The lithospheric structure beneath mature continental rifts : New insights from a dense seismic profile across the Asal-Ghoubbet Rift (Djibouti)

Jérôme Vergne[1], Cécile Doubre[1], Kassim Mohamed[2], Alain Dujardin[1]
Sylvie Leroy[3]

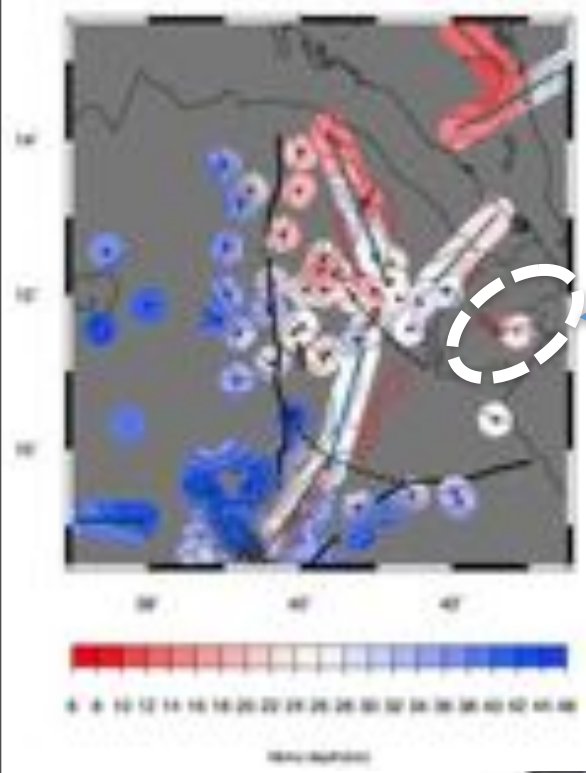
[1] *Ecole et Observatoire des Sciences de la Terre, Université de Strasbourg, FR*

[2] *Geophysical Observatory, CERD, Arta, Djibouti*

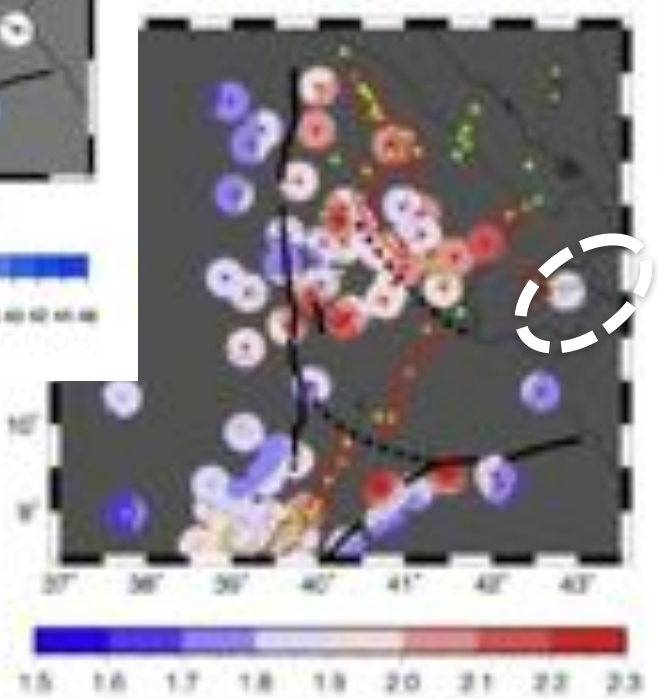
[3] ISTEP, UPMC, FR

Previous studies

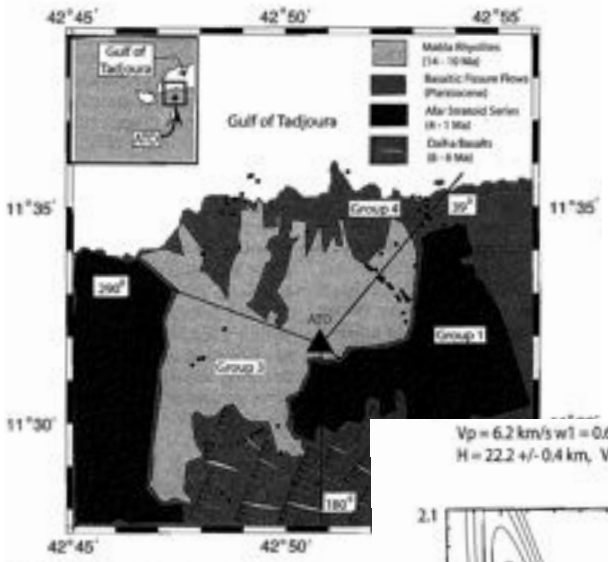
* Hammond et al. (2011)

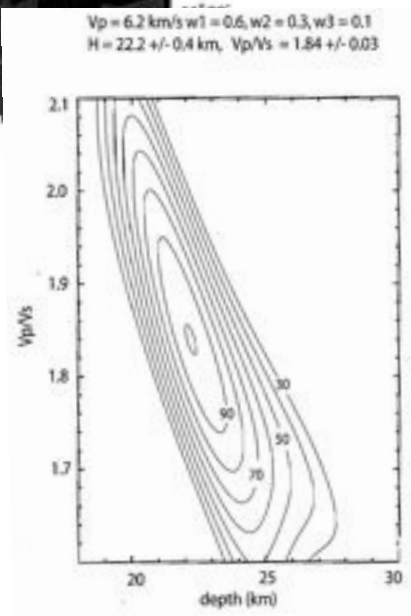


Target area



* Dudga & Nyblade (2006)

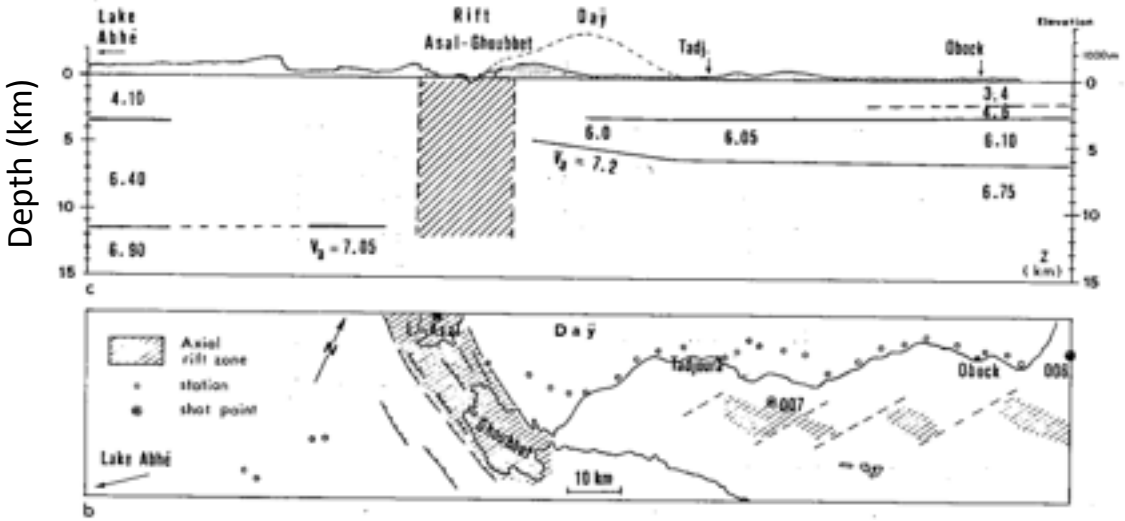




Previous studies

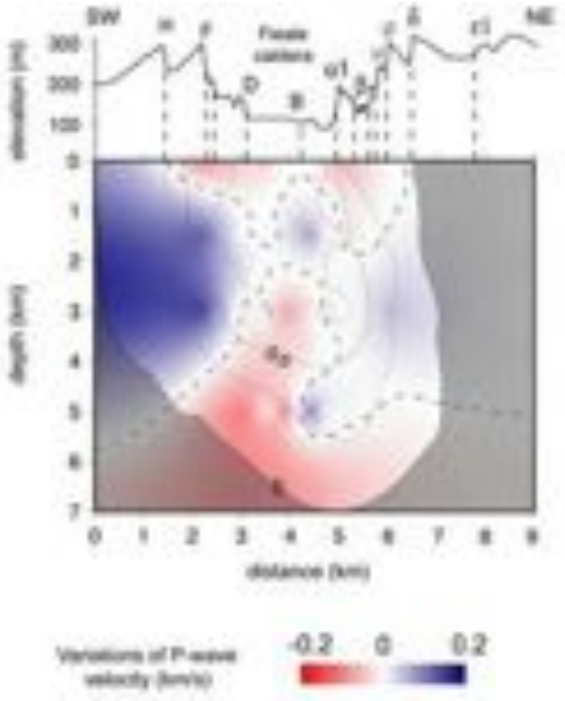
* Ruegg et al. (1975)

Active seismic



* Doubre et al. (2007)

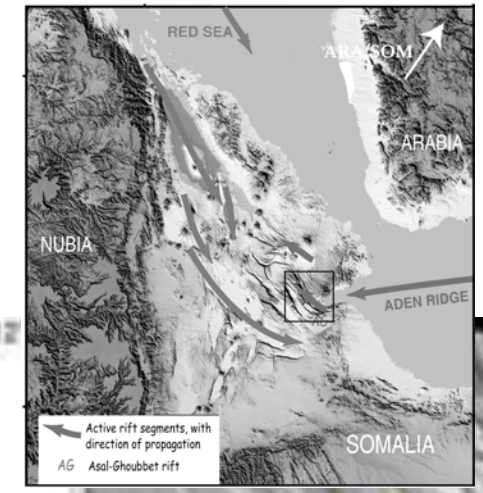
Local tomography

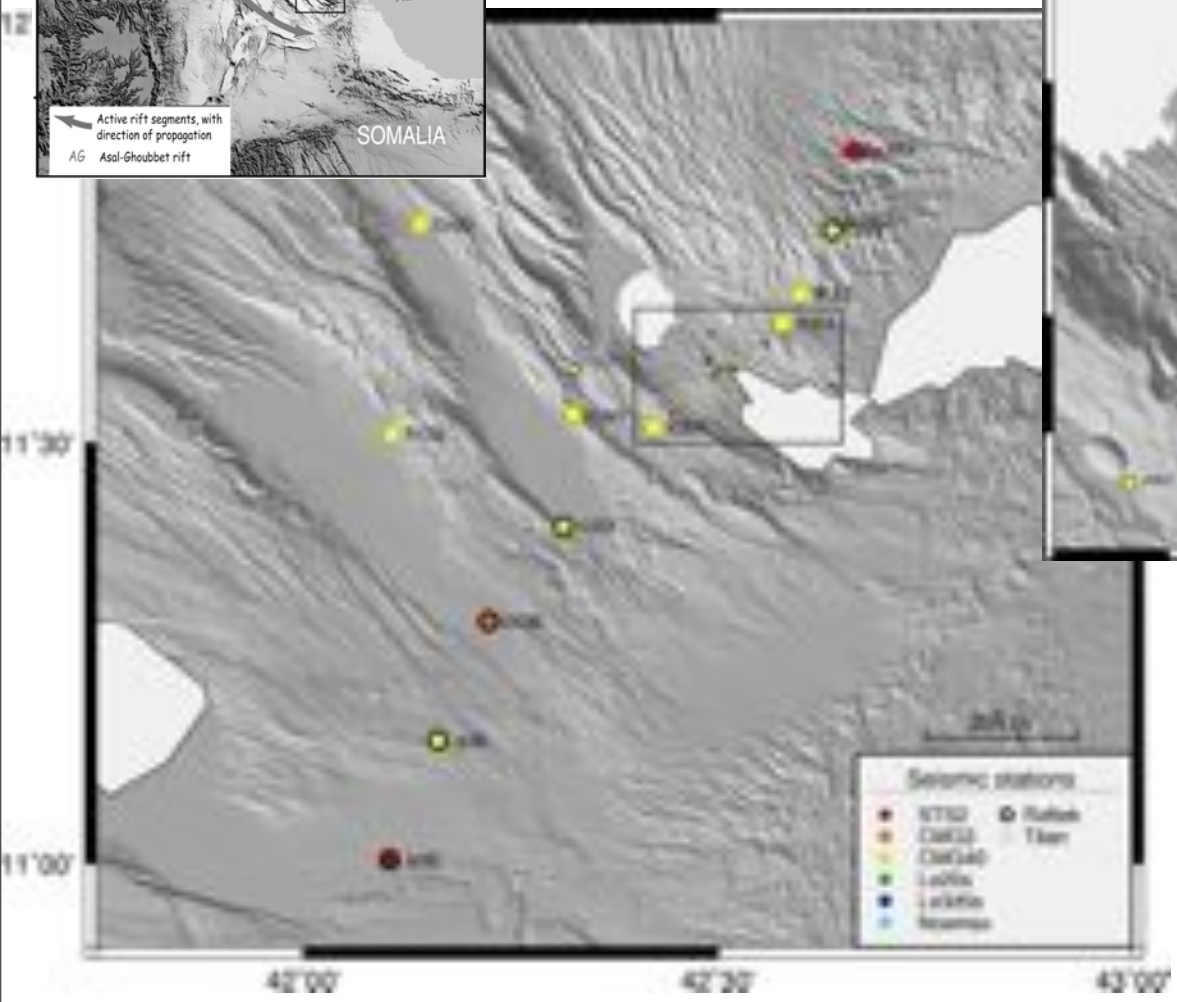


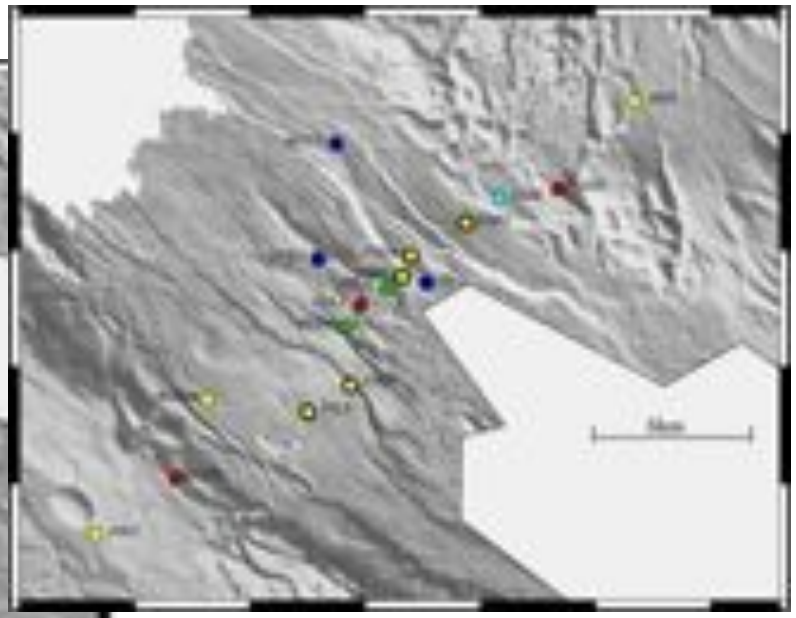
- *High velocities at 10 km depth*
- *Asymmetry between Northern and Southern shoulder*
- *No details across the rift*
- *No information for depth > 15 km*

- No information below 10 km depth

The network



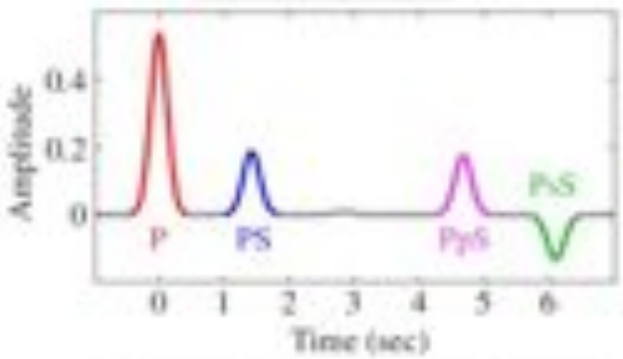


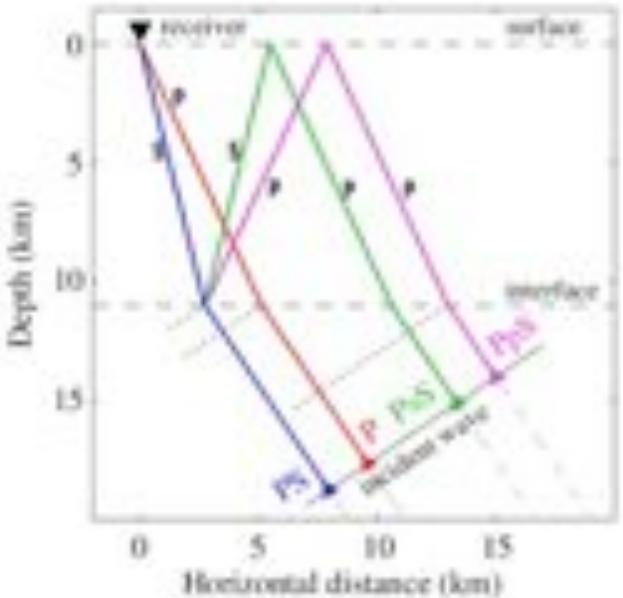


Nb of stations : 33
Station spacing : 0.5 to 15 km
Time span : 11/2009 – 03/2011
Data recovery : ~ 70%

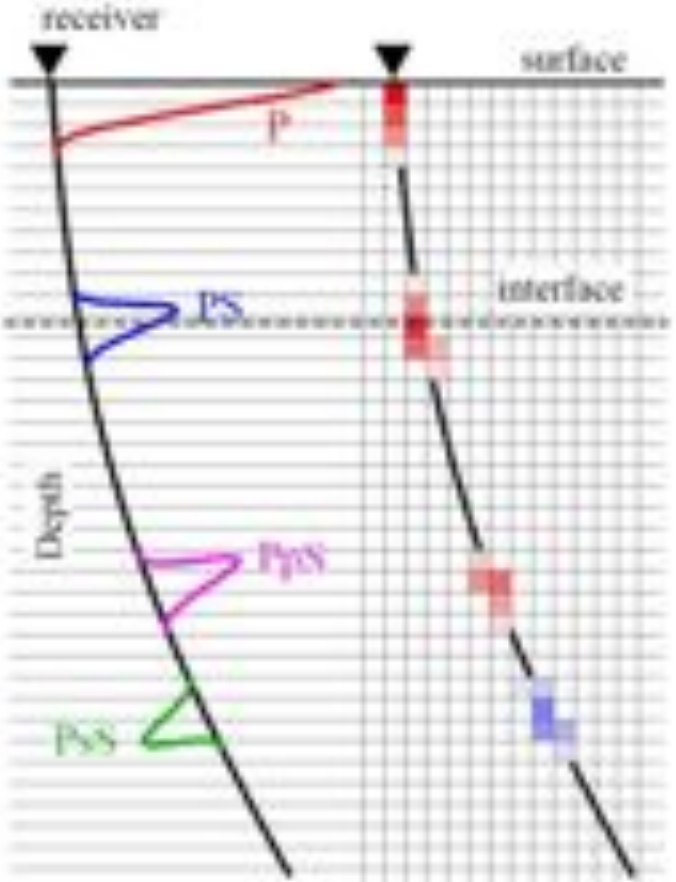
Receiver functions

Conversions

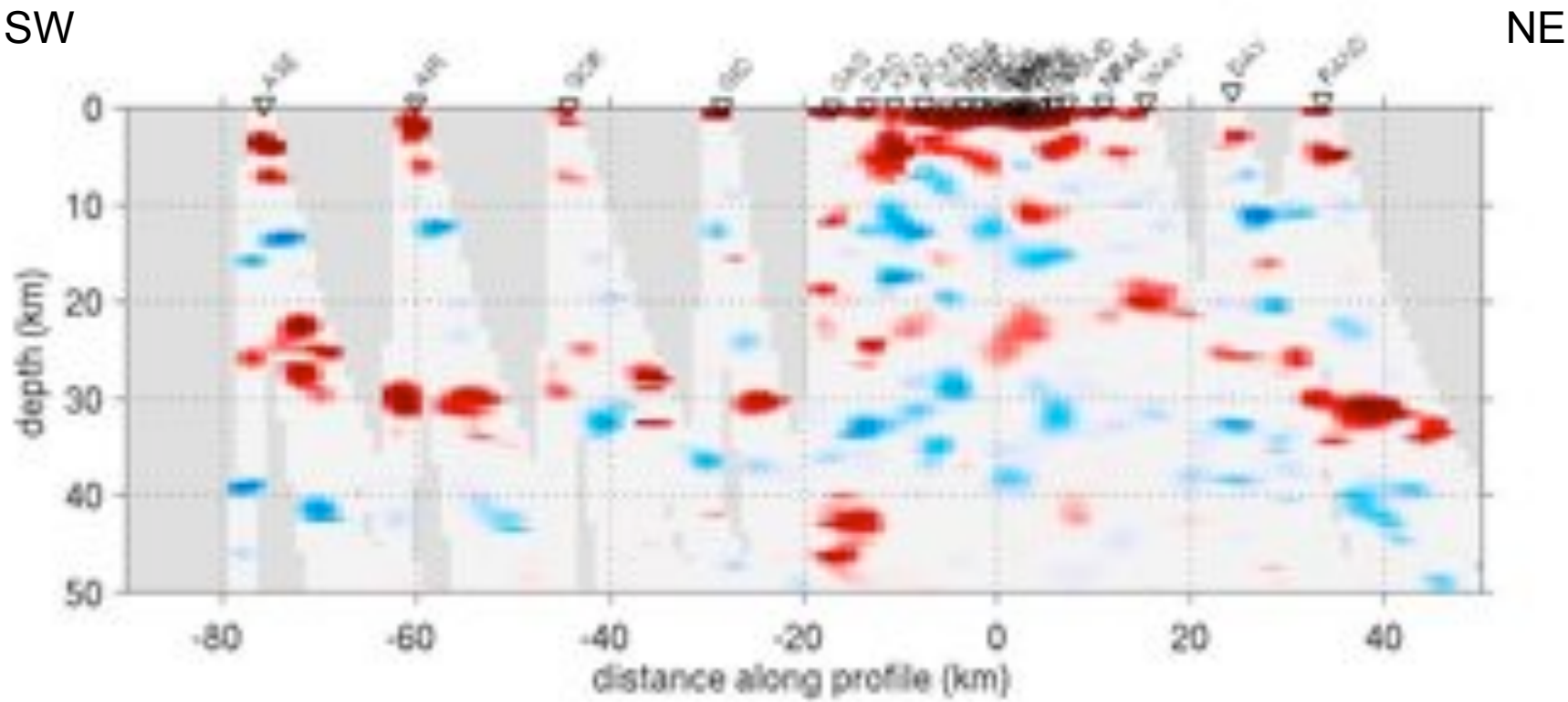




CCP migration

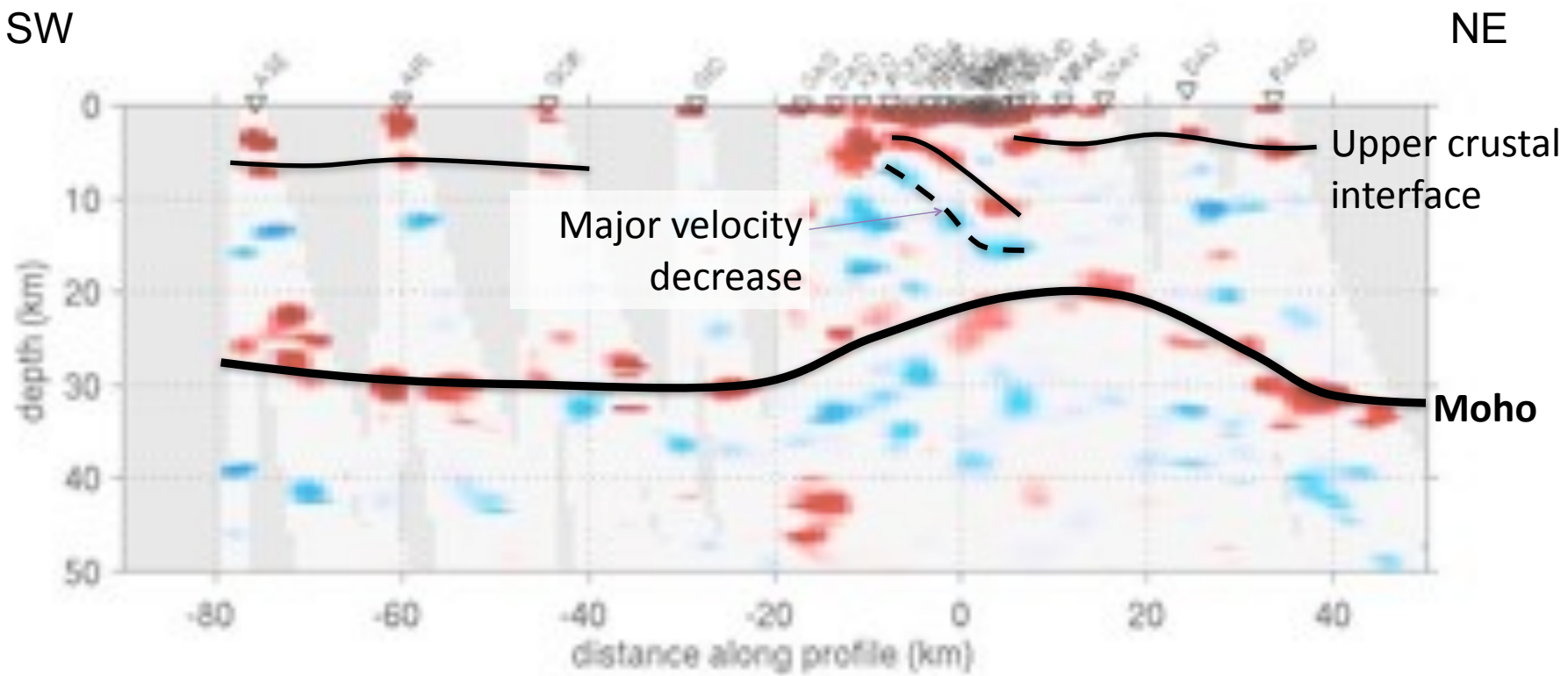


Lithospheric structure along the profile



- Iterative deconvolution with pre-filtering around **1 Hz**
- Number of selected RFs : 1270
- Velocity model : modified IASPEI with Moho depth at 30 km and Vp/Vs = 1.9 in the crust

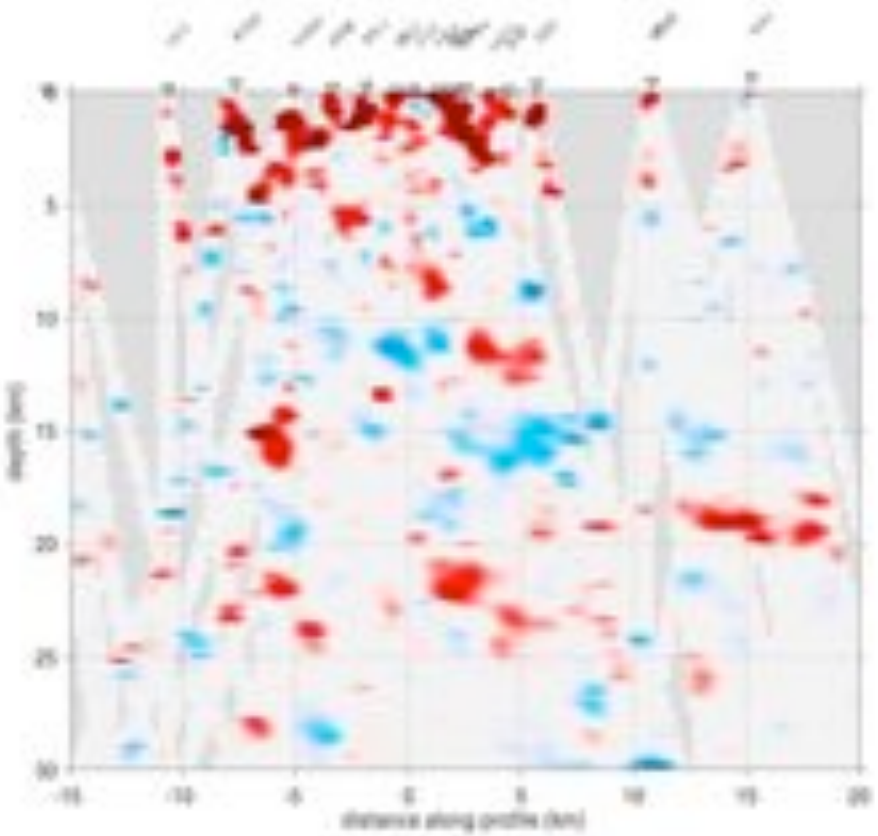
Lithospheric structure along the profile



- ~10 km crustal thinning across the rift
- Complex structure beneath the rift
- Base of sediments/lava flow widely observed at ~4 km depth

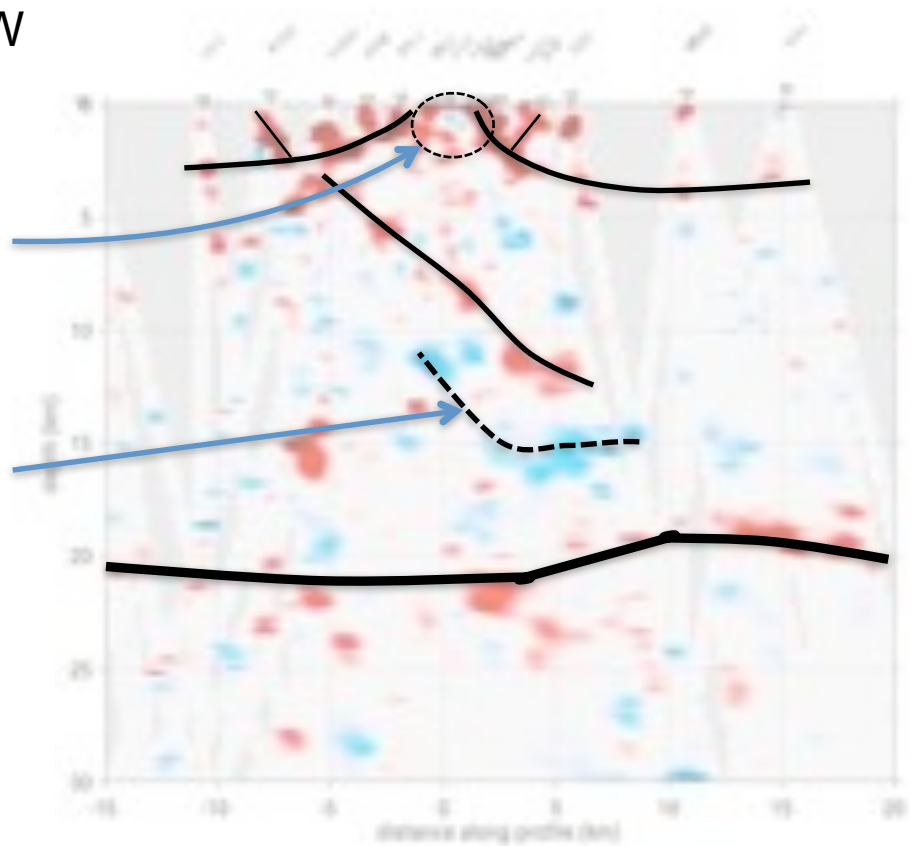
Crustal structure across the rift

SW NE



- Iterative deconvolution with Pre-filtering around **4 Hz**
- Number of selected RFs : 550
- Velocity model : modified IASPEI with Moho depth at 30 km and Vp/Vs = 1.9 in the crust

Crustal structure across the rift



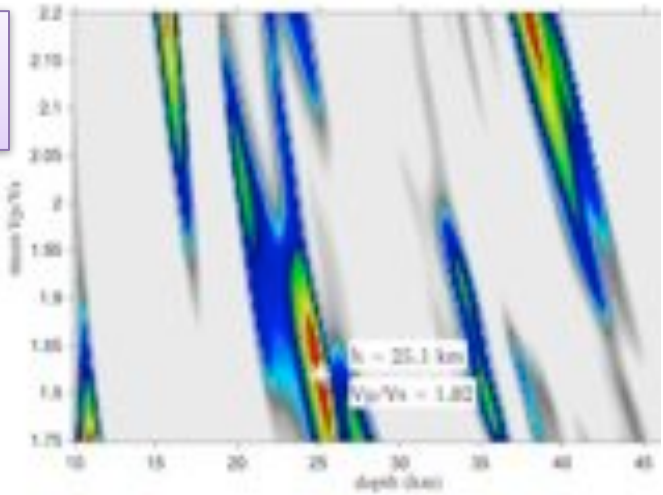
- Relatively symetrical structures in the shallow crust
- Asymetrical deeper crust with 2 dipping structures
- Major low velocity zones at 2 and 15 km depth => partial melting

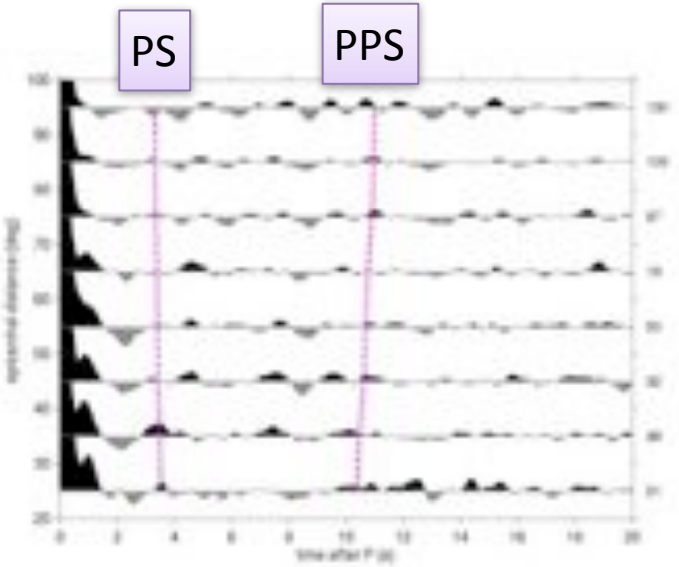
Vp/Vs analysis

Stack of all stations outside the rift

H_{mean} = 25 km

Vp/Vs_{mean} ~ 1.82

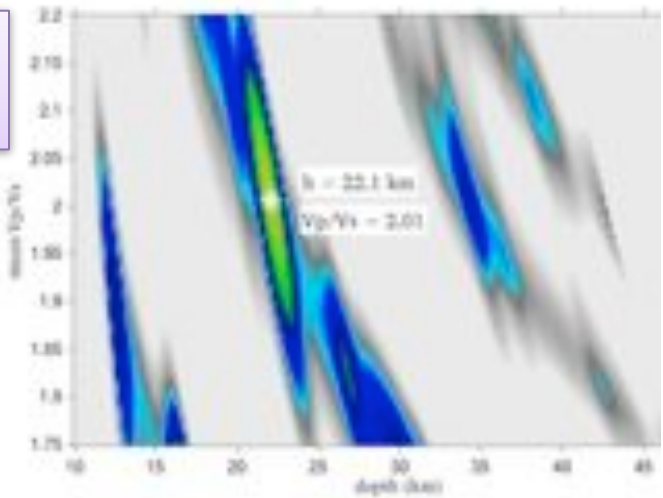


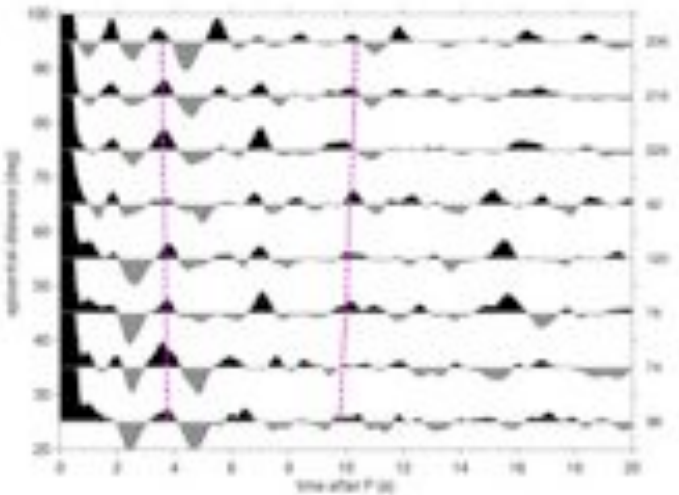


Stack of all stations inside the rift

H_{mean} = 22 km

Vp/Vs_{mean} ~ 2.01

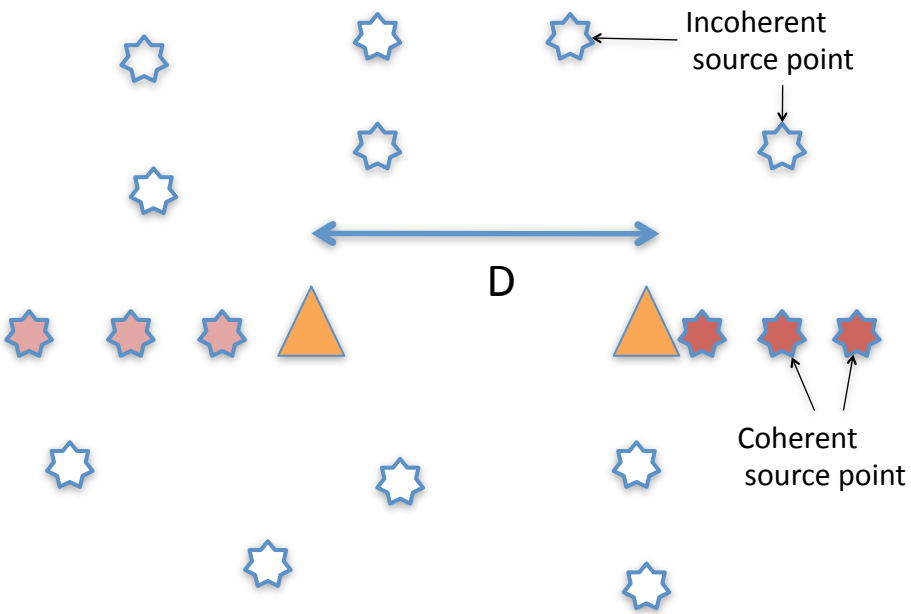


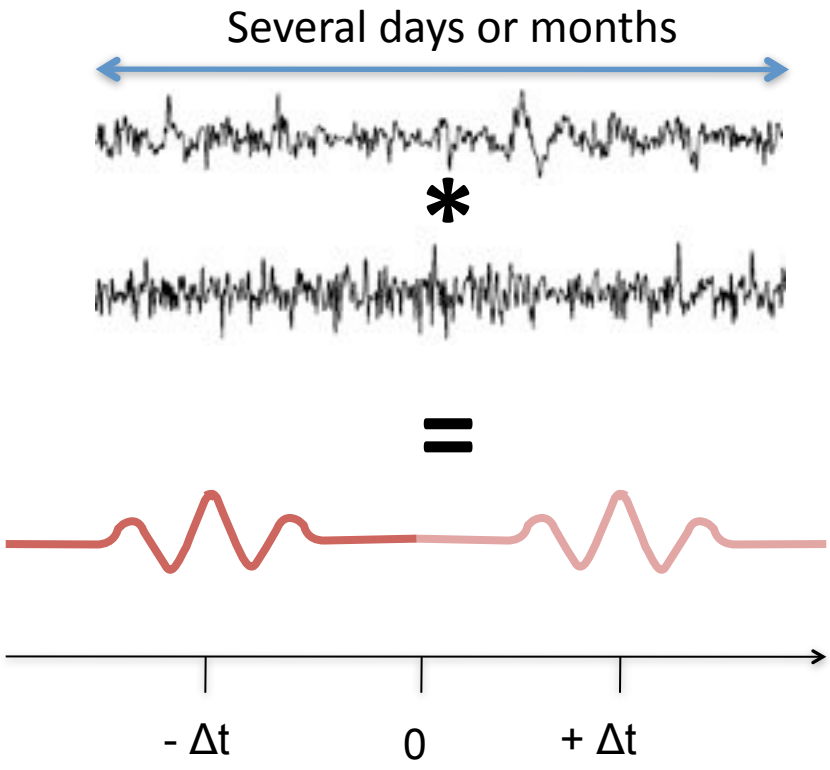


Based on Zhu and Kanamori (2000)

Noise correlation function (NCF)

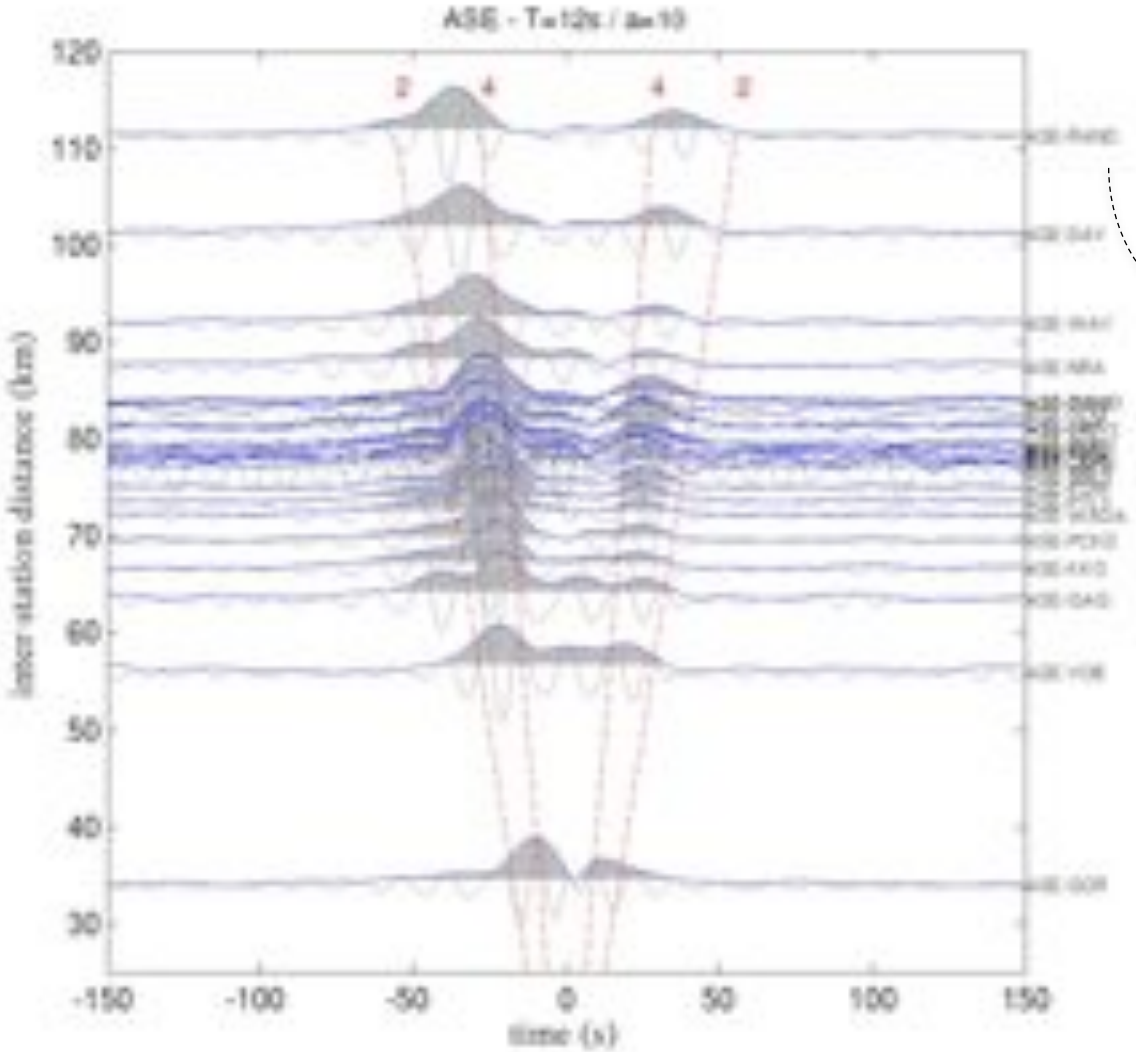
Principle: Cross-correlating long noise records at pairs of stations to recover the Rayleigh group velocity in between them



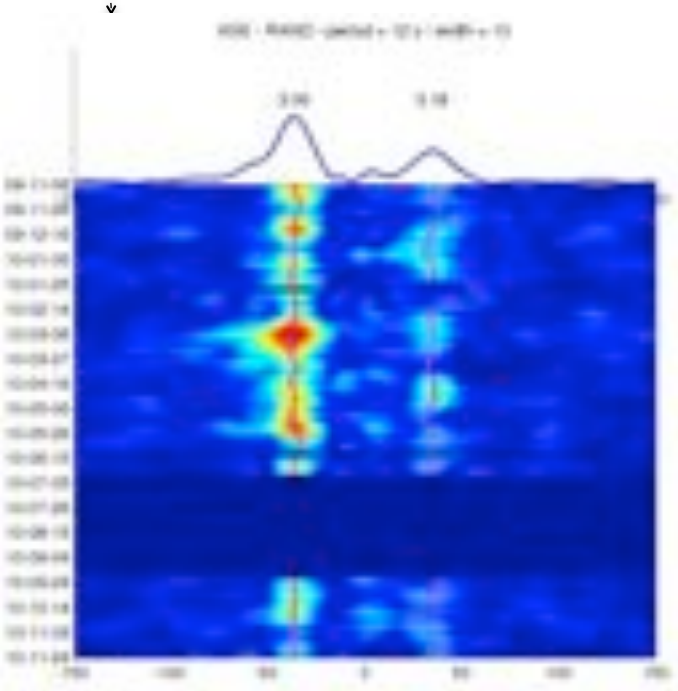


$\Delta t = D/U$

Examples of NCF

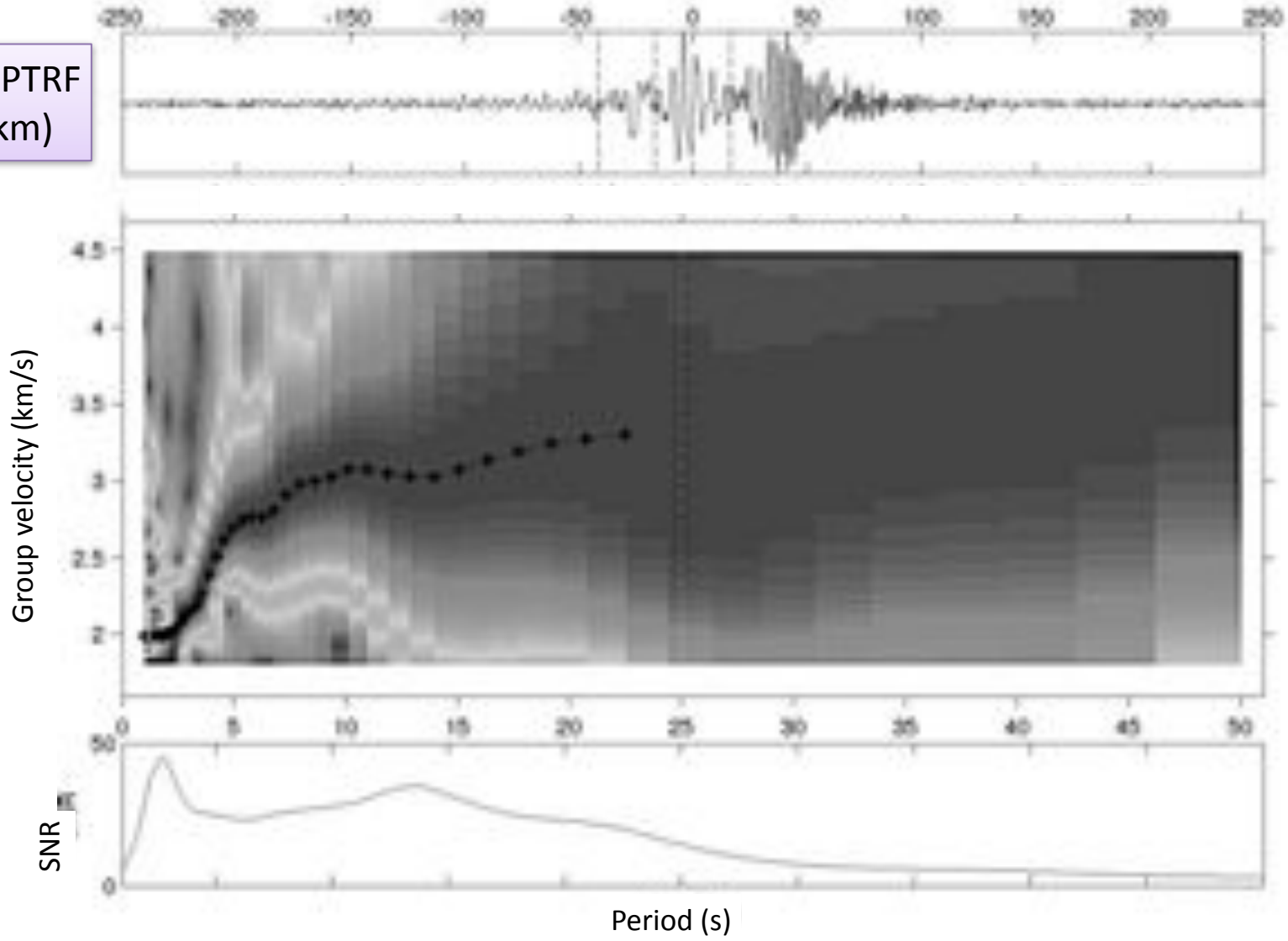


- Base station : ASE
- Gaussian filter : 12s

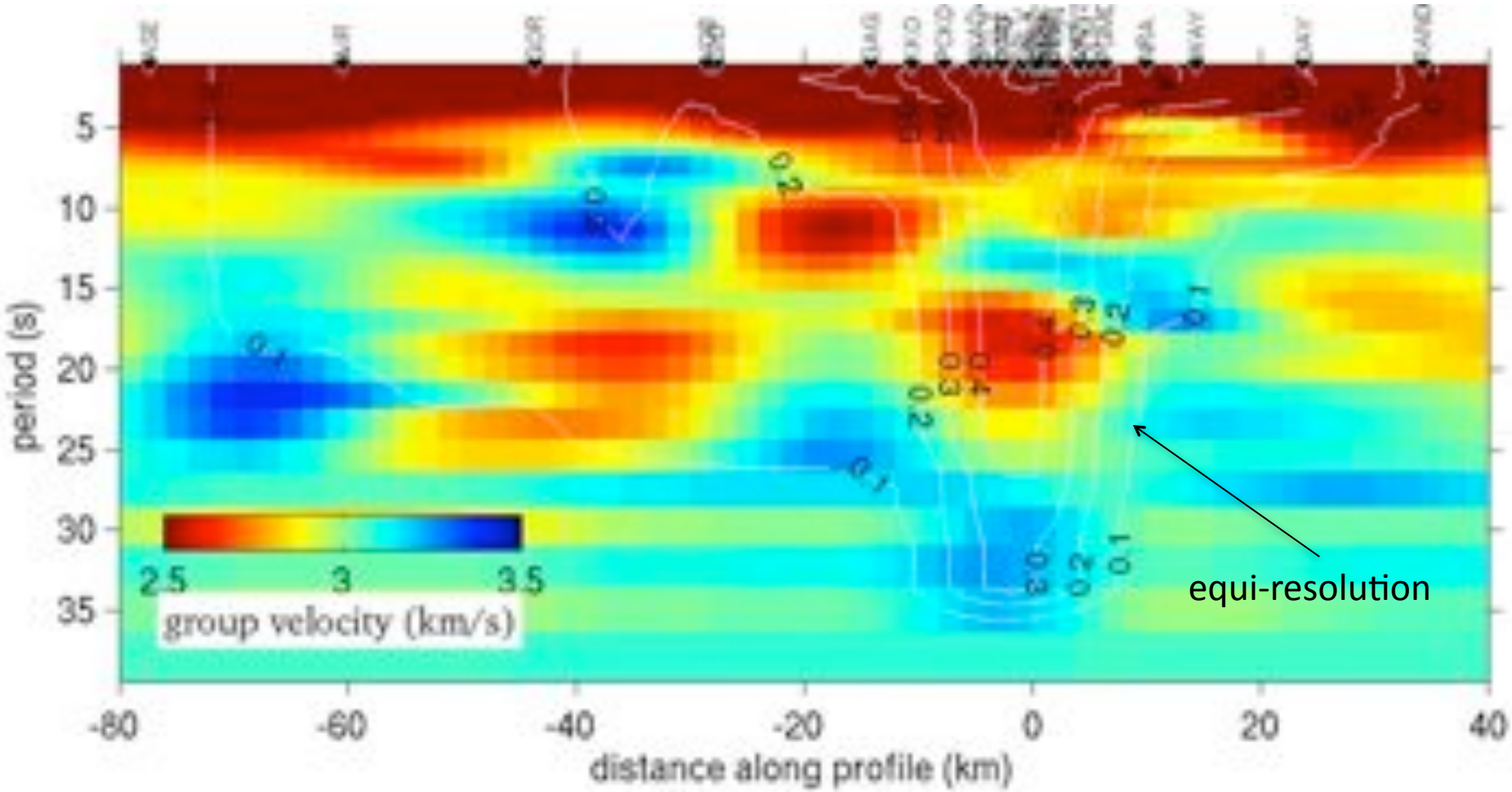


Group velocity estimation

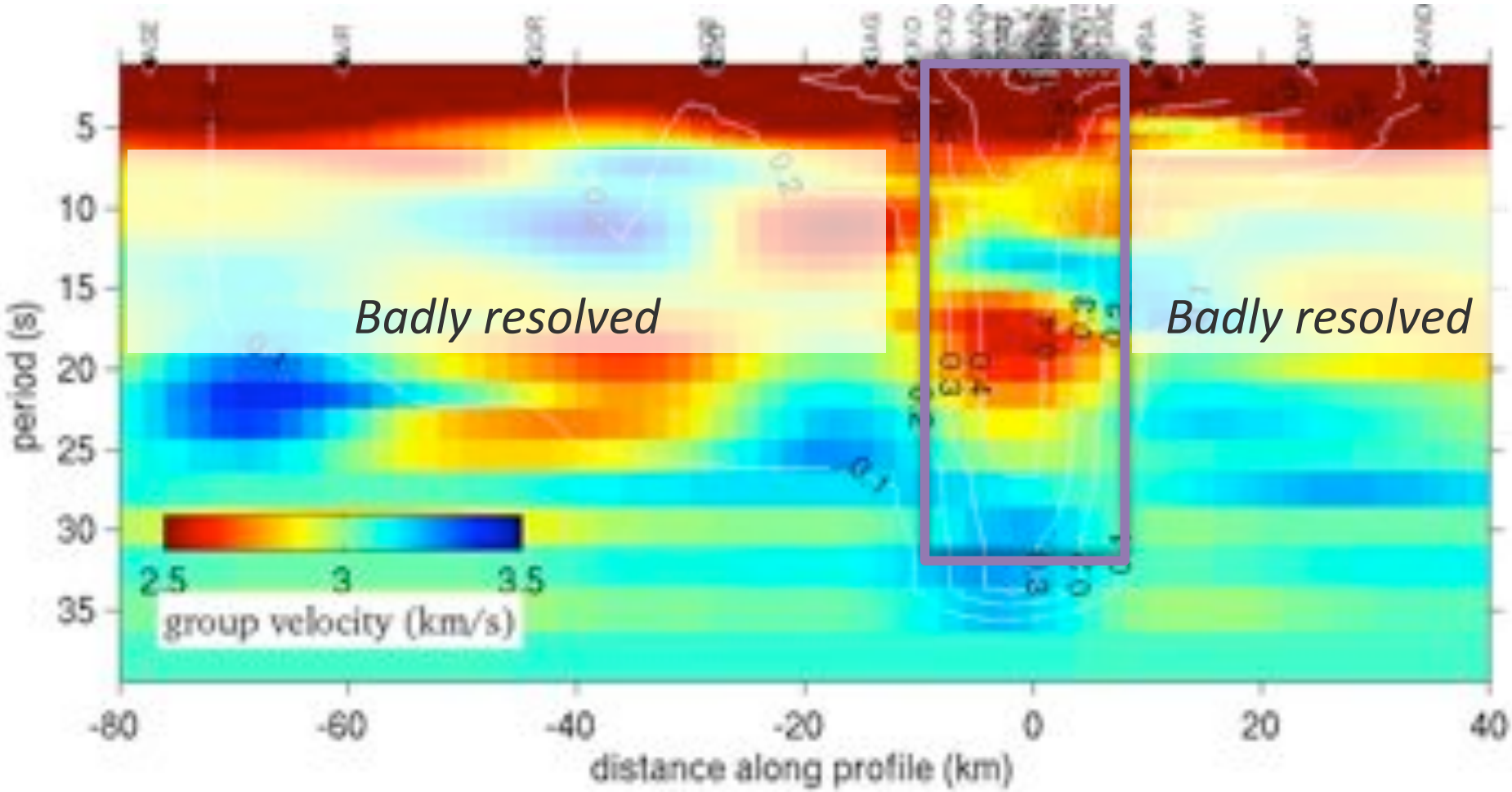
ASE – PTRF
(75 km)



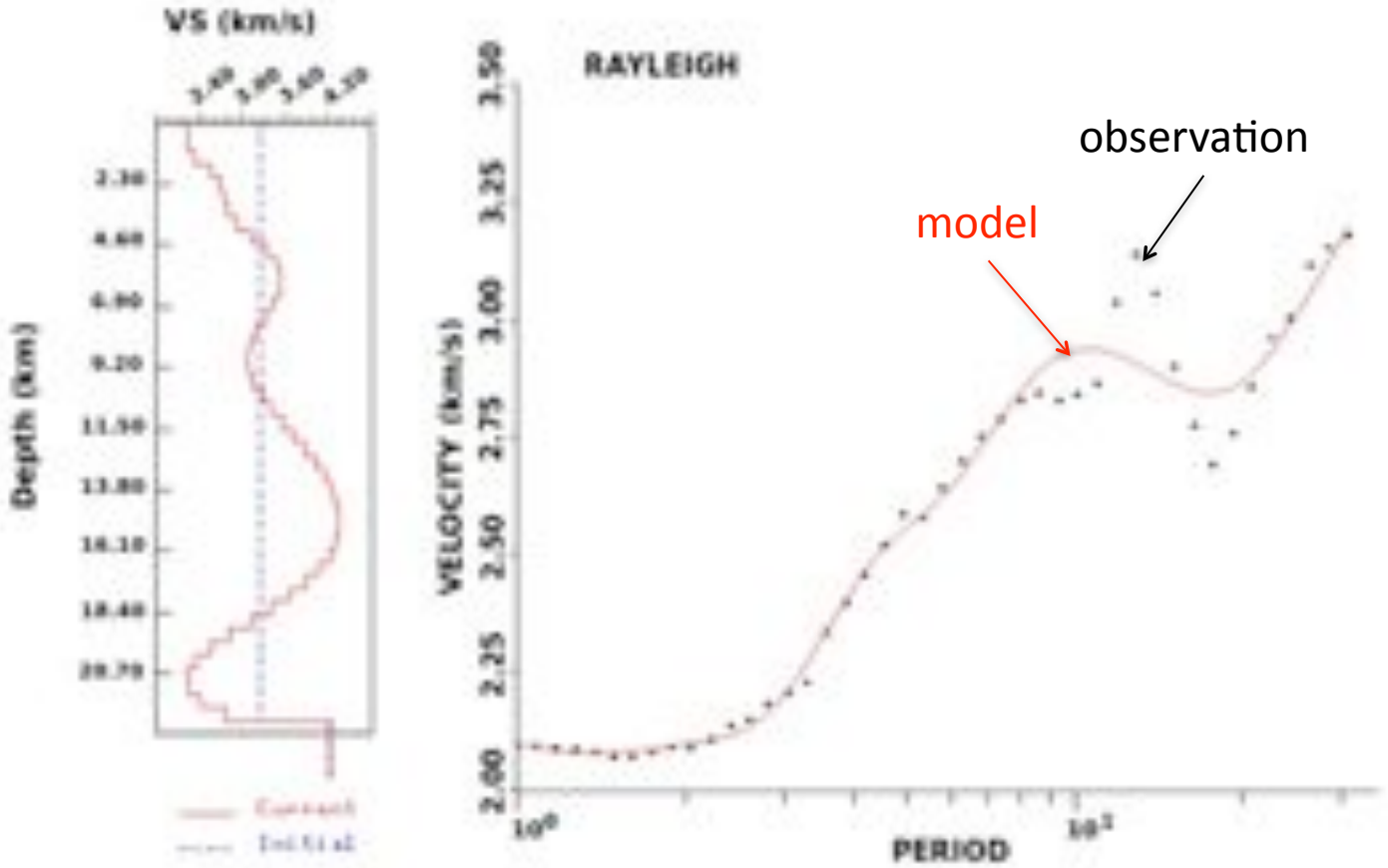
Regionalization of dispersion curves



Regionalization of dispersion curves

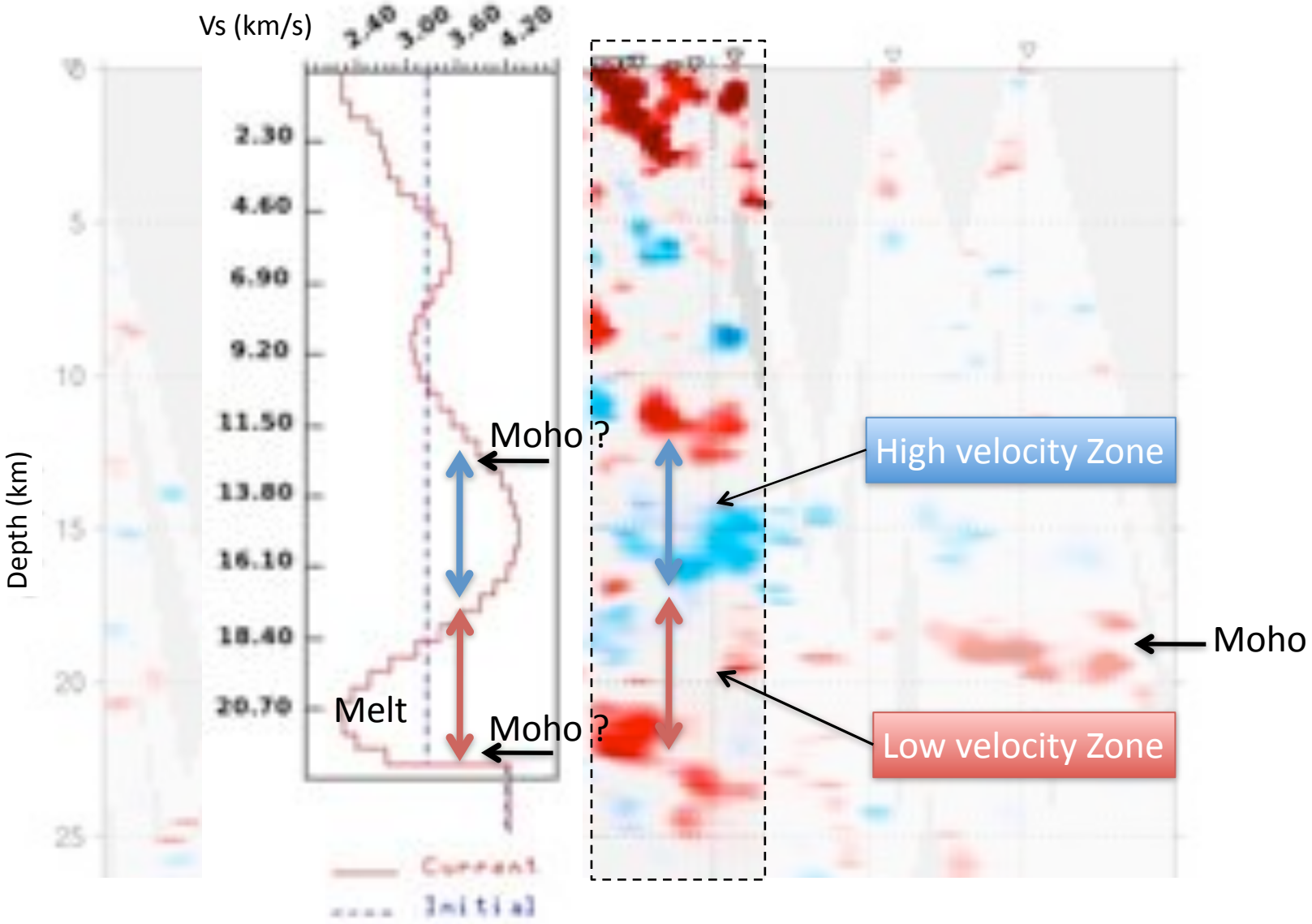


Velocity-depth profile in the rift

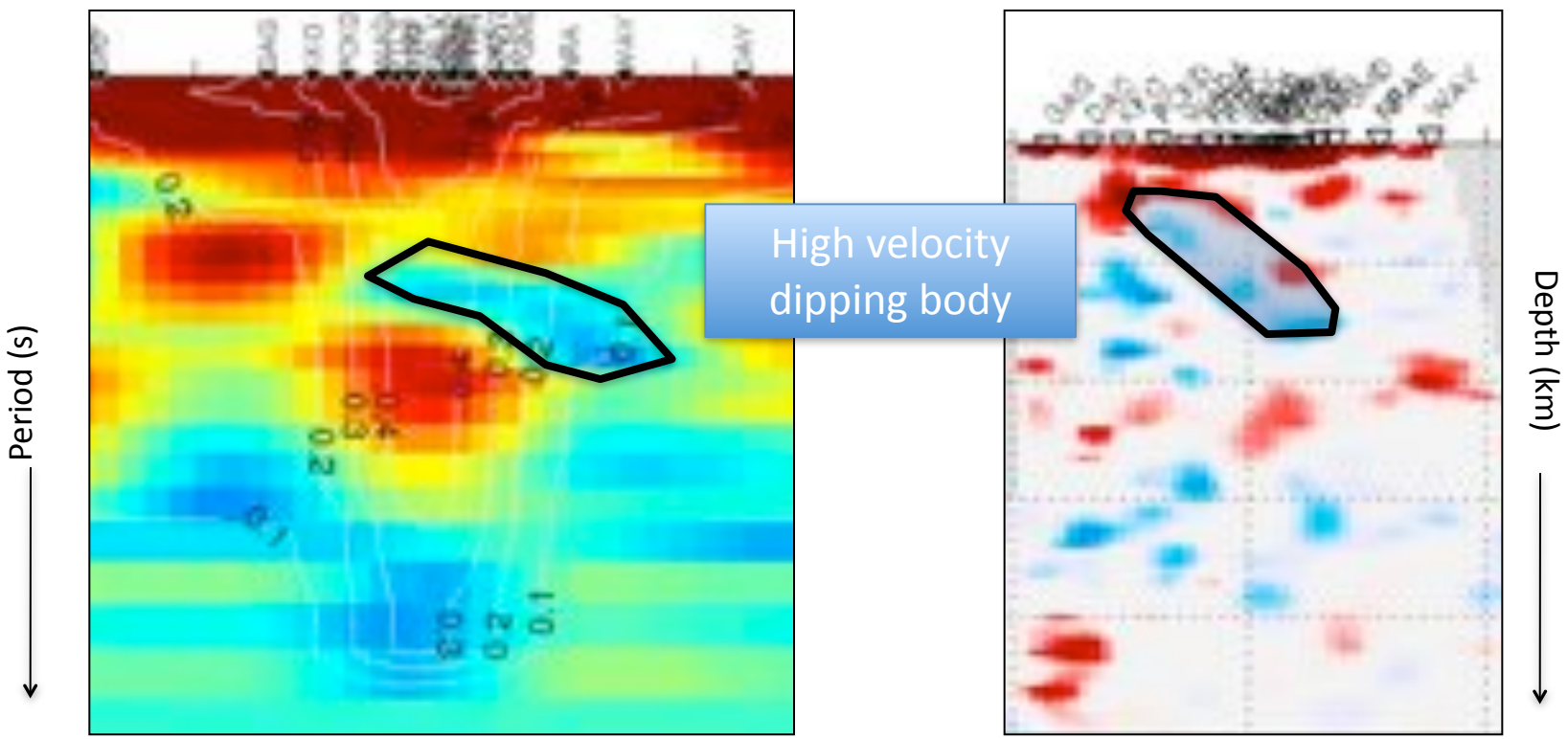


- Inversion of the mean dispersion curve for the rift stations
- Iterative inversion using the CPS330 tools (Hermann, 2002)
- Initial model with uniform velocity down to 22 km

NCF vs RF


Vs (km/s)
2.40
3.00
3.60
4.20
2.30
4.60
6.90
9.20
11.50
13.80
16.10
18.40
20.70
Depth (km)
Moho ?
Melt
Moho ?
High velocity Zone
Low velocity Zone
Moho
Current
Initial

NCF vs RF



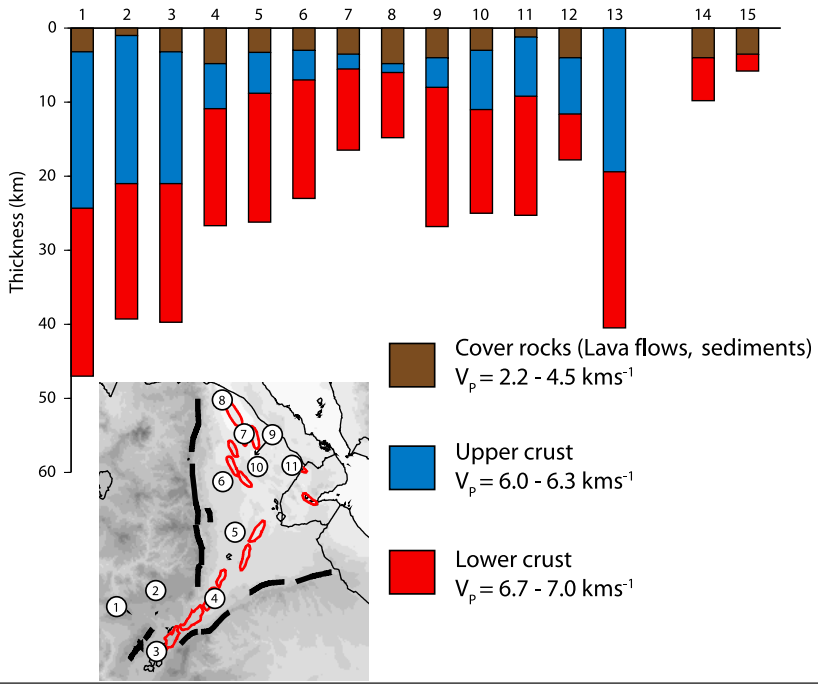
Conclusion

Technical

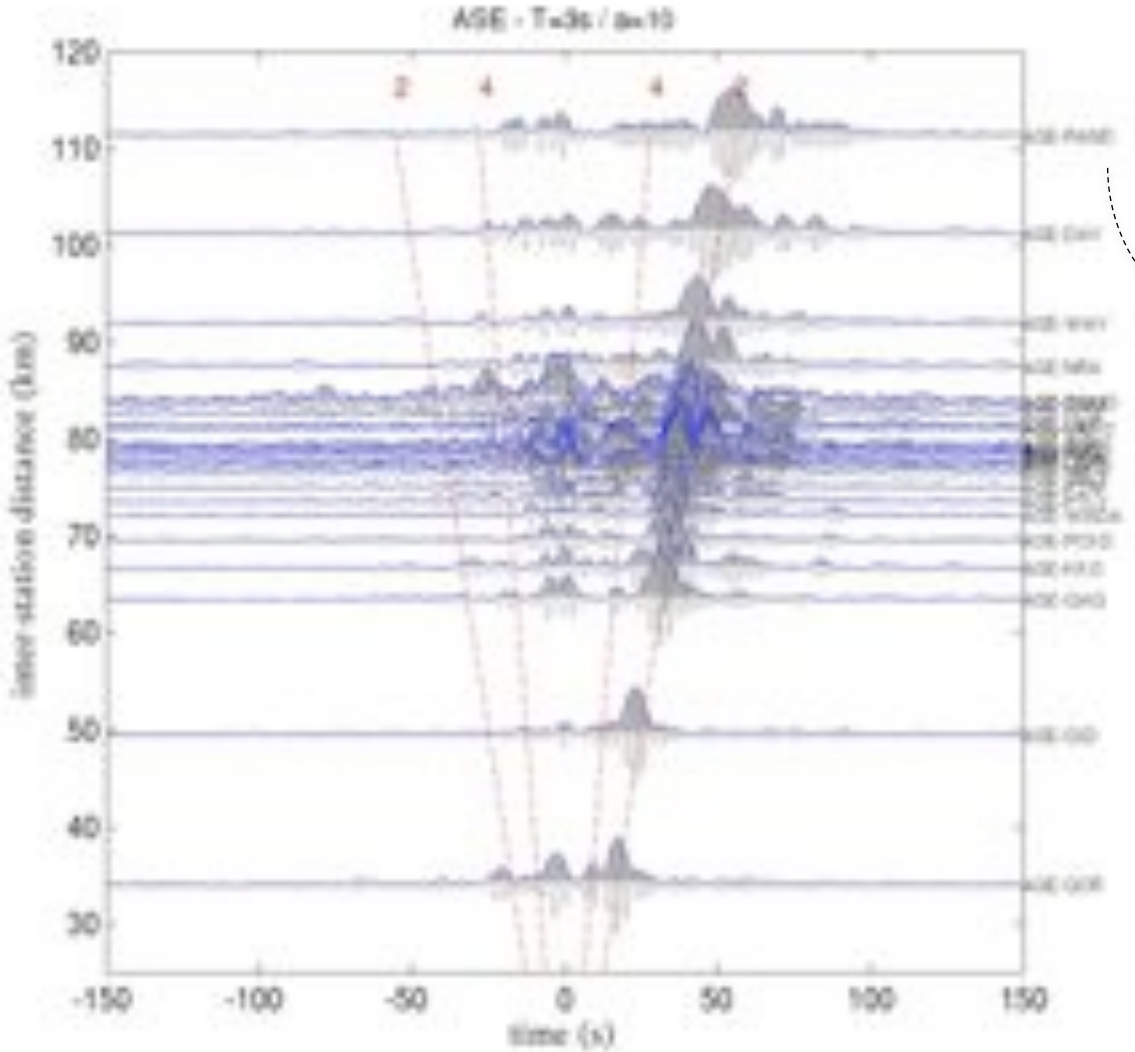
- Use of high station density and high frequency part of teleseismic events enable continous imaging of major interfaces, with Receiver Functions, from the surface down to the lithosphere
- Noise Correlation Functions provide additionnal (and coherent) information about the velocity depth profile inside the rift

Major results

- Depth of the Moho outside the rift: ~25 km
- Depth of the Moho beneath the rift is ambiguous (in term of seismic velocities) : either at 12 or 22 km depth
- Deep magma reservoir (15km depth) below the rift - with partial melting
- Fieale reservoir imaged at very shallow depths (~ 2 km)



Examples of NCF



- Base station : ASE
- Gaussian filter : 3s