GEOCHEMICAL MODELING OF URANYL (UO_2^{2+}) SORPTION TO FERRIHYDRITE COLLOIDS AT A COLORADO TEST SITE

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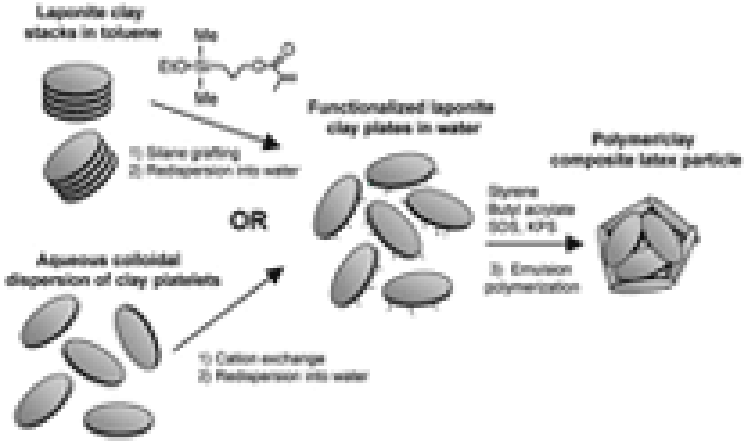
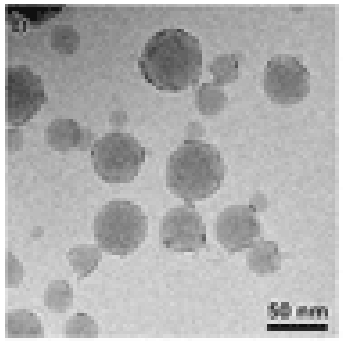
URANIUM IN THE ENVIRONMENT

- Uranium occurs naturally and is a common contaminant in the environment
- Anthropogenic Causes
  - Weapons Production
  - Nuclear Energy
  - Leaching from Mine tailings
  - Scientific/Other Uses

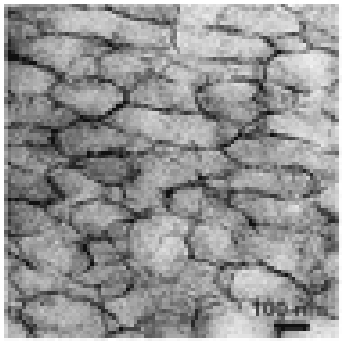
WHAT ARE COLLOIDS?

- Colloids are very small particles
- 1 μm or less in diameter
- Important surface properties that larger particles do not





Cryo-TEM [1] *analysis of poly (styrene-co-butyl acrylate)/ laponite composite particles. The clay platelets are located on the external surface of the polymer latex particles.*



Films produced from the latexes have a honey comb-like morphology, the laponite clay platelets forming the walls of this 3D cage-like structure.

FERRIHYDRITE COLLOID DETERMINATION IN LAB

- $[FeII]_{gw} \xrightarrow{\text{filtration}} [FeII]_{\text{m solution}}$
- $[FeII]_{gw} - [FeII]_{m} = [FeII]_{\text{colloid}}$
- $[FeII]_{gw} + O_2 \xrightarrow{\text{filtration}} [FeII]_{m2}$
- $[FeII]_{gw} - [FeII]_{m2} = [FeII]_{\text{colloid oxide}}$

URANIUM SORPTION DETERMINATION IN LAB

$[UVI]_{gw} + O_2 \xrightarrow{\text{filtration}} [UVI]_{m2}$

$[UVI]_{gw} \approx [UVI]_{m2}$

Laboratory Data: Uncertainty ± 10%
[0.035mg/L] ≈ [0.0343mg/L]

LABORATORY DATA

		8/1/10			10/11/10		
Analyte Name	**DL (mg/l)**	**0.02**	**0.2**	**0.45**	**0.02**	**0.2**	**0.45**
Fe 238.204-A	0.0003	1.750892841	2.197442899	2.408146329	2.811734219	3.546517902	3.585008294
U 367.007-A	0.0219	0.191652426	0.194442353	0.195895166	0.035505268	0.037453638	0.036105829
V 292.402-R	0.0012	0.877213307	0.941803201	1.017288051	0.04291734	0.051996676	0.052140197

Analyte Name	**0.02 oxi**	**0.2 oxi**	**0.45 oxi**
Fe 238.204-A	0.0006	0.001122677	0.010427443
U 367.007-A	0.0343	0.03102043	0.029774605
V 292.402-R	0.0146	0.011377314	0.011507475

CONCEPTUAL MODEL

1. Colloids are present
2. Fe-Oxide Colloids are known to sorb to Uranium
3. Carbonate and Sulfate Uranium complexes are not charged and do not sorb.
4. Does UO_2^{2+} sorb in this system (i.e at the Colorado Test Site)?

HYPOTHESIS (I.E. THE STORY)

- Uranium Ion Does Not Sorb to Ferrihydrite Colloids at the Colorado Test Site
  - The Model Basis was water data from the Colorado test site and the results were compared to the Laboratory Results

COLORADO TEST SITE

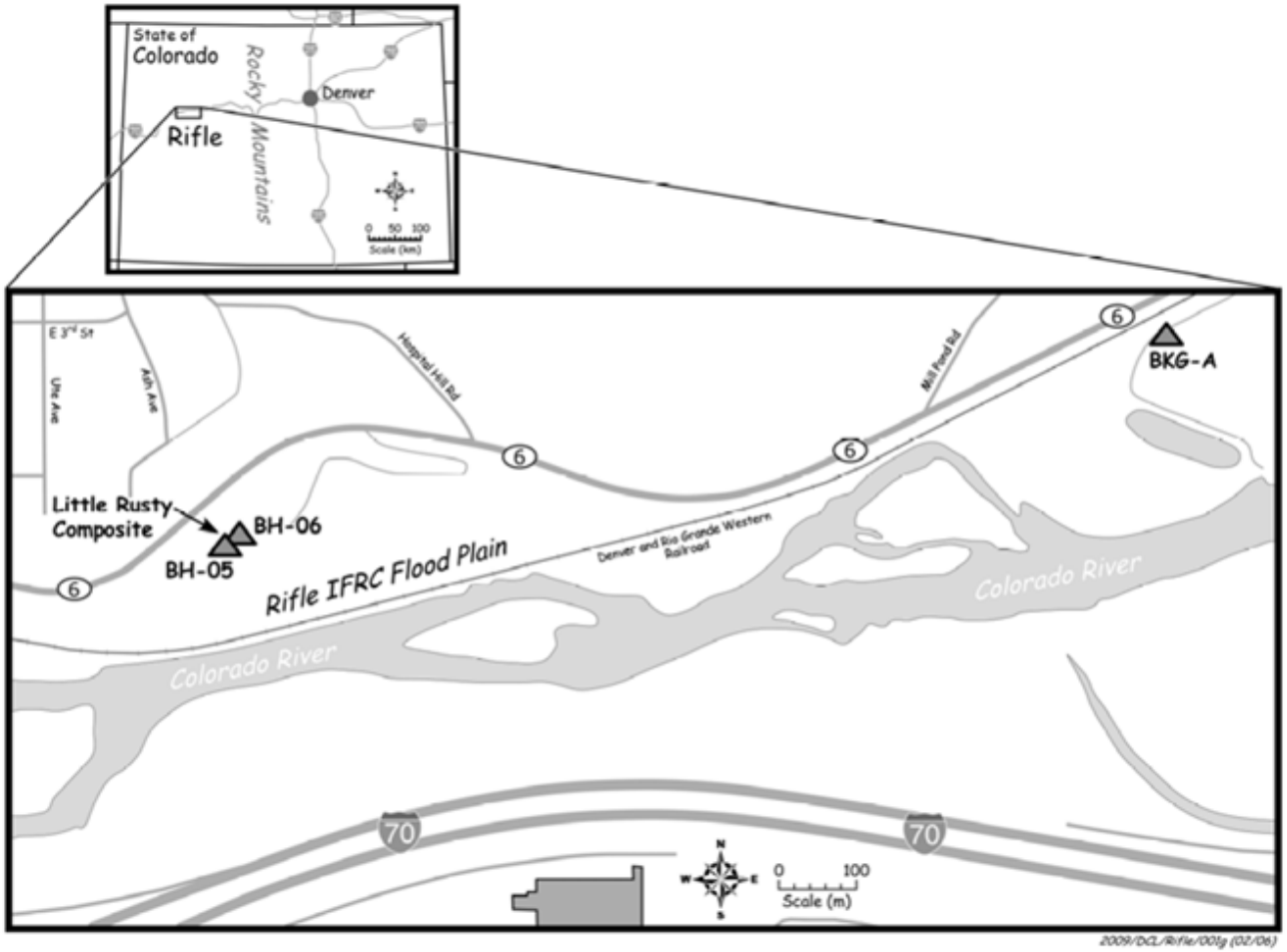
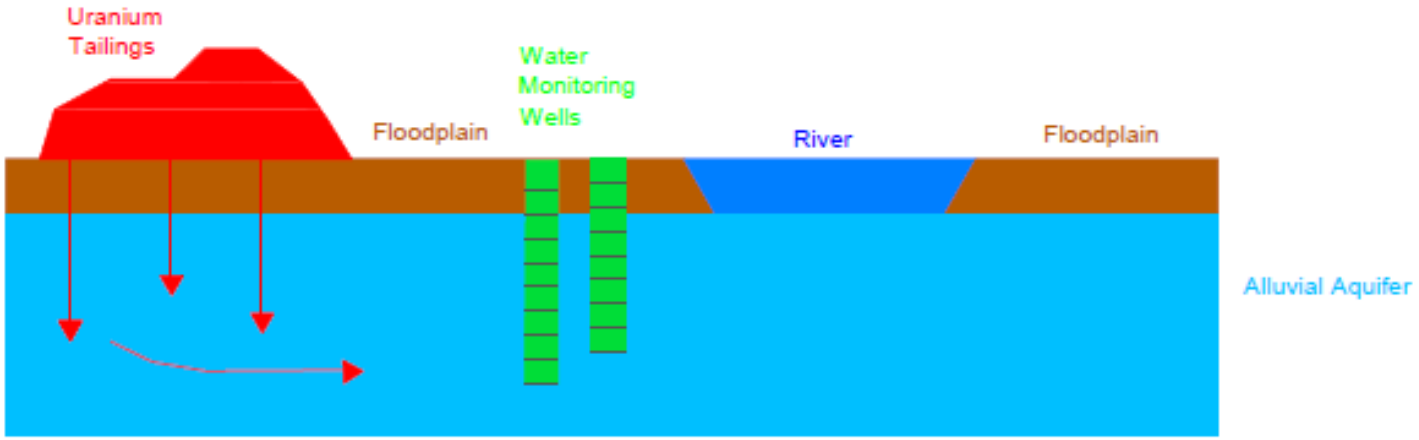


Figure 1. Site map and sampling location of the study site at Rifle, Colorado, USA. The Colorado River flows to the west, towards the left side of the diagram.

COLORADO TEST SITE

- Between 1924-1958 the area hosted Vanadium and Uranium ore processing facilities and mill tailings
- Uranium Mill Tailings located on a flood plain of the Colorado River
- Groundwater flows through unconsolidated Quaternary floodplain deposits that are often coated by iron oxide minerals

GENERAL SITE MODEL



Not to Scale

BASIS WATER PARAMETERS

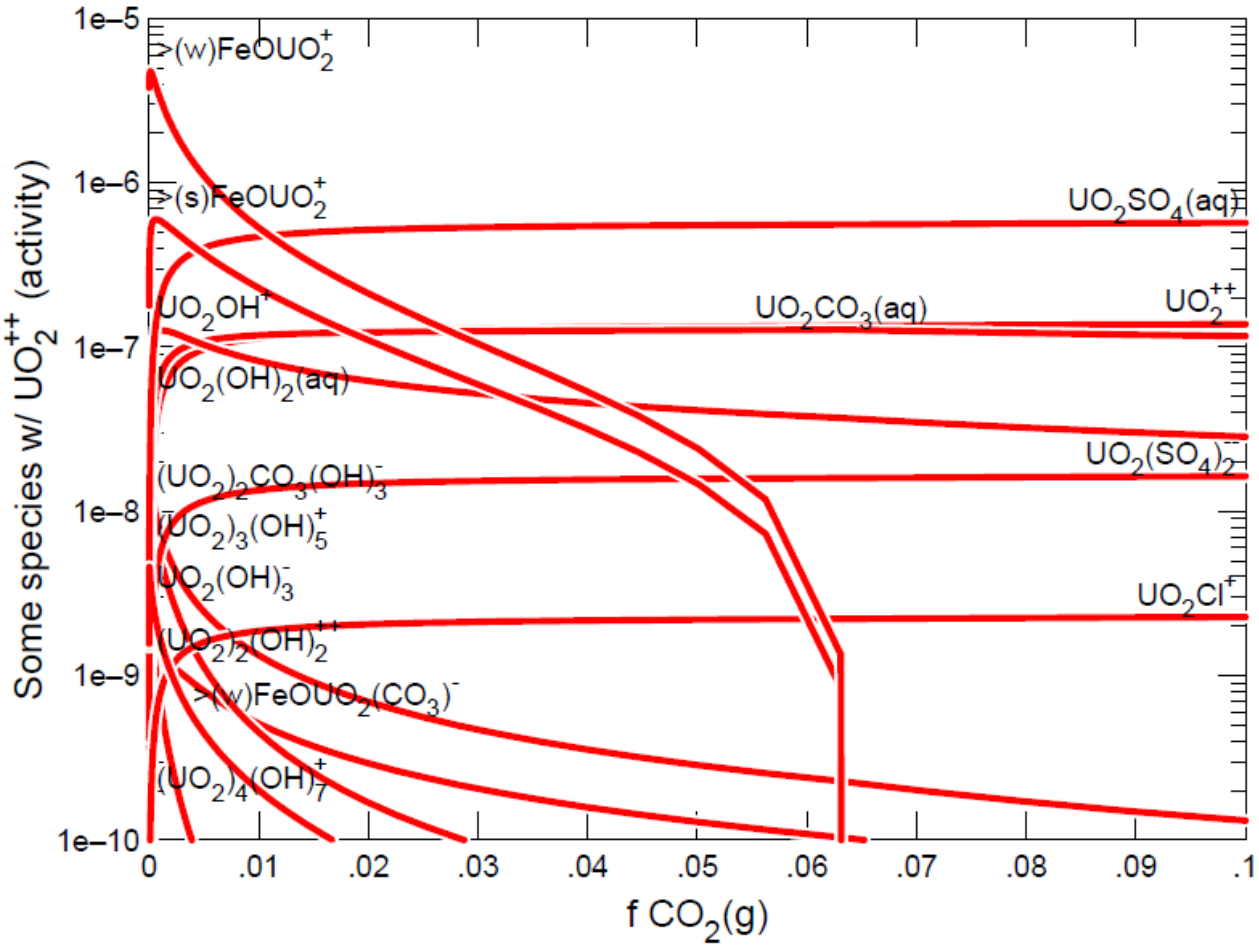
Basis Species	Concentration	Units
pH	7.13	--
Fe(OH)3	2.83	free mg
Cl^-	6.45	mM
SO_4^{2-}	8.75	mM
Na^+	241	mg/L
Mg^{2+}	113	mg/L
Ca^{2+}	232	mg/L
K^+	11	mg/L
UO_2^{2+}	0.034	mg/L
e-	0.35	Eh
CO2	-6	log fugacity

REACTANTS

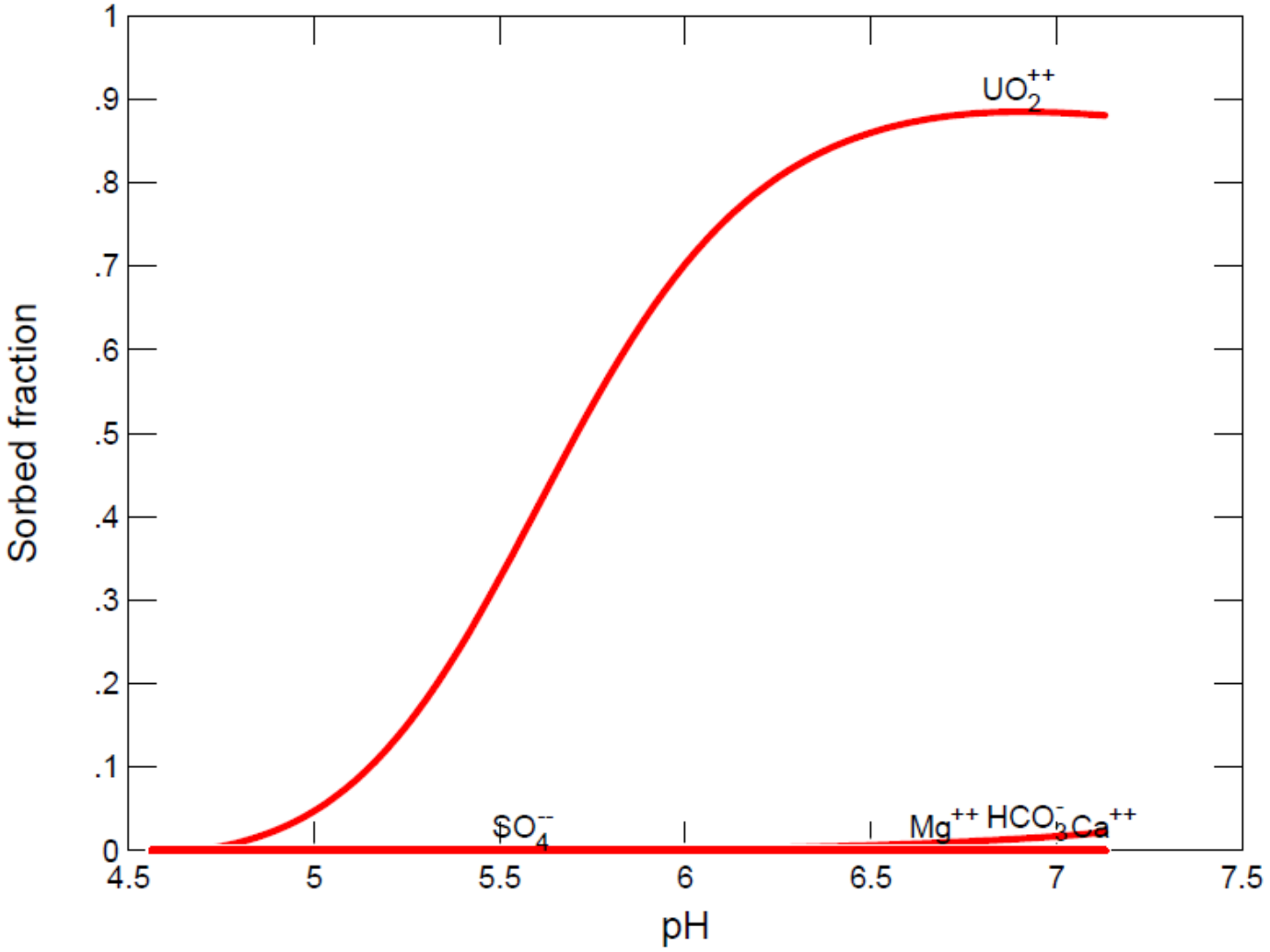
- Run 1 – Initial pH set at 7.13
  - Log fugacity slid from -6 to -1
- Run 2 – Log Fugacity held constant at -2.5 (an average groundwater value)
  - pH slid from 7.1 to 9.0

Reactants			
slide log fugacity	CO2	-1	Run 1
slide	pH	9	Run 2

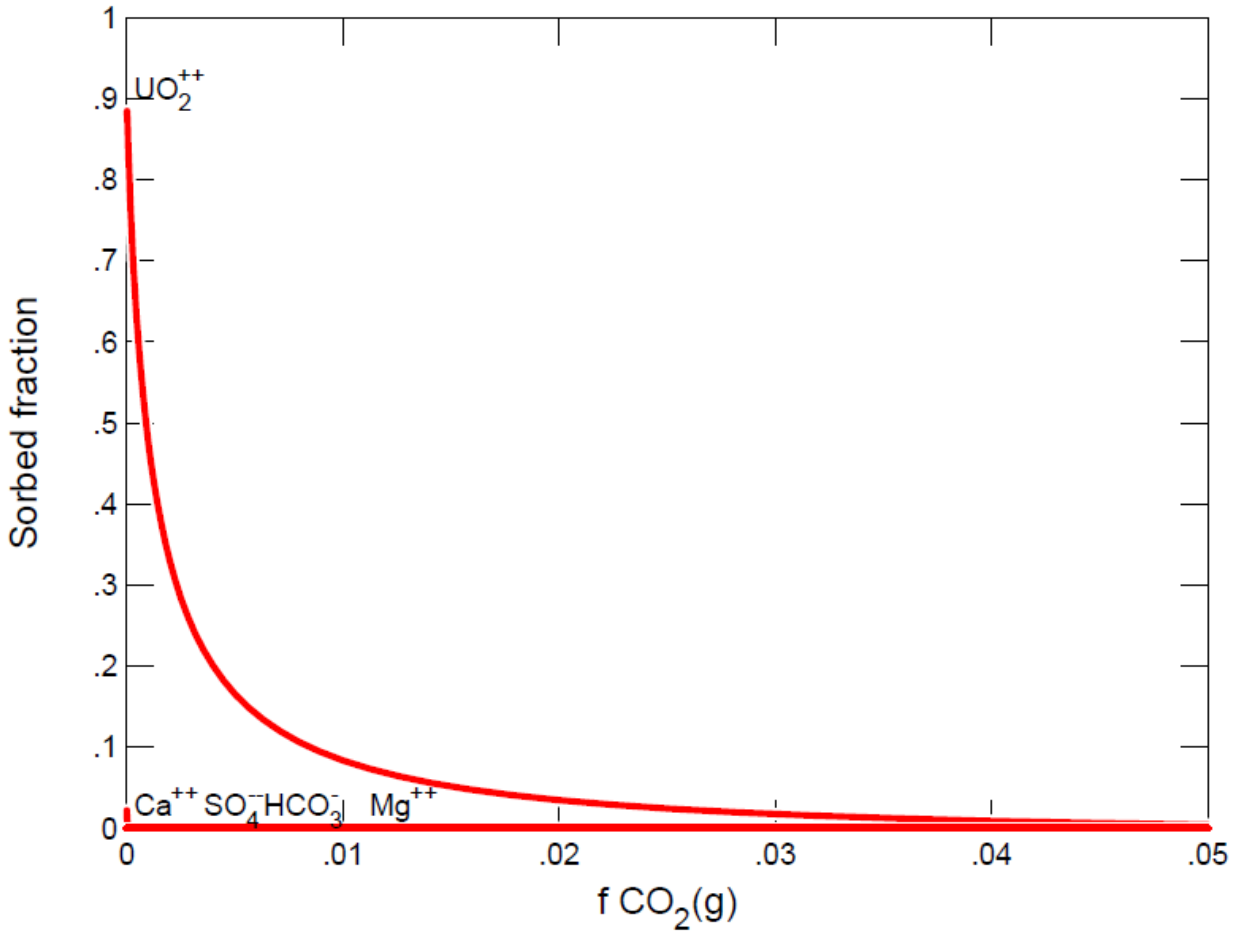
UO_2^{2+} VERSUS FUGACITY CO_2 RUN 1



SORBED FRACTION VS PH RUN 1

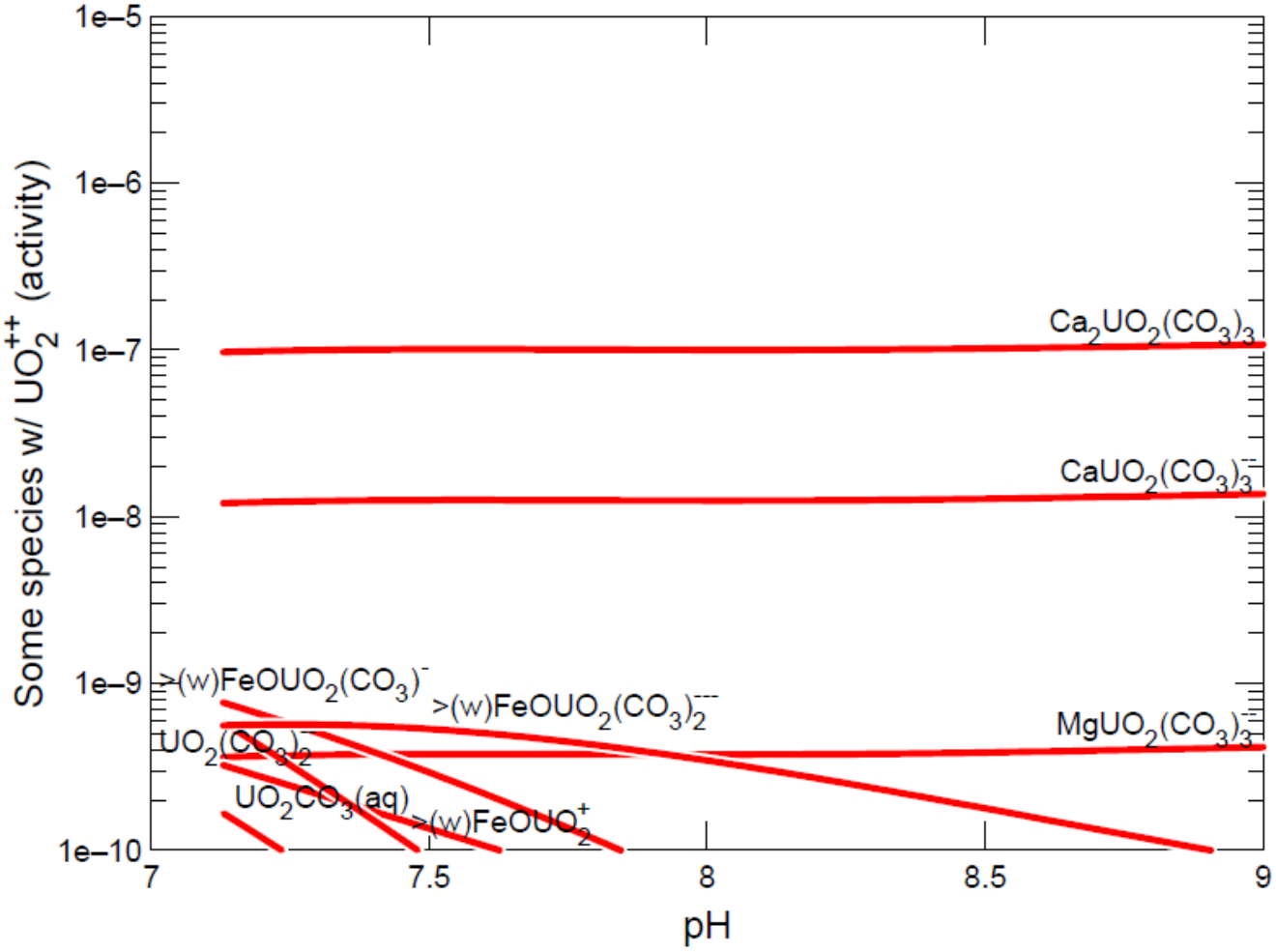


SORBED FRACTION VS FCO2 RUN 1

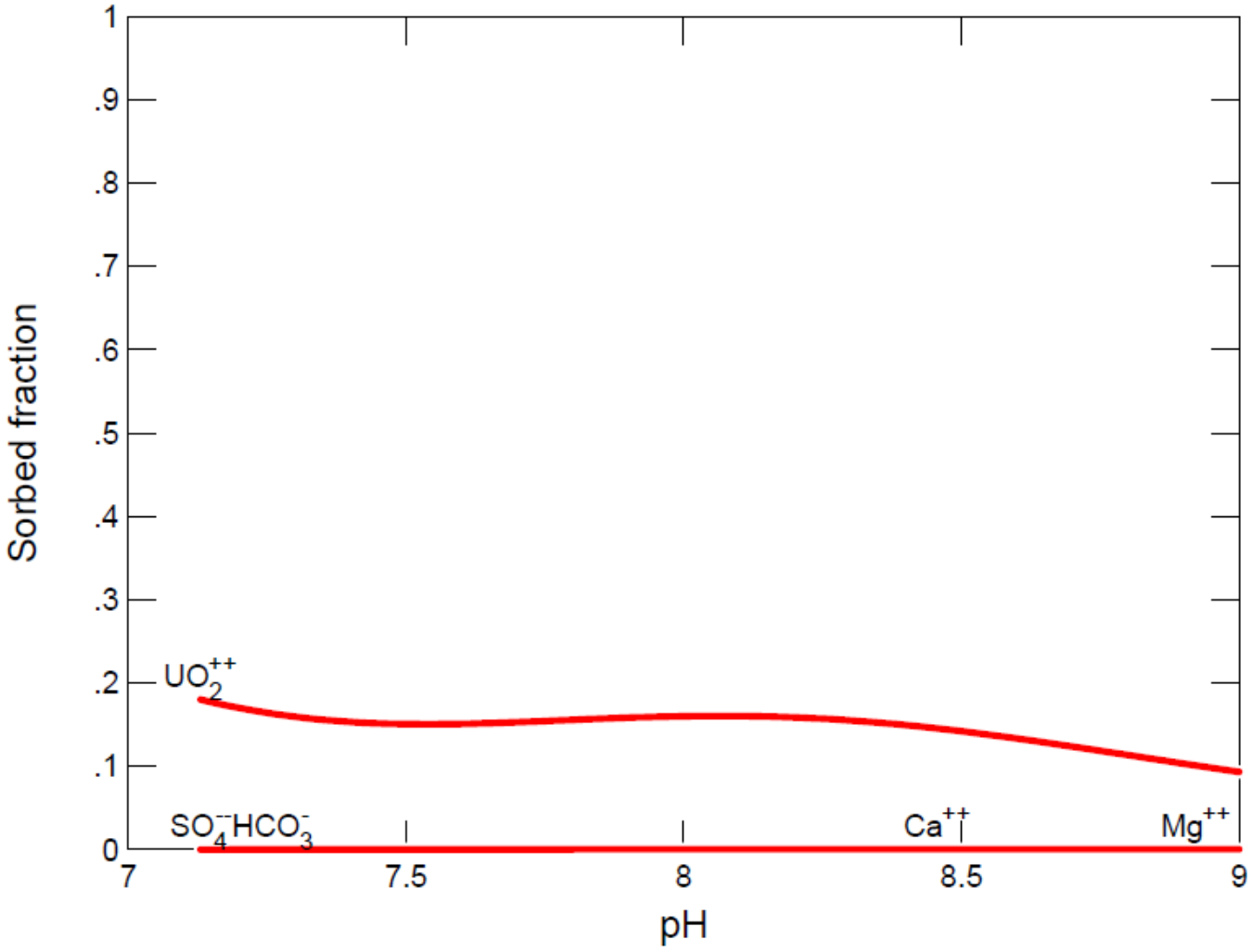


UO2 VERSUS PH

RUN 2 FIXED LOG FUGACITY (-2.5)



RUN 2 - SORBED FRACTION VS PH



CONCLUSIONS

- Uranium sorption is highly dependent on the amount of carbonate in the system.
- Based on the modeling and laboratory results Uranium sorption does not occur at the Colorado Test Site.

THANKS!

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