Pembina Cardium CO_2-EOR Pilot Project: Timelapse Seismic Analysis

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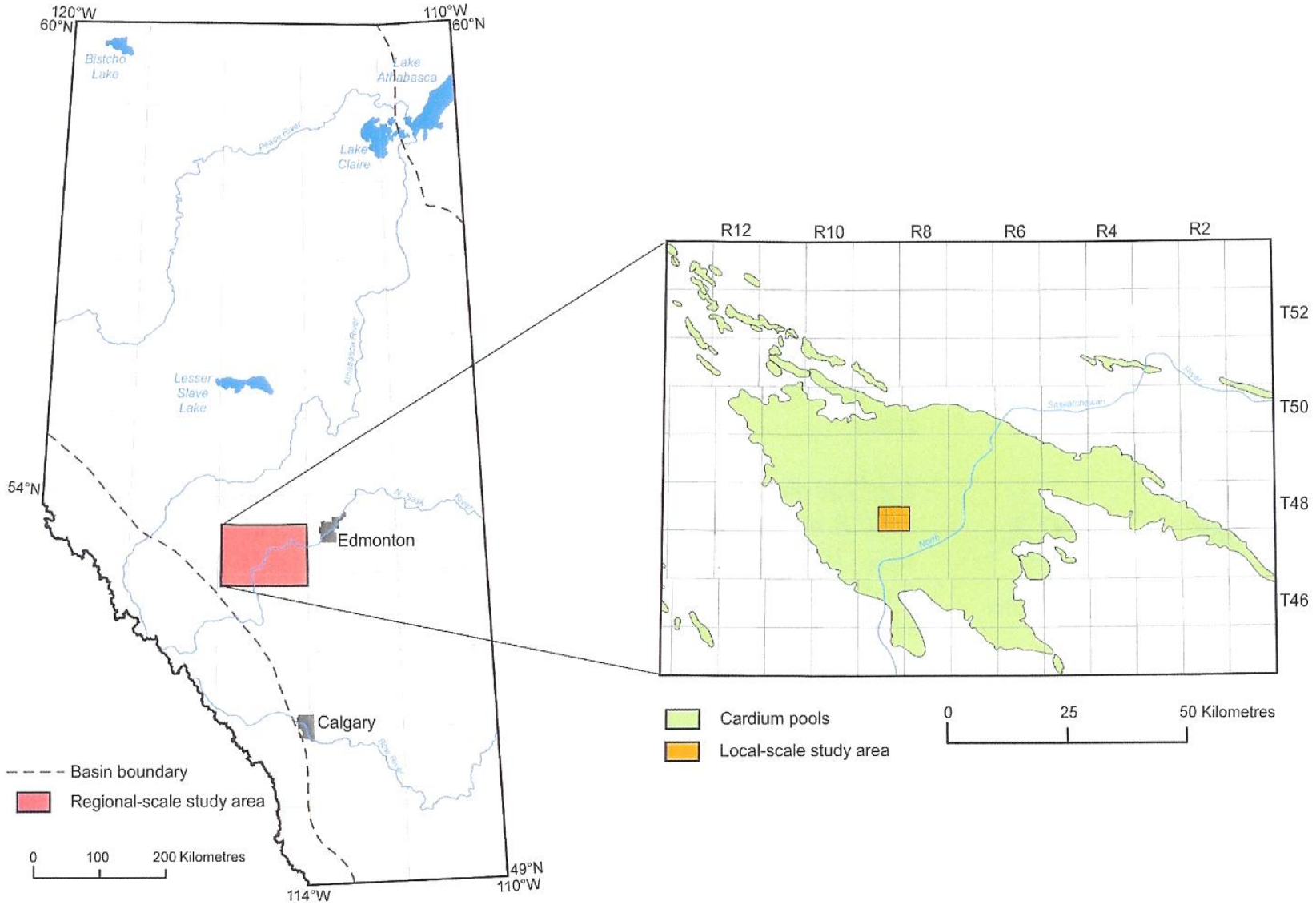
Outline

- Project Overview
- Study Area
- Time-Lapse Seismic Program
- Time-Lapse Interpretation: 2D and 3D
- Modelling: Rock Physics
- Conclusions

Study Area



(Dashtgard et al., 2007)

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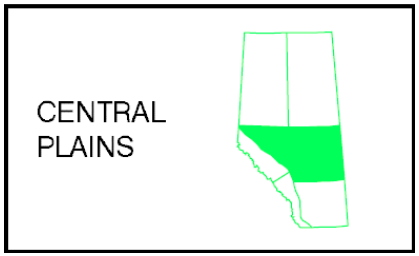
Table of Formations – Central Alberta



LEGEND

LITHOLOGIC COLOUR CODE

- Glacial deposits (drift, soils)
- Clastics (sandstones, siltstones, conglomerate)
- Shales

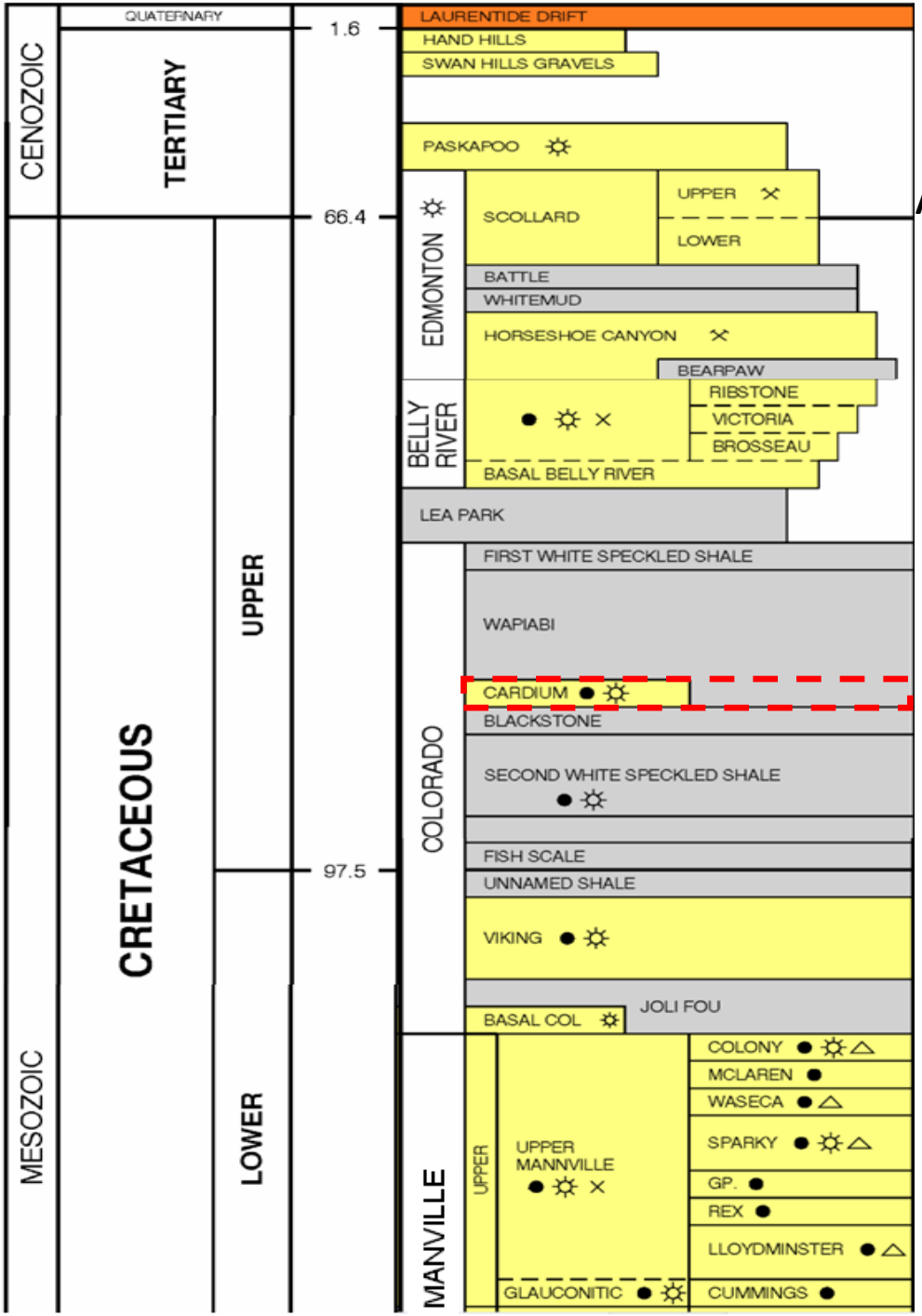
GEOLOGICAL CONTACTS

- Formation, group boundary
- Correlation uncertain
- Terminology transition
- Member, zone, unit boundary

RESOURCES OCCURRENCE

- Gas
- Oil
- Bitumen
- Coal Mining
- Coal Occurrences

(AEUB, 2007)



Ardley Coals (~ 400 m)

Cardium (~ 1600 m)

Viking (~ 1900 m)

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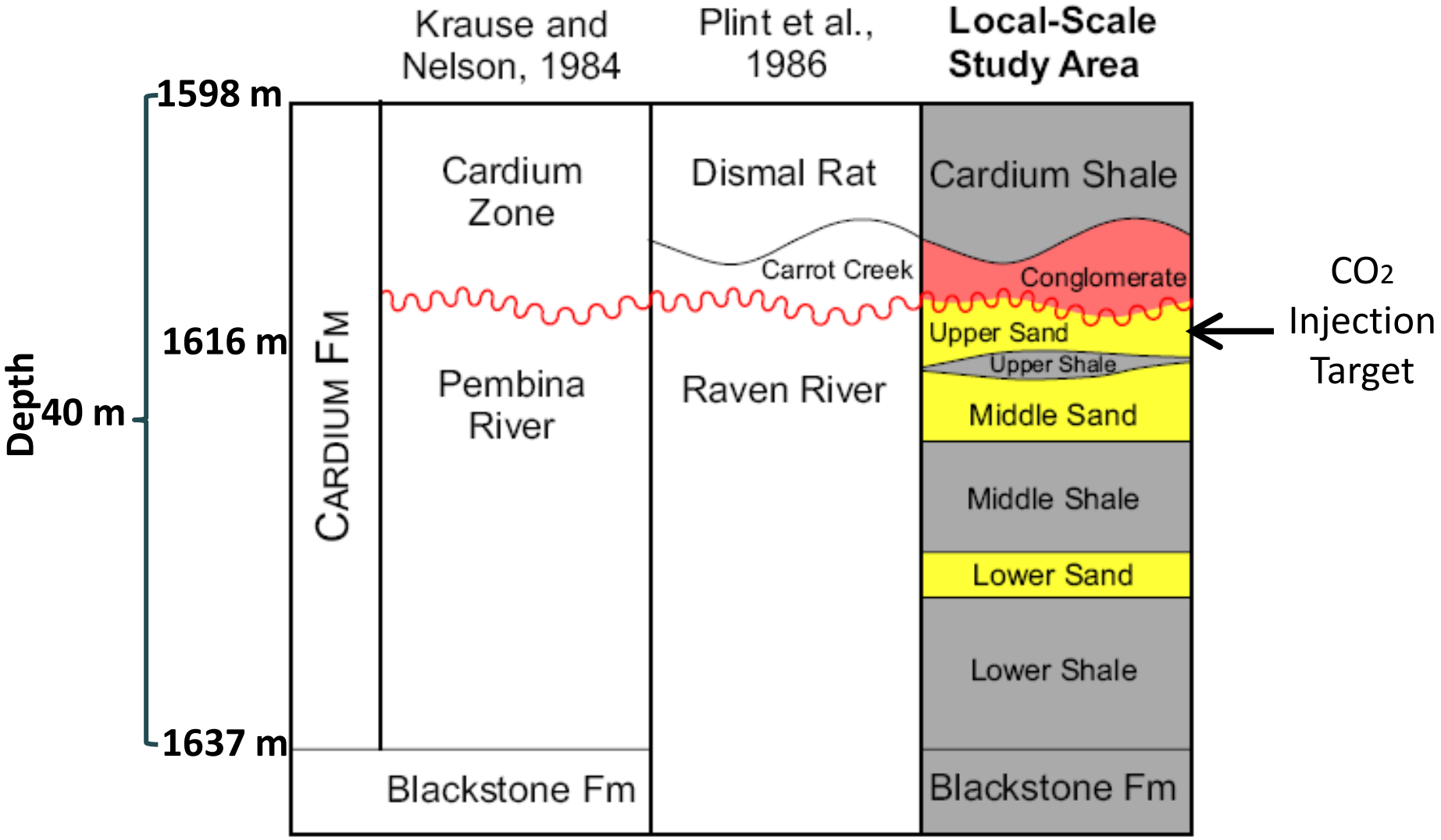
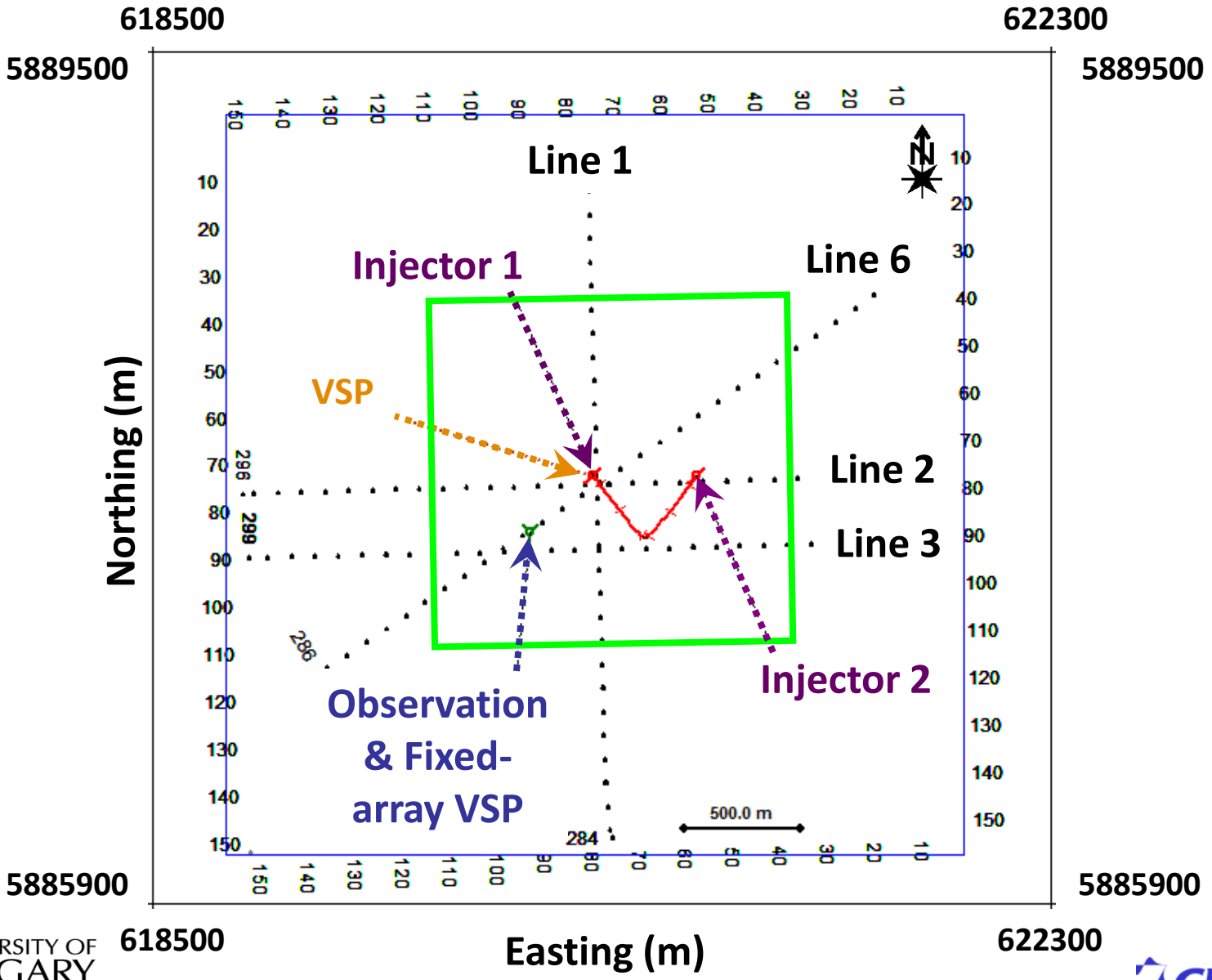
Study Area: Cardium Formation



(Dashtgard et al., 2007)

Seismic Program



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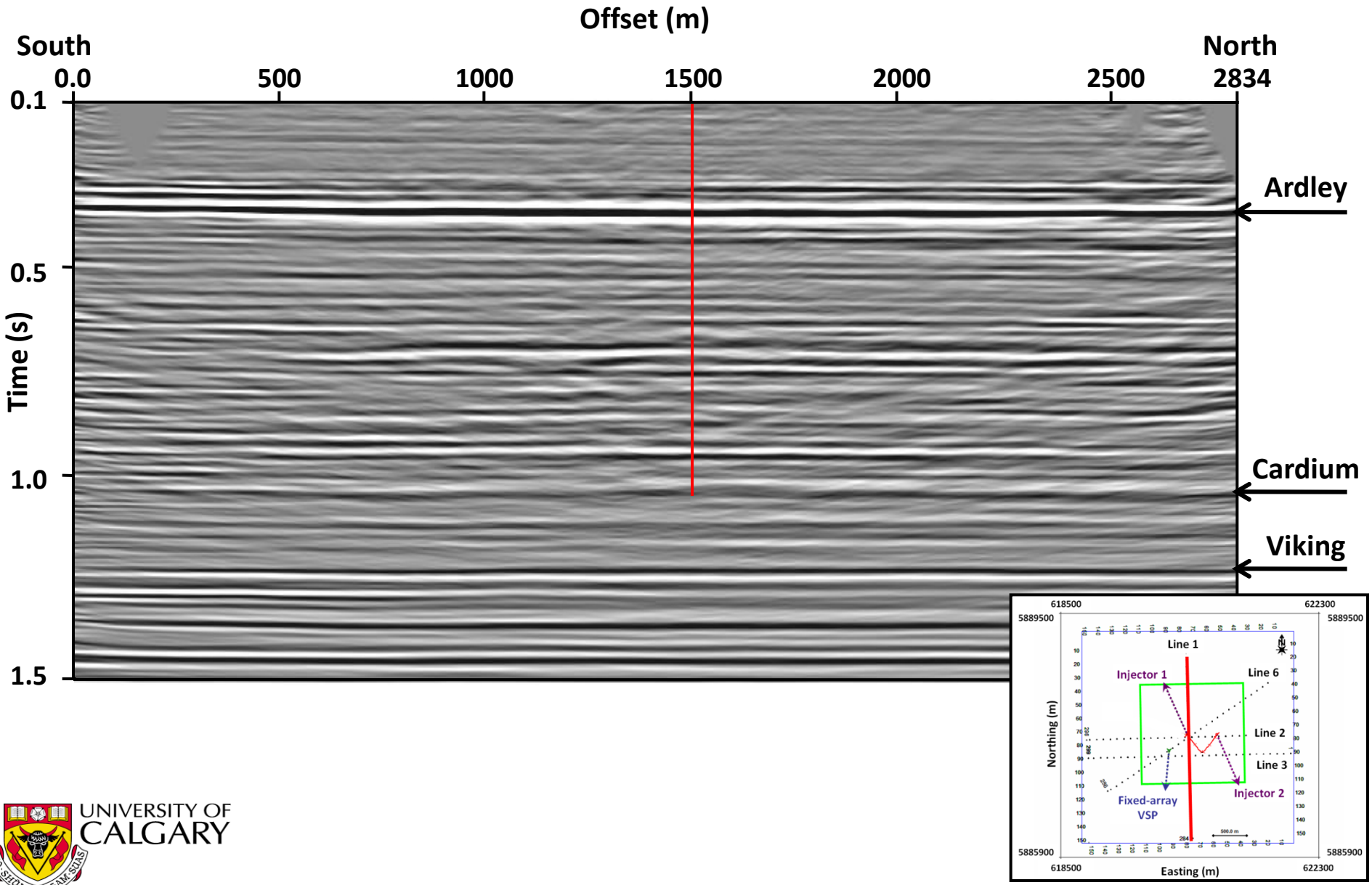
	Seismic Data	Date	CO_2 (tons)
Phase I (baseline)	- Lines 1,2 and 3 - Fixed-array VSP	March 2005	0
Phase II (1st mont.)	- Lines 1,2 and 3 - Fixed-array VSP	Dec. 2005	~ 15,000
Phase III (2nd mont.)	- Lines 1,2 and 3 - Fixed-array VSP - Addition of: 16-level VSP & Line 6	March 2007	~ 45,000

Line 1 - Phase I (P-wave)



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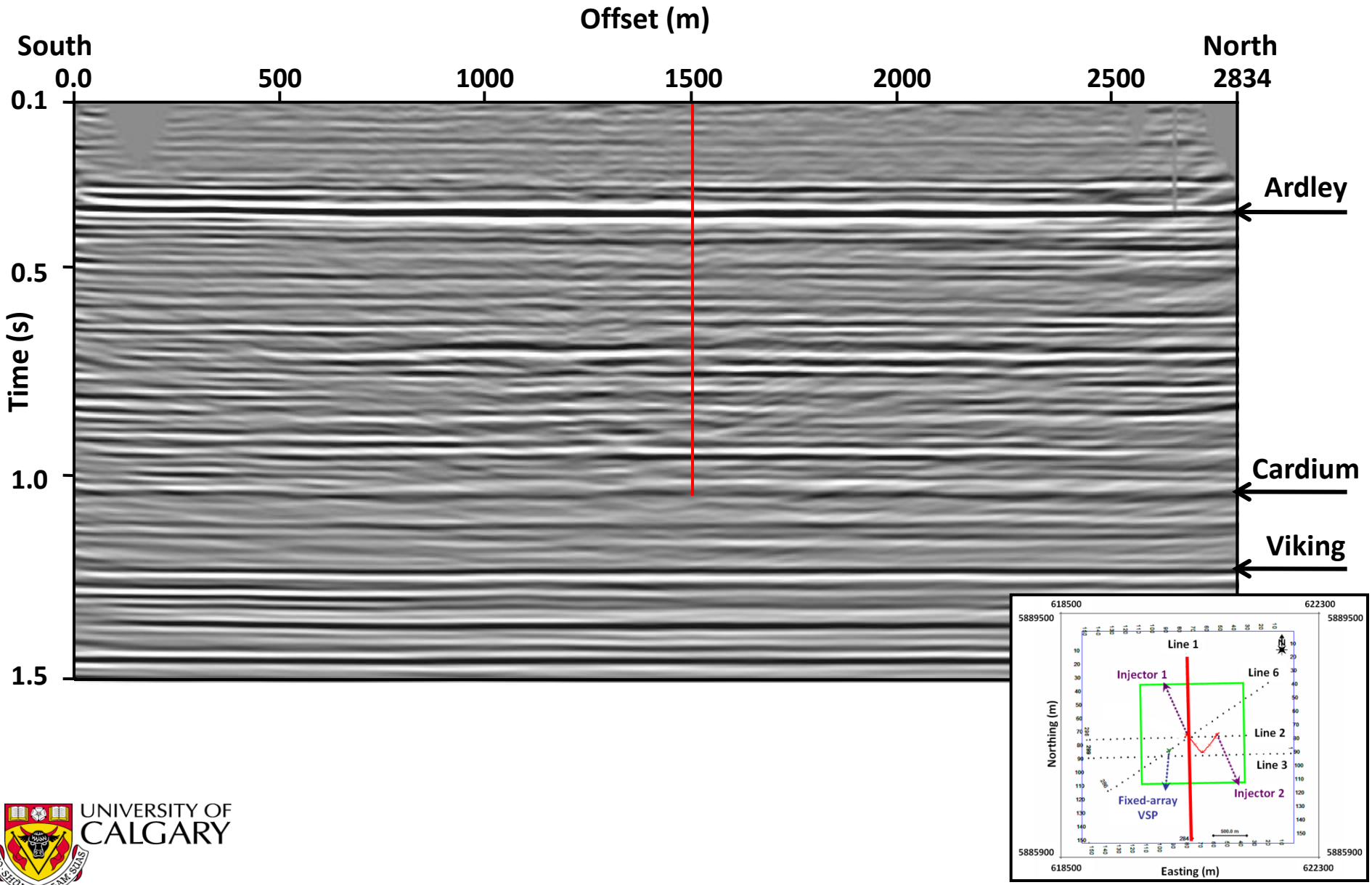
Line 1 - Phase III (P-wave)



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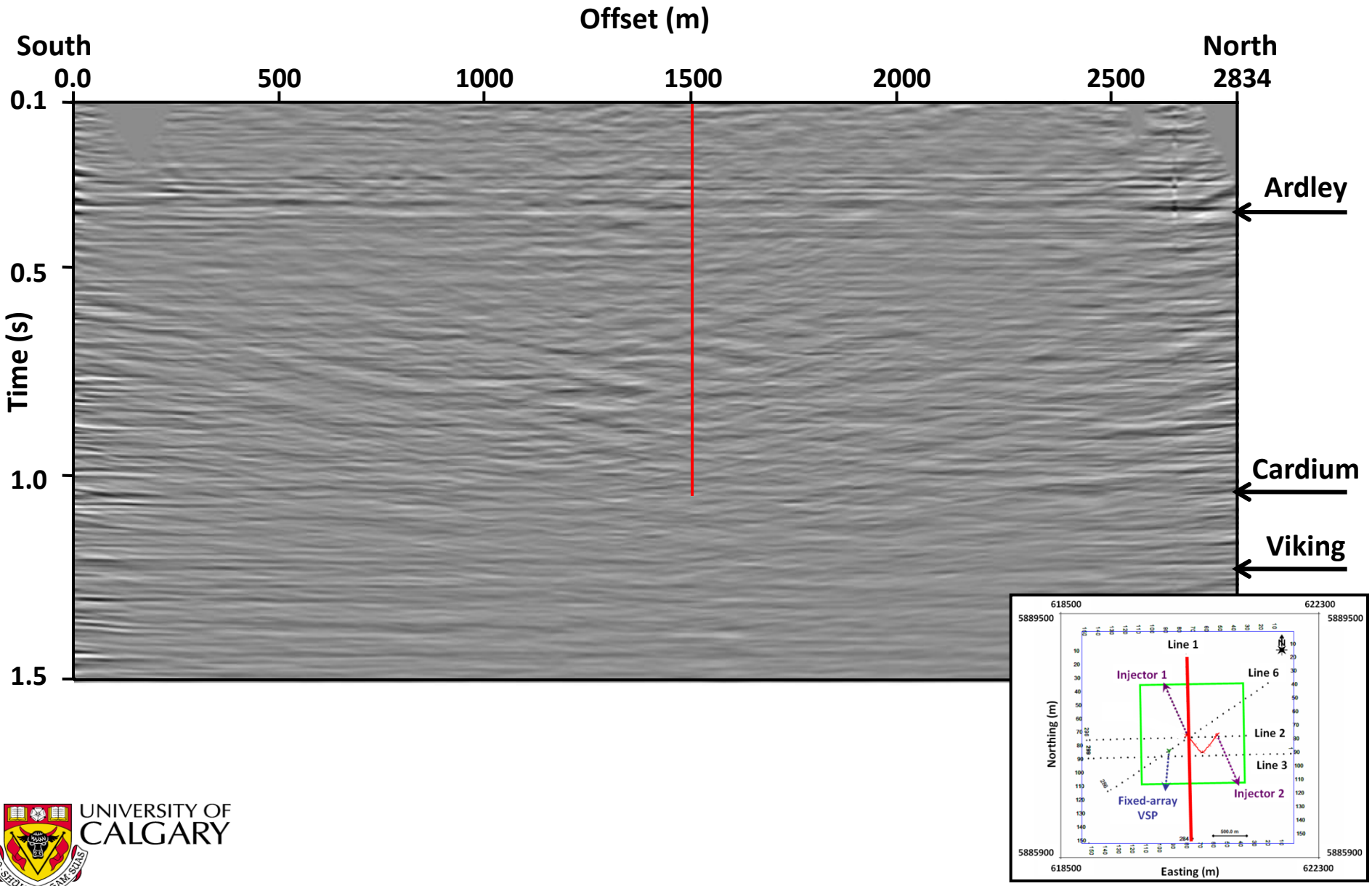
Line 1 - Phase III minus Phase I (P-wave)



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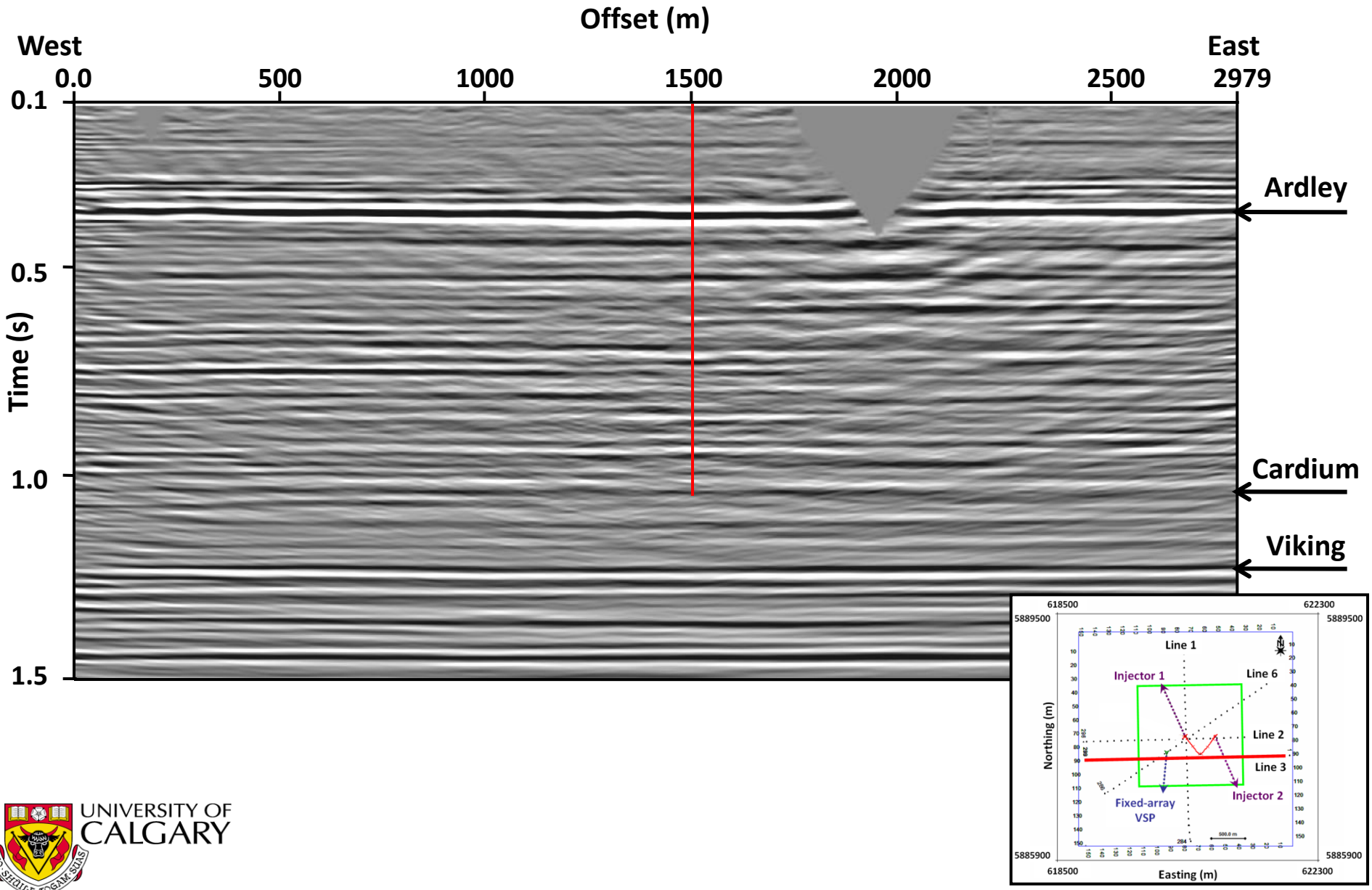
Line 3 - Phase I (P-wave)



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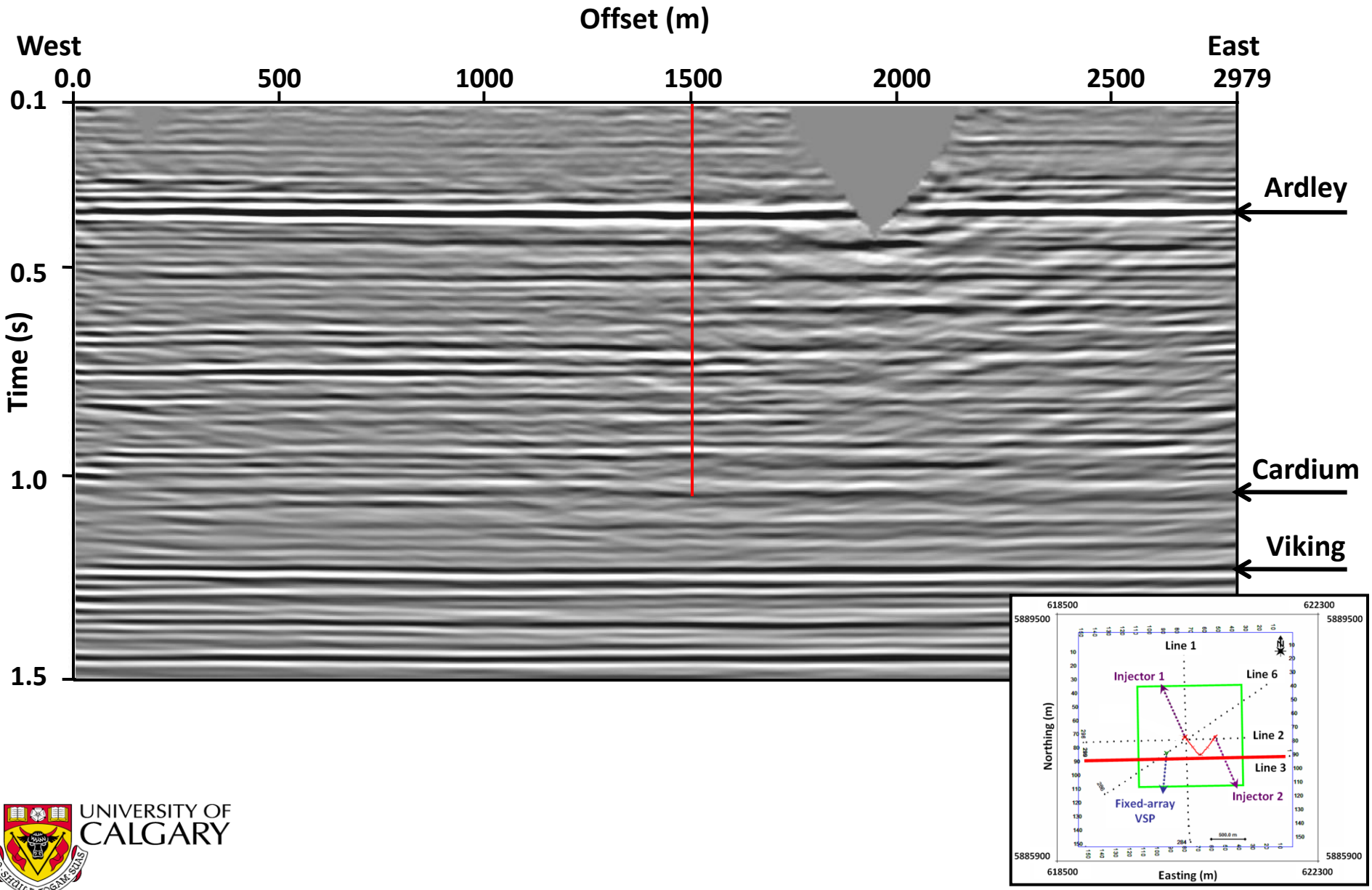
Line 3 - Phase III (P-wave)



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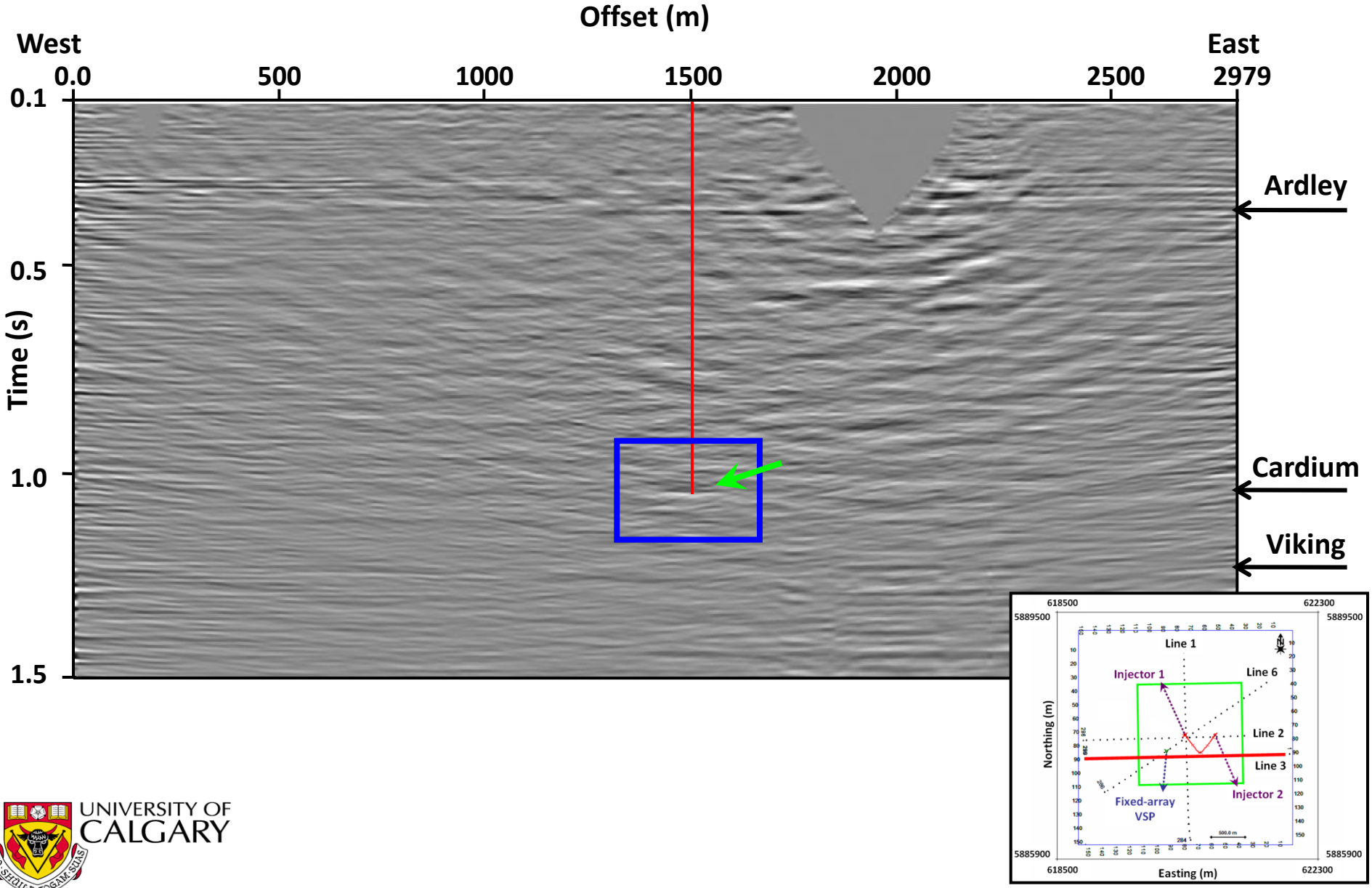
Line 3 - Phase III minus Phase I (P-wave)



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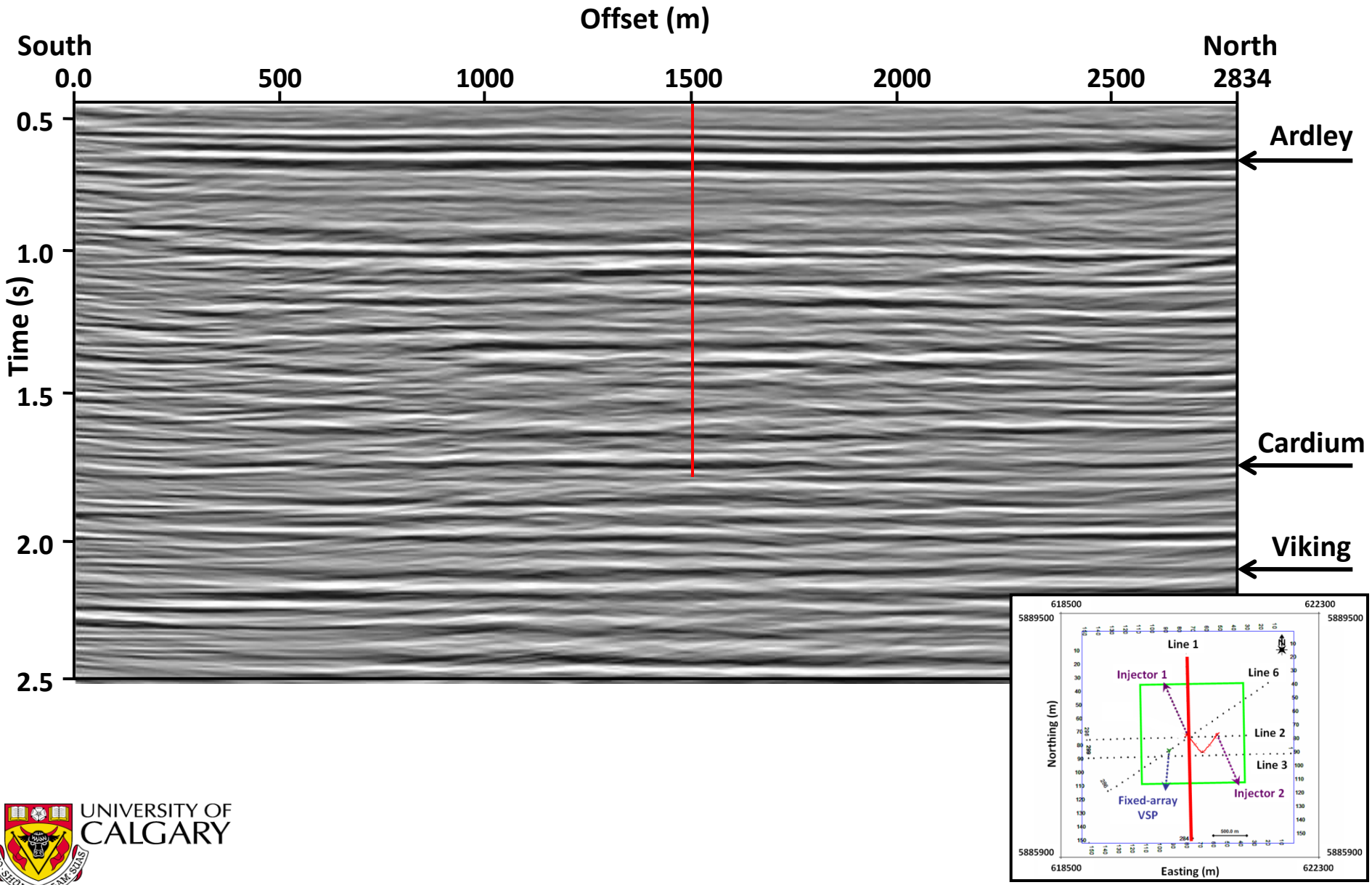
Line 1 - Phase I (converted-wave “PS”)



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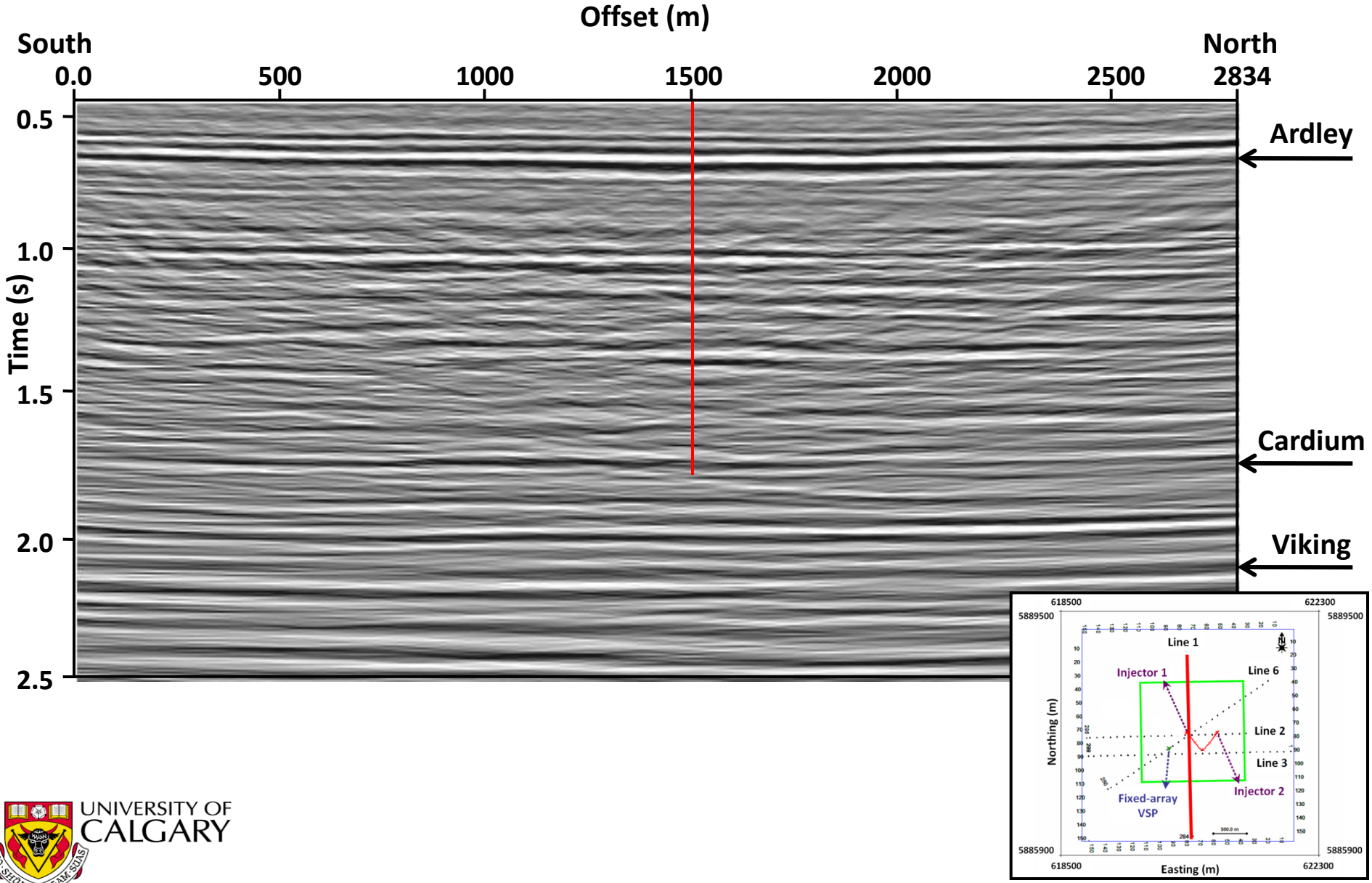
Line 1 - Phase III (converted-wave “PS”)



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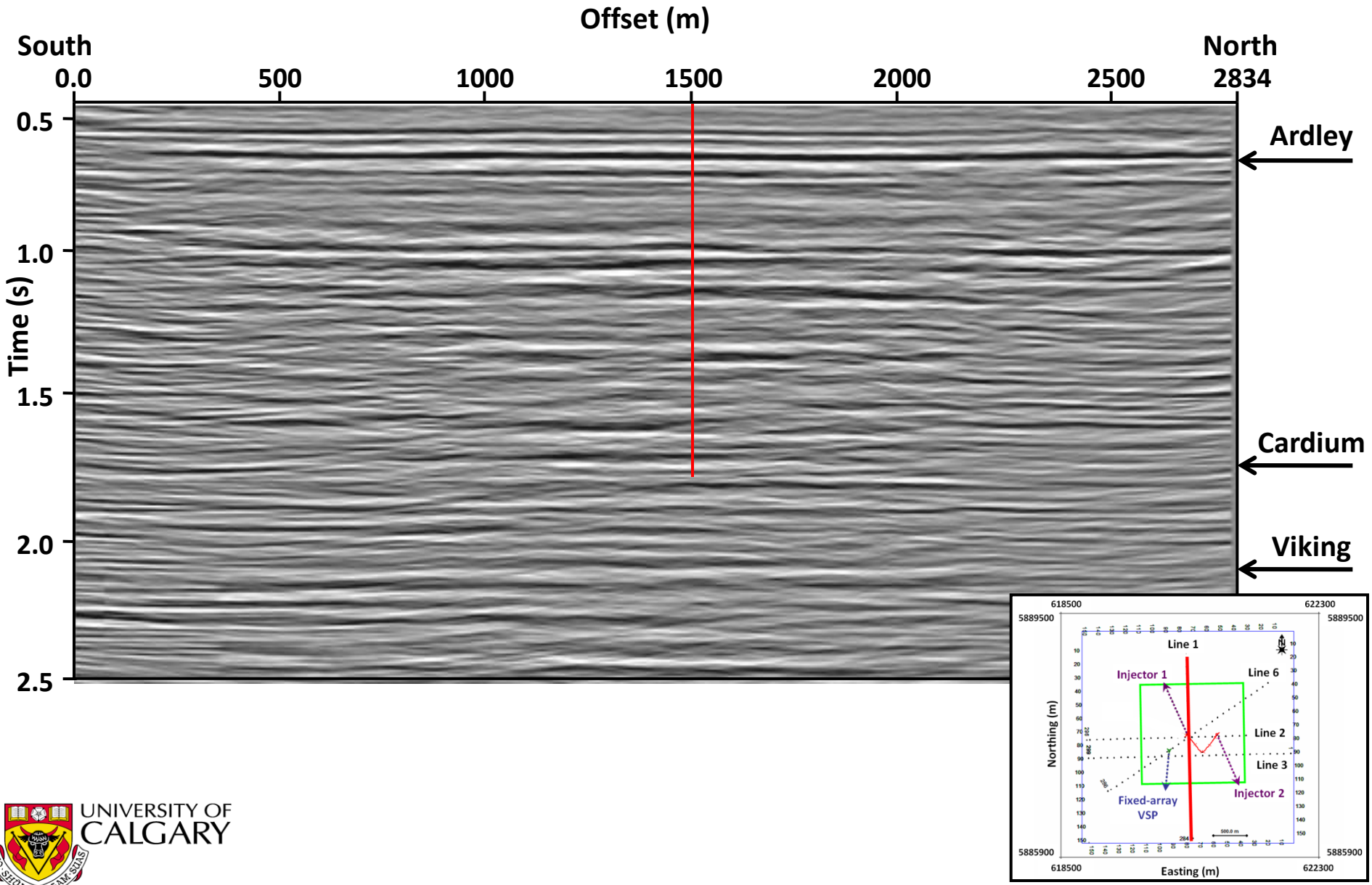
Line 1 - Phase III minus Phase I (converted-wave “PS”)



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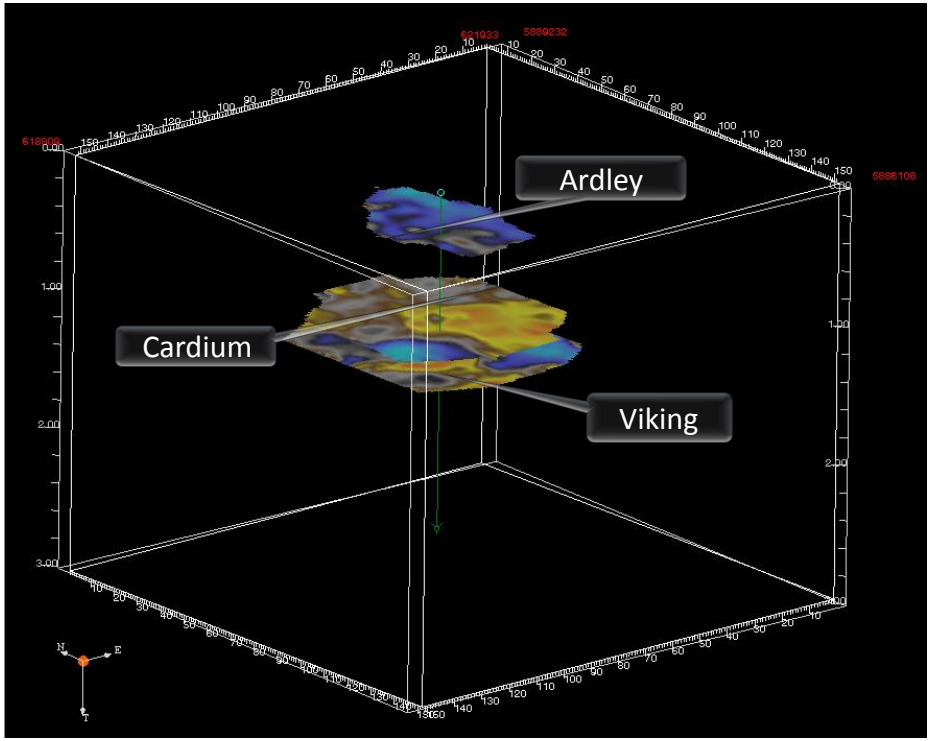
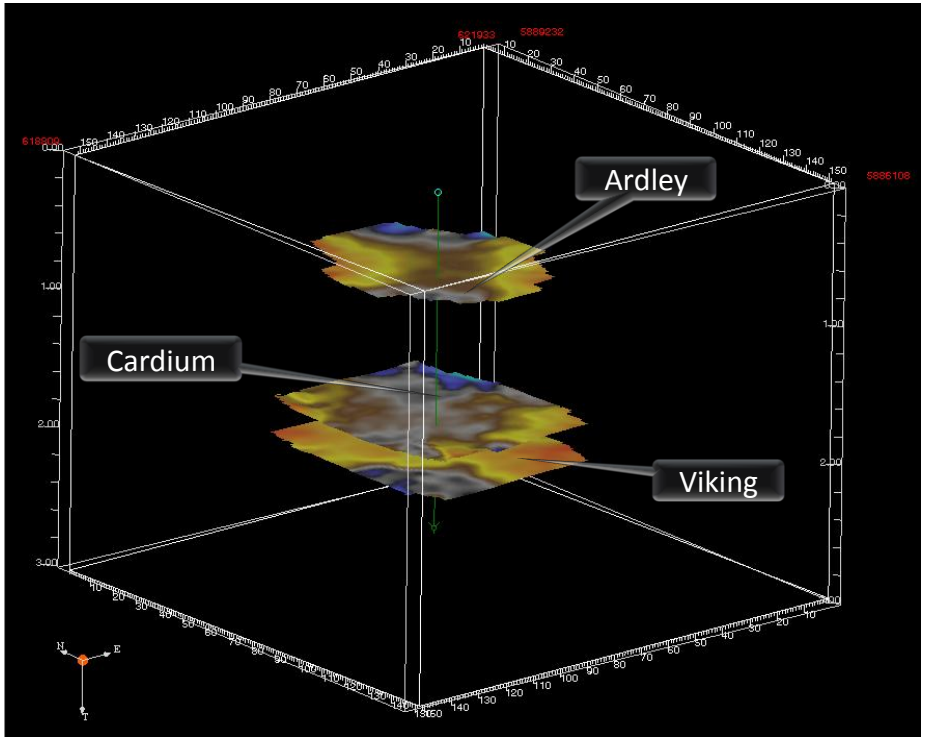
Horizons: Ardley, Cardium and Viking

PP 3D Data



PS 3D Data



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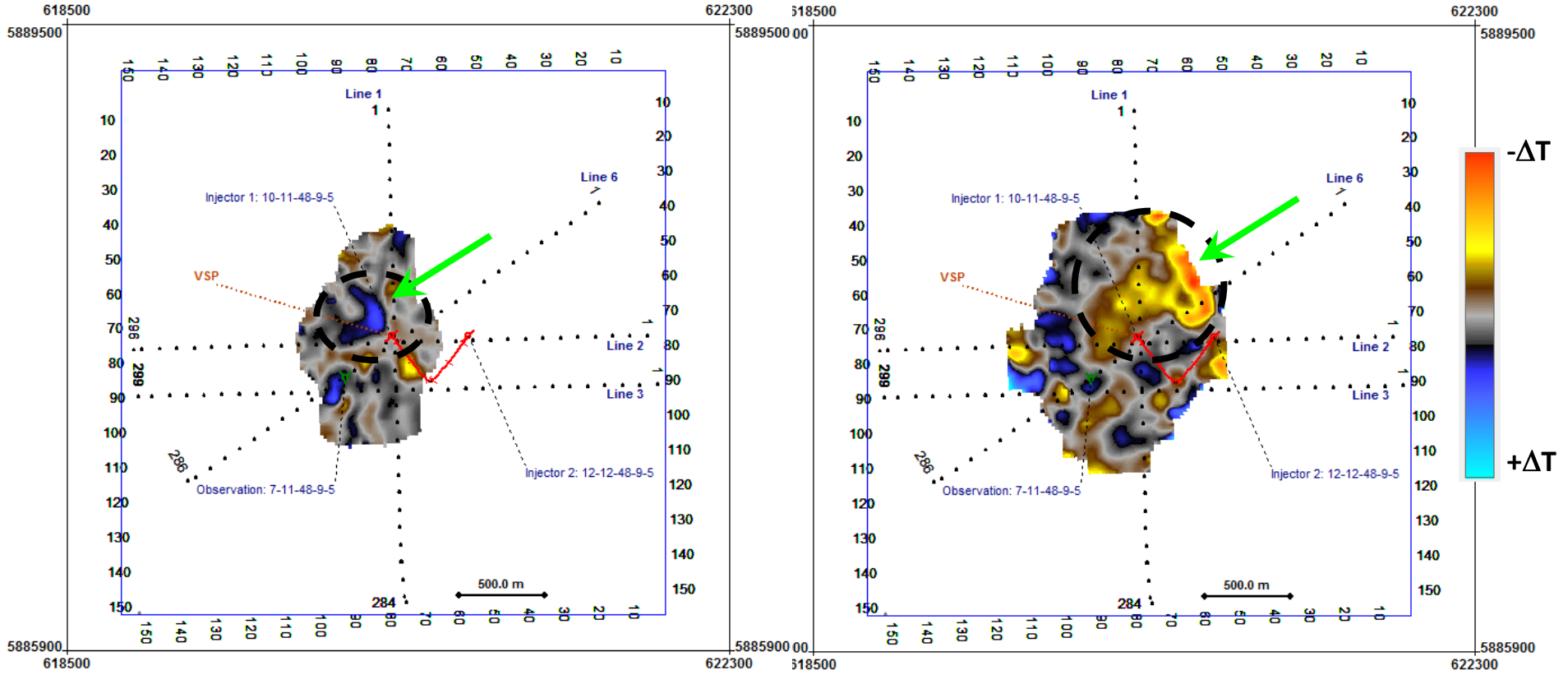
Isochron Difference: Phase III – Phase I

PP Data:

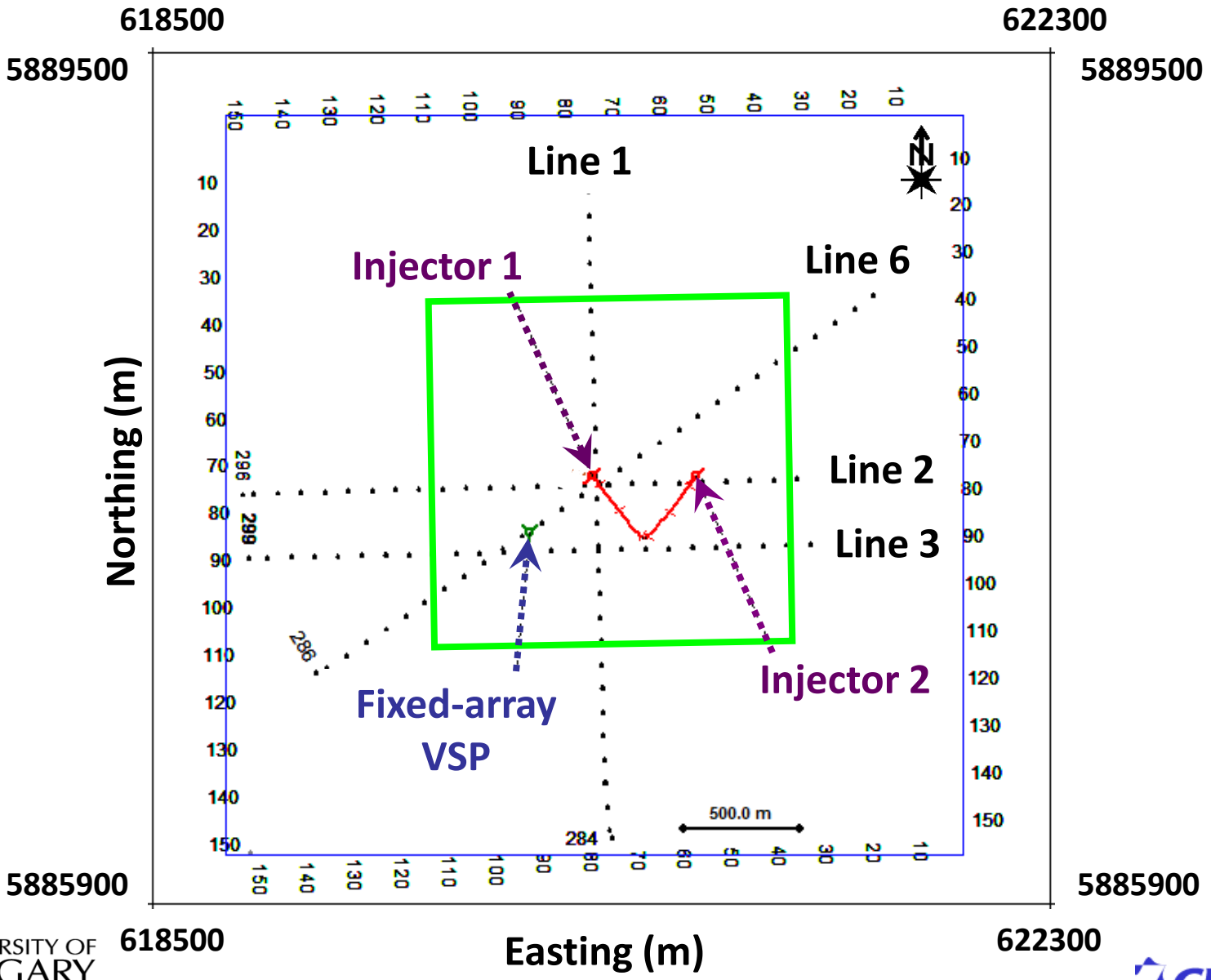
ΔT Viking-Ardley Isochron

PS Data:

ΔT Viking-Ardley Isochron



Seismic Program



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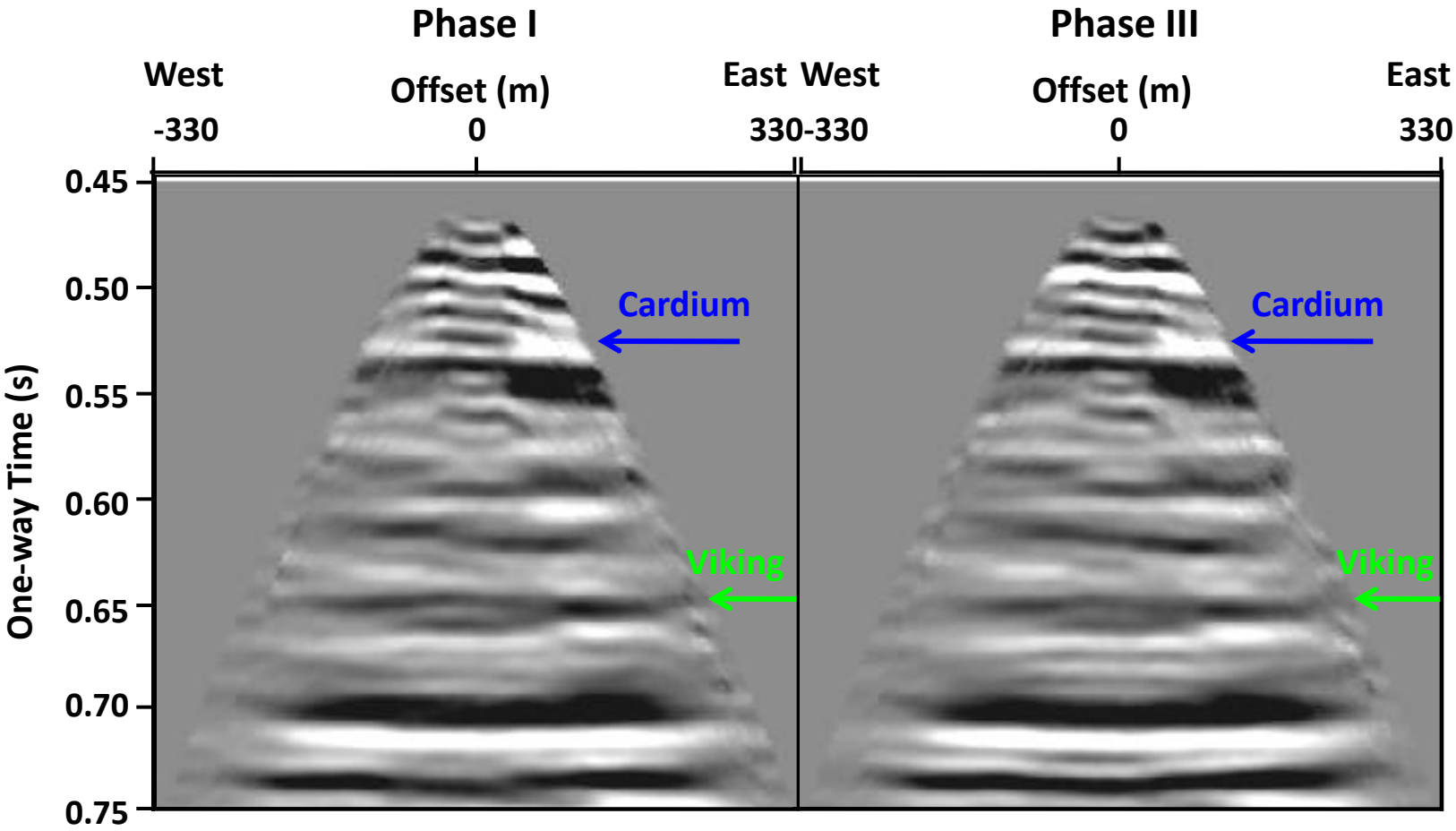
Line 1



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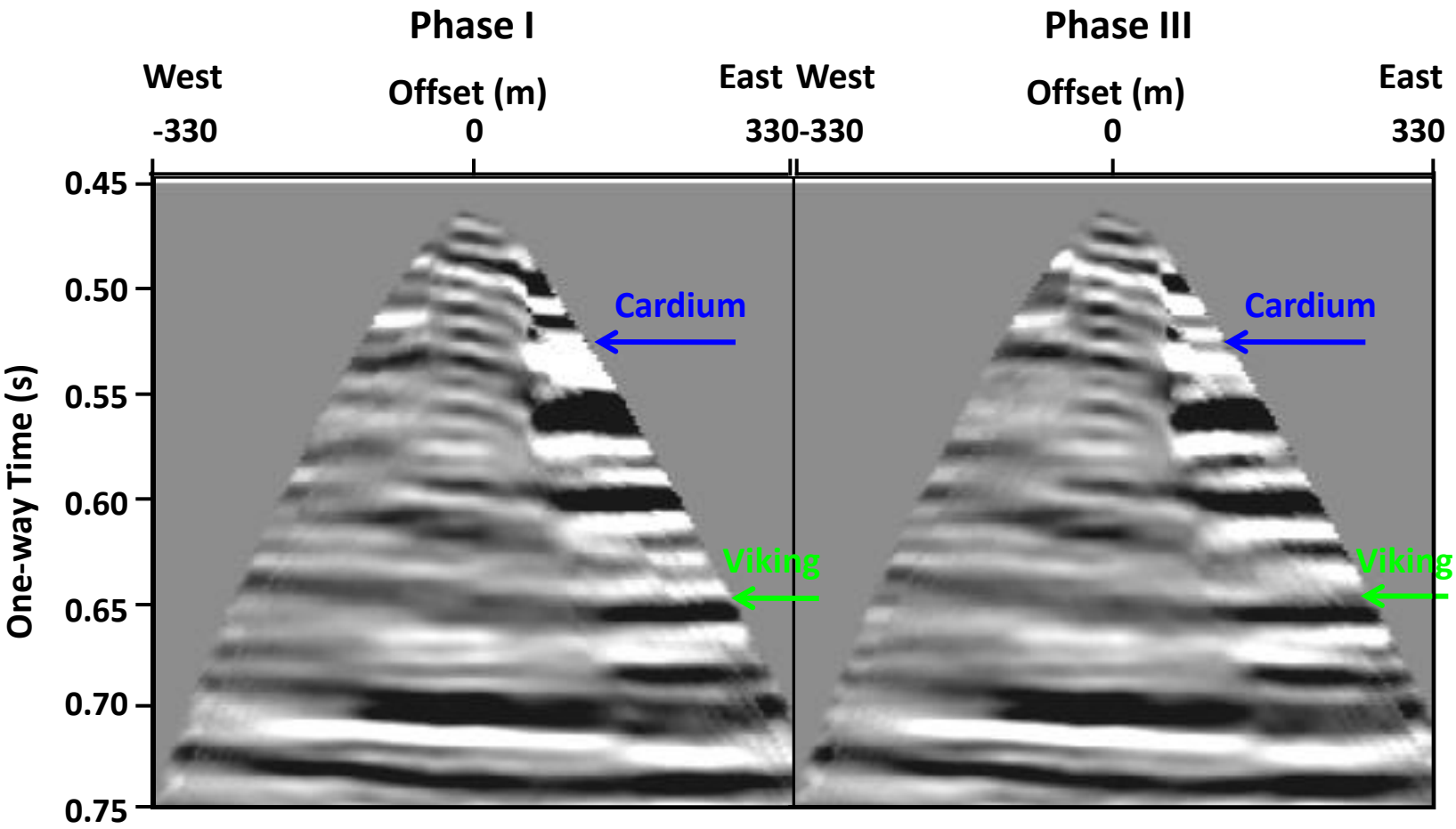
Line 2



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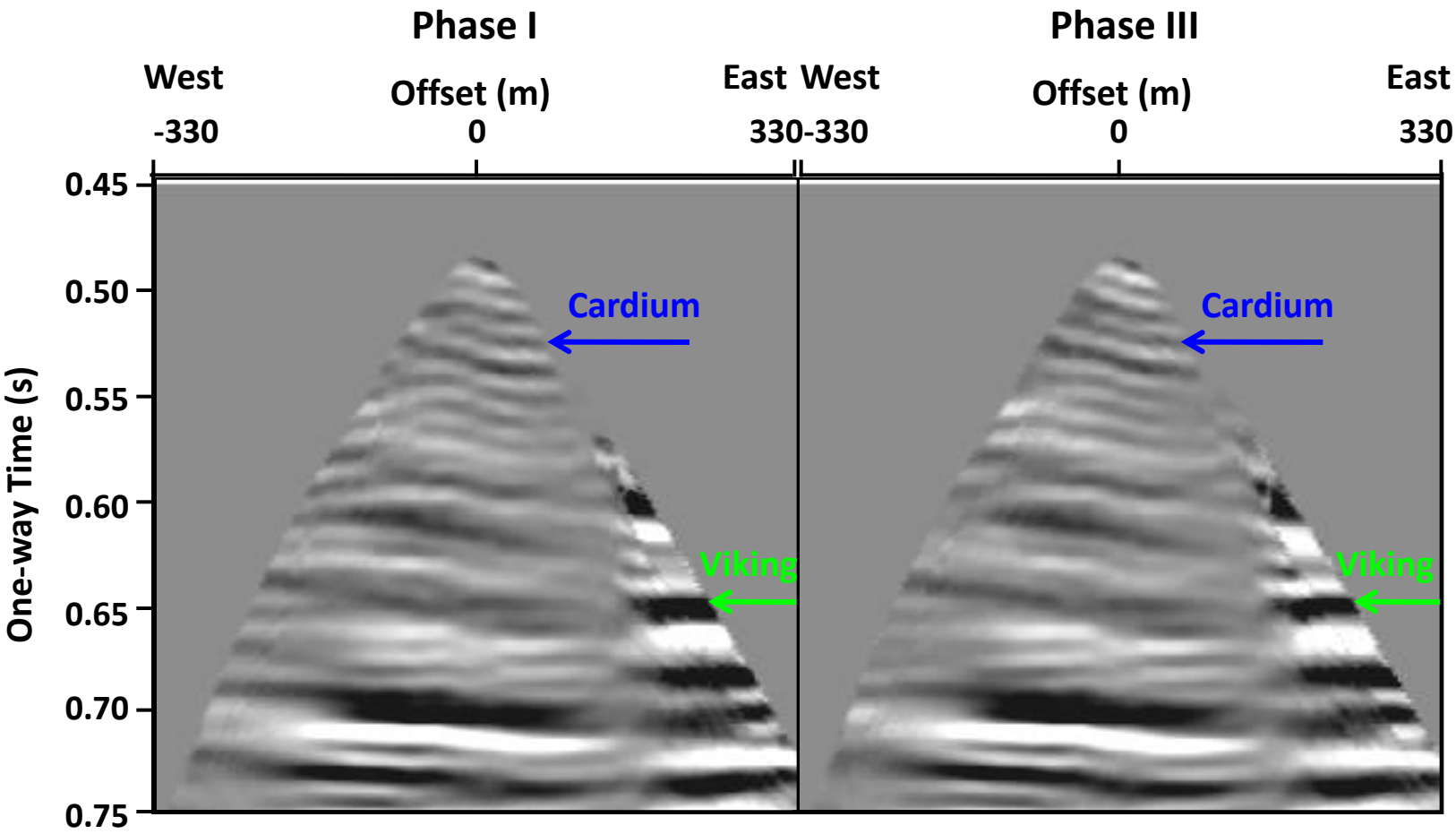
Line 3



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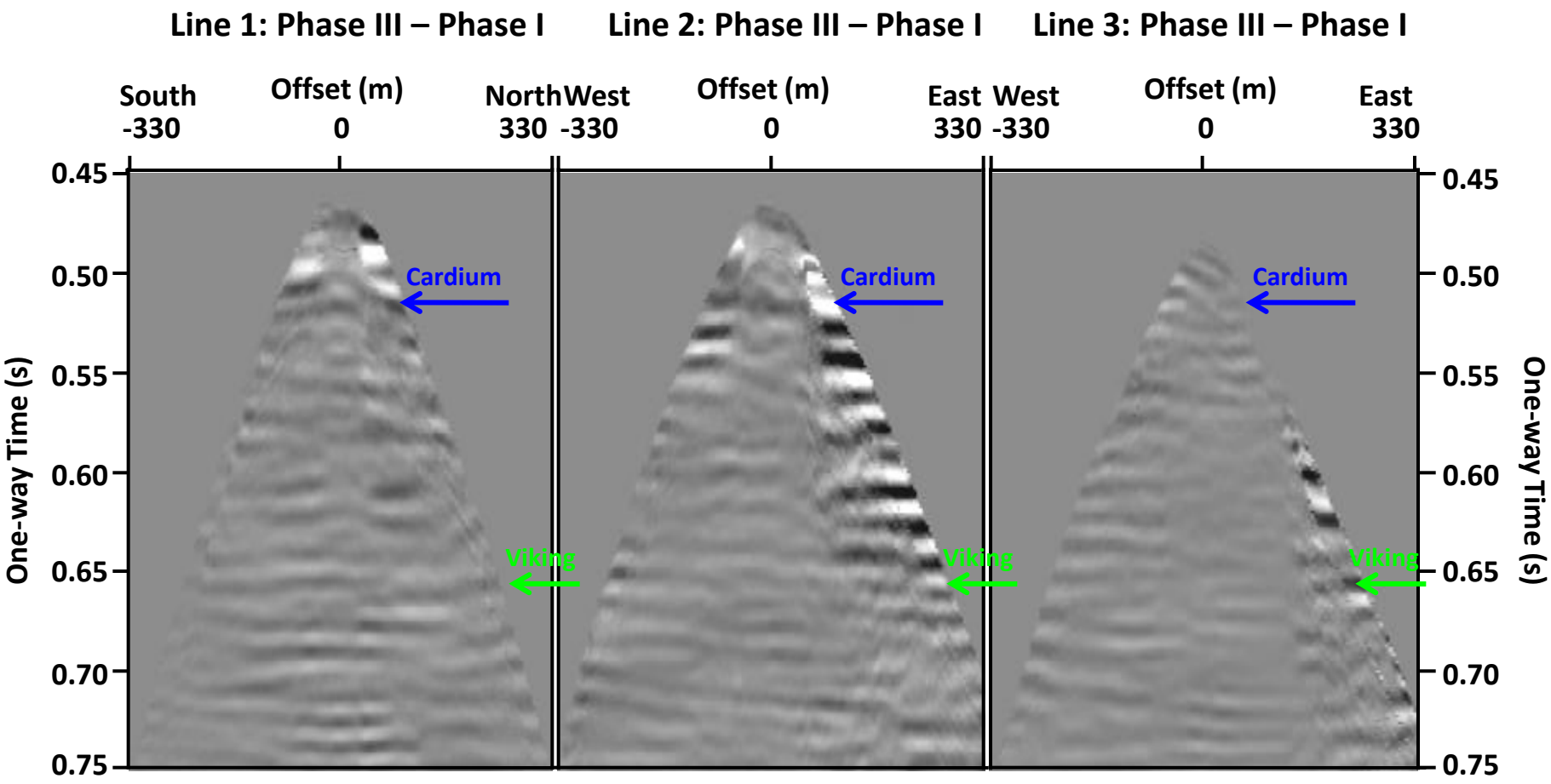
VSP Lines: The Difference



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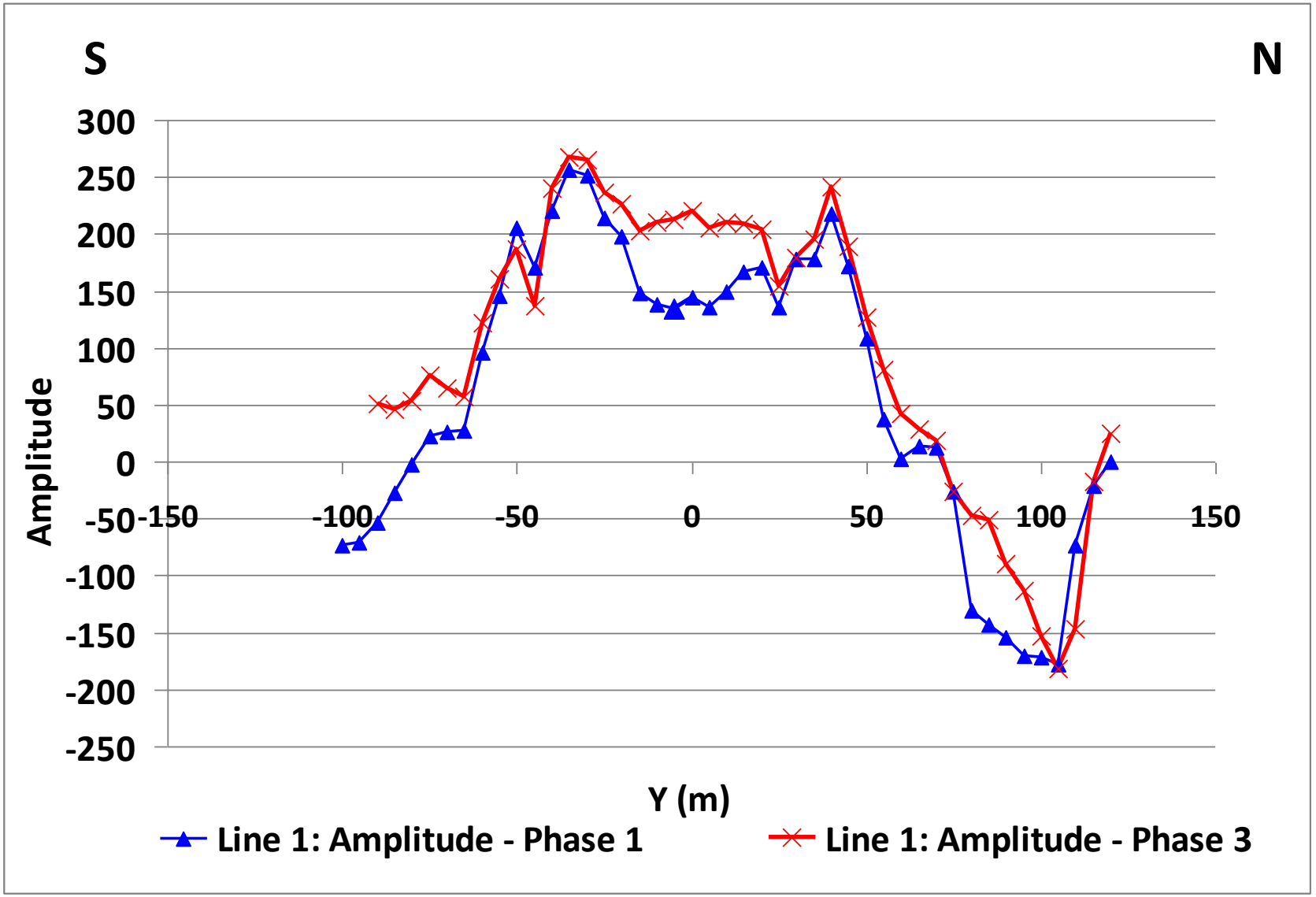
Cardium Amplitude (VSP - Line 1)



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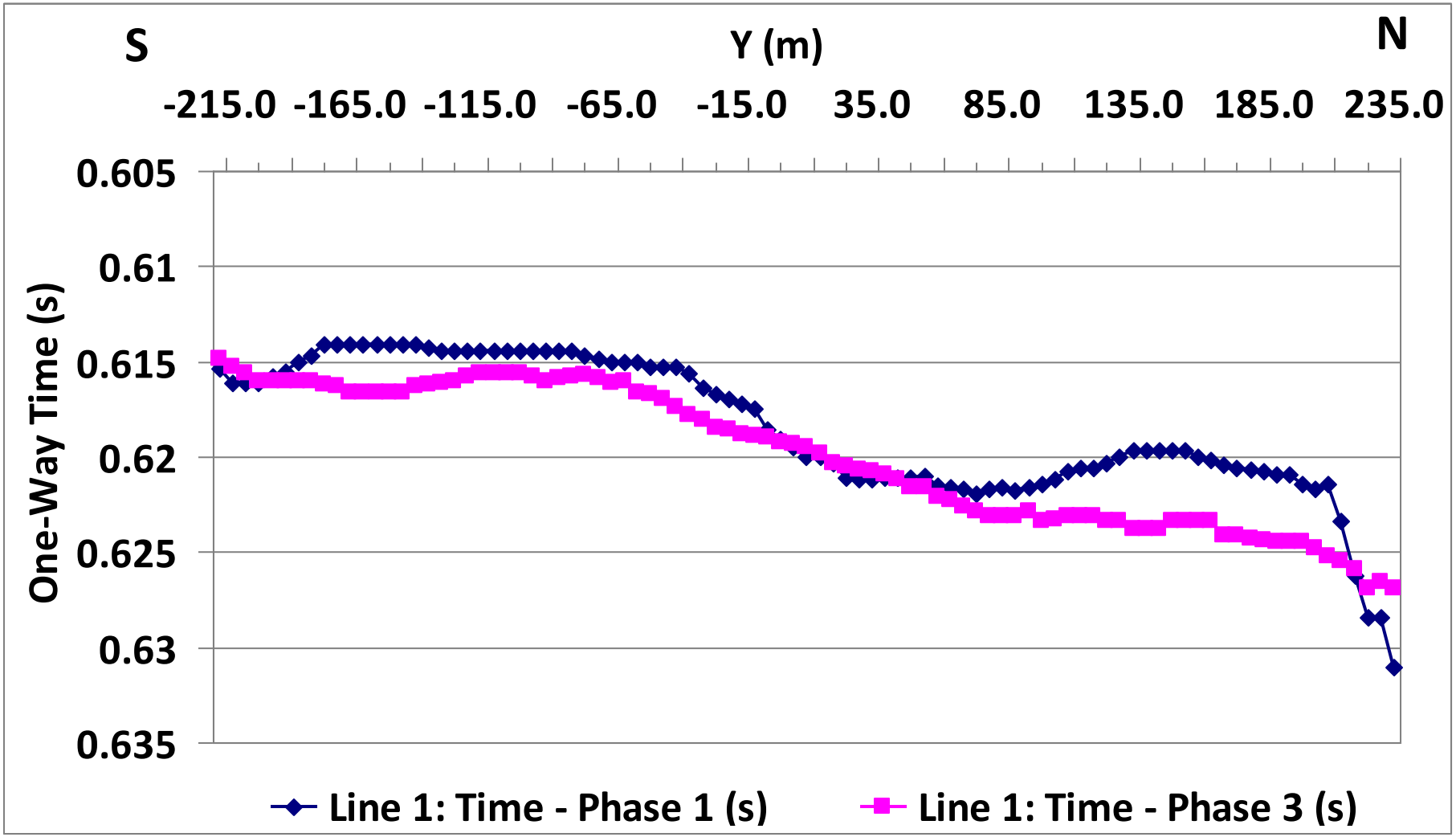
Viking Traveltime Structure (VSP - Line 1)



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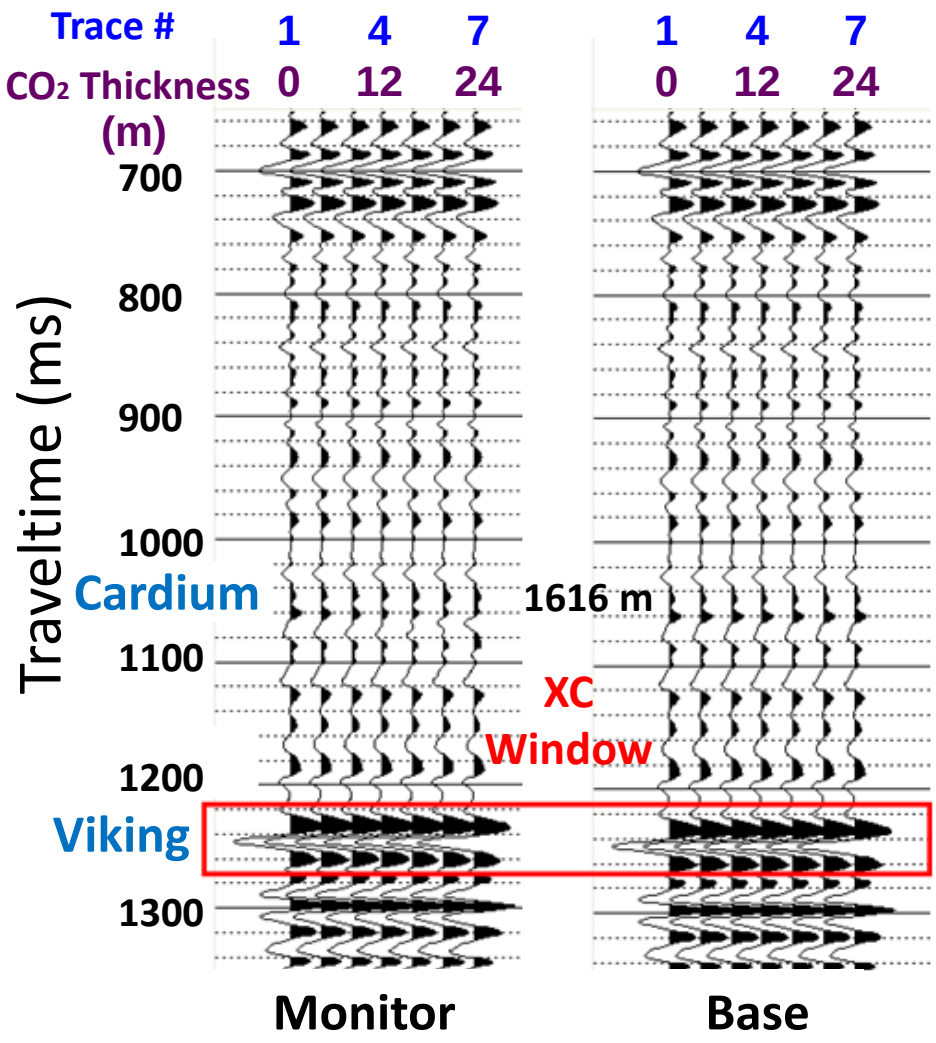
Fluid Replacment Modelling: Zero-Offset Synthetic Seismogram



Parameters for FRM

"Baseline" Saturation	50% H_2O 50% Oil
"Monitor" Saturation	80% CO_2 10% H_2O 10% Oil
CO_2 Plume Thickness "Model"	0 – 24 m
Max. Thickness	10 m
NRMS Window	1040 – 1080 ms

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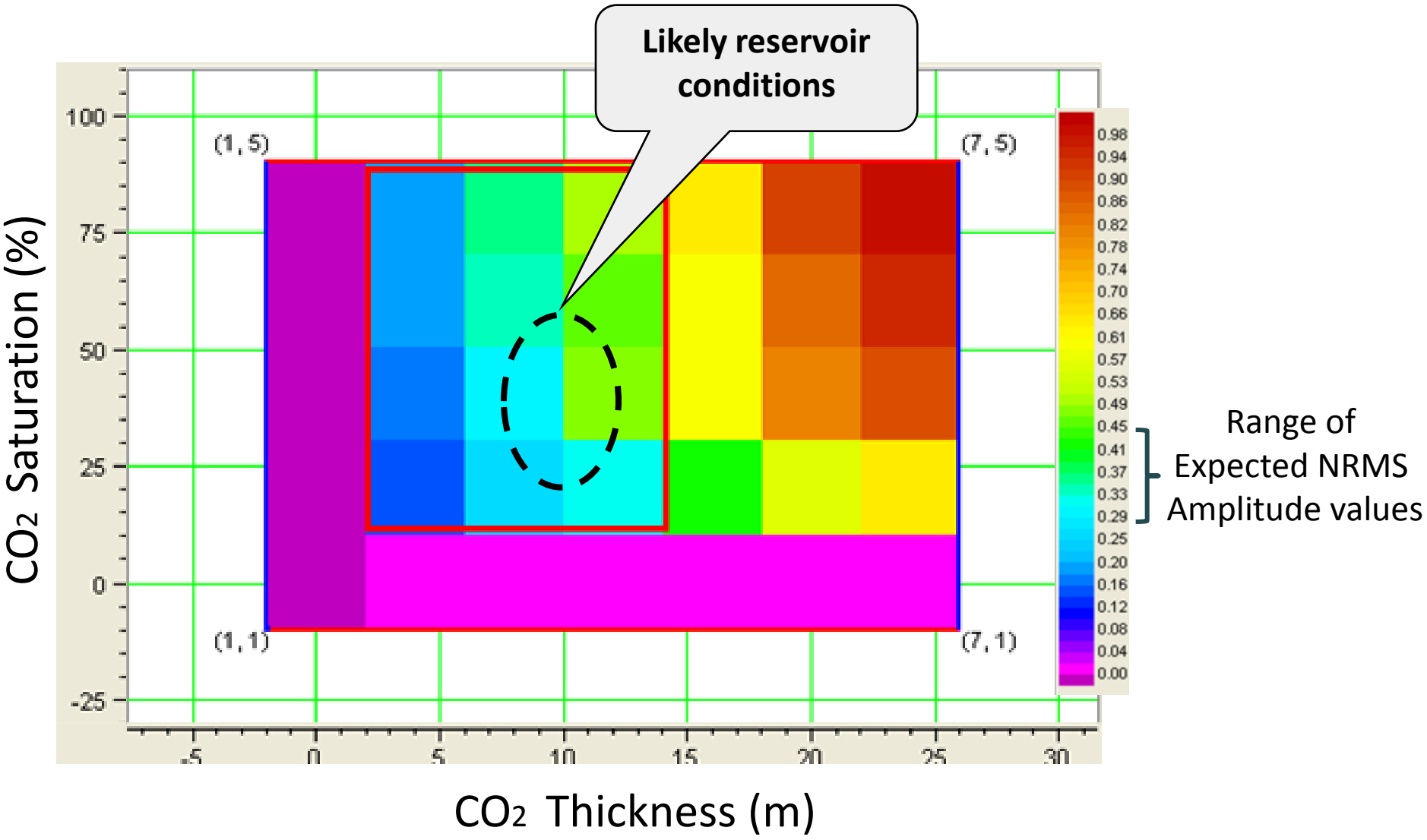
Normalized Root Mean Square (NRMS) Amplitude: Cardium



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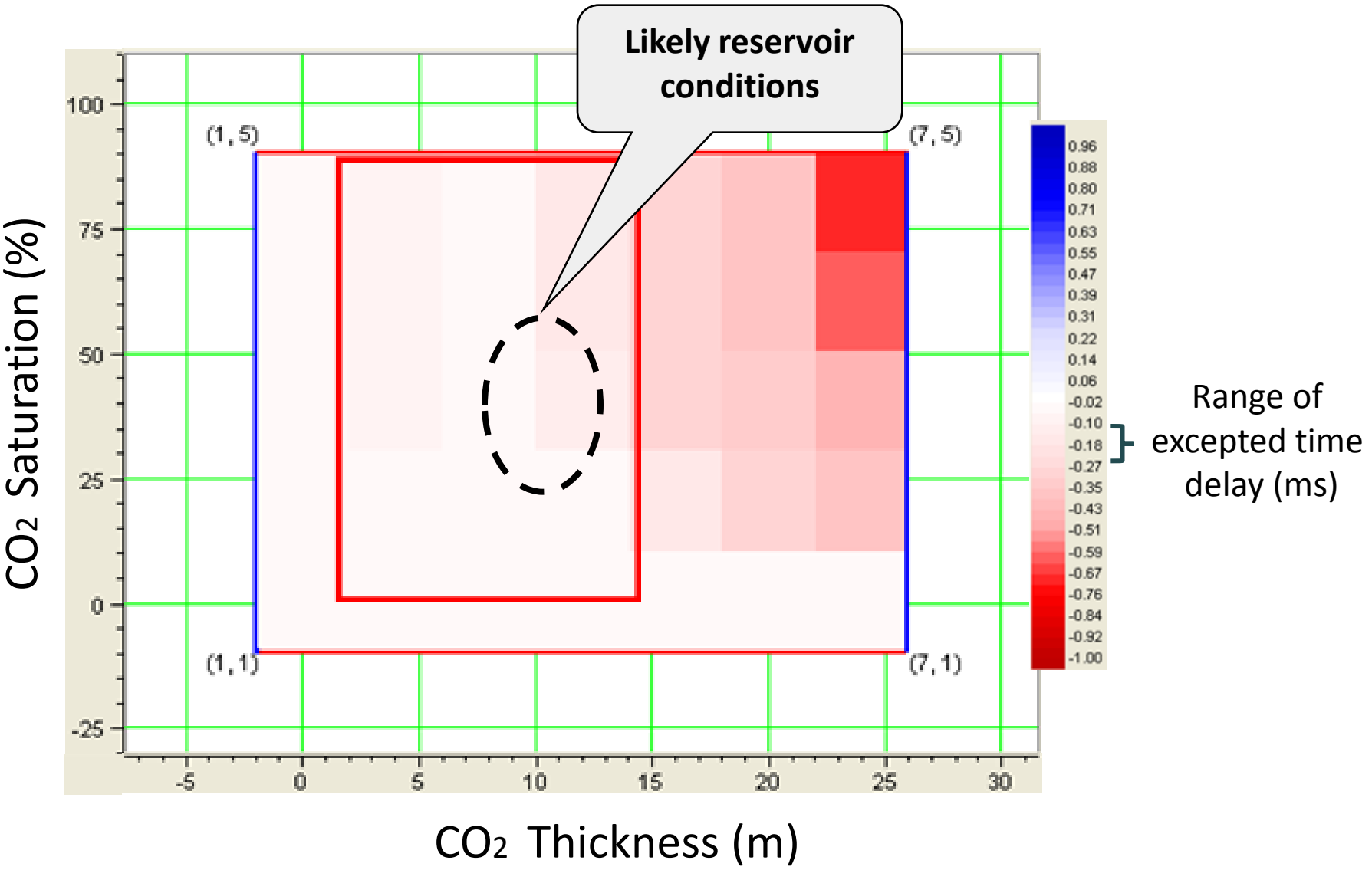
Crosscorrelation (XC) : Viking Traveltime Delay



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Conclusions

- Traveltime and amplitude analysis of the P-wave component of the surface seismic have shown limited success in mapping the injected CO_2.
- However, small timelapse response is observed in the converted-wave (PS) and the fixed-array VSP datasets.
- Possible causes for the weak 4D results:
  1) CO_2 confinement to thin (~ 10 m thick) sandstone members of the Cardium Formation.
  2) Small variations in the physical properties between the in situ fluids and the injected supercritical CO_2.

Acknowledgments

- Fund and Support Provided by:
  - → Alberta Government:
    - Alberta Research Council (ARC)
    - Alberta Energy and Utilities Board (AEUB)
    - Alberta Energy Research Institute (AERI)
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