WATER CHEMISTRY ASSOCIATED WITH THE MARCELLUS SHALE

NDSU Geochemistry

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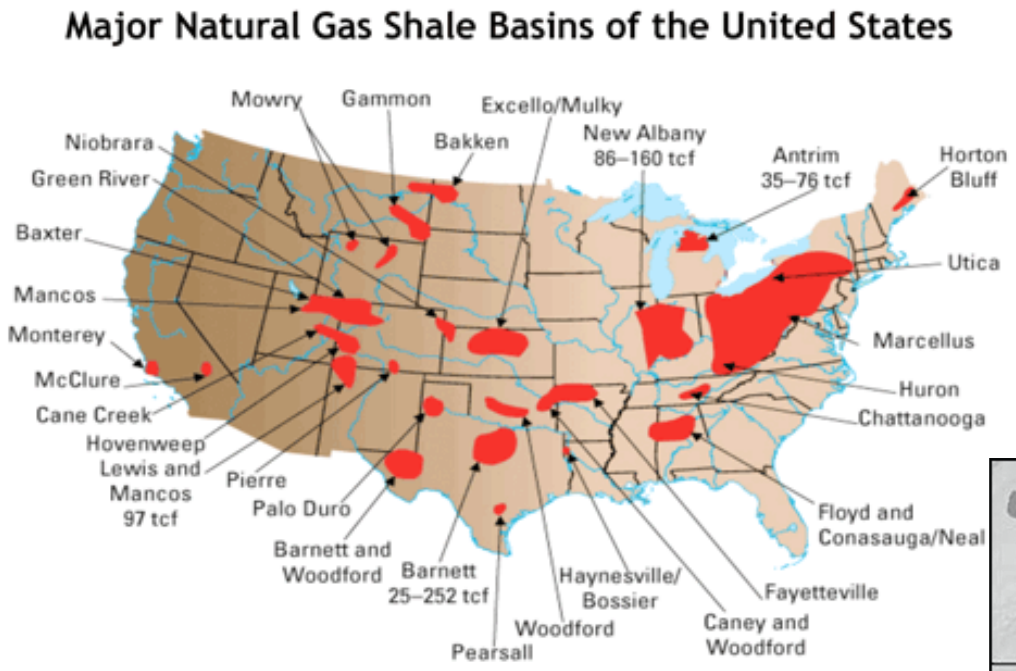
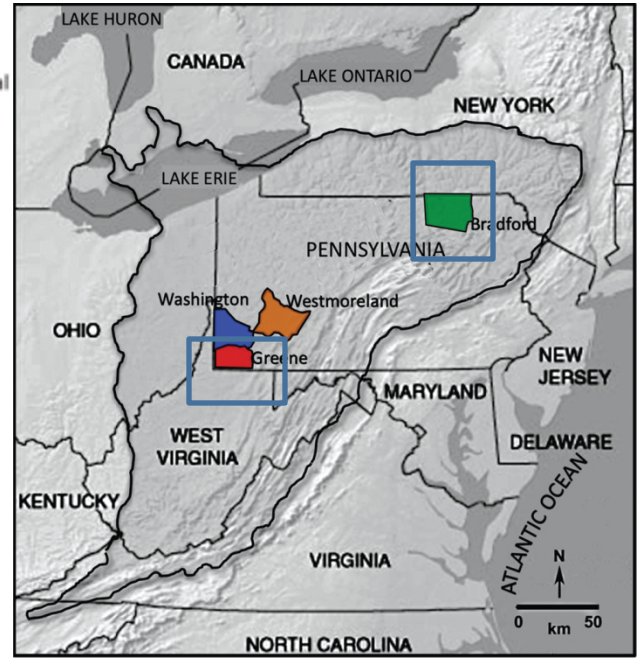
By: Girish Uprety

OUTLINE

- Introduction
  - Location
  - Horizontal Drilling and Fracking
- Analysis
  - TDS
- Results And Discussion
- Modeling- PHREEQC-i
- Conclusion

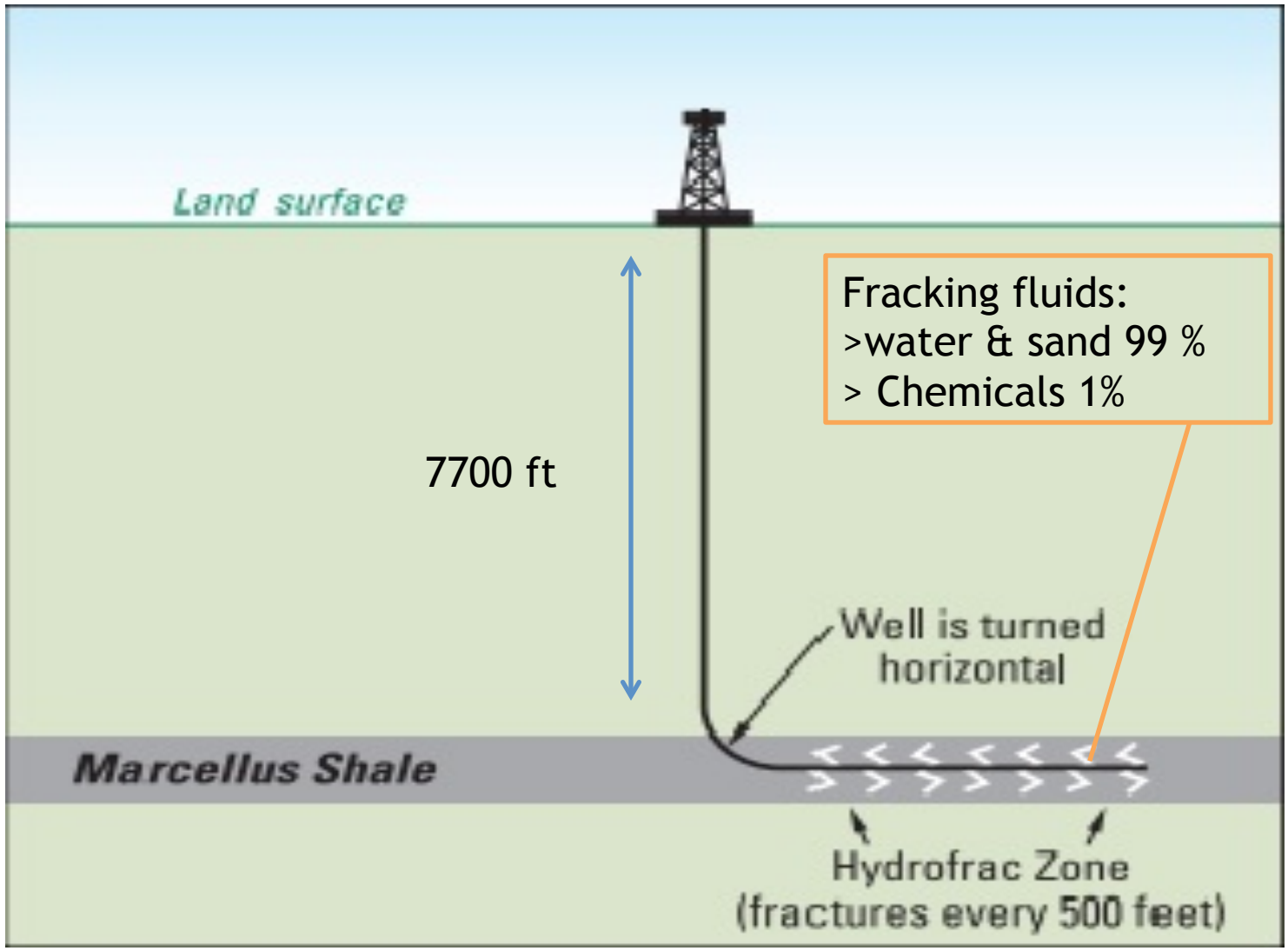
LOCATION





- Expands along NE part of US
- Covers parts of OH, PA, NY & WV
- Extraction in full swing in PA
- Will look at Green Co. & Bradford Co

HORIZONTAL DRILLING AND HYDRAULIC FRACKING



ANALYSIS

- Total Dissolved solids (TDS)
  - Exceeding 200,000 mg/L
  - EPA level 500 mg/L or less
- Samples were collected in different stages.
  - Start of the pumping
  - Prior to recycle or disposal
- High concentration of various element
  - Strontium (Sr), Bromide (Br-), Calcium (Ca), Barium(Ba), and Chloride (Cl)
- Most likely from interaction with the formation water or salt

RESULTS AND DISUSSION

- These water share same characterstics like high TDS
- Predominance of Na and Cl in the dissolved load
- High concentration of Ba and Sr (Up tp 12,000 and 5200 mg/L)
- High concentration of Ba/Sr ratio
  - This due to Ba and SR rich minerals
  - Dissolution of Witherite ($BaCO_3$), Celestite ($SrSO_4$) and Strontianite ($SrCO_3$)

MODELING- PHREEQC-I

- Doesn't do any modelling
- I picked three different samples
  - Two from Bradford County
    - Produced water (BR-A1)
    - Recycled-produced water (BR-A3)
  - One from Greene County
    - Fracking water (GR-AF)

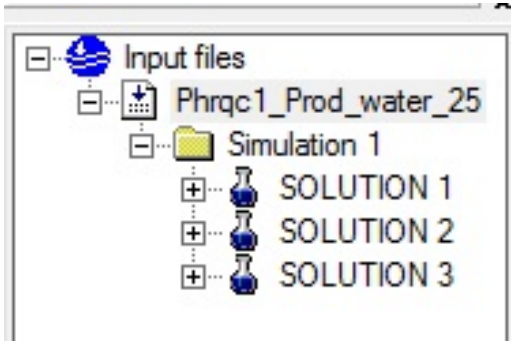
Environmental Science & Technology Article

Table 1. Major Element and Strontium Isotope Data for Marcellus Produced Water Samples

sample/ location	description	mg/L Na	Ca	Mg	Fe	Sr	Ba	Cl	TDS g/L	$^{87}Sr/^{86}Sr^{a}$	ε_{Sr}^{SWb}
Bradford Co., PA											
BR-A1	produced water	30,400	6,120	538	117	1,970	5,490	77,000	109.5	0.710653 ± 07	20.93 ± 0.10
BR-A2	produced water	49,400	20,800	1,750	123	5,230	12,000	159,000	211.4	0.710270 ± 10	15.53 ± 0.14
BR-A3	recycled prod. water	41,900	11,300	1,110	73.7	3,340	7,820	68,000	154.1	0.710742 ± 06	22.18 ± 0.08
Greene Co., PA											
GR-AF	frac water	20,923	4,377	567	16.0	1,389	393	41,900	88.7	0.710084 ± 08	12.90 ± 0.11

CONCLUSION

- Result
  - Fe(OH)3 (a) and Goethite were super saturated
  - Hematite was highly super saturated
  - Halite and gases under saturated
- There were slight variation in values but uniform throughout all 3 samples
- Similar results with temperature at 28 C



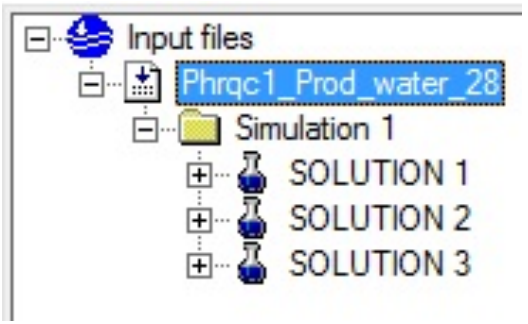


Chart- I
At 25 C and 28 C

Standard temperature

Produced water(Bradford Co. PA):

Phase	SI	log IAP	log KT	
Fe(OH)3(a)	3.47	8.36	4.89	Fe(OH)3
Goethite	9.39	8.39	-1.00	FeOOH
H2(g)	-22.00	-25.15	-3.15	H2
H2O(g)	-1.54	-0.03	1.51	H2O
Halite	-1.33	0.25	1.58	NaCl
Hematite	20.82	16.81	-4.01	Fe2O3
O2(g)	-39.25	-42.15	-2.89	O2

At 28 C

Phase	SI	log IAP	log KT	
Fe(OH)3(a)	3.53	8.42	4.89	Fe(OH)3
Goethite	9.56	8.45	-1.11	FeOOH
H2(g)	-22.00	-25.16	-3.16	H2
H2O(g)	-1.47	-0.03	1.43	H2O
Halite	-1.34	0.25	1.59	NaCl
Hematite	21.17	16.93	-4.23	Fe2O3
O2(g)	-38.25	-41.16	-2.91	O2

Produced-Recycled water(Bradford Co. PA:

Phase	SI	log IAP	log KT	
Fe(OH)3(a)	3.27	8.16	4.89	Fe(OH)3
Goethite	9.20	8.20	-1.00	FeOOH
H2(g)	-22.00	-25.15	-3.15	H2
H2O(g)	-1.55	-0.04	1.51	H2O
Halite	-1.20	0.38	1.58	NaCl
Hematite	20.44	16.43	-4.01	Fe2O3
O2(g)	-39.26	-42.15	-2.89	O2

Phase	SI	log IAP	log KT	
Fe(OH)3(a)	3.33	8.22	4.89	Fe(OH)3
Goethite	9.36	8.26	-1.11	FeOOH
H2(g)	-22.00	-25.16	-3.16	H2
H2O(g)	-1.47	-0.04	1.43	H2O
Halite	-1.21	0.38	1.59	NaCl
Hematite	20.78	16.55	-4.23	Fe2O3
O2(g)	-38.26	-41.17	-2.91	O2

Frac Water(Greene Co. PA):

Phase	SI	log IAP	log KT	
Fe(OH)3(a)	2.68	7.58	4.89	Fe(OH)3
Goethite	8.59	7.59	-1.00	FeOOH
H2(g)	-22.00	-25.15	-3.15	H2
H2O(g)	-1.53	-0.02	1.51	H2O
Halite	-1.85	-0.27	1.58	NaCl
Hematite	19.21	15.21	-4.01	Fe2O3
O2(g)	-39.22	-42.12	-2.89	O2

Phase	SI	log IAP	log KT	
Fe(OH)3(a)	2.74	7.63	4.89	Fe(OH)3
Goethite	8.75	7.65	-1.11	FeOOH
H2(g)	-22.00	-25.16	-3.16	H2
H2O(g)	-1.45	-0.02	1.43	H2O
Halite	-1.86	-0.27	1.59	NaCl
Hematite	19.54	15.31	-4.23	Fe2O3
O2(g)	-38.22	-41.13	-2.91	O2

FUTURE

- Lot of room to analyze in future
- Drilling fluids (unknown)
  - Intelligence Property (IP)
- Interaction of the chemicals with shale formation.

REFERENCE: Geochemical and Strontium Isotope Characterization of Produced Waters from Marcellus Shale Natural Gas Extraction *By: Elizabeth C. Chapman, Rosemary C. Capo, Brian W. Stewart, Carl S. Kirby, Richard W. Hammack, Karl T. Schroeder, and Harry M. Edenborn*

QUESTIONS