WHAT WE KNOW, WHAT WE DON'T KNOW AND WHAT WE NEED TO KNOW ABOUT "DEEP"GROUNDWATER

Mike Wireman
National Groundwater Expert
US EPA – Denver, CO

GWPC Annual Forum
St Louis, MO
September 2013

My remarks are presented as a scientist and are not intended to represent official EPA policy or program decisions

Topics of discussion

- **Introduction**
  - What is “deep” groundwater
  - What are the issues
- **Focus on Sedimentary Basins**
- **Issues**
  - Disposal of waste fluids
  - Management for future water supply
- **Research**
  - Considerations
  - Current efforts
  - Future
- Summary

What is meant by "deep" groundwater?

- **GW beneath the typical depths of today's withdrawals for water supply**
  - **Private water supply wells -10s to 100s ft**
  - **PWS -100s to 1000s of feet**

- **Depends on hydrogeologic setting**
  - **Sedimentary basins - > 15,000 ft**
  - **Columbia volcanics – up to 3000 ft**
  - **Coastal /basin fill sediments – 5000 -10,000 ft**
  - **Glacial deposits – 2000-3000 ft.**

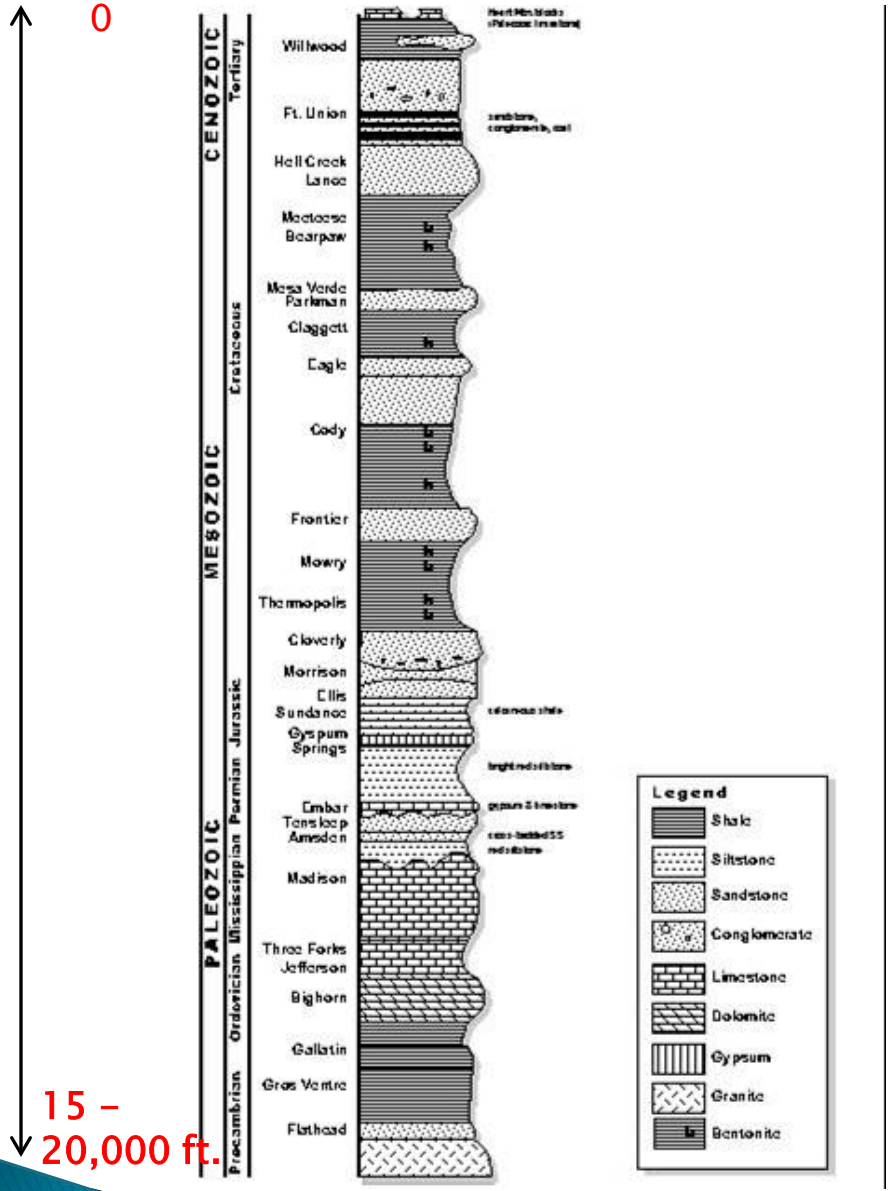
- **Changed over time from "deep stagnant water" to more dynamic understanding - defined not by depth alone, also genesis, age and chemistry (Hebrig, et.al, 2012)**

Why is increased understanding of hydrogeology of "deep" groundwater important?

- ***Disposal Of Industrial Waste Fluids***
- ***Water Supply – (Municipal, Agricultural, Industrial)***
- ***Carbon Sequestration***
- ***Geologic Repositories For Nuclear Waste***
- ***Geothermal Energy***
- ***Development Of Deep Shale Gas***

Focus on Sedimentary Basins

- Basins contain oil /gas, coal, mineral and freshwater resources
- How to manage development of combined resources
- Minimize /mitigate environmental impacts



- Sedimentary basins in Western USA 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).
- Significant meteoric (fresh) water at depth
- Current research indicates significant permeability at depth
- Oil & Gas deposits in shallow & deep formations – gas occurs in deeper shale formations
- Hydrogeology of deep GW is poorly understood due to:
  - Limited use
  - High cost to characterize & develop

Important 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 often contain low TDS groundwater and function as aquifers – sandstones and carbonates
  - Very little known re: transport / fate of contaminant mass load
  - Can cause hydraulically induced seismic events

- Over the past several decades 2.3×10^{10} m^3 (18.6 million AF) of waste water has been injected into the Western Canada Sedimentary Basin (Ferguson, in press)
  - Exceeds the amount of co-produced water –represents a large component of water budget for deep aquifers in basin
  - Represents recharge- effects flow system and water chemistry

Important Issue - Manage for Future Water Supply

- In semi-arid west deep gw resources may become a realistic future source of water supply for industrial, agricultural, municipal use - must look at on regional scale
- Future use more dependant on yield than water quality
- Treatment (desalination)
  - Past 40 years - membrane treatment technology has advanced; costs have significantly reduced; dramatic increase in worldwide use (NAS)
  - 2000 -2005 US desalination capacity grew by 40% (NAS) –TX has 44 municipal desalination facilities
- Sustainability – deep aquifers may be storage dominated – not recharge dominated – can be augmentation / drought protection

Research – hydrogeology of deep aquifers

> a different hydrogeologic model

> need to evolve conceptual models

NEED TO CONSIDER

- Variable density of gw at depth can significantly effect rates and directions of flow
- Large spatial variation in permeability / porosity
  - Fracture zones, clusters
  - Geologic (tectonic structures)
- Requires use of pressure data –not hydraulic conductivity data
- Focused recharge
- Non-equilibrium flow at regional scale
- Flow system scale(s) poorly understood
- Transient at long time frames

What types of data are necessary

- For water supply potential
  - Pressure head data
  - Permeability data
  - Recharge
  - Hydrochemical
  - Isotopic
- Contaminant transport
  - Geochemistry
  - Fluid density and viscosity
  - Mineralogy of geologic media

Current Research

NORTH GERMAN PLAIN

- Tertiary & Quaternary glacial sediments overlying Paleozoic & Mesozoic sedimentary formations – up to 10 Km thick
- Thick sandstones w/ high effective porosity & K, found down to 9700 feet
- Samples from 4000 to 10,500 ft depth – results suggest same origin for all samples – strong meteoric component with some seawater (Naumann ,2000)

SELLAFIELD –NW England

- Coastal basin filled w/ Permo-Triassic sedimentary rocks underlain by Ordivician meta-volcanic rocks
- 20 deep boreholes – up to 6300 ft deep
- 3 GW "Regimes"
  1) Freshwater regime – recharged by modern precip – topographically driven
  2) Mixed freshwater /saline water regime – multiple sources of water – topographically driven & at depth driven by density differences
  3) Basin derived brines regime driven by basin scale processes
- All regimes dominated by meteoric recharge –but with varying ages

Research Needs- Improved Field methods for accurately characterizing deep ground water flow

Single borehole tests –not multiple well tests

- Currently data collected from deep production /injection boreholes /wells is often limited to geophysical logging and core samples.
  - Wells are most often clustered.

- Need to develop hydraulic testing strategy designed to obtain data that is useful for characterizing ground water occurrence and flow
  - Strategy should aim to minimize interference between drilling and data collection – proper sequencing
  - Pore pressure, T, fluid chemistry, local permeability, porosity, storativity

Research Needs- Improved Field methods for accurately characterizing deep ground water flow

Single borehole tests –not multiple well tests

- Need to consider borehole effects –
  - develop down-holes logging methods that can differentiate between original in-situ conditions and borehole damage effects
- Tracer tests- useful for characterizing flow and transport
  - Single well injection withdrawal tests
  - Smart tracers
- Hydrochemical and isotopic data helpful for characterizing flow systems –sources, pathways, flow rates

Research

- **What is happening in near future**
  - ✓2012 – Workshop on Deep Hydrogeology – Uppsala University, Sweden
  - ✓May 2014 – One Day conference planned for Denver – NGWA
  - ✓GSA 2014 –IAH may sponsor a Workshop on Deep Groundwater

Summary

- It is clear that there are significant, potentially usable groundwater resources at depth
- Deep GW under represented in hydrological research
- Not enough is known about transport and fate of contaminants in industrial waste fluids
- Need to improve hydrogeologic data collection from injection /production wells
- Need a coordinated research effort.

THANK YOU

Mike Wireman
National Groundwater Expert
US EPA Region 8
Denver, CO
303-312-6719
wireman.mike@epa.gov