GEOCHEMISTRY OF THE REGIONAL AQUIFER OF THE PAJARITO PLATEAU, NEW MEXICO

Felix Zamora

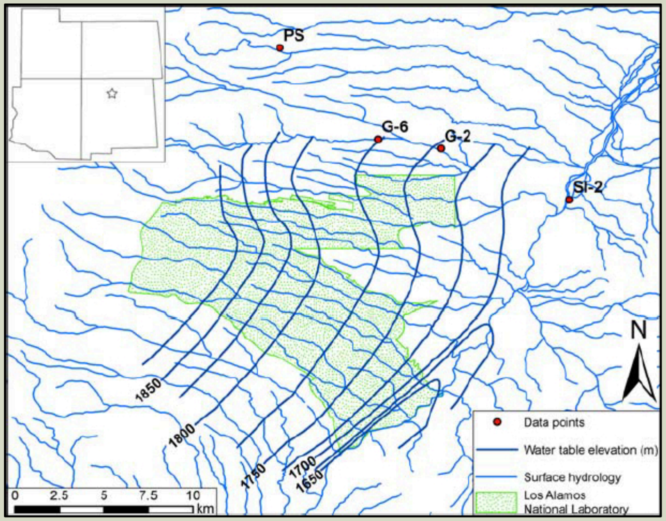
INTRODUCTION

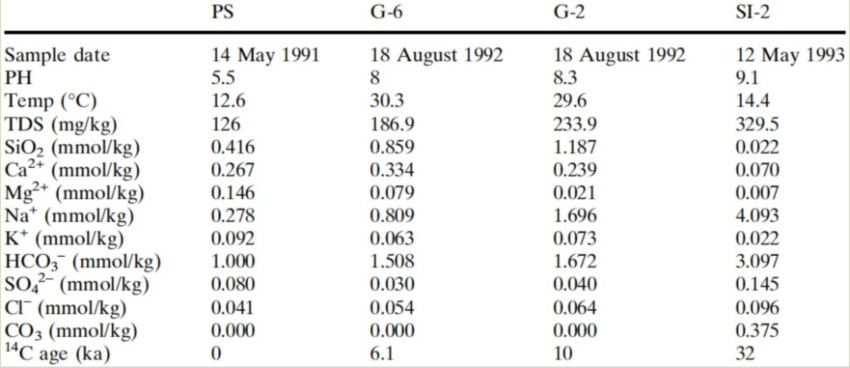
- Laboratory experiments of geochemical reactions typically demonstrate rates that are significantly faster than those observed in natural systems
- In aquifers, this discrepancy is due to multiple complexities including the heterogeneity of the matrix mineralogy, geomorphology, water saturation, the flow rate within the aquifer, land use, and other aquifer properties.
- Understanding how geochemical reactions progress in a natural system is essential to understanding geologic processes and manage water resources more effectively.

GEOLOGIC SETTING

- Espanola Basin – Northwest Trending Syncline
- Santa Fe Group
  - Tesque – alluvial fan deposits originating from the northeast
  - Chamita & Puye – coarse, highly permeable alluvium of the ancestral Rio Grande
  - Bandalier Tuff – late Tertiary volcanics
- Bounded to the east by the Sangre de Cristo Mountains
- Bounded to the west by the Jemez Mountains
- Low Precipitation, High Evaporation
- Well Pumping began ~60 years ago

OBSERVED GEOCHEMISTRY



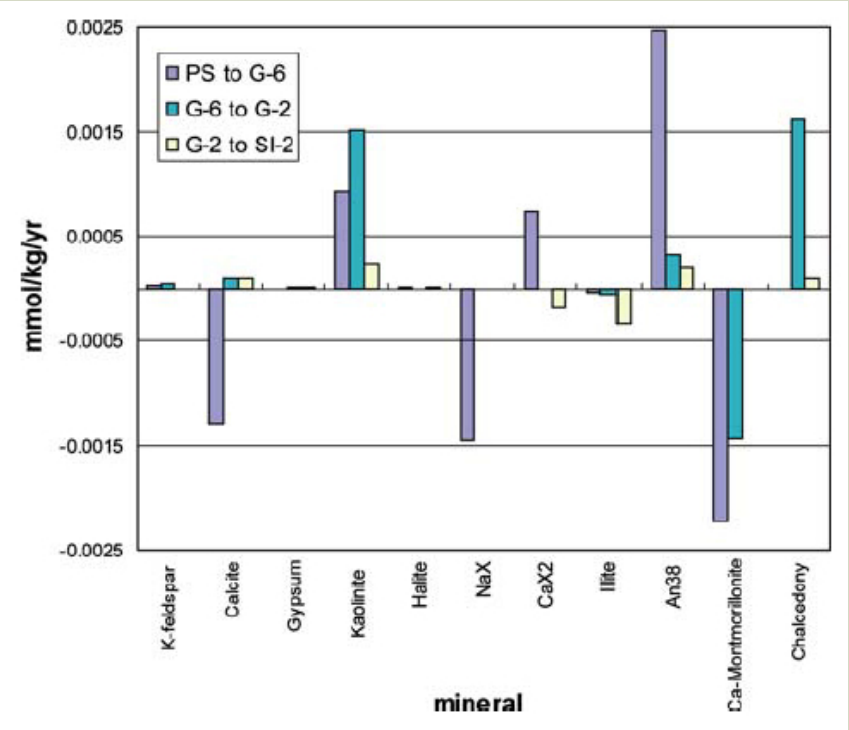


	PS	G-6	G-2	SI-2
Sample date	14 May 1991	18 August 1992	18 August 1992	12 May 1993
PH	5.5	8	8.3	9.1
Temp (°C)	12.6	30.3	29.6	14.4
TDS (mg/kg)	126	186.9	233.9	329.5
SiO_2 (mmol/kg)	0.416	0.859	1.187	0.022
Ca^{2+} (mmol/kg)	0.267	0.334	0.239	0.070
Mg^{2+} (mmol/kg)	0.146	0.079	0.021	0.007
Na^{+} (mmol/kg)	0.278	0.809	1.696	4.093
K^{+} (mmol/kg)	0.092	0.063	0.073	0.022
HCO_3^{-} (mmol/kg)	1.000	1.508	1.672	3.097
SO_4^{2-} (mmol/kg)	0.080	0.030	0.040	0.145
Cl^{-} (mmol/kg)	0.041	0.054	0.064	0.096
CO_3 (mmol/kg)	0.000	0.000	0.000	0.375
^{14}C age (ka)	0	6.1	10	32

- 16.3 km path from the Jemez mountains to the plains of the Rio Grande
- Trends are generally consistent with others observed in the region
- 3 Hypotheses
  - Mineralogic Zones
  - Kinetically Limited Dissolution/ Precipitation Reactions
  - Mixing of waters of different origins

PUBLISHED MODEL

- Inverse mass-balance modeling
- Constrained to specific mineral phases
- Parameters
  - Constraints based on petrographic data and low-Temperature kinetics
  - Dissolution of feldspars; precipitation of clays
- Dissolution Rate
  - $R=(M/\Delta t)(1/S)$
  - Model produces results that are several orders of magnitude slower than laboratory experimental rates



Mass transfer over the different segments of the flow path.
Positive values indicate dissolution, negative values indicate precipitation

AN ALTERNATE MODEL

- Change Parameters
  - No forced dissolution of phases in any segment
  - Continued precipitation of clays

Difference between Mass Transfer results of Alternative and Published Models

	PS to G-6	G-6 to G-2	G-2 to SI-2
K-Spar	-0.000233	-2E-06	0
Calcite	0.00884	-0.000173	-0.00075
Gypsum	-0.0000483	-9.06E-06	0
Kaolinite	-0.005902	-0.005708	-0.00152
Halite	-0.000013	0	-2.87E-05
NaX	0.01006	0.000583	0.00202
CaX2	-0.005032	-0.000291	0.00301
Illite	0.000539	3E-06	0.0073233
Ca-Montmotillonite	0.0135	0.00562	-0.00323
Chalcedony	0	-0.00632	0.0012

- In general, barring the assumption that feldspars and halite dissolve slows the modeled dissolution and precipitation rates
- This may be accomplished if the groundwater quickly became saturated with the species or with a fluctuating water table limiting the availability of water
- Given the low temperature of the system and the abundance observed in petrographic studies, these remain reasonable assumptions

MODEL ASSUMPTIONS AND SHORTFALLS

- Assumes Initial & Final Water are along the same path
  - Possibly a more meandering path with interaction with more varied lithologies
  - Negates potential mixing with younger waters
- Dispersion & diffusion of water within the aquifer
  - Potential changes in concentrations as water enters region with different hydrologic properties
- System operates in a chemical steady state
  - Model does not account for climate fluctuations that could alter the chemistry of the input water
- Assumed mineralogic phases
  - It is difficult to account for all of the significant mineral alterations associated with changing water chemistry

CONCLUSIONS

- Geochemical reactions in the Pajarito Plateau aquifer are driven by low temperature kinetics along with potential mixing with younger waters in the lower regions.
- Laboratory experiments do not capture the complexities of geochemical reactions.
- Field observations provide the means to integrate natural constraints into models and identify variables potentially responsible for the geochemical alterations.
- Models are still hindered by their assumptions and their limited ability to capture the complexity of the natural world.

Reference

Hereford, A.G., Keating, E.H., Guthrie, G.D., Zhu, C., 2007. Reaction and reaction rates in the regional aquifer beneath the Pajarito Plateau, north-central New Mexico, USA. *Environ. Geol.* **52**, 965-977.