GEO2FLOW WORKSHOP USING YOUR DATA

Discover how to model compartments, saturations, and permeabilities for *your* field – not some generic dataset. Learn about the science behind Geo2Flow – not just the "button clicks" - in order to use it more effectively. Engage in interdisciplinary discussions that are stimulated by Geo2Flow's enforcement of consistency in model building. On completion of the workshop, return to your company with knowledge, understanding, and tangible results that can be used immediately.

This document covers the description of the workshop, a detailed description of the data we will use on your field, the workshop outline, a bio on the workshop instructor Dr. Daniel O'Meara, and pricing options (a three or five day workshop).

1. Description

1.1 Background: This workshop is designed for reservoir engineers, geologists, and petrophysicists who want to understand the science and workflows behind building consistent 3D reservoir models of saturations, permeabilities, compartments, and volumetrics. Students will analyze their own field(s) of interest, using Petrel models and ancillary spreadsheets containing capillary pressure and relative permeability curves, MDT/RFT pressures, and poro-perm data from cores. To instill concepts, students will be "hands-on" with Geo2Flow software that implements these workflows. They will consider a range of diverse and high impact scenarios, all of which are consistent with the basic data. The workshop can be either three or five days in duration, depending upon the number of Petrel models and their complexity.

1.2 Objectives : After this workshop, you will be able to:

- Appreciate the fundamentals of capillary pressures and J Functions as they pertain to reservoir modeling.
- Identify compartments or free water elevations using log-derived J Functions.
- Supplement compartmentalization analysis with pressure data.
- Explore the impact of errors that are inherent in permeabilities, irreducible saturations, and Archie's exponents.
- Do quality control on your field(s) of interest.
- Classify log data according to J Facies.
- Upscale net-to-gross, net porosity, horizontal and vertical permeabilities, and J Functions for distributing properties in 3D.

- Ensure that porosity, permeability and water saturation distributions honor data at the wells.
- Estimate both drainage and imbibition relative permeabilities derived from J Functions.
- Calculate volumetrics that are consistent all existing data and interpretations.
- Create multiple, high impact scenarios for simulation studies in order better to understand uncertainties.
- Apply workflows to modeling saturations, permeabilities, compartments, and volumetrics, whether in "data rich" or "data poor" environments.
- Understand the science behind the technology

1.3 Prerequisites: Prior experience with 3D geological or flow simulation models. One or more company Petrel projects of interest (see data requirements below).

1.4 Venue Set Up: The workshop training facility and training computers are to be provided by the purchaser. Often the client's internal room or an offsite room is used. Training can take place on training computers or employee laptops.

2. Project Set Up

2.1 Your Project: Here is what we require: We need a Petrel project that has porosity and water saturation logs at the very least. A permeability log would be nice but is not required. If you have poro-perm core data loaded as logs, then it's all the better. A 3D porosity is required for modeling in 3D. Typically, you may have capillary pressure and relative permeability curves, MDT/RFT pressures, and poro-perm data from cores contained in spreadsheets. That's easily handled with a nifty tool we have for pulling the data out of the spreadsheets easily and quickly for use by Geo2Flow and Petrel. This is enough to get us started with some serious modeling.

2.2 Software set up: Geo2Flow software will be loaded onto the student's laptop or desktop for the duration of the workshop. We can do the installation on the first morning of the workshop or during the week prior to the workshop (at your convenience). Students will be granted a further 15 day Geo2Flow license immediately after the workshop is completed. Petrel software may be obtained from Schlumberger for use during the workshop. If not available, the instructor will show off the Petrel portion of the workshop using his Petrel set up.

2.3 Computer Requirements: If you have a devoted training room, we can set up on its machines. But don't feel limited by a room or computers. If you want to run off of student laptops, we can do this also. In this way, you can ensure that all students are "hands-on" and none "passive" (unless they want to be passive because they are floating in and out

of the workshop). Here is a simple rule of thumb about the quality needed for laptops: if it can run Petrel, then it can handle Geo2Flow. In other words, if the video card, RAM, and CPU are suitable for running Petrel, then they are suitable for Geo2Flow.

2.4 Licensing: In the workshop, we will run with node-locked, server licenses, or demo licenses, depending on your setup. This means that student laptops do not need to be linked up to a central server. Afterwards, we will set you up with "a multiple user" 15 day license so those attending the workshop can follow up with using the software afterwards. So, for this, we'll need domain and machine id information on your server (we will communicate with your IT department for details). In general, we want to ensure that students are free to use Geo2Flow for a period after the workshop.

2.5 Confidentiality: Typically, we execute a Confidentiality Agreement to cover the use of your project and data. Please note: Geo2Flow workshops are offered strictly in company venues – as opposed to public venues - in order to preserve confidentiality.

2.6 Working up the Data: We prefer to obtain your Petrel project and ancillary data at least a week before the workshop. The main reason for doing this is to QC the data and work with you to remedy any issues that would prevent an expeditious use of your data in the workshop. In general, if there are any QC issues that need to be sorted out, we would like to identify them in advance. Instructions on how to transfer your data (FTP site) are given upon receipt of purchase order. If it is impossible to have the project ahead of time, we will handle it on site during the first few hours of the workshop.

2.7 Number of Students: Fifteen students is the maximum, so take advantage of this if you like: the price is the same. A few weeks prior to the course, we will need to get a list of those attending, their email addresses and disciplines.

2.8 Classroom Set Up: Please provide a projector set up that can connect to the instructor's laptop. A white board or flip chart would also be appreciated.

3. Petrel Project Set Up

3.1 Key Points about your Petrel model:

I.   The Petrel model should have porosity and water saturation logs. The hydrostatic equilibrium logs are preferred, those not those significantly altered by, say, a waterflood. For portions of the field that are significantly affected by water encroachment, we calculate synthetic saturation logs to estimate the original, hydrostatic conditions.

II. We need a permeability log; but, this can be done in several ways. If you have one in the Petrel model, that's great. If not, it would be good to have poro-perm core data. Now, you can have these data as logs in Petrel or in a spreadsheet.
III. If you have a facies log, then we will use it.
IV. If we are to do calculations in 3D (to show off our entire workflow), then we need a 3D porosity for porosity.
V. If you have a 3D property for facies, we will use it.

3.2 Spreadsheet Data:
As listed below, there are three main types of data that we read from spreadsheets. In all cases, **make sure the well names in the spreadsheet are exactly the same as in Petrel.** In other words, if Petrel has a name like "Red Head 1", then the spreadsheet must have the same name, not an abbreviation such as "RH1". If the names are different, then Geo2Flow assumes you are reading analog data from another field and will, thus, not be able to connect properties in your model (such as facies or zone) to the imported data.

I. Capillary pressure. If you have capillary pressure data in spreadsheets, we've devised a Petrel plug-in to read it very quickly. For each curve, we expect well name, sample number, measured depth, porosity, permeability, IFT and contact angle.
II. MDT/RFT pressure data. At a bare minimum, we need well name, measured depth (we calculate TVDSS), and pressure. If you have mobility or some kind of remarks on quality (such as "tight", "super-charged", "good test"), we can read them too (in column or row format).
III. Poro-Perm data. If you don't already have a permeability log or poro-perm data in Petrel, then we can read it out of a spreadsheet. The minimum data required is well name, measured depth, porosity, and permeability. If you have facies as well, then we can read it.

3.3 Uploading Spreadsheet Data:
You can upload the individual spreadsheets into the folder on the FTP site that we will provide you (FTP transfer details given upon receipt of Purchase Order).

3.4 PVT Data:
We do not need detailed PVT data in order to get started.

For oil, we can assume "dead" or "live (black)" models.

I. Dead Oil.
  a. API gravity.
  b. Oil formation volume factor.
  c. Black Oil.

II. Black Oil.
  a. API gravity, reservoir temperature, and bubble point.

b. At the bubble point, oil formation volume factor, solution gas-oil ratio, and viscosity.
c. Under-saturated: pressure, oil formation volume factor and viscosity.
d. Gravity of gas and percentages of N2, H2S, and CO2.

III. Gas.
a. Reservoir temperature.
b. Gravity gas and percentages of N2, H2S, and CO2.

IV. Water.
a. Reservoir temperature.
a. Average pressure.
a. Salinity (ppm).

3.5 Questions for you to answer: From previous experience, we can predict questions that we will have about your project. Sometimes, these are obvious but we prefer to check just to ensure we don't get off on the wrong track. You will need to answer:

I. Which wells should we use?
II. Which porosity log should we use? IMPORTANT: This porosity log must be the same that was used to create the 3D porosity in the grid, to ensure an excellent match of the 3D porosity to the upscaled porosity.
III. Is the porosity log that you selected above an effective porosity or a total porosity?
IV. If applicable, if the porosity log that you selected is the effective porosity, please tell us what cutoffs where use to calculate it.
V. Which saturation log should we use?
a. NOTE: The saturation log should not be derived from saturation height functions.

VI. Is there are permeability log? If not, there should be poro-perm data, either in a spreadsheet or in Petrel. If not, we need the equations used to generate a permeability.
VII. If there are multiple models and/or grids, please tell us which one we ought to use first.
VIII. For the model and the grid that you describe above, please tell us:
a. Which 3D porosity should we use?
IMPORTANT: this porosity should be derived from the porosity log you choose in point 2.

b. Is the 3D porosity that you selected a net porosity or gross porosity?
c. We assume that all wells were used to upscale the porosity log. If not all, then please tell us which ones were included or excluded.

d. If applicable, please tell us whether a discrete log (such as facies) was used to bias the upscaling of the porosity.
e. If there is a net-to-gross criteria, please tell us about it or how any net-to-gross property was derived.

4.1 Geo2Flow Workshop Outline:

Technical Overview

- Overview of Geo2Flow®
  - Inputs and Outputs
  - Log-derived J Functions
  - Matching 3D Saturations to Logs
  - Constraining Permeability with Saturation Logs
  - Horizontal and Vertical Permeabilities
  - Identifying Compartments
  - Rock Typing: J Facies
  - Interdisciplinary Workflows
  - Estimating Relative Permeabilities
  - Sources of Error

First "Hands On" Session: Basic Geo2Flow® Functionality

- Run Through All Main Workflow Steps
- Main Interface
- Workflow Managers
- Help documentation

Gathering Data From The Geological Model

- Zones, Blocks, and Partitions
- Porosity and Indicators in 3D
- Well Logs: Required and Optional

Building a Catalog of J Functions

- Background on Capillary Pressure
  - Characteristics of Curves
  - Methods of Measurement
  - Calculation in Reservoir
  - J Functions: Definitions and Models
- Fitting J Functions to Lab Data
  - Unimodal models
  - Bimodal models
  - Dead Volumes Corrections in Mercury Data

Poro-Perm Correlations and Errors

- Describe Porosity Bins
  - Binning Options
- Permeability Log and Error CDFs
  - When Poro-Perm Data Are Available
  - When Permeability Is Estimated
  - Analytical Poro-Perm Models

Fluid Properties

- Fluid properties
  - Phase systems
  - Dead Oil – For Quick Estimations
  - Water Properties - Calculator

Log-Derived J Functions

- Identify log-derived J Functions
  - Using the J Function Catalog
  - Exploring the Data: Filtering
  - Defining Equilibrium Regions
  - Equilibrium Region Partition Dependencies
  - Defining New J Functions
  - Extending Equilibrium Regions

Discussion
- Review and Questions

Sources of Error
- Describe Error Parameters
    - Probability and Cumulative Distribution Functions
    - Permeability Errors
    - Irreducible Saturation Errors
    - Errors in Archie Exponents

J Facies
- Calculation of J Facies From Logs
    - Resolve Inconsistencies
    - Set Indicator Dependencies
    - Interpret cross plots
    - Interpret J Function output

Upscaling Well Logs
- Net-To-Gross Cutoffs
- Inspecting Output: Evidence of Coarse Lumping
- Indicator Equivalencies

Calibrate 3D Gross Porosity
- Data versus Model Plots
    - Outliers
    - Fitting Nodes
    - Modifying Fit Parameters

3D Net Porosity and Net-To-Gross
- Fitting Models

3D Permeabilities
- J Facies Permeability – For Upscaling J Functions
- Horizontal Permeability
- Vertical Permeability

3D Initial Saturations
- Fitting Upscaled J Functions
- Estimating Relative Permeabilities
    - Imbibition Models – Trapping Function

Volumetrics
- Histograms and Tabular Output

Analyze Phase Pressures
- Analyze reservoir pressure
    - Identify equilibrium regions

Detailed Inspection of Output
- J Facies logs
- Blocked J Facies Logs
- Cross plots
- Calculated Archie's exponents

Identifying "Black Swans"
- Assessing Uncertainty: Possibility vs. Probability
- Formulating Scenarios

Wrap-Up of Workshop
- Summary of Geo2Flow
- Questions and Discussion

5.1 Course Instructor: Daniel J. O'Meara, Ph.D.

Dr. Dan O'Meara's thirty nine years of experience in the Oil and Gas Industry are broadly based, encompassing reservoir engineering, geological modeling, petrophysics, software development, academia, management, and consulting. He has worked with major oil companies, national companies, and independents on evaluating some of the largest oil and gas fields in the world. He is internationally recognized as an expert in reservoir characterization and reserves estimation. He has been a Distinguished Lecturer of the Society of Petroleum Engineers, has been Consultant of the Year for Landmark, and has been invited to give numerous presentations on reservoir characterization. His career encompasses both industry and academia.

His Geo2Flow and StrataSim software products have been developed by O'Meara Consulting and marketed worldwide. They have gained respect as leading-edge, interdisciplinary tools that "raise the bar" technically in the arena of reservoir characterization. Through O'Meara-Castagna, Inc., he has collaborated with John Castagna, a well-known geophysicist, on a software product that performs synthetic velocity analysis.

From 2006-2009, Dr. O'Meara was Chief Advisor, Reserves Estimation for the Landmark division of Halliburton. 1992-2006. From 1992-2006, Dr. O'Meara was the Director of the Institute for Reservoir Characterization at the University of Oklahoma. He enjoys an excellent reputation amongst his students and has taught both graduate and undergraduate interdisciplinary courses in the Schools of Petroleum Engineering, Geology and Geophysics, and Business. He was the leader in reforming the University of Oklahoma's Petroleum Engineering undergraduate curriculum, the first major reform in more than twelve years. He has taught numerous courses throughout the industry, including a course in Landmark's "Science behind the Technology" series. In addition, he taught a five-day reservoir characterization course for ConocoPhillips that was offered ten times to an enrollment exceeding two hundred students. Further, he has taught at the Shell Training Center. His courses are characterized by combining understanding of the relevant science with applying it to field examples using software. His students come away ready to tackle real problems.

Dr. O'Meara has managed interdisciplinary teams in industry and academia. He was the leader of British Petroleum's Reservoir Description Team in Houston for three years. He managed several interdisciplinary projects at the University of Oklahoma, including the multi-year Gypsy Project funded by the Department of Energy and 10-15 person reservoir characterization projects for industry partners. Early in his career, he was a researcher for ten years at Shell's Bellaire Research Center. His main areas of interest entailed the measurement of capillary pressure and relative permeability and the rapid simulation of flow in complex geological models. For one year, he was chosen to be an Exchange Scientist at the Royal Dutch Shell Laboratory in the Netherlands.

Dr. O'Meara received his Ph.D. (1979) from Princeton University, specializing in the area of Fluid Mechanics. He also has an M.A. from Princeton and a B.S. from the University of Rochester. To date, he has been awarded five patents for inventions involving measurement of the flow characteristics of reservoir rocks and the assessment of oil and gas reserves.

Dr. O'Meara has actively participated in the University of Oklahoma's Energy Institute of the Americas, thereby developing contacts with Secretaries of Energy and oil industry leaders throughout Latin America. In addition, he has been on the World Business Review Advisory Board.

6.1 Pricing Options: This Geo2Flow Workshop Using Your Data is available
internationally or domestically (USA) for three (3) day or five (5) day sessions. Contact Vicki at vicki@geo2flow.com for All- Inclusive Pricing which covers the work up and the quality assurance of your projects to be used in the workshop, all travel related expenses, the workshop training, and a 15 day Geo2Flow license per student given immediately after the session ends.