

**GEOHERMAL ENERGY UTILIZATION  
ASSOCIATED WITH OIL & GAS DEVELOPMENT**

June 17-18, 2008

**Southern Methodist University  
Dallas, Texas**

**The Capitan Aquifer -  
Ellenburger Production  
Wells – Geothermal  
Engine Source?**



El Capitan Mountain

Prentice Creel, PE

NEW MEXICO

Matador

Verde

Stic

Tatum

est

Morrow

Northwest Shelf

Eddy Co.

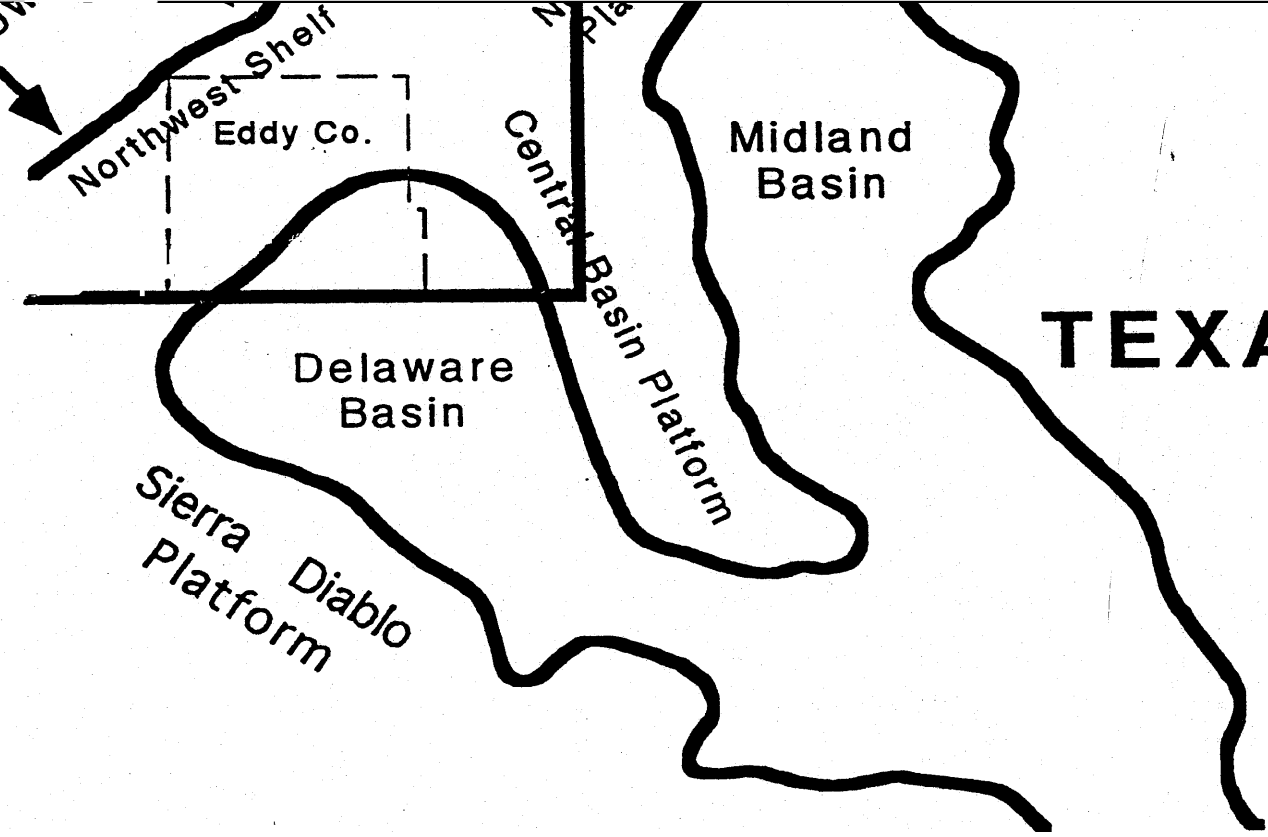
Central Basin Platform

Midland Basin

Delaware Basin

Sierra Diablo Platform

TEXAS



# Looking for a massive water source

- ∅ **Possibility of continuation without pressure depletion**
- ∅ **Fairly low in solids and corrosion aspects**
- ∅ **Hydraulically capable of penetrating heat source and perpetuating a continued flow**

# Fracture Directions



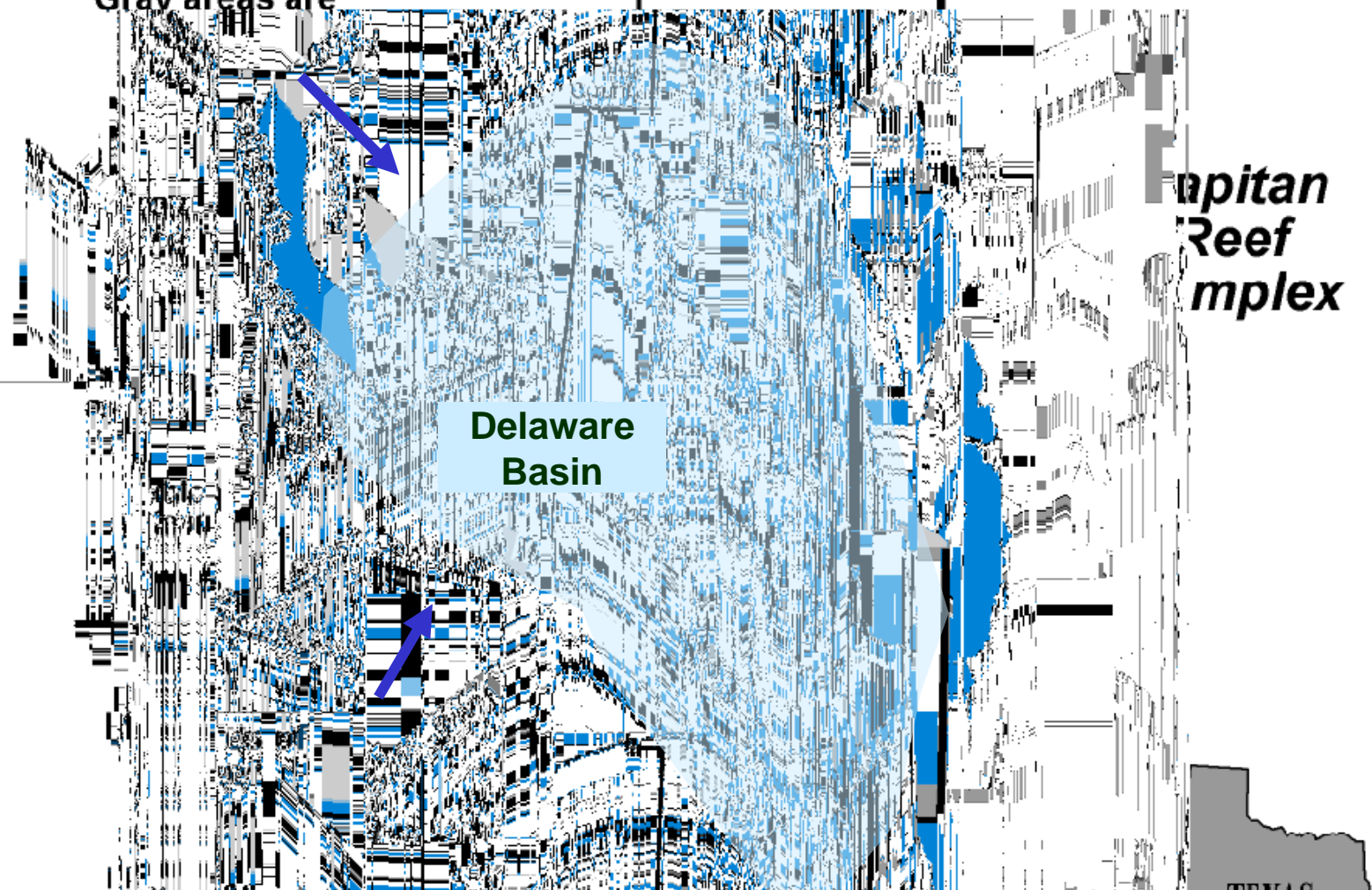
**G<sub>max</sub> DIRECTION (direction of induced hydraulic fracture)**

# Temperature Gradients

# Capitan Reef

- ∅ **Located in west Texas and southeast New Mexico**
- ∅ **Occurs in the Capitan Reef Complex**
  - ∅ Ancient reef which formed around the margins of the Delaware Basin in the Permian Period (~250 million years ago)
    - ∅ algae, sponges, and tiny colonial animals called bryozoans
  - ∅ Excellent exposure of the reef in Guadalupe Mountains National Park

Gray areas are



**Captain  
Reef  
Complex**

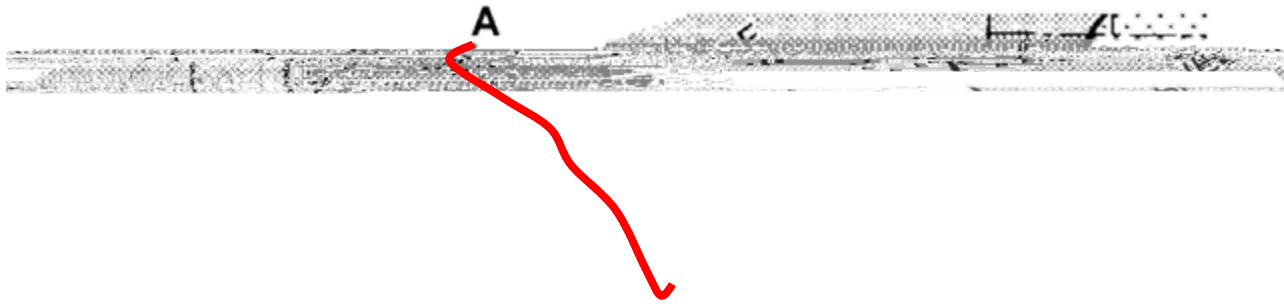
**Delaware  
Basin**

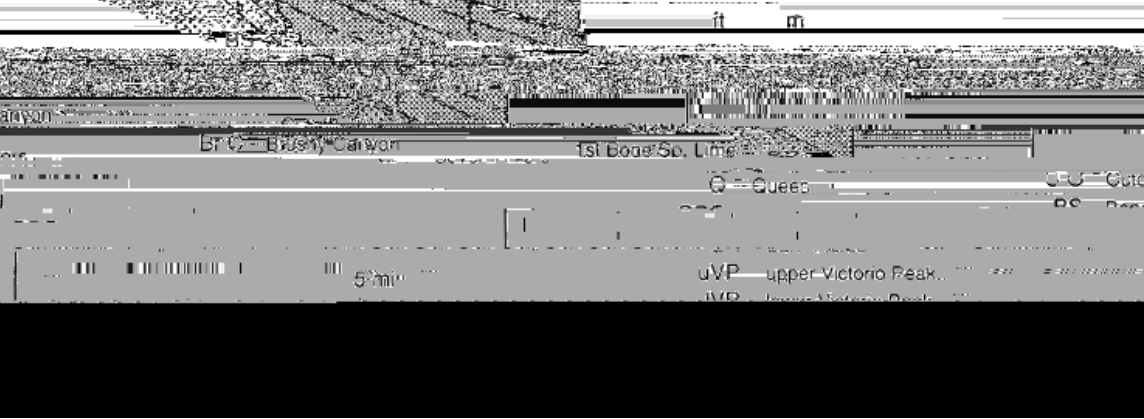
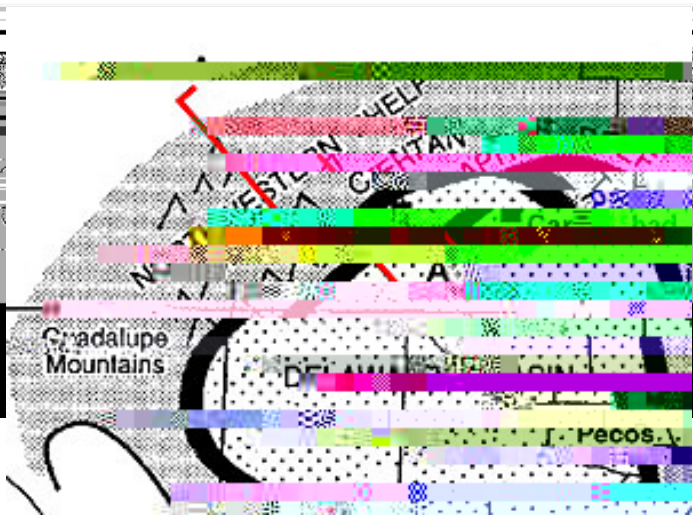
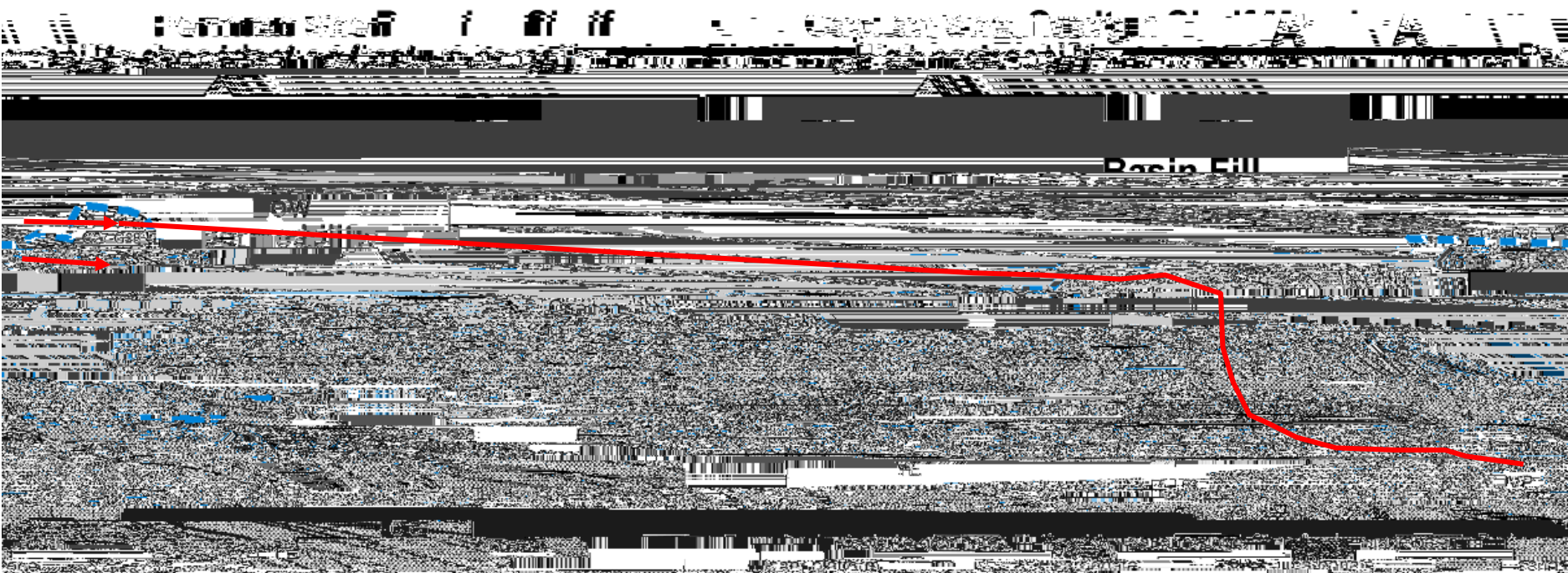


# Geologic History of the Reef

- ∅ **In Permian Period (280 to 225 m.y.a.) New Mexico and Texas were on the coast of a large super-continent**
- ∅ **A shallow inland sea, called the Delaware Basin formed off of the main coast**







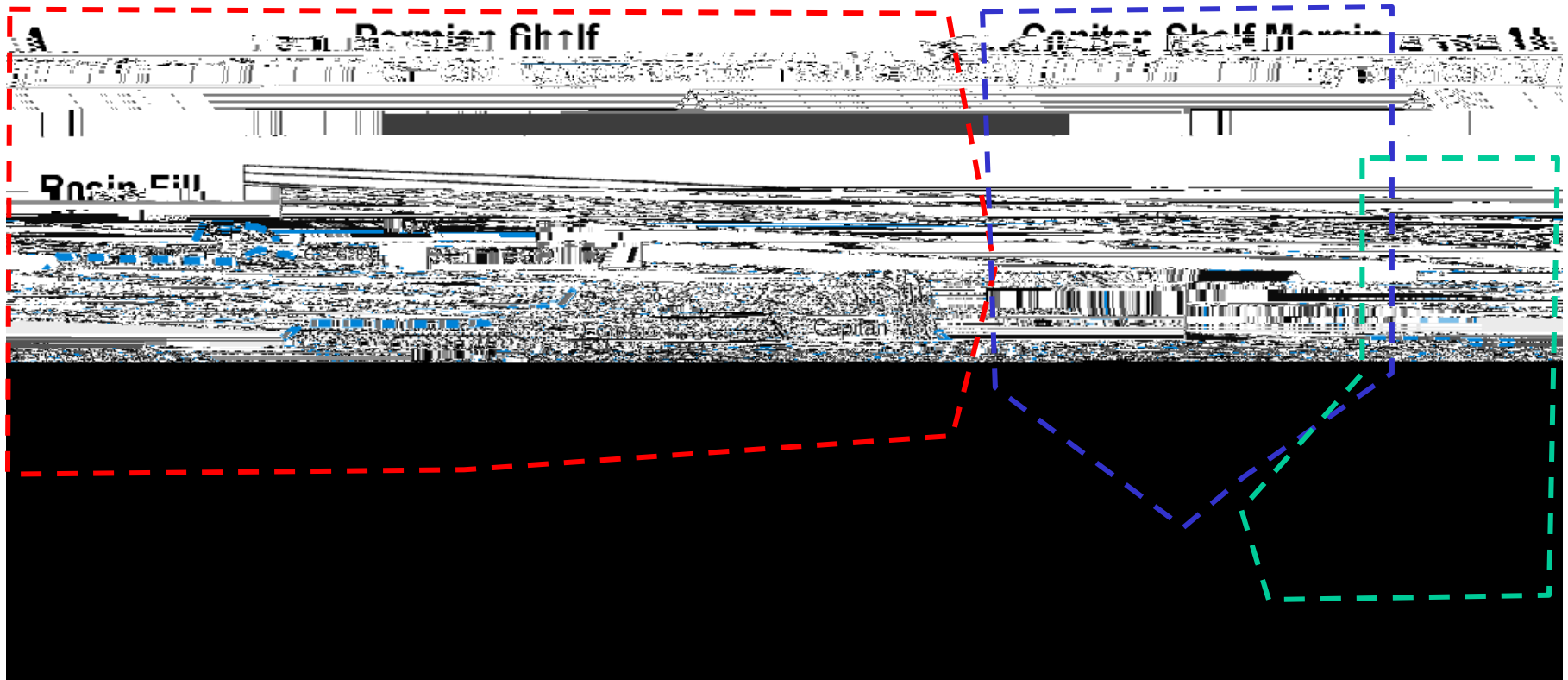


# Hydrogeology of the Capitan

- ∅ **The geologic strata associated with the Capitan aquifer can be divided into three**

The Permian Shelf facies consist of lower permeability carbonate sediments and evaporites (gypsum and rock salt). Permeability is dependant upon fracture porosity, and well yields and water quality are highly variable.

The Capitan Shelf Margin facies



# Groundwater Flow Patterns

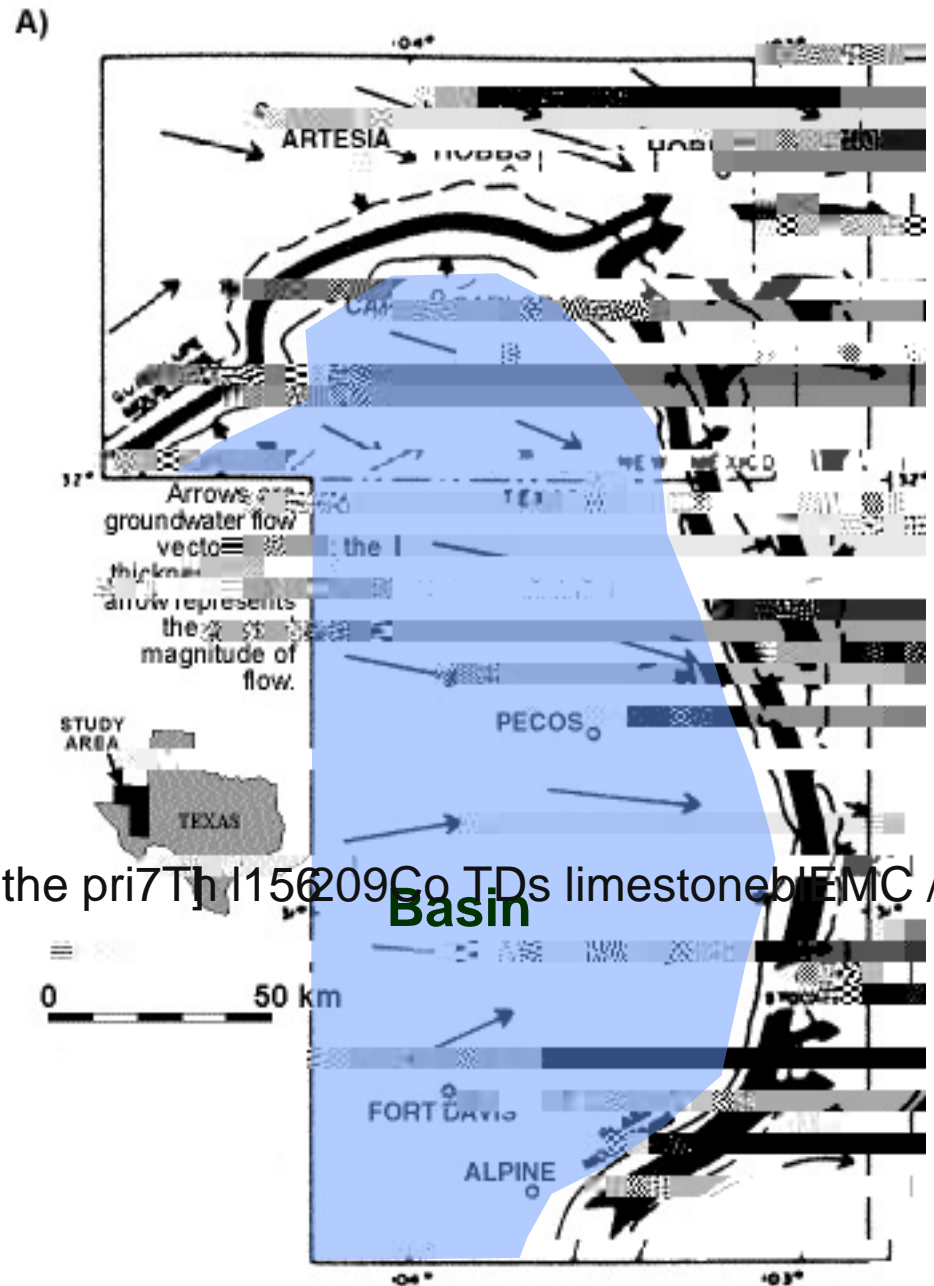
- ∅ **Groundwater flow in the shelf facies and basin fill is generally towards the east**
- ∅ **The high permeability of the Capitan aquifer results in concentrated flow along the trend of the reef, generally towards the north and northeast**

∅ When the aquifer first formed, the regional flow was to the east and southeast (small arrows)

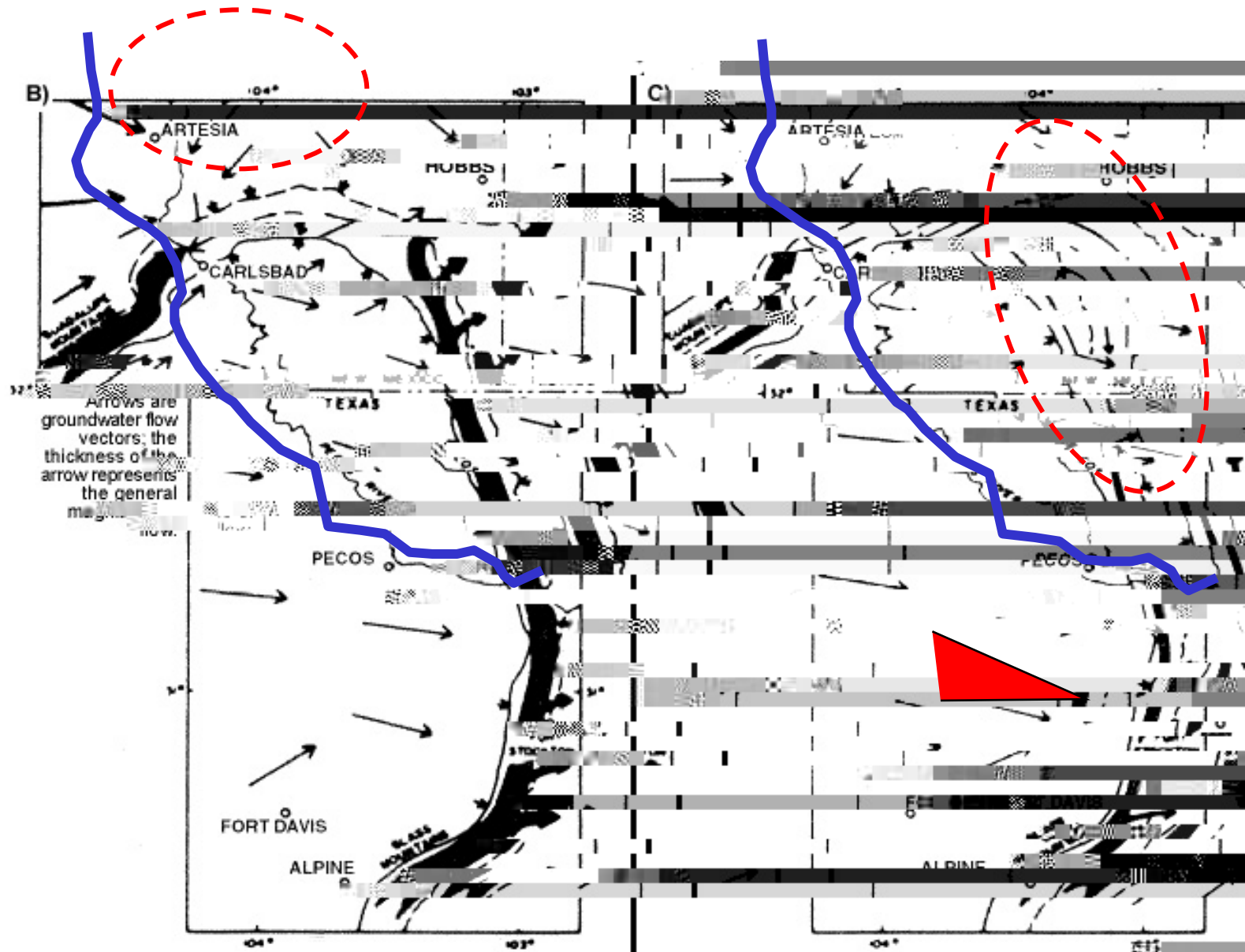
∅ Flow was concentrated along the trend of the reef, and the primary discharge point was somewhere around the town of Hobbs, NM (large arrows)

∅ Exited the Permian rocks and entered the Cretaceous San Andres limestone

∅ Continued on towards the Pecos and the Permian Co. TDs limestone



# Concentrated flow along the trend of the reef, generally towards the north and northeast





# Water Quality

- ∅ **Water in the Capitan is generally poor quality**
  - ∅ Average TDS of 17 samples was 3,059 mg/L; average chloride concentration was 881 mg/L
- ∅ **Water is potable in a few areas**
  - ∅ Mostly near Carlsbad and in some spots in the Glass Mts.
- ∅ **Not enough historical data to identify trends**
- ∅ **Bad – but not that Bad**

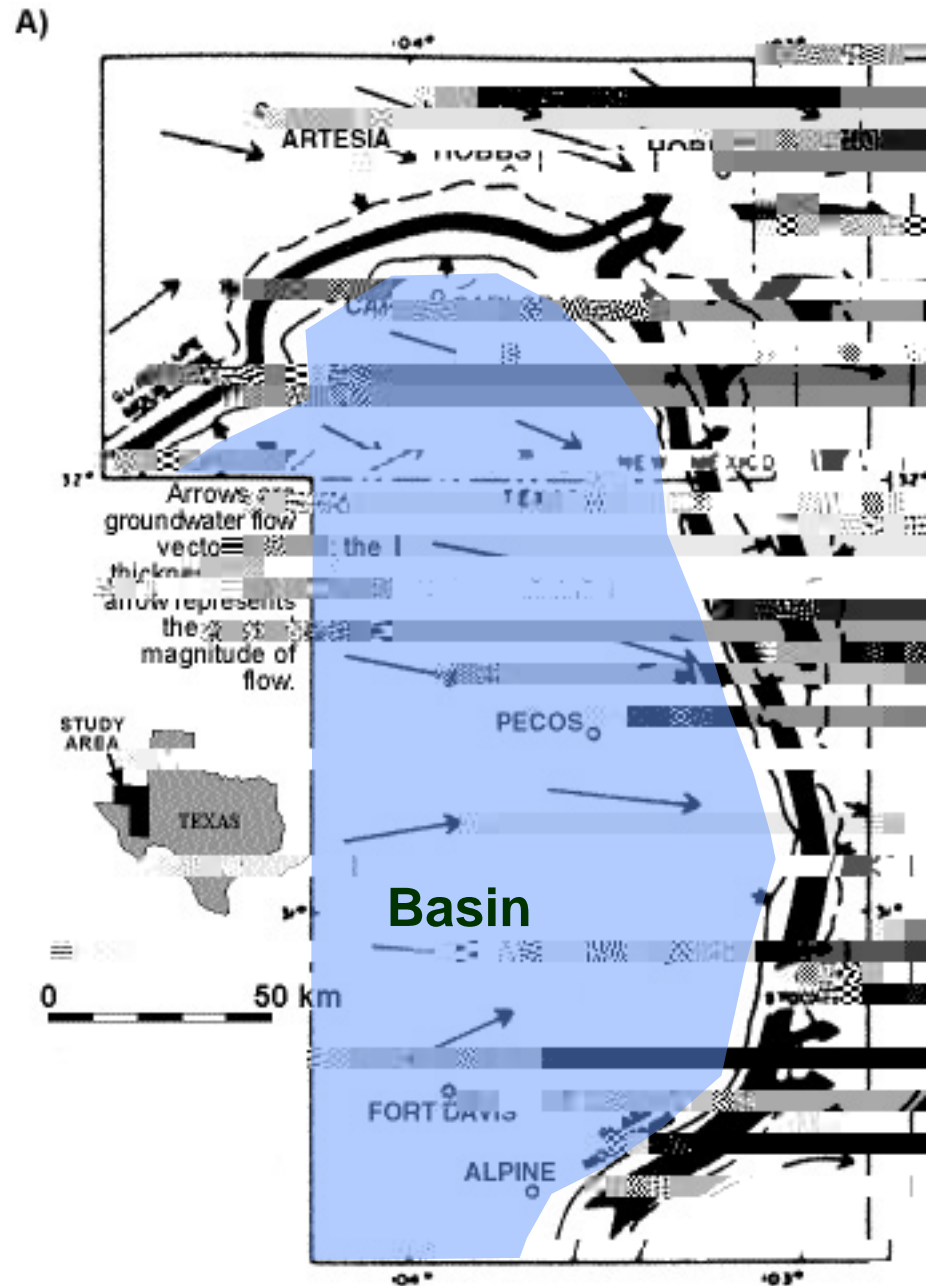
# Capitan Reef

- ∅ **Regionally, groundwater flow is to the east; in the Capitan it was towards the north**
  - ∅ Incision of the Pecos River and development of oil/water interrupted the flow system
- ∅ **Water quality is generally poor**
  - ∅ Good enough for agriculture in most places
  - ∅ Potable water exists near Carlsbad

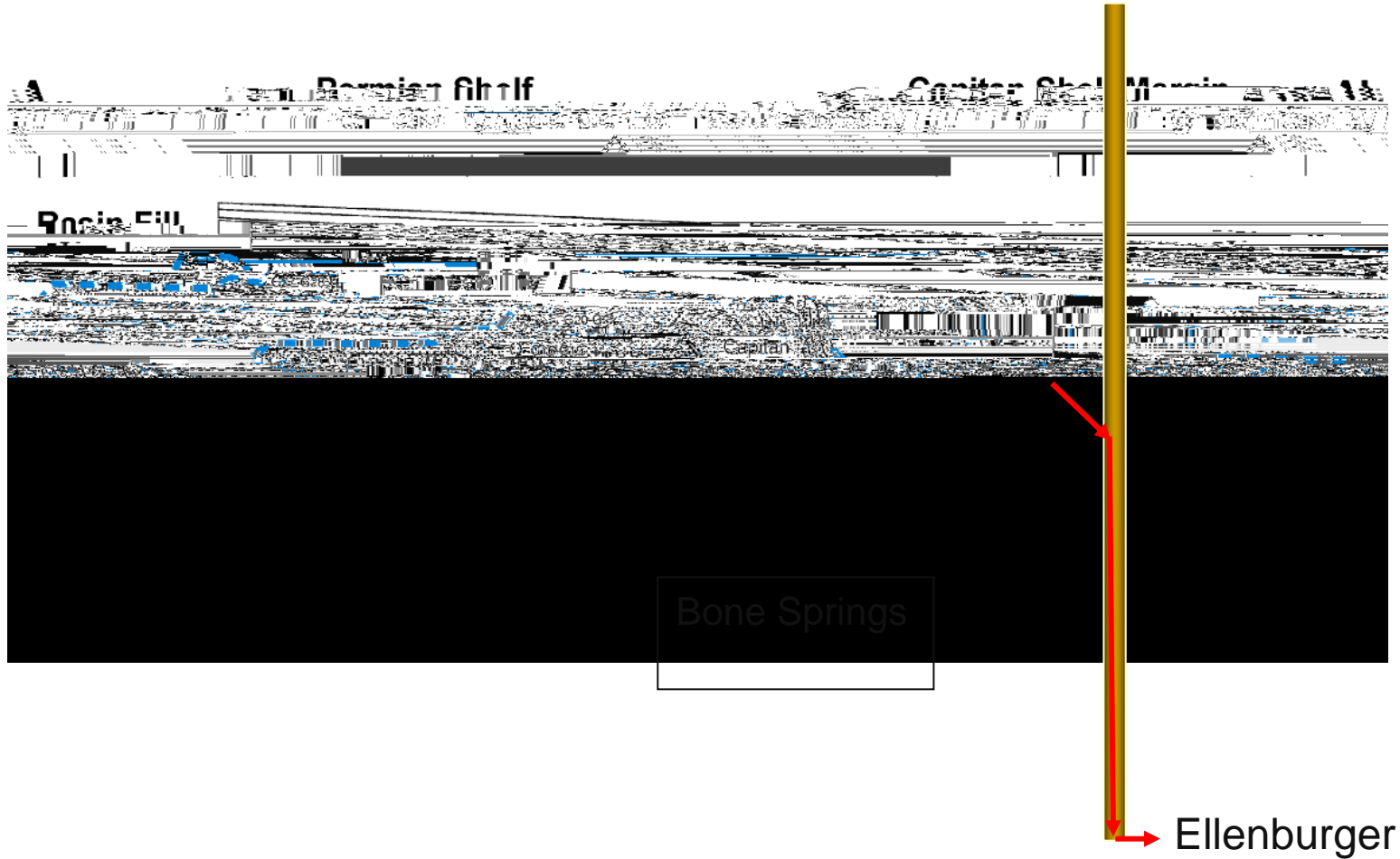
# How to Build a Geothermal Engine

- ∅ Find a dynamic water that is a replenishable Resource
- ∅ Find a temperature Conduction Source
- ∅ Develop these two separate Resources into a Geothermal Engine
  - ∅ Fracture capabilities and engineering
  - ∅ Regulatory acceptance
  - ∅ Environmental acceptance

Where does the interconnection take place – Capitan Reef down to the Ellenburger or other Heat Sources



# Connecting the Formations





# Conversion to Heat Sources from Hydrocarbon Production – Feasible?

Multi-well developments from existing Gas Producers



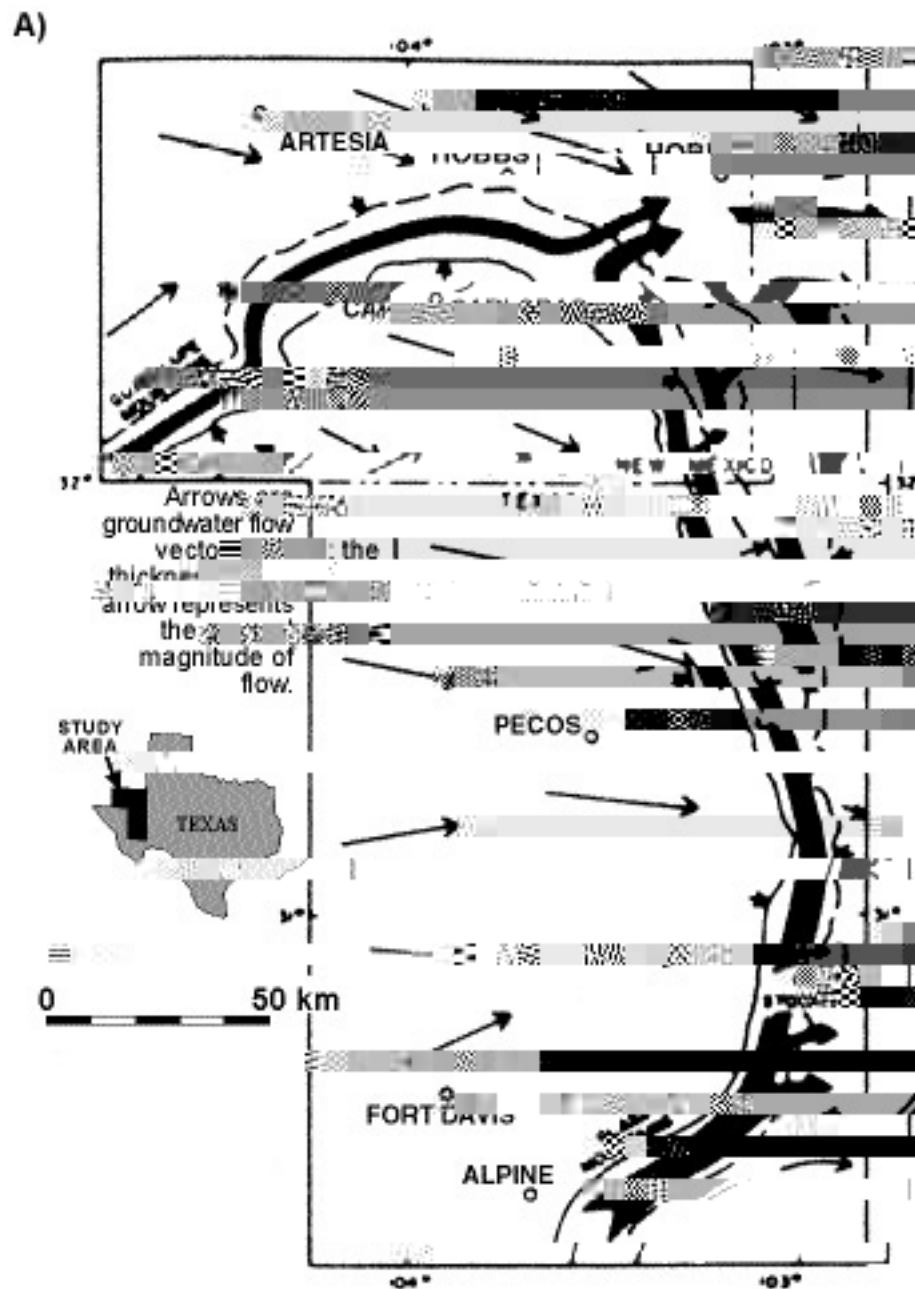
Fractured Inter-well System is natural and can be developed extensively by hydraulic stimulation technology

Temp > 250 F

**Capitan Reef water production and losses**

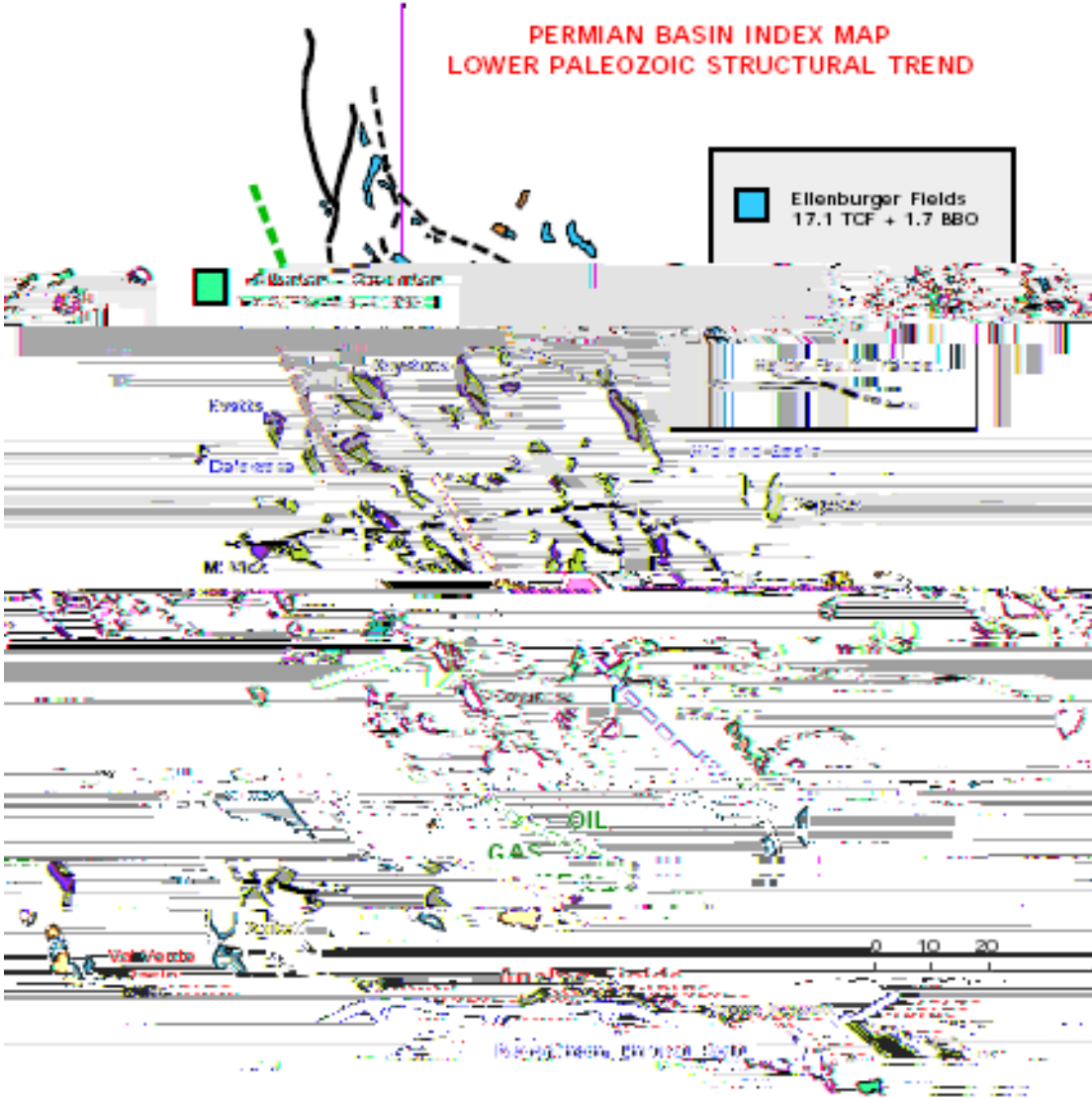
**8.5 ppg load will flow to surface**

**10.0 ppg load will have a loss into the Reef on a vacuum**

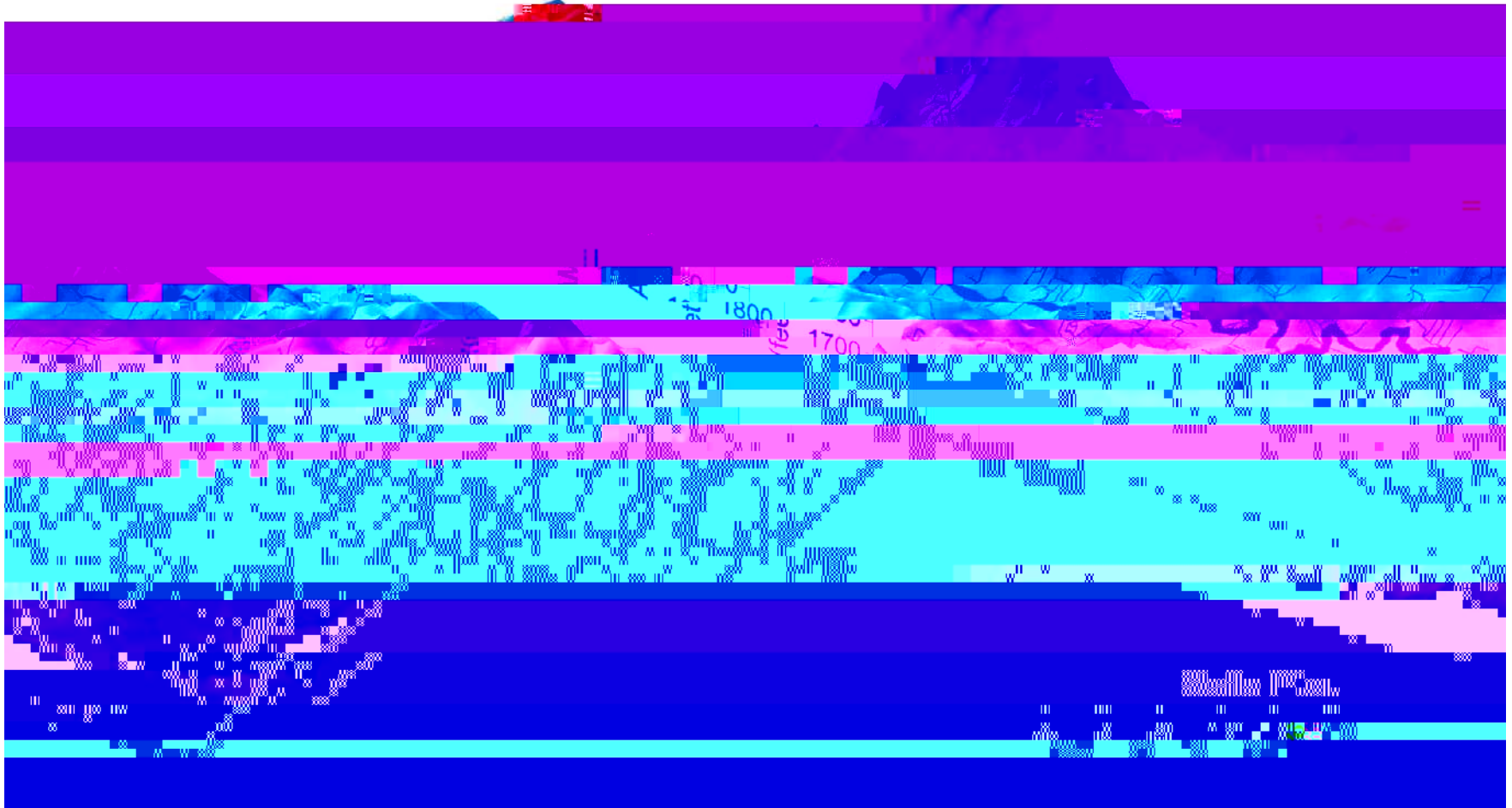




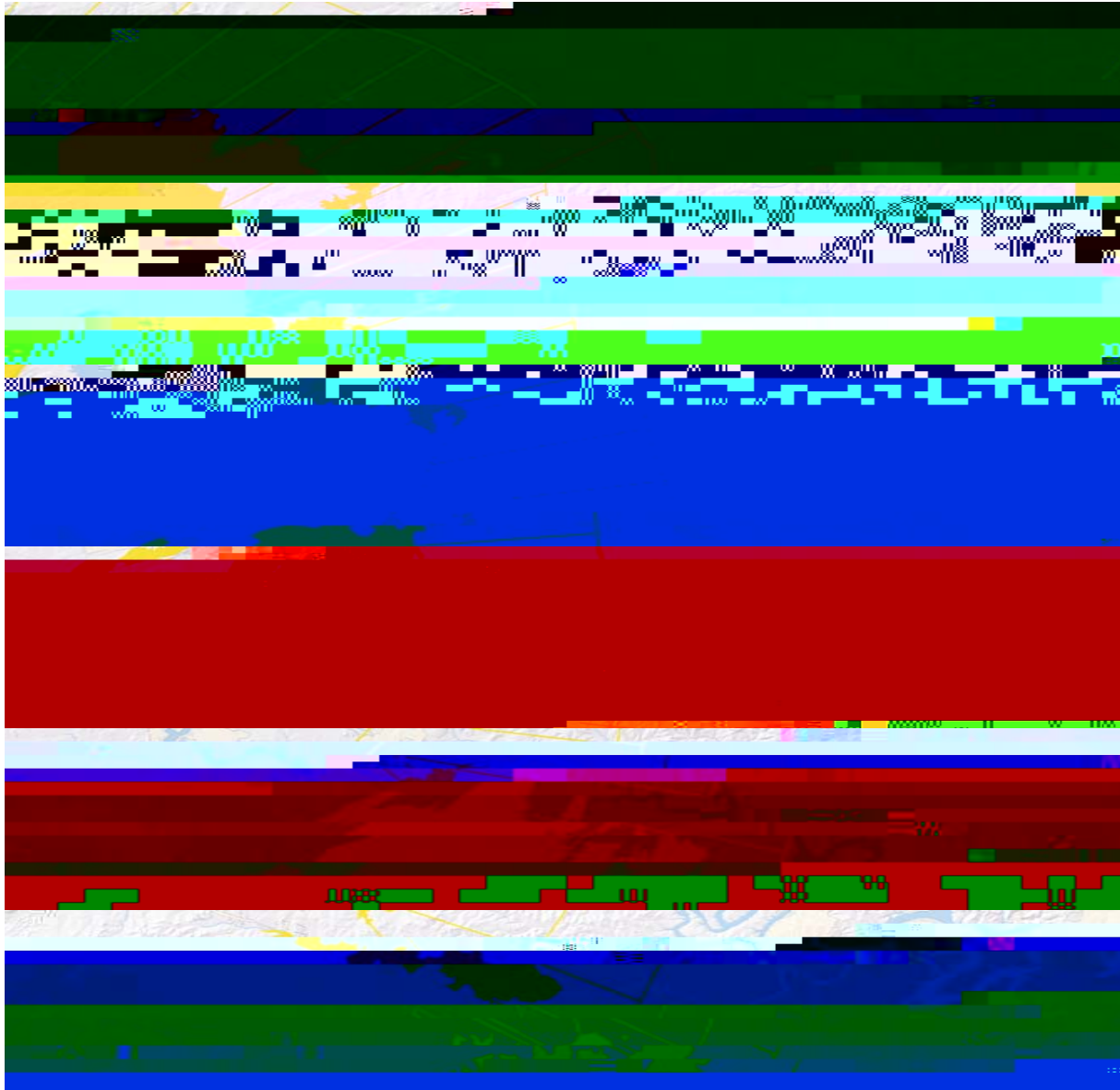
Permian Basin Index map showing 3-D study area and analog fields.



# Groundwater Availability Model for the Ellenburger Aquifer in Southeast Gillespie County, Texas



# ELLENBURGER AQUIFER Central Texas GCD



# Production Enhancement - Biggest CO<sub>2</sub> Frac

