

# Geologic Map of Montana

## Montana Bureau of Mines and Geology



Butte – MT Tech



Billings

Energy and Telecommunication Interim Committee  
March 15, 2024

John Metesh  
Director and State Geologist  
Montana Bureau of Mines and Geology

Background

**HOUSE BILL 333 (61st Legislature)**

**An Act Allowing the Bureau of Mines and Geology to Conduct Geothermal Research**

Section 1. Geothermal research...the Montana Bureau of Mines and Geology shall conduct geothermal research that:

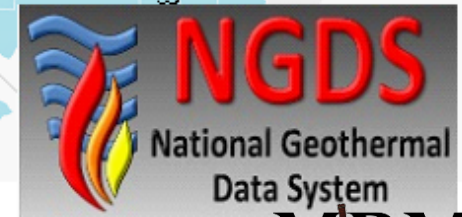
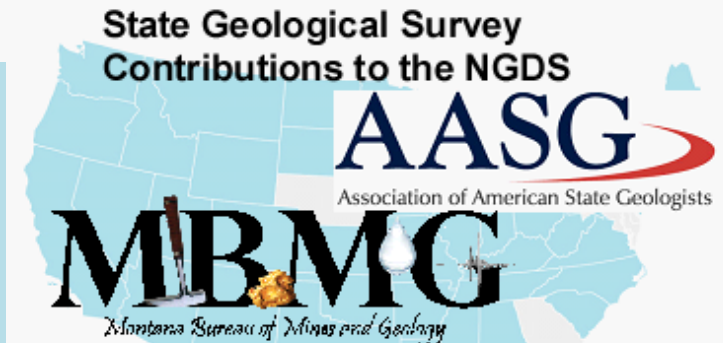
(1a) characterizes the geothermal resource base in Montana;

(6) Prior to September 1 of each even-numbered year, the bureau shall update the energy and telecommunications interim committee on research conducted pursuant to this section and funding received...

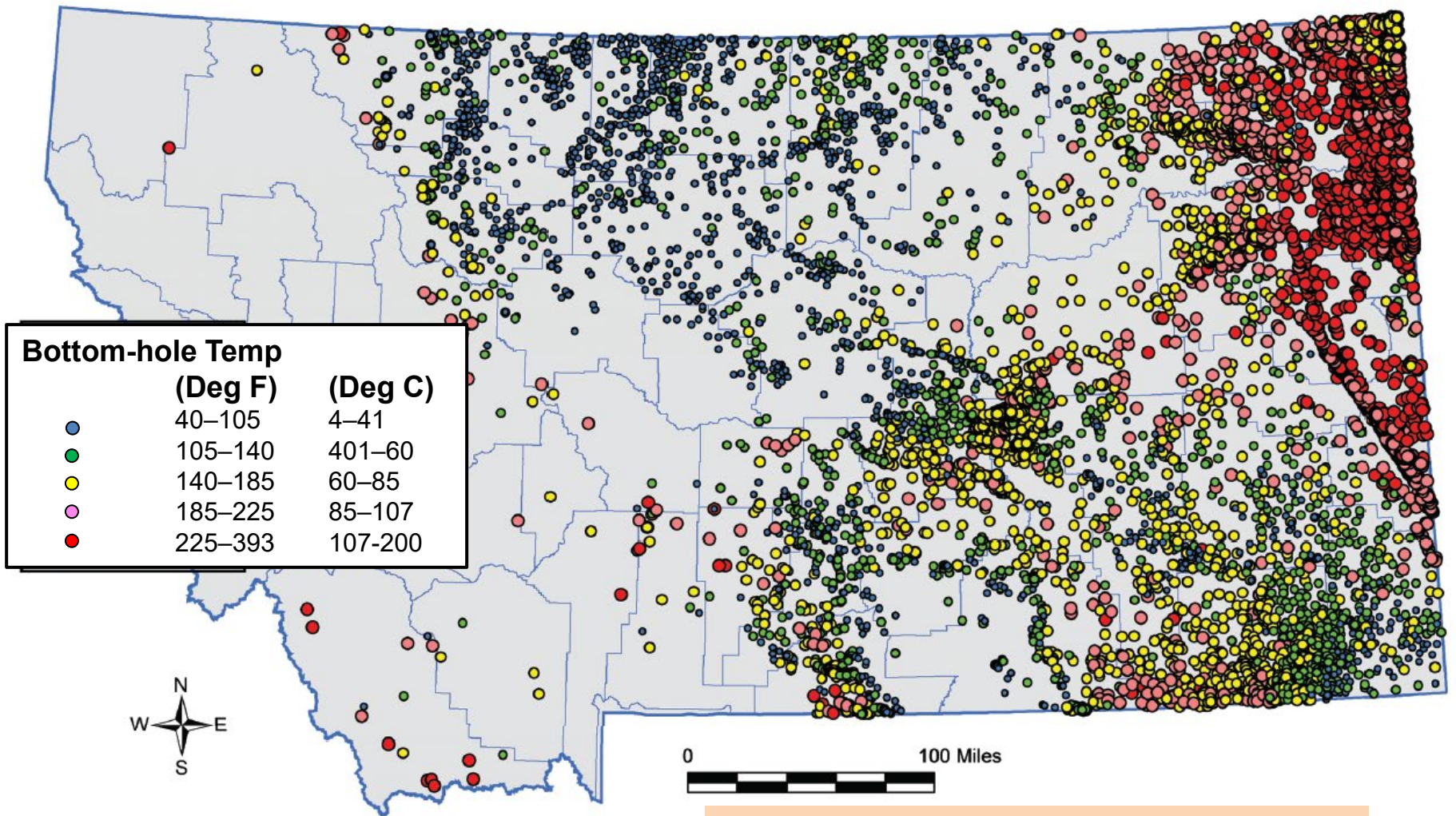
## State Geological Survey Contributions to the National Geothermal Data System (NGDS)

The MBMG continues its participation in the National Geothermal Data System with regular updates.

In addition, we improve public access to geothermal data through our own website...







Bottom hole temperatures  
oil and gas wells

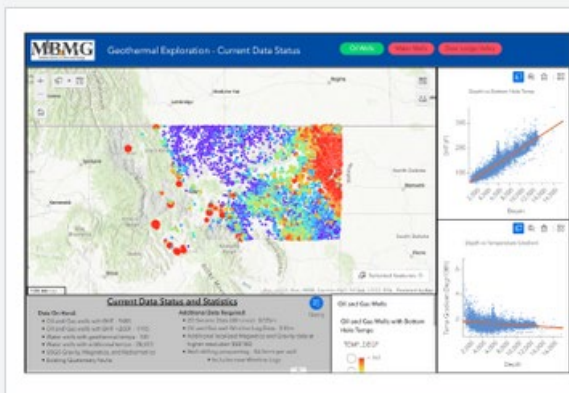
The usual way to provide information  
(online data, publications...)

# The MBMG GIS Data Hub Site

This is the platform for exploring and downloading GIS data and discovering analytics through maps and apps. The Montana Bureau of Mines and Geology (MBMG) GIS maps and apps are available by scrolling down to the [Maps](#) and [Analytical Apps](#) sections below. Alternatively, the tabs at the top of this page will lead you to specific categories of data and analysis. The [Story Maps](#) section at the bottom of this page provides links to topics of special interest, such as Seismic Hazards or Sapphires in Montana. This site will be continuously updated as new maps, applications, and data are released. To visit the MBMG website please click the following link: [MBMG Homepage](#)

## Geothermal Exploration

This app represents the current state of Geothermal Exploration at the Bureau. There is a combination of Oil and Gas well data, water well data, geophysics and geology layers either in hand or needed to be acquired to continue more detailed analysis for exploration.



## Geothermal Exploration

This app represents the current state of Geothermal Exploration at the Bureau.

The newest way to provide information (supported by publications, but...)

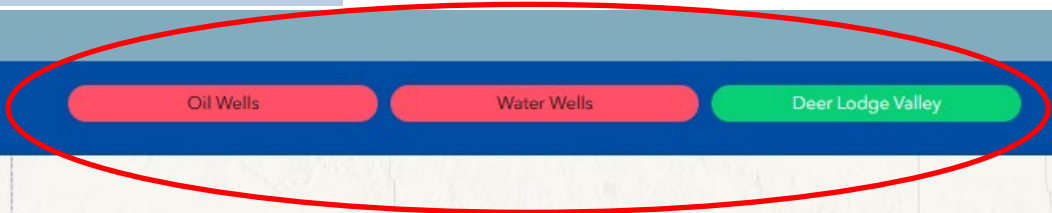


# Same data, but presentation is directed by the user

MBMG GIS Data Hub



Geothermal Exploration - Current Data Status



- Water Wells
- Oil and Gas Wells
  - Oil and Gas Wells with Bottom Hole Temps
  - Oil and Gas Wells with Bottom Hole Temps Heat Map
  - Oil and Gas Wells with Bottom Hole Temps Gradient
  - Oil and Gas Wells with Bottom Hole Temps above 200F
  - Oil and Gas Wells with Bottom Hole Temps above 200F Heat Map
  - Oil and Gas Wells with Bottom Hole Temps above 200F Gradient
- Geophysics Data
  - SEI 2DLines Deer Lodge Valley
  - USGS Magnetic and Radiometric 2023

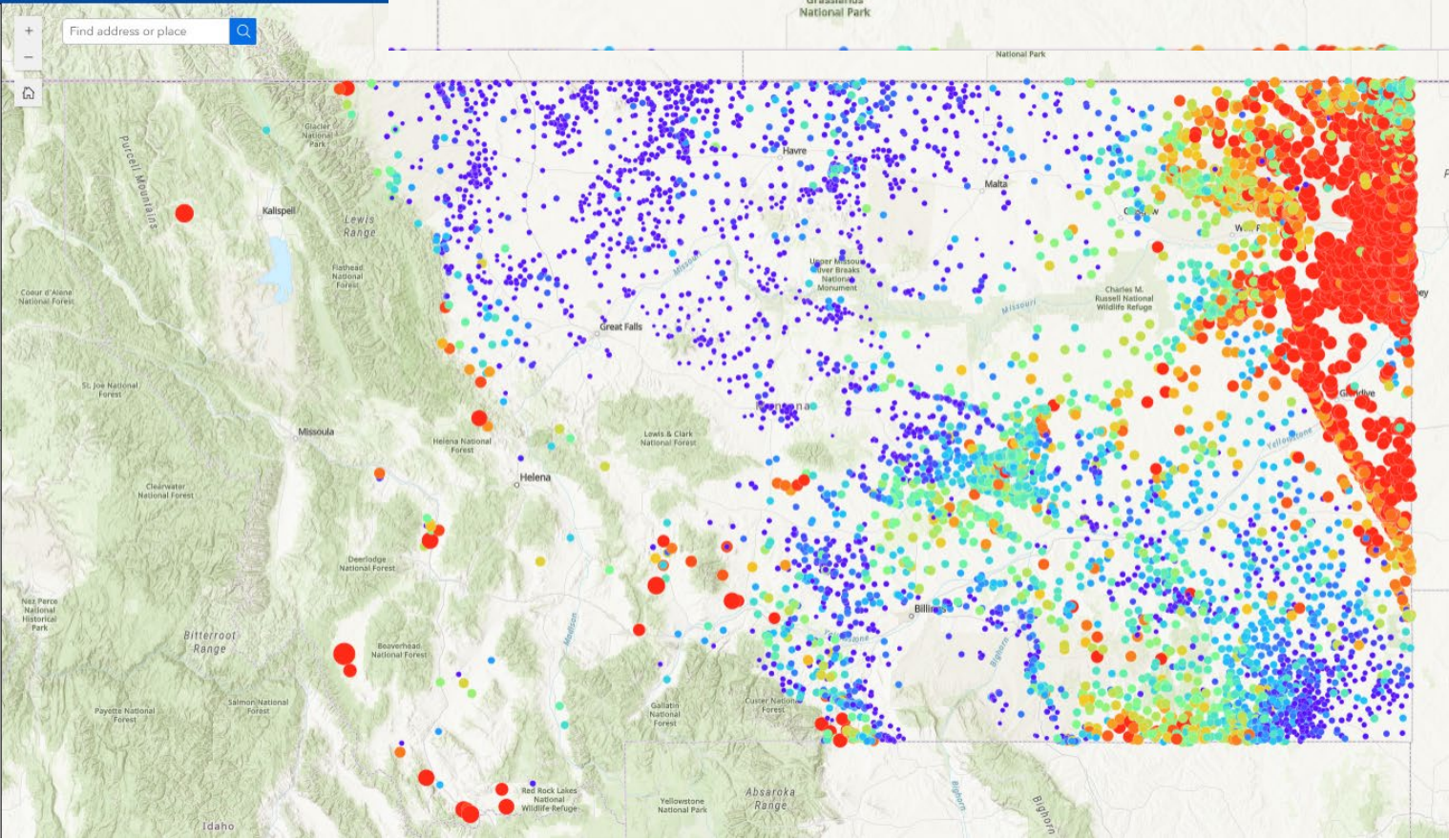
**Oil and Gas Wells**

**Oil and Gas Wells with Bottom Hole Temps**

TEMP\_DEGF

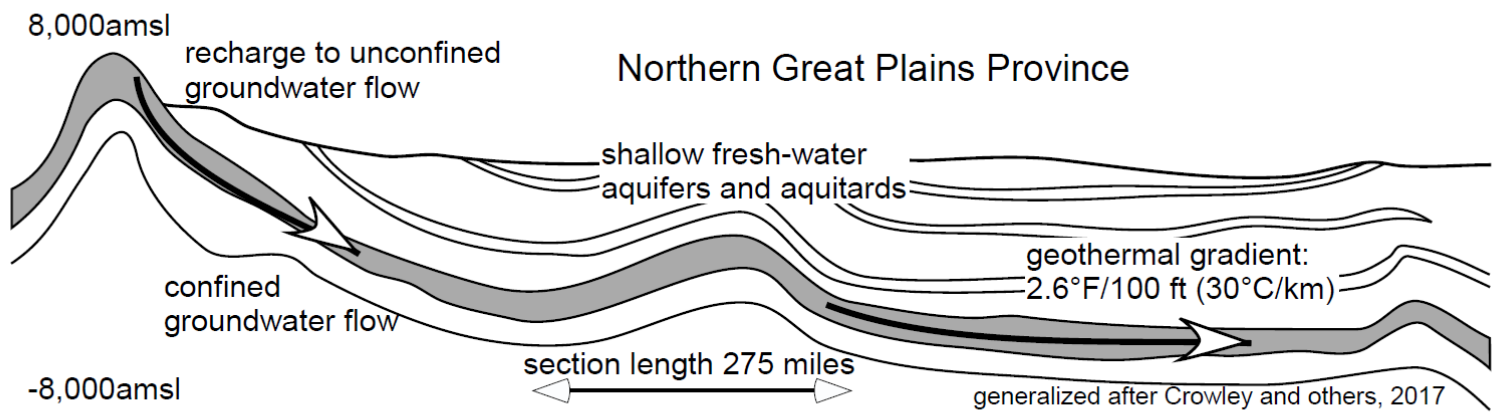
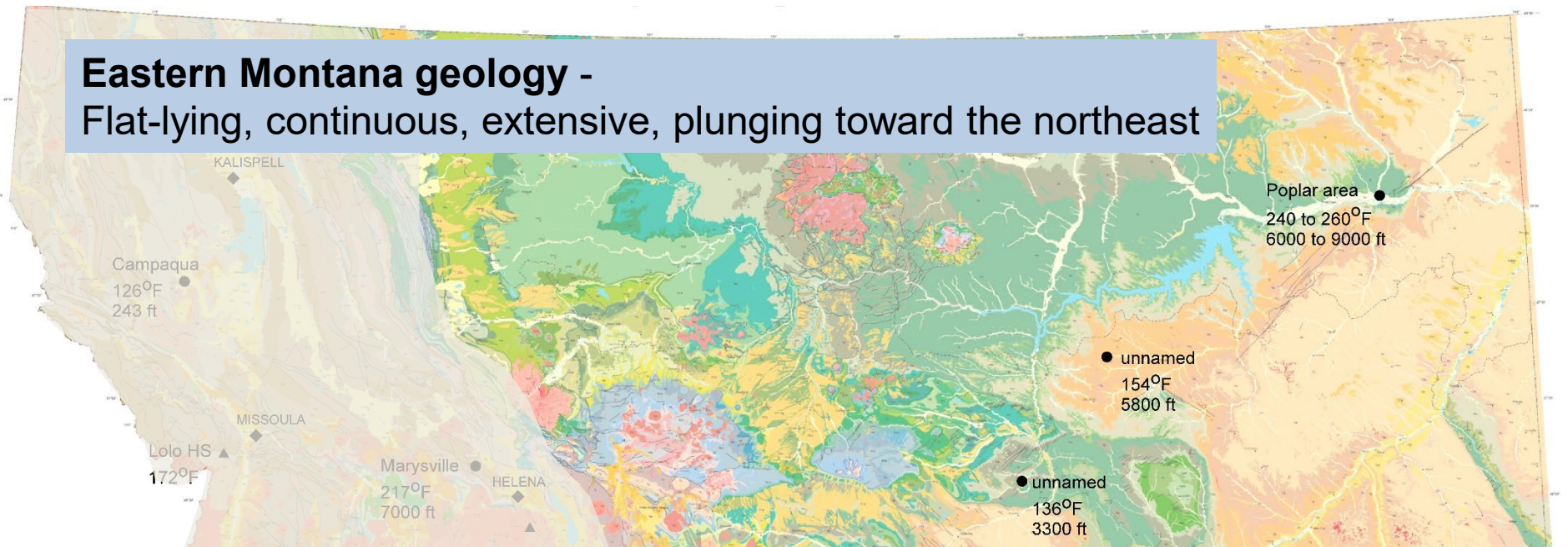
> 362

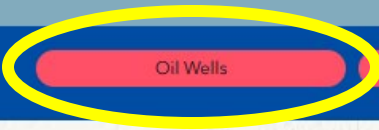
< 58





# Eastern Montana geology - Flat-lying, continuous, extensive, plunging toward the northeast





Oil Wells

Water Wells

Deer Lodge Valley

- >  Water Wells
- >  Oil and Gas Wells
  - >  Oil and Gas Wells with Bottom Hole Temps
  - >  Oil and Gas Wells with Bottom Hole Temps Heat Map
  - >  Oil and Gas Wells with Bottom Hole Temps Gradient
  - >  Oil and Gas Wells with Bottom Hole Temps above 200F
  - >  Oil and Gas Wells with Bottom Hole Temps above 200F Heat Map
  - >  Oil and Gas Wells with Bottom Hole Temps above 200F Gradient
- >  Geophysics Data
- >  Geology100k Seamless
- >  Geology500k

**Oil and Gas Wells**

**Oil and Gas Wells with Bottom Hole Temps**

TEMP\_DEGF

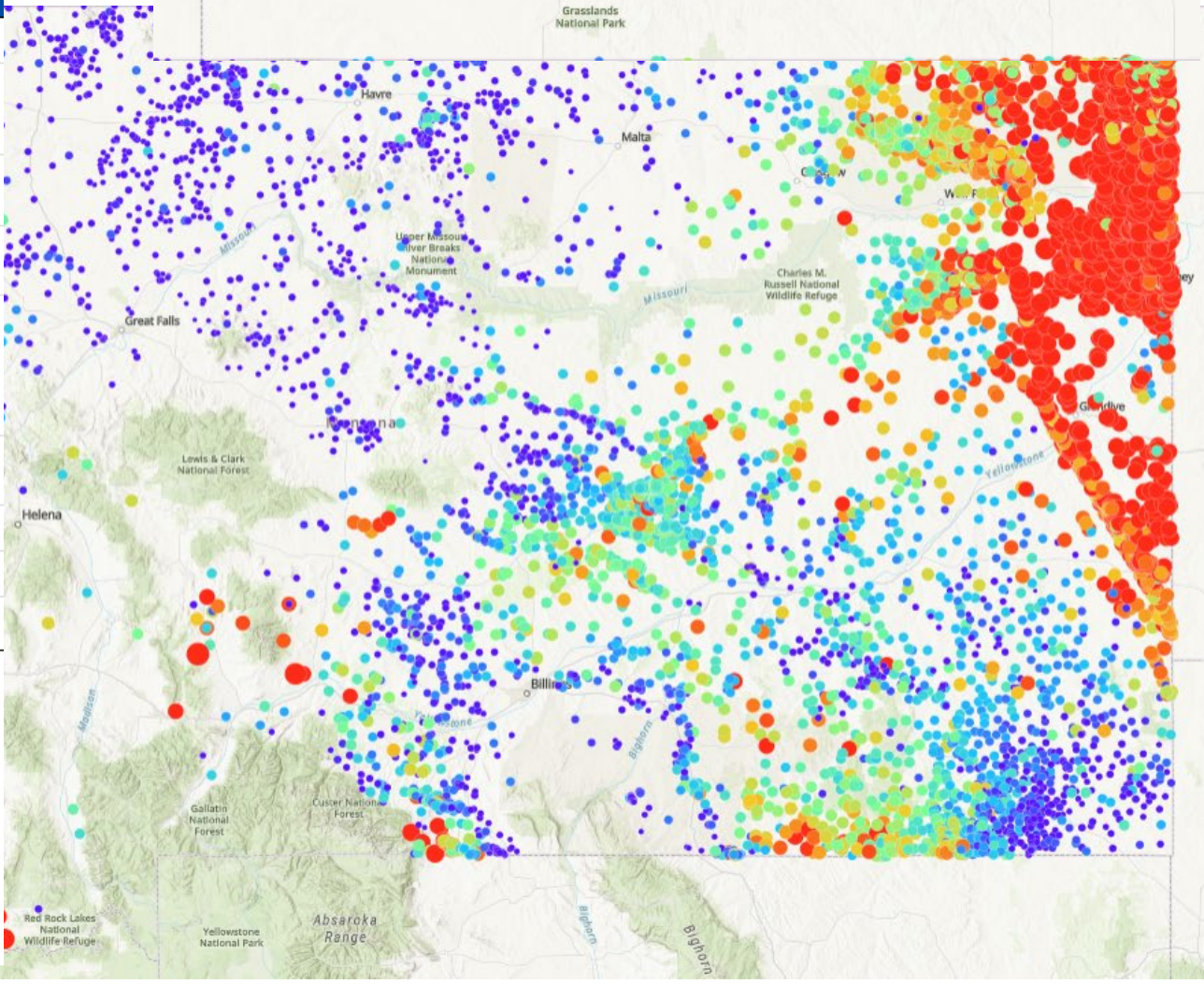
○ > 362

○

○

○

○ < 58



Bottom hole temperatures  
oil and gas wells



- >  Water Wells ...
- ▼  Oil and Gas Wells ...
  - Oil and Gas Wells with Bottom Hole Temps ...
  - Oil and Gas Wells with Bottom Hole Temps Heat Map ...
  - Oil and Gas Wells with Bottom Hole Temps Gradient ...
  - Oil and Gas Wells with Bottom Hole Temps above 200F ...
  - Oil and Gas Wells with Bottom Hole Temps above 200F Heat Map ...
  - Oil and Gas Wells with Bottom Hole Temps above 200F Gradient ...
- >  Geophysics Data ...
- >  Geology100k Seamless ...
- >  Geology500k ...

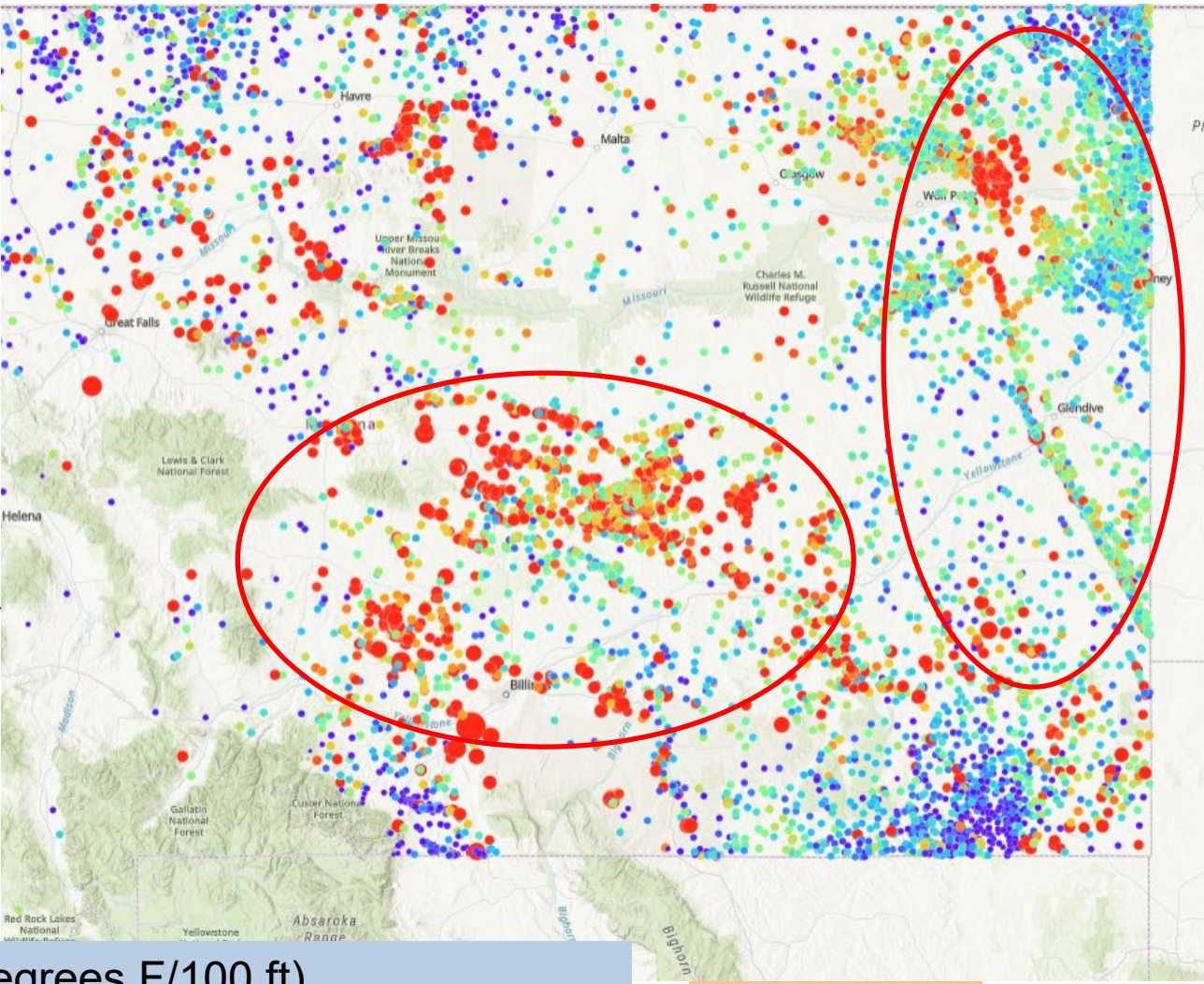
**Oil and Gas Wells**

**Oil and Gas Wells with Bottom Hole Temps Gradient**

Geothermal\_Gradient\_Per100FT

> 6.8

< 0.6



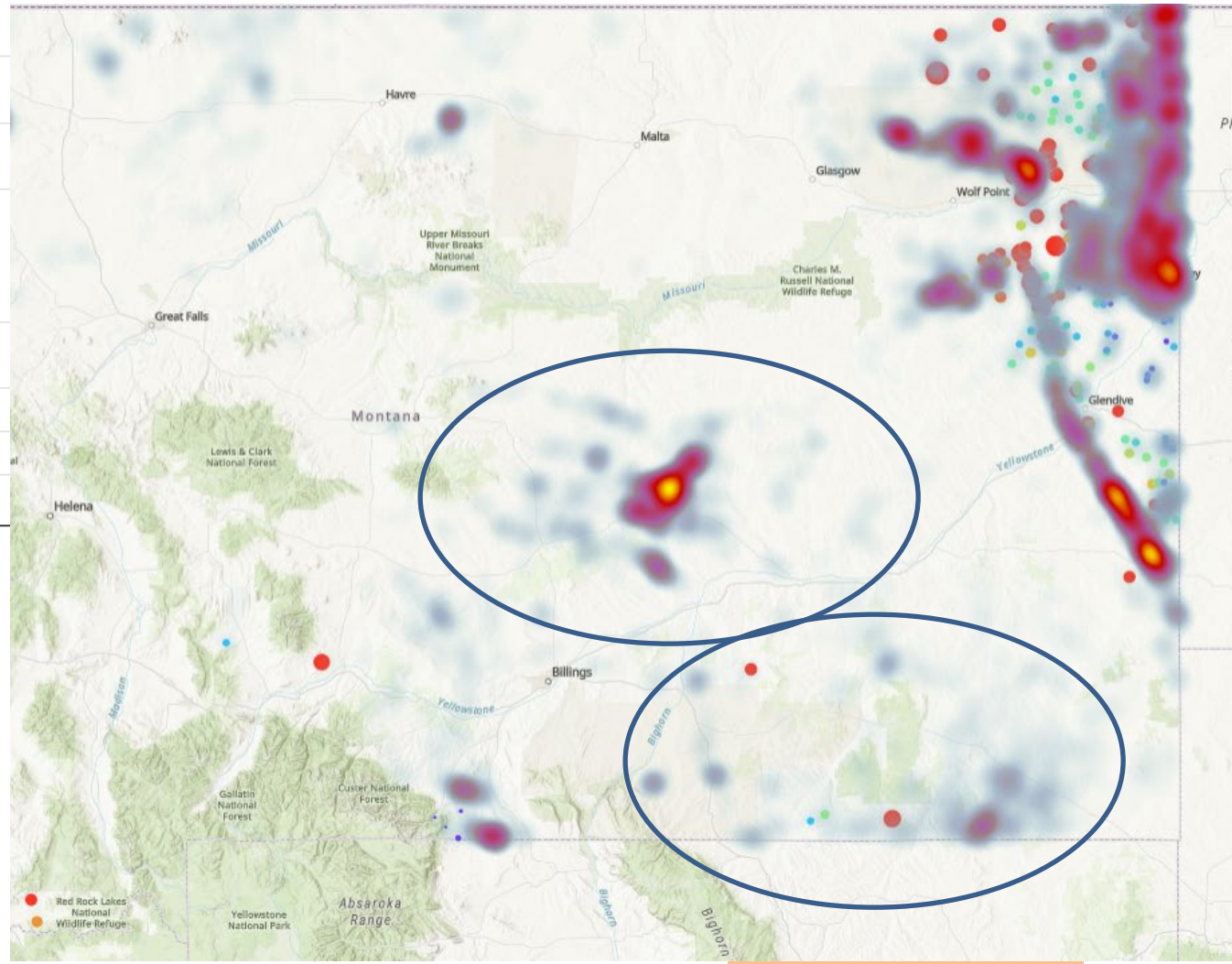
Temperature gradient (degrees F/100 ft)

Compare to bottom hole temperatures in previous slide

Drill deeper?



- >  Water Wells ...
- Oil and Gas Wells ...
  - Oil and Gas Wells with Bottom Hole Temps ...
  - Oil and Gas Wells with Bottom Hole Temps Heat Map ...
  - Oil and Gas Wells with Bottom Hole Temps Gradient ...
  - Oil and Gas Wells with Bottom Hole Temps above 200F ...
  - Oil and Gas Wells with Bottom Hole Temps above 200F Heat Map ...
  - Oil and Gas Wells with Bottom Hole Temps above 200F Gradient ...
- >  Geophysics Data ...
- >  Geology100k Seamless ...
- Geology500k ...



**Oil and Gas Wells**

**Oil and Gas Wells with Bottom Hole Temps Heat Map**

TEMP\_DEGF

**Oil and Gas Wells with Bottom Hole Temps above 200F Heat Map**

TEMP\_DEGF

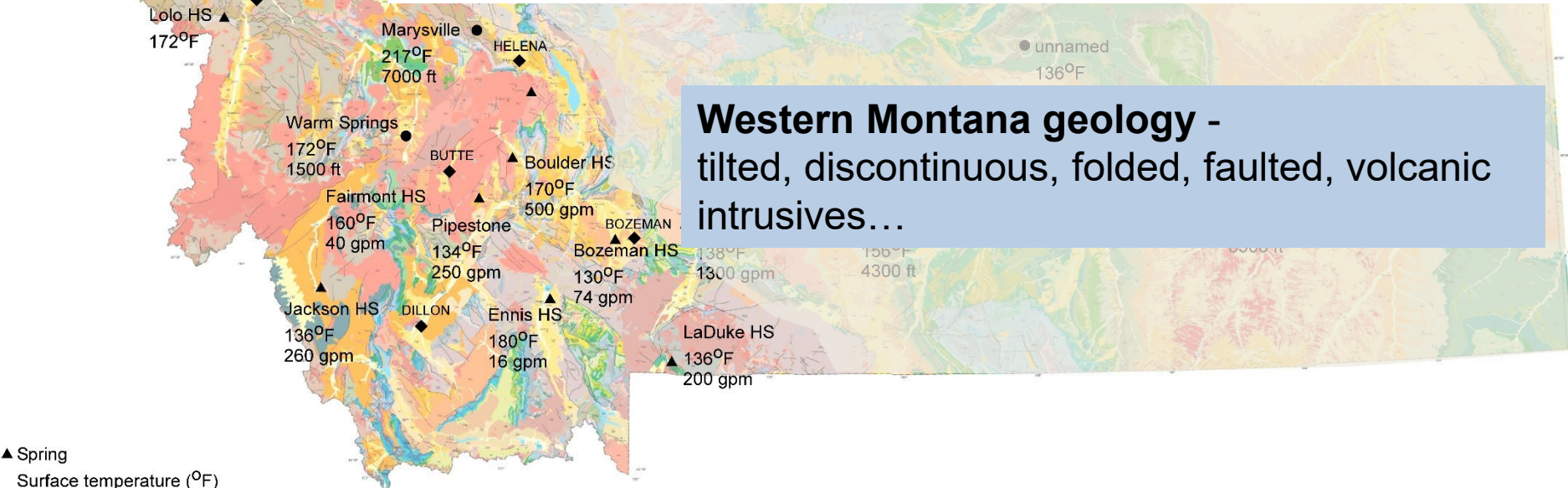
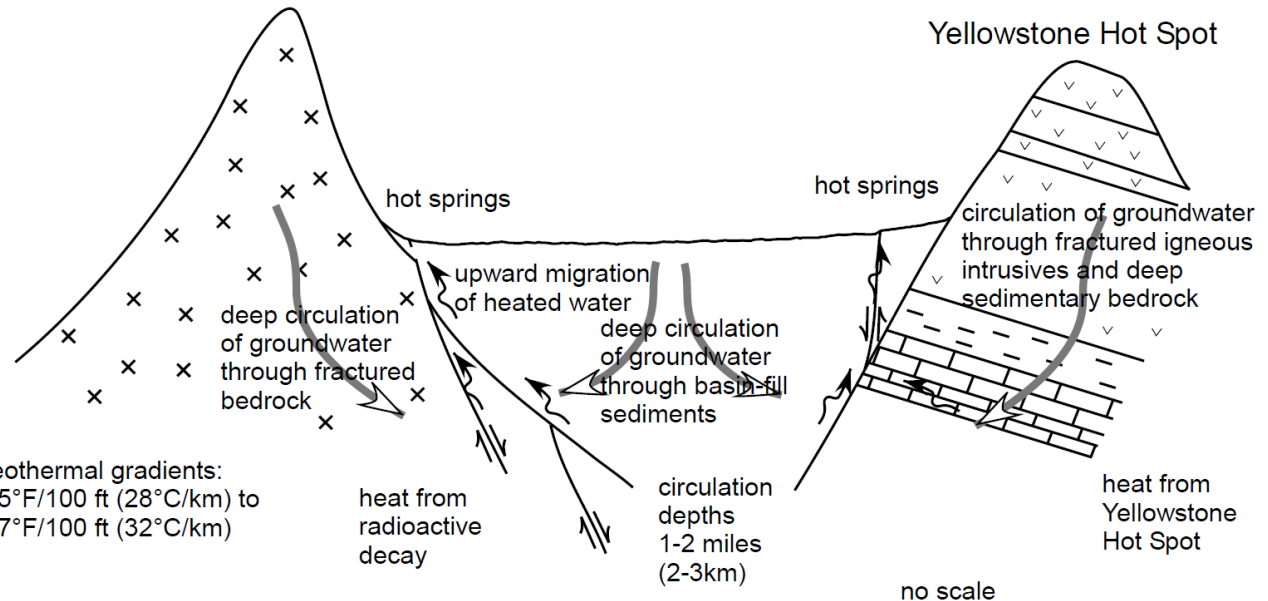
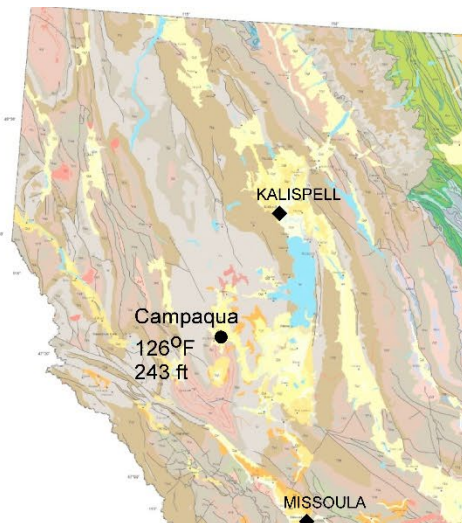
Oil and Gas Wells with Bottom Hole Temps above 200F Gradient

All bottom hole temperatures “heat map” – layers of data

look elsewhere?

## Basin and Range Province

## Yellowstone Hot Spot



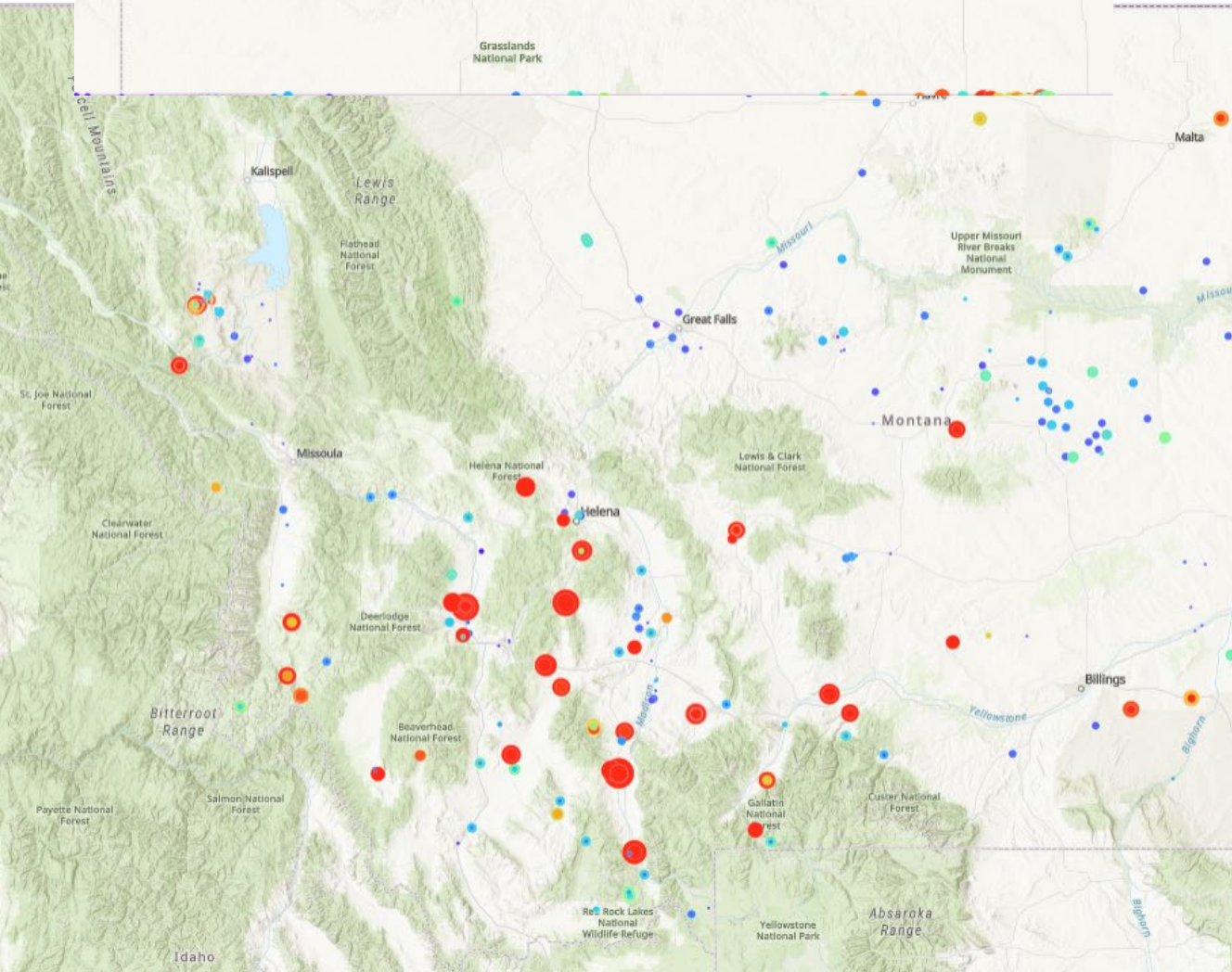
- ▲ Spring
- Well
- Surface temperature (°F)
- surface flow gallons per minute (gpm)
- downhole temperature (°F)
- depth of well (feet below ground surface)



Oil Wells

Water Wells

Deer Lodge Valley

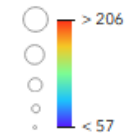


- Water Wells
- Geothermal Sites Original Wells
- Geothermal Sites Original Springs
- Water Well Geothermal Sites
- Water Well Geothermal Sites Heat Map
- Water Well Geothermal Sites Gradient
- Water Wells with Water Temps
- Water Wells with Water Temps Heat Map
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- Oil and Gas Wells
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**Water Wells**

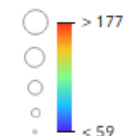
**Geothermal Sites Original Wells**

Temp\_DegF



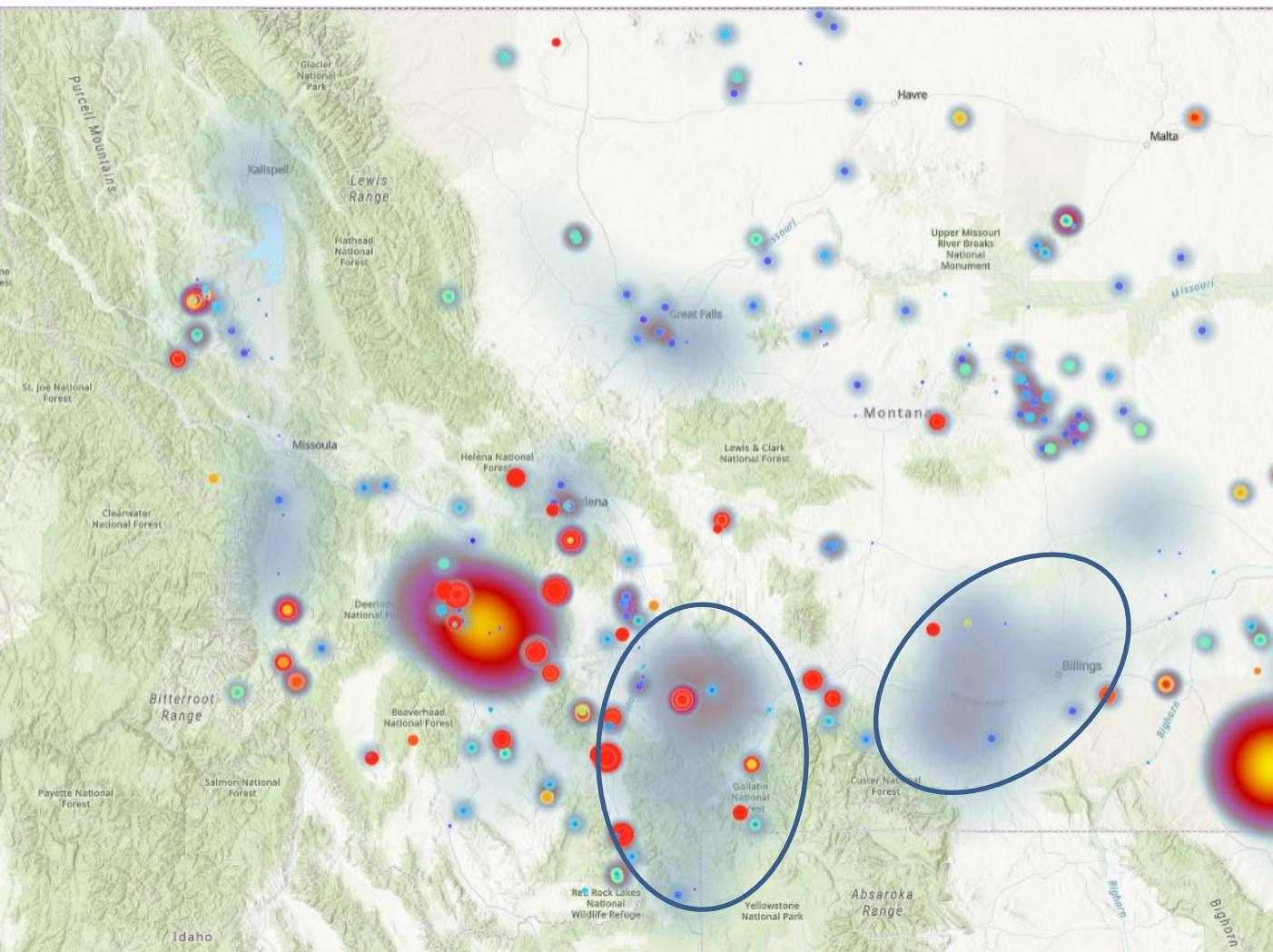
**Geothermal Sites Original Springs**

Temp\_DegF



Geothermal Wells and Springs

# “Heat map” of all wells in GWIC



Are we looking in the right place?

**MBMG**  
Montana Bureau of Mines and Geology

Geotherm

- Water Wells
- Geothermal Sites Original Wells
- Geothermal Sites Original Springs
- Water Well Geothermal Sites
- Water Well Geothermal Sites Heat Map
- Water Well Geothermal Sites Gradient
- Water Wells with Water Temps
- Water Wells with Water Temps Heat Map
- Water Wells with Water Temps Gradient
- Oil and Gas Wells
- Geophysics Data
- Geology100k Seamless
- Geology500k

**Water Wells**

**Geothermal Sites Original Wells**

Temp\_DegF

> 206  
< 57

**Geothermal Sites Original Springs**

Temp\_DegF

> 177  
< 59

**Water Well Geothermal Sites**

**MBMG**  
Montana Bureau of Mines and Geology



## **Exploration – beyond the available data**

Geochemistry of known geothermal areas

Geologic mapping

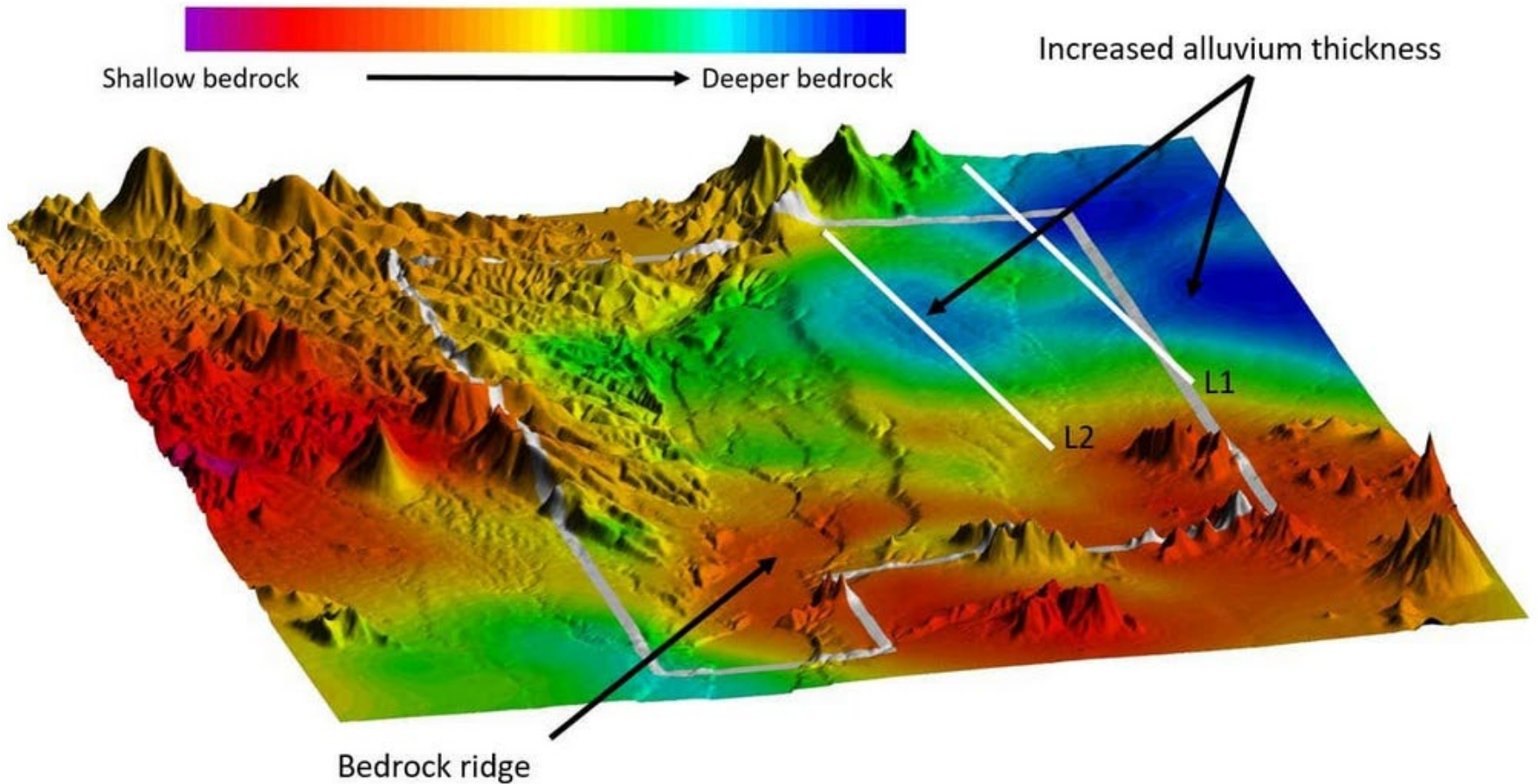
Geophysics

aerial (gravity, magnetics/radiometrics...)

vertical/local (seismic, gravity)

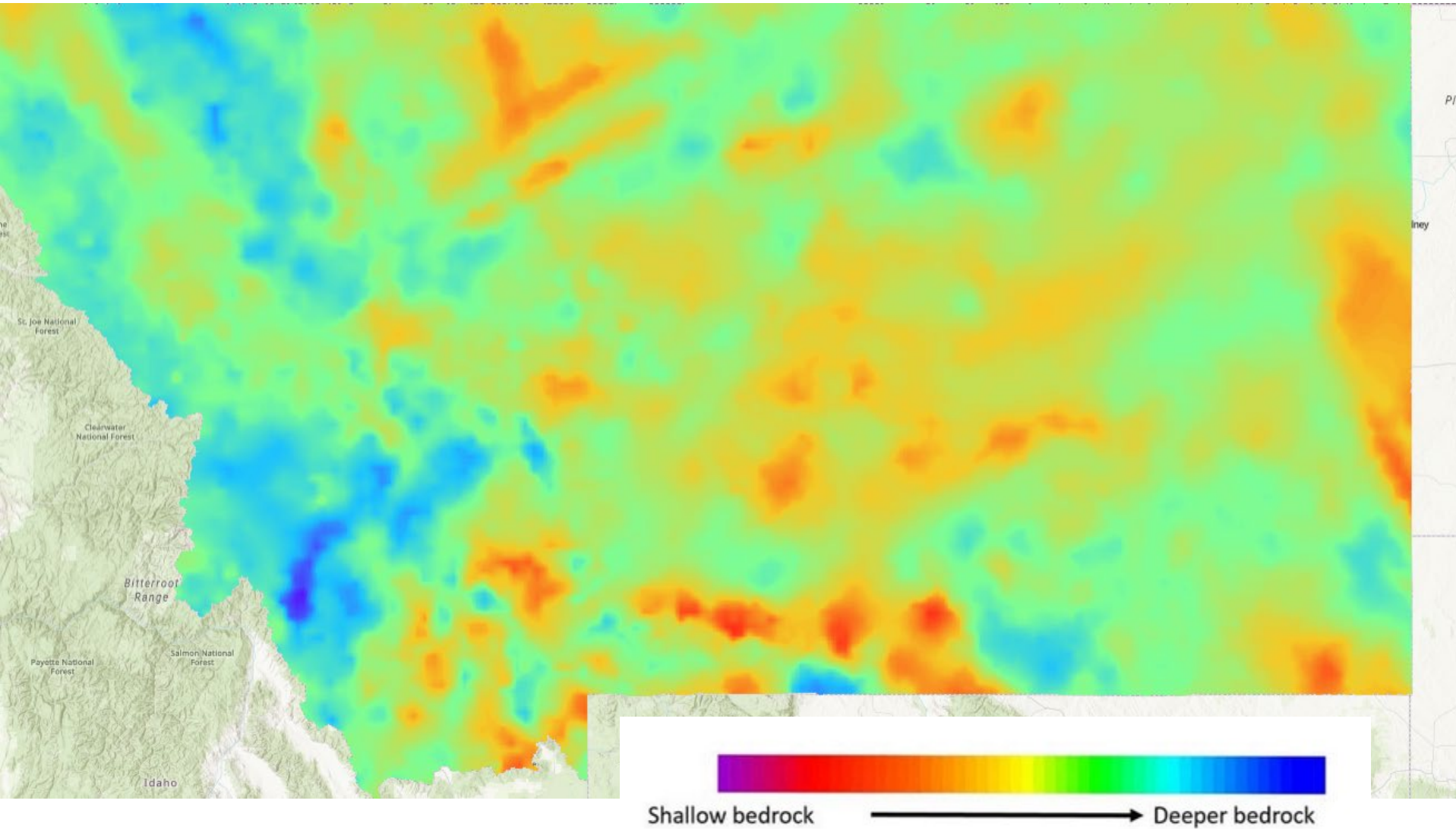
# Aerial gravity

Looking into the subsurface without the need for drilling

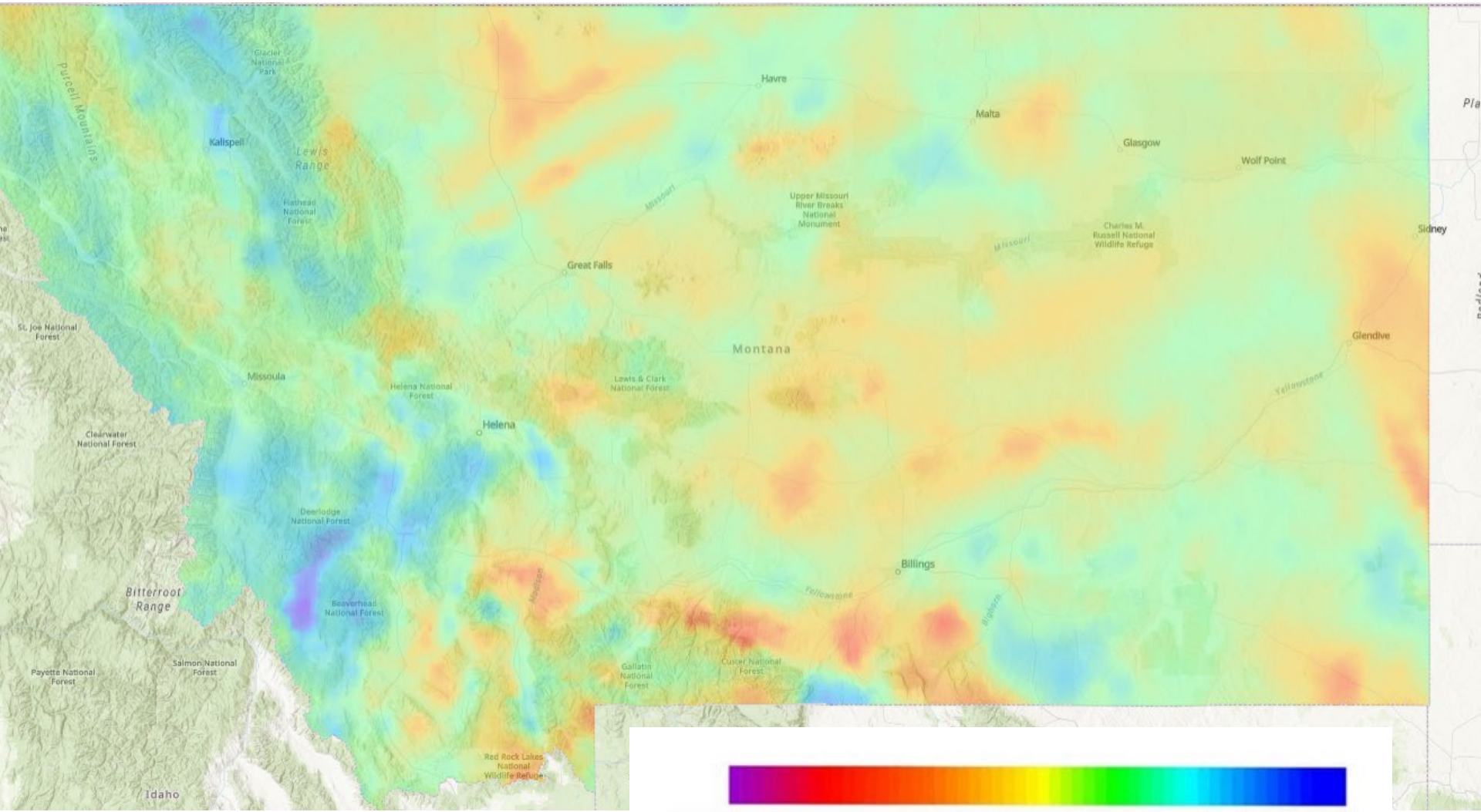




# Isostatic gravity for Montana

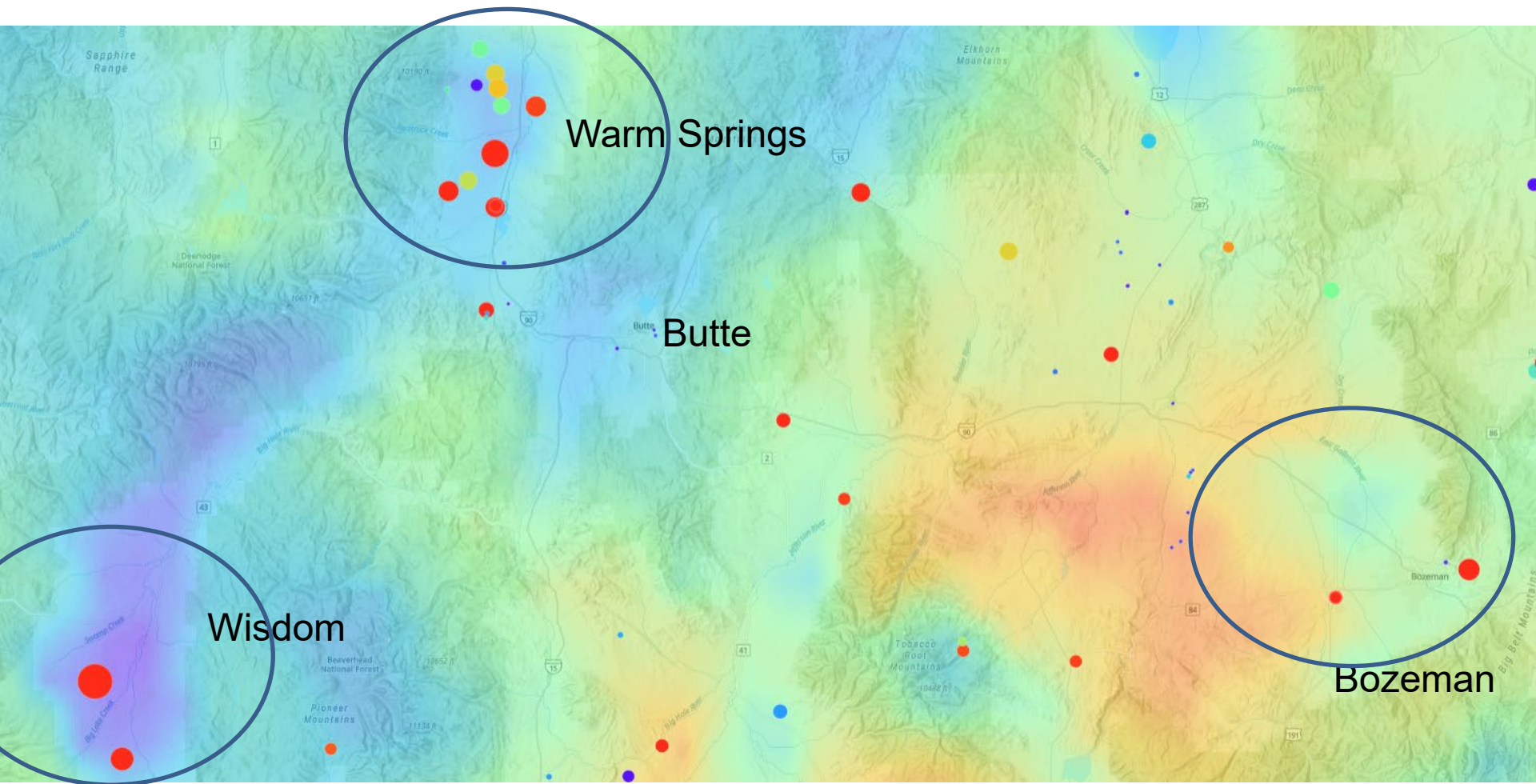


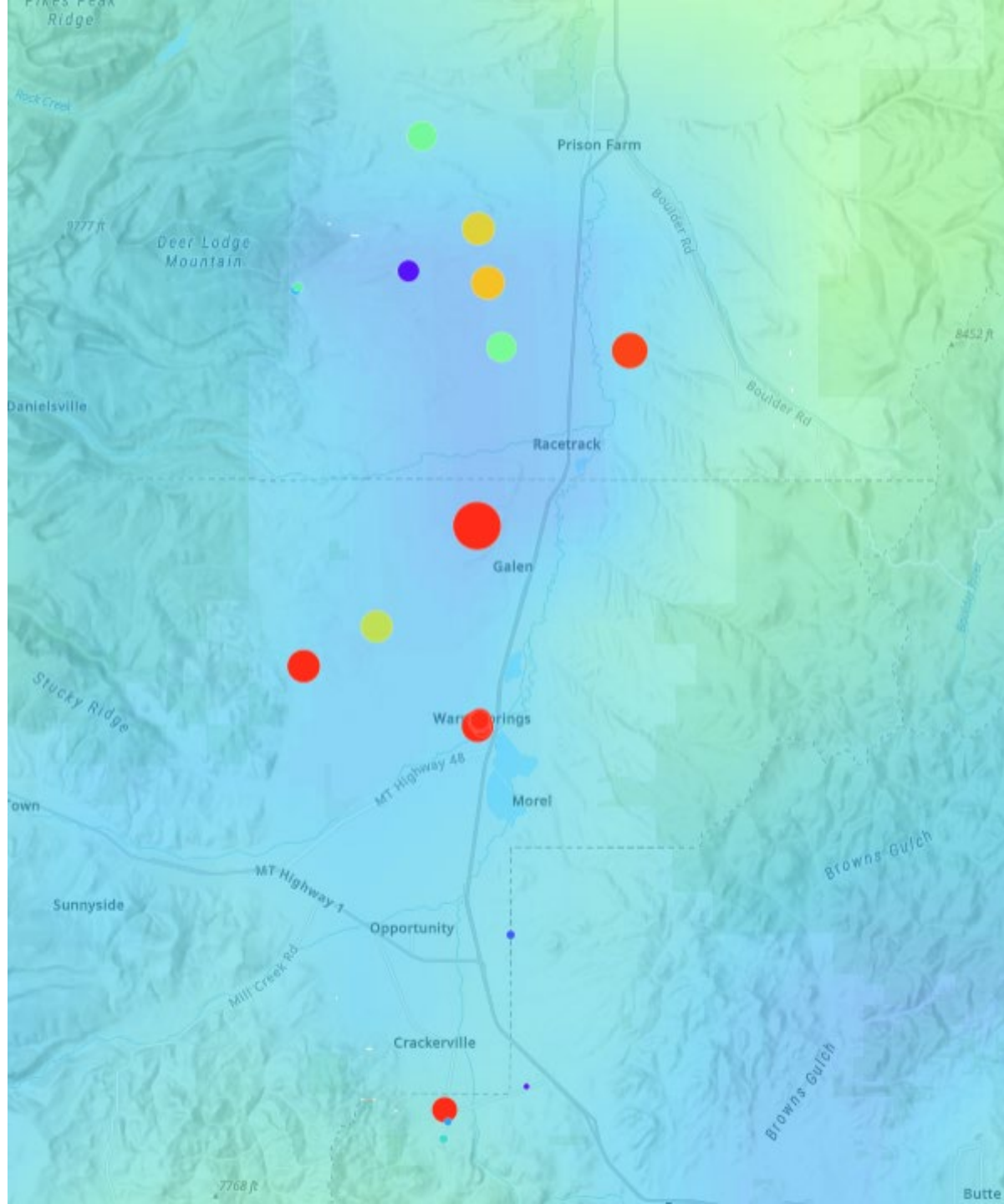
# Isostatic gravity for Montana



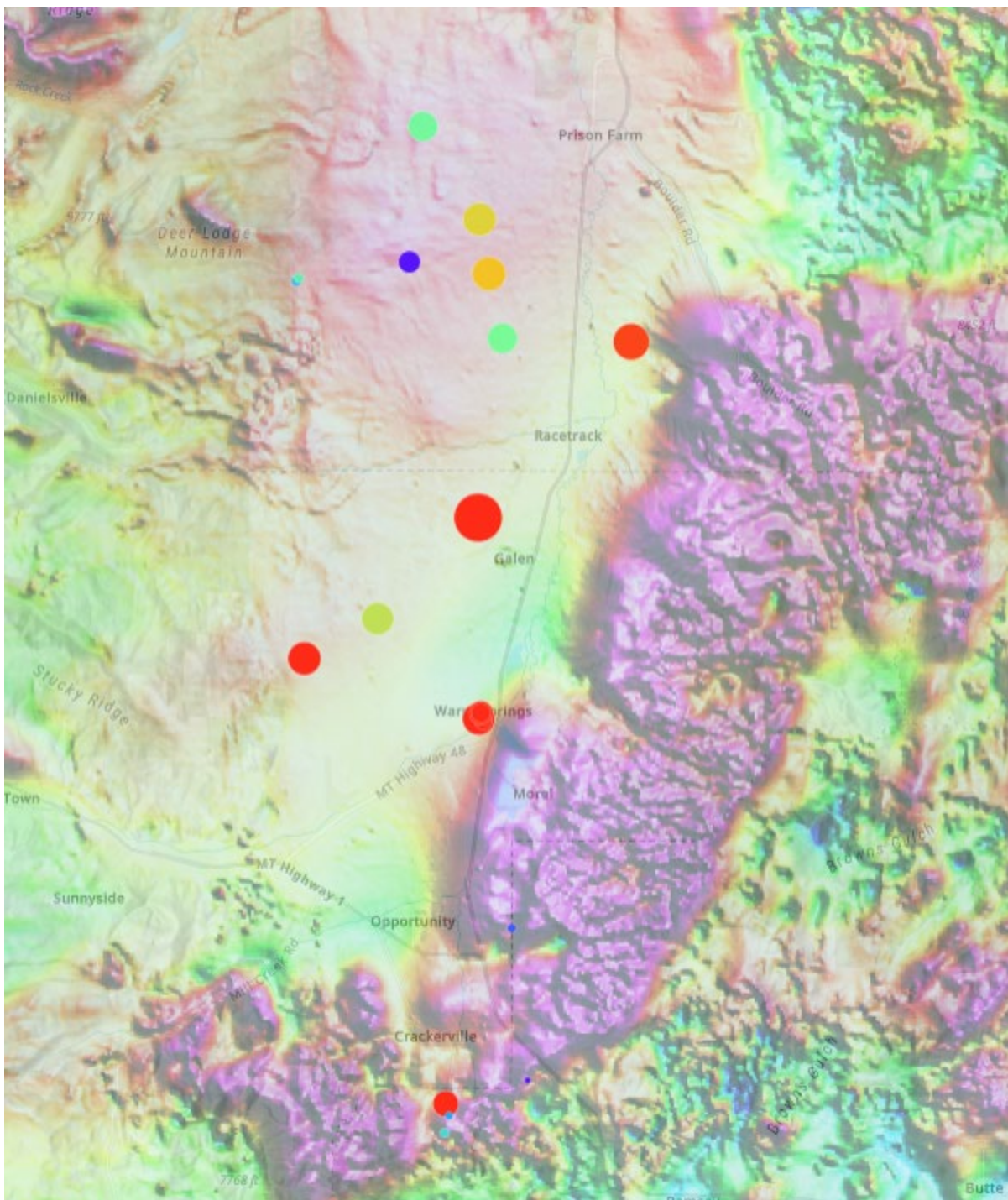
Shallow bedrock → Deeper bedrock

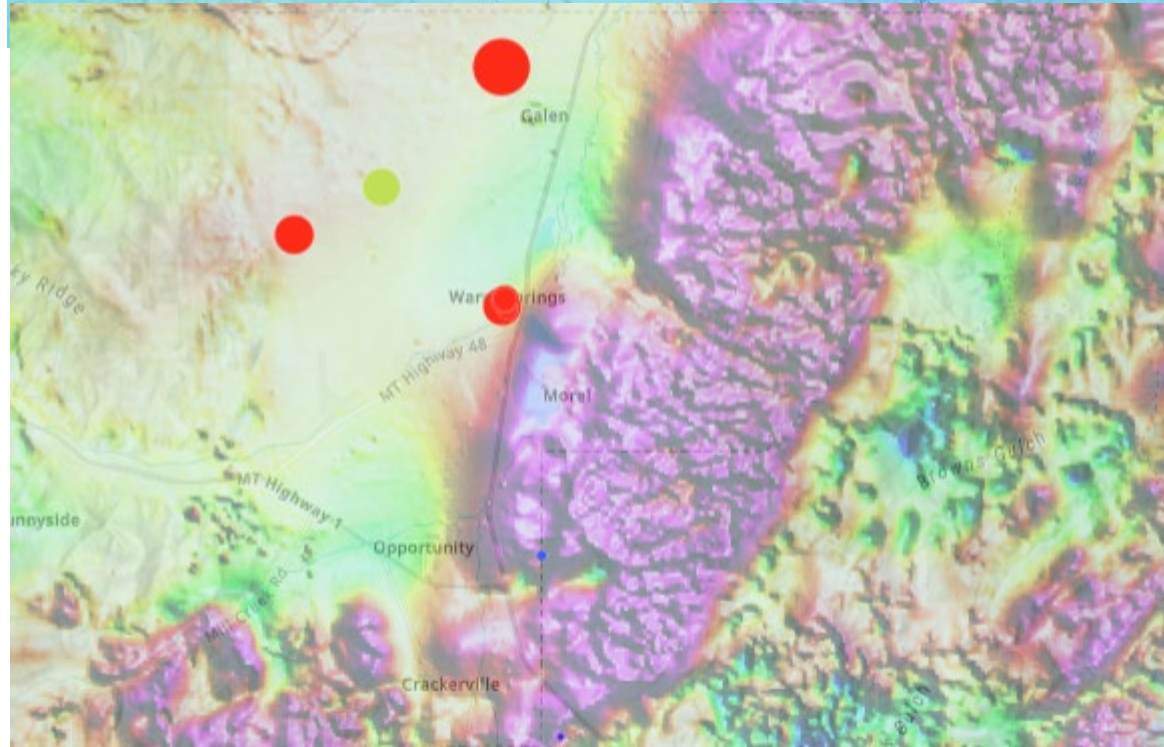
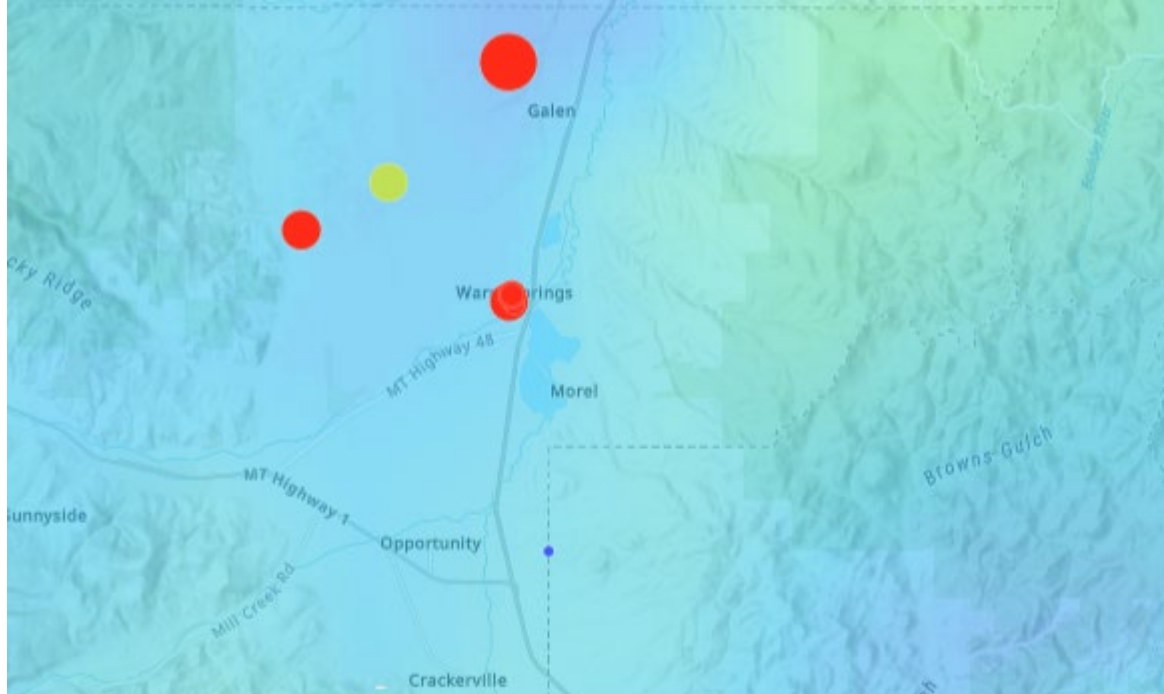




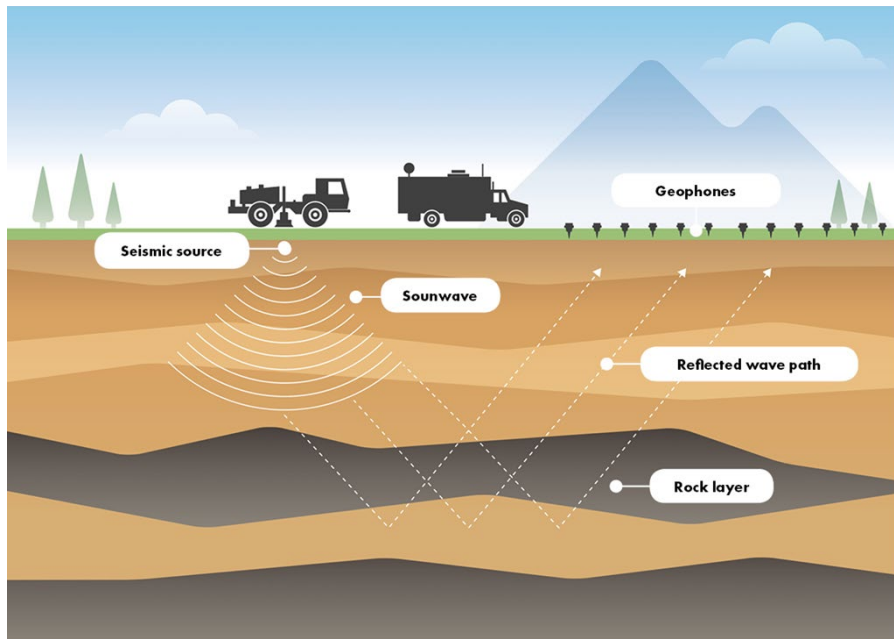










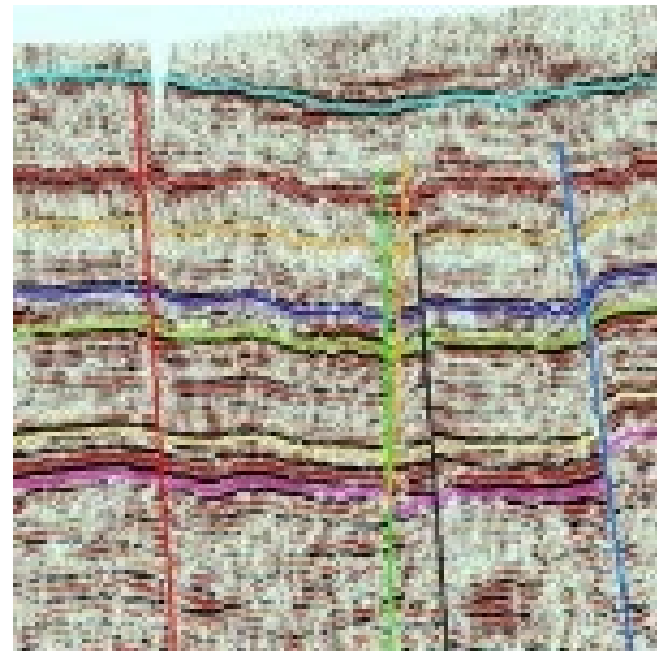


*seismic exploration.*

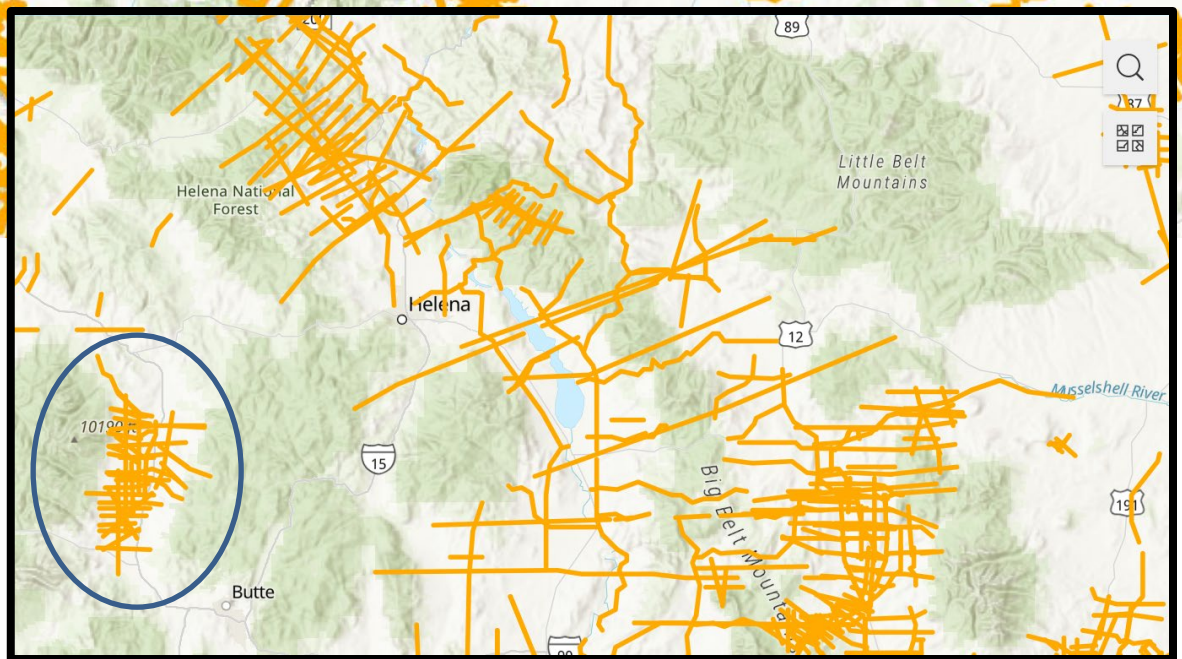
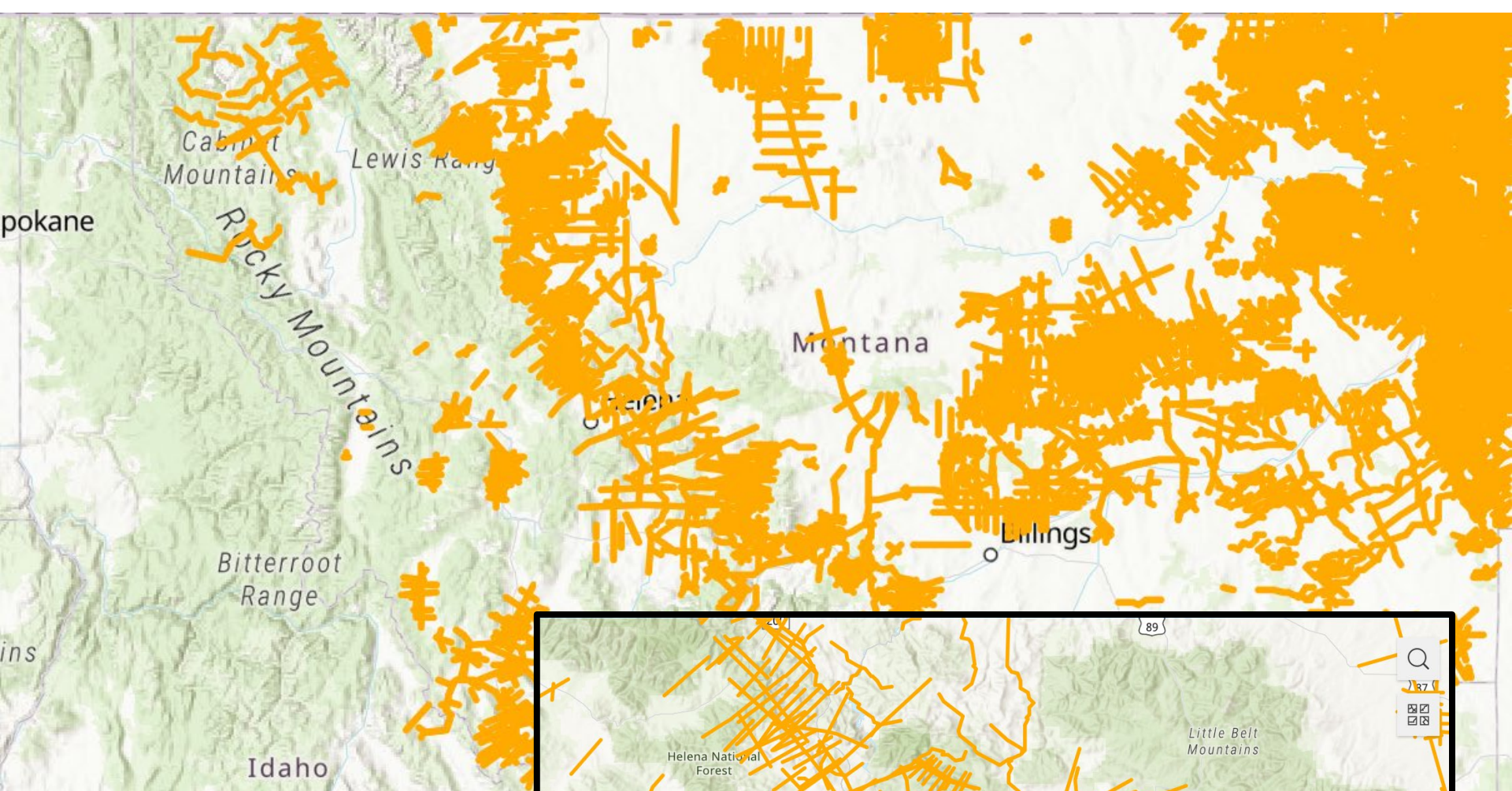
*Image source: [Energy Information Australia](#).*

Now we can “see”

- layers of rock (eastern MT)
- valley depth (western MT)
- faults (western MT)
- formation properties(?)
  - porosity
  - permeability
  - water temperature



*Image source: Zonge International*



Collected by oil and gas  
exploration companies  
1960-1980s

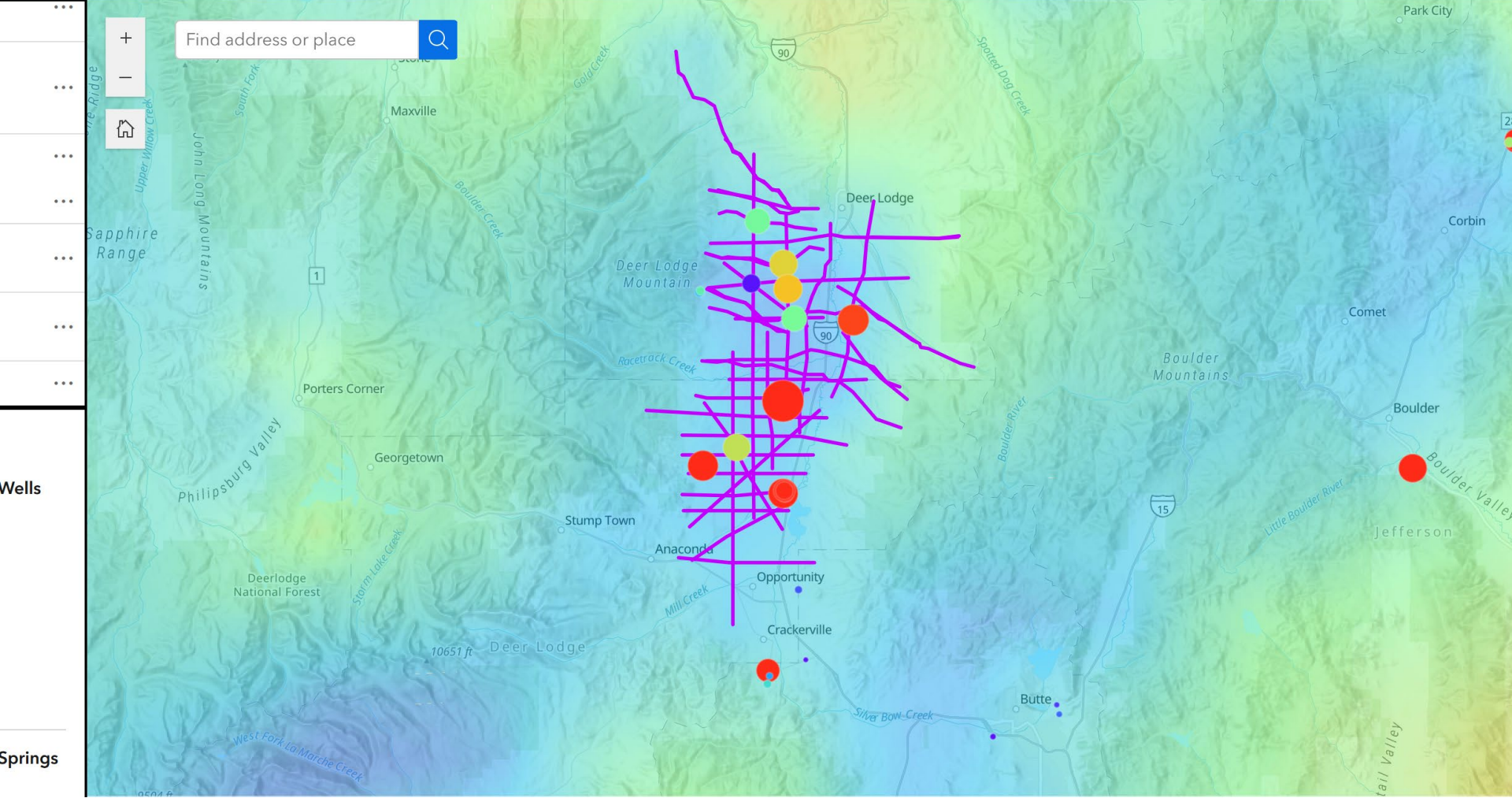


# Geothermal Exploration - Current Data Status

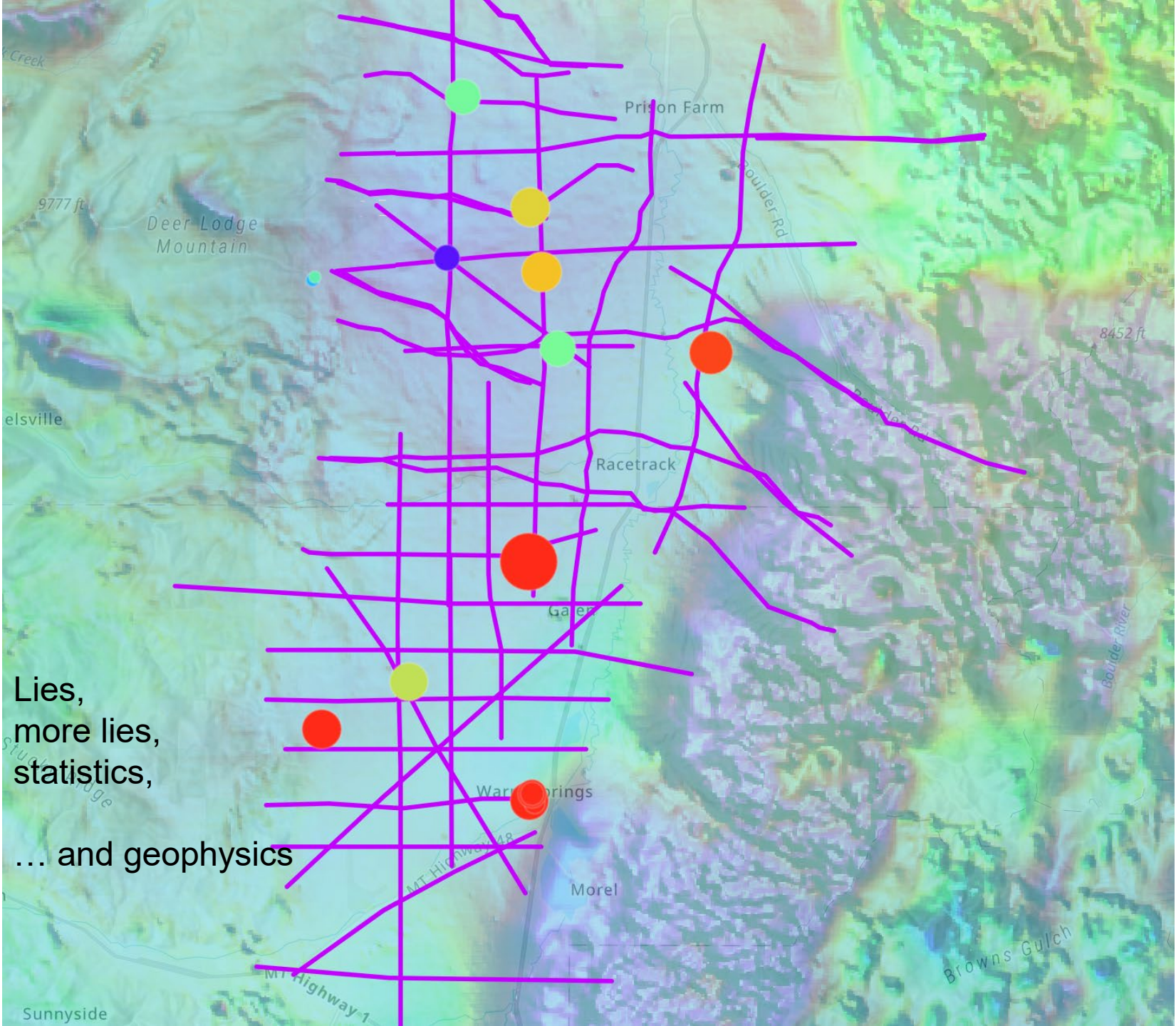
Oil Wells

Water Wells

Deer Lodge Valley







Lies,  
more lies,  
statistics,  
... and geophysics



## **The source of new opportunities**

MBMG Hydrocarbon Program

oil & gas logs

seismic data

Critical mineral exploration/research

Department of Defense (REEs)

Department of Energy (Carbon Ore)

US Geological Survey

large area reconnaissance

AIM

MBMG Ground Water Programs

Managed Aquifer Recharge