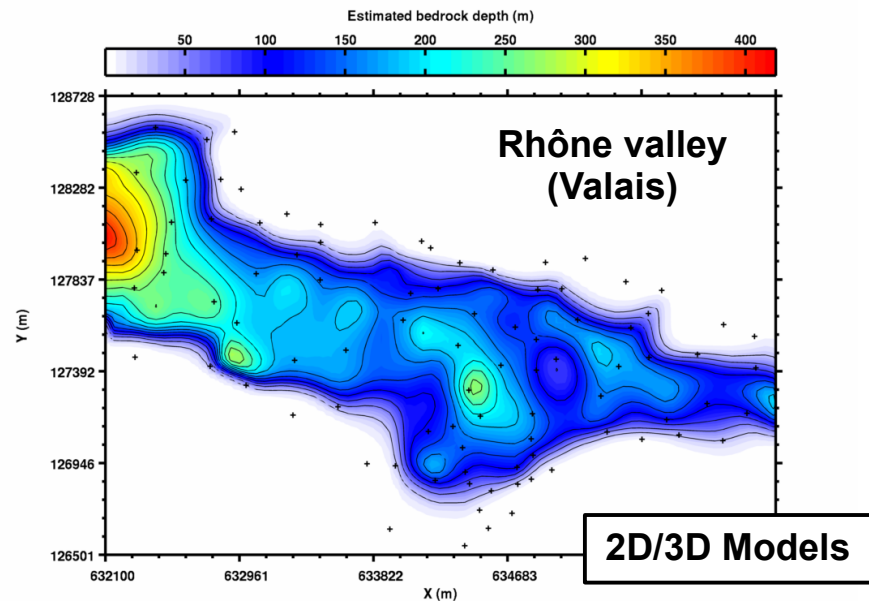
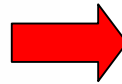
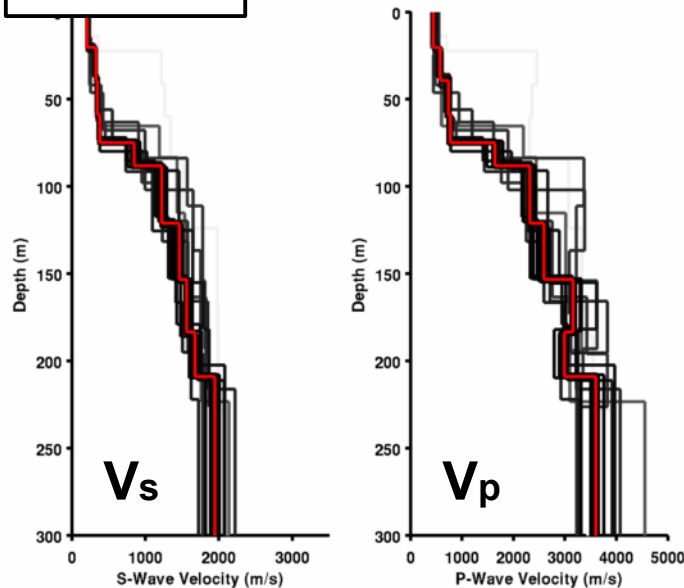


Site Characterization Techniques

Ground Parameter Overview

- The most relevant parameters to characterize the soil behavior are the **seismic velocity of body waves** (V_p and V_s), the **density** (ρ) and the **attenuation factors** (Q_p and Q_s)
- The way these parameters are geometrically distributed controls the modification of ground-motion during an earthquake
- **Shear wave velocity**, in particular, is the most important property in engineering applications
- A sufficient knowledge of these parameters is essential for any **interpretation of recorded earthquake ground motion**

1D Profiles



Indirect (geophysical) investigations

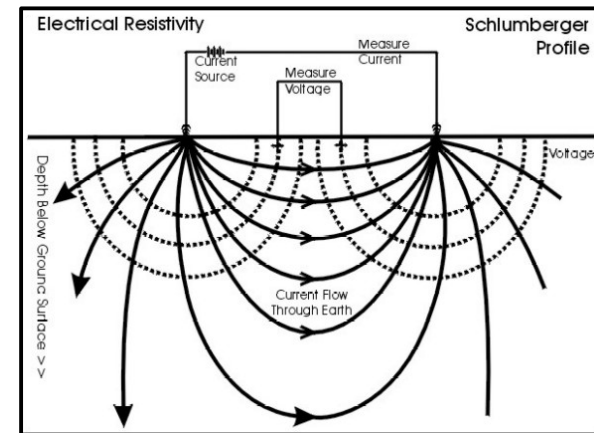
Indirect investigation techniques (or **geophysical methods**) use the properties of the **physical fields** (electric, magnetic, gravity, seismic) to infer information on the soil structure remotely (water table, bedrock depth)

Static-field methods:

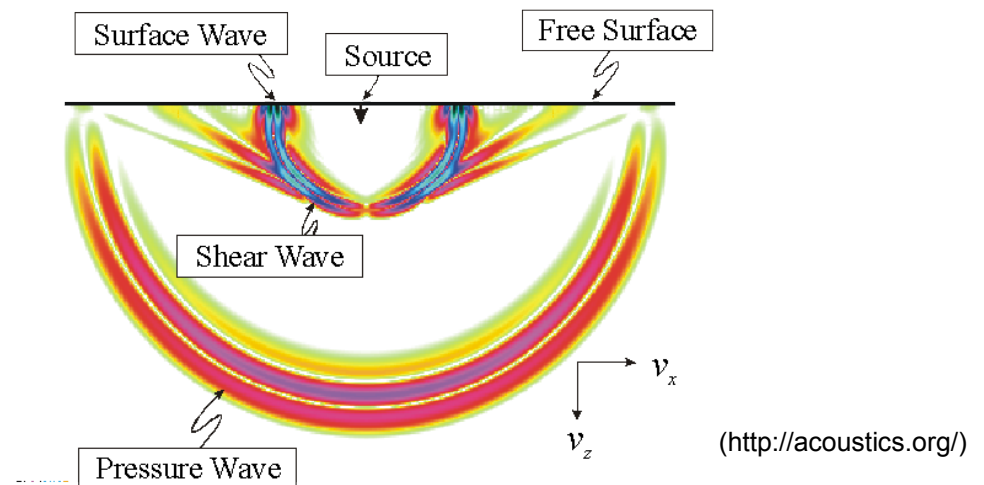
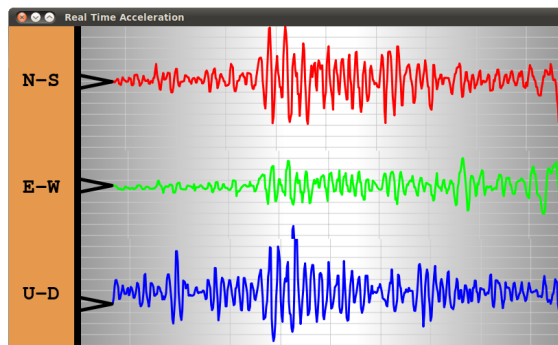
- Electrical methods (resistivity, self-potential)
- Magnetic method (magnetic susceptibility)
- Gravimetric method

Wave-field methods:

- Electromagnetic methods (radar)
- Seismic methods (active and passive)



(<http://www.earthdyn.com>)



(<http://acoustics.org/>)

Active seismic methods

- Make use of an **artificial sources** to generate a seismic signal
- Two major categories: the **travel-time** and **surface wave methods**
- The receivers can be located at the surface or in boreholes

Advantages:

- Good signal quality in noisy environments
- Good resolution on the velocity profile

Disadvantages:

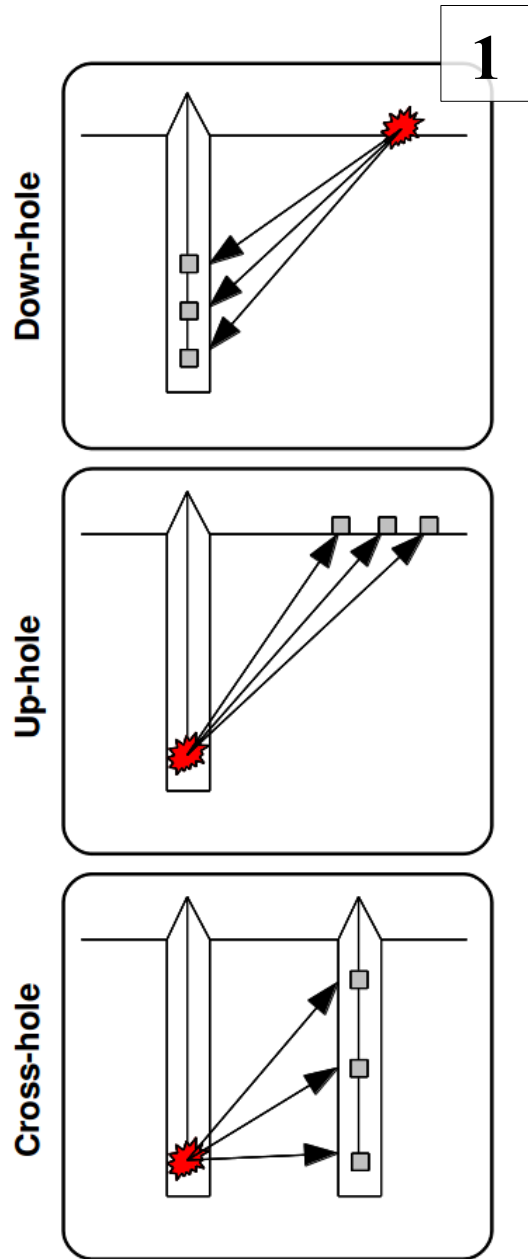
- Scarce penetration depth with conventional sources (e.g. hammer, minigun)
- Relatively high costs of implementation
- They can hardly be used in urban environment

Aaaaaahhh!!!

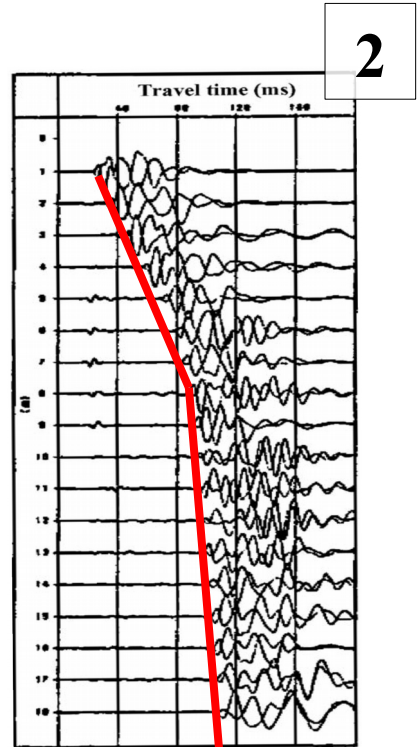


(<http://www.earth.ox.ac.uk>)





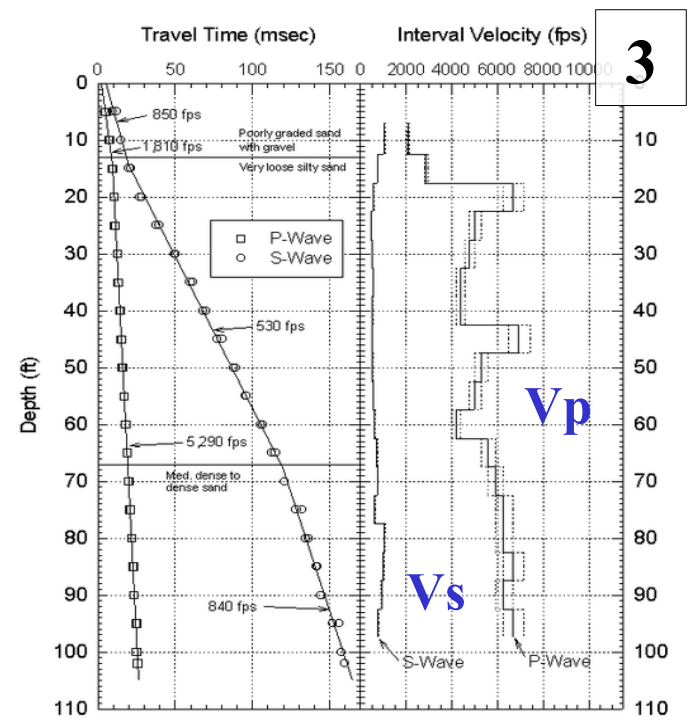
1



2

Takahashi et al. IJRMMS. 2006

Borehole seismic (Travel-time analysis)

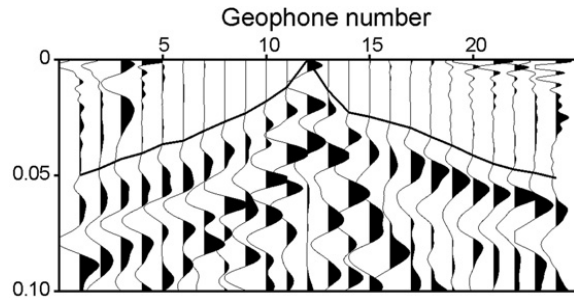


3

Typical results from downhole seismic survey

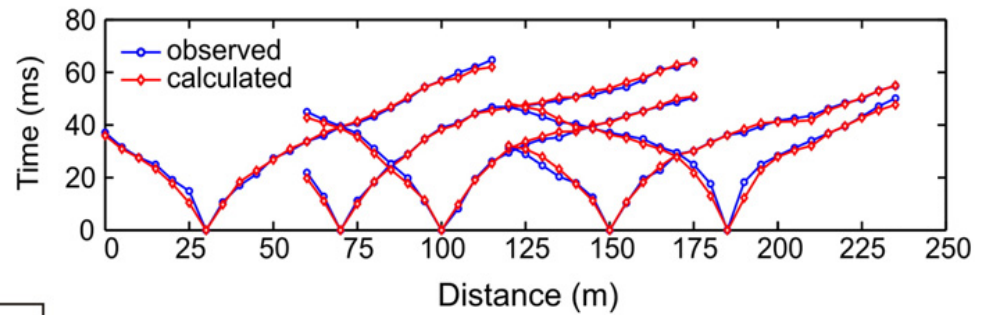
(<http://www.earthdyn.com>)

Acquisition

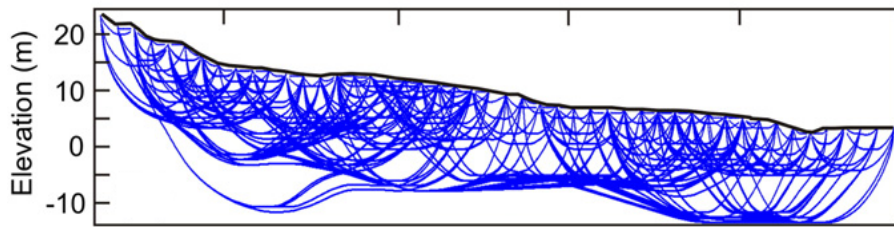


Seismic refraction analysis (travel-time tomography)

Travel time analysis

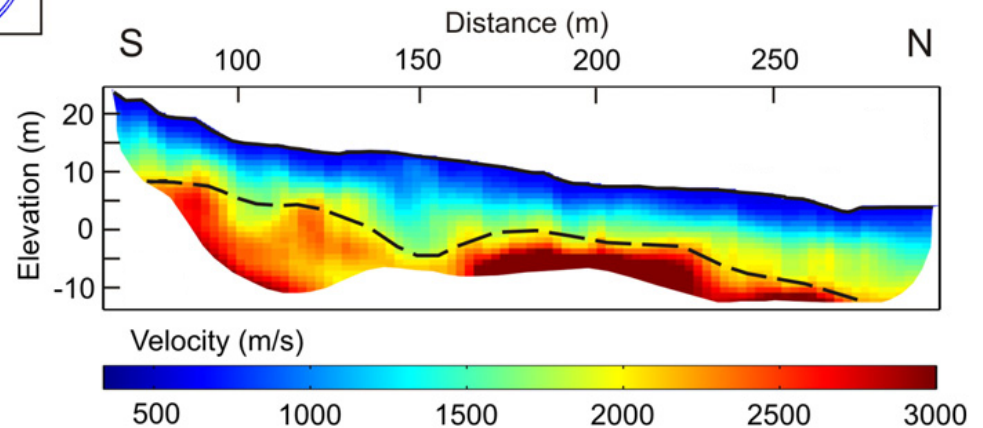


Ray-path modeling

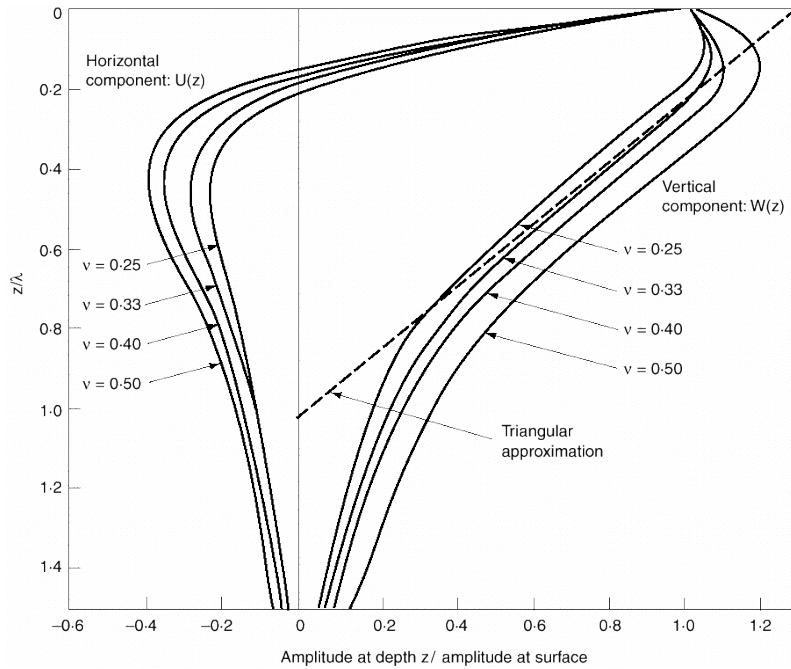


Göktürkler et al., JAG, 2008

Velocity analysis



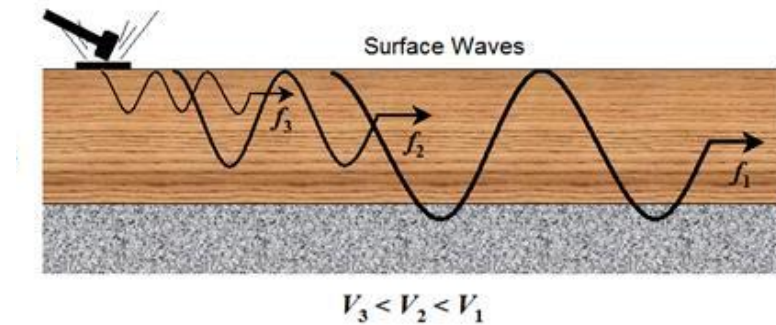
Eigenfunctions



- Velocity is frequency dependent (**velocity dispersion**)
- **Multiple modes** of propagation exist at the same time

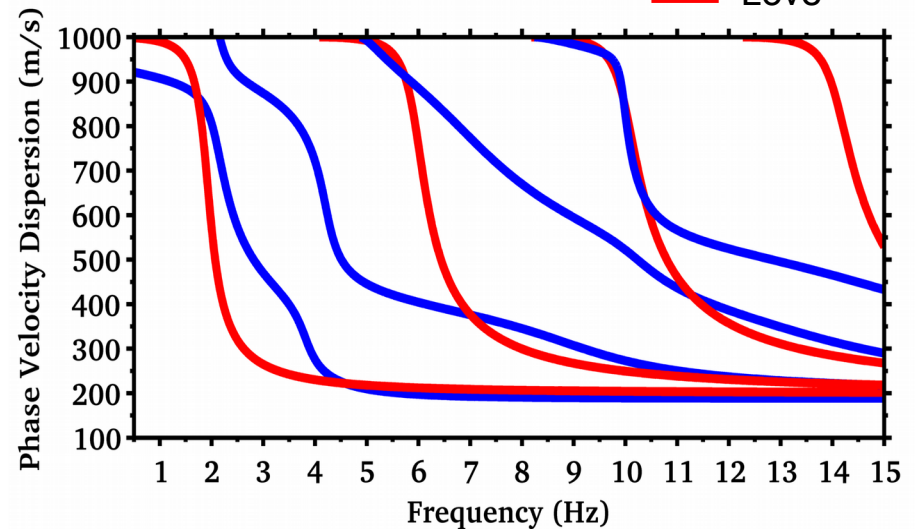
Surface waves

Displacement (**mode eigenfunction**) vanishes with depth



Velocity dispersion

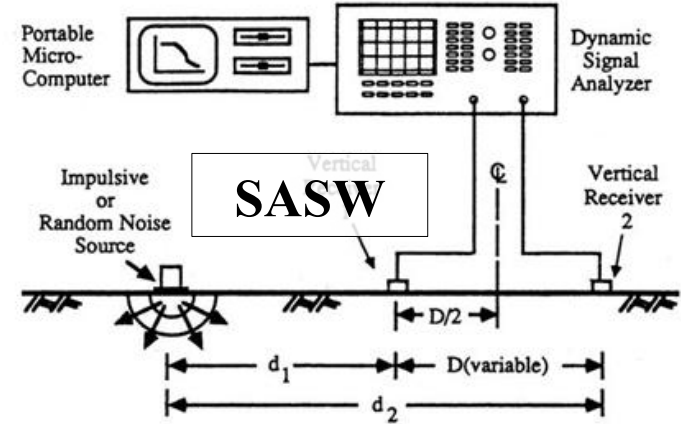
— Rayleigh
— Love



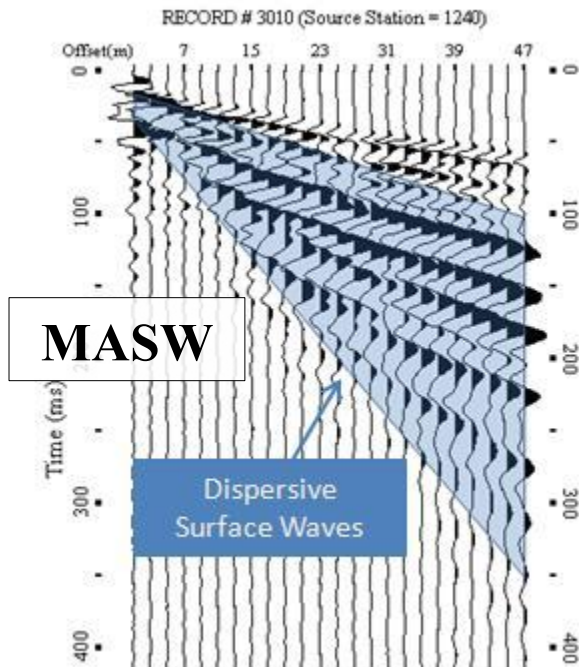
Active surface wave analysis

SASW → Spectral Analysis of Surface Waves
(relative phase delay between pairs of receivers)

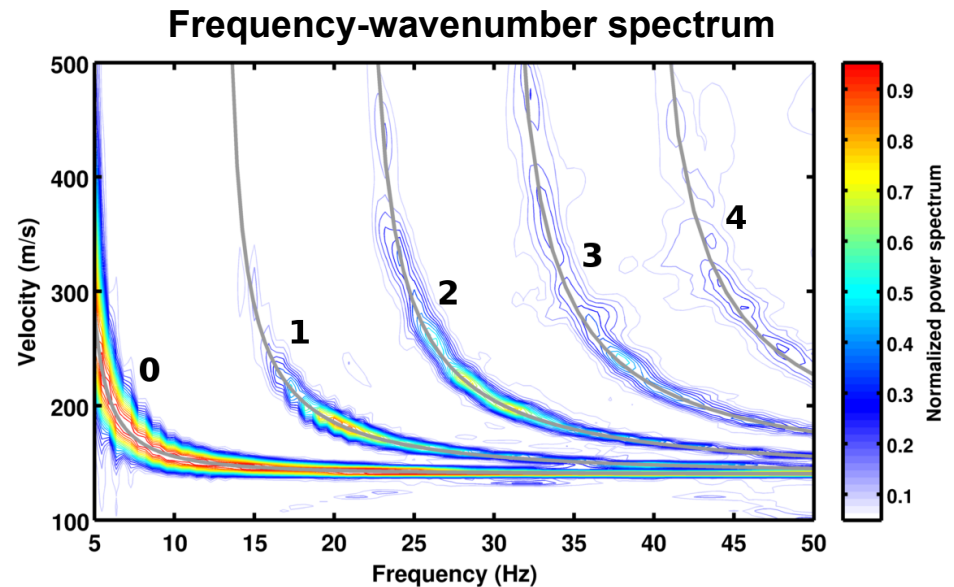
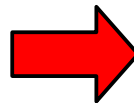
MASW → Multichannel Analysis of Surface Waves
(frequency-wavenumber analysis)



From Rix et al. (1991)

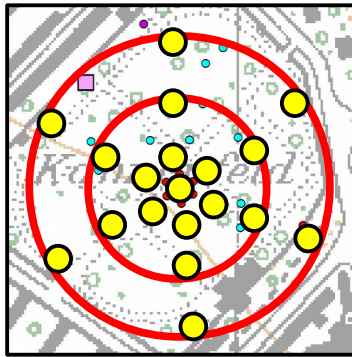


(<http://www.parkseismic.com>)

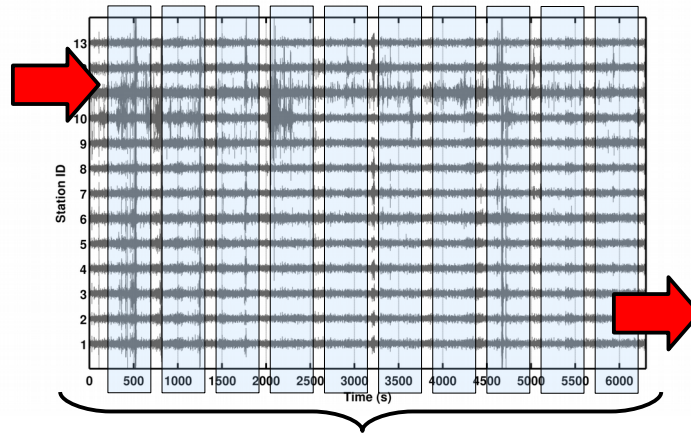


Ambient vibration seismology (Array analysis)

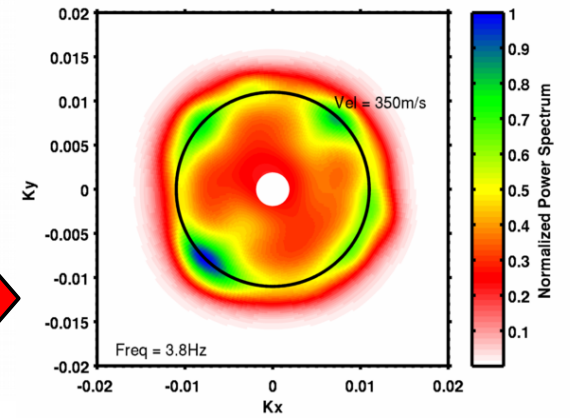
Array deployment



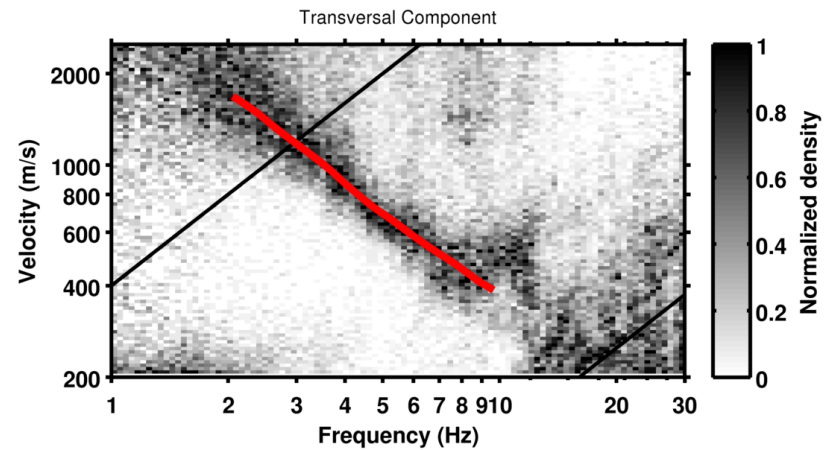
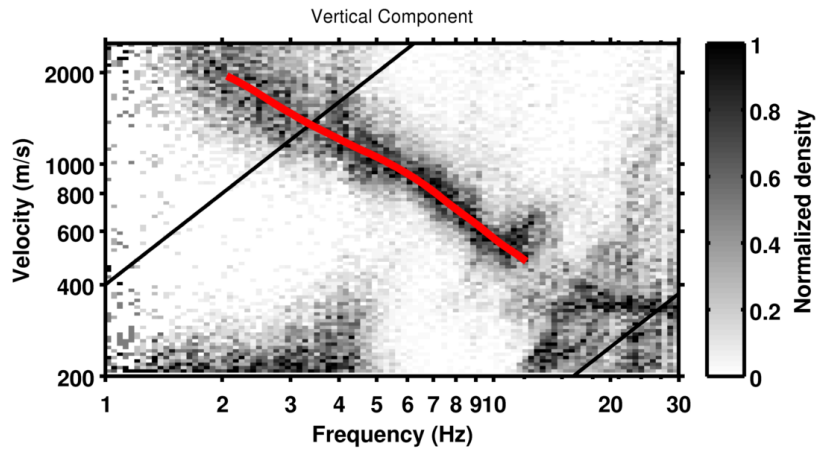
Noise recording



f-k analysis

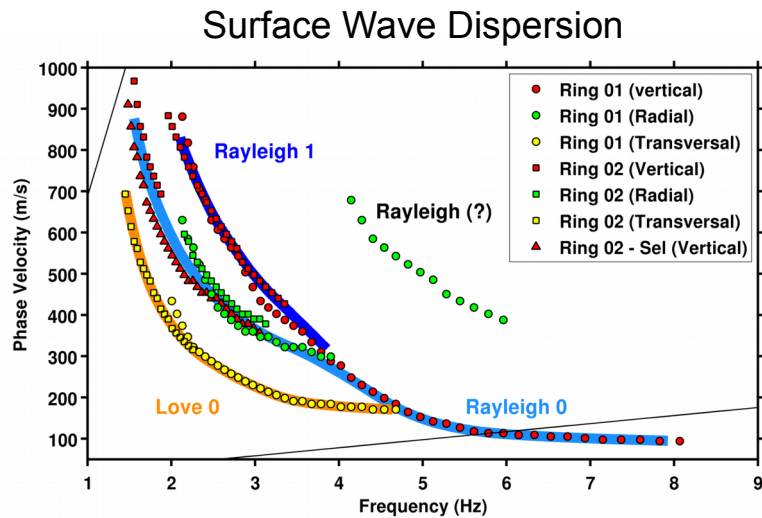
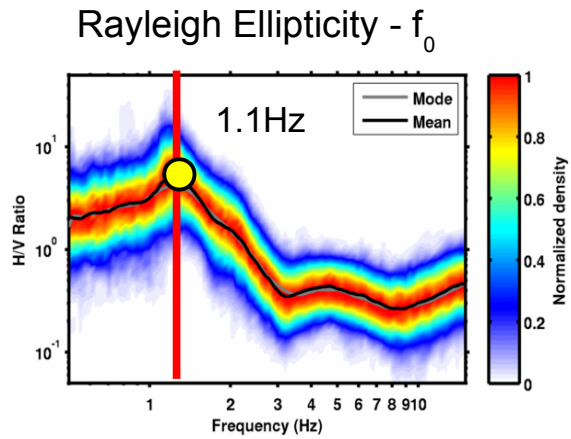


1h40m



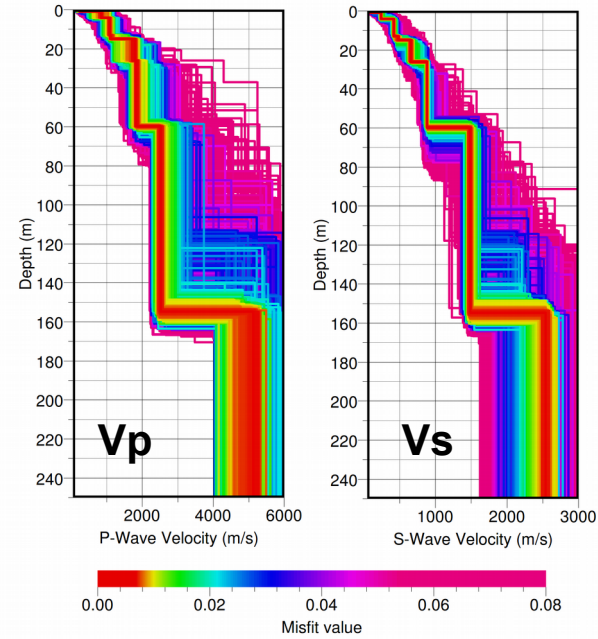
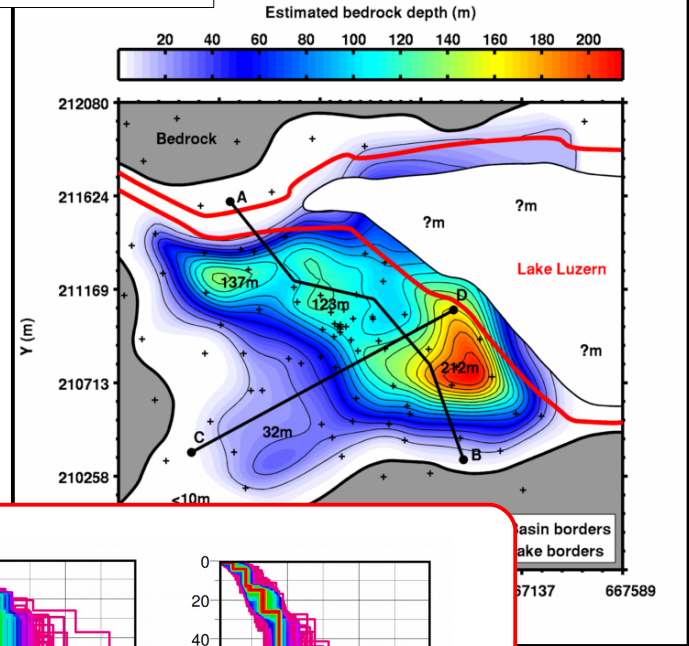
Building the Model

Surface-wave Data



Inversion

Bedrock Map



Velocity Model