Characterization of Deep Groundwater: A Conference Report

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GROUNDWATER RESEARCH & EDUCATION FOUNDATION

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Topical Discussions

- Analysis of data and information to characterize hydrogeologic settings, water quality and flow in deep GW systems
- Adaptation and development of tools and methods for collecting samples and in-situ hydrologic data for deep GW systems

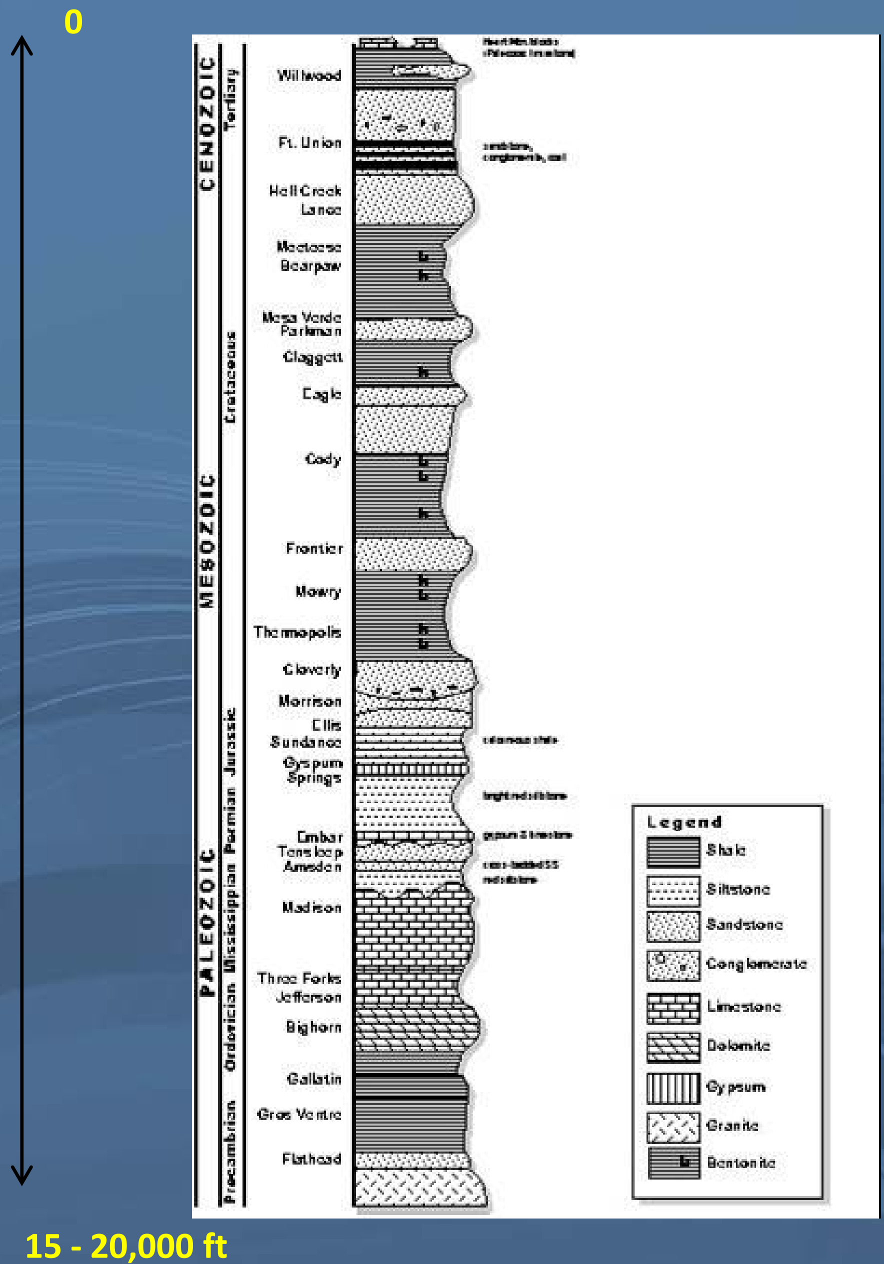
How Deep is Deep?

- PA/NY: 1400 – 1700 ft (Marcellus > 6000 ft)
- Deep Carbonate Aquifer: 1000 – 4000 ft (Water supply)

Heilweil and Brooks (2011)

How Deep is Deep?

- NM: Deep Nonpotable Aquifer: Top of aquifer >2500 feet; TDS>1000 ppm
- Saline groundwater for shale oil development
  - Texas (<3000 ppm, >500 gpm) 1400-5000 feet
  - Alberta
    - Non-saline water (<4000 ppm) pervasive at depth
    - Deep saline formations relatively tight
- Arbuckle Group saline aquifer: >5000 feet (CO_2 storage)
- Deep well injection, Tampa, FL: 8000 feet (Deepest in FL, identified deeper permeable zone than previously known)



- Sedimentary basins in western US commonly have thick carbonate and sandstone formations at depth (1000s of ft) which function as aquifers and aquifer systems. These aquifers extend over very large areas (1000s of mi^2).

- Current research indicates significant permeability at depth -locally

- Hydrogeology of deep GW is poorly understood due to:
  - Limited use
  - High cost to characterize & develop

Sedimentary Basins

How Deep is Deep?

- Borehole disposal for high-level nuclear waste > 6 km (20,000 ft)
- Permeability vs depth: down to 30 km (100,000 ft) Research indicates significant permeability at depth—locally

Key Issue: Disposal of Industrial Waste Fluids

- Increasing with increased oil /gas production, in-situ uranium mining
  - Objective is to store / isolate fluids in deep formations
  - Formations with sufficient permeability to receive waste fluids commonly contain low TDS groundwater and function as aquifers – sandstones and carbonates
  - Limited knowledge about transport and fate of contaminant mass load
  - Can cause hydraulically-induced seismic events

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Key Issue - Manage for Future Water Supply

- Particularly in the semi-arid west, deep groundwater resources may become a future source of water supply
- Future use more dependent on yield than water quality
- Treatment (desalination)
  - Past 40 years - membrane treatment technology has advanced; costs have significantly reduced; dramatic increase in worldwide use
- Sustainability – deep aquifers may be important future source for augmentation during critical periods such as droughts

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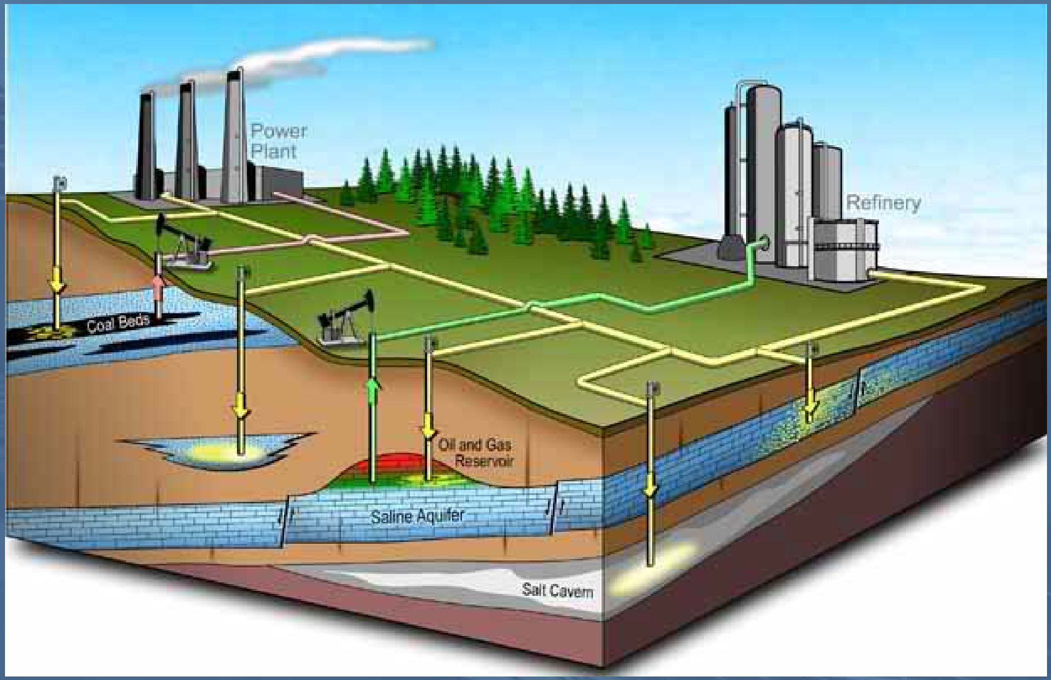
Additional Key Issues

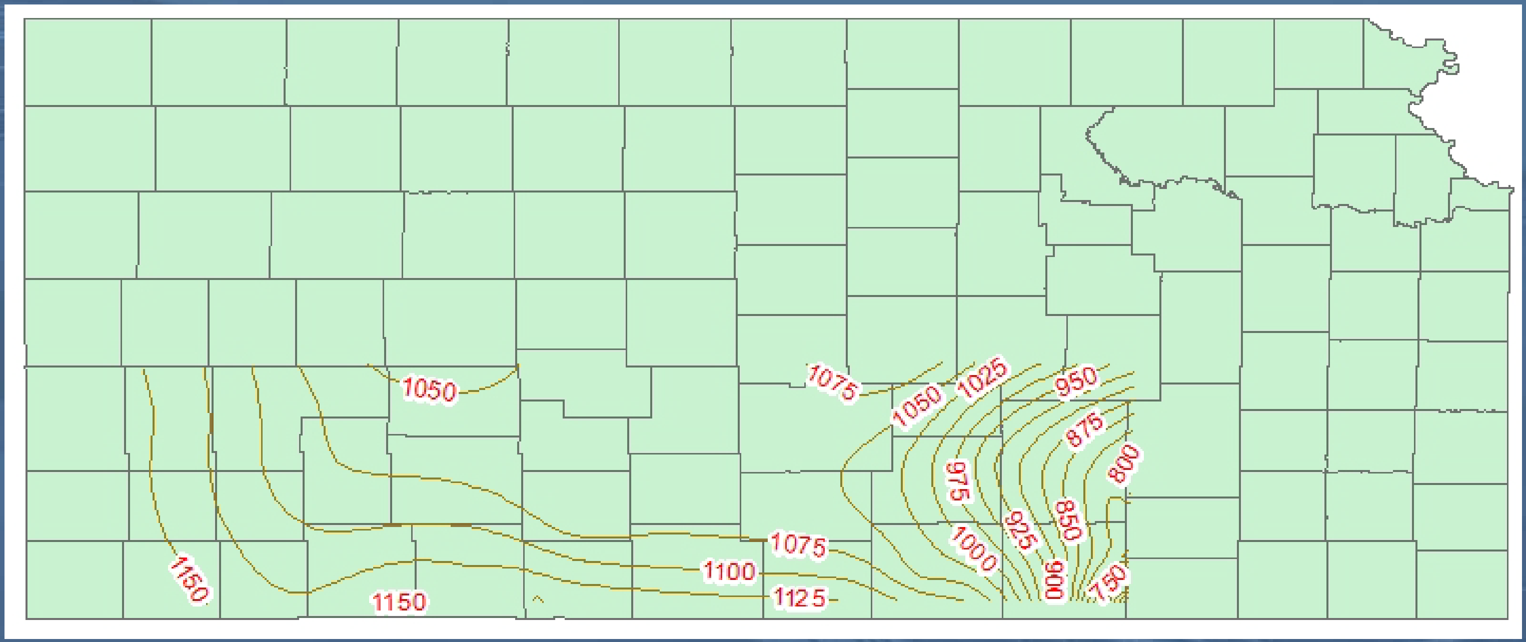
- Carbon sequestration
- Nuclear waste disposal
- Geothermal energy



Using Drill Stem Test Data to Construct Regional Scale Potentiometric Surface in Deep Aquifers

Tiraz Birdie (Tbirdie Consulting, Inc) et al.

- Needed for CCS study
- Requires careful filtering and processing of the raw data (account for salinity at depth; sufficient duration of final shut-in pressure)



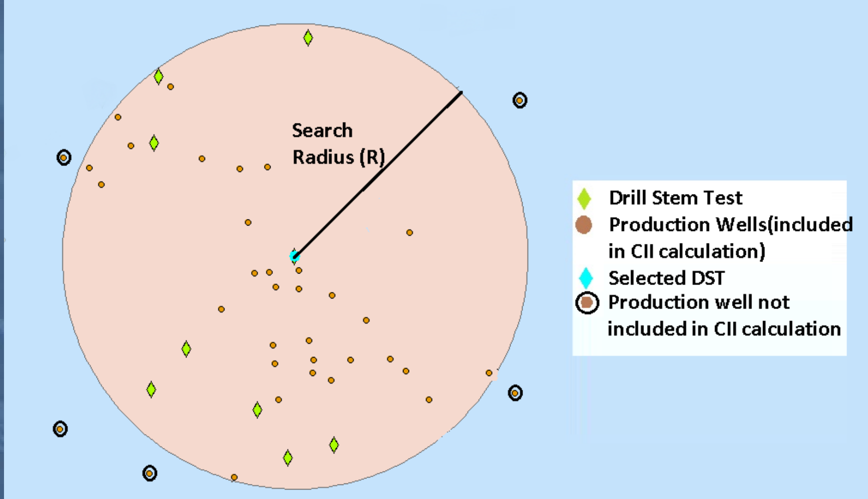
Potentiometric surface constructed using average EFWH value per county

Methodology for Characterizing Deep Groundwater Resources using Studies from the Alberta and Williston Basins

Dan Palombi and Amandeep Singh
Alberta Geological Survey

- *Interference index: log (t/r^2)* where *"t" is the length of time since production and r is distance (radial proximity) between production well and the well where DST pressure was measured*
- The CII index = cumulative sum of inference indices

Also presented Water Driving Force (WDF) to account for density-dependent flow



An Overview of Geophysical Methods to Characterize Deep Aquifers

John Jansen (Leggette, Brashears and Graham)

- Deep groundwater—a natural target for geophysics
- Time Domain Electromagnetic Induction (typical exploration range 100 to 1,500 feet)
- MagnetoTellurics (typical exploration range 500 to 3,000 feet)
- Seismic Reflection (typical exploration depth 100 to 30,000 feet)
- Gravity Surveys (unlimited exploration depths)

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Deep Injection in the Western Canada Sedimentary Basin

Grant Ferguson (University of Saskatchewan)

- 23 km^3 (18.6 million AF) of wastewater has been injected into the Western Canada Sedimentary Basin over the past few decades.
- The amount of water injected is 2 to 3 orders magnitude greater than natural recharge to deep formations in the WCSB.
- There have been few documented cases of environmental problems related to injection wells but monitoring efforts are insufficient to make definitive statements.

See Issue Paper in journal *Ground Water* (Early View)

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Reassessment of the Nation's Saline Groundwater Resources

Jennifer Stanton et al. (USGS)

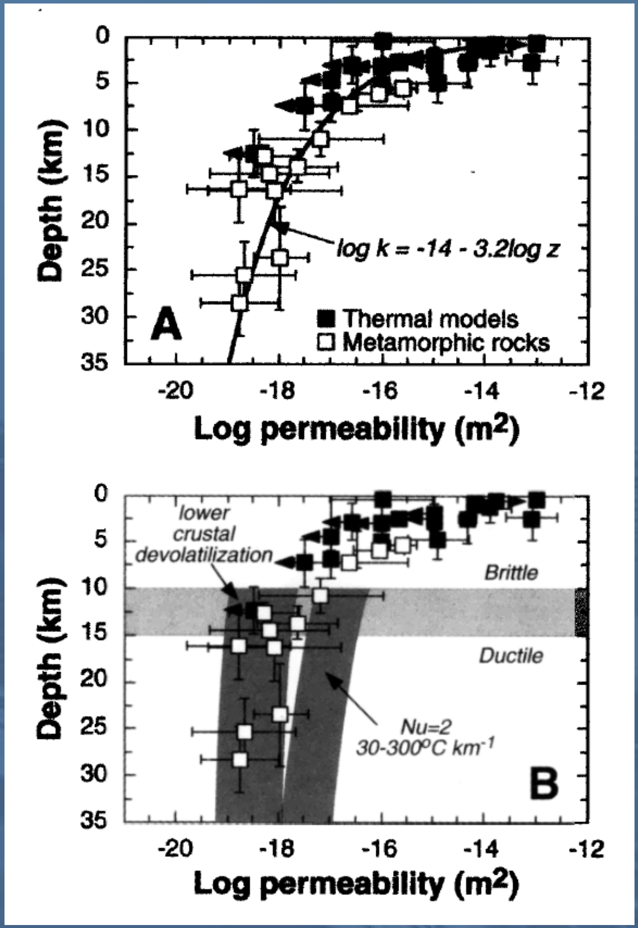
- Brackish aquifers to be studied:
  - Aquifers that have groundwater within 3,000 ft of land surface;
  - Contain dissolved-solids concentrations between 1,000 and 10,000 mg/L; and
  - Can yield usable quantities of water

- Major Study components:
  - Compile readily available information
  - Generate national maps of total dissolved-solids (TDS) concentrations
  - Describe chemical and physical characteristics of brackish aquifers
  - Describe current brackish groundwater use
  - Identify data gaps

http://ne.water.usgs.gov/ogw/brackishgw

Permeability versus depth in Earth's upper crust: An overview

Andrew Manning (U.S. Geological Survey)



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Deep regional groundwater flow in the Northern Great Plains

K. Udo Weyer (WDA Consultants, Calgary)

- Discussed deep regional groundwater flow in the northern Great Plains
- Integral role that aquitards play as part of deep groundwater flow systems
- Challenges existence of postulated long-range (>1000 km) flow systems
- Concepts are important in considering the long-term fate and residence time of carbon sequestration, as well as wastewater disposal at the Athabasca oil sands.

Exploring Deep Groundwater Resources Using the Reverse Circulation (RC) Drilling Method

Steve Schneider (Schneider Water Services)

- Not just for large diameter wells in unconsolidated formations
- Useful for deep (limit >5000 ft?) wells
- Advantages include:
  - Economical
  - Adaptable
  - Can provide aquifer measurements during drilling
  - Cleaner boreholes

Sampling for Multi-Phase Characterization of Deep, Gas-Rich Groundwater Systems

Kevin Krogstad (Golder Associates)

- Gas a complicating and important factor in sampling deep groundwater
- Chemistry may change as gases come out of solution
- Aquifer parameters may be impacted while pumping
- Dissolved gases may be toxic or explosive
- Procedures exist which allow a sample to be collected and maintained at reservoir pressures and isolated from the atmosphere until analyzed

Future Topics

- Naturally occurring tracers and age dating
- Connection of shallow and deep aquifers
- Water rights issues for states
- Characterization of deep confining units and permeability
- Discharges from deep groundwater
- Development of deep water supplies vs. waste disposal
- Mapping salinity
- Historical changes to flow systems from waste injection
- Unintended movement of freshwaters from brackish water removal
- Development strategies for deep aquifers
- Monitoring strategies
- Acquisition of data during well injection permitting that is more usable in assessing aquifer characteristics

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