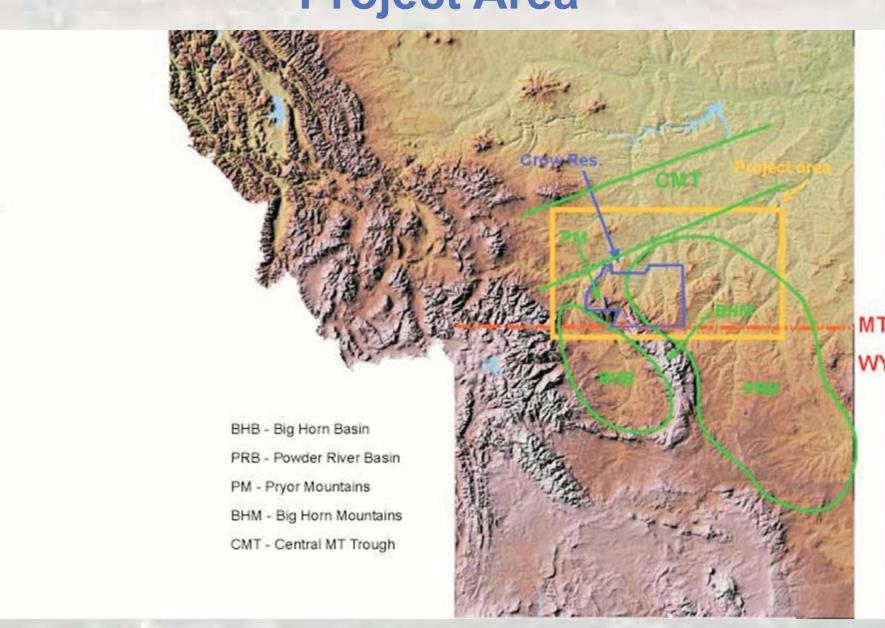
Reservoir Development in the Tensleep Sandstone, Pryor and Bighorn Mountains, South-Central MT

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Project Area



1 Funding and Acknowledgements

- > Funding from the National Energy Technology Laboratory, US Department of Energy.
- > Matching Funds from MT Bureau of Mines and Geology and Ballard Petroleum Holdings, LLC.
- > Cooperator: Crow Tribe granted access to tribal lands.

2 Introduction

The Permo-Pennsylvanian is the most prolific oilproducing system in the Northern Rockies Region. > Bighorn Basin (BHB) produced over 2 BBO.

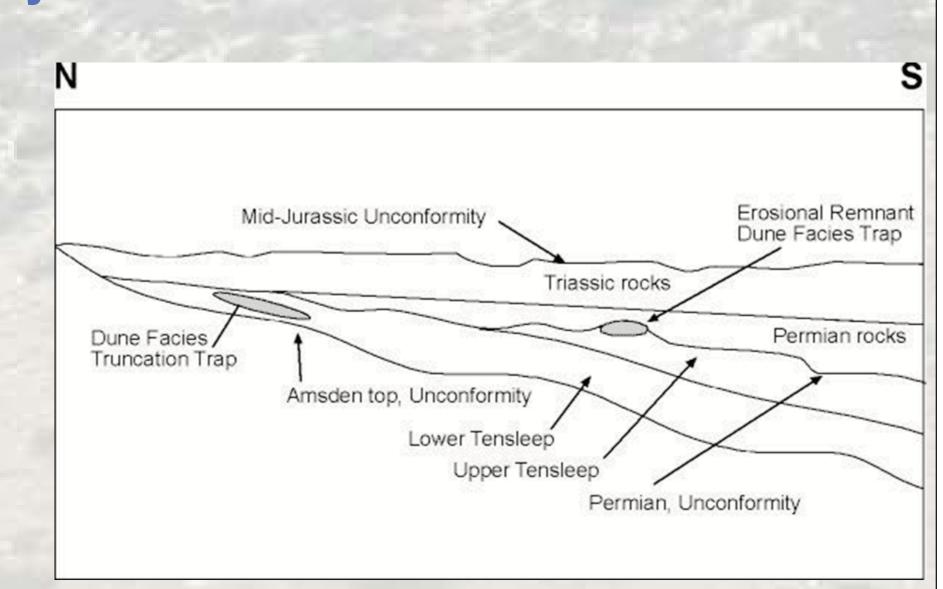
- > Powder River Basin (PRB) produced over 500 MMBO.
- > Production is stratigraphically controlled.
- > In the region most production is associated with structural highs, so exploration has focused on structural features.
- > Possibility of a major stratigraphic accumulation in south-central Montana has long been recognized, but exploration has focused on the zero-edge pinch-out.
- > Working Hypothesis: A primary regional stratigraphic trap occurs south of the zero-edge related to the truncation of reservoir facies within the depositional system and oil in the Tensleep in both the BHB and PRB represent one regional petroleum system.

3 Project Goals

- > Develop new exploration model for the Permo-Pennsylvanian system in south-central Montana.
- > Define an exploration fairway for the system.
- >Ultimately, add oil and gas reserves from new discoveries.

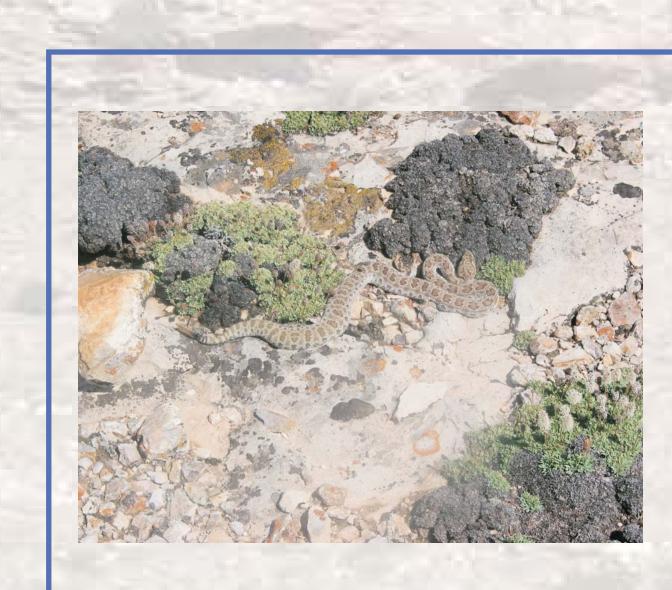
4 General Stratigraphy

- > Mississippian through Mid-Jurassic sequences represent continuous depositional across the region, but were separated by Laramide deformation into BHB and PRB.
- >Permo-Penn system is bounded by unconformities.



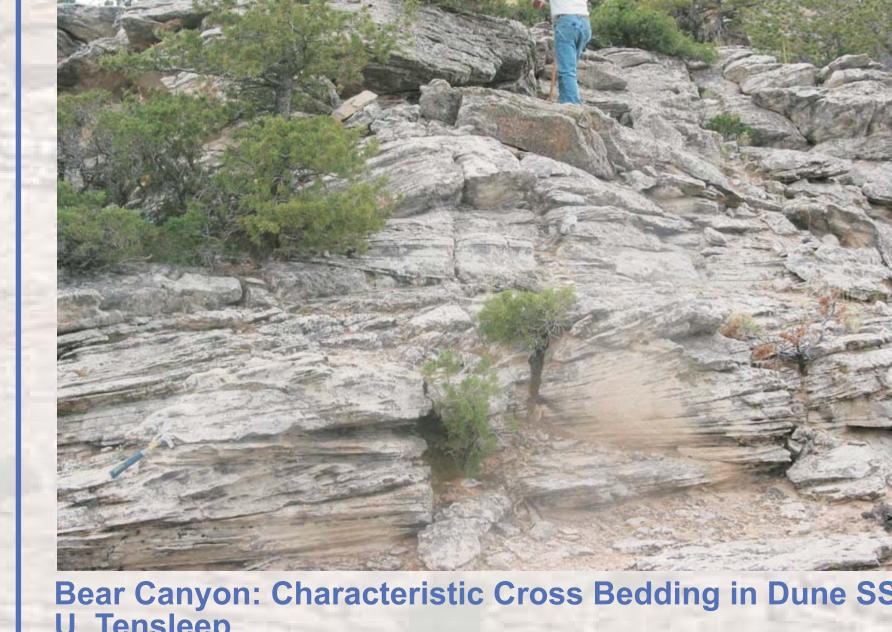
- > Permian Phosphoria in BHB correlates roughly with the Goose Egg Formation in the PRB.
- > Penn Tensleep Sandstone correlates, in general, with the Minnelusa Fm in PRB.
- > Reservoir facies in the Tensleep and the Minnelusa are mainly eolian sandstone.
- > The Permo-Penn system hydrocarbon source has been typed to organic-rich beds of the Phosphoria.

- Total Tensleep thickness varies greatly.
- In the West: Lower and Upper Tensleep
- In the East: only Lower Tensleep; rocks are similar but dune ss develops in this part of the section.



Summary of Field Relationships

- Measured sections show significant relief on unconformities bounding the Tensleep Sandstone.
- Sequences were deposited in near-shore marine, sabkha, and dune environments.
- Lower: cycles of marine ss, locally minor dune sandstone & probable sabkha

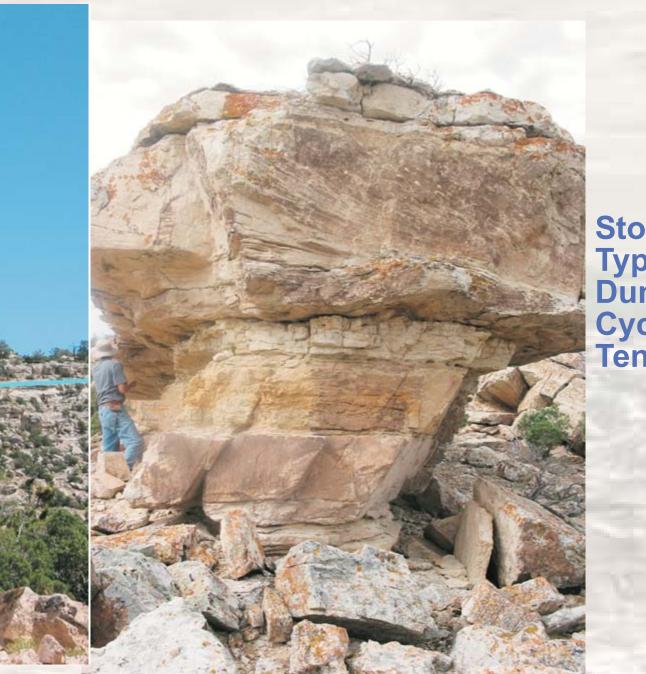


Bear Canyon: L and U Tensleep & Characteristic Facies

Upper Tensleep

Bear Canyon: Characteristic Cross Bedding in Dune SS,

Western Sequences



Stockman Trail



Burrowing of Upper Few Feet Flooding Surface

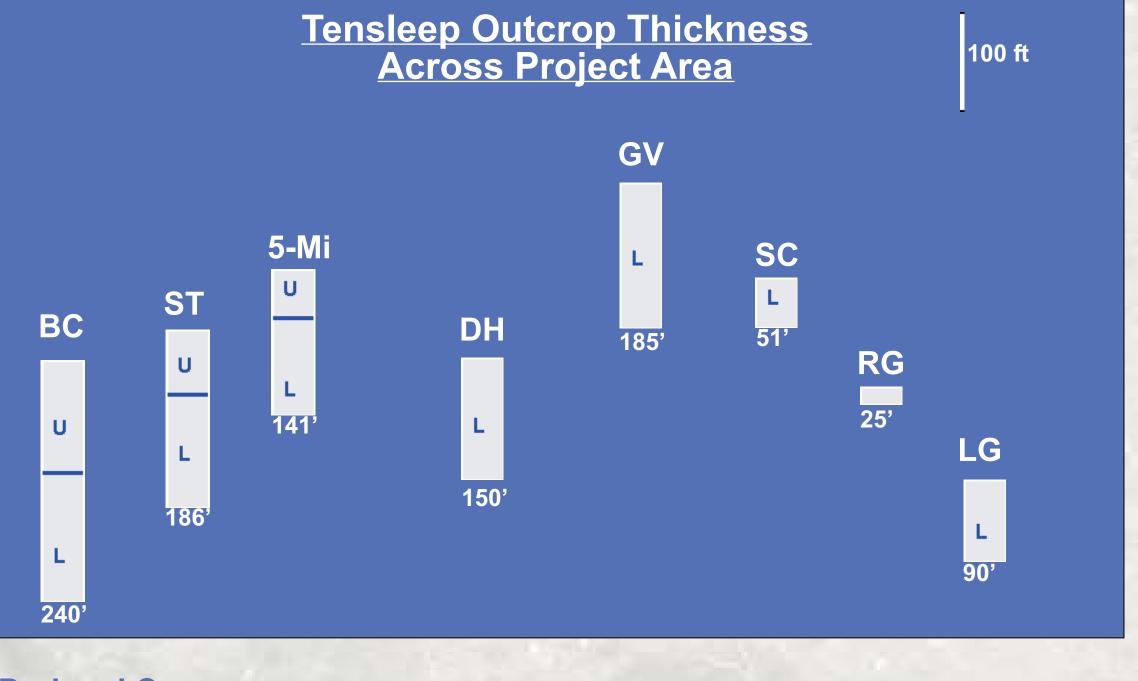


marks top of L. Tensleep

5 Field Investigations

- > Locations of measured sections are shown on the Index Map to the left.
- > Sections were measured at 8 localities. At Dry Head Canyon the Tensleep is exposed continuously for about 8 mi. Therefore 5 sections were measured at BC that locality.
- > The figure to the right illustrates the thickness variations as well as the distribution of the lower and upper Tensleep sections.

BC=Bear Canyon; ST=Stockman Trail; 5-Mi=5 Mile Cr; DH = Dryhead Canyon; GV= Grapevine Canyon; SC=Soap Cr; RG=Rotten Grass Cr; LG=Lodge Grass Cr



Stratigraphic Sequence above and below the Tensleep SS

Eastern Sequences Cycles of dune ss (white) and marine or sabkha dolomitic sandstone and dolomite (brown) in Dramatic Thinning of Tensleep West of Measured Section in Lodge Grass Cycles of dune ss (white) and marine or sabkha dolomitic sandstone and dolomite (brown) in **Dryhead Canyon**

Regional Petroleum System

- Working hypothesis: that oil was generated and migrated before development of Laramide structural features. Therefore, oil from fields in the region should be similar and regional stratigraphic traps probably exist.
- Oil samples were acquired from existing Tensleep producing fields to test our idea.
- The chemical results confirm our interpretation and indicate: "close agreement between all samples from both a thermal maturity history and a common organic source origin" (Geoffrey Bayliss, Geochem Labs Inc).

- 8 Conclusions
 Stratigraphy of the Tensleep is complicated by rapid facies changes and substantial relief on bounding unconformities.
- Reservoir facies are mainly eolian sandstones that pinch out within very short distances. Therefore, well spacing as small as 10 acres may be necessary to tap all potential reservoirs in a
- Organic chemistry of oils from Tensleep fields in the region document one common petroleum system from the same organic source.