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Julia Holzhauer, Daniel Brito

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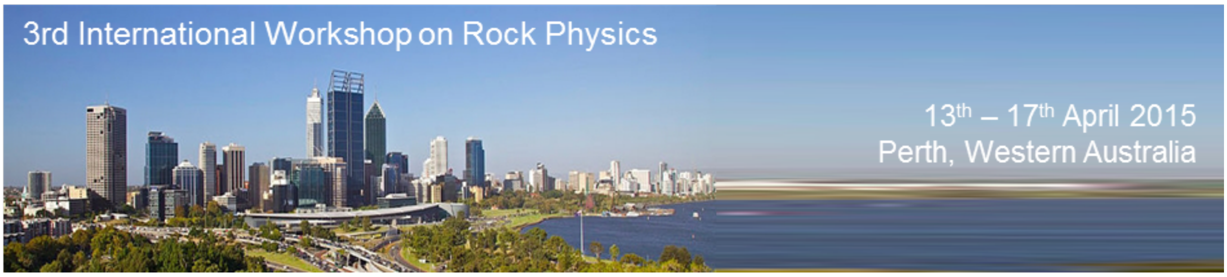

Interpretation of strong seismic attenuation in quartz sand in the kiloHertz range

Bordes C. [a,b], Müller T. [c], Qi Q.[b], Madadi M.[b], Gurevich B.[b,c], Holzhauer J.[a], and Brito D. [a]

[a] *LFC-R Université de Pau et des Pays de l'Adour, France;*
[b] *Department of Exploration Geophysics, Curtin University, Australia;*
[c] *CSIRO Perth, Australia;*
clarisse.bordes@univ-pau.fr

Summary

When a seismic wave propagates in a porous medium, dissipation can occur due to relative fluid displacements and/or heterogeneities of the frame. Numerous theoretical models were proposed in the last decades to describe the mechanisms involved in attenuation and dispersion of seismic waves. In this study we propose to interpret attenuation of both fast and slow P waves recorded closely to the Biot frequency. The experiment consists in propagating seismic waves (kiloHertz range) in quartz sand filled with water. Even if the Biot theory is well suited for the prediction of attenuation levels of the slow P wave, it fails in expecting the very strong attenuation for the fast P wave. In this study, we explore different dissipation phenomena which could be involved in this very strong attenuation.

Introduction

When seismic waves propagates in an heterogeneous medium, elastodynamics is not accurate anymore to describe both phase velocity and attenuation. Indeed, it is commonly admitted that dissipation phenomena can occur, depending on the petrophysical properties and frequency range. Biot (1956) originally described these losses as being due to fluid displacements at the micro-scale. Afterwards, other authors showed meso-scale heterogeneities (larger than the pore size but smaller than the wavelength) can also induce very strong dissipation. For example, patchy saturation may induce very strong attenuation when the distribution of pore fluids is not homogeneous (Pride & Berryman, 2003; Toms et al., 2006, 2007; Muller et al., 2010; Qi et al., 2014). Heterogeneities in porosity and/or permeability can also be involved (Pride & Berryman, 2003). Wave induced fluid flow is also often cited as a potential mechanism at microscopic scale when the wave are propagating in a medium which pores may have different stiffness (Gurevich & Lopatnikov, 1995; Pride & Berryman, 2003). Eventually, grain to grain losses are also involved in unconsolidated media (Stoll & Bryan, 1970; Stoll, 1985; Barrière et al., 2012).

Laboratory measurements of attenuation in quartz sand

The experiment consists of a wooden tank filled with quartz sand and equipped with a pneumatic seismic source. Seismic propagation (in the kiloHertz range) is recorded by broadband accelerometers and water saturation is monitored by capacitive probes (Bordes et al., in press). When reaching the full saturation, raw data clearly show a fast ($\simeq$ 1700m/s) and a slow arrival ($\simeq$ 50m/s). These two arrivals are supposed to be the fast and slow P waves described by Biot (1956). They are perfectly distinct and can be easily extracted from full records for inverse quality factor estimation using cross spectra. As shown on figure

(1), Q^{-1} measured on the second arrival is consistent with inverse quality factor predicted for the slow P wave by the Biot theory. Nevertheless, it fails in predicting the very strong Q^{-1} measured on the first (fast) arrival.

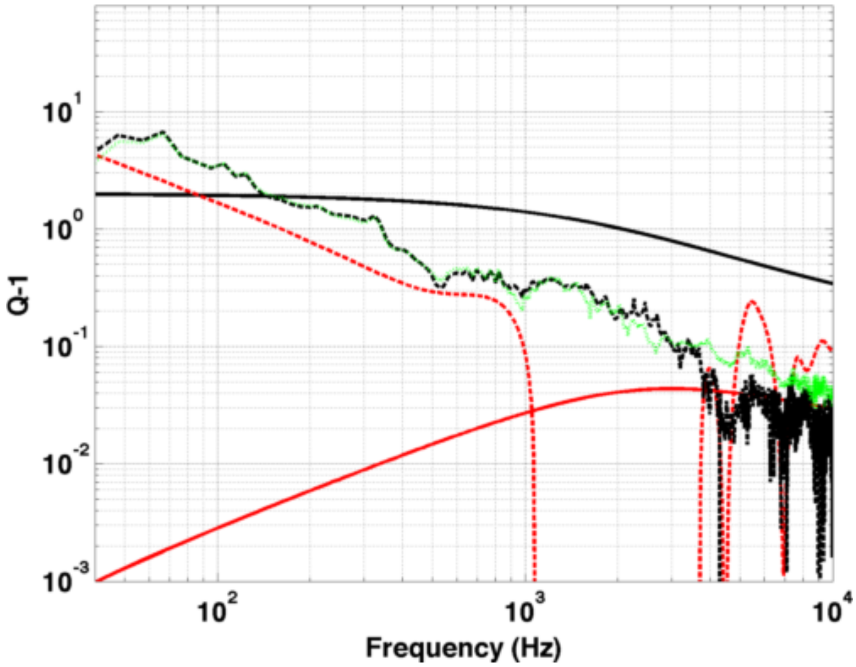

Figure 1: Inverse quality factors measured on fast arrival (red dashed line), slow arrival (black dashed line) and on full record (green line). The theoretical predictions obtained with the Biot theory for fast and slow P waves are respectively displayed by red and black solid lines. (from Bordes et al. (2014))

Perspectives

In unconsolidated sediments (for example quartz sand) Biot's losses are not accurate to explain very strong attenuation of fast P waves. Indeed, it is necessary to implement a complete petrophysical model including different dissipation processes (wave induced fluid flow, porosity heterogeneities, anelastic properties of the frame....) which have different effect on fast and slow P waves. In light of these different mechanisms, we propose to interpret fast and slow P wave attenuation measured in a water fluid sand. We eventually show that these two P waves modes have different sensitivity to these dissipation mechanisms.

Acknowledgements

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