

# **Bouguer Gravity, Geothermal Gradient: Exploration Tools, Denver Basin\***

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## **Abstract**

The distribution of Cretaceous oil fields in the northern Denver Basin is explained, at least in part, by a combination of gravity, magnetic, and geothermal gradient maps. The area studied includes Banner, Kimball, and portions of surrounding counties in southwestern Nebraska.

A geothermal gradient map of the area was constructed using bottom hole temperatures recorded by wireline logs. Gravity and magnetic data were acquired from public sources. Comparison of the maps shows that areas of high geothermal gradient coincide with areas of Bouguer gravity minimums, magnetic positives, and concentrations of oil fields. Few fields exist in areas of low gradient and gravity positives. It is believed that the areas of high geothermal gradient reflect areas of fractured basement rock that have conducted more heat into the sedimentary section. From modeling, it can be shown that the fracture zones have reduced the density of the basement rocks as well as localized the emplacement of granitic intrusions into the basement, which explains the Bouguer gravity and magnetic anomalies.

These fracture zones have localized D and J Sandstone oil fields by causing abrupt changes in the environment of deposition of the sandstones, thus forming stratigraphic traps. Adjacent areas of limited basement fractures have a paucity of traps and production. Not only can existing producing trends in the D and J Sandstones be explained, but other areas in the northern Denver Basin can be shown to have a high potential for production from the Cretaceous sandstones as well as deeper and shallower objectives.

## **Selected References**

Oldham, D.W., 1995, Influence of salt solution collapse on hydrocarbon production and potential, Denver Basin, Colorado, Nebraska, and Wyoming: AAPG Annual Meeting Expanded Abstracts, v. 4, p. 73.

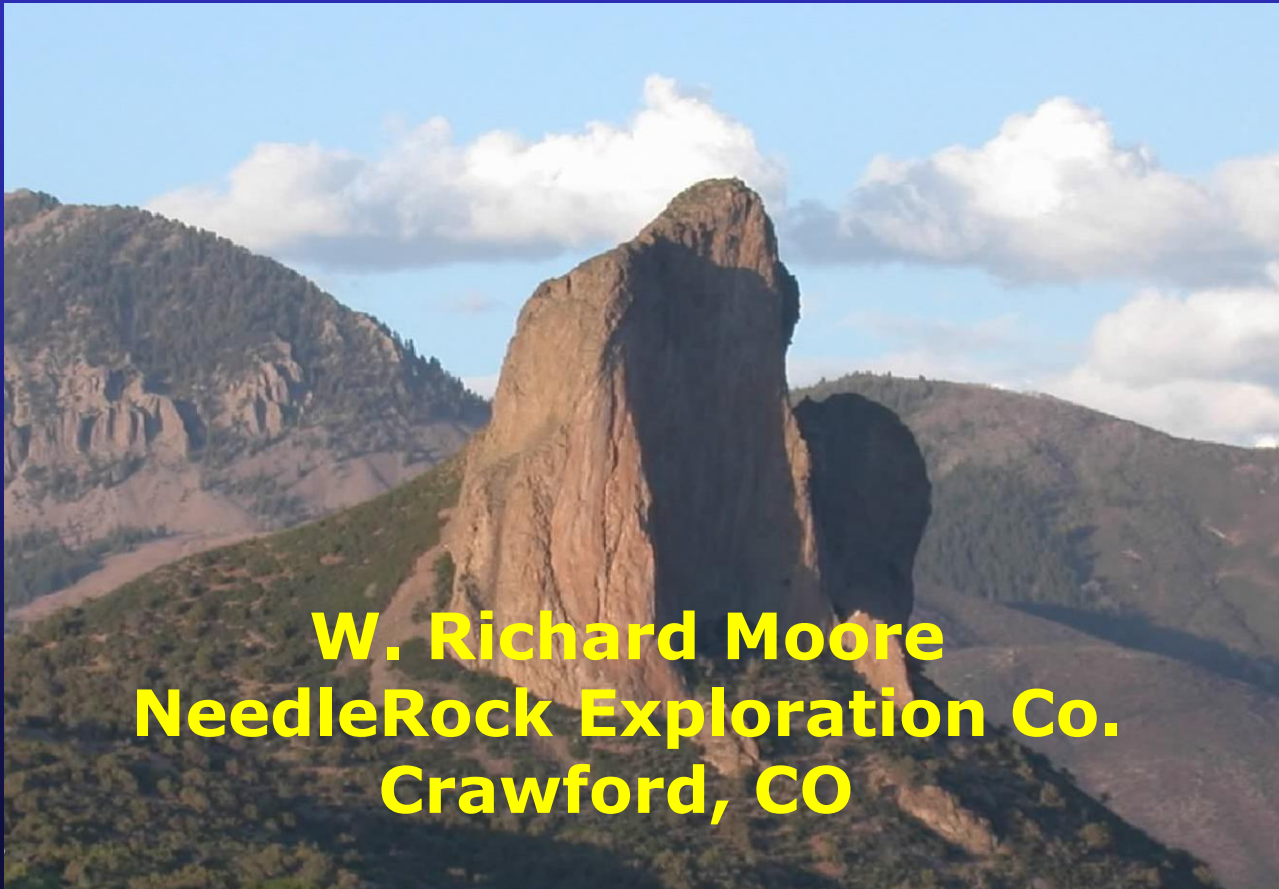
Smagala, T.M., C.A. Brown, and G.L. Nydegger, 1984, Log-derived indicator of the thermal maturity, Niobrara Formation, Denver Basin, Colorado, Nebraska, Wyoming, *in* J. Woodward, F.F. Meissner, and J.L. Clayton, (eds.), Hydrocarbon source rocks of the Greater Rocky Mountain region: RMAG, p. 355-363.

Tweto, O., 1980, Precambrian geology of Colorado, *in* H.C. Kent, and K.W. Porter, (eds.), Colorado geology: RMAG, p. 37-46.

Warner, L.A., 1978, The Colorado Lineament; a middle Precambrian wrench fault system: GSA Bulletin, v. 89/2, p. 161-171.

# **BOUGUER GRAVITY GEOHERMAL GRADIENT**

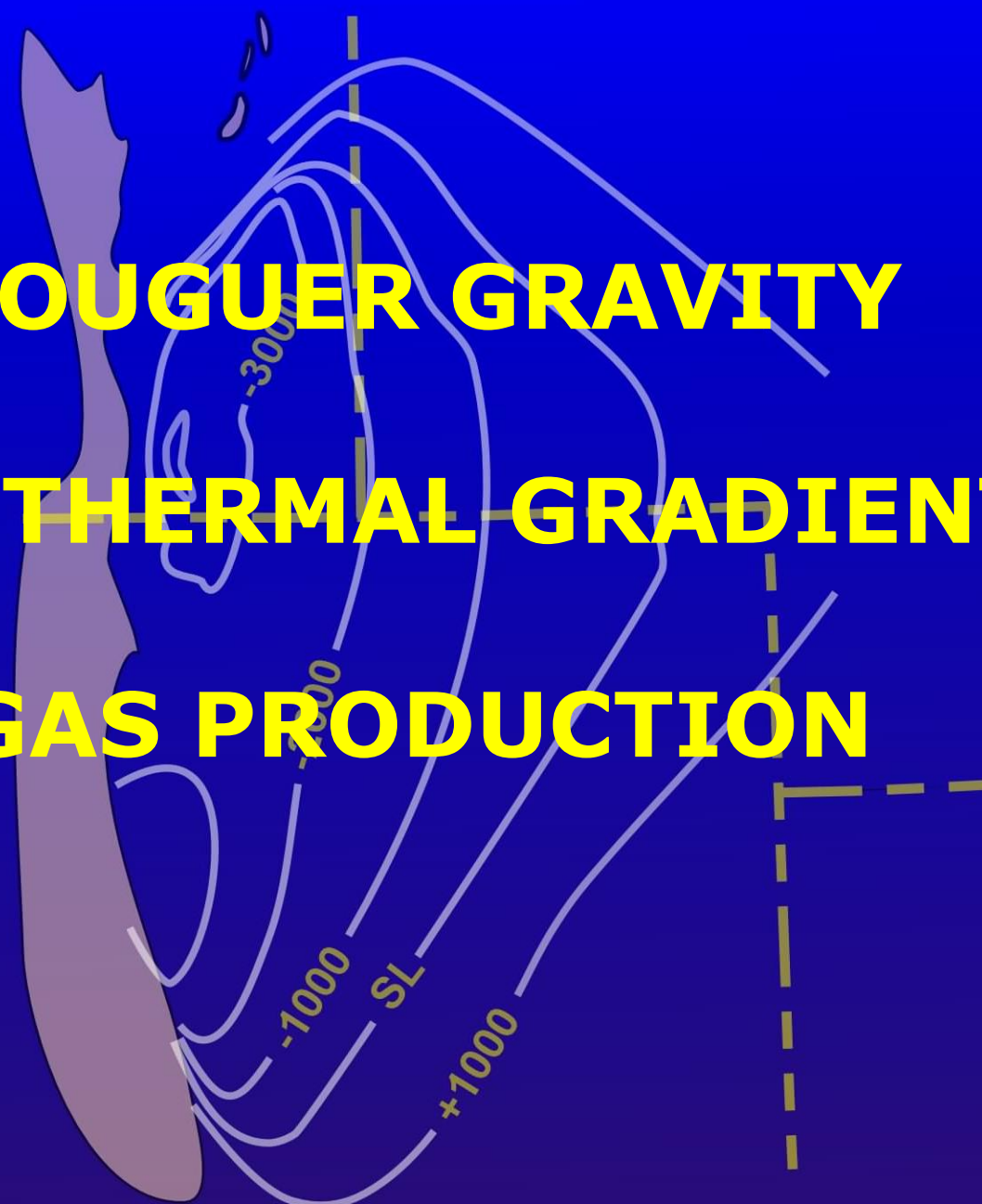
## ***EXPLORATION TOOLS DENVER BASIN***



**BOUGUER GRAVITY**

**GEO THERMAL GRADIENT**

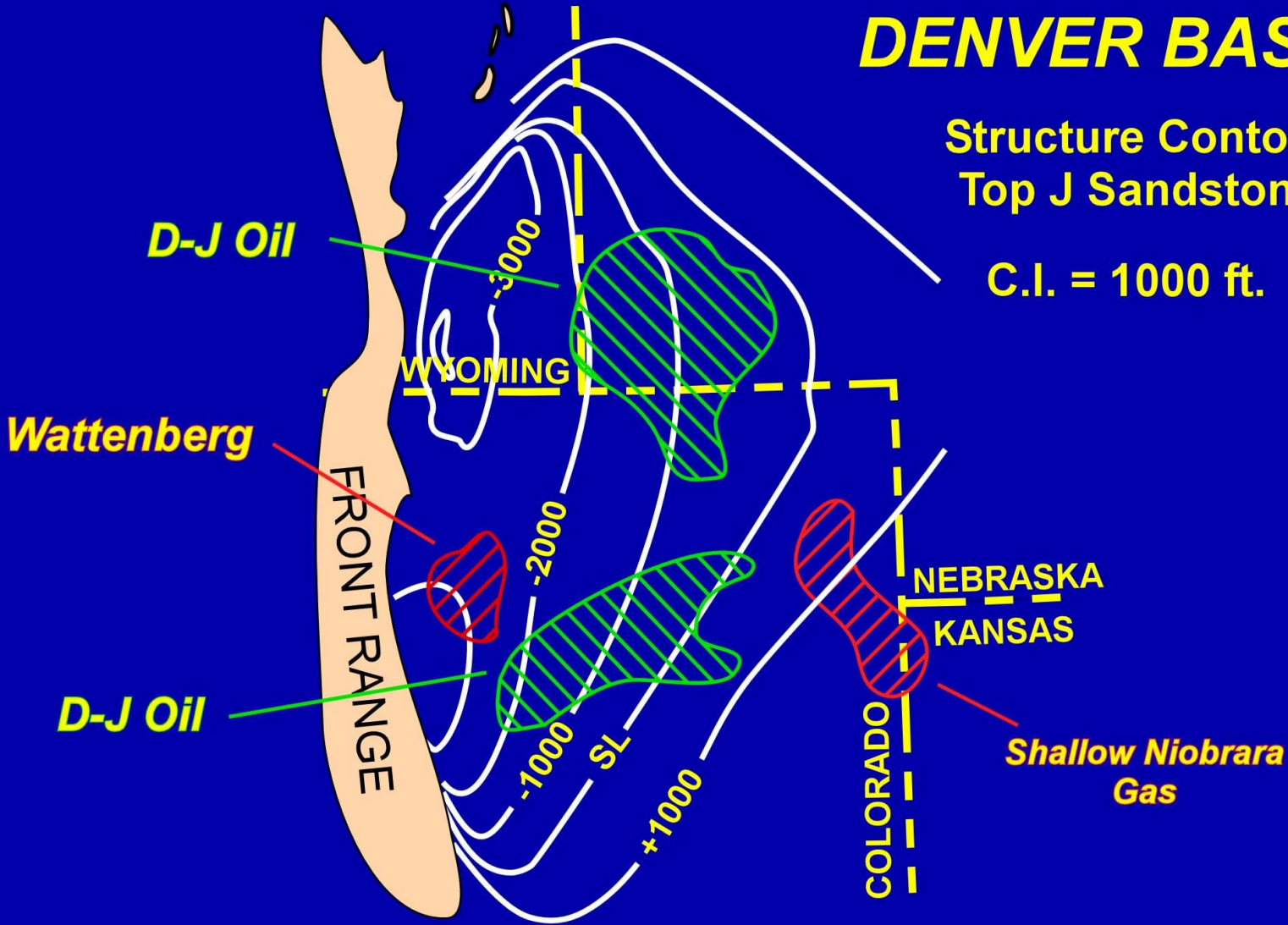
**GAS PRODUCTION**



# DENVER BASIN

Structure Contour  
Top J Sandstone

C.I. = 1000 ft.

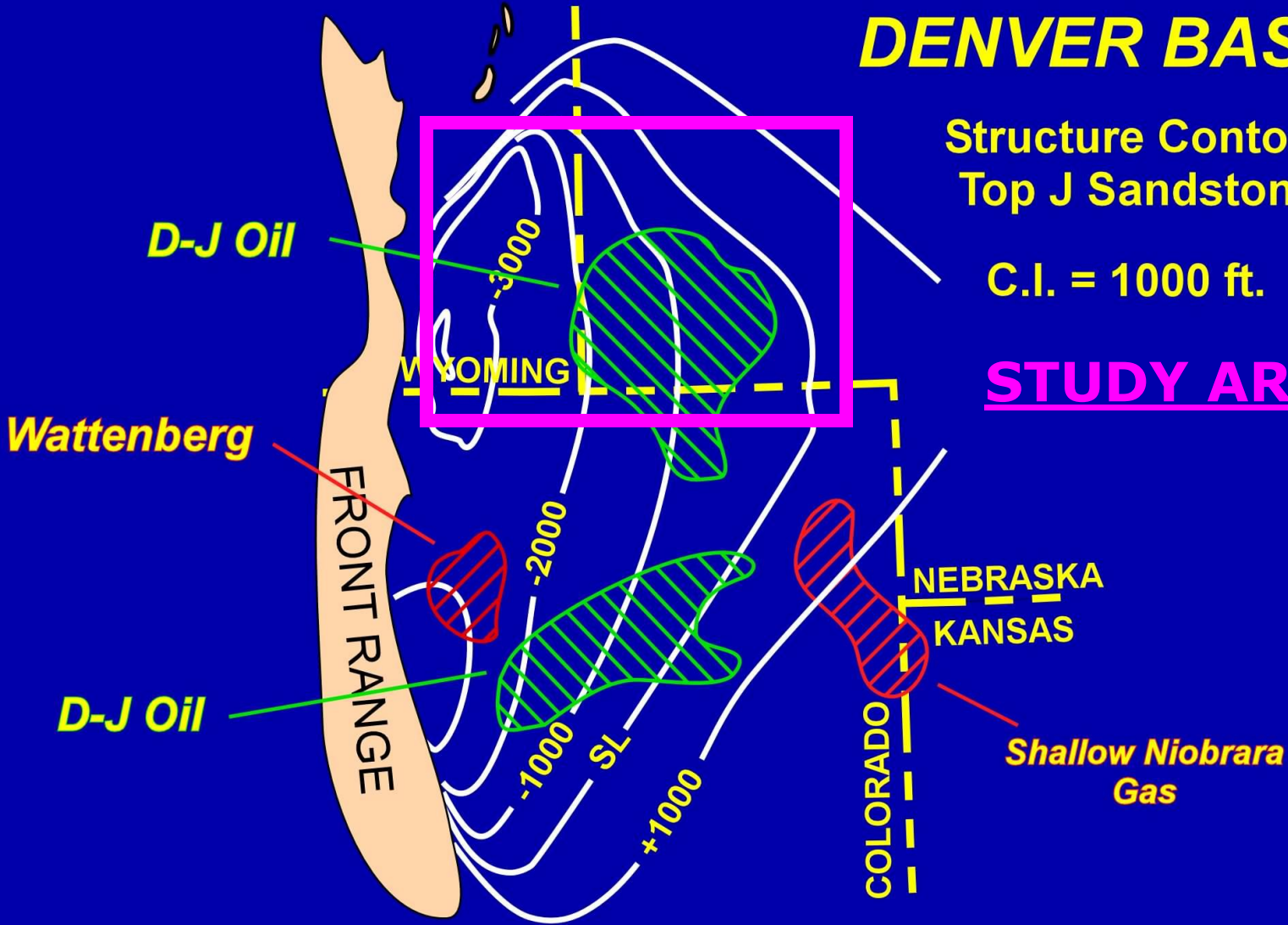


# DENVER BASIN

Structure Contour  
Top J Sandstone

C.I. = 1000 ft.

**STUDY AREA**



Structure Top J SS

C.I. = 500 ft

# Northern Denver Basin

North Platte River

Banner County

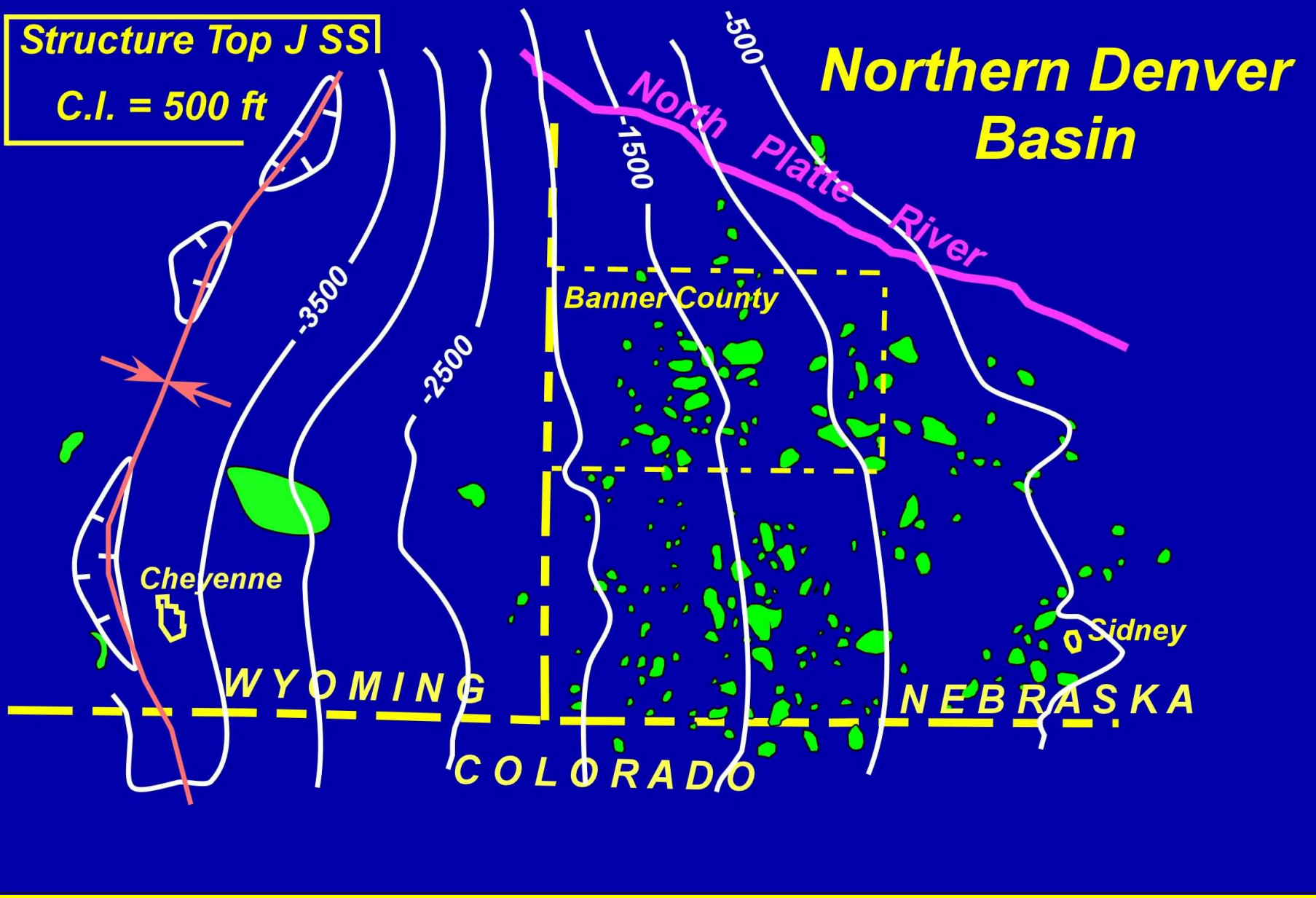
Cheyenne

Sidney

WYOMING

NEBRASKA

COLORADO



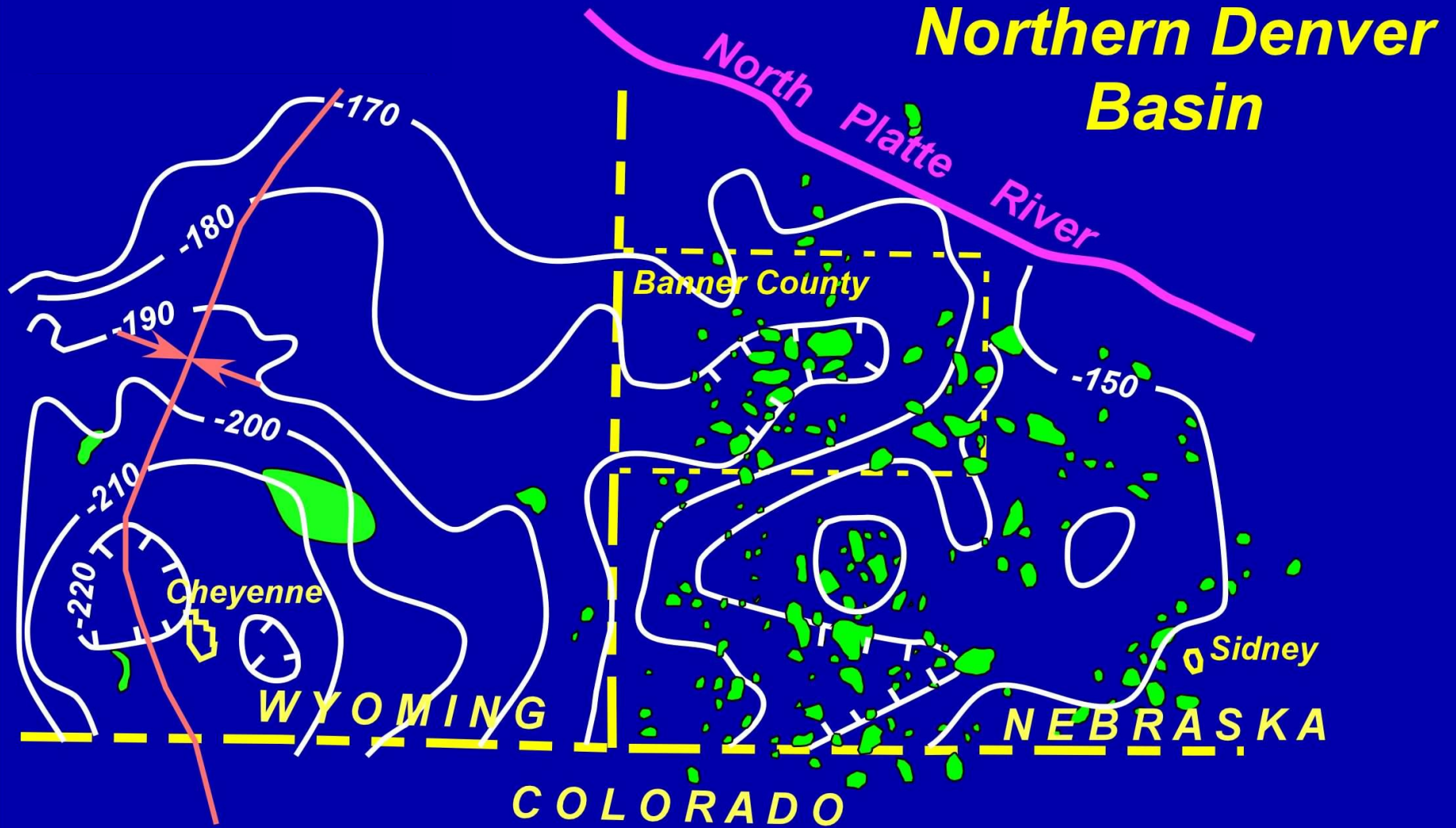
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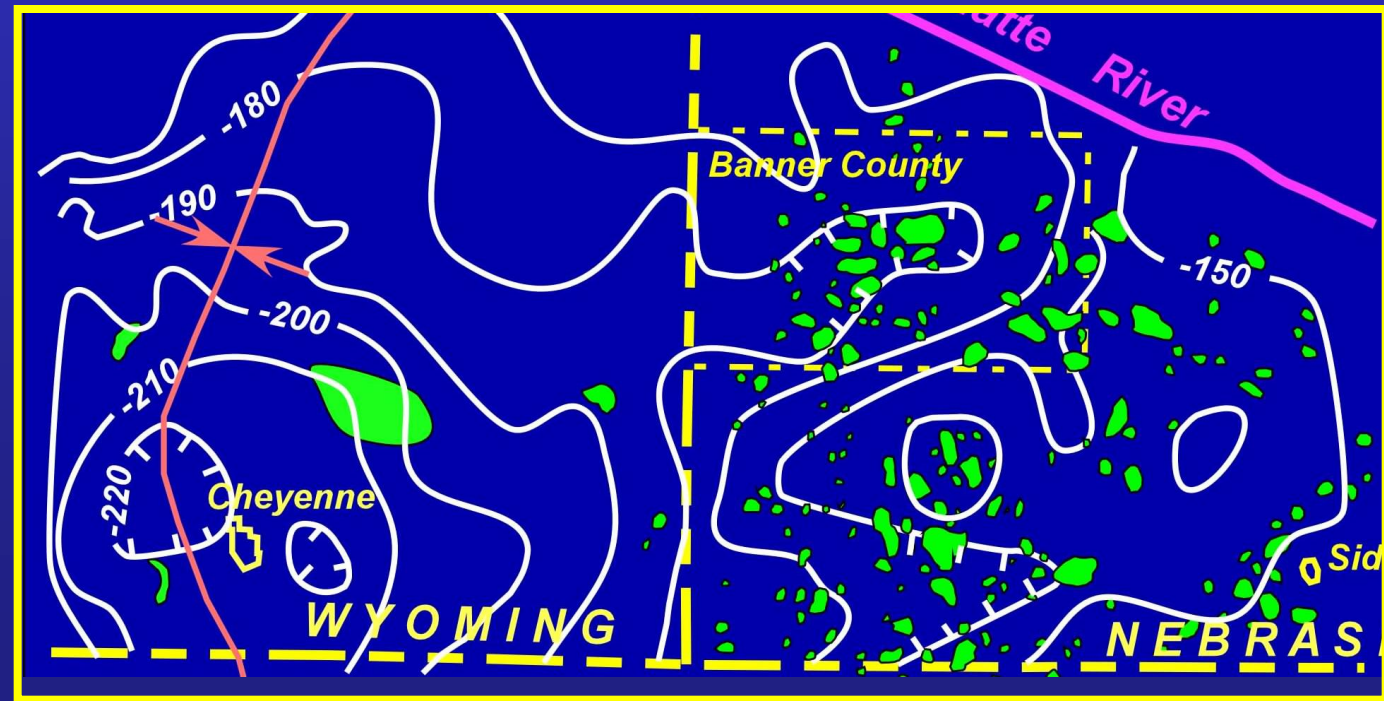
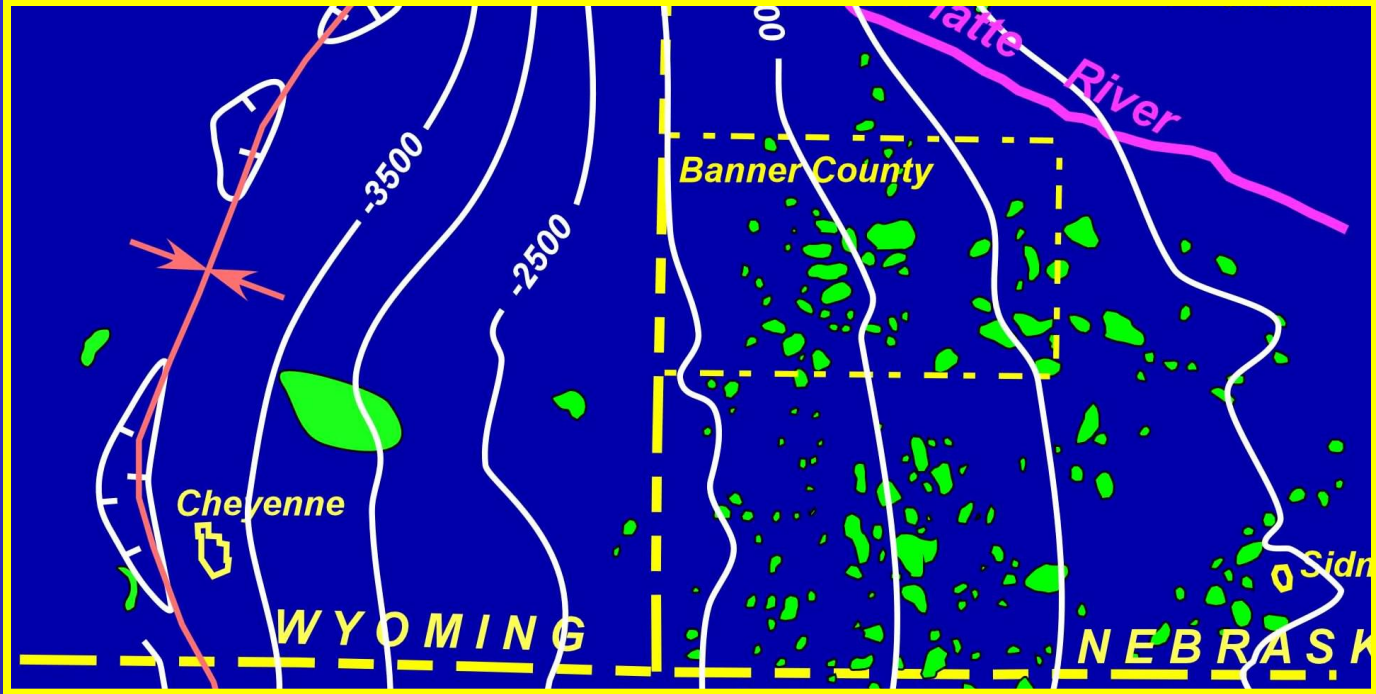
**GEOHERMAL GRADIENT**

**OIL AND GAS PRODUCTION**



# BOUGUER GRAVITY





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**BOUGUER GRAVITY**

**GEOHERMAL GRADIENT**

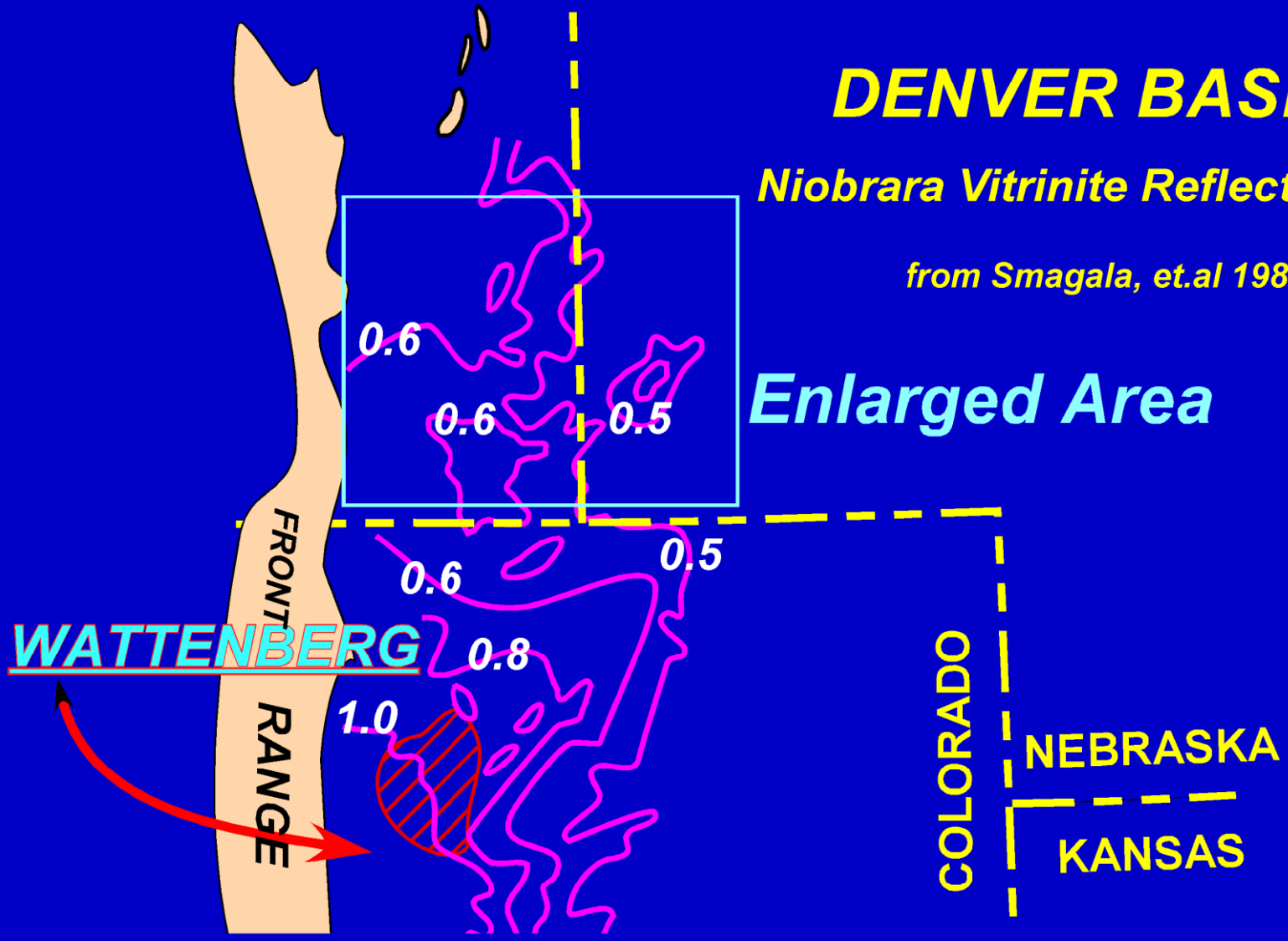
**OIL AND GAS PRODUCTION**

# DENVER BASIN

## Niobrara Vitrinite Reflectance Map

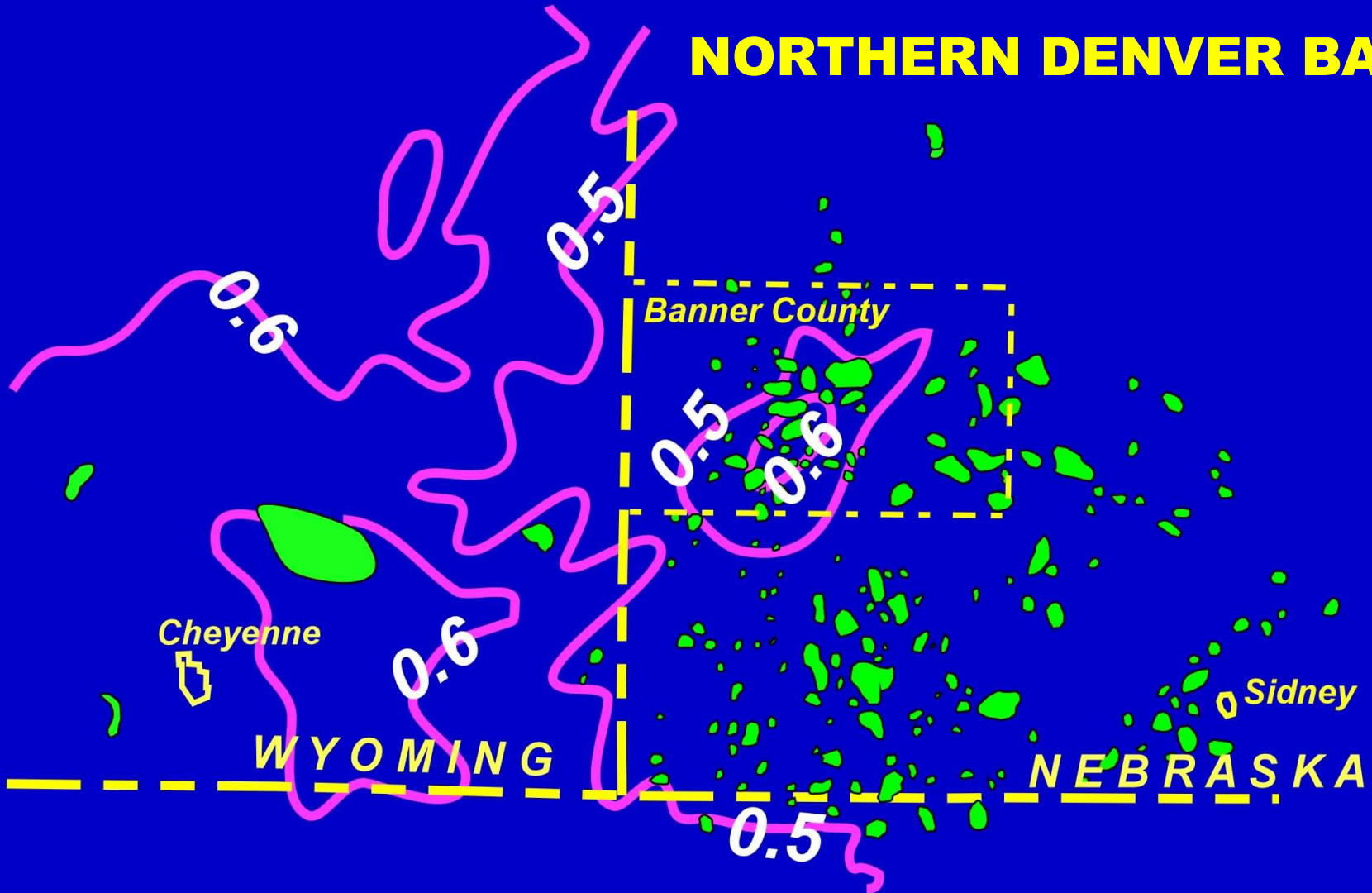
from Smagala, et.al 1984

### Enlarged Area

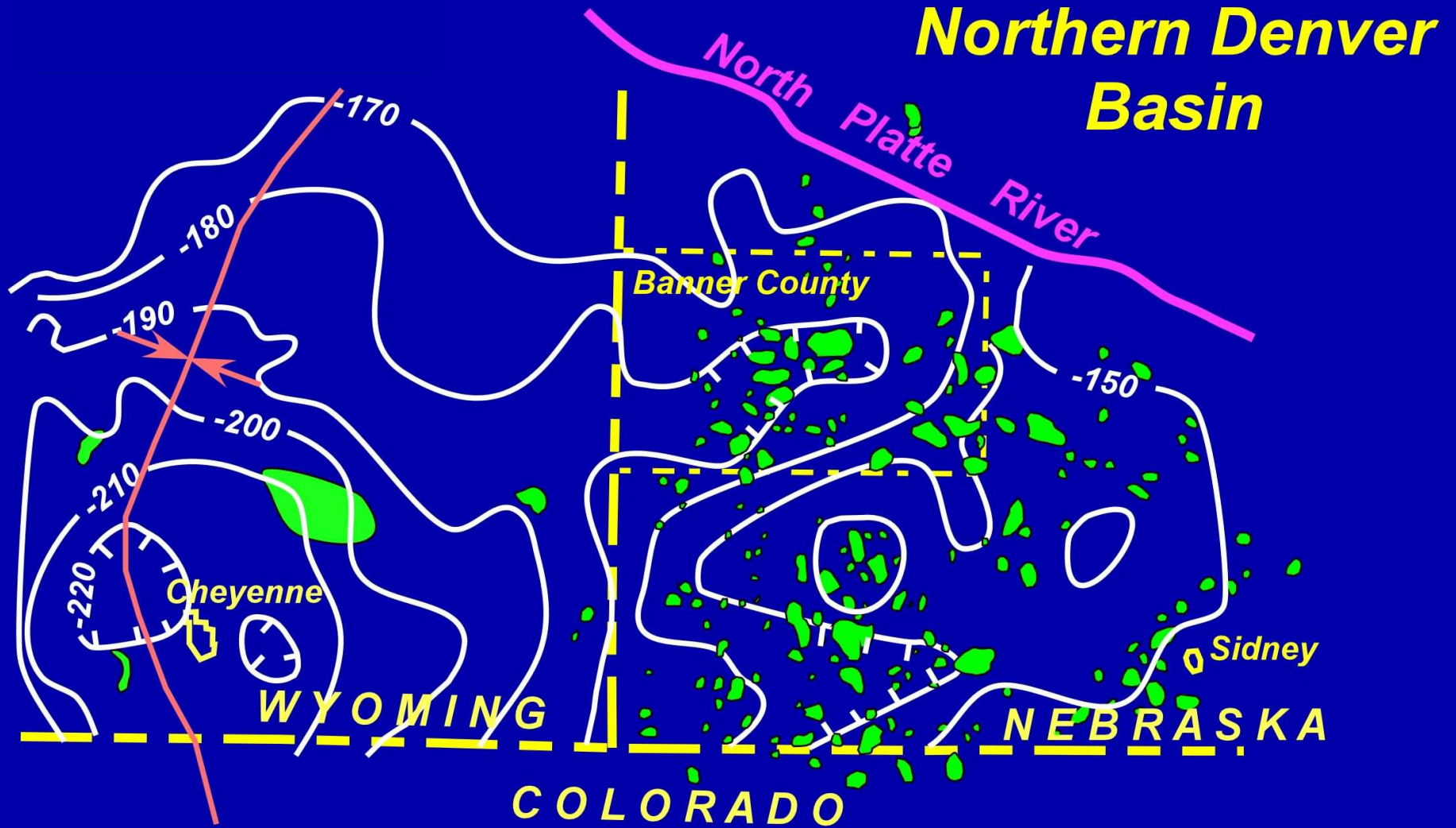


# VITIRINITE REFLECTANCE

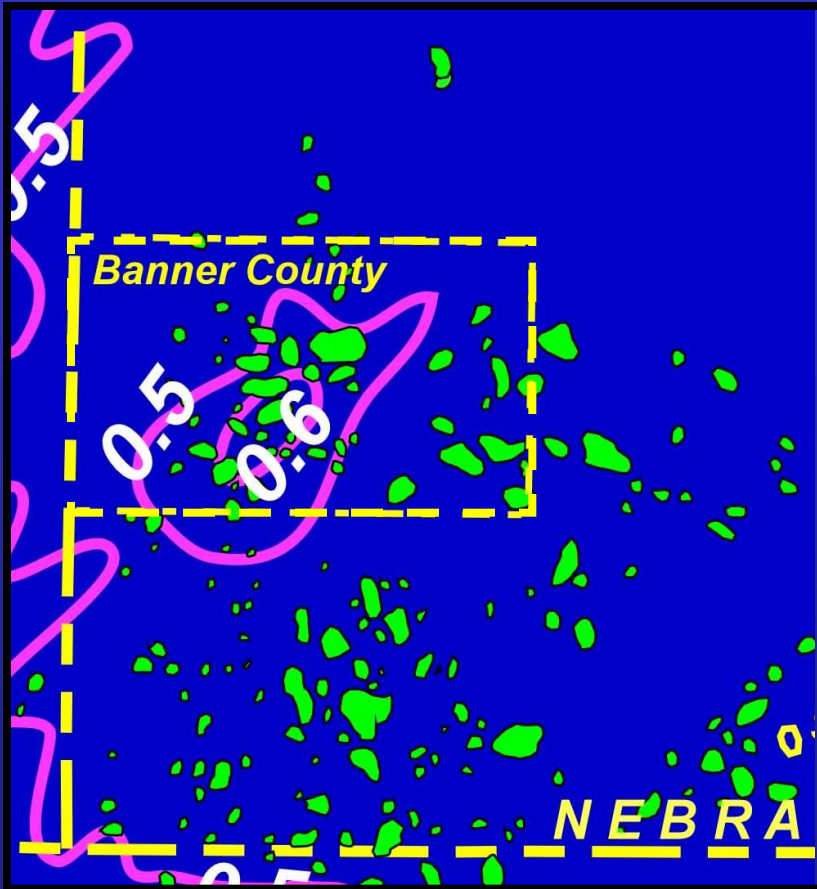
## NORTHERN DENVER BASIN



# BOUGUER GRAVITY



## Vitrinite Reflectance



## Bouguer Gravity



**Structure Top J SS**

**C.I. = 500 ft**

# Northern Denver Basin

**Detail Area**

**Banner County**

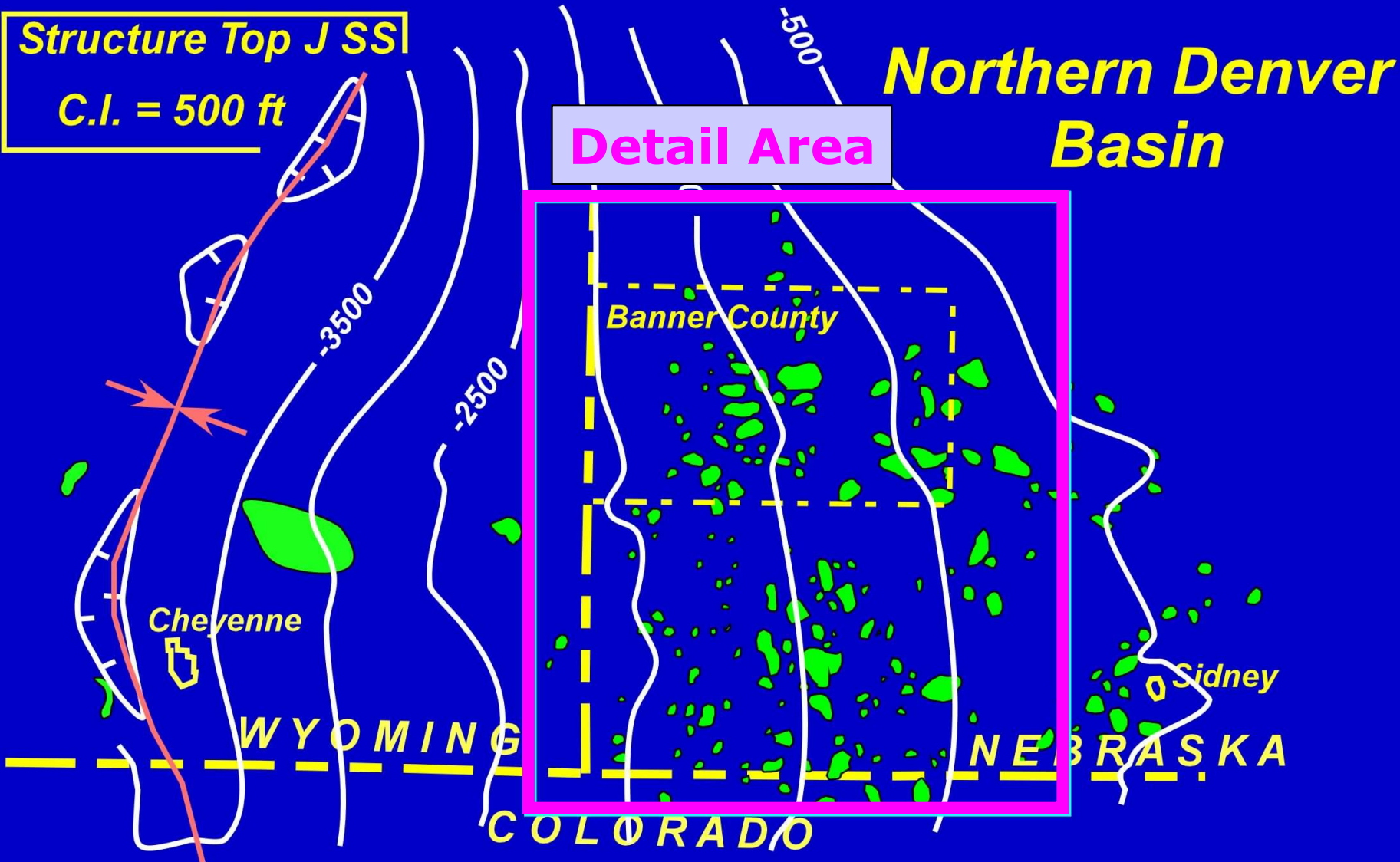
**Cheyenne**

**Sidney**

**WYOMING**

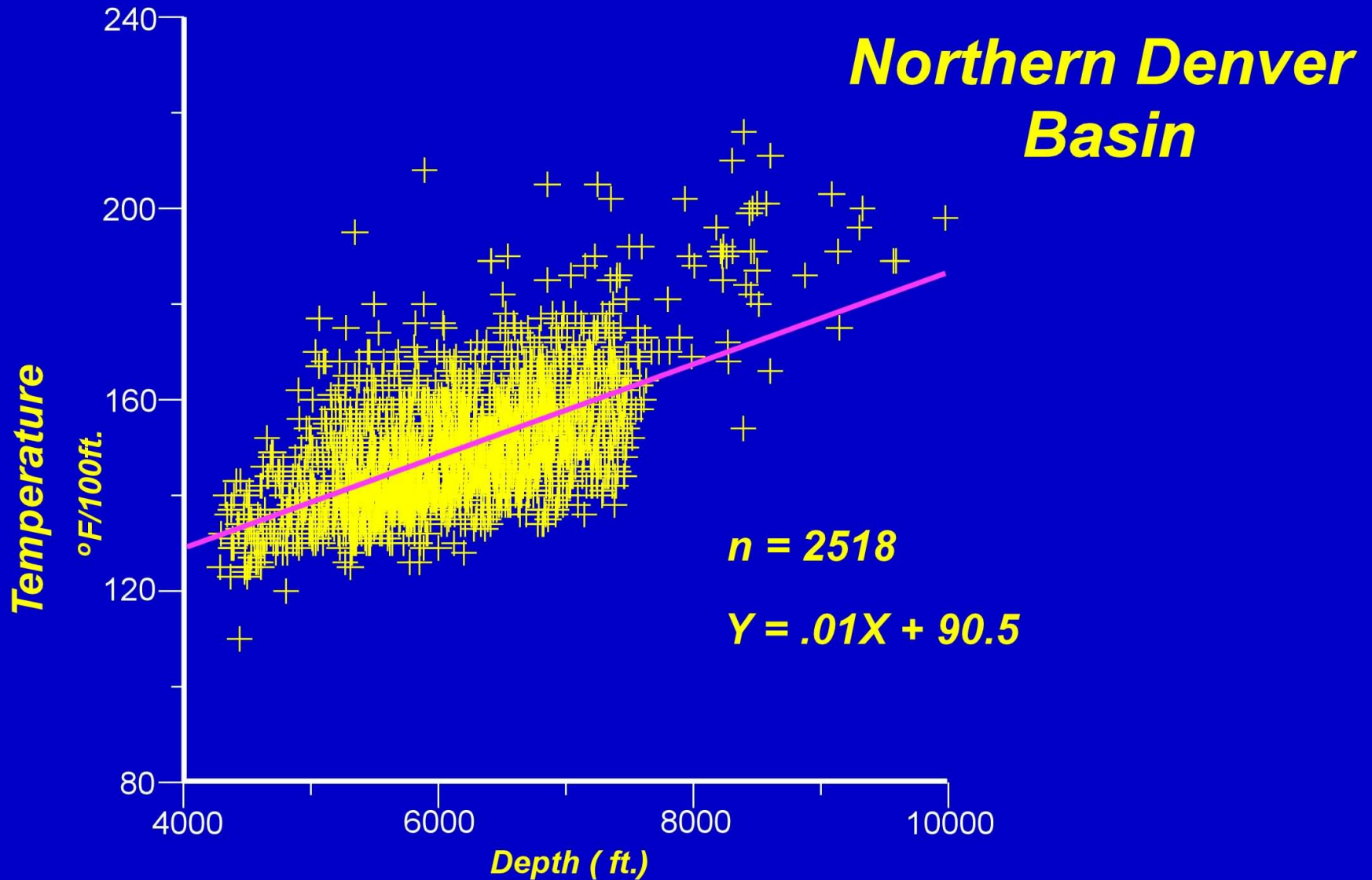
**NEBRASKA**

**COLORADO**





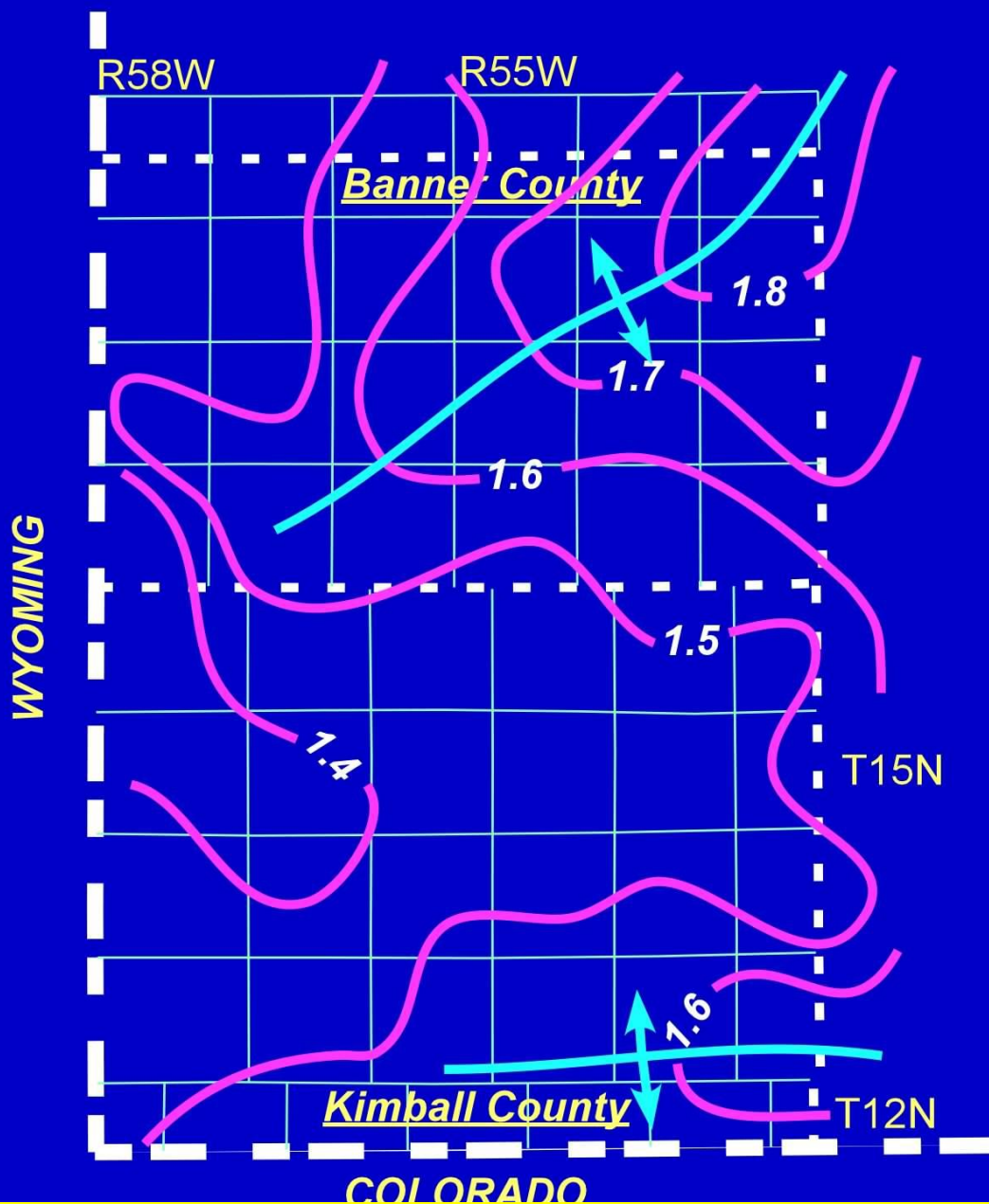
# Temperature vs. Depth



# Geothermal Gradient

Average/Twn

C.I. =  $0.1^{\circ}\text{F}/100\text{ ft}$

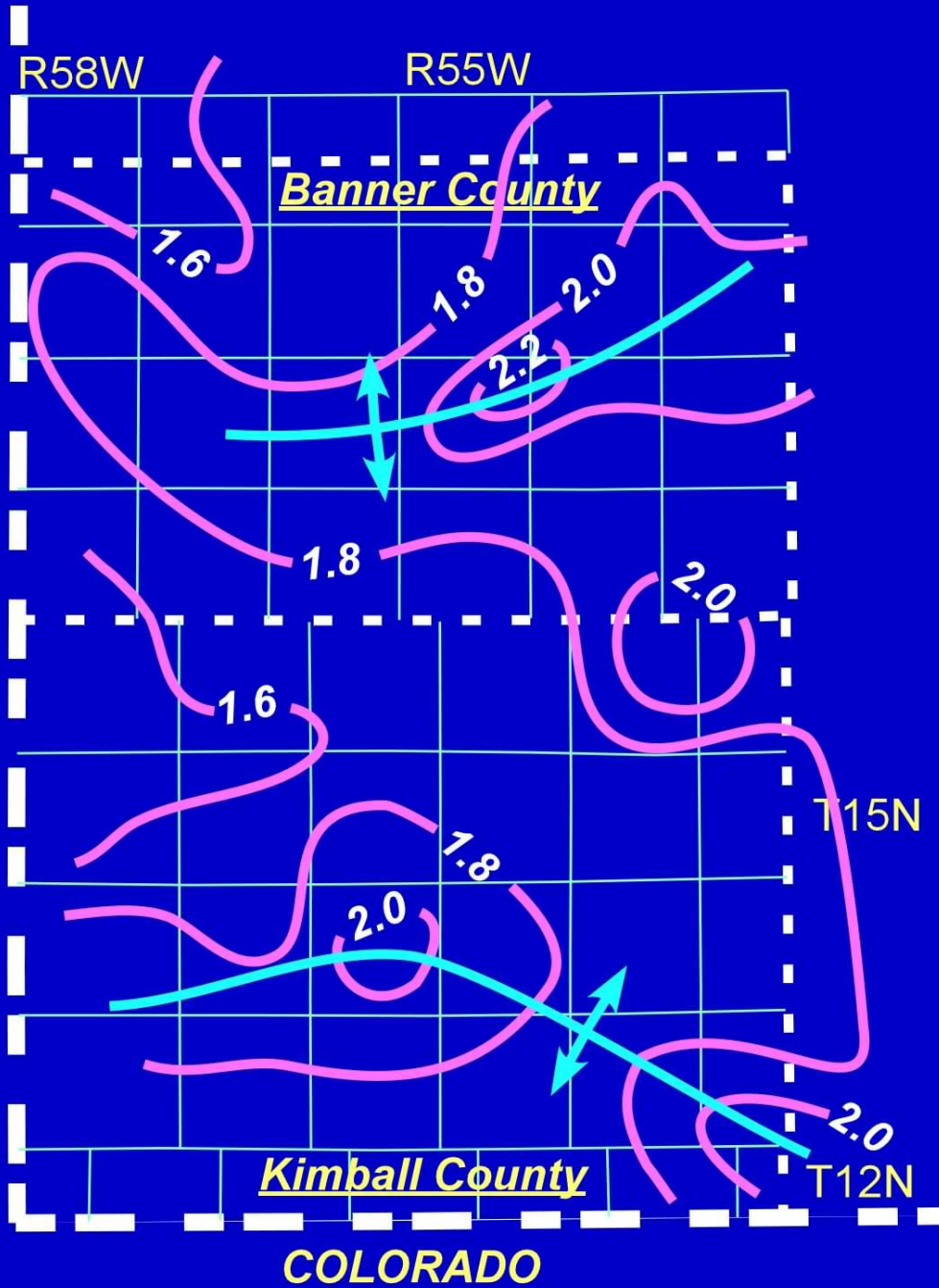


# Geothermal Gradient

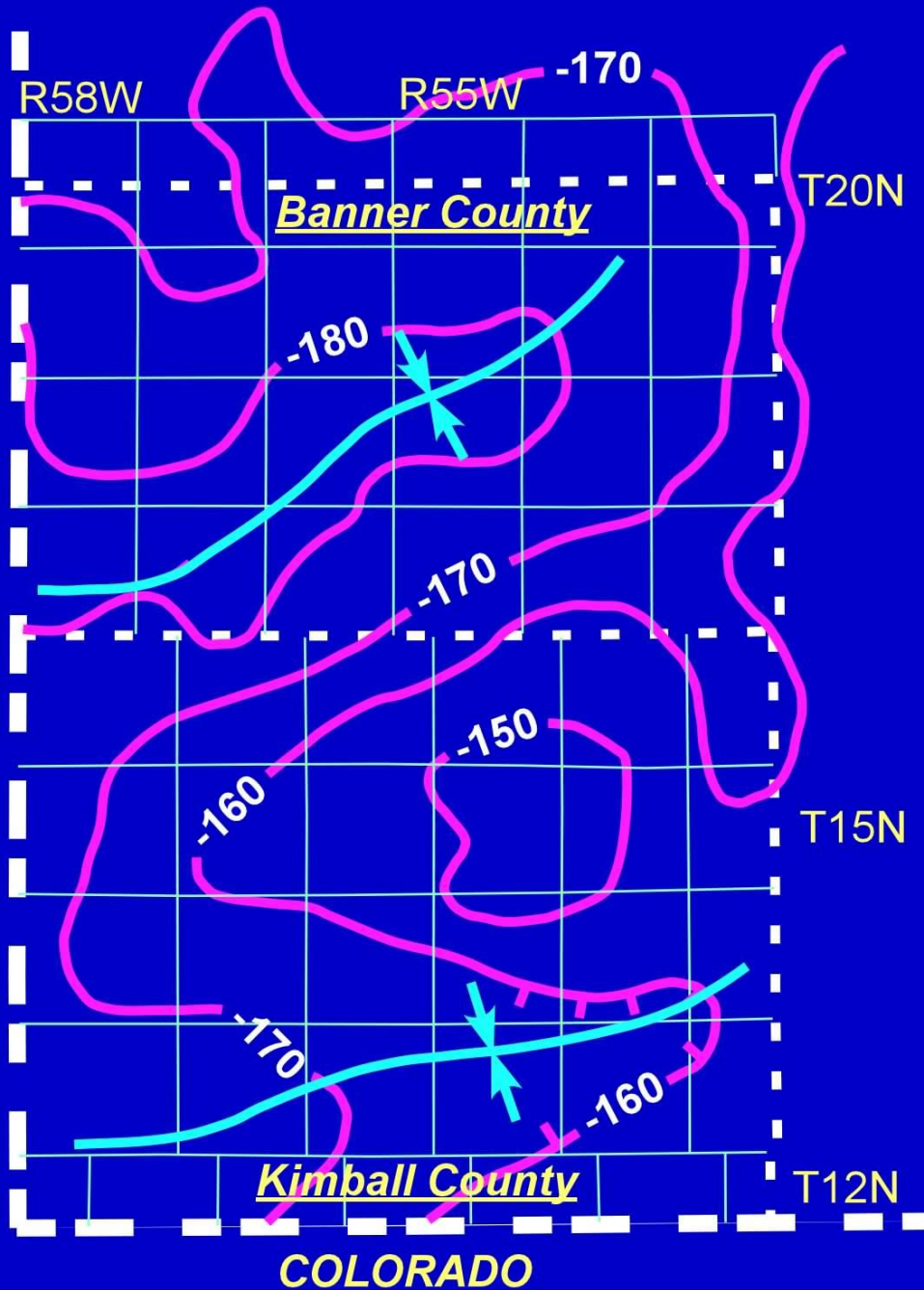
High/Twn

C.I. = 0.2°F/100 ft

WYOMING



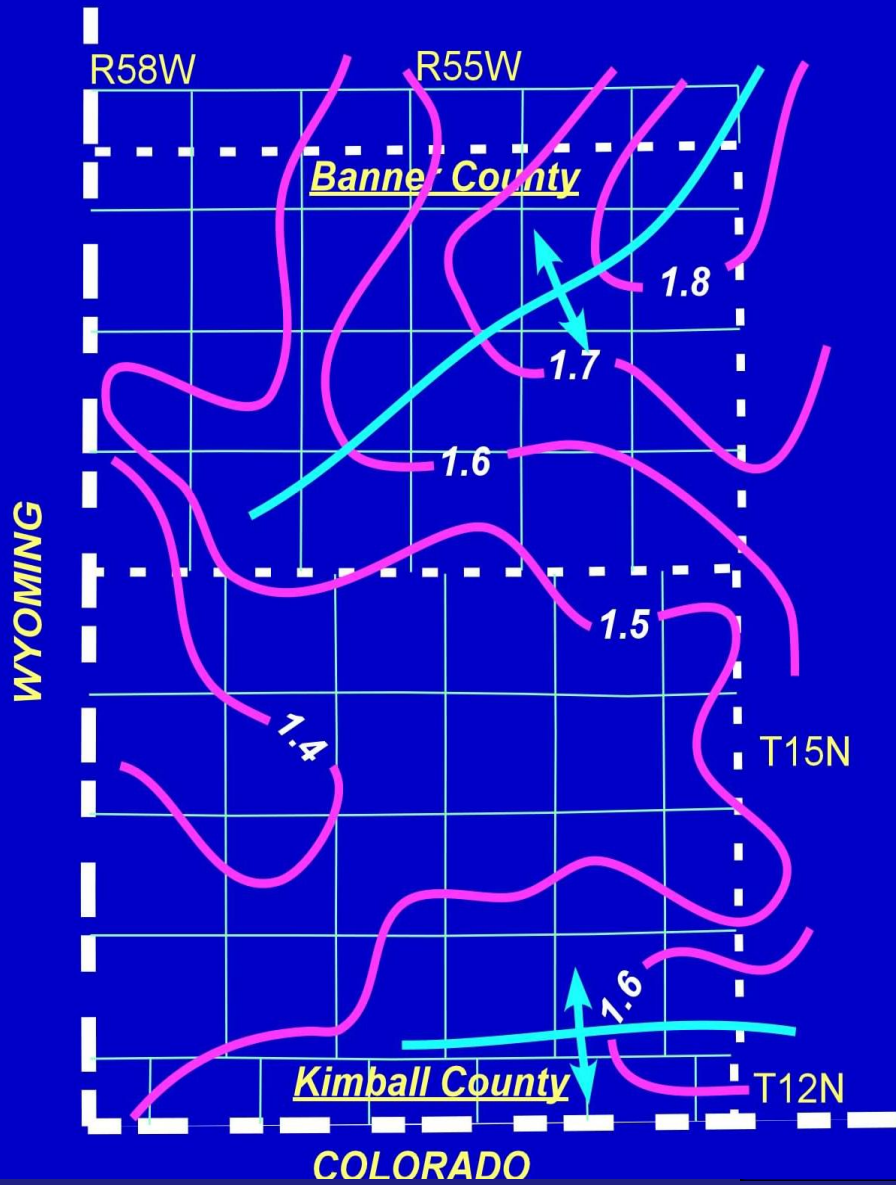
WYOMING



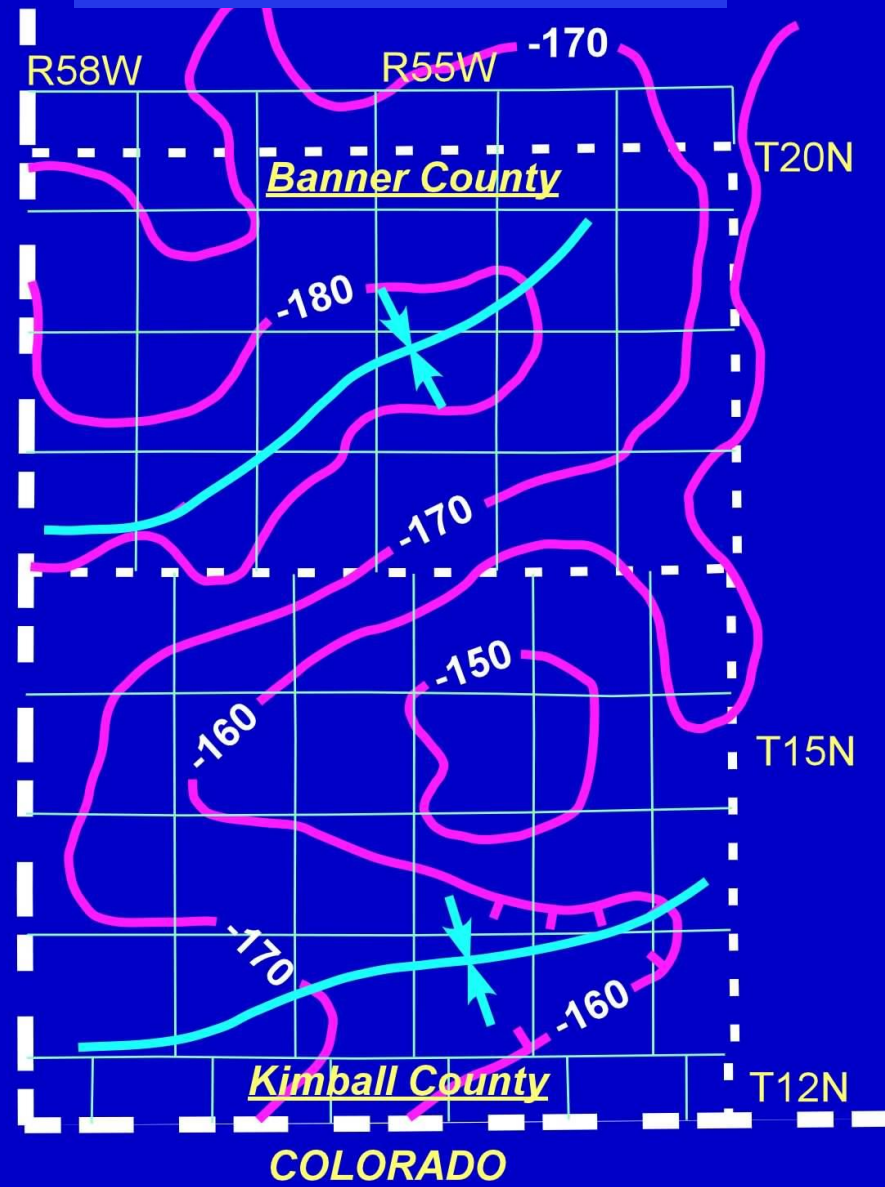
COLORADO

**Bouguer  
Gravity**  
**C.I. = 10 mg.**

# Geothermal Gradient



# Bouguer Gravity

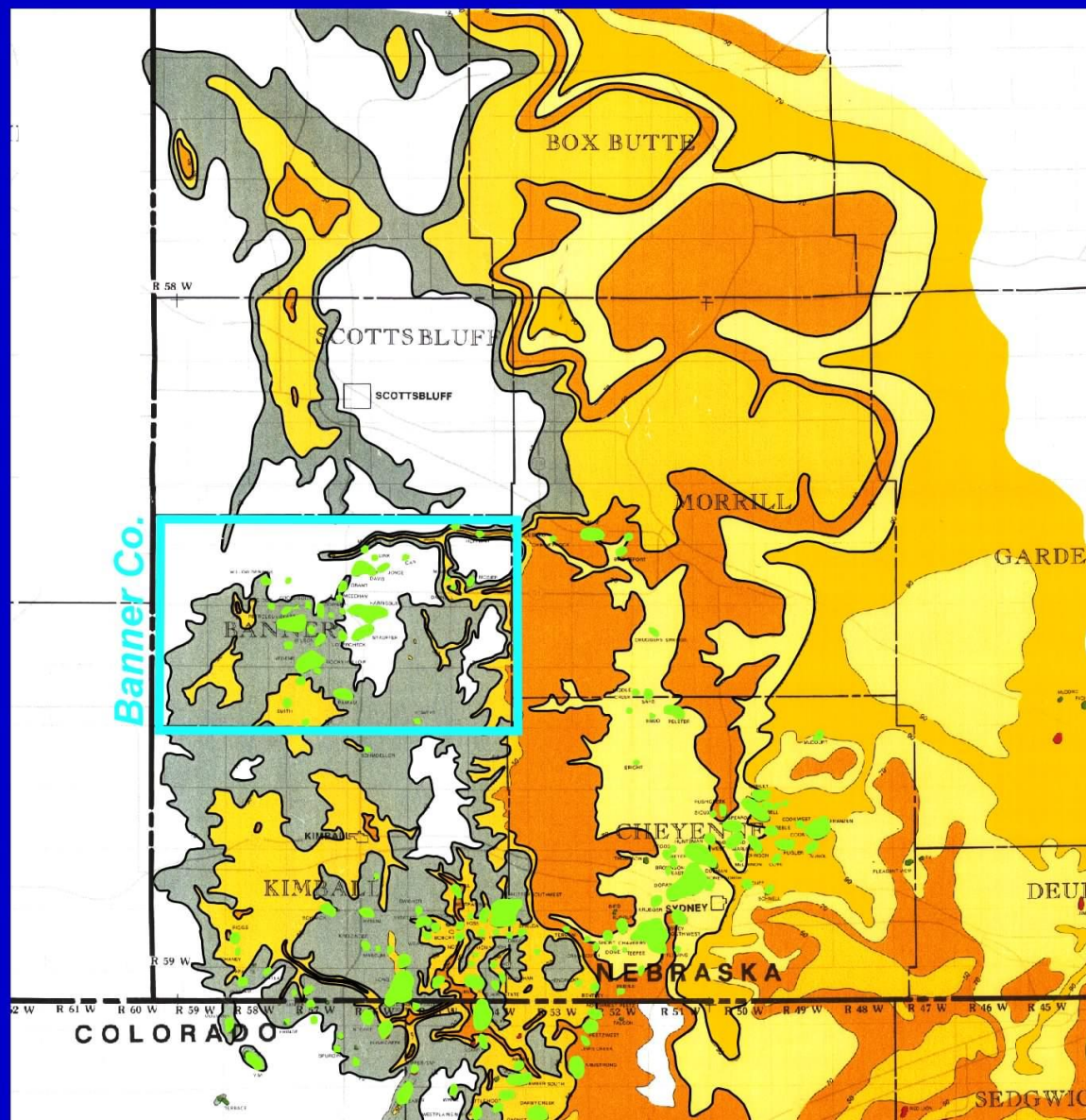


**BOUGUER GRAVITY**

**GEOHERMAL GRADIENT**

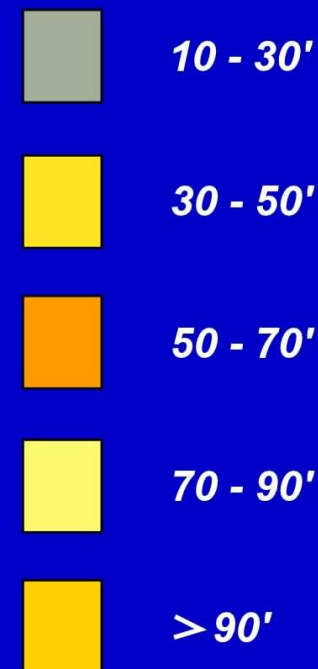
**OIL AND GAS PRODUCTION**

# "D" SANDSTONE ISOPACH



## Northern Denver Basin

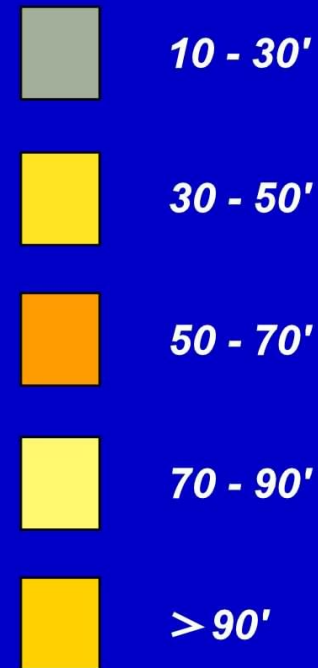
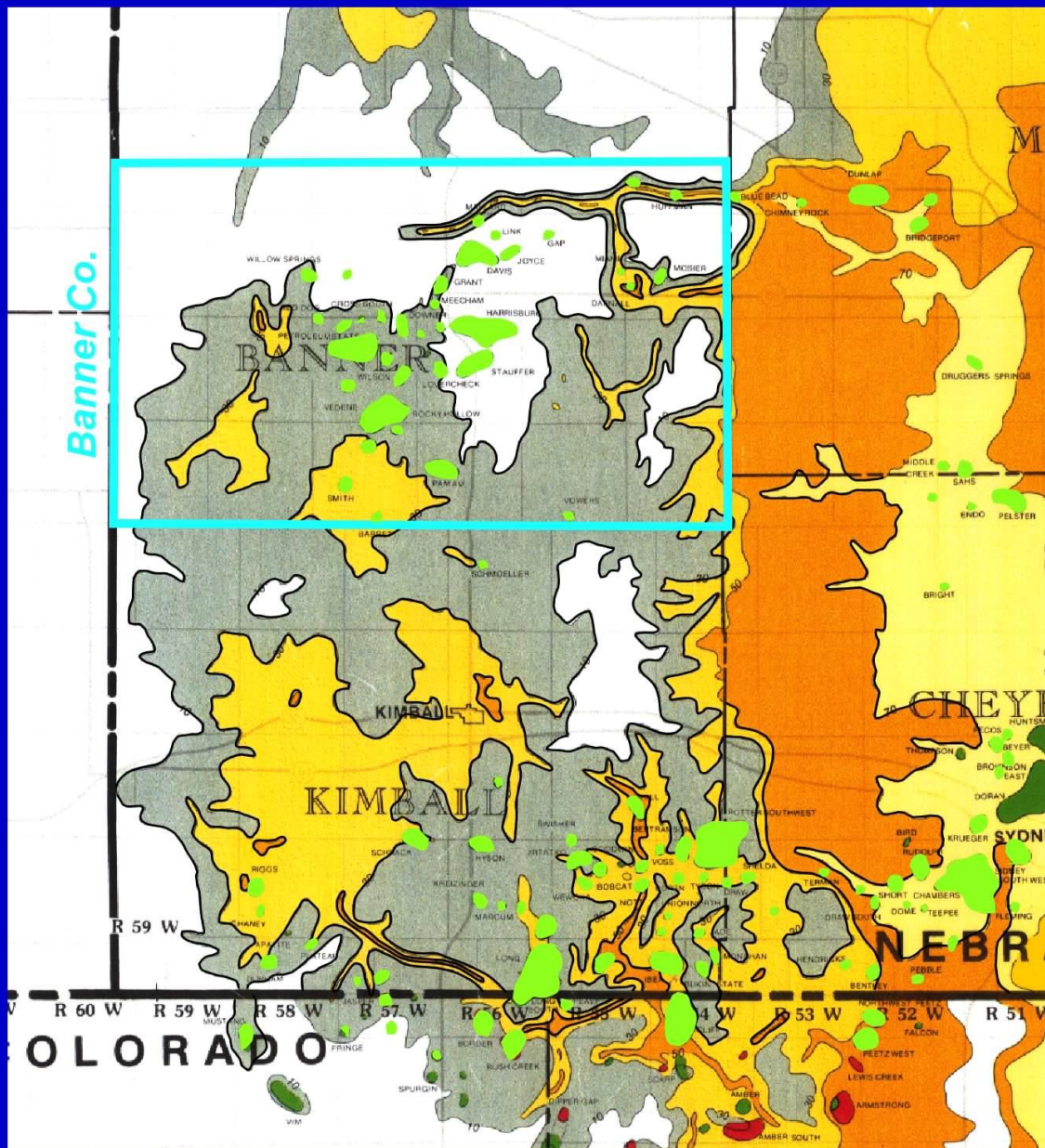
### "D" Sandstone Isopach



# "D" SANDSTONE ISOPACH

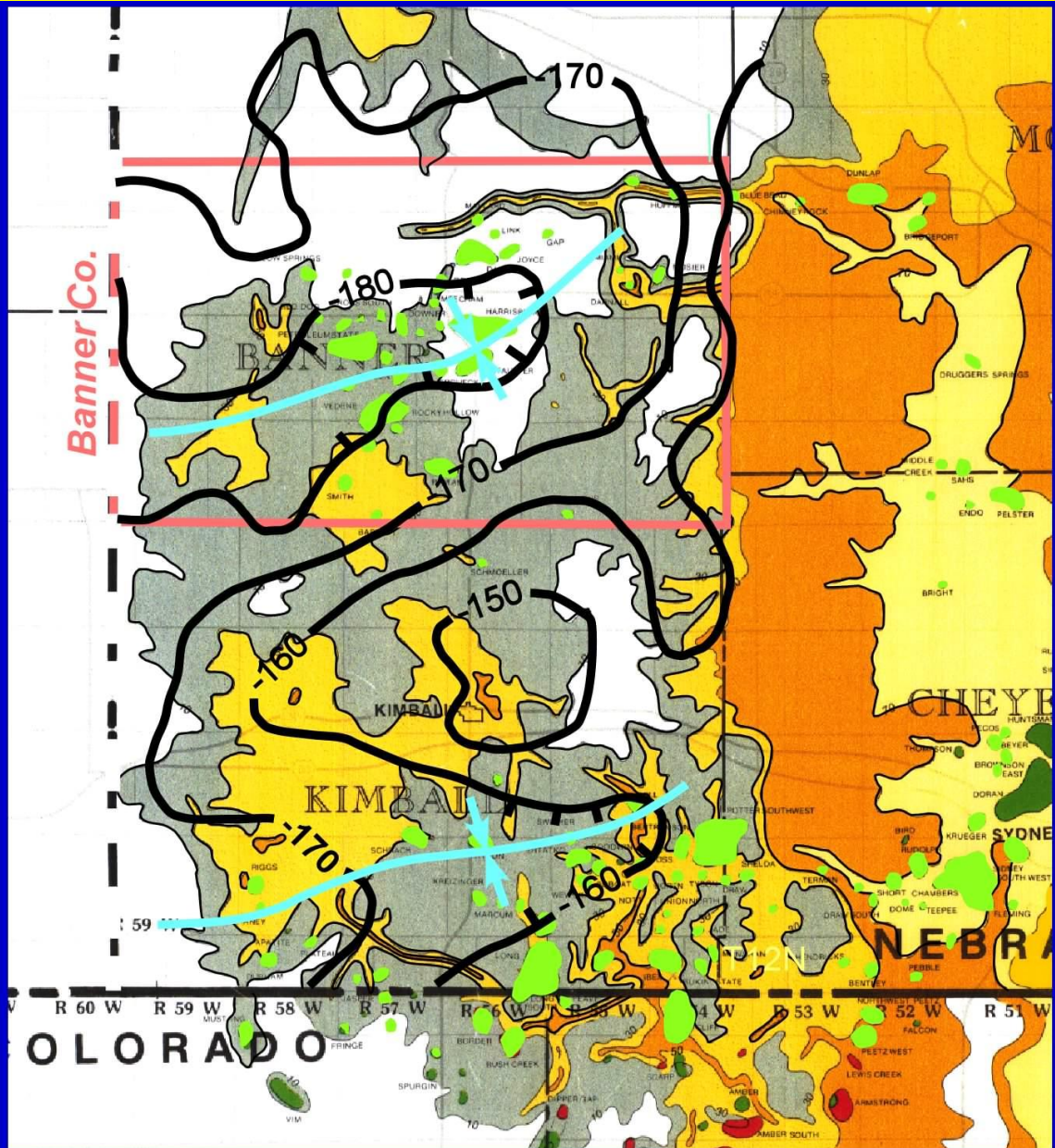
## Northern Denver Basin

### "D" Sandstone Isopach



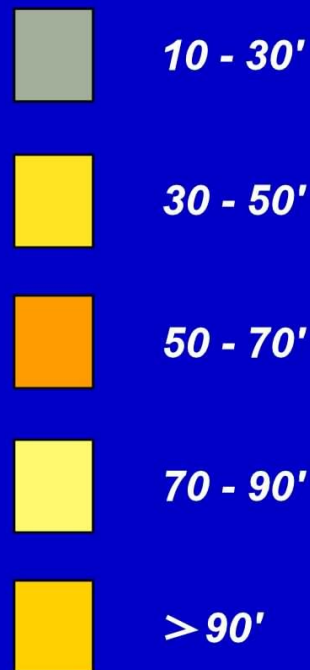


# "D" SANDSTONE ISOPACH & GRAVITY

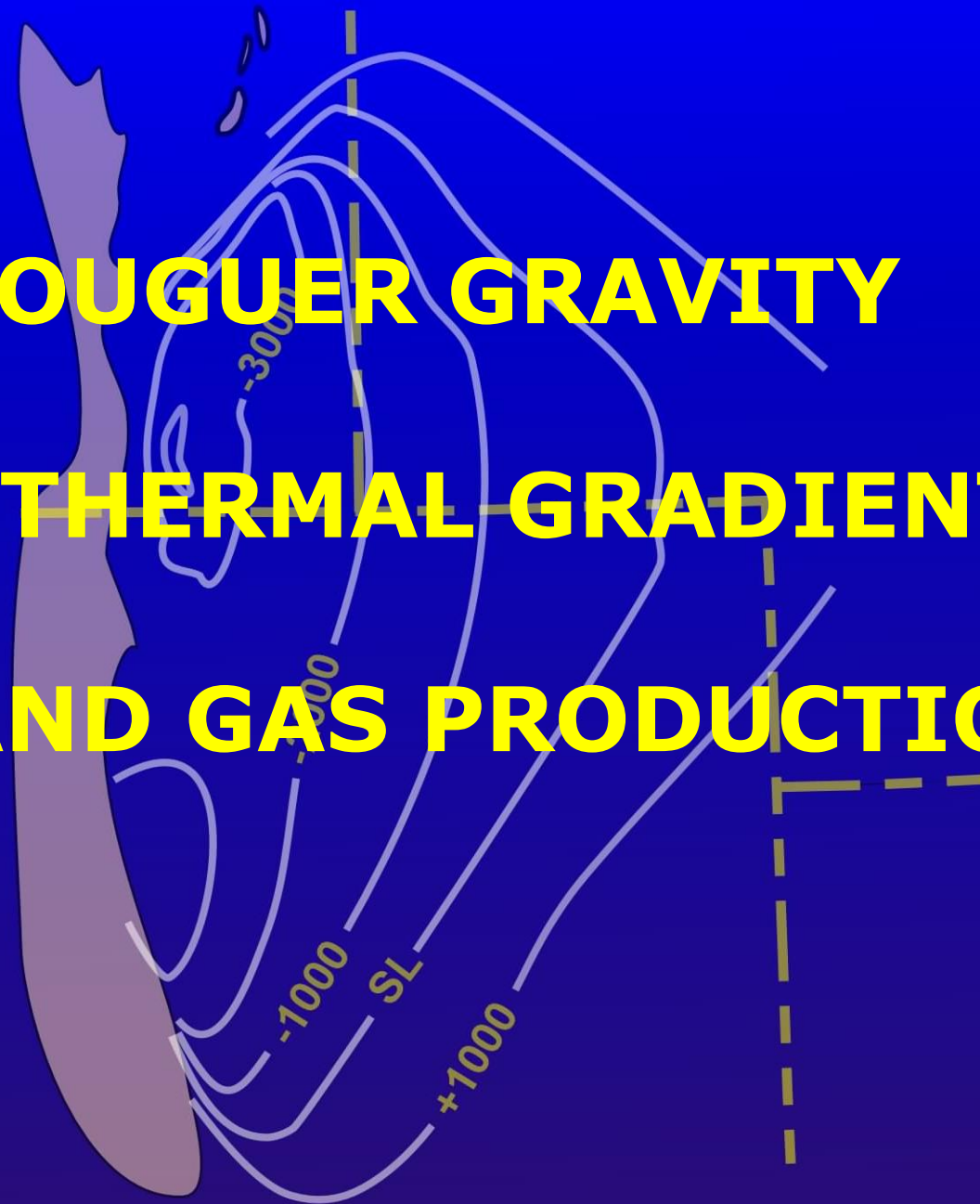


## Northern Denver Basin

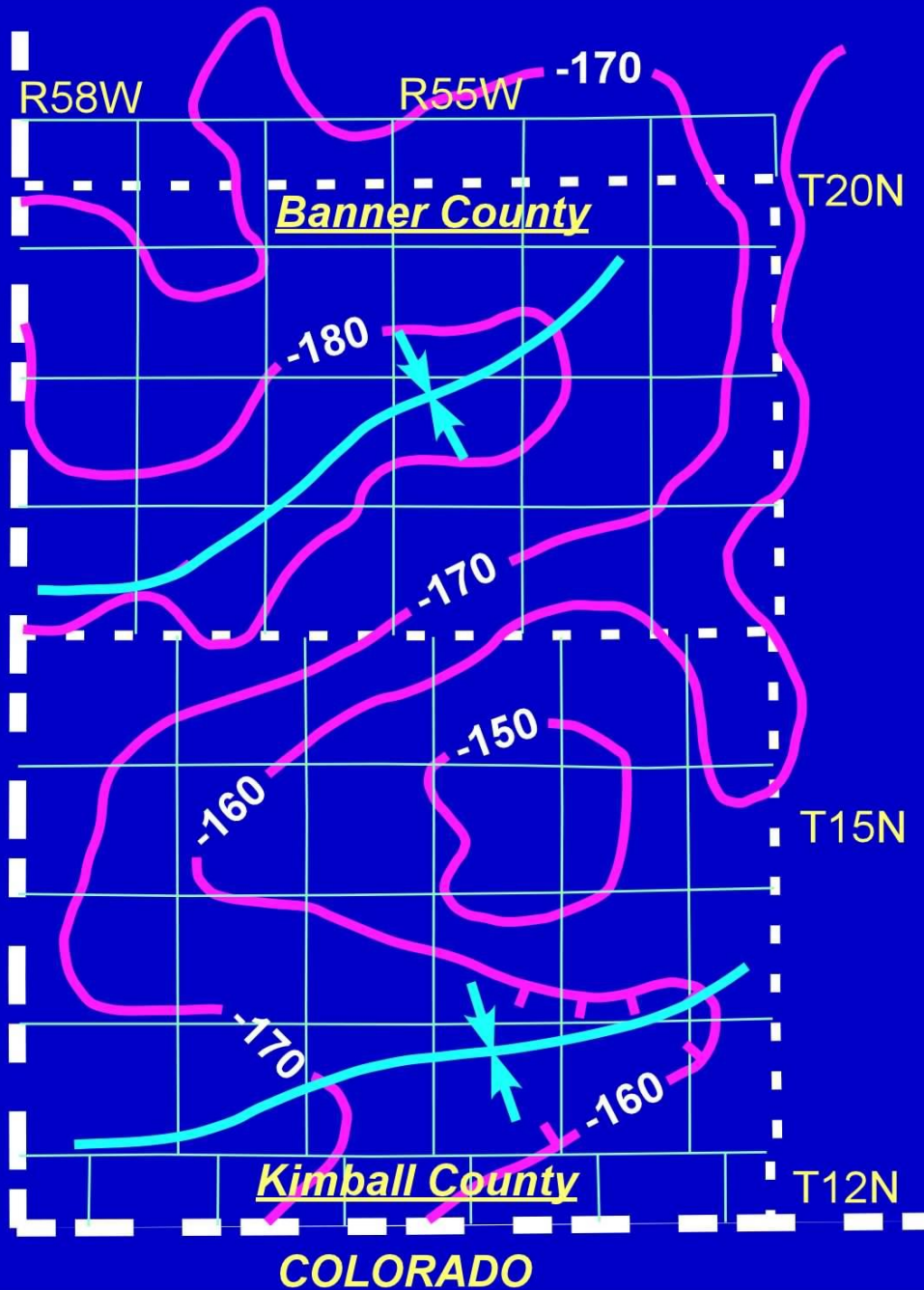
### "D" Sandstone Isopach



**BOUGUER GRAVITY**  
**GEO THERMAL GRADIENT**  
**OIL AND GAS PRODUCTION**

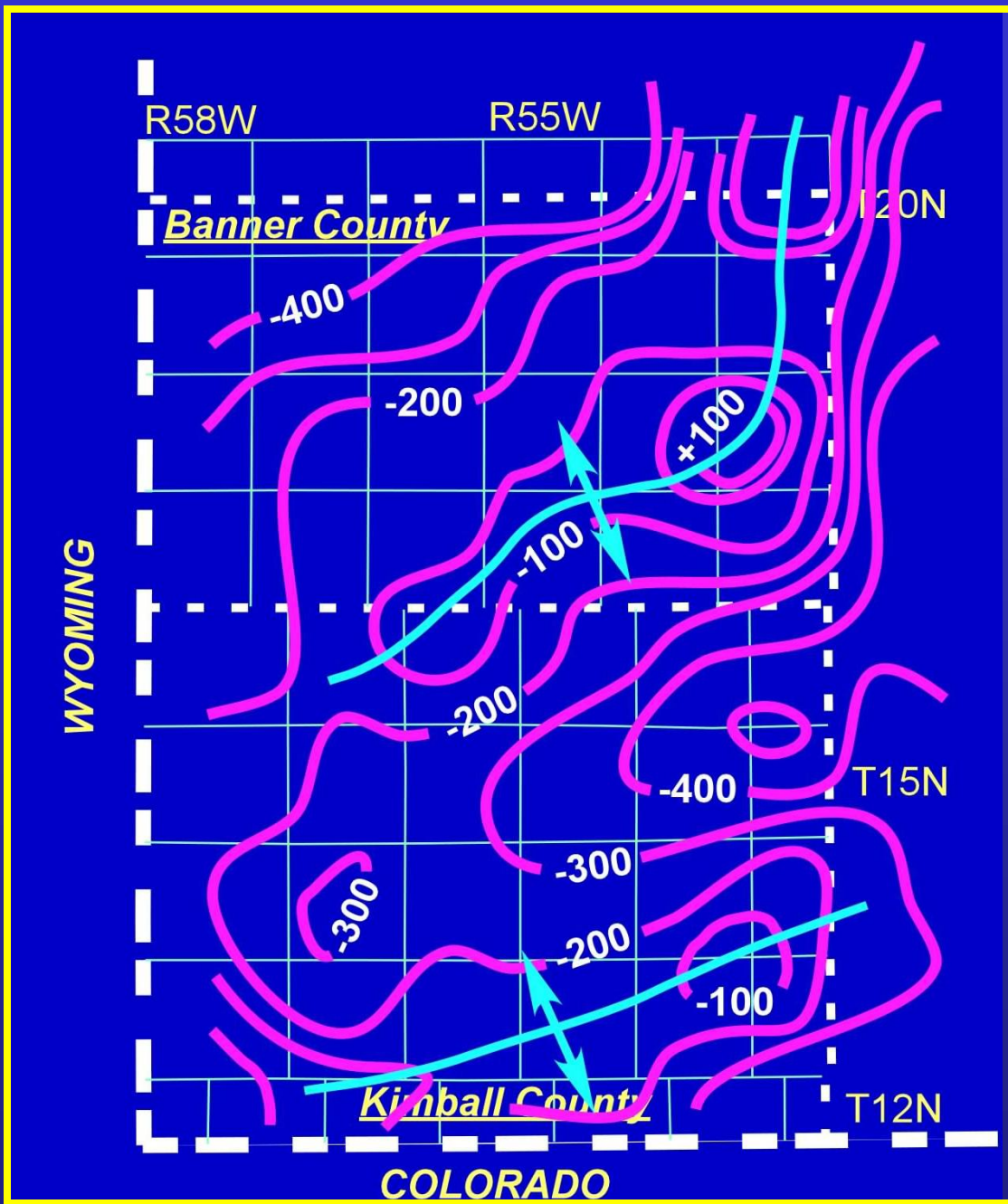


WYOMING



COLORADO

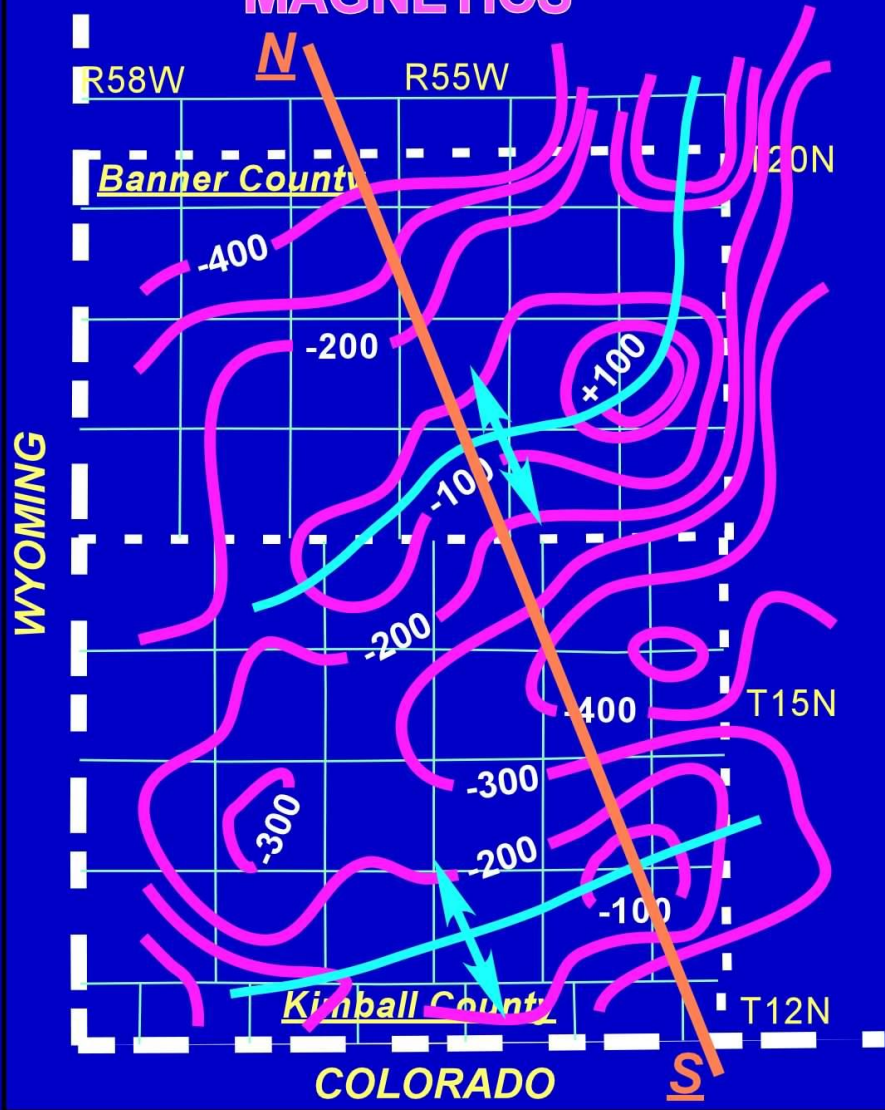
**Bouguer  
Gravity**  
**C.I. = 10 mg.**



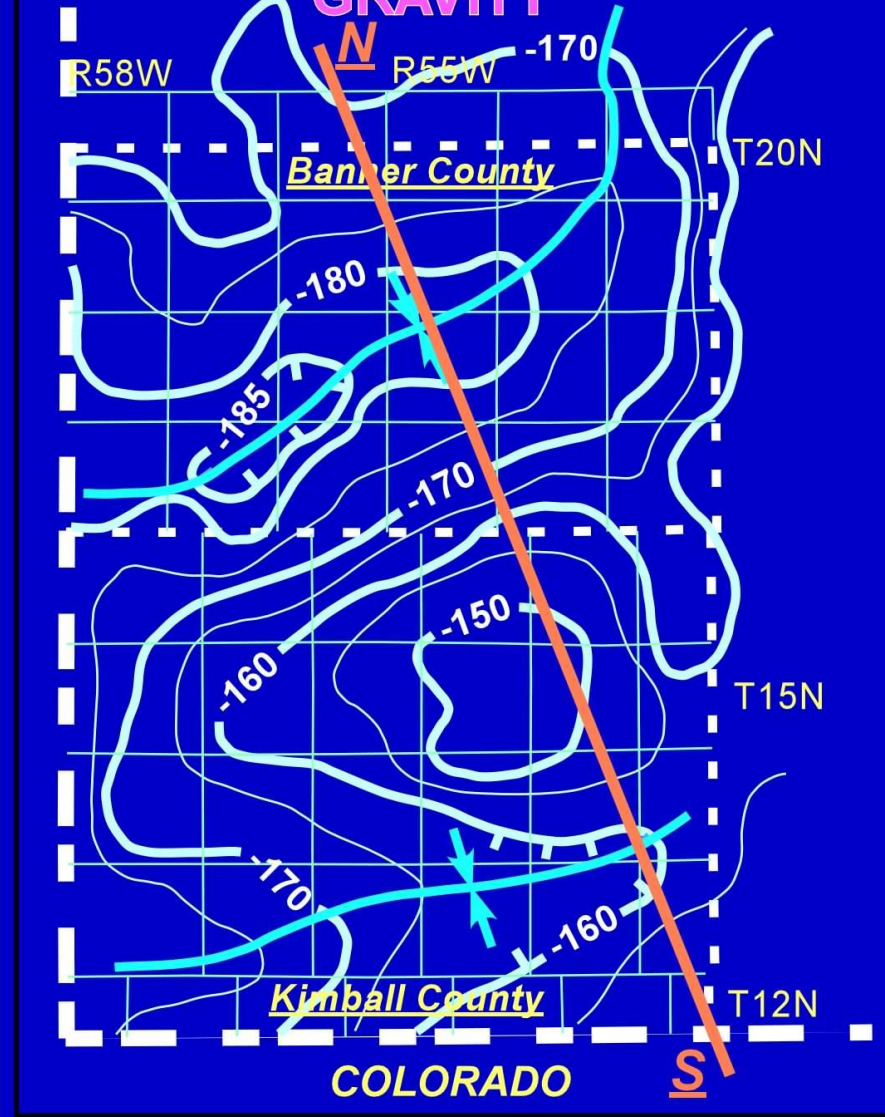
## Aeromagnetics

C.I. = 100 g.

# MAGNETICS

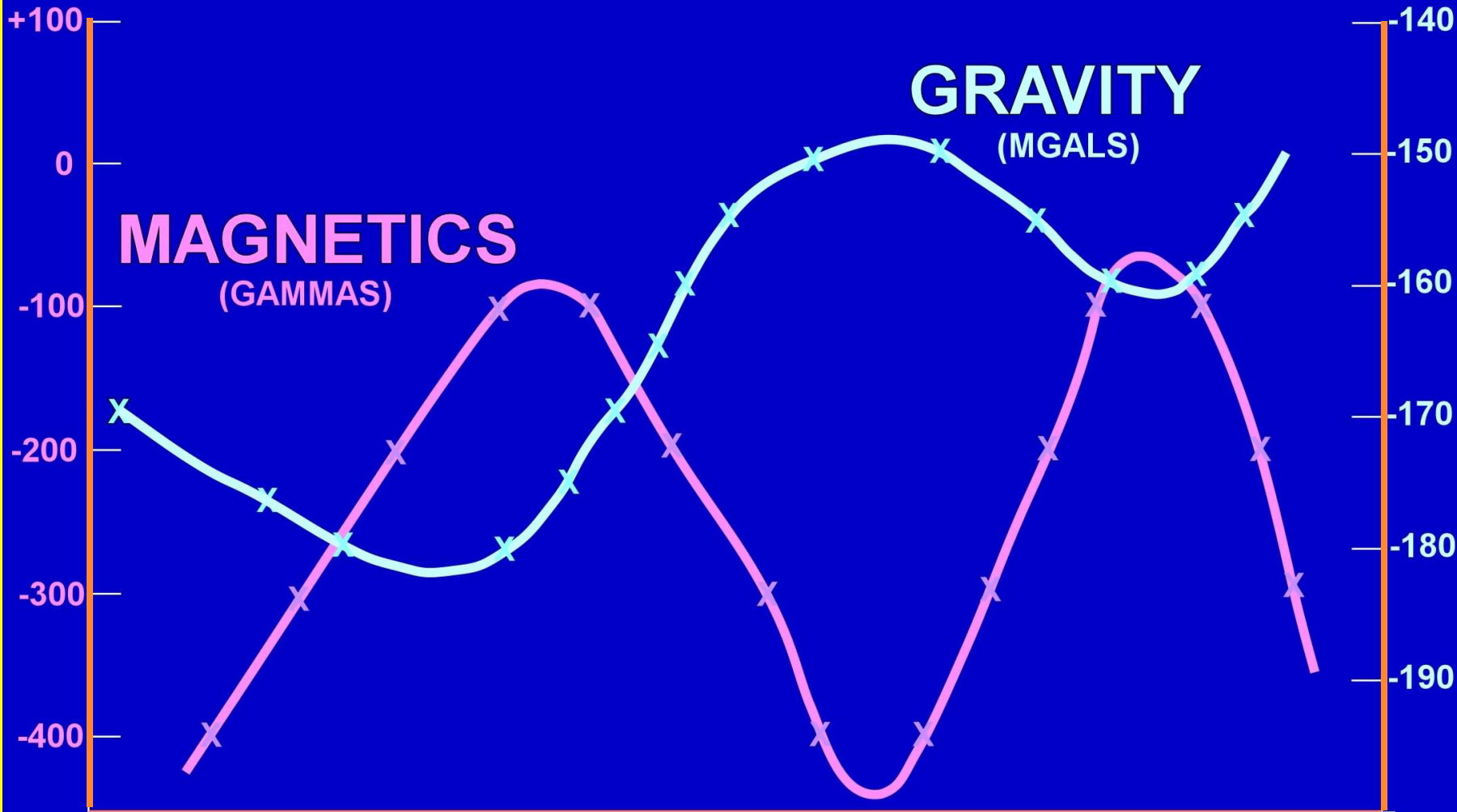


# GRAVITY



**N**

# Northern Denver Basin

**S**

# Denver Basin Subsurface Precambrian Rocks

(after Tweto, 1980)

WY

CO

NE

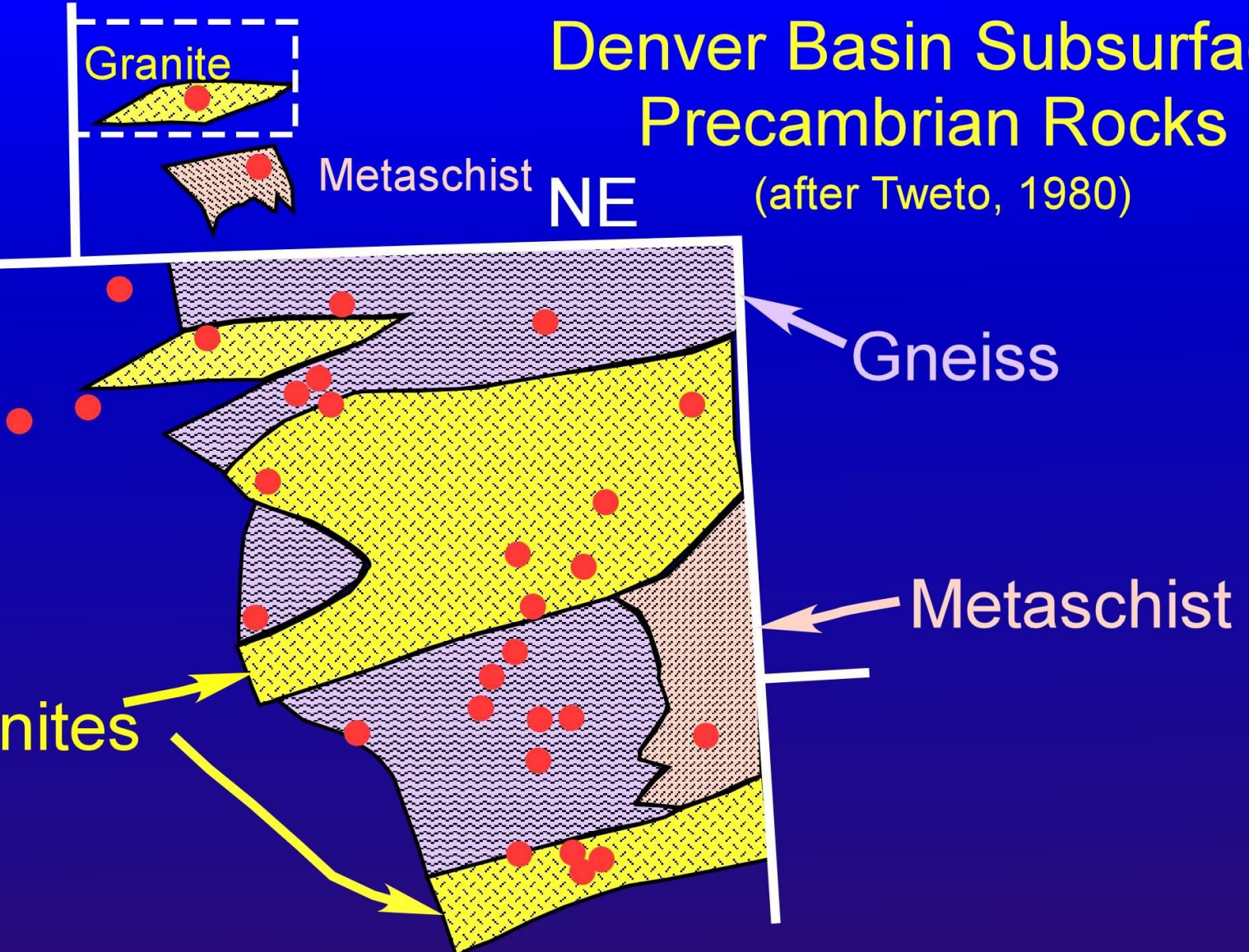
Granite

Metaschist

Gneiss

Metaschist

Granites



# MAGNETIC SUSCEPTIBILITY ( $\times 10^6$ )

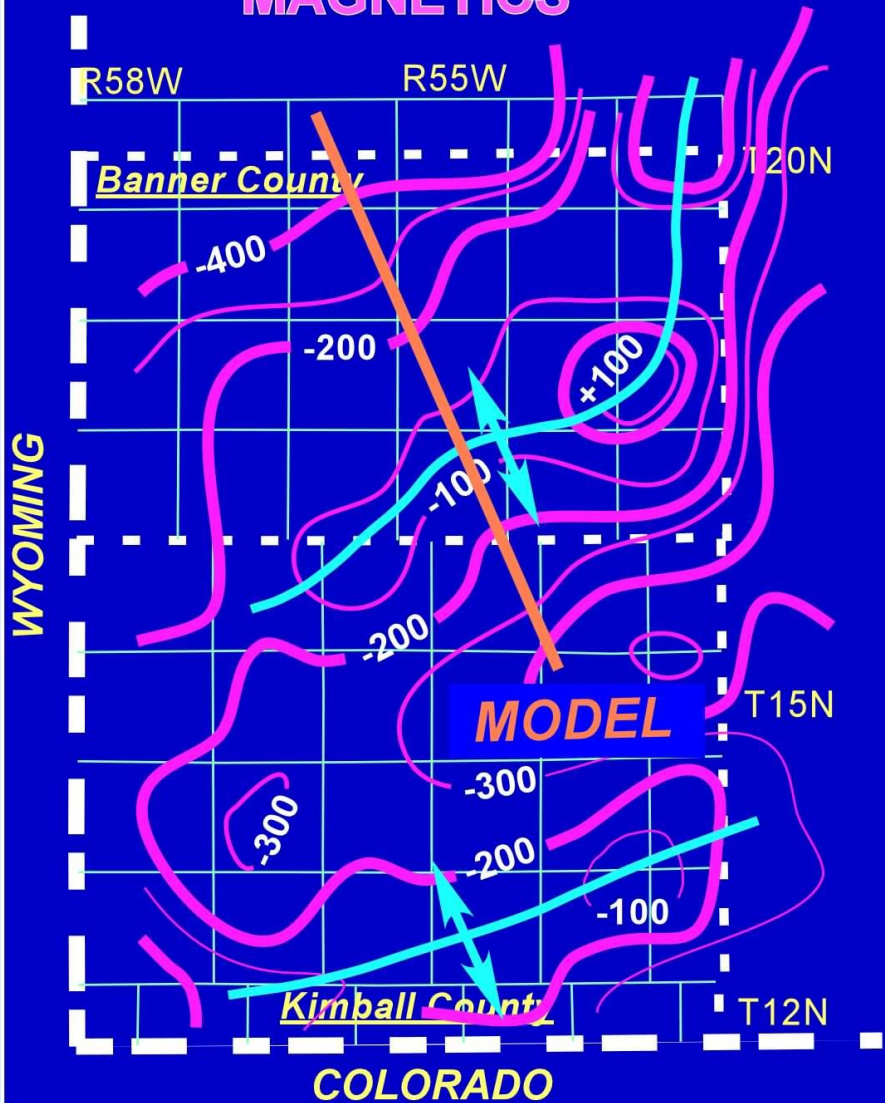
# DENSITY

	Range	Average
Granite	0-4000	200
Schist	25-240	120
Gneiss	10-2000	130

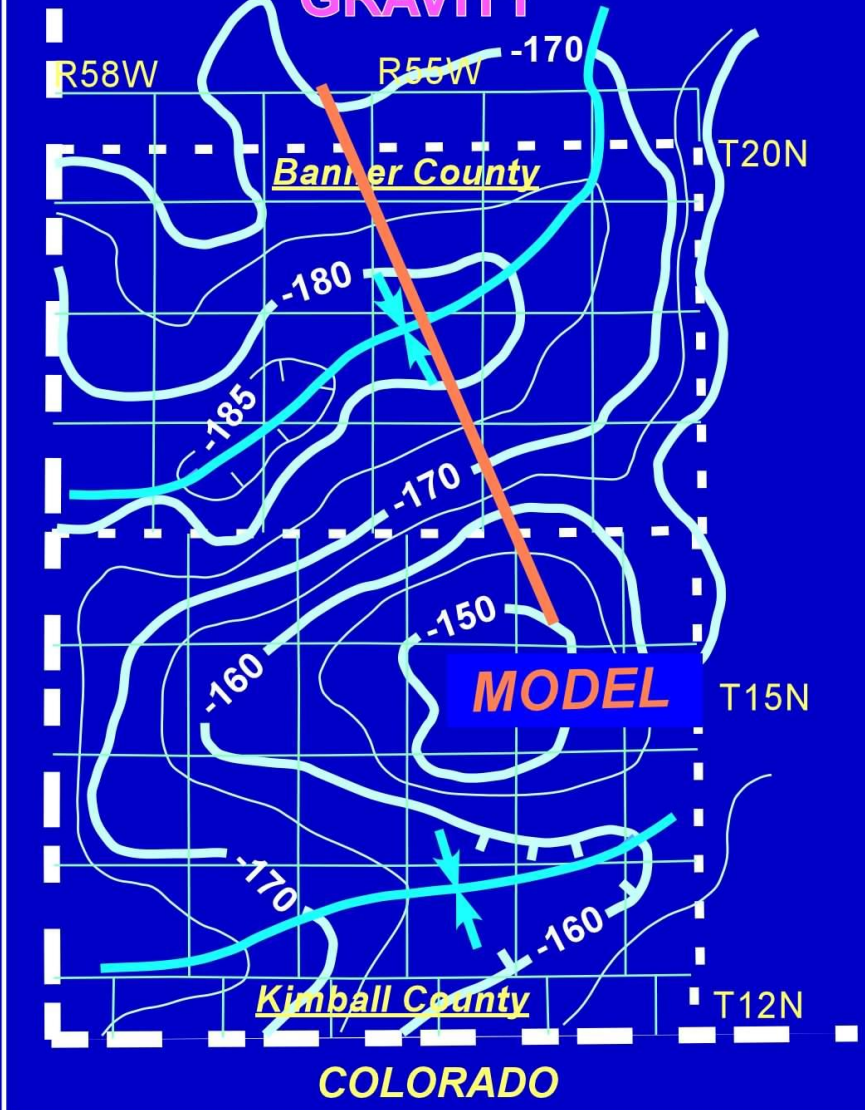
	Range	Average
Granite	2.5-2.8	2.6
Schist	2.7-2.9	2.8
Gneiss	2.6-3.0	2.7

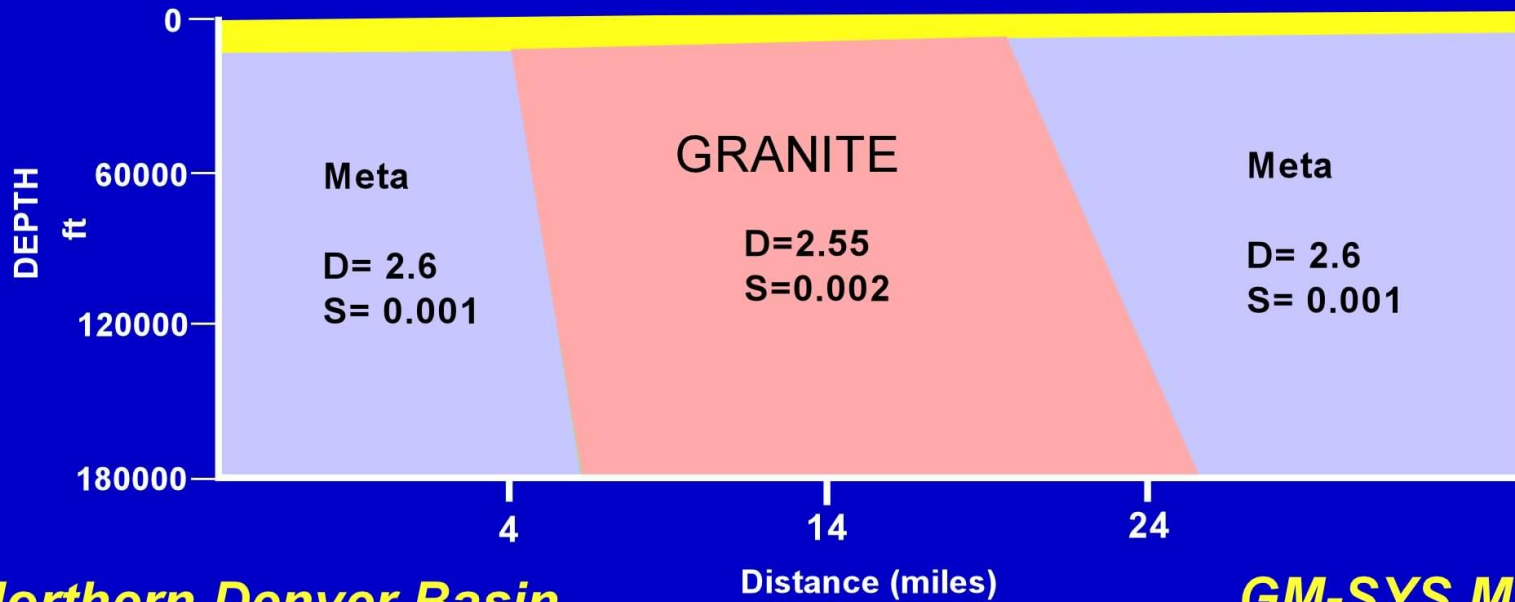
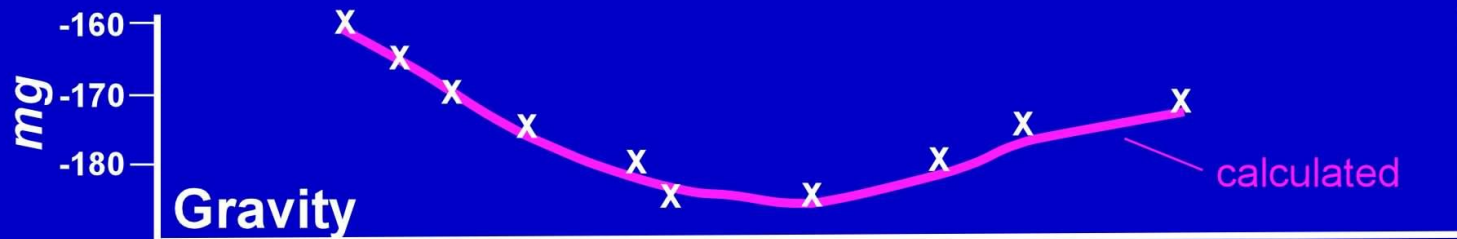
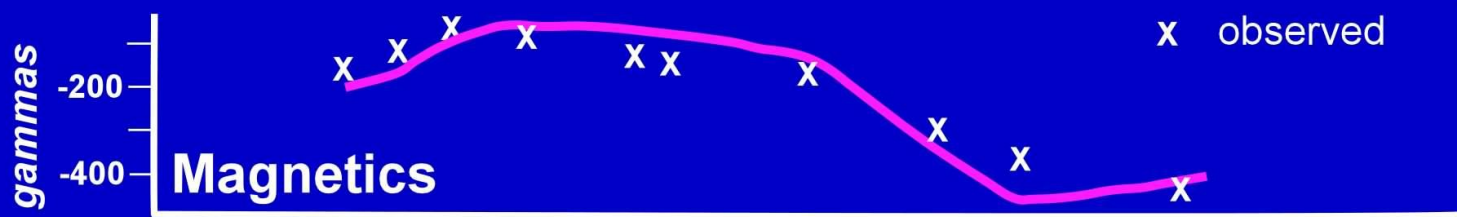


# MAGNETICS



# GRAVITY



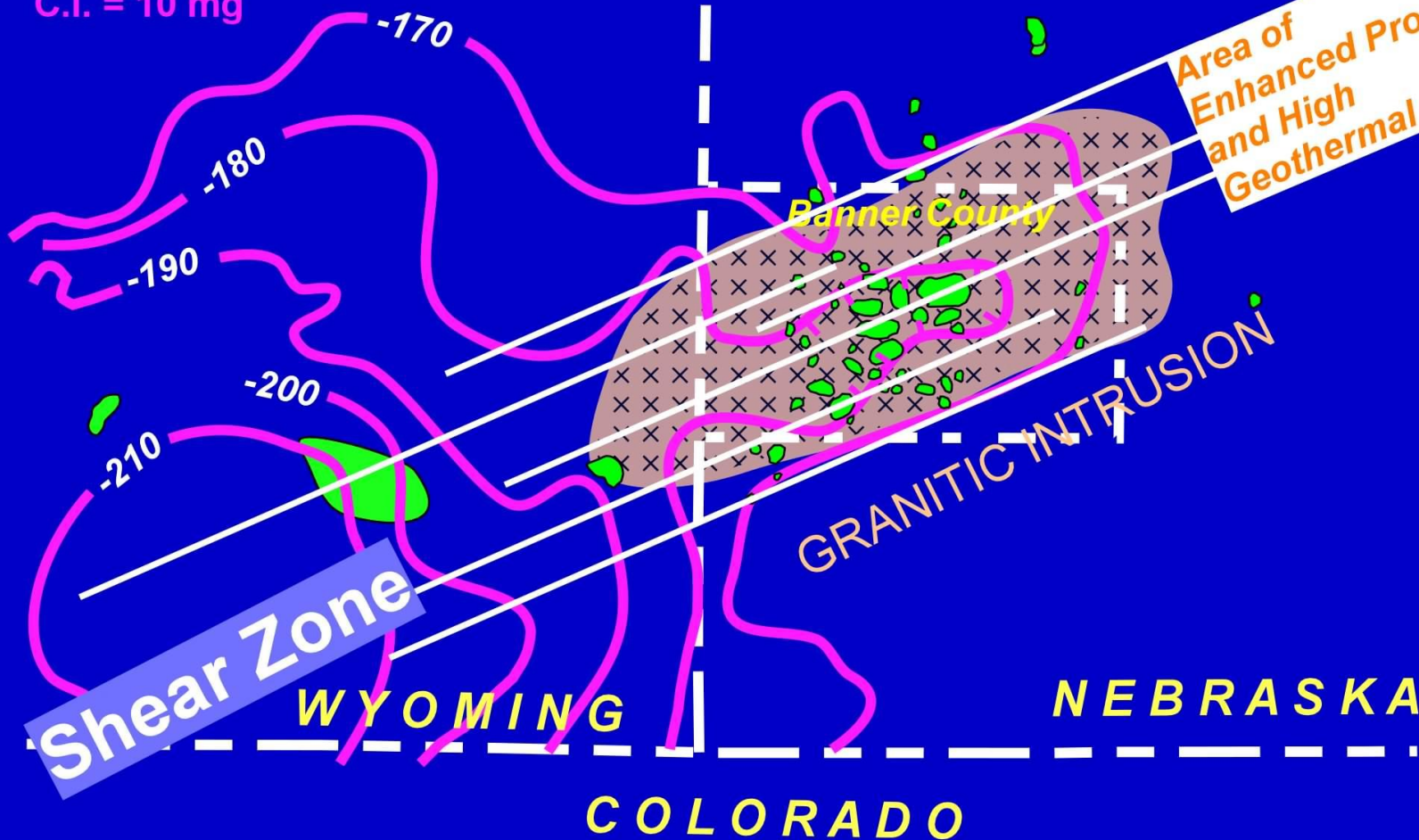


**Northern Denver Basin**

**GM-SYS Model**

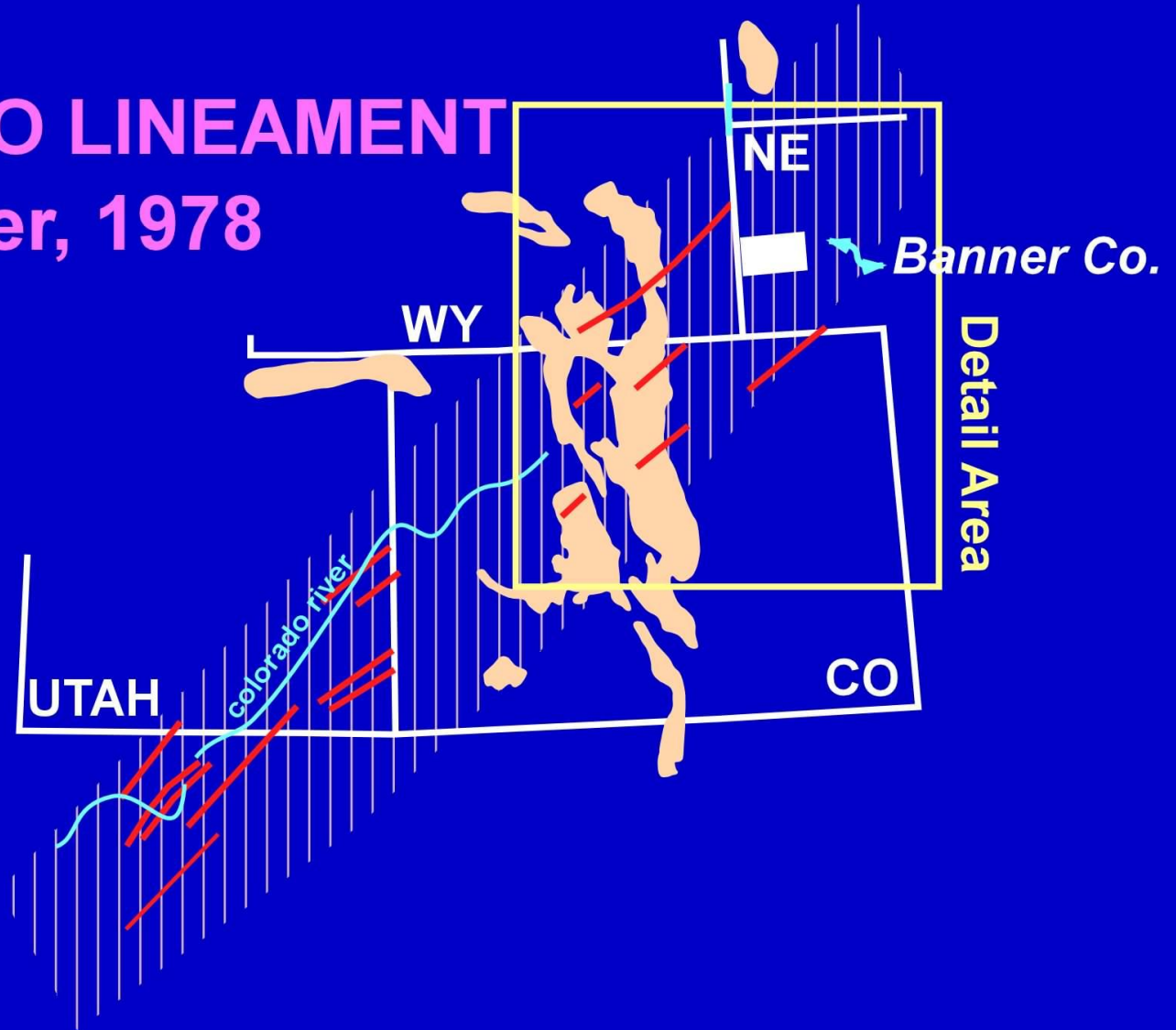
# NORTHERN DENVER BASIN

Bouguer Gravity Map  
C.I. = 10 mg



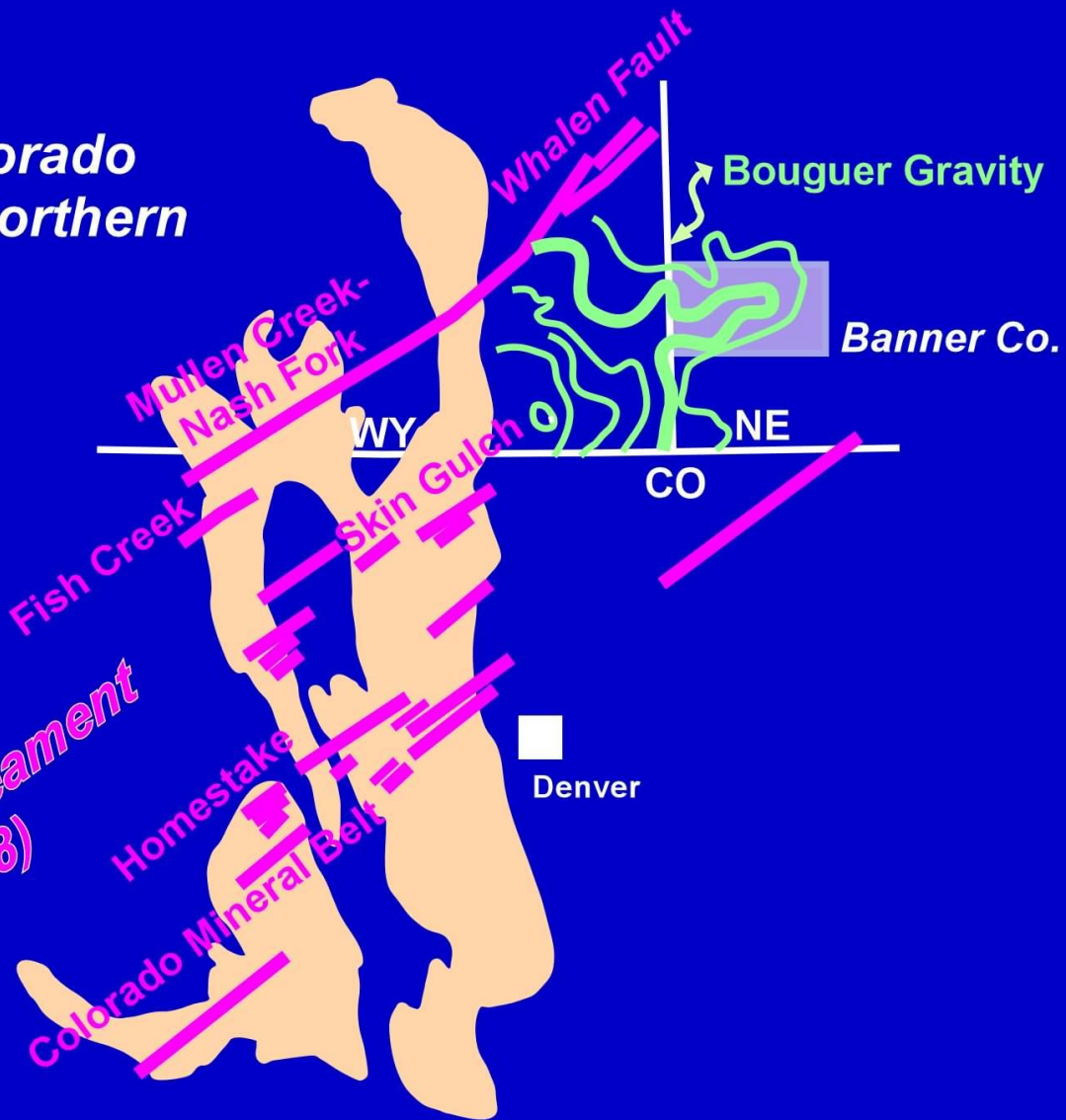
# COLORADO LINEAMENT

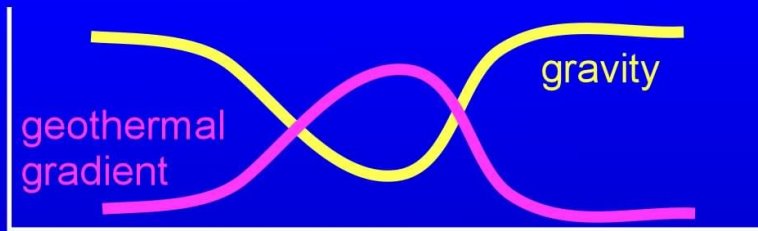
Warner, 1978



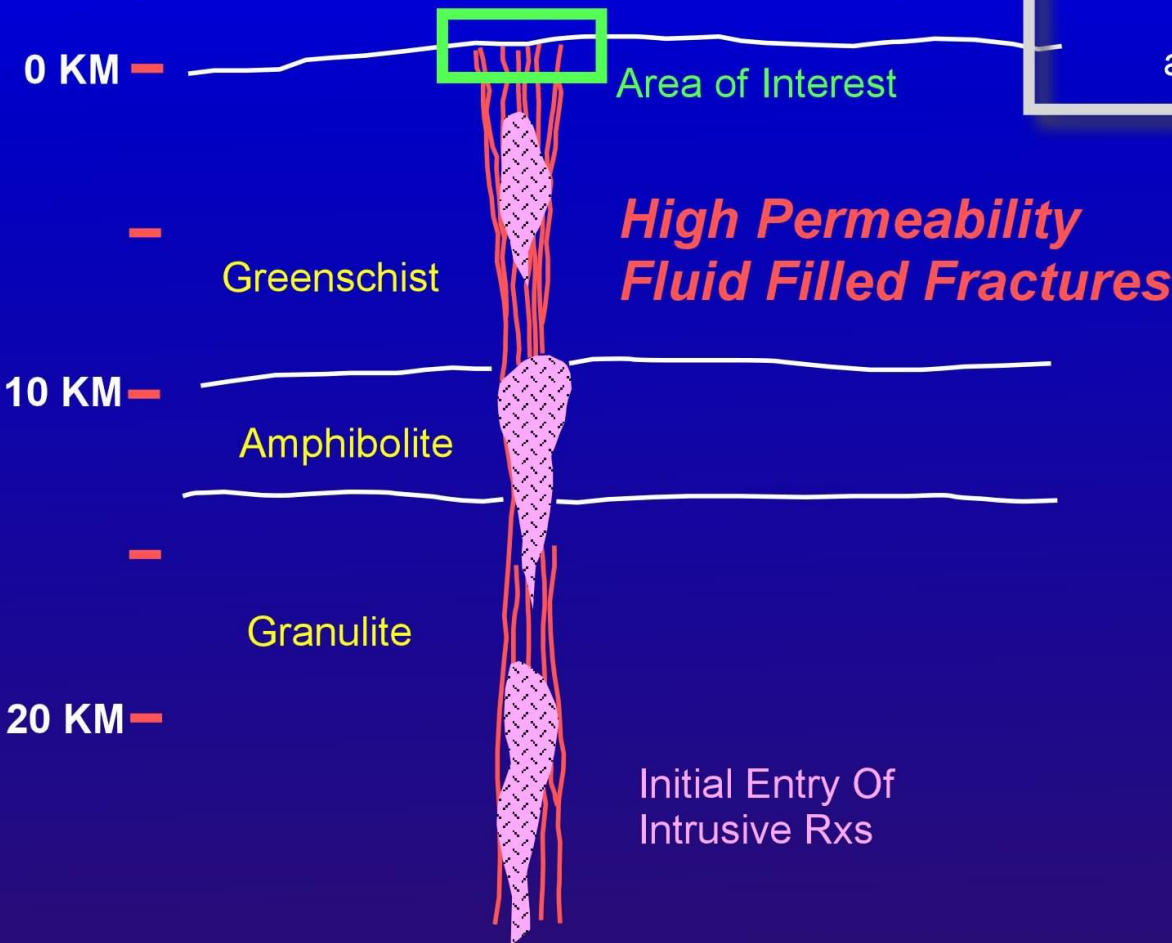
# Extension of Colorado Lineament into Northern Denver Basin

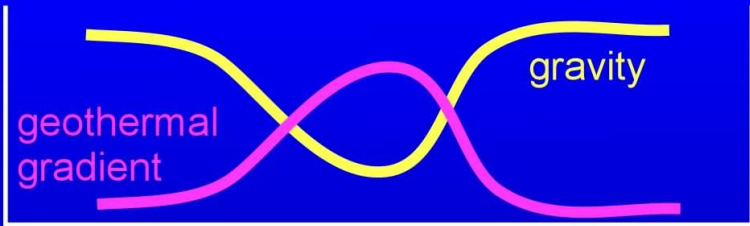
Colorado Lineament  
(Warner, 1978)



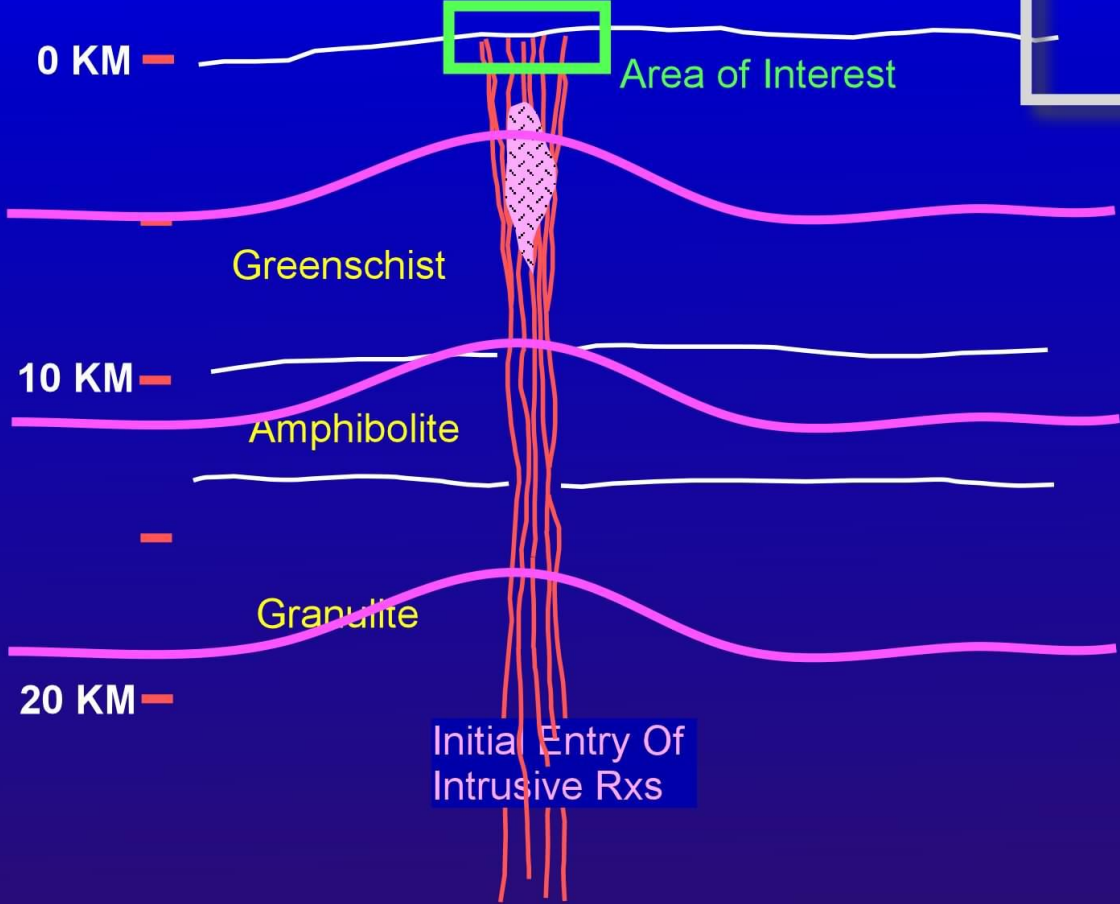


Northern Denver Basin  
Fracture Model  
after (Swan, 1990)

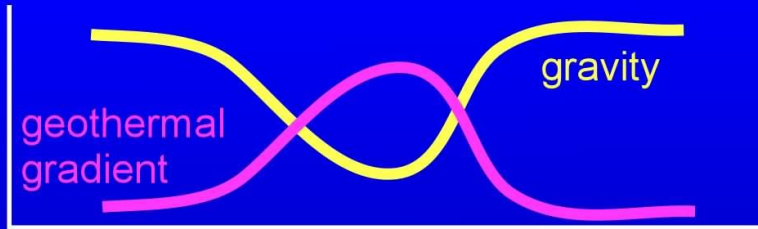




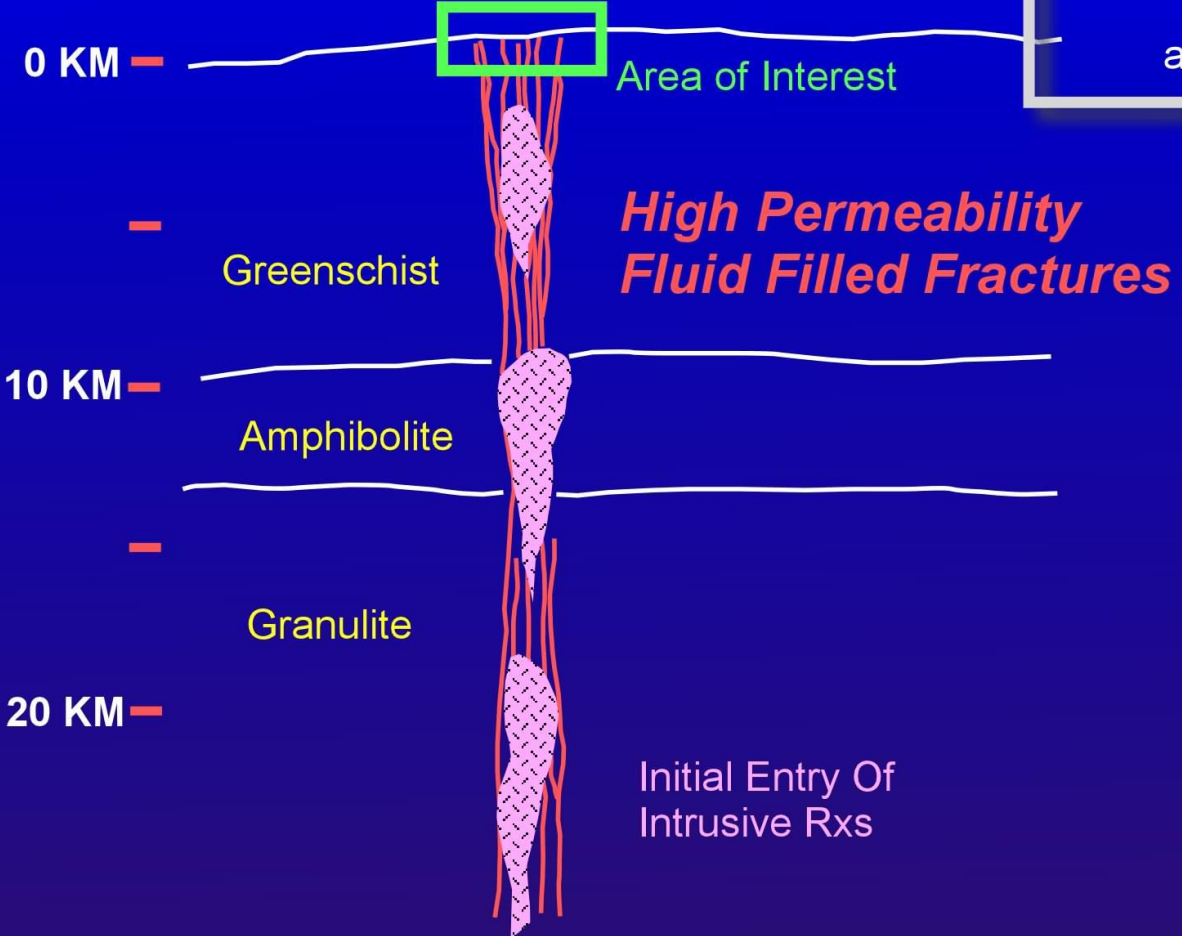
Northern Denver Basin  
Fracture Model  
after (Swan, 1990)



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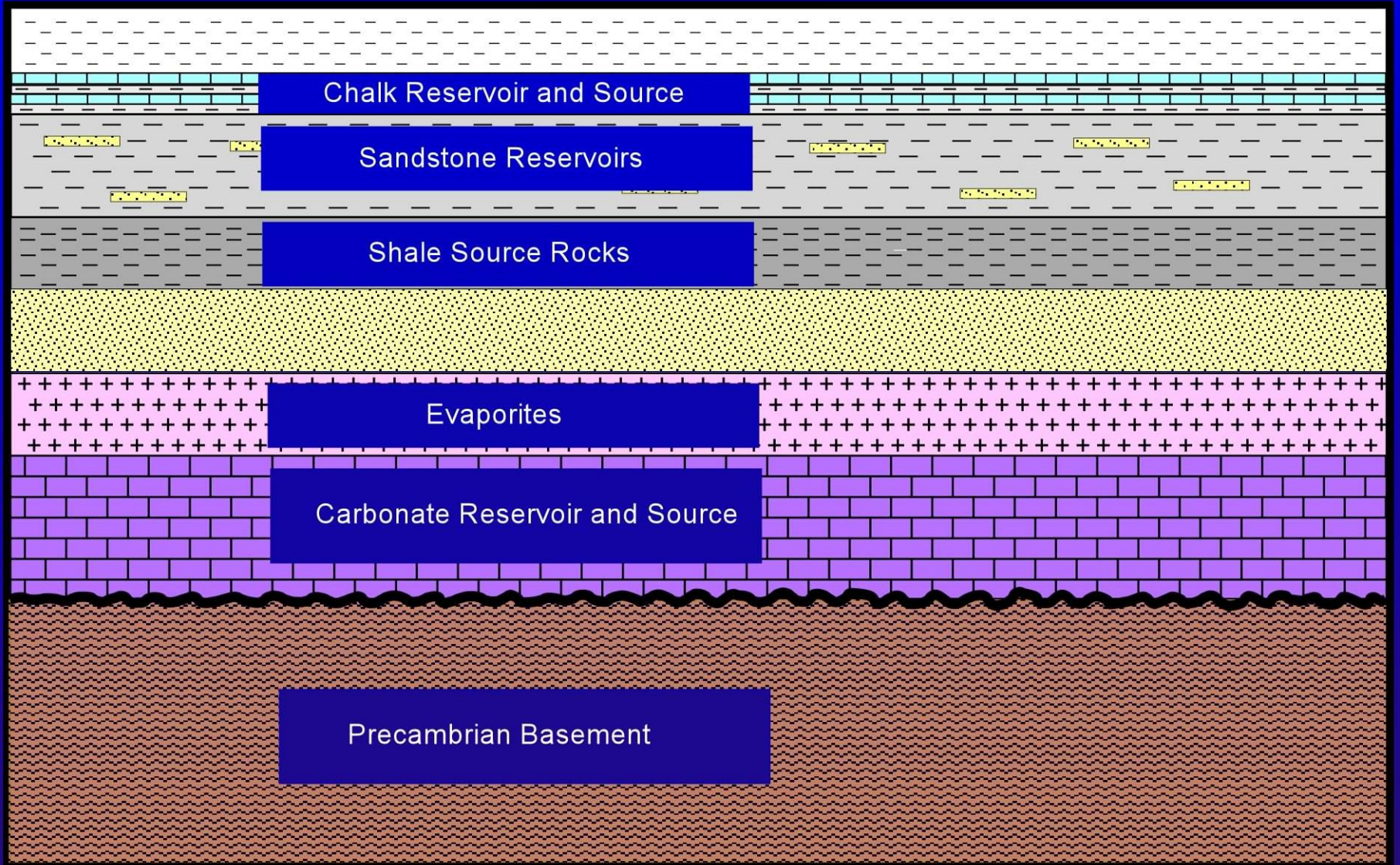


Northern Denver Basin  
Fracture Model  
after (Swan, 1990)

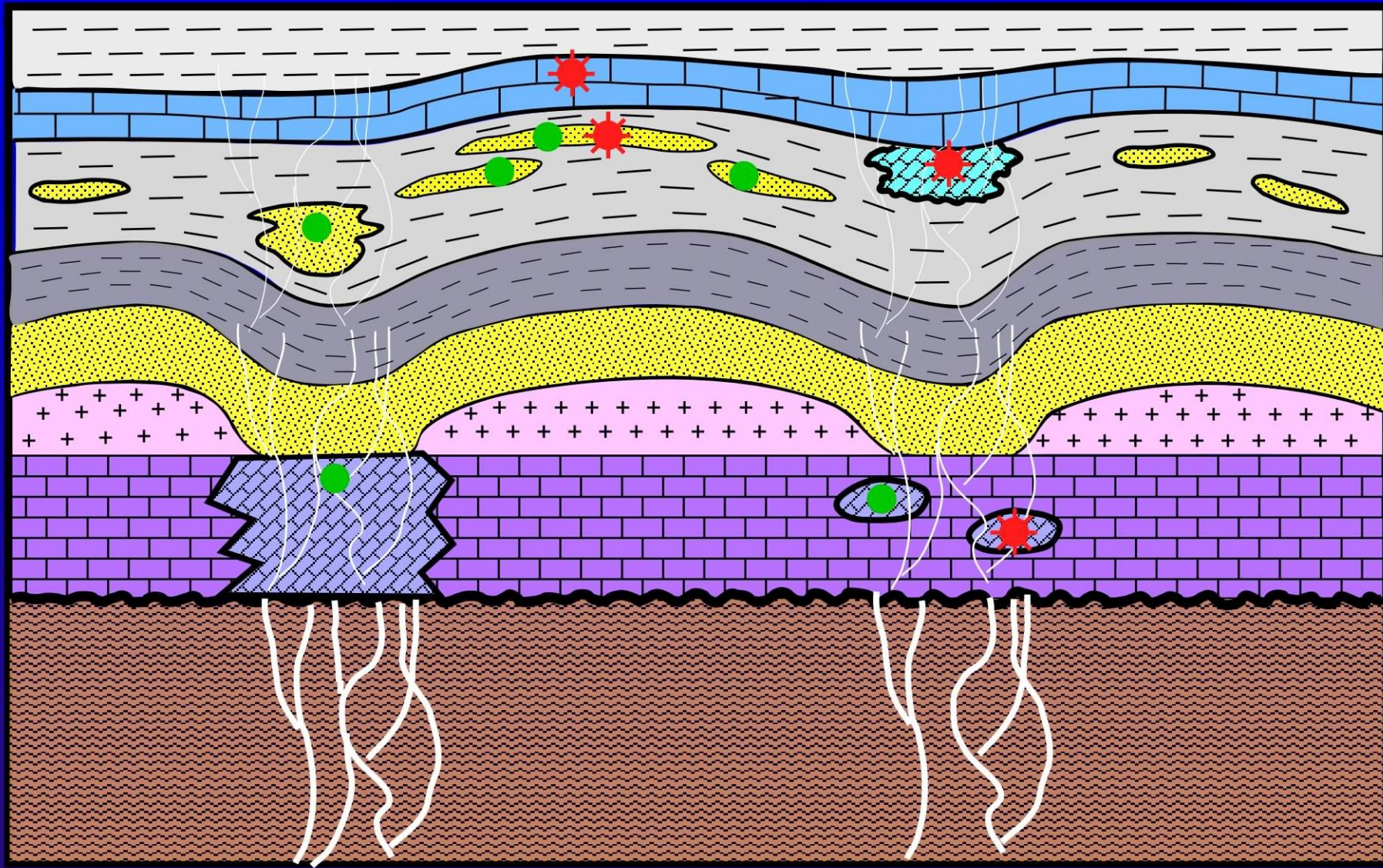




# Northern Denver Basin

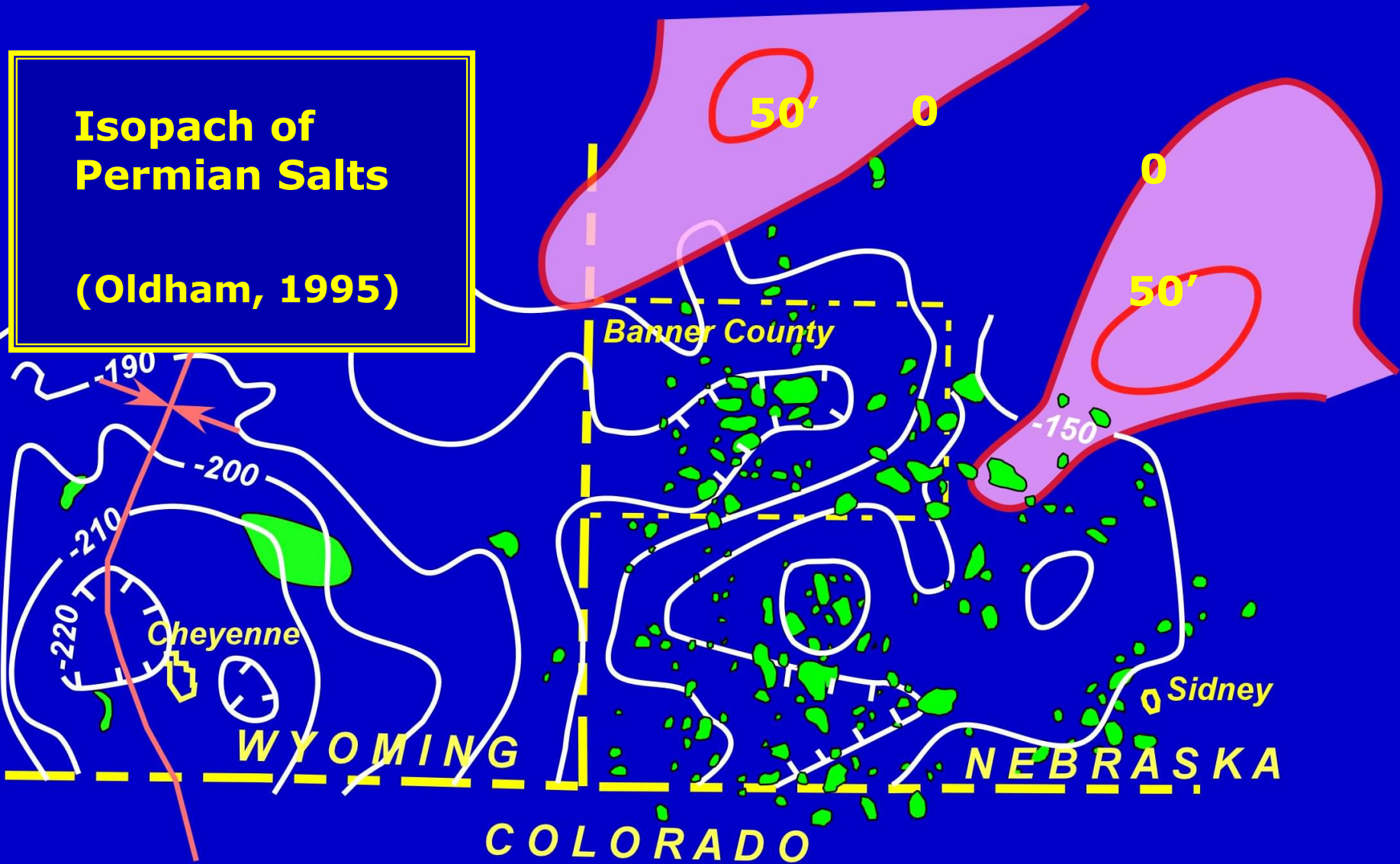


# Northern Denver Basin

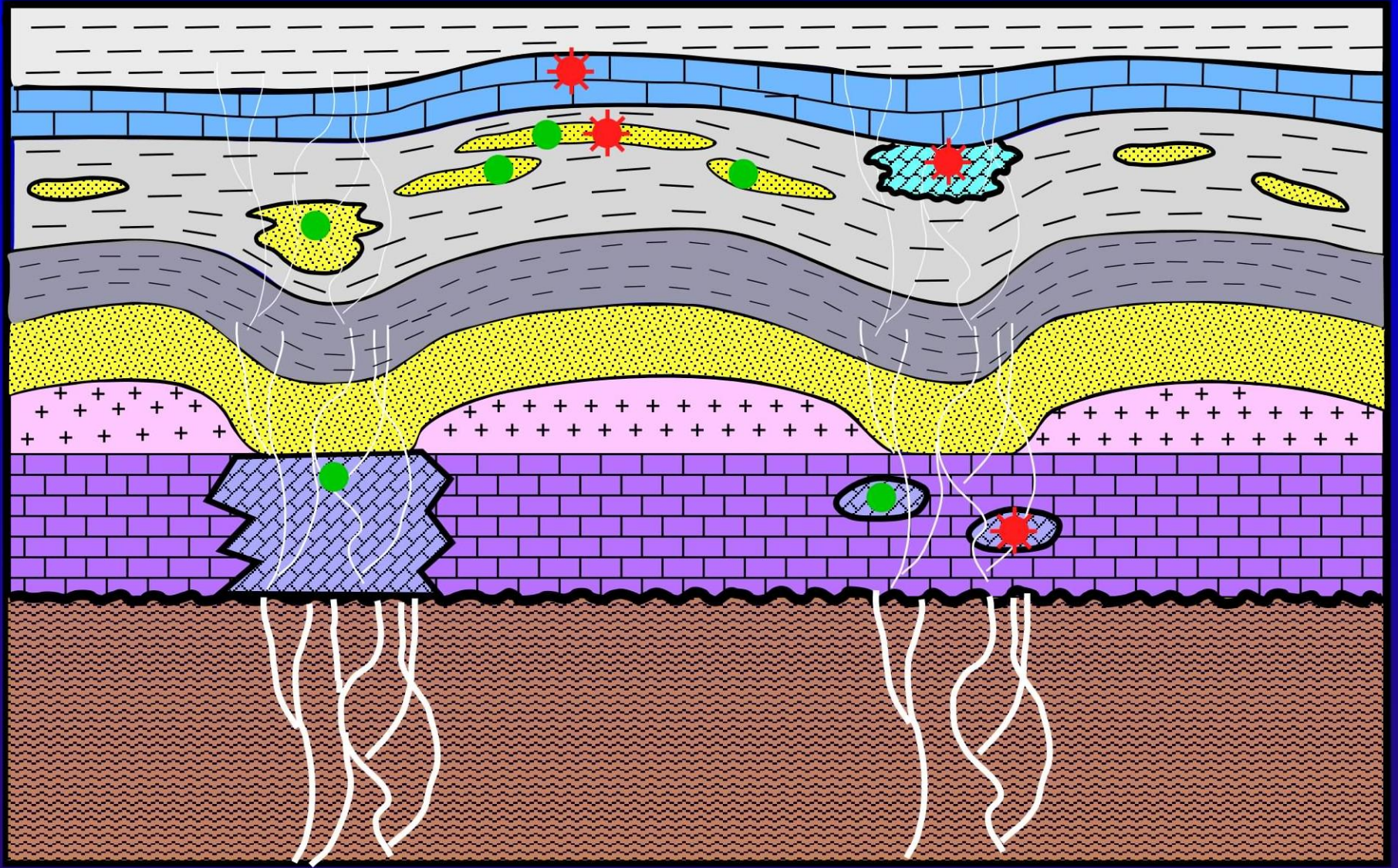


# GRAVITY AND SALT DISTRIBUTION

**Isopach of  
Permian Salts  
(Oldham, 1995)**

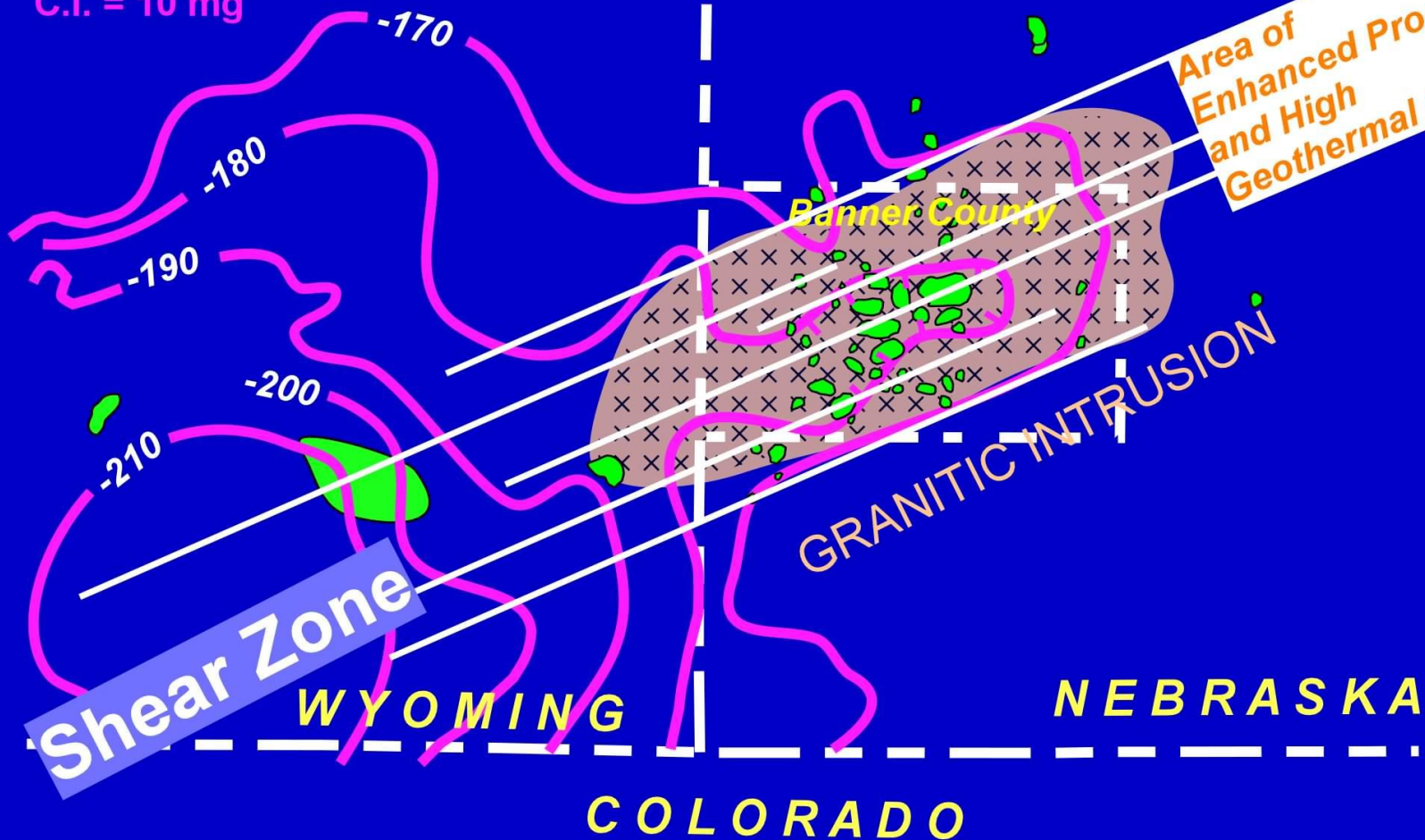


# Northern Denver Basin



# NORTHERN DENVER BASIN

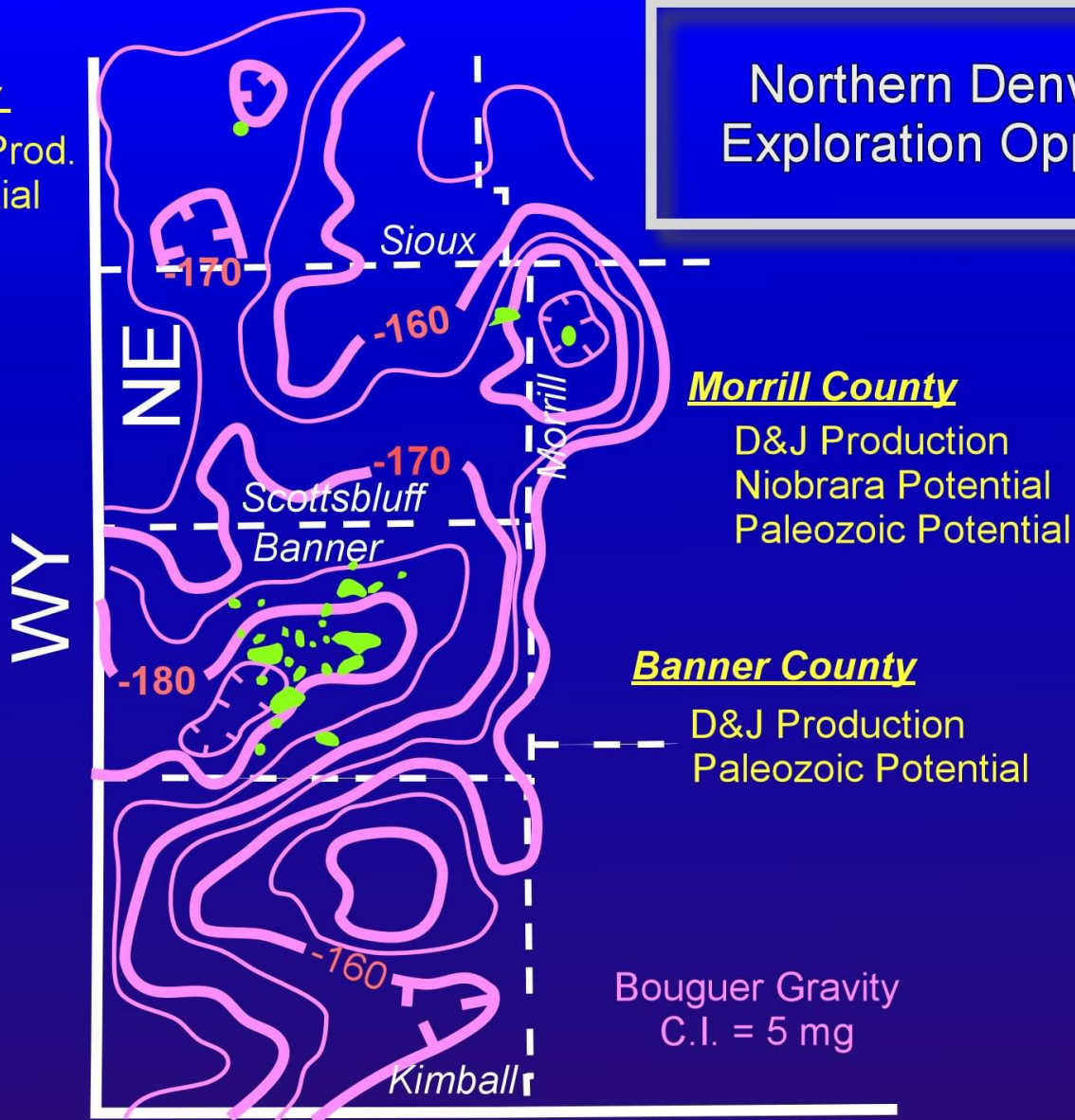
Bouguer Gravity Map  
C.I. = 10 mg



# Northern Denver Basin Exploration Opportunities

## Sioux County

Paleozoic Prod.  
D&J Potential



## Morrill County

D&J Production  
Niobrara Potential  
Paleozoic Potential

## Banner County

D&J Production  
Paleozoic Potential

Bouguer Gravity  
C.I. = 5 mg

# Denver Basin

*Areas of Bouguer Gravity Minima =*

*Areas of High Geothermal Gradient =*

*Areas of Production*

