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SAND2019-11605C

Crude Oil Characterization Research Study

Task 3: Combustion Experiments

Part I: Sample Acquisition & Properties

Crude Oil Quality Association Fall Meeting

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PRESENTED BY

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Sponsors:

- U.S. Department of Energy, Office of Fossil Energy
- U.S. Department of Transportation, Pipeline and Hazardous Materials Administration
- Transport Canada, Transport of Dangerous Goods Directorate

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Project Team



Large, multidisciplinary team representing Sandia and contractors



Crude Oil Characterization Research Study



Objective:

Evaluate whether crude oils currently transported in North America, including those produced from “tight” formations, exhibit:

- physical or chemical properties that are distinct from conventional crudes, and
- how these properties affect parameters required to assess thermal hazard distances from radiant exposure associated with pool fires and fireballs

Motivation:

Crude transport by rail poses risks recognized by US and Canadian regulators and stakeholders



Casselton, ND, Dec 30, 2013

“Bakken crude may be more flammable than previously thought: U.S. regulator”

Reuters: January 2, 2014

Numerous high-profile train accidents in the US and Canada

Open debate whether type of crude (tight vs. conventional) contributes to accident severity

Project Structure



Task 1: Project Administration & Outreach (ongoing)

Task 2: Sampling & Analysis Methods Evaluation (complete)

Task 3: Combustion Experiments

- Part I: Sample Acquisition & Property Testing
- Part II: Combustion Testing

 Today's focus

Task 4: Crude Characterization, Tight vs. Conventional (TBD)

Project Publications



- Luketa, A., T. K. Blanchat, D. L. Lord, A. Cruz-Cabrera, J. Hogge and R. Allen (2019). "Pool Fire and Fireball Experiments in Support of the US DOE/DOT/TC Crude Oil Characterization Research Study." *SAND 2019-9189*. Sandia National Laboratories, Albuquerque, NM.
- Lord, D., R. Allen, D. Rudeen, C. Wocken and T. Aulich (2018). "DOE/DOT Crude Oil Characterization Research Study, Task 2 Test Report on Evaluating Crude Oil Sampling and Analysis methods, Revision 1 - Winter Sampling." *Unclassified Unlimited Release SAND2018-5909*. Sandia National Laboratories, Albuquerque, NM.
- Lord, D. L., R. G. Allen and D. K. Rudeen (2017). "DOE/DOT Crude Oil Characterization Research Study, Task 2 Test Report on Evaluating Crude Oil Sampling and Analysis Methods." *SAND2017-12482*. Sandia National Laboratories, Albuquerque, NM.
- Lord, D., A. Luketa, C. Wocken, S. Schlasner, R. Allen and D. Rudeen (2015). "Literature Survey of Crude Properties Relevant to Handling and Fire Safety in Transport." *Unlimited Release SAND2015-1823*. Sandia National Laboratories, Albuquerque, NM.

7 Sampling Approach



Acquire several crude oils from the US supply chain spanning a measurable range of vapor pressure (VPCR) and light ends content (mass % < C6) representative of U.S. domestic conventional and tight crudes

Maintain and document properties, especially those related to volatility, from the points of acquisition in the supply chains through transportation, storage, and delivery to the point of combustion testing at Sandia

Sampling requirements (via ASTM/GPA standards)

- Closed sampling to preserve light ends, ~3,000 gallons capacity
- Liter-scale subsampling at various points throughout storage and associated with fire testing

Property analysis requirements (via ASTM/GPA standards)

- VPCR, pressurized whole oil composition, relative density, heat of combustion, others...



Task 2 Results Informed Task 3 Methods

Crude oil sampling & analysis methods that met performance requirements in **Task 2** were implemented in **Task 3**

0.5 L water displacement oil cylinder

Oil sampling



upscale

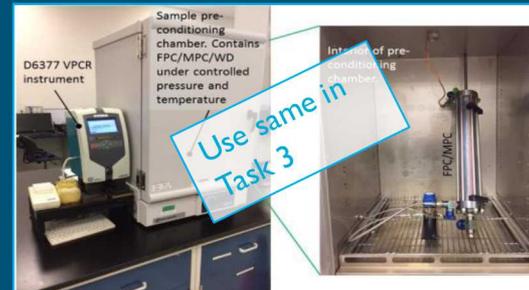
Custom 18,000 L water displacement oil tanker



Vapor pressure



→



ASTM D6377M VPCR_x(T)

Compositional analysis

TVP-95 separator method
GPA 2103-M pressurized composition
Additional pressurized methods

Down-select for best technical performance, availability, cost

GPA 2103-M pressurized composition

Large Oil Samples



Three large samples were acquired for combustion testing

- Truck offloading facility upstream of a rail loading facility in North Dakota (Naming convention: Tight 1, BKN)
- Production facility sales point that handles unconventional shale oil production in Texas (Naming convention: Tight 2, TXSh)
- Stabilized crude from the US Strategic Petroleum Reserve West Hackberry storage site (SPR). (Low-volatility end member of the oil test set)

Selection criteria

- Include oils that represent material within the North American supply chain with at least one from rail transport
- Include oils that span a measurable range of VPCR and light ends content
- Acquire oil from operators that are willing to grant site access and permit release of oil properties data to public domain technical reports

Samples were not selected to represent any specific feature of a producing region such as an average or aggregate sample. They were spot samples from access points in the supply chain relevant to the overall issue of transportation safety.

Crude Oil Visual Properties

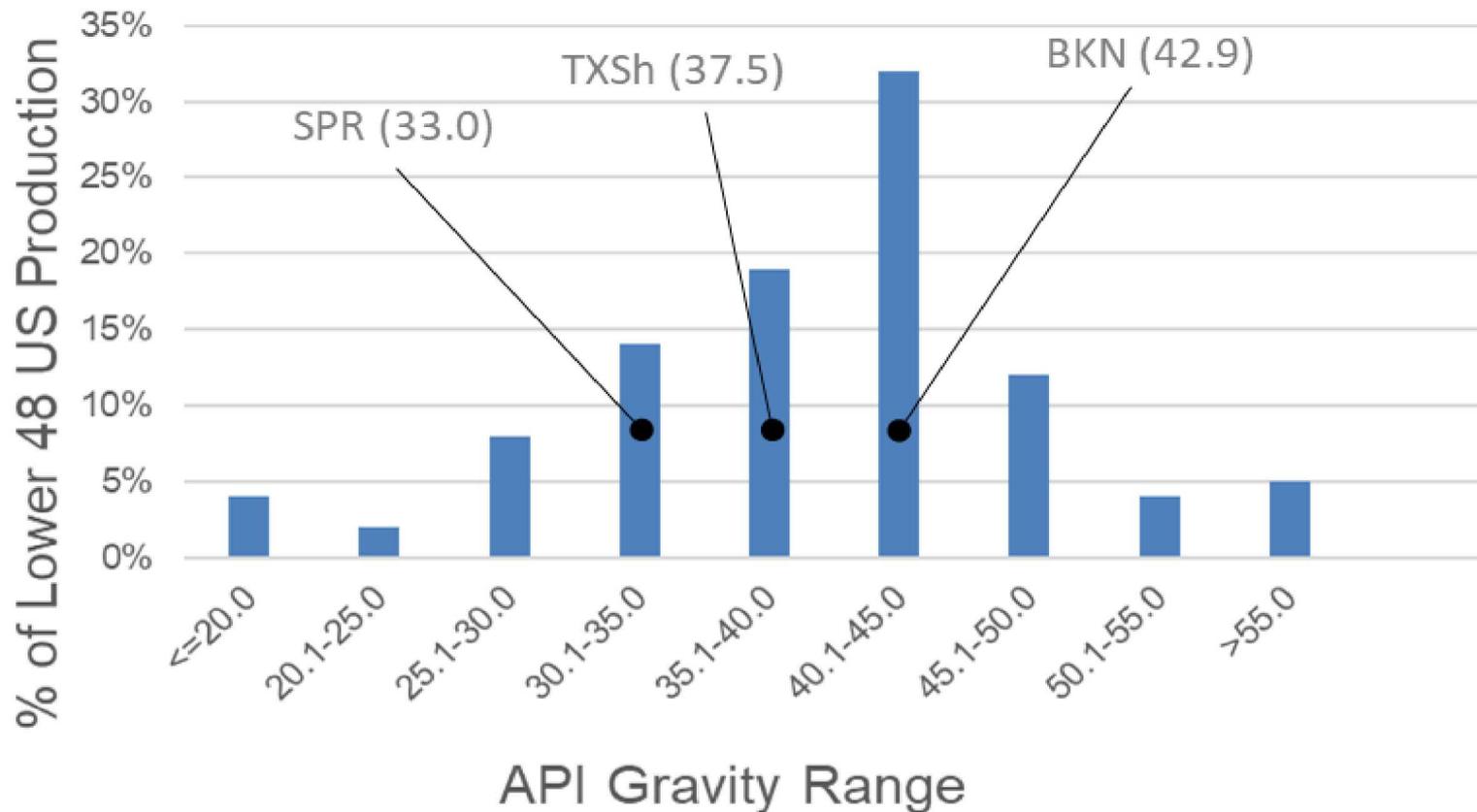


ASTM D4057 bottle samples taken week of July 16, 2018 at Sandia
Oil temperature = 75-80°F, ambient pressure ~11 psia @ 7,000 ft elevation





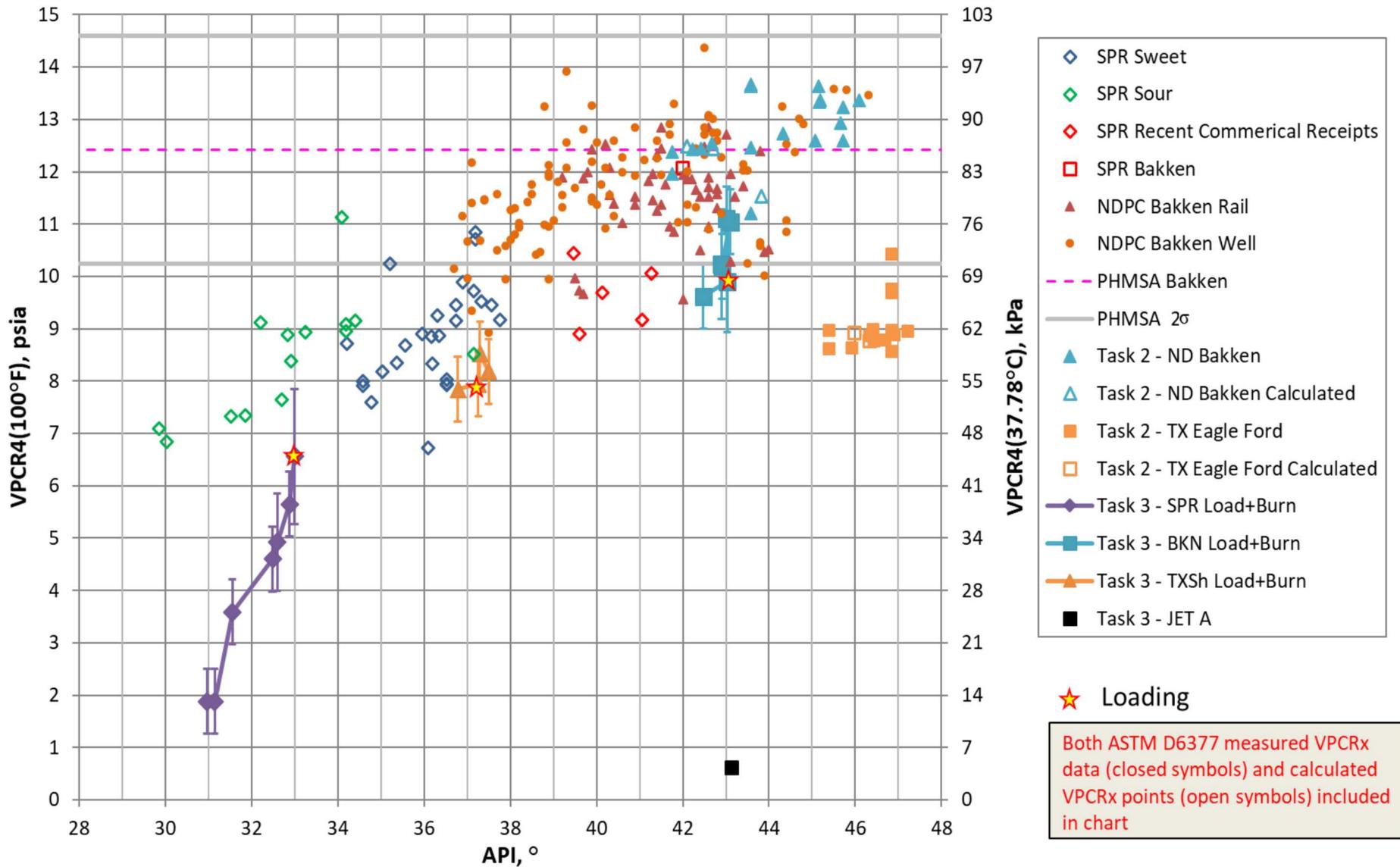
Placement of Burn Samples vs. Lower 48 API



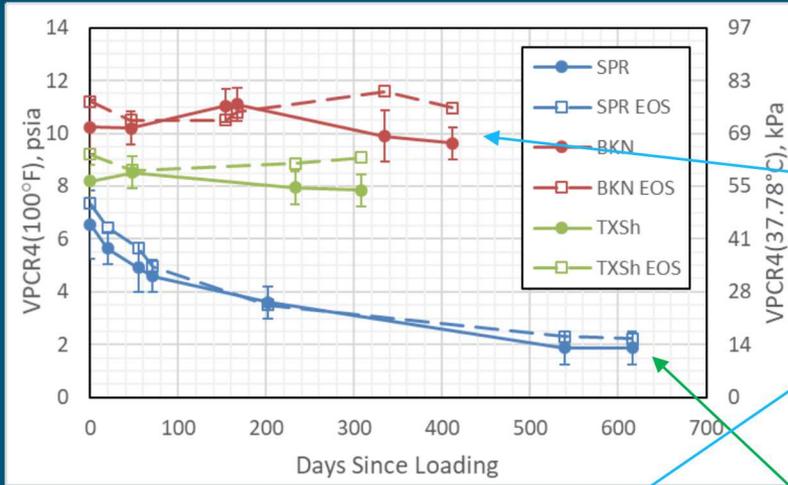
Oct 2016-Oct 2018

Source: U.S. Energy Information Administration

VPCR4 vs. API Gravity of Crude Oils and Test Fuels



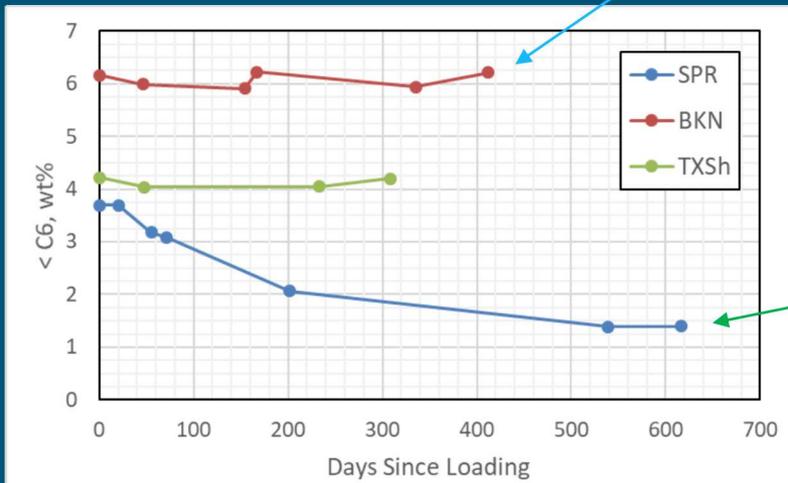
Properties with Time and Storage Type



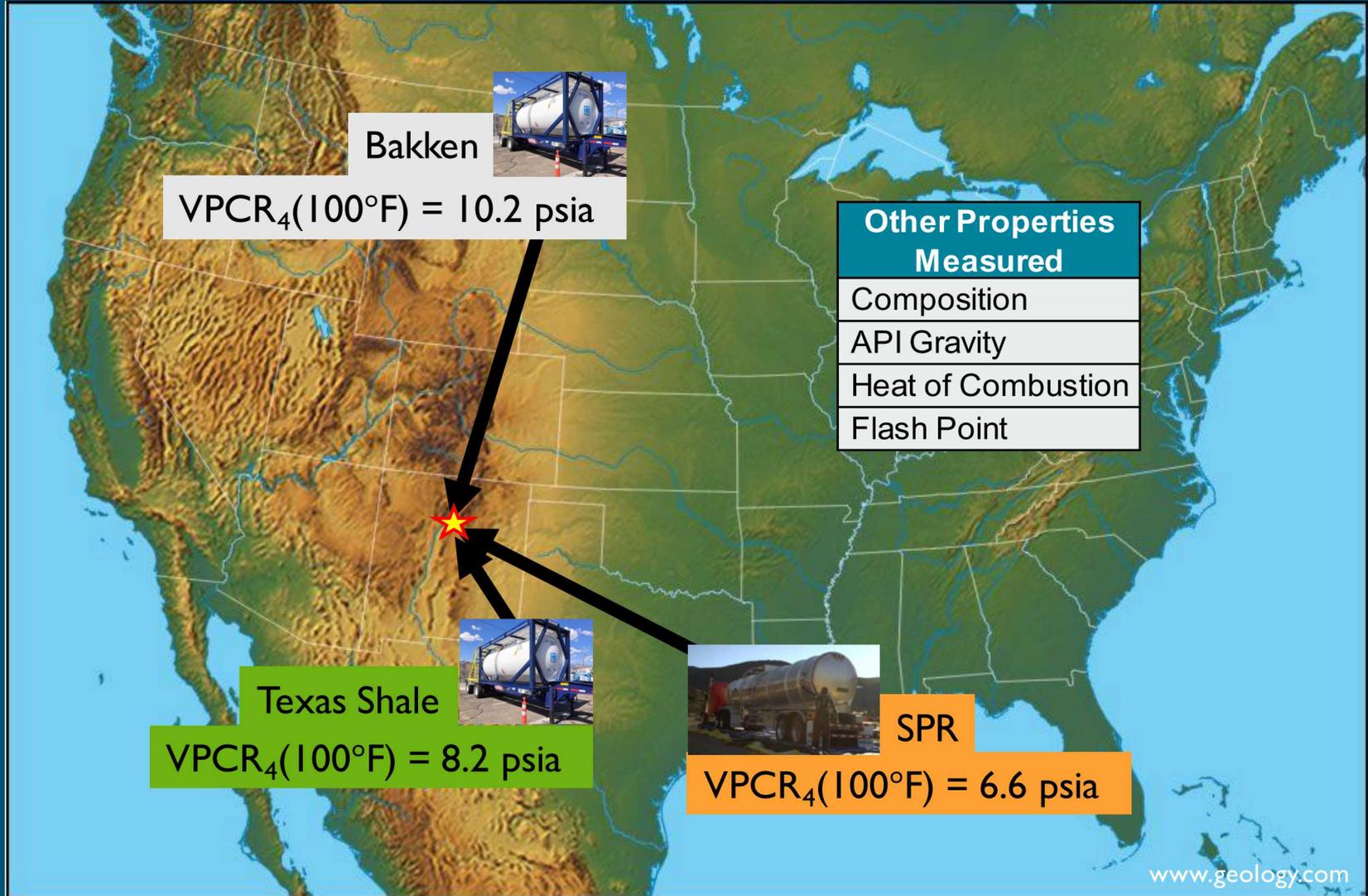
Pressurized Storage (BKN, TXSh)



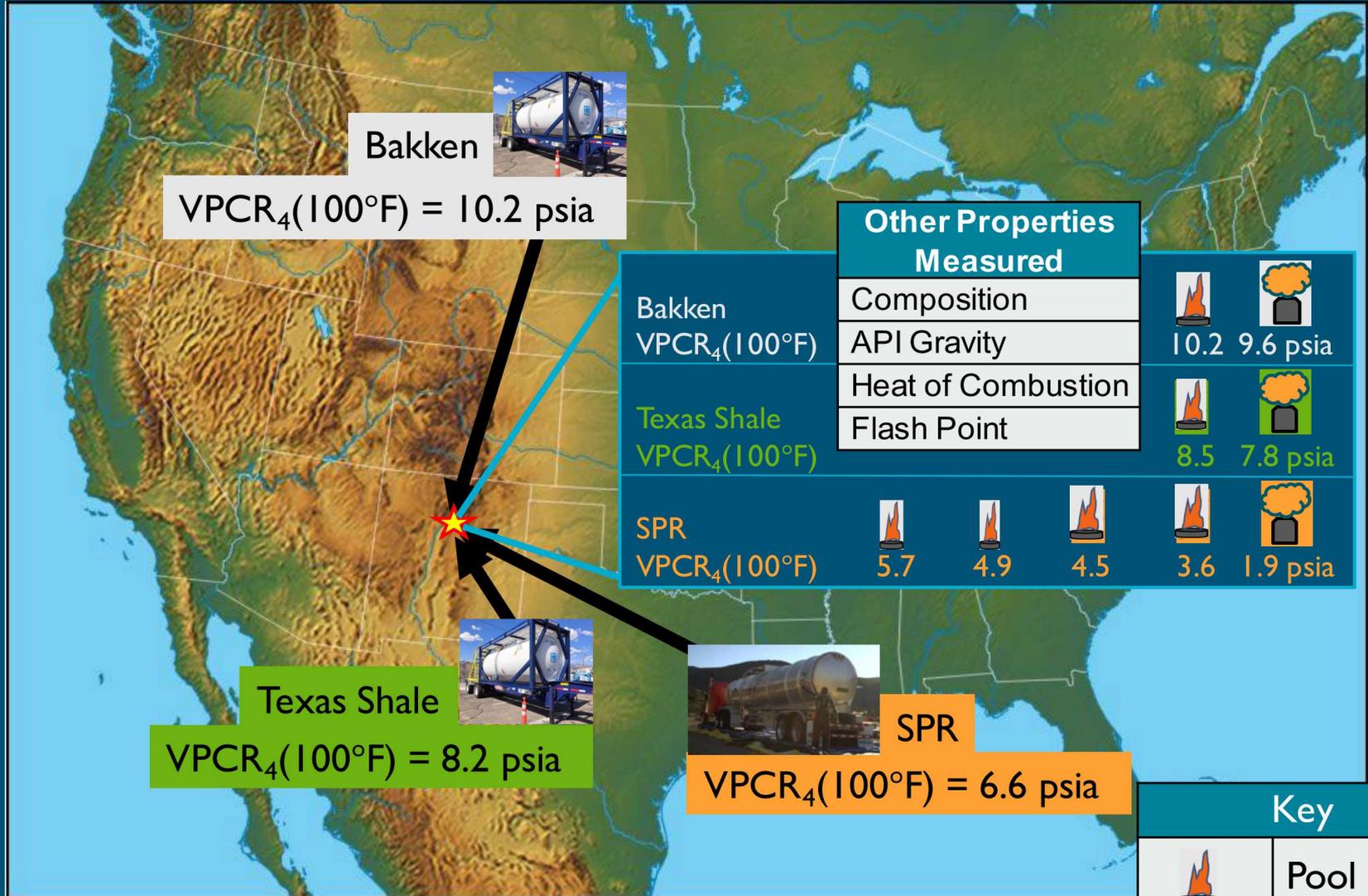
Unpressurized Storage (SPR)



Oil Sampling & Property Measurements



Oil Sampling & Property Measurements



Key	
	Pool Fire
	Fireball



End of Part I