Extensive usage of well data beyond velocity modeling in seismic imaging

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Abstract

Linking geology and geophysics has been done for a very long time and is not a new concept. However, most of this work is being performed in interpretation and seismic attribute domain. The usage of well data to improve the seismic image is lagging, however, it is essential and must be addressed early in the seismic processing sequence and included in the seismic processing steps repeatedly throughout the imaging stream.

The main usage of wells in seismic imaging is in the velocity model building for pre-stack depth migration (PSDM) and to QC full waveform inversion (FWI) results. Both processes require velocities that are as accurate as possible. Besides this practice, well information is needed to determine the phase of the seismic, it assists in choosing more accurate attenuation (Q) values and can help identify multiple energy. This paper addresses the different usages of well information and its applications.

Applications

Seismic data are recorded in time but all exploration efforts are performed in depth and as such a valid time to depth conversion must be performed. The best method to achieve this is to migrate the seismic data in the depth domain. This can only be done successfully if a good velocity model is available. Well velocities that have been edited and smoothed are an essential component of any starting velocity model whether it's a conventional approach or a more sophisticated method like FWI. A velocity model that's being build with the input of validated well velocities will converge sooner and produce a better final migrated depth volume.

Figure 1 shows the link between geological strata and well log responses.

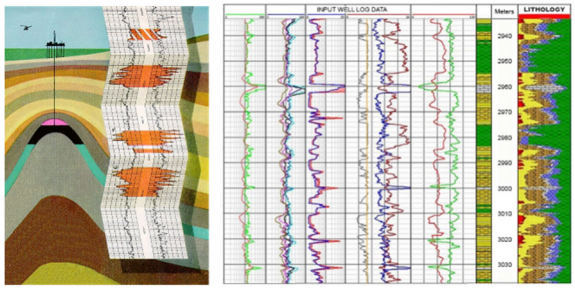

Figure 1: link between geology (left) and log information (right). Modified WIKKI image.

Besides using well information for velocity model building, well markers assist in determining the anisotropic value delta that's being measured by observing the mis-tie of the well markers with the horizons from the corresponding seismic event.

The phase of the seismic data can be determined by cross correlating synthetic seismograms obtained from well data created using wavelets that represent the seismic frequencies of the seismic data at well locations. Seismic data that have been converted to either zero or minimum phase are the key for a successful seismic interpretation. Those data are also essential as input to a seismic attribute analysis.

As seismic waves travel through the rock strata, the energy is attenuated and become weaker. An inverse Q compensation can be applied to account for the energy loss. Determining the amount of this compensation isn't straightforward and in general, various tests are performed to obtain the most accurate value. Applying inverse Q will also affect the phase of the data. Performing well ties before this application and after at a selection of well locations helps in understanding the impact and stability of this process.

Multiple attenuation is often a difficult task. Especially on-shore interbed multiples are nearly impossible to remove with conventional methods such as radon transforms, unless the multiple energy has significant moveout. In many instances, even determining the events that are not caused by primary reflectors can be very tricky. Zero offset synthetic seismograms are multiple free and can be compared with seismic data at the well locations. This is useful for two purposes; first it helps pinpointing the multiples and second it allows us to ascertain the data that have been removed by the de-multiple process and its source; primaries or/and multiples. Figure 2 displays a comparison of the well tie before the multiple attenuation process to the left and after to the right.

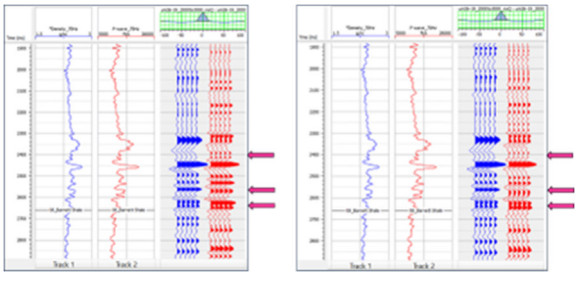

Figure 2: density and sonic log, synthetic seismogram repeated 5 times in blue, seismic data long well trajectory repeated 5 times in red and red arrows indicating possible multiple events. Left image displays the well tie using the input data to the multiple attenuation and the right image shows the same tie using the attenuated seismic image.

Conclusions

Geology and geophysics are linked and using both disciplines in the seismic processing methodologies yields better imaging results which then provides more accurate seismic data for mapping, attribute generation, drilling decisions, etc. This abstract goes beyond discussing the more commonly used applications of well data in this domain and highlights the need to push this further.

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