London Petrophysical Society
“Petrophysics-101” - Basic Formation Evaluation Seminar

Wednesday 18th September 2013.
The Geological Society, Burlington House, London

Agenda

Time	Title / Subject	Speaker	
09:00 - 09:20	*Registration*		
09:20 - 09:30	*Introductions*	*LPS*	
09:30 - 10:15	Fluid distribution in the reservoir: porosity and water saturation, permeability, wettability & capillary pressure	Mike Lovell	University of Leicester
10:15 - 11:00	Logging - Theory and Practice	Adrian Leech	Gaia Earth Science
11:00 - 11:30	*break*		
11:30 - 12:15	Other data - Core, SWC, Pressures and Fluids	Dominic Woodley	BG Group
12:15 - 13:00	Whether we push or pull, what should we worry about ? A review of some of the issues concerning the planning, acquisition and quality control of logs.	Mike Millar	BG Group
13:00 - 14:00	*lunch*		
14:00 - 14:45	Lithology, shale volume and porosity	Jeff Hook	JaysHeath Ltd
14:45 - 15:30	Saturation and fluid contacts	Roddy Irwin	Gaffney-Cline & Associates
15:30 - 16:00	*break*		
16:00 - 16:45	‘Net & Pay’ - the petrophysicist’s input to quantifying the reserves	Andy Stocks	Petra Physics Ltd
16:45 - 17:30	Permeability estimation and saturation-height functions	John Bennett	Perenco
17:30 - 17:40	*Closing Remarks*	*LPS*	
17:40 - 20:30	*Wine and Savouries*		

Fluid distribution in the reservoir: porosity and water saturation, permeability, wettability & capillary pressure

Mike Lovell, Department of Geology, University of Leicester

Abstract

This talk introduces some of the basic concepts and definitions used in petrophysics.

Porosity defines the storage volume of the reservoir and relates to grain size distribution and diagenesis. The porosity is the potential storage space, and we are interested in porosity because, at its simplest, it represents the volume into which hydrocarbons may migrate. We define porosity as the ratio of the pore volume to the total volume, a dimensionless number (i.e. having no units).

Unfortunately in the presence of clay minerals some of the pore space is occupied by water electrostatically bound to the surfaces of the clays. This volume of water is effectively fixed in place and occupies pore space that is not accessible to hydrocarbons and hence reduces the total porosity to an effective porosity. Isolated pores and possibly capillary bound water may also contribute to the reduction in the available porosity from a total porosity to an effective porosity. **Effective porosity** is the plumbing of the system, the interconnected pore volume that is accessible to hydrocarbons and contributes to **permeability**

The proportion of hydrocarbons in the pore space is defined by the **water saturation** (Sw), and convention assumes the hydrocarbons occupy that volume of porosity not occupied by water (hence hydrocarbon saturation is 1-Sw).

In defining an **effective porosity** we need to remember to define an **effective water** saturation; in a similar way if we define a **total porosity** we must define a **total water saturation**.

The distribution of hydrocarbons in the reservoir requires the successful migration of the lower density hydrocarbons into the reservoir, and the displacement of the original pore water. With immiscible fluids, **wettability** determines which fluid coats the surface of the pores, and depends on the chemical and physical properties of the solids and fluids. The grains or solid framework in a water-wet rock are preferentially coated by water with hydrocarbons occupying the centre of the pores, whereas in an oil-wet rock the converse is true.

Permeability is defined by Darcy's law and is the ease with which a fluid flows through the reservoir. **Relative permeability** adapts this law to multiphase flow conditions and is the ratio of **effective permeability** of a fluid at a particular saturation to the **absolute permeability** of that fluid at total saturation. **Relative permeability** is really a ratio of two separate permeability measurements and again is a dimensionless number (i.e. having no units). Thus we have a number of measures of fluid flow.

Capillary pressure is defined by fluid-solid properties (interfacial tension and wettability) but also by pore size (i.e. porosity). Capillary pressure represents the buoyancy force necessary for a hydrocarbon droplet to displace water from a pore during the migration process; as pore size decreases this force increases, thus large pores in the reservoir are more easily drained of water and fill with hydrocarbons more readily than smaller ones. Thus, except where the pore sizes are uniform, the saturation is rarely constant throughout the reservoir. **Wettability** and **capillary pressure** thus control the migration of hydrocarbons into the reservoir and significantly influence the water saturation distribution.

We often discuss these apparently simple and basic parameters independently, but it is clear they are firstly each more complex than they might at first seem, and secondly they are each inter-related. As such these basic parameters are each critically important components of our petrophysical understanding.

Logging - Theory and Practice

Adrian Leech, Gaia Earth Science

Other data - Core, SWC, Pressures and Fluids

Dominic Woodley, BG Group

Abstract

The presentation will cover the basics of acquiring 'other' formation evaluation data (as opposed to GR, resistivity, density, neutron, sonic). Covering conventional and sidewall cores, formation pressures and fluid samples, it will look at the importance of planning the acquisition and subsequent evaluation of these data and how they are can be integrated with other data.

Whether we push or pull, what should we worry about ? A review of some of the issues concerning the planning, acquisition and quality control of electric logs.

Mike Millar, BG-Group

Abstract

The objectives are to give an introduction to the acquisition of log data, to promote understanding of some of the issues and uncertainties involved in using log data, and to show why this is so important the Exploration and Production industry.

This presentation will take a look at some of the issues and uncertainties surrounding the acquisition and use of open-hole electric log data, whether the well is logged by wireline, LWD or any other conveyancing method. It will review the reasons why logs are run and some of assumptions made about logs. It will try to show why the calibration and quality control of logging tools and log curves is so important. Logs are frequently the only safe and cost effective way of collecting accurate borehole data that can be used to meet well objectives and so they add considerable value to our business.

Logs should be run to meet specific objectives defined during the well planning process. Logs then help us meet our well objectives by answering specific questions and needs. Of course logs are not exclusive in achieving these objectives, and it should be remembered that other borehole data such as core, cuttings, gas-logs and well-tests play an important role when used in an integrate formation evaluation programme

Electric logs can be acquired by a variety of conveyancing methods, wireline, wireline on drill-pipe, Logging While Drilling subs in the drill string (LWD), pump down through drill-pipe on slick line or in memory mode or on the end of coiled tubing or wired drill pipe. But whether logs are acquired by pushing or pulling, they all have a number of common quality control and quality assurance (QC/QA) issues with which petrophysicists and other users of log data should concern themselves.

We use calibrations, inferences and interpretations to derive the parameters we want from logs, but we must remember that there is always error and uncertainty getting from log measurements to the curves we require to meet our well objectives. Depth is a fundamental measurement with logs, but it can be subject to error. Depth matching then becomes an issue when comparing different logging runs or wireline with LWD and using log data with core.

Lithology, shale volume and porosity

Jeff Hook, Independent Consultant

Abstract

A petrophysical model of reservoir rocks will be described and the definitions of the different types of porosity considered. A response equation for logging tools based on a volume-weighted average of the components of the model will be developed from the model.

The response equation will be used to determine the shale volume from single logs and from dual log combinations. Shale volume from the gamma ray and spontaneous potential logs will be shown with examples demonstrating the determination of the interpretation parameters. In addition the use of the density-neutron and density-sonic combinations will be shown and the results compared. Following the shale volume determination the estimation of porosity will be covered. Use of single logs, principally density or sonic log, both as standalone data sets and in combination with core data will be demonstrated. Again the density-neutron and density-sonic combinations will be be used and the results compared.

Saturation and fluid contacts

Roddy Irwin, Gaffney-Cline & Associates

‘Net & Pay’ - the petrophysicist’s input to quantifying the reserves

Andy Stocks, Independent Consultant

Permeability estimation and saturation-height functions

John Bennett, Perenco