Seismic Imaging Challenges along crooked-line surveys of Metal Earth project in Abitibi Greenstone belt-*Acquisition footprint*

Saeid Cheraghi

Alno, Sweden
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METAL EARTH

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CANADA FIRST RESEARCH EXCELLENCE FUND

Canada

Laurentian University
Université Laurentienne
HARQUAIL School of Earth Sciences
École des sciences de la Terre

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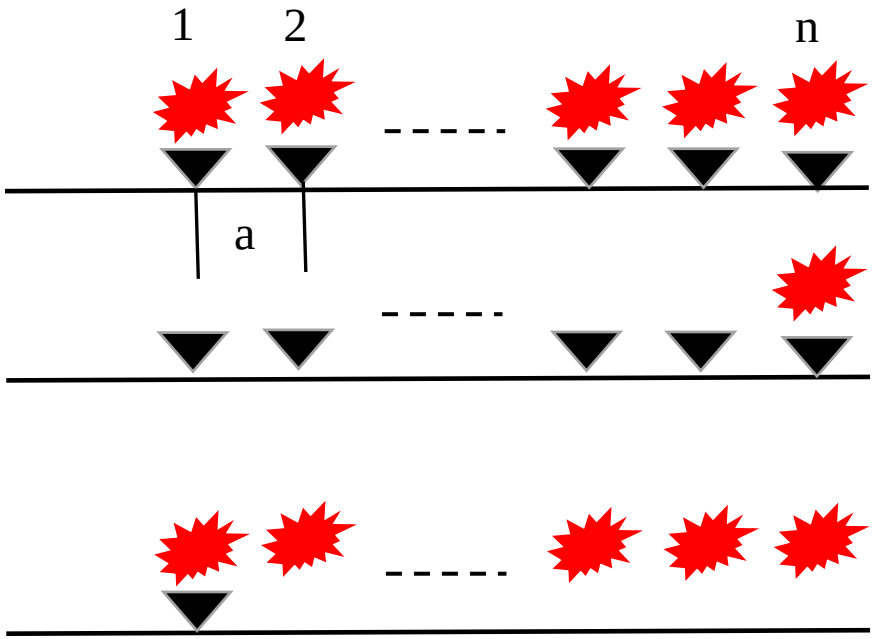
Outline

- Geometry of seismic survey (regularity/irregularity)
- Common-offset DMO corrections and prestack time migration (PSTM)
- DMO corrections and PSTM based on CMP offset distribution: Chibougamau survey
- A parallel geometry acquired in Metal Earth project: Matheson survey
- Seismic imaging in Chibougamau and Matheson

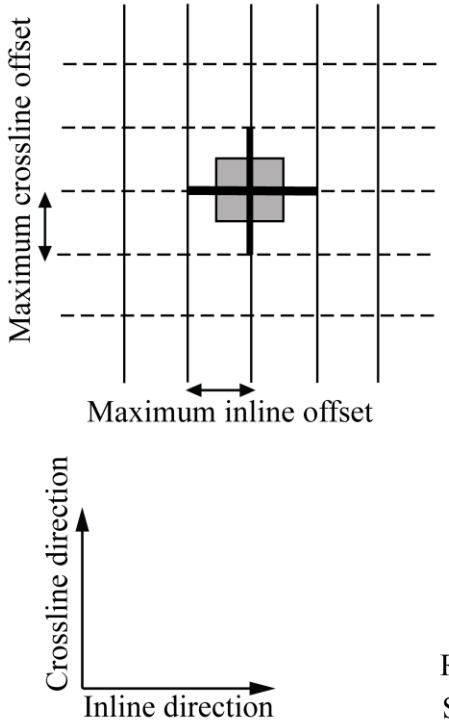
Geometrical attributes of a seismic survey

Wide and narrow azimuth geometry

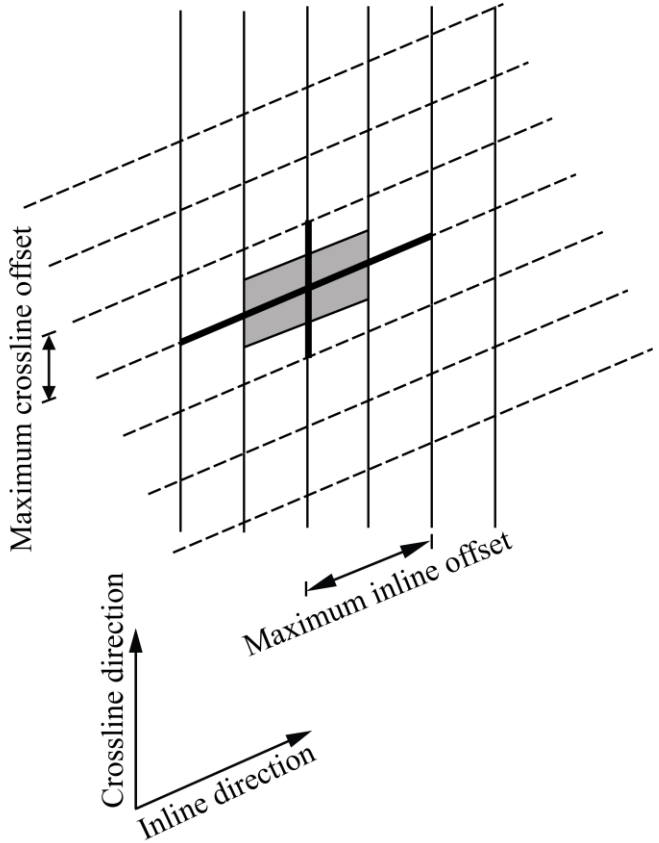
a) Reciprocity of 2D geometry



b) Orthogonal wide azimuth geometry



c) Non-orthogonal narrow azimuth geometry



Modified from Vermeer 1998

Symmetric sampling 2D and 3D seismic data

1. Wavefield sampling:

2D: $W(t, x_s, x_r)$

3D: $W(t, x_s, y_s, x_r, y_r)$

Continuous wavefiled sampling → **Symmetric sampling**

2. Reciprocity in shot and receiver domain in 2D sampling (symmetric sampling) →

$$\Delta x = \frac{1}{2k_{max}} = \frac{V_{min}}{2f_{max}}$$

3. 3D symmetric sampling:

Aspect ratio →

a. Receiver point spacing/shot point spacing

b. Receiver line spacing/shot line spacing

c. Maximum inline offset/maximum crossline offset

Sparsity and irregular offset distribution

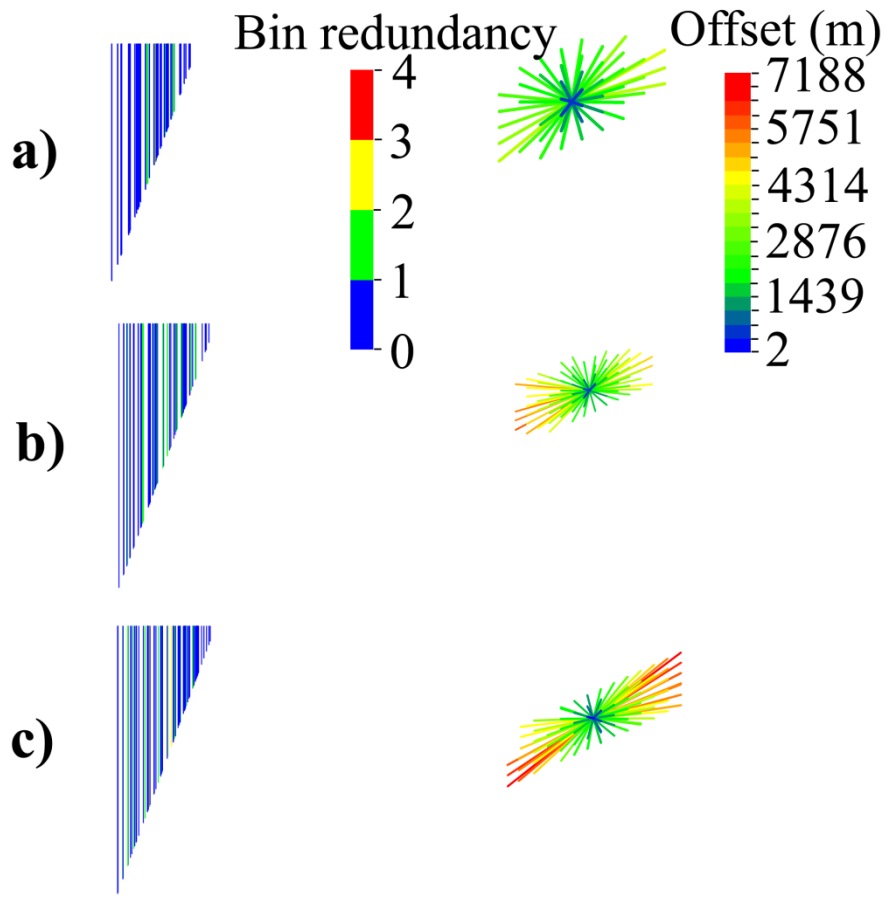
- Presence of natural obstacles
- Inaccessible areas
- Limited budget

Sparsity

Larger shot and receiver line intervals are considered in which cause irregular offset and azimuth distribution

Acquisition footprint

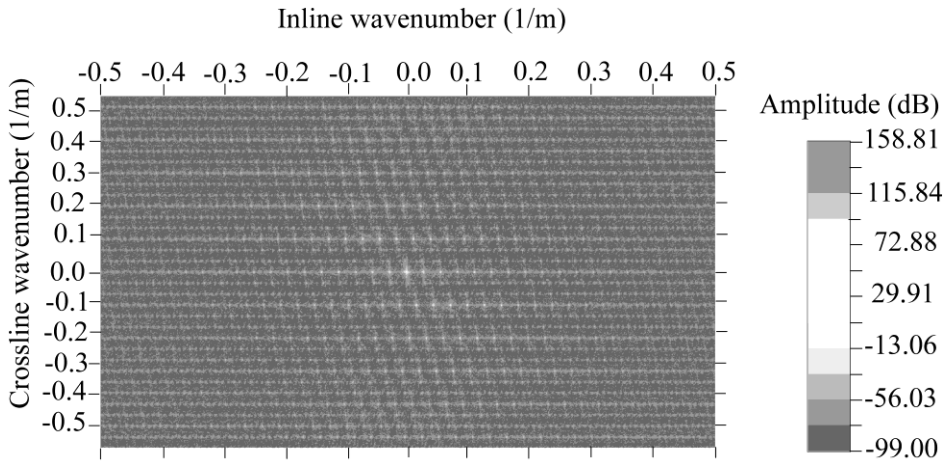
Generating repetitive or periodic artifacts after DMO processing



Modified from Cheraghi et al. 2012

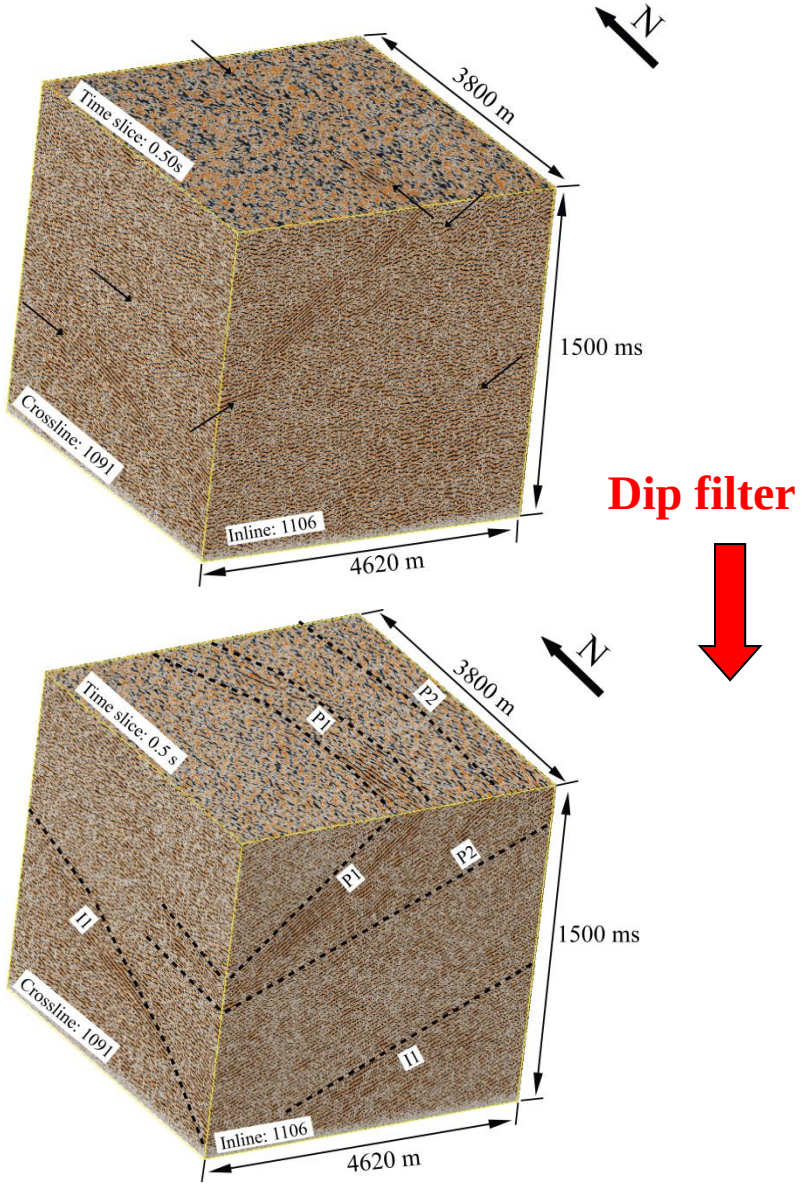
Effects of acquisition footprint

Kx-ky transformation
of trace midpoimts



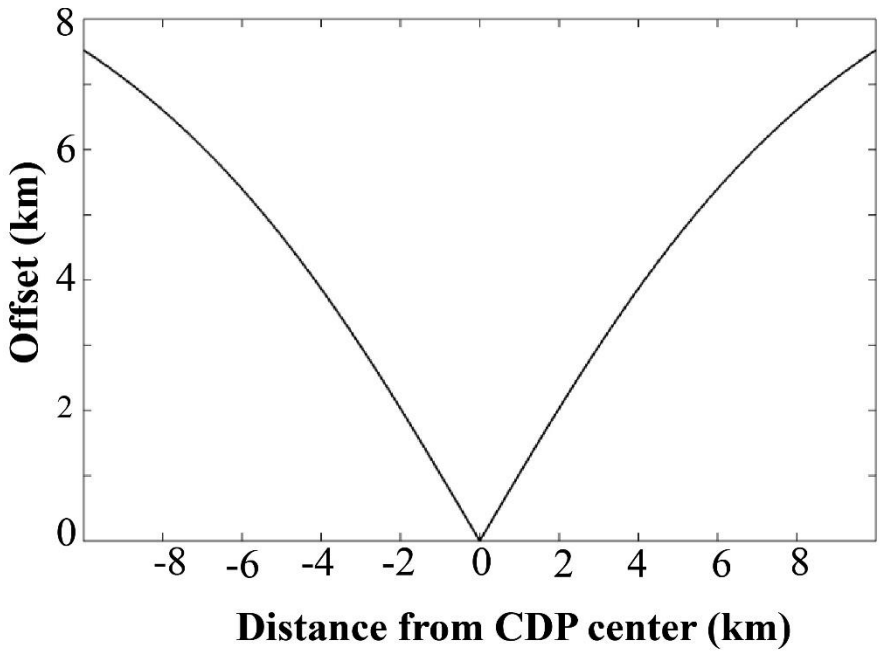
Bin size 11 by 30 m

Done based on a method introduced by Gulunay et al. (2006)



Modified from Cheraghi et al. 2012

DMO corrections and prestack time migration (PSTM)



h: Offset/2

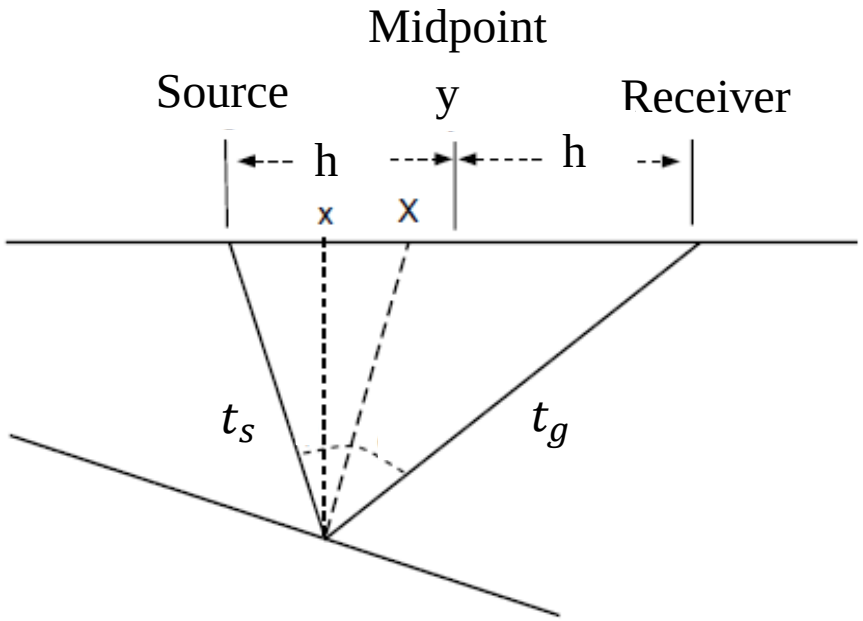
V: velocity

$t = t_s + t_g$

X=zero-offset

$x = imaging\ point$

y=midpoint position



V= 5500 m/s
Sampling interval= 2 ms
t= 4 s
Target depth= 1 s

DMO and PSTM: midpoint and offset distribution

DMO correction: $t_D^2 = t^2 + \frac{4(y-X)^2}{V^2} - \frac{(y-X)^2 t^2}{h^2}$

Modified from Hale, 1991

$$t_{Kirchhof-mig} = t^2 - \frac{4h^2}{V^2} - \frac{4(y-x)^2}{V^2} + \frac{16h^2(y-x)^2}{V^4 t^2}$$

Modified from Fowler, 1997

DMO corrections and prestack time migration (PSTM)

The **regularity/irregularity** of an acquired geometry for Kirchhoff PSTM algorithm or DMO corrections can be defined basically as a concept of an integral summation (Canning and Gardner, 1998):

$$f(x,y,z) = \int w \frac{d}{dt} f(S,R,\tau) dSdR$$

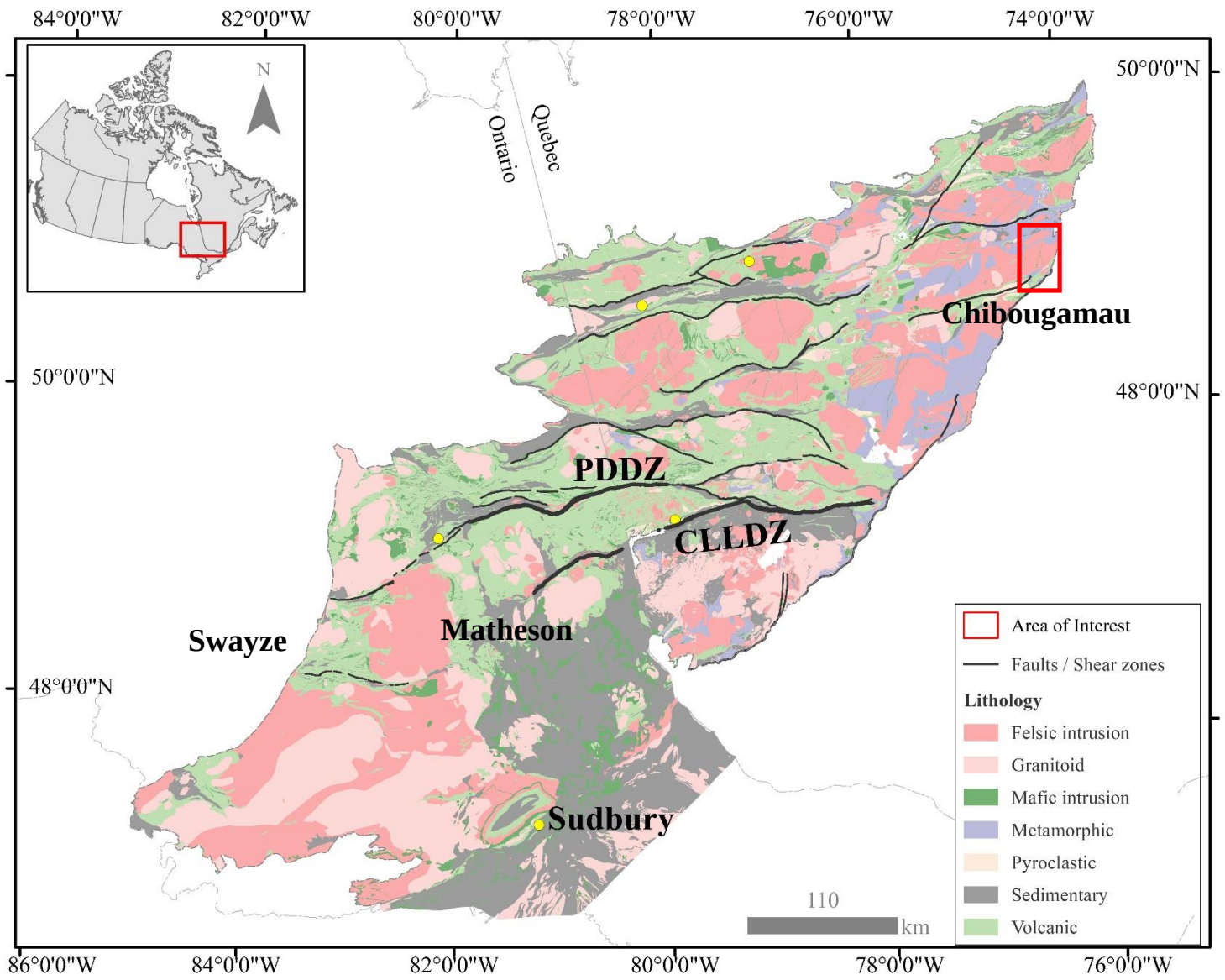
(x,y,z) is a imaging point

τ is travel time

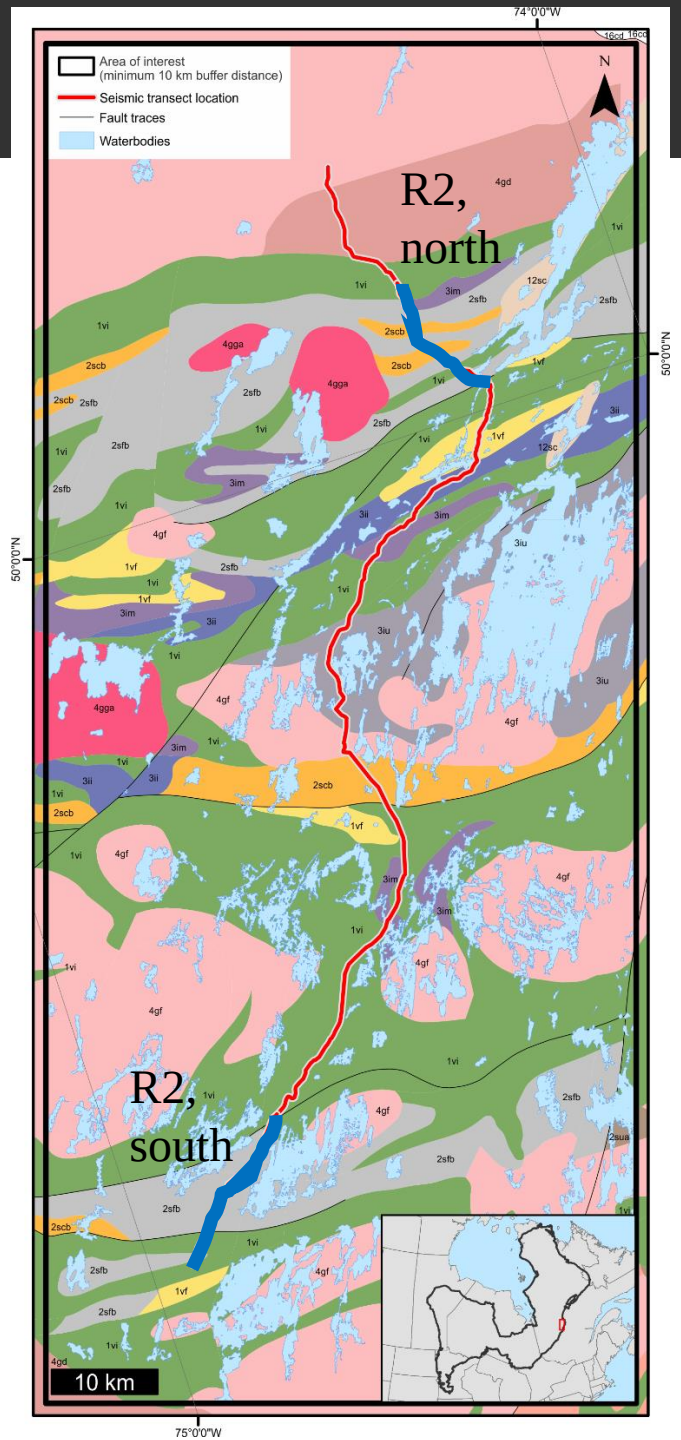
$dSdR$ will be CMP coordinate, i.e. $dx_m dy_m$

offsets are shown by w

Location of Chibougamau research area



Chibougamau transact



Precambrian (0.542 Ga - < 3.85 Ga)
Proterozoic (0.542-2.50 Ga)
Clastic metasedimentary

- Coarse clastic metasedimentary units

Archean (2.5 Ga - < 3.85 Ga)
Granitoids

- Diorite-mozonite-granodiorite suite
- Foliated tonalite suite
- Gneissic tonalite suite

Mafic and ultramafic intrusions

- Mafic intrusions
- Ultramafic intrusions

Metasedimentary units

- Clastic and chemical metasedimentary units
- Coarse clastic metasedimentary units
- Coarse clastic Successor Basin units
- Fine grained clastic metasedimentary units
- Fine clastic Successor Basin units

Metavolcanic units

- Mafic to intermediate metavolcanics
- Felsic to intermediate metavolcanics

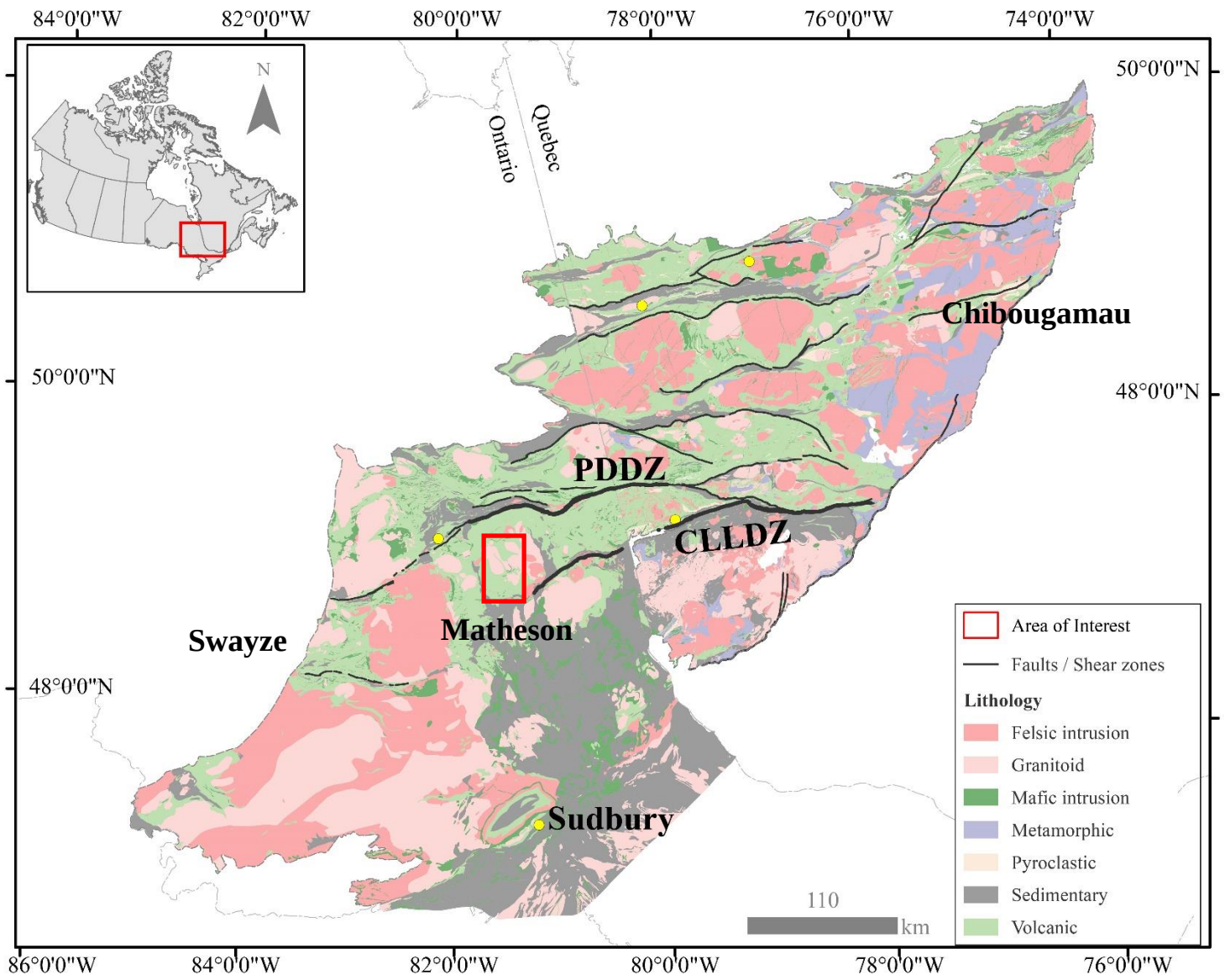
North survey

- **Number of shots: 2281**
- **Number of receivers per shot: 3422**
- **Shot spacing: 6.25 m**
- **Receiver spacing: 12.5 m**

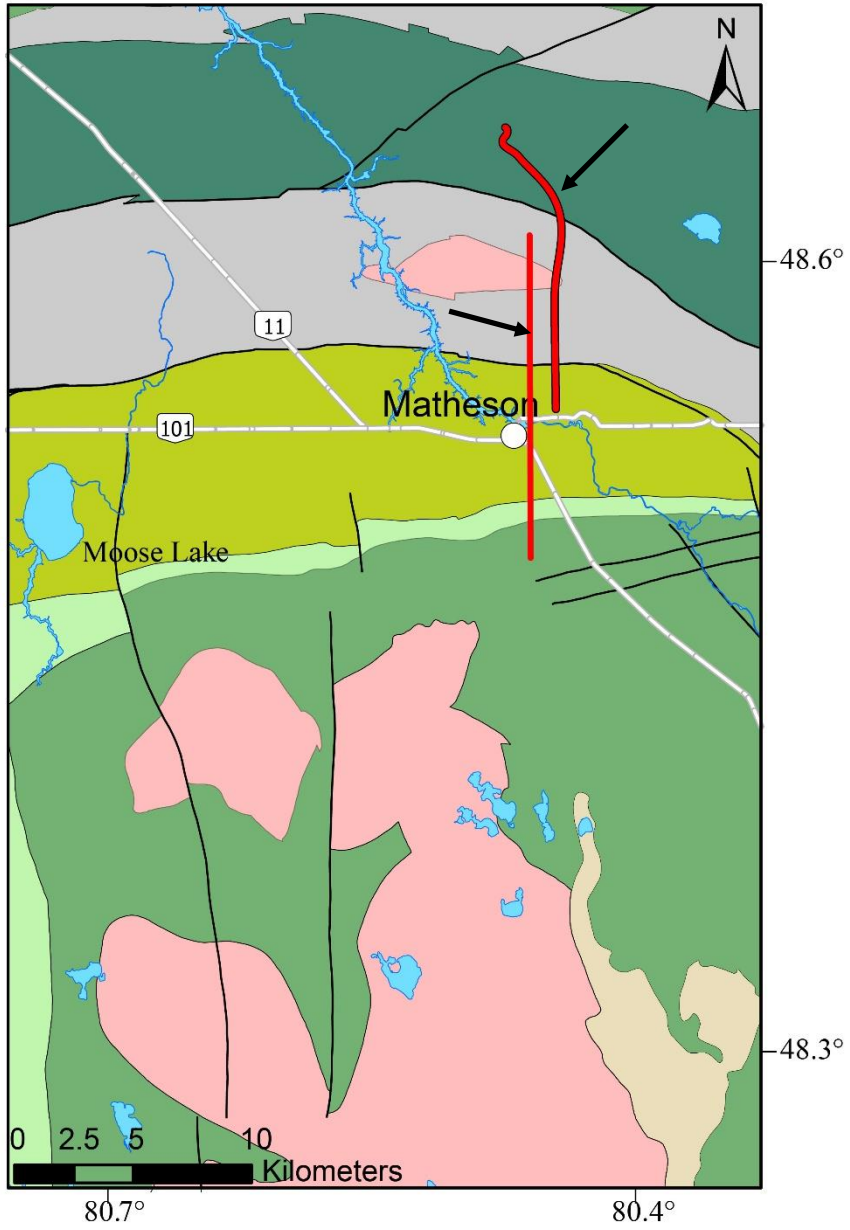
South survey

- **Number of shots: 3126**
- **Number of receivers per shot: 2009**
- **Shot spacing: 6.25 m**
- **Receiver spacing: 12.5 m**

Location of Matheson research area



Matheson geological survey



- **Totally 1829 shots were acquired**
- **Number of receivers per shots: 2667**
- **Shot spacing: 6.25 m**
- **Receiver spacing: 12.5 m for the east survey and 25 m for the west survey**

Lake

Faults

Post Archean Fault

Archean Fault

Lithologies

Huronian, Cover

Porcupine, Sedimentary

Blake River, Lower Unit

Tisdale, Upper Unit

Tisdale, Lower Unit

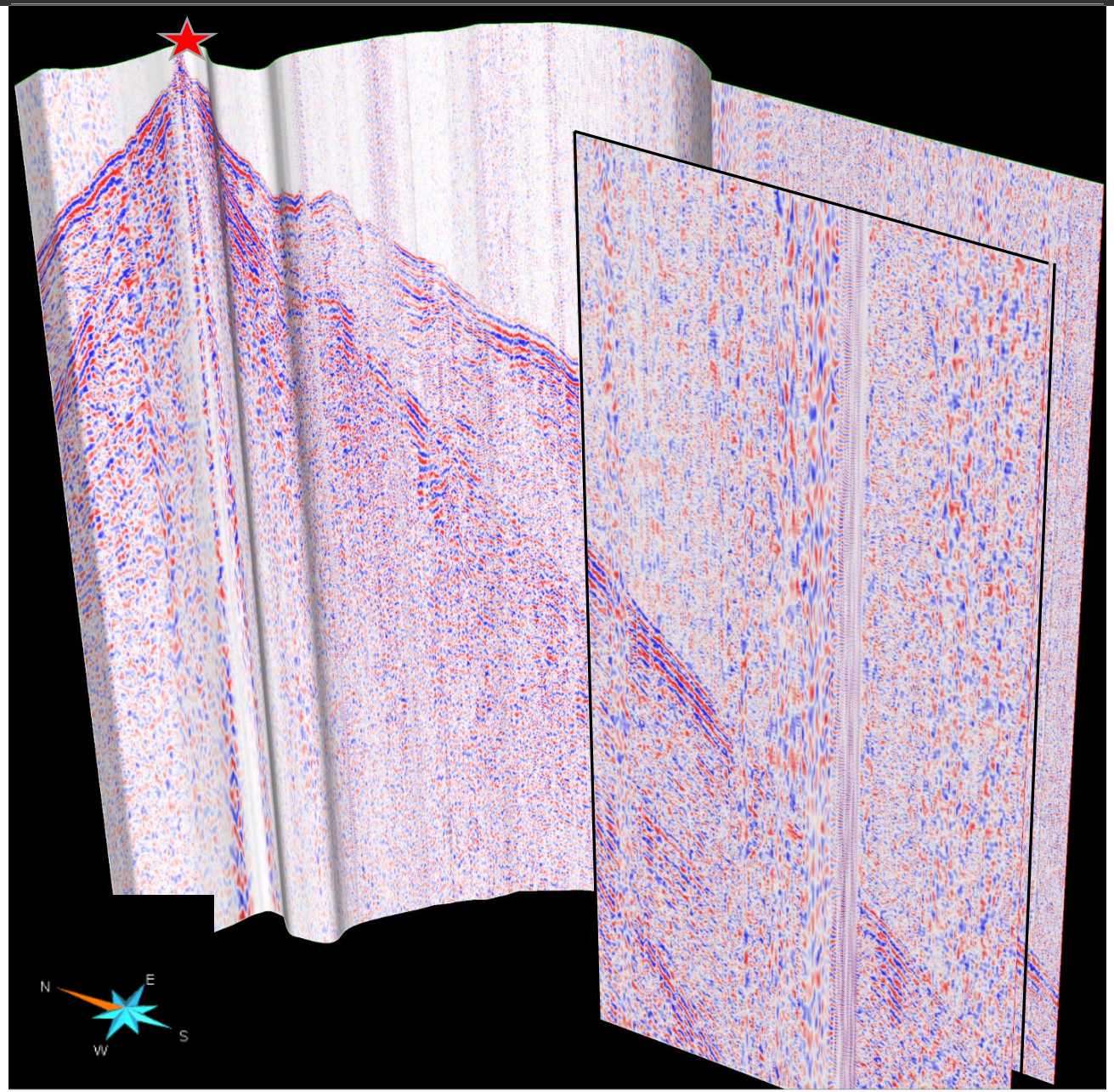
Kidd-Munro , Upper Unit

Intrusive, Syntectonic

Seismic

Seismic profile

Acquired shots in Matheson survey



First shot in the survey
East profile: 978 receivers, 12.5 m spacing
West profile: 213 receivers, 25 m spacing

The distance between two profile is ~ 2 km

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