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Pressure Coring, A New Tool for Unconventional Oil & Gas Characterization

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Summary

Determining accurate oil saturations, gas volumes, content and deliverability are critical when attempting to assess the economics of unconventional plays. These determinations rely heavily on the analysis of freshly cut core. Accurate oil, water and total saturations are dependent on the ability of the laboratory to analyze fresh core. The total gas content, fluid saturations and gas compositions derived from cores are known to contain uncertainties as a result of the lost gases and fluids which escape the core during the ascent out of the hole, hence leaving a data gap which must be accounted for mathematically. In order to eliminate this issue, a new tool has been developed to retrieve core while capturing all gases and fluids in a variable volume sealed coring assembly. With all pore space material and core sample retrieved to surface, the reservoir fluids can be properly quantified.

Introduction

Understanding gas-in-place (GIP) volumes, reservoir bulk properties, and gas deliverability are critical when attempting to assess the risks, economics and potential success of a shale gas play. A key method in meeting this objective is to acquire the highest quality core, which is critical for petrophysical evaluation, stratigraphy, depositional modeling, reservoir engineering, wellbore stability modeling, formation damage prediction, and optimization of drilling and completion fluids.

Traditional core analysis data requires a careful selection of tools to be utilized, strict procedures on location to ensure core is cut properly combined with careful handling procedures to ensure that all required data is accurately documented and measured. If there are mistakes in the field resulting in poor sample quality, inaccurate data, or missing data, these mistakes often cannot be overcome due to the time dependent nature of the operations.

Unlike traditional coring, where the core is exposed to the wellbore, the newly designed coring tool seals the core barrel with a downhole valve, thereby ensuring that the all-important pore space fluids and gases are captured.

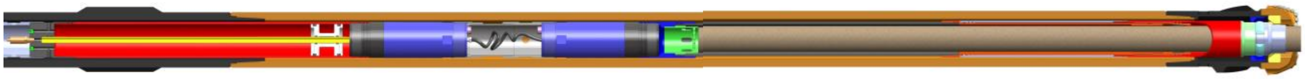
Theory

The tool has been designed to obtain a direct measurement of total gases and fluids by encapsulating the core in a sealed pressure barrel with a series of canisters that are attached to the barrel. The canisters capture all expanding gases and fluids at safe working pressures.

Figure 1 – Specifications of Coring System

Core Diameter:	3” (76mm)
Maximum Core Length:	10' (3m)
Max Temperature (operating)	250°F (125°C)
Max Pressure (operating)	500psi

Figure 2 – Components of Coring System



Example

Dry Gas Target Technical Objective

Shale gas is stored within a reservoir system by three primary mechanisms; 1) gas-filled porosity by compression, 2) adsorbed to organic material present in the rock, and 3) dissolved within the reservoir fluids. One of the primary objectives in a dry gas shale exploration program is to supply the core analysis laboratories with pristine core samples in order to provide sufficient data to enable characterization of bulk rock properties (mineralogy, organic content, porosity and water saturations), and total (sum of adsorbed, absorbed, and free) gas in place volumes over a cored interval.

The upcoming example focuses on helping to determine an accurate gas in place in these types of reservoirs which are a combination of small grain sizes and micro-porosity that are often beyond the technical specifications of today’s formation evaluation technology to accurately determine the amount of gas in place without using a lost gas model to estimate the amount of gas that was lost during a cores trip to surface. Traditionally canister gas content measurements are utilized to estimate sample gas content and then confirmed by a combination of porosity, fluid saturation and adsorbed gas storage capacity data used to quantify total gas storage capacity at reservoir temperature and pressure conditions.

Traditional gas content analysis collects a series of core samples to be placed in canisters for volumetric and compositional analysis. Gas volumes released from the canisters are measured over time until the samples are pulled out of the canisters and crushed to measure any residual gas that is left on the rock. The rate at which the gas expelled from the core plus the total volume of gas that is measured from the canister including the residual gas analysis are used to calculate the amount of gas that was lost (“lost gas”) during the trip out of the hole. The total volume for the samples are then calculated as the sum of the lost gas, measured gas, and crushed gas contents. These estimations can have large error margins as significant volumes of gas are expelled before the core reaches surface.

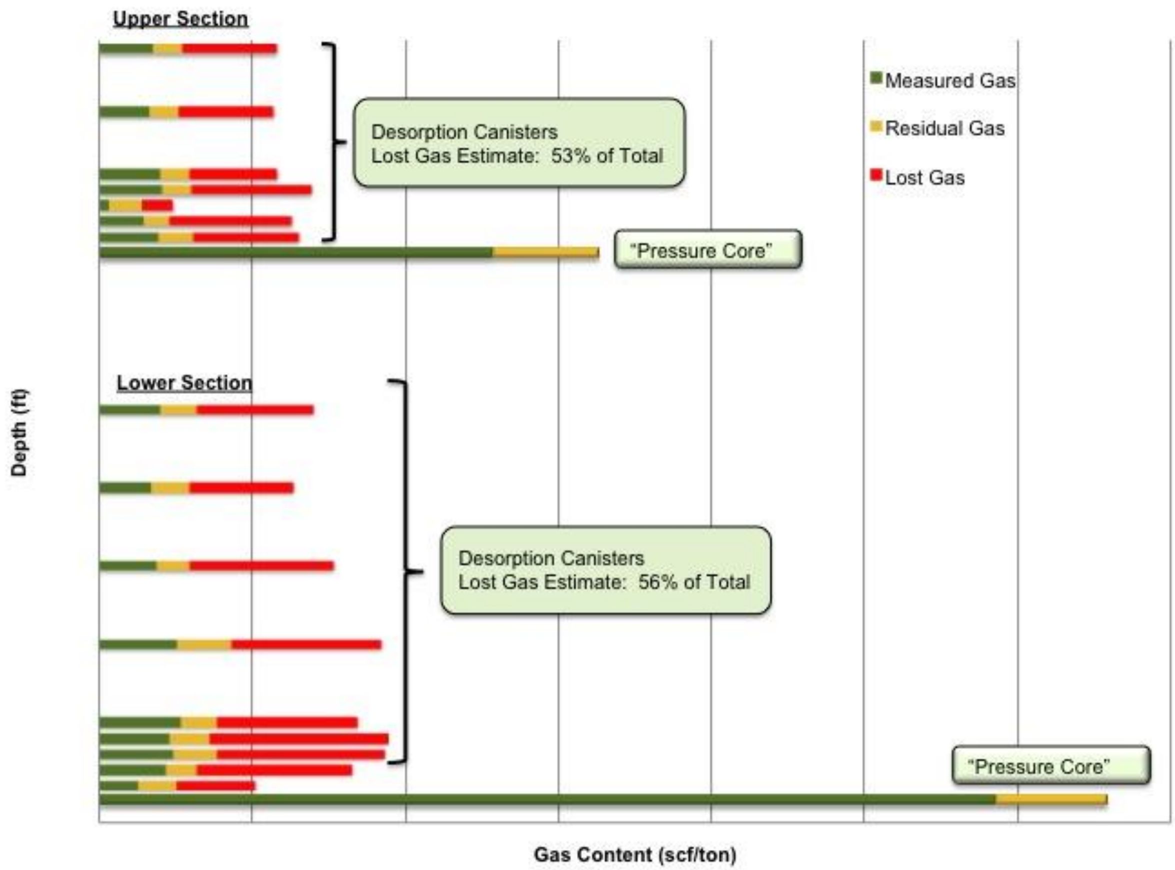
A recent coring program was executed in a dry, shale gas reservoir where no hydrocarbon liquids were present. The objective was to quantify the total amount of gas in place and compare the data results from conventional core versus adjacent pressure core runs. An upper and lower zone were identified with an extensive gas content program performed on each zone followed by a pressure core directly below the samples that were collected for gas content analysis. The program included an upper and lower reservoir objective where 30-foot wireline retrieved conventional core was taken in the upper section followed by a 10-foot pressure core. There was then a 177 foot drill ahead to the next core point where 60 foot of wireline retrieved conventional core was cut followed by 10 foot of pressure core.

Prior to running each pressure core, a wireline retrieved conventional core was obtained and multiple one-foot samples were placed in canisters to determine volumes by using the traditional gas content measurement of combining measured, residual and lost gas.

The pressure coring tool was deployed directly below the conventional core runs. Each pressure core collected a nine-foot long by three-inch diameter core that was sealed downhole and brought to surface under pressure. Once the core reached surface it was transferred from the rig floor to a heated isothermal water bath where total volumes of gas released from the core were measured. Total volumes were measured from the tool on location until negligible volumes were recorded at which point the tool was allowed to cool before the core was transferred to a core transport canister and sent to the laboratory for further analysis. Once the core transport barrel was received at the laboratory it was put back on test for additional gas content volumetric readings. In the laboratory the volume measurements were plotted versus time with all data being fit to a curve to monitor the behavior of the samples. The rate at which the gas evolved from the core was calculated until it was deemed that minimal gas would be lost when processing the core to be analyzed for residual gas analysis. The total gas contents for the pressure core samples were then calculated as the sum of the measured gas from the pressure barrel, the core transport barrel and residual gas analysis.

The as-received gas content numbers for the canister samples versus the pressure core samples were then plotted against each other.

Figure 2 – Graphical Relationship of Canister Data to Adjacent Pressure Core Samples



Note: The above example depicts a recent case history and with regards to client confidentiality all values have been removed however the graph does depict an accurate comparative ratio of gas content volumes.

Conclusions

A distinct difference exists between gas volumes obatined via traditonal methods and the pressure coring assembly. Based on actual data, the ”lost gas” estimation calculated in the traditional method reflects more than 50% of the gas in place downhole. The information shows a significant portion of gas is lost while pulling out of the hole using conventional coring..

In the upper zone, the pressure core is confirming there is two times more gas than what standard gas content analysis determines. In comparison, the lower zone shows more than three times the gas volume.

Based on the results of this project, it is concluded that the pressure coring application provides accurate volumetric measurements of gas in place. Currently, additional laboratory measurements are taking place to further this study. By combining porosity, fluid saturation, and adsorbed gas, gas storage capacity is being quantified at reservoir temperature and pressure conditions. Pressure coring takes the guesswork out of gas content analysis and is suitable for both conventional and unconventional reservoirs.