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Portable Field Kit for Determining Uranium in Water

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ABSTRACT

The pressing need for on-site field analyses of the uranium content of surface and ground waters has promoted the development of a simple, light-weight, relatively cheap, portable kit to make such determinations in the field. Forty to sixty water samples per day can be analyzed for uranium to less than 0.2 parts per billion. The kit was tested in the field with excellent results.

INTRODUCTION

The search for new uranium deposits has in the past been facilitated by determining uranium content of surface and ground waters by various analytical techniques. The down time, that is the time between when the actual sample is collected and the analytical results are received, can be considerable. It is desirable to have analytical results back within a day and the only feasible way to do this is to have on-site field analyses available. A portable field kit that is relatively inexpensive and light weight has been developed to analyze uranium in waters on site.

The equipment for the portable field kit can easily and safely be packed into a 17" X 32" X 13" standard size metal footlocker and shipped by air to the field site. The kit weighs about 50 pounds and total cost is about $4,500. A description of reagents and apparatus is included later in the paper.

Uranium analyses can be made within a day which means more detailed sampling of highly anomalous areas can be conducted immediately rather than the next field season.

Forty to sixty samples per day can be determined for uranium to less than 0.2 parts per billion. The field kit contains enough reagents to determine 400 samples, but can be increased by the addition of more flux.

In May 1978 the portable field kit was tested in central Arizona with good results. Water samples were collected in the test area from springs, wells, and first-order streams. Samples were collected in 100 milliliter plastic bottles and acidified in the evening of the day of collection with 0.2 milliliter of concentrated nitric acid. Aliquots of the samples were evaporated and fused directly with high carbonate flux as suggested for soils by Grimaldi, Ward and Fuyat in Grimaldi (1954, p. 69) and as further modified by Smith and Lynch (1969, p. 4).

FIELD KIT REAGENTS AND APPARATUS[1]

The following list of equipment and reagents are needed for the uranium field kit:

1	Fluorometer, Jarrell-Ash, model GM
20	Platinum dishes, 30 mm X 10 mm
1	Electric hot plate, 9" X 10"
1	Platinum tongs
1	Fisher L. P. Burner
2	Propane bottles, 14 or 16 oz. size
1	Propane torch and hose
1	Halo support (for triangle support)
1	Triangle, 1 1/2" size, nichrome wire covered with silica tubing
2	Asbestos pads (one to cover top of hot plate, one to place hot platinum dishes on)
1	Pair of safety glasses
1	Wire mesh screen, 5" X 5" stainless steel
1	Beaker, 600 ml
1	Stop watch
1	Pipet, 10 ml, serological
1	Pipet, 10 lamda

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[1]The use of brand names is for descriptive purposes only and does not necessarily constitute endorsement by the U.S. Geological Survey.

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1 Measuring scoops, 1/2 teaspoon and 1/8 teaspoon (to measure 2.0 grams flux)

1 Flux, 800 grams in a plastic bottle

1 0.001 percent uranium standard, in 2.4 N nitric acid

1 Hydrochloric acid, 500 ml 6 N in plastic bottle

It should be noted that it is illegal to ship propane bottles and hydrochloric acid by air without a special form. These forms can be obtained from the airline. These items can be purchased locally in the field.

About thirty or more samples can be fused with one 14 ounce bottle of propane.

Standard uranium discs can be taken along to calibrate the instrument. If kept in a plastic bag the discs will remain stable for several days to a week.

REAGENTS

Flux is made with 364 grams each of anhydrous sodium carbonate and potassium carbonate and 72 grams of sodium fluoride; mix the reagents thoroughly and grind to approximately 80 mesh using a Braun ceramic-plated pulverizer. Thoroughly mix the flux again after grinding.

The 0.1 percent uranium stock standard is made by dissolving 0.211 grams certified ACS uranyl nitrate [$UO_2(NO_3)_2 \cdot 6H_2O$] in 100 milliliters of concentrated nitric acid (15 milliliters) and demineralized water (85 milliliters). The 0.001 percent uranium working standard is made by diluting 1 milliliter of the 0.1 percent uranium standard to 100 milliliters of concentrated nitric acid (15 milliliters) and demineralized water (85 milliliters). These standards are stable for more than a year.

PROCEDURE

Measure twenty milliliters of the water sample into a platinum dish and evaporate on a small electric hot plate. Ignite the evaporite (ignition stage) to red heat over a propane burner, cool, and add 2.0 grams of the flux. Fuse the sample with the flux over the propane burner to the hot liquid stage for exactly three minutes. Cool the fused sample on a level surface, then turn the platinum dish upside down to release the disc. Scrape the edges of the disc with a stainless steel wire mesh screen to facilitate fitting it into the fluorometer. Measure the uranium content of the disc in the fluorometer.

Starting with the ignition stage, standards and blanks are prepared in the same way as the samples.

Carefully measure ten microliters of 0.001 percent uranium standard into a platinum dish; very carefully evaporate the measured standard to dryness then ignite to red heat and cool; add flux and proceed as with samples. This standard is equal to 0.1 microgram uranium and is used to calibrate the fluorometer. Set the fluorometer to the 0.1 sensitivity scale and the 0.1 microgram standard to read 50. The fluorometer response is linear. To calibrate for higher uranium values use 100 microliters of the 0.001 percent uranium standard. Set the fluorometer to the 1.0 sensitivity scale and the 1.0 microgram standard to read 50. The blank reading is subtracted from all standard and sample readings in order to make correct calculations of ppb uranium.

The formula for calculating ppb uranium is:

$$\text{ppb uranium} = \frac{\dfrac{0.1 \times (\text{sample reading} - \text{blank})}{50 - \text{blank}}}{20} \times 1000$$

Clean the platinum dishes after each use by soaking them in 6 N hydrochloric acid solution for five minutes, then rinse with tap water and dry.

ANALYTICAL FIELD RESULTS

The portable field kit was flown from Denver to Arizona in May 1978. The field site analysis was located in a motel near an ongoing geochemical sampling program area conducted by members of the U.S. Geological Survey.

Sixty water samples were initially analyzed so that further investigation of the area for uranium potential could be immediately carried out if some of the samples turned out to be high in uranium.

Tables 1, 2, and 3 show the results of the samples analyzed in the field.

TABLE 1.--Uranium content of stream waters from central Arizona in ppb

Sample number	ppb
11W	<0.2
15W	<0.2
32W	0.2
49W	<0.2
72W	<0.2
129W	3.5
132W	<0.2
159W	<0.2
161W	0.4
164W	0.2
165W	<0.2
167W	<0.2
183W	1.7
204W	<0.2
300W	1.3
303W	1.3
304W	0.5
307W	0.9
308W	0.8
309W	<0.2
315W	0.7
316W	<0.2
317W	0.4
320W	0.7

TABLE 2.--Uranium content of spring waters from central Arizona in ppb

Sample number	ppb
4W	0.8
15A	0.3
16W	1.2
52W	<0.2
90W	<0.2
94W	<0.2
120W	0.7
138W	0.2
158W	0.7
160W	0.2
163W	<0.2
171W	<0.2
177W	0.4
195W	2.0
200W	0.2
201W	<0.2
202W	0.8
203W	<0.2
205W	<0.2
207W	<0.2
208W	<0.2
301W	0.2
302W	0.3
305W	1.1
306W	1.3
310W	1.7
311W	0.3
312W	0.7
313W	<0.2
314W	<0.2
319W	0.3
322W	0.9
2001W	50.4

TABLE 3.--Uranium content of well waters from central Arizona in ppb

Sample number	ppb
17W	1.6
189W	5.4
321W	0.4
323W	1.3

PRECISION DATA

Table 4 lists the uranium content, standard deviation, relative standard deviation, pH, and conductivity of six selected water samples from field areas in Arizona and Colorado.

TABLE 4.--Precision of field site determination

Sample Number	pH	Conductivity μmhos/cm	Values of 5 replicates (ppb)		Standard deviation (ppb)	Relative standard deviation (percent)
			Range	Mean		
1 (Ralston Creek)	6.81	43	1.20- 1.96	1.48	0.15	9.95
2 (Soda Springs)	6.43	7,100	8.70-10.00	9.22	.28	3.08
3 (Ute Springs)	7.25	310	1.52- 2.39	2.09	.17	8.09
4 (320 W)	7.20	450	.64- .75	.71	.05	7.04
5 (323 W)	7.60	750	1.28- 1.49	1.38	.03	2.17
6 (2001 W)	7.10	510	50.4-52.6	51.7	.60	1.16

REFERENCES

Grimaldi, F. S., 1954, Collected papers on methods of analysis for uranium and thorium: U.S. Geol. Survey Bulletin 1006, 184 p.

Smith, A. Y., and Lynch, J. J., 1969, Field and laboratory methods used by the Geological Survey of Canada in geochemical surveys, 11. Uranium in soil, stream sediment, and water: Geological Survey of Canada Paper 69-40, 9 p.