

Crustal Stress Map 2.0:

Updating the Stress Map of the Western Canada Sedimentary Basin



Douglas R. Schmitt

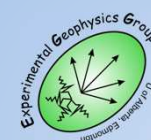
with

*Inga Moeck, Oliver Heidbach,
Karsten Reiter, Maria Grohmann*

Qing Jia, Randy Kofman, Judith Chan, Jaime Melendez



And YOU!?



Stress Map 2.0

- Why map stress?
- Where are we today?
- Where do we want to go? What are we doing now?
- How can we make progress?

Why Map Stress?

Economics

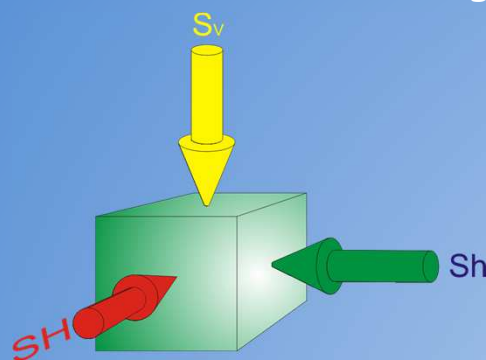
- Wellbore Stability
- Stimulation Layout
- In Situ Permeability
 - Natural Fractures
 - Porous Reservoirs
- Reservoir Damage
- Risk Management →

Liability/Social License

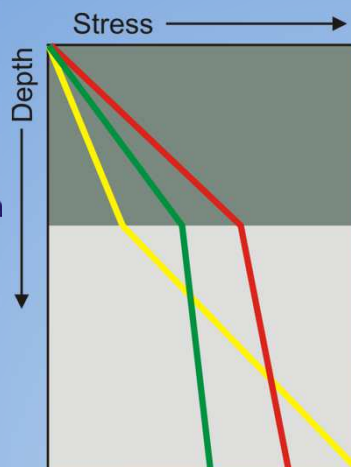
- Triggered Seismicity
- Escape of Fluids
- Uncontained Hydraulic Fractures



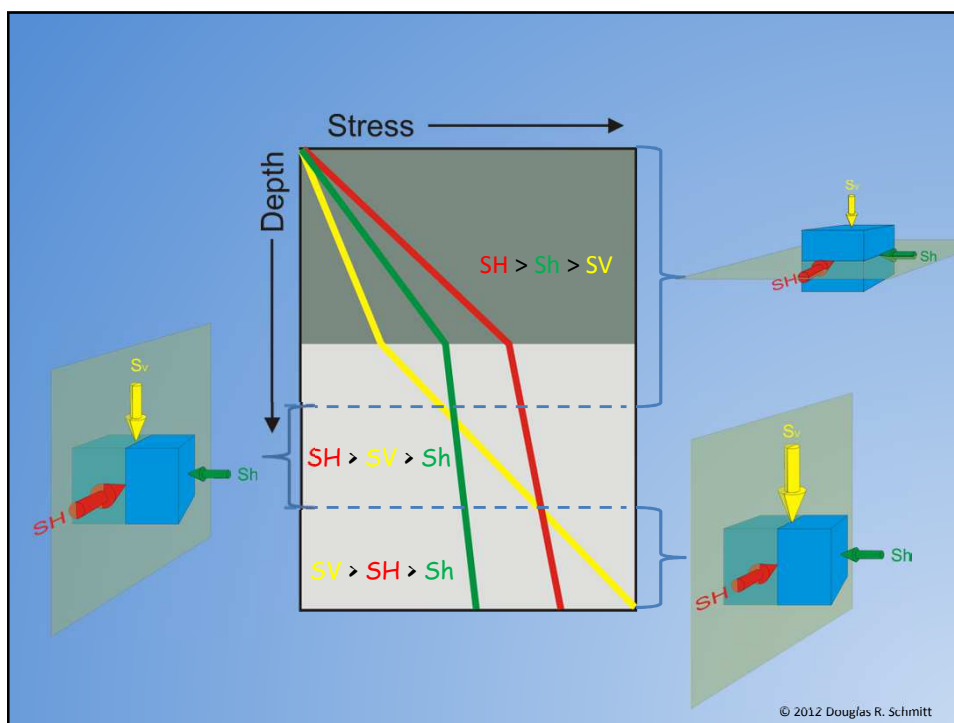
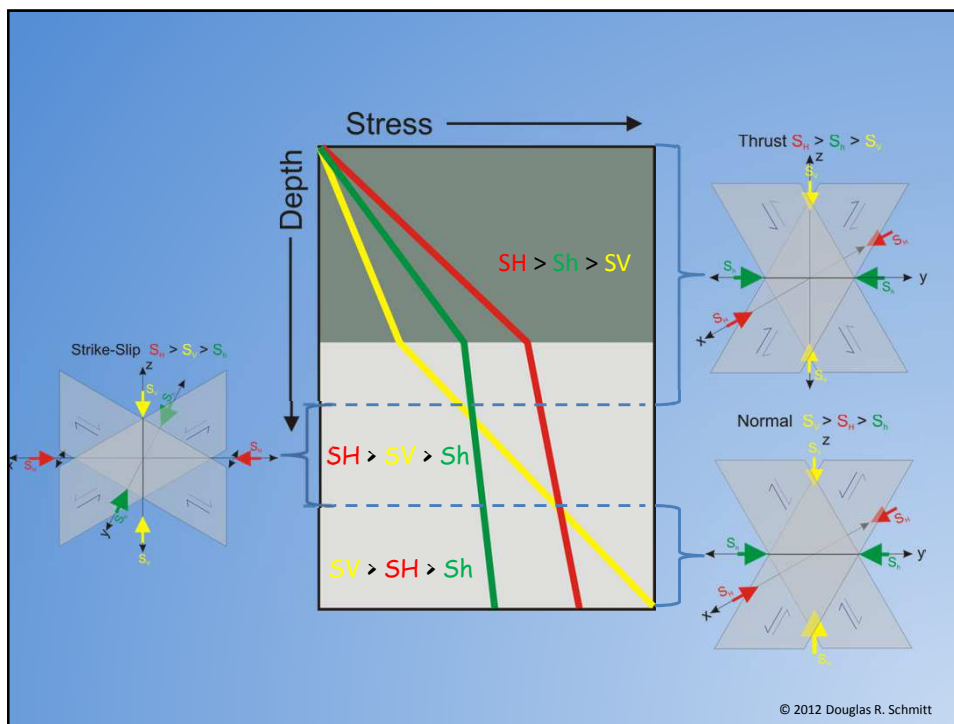
Some Background



$$S = \begin{bmatrix} SH & 0 & 0 \\ 0 & Sh & 0 \\ 0 & 0 & SV \end{bmatrix}$$



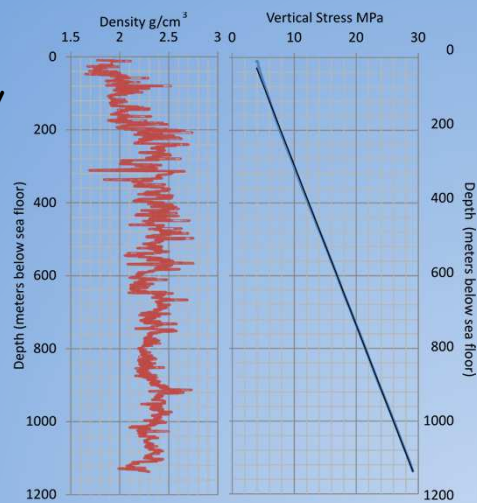
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How can stress be determined?

Vertical Stress -
Integration of density

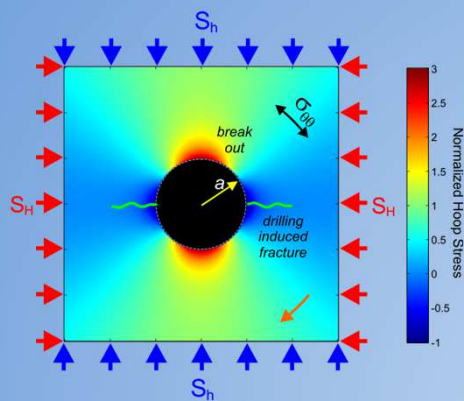
$$S_V(h) = -\int_0^h \rho(h)gdh$$



ANDRILL Core γ - γ density scanner

How can stress be determined?

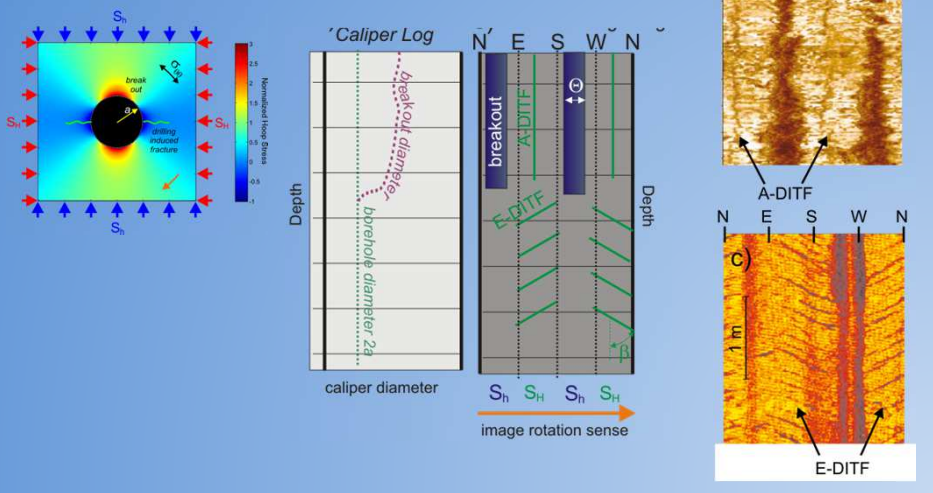
Horizontal Stress - Directions



From Schmitt et al, 2012

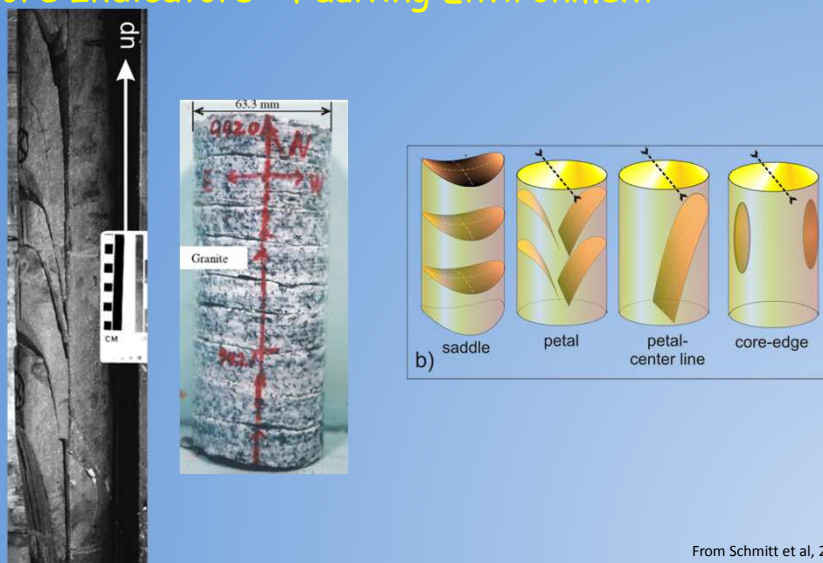
How can stress be determined?

Horizontal Stress - Directions -



How can stress be determined?

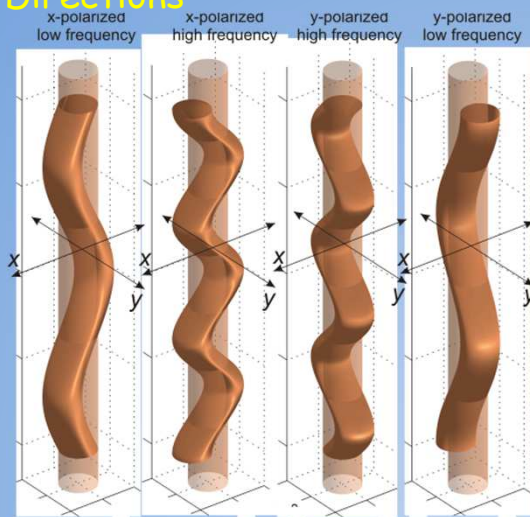
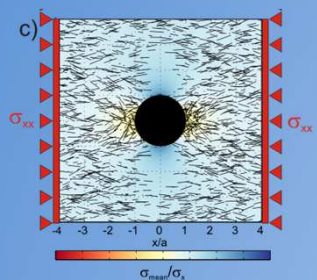
Core Indicators - Faulting Environment



From Schmitt et al, 2012

How can stress be determined?

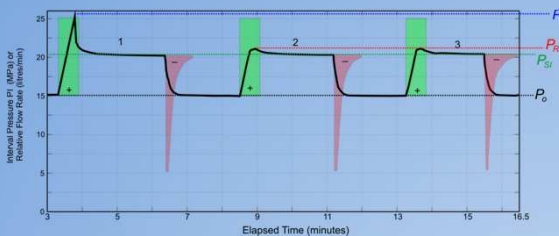
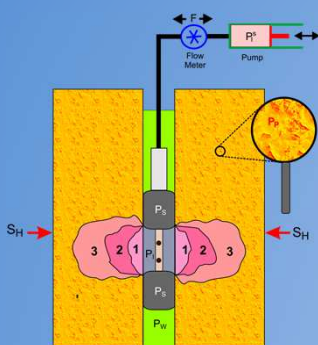
Horizontal Stress - Directions



From Schmitt et al, 2012

How can stress be determined?

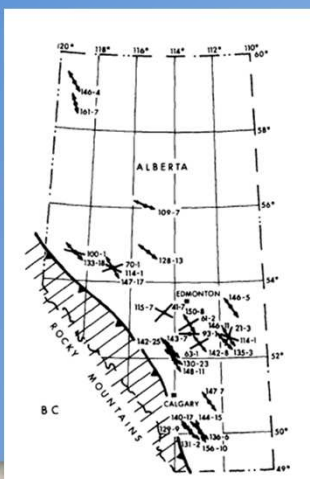
Horizontal Stress - Magnitudes



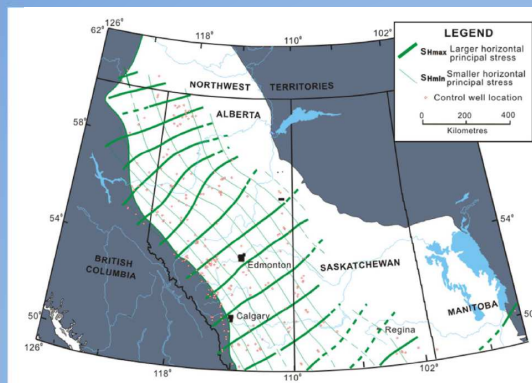
$$S_H = 3S_h + T_o - \Delta\sigma_{\theta\theta}$$

From Schmitt et al, 2012

What do we know? Stress Directions - pretty well



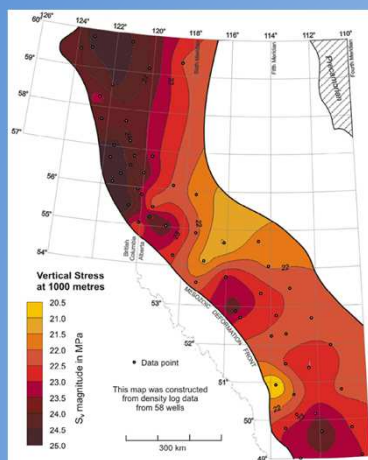
Bell & Gough, EPSL, 1979



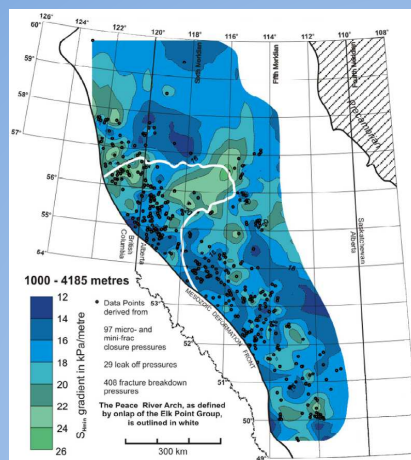
From Grasby et al,
Geological Survey of Canada Open File 6914
2011

What do we know? Stress Magnitudes - not so much?

Vertical Stress - Log Integration



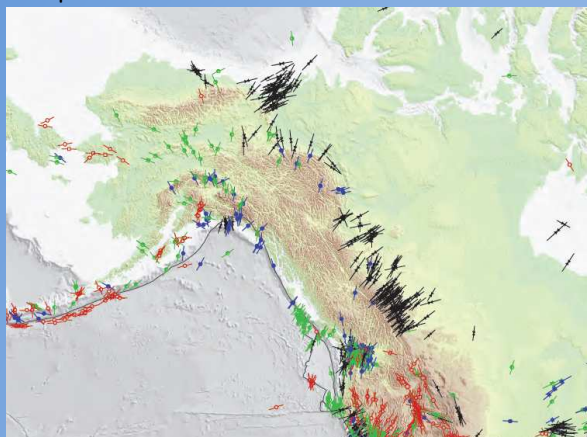
Sh 'gradient' - estimated from tests



From Grasby et al, Geological Survey of Canada Open File 6914, 2011

Where do we want to go?

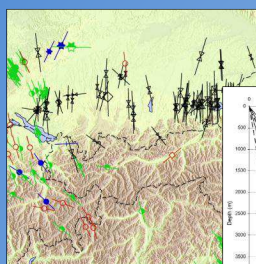
World Stress Map - Latest Version



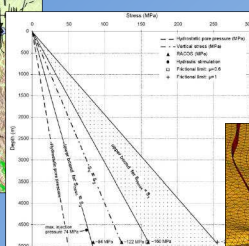
Black symbols indicate direction -
But also say stress environment not known!

From Heidbach et al, 2009

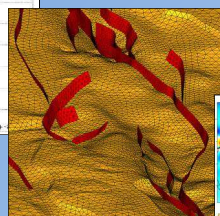
How should we proceed?



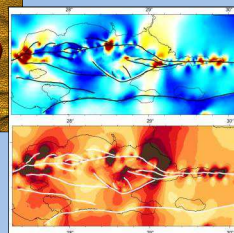
World Stress Map



Stress Magnitudes



Geomechanical Modelling



Absolute Stress State

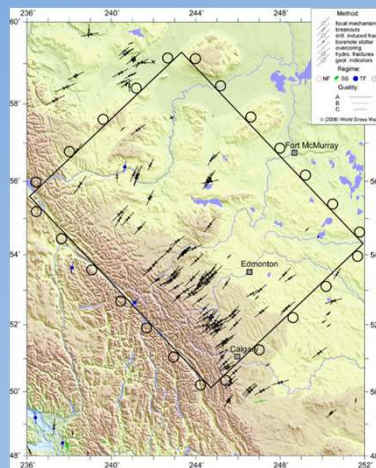
After Oliver Heidbach, GFZ

↑
We are here.

Current Activities

Construction of Geological Stress Model

By Karsten Reiter, GFZ

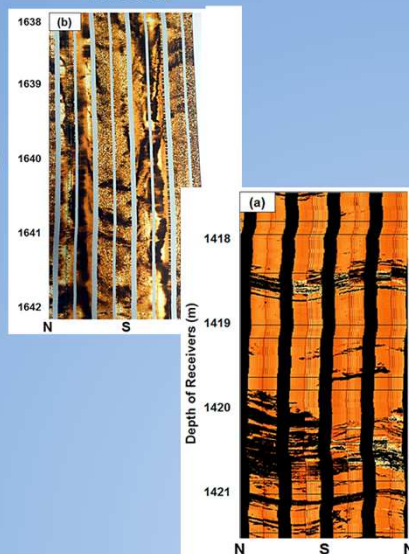


Current Activities

Analysis of Image Logs Hunt Well, Fort McMurray

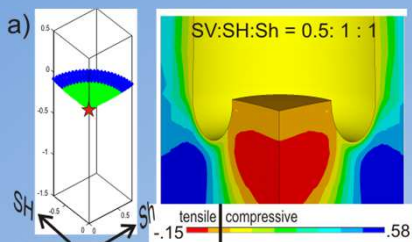
By Judith Chan, U of Alberta

Drilling-induced fractures

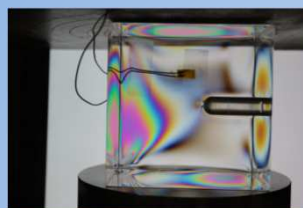


Current Activities

Development of Tools for assessment of drilling induced borehole and core fractures



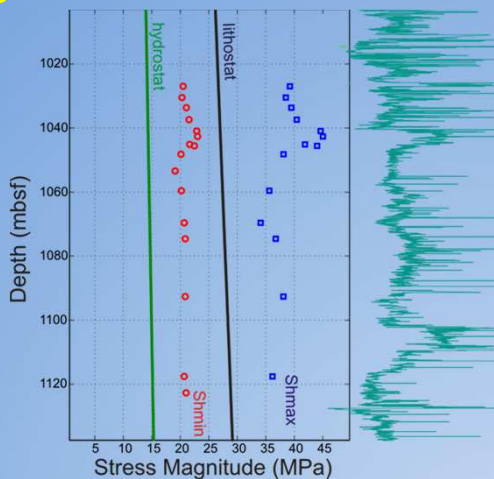
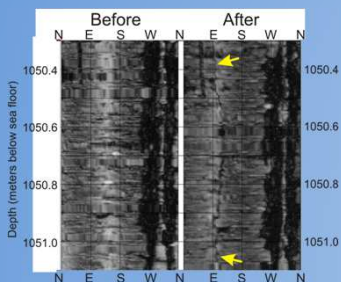
By Maria Grohmann & Suzie (Qing) Jia, U of Alberta



Current Activities

Hydraulic Microfracture Testing

ANDRILL
Doug Schmitt, U of A



The Future: Stress Map 2.0

Compiling Stress Related Information

- Geologic Structure (Major Faults, Natural Fracture Trends)
- Stress Direction Indicators (image logs, dipmeter logs, crossed-dipole logs, core fractures)
- Quantitative Stress Data: (Leak off Tests, minifrac, microfracs, etc.)

Need Community Involvement!

Acknowledgments

- NSERC
- Canada Research Chairs
- Helmholtz-Alberta Initiative
- ANDRILL

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