CHINA UNIVERSITY OF PETROLEUM (BEIJING)

Seismic Dispersion and Attenuation in Shale oil Reservoir :

— Laboratory Experiments and Theoretical analysis

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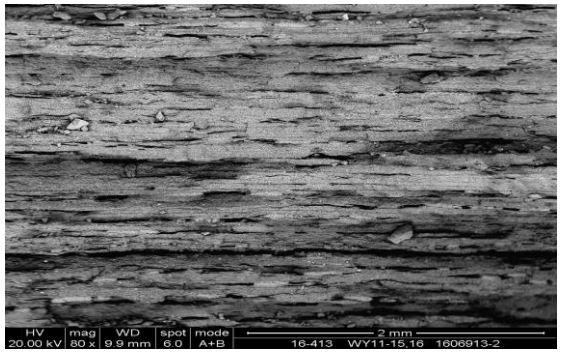
Introduction

Motivation

- shales are anisotropic materials with a transversely isotropic(TI) symmetry. however, the seismic dispersion and attenuation could also be anisotropic in shale oil reservoir?

- Main controlling factors of seismic velocity dispersion and attenuation in shale oil reservoirs: mineral, structure, pore or horizontal micro-cracks and fluid? How to explain it?



Outline of The Report

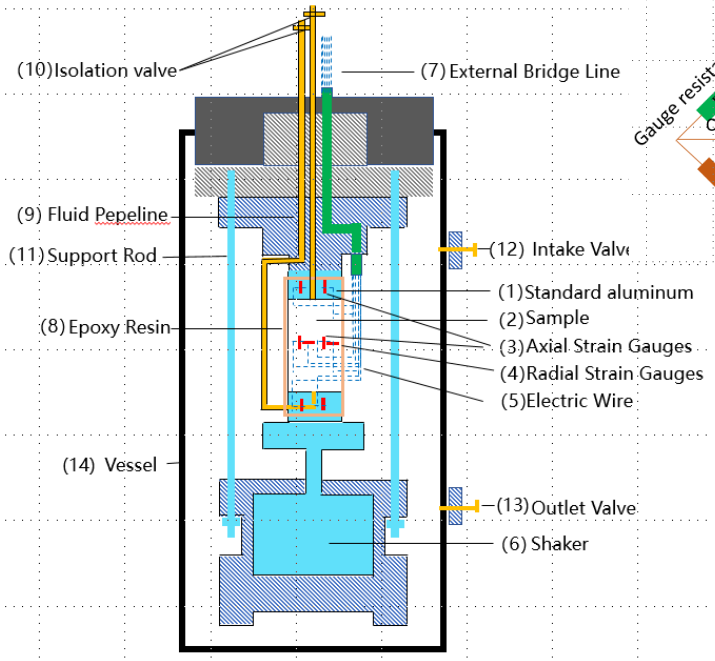
Part Ⅰ: Description of Experiment Details

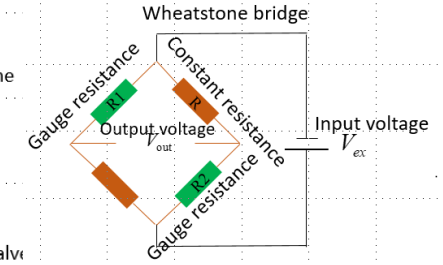
Part Ⅱ: Experimental Results and Discussion

Part Ⅰ:Description of Experiment Details

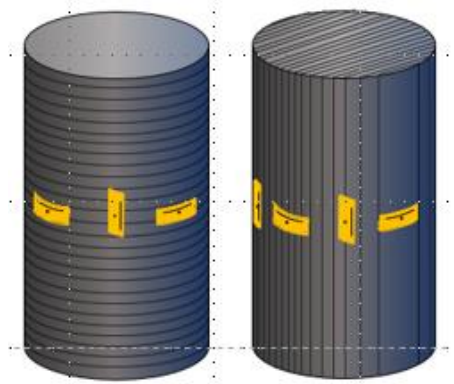
Experimental apparatus and test method

How to get the TI's medium Young's modulus and Poisson's ratio?





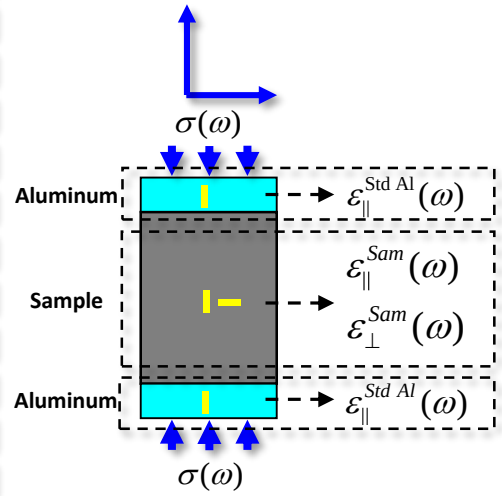
$$\varepsilon = \frac{2V_{out}}{k_{GS} * k_{GF} * V_{ex}}$$



Schematic drawings of the experimental setup (Batzle,2006)

Vertical Sample

Horizontal Sample



Standard Aluminum:

$$E^{Std\ Al} = \frac{\sigma^{Std\ Al}(\omega)}{\varepsilon_{\perp}^{Std\ Al}(\omega)}$$

Shale Sample:

$$E_{H,V}(\omega) = \frac{\sigma^{Sam}(\omega)}{\varepsilon_{\parallel}^{Sam}(\omega)} = \frac{\sigma^{Std\ Al}(\omega)}{\varepsilon_{\parallel}^{Sam}(\omega)}$$

$$= E^{Sam} \bullet \frac{\varepsilon_{\parallel}^{Std\ Al}(\omega)}{\varepsilon_{\parallel}^{Sam}(\omega)}$$

$$\nu_{HH,HV,VH}(\omega) = \frac{\varepsilon_{\perp}^{Sam}(\omega)}{\varepsilon_{\parallel}^{Sam}(\omega)}$$

$$Q_E^{-1}(\omega) = \tan(\theta_{\parallel}^{Std\ Al}(\omega) - \theta_{\parallel}^{Sam}(\omega))$$

E_V, ν_{VH} E_H, ν_{HH}, ν_{HV}

Part Ⅰ:Description of Experiment Details

Description of Samples and Experimental Procedure

The characteristics of the shale and the experimental conditions

The vertical and horizontal samples of the shale oil

V-Sample H- Sample

Table1 Sample information

	V-Sample	H-Sample
Depth	2819.13m	2819.13m
Diameter	38.14mm	38.26mm
Length	56.53mm	55.98mm
density	2.35g/cm^3	2.37g/cm^3
porosity	12.09%	11.95%

Table2 Mineral content

Mineral	%
Quartz	10.6
Clay	17.9
Carbonate	34.3
Glauberite	30.7
Others	6.5

Table3 Fluid properties

Fluid	
Name	White oil
Density	0.82g/cm^3
viscosity	6.56mPas
Saturation	92%

Table4 Experiment conditions

Frequency range		Confining pressure	Saturability	Temperature
1-2000Hz	1MHz	5-30MPa	92%	25℃

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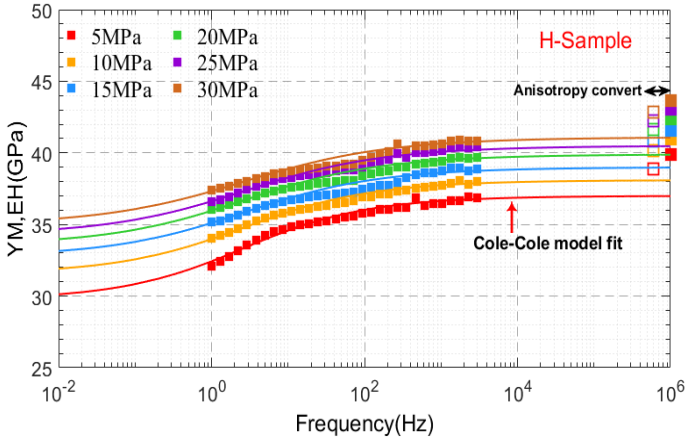
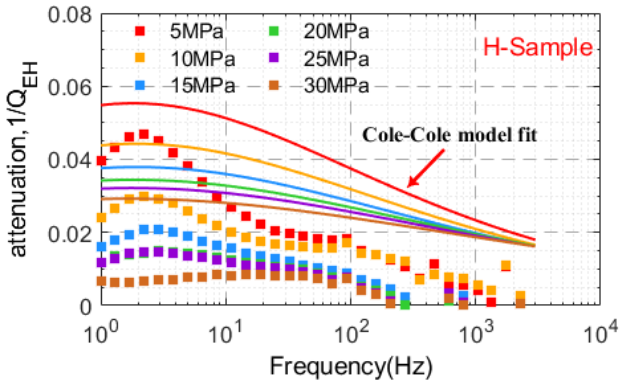
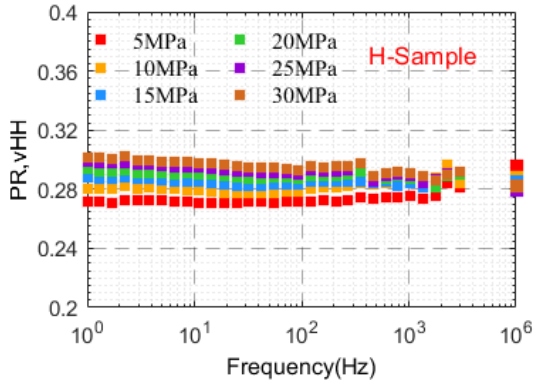
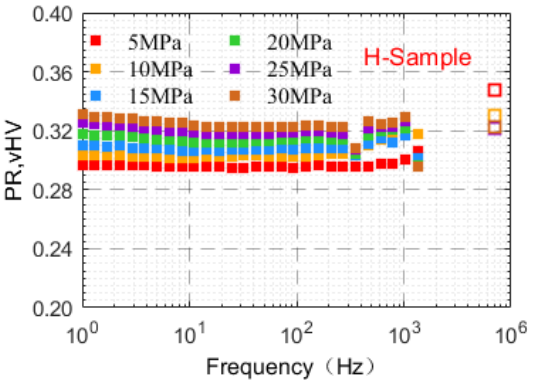
TI's Young's Modulus and Poisson's Ratio and attenuation

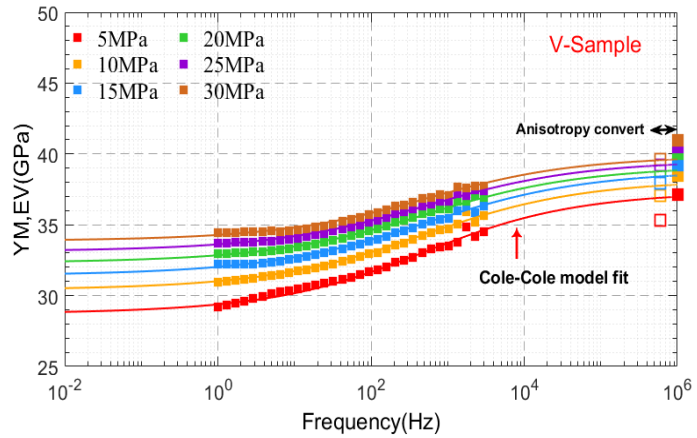
The Young's modulus dispersion and extensional attenuation are anisotropic

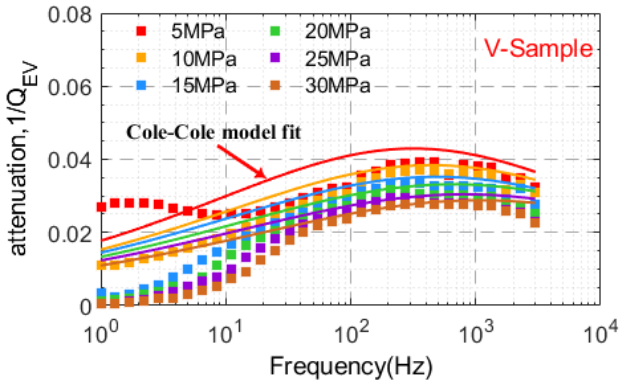


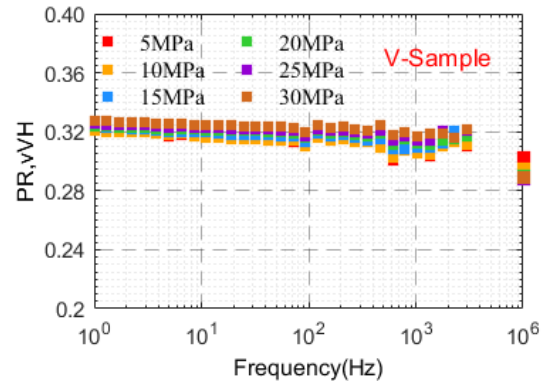


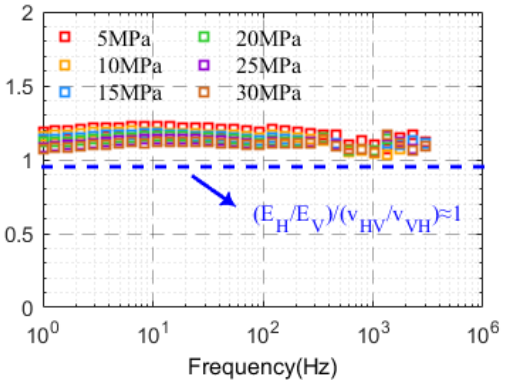








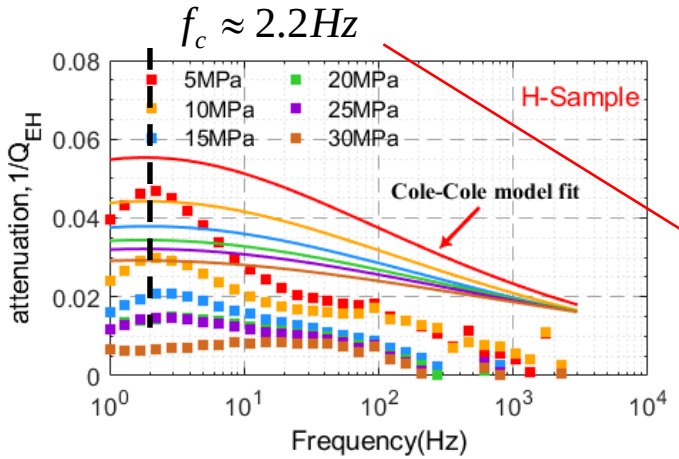


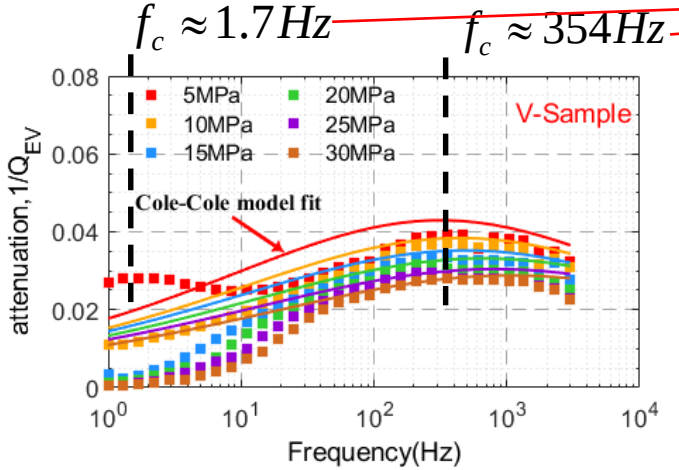


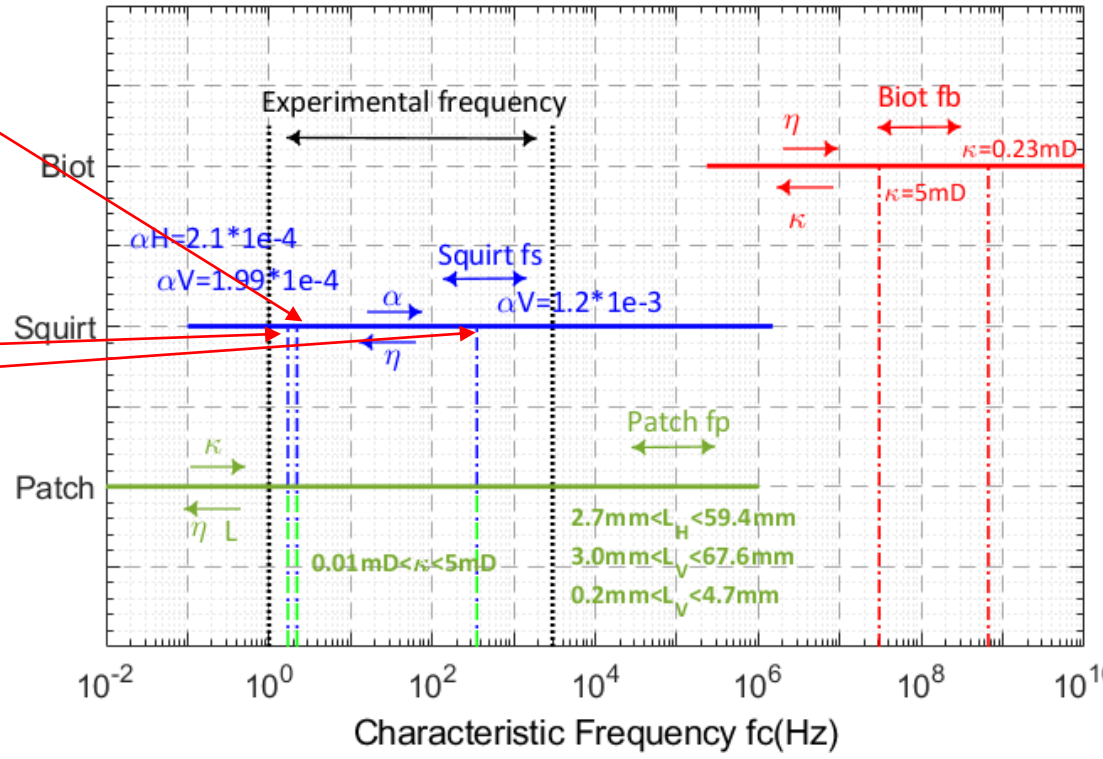
Part Ⅱ:Experimental Results and Discussion

Discussion of dispersion and attenuation

Compare different attenuation mechanisms based on characteristic frequencies







macroscopic scale:

$$f_{biot} \approx \phi\eta / 2\pi\rho_{fl}\kappa \quad ①$$

microscopic scale:

$$f_{squirt} \approx K_0\alpha^3 / \eta \quad ②$$

Mesoscopic scale:

$$f_{patchy} \approx \kappa K_s / \pi L^2 \eta \quad ③$$

Mavko et al. 2009

Conclusions

- Our measurements demonstrate the seismic dispersion and attenuation are anisotropic and pressure-sensitive in shale oil reservoir.

- Shale seismic dispersion and attenuation factors are complex and may include one or more of the existing theoretical mechanisms, mesoscale fluid patchy saturation and microscale squirt-flow.

And further research will be conducted.

Acknowledgement

Thank you for listening!