Summary
This field seminar explores faulting and fracturing processes in Cretaceous carbonate and shale strata in central and west Texas, with a particular emphasis on excellent exposures of the Eagle Ford and equivalent Boquillas Formations. It examines factors that influence the style and intensity of faulting, folding and fracture development from map to fault block scale and the relationship between fracture spacing and mechanical layering.

Learning Outcomes
Participants will learn to:

1. Perform structural interpretations using the basic concepts of faulting, fracturing and mechanical stratigraphy.
2. Assess the role of mechanical stratigraphy and stress conditions on fracture and fault formation in carbonate and shale strata.
3. Evaluate deformation mechanisms that operate in fault zones.
4. Evaluate complex structures like those that control hydrocarbon migration and trapping in carbonate petroleum provinces around the world. The course concentrates on extensional fault systems and contractual structures, with a minor component on strike-slip deformation.
5. Evaluate maps and cross sections that are based on available data and are consistent with structural styles, rules and relationships appropriate for the structural regime, stratigraphic setting and deformation conditions.
6. Assess the relationship between faulting and associated folding.
7. Evaluate many of the fault system features they will encounter during interpretation of seismic and well data in the context of field examples they will observe.
8. Develop an understanding of the regional tectonic setting, stratigraphy and development of central and west Texas.
9. Assess structural styles to be expected in the Eagle Ford Formation, and relate deformation features to mechanical stratigraphy and structural position.

Duration and Training Method
A seven-day field seminar starting in San Antonio, Texas, and ending in Midland, Texas. The proportion of field time to classroom time is about 95:5.

Physical Demand
The physical demands for this class are MODERATE according to the Nautilus Training Alliance field course grading system. Fieldwork is in the Hill Country near San Antonio, where conditions are typically warm-hot and humid, and in west Texas, where the climate is warm-hot and dry. Participants will be taking short to moderate hikes (less than 3.2 km (2 miles) each) over flat to hilly terrain with a maximum
elevation change on a hike of 200 m (660 ft). Transport is by SUVs. Most driving is on black-top roads, but some outcrops are reached via well marked dirt roads. The total driving distance on this course is about 1600 km (1000 miles).

Who Should Attend
The course is aimed at geoscientists, petrophysicists, reservoir engineers, and production engineers working in mechanically layered, deformed rocks especially carbonates and shales in extensional or contractional tectonic settings. It will be of particular interest to any geoscientists, petrophysicists and engineers working in the Eagle Ford play.

Prerequisites and Linking Courses
Familiarity with structural geology concepts would be an advantage but is not essential.

An introduction to structural geology is presented in N016 (Structural Geology for Petroleum Exploration, Nevada, USA), N116 (Structural Geology for Petroleum Exploration, SW England, UK), N041 (Extensional Tectonics and Normal Fault Patterns, Utah, USA), N114 (Extensional Tectonics and Normal Faulting, Nevada and California, USA) and N231 (Understanding, Evaluating and Managing Fractured Reservoirs, includes Core Workshop). The role of structural geology in shale resource plays is examined at the Basic Application level in N259 (From Outcrop to Subsurface: Understanding and Evaluating Shale Resource Plays, Alberta, Canada). The structural geology of resource plays is covered at a Skilled Application level in N206 (Seismic Tools for Unconventional Reservoirs), N279 (Geological Characterization and Engineering of Unconventional Oil and Gas Shales) and N364 (Fracture Architecture, Sedimentology and Diagenesis of Organic-rich Mudstones of Ancient Upwelling Zones with Application to Naturally Fractured Reservoirs, California, USA).

Course Content
This course provides in-depth analysis of faulting and fracturing in carbonate and shale strata using superb exposures in central and west Texas. The outcrops offer analogs for deformation in carbonate reservoirs and shale resource plays around the world. It concentrates on extensional fault systems and contractional structures, with a minor component on strike-slip deformation features.

Particular emphasis will be placed on the Eagle Ford and equivalent Boquillas formations from the San Antonio area through to Del Rio and Big Bend National Park. Excellent exposures provide the opportunity to explore the range of depositional facies and diverse tectonic regimes that influence the style and intensity of faulting, folding and fracture development in this important resource play.

The course covers a range of scales from regional fault networks to details of fault block deformation, relay ramp development and fault zone processes. It also examines relationships between fracture spacing and mechanical layering, including bed thickness.
Introductory lectures set up the regional geology and cover basic concepts of faulting and deformation mechanisms.

Day 0
- Arrive in San Antonio, Texas

Day 1
- Introductory lectures on regional geology and basic concepts of faulting, fracturing and mechanical stratigraphy
- Afternoon field trip to nearby outcrops of Cretaceous carbonate and shale strata (including the Eagle Ford Formation) in the Balcones fault system
- Spend night in San Antonio, Texas

Day 2
- Hidden Valley fault (Canyon Lake Gorge) – seismic-scale normal fault with world class exposure of subseismic-scale fault zone deformation features
- Spend night in San Antonio

Day 3
- Drive from San Antonio to Del Rio, Texas; visit outcrops of the Eagle Ford Formation and equivalent Boquillas Formation and underlying Buda Formation and overlying Austin Chalk in order to study structural style in different facies and mechanical units
- Spend night in Del Rio, Texas

Day 4
- Drive from Del Rio to Marathon, Texas; discussion of various geological features along the route; stops to discuss contractional folding west of Del Rio including outcrops of the Eagle Ford (and equivalent Boquillas) Formation and overlying and underlying units and relationship of fracturing to regional structural setting, stress field, and mechanical stratigraphy. If time permits, will stop west of Sanderson to discuss Marathon fold-thrust belt exposed as a window through the Cretaceous cover
- Spend night in Marathon, Texas

Day 5
- Marathon fold-thrust belt structures (Simpson Springs/Bourland Mountain anticlinorium/synclinorium pair)
- Black Gap Wildlife Management area – Big Brushy Canyon monocline, Heath Canyon relay ramp,
Stillwell Canyon relay ramp developed in the Cretaceous carbonate and shale section
- Contractional folding at Persimmon Gap
- Spend night in Marathon or Chisos Basin, Texas

Day 6
- Big Bend National Park – study contractional folding, thrust faulting, extensional faulting, and extensional fracturing in the Eagle Ford equivalent Boquillas Formation at Ernst Tinaja; normal fault relay ramp development at Cuesta Carlotta; strike-slip and normal faulting in Cretaceous limestones at Boquillas Canyon
- Spend night in Chisos Basin or Study Butte, Texas

Day 7
- Santa Elena Canyon normal fault zone and footwall analysis in Big Bend National Park
- End in Midland, Texas; stay overnight in Midland

Day 8
- Depart from Midland