Integrated Depth Mapping of the Stone Corral from 3D Seismic and Well Control in Dickman Field, Ness County, Kansas

Jennifer Califf

Section I: Executive Summary
The Stone Corral Formation, in Dickman Field, Kansas, shows a depression in the same region as a channel in the top of the Mississippian Limestone about 2000 feet below. The goal is to determine whether or not this channel feature is causing a depression in the Stone Corral.

First, the Stone Corral anhydrite, the Mississippian Limestone, and the Viola Limestone (the base of the Mississippian Limestone) were interpreted from a seismic project. After careful examination of geophysical log data, time-depth pairs for each well were used as control points to convert the time structure maps to depth. There is a depression in the Stone Corral that correlates to the channel feature in the Mississippian Limestone in both time and depth domains.

The same procedure was completed for the Fort Scott Limestone, which lies about 100 feet above the Mississippian Limestone. The Fort Scott also shows traces of the channel depression. It is possible that differential compaction of sand and shale in the Mississippian channel is causing relative depression in the beds above, up to and including the Stone Corral Formation.

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3D Petrophysical Modeling Usning Complex Seismic Attributes and Limited Well Log Data
Mehdi Eftekhari Far, and De-Hua Han, Rock Physics Lab, University of Houston

Summary
A method for 3D modeling and interpretation of log properties from complex seismic attributes (obtained from 3D post stack seismic data) is developed by integrating Principal Component Analysis and Local Linear Modeling. Complex seismic attributes have non-linear relationships with petrophysical properties of rocks. These complicated relationships can be approximated using statistical methods. This method has been tested successfully on real data sets with different lithology and geology settings. Log properties (sonic, gamma ray density etc.) were predicted at the location of the second well (blind well test). It has proved to work with limited log information (data from one well) whereas conventional methods, such as geostatistics, used for this purpose need well log information from several wells to correlate seismic and well data. Once the performance of the model is verified by blind well test, 3D log volumes can be calculated from 3D seismic attribute data.

Rock physics theory and available core and well log information can be used to define rock physics templates (RPTs). Using RPTs, the modeling results of the statistical method are interpreted and also uncertainty of predictions is quantified at places with no well control, in a meaningful way, by considering predictions of different log types simultaneously.

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Energy reassignment of an image for improved dispersion curve picking
Petroleum Geophysics, MSc., Cohort 9.1, University of Houston
Director, Don Van Nieuwenhuis, PhD
Advisor, Chris Liner, PhD
Craig Hyslop

Section I: Executive Summary
The energy reassignment imaging (ERI) technique proposed in this paper improves image processing and picking within a surface-wave noise mitigation suite GRB-3D (Ground Roll Buster 3D), developed by Sunwoong Lee and Warren Ross (Lee et al., 2008). GRB-3D is specifically designed to mitigate surface waves in spatially inhomogeneous media by aligning the surface waves, thereby separating them from seismic reflections, using phase matching techniques and dynamic phase-velocity estimates. This paper presents a brief examination of dispersive surface waves to provide background for both GRB-3D and ERI. The ERI technique is applied early in the GRB-3D operation flow to the image of dispersive surface-wave energy in the frequency-slowness domain. Subsequently, the algorithm used by GRB-3D to image the dispersive energy is briefly explained and a discussion is presented on the complications of imaging dispersive energy in heterogeneous areas. The basic theory behind ERI is presented and ERI is shown to improve the phase-velocity estimates from the frequency-slowness domain. To protect the interests of ExxonMobil and illustrate the operation of GRB-3D and ERI a derived dataset created from field data is used. Development for ERI was done at the ExxonMobilUpstream Research Company.

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Volume Viscosity
Ayoto Kato

Summary:
Viscosity can play an important role in the study on elastic properties of heavy oil (e.g. Han et al., 2008a). At lower temperatures than the glass point, heavy oil acts as a solid material due to its high viscosity (> 1015 cp). At higher temperatures than the liquid point, viscosity is low enough (< nearly 103 cp) so that its effect on velocity can be neglected; it acts as an elastic material like standard liquid. In between these two regions, it acts as a viscoelastic material (so-called quasi-solid state), where wave propagation is strongly dispersive with high attenuation.

Heavy oil in the quasi-solid state has a finite shear modulus induced by shear viscosity. On the other hand the corresponding bulk modulus also significantly increases as compared to conventional oil, which results from additionally induced bulk modulus by the volume viscosity (also called bulk viscosity or second viscosity). The volume viscosity has been considered to have mechanisms such as the molecular rearrangement or the internal mobility (e.g. Litovitz and Davis 1964). However, because accurate measurement is difficult, there is very limited literature concerning the volume viscosity of heavy oil (e.g. Taskoprulu et al. 1961). Thus, we focus on the volume viscosity of heavy oil to investigate the relationship between the shear viscosity and volume viscosity and its-induced bulk modulus.

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Elastic property changes in a bitumen reservoir during steam injection
AYATO KATO, University of Houston, USA
SHIGENOBU ONOZUKA, JOGMEC, Chiba, Japan
TORU NAKAYAMA, JAPEX, Tokyo, Japan

Summary:
The Hangingstone steam-assisted gravity drainage (SAGD) operation of Japan Canada Oil Sands Limited (JACOS) is approximately 50 km south-southwest of Fort McMurray in northern Alberta, Canada. JACOS started the operation in 1997 and has produced bitumen since 1999. The oil-sands reservoirs in Hangingstone occur in the Lower Cretaceous McMurray Formation and are about 300 m in depth. The sedimentary environments are fluvial to upper estuarine channel fill, and the oil-sands reservoirs correspond to vertically stacked incised valley fill with very complex vertical and horizontal distribution.

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Direct Imaging of Group Velocity Dispersion Curves in Shallow Water
Christopher Liner*, University of Houston; Lee Bell and Richard Vorm, Geokinetics

Summary:
Geometric dispersion is commonly observed in shallow water marine data due to post-critical multiples in the water layer over a hard seafloor. Characteristics of the guided waves include formation of distinct propagation modes and associated divergence of phase and group velocity. Methods have been available since 1981 to image phase velocity dispersion curves. Here we report a method to directly image the group velocity curves.

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Seismic reflection study in fluid-saturated reservoir using asymptotic Biot’s theory
Yangjun (Kevin) Liu* and Gennady Goloshubin, University of Houston, Dmitriy Silin, Lawrence Berkeley National Laboratory

Summary:
It is well known that amplitude variations of seismic reflected waves and energy loss are usually associated with fluid-saturated porous rock. However, to quantify such effects and predict the seismic signature generated by fluid saturation is a challenge. This paper presents some study on evaluating seismic response from fluid-saturated porous permeable rock due to the conversion from Fast P wave to Slow P wave using asymptotic Biot’s solution. Since fluid-saturated layer also shows high dispersion, frequency dependency is also taken into account. The difference between 0 Hz calculation and 100 Hz calculation represents the difference between the Gassmann’s theory and Biot’s theory. It can be seen that for homogeneous reservoir, there is no big difference between them, while for heterogeneous reservoir the difference can be as high as 10% of the average amplitude. The heterogeneity may be with respect to porosity, permeability and fluid phase between reservoir layers.
Asymptotic calculations of the Biot’s waves in porous layered fluid-saturated media
Yangjun Liu* and Gennady Goloshubin, University of Houston, Dmitriy Silin, Lawrence Berkeley National Laboratory

Summary:
Biot’s poroelasticity model predicts the existence of a slow compressional (diffusion) wave due to the relative flow of pore fluid with respect to the solid rock. This phenomenon opens an opportunity for investigation of fluid properties of the hydrocarbon-saturated reservoirs, in particular fluid mobility, from seismic amplitude. Low-frequency asymptotic description of the Biot’s model provides relatively simple form of reflection and transmission coefficients. In case of normal incident the coefficients only depend on impedance contrast and small dimensionless parameter that is a product of fluid density, viscosity and rock permeability. All parameters are measurable. The goal of the present study is to use asymptotic solution and propagator matrix method for investigation of the slow P wave effect on reflectivity of the porous layered fluid-saturated media.

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Imaging steeping beds, Beartooth Mountains, Montana
Tania Mukherjee

Summary:
The University of Houston conducted a geophysical field school during August 2009 at the Yellowstone Bighorn Research Association (YBRA) camp near Red Lodge, Montana. Part of the activity was to undertake a detailed geophysical study of the dipping strata near the YBRA camp. Borehole seismic and well logs, from two specially drilled shallow wells, plus a crossing seismic line were acquired. Well logs interpretation indicates a shallow layer (5m) of alluvium, a thicker carbonate layer, then a "redbed" or shaley sandstone. The VSP results indicate a P-wave velocity (Vp) for the carbonate of about 2600 m/s and an underlying (but younger) red-bed with a Vp of about 2800 m/s. From S wave traveltimes in the VSP, we estimate a Vp / Vs value of 2.2 for the limestone and 1.7 for the shaley unit. The velocities are similar in both the VSP data from two wells and a surface-wave inversion. The limestone shows an anomalously high gamma value, which might be due to uranium deposition. Initial interpretation shows the limestone-shale (redbed) encounter to be at 40 m and, from the borehole televiewer; the probable dip of the bed appears to be 45° towards the south.

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S-wave velocity from ground roll inversion: Source-receiver tests and statics
Soumya Roy* and Robert R. Stewart, University of Houston, Houston, TX - 77204

Summary:
Estimating a near-surface S-wave velocity (Vs) structure is important in providing a static solution for multi-component seismic analysis as well as for geotechnical purposes. We use the Multichannel Analysis of Surface Wave (MASW) method to delineate Vs in the near surface (Park et al., 1998; Xia et al., 1999). We applied the MASW method to seismic datasets acquired at the La Marque Geophysical Observatory at the University of Houston Coastal Center, Galveston County, Texas (Figure 1) in March, 2010. There were two major objectives of our study: 1) to test different sources (a 12 lb sledge hammer versus a truck-mounted accelerated weight drop) and various receivers (planted geophones versus a dragged land streamer) and 2) to determine the near-surface S-wave velocity structure in the area. Another goal is also to compare the resolutions of different dispersion curves created by MASW method for different settings and to investigate the consistency of results. The dispersion curves for the seismic lines with planted receivers have lower noise with compare to the land streamer data. Data from lines having planted geophones contain information from greater depth. One of the reasons is the better coupling of planted geophones. Velocity results are consistent though for both types of receivers for the very near surface (7-8m). Analysis shows that the S-wave velocity ranges from 120- 220m/sec for first 7-8m and increases up to about 500m/sec at a depth of 18-20m.

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Attenuation estimation with continuous wavelet transforms.
Shenghong Tai*, De-hua Han, John P. Castagna, Rock Physics Lab, Univ. of Houston.

Summary:
Seismic attenuation measurements from surface seismic data using spectral ratios are particularly sensitive to inaccurate spectral estimation. Spectral ratios of Fourier spectral estimates are subject to inaccuracies due to windowing effects, noise, and spectral nulls
caused by interfering reflectors. We have found that spectral ratios obtained using continuous wavelet transforms as compared to Fourier ratios are more accurate, less subject to windowing problems, and more robust in the presence of noise.

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Local frequency as a direct hydrocarbon indicator

Shenghong Tai, Charles Puryear, John P. Castagna, University of Houston.

Summary:
As a seismic wave propagates, it loses energy due to spherical divergence, scattering, intrinsic absorption and reflection at interfaces where rock properties change. The amplitude and frequency responses of the reflected seismic wave are influenced by a variety of factors including: geologic structure, layer thickness, lithology, and pore fluid properties. When the seismic wave travels back to the surface, it also bring back the information related to stratigraphic features, rock property changes and hydrocarbon accumulations. Each reservoir has its own characteristic seismic frequency response because of its unique rock and fluid properties discriminating it from the surrounding environment. We utilize a spectral decomposition method to extract the characteristic frequency components from seismic data and identify low frequency anomalies. To understand the underlying physical factors of the low frequency anomaly, we build a set of wave-equation based synthetic forward modeling. The result of our analysis shows that seismic waves travel more slowly through gas zone than the background material is a main reason for seismic time series delay and low frequency anomaly in the thin layer reservoir. Our explanation has been applied in the analysis of frequency anomalies corresponding to gas-bearing sands in the Gulf of Mexico fields.

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