# Frequency effects at pre-, near- and post-critical offsets observed on experimental data

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# Fractures

- Fracture direction
- Fracture density

- Vertical set of fractures
- Intercepting system of fractures

- Physical modeling
- Theoretical modeling

# Outline

- Experiment
- Data analysis
- Forward modeling
  - Modeling based on effective reflection coefficients
  - Reflectivity modeling
- RMS data analysis
- Discussion

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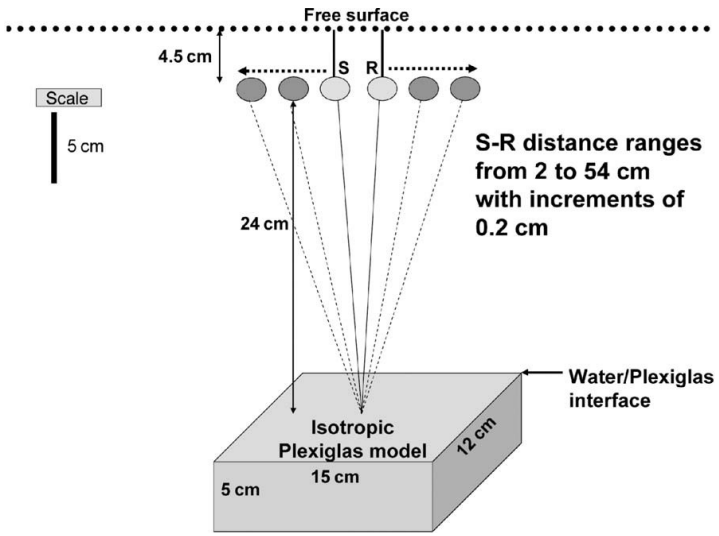
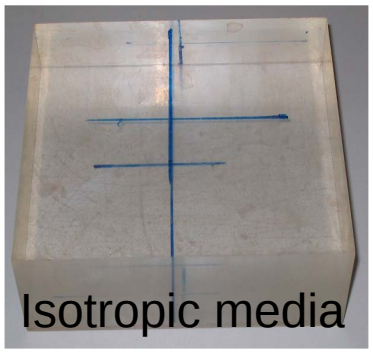
# Experiment

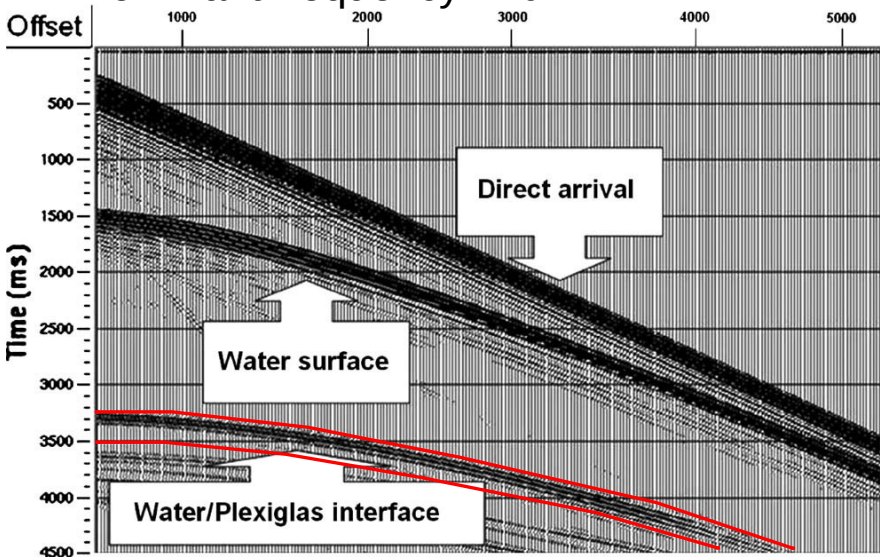



- Plane interface water-plexiglass
- 1 dataset for isotropic media
- 7 datasets for fractured media (Multiazimuth coverage)
- Pre-, near- and post-critical offsets
- Dominant frequency 220 kHz

Alhussain, Curtin University, 2007







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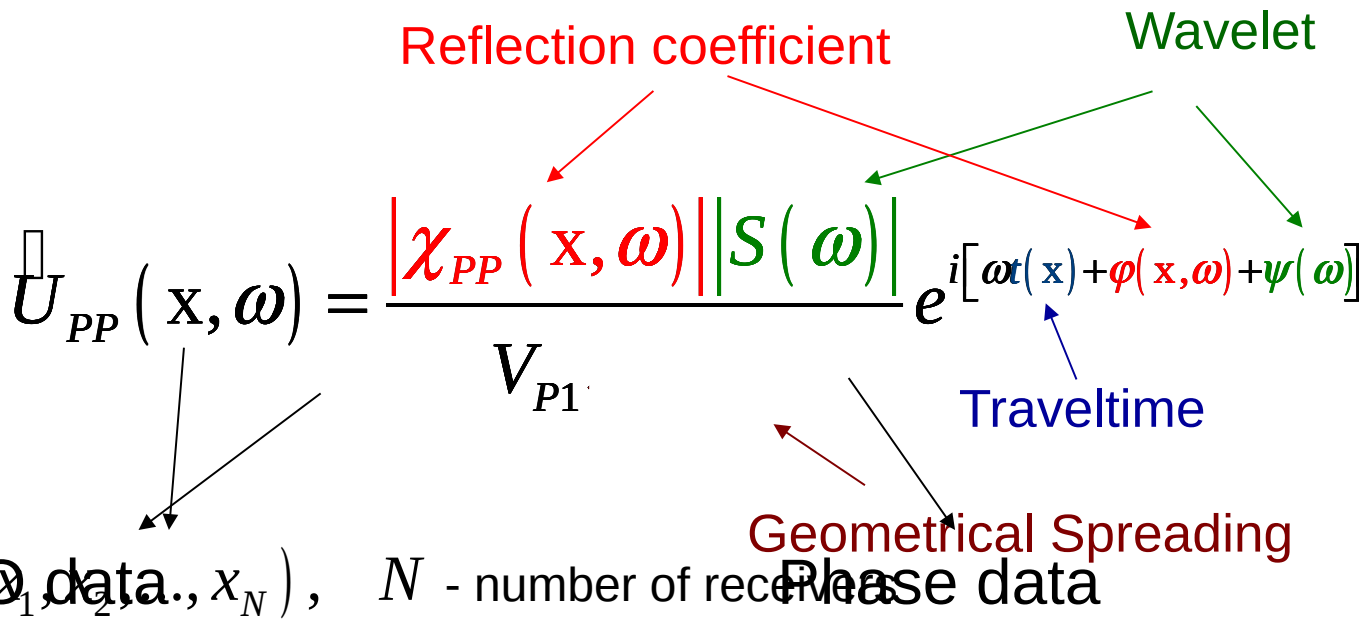
# Data Analysis

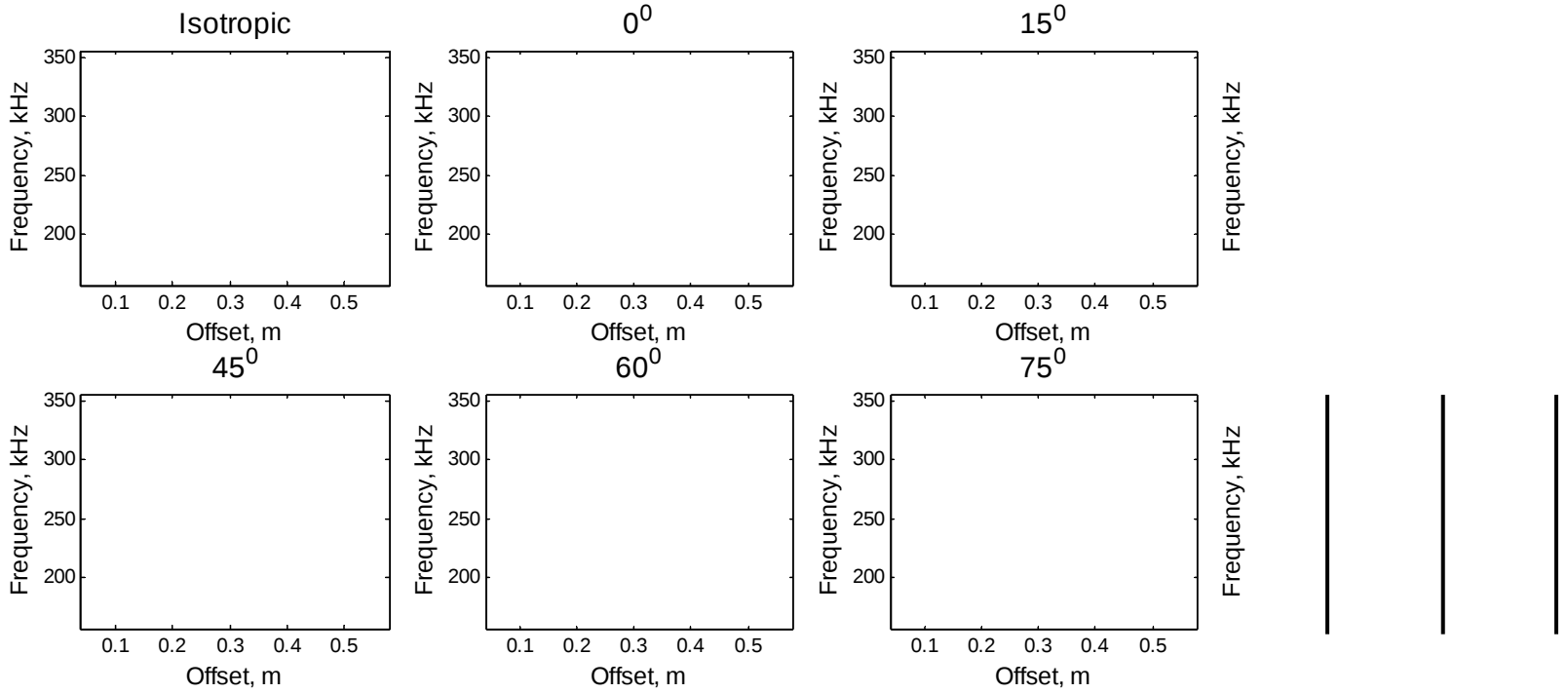



$$\frac{|\mathring{U}_{PP}(x,\omega)|}{|\mathring{U}_{PP}(x_1,\omega)|} = \frac{|\chi_{PP}(x,\omega)|}{|\chi_{PP}(x_1,\omega)|}$$

$$T(x,\omega) = \mathrm{Im}\left[\frac{\partial \varphi(x,\omega)}{\partial \omega} + \frac{1}{\mathring{U}_{PP}(x,\omega)} \frac{\partial \mathring{U}_{PP}(x,\omega)}{\partial \omega}\right] - \left[\frac{\partial \varphi(x_1,\omega)}{\partial \omega} + \frac{1}{\mathring{U}_{PP}(x_1,\omega)} \frac{\partial \mathring{U}_{PP}(x_1,\omega)}{\partial \omega}\right] - t(x)$$

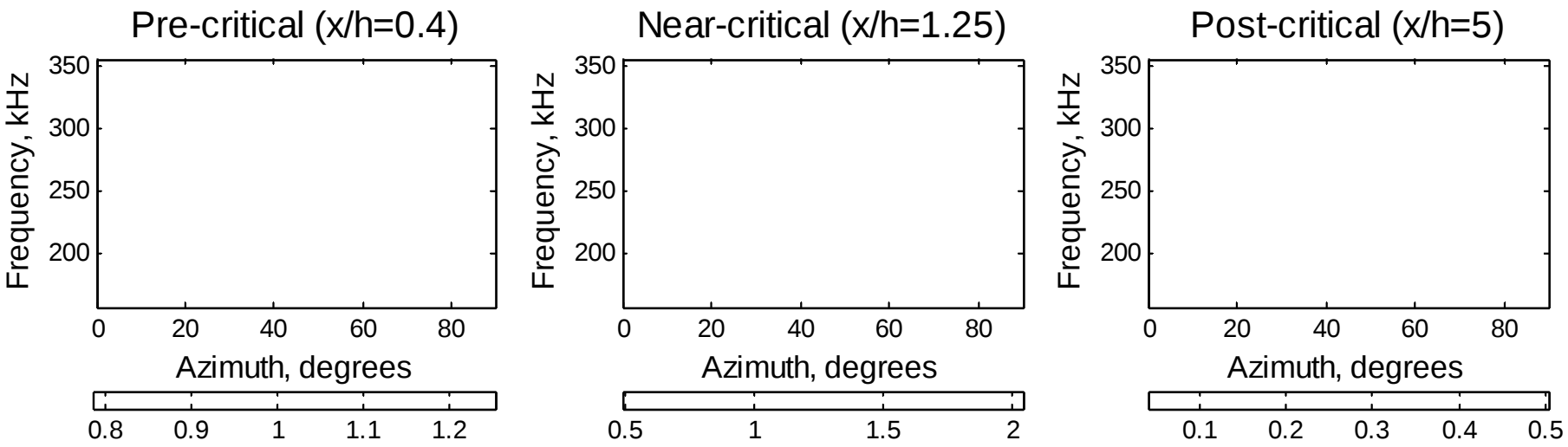
Frequency effects are associated with underburden

# AVO data



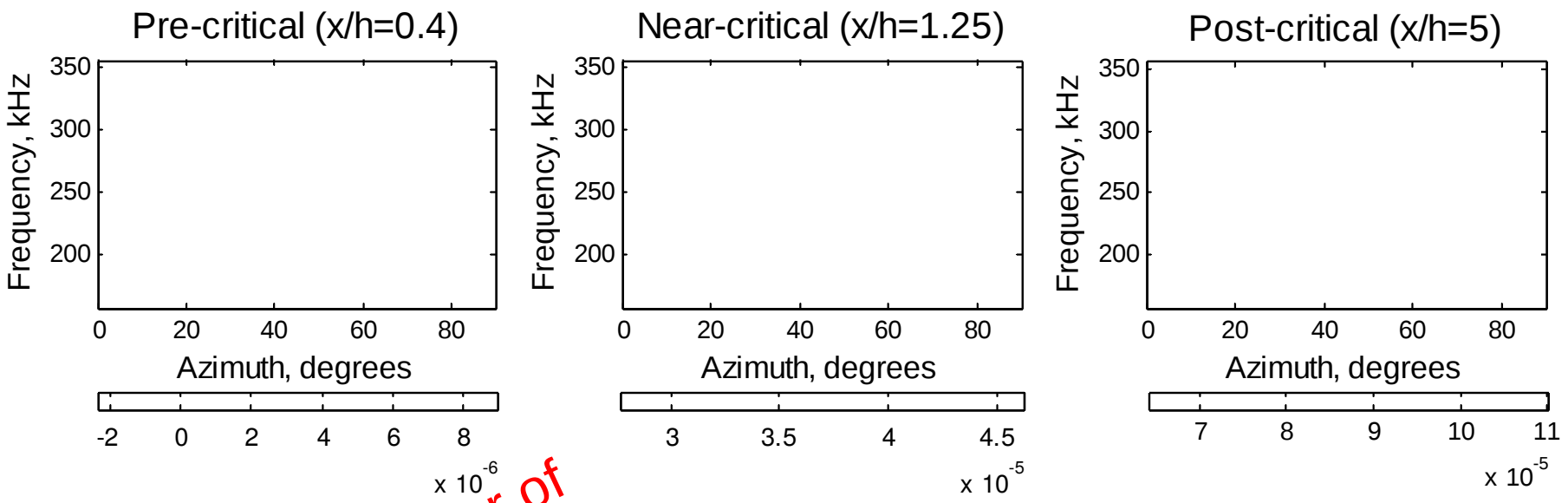

- Azimuthal dependence of amplitudes
- Strong amplitude at near-critical offsets
- Weak amplitude at post-critical offsets
- Frequency effect at pre-, near- and post-critical offsets

# AVO data

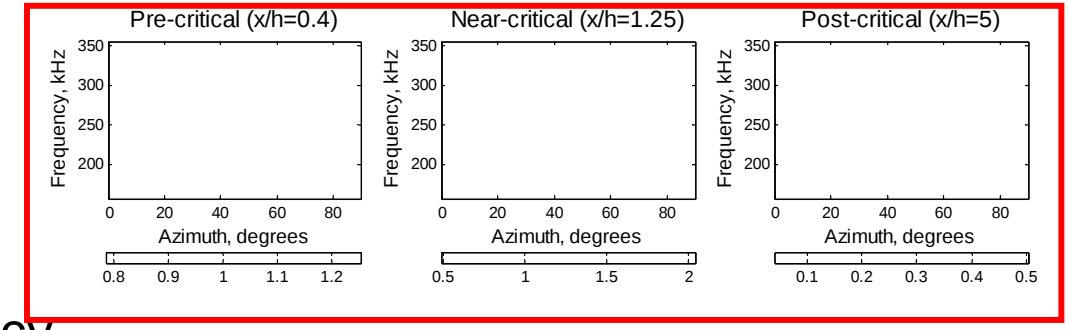



- Periodical changes with frequency
- Azimuthal changes at pre-, near- and post-critical offsets

# Phase data




Indicator of fracture direction




- Periodical changes with frequency
- Azimuthal changes at pre-, near- and post-critical offsets

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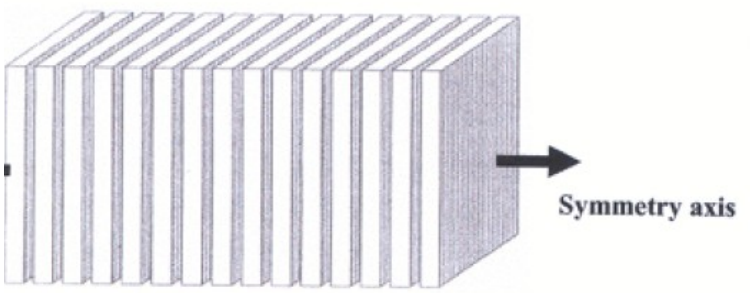
# Forward modeling

- Fractures => HTI model
  - azimuthal dependence




- Near-, post-critical offsets
  - critical angle phenomena

Theory of
Effective reflection coefficients
(ERC) [Ayzenberg et al, 2009]

$$\frac{\left|\mathring{U}_{PP}\left(\mathrm{x},\omega\right)\right|}{\left|\mathring{U}_{PP}\left(x_1,\omega\right)\right|}=\frac{\left|\chi_{PP}\left(\mathrm{x},\omega\right)\right|}{\left|\chi_{PP}\left(x_1,\omega\right)\right|}$$

Reflectivity modeling

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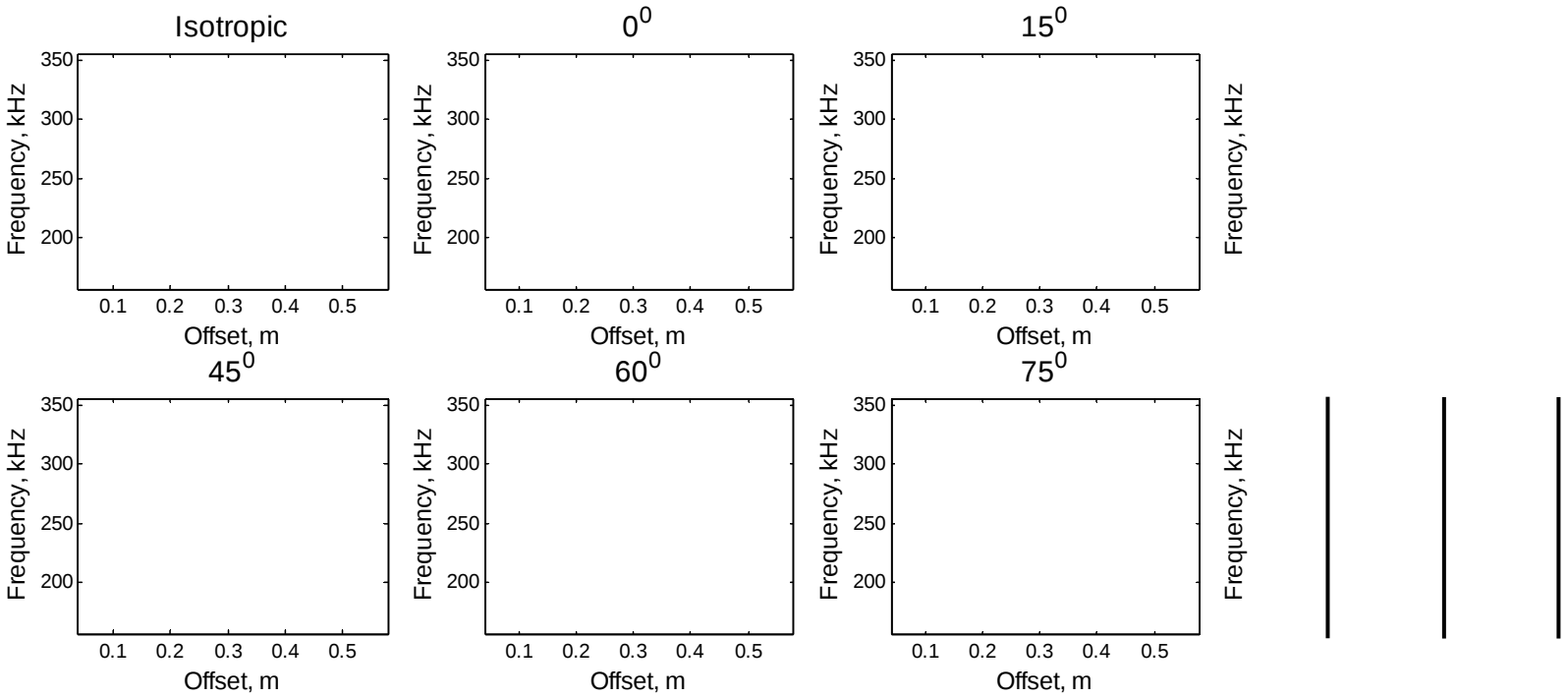
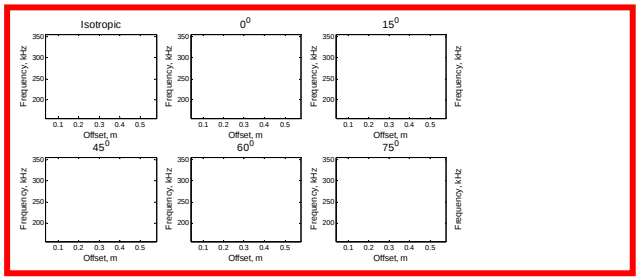
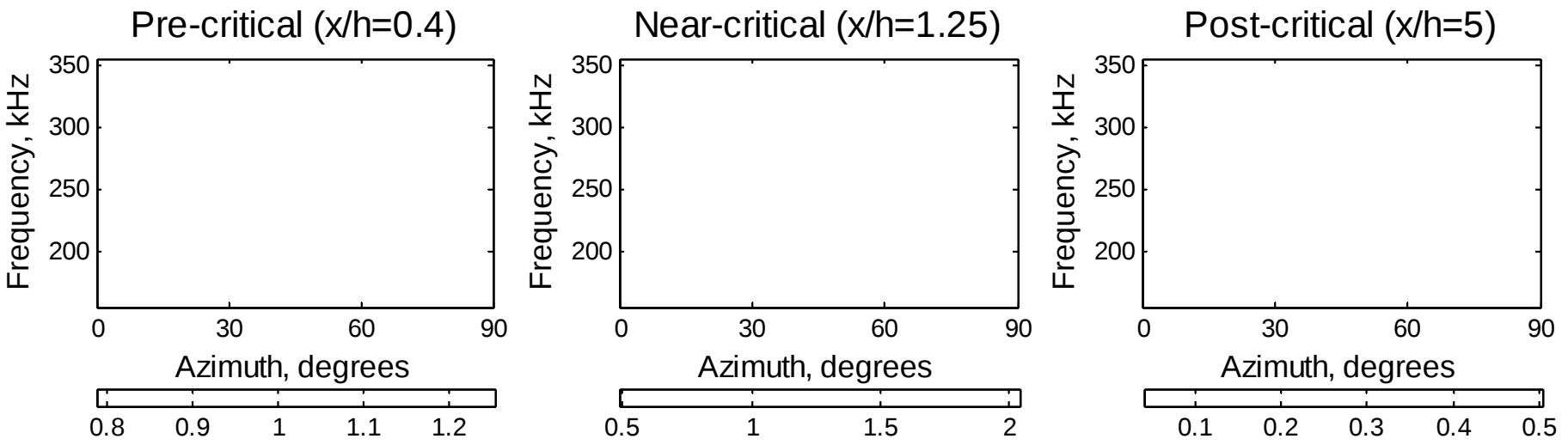
# ERC-based AVO data

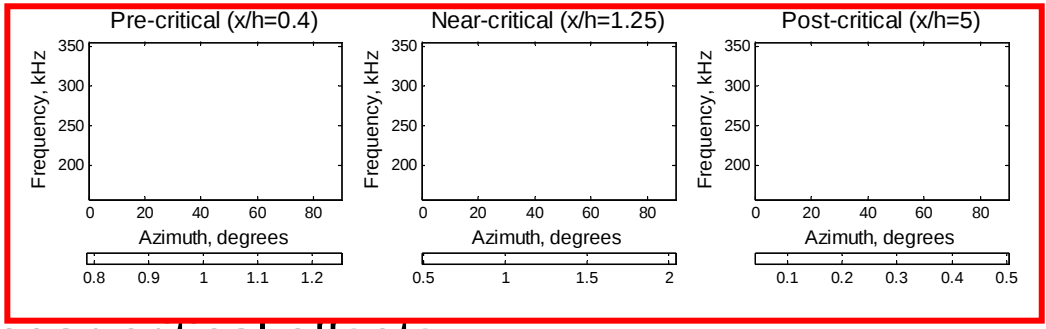



- Strong amplitudes at near-critical offsets
- Weak oscillating amplitudes at post-critical offsets
- Frequency effect at near- and post-critical offsets
- NO frequency effect at pre-critical offsets



# ERC-based AVO data




- NO frequency effect at pre- and near-critical offsets
- Frequency effect at post-critical offsets => Indicator of fracture directions

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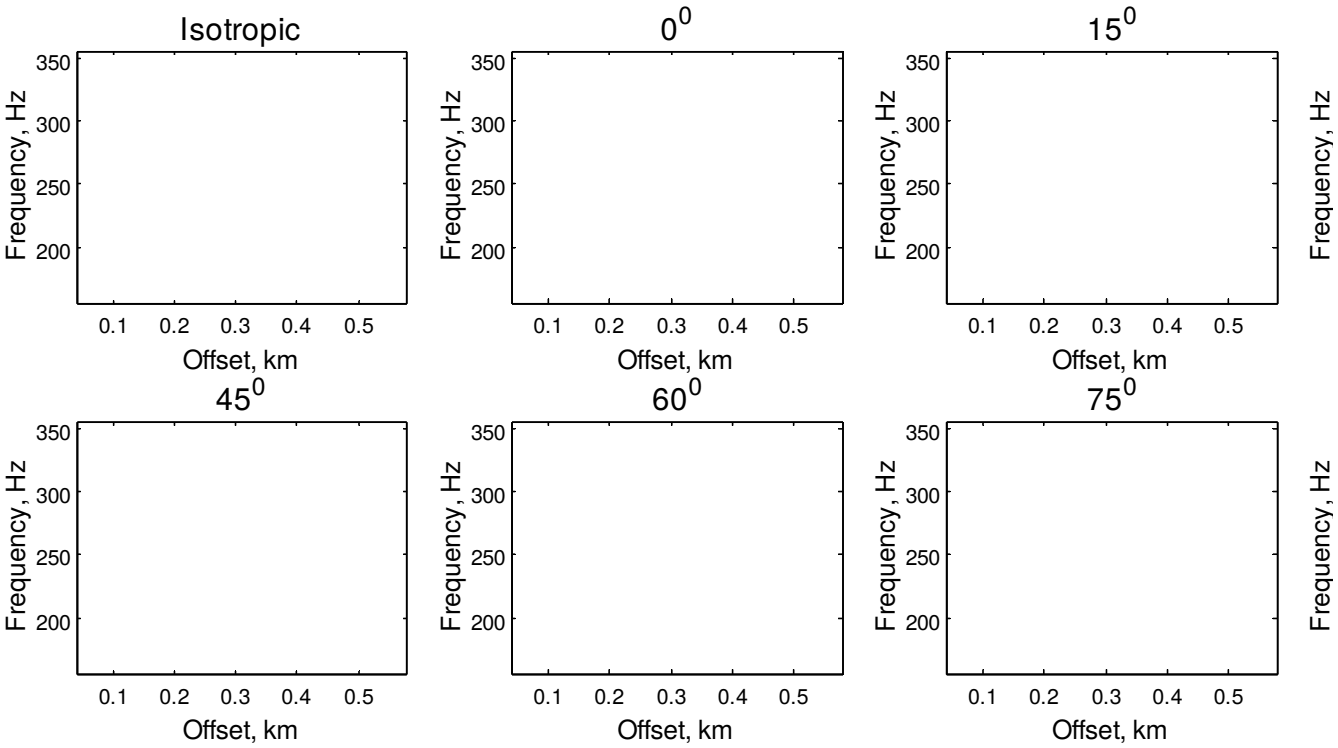
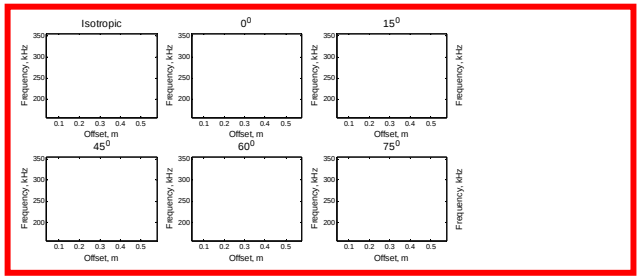
# Reflectivity Modeling




We describe main amplitude characteristics within HTI model BUT do not explain periodical frequency changes



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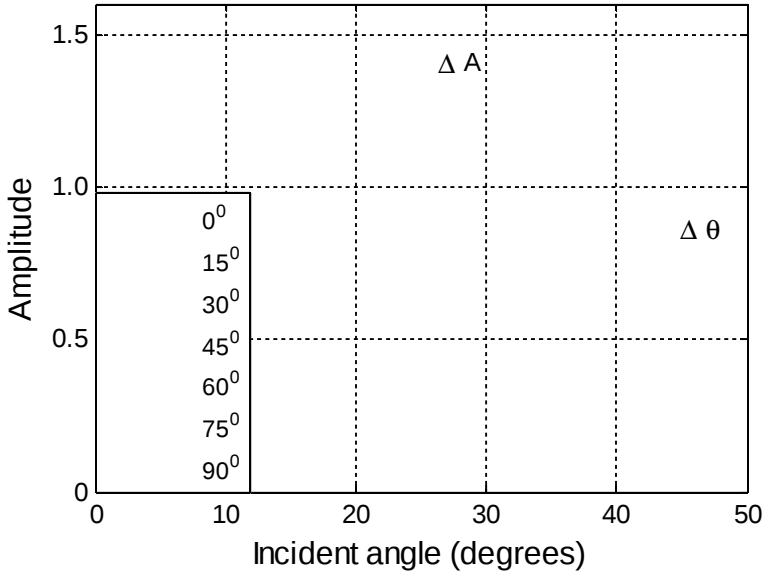
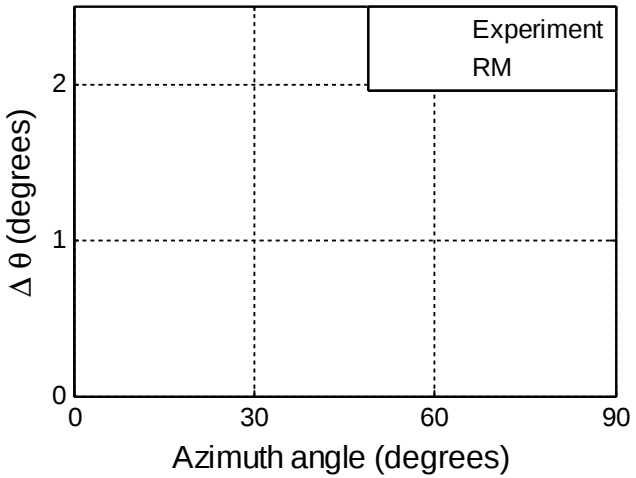
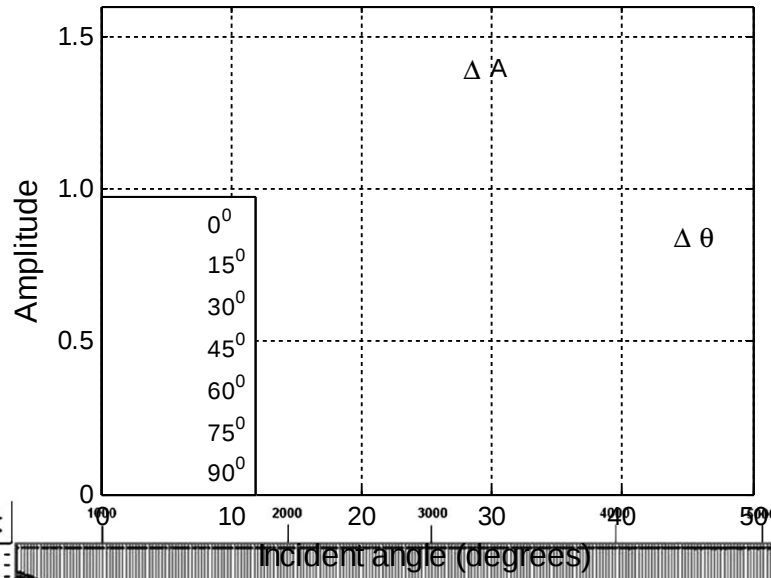
# RMS data

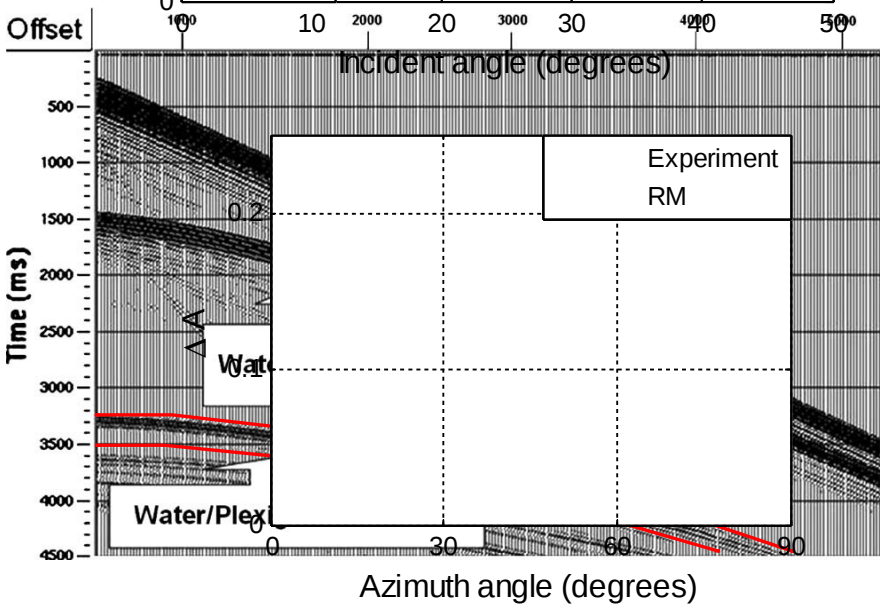
## Experiment




## Reflectivity Modeling



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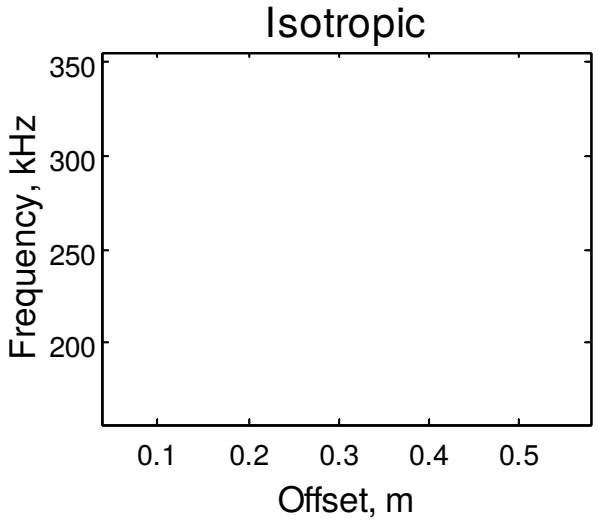
# Possible reasons of misfit

- Finite periodical changes
- Heterogeneity
- Attenuation and dispersion



# Conclusions

- Experimental data show complicated dependence on frequency, azimuth and offset
- HTI model describes general behaviour of the amplitude but does not capture periodical  frequency effects at pre-critical offsets
- Azimuthal dependence on frequency might be a good indicator of the fracture direction
- Exploiting information from post-critical offsets might be a good tool in characterisation of anisotropic media

# Acknowledgments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