

Hydrologic Mixing of Geothermal and Alluvial Groundwater in Dixie Valley, Nevada

Michael R. Rosen, Jena Huntington, and C. Amanda Garcia
U.S. Geological Survey, Nevada



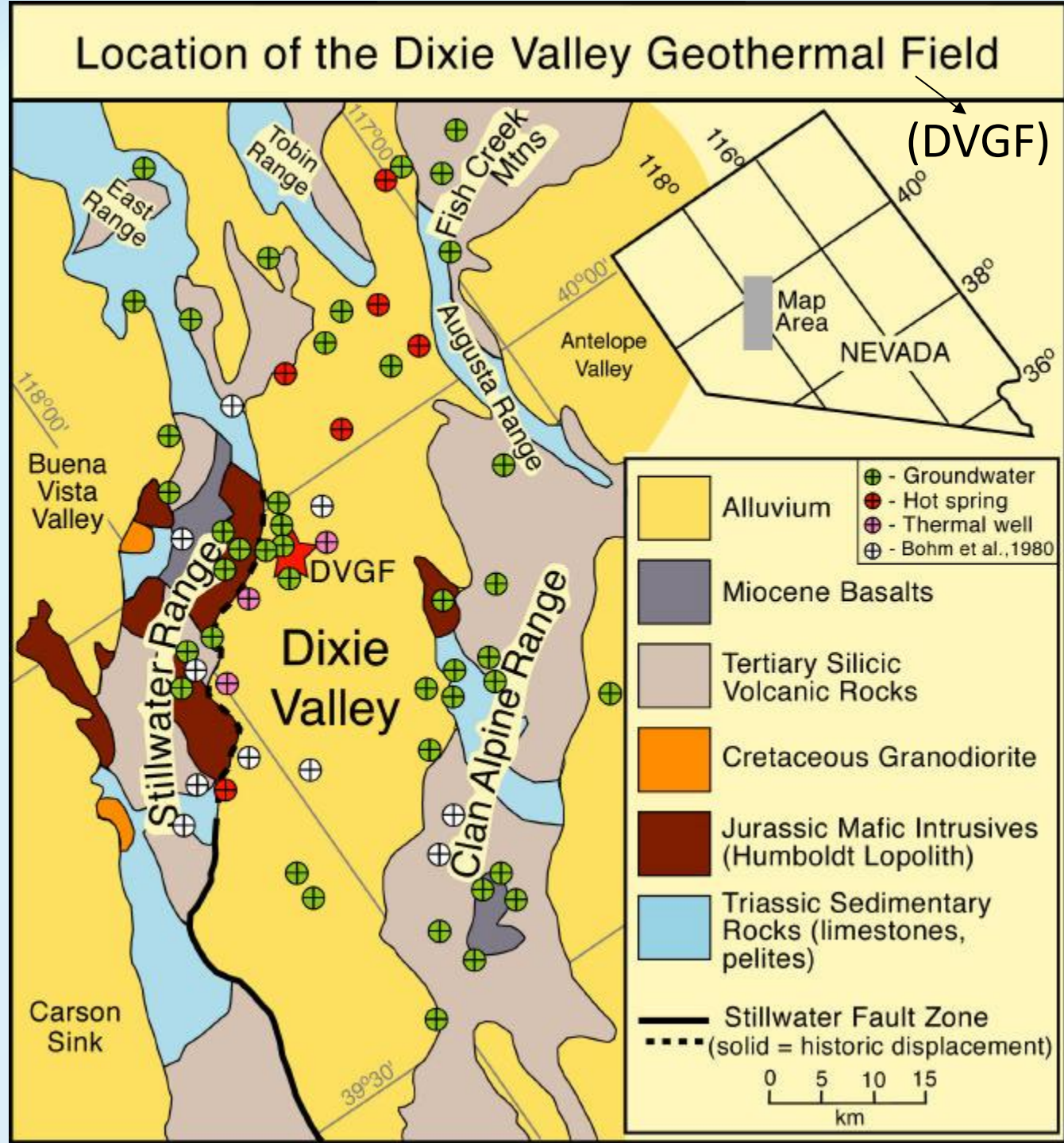
Background

- **Churchill County, Nevada, is looking for an alternative water supply for the city of Fallon**
- **Groundwater in the Dixie Valley basin-fill aquifer is a potential source**
- **Geothermal power plant in Dixie Valley has been operating since early 1990's**
- **The geothermal power plant also requires alluvial groundwater**
- **Concern that potential pumping of alluvial water may affect power plant operations**
- **If there is mixing of geothermal and alluvial aquifer water this may be an issue for potential water resources in the valley**

Dixie Valley is a terminal basin and is the lowest point in Northern Nevada

Studied by Desert Research Institute (1980's) , USGS & National Laboratories in the (1990's, early 2000's) and USGS and consultants (current)

USGS and NL studies found about 15 percent mixing in some areas using ^{36}Cl and other isotopic chemical techniques



Wells used in the current study included many of the old wells used

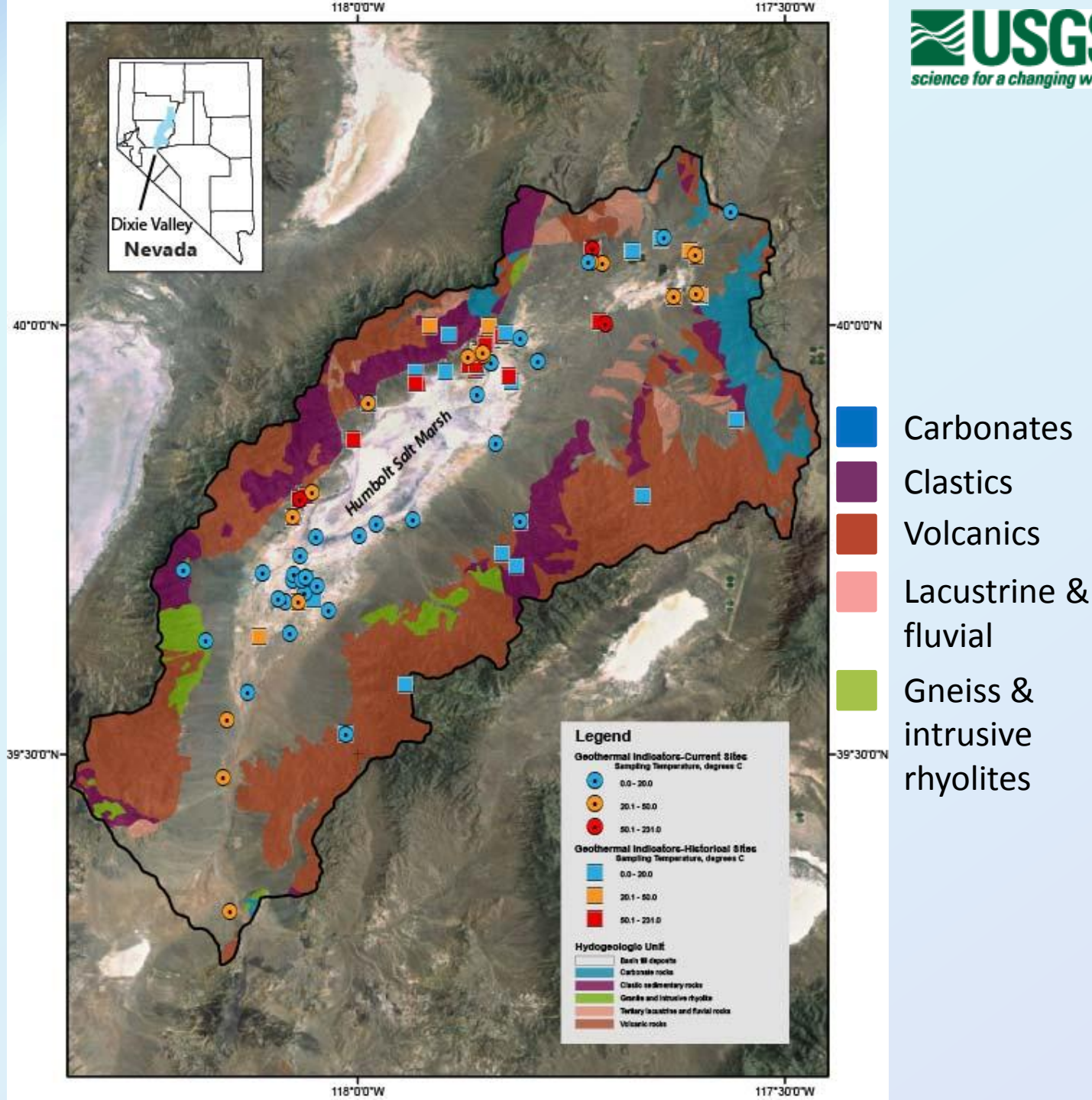
Temperature

New wells sampled

- 0 - 20 °C
- 20.1 - 50 °C
- >50 °C

Historical wells sampled

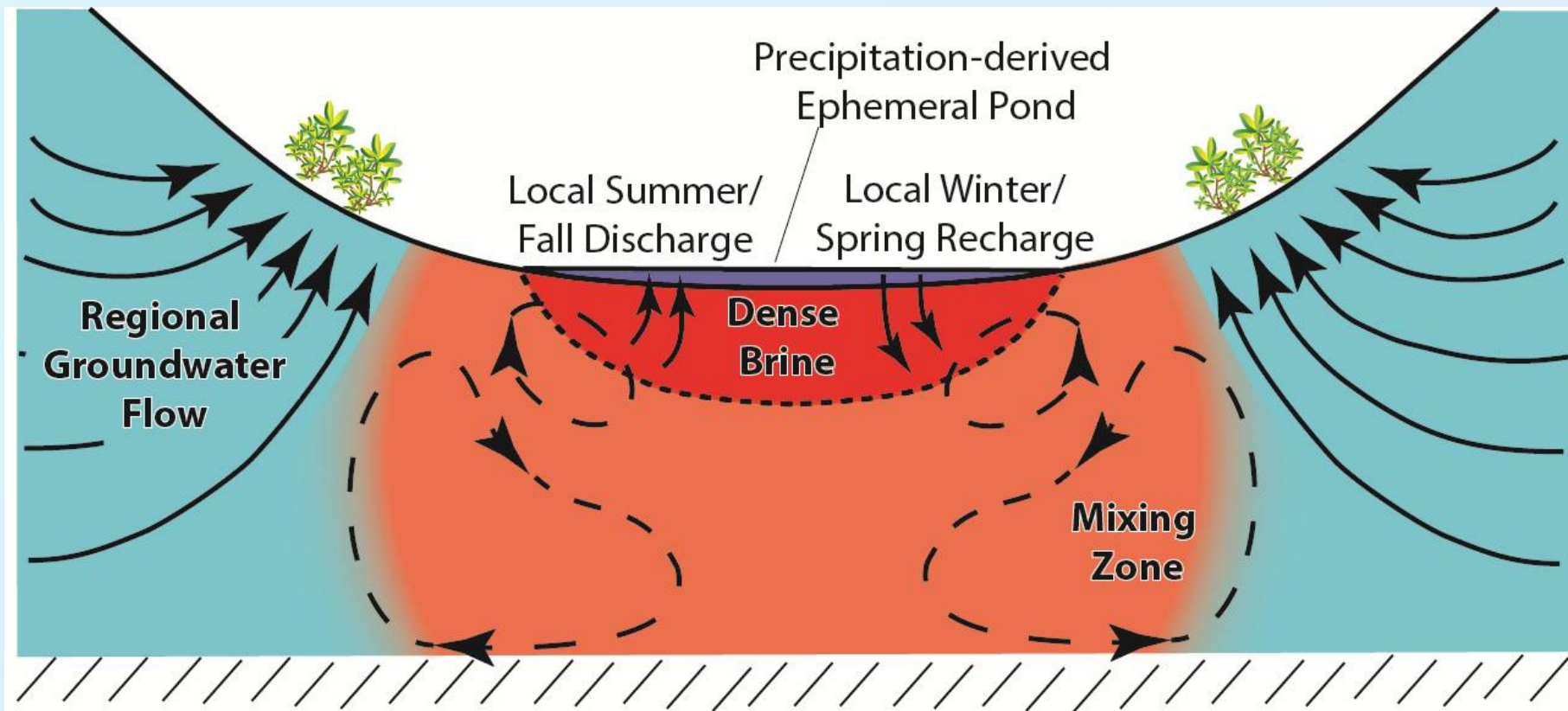
- 0 - 20 °C
- 20.1 - 50 °C
- >50 °C



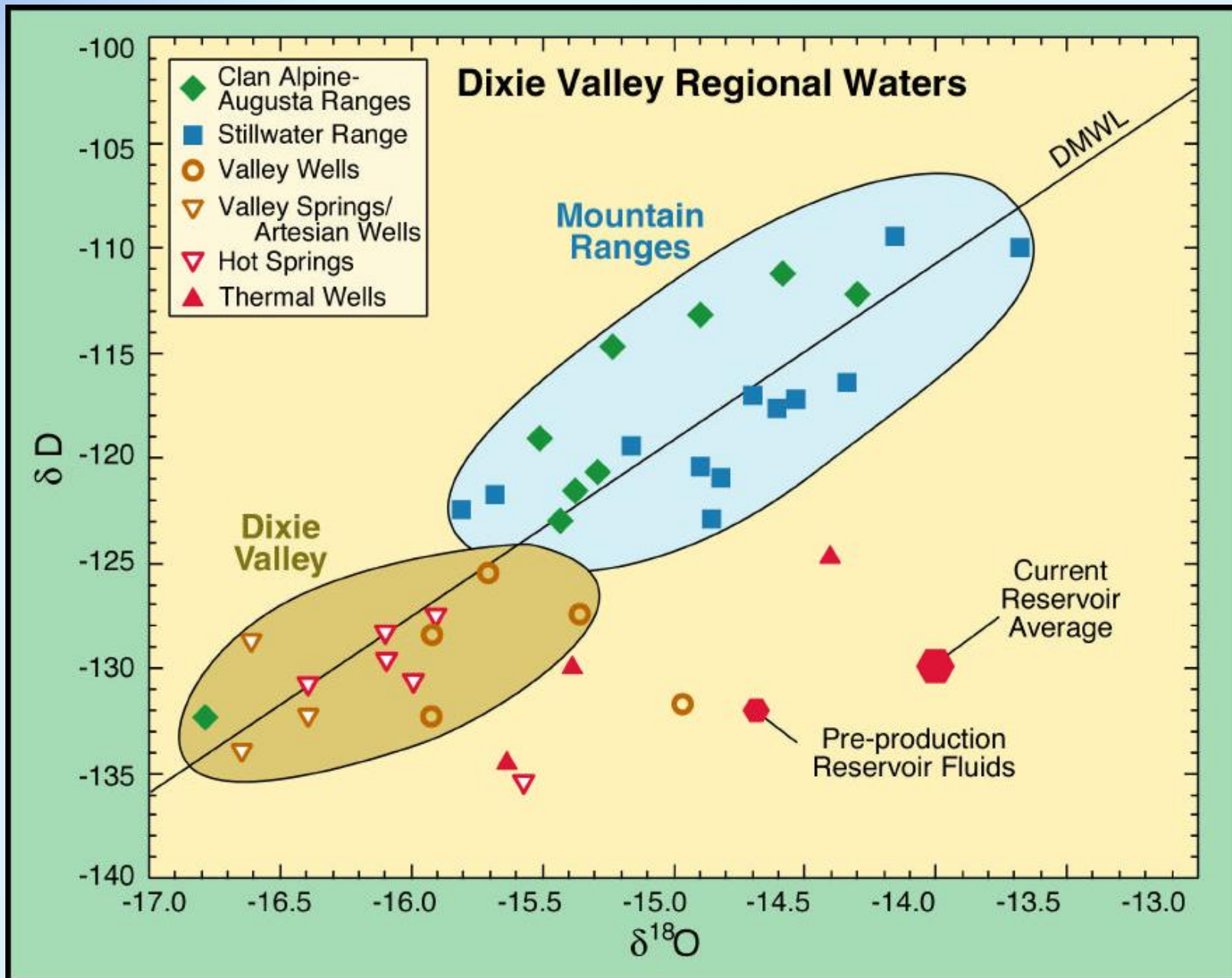
Based on current data including ET, discharge, pump tests, and GW level measurements, the playa currently received limited groundwater and has limited regional flow to the playa

But over long periods of time (1000's of years) diffusive flux of ions may be large

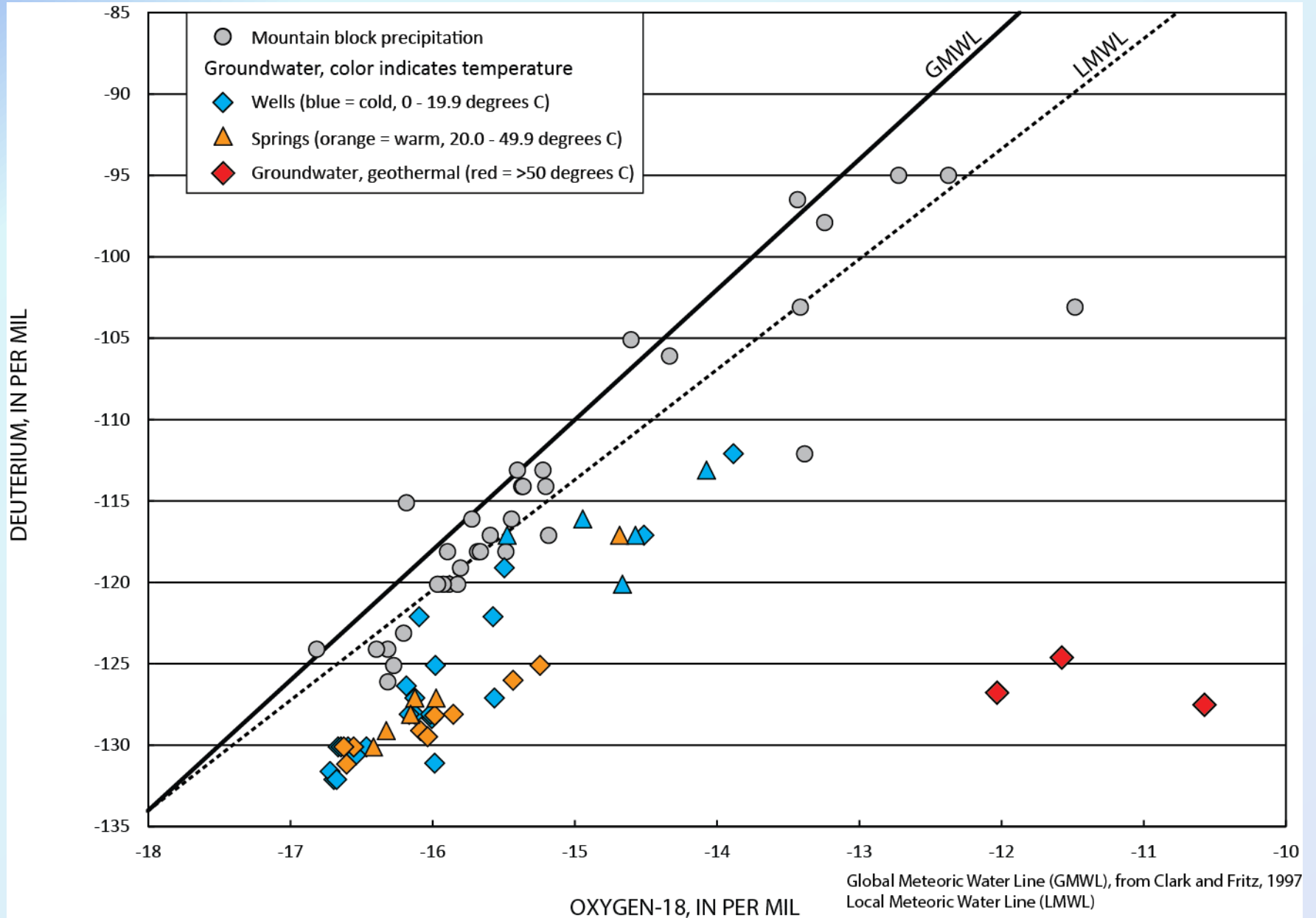
During wetter periods in the past, mixing by flow may have been more important



Isotope Data from Goff et al (2002)



Current Isotope Data



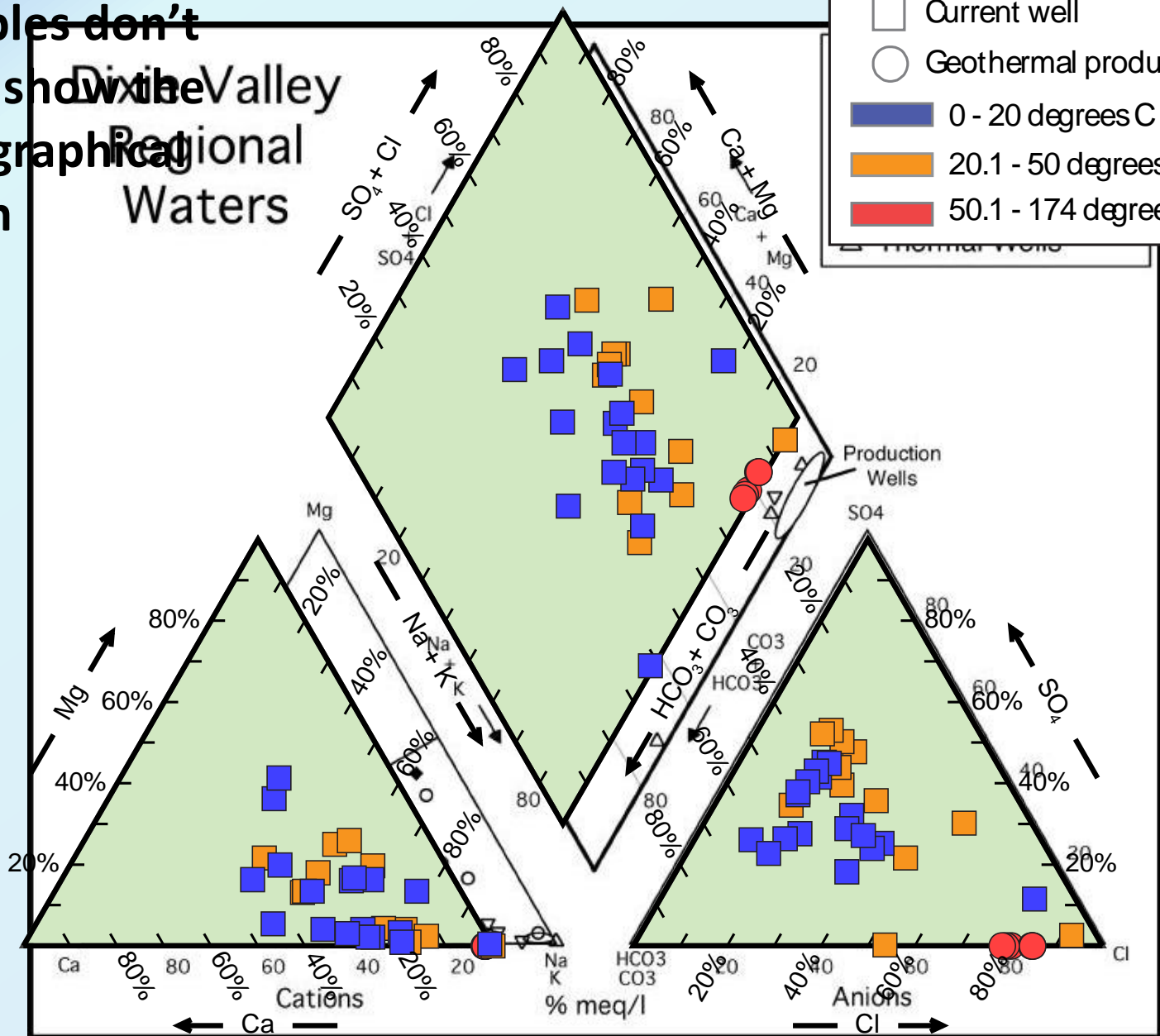
Data from Goff et al. (2002)

New samples don't appear to show the same geographical separation

Dixie Valley Regional Waters

Explanation

- Current well
- Geothermal production well
- 0 - 20 degrees C
- 20.1 - 50 degrees C
- 50.1 - 174 degrees C

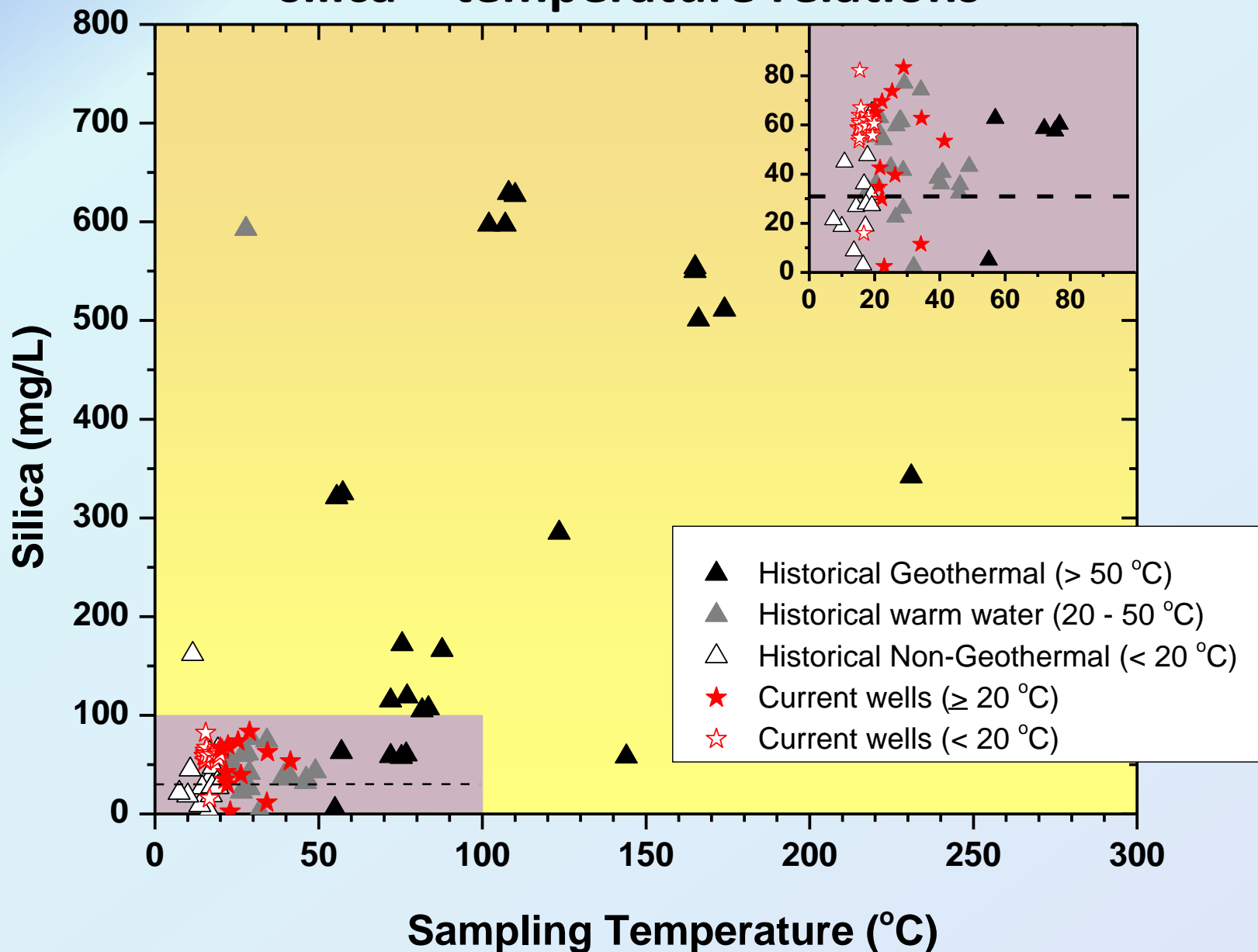


- Isotope data indicate little recent recharge
- Groundwater was likely mostly recharged in colder climate than present (possibly Pleistocene)
- Major ion chemistry indicates different E – W composition of groundwater and possibly mixing of the groundwater near the Playa
- A large percentage of wells have low magnesium concentrations

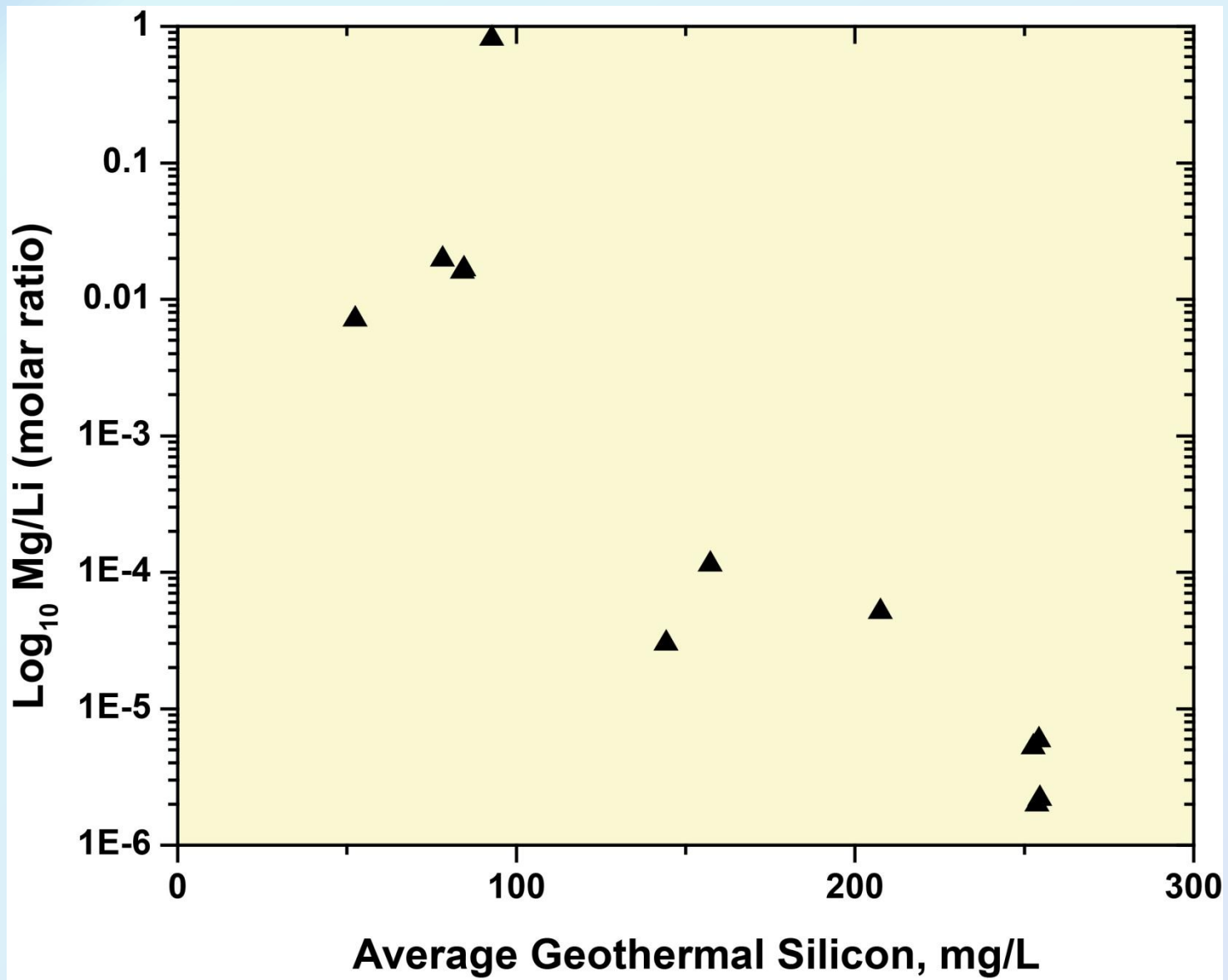


Geothermal Discharge

Most geothermal studies start with silica – temperature relations



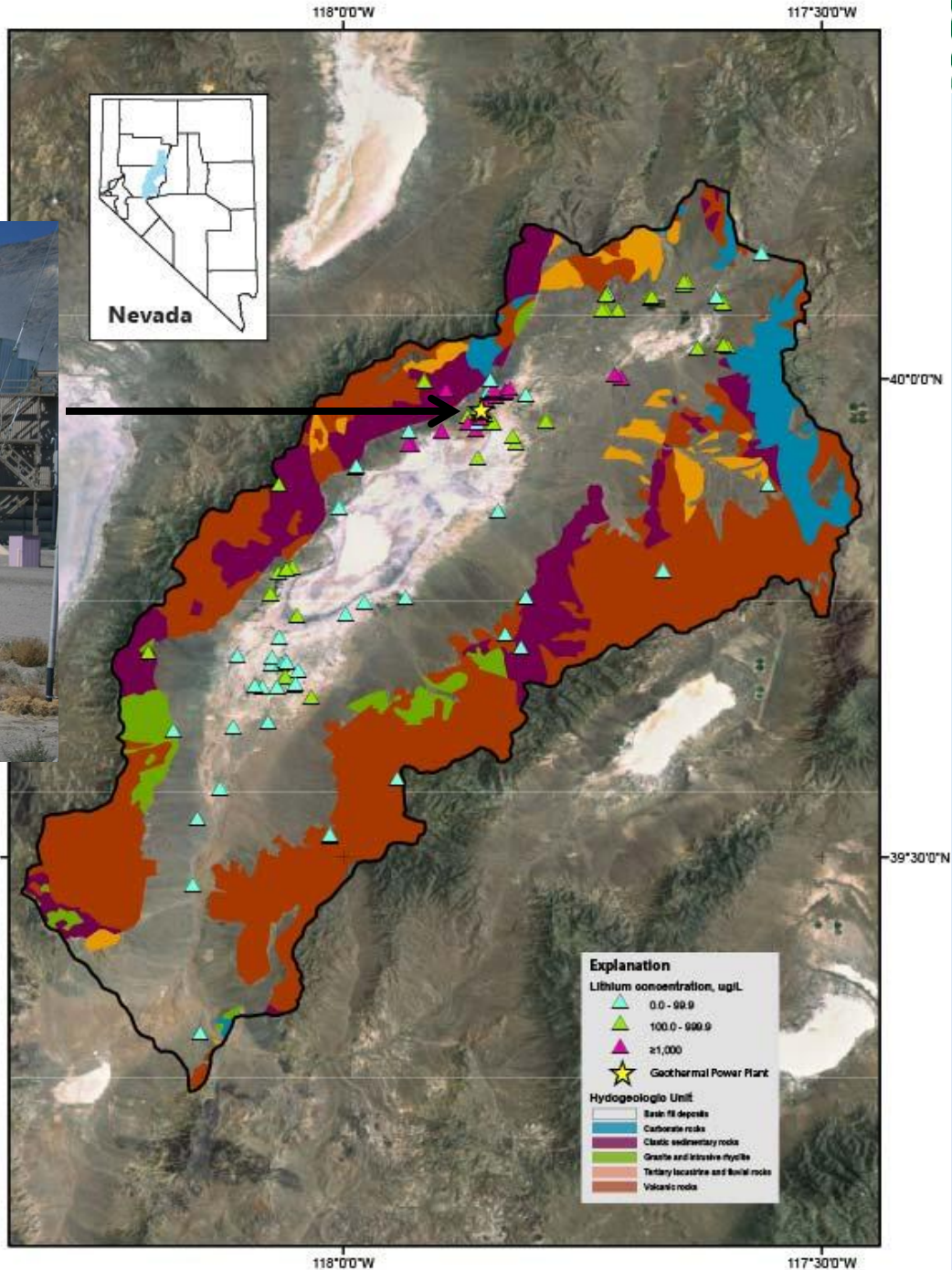
Good correlation between Mg/Li and geothermal silicon from geothermal wells



Lithium



Geothermal power plant



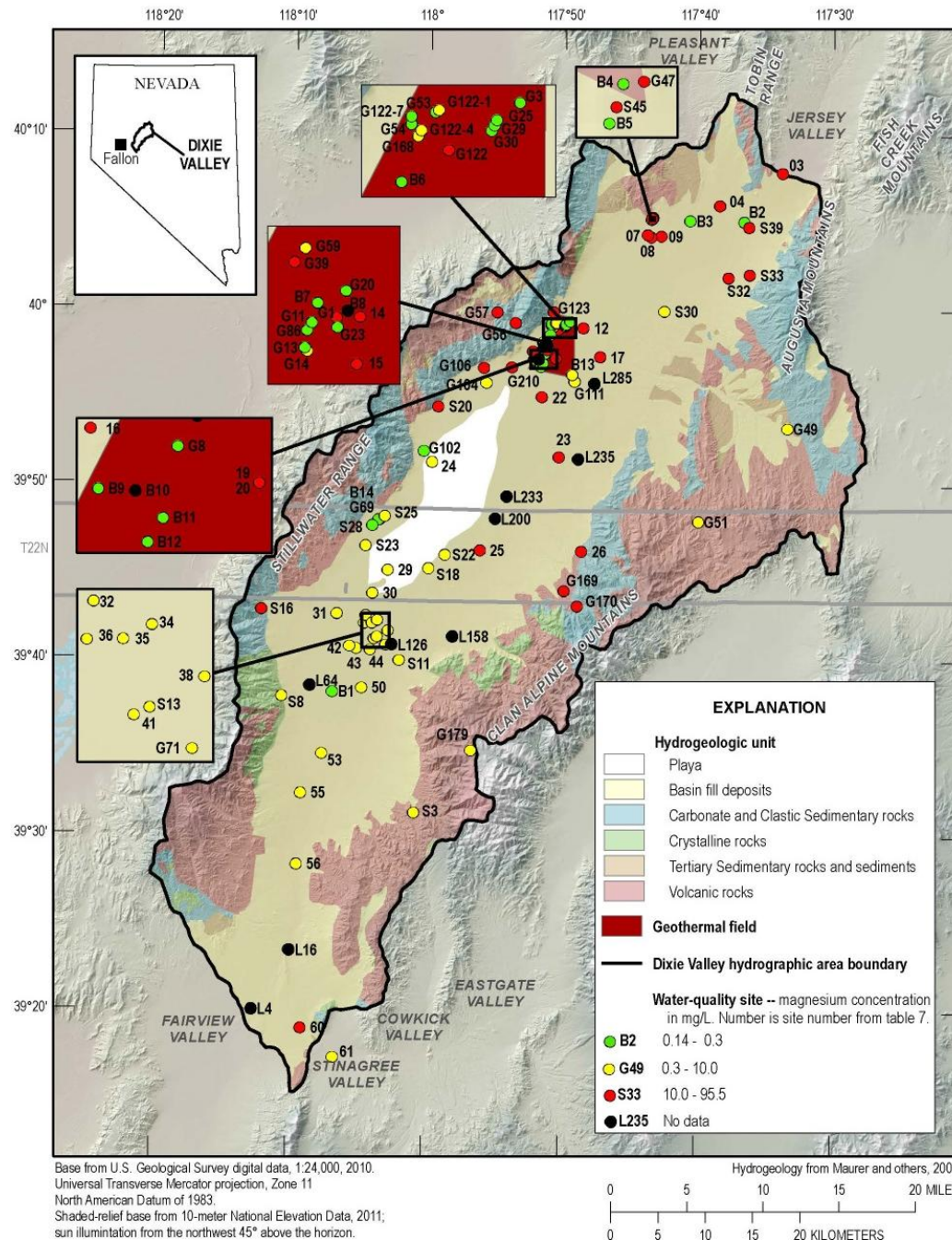
Lithium concentrations

- \triangle $<100 \mu\text{g/L}$
- \triangle $100 - 1,000 \mu\text{g/L}$
- \triangle $>1,000 \mu\text{g/L}$

Magnesium

Mg concentrations

- <0.3 mg/L
- 0.3 – 10 mg/L
- >10 mg/L
- No Data



Many Types of Geothermometers

Most are based on equilibrium chemical reactions at high temperatures

Si, Na-K, Na-K-Ca

Mg – Li

However based on empirical relation

$$T = \frac{2200}{(5.47 + \log \left[\frac{\sqrt{Mg}}{Li} \right])} - 273.15$$



**Given a geothermal reservoir
temperature of about 250 °C**

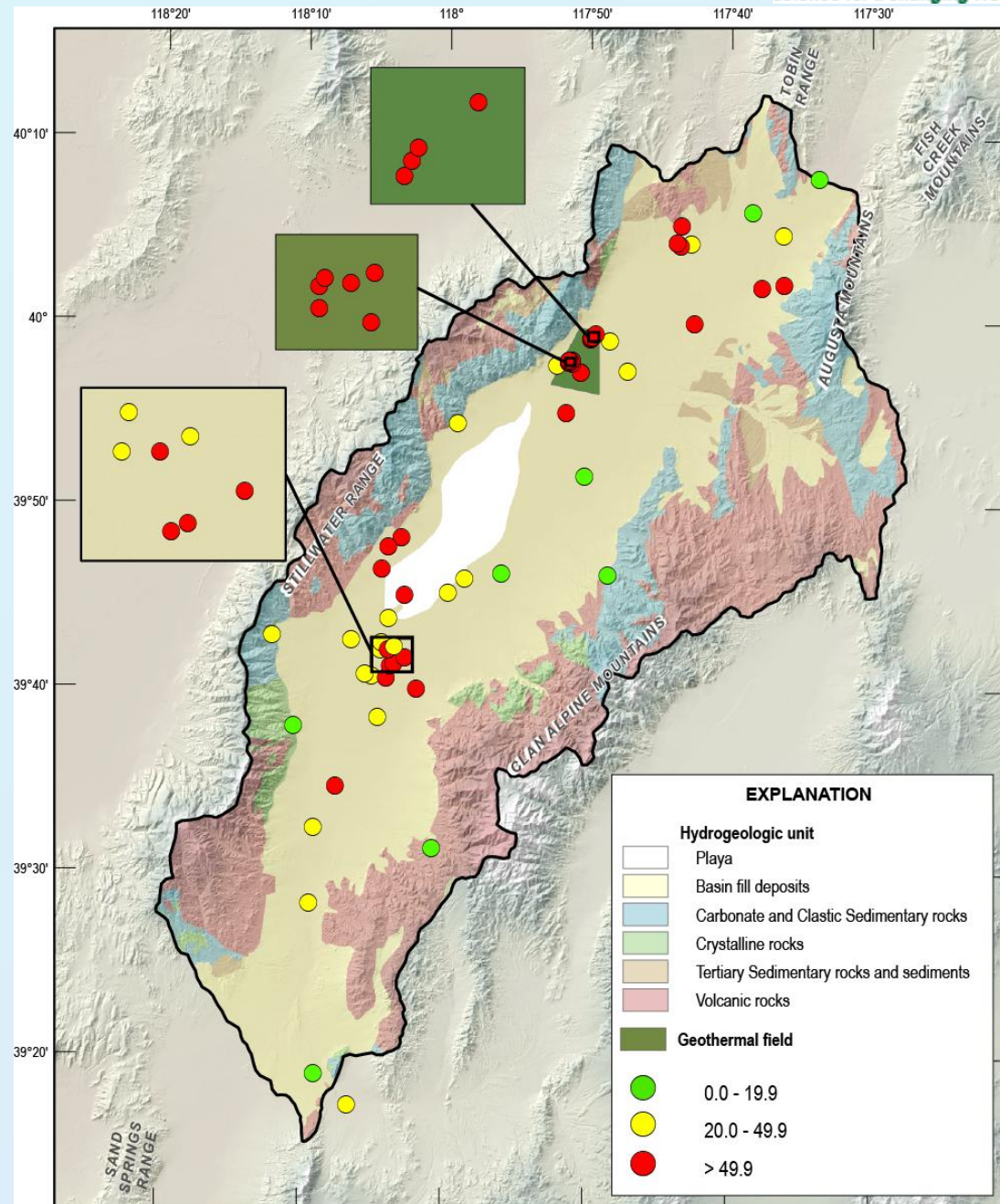
**Mg-Li indicates about 10 percent
mixing (on average)**

	Geothermometers		
	Sampling temperature (°C)	Mg-Li	Na-K-Ca
Average (n = 35)	20.5	44.7	88.2
Maximum	41.4	73.0	206.0
Minimum	14.3	7.2	19.5

Map of Mg-Li geothermometer temperatures

Calculated Temperatures

- <20 °C
- 20 – 50 °C
- >50°C



**Li and Mg can also be used in binary mixing,
or “correcting” geothermometers even
though cold groundwater values aren’t really
known (due to variability)**

Li in geothermal water = 3000 $\mu\text{g/L}$

Mg in geothermal water = < 0.1 mg/L

Li in groundwater = about 500 $\mu\text{g/L}$

Mg in groundwater = around 40-60 mg/L

Li and Mg binary mixing is about 10 - 15 percent

**“Correcting” geothermometers gives around 20 percent
mixing**

Conclusions

Li and Mg are good indicators of geothermal interactions in Dixie Valley (boron could also be used for mixing models)

Three different (although related) methods yield results of about 10- 20 percent – results agree with previous studies using isotopes

Least amount of mixing is in the south and east parts of the basin

South part of the basin is being explored for geothermal resources, has high As and F and would need to be treated

East side of basin would likely be best, but Churchill County has no water rights there!