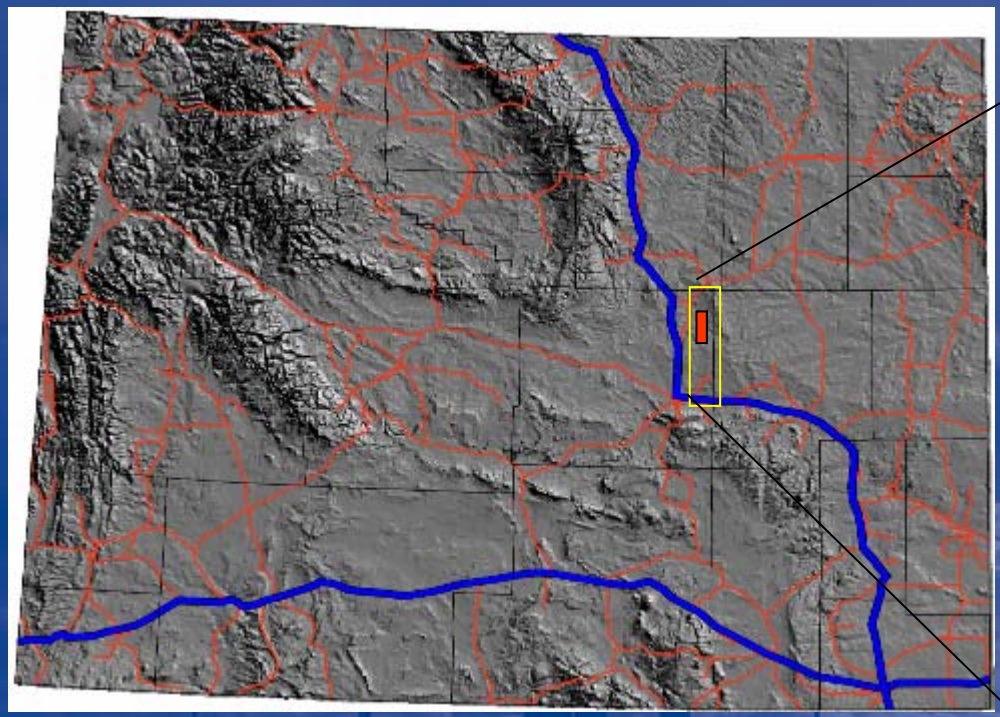
GEOTHERMAL RESOURCES AT NPR-3

Mark Milliken

March 2006

NAVARRO

Rocky Mountain Oilfield Testing CENTER



NPR-3 LOCATION

Salt Creek Anticline Trend

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WHY CONSIDER GEOTHERMAL ASSETS IN A STRIPPER OIL FIELD?

RMOTC will partner with industry and academia to provide a test site for technologies that to reduce energy-related operational costs.

- **Energy efficiency**
- **Energy conservation**
- **Alternative energy sources**

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DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

KEY CHALLENGES

- Acceptance by Industry
- Creation of a Joint Industry Partnership (JIP)
- Consensus on best technologies
- Funding for infrastructure support
- Funding of Projects

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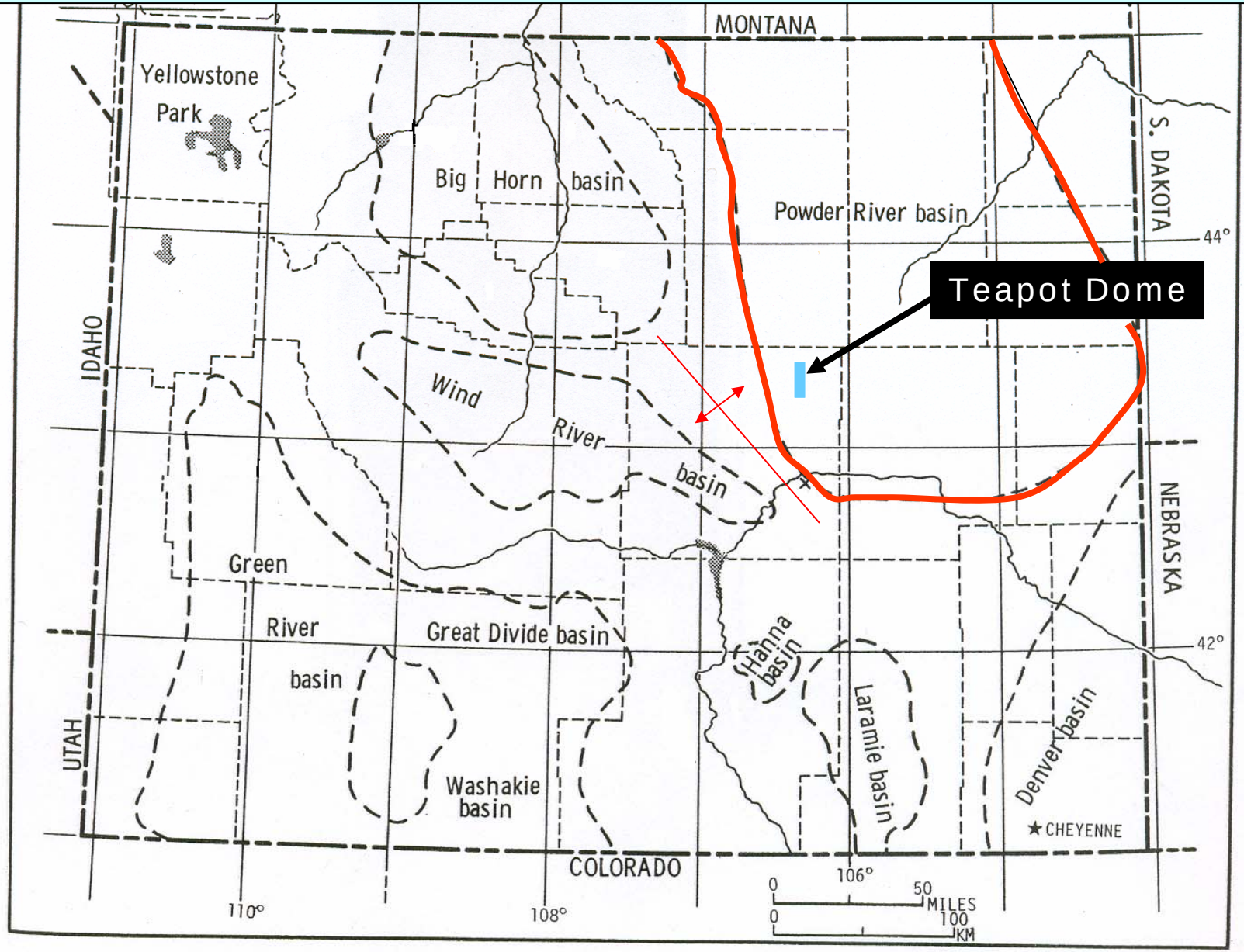
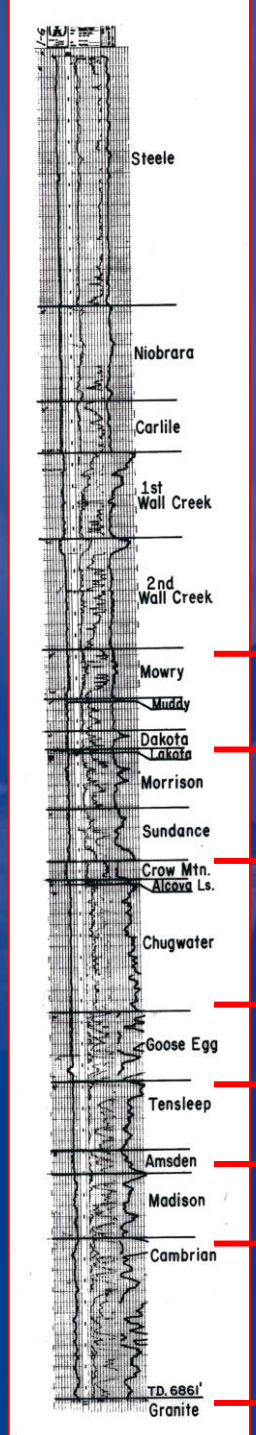
Wyoming Depositional Basin Settings



NPR-3 STRATIGRAPHY



WELL 1-G-10, 1952

- UPPER CRETACEOUS
- LOWER CRETACEOUS
- JURASSIC
- TRIASSIC CHUGWATER
- PERMIAN GOOSE EGG
- PENNSYLVANIAN TENSLEEP
- MISSISSIPPIAN MADSION LS
- CAMBRIAN SS
- PRECAMBRIAN BASEMENT

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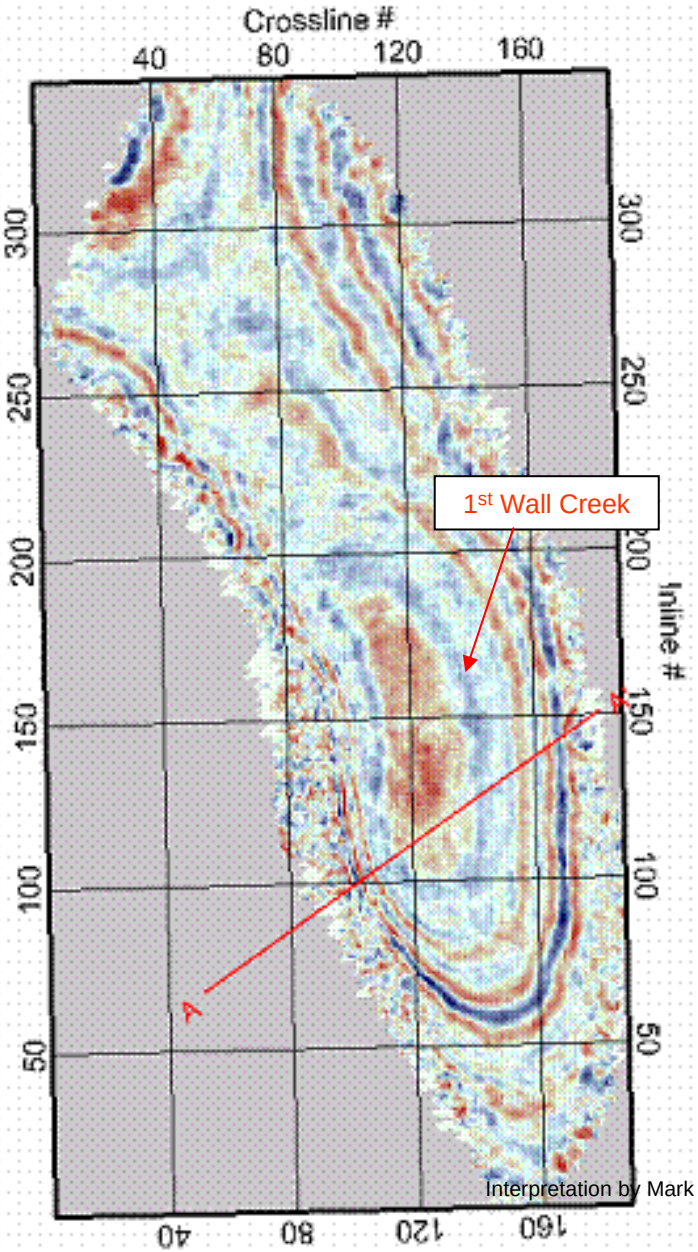
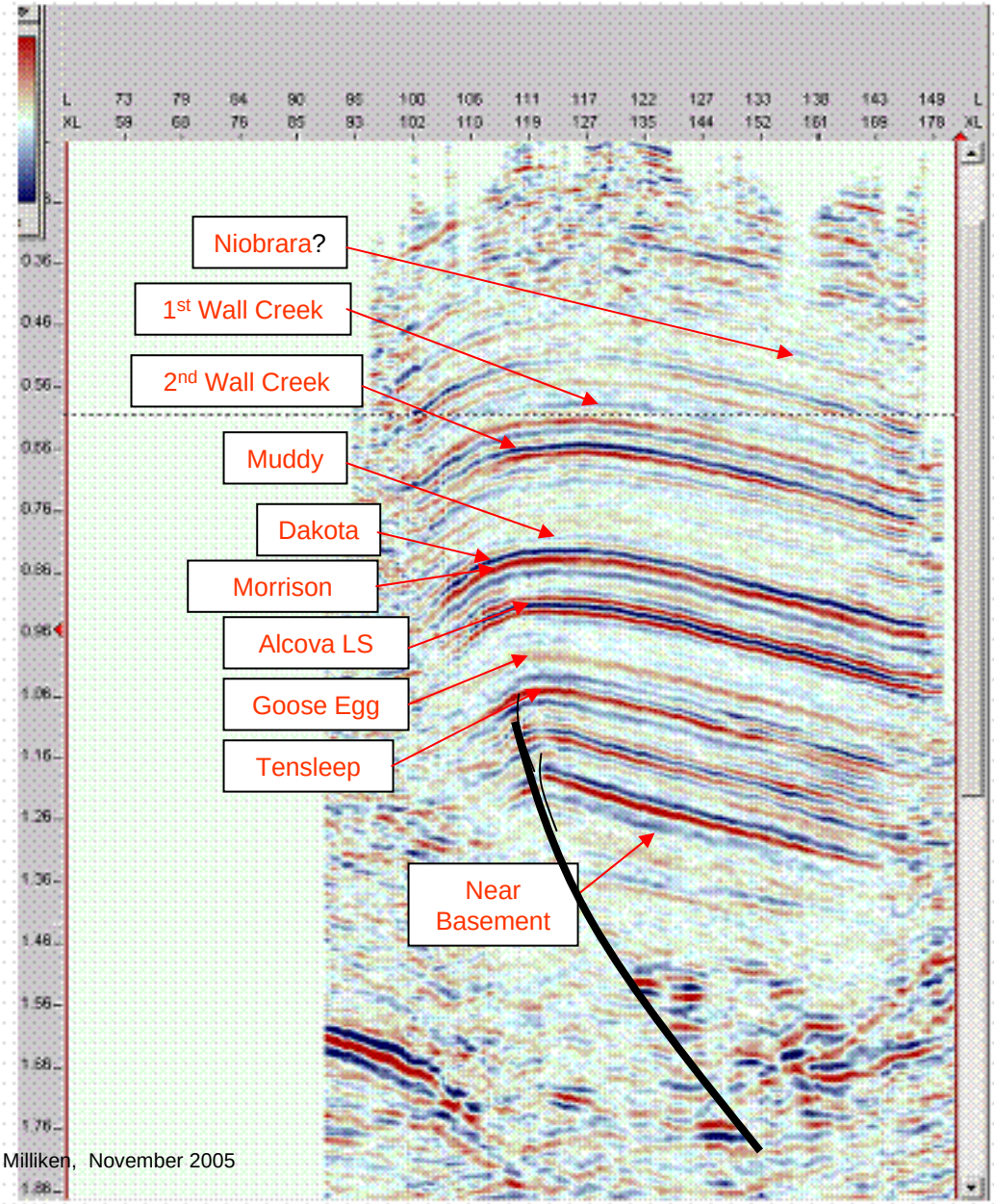
NPR-3 SEISMIC





Interpretation by Mark Milliken, November 2005

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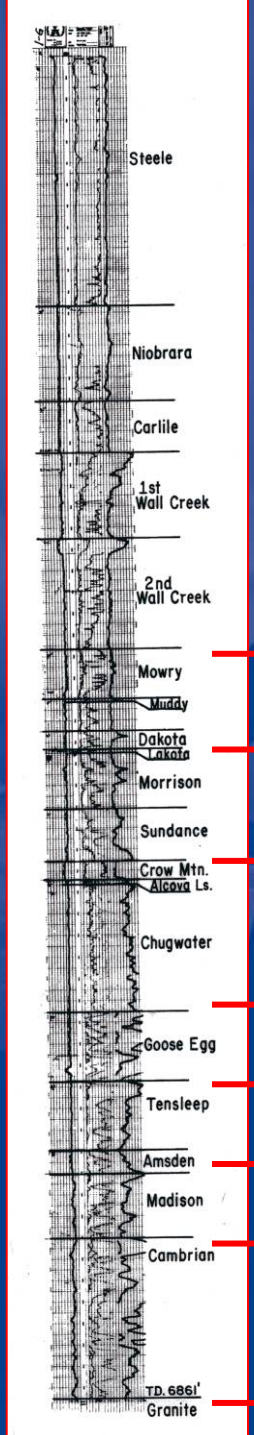

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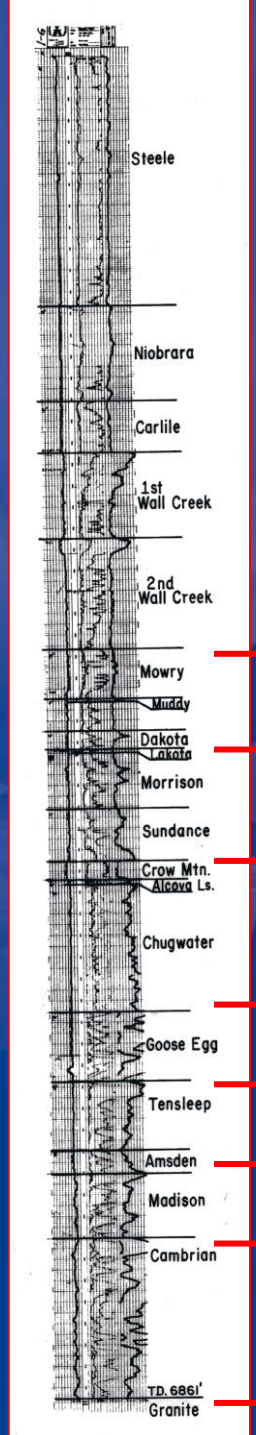
Fractured Precambrian Granite

NPR-3 STRATIGRAPHY



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Fractured Cambrian Sandstone

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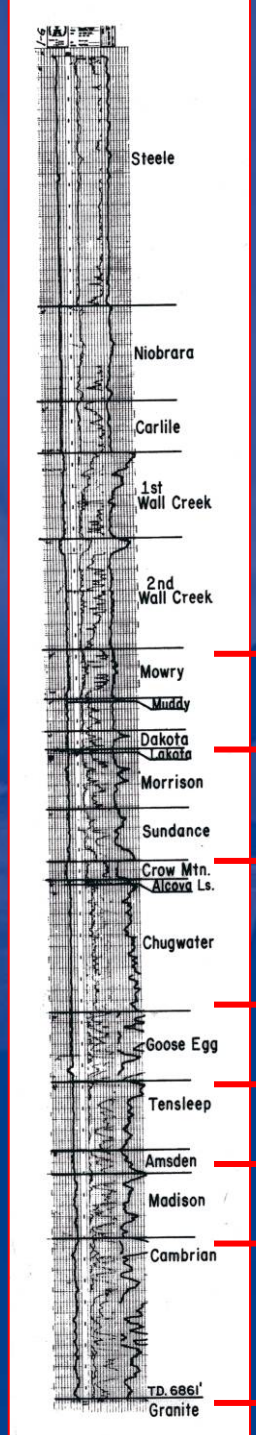

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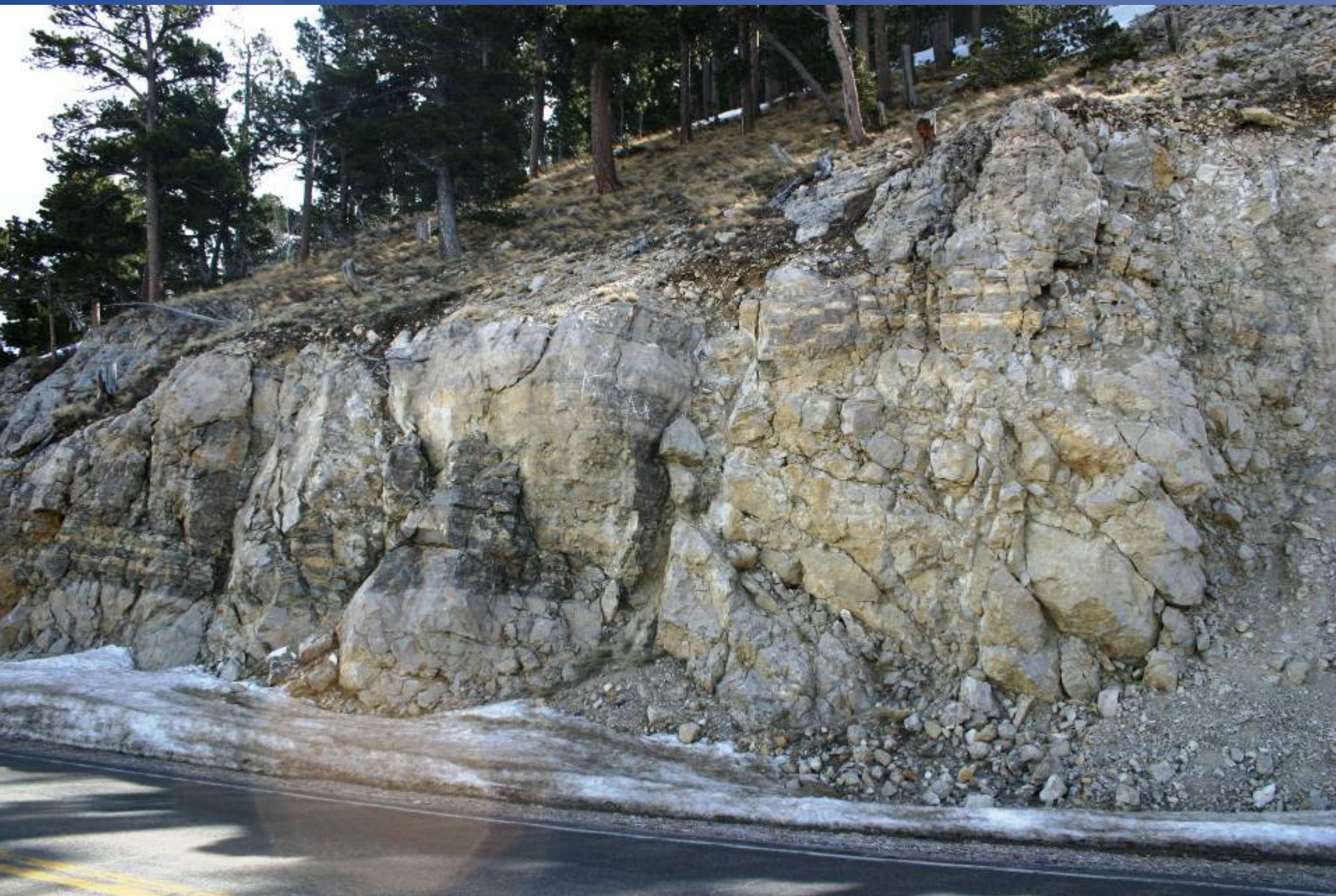
Fractured Madison Limestone



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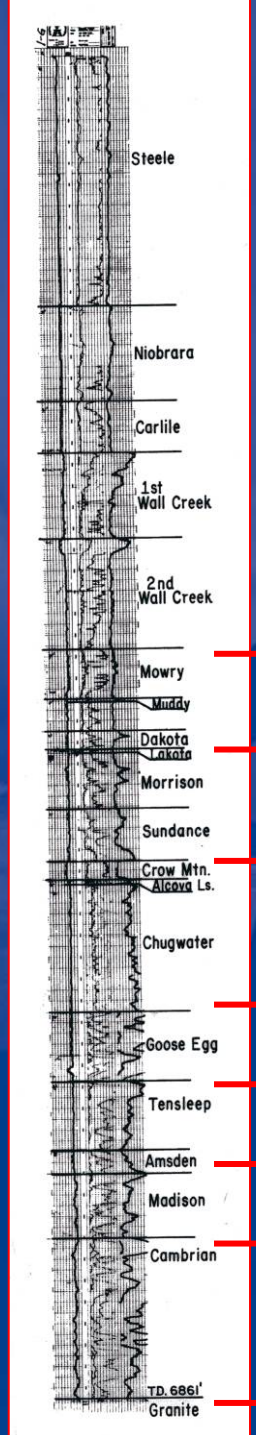

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Pennsylvanian Tensleep Sandstone

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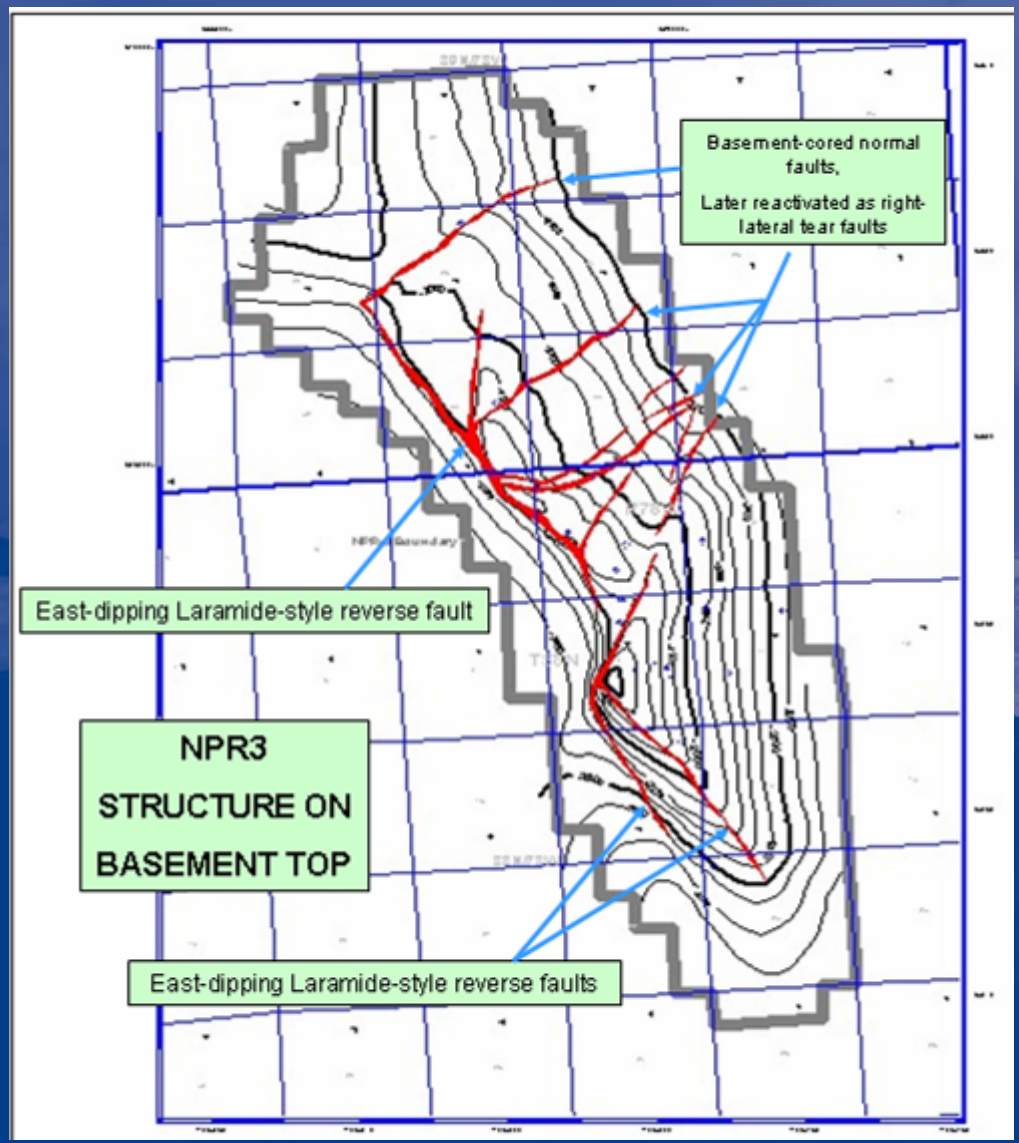
BASEMENT STRUCTURE



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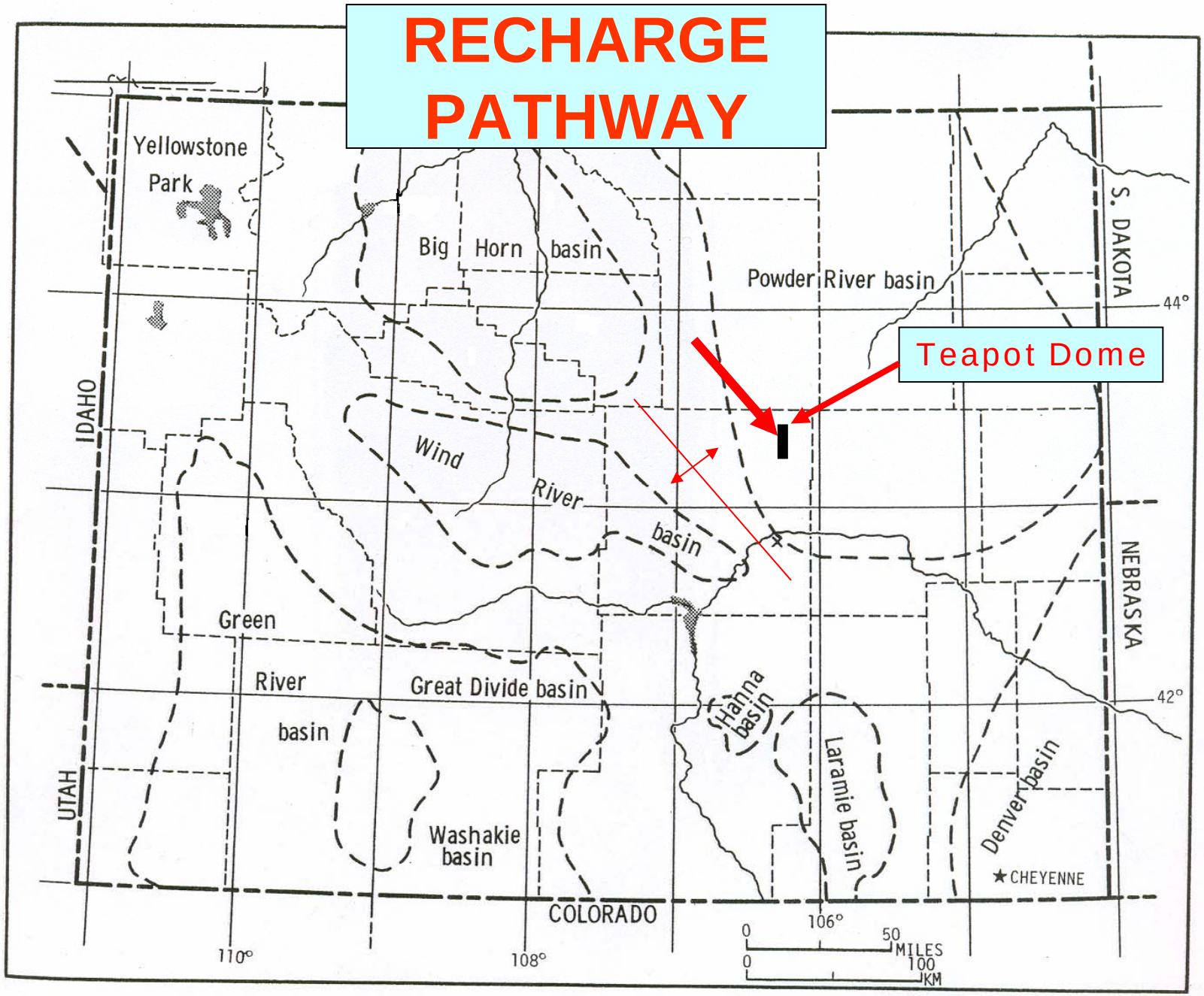
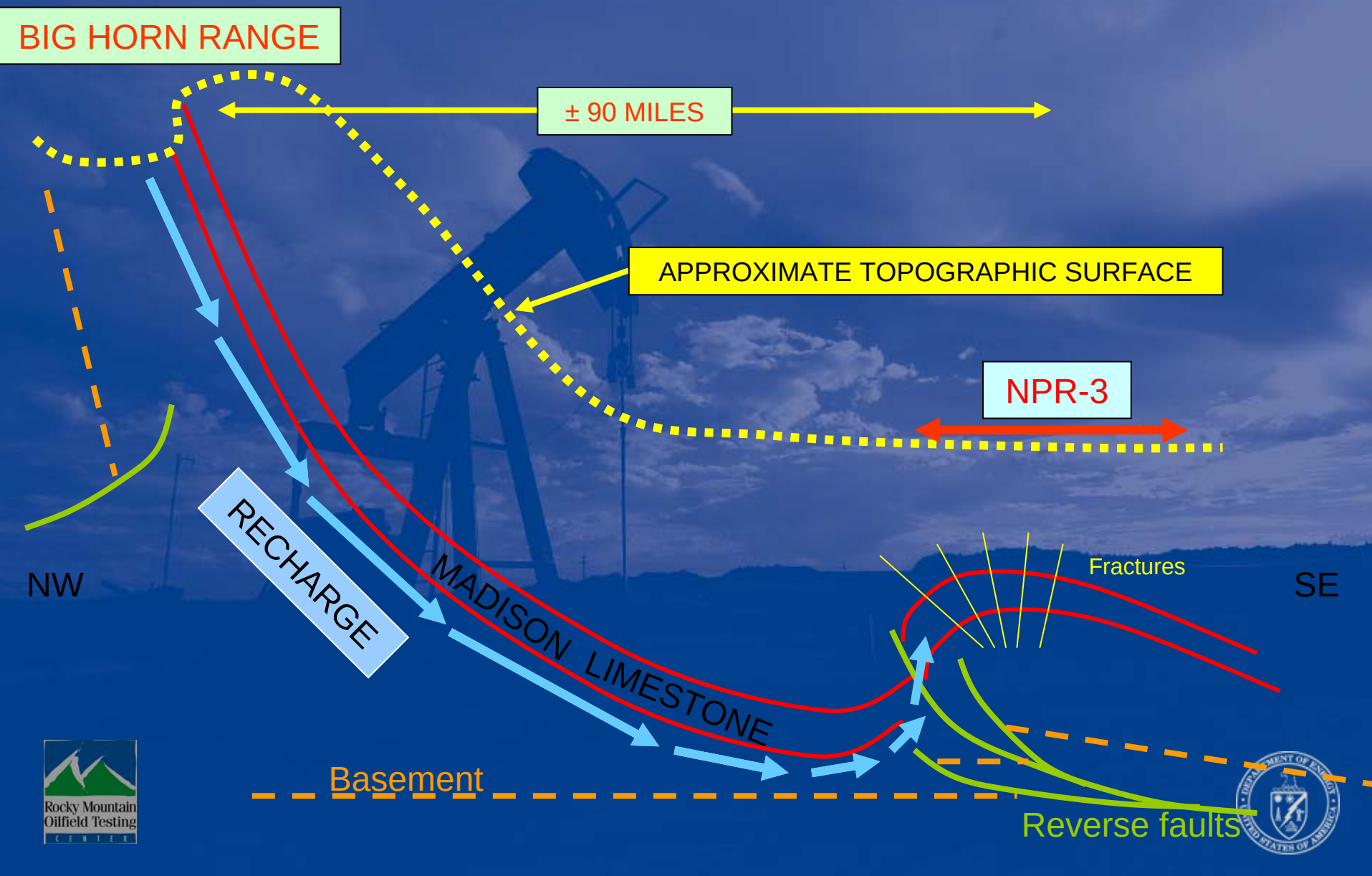
RECHARGE PATHWAY



NPR-3 RECHARGE SYSTEM



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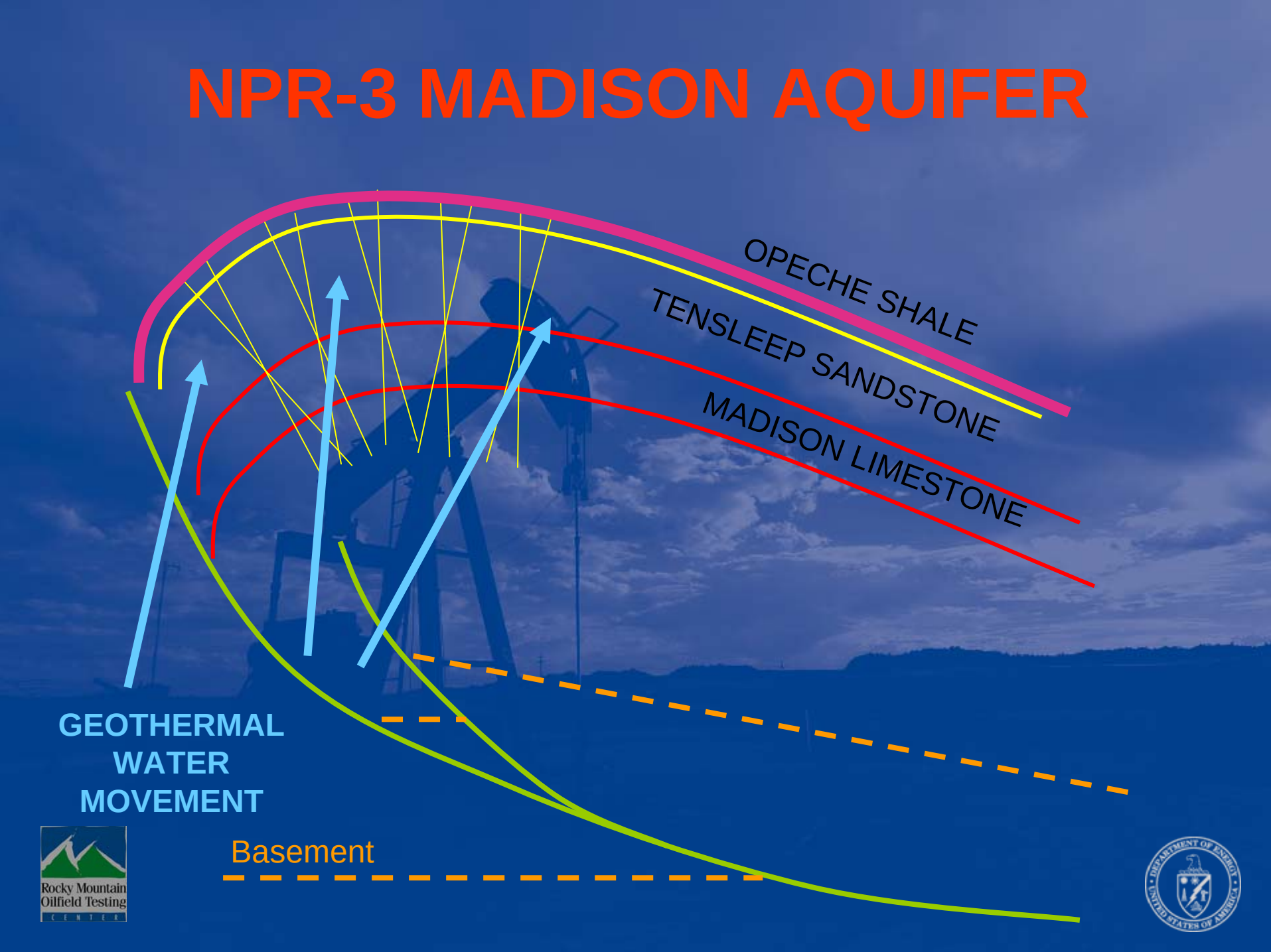
NPR-3 MADISON AQUIFER



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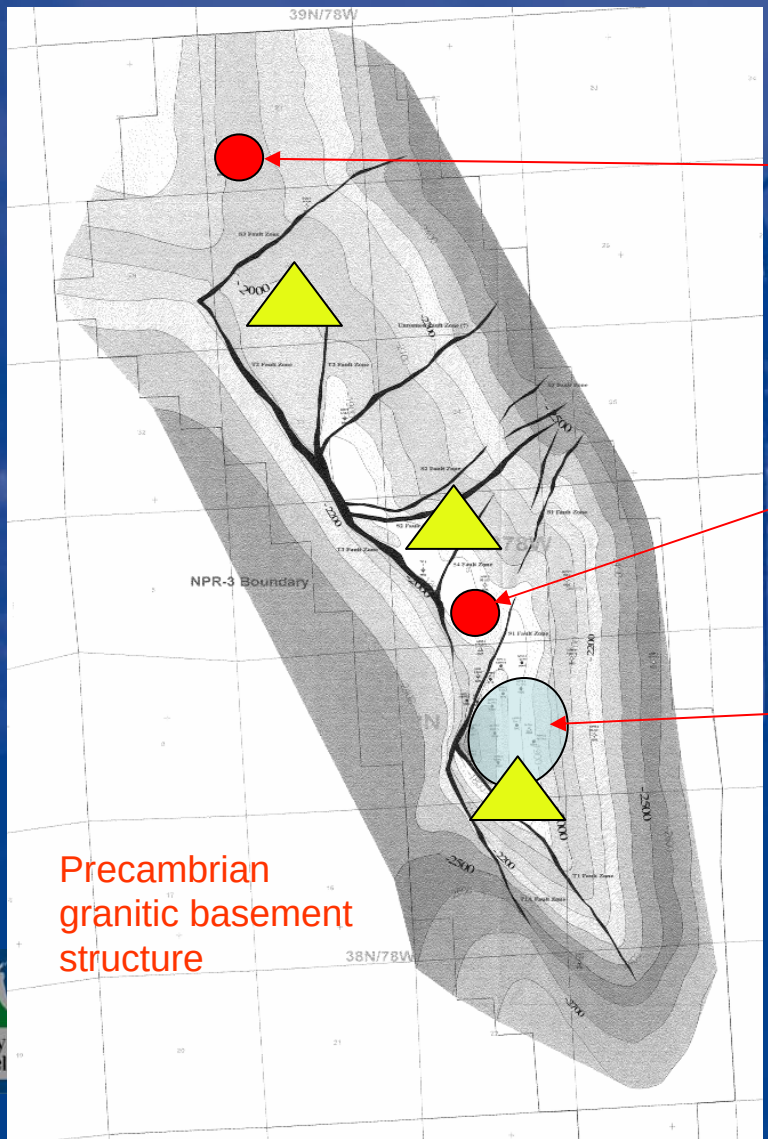
POSSIBLE GEOTHERMAL SUPPLY WELL LOCATIONS



17-WX-21
Madison and Tensleep
Possibly 35 MBWPD flowing

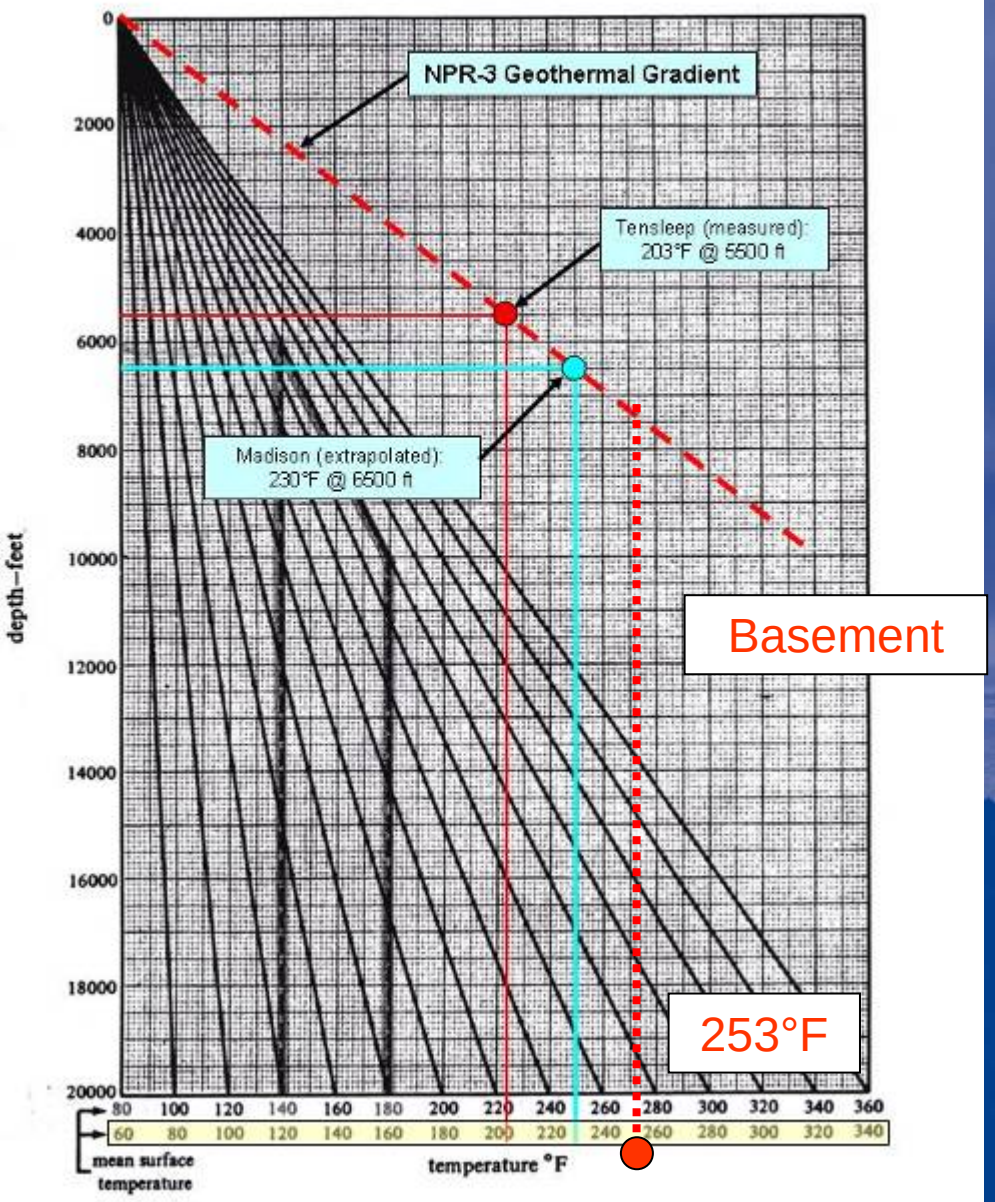
57-WX-3
Madison and Tensleep
Possibly 10 MBWPD flowing

TENSLEEP PRODUCING AREA

OTHER POSSIBLE TENSLEEP SOURCE WELLS AND DEEPENING CANDIDATES

ESTIMATION OF MADISON FORMATION TEMPERATURE

Mark Milliken 1/27/06



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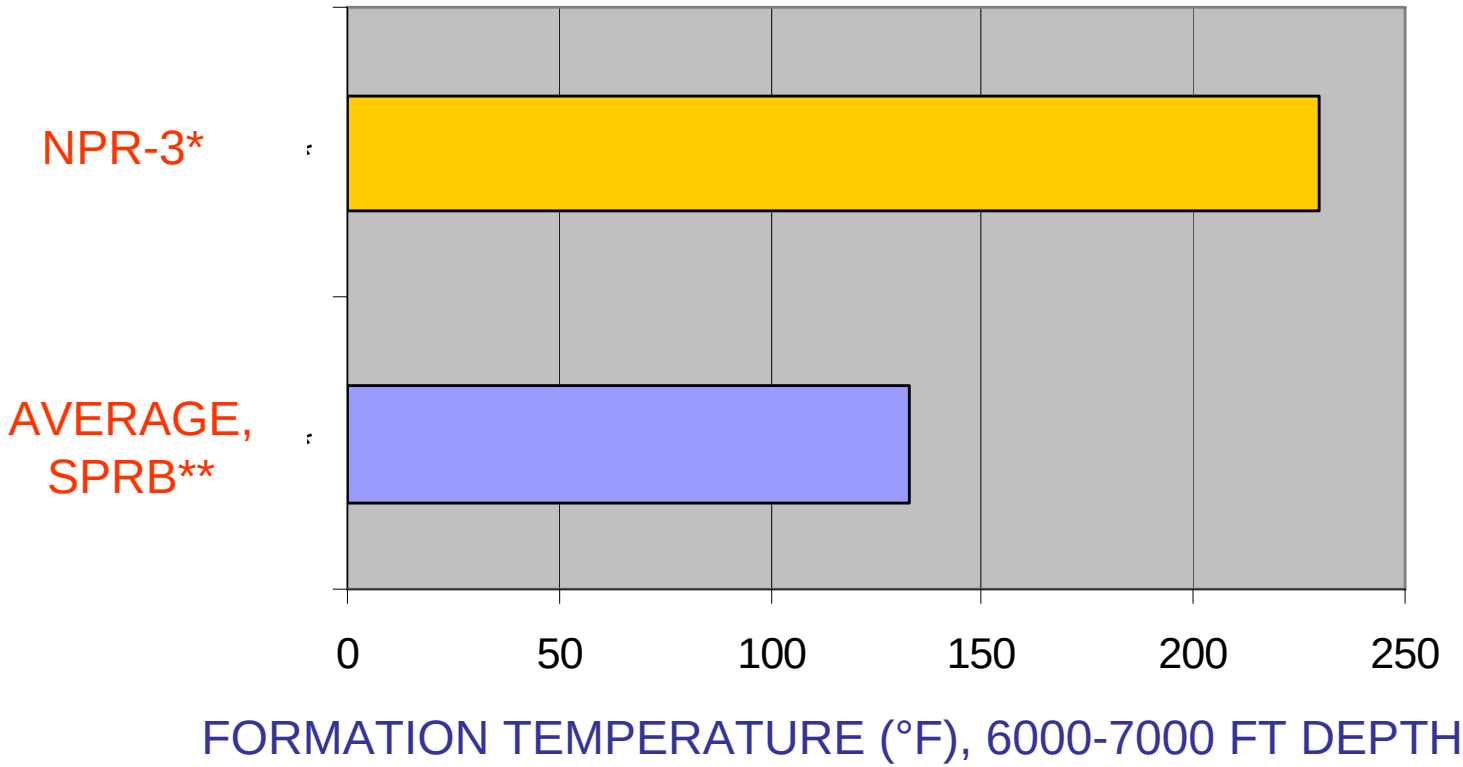
GEOTHERMAL TEMPERATURE COMPARISON

SOUTHERN POWDER RIVER BASIN

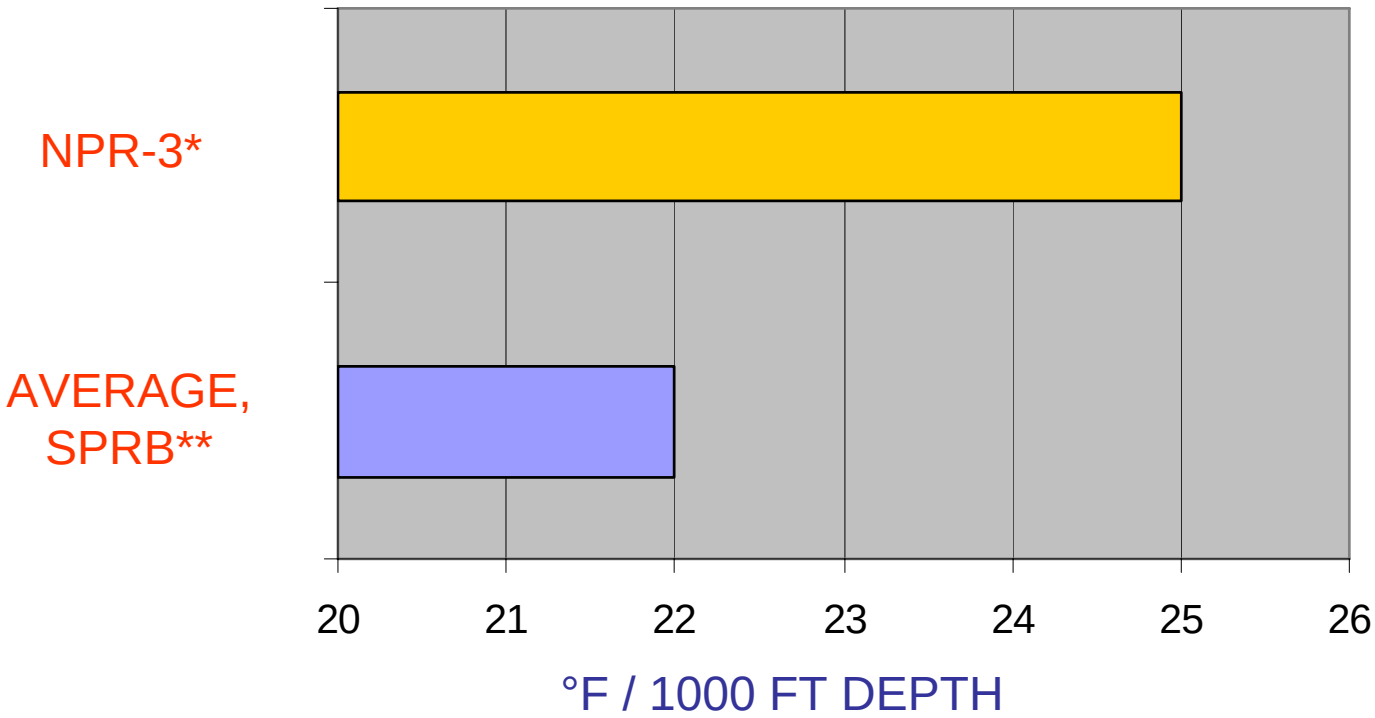


*Projected from Tensleep data

**WGS data, 1986

GEOTHERMAL GRADIENT COMPARISON

SOUTHERN POWDER RIVER BASIN



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*Projected from Tensleep data

**WGS data, 1986

MADISON WATER QUALITY

17-WX-21

DISSOLVED SOLIDS			RESULTS AS COMPOUNDS	
Cations	mg/*l*	meq/*l*		mg/*l*
Sodium, Na (Calc.)	1,758	76.44	as NaCl	
Calcium, Ca	316	15.80	as $CaCO_3$	790
Magnesium, Mg	51	4.20	as $CaCO_3$	210
Barium, Ba	0	0	as $BaSO_4$	0
Cations Total	2,125	96.44		
Anions				
Chloride, Cl	1,032	29.10	as NaCl	1,700
Sulfate, SO_4	1,352	28.12	as Na_2SO_4	2,000
Carbonate, CO_3	0	0	as $CaCO_3$	0
Bicarbonate, HCO_3	2,391	39.22	as $CaCO_3$	1,960
Anions Total	4,775	96.44		
Total Dissolved Solids (Calc.)	6,900			
Total Iron, Fe	19.5		as Fe	19.5
Acidity to Phenolphthalein, CO_2	145		as $CaCO_3$	330
Dissolved Oxygen	0.1			
Sulfide, as H_2S	12.5			

POTENTIAL WATER PRODUCTION RATES

WELL	ZONE	POTENTIAL NEW WATER PRODUCTION RATE MBWPD LOW	HIGH	COMMENTS
17-WX-21	MADISON	20	25	FLOWING
17-WX-21	TENSLEEP	4	10	FLOWING, MUST BE PERFORATED
41-2-X-3	TENSLEEP	1	3	FLOWING, TIGHT FORMATION
41-2-X-3	MADISON	6	12	FLOWING, NEEDS DEEPENING
48-X-28	TENSLEEP	2	6	FLOWING, TOO SMALL TO DEEPEN
61-2-X-15	MADISON	6	12	FLOWING, NEEDS DEEPENING
61-2-X-15	TENSLEEP	2	6	FLOWING, NEEDS CASING, CURRENTLY PLUGGED
57-WX-3	MADISON	2	6	FLOWING, REQUIRES ACIDIZATION
TOTAL NEW FLOWING PRODUCTION		43	80	
TOTAL NEW PUMPING PRODUCTION		86	160	
ALL OTHER	TENSLEEP	40	50	PUT ALL CURRENT WELLS ON PUMP
TOTAL POTENTIAL WATER		126	210	

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NPR-3 GEOTHERMAL HEAT POTENTIAL

Assumptions

1. 130 MBWPD
2. 220° F surface temperature of water
3. 48° Mean ambient temperature (WGS data)
4. 53 MBTU/°F - BWPD

Heat content

Total heat content = (53,000)(220 – 48) X 130,000

= **1.18×10^{12} BTUs per day**

Power potential

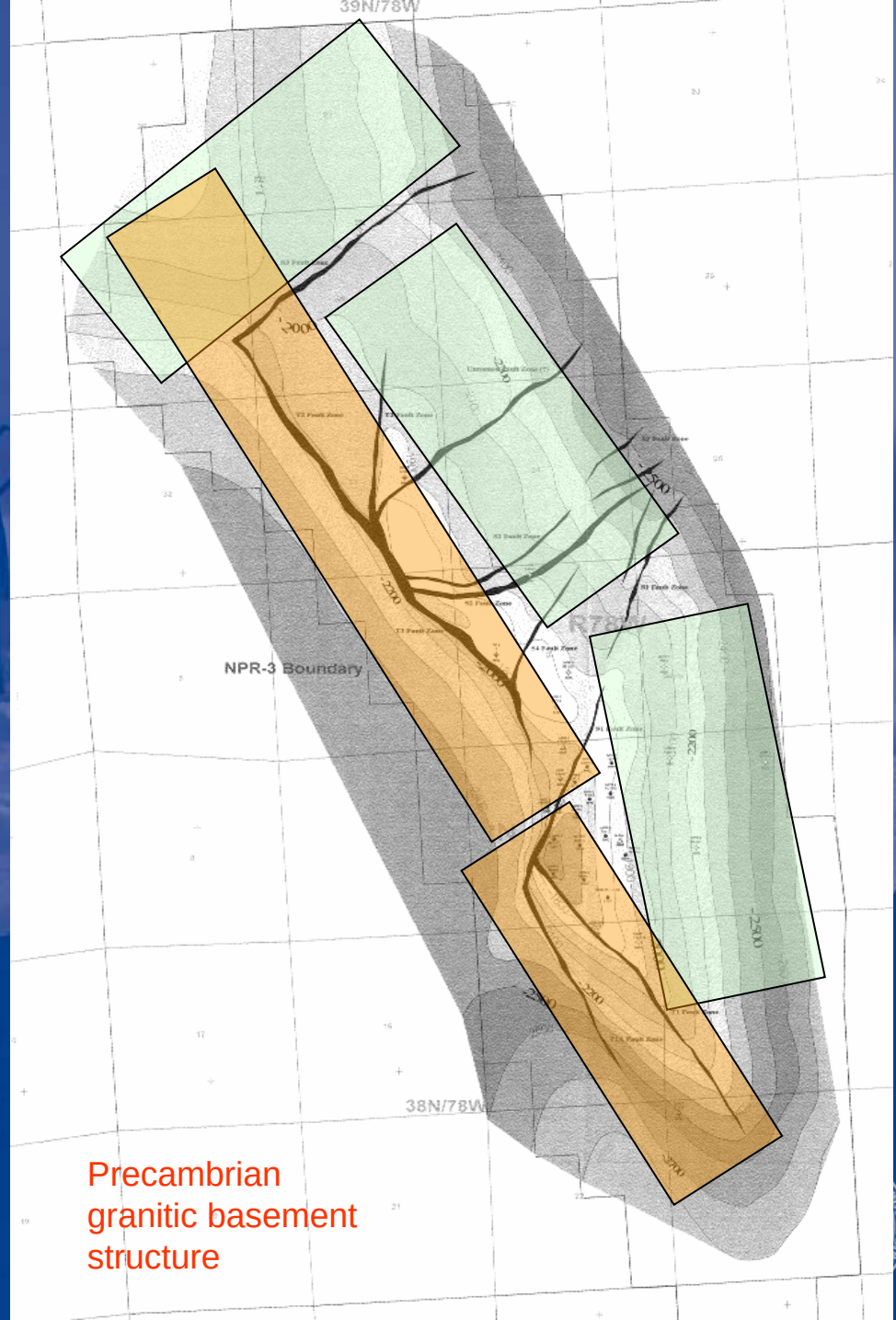
1 MW can be extracted from 1.7 MBWPD at 200° F (SMU data)

For 130 MBWPD, power = 130/1.7 = **76 MW**

POSSIBLE FUTURE GEOTHERMAL DEVELOPMENT AREAS

Madison – Tensleep potential

Fractured basement potential



Precambrian granitic basement structure

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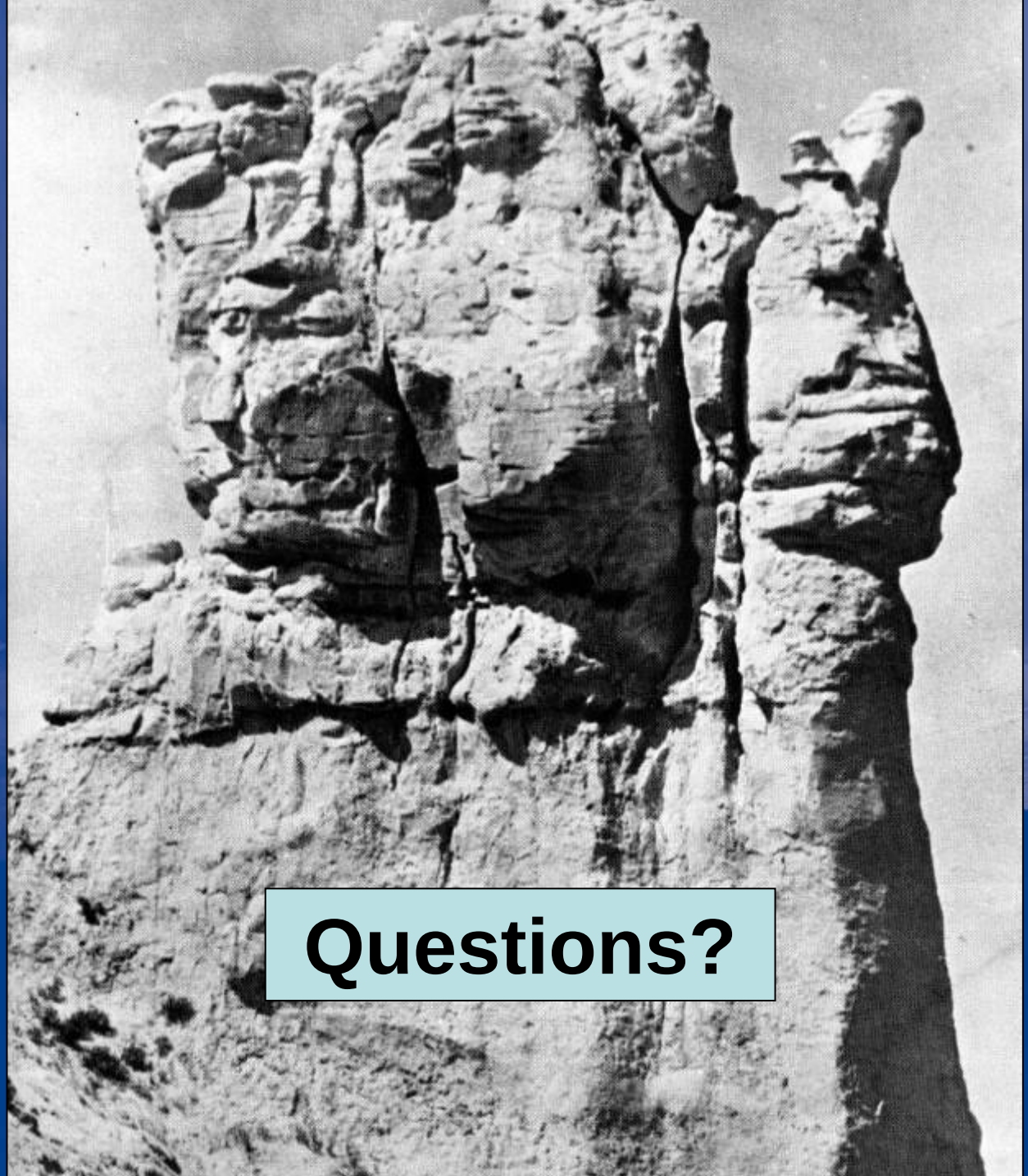

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