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

Athabasca Basin, SK Canada

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**Presentation outline**

- 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
- Acknowledgements
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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 deposit – Generalized geology

- Millennium – 642 m Depth
- Photo Courtesy of the SRC

Sea Level – (m)
- 500 –
- 400 –
- 300 –
- 200 –
- 100 –
- 0 –
- -100 –
- -200 –
- -300 –

West

- Uranium Mineralization Fault
- Calc-silicate Footwall Assemblage
- Pelite/Semipelite
- MFd
- MFc
- MFb
- MFa

Unconformity
- Granitic Assemblage
- Graphitic Metasediments
- Graphitic Marker Pegmatite

Scale: 25 mm
Millennium deposit – Generalized geology

West

East

Overburden

Athabasca Sandstone

Unconformity

Sea Level (m)

Uranium Mineralization

CX-045,047

CX-061

500 –

400 –

300 –

200 –

100 –

0 –

-100 –

-200 –

-300 –

0 50 100 200 300m

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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

**VSP (MSP)**
Vertical reflectors and horizontal reflectors

**Side-scan**
Vertical reflectors only

▲ Seismic Source
■ Surface Receiver
♀ Borehole Receiver
Seismic techniques applied at Millennium

**Surface (3D)**
Horizontal reflectors only

**VSP (MSP)**
Vertical reflectors and horizontal reflectors

**Side-scan**
Vertical reflectors only

▲ Seismic Source  ■ Surface Receiver  ⚪ Borehole Receiver
Borehole seismic surveys – Location map

Legend
- Shaft Pilot Hole
- Seismic Borehole
- VSP Shot Point
- Millennium Deposit

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Seismic coverage

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Seismic survey techniques - Resolution

- Surface 3D Data
- VSP Data
- Side-scan Data

CX-061
Side-scan results – CX-062

West

East

MFd

MFc

MFb

MFa

Depth (m)
3D VSP Cube – Interpretation

CX-045,047  CX-061

Depth (m)

East

Unconformity

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3D VSP Cube – Interpretation

CX-045,047  CX-061

West                                                 East

Depth (m)

-300  -400  -500  -600  -700  -800

West

East

100  0  100  200

(meters)
Simplified structural interpretation

Unconformity map from 3D seismic cube

Millennium Deposit

CX-061
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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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Thank You