Data and new constraints from Magnus-Rex

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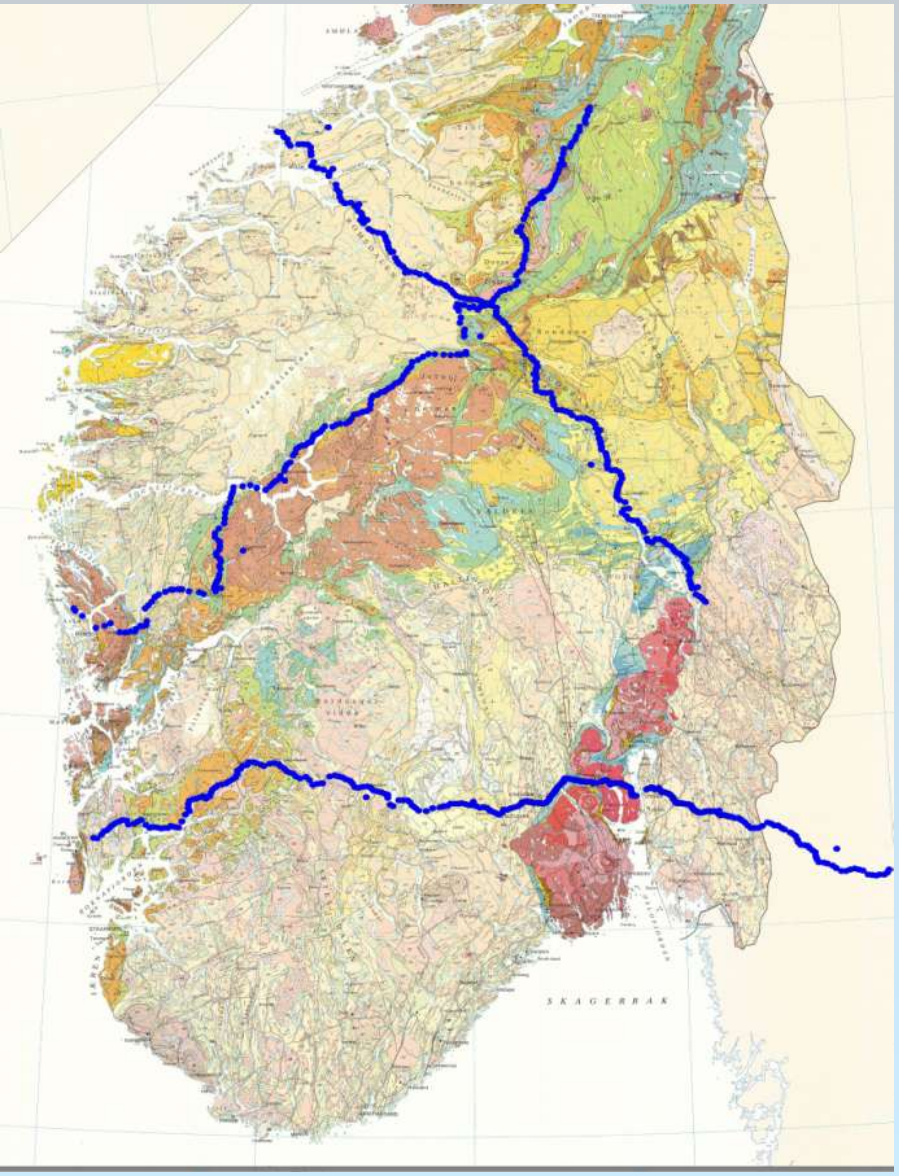
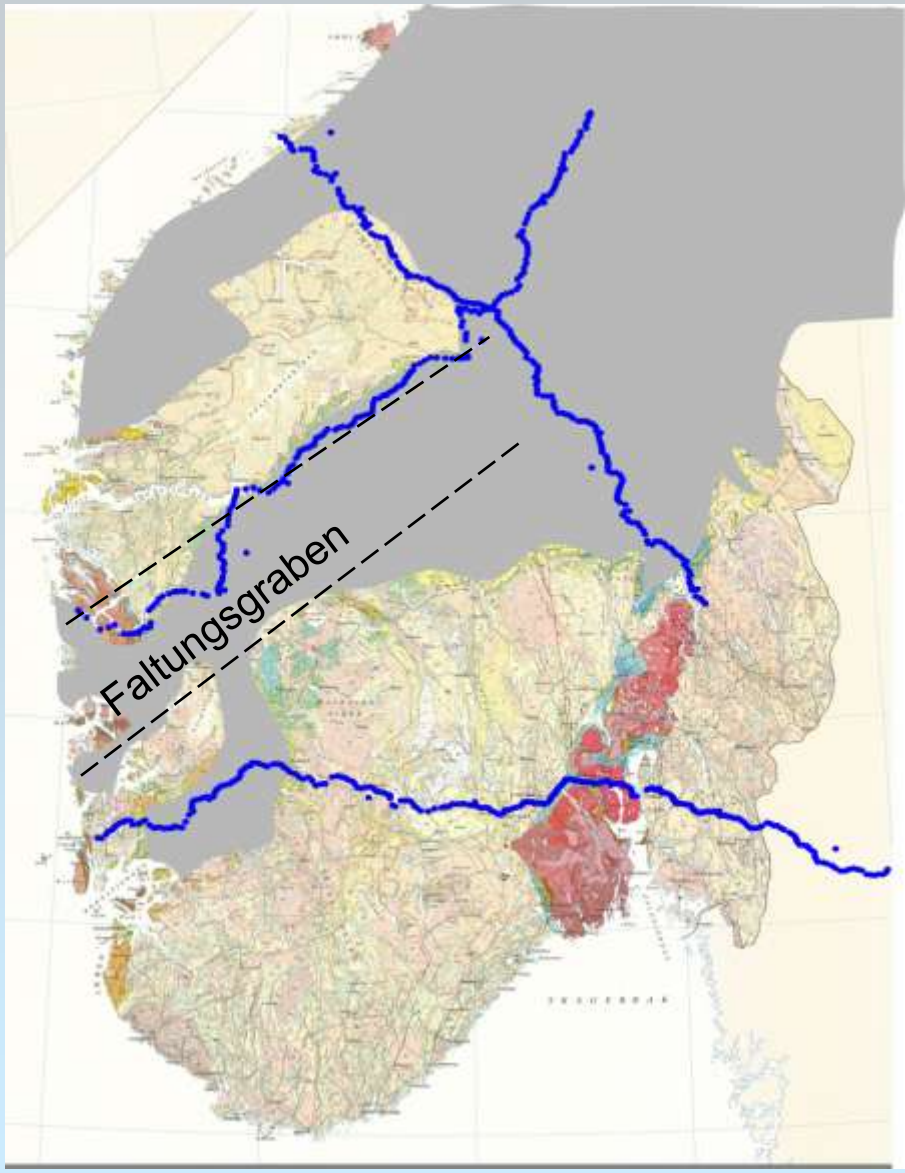
Overview

- Magnus-Rex - Mantle investigations of Norwegian uplift structure- Refraction experiment
- Project goals and preliminary findings from Magnus-Rex
- Field experiment
- Data and interpretations for the southern Scandes and Oslo Graben
- Poisson’s Ratio Models for the upper crust
- Magnus-0

Geologic setting



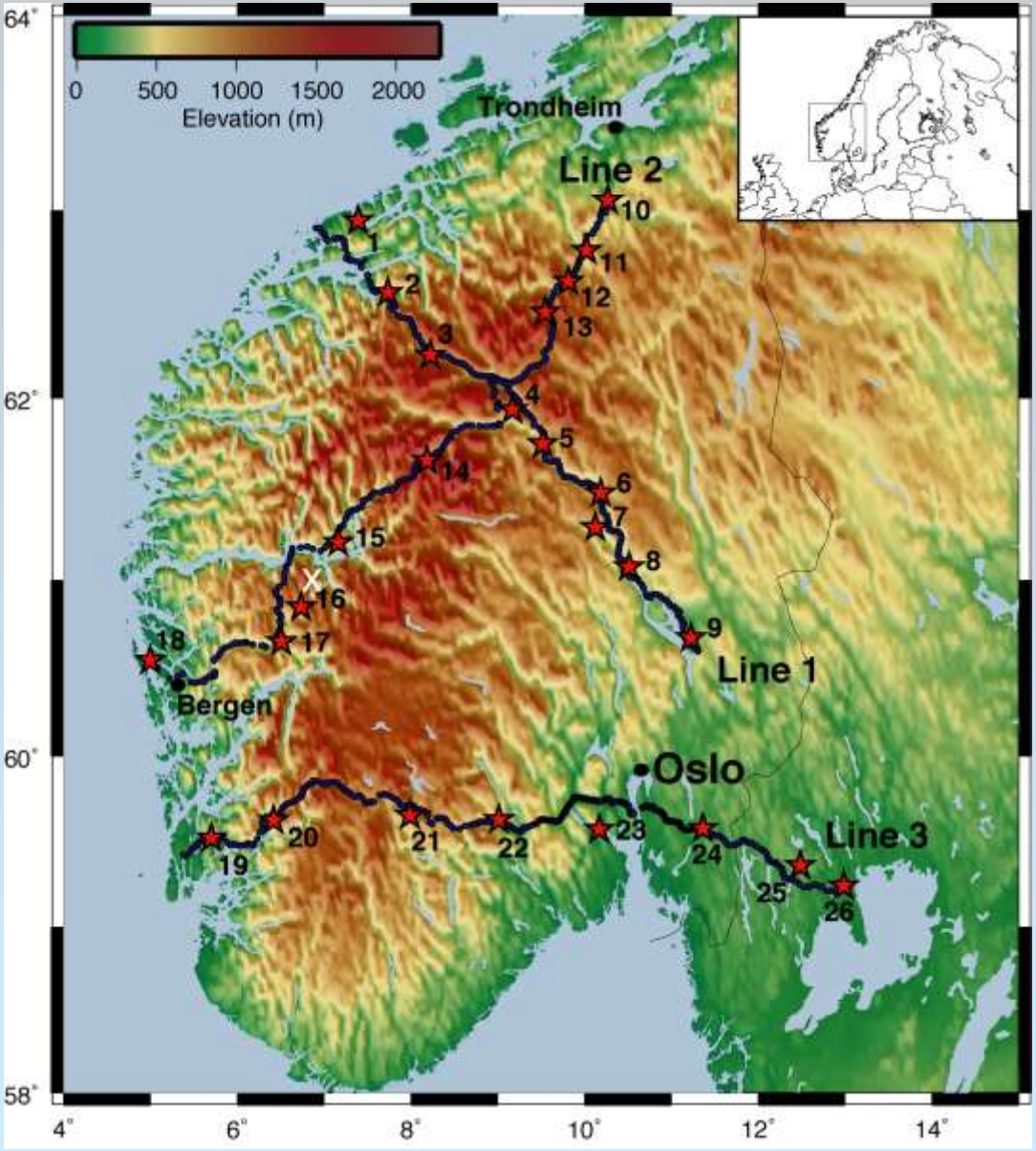
Magnus-Rex seismic Profiles

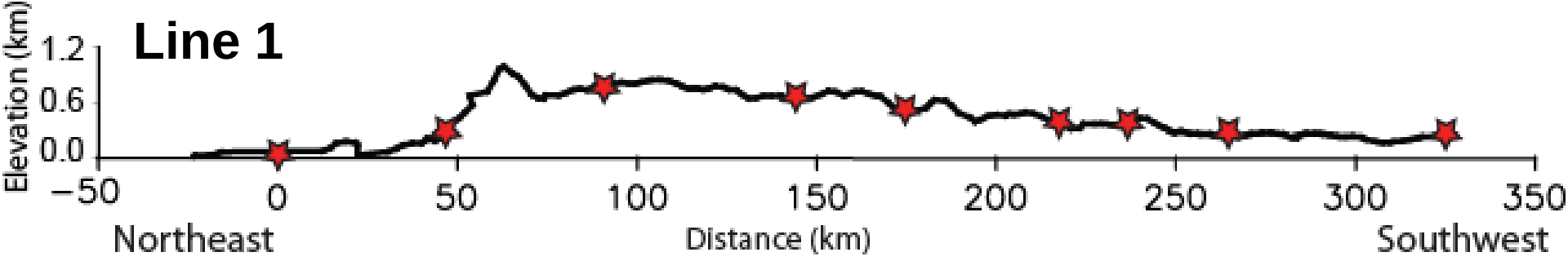


Caledonides in souther Norway

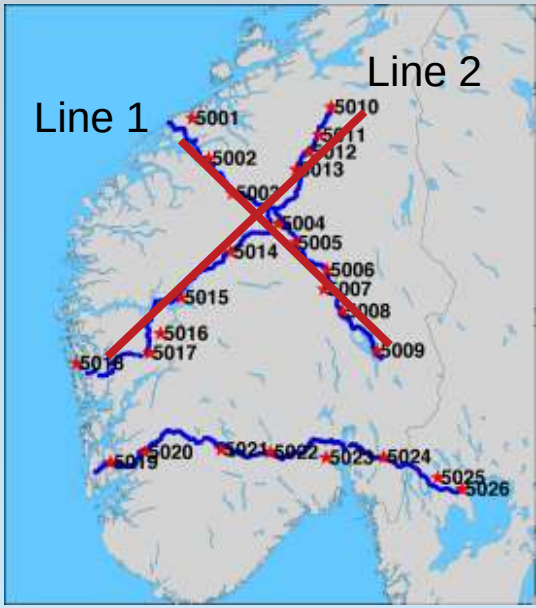
Magnus-Rex

- Refractions profiling of the lithosphere. Best method of obtaining constrains on the velocity structure and thickness of the crust.
- 22 teams, ~750 texan instruments, 26 shots.
- Top down approach to forward modelling
- Constraint on crustal thickness ->
- ± 1 km where Pn and PmP are available.
- ± 2 km where only PmP is available.

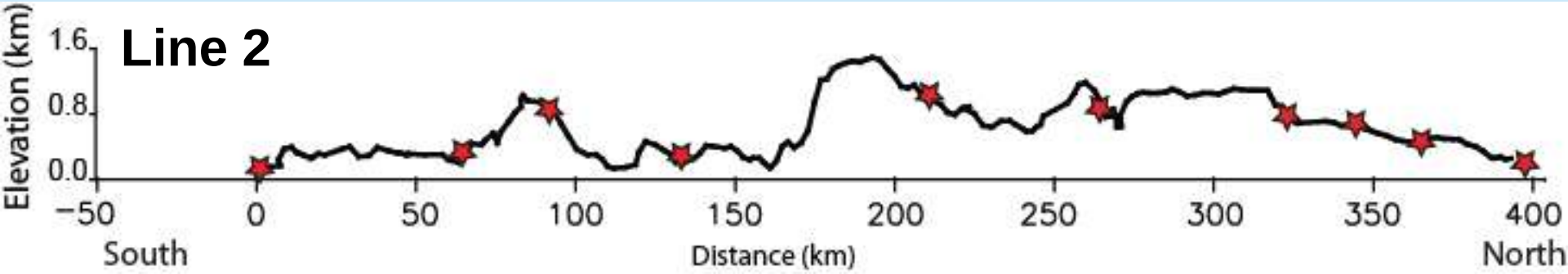




- ~360 km array
- 9 shots (100, 200 and 400 kg charge sizes)
- 174 instruments at 2 km spacing.

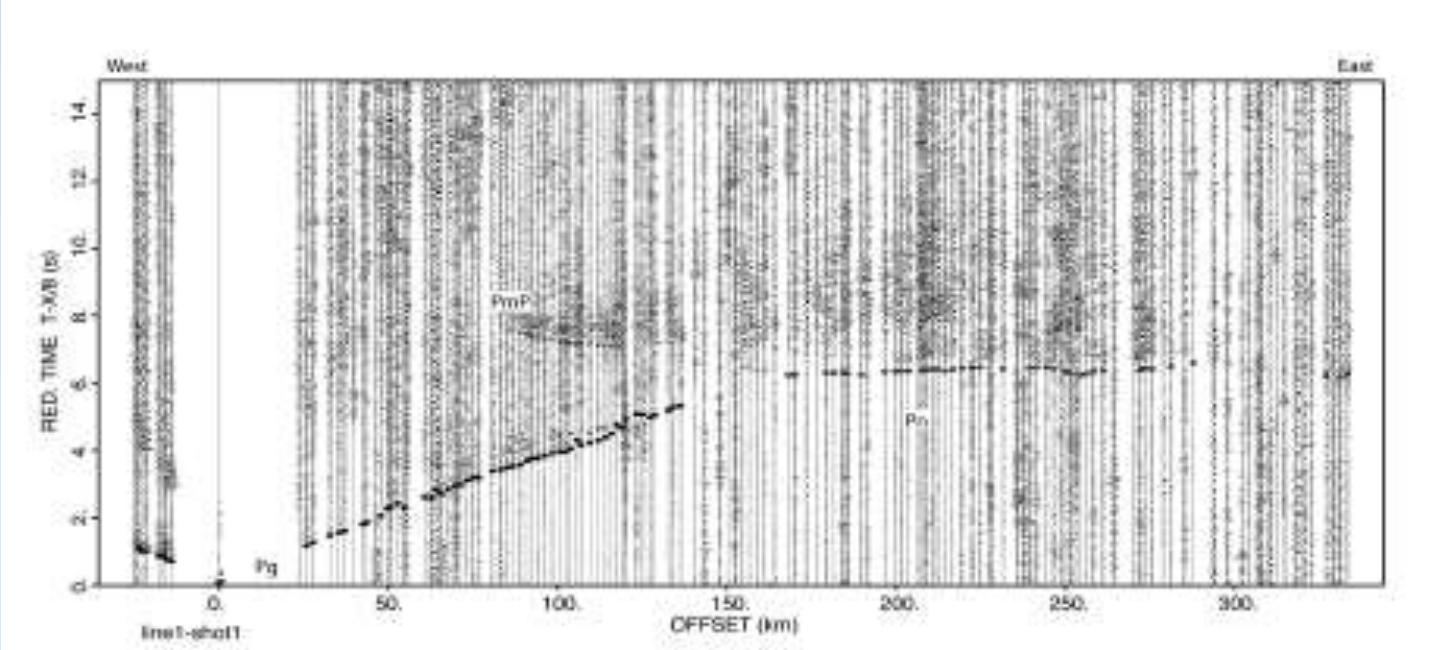


- ~400 km array
- 10 shots (100, 200 and 400 kg charge sizes)
- 200 instruments at 2 km spacing.



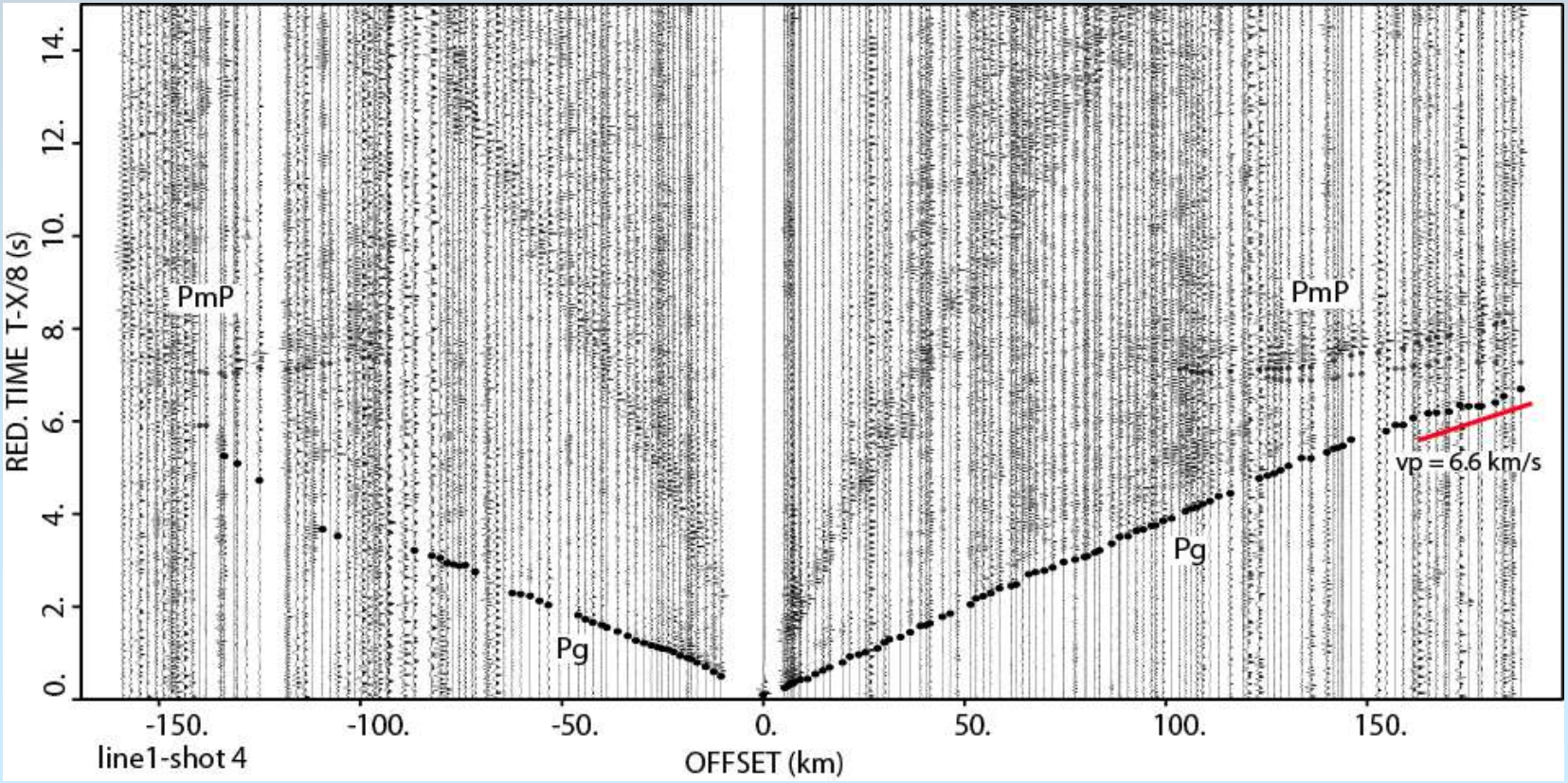
Shot 1 - line 1

- 400 kg charge size
- Pg Vp = 6.0 - 6.3 km/s
- Pn Vp = 8.05 ± 0.1 km/s at xcross > 160 km
- PmP reflection



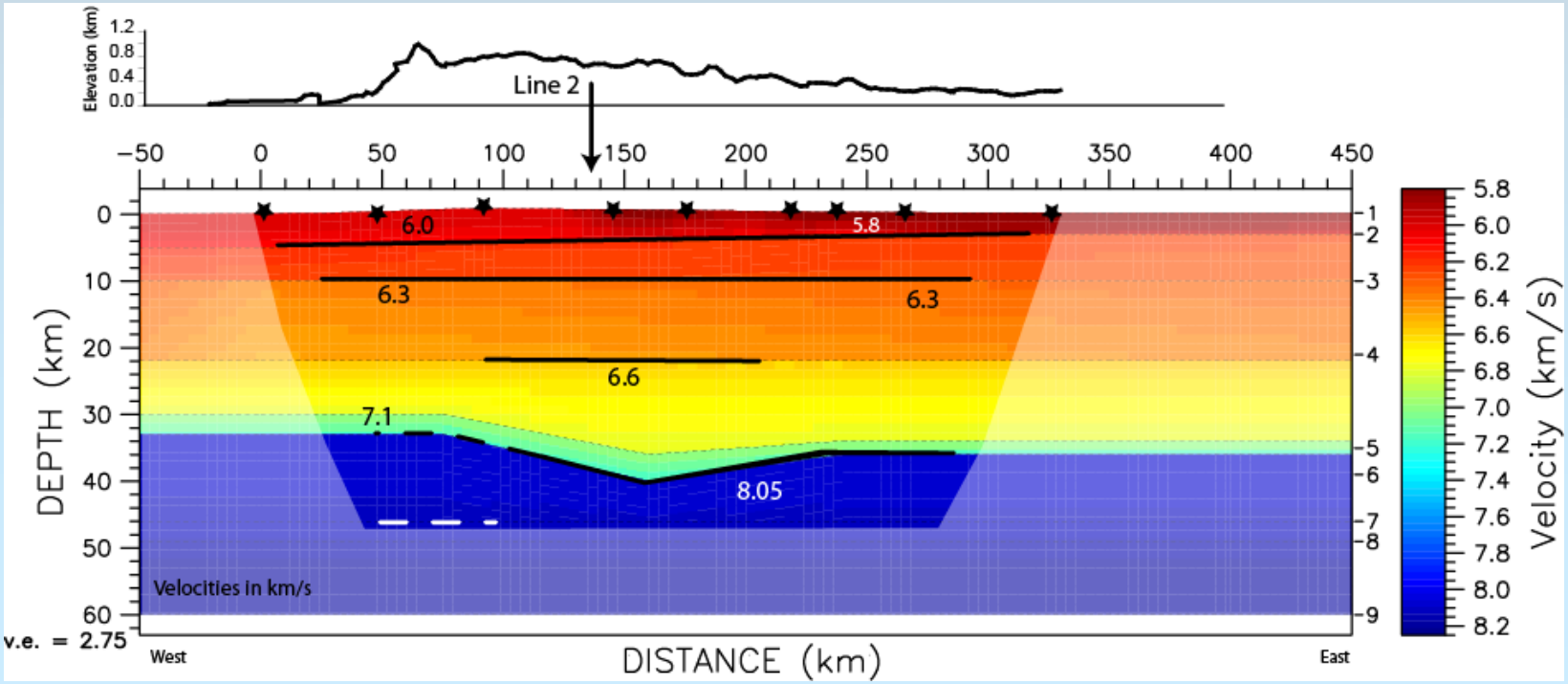
Shot 4 - line1

- 200 kg charge size
- Pg Vp = 5.8 - 6.6 km/s
- PmP -> ~ flat moveout



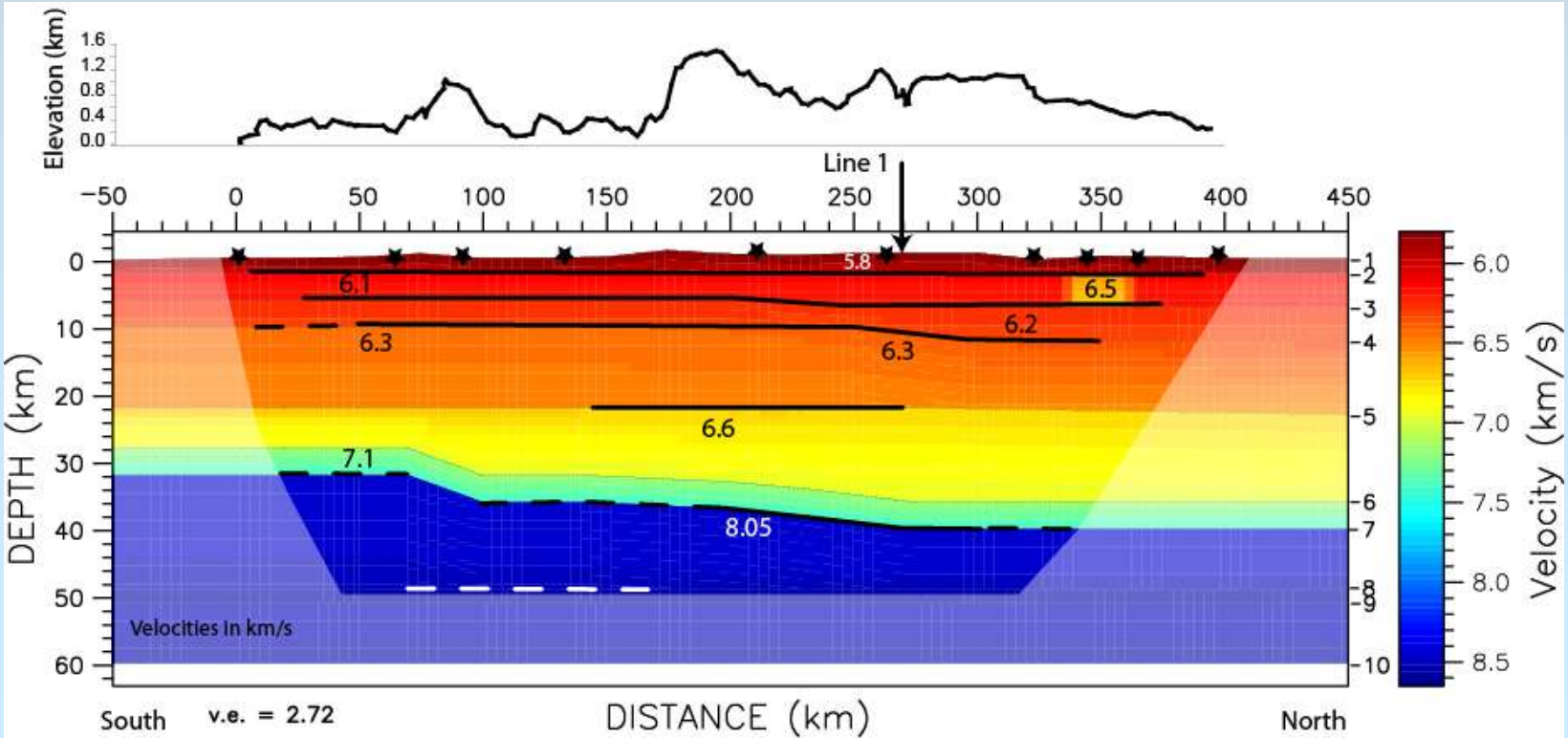
Velocity structure - Line 1

- Thick lines -> refraction velocity and depth constraint
- Thick dashed lines -> reflection structural constraint

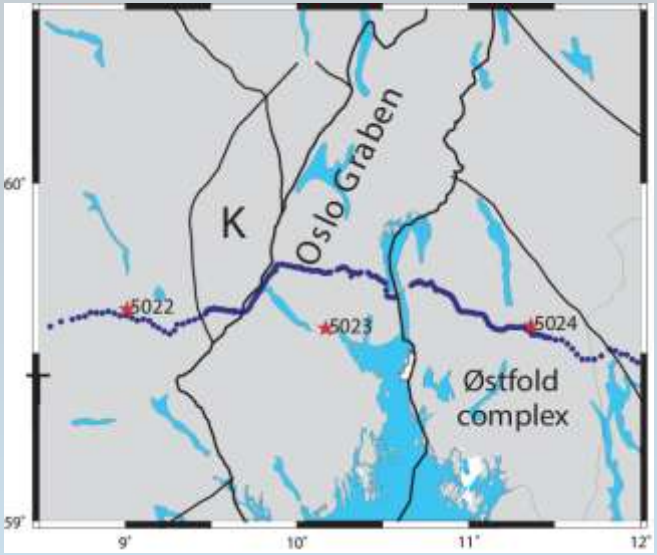


Velocity structure - Line 2

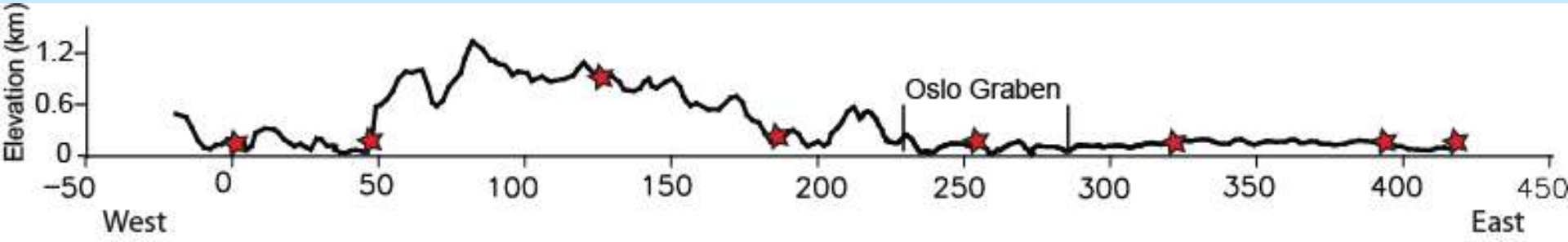
- Thick lines -> refraction velocity and depth constraint
- Thick dashed lines -> reflection structural constraint



Line 3 - E-W across the southern Scandes and Oslo Graben

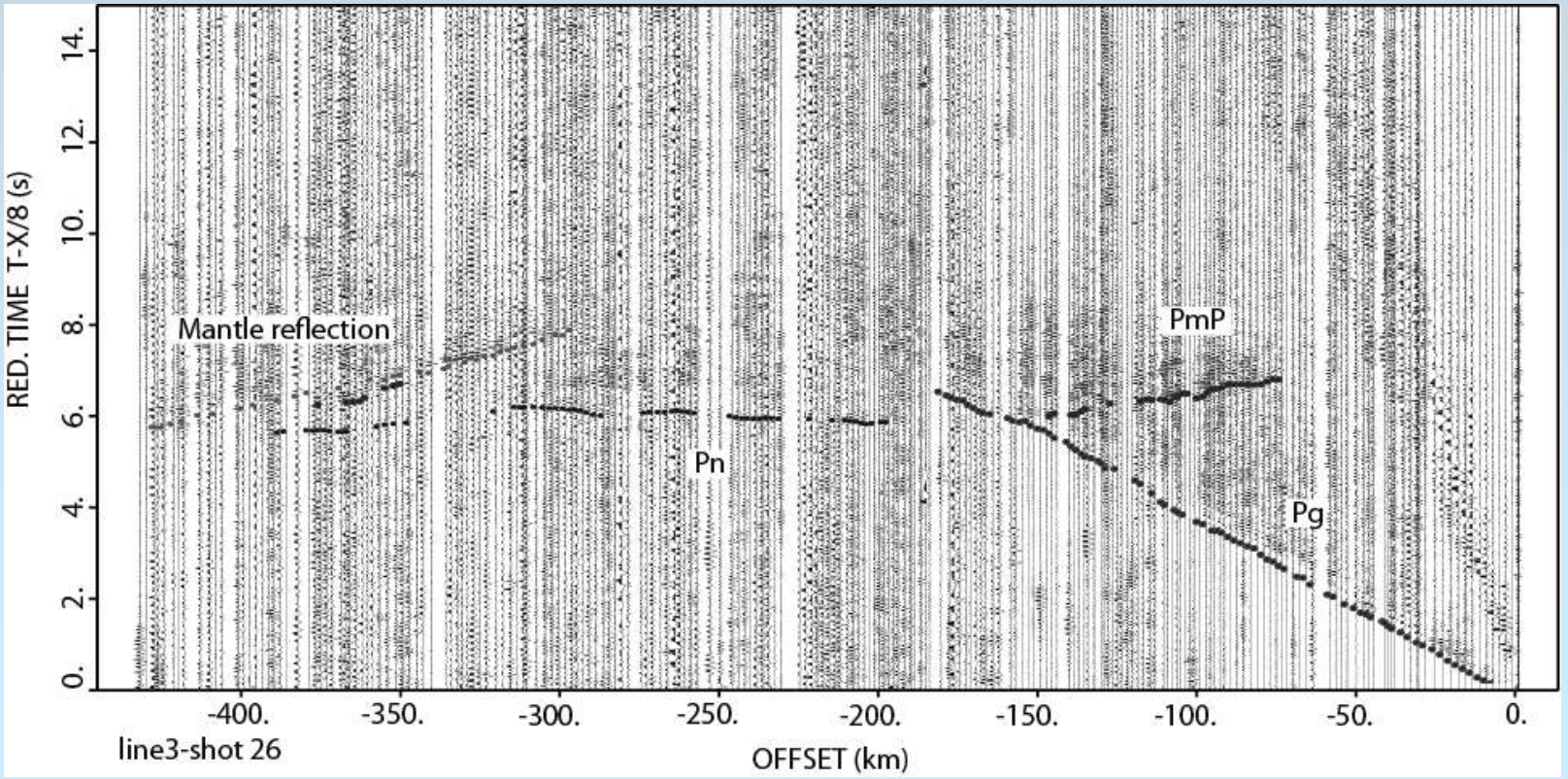


- ~450 km array
- 8 shots (100, 200 and 400 kg charge sizes)
- 330 instruments at 2 km spacing, including a 120 km section at 0.75 km spacing across the Oslo Graben



Shot 26 - line 3

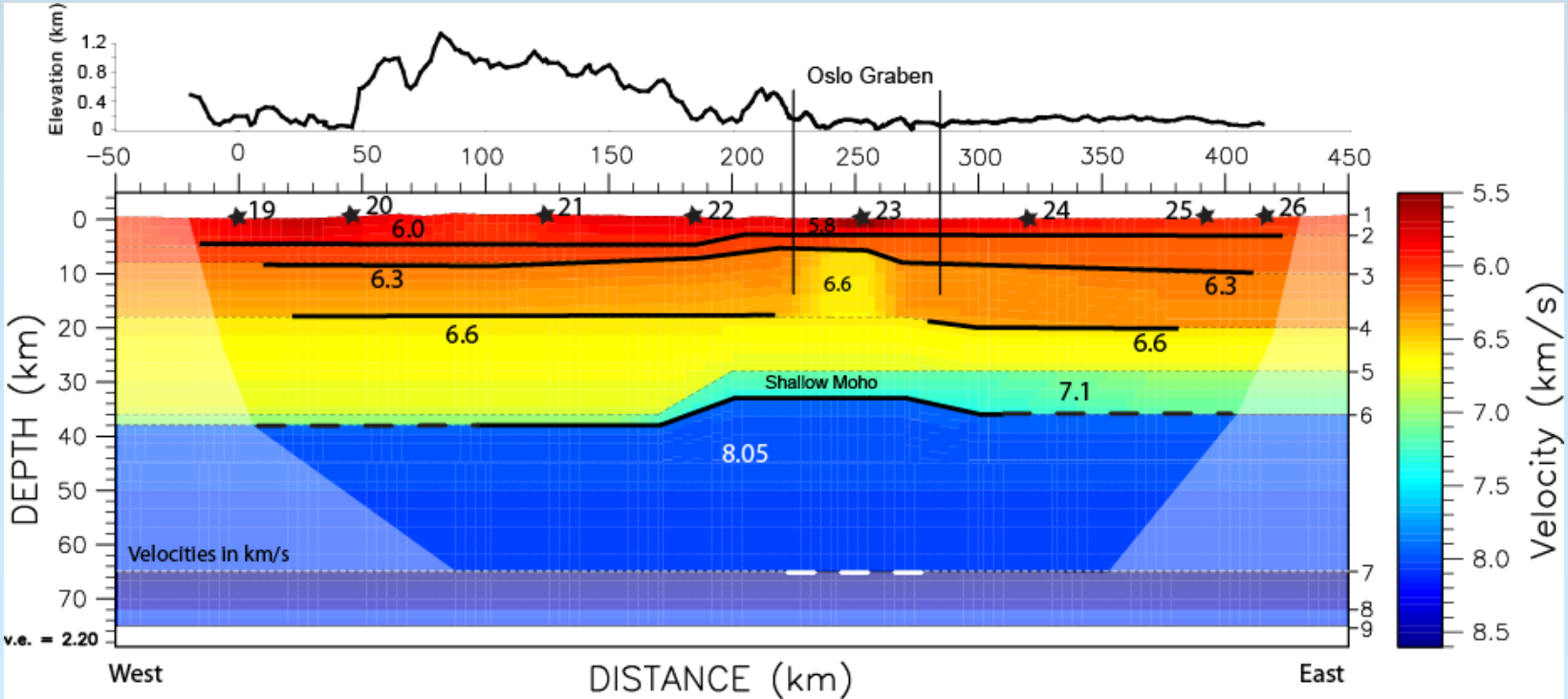
- 400 kg charge size
- Pg Vp = 5.8 - 6.3 km/s
- PmP
- Pn Vp = 8.05 ± 0.1 km/s
- Mantle reflection behind Pn



Velocity structure- Line 2 - deep Moho

Thick lines -> refraction velocity and depth constraint

Thick dashed lines -> reflection structural constraint



Velocity structure- Line 2 - deep Moho

Thick lines -> refraction velocity and depth constraint

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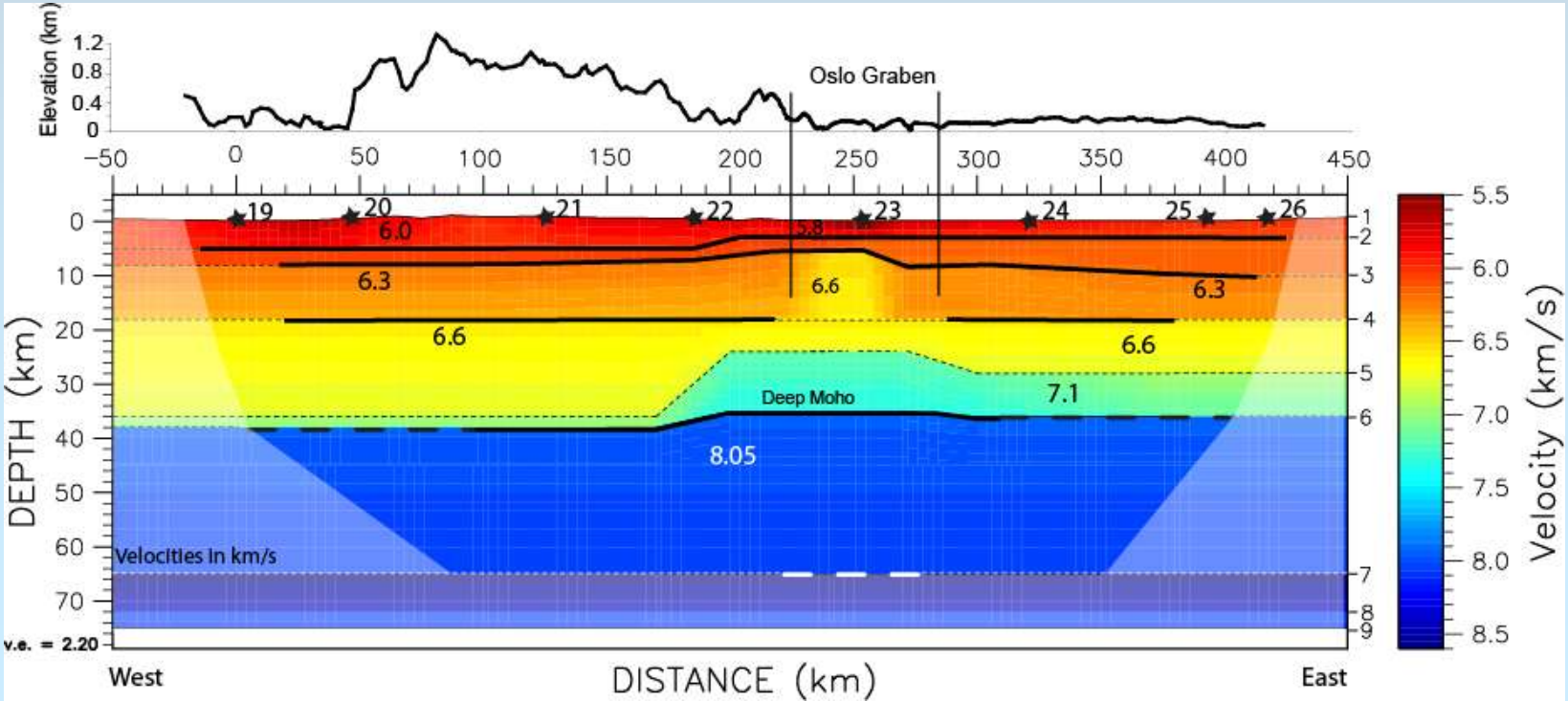


Line 1

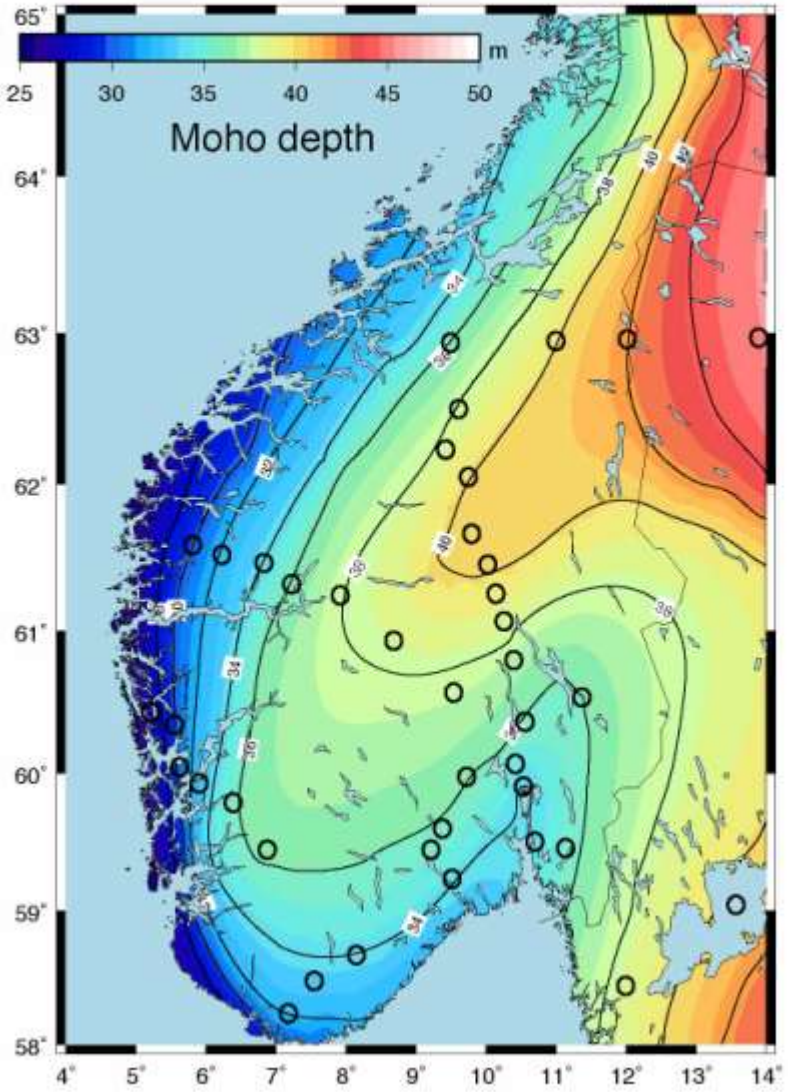
Line 2

Line 3

Moho depth beneath the Magnus-Rex seismic profiles

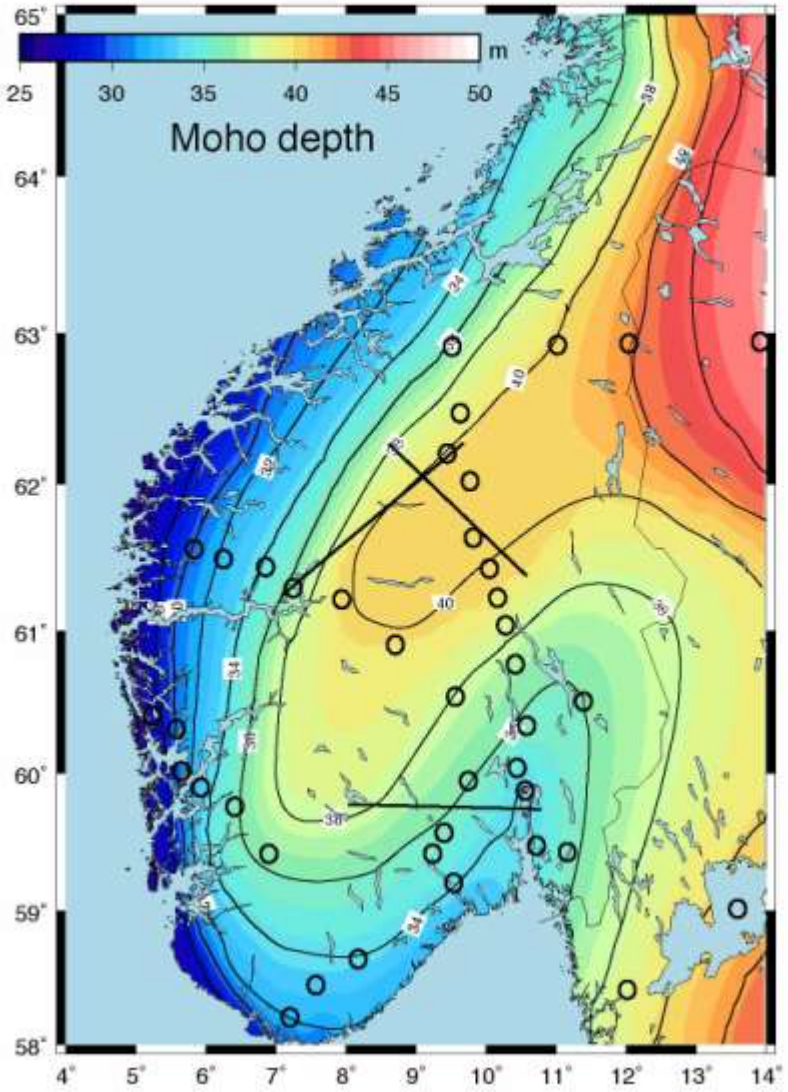
Contour map of crustal thickness

Before



Contour map of crustal thickness

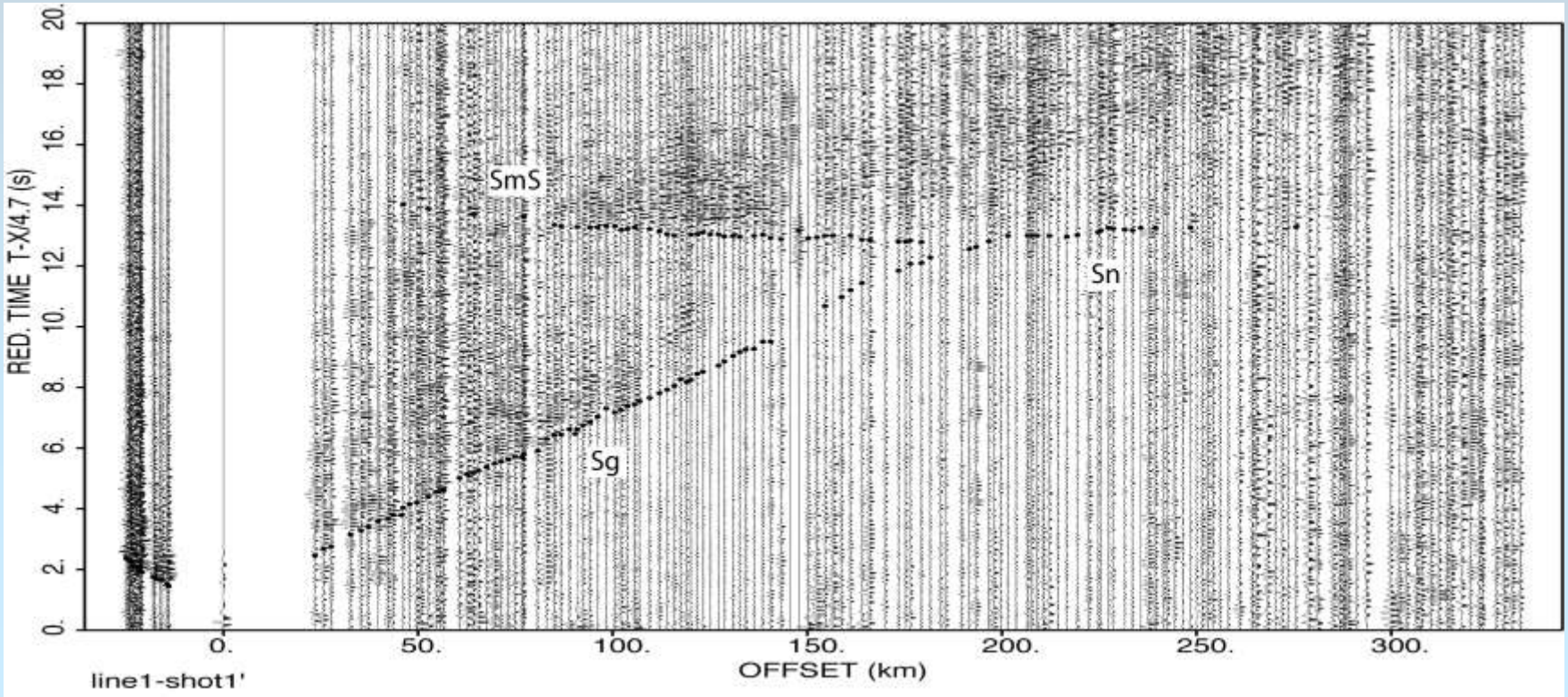
After



Original constraints from earlier refraction seismic studies still stand. Changes inferred are in gaps between previous surveys.

We also recorded S-waves…
Shot 1 - line 1

- 400 kg charge size
- Sg Vs = 3.35 – 3.65 km/s
- Sn Vs = 4.65 ± 0.1 km/s
- SmS reflection



Line 1

Comparing Poisson's ratio (σ) for caledonides to "basement"

Basement = mostly rock deformed in the Sveconorwegian Orogeny from 1250-900 Ma.

Uncertainties in Poisson's Ratio

$\delta\sigma/\sigma = f(\eta)[\delta Vp/Vp + \delta Vs/Vs]$

$f(\eta) = 2\eta^2/(\eta^2 - 1)(\eta^2 - 2)$

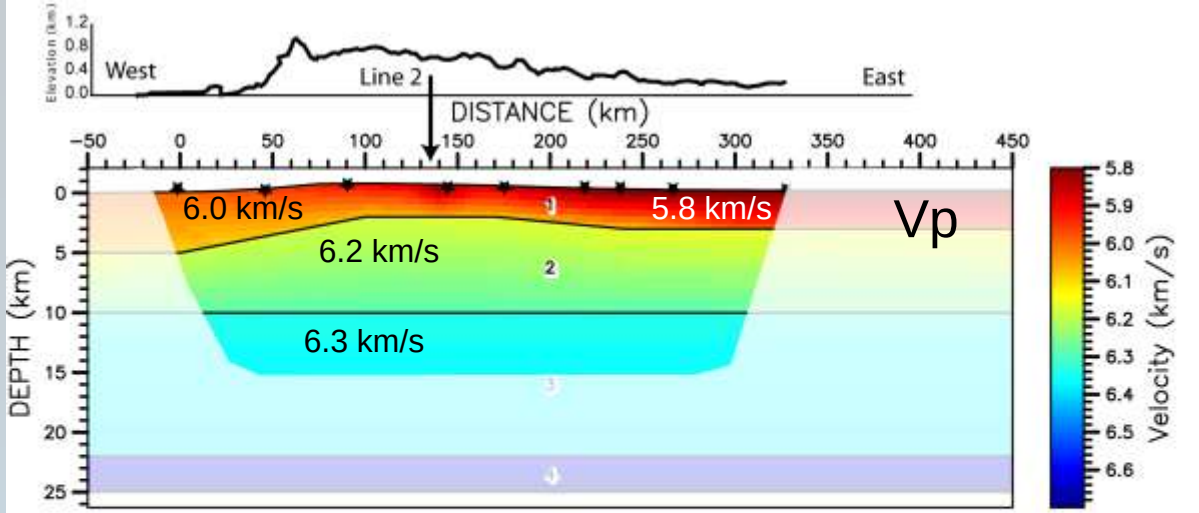
Where $\eta = Vp/Vs$

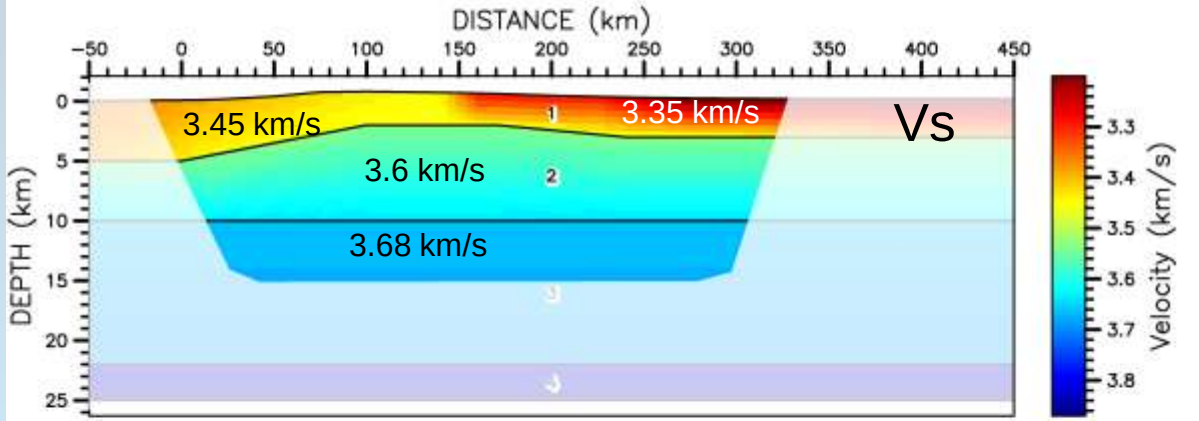
Christensen, (1996).

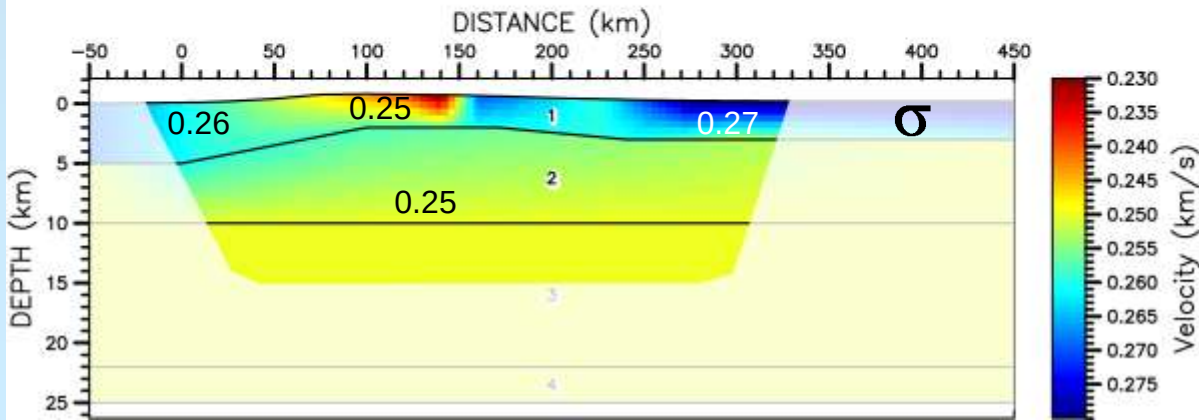
Uncertainties in σ

~ 3.5% or ±0.009 for $\sigma = 0.29$

~ 6.5% or ± 0.014 for $\sigma = 0.20$





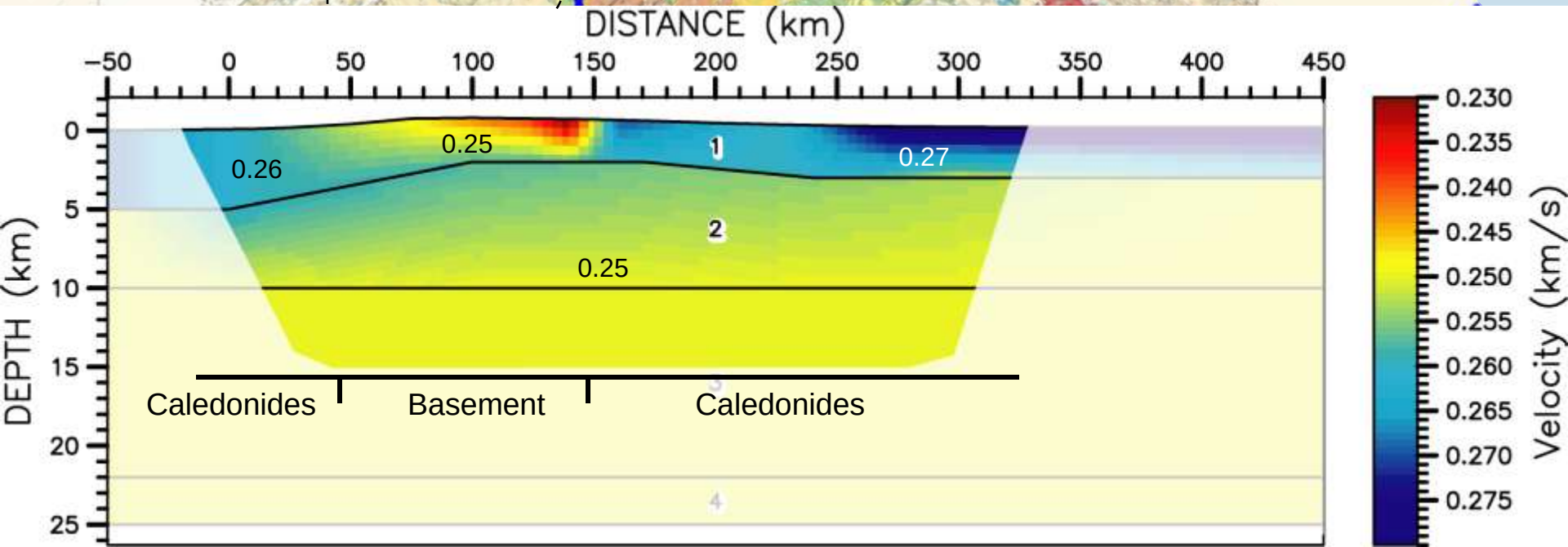


Caledonides: Lower allochthon

Granites, granodiorites.

Fennoscandian shield: granite, granodiorite

Caledonides: Middle Allochthon, quatzite, greywacke, siltstone, limestone



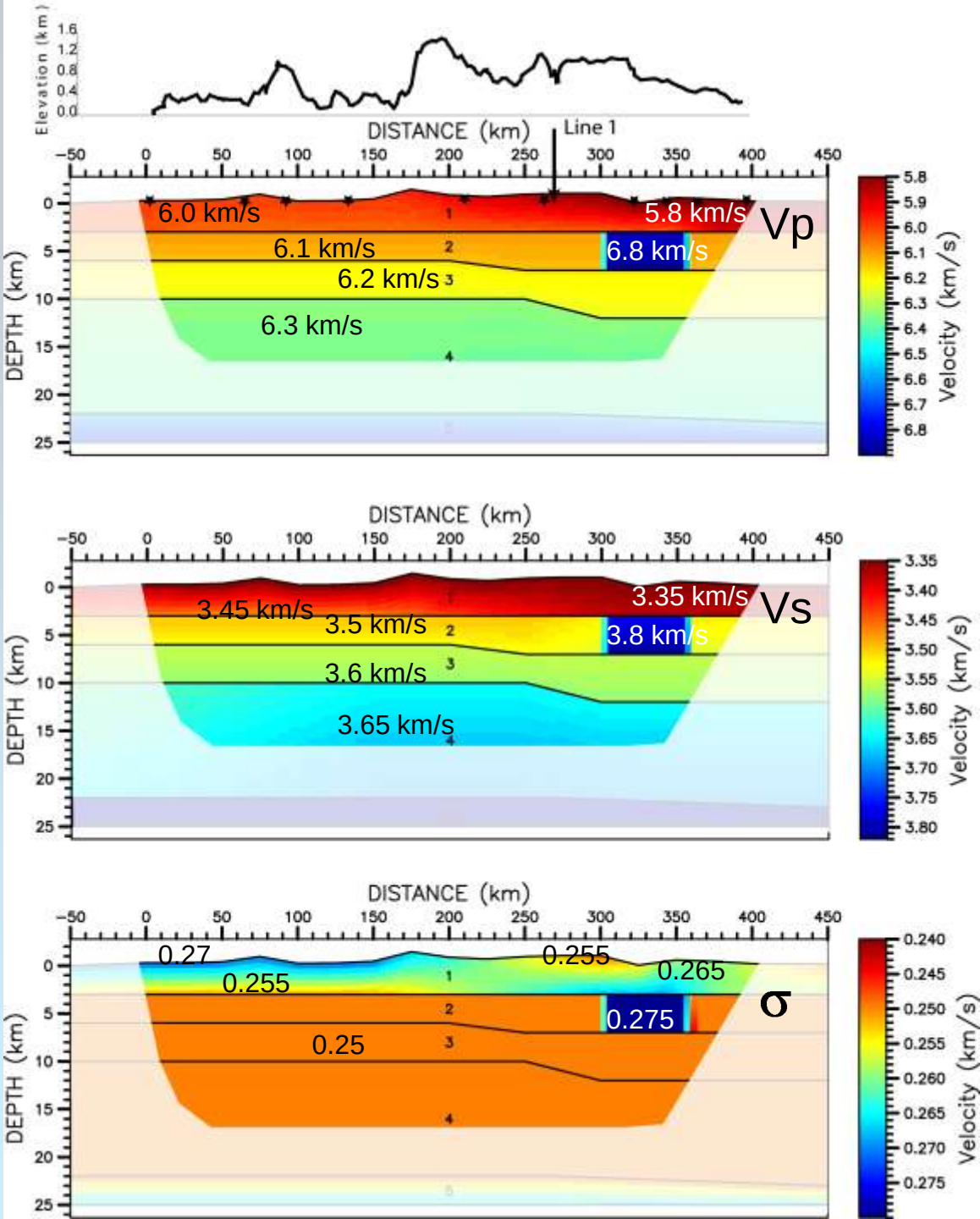
Line 2

Profile line runs ~ north-south - along the western edge of the Faltungsgraben.

Crustal layers thicken to the north

Block of high velocity rock ~ 3 km depth beneath the upper Allochthon.

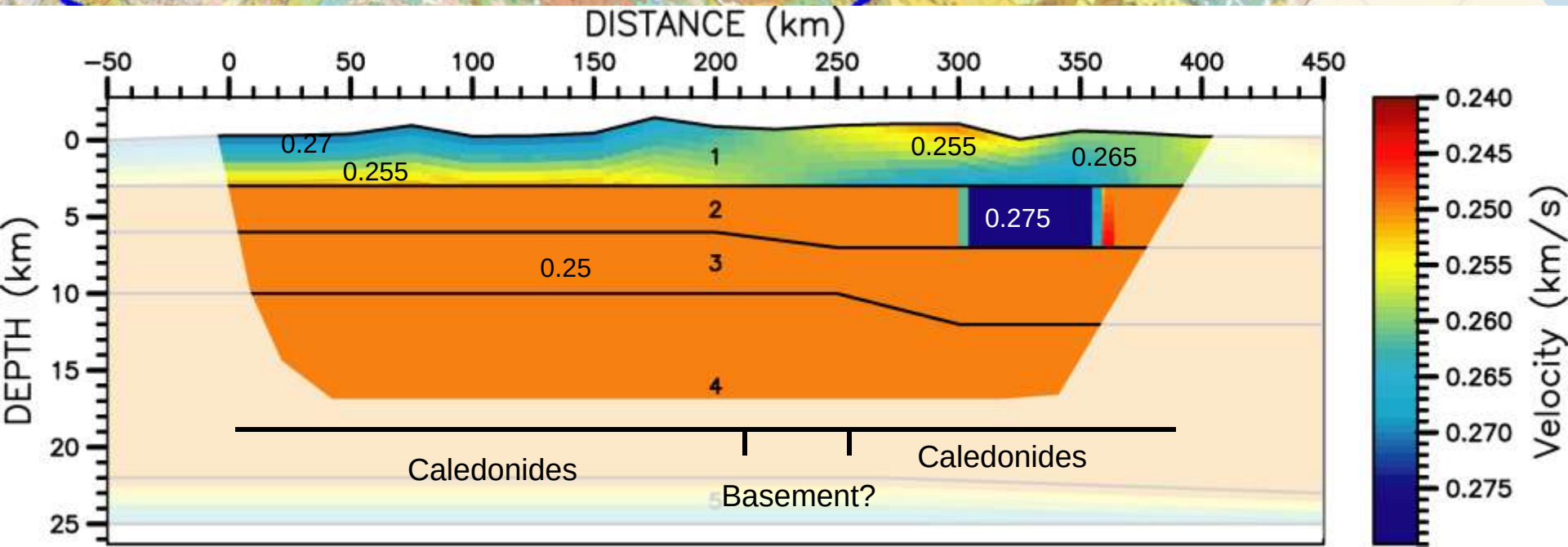
Refracted arrivals down to 15 km depth indicate the crust below the caledonides is more or less uniform σ at a ~10 km scale.



Middle and lower Allochthon: granite, gabbro, anorthosite, quartzite, greywacke

Fennoscandian shield: granite, granodiorite

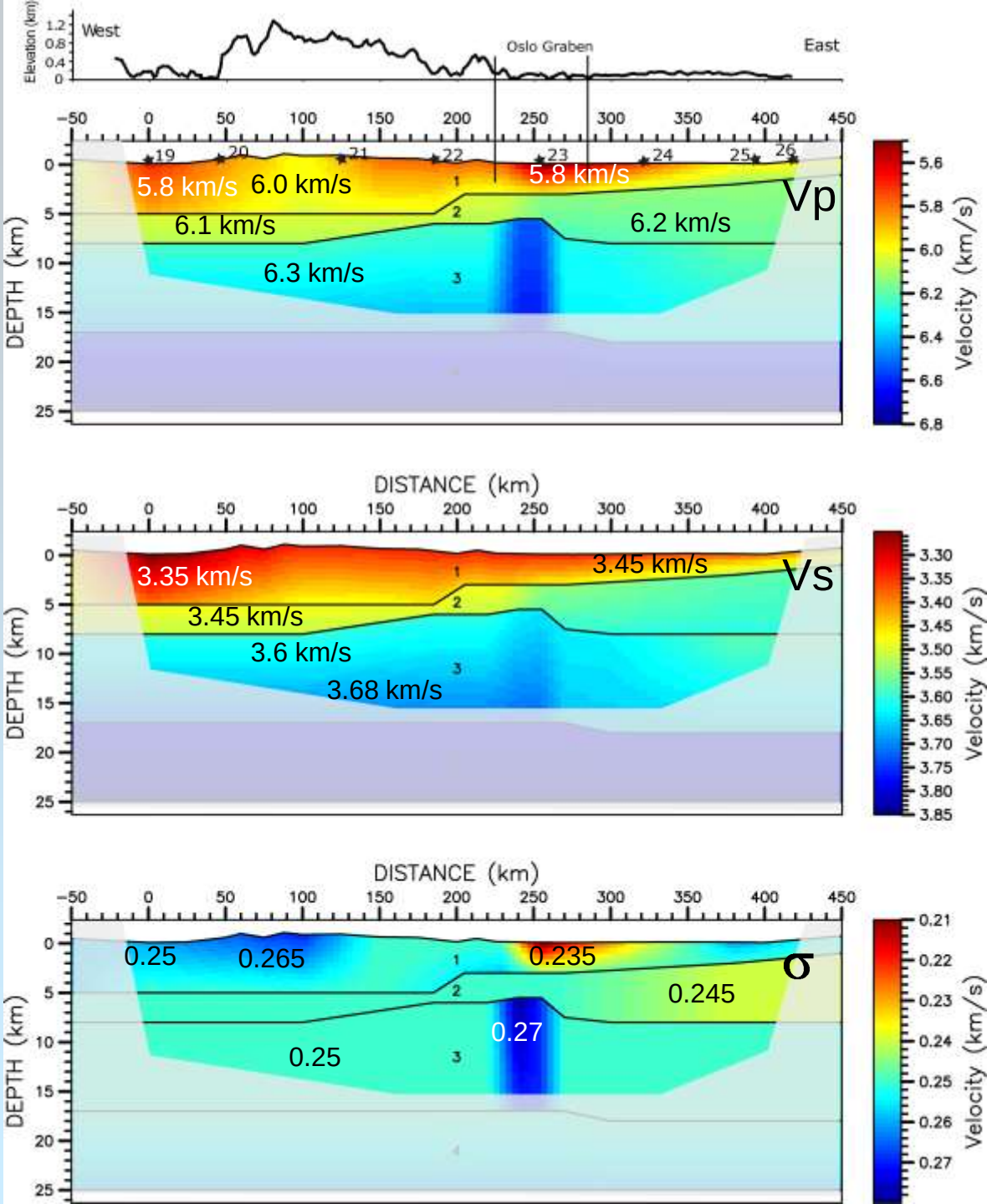
Upper Allochthon: granite, diorite, gabbro, ultramafics, greywacke, conglomerate, felsic, mafic, metavolcanics

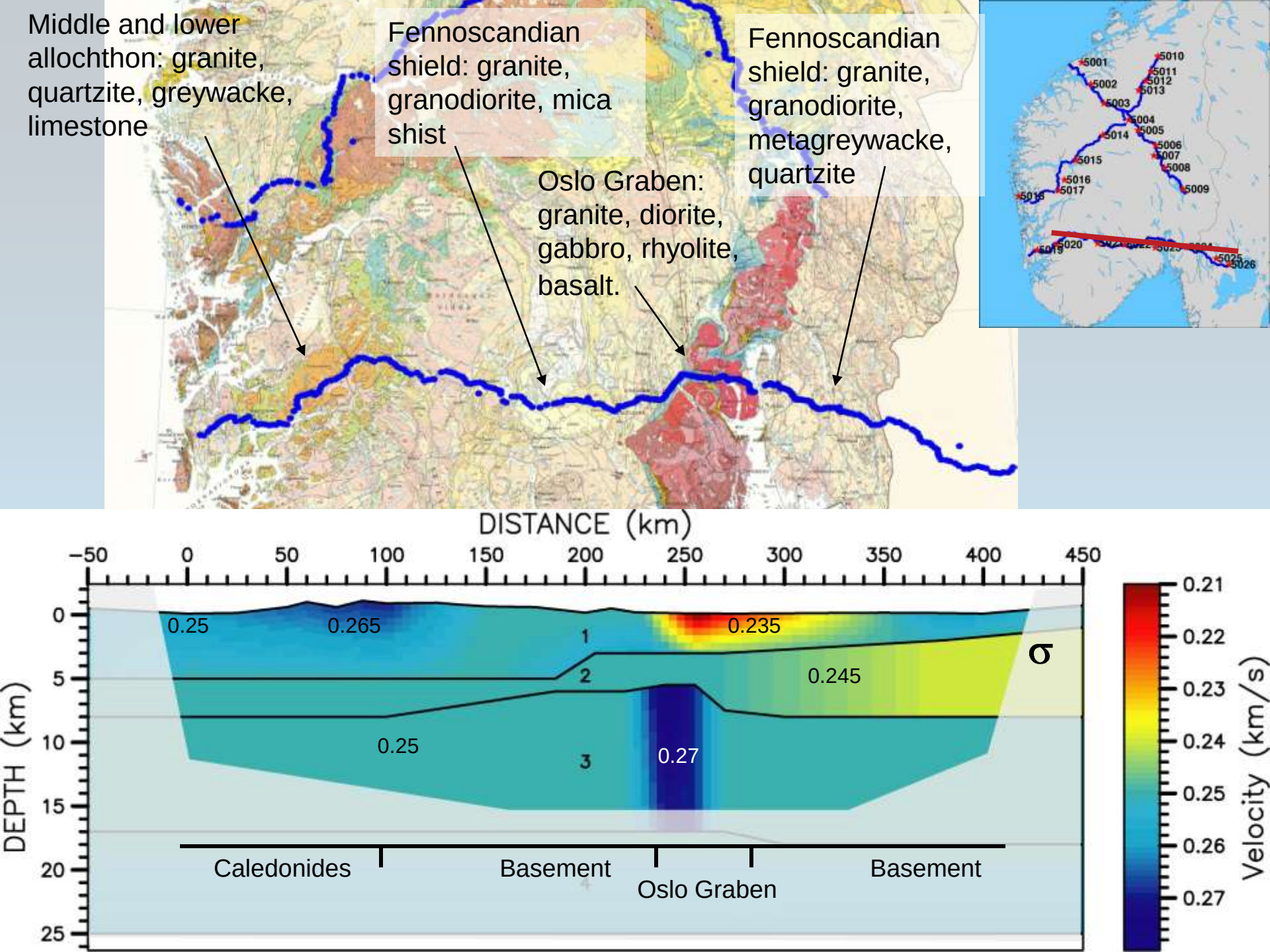


Line three - across southern Norway and the Oslo Graben.

Near suface Vp is slower within the graben.

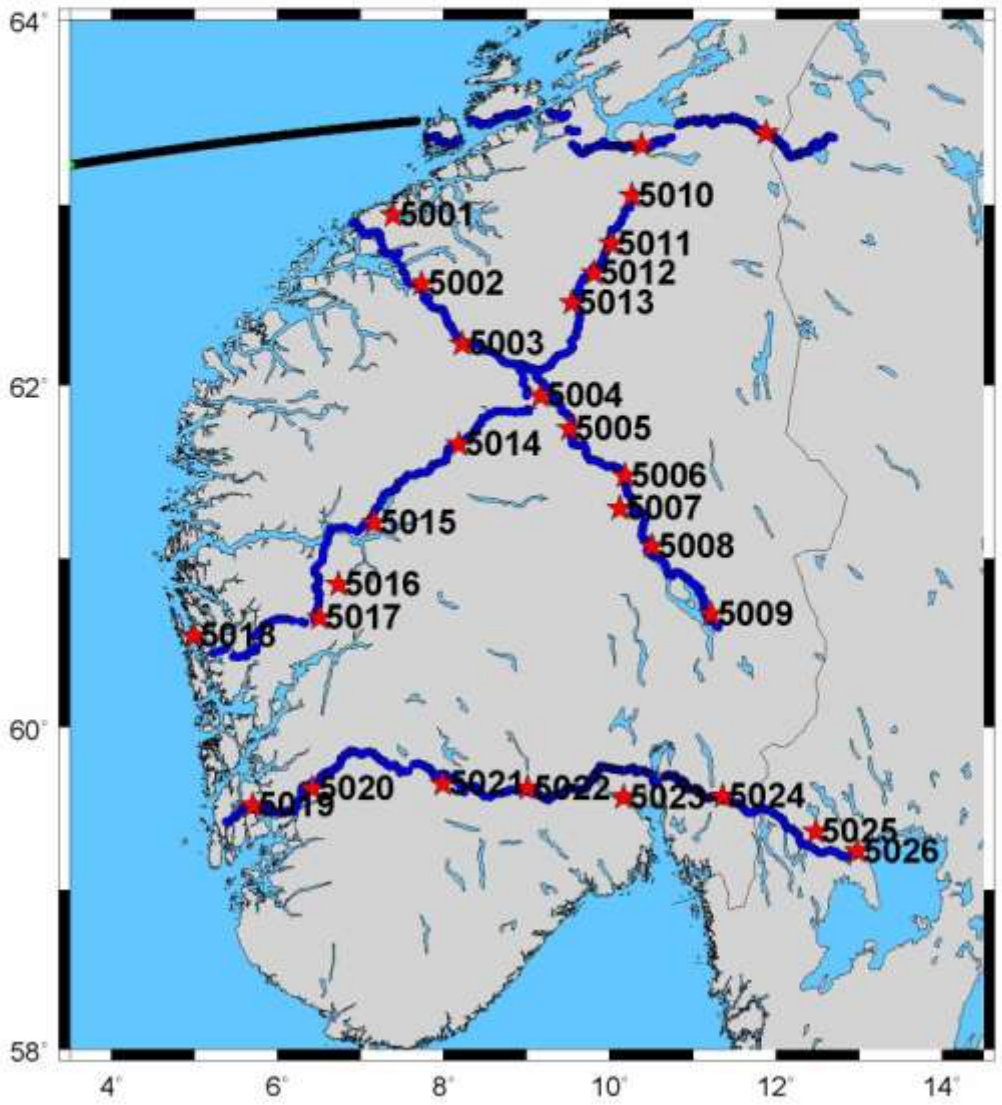
High Vp at depth.

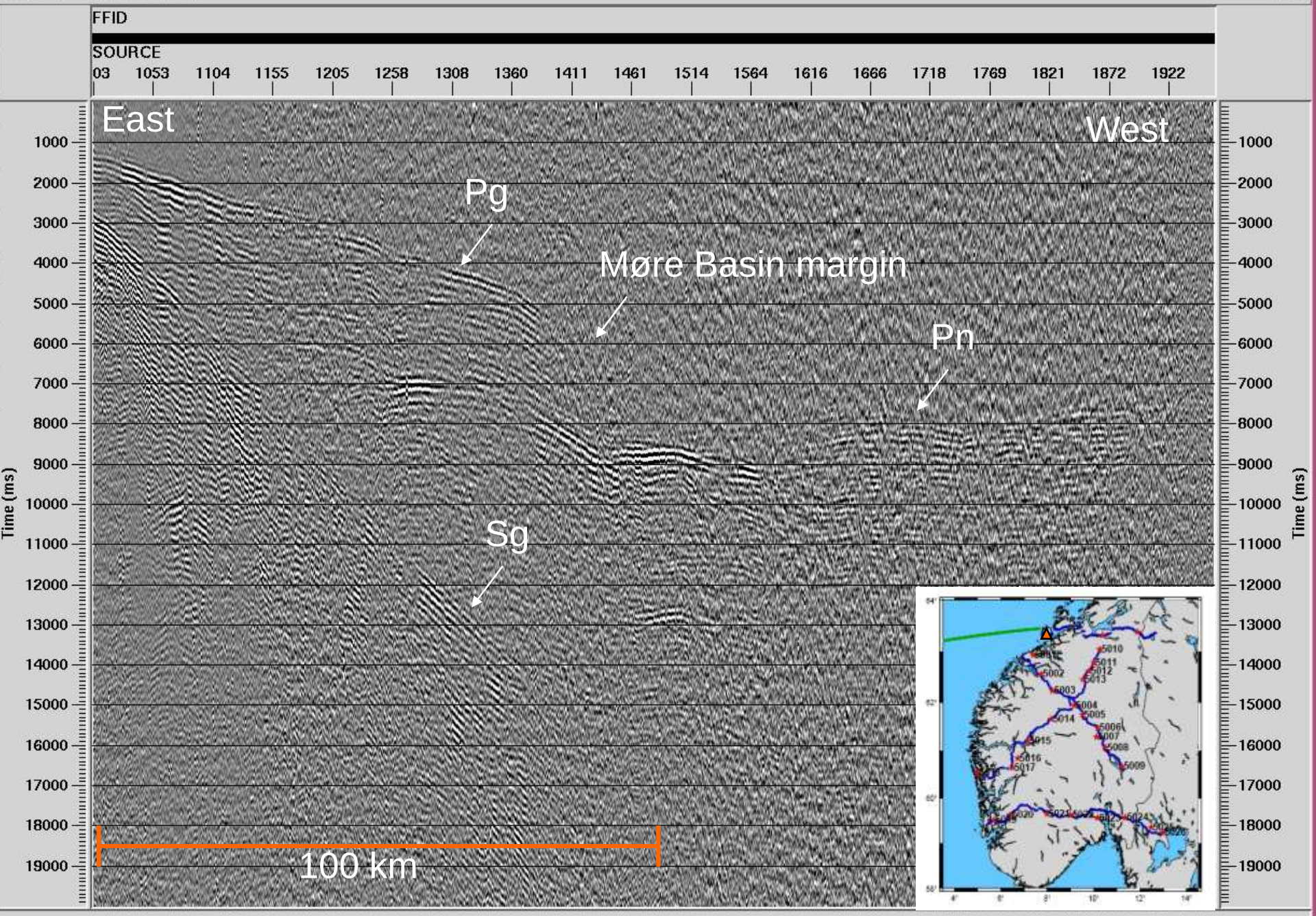



Middle and lower allochthon: granite, quartzite, greywacke, limestone
Fennoscandian shield: granite, granodiorite, mica shist
Oslo Graben: granite, diorite, gabbro, rhyolite, basalt.
Fennoscandian shield: granite, granodiorite, metagreywacke, quartzite
5001
5002
5003
5004
5005
5006
5007
5008
5009
5010
5011
5012
5013
5014
5015
5016
5017
5018
5019
5020
5025
5026
DISTANCE (km)
−50
0
50
100
150
200
250
300
350
400
450
DEPTH (km)
0
5
10
15
20
25
0.25
0.265
0.235
0.245
0.25
0.27
1
2
3
σ
Caledonides
Basement
Oslo Graben
Basement
Velocity (km/s)
0.21
0.22
0.23
0.24
0.25
0.26
0.27

Magnus-0

- Recorded in 2006. onshore/offshore refraction profile for the Trondheim area.
- 200m shot spacing onshore-offshore.
- 5 instument clusters onshore for onshore-offshore shots.
- Onshore shots ~1km receiver spacing.




FFID
SOURCE
03 1053 1104 1155 1205 1258 1308 1360 1411 1461 1514 1564 1616 1666 1718 1769 1821 1872 1922
East
West
Pg
Møre Basin margin
Pn
Sg
100 km
Time (ms)
1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000 15000 16000 17000 18000 19000

Summary

- Crustal thickness beneath the southern Scandes mountains reach ~40 km.
- Crust thickens to the north
- Thins from the central mountains towards the coast and Oslo Graben, and to the south
- Strong S-wave energy is generated by shots in the caledonides, and Poisson's ratios highlight structural/compositional changes within the caldedonides.