Introduction to the special section on 'Seismic Attributes'

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Last month I attended the first joint-society (SEG, AAPG and SPE) technical conference for unconventional resources, named URTeC, held at Denver from August 12-14th. I made a presentation at this conference titled *'Some current workflows for shale gas reservoir characterization'*. The gist of my talk was that there are some key elements of a successful shale gas reservoir such as the *type of shale, its depth, thermal maturity, total organic carbon content, permeability, mineralogy and brittleness*. An optimum combination of these elements leads to an accurate estimate of the gas-in-place as well as the success of the completion and so higher productivity. For determination of brittleness from seismic data, I showed the application of the E-rho attribute, where *E* is the Young's modulus, and rho is the density. For moderate offset data we cannot estimate E by itself, but we can accurately estimate E-rho. For long offset data, we can often estimate density, which then can be used to compute E by itself. In principle, E-rho vs. Poisson's ratio templates contain the same information as lambda-rho vs. mu-rho, or P-impedance vs. S-impedance templates. However, our primary customers are the completion engineers, and much of their geomechanical experience is based on E vs. Poisson's ratio template. Finally, I briefly mentioned about some of the workflows aimed at computation of stress estimates by way of DHSR (differential horizontal stress ratio) (Sena et al., 2011), and closure stress (Goodway et al., 2010; Hunt et al.,2011), etc. More details on this work can be found in focus article 3 in this issue.

At the end of my talk, an individual from the audience got up and said that: "the E-rho attribute that I described is simply a scaled version of the mu-rho and lambda-rho attributes and so does not add anything new", and also that, "the workflow for determination of stress estimates from seismic data were simply a manipulation of the lambda-rho and mu-rho, and again there is no value addition, as far as the interpretation is concerned". Finally, he said that "by way of such manipulations, we tend to oversell the technology". I agree with the first two statements. Indeed, those working Tertiary less consolidated sediments in the Gulf of Mexico have long said that "lambda-rho vs. mu-rho" does not provide additional data than is seen in P-impedance vs. Poisson's ratio templates. Mathematically, this is also true. However, the discrimant between porous dolomite and tight limestone and brittle vs. ductile geomechanical behavior of mudrocks is more easily displayed in lambda-rho vs. mu-rho volumes. In hindsight I would now say that we can be accused of "overcommunicating the technology". When it comes to unconventional reservoirs, our primary customers are the engineers whose geomechanical training is in terms of E and Poisson's ratio. Indeed, both petroleum and civil engineers will use two values of the shear modulus and two values of Poisson's ratio to describe anisotropic materials. Should we expect them to translate Thomsen's anisotropic parameters epsilon, delta, and gamma to their domain of expertise?

Similarly, computation of stress estimates allows a convenient interpretation in terms of the direction of maximum horizontal stress, which in turn helps operators decide on drilling wells perpendicular to that direction, maximizing the likelihood of crossing fractures and so open up more of the shale surface area to production. Structural geologists model tectonic deformation in terms of vertical stress, S_v, maximum horizontal stress, S_H, and minimum horizontal stress, S_h. Given what the stress does to the overburden, S_v, one can use lambda-rho and mu-rho attributes to compute S_H and S_h. Pioneering work on computation of stress estimates from seismic data has been done by Goodway et al. (2010), Starr (2011) and Gray et al. (2012). Starr's work assumes the overburden stress gradient and pore pressure gradient as constants and estimates stress gradients from Poisson's ratio. Gray et al. (2012) demonstrate the estimation of DHSR from a knowledge of Young's modulus, Poisson's ratio and the material normal compliance. Goodway et al. (2010) describe the minimum closure stress equation wherein the minimum pressure required to open a fracture is related to the effective overburden pressure by the term ($\lambda/\lambda+2\mu$), which they refer to as the closure stress scalar. Display of each of these attributes conveys the distribution of the stress estimates which is directly interpretable and so meaningful.

Overselling? Yes we are all familiar with overselling but I believe for some of us, after spending so many years in the industry, we value what we share and offer. Out of our responsibility towards to the geophysical community and the expectation that is reposed in us, we would not make any presentation if we ourselves are not convinced of the true value that we are offering. Overcommunicating? Given the interdisciplinary nature of the unconventional business, we stand accused. Perhaps more importantly, though, the individual did not appreciate the profound importance of using the most apt term in the sense of utility and cross-disciplinary communication. This assessment of aptness may be troublingly subjective to some, but is a real issue when dealing with other professionals in other disciplines. To argue against the sublime usefulness of Young's modulus is akin to Thomsen's tilting at the windmill of Poisson's ratio in his famous article *Poisson was not a geophysicist*. Thomsen's argument, like the one of the critic of E-rho, did not appreciate how such data would be used and with whom.

One of the biggest dangers of overselling an idea or a technology is the rapid rise that will be followed by a rapid crash, when people become aware of the true value. Azimuthal anisotropy and shear wave splitting technologies suffered

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such a crash in the late 1980s when we realized that in many if not most surveys we were measuring changes in horizontal stress (S_H vs. S_h) rather than the intensity and orientation of natural fractures. Interestingly, today we are keenly interested in these latter estimates to guide our horizontal drilling programs.

In this issue of the RECORDER, we have three articles focused on different seismic attributes. In the first article entitled *'Seismic rock physics of bright amplitude oil sands – case study'*, the authors Nanda and Wason, discuss a classic bright spot analysis case study wherein two bright spot seismic anomalies on drilling tested normal grade oil, though they are usually associated with gas. Seismic rock physics analysis led the authors to some interesting inferences, the most significant one being that bright amplitude anomalies are unlikely to be caused by oil saturation.

Jarrod Dunne in his article entitled *'Geologic controls on seismic amplitudes'*, discusses the pitfalls in seismic amplitude interpretation, as a variety of geologic controls could influence the seismic amplitudes. He suggests that structured thinking around geologic controls could lead to quantitative predictions using AVO modeling or inversion techniques.

The third article entitled *'Current workflows in shale gas reservoir characterization'* by Chopra, Sharma and Marfurt, I have already discussed above and so will not repeat here.

I hope you enjoy reading these articles. ℞

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(With comments from Lee Hunt and Kurt Marfurt)

References

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