Overview of the Hugoton Asset Management Project (HAMP)

southwest Kansas and Oklahoma Panhandle

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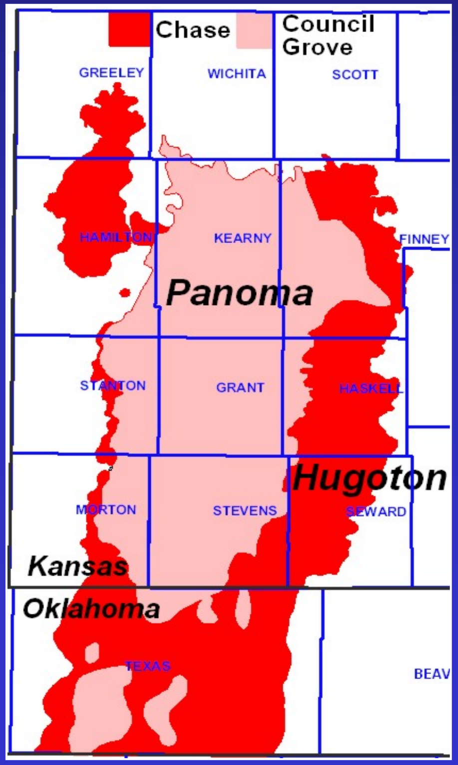
Doveton, and Nathan Winters



Midcontinent AAPG, Oklahoma City
September 13, 2005

Project History

- ✓ Evolved and expanded over many years
- ✓ Wonderful example of an industry – academic – government collaborative project
- ✓ Not possible without a strong commitment by all partners

Started with 5 partners in a 5-year project ('99-'04)

HAMP 9 partners in a 2-year project ('04-'06)

Basic data set (Kansas only)

- Tops set– Grass roots to TD for 15,000+ wells (~9 man-years)
- Dynamic Access Relational Database
  - Tops
  - Proration & Production Data
  - Well Logs
- Type Logs – Interactive
- Fluid Migration Models
- Council Grove – Petrophysics and initial static model

Kansas and OK Panhandle

- Expand data set
- Integrate core, tops, log, petrophysical data
- Build field scale models to help answer fundamental questions

Participants

Industry partners:

Anadarko Petroleum Corporation

BP America Production Company

Cimarex Energy Co.

ConocoPhillips Company

E.O.G. Resources Inc.

Medicine Bow Energy Corporation

Osborn Heirs Company

OXY USA, Inc.

Pioneer Natural Resources USA, Inc.

KGS Scientists:

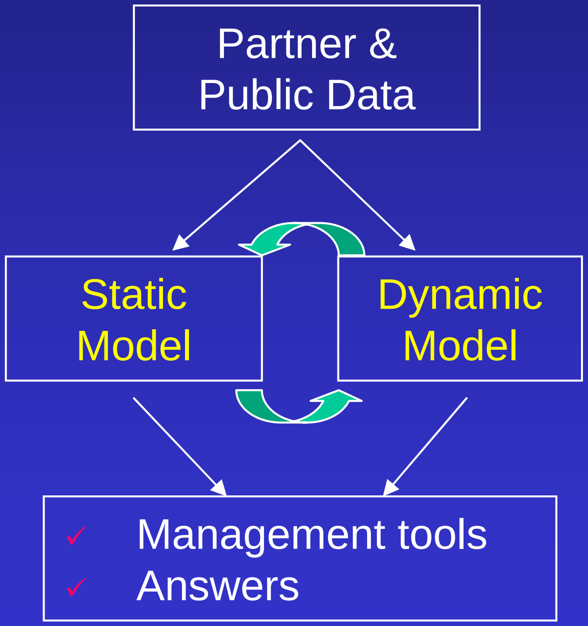
Dubois	Project co-manager (Permian), sedimentology, static model
Carr	Project co-manager (Deep Pools)
Byrnes	Core petrophysics
Bohling	Geostatistics, programming, model
Bhattacharya	Reservoir engineering, simulation
Doveton	Log petrophysics
Victorine	Java programmer (Deep pools)
Winters	Graduate student assistant

Consultants:

Gerlach	Consulting geol., OK Panhandle
Barba	Consulting eng., frac modeling
Brownrigg	Consulting computer engineer

Why HAMP?

How much gas is left?
Where is it located?



Partner & Public Data

Static Model

Dynamic Model

- ✓ Management tools
- ✓ Answers

Principle Products

- Geologic (static) and engineering (dynamic) models for the Permian gas systems
- Simulation studies of Permian gas systems at multiple scales

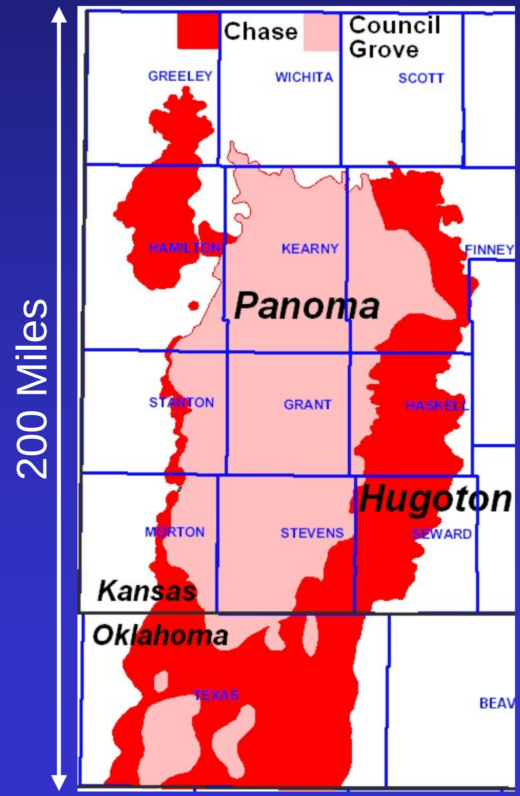
Answer fundamental questions

- Original gas in place at well, region and field scales
- Reservoir connectivity at pore, flow unit, well, inter-well, region and field scales
- Differential depletion in stratigraphically separate zones in the reservoir
- Production decline rates and EUR at ultra low pressures

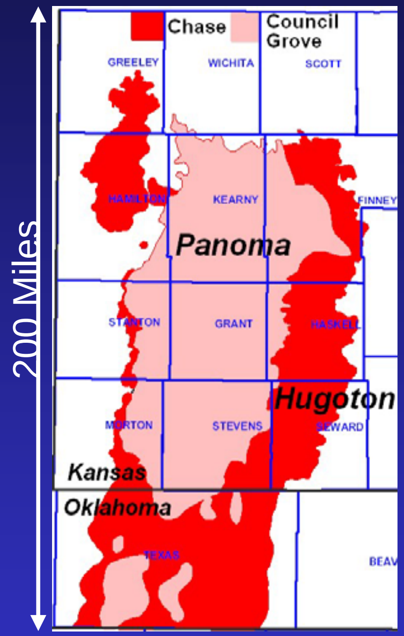
Largest gas field in NA

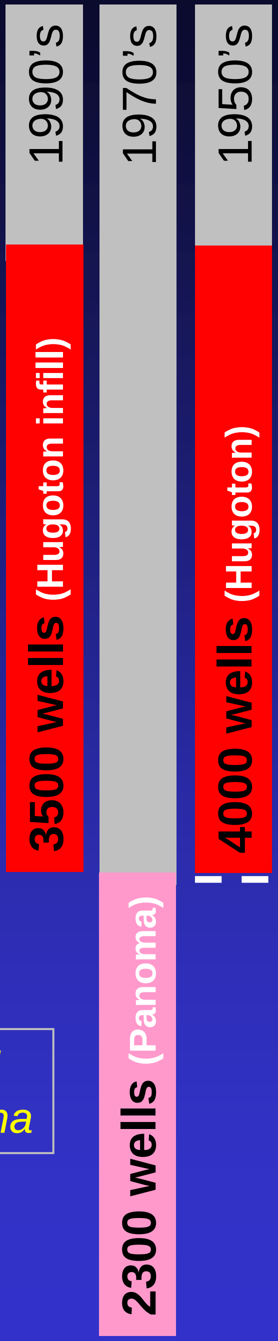
	To date	Remaining ?
Kansas and Oklahoma *(Hugoton and Panoma)*	34 TCF	5-10 TCF

KANSAS	Hugoton	Panoma	Combined
Discovery	1928	1958	
Development	1948	1970	
Infill Drilling	1990	?	
Depth	2,500	2,750	
Wells	7,536	2,345	9,881
Cum. Gas (TCF)	24.7	3.0	27.7
BCF/well	3.3	1.3	2.8
Annual (BCF-2003)	239.9	62.5	302.4
MMCF/Well	31.8	26.7	30.6
Decline (5 Yr. Avg.)	8.7%	7.8%	8.5%



Development History




1990's

3500 wells (Hugoton infill)

1970's

2300 wells (Panoma)

1950's

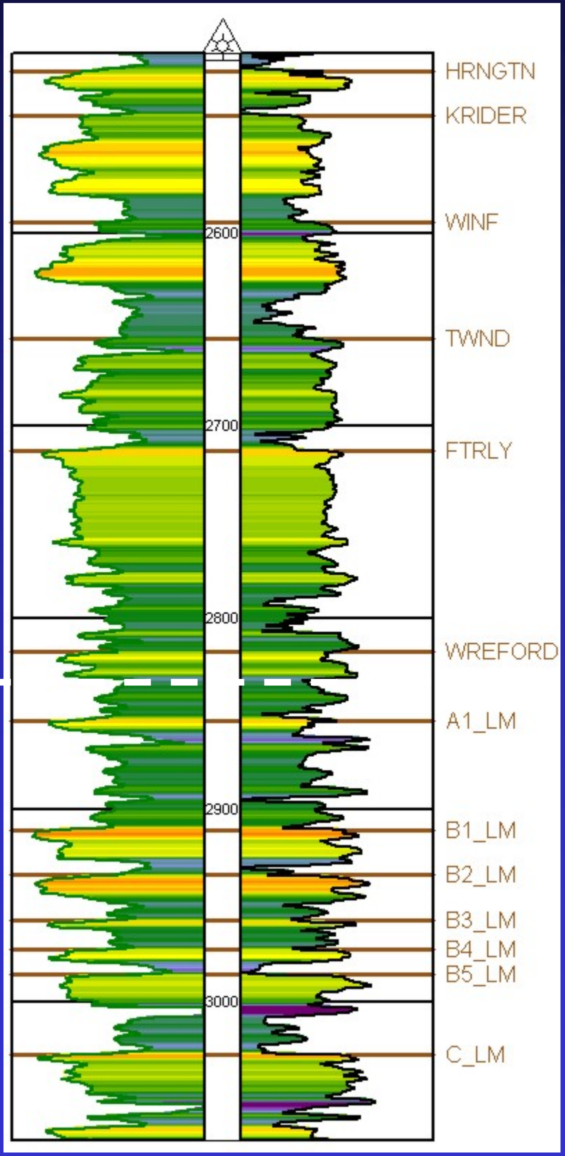
4000 wells (Hugoton)

Thinly layered, alternating carbonate and siltstone reservoir in 13 marine-nonmarine sedimentary cycles

L. Permian

Hugoton (Chase)

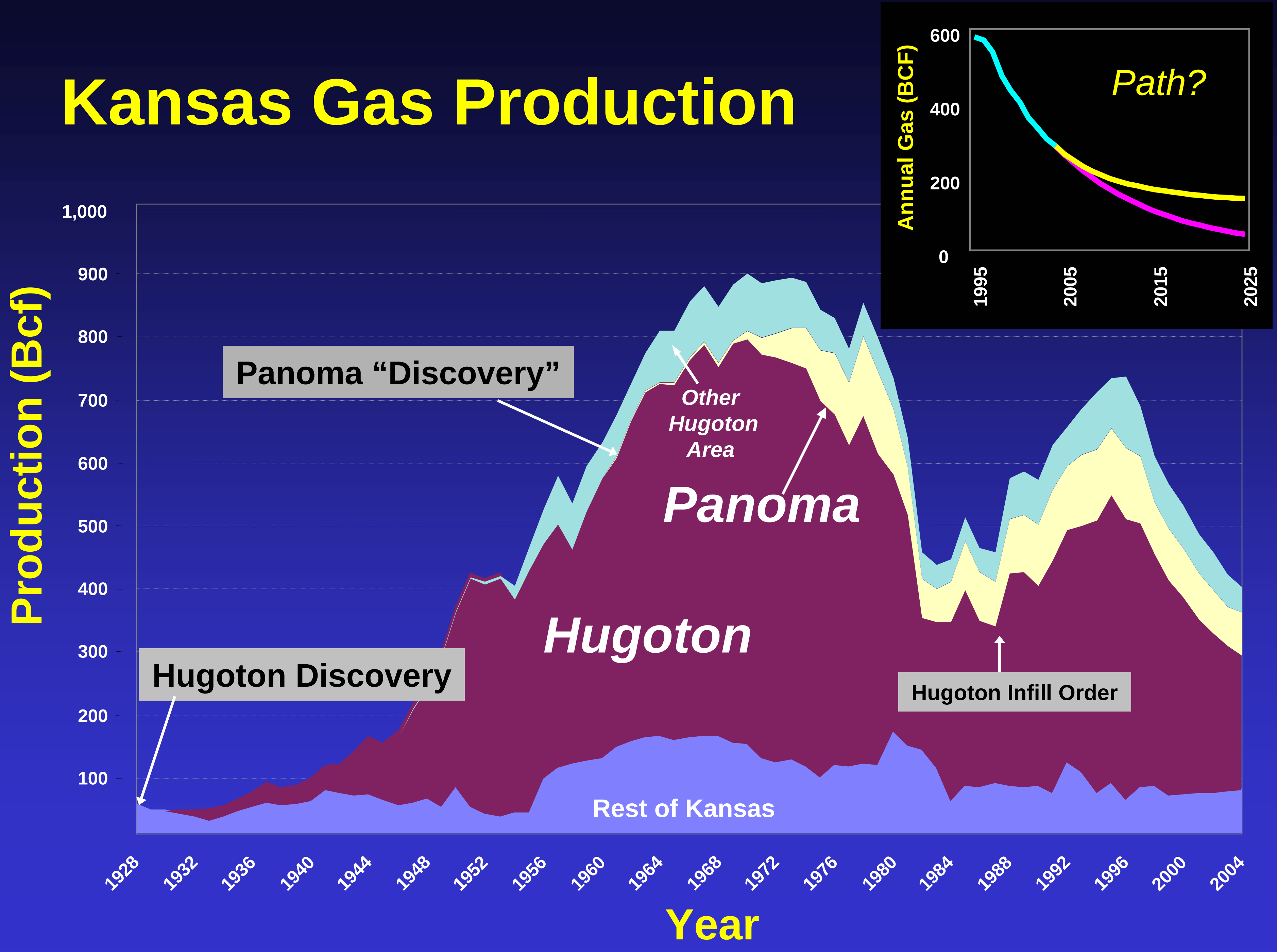
Panoma (Council Grove)



550 feet, 13 cycles

No Hugoton infill wells in Oklahoma

Kansas Gas Production



Determining OGIP and remaining reserves is problematic

Accurate water saturations are not directly measurable due to filtrate invasion *(George, etal, 2004)*
(Volumetric OGIP calculations)

Accurate reservoir pressures (by zone) are not generally available
(Material Balance OGIP calculations)

Rate vs. time with economic cutoff used for remaining reserve estimates are also problematic
(Very slight Δslope has large impact)

Hugoton Asset Management Project

- ✓ Petrophysical property-based water saturations that are rock type (lithofacies) dependent
- ✓ Quantify pressure regimes with reservoir simulation models validated by limited zone pressure data
- ✓ Flattening decline curve should be anticipated. Models will help and project future rates of slope change.

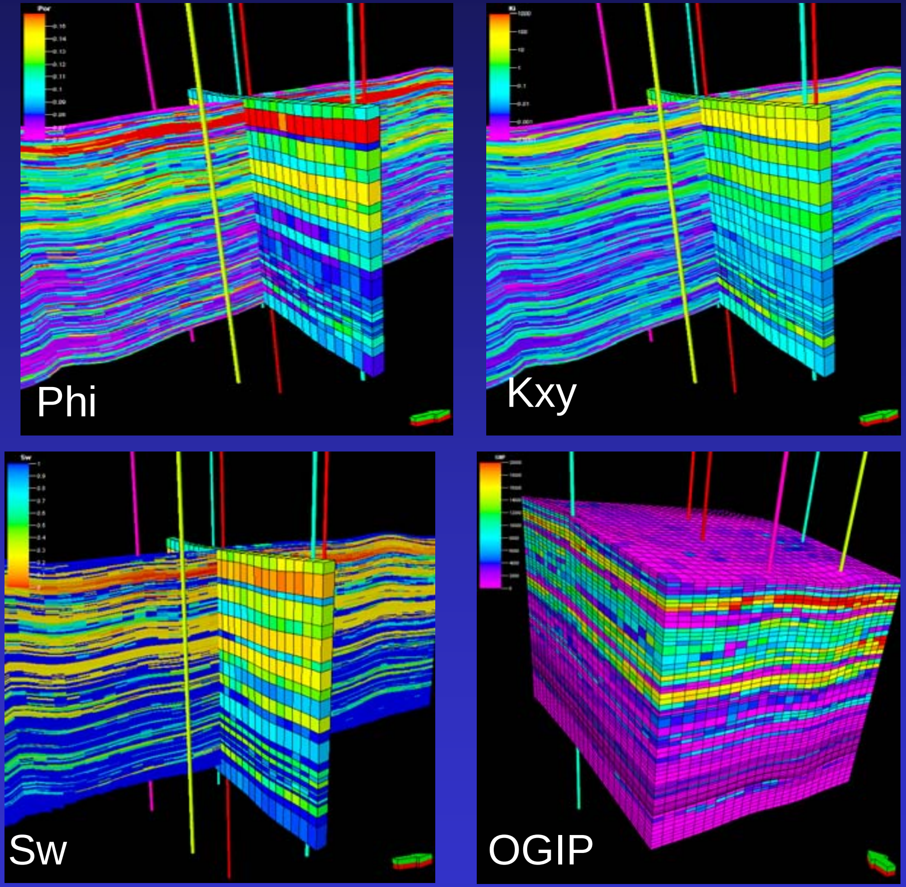
Olson etal (1997) estimated ***Kansas Hugoton OGIP*** at **35 - 38 TCF**
Cumulative to date (Kansas-Hugoton = ***25 TCF***)

Present Concept:
Hugoton (Chase) and the Panoma (Council Grove)

- Thinly layered (stratigraphic zones) with moderate to low crossflow between zones.
- High permeability layers are conduits to the wellbore *(but with variable efficiency)*
- Low permeability layers have insufficient vertical permeability (Kz) to feed flow layers
- Differential depletion and variable pressures between zones*
- Common gas/water and free water level for Hugoton-Panoma *at least in most of Kansas* and possibly part of Oklahoma *and* it is sloped.

**Not new. See Ryan etal, 1994.*

Township scale cellular model of Chase and Council Grove



Intersection of fine-layered model with upscaled layering for simulation

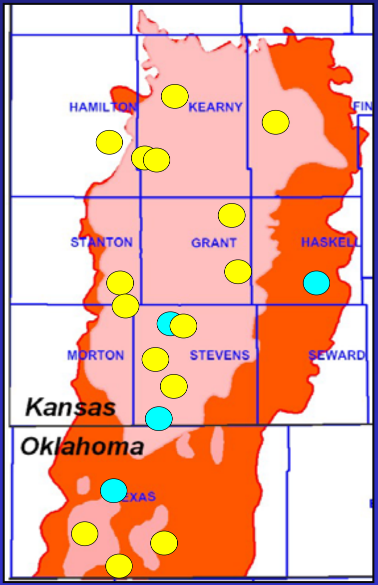
Geomodel Workflow (static model)

Gather data

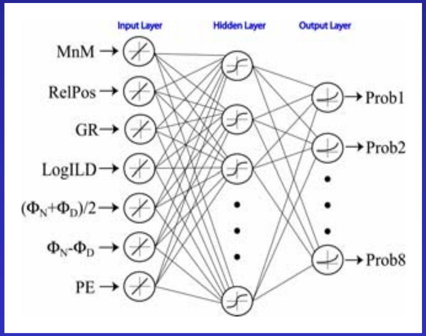
↓

CORE & ELog Var. → Neural Net → NODE WELLS → Stochastic Methods → 3D MODEL

Training Set

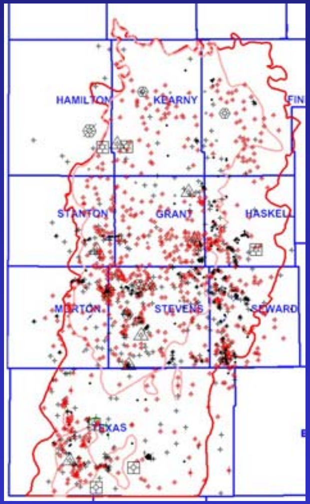


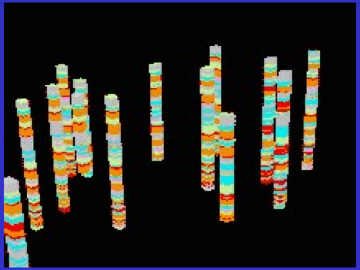
Lithofacies in core tied to log and geologic constraining variables

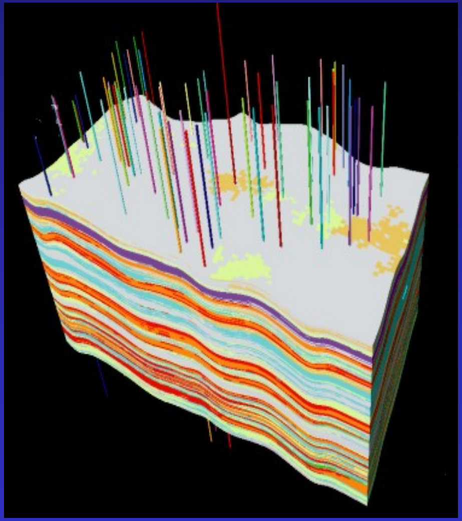


Train neural network and predict lithofacies in non cored wells (nodes)c

1400 “Node” Wells







Fill volume between node wells with facies and properties using stochastic methods

Develop dynamic model through empirical relationships

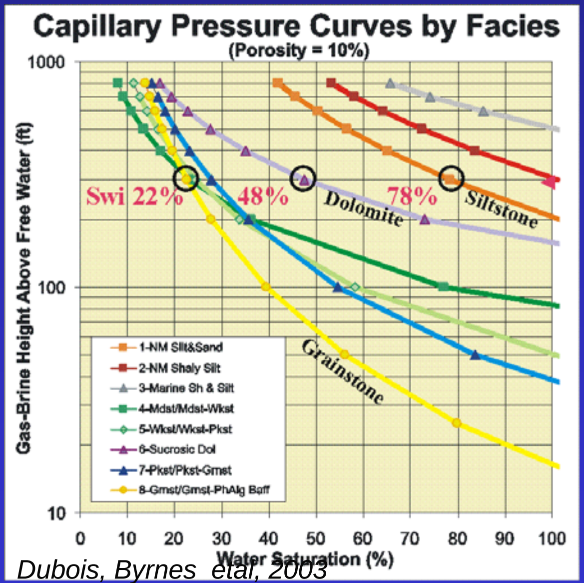
Model, Facies, Phi_{corr} →

Empirical Relations & ***Free Water Level*** →

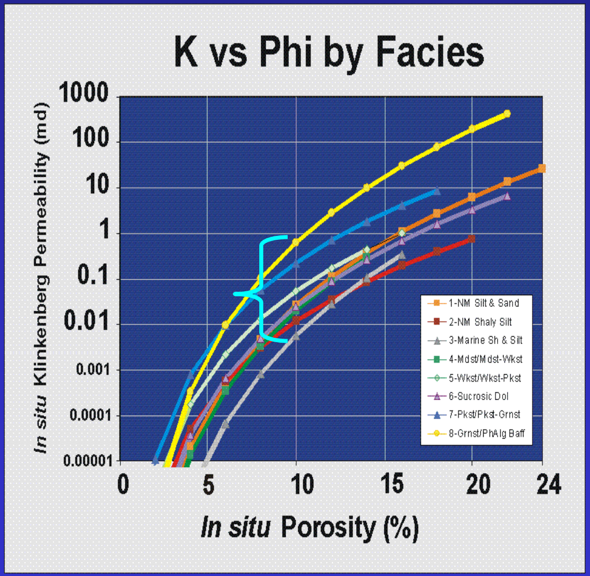
Permeability, Water sat., Rel. Perm. →

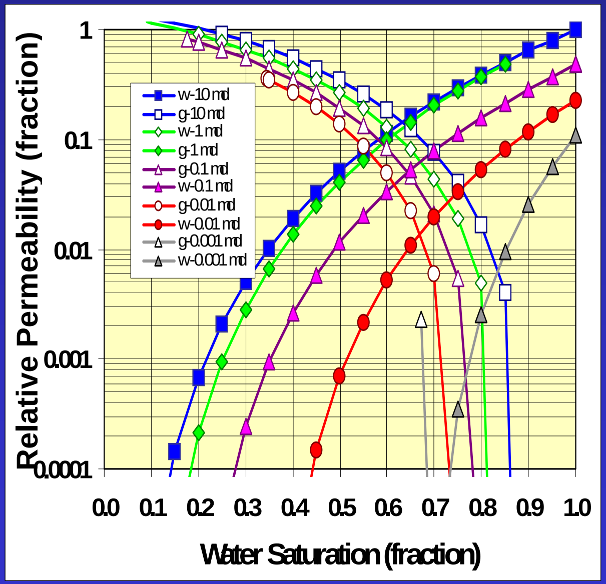
Dynamic Model & Simulation →

Differential Pressure, Corrected MatBal OGIP



Dubois, Byrnes etal, 2003

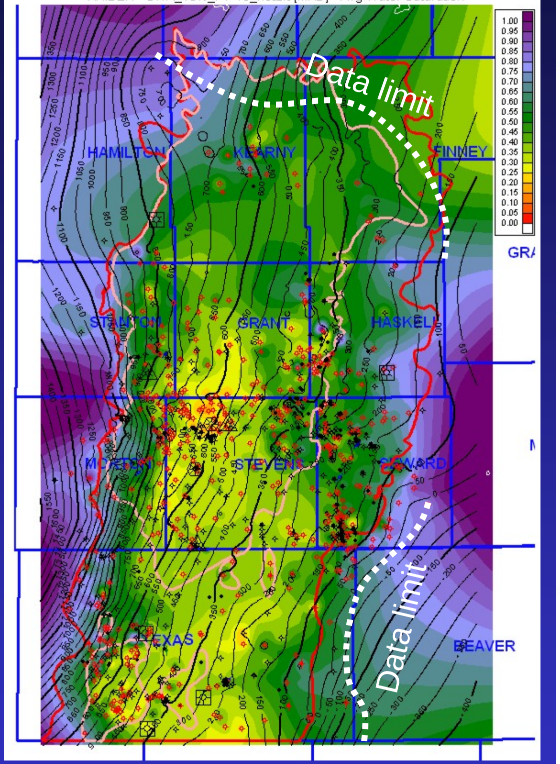




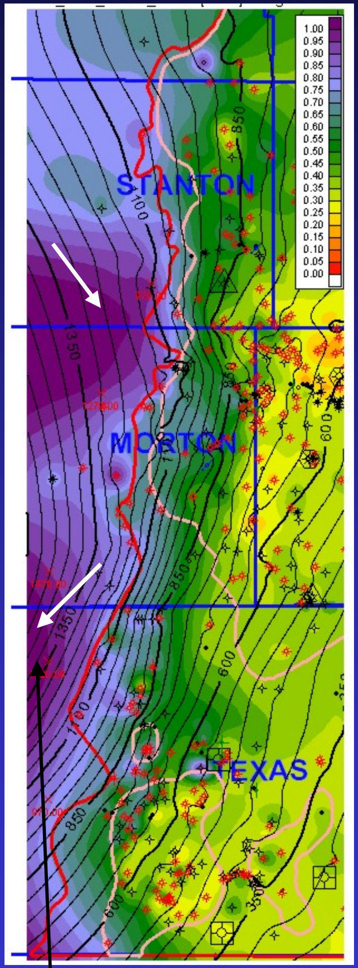
Property-based Sw

Sw mapping support sloped free water level concept

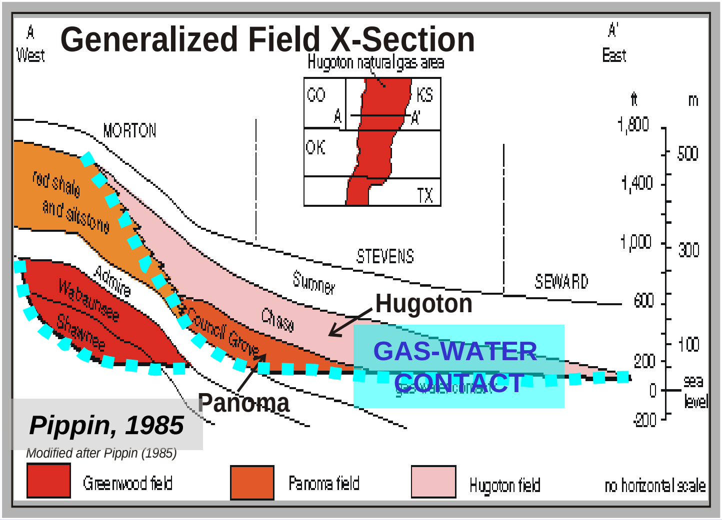
(and G/W contact)



Krider Avg Sw,
phi>10%, F7-9
B/Krider structure
1072 wells

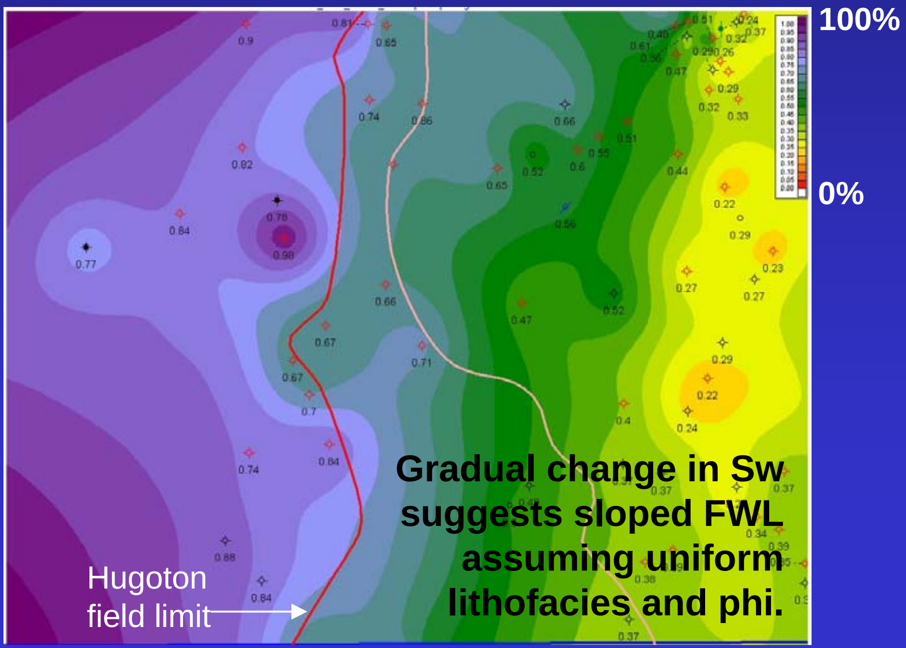


Intersection of structure datum and 100% Sw + 30 feet ~= FWL



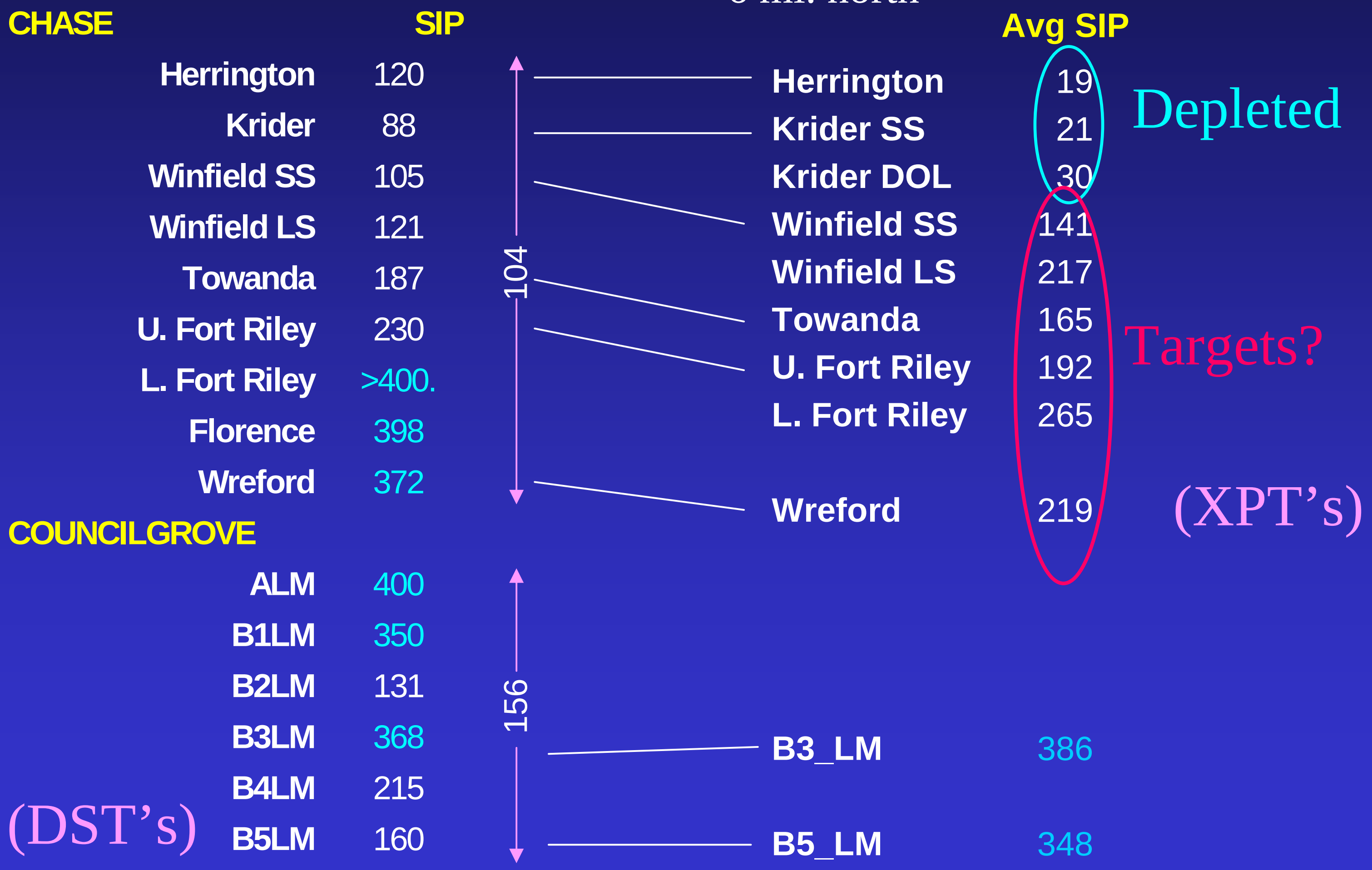
Pippin, 1985

Modified after Pippin (1985)



Gradual change in Sw suggests sloped FWL assuming uniform lithofacies and phi.

DIFFERENTIAL DEPLETION
illustrated by DST and XPT SIP by zones



Foam drilled well (1994)

CHASE

	SIP
Herrington	120
Krider	88
Winfield SS	105
Winfield LS	121
Towanda	187
U. Fort Riley	230
L. Fort Riley	>400.
Florence	398
Wreford	372

COUNCILGROVE

ALM	400
B1LM	350
B2LM	131
B3LM	368
B4LM	215
B5LM	160

(DST's)

New Well (2005)

6 mi. north

	Avg SIP
Herrington	19
Krider SS	21
Krider DOL	30
Winfield SS	141
Winfield LS	217
Towanda	165
U. Fort Riley	192
L. Fort Riley	265
Wreford	219
B3_LM	386
B5_LM	348

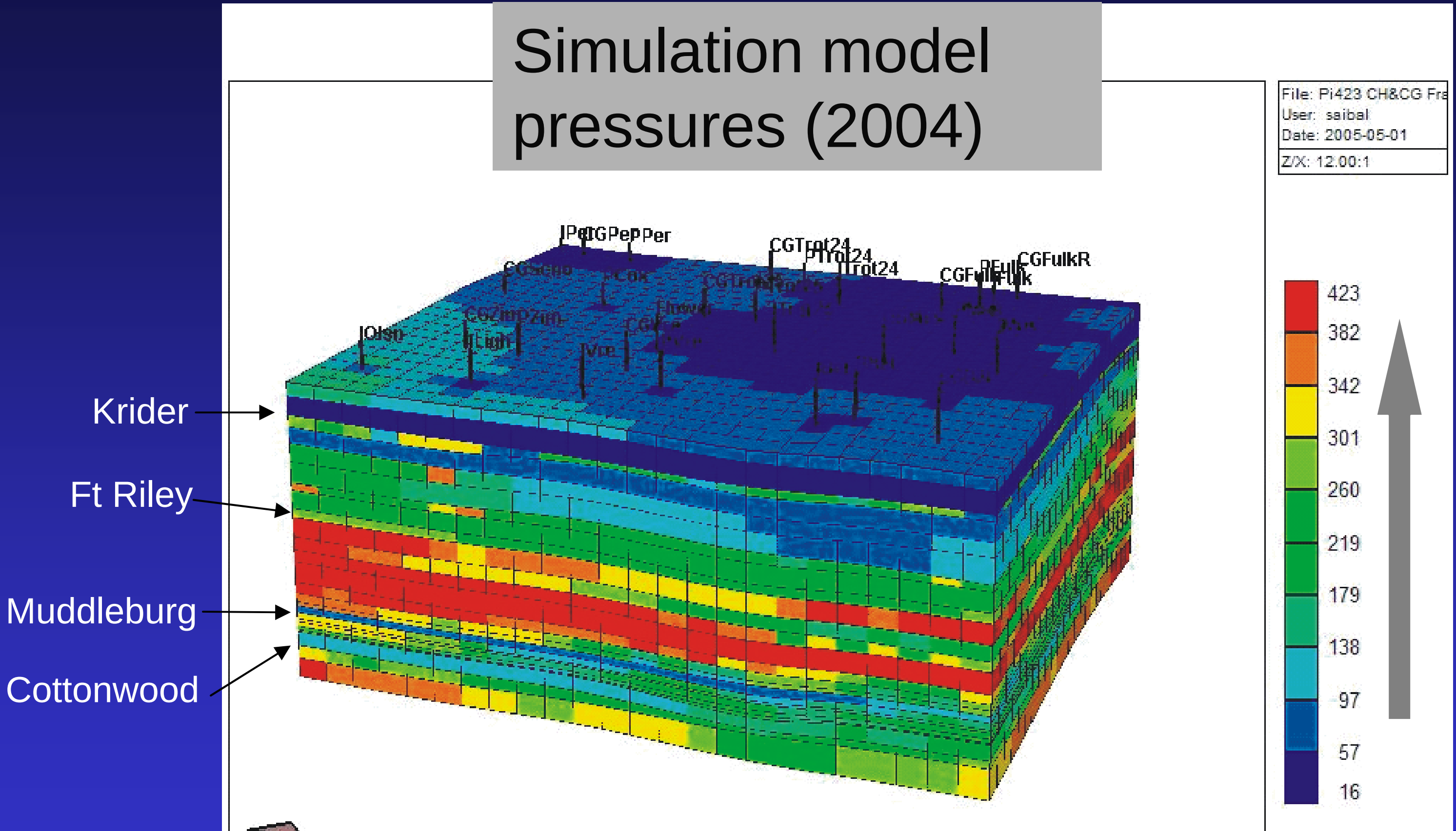
Depleted

Targets?

(XPT's)

**Not new. See Ryan etal, 1994.*

Simulation work matches zone pressures and illustrates differential depletion in a layered reservoir



Simulation model pressures (2004)

Variable zone pressures in 28 well simulation model

Ultimately:

Obtain model match (validate static model) → Correlate pressure to properties (facies, phi, k) and stratigraphy → Project pressures throughout field scale static model → Define "targets"

Challenges

Goal: Develop field model that has sufficient detail to represent fine-scale vertical and lateral heterogeneity in lithofacies, porosity, permeability and water saturation

Data Volume: 13,000 wells, 2000 LAS files, vast petrophysical data set	Automate
Lithofacies is critical at “node” wells	Neural network and automate
Direct measurements of Sw by logs is problematic	Property-based Sw
Free water level varies and not documented	Estimate; automate
Model size is immense (10,000 mi^2, 108 million cells)	Split stratigraphically; upscale

Today’s series of presentations

By KGS staff related to HAMP:

Automation and data processing	Bohling
Core petrophysics	Byrnes
Field geologic model	Dubois
Sandstone in Chase	Winters
Reservoir simulation	Bhattacharya
Pressures and reservoir communication	Dubois
Log Petrophysics	Doveton
Digital petroleum atlas	Carr

The conclusions and insights presented in above talks are preliminary and are based upon work that is still in progress. They are the opinions of the authors and not necessarily those of the industry partners.

Other related talks:

Dynamic field model	Sorensen
Oil Classification	Beserra
Gas saturations in invaded zones	Torres-Verdin

Acknowledgements

We thank our industry partners for their support of the Hugoton Asset Management Project and their permission to share the results of the study.

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