What do Engineers Need from Geophysicists in Shale Resource Plays?

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The greater Horn River Basin shale gas (and possibly oil) basin is one of Canada's exploitation frontiers. The greater Horn River Basin of northeast British Columbia is comprised on 3 major Devonian shale sub-basin areas designated as the Liard Basin, Horn River, and Cordova Embayment. This region is consider to be one of the best shale gas basins, because of favorable source rock, fractured shale styles, and located strategically in the north western portion of the Canada prolific petroleum region with a possible export into the Circum-Pacific's emerging industrial economies. Commercial exploitation of the HRB will depend on shale gas reservoir characterization integrating core, petrophysical model, microseismic passive seismology and 3-D seismic methodologies to support the engineer's need in drilling and development.

We have searched and attempted to exploit low permeability reservoirs for decades, and these reservoir styles have become an increasing important in terms of significant hydrocarbon production. We have found low permeability reservoirs in both clastic and carbonate sedimentary sequence style. As we have continued to attempt to exploit low permeability reservoirs the distinction between reservoir rock and source rock has been blurred. In the 21st century we are now chasing reservoir which are combinations of both source and reservoir rock characteristic, and in such reservoirs the migration path from the "hydrocarbon kitchen" to storage pore space is essentially non-existent. We search and exploit shale resource reservoirs because the source rock shale and low porosity reservoirs within the kitchen are often contain very large quantities of gas and light hydrocarbons in place. We also have found the principal problem in shale resource plays is not finding the hydrocarbons, but successfully exploiting the low permeability/low porosity reservoir characteristic. As such we (geophysicists) are faced more with an engineering exploitation problem than a classic exploration and discovery problem.

Historically, we have used 3-D geophysical images for wellbore steering to avoid perceived geological hazards or enhancements to reservoir production and exploitation. Although we find geo-steering an important technical application of 3-D seismic imaging; there are more technical applications which are often not implemented. We have more recently begun to utilize 3-D seismic image "attributes of curvature" as an indicator of fracture zone intensity variation and micro-faulting within the shale reservoir. Another common application we have implemented includes anisotropic velocity variation as an indicator of fracture zone intensity (or productive fairways) and subsurface stress distribution. We have noted that seismic elastic inversion techniques are used to distinguish between Poisson Ratio variations favorable to horizontal wellbore placement.

Presently, we are observing emergent workflow strategies that integrate large scale 3-D imaging with microseismic observations and petrophysical core data into a geo-mechanical model of the shale reservoir. In the past we have noted that attempts to characterize shale resource plays with core and petrophysical data only have often been misleading or insufficient in useful detail to exploit shale reservoir media. Although engineers and geologist routinely extrapolate core and petrophysical data observations critical information is often lost due to the relative scale of observations. When we examine core and petrophysical data our perspective is a micro-scale, and in contrast when we examine and interpret 3-D seismic data images a marco-scale description is rendered. Hence, our critical workflow path is integrating micro-scale with macro-scale observations, thus linking wellbore data files to macro-scale imaging concepts.

If we are to consider rock mechanics applications to resource plays then traditionally we utilize core lab and well log petrophysical measurements to calculate critical rock properties such as Poison's Ratio, Young's Modulus, and Rigidity. We describe a geo-mechanical stratigraphic layered model which is used as input parameters to hydraulic frac completion design.

These physical variables are used to characterize the resource reservoir matrix and probable reservoir seals. The knowledge is a critical scaling parameter to recognize the hydraulic footprint or SRV. Core samples provide useful physical property information, but the observations are linked closely with mineralogy and rock micro-fabric. Scaling of the core and cuttings information to regional or intra-well perspective has proven difficult unless multiple wellsites are sampled statistically. Petrophysical rock properties measure bedform characteristics within the wellbore environment, thus providing an in-situ perspective of elastic rock properties, but lack the information to characterize low frequency stress strain relationships, and ultimately "host rock" failure characteristics. Today we address some of these limitations with microseismic emissions and measure

- Frac Azimuth and Symmetry
- Frac Height, Wide, and Length
- Stimulated Reservoir Volume

contrasting with model predictions from micro-scaled data. On close examination we presently believe that microseismic emissions and the derived parameters are also correlated with 3D seismic imaging and inversion. Seismic imaging techniques such as 3-D wide azimuth (and more recently advances in 3-D mode converted waveform applications) have been shown to be good indicators of structural and in-stress styling, such as fracture patterns and minor faulting and localized stress heterogeneities. Further, when we calibrate 3-D seismic elastic inversions to wireline petrophysical sonic logging the earth is interpreted in terms of Lambda/Mu-Rho and ultimately Poison's Ratio, Young's Modulus, and Rigidity in a continuum of scale micro to macro.

Hence, an integrated workflow involving core, petrophysical data, microseismic emissions and 3-D seismic imaging and inversion concepts allows for a more robust effective and efficient exploitation of shale resource plays.

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