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Experimental Investigation of Two-Phase Flow in Consolidating and Intact Salt: Analysis of Capillary Pressure Measurements from Core Labs

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Summary

Two-phase flow of brine and air through very low permeability porous media is the dominant fluid flow state in and around geologic repositories for nuclear waste disposal. Constitutive models developed for other subsurface media (shale, sandstone, limestone, etc.) have been adopted but never experimentally parameterized for geologic salt. This report summarizes results of scoping capillary pressure and brine saturation measurements on reconsolidated run-of-mine salt and intact geologic salt samples. These measurements were obtained using mercury injection tests and yielded values of threshold pressure, pore-size distribution, and mercury saturation. The brine capillary pressure curve was then inferred from the raw mercury capillary pressure data. This report also summarizes estimates of the constitutive model parameters from the brine saturation and capillary pressure data (Brooks and Corey, 1964; van Genuchten, 1980). The results suggests that the model of van Genuchten (1980) is better suited for brine-air-salt systems. Additional testing is needed for the low brine saturation range of the capillary pressure curve where the present suite of tests did not yield sufficient data.

The laboratory testing and summary report was financed with Used Fuel Disposition Campaign funding for Salt Disposal Research Field Testing. This report satisfies milestone `M4FT-SN0819032`. The final laboratory report from Core Labs is attached.

Introduction

Two-phase flow of brine and air through very low permeability porous media is the dominant fluid flow state in and around geologic repositories for nuclear waste disposal. Even for initially saturated systems, excavation effects and thermal dry-out due to heat-generating waste lead to establishment of multiple fluid components and phases. Thus, successful numerical modeling of geologic disposal of nuclear waste in salt formations requires validated and verified constitutive models for brine and gas flow through intact, damaged, and reconsolidating crushed salt. Two-phase flow models for waste release scenarios in a geologic repository require constitutive relations for capillary pressure and relative permeability of the geologic medium (Kuhlman and Malama, 2013; Kuhlman, 2014). These media-specific empirical models require experimental measurement to parameterize and validate.

Constitutive models developed for other subsurface media (shale, sandstone, limestone, etc.) have been adopted but never experimentally parameterized for geologic salt. Capillary pressure and relative permeability constitutive relations presently used in repository numerical flow models of ultra-low permeability salt rocks use parameters derived from low permeability sandstones hydrocarbon reservoir rocks. The Multiwell Tight Gas Sands Project (Ward et al., 1987) included rocks with saturated permeabilities in the range 10^{-19} to 10^{-16} m^2. The properties of these rocks have been used as proxies for halite and anhydrite, where capillary pressure and relative permeability data are absent (Davies, 1991; Hansen et al., 2014). Halite (rock salt) and anhydrite have permeabilities on the order of 10^{-22} to 10^{-19} m^2 (Howarth and Christian-Frear, 1997; Beauheim and Roberts, 2002). Thus, with no direct measurements of important physical properties for geologic media of interest, the approach of relying on proxy data can lead to large unquantified and uncharacterized uncertainties in the distributions used in repository model calculations.

Additionally, the nature and variability of the non-linear relation between capillary pressure,

brine saturation, and two-phase flow permeability, which control such flow systems, have scarcely been studied. There is a pronounced data gap for two-phase flow constitutive model parameters needed to populate numerical models to simulate the thermo-hydrologic behavior of geologic media suitable for nuclear waste disposal. Numerical models currently use capillary pressure and relative permeability constitutive relations developed for soils, and lack justification for use in ultra low-permeability rocks. Halite is a viable repository host geologic medium due to its favorable hydraulic properties (i.e., low permeability, creep deformation, and saline pore fluids). Previous work aimed at experimentally determining two-phase constitutive model parameters focused of capillary pressure and single-phase permeability measurements on Salado anhydrite cores (Howarth and Christian-Frear, 1997). Some testing and sample preparation methods to be used in the work proposed here will be adopted from this earlier work. The work reported herein seeks to extend the earlier work on anhydrite to intact halite and reconsolidated run-of-mine (i.e., crushed) salt samples.

Some capillary pressure curve data are available in the literature for fine-grained, well-sorted (i.e., similar to table salt consistency) granular salt (Cinar et al., 2006; Olivella et al., 2011). Capillary pressure curve data characterizing samples well-graded run-of-mine (i.e., a wide distribution of grain sizes as obtained from mining) reconsolidated salt or intact salt samples are not available in the literature.

This report summarizes results of scoping capillary pressure and brine saturation measurements on reconsolidated and intact salt samples conducted by Core Laboratories' Petroleum Services Division. Reconsolidated salt samples were prepared in the Geomechanics Laboratory at Sandia National Laboratories by triaxial consolidation (Broome et al., 2014). Mercury injection tests were used to estimate the pore size distribution and the saturation of a Mercury-Air two-phase flow system. The tests were conducted with injection pressures of up to a maximum (brine-air capillary pressure) of 73 MPa (380 MPa Hg-Air). The tests did not yield significant data in the dry range of the capillary pressure curve. Hence, the data could not be used to estimate the residual brine saturation. This report also summarizes results of the parameters estimation from the provided capillary pressure data using the models of Brooks and Corey (1964) and van Genuchten (1980). The parameters were estimated for two reconsolidated and two intact salt samples, and include the air-entry pressure and pore-size distribution parameters. Three duplicate tests were conducted on one intact sample (identified in the report as 15-1, 15-2, and 15-3) and two on the other (identified as 14-A and B). Whereas the two models appear to explain the data from reconsolidated samples well, the same cannot be conclusively said for the intact salt data. No hysteretic behavior was studied in these scoping tests and no relative permeability measurements are included in this report. Due to issues resaturating the samples, no reliable relative permeability data were obtained. Relative permeability testing did not yield the complete curve from saturation to dryness. This highlights the need for additional testing, particularly at the dry ends of the capillary pressure and relative permeability curves.

The final report from Core Labs, including the raw data, is attached to the end of this report.

Materials and Methods

Mercury injection tests were performed on reconsolidated and intact geologic salt (rock salt, halite) samples to determine the porosity, air-entry pressure, and the empirical capillary pressure function

Figure 1: Prismatic reconsolidated salt sample encased in an epoxy coating.

for Brine-Air binary fluid systems. The experimental approach involves injection of mercury, which serves as the non-wetting phase fluid, into a confined pore spaces saturated with a wetting-phase fluid (air, in this case) at increasing hydrostatic pressures. Core Laboratories' Petroleum Services Division (Core Labs, hereafter) measured directional wetting-phase (air) fluid drainage (mercury displacing air) parallel to the core axis in salt core samples.

Three reconsolidated salt samples were prepared using triaxial cells in the Geomechanics Laboratory at Sandia National Laboratories according to the procedure discussed in Broome et al. (2014). Run-of-mine (crushed) salt samples from the Waste Isolation Pilot Plant (WIPP) geologic repository are reconsolidated under hydrostatic stress conditions up to 20 MPa and temperatures of up to 250°C. The prismatic samples were encased in an epoxy coating (see Figure 1) to achieve a cylindrical shape for which traditional triaxial cells are designed. The samples were subjected to conventional plug tests to determine their single-phase intrinsic gas permeabilities. One sample disintegrated and no useful data were obtained. The dimensions (Length $\times$ width) of the two samples that yielded useful data were 1.16 cm $\times$ 1.13 cm for sample 100-3 and 1.01 cm $\times$ 1.11 cm for 250-1.

Mercury injection tests were also conducted on three intact salt core samples from the WIPP repository by Core Labs. Two samples were of diameter $D = 1.5$ inches, while the third was 4 inches. The two small diameter samples are listed in Table 1 as 14-A and 14-B. At Core Labs the 4-inch diameter sample was sub-sampled for three duplicate measurements. The sub-samples are listed in Table 1 as 15-1, 15-2, and 15-3.

Table 1: Tested reconsolidated (100-3 & 250-1) and intact (15-{1,2,3} & 14-{A,B}) salt samples with sample properties.

Sample	M_{dry} (g)	ρ_g (g/cm^3)	ϕ (%)	k_{gas} (mD)	k_{swan} (mD)	β	P_{e} (MPa)
100-3	8.64	2.05	4.4	1×10^{-4}	1.9×10^{-2}		0.078
250-1	11.05	2.03	3.5	3×10^{-4}	7.9×10^{-5}		2.72
15-1	6.91	2.16	2.4		4.4×10^{-5}		1.69
15-2	9.61	2.15	2.1		2.1×10^{-5}		1.33
15-3	6.17	2.15	2.3		1.4×10^{-5}		2.76
14-A	18.98	2.16	1.4	1.7×10^{1}	4.4×10^{-3}	15.5	0.071
14-B	16.92	2.16	2.0	4.7×10^{-1}	1.7×10^{-2}	0.42	0.046

Results

Prior to mercury injection tests, the samples were subjected to a series of tests to measure routine sample properties listed in Table 1, namely, porosity, ϕ, grain density, ρ_g, intrinsic permeability, k (in milli-Darcies, mD), and the air-entry (threshold) pressure, P_{e}, for an air-water binary fluid system. Steady-state (constant head) intrinsic permeability tests (conventional plug analysis) were conducted on the two reconsolidated samples and one intact sample (14-B) to measure the intrinsic gas permeability, k_{gas}. Intrinsic gas and liquid (k_ℓ) permeabilities are related according to (Klinkenberg, 1941)

$$k_{\text{gas}} = \beta k_\ell \tag{1}$$

where $\beta = 1 + b/P$, b is the Klinkenberg slippage factor and P is pore pressure. The value of the dimensionless ratio β is reported in Table 1 for the samples for which it was determined.

Figure 2 shows the raw mercury injection test results for the two reconsolidated salt samples. Air-Mercury injection (capillary) pressure, P_c, is plotted against mercury saturation, S_{nw}. For an air-mercury binary system, air is the wetting phase and mercury the non-wetting phase. Saturation is simply the fraction of the pore volume occupied by a given fluid. Raw data for the two sets of intact samples are shown in Figure 3. The maximum air-mercury injection pressure achieved in the tests was 380 MPa. Whereas the dry regime appears to be approached for the reconsolidated samples, the same cannot be said of the intact samples; intact salt samples did not yield sufficient data in the dry regime.

Analysis of Results

The capillary pressure data of the reconsolidated samples are replotted in Figure 4 in terms of a brine-air binary fluid system, where brine is the wetting phase and air the non-wetting phase. Data from intact halite samples are shown in Figures 5 and 6. In the Figures, brine saturation, S_{w}, is plotted against the capillary pressure, P_c. These are inferred from the raw mercury saturation and capillary pressure for a mercury-air binary fluid system. This requires knowledge of the wetting phase (w) to non-wetting phase (nw) contact angles ($\theta_{\text{w,nw}}$) and the coefficients of surface tension,

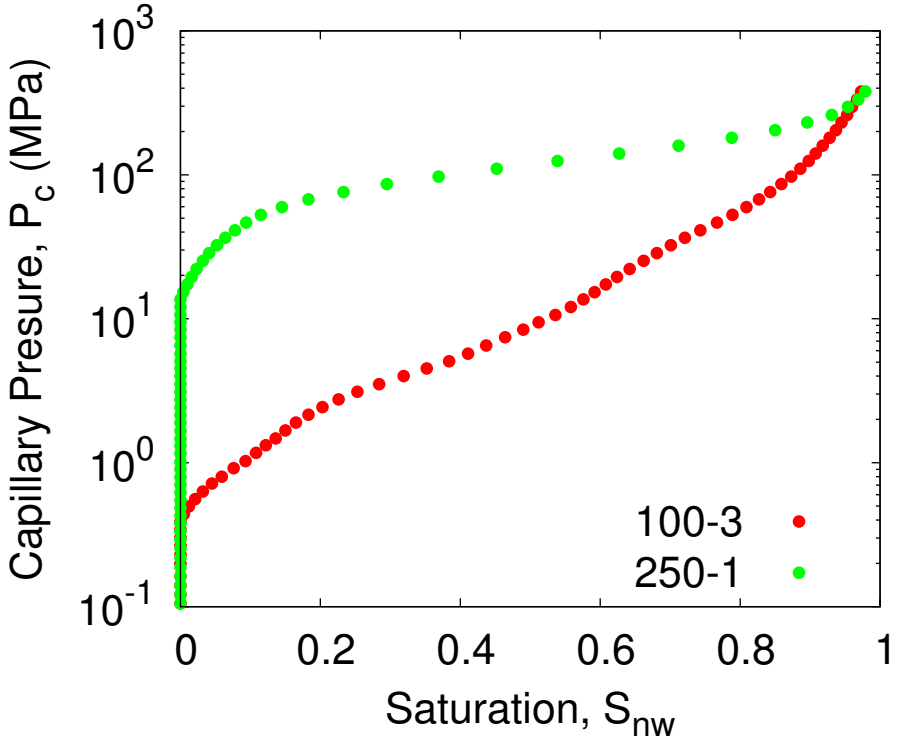
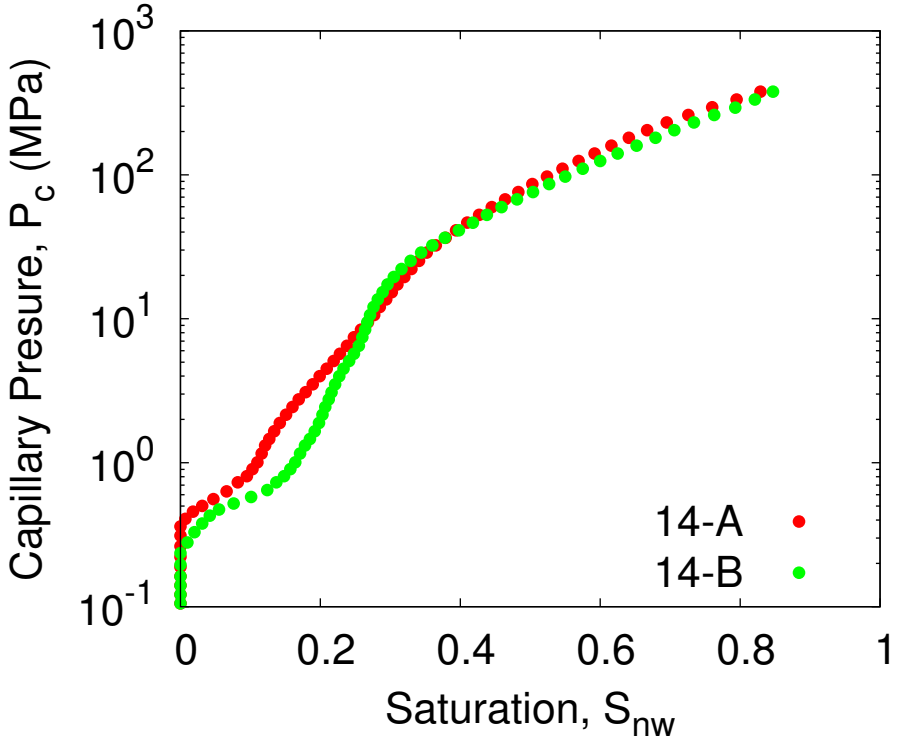


Figure 2: Results of mercury injection tests on reconsolidated salt samples. Air-Mercury capillary pressure, P_c, is plotted against mercury saturation, S_{nw}.



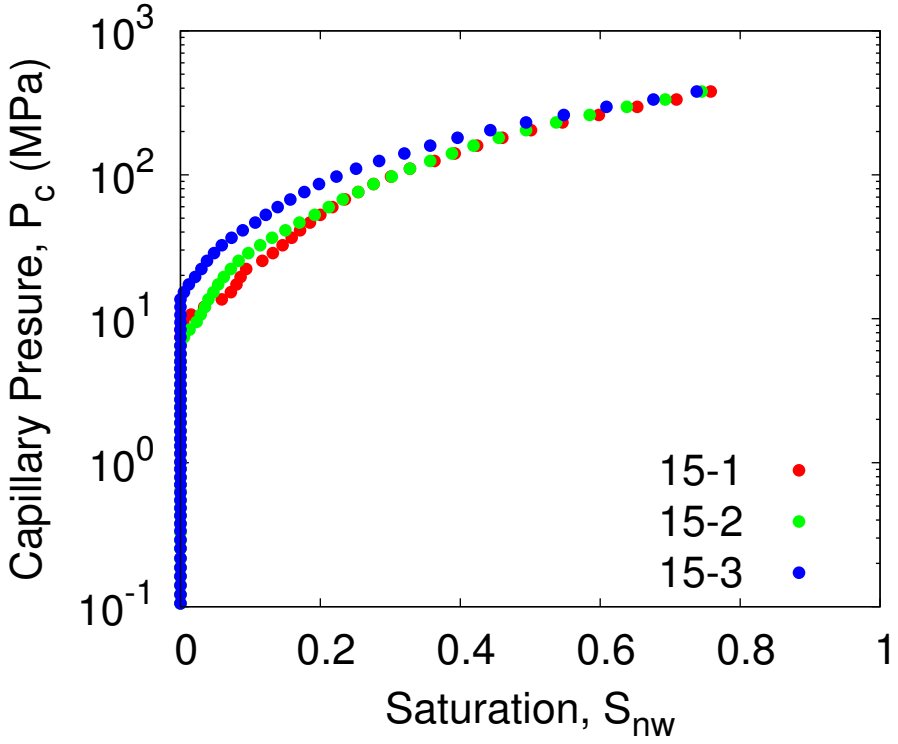


Figure 3: Results of mercury injection tests on intact salt samples. Air-Mercury capillary pressure, P_c, is plotted against mercury saturation, S_{nw}.

Table 2: Tested reconsolidated and intact salt samples with sample properties.

Sample	λ	$\hat{P}_{\rm e}$ (MPa)	n	α (MPa^{-1})
100-3	0.40	0.25	1.53	1.98
250-1	1.40	12.4	3.28	0.054
15-1	0.33	4.51	1.59	0.082
15-2	0.35	5.24	1.63	0.074
15-3	0.42	8.67	1.88	0.045
14-A	0.14	0.085	1.19	3.55
14-B	0.16	0.18	1.21	2.18

($\sigma_{\rm w,nw}$) at the fluid interfaces in the brine-air-halite and mercury-air-halite systems. For purposes of this analysis report, the contact angles used are $\theta_{\rm water,air} = 0°$ and $\theta_{\rm air,Hg} = 140°$. The values of the interfacial surface tension used are $\sigma_{\rm water,air} = 0.072$ N/m and $\sigma_{\rm air,Hg} = 0.485$ N/m.

Figures 4–6 also include model fits to the data. Only the Brooks-Corey and van Genuchten models were considered here. The model parameters estimated using nonlinear least squares are summarized in Table 2. The Brooks-Corey model relates brine saturation, S_w, to capillary pressure, P_c, according to

$$S_w = \begin{cases} 1.0 & P_c < P_{\rm e} \\ \left(\dfrac{P_c}{P_{\rm e}}\right)^{-\lambda} & \text{otherwise} \end{cases} \tag{2}$$

where λ is a pore-size distribution parameters and $P_{\rm e}$ is the air-entry (bubbling or threshold) pressure. These two parameters are estimated from the experimental data and are listed in Table 2. The value of $P_{\rm e}$ estimated from the capillary pressure data is reported in the Table as $\hat{P}_{\rm e}$ to distinguish it from the measured value reported in table 1.

The van Genuchten model relates S_w to P_c according to

$$S_w = (1 + |\alpha P_c|^n)^{-m} \tag{3}$$

where n and α are a pore-size distribution parameters that are directly estimable from the measured capillary pressure and saturation, and $m = 1 - 1/n$. It is typically assumed that $\alpha = 1/P_{\rm e}$ and that the parameter n is related to the Brooks-Corey distribution parameter. For the present analysis, these two parameters were estimated directly from the capillary pressure and saturation data. the estimated parameter values are summarised in Table 2 for all the samples.

Swanson permeabilities, $k_{\rm swan}$, reported in Table 2, were computed for all samples from the capillary pressure curve and pore throat radius data, using the relation

$$k_{\rm swan} = a \left(\left.\frac{S_b}{P_c}\right|_{\rm max} \right)^c \tag{4}$$

where S_b is mercury saturation, P_c capillary pressure, $\left.S_b/P_c\right|_{\rm max}$ is the maximum ratio of S_b to P_c obtained from the empirical capillary pressure curve, and a and c are constants dependent on rock-type. Regression analyses of from sandstone and carbonate rock data give $c \approx 2.0$ and $a \approx 400$

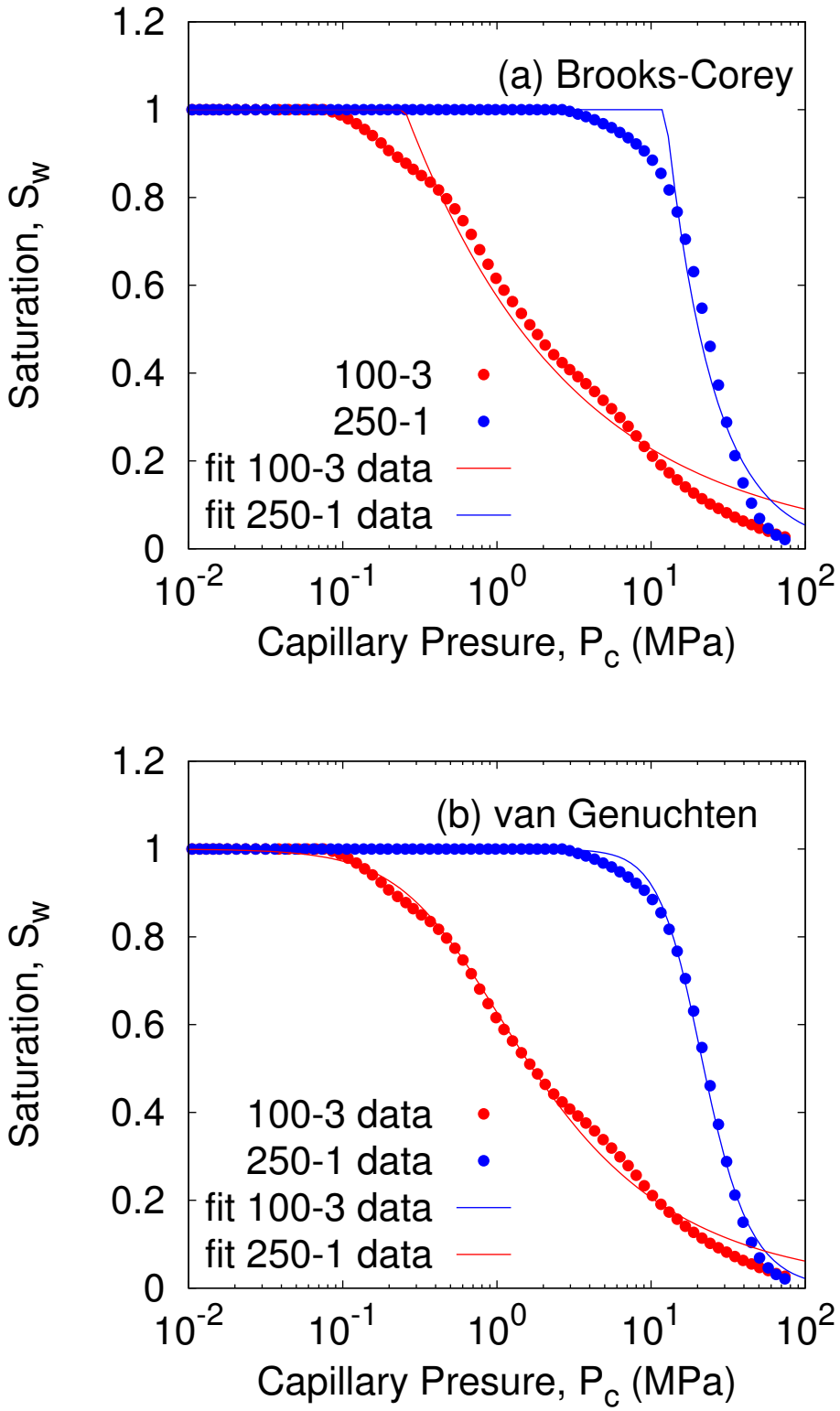


Figure 4: Empirical brine capillary pressure data for reconsolidated salt samples (100-3 and 250-1) with the (a) Brooks-Corey and (b) van Genuchten model fits.

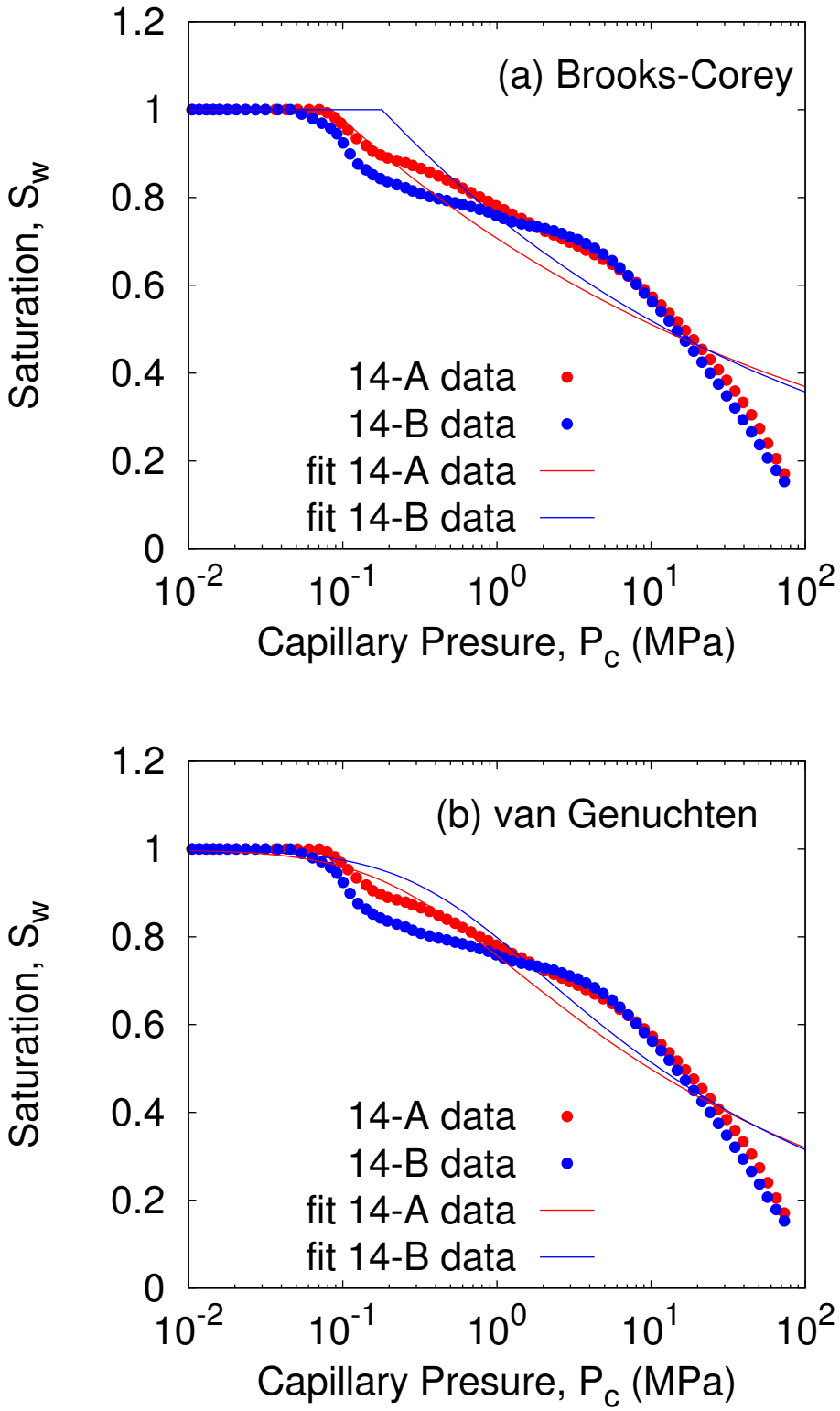


Figure 5: Empirical brine capillary pressure data for intact salt samples (14-A and 14-B) with the (a) Brooks-Corey and (b) van Genuchten model fits.

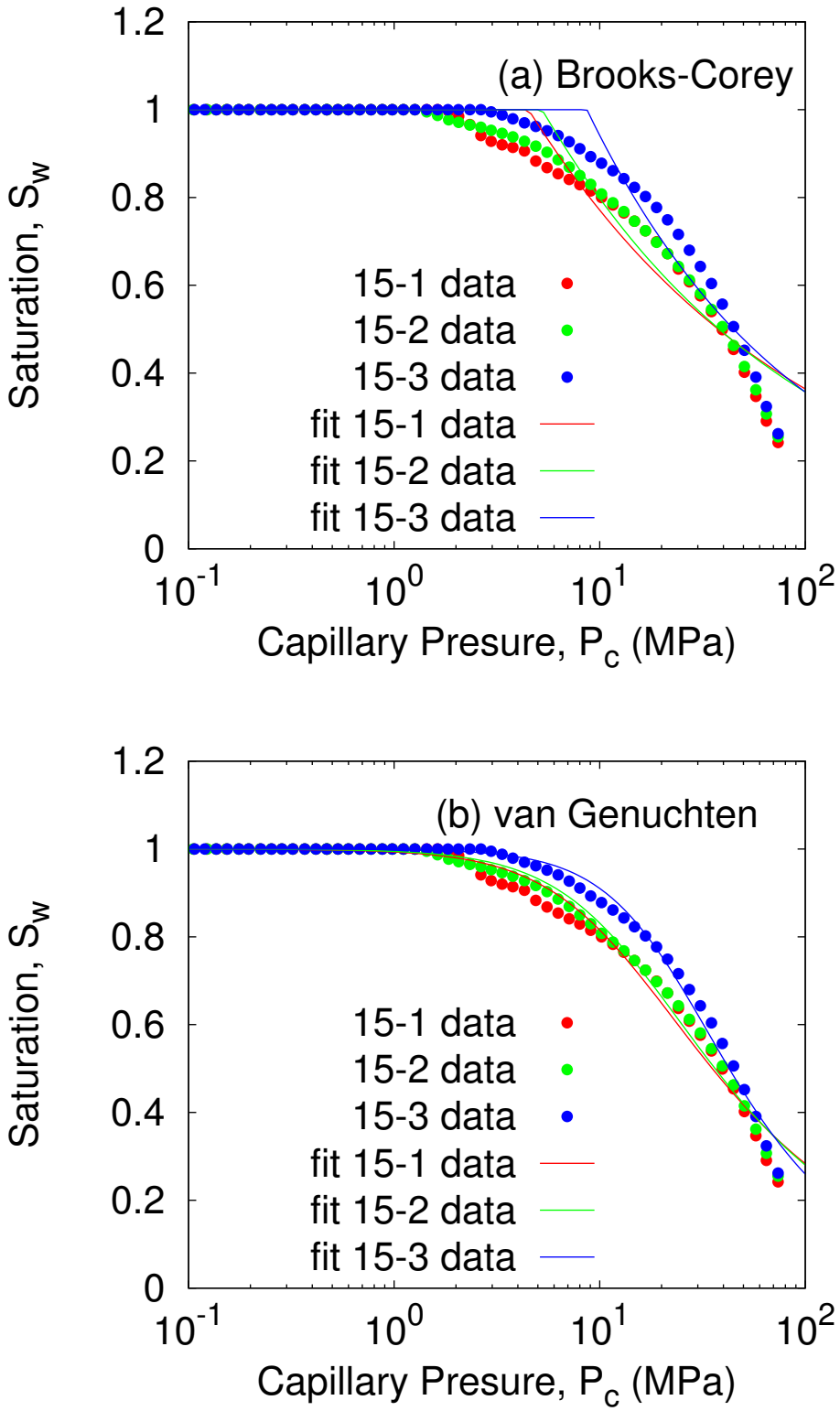


Figure 6: Empirical brine capillary pressure data for intact salt samples (15-1, 15-2, and 15-3) with the (a) Brooks-Corey and (b) van Genuchten model fits.

. Hitherto, there are no data available in the literature on rock salt. Thus, k_{swan} reported by Core Labs is based on a and c parameters from sandstone and carbonate rock data. To obtain useful Swanson permeabilities for rock salt, there is a need to conduct extensive capillary pressure and intrinsic permeability measurements on rock salt.

Discussion and Conclusions

The results summarized herein clearly indicate that capillary pressure data are obtainable of reconsolidated and intact rock salt samples. The data show significant variability among the samples that may be indicative of effects of sample preparation and handling (for reconsolidated samples) as well as significant formation heterogeneity. The variability is also reflected in the parameter estimates obtained with the two constitutive models. Duplicate samples show clearly repeatable measurements, with consistent parameter estimates.

The average grain density of the reconsolidated samples is $\langle \rho_g \rangle = 2.04\ \mathrm{g/cm^3}$, with a mean porosity of $\langle \phi \rangle = 4\%$. This average grain density is slightly smaller than the known solid halite density of $2.16\ \mathrm{g/cm^3}$. The two samples yielded disparate values of Swanson intrinsic permeability, k_{swan}, differing by more than three orders of magnitude. The more permeable sample also had the smaller threshold pressure by over an order of magnitude. The values of the gas permeabilities of the two samples obtained by conventional plug analysis are comparable, averaging $\langle k_{\mathrm{gas}} \rangle = 2 \times 10^{-4}$ mD.

Intact salt core samples yielded average grain densities that are equal to the known solid halite density of $2.16\ \mathrm{g/cm^3}$, with an average porosity of 2.0%. Samples 15-1–3 had a slightly higher average porosity of 2.3% than samples 14-A and B with an average porosity of 1.7%. The average measured threshold pressure for samples 14-A and B was 58.5 kPa, while the average Swanson permeability (equation 4) was 1.1×10^{-2} mD. On the other hand, samples 15-1–3 had an average measured threshold pressure of of 1.93 MPa and an average Swanson permeability of 2.6×10^{-5} mD. Thus, despite the smaller porosity, 14-A and B samples had Swanson permeabilities of about two to three orders of magnitude higher and an average threshold pressure of over one order of magnitude than those of samples 15-1–3. Such results highlight the need for additional testing of a representative set of samples that capture geologic heterogeneity as well as variability attributable to sample preparation and testing.

The two constitutive models considered here fit reconsolidated salt data significantly better than intact halite data. For reconsolidated salt samples 100-3 and 250-1, the van Genuchten models fits the capillary pressure better than the Brooks-Corey model, particularly when approaching full saturation. The Brooks-Corey model is piecewise continuous with a discontinuity in the derivative of saturation at $P_c = P_{\mathrm{e}}$, whereas the model of van Genuchten is continuous and differentiable even as full saturation is approached, although there are known issues with the predicitions of relative permeability from the van Genuchten model when $n \leq 2$ (Ippisch et al., 2006). Both constitutive models showed appreciable departure from the observed capillary pressure behavior for the intact samples. This is especially the case for samples 14-A and 14-B. The observed behavior is clearly indicative of a non-unimodal pore-size distribution, whereas the the Brooks-corey and van Genuchten models was developed porous media with unimodal pore-size distributions. For duplicate samples 15-$\{$1,2,3$\}$, the curvature (concavity) of Brooks-Corey model clearly departs from that of the data. The van Genuchten model is better behaved near saturation but appears to depart

appreciably at the dry end of the capillary pressure curve. The data clearly did not attain zero air saturation at the maximum injection pressure of 73 MPa. There is a need for data at the dry end of the capillary pressure curve given that residual brine saturation is an important parameter in two-phase flow modeling in rock salt.

The results presented herein do not include relative permeability measurements. Though it is theoretically possible to predict the relation between relative permeability and brine saturation, of geologic media based on knowledge of the capillary pressure function (Burdine, 1953; Mualem, 1976), it is preferable to determine it empirically. This is due to the fact that these theoretical models are based on ideal porous media that behave differently from rock salt. There is a need to measure directly rock salt relative brine permeabilities and relate these to pore morphology and capillary pressure.

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ADVANCED CORE ANALYSIS STUDY

Sandia National Laboratories
Reconsolidated Salt Project

FINAL REPORT

Submitted to:

Sandia National Laboratories

September 8, 2015

Performed by:

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September 8, 2015

Sandia National Laboratories
P.O. Box 5800
Albuquerque, New Mexico 87185

Attention Michael Schuhen

Subject: Reconsolidated Salt Project
File: HOU-141015

Dear Mr. Schuhen,

Presented in this report are the final results of the Advanced Core Analysis measurements performed on core plug samples from the Reconsolidated Salt Project. The study was comprised of the following measurements:

Pulse Decay Permeability
High Pressure Mercury Injection
Threshold Entry Pressure

We appreciate the opportunity to be of service to Sandia National Laboratories with this study and look forward to working with you on future projects. If you have any questions concerning this report, please do not hesitate to contact us.

Sincerely,

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Sandia National Laboratories
Reconsolidated Salt Project

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SUMMARY OF RESULTS

The Houston Advanced Technology Center of Core Laboratories received five (5) plug samples, three (3) of which were epoxy-coated salt samples, and one (1) full diameter segment.

Basic properties were originally measured at 800 psi net confining stress on three (3) of the dry samples using either the pulse decay permeameter (PDP-200) for Klinkenberg permeability or steady-state micropermeameter for permeability to air. The basic properties show that Klinkenberg permeability, measured by the PDP-200, were less than 0.0003 md for sample 250-01 and 0.0013 md for sample 100-03. The permeability to air determined by steady-state micropermeameter, for smaple 75-03 was 351 md.

Basic properties were measured on two samples using the CMS-300™ instrument, at 800 psi net confining stress. The resulting Klinkenberg permeabilities were 15.5 md for sample SNL-CH111-14-A abd 0.123 md for sample SNL-CH111-14-B. Porosity measurements were 2.1 and 1.8 percent of bulk volume, respectively. Grain densities were 2.16 g/cm^3.

In preparation for production module tests, SNL-CH111-14-B was remeasured for basic properties, resulting in a Klinkenberg permeability of 0.019 and a porosity of 1.7 percent. The grain density was 2.14 g/cm^3. The sample was not suitable to continue the range of tests required, because it would not retain partial saturations of laboratory oil long enough for measurements, so production module testing was cancelled.

Sample SNL-CH111-14-B was tested for a threshold entry pressure test. The objective of this test was to determine the threshold pressure for gas breakthrough of the sample. The sample was saturated with Isopar-L oil for threshold pressure testing to determine the injection pressure at which gas would start to form continuous flow channels through the pore system. With the fully saturated sample confined in a hydrostatic coreholder, a specific permeability to oil of 0.0190 md was determined. Gas was then injected at one end and the downstream end was monitored for effluent flow. The gas injection pressure started at 0.50 psi and was increased in a gradual stepwise fashion up to 60 psi injection pressure. Breakthrough occurred following equilibrium at 30 psi injection pressure (gas/oil) during the buildup to 60 psi (gas/oil).

Sample SNL-CH111-14A was tested for permeability to brine, but dissolution occurred upon minimal brine injection. Calculated permeability to brine was much higher than the dry, absolute permeability value, meaning that dissolution was taking place, altering the sample structure. The final permeability to brine was 81.9 md, but this is not representative of the original sample matrix.

Sample trims from five (5) of the samples were placed within the glass penetrometers of the Micromeritics AutoPore mercury injection instrument for high pressure mercury injection analysis. Three separate pieces of Sample SNLCH111-15 were tested, indicated by -1, -2, and -3 in the data. A permeability value was calculated from the mercury injection results using the methods of Swanson, B.F. ("A Simple Correlation Between Permeabilities and Mercury Capillary Pressures" Journal of Petroleum Technology, December 1981). The following tables give a brief summary of the mercury injection test results.

High Pressure Mercury Injection

Sample	Swanson Permeability, md	Porosity, fraction	Approximate Threshold Pressure, Psi	Median Pore Throat Radius, μm
250-01m	0.000079	0.035	2032.9	0.00631
100-03m	0.0193	0.044	58.2	0.0839

High Pressure Mercury Injection (continued)

Sample	Swanson Permeability, md	Porosity, fraction	Approximate Threshold Pressure, Psi	Median Pore Throat Radius, μm
SNLCH111-15-1m	0.000044	0.024	1266.1	0.00365
SNLCH111-15-2m	0.000021	0.020	997.6	0.00358
SNLCH111-15-3m	0.000014	0.023	2068.0	0.00318
SNL-CH111-14-Am	0.00439	0.014	53.1	0.00878
SNL-CH111-14-Bm	0.0170	0.020	34.8	0.00994

Apparent mercury injection volumes were corrected using a conformance factor determined for each sample from an evaluation of a plot of the apparent injection volume versus injection pressure. As an extremely non-wetting material, mercury must be forced with pressure to conform around and into surface features. The conformance value is the volume of mercury pressed into surface roughness and around sample edges after the penetrometer chamber is initially filled with mercury. This conformance volume is subtracted from all subsequent apparent injection volumes. Mercury injection data are presented in tabular and graphic form following this discussion. The tabular data include: the injection pressure, mercury saturation, conversions of pressure to other laboratory systems, and estimated height above free water level.

TEST SCHEDULE SUMMARY

Company: Sandia National Laboratories
Reconsolidated Salt Project

File: HOU-141015

Sample Number	Depth, feet	Pulse Decay Permeability	High Pressure Mercury Injection	Threshold Entry Pressure
250-01	n/a	**X**	**X**	
75-03	n/a	**X**		
100-03	n/a	**X**	**X**	
SNLCH111-15	n/a		**X***	
SNL-CH111-14-A	n/a	**X**	**X**	
SNL-CH111-14-B	n/a	**X**	**X**	**X**

*tested three sample pieces: presented as SNLCH111-15-1, SNLCH111-15-2, and SNLCH111-15-3 in the data

Petrophysical Analysis

Pulse Decay Permeability
High Pressure Mercury Injection

LABORATORY PROCEDURES

Basic Rock Properties

1. After trimmimg the samples, each 2-inch sample was dried to a stable dry weight in a convection oven at 220°F, and then cooled to room temperature in a moisture free environment.
2. Permeability to air was determined using a steady-state permeameter on sample 75-03. jThe sample was confined at 800 psi net confining stress and a constant gas flow rate was established through the sample. Pressure differential was measured and used in conjunction with the flow rate and sample and gas parameters to calculate permeability according to Darcy's Law.

   Samples 250-01 and 100-03 were loaded into a PDP-200™ at 800 psi net confining pressure for measurement of permeability to air. The upstream and downstream reservoirs and the sample pore volume were filled with gas to approximately 1,000 psi. At equilibrium, pressure in the upstream reservoir is increased by about 1% of initial (about 10 psi) causing a pressure pulse to flow through the sample. The pulse decay is monitored versus time. Unsteady state gas permeability was calculated for each stress based on pressure decay over time.
3. For the remaining samples, SNL-CH111-14-A and SNL-CH-111-14-B, grain volume was determined for the sample by placing it into a stainless steel matrix cup. It was injected with helium from reference cells of known volume and pressure using the Core Lab AutoPorosimeter. Grain volume was calculated using Boyle's Law of gas expansion. Grain density was calculated by dividing sample dry weight by grain volume.
4. The samples were then loaded into the CMS-300^{TM} for determination of permeability and porosity. An 800 psi net confining pressure was applied.
5. The sample was placed into a rubber sleeve between stainless steel end pieces and confining pressure applied. Helium was injected into the sample from reference cells of known volume and pressure. A direct pore volume was determined using Boyle's Law of gas expansion, then pressure was vented at a known rate and unsteady-state Klinkenberg permeability was determined by pressure decay.
6. Porosity was calculated for the sample as the pore volume fraction of the summation (grain volume + pore volume) bulk volume.

High Pressure Mercury Injection

1. Testing was performed using the Micromeritics Autopore, an automated, high pressure mercury injection device which operates at injection pressures of 0 to 55,000 psia.
2. Each sample trim was weighed, then loaded into a glass penetrometer consisting of a sample chamber attached to a capillary stem with a cylindrical coaxial capacitor. Each penetrometer used was selected on the basis of how well its capacity matched the sample pore volume to maximize accuracy and resolution.
3. The sample/penetrometer assembly was weighed, then placed into the low pressure system.
4. The sample chamber was evacuated and filled with mercury, then the pressure was increased incrementally to slightly above atmospheric pressure. At the end of the low

pressure phase the assembly was temporarily removed and re-weighed, then placed into the high pressure side of the apparatus.

5. Pressures were increased incrementally to a maximum of 55,000 psia.
6. Time was allowed at each incremental pressure for saturation equilibrium. The volume of mercury injected at each pressure was determined by the change in capacitance of the capillary stem.
7. The pressure was decreased to ambient and the sample unloaded. A final weight was recorded to calculate the residual mercury saturation.
8. Micromeritics data were imported to a spreadsheet and the mercury volumes calculated. A conformance (correction for surface roughness) value was selected, volume corrections made, and saturations calculated.
9. Pore throat size, fluid system pressure conversion, and height data were calculated using “typical” parameters which are reported at the end of this discussion.

Other Calculations

1. Pore entry radii were calculated using the formula:

$$Ri = \frac{2T * \cos\theta * C}{Pc}$$

where:
- Ri = Pore entry radius, microns
- T = Interfacial tension
- θ = Contact angle
- C = Unit conversion constant (to microns) = 0.145
- Pc = Mercury injection pressure, psia.

2. J-Function values are calculated from capillary pressure (or mercury injection) data and basic sample properties using the following equation:

$$J\text{-Function} = \frac{0.2166 * Pc * (K/\phi)^{1/2}}{(T * \cos\theta)}$$

where:
- Pc = Injection pressure, psia
- T = Interfacial tension, dyne/cm
- θ = Contact angle
- K = Permeability to air (or Klinkenberg), millidarcys
- ϕ = Porosity, fraction.
- 0.2166 = Factor used to cancel units and make "J" dimensionless

3. Conversions of pressure from one fluid system to the others are calculated using the example formula:

$$Pc_{(g\text{-}w)} = Pc_{(meas.)} * \frac{(T * \cos\theta)_{(g\text{-}w)}}{(T * \cos\theta)_{(meas.)}}$$

where:
- $Pc_{(g\text{-}w)}$ = Capillary pressure in a gas-water system
- $Pc_{(meas.)}$ = Capillary pressure of the measured fluid system
- T = Interfacial tension
- θ = Contact angle

4. Height above free water is calculated from laboratory capillary pressure data using the following equation:

$$Pc_R = Pc_L * (T\cos\theta)_R \div (T\cos\theta)_L$$
$$Height = Pc_R \div (\rho_w - \rho_h)$$

where:
- Pc_L = Laboratory measured capillary pressure
- $T\cos\theta_R$ = Interfacial tension * cosine of contact angle (reservoir)
- $T\cos\theta_L$ = Interfacial tension * cosine of contact angle (laboratory)
- ρ_w = Reservoir density gradient, water
- ρ_h = Reservoir density gradient, hydrocarbon
- T = Interfacial tension
- θ = Contact angle

SUMMARY OF CALCULATION PARAMETERS

Fluid System	(θ) Contact Angle	cosine Contact θ	(T) Interfacial Tension	T cosine θ
Laboratory				
Gas-water	0.0	1.00	72.0	72.0
Oil-water	30.0	0.866	48.0	41.6
Gas-oil	0.0	1.00	24.0	24.0
Air-mercury	140.0	0.765	485.0	372.0
Reservoir				
Oil-water	30.0	0.866	30.0	26.0
Gas-water	0.0	1.00	50.0	50.0

Density Gradients

water = 0.433
oil = 0.346
gas = 0.100

Company: Sandia National Laboratories

File: HOU-141015
Date: 3-Oct-2014
Analyst(s): PJP, TV

Convection Dried

CONVENTIONAL PLUG ANALYSIS – SCAL REPORT

Sample Number	Depth	Confining Stress (psi)	Permeability, millidarcies		Dry Weight (g)	Length (cm)	Diameter (cm)	Footnote
			Klinkenberg	Kair				
250-01	n/a	800	0.0003	-	103.249	5.071	4.036	(1)
75-03	n/a	800	-	351.	108.295	5.145	4.049	(2) (3)
100-03	n/a	800	0.0013	-	105.133	5.102	4.051	(1)

Footnotes :

(1): Sample permeability measured by PDP-200™.

(2): Sample permeability measured by Steady State Micropermeameter.

(3): Sample permeability may be optimistic due to bypass through non-conformances in the epoxy coating.

Company: Sandia National Laboratories

File: HOU-141015
Date: 28-Jan-2015
Analyst(s): PJP, TV

CMS-300™ CONVENTIONAL PLUG ANALYSIS – SCAL REPORT

Sample Number	Confining Stress (psi)	Pore Volume (cm^3)	Porosity fraction	Permeability, millidarcies		Grain Volume (cm^3)	Grain Density (g/cm^3)	Dry Weight (g)	Length (cm)	Diameter (cm)
				Klinkenberg	Kair					
SNL-CH111-14-A	800	1.120	0.021	15.5	17.2	53.232	2.16	114.905	4.807	3.816
SNL-CH111-14-B	800	0.973	0.018	0.423	0.474	53.267	2.16	115.075	4.796	3.822

Pore volumes have been corrected for screens.

Company: Sandia National Laboratories

File: HOU-141015
Date: 21-Jul-2015
Analyst(s): AP, TV

CMS-300™ CONVENTIONAL PLUG ANALYSIS – SCAL REPORT

Sample Number	Depth (ft)	Confining Stress (psi)	Pore Volume (cm^3)	Porosity fraction	Permeability, millidarcies		Grain Volume (cm^3)	Grain Density (g/cm^3)	Dry Weight (g)	Length (cm)	Diameter (cm)
					Klinkenberg	Kair					
14-B	n/a	800	0.922	0.017	0.019	0.026	53.645	2.14	115.068	4.796	3.816

Pore volumes have been corrected for screens.

MERCURY INJECTION DATA SUMMARY

Company: Sandia National Laboratories
File: HOU-141015

Sample:	250-01m	un-	Host Plug	
Depth,feet:	N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:		N/A	-	-
Permeability to Air, md:		N/A	-	-
Swanson Permeability, md:		0.000079	-	-
Porosity, fraction:		0.035	-	-
maximum Sb/Pc, fraction:		0.00011		
R35, microns:		0.00788		
R50 (median pore throat radius):		0.00631		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
0.84	0.000	1.000	128	0.000023	0.163	0.0543	0.0940	0.339	0.675
1.09	0.000	1.000	98.8	0.000030	0.211	0.0704	0.122	0.441	0.876
1.39	0.000	1.000	77.5	0.000038	0.269	0.0898	0.156	0.562	1.12
1.73	0.000	1.000	62.3	0.000048	0.335	0.112	0.194	0.699	1.39
2.11	0.000	1.000	51.1	0.000058	0.409	0.136	0.236	0.853	1.70
2.55	0.000	1.000	42.3	0.000070	0.494	0.165	0.285	1.03	2.05
3.05	0.000	1.000	35.3	0.000084	0.591	0.197	0.341	1.23	2.45
3.58	0.000	1.000	30.1	0.000099	0.694	0.231	0.401	1.45	2.88
4.17	0.000	1.000	25.8	0.000115	0.808	0.269	0.467	1.69	3.35
4.81	0.000	1.000	22.4	0.000132	0.932	0.311	0.538	1.94	3.87
5.50	0.000	1.000	19.6	0.000151	1.07	0.355	0.615	2.22	4.42
6.25	0.000	1.000	17.2	0.000172	1.21	0.404	0.699	2.53	5.02
7.05	0.000	1.000	15.3	0.000194	1.37	0.455	0.789	2.85	5.67
7.90	0.000	1.000	13.6	0.000218	1.53	0.510	0.884	3.19	6.35
8.80	0.000	1.000	12.2	0.000242	1.71	0.568	0.985	3.56	7.07
9.75	0.000	1.000	11.1	0.000268	1.89	0.630	1.09	3.94	7.84
10.8	0.000	1.000	9.98	0.000297	2.09	0.698	1.21	4.36	8.68
11.9	0.000	1.000	9.06	0.000327	2.30	0.768	1.33	4.81	9.56
13.4	0.000	1.000	8.05	0.000369	2.59	0.865	1.50	5.42	10.8
15.3	0.000	1.000	7.05	0.000421	2.96	0.988	1.71	6.18	12.3
17.6	0.000	1.000	6.14	0.000483	3.40	1.13	1.96	7.11	14.1
20.4	0.000	1.000	5.29	0.000561	3.95	1.32	2.28	8.24	16.4
23.6	0.000	1.000	4.56	0.000651	4.58	1.53	2.64	9.54	19.0
27.2	0.000	1.000	3.97	0.000748	5.27	1.76	3.04	11.0	21.9
31.7	0.000	1.000	3.40	0.000872	6.14	2.05	3.54	12.8	25.5
36.9	0.000	1.000	2.92	0.00102	7.15	2.38	4.13	14.9	29.7
42.3	0.000	1.000	2.55	0.00116	8.20	2.73	4.73	17.1	34.0
48.4	0.000	1.000	2.23	0.00133	9.38	3.13	5.42	19.6	38.9
54.8	0.000	1.000	1.97	0.00151	10.6	3.54	6.13	22.1	44.0
62.2	0.000	1.000	1.73	0.00171	12.1	4.02	6.96	25.1	50.0
70.4	0.000	1.000	1.53	0.00194	13.6	4.55	7.88	28.5	56.6
79.3	0.000	1.000	1.36	0.00218	15.4	5.13	8.88	32.0	63.7
90.0	0.000	1.000	1.20	0.00248	17.4	5.81	10.1	36.4	72.3
102	0.000	1.000	1.06	0.00281	19.8	6.59	11.4	41.2	82.0
115	0.000	1.000	0.938	0.00316	22.3	7.42	12.8	46.5	92.4

MERCURY INJECTION DATA SUMMARY

Company: Sandia National Laboratories
File: HOU-141015

Sample:	250-01m	un-	Host Plug	
Depth,feet:	N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:		N/A	-	-
Permeability to Air, md:		N/A	-	-
Swanson Permeability, md:		0.000079	-	-
Porosity, fraction:		0.035	-	-
maximum Sb/Pc, fraction:		0.00011		
R35, microns:		0.00788		
R50 (median pore throat radius):		0.00631		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
131	0.000	1.000	0.823	0.00360	25.4	8.45	14.6	52.9	105
147	0.000	1.000	0.733	0.00405	28.5	9.50	16.4	59.4	118
168	0.000	1.000	0.641	0.00463	32.6	10.9	18.8	67.9	135
190	0.000	1.000	0.566	0.00524	36.9	12.3	21.3	76.8	153
212	0.000	1.000	0.507	0.00585	41.2	13.7	23.8	85.7	170
241	0.000	1.000	0.447	0.00663	46.7	15.6	27.0	97.4	194
275	0.000	1.000	0.392	0.00756	53.2	17.7	30.7	111	221
311	0.000	1.000	0.346	0.00856	60.3	20.1	34.8	126	250
351	0.000	1.000	0.307	0.00967	68.1	22.7	39.3	142	282
398	0.000	1.000	0.271	0.0110	77.1	25.7	44.5	161	320
449	0.000	1.000	0.240	0.0124	87.0	29.0	50.3	181	361
509	0.000	1.000	0.212	0.0140	98.5	32.8	56.9	206	409
579	0.000	1.000	0.186	0.0159	112	37.4	64.8	234	465
655	0.000	1.000	0.165	0.0180	127	42.3	73.2	265	526
734	0.000	1.000	0.147	0.0202	142	47.4	82.2	297	590
828	0.000	1.000	0.130	0.0228	161	53.5	92.7	335	666
945	0.000	1.000	0.114	0.0260	183	61.0	106	382	760
1080	0.000	1.000	0.0999	0.0297	209	69.7	121	436	868
1220	0.000	1.000	0.0884	0.0336	236	78.8	136	493	981
1370	0.000	1.000	0.0787	0.0377	265	88.5	153	554	1100
1540	0.000	1.000	0.0701	0.0423	298	99.4	172	622	1240
1750	0.000	1.000	0.0616	0.0481	339	113	196	707	1410
1980	0.000	1.000	0.0544	0.0545	384	128	222	800	1590
2220	0.004	0.996	0.0486	0.0611	430	143	248	897	1780
2510	0.010	0.990	0.0429	0.0691	486	162	281	1010	2020
2830	0.016	0.984	0.0381	0.0779	548	183	316	1140	2270
3220	0.023	0.977	0.0335	0.0886	624	208	360	1300	2590
3660	0.032	0.968	0.0294	0.101	709	236	409	1480	2940
4150	0.041	0.959	0.0260	0.114	804	268	464	1680	3340
4700	0.052	0.948	0.0229	0.129	910	303	526	1900	3780
5300	0.064	0.936	0.0203	0.146	1030	342	593	2140	4260
5970	0.078	0.922	0.0181	0.164	1160	385	668	2410	4800
6750	0.094	0.906	0.0160	0.186	1310	436	755	2730	5430
7650	0.115	0.885	0.0141	0.211	1480	494	856	3090	6150
8650	0.145	0.855	0.0125	0.238	1680	559	967	3500	6950

MERCURY INJECTION DATA SUMMARY

Company: Sandia National Laboratories
File: HOU-141015

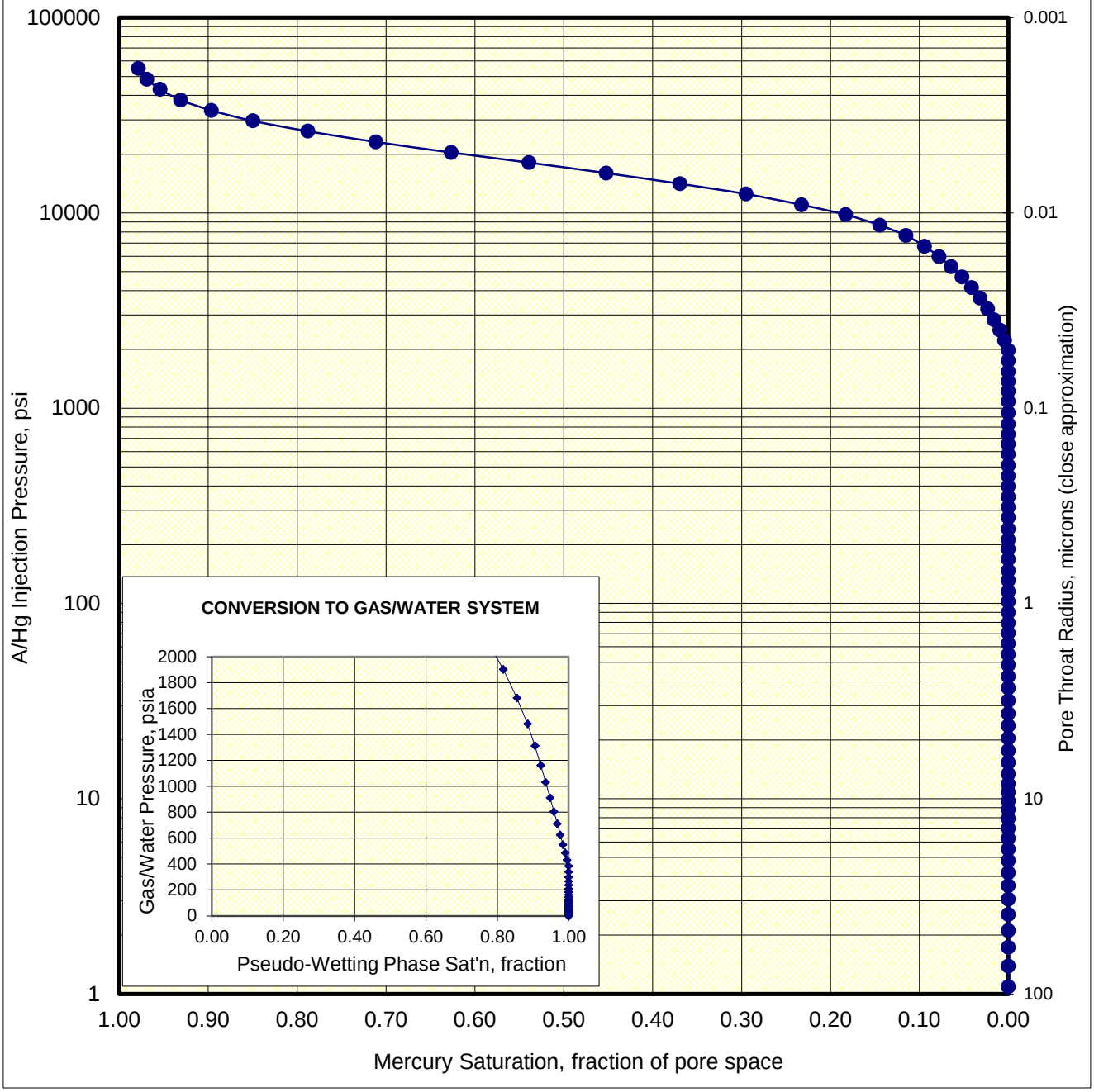
Sample:	250-01m	un-	Host Plug	
Depth,feet:	N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:		N/A	-	-
Permeability to Air, md:		N/A	-	-
Swanson Permeability, md:		0.000079	-	-
Porosity, fraction:		0.035	-	-
maximum Sb/Pc, fraction:		0.00011		
R35, microns:		0.00788		
R50 (median pore throat radius):		0.00631		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
9790	0.183	0.817	0.0110	0.269	1900	632	1090	3960	7870
11000	0.233	0.767	0.00976	0.304	2140	713	1230	4450	8840
12500	0.295	0.705	0.00862	0.344	2420	807	1400	5050	10000
14100	0.369	0.631	0.00763	0.389	2740	913	1580	5700	11300
16000	0.452	0.548	0.00674	0.440	3100	1030	1790	6470	12900
18100	0.539	0.461	0.00596	0.498	3500	1170	2020	7310	14500
20400	0.627	0.373	0.00527	0.563	3960	1320	2290	8240	16400
23100	0.712	0.288	0.00466	0.636	4480	1490	2590	9340	18600
26200	0.788	0.212	0.00412	0.720	5070	1690	2930	10600	21100
29600	0.850	0.150	0.00364	0.814	5730	1910	3310	12000	23800
33500	0.896	0.104	0.00322	0.922	6490	2160	3750	13500	26900
37800	0.931	0.069	0.00285	1.04	7330	2440	4230	15300	30400
43000	0.954	0.046	0.00250	1.18	8340	2780	4810	17400	34600
48400	0.969	0.031	0.00223	1.33	9380	3130	5420	19600	38900
55000	0.979	0.021	0.00196	1.51	10700	3550	6150	22200	44200

Company: Sandia National Laboratories
File: HOU-141015

Sample:	250-01m	un-	Host Plug	
Depth,feet:	N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:		N/A	-	-
Permeability to Air, md:		N/A	-	-
Swanson Permeability, md:		0.000079	-	-
Porosity, fraction:		0.035	-	-
maximum Sb/Pc, fraction:		0.00011		
R35, microns:		0.00788		
R50 (median pore throat radius):		0.00631		

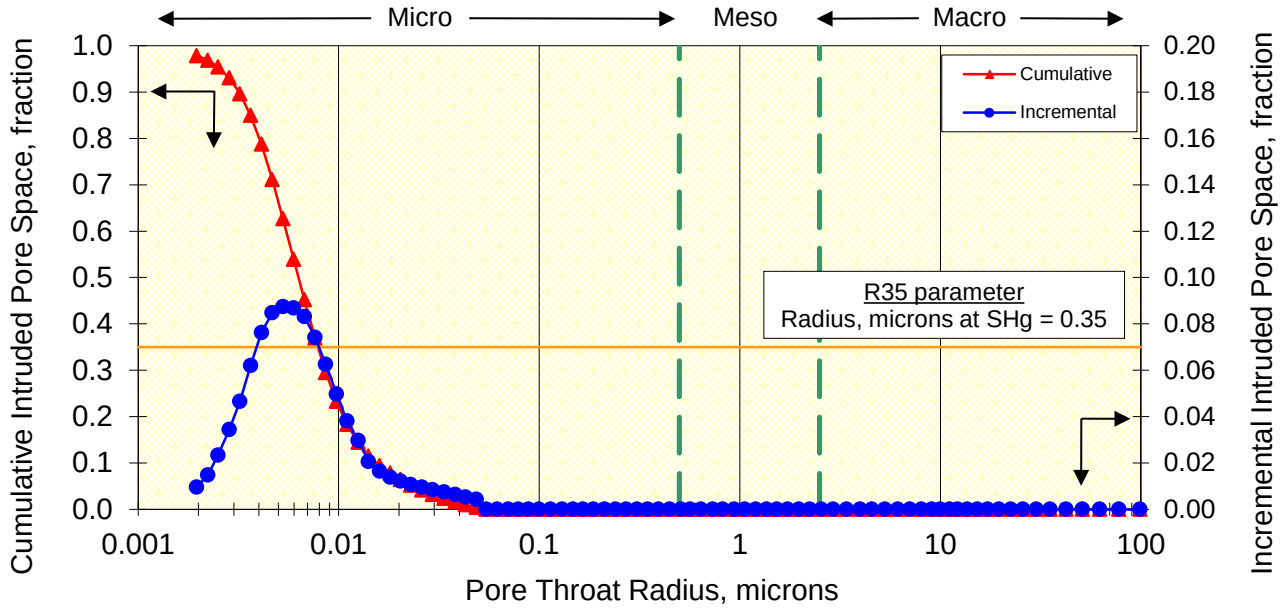
MERCURY INJECTION



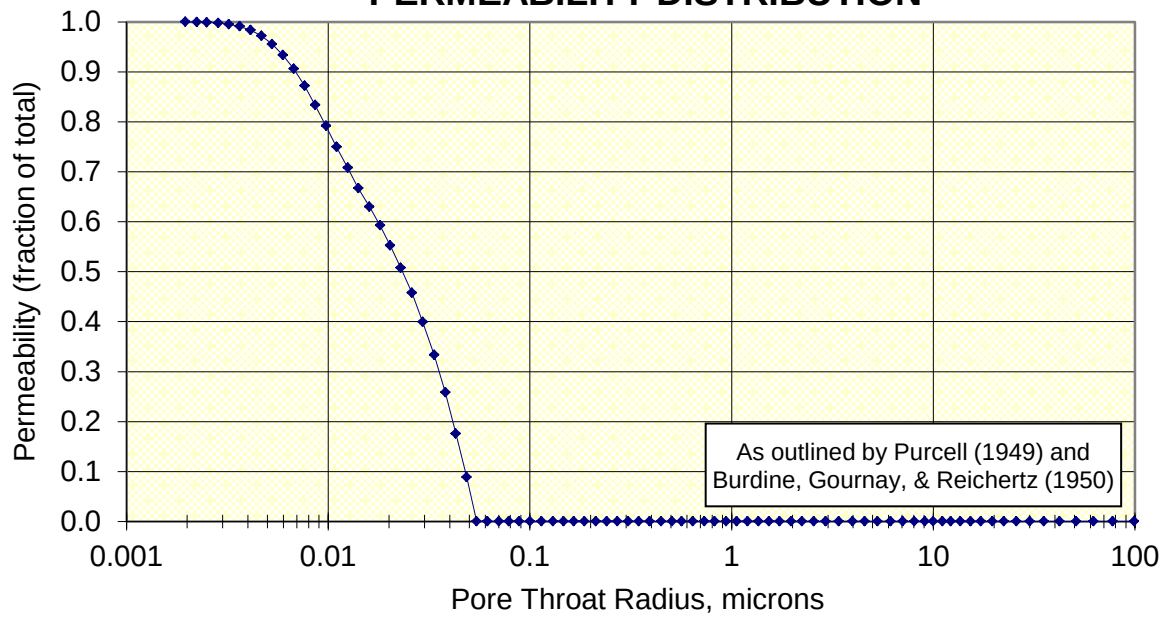
Company: Sandia National Laboratories
File: HOU-141015

Sample:	250-01m	un-	Host Plug	
Depth,feet:	N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:		N/A	-	-
Permeability to Air, md:		N/A	-	-
Swanson Permeability, md:		0.000079	-	-
Porosity, fraction:		0.035	-	-
maximum Sb/Pc, fraction:		0.00011		
R35, microns:		0.00788		
R50 (median pore throat radius):		0.00631		

PORE THROAT RADIUS DISTRIBUTION



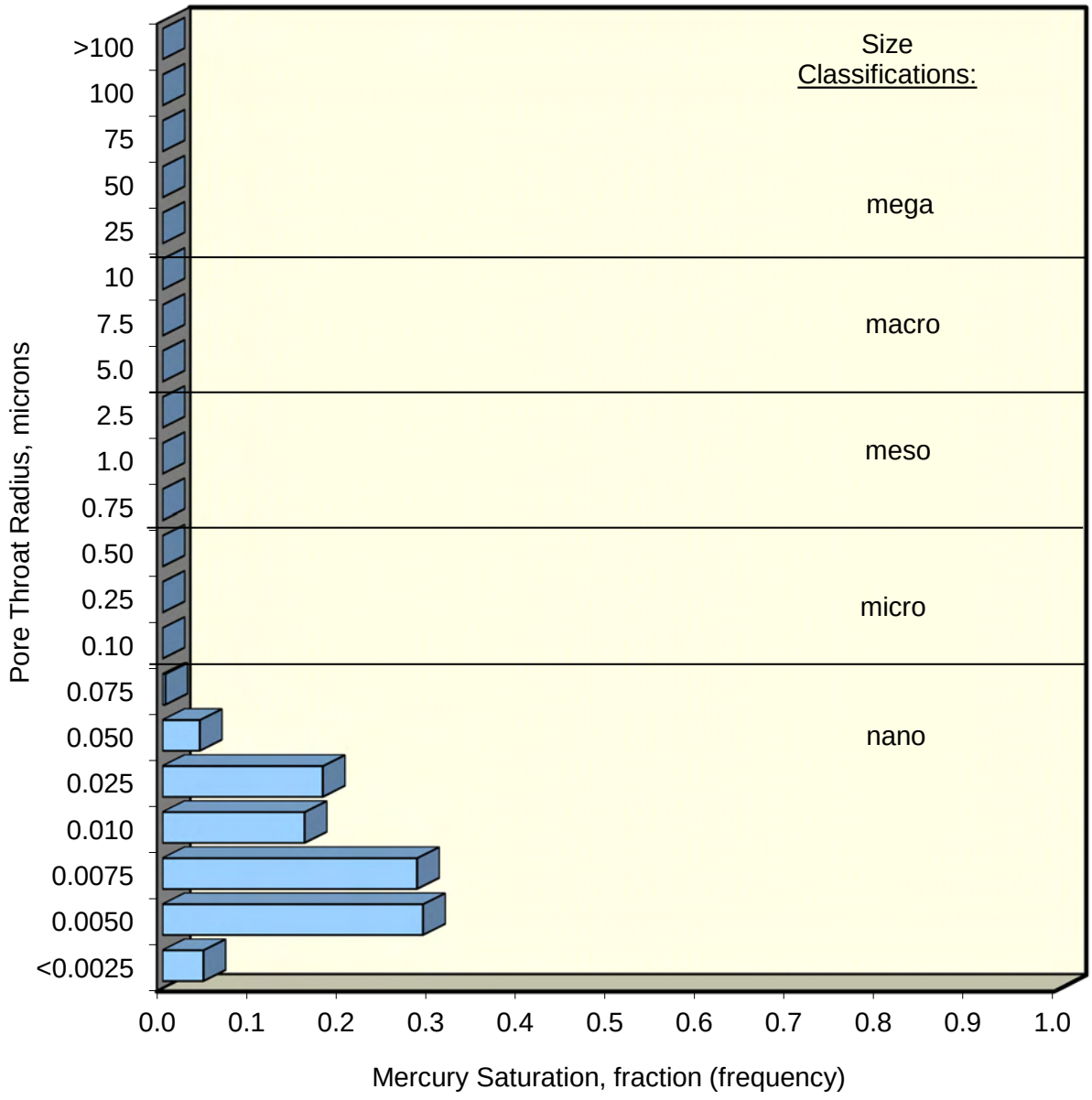
PERMEABILITY DISTRIBUTION



Company: Sandia National Laboratories
File: HOU-141015

Sample:	250-01m	un-	Host Plug	
Depth,feet:	N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:		N/A	-	-
Permeability to Air, md:		N/A	-	-
Swanson Permeability, md:		0.000079	-	-
Porosity, fraction:		0.035	-	-
maximum Sb/Pc, fraction:		0.00011		
R35, microns:		0.00788		
R50 (median pore throat radius):		0.00631		

PORE THROAT SIZE HISTOGRAM



MERCURY INJECTION DATA SUMMARY

Company: Sandia National Laboratories
File: HOU-141015

Sample:	100-03m	un-	Host Plug	
Depth,feet:	N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:		N/A	-	-
Permeability to Air, md:		N/A	-	-
Swanson Permeability, md:		0.0193	-	-
Porosity, fraction:		0.044	-	-
maximum Sb/Pc, fraction:		0.00281		
R35, microns:		0.165		
R50 (median pore throat radius):		0.0839		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
0.84	0.000	1.000	128	0.000323	0.163	0.0543	0.0940	0.339	0.675
1.09	0.000	1.000	98.8	0.000420	0.211	0.0704	0.122	0.441	0.876
1.39	0.000	1.000	77.5	0.000535	0.269	0.0898	0.156	0.562	1.12
1.73	0.000	1.000	62.3	0.000666	0.335	0.112	0.194	0.699	1.39
2.11	0.000	1.000	51.1	0.000812	0.409	0.136	0.236	0.853	1.70
2.55	0.000	1.000	42.3	0.000982	0.494	0.165	0.285	1.03	2.05
3.05	0.000	1.000	35.3	0.00117	0.591	0.197	0.341	1.23	2.45
3.58	0.000	1.000	30.1	0.00138	0.694	0.231	0.401	1.45	2.88
4.17	0.000	1.000	25.8	0.00161	0.808	0.269	0.467	1.69	3.35
4.81	0.000	1.000	22.4	0.00185	0.932	0.311	0.538	1.94	3.87
5.50	0.000	1.000	19.6	0.00212	1.07	0.355	0.615	2.22	4.42
6.25	0.000	1.000	17.2	0.00241	1.21	0.404	0.699	2.53	5.02
7.05	0.000	1.000	15.3	0.00271	1.37	0.455	0.789	2.85	5.67
7.90	0.000	1.000	13.6	0.00304	1.53	0.510	0.884	3.19	6.35
8.80	0.000	1.000	12.2	0.00339	1.71	0.568	0.985	3.56	7.07
9.75	0.000	1.000	11.1	0.00375	1.89	0.630	1.09	3.94	7.84
10.8	0.000	1.000	9.98	0.00416	2.09	0.698	1.21	4.36	8.68
11.9	0.000	1.000	9.06	0.00458	2.30	0.768	1.33	4.81	9.56
13.4	0.000	1.000	8.05	0.00515	2.59	0.865	1.50	5.42	10.8
15.3	0.000	1.000	7.05	0.00589	2.96	0.988	1.71	6.18	12.3
17.6	0.000	1.000	6.14	0.00676	3.40	1.13	1.96	7.11	14.1
20.4	0.000	1.000	5.29	0.00784	3.95	1.32	2.28	8.24	16.4
23.6	0.000	1.000	4.56	0.00910	4.58	1.53	2.64	9.54	19.0
28.8	0.000	1.000	3.74	0.0111	5.58	1.86	3.22	11.6	23.1
33.3	0.000	1.000	3.24	0.0128	6.45	2.15	3.73	13.5	26.8
38.5	0.000	1.000	2.80	0.0148	7.46	2.49	4.31	15.6	30.9
44.0	0.000	1.000	2.45	0.0169	8.52	2.84	4.92	17.8	35.4
50.1	0.000	1.000	2.15	0.0193	9.70	3.23	5.60	20.2	40.3
56.4	0.000	1.000	1.91	0.0217	10.9	3.65	6.31	22.8	45.3
63.9	0.005	0.995	1.69	0.0246	12.4	4.13	7.15	25.8	51.4
72.1	0.012	0.988	1.49	0.0278	14.0	4.66	8.07	29.1	58.0
81.0	0.021	0.979	1.33	0.0312	15.7	5.23	9.06	32.7	65.1
91.6	0.032	0.968	1.18	0.0353	17.8	5.92	10.3	37.0	73.6
104	0.045	0.955	1.04	0.0399	20.1	6.70	11.6	42.0	83.6
116	0.059	0.941	0.925	0.0448	22.6	7.52	13.0	46.9	93.2

MERCURY INJECTION DATA SUMMARY

Company: Sandia National Laboratories
File: HOU-141015

Sample:	100-03m	un-	Host Plug	
Depth,feet:	N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:		N/A	-	-
Permeability to Air, md:		N/A	-	-
Swanson Permeability, md:		0.0193	-	-
Porosity, fraction:		0.044	-	-
maximum Sb/Pc, fraction:		0.00281		
R35, microns:		0.165		
R50 (median pore throat radius):		0.0839		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
133	0.076	0.924	0.813	0.0510	25.7	8.56	14.8	53.8	107
149	0.093	0.907	0.725	0.0572	28.8	9.60	16.6	60.2	120
170	0.108	0.892	0.634	0.0654	32.9	11.0	19.0	68.7	137
192	0.122	0.878	0.561	0.0739	37.2	12.4	21.5	77.6	154
214	0.136	0.864	0.503	0.0824	41.5	13.8	23.9	86.5	172
243	0.150	0.850	0.444	0.0934	47.0	15.7	27.1	98.2	195
276	0.165	0.835	0.390	0.106	53.6	17.9	30.9	112	222
313	0.183	0.817	0.345	0.120	60.6	20.2	35.0	126	252
353	0.203	0.797	0.305	0.136	68.4	22.8	39.5	143	284
400	0.226	0.774	0.270	0.154	77.4	25.8	44.7	162	322
451	0.253	0.747	0.239	0.174	87.3	29.1	50.4	182	363
510	0.284	0.716	0.211	0.196	98.8	32.9	57.1	206	410
580	0.319	0.681	0.186	0.223	112	37.5	64.9	234	466
656	0.352	0.648	0.164	0.253	127	42.4	73.4	265	527
736	0.384	0.616	0.146	0.283	143	47.5	82.3	297	592
830	0.411	0.589	0.130	0.319	161	53.6	92.8	335	667
946	0.437	0.563	0.114	0.364	183	61.1	106	382	760
1080	0.464	0.536	0.0998	0.416	209	69.8	121	436	868
1220	0.490	0.510	0.0883	0.470	237	78.8	137	493	981
1370	0.512	0.488	0.0786	0.528	266	88.5	153	554	1100
1540	0.536	0.464	0.0700	0.593	298	99.4	172	622	1240
1750	0.558	0.442	0.0616	0.674	339	113	196	707	1410
1980	0.576	0.424	0.0544	0.763	384	128	222	800	1590
2220	0.592	0.408	0.0485	0.855	430	143	248	897	1780
2510	0.608	0.392	0.0429	0.966	486	162	281	1010	2020
2830	0.624	0.376	0.0381	1.09	548	183	317	1140	2270
3220	0.642	0.358	0.0335	1.24	624	208	360	1300	2590
3660	0.662	0.338	0.0294	1.41	709	236	410	1480	2940
4150	0.681	0.319	0.0260	1.60	804	268	464	1680	3340
4700	0.701	0.299	0.0229	1.81	911	304	526	1900	3780
5300	0.721	0.279	0.0203	2.04	1030	342	593	2140	4260
5970	0.743	0.257	0.0181	2.30	1160	386	668	2410	4800
6750	0.767	0.233	0.0160	2.60	1310	436	755	2730	5430
7650	0.789	0.211	0.0141	2.94	1480	494	856	3090	6150
8650	0.809	0.191	0.0125	3.33	1680	559	968	3500	6950

MERCURY INJECTION DATA SUMMARY

Company: Sandia National Laboratories
File: HOU-141015

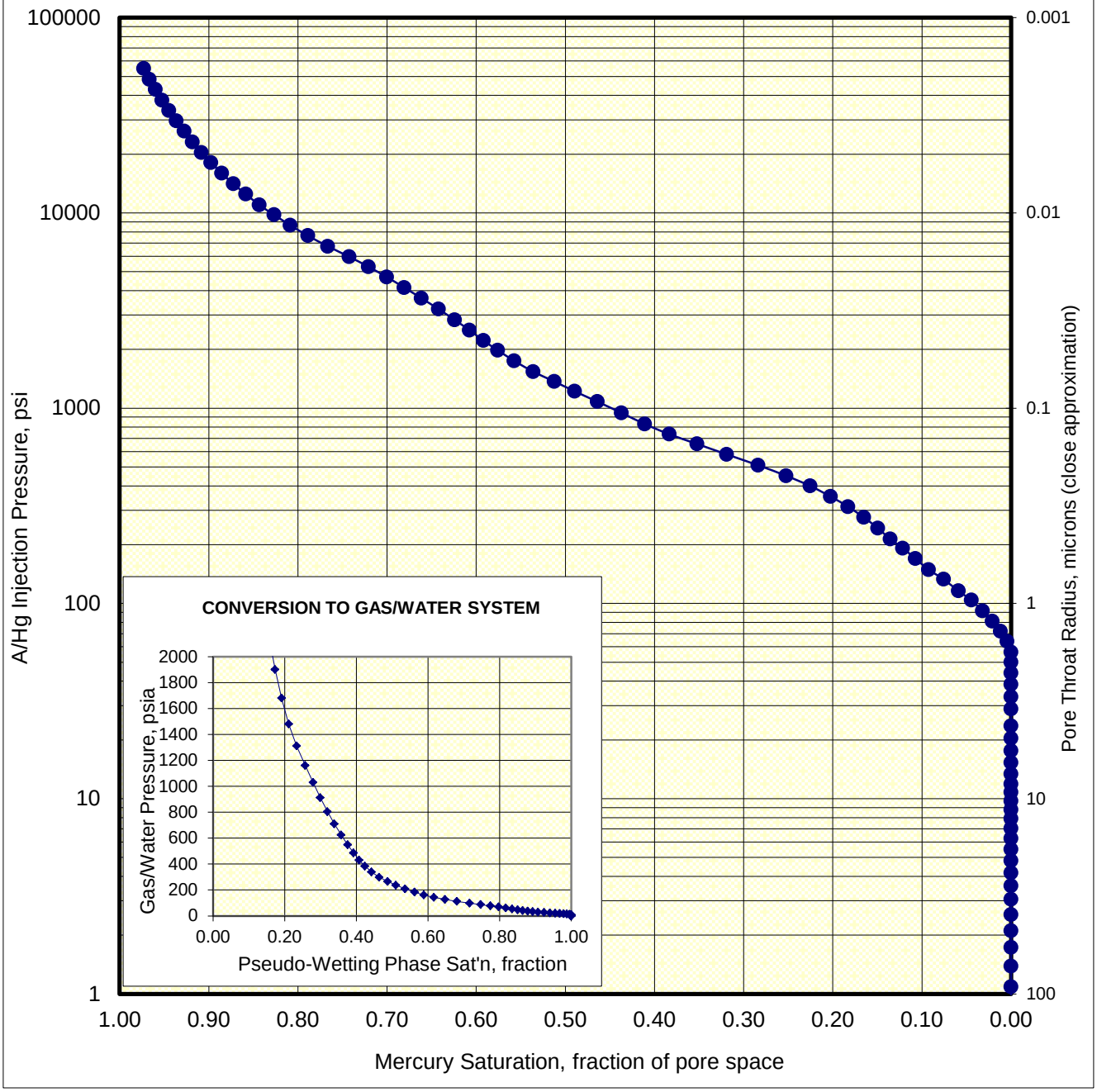
Sample:	100-03m	un-	Host Plug	
Depth,feet:	N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:		N/A	-	-
Permeability to Air, md:		N/A	-	-
Swanson Permeability, md:		0.0193	-	-
Porosity, fraction:		0.044	-	-
maximum Sb/Pc, fraction:		0.00281		
R35, microns:		0.165		
R50 (median pore throat radius):		0.0839		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
9790	0.827	0.173	0.0110	3.77	1900	632	1100	3960	7870
11000	0.843	0.157	0.00976	4.25	2140	713	1240	4450	8840
12500	0.859	0.141	0.00862	4.81	2420	807	1400	5050	10000
14100	0.873	0.127	0.00763	5.44	2740	913	1580	5700	11300
16000	0.886	0.114	0.00674	6.15	3100	1030	1790	6470	12900
18100	0.898	0.102	0.00596	6.96	3500	1170	2020	7310	14500
20400	0.908	0.092	0.00527	7.87	3960	1320	2290	8240	16400
23100	0.918	0.082	0.00466	8.90	4480	1490	2590	9340	18600
26200	0.928	0.072	0.00412	10.1	5070	1690	2930	10600	21100
29600	0.937	0.063	0.00364	11.4	5730	1910	3310	12000	23800
33500	0.945	0.055	0.00322	12.9	6490	2160	3750	13500	26900
37800	0.953	0.047	0.00285	14.6	7330	2440	4230	15300	30400
43000	0.960	0.040	0.00250	16.6	8340	2780	4810	17400	34600
48400	0.967	0.033	0.00223	18.6	9380	3130	5420	19600	38900
55000	0.973	0.027	0.00196	21.2	10700	3550	6150	22200	44200

Company: Sandia National Laboratories
File: HOU-141015

Sample:	100-03m	un-	Host Plug	
Depth,feet:	N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:		N/A	-	-
Permeability to Air, md:		N/A	-	-
Swanson Permeability, md:		0.0193	-	-
Porosity, fraction:		0.044	-	-
maximum Sb/Pc, fraction:		0.00281		
R35, microns:		0.165		
R50 (median pore throat radius):		0.0839		

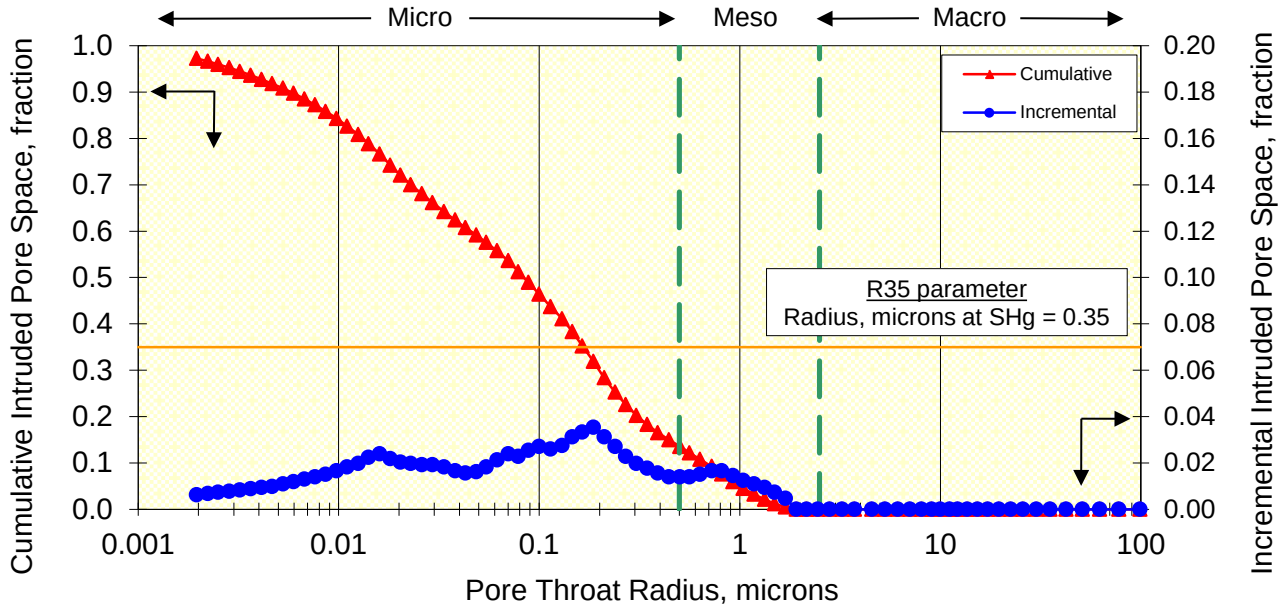
MERCURY INJECTION



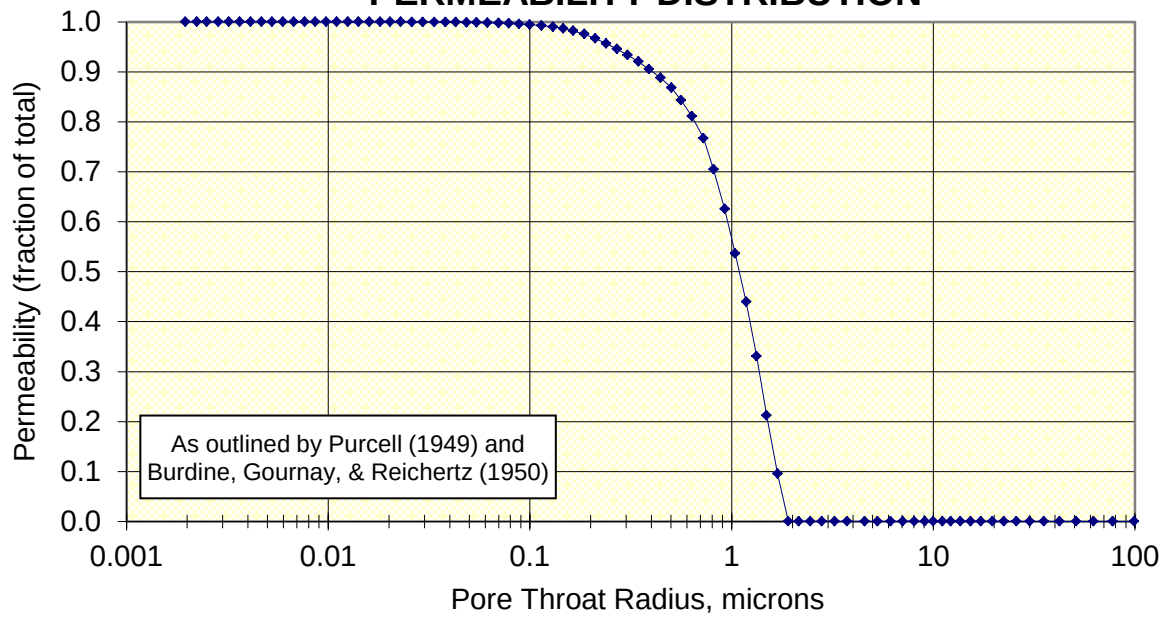
Company: Sandia National Laboratories
File: HOU-141015

Sample:	100-03m	un-	Host Plug	
Depth,feet:	N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:		N/A	-	-
Permeability to Air, md:		N/A	-	-
Swanson Permeability, md:		0.0193	-	-
Porosity, fraction:		0.044	-	-
maximum Sb/Pc, fraction:		0.00281		
R35, microns:		0.165		
R50 (median pore throat radius):		0.0839		

PORE THROAT RADIUS DISTRIBUTION



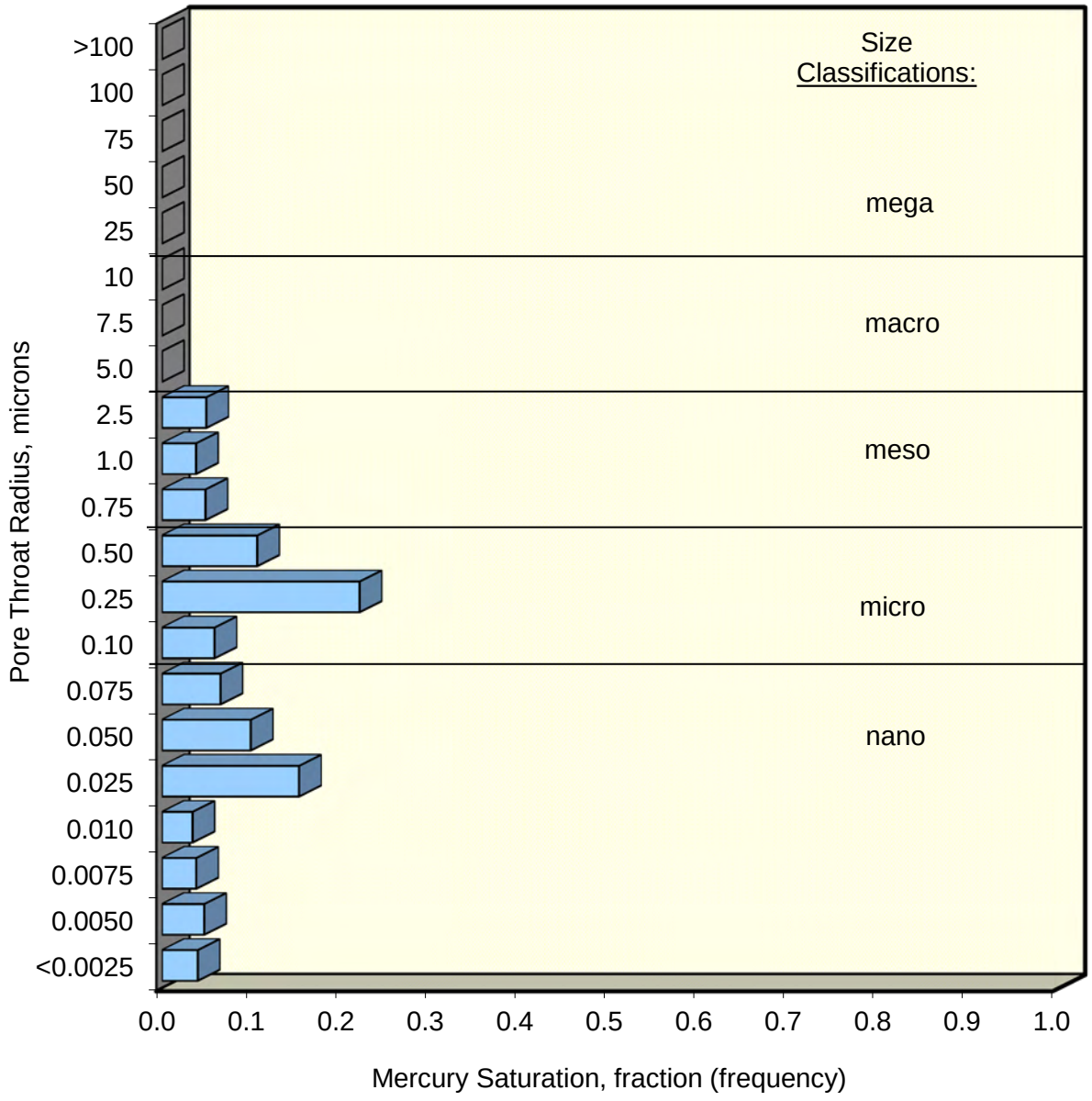
PERMEABILITY DISTRIBUTION



Company: Sandia National Laboratories
File: HOU-141015

Sample:	100-03m	un-	Host Plug	
Depth,feet:	N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:		N/A	-	-
Permeability to Air, md:		N/A	-	-
Swanson Permeability, md:		0.0193	-	-
Porosity, fraction:		0.044	-	-
maximum Sb/Pc, fraction:		0.00281		
R35, microns:		0.165		
R50 (median pore throat radius):		0.0839		

PORE THROAT SIZE HISTOGRAM



MERCURY INJECTION DATA SUMMARY

Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-1m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000044	-	-
Porosity, fraction:	0.024	-	-
maximum Sb/Pc, fraction:	0.00008		
R35, microns:	0.00625		
R50 (median pore throat radius):	0.00365		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
1.09	0.000	1.000	98.8	0.000027	0.211	0.0704	0.122	0.441	0.876
1.39	0.000	1.000	77.5	0.000035	0.269	0.0898	0.156	0.562	1.12
1.72	0.000	1.000	62.6	0.000043	0.333	0.111	0.192	0.695	1.38
2.11	0.000	1.000	51.1	0.000053	0.409	0.136	0.236	0.853	1.70
2.55	0.000	1.000	42.3	0.000064	0.494	0.165	0.285	1.03	2.05
3.04	0.000	1.000	35.4	0.000076	0.589	0.196	0.340	1.23	2.44
3.58	0.000	1.000	30.1	0.000090	0.694	0.231	0.401	1.45	2.88
4.17	0.000	1.000	25.8	0.000105	0.808	0.269	0.467	1.69	3.35
4.81	0.000	1.000	22.4	0.000121	0.932	0.311	0.538	1.94	3.87
5.50	0.000	1.000	19.6	0.000138	1.07	0.355	0.615	2.22	4.42
6.24	0.000	1.000	17.3	0.000157	1.21	0.403	0.698	2.52	5.02
7.05	0.000	1.000	15.3	0.000177	1.37	0.455	0.789	2.85	5.67
7.90	0.000	1.000	13.6	0.000198	1.53	0.510	0.884	3.19	6.35
8.79	0.000	1.000	12.3	0.000221	1.70	0.568	0.983	3.55	7.07
9.74	0.000	1.000	11.1	0.000244	1.89	0.629	1.09	3.94	7.83
10.8	0.000	1.000	9.99	0.000271	2.09	0.697	1.21	4.36	8.68
11.9	0.000	1.000	9.06	0.000298	2.30	0.768	1.33	4.81	9.56
13.4	0.000	1.000	8.05	0.000336	2.59	0.865	1.50	5.42	10.8
15.3	0.000	1.000	7.06	0.000383	2.96	0.986	1.71	6.18	12.3
17.6	0.000	1.000	6.13	0.000441	3.40	1.13	1.97	7.11	14.1
20.4	0.000	1.000	5.27	0.000513	3.96	1.32	2.29	8.24	16.4
23.6	0.000	1.000	4.56	0.000593	4.58	1.53	2.64	9.54	19.0
27.2	0.000	1.000	3.96	0.000683	5.28	1.76	3.05	11.0	21.9
31.4	0.000	1.000	3.43	0.000789	6.09	2.03	3.52	12.7	25.2
36.9	0.000	1.000	2.92	0.000926	7.15	2.38	4.13	14.9	29.7
42.1	0.000	1.000	2.56	0.00106	8.15	2.72	4.71	17.0	33.8
48.0	0.000	1.000	2.24	0.00121	9.31	3.10	5.38	19.4	38.6
54.7	0.000	1.000	1.97	0.00137	10.6	3.53	6.12	22.1	44.0
62.3	0.000	1.000	1.73	0.00156	12.1	4.03	6.97	25.2	50.1
70.5	0.000	1.000	1.53	0.00177	13.7	4.55	7.88	28.5	56.7
79.3	0.000	1.000	1.36	0.00199	15.4	5.12	8.87	32.0	63.7
92.1	0.000	1.000	1.17	0.00231	17.8	5.95	10.3	37.2	74.0
102	0.000	1.000	1.05	0.00256	19.8	6.60	11.4	41.2	82.0
115	0.000	1.000	0.939	0.00288	22.2	7.41	12.8	46.5	92.4
132	0.000	1.000	0.819	0.00330	25.5	8.50	14.7	53.3	106

MERCURY INJECTION DATA SUMMARY

Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-1m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000044	-	-
Porosity, fraction:	0.024	-	-
maximum Sb/Pc, fraction:	0.00008		
R35, microns:	0.00625		
R50 (median pore throat radius):	0.00365		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
147	0.000	1.000	0.734	0.00368	28.4	9.48	16.4	59.4	118
167	0.000	1.000	0.644	0.00420	32.4	10.8	18.7	67.5	134
189	0.000	1.000	0.569	0.00475	36.7	12.2	21.2	76.4	152
213	0.000	1.000	0.506	0.00534	41.2	13.7	23.8	86.1	171
241	0.000	1.000	0.447	0.00605	46.7	15.6	26.9	97.4	194
275	0.000	1.000	0.391	0.00691	53.3	17.8	30.8	111	221
312	0.000	1.000	0.346	0.00783	60.4	20.1	34.9	126	251
352	0.000	1.000	0.306	0.00883	68.2	22.7	39.4	142	283
353	0.000	1.000	0.305	0.00887	68.5	22.8	39.5	143	284
399	0.000	1.000	0.270	0.0100	77.3	25.8	44.6	161	321
448	0.000	1.000	0.240	0.0112	86.8	28.9	50.1	181	360
508	0.000	1.000	0.212	0.0128	98.5	32.8	56.9	205	408
580	0.000	1.000	0.186	0.0146	112	37.4	64.9	234	466
654	0.000	1.000	0.165	0.0164	127	42.2	73.2	264	526
734	0.000	1.000	0.147	0.0184	142	47.4	82.1	297	590
830	0.000	1.000	0.130	0.0208	161	53.6	92.8	335	667
943	0.000	1.000	0.114	0.0237	183	60.9	105	381	758
1080	0.000	1.000	0.0999	0.0271	209	69.7	121	436	868
1220	0.000	1.000	0.0884	0.0306	236	78.7	136	493	981
1380	0.004	0.996	0.0783	0.0345	267	88.9	154	558	1110
1550	0.015	0.985	0.0697	0.0388	299	99.8	173	626	1250
1750	0.034	0.966	0.0616	0.0439	339	113	196	707	1410
1980	0.059	0.941	0.0545	0.0496	383	128	221	800	1590
2220	0.072	0.928	0.0486	0.0557	430	143	248	897	1780
2510	0.080	0.920	0.0430	0.0630	486	162	281	1010	2020
2830	0.086	0.914	0.0381	0.0710	548	183	316	1140	2270
3220	0.094	0.906	0.0335	0.0808	624	208	360	1300	2590
3660	0.117	0.883	0.0295	0.0918	709	236	409	1480	2940
4150	0.132	0.868	0.0260	0.104	804	268	464	1680	3340
4700	0.146	0.854	0.0229	0.118	910	303	525	1900	3780
5300	0.159	0.841	0.0203	0.133	1030	342	593	2140	4260
5970	0.171	0.829	0.0181	0.150	1160	385	668	2410	4800
6750	0.185	0.815	0.0160	0.169	1310	436	755	2730	5430
7650	0.200	0.800	0.0141	0.192	1480	494	856	3090	6150
8650	0.217	0.783	0.0125	0.217	1680	559	967	3500	6950

MERCURY INJECTION DATA SUMMARY

Company: Sandi Natrional Laboratories
File: HOU-141015

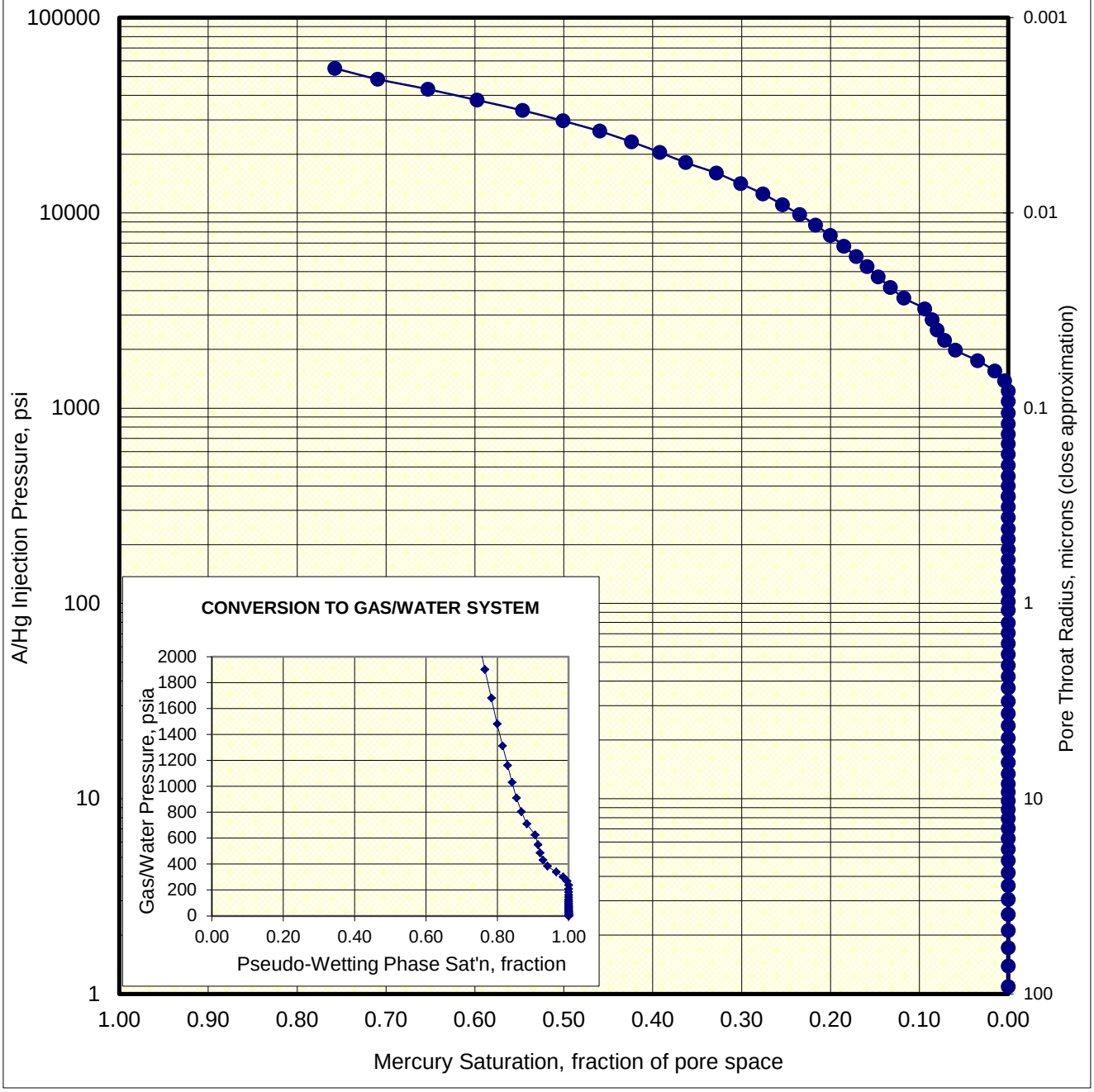
Sample: SNLCH111-15-1m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000044	-	-
Porosity, fraction:	0.024	-	-
maximum Sb/Pc, fraction:	0.00008		
R35, microns:	0.00625		
R50 (median pore throat radius):	0.00365		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
9790	0.235	0.765	0.0110	0.246	1900	632	1090	3960	7870
11000	0.254	0.746	0.00976	0.277	2140	713	1230	4450	8840
12500	0.276	0.724	0.00862	0.314	2420	807	1400	5050	10000
14100	0.301	0.699	0.00763	0.355	2740	913	1580	5700	11300
16000	0.328	0.672	0.00674	0.401	3100	1030	1790	6470	12900
18100	0.363	0.637	0.00596	0.454	3500	1170	2020	7310	14500
20400	0.392	0.608	0.00527	0.513	3960	1320	2290	8240	16400
23100	0.424	0.576	0.00466	0.580	4480	1490	2590	9340	18600
26200	0.460	0.540	0.00412	0.657	5070	1690	2930	10600	21100
29600	0.501	0.499	0.00364	0.742	5730	1910	3310	12000	23800
33500	0.546	0.454	0.00322	0.841	6490	2160	3750	13500	26900
37800	0.598	0.402	0.00285	0.950	7330	2440	4230	15300	30400
43000	0.653	0.347	0.00250	1.08	8340	2780	4810	17400	34600
48400	0.709	0.291	0.00223	1.22	9380	3130	5420	19600	38900
55000	0.758	0.242	0.00196	1.38	10700	3550	6150	22200	44200

Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-1m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000044	-	-
Porosity, fraction:	0.024	-	-
maximum Sb/Pc, fraction:	0.00008		
R35, microns:	0.00625		
R50 (median pore throat radius):	0.00365		

MERCURY INJECTION

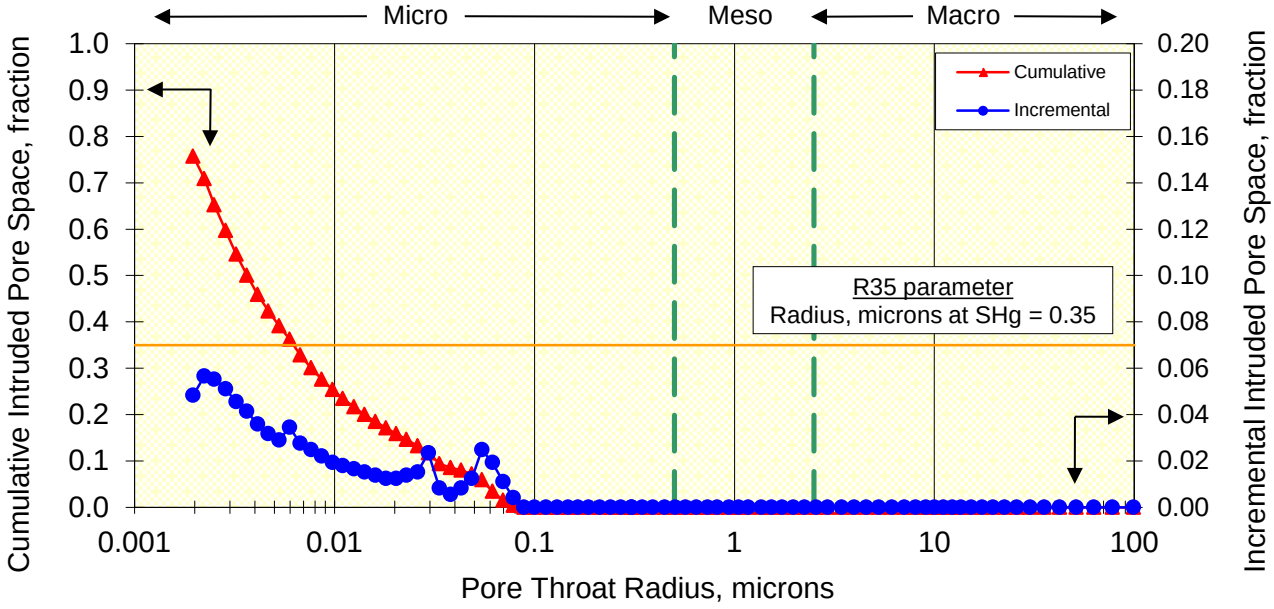


Core Laboratories

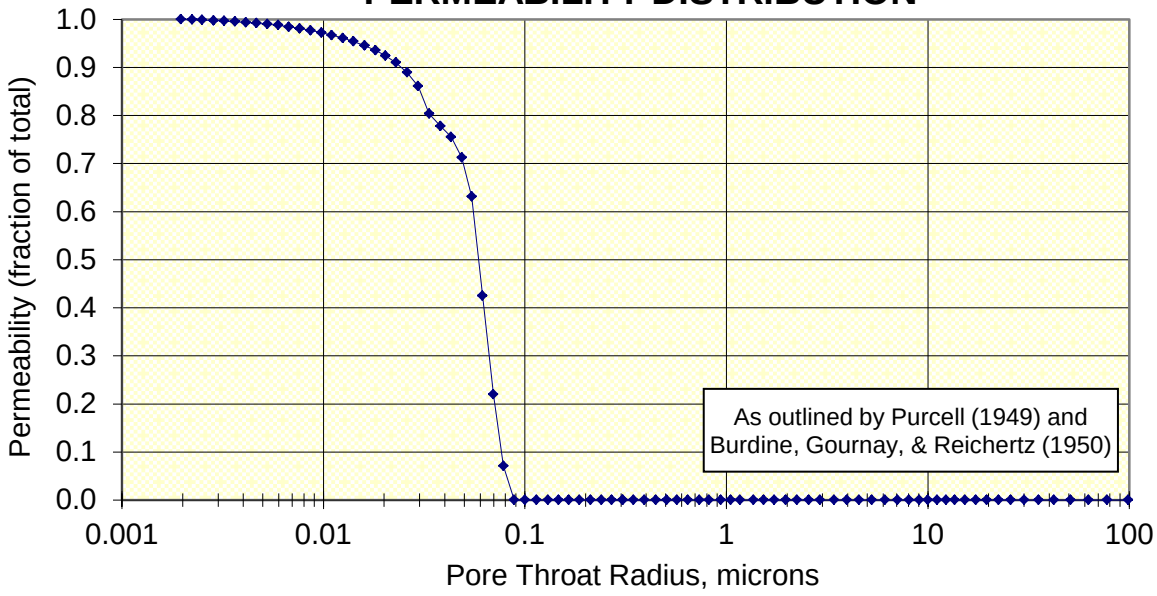
Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-1m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000044	-	-
Porosity, fraction:	0.024	-	-
maximum Sb/Pc, fraction:	0.00008		
R35, microns:	0.00625		
R50 (median pore throat radius):	0.00365		

PORE THROAT RADIUS DISTRIBUTION



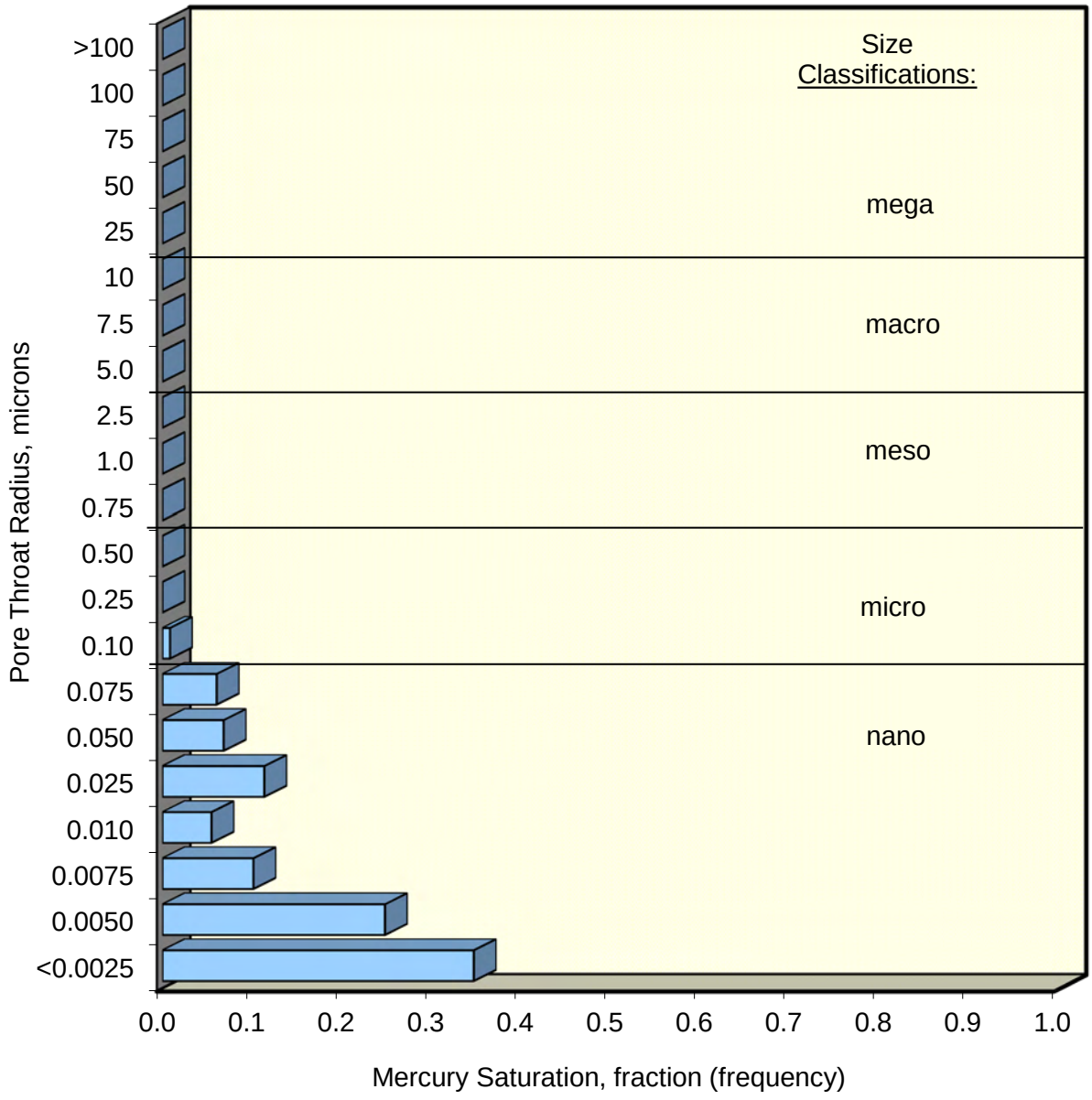
PERMEABILITY DISTRIBUTION



Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-1m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000044	-	-
Porosity, fraction:	0.024	-	-
maximum Sb/Pc, fraction:	0.00008		
R35, microns:	0.00625		
R50 (median pore throat radius):	0.00365		

PORE THROAT SIZE HISTOGRAM



MERCURY INJECTION DATA SUMMARY

Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-2m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000021	-	-
Porosity, fraction:	0.020	-	-
maximum Sb/Pc, fraction:	0.00005		
R35, microns:	0.00615		
R50 (median pore throat radius):	0.00358		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
1.09	0.000	1.000	98.8	0.000021	0.211	0.0704	0.122	0.441	0.876
1.39	0.000	1.000	77.5	0.000026	0.269	0.0898	0.156	0.562	1.12
1.72	0.000	1.000	62.6	0.000033	0.333	0.111	0.192	0.695	1.38
2.11	0.000	1.000	51.1	0.000040	0.409	0.136	0.236	0.853	1.70
2.55	0.000	1.000	42.3	0.000048	0.494	0.165	0.285	1.03	2.05
3.04	0.000	1.000	35.4	0.000058	0.589	0.196	0.340	1.23	2.44
3.58	0.000	1.000	30.1	0.000068	0.694	0.231	0.401	1.45	2.88
4.17	0.000	1.000	25.8	0.000079	0.808	0.269	0.467	1.69	3.35
4.81	0.000	1.000	22.4	0.000091	0.932	0.311	0.538	1.94	3.87
5.50	0.000	1.000	19.6	0.000105	1.07	0.355	0.615	2.22	4.42
6.24	0.000	1.000	17.3	0.000119	1.21	0.403	0.698	2.52	5.02
7.05	0.000	1.000	15.3	0.000134	1.37	0.455	0.789	2.85	5.67
7.90	0.000	1.000	13.6	0.000150	1.53	0.510	0.884	3.19	6.35
8.79	0.000	1.000	12.3	0.000167	1.70	0.568	0.983	3.55	7.07
9.74	0.000	1.000	11.1	0.000185	1.89	0.629	1.09	3.94	7.83
10.8	0.000	1.000	9.99	0.000205	2.09	0.697	1.21	4.36	8.68
11.9	0.000	1.000	9.06	0.000226	2.30	0.768	1.33	4.81	9.56
13.4	0.000	1.000	8.05	0.000255	2.59	0.865	1.50	5.42	10.8
15.3	0.000	1.000	7.06	0.000290	2.96	0.986	1.71	6.18	12.3
17.6	0.000	1.000	6.13	0.000334	3.40	1.13	1.97	7.11	14.1
20.4	0.000	1.000	5.27	0.000389	3.96	1.32	2.29	8.24	16.4
23.6	0.000	1.000	4.56	0.000449	4.58	1.53	2.64	9.54	19.0
27.0	0.000	1.000	3.99	0.000513	5.23	1.74	3.02	10.9	21.7
31.2	0.000	1.000	3.46	0.000592	6.04	2.01	3.49	12.6	25.1
36.6	0.000	1.000	2.94	0.000696	7.09	2.36	4.10	14.8	29.4
41.8	0.000	1.000	2.58	0.000794	8.10	2.70	4.67	16.9	33.6
47.7	0.000	1.000	2.26	0.000908	9.25	3.08	5.34	19.3	38.3
54.4	0.000	1.000	1.98	0.00103	10.5	3.51	6.09	22.0	43.7
62.0	0.000	1.000	1.74	0.00118	12.0	4.01	6.94	25.1	49.8
70.2	0.000	1.000	1.54	0.00133	13.6	4.53	7.85	28.4	56.4
79.0	0.000	1.000	1.36	0.00150	15.3	5.10	8.83	31.9	63.5
91.8	0.000	1.000	1.17	0.00174	17.8	5.93	10.3	37.1	73.8
102	0.000	1.000	1.06	0.00194	19.7	6.58	11.4	41.2	82.0
114	0.000	1.000	0.942	0.00218	22.2	7.39	12.8	46.1	91.6
131	0.000	1.000	0.821	0.00250	25.4	8.48	14.7	52.9	105

MERCURY INJECTION DATA SUMMARY

Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-2m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000021	-	-
Porosity, fraction:	0.020	-	-
maximum Sb/Pc, fraction:	0.00005		
R35, microns:	0.00615		
R50 (median pore throat radius):	0.00358		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
146	0.000	1.000	0.736	0.00278	28.4	9.46	16.4	59.0	117
167	0.000	1.000	0.645	0.00318	32.4	10.8	18.7	67.5	134
189	0.000	1.000	0.570	0.00359	36.6	12.2	21.2	76.4	152
213	0.000	1.000	0.507	0.00404	41.2	13.7	23.8	86.1	171
241	0.000	1.000	0.448	0.00457	46.6	15.5	26.9	97.4	194
275	0.000	1.000	0.392	0.00523	53.3	17.8	30.8	111	221
311	0.000	1.000	0.346	0.00592	60.3	20.1	34.8	126	250
352	0.000	1.000	0.306	0.00668	68.1	22.7	39.3	142	283
353	0.000	1.000	0.305	0.00671	68.4	22.8	39.5	143	284
398	0.000	1.000	0.270	0.00757	77.2	25.7	44.6	161	320
448	0.000	1.000	0.241	0.00851	86.8	28.9	50.1	181	360
508	0.000	1.000	0.212	0.00966	98.5	32.8	56.9	205	408
579	0.000	1.000	0.186	0.0110	112	37.4	64.8	234	465
653	0.000	1.000	0.165	0.0124	127	42.2	73.1	264	525
733	0.000	1.000	0.147	0.0139	142	47.4	82.0	296	589
829	0.000	1.000	0.130	0.0158	161	53.6	92.8	335	666
943	0.000	1.000	0.114	0.0179	183	60.9	105	381	758
1080	0.005	0.995	0.0999	0.0205	209	69.7	121	436	868
1220	0.013	0.987	0.0884	0.0232	236	78.7	136	493	981
1380	0.023	0.977	0.0783	0.0261	267	88.8	154	558	1110
1550	0.029	0.971	0.0697	0.0294	299	99.8	173	626	1250
1750	0.035	0.965	0.0616	0.0333	339	113	196	707	1410
1980	0.040	0.960	0.0545	0.0376	383	128	221	800	1590
2220	0.047	0.953	0.0486	0.0422	430	143	248	897	1780
2510	0.054	0.946	0.0430	0.0477	486	162	281	1010	2020
2830	0.062	0.938	0.0381	0.0538	548	183	316	1140	2270
3220	0.072	0.928	0.0335	0.0612	624	208	360	1300	2590
3660	0.083	0.917	0.0295	0.0695	709	236	409	1480	2940
4150	0.097	0.903	0.0260	0.0789	804	268	464	1680	3340
4700	0.114	0.886	0.0229	0.0893	910	303	525	1900	3780
5300	0.131	0.869	0.0203	0.101	1030	342	593	2140	4260
5970	0.150	0.850	0.0181	0.113	1160	385	668	2410	4800
6750	0.170	0.830	0.0160	0.128	1310	436	755	2730	5430
7650	0.192	0.808	0.0141	0.145	1480	494	856	3090	6150
8650	0.212	0.788	0.0125	0.164	1680	558	967	3500	6950

MERCURY INJECTION DATA SUMMARY

Company: Sandi Natrional Laboratories
File: HOU-141015

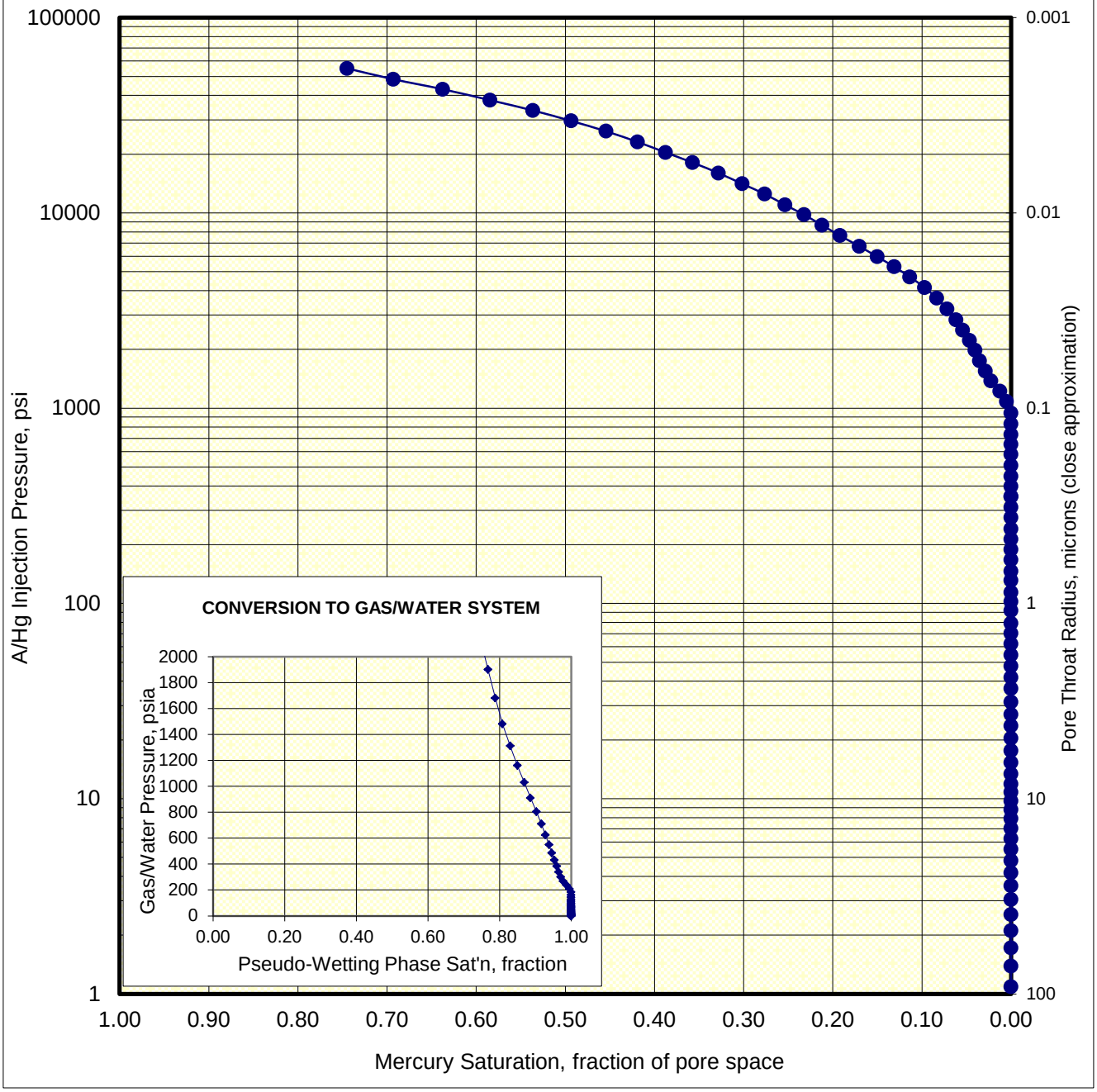
Sample: SNLCH111-15-2m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000021	-	-
Porosity, fraction:	0.020	-	-
maximum Sb/Pc, fraction:	0.00005		
R35, microns:	0.00615		
R50 (median pore throat radius):	0.00358		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
9790	0.232	0.768	0.0110	0.186	1900	632	1090	3960	7870
11000	0.254	0.746	0.00976	0.210	2140	713	1230	4450	8840
12500	0.276	0.724	0.00862	0.238	2420	807	1400	5050	10000
14100	0.302	0.698	0.00763	0.269	2740	912	1580	5700	11300
16000	0.328	0.672	0.00674	0.304	3100	1030	1790	6470	12900
18100	0.357	0.643	0.00596	0.344	3500	1170	2020	7310	14500
20400	0.388	0.612	0.00527	0.389	3960	1320	2290	8240	16400
23100	0.419	0.581	0.00466	0.439	4480	1490	2590	9340	18600
26200	0.455	0.545	0.00412	0.497	5070	1690	2930	10600	21100
29600	0.494	0.506	0.00364	0.562	5730	1910	3310	12000	23800
33500	0.537	0.463	0.00322	0.637	6490	2160	3750	13500	26900
37800	0.585	0.415	0.00285	0.719	7330	2440	4230	15300	30400
43000	0.638	0.362	0.00250	0.818	8340	2780	4810	17400	34600
48400	0.693	0.307	0.00223	0.920	9380	3130	5420	19600	38900
55000	0.745	0.255	0.00196	1.05	10700	3550	6150	22200	44200

Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-2m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000021	-	-
Porosity, fraction:	0.020	-	-
maximum Sb/Pc, fraction:	0.00005		
R35, microns:	0.00615		
R50 (median pore throat radius):	0.00358		

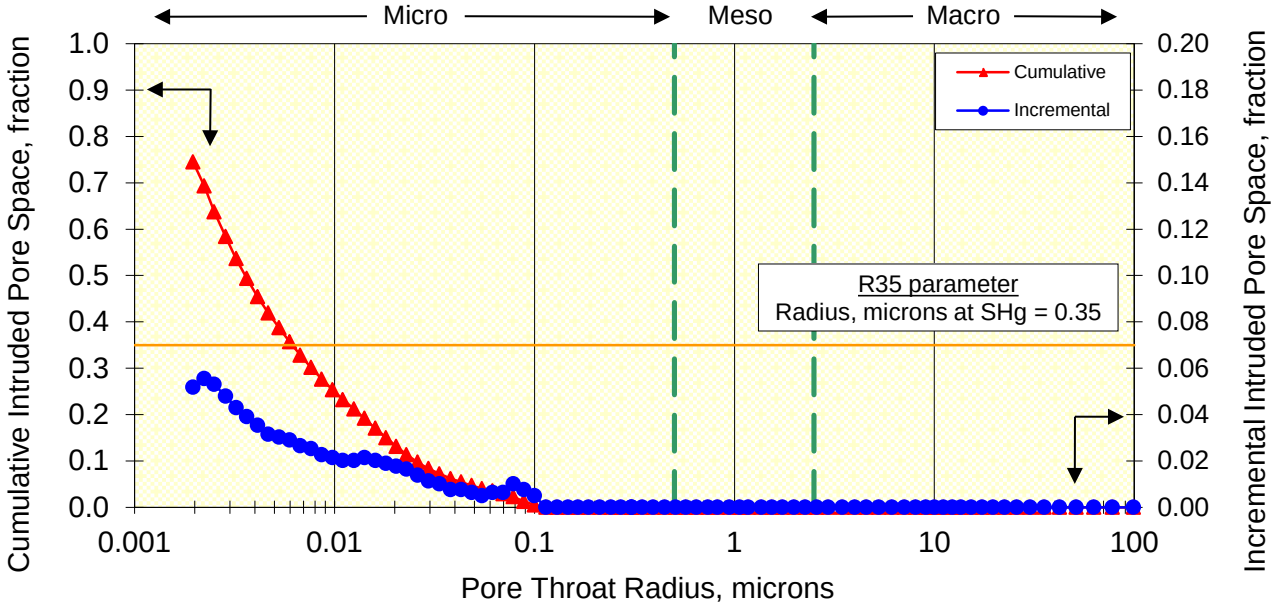
MERCURY INJECTION



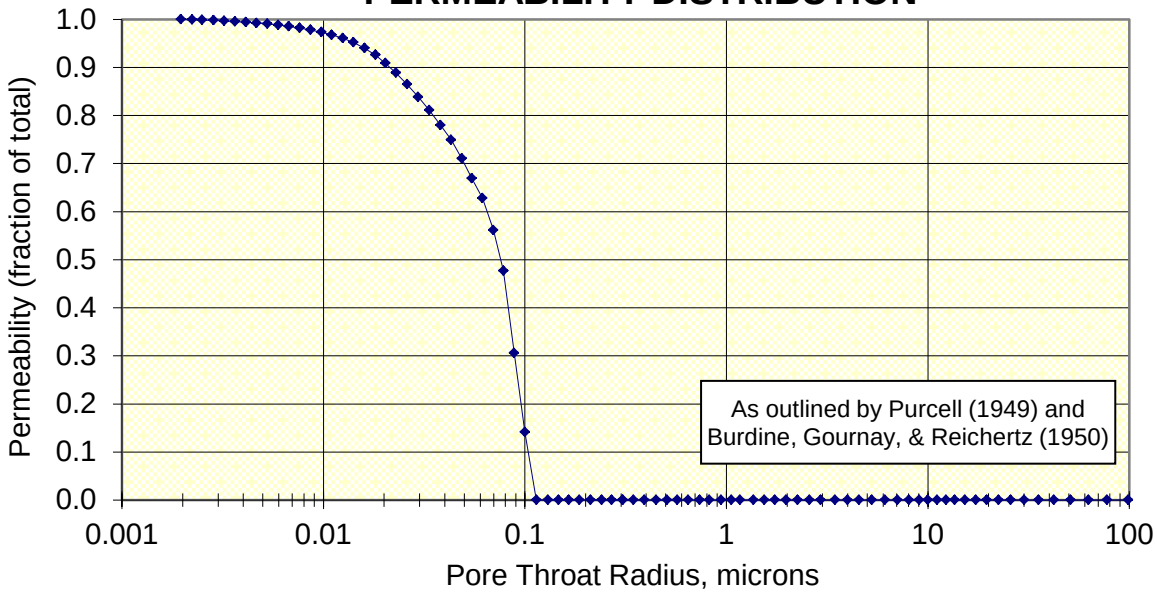
Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-2m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000021	-	-
Porosity, fraction:	0.020	-	-
maximum Sb/Pc, fraction:	0.00005		
R35, microns:	0.00615		
R50 (median pore throat radius):	0.00358		

PORE THROAT RADIUS DISTRIBUTION



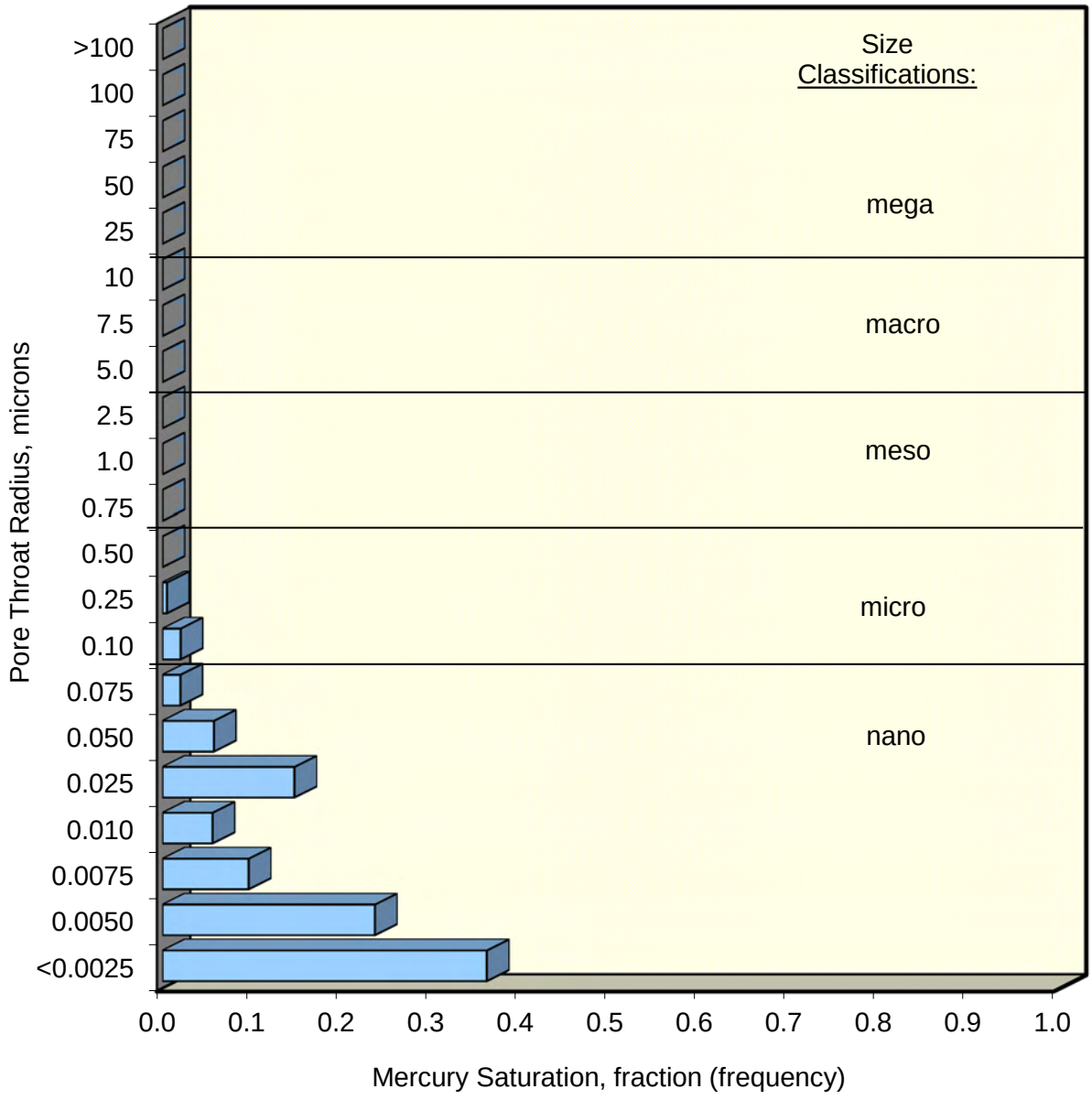
PERMEABILITY DISTRIBUTION



Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-2m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000021	-	-
Porosity, fraction:	0.020	-	-
maximum Sb/Pc, fraction:	0.00005		
R35, microns:	0.00615		
R50 (median pore throat radius):	0.00358		

PORE THROAT SIZE HISTOGRAM



MERCURY INJECTION DATA SUMMARY

Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-3m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000014	-	-
Porosity, fraction:	0.023	-	-
maximum Sb/Pc, fraction:	0.00004		
R35, microns:	0.00477		
R50 (median pore throat radius):	0.00318		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
0.84	0.000	1.000	128	0.000012	0.163	0.0543	0.0940	0.339	0.675
1.10	0.000	1.000	97.9	0.000016	0.213	0.0711	0.123	0.445	0.884
1.38	0.000	1.000	78.1	0.000020	0.267	0.0891	0.154	0.558	1.11
1.72	0.000	1.000	62.6	0.000025	0.333	0.111	0.192	0.695	1.38
2.11	0.000	1.000	51.1	0.000031	0.409	0.136	0.236	0.853	1.70
2.54	0.000	1.000	42.4	0.000037	0.492	0.164	0.284	1.03	2.04
3.03	0.000	1.000	35.6	0.000044	0.587	0.196	0.339	1.22	2.44
3.57	0.000	1.000	30.2	0.000052	0.692	0.231	0.399	1.44	2.87
4.16	0.000	1.000	25.9	0.000060	0.806	0.269	0.465	1.68	3.34
4.81	0.000	1.000	22.4	0.000070	0.932	0.311	0.538	1.94	3.87
5.51	0.000	1.000	19.6	0.000080	1.07	0.356	0.616	2.23	4.43
6.26	0.000	1.000	17.2	0.000091	1.21	0.404	0.700	2.53	5.03
7.04	0.000	1.000	15.3	0.000102	1.36	0.455	0.788	2.85	5.66
7.92	0.000	1.000	13.6	0.000115	1.53	0.512	0.886	3.20	6.37
8.82	0.000	1.000	12.2	0.000128	1.71	0.570	0.987	3.56	7.09
9.75	0.000	1.000	11.1	0.000141	1.89	0.630	1.09	3.94	7.84
10.8	0.000	1.000	9.99	0.000156	2.09	0.697	1.21	4.36	8.68
11.9	0.000	1.000	9.06	0.000172	2.30	0.768	1.33	4.81	9.56
13.4	0.000	1.000	8.05	0.000194	2.59	0.865	1.50	5.42	10.8
15.3	0.000	1.000	7.05	0.000221	2.96	0.987	1.71	6.18	12.3
17.6	0.000	1.000	6.13	0.000254	3.40	1.13	1.97	7.11	14.1
20.4	0.000	1.000	5.29	0.000294	3.94	1.31	2.28	8.24	16.4
23.6	0.000	1.000	4.56	0.000342	4.58	1.53	2.64	9.54	19.0
27.1	0.000	1.000	3.97	0.000392	5.26	1.75	3.03	11.0	21.8
31.5	0.000	1.000	3.42	0.000456	6.11	2.04	3.53	12.7	25.3
36.8	0.000	1.000	2.93	0.000533	7.13	2.38	4.12	14.9	29.6
42.3	0.000	1.000	2.55	0.000611	8.19	2.73	4.73	17.1	34.0
48.9	0.000	1.000	2.21	0.000707	9.47	3.16	5.47	19.8	39.3
54.9	0.000	1.000	1.96	0.000794	10.6	3.55	6.14	22.2	44.1
62.2	0.000	1.000	1.73	0.000899	12.0	4.01	6.95	25.1	50.0
70.3	0.000	1.000	1.53	0.00102	13.6	4.54	7.86	28.4	56.5
79.9	0.000	1.000	1.35	0.00116	15.5	5.16	8.94	32.3	64.2
89.8	0.000	1.000	1.20	0.00130	17.4	5.80	10.0	36.3	72.2
102	0.000	1.000	1.05	0.00148	19.8	6.60	11.4	41.2	82.0
115	0.000	1.000	0.934	0.00167	22.4	7.45	12.9	46.5	92.4

MERCURY INJECTION DATA SUMMARY

Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-3m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000014	-	-
Porosity, fraction:	0.023	-	-
maximum Sb/Pc, fraction:	0.00004		
R35, microns:	0.00477		
R50 (median pore throat radius):	0.00318		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
131	0.000	1.000	0.820	0.00190	25.5	8.49	14.7	52.9	105
147	0.000	1.000	0.734	0.00213	28.5	9.49	16.4	59.4	118
168	0.000	1.000	0.641	0.00243	32.6	10.9	18.8	67.9	135
190	0.000	1.000	0.567	0.00275	36.8	12.3	21.2	76.8	153
213	0.000	1.000	0.505	0.00309	41.3	13.8	23.9	86.1	171
241	0.000	1.000	0.448	0.00348	46.6	15.5	26.9	97.4	194
275	0.000	1.000	0.392	0.00398	53.3	17.8	30.7	111	221
312	0.000	1.000	0.346	0.00451	60.4	20.1	34.9	126	251
352	0.000	1.000	0.307	0.00509	68.1	22.7	39.3	142	283
399	0.000	1.000	0.270	0.00577	77.2	25.7	44.6	161	321
449	0.000	1.000	0.240	0.00650	87.0	29.0	50.2	181	361
509	0.000	1.000	0.212	0.00736	98.6	32.9	56.9	206	409
580	0.000	1.000	0.186	0.00839	112	37.4	64.9	234	466
654	0.000	1.000	0.165	0.00946	127	42.3	73.2	264	526
733	0.000	1.000	0.147	0.0106	142	47.4	82.0	296	589
829	0.000	1.000	0.130	0.0120	161	53.5	92.7	335	666
944	0.000	1.000	0.114	0.0137	183	61.0	106	382	759
1080	0.000	1.000	0.0999	0.0156	209	69.7	121	436	868
1220	0.000	1.000	0.0884	0.0176	236	78.7	136	493	981
1370	0.000	1.000	0.0787	0.0198	265	88.4	153	554	1100
1540	0.000	1.000	0.0700	0.0223	298	99.4	172	622	1240
1750	0.000	1.000	0.0616	0.0253	339	113	196	707	1410
1980	0.000	1.000	0.0545	0.0286	383	128	221	800	1590
2220	0.005	0.995	0.0486	0.0321	430	143	248	897	1780
2510	0.012	0.988	0.0430	0.0363	486	162	281	1010	2020
2830	0.021	0.979	0.0381	0.0409	548	183	316	1140	2270
3220	0.030	0.970	0.0335	0.0466	624	208	360	1300	2590
3660	0.038	0.962	0.0295	0.0529	709	236	409	1480	2940
4150	0.048	0.952	0.0260	0.0600	804	268	464	1680	3340
4700	0.059	0.941	0.0229	0.0680	910	303	525	1900	3780
5300	0.073	0.927	0.0203	0.0766	1030	342	593	2140	4260
5970	0.089	0.911	0.0181	0.0863	1160	385	668	2410	4800
6750	0.107	0.893	0.0160	0.0976	1310	436	755	2730	5430
7640	0.122	0.878	0.0141	0.111	1480	494	855	3090	6140
8650	0.139	0.861	0.0125	0.125	1680	559	968	3500	6950

MERCURY INJECTION DATA SUMMARY

Company: Sandi Natrional Laboratories
File: HOU-141015

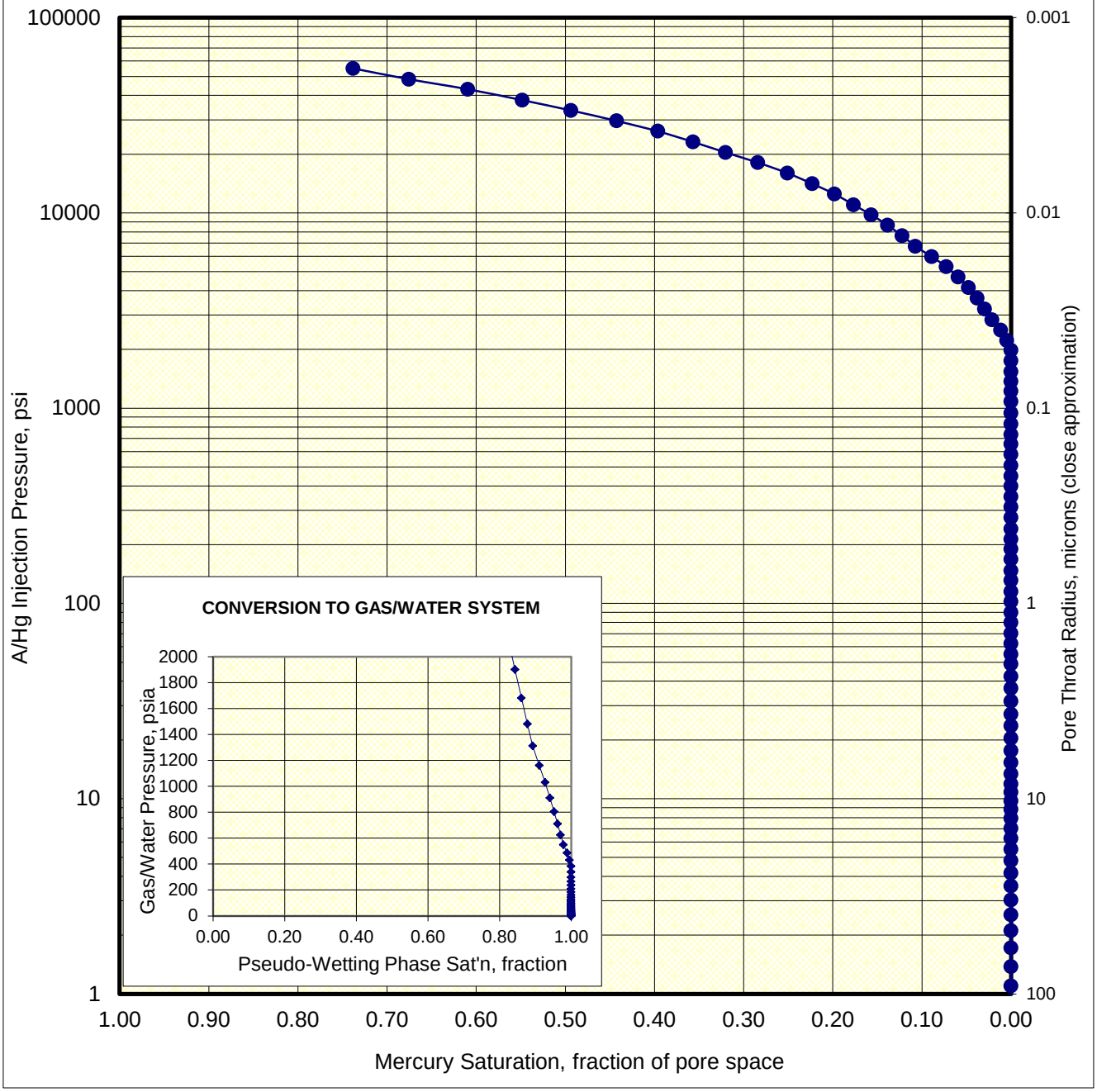
Sample: SNLCH111-15-3m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000014	-	-
Porosity, fraction:	0.023	-	-
maximum Sb/Pc, fraction:	0.00004		
R35, microns:	0.00477		
R50 (median pore throat radius):	0.00318		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
9780	0.157	0.843	0.0110	0.142	1900	632	1090	3950	7860
11000	0.177	0.823	0.00976	0.160	2140	713	1230	4450	8840
12500	0.198	0.802	0.00862	0.181	2420	807	1400	5050	10000
14100	0.223	0.777	0.00763	0.204	2740	912	1580	5700	11300
16000	0.251	0.749	0.00674	0.231	3100	1030	1790	6470	12900
18100	0.284	0.716	0.00596	0.262	3500	1170	2020	7310	14500
20400	0.320	0.680	0.00527	0.296	3960	1320	2290	8240	16400
23100	0.357	0.643	0.00466	0.335	4480	1490	2590	9340	18600
26200	0.396	0.604	0.00412	0.379	5070	1690	2930	10600	21100
29600	0.443	0.557	0.00364	0.428	5730	1910	3310	12000	23800
33500	0.494	0.506	0.00322	0.485	6490	2160	3750	13500	26900
37800	0.548	0.452	0.00285	0.548	7330	2440	4230	15300	30400
43000	0.609	0.391	0.00250	0.623	8340	2780	4810	17400	34600
48400	0.676	0.324	0.00223	0.700	9380	3130	5420	19600	38900
55000	0.738	0.262	0.00196	0.796	10700	3550	6150	22200	44200

Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-3m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000014	-	-
Porosity, fraction:	0.023	-	-
maximum Sb/Pc, fraction:	0.00004		
R35, microns:	0.00477		
R50 (median pore throat radius):	0.00318		

MERCURY INJECTION

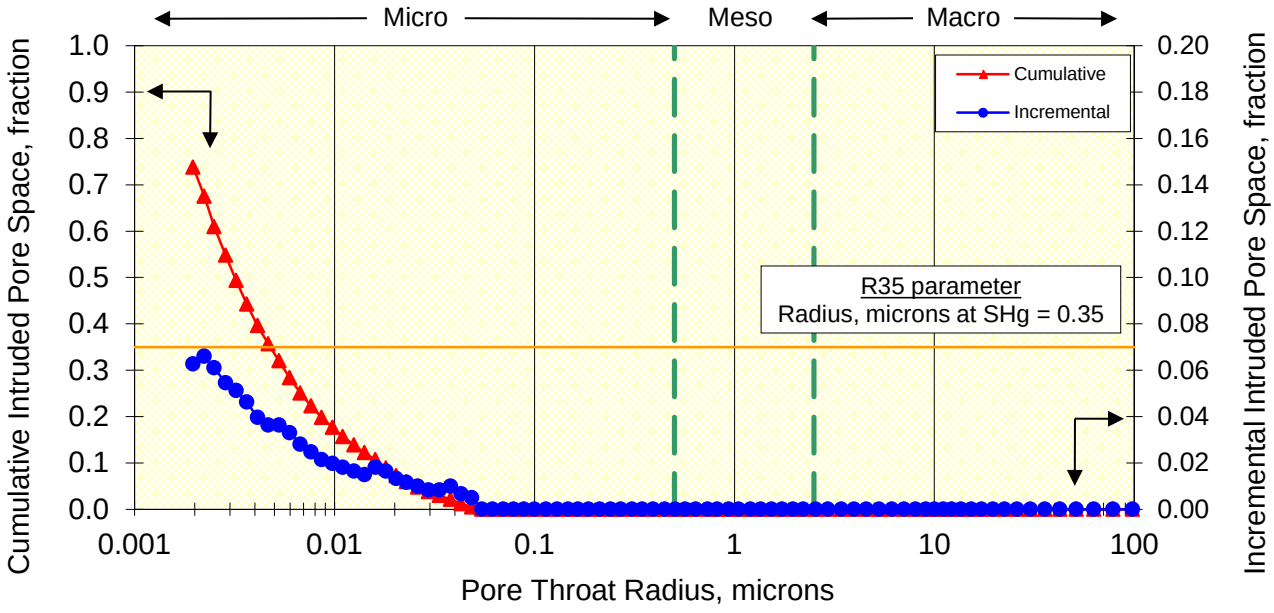


Core Laboratories

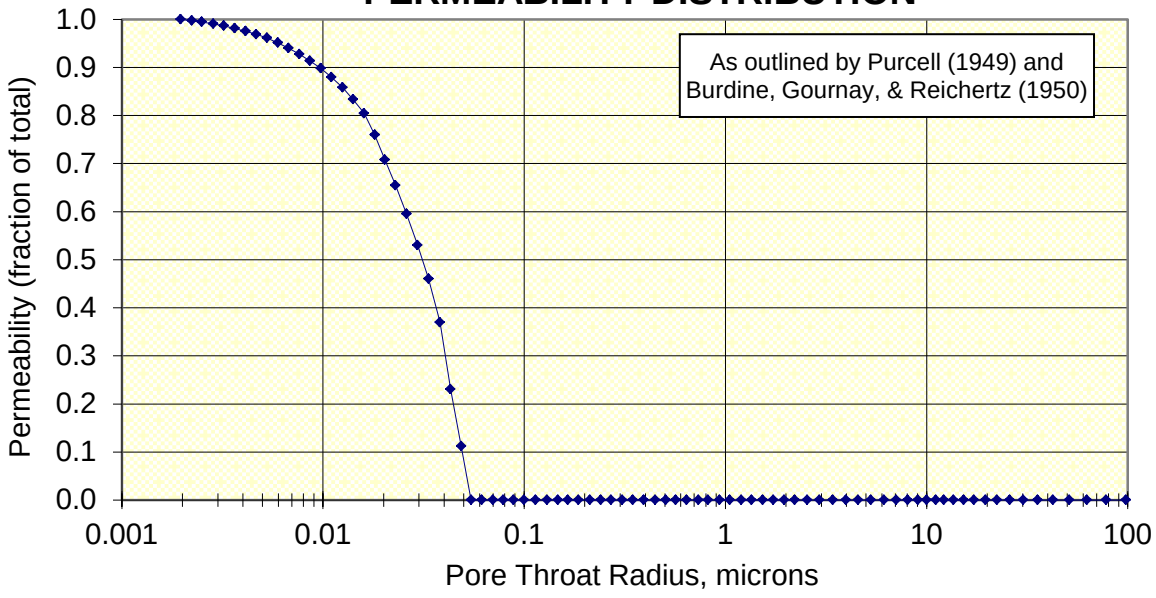
Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-3m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000014	-	-
Porosity, fraction:	0.023	-	-
maximum Sb/Pc, fraction:	0.00004		
R35, microns:	0.00477		
R50 (median pore throat radius):	0.00318		

PORE THROAT RADIUS DISTRIBUTION



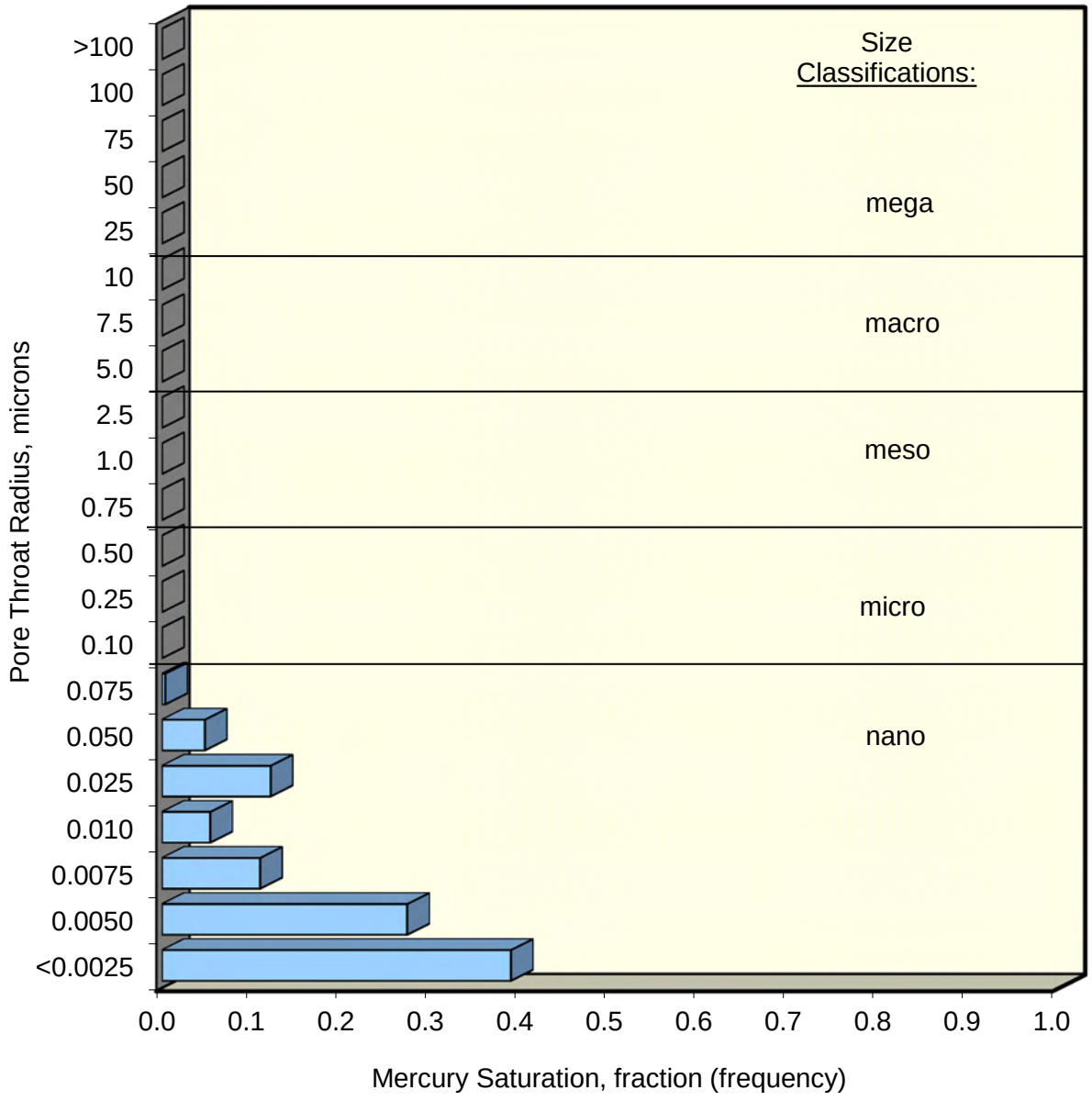
PERMEABILITY DISTRIBUTION



Company: Sandi Natrional Laboratories
File: HOU-141015

Sample: SNLCH111-15-3m	un-	Host Plug	
Depth, meters: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.000014	-	-
Porosity, fraction:	0.023	-	-
maximum Sb/Pc, fraction:	0.00004		
R35, microns:	0.00477		
R50 (median pore throat radius):	0.00318		

PORE THROAT SIZE HISTOGRAM



MERCURY INJECTION DATA SUMMARY

Company: Sandia National Laboratories
File: HOU-141015

Sample: SNL-CH111-14-Am	un-	Host Plug	
Depth: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.00439	-	-
Porosity, fraction:	0.014	-	-
maximum Sb/Pc, fraction:	0.00117		
R35, microns:	0.0265		
R50 (median pore throat radius):	0.00878		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
0.760	0.000	1.000	142	0.000244	0.147	0.0491	0.0850	0.307	0.611
1.10	0.000	1.000	97.9	0.000353	0.213	0.0711	0.123	0.445	0.884
1.38	0.000	1.000	78.1	0.000443	0.267	0.0891	0.154	0.558	1.11
1.66	0.000	1.000	64.9	0.000533	0.322	0.107	0.186	0.671	1.33
2.05	0.000	1.000	52.6	0.000658	0.397	0.132	0.229	0.828	1.65
2.50	0.000	1.000	43.1	0.000803	0.484	0.161	0.280	1.01	2.01
3.00	0.000	1.000	35.9	0.000963	0.581	0.194	0.336	1.21	2.41
3.55	0.000	1.000	30.4	0.00114	0.688	0.229	0.397	1.43	2.85
4.15	0.000	1.000	26.0	0.00133	0.804	0.268	0.464	1.68	3.34
4.80	0.000	1.000	22.4	0.00154	0.930	0.310	0.537	1.94	3.86
5.50	0.000	1.000	19.6	0.00177	1.07	0.355	0.615	2.22	4.42
6.25	0.000	1.000	17.2	0.00201	1.21	0.404	0.699	2.53	5.02
7.04	0.000	1.000	15.3	0.00226	1.36	0.455	0.788	2.85	5.66
7.90	0.000	1.000	13.6	0.00254	1.53	0.510	0.884	3.19	6.35
8.79	0.000	1.000	12.3	0.00282	1.70	0.568	0.983	3.55	7.07
9.74	0.000	1.000	11.1	0.00313	1.89	0.629	1.09	3.94	7.83
10.8	0.000	1.000	9.99	0.00346	2.09	0.696	1.21	4.36	8.68
11.9	0.000	1.000	9.06	0.00382	2.30	0.768	1.33	4.81	9.56
13.4	0.000	1.000	8.05	0.00430	2.59	0.864	1.50	5.42	10.8
15.3	0.000	1.000	7.06	0.00490	2.96	0.986	1.71	6.18	12.3
17.6	0.000	1.000	6.14	0.00564	3.40	1.13	1.96	7.11	14.1
20.4	0.000	1.000	5.28	0.00655	3.95	1.32	2.28	8.24	16.4
23.6	0.000	1.000	4.57	0.00757	4.57	1.52	2.64	9.54	19.0
27.4	0.000	1.000	3.93	0.00880	5.31	1.77	3.07	11.1	22.0
32.2	0.000	1.000	3.35	0.0103	6.24	2.08	3.60	13.0	25.9
38.2	0.000	1.000	2.82	0.0123	7.40	2.47	4.27	15.4	30.7
45.2	0.000	1.000	2.38	0.0145	8.76	2.92	5.06	18.3	36.3
52.4	0.000	1.000	2.06	0.0168	10.2	3.38	5.86	21.2	42.1
59.1	0.007	0.993	1.82	0.0190	11.5	3.82	6.61	23.9	47.5
66.4	0.018	0.982	1.62	0.0213	12.9	4.29	7.43	26.8	53.4
72.7	0.031	0.969	1.48	0.0233	14.1	4.70	8.13	29.4	58.4
81.0	0.047	0.953	1.33	0.0260	15.7	5.23	9.06	32.7	65.1
91.7	0.066	0.934	1.17	0.0294	17.8	5.92	10.3	37.1	73.7
106	0.082	0.918	1.02	0.0341	20.6	6.85	11.9	42.8	85.2
117	0.095	0.905	0.919	0.0376	22.7	7.57	13.1	47.3	94.0

MERCURY INJECTION DATA SUMMARY

Company: Sandia National Laboratories
File: HOU-141015

Sample: SNL-CH111-14-Am	un-	Host Plug	
Depth: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.00439	-	-
Porosity, fraction:	0.014	-	-
maximum Sb/Pc, fraction:	0.00117		
R35, microns:	0.0265		
R50 (median pore throat radius):	0.00878		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
131	0.103	0.897	0.820	0.0422	25.5	8.49	14.7	52.9	105
146	0.110	0.890	0.739	0.0468	28.3	9.42	16.3	59.0	117
168	0.116	0.884	0.642	0.0539	32.5	10.8	18.8	67.9	135
191	0.121	0.879	0.564	0.0614	37.0	12.3	21.4	77.2	154
212	0.127	0.873	0.508	0.0682	41.1	13.7	23.8	85.7	170
240	0.134	0.866	0.448	0.0772	46.6	15.5	26.9	97.0	193
274	0.142	0.858	0.393	0.0880	53.1	17.7	30.7	111	220
313	0.151	0.849	0.344	0.101	60.7	20.2	35.0	126	252
354	0.160	0.840	0.304	0.114	68.7	22.9	39.6	143	285
400	0.169	0.831	0.269	0.128	77.5	25.8	44.7	162	322
448	0.179	0.821	0.241	0.144	86.7	28.9	50.1	181	360
508	0.189	0.811	0.212	0.163	98.5	32.8	56.9	205	408
579	0.199	0.801	0.186	0.186	112	37.4	64.8	234	465
653	0.209	0.791	0.165	0.210	127	42.2	73.1	264	525
738	0.219	0.781	0.146	0.237	143	47.7	82.6	298	593
828	0.228	0.772	0.130	0.266	161	53.5	92.7	335	666
942	0.238	0.762	0.114	0.302	182	60.8	105	381	757
1080	0.248	0.752	0.0998	0.347	209	69.7	121	436	868
1220	0.258	0.742	0.0883	0.392	236	78.8	136	493	981
1370	0.268	0.732	0.0787	0.439	265	88.4	153	554	1100
1540	0.277	0.723	0.0700	0.494	298	99.4	172	622	1240
1750	0.285	0.715	0.0617	0.561	339	113	195	707	1410
1980	0.294	0.706	0.0545	0.635	383	128	221	800	1590
2220	0.302	0.698	0.0486	0.711	429	143	248	897	1780
2510	0.310	0.690	0.0430	0.805	486	162	281	1010	2020
2830	0.320	0.680	0.0381	0.907	548	183	316	1140	2270
3220	0.330	0.670	0.0335	1.03	624	208	360	1300	2590
3660	0.341	0.659	0.0295	1.17	709	236	409	1480	2940
4180	0.352	0.648	0.0258	1.34	810	270	468	1690	3360
4690	0.365	0.635	0.0230	1.51	910	303	525	1900	3770
5300	0.379	0.621	0.0203	1.70	1030	342	593	2140	4260
5970	0.394	0.606	0.0181	1.92	1160	385	668	2410	4800
6750	0.410	0.590	0.0160	2.17	1310	436	755	2730	5430
7640	0.427	0.573	0.0141	2.45	1480	494	855	3090	6140
8650	0.445	0.555	0.0125	2.78	1680	558	967	3500	6950

MERCURY INJECTION DATA SUMMARY

Company: Sandia National Laboratories
File: HOU-141015

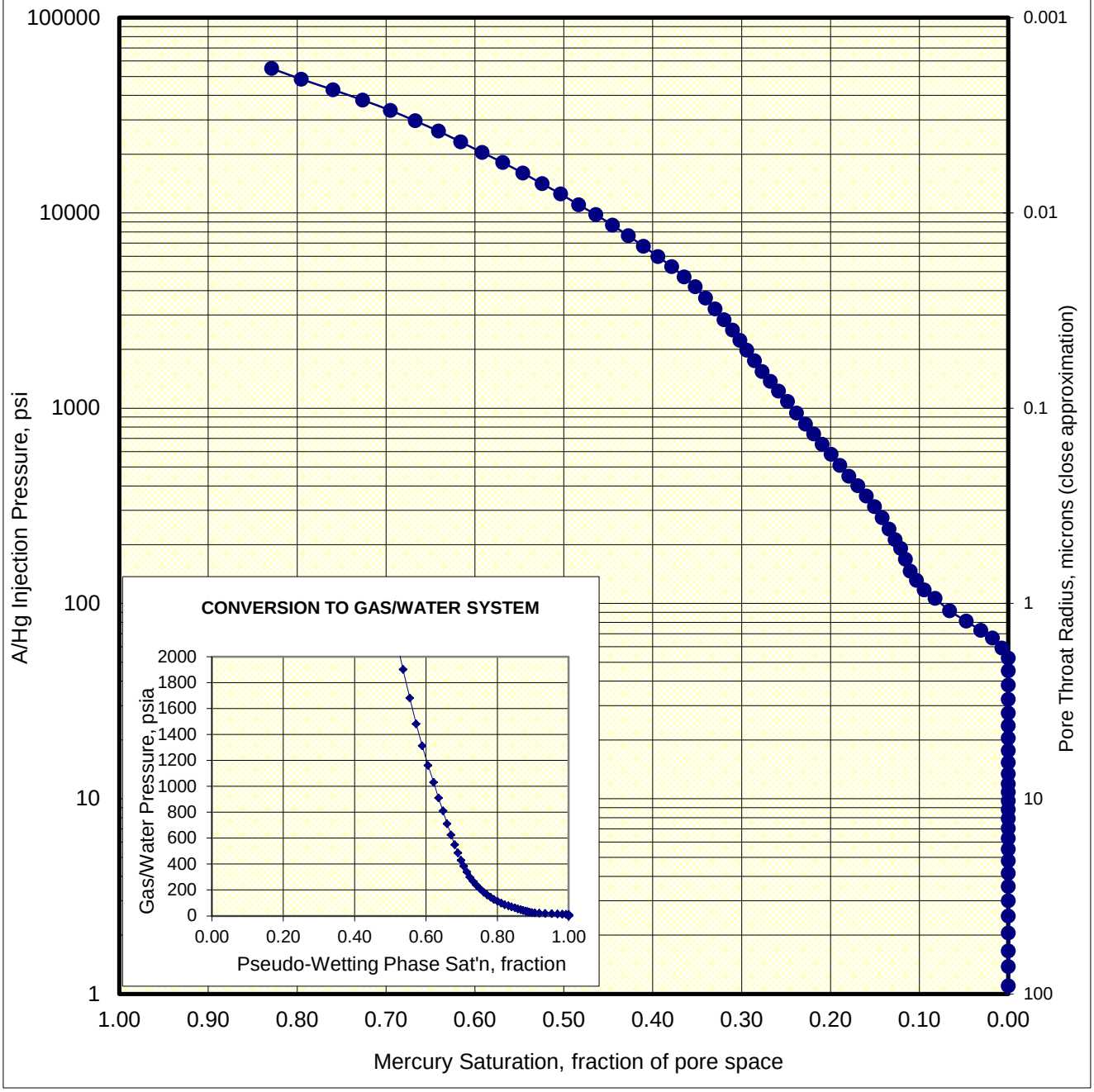
Sample: SNL-CH111-14-Am	un-	Host Plug	
Depth: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.00439	-	-
Porosity, fraction:	0.014	-	-
maximum Sb/Pc, fraction:	0.00117		
R35, microns:	0.0265		
R50 (median pore throat radius):	0.00878		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
9790	0.464	0.536	0.0110	3.14	1900	632	1090	3960	7870
11000	0.483	0.517	0.00976	3.54	2140	713	1230	4450	8840
12500	0.503	0.497	0.00862	4.01	2420	807	1400	5050	10000
14100	0.524	0.476	0.00763	4.54	2740	913	1580	5700	11300
16000	0.546	0.454	0.00674	5.13	3100	1030	1790	6470	12900
18100	0.569	0.431	0.00596	5.80	3500	1170	2020	7310	14500
20400	0.592	0.408	0.00527	6.56	3960	1320	2290	8240	16400
23100	0.616	0.384	0.00466	7.42	4480	1490	2590	9340	18600
26200	0.641	0.359	0.00412	8.40	5070	1690	2930	10600	21100
29600	0.667	0.333	0.00364	9.49	5730	1910	3310	12000	23800
33500	0.695	0.305	0.00322	10.8	6490	2160	3750	13500	26900
37800	0.726	0.274	0.00285	12.1	7330	2440	4230	15300	30400
42700	0.760	0.240	0.00252	13.7	8270	2760	4780	17300	34300
48400	0.795	0.205	0.00223	15.5	9380	3130	5420	19600	38900
54900	0.829	0.171	0.00196	17.6	10600	3550	6150	22200	44100

Company: Sandia National Laboratories
File: HOU-141015

Sample: SNL-CH111-14-Am	un-	Host Plug	
Depth: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.00439	-	-
Porosity, fraction:	0.014	-	-
maximum Sb/Pc, fraction:	0.00117		
R35, microns:	0.0265		
R50 (median pore throat radius):	0.00878		

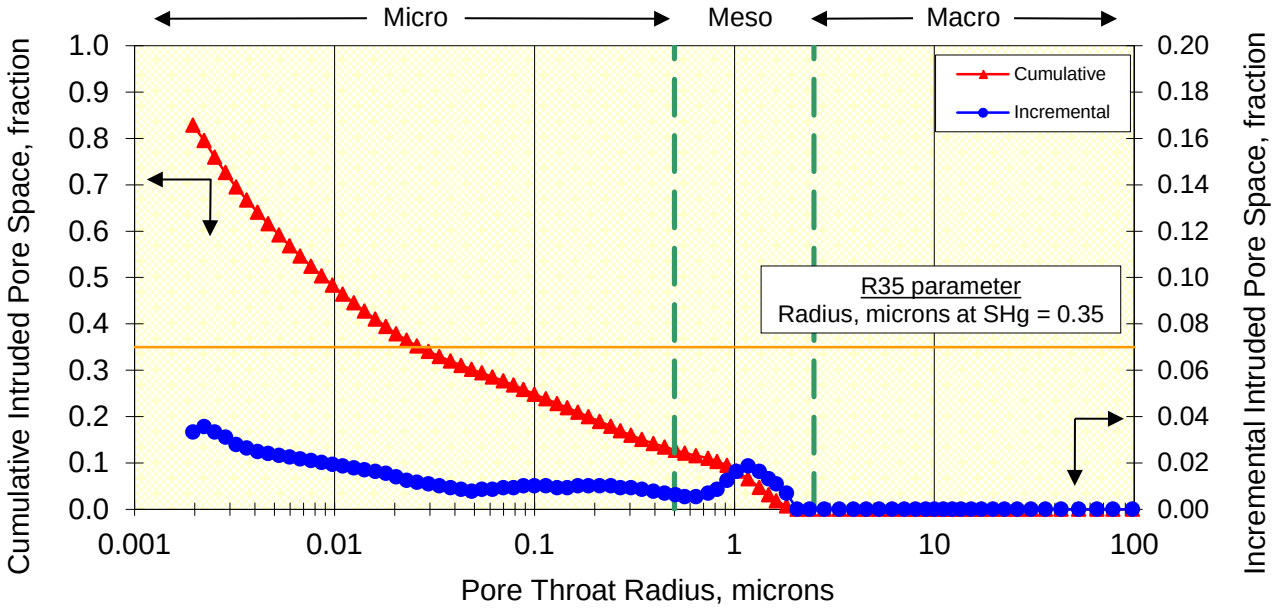
MERCURY INJECTION



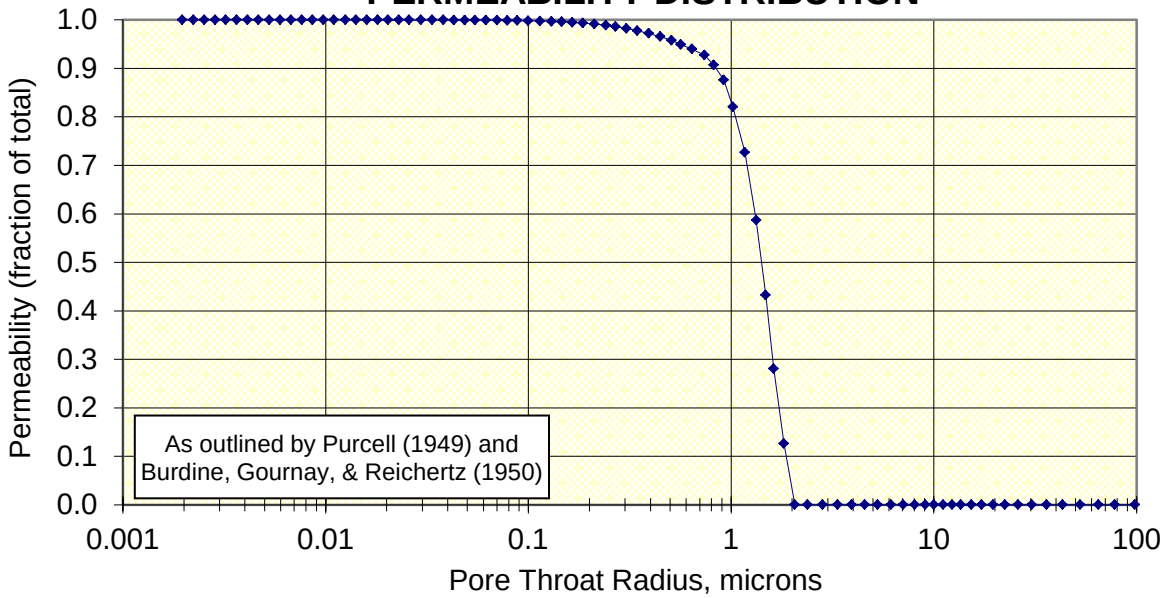
Company: Sandia National Laboratories
File: HOU-141015

Sample: SNL-CH111-14-Am	un-	Host Plug	
Depth: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.00439	-	-
Porosity, fraction:	0.014	-	-
maximum Sb/Pc, fraction:	0.00117		
R35, microns:	0.0265		
R50 (median pore throat radius):	0.00878		

PORE THROAT RADIUS DISTRIBUTION



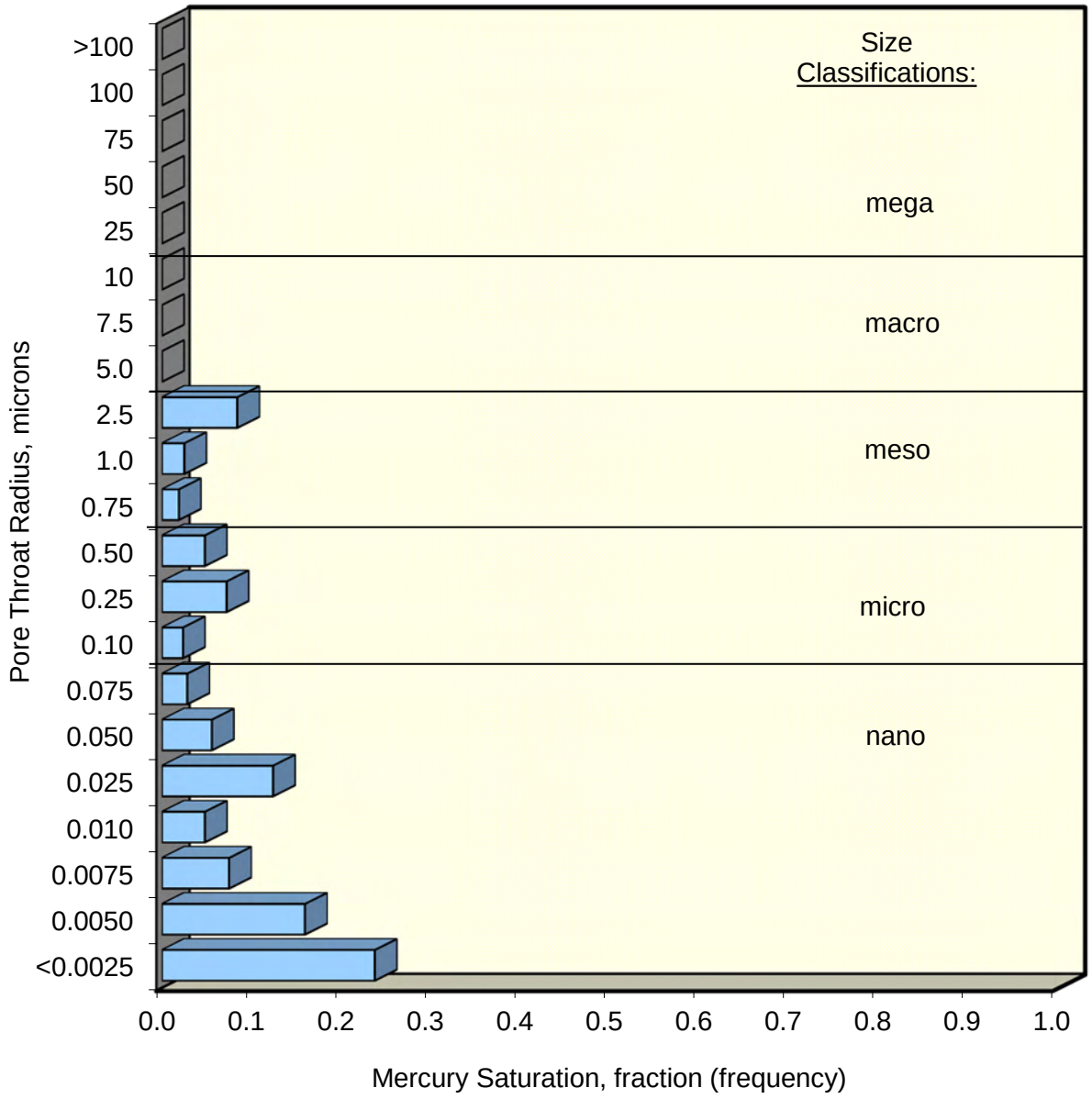
PERMEABILITY DISTRIBUTION



Company: Sandia National Laboratories
File: HOU-141015

Sample: SNL-CH111-14-Am	un-	Host Plug	
Depth: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.00439	-	-
Porosity, fraction:	0.014	-	-
maximum Sb/Pc, fraction:	0.00117		
R35, microns:	0.0265		
R50 (median pore throat radius):	0.00878		

PORE THROAT SIZE HISTOGRAM



MERCURY INJECTION DATA SUMMARY

Company: Sandia National Laboratories
File: HOU-141015

Sample: SNL-CH111-14-Bm
Depth: N/A

	un-stressed	Host Plug	
		n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.0170	-	-
Porosity, fraction:	0.020	-	-
maximum Sb/Pc, fraction:	0.00259		
R35, microns:	0.0248		
R50 (median pore throat radius):	0.00994		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
0.760	0.000	1.000	142	0.000413	0.147	0.0491	0.0850	0.307	0.611
1.10	0.000	1.000	97.9	0.000598	0.213	0.0711	0.123	0.445	0.884
1.38	0.000	1.000	78.1	0.000750	0.267	0.0891	0.154	0.558	1.11
1.66	0.000	1.000	64.9	0.000903	0.322	0.107	0.186	0.671	1.33
2.05	0.000	1.000	52.6	0.00111	0.397	0.132	0.229	0.828	1.65
2.50	0.000	1.000	43.1	0.00136	0.484	0.161	0.280	1.01	2.01
3.00	0.000	1.000	35.9	0.00163	0.581	0.194	0.336	1.21	2.41
3.55	0.000	1.000	30.4	0.00193	0.688	0.229	0.397	1.43	2.85
4.15	0.000	1.000	26.0	0.00226	0.804	0.268	0.464	1.68	3.34
4.80	0.000	1.000	22.4	0.00261	0.930	0.310	0.537	1.94	3.86
5.50	0.000	1.000	19.6	0.00299	1.07	0.355	0.615	2.22	4.42
6.25	0.000	1.000	17.2	0.00340	1.21	0.404	0.699	2.53	5.02
7.04	0.000	1.000	15.3	0.00383	1.36	0.455	0.788	2.85	5.66
7.90	0.000	1.000	13.6	0.00430	1.53	0.510	0.884	3.19	6.35
8.79	0.000	1.000	12.3	0.00478	1.70	0.568	0.983	3.55	7.07
9.74	0.000	1.000	11.1	0.00530	1.89	0.629	1.09	3.94	7.83
10.8	0.000	1.000	9.99	0.00586	2.09	0.696	1.21	4.36	8.68
11.9	0.000	1.000	9.06	0.00646	2.30	0.768	1.33	4.81	9.56
13.4	0.000	1.000	8.05	0.00727	2.59	0.864	1.50	5.42	10.8
15.3	0.000	1.000	7.06	0.00830	2.96	0.986	1.71	6.18	12.3
17.6	0.000	1.000	6.14	0.00955	3.40	1.13	1.96	7.11	14.1
20.4	0.000	1.000	5.28	0.0111	3.95	1.32	2.28	8.24	16.4
23.6	0.000	1.000	4.57	0.0128	4.57	1.52	2.64	9.54	19.0
28.4	0.000	1.000	3.79	0.0154	5.50	1.83	3.18	11.5	22.8
34.2	0.000	1.000	3.15	0.0186	6.63	2.21	3.83	13.8	27.5
40.5	0.010	0.990	2.66	0.0220	7.85	2.62	4.53	16.4	32.6
47.8	0.020	0.980	2.25	0.0260	9.26	3.09	5.35	19.3	38.4
54.9	0.031	0.969	1.96	0.0298	10.6	3.55	6.14	22.2	44.1
62.2	0.042	0.958	1.73	0.0338	12.1	4.02	6.96	25.1	50.0
68.7	0.055	0.945	1.57	0.0374	13.3	4.44	7.69	27.8	55.2
75.5	0.076	0.924	1.43	0.0411	14.6	4.88	8.45	30.5	60.7
83.8	0.101	0.899	1.29	0.0456	16.2	5.41	9.38	33.9	67.4
93.8	0.124	0.876	1.15	0.0510	18.2	6.06	10.5	37.9	75.4
106	0.137	0.863	1.02	0.0576	20.5	6.84	11.8	42.8	85.2
117	0.148	0.852	0.921	0.0636	22.7	7.56	13.1	47.3	94.0

MERCURY INJECTION DATA SUMMARY

Company: Sandia National Laboratories
File: HOU-141015

Sample: SNL-CH111-14-Bm	un-	Host Plug	
Depth: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.0170	-	-
Porosity, fraction:	0.020	-	-
maximum Sb/Pc, fraction:	0.00259		
R35, microns:	0.0248		
R50 (median pore throat radius):	0.00994		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
131	0.157	0.843	0.821	0.0714	25.4	8.48	14.7	52.9	105
146	0.164	0.836	0.740	0.0792	28.2	9.41	16.3	59.0	117
168	0.171	0.829	0.642	0.0912	32.5	10.8	18.8	67.9	135
191	0.178	0.822	0.564	0.104	37.0	12.3	21.4	77.2	154
212	0.185	0.815	0.508	0.115	41.1	13.7	23.7	85.7	170
240	0.192	0.808	0.449	0.131	46.5	15.5	26.9	97.0	193
274	0.198	0.802	0.393	0.149	53.1	17.7	30.6	111	220
313	0.203	0.797	0.344	0.170	60.7	20.2	35.0	126	252
354	0.207	0.793	0.304	0.193	68.6	22.9	39.6	143	285
400	0.212	0.788	0.270	0.217	77.5	25.8	44.7	162	322
447	0.216	0.784	0.241	0.243	86.7	28.9	50.1	181	359
508	0.221	0.779	0.212	0.276	98.5	32.8	56.9	205	408
579	0.227	0.773	0.186	0.315	112	37.4	64.8	234	465
653	0.233	0.767	0.165	0.355	127	42.2	73.1	264	525
738	0.241	0.759	0.146	0.401	143	47.7	82.6	298	593
828	0.248	0.752	0.130	0.450	160	53.5	92.7	335	666
941	0.255	0.745	0.114	0.512	182	60.8	105	380	756
1080	0.260	0.740	0.0998	0.587	209	69.7	121	436	868
1220	0.264	0.736	0.0883	0.663	236	78.8	136	493	981
1370	0.267	0.733	0.0787	0.744	265	88.4	153	554	1100
1540	0.271	0.729	0.0700	0.837	298	99.4	172	622	1240
1750	0.276	0.724	0.0617	0.950	339	113	195	707	1410
1980	0.282	0.718	0.0545	1.07	383	128	221	800	1590
2220	0.289	0.711	0.0486	1.20	429	143	248	897	1780
2510	0.296	0.704	0.0430	1.36	486	162	281	1010	2020
2830	0.305	0.695	0.0381	1.54	548	183	316	1140	2270
3220	0.316	0.684	0.0335	1.75	624	208	360	1300	2590
3660	0.329	0.671	0.0295	1.99	709	236	409	1480	2940
4180	0.344	0.656	0.0258	2.27	810	270	468	1690	3360
4690	0.360	0.640	0.0230	2.55	910	303	525	1900	3770
5300	0.378	0.622	0.0203	2.88	1030	342	593	2140	4260
5970	0.398	0.602	0.0181	3.24	1160	385	668	2410	4800
6740	0.418	0.582	0.0160	3.67	1310	436	755	2720	5420
7640	0.438	0.562	0.0141	4.16	1480	494	855	3090	6140
8650	0.459	0.541	0.0125	4.70	1680	558	967	3500	6950

MERCURY INJECTION DATA SUMMARY

Company: Sandia National Laboratories
File: HOU-141015

Sample: SNL-CH111-14-Bm	un-	Host Plug	
Depth: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.0170	-	-
Porosity, fraction:	0.020	-	-
maximum Sb/Pc, fraction:	0.00259		
R35, microns:	0.0248		
R50 (median pore throat radius):	0.00994		

Injection Pressure, psia	Mercury Saturation, fraction	Pseudo-Wetting Saturation, fraction	Pore Throat Radius, microns	J Values	Conversion to other Laboratory Fluid Systems, psia			Estimated Height Above Free Water, feet	
					G-W	G-O	O-W	G-W	O-W
9790	0.481	0.519	0.0110	5.32	1900	632	1090	3960	7870
11000	0.504	0.496	0.00976	6.00	2140	713	1230	4450	8840
12500	0.527	0.473	0.00862	6.79	2420	807	1400	5050	10000
14100	0.550	0.450	0.00763	7.68	2740	913	1580	5700	11300
16000	0.575	0.425	0.00674	8.69	3100	1030	1790	6470	12900
18100	0.600	0.400	0.00596	9.83	3500	1170	2020	7310	14500
20400	0.625	0.375	0.00527	11.1	3960	1320	2290	8240	16400
23100	0.652	0.348	0.00466	12.6	4480	1490	2590	9340	18600
26200	0.679	0.321	0.00412	14.2	5070	1690	2930	10600	21100
29600	0.706	0.294	0.00364	16.1	5730	1910	3310	12000	23800
33500	0.734	0.266	0.00322	18.2	6490	2160	3750	13500	26900
37800	0.763	0.237	0.00285	20.6	7330	2440	4230	15300	30400
42500	0.793	0.207	0.00253	23.1	8240	2750	4760	17200	34200
48400	0.821	0.179	0.00223	26.3	9380	3130	5420	19600	38900
54900	0.847	0.153	0.00196	29.9	10600	3550	6150	22200	44100

Company: Sandia National Laboratories
File: HOU-141015

Sample: SNL-CH111-14-Bm	un-	Host Plug	
Depth: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.0170	-	-
Porosity, fraction:	0.020	-	-
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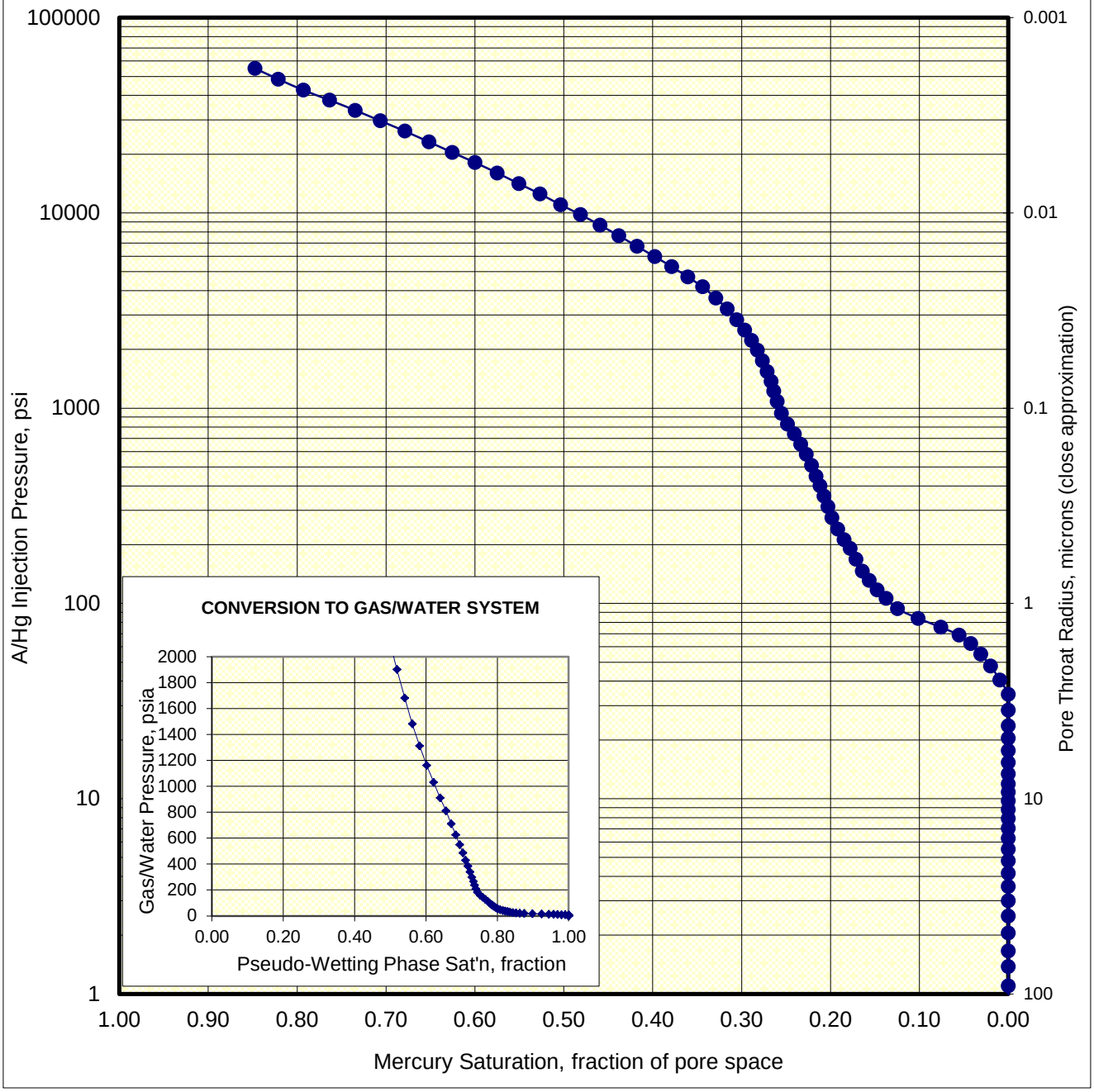
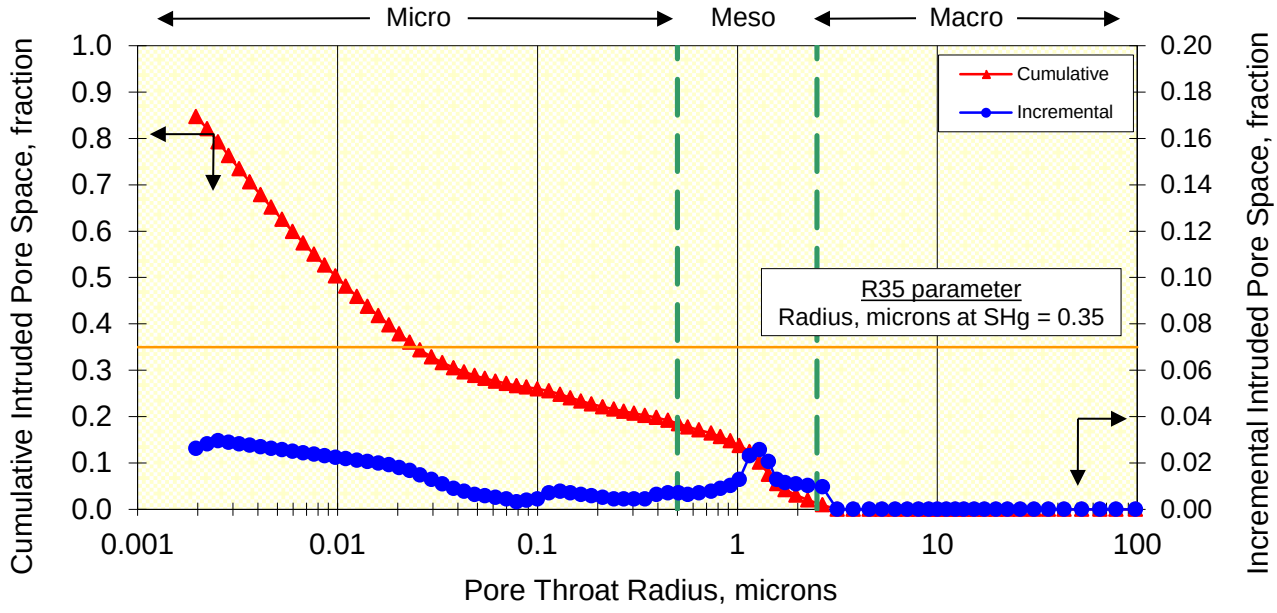
MERCURY INJECTION



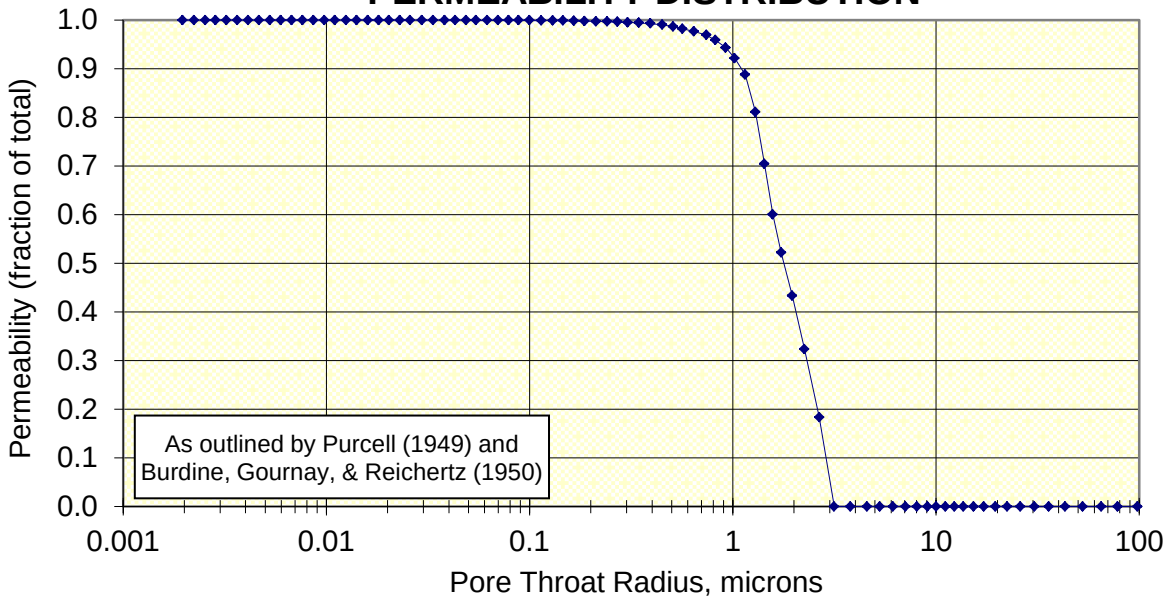
Company: Sandia National Laboratories
File: HOU-141015

Sample: SNL-CH111-14-Bm	un-	Host Plug	
Depth: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.0170	-	-
Porosity, fraction:	0.020	-	-
maximum Sb/Pc, fraction:	0.00259		
R35, microns:	0.0248		
R50 (median pore throat radius):	0.00994		

PORE THROAT RADIUS DISTRIBUTION



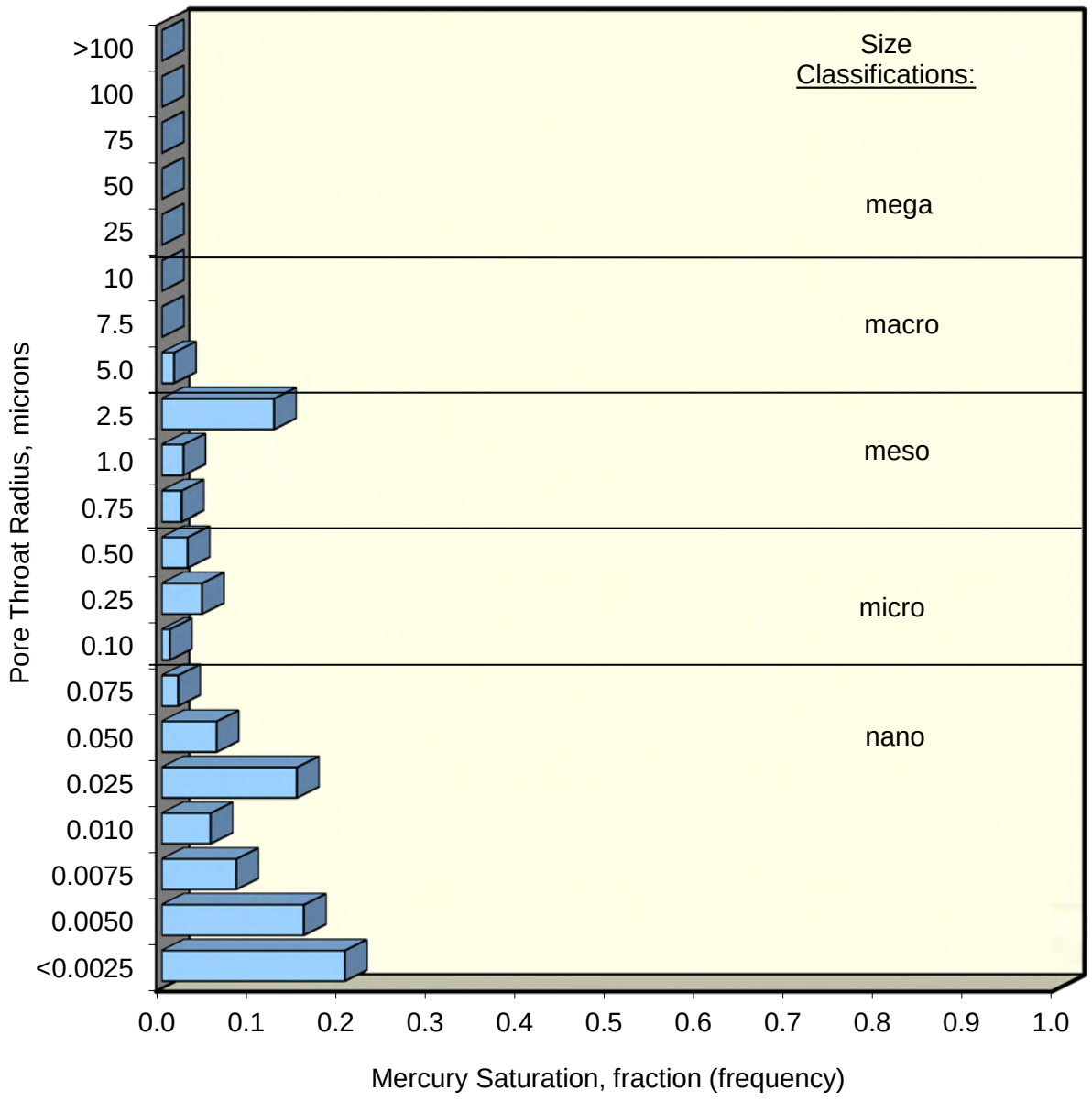
PERMEABILITY DISTRIBUTION



Company: Sandia National Laboratories
File: HOU-141015

Sample: SNL-CH111-14-Bm	un-	Host Plug	
Depth: N/A	stressed	n/a	n/a
Klinkenberg Permeability, md:	N/A	-	-
Permeability to Air, md:	N/A	-	-
Swanson Permeability, md:	0.0170	-	-
Porosity, fraction:	0.020	-	-
maximum Sb/Pc, fraction:	0.00259		
R35, microns:	0.0248		
R50 (median pore throat radius):	0.00994		

PORE THROAT SIZE HISTOGRAM



Core Lab
RESERVOIR OPTIMIZATION

Flow Studies

Threshold Entry Pressure

LABORATORY PROCEDURES

Threshold Entry Pressure

1. The sample was weighed, and then placed under vacuum for 24 hours.
2. After evacuation the sample was pressure saturated in Isopar-L oil for a further 24 hrs and then weighed again
3. The sample was loaded into a hydrostatic coreholder, and 800 psi net confining stress was applied. An oil-filled pipette was attached to the production face of the core holder assembly and oil was injected at a constant differential pressure.
4. Flow rate was determined using the movement of oil in the pipette and specific permeability to oil (Isopar-L) was calculated.
5. The fluid injection manifold was removed and replaced by a threshold entry pressure manifold. The plug was injected with gas (N_2) at constant pressure starting at 0.50 psi and was monitored for signs of gas breakthrough. Breakthrough occurred as pressure was being increased between the 30 and 60 psi points.
6. Sample was unloaded and weighed.

Specific Permeability to Brine

1. ERDA-6 brine was prepared in the laboratory using the formula provided by Sandia National Laboratories, using reagent grade chemicals and deionized water.
2. Synthetic formation brine was filtered to 0.45 microns and degassed. Fluid parameters including viscosity and density were measured at ambient temperature.
3. The dry sample was loaded into a hydrostatic coreholder and 800 psi net confining stress was applied.
4. The sample was flushed with brine to ensure saturation.
5. Brine was injected through each sample at a constant (minimal) pressure. Produced volumes versus time were monitored, and apparent permeability to brine was determined once a stable flow rate was established.
6. Permeability to liquid data were calculated from the experimental data and measured sample and fluid parameters using Darcy's Law.

SUMMARY OF THRESHOLD ENTRY PRESSURE RESULTS

Net Confining Stress: 800 psi Temperature: 68°F
Saturating Fluid: Isopar-L Oil
Displacing Fluid: Gas (air)
Sample Type: Cylindrical Plug Sample
Rock Type: Salt

Company: Sandia National Laboratories
Well: N/A
Location: N/A File: HOU-141015

Sample 14-B	
Injection Pressure, psi	
gas/oil	Conversion to *gas/water
0.50	1.5
1.0	3.0
2.0	6.0
4.0	12.
6.0	18.
8.0	24.
15.0	45.
30.0	**90.**
60.0	**180.**

Bold, gray highlighted area indicates the region of gas breakthrough. Breakthrough occurred following equilibrium at 30 psi but during the pressure buildup to 60 psi (gas/oil system).

SUMMARY OF THRESHOLD ENTRY PRESSURE RESULTS

Net Confining Stress: 800 psi Temperature: 68°F
Saturating Fluid: Isopar-L Oil
Displacing Fluid: Gas (air)
Sample Type: Cylindrical Plug Sample
Rock Type: Salt

Company: Sandia National Laboratories
Well: N/A
Location: N/A

File: HOU-141015

Sample Number	Depth, feet	Length, cm	Diameter, cm	Injection Pressure, psi	
				gas/oil	Conversion to *gas/water
14-B	N/A	4.80	3.82	>30 <60	>90 <180

Fluid System Conversion Values:

$$Pc_{(desired)} = Pc_{(known)} \times \left(\sigma \cos\theta_{(desired)} \div \sigma \cos\theta_{(known)}\right)$$

FLUID SYSTEM	LABORATORY		
	Theta	IFT	IFT*cosTheta
Gas/Water:	0	72	72.0
Gas/Oil:	0	24	24.0

SUMMARY OF LIQUID PERMEABILITY MEASUREMENTS

Temperature: 68°F
Fluid: Formation Brine /Isopar-L Oil

Company: Sandia National Laboratories
Well: N/A
Location: N/A HOU-141015

Salt Sample Number	Depth, meters	Net Confining Stress, psi	Length, cm	Area, cm^2	Permeability, millidarcies		Specific Permeability to Brine, millidarcies	Specific Permeability to Isopar-L, millidarcies
					Klinkenberg	Kair		
14-A	N/A	800	4.81	11.44	15.5	17.2	81.9	-
14-B	N/A	800	4.80	11.47	0.423	0.474	-	0.0190

Sample 14-A appeared competent following saturation with brine but during brine injection for the specific permeability to brine the sample began to dissolve. Pressure decreased with throughput so permeability was measured with minimal brine injection. Calculated Kw is much higher than the dry, absolute permeability value, meaning that dissolution did occur and the Kw value represents an altered sample structure.