Development of a geostatic model for a geoscience field research station in Alberta

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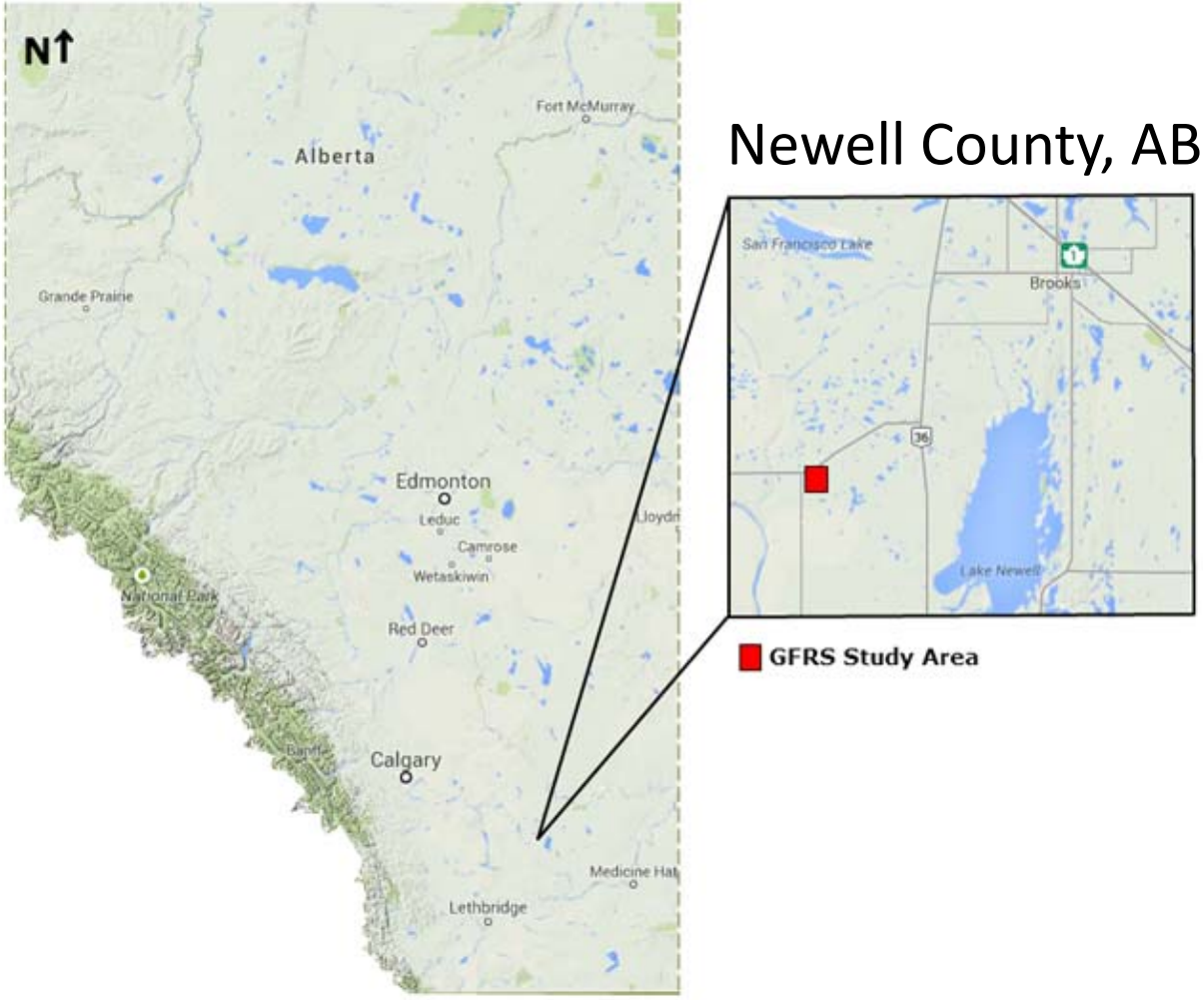
Outline

- Introduction
- Resources
- 5 x 5 km Property Model
- 4 x 5 km Geophysical Model
- Conclusions & Future work
- Acknowlegdments

Location


N
Alberta
Fort McMurray
Grande Prairie
Edmonton
Leduc
Camrose
Wetaskiwin
Red Deer
Calgary
Medicine Hat
Lethbridge
Newell County, AB
San Francisco Lake
Brooks
36
Lake Newell
GFRS Study Area

Objective

✓ **Test limits of current MMV technology (CMC)**

✓ **Develop new MMV technology for fluid monitoring (CMC)**

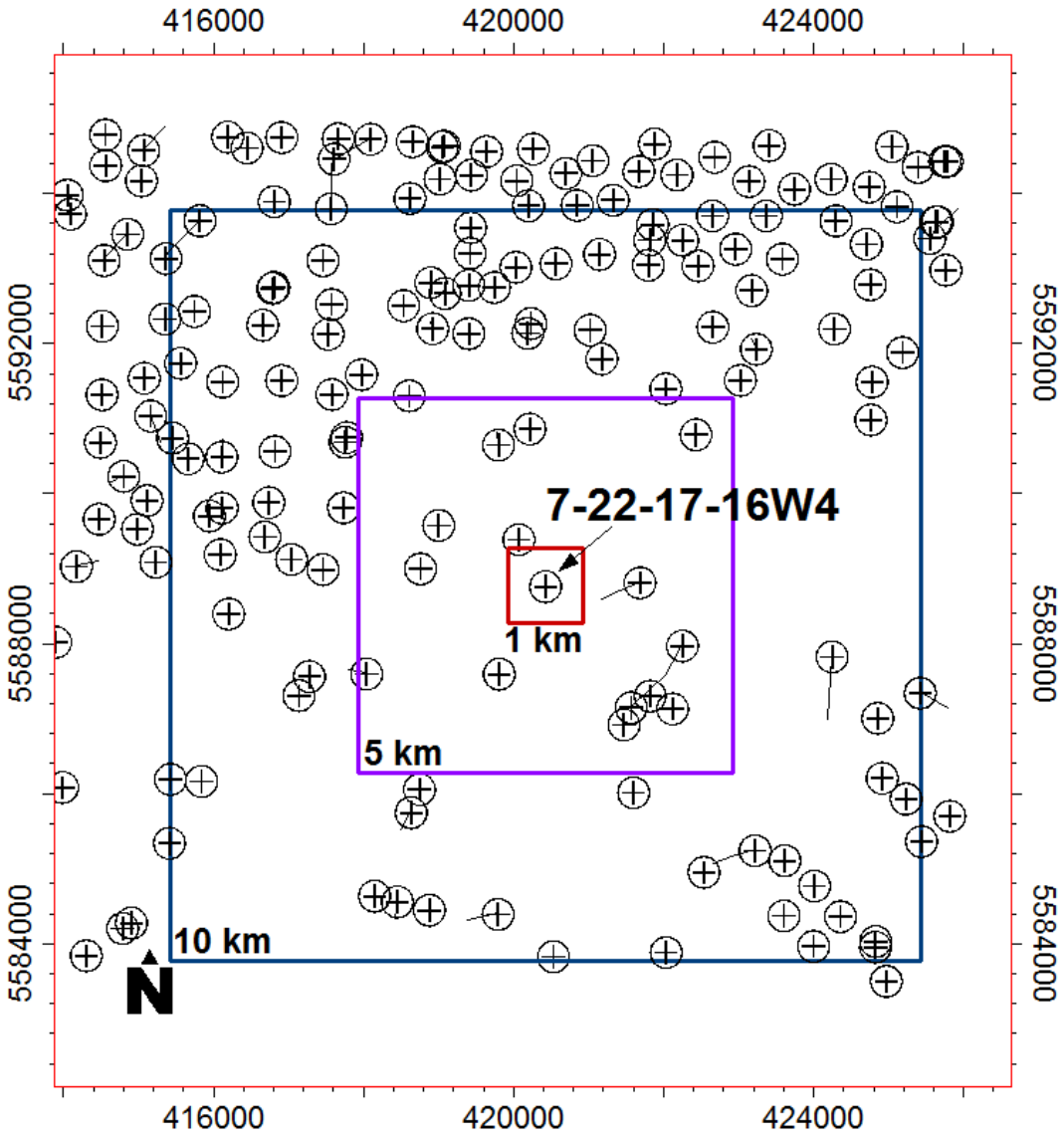
✓ **Site used to improve and enhance 4-D seismology (CREWES) for fluid containment and conformance (CMC)**

Resources

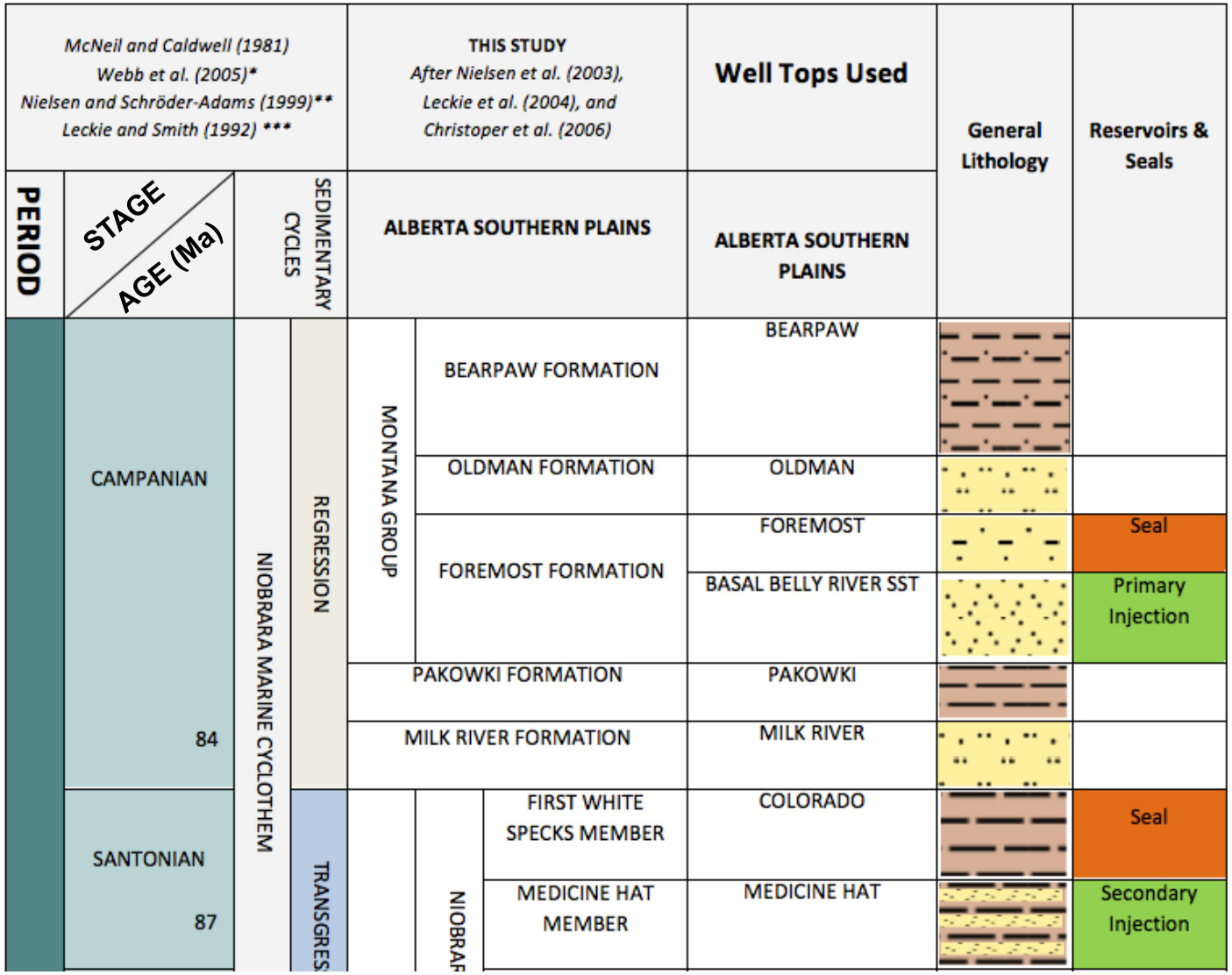
- **Data Suite (IHS Energy)**
  - 191 wells with digital LAS files (>10 km radius)
  - FRS (5 km x 5 km) = 21 wells
  - Limited core data
  - Deviation surveys and locations
  - Well tops
  - Static water levels – 3 m below surface

- **Software**
  - Schlumberger Canada Ltd.
    - Petrel™ E&P Software Platform 2014.1
  - IHS Energy Canada Ltd.
    - Accumap® and Acculogs® 2013
  - MS Office 2012

Data Coverage



Stratigraphic Column



5 km x 5 km Property Model

- Vertical pillar gridding
- Orientation N-S (in-line with GW flow)

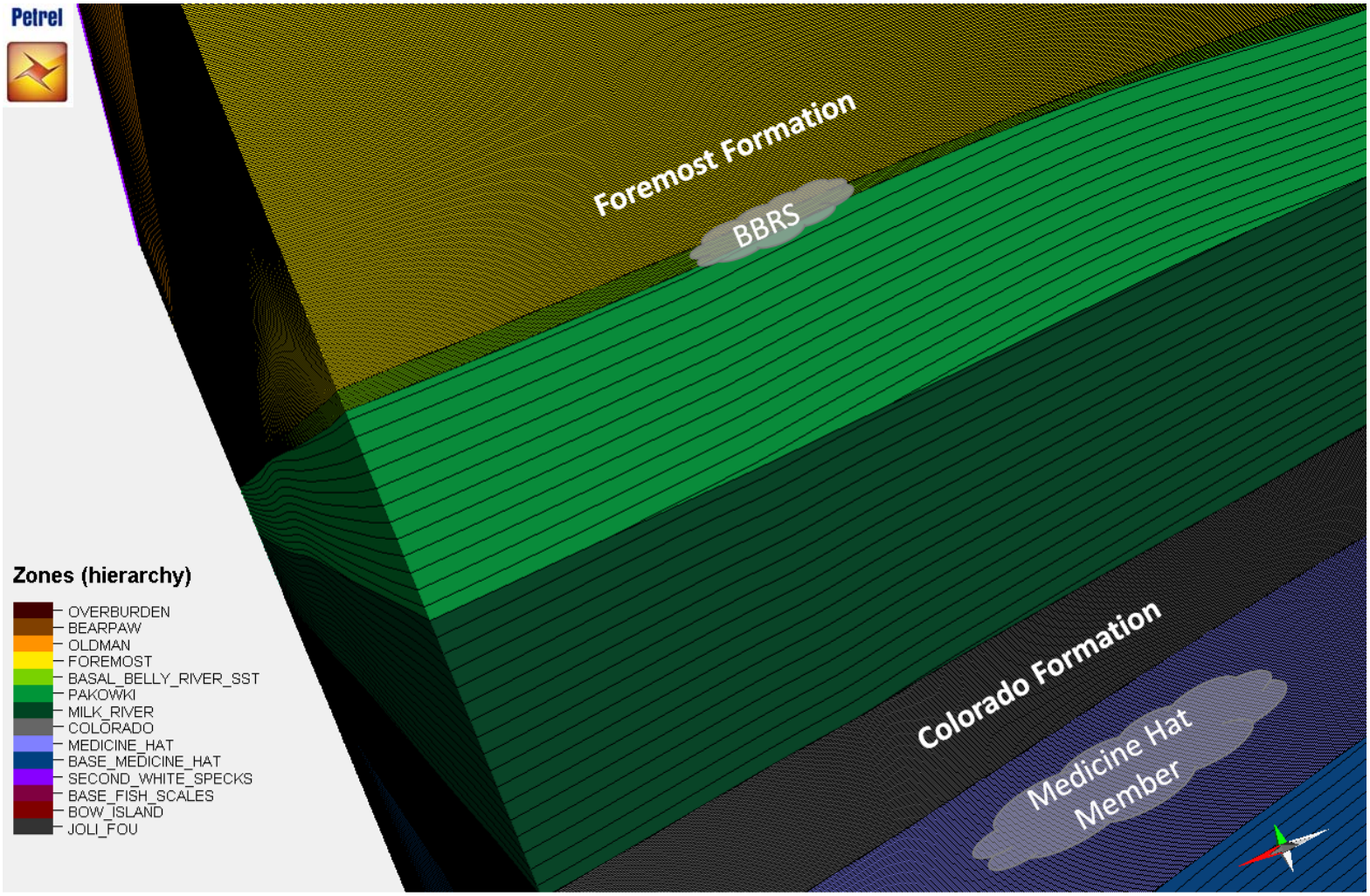
Defined Grid Volume: 200 x 200 x 922 (nI x nJ x nGrid Layers)

- Total #3D cells: 36 million
- Total # faults: 0
- Horizons honour surfaces
  - Surface generation via interpolation – honours well tops

Layering of Cells

- Reference surface
- Zone division based on cell thickness
  - Seal and Target intervals = 0.5 m
  - Non-important intervals = 5 m

Layered Intervals



Property Calculations

- **Well Log Calculator**

$$\varphi_{TOT} = \frac{\varphi_{N(SS)} + \varphi_{\rho(SS)}}{2}$$

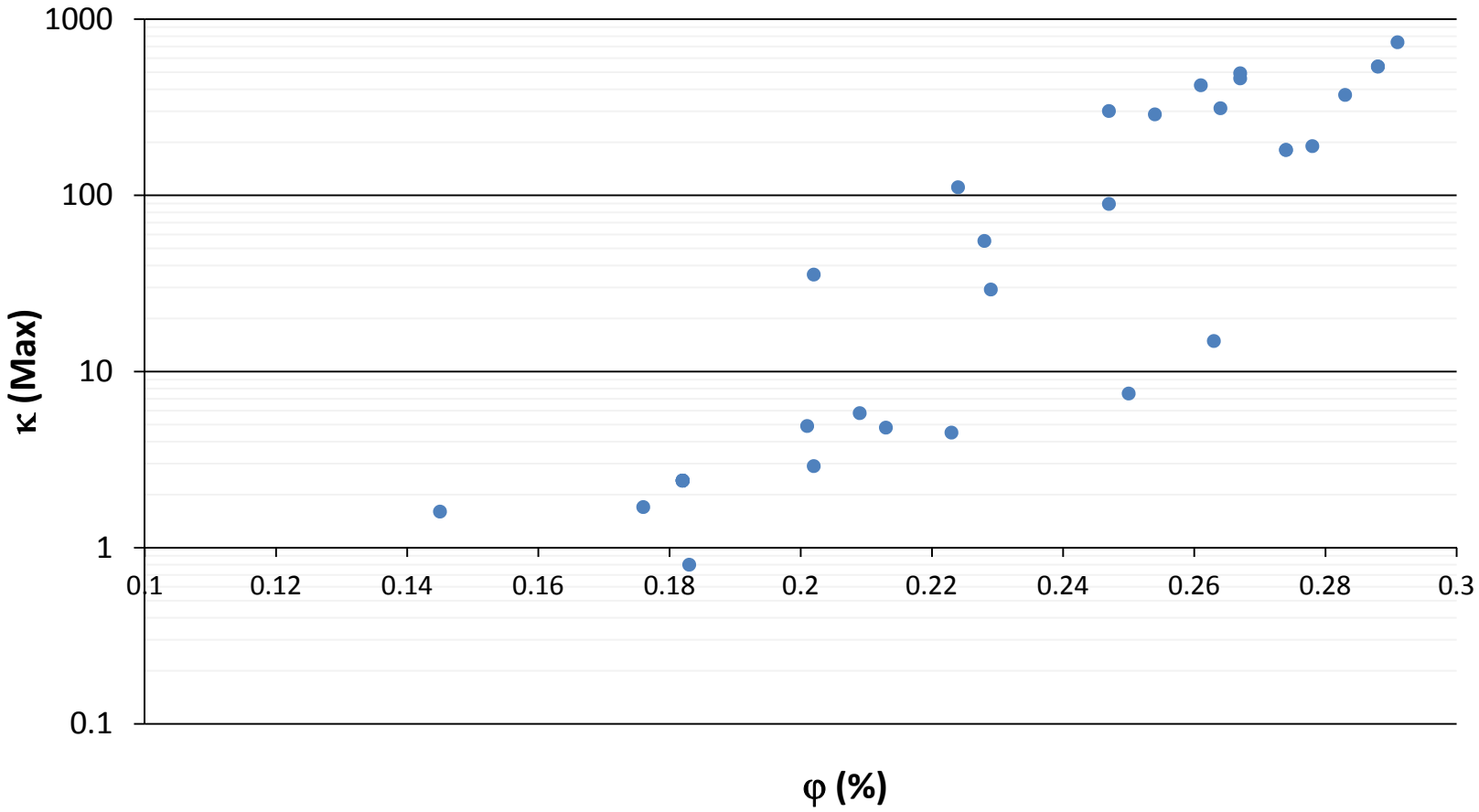
$$V_{SH} = \frac{\gamma - \gamma_{MIN}}{\gamma_{MAX} - \gamma_{MIN}}$$

$$\varphi_E = \varphi_{TOT}(1 - V_{SH})$$

- **Property Calculator**
  - Plotted κ and φ_E from core data
  - Use φ_E in equation of best fit to calculate κ

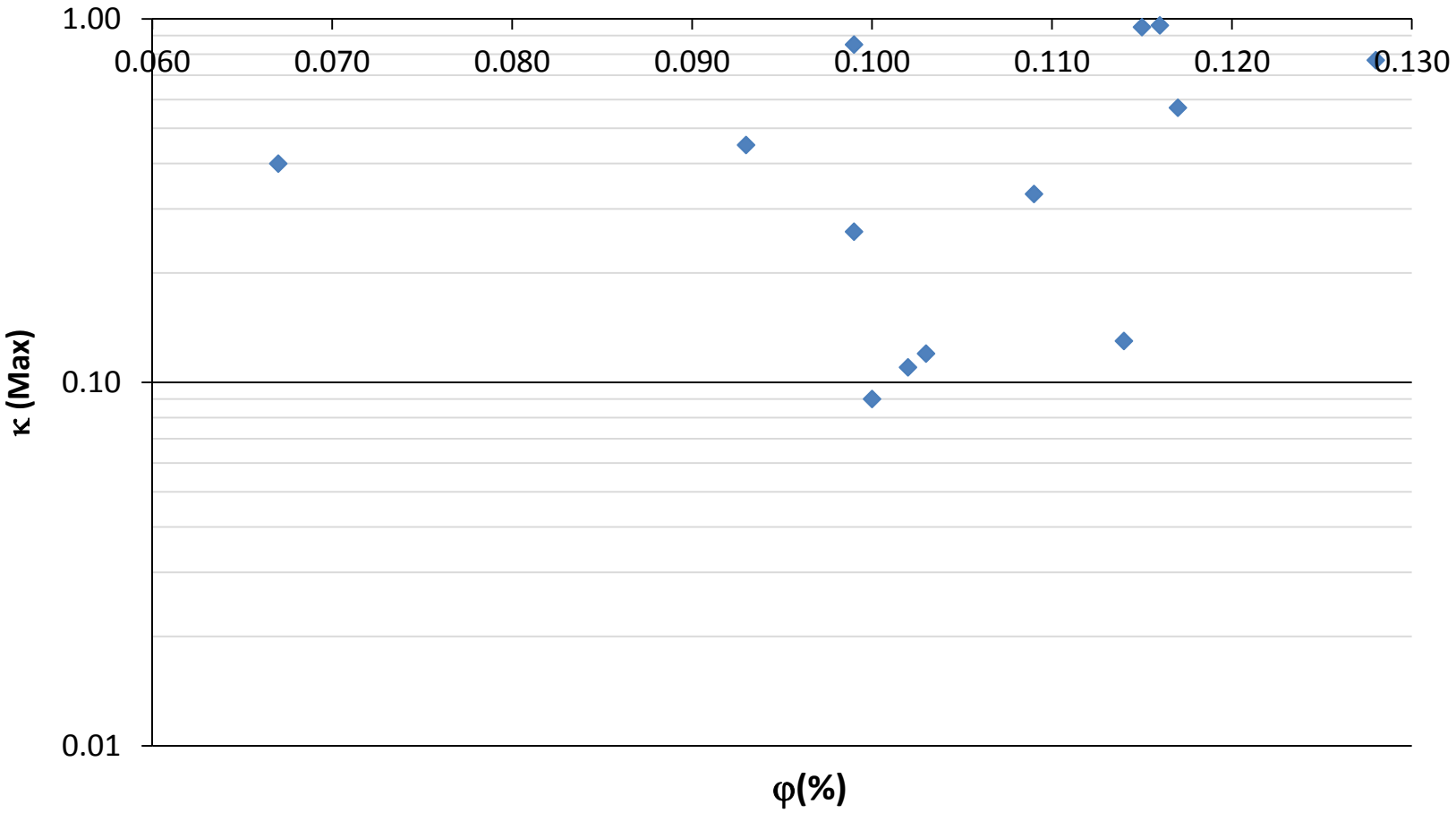
BBRS Core Data

Only two wells – within greater 10 km outside FRS



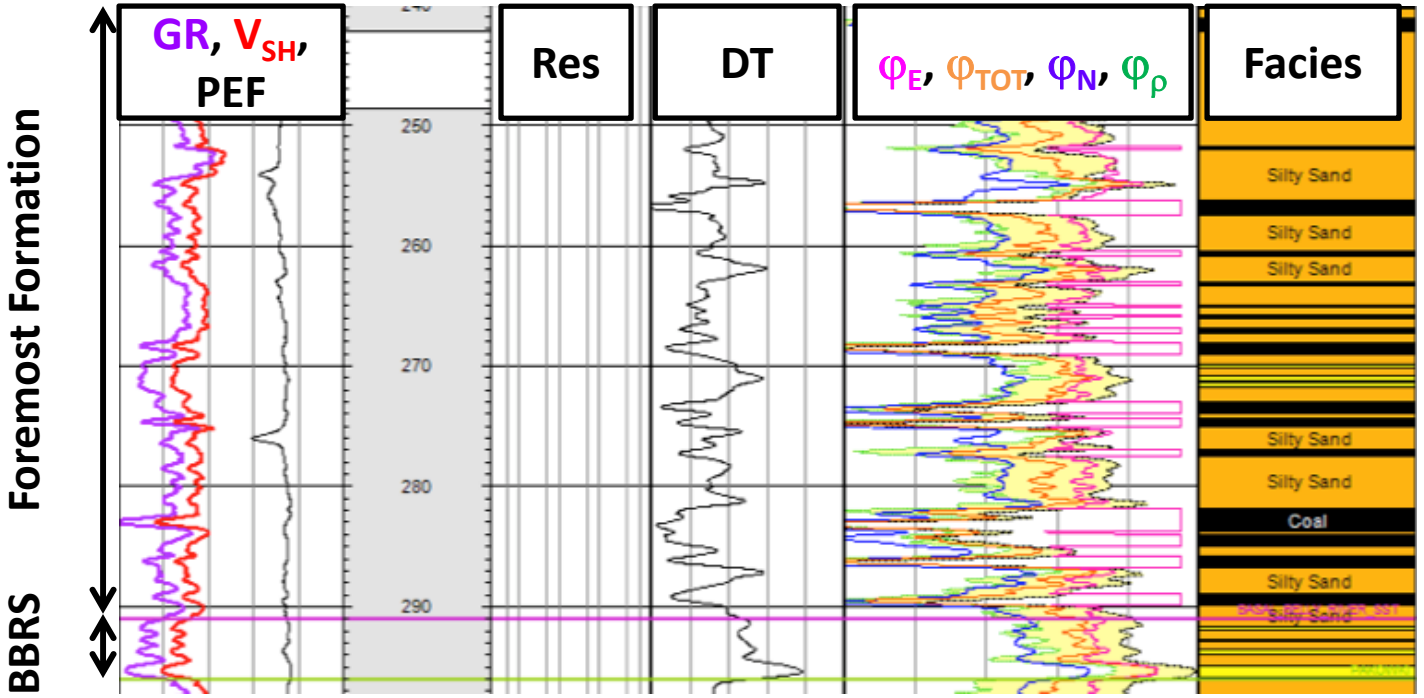
Medicine Hat Member Core Data

Only one well – within greater 10 km outside FRS



Log Cut-offs for V_{SH} and Coal

Facies	Log Cut-off
Coal	RHOB<2; DT>130; PHI_E>0.26; PHIE_E=0.03
Shale	GR>95
Silty-Sand	50<GR<95
Sand	GR<50

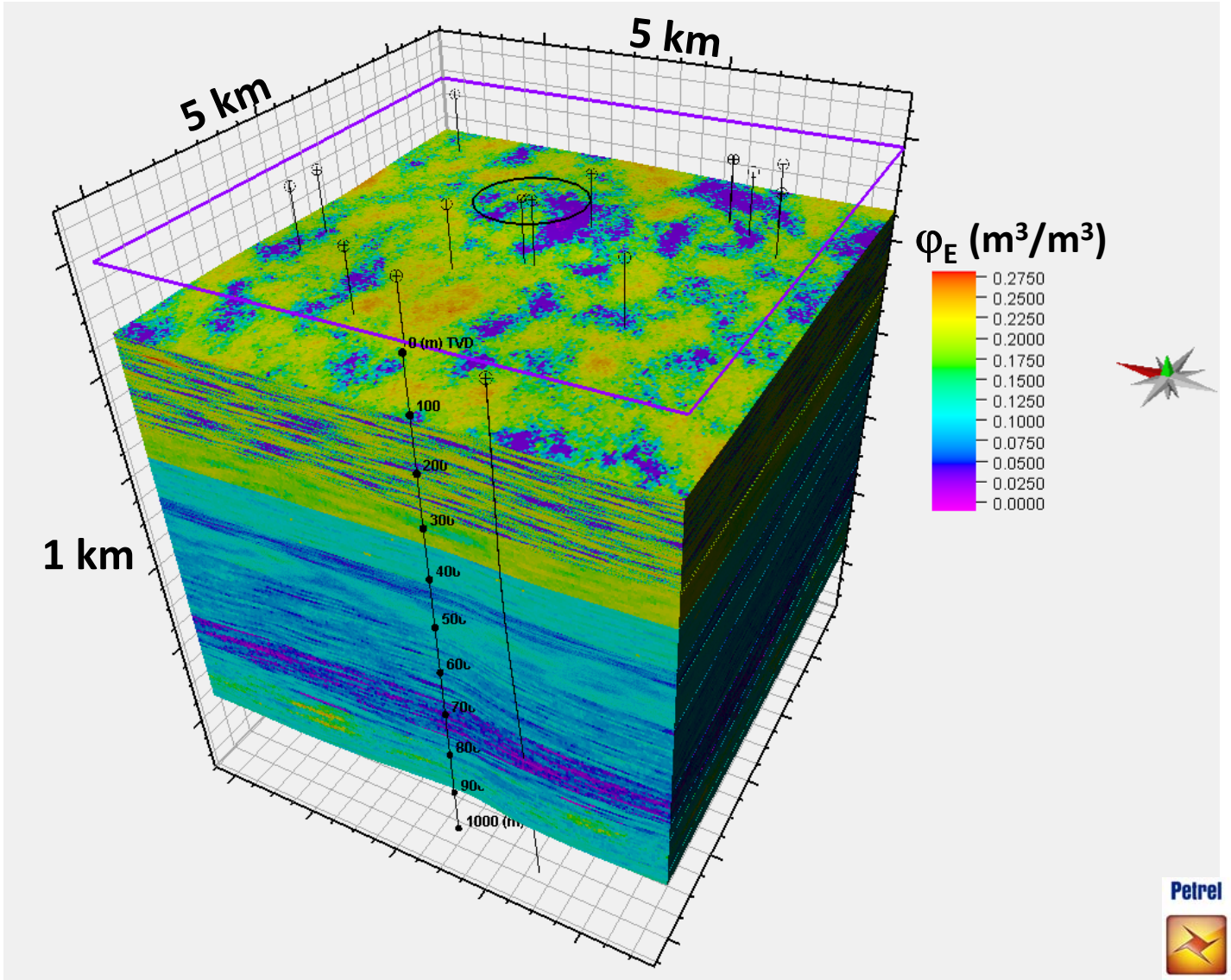


Petrophysical Modeling

- **Gaussian random function simulation algorithm**
  - Conditional Simulation = kriging + unconditional simulation
  - Parallelized = fast computation time
  - Models expected variability and distribution in input data

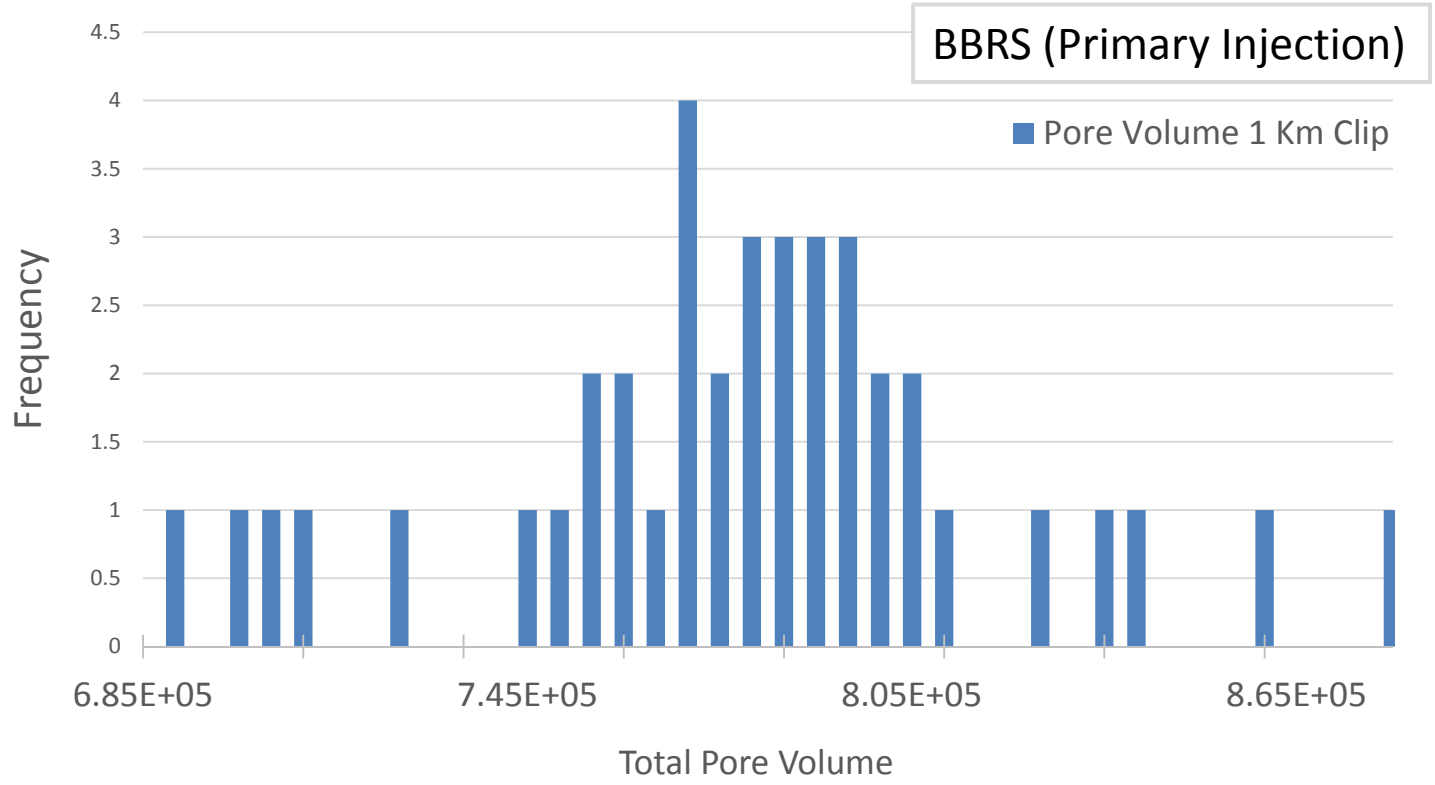
Interval	Type	$\varphi_{E(\%)}$		κ (mD)	
		May 2014 Computation	Nov 2014 Computation	May 2014 Computation	Nov 2014 Computation
Foremost Fm	Seal	0-26	0-28	**0-55**	**0-360**
BBRS	Target	0-25	0-27	**0-85**	**0-300**
Colorado	Seal	0-17	0-14	0-0.46	0-0.57
Medicine Hat Mbr	Target	0-13	0-18	0.02-2.5	0-1

Populated φ_E 5 km x 5 km model

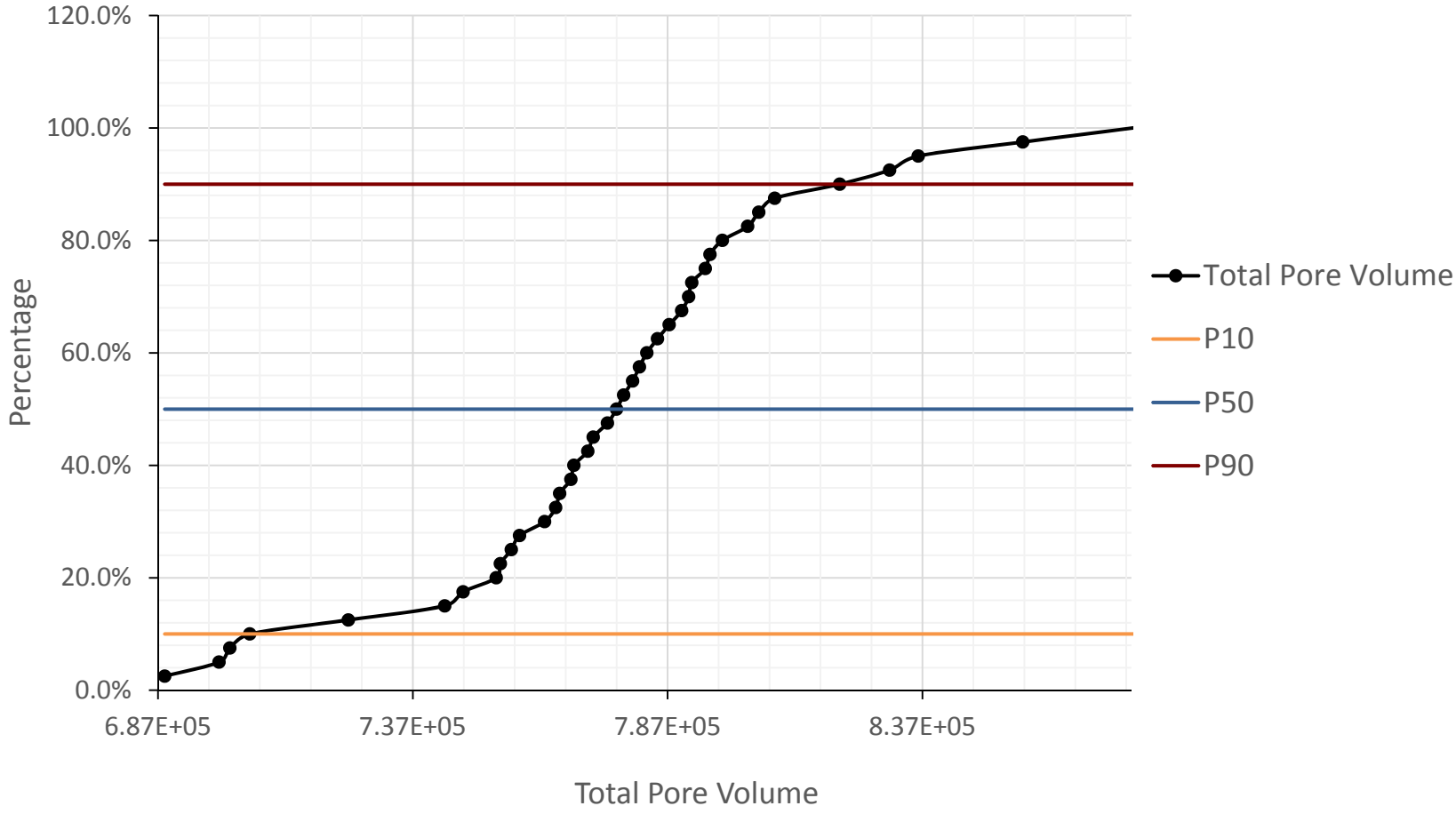


P10/50/90 Framework

- Conservative/Typical/Optimistic values
- Both φ_E and κ were modeled: 40 iterations

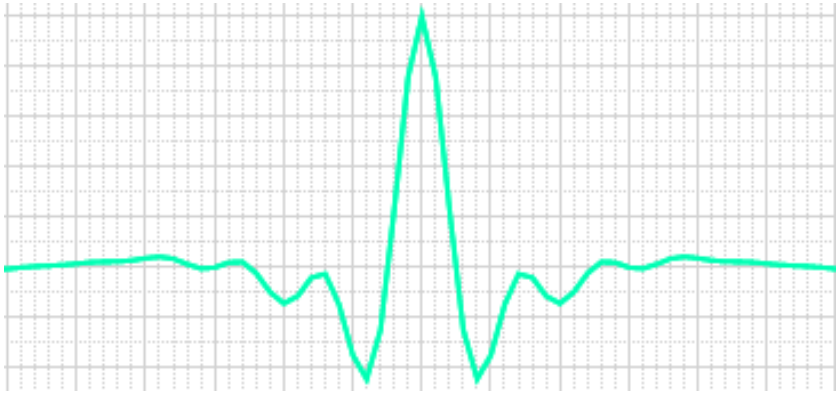


P10/50/90 Framework for BBRS

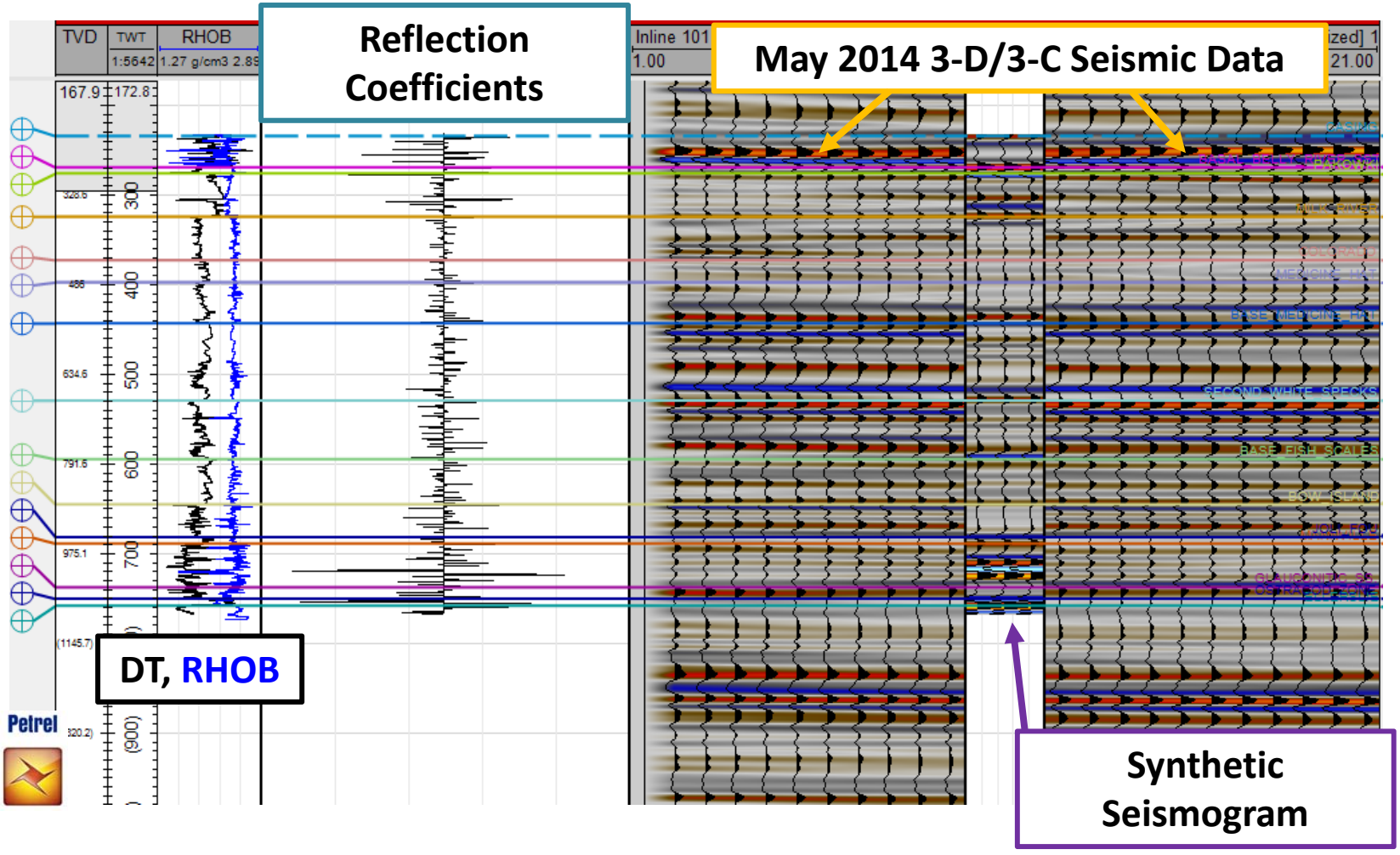


4 km x 5 km Geophysical Model

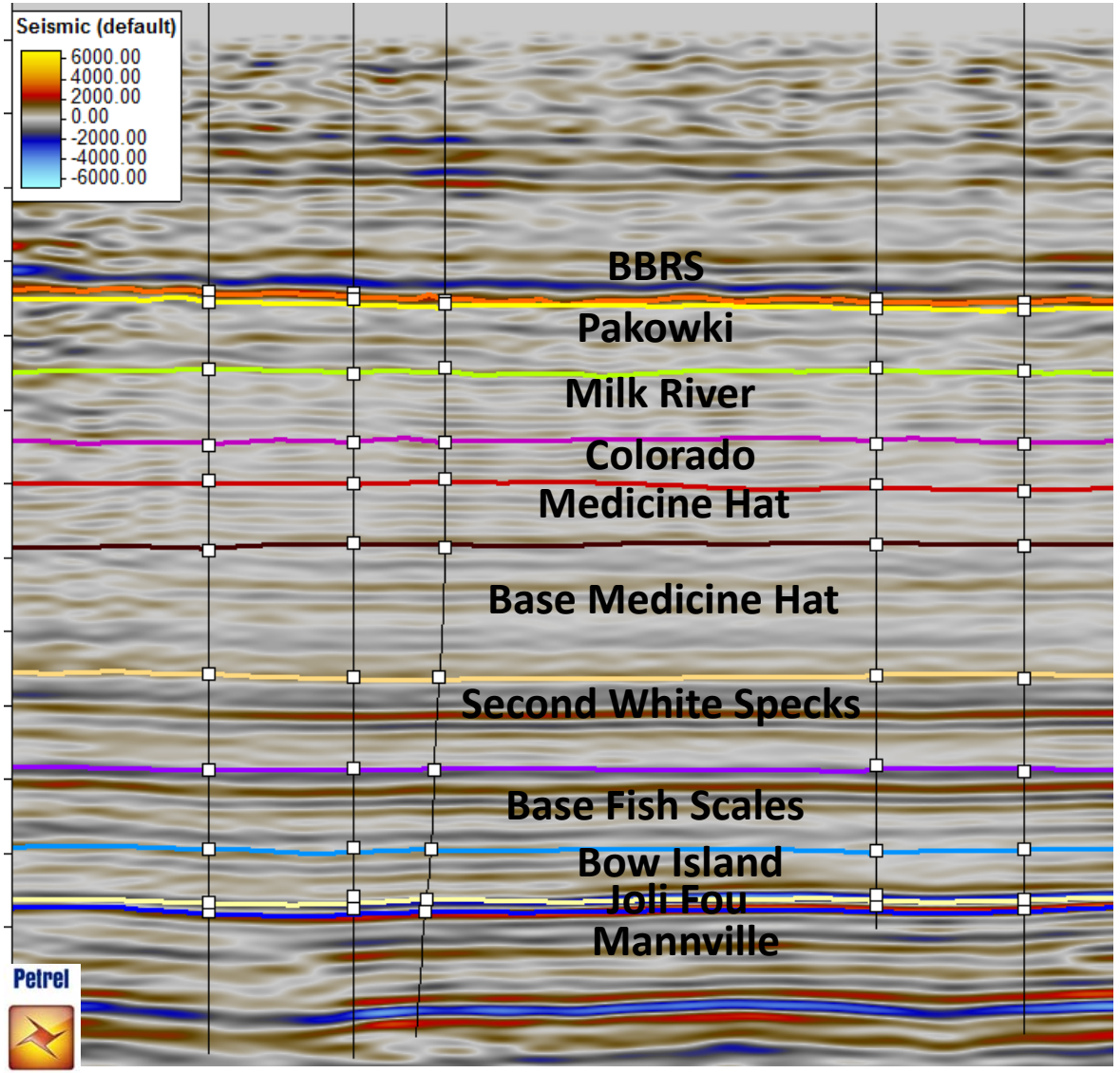
- **Well-ties & Synthetic Seismograms**
  - 8 Well-ties to two 3D seismic reflection volumes
    - '97 Vintage 3D/1C – Cenovus Energy
    - '14 May 3D/3C – CMC
    - Replacement velocity: 2600 m/s
    - SRD: 800 m
    - **NO** checkshot data available – TDR developed on DT
- **Wavelet**
  - Zero-Phase Ormsby
    - (15/20-75/95)
  - Length: 200 ms
  - Sample Rate: 2 ms



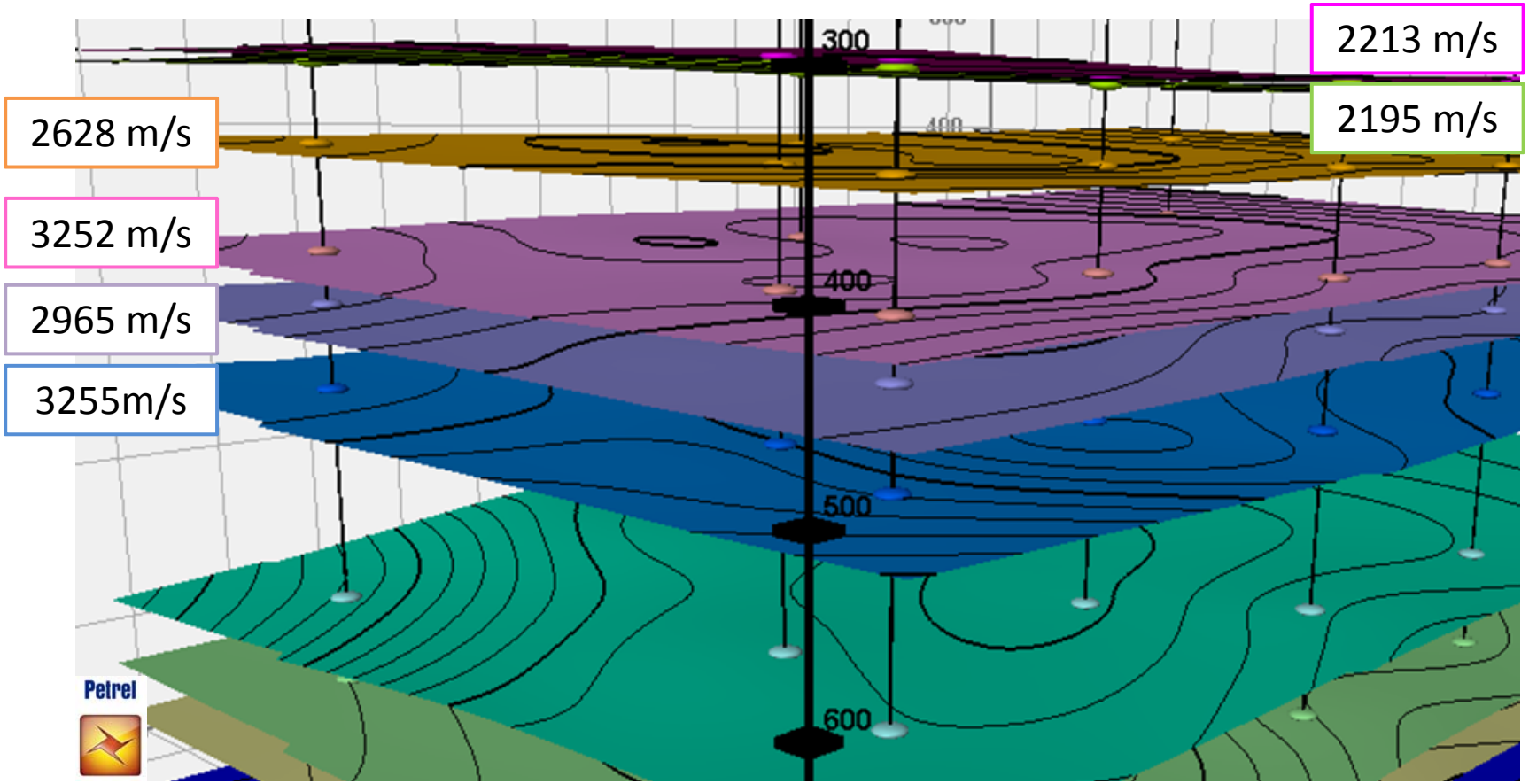
Synthetic Seismogram at 7-22



Five tied wells to ‘97 3D Vintage

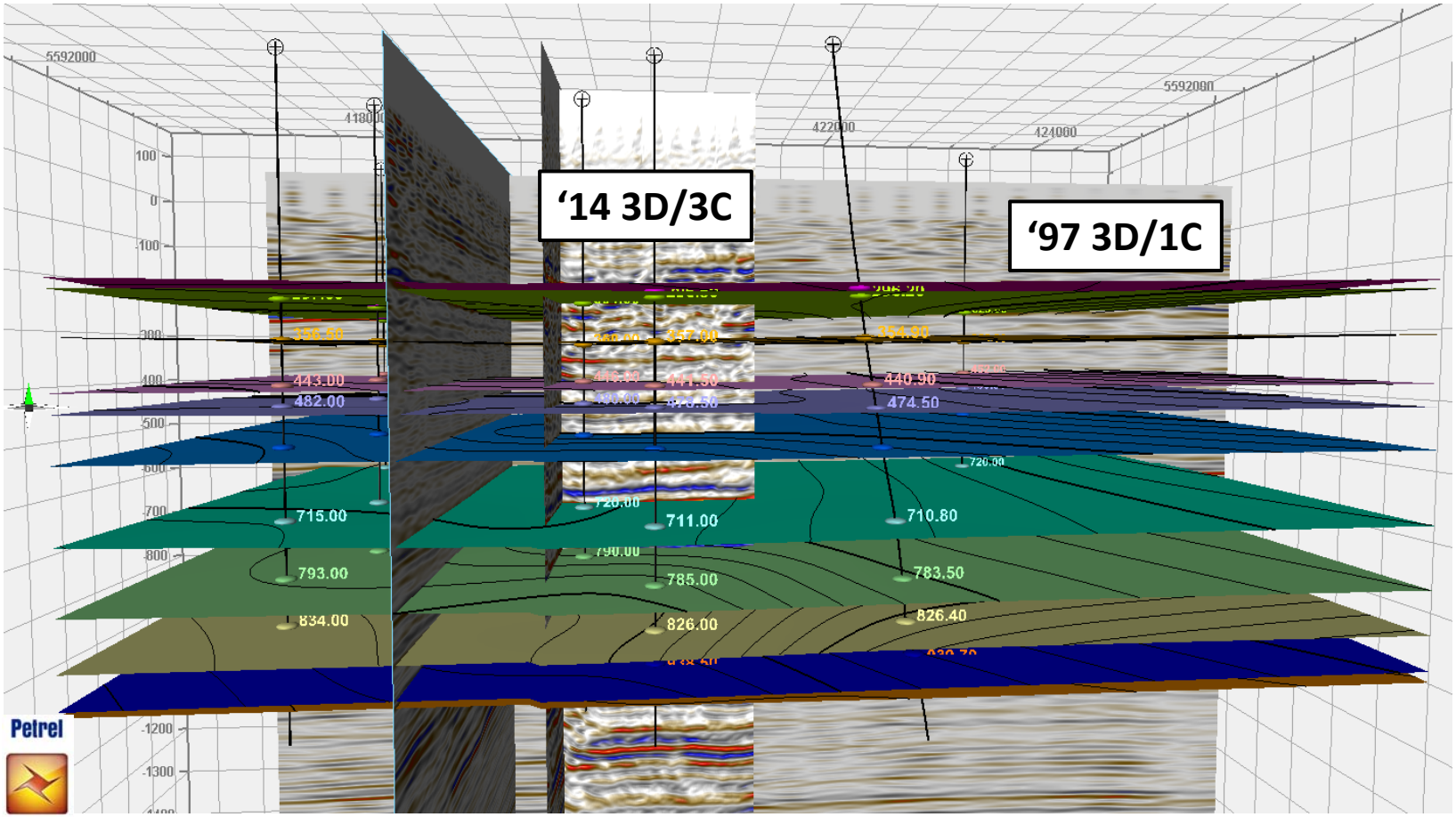


Depth Conversion - Velocity Modeling

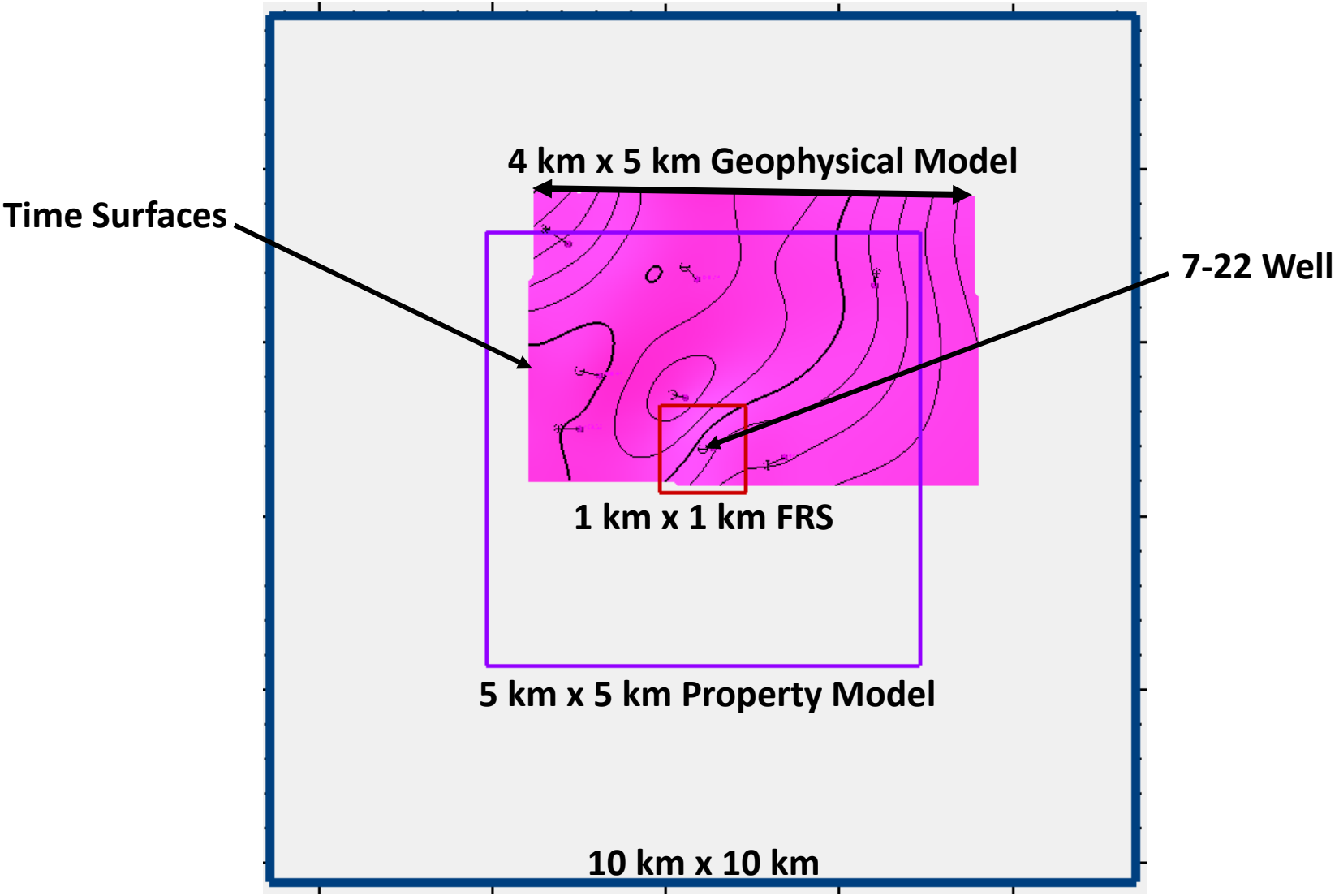


Model Update

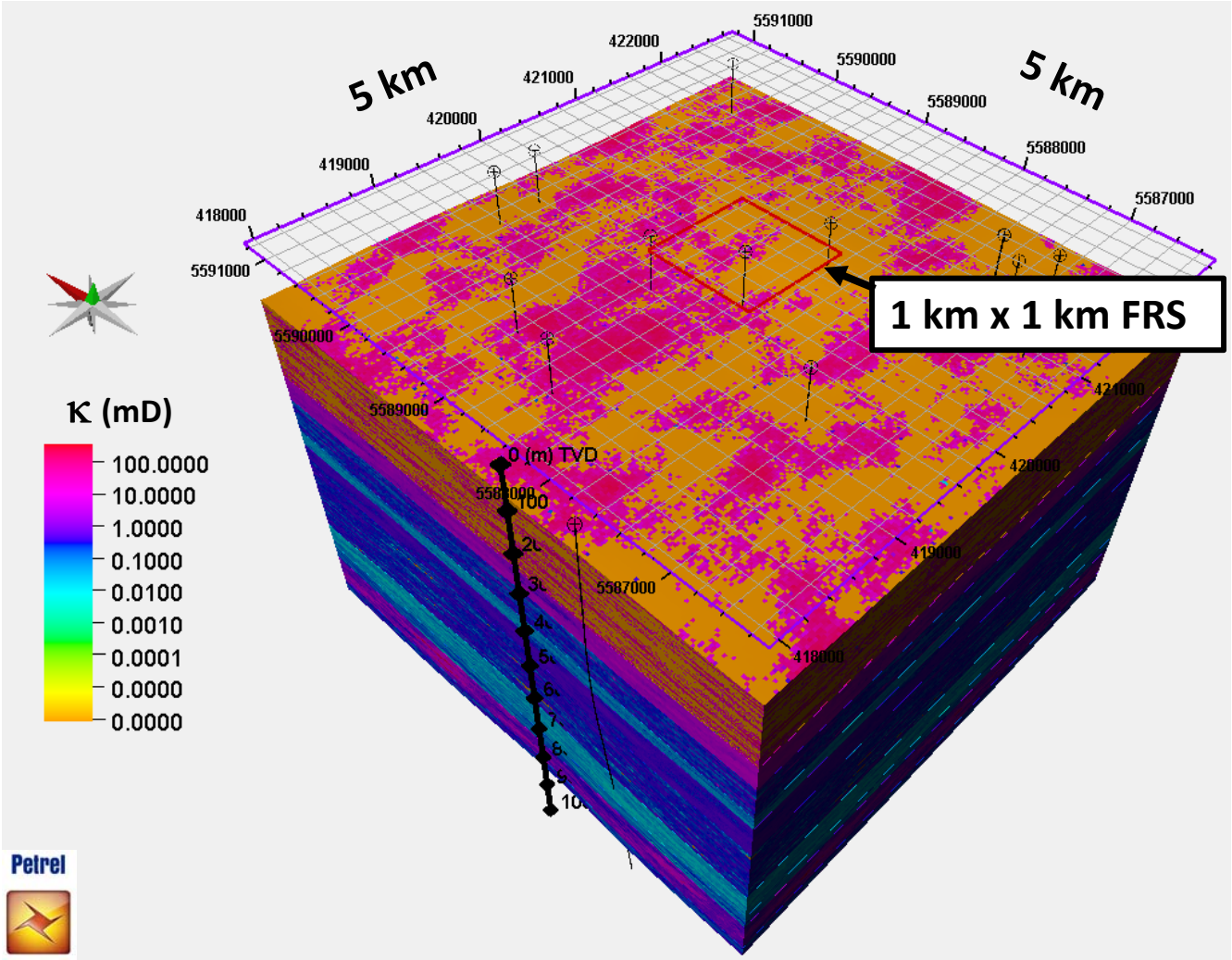
- Weighted 75% depth-converted seismic horizons and 25% well-top interpretation



Model Update



1 km x 1 km Integrated FRS Model



Conclusions

- Developed 5 x 5 km property and 4 x 5 km geophysical model
  - From existing well, core, and seismic data
- Built-in workflows and mechanics
  - Can be easily updated
- P10/50/90 statistics for φ_E and κ
  - Both primary and secondary injection intervals
- BBRS: φ_E: 0-27% κ: 0-360 mD
- Medicine Hat Mbr: φ_E: 0-18% κ: 0-1 mD

Ongoing & Future Work

- Identify sandstone zones in Medicine Hat Mbr using shallow resistivity log
- Simulation of fluid injection
- Study behaviour of P- & S-waves on intervals of injection
- Update model with new logs and core from drilled well

Acknowledgements

- Carbon Management Canada
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- Schlumberger Ltd. Canada