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NREL East Texas Project

April 18, 2018

Overview of Published Reservoir Data Analysis

Introduction

In order to assess the reservoir characteristics in the area surrounding Eastman Chemical, published well data from various sources were compiled into a hydraulic properties content model. This content model was used to analyze the rock characteristics and calculate the RPI (Reservoir Productivity Index) and RFC (Reservoir Flow Capacity) with MATLAB to assess the potential for each reservoir. This analysis is important because the data set can reveal trends regarding geologic units and locations within these units. For example, despite typical variations in rock properties within the same unit in different areas, certain units may consistently display more favorable characteristics than others. By comparing data from different fields and rock units, these general patterns can be used to assess the probability of certain rock properties on or near the Eastman Chemical property.

Methodology

Excel

The data were compiled from published sources such as research papers and field reports into a hydraulic properties content model in Excel. Most of the data consisted of reported field averages with some data coming from specific wells. These data were entered by row with each reservoir characteristic (i.e. porosity, permeability, water saturation, etc.) occupying a specified column in the spreadsheet. After all of the data from our sources were added, sources of error such as misspellings and row duplicates were corrected so that the data set would be ready for analysis.

MATLAB

In MATLAB, a script was written to read data from the hydraulic properties content model and perform a Monte Carlo simulation of RPI and RFC. The 10th, 25th, 50th, 75th, and 90th percentiles of the simulated RPI and RFC values, along with their coefficient of variation, were then written into a reservoir properties content model by MATLAB to analyze the probability of the reservoir characteristics.

Formulas and Variables

The RFC and RPI formulas used were taken from a geothermal resource analysis by Erin Camp (2016). The RFC formula is shown below where k is permeability in millidarcies and H is reservoir thickness in meters.

$$F = kH$$

The RPI formula is shown below where μ is viscosity in pascals per second, D is the distance between the injection and production wells in meters, and r_w is the wellbore radius in meters.

$$RPI = \frac{2\pi kH}{\mu \ln \frac{D}{r_w}}$$

A few assumptions were made for variables in the RPI formula. Since the wellbore radius and the distance between the injection well and production well are not set values at this stage during the project, D was set equal to 1000 m and r_w was set to 0.1 m. Additionally, since water viscosity is a function of temperature and pressure, which were not listed in the data sources, this variable is also an unknown value. In Camp's 2016 report, μ= 0.000299 Pa-s was used as an assumed viscosity for water at temperatures greater than 90°C. Since this study is only concerned with high temperature reservoirs, the same value was assumed for this RPI calculation. This aspect of the calculation may be improved in the future with greater temperature and depth information for the local area. Lastly, since most of the data sources did not specify if the recorded permeability values were the permeability of gas or water, no correction was made to these values.

To create random values for the simulation that reflect the variables' most likely occurrence, a log-normal distribution was used for permeability and a triangular distribution for thickness.

The uncertainty of the variables was determined through a 0-5 scale based on the reliability of the data source. This scale was translated into a standard deviation percentage for each data point in the MATLAB script.

Data

The reservoir properties content model, which included RFC and RPI values from the MATLAB calculations, was used to analyze overall trends between formations. Below is a table that contains averages and the standard deviations of reservoirs between fields. Some values, such as permeability, contain standard deviations that are higher than the average. Of course, negative permeability does not exist. These high standard deviations are mostly the result of a few values that are extremely large relative to the rest of the data for that reservoir. While these high standard deviations are considered relevant and possible to encounter, the probable distribution of the value must be considered.

Table 1 Average reservoir characteristics based on published data. The Geologic Units are in order of depth/age.

Geologic Unit	Permeability (mD)		Thickness (m)		Porosity (%)		Water Saturation (%)		RFC*		RPI**	
	Avg	StD	Avg	StD	Avg	StD	Avg	StD	Avg	StD	Avg	StD
Rodessa Limestone	59.1	61.0	3	2	15	4	21	2	155	137	0.35	0.31
Pettet Limestone	161.5	294.2	5	3	15	2	31	7	299	248	0.67	0.55
Travis Peak Sandstone	62.7	35.7	47	61	15	2	29	5	1772	2314	3.94	5.15
Cotton Valley Sandstone	0.3	1.0	37	33	8	2	31	6	6	19	0.01	0.04

* RFC = Reservoir Flow Capacity

**RPI = Reservoir Productivity Index

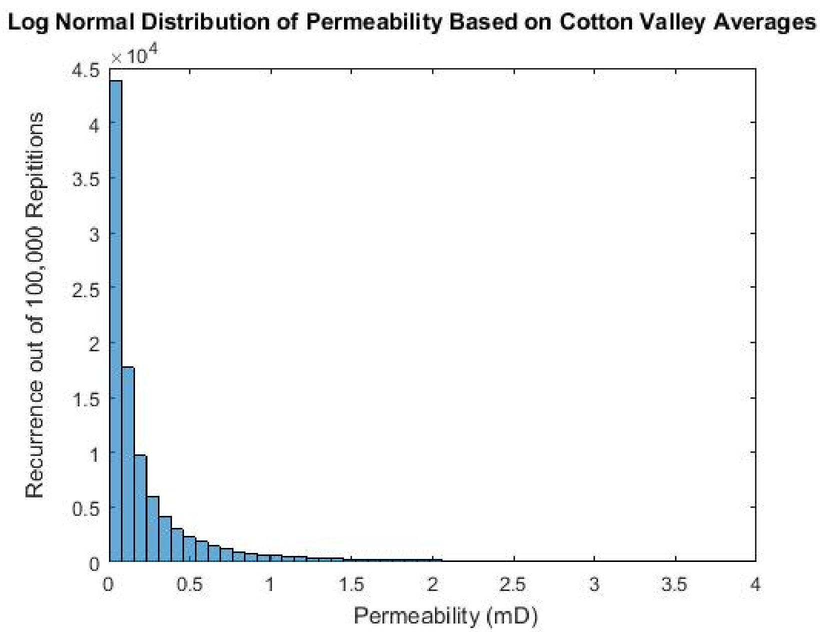

Figure 1 View of probable permeabilites in the Cotton Valley Sandstone based on averages.

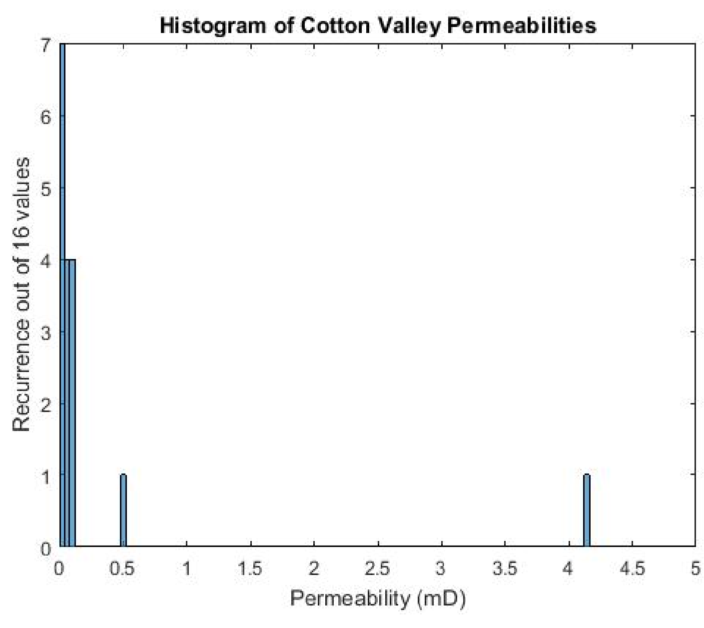

Figure 2 View of permeability distribution from published data

Figure 1 shows the likely permeability values that will be encountered based on the lognormal distribution of field value averages. This figure was created using a Monte Carlo simulation of 100,000 repetitions in order to visualize the mean and standard deviation of the Cotton Valley permeability in Table 1. Figure 2 is a histogram of the actual data used to calculate the mean and standard deviation.

These figures, while similar in their distribution, should not be used to estimate permeability in a specific area. However, they can certainly give insight into which reservoirs tend to show more favorable characteristics.

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