Characterizing Upper Colorado River Basin Sediments

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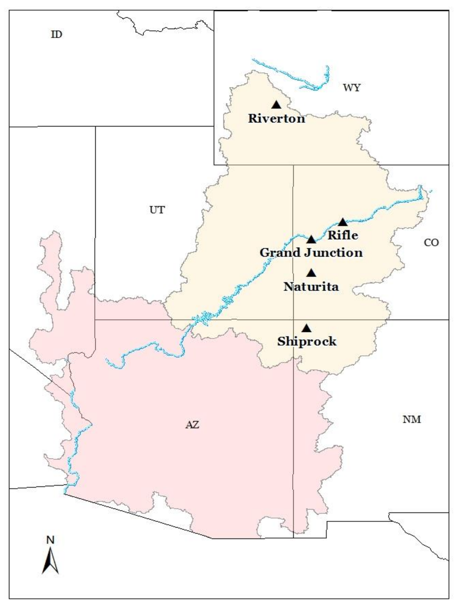


Figure 1. Map of the five study sites (▲), managed by DOE-LM within the Upper Colorado River Basin.

Background

More than 35 million people in the western United States depend on the Colorado River as a resource for drinking water, irrigation systems, and hydropower. Recent climate change reports predict average water levels within the Colorado River Basin will decrease throughout the next century. Decreased river flow may have major impacts within the subsurface that are two-fold: 1) decreased water flowing may result in greater issues of water quality-due to accumulation and concentration of some elements within the subsurface, and 2) a lower water stage may significantly alter the redox cycling within the subsurface and affect major biogeochemical elemental cycles. Therefore, a greater understanding of current subsurface elemental distributions throughout the Upper Colorado River Basin is needed.

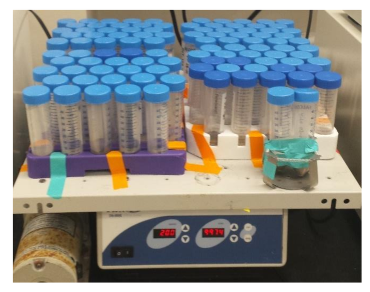
Methods

334 samples from five DOE-LM sites of the Upper Colorado River Basin were characterized by:

Homogenization

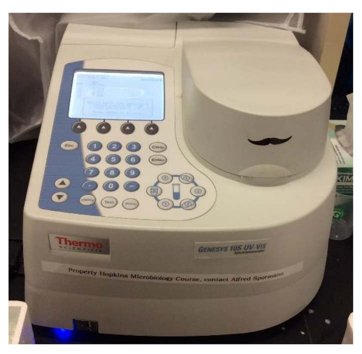
Elemental Analysis (EA)

X-Ray Fluorescence (XRF)



Water Extraction

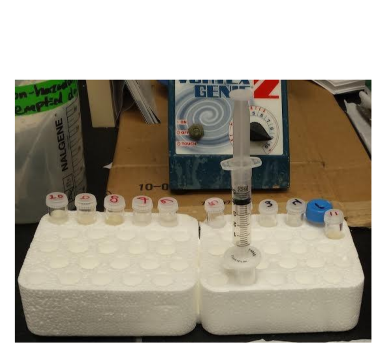
Refractometer



UV-Vis Spectrophotometry

Discrete Analyzer (DA)

pH Meter



Filtration

Centrifuge

Results

Core	Depth range (cm)	Statistics	pH	Salinity (psu)	NH4+ (µM)	NO3- (µM)	NO2- (µM)	C:N	U (µg/g)	V (µg/g)	Fe (µg/g)	Cu (µg/g)	S (%)	P (%)
RVT-855	0-630	*Max*	9	17	220	146.92	65.76	173	44.9	96.5	36470	28.9	1.68	0.21
		Min	7.5	0	3.37	-0.16	-0.03	0.02	0.4	25.3	13420	4	0.05	0.01
		Mean	8.3	5.32	27.36	12.59	5.17	25.1	6.32	53.47	22109.5	14.65	0.47	0.06
		s.e.	0	0.67	4.85	2.9	1.6	4.52	1.09	2.51	772.03	0.73	0.05	0
KB-1	0-234	*Max*	9	9	101.82	111.42	82.79	65	570	86.8	238700	28.6	2.01	0.09
		Min	7.5	0	5.78	0.69	0.09	0.05	0.4	21.5	12170	0.5	0.05	0
		Mean	8.2	3.16	22.44	9.14	4.21	25.1	22.2	49.18	28441.3	14.88	0.44	0.06
		s.e.	0.1	0.47	3.61	3.78	2.77	2.68	18.32	2.48	7075.83	1.13	0.08	0
RVT-877	0-510	*Max*	9	12	86.67	14.78	9.92	51.5	43.1	100.7	42500	33.2	1.6	0.14
		Min	6.9	0	1.88	0.77	0.07	0	0.4	27.9	12850	5.5	0.06	0.04
		Mean	8.2	5.08	23.42	4.94	1.16	15.8	6.12	55.47	23208.8	15.49	0.5	0.07
		s.e.	0.1	0.6	3.29	0.61	0.31	2.23	1.15	3.14	1090.53	1.05	0.07	0
SR-DM-04	0-480	*Max*	8.8	15	90	231.84	1.29	92.5	49.4	197.3	27790	26.7	1.74	0.08
		Min	7.9	0	5.71	2.01	0.25	0	0.3	6	4704	0.8	0.05	0.02
		Mean	8.4	2.05	21.92	27.47	0.57	14.6	3.73	53.93	13182.1	9.41	0.31	0.04
		s.e.	0.1	0.91	4.27	13.43	0.07	5.35	2.45	13.34	1389.27	1.65	0.09	0
SR-20	0-360	*Max*	8.5	2	39.76	93.48	10.16	40.3	0.4	50	24530	22.6	0.34	0.05
		Min	8	0	7.35	3.83	0.07	0	0.4	14.5	8401	2.2	0.07	0.02
		Mean	8.2	0.17	11.03	12.12	1.17	6.18	0.4	25.75	13849.7	8.11	0.14	0.04
		s.e.	0	0.17	2.63	7.4	0.82	3.63	1.0 E-17	3.5	1261.22	1.52	0.02	0
SR-ESCP-01	0-300	*Max*	8.9	8	88.18	374.13	0.8	98.3	5.3	110.8	38120	37.7	0.81	0.08
		Min	7.9	0	13.01	2.2	0.13	0	0.4	7.3	7359	3.3	0.06	0.03
		Mean	8.4	3.09	37.33	59.63	0.39	20.2	1.48	46.06	15234.6	11.65	0.31	0.04
		s.e.	0.1	0.99	7.43	35.62	0.07	10.1	0.49	12.9	3390.61	3.43	0.09	0.01
NA-8.1	0-450	*Max*	8.5	8	170.91	31.22	1.13	174	34.2	96.3	32050	26.3	0.87	0.1
		Min	7.6	0	5.71	2.1	0.25	0	0.4	43.7	19740	10.3	0.06	0.03
		Mean	8.1	2.06	23.51	9.1	0.52	30.5	9.34	65.93	23237.5	15.26	0.29	0.06
		s.e.	0.1	0.61	9.95	2.44	0.06	10.6	2.36	4.42	942.62	0.96	0.06	0
NA-8.2	0-530	*Max*	8.6	5	110	22.61	2.28	70.5	166.8	103.3	32260	20.5	0.63	0.12
		Min	7.7	0	4.76	1.29	-0.07	0	0.4	42.1	17760	9.5	0.06	0.04
		Mean	8.2	0.64	22.47	6.11	0.49	24.3	15.75	62.17	24339.6	15.42	0.19	0.06
		s.e.	0.1	0.28	5.19	1.38	0.12	4.37	7.61	3.94	921.4	0.72	0.03	0
GJ-15B	0-600	*Max*	8.6	0	52.94	217.6	2.29	134	14.5	156.8	58120	27.1	0.3	0.11
		Min	7.6	0	3.64	2.66	0.028	0	0.4	36.6	18450	6.6	0.04	0.05
		Mean	8.1	0	13.46	21.03	0.51	29.1	2.82	79.32	30405	14.63	0.07	0.08
		s.e.	0.1	0	2.56	10.06	0.1	7.24	0.68	6.54	2197.54	1.18	0.01	0
GJ-20	0-550	*Max*	8.5	5	183.64	9.07	1.35	771	19.5	174	30320	84.9	3.37	0.16
		Min	7.6	0	8.1	2.46	0.2	0	0.4	24.9	11580	7.6	0.03	0.02
		Mean	8	2.39	31.89	4.96	0.54	84.1	7.21	86.54	24217.5	24.58	1.06	0.08
		s.e.	0	0.33	6.37	0.35	0.05	29.1	0.84	6.81	843.73	3.2	0.21	0.01
RIF-0748	290-933	*Max*	8.5	n.m.	165.77	0.3	0.16	44.4	2.62	454.1	32.74	72.7	1.11	0.11
		Min	7.6	n.m.	2.48	0.03	-0.0004	15.3	0.32	55.1	16.96	0.4	0.03	0.05
		Mean	8.1	n.m.	36.59	0.09	0.03	30.6	1.05	105.81	27.01	11.59	0.21	0.08
		s.e.	0.1	n.m.	12.5	0.02	0.009	1.84	0.13	24.08	1.02	5.43	0.08	0
RIF-0753	0-930	*Max*	8.4	n.m.	89.19	0.42	0.07	63.2	2.27	433.4	33	102.1	0.75	0.1
		Min	7.7	n.m.	3.38	0.01	-0.0004	17.9	0.32	35.9	16.69	0.4	0.02	0.05
		Mean	8.1	n.m.	18.79	0.11	0.03	38.2	0.82	78.7	24.06	6.84	0.13	0.08
		s.e.	0.1	n.m.	5.51	0.02	0.005	2.45	0.1	17.64	0.94	4.69	0.04	0
RIF-14103	183-597	*Max*	8.3	n.m.	2170.13	18.2	0.16	155	3.72	191.2	30.7	44.1	0.68	0.09
		Min	7.7	n.m.	0.71	0.01	0.003	20.1	0.58	49.3	21.33	0.4	0.02	0.05
		Mean	8	n.m.	569.42	0.95	0.024	40.8	1.32	84.28	24.85	5.22	0.2	0.08
		s.e.	0	n.m.	154.77	0.79	0.007	5.97	0.17	9.17	0.48	2.07	0.04	0
RIF-0749	244-952.5	*Max*	8.4	n.m.	1005.04	1.5	0.38	60.4	1.48	257.4	28740	5.1	0.24	0.09
		Min	7.9	n.m.	6.96	0.004	-0.001	19.3	0.43	44.7	16300	0.4	0.02	0.05
		Mean	8.2	n.m.	175.71	0.2	0.04	36.1	0.76	85.42	24301.4	1.34	0.07	0.07
		s.e.	0	n.m.	94.54	0.11	0.03	3.62	0.08	14.3	981.43	0.38	0.02	0

Table 1. Maximum, minimum, mean, and standard error values of soil characteristics of each respective core from the five sites, collected from 5-10 m depth from the surface.

Characteristics of the 334 samples were identified using the following methods:

- **EA**: C%, N%, C:N
- **XRF**: K, Ca, Mn, Co, U, Cu, V, S, P, Fe, Ni
- **Refractometer**: Salinity (psu)
- **pH probe/meter**: pH
- **DA**: NO_2^-, NO_3^-
- **UV-Vis**: NH_4^+

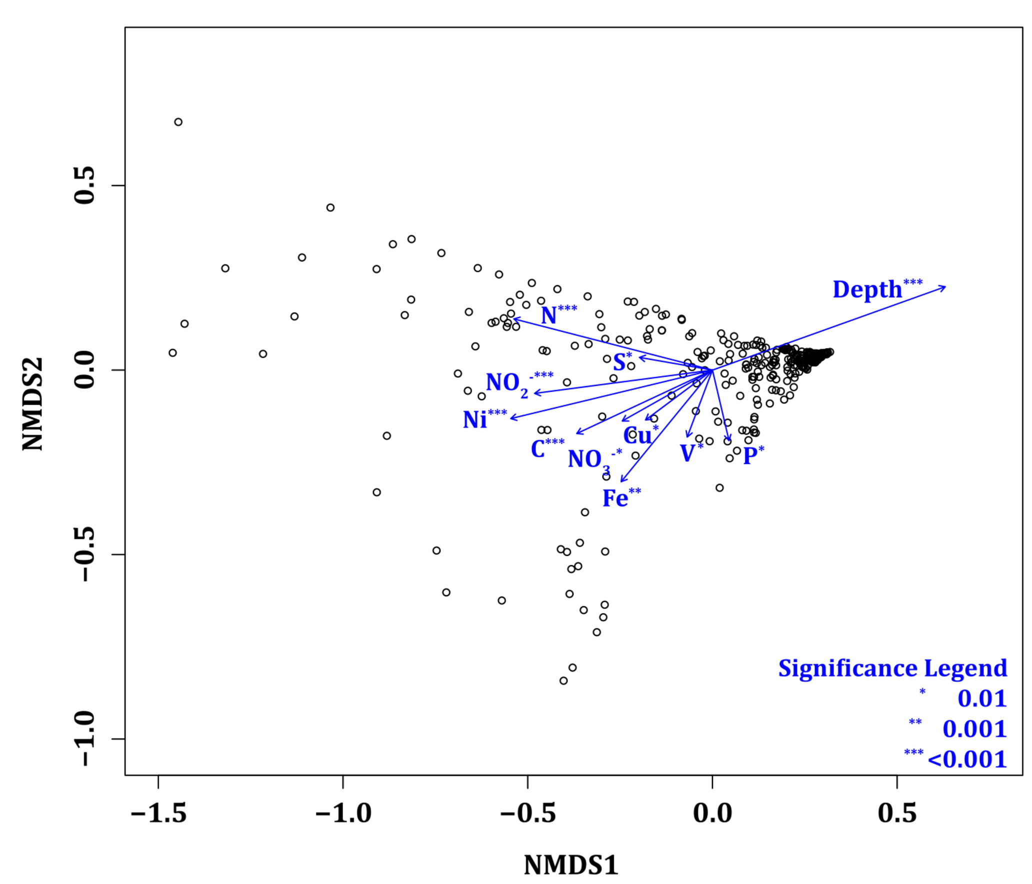


Figure 2. Non-metric multidimensional scaling ordination plot with ammonia-oxidizing archaea and ammonia-oxidizing bacteria abundances as the response variables (○). A high correlation between the % N and the ordination values exists, and the abundances seem to follow the direction of the % N gradient corresponding to depth. Adapted from E.L. Cardarelli, with permission.

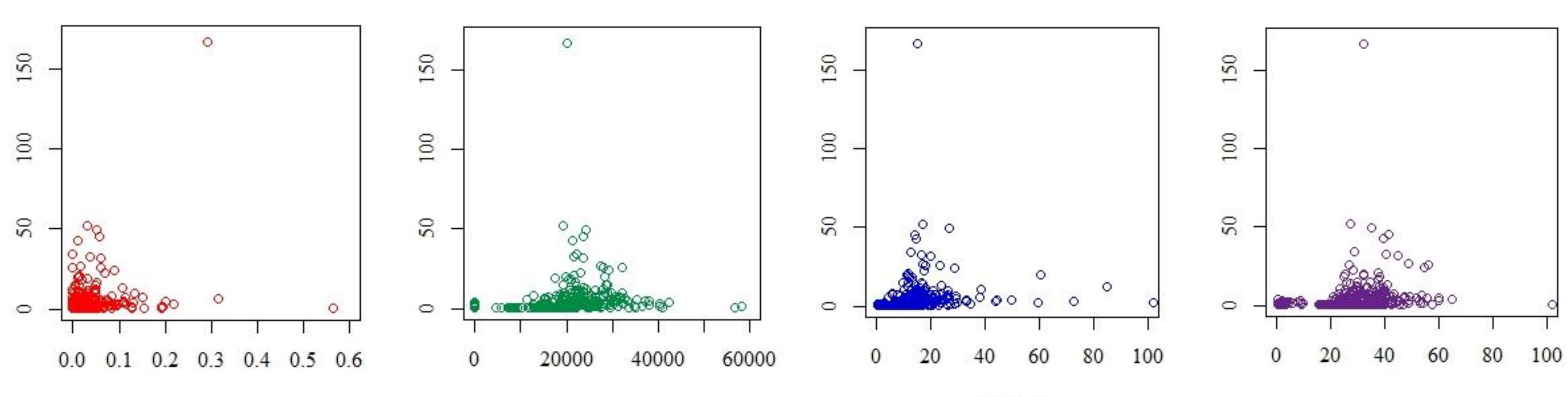


Figure 3. Plots showing elevated peaks between the concentration of uranium in micrograms per gram with respect to total percent nitrogen (○), and micrograms per gram of iron (○), copper (○), and nickel (○) found from all five DOE-LM sites of the Upper Colorado River Basin.

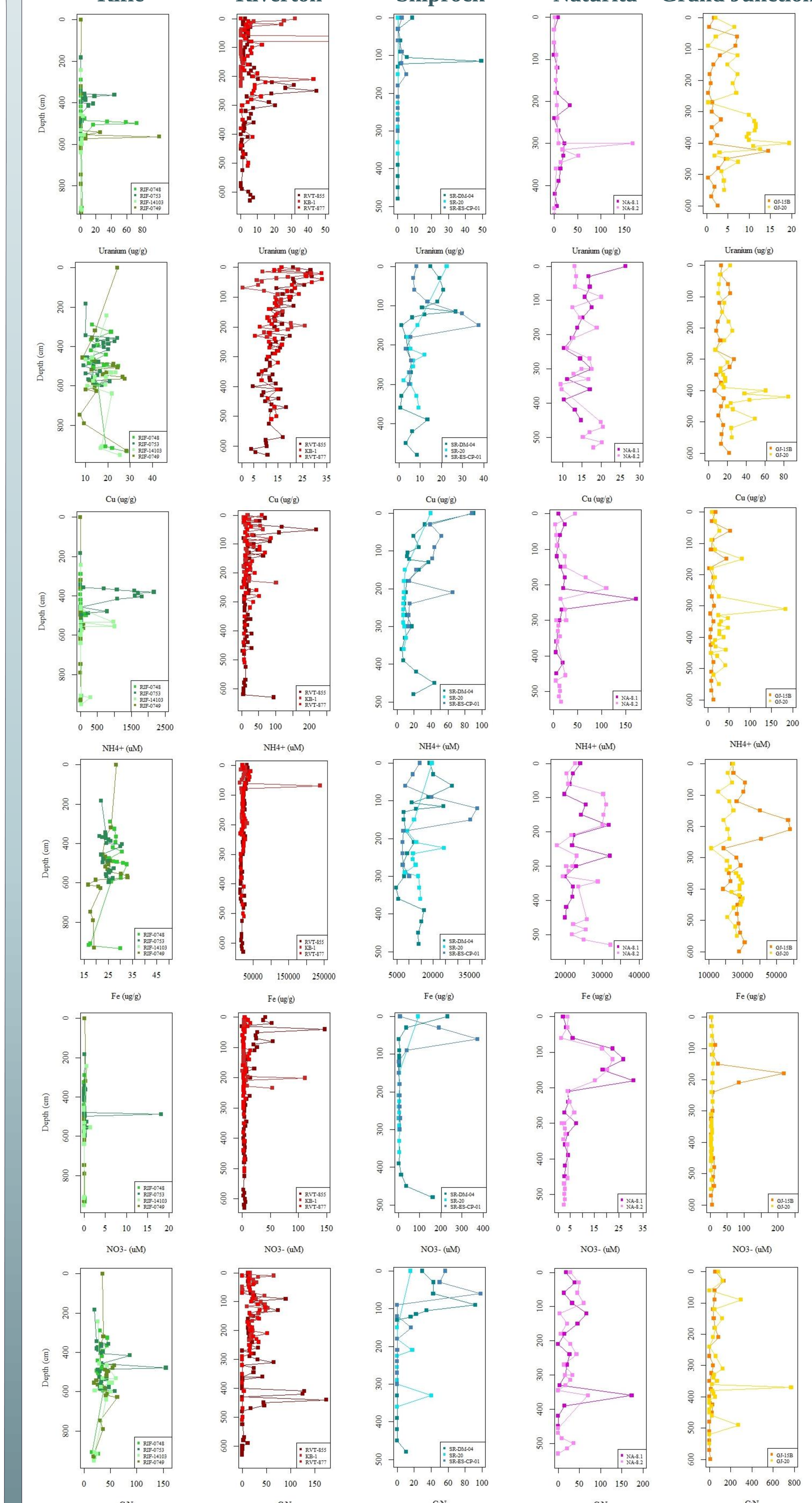


Figure 4. Concentrations of uranium, copper, ammonium, iron, nitrate and carbon:nitrogen (C:N) ratios for each site: Rifle (■), Riverton (■), Shiprock (■), Naturita (■), and Grand Junction (■).

Conclusion

- Elements that show elevated peaks corresponding to uranium concentrations are: nitrogen, vanadium, iron, copper, nickel, sulfur, and phosphorus.
- Overall, the C:N ratio ranged from 0-771
- Salinity values, excluding Rifle, ranged from 0-17 psu; Riverton having the highest salinity.
- Our samples had an average pH of 8.2, a maximum of 9.0 and a minimum of 6.7

This study enhances greater knowledge of elemental distributions throughout the Upper Colorado River Basin, and may help DOE-LM develop regional and site-specific management strategies for future climate scenarios.

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