NURE Legacy Groundwater Data: Evaluation of Basin-Scale Factors Influencing Shallow Brine and Halite Groundwater Impacts

Presented by:

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Presentation Outline

Background
- What is the NURE dataset and why is it useful?
- Halite Deposits…What can they tell us?
- Theories for broad-scale fluid migration in the Appalachian Basin.

NURE Data Geospatial and Statistical Evaluation
- Distinguishing Cl sources using Cl/Br ratios.
- Incremental Spatial Autocorrelation
- Geospatial Exploratory Analyses
- Basin-scale Cl signature correlations

Significance
National Uranium Resource Evaluation (NURE)
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Principal Halite Deposits (Pierce & Rich, 1962)
Seawater Evaporation

Plots of log Cl versus log Br and log MCl₂ (see text for definition) for samples of Dresel (1985) and Poth (1962). Lines are plots of these components for seawater evaporation and for dilution of composition A with freshwater and seawater. The red numbers on these curves are percent of A, which has the following composition: Cl = 177,830 mg/L, Br = 1,700, Na = 78,500, Ca = 31,600, Mg = 3,390, and K = 320; MCl₂ = 1,800 meq/L. A. Plot of log Cl versus log Br. The point labeled "halite dissolution" is the Br:Cl ratio resulting from post-depositional dissolution of halite in low-salinity water. B. Similar plot for log Cl versus log MCl₂.
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Basin Fluid-Flow Mechanisms – Sediment Compaction Drive
Fig. 3. Conceptual model of gravity-driven fluid flow in sedimentary basins. The driving mechanism for flow is the sloping water table which is assumed to be a subdued replica of the topography. The water-table configuration and the subsurface permeability distribution control the geometry of the flow system.

Garven & Freeze, 1984
Figure 16. Regional cross section based on A–A’ in Figure 1B and Evans (1989), showing hypothetical topography immediately after emplacement of Blue Ridge thrust sheet. Wavy lines with arrowhead are used to depict relative flow of synorogenic migrating fluids and interformational mixing.
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Significance
Distinguishing Cl Sources Using Cl/Br Ratios

Cross-plot of Cl/Br mass ratio vs. Cl\textsuperscript{-} for NURE data and conservative end-member mixing curves. Dilute groundwater end-member: Cl\textsuperscript{-}: 0.33, Br\textsuperscript{-}: 0.015, (Mullaney et al. 2009). Halite upper mixing curve end-member: Cl\textsuperscript{-}: 20,000, Br\textsuperscript{-}: 1.482, (Panno et al. 2006, Mullaney et al. 2009). Halite lower mixing curve end-member: Cl\textsuperscript{-}: 20,000, Br\textsuperscript{-}: 4, (Granato 1996, Mullaney et al. 2009). Brine upper mixing curve end-member: Cl\textsuperscript{-}: 196,389, Br\textsuperscript{-}: 640, (Kelley et al. 1973). Brine lower mixing curve end-member: Cl\textsuperscript{-}: 190,808, Br\textsuperscript{-}: 2,760, (Kelley et al. 1973). All units in ppm. Appalachia Basin brine samples from Poth 1962, Kelley et al. 1973, Dresel 1985 and Osborn and McIntosh 2010. Marcellus Shale flowback water samples from Hayes 2009, PADEP 2010 and PADEP 2011.
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Incremental spatial autocorrelation for ABB (solid line) and high-ratio Cl⁻/Br⁻ (dashed line) signatures. Statistically significant (99% confidence level) Z-score peaks at 100 km.
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Cross-section of Upper Devonian through Upper Cambrian strata in south-central New York. Map view illustrated in Figure 3. UD: Upper Devonian, undivided; Dt: Tully Limestone; Dh: Hamilton Group; Dhmr: Marcellus Shale; Don: Onondaga Limestone; LD: Lower Devonian, undivided; Ss: Salina Group; Sl: Lockport Dolomite; Scl: Clinton Group; Sm: Medina Group; UO: Upper Ordovician, undivided; Ot-Obr: Trenton-Black River Limestone; Obk: Beekmantown Group; UC: Upper Cambrian, undivided. Dashed line indicates aggregate thickness of bedded halite throughout the Salina as measured from the Lower Devonian contact (Pierce & Rich 1962). Vertical lines indicate oil and gas well log control.
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Significance
Cross-plots for
(A) ABB signature Cl⁻ [ ] vs. fault distance,
(B) high-ratio Cl⁻/Br⁻ signature Cl⁻ [ ] vs. fault distance and
(C) high-ratio Cl⁻/Br⁻ signature Cl⁻ [ ] vs. Silurian outcrop distance.

Statistical Correlations
(Spearman rho)

ABB: Cl⁻ [ ] & fault dist
Spearman rho = -0.143
P-value: <0.001

High-Ratio: Cl⁻ [ ] vs fault dist
Spearman rho = 0.002
P-value: 0.906

High-Ratio: Cl⁻ [ ] vs Silurian
Spearman rho = -0.030
P-value: 0.031
Significance

• Powerful baseline tool for identifying areas likely or unlikely to be impacted by ABB-related compounds.

• Better understanding of basin hydrodynamics.

• Geochemistry as another line of evidence for identifying structure?
Thank you.....Questions?