POROMETER
FILTER AND MEMBRANE TESTING TECHNOLOGY

APPLICATION NOTE
ASSESSMENT OF POROUS ROCKS BY GAS LIQUID POROMETRY*

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* Based on ***Gas liquid porometry – assessment of an alternative method for the determination of flow relevant parameters of porous rocks***, presented at the International Symposium of the Society of Core Analysts held in Napa Valley, California, USA, 16-19 September, 2013.

Traditionally, mercury injection porosimetry has been used for the determination of flow relevant parameters of porous rocks like permeability and pore throat size distribution. However, it is time consuming, destructive and not environmentally friendly (it requires relatively large quantities of mercury). Alternative techniques have been investigated to reduce waste, time and cost, and which are environmentally responsible. **Gas Liquid Porometry (GLP)** is an established method for membranes and filters, but is also a proven alternative to mercury injection porosimetry for petrophysics applications. It permits obtaining several parameters and information with good accuracy and reproducibility in one individual and fast measurement, reducing the measuring time from several hours to minutes.

METHOD

A typical GLP test requires the impregnation of a porous sample with an **inert and nontoxic wetting liquid** and the use of an inert gas (e.g. nitrogen) to displace the liquid out of the porous network (wet run). The “wet curve” represents the measured gas flow against the applied pressure (inverse proportional to the pore throat size). The gas flow against the applied pressure on the dry sample (“dry run”) is also measured. From the wet curve, the dry curve and the “half-dry curve” data (dividing the flow values of the dry curve by 2) information about the porous network can be obtained (Figure 1).

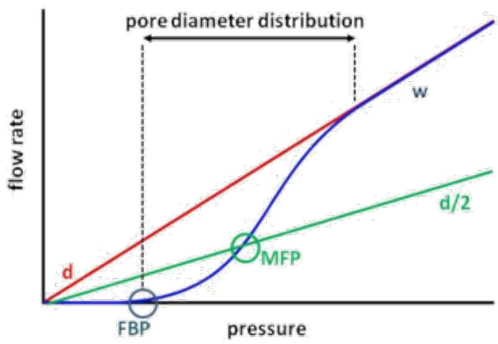

Figure 1: Measuring curves and resulting parameters in GLP (d = dry curve, w = wet curve, d/2 = half-dry curve, FBP = largest pore, MFP = mean flow pore: pore size at which 50 % of the total gas flow can be accounted; minimum pore size: calculated at the pressure where the wet and the half-dry curves meet).

Furthermore, it is possible to determine the cumulative filter flow distribution against the pore size and the corrected differential filter flow, which shows the flow distribution per unit of change in size (commonly defined as pore size distribution).

APPLICATION TO CRETACEOUS SANDSTONES

“Bentheimer sandstone” (quartz sandstone with 10-14% feldspar and up to 6% clay content) has been extensively investigated by core analysis and special core analysis (CAL / SCAL). Scanning electron microscopy and μ-CT imaging show that throat sizes smaller than 5 μm correlate with pore networks, formed by dissolved mineral phases, whereas throats smaller than 500 nm can be attributed to the local pore networks between the clay minerals (throats < 0.04 μm).

GLP measurements of 4-5 mm slices from the end of the plug were carried out by using a POROLUX™ 1000 porometer (POROMETER nv). Additional CAL / SCAL analysis were performed (permeability, BET surface, porosity, NMR, µ-CT), to characterize the corresponding porous networks and to correlate results of Hg-injection and GLP.

RESULTS

The measurements of each sample were replicated six times to evaluate the reproducibility of GLP. Each cycle took only about one hour, so in total this experiment was carried out in less than seven hours, equivalent to the time required for one single conventional Hg-injection test within the same measuring range. Figure 2 shows an average of the GLP curves and binned (left hand side). To compare the results directly with the conventional pore radii distribution – in terms of pore throat bin – a polynomial fitting (best fit: sixth order polynomial; residual sum of squares: 7.45; R-squared: 0.962) needs to be applied. This fitting also allows to recalculate the area underneath of the fitting curve to the same bin sizes used for the mercury experiment (right hand side).

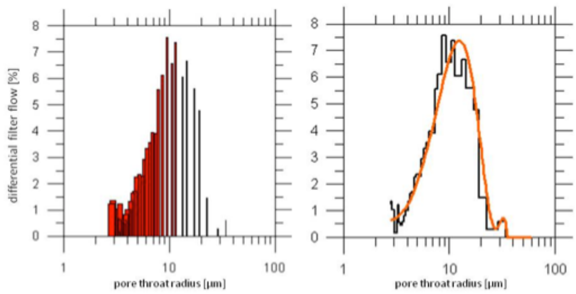

Figure 2: Averaged and re-calculated pore throat distribution (left hand side) and polynomial fitting for better comparison with results of the conventional mercury injection experiment (right hand side).

For comparison, the resulting pore throat bins have been plotted within the pore throat radii distribution obtained with mercury injection porosimetry. Figure 3 illustrates the results of both techniques, showing good accordance with each other. GLP measurements "scatter" a little bit more on the flanks of the main pore throat size, which is attributed to the effect of the recalculation for the comparison of both measurements.

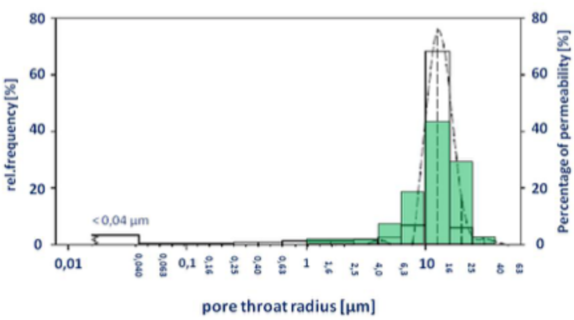

Figure 3: Pore throat radii distribution derived by Hg-injection (faded out) and by GLP (light green).

CONCLUSIONS

CFP has proved to be a versatile and feasible alternative for measuring the effective pore throat radii distribution of porous and permeable sandstones (e.g. Bentheimer type). GLP shows good reproducibility and good accordance with mercury injection experiments. Due to the combination of a non toxic wetting fluid use and application of significantly smaller pressures, this technique permits reusing valuable specimens for further investigations.