understanding of the added value that seismic diffraction brings to current exploration and production projects

Course Outline

First day (4 hrs)

1. Introduction
- Motivation, basic ideas and concepts
- Reflection versus diffraction
- Applications of diffraction analysis and imaging
- Interpretation value

2. History
- Discovery and founding years (1650-1820): Grimaldi, Huygens, Newton, Young, Fresnel, Poisson, Arago
- Scalar diffraction: mathematical foundation — 19th century: Green, Helmholtz, Kirchhoff, Sommerfeld
- Towards Geometrical Theory of Diffraction — early 20th century: Maggi, Rubinowicz, Keller
- Towards Modern Theory: Trorey, Klem-Musatov

3. Diffraction Modeling
- Motivation, definitions, objectives
- Physical modeling
- Numerical modeling: integral methods, boundary layer methods, surface and caustic diffraction, finite differences, time-lapse, scattering methods

Second day (4 hrs)

4. Imaging
- Motivation, definitions, objectives
- Anatomy of diffraction
- Diffraction and standard processing
- Detection of diffracted waves
- Separation of diffracted waves
- Inversion of diffracted waves
- Imaging
- Common Reflection Surface/Multifocusing
- Focusing and velocity estimation
- Fracture detection
- Model-based diffraction imaging
- Illumination: edge and tip diffraction imaging
- Resolution and super-resolution
- Image processing and diffraction imaging

Third day (4 hrs)

5. Applications/case studies

- Carbonate Shales, Carbonate Ridges
- Faults And Fractures, Fault Detection, Reservoir Fault Interpretation, Fractured reservoirs, Basement Fractures
- Fluid Escape Features, Volcanic Pipes, Vertically Aligned Objects
- Channels
- Ground-Penetrating Radar Case Study

Participants' Profile

The course is designed for a general audience of geophysicists, geologists and reservoir engineers.

Prerequisites

Prerequisites are a basic knowledge of seismic processing and imaging and a very elementary mathematical background.

Recommended reading

Klem-Musatov K., Hoeber H.C., Moser T.J. and Pelissier M.A. (editors) 2016. Classical and Modern Diffraction Theory, Geophysical Reprint Series Nr 29, SEG.

Klem-Musatov K., Hoeber H.C., Moser T.J. and Pelissier M.A. (editors) 2016. Seismic Diffraction, Geophysical Reprint Series Nr 30, SEG.

About the Instructor

Tijmen Jan Moser has a PhD from Utrecht University and has worked as a geophysical consultant for a number of companies and institutes (Amoco, Institut Français du Pétrole, Karlsruhe University, Bergen University, Statoil/Hydro, Geophysical Insitute of Israel, Fugro-Jason, Horizon Energy Partners). Since 2005, he has been working as an independent consultant, associated with Z-Terra, SGS-Horizon and others. His main interests include seismic imaging, asymptotic methods, seismic reservoir characterization and diffraction. Since a few years he is also involved in geothermal exploration and microseismic monitoring. He has authored many influential papers on ray theory and ray methods, Born inversion and modeling, macro-model independent imaging, and diffraction imaging, several of which have received Best Paper awards. He has co-chaired Special Sessions devoted to Diffraction at the EAGE conferences of 2010, 2011 and 2012 and the Workshop on Seismic Diffraction Methods for Fault and Fracture Detection at the SEG conference in 2012, co-presented the EAGE Short Course on Seismic Diffraction (2011) and is co-editor of the SEG reprint volumes on Diffraction (2016). He co-organizes the APSLIM-IWSA woskhops taking place in the Czech Republic (2015, 2022). He is Editor-in-Chief of Geophysical Prospecting, has served on SEG's "Geoscientists Without Borders®" and is serving on SEG's Publication Committee and EAGE's Oil, Gas and Geoscience Division Committee and Research Committee. He is a member of SEG and MAA, and honorary member of EAGE.

Case Studies and Practical Considerations in Geophysical Acquisition and Processing Methods

BOREHOLE GEOPHYSICS | CASE STUDY | DEPTH MIGRATION | ELECTROMAGNETISM | ENVIRONMENTAL | GRAVITY | HSSE | LAND SEISMIC | MAGNETICS | MARINE SEISMIC | REMOTE SENSING | RESERVOIR CHARACTERIZATION | SIGNAL PROCESSING

Instructor:	Luca de Vincenzi (Ocre, Belgium)	
Language:	English, French and Italian	
Level:	Foundation	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

This course emphasizes how the aims of the G&G interpretation and the exploration targets have to be understood before starting the preparation of the explorations activities.

The in-field operations will be presented through a very comprehensive set of case studies both using large and small field crews in order to familiarize the Attendees to the research of the less expensive and more technical appropriate solution.

After a preliminary G&G introduction, the course describes how the expected goals of the geophysical survey are elaborated with the G&G interpreters, who work in the area of study. An estimation of the relative budget and procurement procedures shall be quantified with the Legal, Finance and the Exploration Departments.

The HSSE Impact Assessment, including the utilisation of satellite photographs and the scouting in the area of study, are of paramount importance for the survey design and the future management of the operations in the field.

The Invitation to Tender and related evaluation is the link between the preparation phase and the field operations

After definition of the technical program in the field, relations with Governmental Authorities and people living in the area of the survey start in order to carry out the mobilisation of the crew in a smooth way without financial-wise dangerous frictions with local population.

Last, but not least, the supervision (HSSE and QC) of the survey shall be organised.

All the technical, HSSE, logistic, political, and financial aspects of the mobilisation will be described using real cases.

A very wide range of acquisition, processing, interpretation and exploration well results will be presented as, for example, but not limited to: 2D, 3D, 4C, Ocean Bottom Nodes, Transition Zones, simultaneous sources, wide azimuth seismic, broadband seismic, onshore seismic survey using a combination of explosive and vibroseis. All topics are described using case histories and integrated with in-class exercises.

Benefit of real-time processing in a remote processing centre via data transfer by satellite (when applicable) will be emphasized.

Demobilisation will complete the in-field aspect.

Processing will be presented focusing the attention on imaging (signal/noise, vertical and lateral resolutions), Time-to-Depth conversion (PSTM, PSDM), and reservoir characterisation (dual trace inversion, acoustic vs. elastic impedance plots, estimation of fluids and physical properties of rocks).

Exploration well results are presented and discussed.

A portion of the course is allocated to the integrated reprocessing of legacy geophysical and integration with geological data to be applied as a propaedeutic exercise with two objectives:

1. to design the more efficient and less expensive exploration phase, and
2. to have a provisional work-flow of the processing sequence, subject to adjustments after data recording in the field, in order to invite to tender for acquisition and processing of the survey in one go.

Course Objectives

Upon completion of the course, participants will be able to:

1. have a complete outline from the exploration licence awarding until the understanding of the exploration well results,
2. know the advantages, the limits, the challenges and the pitfalls of the Geophysics applied to the O&G exploration,
3. manage the complex relationships between Oil&Gas Companies, Service Contractors and local authorities and population,
4. have a better work integration and sinergies with staffs of the other related departments,

Course Outline

DAY 1

Part 1: Introduction

A. Geological basin analysis (with case studies and exercises)
B. Outline of geophysical methods (Seismic, Gravity, Magnetic, Magnetotelluric, Remote sensing)

Part 2: Preparation of a geophysical survey (with case studies and exercises)

A. Definition of exploration targets
   Legacy data evaluation and interpretation
   Legacy data reprocessing
   G&G integration
B. Preliminary studies in the field
   Satellite images
   HSSE study
   Environmental Impact Assessment
   In-field scouting and relationships with local authorities/ populations
C. Geophysical survey propaedeutic to seismic
D. Invitation to tender (acquisition, processing, HSSE&QC supervision)

DAY 2
Part 3: Seismic survey (onshore and offshore, with case studies and exercises)
A. Principle and methodology
B. Preparation of the survey
C. Acquisition
   Mobilization
   Equipment test
   Work in the field
   Survey management and HSSE (supervision)
   In-field processing
   Restoration
   Demobilization
C. Seismic data processing
   Filters and deconvolutions
   Stacking
   Migration (PostSTM,PSTM/PSDM) and Time-to-Depth conversion

DAY 3
Part 4: AirMag survey (with case studies and exercises)
A. Principle and methodology
B. Survey preparation including authorities approval
C. Acquisition (airborn or on land/water)
D. Processing
E. Interpretation and G&G integration
Part 5: Magnetotelluric (with case studies and exercises)
A. Principle and methodology
B. Survey preparation including authorities approval
C. Acquisition
D. Processing
E. Interpretation and G&G integration
Part 6: Remote sensing (with case studies and exercises)
A. Principle
   Satellite and aircraft recprdings
   Multispectral methodologies
   Passive and active methodologies
B. Survey preparation including authorities approval
C. Acquisition
D. Processing
E. Interpretation and G&G integration

DAY 4
Part 7: Interpretation (with case studies and exercises)
A. Multidisciplinary integration
B. Qualitative geological facies and fluid content evaluation
C. Quantitative reservoir characterisation
D. Exploration well location (including logistic)
E. Borehole seismic
F. Exploration well resuls evaluation
G. Integration and updating of the prognosed vs. actual resuls
Part 8
A. Open discussion
B. Wrap-up
C. Way forward

Participants' Profile

Geophysical (in particular seismic) acquisition and processing users, who wishes to understand the overall chain from the awarding of the exploration licence until the proposal of the exploration well and, in case of success, the location of the appreciation well.

Interpreters and explorationists, who wish to gain some knowledge of geophysical acquisition, processing and reservoir characterisation techniques, their application in exploration and advantages, the limites, the challenges and the pitfalls of the Geophysics applied to the O&G exploration.
People involved in procurement, HSSE, or providing legal support, or young engineers, who wishes to have an outline of the geophysical survey applied to the hydrocarbon exploration.

Prerequisites

Neither a geophysical background, nor mathematics skill is mandatory: because the key for the success of a project is not to have a few experts, but that all involved actors understand what the others departments and users are doing and why.

Recommended Reading

Any basic geophysical reading, pending on available time.

About the Instructor

Project manager with more than 35 years of experience in the oil, gas, and unconventional exploration, working with major and middle-sized oil companies providing a high standard quality work and showing good inter-personnel relationship skills. He has a lot of experience in geophysical acquisition, including borehole, (very often working in challenging environments, solving logistical and political problems, and using leading edge technologies), geophysical processing (applying state-of-the art software and even processing methodologies at research level and not on the market, yet) and geological/geophysical interpretation in several geological basins.

- Very involved in HSSE management and familiar with Safety Management Systems.
- From 08/83 to 08/93 Geophysicist with Total in France and Italy
- From 09/93 to 09/97 Chief geophysicist with Total in Italy
- From 10/97 to 12/05 Chief Geophysicist with Wintershall in the Netherlands and Libya
- From 01/06 to 10/07 Country Representative with Wintershall in Mauritania
- From 11/07 to 12/08 Exploration advisor with Wintershall in the Netherlands
- From 01/09 to 07/11 Team Leader with ENI in Nigeria and Egypt
- From 08/11 to 02/13 Unconventional Tar Sands Project Manager with ENI in Congo Brazaville
- From 02/13 to 07/13 Regional Geophysical and New Venture Manager with ENI in Italy
- From 08/13 to 10/14 Head of Geophysics with CEPSA in Spain
- From 10/14 to 05/20 Head of Geophysics with Dragon Oil in Dubai
- From 06/20 to current Geophysics Senior Advisor with OCSE in Belgium
- Several papers presented and published in International conferences and seminars (e.g.: EAGE Conference in Florence in 2002, in Tunis in 2003 and in Vienna in 2006, GEXP in Libya in 2005, EPC Conference in Tunis 2018, GEO in Bahrein 2018 and 2020, EAGE in Oman 2018, EGYPT in Cairo 2019, ADIPEC in Abu Dhabi 2019, MOC in Alexandria 2019) and. publication in First Break 2006, AAPG 2011 and GEO 2020.
- Chairman/reviewer at EAGE Tight Reservoirs Workshop 2019 in Saudi Arabia, AAPG Stratigraphic Traps of the Middle East 2020 in Saudi Arabia, IPTC 2020 in Saudi Arabia and EAGE Workshop Hotspots on Algeria 2021 Virtual.

Geostatistics for Seismic Data Integration in Earth Models

FILTERING INTERPOLATION INVERSION KRIGING MAPPING SIMULATION SPECTRAL ANALYSIS VELOCITIES

Instructor:	Olivier Dubrule (United Kingdom)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 to 4 live sessions of 4 hours	CPD Points: 4 to 8
	Classroom: 1 to 2 days	CPD Points: 5 to 10

NEW

Course Description

In recent years the use of geostatistics has spread from the world of reservoir characterization to that of velocity analysis, seismic inversion, uncertainty quantification, and more generally to that of seismic data integration in earth models. Nevertheless, many geoscientists still regard geostatistics as little more than a statistical black box. By explaining the concepts and applications, this course clarifies the benefits of geostatistics and helps spread its use.

The course covers the use of geostatistics for interpolation (kriging, etc.), heterogeneity modeling (conditional simulation), uncertainty quantification, and data integration (cokriging, geostatistical inversion, etc.). A variety of applications and examples are presented, including velocity mapping, construction of realistic heterogeneity models, and seismic data integration in stochastic earth models. The relationships between geostatistics and approaches more familiar to geophysicists, such as filtering or Bayesian methods, are also discussed, without entering into mathematical details. A number of case studies are presented, covering examples from various parts of the world.

The short-course presentation provides an overview of basic concepts and applications. The course notes provide a support to the course and further extend some of the more technical considerations.

Course Objectives

As a result of attending this course, geoscientists will better understand how geostatistics fits into their workflow, what tools and techniques they should use depending on the problem at hand, and what added value may result from its use. More specifically, after attending the course, geoscientists will be able to:

- Define the right variogram to use in order to quantify their geological knowledge
- Recognize and discuss the main assumptions that were made in a given geostatistical study
- Interpret the results of a geostatistical heterogeneity modeling exercise, whether based on kriging or conditional simulation
- Choose among the various geostatistical modeling methods proposed by earth modeling software

Course Outline

Part 1: What does the Variogram mean? Ordinary Kriging, External Drift Kriging and Collocated Cokriging for combining seismic and well data, Factorial Kriging for filtering seismic data.

Part 2: Monte-Carlo Simulation, Conditional Simulation, Geostatistical Inversion and Earth Model Uncertainty Quantification.

Participants' Profile

Geoscientists (including geologists, earth modelers, petrophysicists, geophysicists and reservoir engineers) who have been exposed to applications of geostatistics but would like to improve their understanding.

Prerequisites

Very basic statistical knowledge, and ideally some exposure to existing geostatistical software and applications.

About the Instructor

Olivier Dubrule obtained a PhD Degree in Petroleum Geostatistics at Ecole des Mines de Paris in 1981. He then worked for Sohio Petroleum Company in the USA (1982-1986), Shell International in The Netherlands (1986-1991) and, since 1991, he has been with Elf and Total, working in France, the UK and Qatar. Dubrule was Manager of the Total Geoscience Research Centre in Aberdeen (UK) (2004-2008) and of the Total Research Centre Qatar (2008-2011). He was VP Geoscience Training and Technical Image in Pau (France) (2012-2014). Dubrule just retired from Total but continues teaching at Imperial College.

Olivier Dubrule has authored many papers in the field of geostatistics and earth modelling. In 1991, he received the President's prize of the International Association of Mathematical Geology, for "Outstanding Contribution to Mathematical Geology by an individual 35 years or younger". He organized and chaired a number of events organized by SPE, EAGE, SEG or AAPG. Dubrule is the author of AAPG Course Notes Series #38 "Geostatistics in Petroleum Geology", and editor (with E. Damsleth) of "Petroleum Geostatistics" a Special Issue of EAGE's Petroleum Geoscience Journal, published in 2001.He was the SEG/EAGE DISC (Distinguished Instructor Short Course) in 2003 and President of EAGE (European Association of Geoscientists and Engineers) in 2004-2005. His book "Geostatistics for Seismic Data Integration in 3-D Earth Models" was translated in Russian and Farsi.

Integrated Reservoir Modeling

3D CARBONATES CORRELATION GEOSTATISTICS INTEGRATION RESERVOIR CHARACTERIZATION WELL LOG

Instructor:	Prof. Dr Michael Poppelreiter (Shell, Kuwait)	
Language:	English	
Level:	Advanced	
Duration and formats:	Online: 6 live sessions of 4 hours	CPD Points: 12
	Classroom: 3 days	CPD Points: 15

NEW

Course Description

This outcrop-based course provides participants with an overview of the integrated reservoir modeling process, tools and tasks. The data set is from a Tertiary carbonate reservoir. It exposes participants to hands-on integrated reservoir modeling.

A conceptual reservoir model and a digital reservoir model are constructed on paper and digitally. Common sedimentological techniques such as section logging, gamma ray measurements and interpretation of aspect ratios from photo panels and maps will be demonstrated and practiced.

All data required to build models are actual industry data. The uncertainty of all data sets is assessed. Alternative models are constructed. QC of data versus interpretation is an integral part of the course. A strong emphasis is put on stratigraphic correlation framework and structural model building. Property modeling and volumetrics are carried out interactively as a team exercise. Team interaction is a fundamental component of this course.

Course Objectives

Upon completion of the course, participants will be familiar with:

- Reservoir modeling workflow;
- Structural model building;
- Construction of a stratigraphic framework;
- Acquisition and modeling of reservoir body dimensions on a regional and local scale;
- Acquisition, measurement and application of petrophysical properties;
- Integration of data at different scales: thin sections, cores, outcrop panels, petrophysical data and regional geological information depositional system of Tertiary age;
- Well exposed and exceptionally well-studied on a local and a regional scale.

Course Outline

- Introduction
- Review of statistical analysis and probability
- Part 1: Sources of uncertainty in geophysics and reservoir modeling
- Part 2: Modeling uncertainty in seismic reservoir characterization
- Part 3: Geostatistics and spatial uncertainty
- Part 4: Uncertainty and data integration
- Part 5: Structural uncertainty
- Part 6: Uncertainty in reservoir dynamic modeling
- Part 7: Visualizing uncertainty
- Part 8: Value of Information and decision making

Participants' Profile

The course is designed for geologists, geophysicists, engineers, petrophysicists or others involved in reservoir modeling.

Prerequisites

Participants should have knowledge of geology and petrophysics. Students are expected to have a clear understanding of how to use Petrel software as well as some comprehension of the principles of geology and log analysis.

Recommended Reading

Participants are recommended to read before attending the course Kerans and Tinker (1997), SEPM Short Course Note 40.

About the Instructor

Prof. Dr Michael C. Poppelreiter, Director of the South East Asian Carbonate Research Lab (SEACaRL), Shell Chair in Petroleum Geology at the Department of Geosciences, Universiti Teknologi PETRONAS (UTP). From October 2019 he has been working for Shell Kuwait. Area of expertise: Shell Subject Matter Expert for carbonate geology, Outcrop and Regional Geological Studies (focus Middle East), Conceptual Modelling, Reservoir Modelling and 3D Digital Modelling, Project management, CO_2 in carbonate, Technical Assurance & Capability (TA-2), 25 publications and 2 books on borehole image logs and reservoir geology.

Seismic Attributes and Their Applications in Seismic Interpretation

DECOMPOSITION | FAULTS | INTEGRATION | NOISE | WORKFLOWS

Instructor:	Dr Behzad Alaei (Earth Science Analytics, Norway)	
Language:	English, Norwegian, Persian	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

Course Description

Seismic attributes have been increasingly used in both exploration and reservoir characterization and has been integrated in the seismic interpretation process. Seismic attribute analysis can extract information from seismic data that is otherwise hidden and have been used to identify prospects, ascertain depositional environments (e.g. fluvial or deep water channels, carbonate buildups), detect and enhance faults and fracture sets to unravel structural history, and even provide direct hydrocarbon indicators. They have proven to be useful in different geological settings such as clastic, carbonate, and salt related basins as well as different tectonic regimes including extensional, strike-slip, and compressional. Developments in digital recording and modern visualization techniques had great impact on the growth of seismic attributes in the past decades. The purpose of this course is to introduce seismic attributes with their applications in seismic interpretation using examples from different sedimentary basins and also through certain attribute workflows. It is aimed to provide geoscientists with the minimum required theory of how each attribute is generated, with a greater emphasis on the application in the exploration and reservoir characterization.

The course is divided into two parts: attributes review/applications and workflows. The first part starts with a review of seismic attributes and discusses the noise (random and coherent) reduction as one essential step of all attribute studies. The number of seismic attributes has recently increased dramatically causing confusion for geoscientists to select appropriate ones. In this course, trace-based attributes, volumetric dip and azimuth, fault detection and enhancement attributes, volumetric curvature, and frequency decomposition are presented using examples from different geological settings. Frequency decomposition is briefly presented with different decomposition methods such as wavelet transform, Fourier transform and matching pursuit analysis. Examples illustrate the interpretation challenges associated with frequency decomposition data interpretation. The concept of multi-attributes and geobody extraction is introduced at the end of the first part of the course with examples on combinations of amplitude, phase, discontinuity and frequency attributes to visualize different geological objects.

In the second part of the course stratigraphic and structural workflows are presented. The workflows (and the elements for their planning) aim to show the integration of several attributes for specific interpretation purposes, with examples of stratigraphic (fluvial/shallow marine clastic systems, attribute expressions of deep water turbidites and carbonate settings) and structural imaging workflows. Lastly, the course analyses the importance of the integration of seismic attribute analysis processes with the other seismic interpretation (qualitative or quantitative) workflows.

Course Objectives

Upon completion, participants will be familiar with a range of relevant attributes used in seismic exploration and reservoir characterization. They will know the basics of how those attributes were calculated and will gain understanding of their applications in seismic interpretation. They will be able to plan some attribute workflows and they will know how to integrate attribute analysis with other disciplines of qualitative/quantitative seismic interpretation.

Course Outline

Part I: Seismic Attributes

- Introduction:
  - Definition and historical review
  - Structure of the short course
- Input data cleaning:
  - Noise reduction applications with examples
  - Workflow oriented noise removal process
  - Focus on structurally oriented edge preserving methods to remove noise
  - Mean and median filters for noise removal
- Trace-based attributes:
  - Complex trace analysis and the elementary attributes of envelope (reflection strength), instantaneous phase, instantaneous frequency, and cosine of phase attributes
  - Simple examples with interpretation applications
- Dip and Azimuth volumes:
- Quantitative estimate of dip and azimuth through seismic volumes to map morphology of seismic texture
- Introduction and theory
- Dip and Azimuth calculation methods including:
  - Calculating temporal and spatial derivatives of the phase estimated using complex trace analysis
  - Explicit dip scan to find the most coherent reflector
  - Gradient structure tensor
- Examples with applications for both structural and stratigraphic interpretation aspects.

5. Coherence (Measurements of the similarity of seismic waveform)

- Introduction
- Different approaches including:
  - Cross correlation
  - Semblance
  - Variance

- Eigenstructure
- Gradient structure Tensor-based coherence
- Role of dip and azimuth steering volumes on coherence calculation
- Several examples and interpretation criteria

6. Fault attributes, attribute enhancement approaches:
- Identify objects representing faults from background noise.
- Apply filters to enhance already detected faults from background noise.
- Plan different filter sizes to enhance faults with different scales (regional to small scale).

7. Curvature attribute:
- Definition and background theory
- Surface and volume curvature measurements
- Interpretation applications using some examples

8. Frequency decomposition:
- Introduction and mathematics of spectral decomposition using graphic illustrations
- Review of decomposition methods:
  - DFT (discrete Fourier transform)
  - CWT (continuous wavelet transform)
  - MPD (matching pursuit decomposition)
- Examples and applications in layer thickness estimation, stratigraphic variations (seismic facies) and Direct Hydrocarbon detection
- Non-uniqueness will be addressed together with resultant challenges in interpretation of frequency decomposed data

9. Multi attributes, geobody extraction, and iso proportional slicing:
- Some attribute blending methods such as RGB blending, and opacity blending
- Geological object identification
- Machine learning examples of multi attributes
- Selection of appropriate attributes
- Quantitative extraction of certain attribute volumes
- Iso proportional slicing as an important interpretation tool

Part II: Workflows
- Seismic attribute analysis workflow planning:
  - Stratigraphic, structural, reservoir characterization
  - Factors controlling the seismic attribute workflow planning
- Workflow examples: fault imaging, carbonate imaging
- Integration of attribute analysis with other disciplines of seismic interpretation

Participants' Profile

The course addresses geoscientists involved in exploration and production projects where seismic studies play a role and who wish to learn the basic theory of the main seismic attributes used in exploration and production, as well as their applications and how to integrate them in exploration and reservoir characterization studies.

Prerequisites

Participants should have knowledge of seismic interpretation. Mathematical concepts of attributes are presented with minimum required equations and graphic illustrations. Some basic knowledge of seismic exploration may help.

About the Instructor

Dr. Behzad Alaei is geophysicist and co-founder of Earth Science Analytics AS. He has PhD in exploration seismology from University of Bergen, Norway. He has 25 years of industry and research experience focused on seismic exploration, forward modelling of complex structures, seismic imaging, seismic attributes, and machine learning applications in geoscience. He carried out several seismic attribute studies over different sedimentary basins from Asia to Norwegian continental shelf and Gulf of Mexico. In the recent years, he has been involved in the integration of seismic fault attributes with structural geological investigations of faults as well as development of machine learning techniques in geoscience.
He is a member of EAGE, SEG, and CSEG.

Seismic Interpretation: Fundamental for Prospect Generation

2D | CASE STUDY | DEPTH CONVERSION | FAULTS | INTERPRETATION | LAND SEISMIC | MAPPING | OIL AND GAS | ROCK PHYSICS | SEISMIC ATTRIBUTES | SEISMIC STRATIGRAPHY

Instructor:	Dean Powell (Powell Seismic Services, Australia)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

Seismic data provide us with a response from the subsurface, rather than a model of the subsurface. The challenge for the seismic interpreter is to understand this response, manipulate it in accurate and creative ways in order to model the geology that gave rise to it, and in the process identify drilling targets.

This course is designed to help geoscientists meet that challenge by assisting them to:

- understand the basics of seismic acquisition and processing,
- gain familiarity with qualitative and quantitative aspects of the seismic interpretation process,
- utilize various interpretation techniques and tools,
- identify and avoid obstacles that limit the reliability of an interpretation,
- approach interpretation problems with creativity and perseverance,
- apply sound geological reasoning,
- build an understanding of how the ingredients can be integrated to constitute a reliable interpretation,
- evaluate the risk of exploration success,
- journey through the interpretation process to the choice of a drilling location.

The course utilizes a comprehensive 2D interpretation exercise based on an actual exploration scenario. This exercise is tackled in different stages throughout the course, helping participants to progressively incorporate the many aspects of the interpretation process, from the early stages of understanding the geological setting and making the stratigraphic correlations, followed by fault interpretation and horizon mapping, through to depth conversion and geological modeling. Additional exercises and case histories complement the classroom instruction, helping participants develop an open and creative mindset to broader exploration objectives as well as to the detail required for prospect generation. This mindset is one that looks for value in contributions from outside the strictly geophysical arena and also incorporates the geological risking process as a means of injecting rigor into the interpretation process.

Reinforcing the lessons gained from the major interpretation exercise, the concluding case history provides a further illustration of the integration of the available geotechnical data to achieve a successful outcome.

Course Objectives

This is not a survey design course. Survey design is discussed but not covered in detail. After attending this course, the participant will:

- Recognize the limitations imposed on a seismic dataset by acquisition and processing specifications;
- Identify key mapping horizons and play types in a seismic dataset;
- Translate the seismic image into a realistic geological model;
- Generate credible hydrocarbon prospects.

Course Outline

Day 1

- The background: Basic geophysics
- The preparation: Understanding the geology > Exercise stage 1
- The kick-off: Early observations > Exercise stage 2
- The map: Structural interpretation > Exercise stage 3

Day 2

- The model: Seismic stratigraphy
- The detail: Quantitative interpretation > Exercise stage 4
- The risk: Prospect evaluation > Exercise stage 5
- The background: Basic geophysics

Participants' Profile

All those interested in seismic imagery. The acquisition geophysicist may discover an unfamiliar presentation of familiar concepts. The processing geophysicist may discover the causes of some types of perturbations in seismic images. Likewise, the interpreter may gain understanding of the limitations in seismic images. Those in charge of financing these images may understand better why they are so expensive.

Prerequisites

The course is designed especially for early-career geophysicists and geologists as well as students in geoscience disciplines. It will also benefit other professionals involved in oil and gas exploration, particularly engineers and managers who wish to gain a better understanding of the role of seismic data in identifying drilling targets and to make a more informed assessment of the risk associated the decision to drill an exploration well.

About the Instructor

Dean Powell acquired a Bachelor Degree in Applied Science from the Queensland University of Technology at the end of the 1960s. He then began his geophysical career with a Chevron affiliate in West Australia, gaining extensive experience in the acquisition, processing and interpretation of seismic data. Subsequently, he worked as a Perth-based geophysical consultant for many years, providing project management as well as technical services on exploration and development projects in Vietnam, New Zealand and in many of Australia's sedimentary basins.

During the first decade of this century Dean was employed as a Principal Geophysicist with Origin Energy. In this capacity he supervised 2D and 3D seismic acquisition and processing projects, although his main responsibility was the interpretation and mapping of seismic data. Dean provided regional and prospect-scale mapping for exploration in many onshore and offshore regions in Western Australia and other parts of Australia, as well as in Indonesia, Malaysia, New Zealand and Vietnam.

In 2013 Dean resumed his consultancy role, and has been engaged in the provision of seismic acquisition, processing and interpretation services relating to conventional and unconventional prospect generation as well as field development in a number of Australian basins and in the Timor Sea.

Much of Dean's experience has been in poorer data quality areas, enabling Dean to develop particular expertise in the interpretation of poor quality datasets. Over the years, drilling on the basis of Dean's prospect mapping has, to date, resulted in more than a dozen commercially successful wildcat and near-field oil and gas discoveries.

Sub-Surface Uncertainty Evaluation (SUE)

ANISOTROPY INTERPRETATION RESERVOIR MODELING TOMOGRAPHY UNCERTAINTY WELLS WORKFLOWS

Instructor:	Manish Agarwal (Applied Geoscience Pty Ltd, Australia)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

INTRODUCTION TO SEISMIC UNCERTAINTY EVALUATION

1. Sources of Uncertainties (Data Acquisition, processing & Interpretation).
2. Validation with data examples on assessment/quantification & qualifications following standard industry practices. Introduction to new learning techniques/technology.
3. Value addition on how the course will benefit an interpreter, geologist, and a Reservoir Engineer.

SEISMIC UNCERTAINTY ASSESSMENT

1. Geological factors influence on Velocities
2. Review and evaluate various types of velocity (Average, RMS, Stacking, Migration, Pseudo, P&S).

SEISMIC UNCERTAINTY QUANTIFICATIONS

1. Construct geologically reasonable velocity models from the data (include synthetic seismograph creations and concept of geological/geophysical well markers).Hard and soft approaches.
2. Map migration, structural modelling & stochastic depth conversion.
3. Advance WCT(Well Constrained Tomography) workflows to construct geologically plausible models.

SEISMIC UNCERTAINTY QUALIFICATIONS

1. Quantifications to qualification stage: Blind well analysis, equiprobable model, multiple regression models..
2. Update depth conversion models adaptable to local geology and test them through amplitude shut-offs and closure maps
3. Evaluate structural uncertainties by performing Monte Carlo simulation on best reference depth maps
4. Evaluate the products from the multiple realizations: Probability distribution maps, multi-seed structures, amplitude conformance

Course Objectives

Seismic Uncertainty Analysis is a three fold approach to support well planning:

- Assessment, Quantification & Qualification
- Data Analytics is a must to understand data leading to decision (Data2Decision)
- Learn to qualify and quantify your seismic uncertainties: Deterministic and Stochastic
- Deploy Equiprobable models for Uncertainty assessments and qualifications
- Monte Carlo regression engine provides a relatively optimum P10/P50/P90 Volumetric ranges
- Uncertainty reporting and well planning

Course Outline

Day 1 -4HRS

SEISMIC UNCERTAINTIES ASSESSMENT

- Standard practices to evaluate and estimate the Seismic Depth Uncertainties
- Risk and Myths
- Why Quantification & Qualification of seismic depth uncertainties is important in E&P?

QUANTIFICATION OF UNCERTAINTIES (SEIS2WELLS)

- Deterministic Depth Conversion– Hard And Soft Approaches
- Probabilistic Depth Conversion – Variogram & uncertainty modelling
- Additional Techniques : Map Migration, Equiprobable models

ADVANCED RAY BASED DEPTH CALIBRATION (WELL TOMO)

- Tomography Approach For Geological Plausible Velocity Models : Vertical Ray Tomography
- Why it is better de-risking model? Predictions away from the hard data

QUANTIFICATION TO QUALIFICATION

- Blind Well Analysis to test the best technical cases
- Multiple regression models
- Equiprobable modelling

Day 2 -4HRS

QUALIFICATION OF UNCERTAINTIES: DRILL READY SEISMIC (DRS)
- Structural Flexing To Compute Probabilistic Volumetrics
- Spill Point Control And Amplitude Conformance Volumetrics
- Single And Multi-Seed Closures
- Probability And Iso-Probability Closure Maps
- Stacked Reservoir Volumetrics

DEPTH RISKING SCORECARD
- Uncertainty Risking Scorecard
- Depth Uncertainty Communication
- Well Planning and Decision Making from the Uncertainty Cube

- PITFALLS & GENERAL DISCUSSIONS
- Case Studies
- Q&A

Participants' Profile

The course is designed for Geologist, Geophysicist, drilling Engineers and Reservoir Engineers.

Prerequisites

Participants require a working knowledge on basic exploration cycle.

Recommended reading

- Integration of geology with depth conversion using Well-Constrained Tomography, EAGE April 2016
- Managing uncertainty to deliver complex development wells, AEGC September 2019
- Depth conversion and seismic inversion of the Scarborough gas field, ASEG December 2019

About the Instructor

Manish Agarwal is a senior reservoir geophysicist based in Perth with 25 years of experience in Oil&Gas exploration & field development. Areas of expertise include regional & field scale data integration, seismic and well data interpretation (Woodside operated fields: Pluto, Cimatti, Laverda, Browse, Scarborough, Myanmar & Senegal) & geophysical support for field development & drilling (Woodside operated fields: greater Enfield & greater Pluto).
Full cycle of seismic data acquisition (6 years with Schlumberger & SVUL), seismic processing & Q.I. (11 years with CGG) & interpretation and field development (9 years with Woodside and Reliance). Active in support of field development plans, static& dynamic reservoir modelling & well planning.
Experienced in new ventures & exploration, risk mitigation & data development. Involved in Q.C/Interpretation of 4D data from multiple Woodside producing assets (Brunello, Pluto, Laverda & Cimatti).
Developed and integrated technical workflows for time to depth conversion using image ray tomography. Supported drilling and completion teams for geosteering long offset wells. Specialist in quantification of sub-surface depth uncertaintiesand subsequent probabilistic volumetric assessment.

Geological Interpretation of Geophysical Data for Mineral Exploration

ELECTROMAGNETISM | GRAVITY | INDUCED SEISMICITY | MAGNETICS | MINERALS | POLARISATION | RADIOMETRICS | RESISTIVITY

Instructor:	Prof. Michael Dentith (The University of Western Australia, Australia)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 to 5 days	CPD Points: 10 to 25

NEW

Course Description

The purpose of this course is to provide training in how to use geophysical methods in mineral exploration. Designed for industry, government and student geologists seeking to understand how to use geophysical datasets to explore and map, and geophysicists seeking to include more geology in to their interpretations, this course teaches participants to integrate geological and geophysical data in a mineral exploration context.

Core topics include the basic principles of the main geophysical exploration methods used in mineral exploration including the importance of optimal processing and display of these data and the strengths and limitations of the various methods. Particular attention is paid to extracting the maximum amount of geological information from the data, recognising noise-related artifacts in interpretation products and how to deal with the ambiguity when interpreting geophysical datasets.

The course includes practical exploration exercises involving real exploration data.

Course Objectives

On completion of the course participants will:

- Understand how to integrate geological and geophysical information during mineral exploration
- Have the ability to solve exploration challenges using geophysical methods
- Be familiar with state-of-the-methods for analysing petrophysical data
- Understand the capabilities and limitations of the various geophysical data types
- Be aware of the importance of geophysics in the future of mineral exploration

Course Outline

The course comprises modules, the inclusion of which depends on its duration.

2 day course:

1. Introduction to geophysics
- a. Geophysical methods used in mineral exploration
- b. Geophysical anomalies and their sources;
- c. Ambiguity
- d. Geophysical exploration practice
- e. Cost of geophysics

2. Acquisition to display
- a. Signal and noise
- b. Sampling and survey design
- c. Data display

3. Data enhancement
- a. Wavelength-based enhancement
- b. gradient-based enhancements;
- c. Amplitude-based enhancements

4. Gravity and magnetic methods
- a. Basic principles of gravity and magnetism
- b. Reduction of gravity data – the influence of terrain
- c. Reduction of magnetic data – the importance of levelling
- d. Enhancing gravity and magnetic data (derivative-based enhancements, continuation, reduction to the pole)

5. Qualitative interpretation
- a. Understanding petrophysics
- b. Beyond 'geological pattern recognition' in image interpretation
- c. Geophysical expressions of common geological features
- d. Common pitfalls

6. Quantitative interpretation
- a. Representing the sub-surface with a geophysical mode
- b. Forward modelling
- c. Inverse modelling
- d. Analysing a modelling result

7. Electrical and electromagnetic methods
- a. Basic principles of electricity
- b. Electrical properties of rocks
- c. Resistivity method
- d. Induced polarisation method
- e. Basic principles of electromagnetism
- f. Electromagnetic data acquisition and interpretation

5 day course:

1. Introduction to geophysics
- a. Geophysical methods used in mineral exploration
- b. Geophysical anomalies and their sources
- c. Ambiguity
- d. Geophysical exploration practice
- e. Cost of geophysics

2. Practical exercise 1 – geophysical anomalies and exploration strategy

3. Acquisition to display
- a. Signal and noise
- b. Sampling and survey design
- c. Data display

4. Practical exercise 2a - Data display

5. Data enhancement
- a. Wavelength-based enhancement
- b. Gradient-based enhancements
- c. Amplitude-based enhancements

6. Practical exercise 2b – data enhancement

7. Gravity and magnetic methods
- a. Basic principles of gravity and magnetism
- b. Reduction of gravity data – the influence of terrain
- c. Reduction of magnetic data – the importance of levelling
- d. Enhancing gravity and magnetic data (derivative-based enhancements, continuation, reduction to the pole, pseudogravity)

8. Practical exercise 3a – enhancing gravity and magnetic data

9. Petrophysics
- a. Best practice in data collection and analysis
- b. Rock and mineral density and magnetism
- c. Physical properties and common geological processes

10. Practical exercise 3b – analysis of petrophysical data

11. Qualitative interpretation
- a. Beyond 'geological pattern recognition' in image interpretation
- b. Geophysical expressions of common geological features
- c. Common pitfalls

12. Practical exercise 3c – interpretation of gravity and magnetic maps for exploration targeting

13. Quantitative interpretation
- a. Representing the sub-surface with a geophysical model
- b. Regional-residual separation
- c. Forward modelling
- d. Inverse modelling
- e. Analysing a modelling result

14. Practical exercise 3d – modelling magnetic anomalies for exploration targeting

15. Radiometric data
- a. Basic principles of radioactivity
- b. Measuring natural gamma radiation
- c. Processing and displaying radiometric data
- d. Geology and geological processes and their effects on gamma radiation

16. Practical exercise 4 – interpreting radiometric data for exploration targeting

17. Electrical and electromagnetic methods
- a. Basic principles of electricity
- b. Electrical properties of rocks
- c. Resistivity method
- d. Induced polarisation method
- e. Basic principles of electromagnetism
- f. Electromagnetic data acquisition and interpretation

18. Practical exercise 5 – interpreting electrical and electromagnetic data for exploration targeting

19. Seismic reflection method
- a. Seismic waves
- b. Geological causes of variation in seismic properties
- c. Processing and interpretation of seismic data

Participants' Profile

The course is designed for:
- Industry, government and student geologists seeking to understand how to use geophysical datasets to explore for minerals
- Geophysicists seeking to improve the integration of geology in to their interpretations

Prerequisites

Participants should have a basic understanding of the geology of mineral deposits and mineral exploration practice. They should also be familiar with MS Excel.

Recommended Reading

Denṫith, M. and Mudge, S.T., 2014. Geophysics for the Mineral Exploration Geoscientist. Cambridge University Press.

About the Instructor

Professor Mike Dentith is Professor of Geophysics at The University of Western Australia, located in Perth, Western Australia. He has more than 25 years experience in teaching, research and consulting in petroleum and mineral exploration geophysics.

Professor Dentith is a senior and foundation researcher at the Centre for Exploration Targeting, a minerals industry-funded research centre developing new exploration methods for the mining sector, where he leads the geophysical research theme. Current research projects include geophysical signatures of mineral deposits, hard-rock petrophysics, magnetotelluric and seismic methods applied to mineral exploration and using geophysical methods for assessing regional-scale prospectivity. This research is funded by industry and government.

Professor Dentith is co-author of the award winning textbook, Geophysics for the Mineral Exploration Geoscientist, and editor of two case study volumes on the geophysical signatures of Australian mineral deposits. He has run numerous professional courses for industry, government and professional societies in Australia, South American, Asia, Europe and Africa.

Exploring for Minerals Using Geophysics: A Mineral System-Based Approach

ELECTROMAGNETISM GRAVITY INDUCED SEISMICITY MAGNETICS MINERALS POLARISATION RADIOMETRICS RESISTIVITY

Instructor:	Prof. Michael Dentith (The University of Western Australia, Australia)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

The purpose of this course is to familiarise mineral exploration geoscientists with the very latest developments in our understanding of the geophysical responses of mineral systems. The course revises the mineral system concept and considers these ideas in a geophysical context. New targets, in additional to traditional deposit-scale targets are proposed, e.g. fluid/metal source zones, fluid conduits and palaeo-reservoirs.

The geophysical responses of key mineral system components are considered from first principles. Physical property contrasts expected to be associated with different components are described and new methods of analysing petrophysical data are demonstrated. The use in mineral exploration of deep penetrating 'academic' geophysical methods is also described. Methods covered include the magnetotelluric method, deep seismic reflection profiling and teleseismic and ambient noise passive seismic methods.

Finally exploring for mineral systems using geophysical methods is demonstrated using examples from three important deposit styles: carbonate-hosted base metals, magmatic Ni-Cu deposits in mafic/ultramafic rocks and hydrothermal (orogenic) gold.

Course Objectives

On completion of the course participants will:

- Understand the mineral system concept and its implications for geophysical exploration, especially when exploring for blind targets
- Know how to recognise responses from components of mineral system in their geophysical datasets
- Be aware of recent developments in the use of deep-penetrating geophysical methods for mineral exploration
- Understand how to use analyse petrophysical data to predict geophysical responses of mineral system components
- Be familiar with the geophysical characteristics of common mineral system components, including the components of selected magmatic, sedimentary-basin-hosted and hydrothermal mineral systems.

Course Outline

1. Introduction: mineral exploration in 2017
- a. current exploration practice/strategy,
- b. declining discovery rates, rising discovery costs
- c. implications of going 'under cover'
- d. government exploration incentive schemes/public domain data

2. Mineral systems
- a. Description of the concept and implications for mineral exploration
- b. Mineral system classification schemes
- c. The importance of geographically widespread data and deep penetrating geophysical methods
- d. New targets suggested by the mineral systems concept: source, reservoirs, pathways and the importance of associated alteration

3. Petrophysics
- a. A new conceptual framework for petrophysical data: bulk-grain-texture
- b. Importance of proper sampling
- c. Importance of analysing the data in a geochemical/petrological/geological framework
- d. Workflow for petrophysical data in a mineral systems context: analysis in context of lithology, stratigraphy, metamorphism/alteration, location

4. Large scale and deep penetrating geophysical methods
- a. Key mineral systems targets (major faults, craton margins, mantle metasomatism, fluid reservoirs, major magma chambers) and their geophysical expression
- b. Potential field data (responses from mineral system components)
- c. Magnetotelluric data (responses from mineral system components)
- d. Active source seismic methods - deep reflection, refraction data (responses from mineral system components)
- e. Passive seismic methods - teleseismic, ambient noise methods (responses from mineral system components)

5. Geophysics of selected mineral systems
- a. Sedimentary basin-hosted system: Carbonate-hosted base metals (Mississippi Valley-type, Irish style)
- b. Magmatic system: Ni-Cu in mafic/ultramafic intrusions
- c. Hydrothermal system: orogenic gold

Participants' Profile

The course is designed for:

- Industry, government and student geoscientists who are using the mineral system concept to guide exploration and wish to understand how geophysical methods can be integrated in to their exploration strategy
- Geoscientists with a basic understanding of geophysical data sets seeking to be innovative in their use of geophysical exploration methods

Prerequisites

Participants should have a basic understanding of the geology of mineral deposits and mineral exploration practice.

Recommended Reading

McCuaig, T.C. and Hronsky, J.M.A., 2014. The Mineral System Concept: The Key to Exploration Targeting Society of Economic Geologists Special Publication 18, pp. 153–175

About the Instructor

Professor Mike Dentith is Professor of Geophysics at The University of Western Australia, located in Perth, Western Australia. He has more than 25 years experience in teaching, research and consulting in petroleum and mineral exploration geophysics.

Professor Dentith is a senior and foundation researcher at the Centre for Exploration Targeting, a minerals industry-funded research centre developing new exploration methods for the mining sector, where he leads the geophysical research theme. Current research projects include geophysical signatures of mineral deposits, hard-rock petrophysics, magnetotelluric and seismic methods applied to mineral exploration and using geophysical methods for assessing regional-scale prospectivity. This research is funded by industry and government.

Professor Dentith is co-author of the award winning textbook, Geophysics for the Mineral Exploration Geoscientist, and editor of two case study volumes on the geophysical signatures of Australian mineral deposits. He has run numerous professional courses for industry, government and professional societies in Australia, South American, Asia, Europe and Africa.

Microseismic Monitoring for the Energy Industry

ANISOTROPY EARTHQUAKE GEOPHONES INDUCED SEISMICITY ISOTROPY P-WAVE POLARISATION S-WAVE GEOTHERMAL CCS

Instructor:	Dr Leo Eisner (Seismik, Czech Republic)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

Course Description

This newly revised programme explains the principles of microseismic monitoring ranging from single monitoring borehole to surface and near surface networks. The applications cover from conventional to unconventional production, through geothermal energy extraction to CO2 sequestration. We will focus on understanding the measurements made in passive seismic, their use and their uncertainties. The course will also discuss the latest developments in microseismicity from DAS monitoring systems, source mechanisms, tomography and anisotropy to reservoir simulations. Finally, we will discuss social and scientific aspects of (induced) seismicity related to oil and gas reservoir, hydraulic fracturing and unconventional production.

Course Objectives

Upon completion of the course, participants will be able to:

- Select the right type of microseismic monitoring array to meet the goals that need to be monitored;
- Design an optimal array for passive seismic (surface or downhole) monitoring, estimate in it uncertainties of locations for microseismic events;
- Orient downhole geophones from a perforation or calibration shot, estimate approximate distance and depth of a recorded microseismic event;
- Calibrate velocity model;
- Identify shear wave splitting in downhole microseismic datasets;
- Mitigate hazards associated with induced seismicity by fluid injection;
- Determine epicenter from the surface monitoring array and estimate source mechanisms of visible microseismic events;
- Determine if the seismicity in the vicinity of an oilfield is related to injection or extraction of fluids.

Course Outline

1. Introduction: Definitions, a brief review of microseismicity outside of oil industry: water reservoirs, mining, geothermal, CO2 sequestration. Microseismicity and induced seismicity by reservoir production. Historical review of microseismicity in energy industry with focus on hydraulic fracturing (Basel, Soultz, M-site, Cotton Valley, Barnett, etc). Principles of the hydraulic fracturing and geomechanics. Goal of microseismic monitoring and options to meet them.

2. Earthquake seismology: number of unknowns, differences between active and passive seismic. Receivers - how to select optimal type of sensors to meet our goals. Absolute location, relative location. P- and S-wave polarizations. Frequency content of microseismic data. Finite source. Earthquake magnitudes.

3. Downhole monitoring: single well monitoring technique - S-P wave time + P-wave polarization technique location. Horizontal monitoring borehole. Picking strategies for downhole monotoring. Optimal design of downhole monitoring array. Orientation of downhole geophones. Velocity model building and calibration. Inclined/dual and multi well monitoring.

4. Surface monitoring: P-wave location from surface: depth vs. origin time. Detection uncertainty and signal-to-noise ratio. Frequency content, attenuation and detection. Design of surface monitoring array. Calibration and velocity model building. Relative locations: using S-waves recorded at the surface monitoring array. Case study comparing the downhole and surface locations. Why surface microseismic monitoring works, near surface attenuation.

5. Source mechanisms: concept of source mechanism, definition of dip, strike and rake for shear source. Description of shear, tensile, volumetric, CLVD components of source mechanism. Inversion for source mechanisms from single monitoring borehole, multiple monitoring boreholes surface P-wave only data. Radiation pattern of source mechanisms frequently seen in microseismic monitoring. Source mechanisms and stress orientation.

6. Advanced source parametrization: Magnitude: definition and determination, seismic energy, b-values and magnitude of completness, physical liminations of b-values, stress drop, source dimensions.

7. Anisotropy: Introduction to anisotropy. Effect of anisotropic media on S-waves: shear wave splitting. Shear wave splitting observed in microseismic data. Inversion of anisotropic media from P- and S-waves using microseismic events, time lapse changes. Anisotropy and surface monitoring of microseismic events.

8. Reservoir simulations: Current use of microseismicity in oil industry and implementation of microseismicity into modeling. Diffusion model for pressure triggering of microseismic events. Non-linear diffusion and mass balance. Discrete Fracture Networks constrained by microseismicity. Reservoir simulations and history matching.

9. Seismicity in the vicinity of energy exploration. History of felt seismicity related to oil and gas industry. Differentiation of natural and induced seismicity. Seismic moment and total injected volume. Blackpool case study as an example of induced seismicity. Oklahoma and DFW seismicity - natural seismicity? Hazard assesment and mitigation. Social aspects related to development of shale gas.

10. Review of recent reserch effort and case studies in microseismicity. Models of relationship between microseismicity and hydraulic fracturing. Most important things to remember about microseismicity.

Participants' Profile

The course is designed for users and practitioners in microseismic monitoring.

Prerequisites

No requirements prior to the course are needed, although knowledge of seismology and hydraulic fracturing would be beneficial.

About the Instructor

Leo Eisner obtained his MSc. degree in Physics at the Charles University of Prague and Ph.D. in Geophysics from the California Institute of Technology and his M.S in Geophysics from the Charles University in Prague. He spent six years as a Senior Research Scientist with Cambridge Schlumberger Research. He then moved to MicroSeismic, Inc. in 2008 and since 2009 till 2010 he was the Chief Geophysicist. in 2010 he moved to Prague to become Purkyne Fellow at the Czech Academy of Sciences. He worked in the Academy of Sciences until 2017. He founded and he is currently the President of a consulting company Seismik s.r.o. His papers and extended abstracts cover a broad range of subjects, including the seismic ray method, finite-difference methods, seismological investigations of local and regional earthquakes and microearthquakes induced by hydraulic fracturing, etc. He has lead/advised three Ph.D.s and six MSc. theses.

Seismic Fracture Characterization: Concepts and Practical Applications

3D ANISOTROPY CARBONATES MECHANICS MULTICOMPONENT P-WAVE ROCK PHYSICS SEISMIC ATTRIBUTES UNCONVENTIONAL

Instructor:	Dr Enru Liu (ExxonMobil, United States)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW EET

Course Description

The ability to identify fracture clusters and corridors and their prevalent directions within many carbonates and unconventional resources (shale gas, tight gas and tight oil reservoirs) can have a significant impact on field development planning as well as on the placement of individual wells. The characterization of natural fractures is difficult and cannot be achieved by any single discipline or single measurement. Geophysics can identify spatial distributions of fractures and fracture corridors between wells and seismically-derived fracture information to complement (not compete with) other measurements, such as outcrops, core, FMI, cross-dipole and other fracture information. This course is an introduction to the fundamental concepts of seismic fracture characterization by introducing seismic anisotropy, equivalent-medium representation theories of fractured rock and methodologies for extracting fracture parameters from seismic data. With a focus on practical applications, three case studies are presented to demonstrate the applicability, workflow and limitations of this technology: a physical laboratory 3D experiment where fracture distributions are known, a Middle East fractured carbonate reservoir and a fractured tight gas reservoir.

Course Objectives

Upon completion of the course, participants will be able to:

- Understand key geological aspects of fractures and their roles in hydrocarbon exploration and production;
- Understand the fundamental concept of seismic anisotropy and the equivalent medium representation of fractured rock;
- Understand the principal methodologies of seismic fracture characterization using shear-wave splitting and azimuthal variation of seismic attributes;
- Understand the basic data requirement, assumptions, limitations and applicability of seismic fracture prediction technology;
- Apply practical workflow introduced in this course to real seismic data;
- Interpret and integrate seismically-derived fractures with other measurements.

Course Outline

- Introduction: key geological elements
- Fundamental seismic anisotropy
- Equivalent medium representation of fractured rock
- Fracture characterization using P-wave data
- Shear-waves and applications of multicomponent seismology
- Case study 1: 3D Physical laboratory data
- Case study 2: An example from offshore Middle East carbonate reservoir
- Case study 3: An example from tight gas reservoir
- Summary and road ahead

Participants' Profile

The integrated nature of this subject means that the book and the associated course are purposely designed for individuals from all subsurface disciplines including geophysics, geomechanics, rock physics, petrophysics, geology, reservoir modeling and reservoir engineering.

Prerequisites

None. Students as well as experienced geoscientists and engineers should benefit from this course.

About the Instructor

Dr Enru Liu has over twenty-five years of experience working in rock physics, poroelasticity, seismic anisotropy, multicomponent seismology, fracture modelling/characterisation, modelling wave propagation in complex media, seismic attribute analysis and interpretation. He received a BSc in geophysics from the Changchun Geological Institute (now part of the Jilin University, China) and a PhD in geophysics from the University of Edinburgh (UK). He was a Principal Research Scientist at the British Geological Survey (BGS) until March 2007 when he joined ExxonMobil Upstream Research Company (EMURC). While at BGS, he was the principal researcher of the Edinburgh Anisotropy Project — an industry sponsored research consortium since 1988 and was the Principal Investigator of several industry and UK research council funded projects including the NERC Micro-to-Macro programme. He is currently a research associate in the Geophysics Division of EMURC. He has published over 80 papers in peer-reviewed journals on the subject covered in this course. He was an honorary/visiting professor at the China University of Mining and Technology (2003-2007), an honorary fellow of the University of Edinburgh (2005-2008) and a member of the Peer Review College of the UK Natural Environment Research Council (2006-2007). He is a member of the SEG Research Committee, the SEG Development & Production Committee, the EAGE Research Committee and a member of the Editorial Boards of Geophysical Prospecting (2000-2011) and Journal of Seismic Exploration (since 2008). He was the co-recipient of the Cagniard Award from EAGE in 2007 and received an honourable mention of a co-authored paper published in The Leading Edge in 2007.

Seismic Surveillance for Reservoir Delivery

4D INTEGRATION INTERPRETATION MARINE MONITORING SEISMICITY SHELF TIME-LAPSE

Instructor:	Olav Inge Barkved (Petoro, Norway)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW EET

Course Description

Time-lapse seismic surveys or 4D seismic provide snapshots of a producing hydrocarbon reservoir and its surroundings. The benefit of the technology in monitoring fluid and pressure changes and to point out bypassed oil or un-drained compartments has been well documented over the last 10–15 years. Still the technology is undergoing rapid development. One of the recent focuses has been the use of permanent seismic installation allowing for cost- effective frequent surveying, and an added benefit of providing additional recordings that would not be available without the permanent array. In addition, recent case studies have helped raise the awareness of how seismic monitoring techniques can be used to understand possible production induced effects outside the reservoir, often linked to geo-mechanical changes.

This course will provide some context on what is driving the dynamic changes linked to producing a hydrocarbon reservoir and what we should expect to observe using seismic technologies in a varied geological setting. It will address key issues that impact the feasibility of time-lapse seismic and evaluate established methods. However, the focus will be on 'new' technologies, use of a permanent array, frequent seismic surveying and integration of the data.

Examples from the Valhall field will be used extensively to illustrate the potential of seismic data and to articulate issues related to interpretation and integration. This will include data examples from marine towed 4D, frequent surveying using permanently installed sensors, in-well recordings and analysis of passive data, including micro seismicity. Use of seismic surveillance information to support reservoir management, new well delivery and base management will be a central part of the presentation.

Course Objectives

In the course we will aim at addressing:

- What type of fields and mechanism are candidates for seismic surveillance?
- An overview over available technologies for seismic surveillance of producing reservoirs, with a primary focus on time lapse methods and permanent systems
- 4D seismic and linkage to geo-mechanics
- Application and Integration across the disciplines; challenges and benefits
- Case stories
- How we value the seismic surveillance
- How recent example of emerging technologies can tell us what the future will bring

Participants' Profile

This course is of interest to managers, geoscientists and reservoir and petroleum engineers who aim for integrating time-lapse seismic data into the next level of technical and business decisions and anyone else who sees the benefit of tracking changes in the subsurface in a wider sense. The intention is to inspire, educate and possibly entertain individuals on how to embark on a seismic surveillance project and stimulate new ideas for those with some experience in the topic. The course will be biased towards marine seismic applications but this should not prohibit possible usage on land.

Prerequisites

Participants should have a basic appreciation of geosciences and petroleum technical principles linked to producing hydrocarbon.

About the Instructor

Olav Inge Barkved graduated with a Geophysics degree from the Norwegian Institute of Technology in 1983. He spent the first part of his career with Geco, as a Research Scientist, working a variety of aspects related to seismic reservoir characterization, interpretation technology and processing.

In 1992 Olav joined Amoco, and remained through the merger with BP in 1998. He has been supporting the development of the Valhall field in Norway as a geophysicist, technology coordinator and team lead and had a role as a global Advisor in Geophysics. Since 2003 Olav was the project leader of the Valhall Life of Field Seismic delivery program, and in 2006 he received the Norwegian Geophysical Award for his technical contribution and ability to identify and implement emerging technologies to support business objectives in support of field development. BP's Valhall Life of Field Seismic Project has been recognized by the industry by receiving the Norwegian Petroleum Directorates Improved Recovery award, the ONS innovation award and OTC's Distinguished Achievement Award.

In 2013 Olav joined Petoro AS as a senior advisor. Petoro is a company that manage the Norwegian State's large holdings in oil and gas licences on the Norwegian continental shelf.

Olav has also together with his colleagues received The EAGE best paper award in 1997 and in 2009, the Louis Canard Award in 2008 and TLE best paper award in 2008.

Olav is a member of NGF, NPF, EAGE and SEG and served as an EAGE Distinguished Lecturer in 2010.

Seismic Reservoir Characterization: An Earth Modeling Perspective

CARBONATES GEOSTATISTICS INTEGRATION INTERPOLATION INTERPRETATION INVERSION LITHOLOGY ROCK PHYSICS SEDIMENT

Instructor:	Dr Philippe Doyen (Independent Consultant, United Kingdom)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 to 4 live sessions of 4 hours	CPD Points: 4 to 8
	Classroom: 1 to 2 days	CPD Points: 5 to 10

NEW EET

Course Description

Three-dimensional numerical earth models play an increasingly important role in the petroleum industry to improve reservoir management and optimize hydrocarbon recovery. A key challenge for reservoir geoscientists is the quantitative integration of 3D and 4D seismic data into static and dynamic earth modeling workflows. Using a combination of theory and illustrations from real field studies, this two-day course reviews best practices and challenges for constraining earth models with seismic information and quantifying subsurface uncertainty.

Course Objectives

The course objectives of the course are to:

- Provide a practical introduction to techniques and workflows combining geostatistics and rock physics for the construction of seismic-constrained earth models;
- Explain how to integrate quantitatively seismic and well data in earth modelling workflows and evaluate the associated geo-model uncertainty;
- Describe the assumptions and technical limitations of current seismic-based geo-modeling techniques, thus helping reduce the black-box application of software tools;
- Highlight the technical challenges and the road ahead for quantitative seismic interpretation.

Course Outline

The two-days course is divided into 7 modules, which provide an overview of basic concepts and their application to a number of case study examples involving both clastic, carbonate and unconventional reservoirs.

- Module 1 — Introduction to geostatistics and earth modelling from seismic data.
- Module 2 — Geostatistical interpolation techniques for seismic-guided 3-D earth models.
- Module 3 — Stochastic simulation with seismic constraints.
- Module 4 — Seismic lithology and fluid prediction using statistical techniques.
- Module 5 — Stochastic inversion.
- Module 6 — Statistical rock physics.
- Module 7 — Simulator-to-Seismic workflow using 4-D earth models.

Participants' Profile

The course is aimed at geoscientists and engineers who are involved in the construction of earth models and who wish to learn about practical techniques for seismic data integration, combined use of seismic rock physics and geostatistics, uncertainty modeling and quantitative 4D interpretation. The course comes at a time when seismic-based earth modeling has become a key activity for integrated asset teams in the E&P industry. It should therefore be of interest to a broad audience, including technical specialists and managers, who are actively involved or supervise seismic-to-simulator activities. Basic knowledge of seismic inversion techniques and geostatistics is desirable.

Prerequisites

Basic knowledge of seismic inversion techniques ad geostatistics is desirable

About the Instructor

Philippe Doyen, formerly VP R&D for the GeoConsulting business line of CGG, is now working as an independent consultant with worldwide responsibility for technology development in reservoir characterization. Prior to joining CGG in 2003, Philippe was Research Director for Schlumberger Information Solutions (SIS). He has also worked for more than 10 years with Western Geophysical / Western Atlas where he was R&D manager for reservoir geophysics.

Philippe holds MS and PhD degrees in geophysics from Stanford University. He also holds a Mining Engineering degree (1st class) from the University of Louvain, Belgium. Philippe has been an Adjunct Professor at the University of Bergen, Norway, from 2006 to 2012. He was also part-time Geophysics Professor in the Mining Engineering department of the University of Louvain from 1989 to 1992.

Philippe has over 25 years R&D, consulting and teaching experience in seismic reservoir characterization, geostatistics, geological modelling and rock physics. He has developed several patented methods for multi data integration and uncertainty quantification in reservoir modelling.

Geostatistical Reservoir Modeling and Uncertainty Quantification

ELASTICITY GEOSTATISTICS INTEGRATION INVERSION MODELING MONITORING NOISE ROCK PHYSICS TIME-LAPSE

Instructor:	Dr Dario Grana (University of Wyoming, United States)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: Self-paced course - 7 hours recorded material	CPD Points: 3
	Online: IOSC- 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

Reservoir modeling provides a set of techniques to create three-dimensional numerical earth models in terms of elastic, petrophysical and dynamic properties of reservoir rocks. Mathematical/physical models of the reservoir are generally uncertain due to the lack of information, noise in data measurements, approximations and assumptions. The course focuses on geostatistical methods for reservoir modeling and uncertainty quantification techniques for reservoir predictions.

It is divided into four main parts: Geostatistical methods for interpolation and simulation; Rock physics modeling; Geophysical inverse problems; Uncertainty quantification.

Uncertainty propagation from measured data, through physical models to model predictions will be studied with a focus on seismic data inversion, static reservoir characterization, structural modeling, dynamic fluid simulation, and time-lapse monitoring. Real case studies will be presented for each topic to illustrate the proposed workflows.

Course Objectives

Upon completion of the course, participants will be able to:

- Generate multiple reservoir models;
- Understand physical relations between reservoir and geophysical parameters;
- Evaluate the uncertainty of model predictions.

Course Outline

The one-day short course will have the following schedule:
Introduction

- Part 1: Review of statistical analysis and probability
- Part 2: Geostatistics and spatial uncertainty
- Part 3: Rock physics
- Part 4: Geostatistics and spatial uncertainty
- Part 5: Seismic inversion
- Part 6: Uncertainty quantification
- Part 7: Visualizing uncertainty

Case studies will be presented for each section.

Participants' Profile

The course is designed for employees of oil companies in geophysics and reservoir modeling.

Prerequisites

Participants should have knowledge of basic reservoir modeling concepts and of common geophysical data.

About the Instructor

Dario Grana is an associate professor in the Department of Geology and Geophysics at the University of Wyoming. He received a MS in Mathematics at University of Pavia (Italy) in 2005, a MS in Applied Mathematics at University of Milano Bicocca (Italy) in 2006, and a Ph.D. in Geophysics at Stanford University in 2013. He worked four years at Eni Exploration and Production in Milan. He joined the University of Wyoming in 2013. He is coauthor of the book 'Seismic Reflections of Rock Properties', published by Cambridge University Press in 2014. He is the recipient of the 2017 EAGE Van Weelden Award, the 2016 SEG Karcher Award, and the 2015 Best Paper Award in Mathematical Geosciences. His main research interests are rock physics, seismic reservoir characterization, geostatistics, data-assimilation and inverse problems for subsurface modeling.

Operational Geomechanics: Characterization of Rock Stress, Rock Fractures and Rock Stability for Energy, Environmental, and Engineering Industrial Operations in the Lithosphere

Instructor:	Dr Mohammed S. Ameen (Geomechanics and Rock Fractures Expert, United Kingdom, retired from Saudi Aramco)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: not available	-
	Classroom: 1 day	CPD Points: 5

NEW EET

Course Description

This EAGE Education Tour (EET) course starts by introducing definitions of fundamental concepts such as force, stress and strain; which are the building blocks of natural and operationally induced geomechanical failure, both at deep and shallow zones of the Earth lithosphere. In that context natural rock and lithospheric stress homogeneity vs heterogeneity, and isotropy vs anisotropy are also discussed. The course goes on to address and illustrate naturally occurring rock fractures. Natural fractures' statistical, geometric, and kinematic categories, and structural habitats are also discussed.

Subsequently, the course presents the impact of natural fractures on fluid transmissivity /permeability and fluid storativity/effective porosity of rock masses which are crucial in many aspects such as hydrocarbon assets (both conventional and unconventional reservoirs), geothermal, and water reservoirs and nuclear waste repositories, cap seal and fault seal integrity and seismic hazards.

The high-resolution detection, measurement, and diagnosis of fractures and stress indicators on drill bore scale (e.g. oil and gas wells, geothermal wells, site investigation boring in environmental, and geotechnical engineering projects like nuclear waste repositories, dam sites etc) are a starting point to any effective geomechanical assessment of rocks. These are presented focusing particularly (amongst other tools) on borehole image logs like resistivity and ultrasonic images and rock samples such as full diameter drill core, side wall plugs, and cuttings. Quality control on logs- and core-based data is an essential step in assuring reliability of their interpretation and subsequent decision-making. Therefore, the course covers the uncertainties associated with such tools (e.g. natural versus induced fractures; borehole deformation phenomena and their stress/strength implications etc).

Current day Earth stresses are the driving engine for any ongoing natural and artificially induced rock deformation and failure. Operational geomechanics' workflows used for the assessment of in situ stress magnitude and the in-situ stress orientation are introduced and discussed. Uncertainty sources in such workflows are also considered. The application areas of operational geomechanics with a particular attention to borehole instability and other engineering infrastructure integrity risks are then illustrated.

The course will also discuss the concept of rock-based mechanical anisotropy and heterogeneity and how they affect our operational practices. In that context it will discuss the impact on areas such as: hydrofracture stimulation; rock mass stability in deep and shallow environments including tunnels and dams, deep oil and gas boreholes and the seismic stability of existing faults in response to human made activities such as hydraulic fracturing and other operational activities.

Course Outline

The course will cover the principles, and tools relevant to operational geomechanics with specific attention to borehole-scale characterization. The following aspects are covered:

1. Introduction to force, stress and strain;
2. Natural rock fractures: their causes, statistical, geometric, and kinematic categories;
3. Borehole-scale geomechanical tools:
   3.1 Borehole images
   3.2 Borehole rock samples (whole core, plugs, cuttings)
   3.3 Sonic logs and supplementary open hole logs;
4. Rock mechanical characterization based on rock samples and logs;
5. In-Situ Stress Characterization based on rock samples, logs, and special field tests:
   5.1 Assessment of in situ stress magnitude
   5.2 Assessment of in situ stress orientation;
6. Assessment of rock mechanical and in-situ stress anisotropy;
7. Application areas of operational geomechanics.

Participants' Profile

The course is designed for geologists, geophysicists, and engineers working on and managers concerned with natural fractures and in-situ stresses characterization and instability risks of rock masses. The course is relevant to:

1. Oil and gas conventional and unconventional exploration, development and production;
2. Reservoir stimulation (e.g. hydrofracturing);
3. Assessment of geomechanical impact on fluid flow or sealing capacity of rocks (e.g. sealing faults; cap rock integrity etc);
4. Geothermal reservoirs;
5. Nuclear waste repository site investigation;
6. Geotechnical/engineering projects like tunnels, dams foundation, highways etc.

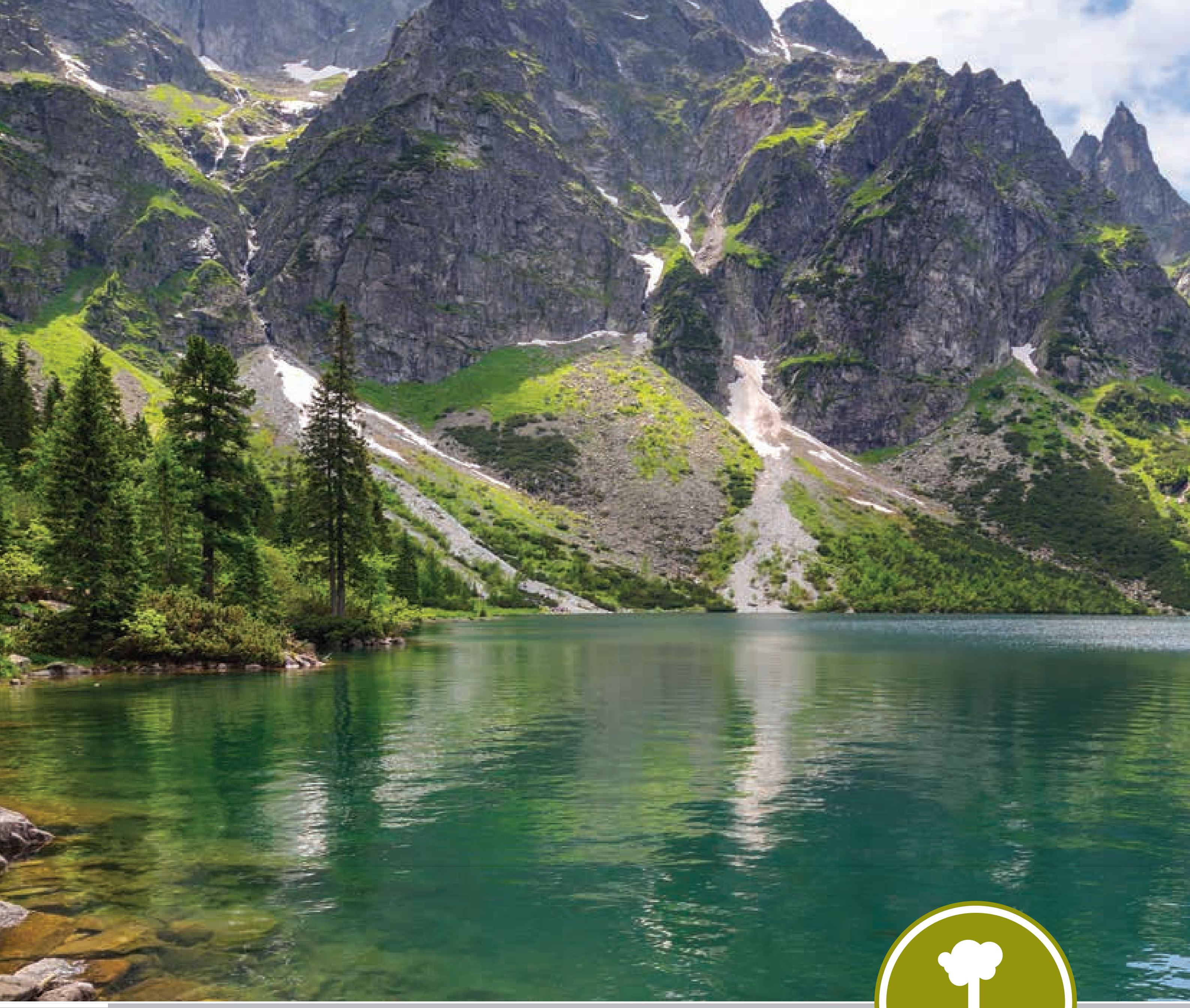
Prerequisites

Participants should have a basic knowledge of geology and a perception of the definition of rock porosity, permeability, and rock mass texture and structure. No software will be utilized in the course.

About the Instructor

Mohammed S. Ameen holds a PhD in structural geology and rock mechanics, from Imperial College, London, 1988 and has had over 30 years industrial and academic experience in the Middle East and Europe. As part of his industrial experience he has spent nearly 22 years working with Saudi Aramco, as the Principal Professional in Geomechanics. Ameen joined the Exploration Organization in Aramco in 1998, and has worked on diverse structural and geomechanical issues for exploration and development on all hydrocarbon provinces in Saudi Arabia, covering both conventional and unconventional resources across the expansive stratigraphic section of the kingdom. His work has covered both carbonate and siliciclastic reservoirs.

Prior to joining Aramco Ameen worked on geomechanical issues related to hydrocarbon exploration and geotechnical projects, e.g. nuclear waste repositories, strategic gas storage in depleted reservoirs, tunnel stabilities etc. Ameen started his career working as an explorationist by pioneering comprehensive fractures and fold traps characterization across the Taurus-Zagros of Iraq, incorporating 30 structural traps. Ameen is an Associate editor of the AAPG Bulletin, and the Journal of Unconventional Oil and Gas Resources (JUOGR). He has been an instructor of industrial courses for the AAPG and in house in Aramco. He has 28 peer-reviewed articles; 3 edited books; one published book on operational geomechanics; and over 900 citations. He has been awarded four US patents, and has filed a few pending patent applications.



Near Surface

ENVIRONMENTAL GEOPHYSICS •
NON-SEISMIC METHODS •

Near-Surface Geoscience

ACOUSTIC DRILLING GEOMORPHOLOGY HAZARDS INTEGRATION INTERPRETATION NOISE REMOTE SENSING SHALLOW

Instructor:	Dr Andreas Laake (Schlumberger, United States)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

This course covers the geological and geophysical concepts governing the near-surface. Methods for investigating and characterizing the near-surface such as remote sensing and surface geophysical methods are presented. The different measurements are archived and integrated in a geographical information system (GIS). The final integration reveals geological information about the near-surface and provides geophysical information for corrections in seismic data processing.

Course Objectives

The course introduces geomorphology as a concept to understand the geological and geophysical characteristics of the near-surface, enabling the students to extract structural and lithological information. This information can be used on one hand for the prediction of shallow drilling hazards and outlining deeper structures and on the other hand for the correction of near-surface effects in seismic data processing.

Course Outline

1. Geomorphology and the near-surface
2. Methods for investigation
3. Near-surface characterization
4. Impact of geomorphology on geophysical data
5. Representation and integration in GIS
6. Interpretation of near-surface geoscientific data

Participants' Profile

Geophysicists and geologists who are working in exploration and are curious to understand the impact of the near-surface on subsurface geophysical data and who wish to understand what the surface geomorphology can tell them about subsurface structures.

Prerequisites

Participants should have a basic knowledge of geophysics and geology.

About the Instructor

Andreas Laake is Geophysical Advisor at WesternGeco. He holds a diploma degree in physics and geology and a PhD degree in physics and geosciences from the University of Kiel, Germany. He held a research position at the Max-Planck-Institute for Hydrodynamic Research in Goettingen (Germany).

Andreas' industrial career began in 1988 as a hydroacoustic scientist with Prakla-Seismos in Germany. At Geco-Prakla in 1993, he started the geophysical design work for single sensor seismic technology which is now known as Q-Land technology. Since 2002, with WesternGeco, he has worked on remote sensing techniques and their integration into the seismic and reservoir workflow. In cooperation with the European Space Agency he developed a technique for characterization and modelling of the near-surface by merging satellite data with geological and geophysical data, which allows the prediction of noise features and the generation of synthetic seismic data prior to seismic data acquisition. This technology is also integrated with geographic information system (GIS) software and reservoir modelling (Petrel).

Subsurface Utility Engineering Detection & Mapping of Subsurface Utilities

SUBSURFACE UTILITY ENGINEERING | SUE | INDUCTION LOCATORS | GPR | GPS | HAZARDS MAPPING | WAVE PROPAGATION | SIGNAL PROCESSING

Instructor:	Dr Sanjay Rana (AF Academy - Aqua Foundation, India)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

Having accurate knowledge of subsurface/ underground/ buried utilities (pipes/ cables/ drains etc.) is critical for any infrastructure project. The successful detection and mapping of buried utilities involves the combination of several techniques, the results of which are synthesized down to a single interpreted plot. The techniques and methodologies used will primarily depend upon the required outcome for the survey, the site conditions and the type of pipes or cables being targeted. Subsurface Utility Engineering (SUE) is an upcoming field dealing with procedure and standards for detection and mapping of underground utilities. The course comprehensively covers all the aspects related to conducting a successful underground utility detection and mapping project.

Course Objectives

Upon completion of the course, participants will be able to:

- Learn how to detect and map buried pipes and cables (metallic & non-metallic) without digging
- Learn Ground Penetrating Radar
- Learn Induction Locators (cable & pipe locators/ radio locators)
- Understand quality levels of SUE (Subsurface Utility Engineering)
- Advanced data processing of Ground Penetrating Radar data
- Avoid accidents/ damage to underground utilities during construction

Course Outline

- Introduction to Subsurface Utility Engineering (SUE)
- Utility Quality Level Attributes
- Steps and procedures for QL-D data collection
- Survey procedures for collecting QL-C data (including use of total station, DGPS, etc.)
- Field Procedure and Approaches for GPR Surveys
- Data Processing of GPR data
- Data interpretation of GPR data
- Field Procedure and Approaches for EPL Surveys
- SUE map preparation guidelines, including plan, L section etc.

Participants' Profile

This course will help professionals, engineers and managers from entire spectrum of construction, infrastructure and municipal sector.

Prerequisites

None

About the Instructor

Dr. Sanjay Rana is a geophysicist by profession. He has been working in the field of engineering geophysics for last 30 years. Dr Rana graduated in 1990 from University of Roorkee, now IIT Roorkee, in M Tech (Applied Geophysics), as Gold Medalist. Dr Rana started his career with UP State Government and also worked briefly as Scientist 'C' with Department of Atomic Energy. He became an entrepreneur in 1995, starting first ever engineering geophysics company in private sector in India.

He has been instrumental in starting full-fledged operations in private sector providing services like seismic refraction, ground penetrating radar, electrical tomography, seismic tomography, Microgravity, magnetic etc. He has carried out geophysical investigations for more than 2000 projects including projects in India, Afghanistan, Bahrain, Singapore, Qatar, Saudi Arabia, Nepal, Bhutan, Kuwait etc. He Initiated the concept of SUE in India in 2001 and is principal author of Indian code/ standard for Subsurface Utility Engineering.

A Gentle Introduction to Electromagnetics (EM) in Geophysics

ANISOTROPY | ELECTROMAGNETISM | ELECTROMAGNETISM | GPR | RESISTIVITY

Instructor:	Dr Jaap C. Mondt (Breakaway, Netherlands)	
Language:	English, Dutch	
Level:	Intermediate	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

Although in the search for hydrocarbons seismic plays the dominant role, complementary data can be very useful. A clear example is that seismic can clearly determine reservoir geometries based on acoustic impedance changes but is less sensitive to the pore-fluids. Electromagnetic measurements, such as Controlled Source EM (CSEM) measures resistivity directly and hence can discriminate between brine and hydrocarbon fill.

You might wonder about the poorer resolution of EM compared with seismic. Indeed, that is the case, but by combining the two independent sources of information, then seismic will give the structure (container) which then can be used as a constraint for the inversion of EM. Another application is in the realm of determining the shape of allochthone salt bodies below which hydrocarbons can be present. Numerous applications can be mentioned in relation to shallow seismic. An obvious one is the use of Ground Penetrating Radar (GPR) for investigating archaeological sites or determining the depth to upwelling deep salt-water due to severe pumping of fresh water for irrigation.

This course is unique in its hands-on exercises and its use of an open-source software Apps developed at UBC.

Course Objectives

Upon completion of this course, participants will be able to:

1. Interpret heuristically the basic equations governing EM phenomena;
2. Explain that EM characteristics/properties and uses depend on the frequency of the electromagnetic "wave";
3. Define the realms of EM diffusion and EM wave propagation;
4. Understand how EM can be used in the search for hydrocarbons, investigating the shallow subsurface for the extend of pollution or salt water penetration;
5. Relate Induced Polarization to the presence of a working hydrocarbon system in the deeper subsurface.

Participants' Profile

All those who are interested in understanding the use of Electromagnetic (EM) methods in Geophysical Applications. These are the geoscientists working in hydrocarbon exploration and exploitation as well as those applying shallow surface geophysics for detecting ore bodies, determining the extend of shallow pollution, foundation engineering, etc.

Prerequisites

Prerequisite is an intermediate level of understanding of physics and geophysics in the context of exploration and production of hydrocarbons and mitigation of pollution, including the issue of salt water penetration.

About the Instructor

Jaap Mondt acquired a MA Bachelor's degree in Geology (University of Leiden), Master's degree in Geophysics (University of Utrecht), PhD in Utrecht on "Full wave theory and the structure of the lower mantle". He then joined Shell Research to develop methods for Quantitative Interpretation. Subsequently he worked in Shell Expro in London where he was actively involved in acquiring, processing and interpreting Offshore Well Seismic data. After his return to the Netherlands he headed a team for the development of 3D interpretation methods using multi-attribute statistical and pattern recognition methods. After a period of Quality Assurance of "Contractor" software for seismic processing, Jaap became responsible for Geophysics in the Shell Learning Centre. During that time, he was also part-time professor in Applied Geophysics at the University of Utrecht. From 2001 till 2005 he worked on the development of Potential Field Methods (Gravity, Magnetics) for detecting oil and gas. Finally, he became a champion on the use of EM methods and became involved in designing acquisition, processing and interpretation methods for Marine Controlled Source EM (CSEM). After his retirement, he founded Breakaway, providing courses on acquisition, processing and interpretation of geophysical data (seismic, gravity, magnetic and electromagnetic data).

In the last couple of years, Jaap developed a keen interest in the use of Machine Learning for Geophysical Applications and developed a practical Machine Learning course for Geophysicists and Interpreters.

Non-Seismic Data Acquisition and Processing: Gravity & Magnetics

ANISOTROPY | ELECTROMAGNETISM | ELECTROMAGNETISM | GPR | RESISTIVITY

Instructor:	Dr Jaap C. Mondt (Breakaway, Netherlands)	
Language:	English, Dutch	
Level:	Intermediate	
Duration and formats:	Online: Extensive Course - self-paced study + 6 live sessions of 2 hours	CPD Points: 10
	Online: IOSC - 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

Non-Seismic methods such as gravity and magnetics provide valuable complementary information about the subsurface that is not provided by Seismic methods. In this course you will learn about these techniques and their use in the search for hydrocarbons, ores, salt-fresh water boundaries, etc.

Course Objectives

Upon completion of this course, participants will be able to understand the use of gravity and magnetics data, how they are acquired, the benefits of employing them in geophysical acquisition projects and how to decide how much money to spend on a Non-Seismic Project.

Course Outline

Part 1: Gravity

- Geophysical Methods
- Gravity Anomaly
- Depth Estimation
- Gravity Response
- Inversion of Gravity Data
- Gravity Resolution

Part 2: Magnetics

- Geo-Mag Signatures
- Magnetic Modelling
- Magnetic Anomaly
- Inversion of Magnetic Data
- Gravity and Magnetic Response
- Geomodel Inversion

Participants' Profile

The course assumes a reasonable understanding of Physics.

Recommended reading

Philip Kearey, Michael Brooks, Ian Hill, *An Introduction to Geophysical Exploration*, John Wiley & Sons, April 2013.

J. D. Fairhead, Advances in Gravity and Magnetic processing and Interpretation, EAGE ISBN 978-94-6282-175-0.

About the Instructor

Jaap Mondt acquired a MA Bachelor's degree in Geology (University of Leiden), Master's degree in Geophysics (University of Utrecht), PhD in Utrecht on "Full wave theory and the structure of the lower mantle". He then joined Shell Research to develop methods for Quantitative Interpretation. Subsequently he worked in Shell Expro in London where he was actively involved in acquiring, processing and interpreting Offshore Well Seismic data. After his return to the Netherlands he headed a team for the development of 3D interpretation methods using multi-attribute statistical and pattern recognition methods. After a period of Quality Assurance of "Contractor" software for seismic processing, Jaap became responsible for Geophysics in the Shell Learning Centre. During that time, he was also part-time professor in Applied Geophysics at the University of Utrecht. From 2001 till 2005 he worked on the development of Potential Field Methods (Gravity, Magnetics) for detecting oil and gas. Finally, he became a champion on the use of EM methods and became involved in designing acquisition, processing and interpretation methods for Marine Controlled Source EM (CSEM). After his retirement, he founded Breakaway, providing courses on acquisition, processing and interpretation of geophysical data (seismic, gravity, magnetic and electromagnetic data).
In the last couple of years, Jaap developed a keen interest in the use of Machine Learning for Geophysical Applications and developed a practical Machine Learning course for Geophysicists and Interpreters.

Gravity and Magnetic Methods for Oil & Gas and Mineral Exploration and Production

3D DENSITY GROUNDWATER INTERPRETATION INVERSION MAGNETIC SURVEY MAGNETICS TIME-LAPSE WATER

Instructor:	Dr Yaoguo Li (Colorado School of Mines, United States)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

EET

Course Description

Gravity and magnetic data are among the oldest geophysical data acquired for the purpose of resource exploration and exploitation. They currently also have the widest areal coverage on the Earth, span a great range of scales and play important roles in mineral, energy and groundwater arenas. The interpretation methods have evolved from data map-based visual inspection, various map enhancements and depth estimation, to quantitative interpretations based on inversions and integrated modeling. In particular, 3D inversion techniques have emerged as a major component in this evolution. The availability of 3D inversion techniques has advanced potential-field interpretation from 'anomaly bump hunting' to 3D imaging of the subsurface by reconstructing the distribution of density or magnetic properties in various geological units and, thereby, have shifted interpretations from the data domain to the model domain. Similarly, inversion techniques are also poised to make major contributions to integrated modeling and interpretation, as well as to differentiating and characterizing geology, geological processes and reservoir dynamics. This course will focus on the methodology, numerical computation, solution strategy and applications of 3D physical property inversions of gravity and magnetic data sets. The course is designed to have two tracks in order to meet the different needs of the EAGE community in mineral exploration and in oil & gas exploration and production. We achieve this by dividing the course into two parts: methodologies common in potential-field methods in Part I and discussion of tools and applications specific to mineral exploration or oil & gas reservoir monitoring in Part II.

Course Outline

Part I: Common concepts and methodologies

1. Fundamentals of potential-field data observed in gravity, gravity gradiometry, and magnetic surveys.
2. Data processing methods based on equivalent source technique and inverse formulation.
3. 3D gravity and magnetic inversions and the practical strategies for their efficient solution and applications to large-scale problems.
4. Binary inversion potential-field data in 3D.
5. Gravity gradiometry.

(option) Part II: Mineral exploration track

1. Inversion and interpretation of magnetic data affected by remanent magnetization.
2. Case histories from mineral exploration.

(option) Part II: Oil & gas track

1. Time-lapse monitoring of oil and gas reservoirs.
2. Inversion of time-lapse gravity data for reservoir properties.

Participants' Profile

Participants are expected to have a basic background in applied geophysics and some knowledge of potential-field methods. We anticipate the geoscientists in the following areas will benefit from the course:

- Potential-field methods
- Mineral exploration
- Integrate interpretation
- Reservoir monitoring
- Groundwater hydrology

About the Instructor

Yaoguo Li received his B.Sc. in geophysics from the Wuhan College of Geology (currently China University of Geosciences) in 1983, and a Ph.D. in geophysics from the University of British Columbia in 1992. He worked with the UBC-Geophysical Inversion Facility at UBC from 1992 to 1999, first as a Post-doctoral Fellow and then as a Research Associate. He is currently an Associate Professor of Geophysics at the Colorado School of Mines and leads the Center for Gravity, Electrical, and Magnetic Studies (CGEM) and the Gravity and Magnetics Research Consortium (GMRC). He is a co-recipient of the 1999 Gerald W. Hohmann Award, SERDP 2007 Project of the Year Award, and 2010 ASEG-PESA Laric Hawkins Award.

His research interests include inverse theory; inversion of gravity, magnetic, and electrical & EM data arising from applied geophysics; and their application to resource exploration, environmental, and geotechnical problems. He has been doing research in these areas and has developed or co-developed a number of program libraries for inverting different types of geophysical data. These include DCIP2D, DCIP3D, GRAV3D, MAG3D, GG3D, BININV3D, and AMP3D.

The Use of Surface Waves for Near Surface Velocity Model Building

2D 3D ALGORITHM DISPERSION INVERSION PASSIVE SAMPLING SHEAR WAVE SPECTRAL ANALYSIS WAVE PROPAGATION

Instructor:	Dr Laura Valentina Socco (Politecnico di Torino, Italy)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Classroom: 1 day	CPD Points: 5

NEW

Course Description

The use of surface wave analysis for near-surface characterization has dramatically increased in the last decade thanks to the possibility offered by this technique for shear wave velocity estimation. New tools and approaches have been developed for surface wave data acquisition and analysis to make the method robust and suitable to complex systems. The course will supply an overview of the method starting from surface wave propagation and dealing with acquisition, processing and inversion of surface wave data. Advantages and weaknesses of different approaches as well as requirements for data acquisition and analysis will be discussed. Recent developments will be presented with example of results and applications to different near-surface problems.

Course Objectives

The course will provide the participants with a wide overview of the main steps of the surface wave method: acquisition, processing and inversion. Different approaches with their potentialities and limitations will be discussed through many practical examples to enable the participants to acquire knowledge about the requirements and design of data acquisition, processing methods and inversion algorithms for different applications from small-scale engineering problems towards large-scale exploration.

Course Outline

- Surface wave propagation in homogeneous and layered media;
- Geometrical dispersion, modal curves and their properties;
- The use of surface wave for near surface characterisation: the method outline;
- Data acquisition: on purpose acquired active data, other active data, passive data;
- Processing: from raw data to dispersion curves;
- Inversion: stochastic methods, linearized methods (1D, pseudo-2d/3D), higher modes
- The final results: resolution and uncertainties
- The requirements for acquisition, processing and inversion.

Participants' Profile

Near-surface geophysicists and exploration geophysicists interested in near-surface velocity models.

Prerequisites

Participants should have basic knowledge of sampling principles, spectral analysis and inversion of seismic data.

About the Instructor

Laura Valentina Socco (1966), is presently Assistant Professor in Applied Geophysics at the Politecnico di Torino (Technical University of Turin), where she took her PhD. Her research work is focused on near surface problems with particular attention to surface wave methods. She is author of about 60 scientific publications in the field of Applied Geophysics in international and national journals and in the proceedings of national and international scientific conferences. She is member of EAGE Research Committee and Educational Committee and is Associate Editor of "Geophysics" and "Near Surface Geophysics". She is vice-director of the Doctorate School of the Politecnico di Torino.

She teaches Applied Geophysics for Petroleum Engineering at Politecnico di Torino and Geophysical Prospecting at University of Turin. She has been member of the High Quality Laboratory DIPLAB (Disaster Planning Laboratory), of Politecnico di Torino since 2002. She is principal investigator for many research projects financed by national and international institutions and by private and public companies.

Convenor of the workshop on "Surface Wave Methods for near surface characterisation", EAGE (Stavanger 2003), she has been designated Guest Editor of a special issue of "Near Surface Geophysics" which was published in 2004.

Satellite InSAR Data: Reservoir Monitoring from Space

DEFORMATION DISPLACEMENT GPS INTERFEROMETRY REMOTE SENSING SENSORS SEQUESTRATION TIME-LAPSE ENVIRONMENT

Instructor:	Dr Alessandro Ferretti (TRE ALTAMIRA, Italy)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

Course Description

Satellite radar data for surface deformation monitoring are gaining increasing attention and not only within the oil and gas community. Co-seismic deformation maps are routinely generated using satellite images acquired before and after an earthquake and radar measurements are now becoming mandatory to be compliant with new environmental regulations. Radar data provide a powerful tool for remotely measuring extremely small surface displacements over large areas and long periods of time, without requiring the installation of in-situ equipment. However, apart from remote sensing and radar specialists, only a relatively small number of geoscientists and engineers understand how a radar sensor orbiting the Earth can actually measure ground displacements of a fraction of a centimetre. This course provides a step-by-step introduction to satellite radar sensors, SAR imagery, SAR interferometry and advanced InSAR techniques. Rather than a tutorial for remote sensing specialists, the course starts from very basic concepts and explains in plain language the most important ideas related to SAR data processing and why geoscientists and engineers should take a vested interest in this new information source. Instead of providing a thorough analysis of InSAR algorithms, the main aim of the course is to diffuse the news about the potential impact of InSAR results on many real-life applications, highlighting where and when they can provide effective solutions. Participants will learn that InSAR is not only an information source for research and development activities, but also a reliable tool that can be applied successfully to many different applications, some of them related to the so-called "energy transition" and the need to run "environmental friendly" energy projects. Special attention is paid to oil and gas applications where surface deformation data can provide valuable constraints on reservoir dynamics, enabling time-lapse monitoring of volumetric strains at depth. Volume changes in the reservoir induced by fluid extraction and injection can induce both subsidence and uplift. Stress changes may then trigger the reactivation of faults and threaten well integrity. Depending on the depth of the reservoir and the characteristics of the cap rock, deformation may also be detectable at the surface. After demonstrating case studies focusing on secondary and tertiary oil recovery, Carbon Capture and Sequestration (CCS) and Underground Gas Storage (UGS), the course describes the available historical archives of SAR images, allowing, even if not at full worldwide coverage, the estimation of surface deformation phenomena since 1992. The course concludes with a brief discussion of the new satellite sensors to be launched in the next few years and the new trends in data integration and visualization.

Course Objectives

Upon completion of the course, participants will be able to:

- understand the key interest of InSAR for geoscientists and engineers;
- understand the basic concepts behind Synthetic Aperture Radar (SAR) sensors;
- appreciate the main differences between SAR and optical images;
- understand the basic data requirements, assumptions, limitations and applicability of SAR interferometry (InSAR);
- discover advantages and limitations of advanced InSAR techniques for estimating sub-centimetre surface deformation phenomena from space;
- realize why InSAR data are becoming a standard tool for surface deformation monitoring;
- compare InSAR data with in situ measurements, such as: GPS and tiltmeters;
- understand how surface deformation can be related to geophysical parameters at depth;
- see how InSAR data are an effective tool for monitoring subsidence phenomena;
- understand the importance of surface deformation monitoring in Cabon Capture and Sequestration (CCS) and Underground Gas Storage (UGS) projects;
- understand why InSAR data can be used as a cost-effective tool for reservoir management, as well as a risk mitigation tool;
- start thinking about future applications of satellite radar data, possibly in synergy with other in-situ observations.

Course Outline

1. Introduction: why are satellite radar data relevant?
2. Synthetic Aperture Radar (SAR) sensors: acquisition geometry and image formation.
3. Measuring range variations: the magic of SAR interferometry (InSAR).
4. A tool for digital elevation model reconstruction and surface deformation analysis.
5. Advanced InSAR techniques: from qualitative to quantitative data.
6. From surface deformation to volume and pressure changes at depth.
7. Overview of possible applications: subsidence monitoring, fault characterization, calibration of geological models, reservoir monitoring.
8. Time-lapse data for Carbon Capture and Sequestration (CCS), Underground Gas Storage (UGS), secondary and tertiary (EOR) oil recovery projects.

9. Available data sources and historical archives of SAR data. A quick overview of other InSAR applications.
10. Summary and future trends.

Participants' Profile

The course is designed for anyone who would like to understand how satellite sensors can measure surface displacements to a fraction of a centimetre from space. It is not a course for radar specialists. Reservoir engineers, geophysicists, geodesists, geologists should all be interested in this new tool for surface deformation monitoring that is becoming more and more a standard. Radar data are still largely unknown but their impact on oil & gas and civil protection applications can be huge.

Prerequisites

Rather than a strong background in remote sensing, geophysics and calculus, curiosity is probably the most important prerequisite. The course can be understood by geoscientists and engineers with a moderate mathematical background.

About the Instructor

Alessandro Ferretti graduated in electronic engineering in 1993 at the Politecnico di Milano (POLIMI). He then received his MSc in information technology from CEFRIEL (1994) and his PhD in electrical engineering from POLIMI (1997). Since 1994 his research efforts have been focused on radar data processing, SAR interferometry and the use of remote sensing information for oil&gas and Civil Protection applications. He is co-inventor of the "Permanent Scatterer Technique" (PSInSAR™) and its advanced version: SqueeSAR™, a technology providing millimetre accuracy surface deformation measurements from satellite radar data.
In 2000 he founded the company "Tele-Rilevamento Europa" (TRE), offering high-quality surface deformation data for many different applications, from oil/gas reservoir surveillance, to landslide monitoring. Since 2008, he has been acting as Chairman of the Board of TRE Canada Inc. In June 2012, Alessandro Ferretti, together with Prof. Fabio Rocca, was awarded the "ENI Award 2012" for the potential impact of the PSInSAR™ technology on the oil&gas sector. TRE is now TRE ALTAMIRA, after the integration with Altamira Information in 2016. Alessandro Ferretti is currently CEO of the TRE ALTAMIRA group, having offices in Milan, Barcelona and Vancouver (BC). He coauthored more than 100 technical publications in international journals.

Reservoir Characterization

ROCK PHYSICS •
GEOMECHANICS •
GEOCHEMISTRY •

Rock Physics for Quantitative Seismic Reservoir Characterization

ELASTICITY | INTEGRATION | INTERPRETATION | LITHOLOGY | MODELING | OFFSHORE | OIL AND GAS | POROSITY | RESERVOIR CHARACTERIZATION | ROCK PHYSICS | SANDSTONE | SATURATION | SHALE | UNCERTAINTY | WORKFLOWS

Instructor:	Prof. Tapan Mukerji (Stanford University, United States)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

The purpose of the course is to give an overview of rock physics observations and models relating reservoir properties such as saturation, lithology, clay content, and pore pressure and their seismic signatures. Understanding this relation can help to improve quantitative seismic interpretation. The course covers fundamentals of Rock Physics ranging from basic laboratory and theoretical results to practical "recipes" that can be immediately applied in the field. Application of quantitative tools for understanding and predicting the effects of lithology, pore fluid types and saturation, saturation scales, stress, pore pressure and temperature, and fractures on seismic velocity. Use of rock physics models requires understanding the assumptions and pitfalls of each model and the uncertainties associated with the interpretations using these models. Analysis of case studies and strategies for quantitative seismic interpretation using statistical rock physics work flows, and suggestions for more effectively employing seismic-to-rock properties transforms in Bayesian machine learning for reservoir characterization and monitoring, with emphasis on seismic interpretation and uncertainty quantification for lithology and subsurface fluid detection.

Course Objectives

On completion of the course, participants will be able to:

- Use rock physics models with a better understanding of assumptions and pitfalls;
- Combine statistical rock physics in quantitative seismic interpretation workflows;
- Select appropriate rock physics models for reservoir characterization;
- Use rock physics models to build appropriate training sets for Bayesian machine learning applications in quantitative seismic interpretation.

Course Outline

- Introduction to Rock Physics, motivation, introductory examples
- Parameters that influence seismic velocities - conceptual overview
- Effects of fluids, stress, pore pressure, temperature, porosity, fractures
- Bounding methods for robust modeling of seismic velocities
- Effective media models for elastic properties of rocks
- Gassmann Fluid substitution – uses, abuses, and pitfalls
- Derivation, recipe and examples, useful approximations
- Partial saturation and the relation of velocities to reservoir processes
- The importance of saturation scales and their effect on seismic velocity
- Shaly sands and their seismic signatures
- Granular media models, unconsolidated sand model, cemented sand model
- Velocity dispersion and attenuation; Velocity Upscaling
- Rock Physics of AVO interpretation and Vp/Vs relations
- Quantitative seismic interpretation and rock physics templates
- Statistical rock physics, Bayesian machine learning and uncertainty quantification
- Rock physics modeling to augment deep learning training data
- Example case studies using AVO and seismic impedance for quantitative reservoir characterization

Participants' Profile

The course is recommended for all geophysicists, reservoir geologists, seismic interpreters, and engineers concerned with reservoir characterization, reservoir delineation, hydrocarbon detection, reservoir development and recovery monitoring.

Prerequisites

No specific prerequisites needed.

Recommended Reading

Participants are recommended to preferably read:

- Avseth, P., Mukerji, T., and Mavko, G., 2005, Quantitative Seismic Interpretation: Applying Rock Physics Tools to Reduce Interpretation Risk, Cambridge University Press
- Mavko, G., Mukerji, T., and Dvorkin, J., 2009, The Rock Physics Handbook, 2nd Edition, Cambridge University Press
- Dvorkin, J., Gutierrez, M, and Grana, D., Seismic reflections of rock properties, Cambridge
- Offset-dependent reflectivity, Castagna & Backus, SEG
- Physical properties of rocks, Schoen, Elsevier

About the Instructor

Tapan Mukerji is a Professor (Research) at Stanford University where he got his Ph.D. (1995) in Geophysics. Tapan co-directs the Stanford Center for Earth Resources Forecasting (SCERF), Stanford Rock Physics and Borehole Geophysics (SRB) and the Basin and Petroleum System Modeling (BPSM) projects at Stanford University. His research interests include rock physics, spatial statistics, wave propagation, and stochastic methods for quantitative reservoir characterization and time-lapse reservoir monitoring. Tapan combines experience in conducting leading edge research, teaching, and directing graduate student research. He was awarded the Karcher Award in 2000 by the Society of Exploration Geophysicists, and received the ENI award in 2014. He is an associate editor for Geophysics, journal of the Society of Exploration Geophysicists, and Computers and Geosciences. In addition to numerous journal publications, Tapan has co-authored The Rock Physics Handbook, Quantitative Seismic Interpretation, and The Value of Information in the Earth Sciences, all published by Cambridge University Press. He has been an invited keynote speaker and instructor for numerous short courses on rock physics and geostatistics, in North and South America, Europe, Africa, Australia and Asia.

3D Printing Geological Models For Education, Research, and Technical Communication - 3D Printing as an Emerging Technology in Geosciences

CARBONATES FRACTURES MODELING PERMEABILITY POROSITY RESERVOIR CHARACTERIZATION ROCK PHYSICS SANDSTONE TOMOGRAPHY

Instructors:	Prof. Dr Franciszek Hasiuk (Iowa State University, United States) and Dr Sergey Ishutov (University of Alberta, United States)	
Language:	English, Russian	
Level:	Foundation	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

3D printing is an emerging technology in the geosciences that provides a fast, cost-effective way to transform digital designs into tangible models. These tangible models enable a physical representation of 3D geometries and enhance communication among researchers, students, technical management, and non-experts. Whereas digital models can be viewed only on a screen, a 3D printed model can be experienced with other senses: it can be viewed at different light angles and manipulated. For research purposes, 3D-printed models can be experimented with in the laboratory to validate numerical predictions of rock properties.

The course is designed in two days to cover broad topics related to various 3D printing applications. Day 1 provides an overview of different 3D printing techniques that use both rock-like materials (e.g., sand, gypsum, clay) and polymers (e.g., plastics, resins). While these cost-effective methods are shaping the future of manufacturing, 3D printing geological media requires profound understanding of capabilities and limitations of each technique and its material properties. Day 1 includes a module on how to digitally design and 3D print models for use in reservoir rock analysis, geomorphology, and paleontology. For reservoir rock analysis, 3D printing of near-identical rock proxies provides an approach to conduct repeatable laboratory experiments without destroying natural rock samples. The course also discusses case studies of 3D printing applications in the geoscience and engineering research as well as in the petroleum industry. Participants will learn how to deploy 3D-printed models to improve technical communication to diverse audiences (e.g., engineers, managers, community stakeholders). The integration of digital data sets with 3D-printed surface and subsurface features will help participant to learn about communication for societal objectives. Discussion of 3D printing as a teaching tool will help students and educators to understand the practical approaches of using 3D-printed models in explaining complex concepts and 3D data. The course will provide insights on future implementation of 3D printing techniques in geosciences, including reduced costs of 3D printers, open-source software, and free access to digital model repositories.

Day 2 involves practical components of using 3D printing for characterization of reservoir rocks and geomorphic features. 3D-printed porous and fracture models are used to investigate fundamental research questions in the areas of single and multiphase fluid flow as well as reactive transport in reservoir sandstones and carbonate rocks. Participants will design 3D-printable models containing pore and fracture networks using CAD and computed tomography data. They will have an opportunity to manufacture their models with local 3D printing shops. In addition, participants will be provided with pre-printed replicas equivalent to their digital models to investigate the fidelity of 3D printing techniques and materials. Participants will learn how 3D-printed models can be used in destructive and non-destructive analyses to study geomechanical and transport properties (e.g., porosity, pore sizes, grain sizes, fracture apertures, connectivity of pore and fracture networks). Participants will also gain experience with TouchTerrain app that allows to generate 3D-printable terrain models with no CAD or GIS software.

Course Objectives

On completion of the course, participants will be able to:

- Understand capabilities and limitations of different 3D printing techniques;
- Demonstrate how to digitally design 3D-printable models using CAD software or computed tomography data;
- Provide the assessment of digital models and their relative 3D-printed replicas;
- Characterize how 3D printing can increase the effectiveness of communicating geoscience data;
- Apply 3D printing in current or future research and teaching.

Course Outline

Day 1: Introduction to 3D printing and review of its current applications

- Lecture "Overview of 3D printing technlogy":
  - Brief history of 3D printing
  - Common 3D printing techniques
  - Materials used and their physical and chemical properties
  - Current and future advances of 3D printing
- Activity "Methods of transforming digital models into 3D-printed objects":
  - Which geoscience data are 3D-printable
  - Which 3D printer and material fit digital model parameters
- Lecture "Applications of 3D printing in the geoscience and engineering research":

- Use of 3D printing in petroleum industry
- 3D printing as a tool in reservoir rock analysis
- Scaling in geomorphology, geomechanics, and groundwater studies

- Activity "3D printing as a communication tool for":
  - Technical management
  - Community stakeholders
  - Researchers presenting their technical studies to both experts and non-experts
- Activity "3D printing as a teaching tool for":
  - Students learning new 3D concepts and models
  - Researchers involved in data exchange
- Live demonstration of 3D printing rock, fossil, and terrain models in the course of day 1

Day 2: Application of 3D printing in modeling porous media and geomorphic features

- Practical exercise "Digital design of 3D-printable models":
  - With CAD (idealized porous models)
  - From computed tomography data (reservoir rock samples)
  - Using TouchTerrain app (terrain models)
- Activity "Assessment of accuracy of 3D-printed models":
  - Success or failure of external and internal features
  - Post-processing efficiency and precision
- Lecture "Validation of flow properties in reservoir rock models":
  - Advantages of destructive tests
  - Limitations of non-destructive tests
  - Value of adding 3D printing into reservoir characterization workflow
- 3D printing models in coordination with local 3D printing service companies
- Live demonstration of 3D printing reservoir rock models

Participants' Profile

The course is designed in 2 days to accommodate a broad range of participant groups. Day 1 of the course covers overview of 3D printing techniques and methods and is intended for general audience. It is useful for students, geoscientists, engineers, who are interested in current advances of 3D printing in research and teaching. It can also be beneficial for managers and stakeholders who want to learn the use of 3D printing in technical communications. Day 2 covers research applications of 3D printing in porous media and geomorphology and involves practical section on creating 3D-printable models of reservoir rocks and terrains. It is beneficial for geologists, petrophysicists, stratigraphers, geophysicists, geomorphologists, reservoir and geomechanical engineers and geomodellers from both industry and academia who are interested in transforming digital models into tangible objects that can be viewed, touched, manipulated, and tested in the lab as natural rocks. Participants will receive hand-on experience on creating digital rock and terrain models, validating their accuracy and exploring the best methods to 3D print them. In addition, day 2 of the course will involve review of current advances in research on 3D printing reservoir rock models that involves investigation of petrophysical and geomechanical properties of 3D-printed rock analogues. Skills obtained during day 1 will allow participants to be engaged in day 2 activities without prerequisites. If participants take only day 2, basic knowledge about major 3D printing techniques and materials as well as CAD modeling and computed tomography is required.

Prerequisites

Prior knowledge of CAD modeling and interpretation of computed tomography data would be useful, but is not required.

Recommended Reading

Ishutov S, Jobe TD, Zhang S, Gonzalez MA, Agar SM, Hasiuk F, Watson F, Geiger S, Mackay E, Chalaturnyk R, 2017. 3D printing for geoscience: fundamental research, education, and applications for the petroleum industry. American Association of Petroleum Geologists Bulletin. DOI: 10.1306/0329171621117056.

Ishutov S, Hasiuk F, Fullmer S, Buono A, Gray J, Harding C, 2017. Resurrection of a Reservoir Sandstone from Tomographic Data Using 3-D Printing. American Association of Petroleum Geology Bulletin 101(9): 1425-1443. DOI:10.1306/11111616038. Invited.

Ishutov S, Hasiuk F, Harding C, Gray JN, 2015. 3-D printing sandstone porosity models. AAPG/SEG's Interpretation 3(3): SX49-SX61. DOI: 10.1190/INT-2014-0266.1.

Hasiuk F, 2014. Making Things Geological: 3-D Printing in the Geosciences. Geological Society of America Today 24: 28–29. Invited.

About the Instructors

Prof. Dr. Franek Hasiuk is an expert in carbonate geology and 3D printing. His dissertation from the University of Michigan involved understanding the secular variation of seawater chemistry and temperature from marine carbonate chemistry. He worked at ExxonMobil Upstream Research for four years where he developed a deep appreciation for carbonate petrophysics while working on a variety of projects including a global synthesis of carbonate microporosity. Since joining Iowa State University, the mission of his "GeoFabLab" has been to better understand the chemistry and petrophysics of rocks by using 3D-printed rock models as well as man-made rocks, like concrete and asphalt.

Dr. Sergey Ishutov is an expert in 3D printing porous media from CAD and tomographic models. He is currently a researcher at the University of Alberta. He has received B.Sc. in petroleum geology from the University of Aberdeen in Scotland and M.Sc. in geology from California State University Long Beach. His research experience is in acquisition, processing, and interpretation of seismic data and analysis of computed tomography data from reservoir core plugs. Dr. Ishutov received multiple awards and research grants from professional societies and industry collaborators to establish foundation research in 3D printing reservoir rock samples. He has work experience at major petroleum companies, including ExxonMobil, Aramco, and Shell.

Applied Microfacies

CARBONATES | DIAGENESIS | MINERALOGY | PERMEABILITY | STRATIGRAPHY | THIN SECTION | WELLS

Instructor:	Prof. Dr Michael Poppelreiter (Shell, Kuwait)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

Hands-on microfacies characterization using industry data sets. Analysis: mineralogy, components, pore types, diagenesis. Participants are instructed on how to capture observations such that patterns and rules might be detected. The course encourages participants to think of processes and products during thin section characterization.

Industry data sets are used to illustrate the use of microfacies characterization to help solve operational issues of carbonate fields. Production increase is demanded. Wells (fully cored) show contrary production behavior. The stratigraphy is 'layer cake' and both wells are perforated in the highest perm interval of a few meters thick.

Thin sections are linked with petrophysical data, openhole logs and production data. Course participants are encouraged to use thin section descriptions to develop a conceptual model for permeability based on a depositional model architecture based on the investigation of available this sections.

Course Objectives

Upon completion of the course, participants will be able to:

- Quality control thin sections.
- Determine the mineralogy of a stained section.
- Characterize fossiliferous and non-fossiliferous components such as ooids or brachiopods.
- Classify the carbonate texture (Dunham) and grain geometry.

Participants' Profile

The course is designed for geologists, petrophysicists, stratigraphers as well as explorers in academic and industry positions.

Prerequisites

Participants should have knowledge of the principles of carbonate geology and a fundamental understanding of petrophysics.

About the Instructor

Prof. Dr Michael C. Poppelreiter, Director of the South East Asian Carbonate Research Lab (SEACaRL), Shell Chair in Petroleum Geology at the Department of Geosciences, Universiti Teknologi PETRONAS (UTP). From October 2019 he has been working for Shell Kuwait.

Area of expertise: Shell Subject Matter Expert for carbonate geology, Outcrop and Regional Geological Studies (focus Middle East), Conceptual Modelling, Reservoir Modelling and 3D Digital Modelling, Project management, CO_2 in carbonate, Technical Assurance & Capability (TA-2), 25 publications and 2 books on borehole image logs and reservoir geology.

Explorational Rock Physics and Seismic Reservoir Prediction

4D | ATTENUATION | CARBONATES | INTERPRETATION | INVERSION | LITHOLOGY | REMOTE SENSING

Instructors:	Dr Per Avseth (Independent Consultant, Norway) and Prof. Dr Tor Arne Johansen (University of Bergen, Norway)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

The field of rock physics represents the link between qualitative geologic parameters and quantitative geophysical measurements. Increasingly over the last decade, rock physics stands out as a key technology in petroleum geophysics, as it has become an integral part of quantitative seismic interpretation. Ultimately, the application of rock physics tools can reduce exploration risk and improve reservoir forecasting in the petroleum industry.

This course covers fundamentals of rock physics, ranging from basic laboratory and theoretical results to practical recipes that can be immediately applied in the field, presenting qualitative and quantitative tools for understanding and predicting the effects of lithology, pore fluid types and saturation, stress and pore pressure, fractures and temperature on seismic velocity and attenuation.

The importance and benefit of linking rock physics to geologic processes, including depositional and compactional trends as well as tectonic uplift and unloading, are key to this course, which demonstrates in detail how to build so-called rock physics templates that can be used to interpret both well log and seismic inversion data in terms of geological trends and reservoir properties. It is important in exploration and appraisal to extrapolate away from existing wells, taking into account how the depositional environment changes as well as burial depth trends. In this way rock physics can better constrain the geophysical inversion and classification problem in underexplored marginal fields, surrounding satellite areas, or in new frontiers.

In particular, we focus on how rock physics properties, fluid sensitivities and associated seismic signatures change as we go from soft sediments in the shallow subsurface to well consolidated rocks that have undergone more severe mechanical and chemical compaction, and even uplift and brittle deformation. Likewise, we show how seismic amplitudes can change drastically as we go from one depositional environment to another, for instance in a channel-levee complex as we go from central axis to the levee and overbank area.

The course includes practical examples and case studies, as well as suggested workflows, where rock physics models are combined with well log and prestack seismic data, sedimentologic information, inputs from basin modeling and statistical techniques to predict reservoir geology and fluids from seismic amplitudes.

Course Objectives

Upon completion of the course participants will understand:

- The link between geologic processes and rock physics properties;
- Pore fluid / rock interactions during wave propagation;
- Upscaling and heterogeneous reservoirs;
- How to build their own rock physics template.
- The ultimate goal is to improve the understanding of seismic amplitudes and predict geologic and reservoir parameters from seismic inversion data and at the same time create awareness about limitations and pitfalls.

Course Outline

- Basic rock physics theory and relations;
- Fluid and lithology substitution for reservoir rocks;
- Pore fluid — rock interactions during wave propagation;
- How to build a Rock Physics template;
- Upscaling and seismic signatures of heterogeneous reservoirs;
- Introduction to shale and carbonate rock physics.

Participants' Profile

The course is intended for geophysicists, geologists and petrophysicists who wish to be involved in quantitative seismic interpretation. The course will focus on how rock physics can be used in exploration but many aspects will also be relevant for production and 4D geophysics.

Prerequisites

Fundamental understanding of physics and mathematics. Educational background and/or practical experience in geology, geophysics and/or petrophysics.

About the Instructors

Per Avseth is a geophysical advisor at Tullow Oil in Oslo, Norway, and adjunct professor in geophysics at the Norwegian University of Science and Technology (NTNU) in Trondheim, Norway. Per received his M.Sc. in Applied Petroleum Geosciences from NTNU in 1994, and his Ph.D. in Geophysics from Stanford University, California, in 2000. Per worked as a research geophysicist at Norsk Hydro in Bergen, 2001-2006. Per's research interests include applied rock physics and AVO analysis, for quantitative seismic exploration and reservoir characterization.

Tor Arne Johansen is a full professor in Reservoir Geophysics at the Department of Earth Science, University of Bergen, and a scientific advisor for NORSAR. He received his PhD in Geophysics in 1990 from Bergen University. His research interests cover remote sensing techniques, rock physics, seismic modelling and processing.

Rock Physics and Computational Geophysics

ANISOTROPY | ATTENUATION | BOREHOLE GEOPHYSICS | ELECTROMAGNETISM | ENVIRONMENTAL GEOPHYSICS | HYDROCARBON EXPLORATION | POROELASTICITY | SYNTHETIC SEISMOGRAMS | VISCOELASTICITY | WAVE SIMULATION

Instructor:	Dr José M. Carcione (OGS, Italy)	
Language:	English, Italian, Spanish	
Level:	Advanced	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

This course presents the fundamentals of the physical principles and computational techniques for wave propagation in anisotropic, anelastic and porous media, including the analogy between acoustic waves (in the general sense) and electromagnetic (EM) waves. The emphasis is on geophysical applications for hydrocarbon exploration, but researchers in the fields of earthquake seismology, rock physics, and material science, -- including many branches of acoustics of fluids and solids (acoustics of materials, non-destructive testing, etc.) -- may also find the material useful. The course illustrates the use of seismic and EM modeling, with an account of the numerical algorithms for computing synthetic seismograms, diffusion fields and radargrams, with applications in the field of geophysical prospecting, seismology and rock physics, such as evaluation of methane hydrate content, upscaling techniques, detection of overpressure, Antarctic and permafrost exploration, exploration of the Earth's deep crust, time-lapse for monitoring of CO_2 injection, seismic modeling in geothermal fields, seismic inversion, etc.

Course Objectives

On completion of the course, participants will be able to:

- Understand the physics of seismic (and EM) wave propagation and diffusion fields in real media, such as rocks and geological formations;
- Solve complex problems using numerical methods, as finite-differences, Fourier techniques, and machine learning methods;
- Apply these concepts to seismic and EM applications, such as hydrocarbon prospection, earthquakes, surface radar applications, EM low-frequency methods for environmental problems, rock physics, etc.

Course Outline

Methods:

- Mechanical viscoelastics models
- The wave equation with attenuation
- Seismic anisotropy
- Seismic attenuation
- Poroelasticity
- Seismic rock physics
- Hooke's law and wave equation
- Forward modeling. Computation of synthetic seismograms
- Reflection coefficients. AVO
- EM rock physics
- Maxwell's equation
- The seismic-EM analogy
- Geo-radar equations
- The diffusion equation in EM prospecting
- Machine learning methods. Neural networks, genetic algorithms, etc.

Applications :

- Fluid flow in porous rocks
- Unconventional resources. Oil and gas shales
- Cross-well seismic and EM methods
- Upscaling methods
- AVO cases
- Rock-physics templates
- Q and velocity anisotropy in fractured media
- Geophone-soil coupling models
- Physics and simulation of waves at the ocean bottom
- Recent advances to model waves in reservoir and source rocks
- Theory, simulation and case histories for detection and quantification of gas hydrates
- Theories for pore-pressure prediction and mud-weight design, with case histories
- Seismic-modeling case histories
- Seismic inversion
- Microseismicity
- Borehole waves
- Injection of fluids and seismic and EM monitoring. Time-lapse cases
- Tools for GPR applications.

Participants' Profile

The course is useful for geologists, geophysicists, petrophysicists and reservoir engineers. The emphasis is on geophysical applications for hydrocarbon exploration, but researchers in the fields of earthquake seismology, rock acoustics and material science – including many branches of acoustics of fluids and solids (acoustics of materials, nondestructive testing, etc.) – may also find this course useful.

Prerequisites

Participants should have knowledge of the basic concepts of wave theory.

Recommended Reading

Participants are recommended to preferably read "Elastic waves in the Earth" (1979) by Pilant, "Physical properties of rocks" (2011) by Schon, and "Wave fields in real media" by Carcione (2015), before attending the course.

About the Instructor

José M. Carcione has the degrees "Licenciado in Ciencias Físicas" (Buenos Aires University), "Dottore in Fisica" (Milan University) and Ph.D. in Geophysics (Tel-Aviv University). From 1978 to 1980 he worked at the "Comisión Nacional de Energía Atómica" at Buenos Aires. From 1981 to 1987 he was employed as a research geophysicist at YPF (national oil company of Argentina). Presently, he is Director of Research at OGS. He was awarded the Alexander von Humboldt scholarship for a post-doc at Hamburg University (1987-1989). In 2007, he received the Anstey award at the EAGE in London and the 2017 EAGE Conrad Schlumberger award in Paris. Carcione published more than 280 journal articles on acoustic and electromagnetic numerical modeling, with applications to oil exploration and environmental geophysics. He is the author of the books "Wave fields in Real Media – Theory and numerical simulation of wave propagation in anisotropic, anelastic, porous and electromagnetic media" (see (Elsevier, 2015, 3rd edition), and "Seismic Exploration of Hydrocarbons in Heterogeneous Reservoirs" (Elsevier, 2015) He has been editor of "Geophysics" since 1999. He has coordinated many projects funded by the EU and private companies. Carcione has been a member of the commission (GEV04) for evaluation of Italian research in the field of Earth Sciences (ANVUR) in the periods 2004-2010 and 2011-2014. Carcione has an H-index: 53, according to Google Scholar.

Modern Seismic Reservoir Characterization

ANISOTROPY AVO ELASTICITY FLUID FRACTURES GEOMECHANICS GASSMANN IMPEDANCE INTERPRETATION LITHOLOGY PORE PRESSURE POROSITY ROCK PHYSICS SHALE

Instructor:	Dr Leon Thomsen (Delta Geophysics, United States)	
Language:	English	
Level:	Advanced	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

Classical reservoir characterization typically assumes that the reservoir is elastically and hydraulically isotropic, and may be adequately analyzed using core and/or log data. However, most real reservoirs are elastically and hydraulically anisotropic, and spatially heterogeneous (on many scales), so that core and/or log data are not representative of the larger reservoir volume. This applies to both conventional and unconventional reservoirs. Hence, the best means to physically characterize most real reservoirs, throughout their volume, uses seismic data, acquired and interpreted anisotropically. This course summarizes the state-of-the-art of seismic reservoir characterization, using anisotropic seismic rock physics. The course normally requires 16 hours of instruction, and includes numerous classroom exercises. Topics include:

- Context: A world with excess supply of oil, and low demand. The shale revolution. Hubbert's extended Peak.
- Physical principles: Aliased data. Inhomogeneous formations. Friendly multiples. Spatial resolution
- Introduction to Anisotropy: Weak. Polar. Azimuthal. Shear wave splitting.
- Lithology: Shale content from anisotropy itself.
- Geomechanics: Without Poisson's ratio or Young's modulus, since these are isotropic concepts.
- Fluids: Logical error in Gassmann poroelasticity.
- Pore pressure: Subsurface fluid compartments. Anisotropic velocities for calibration.
- Anisotropic AVO: Including the anisotropic term in the AVO gradient, a first-order effect!
- Fractures: No penny-shaped cracks. Multiple fracture-sets.
- Permeability: 4D gives the best seismic measure. Impermeable barriers.

Course Objectives

Upon completion of this course, participants will:

- realize that many of the assumptions of conventional reservoir characterization do not apply to the Real World
- understand the basic elements of anisotropic seismics
- be able to implement that understanding to estimate lithology, pore pressure fractures, and permeability from seismic data, with appropriate caveats
- be able to apply post-Gassmann fluids estimation
- be able to forward-model anisotropic AVO, and to find the missing parameter from the data.

Course Outline

Context
The Shale Revolution
Hubbert's Extended Peak
The geophysical response: subsurface physical characterization
Physical principles
Requirement for, and limitations of seismic data
Equation of motion vs wave equation
Friendly multiples
Exercise: Thin layers
Anisotropy
Weak polar anisotropy parameters
Exercise: Plane-wave velocities
P-waves: normal moveout; abnormal moveout
Azimuthal anisotropy
Lithology
Shale content from anisotropy
Geomechanics
Compliance vs stiffness
Young's modulus, Poisson's ratio, bulk modulus
Exercise: geomechanics moduli
Fluids
Biot, Gassmann
Biot vs Gassmann
Brown and Korringa
Determining the parameters
Exercise: Post-Gassmann fluid dependence
Effective media
Fluid effects on anisotropic formations
Exercise: Thin-layer fluid dependence
Pore pressure
Subsurface fluid compartments
Effect of anisotropy on pore pressure estimation
Anisotropic AVO
Effect of polar anisotropy on AVO gradient
Exercise: Anisotropic AVO
Determining the parameter
Effect of azimuthal anisotropy on AVO gradient
Cracks and fractures
Crack formation by unequal stresses
Microfractures and macro joints
Effects of cracks on velocities
Shear wave splitting
Exercise: 2Cx2C rotation

Permeability
Permeability tensor
Cleating in CoalBed Methane
Fractures in the Austin Chalk
4D permeability in the North Sea

Participants' Profile

This course is designed for geophysicists with five or more years of professional experience, whose management expects them to go beyond subsurface imaging to physically characterize subsurface reservoirs. Their conventional tools for doing that are based on demonstrably false assumptions. This course will help them to use their experience in modern ways to address the same challenges.

Prerequisites

This course is designed for geophysicists with five or more years of professional experience, whose management expects them to go beyond subsurface imaging to physically characterize subsurface reservoirs. Their conventional tools for doing that are based on demonstrably false assumptions. This course will help them to use their experience in modern ways to address the same challenges.

About the Instructor

Leon Thomsen holds titles of Chief Scientist at Delta Geophysics, Research Professor at the University of Houston, and Visiting Scientist at Lawrence Berkeley National Laboratory. He holds a B.S. in geophysics from California Institute of Technology (Pasadena), and a Ph.D. in geophysics from Columbia University (New York). He held postdoctoral positions at Centre Nationale de la Recherche Scientifique (Paris), International Business Machines (Palo Alto), and Caltech. He was Assistant, then Associate Professor at the State University of New York (Binghamton), with sabbatical positions at Goddard Institute for Space Studies (New York) and the Australian National University (Canberra).

Leon's industrial career began in 1980, at Amoco's famous research center in Tulsa, where he was the Amoco inventor of what we now call seismic AVO. He led significant revisions to the exploration seismic paradigm, helping to establish the basic ideas of polar anisotropy and azimuthal anisotropy. His 1986 paper, establishing the modern field of seismic anisotropy, is the single-most-cited paper in the history of Geophysics; a Google search of the term "Thomsen parameter" returns over 300,000 hits. In 1995, he moved to Amoco's Worldwide Exploration Group in Houston, where his 1997 paper established the modern field of converted-wave exploration, defining such concepts as "C-waves", "registration", "gamma effective", "diodic velocity", etc. In 2008, Leon retired from BP, and established the consultancy Delta Geophysics (cf. deltageophysics.net).

Leon has served the Society of Exploration Geophysics as Distinguished Lecturer, Vice-President, President (2006-07), and Chairman of the Board of SEAM. He served as SEG/EAGE DISC Instructor in 2002. He holds the SEG"s Fessenden Award, and the Russian Academy of Natural Sciences" Kapitsa Medal. He is an Honorary Member of the Geophysical Society of Houston, and of the EAGE, and is a Foreign Member of the Russian Academy of Natural Sciences.

Geophysics Under Stress: Geomechanical Applications of Seismic and Borehole Acoustic Waves

ANISOTROPY DRILLING ELASTICITY FRACTURES MONITORING PORE PRESSURE PRODUCTION ROCK PHYSICS SAND SHALE

Instructor:	Dr Colin Sayers (Schlumberger, United States)	
Language:	English	
Level:	Advanced	
Duration and formats:	Classroom: 1 day	CPD Points: 5

NEW

Course Description

The state of stress within the earth has a profound effect on the propagation of seismic and borehole acoustic waves, which leads to many important applications of elastic waves for solving problems in petroleum geomechanics. The purpose of this course is to provide an overview of the sensitivity of elastic waves in the earth to the in-situ stress, pore pressure and anisotropy of the rock fabric resulting from the depositional and stress history of the rock and to introduce some of the applications of this sensitivity. The course will provide the basis for applying geophysics and rock physics solutions to geomechanical challenges in exploration, drilling and production. A variety of applications and real data examples will be presented and particular emphasis will be placed on the rock physics basis underlying the use of geophysical data for solving geomechanical problems.

Course Objectives

Upon completion of the course, participants will have an understanding of the sensitivity of elastic waves in the earth to mineralogy, porosity, pore shapes, pore fluids, pore pressures, stresses and the anisotropy of the rock fabric resulting from the depositional and stress history of the rock and how to use this understanding in quantitative interpretation of seismic data and in the construction of mechanical earth models.

Course Outline

The following topics will be addressed in the course:

- Introduction to the effects of stress in the earth. Why pore pressure, in-situ stress and geomechanical properties are important.
- Sediment compaction and the state of stress in the earth. Vertical stress, pore pressure and sediment compaction. Horizontal stress in a relaxed basin. Estimation of the minimum and the maximum horizontal stress. Tectonic strains.
- Pore pressure. Velocity vs. effective stress relations. Pore pressure estimation from velocity. Clay diagenesis. Unloading. The need for fit-for-purpose seismic velocities. Uncertainty analysis. Combining seismic velocities with well velocities for improved pore pressure estimation. Dipping layers and lateral pore pressure transfer.
- Stress sensitivity of sandstones. Third-order elasticity theory. Dependence of elastic wave velocities on porosity in sandstones. The importance of compliant grain boundaries, microcracks and fractures on velocities in sandstones. The use of elastic waves to monitor stress-induced damage.
- Wellbore stability and wave velocities near a borehole. Stress changes in the vicinity of a borehole. Mechanical behavior of rock in the vicinity of a borehole. Stress dependence of elastic wave velocities. Linearized expressions for the change in velocity for small changes in stress.
- Reservoir geomechanics and 4D seismic monitoring. Reservoir stress path. The effect of stress path on rock deformation and failure. Rock failure. Monitoring reservoir stress changes using time-lapse seismic. The difference in reservoir stress path between injection and depletion.
- Fractured reservoirs. Effects of fractures on seismic waves. Multiple fracture sets. Amplitude Versus Offset and Azimuth (AVOA). Simplifications for weak anisotropy. Effects of inequality between the normal and shear compliance of fractures. Microstructural models of fracture compliance.
- The seismic anisotropy of shales. The relation of shale anisotropy to microstructure. The effect of interparticle regions on seismic anisotropy. Clay mineral anisotropy. Effect of disorder in the orientation of clay particles. The static elastic moduli for a TI medium and the implications for hydraulic fracture containment.

Participants' Profile

The integrated nature of this course means that it is suitable for individuals from all subsurface disciplines including geophysics, geomechanics, rock physics, petrophysics, geology, geomodelling and drilling and reservoir and petroleum engineering. The short-course presentation, limited to one-day, will provide an overview of the basic concepts and applications and minimizes the use of mathematical developments. As a result, the course presentation does not require a theoretical background and can be attended by a broad section of working geoscientists and engineers interested in applying geophysical data to the solution of geomechanical problems. The course book will provide support for the lecture and further extend some of the more technical considerations.

Prerequisites

Participants should have a basic knowledge of geology, geophysics and petrophysics.

Recommended Reading

Geophysics Under Stress: Geomechanical Applications of Seismic and Borehole Acoustic Waves, by Colin M. Sayers.

About the Instructor

Colin Sayers is a Scientific Advisor in the Schlumberger Seismic for Unconventionals Center of Excellence in Houston, providing consultancy in geophysics, rock physics, drilling and reservoir geomechanics and the characterization of fractured reservoirs. He entered the oil industry to join Shell's Exploration and Production Laboratory in Rijswijk, The Netherlands in 1986, and moved to Schlumberger in 1991.

His technical interests include geophysics, rock physics, drilling and reservoir geomechanics, pore pressure prediction, wellbore stability analysis, analysis of production-induced reservoir stress changes, subsidence, fault reactivation, 3D mechanical earth modelling, sanding, fractured reservoir evaluation, borehole/seismic integration, stress-dependent acoustics, advanced sonic logging, AVAZ, fluid flow in fractured reservoirs.

He is a member of the AGU, EAGE, GSH, HGS, SEG, SPE and SPWLA, and the SEG Research Committee. He has served on the editorial board of Geophysical Prospecting, the International Journal of Rock Mechanics and Mining Science, and The Leading Edge. He has a B.A. in Physics from the University of Lancaster, U.K., a D.I.C. in Mathematical Physics and a Ph.D. in Physics from Imperial College, London, U.K. He has published numerous papers and holds several patents in the areas covered by this course.

He was the 2010 chair of the editorial board of The Leading Edge, and presented the 2010 SEG/EAGE Distinguished Instructor Short Course on "Geophysics under stress: Geomechanical applications of seismic and borehole waves". In 2013 he was awarded Honorary Membership of the Geophysical Society of Houston "In Recognition and Appreciation of Distinguished Contributions to the Geophysical Profession". He was awarded 2013 Best Paper in The Leading Edge, Society of Exploration Geophysicists.

Applied Oilfield Geomechanics

4D SEISMIC | CALIBRATION | DISPLACEMENT | FAULT RE-ACTIVATION | MECHANICAL PROPERTIES | MUD WEIGHT | PORE PRESSURE | STRAIN | STRESS | WELLBORE STABILITY

Instructor:	Dr Jorg Herwanger (MP Geomechanics, United Kingdom)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 to 4 live sessions of 4 hour	CPD Points: 4 to 8
	Classroom: 1 to 2 days	CPD Points: 5 to 10

NEW

Course Description

3D geomechanical models are frequently used to assess the state of stress inside the Earth. Knowledge of the stress-state in a reservoir and the surrounding rock allows assessing the risk of reservoir compaction, wellbore failure, sanding, breach of seal integrity and fault re-activation amongst others. Three-dimensional seismic data and inversion models can be used in building geomechanical models and time-lapse (4D) seismic data provide a means of calibrating the dynamic behaviour of reservoir geomechanical models. The purpose of this course is to provide an overview of currently available workflows to build and run calibrated 3D and 4D geomechanical models, maximizing the use of seismic data.

By attending the course, participants will deepen their insight into each of the elements that comprise a 3D and 4D geomechanical model. Special attention is given to the way that seismic data assist in the process, what other data sources are required, how to calibrate geomechanical models and finally, how to interpret geomechanical models for a range of applications.

Course Objectives

The purpose of this course is to:

1. Provide an overview of the currently available techniques of building and calibrating 3D and 4D geomechanical models;
2. Demonstrate the interaction between rock properties, pore pressure and stress state;
3. Apply the knowledge of stress state from geomechanical models to field development and reservoir management;
4. Understand the limitations of current workflows and techniques and give a glimpse of the road ahead.

Course Outline

- Introduction: Applications of geomechanics in the oilfield life-cycle;
- Rock mechanical properties:
  - Elastic and strength properties;
  - How do you derive mechanical properties in practice.
- Stress and strain tensors:
  - Workflow for building 3D and 4D geomechanical models;
  - Calibration of 3D geomechanical models using well-centric 1D geomechanical models;
  - Analysis and display of displacement vectors, strain tensors and stress tensors.
- Case studies:
  - Building a 3D geomechanical model using seismic AVO inversion in an onshore tight gas reservoir;
  - Geomechanical controls on hydraulic stimulation;
  - Wellbore stability for inclined wells: Why inclined and horizontal wells behave differently from vertical wells;
  - Multiple uses of 3D and 4D geomechanical flow models: Applications in a deepwater carbonate and clastic fields;
  - Stress rotations during production and their impact on hydraulic stimulation.

Participants' Profile

Geomechanics projects integrate data and models from many different subsurface disciplines, including geophysics, rock mechanics testing, geology, geomodelling, rock physics and reservoir engineering. The course is designed for practising geoscientists and engineers and demonstrates how their discipline knowledge contributes to geomechanical modeling.

The course is also beneficial to students of petroleum geoscience (geophysics and geology). Finally, the course also appeals to managers of subsurface teams, increasing the appreciation of the complexity of the subsurface workflows that his or her team needs to address.

Prerequisites

This course is aimed at geoscientists and engineers with an interest in geomechanics, be their background in geology, geophysics, rock physics, reservoir engineering or geomechanics. The course was developed mainly with a practicing geophysicist or geologist in mind. The course has an emphasis on making the physics behind the presented techniques accessible and clear and will appeal to curious and inquisitive people. This course is also suited for Master's and PhD students as the course (material) is designed in such a way that the principles of geomechanics become clear.

Geomechanics is still a relatively new discipline in the oilfield environment and is not taught as part of most university Geoscience-programs. Therefore a lot of graphic examples are included in the course material to aid intuitive understanding.

About the Instructor

Jorg Herwanger is a Director at MPGeomechanics, a geomechanics consulting and software company he co-founded in July 2016. His work combines experimental observations and the development of mathematical models and workflows in seismic, rock physics and reservoir geomechanics. Working closely with clients and his team, he carries out 3D and 4D geomechanical projects, integrating 1D geomechanical models, seismic inversion methods, rock physics and pore pressure predictions into reservoir flow and geomechanical models. Previous companies he worked for included Ikon Science and Schlumberger. Before working in the upstream oil and gas industry, Jorg's interest was in the development and computer implementation of tomographic methods to determine anisotropic electrical properties from observed crosswell data. He combined these newly developed techniques with anisotropic velocity tomography to detect and evaluate fractures. Jorg is a member of EAGE, SPE and SEG. He served as an EAGE Distinguished Lecturer from 2007-2009, and EAGE Education Tour (EET-5) Lecturer in 2011-2012, and was the 2016-2018 EAGE Education Officer on the EAGE Board. For the EET-5, Jorg wrote the eponymous book on "Seismic Geomechanics". Jorg holds a Diplom degree from Technische Universitat Clausthal, Germany and a PhD from Imperial College, London, U.K., both in Geophysics

Oilfield Geomechanics: Application to Drilling, Completions, Reservoir, Production, Geology and Geophysics

COMPACTION | FAULT REACTIVATION | FAULTS | FLUID | FLOW | FRACTURES | HYDRAULIC | FRACTURING | IN-SITU STRESS | PORE PRESSURE | PRODUCTION PREDICTION | ROCK DEFORMATION | ROCK MECHANICS | ROCK STRENGTH | SAND PRODUCTION | PREDICTION | SUBSIDENCE | UNCERTAINTIES | WELLBORE STABILITY

Instructor:	Dr David Wiprut (Baker Hughes United States)	
Language:	English	
Level:	Intermediate	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 3 days	CPD Points: 15

NEW

Course Description

Stress and pressure act on every reservoir, wellbore and completion. The process of drilling, production and injection will modify stresses and pressures, sometimes to the extent that the risks for failures in and around the producing wells or even at the surface increase considerably. Geomechanics is the study of the interaction between current-day stresses and pre-existing structures and lithologies. By understanding how stresses and rock properties interact, a large number of oilfield problems and operations can be addressed and optimized, including wellbore instability, sand production, fault reactivations, fracture permeability, pore pressure prediction, casing collapse and shear, compaction and subsidence, hydraulic fracturing, and more.

This course provides participants with a solid understanding of rock mechanics, rock mechanical properties, and the associated laboratory measurements and procedures used to determine these properties. Additionally, participants will learn how stresses and pressures in the earth are measured and constrained, through various tools and techniques of analysis. The participants will understand the risks for mechanical rock failure during drilling and field development, the implications of these failures over the life of the well and field, and how these can be managed and mitigated.

The course is operationally focused and designed to provide an understanding of how drilling and operating costs can be lowered, risks and uncertainties reduced, productivity increased, field development strategies optimized, well planning supported, and safety improved in conventional and unconventional reservoirs.

With 18 exercises, in-chapter and end-of-chapter class discussion questions, and hands-on demonstrations, this industry-leading class helps to ensure the participants are ready to identify the geomechanical risks hiding in every field.

The training course will provide course participants with a detailed understanding of geomechanical modeling and model applications. They will learn about:

- Rock deformation and mechanics
- Rock failure and rock strength
- Determination of the in-situ stresses
- Pore pressure prediction
- Wellbore stability
- Sand production prediction
- Casing collapse and shear
- Fractures, faults, and fluid flow
- Hydraulic fracturing
- Compaction and subsidence

Course Objectives

Course participants will:

- Calculate stresses, pressures, and rock properties
- Calculate when faults will slip and determine the consequences of slip
- Calculate stress concentrations around wellbores drilled in principal stress directions
- Run a quick-look sand production prediction calculation
- Gain a better understanding of their future reservoir challenges and how geomechanics affects their well planning and reservoir decisions.

Course Outline

Day 1: Overview Basic constitutive laws

- Rock failure
- Pore pressure
- The tectonic stress field – basic principles
- n-situ stress determination

Day 2: In-situ stress determination

- Building a geomechanical model – data inputs
- Wellbore stability
- Fracture pressure

Day 3: Geomechanics applied to completions engineering

- Sand production prediction
- Casing collapse and shear Geomechanics for geology & geophysics applications
- Fractures and faults in three dimensions
- Fracture permeability
- Fault leakage
- Geomechanics applied to reservoir engineering
- Water floods and hydraulic fracturing
- Production effects - compaction and normal faulting in reservoirs

Participants' Profile

This is a intermediate course for anybody interested or involved in subsurface oilfield operations. Anyone impacted by rock failures, from beginning engineers to highly experienced supervisors and managers, can benefit from understanding geomechanics.

Prerequisites

Knowledge of oilfield operations and practices is desirable, but not cessary.

About the Instructor

Dr. David Wiprut has been working on geomechanics problems in the oil and gas industry since 1996. He received his Ph.D. from Stanford University in 2000 studying the state of stress, wellbore stability, and fault leakage in the northern North Sea. Dr. Wiprut has continued to work on similar issues with GMI and subsequently Baker Hughes since earning his degree, and has accumulated extensive experience working on geomechanics problems throughout the world. Dr. Wiprut oversees external training activities world-wide for Baker Hughes Geomechanics Services, advises on technical issues for geomechanics consulting projects, and manages the geomechanics competency and career progression program.

Seismic Geomechanics: How to Build and Calibrate Geomechanical Models using 3D and 4D Seismic Data

GEOMECHANICS PETROPHYSICS CROSS DISCIPLINE

Instructor:	Dr Jorg Herwanger (MP Geomechanics, United Kingdom)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 4

EET

Course Description

Three-dimensional geomechanical models are becoming more frequently used to assess the state of stress inside the Earth. Knowledge of the stress-state in a reservoir and the surrounding rock allows assessing the risk of reservoir compaction, wellbore failure, sanding, breach of seal integrity, fault re-activation and allows the design of mitigation for these issues. Three-dimensional seismic data and inversion models can be used in building geomechanical models and time-lapse (4D) seismic data provide a means of calibrating the dynamic behavior of reservoir geomechanical models. The purpose of this course is to provide an overview of currently available workflows to build and run calibrated reservoir geomechanical models maximizing the use of 3D and 4D seismic data. Rock-physics, relating the state of stress in the Earth and the propagation velocity of seismic waves, forms the link between seismic observations and the geomechanical model, and this link will be discussed both from experimental data and from a theoretical viewpoint. Attendees will learn how a combination of 3D geomechanical models, coupled to flow models, built and calibrated with 3D and 4D seismic data help in creating a deep understanding of the reservoir depletion processes and the state of stress in the reservoir and surrounding rock.

Course Objectives

The purpose of this course is to:

- Provide an overview over currently available workflows to build, run and calibrate reservoir geomechanical models maximizing the use of 3D and 4D seismic data;
- Apply the understanding gained from running such workflows to field development and reservoir management;
- Understand the limitations of current workflows and techniques and give a glimpse of the road ahead.

Course Outline

The course addresses the following issues:

- Field observations of geomechanically induced time-lapse seismic signals. Where do they occur and why?
- Building a 3D geomechanical model. Demonstrating a seismic-to simulation workflow, including building a framework model to surface and property population from seismically derived properties.
- Running coupled modeling of a reservoir simulation model and a geomechanical model. Non-linear stress-strain relationship, reservoir compaction, failure models, stress and strain tensors.
- Rock-physics for elastic and inelastic deformation. Velocity-stress relationship for elastic and inelastic deformation. Velocity during loading and unloading. Stress-induced velocity anisotropy.
- Time-lapse seismic observations. Time-lapse time-shifts, AVO attributes, shear-wave splitting.
- Case-study of integrating flow model, geomechanical model and time-lapse observations.

Participants' Profile

The integrated nature of the subject and approach makes this course appealing to practitioners and researchers from a wide range of subsurface disciplines, ranging from geophysics, geomechanics, geomodelling, geology, rock physics and reservoir engineering. Practising geoscientists and engineers will appreciate the inter-disciplinary approach to addressing reservoir management issues and should be able to use ideas and approaches taught in this course in their day-to-day work. The course draws heavily on field observations and examples, while limiting the use of mathematical developments. This makes the course appealing to a wide cross-section of geoscientists and engineers that are interested in the inter-related nature of the subsurface disciplines. It should also be appealing to managers of cross-disciplinary subsurface teams, increasing the appreciation of the complexity of the subsurface workflows that his or her team needs to address.

Prerequisites

This course is aimed at geoscientists and engineers with an interest in integration between the different subsurface disciplines. The course presents both currently available seismic-to-simulation techniques. The course has an emphasis on making the physics behind the presented techniques accessible and clear and will appeal to curious and inquisitive people. This course is also suited for Master's and PhD students as the course (material) is designed in such a way that the principles of geomechanics become clear. Geomechanics is still a relatively new discipline in the oilfield environment and is not taught as part of most university Geoscience-programs. Therefore a lot of graphic examples to aid intuitive understanding are included in the course material.

About the Instructor

Jörg Herwanger is a Director at MPGeomechanics, a geomechanics consulting and software company he co-founded in July 2016. His work combines experimental observations and the development of mathematical models and workflows in seismic, rock physics and reservoir geomechanics. Working closely with clients and his team, he carries out 3D and 4D geomechanical projects, integrating 1D geomechanical models, seismic inversion methods, rock physics and pore pressure predictions into reservoir flow and geomechanical models. Previous companies he worked for included Ikon Science and Schlumberger. Before working in the upstream oil and gas industry, Jörg's interest was in the development and computer implementation of tomographic methods to determine anisotropic electrical properties from observed crosswell data. He combined these newly developed techniques with anisotropic velocity tomography to detect and evaluate fractures. Jörg is a member of EAGE, SPE and SEG. He served as an EAGE Distinguished Lecturer from 2007-2009, EAGE Education Tour (EET-5) Lecturer in 2011-2012, and was the EAGE Education Officer on the EAGE Board from 2016-2018. For the EET-5, Jörg wrote the eponymous book on "Seismic Geomechanics". Jörg holds a Diplom degree from Technische Universitat Clausthal, Germany and a PhD from Imperial College, London, U.K., both in Geophysics.

Petroleum Fluids and Source Rocks in E&P Projects

FLUID | GEOCHEMISTRY | ISOTOPE ANALYSIS | KEROGEN | OIL AND GAS | SHALE | UNCONVENTIONAL

Instructor:	Prof. Dr Alexei Milkov (Colorado School of Mines, United States)	
Language:	English, Russian	
Level:	Foundation	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 3 days	CPD Points: 15

NEW

Course Description

The course enables participants to interpret fluids and source rock data to add value to E&P projects from exploration to environmental remediation. Examples and case studies come from both conventional and unconventional petroleum systems around the world. The learning objectives are achieved through well-illustrated lectures, numerous hands-on exercises and active class discussions.

We will cover the following topics:

- Fundamentals of petroleum composition and properties;
- Sampling of rocks and fluids;
- Analytical techniques used to evaluate potential of source rocks and composition of petroleum fluids;
- Characterization and risking of source rocks and prediction of fluid properties in exploration prospects;
- Interpretation of data from drilled exploration wells to assess the value of the discovery;
- Use of geochemical data to assess reservoir compartmentalization during appraisal and development;
- Geochemical surveillance of oil & gas production;
- Use of geochemical data to locate producing intervals and allocate petroleum production;
- Identification of oil sources for petroleum spills and leaks.

Course Objectives

Upon completion of the course, participants will be able to:

Identify and propose geochemical solutions for E&P business problems;

- Design cost-effective fit-for-purpose sampling/analysis programs for source rocks and petroleum fluids;
- Construct expulsion profiles for different types of source rocks;
- Predict fluid properties and product value in exploration and production wells;
- Correlate oils to source rocks;
- Interpret the origin of hydrocarbon and non-hydrocarbon natural gases;
- Integrate geochemical interpretations into holistic petroleum systems analysis;

Course Outline

Day 1. Fundamentals of petroleum geochemistry. Sampling and analytical techniques

The first day introduces the participants to petroleum geochemistry. You will learn the composition of natural gases and oils and how to interpret gas and oil data. This will be followed by the discussion of sampling and analytical techniques for source rocks and petroleum fluids.

- Welcome and introductions;
- Petroleum composition and phases;
- Interpretation of hydrocarbon and non-hydrocarbon natural gases (molecular composition and isotopes);
- Interpretation of oils (from bulk parameters to biomarkers);
- Post-accumulation processes (biodegradation, thermal sulfate reduction, water-washing etc.);
- Sampling techniques (surface, drilling, production);
- Analytical techniques (Rock-Eval, gas chromatography (GC), mass-spectrometry (GC/MS)).

Day 1 exercises: several short interpretation assignments followed by the major exercise on matching oil samples with whole oil GC traces.

Day 2. Petroleum exploration and drilling the prospect

The second day starts with the discussion of source rocks. Participants will interpret the quality and the potential of source rocks and will model petroleum expulsion. This will be followed by the discussion of exploration drilling and the data necessary to interpret the outcomes of exploration projects.

- Source rock presence, maturity and potential;
- Expulsion from various organofacies;
- Prediction of fluid properties in exploration projects;
- 1D burial history and maturity;
- Fluids and pressure;
- Petroleum seeps;
- Oil-source correlations.

Day 2 exercises: mapping and interpreting source rocks; building expulsion profiles for various source rocks; constructing pressure profiles in subsurface; oil-source correlation.

Day 3. Appraisal, development, production, environmental and downstream projects

The third day focuses on the integration of petroleum geochemical data with other subsurface datasets to assist in appraisal, development and production of petroleum reservoirs. This will be followed by the discussion of petroleum spills and leaks. We will finish the course by studying how understanding of source rocks and petroleum fluids help create value in downstream projects.

- Reservoir compartmentalization;
- Time-lapse geochemistry (surveillance);
- Production allocation;
- Petroleum spills and leaks;
- Oil value;
- Gas value.

Day 3 exercises: unravelling compartmentalization of a reservoir; determining sources of oils collected after a major offshore spill.

Participants' Profile

The course is designed for geoscientists, engineers and managers who work on exploration, appraisal, development, production and environmental projects and require competency in petroleum fluids and source rocks.

About the Instructor

Alexei V. Milkov is Full Professor and Director of Potential Gas Agency at Colorado School of Mines and a consultant to oil and gas industry. After receiving PhD from Texas A&M University, Dr. Milkov worked for BP, Sasol and Murphy Oil as geoscientist and senior manager. He explored for conventional and unconventional oil and gas in over 30 basins on six continents and participated in the discovery of more than 4 Billion BOE of petroleum resources. He also worked on several appraisal and production projects. Dr. Milkov has deep expertise in oil and gas geochemistry, petroleum systems modeling, exploration risk analysis, resource assessments and portfolio management. He published 50 peer-reviewed articles. Dr. Milkov received several industry awards including J.C. "Cam" Sproule Memorial Award from the American Association of Petroleum Geologists (AAPG) for the best contribution to petroleum geology and Pieter Schenck Award from the European Association of Organic Geochemists (EAOG) for a major contribution to organic geochemistry.

Interpretation of Natural Gases

GEOCHEMISTRY | ISOTOPE ANALYSIS | OIL AND GAS | SHALE | UNCONVENTIONAL

Instructor:	Prof. Dr Alexei Milkov (Colorado School of Mines, United States)	
Language:	English, Russian	
Level:	Foundation	
Duration and formats:	Online: 2 live sessions of 4 hours	CPD Points: 4
	Classroom: 1 day	CPD Points: 5

NEW

Course Description

This course enables participants to add value in E&P projects through interpretation of natural gases. Examples and case studies come from both conventional and unconventional petroleum systems around the world. The instructor will transfer his practical knowledge of most important and relevant theories, interpretation tools and applications used in the industry. The learning objectives are achieved through well-illustrated lectures, numerous hands-on exercises, active class discussions and competitive games.

We will cover the following topics:

- Fundamentals of natural gas composition and properties;
- Sampling of natural gas during drilling and production;
- Analytical techniques used to determine molecular and isotopic composition of natural gases;
- Interpretation of hydrocarbon gases (origin and processes);
- Interpretation and prediction of non-hydrocarbon gases (CO_2, N_2, H_2S, He and others);
- Using gas data and models to solve business problems in exploration, appraisal/development, production and environmental projects.

Course Objectives

Upon completion of the course, participants will be able to:

- Design cost-effective fit-for-purpose sampling/analysis programs for natural gases;
- Evaluate molecular and isotopic composition of hydrocarbon gases and interpret their origin (primary microbial, secondary microbial, thermogenic, abiotic) using state-of-the-art genetic diagrams;
- Interpret the source, maturity, mixing and post-accumulation alterations of hydrocarbon gases;
- Interpret the origin and sources of non-hydrocarbon gases (carbon dioxide, nitrogen, hydrogen sulfide, helium and others);
- Use gas data to solve business problems in exploration, appraisal/development, production and environmental projects;
- Identify and propose geochemical solutions for E&P business problems.

Course Outline

- Fundamentals of natural gas composition and properties;
- Sampling of natural gas during drilling and production;
- Analytical techniques used to determine molecular and isotopic composition of natural gases;
- Interpretation of hydrocarbon gases (origin and processes);
- Interpretation and prediction of non-hydrocarbon gases (CO_2, N_2, H_2S, He and others);
- Using gas data and models to solve business problems in exploration, appraisal/development, production and environmental projects.

Participants' Profile

The course is designed for geoscientists, engineers and managers who work on exploration, appraisal, development, production and environmental projects and require competency in natural gases.

About the Instructor

Alexei V. Milkov is Full Professor and Director of Potential Gas Agency at Colorado School of Mines and a consultant to oil and gas industry. After receiving PhD from Texas A&M University, Dr. Milkov worked for BP, Sasol and Murphy Oil as geoscientist and senior manager. He explored for conventional and unconventional oil and gas in over 30 basins on six continents and participated in the discovery of more than 4 Billion BOE of petroleum resources. He also worked on several appraisal and production projects. Dr. Milkov has deep expertise in oil and gas geochemistry, petroleum systems modeling, exploration risk analysis, resource assessments and portfolio management. He published 50 peer-reviewed articles. Dr. Milkov received several industry awards including J.C. "Cam" Sproule Memorial Award from the American Association of Petroleum Geologists (AAPG) for the best contribution to petroleum geology and Pieter Schenck Award from the European Association of Organic Geochemists (EAOG) for a major contribution to organic geochemistry.

Training and Development

HUMAN RESOURCES •

Mitigating Bias, Blindness and Illusion in E&P Decision Making

BIAS | CALIBRATION | DECISION MAKING | ECONOMICS | ESTIMATION | HEURISTICS | INTUITION | OBJECTIVITY | OVERCONFIDENCE | PLANNING | POST-APPRAISAL | UNCERTAINTY | WORKFLOWS RISK

Instructors:	Marc Bond (Rose & Associates, United Kingdom) and Creties Jenkins (Rose & Associates, United States)	
Language:	English	
Level:	Foundation	
Duration and formats:	Online: 4 live sessions of 4 hours	CPD Points: 8
	Classroom: 2 days	CPD Points: 10

NEW

Course Description

Decisions in E&P ventures are affected by cognitive bias, perceptual blindness, and various forms of illusion which permeate our analyses, interpretations and decisions. This two-day course examines the influence of these cognitive pitfalls and presents techniques that can be used to mitigate their impact.

"Bias" refers to errors in thinking whereby interpretations and judgments are drawn in an illogical fashion. "Blindness" is the condition where we fail to see an unexpected event in plain sight. "Illusion" refers to misleading beliefs based on a false impression of reality.

All three—Bias, Blindness, and Illusion--can lead to poor decisions regarding which work to undertake, what issues to focus on, and whether to continue investing time, effort, and money in a given project. The course begins by examining how these cognitive errors affect us. Several different errors are discussed, including: Perceptual Blindness; Illusions of Potential, Knowledge and Objectivity; and Anchoring, Availability, Confirmation, Framing, Information, Overconfidence and Motivational Biases. Exercises, videos, and examples help illustrate how these manifest themselves in our daily activities and affect our judgment, often without us realizing it. We then focus on the oil and gas industry where drilling portfolios, production forecasts, resource assessments, and other activities are regularly impacted. Techniques are presented that can be used to mitigate cognitive errors and examples are shown where these techniques have worked.

A key element of the course are the mitigation exercises which give participants a chance to apply what's been learned to real-life situations. For example, what elements of the "anchoring bias" led to the belief that the exploration potential of a prospect offshore Brazil was much greater than it turned out to be? Or, what elements of the "confirmation bias" led to a decision regarding which analogous data should be used to predict the outcome of a new drilling project?

The second day includes a series of exploration and appraisal case studies resulting in both positive and negative outcomes. Participants are asked to identify cognitive errors contributing to the project results, and which of these had the greatest impact. This is followed by a 3-hour, real-world exercise using project data to give participants practice in addressing cognitive errors. The exercise requires participants to list all of their assumptions followed by a list of the contrary assumptions. This is followed by an assessment of the impacts if the contrary assumptions are true, and what key types of data / analyses will be required to determine which set of assumptions are correct. Finally, the participants identify cognitive errors leading to the actual project outcome.

The course concludes by presenting a summary 'toolkit' with mitigation techniques that can immediately be applied to project work and decisions. This includes a laminated card listing the various types of bias, blindness and illusion on one side, and the six key steps to mitigate these cognitive errors on the flip side. This helps participants immediately apply the concepts to their daily work.

Course Objectives

Upon completion of the course, participants will be able to:

- Identify the influence of Bias, Blindness and Illusion on their analyses, interpretations and decisions;
- Apply techniques that will mitigate the impact of these in their project work and decision-making;
- Ensure that their behavior does not unwittingly reinforce these cognitive errors in others.

Course Outline

1. Introduction (1 hour)
2. Blindness and Illusion (3 hours)
   a. Perceptual Blindness
   b. Illusion of Knowledge, Potential, and Objectivity
3. Bias (4 hours)
   a. Anchoring, Availability, Confirmation, Framing, Information, and Overconfidence Bias
   b. Motivational Bias
4. Case Studies--an appropriate subset of these will be chosen (2 hours)
   a. Plio-Pleistocene Sandstone (Exploration Well)
   b. Cambrian Sandstone (Field Appraisal)
   c. Pliocene Sandstone (Exploration 'Drill or Drop')
   d. Jurassic Sandstone (Exploration License Round)
   e. Cretaceous Shale (Field Appraisal)
   f. Cambrian Sandstone (Field Appraisal)
5. Real-World Exercise--one of these will be chosen (3 hours)
   a. Triassic sandstone, structural play (Exploration Well)
   b. Fractured carbonate, waterflood potential (Field Appraisal)
6. Summary 'Toolkit' (1 hour)

Participants' Profile

This course is designed to have broad appeal to all levels and disciplines within an organization: junior to senior level geoscientists, junior to senior level engineers, analysts, landmen, HSE, HR, etc. And mid-level to senior managers and executives.

About the Instructors

The course is designed to be taught be one instructor. However, two different instructors are available to teach the course.

Marc Bond (MSc Geophysics, Colorado School of Mines) is an Associate with Rose & Associates specializing in exploration and appraisal assessments. He is actively involved in ensuring that the technical work underpinning an evaluation has appropriately reflected the opportunity and captures both the uncertainty and risk, leading to effective decision-making. He has over 35 years' international experience in the oil and gas industry. Previously he worked for BG Group and Tenneco Oil where he held a variety of management and technical assignments, with his most recent roles including: Chief Geophysicist; Subsurface Assurance Manager for conventional and unconventional exploration, appraisal and development projects; and Exploration Manager Bolivia.

Creties Jenkins (P.E., P.G.) is a Partner with Rose and Associates specializing in the characterization of unconventional reservoirs. Over the last 15 years he has conducted integrated studies, project reviews, and resource evaluations for 50+ companies and taught 100+ industry courses and workshops. He has served as a technical editor, distinguished lecturer, distinguished author for SPE, and is a past president of the Energy Minerals Division of AAPG. Creties has 30+ years of experience having previously worked at Tenneco, ARCO, and DeGolyer & MacNaughton. He holds a BSc in Geological Engineering and a MSc in Geology from the South Dakota School of Mines.

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