Incorporating uncertainty in the quantitative interpretation workflow

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QI geophysicist are: often asked questions like:

1) Is this feature on the seismic data a direct-hydrocarbon-indicator (DHI), and how much does this increase the probability of a successful well?
2) Is this fault block with anomalous amplitudes filled with oil or gas?
3) What is the total oil-volume in place (STOIIP) for the reservoir?

The temptation (and pressure!) is there to give 'straight' answers to these questions. However, application of Bayes' rule is very appropriate in these situations. Bayes' formulated a well-known mathematical approach for updating our perceptions when additional information becomes available. It combines this new information with existing knowledge and also takes into account the uncertainty in using the new information.

The use of Bayes' rule in the above mentioned QI problems could look like this:

1) The prior probability of finding gas in a specific prospect with a dubious trap is 8%. The suspected DHI has a reliability score of 61% and a measurement uncertainty of 20%. Given these DHI scores and the prior probability, the posterior probability of finding gas given the observed DHI is 20%. The updated probability achieves a good compromise between having a likely DHI but a low chance for the trap sealing.
2) A Monte Carlo technique is used to model a large number of reservoir models. These models have varying thickness, net/gross and porosity in the reservoir. Furthermore, the acoustic properties of the sandstones and shales are allowed to vary. Close cooperation with the geophysicist, the geologist and the petrophysicist is required to put realistic bounds on the degree of variation for each parameter. Synthetic seismic attributes are calculated from the reservoir models. The observed attribute map is calibrated to the model in an area where the fluid phase is known. Bayes' rule is subsequently used to calculate fluid phase probability maps over the fault block.
3) Reservoir models, which are realistic from a geological point of view, but result in a large range of possible STOIIP, can be constrained using inversion of seismic data while taking into account the uncertainty in geological, geophysical, and petrophysical information. In this case, the results are a suite of reservoir models, which are consistent with all the data. Typically, this process reduces the uncertainty in STOIIP.