The guided wave in the subduction zone

Speaker : Mu-Ching Liu

Reference

- Dispersion of regional body waves at 100-150 km depth beneath Alsaska: In situ constraints on metamorphism of subducted crust

(Geoffrey A. Abers and Golam Sarker 1996)

- Guided waves propagating in subducted oceanic crust

(S.Martin and A.Rietbrock C.Haberland and G. Asch 2003)

Abstract

- 1. Introduction
- 2. Data

  Alaska & Chile subduction zone
- 3. Method
- 4 Conclusion

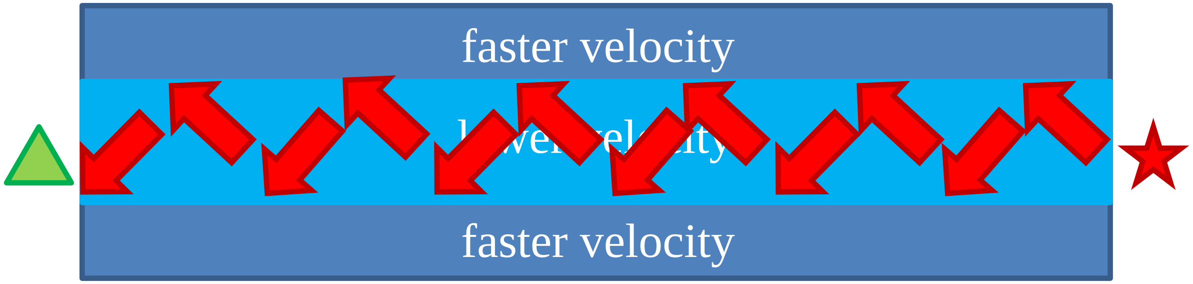
Introduction

- What is guided wave?
- Background:

  Any continuous layered structure that is slow compared to bounding media.

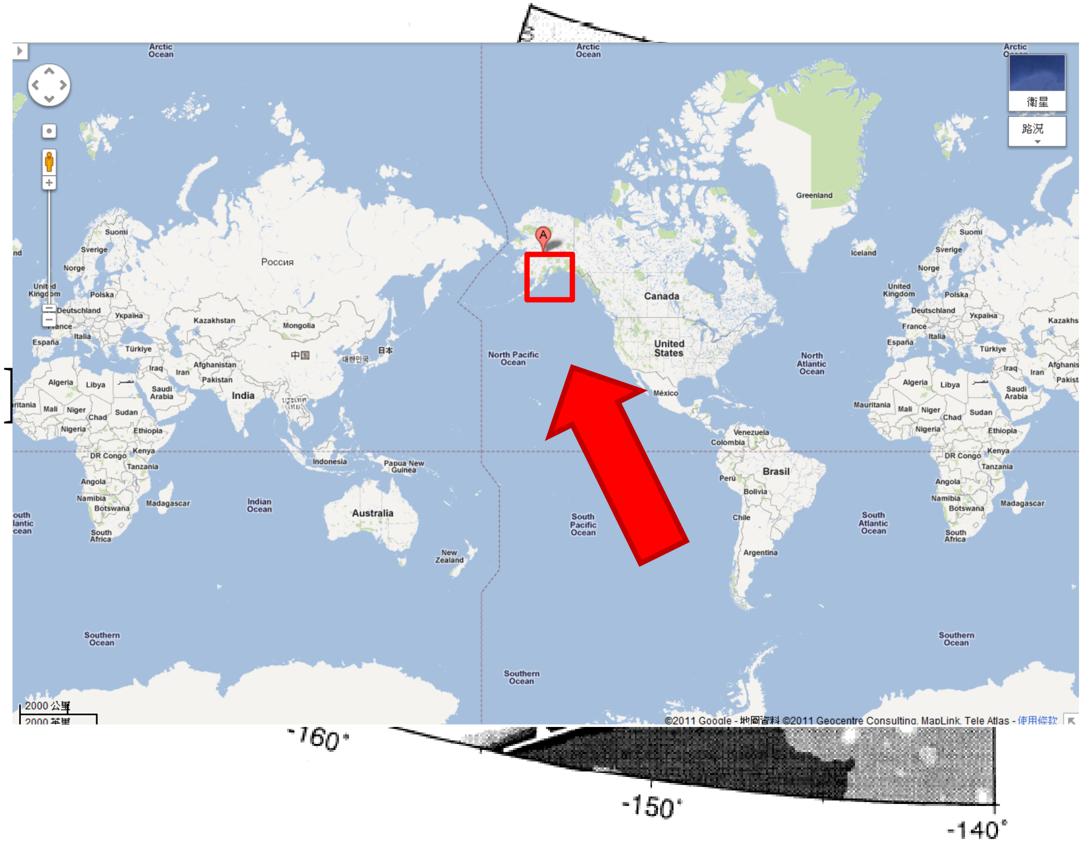
- Phonomena:

  The structure causes, for certain source-receiver configurations,internally reflected waves that produce prominent interference patterns called guided wave.



Data-1

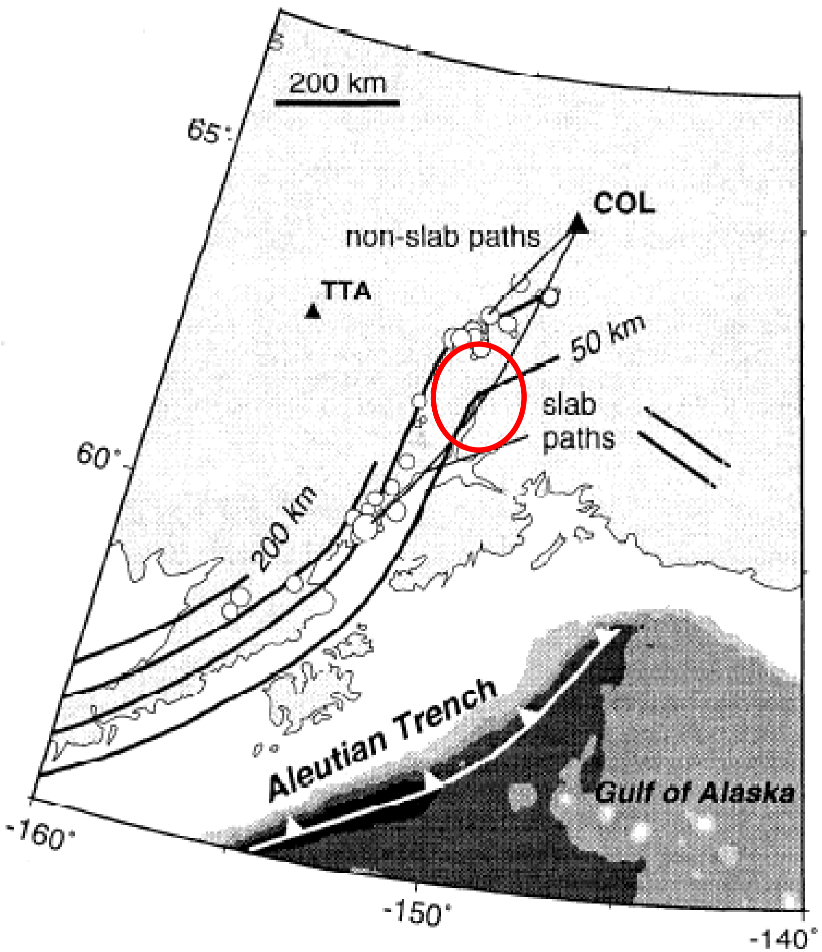
- Study area : Alaska
- Global seismic Network station :COL
- 1992~1993
- I. traverse slab
  #22
  300~800km
- II.don’t traverse sl
  #31
  100~170km

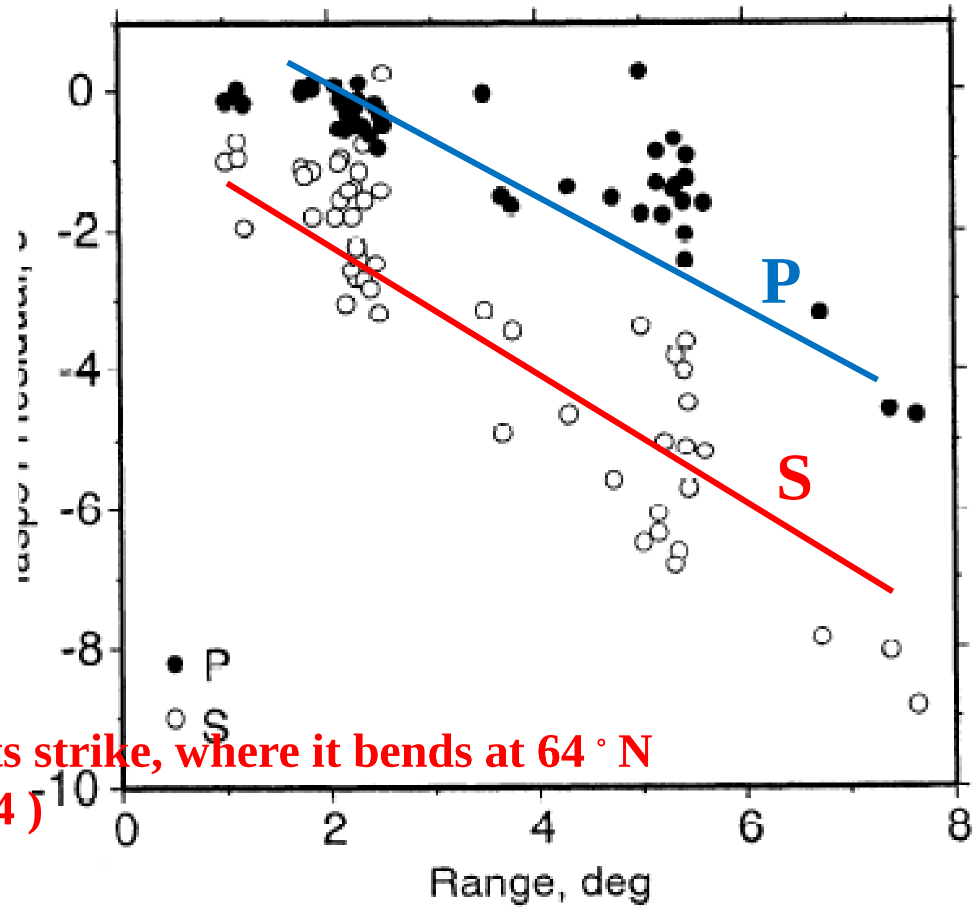


Data-1-travel time

Engdahl,1991)

ce

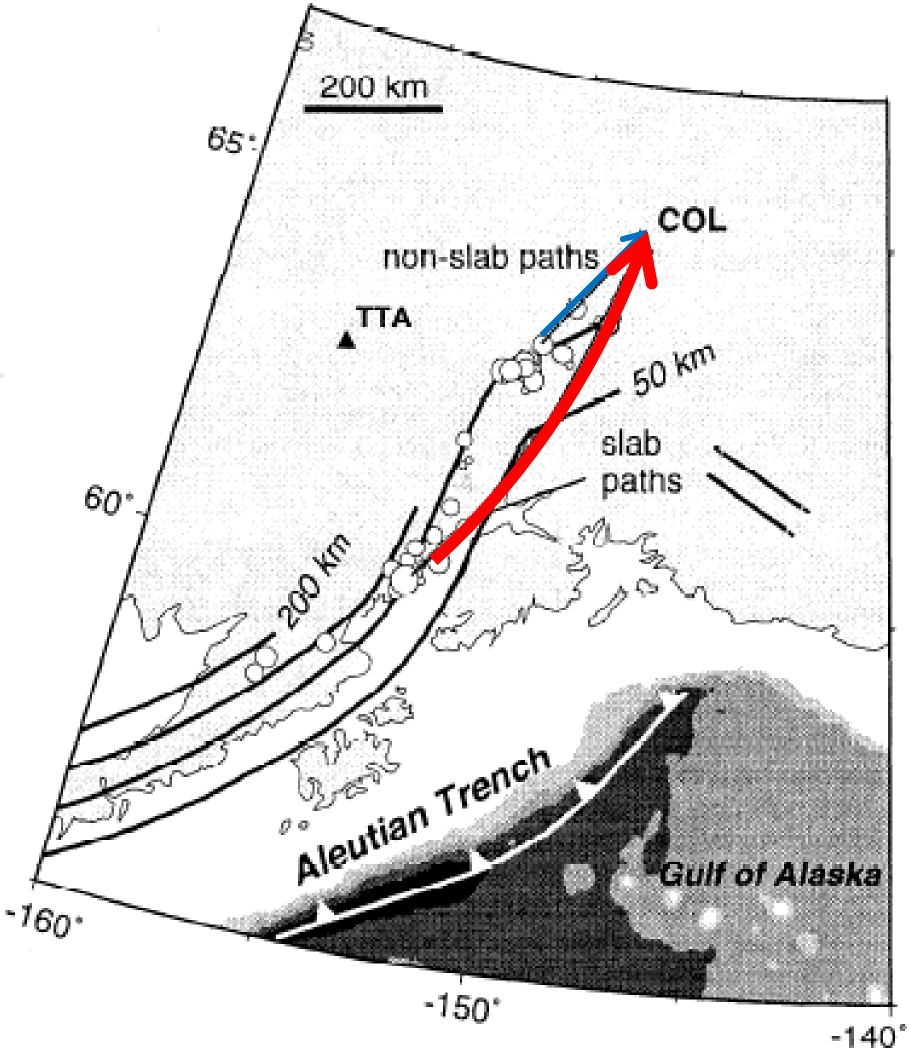




These rays travel within the slab along its strike, where it bends at 64 ◦ N

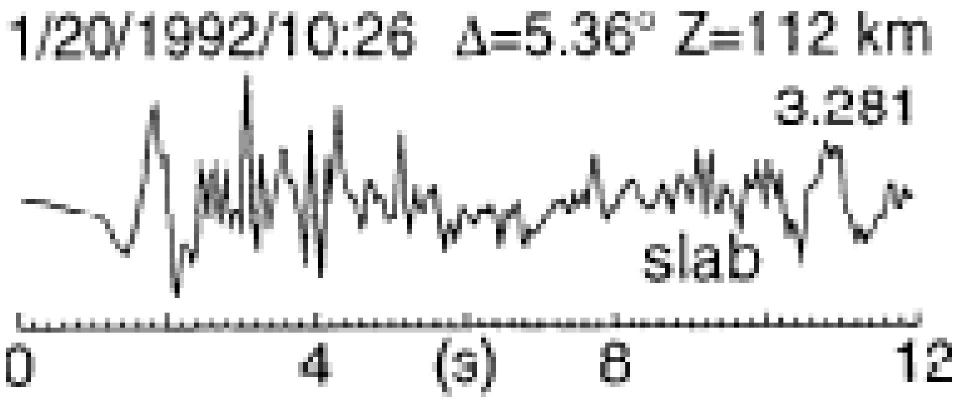
(Zhao et al 1995 ,Reoker 1989, Aber 1994)

Data-1-dispersion



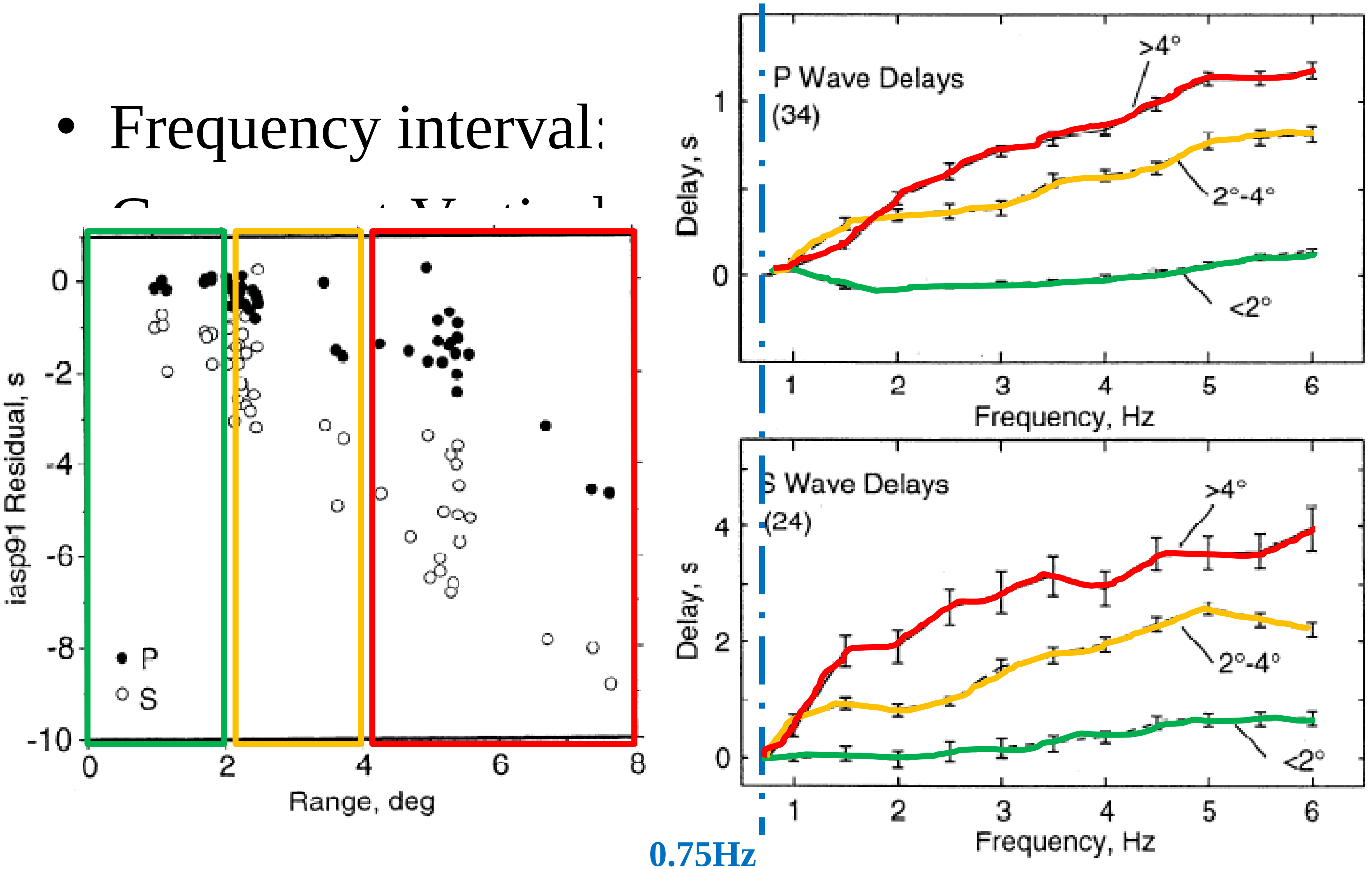
No-slab paths

slab paths



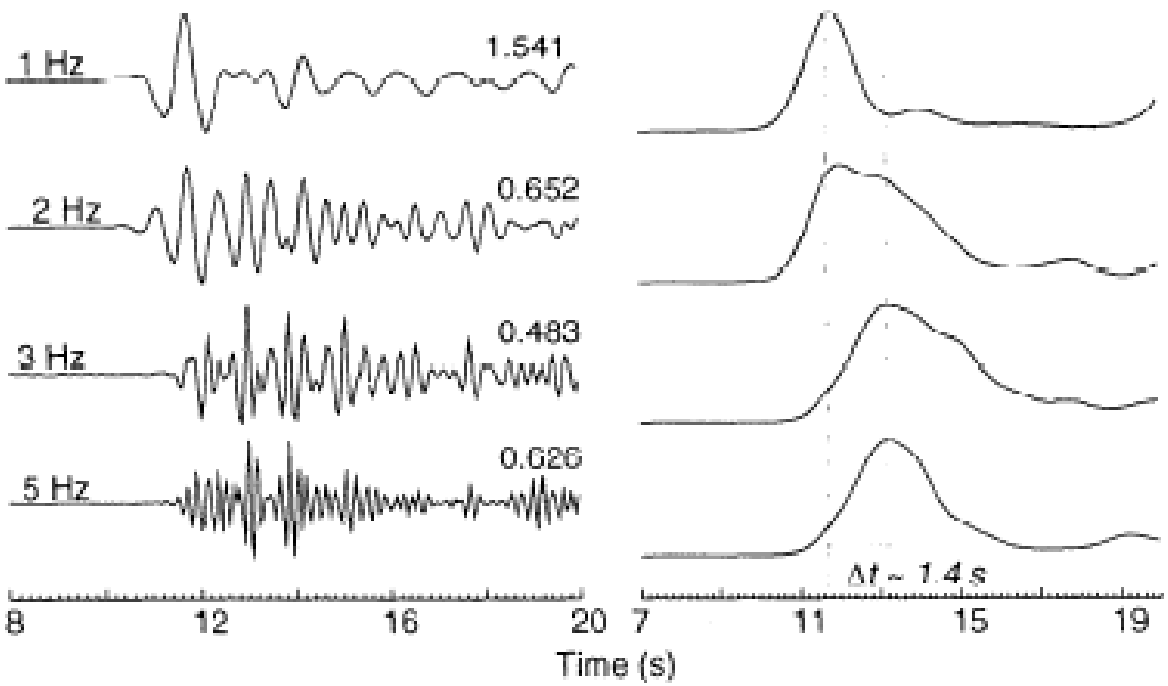
Data-1-dispersion

- Frequency interval:



Data-1-Amplitude

- Amplitude is high also at high frequency
- High frequency energy is enhanced by wave guided ?



Discussions

- What could cause this phenomena ?

1. Only slab path event can be observed this effect
2. This dispersion is not seen at all regional network station
3. Simple phase conversions off a slab mantle interface can not explain the frequency dependence and amplitude behavior of the later phase

Discussions

- 2D finite difference (Keiswetter et al 1996)

-10~20% velocity variation at 0.5~1 km scales both along and across the slab which is caused by fluid , melt by volume or by differences in behavior of fine grained basalt and coarse-grain gabbro . (Hacker, 1996)

- 1D wave guides

-The large variations will be present only across the strike of the slab

Discussions-waveguide effect

- 1.Estimate waveguide dimension

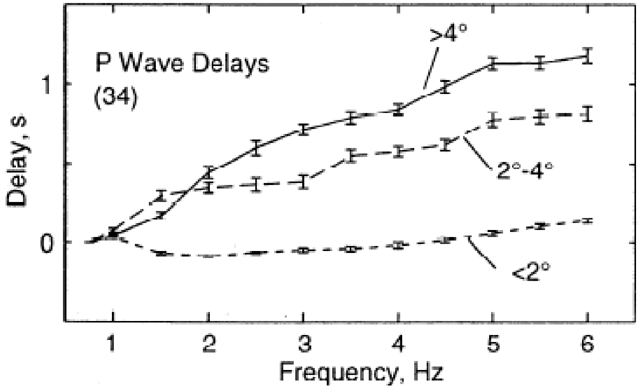
Inspect dispersion curves for a characteristic frequency visually

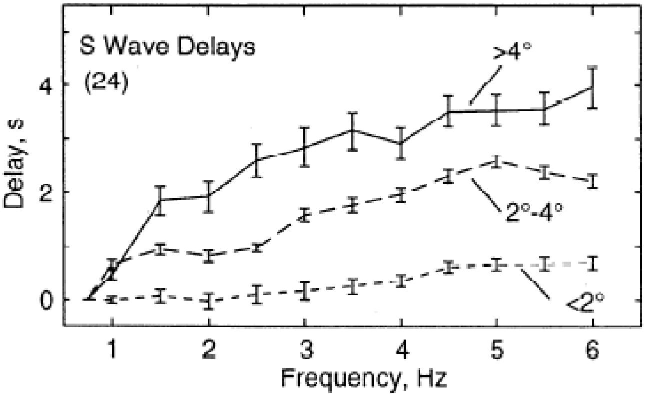
- 2.Caculate fundamental-mode dispersion for a low velocity acoustic channel. (Gubbins and Snieder (1991))

These solution can give estimates of group velocity as a function of frequency

- 3.Grid search

Determine the layer thickness and velocity that best explains the observations

- 



Discussions-waveguide effect

- Channel thickness : 2.4km for P wave,1.9km for S wave

  Uncertainties : 1~3 km
- Velocity perturbation : 2.6% for P wave, 4.5% for S wave

  Uncertainties : 1%

  Because many of dispersion curves clearly show effects at frequencies below 3 Hz (λ=2.7km) channels thinner than 2-3 km don't realistic.

Channel thickness : 2-5.5km

Velocity perturbation:1.5-4% for P, 3~6% for S

Summary

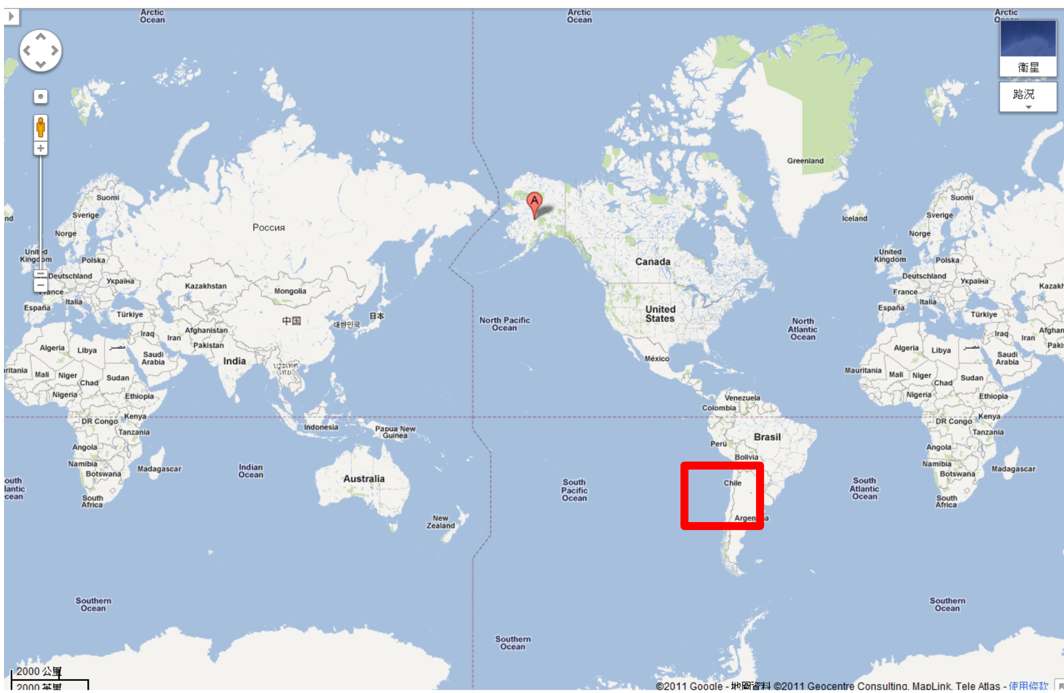
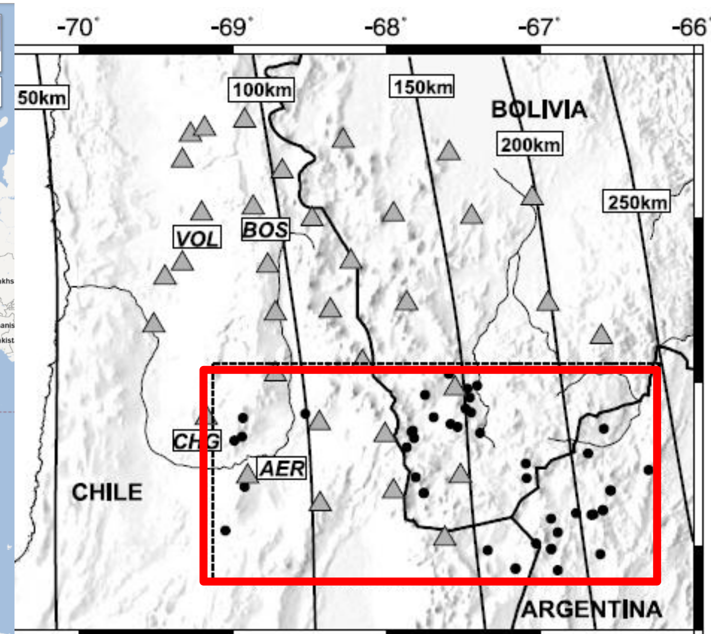
- In equilibrium condition,dry gabbroic crust should convert to eclogite at depth of 20—30km (Ahrens and Schubert)
- Eclogite is 15-20% denser and faster than gabbro and should have seismic velocities that are close to or exceeding that of the surrounding mantle (Helffrich et al 1989; Gubbins er al 1994)
- These reactions may be too sluggish at slab temperatures (Ahrens and Schubert,1975)

Summary

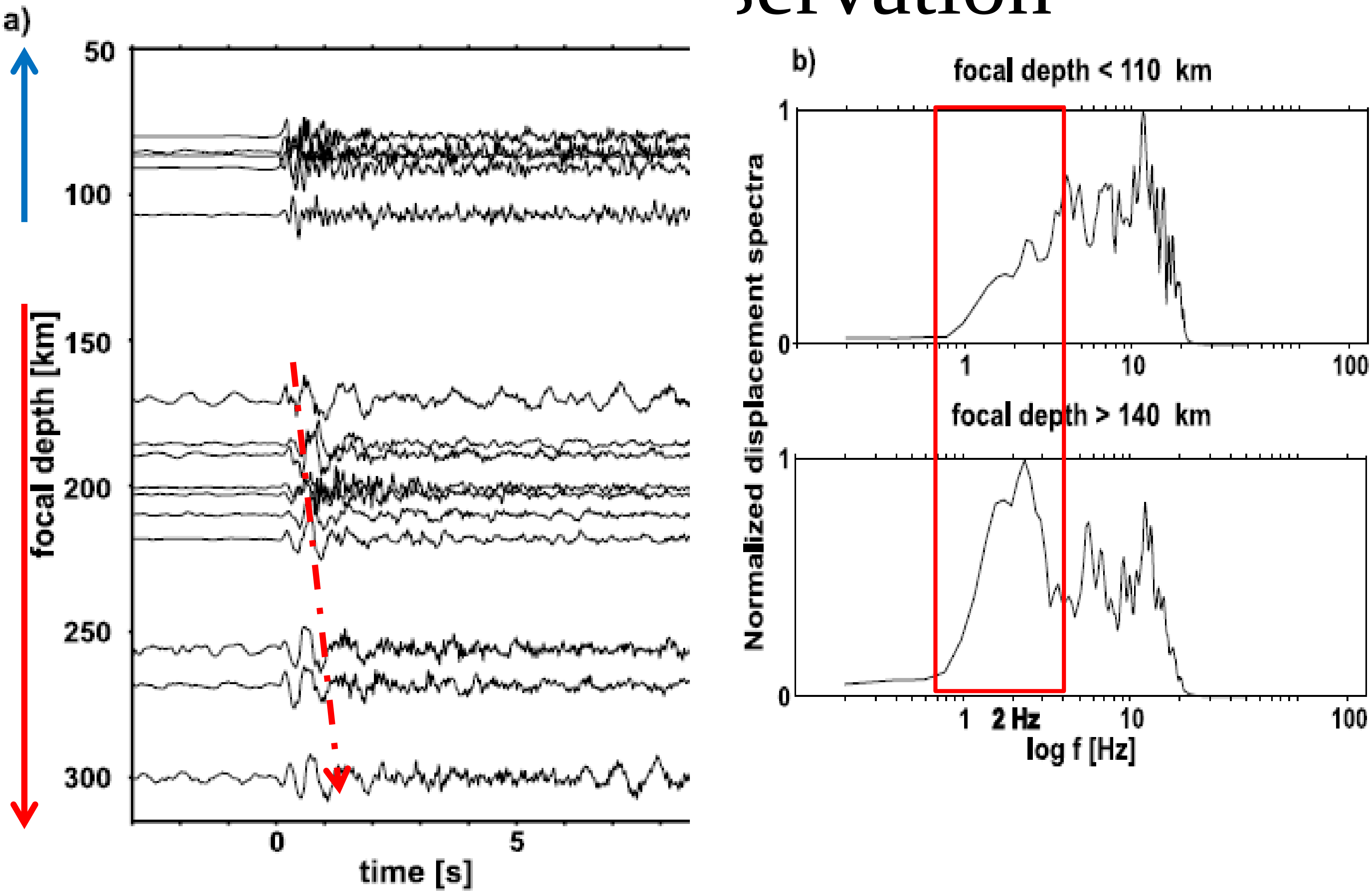
- The dispersion imply a low velocity wave guided that likely reflects subduction of oceanic in some day.
- Pronounced dispersion of body waves that follow slabs suggest significant structure at 2-6 km length scale in Alaska.

Data-2

- Study area :Chile-Peru subduction zone
- ANCORP’96 campaign station:AER
- November 1996 - March1997

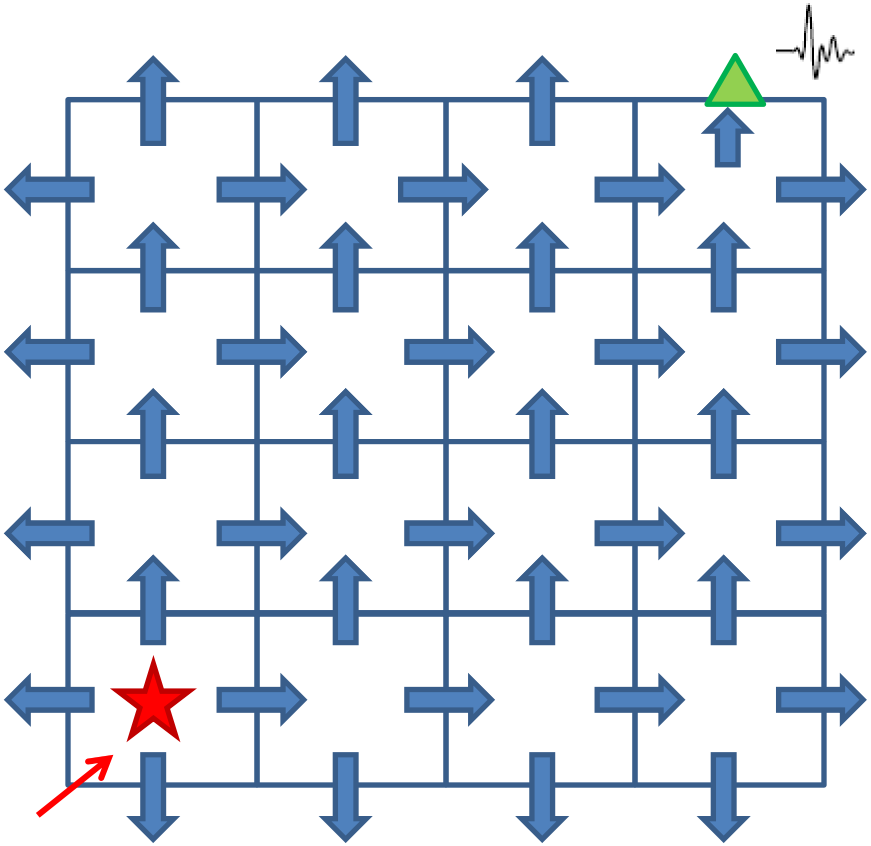



Data-2-observation



methodology

- Finite difference simulation



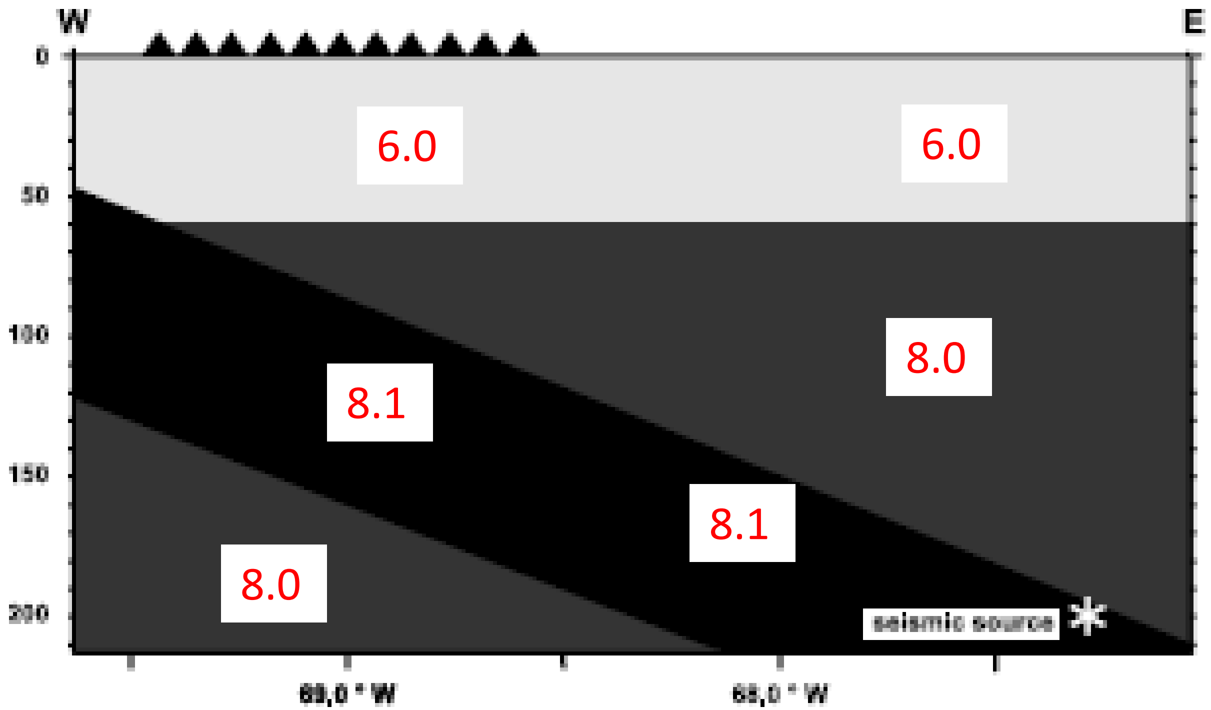
Finite: finite grid number
Difference: calculation method

Grid spacing : 40 m
Source wavelet :delta impulse
Explosive Source
Low pass filtering :8.5Hz
Model dimension: 330km*260km

Source parameter ex. Focal mechanism, location,Source wavelet

Finite difference simulation

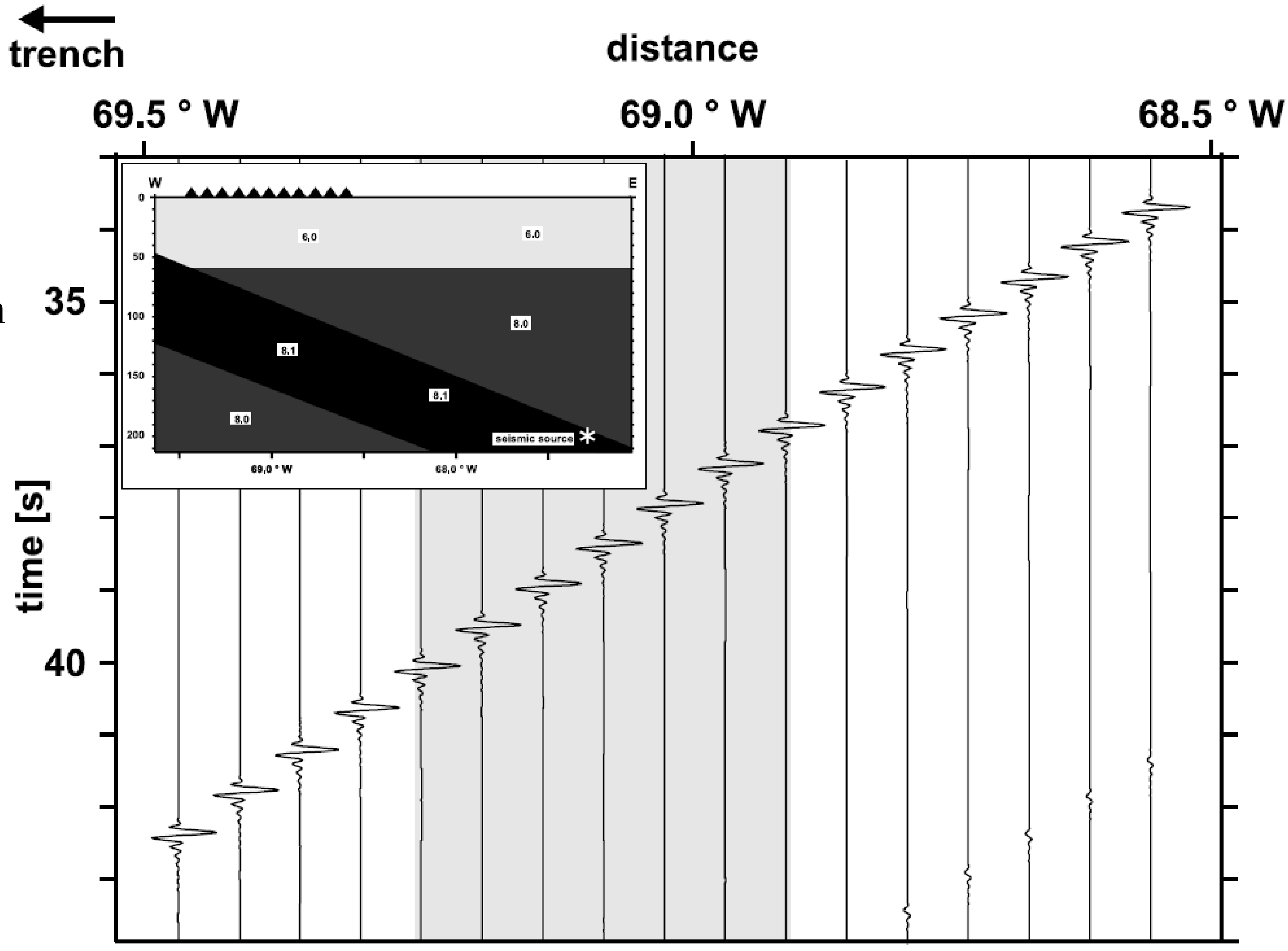
- Reference : refraction seismic studies (Lessel,1997;Patzwahl,1998),Ps converted waves (Bock et al ,Yuan et al 2000)



Model:Original

No low frequency energy emerges

Focal depth : 200 km
The event located 5 km below slab surface



ANCORP Working
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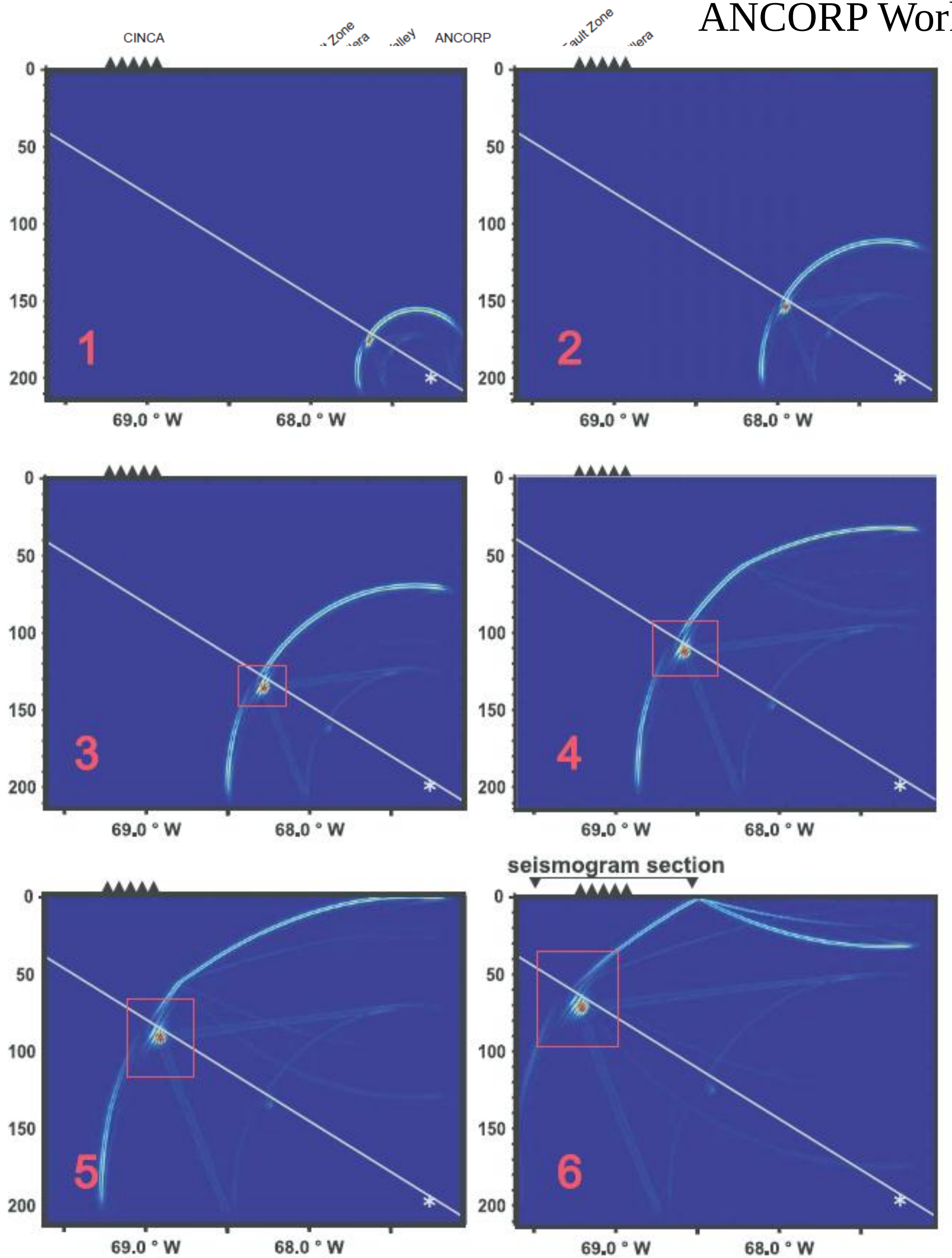
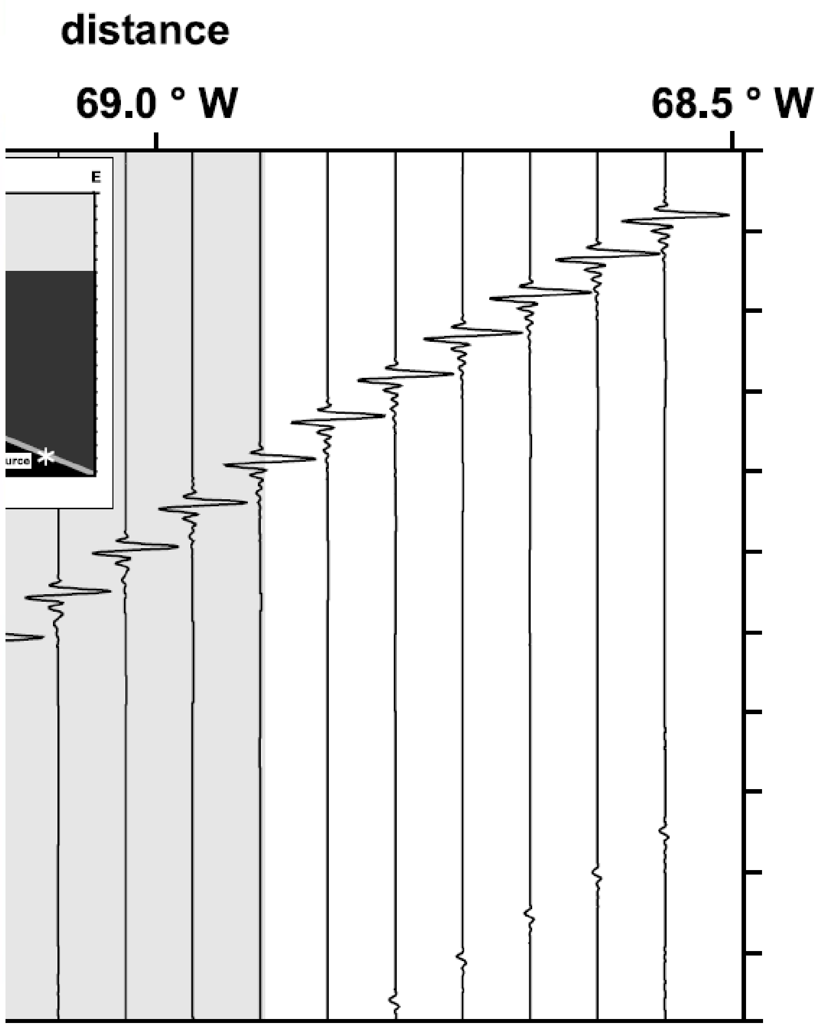
Model

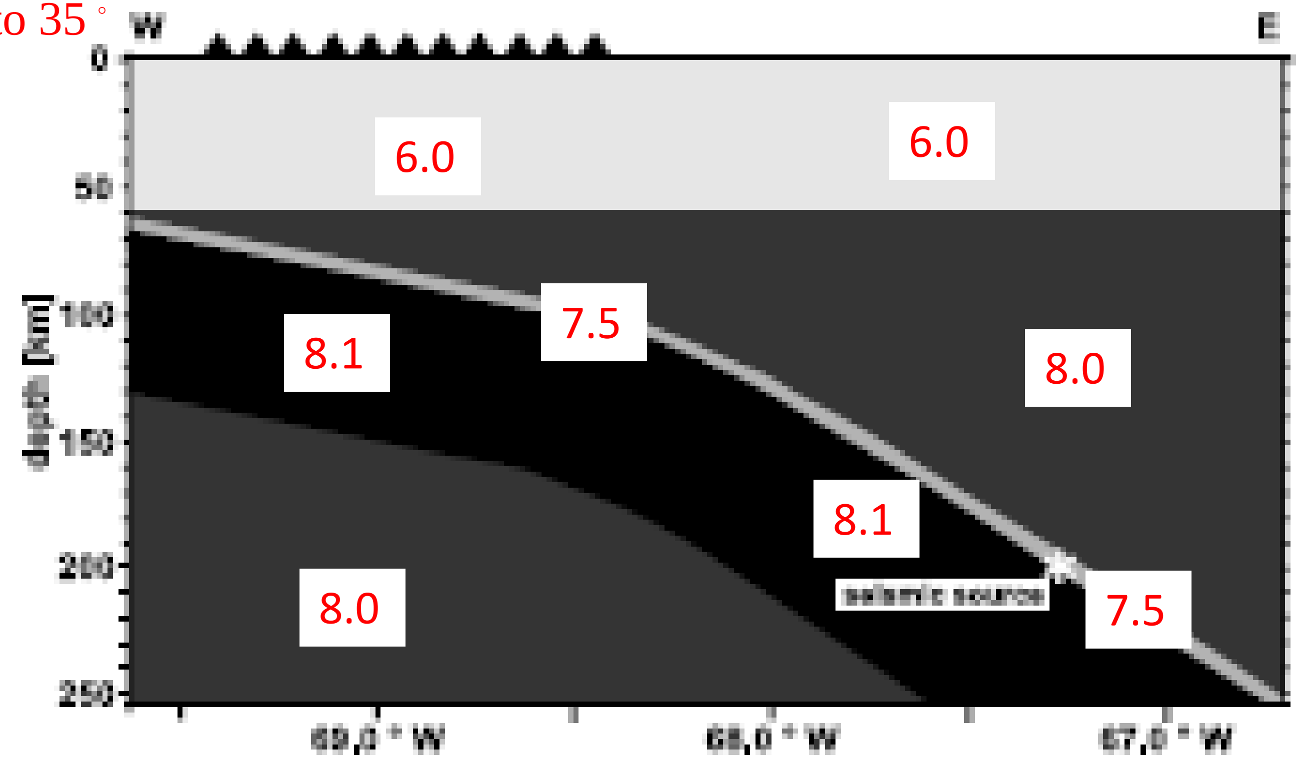




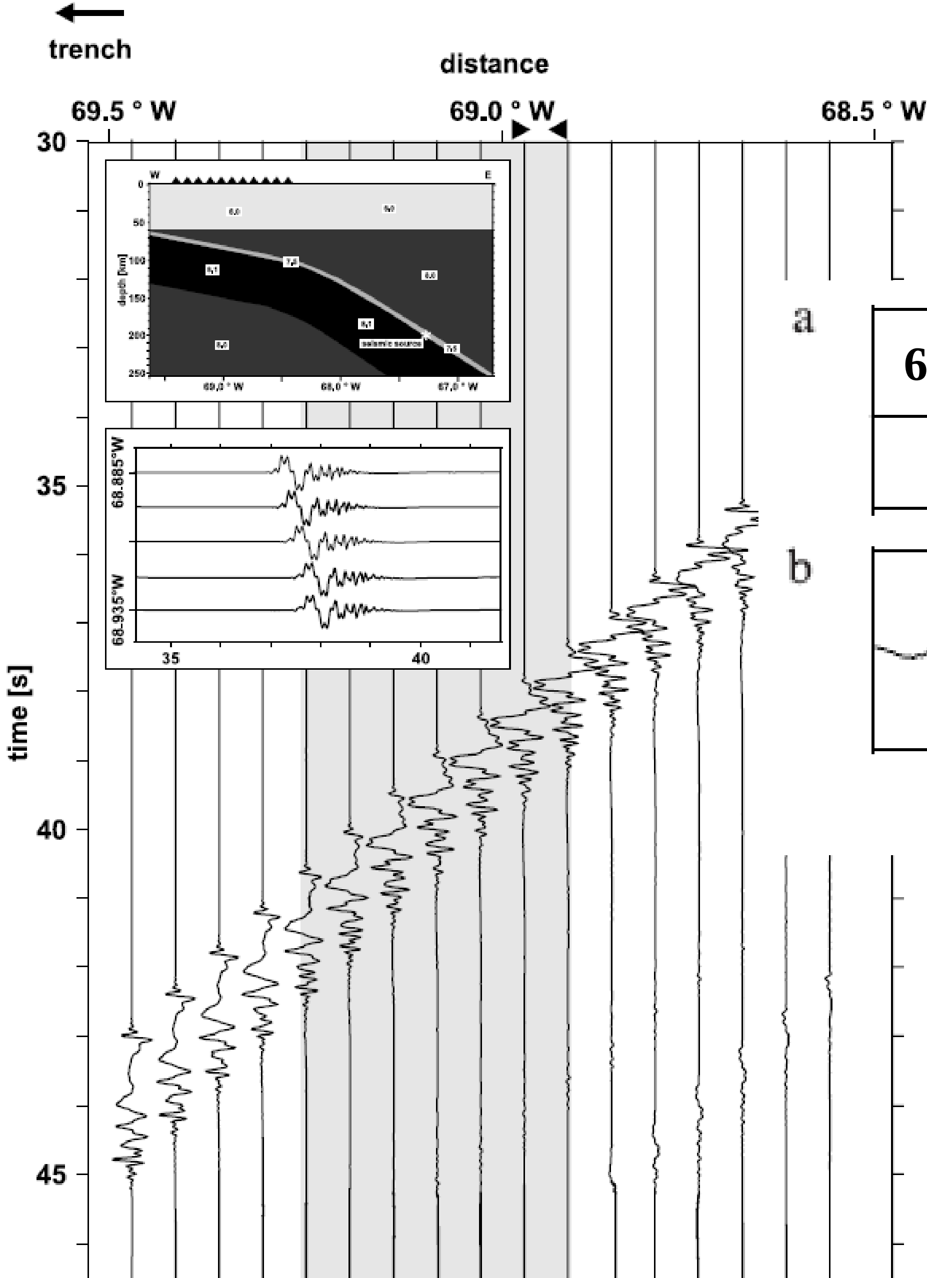
Model

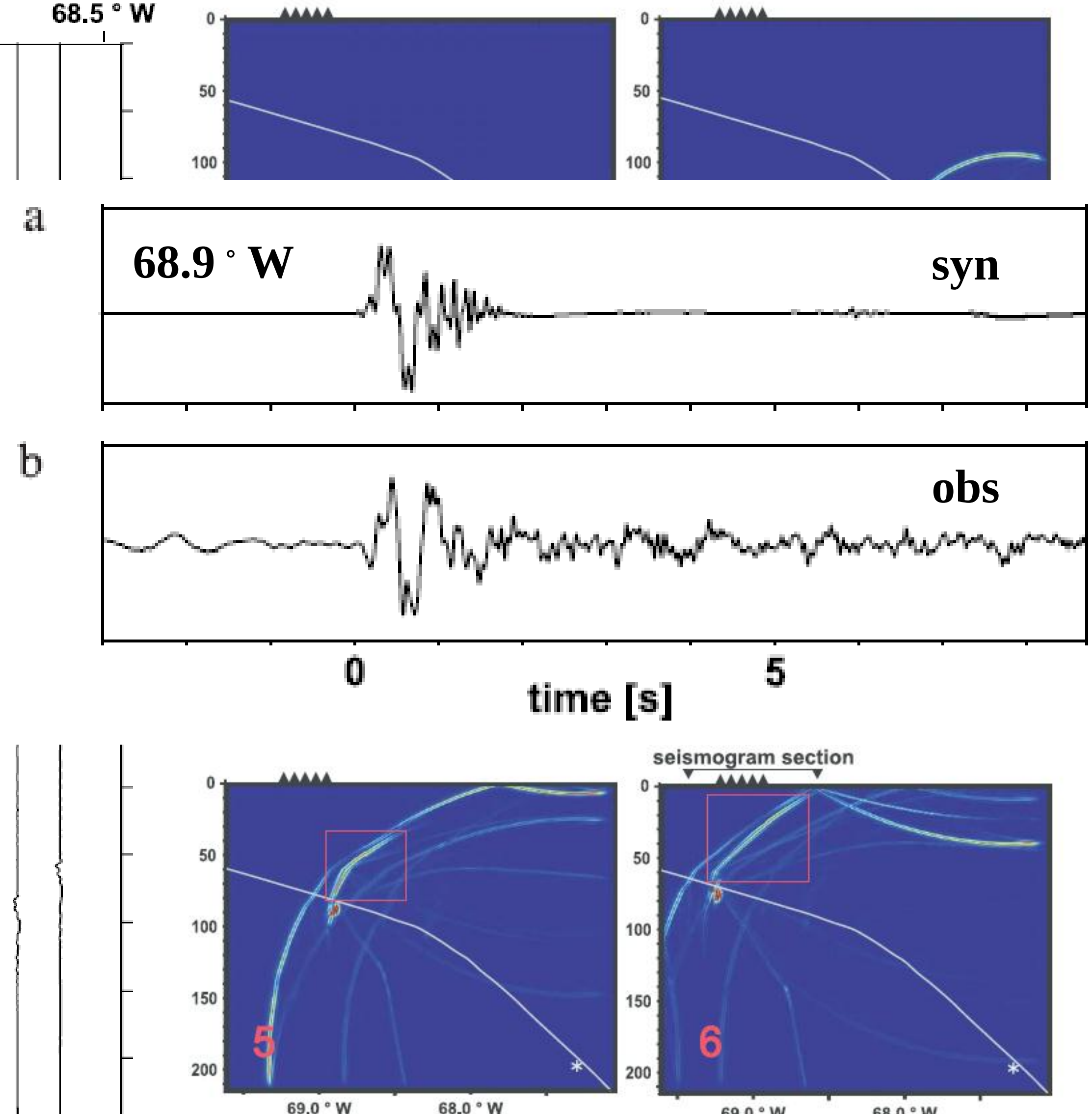
- Because the initial model appears oversimplified and unsuited to explain ,the slab geometry was adjusted

Bending downward in the depth range of 90-150km
Angle varies from 16 ° to 35 °

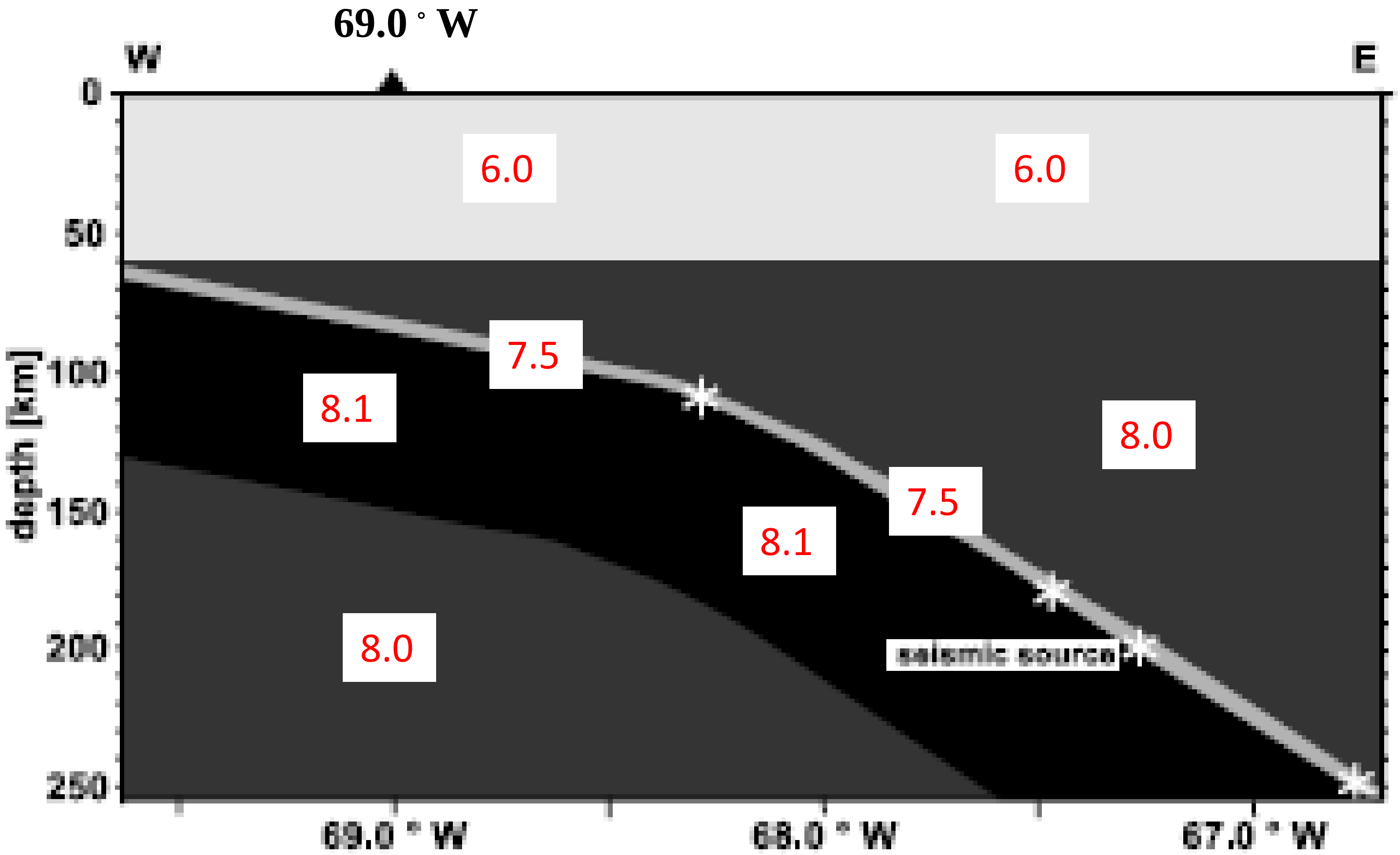


Model:Adjust





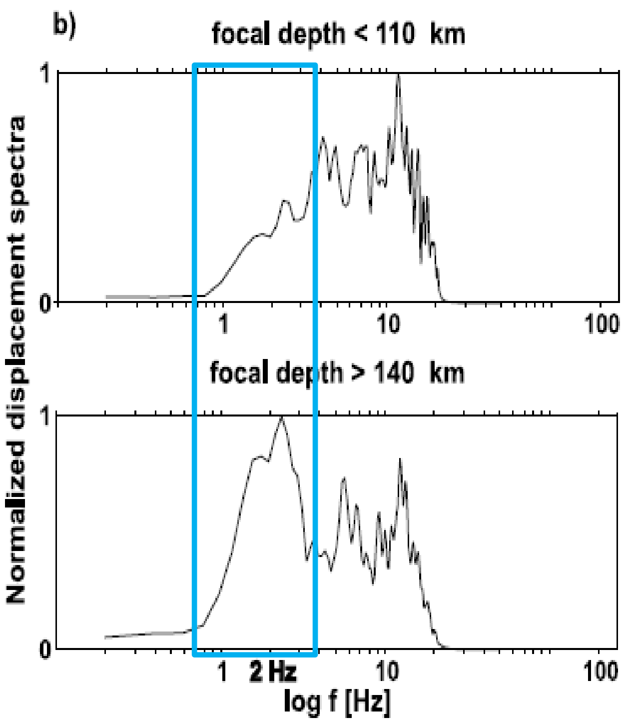
Model: Source Depth

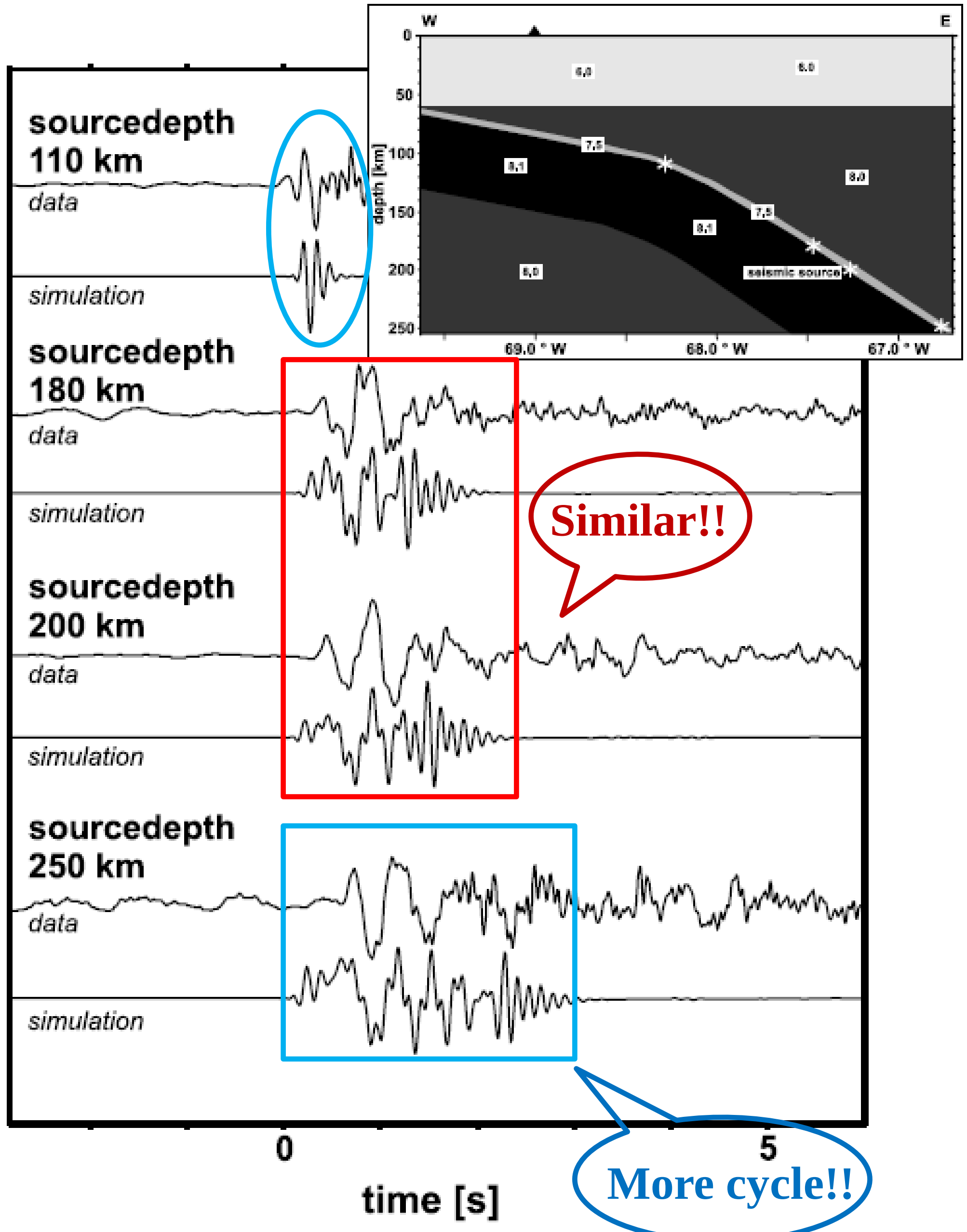


Model: S

- 110 km :

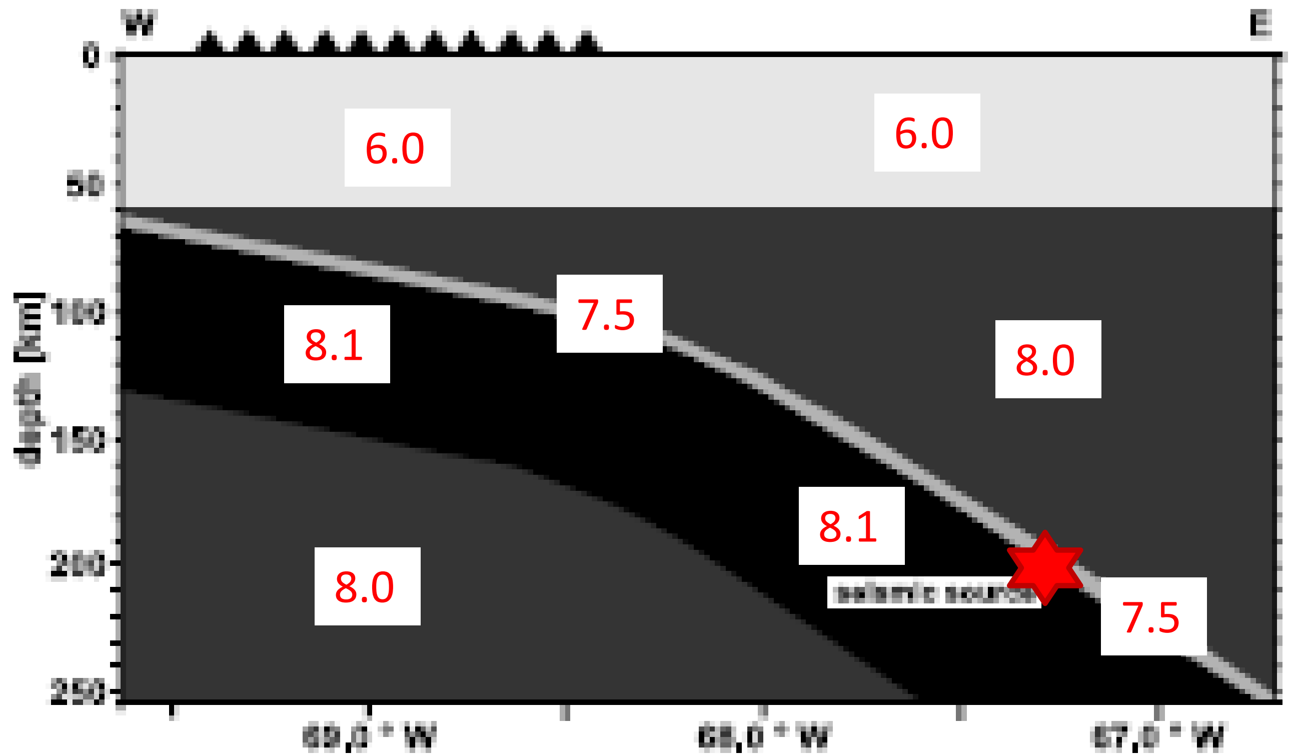
No guided wave





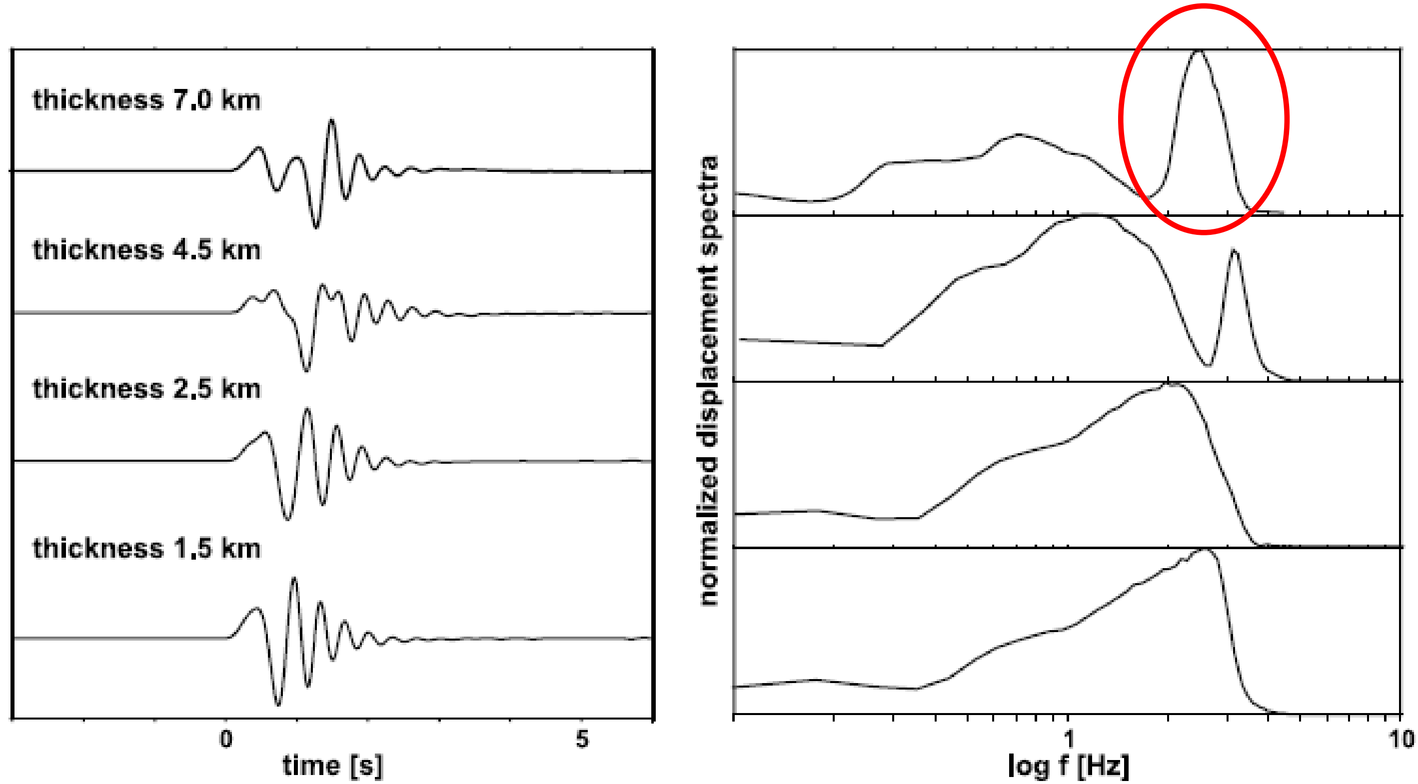
Model: Waveguided thickness

- Basis model
- Focal depth:200km
- Thickness:1.5-7.0km



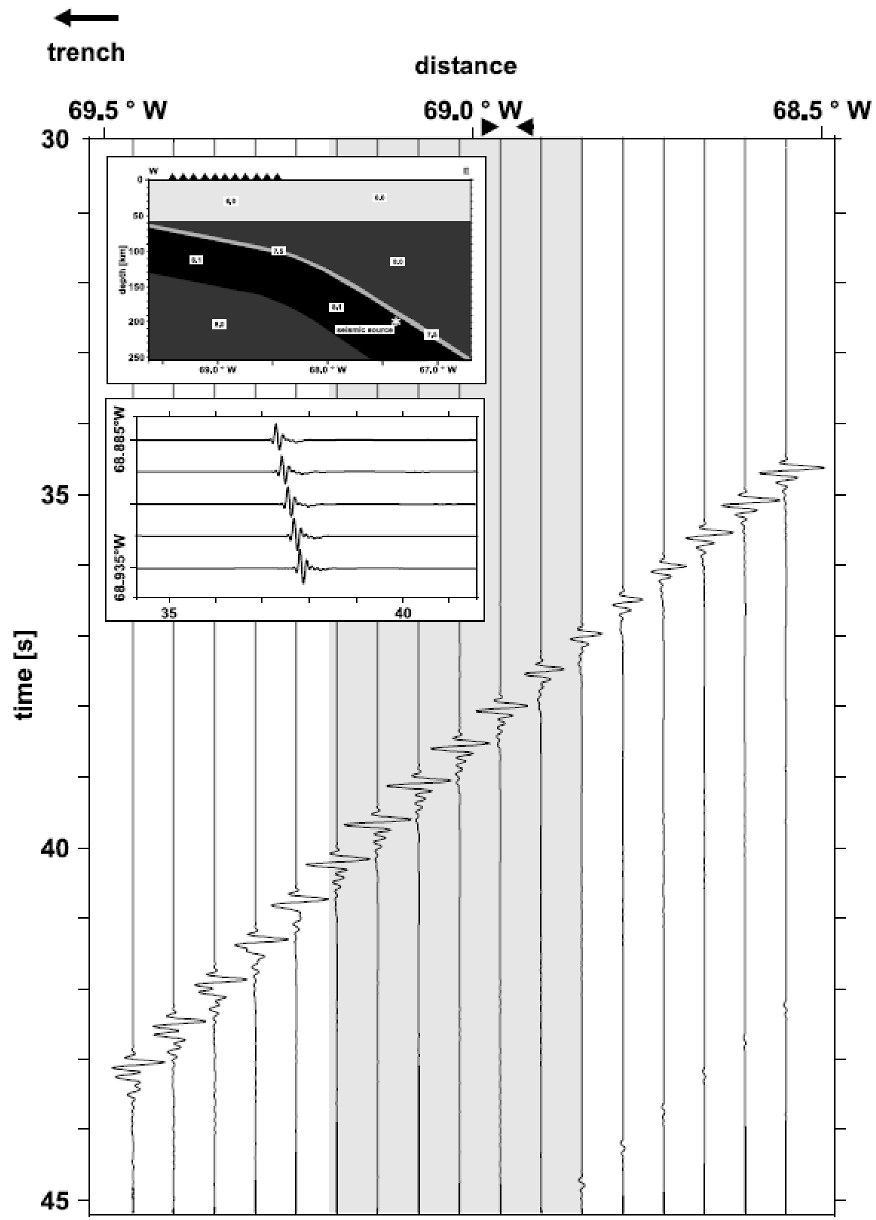
Model: Waveguided thickness

- Layer of width greater than 4.5km do not yield strong low frequency guided wave energy



Model: source location

- Waveguide effect is much less intense for sources located outside the structure
- Body wave phase now mask the guided wave energy



Model: source location

- Low velocity layer exists only down to depth of 160 km in Chile-Peru subduction zone

(Bock et al 2000)

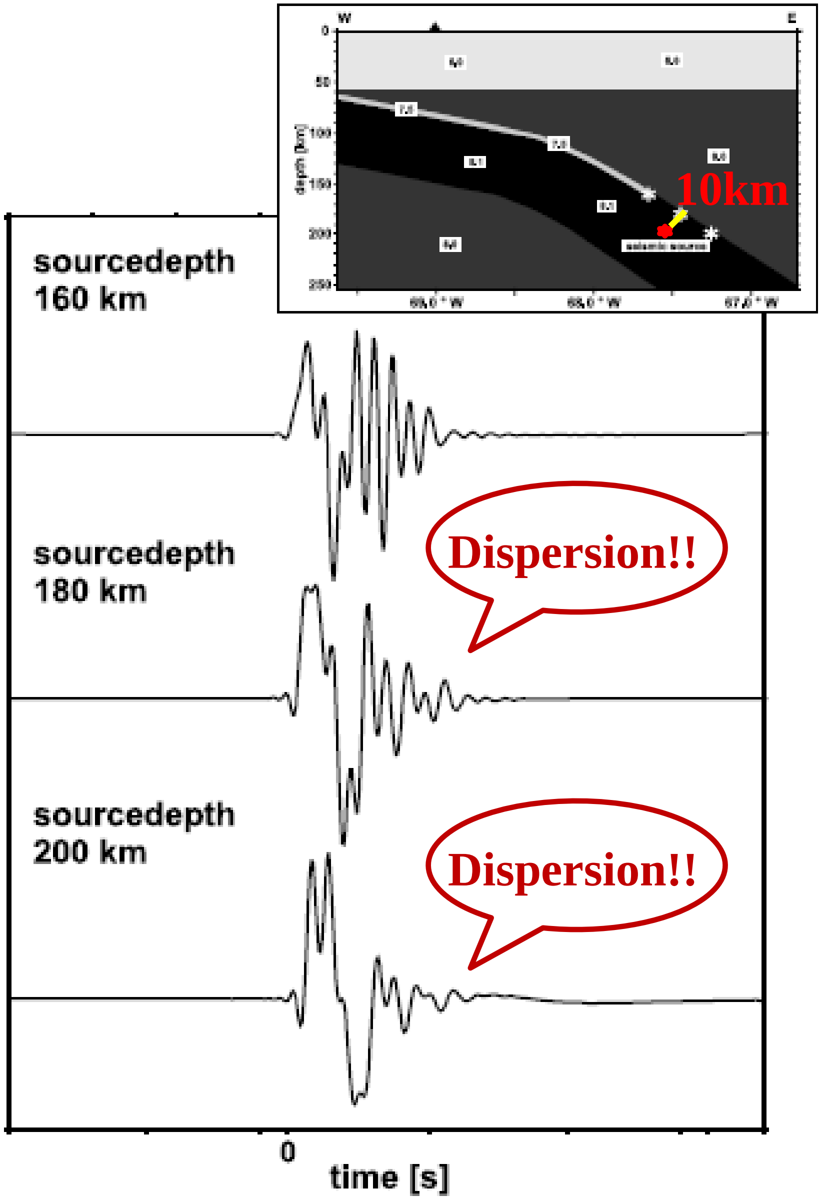
- Are the observed guided wave for focal depth greater than 160km caused by this structure ?

Model: source location

1. The waveguide also influences signals from sources located near the slab surface in continuation of the former low-velocity subducted crust

2.Simulations with sources located more than 10 km away from the slab surface failed to produce guided wave

Deep source registered in the ANCORP campaign are located in continuation of the already transformed low velocity structure



Summary

- At the Chile Peru subduction zone, bending downward in the depth range of 90-150km and the angle varies from 16° to 35° .
- It resembles a rather thin layer (<4.5 km) of 7% low velocity at the slab surface reaching down to depth of 160 km.

Conclusion

- The reactions which gabbroic crust convert to eclogite reactions may be too sluggish at slab temperatures .
- Guided wave is a good tool to deduce slab low velocity structure
- The dispersion imply a low velocity wave guided that likely reflects subduction of oceanic in some day

Thanks for your attention