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The Effectiveness of Stream-Sediment Sampling Along the Rio Ojo Caliente, New Mexico

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Introduction

Uranium occurrences in pegmatites of the Petaca-Ojo Caliente area, Rio Arriba County, N. Mex., have been recognized since 1930. The presence of anomalous uranium in this region was reflected in a surface-water sample, but not in the stream-sediment sample, taken from the Rio Ojo Caliente in 1975 during a general geochemical-sampling-technique study. During 1976 a detailed geochemical study was conducted of the water and stream sediments in the tributaries of the Rio Ojo Caliente above the USGS gaging station 4 km below La Madera to determine (1) the source of the anomaly in the water and (2) why the stream-sediment samples did not contain a corresponding anomaly.

Geology

The rocks in the Petaca-Ojo Caliente area are predominantly Precambrian quartzites and quartz-mica schists with lesser amounts of Precambrian amphibole schists, meta-rhyolites, and a medium-grained granite. These Precambrian units are transected by pegmatite bodies and quartz veins containing sparsely disseminated crystals of uranium minerals (Jahns, 1946). The most abundant uranium-bearing mineral is samarskite; but uraninite, occurring as crystals in albite and quartz, gummite, uranophane, monazite, sabugalite, and meta-torbernite are also present. No Paleozoic or Mesozoic rocks are exposed in the area above La Madera, although the Tertiary Carson Conglomerate (conglomerates overlain by tuffaceous sandstone) and the Santa Fe Formation are present in the vicinity of Las Tablas and northeast from La Madera respectively. Quaternary basalts cap many of the mesas, and Quaternary

alluvium has been deposited to form flat valley bottoms in some places along the Tusas and Vallecitos Rivers.

Shipments of uranium ore from the Petaca-Ojo Caliente area have not been of economic grade. "Attempts have been made in the past to recover samarskite as a by-product of mica mining, and a few thousand pounds have been marketed for niobium and tantalum" (Chenoweth, 1974).

Uranium Content of the Stream Sediments

Two size fractions from the stream sediments were analyzed: (1) the <150 µm (100 mesh) and (2) the <90 µm (170 mesh) fractions. Uranium values for samples <150 µm are shown in figure 1; only one sample containing 6.7 ppm uranium, barely above the anomaly threshold of 5.8 ppm, was determined to be anomalous (taken as two standard deviations above the mean). This sample from La Jara Canyon above Vallecitos was far removed upstream from the sites containing anomalous uranium concentrations in water. The source of the uranium anomaly in the waters of the Rio Ojo Caliente at the USGS gaging station below La Madera was readily traced through water sampling from the Rio Ojo Caliente up Canada de la Cueva to a ground-water source (Wenrich-Verbeek, 1977b). These anomalous water samples were an order of magnitude above background, yet neither the Rio Ojo Caliente nor Canada de la Cueva stream-sediment fractions <150 µm contained anomalous uranium concentrations.

If the sample is restricted to the fine fraction, <90 µm, sediments from these two streams do contain anomalous uranium concentrations, although not to the extent of the water samples. Uranium concentrations of 9.6 and 11.1 ppm respectively, shown in figure 2, are above the background value of 8.4 ppm. The restriction of the anomalous uranium to the fine size fraction reflects the role adsorption properties of fine particles play in the incorporation of uranium from the water onto the stream sediments. Hence, if the

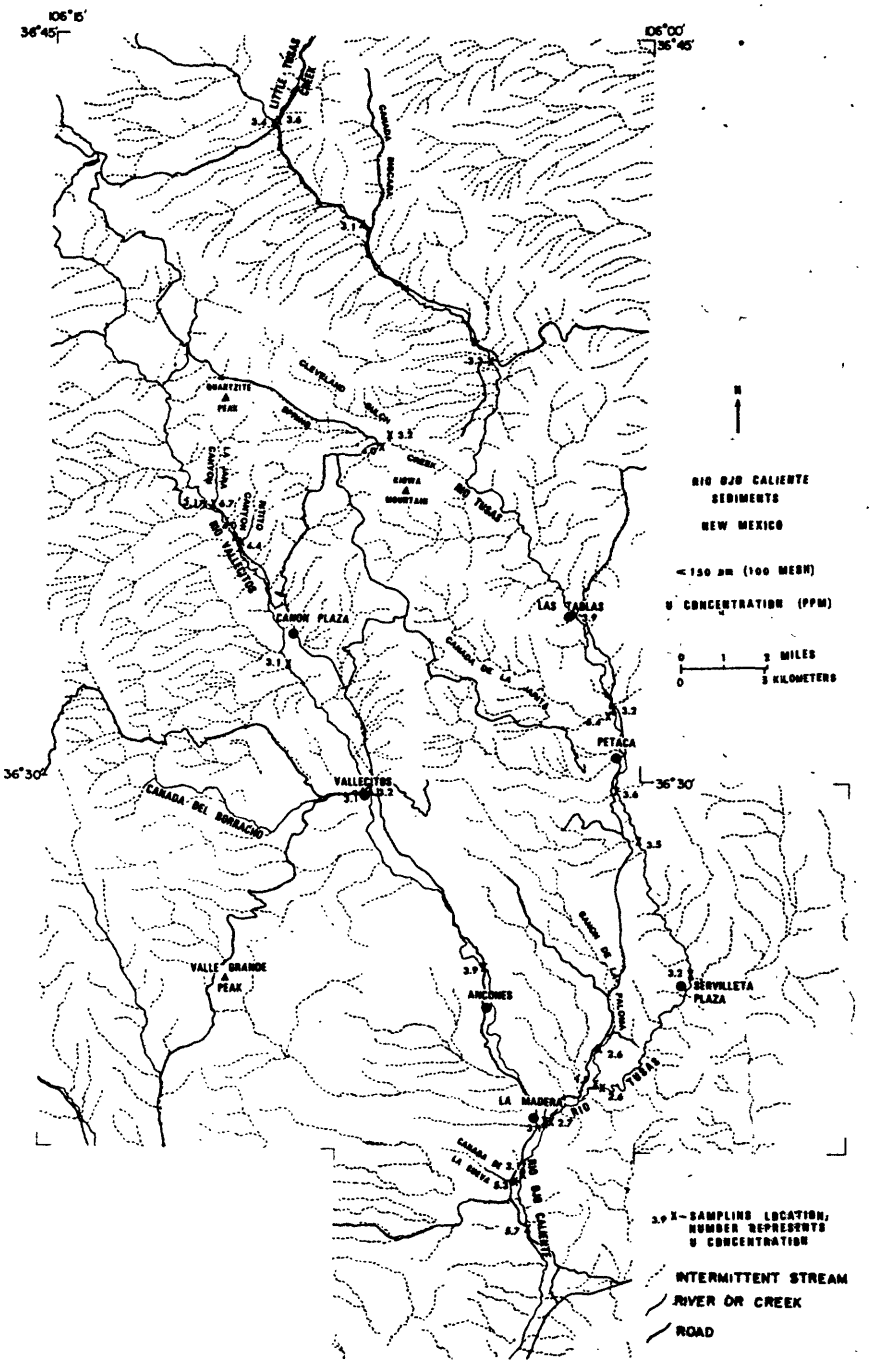

Figure 1. Map of the Rio Ojo Caliente drainage basin, Rio Arriba County, N. Mex., showing uranium concentration (ppm) in stream sediments for the <150 µm size fraction. One site, La Jara, is barely anomalous - the remainder are below the anomaly threshold of 5.8 ppm.

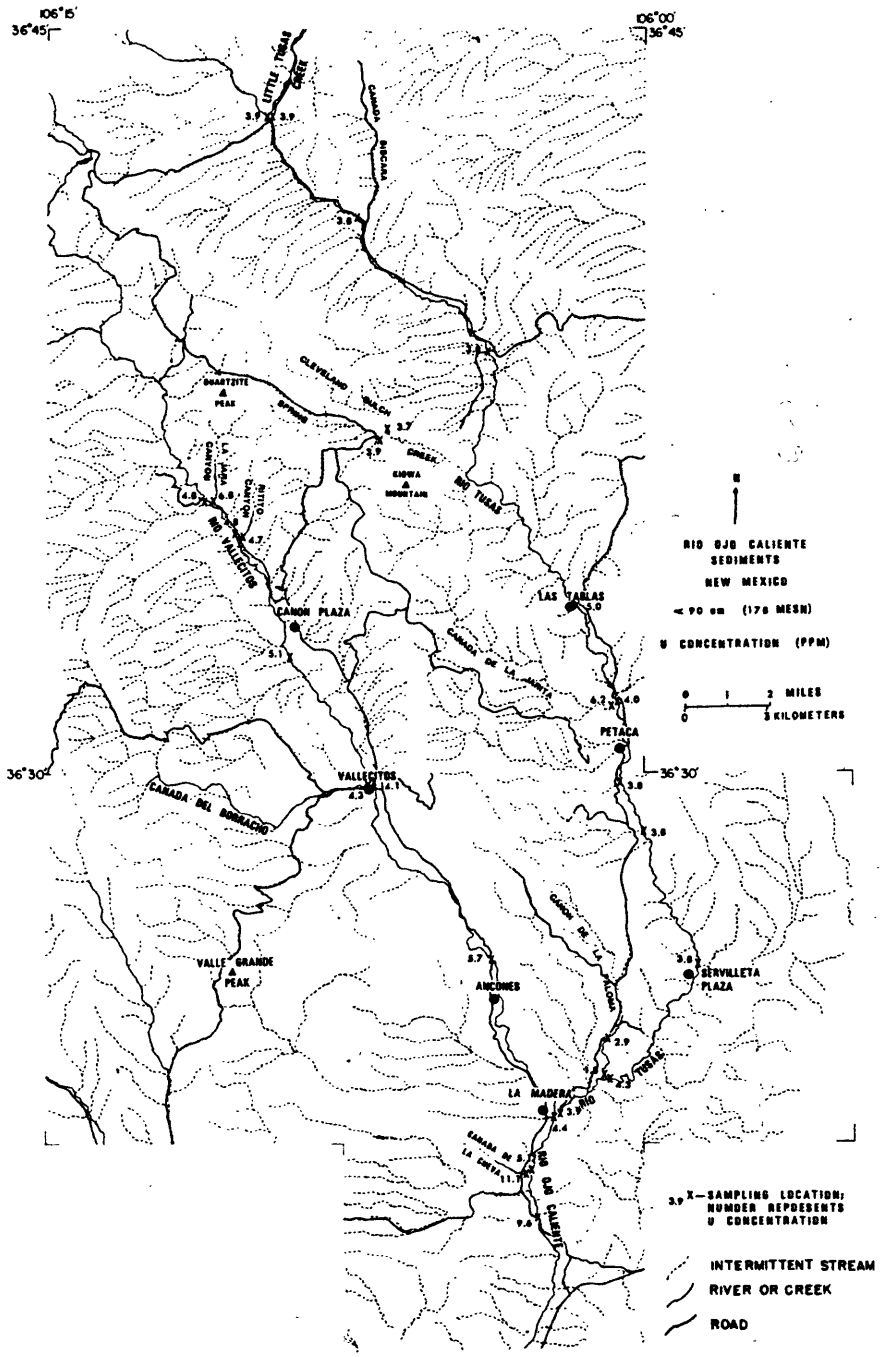

Figure 2. Map of the Rio Ojo Caliente drainage basin, Rio Arriba County, N. Mex., showing uranium concentrations in stream sediments for the fine size fraction, < 90 μm. Two sites, Rio Ojo Caliente below Canada de la Cueva and Canada de la Cueva, contain low anomalous uranium concentrations (above the anomaly threshold of 8.4 ppm).

search for buried uranium deposits is a major consideration, then sampling should be restricted to the fine sediment fraction (<90 μm), which can better delineate a uranium halo brought to the surface by ground water than can the coarse fraction. Nevertheless, in most regional reconnaissance surveys, the anomaly threshold for the fine sediment fraction is frequently higher than 7.8 ppm and these streams would, therefore, not be investigated further..

Correlations between Uranium and other Elements

Correlation coefficients were determined between uranium and 32 trace and major elements in the stream sediments for four different groups: (1) all samples for the <150 μm size fraction, (2) all samples for the <150 μm size fraction except those for the Rio Ojo Caliente at the USGS gaging station and Canada de la Cueva, (3) all samples for the 150 to 90 μm size fraction, and (4) all samples for the <90 μm size fraction.

The element correlations and their significances are listed in Table 1. With the exception of the coarse 150 to 90 μm size fraction (3), the significant correlations are relatively consistent for the data groups. Fewer elements correlate significantly with uranium in the coarse fraction; two, Pb and Se, correlate significantly (at the 99% confidence limit) with uranium only in the coarse fraction. This is readily explained by the lack of significant adsorption effects on both Pb and Se (both have a 0.0 correlation coefficient with grain size), which appear to be one of the primary controls on uranium in the fine fraction. In the coarse fraction, the association of these elements with uranium may be due to their coexistence in the same or similar mineral phases.

Some elements show significant correlations in only the fine sediment fraction: Al, Mg, Sc, and Ga show negative correlations and La, a positive

Table 1. Correlation coefficients between uranium and coexisting elements in stream sediments
** Significant at the 99% confidence limit; * Significant at the 95% limit

Coexisting Elements	All Samples < 150µm			Samples <150µm except ones with anomalous U			All Samples 150 - 90µm			All Samples < 90µm		
	r	n	Sign.	r	n	Sign.	r	n	Sign.	r	n	Sign.
Th	0.74	54	**	0.60	52	**	0.37	28	*	0.76	27	**
SiO_2	-0.09	54		-0.20	51		-0.28	28		0.31	27	
Al_2O_3	-0.12	54		0.16	51		-0.01	28		-0.68	27	**
Fe_2O_3	0.26	54		0.18	51		0.20	28		0.35	27	
MgO	-0.18	54		-0.12	51		-0.17	28		-0.45	27	*
CaO	-0.23	54		-0.29	51	*	-0.27	28		-0.32	27	
Na_2O	-0.36	54	*	-0.25	51		-0.34	28		-0.54	27	**
K_2O	0.05	54		0.06	51		0.18	28		-0.01	27	
TiO_2	0.51	54	**	0.28	51	*	0.23	28		0.62	27	**
P_2O_5	0.22	54		0.43	51	**	0.32	28		-0.29	27	
MnO	0.20	54		0.35	51	**	0.53	28	**	-0.11	27	
Ba	0.01	54		-0.20	52		-0.32	28		0.06	28	
Be	0.34	54	*	0.25	52		0.32	27		0.38	28	*
Co	0.07	54		0.01	52		0.21	27		-0.06	28	
Cr	0.12	54		0.15	52		0.01	28		-0.08	28	
Cu	0.04	54		0.06	52		0.13	28		-0.23	28	
La	0.36	54	**	-0.00	21		-0.17	8		0.54	15	*
Nb	0.21	54		0.27	52	*	0.23	28		0.29	28	
Ni	-0.10	54		-0.11	52		-0.02	28		-0.30	28	
Pb	0.18	54		0.27	52	*	0.45	28	*	0.02	28	
Sc	-0.05	54		-0.04	50		-0.12	25		-0.39	28	*
Sr	-0.41	54	**	-0.42	52	**	-0.52	28	**	-0.46	28	*
V	0.29	54	*	0.19	52		0.24	28		0.27	28	
Y	0.35	54	**	0.41	52	**	0.24	28		0.21	28	
Zr	0.61	54	**	0.48	52	**	0.34	28		0.56	28	**
Ga	-0.15	54		0.10	52		0.13	27		-0.55	28	**
Yb	0.48	54	**	0.50	51	**	0.29	27		0.35	27	
Nd	0.25	54		0.18	24		0.03	9		0.00	17	
As	0.57	54	**	0.58	52	**	0.74	28	**	0.43	28	**
Zn	0.24	54		0.22	52		0.31	28		0.09	28	
Grain Size	0.48	54	**	0.53	52	**						
Se	0.22	54		0.58	18	*	0.78	11	**	0.14	7	

correlation with uranium. These correlations are important because the negative correlation between Al_2O_3 (Ga substitutes commonly for Al in crystal lattices) and perhaps also Mg indicates that the sediment phase adsorbing uranium in the Petaca area is not clay. No significant correlation in any of the four groups exists between uranium and Fe_2O_3; hence, this also is not an adsorption medium for uranium in this area. The uranium is being adsorbed onto organic material, as a significant correlation exists between uranium and organic carbon, as well as inorganic carbon, which suggests the association of uranium with carbonate compounds. It might also be mentioned that anomalous amounts of Fe were encountered in the sediments of Cleveland Gulch, which contains an iron-rich schist (Jahns, 1946); this illustrates the ease with which Fe shows up in the sediments when available in significant quantities.

The strongest significant correlations are shown between U and Th, As, Zr, TiO_2 (particularly in the fine fraction), Na_2O (negative), and Sr (negative). Highly significant correlations commonly exist between U and Th and As in stream sediments (Wenrich-Verbeek, 1977a); Th and As appear to be the most commonly associated elements with uranium. Abundant ilmenite exists in the quartz veins and quartz-rich pegmatites in this area, which also contain samarskite, probably accounting for the U and Ti association. When the anomalous samples, those controlled by adsorption of uranium rather than the local mineralogy, are removed, P_2O_5 shows a significant correlation at the 99% confidence limit with uranium. This, of course, is a reflection of such phosphate minerals in the stream sediments contributing uranium as monazite, sabugalite, and metatorbernite. The sediment sample from La Jara Canyon that contained anomalous uranium in the <150 µm size fraction also contained anomalous P_2O_5, strongly suggesting that the uranium

was included in the sediment as detrital grains of the above U-bearing phosphate minerals and is consequently not a reflection of a buried deposit.

An R-mode factor analysis was run on these sediment samples. With four factor groups, only 62% of the variation was explained and many secondary relations and moderately low factor loadings existed, suggesting that a large number of different geochemical and mineralogical conditions are controlling the elements in this area. For instance, at least four controls exist on the uranium in sediments in this area: (1) the amount of uranium in the ground-water source, (2) its ability to be adsorbed onto the sediments, (3) the amount of uranium in the samarskite-bearing pegmatites, and (4) the ability of the uranium-bearing minerals to reach the stream channels and be transported.

Conclusions

The low uranium content of the stream sediments from these high uranium waters can be explained by (1) the presence of a ground-water source for the uranium and (2) insufficient time for the uranium in the water to be adsorbed onto the sediments. Although a stream sediment anomaly in the streams containing high uranium waters can not be established with a size fraction <150 μm, enough uranium has been adsorbed by the fine fraction that a small local anomaly can be outlined using only the fraction size <90 μm. Thus, because adsorption appears to be a major control on the uranium in the fine fraction and detrital minerals control the uranium in the coarse fraction, if we assume that buried deposits are of prime importance because most surface deposits have been recognized, then sampling should be restricted to the fine fraction (<90 μm). Nevertheless, in a case where ground water is the contributing source for uranium, as was shown above by the low anomalous uranium values, even in the fine fraction, stream-sediment sampling

alone is not an effective technique for detecting uranium anomalies. This emphasizes the necessity of water sampling in conjunction with stream-sediment sampling.

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