Stratigraphic Characterization of the Birds Nest Aquifer in the Uinta Basin, Utah: Implications for Saline Water Disposal from Natural Gas Production

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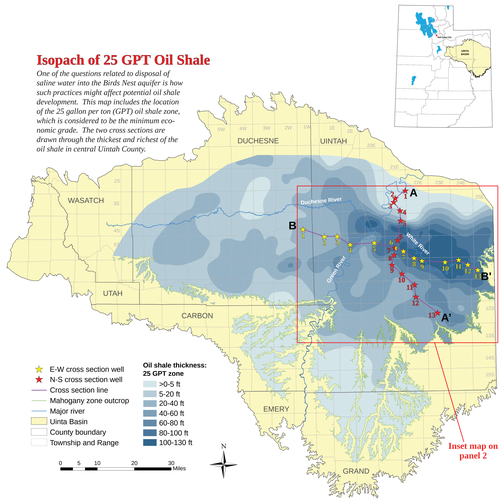
Project funded by: U.S. Department of Energy - National Energy Technology Laboratory and Utah Geological Survey

Project Web site: http://geology.utah.gov/emp/UBwater_study

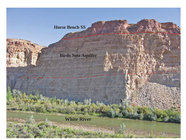
ABSTRACT

During deposition of the upper Green River Formation in the late Eocene, Utah's Lake Uinta transitioned from a balanced-filled basin dominated by organic-rich, laminated marlstone, to an underfilled restricted basin. During this time, the saline mineral nahcolite formed within the deep-lake sediments (depocenter in central Uintah County) as isolated crystals, nodules ranging up to one foot in diameter, and beds ranging from less than an inch to 2 feet thick. Post-deposition, the saline mineral shortite formed in fracture zones several feet thick. More recently, the Birds Nest aquifer developed from the dissolution of these saline minerals. This aquifer, ranging in thickness from <100 feet on the basin margins to >300 feet in the basin's depocenter, is targeted by natural gas operators as a potential saline water disposal zone. Understanding the aquifer's areal extent, thickness, water chemistry, and zones of differential dissolution will help determine possible saline water disposal volumes and safe disposal practices, both of which could directly impact the success of increased petroleum production in the region.

Preliminary research shows the Birds Nest's water chemistry in the north (averaging >10,000 ppm TDS and as high as 100,000 ppm TDS) is distinct from that in the south (averaging <10,000 ppm TDS and down to near 1000 ppm TDS). This abrupt change in water chemistry is most likely due to the differing amounts of saline mineral dissolution in the two areas; the southern area may have been flushed clean, whereas saline minerals in the northern area are still actively dissolving. The presence of intact nahcolite in the Utah State 1 core (section 26, T. 9 S., R. 21 E.) – displayed with this poster –demonstrates that there are still zones of no dissolution north of the 10,000 ppm TDS line. Just to the south of this well, the saline minerals in the Birds Nest show significant dissolution, as seen in the Utah State 13X-2 core (section 2, T. 10 S., R. 21 E.) – also displayed. Separating these two areas is a prominent gilsonite vein that cross-cuts the Birds Nest aquifer. Northwest-trending gilsonite veins seem to influence ground-water flow patterns in the Birds Nest by creating "channels" of dissolution and impermeable barriers to flow. In addition, research shows the Birds Nest aquifer in this area is divided into two or three stratigraphic zones of dissolution each roughly 40 feet thick; it is currently unclear if these zones are hydraulically connected or if the Birds Nest as a whole is vertically connected to other water-bearing zones both above and below. New insights into the structure of the Birds Nest aquifer will play an important role in future disposal practices, including how best to protect freshwater resources in the area.



Birds Nest aquifer in outcrop along Evacuation Creek, eastern Uinta Basin. The large cavities resulted from the dissolution of nahcolite nodules, creating the aquifer's porosity and permeability.



PROBLEM

The Birds Nest aquifer is poorly understood and needs further study to determine potential impacts of saline water disposal.

- What is its areal and stratigraphic extent?
- How is it related to Utah's oil shale deposits?
- What causes the differing zones of dissolution and salinity?

Eastern Uinta Basin natural gas producers have identified the Birds Nest aquifer, located in the Parachute Creek Member of the Green River Formation, as the most promising reservoir suitable for large-volume saline water disposal. This aquifer, ranging in thickness from less than 100 feet on the basin margins to greater than 300 feet in the basin's depocenter, formed from the dissolution of saline minerals which left behind large open cavities and fractured rock. Understanding the aquifer's areal extent, thickness, water chemistry, and zones of differential dissolution will help determine possible saline water disposal volumes and safe disposal practices, both of which could directly impact the success of increased hydrocarbon production in the region.

The Birds Nest aquifer is typically several hundred feet above the richest oil shale interval called the Mahogany zone. A significant concern is that saline water disposal into the Birds Nest by conventional gas producers could hinder oil shale development by creating unforeseen water disposal problems.

RESEARCH / DELIVERABLES

- Conduct comprehensive literature review and historic data collection.
- Evaluate the Birds Nest aquifer in core:
  - 20 wells have been identified as having all or part of the Birds Nest captured in core.
  - 10 cores have been examined to date (see map on panel 2).
- Evaluate the Birds Nest aquifer on outcrop:
  - Good outcrop exposures can be found on the eastern side of the basin.
- Evaluate the Birds Nest aquifer on geophysical log.
- Determine how disposal into the Birds Nest aquifer could affect future oil shale development.
- Evaluate the oil shale resource within the Birds Nest interval.
- Determine how gilsonite veins might influence water flow and saline mineral dissolution.
- Create a GIS database and maps showing:
  - Outcrop,
  - Thickness,
  - Lateral extent,
  - Water quality, and
  - Interburden between Birds Nest and "economic" oil shale zones.

PRELIMINARY CONCLUSIONS

- The southern portion of the Birds Nest aquifer contains much smaller saline mineral crystals (<1 inch) as compared to the large (up to 1 foot) nodules found near the basin's depocenter.
  - This transition occurs at about Township 10 South.
- Gilsonite veins seem to influence ground-water flow in the Birds Nest aquifer, in some cases creating barriers to flow.
  - A gilsonite vein runs between the two nearby cores displayed with this poster.
  - The core to the south (Utah State 13X-2) shows significant saline mineral dissolution, whereas the core to the north (Utah State 1) shows no saline mineral dissolution.
- Gilsonite took advantage of a pre-existing northwest-trending joint/fracture system; some joints/fractures may not be filled with gilsonite and could provide pathways for vertical water movement.
- There is potential for vertical water movement along the gilsonite rock interface.
  - Often the gilsonite nearest the host rock displays highly pencilated fractures.
- Saline water disposal into the Birds Nest aquifer should be accompanied by down-dip water monitoring in aquifers both above and below the disposal unit.
- The northern and western extent of the Birds Nest aquifer is poorly understood due to lack of core from those areas.