



Acquisition and processing of the Youanmi and Southern Carnarvon seismic surveys

Ross Costelloe & Leonie Jones (presented by Russell Korsch)



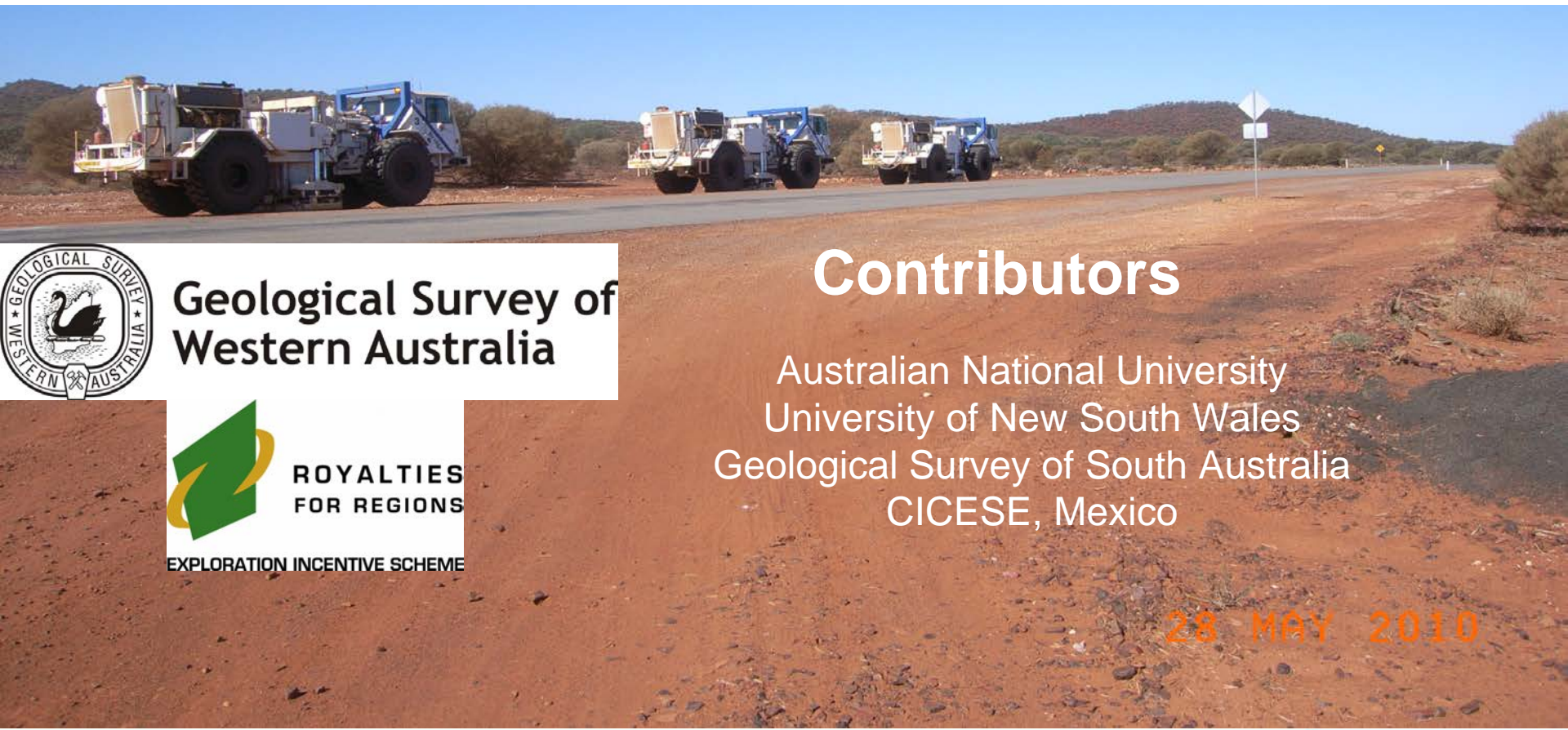
Project Partners



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



Australian Government
Geoscience Australia



**Geological Survey of
Western Australia**



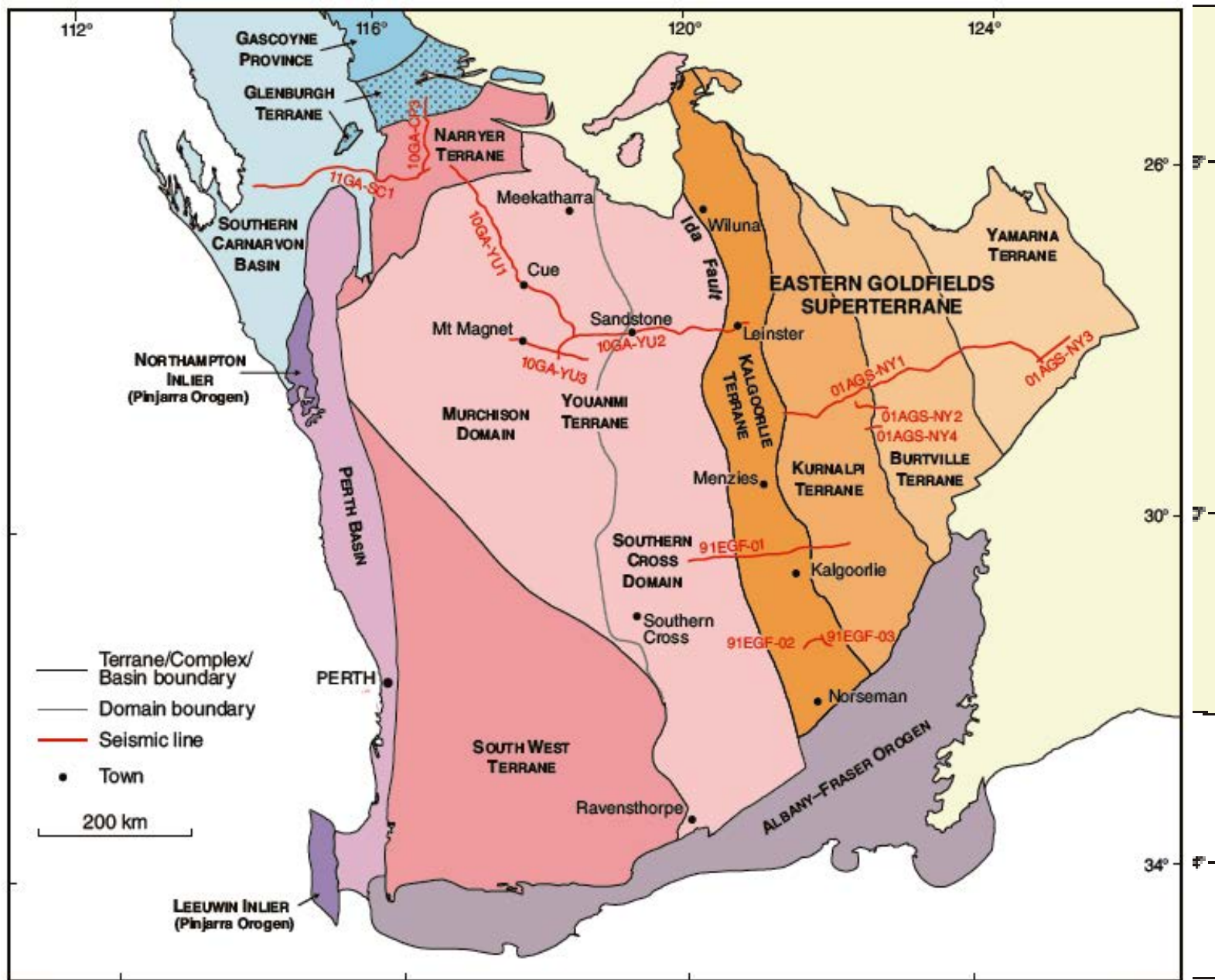
**ROYALTIES
FOR REGIONS**

EXPLORATION INCENTIVE SCHEME

Contributors

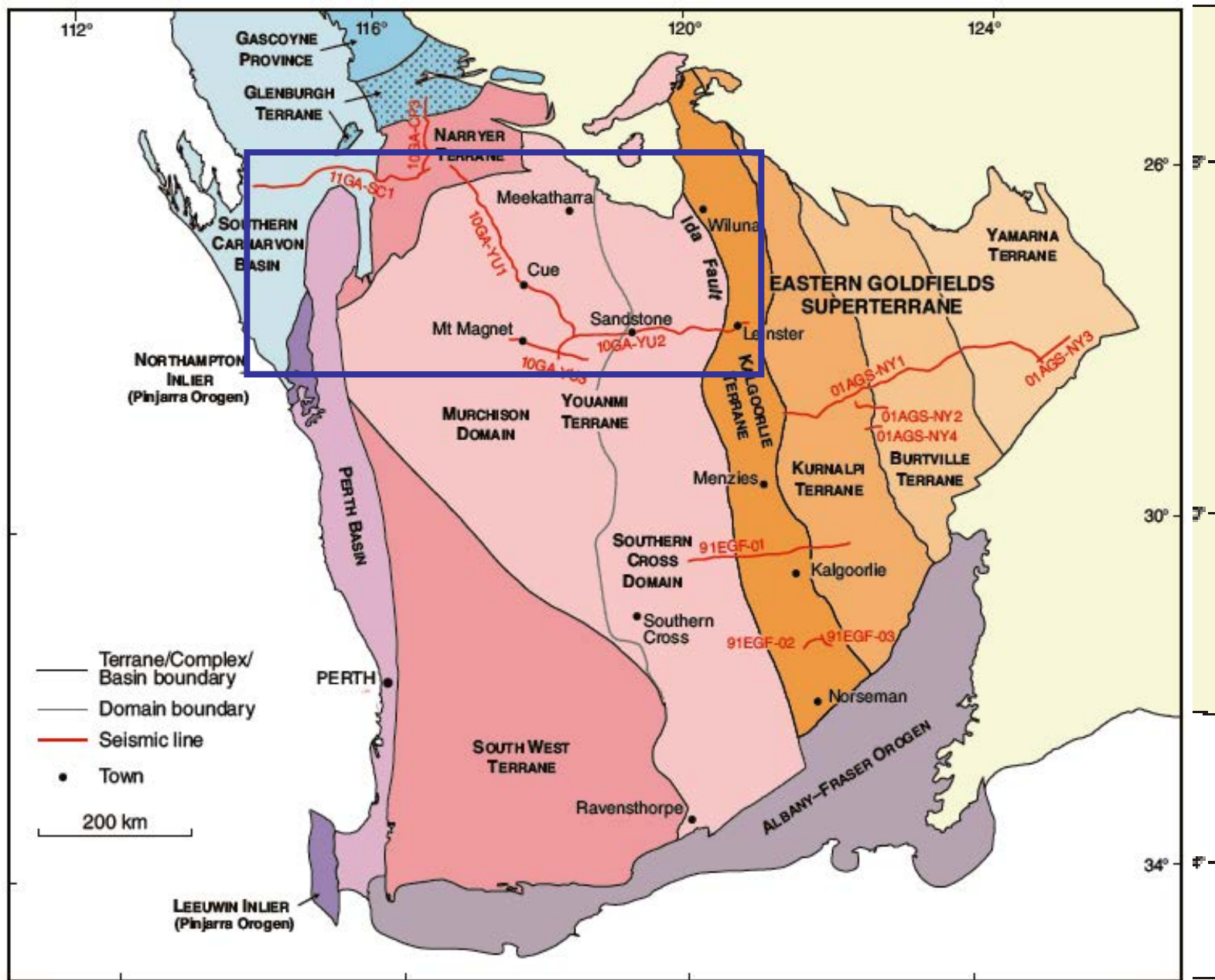
Australian National University
University of New South Wales
Geological Survey of South Australia
CICESE, Mexico

28 MAY 2010



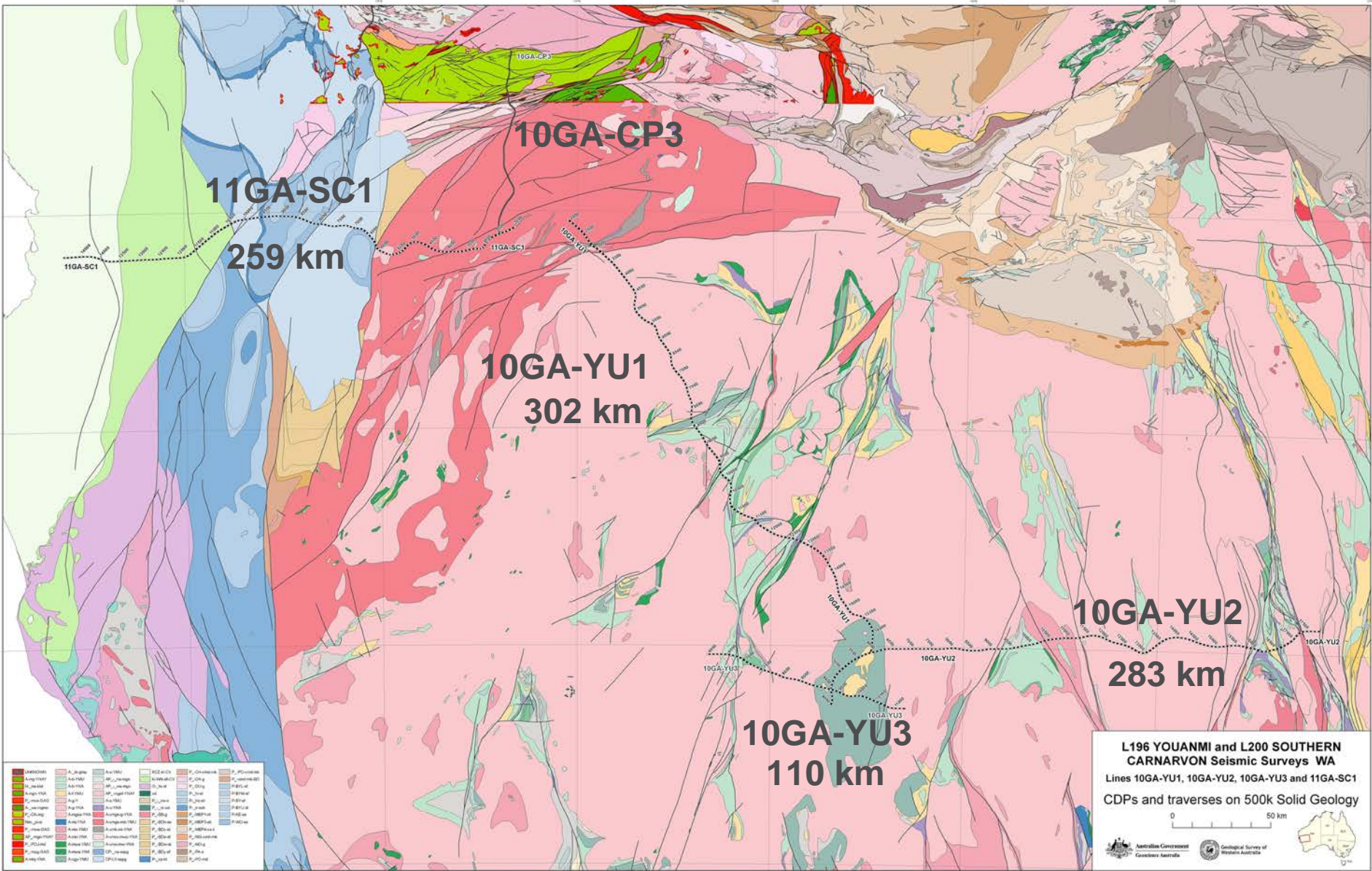
SW223c

12.02.13 1:13



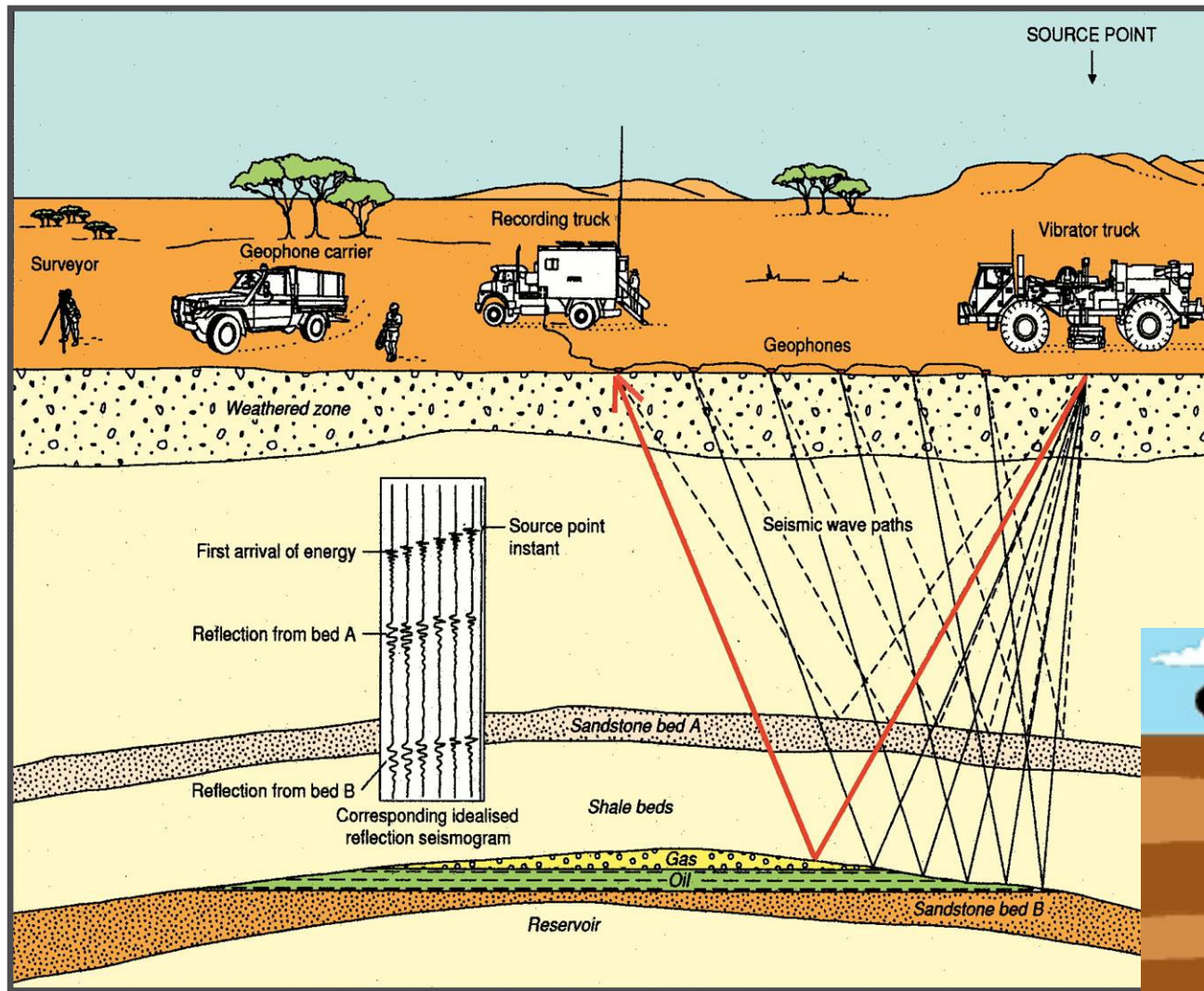
SW223c

12.02.13 1:13

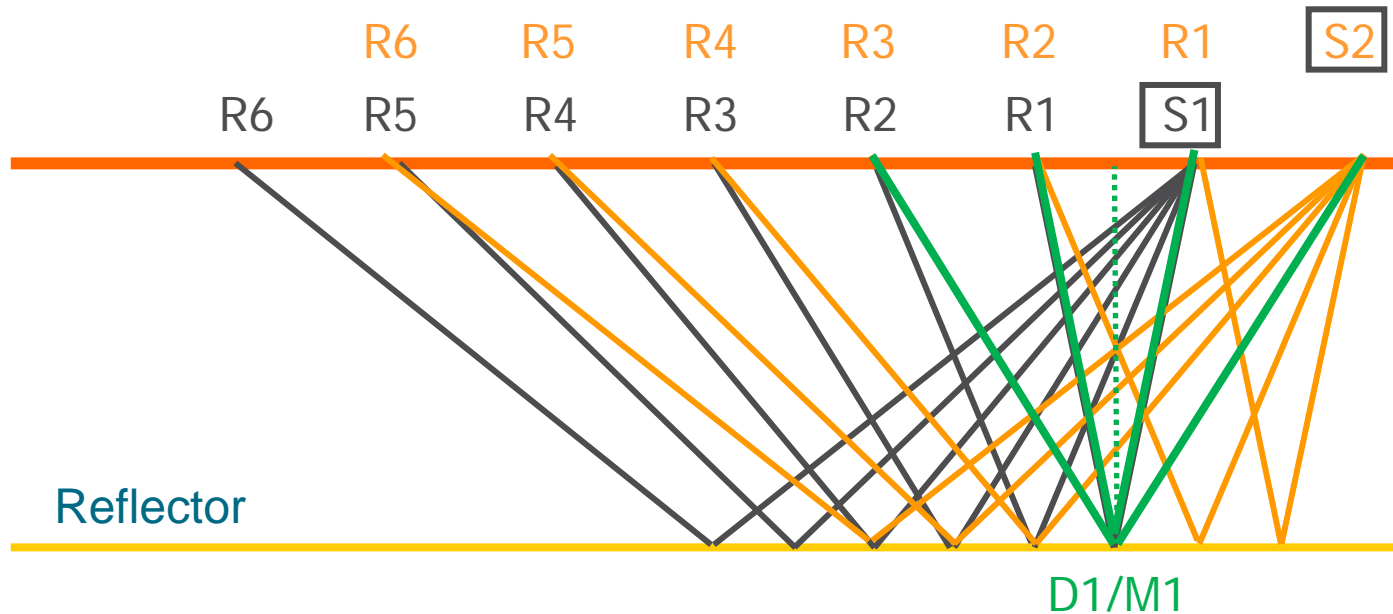


Total = 954 line km

Seismic Reflection Acquisition



CMP (Common Mid Point) Method

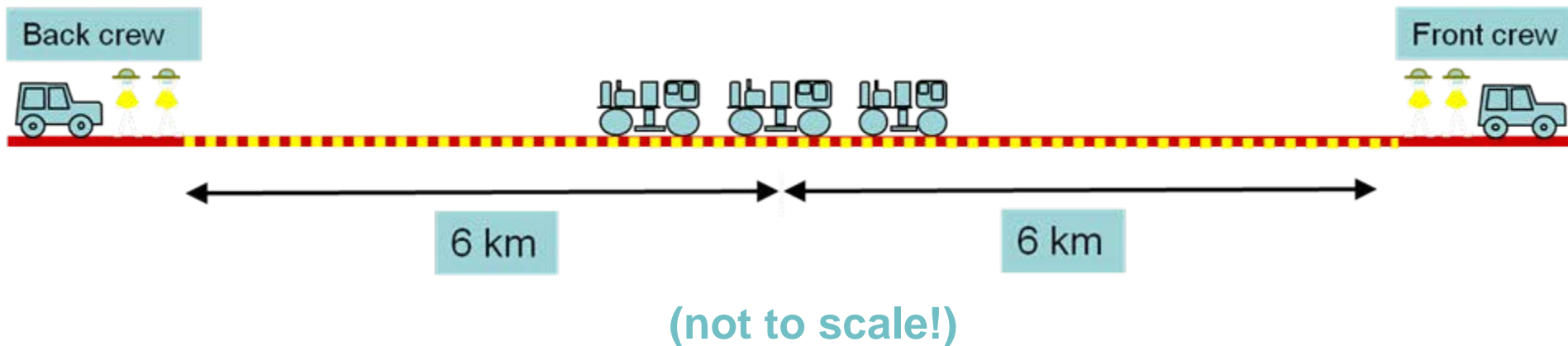


- Depth point D1/M1 is sampled by R1 for Shot 1, R3 for Shot 2 and R5 for Shot 3 (not shown).
- All paths with common midpoint are brought into a gather – 75 fold sampling for most of Youanmi & Southern Carnarvon surveys (150 fold across the greenstone belts)

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



Front Crew

Laying cable



Stomping geophone



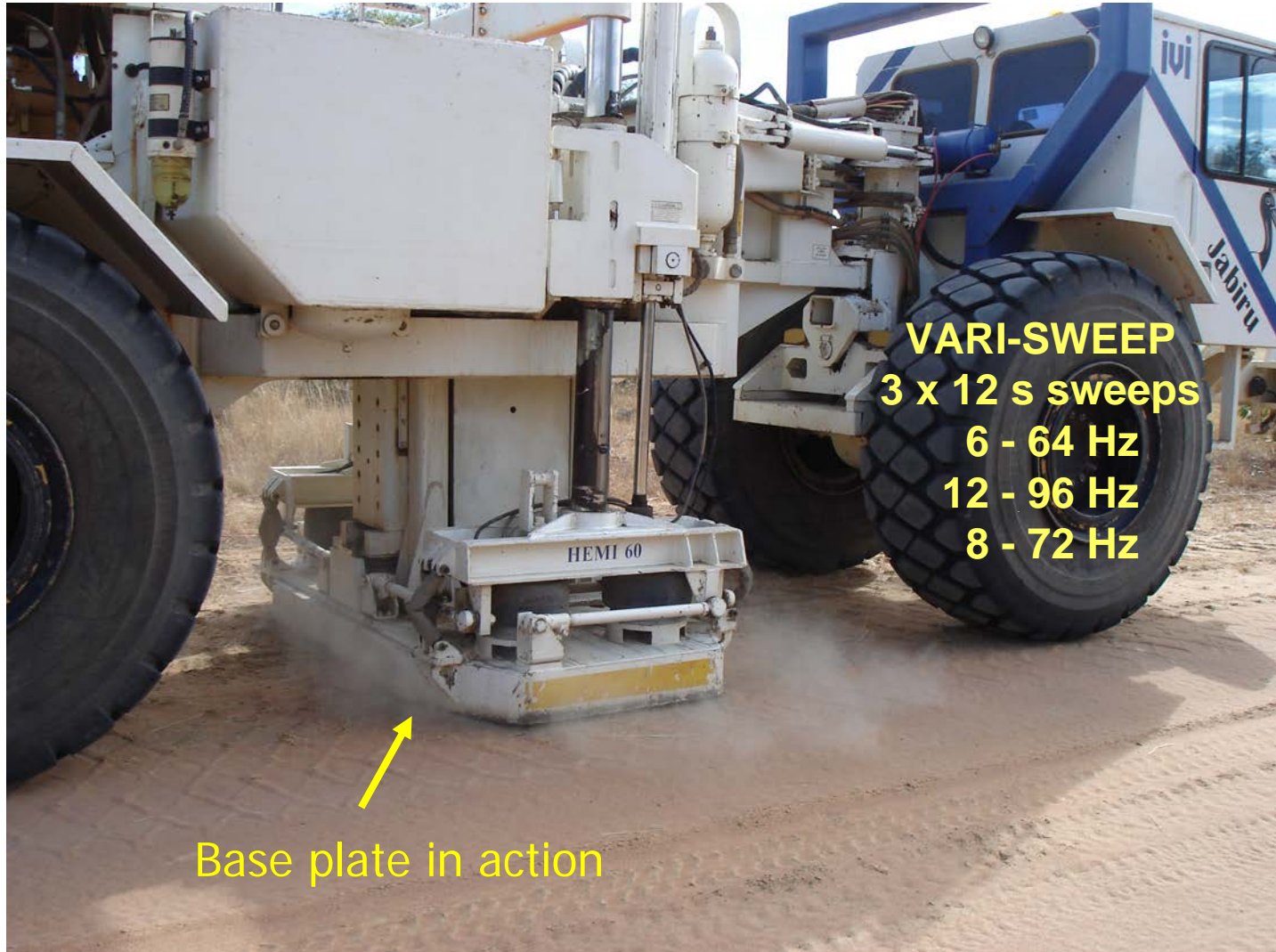
Acquisition Parameters

300 channels

Record 20 s
Sampled @ 2 ms



Acquisition Parameters



Back Crew



Pinning geophones



Pulling in cable

Seismic Data Recording and QC



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

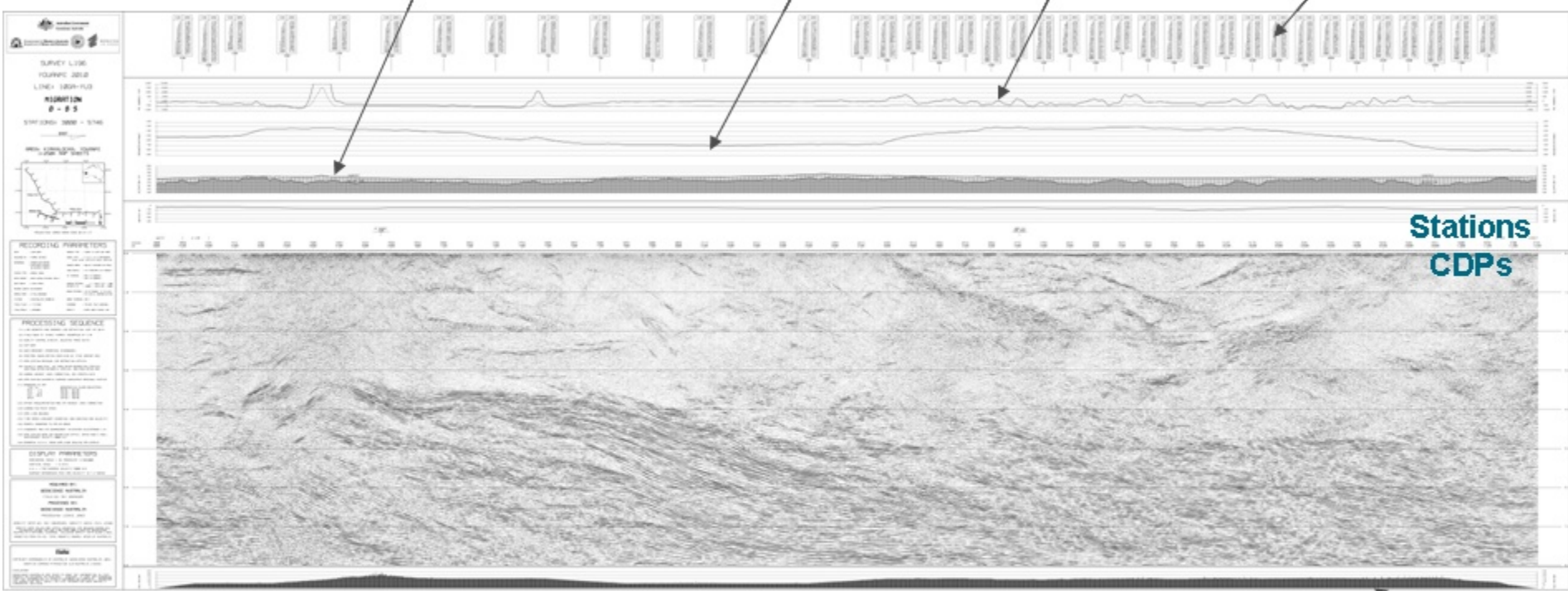
Side panel

Refraction statics
(~ depth to bedrock)

Gravity profile

TMI profile

Stacking velocities



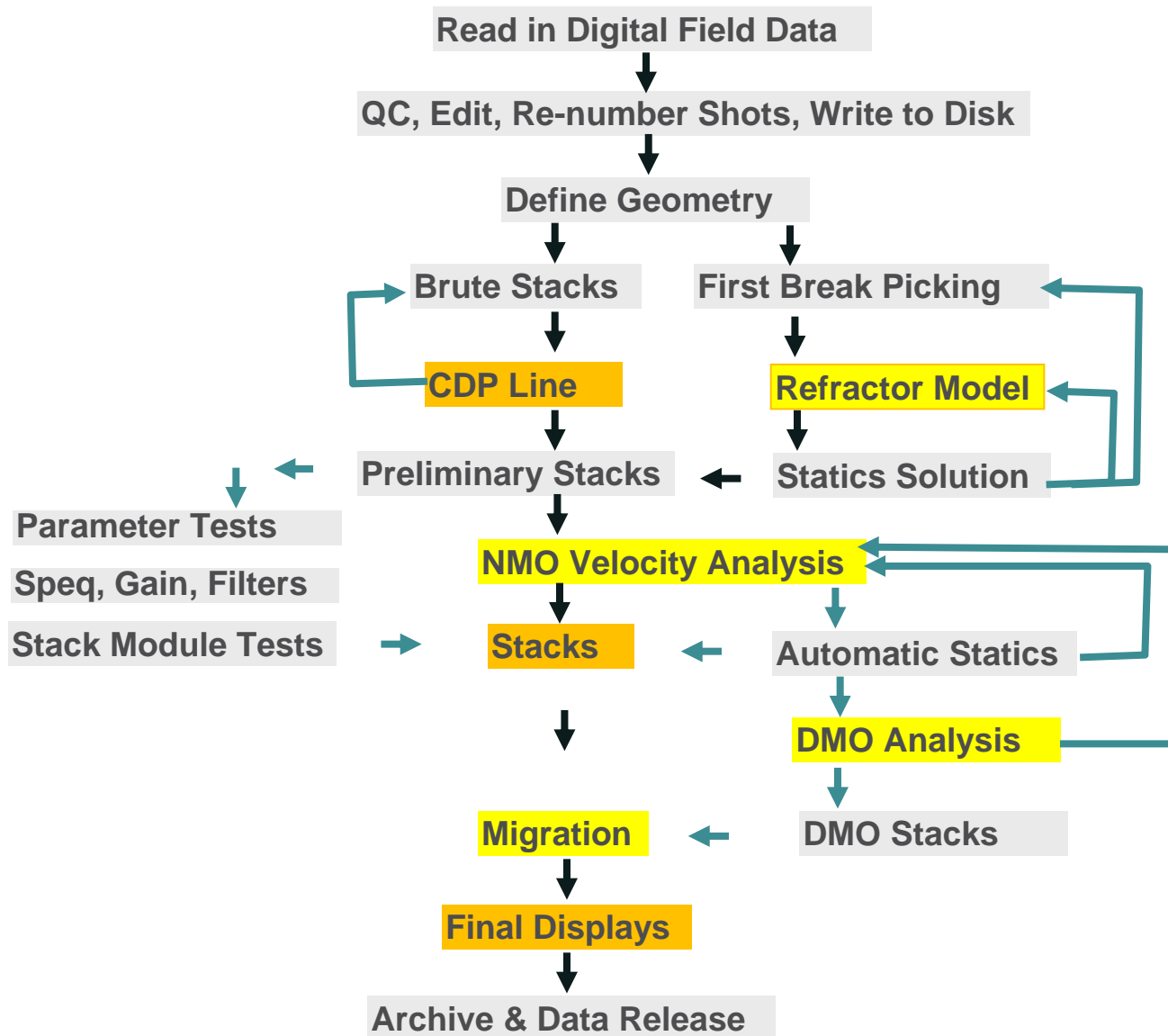
Horizontal scale – CDP (m) (CDP interval = 20 m)

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

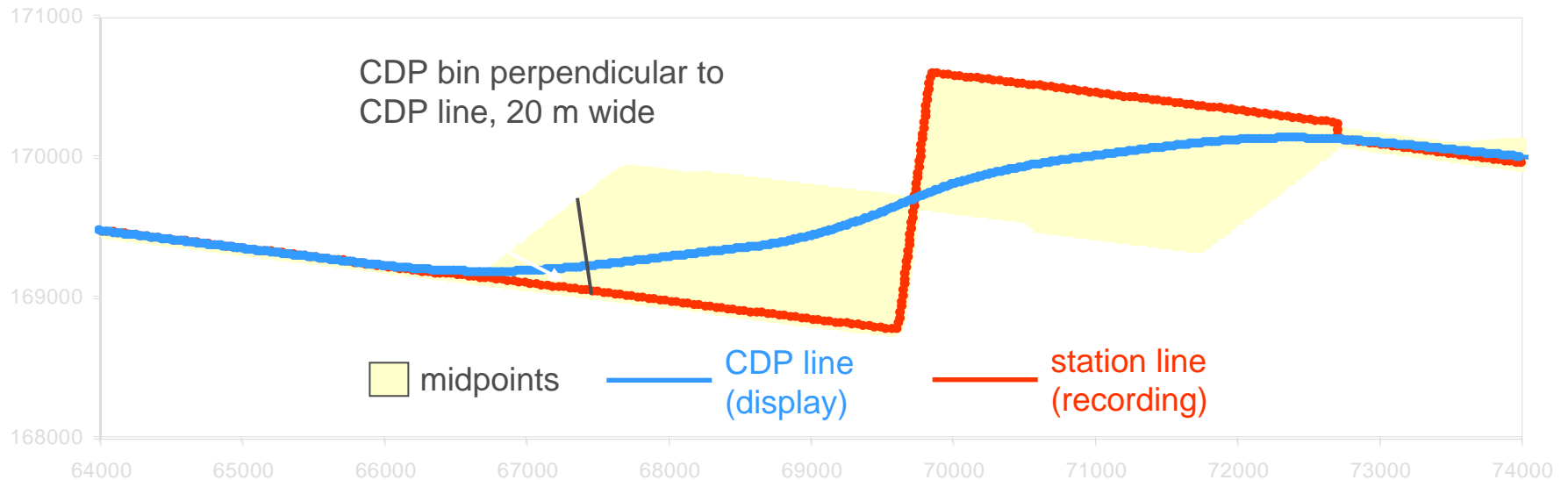
DMO correction - allows imaging of steep reflectors

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



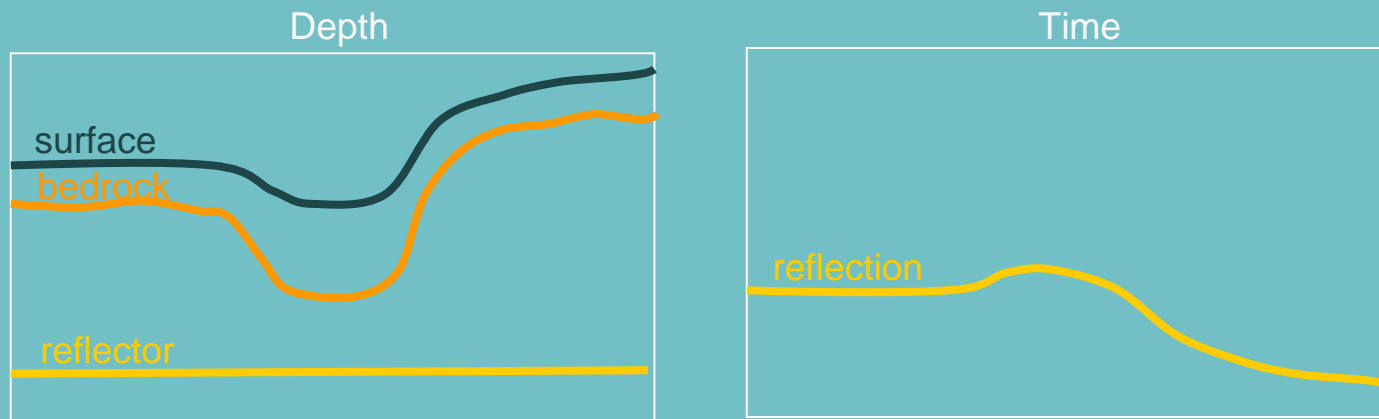
Allows for the scatter of midpoints. A best fitting CDP line is defined. Shot-receiver midpoints are assigned to the nearest CDP bin. Traces are then sorted into CDP gathers.

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

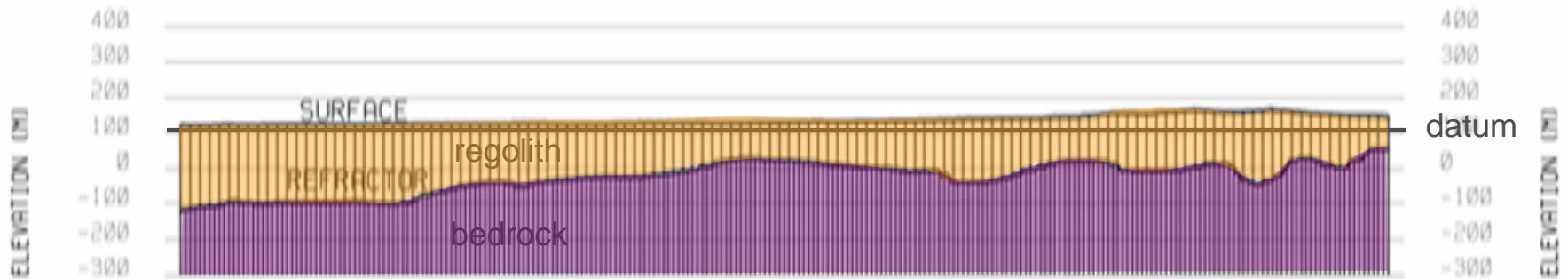
Short wavelength variations in two-way travel time (TWT) misalign reflections and degrade the stack (sum of traces)



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

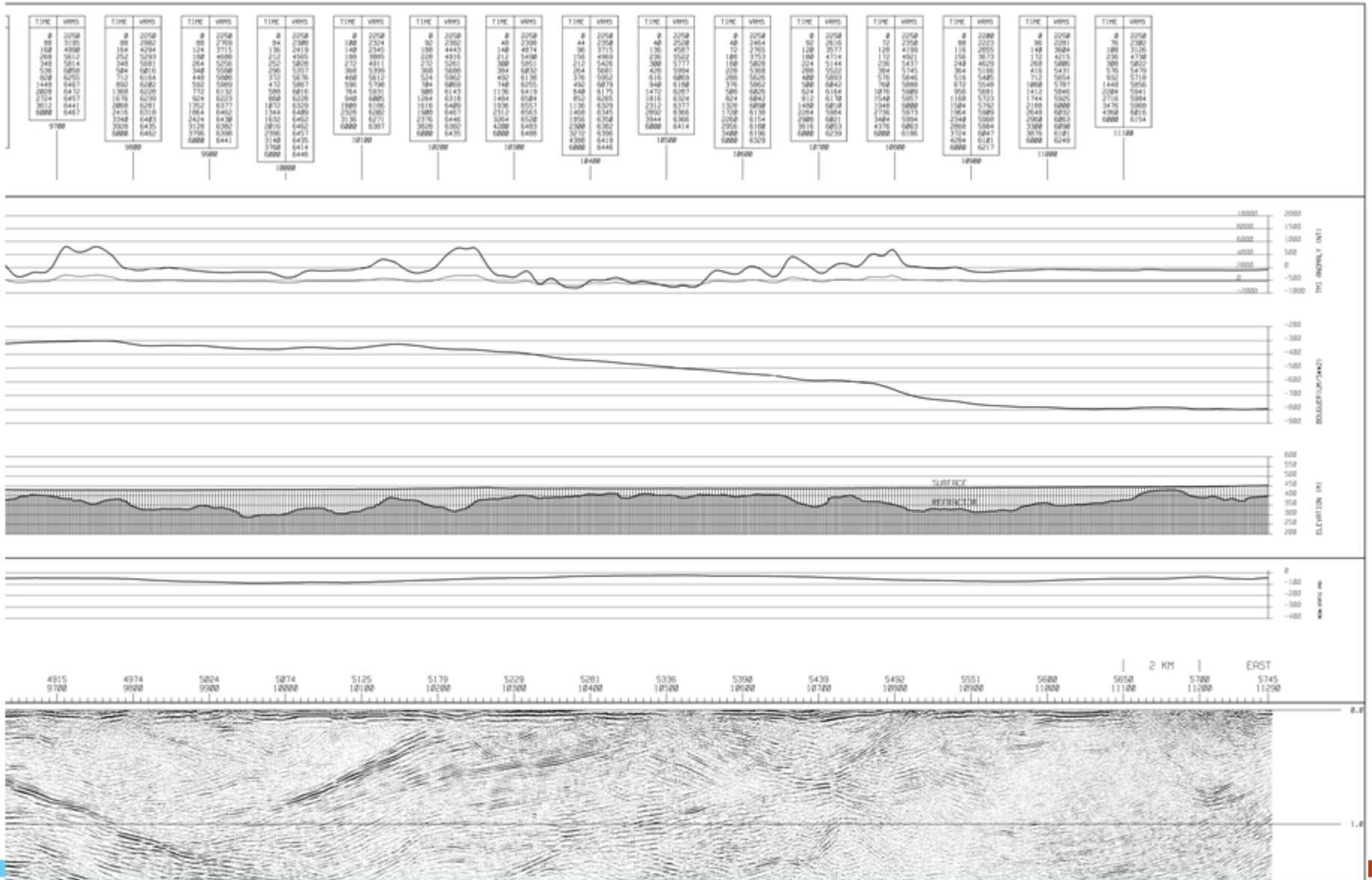
NMO correction corrects for source-receiver offset

Stacking velocity is the velocity giving best stack

Velocity analysis is:

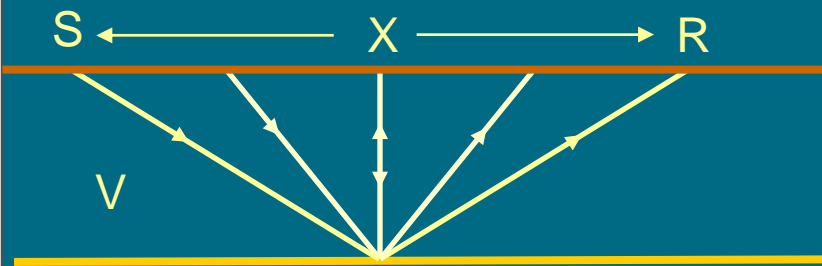
- ❖ Done every 4 km (on average) along lines
- ❖ Repeated after dip moveout (DMO) correction
- ❖ Most critical and difficult in top 1 second
- ❖ Used as starting point for migration velocity

Stacking Velocities (time-velocity pairs)



Normal Moveout (NMO) Correction

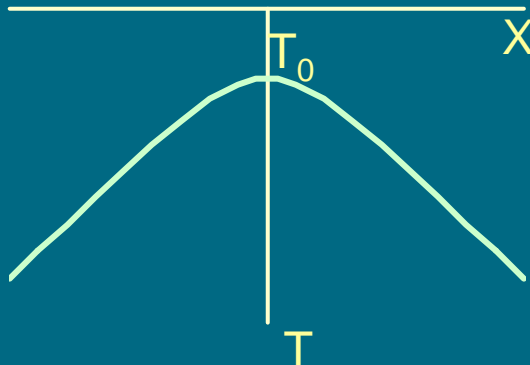
Horizontal reflector



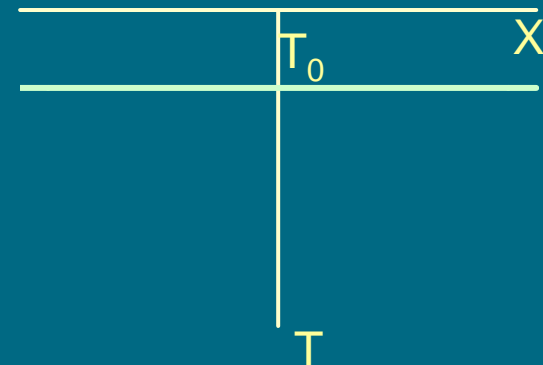
Moveout relationship

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

Uncorrected CDP gather



Corrected CDP gather

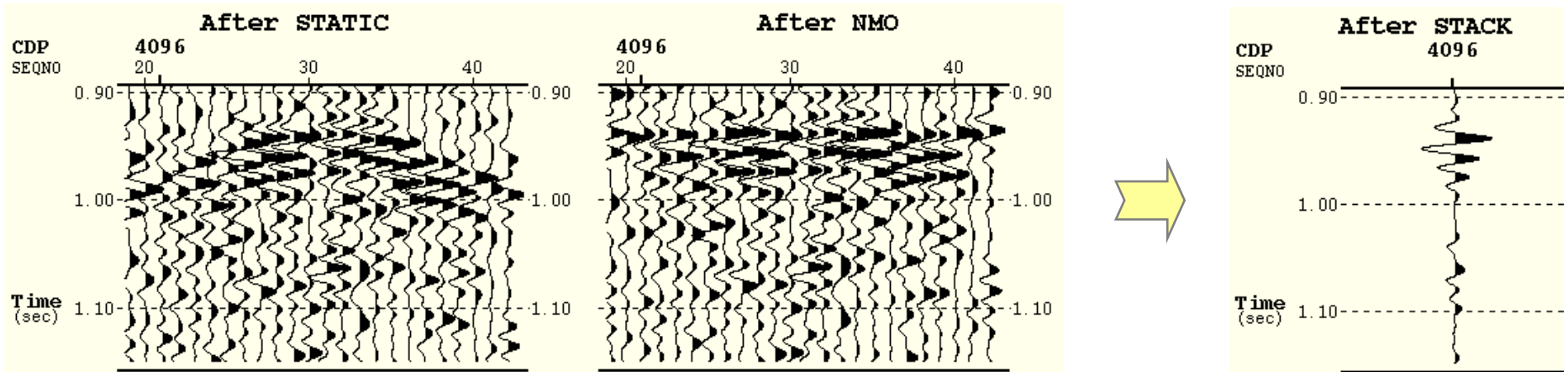


Normal Moveout Correction and Stack

Uncorrected CDP gather

Corrected CDP gather

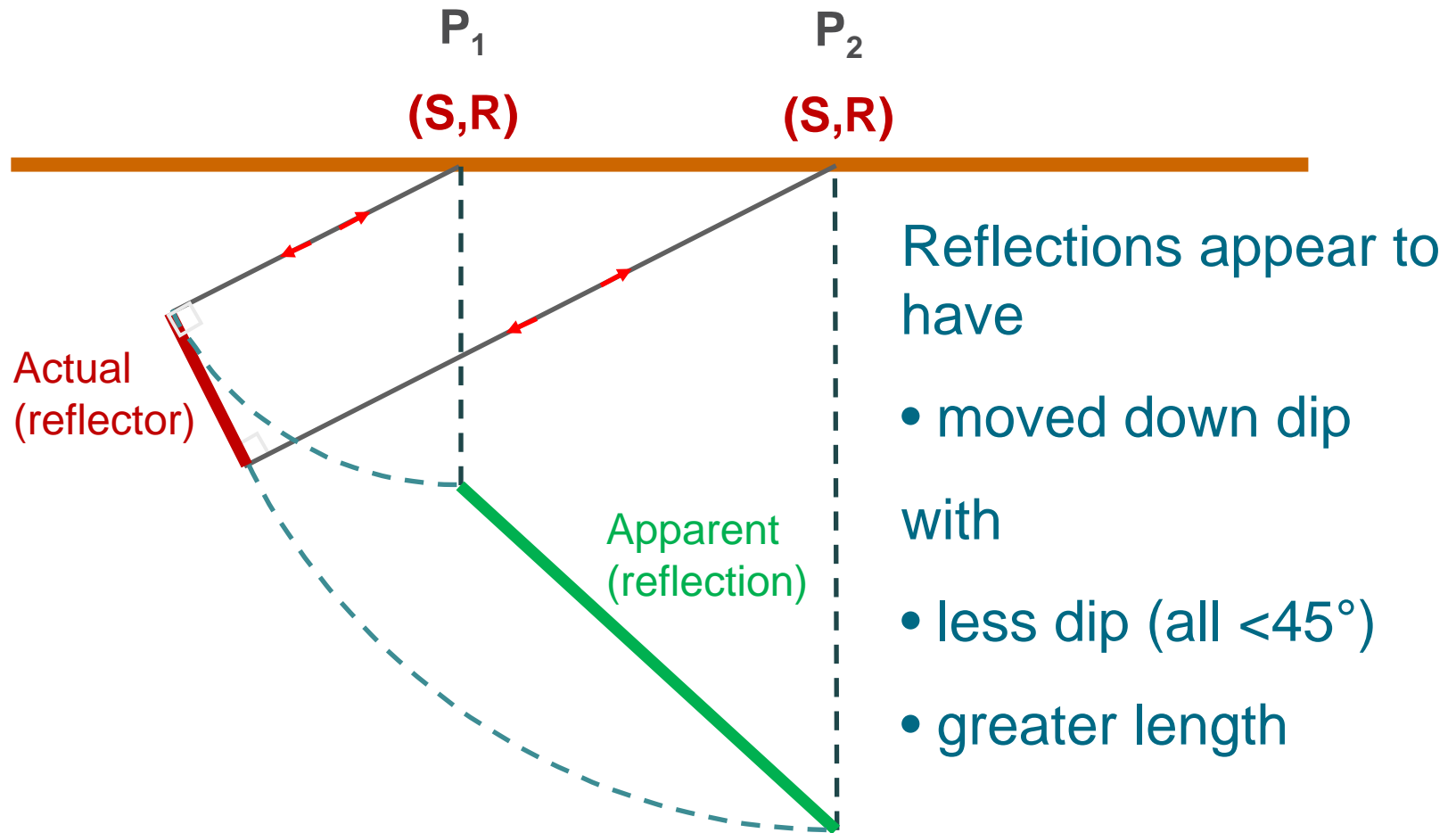
Stacked seismic trace



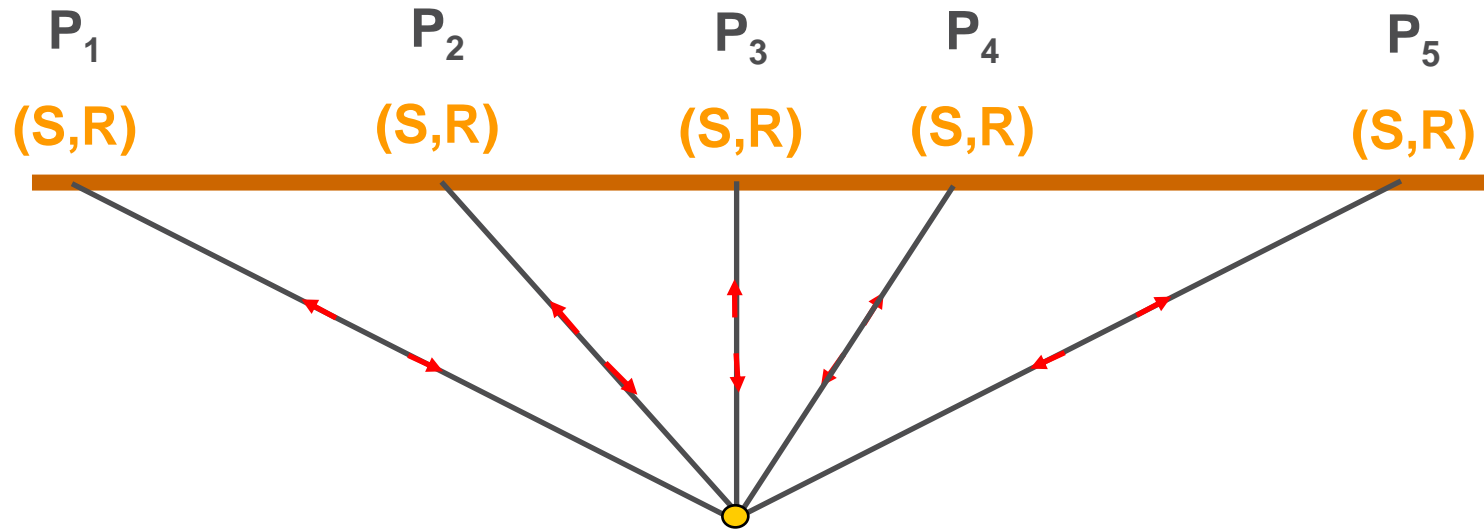
Stacking improves signal to noise by \sqrt{n} , where n is the fold

n	10	75	150
\sqrt{n}	3	9	12

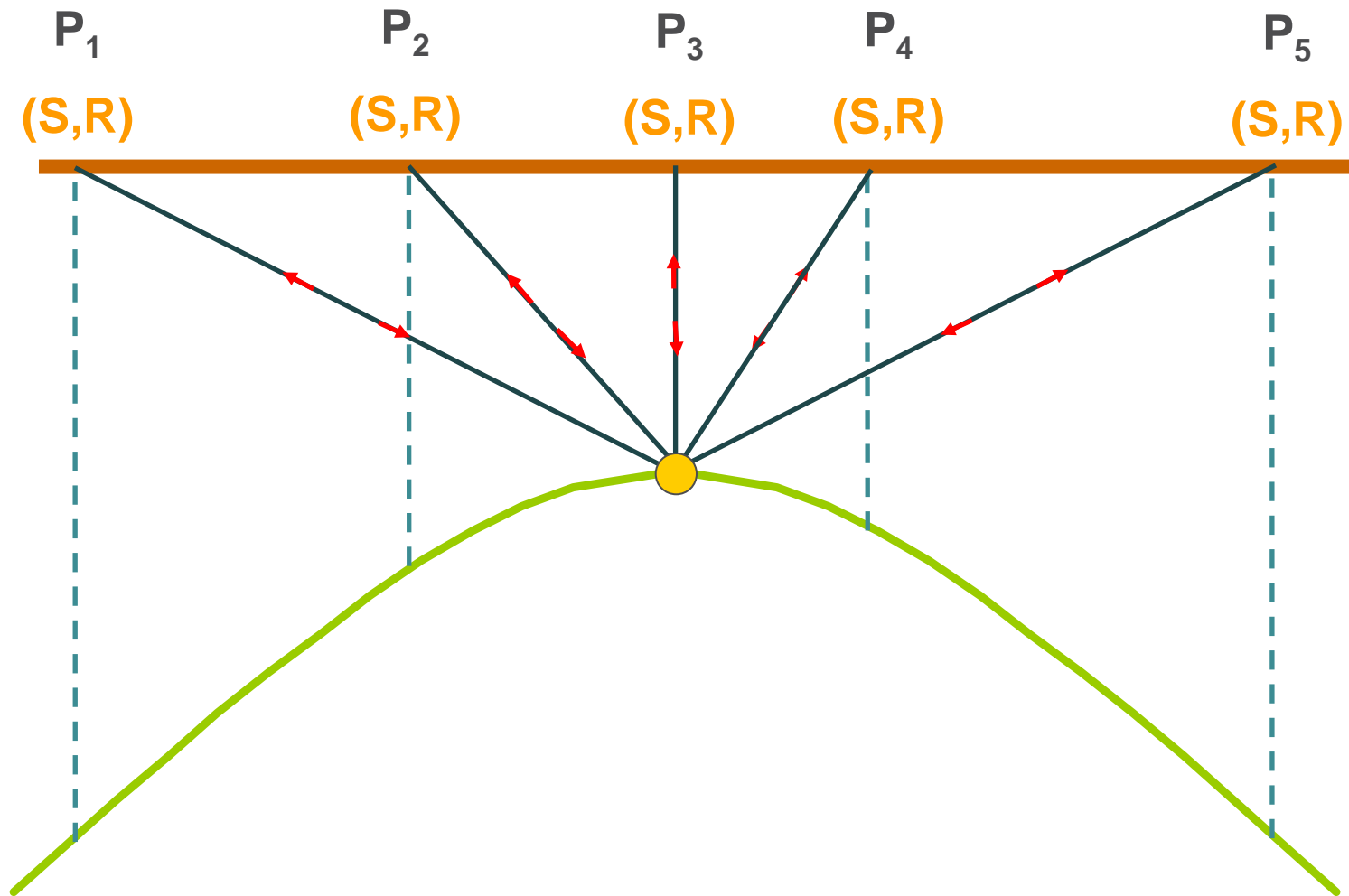
Imaging of Dipping Reflectors on Stack Section



Generation of Diffractions



Generation of Diffractions (point source)



Migration

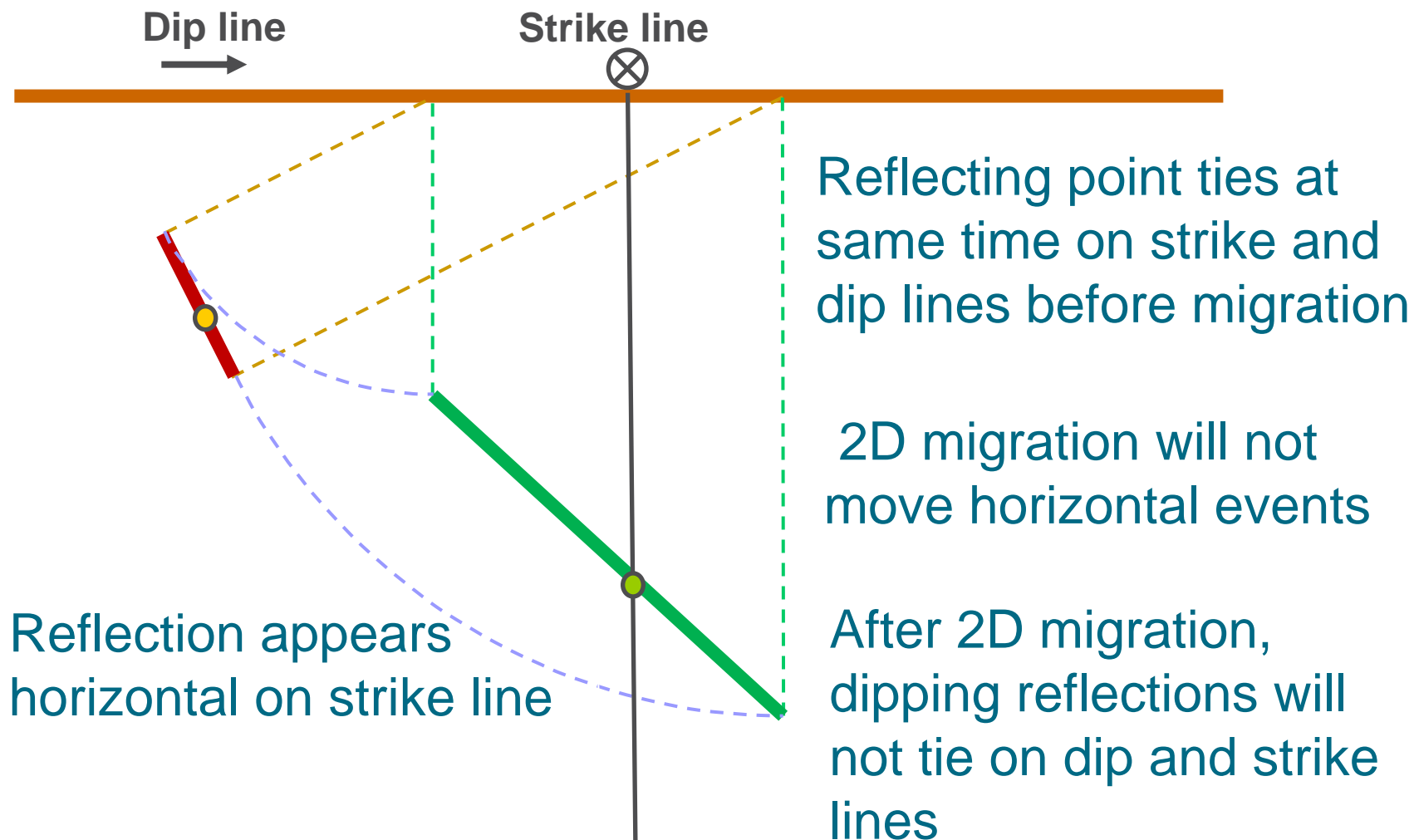
Migration improves a seismic image by

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

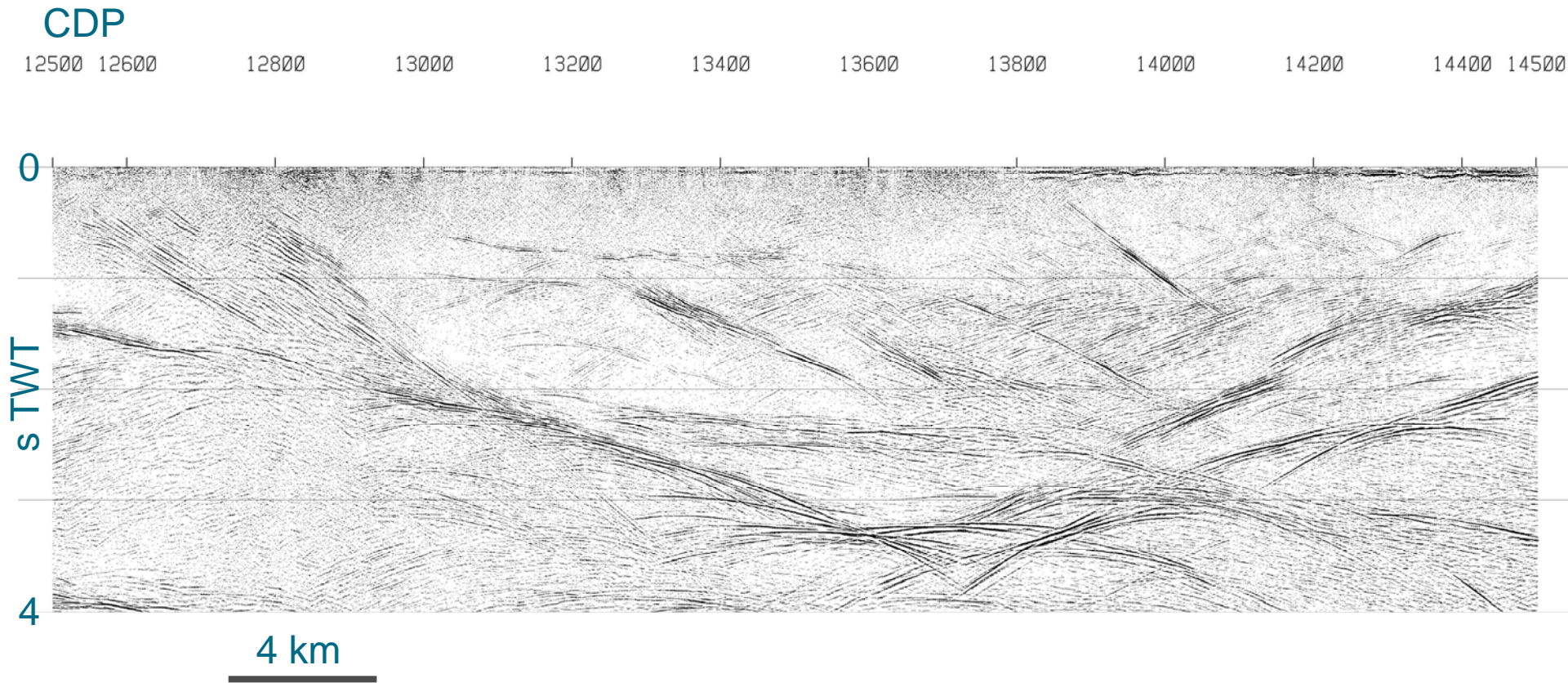
Migration can be evaluated by

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

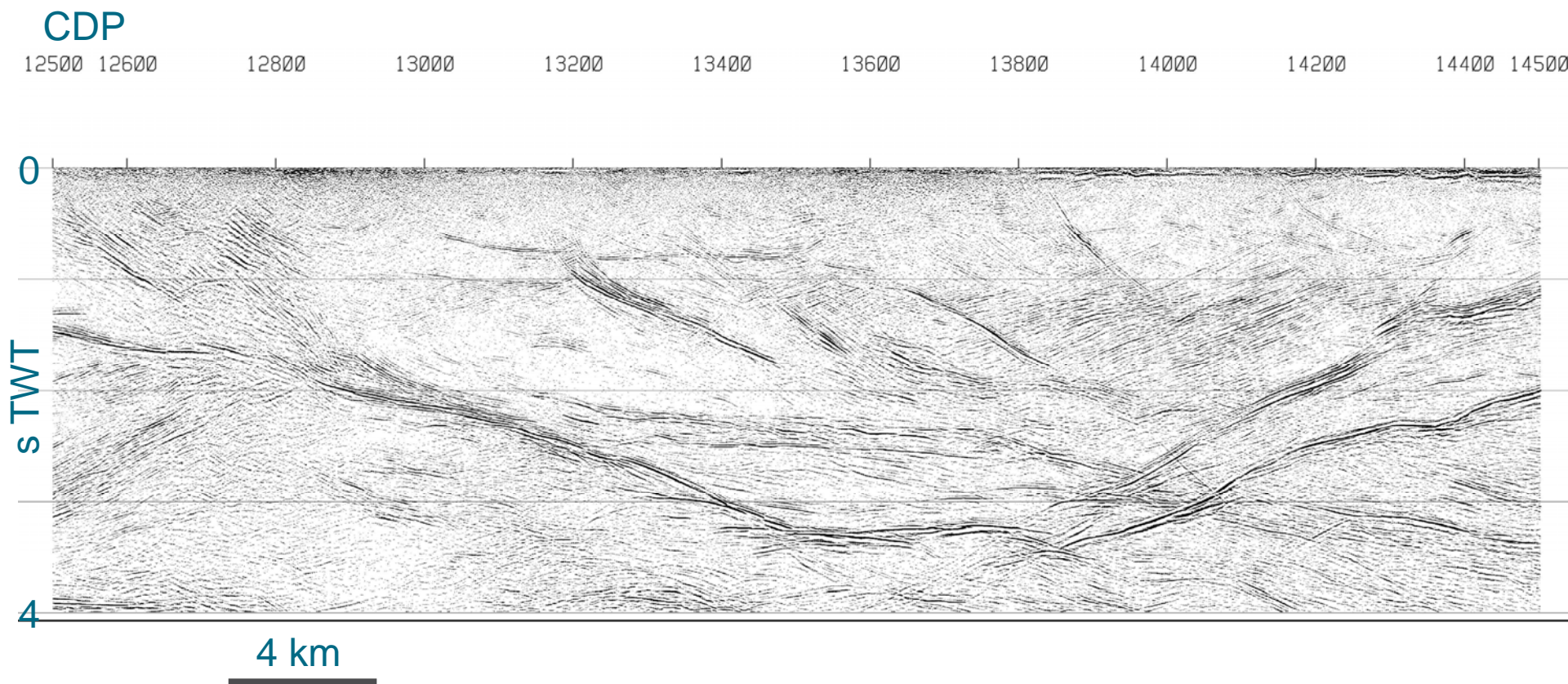
Limitations of 2D Migration



Portion of 10GA-YU1 - Stack

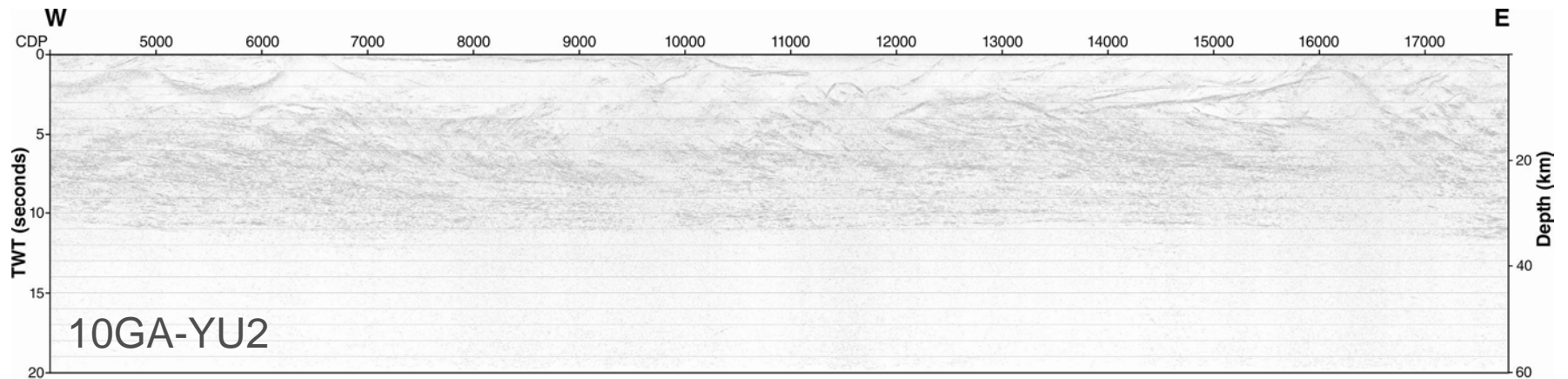
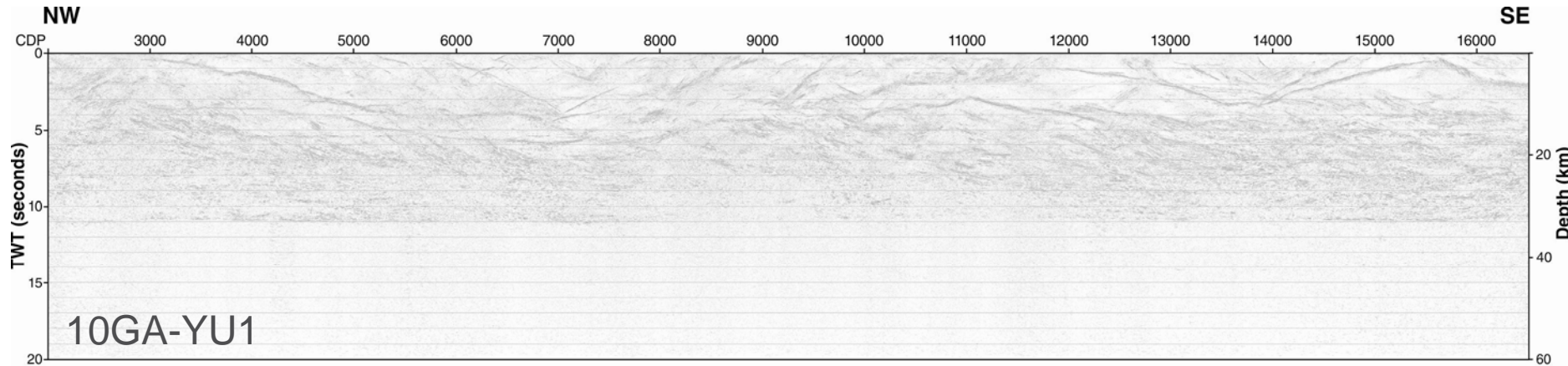


Portion of 10GA-YU1 - Migration

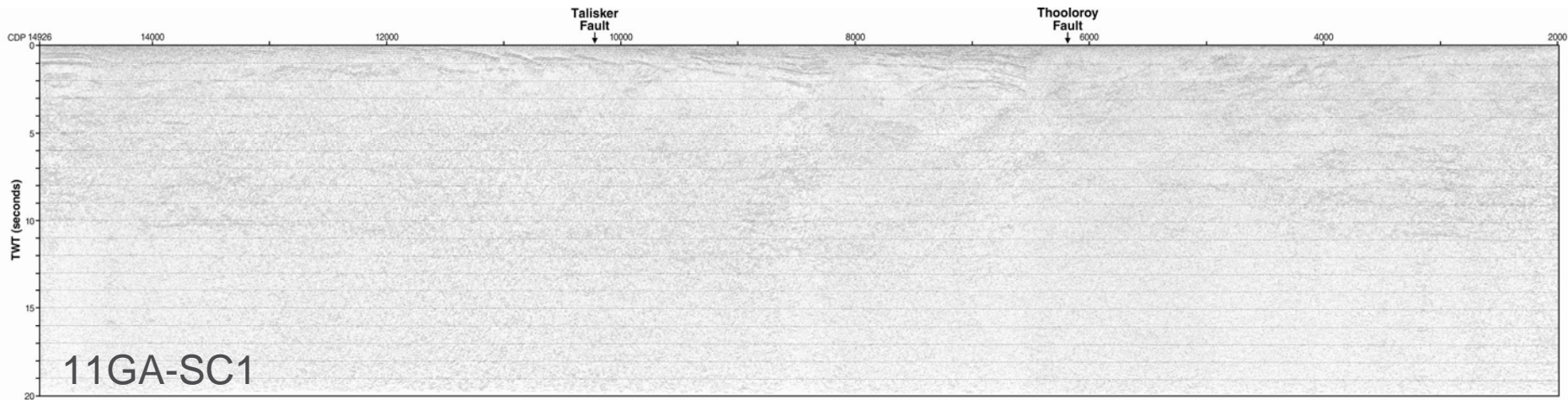
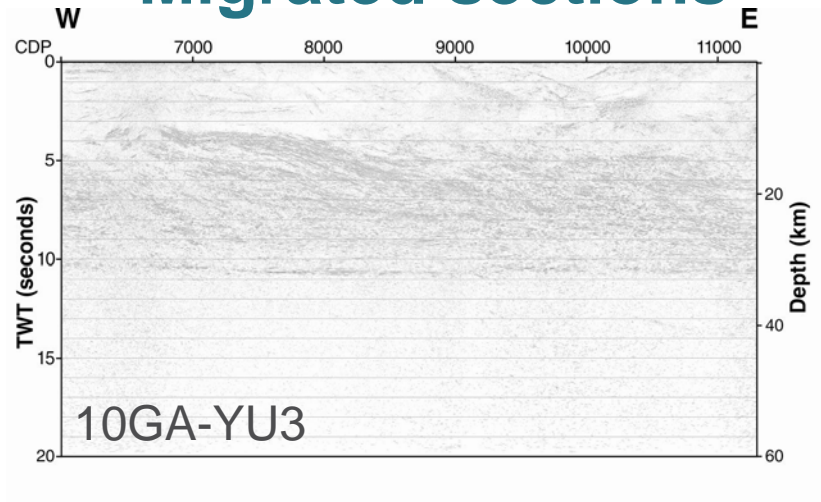


Final Displays – 1

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



THANK YOU

Seismic data and interpretations can be downloaded from:
<http://www.ga.gov.au/minerals/projects/current-projects/seismic-acquisition-processing.html>

Phone: +61 2 6249 9111

Web: www.ga.gov.au

Email: Russell.Korsch@ga.gov.au

Address: Cnr Jerrabomberra Avenue and Hindmarsh Drive, Symonston ACT 2609

Postal Address: GPO Box 378, Canberra ACT 2601