
In-situ Stress Regime in Cretaceous Strata of Southwest Saskatchewan

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Outline

- Introduction
- Vertical in-situ stress magnitude.
- Minimum horizontal in-situ stress magnitude.
- Horizontal stresses orientation.
- Stress/permeability relationship.
- Conclusion.

Background

- Coalbed Methane – important source of natural gas.
- CBM exploitation sensitive to in-situ stress; especially permeability.
- Relatively limited CBM activity in Saskatchewan to date.
- Project objective: Characterize in-situ stress in potential CBM targets in Sask.

Stratigraphy of SW Saskatchewan

ERA	PERIOD	EPOCH	SOUTHERN SASKATCHEWAN	
CENOSOIC	QUATERNARY		GLACIAL DRIFT	
	TERTIARY	NEOCENE	WOOD MNT	
		PALEOCENE	CYPRESS HILLS SWIFT CURRENT RAVENS CRAG	
MESOZOIC	CRETACEOUS	Upper Cretaceous.	FRECHMAN	
			BATTLE WHITE JD EASTEND	
			BEARBAW	
			B.R. OLDMAN FOREMOST RIBSTONE	
			LEA PARK	
		MLK RIVER ALDERSON MLK RIVER		
		L Cret.	COLORADO GROUP	FIRST WHITE SPECKS
				2W SPECKS
				BELLE FOURCHE
				FISH SCALE
WESTGATE				
VIKING				
JOLIFOU				
Mnvl PENSE				
CANTUAR				
UPPER JURASSIC				

Coal-bearing strata

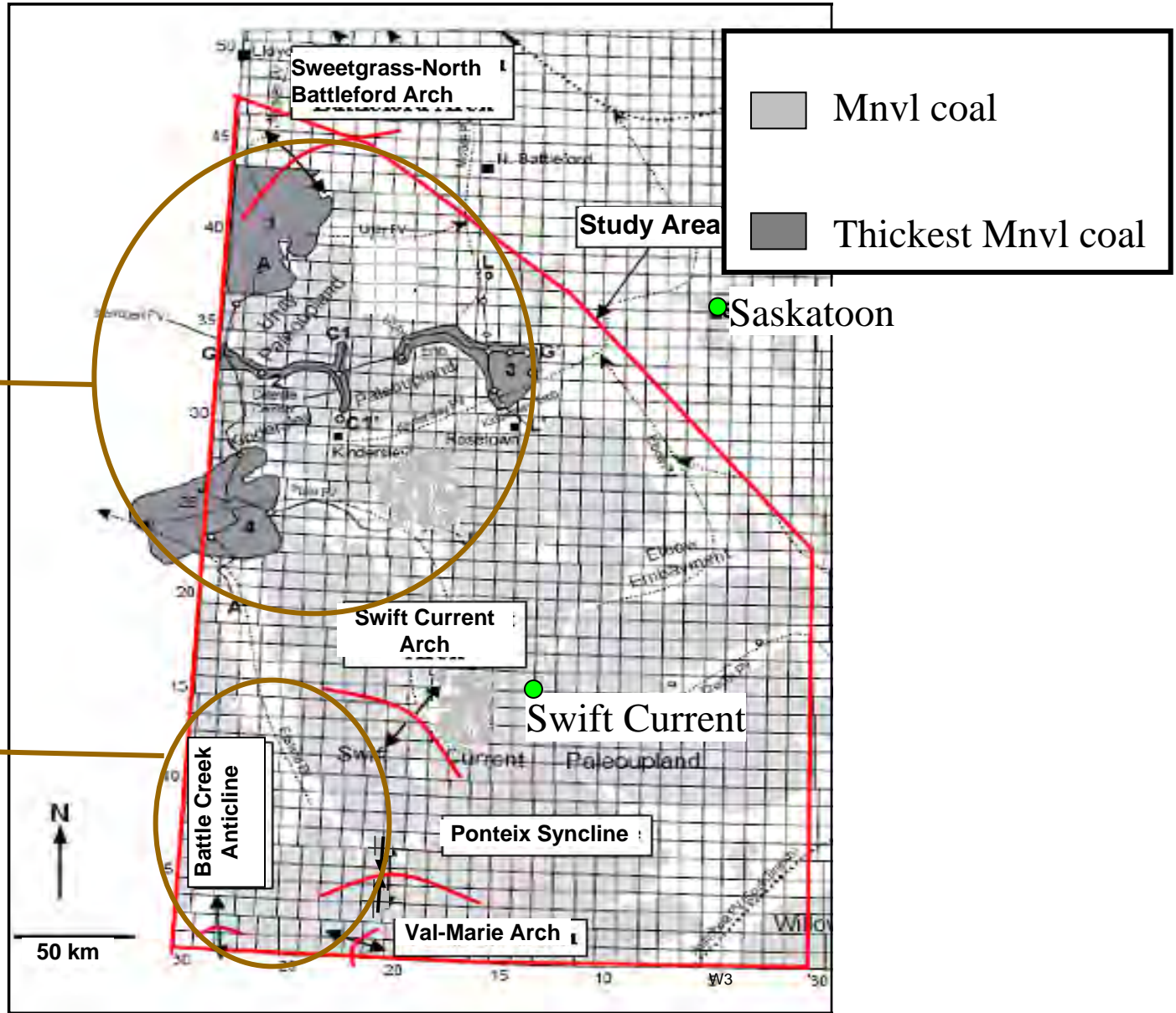
Belly River Fm.

Mannville Gp.

Study Area

Mnvl

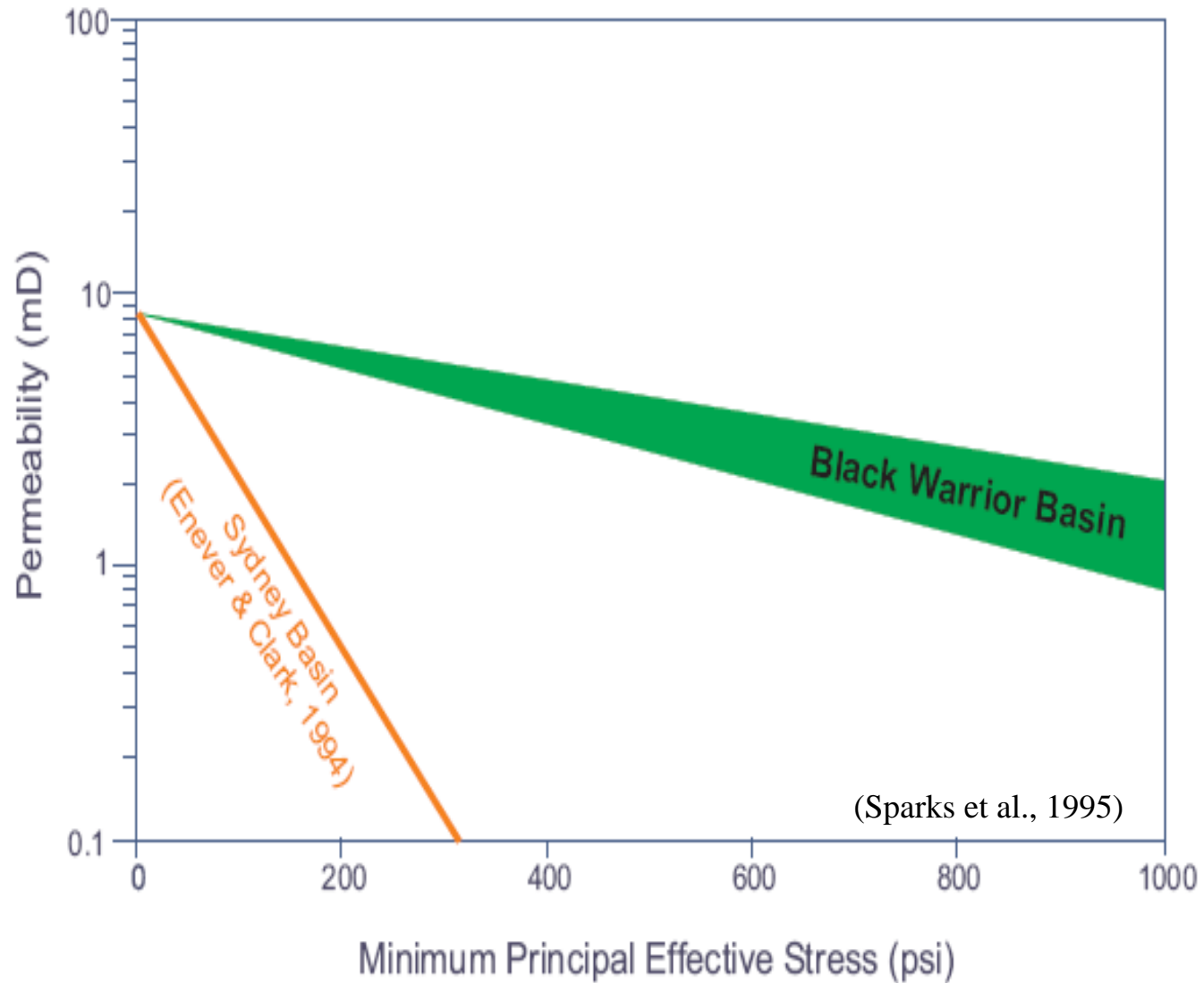
BR



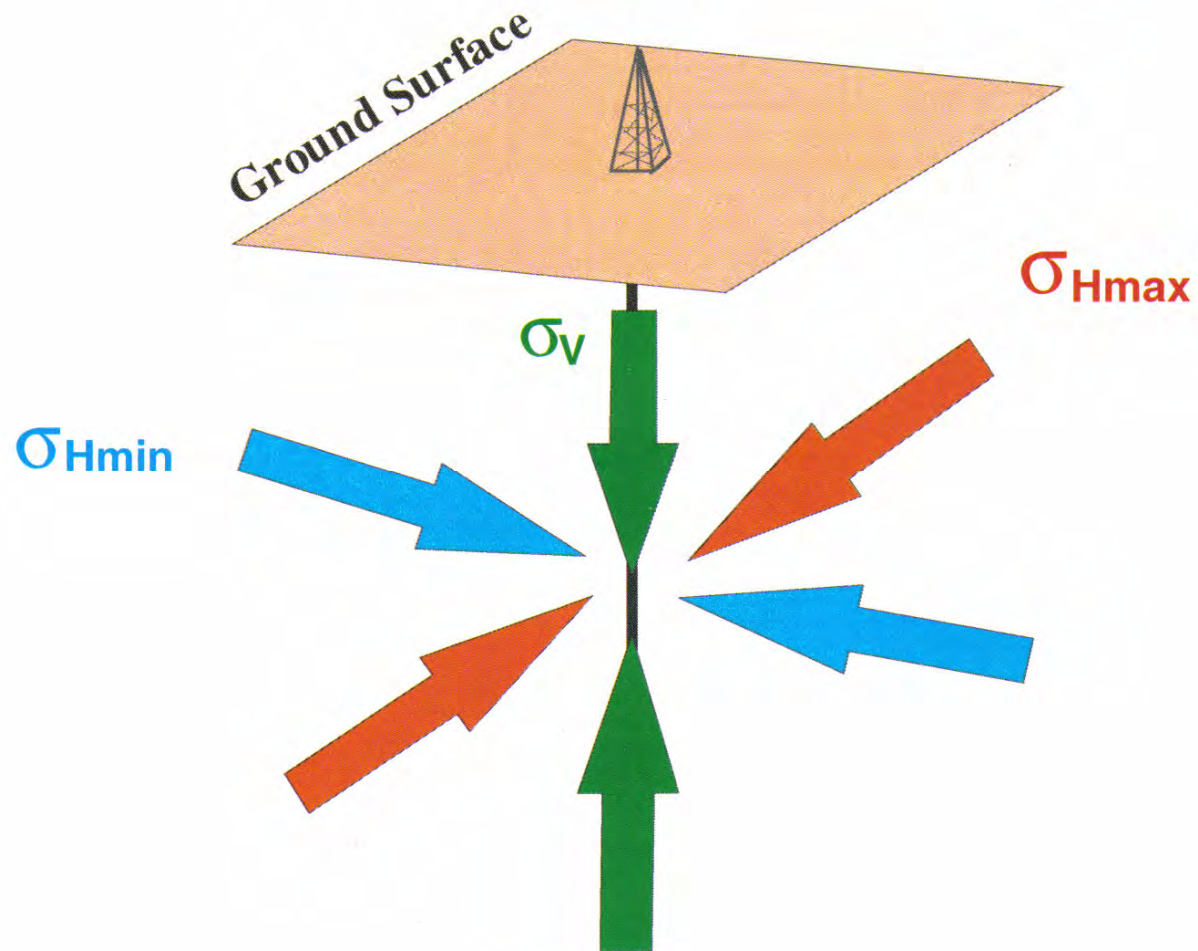
(After Bend and Frank, 2004; Christopher et al., 1971)

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Relationship Between Permeability and Effective Stress for Coal



In-situ Stresses at a Point in the Subsurface



Calculation of Vertical In-situ Stress

$$\sigma_V = \int_0^z \rho_b g dz$$

Where:

σ_v = Vertical in-situ stress

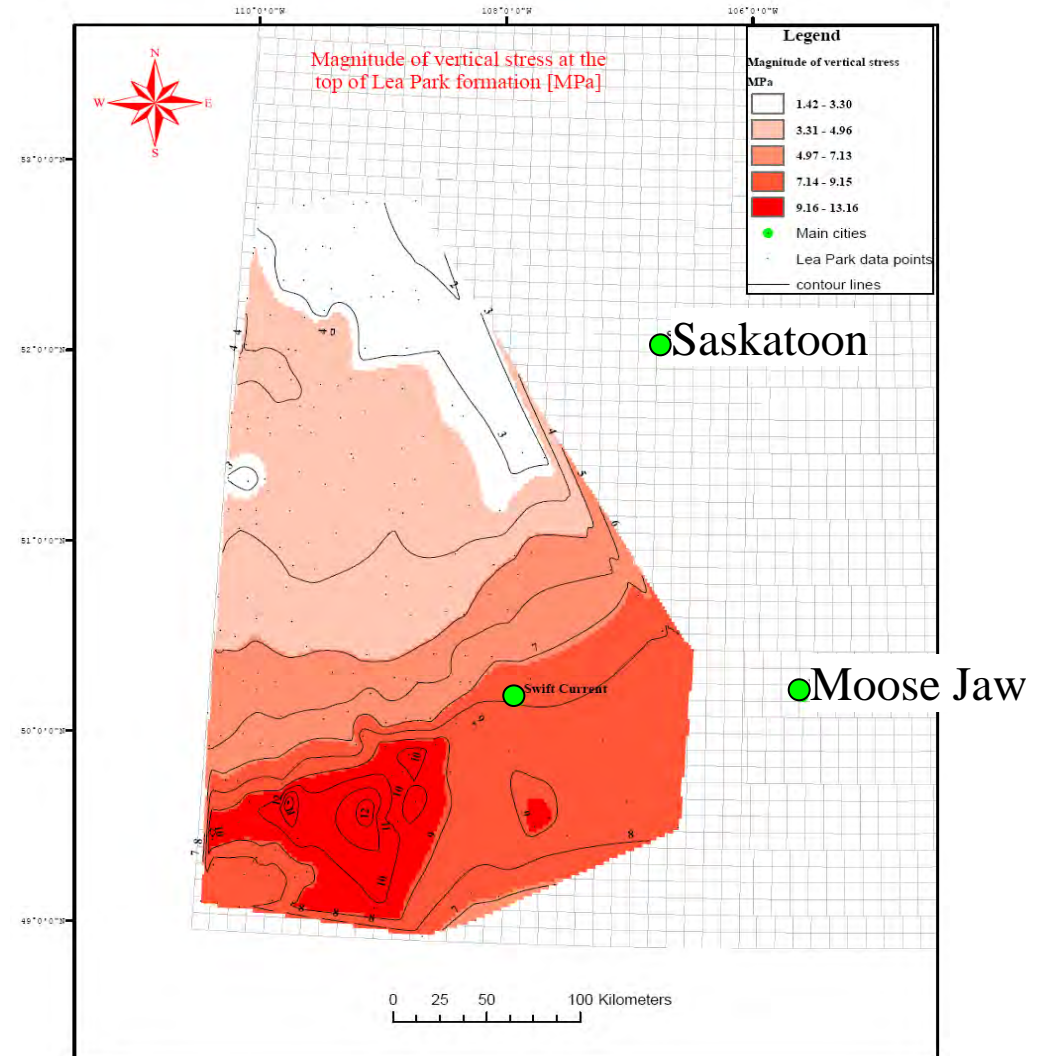
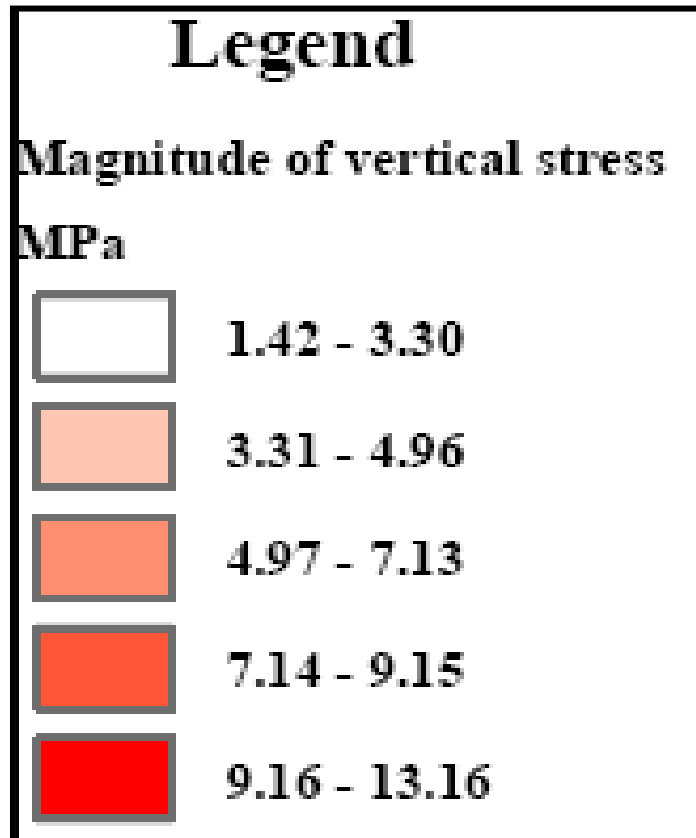
ρ = Bulk density

z = Depth

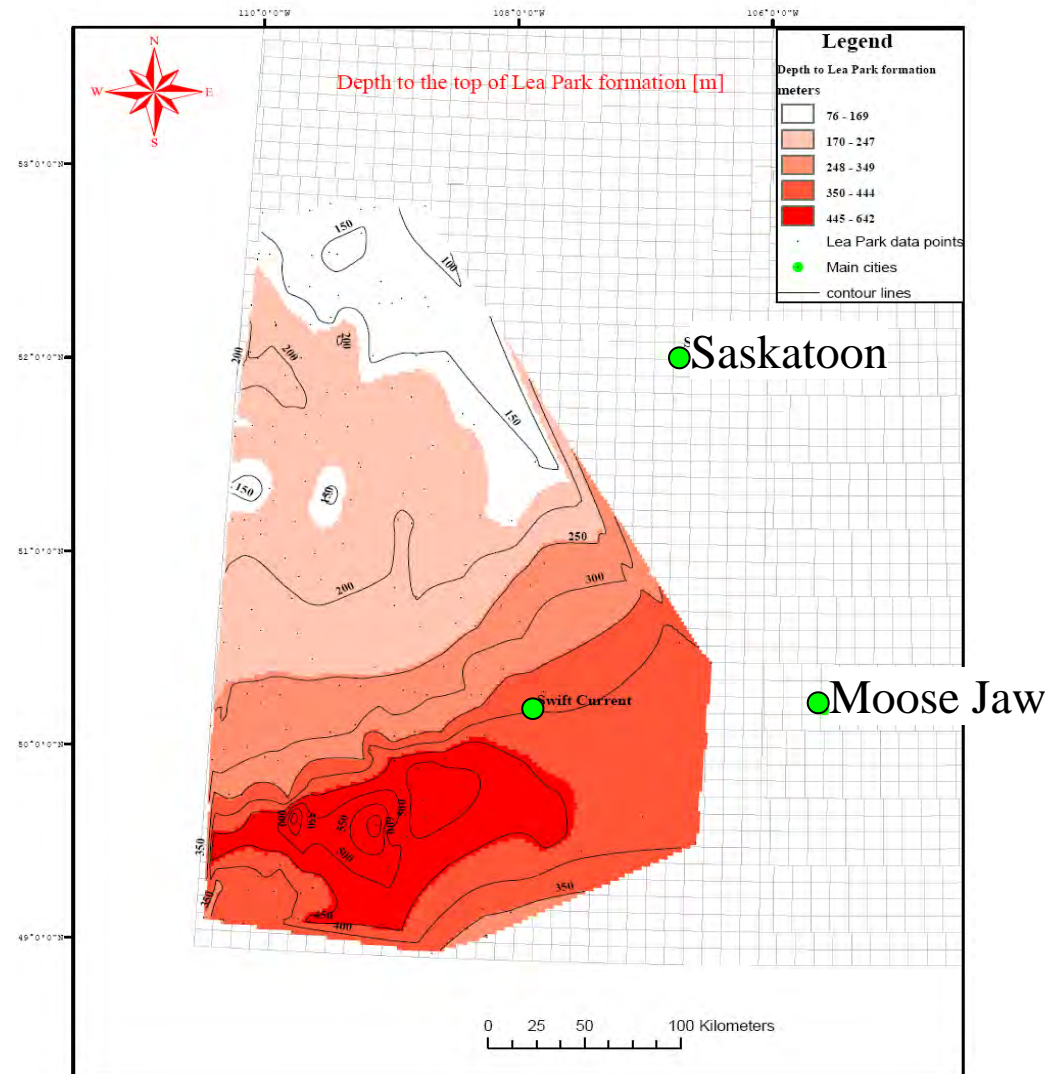
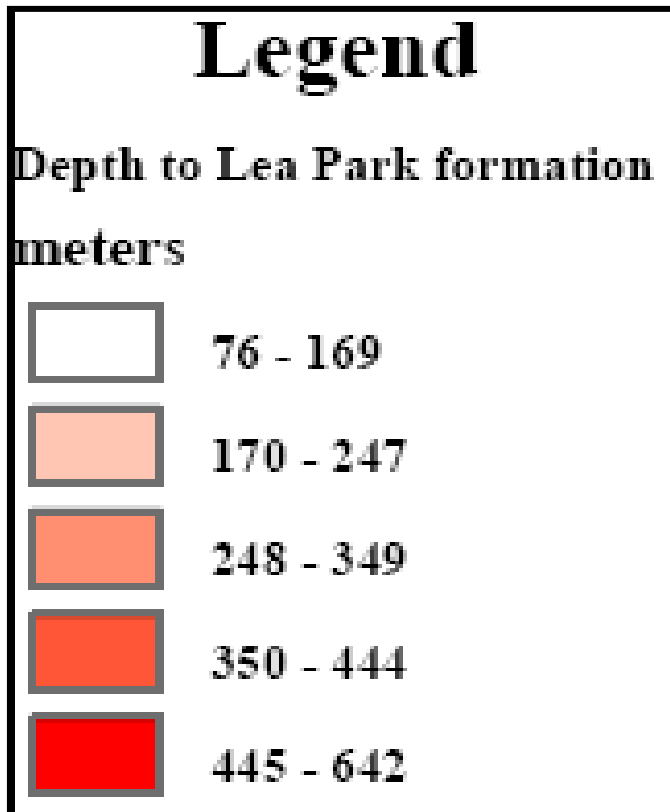
$g = 9.81 \text{ m/s}^2$

Over 250 wells were analyzed for this study.

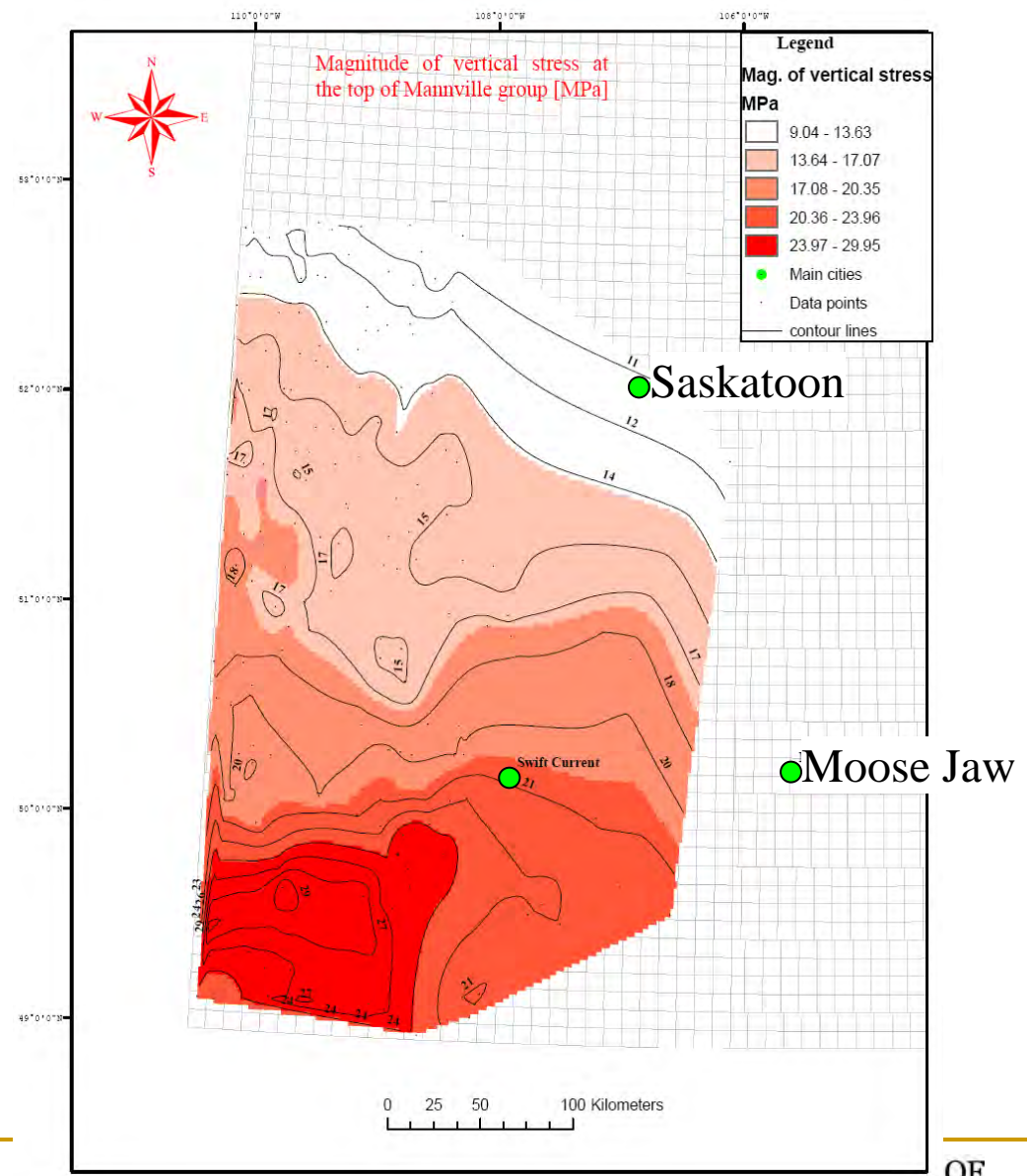
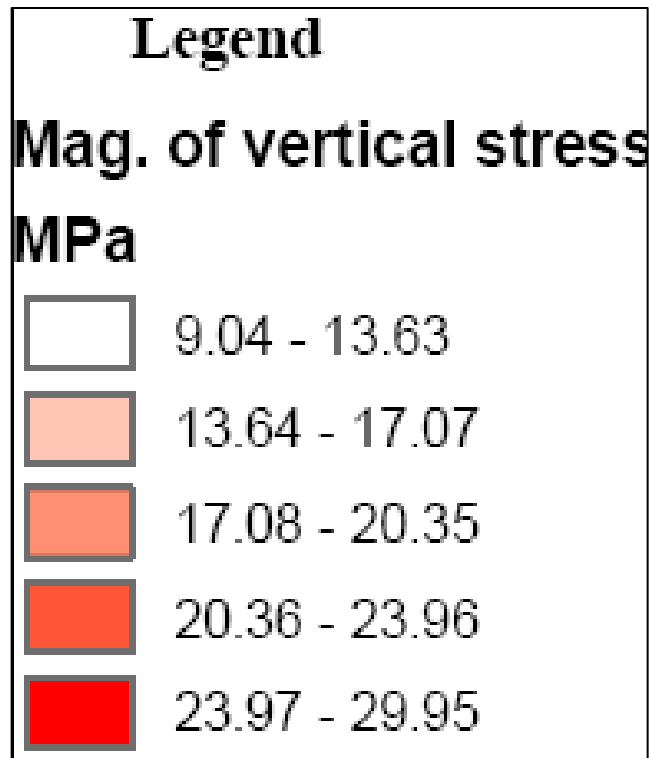
Vertical Stress Magnitude - Top of Lea Park Fm.



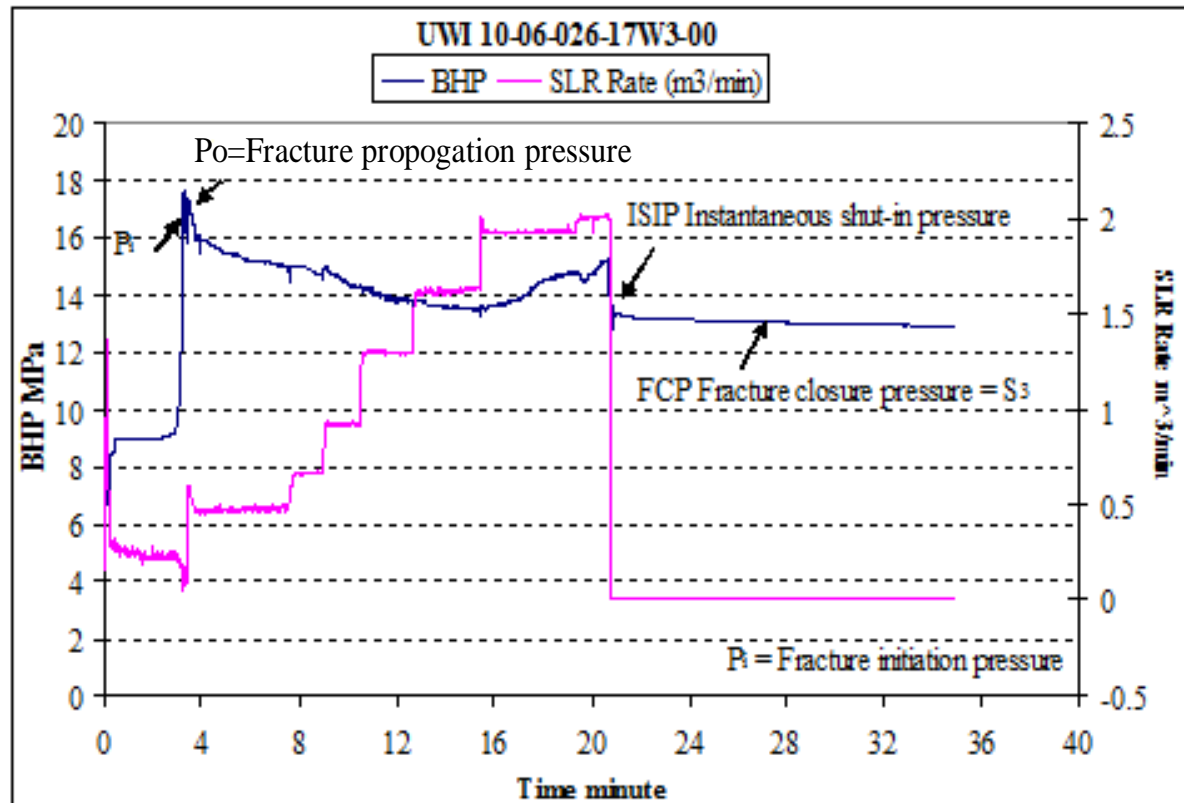
Depth - Lea Park Fm.



Vertical Magnitude-Top of Mannville Group



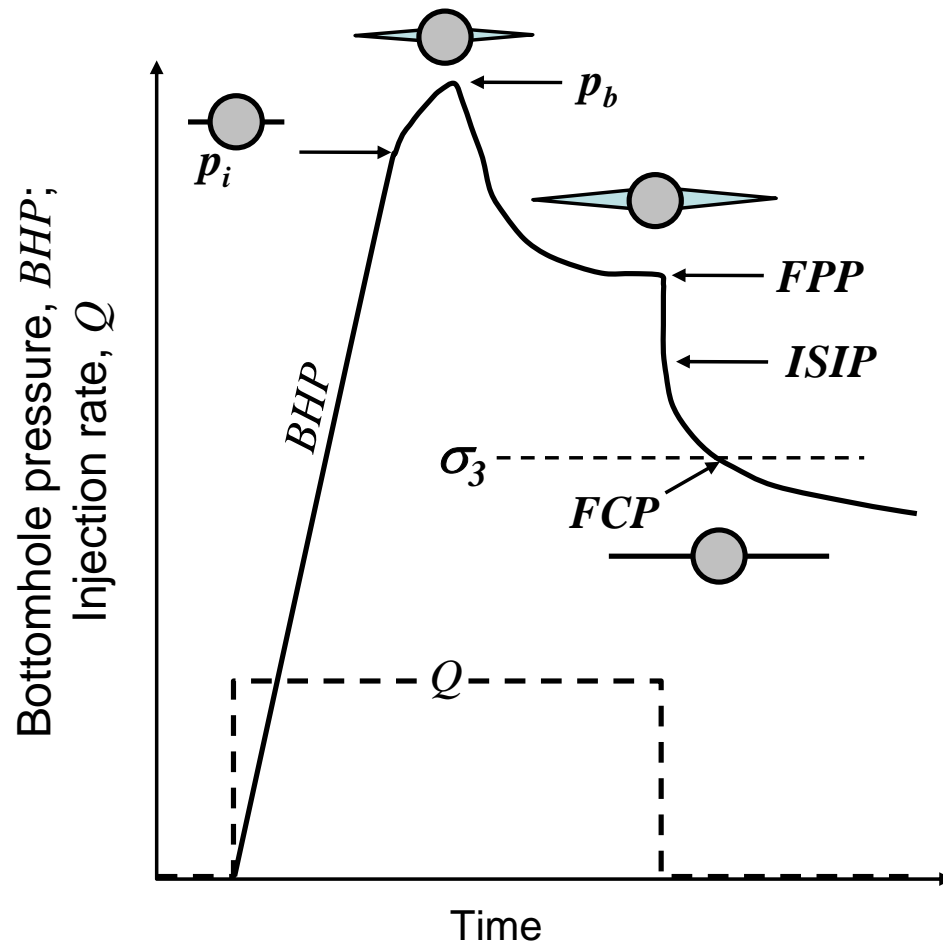
Estimation of the Magnitude of Horizontal In-situ Stress



Pressure vs. time - fracture treatment.

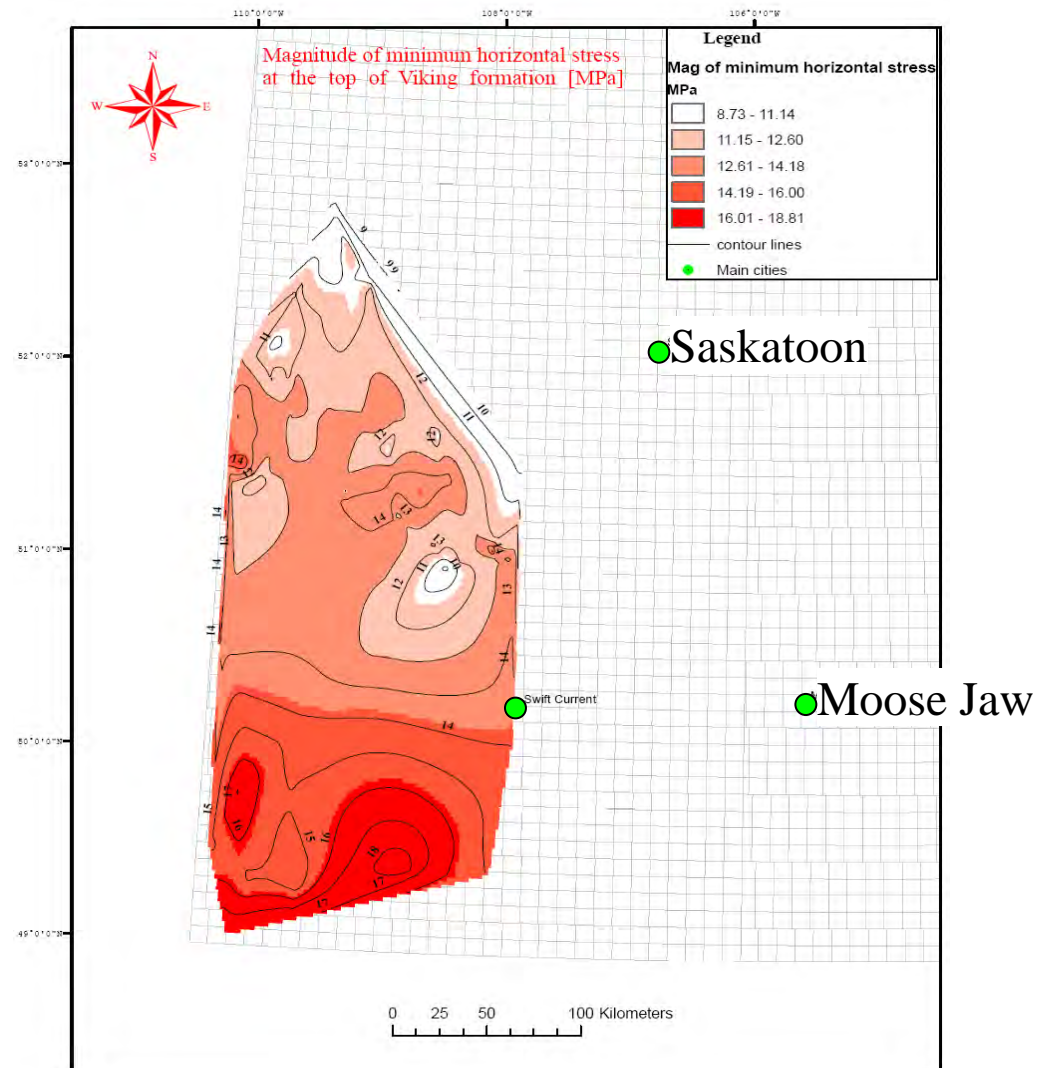
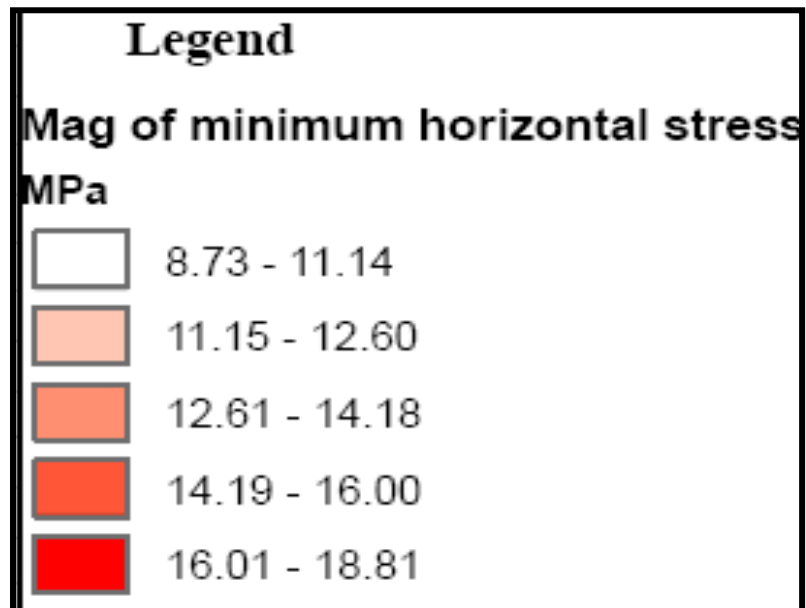
- > 2000 fracture treatment records provided by BJ Services
- 120 selected for analysis; mostly Viking Fm.

Estimation of the Magnitude of Horizontal In-situ Stress

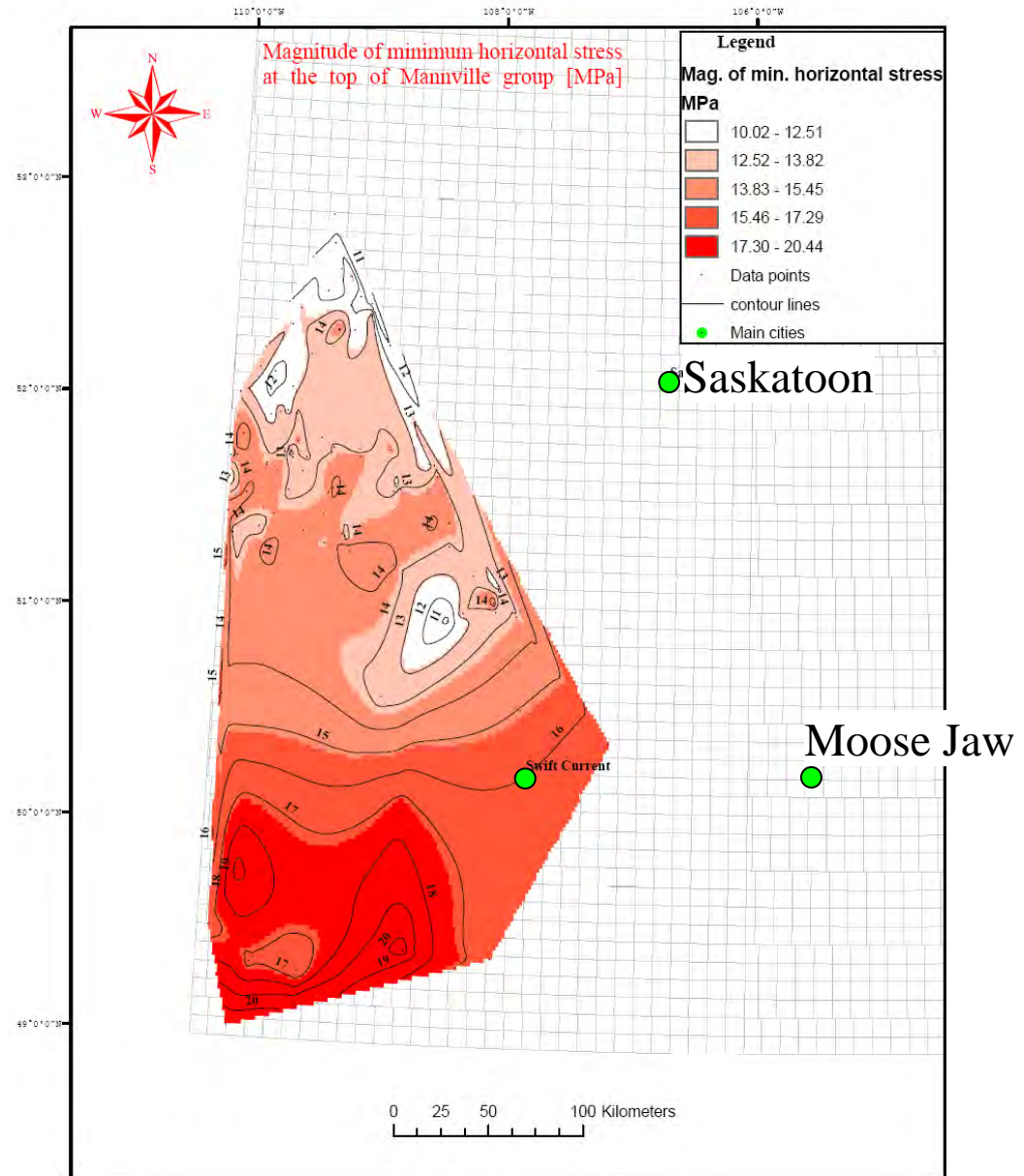
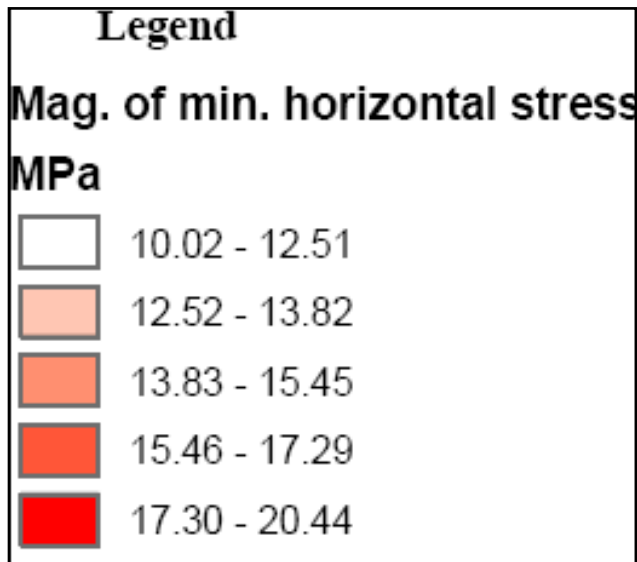


Our analyses (12 wells):
→ $\sigma_{Hmin} = 0.89 \text{ ISIP}$

Minimum Horizontal Stress Magnitude – Viking Fm.

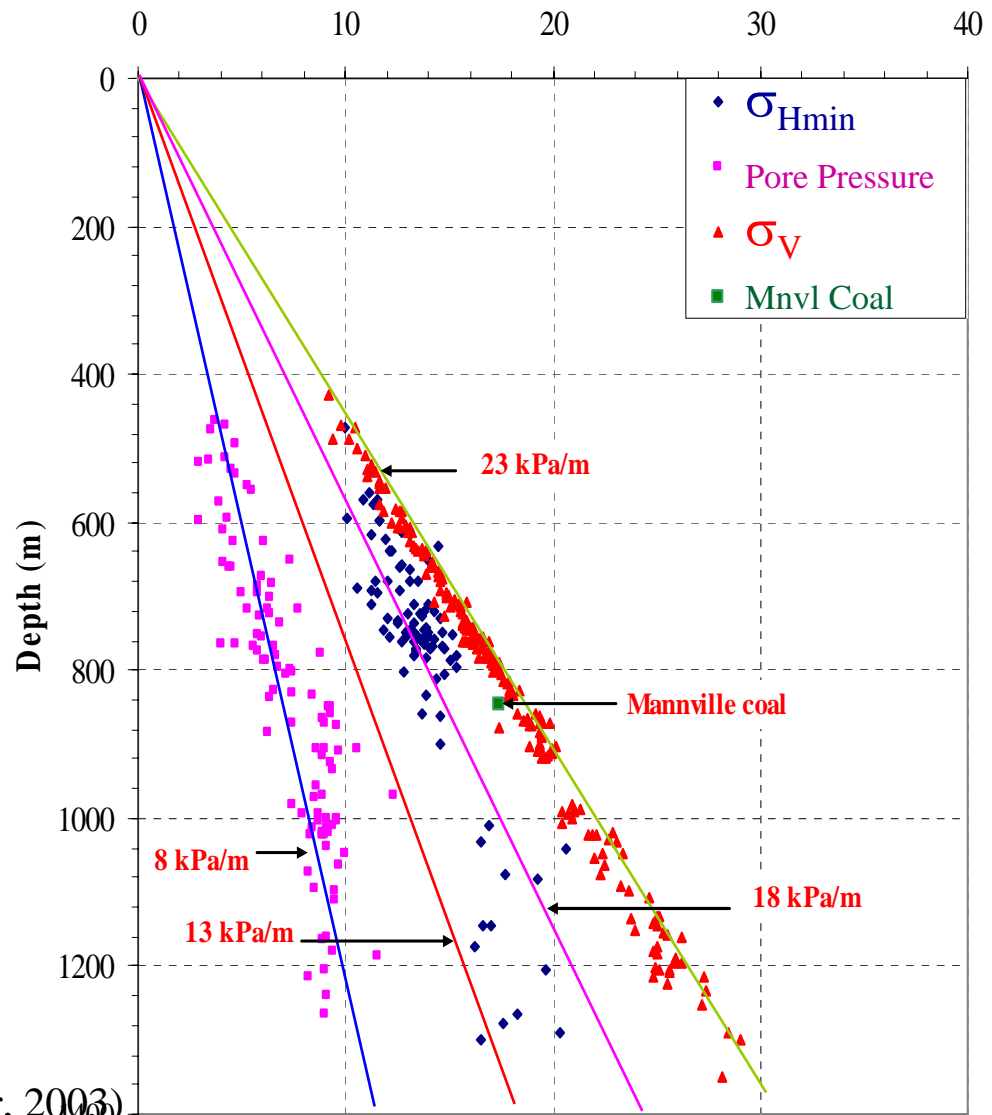


Minimum Horizontal Stress Magnitude – Mnl. Gp.



Relationship Between Pore Pressure, Minimum Horizontal Stress and Vertical Stress

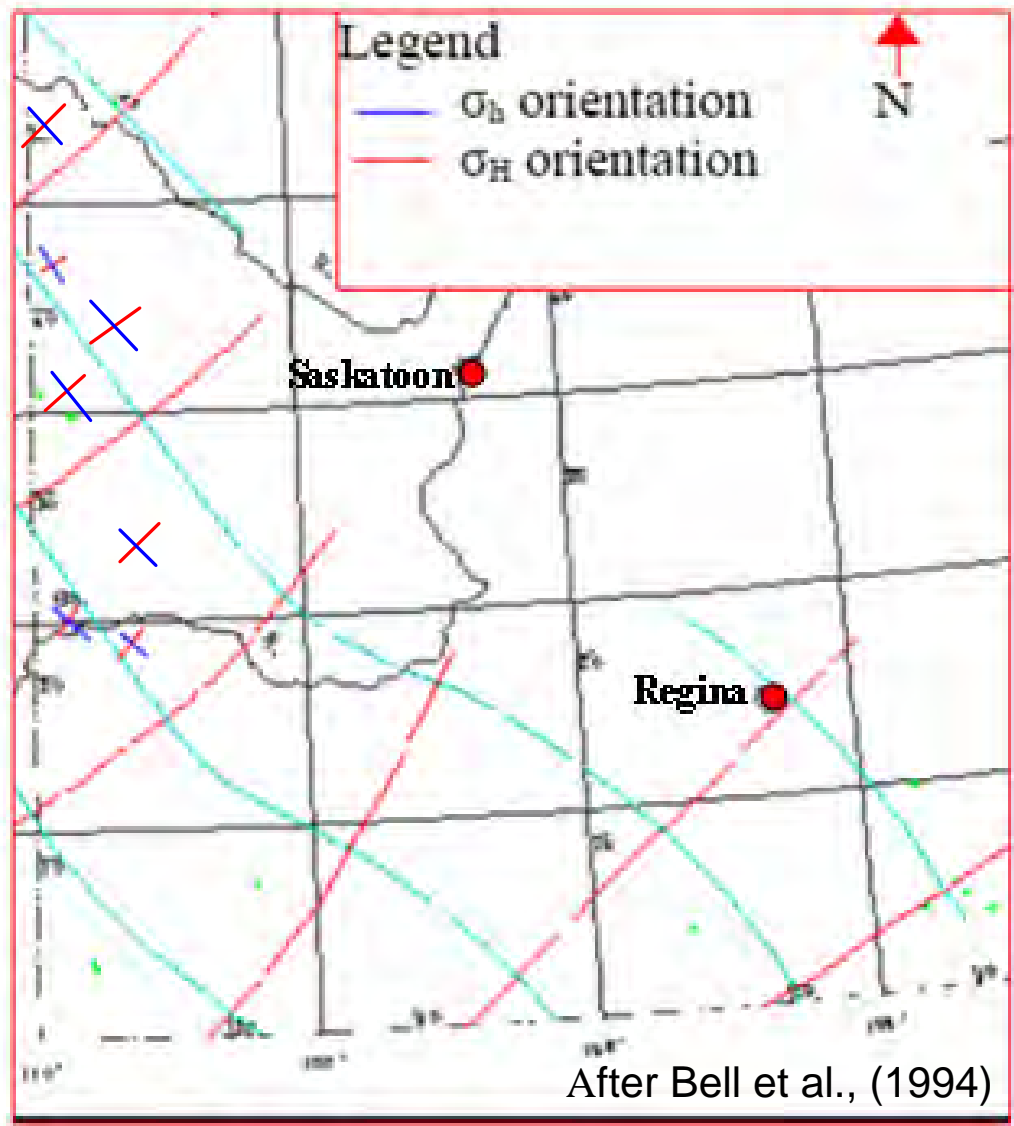
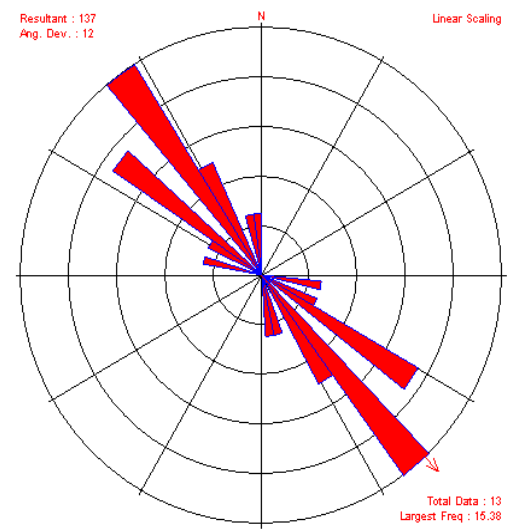
Stress and formation pressure magnitude (MPa)



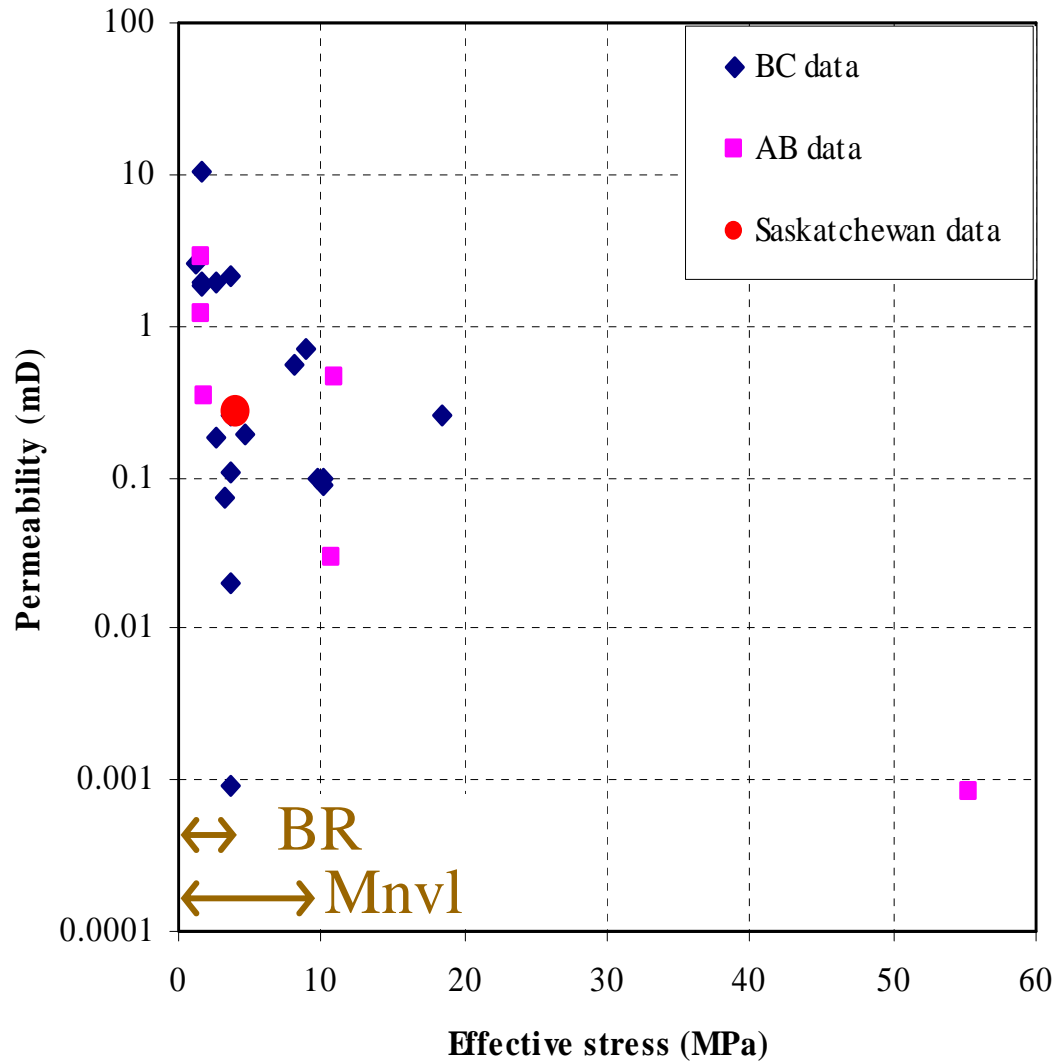
(Pore pressure data from Christopher, 2003)

Orientation of Horizontal Stresses

σ_{Hmin}



Relationship Between Permeability and Effective Stress



(AB BC data after Gentzis (2004);
SK data from S.I.R.)

Conclusion / Recommendations

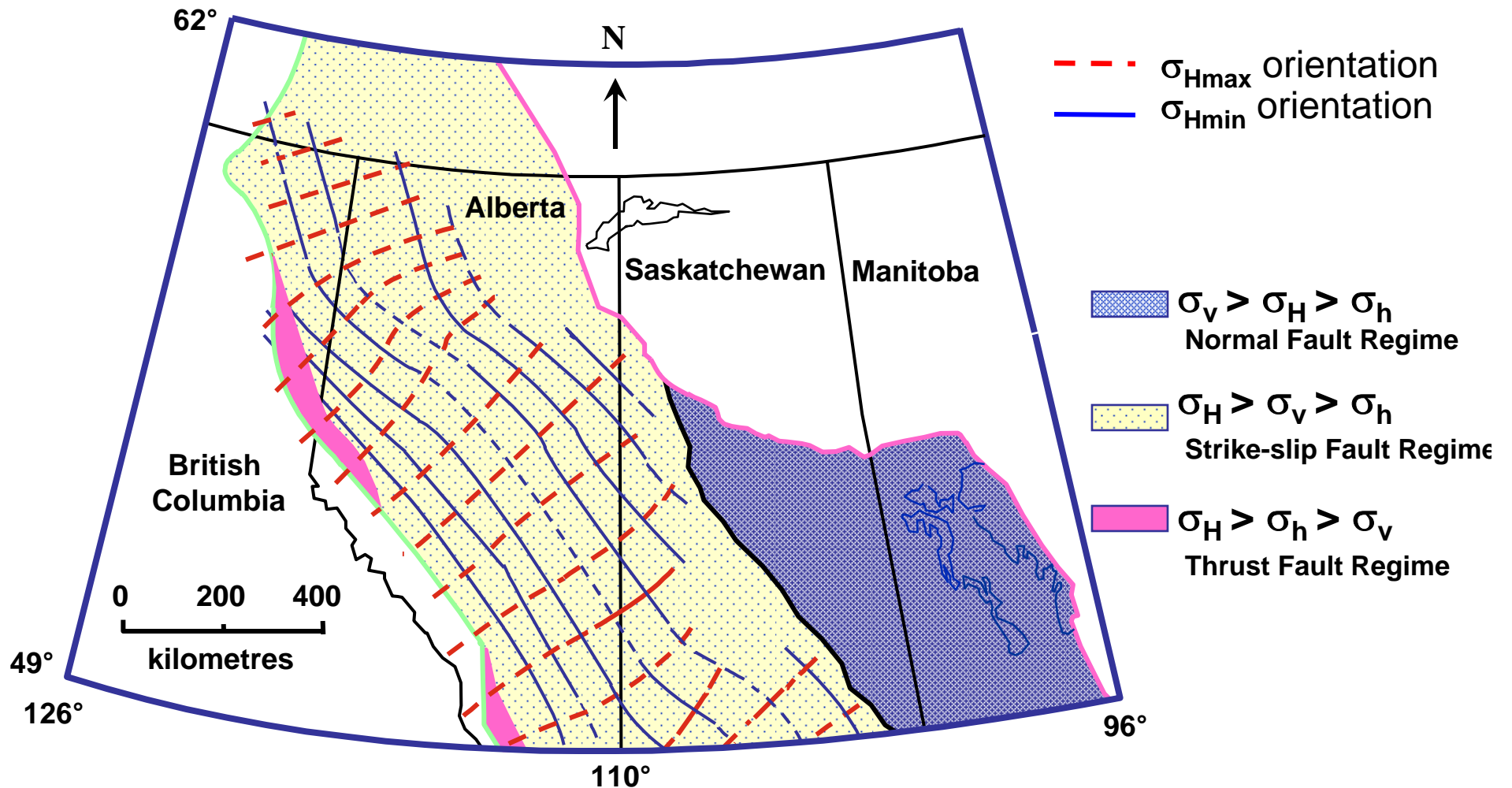
- Top Lea Park (base Belly River)
 - $\sigma_V \sim 7 - 13$ MPa
- Top Mannville
 - $\sigma_V \sim 13 - 19$ MPa
 - $\sigma_{Hmin} \sim 13 - 15$ MPa
- Hydraulic Fracture Orientation \sim NE - SW
- σ_V magnitude primarily controlled by depth of burial.
- σ_{Hmin} magnitude controlled by depth, pore pressure, lithology.

- More data needed to estimate the σ_{Hmin} .
- Special core analysis to measure permeabilities at stress.

Acknowledgement

- PTRC
- BJ Service Company of Canada (Robert Hawkes, Keri Yule)
- Advanced Geotechnology (Pat McLellan)
- Husky Energy (Craig Lamb)
- Nexen Inc. and EnCana Corp.

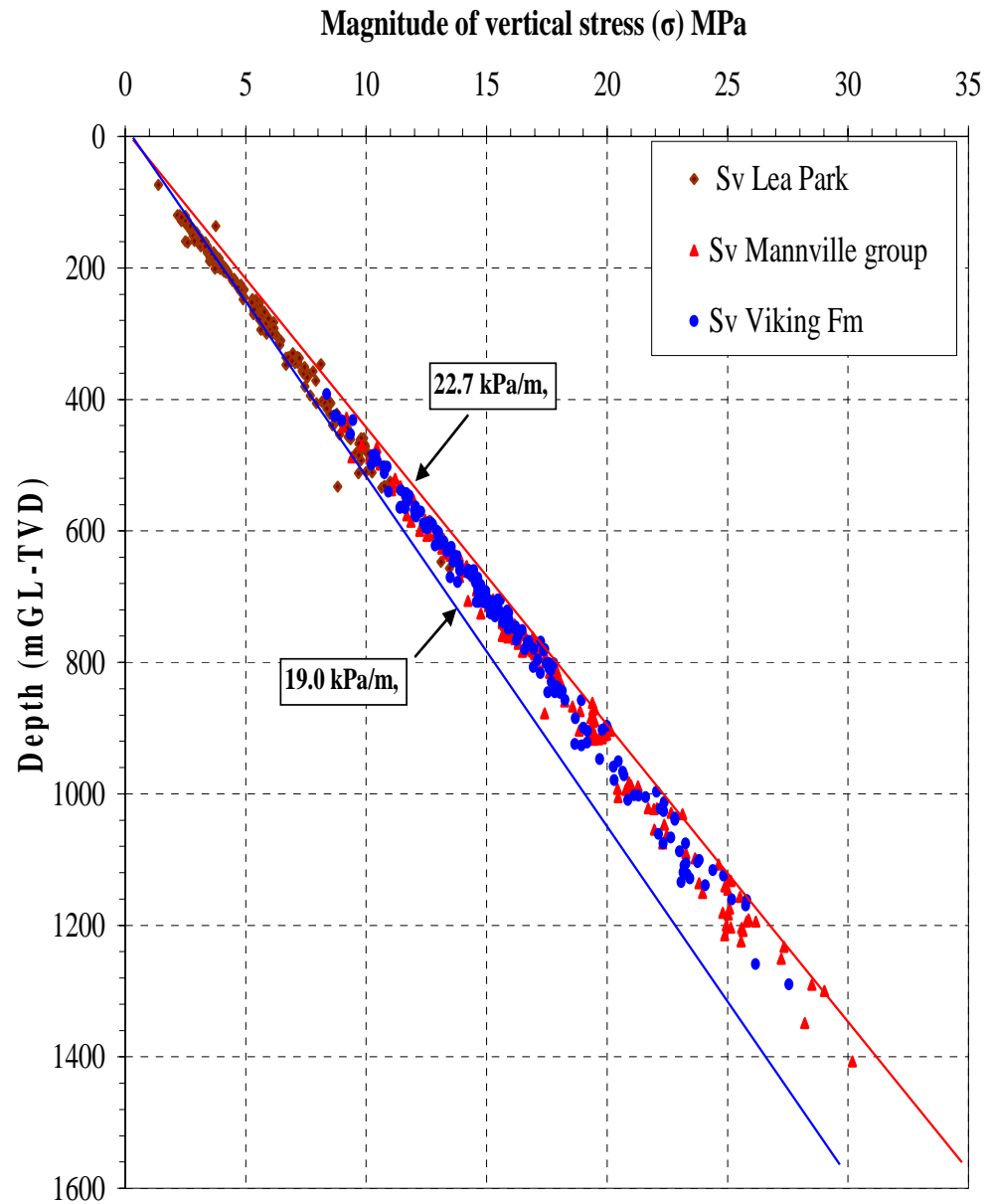
Thank you



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(after Bell et al., 1994)

General Trend of Vertical Stress in Southwest Saskatchewan



Depth to the Top of Mannville Group

Depth range:
430 m to 1390 m

