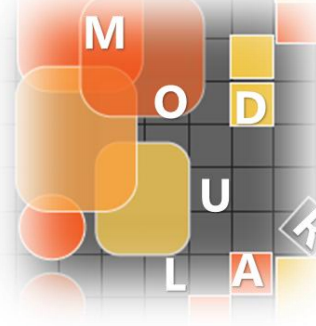
Customized and
On-Demand
Geoscience
Knowledge Services

Remote Modules Catalog 2020/2021

Modular Training



What it is

We have broken down the content of our training courses into modules of half-day length in order to allow clients to design their own courses with their preferred topics, length and structure.

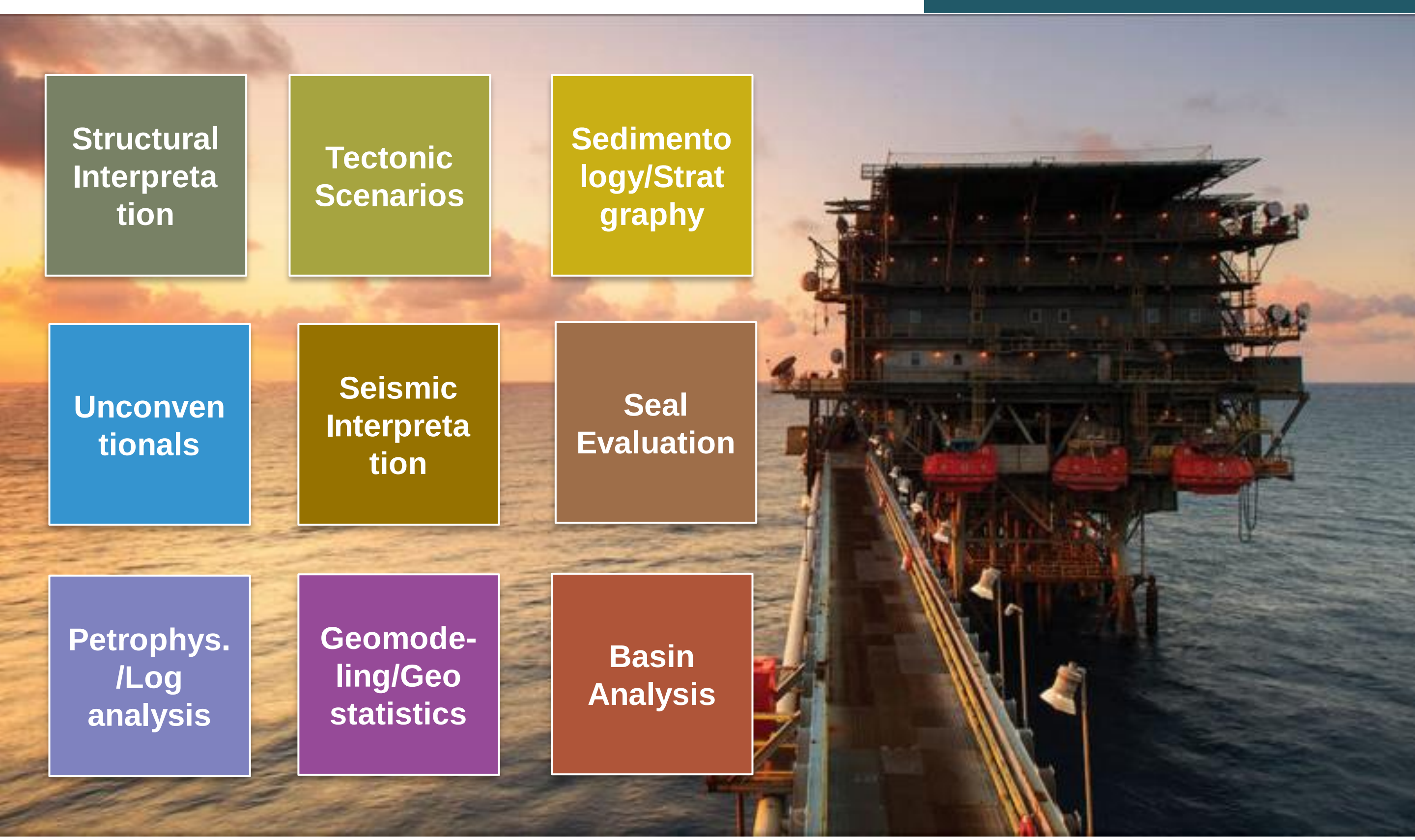
- **Taught online by a live-instructor**
- **1 module = half-day long session (3.5 hrs)**
- **Chose am or pm sessions or split sessions in two**
- **Instructor presentations, exercises and discussions with sufficient breaks**

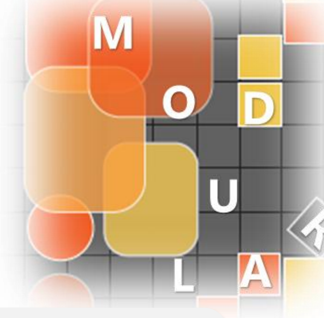
COST of Modules

1 module = USD 850

≥ 6 modules = USD 750

for up to 25 participants





Modular Training

How it works

1 **Browse our 150 module(s), organized by disciplines in our table of content and module maps**

2 **Click on the modules in the interactive maps to find the module descriptions.**

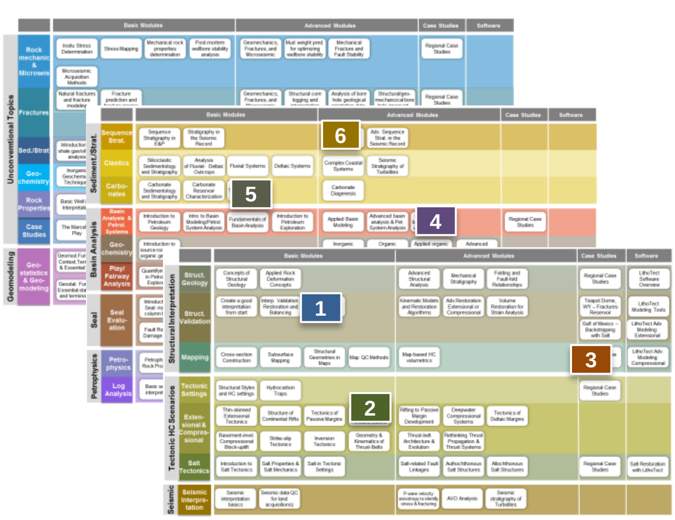
3 **Combine modules into a course of preferred content, length and structure**

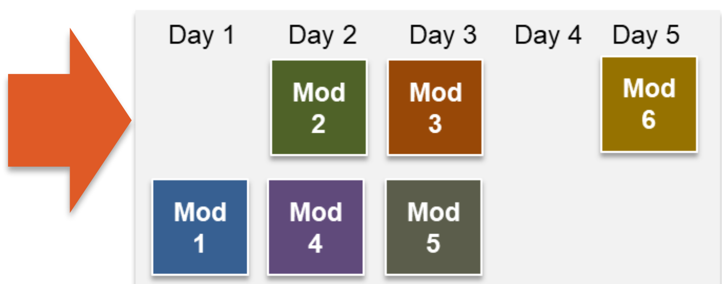
4 **Fill in the form and send us your custom-designed course. We will contact you with a proposal**

OR

Let us know what you are looking for and we design course options for you. CONTACT US

1 Module = 1/2 day





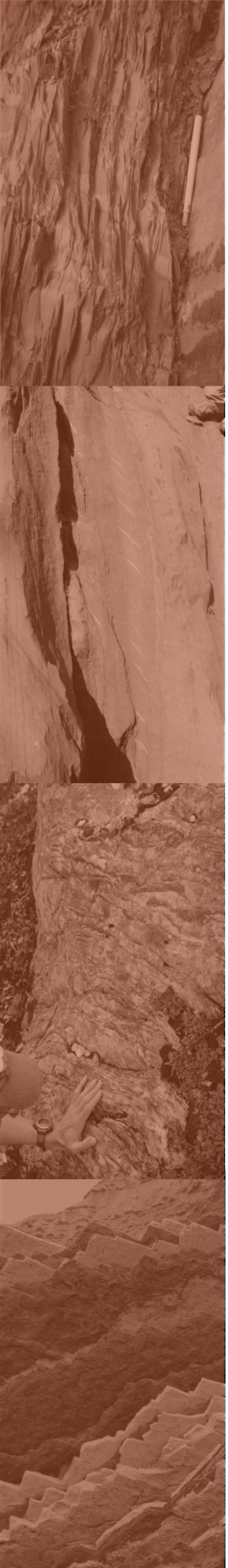


Table of Content

Each module is a half-day of onsite instruction and can be combined with others into a training course of desired length.

MODULES MAP Block A

		Basic Modules	Advanced Modules	Applied Modules
Structural Interpretation	Structural Geology	Concepts of Structural Geology; Applied Rock Deformation Concepts	Advanced Structural Analysis; Mechanical Stratigraphy; Folding and Fault-fold Relation-ships	Regional Case Studies; LithoTect Software Overview
Structural Interpretation	Structural Validation	Create a good inter-pretation from start; Interp. Validation: Restoration and Balancing; Cross-section Balancing techniques	Kinematic Models and Restoration Algorithms; Advanced Restoration Extens. or Compress.; Volume Restoration for Strain Analysis	Teapot Dome, WY – Fractured Reservoir; LithoTect Modeling Tools; GOM– Back-stripping with Salt; LithoTect Advanced Modeling: Extensional
Structural Interpretation	Mapping	Cross-section Construction; Subsurface Mapping; Structural Geometries in Maps; Map QC Methods	Map-based HC volumetrics	Regional Case Studies; LithoTect Advanced Modeling: Compress.
Tectonic HC Scenarios	Tectonic Settings	Structural Styles and HC settings; Hydrocarbon Traps		Regional Case Studies
Tectonic HC Scenarios	Extensional & Compressional	Thin-skinned Extensional Tectonics; Structure of Continental Rifts; Tectonics of Passive Margins; Structures of Intra-cratonic & Foreland Basins; Basement-involved Compress. Blockuplift; Strike-slip Tectonics; Inversion Tectonics; Geometry & Kinematics of Thrust-Belts	Rifting to Passive Margin Develop-ment; Deepwater Compress. Systems; Tectonics of Deltaic Margins; Thrust-belt Architecture & Evolution:; Rethinking Thrust Propagation & Thrust Systems	
Tectonic HC Scenarios	Salt Tectonics	Introduction to Salt Tectonics; Salt Properties & Salt Mechanics; Salt in Tectonic Settings	Salt-related Fault Linkages; Authoch-thonous Salt Structures; Alloch-thonous Salt Structures	Regional Case Studies; Salt Restoration with LithoTect
Seismic	Seismic Interpretation	Seismic inter-pretation basics; Seismic data QC for land acquisitions	P-wave velocity anisotropy to identify stress & fracturing; AVO Analysis; Seismic stratigraphy of Turbidites	

MODUES MAP Block A

Each module is a half-day of onsite instruction and can be combined with others into a training course of desired length.

MODULES MAP Block B

		Basic Modules	Advanced Modules	Applied Modules
Sedimentology/Stratigraphy	Sequence Stratigraphy	Sequence Stratigraphy in E&P; Stratigraphy in the Seismic Record	Adv. Sequence Stratigraphy in E&P; Adv. Sequence Strat. in the Seismic Record	
Sedimentology/Stratigraphy	Clastics	Siliciclastic Sedimentology and Stratigraphy; Analysis of Fluvial-Deltaic Outcrops; Fluvial Systems; Deltaic Systems	Complex Coastal Systems; Seismic Stratigraphy of Turbidites	
Sedimentology/Stratigraphy	Carbonates	Carbonate Sedimentology and Stratigraphy; Carbonate Reservoir Characterization; Tight Carbonates	Carbonate Diagenesis	
Basin Analysis	Basin Analysis	Introduction to Petroleum Geology; Intrduction to Basin Modeling/ Pet.System Analysis; Fundamentals of Basin Analysis; Introduction to Petroleum Exploration	Applied Basin Modeling; Advanced basin analysis & Pet. Syst. Analysis; Applications of basin modeling in unconventionals	Regional Case Studies
Basin Analysis	Geochemistry	Introduction to source rock evaluation organic geochem	Inorganic Geo chemical Techniques; Organic Geochemical Techniques; Applied organic geochemist in petroleum exploration; Advanced Geochem. Interpretation	
Basin Analysis	Play/Fairway Analysis	Quantifying Risk in Petroleum Exploration; Using decision trees to quantify risk; Using seismic data & Geostat. to quantify risk	Ranking prospects or plays	
Seal Evaluation	Seal Evaluation	Introduction to Seal: risk and column height; Trap, seal and HC fill; Evaluating Fault Seal; Evaluating Top Seal; Fault Rocks & Damage Zones	Structural reactivation and seals; Seal Evaluation of geo-pressured prospects; Seal evaluation of Carbonate Prospects	Regional Case Studies
Petrophysics	Petrophysics	Petrophysical Rock Properties; Petrophysical evaluation of mudrock		Regional Case Studies
Petrophysics	Log Analysis	Basic well log interpretation	Fracture Analysis from dipmeter logs; Advanced Log Analysis; 6	

Each module is a half-day of onsite instruction and can be combined with others into a training course of desired length.

MODULES MAP Block C

Topic group	Topic	Basic Modules	Advanced Modules	Applied Modules
Unconvemtional Topics	Rock mechanic & Microseismic	Insitu Stress Determi-nation; Stress Mapping; Mechanical rock properties determi-nation; Post-mortem wellbore stability analysis; Micro-seismic Acquisition Methods	Geo-mechanics, Fractures, and Micro-seismic; Mud weight pred. for optimizing wellbore stability; Mechanical Fracture and Fault Stability	Regional Case Studies
Unconvemtional Topics	Fractures	Natural fractures and fracture modeling; Fracture prediction and fracture proxies	Geo-mechanics, Fractures, and Micro-seismic; Structural core logging and interpreta-tion; Analysis of bore hole geological orientation data; Structural/ geo-mechanical bore hole image int..; Fracture Analysis from dipmeter logs; Fracture modeling & Fractured Reservoir Charact,	Regional Case Studies
Unconvemtional Topics	Sed./Strat	Introduction to shale gas/oil play analysis; Stratigraphic and depos. processes in shale basins; Tight Carbonates	Mudrock sedimen-tology	
Unconvemtional Topics	Geo-chemistry	Inorganic Geo-chemical Techniques; Organic Geo-chemical Techniques	Reservoir Geo-chemistry; Applications of basin modeling in unconven-tionals	
Unconvemtional Topics	Rock Properties	Basic Well Log Inter-pretation; Advanced Well Log Inter-pretation; Physical Rock Properties; Petro-physical Evaluation Mudrocks		Core workshop in Austin, Houston or client offices
Unconvemtional Topics	Case Studies	The Marcellus Play; The Eagle Ford Play; The Haynesville Play		
Geomodeling/Geostat.	Geomodeling	Geomod. Fundam. 1 Context,Terminology& Essent Stat; Geomod. Fundam. 2 Estimation/ Kriging Stoch.Simul; Geomod. Fundam. 3 Generaliz. Subsurface Workflows; Geomod. Fundam. 4 Generaliz. Subsurface Workflows		
Geomodeling/Geostat.	Geostatistics	Geostat. Intro. 1 Essential statistic and terminology; Geostat. Intro. 2 Geostatis-tical Estimation; Geostat. Intro. 3 Geostatis-tical Simulation; Geostat. Intro. 4 Facies Simulations	Petroleum Geostat. 1 Hands-on; Petroleum Geostat. 2 Hands-on; Petroleum Geostat. 3 Hands-on; Petroleum Geostat. 4 Hands-on	

Basic *Module StG_BM_1.1*

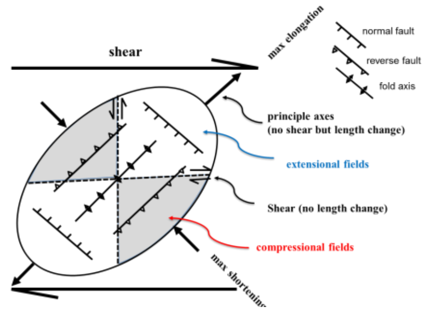
Concepts of Structural Geology

This module covers basic concepts of Structural Geology as they apply to HC workflows, from rock deformation and stress/strain theory to resulting structures such as folds, faults, foliations and lineations. The overview style of this module serves as a refresher of Structural Geology or as a quick basis for workflows requiring Structural Geology. Topics discuss concepts of deformation including stress/strain theory and rheology and then move to the resulting geometries and how they are interpreted in terms of their boundary conditions.

- Strain theory
- Stress theory
- Deformation mechanisms
- Rheology
- Mechanical stratigraphy
- Folds mechanics and geometries
- Fault mechanics and geometries
- Fractures

This module serves as Foundation for further Structural Geology Modules or as a quick refresher for the Structural Geology main concepts.

Experts: Catalina Luneburg, Jim Granath, Bob Ratliff, Steven Boyer, TBD



Basic *Module StG_BM_1.2*

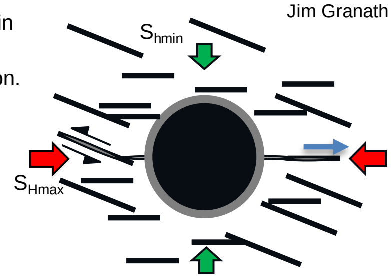
Applied Rock Deformation Concepts

Faults and fractures form when rocks respond as brittle materials in response to differential stress. Their influence on production can be negligible or crucial, and understanding their influence in reservoirs is important for optimum production. This module covers basic concepts of earth stress that lead to faulting and fracturing in sedimentary rocks. The module is a basic introduction to brittle deformation in the geologic environment and how fractures in the reservoir impact production, how they respond to stress perturbations, during production, and how they are impacted by drilling and hydraulic stimulation.

- Fault and fracture nomenclature
- Andersonian faulting
- Fractures formed in tension
- Compressional fractures
- Joint formation
- Relationship of fractures to structure
- Strain accommodation by fractures
- Wellbore stability in deformed and fractured rocks
- Hydraulic fracture stimulation and natural fracture interaction

Examples from Gulf Coast Basin and Appalachian Basin.
Focus is on interaction between rocks. fractures and applied stress, natural or induced

Experts: Sherilyn Williams-Stroud, Jim Granath



View down the wellbore, with two fracture sets, and fracture/stress interaction.

Advanced *Module StG_AM_1.3*

Advanced Structural Analysis

HC exploration and development relies on a sound understanding of the structural model and evolution of the area of interest. As more structurally complex areas are explored, the ability to analyze these methodically and confidently is critical. The advanced Structural Analysis module builds on the basic structural concepts module and focusses more on the 2D and 3D interpretation of complex structural geometries and their quantitative analysis. How can we unravel the deformation history of superposed fault and fold patterns from multiple deformation phases e.g. successive episodes of folding and thrusting on an extensional area of rifting? How do we combine the information and the scales from geologic maps and sections, seismic profiles, wells and outcrop data.

- Structural analysis techniques from stereonet to strain analysis to section balancing
- Influence of pre-existing structure and structural reactivations
- Superposed folding and faulting
- Challenges of 3D structural analysis
- The structural analysis workflow guide

We will try integrate regional examples of your choice.

Experts: Catalina Luneburg, Jim Granath, TBD

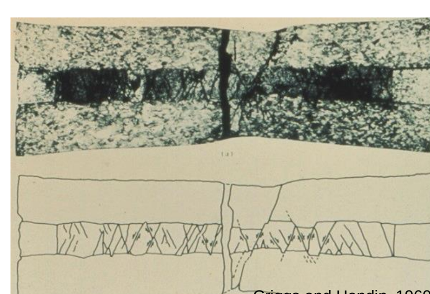
Advanced *Module StG_AM_1.4*

Mechanical Stratigraphy

Mechanical stratigraphy subdivides stratified rock into discrete mechanical units defined by properties such as tensile strength, elastic stiffness, brittleness, and fracture mechanics properties. These mechanical subdivisions control deformation and influence folding, failure mode, fault geometry, and displacement gradients. Examples of mechanical stratigraphy include layer-bounded faults that do not extend into the layers above and below.
The modules also discusses fracture stratigraphy, which subdivides rock into fracture units according to extent, intensity, or some other observed fracture attribute. Fracture stratigraphy reflects a specific loading history and mechanical stratigraphy during failure.

- What is Mechanical Stratigraphy?
- Mechanical rock properties
- Rock properties over time
- Fracture stratigraphy and its relationship to mechanical stratigraphy
- Relationship between fracture spacing and bed thickness
- Examples of fracture stratigraphy and mechanical stratigraphy

Experts: Catalina Luneburg, Jim Granath, TBD



Griggs and Handin, 1960

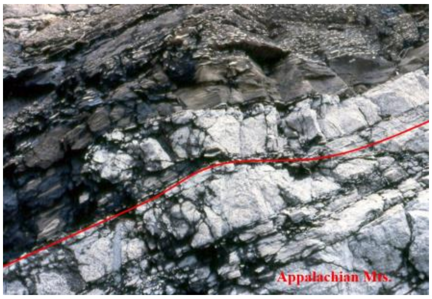
Advanced *Module StG_AM_1.5*

Folding and Fault-fold Relationships

Recognizing and treating folds and faults in seismic data is a familiar issue to interpreters, and getting them correctly is crucial to the exploration and exploitation process. Placing faults in their right place is commonly not an easy task, and many a well has been lost and many a prognosis has been busted because steep dips or unexpected faults were encountered during drilling. The time-honored practice of placing faults at reflection terminations is surprisingly pitfall-prone in even the most simple seeming seismic lines. This module explores the properties of folds in seismic lines and their relationships to faults on a kinematic basis. It compares compressive to extensional systems, and illustrates the principles with case studies. It uses demonstrative videos and exercises along with conventional presentations

- Stress during normal faulting and tectonic conditions conducive to normal faulting
- Progressive deformation: the evolution of brittle to ductile to brittle deformation
- Nucleation and progagation of faults and the consequences to surrounding rock
- Folding style: stratigraphy and its control over style
- Folding style: buckle folds, fault-controlled geometries, fold-accommodating faults
- Variety of fold-fault relationships
- Use of restoration as an interpretation-validation technique
- "SCAT" (Statistical Curvture Analysis Techniques)
- Case study: the Sande anticline in Papua Province, Indonesia—a well gone wrong

Experts: Jim Granath, Catalina Luneburg, Bob Ratliff, TBD



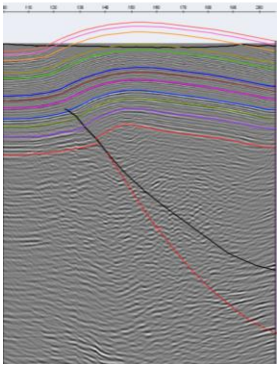
Basic *Module StV_BM_2.1*

Create a good Interpretation from the start

This modules combines seismic interpretation and structural validation techniques in order to create a balanced interpretation from the start. The impact of seismic velocity models and processing on the structural interpretation is discussed and the seismic expression of main structural features is studied in different examples. Methods are demonstrated that validate the seismic interpretation of faults and folds by predicting a valid fault trace and hangingwall shape using manual and digital tools.

- Geological controls on the propagation, reflection, and refraction of seismic waves
- Data acquisition and processing and impact on interpretation
- Seismic velocity models
- Recognizing stratigraphic and structural features in seismic section
- Seismic interpretation of different structural styles
- Interpretation validation techniques
- Method of fault prediction and depth to detachment
- Forward modeling techniques to model shape of hanging wall
- Examples of balancing while interpreting

Experts: Catalina Luneburg, Jim Granath, TBD



Basic *Module StV_BM_2.2*

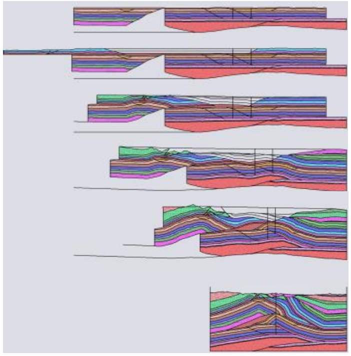
Interpretation Validation: Restoration & Balancing

Creating structurally viable 2D and 3D interpretations is critical for high-quality and high-confidence geological models. This module introduces restoration and balancing techniques to reduce uncertainties from poor seismic imaging, limited outcrop control or difficult well correlations. Restoration styles and a variety of different restoration scenarios are presented with examples and exercises.

- Validation concepts: admissibility, accuracy, restoration and balancing
- Kinematic models of restoration and balancing
- The restoration process and restoration rules
- Line-length and area balancing and the concept of a pin line
- Single-step and time-step restorations, Independent and contiguous restoration, Backstripping and forward modeling
- Restoration scenarios: Planar, listric, Ramp flat, Fault-related folds: fault bend, fault propagation, trishear, Extensional and compressional, thrust sequences, Salt-related deformation, Fractures and strain

This module is an introductory and overview module for restoration and balancing techniques

Experts: Catalina Luneburg, Bob Ratliff, Jim Granath, TBD



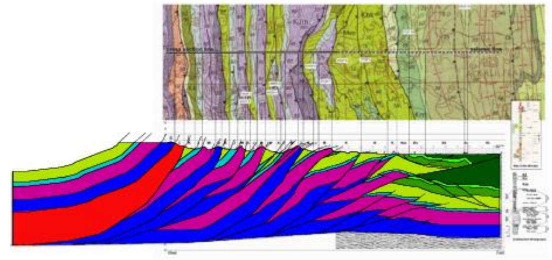
Basic *Module StV_BM_2.3*

Cross-section Balancing Techniques

Cross-section balancing has traditionally been a method to validate geologic interpretations, reduce the uncertainties and create evolutionary time steps. This module introduces all principles and techniques, manual and digital, necessary to balance cross sections. Topics include manually constructing a cross-section, using kinematic models and assumptions to create a balanced section. Applications focus on balancing sections through Fold- and Thrust Belts such as the Covenant Field, Central Utah Thrustbelt,,

Experts: Catalina Luneburg, Bob Ratliff, Jim Granath, TBD

- Kinematic models of balancing
- Pin lines and loose lines, what they are and how to use them
- Assumptions of plane strain, bed thickness and – bed length conservation and other assumptions
- Cross-section construction: transport direction, line of section, folds and faults
- Sequence of deformation
- Restoration of a ramp, a duplex
- In-sequence thrusting, Forward-ramping faults, Kink-style folds



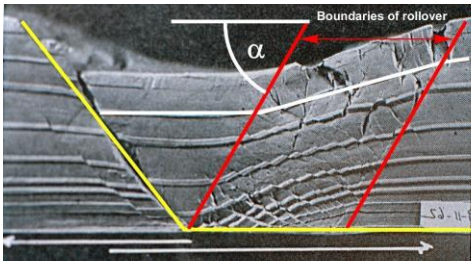
Advanced *Module StV_AM_2.4*

Kinematic Models and Restoration Algorithms

Experts: Catalina Luneburg, Bob Ratliff, Jim Granath, TBD

Restoration and balancing techniques use kinematic models to restore geometries in accordance with geologic concepts. This module goes into more depth of restoration methods and explores the differences and properties of kinematic models. In this context, also fault prediction and depth to detachment as well as strain and shear angle calculations are discussed.

- Rigid block restoration: rigid and internally deformed models of full graben and half graben
- Domino-style deformation, rotated block calculations and half grabens
- Simple shear restoration: vertical and oblique shear
- Strain and shear angle calculations in hangingwall rollover structures
- Flexural slip restoration
- Area balancing, area/depth relationships, concepts of displacement and lost area, effects of growth stratigraphy
- Fault prediction/depth to detachment, hangingwall shape prediction
- Trishear and drape folds
- Examples and exercises: Rhine Graben, Golf of Suez, Teapot Dome WY, Vicksburg etc



Groshong, 1990

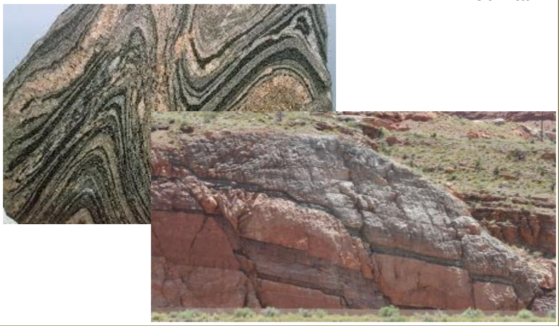
Advanced *Module StV_AM_2.5*

Advanced Restoration – Extensional/Compressional

Experts: Catalina Luneburg, Jim Granath, Bob Ratliff

This module focusses on advanced restoration concepts and techniques of either extensional or compressional structures using different regional examples. More advanced techniques and more complex examples are used than in the basic module.

> As available we use examples of regions of your choice and/or your own data and projects with appropriate preparation time



- Review of extensional or compressional structures
- Kinematic models of restoration and balancing appropriate for extension or compression
- Extensional scenarios: backstripping, decompaction and isostacy, Salt-related deformation
- Compressional scenarios: Planar, listric, Ramp flat, Fault-related folds: fault bend, fault propagation, trishear,

Advanced *Module StV_AM_2.6*

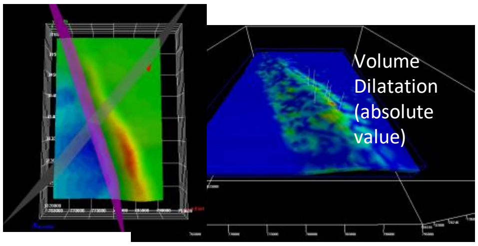
Volume Restoration for Strain Analysis

Experts: Sherilyn Williams-Stroud, TBD

Bodies of rock are deformed in the geological environment in response to a 3 dimensional state of stress. While 2D restoration can model and validate critical geometrical constraints, if a rock body has undergone strain leading to fracture development, volume restoration in 3 dimensions is required in order to capture the range of fracture orientations that could have formed to accommodate strain in the rock. The purpose of this module is to demonstrate volume restoration and validation followed by forward modeling to capture modeled volume strains, and then convert those strains to properties that can be used to define and constrain fracture sets.

- Plane strain versus 3D strain
- Kinematic restoration
- Why plane strain is insufficient to characterize fractures
- Mode I and mode II fracture orientations from strain tensor
- Proxies for strain intensity
- Geomechanical restoration
- Kinematic versus geomechanical restoration methods (pros and cons)
- Scenario testing

> - Examples from Arabian Gulf, Appalachian Basin
> - Comparisons of kinematic/restoration and geomechanical restoration results



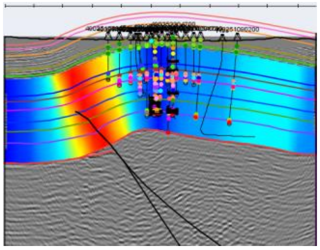
Case Study *Module StV_CM_2.7*

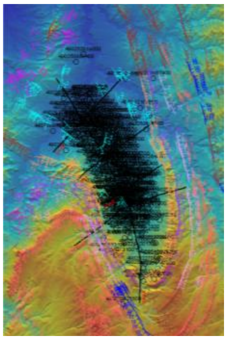
Teapot Dome, WY – Fractured Reservoir

Experts: Catalina Luneburg, Bob Ratliff

Teapot Dome, WY is a well studied oil field of fractured reservoir type with an extensive data set. The structure is an asymmetric, doubly plunging, basement-cored anticline, associated with a large NS trending fault. Key sections through the structure have been balanced and forward modeled using trishear deformation. Dip, curvature and strain have been calculated for different steps of the model to illustrated their evolution over time. These attributes can be used as fracture proxies and compared to observed fracture patterns and well productivity.

- Structural Analysis of Teapot Dome anticline and faults
- Fracture patterns around Teapot Dome
- Trishear forward modeling of the Teapot Dome anticline and major fault
- Dip and curvature distributions across key sections
- Calculating strain from forward models
- Strain distributions across Teapot Dome anticline
- Using strain as a fracture proxy and to predict fractures



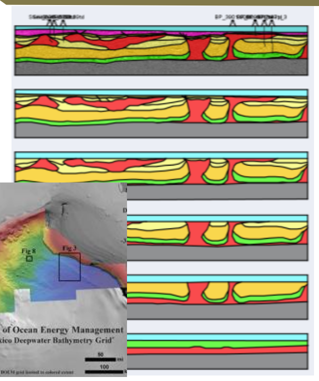


Case Study *Module StV_CM_2.8*

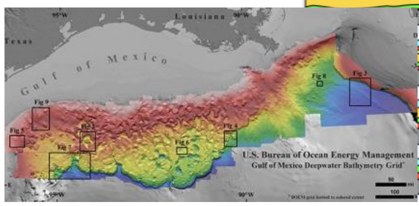
Gulf of Mexico – Backstripping with Salt

Experts: Catalina Luneburg, Bob Ratliff, Jim Granath

This case study illustrates the restoration of a salt-dominated extensional section in the Mississippi Canyon, Gulf of Mexico. The section is restored and discussed in the context of the structural development of the Gulf of Mexico. Restoration and modelling techniques for backstripping with salt bodies are demonstrated with the appropriate kinematic models and decompaction and isostactic adjustments. The unique properties of salt present challenges to section balancing that are illustrated with different salt-related geometries.



- Gulf of Mexico structural history
- Review of extensional geometries and allochthonous salt structures
- Structural Analysis of salt bodies of GOM Mississippi Canyon seismic section
- Kinematic models for salt restoration
- Sequential restoration and backstripping with decompaction and isostatic adjustment
- Restoration of salt-withdrawal minibasins with complex history



Software *Module StV_SM_2.9*

LithoTect Software Overview

First Introductory LithoTect Software Training Module: Projects, Data and Interpretation

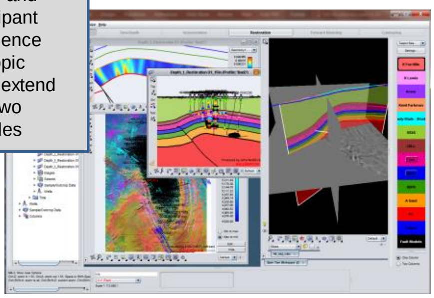
Experts: Catalina Luneburg Bob Ratliff

LithoTect Software is a structural restoration and balancing software package.

This module trains participants on learning the main functionality of the software focusing on introductory tools such as creating a project, a geologic column, importing data, and applying seismic interpretation tools as well as time/depth conversion. Different types of data are imported such as DEMs and images, 2D and 3D seismic data, well data (vertical and deviated wells, well logs, dip meter) etc. Sections are constructed with well and dip projections and basic interpretation tools.

- Introduction to LithoTect user interface and menus
- Overview of main LithoTect functionality
- How to create a project and data base
- The geologic column
- Importing data: DEMs, images, seimic, well data
- Exporting data and interpretations
- Data extraction and projection
- Time/depth conversion
- Section construction
- Seismic interpretation tools

Depending on scope and participant experience this topic could extend over two modules



Software *Module StV_SM_2.10*

LithoTect Modeling Tools

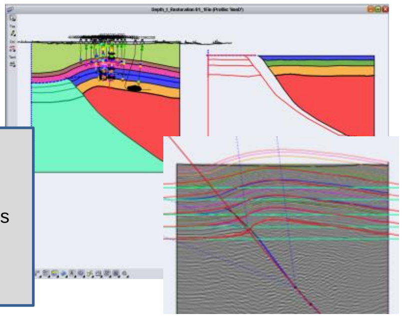
Experts: Catalina Luneburg, Bob Ratliff

The second introductory module for LithoTect Software trains participants on the restoration and modeling tools. Restoration tools are based on kinematic models such as flexural slip, vertical/oblique shear, slip line or area balancing. Transform operations undeform individual fault blocks using independent or contiguous section restoration whereas fault slip restoration interactively allows to move the hangingwall to restore the fault. Fault prediction and forward modeling techniques are discussed as well as geometry fields which allow to visualize dip, curvature and strain distributions.

- LithoTect kinematic models
- Fault slip modeling
- Transform restoration: vertical/oblique shear and flexural slip
- Fault Prediction tool
- Forward Modeling techniques
- Geometry Fields: dip, curvature, strain
- Restoration methods: independent and contiguous restoration

Second Introductory LithoTect SoftwareTraining Module: Restoration and Modeling Tools

Depending on scope and participant experience this topic could extend over two modules



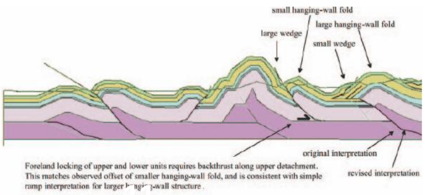
Software *Module StV_SM_2.11*

LithoTect Advanced Modeling: Compressional

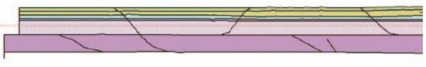
Advanced modeling techniques are used in real-world scenarios. This module focusses on advanced methodology of restorations in **compressional settings**.

Experts: Catalina Luneburg, Bob Ratliff

The restoration examples focus on foreland fold- and thrust belts where detachment levels, sequence of thrusting and the deformation history are analyzed and then modeled using restoration techniques such as interactive modeling (between deformed and undeformed state) and in particular fault-related folding styles such as fault bend faults, fault propagation faults and trishear.



Bosol et al. 2005



- Kinematic models in compressional settings
- Compressional restoration tools and methods
- Single-step and sequential restorations
- Interactive modeling, restoring and forward modeling at the same time
- Thrust belt examples

Software *Module StV_SM_2.12*

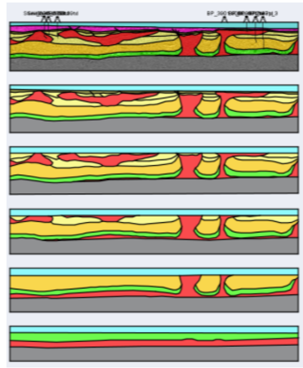
LithoTect Advanced Modeling: Extensional

Advanced modeling techniques are used in real-world scenarios. This module focusses on advanced methodology of restorations in **extensional settings**.

Examples of extensional structures in rift settings are used to illustrate backstripping workflows and the significance of timing decompaction/isostatc adjustment and restoration. Kinematic models such as vertical/oblique shear and flexural slip as well as rigid block models are used in restoration and forward modeling workflows.

- Extensional restoration tools and methods
- Kinematic models in extensional settings
- Extensional restoration tools and methods
- Single-step, sequential, backstripping workflows
- Decompaction, isotatic adjustment (airy, flexural), subsidence adjustment

Experts: Catalina Luneburg, Bob Ratliff



Basic *Module Map_BM_3.1*

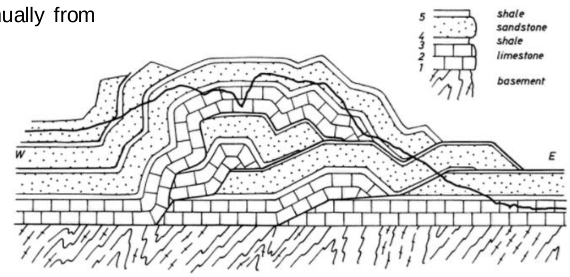
Cross-section Construction

Cross-sections are key to understanding the 3D structure of a geologic area.

This module teaches how to create a cross section from map and other data, starting with choosing an appropriate line of section, then constructing lines and contacts manually from dip domains and other data, and projecting data onto the section.

- Cross section construction
- Line of section, vertical and horizontal exaggeration
- Construct topography
- True and apparent dip, true and apparent thickness
- Manual construction, dip interpolation, dip domain mapping
- Arc, kink and other methods, dip domains
- Data projection, data interpolation
- Dip sequence analysis (SCAT)
- Balancing Criteria

Experts: Catalina Luneburg, Jim Granath



0 1 km *Ramsay and Huber, 1987*

Basic *Module Map_BM_3.2*

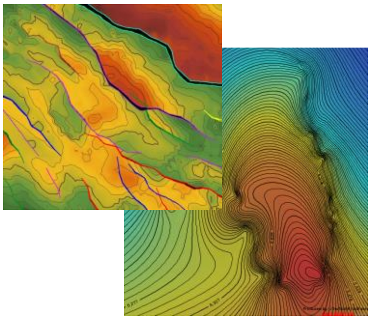
Subsurface Mapping Techniques

Valid and accurate maps of the subsurface are most critical in petroleum exploration and production whether for the construction of a 3D framework model and definition of the trap architecture or for drilling wells, calculating HC reserves, and characterizing and modeling reservoirs.

This module introduces concepts and techniques for creating different types of maps from 2D/3D seismic and well data. Structure maps and contouring techniques as well as isopach and attribute maps are illustrated with hands-on exercises of various tectonic scenarios. 3D seismic (attributes) and well (log) data are interpreted and interpolated based on valid geological assumptions and considering the variation in scale.

- Create structure maps using different contouring styles and techniques for well and seismic data (manual, computer)
- Create thickness maps and measure thicknesses: isopach and isochore maps of planar and folded beds
- Input data: 3D seismic, well data, log correlations, well tie workflows

Experts: Catalina Luneburg. Jim Granath, TBD

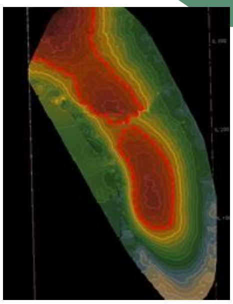


Basic *Module Map_BM_3.3*

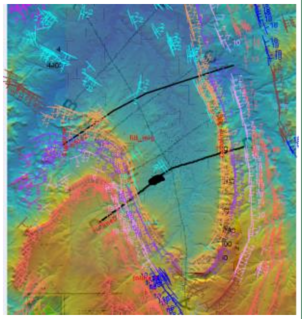
Geologic Structures in Maps

This module builds on the Subsurface Mapping Techniques and focusses on examples and exercises from different geological scenarios.
How are faults and linked faults expressed on maps, how do we recognize folded structures and salt-related geometries. Dip domains and orientation data are used with other predictive tools to analyze map structures.

- Structural Geometries in maps
- Recognize and analyze fold geometries by morphology, dip domains, and orientation data
- Recognize and analyze fault geometries as discontinuities, growth faults, linked faults
- Identify salt geometries of authochthonous and allochthonous salt
- Predict and analyze fluid contacts by subsurface pressure, Allan maps and fault seal techniques



Experts: Catalina Luneburg. Jim Granath, TBD

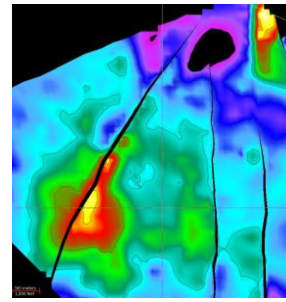


Basic *Module Map_BM_3.4*

Map QC Methods

Quality of all different types of maps is essential for related HC workflows. This module revises techniques of quality control and geologic validation from the input data to the map construction methods to the interpretation of geologic structures. Exercises and examples are used to illustrate pitfalls and challenging scenarios.

Experts: Jim Granath, Catalina Luneburg

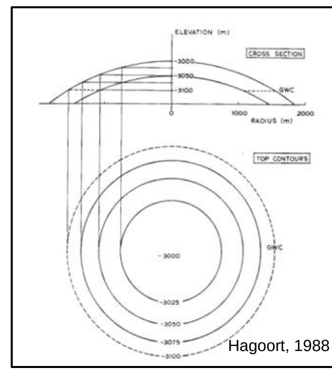


- Quality Control and validation
- Apply geometric and geological compatibility concepts
- Validate structural geometries
- Analyze seismic attributes and QC tools
- Learn about pitfalls and challenges with hands-on examples
- Examples include: fault intersections, fault terminations, salt-overhangs, contouring artefacts etc.

Advanced *Module Map_AM_3.5*

Map-based Volumetrics

Estimating HC reserves accurately is critical for decisions production of a field. Volumetric calculations include gross rock volume (GRV) factors such as net-to-gross ratio, porosity, water saturation and formation volume factor. Original oil in place (OOIP) and original gas in place (OGIP) refer to the total volume of hydrocarbon stored in a reservoir prior to production. Reserves or recoverable reserves are the volume of hydrocarbons that can be profitably extracted from a reservoir using existing technology.



Hagoort, 1988

- HC reserve estimates
- 2D and 3D methods of HC volumetric estimates and uncertainty
- Calculating GRV, OOIP, STOOIP and RHCR
- Depth conversion and other uncertainties
- Deterministic vs stochastic calculations

Experts: Catalina Luneburg, Jim Granath

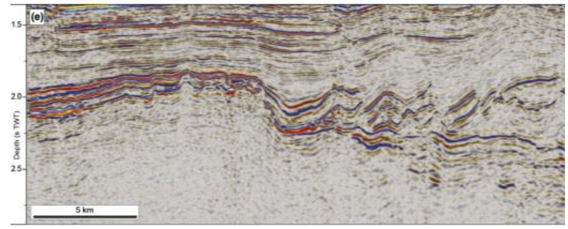
Basic *Module Tec_BM_1.1*

Structural Styles and HC Settings

Experts: Catalina Luneburg, Jim Granath, Bob Ratliff, Steven Boyer

Quality and confidence of seismic interpretation and trap architecture improves significantly with analysis of structural style and related geometrical features. This module focusses on the expression of structures in modern seismic and the geometric assemblages related to different tectonic scenarios. More than on the mechanical concepts and driving forces emphasis is on the resulting structural features and structural HC traps. The following tectonic and HC scenarios are studied: This module is an overview of extensional and compressional examples.

- Thin-skinned and thick-skinned extension
- Extensional fault geometries, linkages, ramps etc, Growth fault structures and growth stratigraphy
- Compressional tectonics
- Salt tectonics with authochthonous and allochthonous structures, salt sheets, canopies, mini-basins, rafts etc
- Strike-slip tectonics
- Inversion tectonics



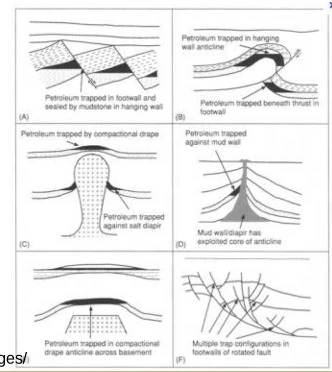
Basic *Module Tec_BM_1.2*

Hydrocarbon Traps

Experts: Catalina Luneburg, Jim Granath, Bob Ratliff, Steven Boyer

This module discusses structural traps in various tectonic settings such as hanging wall rollover structures, tilted blocks, fault traps etc as well as the critical trap components and factors controlling porosity, permeability etc.

- HC traps in different tectonic scenarios worldwide
- Components of a trap
- Primary and secondary traps
- Structural traps: roll-over anticlines, tilted blocks. Fault traps, diapiric traps, gravitation and compactional structures
- Factors controlling porosity and permeability: deformation mechanisms, fault conduits, fault porosity
- Faults and fluid migration, sealing vs non-sealing
- Fractured reservoirs



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Basic *Module Tec_BM_2.1*

Thin-skinned Extensional Tectonics

Experts: Jim Granath, John Karlo, Catalina Luneburg

The familiar ‘growth fault’ is the epitome of thin-skinned extension: a listric normal fault creates accommodation space for sedimentation in its hanging wall in a passive margin setting. The geometrically necessary roll over creates an ideal hydrocarbon trap. Often coupled with salt tectonics, this is the fundamental structural element of passive continental margins where subsidence and especially strong sedimentation sets up many of the world-class hydrocarbon provinces in the marine environment. It is the characteristic structural style of deltas, for example. But this style is not limited to such tectonic settings. It is often the near-surface structure of volcanic and block uplift mountain belts, of oceanic islands, and fold and thrust belts. This module examines the fundamental dynamics of extensional detachment within sedimentary sections, the controls exerted by stratigraphic architecture, and the role of fluids in the evolution of the systems.

- Environments prone to thin-skinned extension: from deltas and passive margins to volcanic provinces, oceanic islands, and massive slope failure in mountain chains
- Mechanical stratigraphy and its role in detachment tectonics
- Fluids and the role of effective normal stress in controlling listric faulting
- Fundamental geometric elements of thin-skinned faulting and syntectonic sedimentation
- Review of salt tectonics and the Interdependence of salt and thin-skinned extension
- Trapping styles in thin-skinned environments
- Restoration algorithms and schemes for extensional tectonics
- Interpretation exercises, cross section and restoration techniques
- Virtual field trip to see effects of growth faulting on urban life in Houston, TX

Basic *Module Tec_BM_2.2*

Structure of Continental Rifts

Experts: Jim Granath, John Karlo, Catalina Luneburg

Continental extensional terranes or “rifts” are some of the most hydrocarbon productive provinces in the world. For example, Paul Mann and his coauthors of a paper in the Giant Oil and Gas Fields AAPG Memoir for the 1990’s found that 66% of giant oil and gas fields occur in passive margins or continental rifts. This module covers the basics of extensional deformation, i.e. normal faulting, and the character of the rift structural style in modest amounts of extension. High degrees of extension and the evolution into continental extensional margins form a separate module entitled “Rifting to passive margin development.”

- Stress during normal faulting and tectonic conditions conducive to normal faulting
- Anatomy of normal faults and normal fault systems
- Kinematic development of normal faults and their linkages
- Graben, half graben, and domino structural styles and their interrelationships across scales
- Implications of fault linkage to sedimentation, topography, and petroleum systems
- Relationship of rifting to thermal history and to magmatism and volcanism
- Typical traps in 2- and 3-D, typical evolution of a petroleum province’s exploration history
- Case studies: North Sea, SE Asia, Gulf of Suez, East Africa, Rio Grande, Grand Teton
- Interpretation exercises, cross section and mapping techniques, restoration approaches

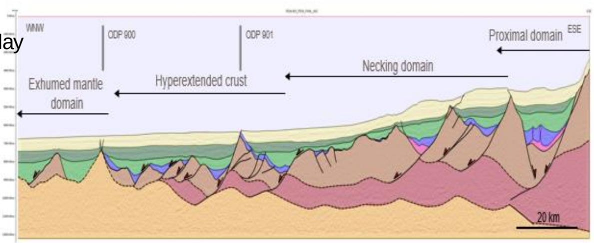
Basic *Module Tec_BM_2.3*

Tectonics of Passive Margins

Experts: John Karlo, Jim Granath

Understanding a play or prospect should begin from the bottoms up. For offshore exploration this often means understanding the evolution of the continental margin and where in that evolutionary scheme one's exploration focus is located. This module takes a very a very pragmatic data driven approach to identifying the various domains of passive margins and relating those domains to fundamental geologic factors that impact exploration.

- Mantle Exhumation Model
  - The Iberia – Newfoundland Transect
  - Exposures of the Tethyan Margin in the Alps
- Expressions of the Exhumation Model in other basins
  - South Atlantic
  - Gulf of Mexico
- Passive Margin Stratigraphy
  - Proximal Domain Rift Basins
  - The South Atlantic Subsalt Play
- Passive Margins and Salt Tectonics
- Magma Rich Margins
  - Uruguay-Namibia
  - Baltimore Canyon
- Transform Margins
  - East Africa
  - West Africa



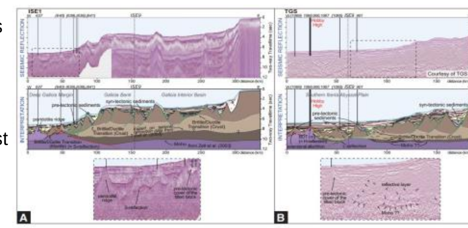
Advanced *Module Tec_AM_2.4*

Rifting to Passive Margin

Experts: Jim Granath, Catalina Luneburg

Basement-involved extension in the extreme forms the basis for the structural style of divergent plate margins, either entirely within the oceanic realm or in the cases where continental crust is involved as the stretched underpinning of continental passive margins. Much of the offshore industry is targeted at petroleum systems that are founded in such extended crust with a similarly extended overlying sedimentary prism and commonly another, separate overlying thin-skinned structural system. This situation is the subject of perhaps the most active research in structural styles at the present time. This module explores how the basement-involved extension evolves from simpler continental rifting to a fully tapered continental margin, essentially the transition of a continental margin from rift to drift

- A quick review of basics of extensional fault formation and linkage, if not covered in a preceding module
- Overprinting of fault systems and the process of hyperextension
- The history of thinking on the evolution of passive margins (McKenzie and Wernicke models and the origin of Basin Modeling) and the problems involved in these early approaches
- Volcanic and non-volcanic margins: their basic architecture
- Continental lithospheric architecture and current thinking on how it extends
- Petroleum systems of continental margins
- Some onshore analogs: Basin and Range of North America, SE Turkey
- Case examples: Gulf of Mexico, West Africa, Brazil
- Interpretation exercises



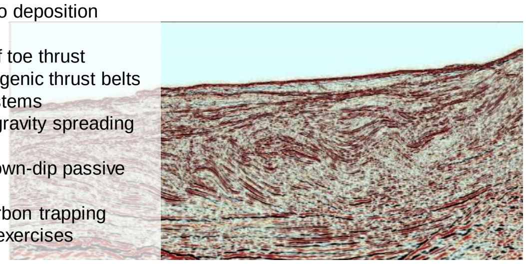
Advanced *Module Tec_AM_2.5*

Deepwater Compressional Systems

Experts: Jim Granath, John Karlo, Catalina Luneburg

This module is an advanced treatment of the thin-skinned extensional module to cover the structural geology of passive margin compressive environments, aka the 'toe thrust systems' developed at the base of slope in continental margins. It emphasizes those at the expense of the academically important accretionary prism systems for the simple reason that the latter are usually devoid of hydrocarbon potential. The one exception to that is the north coast of Borneo where deltaic input into the accretionary prism environment sets up a unique situation on the southern margin of the South China Sea. The geometry as expressed in seismic data and the kinematic reasons for toe thrust geometry are specifically considered. We examine primarily GOM, Brazilian, Malaysian, and West African examples

- Stress during normal faulting and tectonic conditions conducive to normal faulting
- The characteristics and dynamic controls on thin-skinned extensional systems (aka 'growth faults') and their down-dip compressional counterparts (aka 'toe thrust systems)
- Elements of the system in 3D: geometrical examples and relationship to deposition ('growth')
- Settings and occurrences of toe thrust systems: comparison of orogenic thrust belts and extensionally-linked systems
- Kinematics and dynamics: gravity spreading v gravity gliding
- involvement of salt in the down-dip passive margin system
- Case histories and hydrocarbon trapping
- Interpretation and analysis exercises



Advanced *Module Tec_AM_2.6*

Tectonics of Deltaic Margins

Experts: John Karlo, Jim Granath

The sediment load of major rivers causes its own gravity driven tectonics with up dip extensional and downdip contractional domains. This module takes the approach of examining the Niger Delta Basin as a type section of a deltaic margin but then compares and contrasts it with the Gulf of Mexico where the involvement of salt adds to the structural complexity.

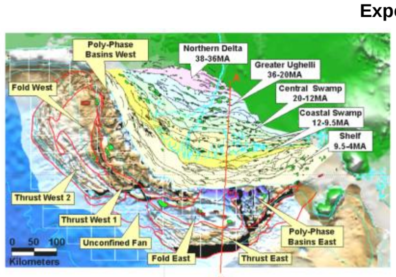
Paired extension and contraction

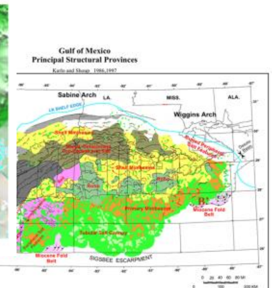
Niger Delta

- Extensional depobelts structure and stratigraphy
- Listric faulting
- Minibasin Province and the shale diapir myth
- Toe thrust structure and stratigraph

Gulf of Mexico

- Breakdown of structural provinces
- Texas shelf detachment tectonics
- Salt involved tectonics of the Louisiana shelf
- Deepwater salt tectonics



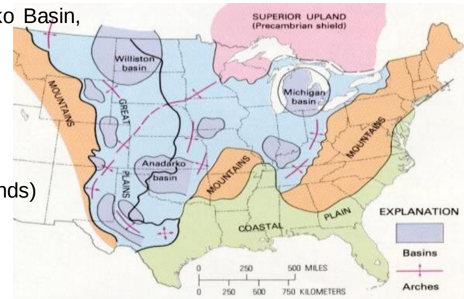


Basic *Module Tec_BM_2.7*

Structure of intra-cratonic & foreland basins

Experts: Jim Granath, Catalina Luneburg

Long before they were the habitat for unconventional plays (e.g. the Permian, Barnett, Bakken, and Marcellus plays), intracratonic and foreland basins were the bread and butter of onshore oil and gas exploration. This module draws from examples in the North American midcontinent, North Slope of Alaska, and much of North Africa, but can be applied to interior of any continent. Major oil fields have long been productive in these environments, such as Prudhoe Bay or the field of the Anadarko Basin, from structures that are intrinsically related to the arches and domes typical of these low-dip environments as well as stratigraphic and combination traps.



- The architecture of continental lithosphere; isostacy and flexural of continental blocks
- Typical basins such as the Michigan, Bakken, Appalachian, North Slope, etc.
- Long-distance migration and its role in intracratonic h/c systems
- Trap types intrinsic to low-dip environments: arches, domes, stratigraphic traps (e.g. tar sands)
- Incidental traps related to karst, salt dissolution, weathered basement, etc.
- Elements of unconventional plays: examples from North America
- Exercises in interpretation and recognition of subtle structural plays

Basic *Module Tec_BM_2.8*

Basement-involved Compressional Uplift

Experts: Jim Granath, Catalina Luneburg

The largest complex of oil fields in the world occurs in association with foreland deformation within the Arabian plate: the Ghawar fields lie within the Arabian craton where steep basement-involved faults have been repeatedly reactivated by flexure of the Arabian crust. Elsewhere world-class petroleum provinces are developed in similar regions peripheral to orogenic belts, such as the North American Laramide. Although other major mountain belts fall in this category, such as the Caucasus or the Moroccan Atlas, this structural style is more widely distributed than is commonly realized, and plays a major role in intraplate deformation along with other allied structural patterns, even when it does not form spectacular mountain belts. The petroleum forming traps occur in folded sediments above basement blocks, so that the two keys to exploration here are understanding the shape, distribution, and motion of the basement blocks, being able to predict the effects on the cover sediments

- Rheological architecture of the continental crust;
- Importance of fault shape and steepness in defining block-uplift geometries.
- Basement deformation: rigid block v dispersed intra-basement slip
- Deformation of the cover sequence along block edges at a variety of scales
- Linkage to other structural styles: strike-slip, thrust, and normal faults in 3-dimensional blocks
- Intra-plate block fields; Hydrocarbon occurrences and trapping styles
- Case studies: Laramide of North America, Arabian Plate block fields, Permian Basin, Colorado Plateau
- Interpretation exercises and cross section construction, restoration.

Basic *Module Tec_BM_2.9*

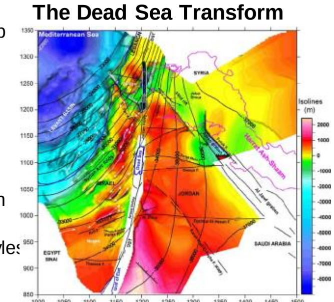
Strike-slip Tectonics

Experts: Jim Granath, Catalina Luneburg, Bob Ratliff

Strike-slip systems are usually epitomized by the great contemporary continental transform systems of the world, such as the San Andreas system (California), the Alpine system in (New Zealand), the El Pilar faults (South America), or the Great Anatolian fault (Turkey), but also play a pivotal role within orogenic belts (Great Glen, Iranian, & Sumatran faults), within continental block-faulted terranes (such as the Central African shear zone or Southern Oklahoma and the Ancestral Rocky Mountains), and other environments. Note that the San Andreas, the El Pilar, the Sumatran fault, Central Africa and Southern Oklahoma are all world class petroleum provinces. This module covers the kinematics of strike-slip environments across many scales of development as well as classic examples around the world.

- A natural history of strike-slip hydrocarbon-bearing provinces around the world
- The basic elements of the strike-slip strain environment: the simple shear strain model
- Fracture initiation and growth into finite structures; exercises with rupture maps in Iran and California.
- Development of basins in connections with strike-slip tectonics: the principles of restraining and releasing bends and overlaps.
- Evolution of pull-apart basins with examples in California, Dead Sea 'Rift'
- Evolution of restraining structures: example--the Mt. Denali area in Alaska
- Transform continental margins and their hydrocarbon resources
- Intra-continental strike-slip & relationship to other styles
- Case histories
- Interpretation exercises

The Dead Sea Transform



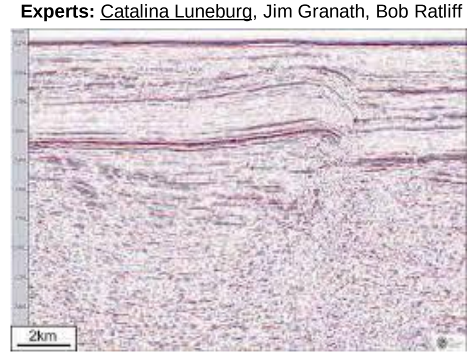
Basic *Module Tec_BM_2.10*

Inversion Tectonics

Experts: Catalina Luneburg, Jim Granath, Bob Ratliff

Inversion tectonics represents the compressional overprint of older extensional structures. The inversion of e.g. rift system leads to expanded sections often associated with world-class petroleum systems. This module analyzes the concept of inversion and resulting geometries.

- Concept of inversion
- "Null point" and inversion ratio
- Expanded growth section
- Kinematic models for inversion
- Quantitative kinematic model for a rotated block above listric fault
- Inversion in thin-skinned domains
- Seismic examples and exercises: North Sea profile, South Hewritt
- Classic examples worldwide e.g. Sunda Fold



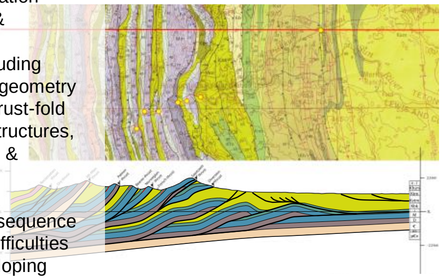
Basic *Module Tec_BM_2.11*

Geometry and Kinematics of Thrust-Belts

Experts: Steve Boyer, Jim Granath, Catalina Luneburg

Thrust belts have provided fruitful targets for hydrocarbon exploration for over 50 years. Successes in Alberta, Canada (1960s-1970s) led to improved knowledge of thrust belt geometry and kinematics and spurred exploration worldwide. This module covers exploration efforts, including 2D & 3D geometry of single folds and thrust systems e.g. fault duplexes. Attention is paid to the variation of structural style in strike direction, including vertical/inclined lateral ramps and their impact on trap geometry and integrity. Understanding thrust kinematics and sequence is essential to understanding hydrocarbon systems and predicting the distribution of potential traps within a thrust terrane. Analysis of fold and fault geometries relative to synorogenic sediments can help establish relative timing of thrust emplacement relative to HC generation and entrapment. Unfortunately, in many thrust belts the synorogenic record may not be preserved, so the course illustrates geometric techniques that can be applied to unravel thrust sequence.

- Characteristics of typical thrust belts
- Geometry of thrust-related folds
- Typical structures within a single thrust sheet
- Duplexes, triangle zones & other thrust systems
- Mechanical stratigraphy & its impact on deformation mechanisms, geometry of thrust-related structures & sequence of deformation
- Problems of cross-section construction & balancing in fold-&thrust belts
- 3D geometry of thrust-fold systems, including lateral thrust ramps and variation in fold geometry
- Deformational fabrics and fractures in thrust-fold belts, their timing, relationship to other structures, & impact on HC generation, entrapment & reservoir quality
- Overview of the mechanics of thrust-belt development and implications for thrust sequence
- Geometry of typical thrust-belt traps & difficulties often encountered in exploring and developing



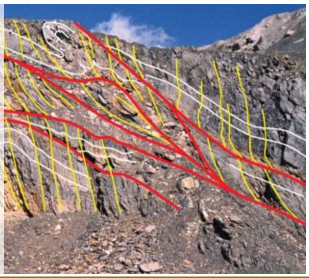
Basic *Module Tec_BM_2.12*

Thrust-belts Architecture & Evolution:Implications for Hydrocarbon systems

Experts: Steve Boyer, Jim Granath, Catalina Luneburg

Outcrop observations and complexities encountered in the development of oil and gas fields reveal that thrust-belt structures are far more complex than what is imaged on reflection seismic data, including the most modern 3D data. This complexity is due to the protracted deformation that occurs over tens of millions of years and involves numerous deformational mechanisms at all scales. Often ignored are the deformation mechanisms that are operating at the hand-specimen and outcrop scales, yet these mechanisms affect reservoir quality, the migration and entrapment of hydrocarbons, and have implications for the viability of cross-section balancing. Therefore, this course looks not only at the geometry and kinematics of structures at the oil-field or reflection seismic scale; it delves in great detail into the sequence of deformation at the hand-specimen and outcrop scale and relates structures at that scale to the geometry and kinematics of structures at the oil-field scale. We examine the implications for the development of hydrocarbon systems in foreland basins.

- Sequence of deformation at all scales
- Thrust mechanics & its role on deformation seq,
- Role of deformation sequence on hydrocarbon generation, migration & entrapment
- Interactions between pressure-solution & fracturing during the evolution of thrust-belt structures, with discussion of implications for fluid flow & hydrocarbon migration
- Distribution of traps within thrust belts & associated foreland basins
- Role of thrust belts in generating distal foreland hydrocarbon traps & tar-sand deposits
- Interaction between thin-skinned thrust deformation & previous &/or subsequent basement-involved contractional deformation &/or thin-skinned extension
- Implications of deformation sequence on the construction & balancing of cross sections in thrust belts & related transpressional terranes



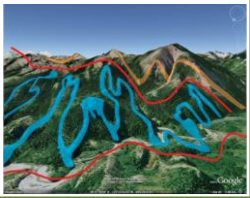
Advanced *Module Tec_AM_2.13*

Rethinking Thrust Propagation & Thrust Systems

Experts: Steve Boyer

Thrust belts have provided fruitful targets for HC exploration for over 50 years. Successes in Alberta, Canada, in the 1960s and 1970s led to an improved knowledge of thrust belt geometry and kinematics and spurred exploration.This module covers the lessons learned from these exploration efforts, including the 2D & 3D geometry of single folds and thrust systems such as fault duplexes. Special attention is paid to the variation of structural style in strike direction, including vertical/inclined lateral ramps and impact on trap geometry and integrity. Understanding thrust kinematics and sequence is essential to HC systems and predicting distribution of potential traps. Analysis of fold and fault geometries relative to synorogenic sediments helps establish relative timing of thrust emplacement relative to HC generation and entrapment. Unfortunately, in many thrust belts the synorogenic record may not be preserved, so the module illustrates geometric techniques that can be applied to unravel thrust sequence

- Review of established examples of fold-&-thrust belt structures (the classics)
- Current knowledge regarding the mechanics & kinematics of structures in thrust belts
- Examination of critical exposures of fold-fault structures that do not fit classical models
- New models to explain diversity of thrust-belt structures
- New models of thrust propagation, especially in carbonate sequences
- New models for duplex zones, including fold, cleavage, flowage & hybrid duplexes
- New approaches to thrust-belt exploration based on revised models of thrust propagation



Basic *Module Sal_BM_3.1*

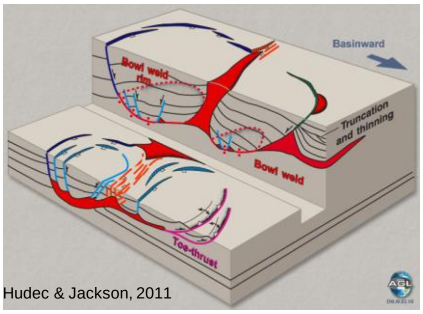
Introduction to Salt Tectonics

Experts: Jim Granath, Catalina Luneburg,TBD

Salt is a unique geological material in several ways, and plays a critical role in many hydrocarbon provinces, from altering the heat field to providing perfect sealing material, creating unique traps, and governing sedimentation patterns. On the negative side, salt presents unique seismic imaging problems.

This module provides an overview of salt tectonics in the petroleum setting; it can be integrated with broader treatments of structural styles, or serve as an introductory chapter in a more thorough discussion of salt.

- Importance of salt in hydrocarbon provinces
- Salt as a rock: why does it behave so differently from other geological materials?
- Brief review of salt depositional systems
- Involvement of salt in deformational systems: as a detachment surface
- Halokinesis and salt structures: roller-diapir-pedestal-canopy; welds and withdrawal geometries
- Autochthonous and allochthonous salt systems
- Salt in relation to sedimentation and fault systems; passive margins, deltas
- Interpretation and restoration in salt systems



Hudec & Jackson, 2011

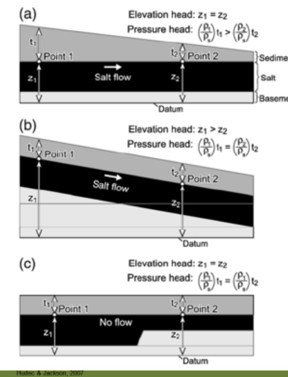
Basic *Module Sal_BM_3.2*

Salt Properties and Salt Mechanics

Salt tectonics is controlled by salts unique physical properties and deformation behavior. This module teaches the physical properties' of salt with respect to other sediments and its response to deformation due to its low yield strength and viscous behavior. The mechanics of salt flow is discussed in the context of the driving forces, gravitation and displacement.

- Depositional models of salt
- Origin of evaporate basins
- Salt physical properties: density, mobility, thermal conductivity, velocity
- Salt deformation and strength
- Salt as a seal
- Salt flow and mechanics
- Historical and modern interpretations
- Driving forces of salt flow, gravitational and displacement loading, hydraulic head

Experts: Catalina Luneburg, Jim Granath



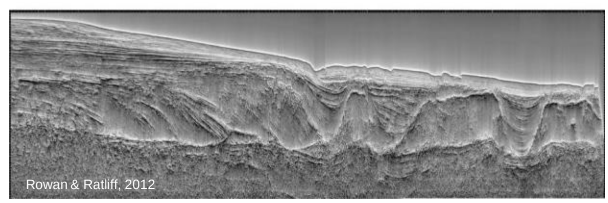
Basic *Module Sal_BM_3.3*

Salt in Tectonic Settings

Experts: Jim Granath, Catalina Luneburg

Salt plays a role in the structure of many different tectonic settings, including those that are solely governed by the motion of the salt itself. A large part of its role stems from its unique geological properties as an extremely weak, highly heat conductive ionic solid. In this module we review salt's uniqueness and discuss examples of salt behavior in a number of tectonic settings.

- Salt as a unique material: strength considerations and a review of its physical properties
- Salt as a stratigraphic element in basins
- Salt in compressional settings: weakness and role as the perfect detachment surface
- Salt in thin-skinned fold and thrust belts
- Salt in extensional settings
- Thin-skinned extension and its intimate linkage to salt on passive margins



Rowan & Ratliff, 2012

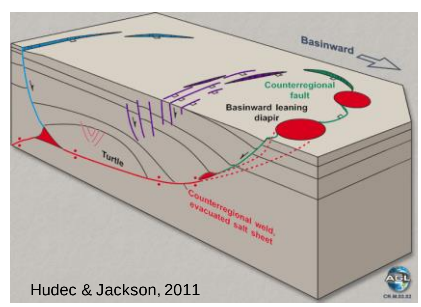
Advanced *Module Sal_AM_3.4*

Salt-related Fault Linkages

The motion of salt is intimately linked to the kinematics of fault systems in many hydrocarbon provinces around the world, especially in passive margin environments. A realization of what to expect in salt-dominated environments is critical to success in interpretation programs. These systems can feature extensional, contractional, and strike-slip elements working in tandem. In addition, the added dimension that salt can and often does entirely withdraw from the structure can challenge interpretation.

Experts: Jim Granath, Catalina Luneburg, TBD

- Authochthonous salt and its role growth fault systems
- Fault systems related to salt motion: symmetric and asymmetric, growth-fault relationships, rollover faults, regional and stepped counter-regional fault arrays, 'Roho' systems
- Allochthonous salt systems: salt-stock and canopy connections, salt nappes
- Welds as structural elements: primary, secondary, and tertiary welds
- Salt as a detachment in extensional and contractional systems



Hudec & Jackson, 2011

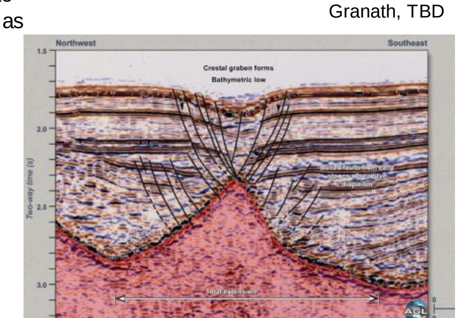
Advanced *Module Sal_AM_3.5*

Autochthonous Salt Structures

Autochthonous salt is in salt place still linked to its original depositional layer. Due to its properties salt will become mobile and start to flow forming salt domes, - stocks and - walls form by the process of diapirism. The different stages of the diaper life cycle are discussed from reactive to active and passive stages. In addition, salt detachments and salt rollers are discussed as well as turtle structures and salt-cored anticlines.

Experts: Catalina Luneburg, Jim Granath, TBD

- Diapirs and diapirism in extension
- Geometries of salt stocks, salt walls
- Life cycle of a diaper, styles of diapir growth
- Reactive stage, active stage and passive stage
- Salt diaper piercement and overburden
- Diapir shape and evolutionary stage
- Detachment faults and salt rollers, Turtle structures
- Near diaper deformation, flaps and mega flaps
- Diapirs in regional shortening: salt anticlines



Hudec & Jackson, 2011

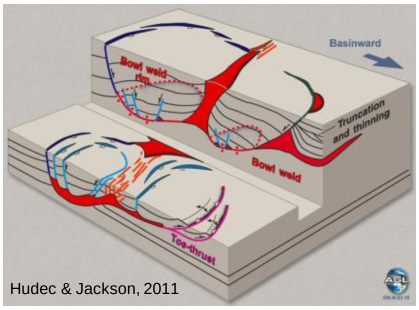
Advanced *Module Sal_AM_3.6*

Allochthonous Salt Structures

Experts: Catalina Luneburg, Jim Granath, TBD

Allochthonous salt is detached from its depositional horizon, emplaced at the surface where it has spread laterally to form a 'canopy' that is in turn overstepped by subsequent sedimentation.
This module discusses the formation of salt sheets and various models of advancement, as well as salt canopies, stepped counter regional systems, salt nappes and mini basins, and salt welds.

- Salt sheet emplacement and advancement models
- Extrusive advance, open-toed advance, thrust advance, salt-wing intrusion
- Plug-fed extrusion and plug-fed thrusts and source-fed thrusts
- Salt canopies, stepped counter-regional systems
- Salt-based detachment systems, Roho systems
- Salt nappes and salt mini basins
- Salt welds and salt weld timing,



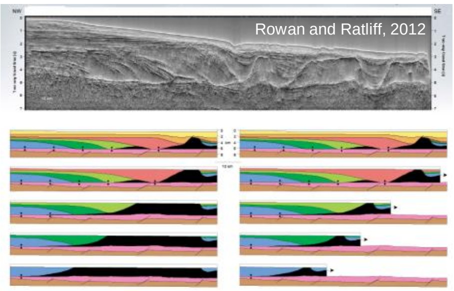
Software *Module Sal_SM_3.7*

Salt Restoration with LithoTect

Experts: Catalina Luneburg, Bob Ratliff, TBD

Salt's unique properties poses challenges to structural restorations as e.g. the fundamental assumptions of plane strain and area conservation are not valid. Sub - and supra salt domains are restored independently and decompaction and isostacy are key factors of backstripping restoration workflows. Examples of salt evacuation, expulsion rollovers, complex mini basins and other allochthonous salt structures are used to introduce salt-specific restoration techniques.

- Salt properties and flow mechanics
- Extensional restorations
- Decompaction and isostacy
- Restoration methodology and backstripping workflow
- Salt evacuation versus expulsion
- Restoration of diapir width
- Passive diapir restoration
- Mini basins and timing of salt evacuation



Basic *Module Seis_BM_1.3*

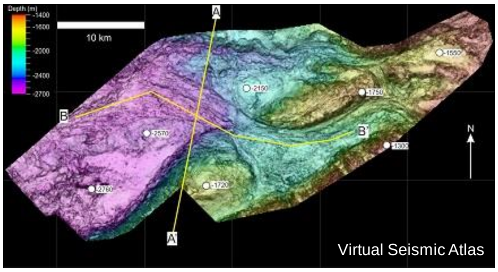
Seismic data QC for land acquisitions

…understanding acquisition and processing pitfalls and how to deal with them.

Experts: Tanya Inks, TBD

The interpretation of seismic data is much more than just drawing lines on wiggles! To truly interpret data and have results that are meaningful, and more importantly trust-worthy, the data quality must be scrutinized. Understanding "error bars" on seismic interpretation products depend on reviewing acquisition and processing to determine potential pitfalls in the data that could affect your confidence in the seismic interpretation.

- 3D design variations
- Skips, offsets and data holes (no permit areas) – how these affect your data
- Surface conditions including surface geology, weather and wind
- Statics
- Asking for the right QC tools in acquisition and processing
- Processing 101 – where can they go wrong?
- So, your data has problems, what can you do?
- How do you communicate data quality to others?



Advanced *Module Seis_AM_1.3*

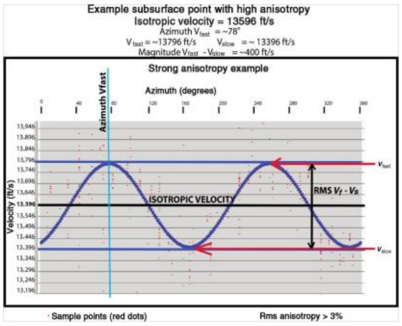
Using P-wave velocity anisotropy to identify stress and fracturing

Integration with x-dipole sonics, outcrop, bore hole breakouts and other rock data

Experts: Tanya Inks, TBD

Wide azimuth land 3D surveys are candidates for azimuthal processing that allows interpreters to look at velocity anisotropy, a tool for better understanding fracturing and mechanical behaviors in potential or existing oil and gas reservoirs. Seismic data are sensitive to variations in fracturing at the scale of individual pads or even individual wells. Integration with well data, outcrop data, subsurface information, as well as public data, are important to show possible variations in the stress field or fracture induced anisotropies that can have a significant effect on production.

- Processing for velocity anisotropy – requirements for data that is acquired
- The attributes that are calculated in P-wave velocity anisotropy processing
- Define velocity anisotropy and discuss the possible geologic implications of velocity anisotropy.
- Discuss the importance of reviewing other data that shows the behavior of fracturing as well as regional stresses in an area of interest.
- Using X-dipole sonic data to look at stress variations in the borehole
- Marcellus case study looking at Marcellus fracturing and the implications relative to production.
- Other geologic settings that may benefit from the analysis of P-wave velocity anisotropy.
- How to find more information about velocity anisotropy.



Advanced *Module Seis_AM_1.4*

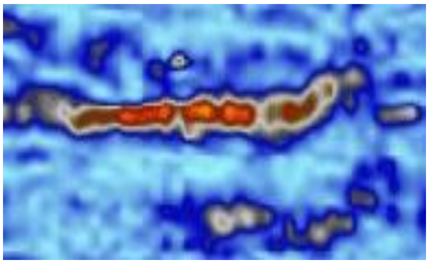
Principles of AVO Analysis

Experts: TBD

Having an understanding of what an AVO response on seismic data looks like is critical to picking a proposed location. This module provides an understanding of the role of seismic petrophysics using amplitude variations with offset. Understanding basic rock physics and the behavior of the propagating seismic waves is a significant part of the course, related to adv advanced seismic interpretation, rock and fluid characterization, including hydrocarbon identification and quantification

This module is intended to provide an understanding of the current state of the technology. Topics are reinforced by exercises that gives the participants practical methods of integrating the course material into their work. A personal computer is necessary for this module

- Understand the principles of seismic wave propagation and the attributes of seismic measurements utilized in AVO interpretation .
- Learn the pros and cons of various interpretation methods.
- Learn how to integrate well data into AVO analysis

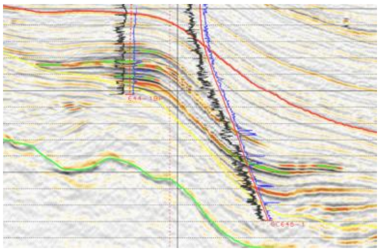


Advanced *Module Seis_AM_1.5*

Seismic Stratigraphy of Turbidites

Reconnaissance, regional correlation and mapping is mostly done in cross section view, even if the data is a 3D cube. Thus, a necessary starting point for deepwater exploration is understanding of the seismic expression of the primary turbidite depositional facies and their likely reservoir distribution as is seen in cross section view. This module teaches the seismic recognition and characterization of the geologic facies in both ponded and unconfined settings.

- Turbidite channel architecture
- The toe of slope myth
- Seismic characterization of unconfined turbidites
- Structural zonation of reservoir facies in deepwater toe thrust belts
- Case studies
- Turbidite facies and ponding in intra-slope basins
- Syntectonic onlap traps
- Work process for turbidite strat traps
- Case studies
- Predictive trends for reservoir n/g in single loop and loopset turbidites



Experts: John Karlo, TBD

Basic — *Module Sed_BM_1.1*

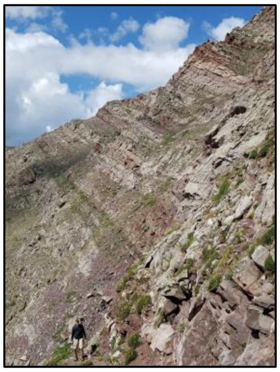
Sequence Stratigraphy in E&P

This module introduces basic concepts of stratigraphy by first reviewing process sedimentology and the resultant deposits (facies). We then explore coeval depositional systems and how they relate spatially and temporally. The cyclicity inherent in the stratigraphic record is demonstrated and its utility explored.
This modules is the basic introduction to the advanced version.

First Introductory module on Sequence Stratigraphy

- Review of basic stratigraphic concepts ("Cyclicity in 4 Dimensions"); Walther's Law; base level.
- Review of depositional systems (it's all about the gradient!) and facies
- Stratigraphic validation (physics governs processes)
- Cycle recognition / facies successions within and across depositional systems
- Carbonates differ from siliciclastics; physical vs biological processes of deposition

Experts: Katie Joe McDonough. Ursula Hammes, TBD



Advanced — *Module Sed_AM_1.2*

Advanced Sequence Stratigraphy in E&P

Correlation techniques and sequence stratigraphic methods are demonstrated in a variety of basins. Methods include cycle recognition across depositional systems, stacking patterns in various geomorphic positions, Wheeler (chronostratigraphic) diagrams, and combining different scales represented by different data collection (seismic, outcrop, core, log). Hands-on exercises demonstrate how sequence stratigraphic interpretation techniques improve the quality of stratigraphic interpretations.

This module builds on the basic introduction module.

OPTIONS
- Examples from NPRA, Bahamas, Book Cliffs, Delaware Basin, Gulfe du Lyon, Mallorca
- Focus on Exploration or Production scale

- The concept of chronostratigraphy; Wheeler diagrams
- Cycles, parasequences, systems tracts, sequences, mega-sequences
- Correlation scenarios and examples

Second, advanced module on Sequence Stratigraphy

Experts: Katie Joe McDonough. TBD

Basic — *Module Sed_BM_1.3*

Stratigraphy in the Seismic Record

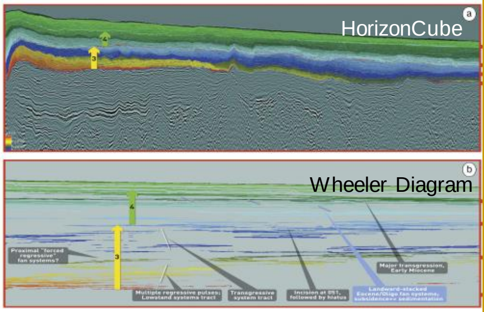
This module reviews basic concepts of process sedimentology, how depositional systems change through time (stratigraphy), and how stratigraphy is viewed in seismic data. The cyclicity inherent in the stratigraphic record is demonstrated and used to fully tie to seismic data.

This module is the basic introduction to the advanced version

- Review of depositional systems, facies and facies successions (cycles)
- Review of stratigraphic concepts ("Cyclicity in 4 Dimensions"); Walther's Law; base level.
- Recognition of multi-scale cyclicity and stratal geometry in seismic data
- Recognition of seismic facies related to depositional facies

First Introductory module on Stratigraphy in the Seismic Record

Experts: Katie Joe McDonough. Ursula Hammes, TBD



McDonough et al. (2013)

Advanced — *Module Sed_AM_1.4*

Advanced Stratigraphy in the Seismic Record

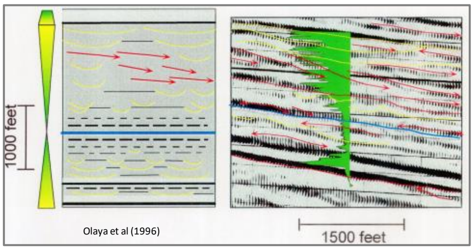
Correlation techniques and sequence stratigraphic interpretation methods are applied in a variety of basin types and settings. Cyclicity and stacking patterns in various geomorphic positions are recognized across depositional systems.
Chronostratigraphy aids combining different scales represented by different data collection (seismic, outcrop, core, log). Hands-on exercises demonstrate how sequence stratigraphic interpretation techniques improve the quality of seismic interpretations.
This module builds on the basic introduction module.

OPTIONS
- Examples from West Africa, NPRA, Bahamas, Book Cliffs, Delaware Basin, Gulfe du Lyon, Mallorca
- Focus on Exploration or Production scale

- Chronostratigraphy and hierarchy of cycles, parasequences, systems tracts, sequences, mega-sequences
- Petroleum systems in the seismic stratigraphic record

Second advanced module on Stratigraphy in the Seismic Record

Experts: Katie Joe McDonough. TBD



Basic *Module Cla_BM_2.1*

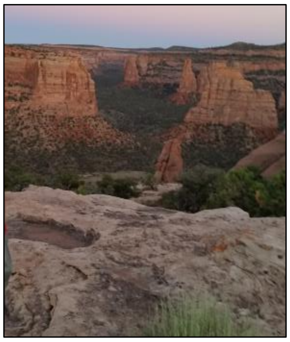
Siliciclastic Sedimentology and Stratigraphy

This module introduces basic concepts of process sedimentology in siliciclastics and associated facies and successions. We explore siliciclastic depositional systems and how they relate spatially and temporally. We emphasize cycle recognition in many depositional environments, and stacking patterns in various geomorphic positions. We demonstrate the different scales represented by variable data types (seismic, outcrop, core, log), and how to integrate them. Exercises demonstrate that a process sedimentology approach to interpretation leads to high quality stratigraphic interpretations.

OPTIONS
- Examples from Book Cliffs, CO Front Range, Walther's Law, Gulfe du Lyon
- Focus on Exploration or Production scale

- Siliciclastic physical processes—first principles—it's all about the gradient!
- Component grains, textures, classification, facies
- Cycle recognition / facies successions within and across depositional systems
- Cycle stacking patterns, unconformities, condensed sections
- Fluvial/alluvial, shoreface, deltaic, deep water environments
- Chronostratigraphy; Wheeler diagrams
- Cycles, parasequences, systems tracts, sequences, mega-sequences
- Correlation scenarios and examples

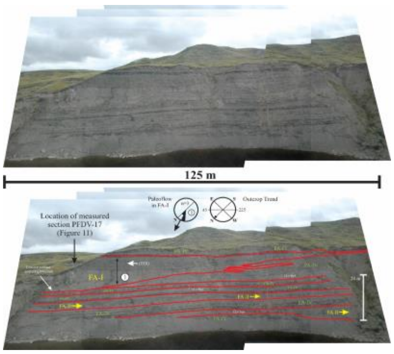
Experts: Katie Joe McDonough. Peter Flaig, TBD



Basic *Module Cla_BM_2.2*

Facies & Architectural Analysis of Fluvial-Deltaic Outcrops

Laterally extensive outcrop belts offer a fantastic opportunity to examine sub-seismic scale facies trends and the lateral-vertical distribution of reservoir and non-reservoir intervals. Coupling outcrop-based sedimentologic and ichnologic observations with the examination of high resolution imagery (e.g. GigaPan, Drone photogrammetry-video) provides unique insight into the identification of depositional systems, architectural element geometries, key surfaces, and barriers and baffles to flow in reservoir analogues. Exercises that employ high resolution imagery coupled with measured stratigraphy illustrate the advantages of this multifaceted technique to help quantify and predict facies trends and architectural element geometries



- Facies and architectural element identification
- Basic ichnology
- GigaPan image analysis
- Drone photogrammetry
- Depositional system interpretation

Experts: Peter Flaig. TBD

Basic *Module Cla_BM_2.3*

Fluvial Systems

We examine modern river geomorphologies and floodplain environments using satellite imagery and aerial photography. Ancient fluvial deposits of braided, meandering, straight-fixed, and mixed systems are examined in outcrop, core, and wireline logs. Channels and channel belts are compared. Typical floodplain environments and paleosols are investigated. Architectural elements and reservoir-non vs. reservoir intervals are discussed. Common fluvial facies, facies stacking, and stratal stacking in different fluvial systems are analyzed.

Experts: Peter Flaig. TBD

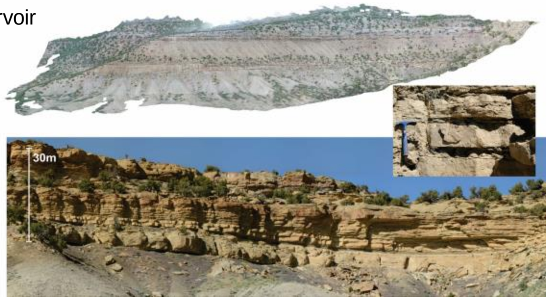
- Basic Paleopedology
- Internal architectures of fluvial systems
- Satellite and GigaPan image analysis
- Drone photogrammetry analysis

Basic *Module Cla_BM_2.4*

Deltaic Systems

We examine modern delta geomorphologies and deltaic sub-environments using satellite imagery and aerial photography. Ancient deltaic deposits containing fluvial-flood dominated, wave-modified, and tide-modified sedimentary structures and internal architectures are examined. Facies, architectural elements, and reservoir-non reservoir intervals are compared-contrasted between delta types and in mixed systems.

Experts: Peter Flaig. TBD



- Common deltaic facies
- Basic ichnology
- Internal architectures of deltas
- Satellite and GigaPan image analysis
- Drone photogrammetry analysis
- Basic sequence stratigraphy

Basic *Module Cla_BM_2.5*

Complex Coastal Systems

Experts: Peter Flaig, TBD

We examine environments that include, but are not limited to: estuaries, barrier islands, tidal inlets, lagoons, backbarriers, flood tidal deltas, bayhead deltas, washover fans, strand plains, swamps, tidal flats, and shorefaces. We use satellite imagery and aerial photography to identify classic modern examples of each of these environments. We discuss the geomorphology, geomorphic evolution, and preservation potential of each environment and examine examples of the resultant stratigraphy in ancient deposits. Typical facies, architectural element geometries, and stratal stacking are discussed.

- Basic stratal architecture analysis
- Basic ichnology
- Satellite and GigaPan image analysis
- Drone photogrammetry analysis
- Basic sequence stratigraphy

Advanced *Module Cla_AM_2.6*

Seismic Stratigraphy of Turbidites

Experts: John Karlo, TBD

Reconnaissance, regional correlation and mapping is mostly done in cross section view, even if the data is a 3D cube. Thus, a necessary starting point for deepwater exploration is understanding of the seismic expression of the primary turbidite depositional facies and their likely reservoir distribution as is seen in cross section view. This module teaches the seismic recognition and characterization of the geologic facies in both ponded and unconfined settings.

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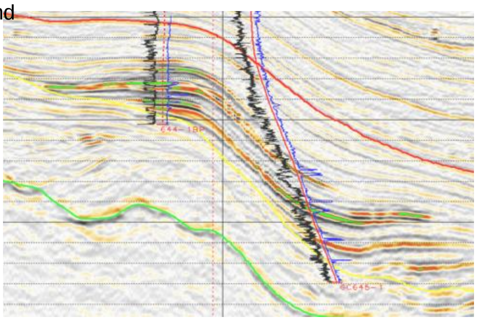


Basic *Module Car_BM_3.1*

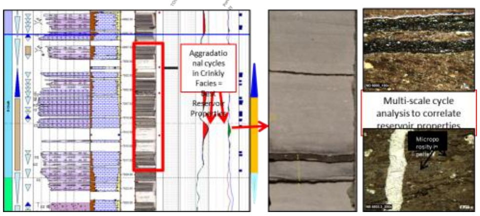
Carbonate Sedimentology and Stratigraphy

Experts: Katie-Joe Mc Donough, Ursula Hammes, TBD

This module introduces basic concepts of process sedimentology in carbonate environments and associated facies and successions. We explore carbonate depositional systems and how they relate spatially and temporally. We emphasize cycle recognition in disparate carbonate depositional environments, and stacking patterns in various geomorphic positions. We demonstrate the different scales represented by variable data types (seismic, outcrop, core, log), and how to integrate them. Exercises demonstrate that a process sedimentology approach to interpretation leads to high quality stratigraphic interpretations.

- Carbonate biogenic vs physical processes—first principles and environmental controls; carbonate factory
- Component grains, textures, classification (Dunham), facies
- Cycle recognition / facies successions within and across depositional systems
- Cycle stacking patterns, unconformities, condensed sections
- Platform, ramp, shelf, deep water (open marine) environments
- Chronostratigraphy; Wheeler diagrams
- Cycles, parasequences, systems tracts, sequences, mega-sequences
- Correlation scenarios and examples

OPTIONS
- Examples from Bahamas, Mallorca, Delaware Basin
- Focus on Exploration or Production scale



Deacon et al. (2013)

Basic *Module Car_BM_3.2*

Carbonate Reservoir Characterization

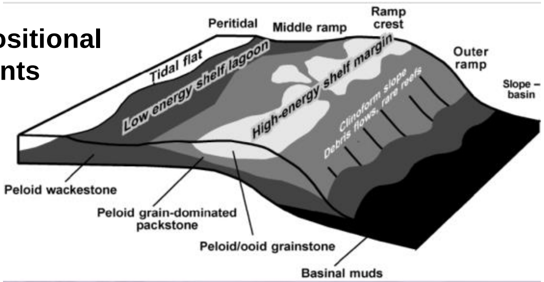
Experts: Ursula Hammes, Katie Joe McDonough, TBD

Carbonate reservoirs comprise >50% of the world's oil and gas reserves. Porosity and permeability is influenced by facies, fractures, and diagenesis. This course addresses basic concepts to characterize carbonate reservoir heterogeneities by addressing porosity, permeability, and variations and influence of facies. Pore classification schemes will be addressed and applied including petrophysical parameters.

Carbonate reservoirs
- Depositional environments
- Pore types
- Diagenesis

Characterization Techniques
- Modern and ancient carbonate depositional environment analogs
- Dunham facies classification
- Lucia pore classification
- Diagenesis

Carbonate Depositional Environments

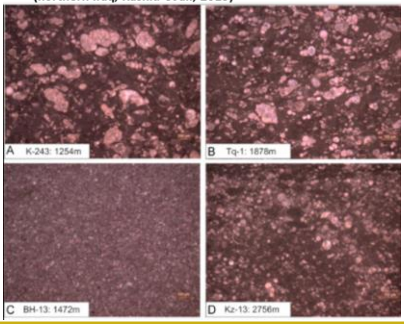


Basic *Module Car_BM_3.3*

Tight Carbonates

With advanced horizontal drilling techniques tight carbonates become a prolific target for exploration. The distribution of reservoir quality in tight carbonates depends primarily upon how diagenetic processes have modified the rock microstructure, leading to significant heterogeneity and anisotropy. The size and connectivity of the pore network may be enhanced by dissolution or reduced by cementation and compaction. This class will explore the controls on tight carbonates and how to address porosity and permeability concerns.

Thin-section photomicrograph examples of tight carbonates (northern Iraq, Rashid et al., 2015)



Tight Carbonate Reservoirs
- Depositional environments
- Pore types
- Diagenesis
- Permeability evolution

Characterization Techniques
- Thin-sections
- SEM analyses

Experts: Ursula Hammes, TBD

Advanced *Module Cla_AM_3.4*

Carbonate Diagenesis

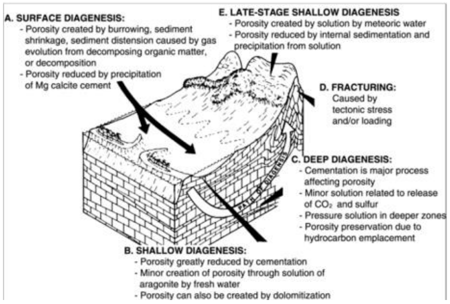
Experts: Ursula Hammes, TBD

Carbonate reservoir performance is heavily influenced by depositional and diagenetic processes. Depositional processes control the initial pore-size distribution and the geometry of the individual depositional facies. The diagenetic overprint modifies the pore-size distribution and controls the productivity of depositional facies. In some cases, reservoir quality and flow characteristics are totally controlled by diagenesis as in karsted reservoirs. This module will address techniques on how to determine the paragenetic sequence and characteristics of cements and dolomites.

Carbonate diagenetic environments
- Surface/shallow diagenesis
- Deep diagenesis
- Type of cements

Characterization Techniques
- Thin-section identification
- SEM techniques
- Paragenesis

Carbonate diagenetic environments (from Harris et al., 1985)



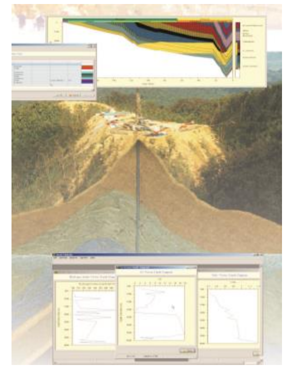
Basic *Module Bas_BM_1.1*

Introduction to Petroleum Geology

This module introduces basic concepts of petroleum geology and its applications in petroleum exploration and production. The elements of a petroleum system, reservoir rocks, source rocks and cap rocks and different trap formations with their physical and chemical specifications will be described. Different types of petroleum systems in conventional and unconventional resources will be introduced to students using samples of real plays
A short overview of exploration & production methods and steps will be provided to students including geophysics, geochemistry, and petrophysics. Hands-on exercises will help student to identify petroleum systems and map event chart from published papers.

- Introduction to petroleum geology
- Applications of petroleum geology in petroleum exploration and production
- Petroleum system elements and process
- Source rocks and petroleum geochemistry
- Reservoir rocks (porosity, permeability, fluid flow concepts)
- Cap rocks (capillary pressure and seal capacity)
- Trap formations
- Petroleum systems in conventional and unconventional
- Exploration and production workflow (geophysics, geochemistry, petrophysics)

Experts: Afshin Fahti, TBD



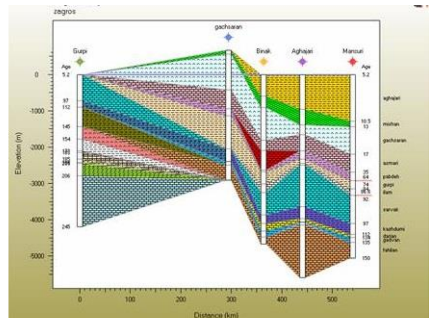
Basic *Module Bas_BM_1.2*

Introduction to Basin Modeling / Petroleum System Analysis

Experts: Afshin Fahti, TBD

This module introduces theory and basic concepts of basin modeling and petroleum system analysis in terms of understanding applications of basin modeling in real world projects.
The most important petroleum system elements and processes related to conventional and unconventional plays are explained using different examples of plays from well-known conventional and unconventional reservoirs in the world.
Steps of a basin analysis projects will be explained to students. Software applications in basin modeling will be introduced to student with their advantages to each other.

- Introduction to basin modeling
- Petroleum system (elements, process)
- Steps of a basin modeling process
- 1D, 2D and 3D basin modeling
- Back stripping and forward modeling
- Generation, migration and accumulation of hydrocarbons
- Inputs and outputs in basin modeling
- Basin modeling in conventional plays
- Basin modeling in unconventional plays
- Software programs in basin modeling
- Steps of a basin analysis project



Basic *Module Bas_BM_1.3*

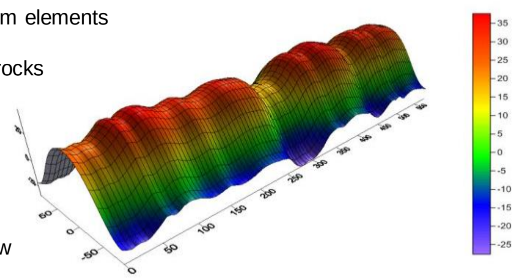
Fundamentals of Basin Analysis

Experts: Afshin Fahti, TBD

This module introduces mathematical concepts behind most important processes in basin analysis and their importance and effects in a model.

Source rocks, reservoir rocks, and seal rocks physical and chemical properties and their effects on basin models will be explained. Kinetic models of generation, fluid flow simulation and different migration methods will be introduced and compared to each other and accumulation simulation, seal capacity, back stripping and forward modeling, compaction and de-compaction concepts, heat flow simulation, sediment water interface heat flow concepts will be introduced to students

- An overview to basin modeling
- What is a numerical basin model
- Physical properties of petroleum system elements
- Petroleum system process
- Hydrocarbon generation from source rocks
- Expulsion and primary migration
- Secondary migration
- -Fluid flow simulation in basin scale
- Accumulation and seal capacity
- Compaction and de-compaction
- Heat flow simulation in basin scale
- SWIT, paleo temperature and heat flow



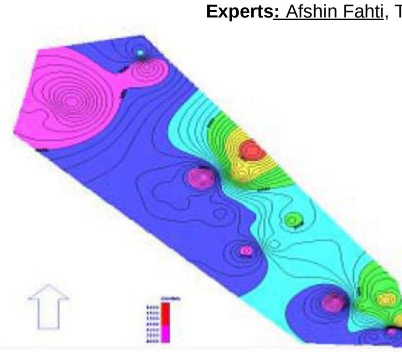
Basic *Module Bas_BM_1.4*

Introduction to Petroleum Exploration

Experts: Afshin Fahti, TBD

This module introduces basic concepts of petroleum exploration. It will explain the steps of an exploration study. The workflows for exploration conventional and unconventional resources will be explained to students. In here the basics and applications of Geophysics methods,, organic geochemistry, and source rock evaluation, basin modeling, sedimentary basins, petroleum system elements and their applications will be explain to students.

- Review of basic petroleum geology concepts
- Review of basic petroleum exploration
- Geophysical methods
- Seismic in petroleum exploration
- Organic geochemical methods
- Source rock evaluation and its applications
- Petroleum system concepts in conventional and unconventional plays
- Sedimentary analysis and petroleum exploration
- Steps and workflow of an exploration study



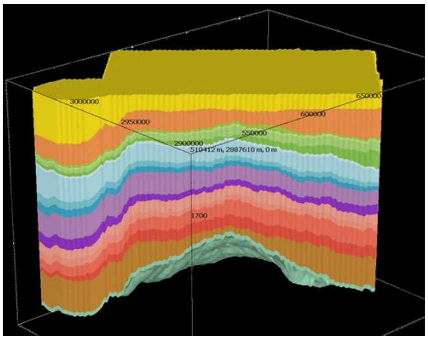
Advanced *Module Bas_AM_1.5*

Applied Basin Modeling

In this module students will learn about step by step basin modeling. They will learn how to build a basin model (1D,2D and 3D). This module will talk about input parameters in basin modeling, it will shows the calibration methods for a model and student will understand which simulation method should be used during modeling a basin. They will learn about the output parameters and meaning of each output parameter. They also will learn how to use organic geochemistry and source rock evaluating results in a basin model. At the end they will learn about sensitivity analysis methods and how to reduce risks in exploration.

- Review of basic basin modeling
- Review of petroleum system elements and process
- Review of organic geochemistry data used in basin modeling
- Input data for a 1D model
- Calibration of a 1D model
- Outputs of a 1D model
- Input data for a 2D model
- Calibration of a 2D model
- Outputs of a 2D model
- Input data for a 3D model
- Calibration of a 3D model
- Outputs of a 3D model
- Advantage and disadvantages of 1D, 2D and 3D
- Sensitivity analysis and risk assessment

Experts: Afshin Fahti, TBD



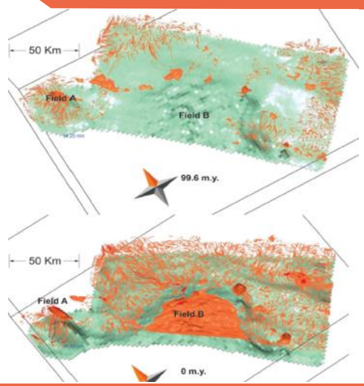
Advanced *Module Bas_AM_1.6*

Advanced Basin Modeling/ Petroleum System Analysis

Experts: Afshin Fahti, TBD

This module explain applications of basin analysis in different basins. It will describe examples of 1D, 2D and 3D basin models in conventional and unconventional resources. It will explain how to build those models, what is steps of the modeling procedure and students will learn how to interpret those models results with organic geochemistry and source rock evaluation results together to have a better understanding of those study areas.

- Review of basic basin analysis methods
- Conventional and unconventional resources
- Organic geochemistry and basin analysis
- An overview of 1D, 2D and 3D models
- Steps of an organic geochemistry project
- Steps of a basin analysis project
- Case study of a regional 1D basin modeling project
- Case study shows a 2D basin modeling project
- Case study shows a 3D basin modeling study
- Case study shows an unconventional basin modeling study
- Applications of basin modeling in reservoir scale models

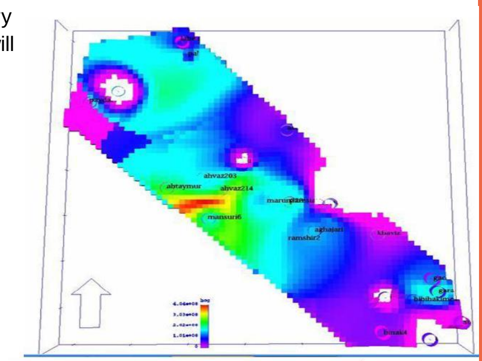


Advanced *Module Bas_AM_1.7*

Applications of Basin Modeling in Unconventionals

This module introduces basic concepts of unconventional resources geology, petroleum system elements in unconventional resources and their characteristics, organic geochemistry of unconventional resources, and source-reservoir rock evaluation methods. This module will explain the applications of basin analysis to evaluate unconventional resources and identify best drilling zones

- Review of basic unconventional resources concepts
- Review of basin modeling concepts
- Unconventional petroleum system elements
- Unconventional petroleum system processes
- Organic geochemistry of unconventional resources
- Comparing basin modeling methods in conventional and unconventional resource
- Unconventional basin modeling project steps
- Unconventional basin models inputs and outputs



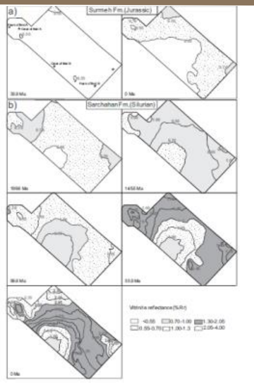
Experts: Afshin Fahti, TBD

Basic *Module GCh_BM_2.1*

Introduction to source rock evaluation / organic geochemistry

This module introduces basic concepts of source rock evaluation and organic geochemistry. It starts by providing theories on origin of organic matters in sediments and will present the hydrocarbon generation mechanisms, kerogen types and their differences, organic facies modeling methods and its applications, and will continued to introduce general laboratory methods used to evaluate source rocks and interpretation of results. A short view of GC and GC-MS methods and biomarker analysis

- Review of basic petroleum systems
- Review of basic petroleum geochemistry
- Origin of organic matters in source rocks
- Hydrocarbon generation
- Maturity indicators in source rocks
- Ro% measurement and interpretation
- GC-MS analysis and biomarkers
- Kerogen and kerogen types
- Organic facies modeling methods
- Leco and Rock-Eval anlysis
- Evaluate source rocks



Experts: Afshin Fahti, TBD

Advanced *Module GCh_AM_2.2*

Inorganic Geochemical Techniques

Inorganic geochemical techniques will teach the instrumentation used to generate inorganic data used to identify favorable frac intervals and compare to petrophysical logs (e.g., XRD, ICP, XRF instruments). Chemostratigraphic principles will be applied to identify potential frac intervals and relate to sequence stratigraphy.

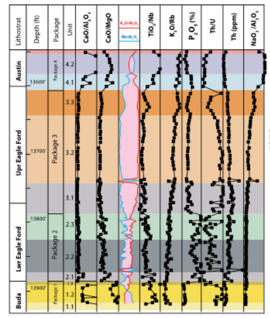
Experts: Ursula Hammes, TBD

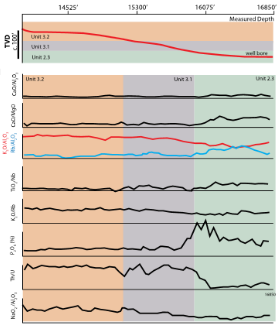
Inorganic Geochemical Techniques

- XRF
- XRD
- MCIP
- Elements important for identifying reducing conditions

Chemostratigraphy

- Paleogeography
- Clastic input
- Ocean chemistry
- Paleo climate
- Organic matter input flux and preservation





Advanced *Module GCh_AM_2.3*

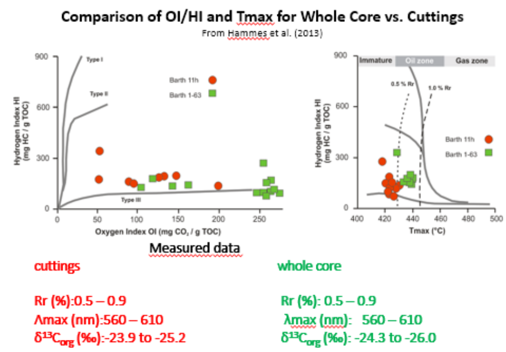
Organic Geochemical Techniques

Experts: Ursula Hammes, TBD

Overview of source rock evaluation: learn how to interpret organic-matter type and richness, maturity and interpretation of geochemical results incorporating TOC, rock-eval and biomarker data.

Organic Geochemical Tools

- TOC analyses
- Rockeval
- Biomarker
- Elements important for identifying reducing conditions

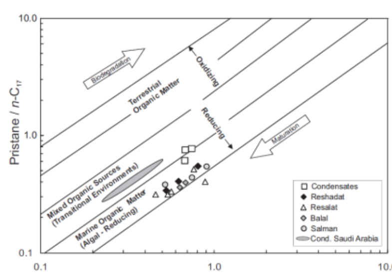


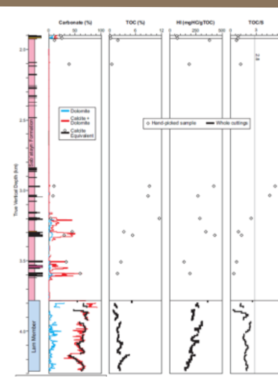
Advanced *Module GCh_AM_2.4*

Applied Organic Geochemistry in Petroleum Exploration

This module introduces applied source rock evaluation and organic geochemistry in exploration oil and gas. It will starts by providing interpretation methods to use results of source rock analysis and biomarkers. It will followed by providing interpretation samples and exercise from well-known source rocks.

- Review of basic organic geochemistry
- Review of basic sampling and analysis methods
- Leco analysis results interpretation
- Rock-Eval analysis results interpretation
- GC-MS analysis results graphs and interpretation
- Real world examples of applications of provided methods





Experts: Afshin Fahti, TBD

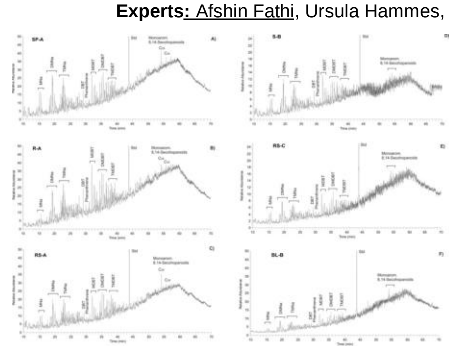
Advanced *Module GCh_AM_2.5*

Advanced Geochemical Interpretation

Experts: Afshin Fathi, Ursula Hammes,

This module explain applied organic geochemistry methods in source rock evaluation and biomarker analysis, oil to oil correlation, oil to source rock correlation projects. It will starts by providing interpretation methods to use results of organic geochemistry analysis. It will followed by providing interpretation samples and exercise from well-known basins.

- Review of organic geochemistry analysis methods
- Review of interpretation methods for LECO, Rock Eval and GC-MS analysis
- -Applications of organic geochemistry in conventional resources exploration
- Applications of organic geochemistry in unconventional resources exploration
- Applications of organic geochemistry in basin analysis
- Real world examples of applications of provided methods



Basic

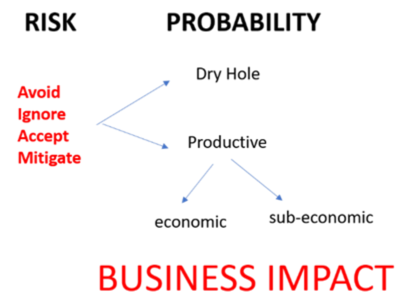
Module PFA_BM_3.1

Quantifying Risk in Petroleum Decisions

What is risk and how can we quantify it? How can we define the uncertainty associated with a well, prospect or play? This module explains the various methods of quantifying risk and uncertainty, how to use them and which one is the most appropriate method. Hands-on exercises will demonstrate how risk assessment can be used to quantify outcomes for better decision making.

- Review various decision-making methods used in the oil and gas industry
- Examine various tools and methods of identifying, quantifying and managing the risks and uncertainties
- Determine appropriate risk methods for well, prospect or play evaluations
- Case studies
- Exercises designed to reinforce the concepts

Experts: TBD



Basic

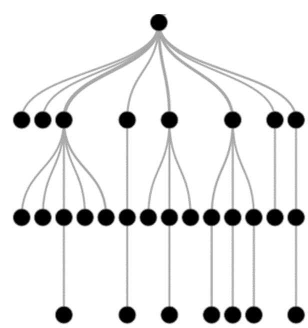
Module PFA_BM_3.2

Using Decision Trees to Quantify Risk

Good technical and business decisions are based on competent analysis of project costs, benefits and risks. Participants learn the decision analysis process and foundation concepts so they can actively participate in multi-discipline evaluation teams. The focus is on designing and solving decision models. About half the problems relate to exploration. The methods apply to R&D, risk management, and all capital investment decisions. Probability distributions express professional judgments about risks and uncertainties and are carried through the calculations. Decision tree and influence diagrams provide clear communications and the basis for valuing each alternative. Monte Carlo simulation is experienced in detail in a hand-calculation exercise. Project modeling fundamentals and basic probability concepts provide the foundation for the calculations. The mathematics is straightforward and mostly involves only common algebra. The emphasis is on practical techniques for immediate application. This is a fast-paced course and recommended for those with strong English listening skills. This course is intended as the prerequisite for the Advanced Decision Analysis with Portfolio and Project Modeling course.

- Evaluate decision tree models and extract key insights
- Use decision trees to value various outcomes
- Use Monte Carlo simulation software with optimization
- Develop models for projects and portfolios

Experts: TBD



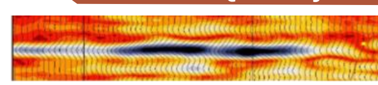
Advanced

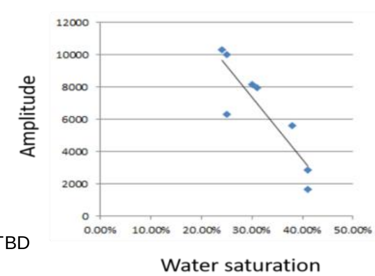
Module PFA_AM_3.3

Using Seismic Data and Geostatistics to Quantify Risk

This module discusses the basics of geostatistics as applied to the exploration business. Through examples and exercises, the concepts of how geostatistics are used, the types of distributions used and how seismic data can be used to define these parameters.

- Concepts of Geostatistics
- Types of distributions and their applications
- Estimating the ranges of reservoir properties
- Using seismic attributes to estimate reservoir properties
- Integration of seismic attributes into risk assessments





Experts: TBD

Advanced

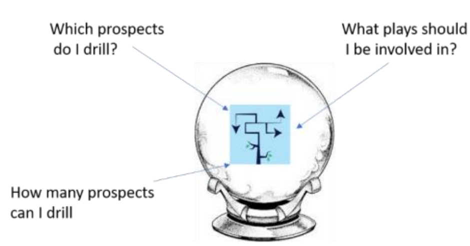
Module PFA_AM_3.4

Ranking Prospects for Plays

The course looks as several approaches to develop probabilistic play and prospect assessment procedures that are consistent and repeatable to evaluate and rank plays and prospects. The concepts and techniques learned in the course are applied to real industry examples in exercises and workshops.

- understanding ranking criteria
- company's tolerance for risk
- numerical ranking for prospects
- use of metrics to define the optimum portfolio

Experts: TBD



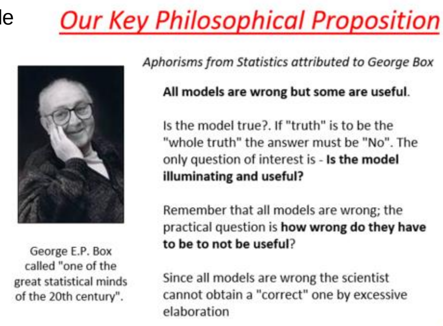
Basic — *Module Sea_BM_1.1*

Introduction to Seal: Risk and Column Hight

This module summarizes the context for seal evaluation by exposing what is the real state of the art – what do we actually know. In the 2012 EAGE poll of practicing seal experts, on every question there was a significant minority who disagreed about some aspect of seal evaluation. Beyond this major concepts are poorly documented and often extrapolation is based on a single study. This module provides the basis for doing meaningful evaluation given the uncertainties and limits of the evaluation methodologies.

- The state of the art – the inconvenient truths
- Conflicting views and the EAGE experts survey
- A practical philosophy for seal evaluations
- Using risking matrices
- Key issues to having a good workflow
- Applying Play Based Exploration to seal risking and column height controls
- Map integrity as the starting point and the basics of quality control of maps
- Calibration of chimneys and seal risks

Experts: John Karlo, TBD



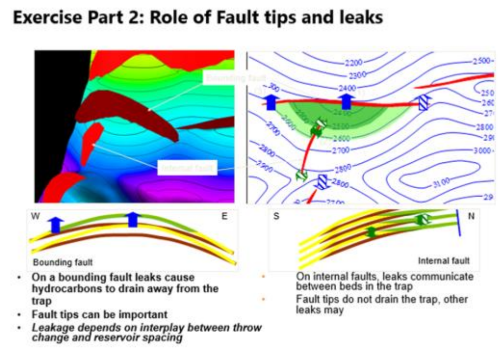
Basic — *Module Sea_BM_1.2*

Trap, seal and HC fill

This module presents the foundation of the trap concept, applying explicit definition of fill and leak point identification. Thinking in terms of hydrocarbon migration and fill leads to prioritizing the importance of structural elements, geometry and interpretation issues, possibly recognizing elements that one might otherwise have ignored or simplified. Understanding the trap model is the starting point to both properly portray the trap and to know what about it one needs to evaluate

- Trap types and trap geometries
- Gussow's principle of entrapment
- Sales seal based classification of trap types
- Faults, migration and charge
- EI330 migration caught in the act
- Juxtaposition and connectivity
- Constructing fault plane profiles
- Identifying fill – spill locations
- Degree of trap fill

Experts: John Karlo, TBD



Basic — *Module Sea_BM_1.3*

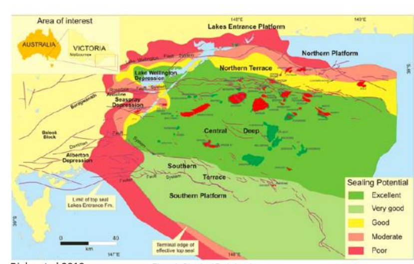
Evaluating Top Seals

Top seal is not usually a yes-no question of risk but is much more a question of how much column a seal can retain. This module presents the physical processes of capillary top seal and how to quantitatively evaluate the column height potential. As not all shale is the same, one focus of the module is on what geologic factors control the physical properties of the seal and how best to predict seal capacity. One misconception is that top seal can be "blown", however, capillary failure of a capillary top seal does not empty the trap. This module also teaches how to evaluate the remaining column of "failed" traps.

- The physics of capillary membrane seals
- Characterizing seal properties
- Facies controls of top seal capacity
- Top seals and seismic stratigraphy
- Snap off theory in seal failure
- Applying Play Based Exploration to top sea
- Case studies of PBE, facies and seal
- Predicting trapped column height

Experts: John Karlo, TBD

What do you know and where do you know it?



Divko et al 2010 Figure 1. Gippsland Basin location map.

Basic — *Module Sea_BM_1.4*

Evaluating Fault Seals

This module presents the two main processes that result in fault seals: smear of ductile top seal lithologies as monoclinal drapes on the fault plane and seal against shaley fault gouges. Each of these mechanisms is important under different conditions so the geologic controls on and the calibration of these mechanisms are described along with how to quantitatively evaluate the fault seal risk and controls on column height for a prospect.

- The factors for formation of Shale Smear
- The role of mechanical contrast in shale smear
- Localization at releasing crossovers
- Smear quantification as Shale Smear Factor
- Case studies of SSF
- When and how to evaluate Shale Smear controls on column height
- Empirical studies as basis to and calibration of Shale Gouge seals
- Application of SGR, Fault plane profiles, triangle diagrams
- SGR case studies
- SGR calibrations, capillary theory and hydrocarbon column capacity
- Log normal distribution and the Probit scale
- Dealing with structural and stratigraphic uncertainty
- Dynamic fault seal
- Transmissibility multipliers – predicting fault zone thickness and permeability

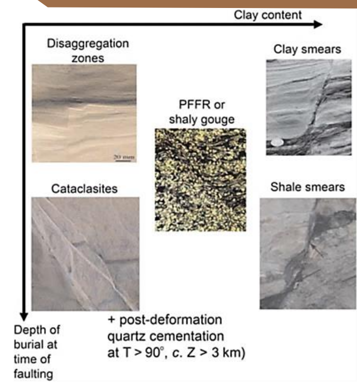
Experts: John Karlo, TBD

Basic *Module Sea_BM_1.5*

Fault rocks and damage zones

This module presents how faults nucleate and evolve, generating the various components that make up a fault zone. The different types of fault rocks that may form part of the fault core are described along with their physical properties.

- Fault evolution and architecture
- Physical character and components of fault zones
- Damage zones and fault core facies
- Statistics of fault zone and core dimensions
- Characterizing fault rock porosity, permeability and capillary entry pressure



Experts: John Karlo, TBD

Advanced *Module Sea_AM_1.6*

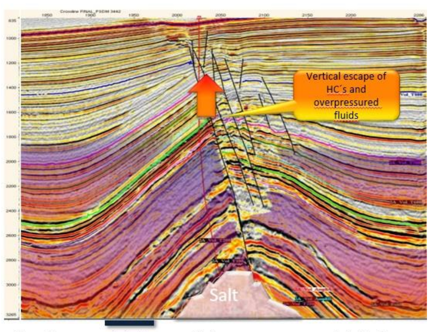
Structural Reactivation and Seals

This module presents how to evaluate seal risk associated with fault reactivation. There are two main phenomenon. In inverted settings, failure of seals that were compacted owing to burial and that are now at shallower depths are liable to brittle failure. Brittleness, however is not a measurable physical property and the various surrogates for measuring/predicting brittleness are presented

A second phenomenon results that in many areas the subsurface stresses are in equilibrium with the failure conditions of the rocks and there is some optimally oriented subset of pre-existing faults that act as pressure valves by being just on the verge of failure. "Critically stressed fault theory" is taught as a means of identifying what faults may be at high risk of reactivation and seal leakage.

- Structural Inversion
- Recognizing subtle indicators of reactivation
- Predicting brittle failure of top seals
- Case studies of brittle failure
- Critically stressed fault concept
- What do published studies of CSF concept tell us?
- Determination of the present day stress field
- Using the 3D Mohr's circle

Experts: John Karlo, TBD



Overlay = model of present day overpressure distribution

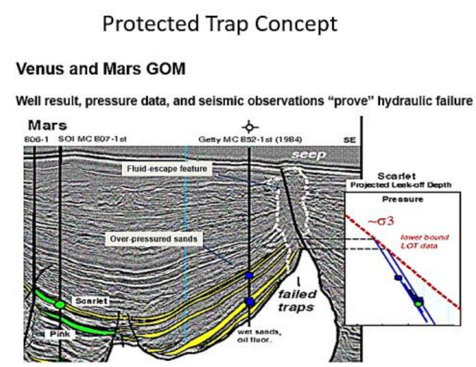
Advanced *Module Sea_AM_1.7*

Seal Evaluation of Geopressured traps

This module presents the issues of seals in hard geopressure conditions. Geopressure at more moderate levels enhances seal capacity but at higher pressure levels can lead to limiting column heights or full loss of column owing to hydrofracture of the seals - a hybrid mechanism mixing large-scale micro fracture formation and capillary leakage. Failure of one trap in a set of connected traps however can serve as a pressure valve and prevent failure of the connected deeper traps. This module thus also presents the pressure protected trap concept and using it in exploration.

- EI330 migration caught in the act
- Hydrofacture caused seal failure
- What does hydrofracture look like in outcrop
- Risking hydrofracture of seals
- North sea HPHT
- Hydrofrac case studies
- Protected trap concept in the Gulf of Mexico
- Protected trap case studies

Experts: John Karlo, TE



Advanced *Module Sea_AM_1.8*

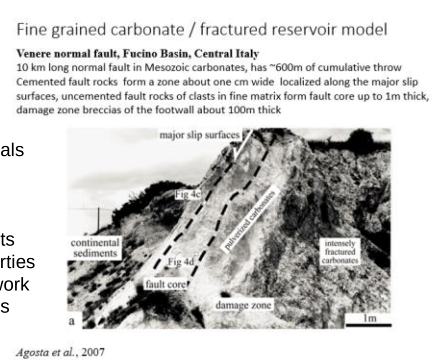
Seal Evaluation of Carbonate Prospects

Fault seal in carbonates is the least understood subject in seal evaluation. Mostly because it has generally been ignored due to the assumption that carbonates are brittle and faults would act as conduits not barriers. This widely held belief has resulted in a failure to develop a coherent theory and workflow for evaluation. The lack of a coherent basis, however, doesn't negate the need to do an evaluation when one has a carbonate prospect. Seals of carbonate against carbonate arise from shale or evaporite smear draping the fault plane and/or from micro-brecciation creating impermeable carbonate fault gouge.

However, fault gouge seal in carbonate traps is very poorly understood or documented. Nevertheless this module presents what is known about fault seals in carbonates. Because of high uncertainty and scant empirical basis, a major module focus is on what philosophy to use in quantifying seal potential for these mechanisms.

- Examples of carbonate on carbonate fault seals
- Sate of the art-what do we actually know
- Philosophy for risking carbonate fault seal
- Geometric factors that impact seal potential
- Shale Smear potential for carbonate prospects
- Carbonate gouge model and fault rock properties
- Criteria for when carbonate fault seals may work
- Case studies of carbonate on carbonate seals

Experts: John Karlo, TBD



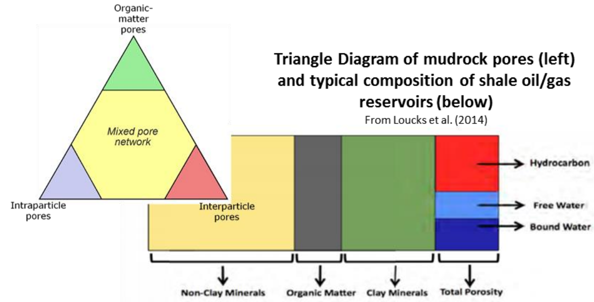
Basic *Module Pet_BM_1.2*

Petrophysical evaluation of mudrocks

Learn how to identify and classify porosity in SEM pictures including comparison of point-counts and measured porosity and methods for calculating TOC, porosity, lithology and water saturation from wireline logs.

Experts: Ursula Hammes, TBD

- Porosity
    - Porosity from wire-line logs
    - Porosity from core measurements
    - Porosity from SEM pictures
    - Comparisons on point-counts and measured porosity
- Permeability
    - Permeability measurements and pitfalls
- Wireline log calculations and interpretation
    - Methods for calculating TOC from wireline logs
    - DLogR and Multimin methods
    - Lithology, porosity, and attribute modeling from wireline logs using Multimin



Triangle Diagram of mudrock pores (left) and typical composition of shale oil/gas reservoirs (below)
From Loucks et al. (2014)

Basic *Module Pet_BM_2.1*

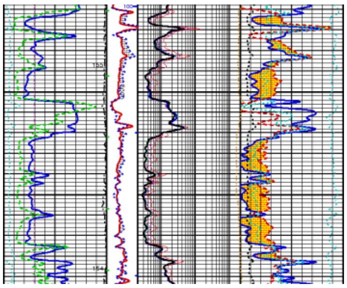
Basic Well Log Interpretation

This module introduces the basic concepts and understanding of well log acquisition and interpretation for subsurface and reservoir studies. Actual log examples are used to illustrate basic principles for determining reservoir properties such as porosity, mineralogy, formation actor, saturation, and hydrocarbon type.

Experts: Tom Temples, TBD

First Introductory module on Log Interpretation

- Understand wireline log acquisition techniques,
- Understand the fundamental physics of log measurements
- Perform basic log interpretation to identify and characterize reservoirs.
- Conventional logs: Caliper, Gamma Ray, Resistivity, Sonic, Neutron, Density



Advanced *Module Pet_AM_2.2*

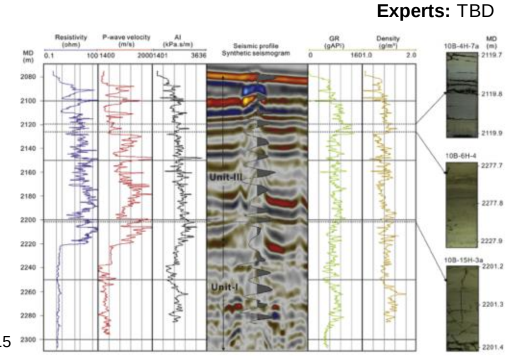
Advanced Log Analysis

This module builds on the basic Well Log Interpretation module and introduces concepts of log manipulation, CPI as well as integration with seismic data.

Experts: TBD

Second advanced module on Log Interpretation

- Log Manipulation/Editing
- Basics of a simple CPI: volume of shale, VSH and Porosity, Φ
- Well Log Interpretation and Integration with Seismic.



Kang et al., 2015

Advanced *Module Pet_AM_2.3*

Fracture Analysis from Dipmeter Logs

Dipmeter and image logs are valuable tools for collecting fracture and structure data from the reservoir. High resolution image logs can provide detailed images of bedding and fractures, but only for the small sample of the reservoir that is penetrated by the well. Methods to interpolate fracture properties away from the well are presented in this course, including how to make correct for sampling orientation bias. A very effective method to model structural dip and identify faulting not actually intersected by the wellbore called SCAT will also be demonstrated. Fracture orientation analysis, methods to separate orientation data into realistic fracture subsets, and fracture transmissivity characteristics identifiable in image logs will be discussed.

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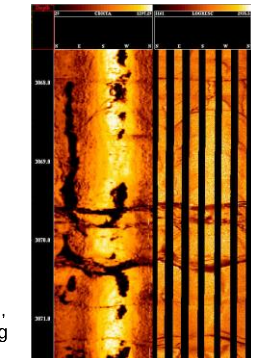
- How dipmeter logs are acquired
- Types of image logs
- Identification of fractures in image logs
- Fractures and failure features in image logs
- Fracture orientation analysis
- Assessing fracture characteristics
- Methods to characterize fracture transmissibility

- Examples from Williston Basin, Arkoma Basin, and others
- Focus is on identifying significant (potentially productive) fractures in the wellbore.

Experts: Sherilyn Williams-Stroud, Jim Granath, Alfred Lacazette, Catalina Luneburg



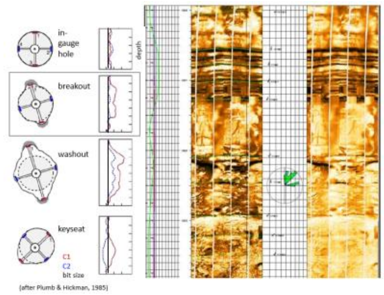
Basic *Module GeM_BM_1.1*

Insitu Stress Determination

The 3-D in situ stress state affects all oil and gas operations from drilling to production. This module teaches participants what types of data can be used to determine in situ stress, and how to quantify the full geomechanical setting, including the three principal stress magnitudes and orientations, mechanical rock properties, and pore pressure. It will also provide an overview of the various ways in which knowledge of the state of stress can be applied to reduce risk and cost and improve production results.

- Earth stresses – what are they and where do they come from
- Classifying various states of stress
- Why it is important to know stress magnitudes for drilling, completions and production
- Quantifying the components of the geomechanical setting: principal stress magnitudes and directions, pore pressure, mechanical rock properties

Experts: Amy Fox, Alfred Lacazette, Sherilyn Williams Stroud



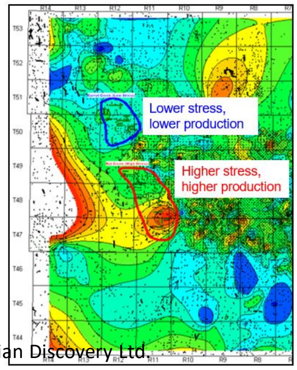
Basic *Module GeM_BM_1.2*

Stress Mapping

Where geomechanical data sources are plentiful and available, such as well-developed plays or regions with publically accessible databases, stress maps can be constructed that can reveal major and/or more subtle insights into the geomechanical characteristics of a play/region. There are many types of stress maps that can be developed, and data sources and interpretation methods differ for each. This course will provide an overview of these data sources, determining data quality, and interpreting data to create regional stress maps.

- Types of stress maps
- Examples of stress maps and the value they provided
- The World Stress Map project, creating custom maps from its database and contributing data to the project
- Types of data that may be used in stress mapping
- Potential data sources
- How to create stress maps

Experts: Amy Fox, Jim Granath, Al Lacazette, Sherilyn Williams Stroud



Canadian Discovery Ltd.

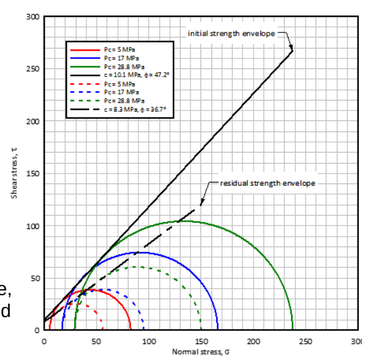
Basic *Module GeM_BM_1.3*

Mechanical Rock Properties Determination

Mechanical rock properties are a critical part of understanding the geomechanics of a play. Routine core analysis does not provide the data needed to understand the mechanical properties of the rock. Sources for this information can include special tests on core, logs, wellbore failure observed in image logs or through drilling experience, and more. Not only is it important to know how to vet and use data from different sources, it is also important to understand the differences between static and dynamic rock properties, anisotropy, and what different moduli mean. This module focuses on these topics.

- Unconfined vs. confined triaxial tests on core
- Evaluating core test quality
- The rock strength envelope and how to determine it
- The definition of rock moduli
- Static vs. dynamic rock properties
- Rock property anisotropy
- Rock properties from logs
- Rock properties from scratch, hardness and indentation tests
- Where to apply knowledge of rock properties in geomechanical problems

Experts: Amy Fox, Alfred Lacazette, Sherilyn Williams Stroud



Basic *Module GeM_BM_1.4*

Post-mortem Wellbore Stability Analysis

Experts: Amy Fox, TBD

Tight spots? Stuck pipe? Cavings coming over the shakers? Lost circulation? This module teaches how to interpret daily drilling reports and other well data from a geomechanical perspective to provide insight into what potential geomechanical mechanism may have caused drilling problems, from minor to severe. The module explains the relationship between in situ stress and wellbore problems. It will illustrate how drilling problems are a hidden source of NPT and excess cost.

- Explanation of the wellbore stress concentration
- Geomechanical clues in daily drilling reports
- Interpreting caliper data for geomechanical wellbore failure
- Relating lost circulation to stress
- Building geomechanical well summaries

Basic *Module GeM_BM_1.5*

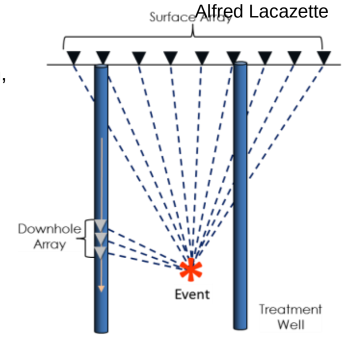
Microseismic Acquisition Methods and Data Interpretation

Experts: Sherilyn Williams-Stroud, Alfred Lacazette

Microseismic data contains a wealth of information beyond the dots in the box. The type of additional information that is available is dependent on the method used to acquire the data and the methods used to process the data. This module will introduce students to the various data acquisition methods and with a discussion of the strengths and weaknesses inherent in each method. Processing methods will also be introduced, with descriptions of the different products that are generated by each method including the tomographic imaging to map fractures. A basic overview of source mechanism inversions, stress inversion, and fracture interpretations will illustrate recommended methods of using the information that can be extracted from microseismic monitoring data.

- Passive seismic imaging downhole array configuration
- How events are detected in downhole monitoring
- Passive seismic imaging horizontal array configuration
- Event detection from horizontal array and relationship to reflection seismic
- Event location error
- Effect of layered rock and velocity model on event location accuracy
- Source mechanism inversion requirements
- Using source mechanisms to infer stress state
- Using tomographic imaging to infer reservoir fluid pressure

- Examples from Gulf Coast Basin, Central U.S., Appalachian Basin
- Focus is on understanding appropriate uses of ms data for optimal effectiveness of a monitoring job



Advanced *Module GeM_AM_1.6*

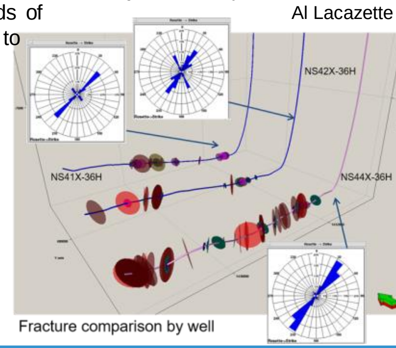
Geomechanics, Fractures and Microseismic

Experts: Sherilyn Williams-Stroud, Al Lacazette

This module covers aspects of structural analysis related to natural fracture development, induced and reactivated fracturing from hydrofrac stimulation, and how the state of stress in the earth impacts all types of fracturing. The relationship of natural seismicity to faults and induced seismicity to fractures is discussed, with focal mechanism interpretation and fracture orientation analysis. The various methods of microseismic data acquisition are compared, with discussion of how to interpret the results and how to use them to develop fracture constraints to generate fracture flow properties in reservoir models.

- Stress in the earth
- Rock mechanics and fracture analysis
- Microseismic data acquisition methods
- Stress and strain and fractures
- Event energy
- Event location error
- Focal mechanism solutions
- Natural versus induced seismicity
- Discrete fracture network modeling
- Upscaling fracture flow properties for reservoir simulation
- Stimulated reservoir volume models

- Examples from Gulf Coast Basin, Williston Basin, Applachian Basin
- Focus is on integrating the observation data with rock mechanics and reservoir modeling



Fracture comparison by well

Advanced *Module GeM_AM_1.7*

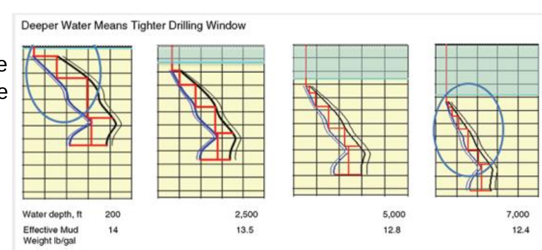
Mud Weight Predictions for Proactively Optimizing Wellbore Stability

Experts: Amy Fox, TBD

This module illustrates through examples how combining knowledge of in situ stresses and mechanical rock properties can enable the calculation of the mud weight window for drilling new wells. Because of the stress concentration in the near-wellbore area, the old rule of thumb that mud weight should be between the pore pressure and the minimum stress is not correct in most cases. The mud weight window should be defined as mud weights above which drilling-induced compressive failure (breakouts) is within tolerated limits and below that which would induce tensile fracturing and potential lost circulation.

- In situ stress and the wellbore stress concentration
- Wellbore failure types
- Geomechanical drilling events in daily drilling reports
- Setting tolerance limits for wellbore failure while drilling
- Calculating mud weight windows for different stress settings and well trajectories

JPT, June 2014



This illustration shows how the drilling window—the difference between the effective mud weight needed to offset the pore pressure for well control (blue line) and the lever where it will fracture the rock. These illustrate drilling a wellbore 14,800 ft deep into the same formation. Courtesy of Chevron.

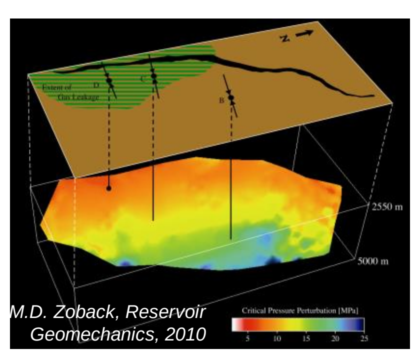
Advanced *Module GeM_AM_1.8*

Mechanical Fracture and Fault Stability

The stability of fractures and faults depends on the frictional strength of, and the shear and normal stress acting on, the fracture/fault planes. Using knowledge of in situ stresses and fluid pressures, this module teaches how to model slip potential on failure surfaces under existing or hypothetical conditions (e.g., fluid injection). This type of analysis is critical to understand processes such as induced seismicity or fluid production from naturally fractured reservoirs

- Types of fractures and faults
- In situ stress
- Shear and normal stress on planes
- Fracture/fault cohesion
- Critically stressed fractures
- Fluid production in naturally fractured reservoirs
- Effects of depletion or injection on fractures/faults

Experts: Amy Fox, Alfred Lacazette, Sherilyn Williams Stroud



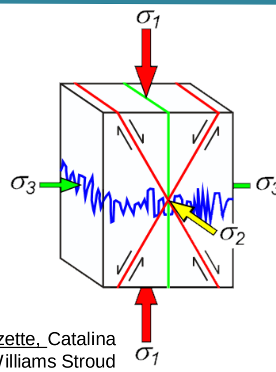
M.D. Zoback, Reservoir Geomechanics, 2010

Basic *Module Frac_BM_2.2*

Natural fractures and fracture modeling

Natural fractures are always present in all oil and gas reservoirs. Fractures affect fluid-flow in some reservoirs more strongly that others. Fractures may aid or impede the movement of oil/gas to the wellbore, cause premature water breakthrough, cause seal failure, or connect the reservoir to aquifers. Different fracture types have different fluid-flow properties, form in different orientations relative to the earth stresses that caused fracture formation, and obey different spacing/intensity laws. This module will review fracture types and characteristics, controls on fracture development, and the basics of fracture modeling.

- Natural fracture types
- Fluid-flow characteristics and orientations of fracture types
- How fractures form and why it matters
- Distinguishing natural fractures from induced fractures in core, borehole images, and outcrop
- Relationship of fractures to seismic-scale structures
- Effects of natural fractures on artificial hydraulic fractures
- Overviews of equivalent-media and Discrete Fracture Network (DFN) fracture modeling
- Case studies



Experts: Alfred Lacazette, Catalina Luneburg, Sherilyn Williams Stroud

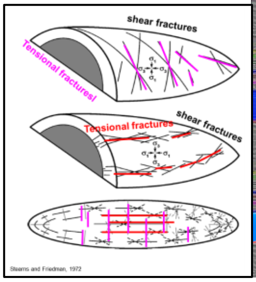
Basic *Module Frac_BM_2.2*

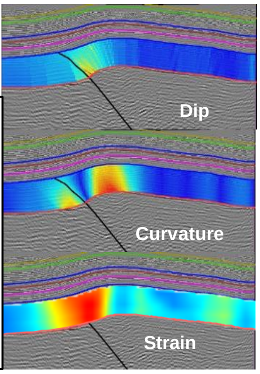
Fracture prediction and fracture proxies

Predicting natural fracture systems, their distribution, orientations and intensities is critical for reservoir porosity and permeability and their interaction with induced fractures. Challenges lie in the difficulty of recognizing fracture pattern, their mechanics and relation to present and paleo stresses and their limited direct measurements as well as scale of observation. Facture models rely on the quantitative analysis of fracture proxies such as geophysical attributes and well logs as well as curvature and dip, and stress/strain. This module explores different fracture proxies illustrated on different examples

- Natural fracture types
- Fracture patterns around structures; folds and faults
- Overview and examples of fracture proxies
- Seismic attributes and anisotropy, well logs and production histories
- Curvature, dip and strain analysis

Experts: Catalina Luneburg, Alfred Lacazette





Advanced *Module Frac_AM_2.3*

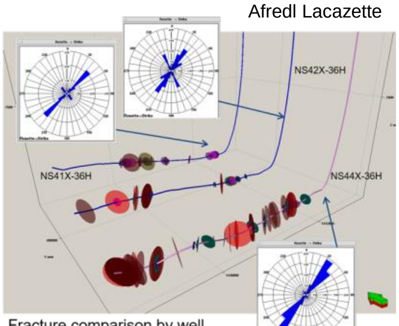
Geomechanics, Fractures, and Microseismic

This module covers aspects of structural analysis related to natural fracture development, induced and reactivated fracturing from hydrofrac stimulation, and how the state of stress in the earth impacts all types of fracturing. The relationship of natural seismicity to faults and induced seismicity to fractures is discussed, with focal mechanism interpretation and fracture orientation analysis. The various methods of microseismic data acquisition are compared, with discussion of how to interpret the results and how to use them to develop fracture constraints to generate fracture flow properties in reservoir models.

- Examples from Gulf Coast Basin, Williston Basin, Applachian Basin
- Focus is on integrating the observation data with rock mechanics and reservoir modeling

- Stress in the earth
- Rock mechanics and fracture analysis
- Microseismic data acquisition methods
- Stress and strain and fractures
- Event energy
- Event location error
- Focal mechanism solutions
- Natural versus induced seismicity
- Discrete fracture network modeling
- Upscaling fracture flow properties for reservoir simulation
- Stimulated reservoir volume models

Experts: Sherilyn Williams-Stroud, Afredl Lacazette



Fracture comparison by well

Advanced *Module Frac_AM_2.4*

Structural/geomechanical core logging and interpretation

Core is a rich source of data on natural fractures and the present-day reservoir stress. The module consists of a classroom session followed by hands-on work with the client's own cores. Students will learn how to distinguish the types of natural and induced fractures, how to log them, how to interpret neostress (e.g. present-day or in-situ stress) from induced fractures and paleostress (ancient, natural-fracture forming stresses) from natural fractures.

- Review of natural fracture types and properties.
- Types of induced fractures and their significance.
- Distinguishing natural from induced fractures.
- Procedures for logging fractures in core.
- Interpreting paleostress from natural fractures.
- Oriented core vs. orienting core with borehole images.

Experts: Alfred Lacazette, Sherilyn Williams Stroud, Amy Fox

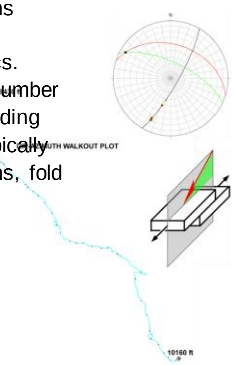
Figure: Petal and petal-centerline fractures in acoustic amplitude image (left) and core (right). These induced fractures form ahead of the drill bit. Centerline fractures are perpendicular to the minimum principal stress, and hence parallel to the maximum stress. Petal fractures strike parallel to the maximum stress.

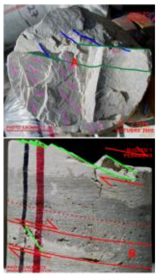
Advanced *Module Frac_AM_2.5*

Analysis of borehole geological orientation data

The course will cover two- and three-dimensional orientation statistical methods for interpreting subsurface structural data. Borehole orientation measurements of bedding, joints, faults, and fault-slip directions made in core and borehole images can precisely delineate reservoir structure and fracture system properties including intensity (natural fracture surface area/rock volume) and fluid-flow characteristics. Borehole observations can also provide detailed information on the structural history including the number and sequence of deformation events and the paleostress fields that caused each event. Understanding the structural history leads to better structural and fracture reservoir models. Such data sets are typically large and noisy. Orientation statistics are used to separate signal from noise, determine dip-domains, fold axial planes, sort fractures into sets, and determine paleostress orientations.

- Representation of 3D structural data.
- Basic orientation statistics.
- Statistical Curvature Analysis Techniques (SCAT).
- Fault-slip indicators in core and borehole images.
- Paleostress analysis.





Experts: Alfred Lacazette, Sherilyn Williams Stroud, Amy Fox

Advanced *Module Frac_BM_2.6*

Structural/geomechanical borehole image interpretation

Borehole images provide detailed information on reservoir fractures, reservoir neostress (present-day stress), reservoir-scale structural geology that can control fracture development, sedimentary facies and structures, and other features. This module focuses on hands-on image interpretation, preferably with the client's own data. Each student will be provided with a temporary license for LR Senergy's Interactive Petrophysics software. The module will focus on basic and advanced methods to characterize natural and induced fractures, breakouts, and other features required to develop the detailed understandings of earth stress and fine-scale reservoir structure. These data are used to determine subsurface fracture system properties and earth stress and their variations throughout the reservoir.

Experts: Alfred Lacazette, Sherilyn Williams Stroud, Amy Fox

- Borehole imaging technologies and their strengths and weaknesses.
- Identifying and measuring breakouts and induced fractures.
- Identifying and measuring natural fracture types.
- Identifying faults and fault zones – the most commonly misidentified features in image logs.
- Integrating petrophysical and borehole image data.
- Data collection for detailed structural interpretation.
- Case studies, preferably with the client's own data

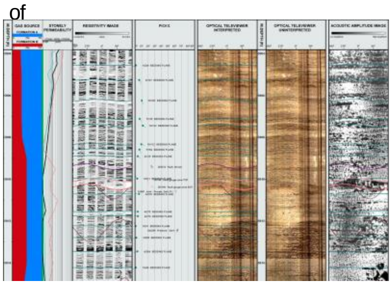


Figure: Minor fault gouge zone in three types of borehole images from an unconventional reservoir. The mechanically-soft, electrically-resisitive gouge zone is impermeable. A fault-related fold above the fault produced microfracture permeability that carries gas from a deeper reservoir, as shown by quadrupole mass-spectrometer drilling gas data. These features are borehole-scale examples of larger reservoir-scale structures.

Advanced *Module Frac_AM_2.7*

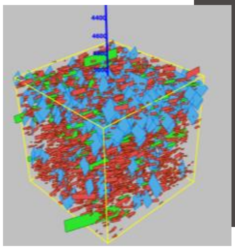
Fracture Modeling and Fractured Reservoir Characterization

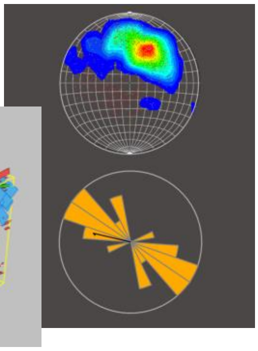
This module introduces the different types of fractured reservoirs and how they impact fluid flow from the reservoir to the well. Modeling of fractured reservoirs is via discrete fracture network (DFN) modeling is introduced as a method to illustrate fracture flow behavior. The module covers methods for collecting fracture data from various sources, analysis and conditioning of fracture data, creation of DFN models, methods to validate DFN models using well test simulations and well production data. Methods for upscaling fracture properties from the near-wellbore to full field simulation will be explained and demonstrated.

- Types of fractured reservoirs
- Important fracture characteristics
- Statistical analysis of fracture data
- Fracture model definitions
- Fracture modeling methods
- DFNs from image log analysis
- Building DFNs from geological fracture drivers
- Constraining DFNs with seismic attributes
- Creating DFNs from microseismic data
- Validation of DFN models with production data
- Upscaling fracture properties for full-field simulation

- Examples from Bakken and the Mid-Continent USA
- Focus is on understanding different impacts of fractures on reservoir behavior

Experts: Sherilyn Williams-Stroud, Alfred Lacazette





Advanced *Module Frac_AM_2.8*

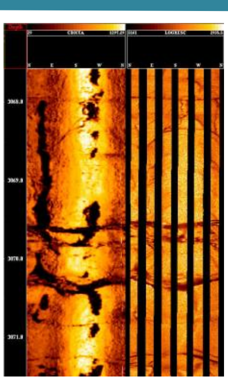
Fracture and Structural Analysis from Dipmeter Logs

Dipmeter and image logs are valuable tools for collecting fracture and structure data from the reservoir. High resolution image logs can provide detailed images of bedding and fractures, but only for the small sample of the reservoir that is penetrated by the well. Methods to interpolate fracture properties away from the well are presented in this course, including how to make correct for sampling orientation bias. A very effective method to model structural dip and identify faulting not actually intersected by the wellbore called SCAT will also be demonstrated. Fracture orientation analysis, methods to separate orientation data into realistic fracture subsets, and fracture transmissivity characteristics identifiable in image logs will be discussed.

- How dipmeter logs are acquired
- Types of image logs
- Identification of fractures in image logs
- Fractures and failure features in image logs
- Fracture orientation analysis
- Assessing fracture characteristics
- Methods to characterize fracture transmissibility

- Examples from Williston Basin, Arkoma Basin, and others
- Focus is on identifying significant (potentially productive) fractures in the wellbore.

Experts: Sherilyn Williams-Stroud, Jim Granath, Alfred Lacazette, Catalina Luneburg



Basic *Module UnSt_BM_3.1*

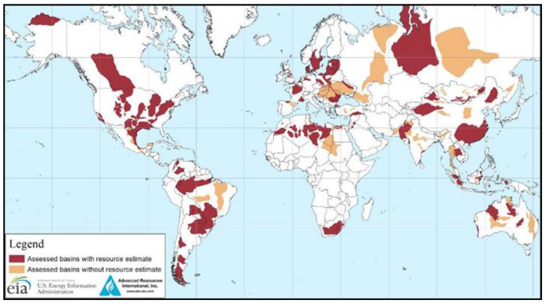
Introduction to Shale Gas/Oil Play Analysis and Techniques for Characterization of Mudrocks

This module provides an overview of organic-rich mudrock systems such as carbonate- and clastic-dominated shale systems with examples from different North American resource plays and methods to characterize those systems

- Overview of organic-rich mudrock systems
  - Carbonate-dominated systems
  - Clastic-dominated systems
  - Mud-dominated systems
  - Importance of Paleogeography and Tectonic Setting
- Techniques for characterization of mudrocks (overview)
  - Paleogeographic and tectonic setting
  - Sedimentology
  - Sequence Stratigraphy
  - Geochemistry
  - Petrophysics
  - Seismic and Geomechanics
  - Fractures

Experts: Ursula Hammes, TBD

World-wide shale basins (EIA, 2015):



Basic *Module UnSt_BM_3.2*

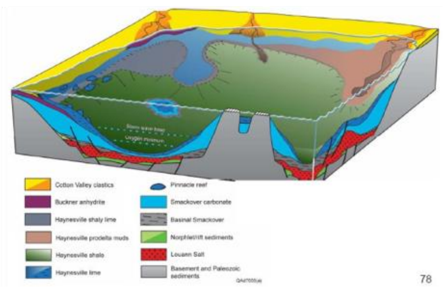
Stratigraphic and depositional processes in Shale Basins

Learn how stratigraphic and depositional processes influence regional correlations and facies variations of organic-rich mudrocks with respect to calcareous, siliceous and clay-rich shales. Apply sequence stratigraphic principles and facies interpretations to identify best organic-rich and frackable intervals. Predict most prolific source intervals.

- Stratigraphic Framework
  - Regional correlations and variations
  - Sequence stratigraphy
  - Shelf to basin correlations
- Depositional processes
  - Calcareous shales (Haynesville, Eagle Ford example)
  - Siliceous shales (Barnett, Bakken example)
  - Clay-rich shales (Tuscaloosa Marine Shale; GOM Tertiary Shale)

Experts: Ursula Hammes, Katie Joe McDonoughTBD

Example of Haynesville depositional model:



Basic *Module UnSt_BM_3.3*

Tight Carbonates

With advanced horizontal drilling techniques tight carbonates become a prolific target for exploration. The distribution of reservoir quality in tight carbonates depends primarily upon how diagenetic processes have modified the rock microstructure, leading to significant heterogeneity and anisotropy. The size and connectivity of the pore network may be enhanced by dissolution or reduced by cementation and compaction. This module will explore the controls on tight carbonates and how to address porosity and permeability concerns.

Tight Carbonate Reservoirs

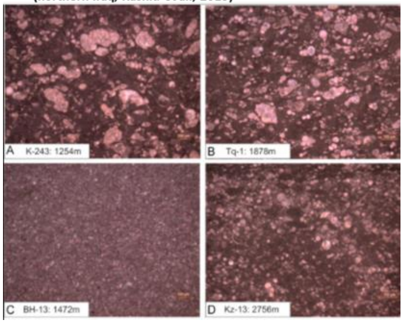
- Depositional environments
- Pore types
- Diagenesis
- Permeability evolution

Characterization Techniques

- Thin-sections
- SEM analyses

Experts: Ursula Hammes, TBD

Thin-section photomicrograph examples of tight carbonates (northern Iraq, Rashid et al., 2015)



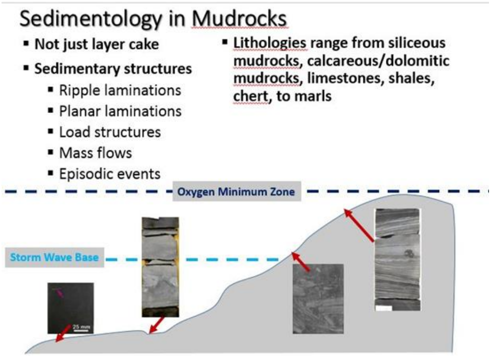
Advanced *Module UnSt_AM_3.4*

Mudrock sedimentology and factors resulting in organic-rich deposits

Diverse sedimentary structures, fauna, depositional processes and their inter- and intrabasinal variations and factors determining organic-rich deposits are crucial to understand mudrock systems. Factors such as paleogeography, ocean chemistry and tectonic influences derived from modern examples will be explored.

- Mudrock Sedimentology
  - Sedimentary structures
  - Facies and fauna
  - Organic-rich vs. organic-poor lithologies
  - Facies types
- Factors controlling organic-rich deposits
  - Paleogeography
  - Clastic input
  - Ocean chemistry
  - Paleo climate
  - Organic matter input flux and preservation

Experts: Ursula Hammes, Katie Joe McDonough.,TBD



Basic *Module UnCh_BM_4.1*

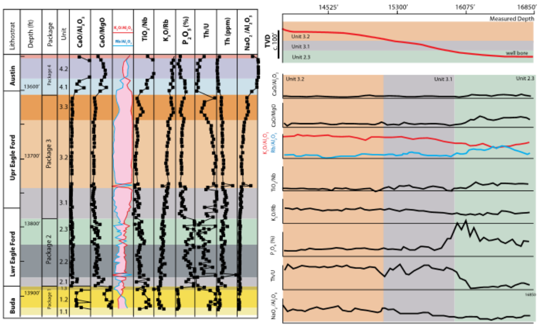
Inorganic Geochemical Techniques

Inorganic geochemical techniques will teach the instrumentation used to generate inorganic data used to identify favorable frac intervals and compare to petrophysical logs (e.g., XRD, ICP, XRF instruments). Chemostratigraphic principles will be applied to identify potential frac intervals and relate to sequence stratigraphy.

Experts: Ursula Hammes, TBD

Inorganic Geochemical Techniques

- XRF
- XRD
- MCIP
- Elements important for identifying reducing conditions



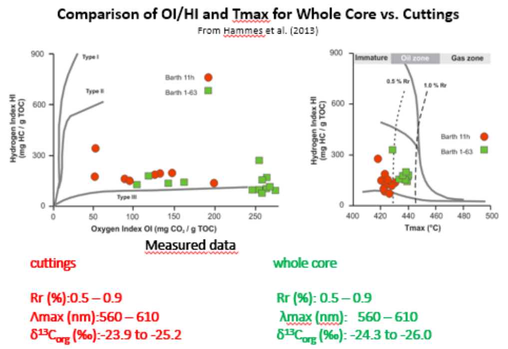
Basic *Module UnCh_BM_4.2*

Organic Geochemical Techniques

Overview of source rock evaluation: learn how to interpret organic-matter type and richness, maturity and interpretation of geochemical results incorporating TOC, rock-eval and biomarker data.

Organic Geochemical Tools

- TOC analyses
- Rockeval
- Biomarker
- Elements important for identifying reducing conditions



Experts: Ursula Hammes, TBD

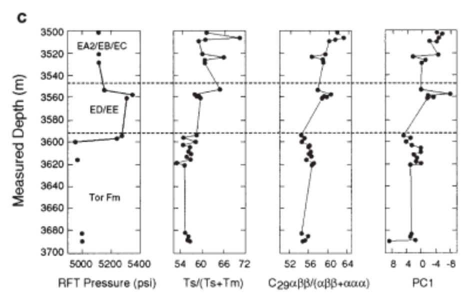
Advanced *Module UnCh_AM_4.3*

Reservoir Geochemistry

This module will teach how to use organic geochemistry to evaluate conventional and unconventional reservoirs by introducing case studies and exercises. Geochemical interactions with mineral surfaces and water, nitrogen and oxygen compounds in petroleum may exert an important influence on the pressure/volume/temperature (PVT) properties of petroleum, viscosity and wettability. The distribution of these compounds in reservoirs is heterogeneous on a submeter scale and is partly controlled by variations in reservoir quality. The implied variations in petroleum properties and wettability may account for some of the errors in reservoir simulations

- **Reservoir Chemistry**
  - Tools
  - Analyses
  - Understand rock/fluid interactions
  - Help engineers understand residual oil
- **Chemostratigraphy**
  - Paleogeography and paleo climate
  - Clastic input
  - Ocean chemistry
  - Identify frac intervals
  - Organic matter input flux and preservation

Experts: Ursula Hammes, Afshin Fahti



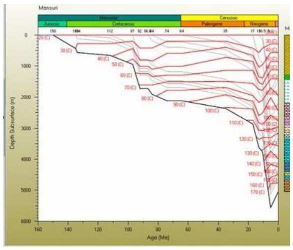
Advanced *Module UnCh_AM_4.4*

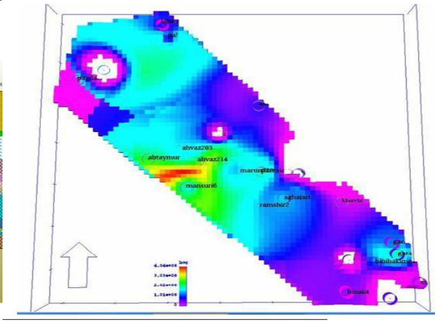
Applications of basin modeling in unconventionals

This module introduces basic concepts of unconventional resources geology, petroleum system elements in unconventional resources and their characteristics, organic geochemistry of unconventional resources, and source-reservoir rock evaluation methods. The module will explain the applications of basin analysis to evaluate unconventional resources and identify best drilling zones.

Experts: Afshin Fahti, TBD

- Review of basic unconventional resources concepts
- Review of basin modeling concepts
- Unconventional petroleum system elements
- Unconventional petroleum system processes
- Organic geochemistry of unconventional resources
- Comparing basin modeling methods in conventional and unconventional resource
- Unconventional basin modeling project steps
- Unconventional basin models inputs and outputs





Basic

Module UnP_BM_5.1

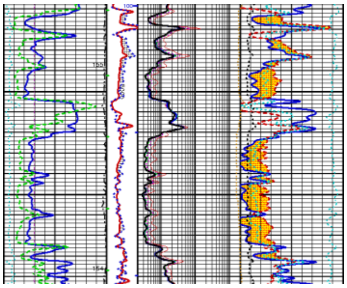
Basic Well Log Interpretation

This module introduces the basic concepts and understanding of well log acquisition and interpretation for subsurface and reservoir studies. Actual log examples are used to illustrate basic principles for determining reservoir properties such as porosity, mineralogy, formation actor, saturation, and hydrocarbon type.

Experts: Tom Temples, TBD

First Introductory module on Log Interpretation

- Understand wireline log acquisition techniques,
- Understand the fundamental physics of log measurements
- Perform basic log interpretation to identify and characterize reservoirs.



Advanced

Module UnP_BM_5.2

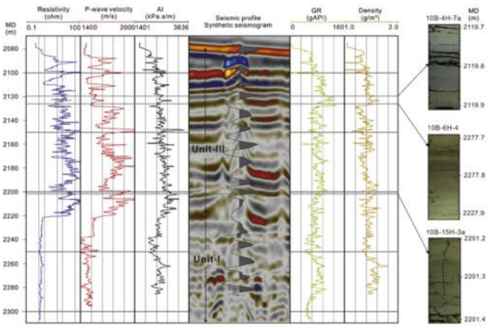
Advanced Well Log Interpretation

This module builds on the basic Well Log Interpretation module and introduces concepts of log manipulation, CPI as well as integration with seismic data.

Experts: TBD

Second advanced module on Log Interpretation

- Log Manipulation/Editing
- Basics of a simple CPI: volume of shale, VSH and Porosity, Φ
- Well Log Interpretation and Integration with Seismic.



Kang et al., 2015

Basic

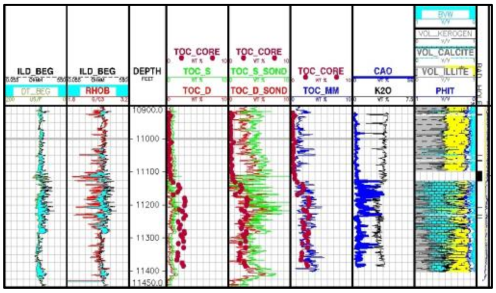
Module UnP_BM_5.3

Petrophysical Rock Properties

Rock physical properties are key elements of the reservoir model as they pertain to rock-fluid interaction that ultimately control amount of HC present . This module introduces types of physical rock properties such as lithology, porosity, water saturation and permeability, compressibility, capillary characteristics, rock stress, fluid-rock interaction. Methods used to measure reservoir petrophysical properties from cores, logs and well tests data. Results are correlated and integrated for reservoir characterization and modeling.

Experts: TBD

- Different physical rock properties
- Methods to evaluate rock properties
- Core analysis, acquisition, interpretation, and quality checks
- Theory and basics of resistivity, radioactivity, acoustic tools
- Impact of rock properties on the reservoir model



Basic

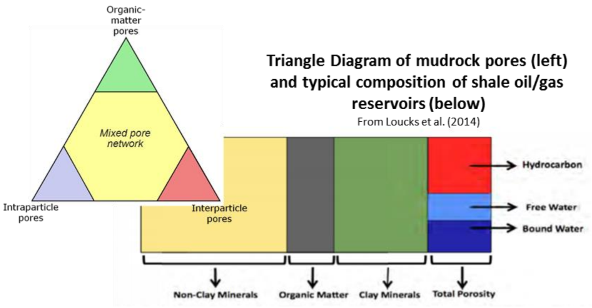
Module UnP_AM_5.4

Petrophysical evaluation of mudrocks

Learn how to identify and classify porosity in SEM pictures including comparison of point-counts and measured porosity and methods for calculating TOC, porosity, lithology and water saturation from wireline logs.

Experts: Ursula Hammes, TBD

- Porosity
    - Porosity from wire-line logs
    - Porosity from core measurements
    - Porosity from SEM pictures
    - Comparisons on point-counts and measured porosity
- Permeability
    - Permeability measurements and pitfalls
- Wireline log calculations and interpretation
    - Methods for calculating TOC from wireline logs
    - DLogR and Multimin methods
    - Lithology, porosity, and attribute modeling from wireline logs using Multimin



Case Study *Module UnP_WM_5.5*

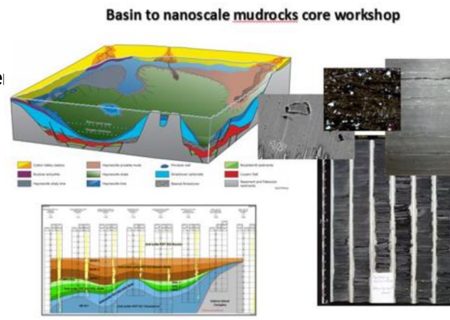
Core workshop in Austin, Houston or individual company offices

Basin to nanoscale core workshop using sedimentological, stratigraphical, geochemical and petrophysical techniques to characterizes shale oil/gas plays: Examples from different shale plays: e.g., Haynesville, Eagle Ford, Barnett, Pearsall, Bakken, Wolfcamp and others. This core worl may be 2 to 5 days in Austin, Houston or company offices.

Experts: Ursula Hammes, TBD

- Core workshop
- Examine cores from Eagle Ford, Haynesville, Bossier, Bakken, Barnett, Wolfcamp and othe
- Apply techniques to characterize the mudrock reservoirs such as
- Paleogeographic and tectonic setting
- Sedimentology
- Sequence Stratigraphy
- Geochemistry
- Petrophysics
- Seismic and Geomechanics
- Fractures

- The core workshop exceeds module length – see under Specialty Courses



Case Study *Module UnC_CM_6.1*

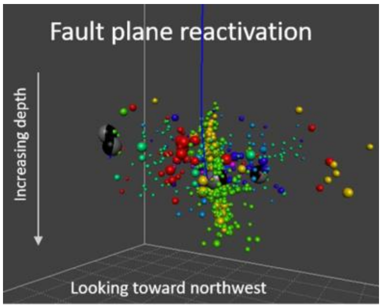
The Marcellus Play

The Marcellus Shale play holds ?% of the currently recoverable unconventional resources in the United States. The geological history of the source rocks created fracture sets from a previous deformation episode that coincidentally parallel to the current stress tensors in the basin. The fractures, which are important for production, were initially formed by natural hydraulic fracturing, providing a vivid modern example of how the interaction of stress, fluid pressure, and rock mechanical properties can create fluid pathways necessary for migration (paleo geology) and production (present day geology). This course provides a geologic overview of the formation of the basin, the deformation history, timing of source rock development, and hydrocarbon migration to lay the foundation for optimal approaches for unconventional oil and gas exploitation.

- Examples of fractures in Marcellus rock outcrops
- Discussion of stimulation results/effectiveness
- Focus is on understanding the basin history to predict resource potential

Experts: Sherilyn Williams-Stroud, Alfred Lacazette, Catalina Luneburg, Tanya Inks

- Andersonian stress states and faults
- Fault and fracture nomenclature
- Fractures formed in tension
- Compressional fractures
- Joint formation
- Relationship of fractures to structure
- Strain accommodation by fractures
- Wellbore stability in deformed and fractured rocks
- Hydraulic fracture stimulation and natural fracture interaction



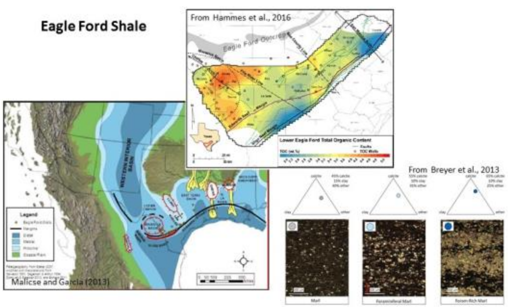
Case Study *Module UnC_CM_6.2*

The Eagle Ford Play

This course will cover geological models, stratigraphy and distribution of porous, organic-rich, and calcitic/organic-rich intervals in the Eagle Ford shale of South Texas. Factors determining organic-, clay-, and calcite-rich lithologies in areal and stratigraphic distribution

- Eagle Ford specific workshop (including core viewing)
  - Examine cores from updip to downdip Eagle Ford Shale
  - Apply techniques to characterize the Lower Eagle Ford reservoirs such as
  - Paleogeographic and tectonic setting
  - Sedimentology
  - Sequence Stratigraphy
  - Geochemistry
  - Petrophysics
  - Seismic and Geomechanics
  - Fractures
- Relate geology to production

Experts: Ursula Hammes, TBD



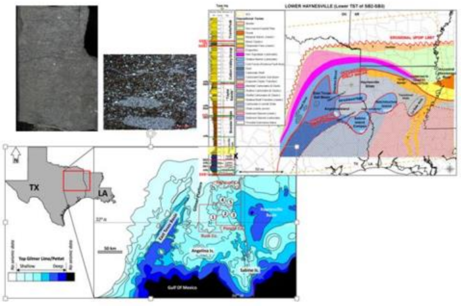
Case Study *Module UnC_CM_6.3*

The Haynesville and Bossier Shale Plays

This course will cover geological models, stratigraphy and distribution of porous, organic-rich, and calcitic/siliciclastic-rich intervals in the Haynesville and Bossier Shales of East Texas and West Louisiana. Factors determining occurrence of organic-rich intervals and distribution of porous, organic-rich, and calcitic/siliciclastic-rich intervals will be explored

- Haynesville and Bossier Shale specific workshop (including core viewing)
  - Examine cores from Bossier and Haynesville shales
  - Apply techniques to characterize the Bossier and Haynesville shale reservoirs such as
    - Paleogeographic and tectonic setting
    - Sedimentology
    - Sequence Stratigraphy
    - Geochemistry
    - Petrophysics
    - Seismic and Geomechanics
    - Fractures
- Relate geology to production

Experts: Ursula Hammes, TBD



MODULES MAP

Module = ½ day training

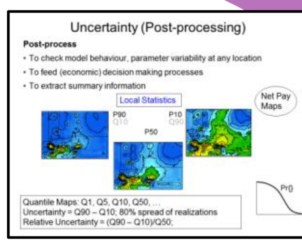
Geomodeling/Geostat.		Basic Modules				Advanced Modules				Applied Modules
	Geomodeling	Geomod. Fundam. 1 Context,Terminology& Essent Stat	Geomod. Fundam. 2 Estimation/ Kriging Stoch.Simul	Geomod. Fundam. 3 Generaliz. Subsurface Workflows	Geomod. Fundam. 4 Generaliz. Subsurface Workflows					
	Geostatistics	Geostat. Intro. 1 Essential statistic and terminology	Geostat. Intro. 2 Geostatis-tical Estimation	Geostat. Intro. 3 Geostatis-tical Simulation	Geostat. Intro. 4 Facies Simulations	Petroleum Geostat. 1 Hands-on	Petroleum Geostat. 2 Hands-on	Petroleum Geostat. 3 Hands-on	Petroleum Geostat. 4 Hands-on	

MODULES DESCRIPTIONS

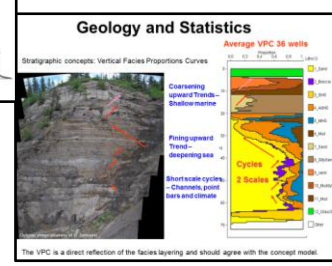
Basic

Geomodeling Fundamentals Modules 1-4

Geomodeling today is integral to a successful business strategy in many hydrocarbon reservoirs. The sub-surface team uses the Geomodel to render the geologic interpretation into a digital format suitable for input to reservoir simulation software, well planning, uncertainty analysis, volumetrics, and a variety of decision making processes. A key goal in the Geomodeling practice is to provide an image of reservoir heterogeneities critical to better understanding the physical hydrocarbon extraction processes and resource. Geomodels help reveal the impact of the various reservoir multi-scale features on dynamic behavior.



Experts: David Garner, TBD



The course subjects cover a broad scope of geomodeling applicable to offshore, onshore mature, unconventional and oilsands reservoirs. The course intent is to provide grounding in geomodeling thought process, and to place high level topics into their basic integrated context. By the end of the course, each topic will have been defined and discussed and related to general workflows with examples. Additional reading material will be listed in the notes.

Basic *Module Mod_BM_1.1*

Geomodeling Fundamentals Module 1

- Generalized workflow guidelines
- Background for exploratory data analysis
- Regionalized variables
- Univariate statistics-measures of position, shape, spread, box plots
- Bivariate Statistics, Normal Score transform, Facies Proportions
- Quantifying spatial variability through Variography; Theory, Practice, Tips

Overview of Geostatistics: Context, terminology and essential statistics for a foundation Geomodeling and the multi-disciplinary team

Basic *Module Mod_BM_1.2*

Geomodeling Fundamentals: Module 2

- Estimation techniques for 2D mapping and 3D models
- Kriging theory: simple, ordinary, and by hand with a variogram model;
- Kriging weights, Cross validation, stationarity
- Simulations of continuous variables, trend models
- Facies Simulations methods-algorithm overviews, strengths, weaknesses
- Transition Probabilities

Overview of Geostatistics: Estimation, kriging, and stochastic simulation methods as grounding in techniques

Basic *Module Mod_BM_1.3*

Geomodeling Fundamentals Module 3

- Hierarchical Methodology
- Structural/Stratigraphic Framework; Gridding;
- Facies and Petrophyiscal Preparation, quality and issues; Electrofacies;
- 1D to 3D Facies Proportions workflows, trends and seismic integration
- Property modeling topics: trends, measurement scale, percolation, volumetrics and best practices; Checking results; Examples

Generalized subsurface workflows and practice

Basic *Module Mod_BM_1.4*

Geomodeling Fundamentals: Module 4

- Upscaling and Downscaling Methods; unique variables, issues
- Post Processing and Uncertainty; Decision Making and Reservoir Management;
- Volumetric uncertainty, bias and accuracy;
- Net Pay, Local Connectivity, Ranking; Well placement;
- Proxies for Direct Performance Prediction: Physical, Statistical, from 3D models to 2D map resource areas;
- Statistical Play Forecasting & Mapping

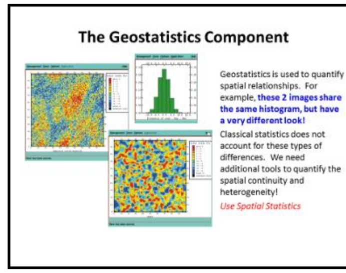
Generalized subsurface workflows and practice

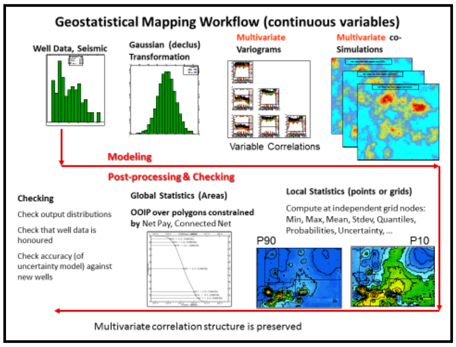
Basic

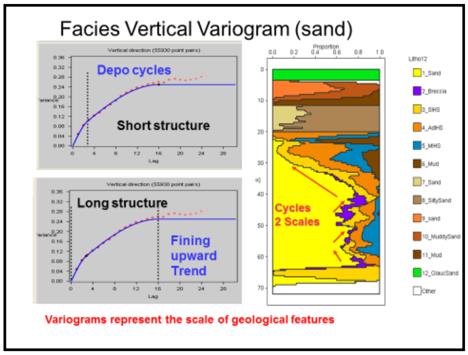
Geostatistics Introduction Modules 1-4

Experts: David Garner, TBD

Geostatistics is the mathematical engine of spatial data analysis and geomodeling. Spatial data used by subsurface teams in the hydrocarbon industry is information with a location, i.e., data with coordinates. Dominant uses of geostatistics in the industry are mapping, integrating diverse variables, building geomodels, and resource evaluation. Uncertainty is a fundamental topic because the applications are stochastic and the data provide a sparse or imprecise sampling of reservoirs. Geostatistical theory and current best practices are explained along with a variety of practical tips. Uses of probabilistic results are illustrated and discussed. Context for the subsurface team is given to improve communication across disciplines. Gaps in commercial software are noted.







Lecture Based Training

Overview of Theory and Practic

Basic

Geostatistics Introduction Module 1

Module Stat_BM_2.1

Purpose: Background for exploratory data analysis and preparing for mapping and modeling.

Essential statistics and terminology

- Regionalized Variables: Data Types, definitions
- Univariate Statistics: Measures of position, spread, and shape; proportions, stationarity, proportional effect
- Box plots, Q-Q plots
- Bivariate Statistics: Covariance and correlation
- Quantifying Variability/Spatial Continuity: Variograms- experimental, anisotropy; hand calculations; variogram maps; Behaviour and Tips
- Variogram Models: illustrations; nested, issues, fitting tips and tricks

Basic

Geostatistics Introduction: Module 2

Module Stat_BM_2.2

Geostatistical Estimation

- General estimation techniques
- Kriging: simple and ordinary; Kriging by hand with a variogram model; Kriging weights, Cross validation, stationarity
- Multi-variate: Co-Kriging; collocated co-Kriging; Kriging with External Drift;
- Trends in data: handling non-stationarity
- Case examples with mapping
- Geostatistical Depth conversion introduction

Basic

Geostatistics Introduction Module 3

Module Stat_BM_2.3

Simulation

- Simulation versus Estimation concepts
- Conditional Simulation; random walk and search neighbourhood
- Sequential Gaussian Simulation processes
- Trends and secondary data
- Post-processing topics: probabilities and uncertainty; volumetrics
- Checking results

Basic

Geostatistics Introduction: Module 4

Module Stat_BM_2.4

Facies Simulations

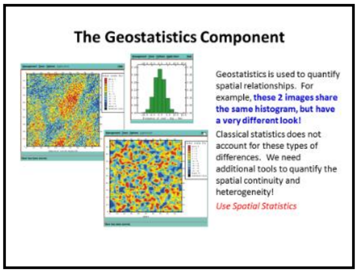
- Facies inputs: Visual versus Electrofacies; scale and checking
- Stochastic Methods summary
- Stratigraphic coordinate systems,
- Facies trend modeling: 1D to 3D proportions; integration of seismic attributes
- Object methods-summary
- Pixel methods: Illustration of algorithms for Truncated Gaussian, Sequential Indicator simulation, Multiple Point Statistics, Truncated Pluri-Gaussian
- Post-processing and checking results: summarizing uncertainty, probabilities, volumetrics,

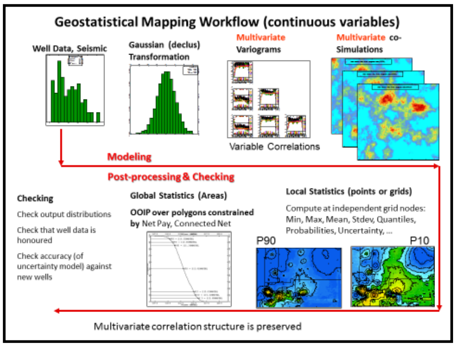
Advanced

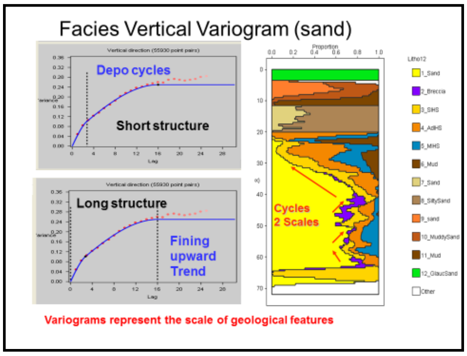
Geostatistics Fundamentals
Modules 1-8

Geostatistics is the mathematical engine of spatial data analysis and geomodeling. Spatial data used by subsurface teams in the hydrocarbon industry is information with a location, i.e., data with coordinates. Dominant uses of geostatistics in the industry are mapping, integrating diverse variables, building geomodels, and resource evaluation. Uncertainty is a fundamental topic because the applications are stochastic and the data provide a sparse or imprecise sampling of reservoirs. Geostatistical basic theory and best practices are explained along with a variety of practical tips. Uses of probabilistic results are illustrated and discussed. Context for the subsurface team is given to improve communication across disciplines. Gaps in commercial software are noted.

Experts: David Garner, TBD







Lecture Based Training Overview of Theory and Practice Combined with Computer Based Training

Toolkit: Isatis by Geovariances
Hands-on exercises to advance the theory and practical learnings.
Learnings are transferable to geomodeling software packages.

Advanced

Module PStat_AM_3.1 -3.2

Petroleum Geostatistics
Modules 1 & 2

Essential statistics and terminology

1.1 Background for exploratory data analysis and preparing for mapping and modeling

- Theory of Regionalized Variables and stationarity: Data Types, definitions
- Univariate Statistics: Measures of position, spread, and shape;Box plots, Facies proportions
- Bivariate Statistics: Covariance, correlation, Q-Q plots, Normal score transforms, Principal components

1.2 Quantifying spatial variability/continuity through Variography

- Experimental variograms: hand calculations, anisotropy, variogram maps, behaviour, sensitivity to outliers
- Model variograms: Terminology, illustrations of structures, nesting, anisotropy, issues of trends; calculation, fitting tips, tricks, impact of choices

Advanced

Module PStat_AM_3.3 -3.4

Petroleum Geostatistics
Modules 3 & 4

Geostatistical Estimation

1.3 Estimation techniques for 2D mapping and 3D models

- General estimation techniques
- Kriging: simple and ordinary; Kriging by hand with a variogram model; Kriging weights, Cross validation, stationarity assumptions; Anisotropy, Block Kriging, support (scaling) effect

1.4 Multivariate estimation

- Multi-variate: Co-Kriging; collocated co-Kriging
- Trends in data: handling non-stationarity, Kriging with External Drifts-Universal Kriging
- Introduction to Geostatistical Depth conversion

Advanced

Module PStat_AM_3.5 -3.6

Petroleum Geostatistics
Modules 5 & 6

Geostatistical Simulation

1.5 Introduction to stochastic simulation theory and practice for continuous variables

- Simulation versus Estimation concepts, purpose and comparisons
- Conditional Simulation methods; random walk and search neighbourhoods
- Sequential Gaussian Simulation type processes

1.6 Post-processing and uncertainty management topics

- Calculating probabilities, volumetrics with constraints, uncertainty assessment over polygons or pads, ranking
- Simulation with trends, univariate and secondary data, e.g. seismic attributes;
- Checking results practices

Advanced

Module PStat_AM_3.7 -3.8

Petroleum Geostatistics
Modules 7 & 8

Facies Simulations

1.7 Preparation for Facies-type simulations

- Facies inputs: Visual versus Electrofacies; scale, petrophysical consistency, transition probabilities
- Stratigraphic versus structural coordinate systems
- Facies trend modeling 1D to 3D, Integration workflows using Seismic data for facies proportions

1.8 Stochastic Facies Simulation Methods Overview and Practice

- Object methods-brief summary
- Pixel- four methods: Illustration and application of algorithms for Truncated Gaussian (TG), Truncated Pluri-Gaussian (PGS), Sequential Indicator Simulation (SIS), Multiple Point Statistics (MPS)
- Post-processing topics and checking results: summarizing uncertainty, probabilities, volumetrics, ranking and choosing, entropy

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