MEWBOURNE COLLEGE OF EARTH AND ENERGY
RONNIE K. IRANI
CENTER FOR ENERGY SOLUTIONS
The UNIVERSITY *of* OKLAHOMA

Seismic Attributes for Resource Plays

(32 hours)

ABSTRACT

Seismic attributes are routinely used to map seismic geomorphology and reservoir quality. With the more recent focus on unconventional resource plays, seismic attributes are also being used to evaluate completion quality and potential drilling hazards. Geometric attributes such as coherence and curvature are invaluable in identifying geohazards from 3D seismic data. Curvature and aberrancy are direct measures of strain, which along with thickness and lithology can indicate the location and intensity of natural fractures. Prestack inversion for Young's modulus and Poisson's ratio (or equivalently for λρ and μρ) can be used (when calibrated against core and ECS logs) to estimate TOC and "brittleness". A more quantitative estimate of brittleness and completion quality requires the use of microseismic and production log data. Velocity and amplitude anisotropy, calibrated against image logs and microseismic data provide measurements of open natural fractures and the present-day direction of maximum horizontal stress that can be used to guide the placement of lateral wells.

Much of today's resource play drilling activity focuses on prioritizing properties, reducing costs, and holding acreage. As resource plays mature, we will want to identify bypassed pay and evaluate the benefits of restimulation. Geology, and hence seismic data and seismic attributes is only one of the components necessary to predict successful completion and estimate ultimate production. Conversely, while typically considered to be the driller's problem, we predict that seismic data and seismic attributes will be able to statistically identify areas of slower rate of penetration and number of bit trips.

In this course, we will gain an intuitive understanding of the kinds of seismic features identified by 3D seismic attributes, the sensitivity of seismic attributes to seismic acquisition and processing, and of how 'independent' seismic attributes are coupled through geology. Attributes are only as good as the data that goes into them. For this reason, we will also address components of seismic acquisition, reprocessing, and data conditioning. We will review a sufficient amount of theory for inversion, bandwidth extension, cluster analysis, and neural networks to elicit the implicit assumptions made using this these technologies. Advanced knowledge of seismic theory is not required; this course focuses on understanding and practice.

Concepts and algorithm description will be general, but workflows will be illustrated through application to the Barnett Shale, Woodford Shale, and Mississippi Lime resource plays. Case studies will discuss workflows for Vaca Muerta Shale, Utica Shale, Bone Spring and Wolfcamp Shale and the Duvernay Shale resource plays.

COURSE OUTLINE

A Short Overview of Spectral Decomposition

A very brief overview of spectral decomposition, which is commonly used in conjunction with elastic inversion attributes to break out lithofacies. Summary of assumptions made in bandwidth extension and Q estimation.

A Short Overview of Geometric Attributes

A summary of volumetric coherence, amplitude and structural curvature, reflector shapes, lineaments, reflector rotation and convergence

Attribute Prediction of Fractures and Stress

Correlation of curvature, impedance, and seismic anisotropy to natural fractures and stress orientation.

Statistical multiattribute analysis

Fundamentals of geostatistics, including colocated cokriging

Unsupervised Multiattribute Classification

Workflows that identify seismic facies without prior interpreter control such as k-means, principal components, self-organizing mapping, and generative topographic mapping

Supervised Multiattribute Classification

Workflows that use well control or interpreter-defined polygons to predict specific seismic facies including probablilistic neural networks, random forest decision trees, and convolutional neural networks

Inversion for Acoustic and Elastic Impedance

A hierarchal overview of inversion - emphasizing the assumptions and interpreter input to each process. If the audience is intimate with inversion, this part will be greatly compressed.

Seismic Data conditioning

Poststack footprint suppression and prestack data conditioning for inversion and anisotropy analysis

Attributes and hydraulic fracturing of shale reservoirs

Review of microseismic methods and the relationship of microseismic events to surface seismic measurements.

Case Studies

Discussion about characterization of shale formations in North America and Argentina

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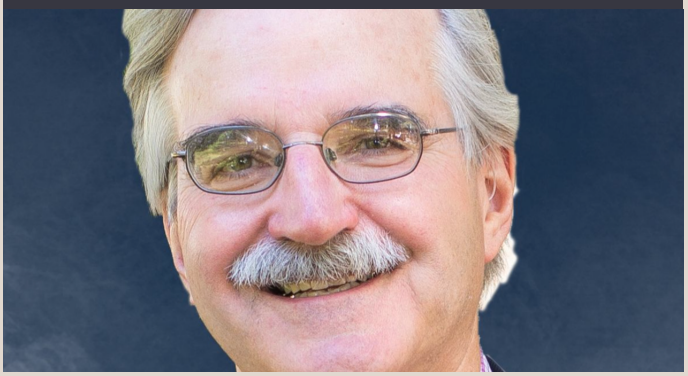

Kurt J. Marfurt , Ph.D.

Professor Marfurt joined The University of Oklahoma in 2007 where he serves as the Frank and Henrietta Schultz Professor of Geophysics within the ConocoPhillips School of Geology and Geophysics. Marfurt's primary research interest is in the development and calibration of new seismic attributes to aid in seismic processing, seismic interpretation, and reservoir characterization. Recent work has focused on applying coherence, spectral decomposition, structure-oriented filtering, and volumetric curvature to mapping fractures and karst with a particular focus on resource plays. Marfurt earned a Ph.D. in applied geophysics at Columbia University's Henry Krumb School of Mines in New York in 1978 where he also taught as an Assistant Professor for four years. He worked 18 years in a wide range of research projects at Amoco's Tulsa Research Center after which he joined the University of Houston for 8 years as a Professor of Geophysics and the Director of the Allied Geophysics Lab. He has received SEG best paper (for coherence), SEG best presentation (for seismic modeling), as a coauthor with Satinder Chopra best SEG poster (one on curvature, one on principal component analysis) and best AAPG technical presentation, and as a coauthor with Roderick Perez Altimar Interpretation best paper (on brittleness). Marfurt served as the 2006 EAGE/SEG and as the 2018 SEG Distinguished Short Course Instructor (on seismic attributes). He has served as Editor in Cheif and currently serves as Deputy Editor in Cheif for the AAPG/SEG Journal Interpretation.

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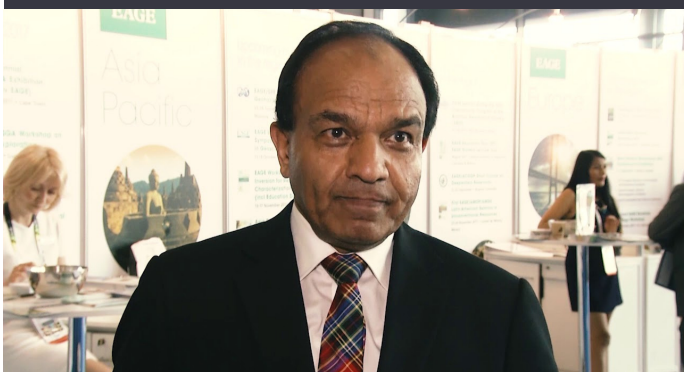

Satinder Chopra

Satinder Chopra received M.Sc. and M.Phil. degrees in physics from H. P. University, Shimla, India. He joined Oil and Natural Gas Corporation Limited (ONGC), the leading national oil company of India in 1984 and served there till 1997. In 1998 he joined CTC Pulsonic at Calgary, which later became Scott Pickford and Core Laboratories Reservoir Technologies. In November 2004 he joined Arcis Seismic Solutions, Calgary, which in turn was bought by TGS in 2012. He worked at TGS, Calgary as Chief Geophysicist (Reservoir) till July 2020. In September 2020, Satinder started his own company, SamiGeo Consulting Ltd., and now offers Reservoir Characterization services to the oil and gas industry.

Satinder has 36 years of experience as a geophysicist specializing in the special processing, and interactive interpretation of seismic data. He has rich experience in processing various types of data such as vertical seismic profiling, well log data, and seismic data, as well as excellent communication skills, as evidenced by the several presentations and talks delivered and books, reports, and papers written. He has been the 2010–2011 CSEG Distinguished Lecturer, the 2011–2012 AAPG/SEG Distinguished Lecturer, and the 2014–2015 EAGE e-Distinguished Lecturer. At present, he is the editor of the AAPG Explorer Geophysical Corner, and the 'Canadian Journal of Exploration Geophysics'. His research interests focus on techniques that are aimed at characterization of reservoirs. He has published eight books and more than 480 papers and abstracts and likes to make presentations at any beckoning opportunity. His work and presentations have won several awards, the most notable ones being the EAGE Honorary Membership Award (2017), CSEG Honorary Membership (2014) and Meritorious Service (2005) Awards, 2014 APEGA Frank Spragins Award, the 2010 AAPG George Matson Award and the 2013 AAPG Jules Braunstein Award, SEG Best Poster Awards (2007, 2014), CSEG Best Luncheon Talk award (2007), and several others. He is a member of SEG, CSEG, CSPG, EAGE, AAPG, and APEGA (Association of Professional Engineers, Geologists, and Geophysicists of Alberta).