Some Workstation Techniques for Defining Reservoirs in Difficult Data Areas

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Seismic workstations now include a whole range of programs that define various seismic attributes and even do some actual wavelet processing. These processes can be used to some extent for reservoir evaluation where the current state of the art seismic techniques cannot be implemented.

Some areas of the world are notorious for low resolution seismic data and noise problems that preclude the use of amplitude versus offset approaches to reservoir determination. This is the case in the desert areas of North Africa that have a near surface configuration that to date has defied all attempts to acquire the high resolution and high fidelity seismic data necessary for direct reservoir evaluation.

The near surface is comprised of discontinuous highly reflective features, which generate high frequency and high amplitude lateral reflections. Underlying this is a section of high acoustic impedance carbonates and evaporites, which greatly attenuate the down going signal energy. This combination produces a seismic record that has high energy and high frequency lateral reflections superimposed on a low amplitude vertical reflection sequence.
The noise is omni-directional and therefore it is unlikely that noise attenuation techniques available can be used in a way that will preserve amplitudes in unstacked traces to the level that they can be used for amplitude versus offset investigations. This high energy and high frequency noise also has such a detrimental effect on the deconvolution process that the stacked data is usually limited in useable frequency content.

This precludes conventional approaches to mapping reservoirs, but reservoir evaluation is critical to field development, and any additional information that can be derived from the seismic data will help improve the development results. In addition to the normal function of workstations, there are several programs within the workstation suite designed for specific applications that can be used in a way that will yield some of this vital reservoir information.

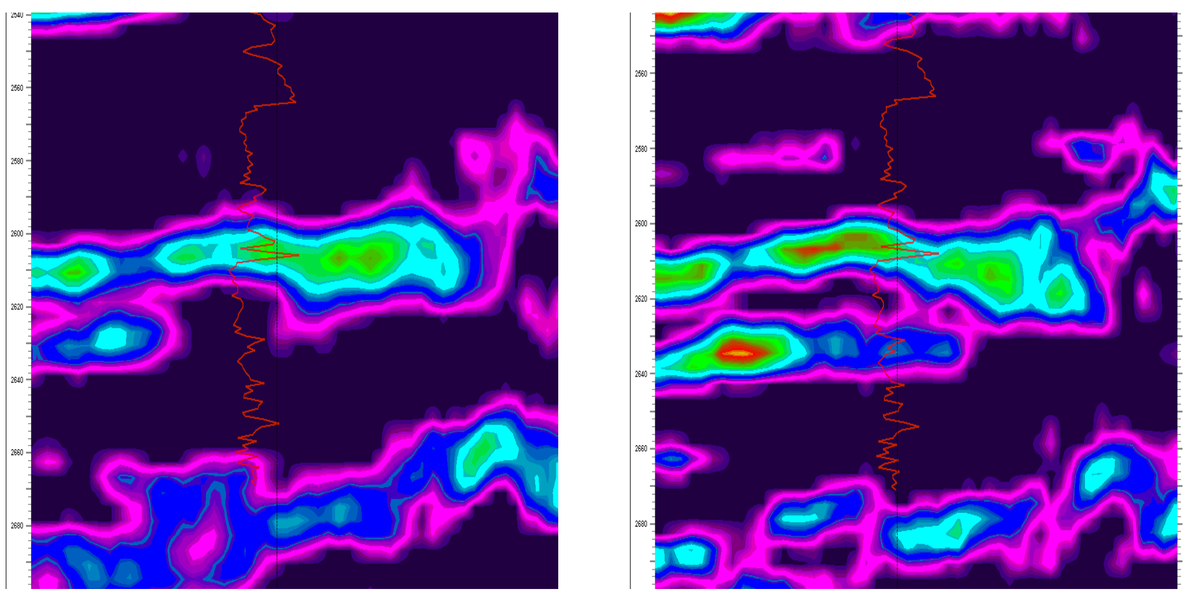
The key to this is not to think of measuring the reservoirs directly; but to identify the effect of the reservoir on the seismic data. In the simple case this can be time dilation caused by thickened low velocity material of the reservoir, but it can also be amplitude and character effects that can be mapped to give a bit more information about the reservoir and its distribution. 3D data provides the dimension of shape, and the use of colour displays allows very high amplification of very subtle changes. All that is necessary is to extract the subtle information, amplify the variances with colour, and display the resultant shapes.

Instead of measuring the reservoir properties directly from the seismic data, it is the morphology that is identified, calibrated to well data, and inferred reservoir properties are extracted from the shape and distribution of the reservoir. This process can generally define reservoir distribution, extent, and most importantly reservoir edges due to faulting or other terminating effects. The workstations have two sets of facilities that need to be brought into play in order to map reservoirs in this way.

The first facility is the ability to enhance the seismic data itself. The facilities available range from simple filtering and basic well ties that provide linear phase and amplitude corrections up to the equivalent of wavelet processing with such facilities as match filters. Sometimes all that is needed is the filtering off of dominant low frequencies allowing variations in amplitude in the higher frequency range to become more prominent. At the other extreme it may take a full blown spectral match as provided by the match filter to bring the data up to the level at which subtle variations can be mapped.

Essentially a VSP and the corresponding seismic data trace both have the same reflectivity sequence convolved with their respective wavelets. By matching the wavelet of the seismic data to the wavelet of the VSP the overall resolution of the seismic data can be improved, and just this process alone is usually sufficient to bring the data to the level that actual reservoir amplitudes can be mapped directly.

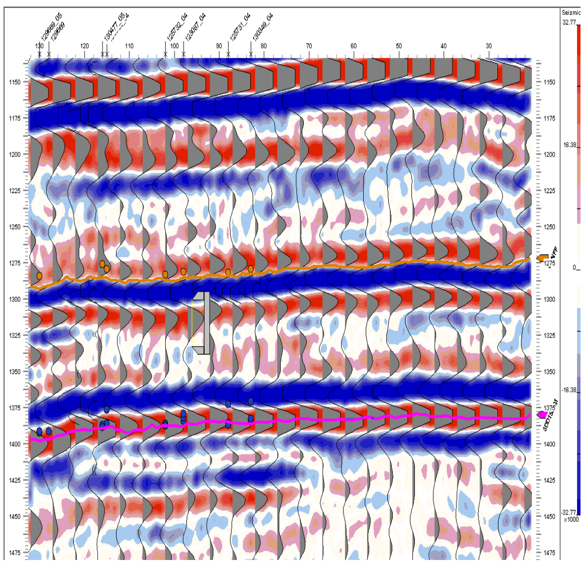
This example shows the data resolution before and after a match filter application using a VSP as a reference.

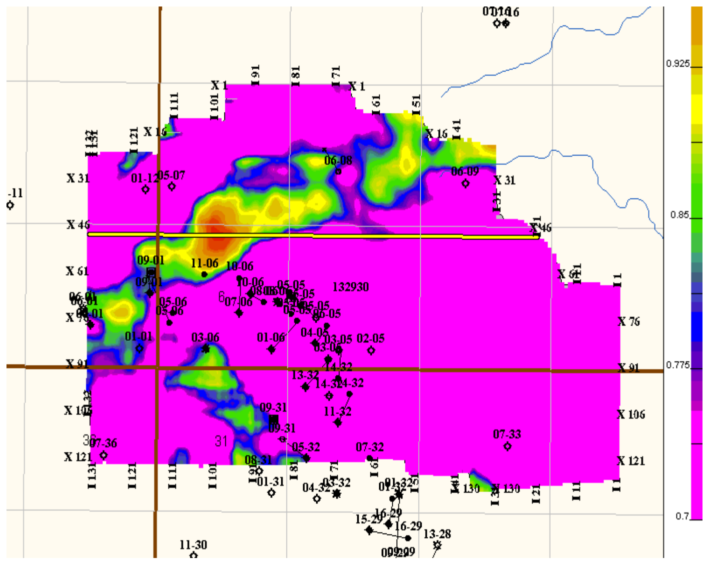


The second facility is the programs in the workstation that allow the identification of various attributes. The simplest of these is just the straight amplitude display. The trick is in the way the amplitudes are displayed. If reservoir attributes change by only 10% of the overall amplitude, then the entire colour range for display should be limited to this 10% range. If there is a statistically significant change of amplitude within the data, a smoothed amplitude map with this amplified colour variation will show trends that would not otherwise be visible.

A very simple program that is available on several workstations uses a correlation value to map the character of a reflection. A small portion of a trace over a seismic event is chosen as a standard, and this standard is correlated against every other trace in the survey over a specified window. If the event is very strong and consistent the survey may show a correlation value of over 0.90 everywhere. If the entire colour range is set between 0.90 and 1.00 then small variations become quite obvious, and the pattern of these variations give information about the reservoirs that they represent. There is a simple verification of the results of this method. If a portion of a trace that is non-reservoir is used as the reference, then the reservoir should show up as a pattern of poor correlation.

In the example below a peak that is lower frequency than the rest of the traces for the reflection is taken as the reference trace. The correlation produces the map on the right that shows the trend of the correlation strength, from which a geological interpretation of the morphology can be made.





The critical part of the exercise is converting the observed shapes of the output maps into meaningful quantitative values for reservoir evaluation. This requires a collaborative effort from all the disciplines involved. It is quite a simple task to calibrate a clearly defined feature such as a point bar in a well-defined channel, but it is another thing to quantify the reservoir parameters of an unrecognizable morphology.

If a geological model is not clearly represented by the observed shape of the reservoir, then the best that can be done is to answer some of the engineering questions such as what is the size and shape of the reservoir; if the production testing indicates a barrier a certain distance from the well bore, where is this barrier most likely to be; if the feature is large how large is it; where does the reservoir attribute change; and most importantly are there places to avoid? Just answering these questions is substantially better than being limited to only providing structural information to define the pool.

This type of approach essentially uses programs in a fashion for which they were not designed, so flexibility of the programming becomes a key factor in using this approach to define reservoirs. This is not a rigorous approach and relies on trial and error to get the best possible result, so the simpler the programming is to use the easier it is to obtain results.

Conclusions

When the seismic data quality is inadequate to evaluate reservoirs according to standard industry practice, there are options available using workstations and a little ingenuity that at least can give part of this reservoir evaluation.

The key to this approach is to identify the effects of the reservoir on the seismic data instead of trying to map the reservoir itself.

The more flexible the programming is on the workstation, the easier that this approach can be carried out.

Any additional information that can be derived from this approach is far better than no information even if it just identifies places that should be avoided as drilling locations.

References

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