LESSONS LEARNED FROM DISTRIBUTIONS AS GEOLOGICAL ANALOGS

WHICH DISTRIBUTION SHAPES ARE APPROPRIATE ?

Geological analogs can be inappropriately applied in exploration, often leading to a deterioration of project value.

A natural place to start considering discovery analogs is with **distributions of EUR** (estimated ultimate recovery), and their component parts (e.g. area, porosity and production rate) for related trends. Examination of such data helps avoid the bias of selecting the wrong distribution shape in the assessment.

The lognormal distribution often best approximates discovery data with broad variance distributions.

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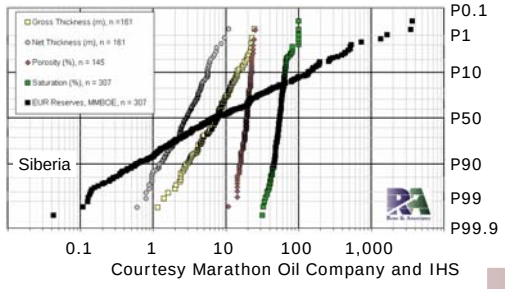
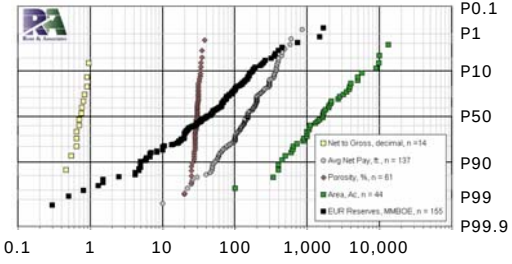
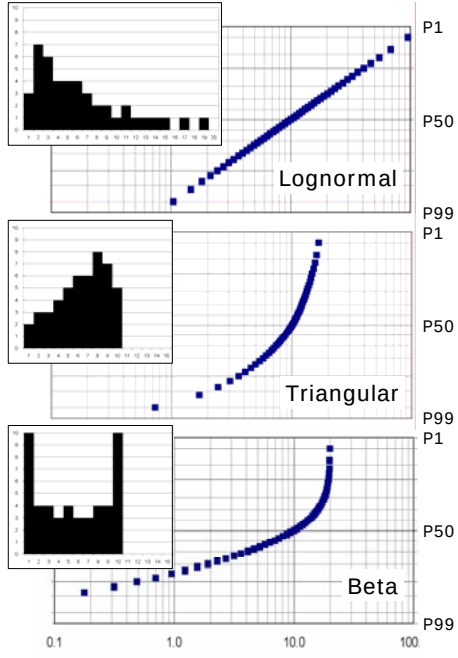


Courtesy Marathon Oil Company and IHS



Derived from Cossey & Associates Inc. Deepwater Database



Lognormal distributions tend to best approximate resource data and their components, but **the Beta distribution is a flexible alternative for components expressed as percentages** such as % gas, net/gross, porosity or recovery efficiencies

Let's take a look at the versatile Beta distribution

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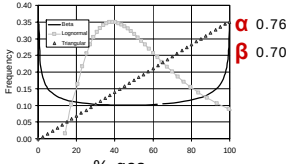
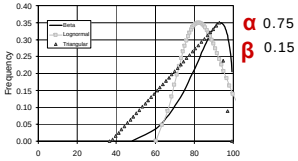
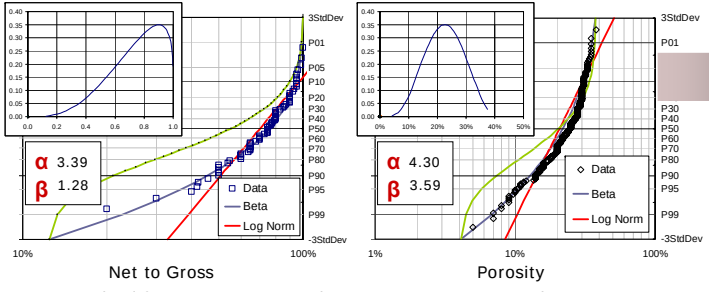
BETA DISTRIBUTIONS offer considerable flexibility for characterizing a wide range of skewed and truncated distributions associated with components expressed as percentages.







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Background on the Beta

Built from α and β, which are related to mean μ and variance ν

$$\alpha = \mu\left[\frac{\mu(1-\mu)}{\nu} - 1\right]$$

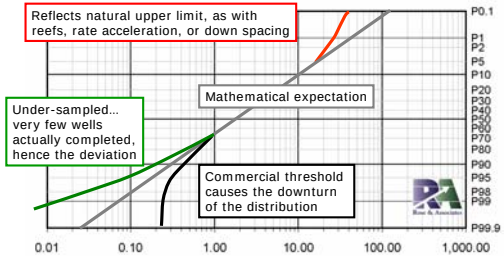
$$\beta = [1-\mu]\left[\frac{\mu(1-\mu)}{\nu} - 1\right]$$

$$\mu = (0.3)(P10) + (0.4)(P50) + (0.3)(P90)$$

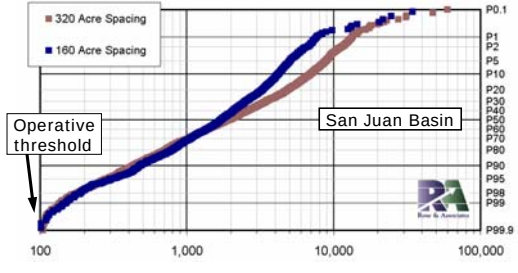
$$\nu = [(0.3)(P10)^2 + (0.4)(P50)^2 + (0.3)(P90)^2] - \mu^2$$

Enough Math

DEVIATIONS FROM EXPECTATION



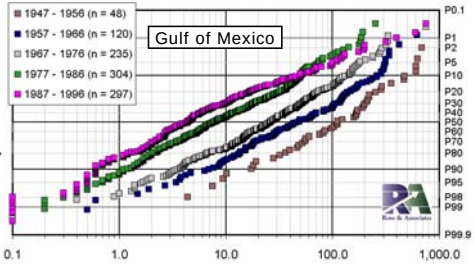
Frequent **deviations from the pure mathematical expectation** of distribution shapes can add confusion for decision makers, but these are often related to either growth limitations within geologic systems or business interventions associated with the desire for increased profitability.



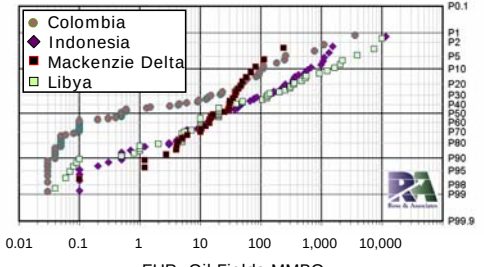
MMCFE

THE FORGOTTEN END

The part of the distribution most overlooked is the low end. However, these low EUR data, often considered "not possible for our company," are a critical component of unbiased analog assessment.



MMBOE



EUR, Oil Fields MMBO

Courtesy WoodMac

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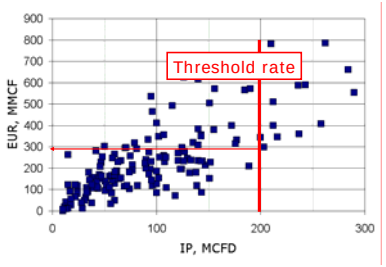
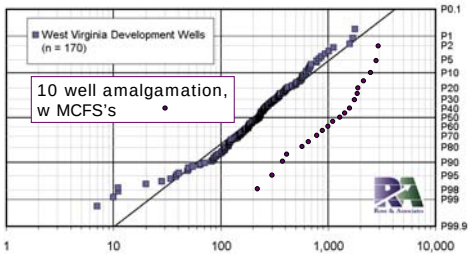
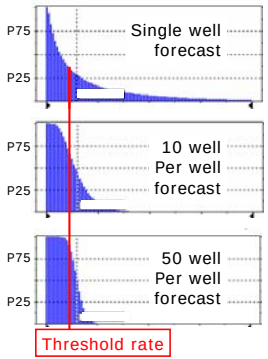
LESSONS LEARNED FROM DISTRIBUTIONS AS GEOLOGICAL ANALOGS

UNCONVENTIONAL RESOURCE PLAY ANALYSIS

In **unconventional resource plays** where individual anomalies are difficult to differentiate, EUR-per-well distributions are helpful, particularly in portfolio amalgamation techniques. Associated minimum commercial production rates are more appropriate to monitor rather than the MCFS, since you have to complete wells to determine their value.







Portfolio forecast:

"10 well program has a 65% chance of meeting per well rate forecast, with a P90:P10 resource expectation of 380 to 2400 MMCF"

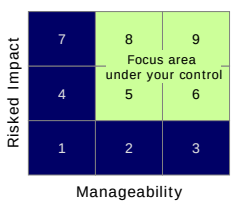
UNCONVENTIONAL RESOURCE PLAY ANALYSIS
10 Step Process

1. Gather data: EUR, IP's, porosity, sat. etc.; completion & operating constraints.
2. Define materiality, evaluation template & economic metrics (e.g.: produced volumes, well spacing, budget)
3. Determine land capture required and probability of capture
4. Relate EUR trends vs. geologic & operational variations
5. Plot net pay vs rate vs EUR vs decline rates
6. Look for differences from fracturing & capture vs acceleration
7. Establish type curves and CRS maps for each geologic trend
8. Establish drainage area per well for each trend
9. Evaluate impact of well count on required confidence (see left)
10. Prepare scenarios on different prices, timing and costs

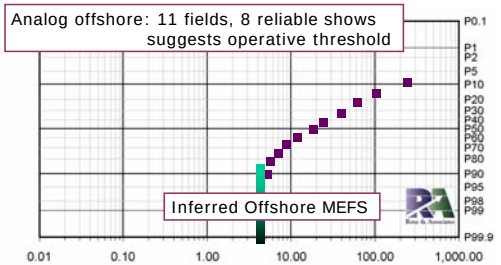
Compare, Rank and Choose Play to Pursue

Seven Conditions for Confidence in Delivery

1. Understand the direction, deliverables, accountabilities
2. Know the key Uncertainties in delivering your targets
3. Ensure actions are taken to manage the Uncertainties under your control
4. Ensure the basic processes can be relied upon
5. Seek challenge to ensure objectivity
6. Ensure that the right conversations take place at the right time with the right people
7. Measure your performance, understand it and act on it



FSD RECONSTRUCTION



If a target prospect or onshore trend has an offshore analog, the field size distribution of the analog trend needs to be **re-constructed** with underreported minimal discoveries to reveal its true character.