

The Application of Borehole Seismic Techniques in Mine Development at the Millennium Uranium Deposit

Athabasca Basin, SK Canada

Garnet Wood and Clare O'Dowd – Cameco Corporation*

Calin Cosma and Nicoletta Enescu – Vibrometric Canada Ltd.

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- Millennium Deposit – Location and Geology
- Technical Problems Related to Mine Development
- Objectives of the Seismic Program
- Seismic Techniques Applied at Millennium
- Borehole Seismic Results
- Conclusions
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Location map



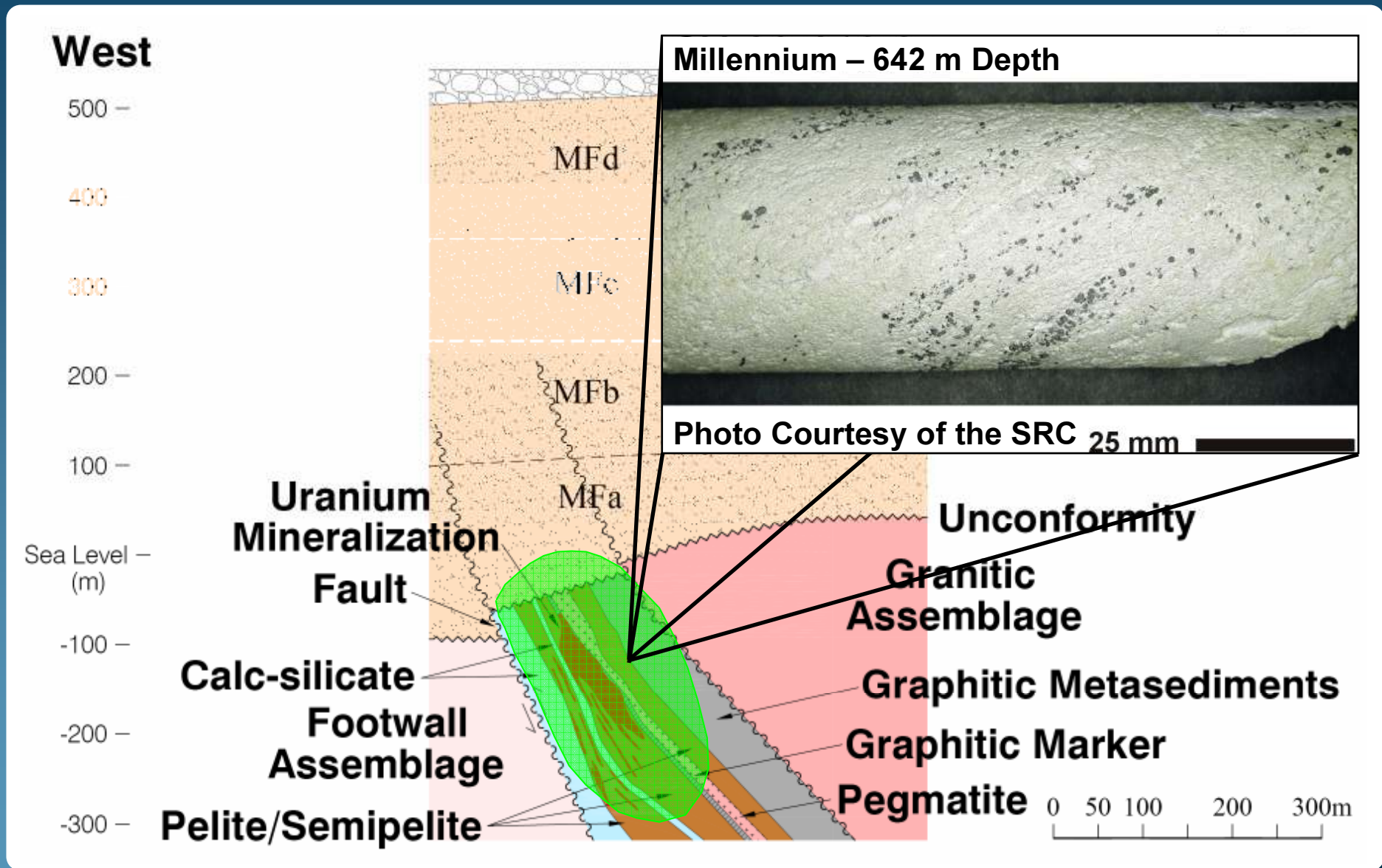
Millennium deposit – Current status



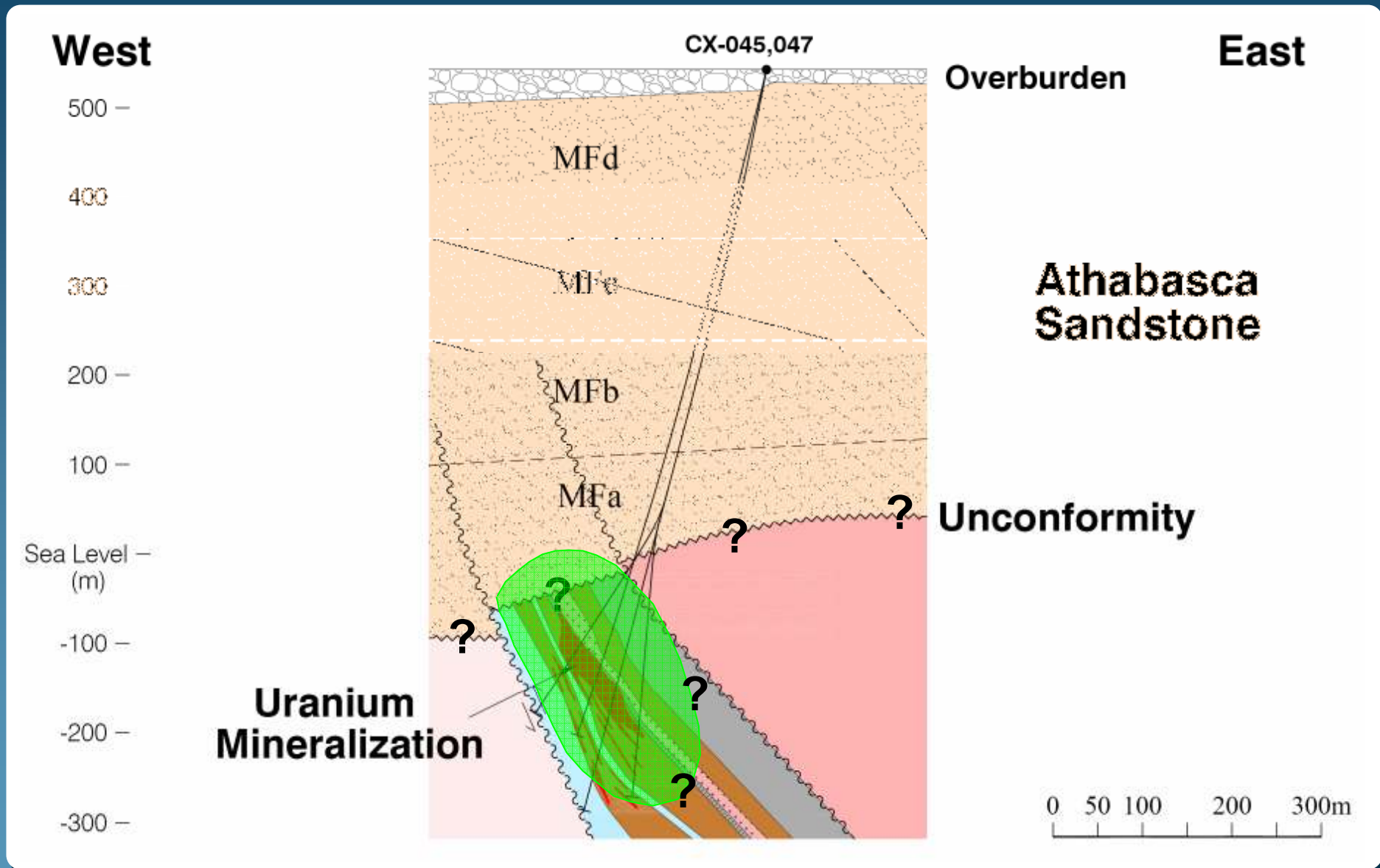
- Resources
 - Indicated 469,000 t @ 3.84% U (18.01 t U)
 - Inferred 214,000 t @ 1.75% U (3.745 t U)
- Mineralization is basement-hosted, therefore can be mined conventionally
- Prefeasibility was undertaken in 2006
- Feasibility study commissioned in 2008
- Development proposal submitted to regulators upon successful completion of feasibility
- Initial production is scheduled for 2017

Millennium Exploration Camp

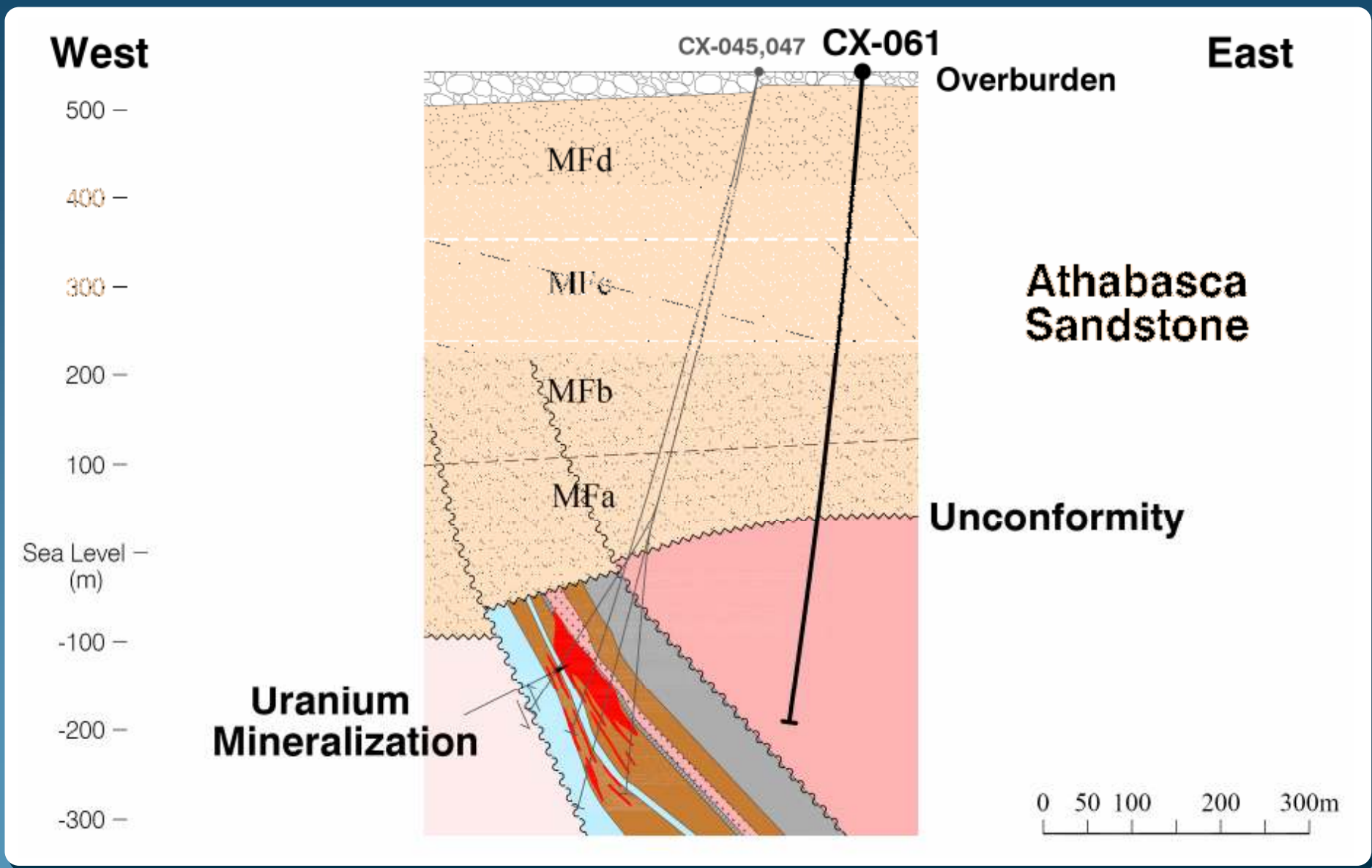
Millennium deposit – Generalized geology



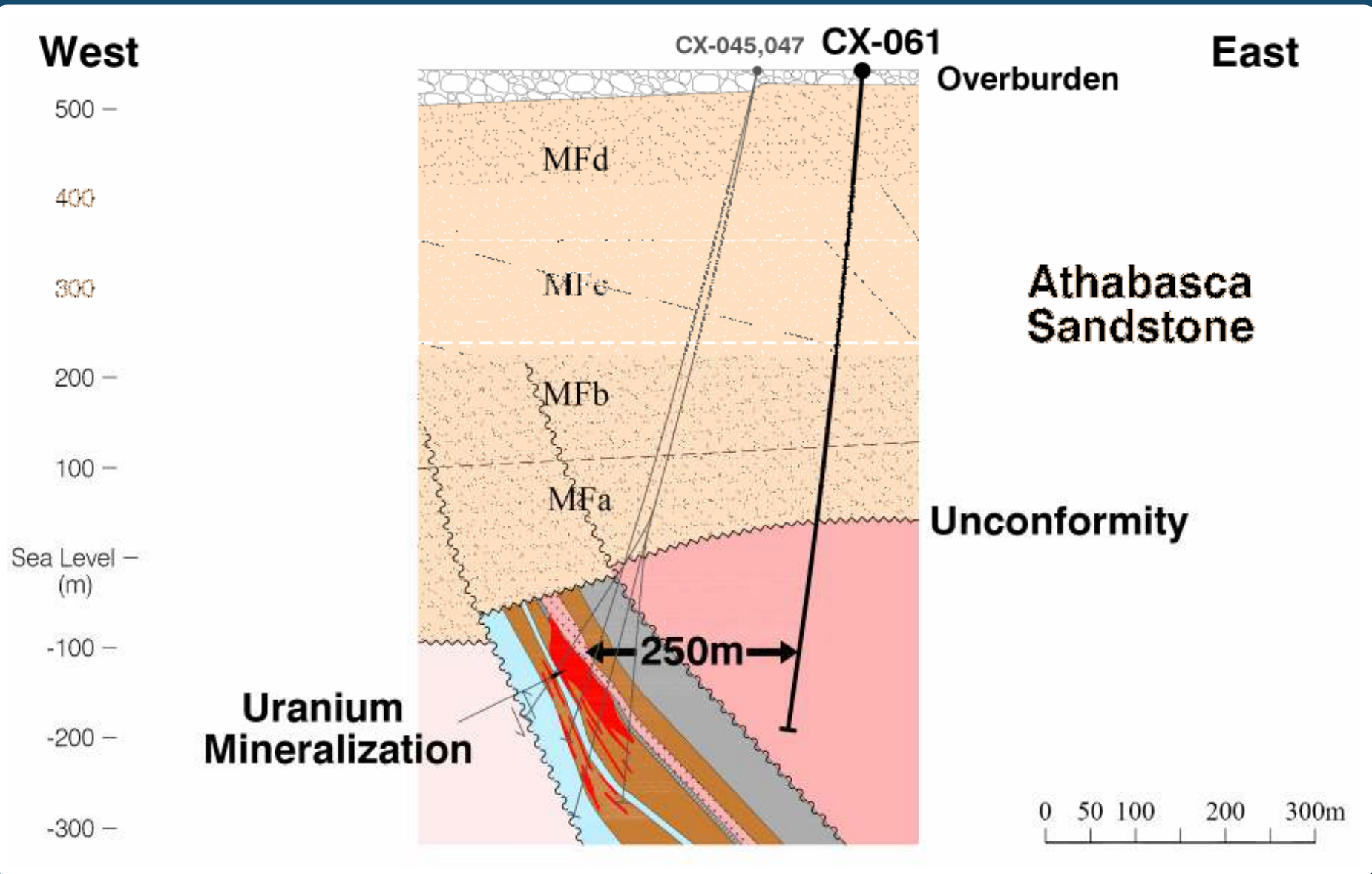
Millennium deposit – Generalized geology



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Millennium deposit – Generalized geology



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Pre-Feasibility – Technical problems



- Shaft sinking is the highest identifiable technical risk to completion of pre-production development
- The shallowest location of the unconformity is important for shaft sinking to minimize costs
- Location and nature of the unconformity above planned mine workings is critical for mine design

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Millennium seismic program – Objectives



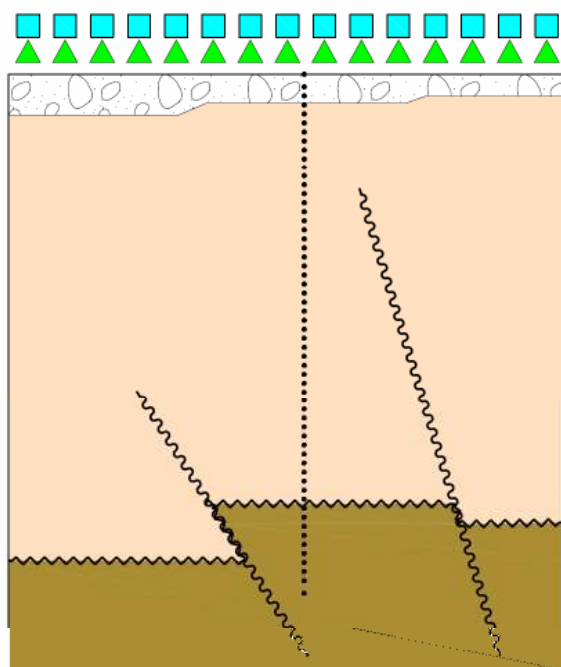
- Map, in detail, the location of the sandstone/basement unconformity in proximity of the planned mine infrastructure
- Image vertical to sub-vertical structure in and around the proposed mine infrastructure
- Provide geotechnical information on the Athabasca Group sandstone and basement rocks hosting the deposit
- Assess the use of seismic techniques in directly imaging Millennium style uranium mineralization or alteration

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Seismic techniques applied at Millennium

Surface (3D)

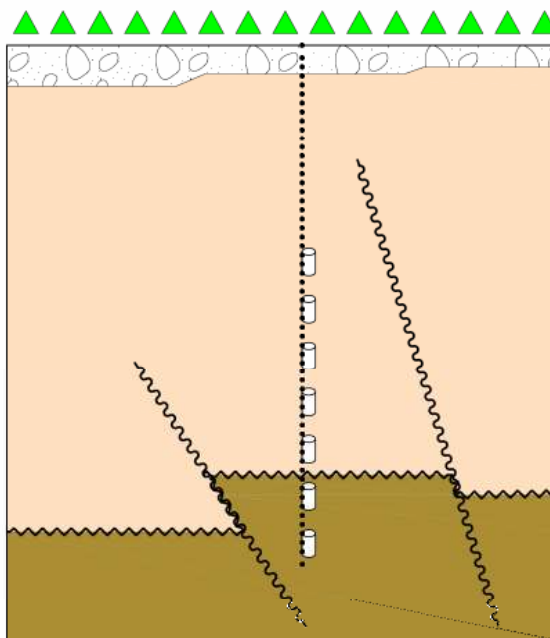
Horizontal reflectors only



▲ Seismic Source

VSP (MSP)

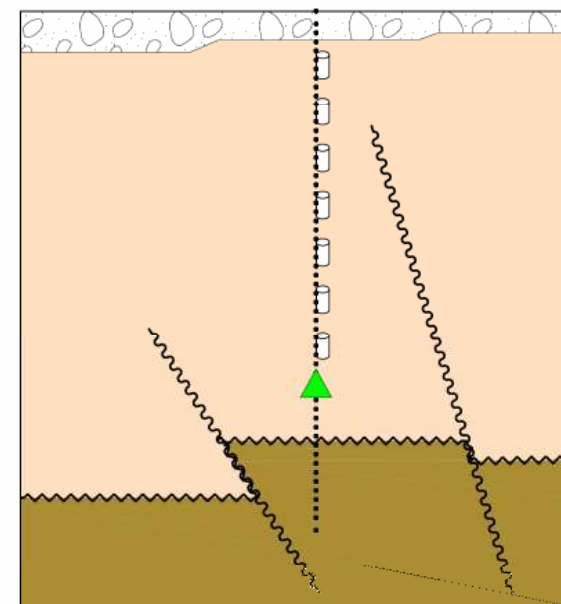
Vertical reflectors and horizontal reflectors



■ Surface Receiver

Side-scan

Vertical reflectors only

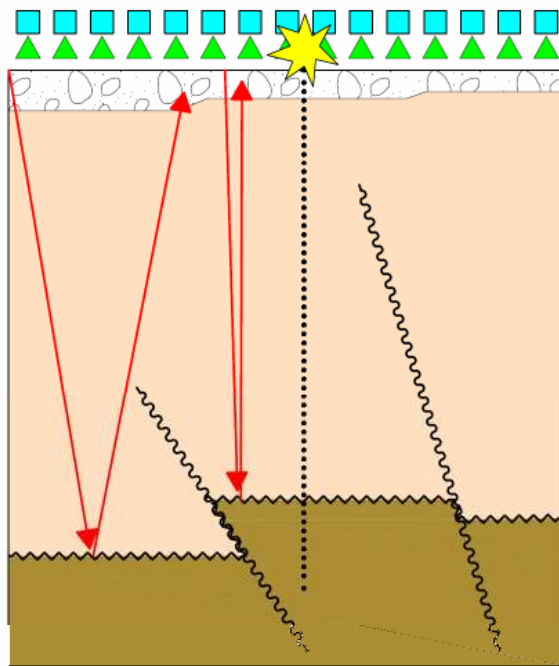


□ Borehole Receiver

Seismic techniques applied at Millennium

Surface (3D)

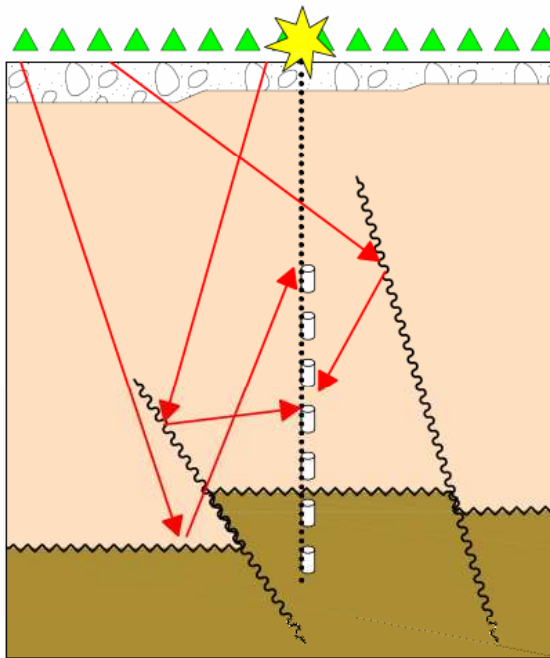
Horizontal reflectors only



▲ Seismic Source

VSP (MSP)

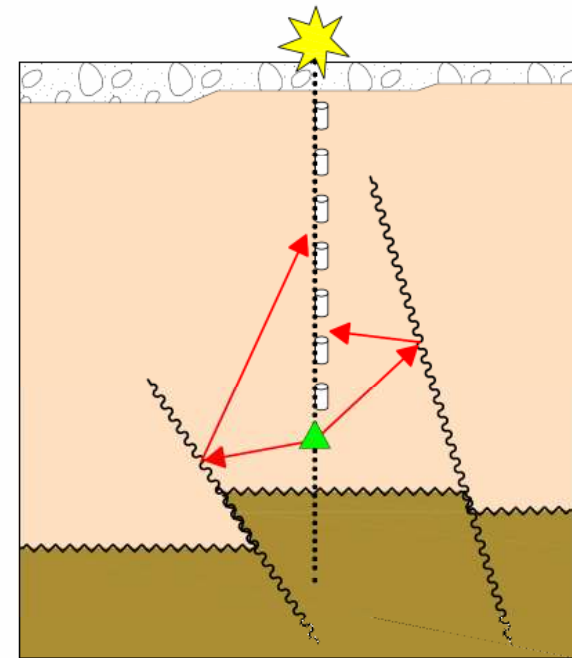
Vertical reflectors and horizontal reflectors



■ Surface Receiver

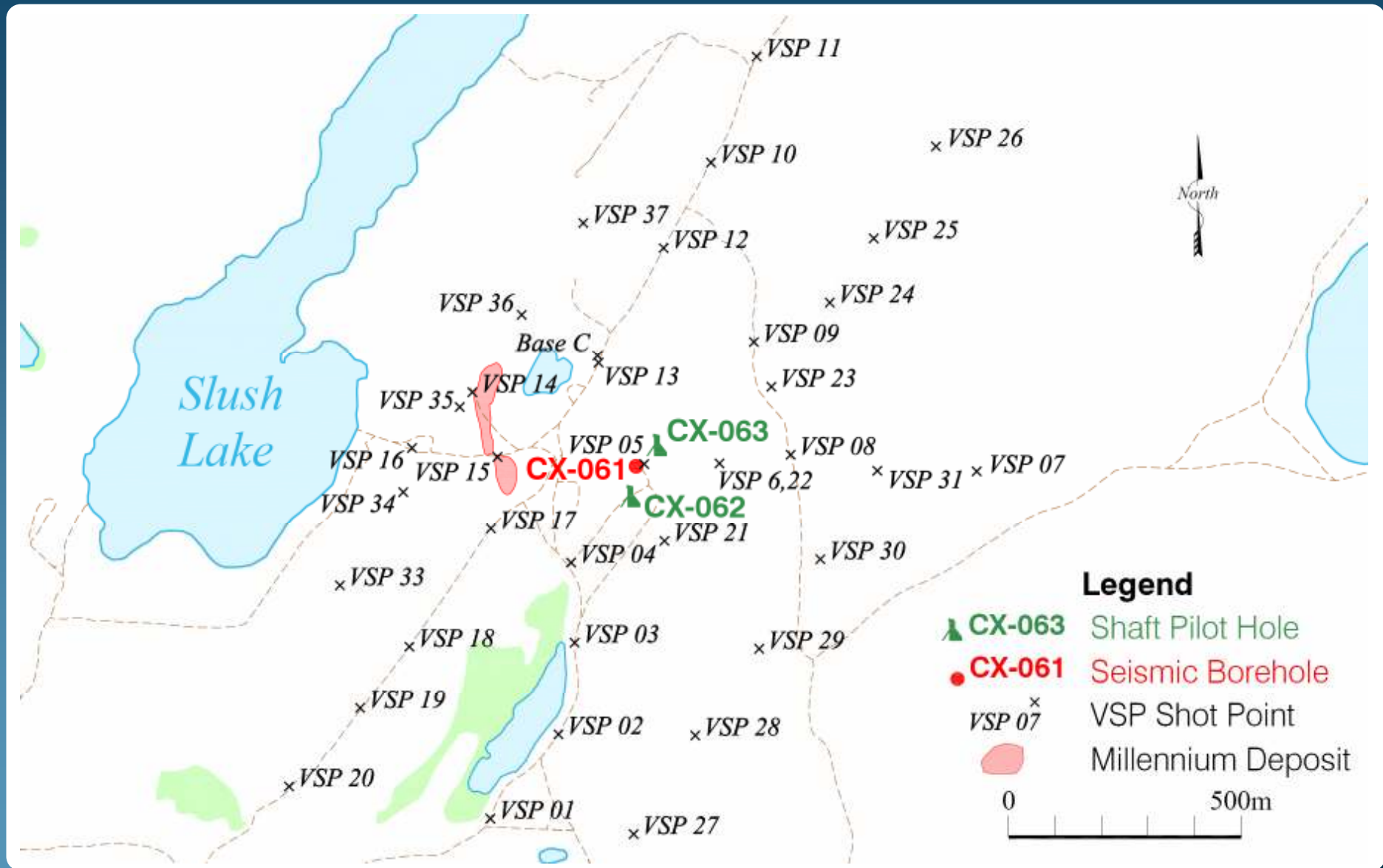
Side-scan

Vertical reflectors only



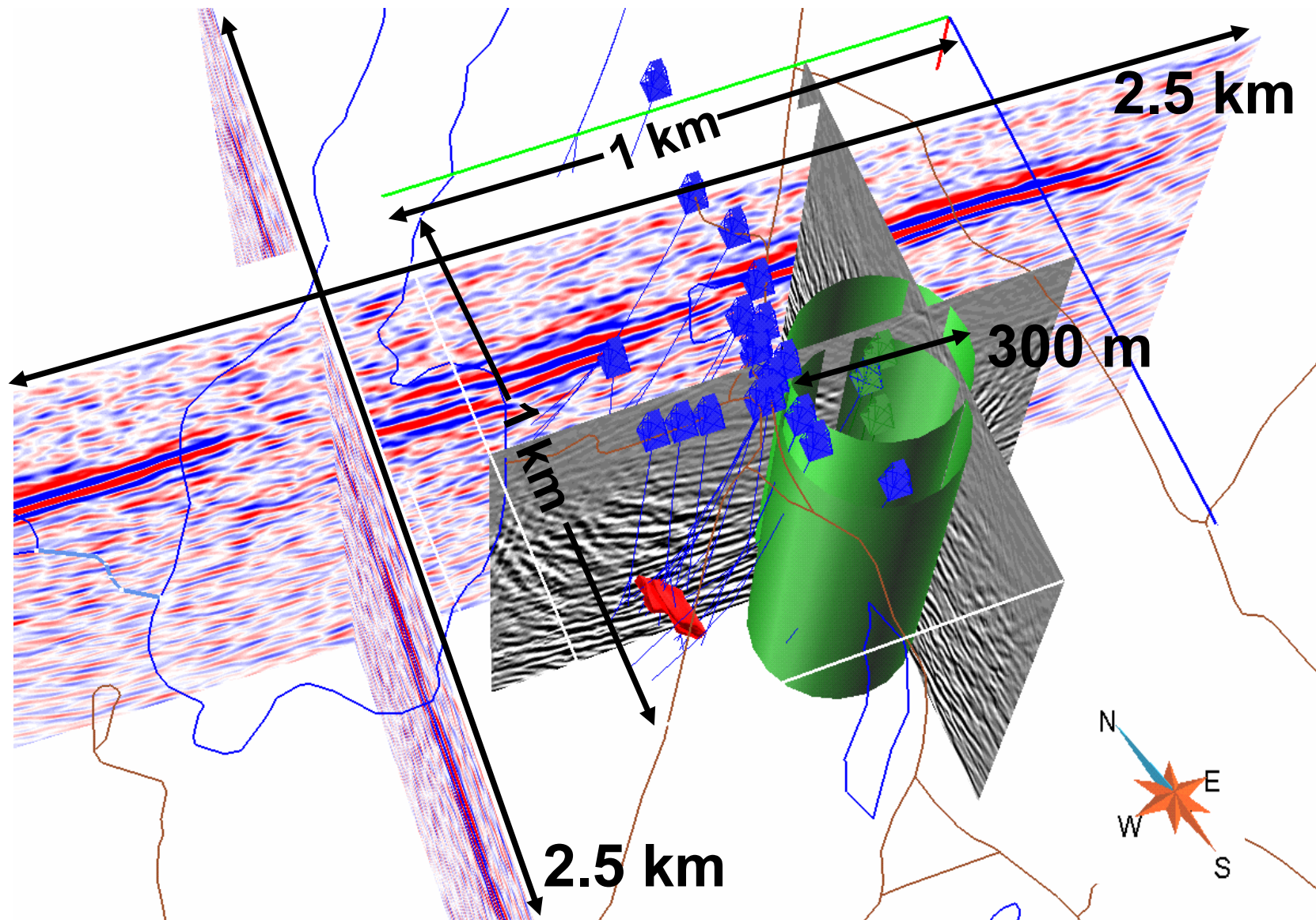
□ Borehole Receiver

Borehole seismic surveys – Location map

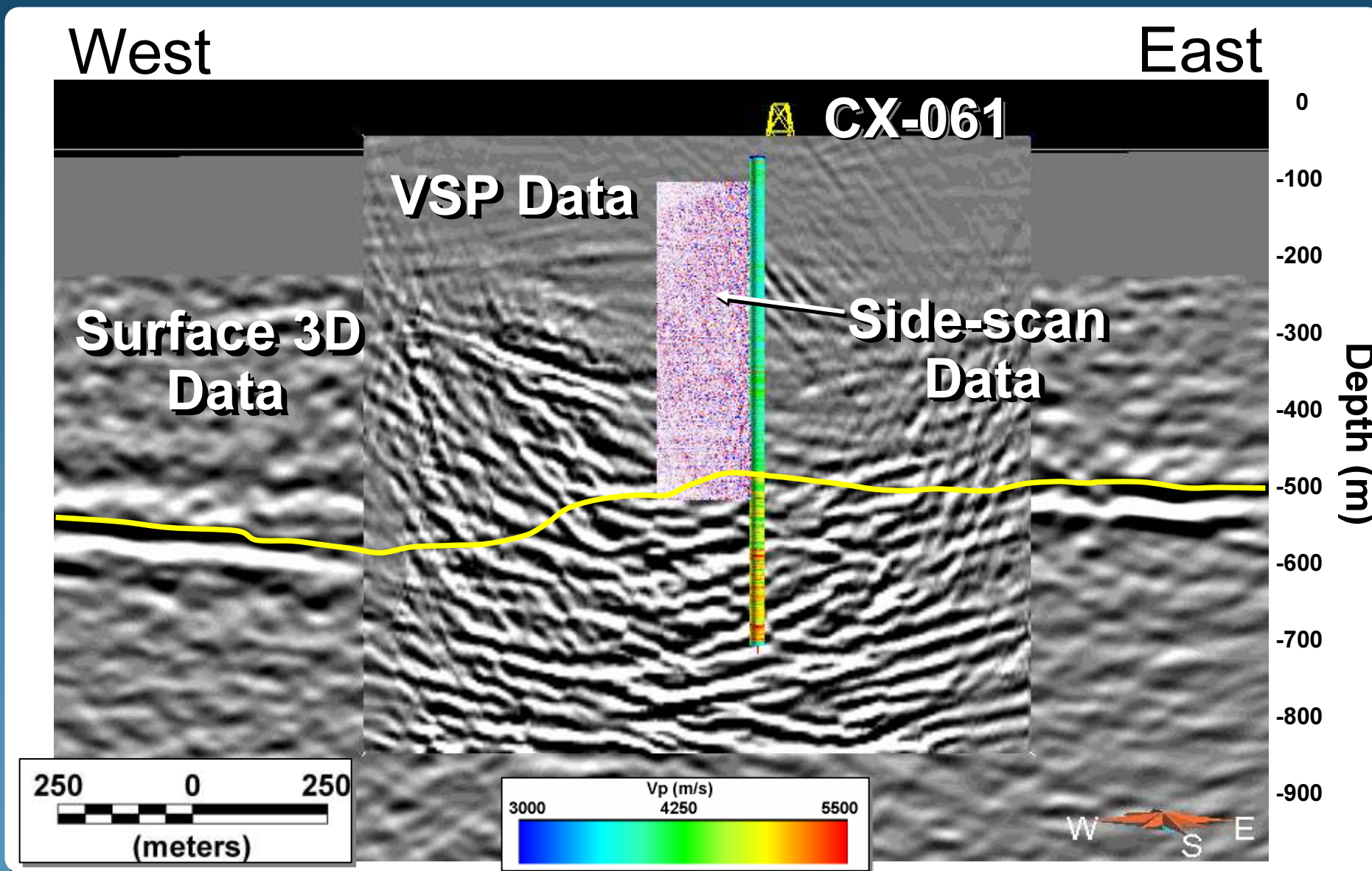


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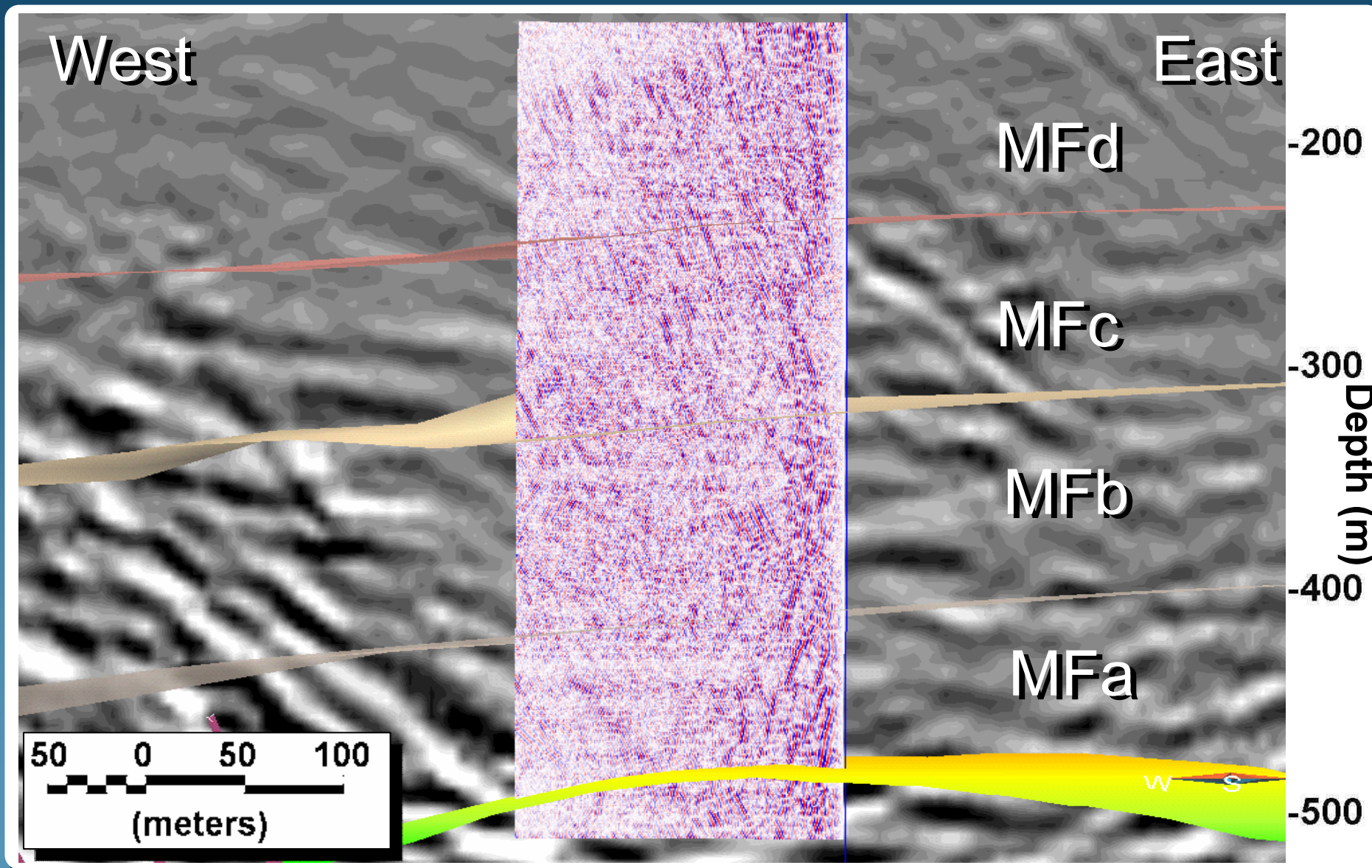
Seismic coverage



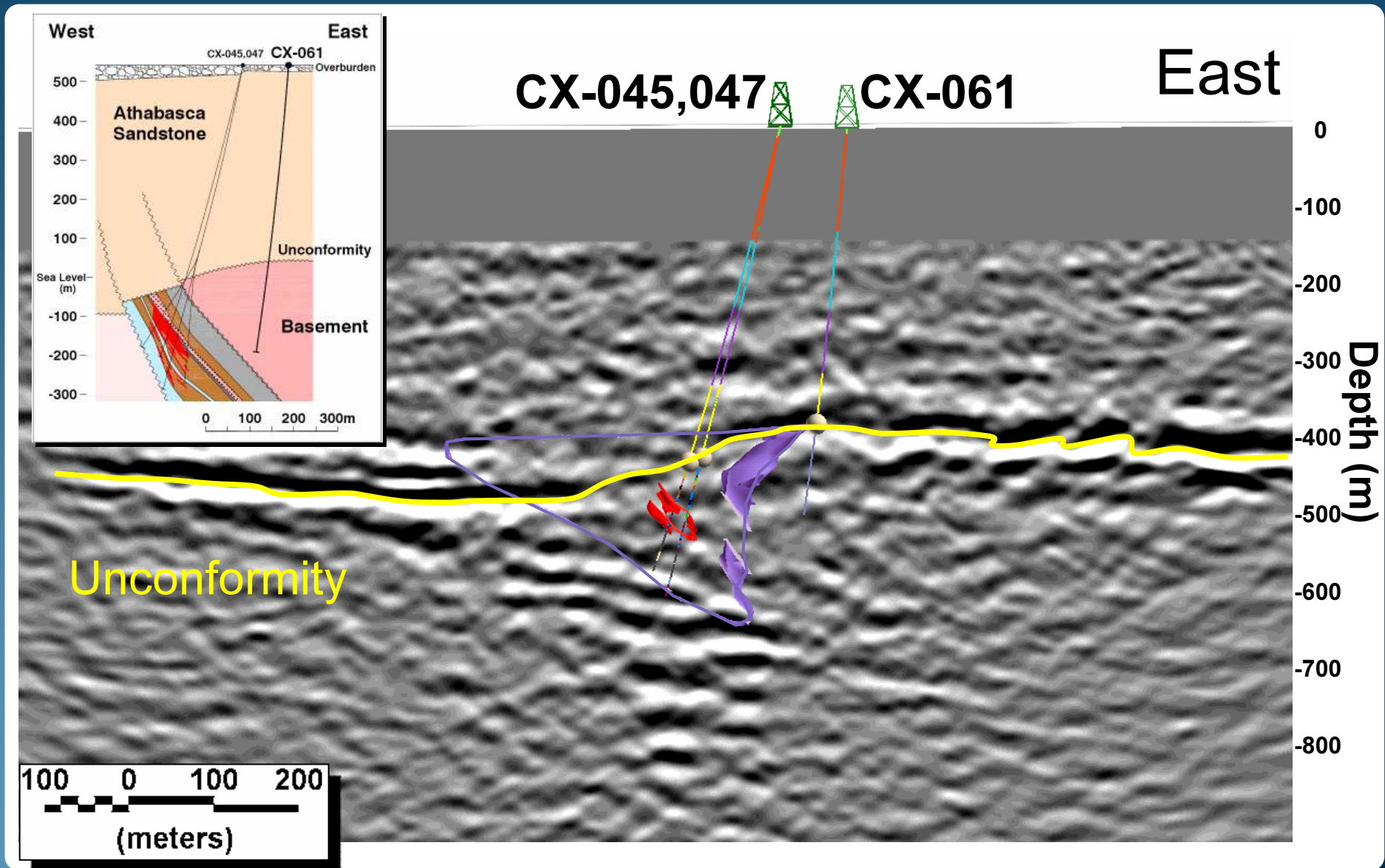
Seismic survey techniques - Resolution



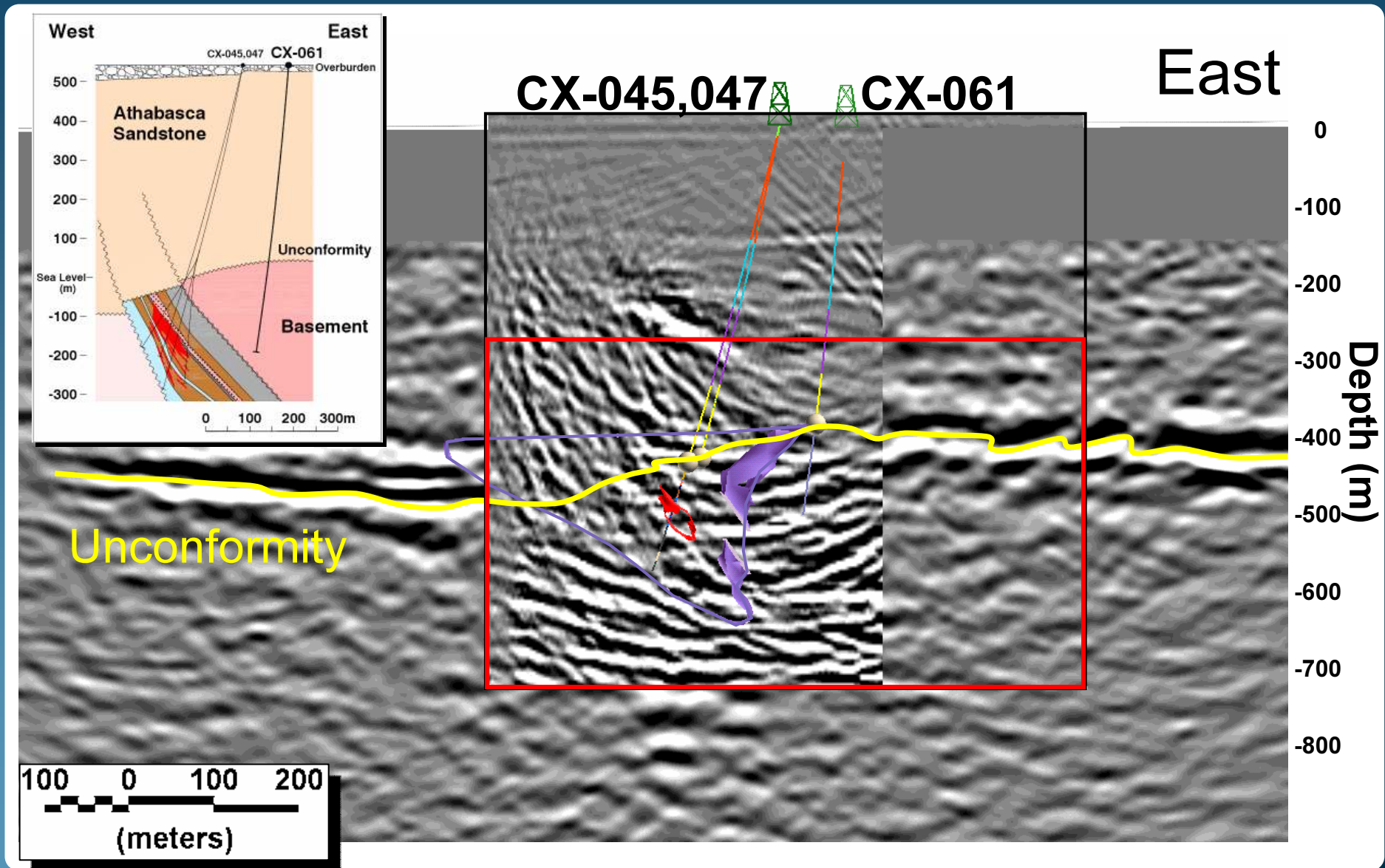
Side-scan results – CX-062



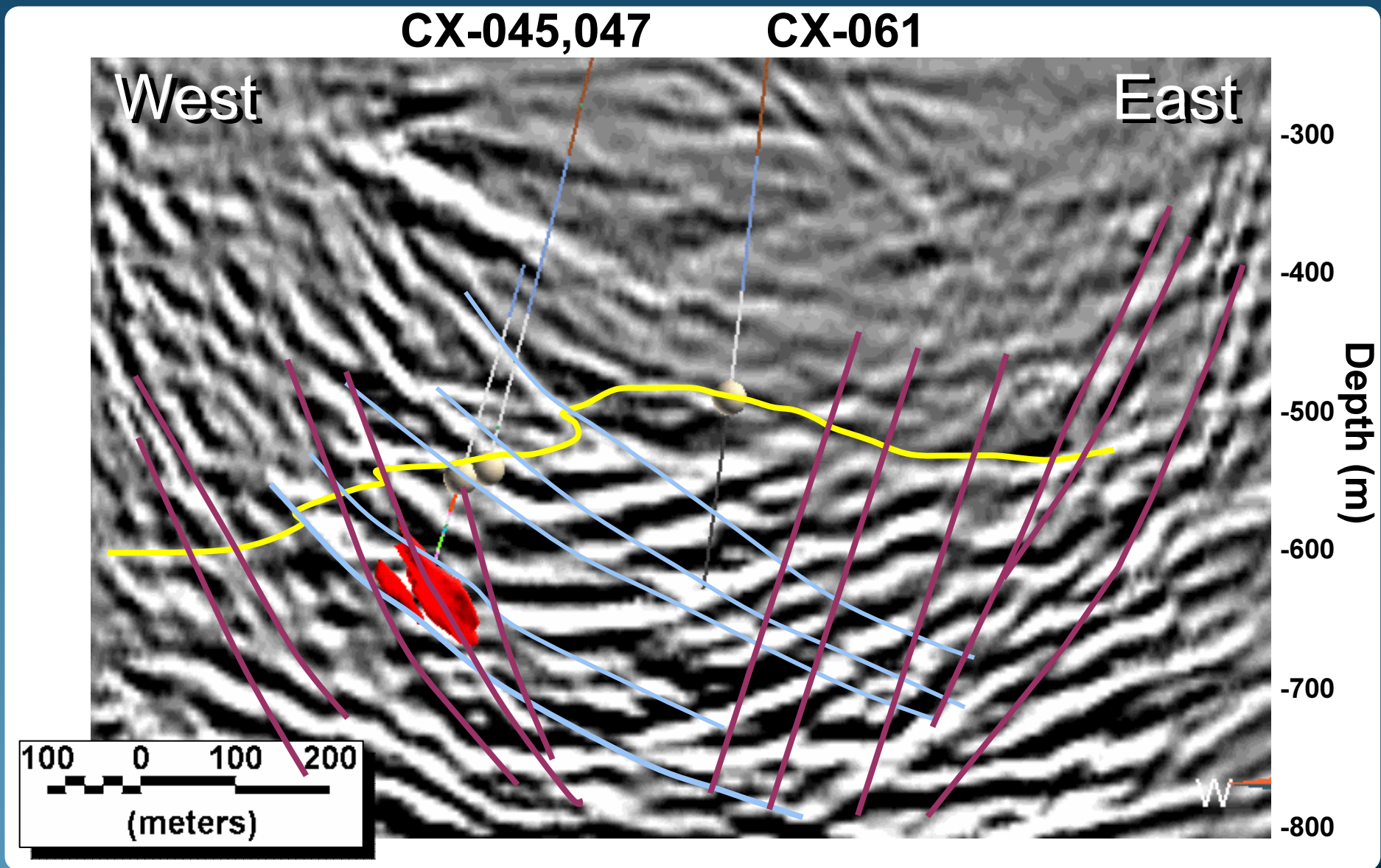
3D Surface seismic interpretation



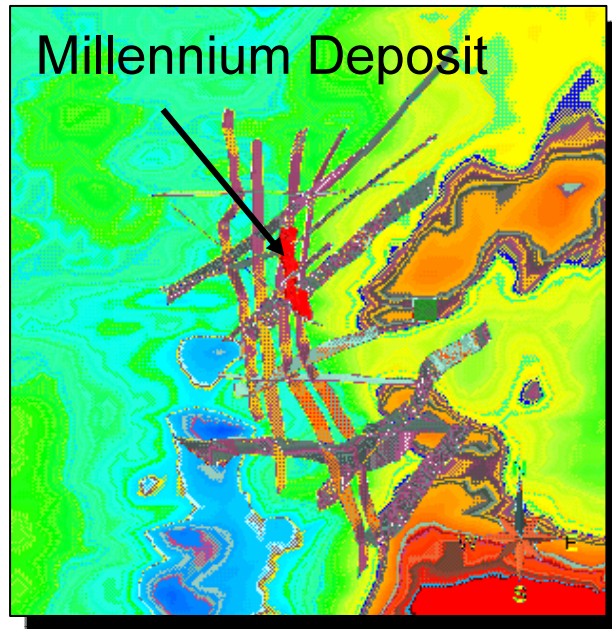
3D VSP Cube – Interpretation



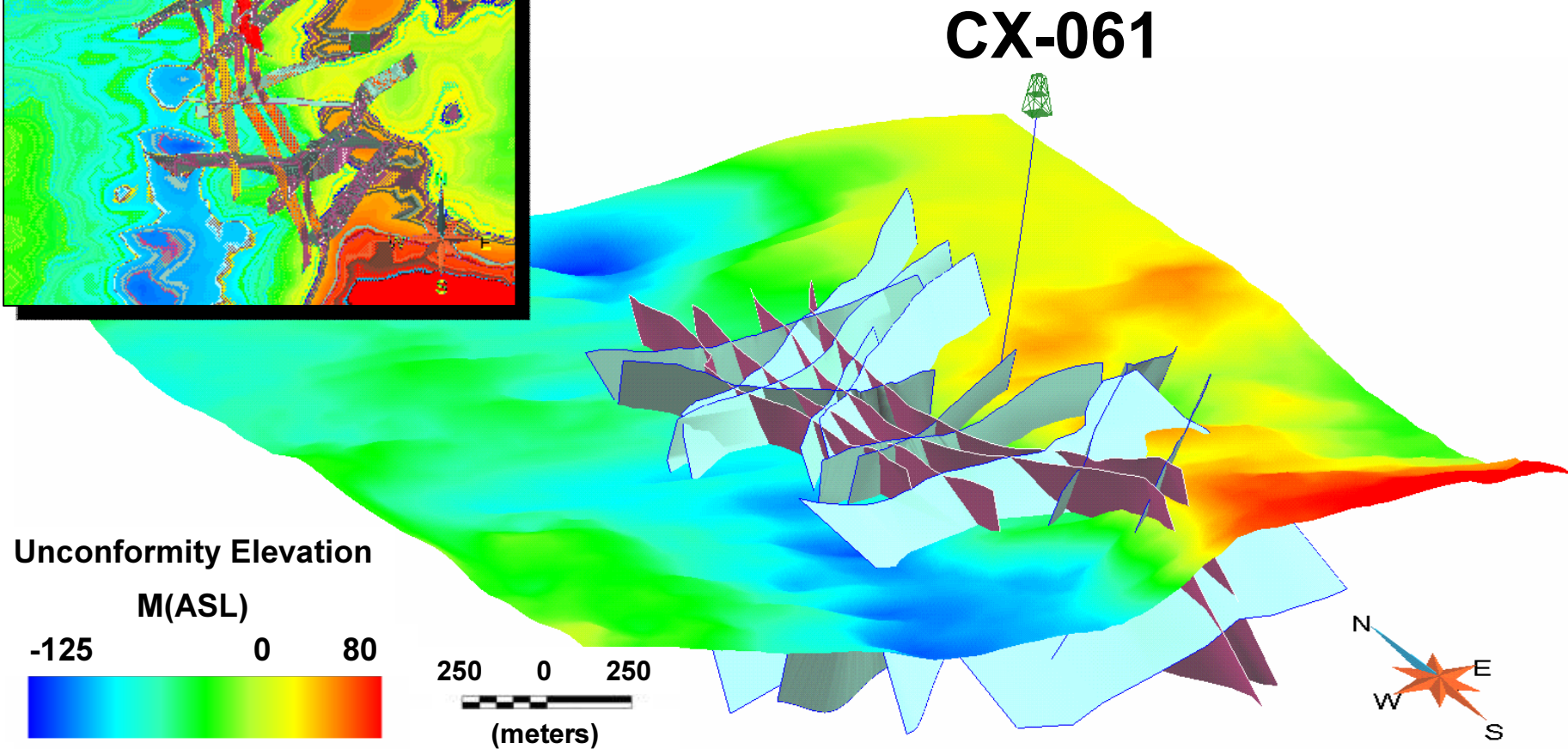
3D VSP Cube – Interpretation



Simplified structural interpretation



Unconformity map from 3D seismic cube



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Conclusions (1)

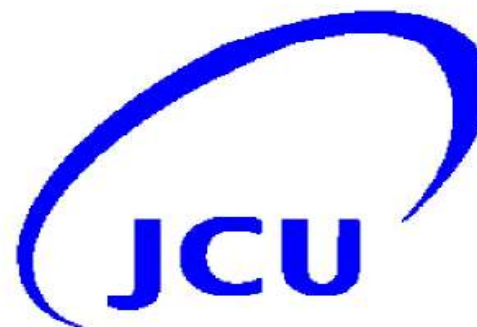
- Side-scan surveys confirmed the competency of the Athabasca Group sandstones in proximity of the shaft pilot holes
- VSP surveys provided detailed information on the location of the unconformity proximal to the shaft pilot holes and above the proposed mine workings
- VSP surveys imaged potential post-Athabasca faults that can be addressed in the mine development plan

Conclusions (2)

- Processing and interpretation of the multiple datasets is complex and time consuming
- The borehole seismic data has enhanced the understanding of both the 3D seismic cube and the geology hosting the deposit
- The seismic dataset are dynamic. Continued processing and interpretations are required as additional geological information become available
- Seismic surveys are now accepted as one of the discriminatory tools for shaft site selection during mine development at Cameco.

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Millennium 3D seismic grid

