ACQUISITION & PROCESSING OF THE 2008 GOMA SEISMIC SURVEY (L190)

Geoscience Australia
Onshore Energy and Minerals Division
Seismic Acquisition & Processing Project

Australian Government
Geoscience Australia

AuScope

Government of South Australia
Primary Industries and Resources SA

Northern Territory Government

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Australian Government

Geoscience Australia

Acknowledgements

Acquisition: Jenny Maher, Ross Hill, Geoff Price, Aki Nakamura, Erdinc Saygin, Frank Brassil, Paul Levier

Processing: Josef Holzschuh, Ross Costelloe, Leonie Jones, Tanya Fomin

Seismic Acquisition & Processing Project

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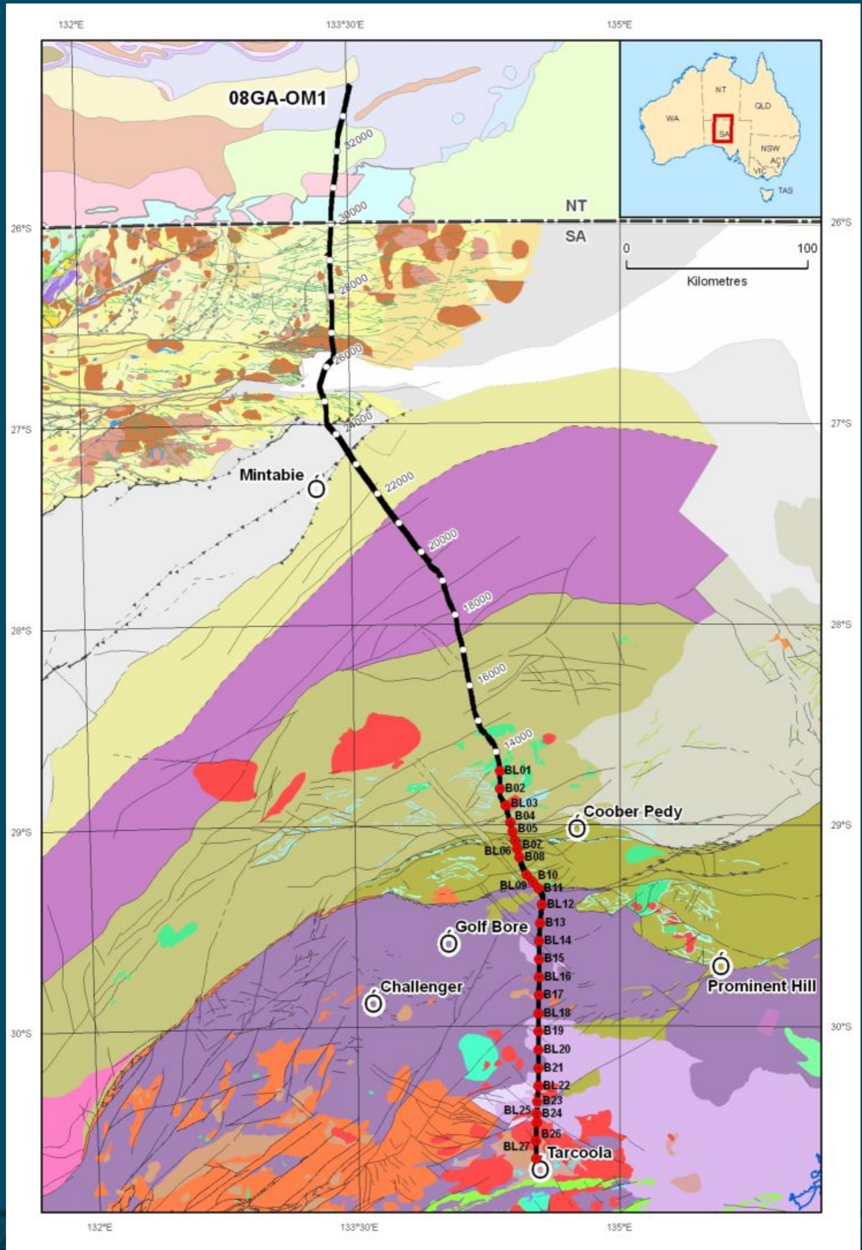
Line 08GA-OM1



Acquired between 3 November and 13 December 2008

634.4 km Seismic Reflection & Gravity Data @ 400 m spacing

250 km Magnetotelluric Data @ 10 km spacing

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Seismic data acquisition

Terrex Seismic was contracted to acquire the seismic data

Between 30 and 40 on crew at any time

Dynamic Satellite Surveys (DSS) was subcontracted by Terrex to survey and peg the line and to acquire the gravity data

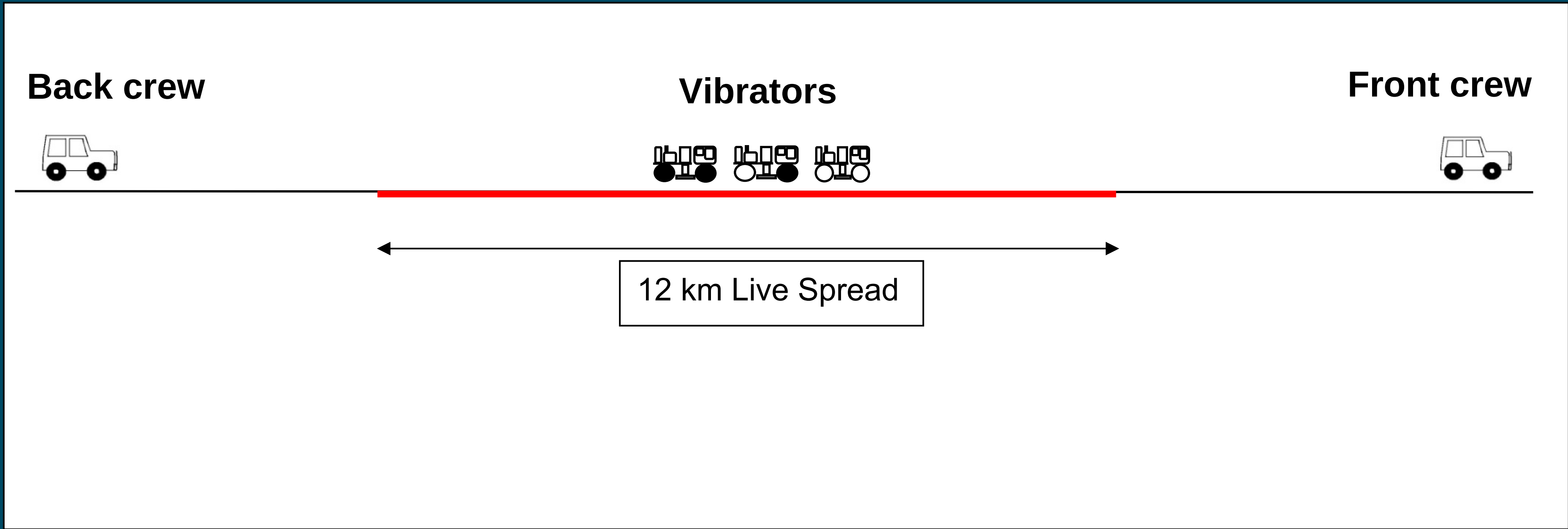
Vibrators at start of GOMA line

Seismic data acquisition parameters

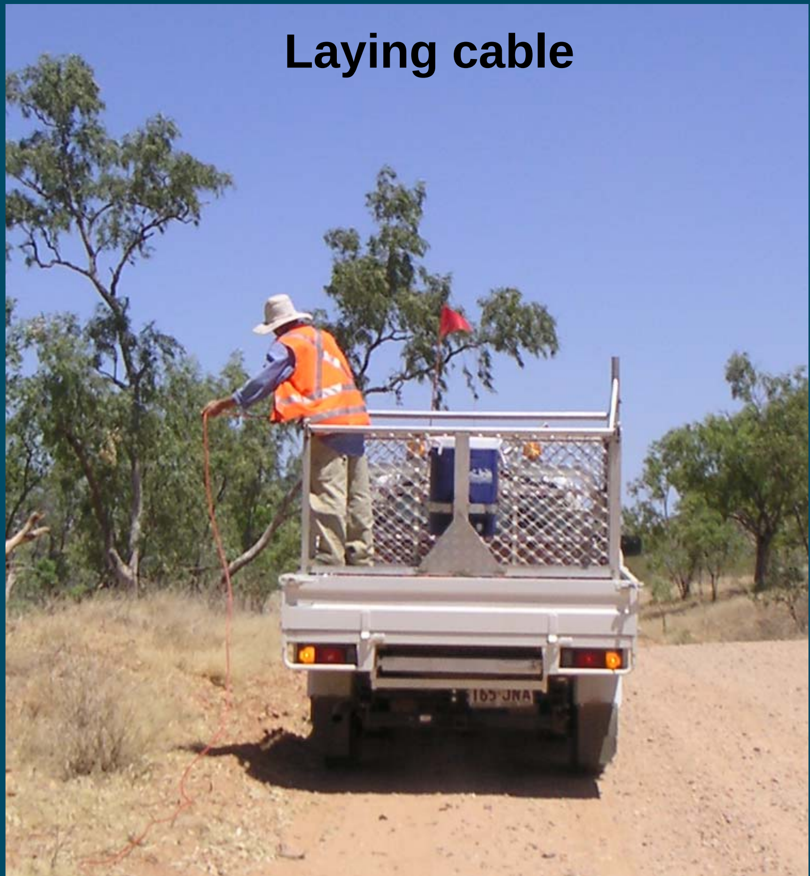
Split spread with maximum 6 km offset

300 channels at 40 m intervals

80 m VP interval



Front Crew



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Back Crew

Picking up geophones

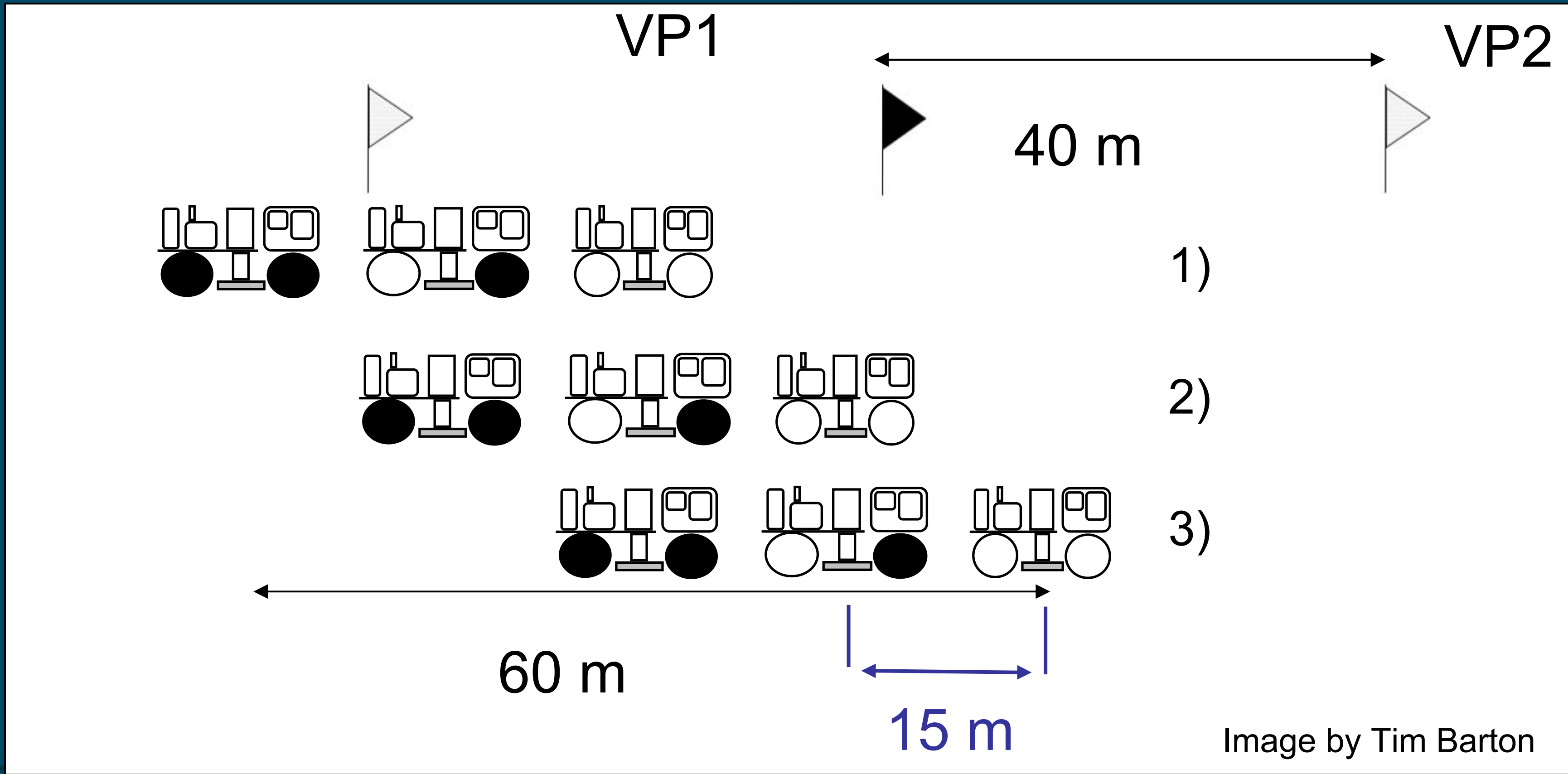
Pulling in cable

Seismic data acquisition parameters

Source Array: 60 m centred between pegs

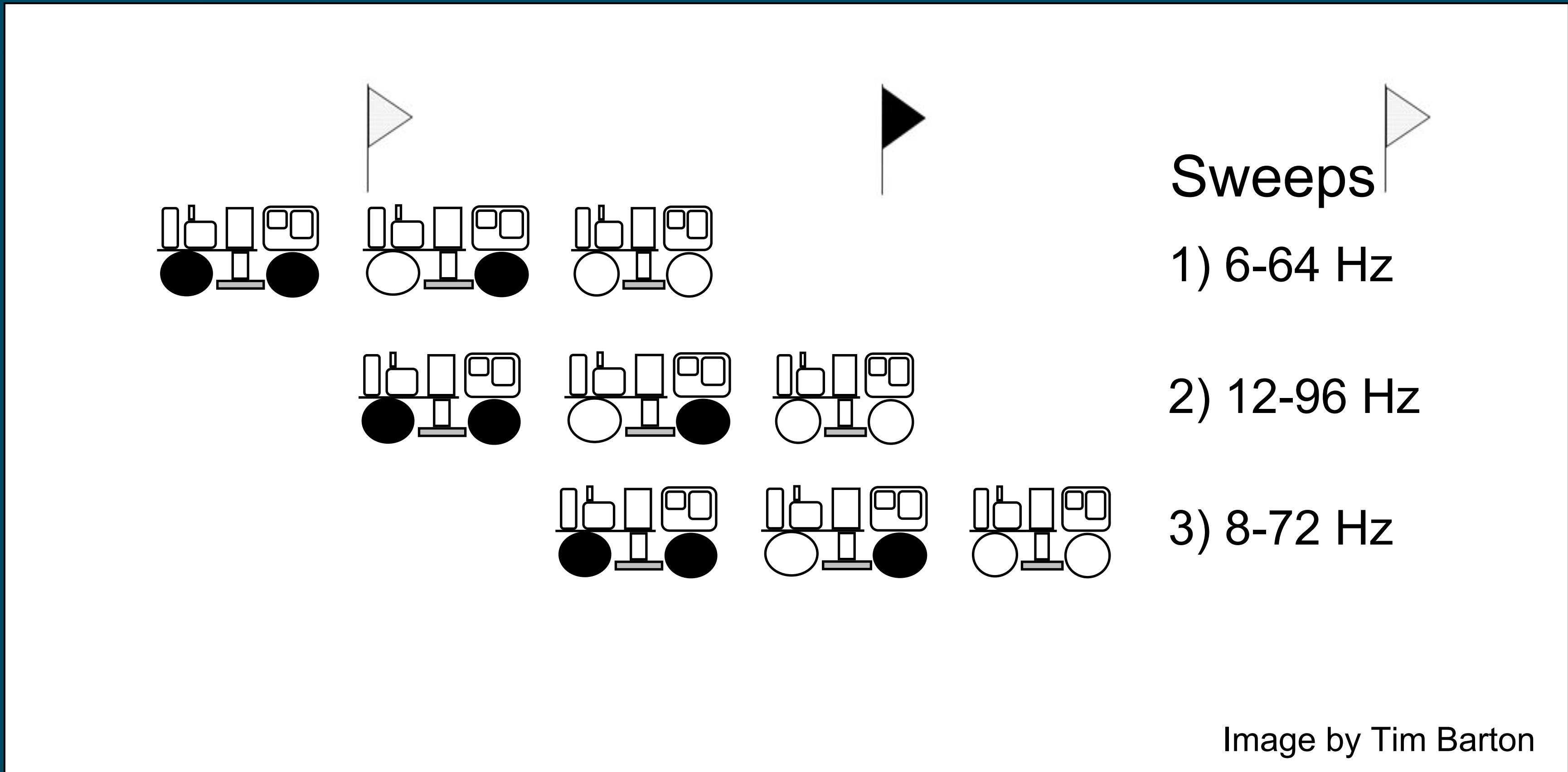
Vibe Config: 15 m pad/pad 15 m move up

Vibe Point (VP) Interval: 80 m



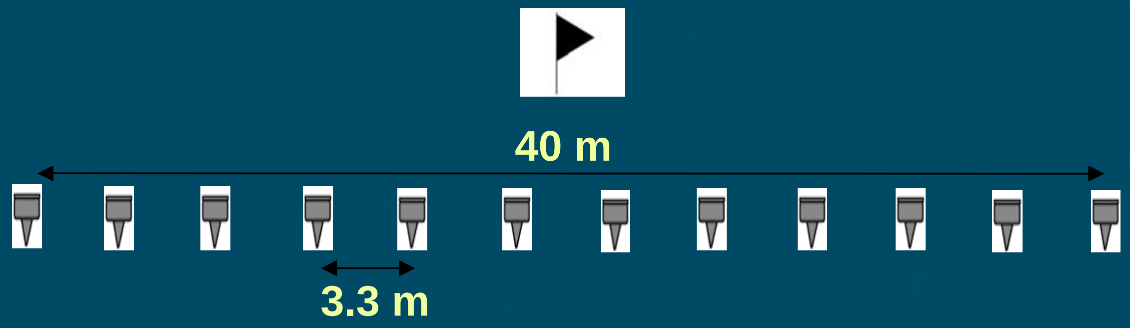
Seismic data acquisition parameters

3 x 12 seconds variable frequency linear sweeps



Seismic data acquisition parameters

Receiver array: 12 geophones over 40 m centred on peg



Receiver elements: Vertical component geophones

Seismic data acquisition parameters

Recording system
  Sercel SN388

Data - SEG-D
  demultiplexed

3490E tapes

Avg. production

3 tapes/day

185 VPs/day

14.76 km/day

Acquisition Issues

1 or 2 trains/day

15 to 30 minutes Standby

Acquisition Issues

Rain !

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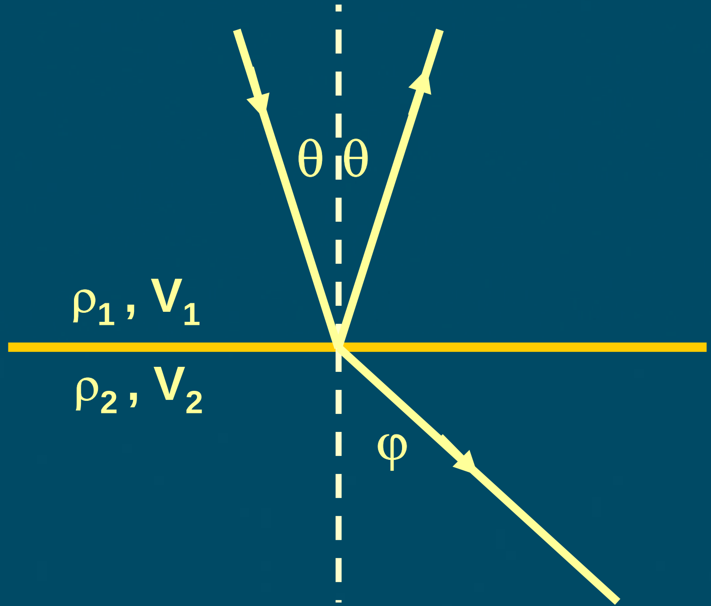
Some Seismic Reflection Basics

Behaviour of Seismic Waves at an Interface

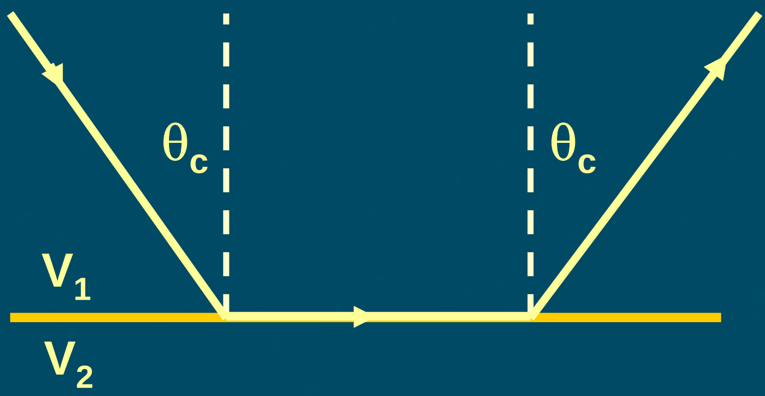
Seismic reflection image

Reflection



Weathering correction (statics)

Critical Refraction



$\sin \theta_c = V_1/V_2$ for $V_2 > V_1$

Snell's Law $\sin \theta / \sin \varphi = V_1/V_2$

Reflection Coefficient governs amplitude of reflected waves

$$RC = \frac{\rho_2 V_2 - \rho_1 V_1}{\rho_2 V_2 + \rho_1 V_1}$$

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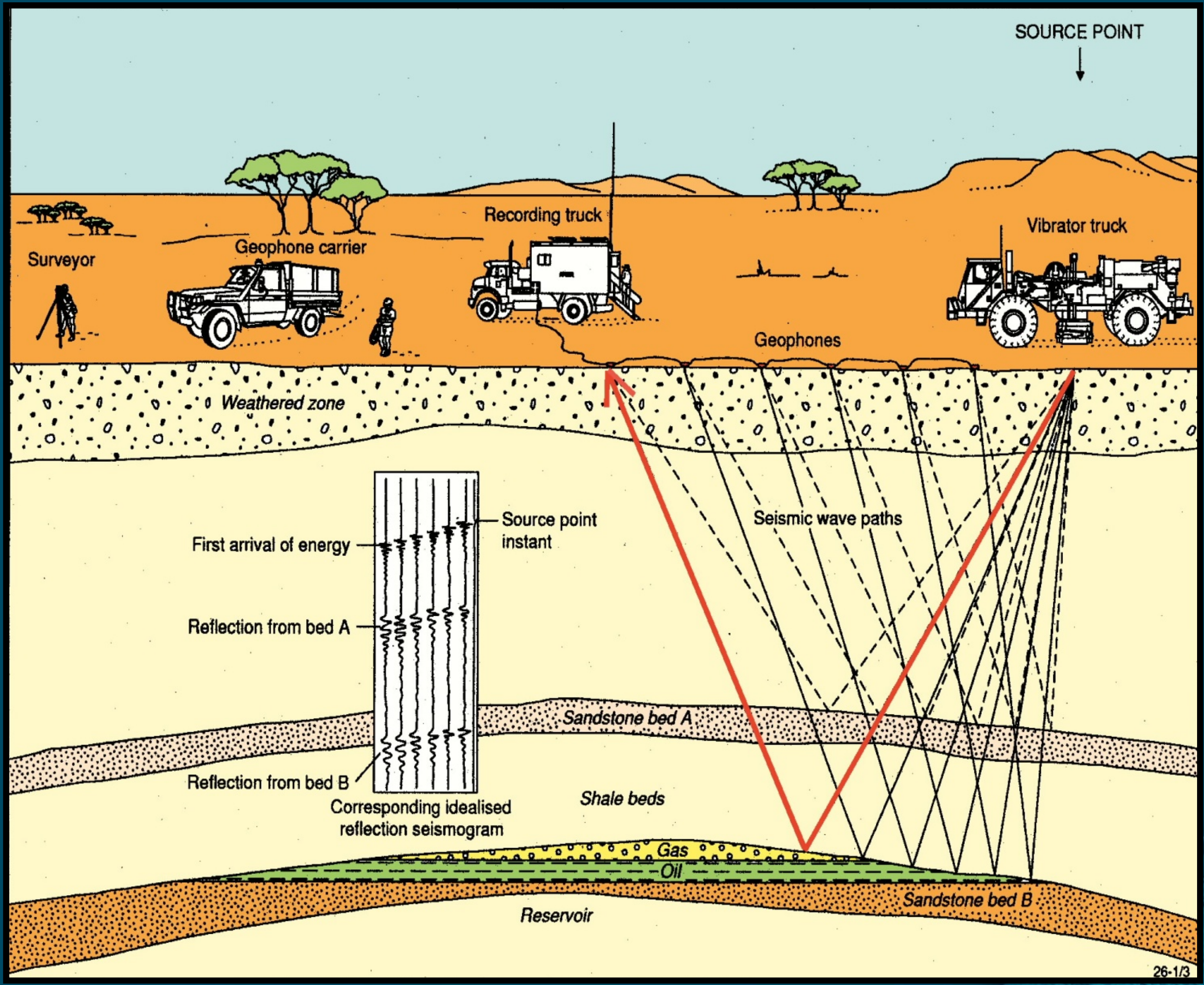
Seismic Reflection Method



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Seismic Processing

Overall goal

To produce an image of the sub-surface

by

Enhancing and correctly positioning reflections

and

Reducing undesired energy (noise)

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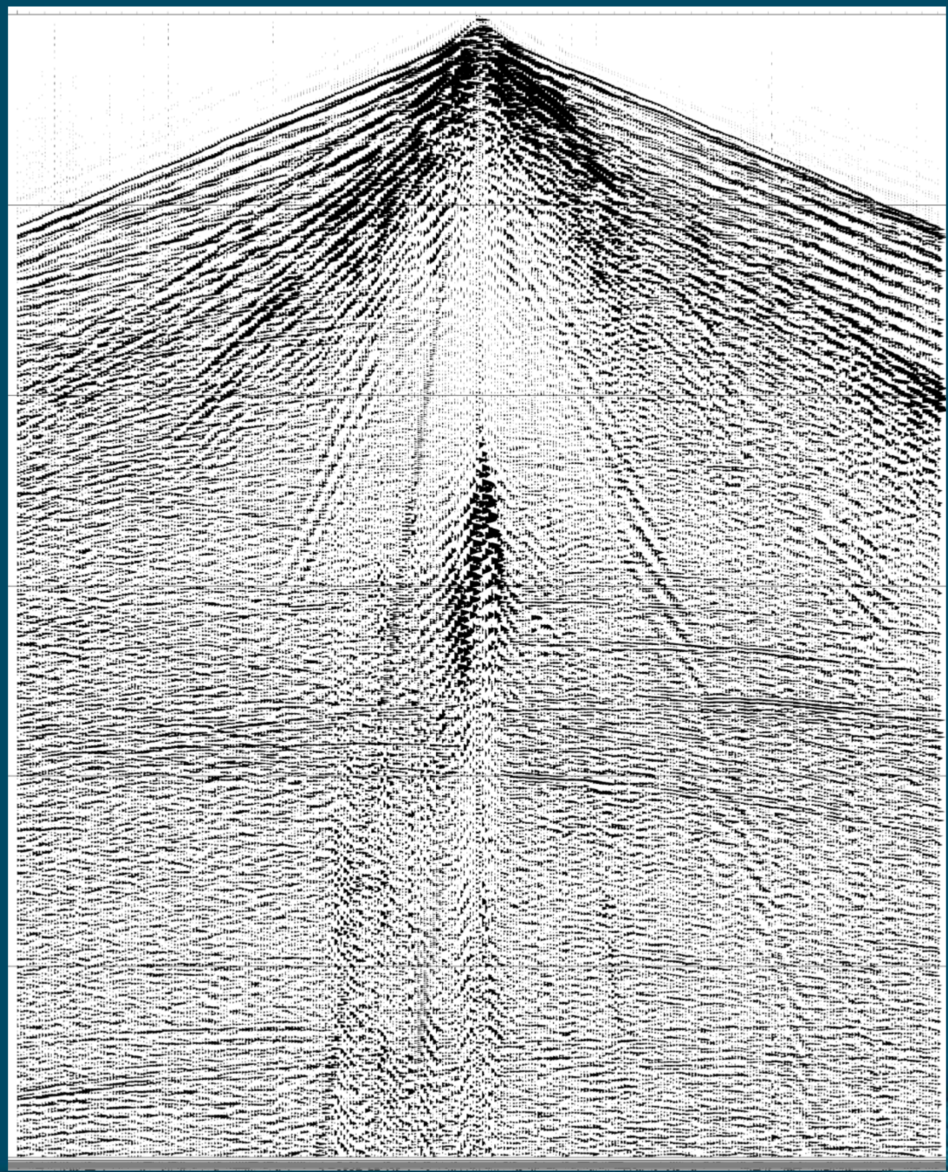
Shot Record



0
1
2
3
4
5
6

Time (Seconds)

Offset (metres) 6000 0 6000

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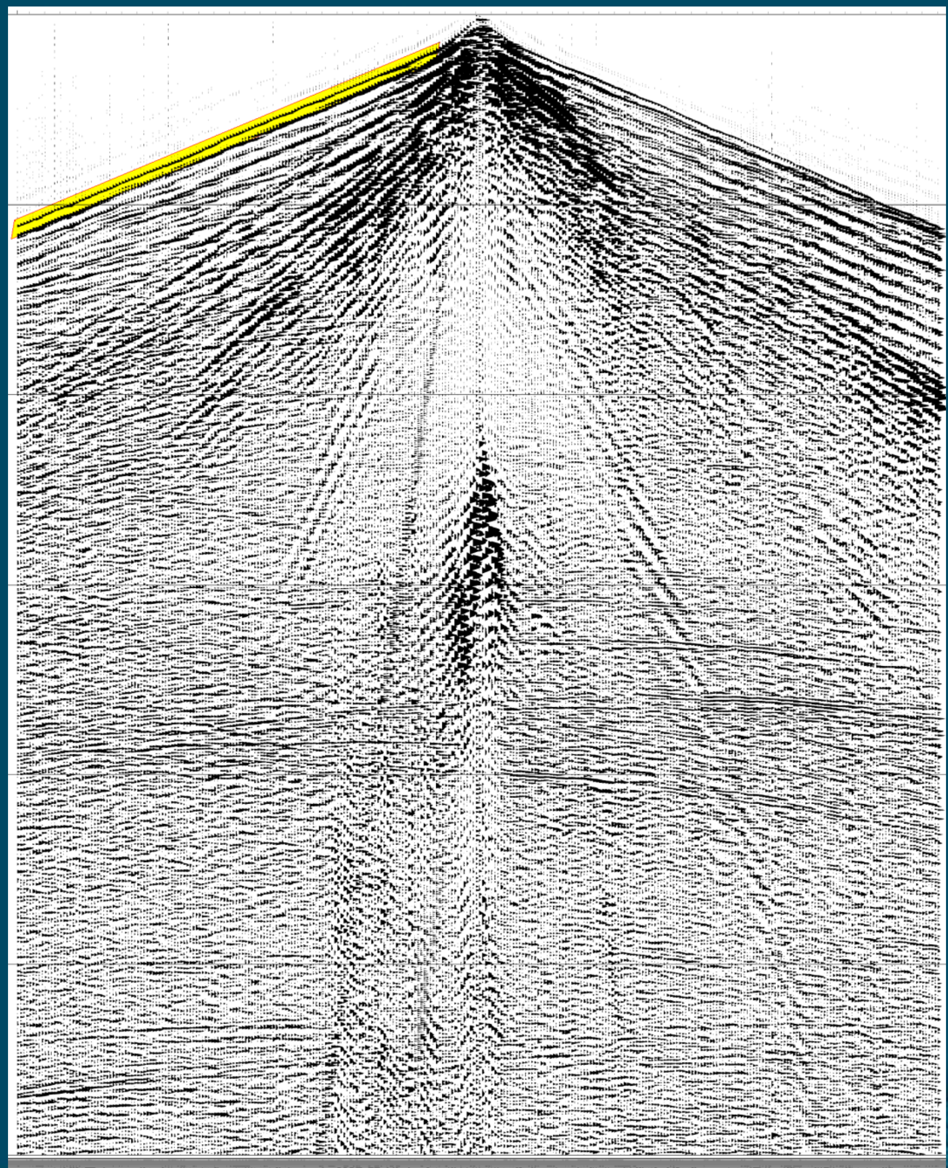
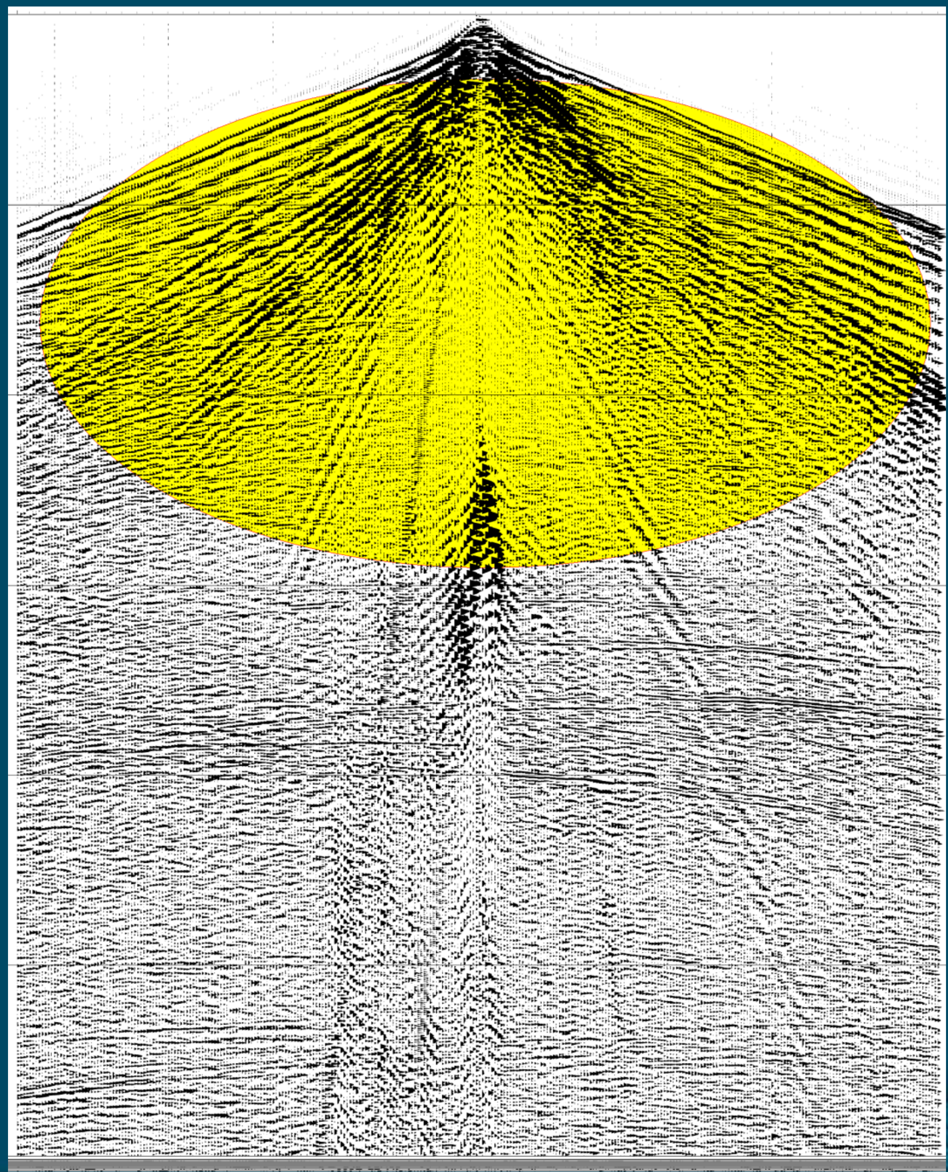
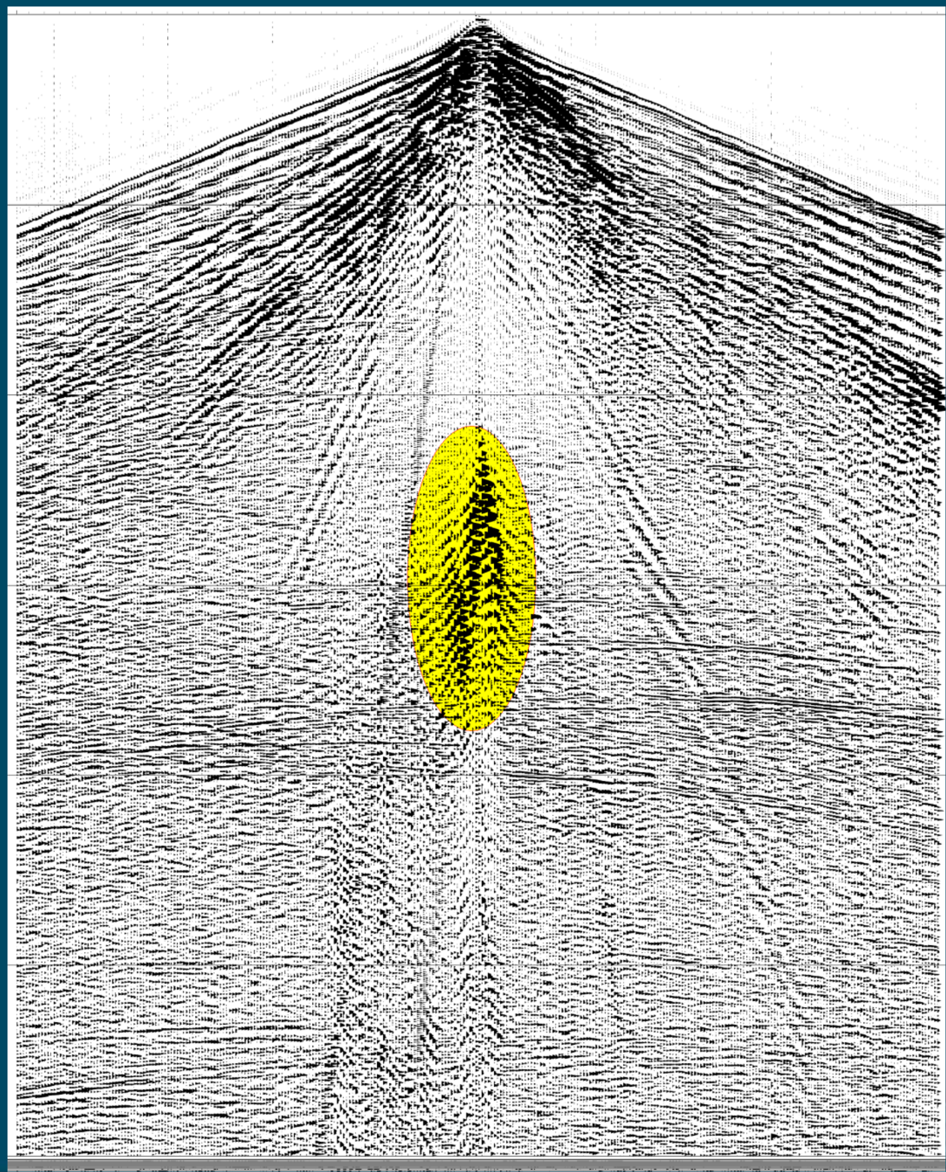
Shot Record


Refraction
First arrival
0
1
2
3
4
5
6
Time
(Seconds)
Offset (metres)
6000
0
6000

Shot Record

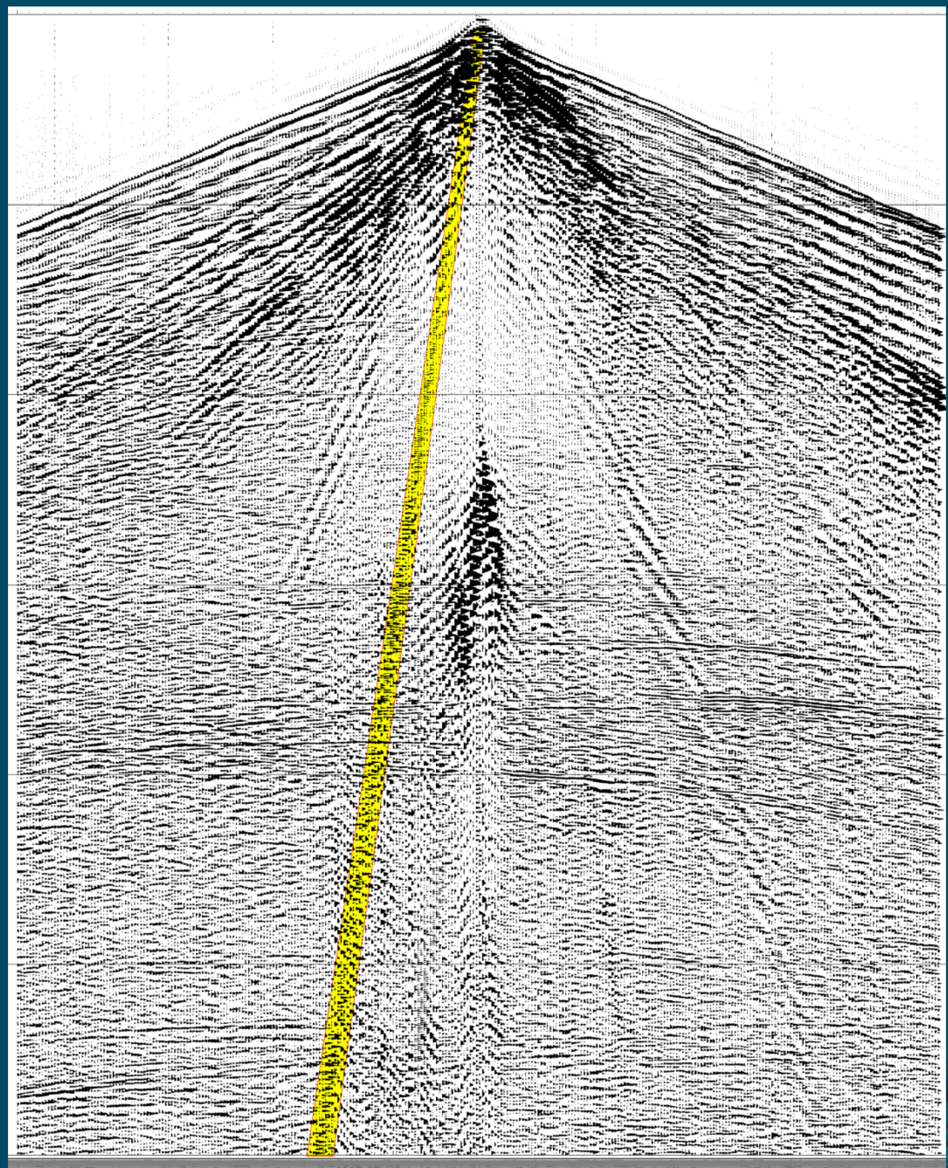


Shot Record

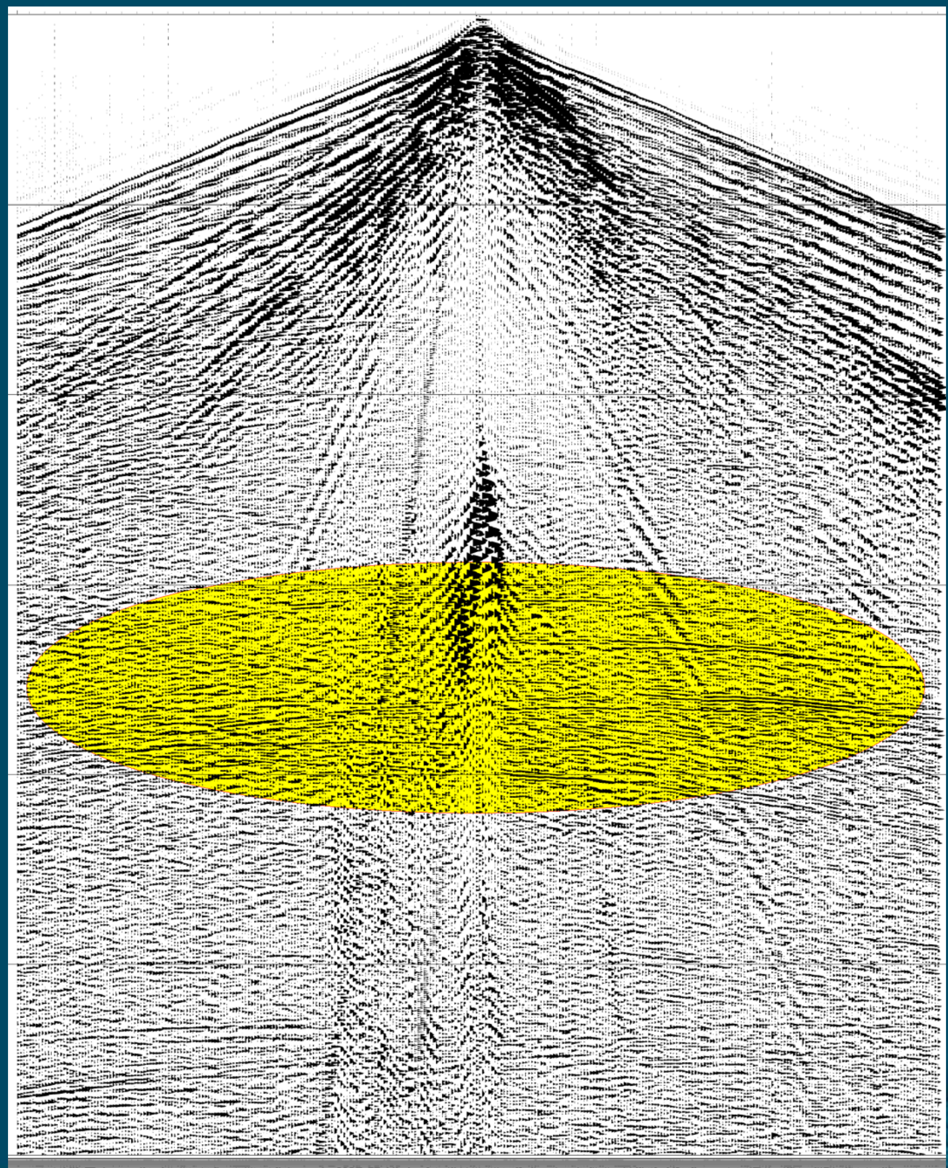


Near trace distortion

Shot Record

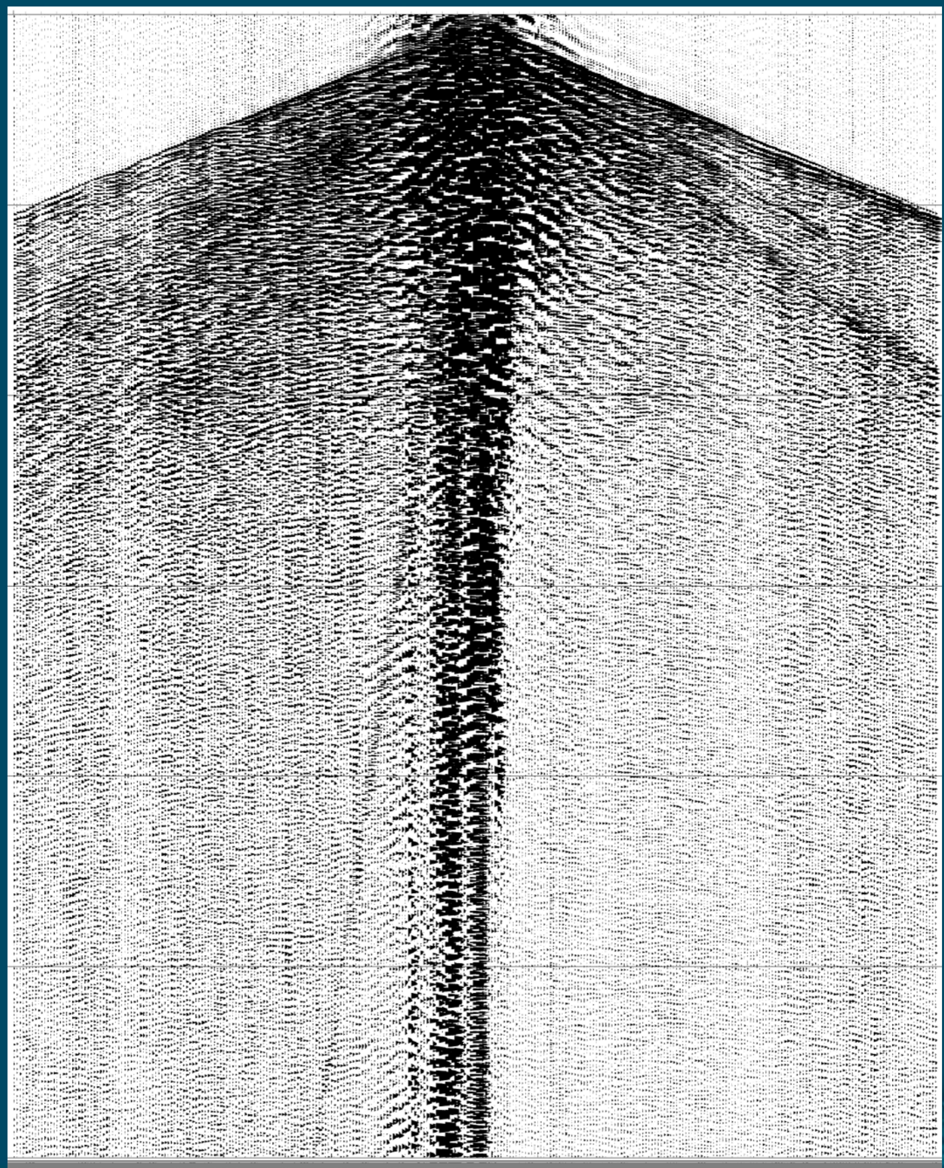


Shot Record


0
1
2
3
4
5
6
Time (Seconds)
Reflections
Offset (metres)
6000
0
6000

Shot Record with SPEQ

Shot Record - non sedimentary basin



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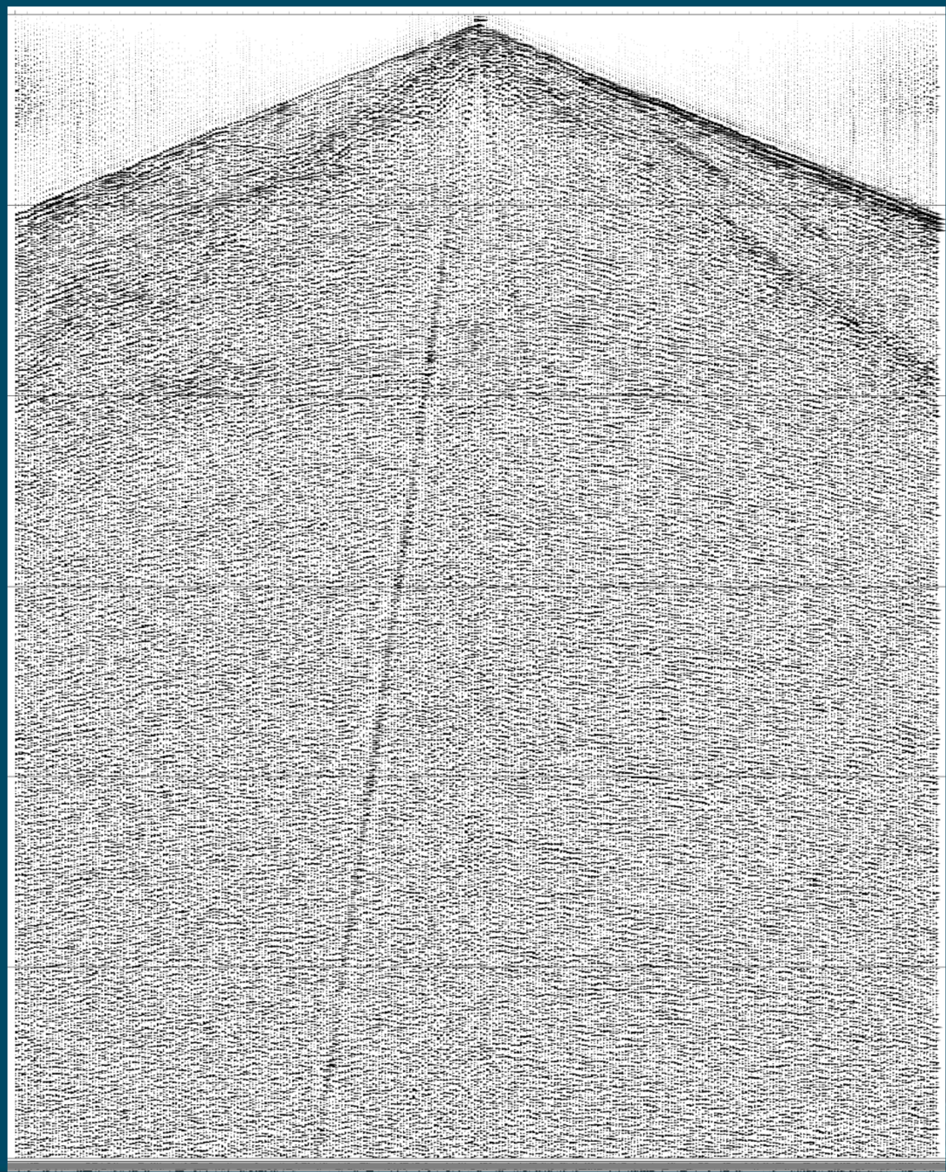
Shot Record SPEQ - non sedimentary basin



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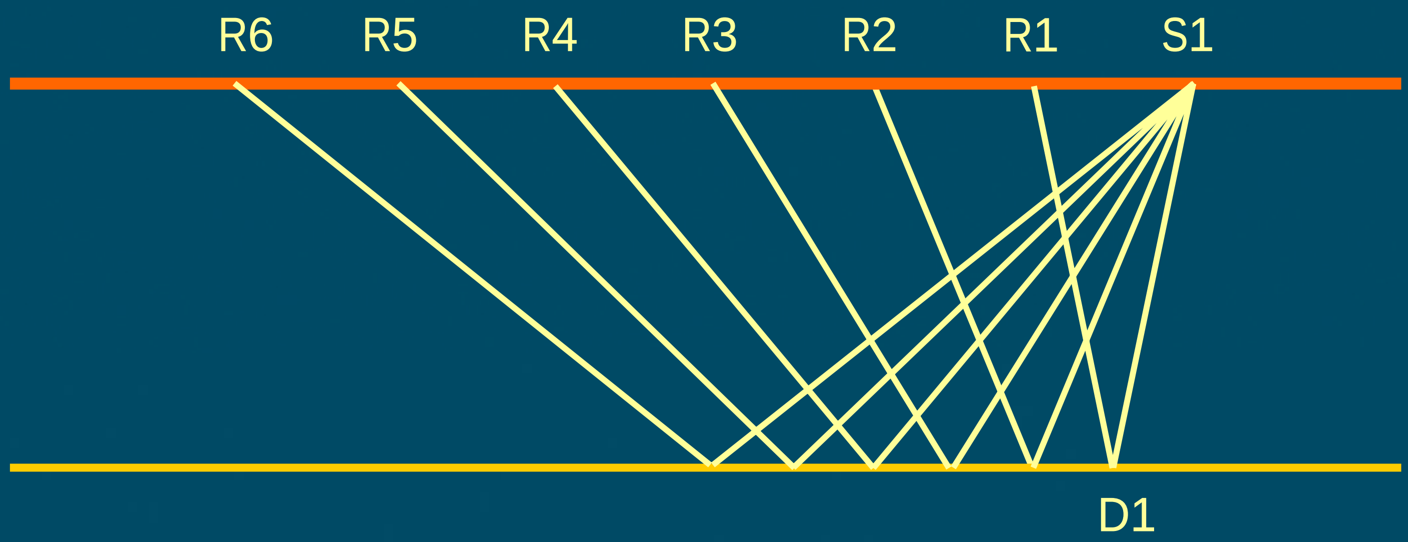
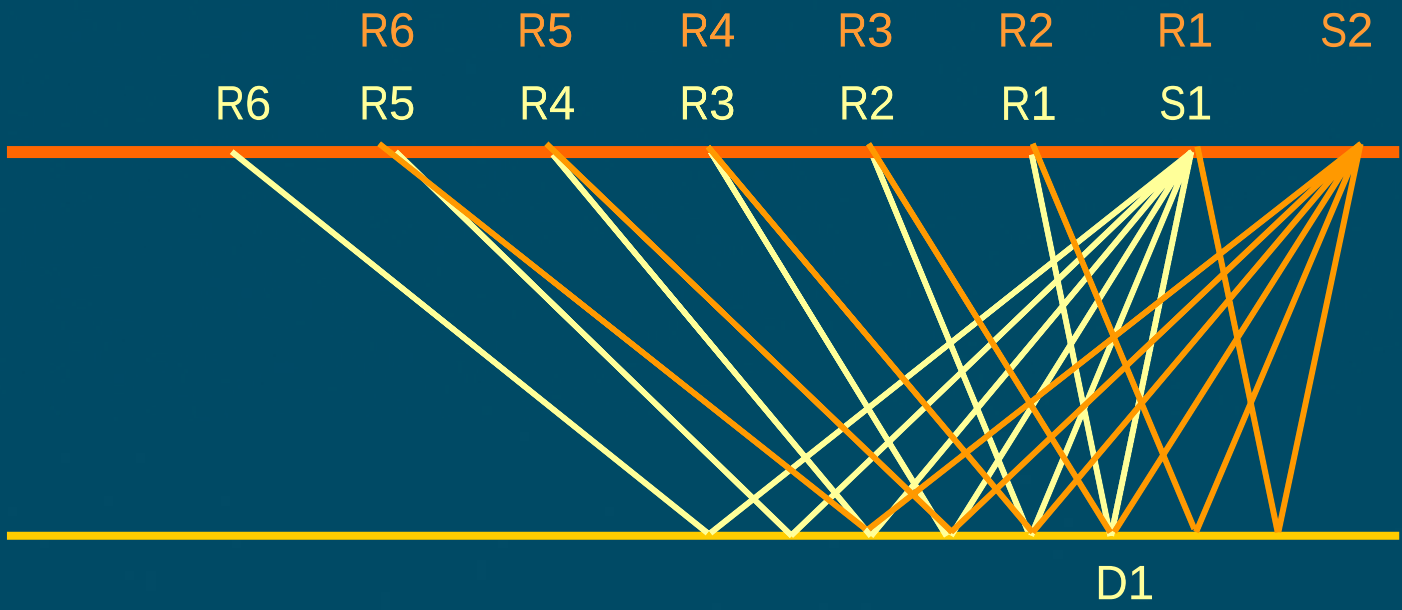
CDP (Common Depth Point) Method



- Reflecting points on the reflector are separated by half the receiver spacing.
- This example has 6 channels (receivers)

CDP (Common Depth Point) Method



- Depth point D1 is sampled by R1 for Shot 1, R3 for Shot 2 and R5 for shot 3 (not shown).
- Fold is the number of times a depth point is sampled.
- In this example, the fold is 3

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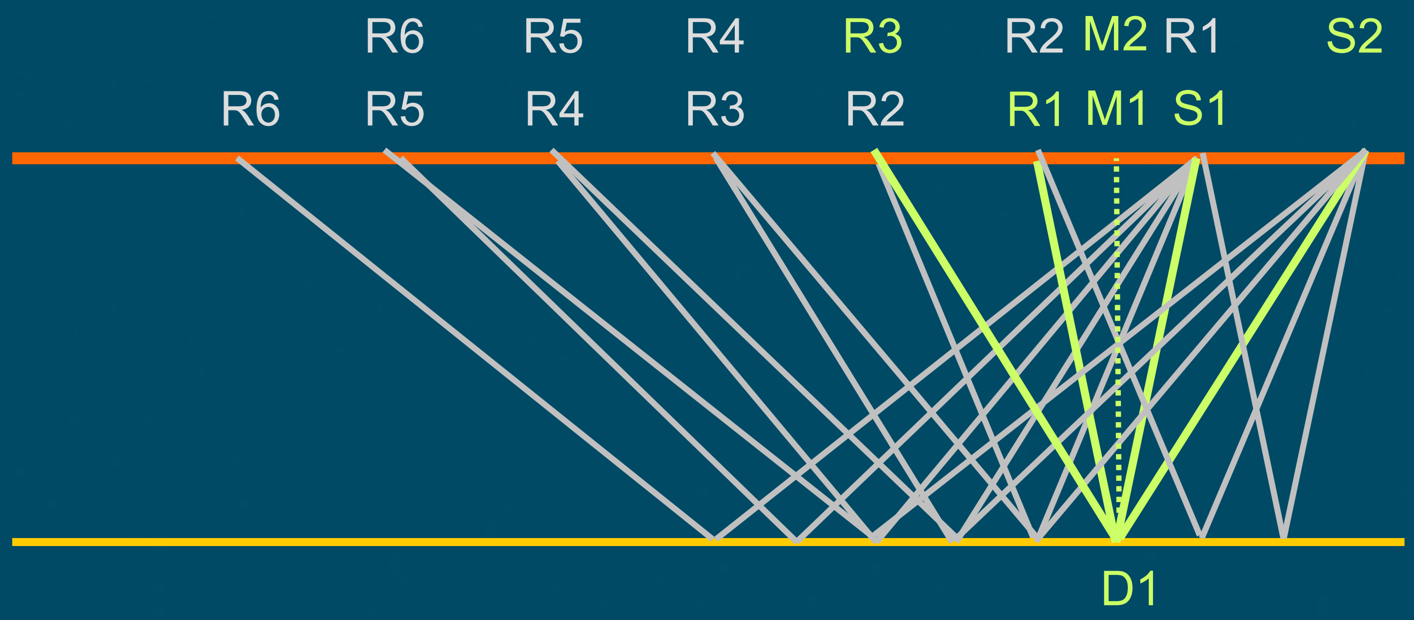
CDP (Common Depth Point) Sorting



- Group source-receiver pairs with common midpoints

Processing Sequence

Setup Geometry

↓

Statics Correction

↓

NMO Velocity Analysis

↓

Auto-statics Correction

↓

DMO

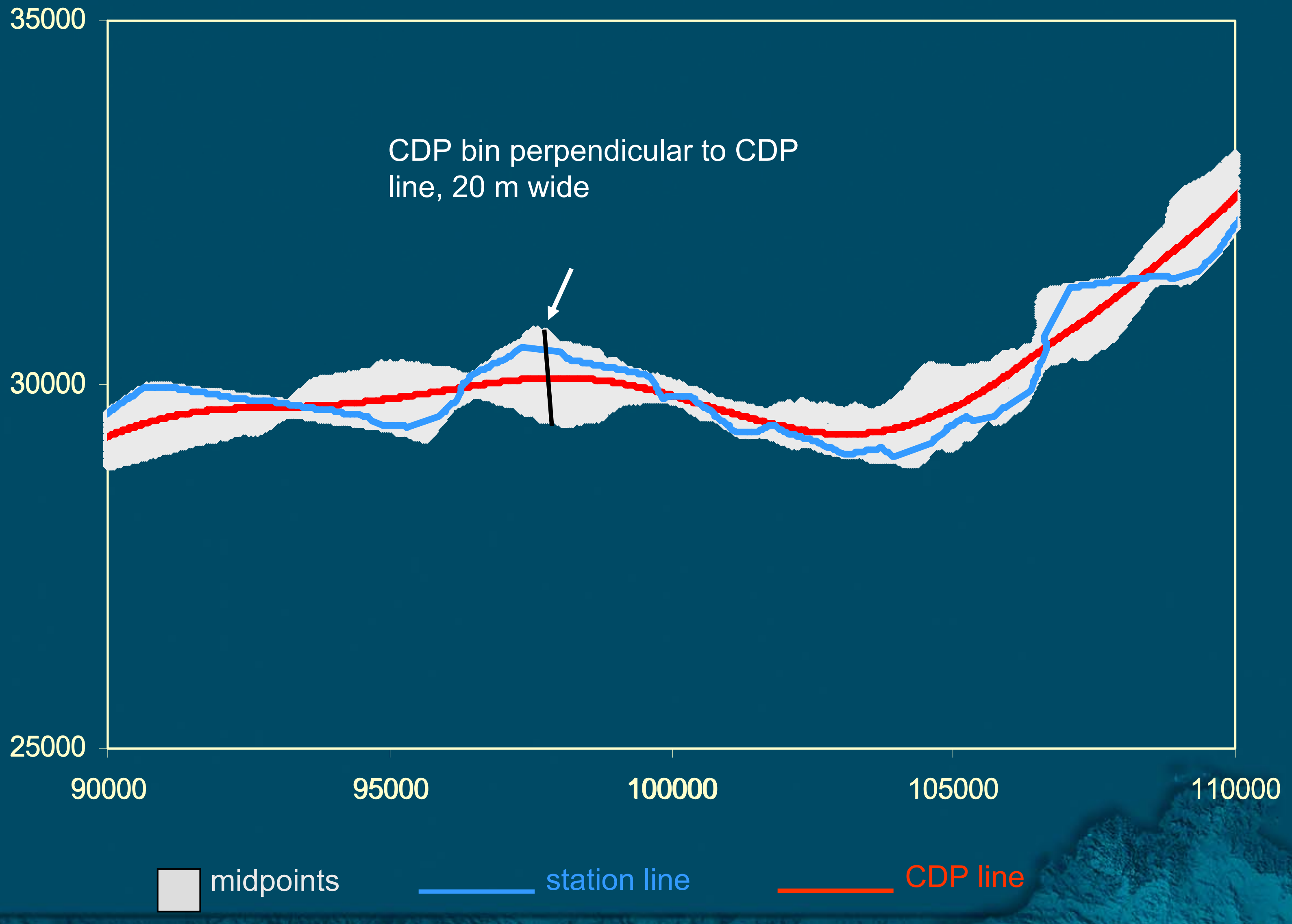
↓

Stack

↓

Migration

Crooked Line Geometry



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Refraction Statics Calculation

Corrects for variable travel time in the regolith, using a model of regolith thickness, determined from first arrivals (refractions) on shot records

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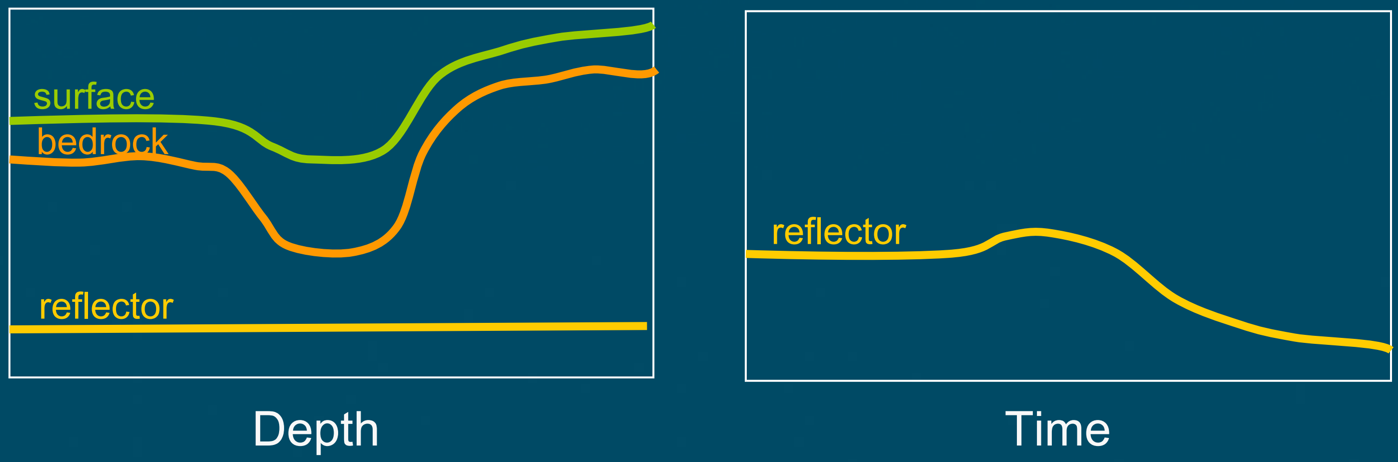
Why are Statics needed?

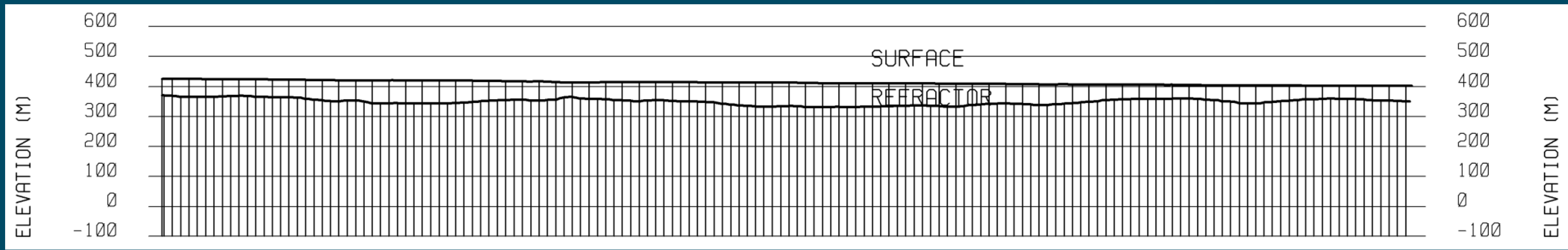
- Long (spatial) wavelength variations in two way travel time (TWT) create spurious structure on seismic sections



- Short (spatial) wavelength variations in TWT degrade the stack response (destructive interference of reflections)

Refractor Model Solution

- Displayed on top of seismic section plots



- Indicative of regolith thickness, but not exact, due to difficulty of accurate determination of V_w, with regional receiver spacing of 40 m
- Datum 500m AHD

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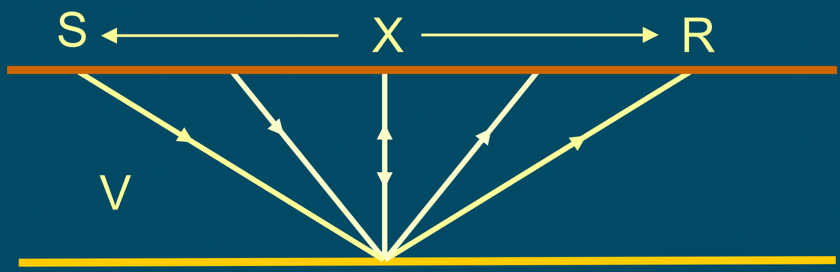
Refractor Model Solution

- First breaks picked from all **7952** shots
- Offset ranges picked where changes in regolith occur
- Noisy traces and poor first break traces omitted

- Interactive and **time consuming**
- Required several iterations to produce appropriate refractor model

Normal Moveout (NMO) Correction

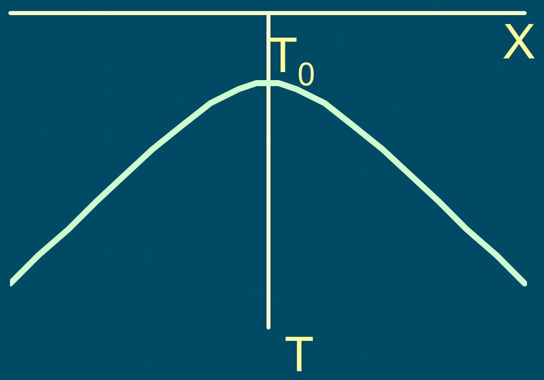
Horizontal reflector



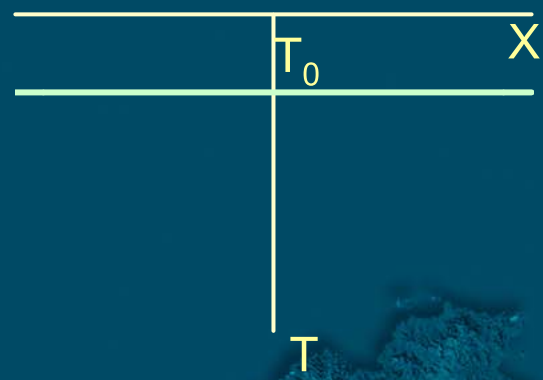
Moveout relationship

$$T^2 = T_0^2 + X^2 / V^2$$

Uncorrected CDP gather

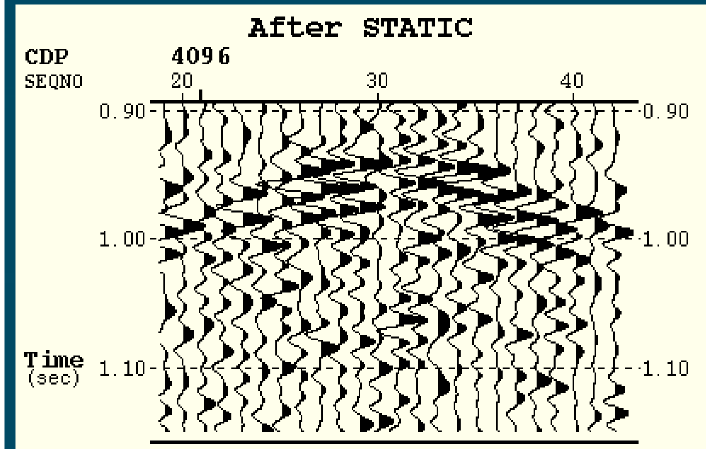


Corrected CDP gather

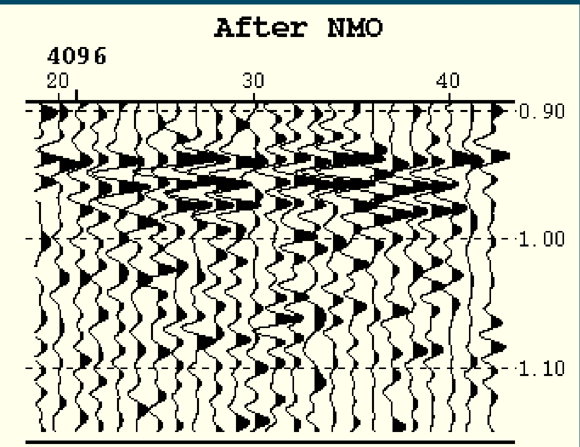


Normal Moveout Correction and Stack

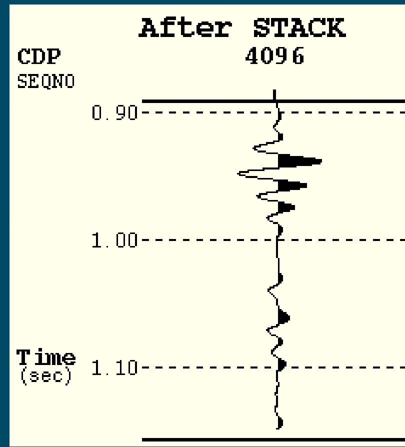
Uncorrected CMP gather



Corrected CMP gather



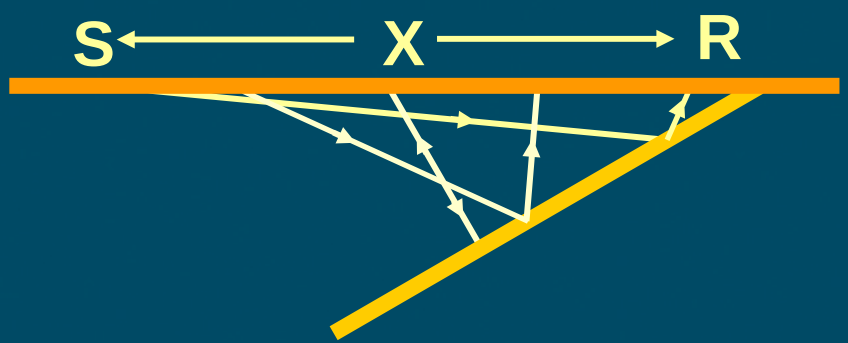
Stacked seismic trace

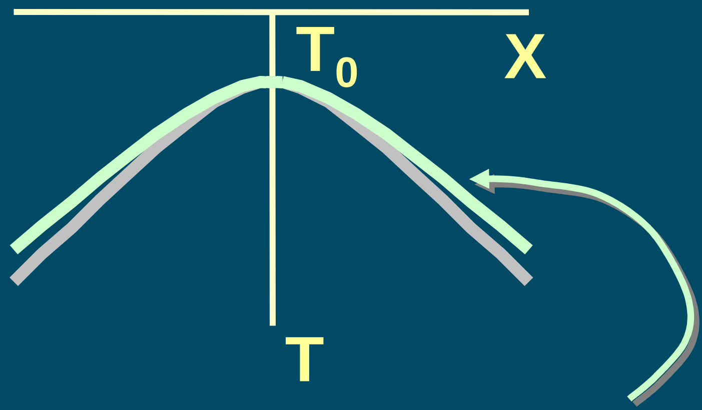


Stacking improves signal to noise by $\sqrt{n}$, where n is the fold

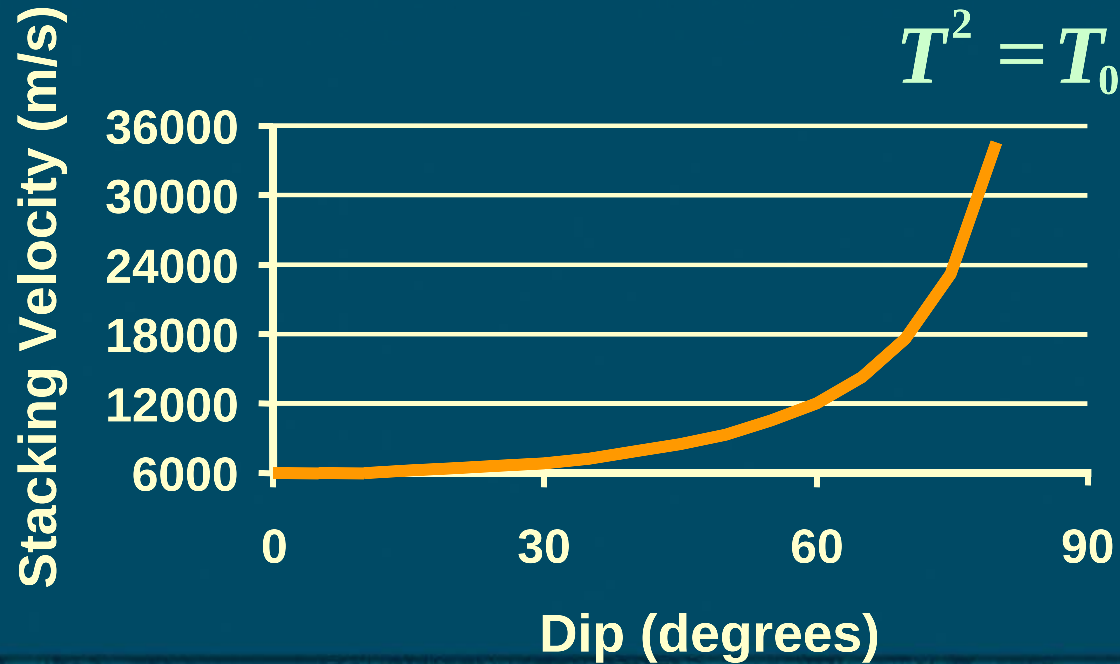
n	10	75	120
$\sqrt{n}$	3	8.7	11

Effect of Dip on Stacking Velocity





$$T^2 = T_0^2 + X^2 \cos^2 \alpha / V^2$$



Need Dip Moveout Correction (DMO)

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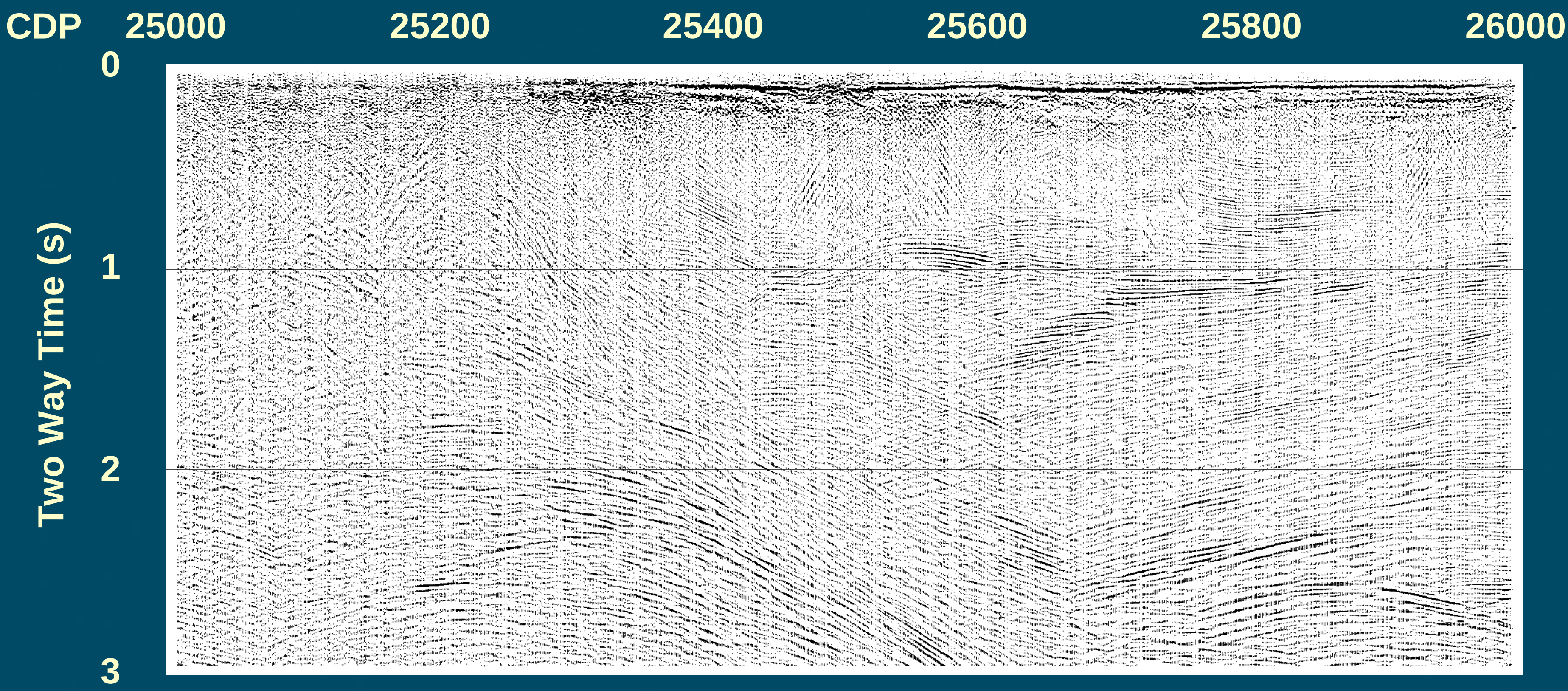
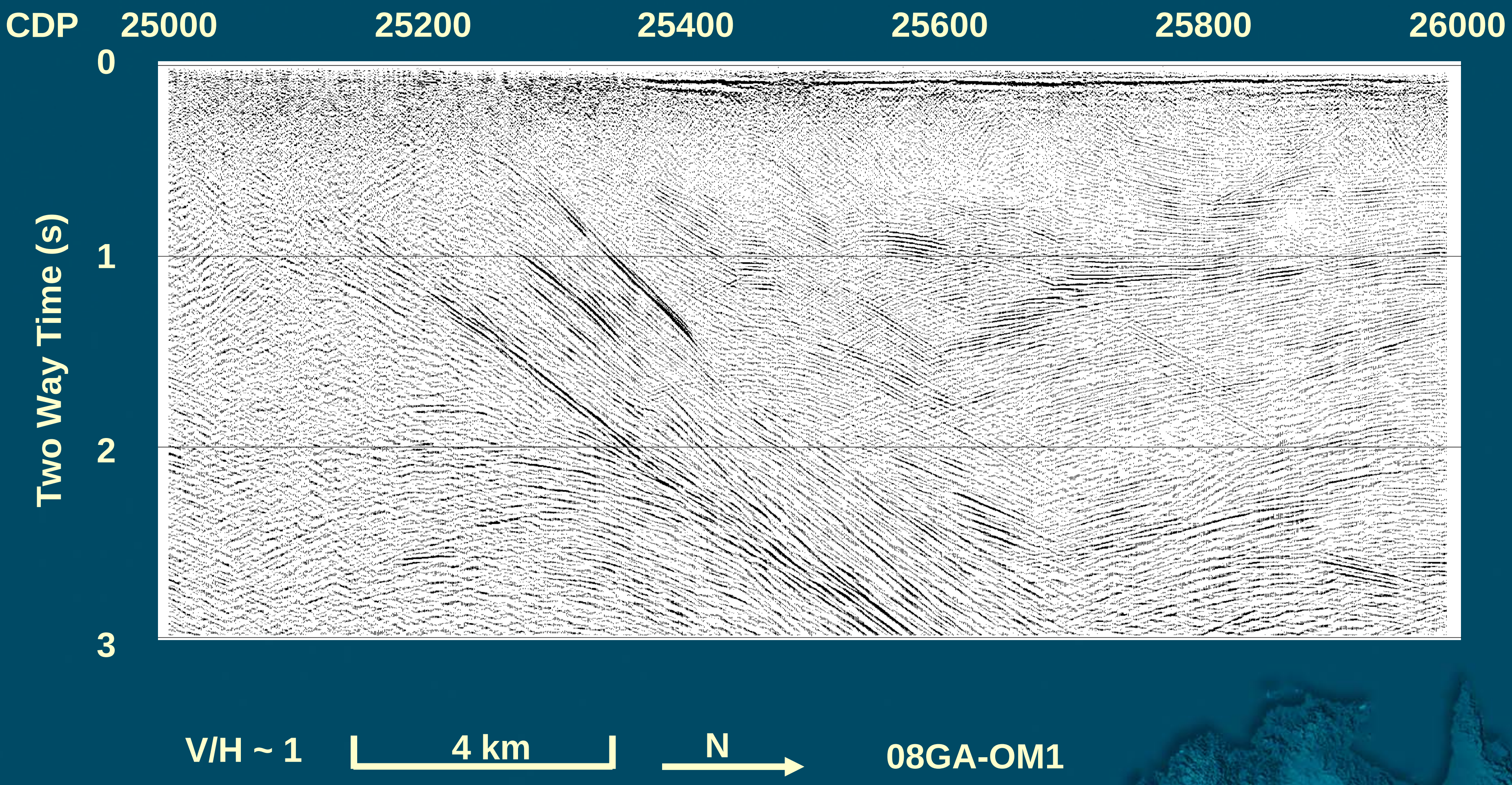
Stack without DMO



V/H ~ 1 | 4 km | N → | 08GA-OM1

Stack with DMO



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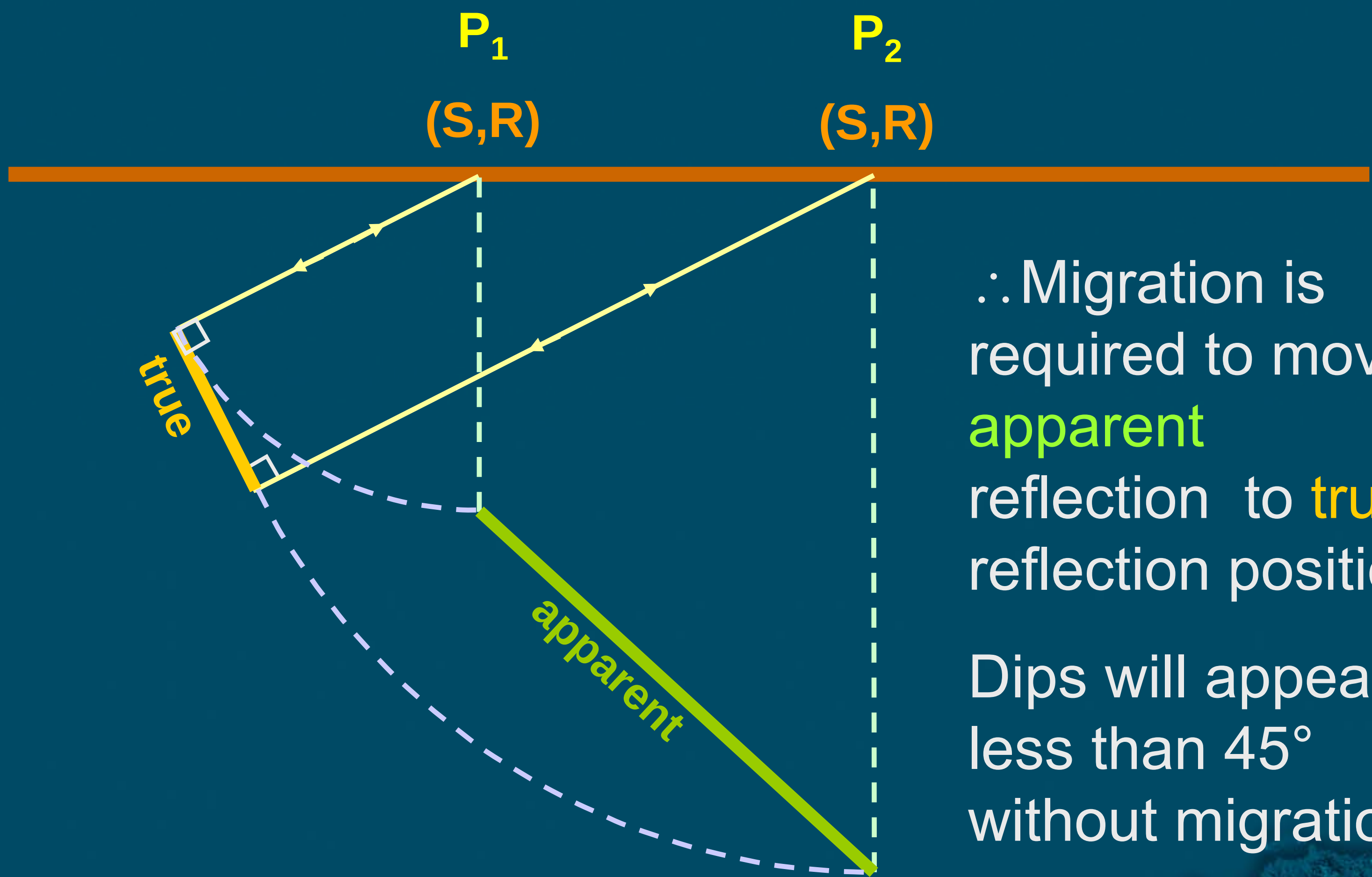
Migration of Dipping Reflection



∴ Migration is required to move apparent reflection to true reflection position

Dips will appear less than 45° without migration

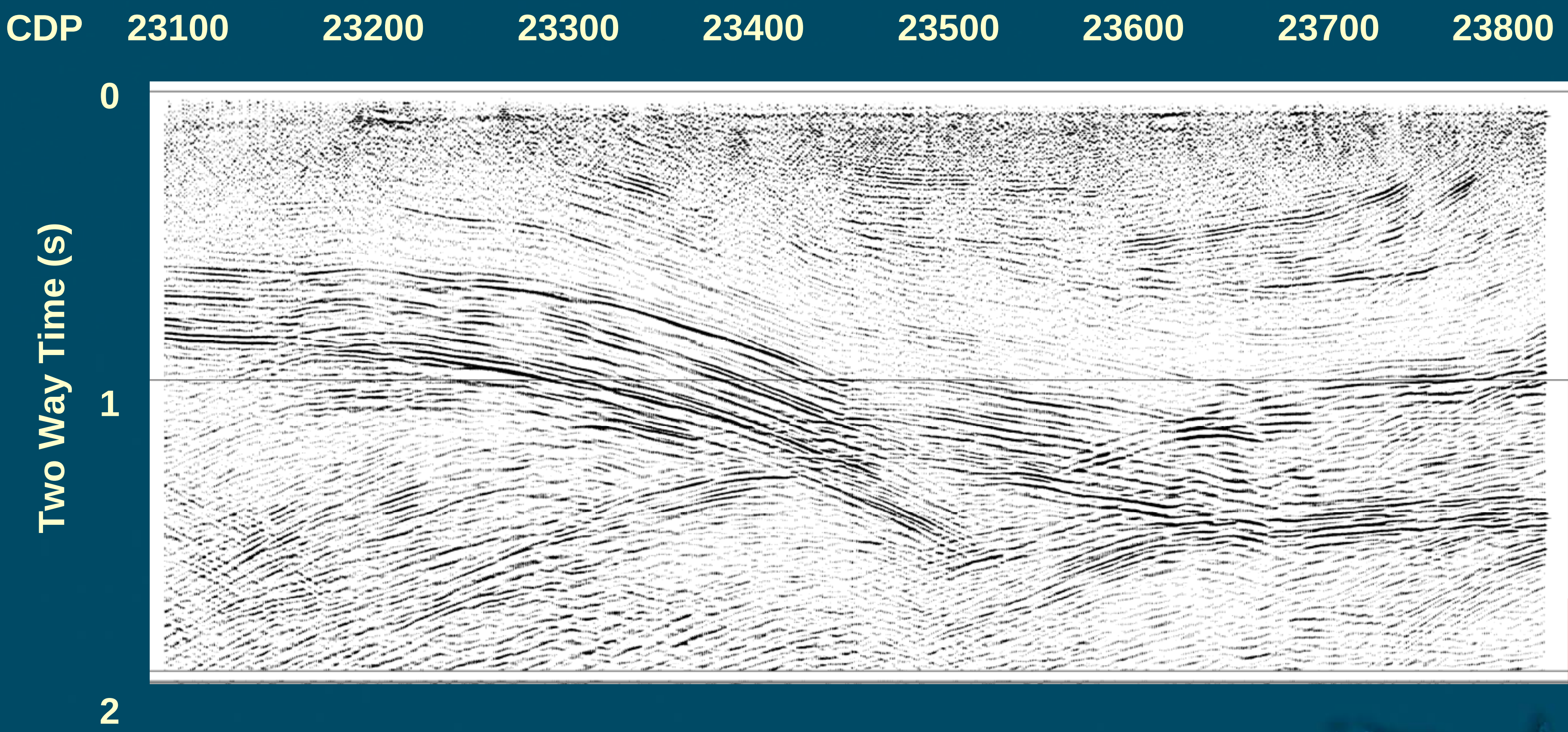
Results of Migration

Migration improves a seismic image by

- Moving reflections to their correct positions
- Steepening the dip of dipping reflections
- Collapsing diffractions

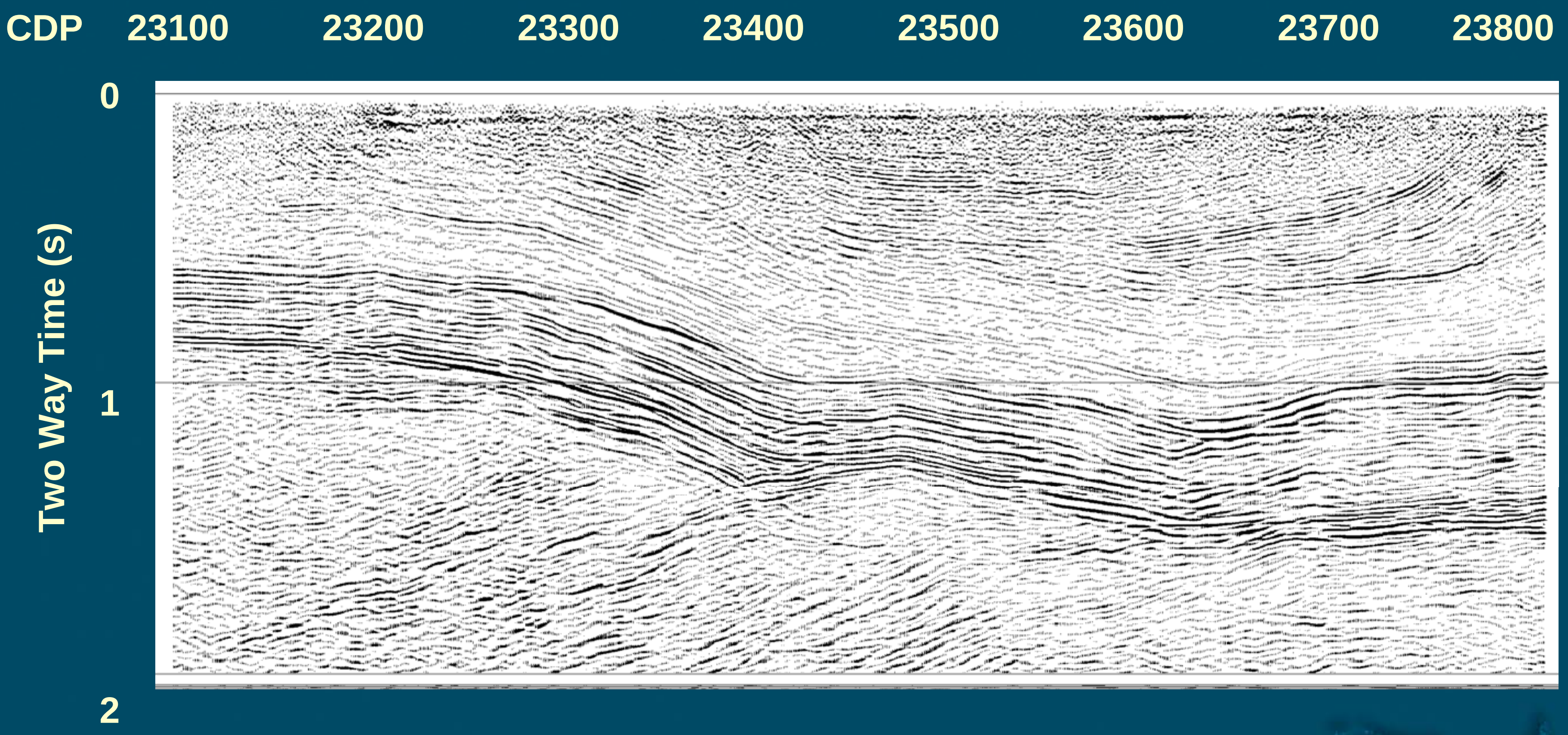
- Migration was implemented using an ω-x algorithm which uses a finite-difference approximation to the monochromatic wave equation

Stack



V/H ~ 1 4 km N 08GA-OM1

Migration



V/H ~ 1 | 4 km | N → | 08GA-OM1

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Processing Issues

First Breaks and Refractor Model:

In places, First Breaks difficult to pick because of low signal to noise ratio

Single refractor model gave best statics over entire line

Processing Issues

Low velocity basins:

Difficult to discriminate surface noise from the vibrators from reflection signal at early times by stack response (Arckaringa Basin)

Processing Issues

Signal strength variations:

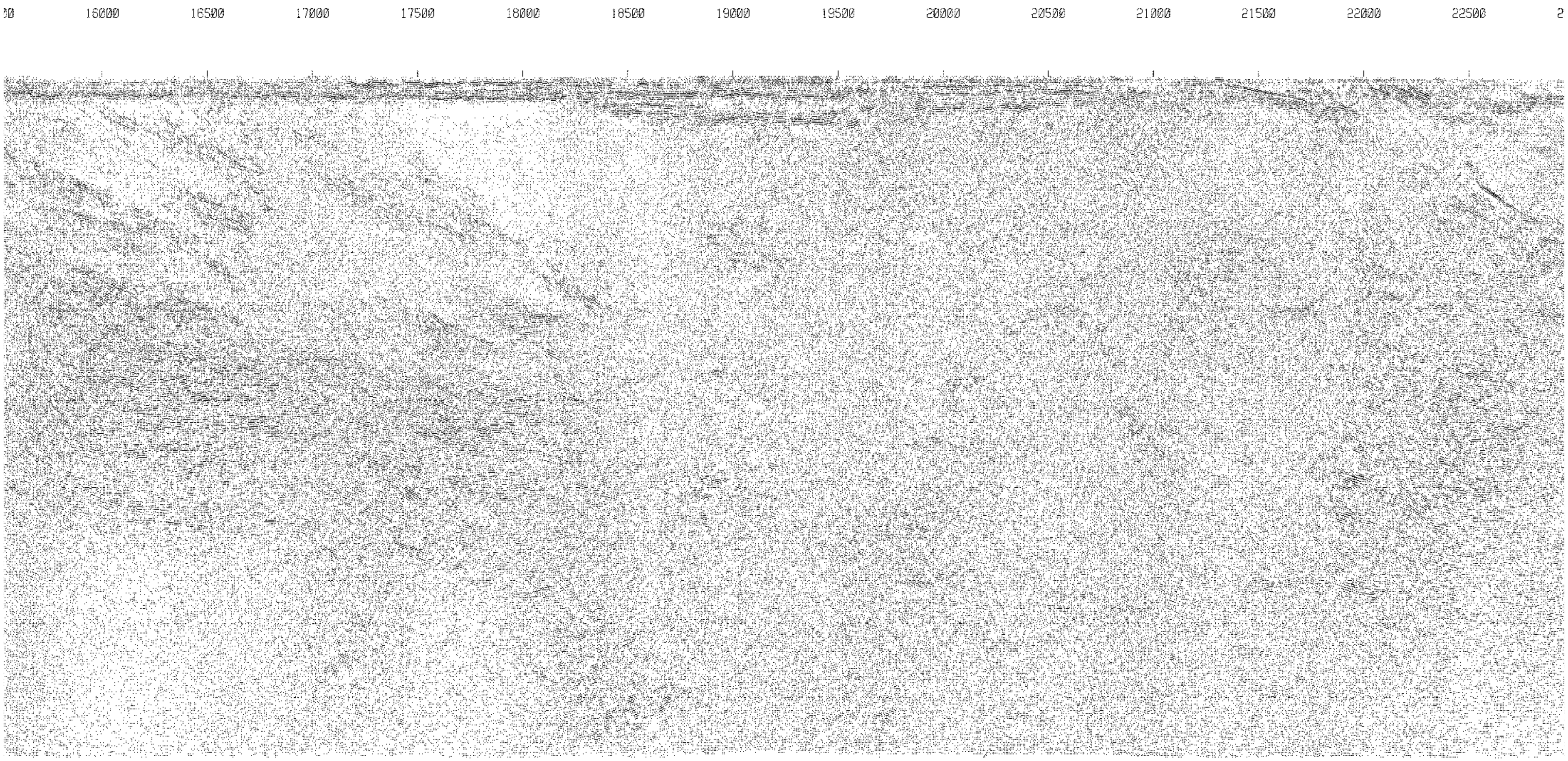
Affecting migration

Artifacts (smiles) generated where high amplitudes juxtaposed with low amplitudes

Results

Final sections image the whole crust to the Moho

Achieved important new images of crustal structure and architecture relating the Amadeus Basin, the Musgrave Block, the Officer Basin and the Gawler Block


16000
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22500

Questions?