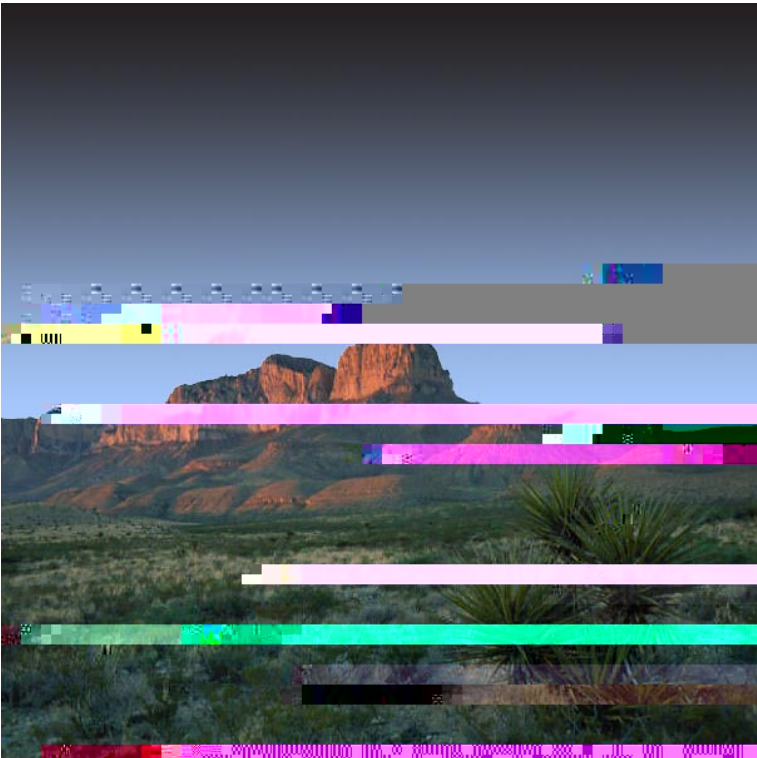


**GEOHERMAL ENERGY UTILIZATION
ASSOCIATED WITH OIL & GAS DEVELOPMENT**

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

Colorado

Permian
Morrow
Shelf
Tatum
Platform

Morrow
↓

Northwest Shelf
Eddy Co.

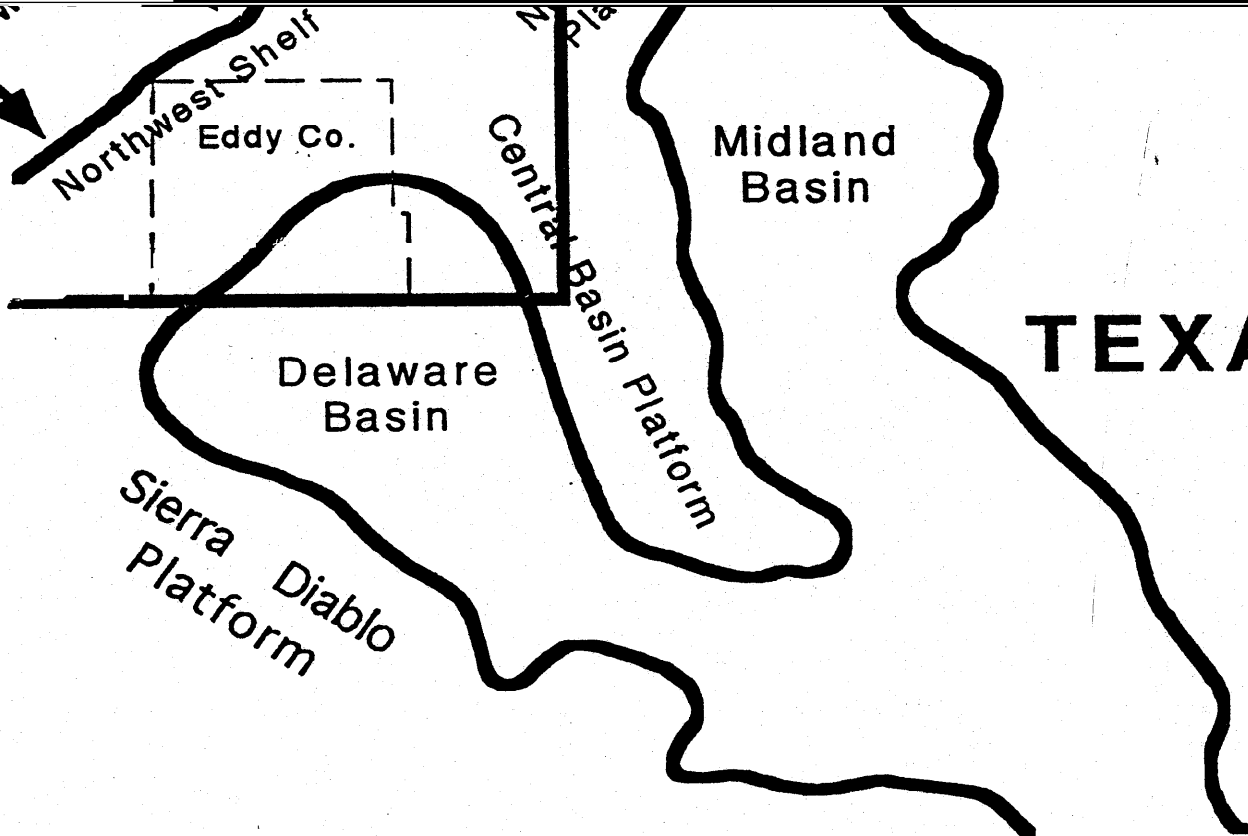
Central Basin Platform

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



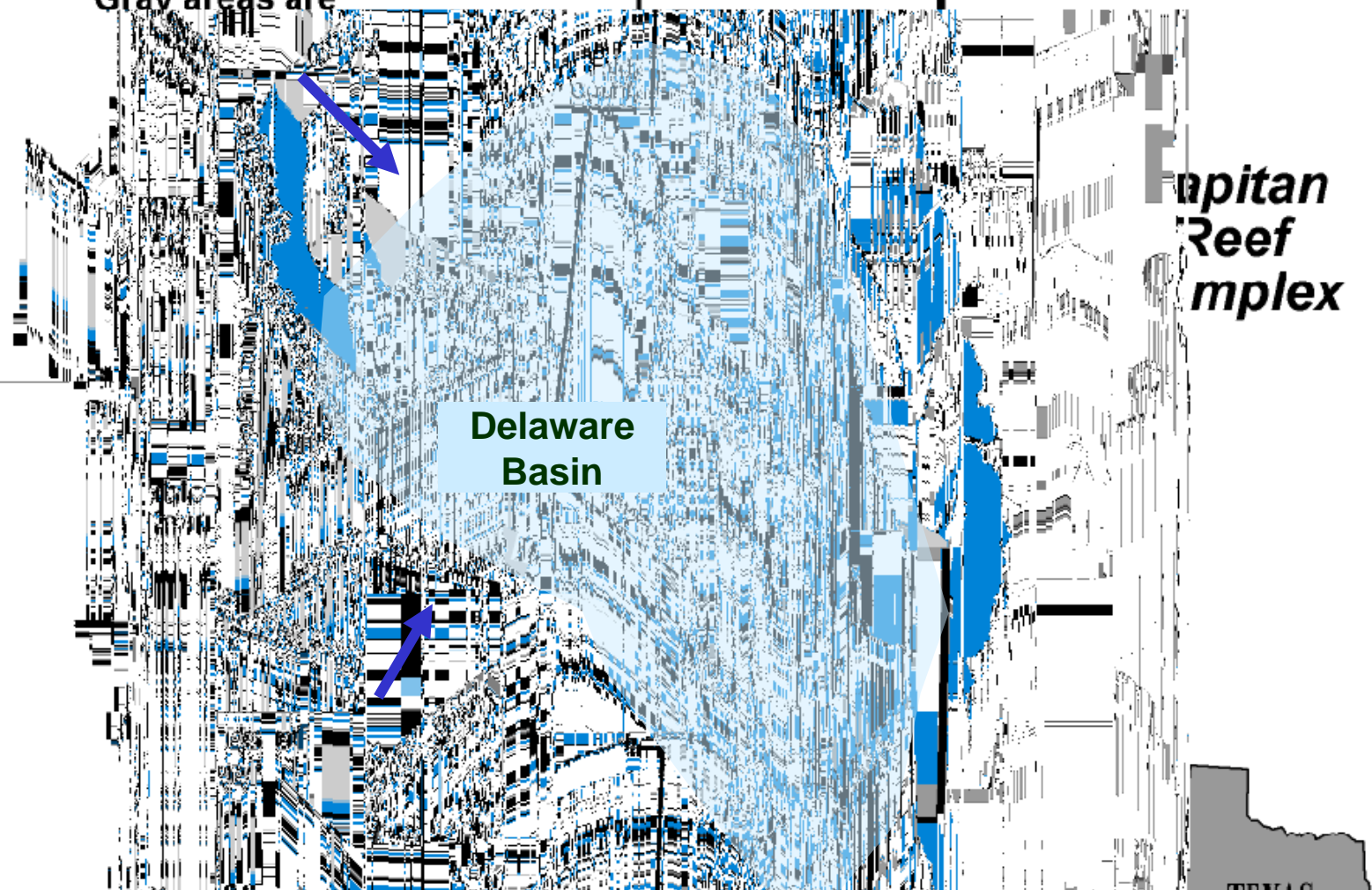
G. DIRECTION (direction of induced hydraulic fracture)

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



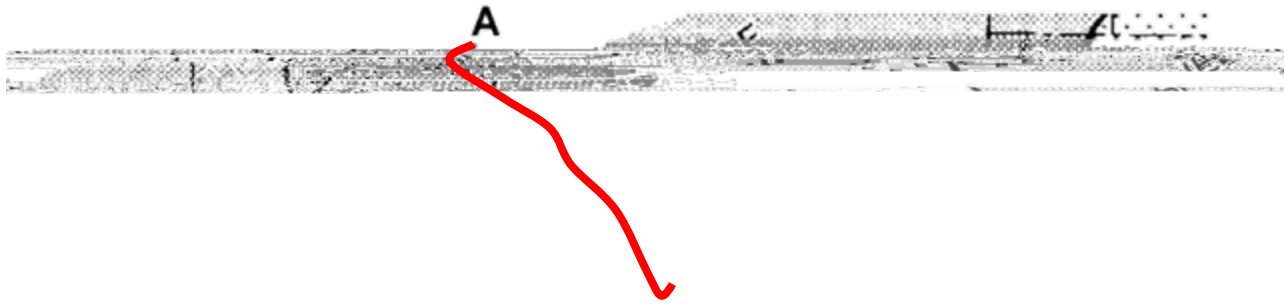
**Captain
Reef
Complex**

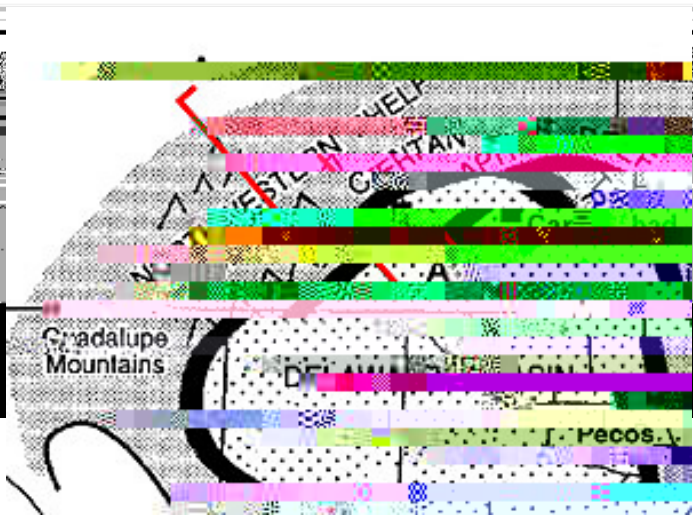
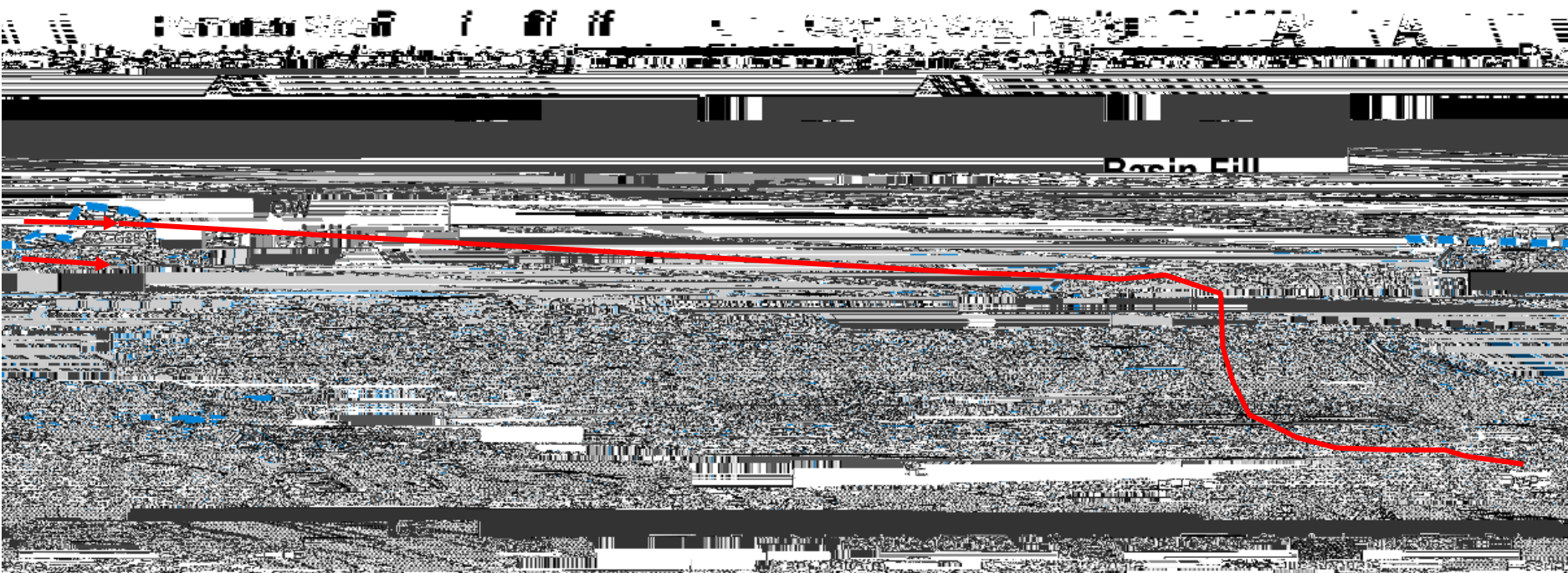
**Delaware
Basin**



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**





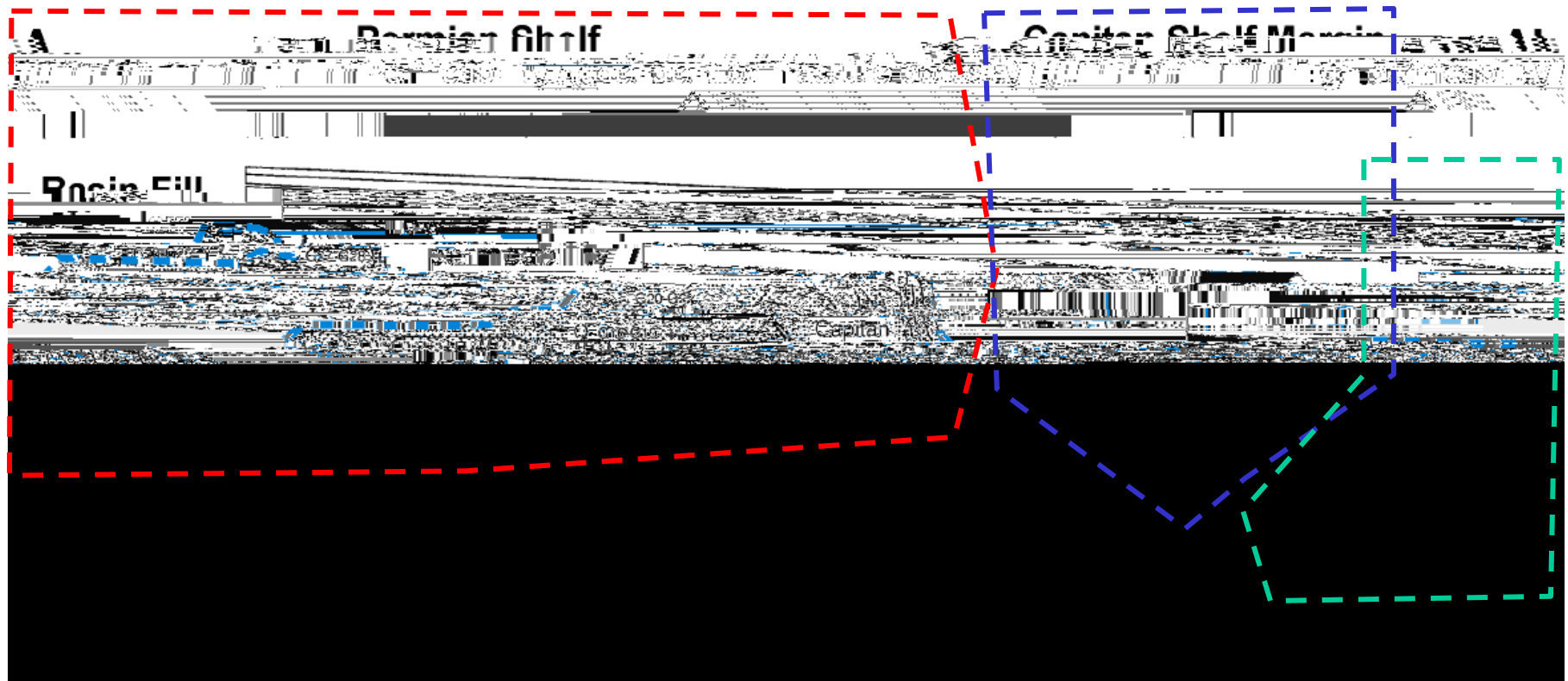


Hydrogeology of the Capitan

- ∅ **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.

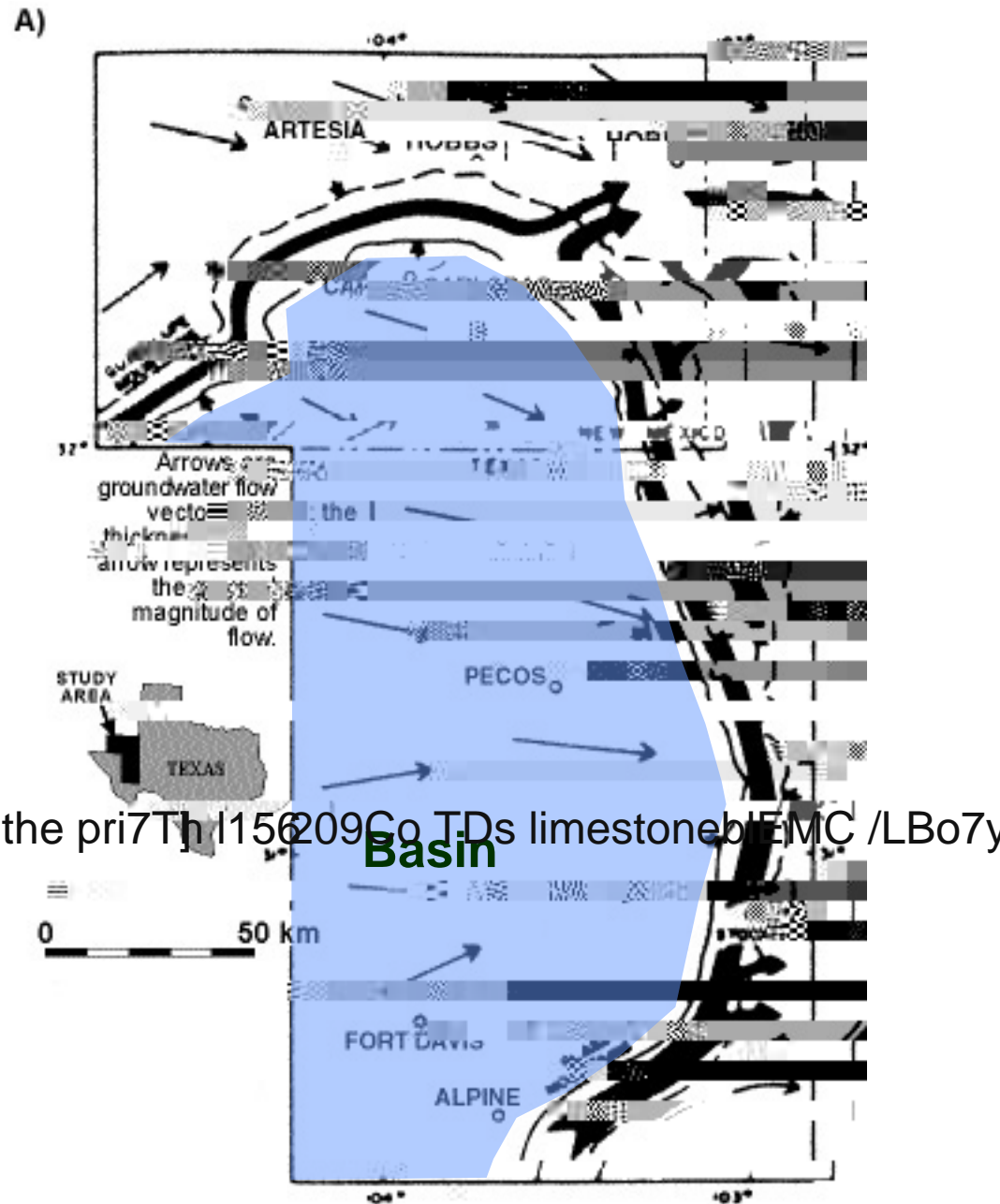
The Capitan Shelf Margin facies



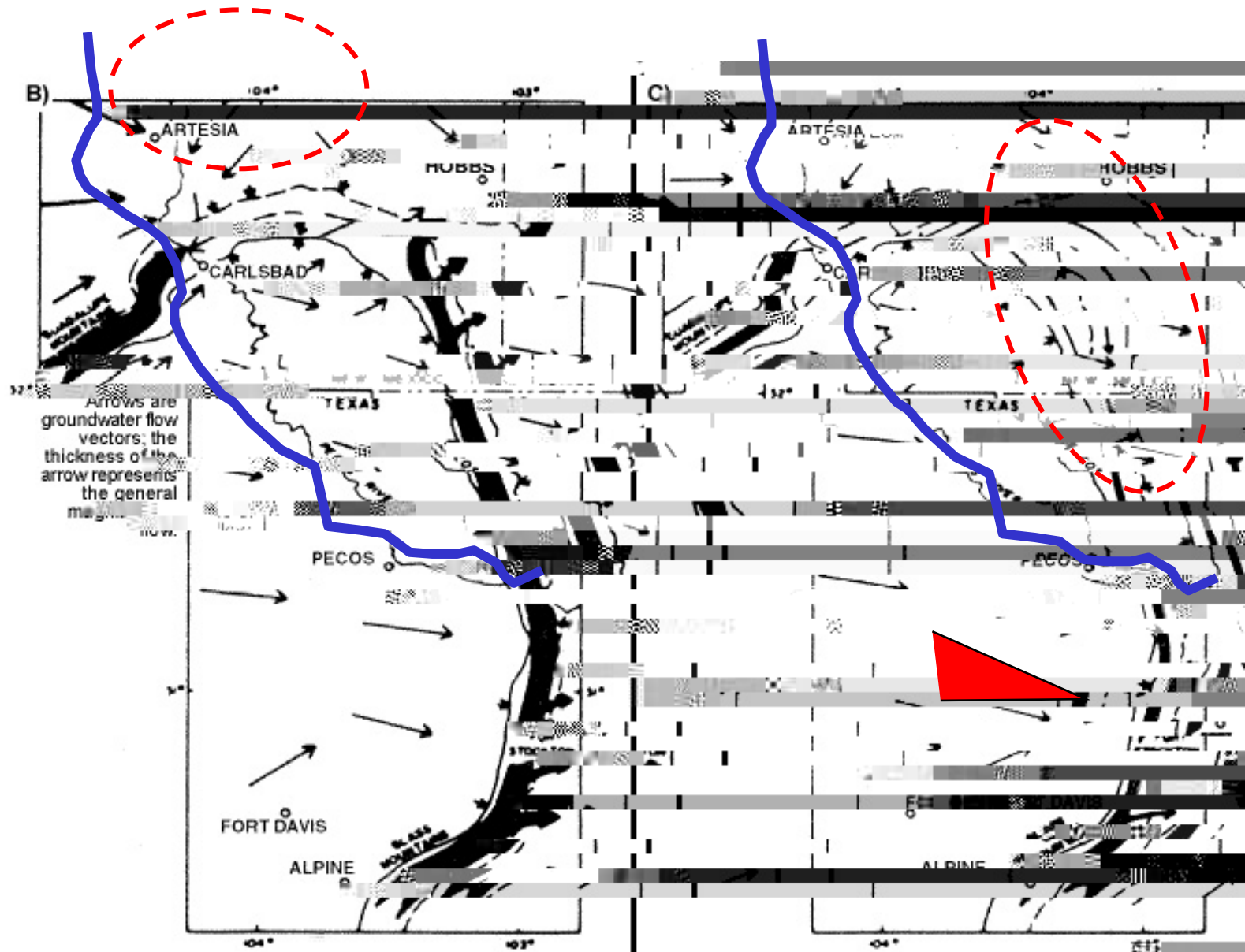
Groundwater Flow Patterns

- ∅ **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 Fort Davis 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**

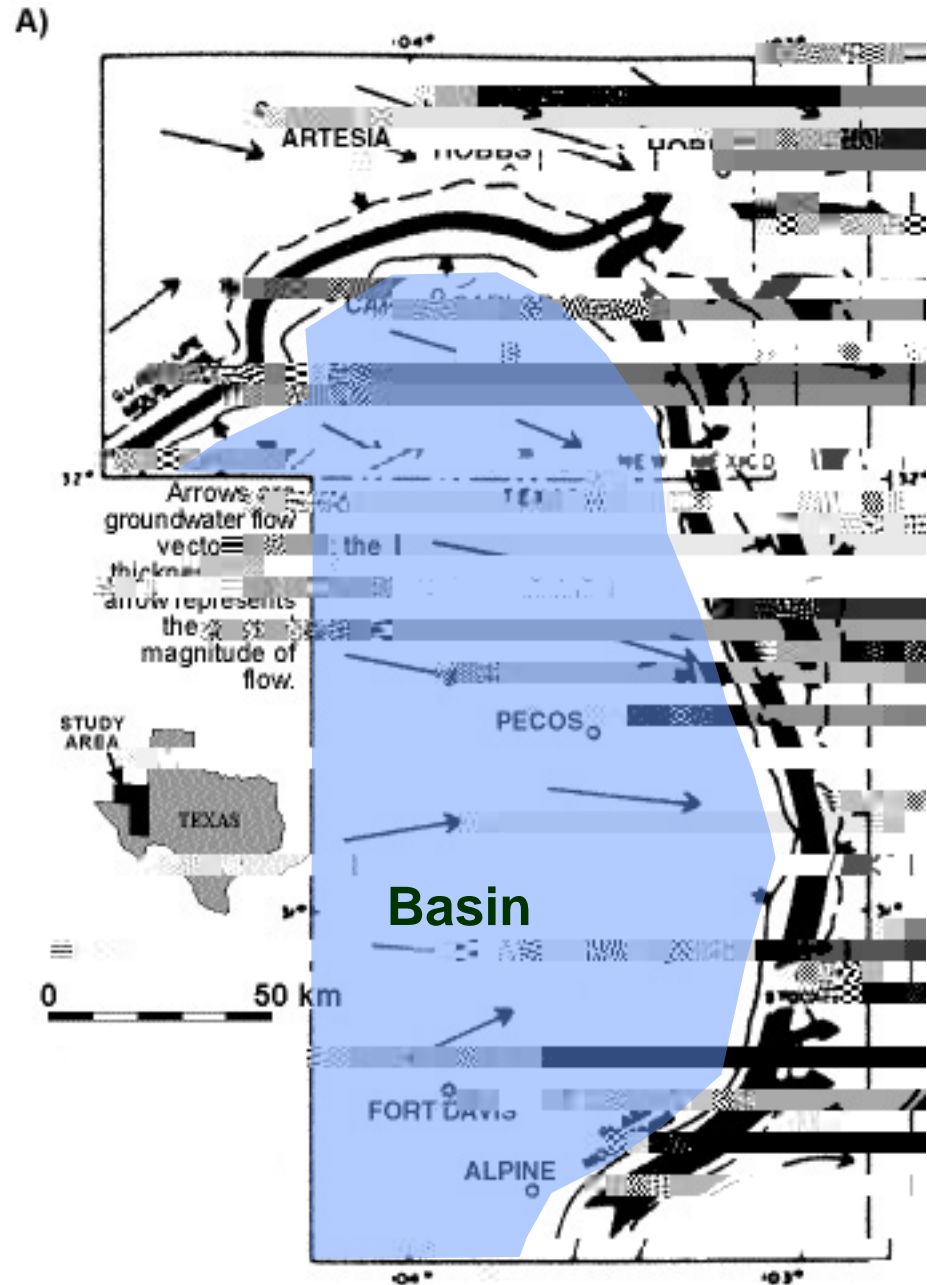
Capitan Reef

- ∅ **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

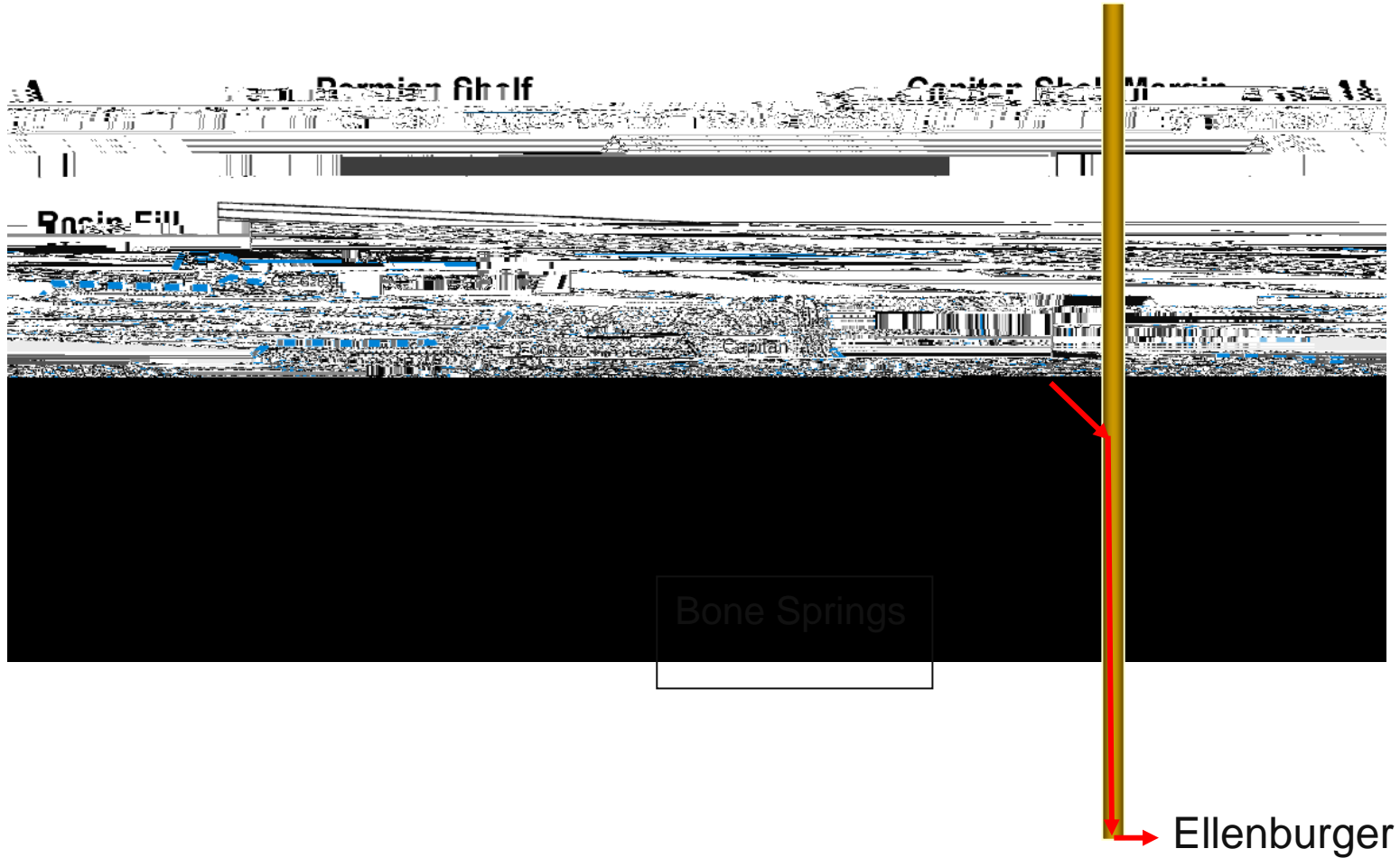
How to Build a Geothermal Engine

- ∅ 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

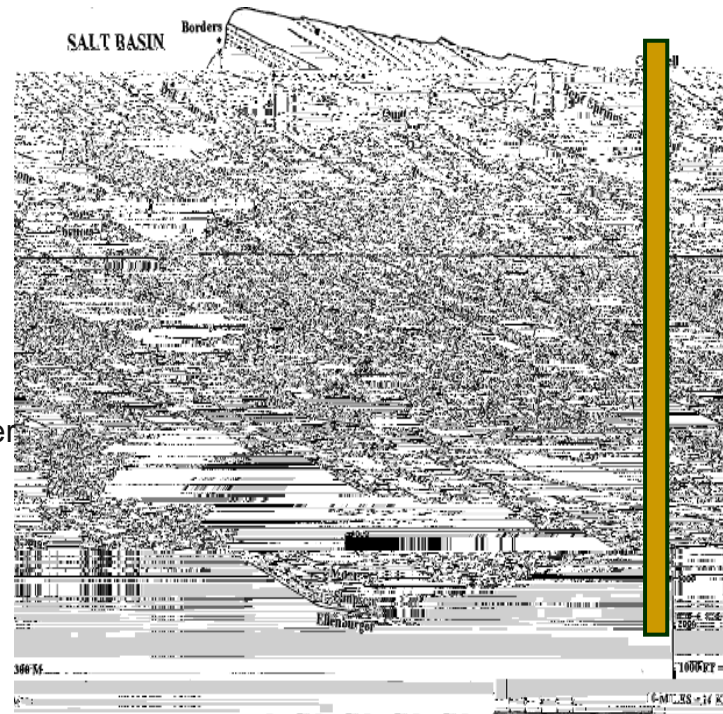
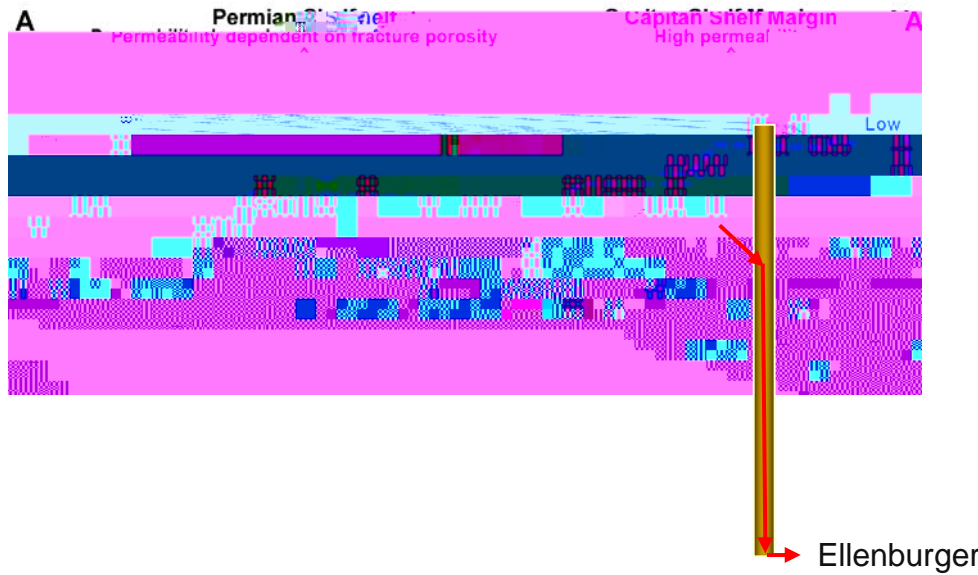


Connecting the Formations





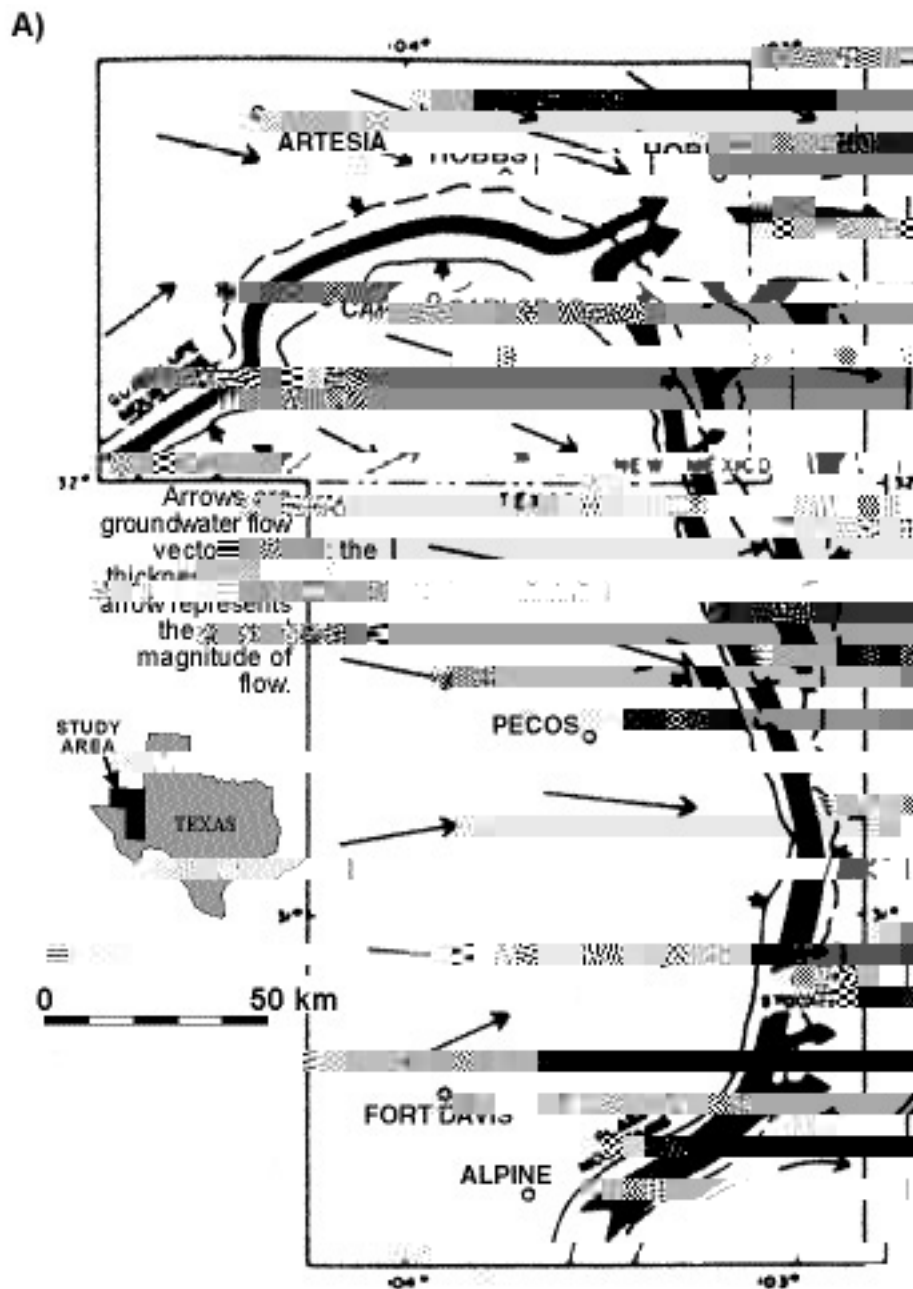
Conversion to Heat Sources from Hydrocarbon Production – Feasible?



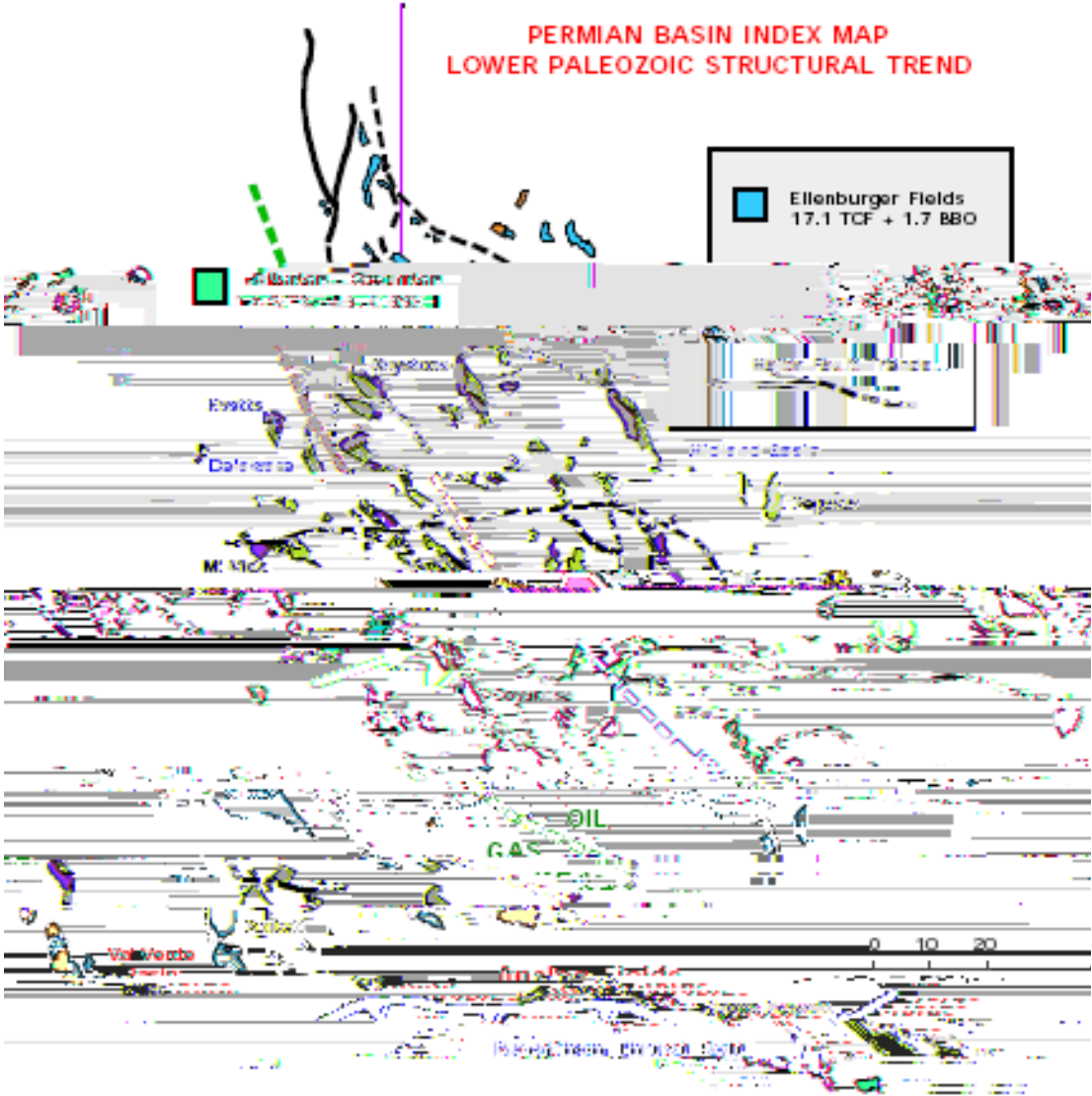
Capitan Reef water production and losses

8.5 ppg load will flow to surface

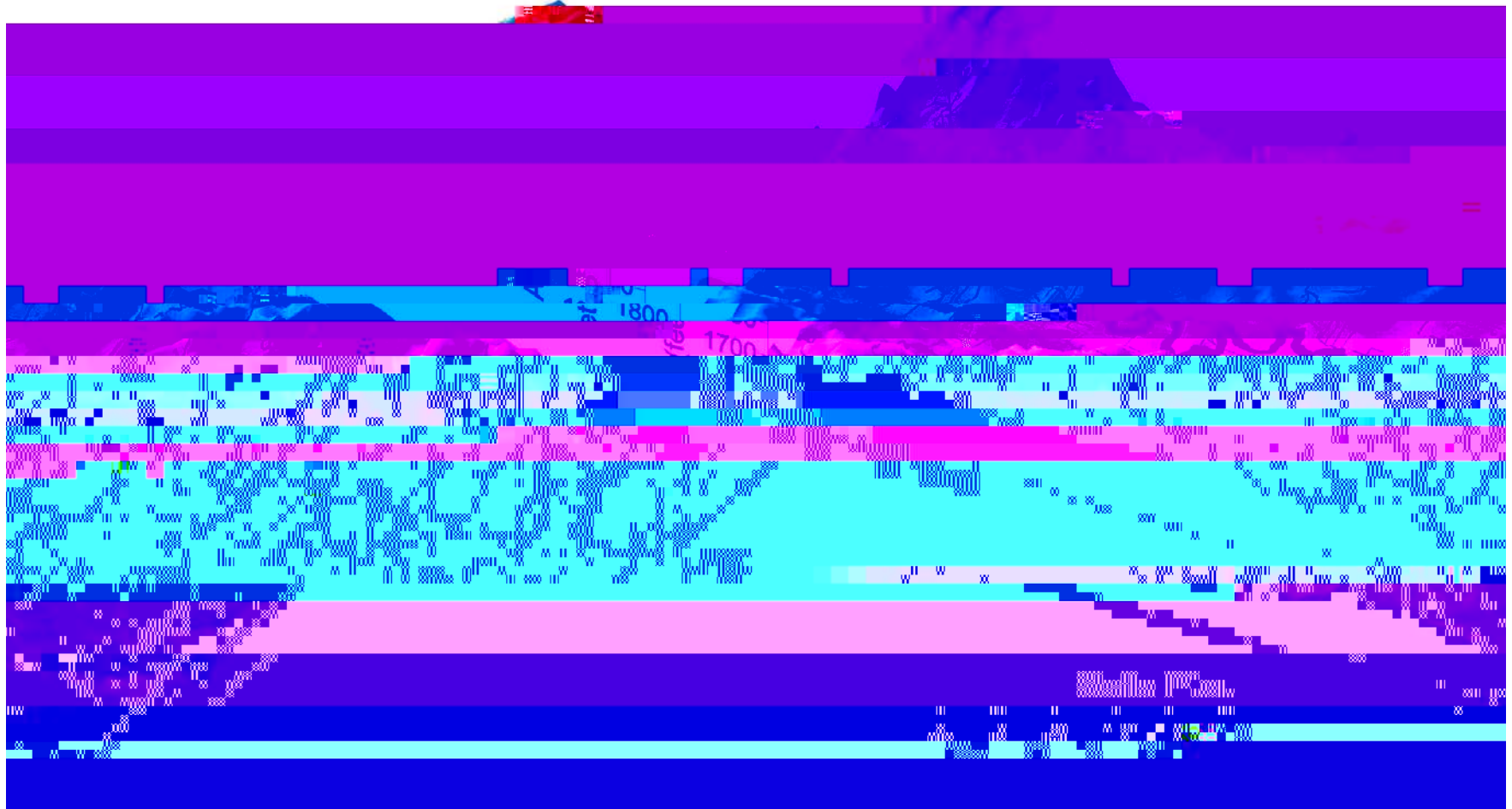
10.0 ppg load will have a loss into the Reef on a vacuum



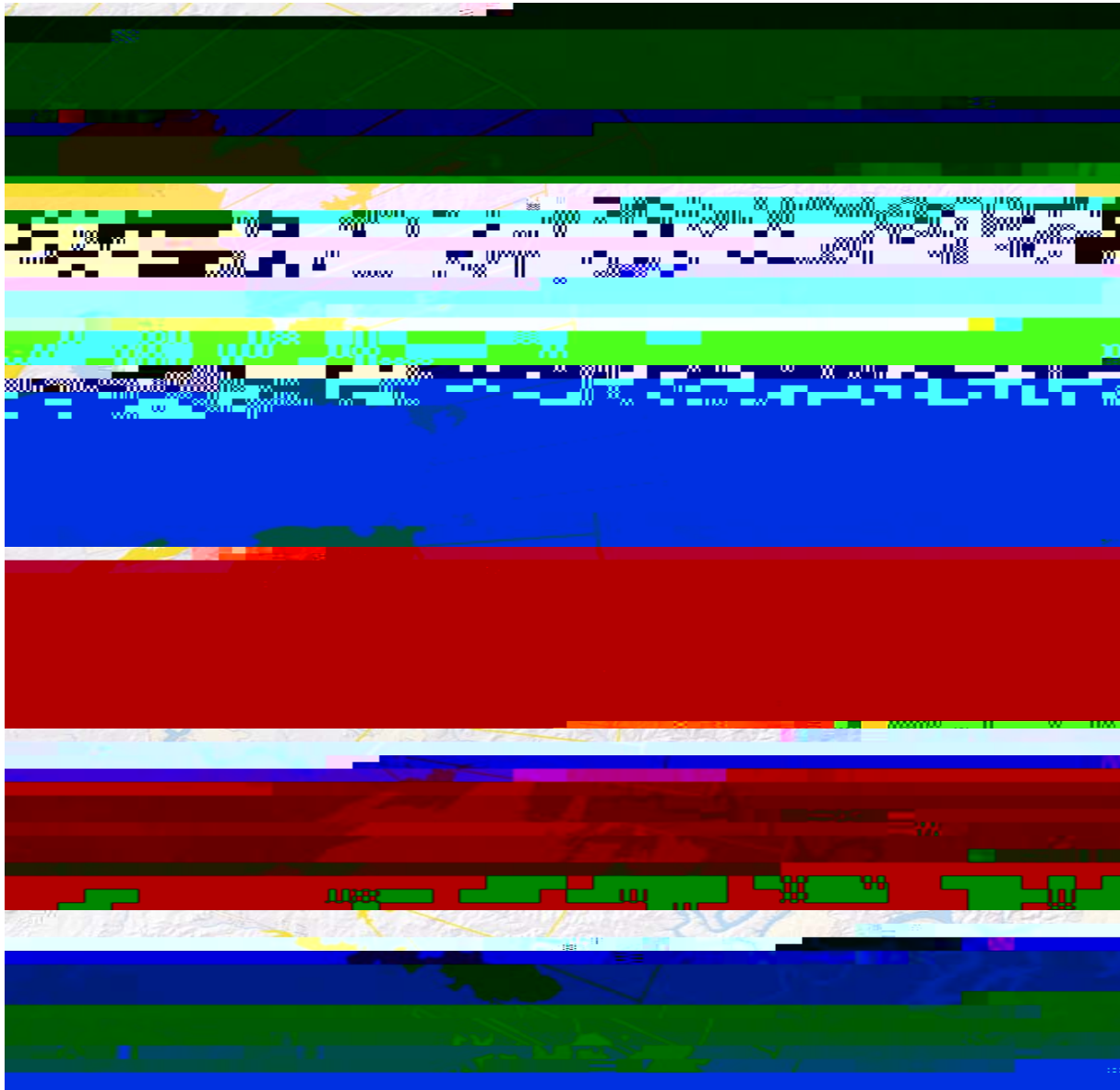
Permian Basin Index map showing 3-D study area and analog fields.



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



ELLENBURGER AQUIFER Central Texas GCD



Production Enhancement - Biggest CO₂ Frac

