Robust AVO

BELVEDERE MAORPET

Robust AVO is a specific proprietary solution of the Amplitude Versus Offset method

The seismic method deals with two types of waves; the so called “p” and the “s” waves. The seismic exploration technique is based mainly on the “p” (primary) waves. It is not easy to generate “s” (secondary) waves and also, they attenuate pretty fast.

When the propagating “p” wave arrives to a seismic reflector surface, the wave will split into four parts: reflected “p” wave, reflected “s” wave, transmitted “p” wave and transmitted “s” wave. The “s” waves propagate much slower than the “p” waves, and also they loose a lot more energy, so it is very rare to see “s” waves on the recorded seismic. On the conventional seismic time sections we see usually the “p” waves only.

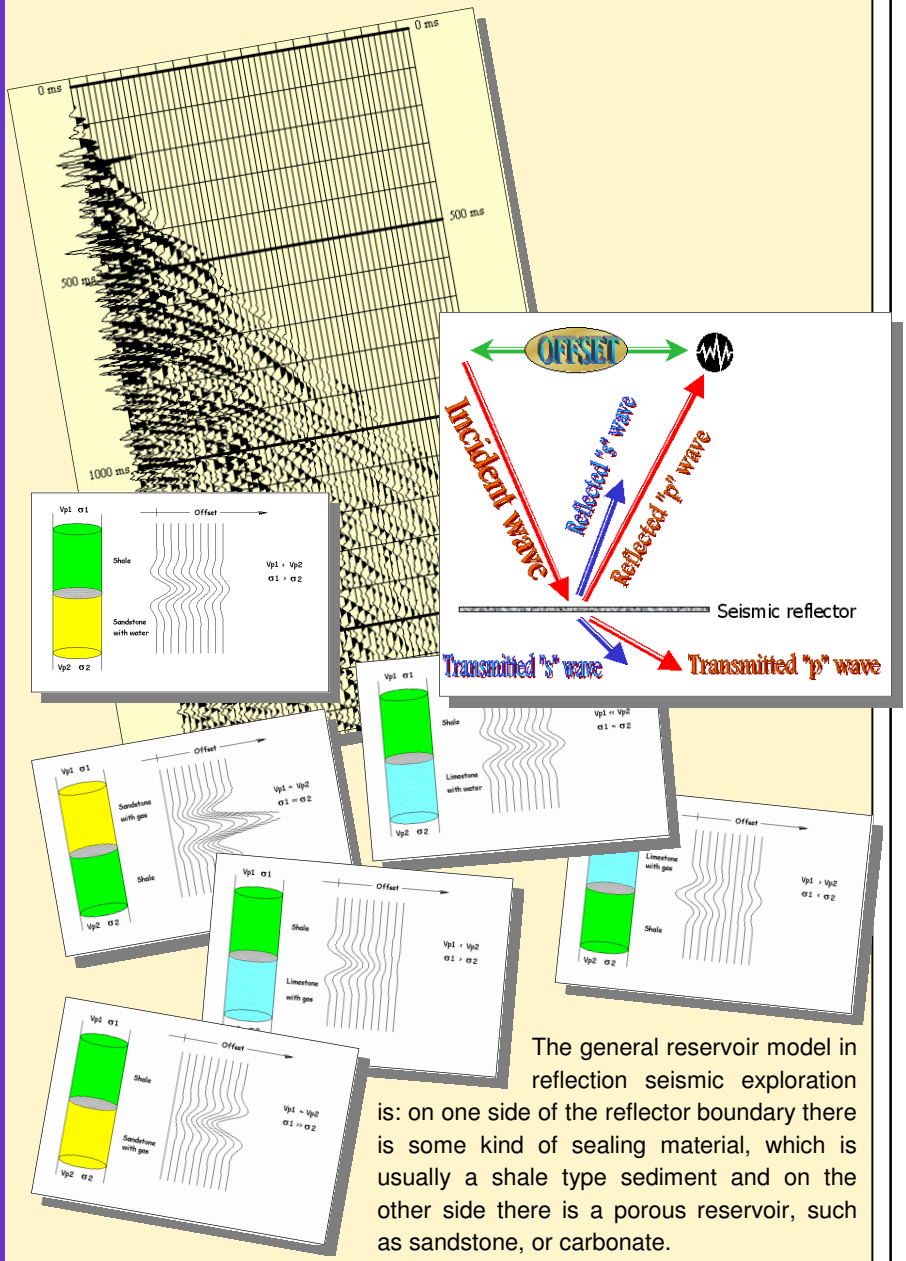
We can see the indirect effect of the generated “s” waves on the amplitudes of the reflected “p” waves. During the splitting of the waves at the reflector surface some part of the energy departs with the “s” waves. We will not see the “s” wave itself, but the amount of the missing energy can be estimated from the energy variations of the reflected “p” waves. This is what we can record at the surface.

The energy splitting at the reflector is incident angle dependent. In reflection seismic practice we use the source to receiver distance (offset) instead of the angle of incidence, but the two can be computed from each other, using the depth and the wave propagation velocity. So, we can say, the energy splitting is offset dependent. This is why we call the method as AVO: amplitude variation by offset, or amplitude versus offset.

There are several equations describing the angle dependence of the reflected amplitudes. The most basic equation was developed by Mr. Zöplitz, but it is too complicated for the everyday use. There were several simplifications published, probably the most known were made by Mr. Shuey and a different version by Mr. Fatti and co.

All equations contain the so called “Poisson ratio” parameter. This parameter gives the measure, how much a body’s cross radius extends, when we compress it’s length. This parameter has the value of 0.5 in case of incompressible materials, such as water and has the value of close to zero in case of compressible gases.

This means, the AVO is an excellent indicator when the pore content changes from water to gas.



The general reservoir model in reflection seismic exploration is: on one side of the reflector boundary there is some kind of sealing material, which is usually a shale type sediment and on the other side there is a porous reservoir, such as sandstone, or carbonate.

Considering the basic combinations there were efforts to classify the AVO cases. Unfortunately this classification was just growing and growing as more and more examples were described.

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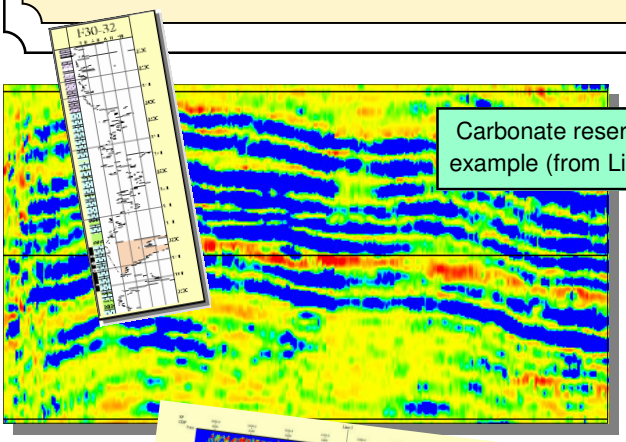
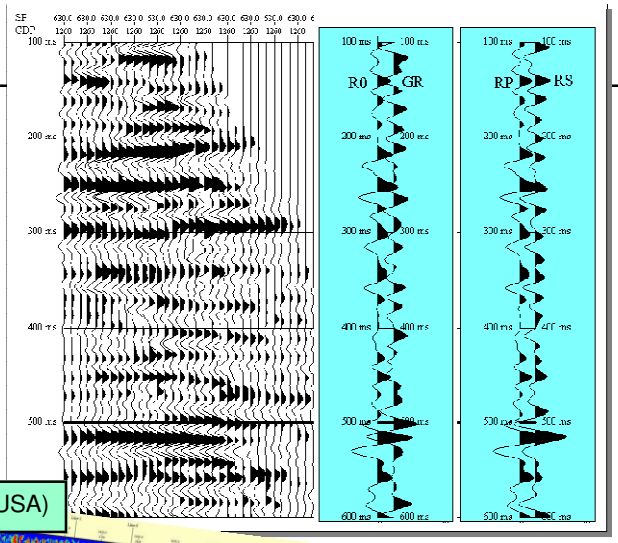
During the conventional AVO analysis we compute the so called intercept (Ro), which is the amplitude at zero angle and the gradient (GR), which is the amplitude variation by the angle.

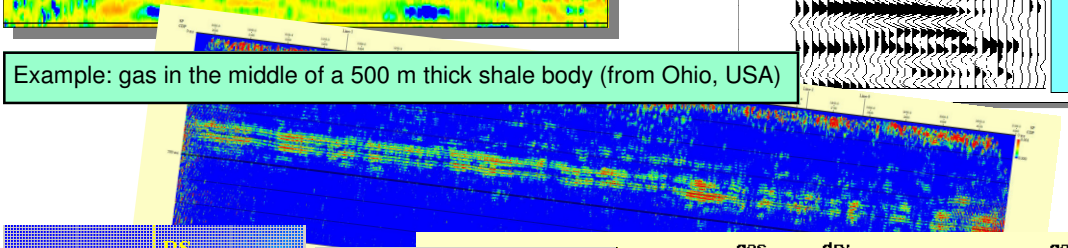
Instead of the Ro-GR, we can compute the so called “p” wave and “s” wave reflectivity (RP, RS). The RP is just the same as the intercept; while the RS is a computed value. It represents the “s” wave reflectivity. This solution is known in the seismic literature as “Fatti’s equation”.

Belvedere MAORPET Inc’s “robust” solution is based on the RP-RS reflectivity values. The advantage is: these time sections are just similar to any seismic time sections, such as the conventional stack.

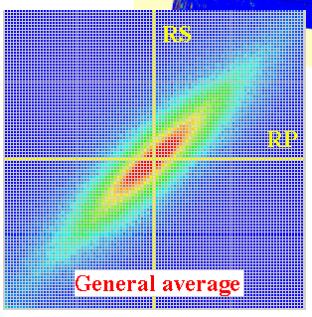


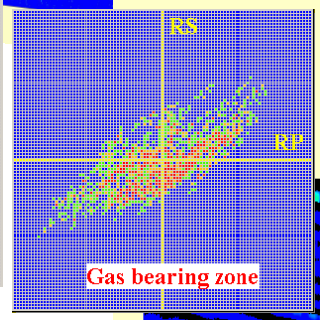
Carbonate reservoir example (from Libya)





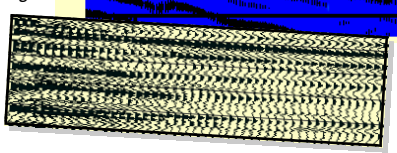
Example: gas in the middle of a 500 m thick shale body (from Ohio, USA)





In the “Robust AVO” solution a measure of the disorder of the “p” and “s” wave reflectivity cross plot is displayed. The plot becomes unorganized at the gas bearing zones . While the Ro-GR based studies must be fitted into AVO classes, this method works for any kind of reservoir.

These displays are considered as warning indicators only. In case of visible anomalies the seismic interpreter must go back to the original seismic and must study the un-stacked CDP gathers.



Characteristic example of sandstone reservoir. Even the leakage problems are visible. (from Algeria)