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Special Core Analysis for the SeiFaBa Project

Ultrasonic velocity measurements on 12 plug samples from the Lopra-1, Vestmanna-1 and Glyvursnes-1 wells, Faroe Islands

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The SeiFaBa Project is funded by the Sindri Group

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G E U S

Contents

1. Introduction

By request of Dr. Peter Japsen (GEUS) on behalf of the SeiFaBa Project, GEUS Core Laboratory has carried out ultrasonic velocity determinations on 1.5" plug samples from three wells on the Faroe Islands. 1 plug sample from the Vestmanna-1 well, 6 plug samples form the Glyvursnes-1 well and 5 plug samples from the Lopra-1 well were analysed, i.e. a total of 12 samples.

The analytical programme was specified by Dr. Peter Japsen and included the following services:

- Conventional core analysis: gas permeability, He-porosity, and grain density determination.
- P and S wave velocities measured at four different hydrostatic pressure conditions covering the expected range of reservoir pressure conditions. All 12 samples were measured in a water-saturated state and 4 of the samples were also measured in a gas-saturated state. Table 1.1 gives an outline of the saturation conditions and pressure conditions for all the ultrasonic measurements.

The analytical programme is identical to the analytical programme used for most of the samples in a previous study for the SeiFaBa Project (Olsen, 2005).

The measurements were conducted in the period from October 7th 2005 to November 24th 2005.

Preliminary results were forwarded by e-mail to Dr. Peter Japsen and Dr. Regin Waagstein on December 21st 2005.

The SeiFaBa Project is funded by the Sindri Group.

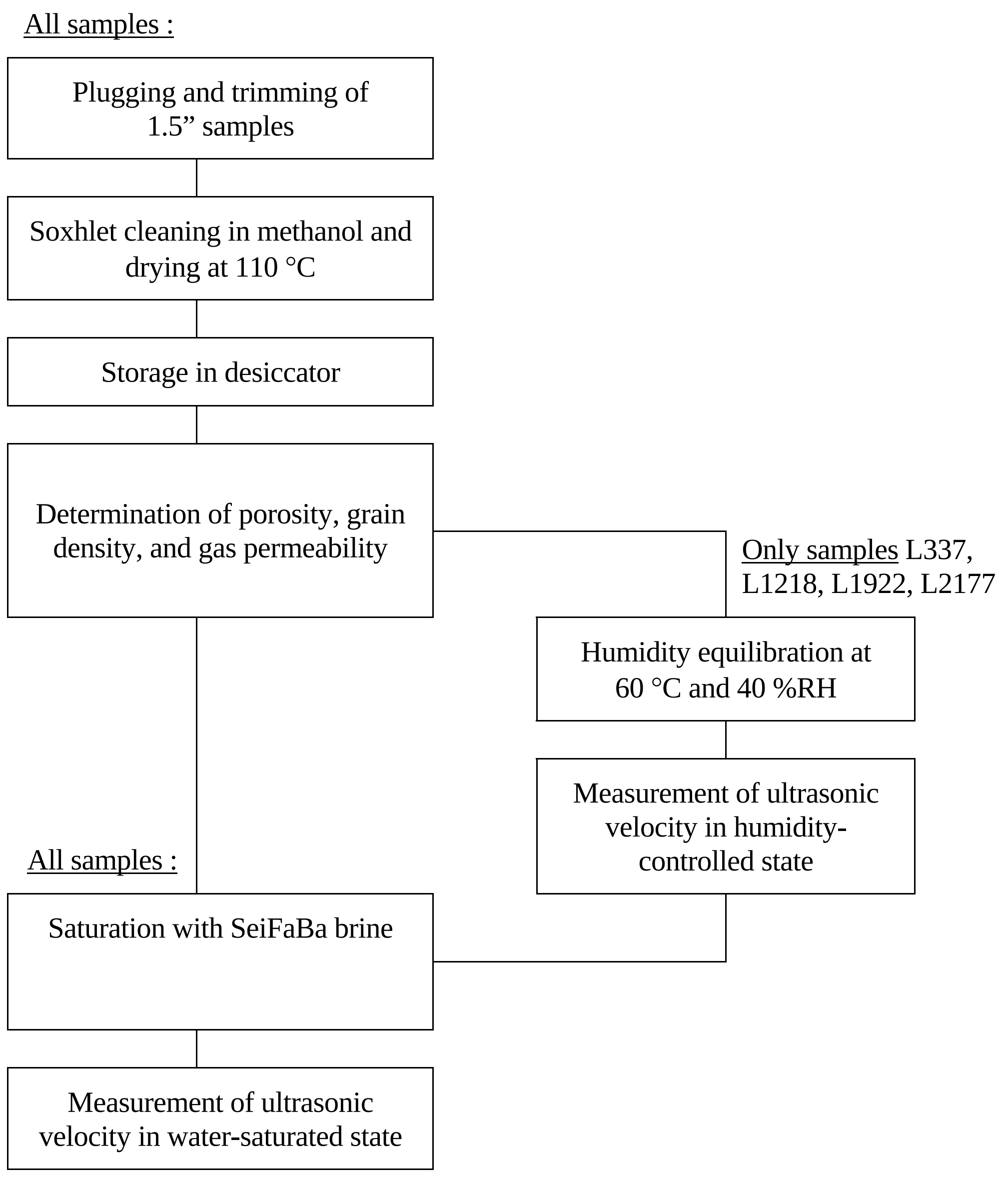
Table 1.1 Overview of saturation and hydrostatic pressure conditions for the ultrasonic measurements.

Well and sample id.	Measurements in water-saturated condition				Measurements in gas-saturated condition			
	100 (bar)	200 (bar)	300 (bar)	Repeat 300 (bar)	100 (bar)	200 (bar)	300 (bar)	Repeat 300 (bar)
Lopra-1 Samples L337, L1218, L1922, L2177	•	•	•	•	•	•	•	•
Lopra-1 Sample L862 Vestmanna-1 V16 Glyvursnes-1 G8, G21, G45, G57, G60, G61	•	•	•	•				

Sample G21 was subject an extended analytical programme because of the condition of the sample.

2. Sampling and analytical procedure

2.1 Schematic outline of the analytical procedure



2.2 Sample material

Dr. Regin Waagstein of GEUS selected the sample material for this study. The samples come from the wells Lopra-1, Vestmanna-1 and Glyvursnes-1. Lopra-1 is situated onshore the island of Suduroy, while Vestmanna-1and Glyvursnes-1 are situated onshore the island of Streymoy. Lopra-1 was drilled in 1981 and the well was deepened in 1996. Vestmanna-1 was drilled in 1980, and Glyvursnes-1 in 2002. Refer to Waagstein &

Table 2.1. Basic sample data and conventional core analysis results.

Sample id.	ComLab id. 1)	Depth (m)	Lithology	Gas perm (mD)	Porosity (%)	Gr. dns. (g/cm^3)	Length (mm)	Diam-eter (mm)
Lopra-1 samples:								
L337	L1-0337.5	337.81	Massive basalt lava	0.006	1.46	2.973	41.68	37.76
L862	L1-0861.7	862.11	Massive basalt lava	0.005	0.90	3.001	41.11	37.63
L1218	L1-1218.5	1218.19	Massive basalt lava	0.005	1.94	3.012	40.44	37.69
L1922	L1-1922.9	1922.81	Massive basalt lava	0.005	2.66	3.027	40.64	37.64
L2177	L1-2177.3	2177.58	Massive basalt lava	0.007	1.88	3.026	40.20	37.70
Vestmanna-1 samples:								
V16	VM1-555.25	555.16	Massive basalt lava	2.82	13.53	3.042	37.16	37.70
Glyvursnes-1 samples:								
G8	GL1-041	41.35	Tuff	17.4	34.37	2.824	36.33 2)	37.74
G21	GL1-225	225.83	Vuggy basalt lava	0.072	13.48	3.028	40.94	37.71
G45	GL1-435	435.78	Slightly vuggy basalt lava	0.032	12.59	3.023	39.01	37.84
G57	GL1-508	508.85	Slightly vuggy basalt lava	0.064	16.08	2.967	38.03	37.73
G60	GL1-545	545.69	Massive basalt lava	0.171	11.82	3.085	39.87	37.71
G61	GL1-546	546.43	Massive basalt lava	0.076	10.21	2.964	40.86	37.69

1) Corresponding rock chemistry sample.
2) Sample G8 was trimmed to a shorter length before the ultrasonic measurements.

Andersen (2003) for information about Vestmanna-1 and Glyvursnes-1, and to Berthelsen et al (1984) for information about Lopra-1 and Vestmanna-1.

Table 2.1 gives a list of the 12 samples of the study together with a lithological classification. Sample G21 was a vesicular lava that required special treatment before the ultrasonic measurements could be performed. More details of the samples are presented in the description of the measurements.

2.3 Initial sample preparation and conventional core analysis

The samples from Vestmanna-1 and Glyvursnes-1 were existing 1.5” plug samples for which the preparation started with a trimming of the sample ends. The Lopra-1 samples were new samples cut from core sections forwarded by Faroese Geological Survey. All plugs were trimmed to a length of approximately 40 mm. Most of the samples were consolidated and presented no problems with disintegration. However, sample G8, being a poorly consolidated sediment, at a later stage had to be trimmed again to a shorter length to be able to conduct the ultrasonic measurements. The samples were cleaned in a Soxhlet extractor by refluxing with methanol to remove any salt from the pores and then dried at 110 ^oC. The samples were stored in a desiccator until conventional core analysis.

All samples underwent conventional core analysis with measurement of gas permeability, He-porosity, and grain density. Results are given in Tables 2.1. Refer to Chapter 4 for a description of the conventional core analysis methods.

Table 2.2. Water saturation of samples in humidity-controlled state.
The calculation assumes a water density of 0.997 g/ml.

Sample id.	Bulk volume (ml)	Pore volume (ml)	Helium porosity (%)	Weight after drying @ 110 °C (g)	Weight after drying @ 60 °C, 40 %RH (g)	Water contents in humidity-controlled state (ml)	Water contents in humidity-controlled state (%PV)
Lopra-1 samples							
L337	46.96	0.69	1.46	137.56	138.04	0.48	70
L1218	45.57	0.88	1.94	134.59	135.03	0.44	50
L1922	45.74	1.22	2.66	134.76	135.60	0.84	69
L2177	45.31	0.85	1.88	134.55	135.07	0.52	61

2.4 Ultrasonic measurements on samples in humidity-controlled state

Four of the samples with id's L337, L1218, L1922, and L2177 were selected for ultrasonic measurements in humidity–controlled state. The samples were placed in a humidity-controlled oven at 60 °C and 40 % relative humidity until weight measurements showed that an equilibrium state was established. Table 2.2 presents the equilibrium weights and the water contents calculated from these weights.

The calculated water saturation values fall in a fairly narrow interval from 50 to 70 % of PV. On average, the 4 samples gained 0.57 g of weight, equivalent to 0.6 ml of salt-free water, from the initial drying at 110 °C to the end of the humidity drying. It is suggested that the water at least to some extent occurs absorbed to the minerals of the samples. Please note that the pore volumes of the samples are small, and therefore the uncertainty of the measurements creates a relatively large uncertainty on the results in the columns "*Water contents in humidity-controlled state (%PV)*". However, weighing a dry sample is a very accurate measurement, and the calculated water volumes of the samples in the column *"Water contents in humidity-controlled state (ml)"* cannot result from measuring errors.

When the samples had reached equilibrium with the atmosphere in the humidity-controlled oven the ultrasonic velocities were measured with the procedure presented in Table 2.5. The same procedure was later used for measurements of the sample in water-saturated state, cf. Section 2.5. The samples were mounted in a modified AutoLab 500 Ultrasonic system (New England Research) and the ultrasonic transit times were measured with a Tektronix Model TDS3012 digital oscilloscope connected to a PAR spike-generator. The details of the ultrasonic measurements are described in Chapter 3. Results are presented in Chapter 5.

2.5 Ultrasonic measurements on water-saturated samples

After conventional core analysis, in case of samples L862, V16, G8, G21, G45, G57, G60, and G61, or ultrasonic measurements, in case of samples L337, L1218, L1922, and L2177, the samples proceeded to ultrasonic measurements in water-saturated state, cf. the flowchart in Section 2.1.

They were saturated with simulated formation water by a vacuum/pressure saturation procedure, which included vacuum saturation for one day followed by pressure saturation at 100 bar for at least 2 days. Table 2.3 presents the composition of the simulated formation water. The samples were weighed in the dry state before the saturation and after the saturation they were weighed both directly on a balance and submerged in simulated formation water as part of an Archimedes test. The resulting water contents are presented in Table 2.4. All samples with a pore volume above 1 ml has a water content equivalent to a water saturation between 97 and 104 %, indicating that the pore volume is completely filled with water, i.e. S_w=100 %.

Table 2.3. Composition of SeiFaBa simulated formation water.

Element	Concentration (mg/l)
Na^+	23,000
K^+	10,000
Ca^{2+}	2,554
Cl^-	49,054
TDS	84,608

As a saturation check the column "*Water excess/deficit relative to S_w=100% (ml)*" is useful as it gives the deviation from the S_w=100% condition as a volume. It is seen that for all samples the deviation lies in the range from -0.2 to +0.3 ml, which is an acceptable deviation.

For three samples with pore volumes below 1 ml, i.e. samples L337, L862, and L1218, a water saturation between 110 and 156 % is calculated. These aberrant saturation values are probably partly caused by the low pore volume of these samples. However, it is possible that minerals within the samples absorbed part of the excess water, compare with Section 2.4.

It is concluded that all samples were fully saturated with water at the time of ultrasonic measurement in water-saturated state.

Two different time schedules were used for the ultrasonic measurements of water-saturated samples. All samples were measured with the schedule of Table 2.5, which is termed the *standard schedule*.

Sample G21 is lava with many vesicles up to 5 mm in size with sharp edges. Such samples can only be measured with the ultrasonic equipment up to a confining pressure of 100 bar, as attempts to increase the confining pressure above this limit may inflict damage to equipment. Therefore, sample G21 was measured

Table 2.4. Water saturation of samples in water-saturated state.
Determined by Archimedes test.
The calculation assumes a water density of 1.054 g/ml.

	Sample id.	Archimedes bulk volume (ml)	Archimedes pore volume (ml)	Archimedes porosity (%)	Weight after drying @ 110 °C (g)	Weight after saturation with water (g)	Water contents in water-saturated state (ml)	Water contents in water-saturated state (%PV)	Water excess / deficit relative to S_w=100 % (ml)
Lopra-1									
	L337	46.91	0.64	1.36	137.56	138.53	0.92	144	0.3
	L862	46.24	0.36	0.79	137.68	138.28	0.57	156	0.2
	L1218	45.54	0.86	1.88	134.59	135.58	0.94	110	0.1
	L1922	45.69	1.17	2.57	134.76	136.05	1.22	104	0.1
	L2177	45.28	0.81	1.79	134.55	135.40	0.81	100	0.0
Vestmanna-1									
	V16	41.56	5.63	13.54	109.30	115.24	5.64	100	0.0
Glyvursnes-1									
	G8	21.39	7.38	34.48	39.58	47.31	7.33	99	0.0
	G21	45.83	6.07	13.25	120.37	126.56	5.87	97	-0.2
	G45	43.85	5.49	12.51	115.98	121.58	5.31	97	-0.2
	G57	42.63	6.84	16.04	106.19	113.58	7.01	103	0.2
	G60	44.71	5.23	11.70	121.78	127.32	5.26	100	0.0
	G61	45.75	4.61	10.08	121.93	126.78	4.60	100	0.0

twice in the water-saturated state. First, it was measured at a confining pressure of 100 bar using the procedure of Table 2.6. Then, the large vesicles of the sample were padded with a plastic filler. After curing, and resaturation with water, sample G21 was again measured in the ultrasonic equipment now with the standard procedure of Table 2.5. Comparison of the ultrasonic results at 100 bar confining pressure before and after padding indicates that the padding with plastic filler did not influence the ultrasonic results at 100 bar confining pressure (Table 5.2, Figs. 5.1, 5.3, 5.5 and 5.9). Therefore, it is concluded that the ultrasonic results at 200 and 300 bar confining pressure are probably also un-influenced by the padding.

The water-saturated samples were mounted in a modified AutoLab 500 Ultrasonic system (New England Research) and the ultrasonic transit times were measured with a Tektronix Model TDS3012 digital oscilloscope connected to a PAR spike-generator. The details of the ultrasonic measurements are described in Chapter 4. Results are presented in Chapter 5.

2.6 Pore volume reduction and length reduction

During measurement of samples in water-saturated state, the outlet from the ultrasonic core holder was connected with a Mettler balance and the production of water was continuously logged. From the water production data the pore volume reduction were calculated by assuming that the amount of produced water, W_w corresponded to the pore volume reduction, ΔPV

$$\Delta PV = W_w / \rho_w \quad \text{Eq. 2-1}$$

where ρ_w is the water density. The results of the calculation are presented in Table 2.7. The column *Equilibrium status* contains an evaluation of the degree of equilibrium reached by the set-up. For one sample with very low permeability, sample L1922, the production of water continued to the ultrasonic measurements started and in this instances the calculated porosity reduction may not represent the equilibrium state. For sample G21 the

Table 2.5. Standard schedule for ultrasonic measurements. Applies to all samples, except the first of the two measurements on sample G21. Applies to measurements in both humidity-controlled state (60 °C, 40 %RH) and water-saturated state.
Pressure ramping up @ 200 bar/h.
Pressure ramping down @ 400 bar/h.

Step no.	Description	Cumulate time hh:mm
1	Mount sample in core holder	00:15
2	Pressure ramping 0 to 15 bar in 2 min	00:17
3	Pressure ramping 15 to 100 bar in 25.5 min	00:43
4	Stabilizing at 100 bar for 120 minutes	02:43
5	Ultrasonic measurements at 100 bar	02:53
6	Pressure ramping 100 to 200 bar in 30 min	03:23
7	Stabilizing at 200 bar for 120 minutes	05:23
8	Ultrasonic measurements at 200 bar	05:33
9	Pressure ramping 200 to 300 bar in 30 min	06:03
10	Stabilizing at 300 bar for 120 minutes	08:03
11	Ultrasonic measurements at 300 bar	08:13
12	Stabilizing at 300 bar for approx. 15 hours	23:13
13	Ultrasonic measurements at 300 bar	23:23
14	Pressure ramping 300 to 0 bar in 45 min	24:08

Table 2.6. Reduced schedule for the first of two ultrasonic measurements on samples G21 in water-saturated state.
Pressure ramping up @ 200 bar/h.
Pressure ramping down @ 400 bar/h.

Step no.	Description	Cumulate time hh:mm
1	Mount sample in core holder	00:15
2	Pressure ramping 0 to 15 bar in 2 min	00:17
3	Pressure ramping 15 to 100 bar in 25.5 min	00:43
4	Stabilizing at 100 bar for 120 minutes	02:43
5	Ultrasonic measurements at 100 bar	02:53
6	Stabilizing at 100 bar for approx. 15 hours	17:53
7	Ultrasonic measurements at 100 bar	18:03
8	Pressure ramping 100 to 0 bar in 15 min	18:18

water production also continued until the ultrasonic measurements, undoubtedly because of sleeve material creeping into the open vesicles of the sample. The porosity reduction data for sample G21 is therefore dubious. For all other samples the set-up seemed to reach equilibrium and the porosity reduction data are considered valid.

The porosity reduction versus porosity relationship is presented in graphical form in Fig. 2.1 for samples in the 100 bar, 200 bar, 300 bar and 300 bar repeat states. It is seen that for each stress state the porosity reduction shows a fair correlation with porosity, though the correlations show considerable scatter. The simple linear regressions shown in the figure give rather poor accounts of the variations. Sample G8 in particular deviates from the linear correlation, and this sample is excluded from the regressions. Being a tuff, sample G8 clearly has a much higher compressibility.

As expected, the porosity reduction increases regularly with the stress. The porosity reduction data for sample G21 probably overestimates the porosity reduction as some intrusion of the rubber sleeve of the core holder into the vesicles of the sample probably took place. Such intrusion will appear in the data as an additional porosity reduction. Fig. 2.1 shows that the porosity reduction for sample G21 is significantly larger than for samples G45, G57 and G60 that have similar porosities. This may indicate that the effect of rubber intrusion on the porosity reduction of sample G21 is significant but not excessive. The porosity reduction of sample V16 is much larger than what would be expected by comparison with samples of similar porosity.

The additional 13 hours of equilibration for the 300 bar repeat measurements caused very little additional porosity reduction, except for sample G8 (Fig. 2.1).

The length of a sample is important for the calculation of the ultrasonic velocity. A model for calculating the reduction in sample length, ΔL, is applied that assumes isotropic contraction of the pore volume without any change to the grain volume:

$$\Delta L = L\left(1 - \sqrt[3]{1 - \Delta\Phi}\right) \qquad \text{Eq. 2-2}$$

where L is the length of the sample without confining pressure and ΔΦ is the porosity reduction. The reduced length, L-ΔL, is used for all ultrasonic velocity calculations on water-saturated samples. For the humidity-controlled state no data for porosity or length reduction are available, and the reduced length, L-ΔL, calculated for the water-saturated state were also used for calculating the ultrasonic velocities in the humidity-controlled state.

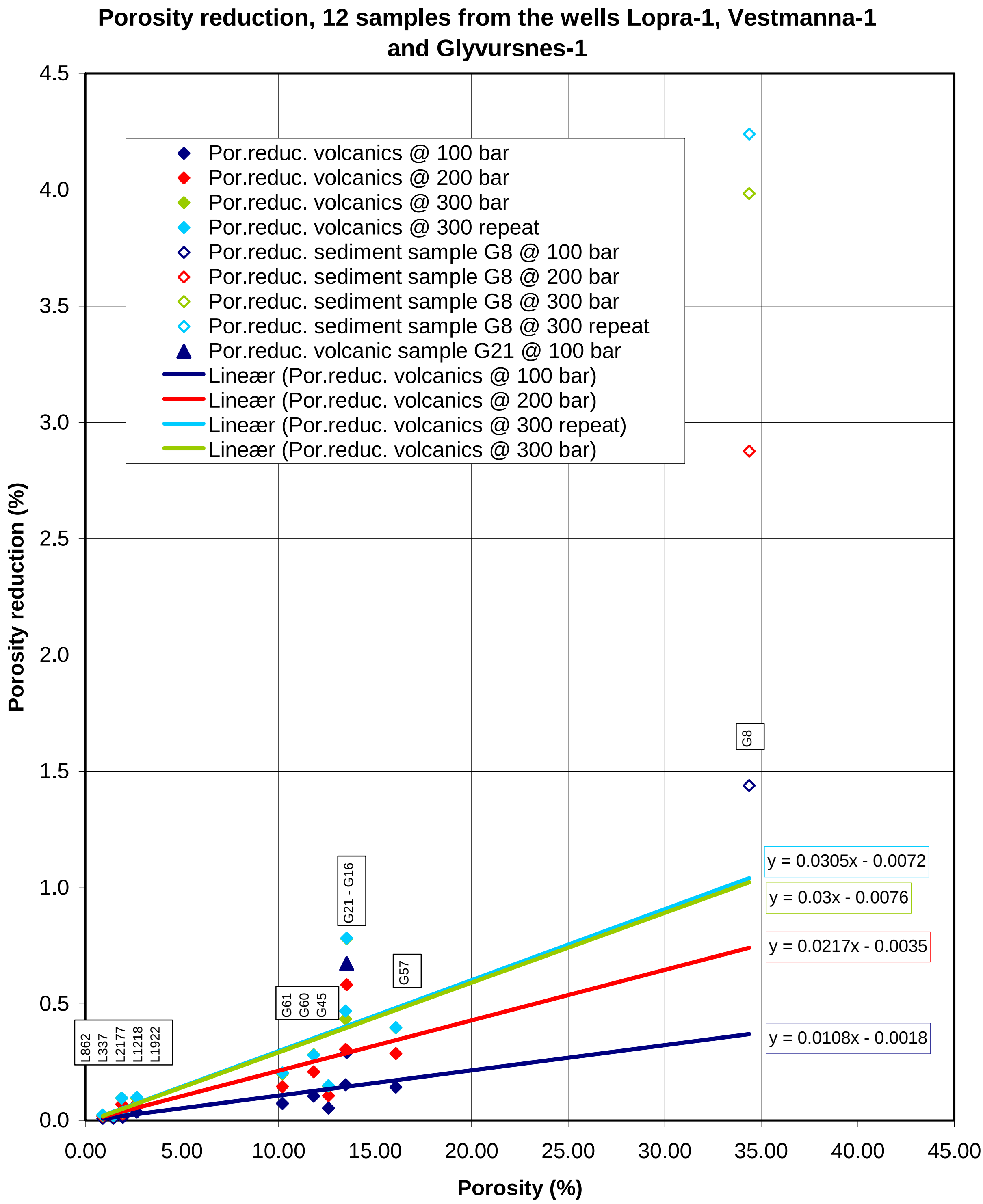


Fig. 2.1. Porosity reduction vs. porosity for samples in the 100 bar, 200 bar, 300 bar and 300 bar repeat stress state. The figure shows all data from the presenty study. Also shown are linear regressions for the stress states. Sediment sample G8 and volcanic sample G21 before padding with plastic filler are excluded from the regressions.

Table 2.7. Porosity reduction as function of confining pressure.

Sample id.	Equilibrium status	Gas perm (mD)	Porosity 0 bar (%)	Porosity reduction 100 bar (%)	Porosity 100 bar (%)	Porosity reduction 100 rep (%)	Porosity 100 rep (%)	Porosity reduction 200 bar (%)	Porosity 200 bar (%)	Porosity reduction 300 (%)	Porosity 300 (%)	Porosity reduction 300 rep (%)	Porosity 300 rep (%)
Lopra-1													
L337	Equilib. OK	0.006	1.46	0.01	1.45	-	-	0.02	1.44	0.02	1.44	0.02	1.44
L862	Equilib. OK	0.005	0.90	0.01	0.89	-	-	0.02	0.88	0.02	0.88	0.02	0.88
L1218	Equilib. OK	0.005	1.94	0.01	1.93	-	-	0.03	1.91	0.04	1.90	0.04	1.90
L1922	Some disequil.	0.005	2.66	0.04	2.62	-	-	0.07	2.59	0.09	2.57	0.10	2.56
L2177	Equilib. OK	0.007	1.88	0.03	1.85	-	-	0.07	1.81	0.10	1.78	0.10	1.78
Vestmanna-1													
V16	Equilib. OK	2.82	13.53	0.29	13.24	-	-	0.58	12.95	0.78	12.75	0.78	12.75
Glyvursnes-1													
G8	Equilib. OK	17.4	34.37	1.44	32.93	-	-	2.88	31.49	3.98	30.39	4.24	30.13
G21	Some disequil.	0.072	13.48	0.67	12.81	0.84	12.64	-	-	-	-	-	-
G21 padded	Some disequil.	-	13.48 [1)]	0.15	13.33	-	-	0.31	13.17	0.44	13.04	0.47	13.01
G45	Equilib. OK	0.032	12.59	0.05	12.54	-	-	0.11	12.48	0.15	12.44	0.15	12.44
G57	Equilib. OK	0.064	16.08	0.14	15.94	-	-	0.29	15.79	0.40	15.68	0.40	15.68
G60	Equilib. OK	0.171	11.82	0.10	11.72	-	-	0.21	11.61	0.28	11.54	0.28	11.54
G61	Equilib. OK	0.076	10.21	0.07	10.14	-	-	0.15	10.06	0.20	10.01	0.20	10.01

1) Porosity value for G21 before padding.
- = not analyzed.

3. Ultrasonic measurement methods

3.1 Procedure for the ultrasonic measurements

The ultrasonic equipment consists of a modified AutoLab 500 Ultrasonic system (New England Research) connected to a PAR spike-generator and a Tektronix TDS3012 2-channel digital phosphor oscilloscope. The system generates P- and S-wave signals with nominal centre frequencies of 700 kHz. The S-wave velocity of a sample is usually measured in two orthogonal directions denoted S1 and S2. The actual core samples from the Lopra-1, Vestmanna-1 and Glyvursnes-1 wells were not oriented and, therefore, the S1 and S2 velocities could not be related to any geographical direction. Therefore, S1 and S2 velocities were measured relative to an arbitrary mark on each sample. The mean value of S1 and S2 is reported as “S velocity”.

A plug sample was mounted in the ultrasonic core holder with an ultrasonic transmitter at one end and an ultrasonic receiver at the other end. A rubber sleeve was mounted around the cylinder surface to isolate the plug sample from the pressure medium. Contact paste was not applied to the sample ends. Hydrostatic pressure was applied to the sample with a Quizix SP-5400 high-pressure pump system. The initial pressure build-up to 15 bar was accomplished rapidly, i.e. within 2 minutes to ensure a good seal of the rubber sleeve. All subsequent pressure changes were applied more slowly with the pressure ramping facility of the Quizix pump system that provided a linear evolution of pressure vs. time. Before ultrasonic measurements the sample was allowed to equilibrate for 2 or 15 hours at the target confining pressure. When unloading the core holder, the confining pressure was decreased with a rate that was twice the rate used for loading the sample. Schedules of the measurement procedures are provided in Tables 2.5 and 2.6.

The pores of the sample were maintained at atmospheric pressure trough an open outlet. For the water-saturated samples, the outlet was connected to a cuvette placed on a Mettler balance and data logging of the balance was maintained during sample pressurization and ultrasonic measurements. This allowed quantification of the fluid production and thus enabled determination of the pore volume reduction, and sample length reduction.

The temperature in the laboratory during the ultrasonic measurements was 23 ± 2 °C.

The P- and S-wave data were saved digitally in CSV-format for later analysis. Screen-dumps from the oscilloscope were saved in TIF-format. Cf. Chapter 6 for data documentation.

3.2 Analysis of the ultrasonic signal

The ultrasonic signals were analysed with the program *firstarrival* made by Ødegaard A/S. It determines the first arrival of the ultrasonic wave train from a table of amplitude versus time in CSV-format.

The ultrasonic velocity, *V*, is calculated from the following equation.

$$V = \frac{L}{t_{transit} - t_{delay}} \quad \text{Eq. 3-1}$$

where L is the sample length, $t_{transit}$ is the measured total travel time, and t_{delay} is the system delay. The system delay is an inherent system property representing the time taken for the ultrasonic signal to travel through the transducers plus any delays caused by the electronics. The system delay for the Autolab 500 system was determined by calculating a 4-point linear regression on 4 calibration standards of different lengths and constant ultrasonic velocity. The principle is shown in Fig. 3.1. Three of the calibration standards (Alu1, Alu2 and Alu3)

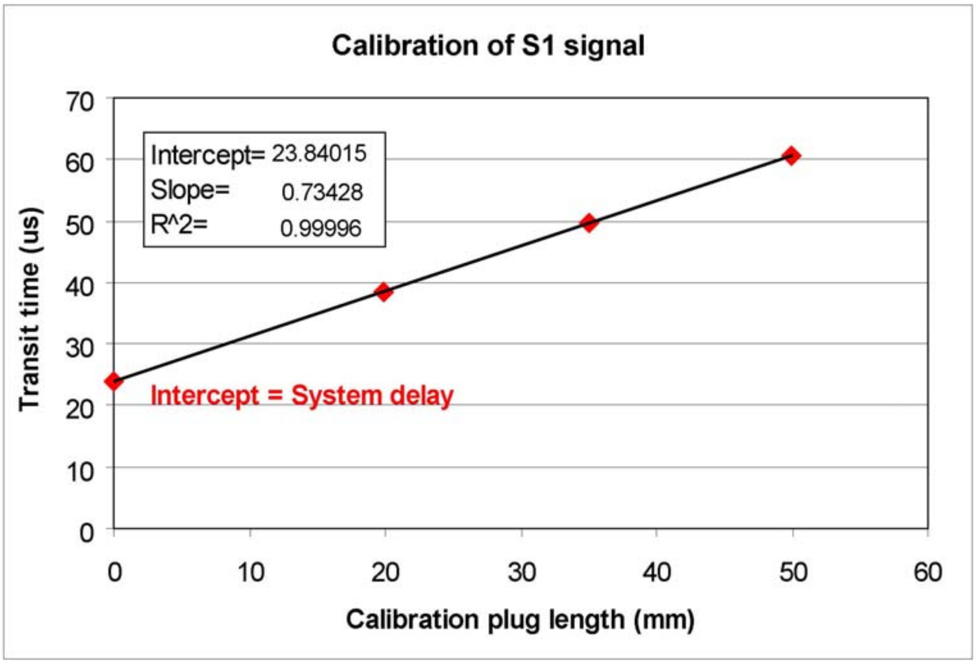


Fig. 3.1 Principle of determining the system delay from a regression on 4 data points.

are cylindrical aluminium plugs of known length; the fourth calibration standard is a configuration of length zero, i.e. the ultrasonic transducers are mounted head-to-head. System delays were determined for P, S1 and S2 waves at all the four pressure conditions used for measurements, i.e. 100 bar, 200 bar, 300 bar and 300 bar repeat. The calibration was conducted in September-October 2005. The system delays and the associated regression correlation coefficients are listed in Table 3.1. The system delays show a small but significant dependence on confining pressure, which is the usual behaviour of the equipment. All calibration data are included in the Excel file with project data, cf. Chapter 6 Documentation of Data.

3.3 Precision and reproducibility of ultrasonic data

The precision of the ultrasonic results may be assessed from 1) a precision evaluation of the analytical data for each sample and 2) measurements on a secondary standard with identification Alu6061.

3.3.1. Precision evaluation of the analytical data for each sample

The program *firstarrival* returns the precision parameters ”Local uncertainty” and “Global uncertainty” for every data set, cf. Section 3.4 “The arrival picker program”. The precision of the ultrasonic measurements may be assessed from these precision parameters in combination with an estimate of the uncertainty of the plug

Table 3.1 System delays, for ultrasonic calibration October 2005.

Hydrostatic pressure (bar)	P signal (µs)	Corr. coef. R^2 for P signal	S1 signal (µs)	Corr. coef. R^2 for P signal	S2 signal (µs)	Corr. coef. R^2 for P signal
100	13.7493	0.9997	24.6303	0.9998	25.2737	0.9998
200	13.7029	0.9998	24.5661	0.9999	25.2166	0.9999
300	13.7000	0.9998	24.5389	1.0000	25.1904	1.0000
300 repeat	13.6797	0.9999	24.5109	1.0000	25.1753	1.0000

length determination. Precision estimates for all measurements are presented in Tables A.1 to A.6 of Appendix A. The uncertainty of the plug length is estimated to a fixed value of 0.1 mm and this leads to the error estimates given in the column “Error on velocity from length”. The *firstarrival* parameter "Local uncertainty" is a measure of the signal noise, and leads in the error estimates listed in column “Error on velocity from noise”. The column “Total error” is the sum of the error estimates “Error on velocity from length” and “Error on velocity from noise”.

The *firstarrival* parameter "Global uncertainty" is a measure of the probability of picking the wrong signal. It is listed in column “Global uncertainty”. The risk that *firstarrival* picks a wrong signal from the ultrasonic data set increases with the value of this parameter. For values above approximately 0.5 there is a significant risk that *firstarrival* has picked a wrong signal. The parameter “Global uncertainty” is only used as a guidance for identifying problematic picks. All *firstarrival* picks are checked manually and erroneous picks are corrected, cf. Section 3.4 "The arrival picker program". Instances of manual picking are termed *forced picking* and are marked with the comment “Forced pick” in Tables A.1 to A.6.

For the water-saturated measurements the mean total error for all the 50 measurements of P, 50 measurements of S1 and 50 measurements of S2 ultrasonic velocities is respectively 0.44 %, 0.48 % and 0.48 % of the calculated velocity, cf. Tables A.1 to A.3. For the gas-saturated measurements the mean total error for all the 16 measurements of P, 16 measurements of S1 and 16 measurements of S2 ultrasonic velocities is respectively 0.36 %, 0.33 % and 0.34 % of the calculated velocity, cf. Tables A.4 to A.6. For many samples roughly half of the error stems from signal noise and half from uncertainty of length determination. Only for sample G8 does the total error exceeds 1.0 %, with the largest error of 2.86 % occurring for the measurement of S2 in water-saturated state at 200 bar. The cause of the high uncertainty for sample G8 is partly the short length of this sample - 19 mm opposed to the standard length of 40 mm, and partly larger noise level, possibly because of the sedimentary nature of this sample.

The error estimates listed in Tables A.1 to A.6 do not include possible systematic errors or calibration inaccuracies and should be regarded as minimum errors.

3.3.2. Measurements on standard Alu6061

Standard Alu6061 is a secondary standard of aluminium provided by New England Research that also provided standard values for the P- and S-wave velocities of this sample. During the present work it was measured two times at the four pressure steps 100 bar, 200 bar, 300 bar, and 300 bar repeat with the time schedule of Table 2.5 that was also used for most of the samples. The results are listed in Table 3.2 and plotted in Fig. 3.2 together with the nominal ultrasonic velocities for the standard. The results indicate a mean error of +1.15 % for P measurements, and a mean error of +0.60 % for S measurements, with no significant difference between S1 and S2. However, it is evident that the measured P and S velocities are dependent on the confining pressure, cf. Fig. 3.2. This is the usual behaviour of the equipment. It has not been possible to obtain information about the confining pressure pertinent to the nominal velocities supplied by New England Research.

3.3.3. Summary of precision

The precision (reproducibility) of the ultrasonic velocity determinations is considered to be better than 1 % at 1 σ level. The accuracy of the P determinations is considered to be better than 1.2 %. The accuracy of the S determinations is considered to be better than 1 %.

3.4 The arrival picker program

Whenever possible a program named *firstarrival* is used for determining the transit time of the ultrasonic signals. The program was developed by Ødegaard A/S. Compared to manual picking of the transit time the use of a computer program eliminates the subjectivity of manual picking, and objective information about precision becomes available. The input to the program consists of 1) a comma-separated file (CSV-file) listing time and

Table 3.2 Measurements on standard Alu6061, calibration September-October 2005.

Nominal value or pressure condition	Ultrasonic P velocity (m/s)	Deviation from nominal P velocity (%)	Ultrasonic S1 velocity (m/s)	Deviation from nominal S velocity (%)	Ultrasonic S2 velocity (m/s)	Deviation from nominal S velocity (%)
Nominal value	6396		3125		3125	
1st measurement:						
100 bar	6425	+0.45	3132	+0.21	3142	+0.54
200 bar	6446	+0.78	3139	+0.46	3145	+0.64
300 bar	6503	+1.68	3144	+0.62	3144	+0.60
300 repeat	6472	+1.19	3145	+0.66	3146	+0.68
2nd measurement:						
100 bar	6440	+0.69	3130	+0.17	3141	+0.50
200 bar	6476	+1.25	3151	+0.84	3146	+0.67
300 bar	6507	+1.73	3154	+0.94	3146	+0.66
300 repeat	6489	+1.46	3147	+0.71	3148	+0.73

signal amplitude, 2) a search interval specifying the time interval to be searched, and 3) a parameter specifying whether a positive or a negative deflection from zero shall be picked.

firstarrival identifies the first significant deflection of the ultrasonic signal and determines the transit time at the extremum, the amplitude at the extremum and two uncertainty parameters, the *global uncertainty* and the *local uncertainty*, for the arrival event. The first amplitude extremum is used as the arrival event rather than the first

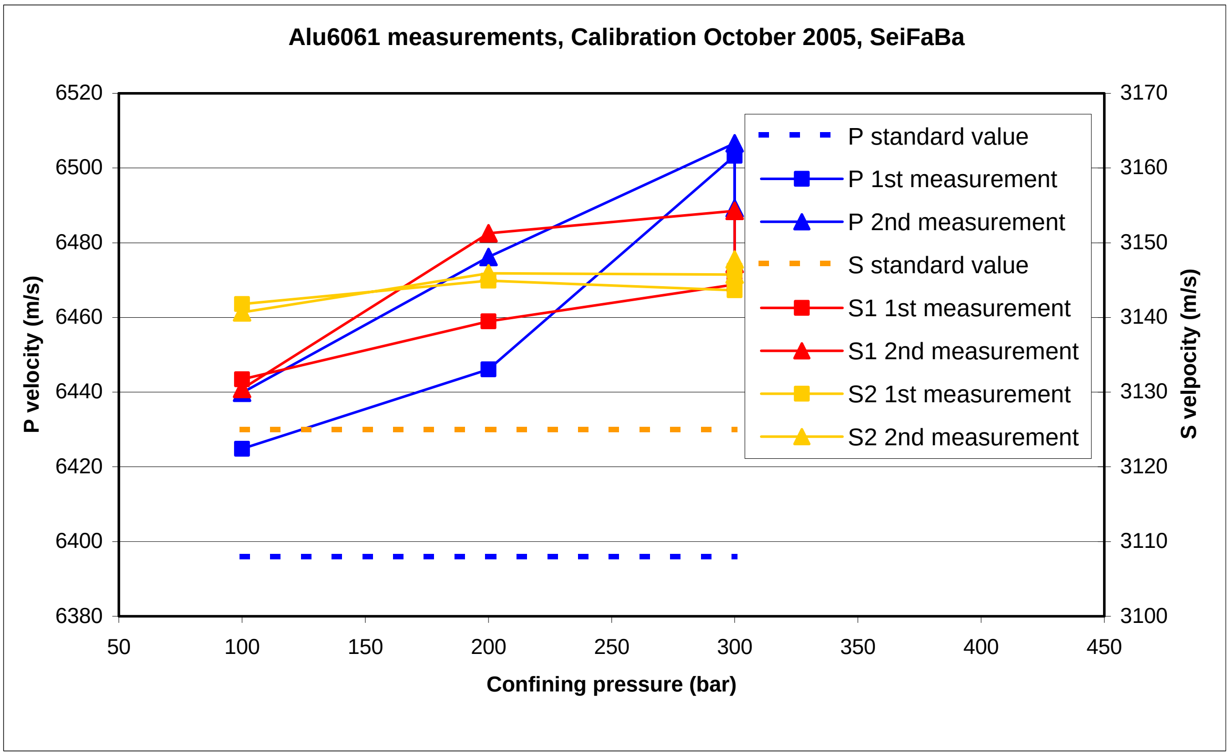


Fig. 3.2. Ultrasonic velocities measured on standard Alu6061.

deviation from the baseline because this causes the algorithm to be much more robust in case of noisy data. The difference between the two methods is negligible, because the same procedure is used for both calibration and sample measurements and because the width of signal peaks are nearly constant (being governed by the 700 kHz centre frequency). The offset between first deviation from zero and first extremum is therefore the same for sample and calibration, and the effect cancels out.

On some occasions when the ultrasonic signal is very noisy the *firstarrival* program may pick a wrong signal peak and thus result in a wrong transit time. Or, in extreme cases, the program may fail to detect a signal peak at all. Therefore, the transit time determinations of the *firstarrival* program are always checked manually. In case they are deemed wrong it is first attempted to force *firstarrival* to pick the correct extremum by reducing the search interval – a procedure termed *forced picking*. If this procedure fails manual picking of the transit time is performed - a procedure termed *manual picking*. In case of forced picking objective information about local precision is still available. In case of manual picking objective information about precision is not available.

The output from the *firstarrival* program consists of 1) a pick of the extremum identified as the arrival of the ultrasonic signal, 2) a global uncertainty parameter, 3) a local uncertainty parameter, and 4) an amplitude at the pick.

3.4.1 Picking the arrival of the ultrasonic signal

firstarrival looks for an event consisting of two consecutive local extrema with amplitudes of opposite sign. The search can be limited to a given time interval and to a given polarity, i.e. the sign of the first extremum. In a typical ultrasonic signal the desired event will give the maximum output in the following non-linear object function:

$$\frac{\left|FirstExtremumAmplitude - 2 * SecondExtremumAmplitude\right|}{HeadAmplitude} \qquad \text{Eq. 3-2}$$

Where the HeadAmplitude denotes the maximum absolute amplitude of the signal in an interval ending just before the onset of the half period containing the first extremum. The length of the interval has been set to 5 mean periods, i.e. 5 divided by the mean frequency. The precise time of the first extremum is found using Newton-Raphson local optimisation starting from the solution determined previously and using sinc interpolation between the samples.

3.4.2 Local uncertainty (Error-band):

To describe how much the picked time could be wrong due to additive noise moving the chosen extremum of the observable signal, the local uncertainty is computed. The computed HeadAmplitude is used as a noise estimate in that computation.

3.4.3 Global uncertainty:

To describe how easy it is to identify the desired event, the global uncertainty is defined as the ratio of the object function for the second largest value and the largest value. The global uncertainty takes values between 0 and 1, where 0 represents a very easy case and 1 means that two or more picks were equally good, or in fact equally bad.

3.4.4 Amplitude at pick

The amplitude of the Newton-Raphson optimisation at the picked time is reported as the amplitude at the pick.

4. Conventional core analysis methods

The following is a short description of the methods used by GEUS Core Laboratory. For a more detailed description of methods, instrumentation and principles of calculation the reader is referred to API recommended practice for core analysis procedure (API RP 40, 1998).

4.1 Gas permeability

The plug is mounted in a Hassler core holder, and a confining pressure of 400 psi applied to the sleeve. The specific permeability to gas is measured by flowing nitrogen gas through a plug of known dimensions at differential pressures between 0 and 1 bar. No back-pressure is applied. The readings of the digital gas permeameter are checked regularly by routine measurement of permeable steel reference plugs.

4.2 He-porosity and grain density

The porosity is measured on cleaned and dried samples. The porosity is determined by subtraction of the measured grain volume and the measured bulk volume. The Helium technique, employing Boyle's Law, is used for grain volume determination, applying a double chambered Helium porosimeter with digital readout, whereas bulk volume is measured by submersion of the plug in a mercury bath using Archimedes principle. Grain density is calculated from the grain volume determination and the weight of the cleaned and dried sample.

4.3 Precision of conventional core analysis data

Table 4.1 gives the precision (= reproducibility) at the 68% level of confidence (+/- 1 standard deviation) for routine core analysis measurements performed at GEUS Core Laboratory.

Table 4.1. Precision of conventional core analysis data.

Measurement	Range, mD	Precision
Grain density		0.003 g/cc
Porosity		0.1 porosity-%
Gas Permeability	0.001-0.01 0.01-0.1 > 0.1	25% 15% 4%

5. Results of the ultrasonic measurements

The results of the ultrasonic measurements are presented in the following tables and figures:

Table 5.1: Results of ultrasonic measurements on 4 samples in humidity-controlled state, 60 °C and 40 %RH.
Table 5.2: Results of ultrasonic measurements on 12 samples in water-saturated state, S_w=100 %.

Values reported in Tables 5.1 and 5.2 as "Mean S velocity" are the mean of S measurements in two orthogonal directions identified as S1 and S2. Basic data for the underlying P, S1 and S2 measurements are given in Tables A.1 to A.6.

For ease of reference samples in humidity-controlled state are also referred to as *gas-saturated*. The ultrasonic velocity results have been plotted as follows:

Fig. 5.1 V_P and V_S vs. porosity for 12 samples in *water-saturated* state, S_w=100 %.
Fig. 5.2 V_P and V_S vs. porosity for 4 samples in *gas-saturated* state.
Fig. 5.3 V_S vs. V_P for 12 samples in *water-saturated* state, S_w=100 %.
Fig. 5.4 V_S vs. V_P for 4 samples in *gas-saturated* state.
Fig. 5.5 V_P/V_S ratio vs. porosity for 12 samples in *water-saturated* state, S_w=100 %.
Fig. 5.6 V_P/V_S ratio vs. porosity for 4 samples in *gas-saturated* state.
Fig. 5.7 V_P in *water-saturated state*, S_w=100 %, vs. V_P in *gas-saturated* state for 4 samples.
Fig. 5.8 V_S in *water-saturated state*, S_w=100 %, vs. V_S in *gas-saturated* state for 4 samples.
Fig. 5.9 V_P and V_S vs. confining pressure for 12 samples in *water-saturated* state, S_w=100 %.
Fig. 5.10 V_P and V_S vs. confining pressure for 4 samples in *gas-saturated* state.

In Figs. 5.1 to 5.10 measurements on the same sample at different confining pressure are plotted with the same symbol connected by a line with the same colour as the symbol.

For most samples the ultrasonic S1 and S2 velocities deviate less than 1 %, and these sample may be considered isotropic as regards transmission of S waves. However, for samples V16, G61, L1922 and L2177 the measured S1 and S2 velocities for water-saturated samples deviate more than 1 % (Table 5.2). In the case of sample L2177 the deviation exceeds 3 %. Samples L1922 and L2177 were also measured in gas saturates state and for this situation the S1 and S2 velocities deviate even more than for the water-saturated state with deviations up to 7 % (Table 5.1). Samples V16, G61, L1922 and L2177 therefore appears to be anisotropic as regards transmission of S waves.

Table 5.1. Results of ultrasonic measurements on samples in humidity-controlled state, 60 °C, 40 %RH.

Sample id.	Confining presssure (bar)	Porosity (%)	Reduced porosity (%)	P velocity (m/s)	S1 velocity (m/s)	S2 velocity (m/s)	Mean S velocity (m/s)	P / S Ratio	S1 / S2 Ratio
Lopra-1 samples:									
L337	100	1.46	1.45	5857	3289	3289	3289	1.781	1.000
L337	200	1.46	1.44	5856	3291	3296	3293	1.778	0.998
L337	300	1.46	1.44	5853	3287	3299	3293	1.777	0.997
L337	300 rep	1.46	1.44	5862	3283	3296	3289	1.782	0.996
L1218	100	1.94	1.93	5833	3331	3351	3341	1.746	0.994
L1218	200	1.94	1.91	5800	3322	3343	3333	1.740	0.994
L1218	300	1.94	1.90	5795	3320	3337	3329	1.741	0.995
L1218	300 rep	1.94	1.90	5793	3312	3330	3321	1.744	0.995
L1922	100	2.66	2.62	5560	3105	3219	3162	1.758	0.965
L1922	200	2.66	2.59	5579	3143	3220	3182	1.754	0.976
L1922	300	2.66	2.57	5661	3180	3234	3207	1.765	0.983
L1922	300 rep	2.66	2.56	5661	3184	3244	3214	1.761	0.982
L2177	100	1.88	1.85	5841	3403	3175	3289	1.776	1.072
L2177	200	1.88	1.81	5899	3416	3212	3314	1.780	1.064
L2177	300	1.88	1.78	5976	3441	3241	3341	1.788	1.062
L2177	300 rep	1.88	1.78	5963	3429	3245	3337	1.787	1.057

rep = repeat measurement next day.

Table 5.2. Results of ultrasonic measurements on samples in water-saturated state, S_w=100 %.

Sample id.	Confining pressure (bar)	Porosity (%)	Reduced porosity (%)	P velocity (m/s)	S1 velocity (m/s)	S2 velocity (m/s)	Mean S velocity (m/s)	P / S Ratio	S1 / S2 Ratio
Vestmanna-1 samples:									
V16	100	13.53	13.24	4220	2144	2200	2172	1.943	0.974
V16	200	13.53	12.95	4354	2284	2328	2306	1.888	0.981
V16	300	13.53	12.75	4451	2359	2400	2380	1.870	0.983
V16	300 rep	13.53	12.75	4466	2375	2419	2397	1.863	0.982
Glyvursnes-1 samples:									
G8	100	34.37	32.93	2537	1114	1128	1121	2.263	0.988
G8	200	34.37	31.49	2613	1165	1171	1168	2.237	0.994
G8	300	34.37	30.39	2689	1207	1210	1208	2.225	0.997
G8	300 rep	34.37	30.13	2717	1236	1239	1238	2.195	0.998
G21	100	13.48	12.81	4538	2409	2406	2407	1.885	1.001
G21	100 rep	13.48	12.64	4562	2420	2432	2426	1.880	0.995
G21 pad	100	13.48	13.33	4534	2402	2432	2417	1.876	0.988
G21 pad	200	13.48	13.17	4594	2476	2497	2486	1.848	0.992
G21 pad	300	13.48	13.04	4646	2517	2536	2526	1.839	0.992
G21 pad	300 rep	13.48	13.01	4658	2524	2547	2535	1.837	0.991
G45	100	12.59	12.54	5440	3064	3058	3061	1.777	1.002
G45	200	12.59	12.48	5440	3055	3062	3059	1.778	0.998
G45	300	12.59	12.44	5459	3063	3066	3064	1.781	0.999
G45	300 rep	12.59	12.44	5462	3058	3069	3064	1.783	0.996
G57	100	16.08	15.94	4242	2296	2281	2289	1.853	1.006
G57	200	16.08	15.79	4313	2341	2327	2334	1.848	1.006
G57	300	16.08	15.68	4363	2364	2355	2359	1.849	1.004
G57	300 rep	16.08	15.68	4353	2367	2359	2363	1.842	1.004
G60	100	11.82	11.72	4622	2393	2403	2398	1.928	0.996
G60	200	11.82	11.61	4739	2501	2493	2497	1.898	1.003
G60	300	11.82	11.54	4803	2566	2540	2553	1.881	1.010
G60	300 rep	11.82	11.54	4817	2575	2550	2563	1.879	1.010
G61	100	10.21	10.14	5050	2731	2686	2708	1.865	1.017
G61	200	10.21	10.06	5102	2773	2743	2758	1.850	1.011
G61	300	10.21	10.01	5135	2796	2773	2785	1.844	1.008
G61	300 rep	10.21	10.01	5102	2794	2779	2786	1.831	1.005

rep = repeat measurement next day.

continue next page

pad = Sample G21 after being padded with plastic filler.

Table 5.2 cont'd. Results of ultrasonic measurements on samples in water-saturated state, S_w=100 %.

Sample id.	Confining presssure (bar)	Porosity (%)	Reduced porosity (%)	P velocity (m/s)	S1 velocity (m/s)	S2 velocity (m/s)	Mean S velocity (m/s)	P / S Ratio	S1 / S2 Ratio
Lopra-1 samples:									
L337	100	1.46	1.45	6089	3342	3345	3343	1.821	0.999
L337	200	1.46	1.44	6060	3338	3349	3343	1.813	0.997
L337	300	1.46	1.44	6065	3344	3346	3345	1.813	0.999
L337	300	1.46	1.44	6052	3334	3354	3344	1.810	0.994
L862	100	0.90	0.89	6250	3456	3449	3452	1.810	1.002
L862	200	0.90	0.88	6235	3437	3442	3440	1.813	0.999
L862	300	0.90	0.88	6232	3436	3439	3437	1.813	0.999
L862	300	0.90	0.88	6231	3428	3443	3436	1.814	0.996
L1218	100	1.94	1.93	5981	3350	3352	3351	1.785	0.999
L1218	200	1.94	1.91	5979	3352	3365	3358	1.780	0.996
L1218	300	1.94	1.90	5990	3353	3365	3359	1.783	0.997
L1218	300	1.94	1.90	5990	3352	3366	3359	1.783	0.996
L1922	100	2.66	2.62	6115	3321	3231	3276	1.867	1.028
L1922	200	2.66	2.59	6106	3324	3251	3288	1.857	1.022
L1922	300	2.66	2.57	6103	3332	3264	3298	1.851	1.021
L1922	300	2.66	2.56	6120	3335	3272	3303	1.853	1.019
L2177	100	1.88	1.85	6567	3478	3318	3398	1.933	1.048
L2177	200	1.88	1.81	6525	3476	3340	3408	1.915	1.041
L2177	300	1.88	1.78	6525	3483	3359	3421	1.907	1.037
L2177	300	1.88	1.78	6510	3476	3367	3422	1.903	1.032

rep = repeat measurement next day.

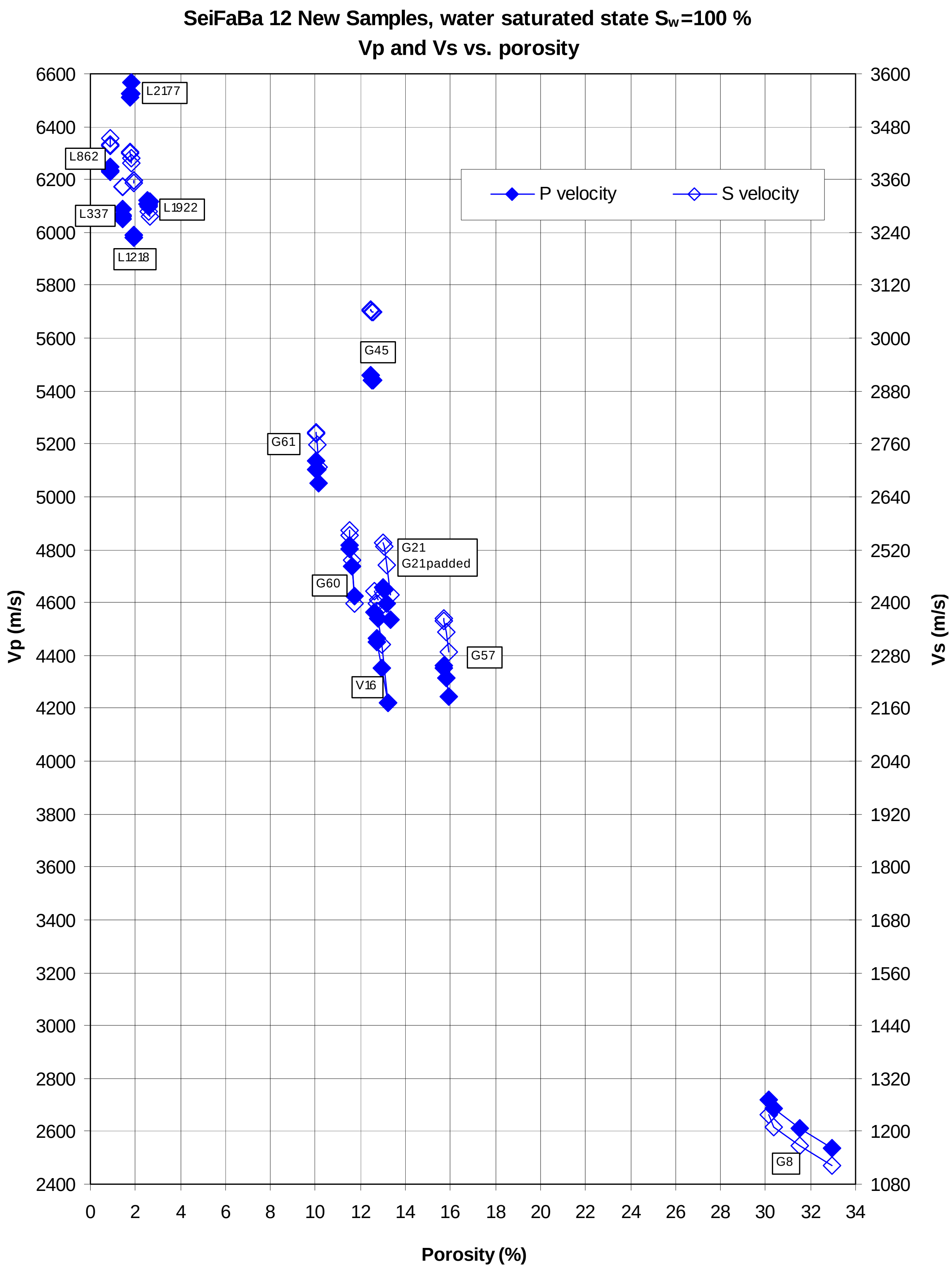


Fig. 5.1. V_P and V_S vs. porosity for 12 samples in water-saturated state, S_w=100 %.

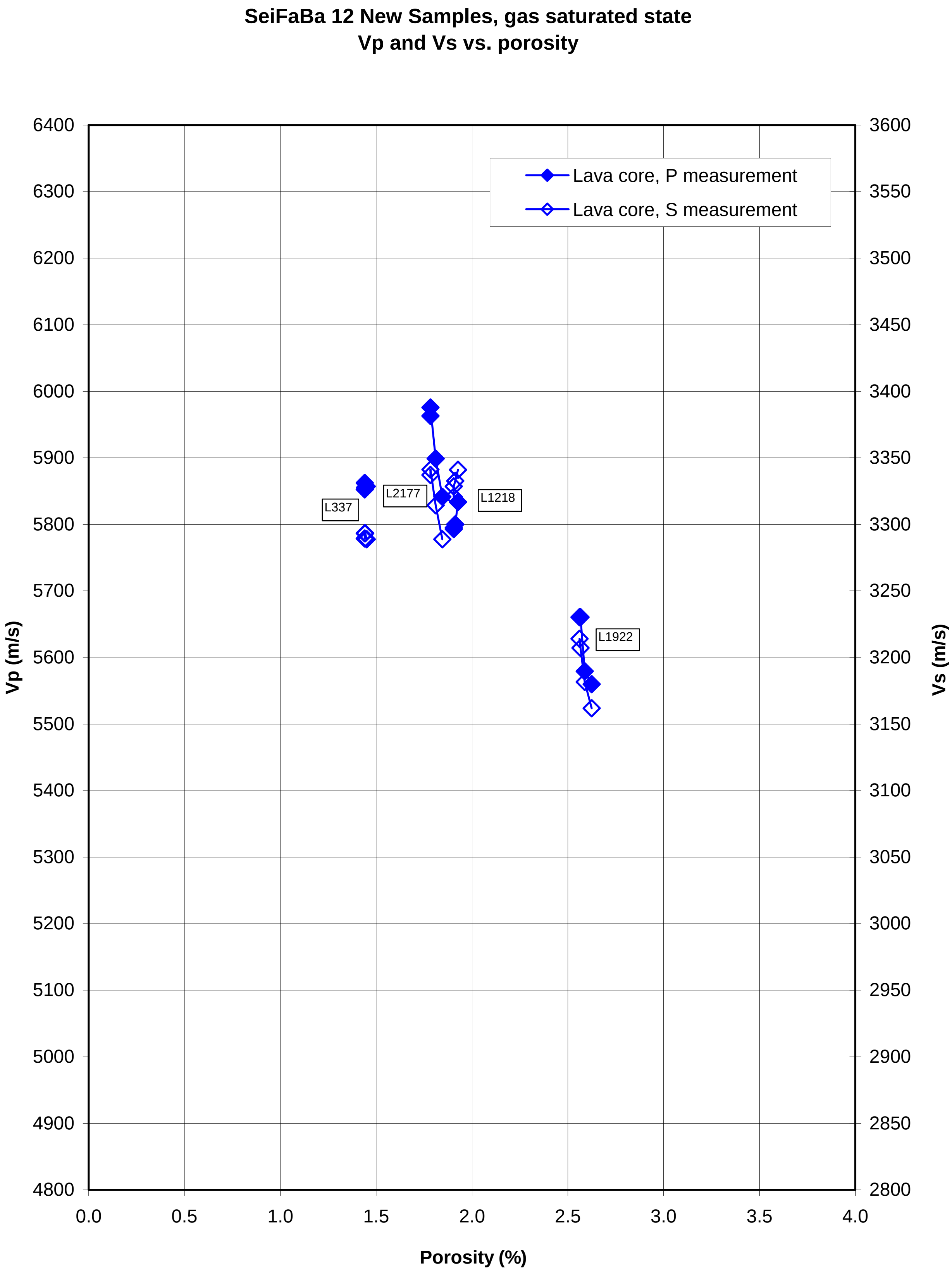


Fig. 5.2. V_P and V_S vs. porosity for 4 samples in gas-saturated state.

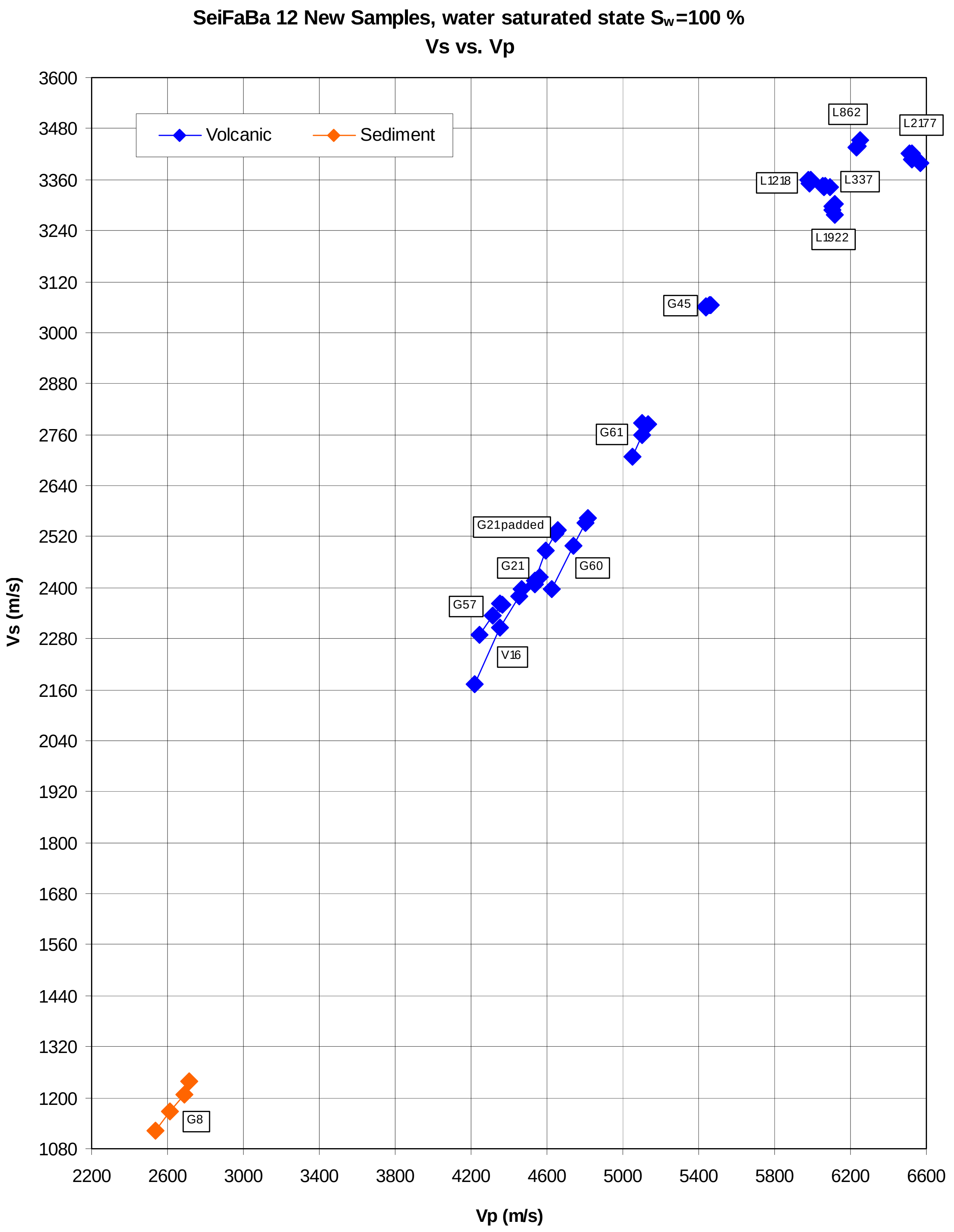


Fig. 5.3. V_S vs. V_P for 12 samples in water-saturated state, S_w=100 %.

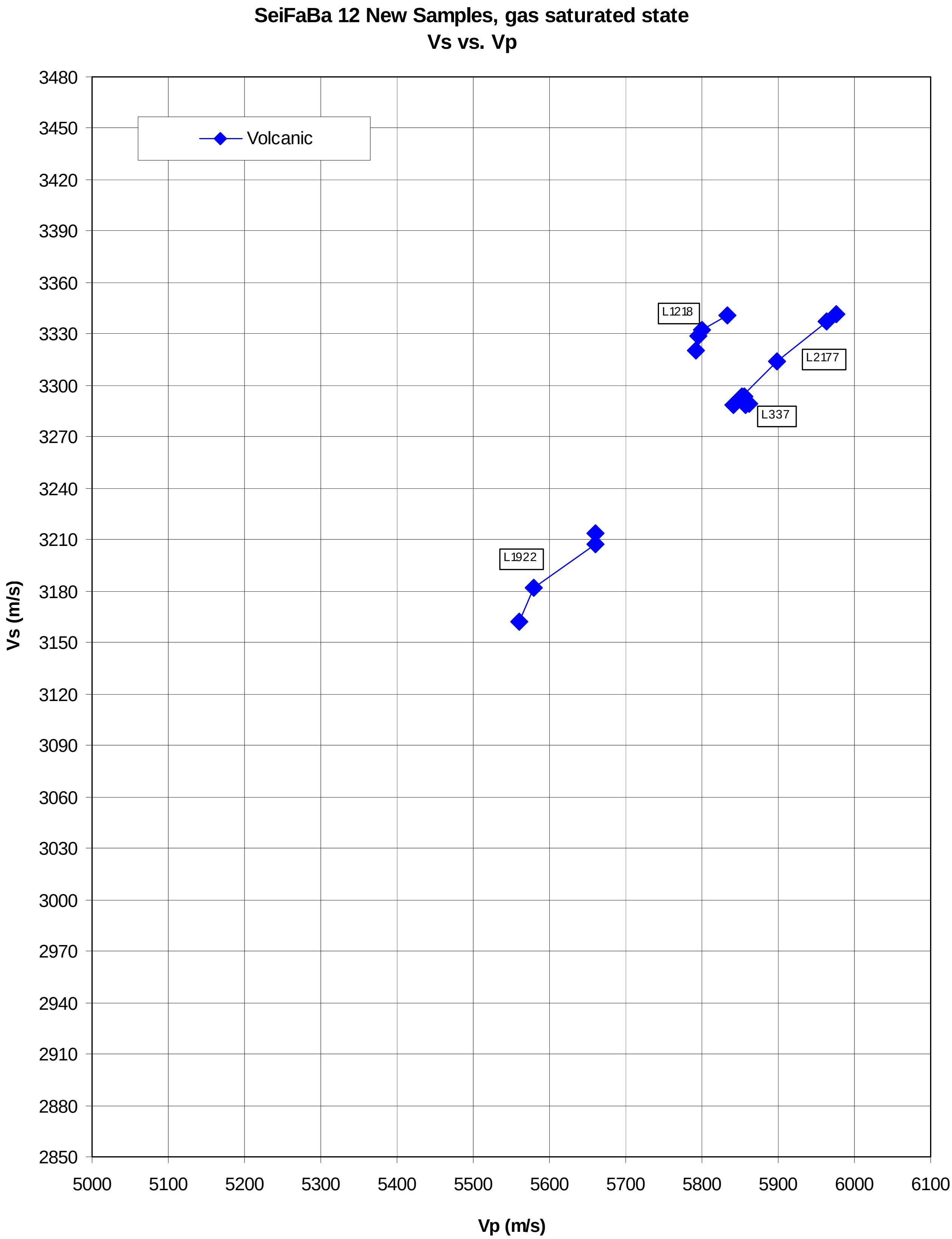


Fig. 5.4. V_S vs. V_P for 4 samples in gas-saturated state.

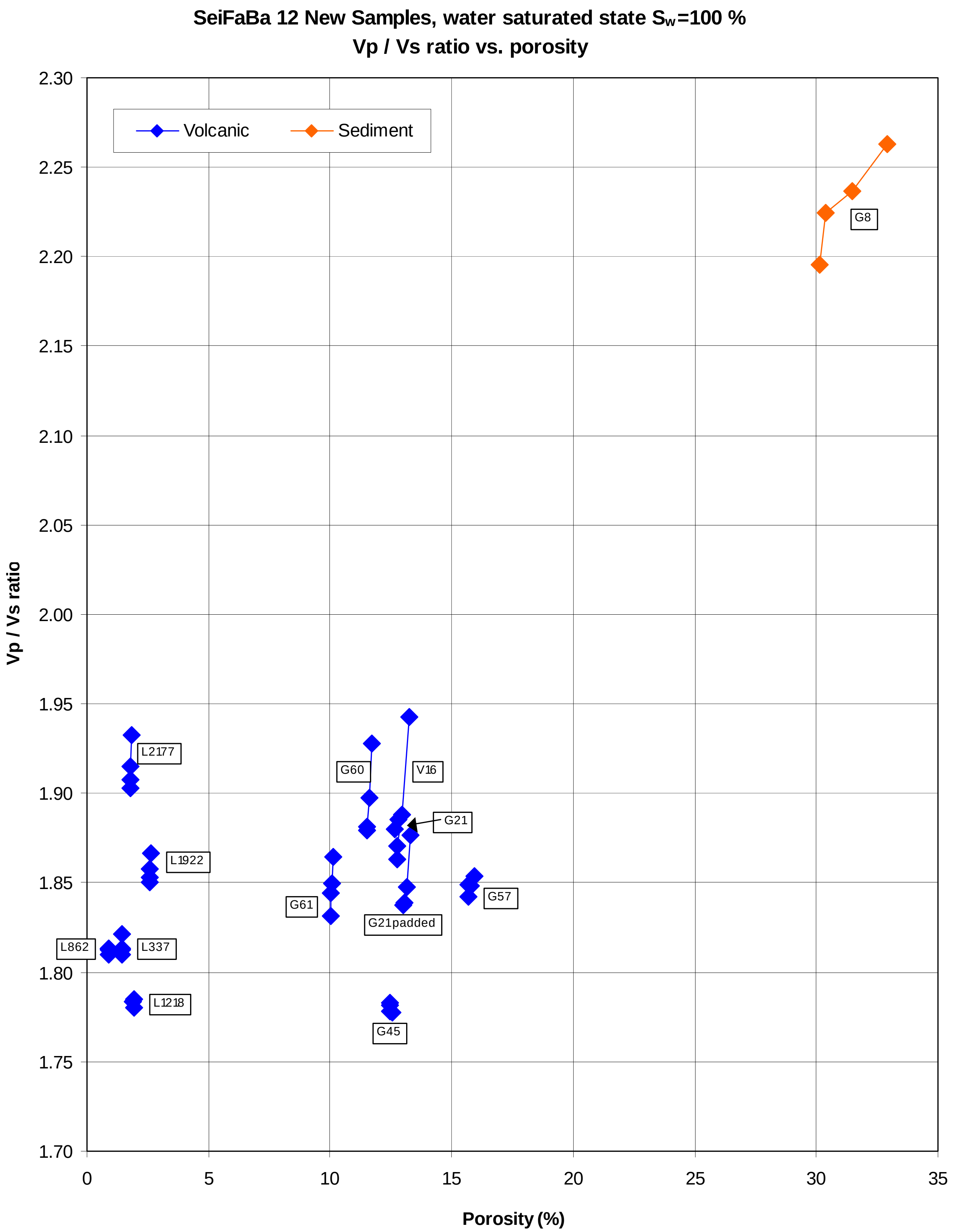


Fig. 5.5. V_P/V_S ratio vs. porosity for 12 samples in water-saturated state, S_w=100 %.

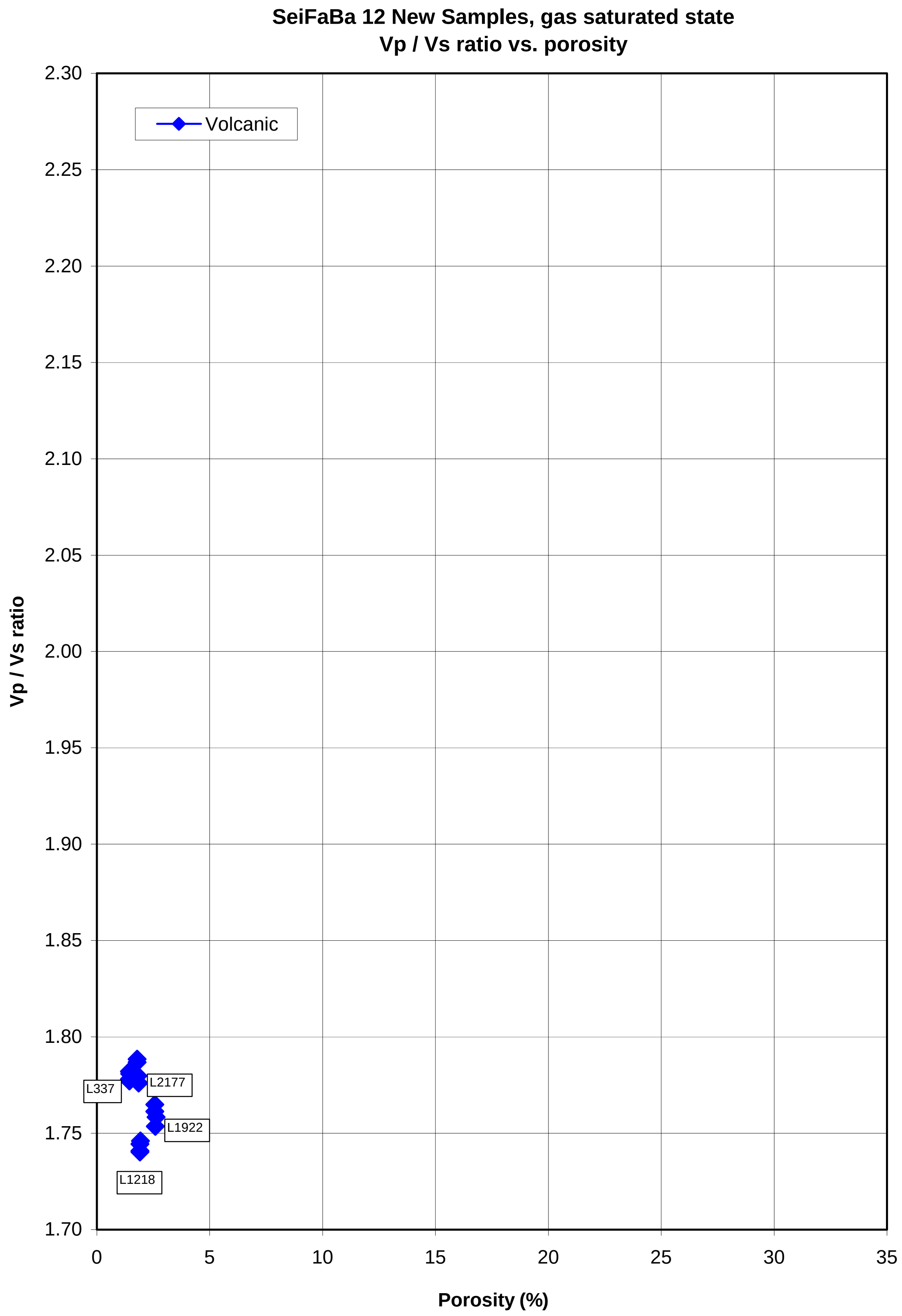


Fig. 5.6. V_P/V_S ratio vs. porosity for 4 samples in gas-saturated state.

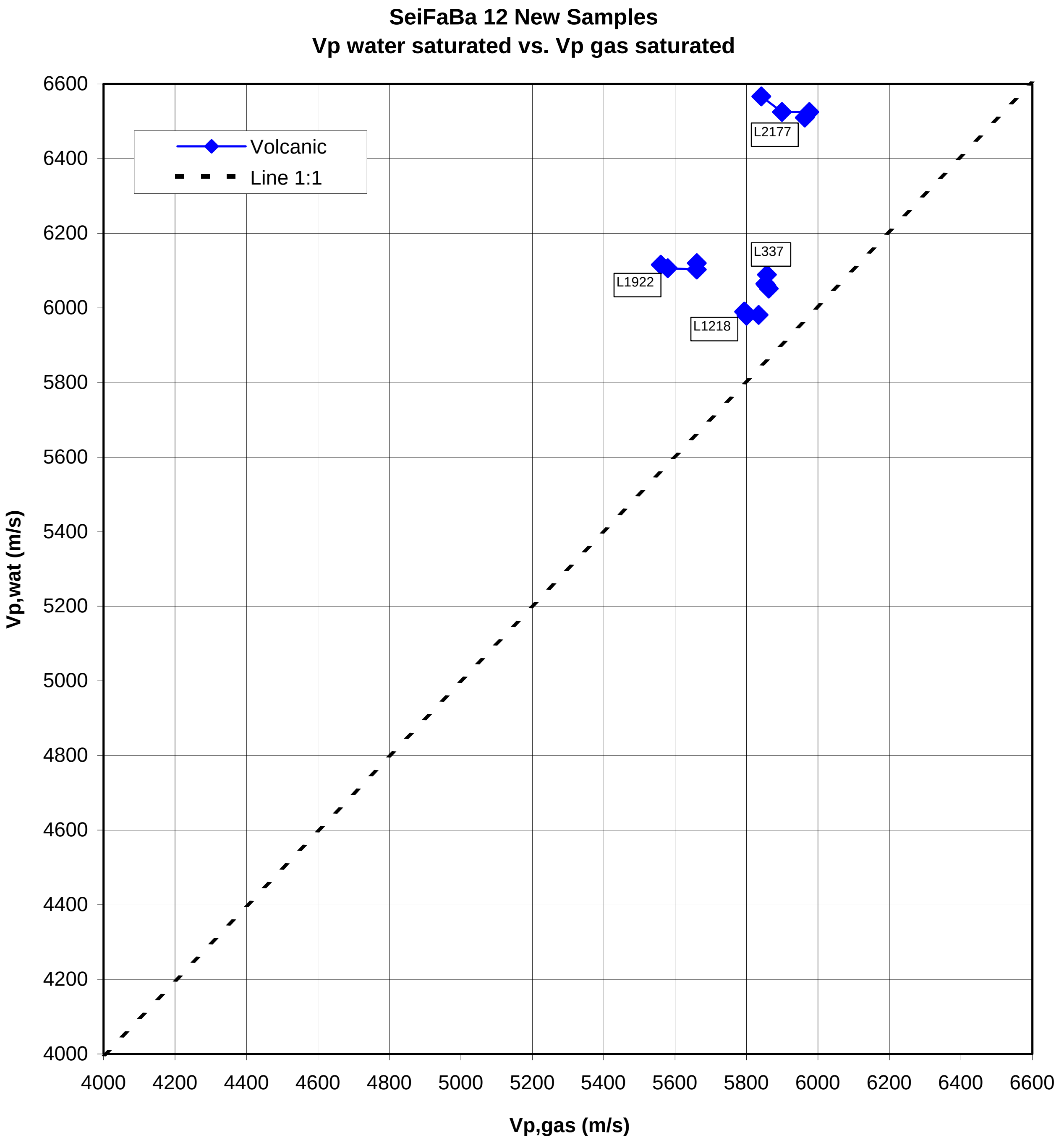


Fig. 5.7. V_P water-saturated, S_w=100 %, vs. V_P gas-saturated for 4 samples. Please note that the effect of increased pressure is greater for Vp,gas than for Vp,wat.

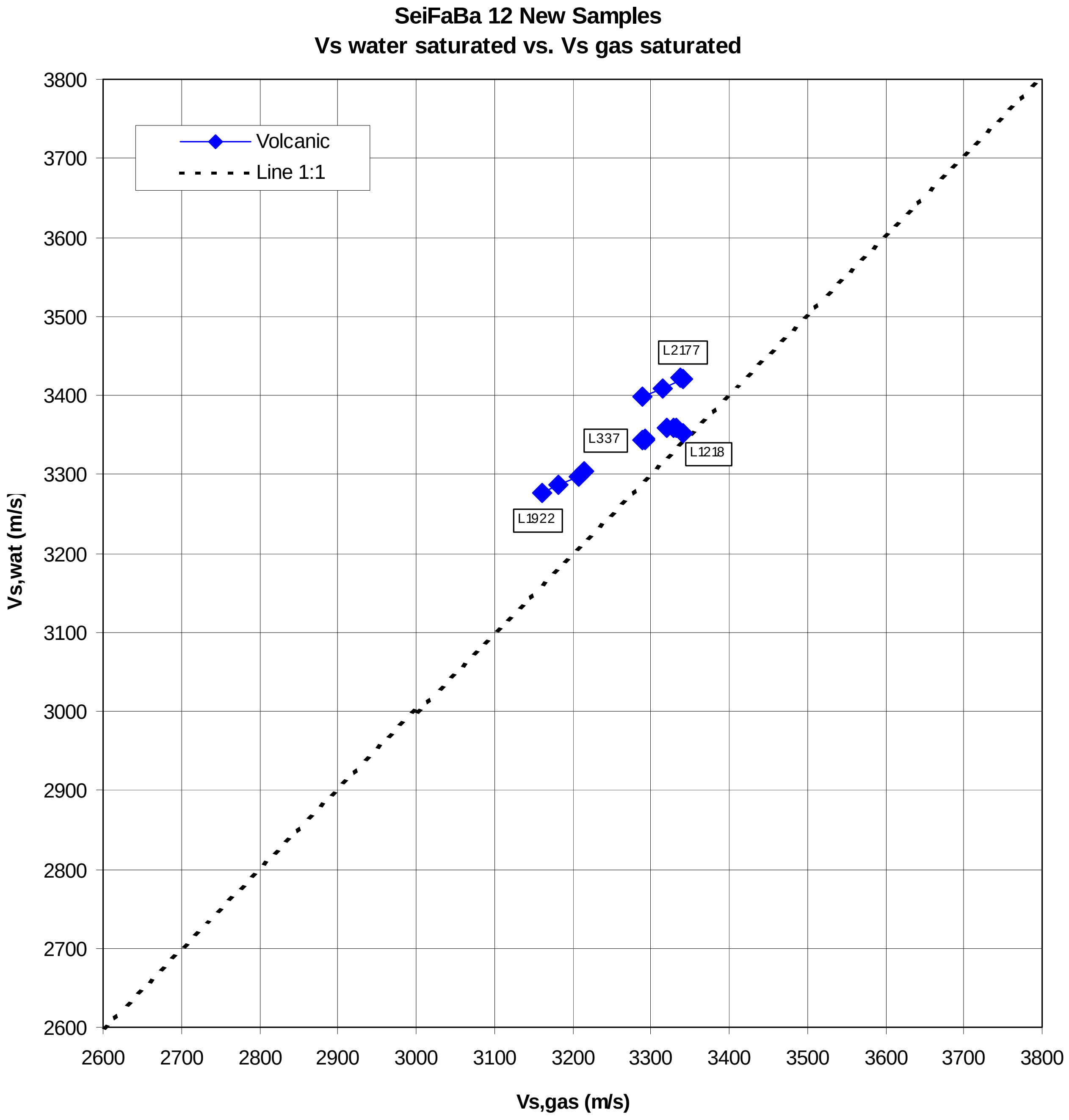


Fig. 5.8. V_S water-saturated, S_w=100 %, vs. V_S gas-saturated for 4 samples.

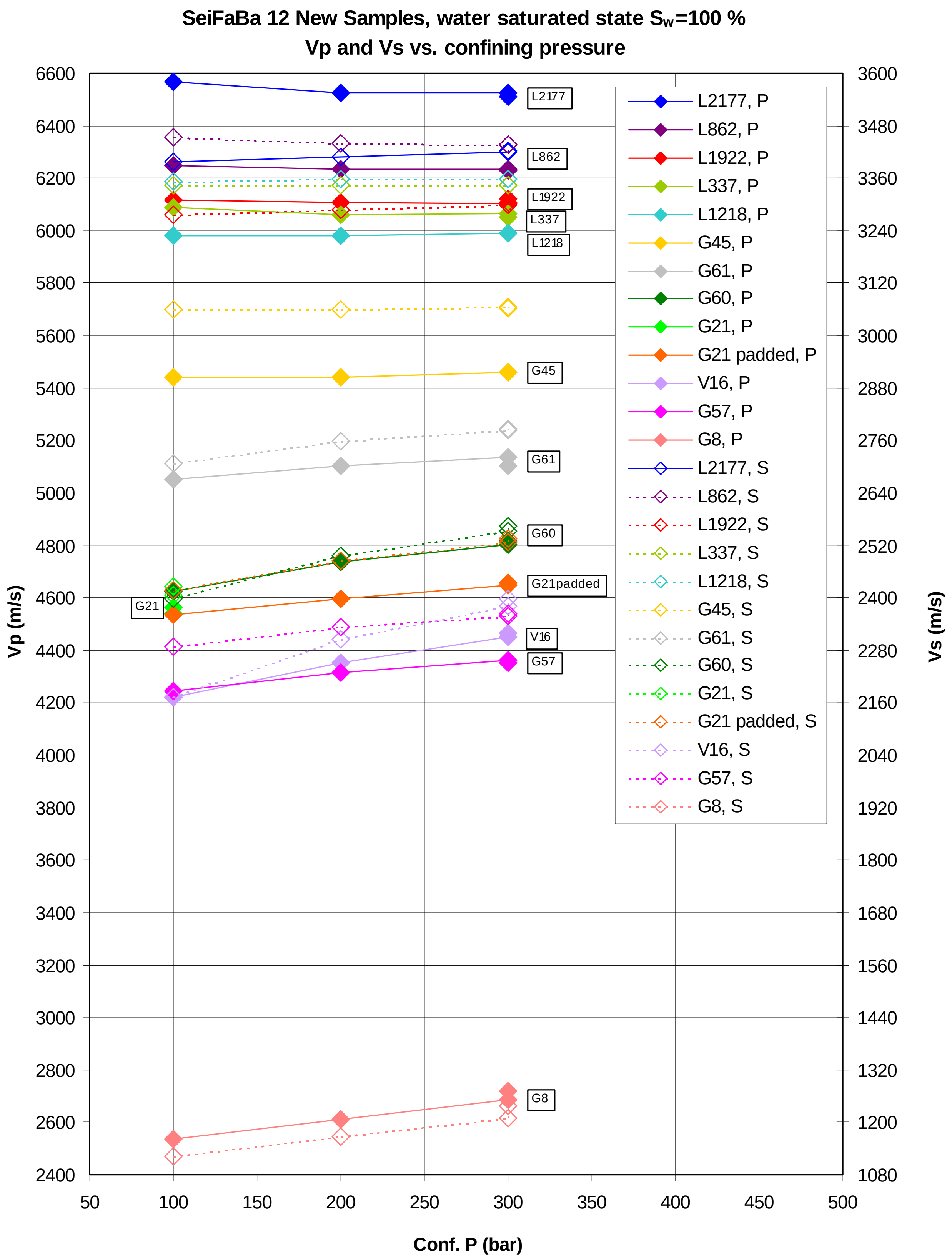


Fig. 5.9. V_P and V_S vs. confining pressure for 12 samples in water-saturated state, S_w=100 %.

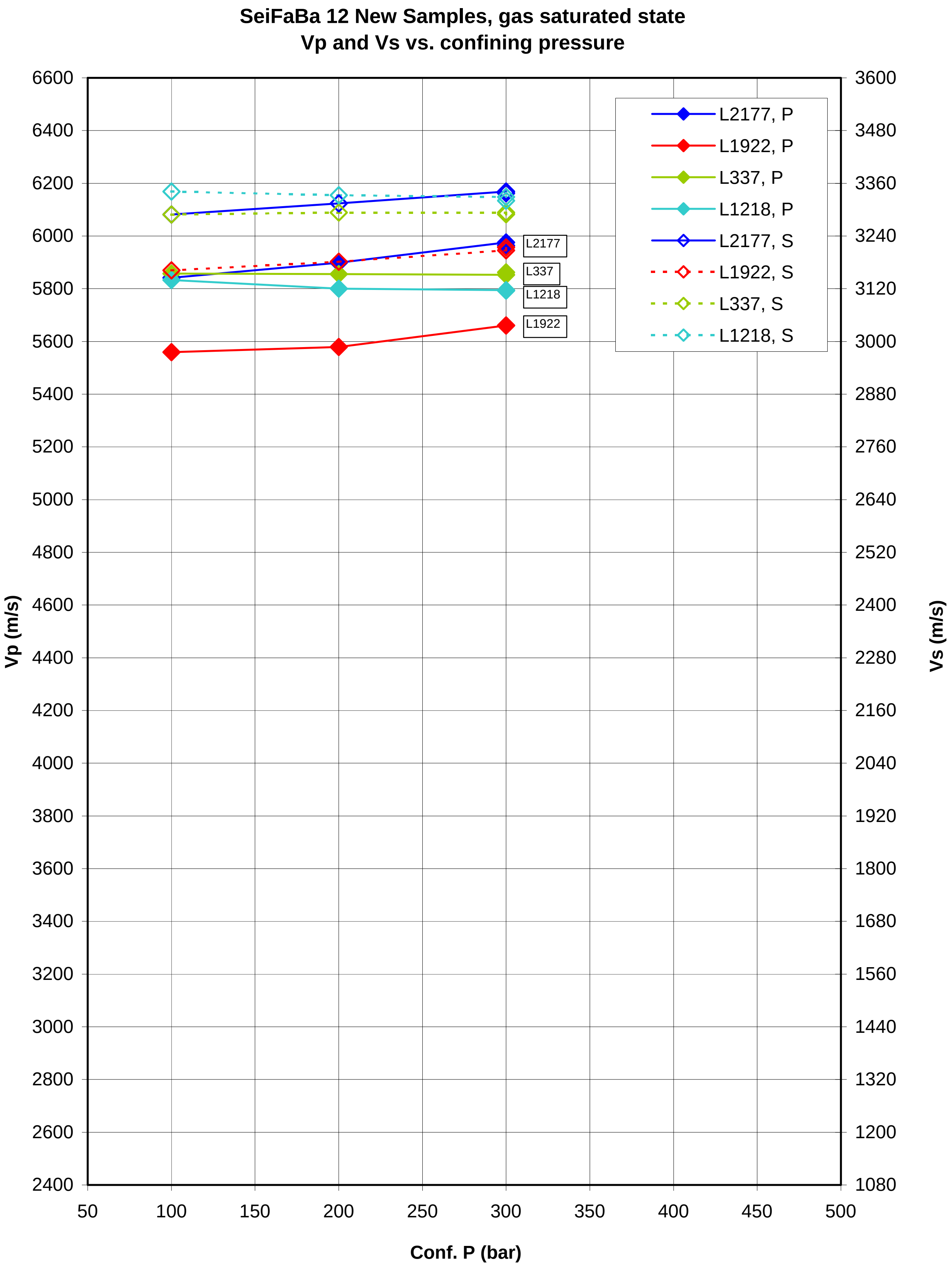


Fig. 5.10. V_P and V_S vs. confining pressure for 4 samples in gas-saturated state.

6. Documentation of data

This report contains a CD with all the data of the present work. It contains one top-level folder named “SeiFaBa_12new”, with three sub-directories named “WaterSaturated”, “HumidityControlled” and “Calibration”. The data for measurements in humidity-controlled state can be found in the “HumidityControlled” subfolder, and the data for measurements in the water-saturated state can be found in the “WaterSaturated” subfolder. The calibration data can be found in the subfolder "Calibration". At the top level, all results are placed in the spreadsheets *sonic_SeiFaBa_12new.xls*, which is an Excel2000 file. This report is present as *sonic_SeiFaBa_12new.pdf*.

In each folder "HumidityControlled" and "WaterSaturated" subfolders are present with sample identification as names, containing the data for the respective samples. For each sample the following files are present:

1) Files with wave train data stored in comma separated files (*.csv)
2) Screen-dumps of the oscilloscope in tif-format (*.tif)
3) Plots indicating the position of firstarrival picks in gif-format (*.gif).

For these files the filenames are constructed as follows:

<sample id.>_<state_><measurement type>_<hydrostatic pressure>_<date>.<file type>

where

<sample id.> is the identification of the sample,
<state_> is either *gas* indicating humidity-controlled state or *wat* indicating water-saturated state,
<measurement type> is given as P (P-wave) or S1 (S1-wave) or S2 (S2-wave),
<hydrostatic pressure> is the hydrostatic pressure in bar,
<date> is a shorthand date with format ddmmyy,
<file type> is csv, tif, or gif.

Every folder in addition contains:

4) A file with output from program *firstarrival* (*.res).

Every sample folder for water-saturated samples in addition contains

5) A text file <sample id.>.txt with a Mettler log,
6) An Excel file <sample id.>wat.xls with the calculation of pore volume reduction.

The clock of the oscilloscope, the clock of the attached PC, and the clock of the Quizix pump system were kept synchronized within ½ minute within the data acquisition period September 28th 2005 to November 24th 2005 to allow comparison of the Mettler logs and the ultrasonic data.

7. References

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Appendix A. Basic data, results, and precision

Basic data, results and precision parameters for all measurements are presented in Tables A.1 to A.6.

These tables report the full output from the *firstarrival* program in the columns labelled *First arrival of <id.> signal*, *Local uncertainty*, *Global uncertainty*, and *Amplitude at pick*. This is true even for measurements where the identification of the ultrasonic signal, and thus the calculation of an ultrasonic velocity, failed.
In these instance the output from *firstarrival* is reported but the velocity and precision parameters are marked with the symbol “-“ denoting that the data values are absent. In addition the measurement is commented, "No pick possible".

Tables A.1 to A.3 reports data from measurement of the samples in fully water-saturated state, i.e. $S_W = 100$ %.
Tables A.4 to A.6 reports data from measurement of the samples in humidity-controlled state, i.e. 60 °C and 40 % relative humidity.

Table A.1. Page 1 of 2. Basic data, results, and precision of ultrasonic measurements.
Ultrasonic P signals measured on 12 samples in water saturated condition, S_w=100 %.

Sample id.	File id.	Conf. pressure (bar)	Reduced porosity (%)	Reduced length (mm)	First arrival of P signal (us)	Local un-certainty (us)	Global un-certainty	Amplitude at pick (mV)	P velocity (m/s)	Error on velocity: from length (m/s)	Error on velocity: from noise (m/s)	Error on velocity: Total error (m/s)	Total error (%)	Comment
Vestmanna-1 samples:														
V16	16V_maet_P_100_071105	100	13.24	37.22	22.5704	0.020617	0.0510993	0.0339697	4219.86	11.34	3.85	15.19	0.36	
V16	16V_maet_P_200_071105	200	12.95	37.19	22.2433	0.0284755	0.0729856	0.0425727	4354.32	11.71	5.57	17.28	0.40	
V16	16V_maet_P_300_071105	300	12.75	37.16	22.0491	0.0209506	0.054546	0.0463157	4451.10	11.98	4.23	16.21	0.36	
V16	16V_maet_P_300_081105	300 rep	12.75	37.16	22.0009	0.046599	0.104556	0.0446485	4466.01	12.02	9.46	21.48	0.48	
Glyvursnes-1 samples:														
G8	G8_maet_P_100_281105	100	32.93	18.91	21.2024	0.0415991	0.0988119	0.0249185	2537.00	13.42	4.98	18.39	0.73	
G8	G8_maet_P_200_281105	200	31.49	18.82	20.9038	0.128804	0.21245	0.025026	2613.02	13.89	16.10	29.99	1.15	
G8	G8_maet_P_300_281105	300	30.39	18.74	20.672	0.103605	0.190672	0.0291644	2688.50	14.34	13.47	27.82	1.03	
G8	G8_maet_P_300_291105	300 rep	30.13	18.73	20.5721	0.054765	0.119531	0.0369964	2717.14	14.51	7.23	21.74	0.80	
G21	G21_maet_P_100_291105	100	12.81	40.95	22.7721	0.032602	0.0895209	0.0200942	4538.23	11.08	6.50	17.58	0.39	
G21	G21_maet_P_100_301105	100 rep	12.64	40.92	22.7203	0.0588237	0.151264	0.0165689	4561.84	11.15	11.81	22.96	0.50	
G21_pad	G21_maet_P_100_011205	100	13.33	41.00	22.791	0.0406868	0.111021	0.0185839	4534.45	11.06	8.09	19.15	0.42	
G21_pad	G21_maet_P_200_011205	200	13.17	40.98	22.6223	0.0440803	0.116425	0.0215719	4594.29	11.21	8.95	20.16	0.44	
G21_pad	G21_maet_P_300_011205	300	13.04	40.96	22.5155	0.0346753	0.0910845	0.0219904	4646.40	11.34	7.16	18.50	0.40	
G21_pad	G21_maet_P_300_021205	300 rep	13.01	40.96	22.4725	0.0614269	0.157641	0.0220745	4657.86	11.37	12.73	24.10	0.52	
G45	G45_maet_P_100_081105	100	12.54	39.01	20.9207	0.0162141	0.0462331	0.0800329	5440.10	13.94	4.22	18.16	0.33	
G45	G45_maet_P_200_081105	200	12.48	39.01	20.8734	0.0312335	0.0851618	0.0726762	5439.84	13.95	8.14	22.09	0.41	
G45	G45_maet_P_300_081105	300	12.44	39.00	20.8446	0.0320471	0.0866966	0.0691459	5458.78	14.00	8.39	22.39	0.41	
G45	G45_maet_P_300_091105	300 rep	12.44	39.00	20.8206	0.0469519	0.119334	0.0628917	5461.57	14.00	12.32	26.32	0.48	
G57	G57_maet_P_100_161105	100	15.94	38.04	22.7165	0.0523704	0.126362	0.0417651	4242.33	11.15	9.78	20.93	0.49	
G57	G57_maet_P_200_161105	200	15.79	38.02	22.5191	0.0400846	0.0947056	0.0475521	4312.93	11.34	7.68	19.02	0.44	
G57	G57_maet_P_300_161105	300	15.68	38.01	22.4122	0.0532875	0.111571	0.0478731	4362.78	11.48	10.37	21.85	0.50	
G57	G57_maet_P_300_171105	300 rep	15.68	38.01	22.4114	0.059562	0.121025	0.0488974	4353.03	11.45	11.57	23.02	0.53	
G60	G60_maet_P_100_141105	100	11.72	39.96	22.3934	0.0444069	0.103755	0.0421644	4622.36	11.57	9.17	20.73	0.45	
G60	G60_maet_P_200_141105	200	11.61	39.94	22.1308	0.0431588	0.0946458	0.0518821	4739.30	11.87	9.24	21.11	0.45	
G60	G60_maet_P_300_141105	300	11.54	39.93	22.0138	0.0532603	0.114352	0.0553615	4803.12	12.03	11.62	23.65	0.49	
G60	G60_maet_P_300_151105	300 rep	11.54	39.93	21.97	0.0585805	0.118483	0.0560938	4816.79	12.06	12.84	24.91	0.52	
G61	G61_maet_P_100_151105	100	10.14	40.81	21.8301	0.0603324	0.117743	0.0370469	5050.26	12.38	13.96	26.33	0.52	
G61	G61_maet_P_200_151105	200	10.06	40.80	21.7006	0.0449503	0.0901614	0.0427851	5101.51	12.50	10.57	23.07	0.45	
G61	G61_maet_P_300_151105	300	10.01	40.79	21.6438	0.0464514	0.0886506	0.0447439	5135.15	12.59	11.02	23.61	0.46	
G61	G61_maet_P_300_161105	300 rep	10.01	40.79	21.6743	0.0470518	0.0870182	0.0443999	5102.47	12.51	11.08	23.59	0.46	

Table A.1. Page 2 of 2. Basic data, results, and precision of ultrasonic measurements.
Ultrasonic P signals measured on 12 samples in water-saturated condition, S_w=100 %.

Sample id.	File id.	Conf. pressure (bar)	Reduced porosity (%)	Reduced length (mm)	First arrival of P signal (us)	Local un-certainty (us)	Global un-certainty	Amplitude at pick (mV)	P velocity (m/s)	Error on velocity from length (m/s)	Error on velocity from noise (m/s)	Error on velocity Total error (m/s)	Total error (%)	Comment
Lopra-1 samples:														
L337	L337_maet_P_100_171105	100	1.45	41.82	20.617	0.0147485	0.0472636	0.128028	6089.20	14.56	4.36	18.92	0.31	
L337	L337_maet_P_200_171105	200	1.44	41.82	20.6036	0.0186747	0.0589523	0.132239	6059.92	14.49	5.49	19.98	0.33	
L337	L337_maet_P_300_171105	300	1.44	41.82	20.5949	0.0232225	0.0703477	0.134668	6064.93	14.50	6.84	21.34	0.35	
L337	L337_maet_P_300_181105	300 rep	1.44	41.82	20.5895	0.0188937	0.0571733	0.136099	6051.88	14.47	5.55	20.03	0.33	
L862	L862_maet_P_100_181105	100	0.89	41.21	20.3432	0.0136316	0.0459931	0.140045	6249.54	15.17	4.19	19.35	0.31	
L862	L862_maet_P_200_181105	200	0.88	41.21	20.3119	0.0196328	0.0665594	0.130016	6235.10	15.13	6.03	21.16	0.34	
L862	L862_maet_P_300_181105	300	0.88	41.21	20.3118	0.0146549	0.0485403	0.131201	6232.33	15.12	4.50	19.62	0.31	
L862	L862_maet_P_300_211105	300 rep	0.88	41.21	20.2933	0.0188505	0.0605371	0.132253	6230.63	15.12	5.79	20.91	0.34	
L1218	L1218_maet_P_100_211105	100	1.93	40.52	20.5233	0.0092497	0.0313152	0.198071	5981.43	14.76	2.70	17.46	0.29	
L1218	L1218_maet_P_200_211105	200	1.91	40.52	20.4795	0.0156991	0.0499207	0.183907	5978.88	14.76	4.58	19.34	0.32	
L1218	L1218_maet_P_300_211105	300	1.90	40.52	20.4641	0.0106691	0.0340768	0.176345	5989.74	14.78	3.12	17.91	0.30	
L1218	L1218_maet_P_300_221105	300 rep	1.90	40.52	20.4436	0.0175335	0.0536375	0.178216	5989.92	14.78	5.14	19.92	0.33	
L1922	L1922_maet_P_100_221105	100	2.62	40.74	20.4103	0.0214072	0.0701595	0.113971	6115.48	15.01	6.41	21.43	0.35	
L1922	L1922_maet_P_200_221105	200	2.59	40.73	20.373	0.0146959	0.0473534	0.131755	6106.43	14.99	4.40	19.40	0.32	
L1922	L1922_maet_P_300_221105	300	2.57	40.73	20.3736	0.0183986	0.0581871	0.138214	6102.73	14.98	5.51	20.50	0.34	
L1922	L1922_maet_P_300_231105	300 rep	2.56	40.73	20.3346	0.0206276	0.0681168	0.140463	6119.79	15.03	6.21	21.23	0.35	
L2177	L2177_maet_P_100_231105	100	1.85	40.28	19.8826	0.0147319	0.0492933	0.142038	6566.68	16.30	4.87	21.17	0.32	
L2177	L2177_maet_P_200_231105	200	1.81	40.27	19.8743	0.0172633	0.0523659	0.144225	6525.41	16.20	5.67	21.87	0.34	
L2177	L2177_maet_P_300_231105	300	1.78	40.27	19.8713	0.0170807	0.0497581	0.147166	6524.88	16.20	5.61	21.81	0.33	
L2177	L2177_maet_P_300_241105	300 rep	1.78	40.27	19.8649	0.0219885	0.061277	0.148332	6510.24	16.17	7.21	23.37	0.36	

Table A.2. Page 1 of 2. Basic data, results, and precision of ultrasonic measurements.
Ultrasonic S1 signals measured on 12 samples in water-saturated condition, S_w=100 %.

										Error on velocity				
Sample id.	File id.	Conf. pressure (bar)	Reduced porosity (%)	Reduced length (mm)	First arrival of S1 signal (us)	Local un-certainty (us)	Global un-certainty	Amplitude at pick (mV)	S1 velocity (m/s)	from length (m/s)	from noise (m/s)	Total error (m/s)	Total error (%)	Comment
Vestmanna-1 samples:														
V16	16V_maet_S1_100_071105	100	13.24	37.22	41.991	0.115187	0.276926	-0.030009	2144.15	5.76	5.88	11.64	0.54	
V16	16V_maet_S1_200_071105	200	12.95	37.19	40.8463	0.0967365	0.242735	-0.051004	2284.22	6.14	5.41	11.55	0.51	
V16	16V_maet_S1_300_071105	300	12.75	37.16	40.2919	0.0576989	0.127904	-0.067046	2359.09	6.35	3.38	9.73	0.41	
V16	16V_maet_S1_300_081105	300 rep	12.75	37.16	40.1578	0.0623403	0.140135	-0.07414	2375.08	6.39	3.69	10.08	0.42	
Glyvursnes-1 samples:														
G8	G8_maet_S1_100_281105	100	32.93	18.91	41.5972	0.442036	0.6169	-0.02216	1114.43	5.89	11.84	17.74	1.59	
G8	G8_maet_S1_200_281105	200	31.49	18.82	40.7196	0.388303	0.593919	-0.031957	1164.83	6.19	11.11	17.30	1.49	
G8	G8_maet_S1_300_281105	300	30.39	18.74	40.0739	0.244747	0.410766	-0.030483	1206.58	6.44	7.37	13.81	1.14	
G8	G8_maet_S1_300_291105	300 rep	30.13	18.73	39.6576	0.17081	0.487458	-0.03498	1236.42	6.60	5.33	11.93	0.96	
G21	G21_maet_S1_100_2911205	100	12.81	40.95	41.6312	0.0834529	0.473674	-0.016917	2408.55	5.88	4.83	10.71	0.44	
G21	G21_maet_S1_100_301105	100 rep	12.64	40.92	41.541	0.0565358	0.298894	-0.019822	2420.02	5.91	3.29	9.21	0.38	
G21_pad	G21_maet_S1_100_011205	100	13.33	41.00	41.7015	0.0922966	0.364994	-0.021227	2401.66	5.86	5.32	11.17	0.47	
G21_pad	G21_maet_S1_200_011205	200	13.17	40.98	41.1184	0.120377	0.436891	-0.026212	2475.68	6.04	7.25	13.29	0.54	
G21_pad	G21_maet_S1_300_011205	300	13.04	40.96	40.8156	0.115398	0.345001	-0.027602	2516.50	6.14	7.11	13.26	0.53	
G21_pad	G21_maet_S1_300_021205	300 rep	13.01	40.96	40.7386	0.114163	0.966504	-0.028723	2523.81	6.16	7.07	13.23	0.52	
G45	G45_maet_S1_100_081105	100	12.54	39.01	37.3635	0.074541	0.160071	-0.061158	3063.90	7.85	6.11	13.97	0.46	
G45	G45_maet_S1_200_081105	200	12.48	39.01	37.3322	0.0322423	0.0626132	-0.092197	3055.45	7.83	2.64	10.47	0.34	
G45	G45_maet_S1_300_081105	300	12.44	39.00	37.2725	0.0254887	0.0529653	-0.110039	3062.83	7.85	2.09	9.95	0.32	
G45	G45_maet_S1_300_091105	300 rep	12.44	39.00	37.2644	0.039911	0.111696	-0.11032	3058.03	7.84	3.28	11.12	0.36	
G57	G57_maet_S1_100_161105	100	15.94	38.04	41.1974	0.110477	0.509582	-0.038073	2296.23	6.04	6.16	12.19	0.53	
G57	G57_maet_S1_200_161105	200	15.79	38.02	40.8085	0.0560595	0.216626	-0.061119	2341.01	6.16	3.22	9.37	0.40	
G57	G57_maet_S1_300_161105	300	15.68	38.01	40.62	0.0648868	0.269471	-0.069	2363.61	6.22	3.78	9.99	0.42	
G57	G57_maet_S1_300_171105	300 rep	15.68	38.01	40.5689	0.0783665	0.32652	-0.072274	2367.01	6.23	4.57	10.80	0.46	
G60	G60_maet_S1_100_141105	100	11.72	39.96	41.3291	0.105267	0.444453	-0.039493	2392.76	5.99	6.09	12.08	0.50	
G60	G60_maet_S1_200_141105	200	11.61	39.94	40.5349	0.0811577	0.179098	-0.058076	2501.26	6.26	5.01	11.27	0.45	
G60	G60_maet_S1_300_141105	300	11.54	39.93	40.0998	0.068103	0.177676	-0.066391	2566.19	6.43	4.36	10.78	0.42	
G60	G60_maet_S1_300_151105	300 rep	11.54	39.93	40.0174	0.0601217	0.159835	-0.071035	2575.22	6.45	3.87	10.32	0.40	
G61	G61_maet_S1_100_15105	100	10.14	40.81	39.5722	0.126169	0.433305	-0.040661	2731.26	6.69	8.71	15.40	0.56	
G61	G61_maet_S1_200_151105	200	10.06	40.80	39.2779	0.0697804	0.152735	-0.064191	2773.30	6.80	4.93	11.72	0.42	
G61	G61_maet_S1_300_151105	300	10.01	40.79	39.1262	0.0751079	0.161694	-0.071901	2796.45	6.86	5.37	12.22	0.44	
G61	G61_maet_S1_300_161105	300 rep	10.01	40.79	39.111	0.0778813	0.193776	-0.074039	2793.97	6.85	5.56	12.41	0.44	

Table A.2. Page 2 of 2. Basic data, results, and precision of ultrasonic measurements.
Ultrasonic S1 signals measured on 12 samples in water saturated condition, S_w=100 %.

Sample id.	File id.	Conf. pressure (bar)	Reduced porosity (%)	Reduced length (mm)	First arrival of S1 signal (us)	Local un-certainty (us)	Global un-certainty	Amplitude at pick (mV)	S1 velocity (m/s)	Error on velocity from length (m/s)	Error on velocity from noise (m/s)	Error on velocity Total error (m/s)	Total error (%)	Comment
Lopra-1 samples:														
L337	L337_maet_S1_100_171105	100	1.45	41.82	37.1452	0.0940542	0.229657	-0.091142	3341.53	7.99	8.46	16.45	0.49	
L337	L337_maet_S1_200_171105	200	1.44	41.82	37.0948	0.0316366	0.0803163	-0.174603	3337.74	7.98	2.85	10.83	0.32	
L337	L337_maet_S1_300_171105	300	1.44	41.82	37.0449	0.0301564	0.102251	-0.215333	3343.77	8.00	2.72	10.72	0.32	
L337	L337_maet_S1_300_181105	300 rep	1.44	41.82	37.052	0.0265305	0.0788539	-0.249474	3334.42	7.97	2.39	10.36	0.31	
L862	L862_maet_S1_100_181105	100	0.89	41.21	36.5529	0.087564	0.438767	-0.124148	3456.37	8.39	8.28	16.67	0.48	
L862	L862_maet_S1_200_181105	200	0.88	41.21	36.554	0.0591831	0.232142	-0.182309	3437.43	8.34	5.57	13.91	0.40	
L862	L862_maet_S1_300_181105	300	0.88	41.21	36.5327	0.0452447	0.142639	-0.211909	3435.69	8.34	4.26	12.59	0.37	
L862	L862_maet_S1_300_211105	300 rep	0.88	41.21	36.5315	0.0374434	0.129622	-0.256541	3428.03	8.32	3.51	11.83	0.35	
L1218	L1218_maet_S1_100_211105	100	1.93	40.52	36.724	0.0764155	0.307872	-0.136339	3350.36	8.27	6.97	15.24	0.45	
L1218	L1218_maet_S1_200_211105	200	1.91	40.52	36.6545	0.0554034	0.143206	-0.205818	3351.67	8.27	5.07	13.34	0.40	
L1218	L1218_maet_S1_300_211105	300	1.90	40.52	36.6219	0.0469345	0.124096	-0.227486	3353.08	8.28	4.30	12.57	0.37	
L1218	L1218_maet_S1_300_221105	300 rep	1.90	40.52	36.5987	0.0366187	0.160936	-0.265006	3351.75	8.27	3.35	11.63	0.35	
L1922	L1922_maet_S1_100_221105	100	2.62	40.74	36.895	0.0271815	0.138758	-0.2186	3321.34	8.15	2.45	10.60	0.32	
L1922	L1922_maet_S1_200_221105	200	2.59	40.73	36.8206	0.0232984	0.150174	-0.276069	3323.70	8.16	2.10	10.26	0.31	
L1922	L1922_maet_S1_300_221105	300	2.57	40.73	36.7621	0.0220592	0.0913236	-0.295185	3331.96	8.18	2.00	10.18	0.31	
L1922	L1922_maet_S1_300_231105	300 rep	2.56	40.73	36.7245	0.0204634	0.0715778	-0.31844	3334.53	8.19	1.86	10.05	0.30	
L2177	L2177_maet_S1_100_231105	100	1.85	40.28	36.2114	0.0389011	0.163354	-0.143412	3477.69	8.63	3.74	12.37	0.36	
L2177	L2177_maet_S1_200_231105	200	1.81	40.27	36.1517	0.0474468	0.225624	-0.192683	3475.93	8.63	4.56	13.19	0.38	
L2177	L2177_maet_S1_300_231105	300	1.78	40.27	36.1012	0.0434893	0.253175	-0.215069	3482.62	8.65	4.20	12.84	0.37	
L2177	L2177_maet_S1_300_241105	300 rep	1.78	40.27	36.0946	0.0362637	0.227012	-0.225823	3476.20	8.63	3.49	12.13	0.35	

Table A.3. Page 1 of 2. Basic data, results, and precision of ultrasonic measurements.
Ultrasonic S2 signals measured on 12 samples in water-saturated condition, S_w=100 %.

Sample id.	File id.	Conf. pressure (bar)	Reduced porosity (%)	Reduced length (mm)	First arrival of S2 signal (us)	Local un-certainty (us)	Global un-certainty	Amplitude at pick (mV)	S2 velocity (m/s)	Error on velocity from length (m/s)	Error on velocity from noise (m/s)	Error on velocity Total error (m/s)	Total error (%)	Comment
Vestmanna-1 samples:														
V16	16V_maet_S2_100_071105	100	13.24	37.22	42.1909	0.0828063	0.231605	-0.017949	2200.35	5.91	4.32	10.23	0.46	
V16	16V_maet_S2_200_071105	200	12.95	37.19	41.1916	0.0650471	0.151816	-0.03213	2327.86	6.26	3.68	9.94	0.43	
V16	16V_maet_S2_300_071105	300	12.75	37.16	40.6726	0.0364517	0.0839464	-0.041662	2400.35	6.46	2.15	8.61	0.36	
V16	16V_maet_S2_300_081105	300 rep	12.75	37.16	40.5404	0.0421464	0.101219	-0.047032	2418.64	6.51	2.51	9.02	0.37	
Glyvursnes-1 samples:														
G8	G8_maet_S2_100_281105	100	32.93	18.91	42.0402	0.0316231	0.300626	-0.008222	1127.75	5.96	0.85	6.81	0.60	S2 forced pick
G8	G8_maet_S2_200_281105	200	31.49	18.82	41.2791	0.960693	0	-0.02733	1171.43	6.23	27.26	33.49	2.86	S2 forced pick
G8	G8_maet_S2_300_281105	300	30.39	18.74	40.6785	0.639129	0	-0.025533	1210.24	6.46	19.01	25.47	2.10	S2 forced pick
G8	G8_maet_S2_300_291105	300 rep	30.13	18.73	40.291	0.556442	0	-0.028133	1238.95	6.62	17.11	23.73	1.92	S2 forced pick
G21	G21_maet_S2_100_291105	100	12.81	40.95	42.2926	0.0428051	0.550367	-0.007999	2405.99	5.88	2.44	8.31	0.35	
G21	G21_maet_S2_100_301105	100 rep	12.64	40.92	42.0995	0.0284763	0.576658	-0.010828	2432.22	5.94	1.65	7.59	0.31	
G21_pad	G21_maet_S2_100_011205	100	13.33	41.00	42.1337	0.0526356	0.210924	-0.011832	2431.73	5.93	3.04	8.97	0.37	
G21_pad	G21_maet_S2_200_011205	200	13.17	40.98	41.63	0.064135	0.145479	-0.015616	2496.64	6.09	3.85	9.94	0.40	
G21_pad	G21_maet_S2_300_011205	300	13.04	40.96	41.34	0.074513	0.176679	-0.017633	2536.31	6.19	4.57	10.76	0.42	
G21_pad	G21_maet_S2_300_021205	300 rep	13.01	40.96	41.258	0.059058	0.136537	-0.018988	2546.57	6.22	3.65	9.86	0.39	
G45	G45_maet_S2_100_081105	100	12.54	39.01	38.0328	0.0397429	0.107647	-0.041147	3057.66	7.84	3.20	11.03	0.36	
G45	G45_maet_S2_200_081105	200	12.48	39.01	37.9536	0.0247168	0.0561025	-0.069242	3062.44	7.85	1.99	9.85	0.32	
G45	G45_maet_S2_300_081105	300	12.44	39.00	37.9107	0.0299541	0.072709	-0.087317	3066.04	7.86	2.42	10.28	0.34	
G45	G45_maet_S2_300_091105	300 rep	12.44	39.00	37.8831	0.0288129	0.0706333	-0.08974	3069.03	7.87	2.33	10.20	0.33	
G57	G57_maet_S2_100_161105	100	15.94	38.04	41.9479	0.0786346	0.189829	-0.033019	2281.47	6.00	4.28	10.27	0.45	
G57	G57_maet_S2_200_161105	200	15.79	38.02	41.5595	0.0459641	0.098411	-0.058094	2326.61	6.12	2.57	8.69	0.37	
G57	G57_maet_S2_300_161105	300	15.68	38.01	41.3282	0.0447204	0.101705	-0.067055	2355.31	6.20	2.55	8.75	0.37	
G57	G57_maet_S2_300_171105	300 rep	15.68	38.01	41.2898	0.0518511	0.121593	-0.070578	2358.71	6.21	2.96	9.17	0.39	
G60	G60_maet_S2_100_141105	100	11.72	39.96	41.9011	0.061127	0.1431	-0.03677	2403.02	6.01	3.51	9.52	0.40	
G60	G60_maet_S2_200_141105	200	11.61	39.94	41.2373	0.0316034	0.0674348	-0.060859	2493.16	6.24	1.91	8.15	0.33	
G60	G60_maet_S2_300_141105	300	11.54	39.93	40.9137	0.0347649	0.0792422	-0.074099	2539.69	6.36	2.16	8.52	0.34	
G60	G60_maet_S2_300_151105	300 rep	11.54	39.93	40.8328	0.0421752	0.0984224	-0.081235	2550.39	6.39	2.63	9.02	0.35	
G61	G61_maet_S2_100_151105	100	10.14	40.81	40.4692	0.045978	0.0872949	-0.035401	2685.66	6.58	3.05	9.63	0.36	
G61	G61_maet_S2_200_151105	200	10.06	40.80	40.0898	0.0411256	0.0891963	-0.054	2743.21	6.72	2.81	9.54	0.35	
G61	G61_maet_S2_300_151105	300	10.01	40.79	39.9006	0.0379808	0.085338	-0.060048	2773.09	6.80	2.64	9.44	0.34	
G61	G61_maet_S2_300_161105	300 rep	10.01	40.79	39.855	0.0333838	0.0742309	-0.062266	2778.82	6.81	2.33	9.14	0.33	

Table A.3. Page 2 of 2. Basic data, results, and precision of ultrasonic measurements.
Ultrasonic S2 signals measured on 12 samples in water saturated condition, S_w=100 %.

Sample id.	File id.	Conf. pressure (bar)	Reduced porosity (%)	Reduced length (mm)	First arrival of S2 signal (us)	Local un-certainty (us)	Global un-certainty	Amplitude at pick (mV)	S2 velocity (m/s)	Error on velocity from length (m/s)	from noise (m/s)	Total error (m/s)	Total error (%)	Comment
Lopra-1 samples:														
L337	L337_maet_S2_100_171105	100	1.45	41.82	37.7738	0.0395032	0.122681	-0.088097	3345.46	8.00	3.50	11.50	0.34	
L337	L337_maet_S2_200_171105	200	1.44	41.82	37.7031	0.0257978	0.0666934	-0.148222	3349.03	8.01	2.29	10.30	0.31	
L337	L337_maet_S2_300_171105	300	1.44	41.82	37.6888	0.0283573	0.0693796	-0.175124	3345.81	8.00	2.52	10.52	0.31	
L337	L337_maet_S2_300_181105	300 rep	1.44	41.82	37.6441	0.0235407	0.0571059	-0.200417	3353.76	8.02	2.10	10.12	0.30	
L862	L862_maet_S2_100_181105	100	0.89	41.21	37.2231	0.0275759	0.0867946	-0.074122	3448.60	8.37	2.55	10.92	0.32	
L862	L862_maet_S2_200_181105	200	0.88	41.21	37.1893	0.0236088	0.0679849	-0.105977	3441.80	8.35	2.18	10.54	0.31	
L862	L862_maet_S2_300_181105	300	0.88	41.21	37.1742	0.016036	0.0448401	-0.124401	3438.57	8.34	1.48	9.83	0.29	
L862	L862_maet_S2_300_211105	300 rep	0.88	41.21	37.143	0.0205147	0.0523748	-0.156906	3443.18	8.36	1.90	10.26	0.30	
L1218	L1218_maet_S2_100_211105	100	1.93	40.52	37.3597	0.0272607	0.0714334	-0.098282	3352.48	8.27	2.45	10.72	0.32	
L1218	L1218_maet_S2_200_211105	200	1.91	40.52	37.2589	0.0244442	0.0612189	-0.143636	3364.50	8.30	2.21	10.51	0.31	
L1218	L1218_maet_S2_300_211105	300	1.90	40.52	37.232	0.0283665	0.0813902	-0.165036	3364.61	8.30	2.56	10.87	0.32	
L1218	L1218_maet_S2_300_221105	300 rep	1.90	40.52	37.2131	0.0188597	0.0448801	-0.195618	3365.68	8.31	1.71	10.01	0.30	
L1922	L1922_maet_S2_100_221105	100	2.62	40.74	37.8822	0.0263857	0.0701715	-0.188099	3230.76	7.93	2.25	10.18	0.32	
L1922	L1922_maet_S2_200_221105	200	2.59	40.73	37.7437	0.0329447	0.141195	-0.224261	3251.38	7.98	2.84	10.82	0.33	
L1922	L1922_maet_S2_300_221105	300	2.57	40.73	37.67	0.0281378	0.0907157	-0.228	3263.51	8.01	2.44	10.45	0.32	
L1922	L1922_maet_S2_300_231105	300 rep	2.56	40.73	37.6232	0.0247795	0.0658784	-0.234283	3271.77	8.03	2.15	10.19	0.31	
L2177	L2177_maet_S2_100_231105	100	1.85	40.28	37.412	0.0596274	0.681575	-0.312315	3318.03	8.24	5.29	13.53	0.41	
L2177	L2177_maet_S2_200_231105	200	1.81	40.27	37.274	0.0685174	0.838299	-0.375851	3339.92	8.29	6.14	14.43	0.43	
L2177	L2177_maet_S2_300_231105	300	1.78	40.27	37.1794	0.0646578	0.776377	-0.355015	3358.67	8.34	5.84	14.18	0.42	
L2177	L2177_maet_S2_300_241105	300 rep	1.78	40.27	37.1334	0.0635493	0.760518	-0.360498	3367.36	8.36	5.76	14.13	0.42	

Table A.4. Page 1 of 1. Basic data, results, and precision of ultrasonic measurements.
Ultrasonic P signals measured on 4 samples in humidity-controlled condition, T=60 °C, RH=40 %.

Sample id.	File id.	Conf. pressure (bar)	Reduced porosity (%)	Reduced length (mm)	First arrival of P signal (us)	Local un-certainty (us)	Global un-certainty	Amplitude at pick (mV)	P velocity (m/s)	Error on velocity from length (m/s)	Error on velocity from noise (m/s)	Error on velocity Total error (m/s)	Error on velocity Total error (%)	Comment
Lopra-1 samples:														
L337	L337_gas_P_100_071005	100	1.45	41.82	20.8892	0.0588882	0.172703	0.0424077	5857.06	14.01	16.51	30.52	0.52	
L337	L337_gas_P_200_071005	200	1.44	41.82	20.8443	0.021229	0.0679497	0.0756044	5855.67	14.00	5.96	19.97	0.34	
L337	L337_gas_P_300_071005	300	1.44	41.82	20.845	0.0178437	0.0556583	0.0906259	5852.64	14.00	5.01	19.01	0.32	
L337	L337_gas_P_300_101005	300 rep	1.44	41.82	20.813	0.0202642	0.061374	0.093199	5862.26	14.02	5.71	19.73	0.34	
L1218	L1218_gas_P_100_111005	100	1.93	40.52	20.6951	0.0345754	0.116204	0.0541707	5833.48	14.40	9.75	24.14	0.41	
L1218	L1218_gas_P_200_111005	200	1.91	40.52	20.6886	0.0299603	0.10566	0.0872483	5799.91	14.32	8.40	22.71	0.39	
L1218	L1218_gas_P_300_111005	300	1.90	40.52	20.6917	0.0178063	0.0588368	0.103856	5794.75	14.30	4.99	19.29	0.33	
L1218	L1218_gas_P_300_121005	300 rep	1.90	40.52	20.6737	0.025019	0.078097	0.100399	5792.86	14.30	7.01	21.31	0.37	
L1922	L1922_gas_P_100_121005	100	2.62	40.74	21.076	0.0274055	0.0926583	0.0708661	5559.83	13.65	7.23	20.88	0.38	
L1922	L1922_gas_P_200_121005	200	2.59	40.73	21.003	0.0225563	0.0751671	0.105392	5579.44	13.70	5.99	19.69	0.35	
L1922	L1922_gas_P_300_121005	300	2.57	40.73	20.8948	0.0220281	0.0677784	0.1144	5660.64	13.90	5.97	19.87	0.35	
L1922	L1922_gas_P_300_131005	300 rep	2.56	40.73	20.8743	0.0267453	0.0803564	0.116352	5660.71	13.90	7.25	21.15	0.37	
L2177	L2177_gas_P_100_131005	100	1.85	40.28	20.6441	0.0214052	0.0736332	0.0809546	5841.42	14.50	6.06	20.56	0.35	
L2177	L2177_gas_P_200_131005	200	1.81	40.27	20.5296	0.0153035	0.0502315	0.125314	5899.03	14.65	4.40	19.05	0.32	
L2177	L2177_gas_P_300_131005	300	1.78	40.27	20.4386	0.0127938	0.0419185	0.139952	5975.57	14.84	3.74	18.58	0.31	
L2177	L2177_gas_P_300_141005	300 rep	1.78	40.27	20.4324	0.0202563	0.0620046	0.134037	5963.12	14.81	5.91	20.72	0.35	

Table A.5. Page 1 of 1. Basic data, results, and precision of ultrasonic measurements.
Ultrasonic S1 signals measured on 4 samples in humidity-controlled condition, T=60 °C, RH=40 %.

										Error on velocity				
		Conf.	Reduced	Reduced	First arrival	Local un-	Global un-	Amplitude		from	from	Total	Total	
Sample	File	pressure	porosity	length	of S1 signal	certainty	certainty	at pick	S1 velocity	length	noise	error	error	
id.	id.	(bar)	(%)	(mm)	(us)	(us)		(mV)	(m/s)	(m/s)	(m/s)	(m/s)	(%)	Comment
Lopra-1 samples:														
L337	L337_gas_S1_100_071005	100	1.45	41.82	37.3448	0.0291311	0.0762231	-0.156343	3289.07	7.87	2.57	10.43	0.32	
L337	L337_gas_S1_200_071005	200	1.44	41.82	37.2738	0.035876	0.0977663	-0.21919	3290.73	7.87	3.17	11.04	0.34	
L337	L337_gas_S1_300_071005	300	1.44	41.82	37.259	0.0331774	0.0972767	-0.239154	3287.49	7.86	2.93	10.79	0.33	
L337	L337_gas_S1_300_101005	300 rep	1.44	41.82	37.249	0.0361607	0.115625	-0.248619	3282.86	7.85	3.19	11.04	0.34	
L1218	L1218_gas_S1_100_111005	100	1.93	40.52	36.7926	0.026606	0.0642692	-0.209991	3331.46	8.22	2.41	10.63	0.32	
L1218	L1218_gas_S1_200_111005	200	1.91	40.52	36.7621	0.0356988	0.12546	-0.265322	3322.10	8.20	3.23	11.43	0.34	
L1218	L1218_gas_S1_300_111005	300	1.90	40.52	36.7424	0.0329948	0.104947	-0.285218	3319.97	8.19	2.98	11.18	0.34	
L1218	L1218_gas_S1_300_121005	300 rep	1.90	40.52	36.7443	0.0325066	0.085589	-0.290667	3311.86	8.17	2.93	11.10	0.34	
L1922	L1922_gas_S1_100_121005	100	2.62	40.74	37.7487	0.0150672	0.0323332	-0.329895	3105.20	7.62	1.24	8.86	0.29	
L1922	L1922_gas_S1_200_121005	200	2.59	40.73	37.5236	0.0171081	0.0376453	-0.380576	3143.38	7.72	1.43	9.15	0.29	
L1922	L1922_gas_S1_300_121005	300	2.57	40.73	37.3446	0.0210911	0.0478597	-0.375812	3180.40	7.81	1.80	9.61	0.30	
L1922	L1922_gas_S1_300_131005	300 rep	2.56	40.73	37.3017	0.0212663	0.0486536	-0.385123	3184.06	7.82	1.82	9.63	0.30	
L2177	L2177_gas_S1_100_131005	100	1.85	40.28	36.4658	0.0375812	0.117554	-0.159868	3402.94	8.45	3.51	11.96	0.35	
L2177	L2177_gas_S1_200_131005	200	1.81	40.27	36.3534	0.0366913	0.105256	-0.205798	3416.45	8.48	3.45	11.93	0.35	
L2177	L2177_gas_S1_300_131005	300	1.78	40.27	36.2405	0.0414375	0.145448	-0.200158	3441.16	8.55	3.93	12.48	0.36	
L2177	L2177_gas_S1_300_141005	300 rep	1.78	40.27	36.2543	0.0358206	0.116228	-0.21062	3428.92	8.52	3.39	11.90	0.35	

Table A.6. Page 1 of 1. Basic data, results, and precision of ultrasonic measurements.
Ultrasonic S2 signals measured on 4 samples in humidity-controlled condition, T=60 °C, RH=40 %.

Sample id.	File id.	Conf. pressure (bar)	Reduced porosity (%)	Reduced length (mm)	First arrival of S2 signal (us)	Local un-certainty (us)	Global un-certainty	Amplitude at pick (mV)	S2 velocity (m/s)	Error on velocity from length (m/s)	Error on velocity from noise (m/s)	Error on velocity Total error (m/s)	Total error (%)	Comment
Lopra-1 samples:														
L337	L337_gas_S2_100_071005	100	1.45	41.82	37.9903	0.0232422	0.0513918	-0.109315	3288.51	7.86	2.01	9.88	0.30	
L337	L337_gas_S2_200_071005	200	1.44	41.82	37.9045	0.0208723	0.0450379	-0.160654	3295.87	7.88	1.81	9.70	0.29	
L337	L337_gas_S2_300_071005	300	1.44	41.82	37.8662	0.0198135	0.0434635	-0.175037	3298.98	7.89	1.73	9.62	0.29	
L337	L337_gas_S2_300_101005	300 rep	1.44	41.82	37.8622	0.0256846	0.0556125	-0.180095	3296.10	7.88	2.24	10.12	0.31	
L1218	L1218_gas_S2_100_111005	100	1.93	40.52	37.3664	0.0184131	0.0443823	-0.11958	3350.62	8.27	1.65	9.92	0.30	
L1218	L1218_gas_S2_200_111005	200	1.91	40.52	37.335	0.020564	0.0483308	-0.160254	3343.38	8.25	1.84	10.09	0.30	
L1218	L1218_gas_S2_300_111005	300	1.90	40.52	37.3307	0.0260548	0.0619646	-0.184545	3337.26	8.24	2.33	10.57	0.32	
L1218	L1218_gas_S2_300_121005	300 rep	1.90	40.52	37.3437	0.0251675	0.0592868	-0.186033	3329.55	8.22	2.24	10.46	0.31	
L1922	L1922_gas_S2_100_121005	100	2.62	40.74	37.9298	0.0394333	0.080234	-0.075938	3218.61	7.90	3.35	11.25	0.35	
L1922	L1922_gas_S2_200_121005	200	2.59	40.73	37.8659	0.027063	0.0600973	-0.120848	3219.97	7.91	2.30	10.21	0.32	
L1922	L1922_gas_S2_300_121005	300	2.57	40.73	37.7838	0.032847	0.0745364	-0.141156	3234.02	7.94	2.81	10.75	0.33	
L1922	L1922_gas_S2_300_131005	300 rep	2.56	40.73	37.73	0.0324275	0.073699	-0.145078	3243.94	7.97	2.79	10.75	0.33	
L2177	L2177_gas_S2_100_131005	100	1.85	40.28	37.9598	0.0583197	0.524341	-0.400005	3174.75	7.88	4.88	12.76	0.40	
L2177	L2177_gas_S2_200_131005	200	1.81	40.27	37.7535	0.0585105	0.573327	-0.530256	3212.18	7.98	4.98	12.95	0.40	
L2177	L2177_gas_S2_300_131005	300	1.78	40.27	37.6136	0.0629203	0.728233	-0.516001	3241.28	8.05	5.42	13.47	0.42	
L2177	L2177_gas_S2_300_141005	300 rep	1.78	40.27	37.5824	0.0620216	0.714172	-0.525174	3245.50	8.06	5.36	13.42	0.41	