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Integrated Analysis of the Bakken Petroleum System: U.S. Williston Basin

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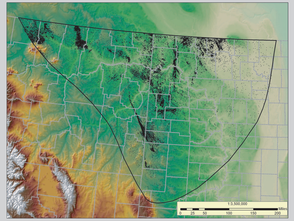
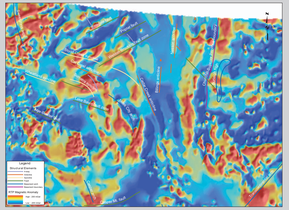
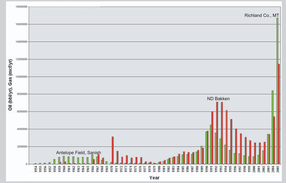


The U.S. portion of the Williston Basin contains more than 30,000 wells drilled since the early 1900's that produce from more than 20 intervals.



Major structural elements and crustal boundaries can be interpreted from reduced-to-pole (RTP) magnetic data.

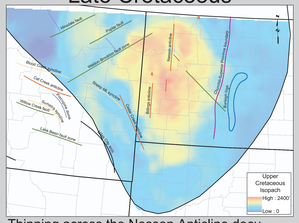


Annual production from the Bakken showing early exploration in the basal Sanish sand, Bakken shale exploration in the early 1990's, and the recent drilling in the middle Bakken in Richland County, Montana.

Data Sources:
- IHS Energy
- NDGS
- USGS
- Humble Geochem. Serv.

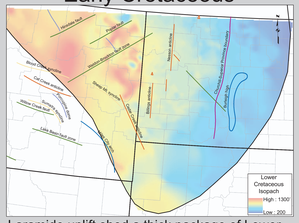
Technology:
- ESRI ArcGIS
- IES PetroMod3D
- Spotfire DecisionSite

Late Cretaceous



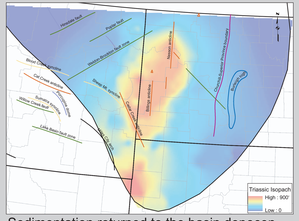
Thinning across the Nesson Anticline documents its inception during the latest Cretaceous.
Maximum depth of burial and temperature were also reached during the latest Cretaceous.

Early Cretaceous



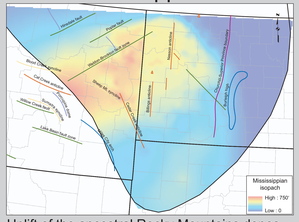
Laramide uplift shed a thick package of Lower Cretaceous clastics in to the western part of the basin.
Deposition was localized by reactivated basement faults in the northwest part of the basin.

Triassic



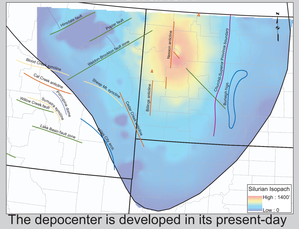
Sedimentation returned to the basin depocenter.
The thick in the southern portion of the area is related to deposition in the Powder River Basin to the southwest.

Mississippian



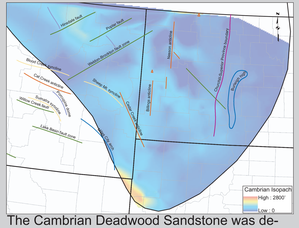
Uplift of the ancestral Rocky Mountains deposited a thick sequence of post-Bakken strata along the western margin and in the basin's depocenter.

Silurian



The depocenter is developed in its present-day location.
A carbonate platform developed along the basin's eastern edge, while sedimentation was minimal to the west.

Cambrian



The Cambrian Deadwood Sandstone was deposited unconformably above Precambrian basement.
Basement faults localized Cambrian sedimentation patterns.

The Bakken Formation straddles the Devonian-Mississippian boundary and is one of more than 20 oil and gas producing formations in the Basin. The Williston Basin chronostratigraphic column highlights stratigraphic units used to make the regional 22 depth structure and 19 isopach maps that form the foundation of our regional analysis, as well as the primary input in to the three-dimensional basin model.

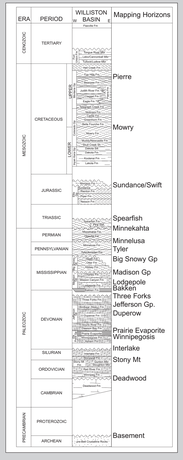
The Bakken Formation is informally subdivided in to a middle dolomitic or silty member, which is sandwiched between upper and lower organic-rich, black shales. The black shales have generated approximately 300 BBO. Drilling in the active trend in Richland County, Montana is focused on the uppermost lithologic unit in the middle Bakken, which is predominantly dolomite in Montana and becomes more siliciclastic in North Dakota.

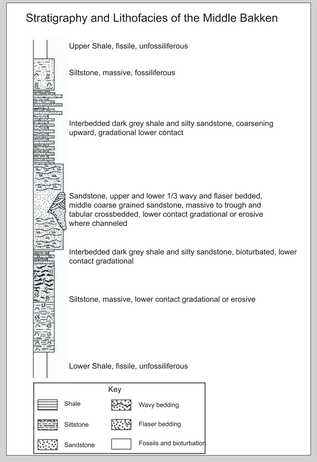
The Middle Bakken also contains a thick sand-rich unit that is present in North Dakota and Canada, but not Montana. This Sandstone unit presents an additional, largely untested target in the middle Bakken. It also provides the migration pathway for Bakken-sourced oils in to Saskatchewan.

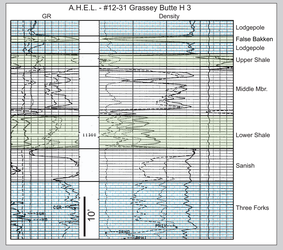
The Bakken Formation pinches out along the southwestern margin of the Basin. In the Richland County trend, the middle Bakken directly overlies low permeability Three Forks carbonates and is overlain by the upper shale, which serves as the top seal. This stratigraphic trap is highly effective and is a major control over the geographic extent which is termed the Siltstone Pinch-Out Play.

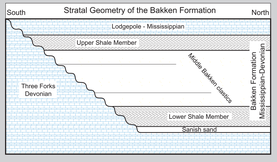
The fundamental controls of middle Bakken prospectivity are

1) Trapping Mechanism
   - the pinch-out forms a highly effective stratigraphic trap along the southwestern basin margin
   - the pinch-out also enhances oil accumulation, with oil saturation >90% measured in the reservoir
   - structural or combination structural/stratigraphic traps will be necessary for the middle Bakken to be prospective elsewhere
2) Maximum Temperature
   - maximum temperature was reached in the early Tertiary and has decreased since, "freezing" the petroleum system
   - maximum temperature greater than 100C is important for
     * oil generation and expulsion
     * natural fracture development
     * optimal reservoir quality development

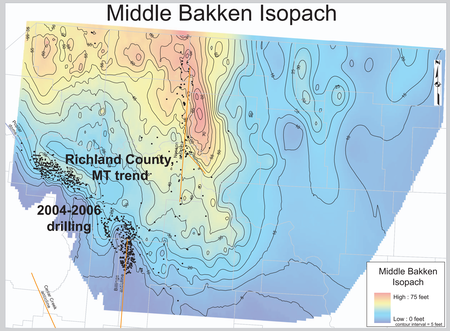






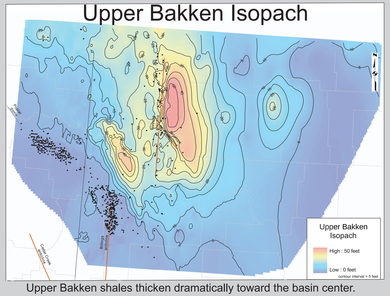


Middle Bakken Isopach



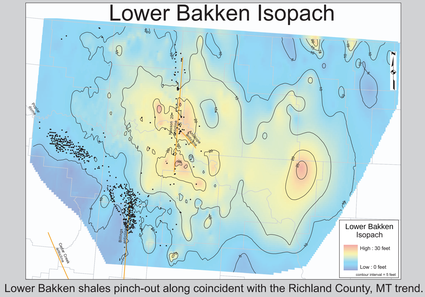
Middle Bakken dolomites thicken subtly in the current area of activity.
The sandy unit is well developed and thickens to the north.UUUUUU

Upper Bakken Isopach



Upper Bakken shales thicken dramatically toward the basin center.

Lower Bakken Isopach



Lower Bakken shales pinch-out along coincident with the Richland County, MT trend.