

AV History of Geologic Investigations and Oil Operations at Teapot Dome, Wyoming*

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Abstract

The Rocky Mountain Oilfield Testing Center (RMOTC), a U.S. Department of Energy (DOE) site, operates the Teapot Dome Oilfield near Casper, Wyoming, as a technology testing and demonstration center. In addition to the testing projects, the field still produces over 200 barrels of oil per day from several hundred active wells. Teapot Dome has a rich, sometimes infamous history, which provides context for current operations.

History

The structure was initially discovered and named by USGS geologist Carroll H. Wegemann in 1911 ([Figure 1](#)), as a probable oil-bearing anticline on trend with the giant Salt Creek Field ([Table 1](#): selected references). Wegemann named it after Teapot Creek, which flows across the north end of the dome, just upstream from where it joins Salt Creek, part of the Powder River drainage system. Farther upstream, Teapot Creek flows past Teapot Rock ([Figure 2](#)), named much earlier by pioneers and travelers for its resemblance to a teapot. Subsequent erosion has reduced the outcrop significantly, such that the resemblance is less apparent today. Contrary to a popular misconception, Teapot Rock is not located within sight of Teapot Dome.

In 1915 the area encompassing Teapot Dome was established as Naval Petroleum Reserve No. 3 ([Figure 3](#)) and was placed off limits for development. The Teapot Dome Scandal ([Figure 4](#)) during the Harding administration of the 1920s involved transfer from the Navy to the Department of the Interior, non-competitive leasing to Mammoth Petroleum (Sinclair), and drilling the reserve. [Figure 5](#) is of a gusher drilled during the 1920s. Congressional investigation uncovered bribes paid by Harry Sinclair to Interior Secretary Albert Fall. The eventual outcome of the scandal was the U.S Supreme Court invalidating the leases and shutting-in the field in 1927. A subsequent act of Congress in 1928 transferred jurisdiction back to the Navy, and re-established the site as a reserve once more.

In 1930, a technical report by Lt. Commander C.A. Trexel was submitted to the Director of the Naval Petroleum Reserves; it contains an excellent summary of the drilling and production operations at the site during the decade of the 1920's. It also included a brief summary of the geology known at the time.

Most published geologic studies that included references to Teapot Dome prior to 1930 were ancillary to studies of the Salt Creek field, by Wyoming State Geologists and staff. Wegemann was also primarily looking at Salt Creek, and published two USGS Bulletins – the aforementioned in 1911, and another in 1918. The lands were withdrawn in 1909 and not opened for development until 1922. Wegemann (1918) notes two wells drilled just outside the boundary on the west flank that had shows in the Shannon.

Nevertheless, there was some drilling during the withdrawal period. The first discovery of oil on Teapot Dome was in September, 1914, by the Pioneer Oil and Refining Company. However, *“The only production attempted from these wells were tests which indicated that they would produce from 3 to 6 barrels each per day. As a matter of fact these wells were drilled and possibly pumped for the first two days but they were never worked thereafter.”* (Trexel, 1930). In 1917, *“Mr. Glenn B. Morgan, Mineral Surveyor of the General Land Office, reported on the validity of the placer claims on the Teapot Naval Reserve. In conclusion he stated that there were no valid titles to the lands in the Naval Reserve; that the asserted claims could not withstand the force and effect of the executed withdrawal orders; that the occupants of the Reserves were merely trespassers having no shadow of right or title thereto and stated that the work they were doing was with a view of obtaining leasing privileges in the event of the passage of a law of that nature.”* (Trexel, 1930).

The 1920s saw transcribed testimony before Congress in association with the Teapot Dome scandal investigation, but no definitive published geologic studies. The first comprehensive geologic study focused primarily on Teapot Dome was USGS Professional Paper 163 by W. T. Thom, Jr., and Edmund M. Spieker in 1931, titled, “The significance of geologic conditions in Naval Petroleum Reserve No. 3, Wyo.”

I could not locate photos of Wegemann, Thom, or Spieker, but they served under George Otis Smith (Figure 6) during his term as USGS Director. There is this relevant entry on the USGS history page: *“Director Smith also served as Chairman of a three-man commission appointed by President Calvin Coolidge in March 1924, after the **Teapot Dome** scandal, to study the efficient management of the naval petroleum reserves”*.

Today, remnant vestiges can be seen of the development during the 1920s, including concrete foundations, fireplaces, sidewalks, excavations, and old pipes (Figures 7, 8, and 9).

The federal government eventually authorized full field development in the 1970s. High-resolution, low-altitude aerial photography obtained at this time has now been indexed and incorporated into a GIS system, and this provides a basis for surface geologic mapping initiatives as well as locating historical sites from the development of the 1920s. Please refer to Search and Discovery Article #40309 (2008) by B.S. Black, J.W. Buelt, and T. Anderson (<http://www.searchanddiscovery.net/documents/2008/08201black/index.htm>). RMOTC staff have now created a historic map of the 1920s “camps” (townsites) in the Teapot Dome Oilfield area.

Current Activity

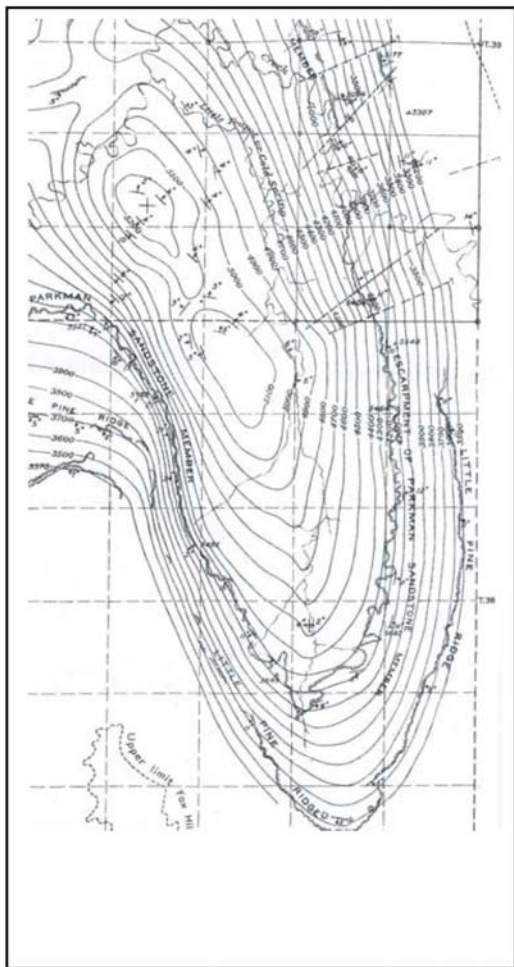
The author is conducting numerous scientific studies at the site, including collaborations with academic research partners. This includes subsurface interpretation and modeling in support of field operations (Figure 10), research studies, and enhanced oil recovery opportunities, including carbon dioxide injection. Detailed surface geological mapping is also included in this effort. One recent project has been mapping the

Quaternary terraces and relating those terrace ages to expected soil conditions as well as historic cultural sites ([Figure 11](#)).

One objective of a planned future Visitors Center will be to recognize the historical contribution to the site, the evolution of geologic understanding, and the establishment of RMOTC itself as a testing center, helping visitors to become aware of the activities over the past 100 years.

Prior and ongoing research partners are:

University of Houston
Stanford University
University of Wyoming
Enhanced Oil Recovery Institute (UW)
Wyoming State Geological Survey
University of Manchester
Cambridge University
Energy Geoscience Institute
Energistics
Public Petroleum Data Model
Environment System Research Institute
National Energy Technology Laboratory
Colorado School of Mines
Colorado Energy Research Institute
Lawrence Livermore National Laboratory
Princeton University
West Virginia University
Brigham Young University
Sandia National Laboratory
Southwest Research Institute
U.S. Geological Survey
Texas A&M University
Lawrence Berkeley National Laboratory
Los Alamos National Laboratory



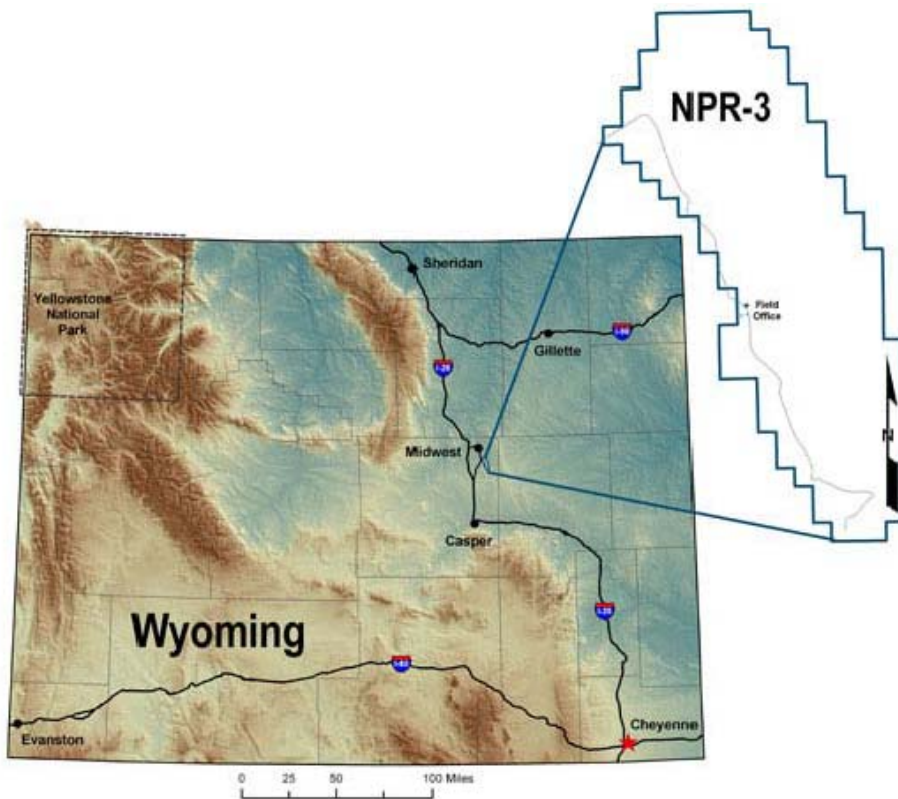


Figure 3. Location of Teapot Dome area (NPR-3).

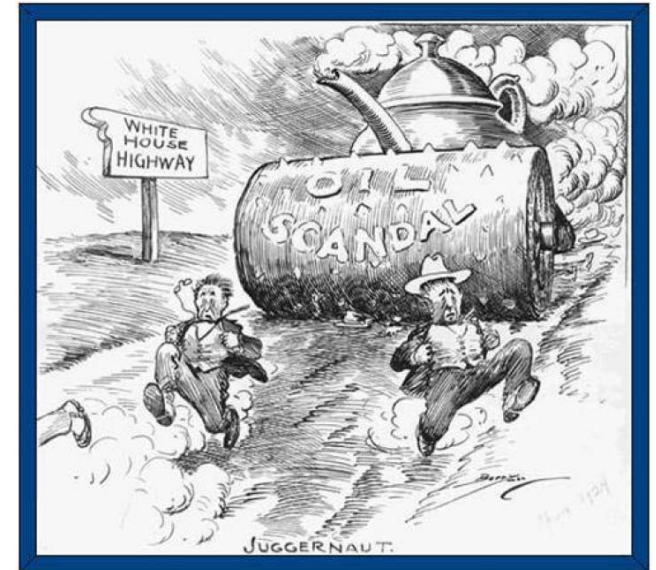


Figure 4. Cartoon printed during Teapot Dome scandal.

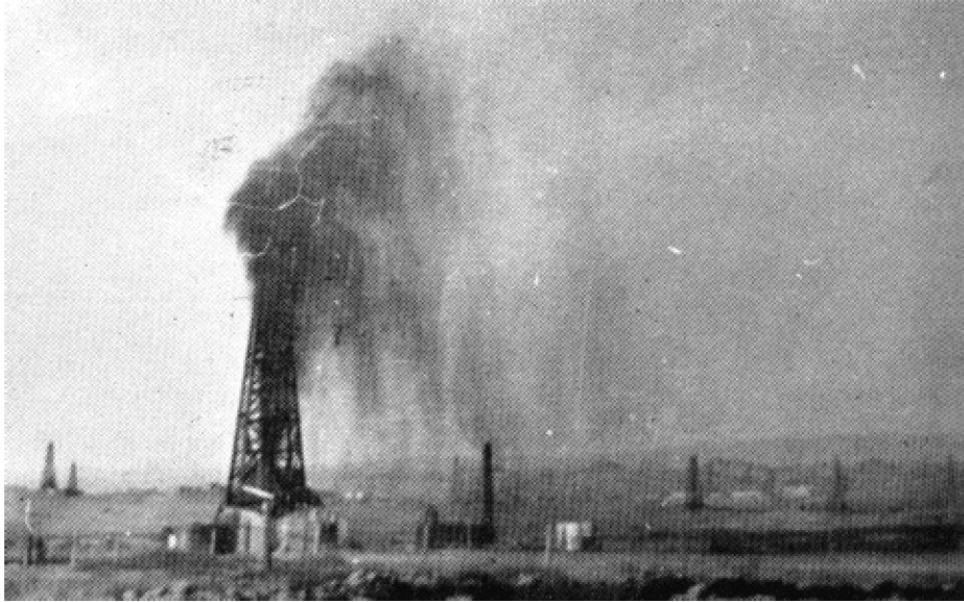


Figure 5. Well 301, which flowed 28,000 B/D for six days from fractured shale.



Figure 6. George Otis Smith, USGS Director, who served on commission by President Calvin Coolidge in 1924.



Figure 7. Sinclair pumping station, 1927, above same site today.



Figure 8. Mainfold house (left) pump house (center), and water supply pit.

Mammoth Main Camp, 1927 vs today:



Figure 9. Mammoth main camp, 1927 (left), and site today.



Figure 10. Drilling rig currently used in NPR-3.

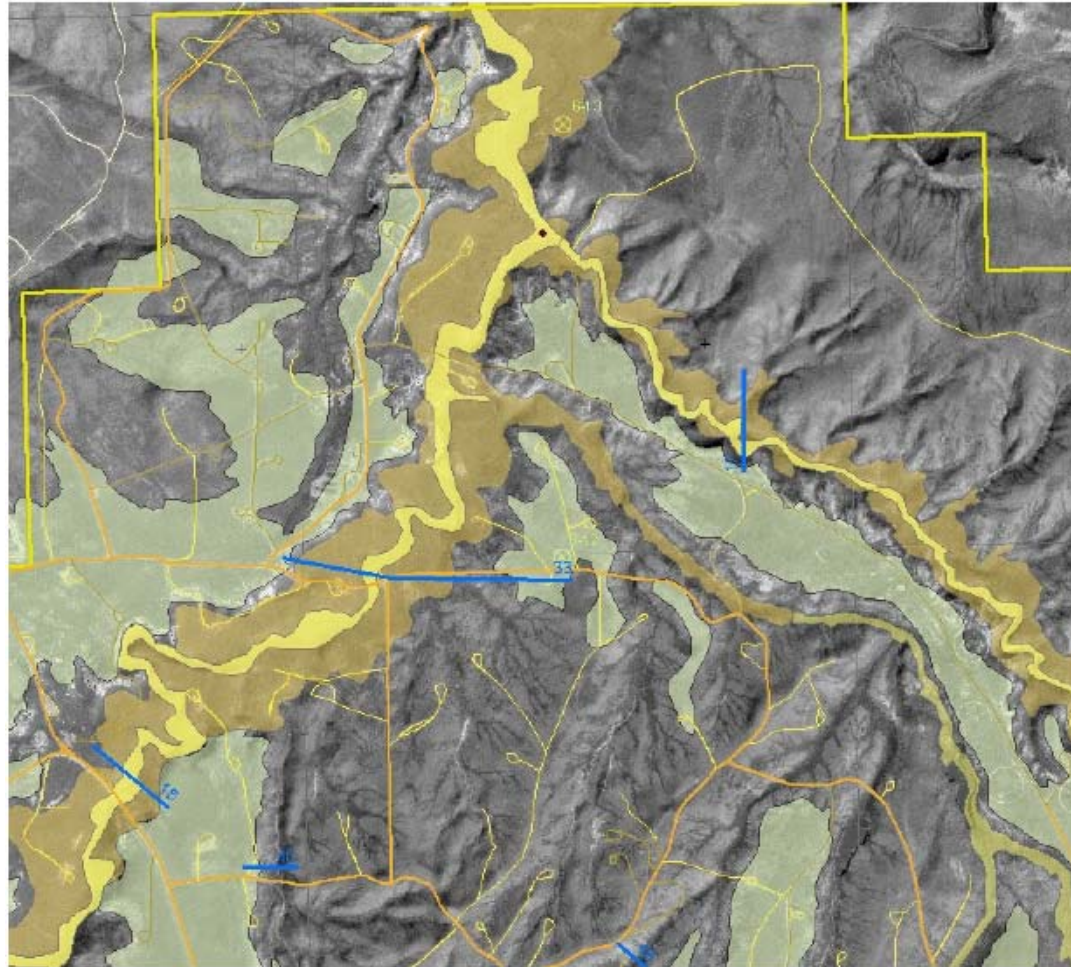


Figure 11. Geologic map of terrace units in north "end" of Teapot Dome.

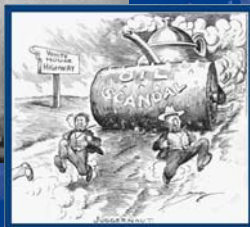
Year	Author	Title	Reference
1886	Aughey	Annual Report of the Territorial Geologist to the Governor of Wyoming.	
1888	Ricketts	Annual Report of the Territorial Geologist to the Governor of Wyoming.	
1893	Knight	Salt Creek oil field	Univ. WY Science Series Bulletin 14
1896	Knight and Slosson	The petroleum of Salt Creek, Wyo	Univ. WY Petroleum Series Bulletin 1
1911	Wegemann	The Salt Creek oil field, Wyoming (first mention of “Teapot Dome”)	U.S. Geological Survey Bulletin 452
1912	Jamison	The Salt Creek Oil Field, Natrona County, Wyoming	State of Wyoming Geologist’s Office, Bulletin 4, Series B
1914	Trumbull	The Salt Creek Oil Field, Natrona County, Wyoming	State of Wyoming Geologist’s Office, Bulletin 8, Series B
1918	Wegemann	The Salt Creek oil field, Wyoming	U.S. Geological Survey Bulletin 670
1923	Wegemann	A report on the position of the dividing line between Salt Creek/ Teapot Dome	67th U.S. Congress, 2nd Session, Senate Document 210
1923	Lewis	Report of the geological conditions of Teapot Dome	Hearings before the Committee on Public Lands and Surveys: U.S. Senate Resolution 282 & 294
1925	Estabrook and Rader	History of production of Salt Creek oilfield, Wyoming	Amer. Inst. of Mining, Metal., and Petrol. Engineers Transactions no. 5103
1926	Estabrook and Rader	Petroleum development and technology in 1925	Amer. Inst. of Mining, Metal., and Petrol. Engineers Transactions no. 1570
1927	Link	Origin and significance of “epi-anti-clinal” faults as revealed by experiments	AAPG Bulletin, vol. 11
1929	Beck	Salt Creek Oil Field, Natrona County, Wyoming	Structure of Typical American oil fields, vol. II: AAPG
1930	Trexel	Compilation of data on Naval Petroleum Reserve No. 3 (Teapot Dome), Natrona County, Wyoming	Report to Director, Naval Petroleum and Oil Shale Reserves-Colorado, Utah, and Wyoming
1931	Stabler	Waters of the Salt Creek-Teapot Dome uplift	U.S. Geological Survey Professional Paper 163
1931	Thom and Spieker	The significance of geologic conditions in Naval Petroleum Reserve No. 3, Wyo	U.S. Geological Survey Professional Paper 163

Table 1. Key historical references, Teapot Dome.

History of Geologic Investigations and Oil Operations at Teapot Dome, Wyoming



Well 301, 28,000 BOPD
for 6 days, fractured shale



Tom Anderson, Chief Scientist, Rocky Mountain
Oilfield Testing Center (RMOTC), Casper, Wyoming



150 Years of the Oil Industry



*Celebrating the Story-
Progress from Petroleum*



In 1859, "Colonel" Edwin L. Drake and the Seneca Oil Company struck oil in the Venango Oil Field near Titusville, PA. The Drake Well started producing about 40 barrels of oil a day. From such humble beginnings the petroleum industry developed. August 27, 2009 will mark the 150th anniversary of the Drake Well discovery.



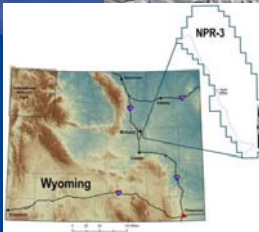
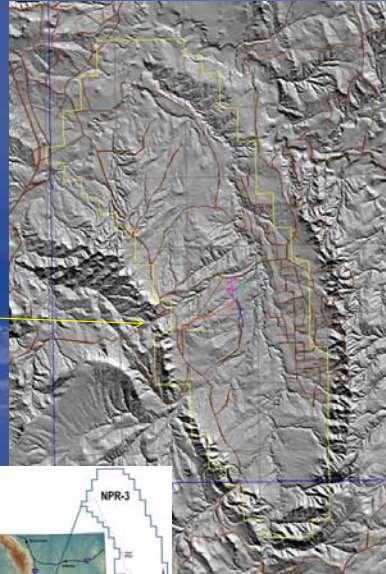
See: www.oil150.com , www.aoghs.org , and www.drakewell.org/



Presenter's Notes: The city of Baku, Azerbaijan, also claims to be the birthplace of oil: "Oil has been scooped from surface diggings around Baku since at least the 10th century."

Outline

- What is RMOTC
 - Testing center
 - Natural geological laboratory
- History
 - Early geology
 - Teapot Dome
 - RMOTC
- Geology
 - Mapping Quaternary terraces
 - Surface geologic mapping
 - Ongoing research studies



Note: all images RMOTC
unless otherwise credited

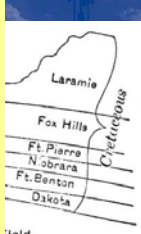
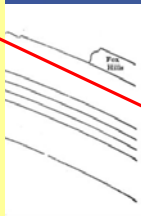


Early Geology: selected reference table, 1886-1931

Year	Author	Title	Reference
1886	Aughey	Annual Report of the Territorial Geologist to the Governor of Wyoming.	
1888	Ricketts	Annual Report of the Territorial Geologist to the Governor of Wyoming.	
1893	Knight	Salt Creek oil field	Univ. WY Science Series Bulletin 14
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1926	Estabrook and Rader	Petroleum development and technology in 1925	Amer. Inst. of Mining, Metal., and Petrol. Engineers Transactions no. 1570
1927	Link	Origin and significance of "epi-anticlinal" faults as revealed by experiments	AAPG Bulletin, vol. 11
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Period	Formation		Lithology	Thickness	Depth (feet)	Productive
Quaternary	Kaycee			0-50		
Upper Cretaceous	Steele			195		
		Sussex		30	225	□
				290		
		Shannon		120	515 635	■
				1355		■
	Niobrara Shale			450	1990	■
	Carlisle Shale			240	2440	□
	Frontier	1st Wall Creek		160	2680	□
				245	2840	
		2nd Wall Creek		65	3085	■
		3rd Wall Creek		175	3150	
			5	3325 3330	■	
		265				
Lower Cretaceous	Mowry Shale			230	3595	
	Muddy Sandstone			15	3825	■
	Thermopolis Shale			135	3840	
				85	3975	■
Jurassic	Dakota			10	4060	■
	Lakota			80	4070	■
	Morrison			270		□
	Sundance	Upper		95	4340	
		Lower		150	4435	
Triassic	Chugwater Group	Crow Mtn		80	4555	
		Alcova LS		20	4665	
				20	4665	
		Red Peak		520		□
Permian	Goose Egg			320	5205	□
Pennsylvanian	Tensleep			320	5525	■
	Amsden			160	5845	
Mississippian	Madison			300	6005	
Cambrian through Devonian	Undifferentiated			780	6305	
Pre-Cambrian	Granite				7085	

There Was Salt Creek

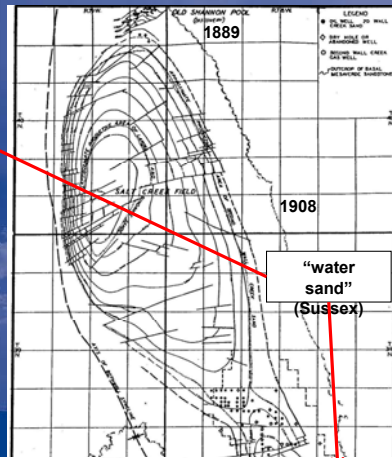


Aughey,
1885

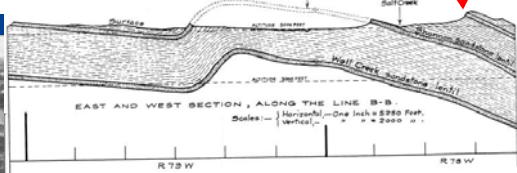
Beck,
1929

Knight,
1896

Trumbull,
1914



“water
sand”
(Sussex)



First Mapping

Carroll H. Wegemann, USGS geologist, completed the first comprehensive study of the Salt Creek Field area in 1911 (USGS Bulletin 452), including Teapot Dome, shown here – the first structure map made and prior to any drilling. He was also the first to name the structure “Teapot Dome”, after Teapot Creek.

Teapot
Rock

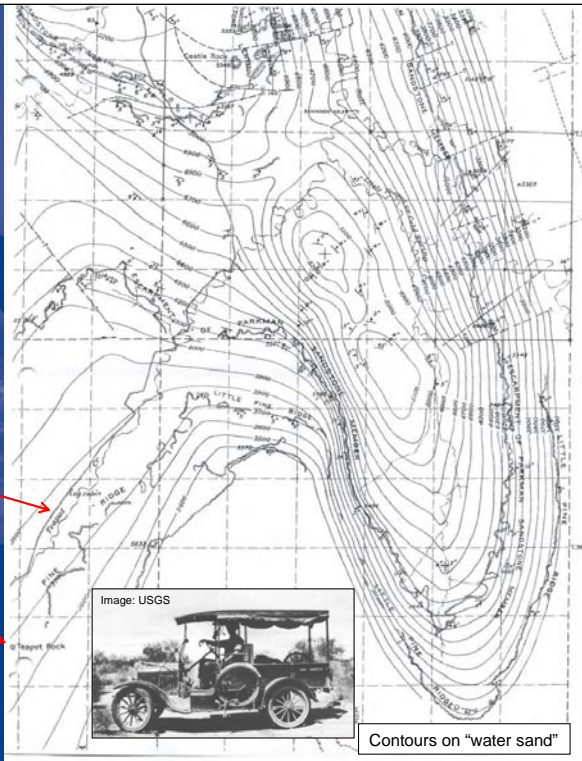


Image: USGS

Contours on “water sand”

Naval Petroleum Reserves Are Born

- 1908: Dr. Otis Smith, USGS Director, recommends DOI retain oil lands for fuel reserve for Navy.
- 1909: President Taft withdraws 3,000,000 acres in WY and CA.
- 1910: Concern over the President's authority to withdraw lands, so Congress passes the Pickett Act.
- 1910: Withdrawn lands over Salt Creek Field reinstated, but Teapot Dome area remains off limits
- 1912: President Taft Executive Order creates NPR-1 and NPR-2 in California.
- 1915: President Wilson Executive Order creates NPR-3 at Teapot Dome.

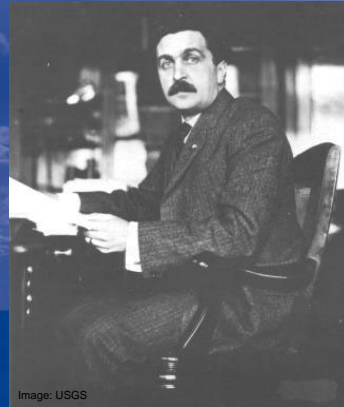


Image: USGS

George Otis Smith, Director of the
U.S. Geological Survey, 1907-1930.



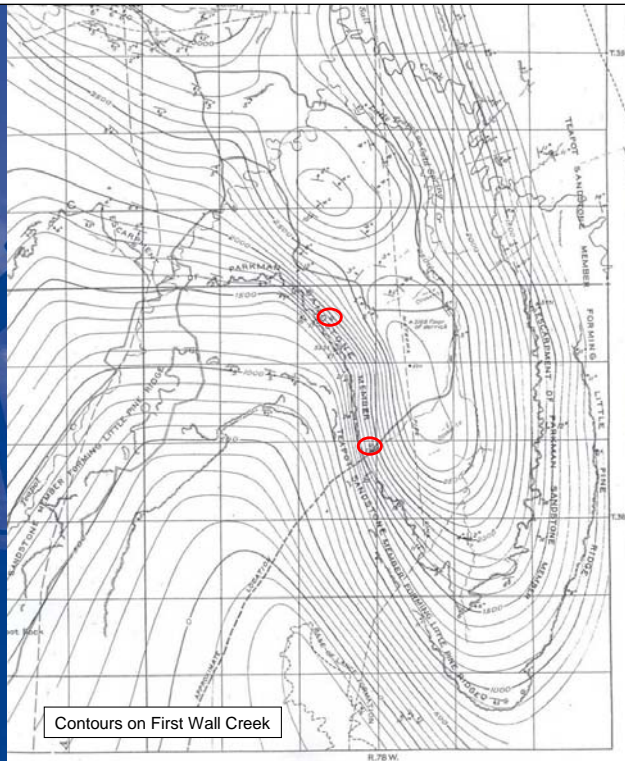
Revision - 1918

Wegemann published a revised study of the Salt Creek Field area (USGS Bulletin 670). His 1918 map adds two Shannon wells on the west flank (just outside the NPR-3 boundary) and extended the anticlinal crest southward.

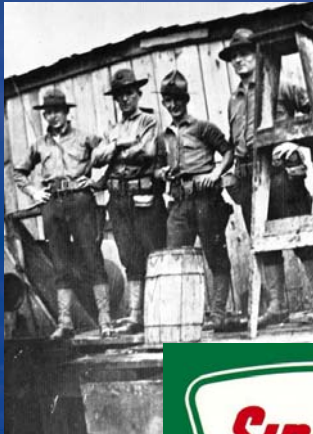
Image: USGS



Field work in the Salt Creek/Teapot Dome area 1910-1920



The Scandal Begins



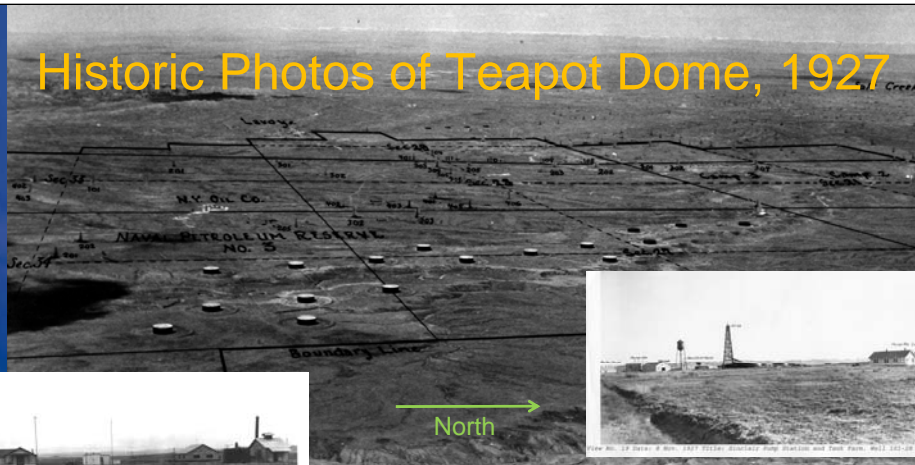
U.S. Marines
land at Teapot
Dome, 1922,
eject Mutual Oil
Co. squatters!



- 1921: Senator Albert Fall (NM) becomes President Harding's Secretary of the Interior, has NPRs moved to DOI, then quickly moves to open reserves to private exploitation.
- 2/22: Harry Sinclair incorporates Mammoth Oil Company.
- 3/22: Sinclair buys and quitclaims all existing mining claim rights at Teapot Dome, and applies for a lease on all of Teapot Dome.
- 4/22: Mammoth is secretly awarded a noncompetitive lease covering all of Teapot Dome, with no restrictions.
- 4/22: Congress calls for an investigation of NPR-3.



Historic Photos of Teapot Dome, 1927



View No. 12 North, 8 Nov. 1927. Teapot Dome pump station and tank farm. Well 101-10 in foreground.



View No. 13 North, 8 Nov. 1927. Teapot Dome pump station and tank farm. Well 101-10 in foreground.



View No. 14 North, 8 Nov. 1927. Teapot Dome pump station and tank farm. Well 101-10 in foreground.



View No. 15 North, 8 Nov. 1927. Teapot Dome pump station and tank farm. Well 101-10 in foreground.



View No. 16 North, 8 Nov. 1927. Teapot Dome pump station and tank farm. Well 101-10 in foreground.



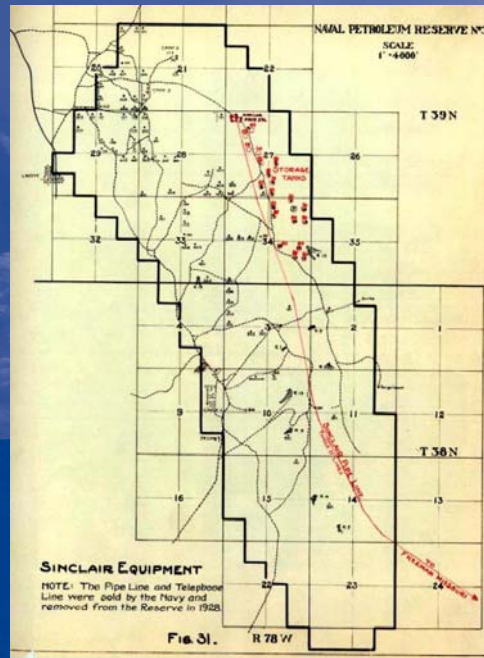
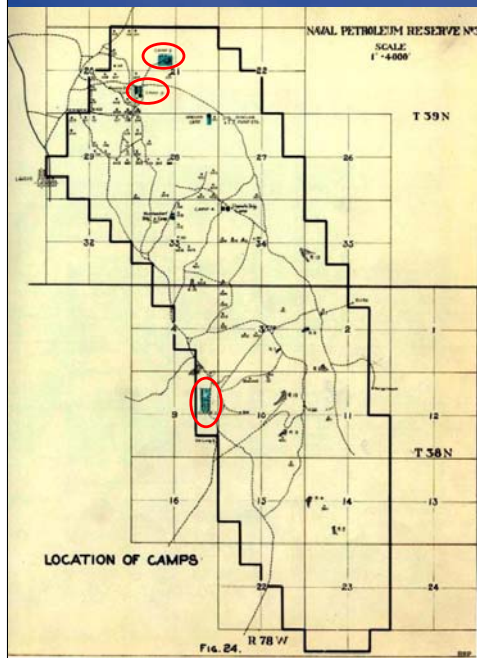
View No. 17 North, 8 Nov. 1927. Teapot Dome pump station and tank farm. Well 101-10 in foreground.

Congress Investigates

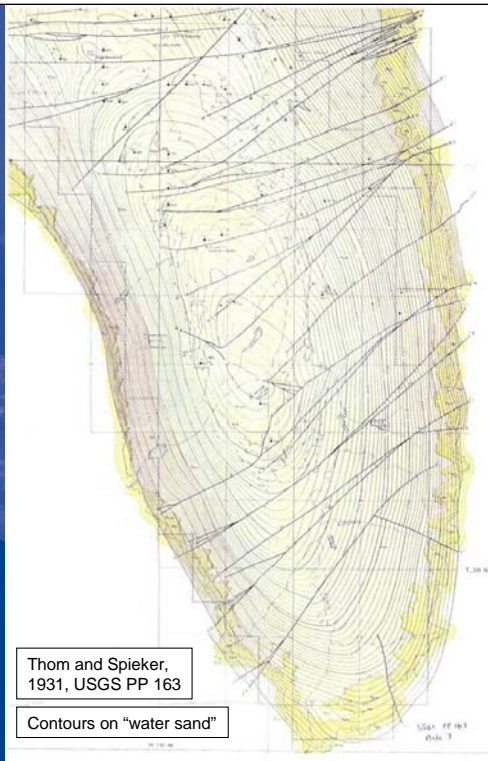
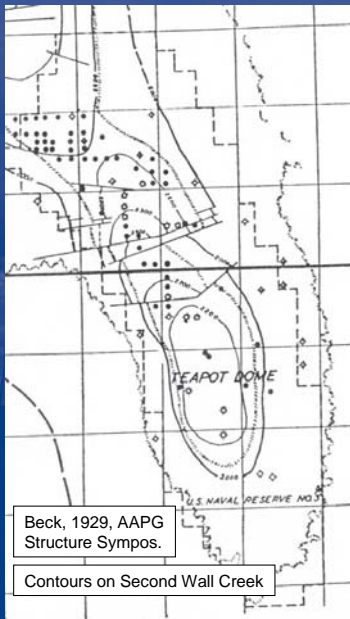
- 8/23: Harding dies, and Coolidge becomes President.
- 10/23: Senate Committee hearings are convened.
- Investigators find that the Sinclair leases were fraudulent, and that EO 3474, transferring lands from Navy to DOI, was illegal and should be set aside.
- 3/24: U.S. files suit to cancel Mammoth's Teapot Dome lease.
- 6/25: Court overrules the U.S., and upholds Sinclair. The U.S. appeals.
- 3/27: President Coolidge EO 4614 overturns EO 3474, and returns NPRs to Navy control.
- 10/27: Supreme Court rules in favor of U.S. and immediately shuts in Teapot Dome.
- 2/28: Just to be sure, Congress passes an Act to transfer jurisdiction of NPRs from DOI back to the Navy.
- 1930: Lt. Trexel Report



Maps from Trexel Report, 1930

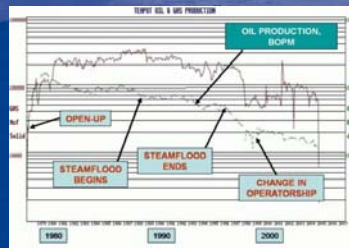


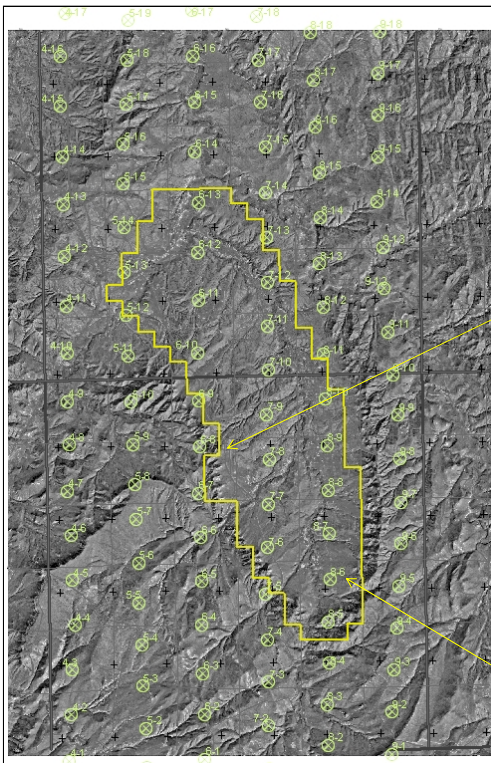
Geologic Maps after the 1920s Development



Teapot Dome Since Then

- Some exploratory and drainage offset wells were drilled in the '50s and '60s.
- **NPR-1 and NPR-3 opened to full development in 1976.**
- 1977: NPR jurisdiction transferred from Navy to (newly created) DOE.
William H. 'Skip' Curry publishes excellent AAPG Bulletin summary article
- Subsequent development and IOR projects raised rates to 5000 BOPD in 1979-80.
- **1995 - present: Rocky Mountain Oilfield Testing Center.**
- (1998: NPR-1 (Elk Hills, CA) sold to Occidental)
- (2000: NOSR-2 transferred to Ute Tribe, and NOSR-1, NOSR-3, and NPR-2 (Buena Vista Hills, CA) transferred to DOI)
- Current production is 200-300 BOPD.





Low Altitude (1976) Air Photo Centers

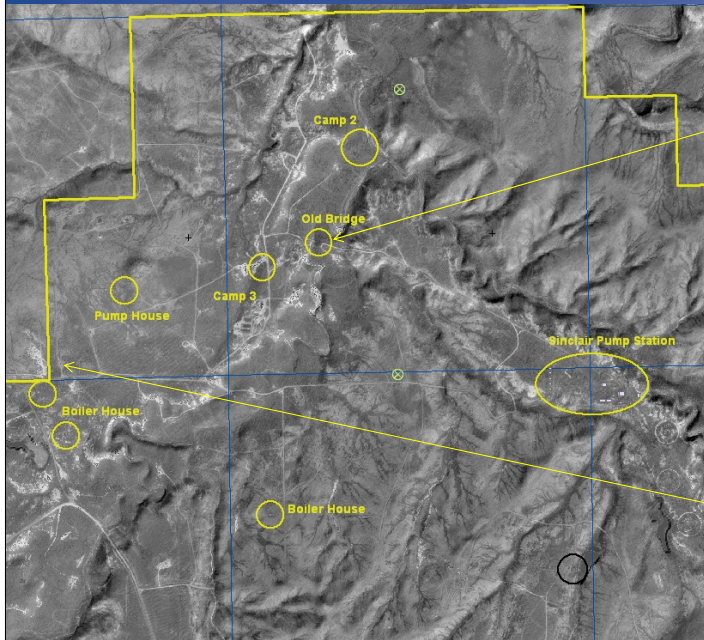


1927



2008

Historic Sites in the North End of NPR-3



Well 402-20
22nd well drilled, 20 Feb 1923
Cost \$30,000
IP 8000 BOPD
Flowing 510 BOPD March, 1924
Cum 582,000 BO 31 Dec 1927

*"Best Second
Wall Creek well
in the field"*



Sinclair Pump Station

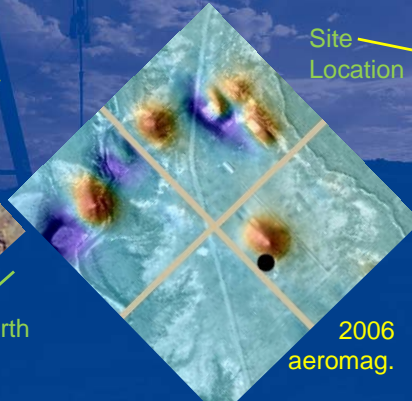
1927



2008



1976 air
photo



2006
aeromag.

Site
Location



Sinclair Pump Station Remnants

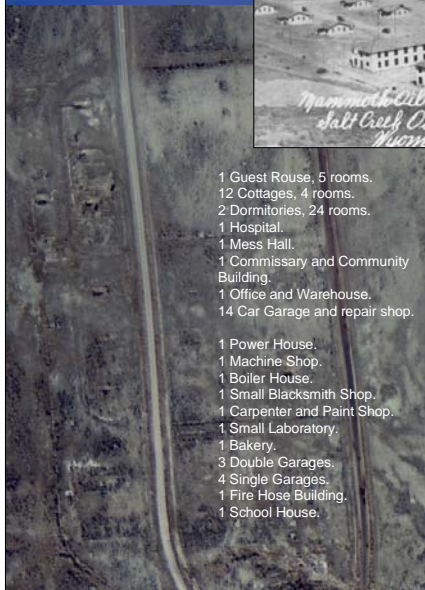


View NW, 1/17, 1927, 1/18, 1927, Location of Camera: Sinclair Pump Station, 1927, Sinclair Pump Station, Interior Pump Room.



Mammoth Main Camp

1976 air photo



- 1 Guest House, 5 rooms.
- 12 Cottages, 4 rooms.
- 2 Dormitories, 24 rooms.
- 1 Hospital.
- 1 Mess Hall.
- 1 Commissary and Community Building.
- 1 Office and Warehouse.
- 14 Car Garage and repair shop.

- 1 Power House.
- 1 Machine Shop.
- 1 Boiler House.
- 1 Small Blacksmith Shop.
- 1 Carpenter and Paint Shop.
- 1 Small Laboratory.
- 1 Bakery.
- 3 Double Garages.
- 4 Single Garages.
- 1 Fire Hose Building.
- 1 School House.

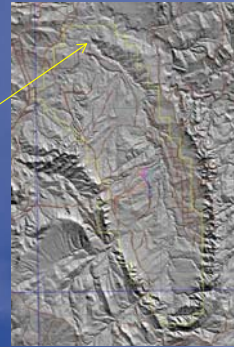


North





This camp was in reality a pump station to which the oil from the Reserve was run by gravity through the oil gathering system, there gauged, and pumped to the tanks of the Sinclair Pipeline Company. This camp included 1 Cottage, 5 rooms, 1 Boiler House with 3 boilers, 1 Pump Building, 40'x 80', 6 Steel Tanks.



Camp
2

North



"Pumping Power" – Boiler House Sec 29



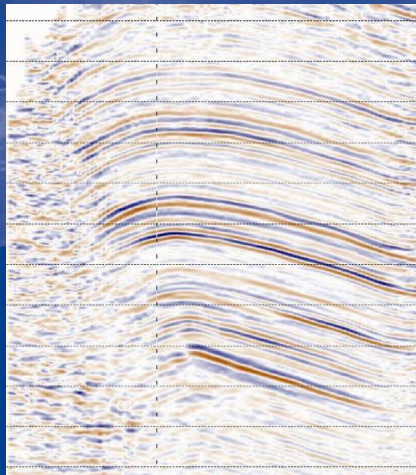
North



The Modern Era: Data Management Project

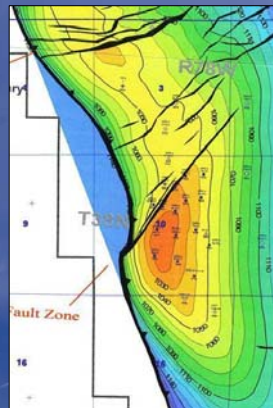
An internal project was initiated in 2004 to update the NPR-3 database. Its true value as an asset and fundamental part of the RMOTC infrastructure was not generally recognized, and it was not in a form where that value was seen and usable by our partners.

- Most data were not digital, and therefore could not be used “as-is” in building a geological model or in numerical analysis
- The data were poorly organized and catalogued
- There was poor access, especially outside RMOTC for project partners
- No modern subsurface modeling existed
- We didn't have true GIS capabilities



Data Management Project Scope

- Wells
 - Files/Headers
 - Locations
 - Tops
 - Logs
- Basemap data (culture, well locations, section corners and lines, orthophoto image, topography, facilities, roads, drainages, etc)
- Seismic
 - 2D lines
 - 3D volume
 - Synthetics
 - Horizons
 - Faults
 - Depth conversion
- Production & Drilling
- Geologic Models
- Reservoir simulation

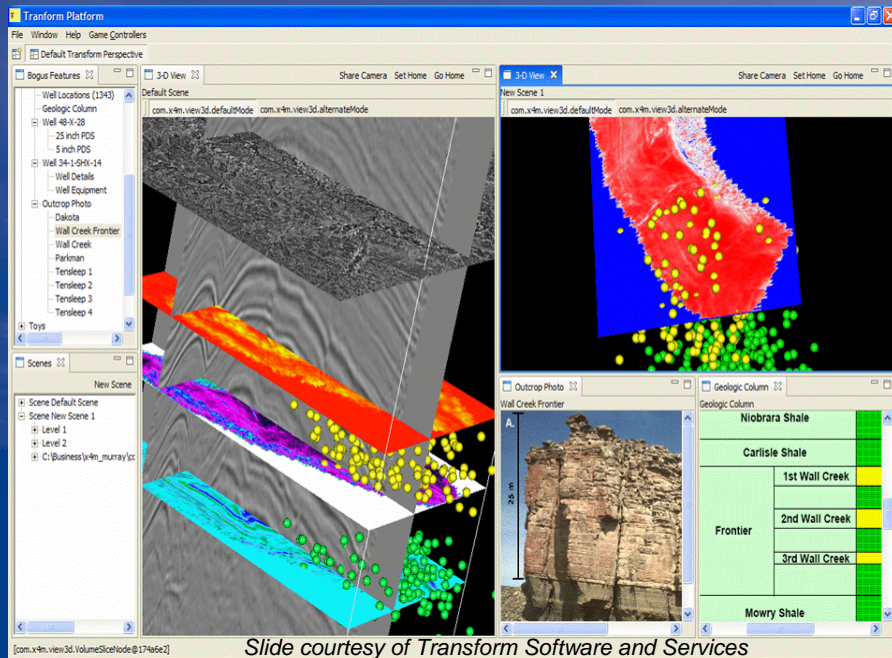


High-level Task List



- Digitize logs from “deep wells”
- Import wells and logs into mapping system
- Build cross sections
- Create structure maps
- Do full 3D integrated seismic interpretation of multiple key horizons and faults
- Do seismic depth conversion
- Build a 3D geocellular model
- Run dynamic flow simulation, perform history match and tune model for fit
- Load production history and completions data
- Implement real-time production data capture and surveillance
- Load (historic) drilling data into a system
- Instrument drilling rig for real-time operational data capture
- Integrate partner scientific research

New Visualization Methods

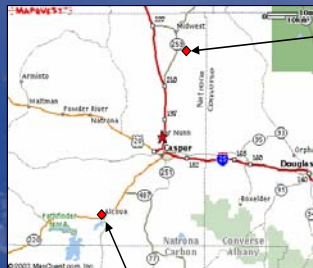


Slide courtesy of Transform Software and Services

Example: Fracturing and Faulting at Teapot Dome



Left: Conjugate normal faults and fractures in outcrop. Photo from Scott Cooper, Sandia National Laboratory.



Teapot Dome

Left: Location of Casper, Teapot Dome, and Alcova.

Below: The Alcova Anticline, an NPR-3 analog. Shown is the northwest canyon wall, site of 2004 LIDAR acquisition. Photo from N. Hurley, Colorado School of Mines.

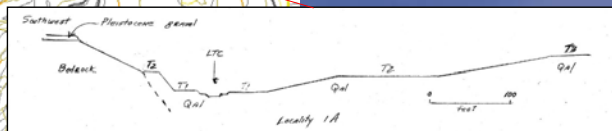
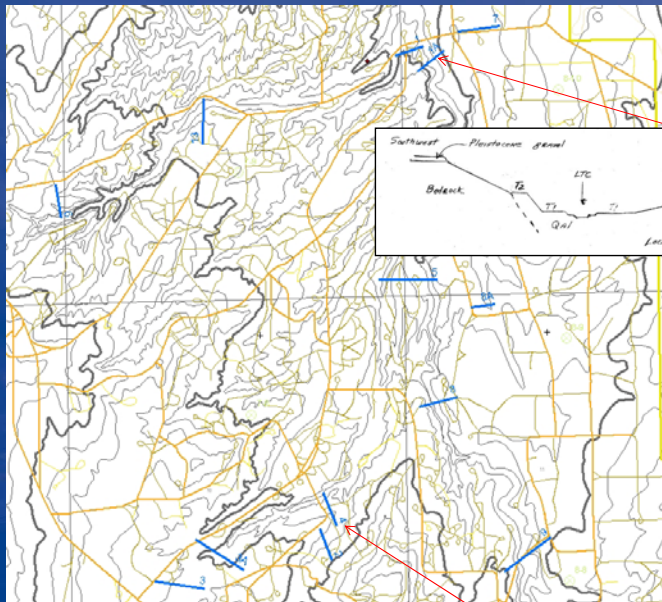
Alcova Anticline



Recent Work: Mapping Quaternary Terraces

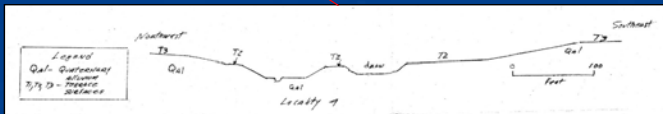


Terrace Mapping

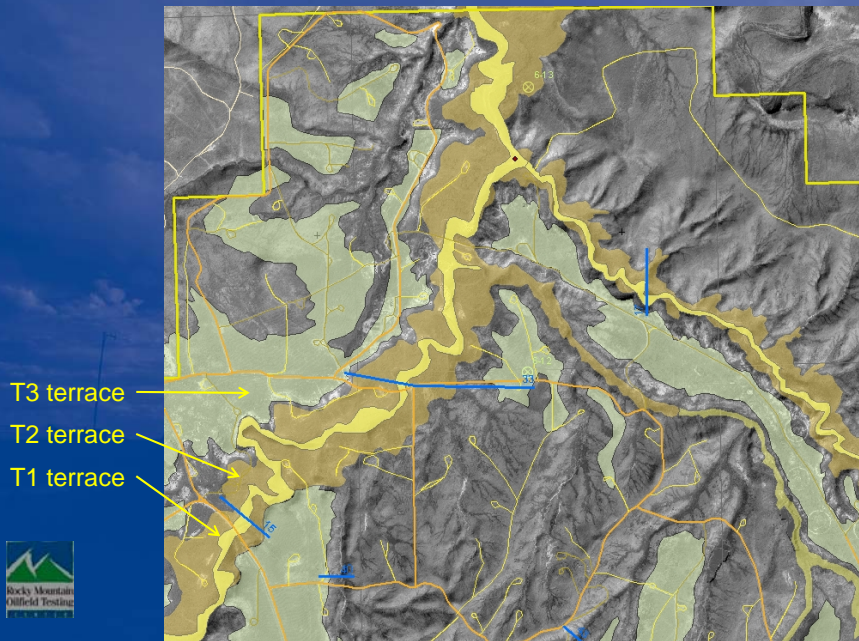


Terrace profiles interpreted by John Albanese, Consulting Geo-Archeologist. He provided hand-drawn profiles (cross-sections) and a topographic base with hand-drawn profile localities. My goal was to input his data into GIS and create a full areal coverage map of these terraces:

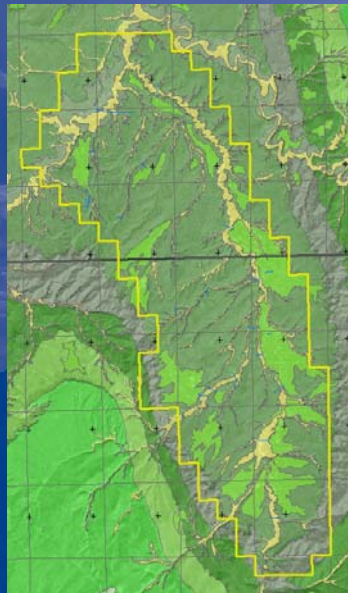
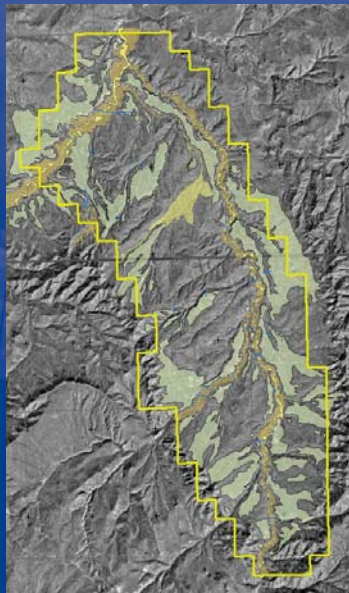
- T3 (oldest, 10,000 YBP)
- T2 (2,000 YBP)
- T1 (500 YBP)
- T0 (present stream)



Final Composite Map – N End



Final full detailed map of terraces, compared to old regional geologic map



Additional Detailed Surface Mapping

The “bedrock” areas exposed between the terraces are being mapped next, working with summer geologic interns to augment our own staff.

Another surface mapping task is to complete the mapping of the Mesaverde Fm hogbacks rimming the dome



Steele Shale
Bentonite markers
Sussex Sand
T0 terrace
T1 terrace
T2 terrace
T3 terrace



Prior and Ongoing Research Partners

- University of Houston
- Stanford University
- University of Wyoming
- Enhanced Oil Recovery Institute (UW)
- Wyoming State Geological Survey
- University of Manchester
- Cambridge University
- Energy and Geoscience Institute
- Energetics
- Public Petroleum Data Model
- ESRI
- National Energy Technology Laboratory
- Colorado School of Mines
- Colorado Energy Research Institute
- Lawrence Livermore National Laboratory
- Princeton University
- West Virginia University
- Brigham Young University
- Sandia National Laboratory
- Southwest Research Institute
- U. S. Geological Survey
- Texas A&M University
- Lawrence Berkeley National Laboratory
- Los Alamos National Laboratory



Geologic investigations continue at RMOTC, building upon a rich legacy of early historic studies and operations at Teapot Dome

