Geothermal Resources within the Eastern Great Basin of Utah

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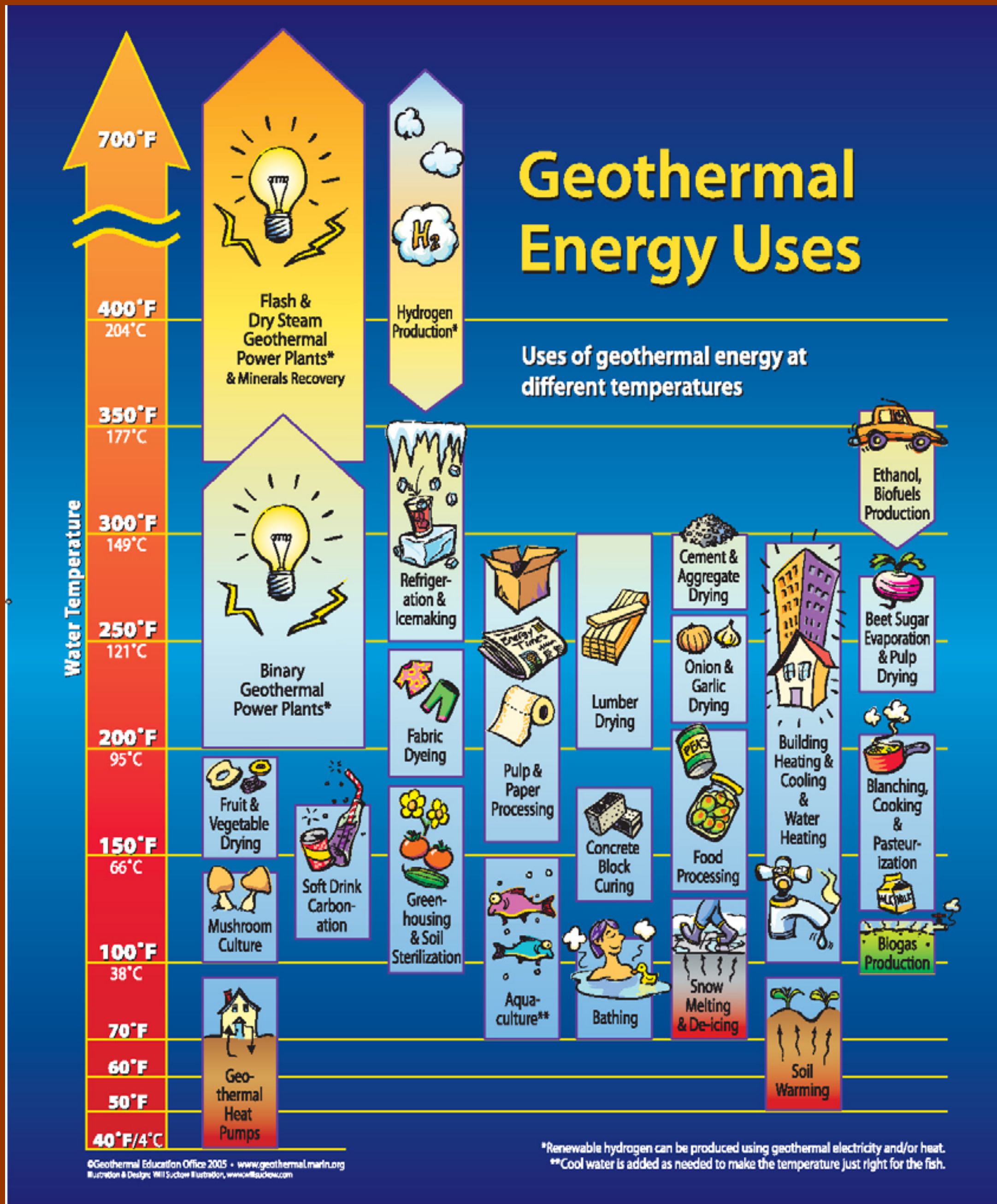
Utah Geological Survey
April 22, 2008

Utah Geothermal Working Group

Geothermal Energy Uses



Geothermal Education Office

http://www.geothermal.marin.org/

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World Wide Geothermal Plants

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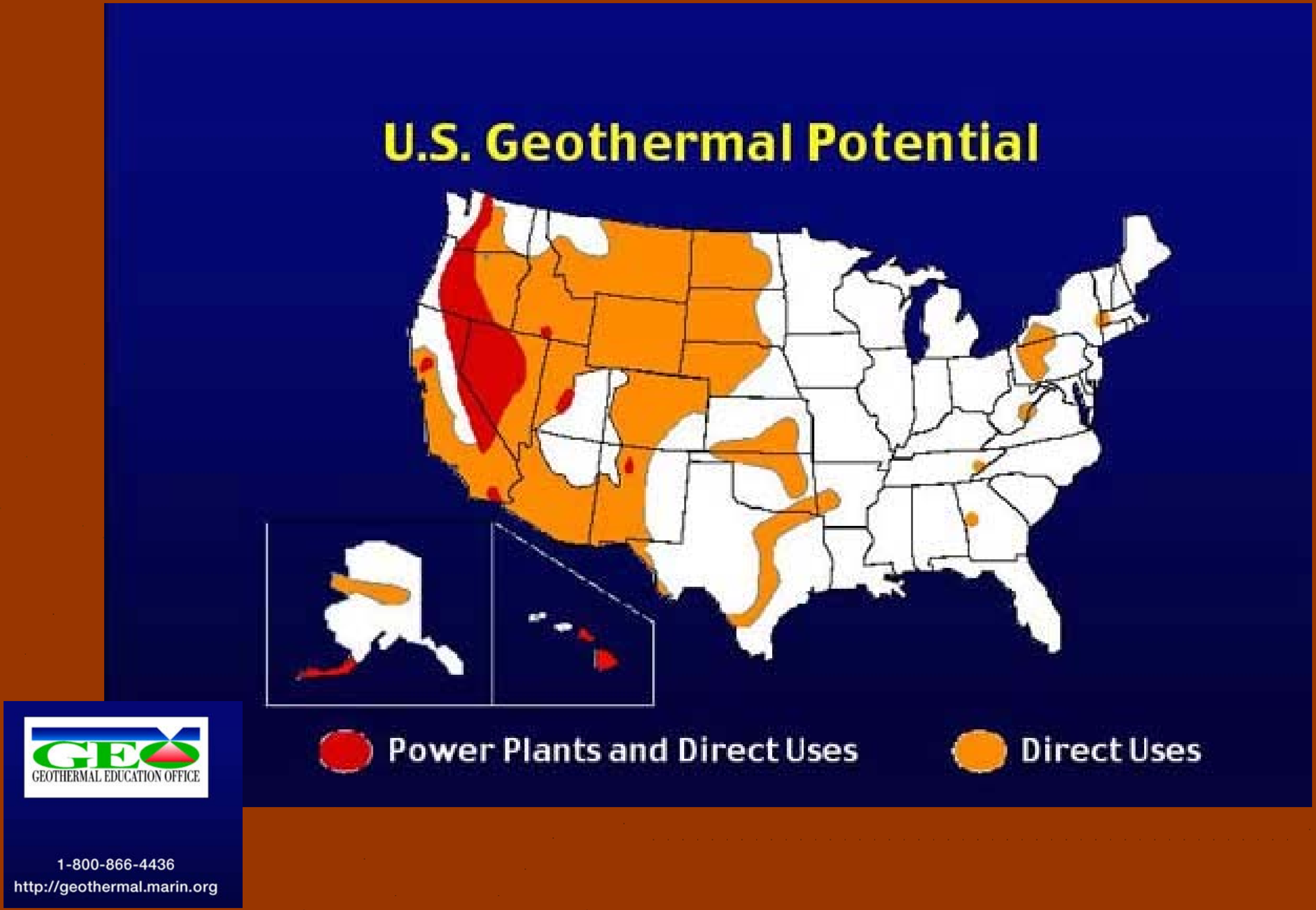
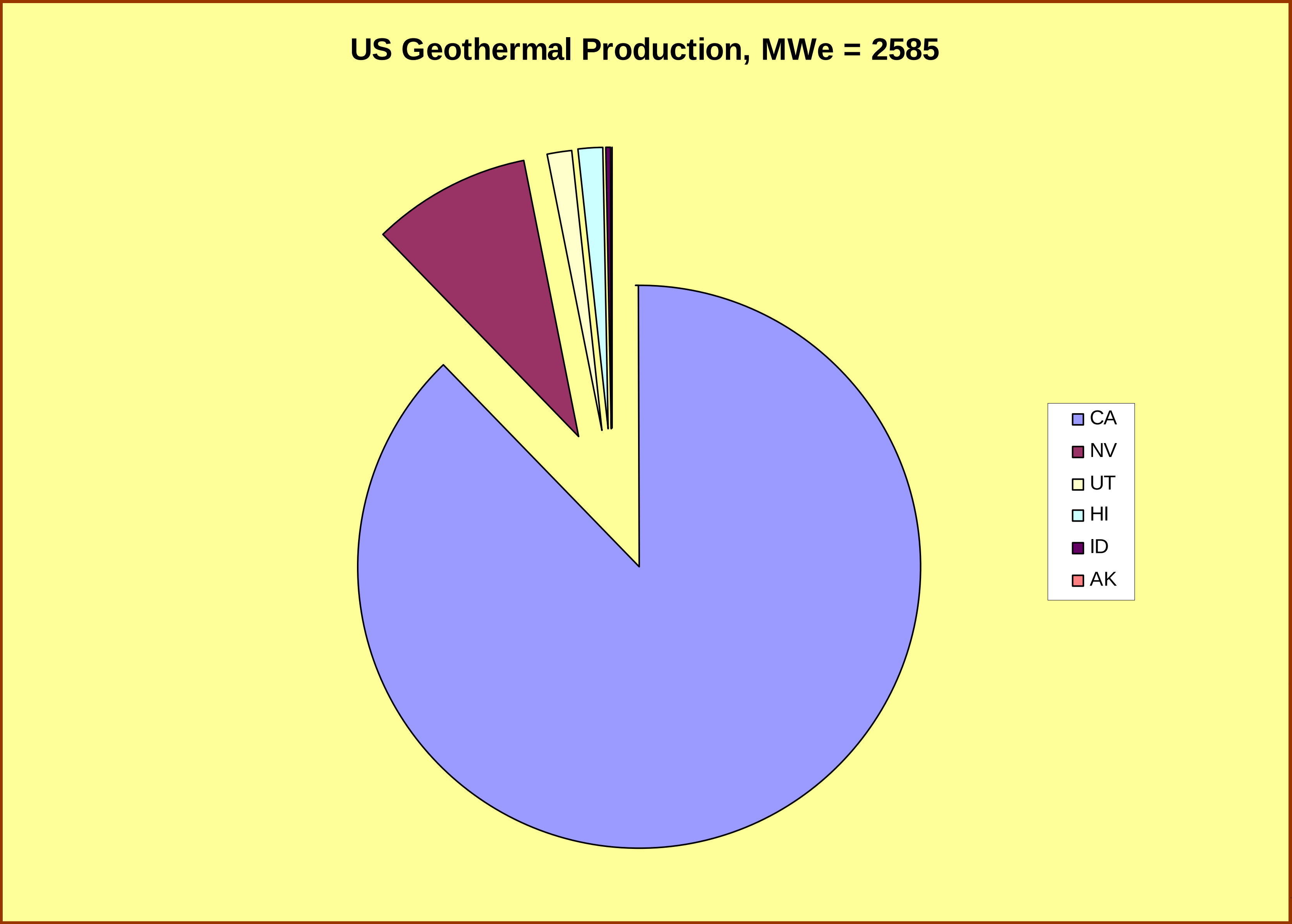
U.S. Geothermal Potential



US Geothermal Production



US Geothermal Production

State	Geothermal Area	Mwe
CA	The Geysers	1421
	Imperial Valley	530
	Honey Lake	3.8
	Mammoth Lakes	40
	Coso Hot Springs	274
	Subtotal	**2268.8**
HI	Puna Geothermal	**30**
UT	Roosevelt Hot Spr.	**37**
	Cove Fort-Sulfurdale	-
ID	Raft River	**10**
AK	Chena Hot Sprs.	**0.4**

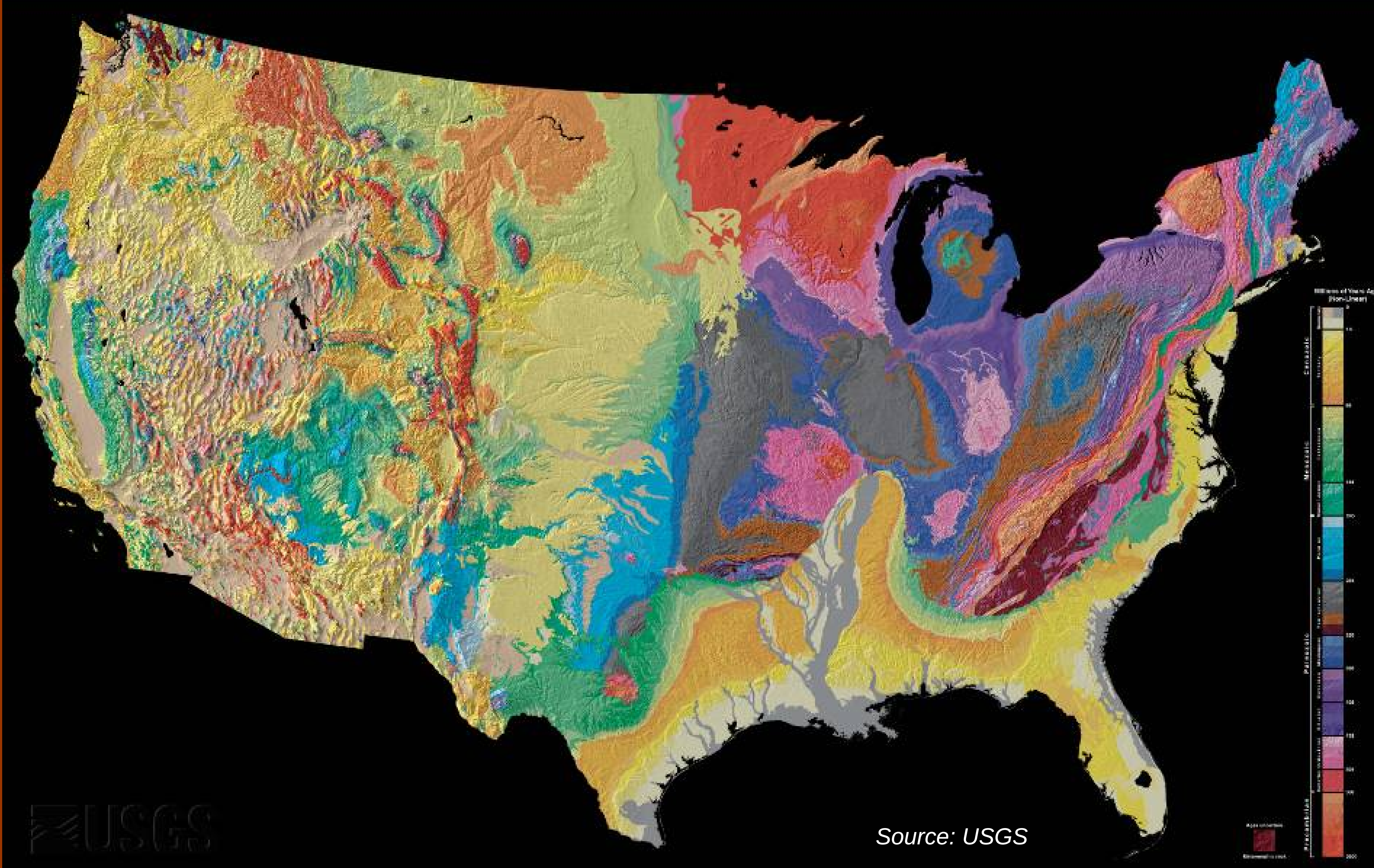
State	Geothermal Area	Mwe
NV	Beowawe	16.6
	Brady	21.1
	Desert Peak	12.5
	Dixie Valley	62
	Empire	4.8
	Soda Lake	26.1
	Steamboat	58.4
	Stillwater	21
	Wabuska	2.2
	Steamboat Hills	14.4
	Subtotal	**239.1**

Total = 2585.3 MWe

US Geothermal Direct Use

Use	# of Installations	Installed Capacity (MWt)	Annual Energy Use 10^9 Btu	Annual Energy Use TJ	Capacity Factor
Space Heating	1000	90	900	948	0.33
District Heating	18	105	628	662	0.20
Aquaculture	45	140	2,910	3,067	0.70
Greenhouses	37	129	1,164	1,227	0.30
Agriculture Drying	3	20	290	305	0.49
Industrial Processing	4	7	72	76	0.34
Resorts/Spas/Pools	219	107	2,370	2,498	0.74
Snow Melting	5	2	16	17	0.27
Subtotal	1,331	600	8,350	8,800	0.47
Geo. Heat Pumps	450,000	3,400	12,250	12,900	0.12
Total		4,000	20,600	21,700	0.17

Conterminous U.S. Geology



Source: USGS

Basin & Range Characteristics

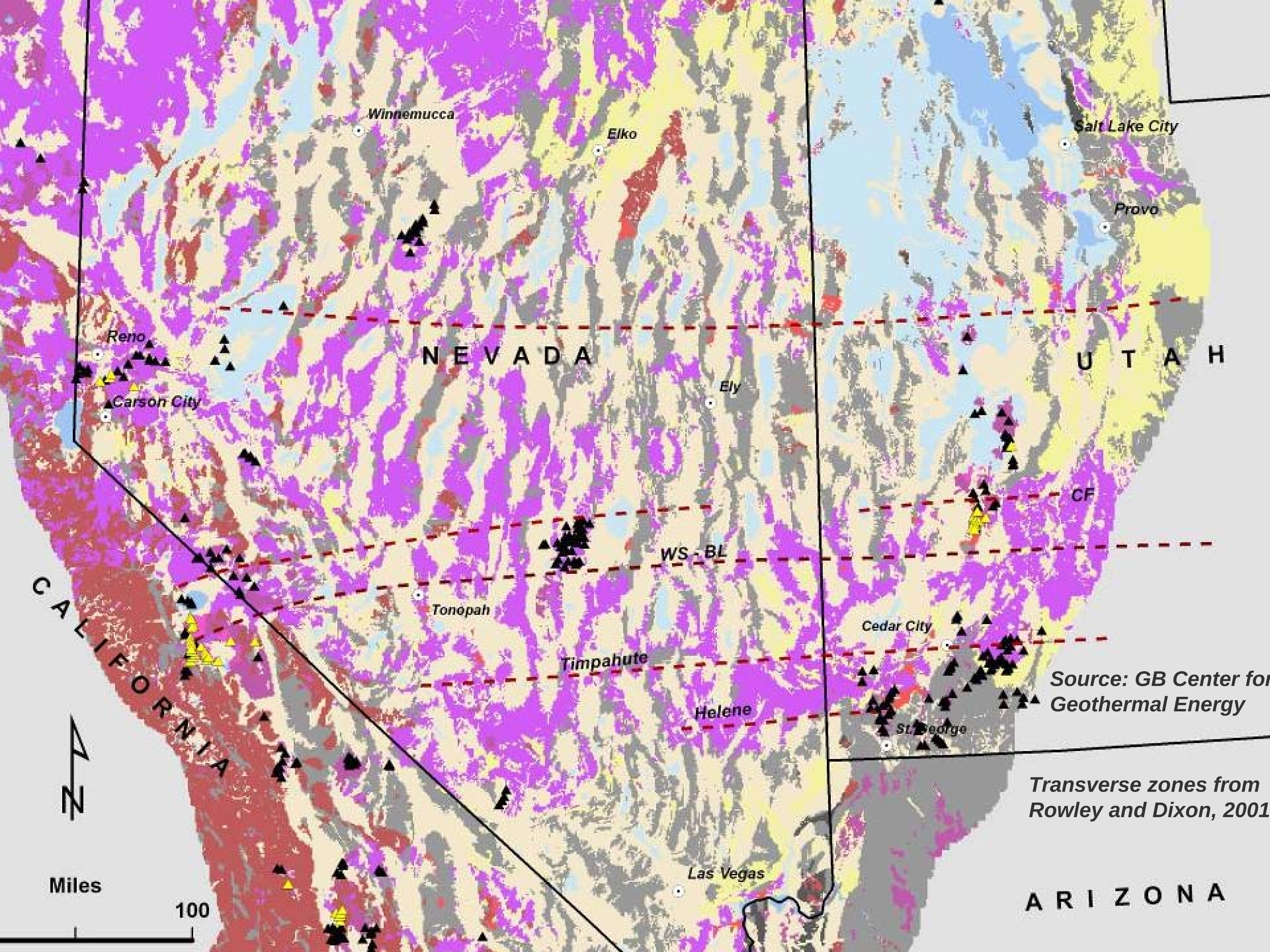
- Extraordinary E-W extension
- North-trending fault blocks
- Bimodal magmatism
- Bilateral symmetry
- Outward younging magmatism & tectonism
- N to NW-trending rift zones & geophysical anomalies
- <u>East-trending transverse zones</u>

(Rowley and Dixon, 2001)

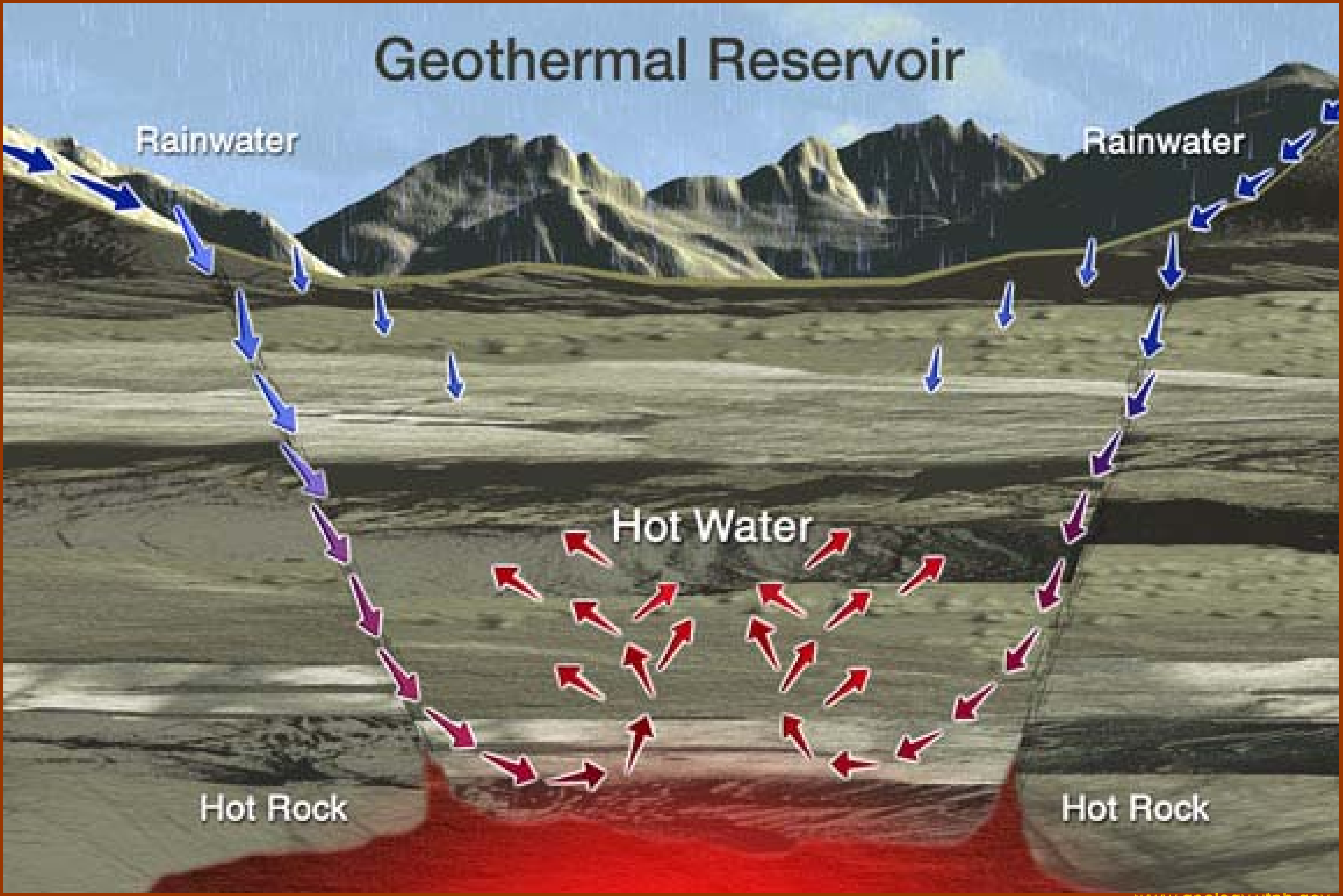
Great Basin Evolution

- Current B & R features formed since 20 Ma
- Some features inherited from pre-basin-range (middle Cenozoic; 45 to 20 Ma)
- Pre- B & R formed during subduction of Pacific plate beneath western NA
- Pre- B & R characterized by extension but expressed more by voluminous calc-alkaline, shallow intrusions (partial melts of crustal rocks) in east-trending igneous belts and metamorphic core complexes (than by faults)
- After 20 Ma, subduction ceased; relative motion between NA and NE Pacific Basin taken up by San Andreas/Walker Lane transform
- Boundary traction forces led to E-W extension along N-S B&R structures

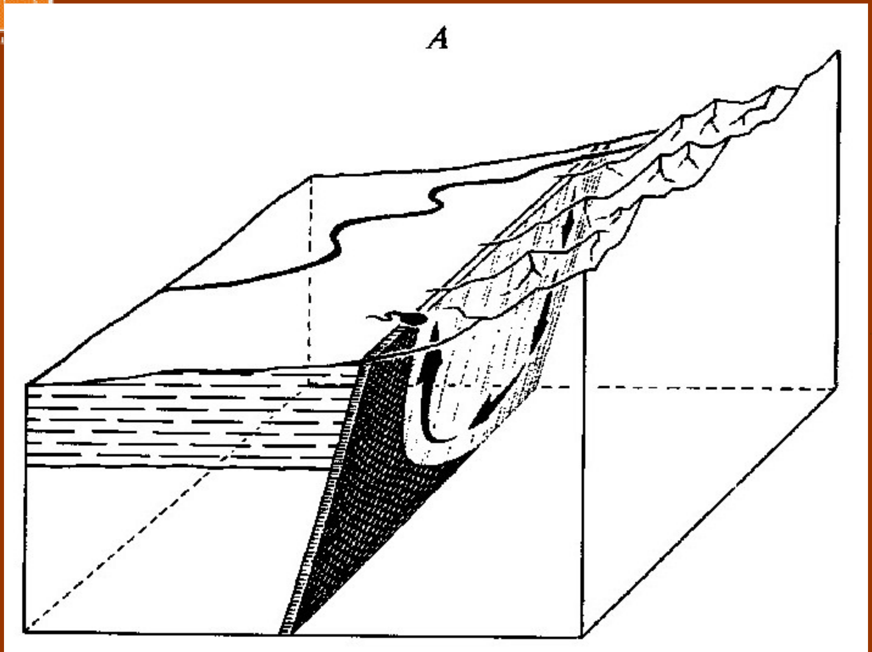
(Rowley and Dixon, 2001)

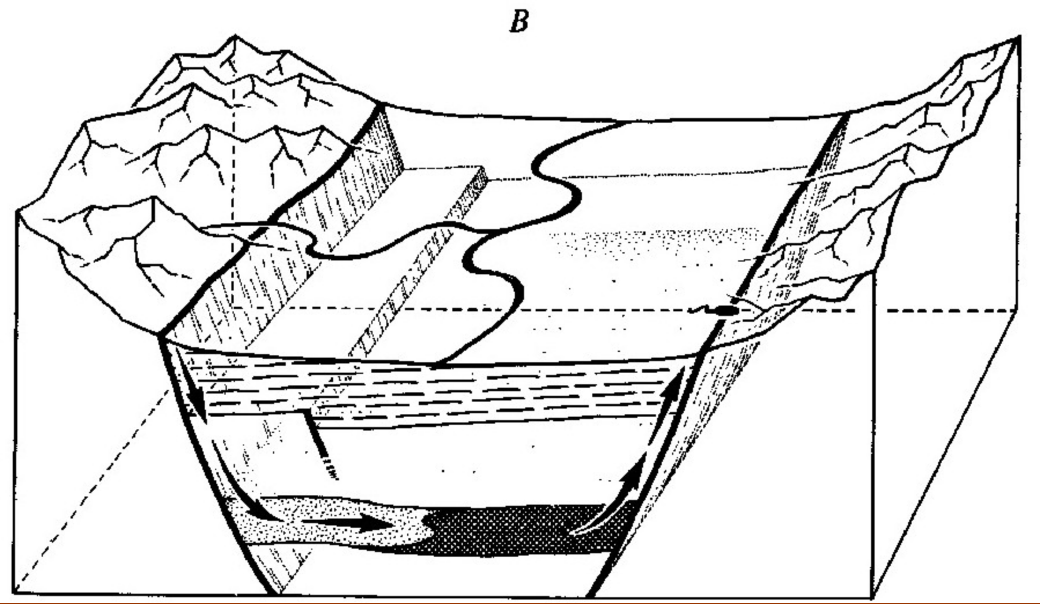

Winnemucca
Elko
Salt Lake City
Provo
Reno
Carson City
NEVADA
UTAH
Ely
CF
WS - BL
Tonopah
Cedar City
Timpahute
Helene
St. George
CALIFORNIA
Las Vegas
ARIZONA
Miles
100
Source: GB Center for Geothermal Energy
Transverse zones from Rowley and Dixon, 2001

Hydrothermal Convection System Concepts

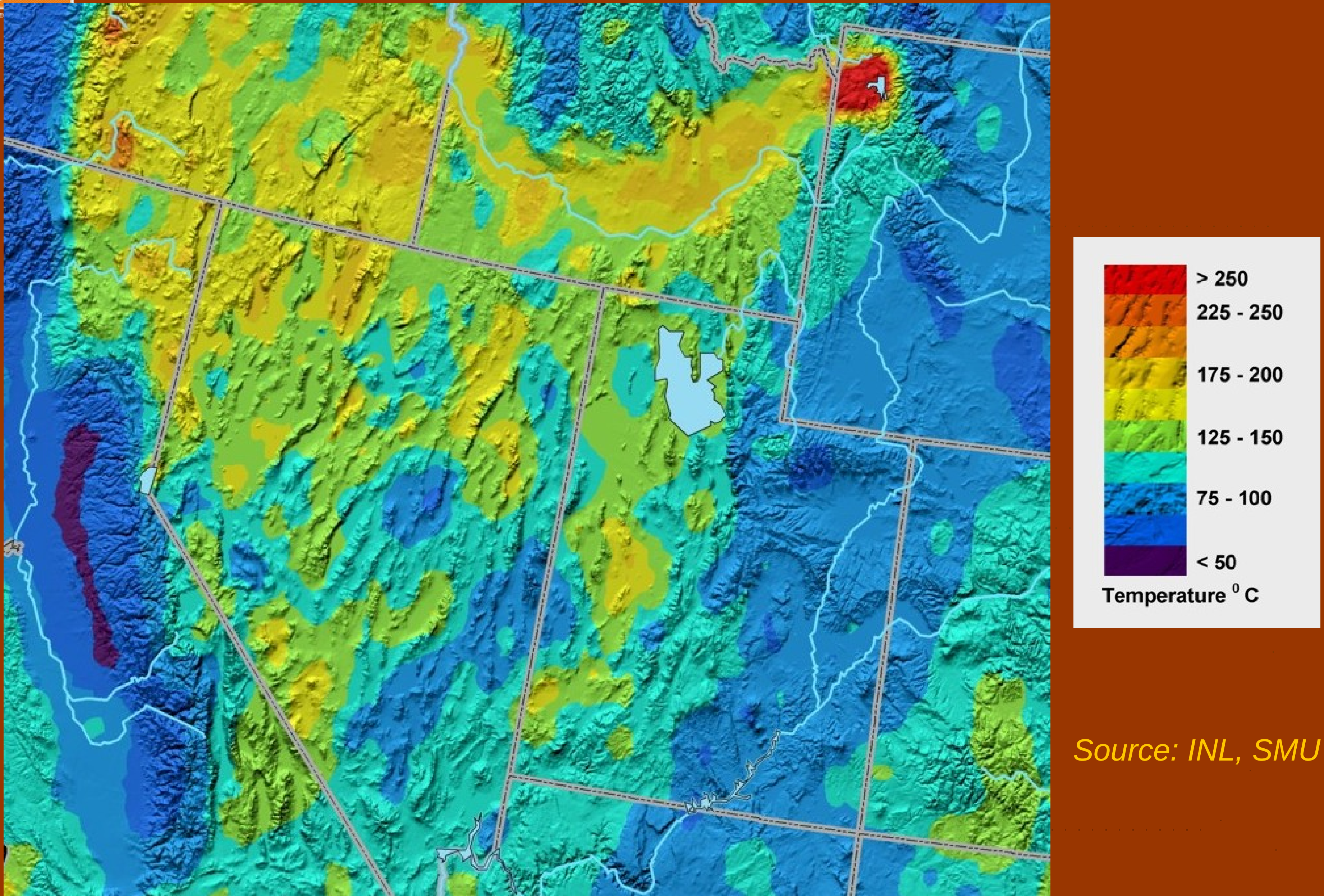


Hydrothermal Convection System Models



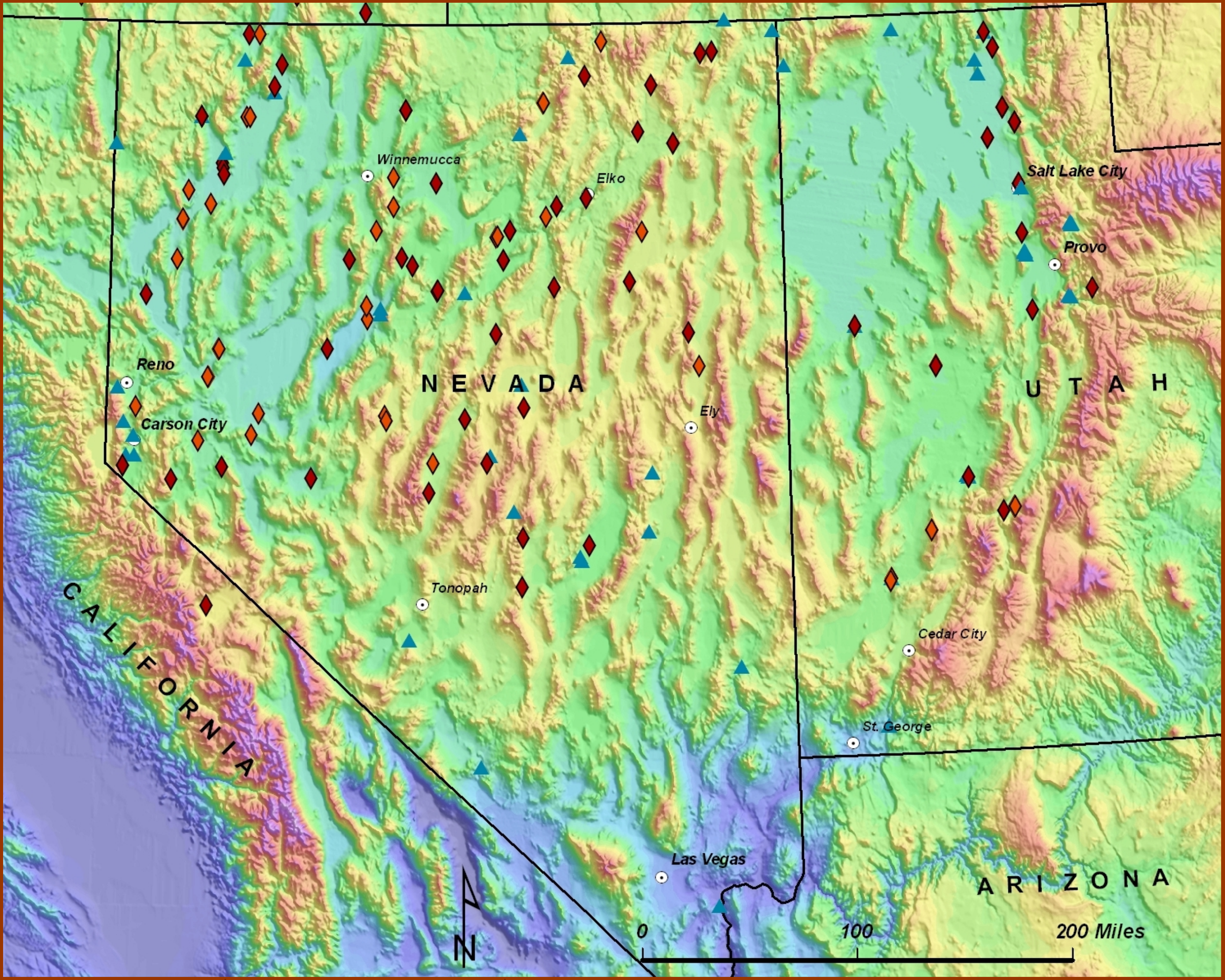


Temperature at 3 km Depth

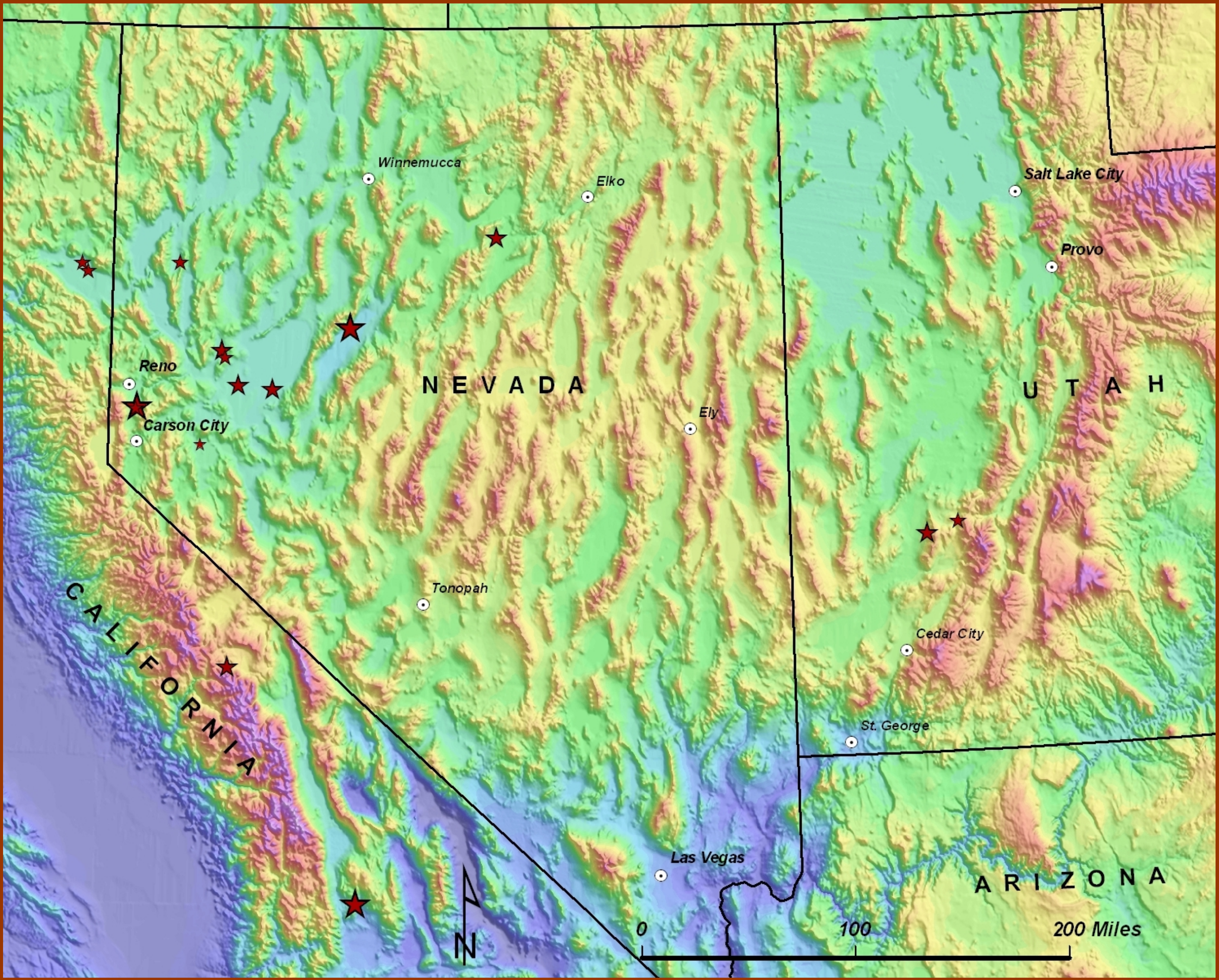


Source: INL, SMU

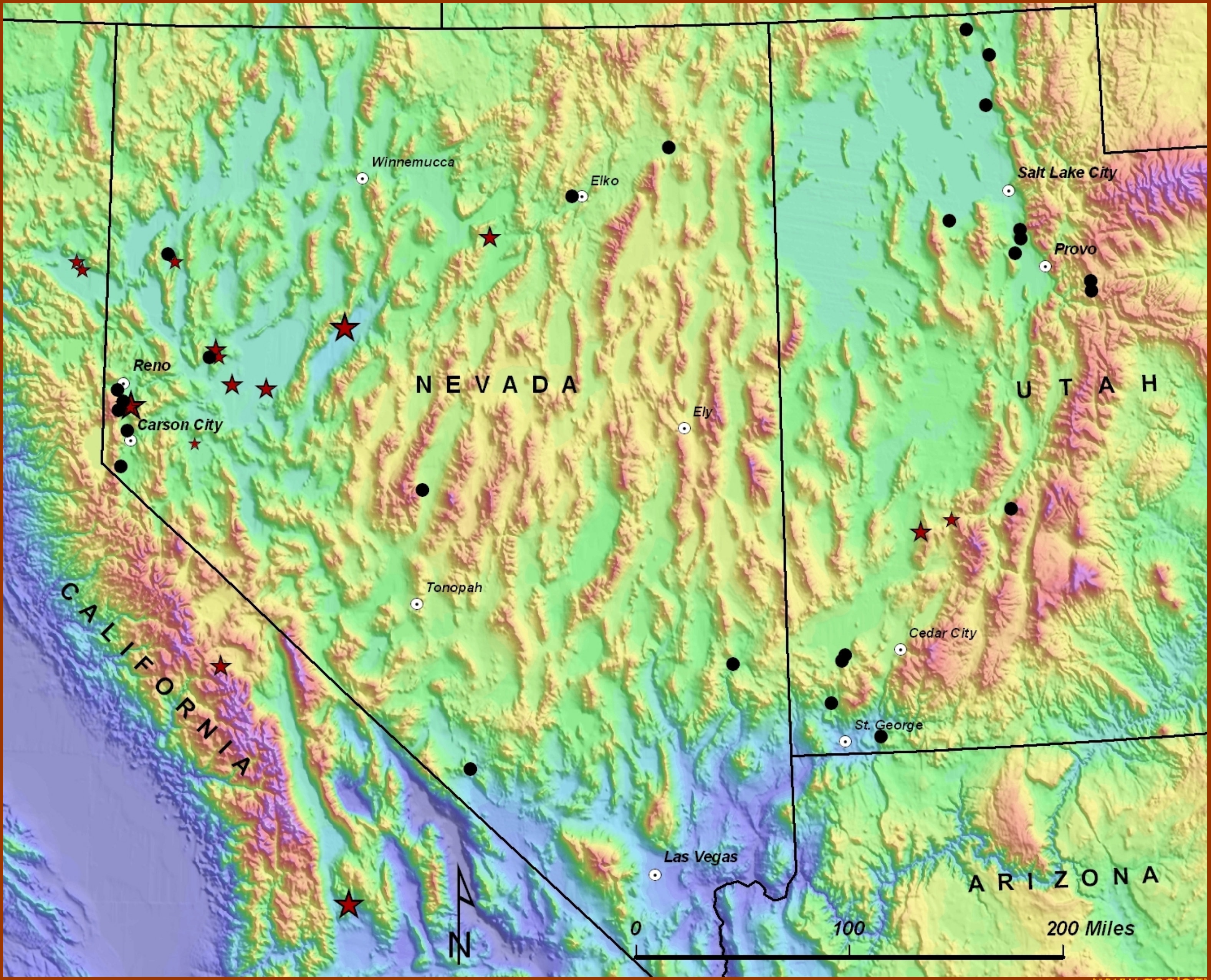
GB Thermal Springs



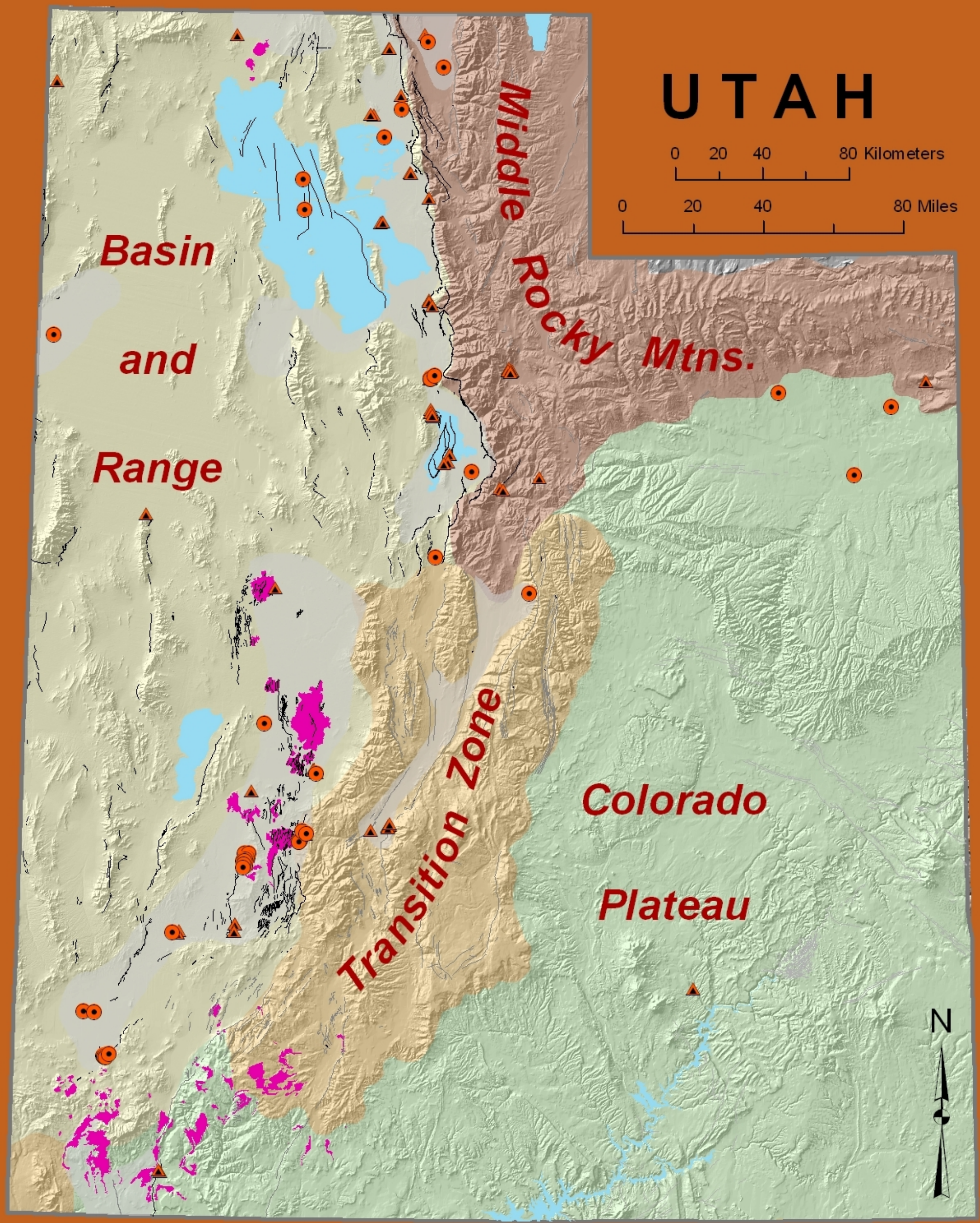
GB Geothermal Power Plants



GB Geothermal Power Plants



Physiographic Regions



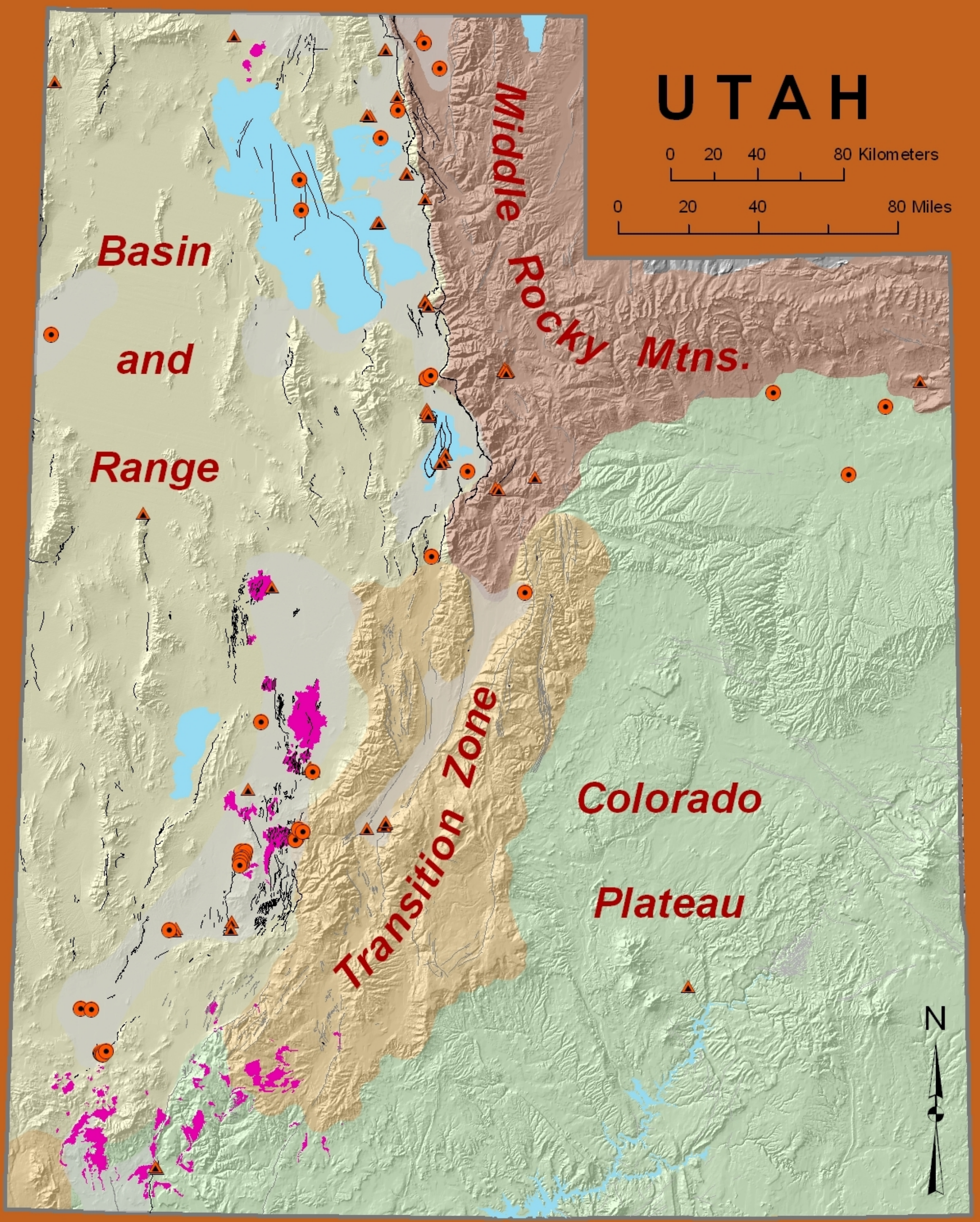
Middle Rocky Mtns. – Wasatch Range, Uinta Mtns; pre-Cenozoic sedimentary/metamorphic rocks; Cenozoic plutonic rocks.

Colorado Plateau – So. Central, So. Eastern Utah; broad regional uplift; ~ flat-lying Mesozoic, Paleozoic sedimentary rocks; scattered Cenozoic volcanic rocks along western margin.

Basin & Range – Western Utah; numerous N-S fault-tilted mountain ranges; region of active tectonics; wide variation of rock ages and compositions (pC to Holocene); late Cenozoic valley-fill as much as 3,000 m thick.

Transition Zone – Central Utah; contains elements of CP & BR provinces

Late Cenozoic Tectonics



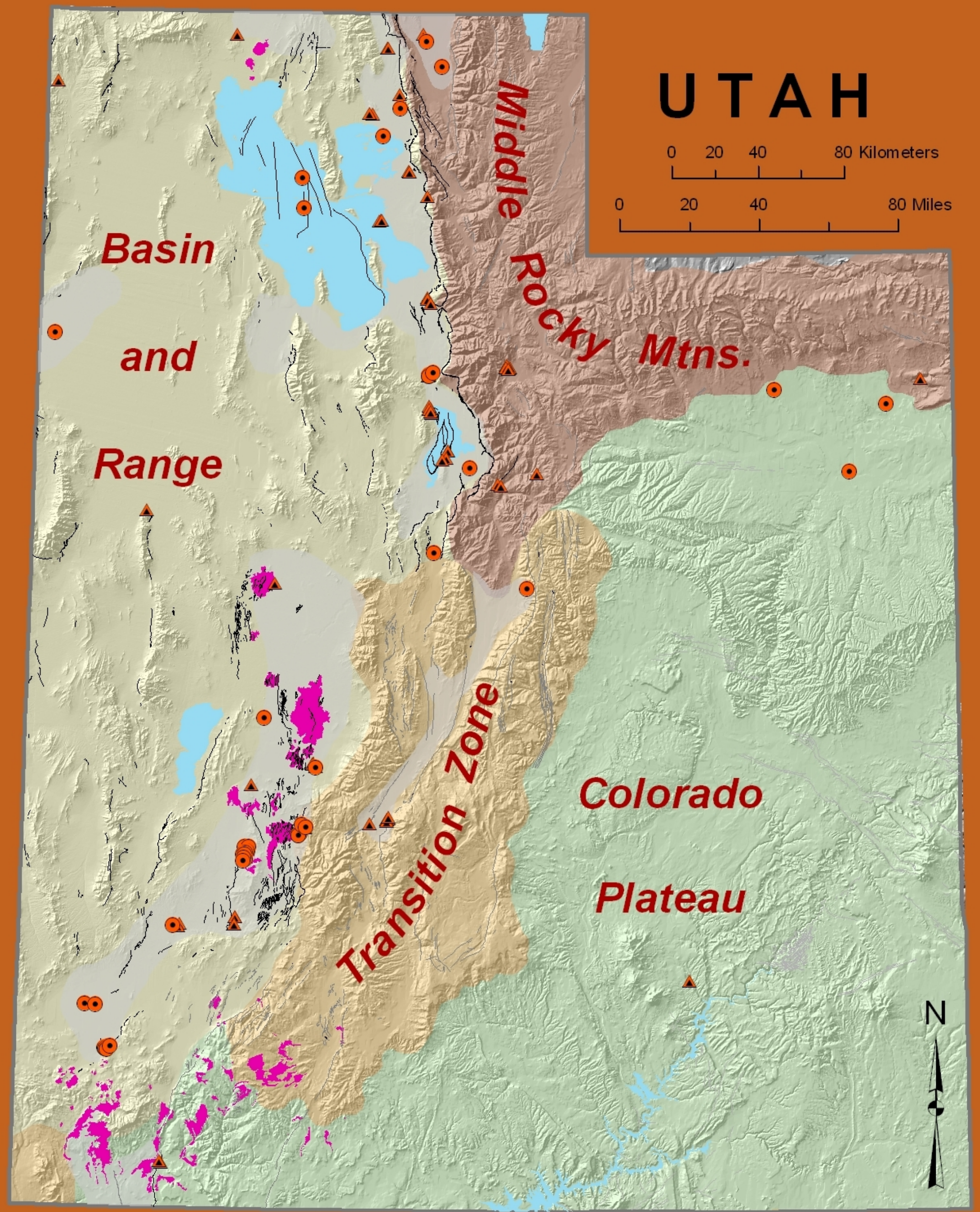
Basin & Range terminates at Wasatch Fault in N Utah and against High Plateaus (TZ) in central/southern Utah.

Before Basin-Range extension, voluminous mid-Cenozoic, silicic volcanism and hydrothermal activity within E-W belts

East-West structural extension over past 17 million years creates N-S fault-tilted blocks and bimodal (basalt & rhyolite) volcanism.

Quaternary faulting distributed throughout Basin & Range, concentrated along eastern edge – Wasatch (210 mi), Hurricane (155 mi); ISB.

Geothermal Resources in Utah



Main Resource Areas Include:

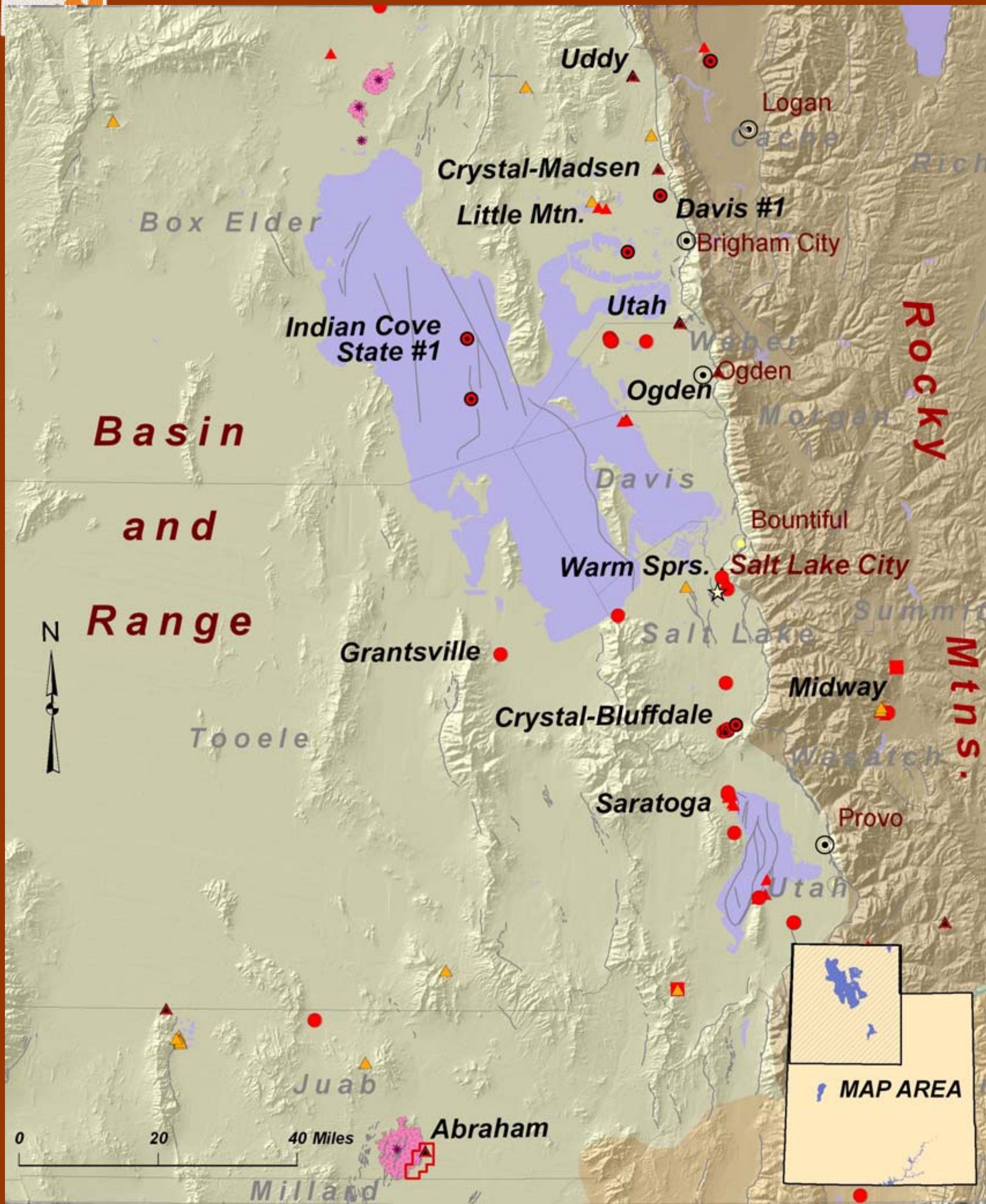
Basin and Range – Escalante Desert, Black Rock Desert, Sevier Desert, Wasatch Front Valleys

Transition Zone – Tushar Mtns., Sevier Valley, St. George Basin

Rocky Mtns. Wasatch Back, (Heber Valley, Cache Valley)

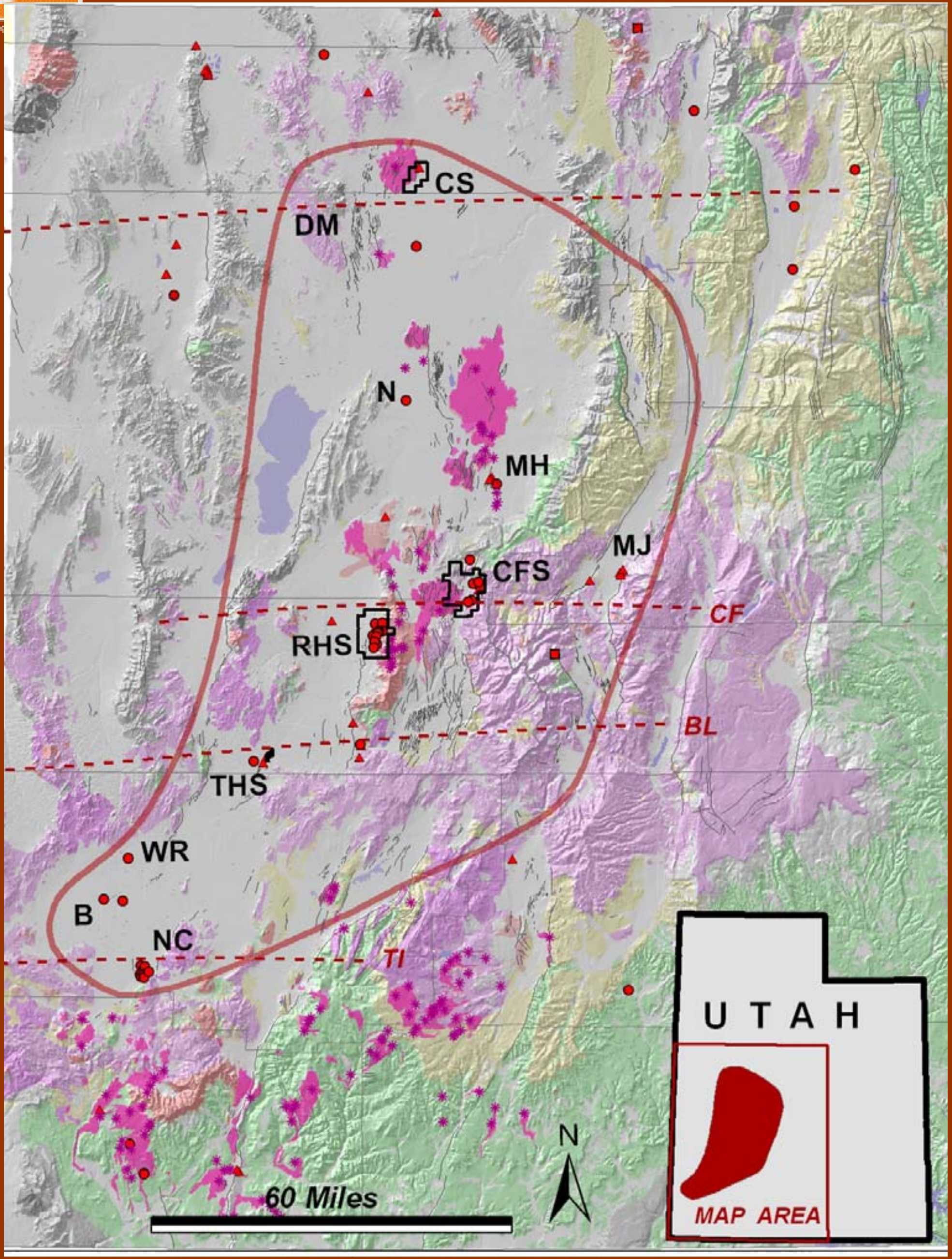
Colorado Plateau – Uinta Basin

Northern Utah



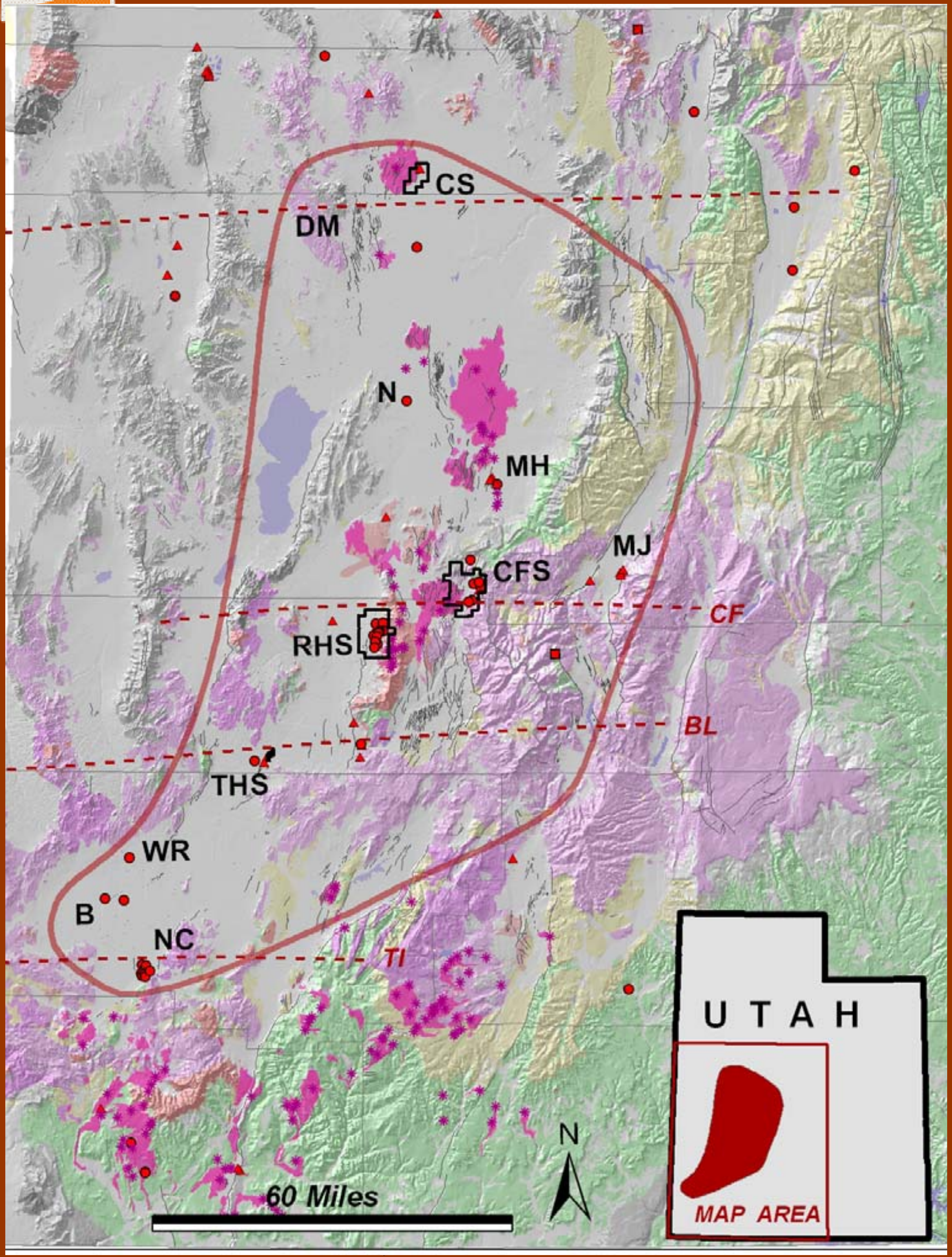
- Wasatch Front Valleys
- Eastern B&R province (terminates at Wasatch Fault)
- Identified low & moderate-temperature systems associated with B&R faults
- Possible deep high-temperature systems (i.e. Davis #1 & Indian Cove wells)
- Recent discovery at Corner Canyon near Draper (200°F)

Sevier Thermal Area



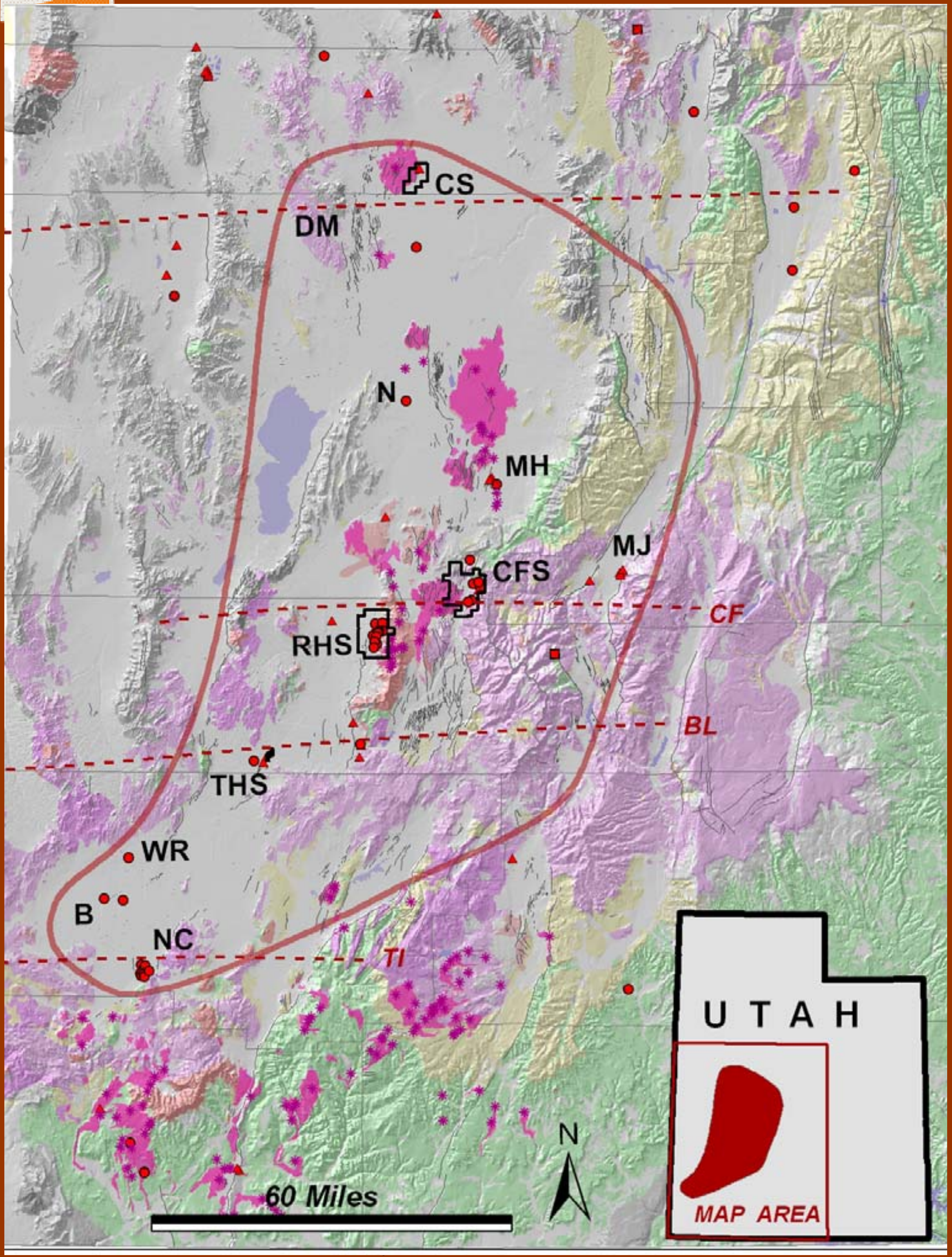
- Located in SW Utah
- Eastern B&R province and B&R-CP Transition Zone
- Most identified moderate and high-temperature systems in Utah
- Several geothermal areas situated near transverse zones of Rowley and Dixon (2001)

Sevier Thermal Area

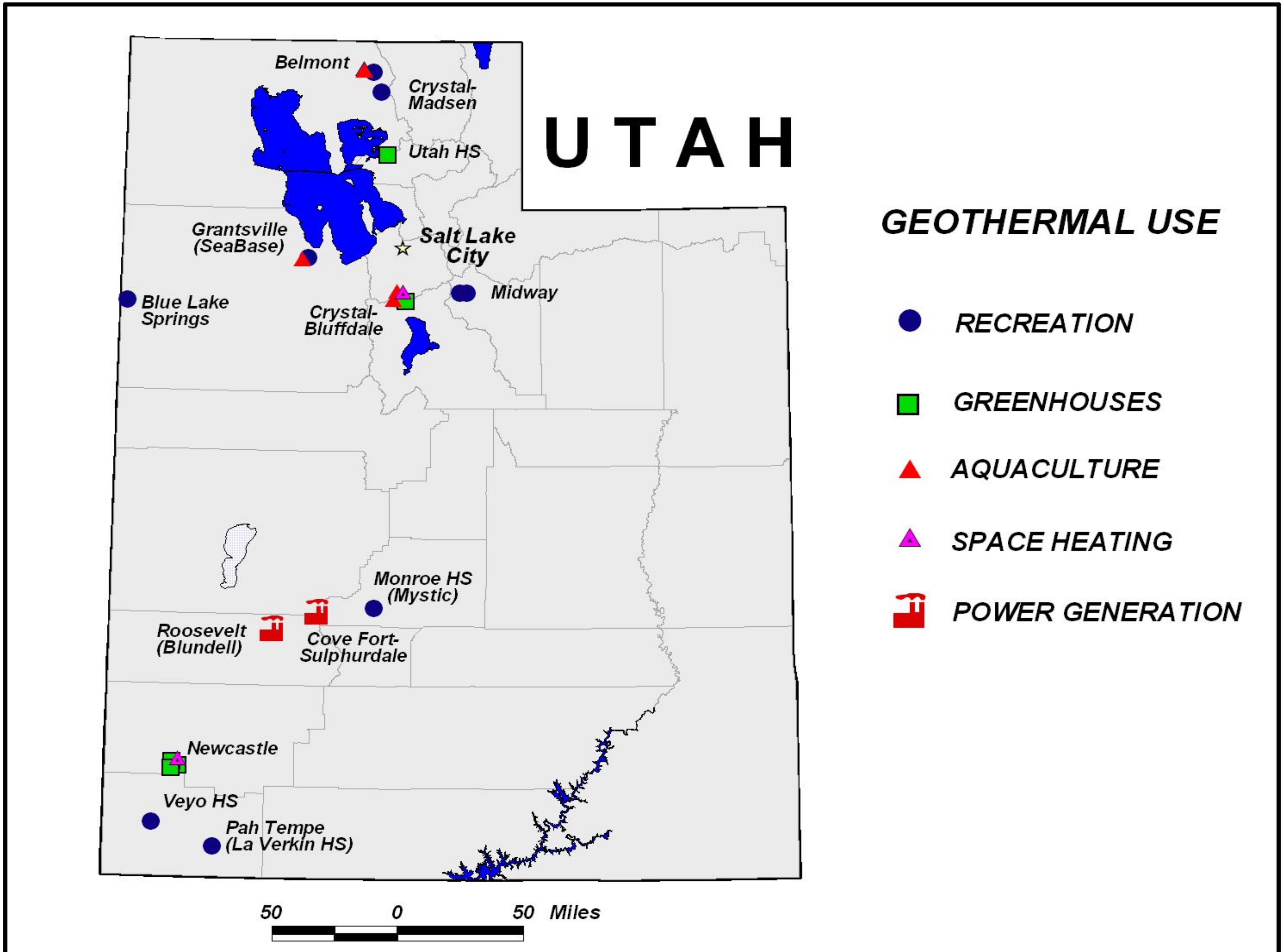


- Abundant late Cenozoic normal faults
- Tertiary plutonic and volcanic rocks
- Quaternary (bimodal) basalt and rhyolite
- High regional heat flow
- Complex structural history
- Active seismicity (ISB)
- “transverse zones” – Rowley and Dixon (2001)

Sevier Thermal Area

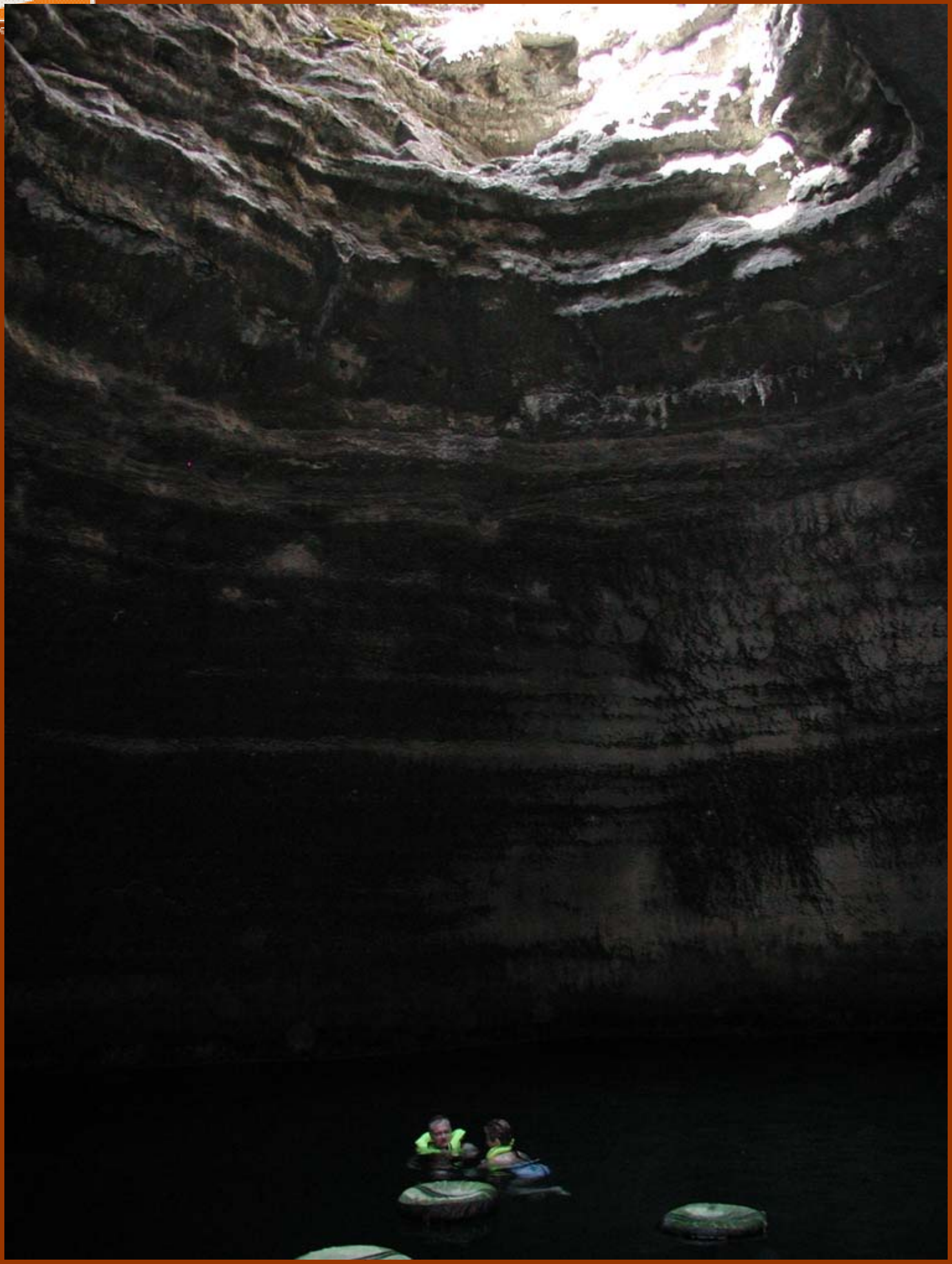


- Centered on RHS and CFS – geothermal power projects
- Drum Mtns. – WWV - Crater Springs – prospect
- Neels RR Siding Well - prospect
- Meadow-Hatton – undeveloped
- Monroe-Joseph – resort
- Thermo HS – undeveloped
- Beryl-Woods Ranch – prospect
- Newcastle – large, commercial greenhouses


UTAH
GEOTHERMAL USE
RECREATION
GREENHOUSES
AQUACULTURE
SPACE HEATING
POWER GENERATION
Belmont
Crystal-Madsen
Utah HS
Grantsville (SeaBase)
Salt Lake City
Blue Lake Springs
Crystal-Bluffdale
Midway
Monroe HS (Mystic)
Roosevelt (Blundell)
Cove Fort-Sulphurdale
Newcastle
Veyo HS
Pah Tempe (La Verkin HS)
50 0 50 Miles


Geothermal
Greenhouses –
Newcastle, UT


Milgro Nurseries, Newcastle, Utah
Geothermal Space Heat



The Homestead Crater
Homestead Resort
Midway, Utah

"Of all the unique and wonderful activities you'll be part of at the Homestead, there is nothing quite like the Homestead Crater. It is a 55-foot tall, beehive-shaped limestone rock that nature has hollowed out and filled with 90° to 96° water. We have created a tunnel through the rock wall at ground level and built decks and a soaking area for our guests and the public to access the crystal clear mineral water. You can go swimming, scuba diving, snorkeling or enjoy a therapeutic soak."

Source: The Homestead Website at http://www.homesteadresort.com/leisure/crater.html


The Homestead Crater
Midway, Utah

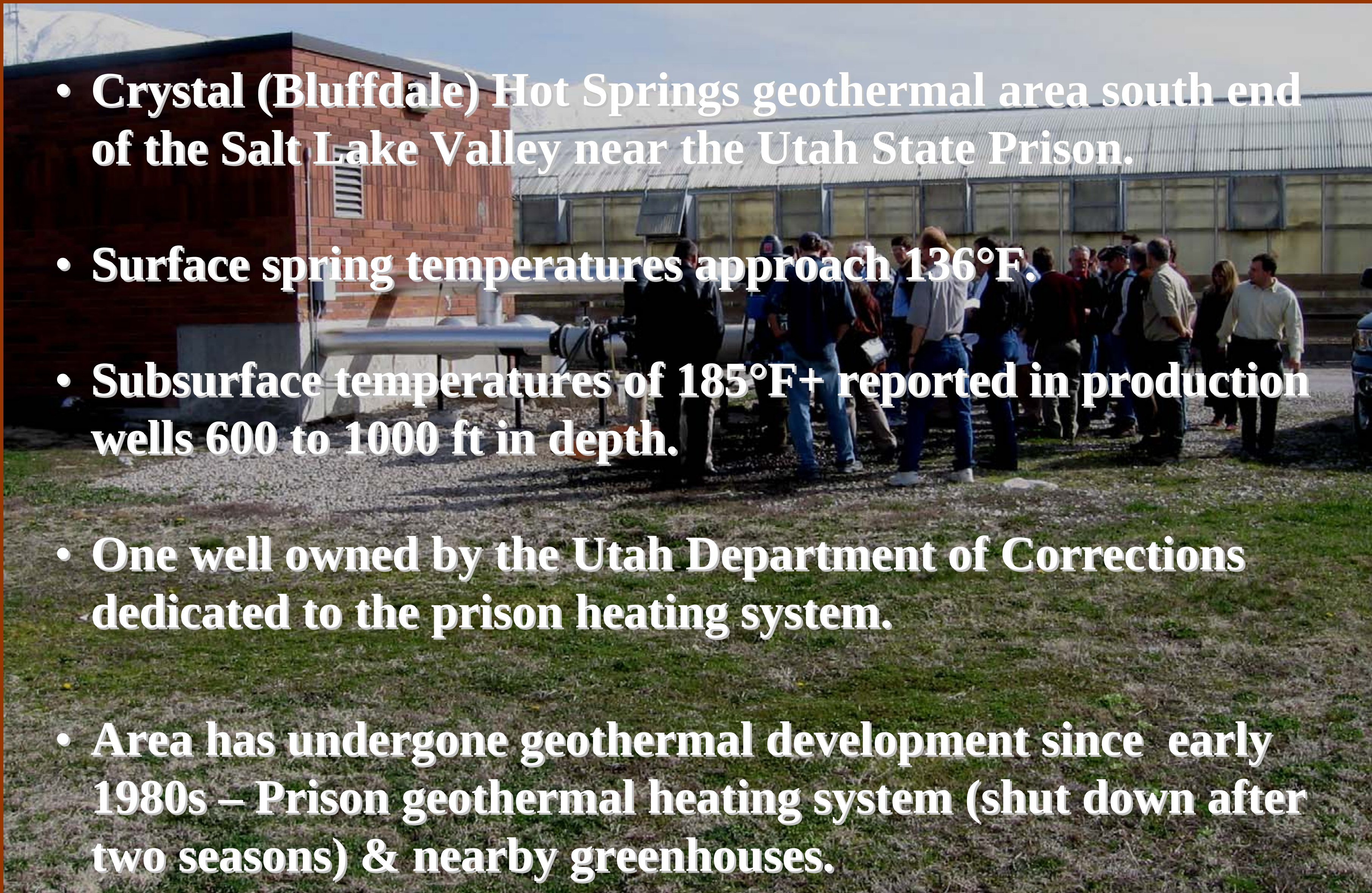

The Homestead Crater
60 ft Dive Pool


60 ft Dive Pool
90°F year-round
Bonneville SeaBase
Tooele County, Utah
Scuba Diving

Bonneville SeaBase, Grantsville

Bonneville SeaBase, Grantsville

Utah State Prison Space Heating

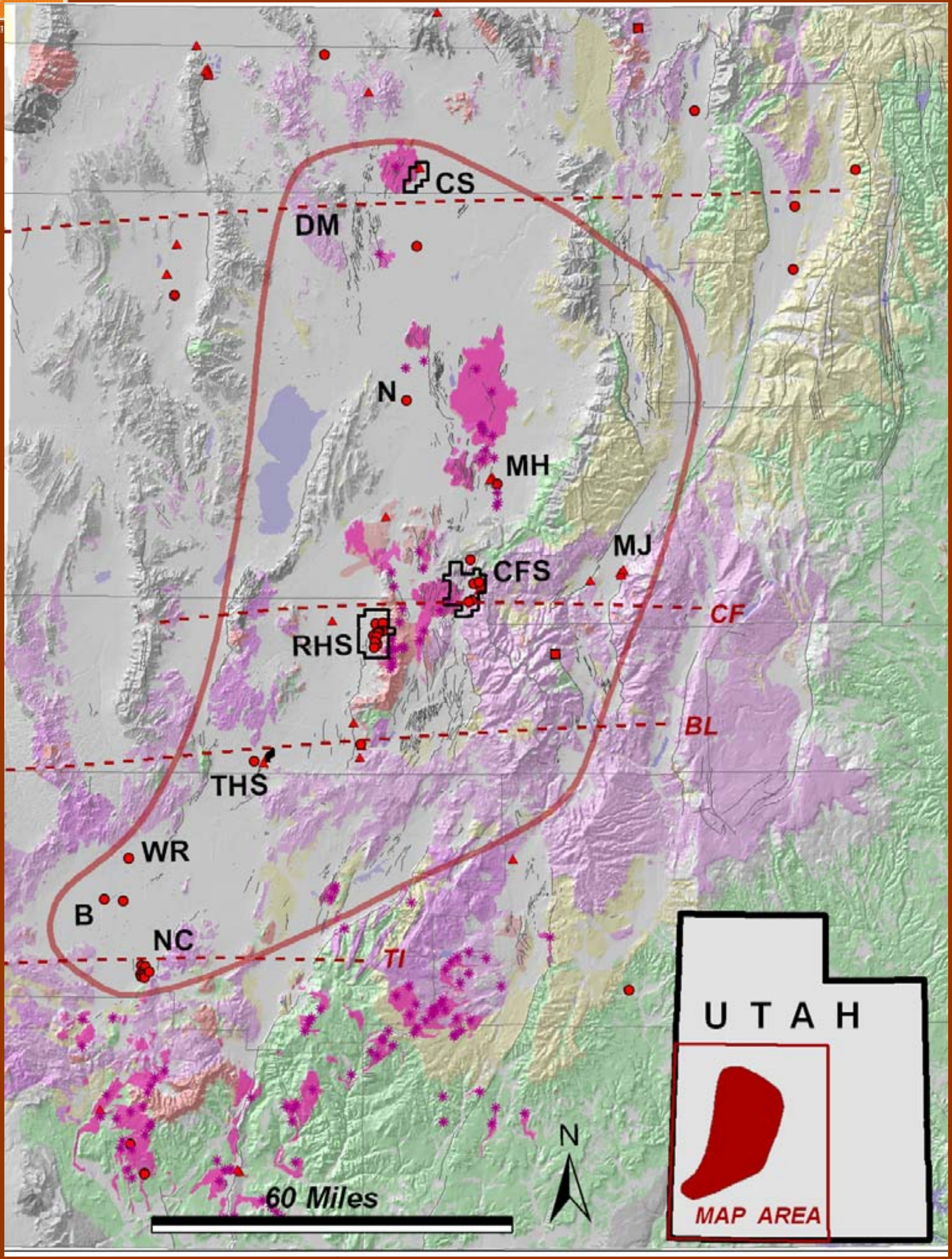


- Crystal (Bluffdale) Hot Springs geothermal area south end of the Salt Lake Valley near the Utah State Prison.
- Surface spring temperatures approach 136°F.
- Subsurface temperatures of 185°F+ reported in production wells 600 to 1000 ft in depth.
- One well owned by the Utah Department of Corrections dedicated to the prison heating system.
- Area has undergone geothermal development since early 1980s – Prison geothermal heating system (shut down after two seasons) & nearby greenhouses.

Utah State Prison Space Heating

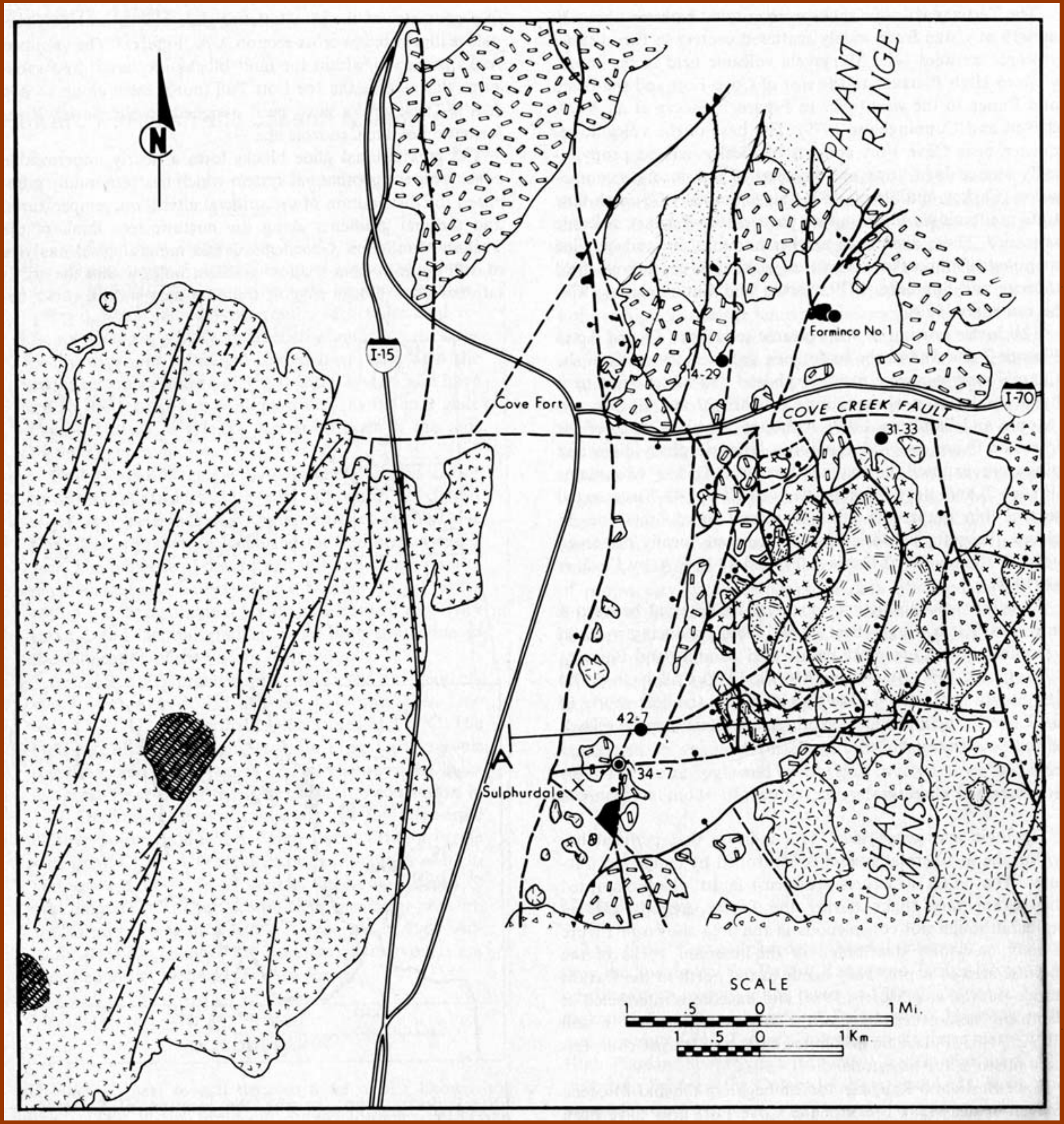
- Johnson Controls, Inc. (ESCO) entered a long-term agreement in 2003 (?) with UDC to provide heat to the minimum-security wing.
- Geothermal heating system came back on line in January 2004 after shut down for most of the past 20 years, due to calcite scaling.
- Phase I - Johnson re-engineered the heating system to eliminate the scaling and provide space and water heating to about 40,000 ft^2 of the complex.
- Phase II - completed in the fall of 2005, heating system currently supplies heat and domestic hot water for 332,665 ft^2.

Cove Fort-Sulphurdale



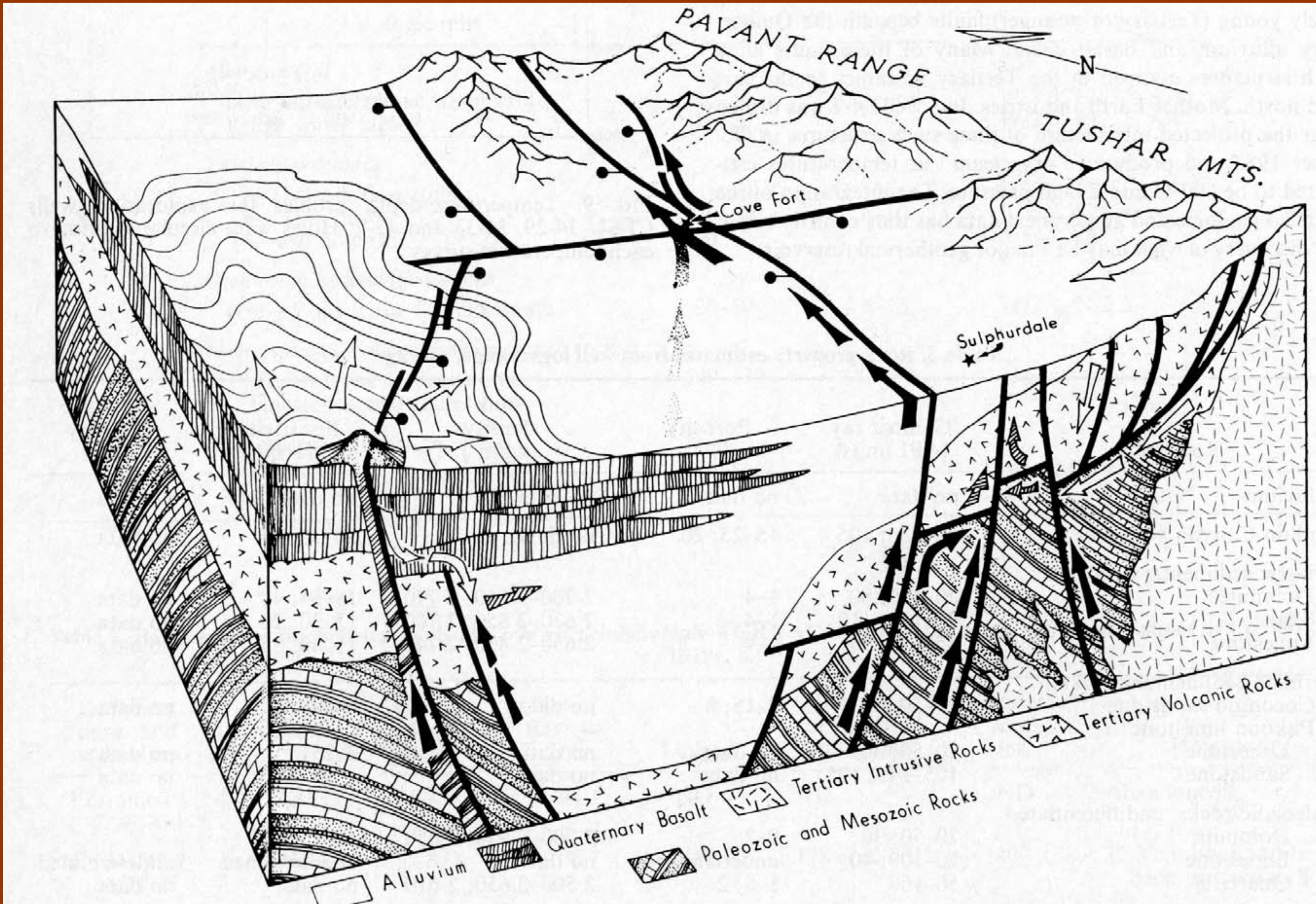
- **Dry steam at about 300°F in shallow (600 – 1300 ft)**
- **Fractured Paleozoic sandstone reservoir.**
- **Liquid-dominated system at depths > 2,000 ft.**

Cove Fort-Sulphurdale

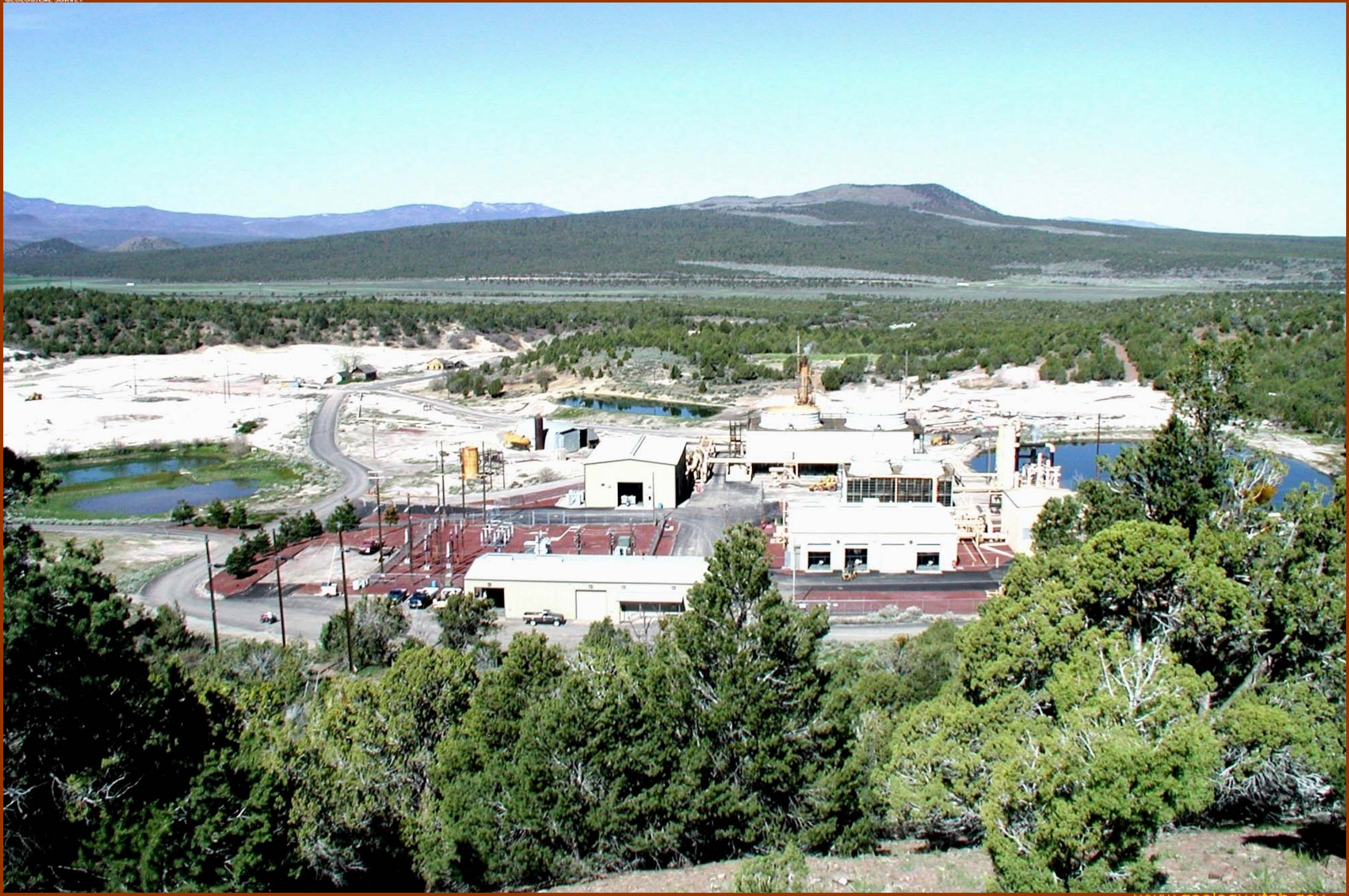


Sulphur deposits are found over an area of 47 sq km, but high thermal gradients are found over a much larger area.

Cove Fort-Sulphurdale



Cove Fort-Sulphurdale



Cove Fort-Sulphurdale

- UMPA and Provo City operated four binary-cycle power units (3 MW), a turbine generator (2 MW), and a condensing turbine (8.5 MW). Production since mid-1980s
- Amp Resources purchased the UMPA-Provo power facility in 2003, shut down the plant, preparing to dismantle and build a new plant
- December 2005, Amp announced signing a 20-year power purchase agreement with PacifiCorp for 37 to 42 MW using Kalina-cycle technology
- March 2007, Enel North America, Inc. acquired AMP holdings, including the Cove Fort-Sulphurdale facility. On June 20, 2007, Enel successfully bid on three federal geothermal lease tracts (Fishlake NF) at Cove Fort-Sulphurdale KGRA that total 6,018 acres
- Present status – Rebuilding

PacifiCorp Blundell Expansion

- Roosevelt Hot Springs geothermal area situated on the west flank of the Mineral Range in Beaver County.
- 26 MW (gross) Blundell plant operating since 1984.
- Steam separated from hot brine at temperatures over 500°F from four production wells (4,000 – 7,000 ft).
- Hot brine returned to reservoir at temperatures ~ 350°F through three injection wells.

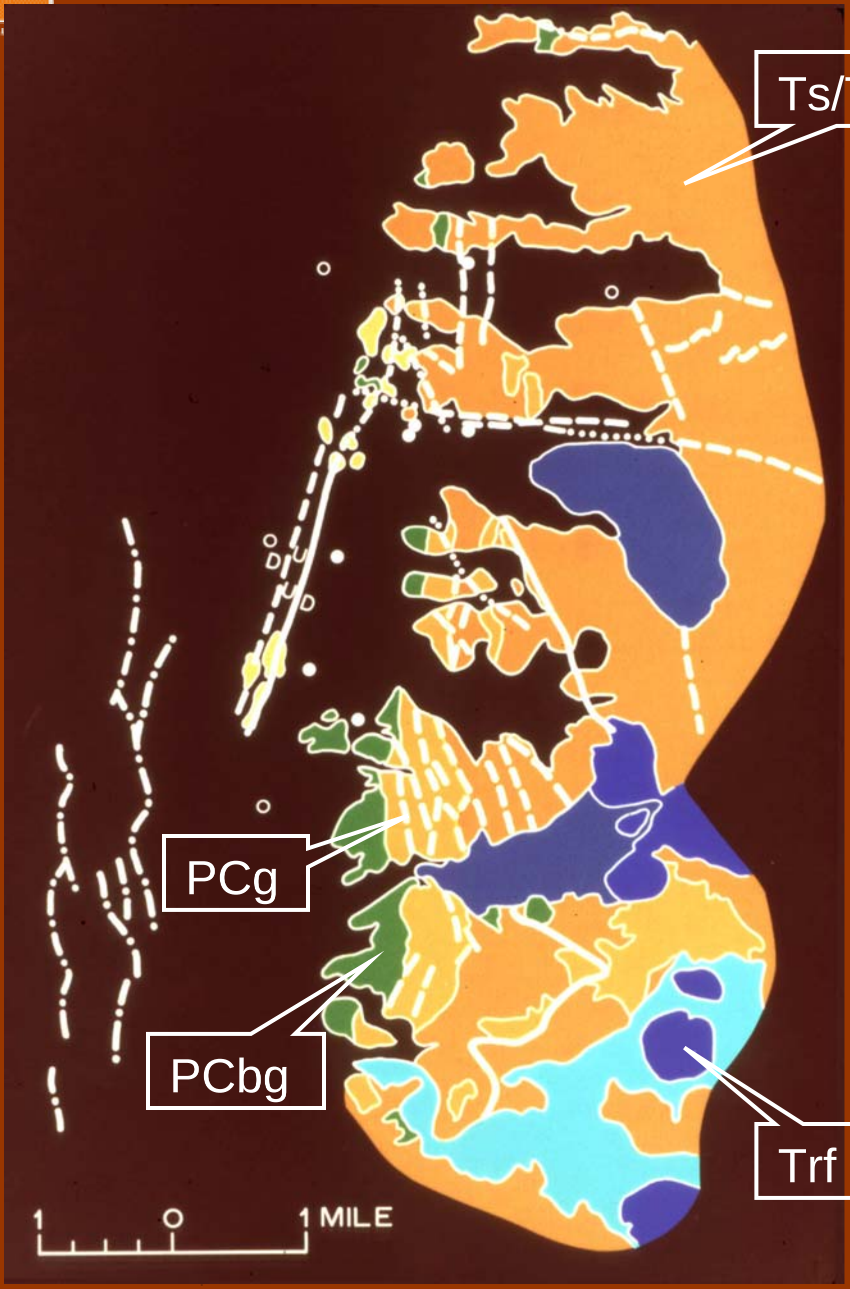
PacifiCorp Blundell Expansion (cont.)

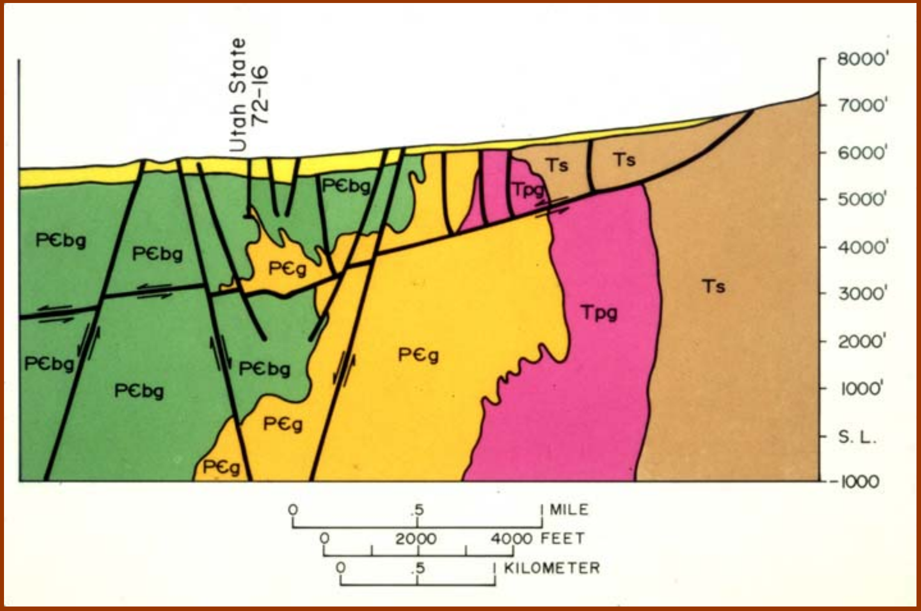
- April 11, 2006 - PacifiCorp announced planned, 11 MW expansion using a "bottoming cycle"
- Contracted Ormat Nevada, Inc. to provide an 11-MW OEC unit to extract heat from hot brine return fluid
- Contracted CEntry Constructors & Engineers for engineering and construction of the project
- Expected power production - November 15, 2007

PacifiCorp Blundell Expansion

- Mineral Range - complex of Tertiary-age intrusions and Precambrian metamorphic rocks
- Crosscut by a low-angle, west-dipping detachment zone and Basin-and-Range faults
- Active geothermal system is associated with relatively young igneous activity, expressed as Quaternary rhyolite domes & flows (0.5-0.8 Ma)
- Recent Basin and Range-style north-south faulting on the west side of the range, an older east-west fault system, and a still older system of near-vertical faults associated with the low angle detachment zone
- Opal Mound fault - important conduit for geothermal fluids - defines the western boundary of a small graben that contains much of the geothermal resource
- Production from the Roosevelt geothermal area is primarily from highly fractured Tertiary granite and Precambrian metamorphic rocks

Detailed Structural Map

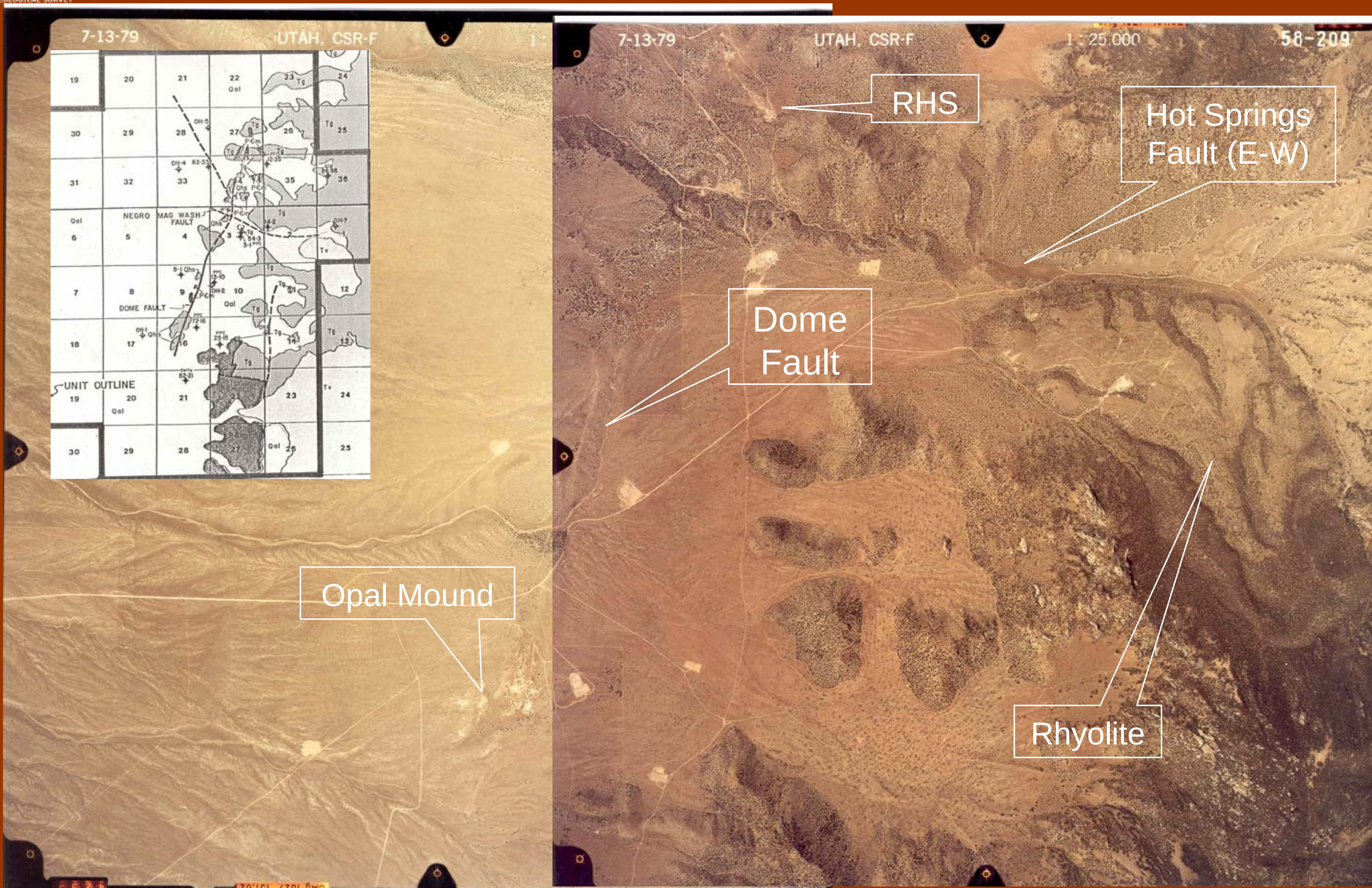




Sibbett and Nielson (1980)

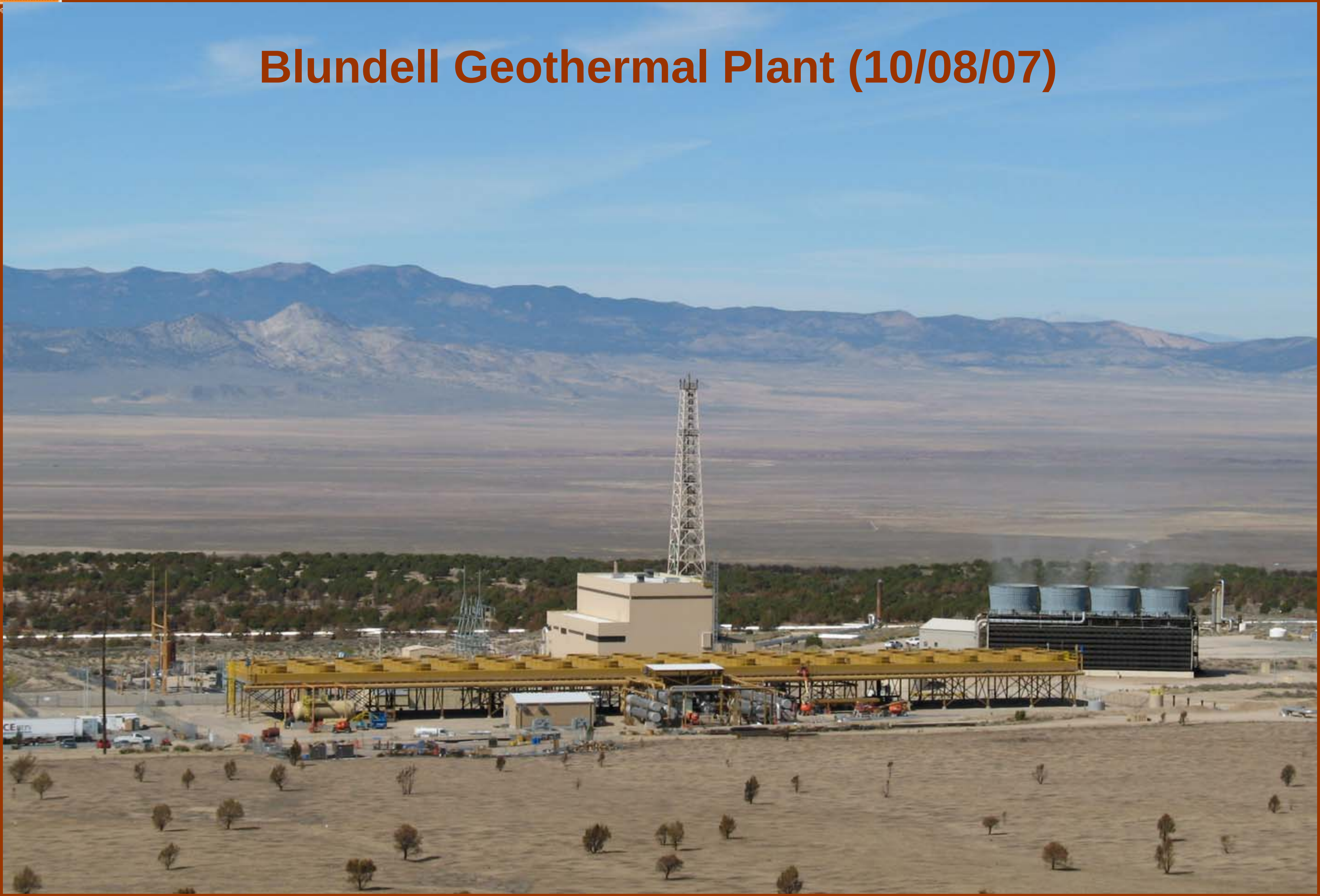
UTAH GEOLOGICAL SURVEY

Roosevelt Hot Springs KGRA – Aerial View

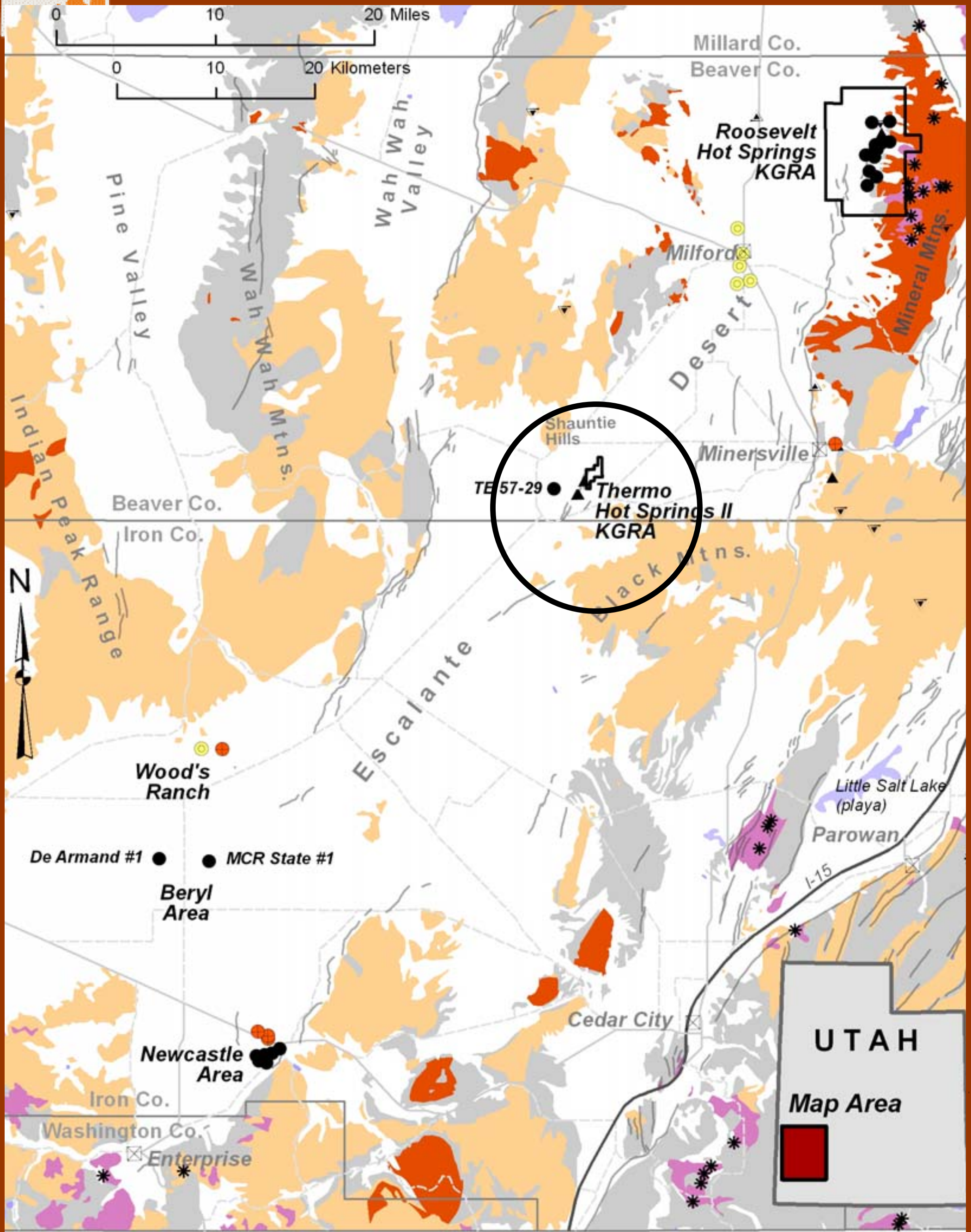


PacifiCorp Blundell Expansion (cont.)

Blundell Geothermal Plant (10/08/07)



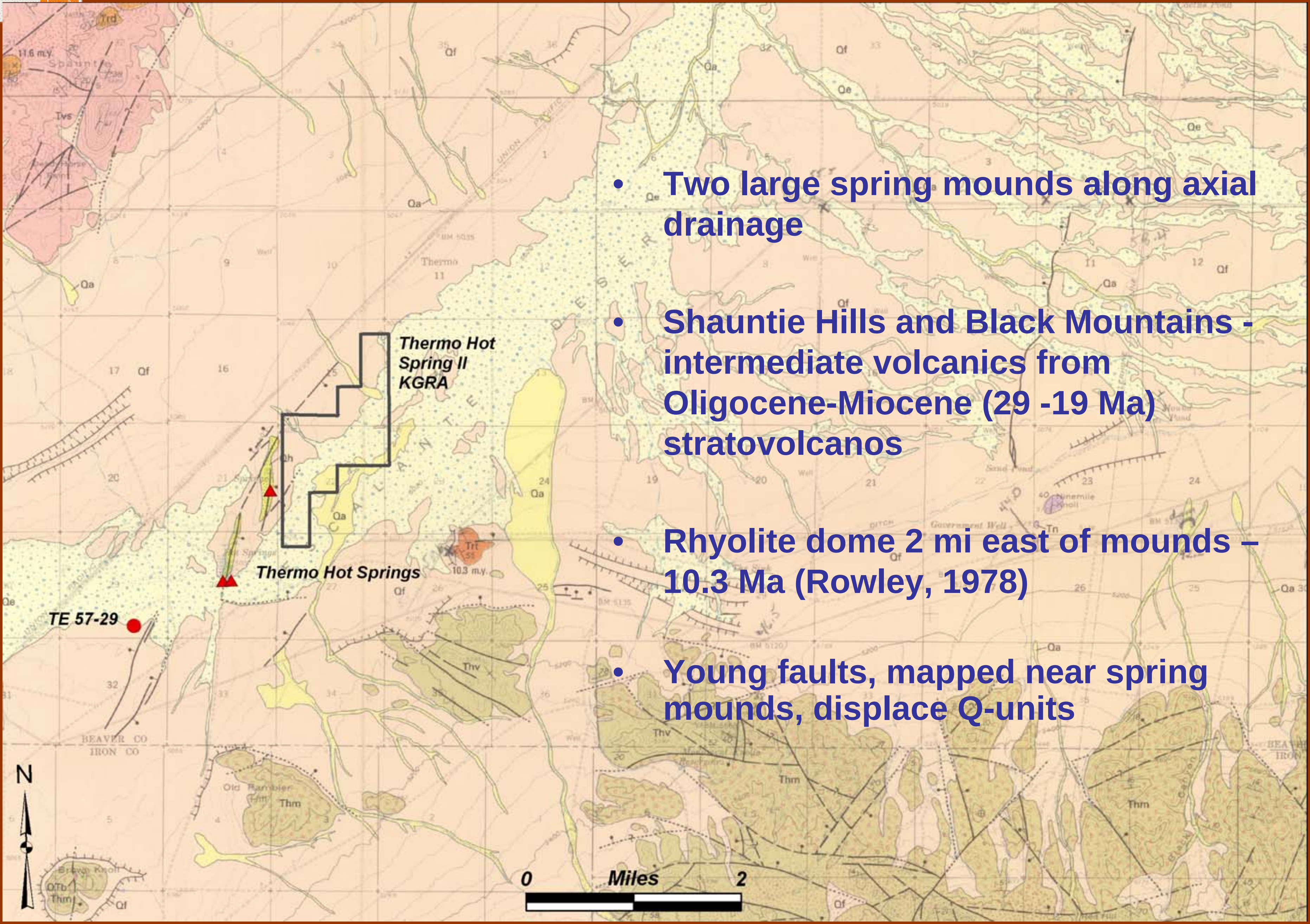
Thermo Hot Springs



Northeast Escalante Desert

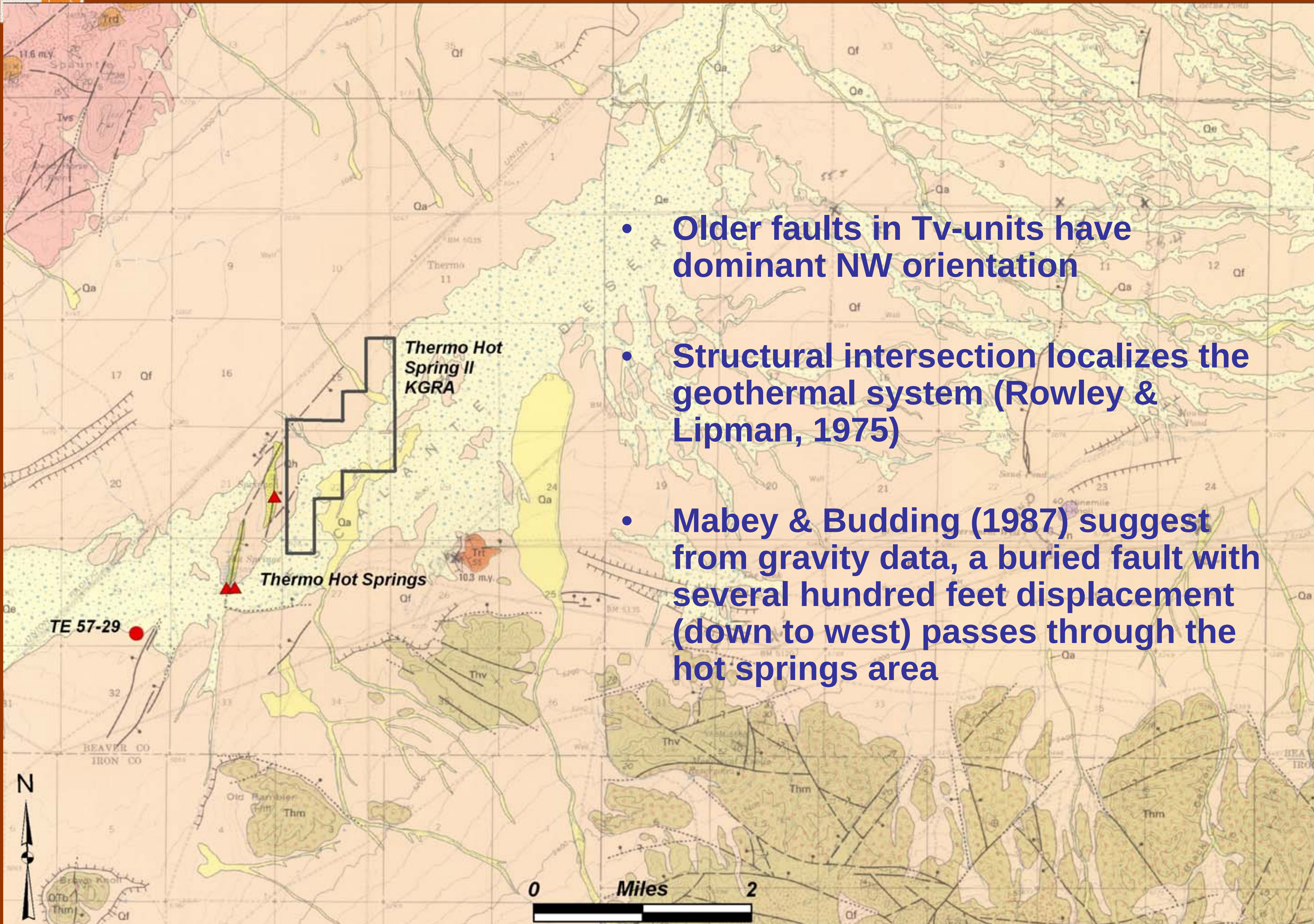
UTAH GEOLOGICAL SURVEY

Thermo Hot Springs



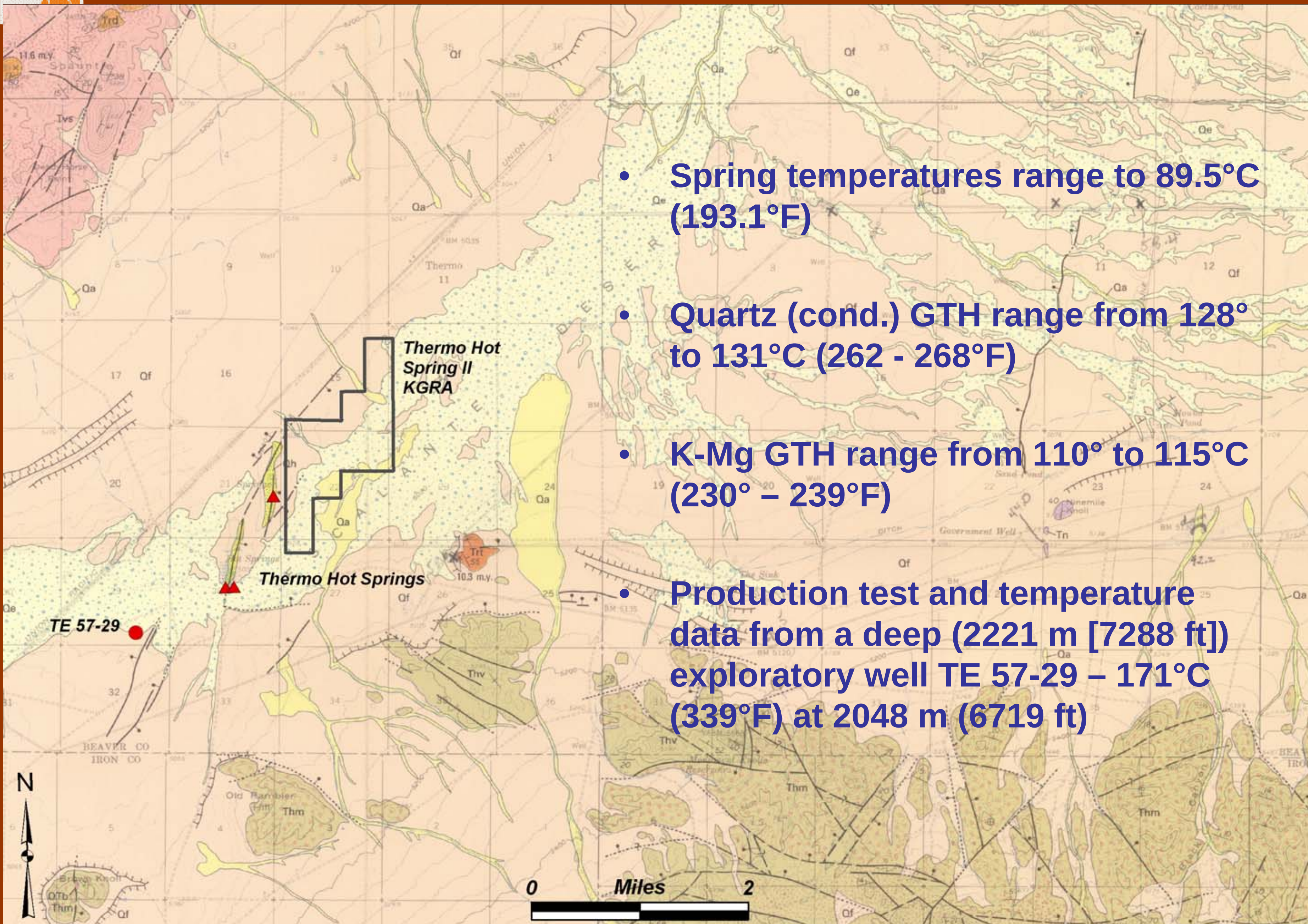
- Two large spring mounds along axial drainage
- Shauntie Hills and Black Mountains - intermediate volcanics from Oligocene-Miocene (29 -19 Ma) stratovolcanos
- Rhyolite dome 2 mi east of mounds – 10.3 Ma (Rowley, 1978)
- Young faults, mapped near spring mounds, displace Q-units

Thermo Hot Springs



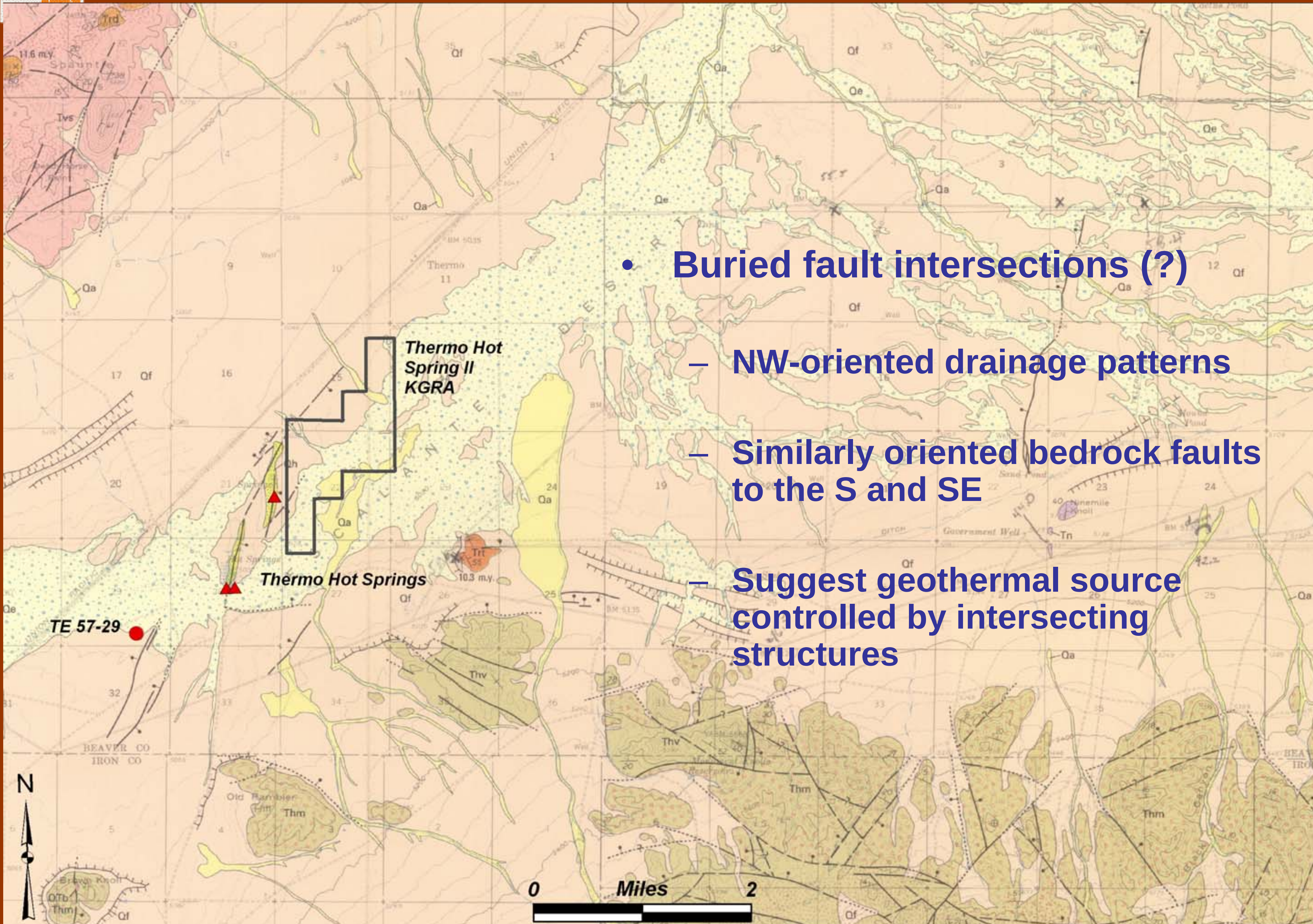
- Older faults in Tv-units have dominant NW orientation
- Structural intersection localizes the geothermal system (Rowley & Lipman, 1975)
- Mabey & Budding (1987) suggest from gravity data, a buried fault with several hundred feet displacement (down to west) passes through the hot springs area

Thermo Hot Springs



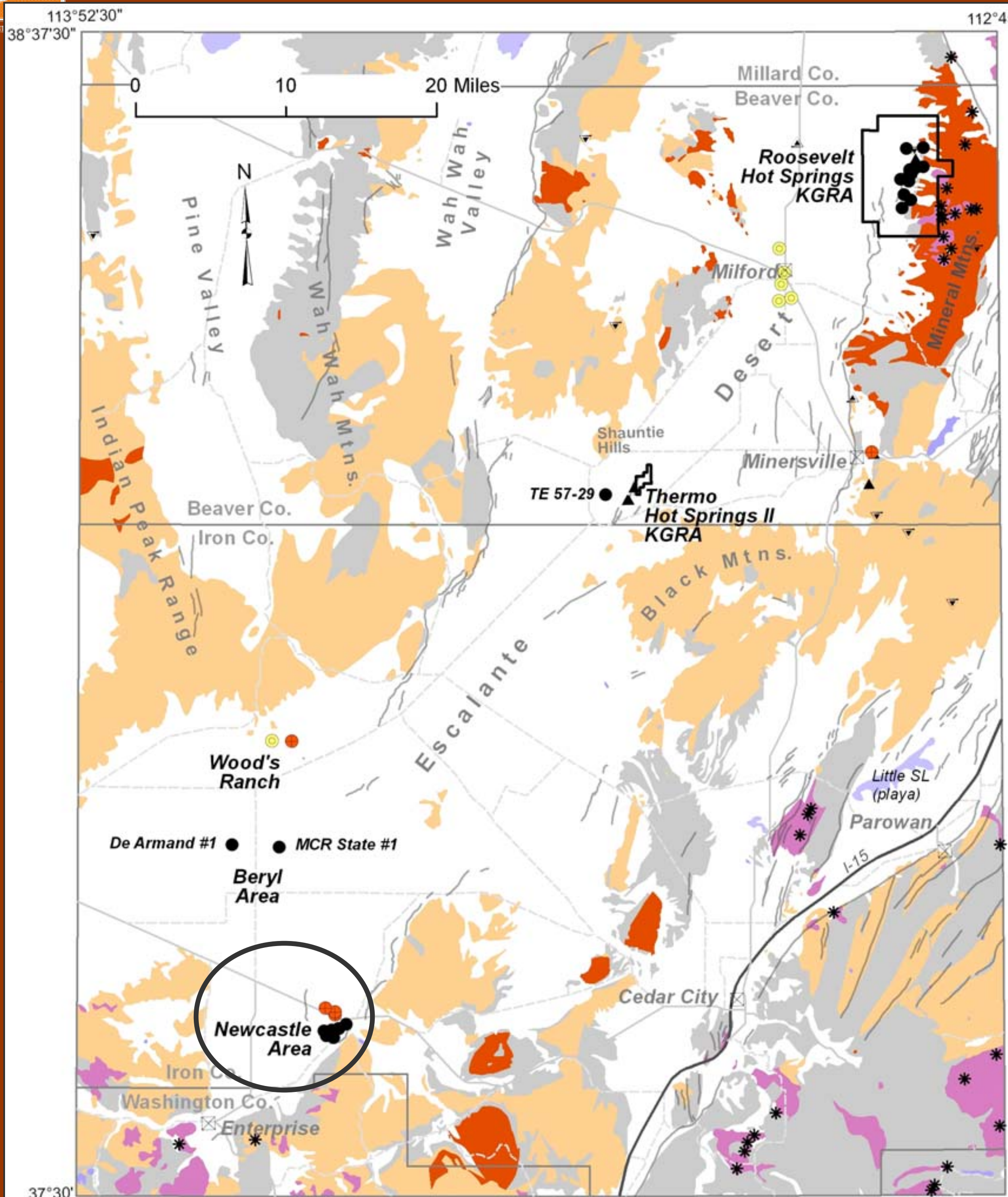
- Spring temperatures range to 89.5°C (193.1°F)
- Quartz (cond.) GTH range from 128° to 131°C (262 - 268°F)
- K-Mg GTH range from 110° to 115°C (230° – 239°F)
- Production test and temperature data from a deep (2221 m [7288 ft]) exploratory well TE 57-29 – 171°C (339°F) at 2048 m (6719 ft)

Thermo Hot Springs



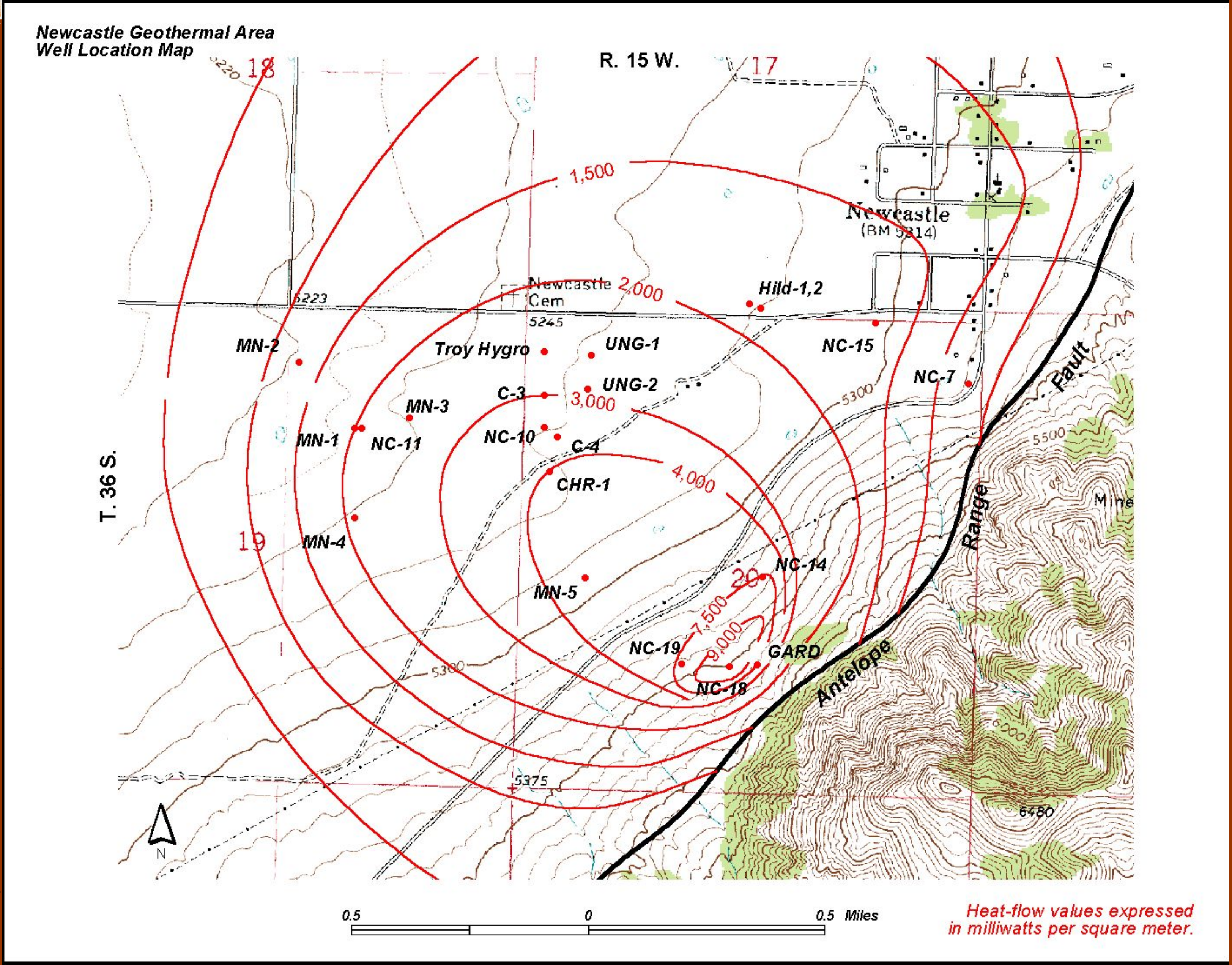
- Buried fault intersections (?)
  - NW-oriented drainage patterns
  - Similarly oriented bedrock faults to the S and SE
  - Suggest geothermal source controlled by intersecting structures

Newcastle Area



- Blind geothermal resource (1975)
- Measured Temp -118°C
- Estimated Resource Temp – 130°C
- Depth – from 150 m
- Fluid – 1000 to 1100 mg/L
- Geothermal fluid originate along a range-front fault to the SE, then flows into a buried alluvial aquifer
- Thermal Aquifer is tapped by production & injection wells

Newcastle Area



Newcastle Area – Milgro Newcastle Inc.

Geothermal Websites

- http://geothermal.org/ - Geothermal Resources Council
- http://www.geothermal.marin.org/ - Geothermal Education Office
- http://www.geo-energy.org/ - Geothermal Energy Association
- http://geoheat.oit.edu/ - OIT Geo-Heat Center
- http://www.smu.edu/geothermal/ - SMU Geothermal Program
- http://geology.utah.gov/ - Utah Geological Survey