Integration of Independent Exploration Data

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EXTENDED ABSTRACT

Modern petroleum exploration is a multi-tool, integrated information science. Probability theory provides a simple means for predicting outcome by integrating independent exploration methods.

An important aspect of integration is assessment of the probability of a successful well by integration of several independent techniques with different probabilities for success. Combined probability of success is given by two simple equations.

The probability of any one of n independent events is given by

$$P(E_1 \text{ or } E_2 \text{ or } \ldots \text{ or } E_n) = 1 - (1 - PE_1)(1 - PE_2) \ldots (1 - PE_n),$$

and in the case of exploration integration

$$P_{int} = 1 - (1 - PW_1)(1 - PW_2) \ldots (1 - PWn),$$

where PW_1 is the probability of a successful well using technique 1. Then $(1 - PW_1)$ is the probability of W_1 not occurring (a dry hole). Multiplying the terms $(1 - PW_1)(1 - PW_2) \ldots (1 - PW_n)$ gives the probability of drilling a dry hole using integrated techniques. Subtracting that quantity from 1 gives the probability of at least one successful well.

For example, if we have 2 independent exploration methods with each yielding a wildcat well 50% of the time, the probability of a well from integrating both methods is

$$P_{int} = 1 - (1 - 0.5)(1 - 0.5) = 0.75 = 75\%.$$

Pirson (1941) published an early application of probability theory applied to exploration integration. Saunders et al (2002) applied the technique in a successful integrated exploration program. Simple probability theory predicts the integration outcome when independent exploration standalone probabilities are known.

A case study in the eastern shelf of the U.S. Midland Basin by Rice et al. (2016) illustrated integration of 3D seismic, subsurface geological, and surface geochemical data to improve drilling results beyond those of any method used alone. In that case, 3D seismic data and subsurface geology were integrated using a simple overlay concept illus-

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trated in Figure 1, which was derived from the equations above. The integration resulted in 4/7 = 57% successful wells. After integrating surface geochemistry, results improved to 4/5 = 80%. Similar high success rates reported in the literature and attributed to particular methods now can be shown to have resulted from integration of independent methods.

While the course of individual method improvement progresses, integration can immediately boost drilling success. Even great methods can be made better by integration. A 90% successful method can be improved to 95% by integrating with a 50% method. While using more than one method increases cost and complexity, increased success is the benefit. There is little reason not to integrate, and there is every reason to integrate.

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