

# **GC Geophysical Uncertainty: Often Wrong, But Never in Doubt\***

**By**  
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Search and Discovery Article #40182 (2005)  
Posted December 23, 2005

\*Adapted from the Geophysical Corner column, prepared by the author, in AAPG Explorer, November, 2005, and entitled "Often Wrong, But Never in Doubt." Appreciation is expressed to Alistair Brown, editor of Geophysical Corner, and to Larry Nation, AAPG Communications Director, for their support of this online version.

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## **General Statement**

Geophysics in the oil and gas business is a predicting science, but geophysicists and geologists are not generally advanced in the art of describing geophysical uncertainty. Every client really wants to know: What do you predict? How certain are you? But what clients actually ask for are results via simple and low uncertainty communication -- the "silver bullet" syndrome. As a result, geophysicists have historically focused strongly on the quality and tools of the profession, and less on their uncertainty.

## **Geophysical Uncertainty**

So let's look at some examples of communicating geophysical uncertainty. Estimating uncertainty is important for key economic decisions. An example of this is a calculation of Value of Information (VOI) for seismic data, estimating the price/value prior to acquisition.

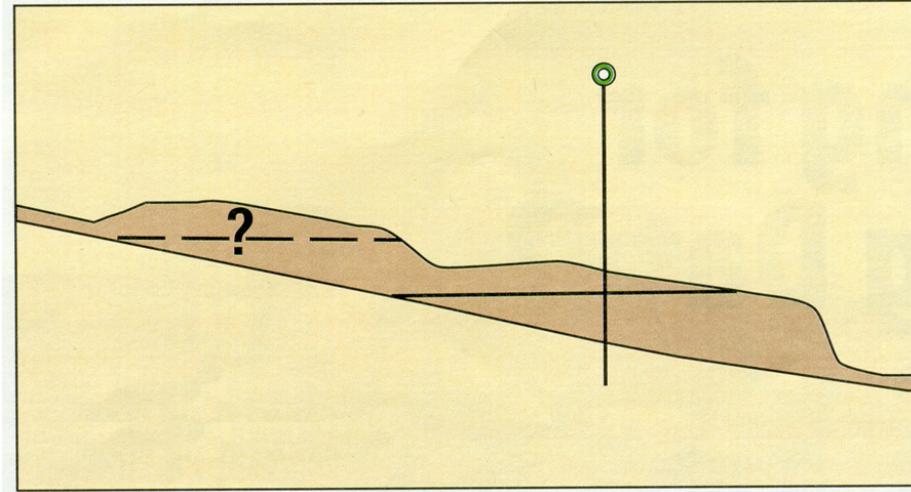
The problem to be illustrated is a risky up-dip extension of a discovery well based on 2-D seismic. The decision to be made is whether to drill and test a delineation well for \$20MM or shoot a \$5MM 3-D seismic first. If the 3-D seismic data is acquired, there is an option to review the data and then consider proceeding on to a delineation well or not.

## **VOI Process**

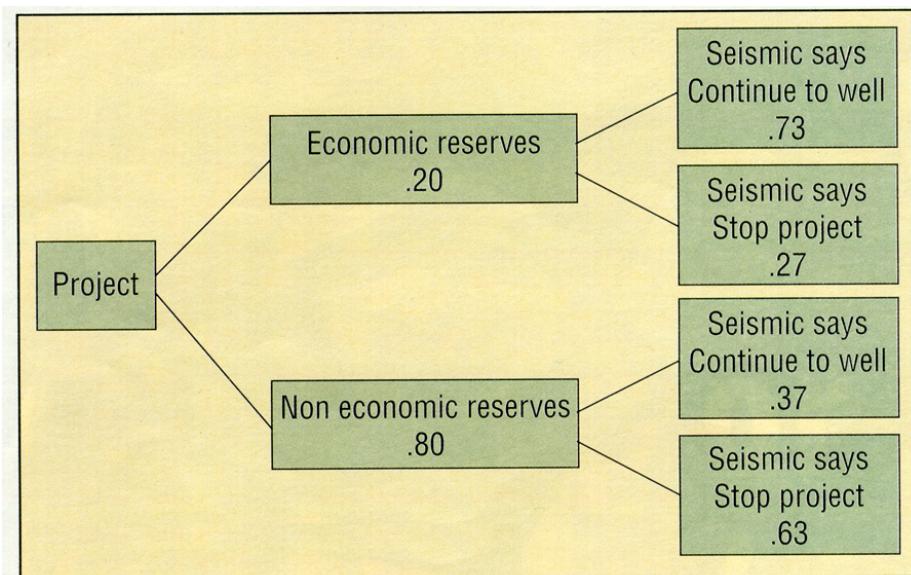
The VOI process will take several steps. We will start with a probability tree based on an estimate that there is a 20 percent chance of an up-dip accumulation (Figure 1). Will seismic data clearly confirm or deny this? The seismic experts say that if the project is economic, seismic and a well will confirm it's a good project only 73 percent of the time, and incorrectly state it's a bad project the other 27 percent. However, if the project is not good, seismic data will confirm this 63 percent of the time, and incorrectly suggest a good project the other 37 percent (Figure 2). This is based on factors of seeing compartmentalization, direct hydrocarbon indicators, or reservoir of a sufficient size.

The decision tree for drilling the well only (Figure 3) shows different results. The biggest risk considered in drilling without 3-D seismic was locating the well in the wrong place (wrong compartment, too far down dip, poor stratigraphic spot). As the probabilities of the decision tree suggest, well data alone is not considered as definitive of success or failure as having the seismic data.

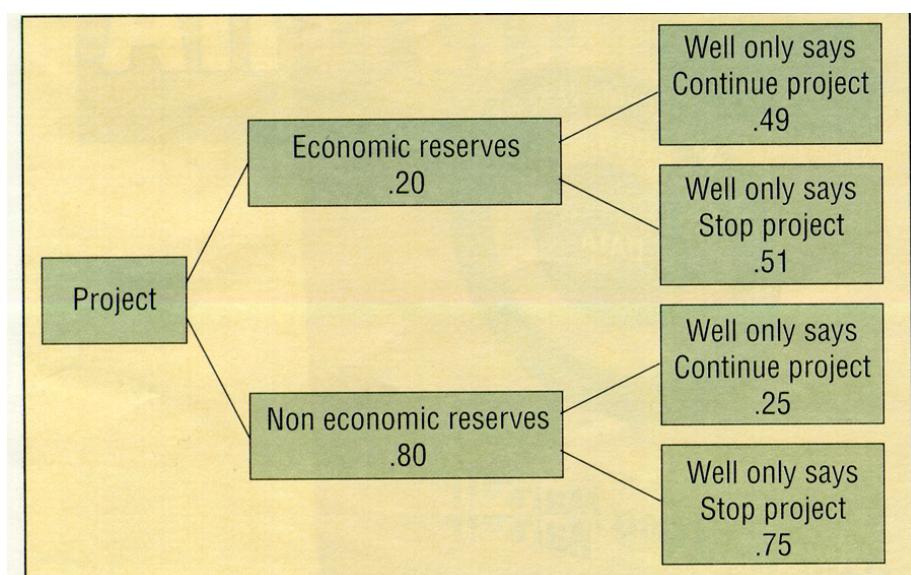
In the next step, Bayes' rule allows for a reversal of the decision tree. Figure 4 shows the seismic tree reversed. I will ask you to refer to a text on decision analysis or ask someone who knows how to reverse the tree -- but, really, the math is quite simple. For instance, the probability that the seismic survey will say to continue the project and drill a delineation well is calculated from the original probability tree,  $.45 = (.20 * .73 + .80 * .38)$ .



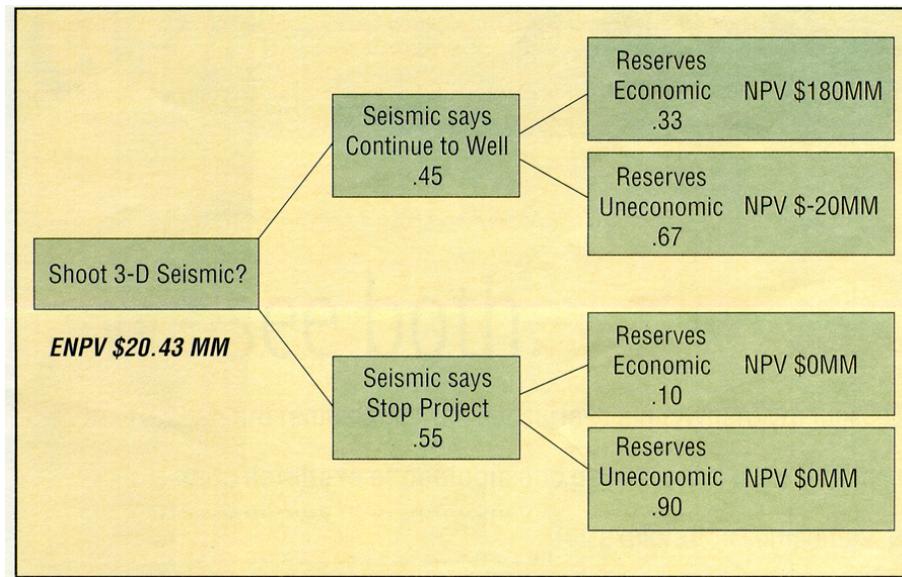
**Figure 1. Delineate updip?**



**Figure 2. Decision tree using 3-D seismic.**



**Figure 3. Decision tree using delineation well only.**



**Figure 4. Reversed decision tree for 3-D seismic.**

In the next step, the decision tree is back calculated for expected net present value (ENPV). The \$200MM valued project with a delineation well cost of \$20MM would have an ENPV of \$20.7MM. This is calculated by a sum of the probabilities on the “go ahead” branches of the project  $[($200MM - \$20M) * .33 + (-\$20MM) * .67] * .45 = \$20.7MM$ .

This compares favorably with only drilling the well and using no 3-D seismic data. A separate reversed decision tree for drilling a well alone (not shown) has ENPV of only \$14.8MM. The difference in ENPV is more than the \$5MM cost of the seismic data, so the price of 3-D seismic is in range. However, spending \$10MM on 3-D seismic would be considered to be a questionable decision -- the data would be too expensive for the information provided.

The previous example does quantify VOI, but it doesn't make for a very simple communication with the client, and that is also important. As a rule, decision makers prefer not to work with complexity when possible. Some even react to discussions of uncertainty quite negatively, even undermining faith in geophysical technology.

So “keep it simple” is a pretty important rule.

### Scorecard for DHI

Are there examples where we simultaneously quantify and simplify? Taking a cue from the academic world -- yes. Grading! This is an example of using many different factors (tests, class participation, essays, etc.), weighting them in a non-linear fashion, comparing to other students and calibrating with long-term standards or benchmarks. An oil and gas geophysical extension of this concept is evaluating direct hydrocarbon indicators (DHIs) through scorecards (Figure 5). Are the characteristics shown really a good DHI? How certain are we? The 3-D seismic line shows high amplitude with a potential flat spot. The value of amplitude-above-background is consistent with a low impedance gas as modeled from an adjacent well, and the amplitude map shows an up-dip fault termination with down-dip conformance to structure.

How are these characteristics then evaluated? The scorecard for this example shows high marks, but not a perfect DHI. Like our example of grading students, oil and gas workers may disagree on the quality of the seismic attributes or exactly how to sum their weights. But the advantages of a detailed scorecard for grading are several:

- First, it employs a standardized checklist of attributes, which means a consistent set of expected products are reviewed and an unbiased evaluation is more likely.

- More importantly, the grades are compared to a history of similar examples. By checking results against the scorecard predictions, the guidelines are set for DHIs as a calibrated tool and the grade can be used in quantitative risk prediction.

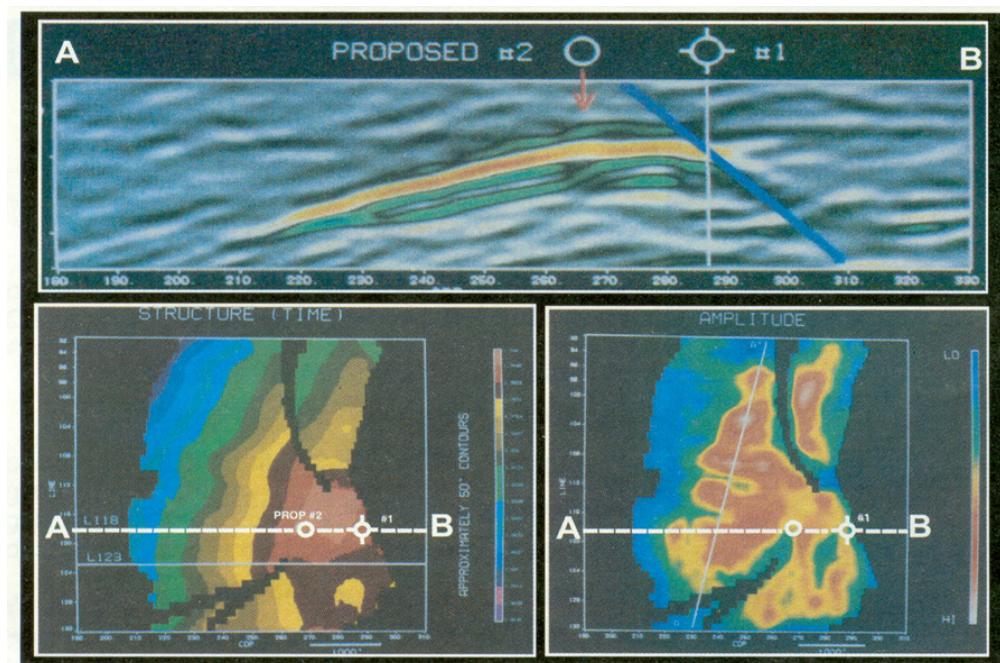


Figure 5. Seismic attributes: direct hydrocarbon detection?

### Summary

The use of VOI and a scorecard for DHI are only two measures of uncertainty in oil and gas projects. Users of reservoir geophysics, especially, are employing increasingly more sophisticated decision tools and integrating uncertainty with more demands on uncertainty description and accuracy. Professionals who use seismic data results have a desire to understand what the data are able to predict, but also want to know how certain a geophysicist can be in their prediction.

Geophysical uncertainty is not a threat, but a valued deliverable.