Acquisition and processing of the Youanmi and Southern Carnarvon seismic surveys

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Project Partners

Government of **Western Australia**
Department of **Mines and Petroleum**

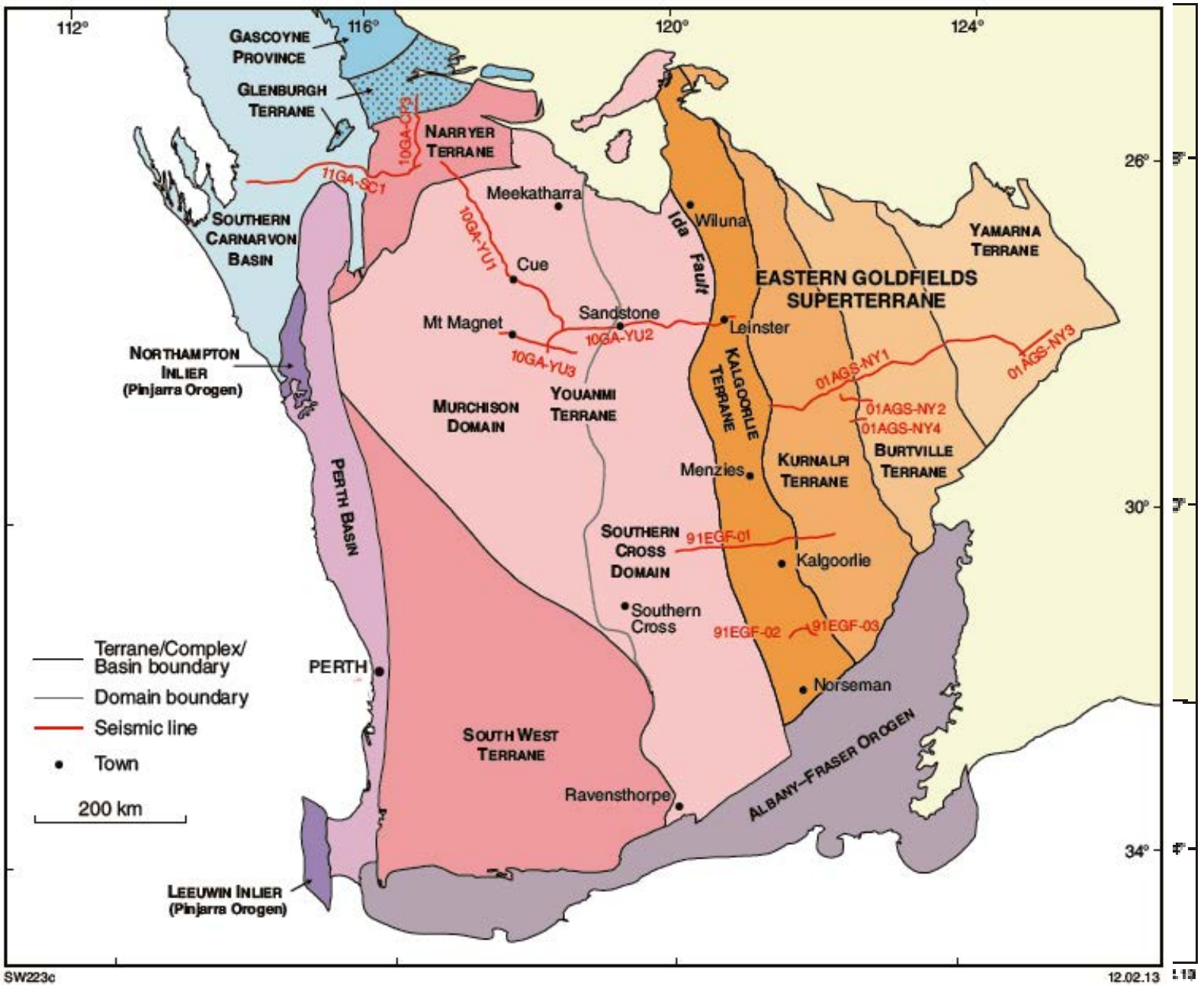
Australian Government
Geoscience Australia

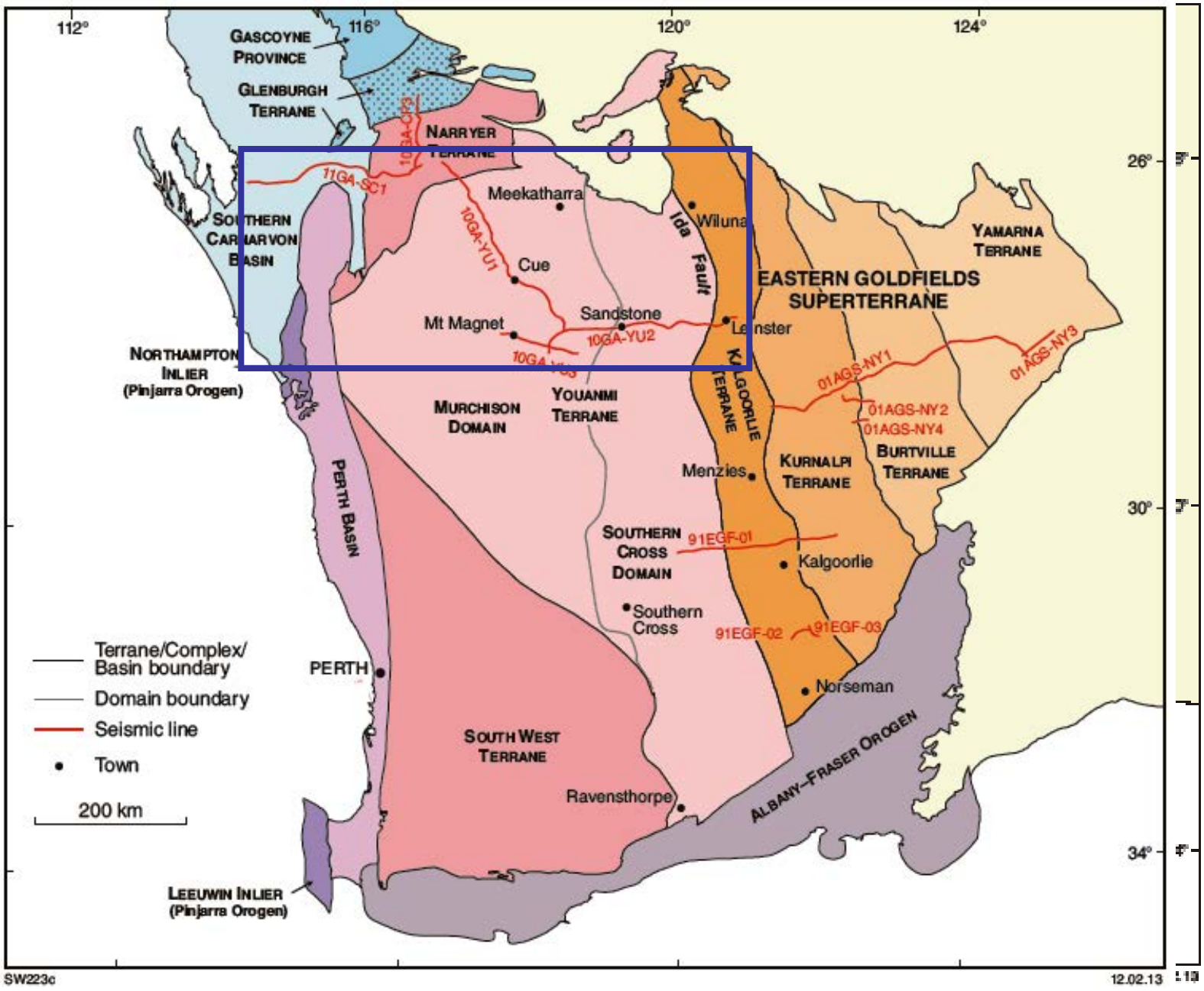
Geological Survey of Western Australia

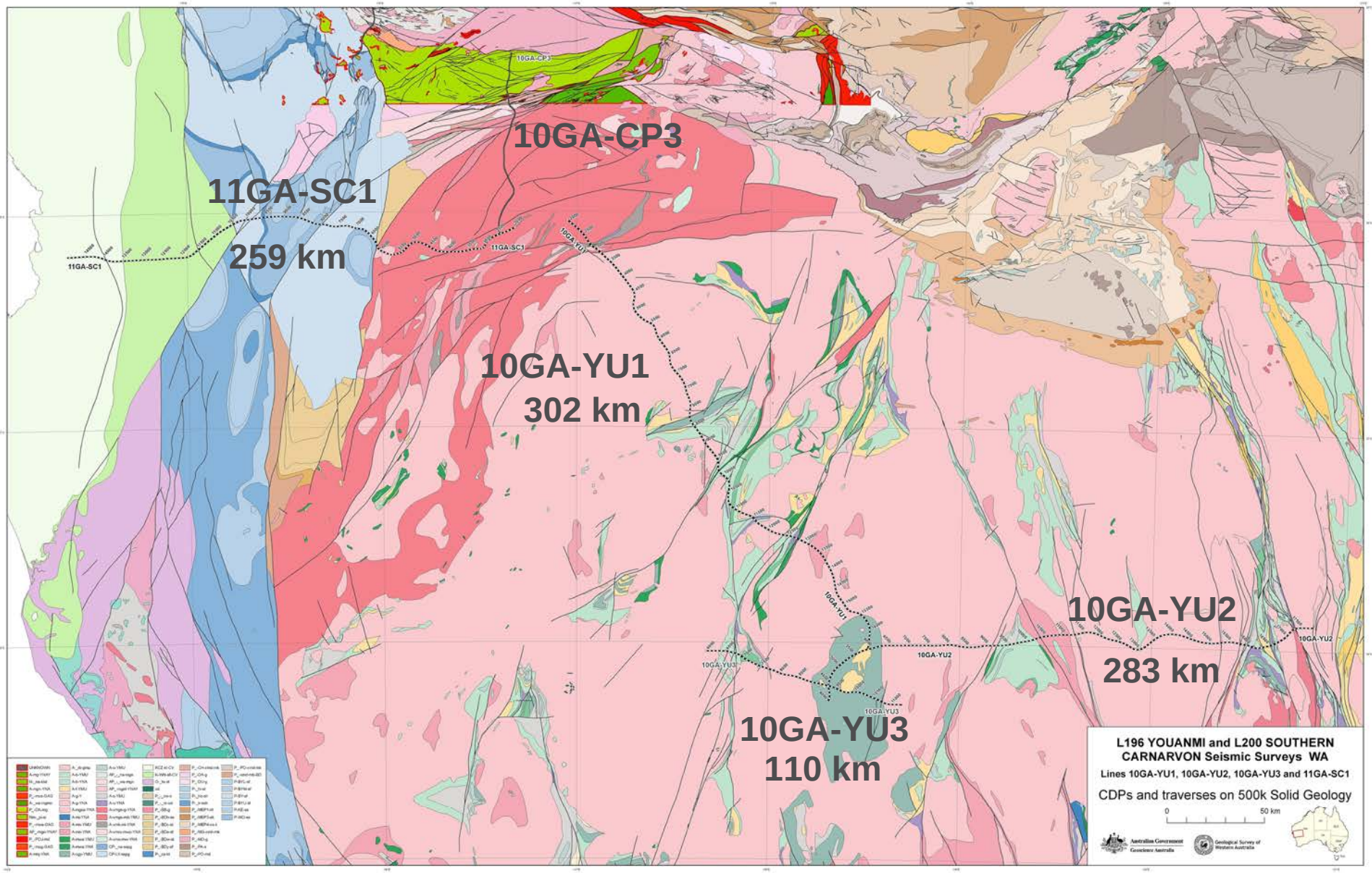
ROYALTIES FOR REGIONS
EXPLORATION INCENTIVE SCHEME

Contributors

Australian National University
University of New South Wales
Geological Survey of South Australia
CICESE, Mexico

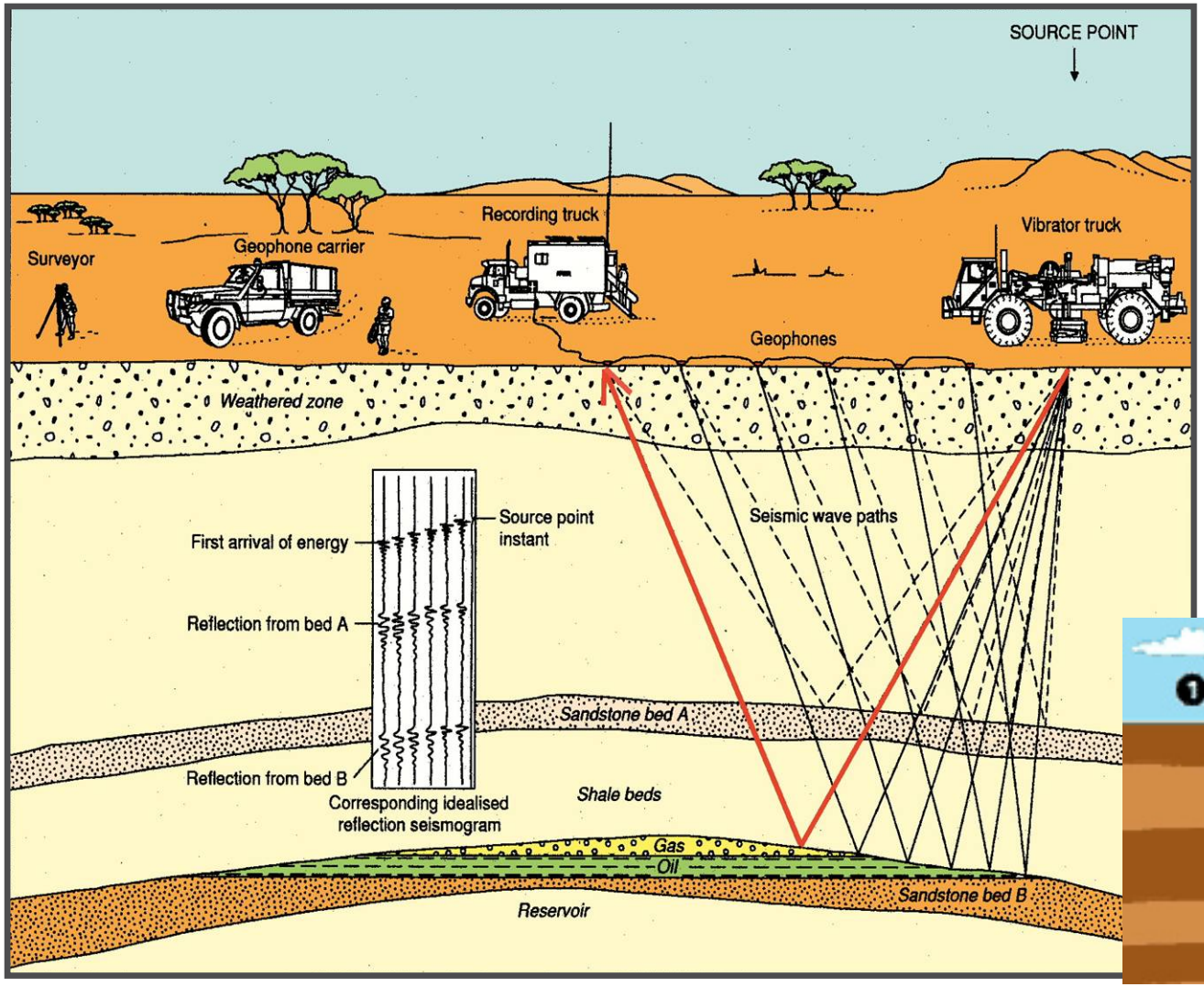


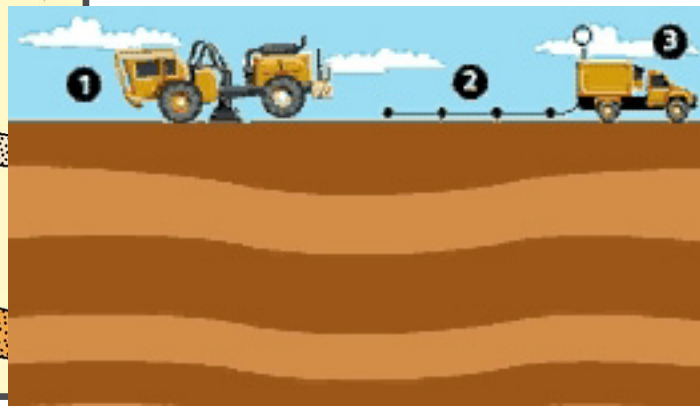




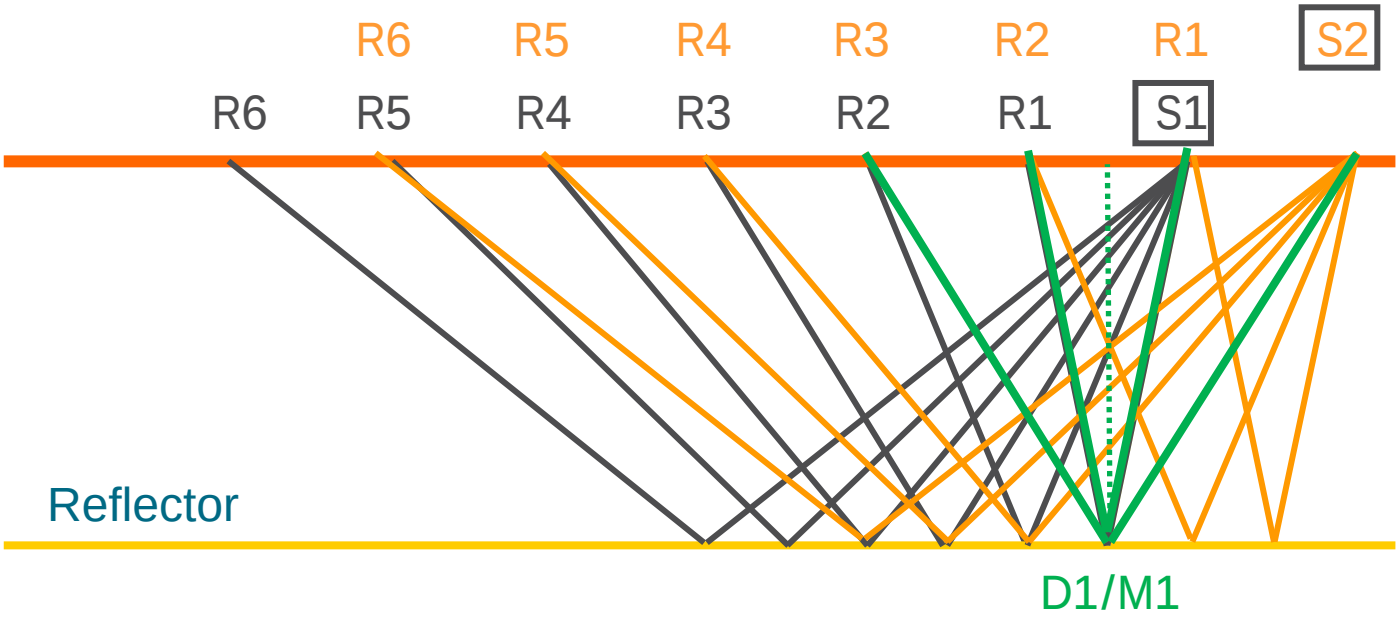
Total = 954 line km

Seismic Reflection Acquisition





CMP (Common Mid Point) Method



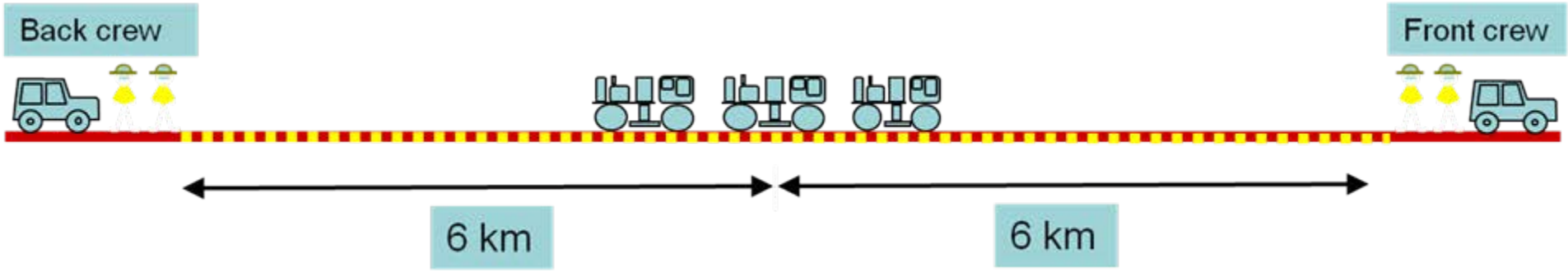
- Depth point D1/M1 is sampled by R1 for Shot 1, R3 for Shot 2 and R5 for Shot 3 (not shown).
- All paths with common midpoint are brought into a gather – 75 fold sampling for most of Youanmi & Southern Carnarvon surveys (150 fold across the greenstone belts)

Seismic Acquisition

Symmetrical split spread with maximum 6 km offset

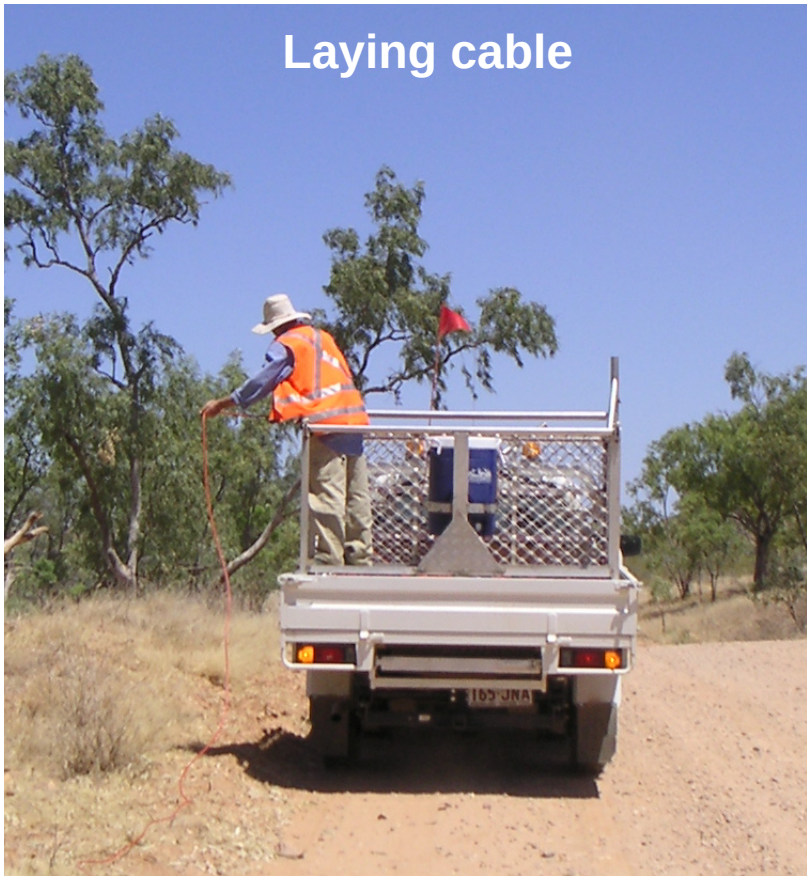
300 channels, receiver groups at 40 m intervals

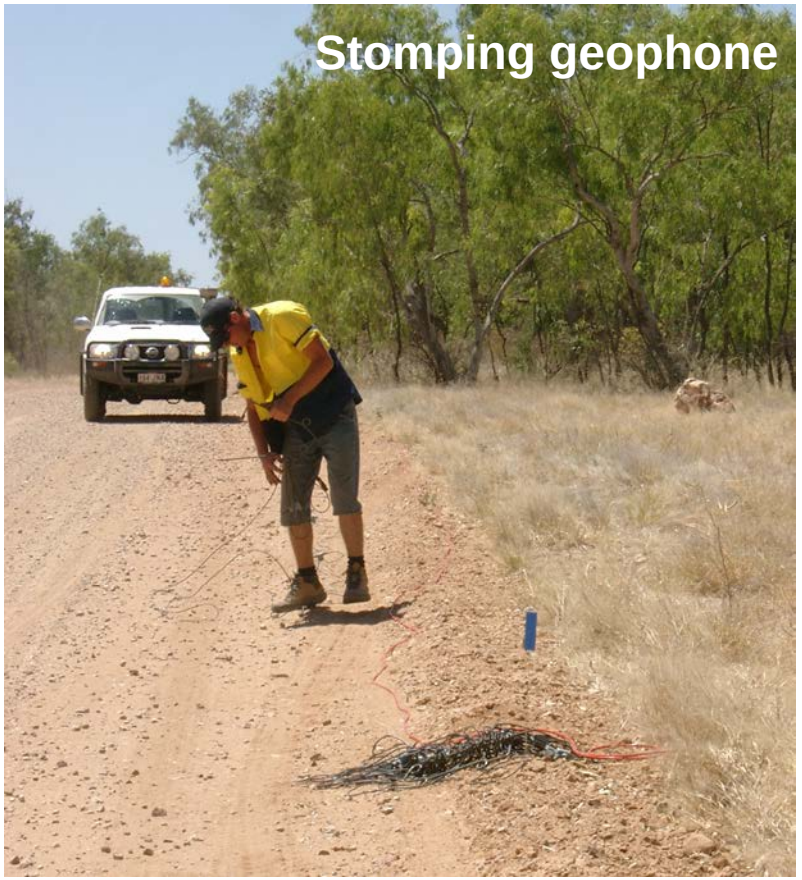
Vibe points every 80 m (= 75 fold),
but every 40 m (= 150 fold) over the greenstone belts



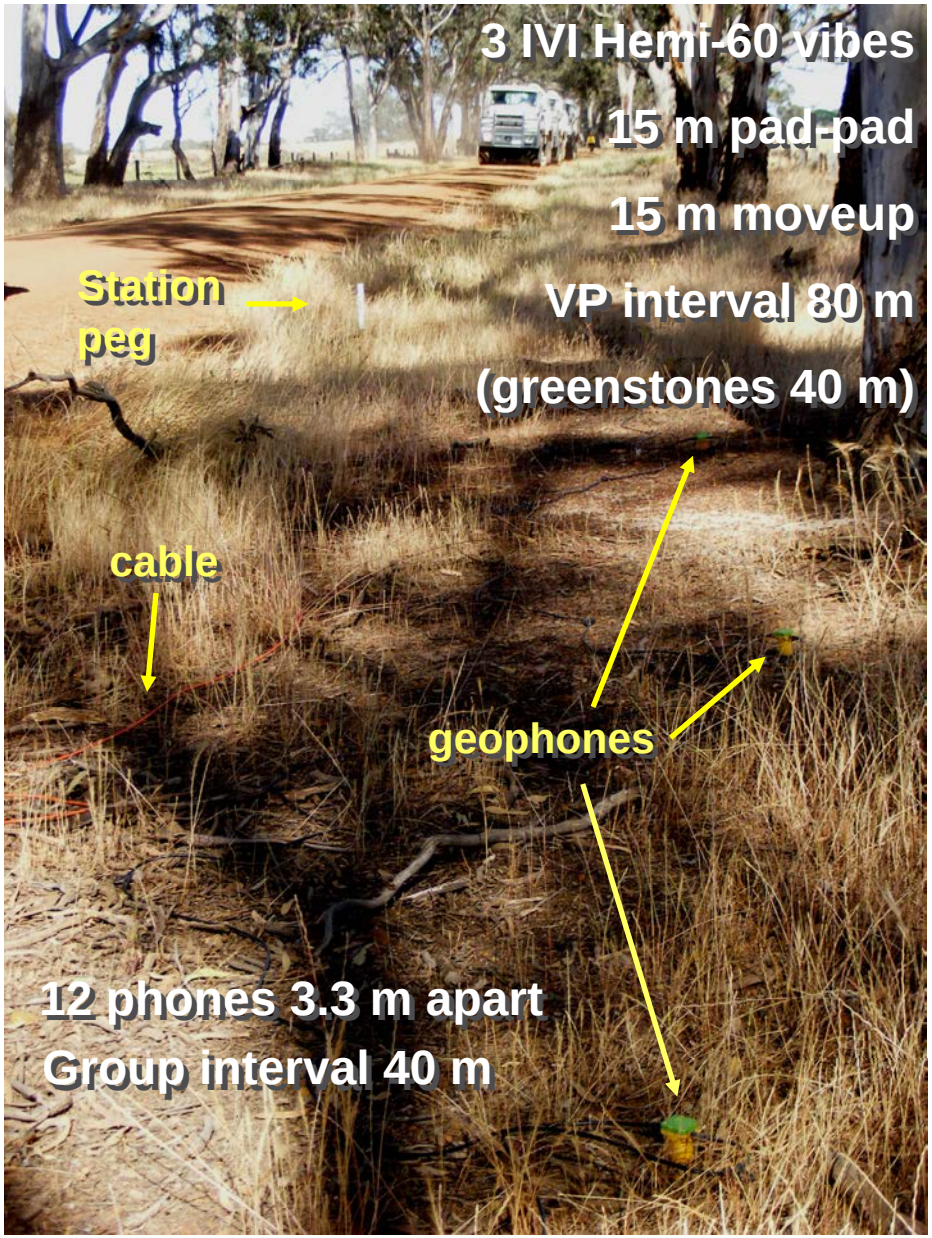
(not to scale!)

Front Crew





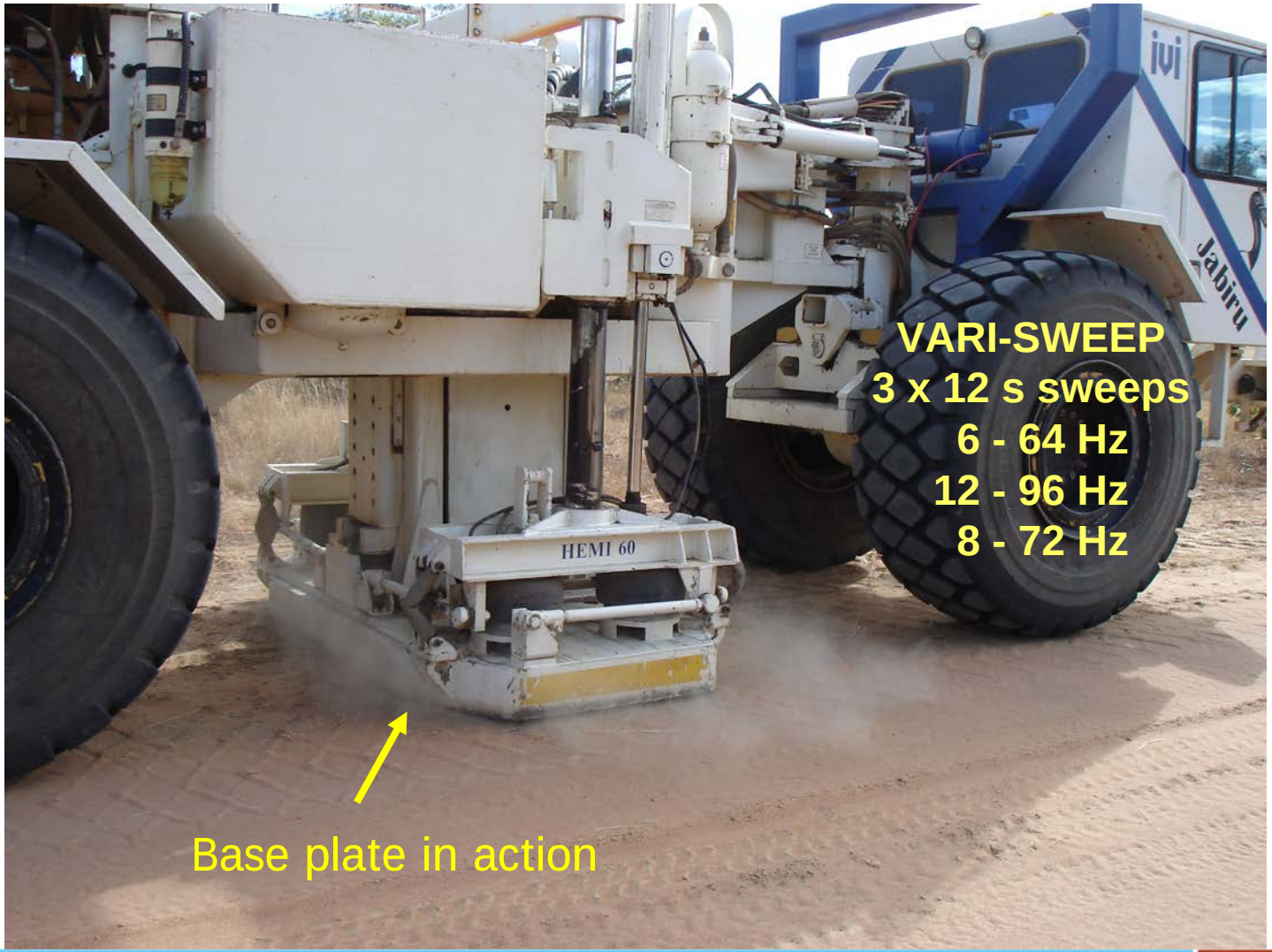
Acquisition Parameters



300 channels

Record 20 s
Sampled @ 2 ms

Acquisition Parameters



Back Crew

Pinning geophones

Pulling in cable

Seismic Data Recording and QC

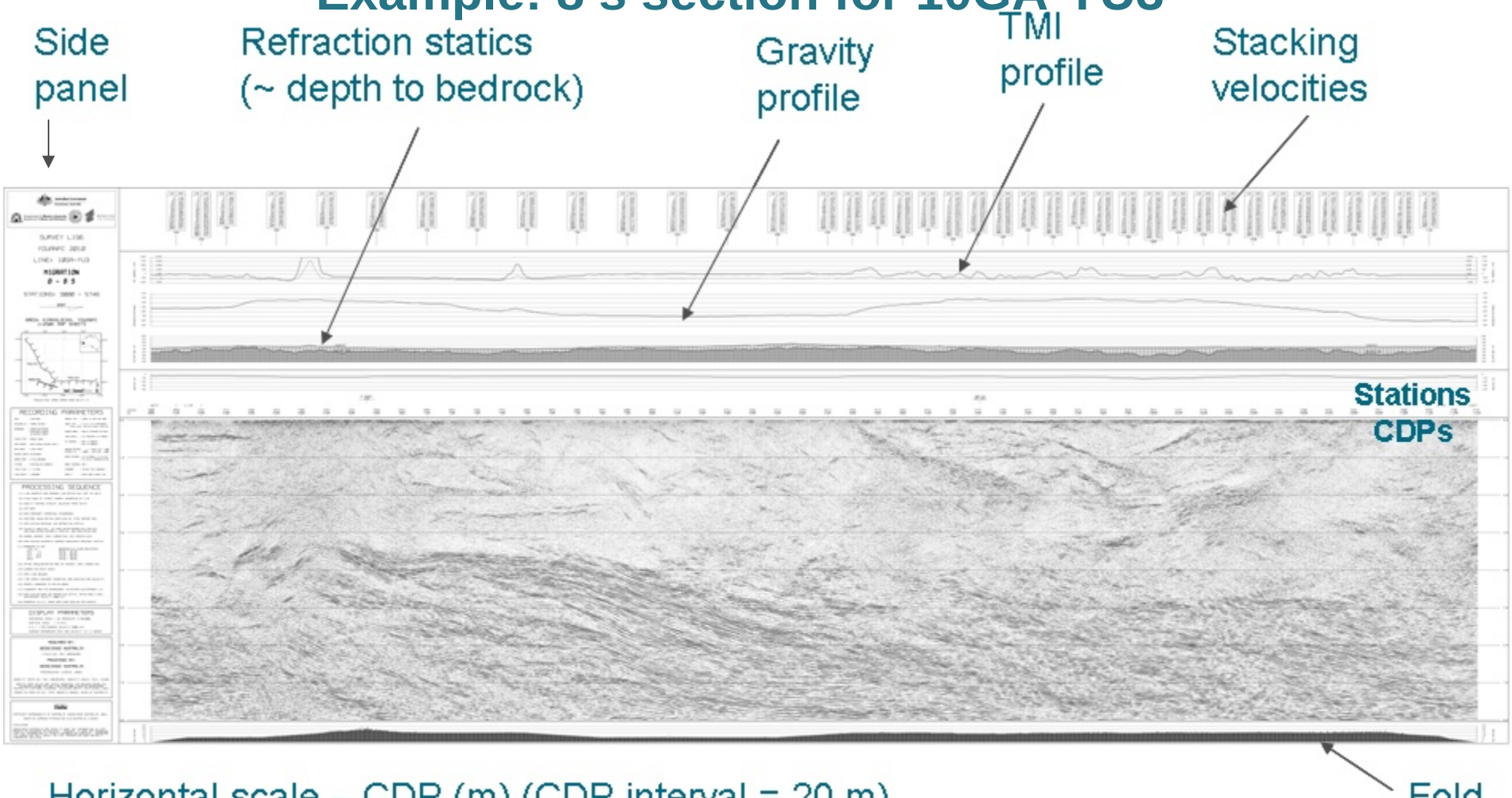
Observers & Sercel 428XL Recording System

GA's In-field QC & Processing Centre

Seismic Processing

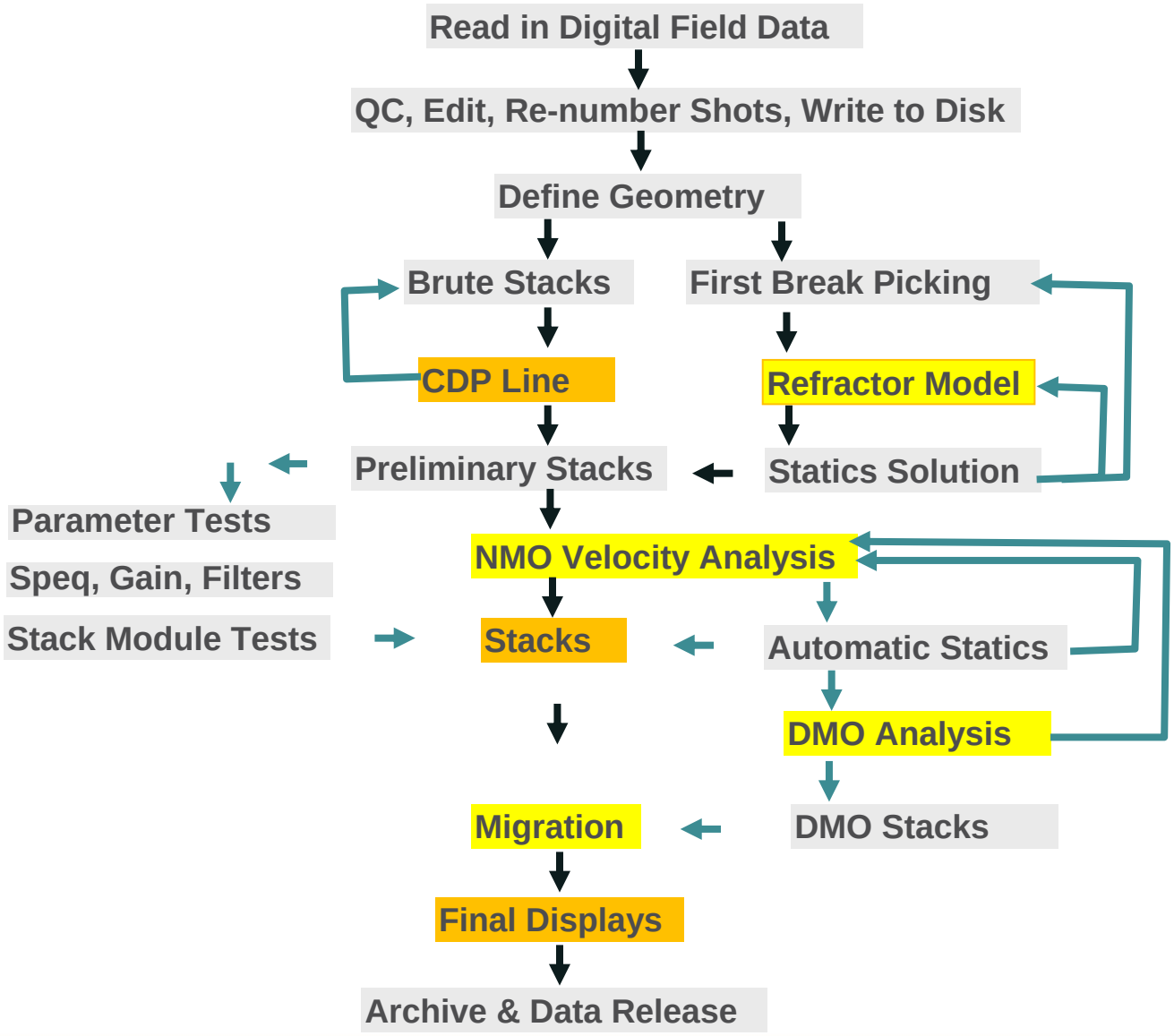
Overall goal is to produce an image of the subsurface by enhancing and correctly positioning reflections, and reducing undesired energy (noise)

Layout of a seismic section
Example: 8 s section for 10GA-YU3



Horizontal scale – CDP (m) (CDP interval = 20 m)
Vertical scale – two-way travel time (s)
Display V:H = ~1:1 (assuming an average crustal velocity of 6000 ms^{-1})
i.e. 1 s = ~3 km

Seismic Processing



Key Reflection Processing Steps

Crooked line geometry definition - including CDP line

CDP sort - collects traces with common mid point

Refraction statics – correct for time delays in regolith

Spectral equalisation - suppresses low frequency noise

NMO correction - corrects for source-receiver offset

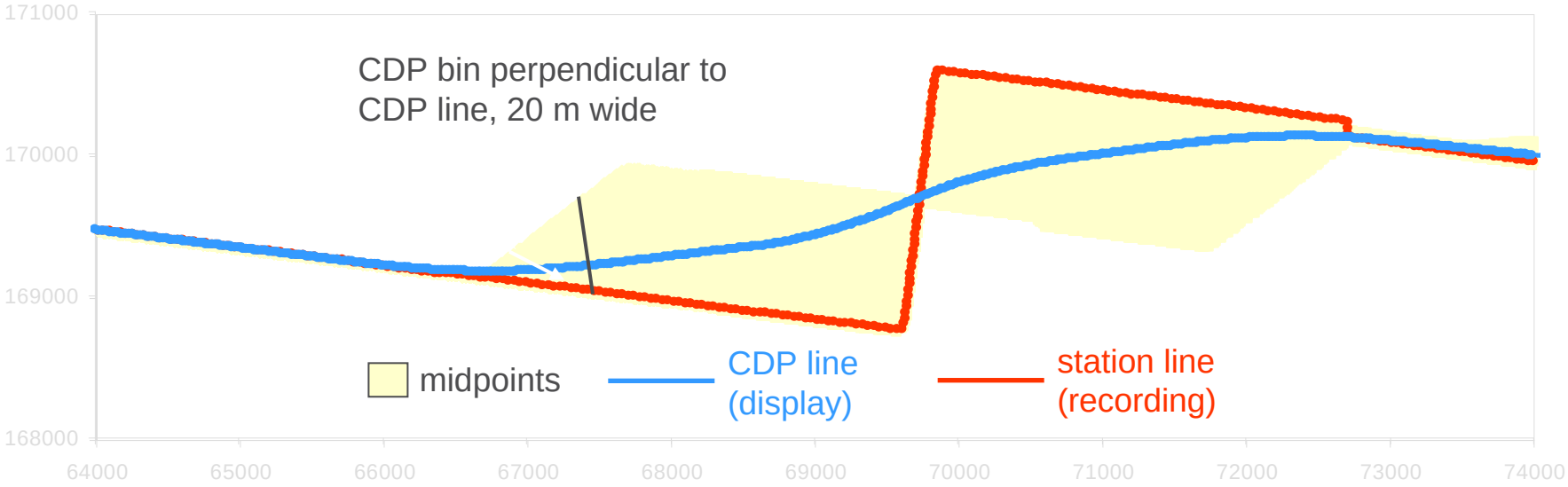
DMO correction - allows imaging of steep reflectors

Common mid-point stack – improves signal to noise

Migration - moves reflections to correct positions

Coherency enhancement - amplifies coherent events

Geometry and CDP Sort - Crooked Line



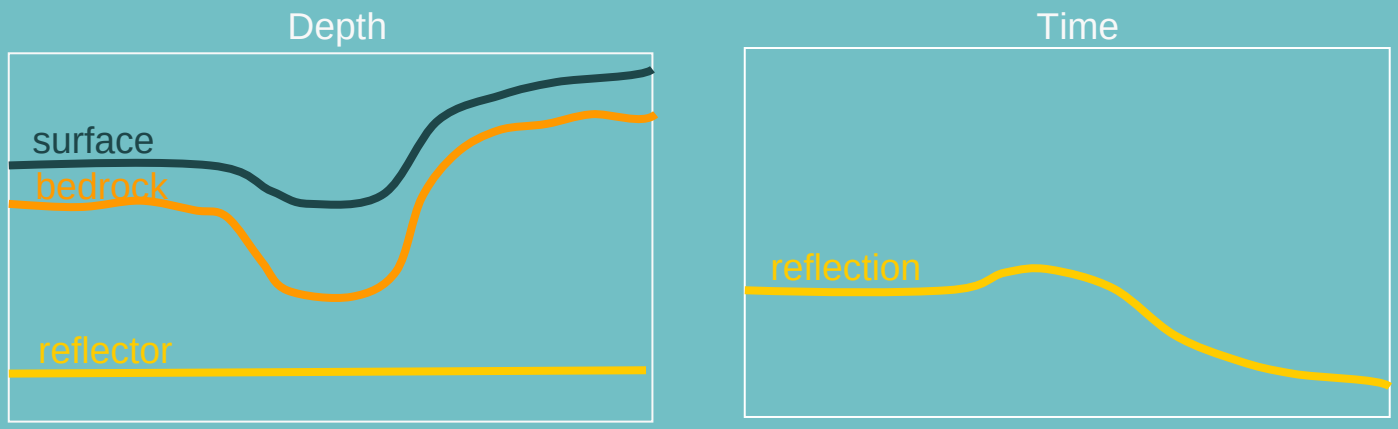
Allows for the scatter of midpoints. A best fitting CDP line is defined. Shot-receiver midpoints are assigned to the nearest CDP bin. Traces are then sorted into CDP gathers.

The processed seismic section follows the CDP line.

Refraction Statics Calculation

Refraction statics calculated from first arrivals on shot records, fine tuned by automatic residual statics, correct for time delays due to topography and low velocity regolith

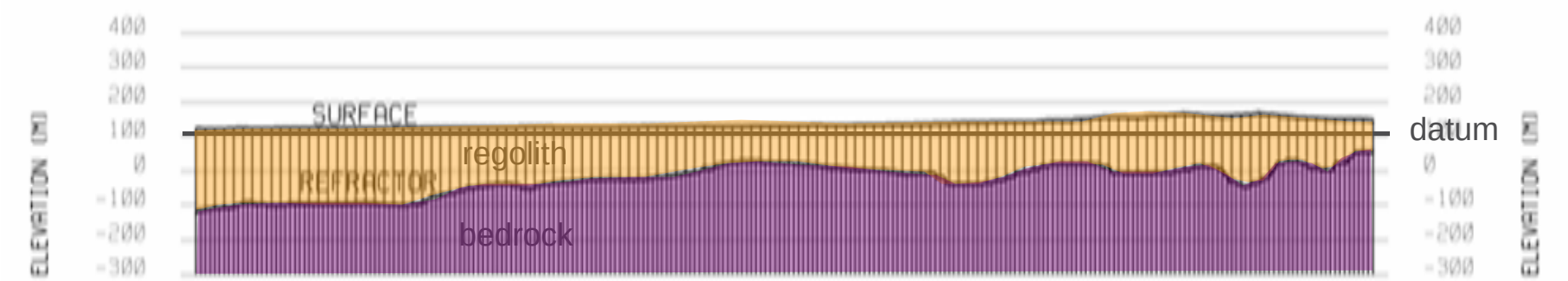
Short wavelength variations in two-way travel time (TWT) misalign reflections and degrade the stack (sum of traces)



Long wavelength variations in TWT create spurious structure on seismic sections

Refraction Statics Calculation

Displayed on top of seismic section plots



Indicative of depth to bedrock (approx. regolith thickness), but not exact, due to difficulty of accurate determination of V_1, with regional receiver spacing of 40 m

Stacking (NMO) Velocity Analysis

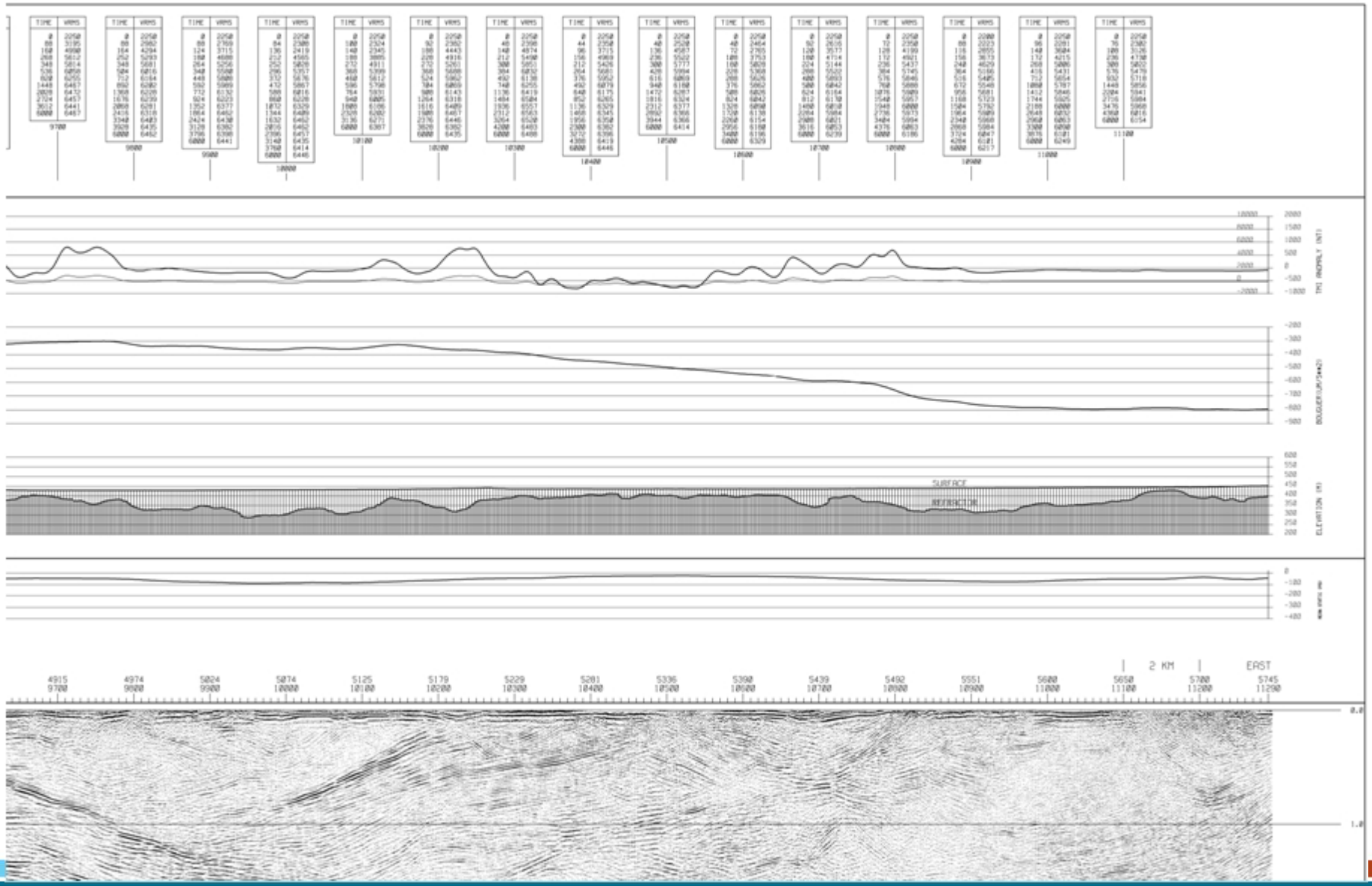
NMO correction corrects for source-receiver offset

Stacking velocity is the velocity giving best stack

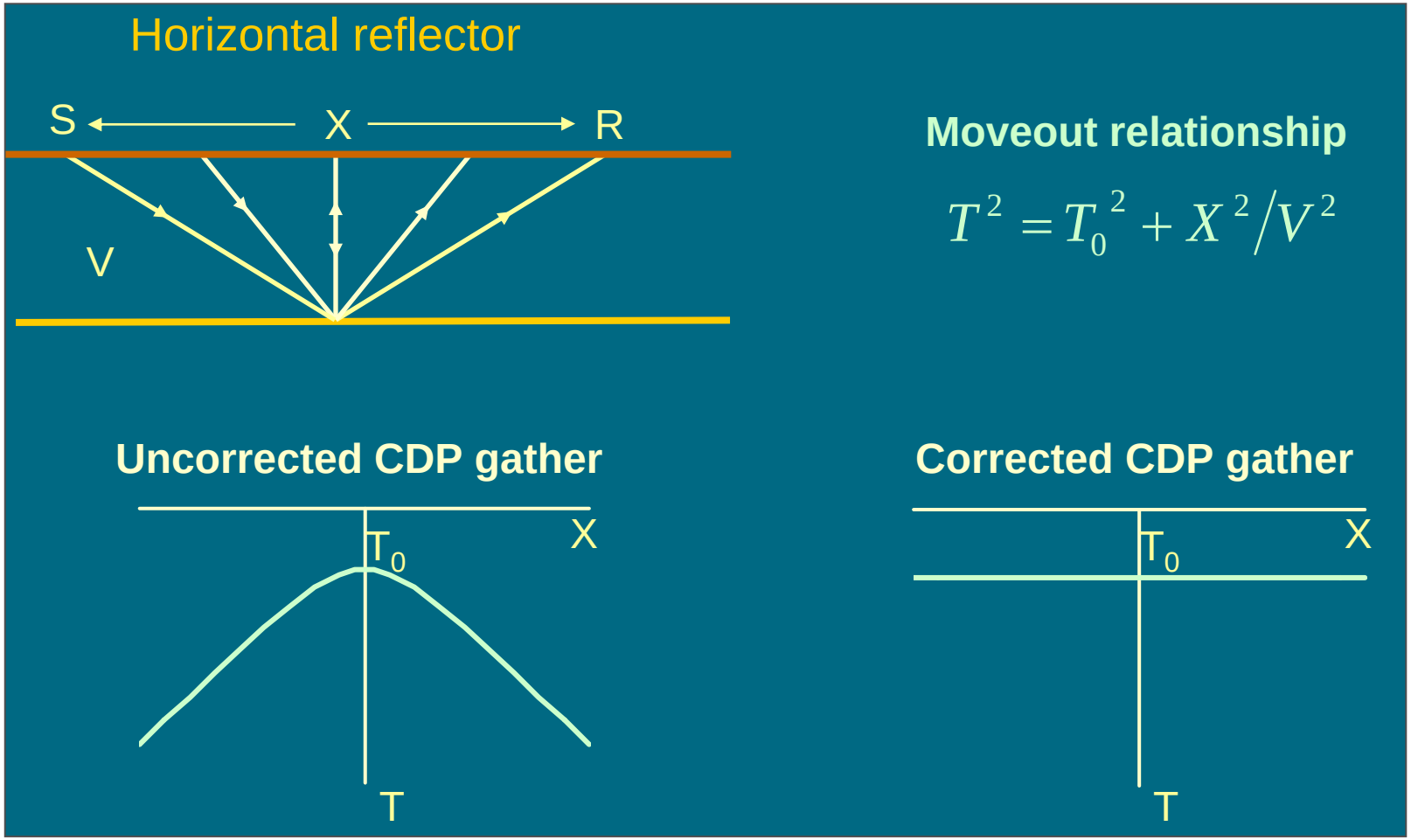
Velocity analysis is:

- **Done every 4 km (on average) along lines**
- **Repeated after dip moveout (DMO) correction**
- **Most critical and difficult in top 1 second**
- **Used as starting point for migration velocity**

Stacking Velocities (time-velocity pairs)

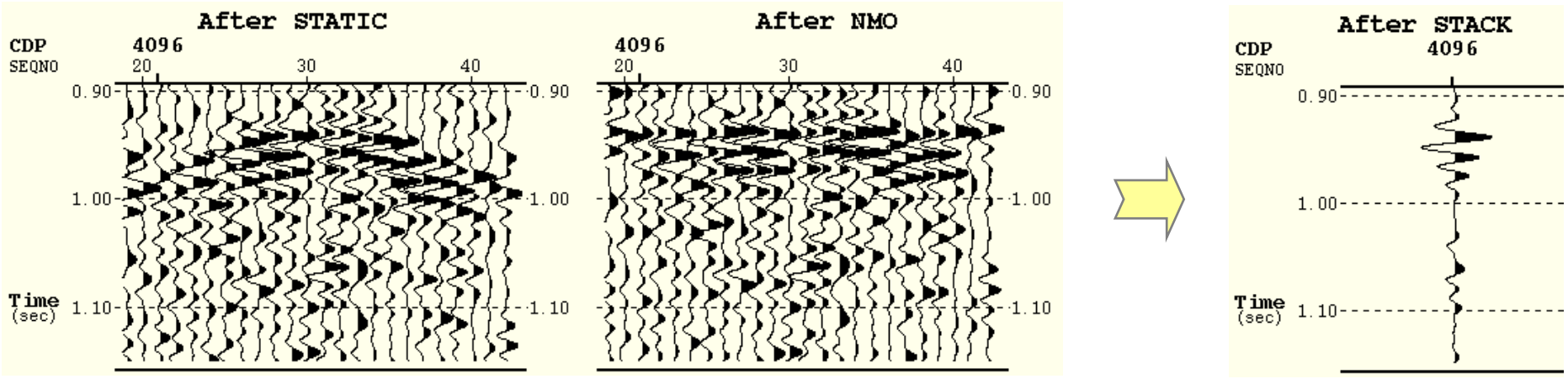


Normal Moveout (NMO) Correction



Normal Moveout Correction and Stack

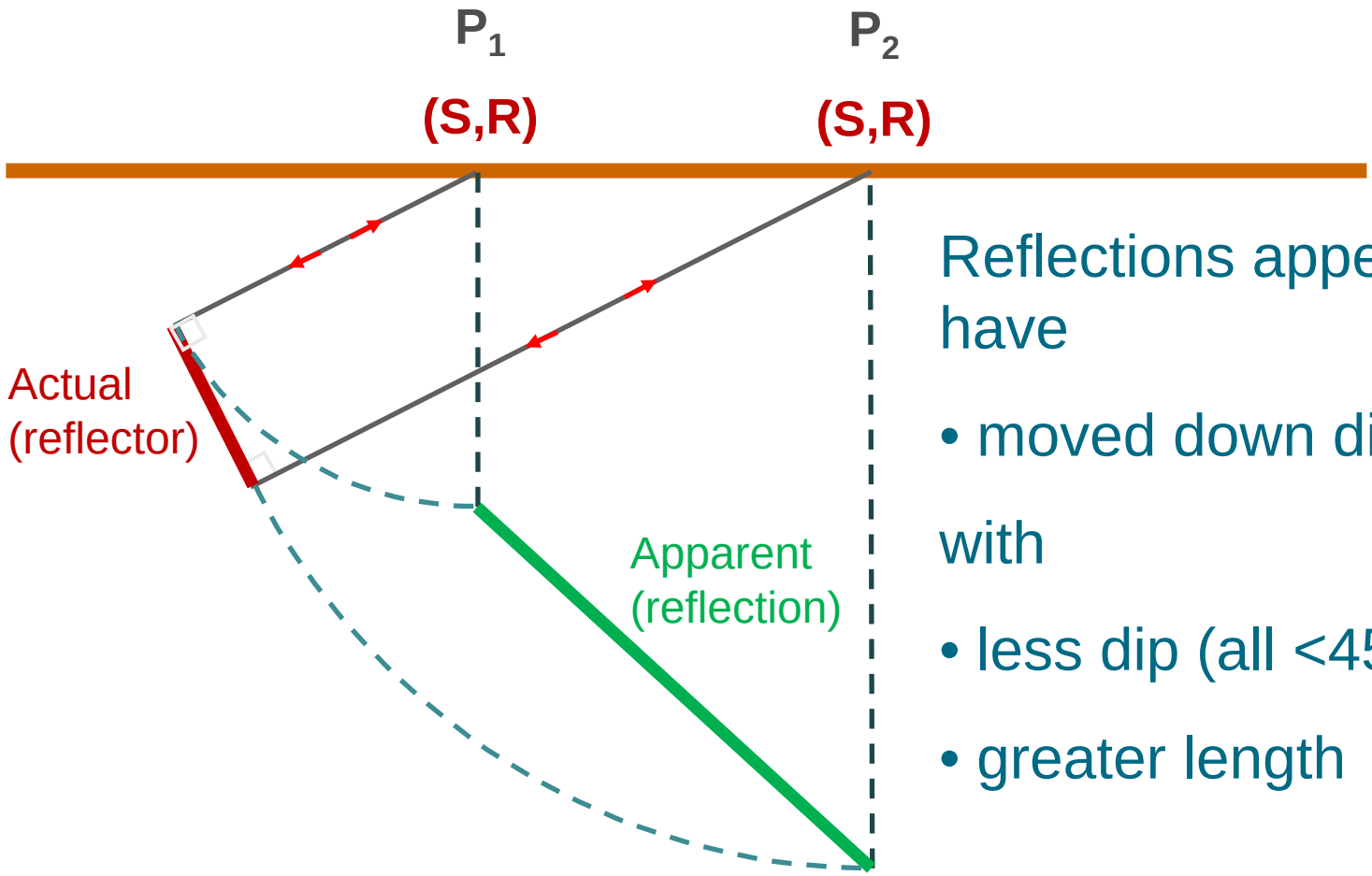
Uncorrected CDP gather **Corrected CDP gather** **Stacked seismic trace**



Stacking improves signal to noise by √n, where n is the fold

n	10	75	150
√n	3	9	12

Imaging of Dipping Reflectors on Stack Section



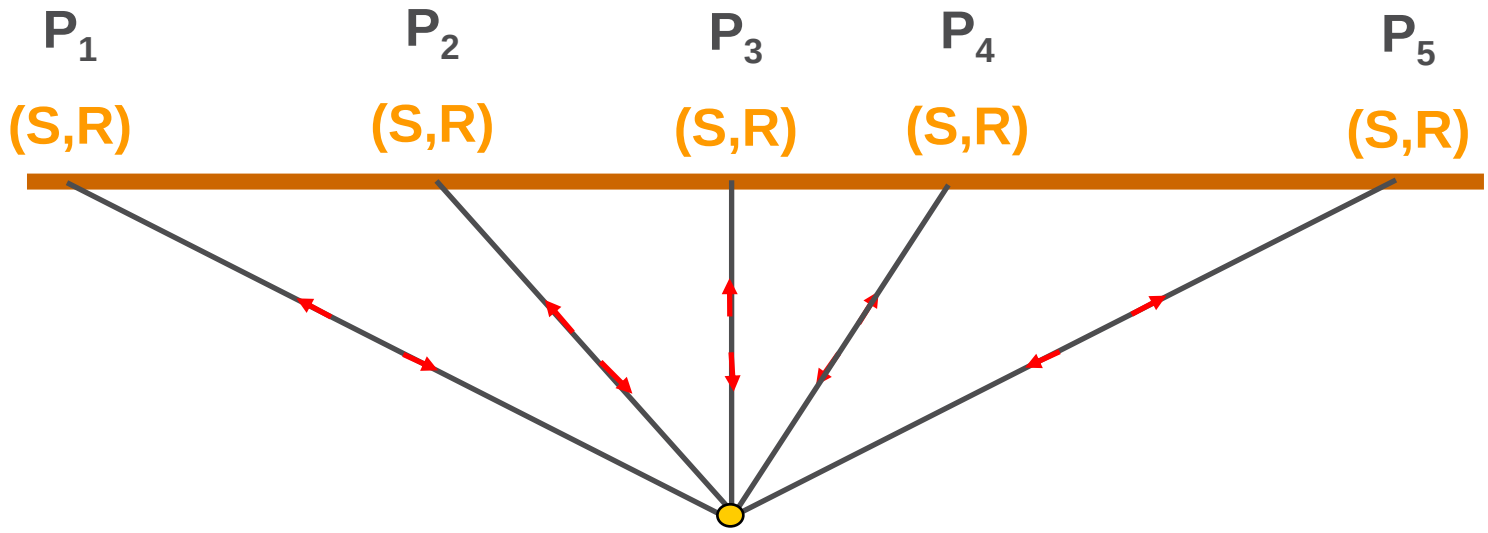
Reflections appear to have

- moved down dip

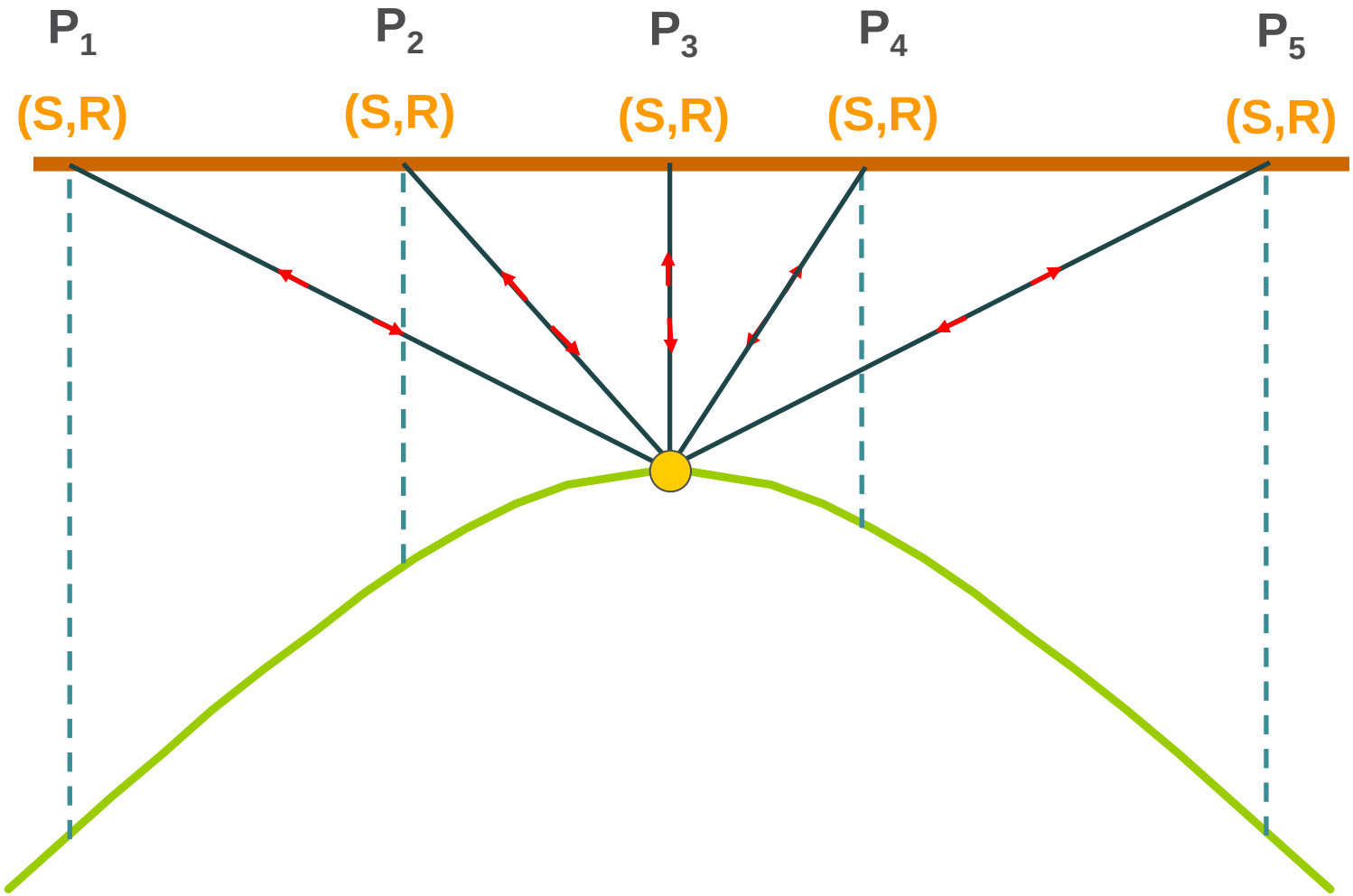
with

- less dip (all <45°)
- greater length

Generation of Diffractions



Generation of Diffractions (point source)



Migration

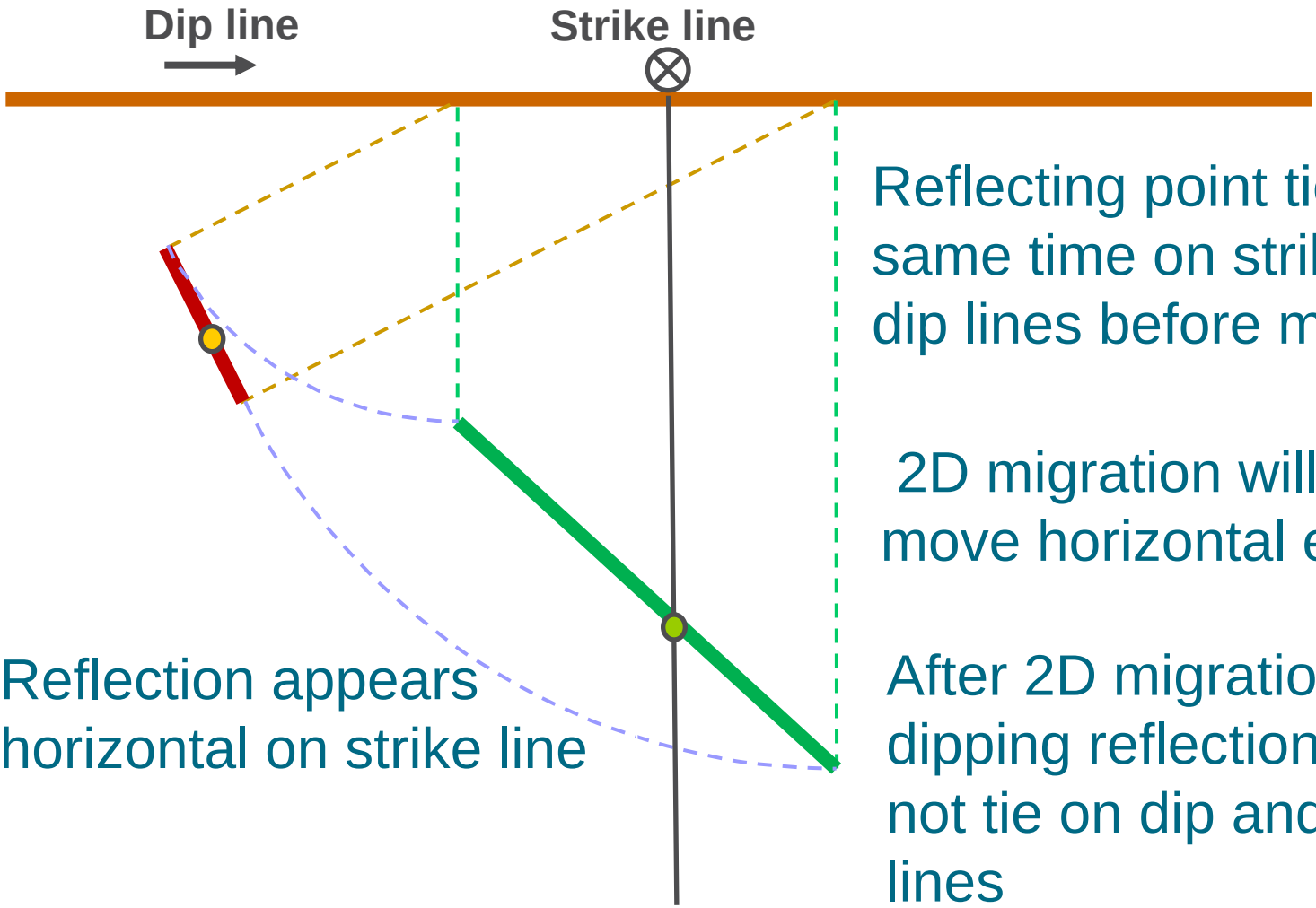
Migration improves a seismic image by

- moving reflections to their correct positions
- steepening the dip of dipping reflections
- collapsing diffractions

Migration can be evaluated by

- appearance of diffractions (curves v smiles)
- juxtaposition of reflections of different dip

Limitations of 2D Migration



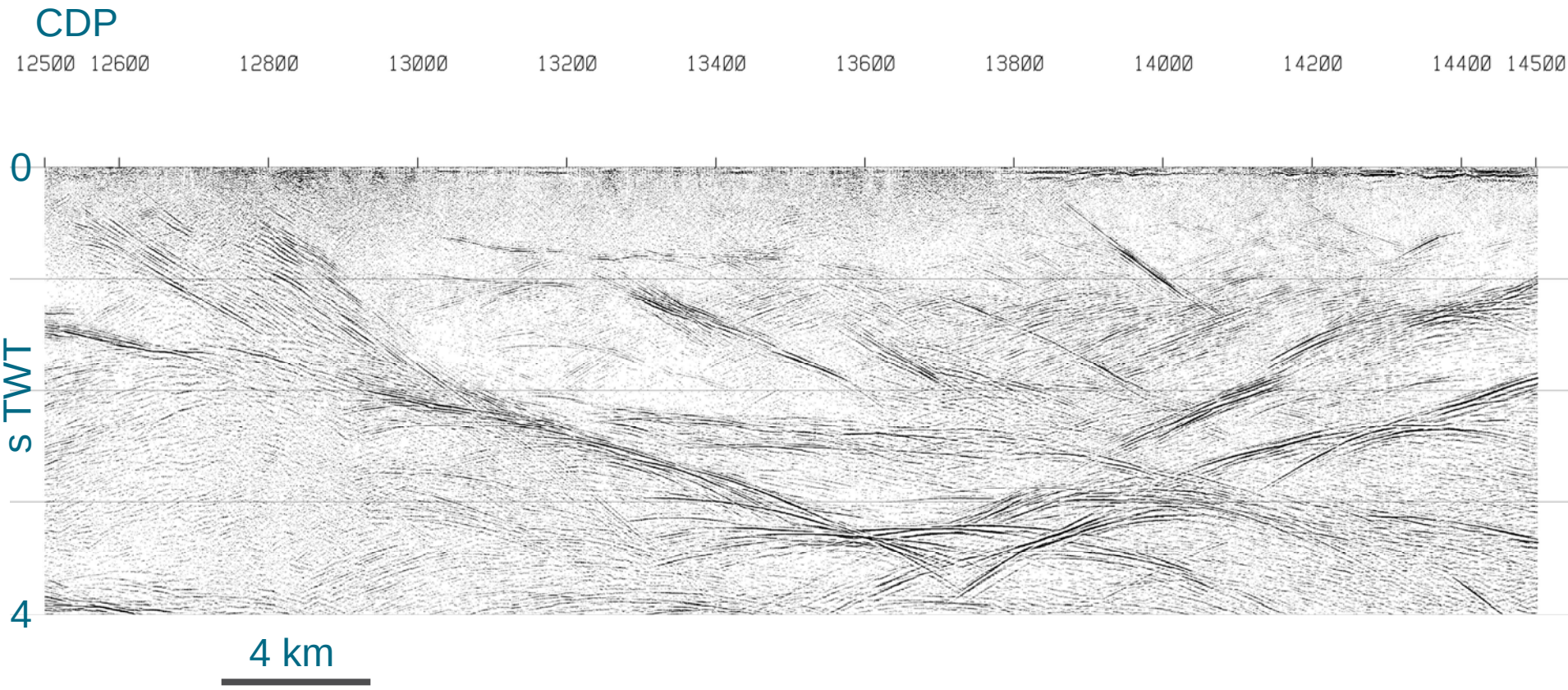
Reflecting point ties at same time on strike and dip lines before migration

2D migration will not move horizontal events

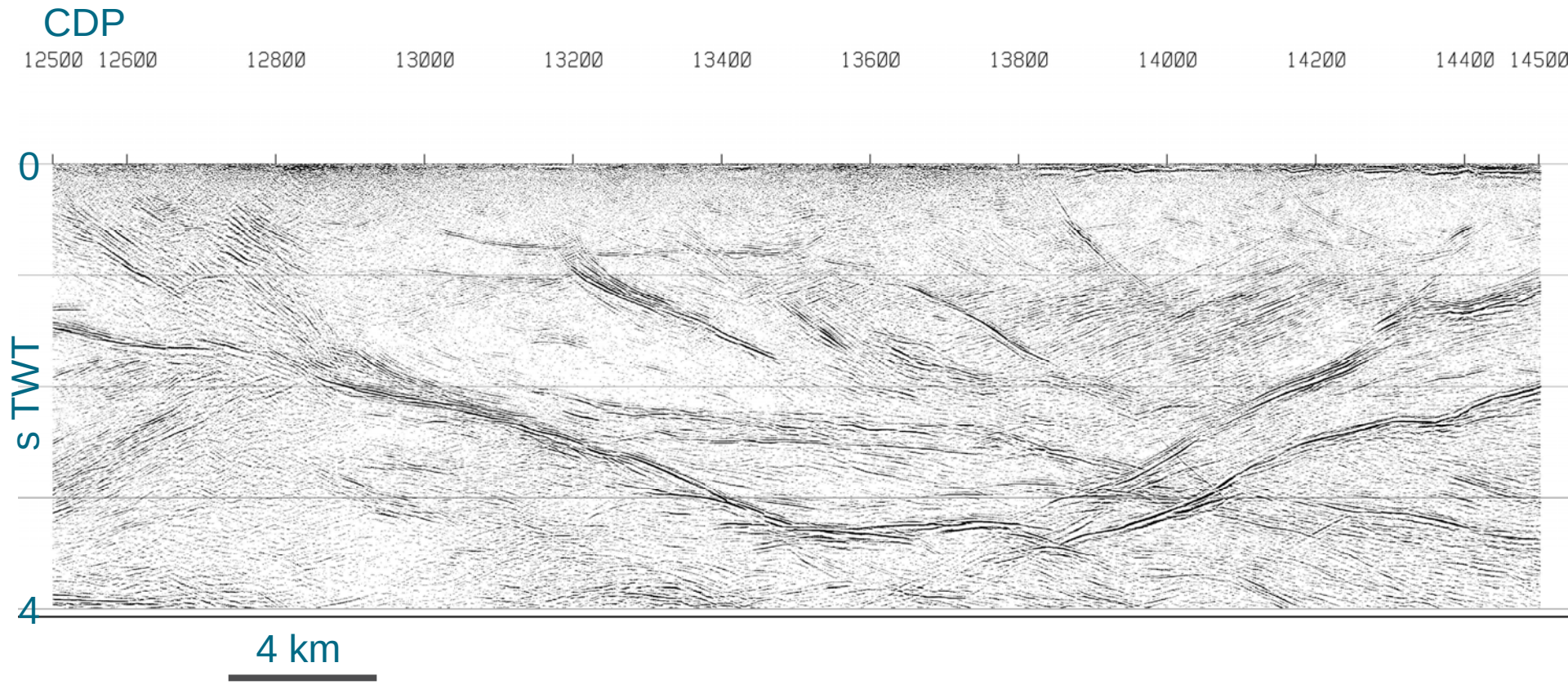
Reflection appears horizontal on strike line

After 2D migration, dipping reflections will not tie on dip and strike lines

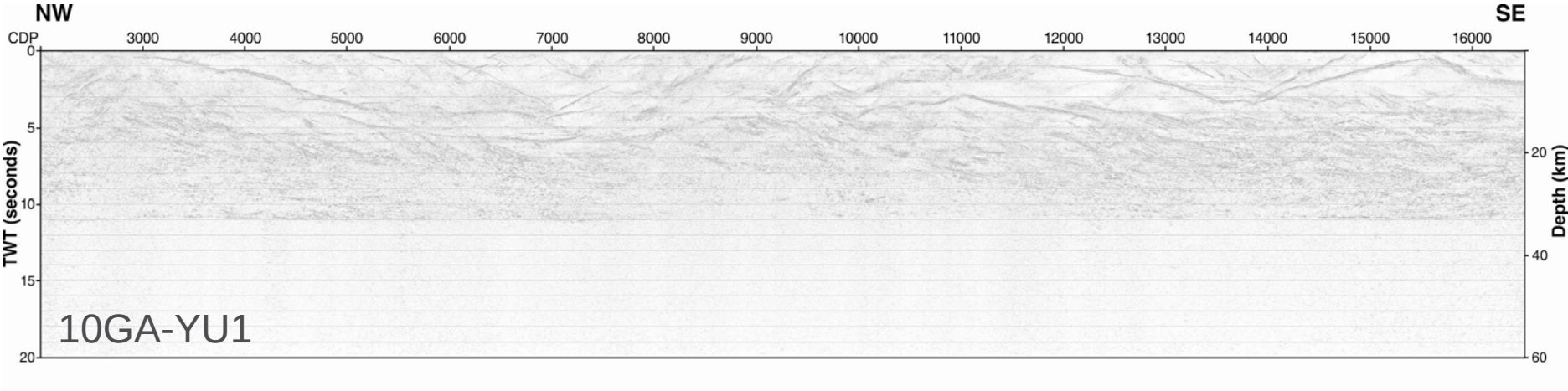
Portion of 10GA-YU1 - Stack

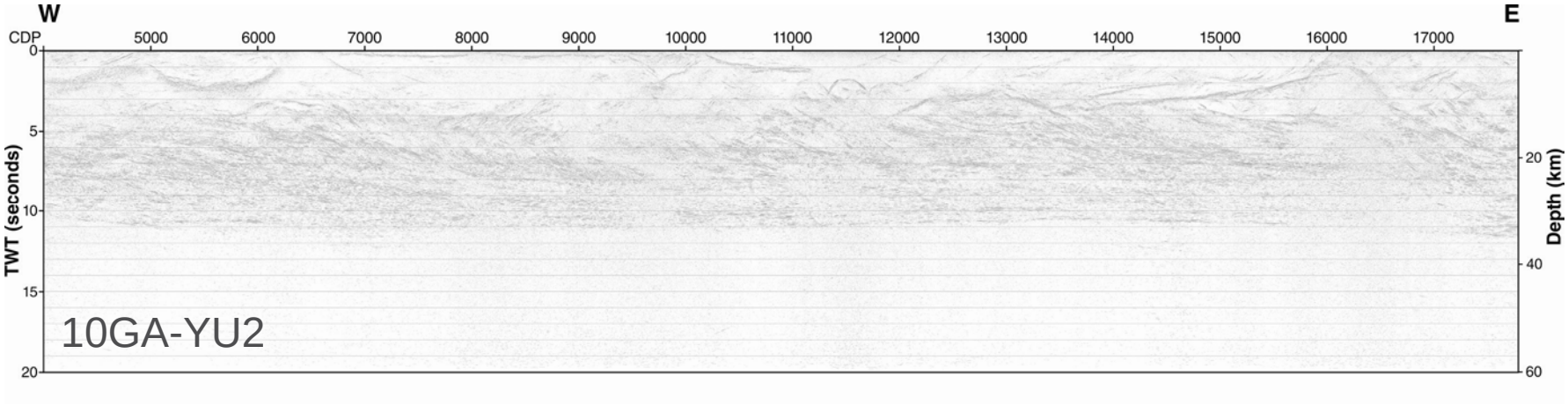


Portion of 10GA-YU1 - Migration

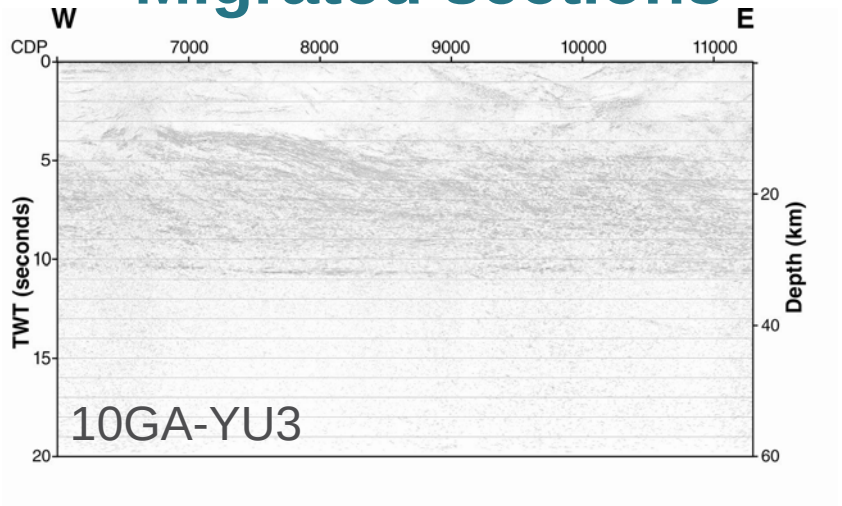


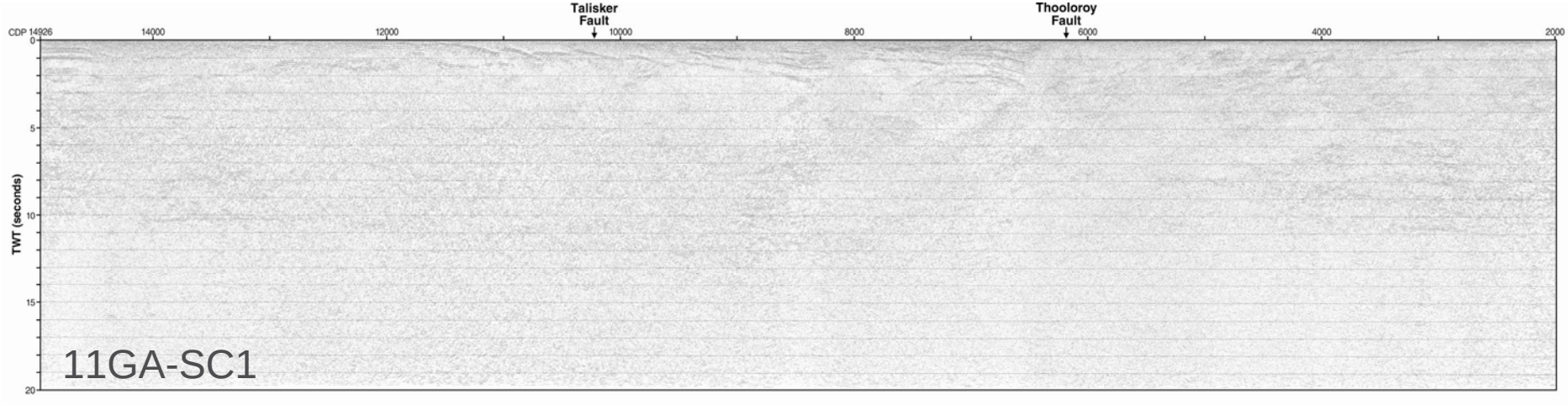
Final Displays – 1
Migrated sections





Final Displays – 2
Migrated sections





Caveats for Interpretation

Faults may be reflective, or identify by terminations

Angular unconformities may have variable amplitude & polarity

Dipping reflectors will not be imaged correctly if crossed obliquely

Dipping reflectors at end of lines may not be completely imaged

2D migration will not remove out-of-plane (sideswipe) reflections

Curved events (migration smiles) at section edges are artefacts

Seismic section is in two-way travel time – low velocity layers at top will appear thicker

Seismic resolution is of the order of 50 m in hard rock (to see top and bottom of a layer), better in sedimentary basins

Conclusions

695 km of 75-fold and 150-fold deep crustal seismic reflection data were acquired for the Youanmi survey, using the CDP continuous profiling method

259 km of 75-fold deep crustal seismic reflection data were acquired for the Southern Carnarvon survey, using the CDP continuous profiling method

Geoscience Australia processed the data, using commercial industry standard software.

Key steps included refraction statics and velocity analysis. DMO and migration were essential for imaging steep reflectors

High quality seismic sections imaged the crust from the base of regolith to Moho, revealing previously unknown structures in areas of no outcrop

Australian Government
Geoscience Australia

Seismic data and interpretations can be downloaded from:

http://www.ga.gov.au/minerals/projects/current-projects/seismic-acquisition-processing.html

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