HYDROCHEMISTRY OF LAVA TUBE SPRING AND THE RIO GRANDE, TAOS COUNTY, NEW MEXICO

BY

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I. Introduction

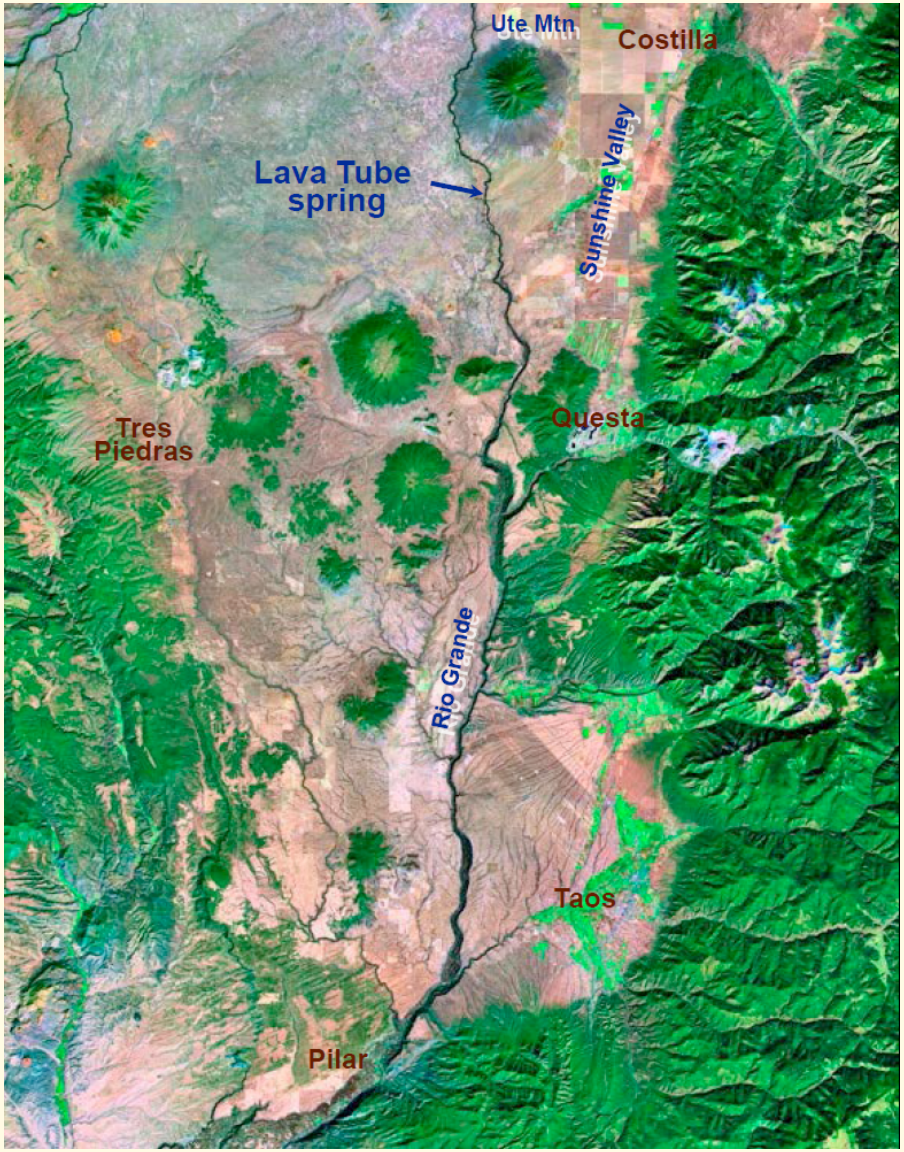
II. Flow Rates and Mixing

III. Aqueous Chemistry

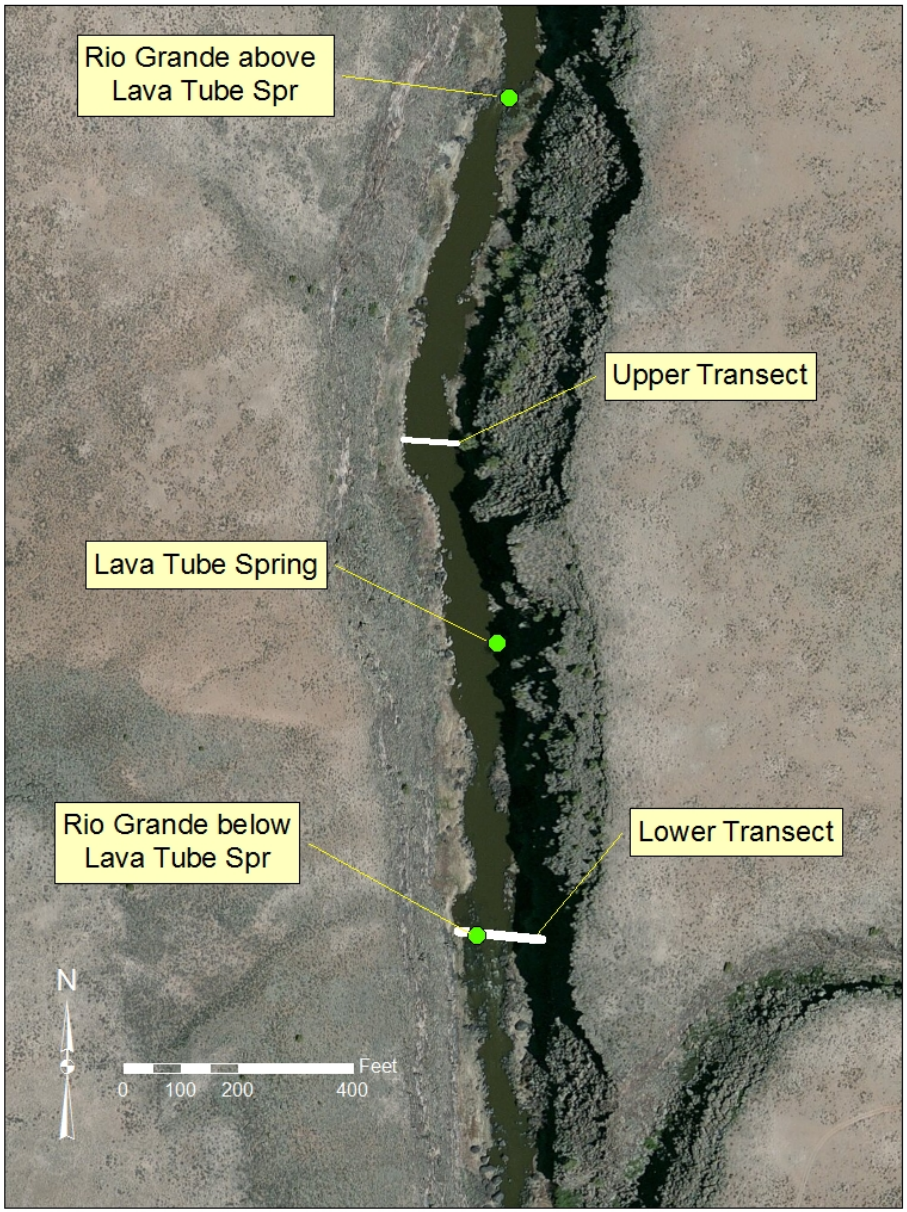
IV. Batch Equilibrium Modeling

V. Summary

LOCATION MAP OF LAVA TUBE SPRING AND SURROUNDING AREA, TAOS COUNTY



MAP SHOWING LAVA TUBE SPRING, RIO GRANDE, AND SURFACE WATER TRANSECTS, TAOS COUNTY



PHOTOGRAPH OF LAVA TUBE SPRING DICHARGING INTO THE RIO GRANDE (Source: P. Bauer and P. Johnson, 2010)

Bauer, P. W. and Johnson, P. S., 2010, A rare, large artesian subaqueous spring in the upper Rio Grande: New Mexico Geology, Vol. 32, no. 1, 26-29 pp.

SURFACE WATER FLOW IN THE RIO GRANDE ABOVE AND BELOW LAVA TUBE SPRING (LTS), TAOS COUNTY, NEW MEXICO

Parameter	Above LTS	Below LTS
Total Width (ft)	72.6	84.7
Average Depth (ft)	2.81	1.58
Total Area (ft^2)	175	98.9
Average Velocity (ft/sec)	0.38	0.87
Total Discharge (ft^3/sec)	67	95
No. Measurements	42	56

FIELD PARAMETERS FOR LAVA TUBE SPRING (LTS) AND RIO GRANDE SURFACE WATER

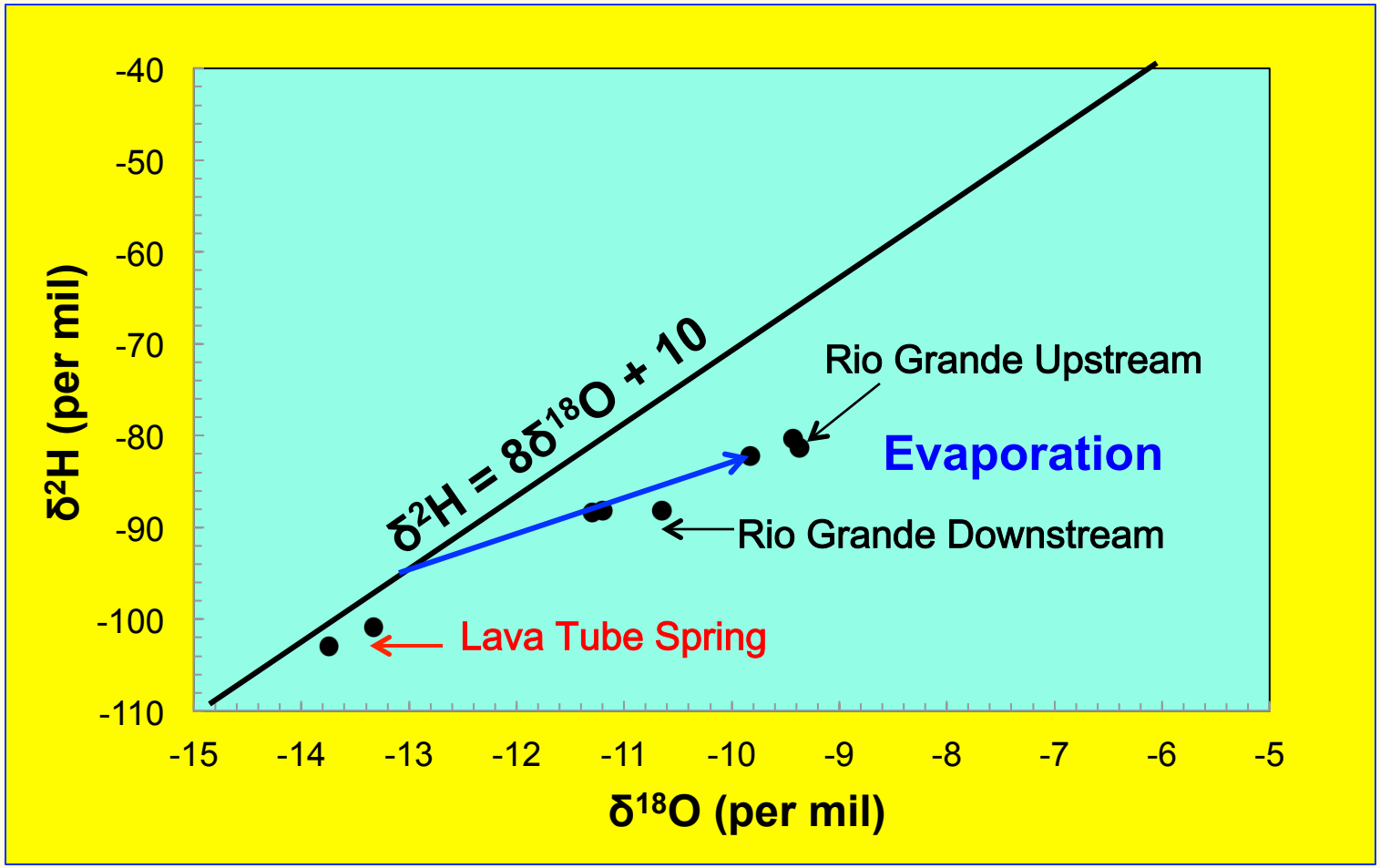
Parameter	Above LTS	Lava Tube Spring	Below LTS
pH	7.56	7.58	7.49
Temperature (°C)	22.5	16.7	20.5
Specific Conductance (µS/cm)	395	191	337
ORP (mV)	+96.7	+103	+100
Eh (mV)	+341	+347	+344
Dissolved Oxygen (mg/L)	9.36	8.84	9.57

Note: Three measurements of each parameter were taken at each Rio Grande location. One measurement Of each parameter was taken at LTS.

ANALYTICAL METHODS

Analyte Suite	*Analytical Methods*
Anions	Ion Chromatography
Metals-Trace Elements	High Resolution-Mass Spectrometry, Inductively Coupled-Mass Spectrometry
Stable Isotopes	Isotope Ratio Mass Spectrometry
Tritium	Electrolytic Enrichment

$\delta^{18}O$ VERSUS $\delta^{2}H$ AT LAVA TUBE SPRING AND THE RIO GRANDE



RESULTS OF MIXING CALCULATIONS USING TRACER CONCENTRATIONS AND PHYSICAL PARAMETERS FOR LAVA TUBE SPRING AND THE RIO GRANDE

Parameter	Above	Lava Tube Spring	Below	Mixing
Cl (mg/L)	11	4	9	0.29
^{3}H (TU)	4.14	0.12	2.88	0.31
$\delta^{2}H$ (‰)	-81.82	-102.91	-88.28	0.31
U (µg/L)	1.53	2.23	1.79	0.37
$\delta^{18}O$ (‰)	-9.54	-13.56	-11.05	0.38
SO_4 (mg/L)	38	14	29	0.38
Discharge (ft^3/sec)	67	28	95	0.29
Temp. (°C)	22.5	16.7	20.5	0.34

Note: Three filtered-nonfiltered samples were collected at each Rio Grande location. One sample was collected at LTS. TU = tritium unit (3.222 pCi/L). Input from small discharging springs located above Lava Tube spring is assumed to be negligible.

Mixing Eq. $C = A(X) + B(1 - X)$

where A = parameter A (upstream), B = parameter B (lava Tube spring), C = parameter C (downstream), and X = mixing fraction.

AVERAGE SOLUTE CONCENTRATIONS FOR LAVA TUBE SPRING (LTS) AND THE RIO GRANDE

Parameter (mg/L)	Above LTS	Lava Tube Spring	Below LTS
Ca	32.8	20.9	28.7
Mg	7.52	6.93	7.30
Na	40.1	13.8	31.4
K	7.0	2.7	5.55
SO_4	38	14	29
HCO_3	175	116	145
Cl	11	4	9
SiO_2	26.1	38.8	29.6

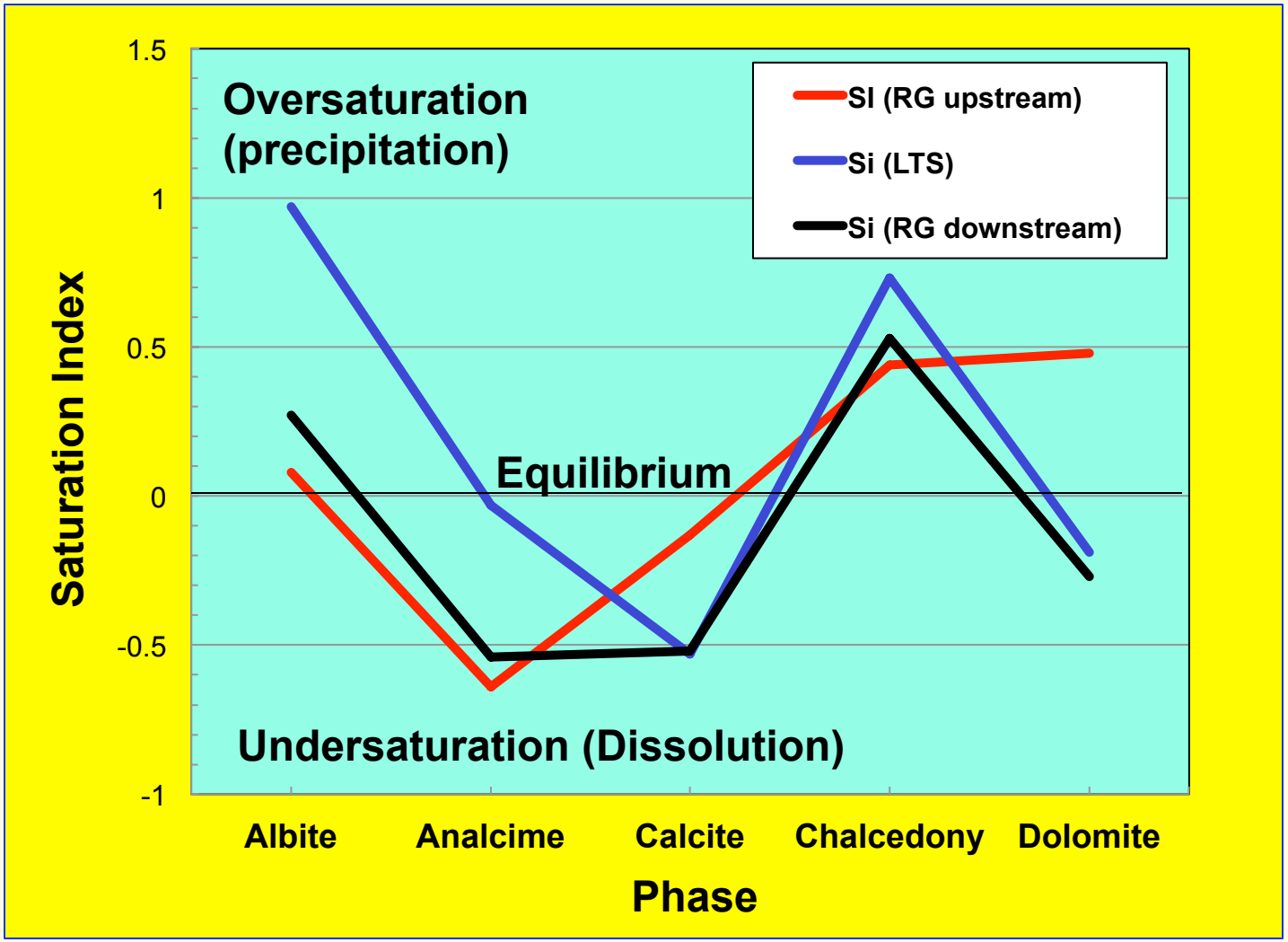
Note: Three filtered samples were collected at each Rio Grande location. One filtered sample was collected at LTS.

AVERAGE SOLUTE CONCENTRATIONS FOR LAVA TUBE SPRING (LTS) AND THE RIO GRANDE

Parameter (µg/L)	Above LTS	Lava Tube Spring	Below LTS
Al	1.44	0.39	1.26
As	4.57	2.52	3.53
B	88.1	33.2	74.0
Cr	0.085	2.03	0.714
Fe	0.01 U	0.01 U	0.01 U
Mn	9.39	0.26	6.37
Sr	243	167	228
U	1.53	2.23	1.79

Note: Three filtered samples were collected at each Rio Grande location. One filtered sample was collected at LTS. U means nondetected analyte.

RESULTS OF SATURATION INDEX CALCULATIONS USING PHREEQC



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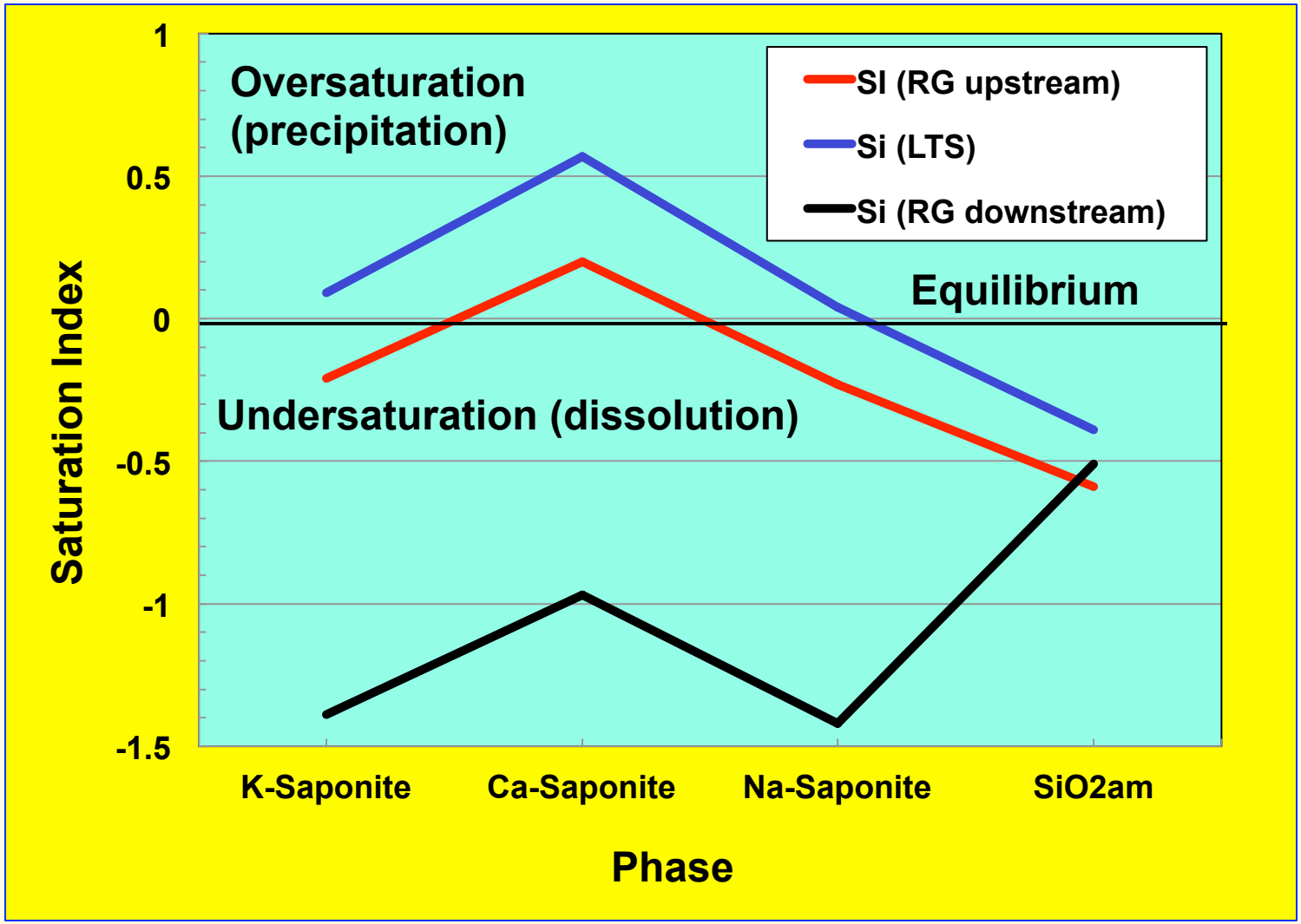

SUMMARY

Lava Tube spring is the largest single active spring in New Mexico, with calculated discharge rates 5835 gal/min in fall 2009 and 12,565 gal/min in July 2012.

Groundwater discharging from Lava Tube spring mixes with the Rio Grande surface water and constitutes between 29 and 38 percent of chemical tracers.

Rio Grande surface water and groundwater discharging from Lava Tube spring are characterized by a Na-Ca-HCO_3 composition.

Recharge water for Lava Tube spring occurs at a higher elevation than the Rio Grande (showing some evaporation) based on lighter $\delta^{18}O$ and $\delta^{2}H$ values.

Lava Tube spring approaches equilibrium with respect to Na- and K-saponite and analcime most likely produced from hydrolysis reactions with Servilleta basaltic glass.

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