

# What is seismic modeling used for

B. Arntsen

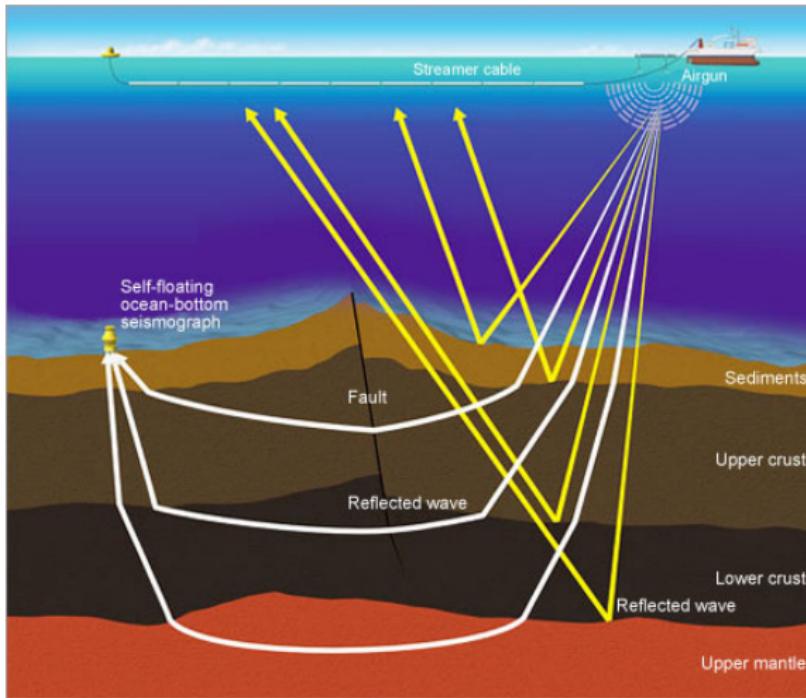
NTNU  
Department of Geoscience  
[borge.arntsen@ntnu.no](mailto:borge.arntsen@ntnu.no)

Svalbard April 2024

# Content

1. What is seismic modeling?
2. What is it used for?

# What is seismic modelling

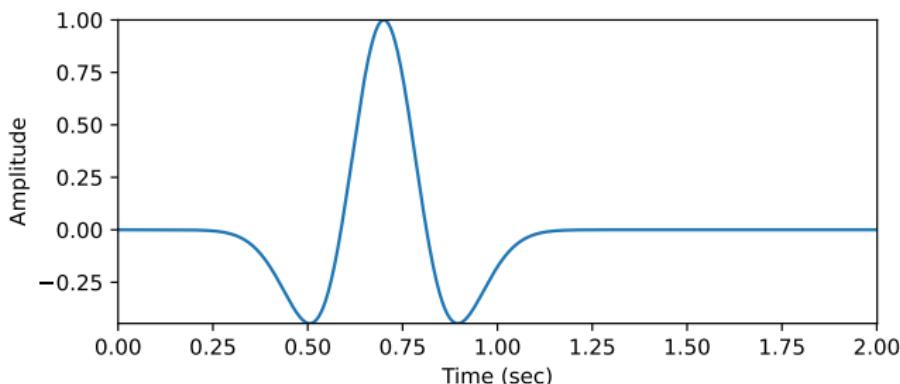
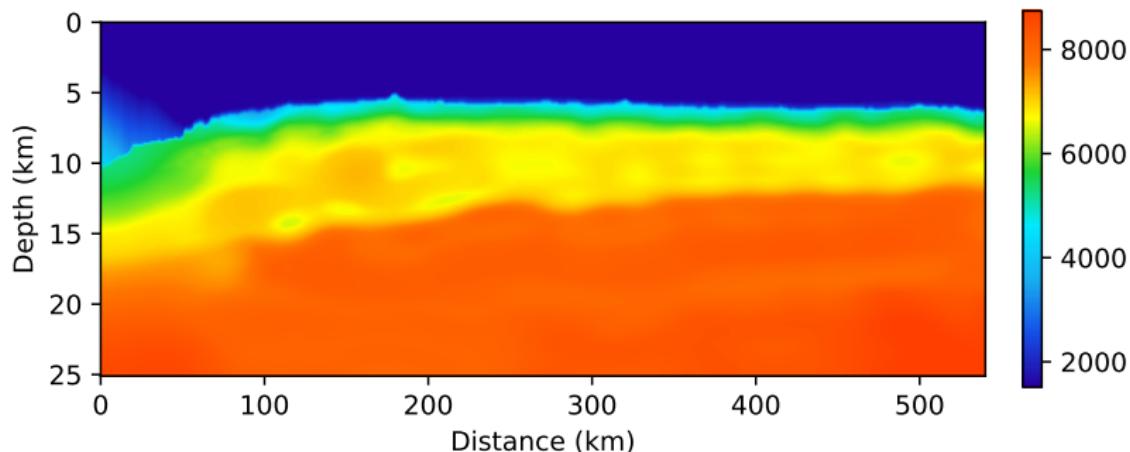


Credit: Japan Agency for Marine-Earth Science and Technology

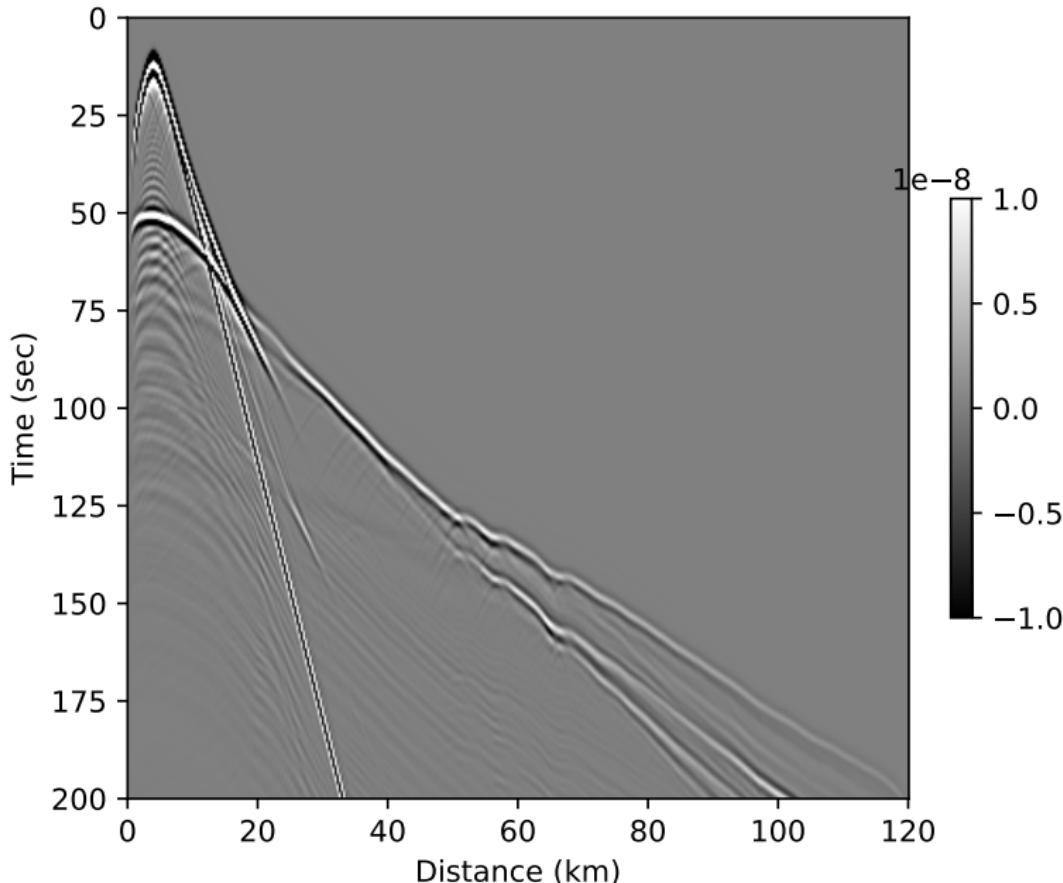
# What is seismic modeling?

- ▶ Simulation of seismic data
- ▶ Numerical solution of equations describing elastic waves in rocks
  - ▶ Newtons law:  $Force = mass \times acceleration$
  - ▶ Hooks law:  $Stress = stiffness \times displacement$
- ▶ Input is a numerical model of stiffness, density and description of seismic source
- ▶ Output is simulated data

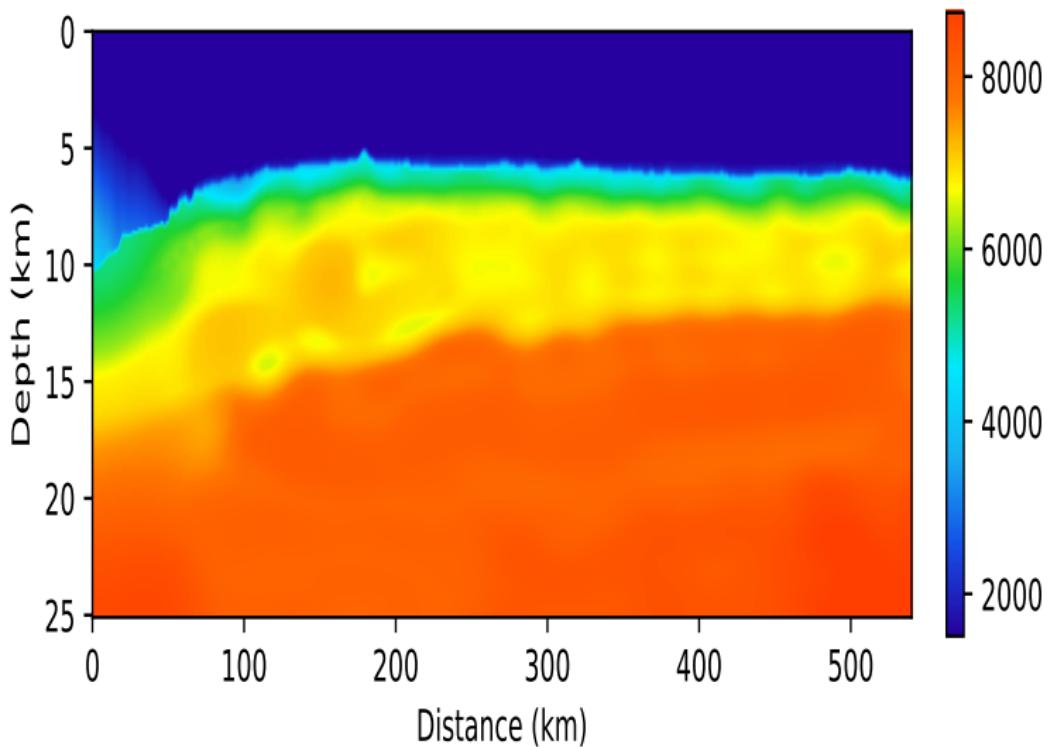
# What is seismic modeling?



# What is seismic modeling?



# What is seismic modeling?



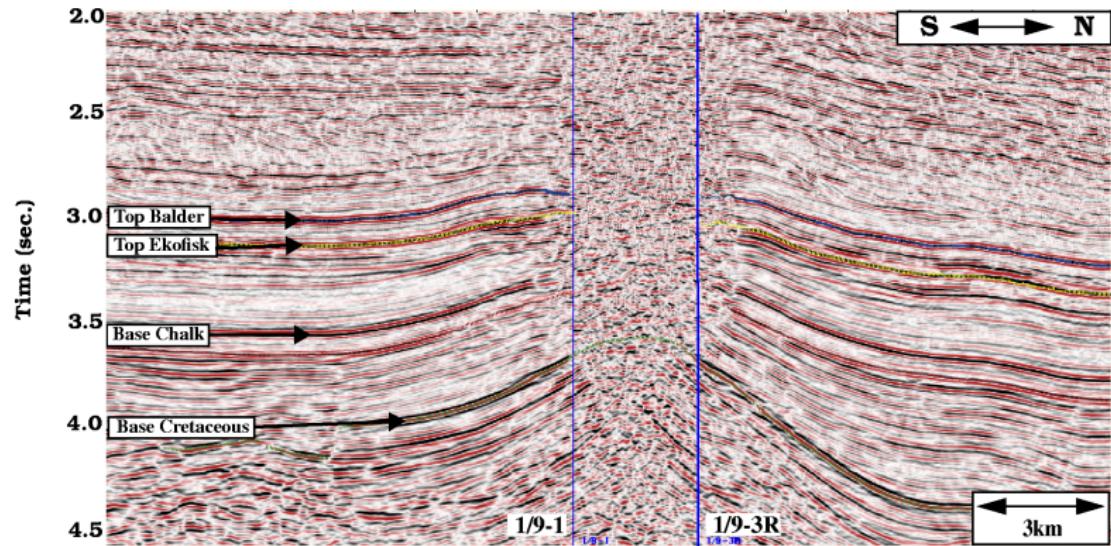
# What is seismic modeling used for

Interpretation of seismic data in terms of

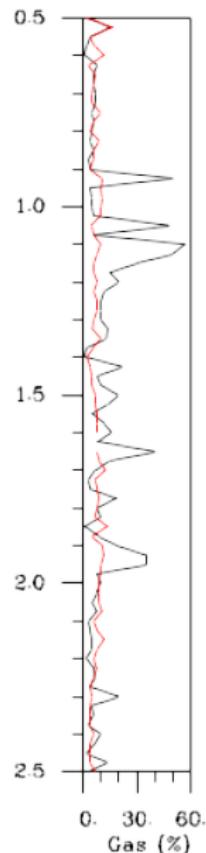
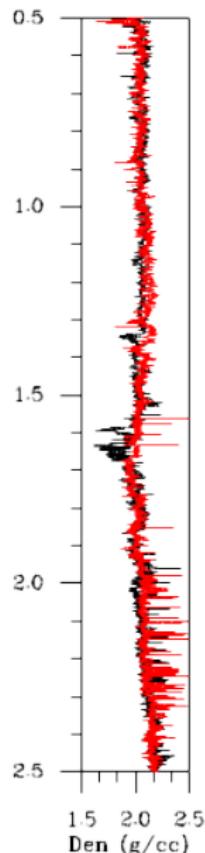
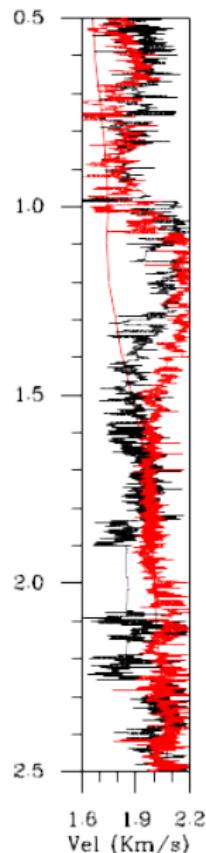
- ▶ Geological structures'
- ▶ Geological processes
- ▶ Geometry of geological bodies
- ▶ Rock types
- ▶ Fluids

In the following we show three examples of the use of seismic modelling.

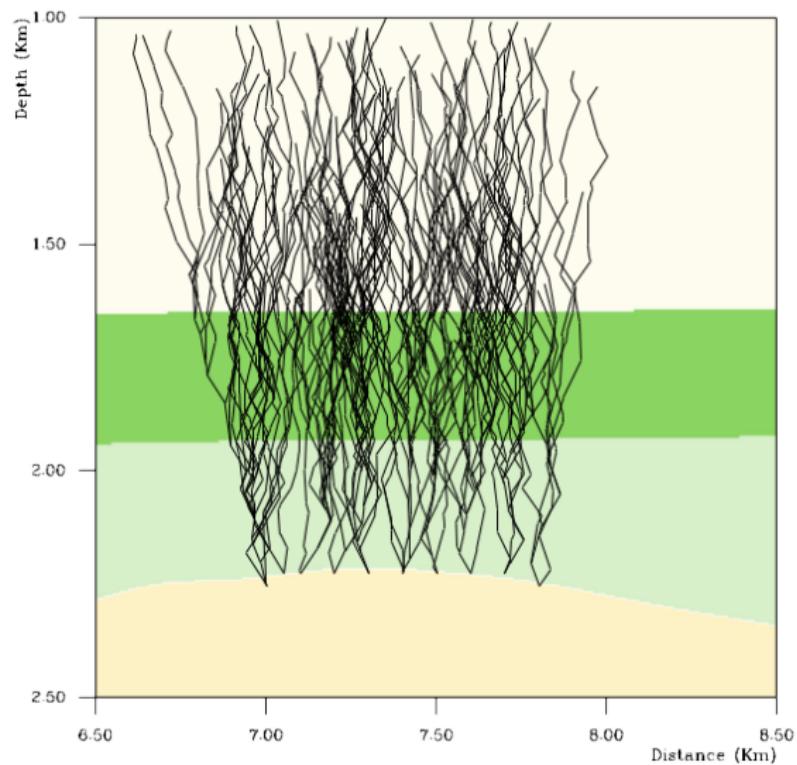
# Gas chimneys



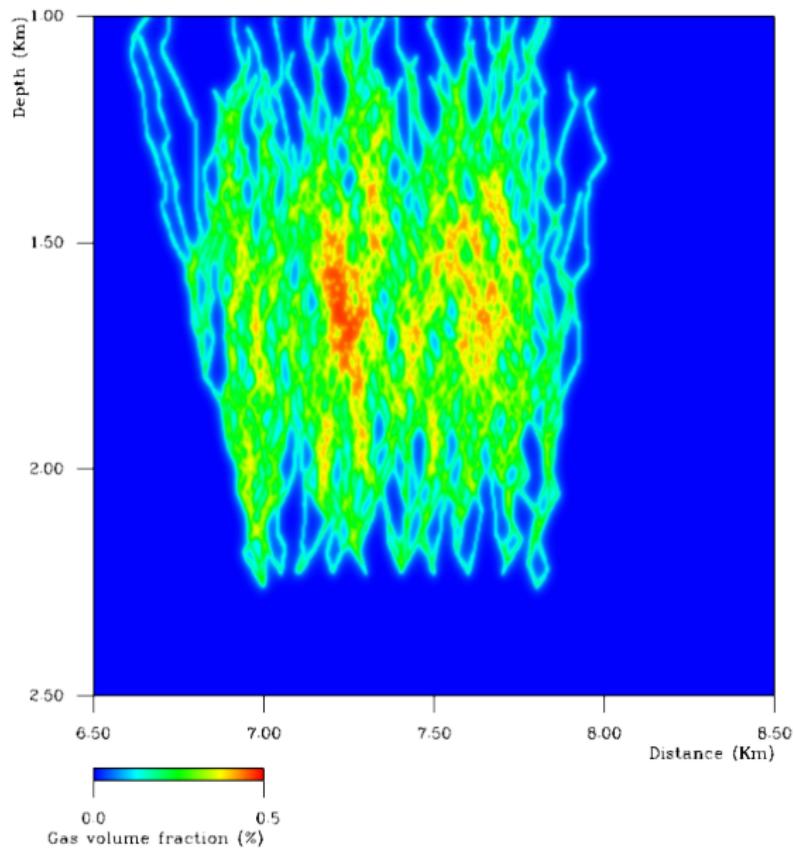
## Well logs show free gas



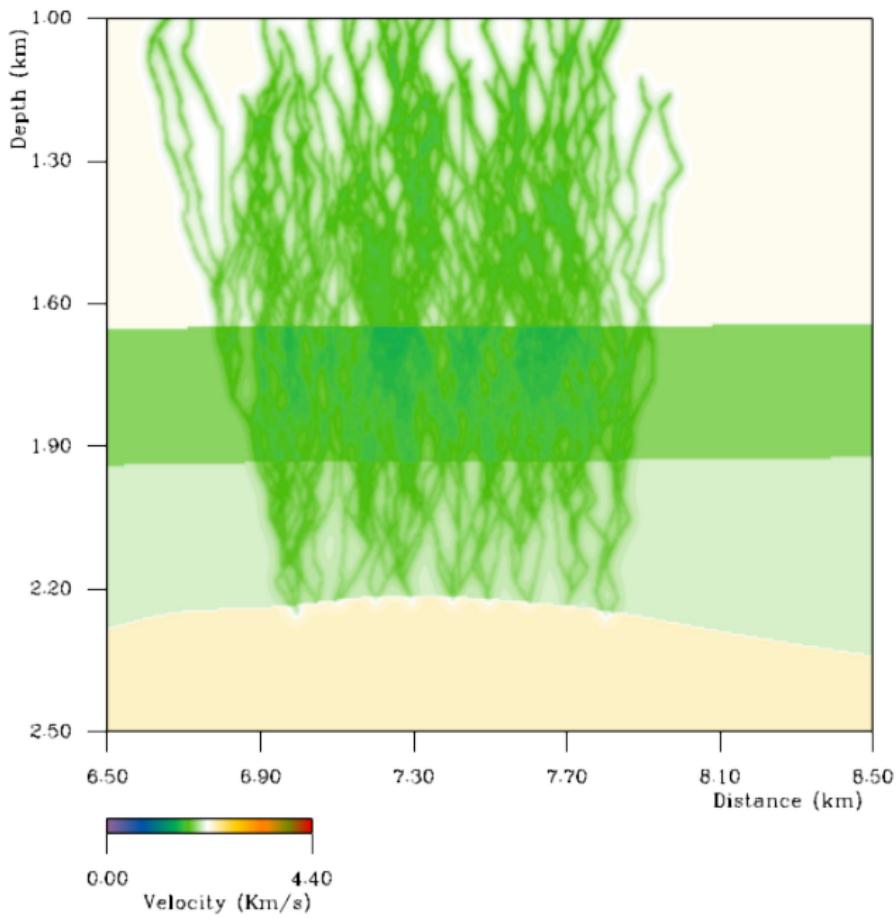
# Fracture network



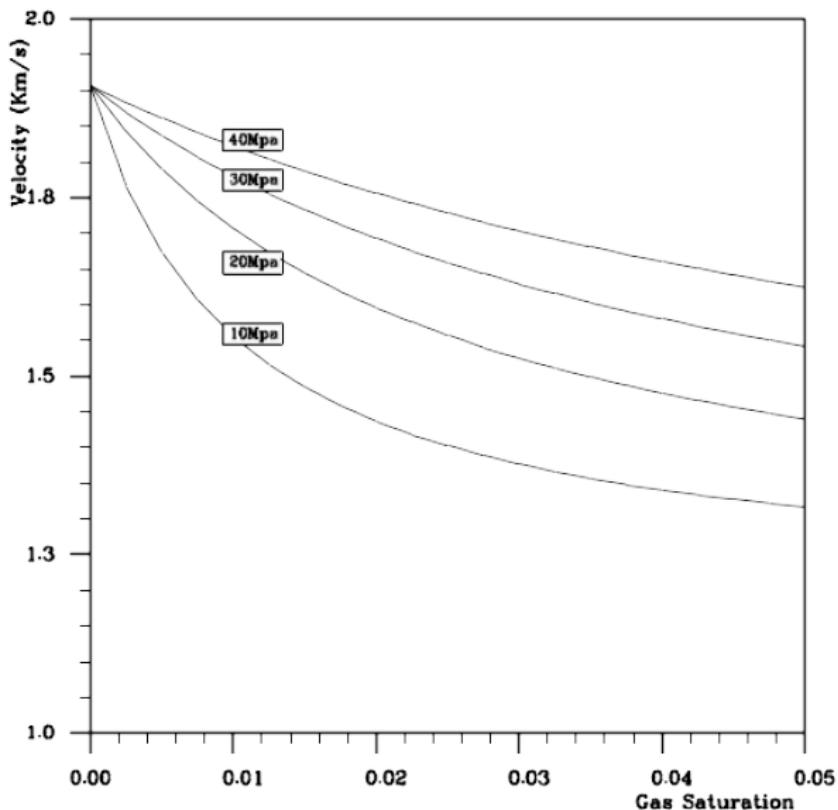
# Gas saturation



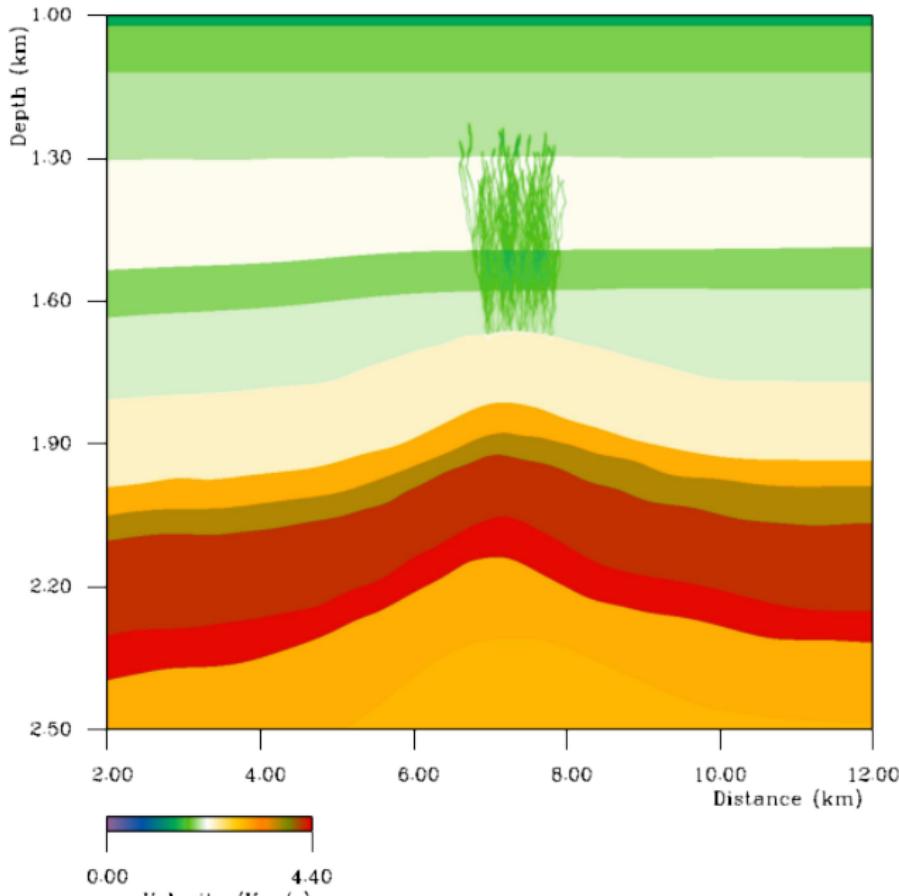
# Seismic Velocity model for chimney



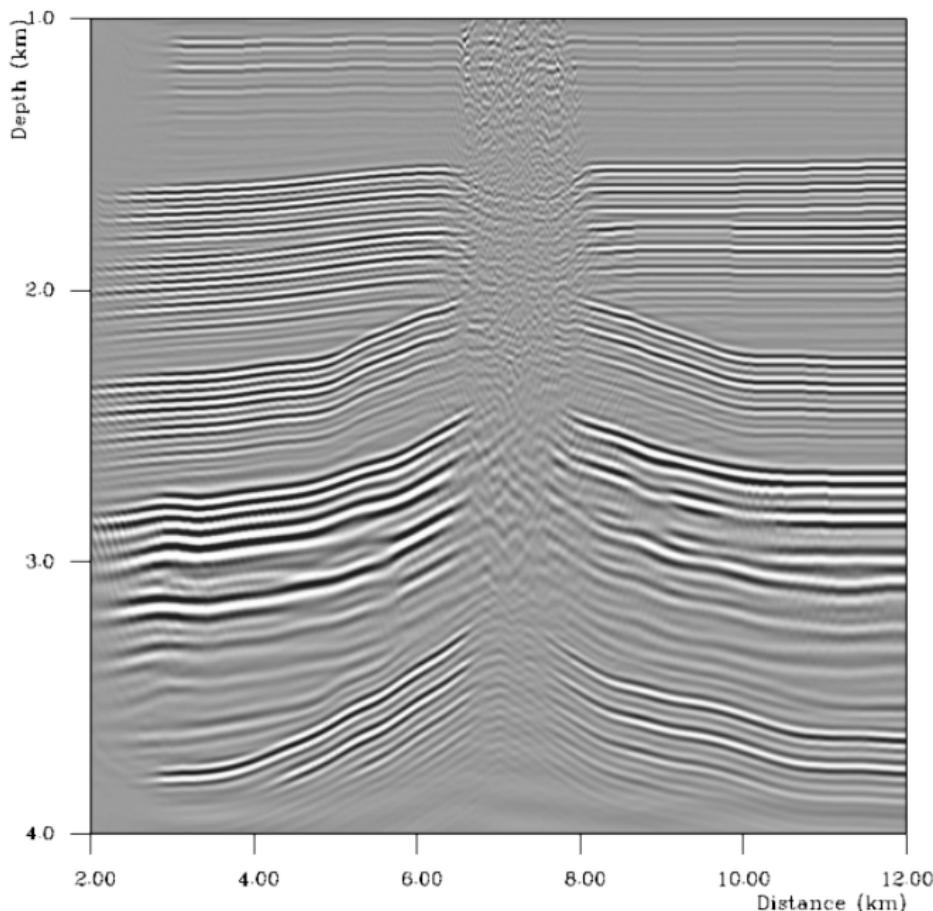
# Seismic Velocity model for chimney



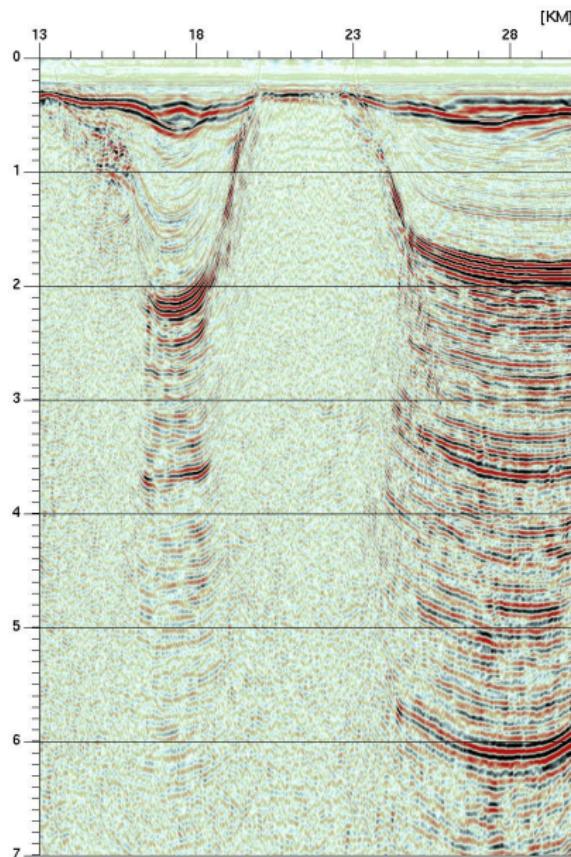
# Seismic Velocity model for chimney



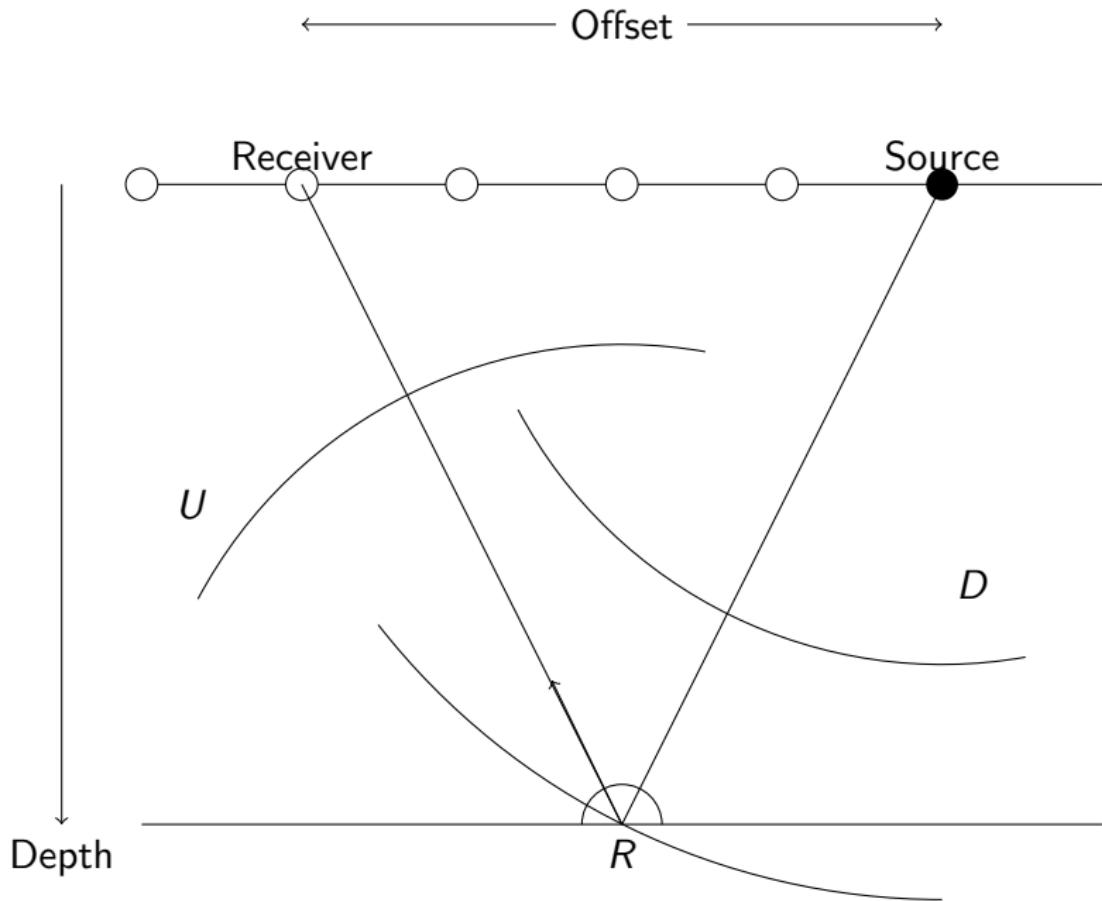
# Seismic Velocity model for chimney



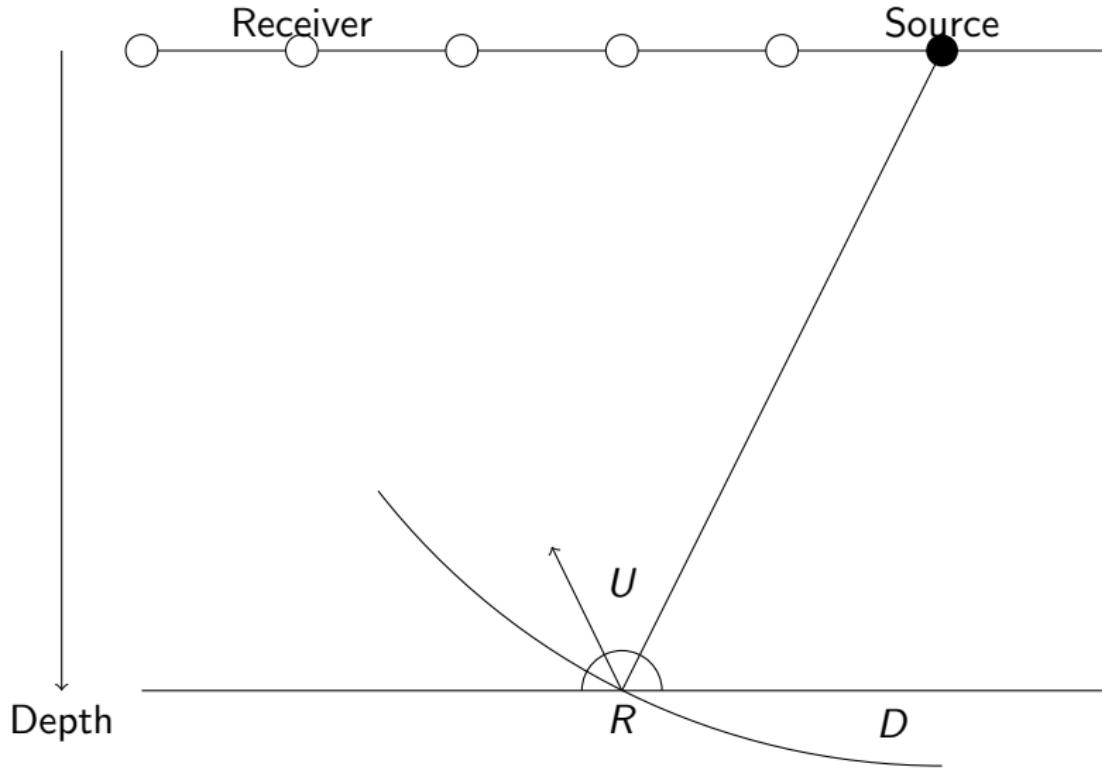
# Seismic Imaging



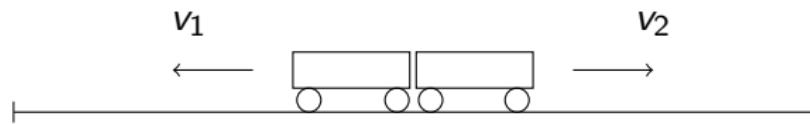
# Seismic Imaging



# Migration principles



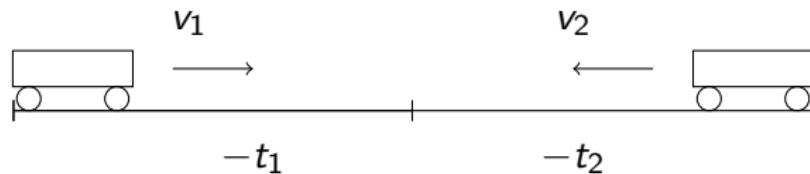
# Time reversal 1



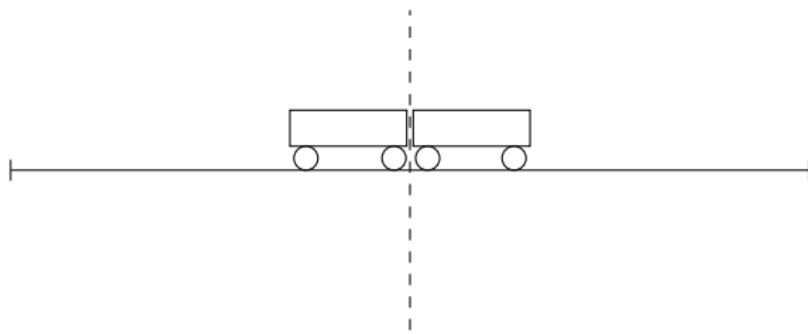
## Time reversal 2



## Time reversal 3



# Time reversal



# Seismic imaging

Forward modeling

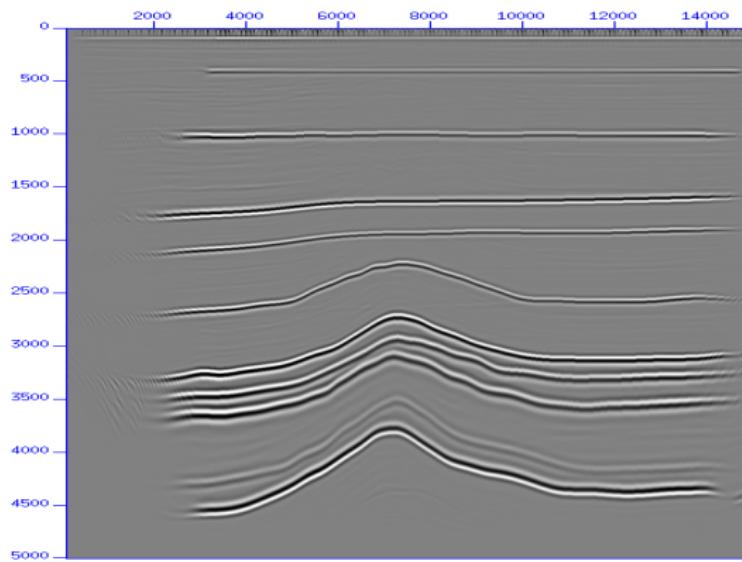
## Time reverse modeling

Backward modeling

# Cross correlation

Imaging

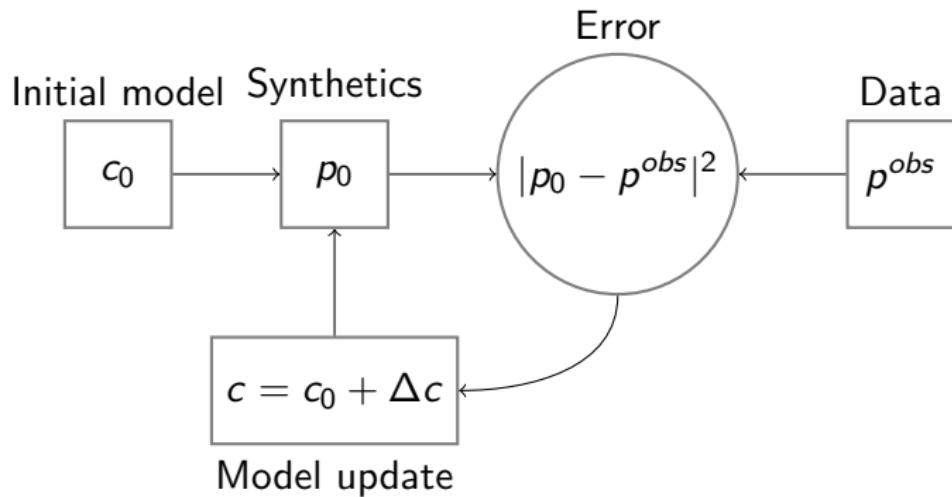
# Complete image



---

# Introduction

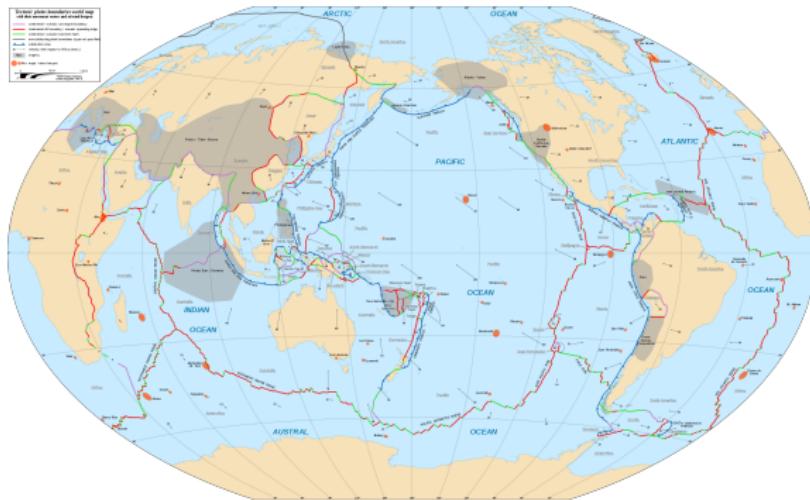
## Full Waveform Inversion loop



# Full Waveform Inversion

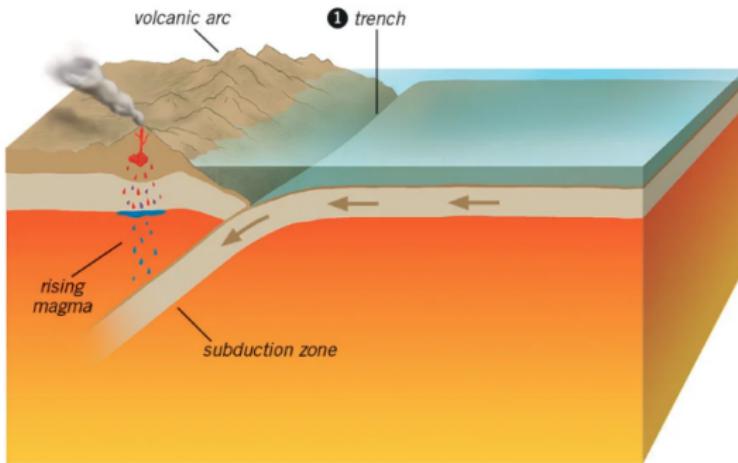


# Full Waveform Inversion



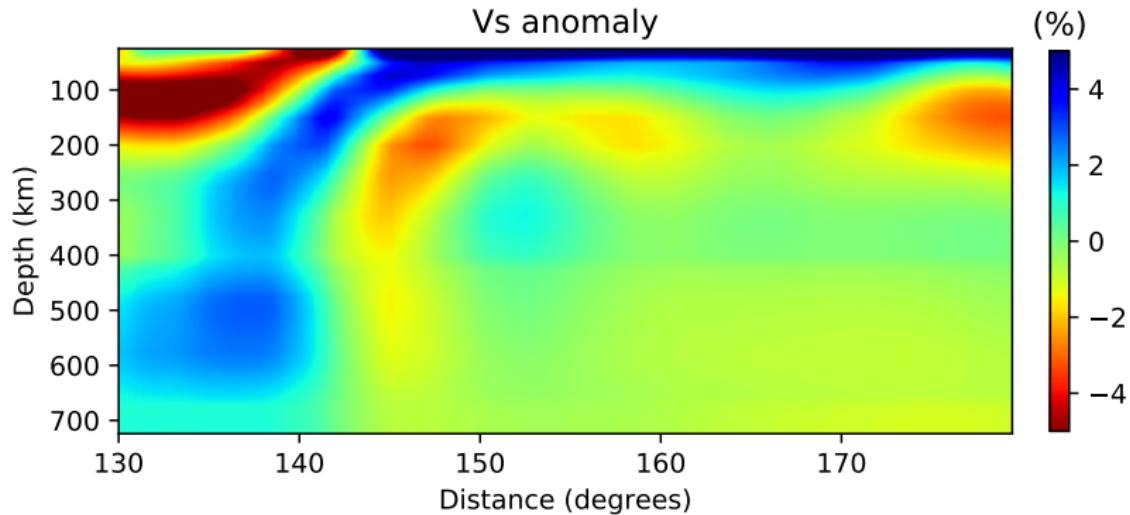
Credit: *Wikipedia*

# Full Waveform Inversion



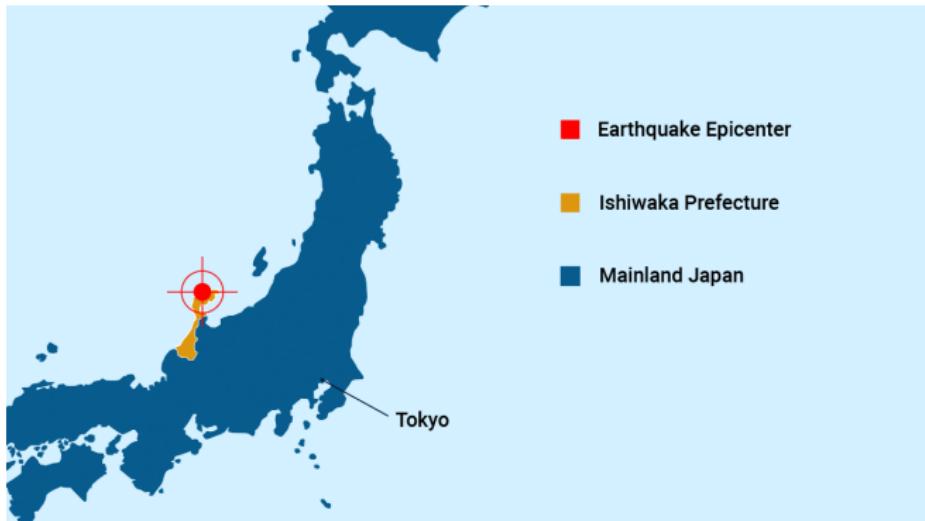
Credit: <https://answersingenesis.org/geology/plate-tectonics/plate-tectonics-reality-behind-theory/>

# Full Waveform Inversion



Credit: Schaeffer, A.J. and S. Lebedev: "Global shear speed structure of the upper mantle and transition zone",  
Geophysical Journal International, 194, pg 417-449, 2013. doi:10.1093/gji/ggt095.

# Full Waveform Inversion

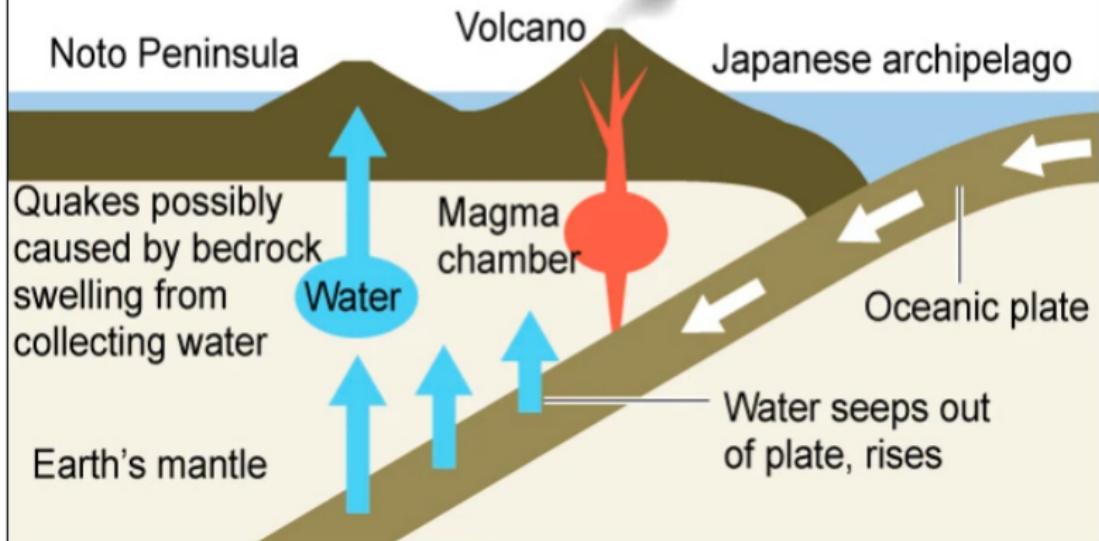


Credit: Wikipedia

# Full Waveform Inversion

## Crustal deformation beneath Noto Peninsula

(As hypothesized by Takuya Nishimura)



# Full Waveform Inversion



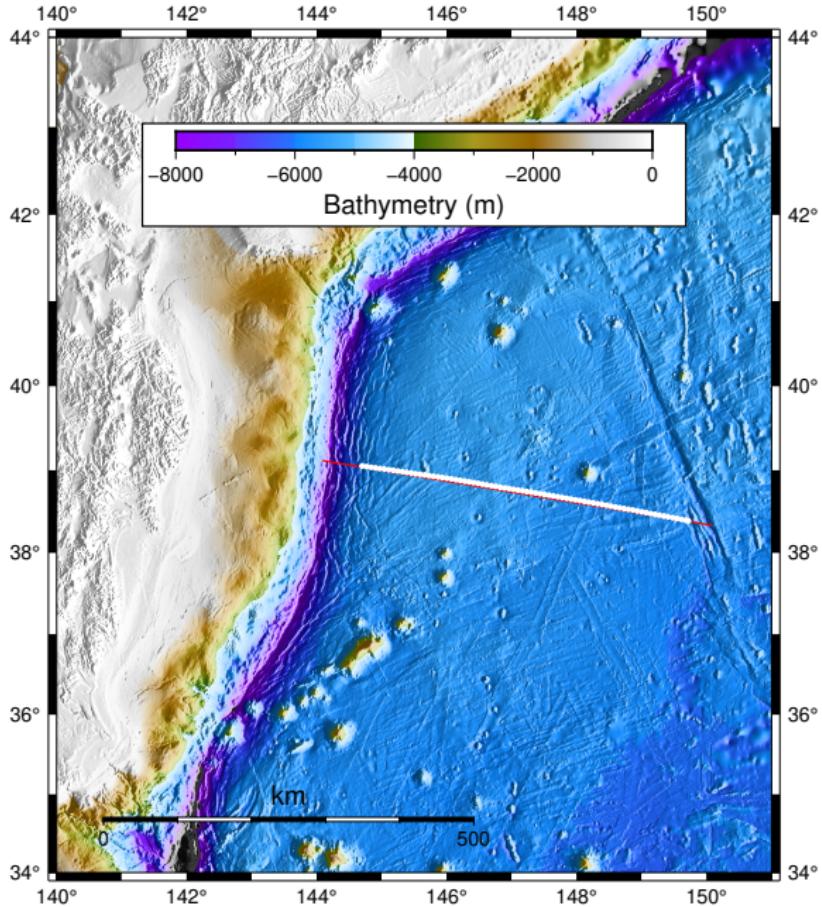
Credit:<https://www.z2data.com/insights/japans-2024-noto-peninsula-earthquake-impact-report>

# Full Waveform Inversion

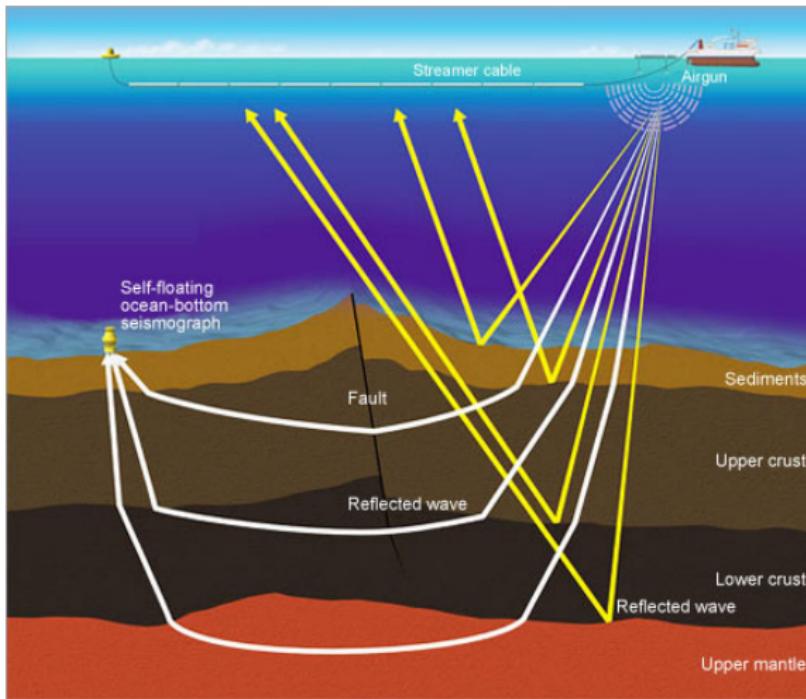


Credit:<https://www.z2data.com/insights/japans-2024-noto-peninsula-earthquake-impact-report>

# Full Waveform Inversion



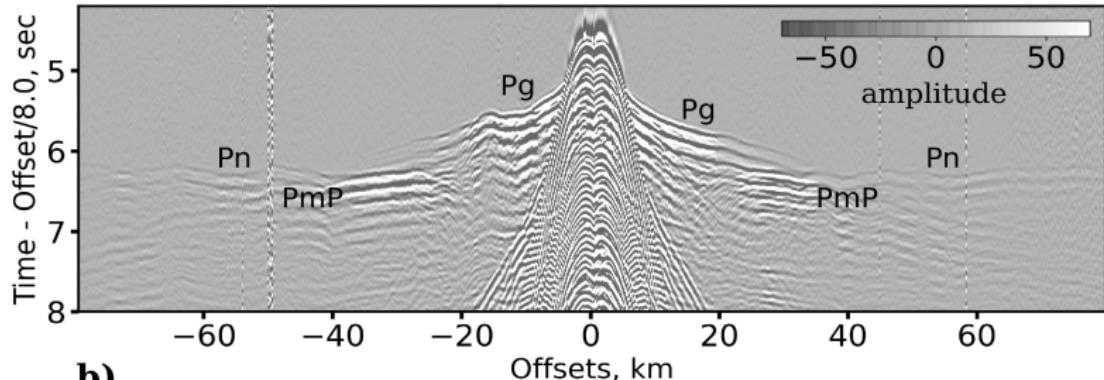
# Full Waveform Inversion



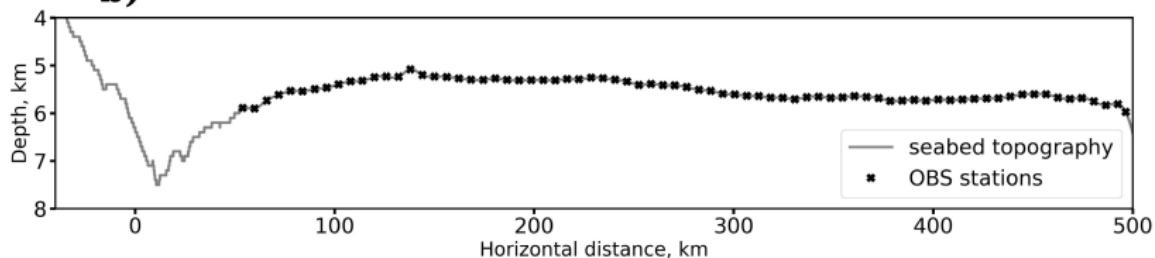
Credit: Japan Agency for Marine-Earth Science and Technology

# Full Waveform Inversion

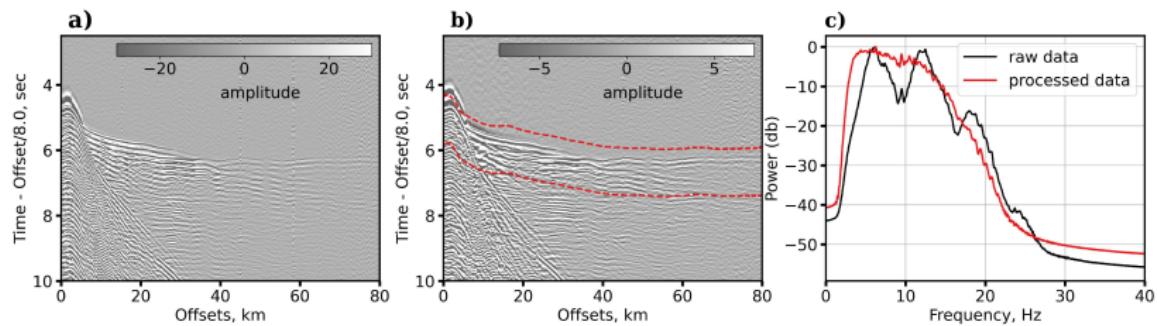
a)



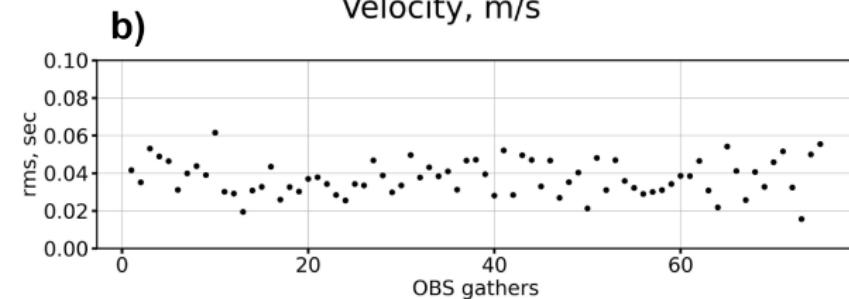
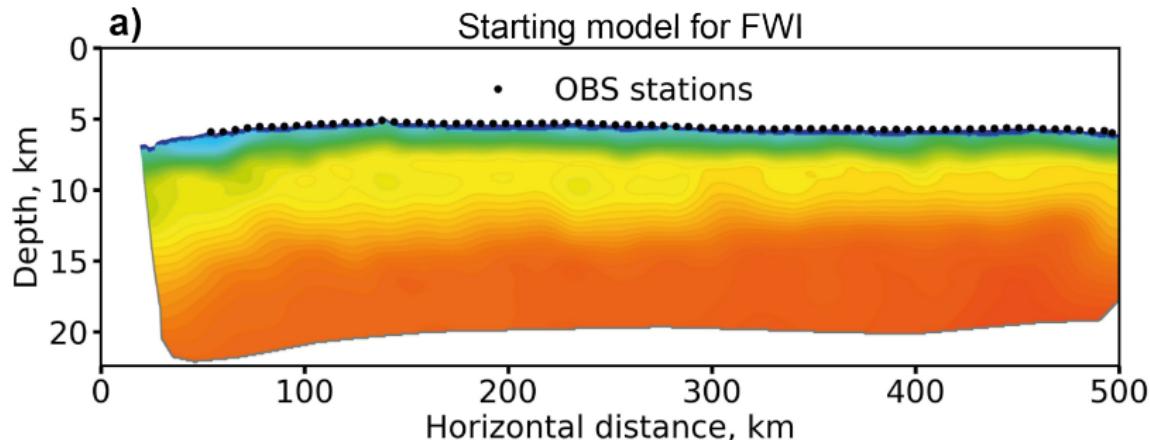
b)



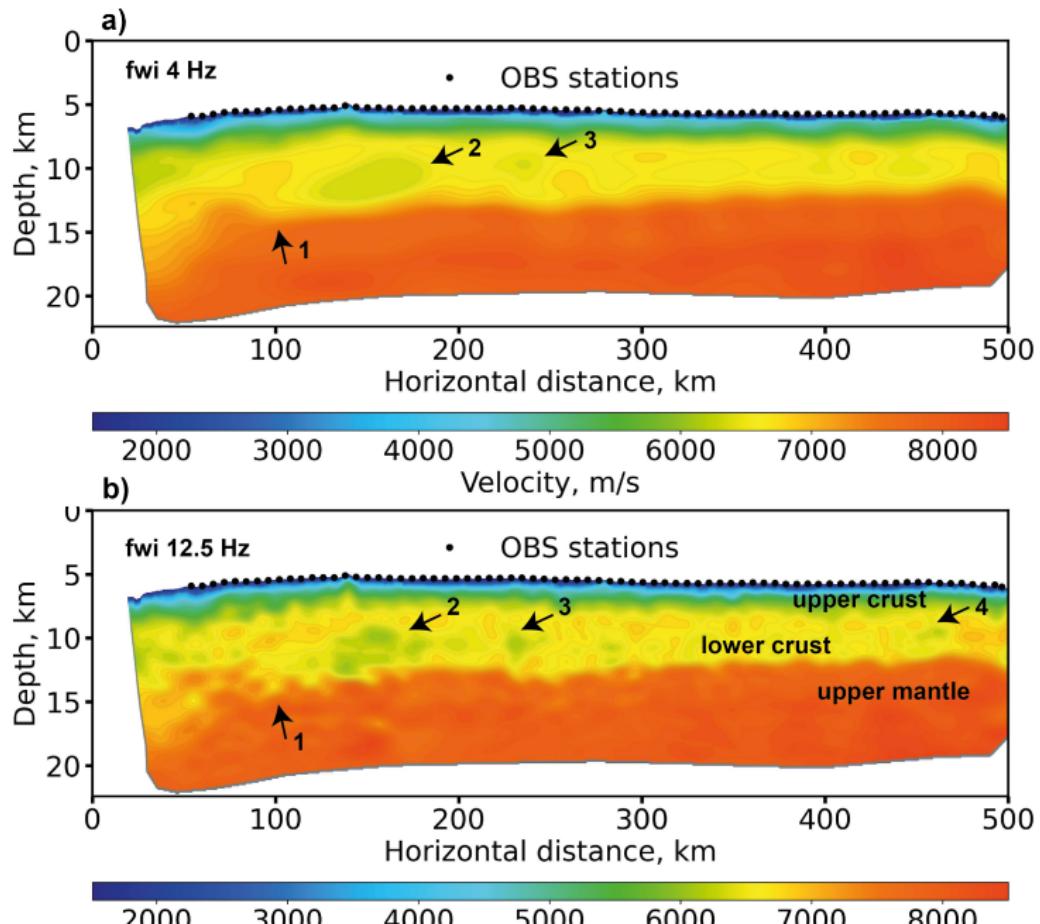
# Full Waveform Inversion



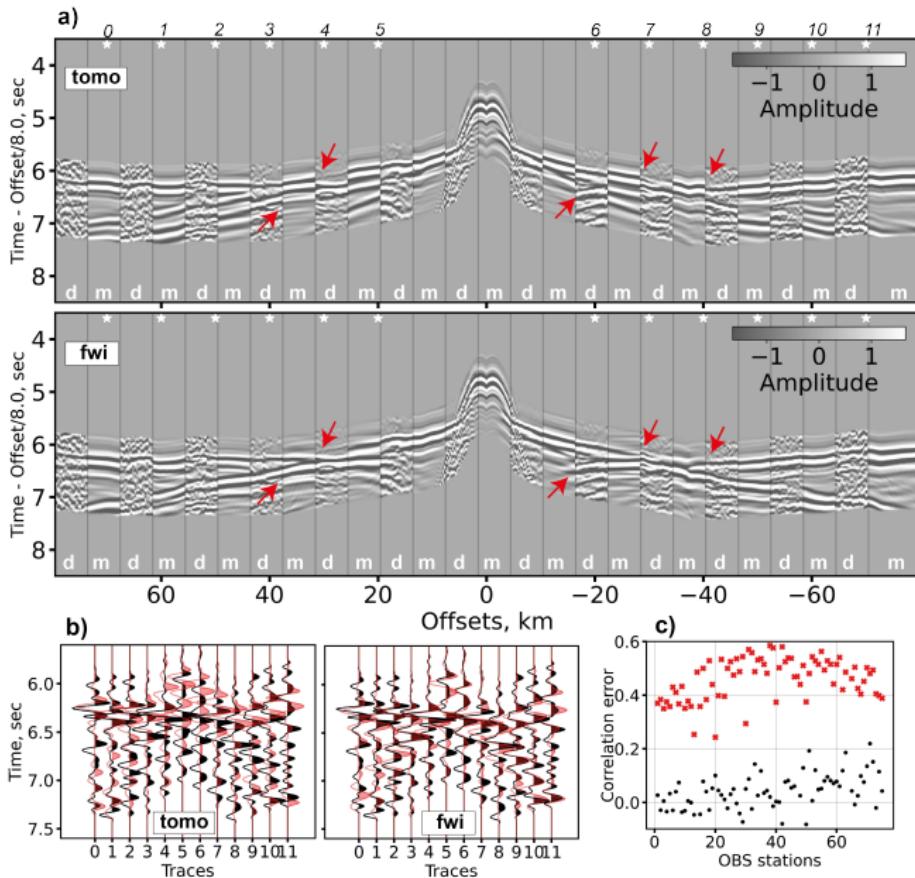
# Full Waveform Inversion



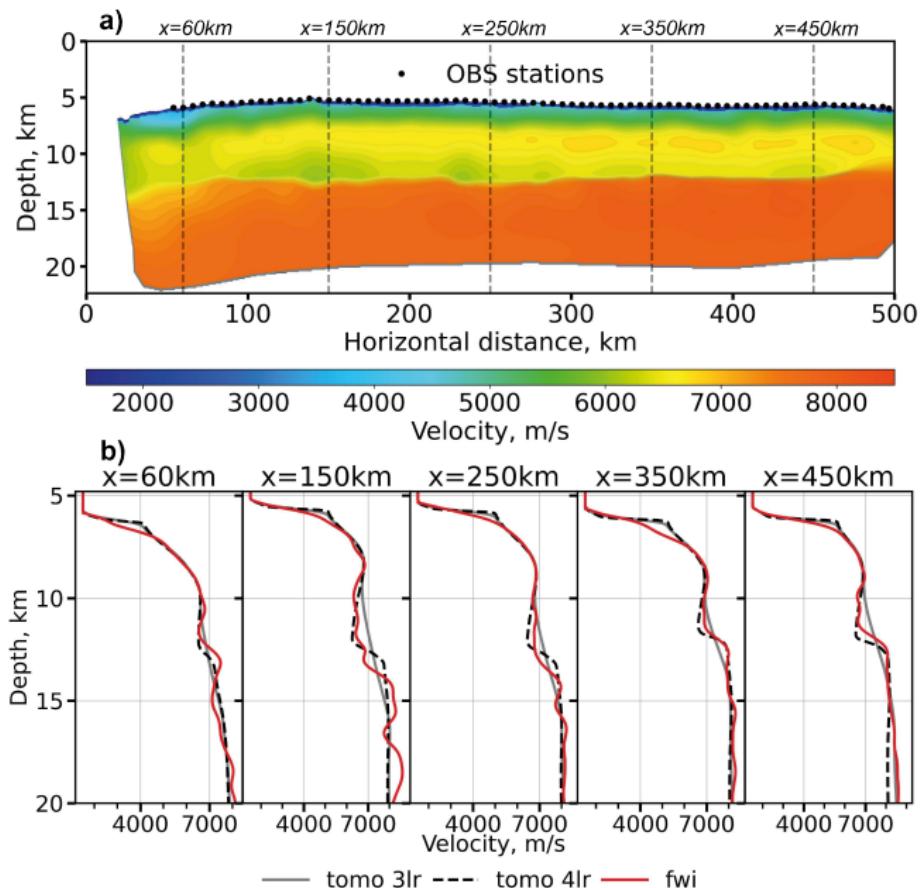
# Full Waveform Inversion



## Full Waveform Inversion



# Full Waveform Inversion



# Full Waveform Inversion

