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By

J. E. Peterson, S. E. Buell, R. A. Cadigan,
J. K. Felmlee, and C. S. Spirakis

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URANIUM RADIUM, AND SELECTED METALLIC-ELEMENT ANALYSES OF SPRING WATER AND TRAVERTINE SAMPLES FROM THE GRAND CANYON, ARIZONA

By J. E. PETERSON, S. E. BUELL, R. A. CADIGAN,
J. K. FELMLEE, AND C. S. SPIRAKIS

Samples for this report were collected from springs and travertine deposits along the Colorado River in the Grand Canyon, Arizona. Sampling was done in April and May of 1976. Data obtained from these samples will be used by R. A. Cadigan and J. K. Felmlee as part of a project designed to determine the value of subsurface waters in prospecting for uranium deposits.

Sample sites were preselected at approximately equal intervals, but river conditions and accessibility forced some modification of the sampling plan at each spring visited, a 2-liter untreated water sample was collected to be analyzed for uranium and radium. At two of the sample locations, an additional 4-liter water sample was collected, filtered, acidified, and later analyzed for the 24 additional elements listed in table 2. A more detailed description of the sampling technique is presented in Brown and others, 1970. All samples were placed in full, tightly capped plastic containers. Temperature and conductivity were measured in the field. Measurements of the pH of the non-acidified samples were made in the laboratory a few weeks after the samples were collected.

An effort was made to collect the freshest possible travertine samples, but the freshness of the samples varied, as noted in the descriptions of the sample sites.

Analyses were performed by laboratories of the U.S. Geological Survey. Radium values were determined by radiochemical methods; uranium, by extraction fluorometry; eU (equivalent uranium), by beta-gamma count; and other elements, by semiquantitative emission spectrography. Table 1 is a description of the sample sites. The analytical results for spring water are presented in table 2. Table 3 gives the analyses of the travertine samples.

Table 1.--Description of sample sites

[River miles measured downstream from Lee's Ferry on the Colorado River. Left and right banks refer to directions while facing downstream]

Sample CF-1: Vasey's Paradise, 36°29'57"N, 111°51'26"W. Coconino County. 4-29-76. River mile 31.9, right bank. Collected 2 liters raw water from spring issuing from Redwall Limestone. Temperature=18°C, conductivity=340. Discharge approx. 2,000 liters/minute (Buell est.). Scintillometer reading (Mt. Sopris Model SC-131A, #396)=20 counts/sec.

Sample CF-2: 36°28'42"N, 111°50'46"W. Coconino County. 4-29-76. River mile 34.1, right bank. Collected grab sample of travertine from stalactite-like mass on Redwall Limestone. No water flowing.

Sample CF-3: 36°28'37"N, 111°50'42"W. Coconino County. 4-29-76. River mile 34.2, right bank. Collected 2 liters raw water from multiple-outlet springs issuing from Redwall Limestone. Temperature=18°C, conductivity=360. Discharge approx. 60 liters/minute (cumulative, all outlets, Peterson est.).

Sample CF-4: Approx. 36°02'45"N, 111°55'30"W. Coconino County. 5-2-76. Approx. river mile 77, left bank, just below Hance Rapid. Difficult landing. Travertine collected from small dry spring at base of Bass Limestone.

Sample CF-5: Travertine Canyon, 36°06'09"N, 112°13'04"W. Coconino County. 5-3-76. River mile 95.4, left bank. Grab sample collected from fallen travertine conglomerate boulder. No water flowing.

Sample CF-6: Garnet Canyon(?), 36°12'50"N, 112°25'15"W. Coconino County. 5-5-76. Approx. river mile 114.5, left bank. Collected fresh (damp) travertine coating red syenite(?) dike and garnetiferous biotite-chlorite gneiss country rock. No water flowing. Scintillometer readings: travertine, 120 counts/sec.; gneiss, 90 counts/sec.; syenite(?), 200-240 counts/sec.

Sample CF-7: 36°12'01"N, 112°25'51"W. Coconino County. 5-5-76. River mile 115.5, left bank, canyon at flexure in Tapeats Sandstone. Collected grab sample of travertine from float boulder, probably from Muav Limestone. No water flowing.

Sample CF-8: Royal Arch Creek (Elve's Chasm) 36°11'50"N, 112°26'56"W. Coconino County. 5-5-76. River mile 116.5, left bank. Collected grab sample of travertine from float boulder at mouth of creek, probably from Muav Limestone. No spring, but water in creek. Scintillometer reading: Approx. 90 counts/sec. everywhere from Elve's Chasm to mouth of Royal Arch Creek.

Sample CF-9: 36°23'22"N, 112°31'00"W. Coconino County. 5-7-76. River mile 136.7, left bank, just below Deer Creek Falls on opposite bank. Fresh travertine, part still damp, collected from mass at base of Tapeats Sandstone. No water flowing.

Sample CF-10: 36°20'44"N, 112°40'15"W. Mohave County. 5-7-76. River mile 147.9, right bank. Collected travertine and 2 liters raw water from spring issuing from Muav Limestone. Temperature=19°C, conductivity=1,350. Discharge=approx. 8 liters/minute (Buell est.).

Sample CF-11: 36°20'47"N, 112°43'29"W. Mohave County. 5-7-76. River mile 151.5, right bank. Collected fresh travertine and 2 liters raw water from spring issuing from Muav Limestone. Temperature=20°C, conductivity=2,130. Discharge=approx. 4 liters/minute (Buell est.).

Sample CF-12: 36°18'36"N, 112°45'45"W. Mohave County. 5-8-76. River mile 155.8, right bank, just above Havasu Creek. Travertine collected from slowly dripping spring under overhanging ledge in Muav Limestone. Insufficient flow for water sample.

Sample CF-13: Havasu Canyon. 36°18'18"N, 112°45'32"W. Coconino County. 5-8-76. River mile 156.7, left bank. Fresh $CaCO_3$ collected with plant material from bottom of Havasu Creek approx. 400 meters from mouth. Insufficient time to search for source springs for water samples.

Sample CF-14: Fern Glen Canyon. 36°15'43"N, 112°55'03"W. Mohave County. 5-8-76. River mile 168, right bank. Travertine and 2 liters raw water collected from main (lowest) dripping spring, issuing from Muav Limestone. Temperature=17°C, conductivity=1,830. Discharge=approx. 4 liters/minute (cumulative, Peterson est.). Scintillometer reading=80-100 counts/sec.

Sample CF-15: Lava Falls. 36°11'39"N, 113°04'59"W. Coconino County. 5-9-76. River mile 179.3, left bank, springs extend for several hundred meters at edge of river, issue from Muav Limestone. Collected fresh travertine from several locations, and 2 liters raw water and 4 liters filtered and acidified water accumulated from several locations (6 ml concentrated nitric acid required to reach pH<2). Temperature=26°C, conductivity=1,340. Discharge (cumulative)=very roughly 2,000 liters/minute (Buell est.). Scintillometer reading=60 counts/sec., steady, no peaks.

Sample CF-16: Pumpkin Spring. 35°54'59"N, 113°19'59"W. Coconino County. 5-11-76. River mile 212.9, left bank. Small travertine-enclosed pool formed by spring issuing from Tapeats Sandstone. Collected 2 liters raw water and 4 liters filtered and acidified water (12 ml concentrated nitric acid required to reach pH<2) from source of spring. Temperature=25°C, conductivity=11,900. Discharge= approx. 2 liters/minute (Buell est.). Scintillometer readings: radiation fluctuates, 380 counts/sec. at "hot spot" about 0.3 meters above source (source is submerged). 420 counts/sec. at overflow point on upriver end of pool. 180-200 counts/sec. elsewhere. Travertine collected from "hot spot" near source, from underwater at source, and from overflow point on upriver end of pool.

Table 2.--Analyses of spring water

[Element values in µg/ℓ except as indicated. Blank spaces indicate no analyses]

Sample number	CF-1	CF-3	CF-10	CF-11	CF-14	CF-15	CF-16
River mile	31.9	34.2	147.9	151.5	168.0	179.3	212.9
Temperature (°C)	18	18	19	20	17	26	25
Conductivity (µmhos/cm at 25°C)	340	360	1,350	2,130	1,830	1,340	11,900
pH	8.2	8.0	8.3	8.3	8.1	7.4	6.7
Ra (µµg/l)	0.15	0.17	0.36	0.66	0.10	0.36	23.0
U	.5	.5	6.4	8.5	3.6	3.5	7.1
Al	---	---	---	---	---	20	210
Ba	---	---	---	---	---	200	100
Be	---	---	---	---	---	<5	<30
Bi	---	---	---	---	---	<30	<200
B	---	---	---	---	---	550	12,000
Cd	---	---	---	---	---	<1	<1
Cr	---	---	---	---	---	<20	<130
Co	---	---	---	---	---	<20	<130
Cu	---	---	---	---	---	<5	<30
Ga	---	---	---	---	---	<10	<60
Ge	---	---	---	---	---	<40	<250
Fe	---	---	---	---	---	20	1,200
Pb	---	---	---	---	---	<20	<140
Li	---	---	---	---	---	230	3,000
Mn	---	---	---	---	---	<20	210
Mo	---	---	---	---	---	<10	<60
Ni	---	---	---	---	---	<20	<130
Ag	---	---	---	---	---	<2	<15
Sr	---	---	---	---	---	390	10,000
Sn	---	---	---	---	---	<20	<140
Ti	---	---	---	---	---	<20	<90
V	---	---	---	---	---	<10	<60
Zn	---	---	---	---	---	<1	10
Zr	---	---	---	---	---	<30	<200

Table 3.--Analyses of travertine samples

[Values in ppm; lower detection limits shown in parentheses; blank indicates not detected; elements not detected in any samples at the limits shown Ag, 0.5; As, 1,000; Au, 20; Bi, 10; Cd, 50; Mo, 3; Nb, 10; Pd, 2; Pt, 50; Sb, 200; Sc, 5; Sn, 10; Te, 2,000; U, 500; W, 100; Zn, 300; P, 2,000; Ce, 200; Ge, 10; Hf, 100; In, 10; Li, 100; Re, 50; Ta, 500; Tl, 50; Eu, 100]

Sample No.--	CF-2	CF-4	CF-6	CF-7	CF-8	CF-9	CF-10
River mile--	34.2	77.0	114.5	115.5	116.5	136.7	147.9
Fe (10)----	2,000	1,500	300	300	200	7,000	7,000
Mg (20)----	15,000	1,000	50	1,500	2,000	15,000	10,000
Ca (20)----	All calcium values exceed 100,000						
Ti (2) ---	150	150	10	5	5	500	500
Mn (1)-----	200	100	7	7	5	70	70
B (20) ----	---	50	20	---	---	---	---
Ba (2)-----	200	30	5	15	70	300	150
Be (1)-----	---	---	---	---	---	---	---
Co (2)-----	---	---	---	---	---	---	---
Cr (1) ----	15	7	2	2	3	7	15
Cu (1)-----	1.5	1	---	---	1.5	7	7
La (30)----	---	---	---	---	---	---	---
Ni (3)-----	---	---	---	---	---	---	3
Pb (10)----	---	---	---	---	---	---	---
Sr (5)-----	700	2,000	1,000	70	200	700	1,000
V (5) -----	5	---	---	---	---	15	15
Y (10) ----	---	---	---	---	---	---	---
Zr (10)----	50	30	---	---	---	70	200
Si (20)----	10,000	20,000	2,000	700	700	70,000	70,000
Al (100)---	7,000	3,000	700	5,000	3,000	20,000	15,000
Na (500)---	2,000	5,000	7,000	---	---	5,000	7,000
K (7,000)--	---	---	---	---	---	7,000	7,000
Ga (5) ----	---	---	---	---	---	5	5
Yb (1) ----	---	---	---	---	---	---	---
eU (10) ---	---	10	10	10	---	20	---

Table 3.--Analyses of travertine samples--Continued

Sample No.	CF-11	CF-12	CF-13	CF-14	CF-15	CF-16
River mile	151.5	155.8	156.7	168.0	179.3	212.9
Fe (10)---	2,000	1,000	200	500	7,000	10,000
Mg (20)---	7,000	7,000	10,000	2,000	7,000	7,000
Ca (20)---	All calcium values exceed 100,000					
Ti (2) ---	150	150	2	70	500	1,000
Mn (1) ---	15	20	5	10	70	300
B (20) ---	---	---	---	---	---	---
Ba (2) ---	30	30	500	20	500	700
Be (1) ---	---	---	---	---	---	1
Co (2) ---	---	---	---	---	---	2
Cr (1) ---	2	2	2	2	15	50
Cu (1) ---	1	1.5	---	1	3	5
La (30)---	---	---	---	---	---	30
Ni (3) ---	---	---	---	---	5	3
Pb (10)---	---	---	---	---	---	10
Sr (5) ---	1,500	1,000	500	700	300	1,000
V (5)-----	5	5	---	---	15	10
Y (10) ---	---	---	---	---	---	15
Zr (10 ---	---	50	---	---	50	500
Si (20)---	15,000	30,000	2,000	10,000	50,000	>100,000
Al (100)--	5,000	3,000	700	1,500	10,000	20,000
Na (500)--	1,500	2,000	1,500	500	3,000	10,000
K (7,000)	---	---	---	---	---	15,000
Ga (5) ---	---	---	---	---	5	7
Yb (1) ---	---	---	---	---	---	2
eU (10)---	---	---	---	---	---	20

REFERENCES CITED

Brown, Eugene, Skougstad, M. W., and Fishman, M. J., 1970, Methods for collection and analysis of water samples for dissolved minerals and gases, Ch. A1: U.S. Geol. Survey Techniques of Water-Resources Inv. TWI 5-A1, 160 p.