Fracture Characterization from Elastic Waves – An Ultrasonic Experimental Approach

José Jadson S. de Figueiredo
Federal University of Pará
Joerg Schleicher
University of Campinas
National Institute of Petroleum Geophysics (INCT-GP)

Robert R. Stewart
and
Nikolay Dayur
Uinversty of Houston
Allied Geophysical Laboratories

Motivation

Shaw (2005)

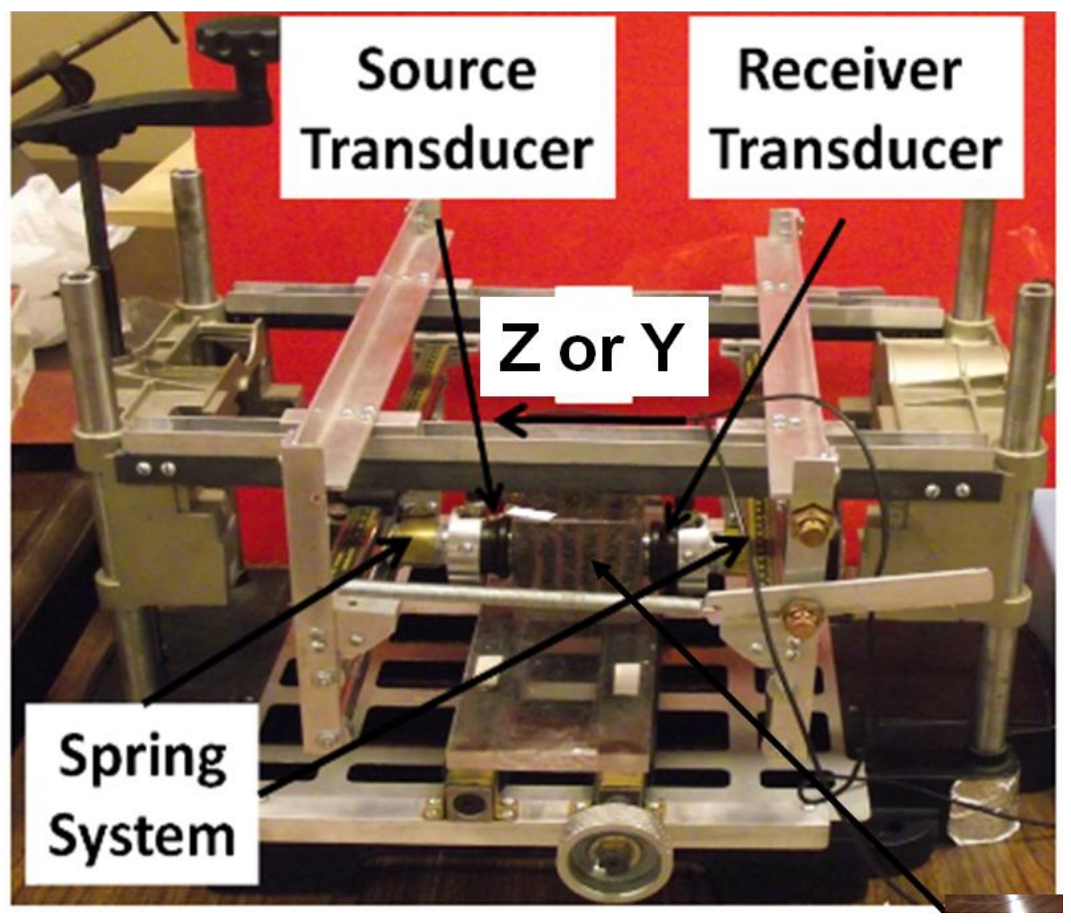
Increase reliability

- Fracture orientation
- Fracture density
- Fluid properties (type, S_w and P_e)
- Fracture size
- Fracture spacing
- Farcture aperture

Increase uncertainty

Fractures or cracks with preferential orientation → anisotropy

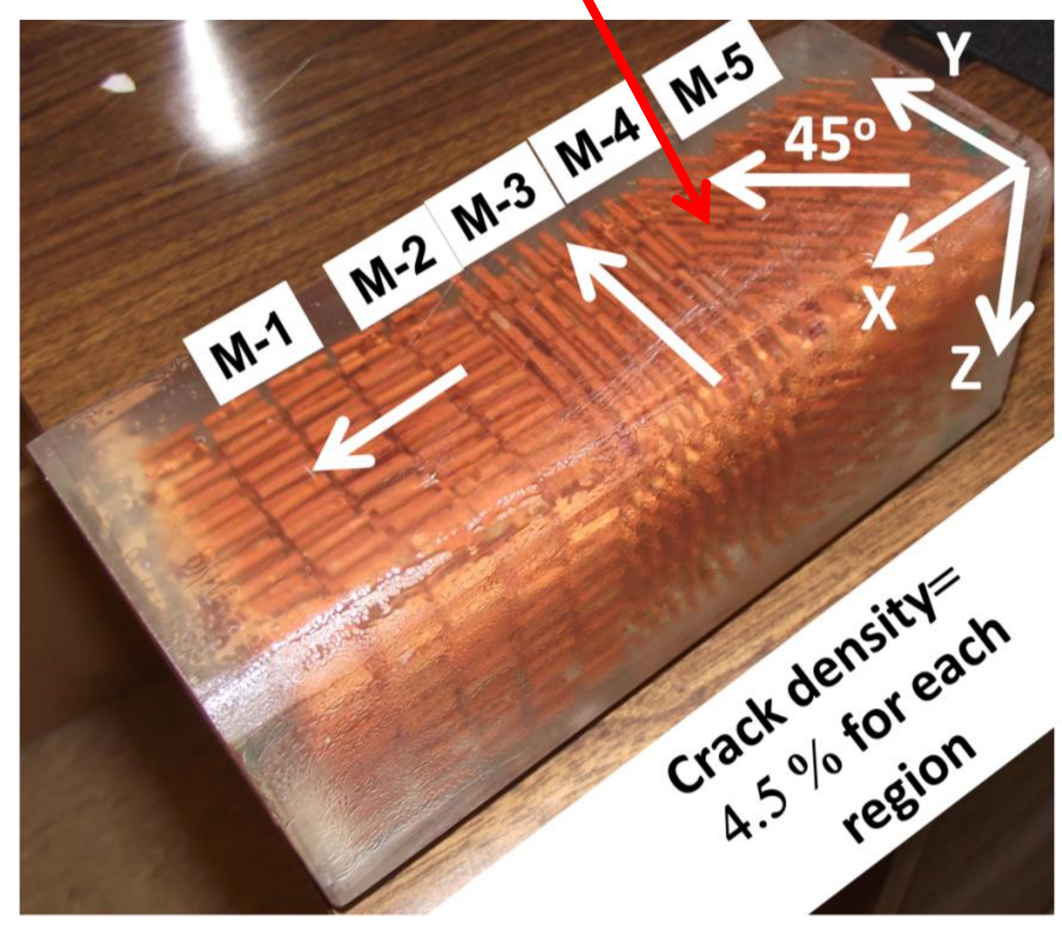
Measurement setup



Ultrasonic polarization recording

Sample preparation

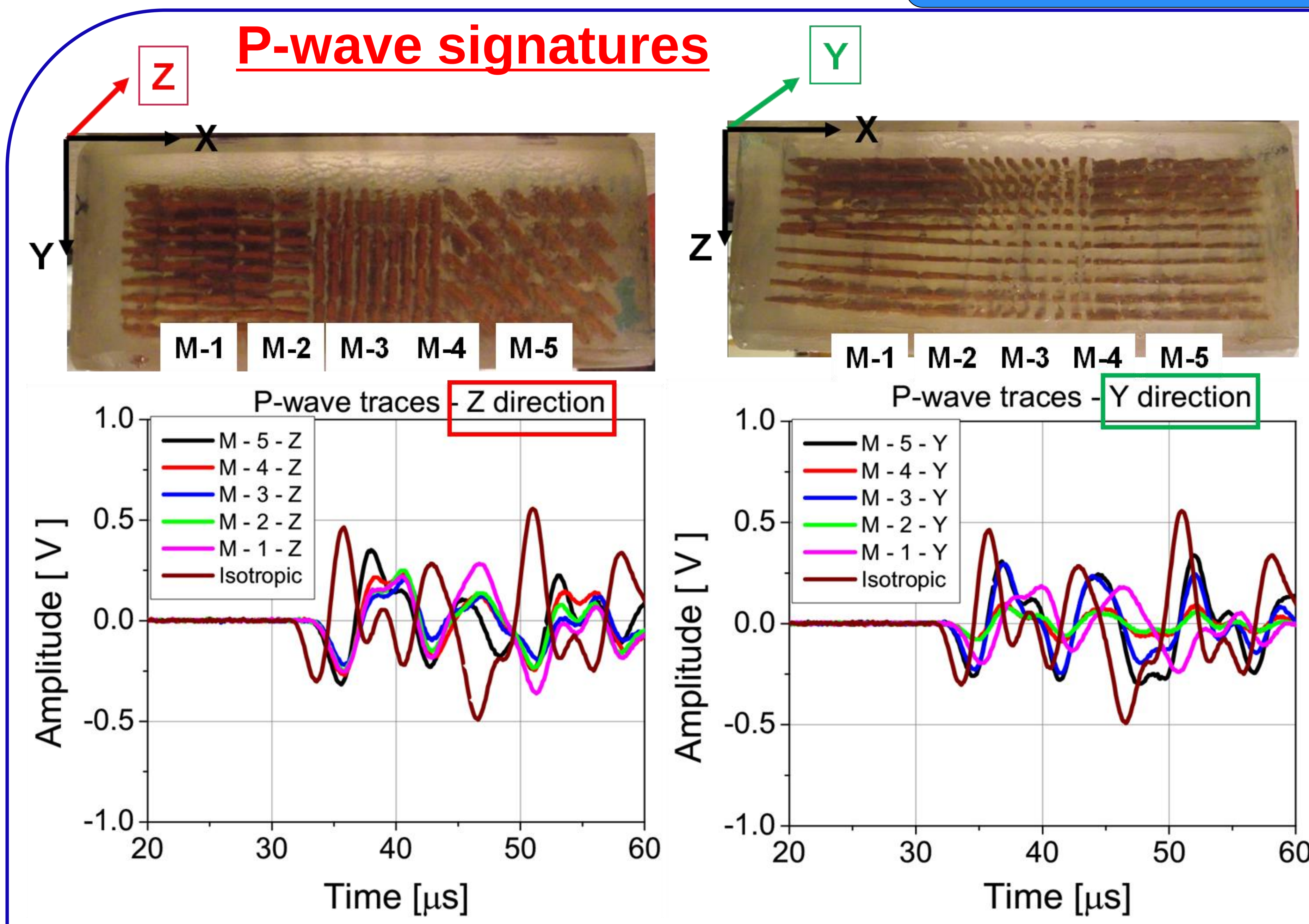
Rubber strip cracks



Multi-dimensional fracture model

Results

P-wave signatures



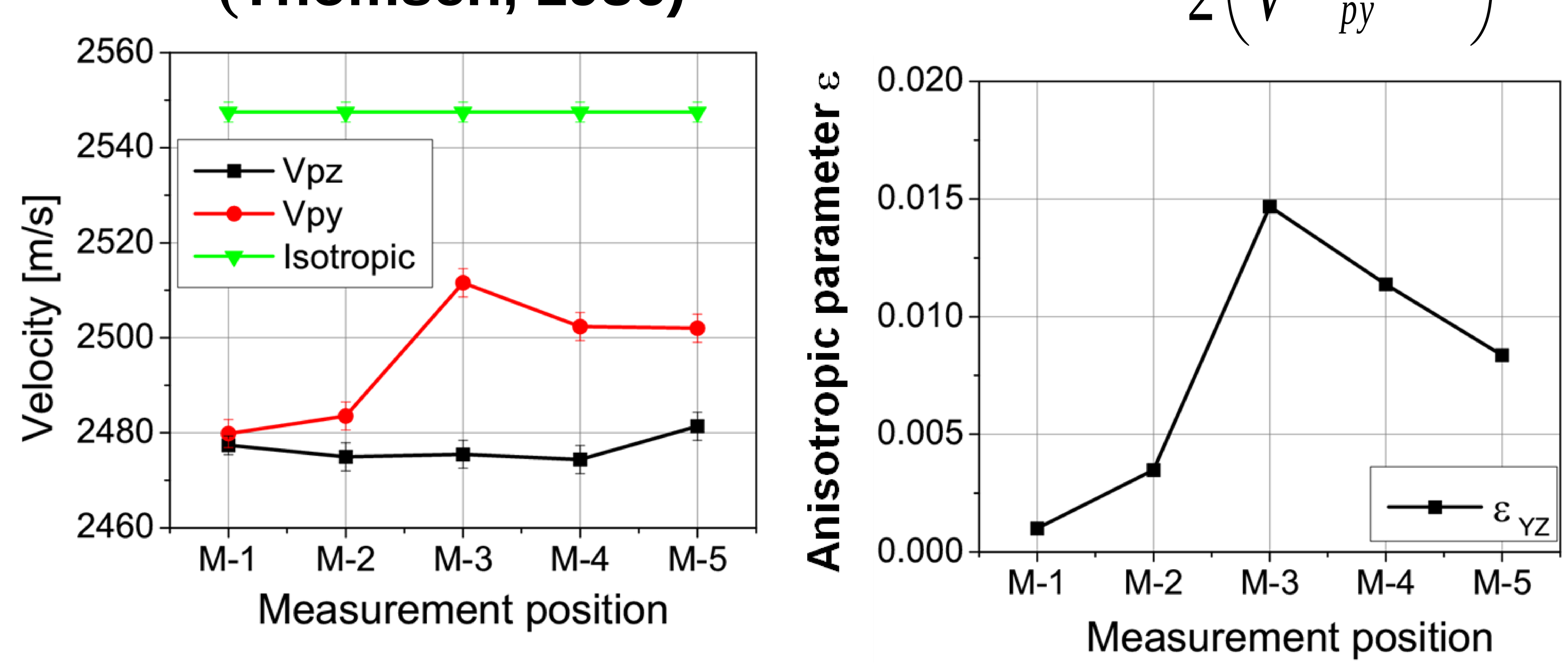
Anisotropy parameter γ (Thomsen, 1986)

$$\gamma_{s1,s2} = \frac{1}{2}\left(\frac{V^2_{s1}}{V^2_{s2}} - 1\right)$$

P-wave velocities

Anisotropy parameter ε (Thomsen, 1986)

$$\varepsilon_{yz} = \frac{1}{2}\left(\frac{V^2_{pz}}{V^2_{py}} - 1\right)$$



Cross-correlation technique (Kennett, 2002)

Taking two traces → $(S,H)=(S(S_1,S_2),H(S_1,S_2))$

Polarization angle — Delay time

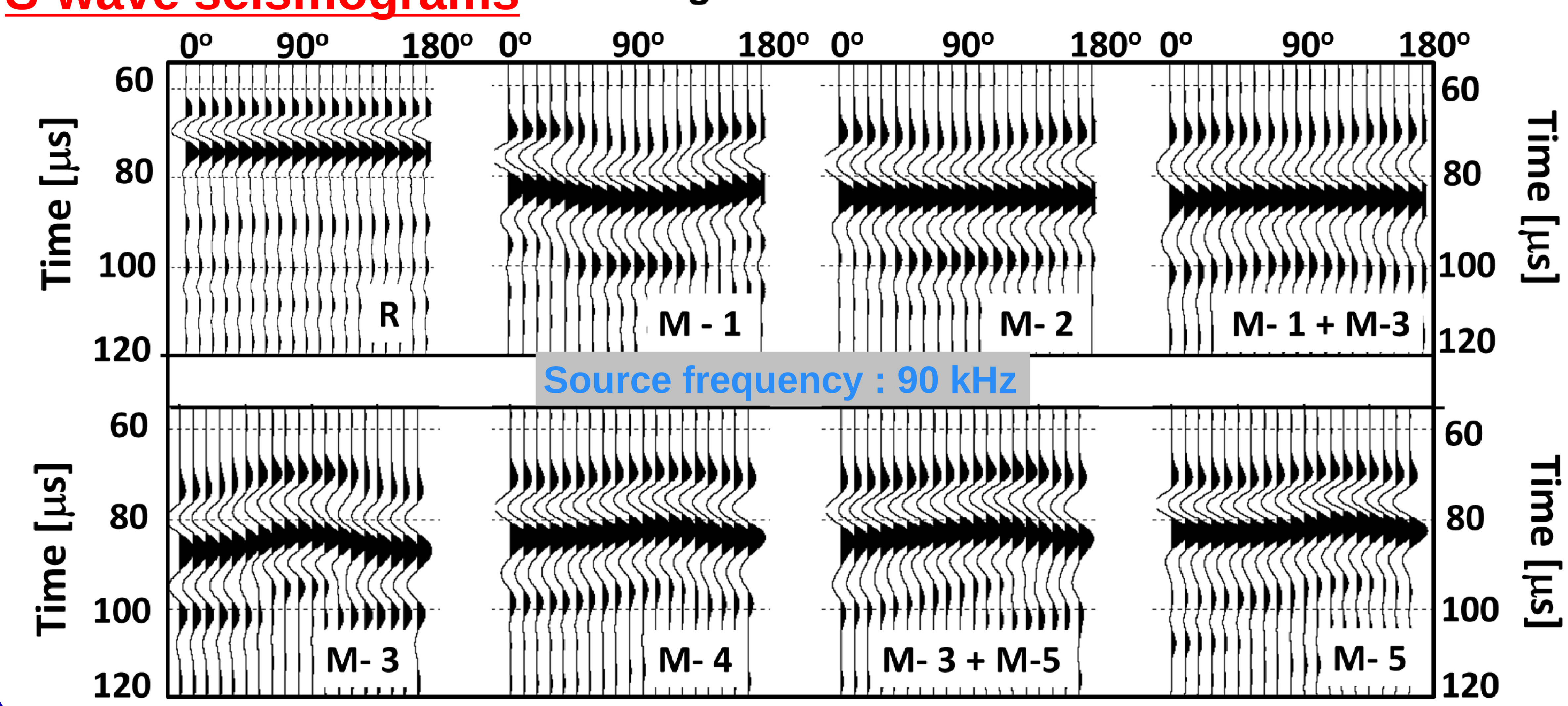
$$S(\theta,t) = S1(t)\cos(\theta) - S2(t+\delta t)\sin(\theta),$$

$$H(\theta,t) = S1(t)\sin(\theta) + S2(t+\delta t)\cos(\theta),$$

$$R(\theta,t) = \sum_{i=1}^{n} S(\theta,t_i)H(\theta,t_i+\delta t)$$

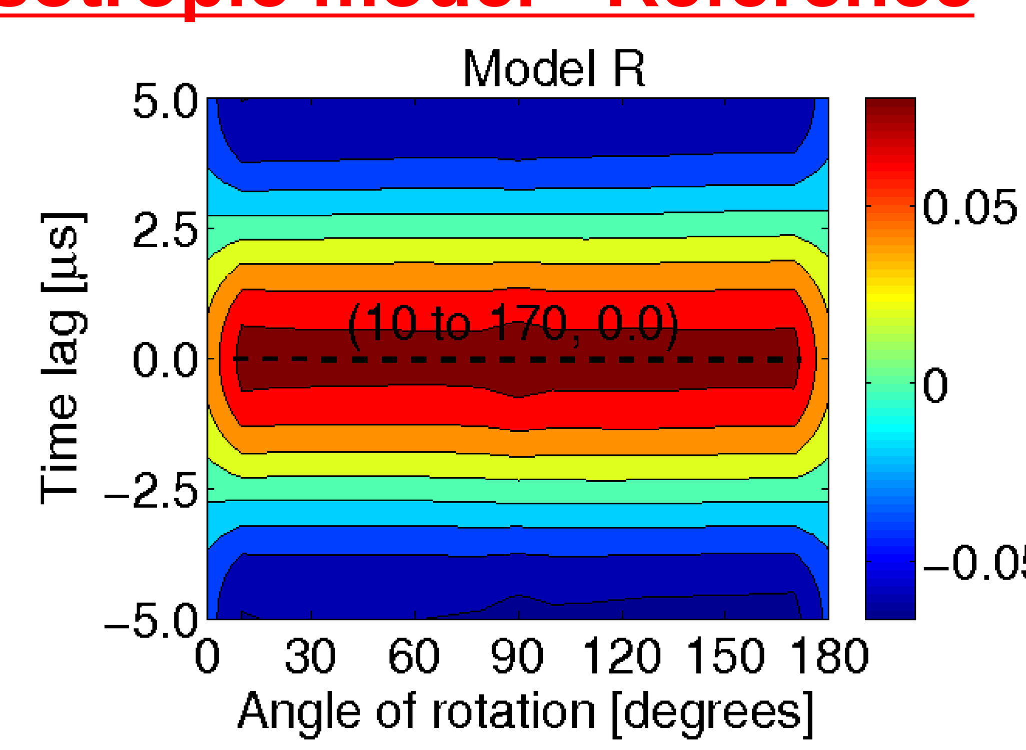
S-wave seismograms

Angle of rotation



S-wave propagation in Z direction

Isotropic model - Reference



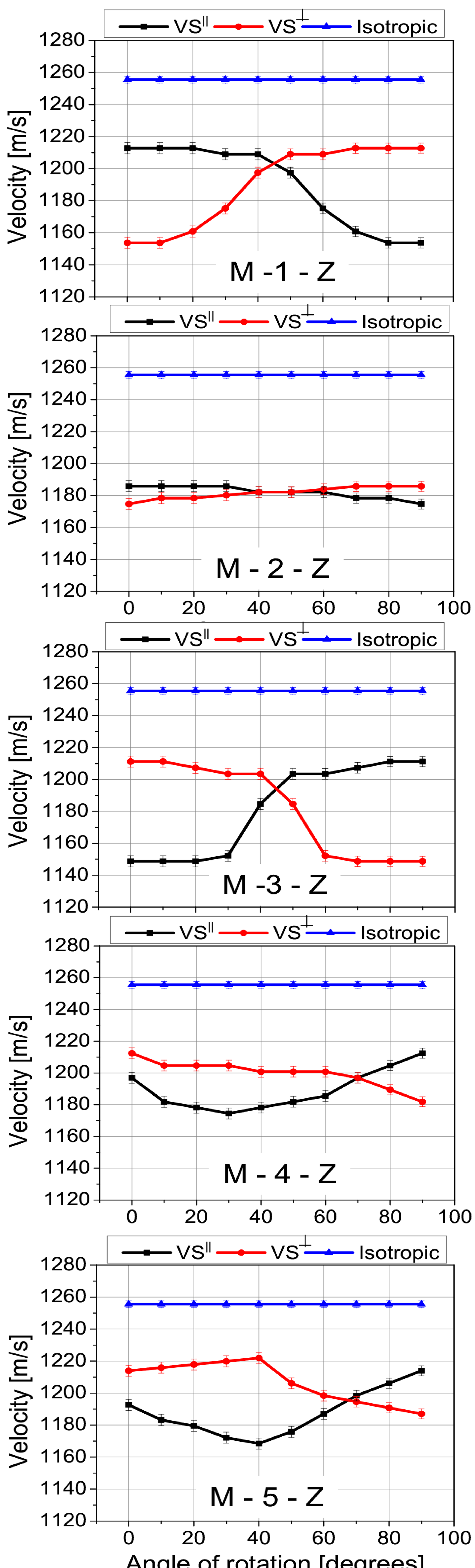
Fracture Characterization from Elastic Waves – An Ultrasonic Experimental Approach

José Jadsom S. de Figueiredo
Federal University of Pará
Joerg Schleicher
University of Campinas
National Institute of Petroleum Geophysics (INCT-GP)

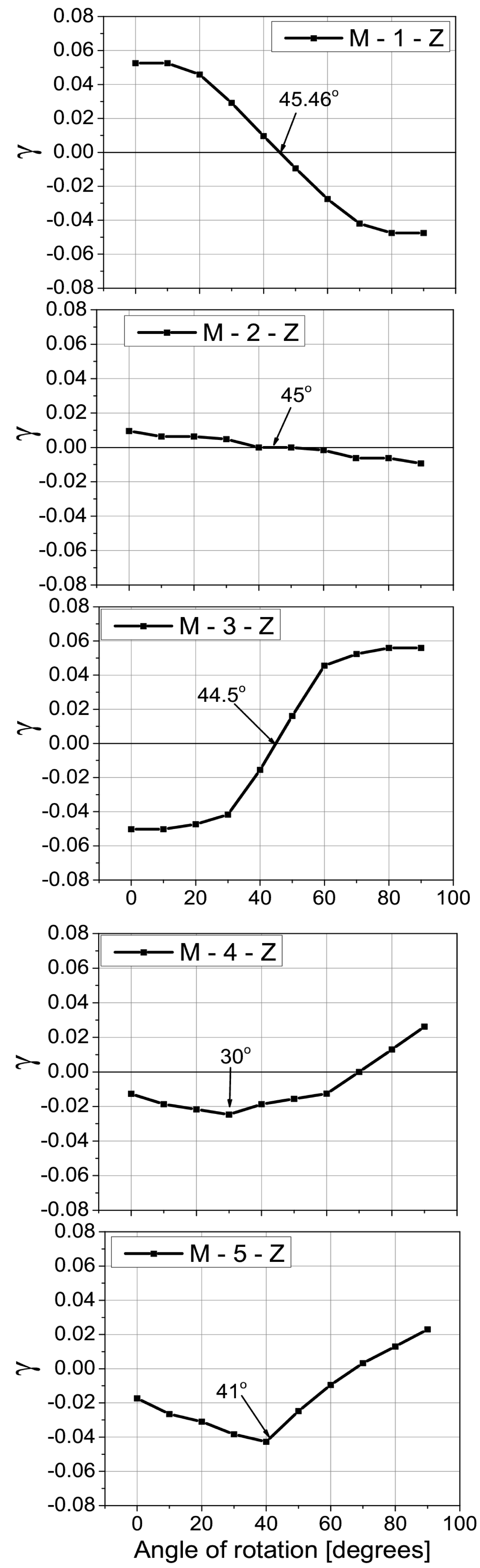
Robert R. Stewart
and
Nikolay Dayur
Uinversty of Houston
Allied Geophysical Laboratories

Results

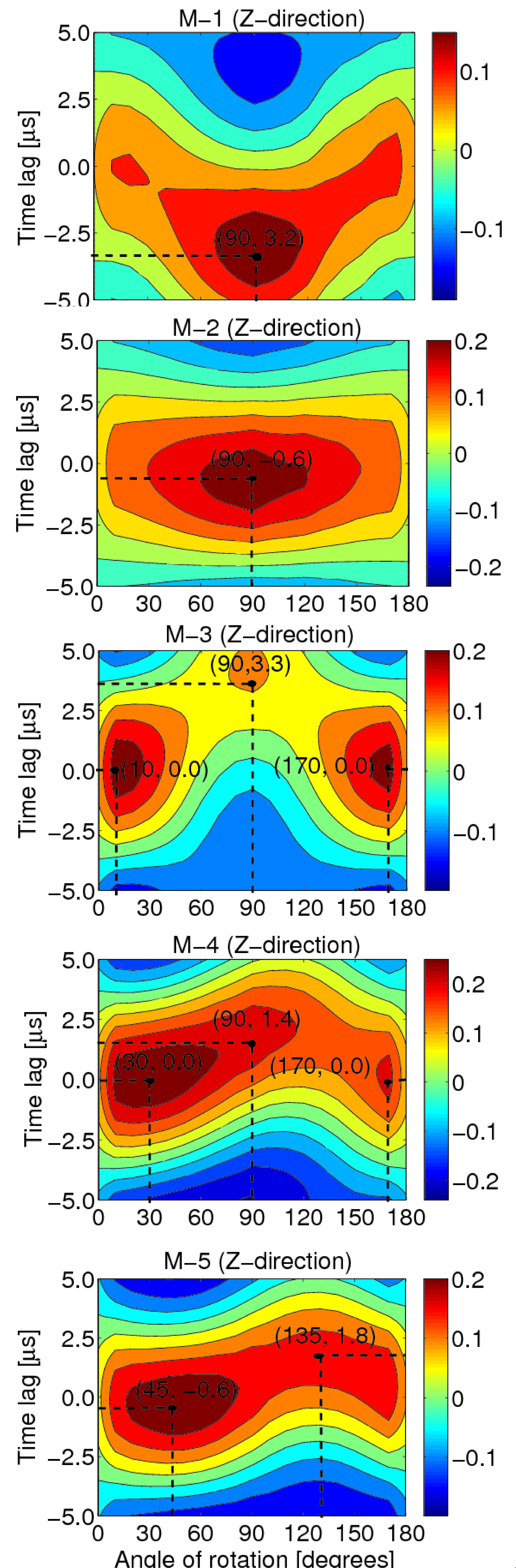
S-wave velocities



Anisotropy parameter γ



Correlograms



Conclusions

- ➢ S-wave is more influenced than P-wave by preferential orientation of cracks ;
- ➢The crack orientation was found by integrating cross-correlation with analysis of anisotropy parameter γ ;
- ➢ The anisotropy parameter γ is more efficient to estimate the fracture zone;

Acknowledges

- ❑ **AGL sponsors for financial support and Brazilian Agencies CNPQ and CAPES for scholarship.**
- ❑ **AGL students: Bode Omoboya, Emarah Pacal and Anoop William.**
- ❑ **Dr. Bob Wiley for expert advice about physical modeling.**