Exploration & Production Technology

delivering breakthrough solutions

Overburden shear wave splitting due to reservoir compaction above a rigid basement

Pamela Tempone, BP, and Erling Fjær, SINTEF

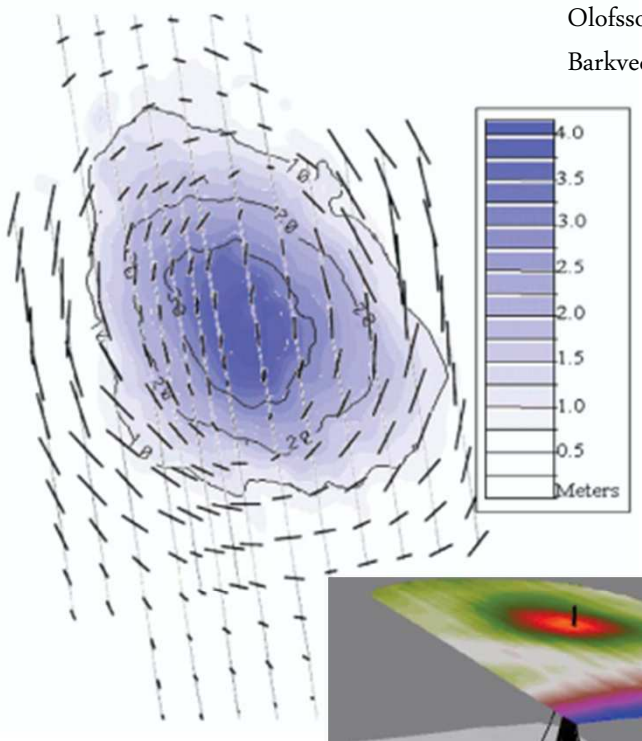
Predicting shear wave splitting

OBJECTIVE:

1. **Predict** SWS using **simple tool**
2. Include **heterogeneity** in the form of rigid basement

RESULT:

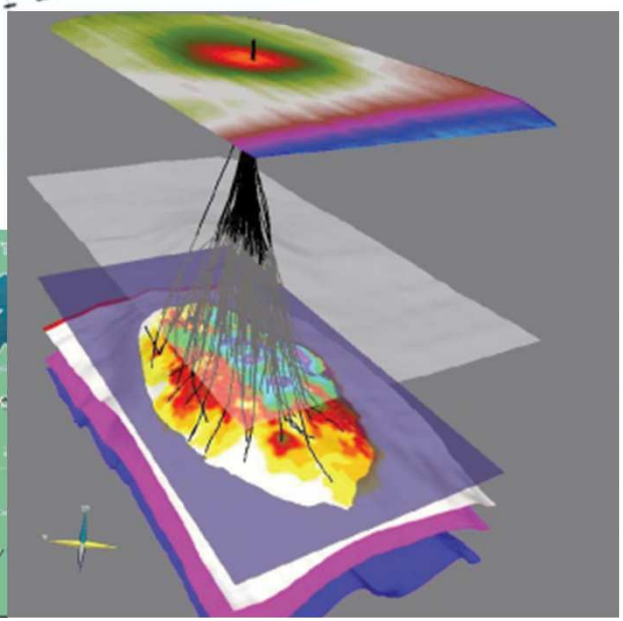
Larger effect at shallow depth



Olofsson et al. (2003)

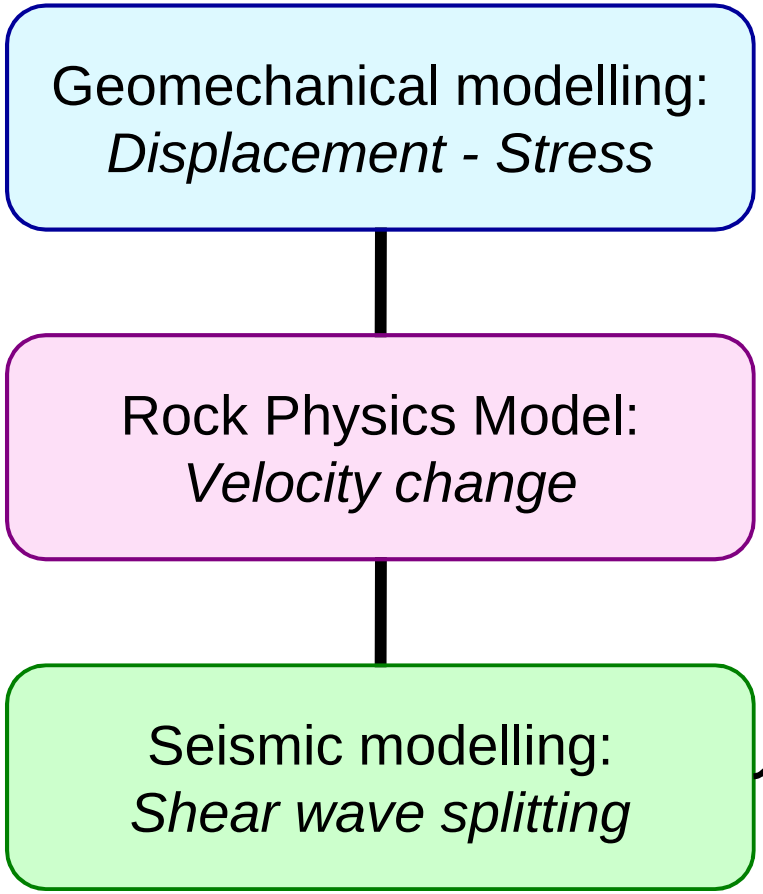
Barkved et al. (2005)

- Splitting of shear wave due to anisotropy
  - bedding
  - in-situ stress
  - orientation of cracks or fractures
- Compacting reservoir
  - Volume decrease of reservoir
  - Rock deformation
  - Stress and strain changes



SST

4D seismic and Geomech modelling



- 4D feasibility studies
  - Can predicted compaction change 4D signal?
  - Can shear wave splitting be detected in the overburden?
  - Survey planning?
  - Processing planning?
  - Well positioning effected?
  - Well stability and safe drilling?

Geomechanical model: Rigid Basement

Geomechanical modelling

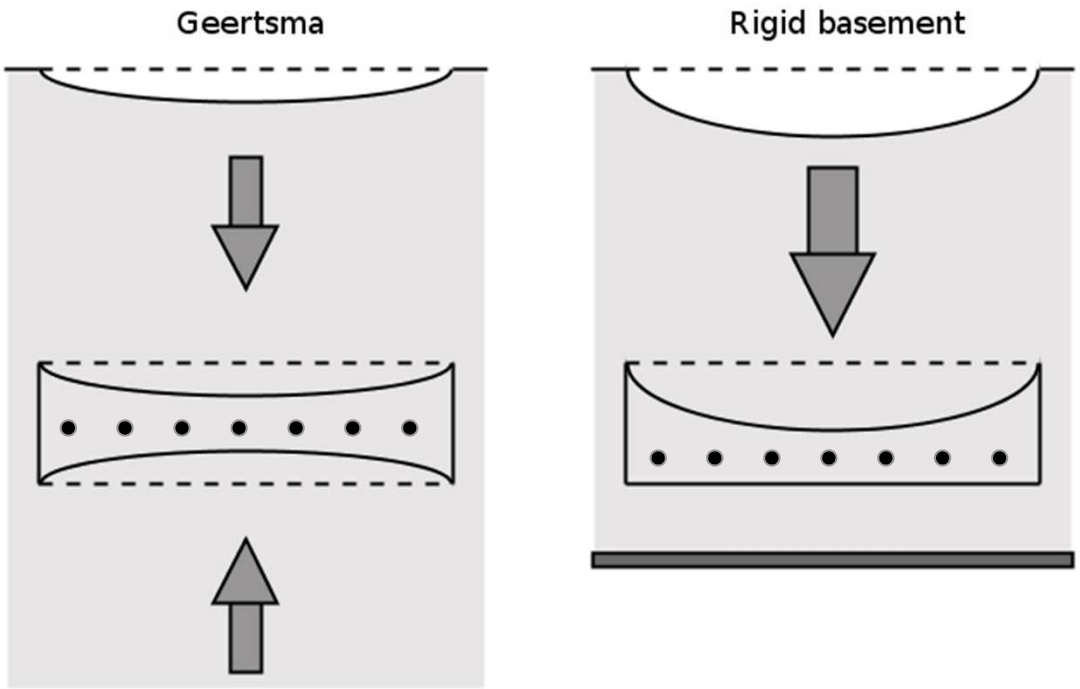
- Analytical solution (Geertsma's)
- Numerical solution (FEM)

Why rigid basement

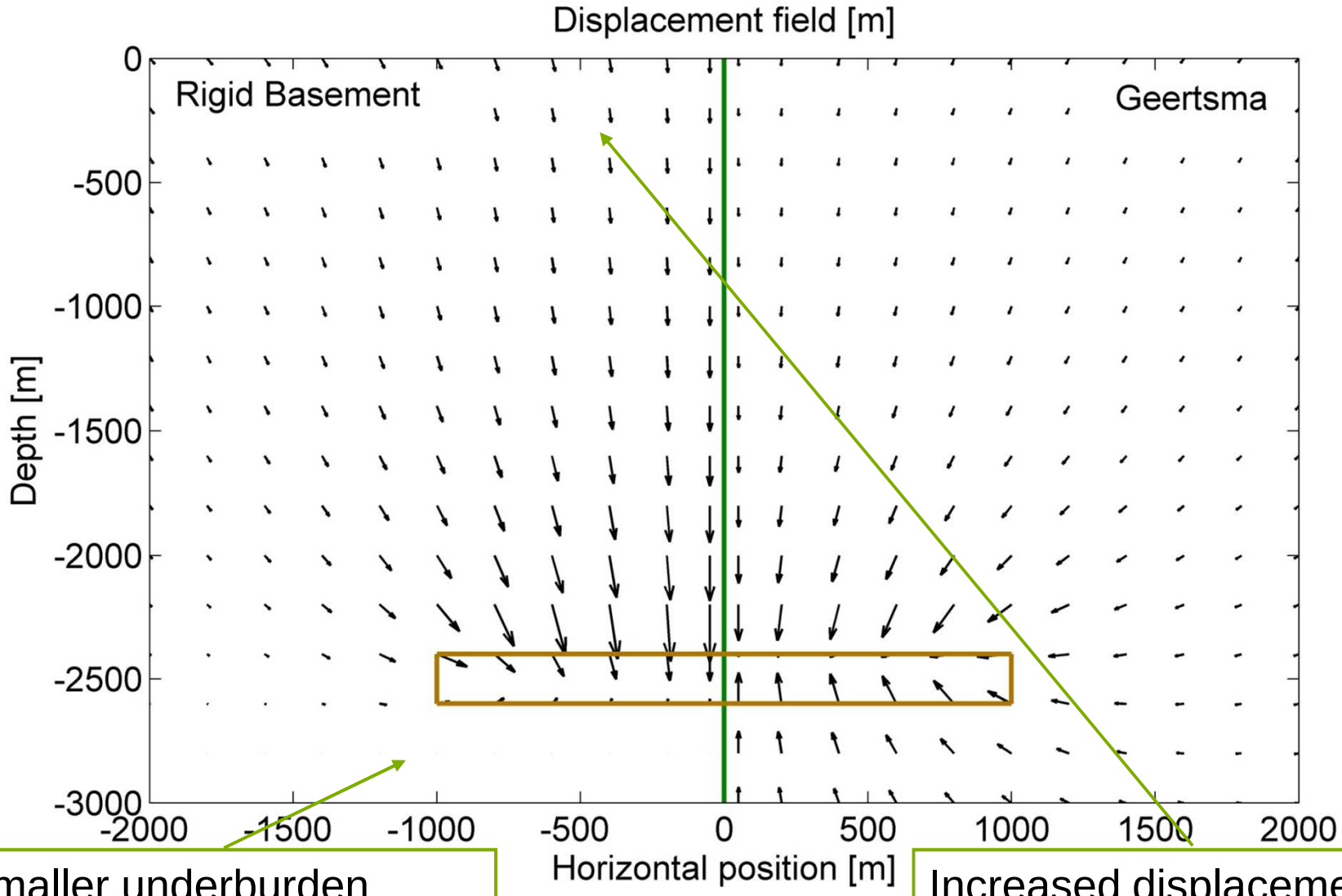
- Stiffness increase vs Depth
- Minimum input parameters
- Break symmetry

Assumptions

- Linear elasticity
- Isotropy
- Homogeneity



Displacement field

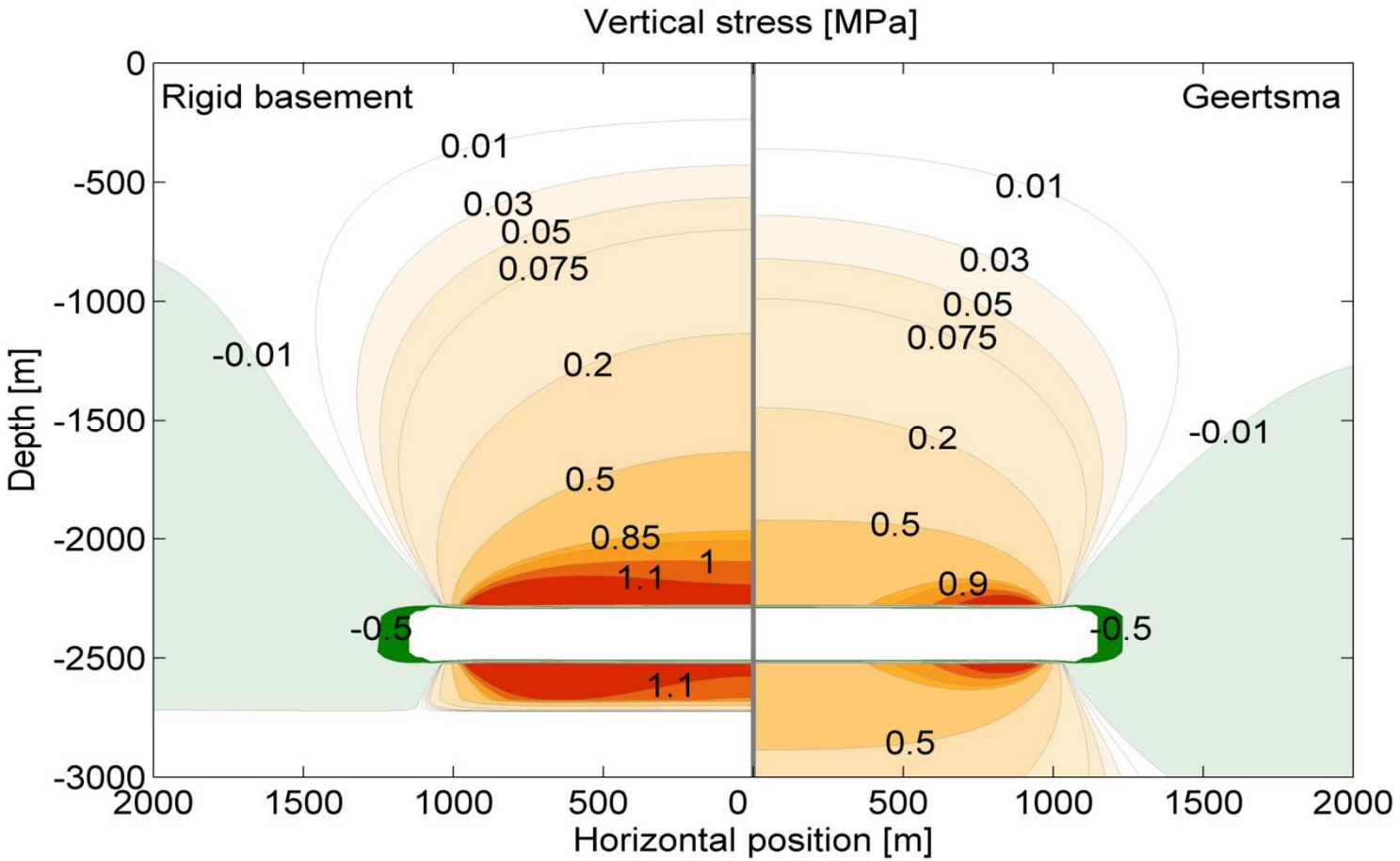


Smaller underburden displacement

Increased displacement of the overburden

Stress field

- Overburden stretches vertically
- Underburden stretches vertically close to the reservoir
- Vertical strain decreases more rapidly in the underburden



Rock physics model

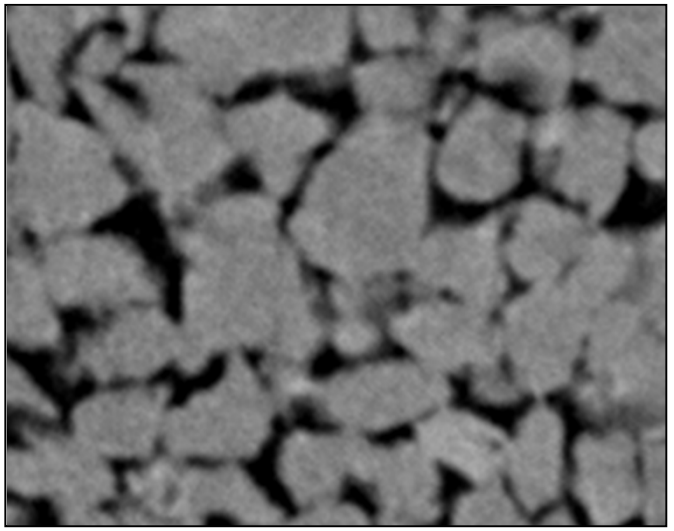
Link between stress/strain and velocity changes

Rock physics model

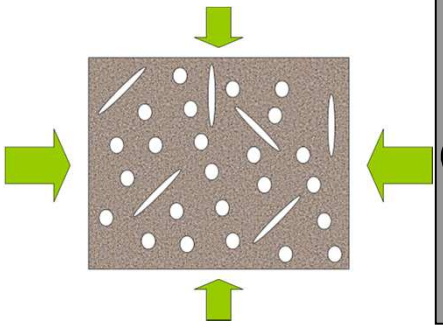
- Stress-sensitive framework of cracks
- Seismic velocities depend on crack density and porosity
- Crack density is stress and strain dependent
- Porosity depends on volumetric strain

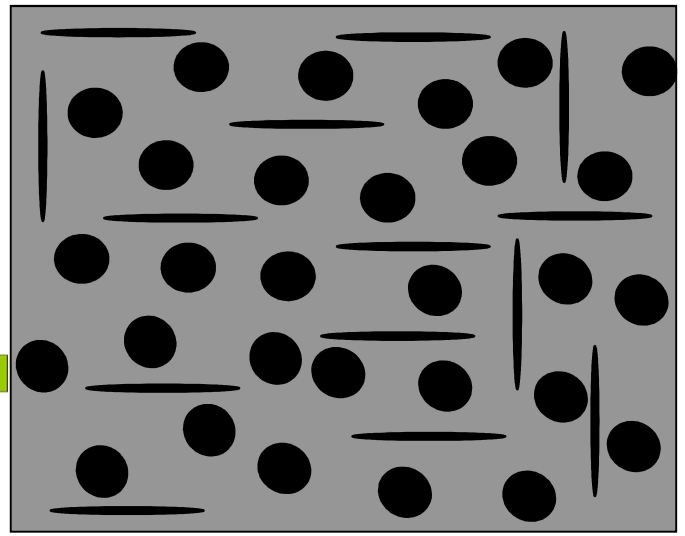
Parameters

- Overburden velocity model
- Initial porosity
- Crack density and shape
- Stress and strain



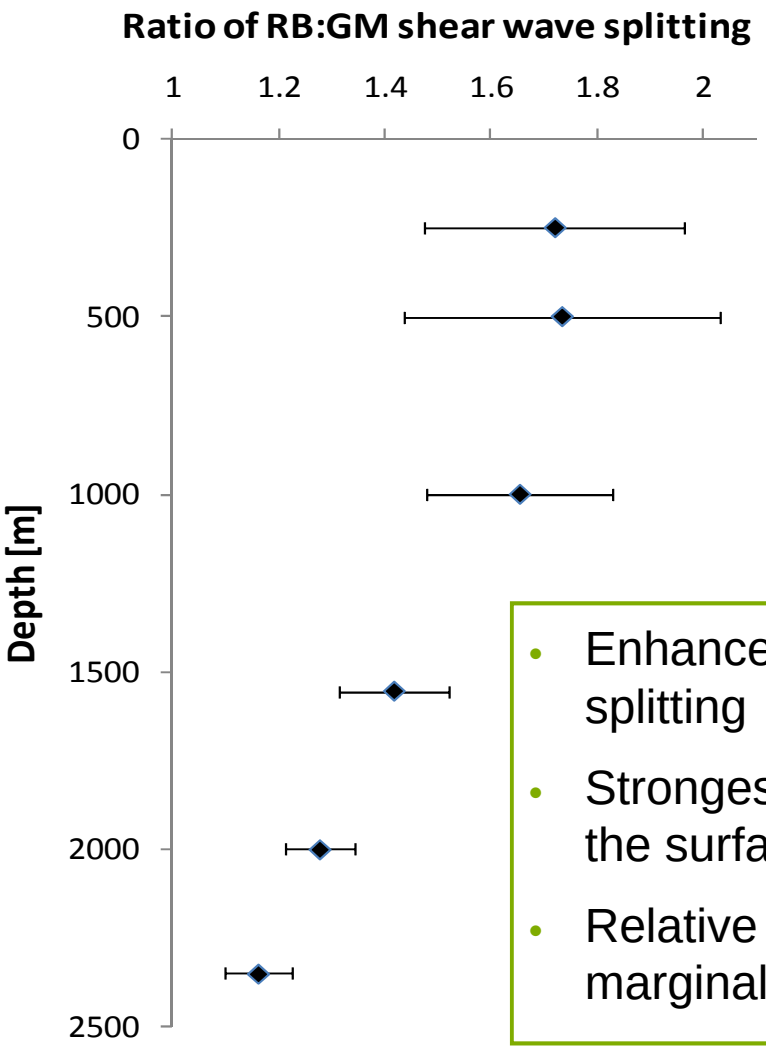
Castlegate sandstone



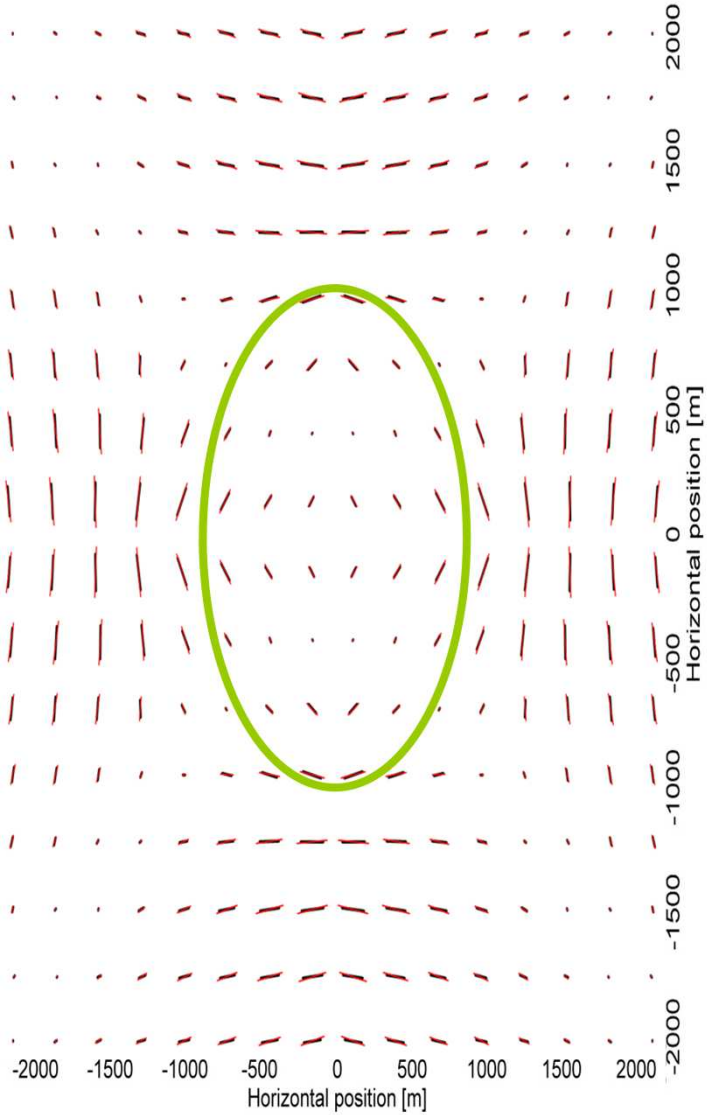


Rock physics model

Shear wave splitting



- Enhanced shear wave splitting
- Strongest effect near the surface
- Relative orientation marginally effected



SST

Conclusions

- The presence of the rigid bottom **enhances the change in shear wave splitting**
- A stiffer layer below a compacting reservoir may have significant **impact on 4D seismic data**
- At **interpretation stage**, this effect has to be taken into consideration
- RB and Geertsma's models as **boundaries** of real geology
- Useful tool to **assess probability of occurrence** of SWS due to reservoir compaction
  - 4D survey and processing planning
  - Drilling risk estimation
  - Well positioning

Acknowledgments

NTNU – Trondheim
Norwegian University of
Science and Technology