# Practical Applications of the Ground-roll Inversion

***Soumya Roy***

Estimation of the near-surface shear-wave velocity structures is very important for different petroleum as well as non-petroleum purposes. Shear-wave velocities can be derived using the ground-roll inversion method. We have used the Multichannel Analysis of Surface Waves (MASW) method to estimate those velocities. This method is based on the frequency-dependent properties of the ground-roll. Once the high-resolution shear-wave velocity structure is estimated then it can be applied for various practical purposes. In this paper, some of those applications (density prediction; and statics estimation) have been presented. A proper knowledge of two important rock properties - seismic velocity and bulk density can be very helpful in estimating the reflection coefficients and hence generating synthetic seismograms. If density information is unavailable then it can be predicted by using Gardner's relation. We used a modified Gardner's relation to predict bulk densities from shear-wave velocities estimated from noninvasive ground-roll inversion method. Different types of seismic data sets have been used- i) Modeling data (numerical and physical modeling);and ii) Field data: Red Lodge, Montana, and the Meteor Crater, Arizona. Predicted densities are consistent with known values with maximum error of 0.5 gm/cc. We find exponential values for the modified Gardner's relation formula varying from 0.21 to 0.234 while the suggested value is 0.22. The prediction of bulk densities for varied materials maintains a confidence level of above 90 %. Another important application of the ground-roll inversion is the calculation of the simple shear-wave statics which can be used during the multicomponent seismic analysis. For highly complex, unconsolidated, low-velocity near-surface of the Meteor Crater site, the simple shear-wave statics are calculated which vary between 40 to 70 ms for a 45 m deep model. ■

# Oligocene Shortening in the Little Burro Mountains of SW New Mexico and its Tectonic Implications

***Donald W. Tomlinson, Peter Copeland, Thomas J. Lapen and Michael A. Murphy***

There are numerous well documented examples of Laramide-style shortening in SW New Mexico. Ranges such as the Big Hatchets and the Florida Mountains exhibit classic examples of Laramide thrust faulting. Unfortunately the youngest part of the stratigraphy for this region is Cretaceous, rendering it difficult to bracket the age of Laramide termination. From sparsely known Laramide ages in the region, it is suffice to note that Laramide shortening in SW New Mexico has proven to be more complex than most modeled interpretations are capable of deducing. Recent observations by Copeland et al. (2011) show that shortening is younger than 34.6 Ma in the Silver City Range of southwest New Mexico. This has important implications for the timing and nature of the switch from regional shortening to regional extension.

The Little Burro Mountains were targeted for further studies due to structural similarities with the Silver City Range (Paige, 1916). The stratigraphy of the Little Burros consists of a Prtoterozoic granite basement unconformably below Cretaceous Beartooth quartzite and Colorado shale. Unconformably above the Cretaceous units are a series of Tertiary volcanic rocks. They consist of andesite lavas and breccias succeeded by the tuff of Indian Peak and the tuff of Wind Mountain. A Tertiary basaltic andesite and fan deposits unconformably cap the tuff of Wind Mountain.

Field mapping focused on the Tertiary volcanic rocks and how they relate to the Laramide deformed Cretaceous beds. The results clearly show a monoclinal fold with an axial trace trending NW-SE. This corresponds with the structural style of Laramide for the rest of the region, which is generally agreed to be caused by a NE propagation of shortening (Bird, 1988; Seager, 2004). The Little Burro monocline displays modestly dipping beds of ~12° in the backlimb, which steepen to ~30° in the forelimb. Field evidence and trishear fault-propagation-fold modeling supports the idea that the broad interlimb angle of the Little Burro monocline is derived from a deeply rooted blind thrust fault. Normal faults run orthogonal to the axial trace of the fold with low displacement (10s of meters). They are interpreted to have formed from variations of shortening along strike of the thrust

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fault as well as accommodation of flexure in the structure. The youngest folded unit associated with shortening is the ash-flow tuff of Wind Mountain. A sample of this felsic tuff was dated by U-Pb on zircons using LA-ICPMS. Using Plešovice as a standard (Sláma et al., 2008), the age $Pd^{206}/Pd^{208}$ came out to 28.83 ± 0.46 Ma.

These results suggest Laramide-style shortening was active in the late Oligocene. Examples of rift-related extension and arc volcanism are known to pre-date this age (Mack, 2004; Chapin *et al.,* 2004; McIntosh *et al.,* 1991), suggesting that compressional shortening, arc volcanism and extension were all active in this region during the late Eocene and Oligocene. This complex regional tectonics can be explained by delamination of eclogitized continental lithosphere (Decelles *et al.,* 2009) followed by continued crowding of basal continental lithosphere from a shallow subducted Farallon plate.

# Integrated Seismic Texture Segmentation and SOM Cluster Analysis for Channel Delineation

***Malleswar Yenugu***

In recent years, 3D volumetric attributes have gained wide acceptance by seismic interpreters. The early introduction of the single-trace complex trace attribute was quickly followed by seismic sequence attribute mapping workflows. Three-dimensional geometric attributes such as coherence and curvature are also widely used. Most of these attributes correspond to very simple, easy-to-understand measures of a waveform or surface morphology. However, not all geologic features can be so easily quantified. For this reason, simple statistical measures of the seismic waveform such as rms amplitude and texture analysis techniques prove to be quite valuable in delineating more chaotic stratigraphy.

I coupled structure-oriented texture analysis based on the gray-level co-occurrence matrix with self-organizing maps (SOM) clustering technology and applied it to classify seismic textures. By this way, I expect that this workflow should be more sensitive to lateral changes, rather than vertical changes, in reflectivity. I applied the methodology to a 3D seismic survey acquired over Osage County, Oklahoma, USA. The results indicate that this method can be used to delineate meandering channels as well as to characterize chert reservoirs.

# Seismic Wavelet Phase Estimate

***Jiangbo Yu***

In this study we develop a seismic wavelet phase estimation procedure using a histogram matching technique that recovers the wavelet phase information from seismic data with the help of well logs. This method is compared with kurtosis phase estimation and optimum Wiener filter wavelet estimation methods. Limitations and assumptions of these three methods are discussed.

Histogram matching is a type of seismic wavelet estimation which extracts phase information based on the statistical properties of seismic data. Compared with other wavelet estimation methods – kurtosis phase estimation and optimum Wiener filter wavelet estimation, matching histogram can do the phase estimation without a super-Gaussian distribution assumption for reflectivity amplitude and won't be affected by timing relationship between seismic data and reflectivity from well log. The phase rotation is performed on the seismic deconvolution output in order to minimize the difference between the histogram of the amplitude of the reflection series from well logs and that of the seismic deconvolution output in a L2 sense. The phase rotation which renders the minimum misfit is considered as the phase of the wavelet. By doing this, no assumption is needed for the amplitude distribution of reflectivity series; non-minimum-phase wavelet can be extracted from seismic data.

Both synthetic seismic traces and real seismic traces are tested using those three methods. Histogram matching method could give phase estimation with error less than 20 degree even given with small amount of data, Gaussian distributed reflectivity and inaccurate timing relationship between well logs and seismic data.