

TEST 18. Experiments using dry core data depth 3098.68

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SUMMARY

This experiment assumes 39 layers of Material composed of 7 minerals including 23 % kero-
gen as a mineral. Material 1 has 6 % porosity

Also we have 3 layers of Material 2 consisting of kerogen with porosity 6 % with properties
as in Propiedades-minerales.pdf que mando Ariel para el mu.

Layer 1 has proportions as in code Voight-Reuss-Ariel.f (Configuracion 1) but changed to get
porosity 6 %

$f1 = 0.1068$

$f2 = 0.0237$

$f3 = 0.3727$! increase clay original 0.2727

$f4 = 0.1461$! decrease quartz original 0.2461

$f5 = 0.0257$

$f6 = 0.035$

$f7 = 0.23$

Key words: layered VTI media, finite Element, harmonic experiments

1 INTRODUCTION

2 TEST 18

Depth 3094.68 m as in Notas.pdf from Ariel

2.1 data for 7 minerals with kerogen as mineral 7

Fluid properties

K-air = 1.01325d5 (Pa)

rho-air = 1.225d0 kg/m^3

eta-air = 1.805d-5 Pa . s

K-water = 1000.d0 (Pa)

rho-water = 1000.d0 kg/m^3

eta-water = 0.001d0 Pa . s

Minerals density

rhos-calcite = 2720.d0 kg/m^3 density of Calcite (mineral 1)

rhos-dolomite = 2900.d0 kg/m^3 density of Dolomite (mineral 2)

rhos-clay = 2700.d0 kg/m^3 density of Clay (mineral 3)

rhos-quartz = 2650.d0 kg/m^3 density of Quartz (mineral 4)

rhos-plagioclase = 2650.d0 kg/m^3 density of plagioclase (mineral 5)

rhos-pyrite = 5000.d0 kg/m^3 density of pyrite (mineral 6)

rhos-kerogen = 1400.d0 kg/m^3 density of kerogen (mineral 7)

Proportions of Calcite, Dolomite, Clay, Quartz, plagioclase, pyrite

phi1 = 0.1068 Calcite proportion

phi2 = 0.0237 Dolomite proportion

phi3 = 0.3727 ! increase clay original 0.2727

$\phi_4 = 0.1461$ Quartz proportion decrease quartz original 0.2461

$\phi_5 = 0.0257$ plagioclase proportion

$\phi_6 = 0.035$ Pyrite porportion

$\phi_7 = 0.23$ Kerogen proportion

porosity (ϕ_8) = 0.06

Material properties of minerals and air as a fluid

$K_1 = 70 \cdot 10^9$ Calcite bulk modulus (GPa)

$K_2 = 85 \cdot 10^9$ bulk modulus Dolomite (GPa)

$K_3 = 15 \cdot 10^9$ Clay bulk modulus (GPa)

$K_4 = 35 \cdot 10^9$ Quartz bulk modulus (GPa)

$K_5 = 70 \cdot 10^9$ plagioclase bulk modulus (GPa)

$K_6 = 120 \cdot 10^9$ pyrite bulk modulus (GPa)

$K_7 = 3.0 \cdot 10^9$ Kerogen bulk modulus (GPa)

$\mu_1 = 40 \cdot 10^9$ shear modulus calcite (GPa)

$\mu_2 = 45 \cdot 10^9$ shear modulus dolomite (GPa)

$\mu_3 = 15 \cdot 10^9$ Shear modulus Clay (GPa)

$\mu_4 = 40 \cdot 10^9$ Shear modulus Quartz (GPa)

$\mu_5 = 38.49$ Shear modulus plagioclase

$\mu_6 = 100 \cdot 10^9$ Shear modulus pyrite

$\mu_7 = 2.0 \cdot 10^9$ Kerogen shear modulus (GPa)

With this bulk moduli of each mineral and a generalized Krief as in paper 42 we get the values

K_m y μ_m of the composite rock (Material 1)

$K_m = 20.24$ (GPa)

$\mu_m = 17.44$ (GPa)

We also computed

K-Reuss (GPa) = 9.24

K-Voight (GPa) = 26.88

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$\mu\text{-Reuss (GPa)} = 6.80$

$\mu\text{-Voight (GPa)} = 23.17$

Other input data for the pij codes:

K_s computed using the Biot coefficient α measured in the dry code

$\alpha = 0.15$ and using K_m computed as explained above:

$K_s = K_m / (1 - \alpha)$

yields

$K_s = 23.81$ (GPa) (goes to the input files of the pij codes)

We also computed the average density of material 1 (goes to the input files of the pij codes)

Composite density of material 1 ESTO hay que ARREGLAR $= 2350 \text{ kg/m}^3$

For material 2 (Kerogen) we have 1 laye of porosity 6 % wih properties

$ks(2) = 3.d0$

En las corridas se uso 5.d+9 Mod. Bulk granos solidos (Pa) Kerogen

$ros(2) = 1400.d0$ densidad granos solidos (kg/m^3)

$km(2) = 4.3d+9$ GPa Kerogen

$mum(2) = 1.3d+9$ GPa Kerogen

$phi(2) = 0.06d0$ porosidad

$kappa(2) = 2.75d-18$ permeabilidad (m^2)

Additional data is

Air density $= 1.225 \text{ kg/m}^3$

water density $= 1000 \text{ kg/m}^3$

air bulk modulus $K\text{-air} = 1.0132510^5$ (Pa)

Air viscosity $\eta\text{-air} = 1.80510^{-5}$ (Pa . s)

water viscosity $= 0.001d0$ (Pa . s)

VTI experiments

We run the pij codes using the above data and then copy p11.freq, p33.freq, p55.freq, p66.freq and eps11.freq, eps33.freq into the directory where we have the backus4 code

We use in the input file

for a 1 mm thickness square sample

number of periods: 1

mesh size: $2.38095238 \cdot 10^{-5}$

size of layer 1 in subintervals 39

size of layer 1 (m) $9.2857142 \cdot 10^{-4}$

size of layer 2 (Kerogen)in subintervals 3

size of layer 2 (m) $7.142857142 \cdot 10^{-5}$

2.2 Computed VTI phase velocities using the dry-core data.

Table 1 summarizes the results of the VTI experiments on a 1 mm thickness dry sample having 1 periods of 39 dry layers with a combination 7 minerals including kerogen and 1 dry Kerogen layer.

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Table 1. Phase velocities from the harmonic experiments and the measured ones, error percentage. Measured values were taken from file Notas.pdf. Frequency is 1 MHz

Phase velocity vp (m/s)	Computed	Measured	Percentage error
v11	4538.78	4331	4.78 %
v33	4033.84	4217.47	4.3 %
v55	2075.7	2193.61	5.3 %
v66	2729.82	??	?? %

Table 2. Numerical pij values from the VTI experiments. Frequency is 1 MHz

p11
(44194062270.862778,78974517.122855112)
p33
(34907797973.333115,31758051.178474706)
p55
(9243098427.4961338,1.42039999999999994E-013)
p66
(15986584902.135059,5922783.2391896239)
p13
(10506610493.317066,-92310982.475791544)

Habia un error en el codigo p66, hay que roatr la muestrar 90 grados, Ahorase ve p66 distinto que p55 y se ve la onda SH

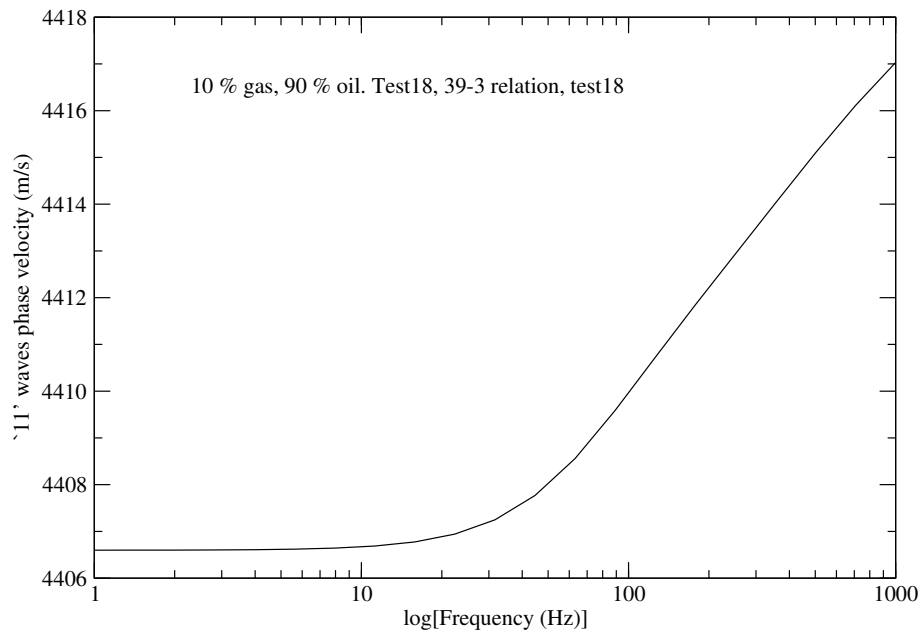


Figure 1. Test 18. '11' waves phase velocity as function of frequency. The medium consists of 1 period of 39 layers of the composite porous solid including kerogen as a mineral (mineral 7) and 3 kerogen layer (relation 39-1). Material 1 has 23 % of kerogen as mineral 7. The pore space in both Materials is saturated with an effective fluid with 10 % gas and 90 % oil.

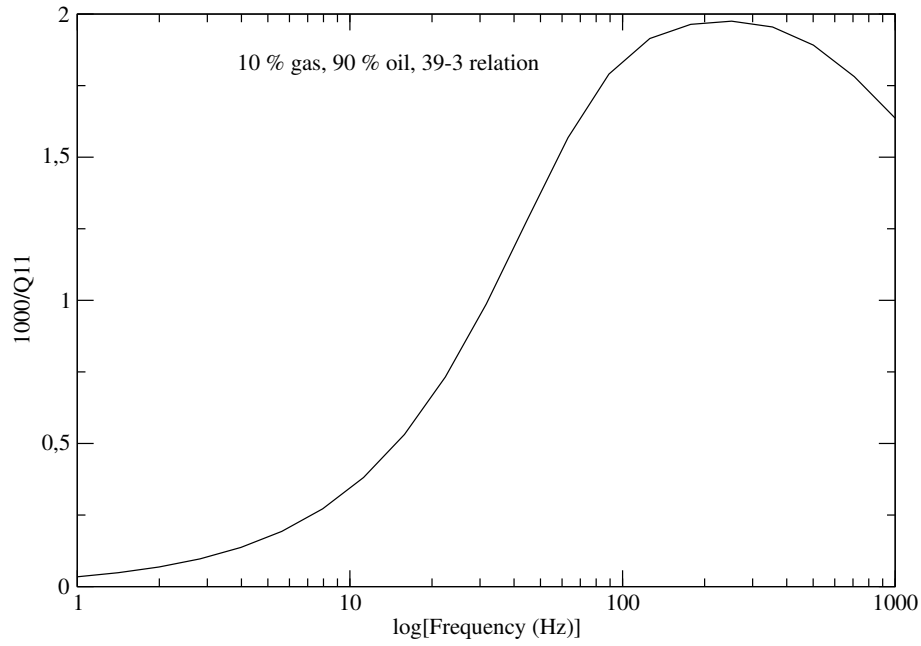


Figure 2. Test 18. ‘11’ waves attenuation factor $1000/Q_{11}$ as function of frequency. The medium consists of 1 period of 39 layers of the composite porous solid including kerogen as a mineral (mineral 7) and 3 kerogen layer (relation 39-1). Material 1 has 23 % of kerogen as mineral 7. The pore space in both Materials is saturated with an effective fluid with 10 % gas and 90 % oil.

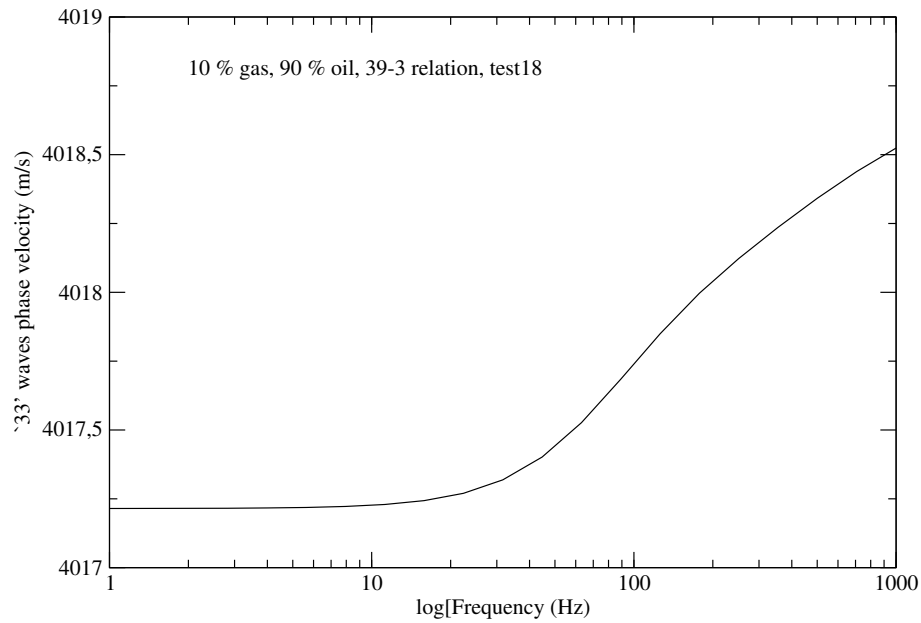


Figure 3. Test 18. '33' waves phase velocity as function of frequency. The medium consists of 1 period of 39 layers of the composite porous solid including kerogen as a mineral (mineral 7) and 3 kerogen layer (relation 39-1). Material 1 has 23 % of kerogen as mineral 7. The pore space in both Materials is saturated with an effective fluid with 10 % gas and 90 % oil.

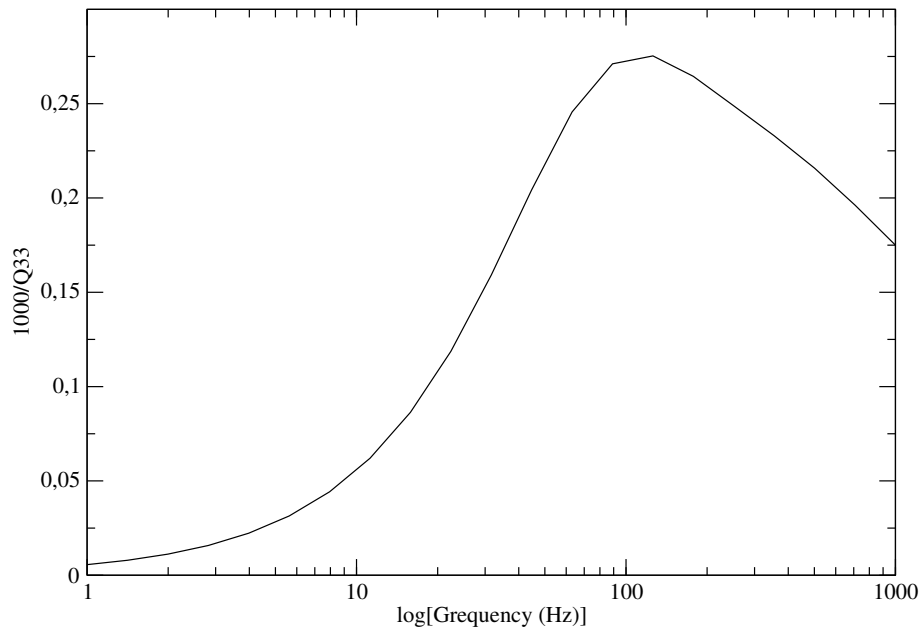


Figure 4. Test 18. ‘33’ waves attenuation factor $1000/Q_{33}$ as function of frequency. The medium consists of 1 period of 39 layers of the composite porous solid including kerogen as a mineral (mineral 7) and 3 kerogen layer (relation 39-1). Material 1 has 23 % of kerogen as mineral 7. The pore space in both Materials is saturated with an effective fluid with 10 % gas and 90 % oil. Note that the attenuation peak is shifted to higher frequencies as compared with ‘11’ waves. This is also observed in paper 91.

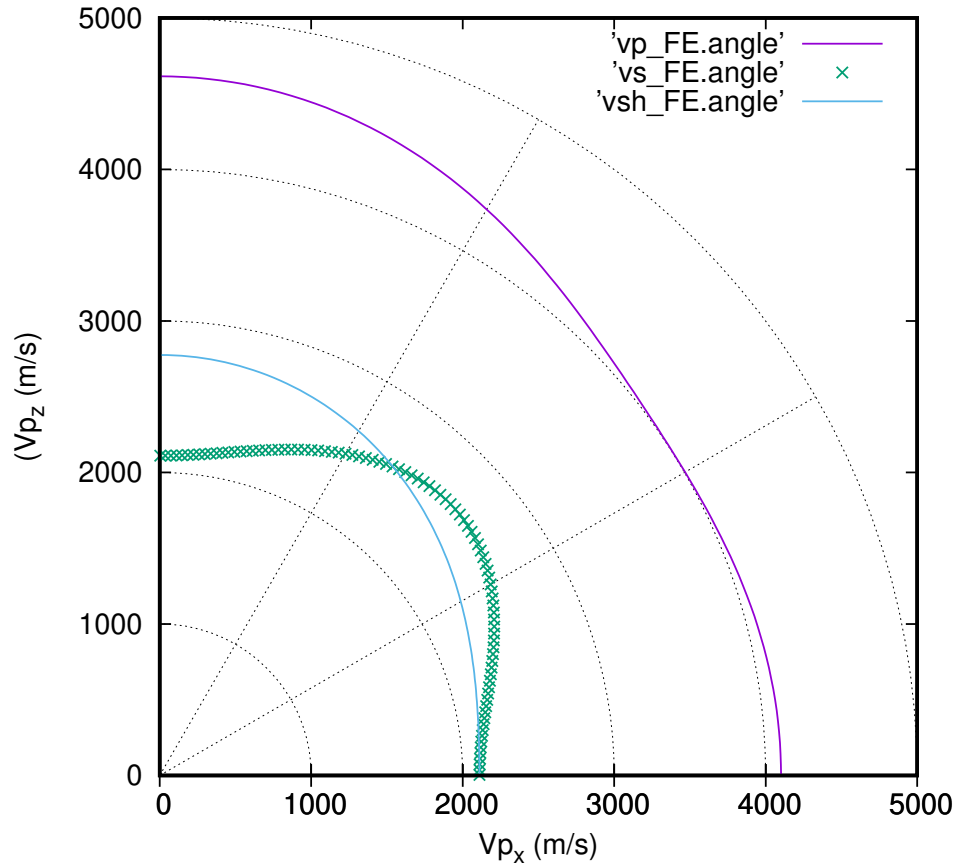


Figure 5. Test 18. Polar representation of phase velocities of qP, qSV and SH waves at 1 MHz. The medium consists of 1 period of 39 dry layers of the composite porous solid including kerogen as a mineral (mineral 7) and 3 dry kerogen layer (relation 39-3). Material 1 has 23 % of kerogen as mineral 7.

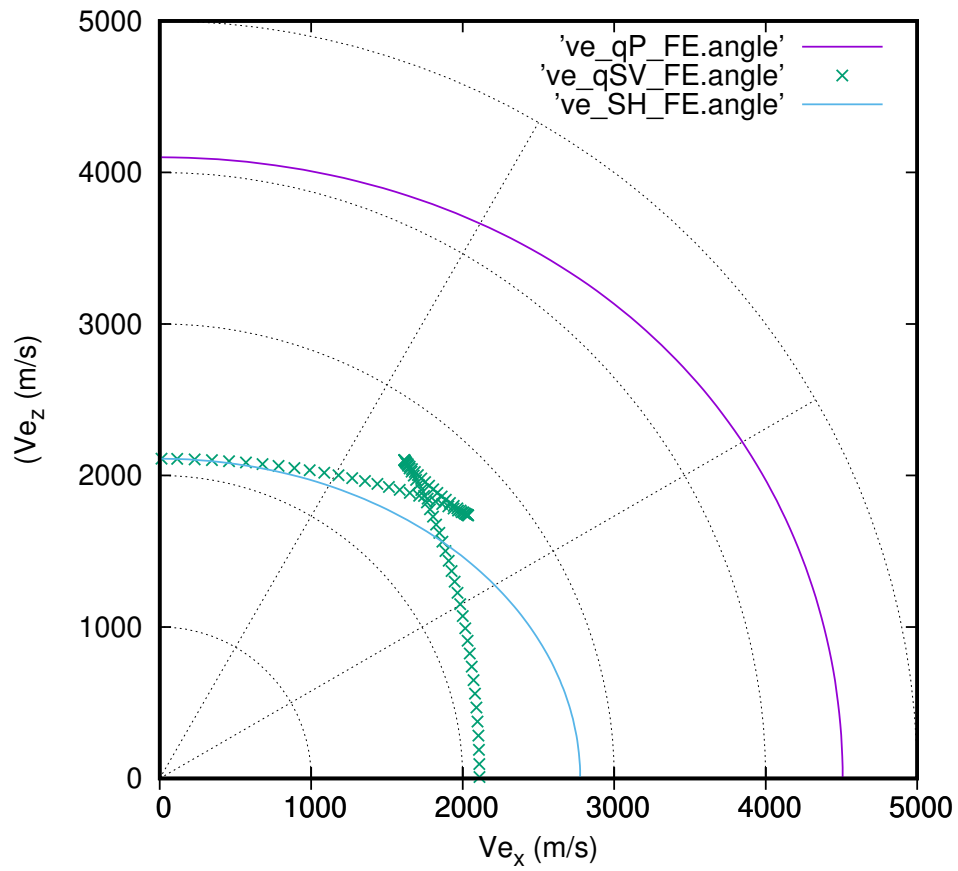


Figure 6. Test 18. Polar representation of energy velocities of qP, qSV and SH waves at 1 MHz. The medium consists of 1 period of 39 dry layers of the composite porous solid including kerogen as a mineral (mineral 7) and 3 dry kerogen layer (relation 39-1). Material 1 has 23 % of kerogen as mineral 7