

# Geopressured Geothermal Resource and Recoverable Energy Estimate for the Wilcox and Frio Formations, Texas

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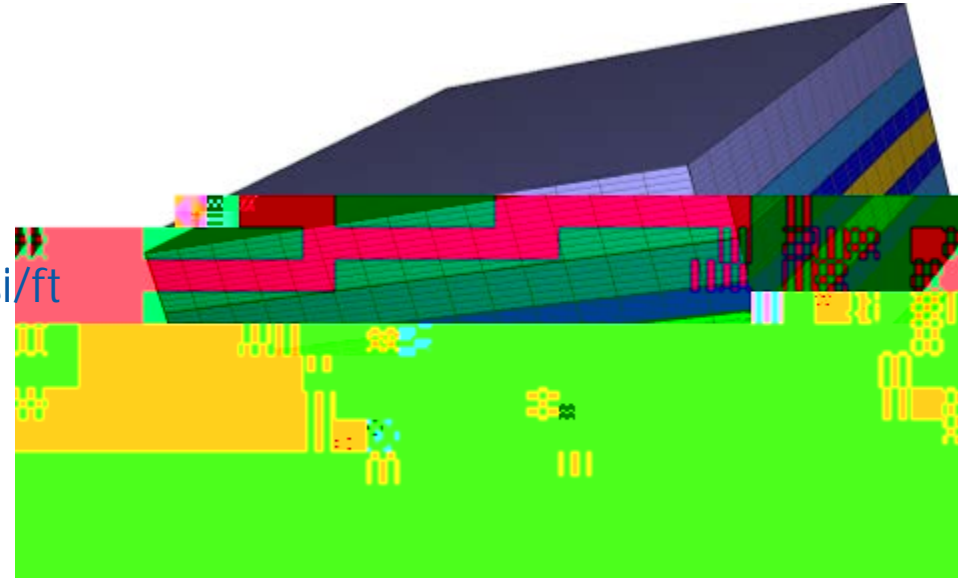
San Diego, California



## Geopressured Geothermal Resource Definition

### Geopressure Definition\*

- Greater than hydrostatic
  - Freshwater/Brackish – 0.433 psi/ft
  - Salt Water – 0.465 psi/ft
- Soft Geopressure
  - Hydrostatic to 0.7 psi/ft
- **Hard Geopressure**
  - **0.7 – 1.0 psi/ft (lithostatic pressure gradient)**

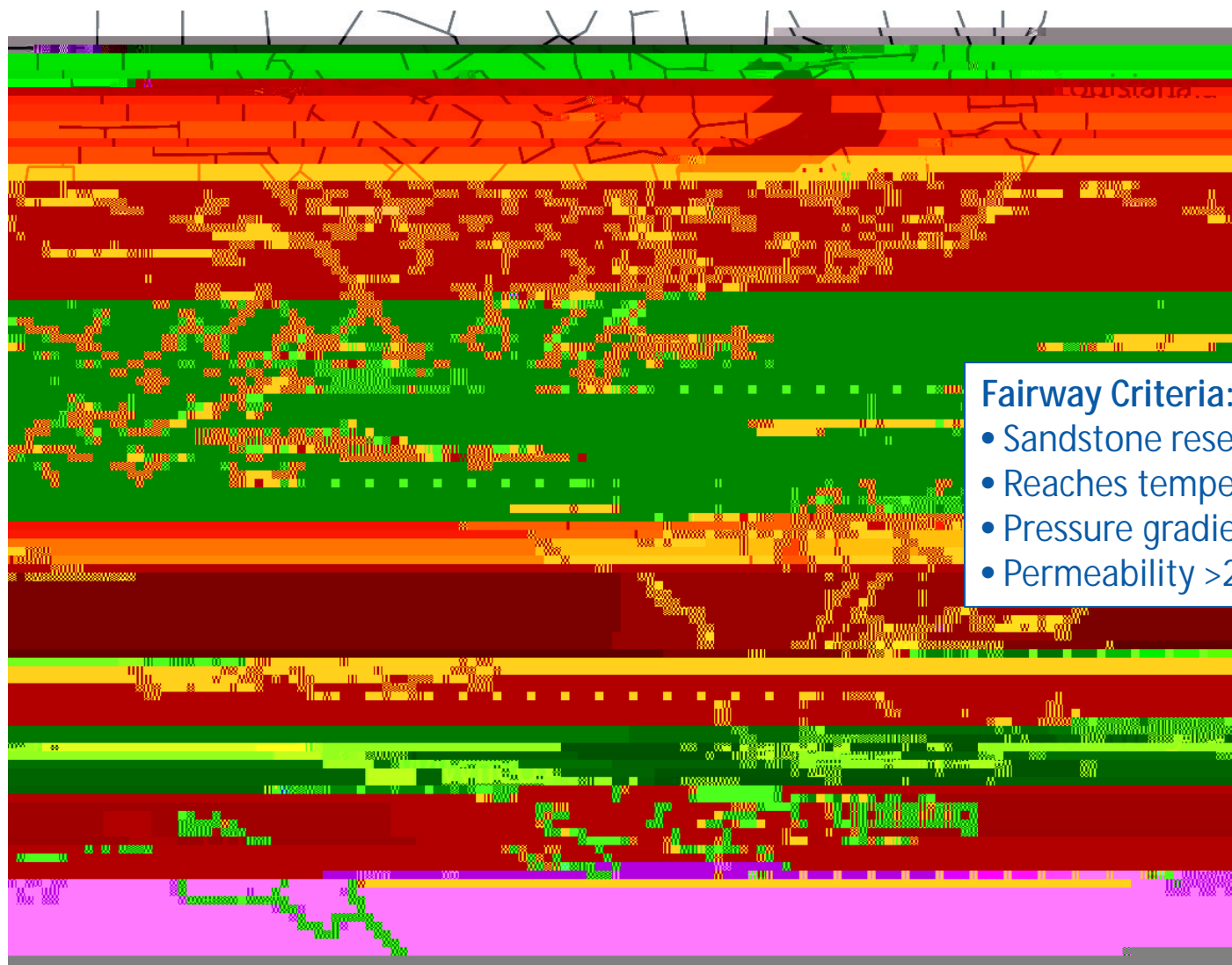


### Geothermal

- Temperature > 212°F (100°C)
- DOE Criteria for Design Wells drilled in 1979
  - Temperature > 275°F (135°C)

\* Loucks, R.G., D.L. Richmann, and K.L. Milliken. 1981. "Factors Controlling Reservoir Quality in Tertiary Sandstones and Their Significance to Geopressured Geothermal Production." Report of Investigations No. 111. The University of Texas at Austin, Bureau of Economic Geology.

## Texas Fairways



### Fairway Criteria:

- Sandstone reservoir volume  $> 3 \text{ mi}^3$
- Reaches temperature  $> 300^\circ\text{F}$
- Pressure gradient  $> 0.7 \text{ psi/ft}$
- Permeability  $> 20 \text{ mD}$

Source: Bebout et al.(1982, 1983)

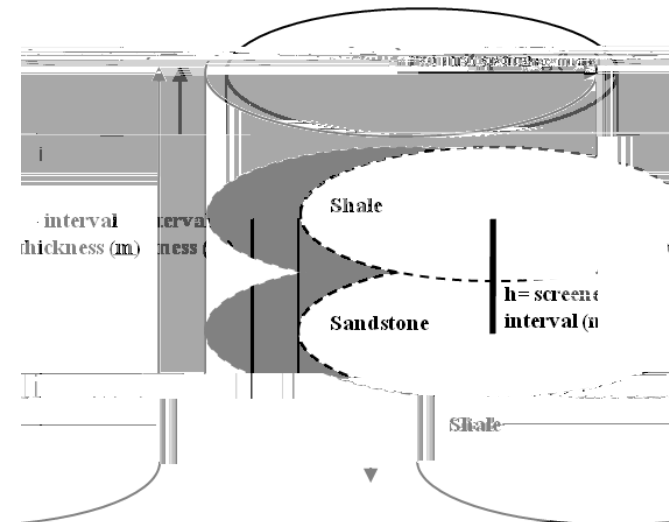
## Resource Estimate

### TOUGH2 Reservoir Simulator (LBNL & UC Berkeley)

- Multiphase flow in porous media
- Equation of state for water, salt, and gas:  $H_2O$ ,  $NaCl$ ,  $CH_4$
- Incorporates: capillary pressure, relative permeability, and pore compressibility

### Methodology

1. Develop conceptual reservoir model
2. Determine model structure
  - 2D radial axisymmetric grid
3. Add layer properties
  - Wilcox gas saturation = 5%
  - Frio gas saturation = 1%
4. Calibrate natural state of model
  - Run for 100 years without production
5. Simulate reservoir production
  - 20 years of production
  - Constant pressure constraint of 110% of hydrostatic at top of producing interval



2D Radial Axisymmetric Grid



# Geopressured Geothermal Resource Estimate: Frio and Wilcox Formations

Wilcox Fairways	Zapata	Duval	Live Oak	De Witt	Colorado	Harris
Depth to Top of GP-GT Resource(m) <sup>1</sup>	2,438	3,078	2,438	2,743	3,048	3,505
Depth to Bottom (m) <sup>1</sup>	3,657	4,023	3,810	3,658	4,267	4,704
Rounded Interval Thickness (m)	1,200	940	1,360	920	1,230	1,200
Sandstone Thickness (m) <sup>1</sup>	180	180	180	160	495	300
Shale Thickness (m) <sup>1</sup>	1,020	760	1,180	760	735	900
Depth to Top of Sandstone Reservoir I (m) <sup>1</sup>	2,926	3,353	2,804	3,197	3,341	3,810
Depth to Top of Sandstone Reservoir II (m) <sup>1</sup>	3,200	3,658	3,353	3,249	3,475	4,115
Porosity (%) <sup>1</sup>	19	14	15	18	14	15
Permeability Sandstone (mD) <sup>1,2</sup>	27	44	35	40	150	19
Pressure at Top (Pa) <sup>1</sup>	3.45E+07	4.89E+07	3.45E+07	2.69E+07		







# Geopressured Geothermal Resource Estimate: Frio and Wilcox Formations

Frio Fairways - Reservoir I	Hidalgo	Armstrong	Corpus Christi	Matagorda	Brazoria
	Largest Fault Spacing	Thickest Sandstone	Smallest Fault Spacing		
Depth to Top of GP-GT Resource (m) <sup>3</sup>	2,743	3,150	3,569	4,291	3,388
Depth to Bottom (m) <sup>4</sup>	3,854	4,913	4,468	4,808	4,692
Rounded Interval Thickness (m)	1,100	1,770	900	510	1,300
Sandstone Thickness (m) <sup>4</sup>	275	660	40	30	175
Shale Thickness (m) <sup>4</sup>	825	1,110	860	480	1,125
Depth to Top of Sandstone (m) <sup>4</sup>	3,368	4,050	4,229	4,571	4,313
Porosity (%) <sup>3</sup>	15	23	18	20	15
Pressure at Top (Pa) <sup>3</sup>	4.53E+07	4.99E+07	6.05E+07	6.79E+07	5.36E+07
Pressure at Bottom (Pa) <sup>3</sup>	5.71E+07	7.78E+07	7.07E+07	7.25E+07	7.43E+07
Temperature Range (°C) <sup>6</sup>	108–146	139–178	134–165	149–168	120–163
Fault Spacing (km) <sup>5</sup>	15.5	8.0	3.2	8.0	11.2
Area Represented (km <sup>2</sup> ) <sup>5</sup>	1,187	194	332	362	990





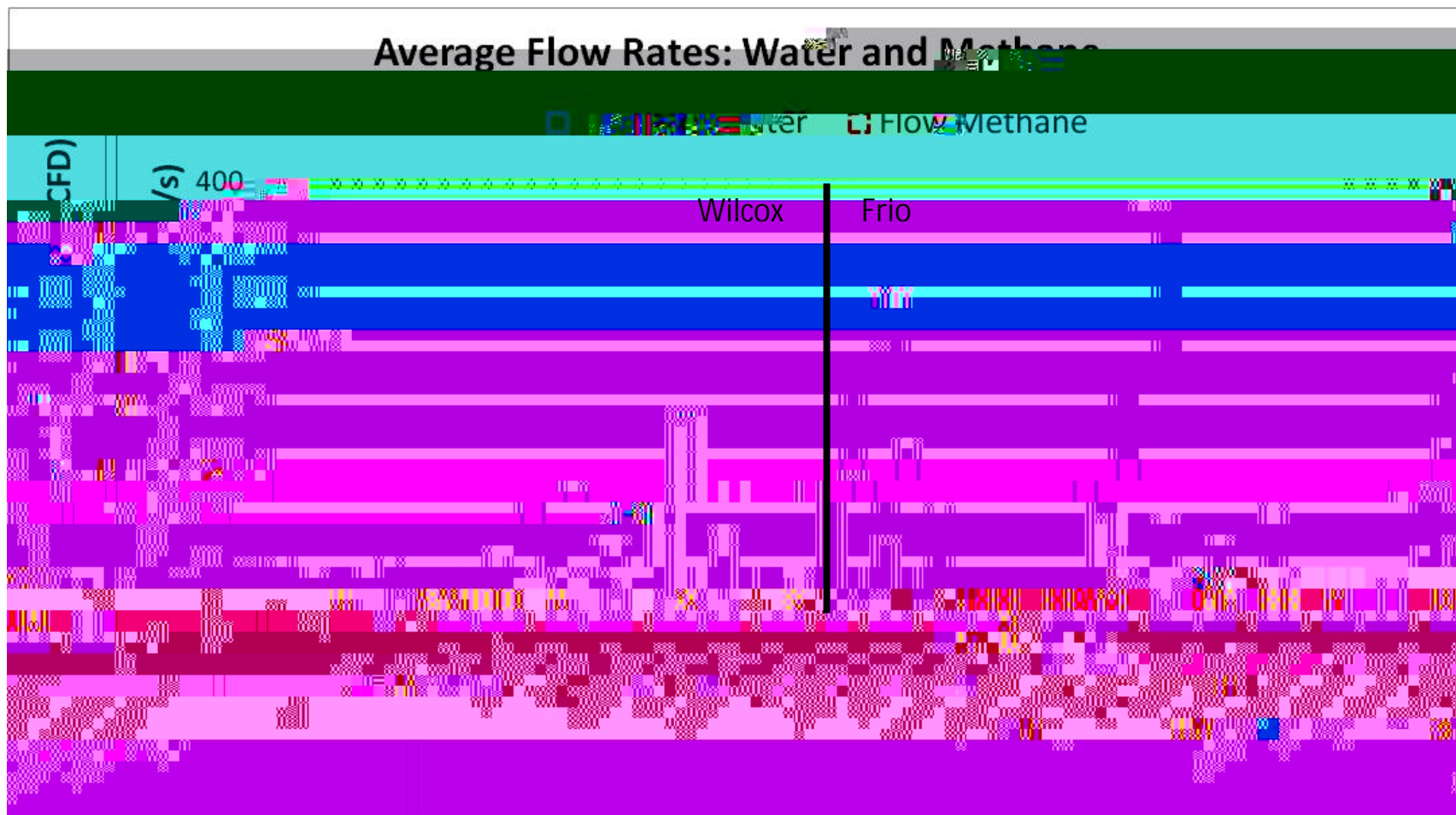




## Results: Frio Fairway Recoverable Energy

Frio Fairway	Reservoir Type	Average Water Flow Rate (kg/s)	Average Methane Flow Rate 1-1(1)(75 201)10 )1(W 1.6323	

## Results: Frio and Wilcox Reservoirs - Average Flow Rates









# Geopressured Geothermal Resource Estimate: Frio and Wilcox Formations

