

Detecting fractures using time-lapse 3C-3D seismic data

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Outline

- Introduction
 - Geology and objective
 - Previous study
- Time-lapse 3C seismic data interpretation
- Conclusion and future work
- Acknowledgements

The background of the slide is a photograph of a construction site. A large yellow crane is the central focus, with its boom extending upwards. In the lower-left foreground, a worker wearing a hard hat and safety vest is visible, looking towards the crane. The scene is set against a bright, hazy sky, suggesting a sunny day. The overall color palette is dominated by the yellow of the crane and the blue of the sky.

Objective

Delineate fractures to prevent/monitor brine inflow using 3C seismic data.

Can we use 3C seismic data to detect them?

Previous study and findings

- ❑ Velocity decreases when fractures are present
- ❑ S velocity drops significantly (over 20%)
- ❑ V_p/V_s increases with fracturing
- ❑ Visible changes (time shift, amplitude change) in PP and PS synthetic seismograms with fracturing
- ❑ P- and S-velocity anisotropy with aligned fractures
- ❑ Strong seismic velocity anisotropy on horizontal components
- ❑ Distinct shear-wave splitting effect
- ❑ Changes in converted-waves (PS) with fracturing show promise as an indicator of rock alteration

Surface seismic interpretation

Seismic response of fractures:

Vp, Vs decrease <-- --> Time shift on PP and PS data

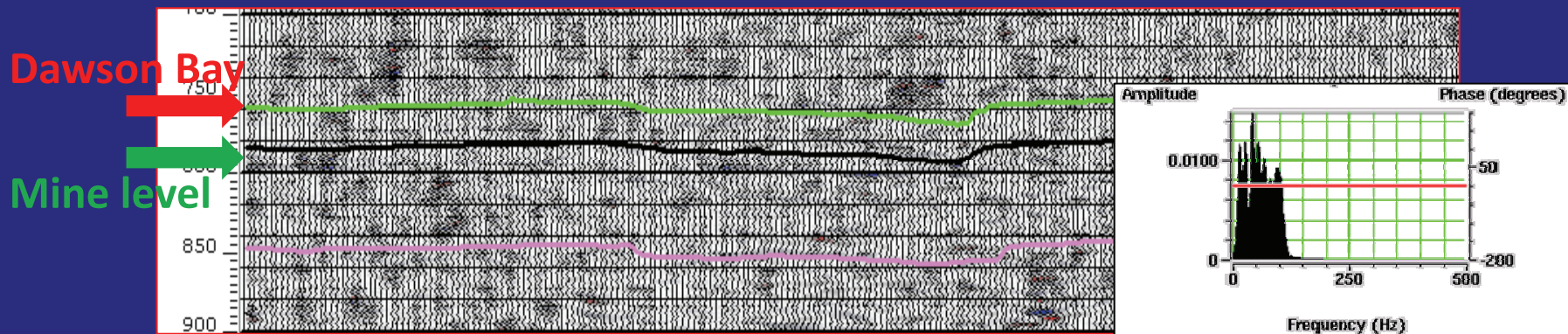
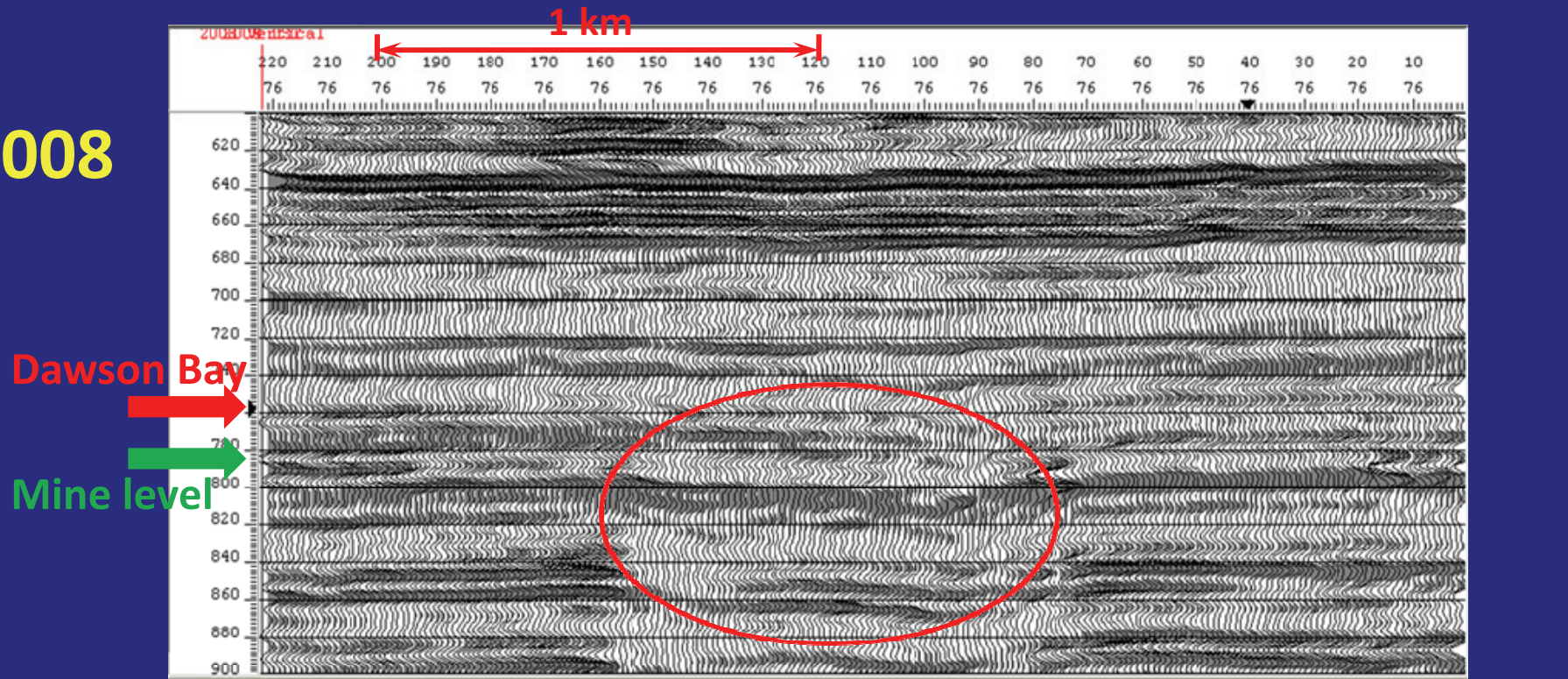
Vp, Vs, ρ changes <-- --> Amplitude changes

More Vs decrease <-- --> Vp/Vs increase

Vs anisotropy <-- --> Shear-wave splitting

PP data (W-E line)

2008

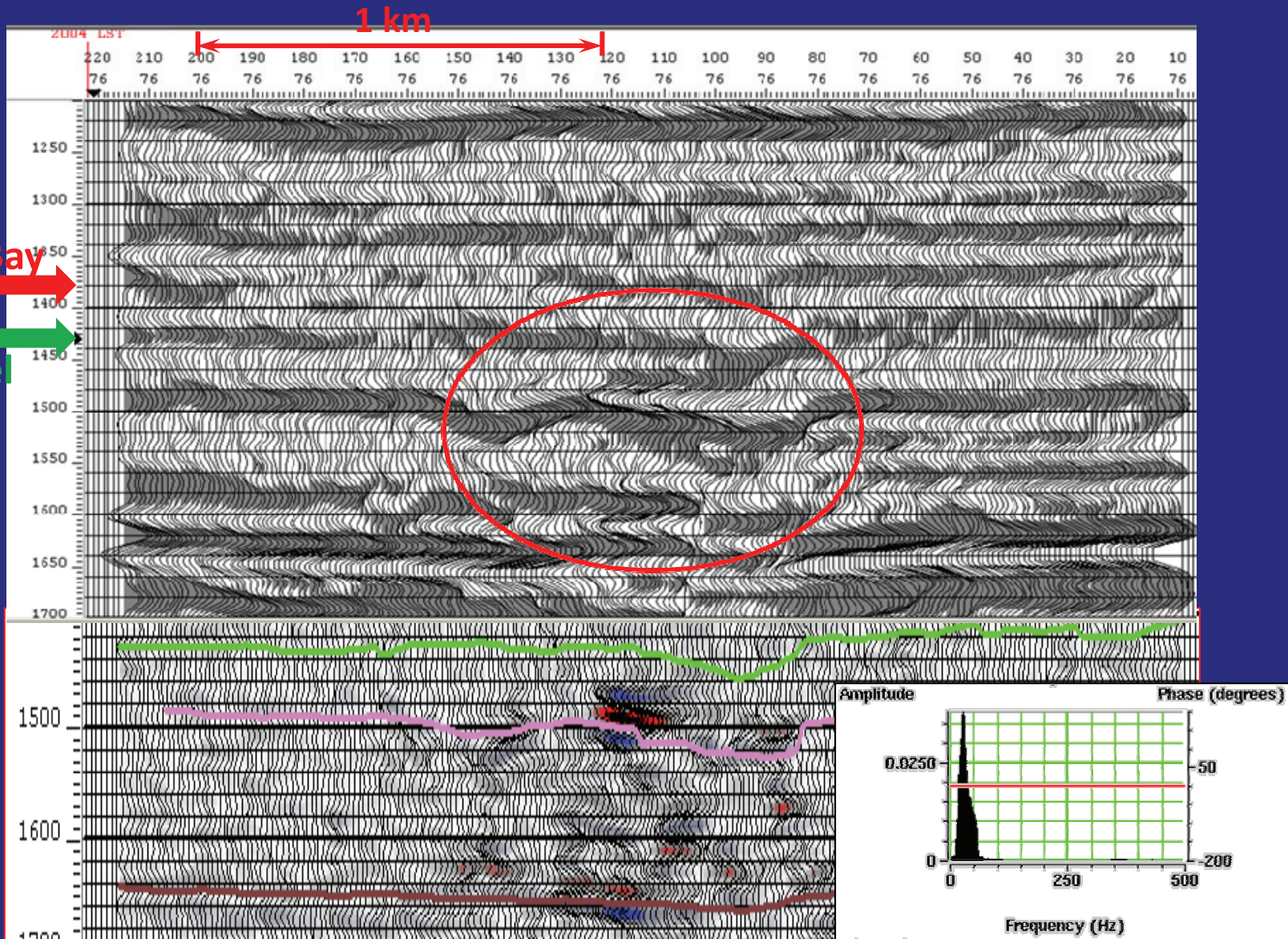


PS data (W-E line)

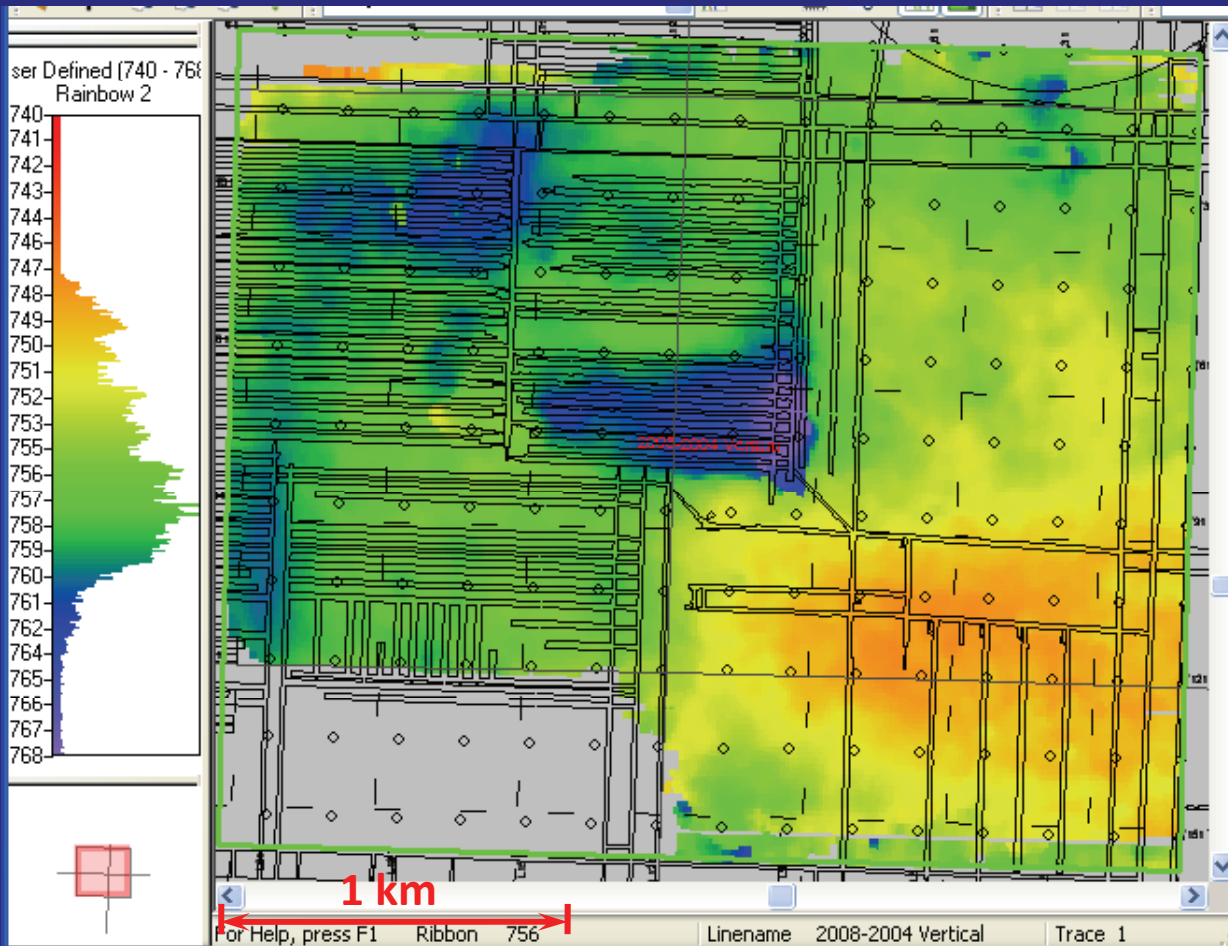
2008

Dawson Bay

Mine level

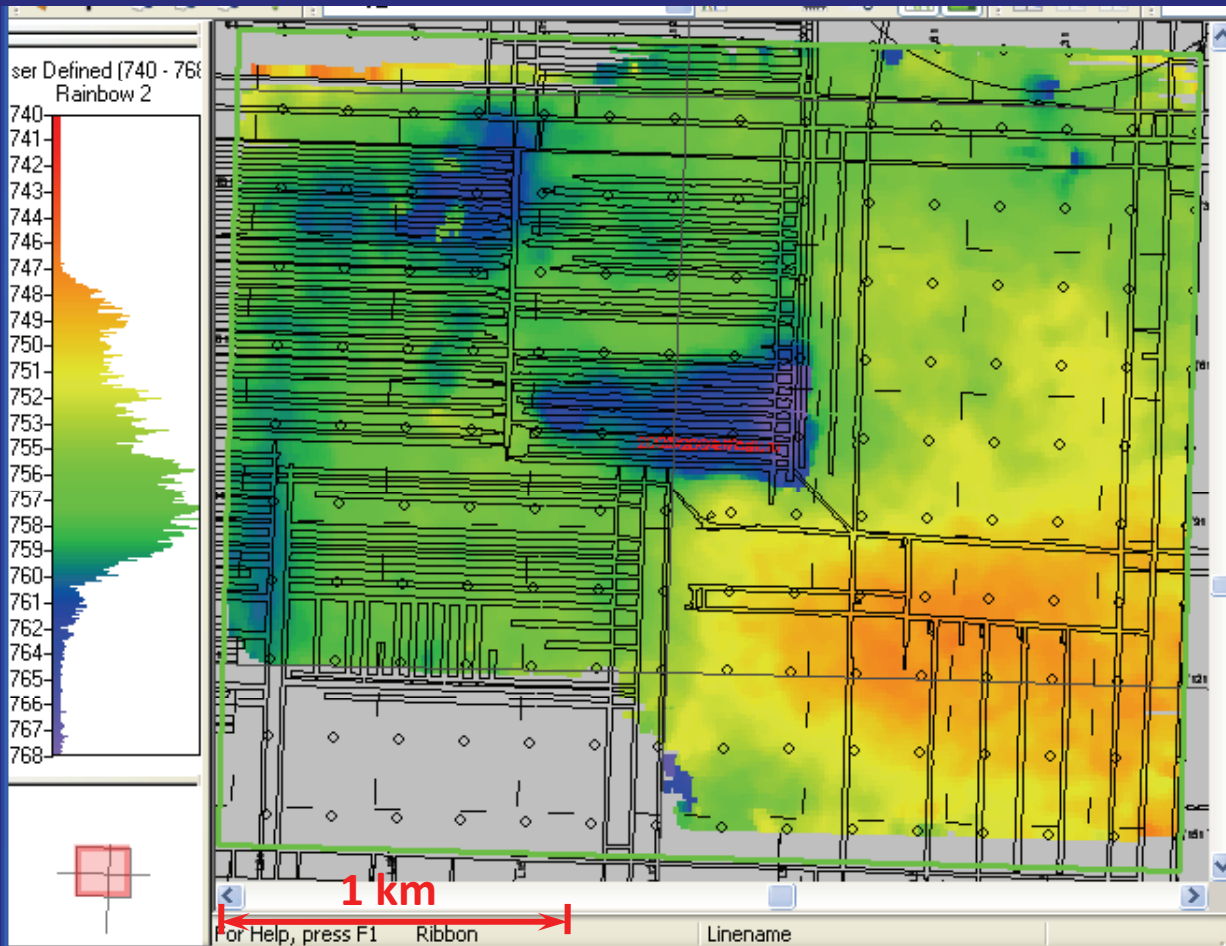


Time structure: Dawson Bay Formation



PP 2004

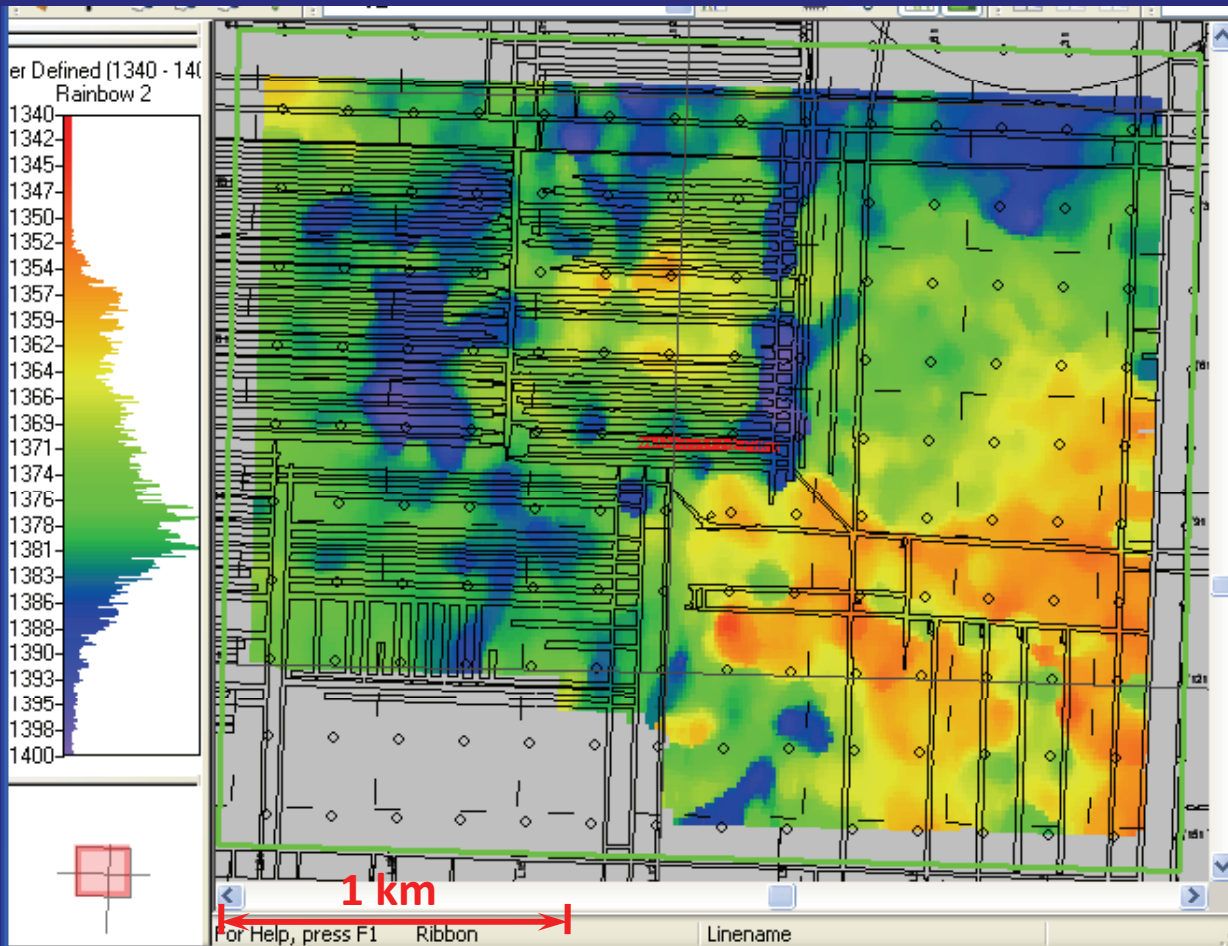
Time structure: Dawson Bay Formation



A little pull up

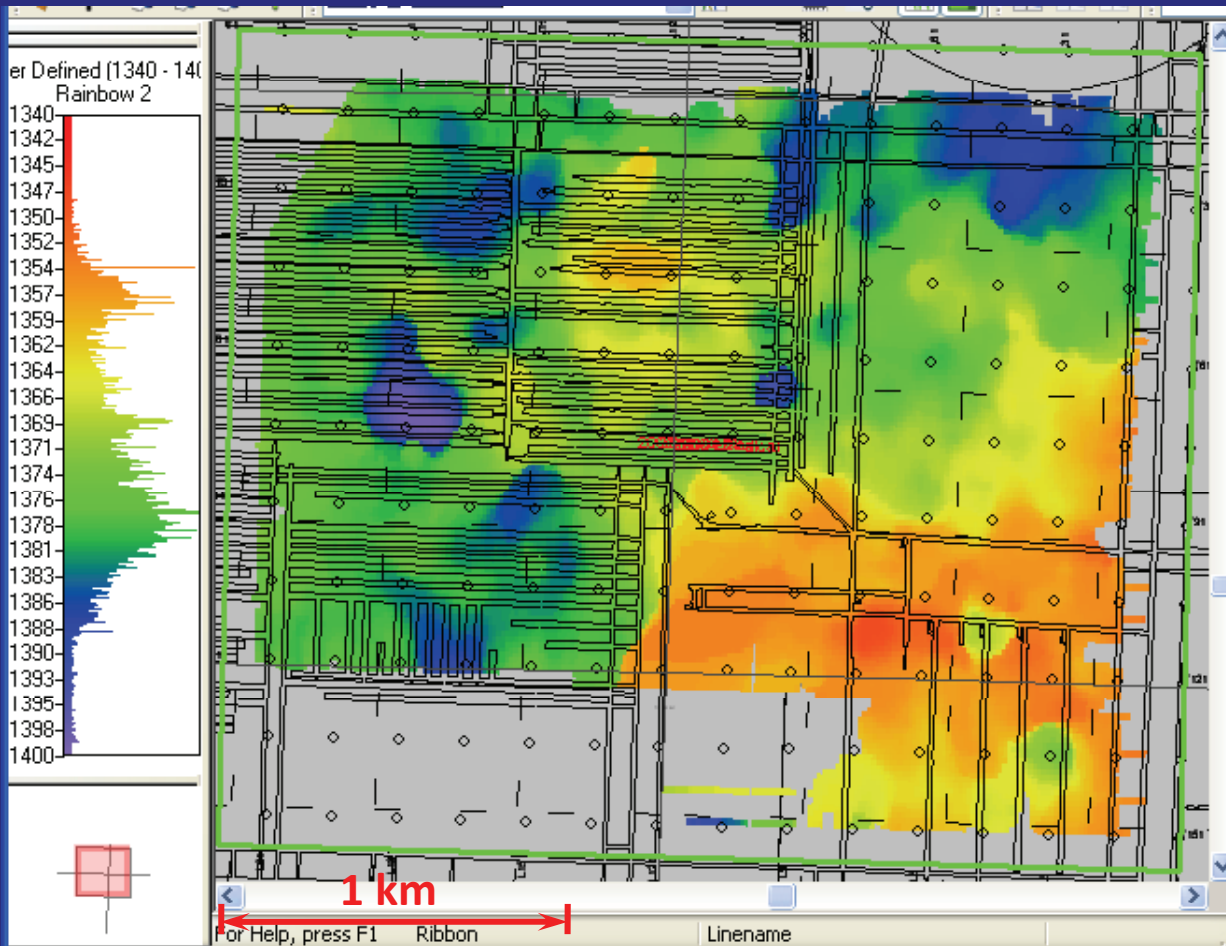
PP 2008

Time structure: Dawson Bay Formation



PS 2004

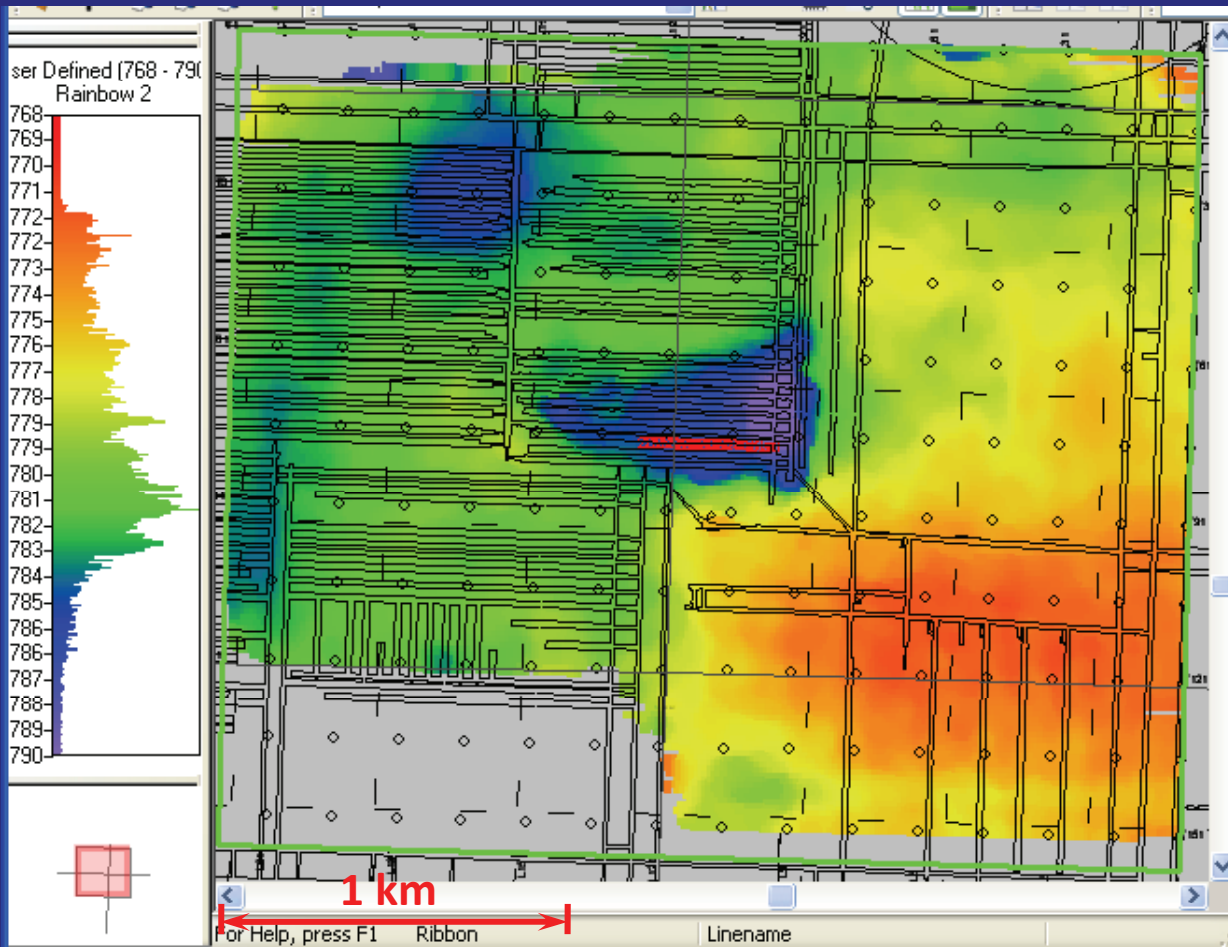
Time structure: Dawson Bay Formation



A little pull up
Something happens above the DB?

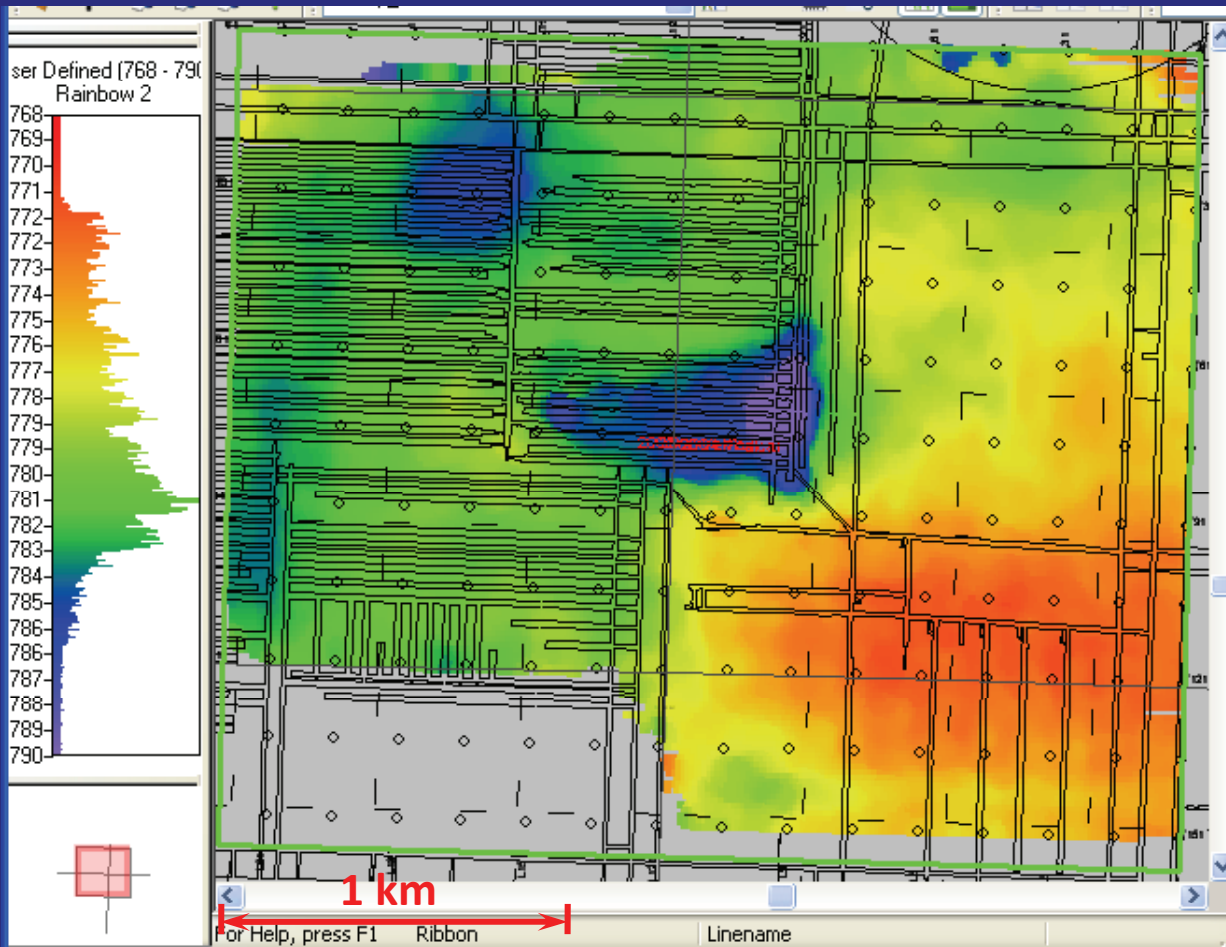
PS 2008

Time structure: Prairie Evaporite Formation



PP 2004

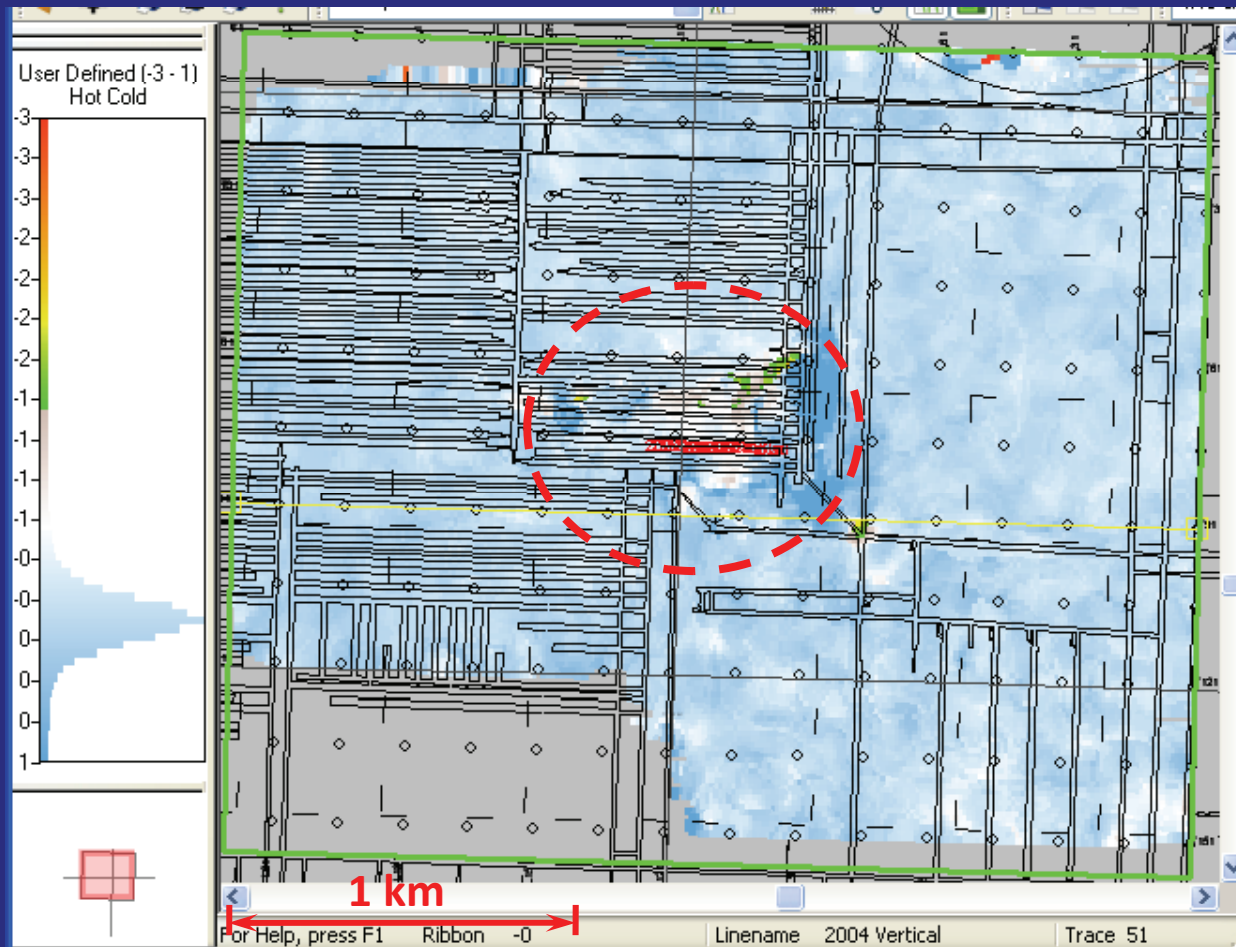
Time structure: Prairie Evaporite Formation



Mostly push
down –
fracture
effect

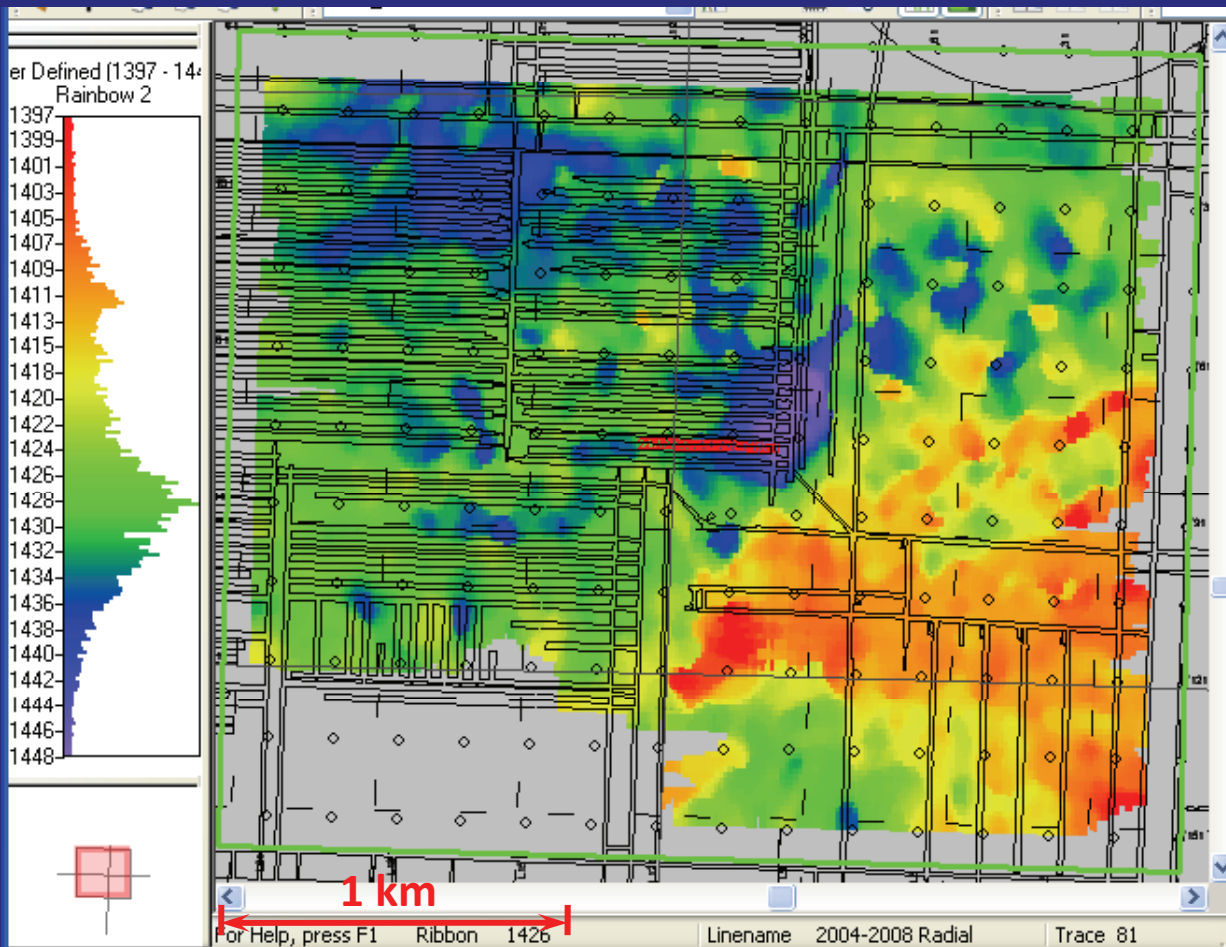
PP 2008

Prairie Evaporite Formation PP time shift 2008-2004



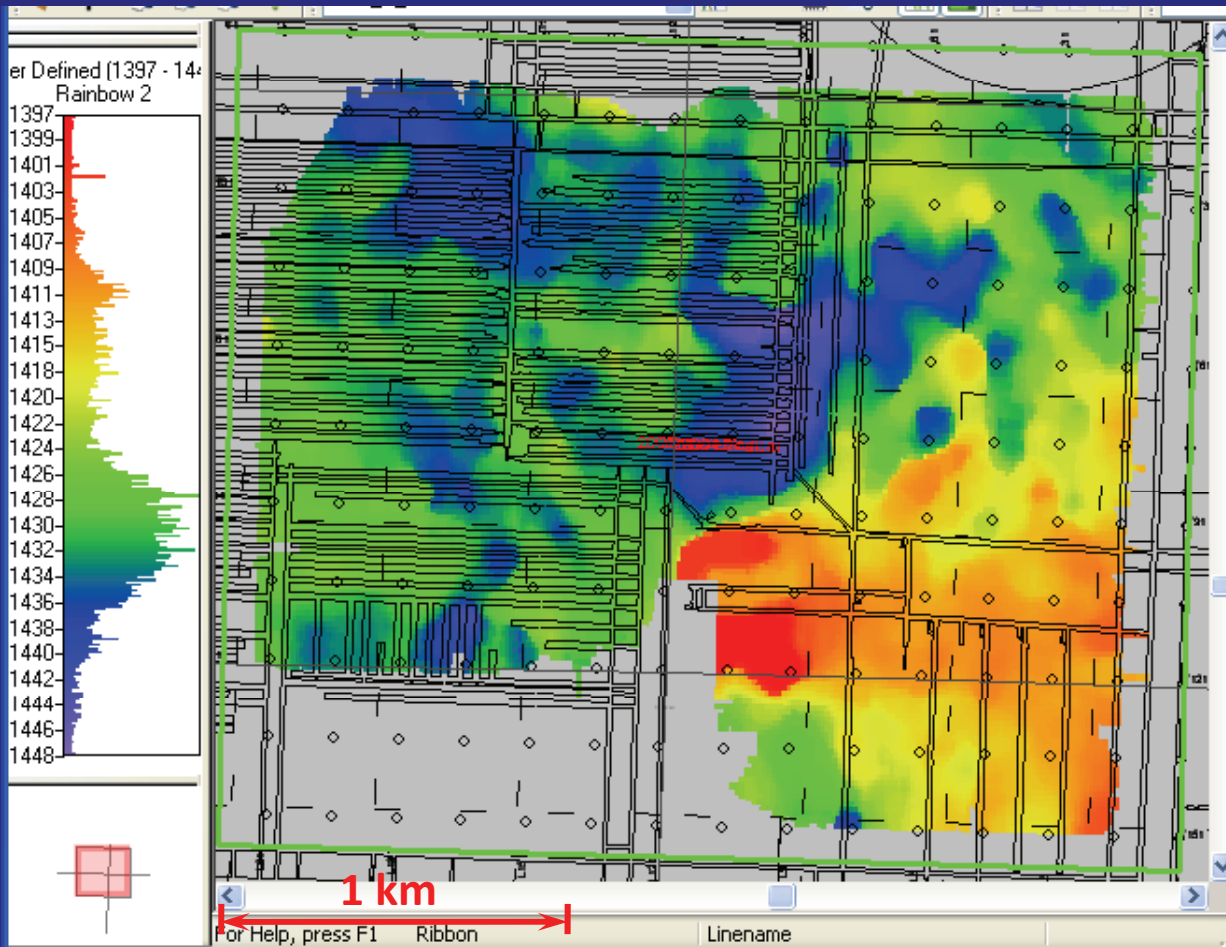
Small time shift, up to about 1-2 ms push down

Time structure: Mine level



PS 2004

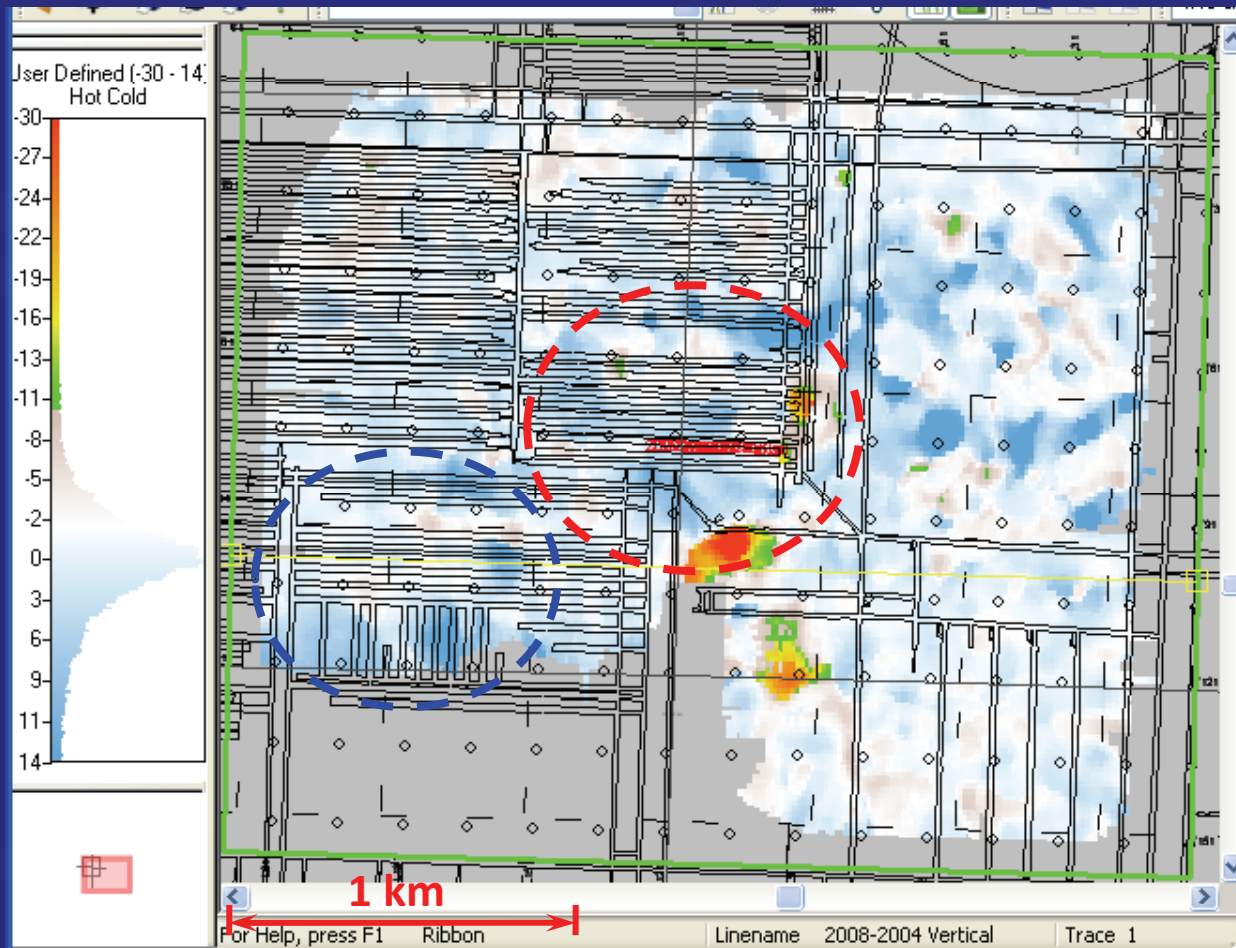
Time structure: Mine level



Mostly push
down –
fracture
effect

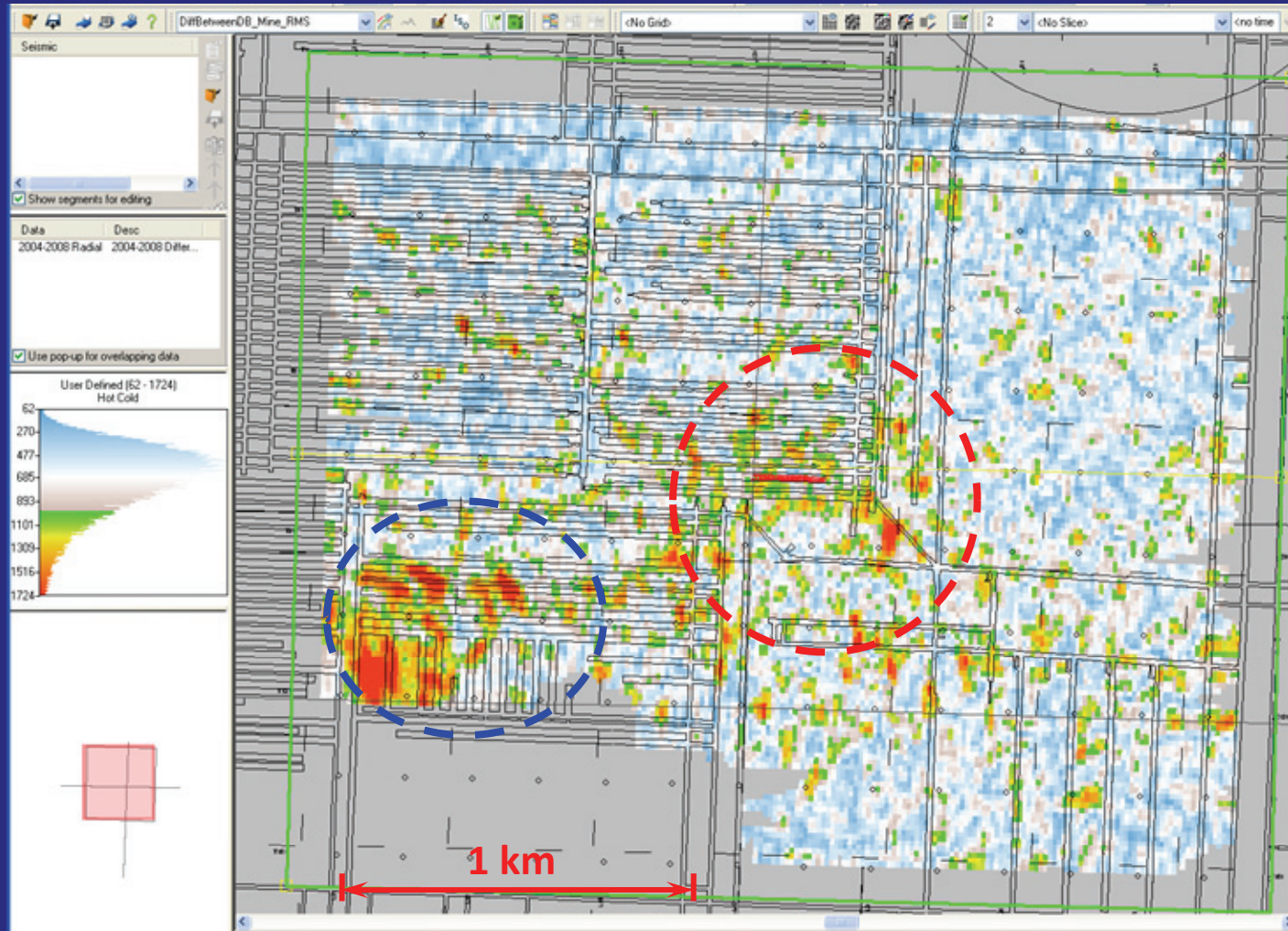
PS 2008

Mine level PS time shift 2008-2004



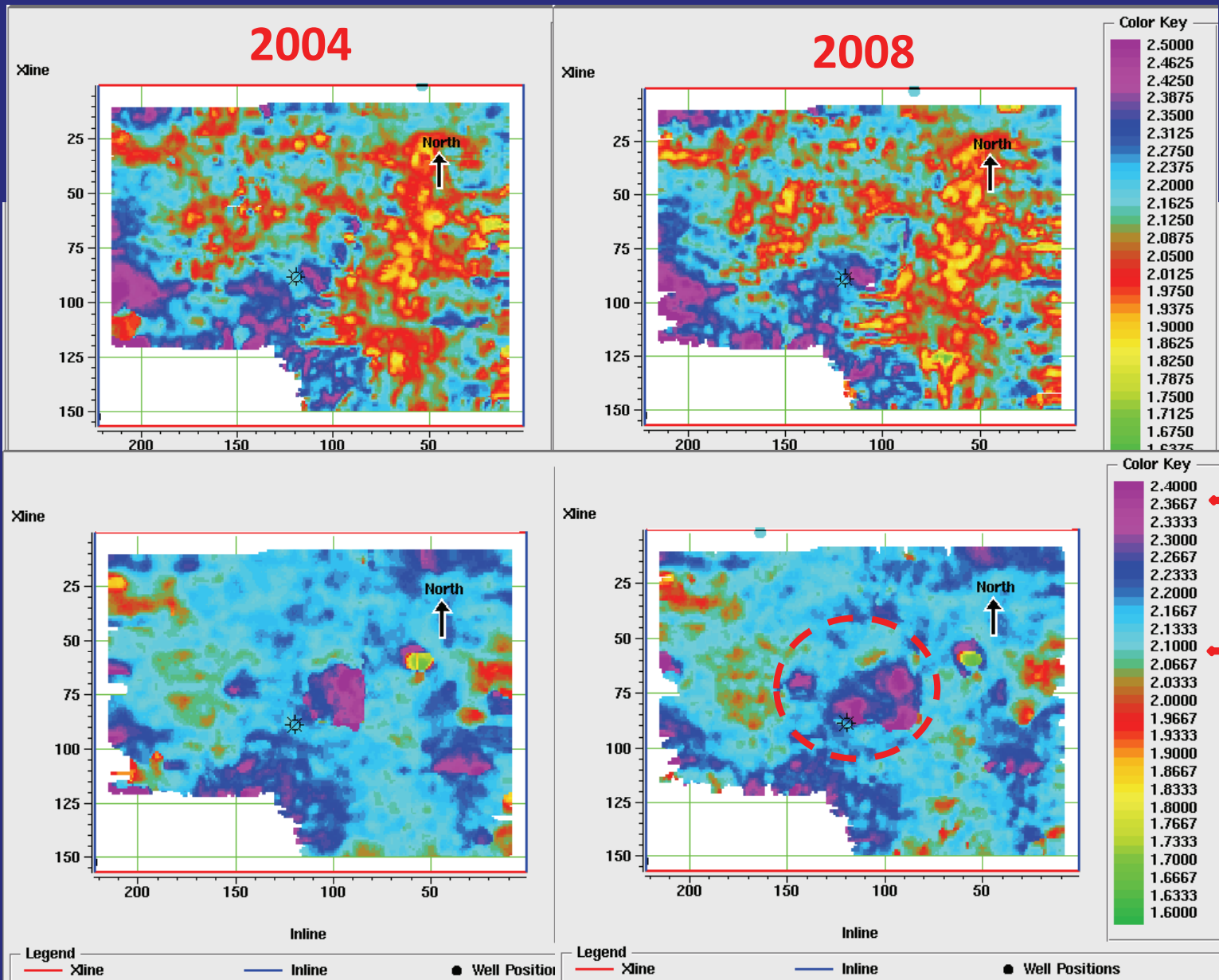
larger time shift, up to about 10 ms push down

RMS amplitude difference of PS data between 2004 and 2008 survey

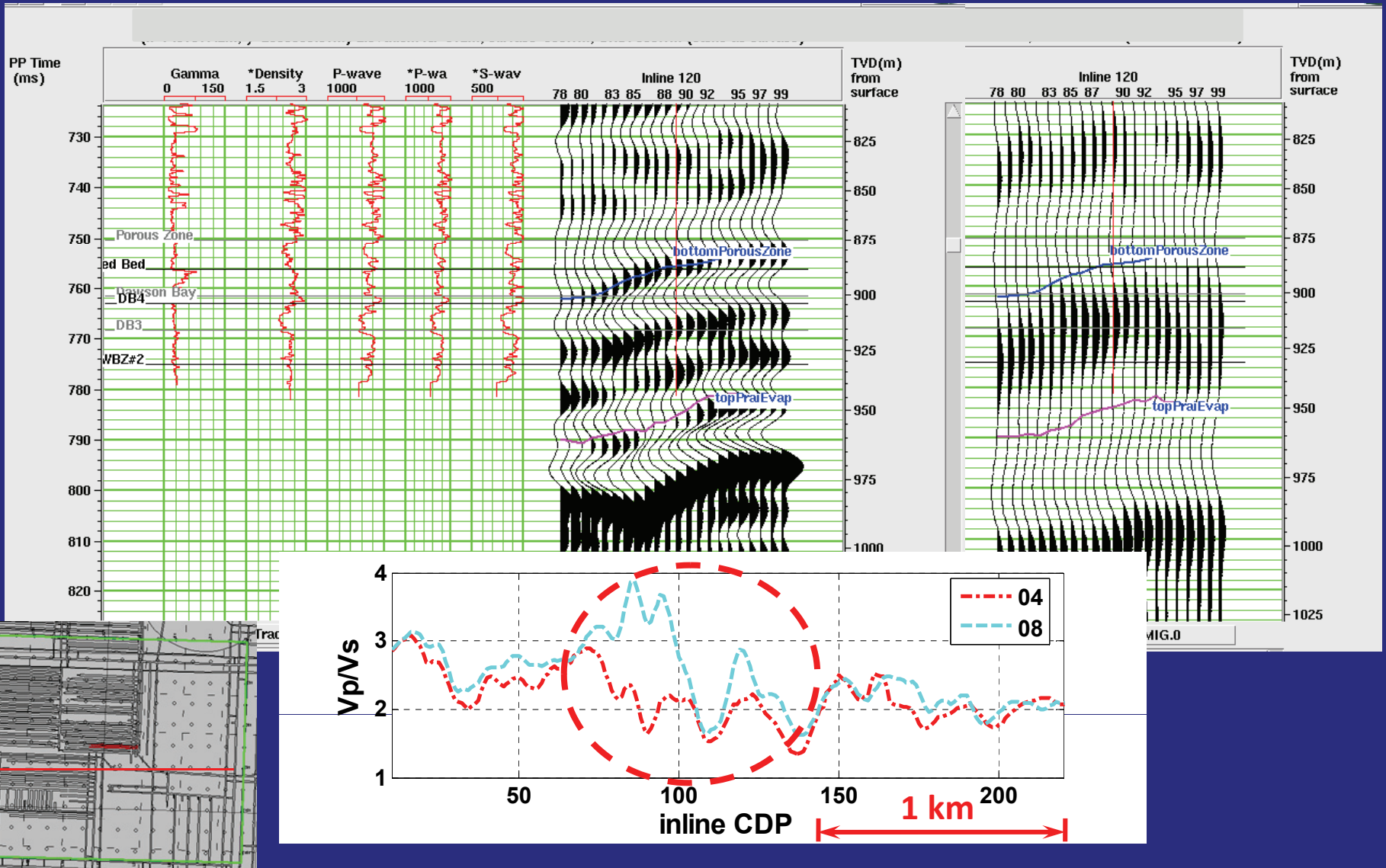


Window: from the Dawson Bay to mine level

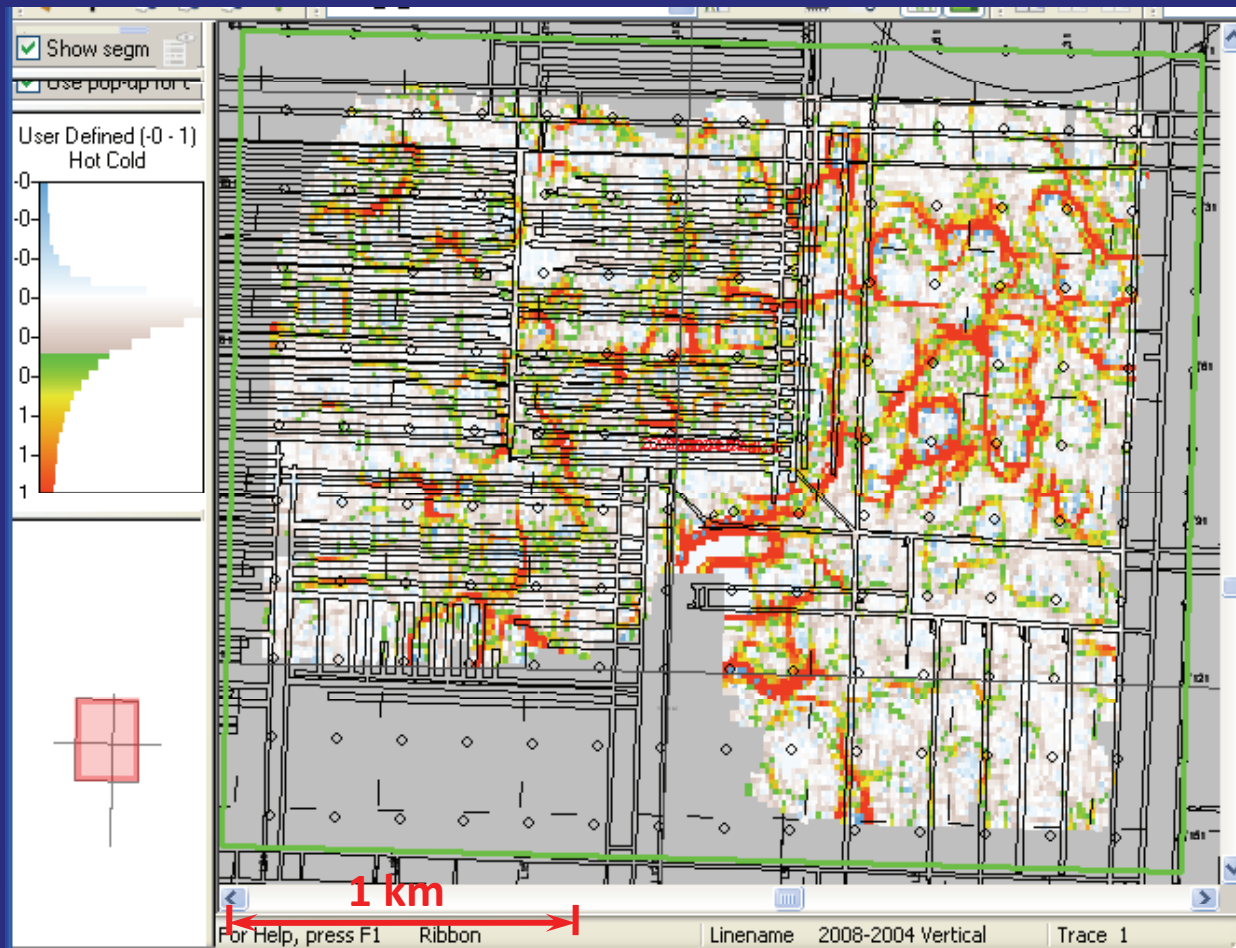
Vp/Vs maps



Interval Vp/Vs values of the studied fracture zone (west-east line)

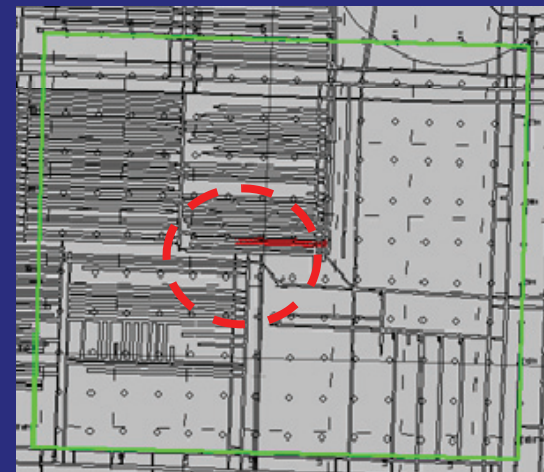


Curvature at mine level (PS 2008)



Conclusion

- Time delay especially on radial data
- Dimming of reflections on radial data below Dawson Bay F.M.
- V_p/V_s increase
- Major change area outlined by red circle (amplitude, V_p/V_s , time structure, curvature)



Future work

Analyze the field time-lapse 3C-3D pre-stack seismic data for fracture orientation and intensity

- Velocity anisotropy
- Shear-wave splitting

Acknowledgements

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- CREWES sponsors