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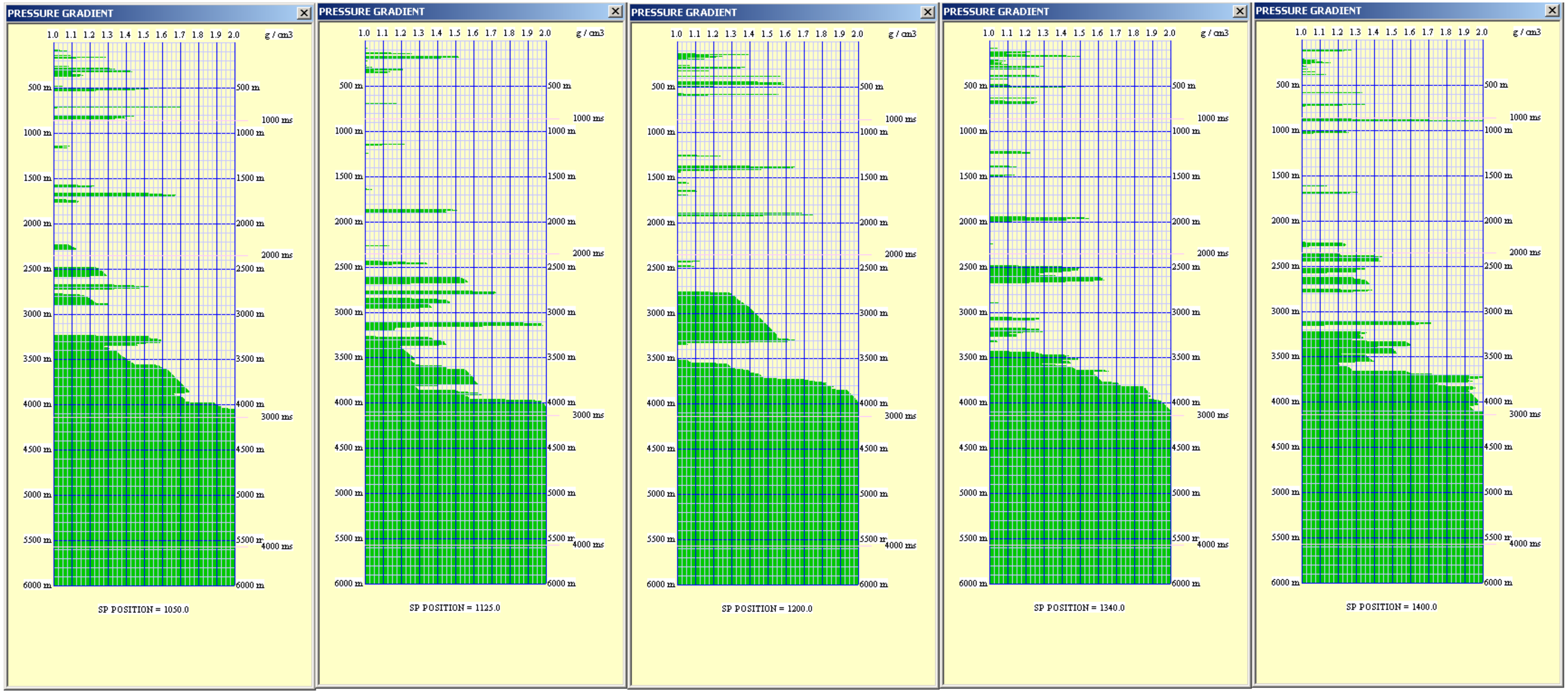

Overpressure, frequency studies, detecting gas accumulations

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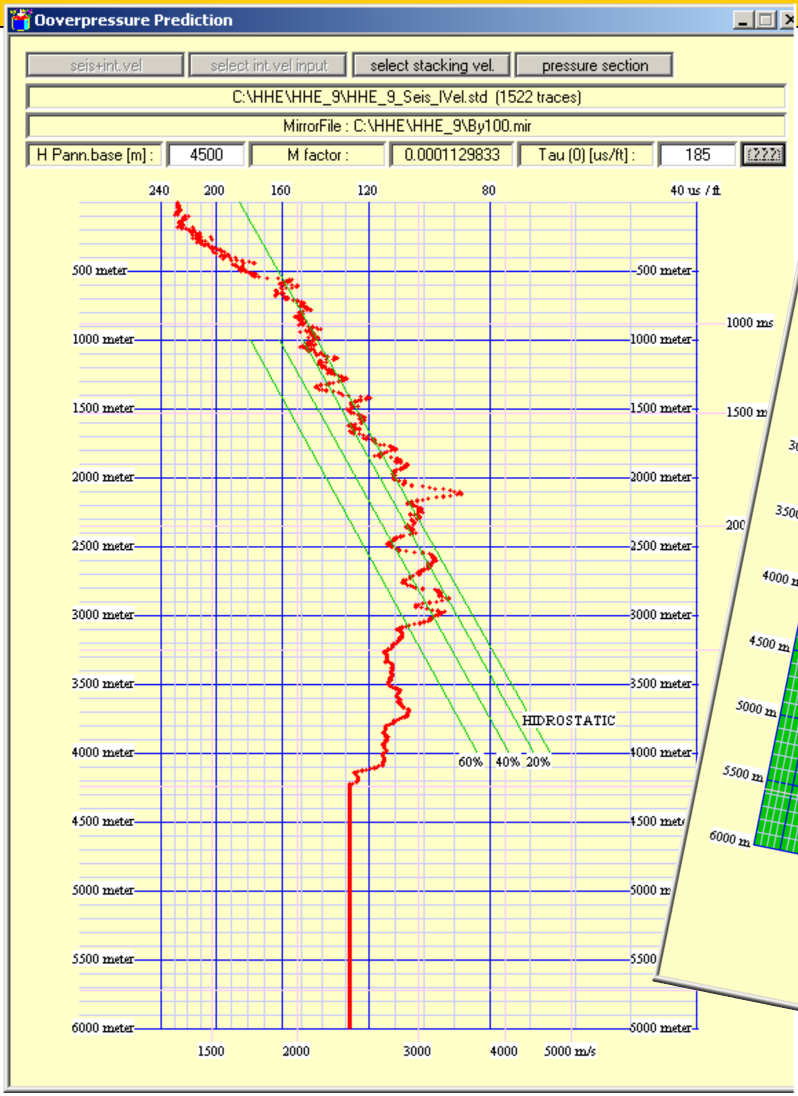

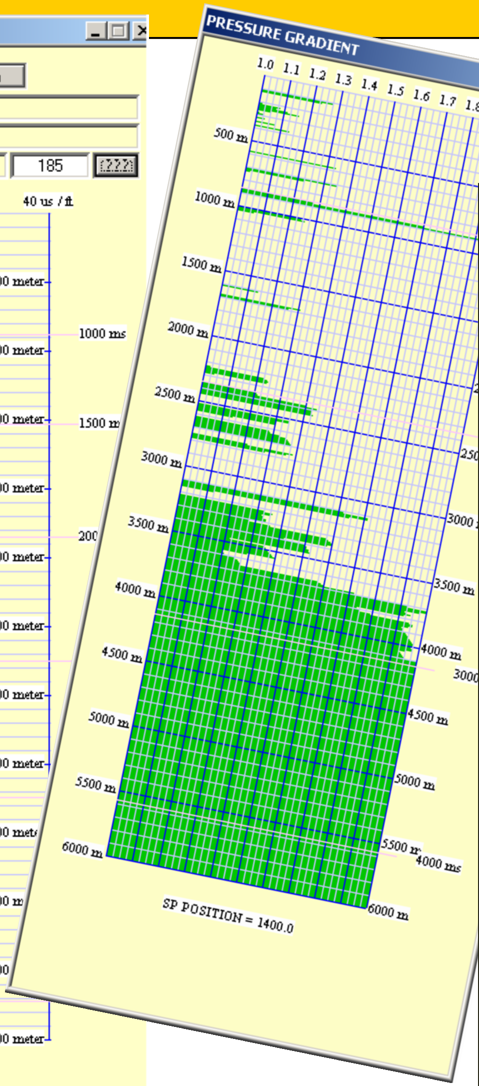

Estimating pore pressures and predicting over pressured zones on the basis of seismic wave propagation velocities is an old story. We started to study this topic at the late seventies, when the first international articles were presented. Soon it became an industry standard method all over the World. It has been tested several times, cross checked with actual mud weights and other indicators, such as drill head advancement … etc.

The basic concept is: in closed, encapsulated zones the pore fluid—since it is practically incompressible—does not let the sediments to finish their normal compaction. As a consequence, the porosity remains higher than the expected value. High porosity means slower wave propagation velocities, and this feature might be detected by detailed wave propagation velocity analyses.

At Belvedere Maorpet Inc. we use our own phase rotational velocity analysis method to obtain so called interval velocities. The accuracy is good enough to continue delicate studies, such as pore pressure estimations.

Using acoustic/sonic well logs, they used to select the shale-like sediment samples for the study. Of course one can not go into these details in case of seismic velocities. Here one has to use some kind of trends, fitted to the wave propagation velocities.

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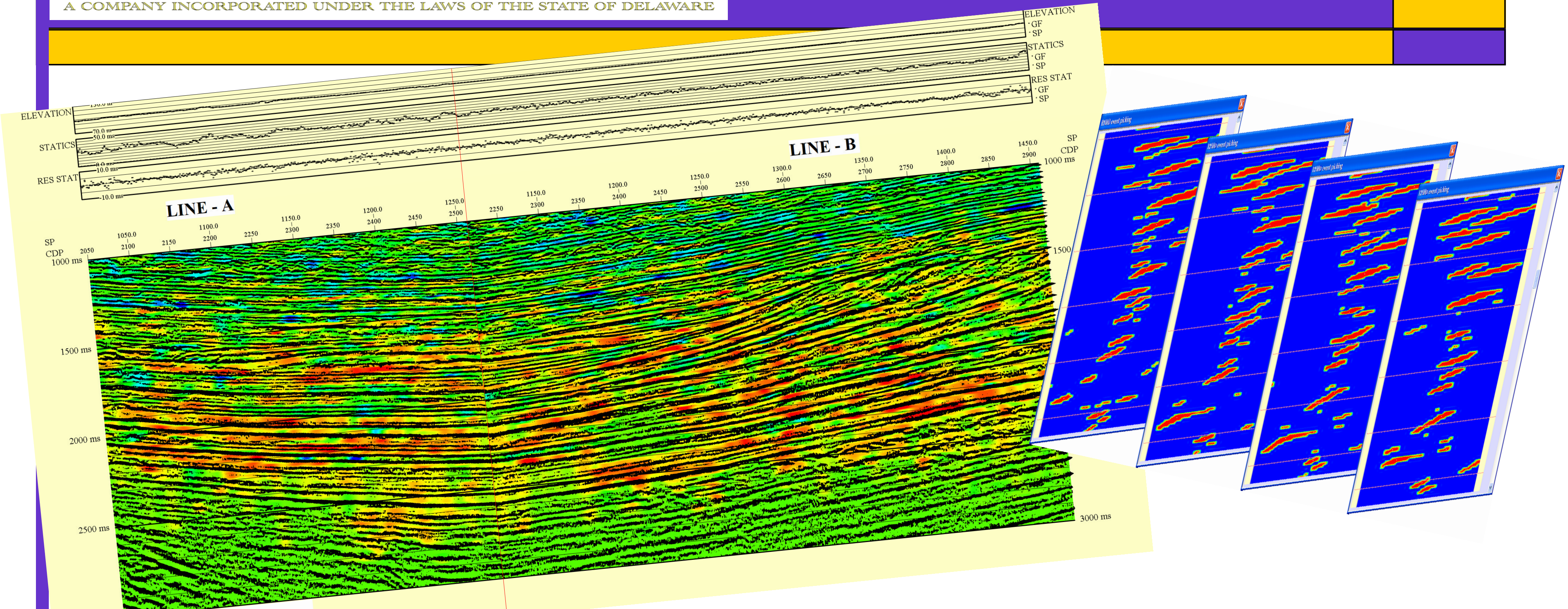


This picture shows the accuracy of our velocity analysis. The two intersecting seismic time sections were processed independently and so were the interval velocities computed as well.

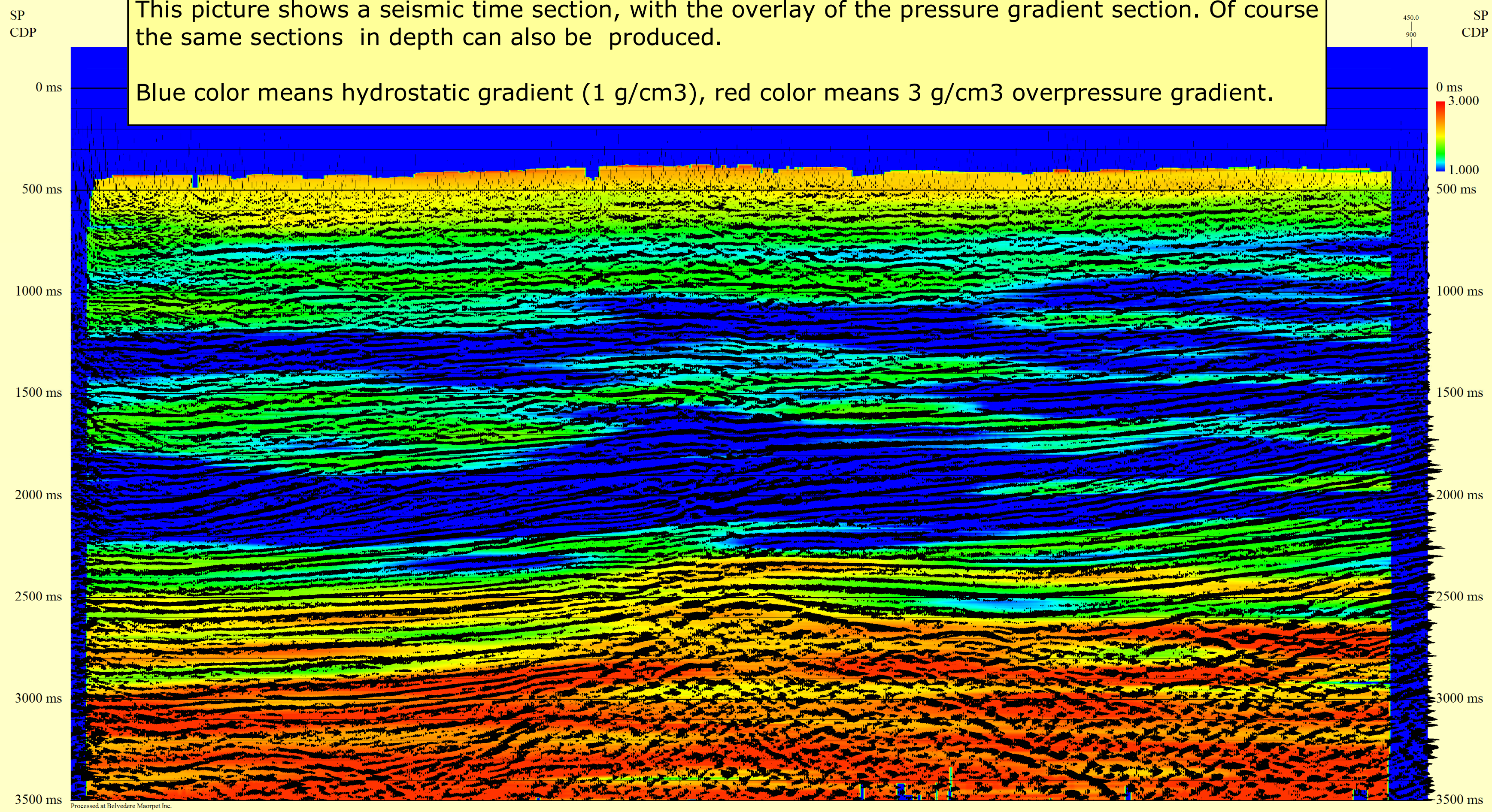
The picture shows how the interval velocities fit together at the intersecting point. One can see, that even the small details fit very accurately. The errors are in the range of 1-1.5 %, what represents an outstanding good accuracy, concerning interval velocities.

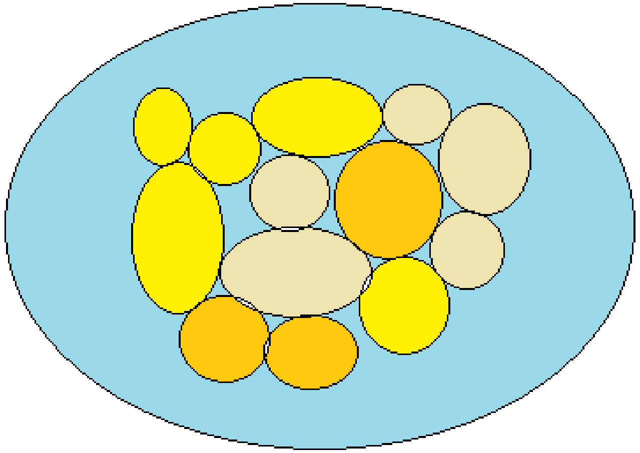
We try to use all available reflections, so we obtain a nearly continuous velocity function, as detailed, as the resolution of the seismic let it be.

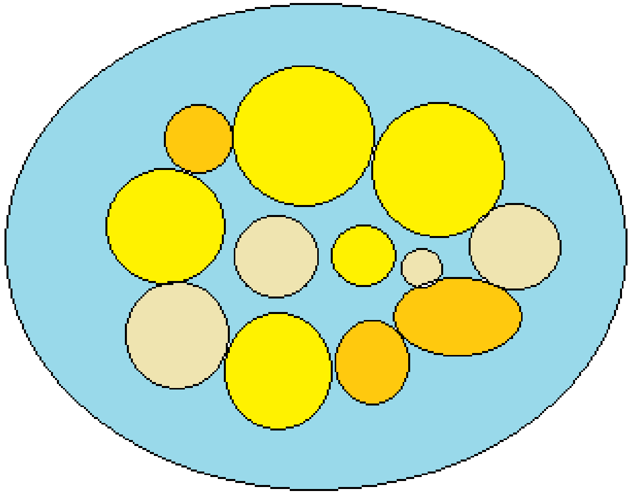
Red color means high velocity, blue/green: slow velocities

As a routine, we compute and display the pressure gradient values, not the pressures. The pressure gradient is equivalent to the mud density, what can balance the pore pressures at the given depth. This picture shows a seismic time section, with the overlay of the pressure gradient section. Of course the same sections in depth can also be produced.

Blue color means hydrostatic gradient (1 g/cm3), red color means 3 g/cm3 overpressure gradient.







Now, we arrive to something non conventional.

At conventional signal processing it is generally accepted that using linear systems one can only loose information by filtering. Once a frequency component is filtered out, it will never come back by linear filtering. The earth is acting as a linear filter, so the propagating seismic signal should only loose its frequency content, as the time passes.

But, just imagine a plate, containing some pebbles, or beans. Try to move the plate by a regular frequency. If the pebbles are bonded together, the generated sound frequency will be the same, as you have moved the plate.

What happens, when the pebbles are loose, not bonded? They will generate a much higher frequency, some kind of a rattling noise.

Something similar can happen with the seismic wave in the earth as well.

In the overpressured, sealed zones, where the fluid holds a good part of the overburden pressure, the rock stress will be lower. Here the sediment pieces are more free, than in the well compacted areas. These particles can produce the "rattling noise", so the frequency content can increase, indeed.

This might give us a chance to estimate the rock stress. The anomalously low rock stress means, the area must be over pressured.

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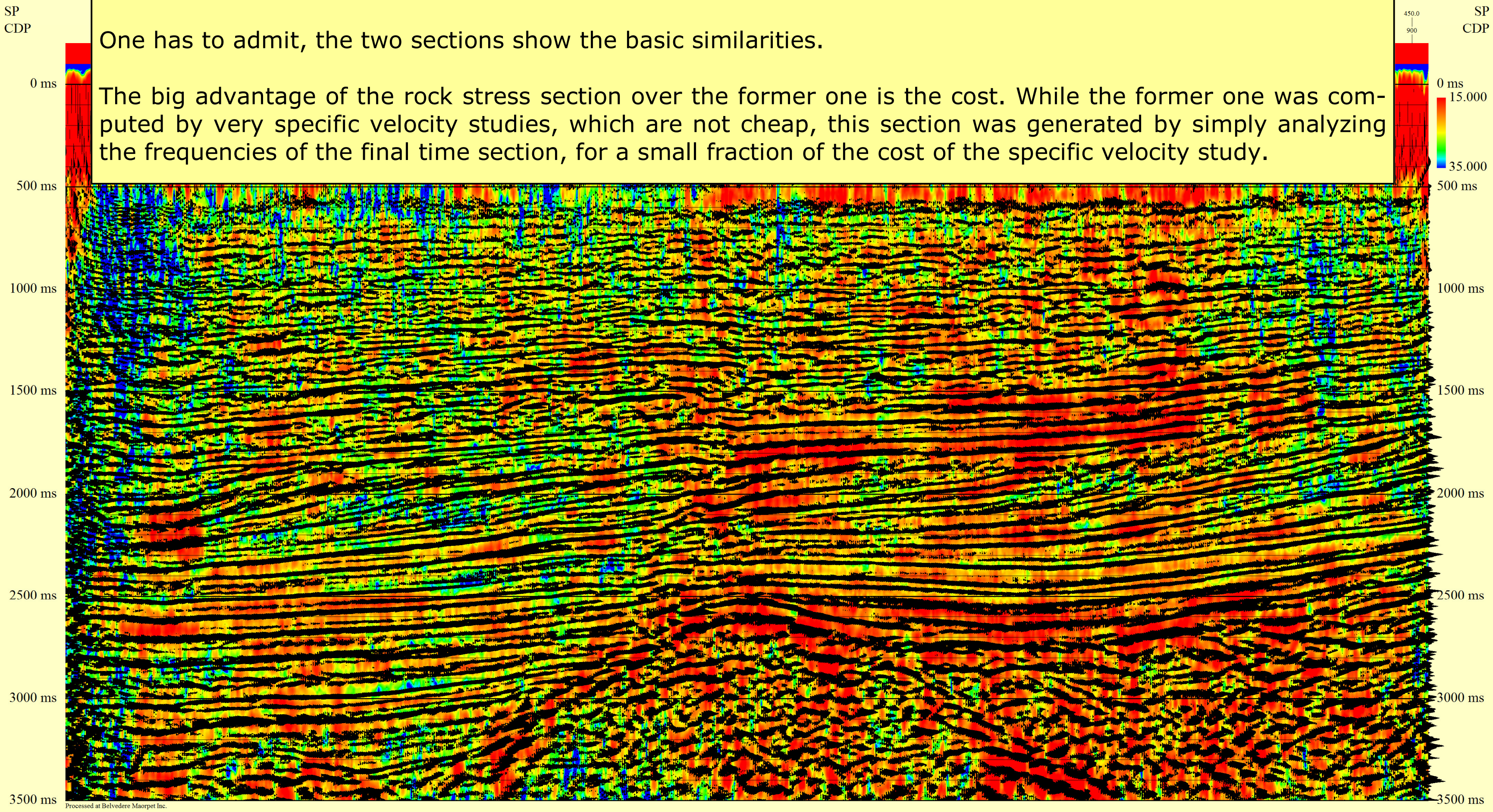
This here is a “rattling noise” section. One might call it rock stress section. The red color means low rock stress, which is equivalent to high pore pressures. The seismic section is the same as you have seen it two pages earlier.

One has to admit, the two sections show the basic similarities.

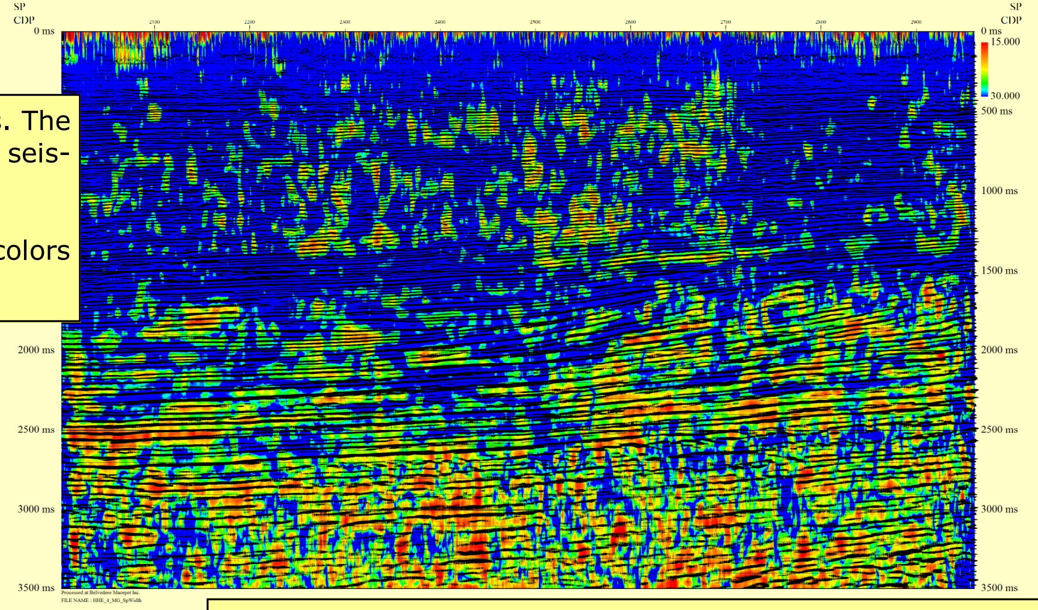
The big advantage of the rock stress section over the former one is the cost. While the former one was computed by very specific velocity studies, which are not cheap, this section was generated by simply analyzing the frequencies of the final time section, for a small fraction of the cost of the specific velocity study.

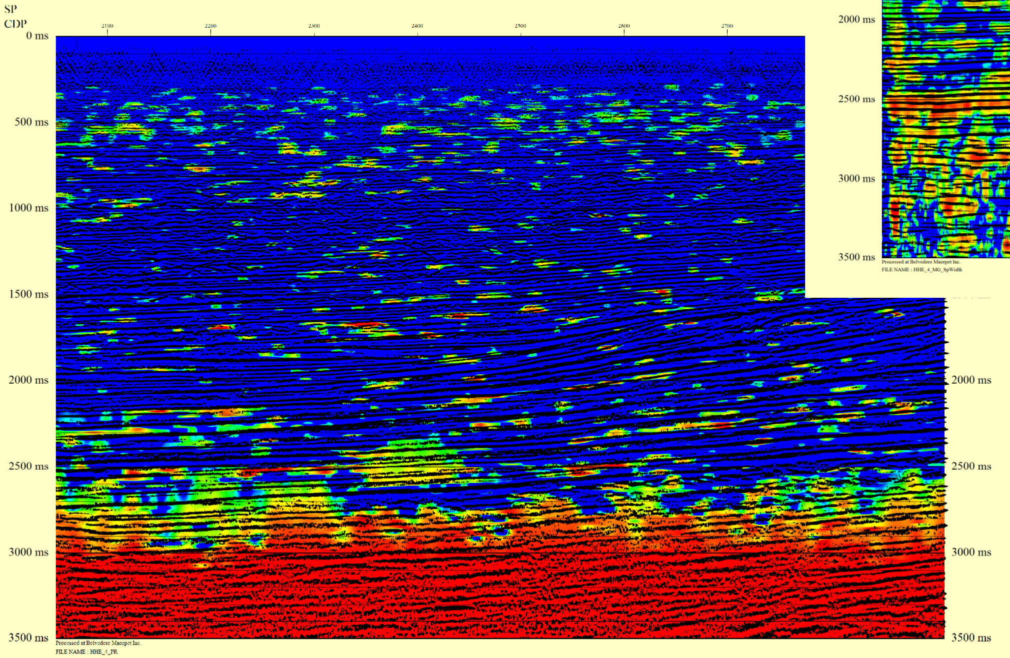


Global Press, 2011

Here again, you see another seismic section in two versions. The bottom one is the pressure gradient section obtained from seismic velocities.

The second one to the right is the rock stress section. Red colors mean low rock stress (high pore pressure).





It is important to mention that the study based on the wave propagation velocity is a well established, tested, controlled method. The results are as reliable as they were computed from measured well logs.

While the rattling noise based method still has quite a few open questions.

But, it is cheap …

Price comes to specific importance when the data volume is large, such as in case of a 3D survey.

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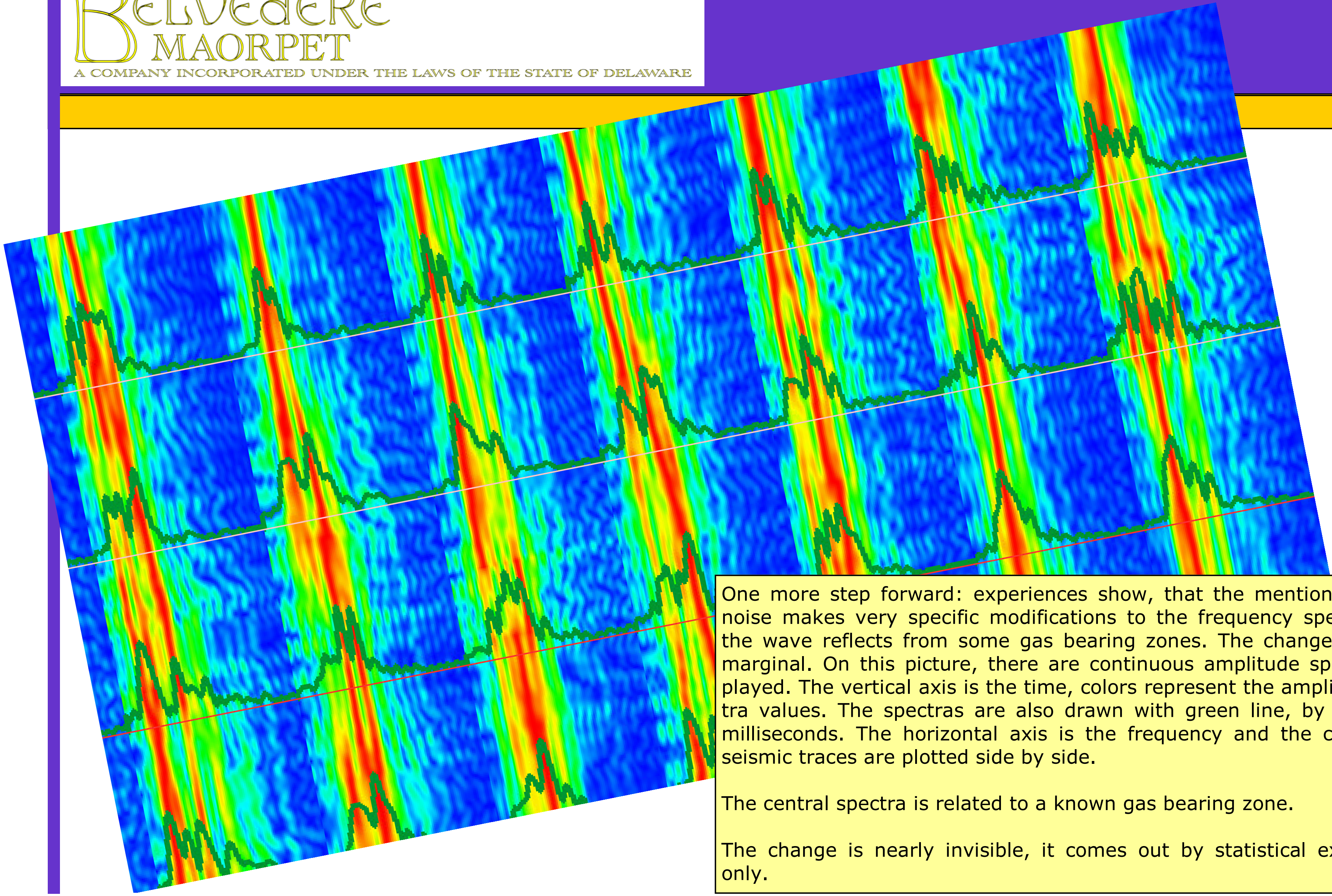

One more step forward: experiences show, that the mentioned rattling noise makes very specific modifications to the frequency spectra when the wave reflects from some gas bearing zones. The changes are very marginal. On this picture, there are continuous amplitude spectras displayed. The vertical axis is the time, colors represent the amplitude spectra values. The spectras are also drawn with green line, by every 100 milliseconds. The horizontal axis is the frequency and the consecutive seismic traces are plotted side by side.

The central spectra is related to a known gas bearing zone.

The change is nearly invisible, it comes out by statistical examination only.

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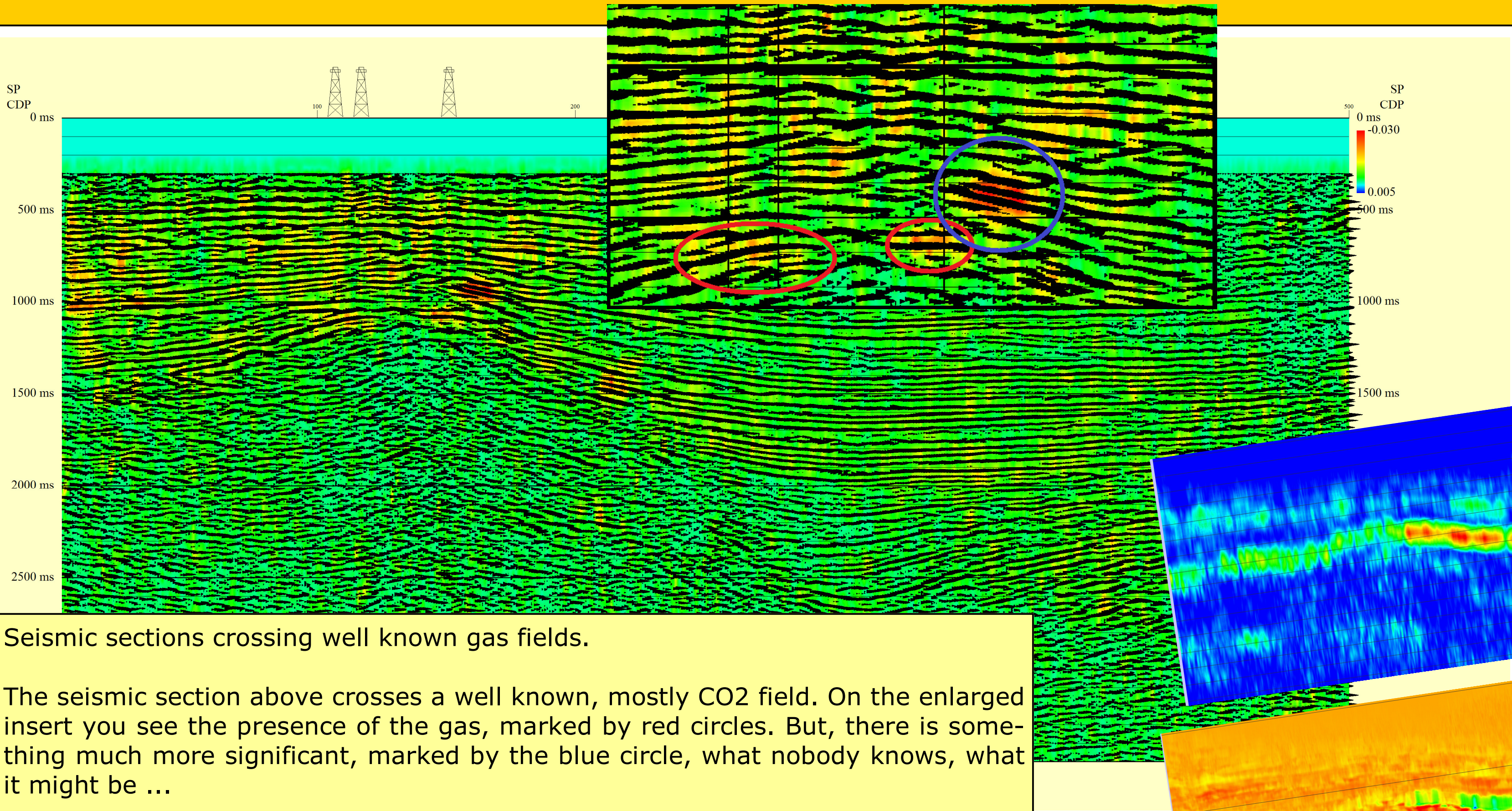

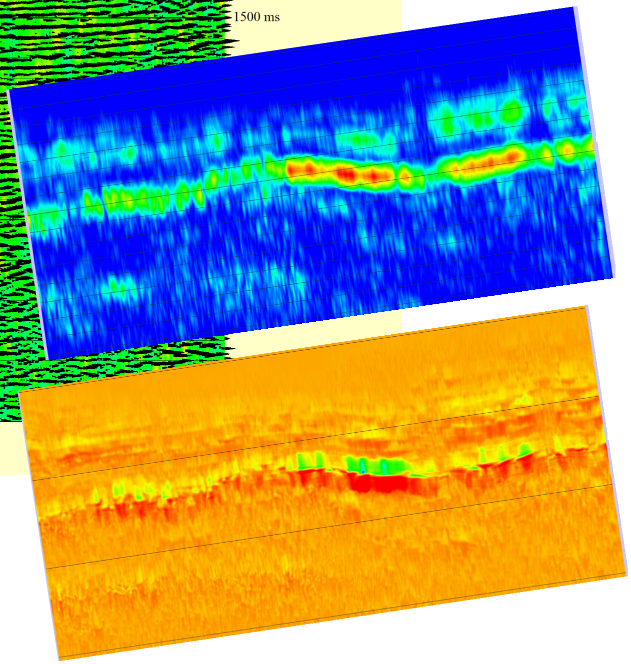

Seismic sections crossing well known gas fields.

The seismic section above crosses a well known, mostly CO2 field. On the enlarged insert you see the presence of the gas, marked by red circles. But, there is something much more significant, marked by the blue circle, what nobody knows, what it might be ...

The picture to the right shows a known gas producer layer, where the reservoir is porous carbonate. The two inserts are different statistical approaches to the same problem.

It looks like, the use of the “rattling noise” has still a few options to investigate.

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