



CSPG Short Education Course

Applied Structural Geology for the Western Canada Basin

Instructor: Marian Warren, Jenner GeoConsulting Inc. and Mark Cooper, Sherwood Geoconsulting Inc.

Location: CSPG Classroom, +15 level, 540-5 avenue SW, Calgary AB

Cost: Member Price - \$1725.00+gst
Non-Member Price - \$2325.00+gst

Date: February 7-9, 2023, | 8:30am-4:00pm

Course Overview

We offer this course with focus on applied first principles in structural geology, toward illustrating the role of structure and tectonics to influence depositional history, deformation features and fluid flow specifically in the Western Canada Basin. The main emphasis is on hydrocarbon plays; however, many of the principles are equally useful in hydrogeology, geothermal energy, and non-petroleum reservoir applications.

For industry in western Canada, the focus historically has been on exploitation of stratigraphic plays in the foreland basin, but increasingly we recognize that structural events through time, often subtle, have had a significant influence on components of many conventional and unconventional plays, including source/reservoir/seal deposition, trapping (both stratigraphic and structural), fracture character and distribution, and in-situ stress variations. We also recognize structures within the basin originating from different stress regimes and with potentially different implications, making their correct identification important: extensional, compressional, strike slip and inversion structures. Based on our combined many decades of industry and academic experience in western Canada and globally, we offer a practical and applied approach to structural geology, supported by abundant industry examples and case studies.

Course Format and Description

This workshop-style classroom course emphasizes using basic principles toward correctly identifying and interpreting a variety of structures at several scales (basin, play, prospect and reservoir), with practical petroleum exploration, development and production applications as the main illustrative examples. Integration and prediction between seismic and sub-seismic scales is also discussed. Fundamental concepts presented in lectures are supplemented with abundant seismic, well and outcrop examples from many petroleum provinces (including western Canada), detailed case studies from western Canada/USA and numerous short interpretation exercises. Main topics include:

- Introduction and brief review of fundamental concepts and terminology
- Overview of the tectonic and structural history of the Western Canada Basin
- Extensional fault systems, interpretation techniques and petroleum considerations
- Compressional systems, interpretation techniques and petroleum considerations
- Tectonically inverted structures and petroleum implications
- Fundamentals of strike-slip fault systems and petroleum implications
- Fault analysis techniques and predicting reservoir-scale deformation
- Basic principles of stress and geomechanics
- Characterization of naturally fractured reservoirs
- Detailed Western Canada Case Studies



Objectives

The main goals are:

- 1) to improve participants' interpretation skills by developing an understanding of structural geometry and evolution and applying appropriate structural models to better assess risks and opportunities. Participants who complete the course should be able to apply first principles to create structural interpretations or "sense-check" existing ones for first-pass viability, and recognize the potential petroleum (or other, e.g., hydrogeological) implications.
- 2) continue to raise awareness of the critical role of structural events in the WCSB and of their interaction with depositional processes, stress regimes, fluid flow and other commercially important elements of the basin.

Who should attend?

This course is aimed primarily at geologists and seismic interpreters, but some reservoir engineers and managers also find it useful. The course is designed for experience levels from new graduate to about 10-15 years, although geoscientists with up to 30 years of experience have found previous versions useful.



Image 1: Fracture intensity (spacing) varies with grain size, bed thickness and other parameters between two beds in a Montney-equivalent Triassic outcrop, Alberta (M. Warren)



Image 2: A faulted and fractured anticline outcrop, Pembrokeshire, UK, serve as a small-scale analog to subsurface trap complexities that are difficult to image seismically (M. Warren).

Instructor Biographies



Marian J. Warren holds undergraduate degrees in geology and astronomy/physics. She served as an astronomical observatory technician and Instructor in astronomy at Williams College, Massachusetts, before completing an M.S. in Geology at the University of Vermont and a PhD at Queen's University, Ontario, with a thesis in southern Canadian Cordilleran tectonics. She subsequently worked at EnCana in roles as geologist, seismic interpreter and structural specialist for WCSB and international/frontier projects, and successfully tested structurally influenced new plays in the Alberta basin. She also provided structural geology training courses for EnCana and served on domestic and international technical peer review committees.

Marian became an independent consultant in 2008 (Jenner GeoConsulting Inc.), to focus on exploration projects worldwide in structurally complex settings, and on developing and presenting industry training courses and field trips. Consulting projects within



the last few years have included assessments of components of naturally fractured plays and reservoirs in several locations in Europe, the Middle East and the Americas, as well as conventional fold-thrust exploration. Her consultancy was also affiliated with consultancy Rock Deformation Research in Leeds, UK (from 2009 until its sale in 2014), whose activities focused on characterizing reservoir-scale deformation and its impact on fluid flow. In addition to a traditional structural focus, however, Marian continues to develop her key interest in the interaction between structure and sedimentation, and the implications for commercial play elements.

Marian has been a co-recipient of the CSPG Medal of Merit, winner of the AAPG Matson Award, and she has served as an AAPG Distinguished Lecturer in North America. She is most recently a co-winner of the 2022 CSPG Pemberton award for best Core Conference presentation, featuring an integrated stratigraphic and structural approach to successful Mississippian exploration in the Alberta basin. She also now co-teaches with Mark Cooper a structural module for the University of Alberta Integrated Petroleum Geosciences MSc program.



Mark Cooper graduated with a B.Sc. geology degree from Imperial College, London in 1974 and with a Ph.D. from Bristol University in 1977. He taught geology at University College Cork prior to joining BP in 1985 to work on structurally complex basins based in London. Mark moved to BP Canada, Calgary in 1988 where he worked on exploration in the foothills including the successful Sukunka-Bullmoose gas play in NE British Columbia. Mark also worked for BP in Colombia on the team that drilled the discovery wells on the Cupiagua, Volcanera and Florena Fields.

In 1994 he joined PanCanadian and worked on the BC foothills, western Newfoundland, Quebec, the Gulf of Mexico, the Scotian Shelf and various international projects. He worked on frontier and international projects in Oman, Qatar, Yemen, Eastern Europe and Greenland after the merger that created EnCana in 2002 managing the Middle East and Global New Ventures groups for EnCana. Mark retired from EnCana as VP Middle East and Global New Ventures at the end of 2007 and now has his own consulting practice (Sherwood GeoConsulting Inc.) specializing

in International Exploration and Structural Geology.

A significant part of Mark's consulting practice is teaching professional training courses on the application of structural geology in petroleum exploration. Mark recently completed a study with Petrel Robertson for Geoscience BC on "Waste Water Disposal Montney Play BC." Mark also holds an Honorary Chair in Petroleum Geology at the University of Aberdeen. He has published over 50 papers, co-edited a book on Inversion Tectonics and has served as an advisory editor for the Journal of the Geological Society. He was a co-winner of the CSPG Link Award in 1997, served as an AAPG Distinguished Lecturer for 1999-2000, was a co-winner of the AAPG Matson Award in 2002 and was the recipient of a Distinguished Service Award from AAPG in 2014. Mark has been heavily involved with both the Canadian Society of Petroleum Geologists and the AAPG serving on committees in both organizations over the last 10 years. Mark was President of the CSPG in 2017. He also now co-teaches with Marian Warren a structural module for the University of Alberta Integrated Petroleum Geosciences MSc program.