

**U. S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY**

**Geochemical Anomalies in the Vicinity of the
Three Rivers Area, Otero Co. , New Mexico**

by

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Open-File Report 97-261

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INTRODUCTION

In the Spring of 1996, field work was carried out in support of a mineral resource and environmental geochemical investigation of the Caballo Resource Area in south central New Mexico in Otero and Sierra Counties, on lands administrated by the U. S. Bureau of Land Management, Las Cruces, New Mexico. This report describes the potential for rare earth element (REE) and Au mineralization in the Three Rivers area.

Study Area

The study area is located approximately 32 miles north of Alamogordo, New Mexico in northeastern Otero County (Fig. 1). The study area lies within the northern Chihuahuan desert. The climate is semi-arid with hot dry summers and mild winters. Vegetation is mostly mixed desert scrub and desert grassland.

The study area lies within the Sacramento section of the Basin and Range physiographic province (Fenneman, 1931). The area is characterized by small Tertiary-age (?) alkaline igneous rocks that intrude Triassic and Cretaceous sediments. Much of the surface is low relief and consists of coalescing alluvial fans whose source is the Godfrey Hills and the western flank of Black Mountain to the east.

The upper reaches of Three Rivers is the only perennial stream in the study area. A dendritic pattern of ephemeral streams is present and after storms, these ephemeral streams may flow for short periods of time. The study area drains into Three Rivers and the Tularosa Basin. Regional ground water flow, based on ground water surface elevations (Fig. 2), is to the Tularosa Basin to the west. The source of recharge to the water bearing formations is local precipitation and runoff from the upper western slopes of Black Mountain to the east.

Geology

The study area lies along the southwestern side of the Godfrey Hills and northwest of the Black Mountain stock. The Godfrey Hills consists of Walker Andesite Breccia overlain by the Godfrey Hills Trachyte (Thompson, 1972). The Black Mountain stock consists of hornblende syenite, quartz syenite, and alkali gabbro-syenogabbro (Moore and others, 1988). Underlying sedimentary rocks consist of Cretaceous Mesaverde Group, Cretaceous Dakota Sandstone, Permian San Andres Limestone, and Permian Yeso Formation. Within the study area, small outcrops of Tertiary (?) lamprophyre and trachyte dikes and sills intrude the sedimentary rocks. Most of the surface is low relief and covered with Recent sediments consisting of coalescing alluvial fans whose source is the Godfrey Hills and the western flank of Black Mountain to the east.

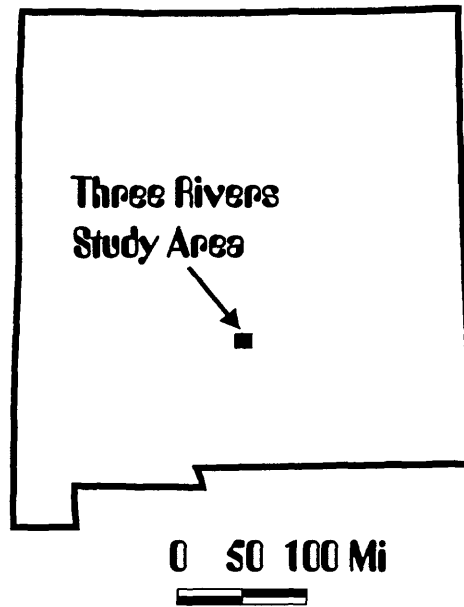


Figure 1. Location map showing the Three Rivers area

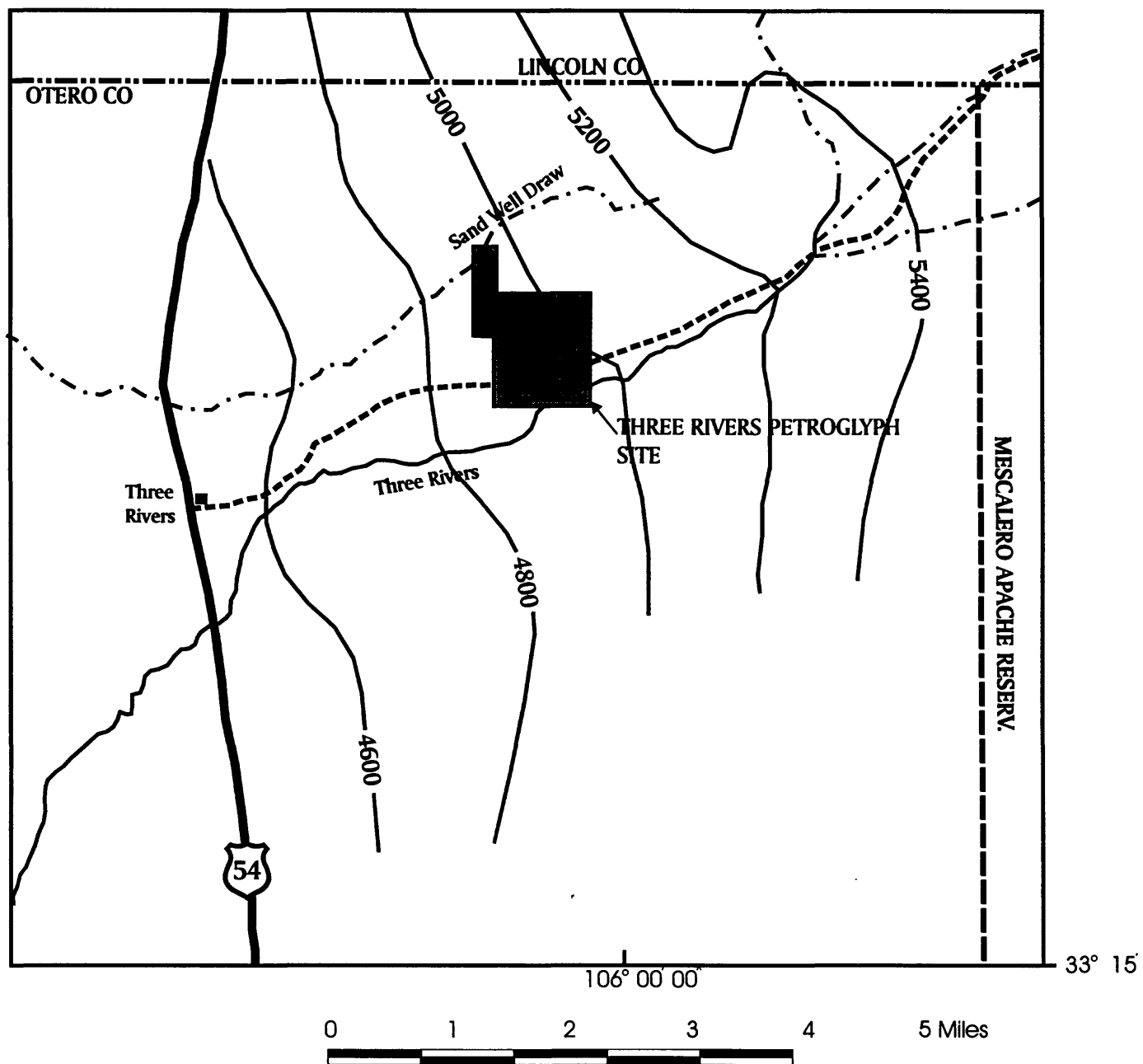


Figure 2. Map showing showing contours on the water table in feet in the Three Rivers study area

Mining History

The area has probably been prospected for a variety of metals, but to date, no development or production has occurred. The closest mining took place in the Three Rivers district to the east and the Tularosa district, approximately 10 miles southeast of the study area. Small amounts of Fe ore from replacement iron-copper deposits were mined in the Three Rivers district (Harrer and Kelley, 1963). The Tularosa district contained sandstone-hosted red-bed type copper mineralization. The production is not known but was probably small (Anderson, 1957). Alkaline igneous rocks are present in the vicinity of the study area and are known in New Mexico to have potential for deposits of gold and silver deposits (North and McLemore, 1988).

Methods

Waters were collected from 4 wells, 5 springs, and Three Rivers (Fig. 3) within the study area during April 25-26, 1996. Generally, wells were pumping prior to arrival at the site. If the wells were not pumping, they were allowed, if possible, to pump for 15 minutes before collecting the sample. Temperature, pH, and conductivity were measured at the site. Samples were collected into high-density polyethylene acid-washed bottles. For the dissolved cation analyses, a 60-ml sample was filtered through a 0.45 μm -membrane filter and acidified with reagent-grade concentrated nitric acid to $\text{pH} < 2$. A second 60-ml sample was collected and acidified without filtering to determine total cations in solution. A 125-ml sample was filtered but not acidified for anion analyses. The samples were stored in an ice chest and kept cool until analyzed.

Upon return to the laboratory, alkalinity as HCO_3^- , was determined by titration with H_2SO_4 using a Grans plot technique (Orion Research, Inc., 1978). Ca, Mg, Na, K, and SiO_2 were determined by flame atomic absorption spectrophotometry (Perkin-Elmer Corp., 1976). Sulfate, chloride, nitrite + nitrate, and fluorine were determined by Water Resource Division (W. D'Angleo-analyst) by ion chromatography (Fishman and Pyen, 1979). The remaining elements were analyzed by ICP-MS by ACTLABS, Wheatridge, Colorado.

Stream sediments were collected by compositing the sample across the width and depth of the active drainage channel. The drainages were dry at the time of collection. In the laboratory, the samples were sieved at 0.180 μm and the less than fraction analyzed by instrumental neutron activation analysis or inductively coupled plasma emission after total digestion by ACTLABS, Wheatridge, Colorado.

RESULTS

The chemical analyses for the 10 water samples (Fig. 3) are shown in Table 1. The waters are high in dissolved solids. Conductivity ranges from 1504 to 5090 $\mu\text{S}/\text{cm}$. The pH values range from 7.16 to 8.18. The waters are fresh to slightly saline and classified according to

Table 1. Chemical analyses of well waters collected in the Three Rivers area, south-central New Mexico

Site No.	Comments	pH	Conductivity uS/cm	Temperature Centigrade	Ca ppm	Mg ppm	Na ppm	K ppm	SiO ₂ ppm	Alkalinity ppm
TR01	Sand well	7.16	2420	20.2	380	62	170	1.9	25	183
TR02	New well	7.25	2040	19.7	240	61	150	3.9	28	141
TR04	Three Rivers	7.61	1990	18.6	330	45	110	0.9	24	281
TR05	Fall spring	7.72	3010	12.7	570	64	140	2.5	23	205
TR06	Crawford spring	7.38	1504	18.5	185	49	77	7.2	65	153
TR07	Golondrina well	8.14	1685	17.9	220	49	100	2.4	37	165
TR08	Crawford well	7.26	1620	24	220	61	56	7.2	73	140
TR26	Kitty spring	7.24	4800	19.9	670	180	370	7.2	24	177
TR27	Aguilar spring	7.28	5090	19.9	680	270	350	7.3	21	233
TR28	Crosby spring	8.18	4400	20.6	660	190	280	8.2	22	120

Table 1 (cont.)

Sulfate ppm	Cl ppm	F ppm	NO ₂ +NO ₃ ppm	Cu ppb	Zn ppb	Li ppb	Al ppb	Cr ppb	Mn ppb	Fe ppb	Co ppb	Ni ppb
1000	220	0.3	3	8.2	45	27	52	23	5.8	122	1	4.2
750	210	0.9	2.6	6	305	41	17	12	5.4	133	0.6	5.3
720	190	0.6	<0.02	1.2	2	14	21	7	5.6	45	0.6	2.1
1200	390	0.2	<0.02	1.8	10	16	40	13	23	93	1.1	4.7
510	160	0.8	3	1.8	21	29	9	6	0.3	34	0.3	1.3
770	90	1	<0.02	2.4	9	15	19	5	8.9	114	0.5	<0.02
560	180	0.6	4.4	17	380	26	22	6	3.6	47	0.4	1
2000	620	0.8	1.3	2	37	25	23	15	461	124	1.8	4.2
2200	780	0.9	<0.02	1.8	7	43	21	17	720	61	1.8	6.7
2000	620	0.9	0.73	2.1	8	26	18	15	3.2	53	1.1	4.4

Table 1 (cont.)

As ppb	Se ppb	Br ppb	Mo ppb	U ppb	Pb ppb	La ppb	Ce ppb	Pr ppb	Nd ppb	Tb ppb	Yb ppb	Lu ppb
1.8	4.3	360	3	5.3	1.7	34	60.0	9.7	23.0	4.3	3.2	4.2
1.1	7.4	419	5.4	4.1	1	4.7	8.4	1.9	3.0	0.9	0.8	0.83
1	4.1	276	8	4.1	0.8	1.7	3.3	0.6	1.2	0.3	0.3	0.34
1.6	4.5	517	2.8	3.1	0.8	2	3.9	0.8	1.3	0.4	0.3	0.45
1	6.6	262	3.3	2.8	0.6	0.39	0.8	0.1	0.2	0.1	0.1	0.13
1.3	1.5	134	10	2.9	0.5	0.58	1.1	0.2	0.4	0.2	0.1	0.09
1.3	5.9	276	4.1	4.1	3.3	0.48	1.0	0.2	0.4	0.1	0.2	0.09
4.5	5.2	707	12	8.6	0.9	1.5	3.8	0.4	1.3	0.3	0.2	0.23
2.8	3.4	797	5.7	3.6	0.7	0.95	2.1	0.3	0.6	0.2	0.2	0.2
2.7	5.6	675	9.7	7.1	0.9	2.7	4.0	0.7	1.8	0.3	0.2	0.1

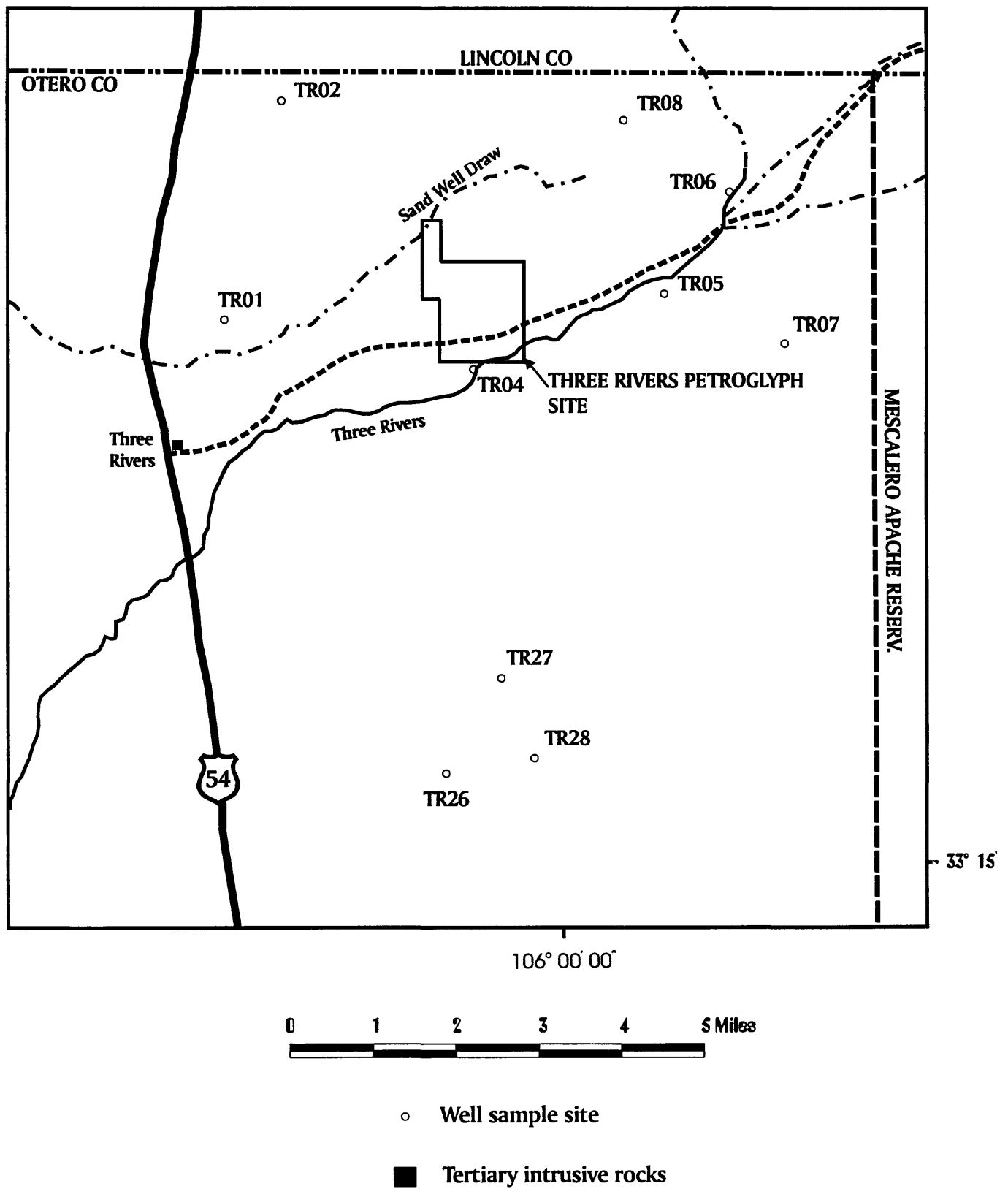


Figure 3. Map showing showing locations of sites sampled in the Three Rivers study area

the dominant cation and anion. All ten samples are Ca^{2+} - SO_4^{2-} dominant waters.

The concentrations of the heavy metals is generally low. The highest concentrations is manganese, with values up to 720 ppb, zinc, with values to 380 ppb, and iron, with values to 124 ppb. The remaining heavy metals are lower in concentrations. Of the base metals, only Cu, Mo, Cr, and U occur in concentrations above normal background abundances (Table 1). When water is pumped from the wells, the water comes into contact with metal pumps, pipes, and rods, which may be the source for the anomalous values of Fe, Zn, Cu, and Mo in the well water. Concentrations of rare earth elements La, Ce, Pr, Nd, Tb, Yb, and Lu are highly anomalous compared to average stream waters (Table 2). Most of the remaining trace elements are generally at background-type concentrations of less than 1 ppb.

In addition to the water samples, stream sediment samples were collected in fall, 1996 in the vicinity of well site TR01 (Fig. 3), which was anomalous in REE (Table 1). The high concentrations of REE in the well water suggest that the source is in the immediate vicinity and upstream from well site TR01 and that the source is a soluble REE-bearing mineral. No other water sources were available for sampling in the immediate area, therefore a stream sediment survey was carried out to determine the potential sources for REE mineralization (Fig.4).

The results of the stream sediment survey is shown in Table 3. Copper concentrations in the stream sediments are low, a few sites are weakly anomalous in Pb and Zn, and the REE elements are probably above background values. The most significant geochemical anomaly is gold, which reaches a value of 0.4 ppm at site S01. Other sites are weakly anomalous in gold concentrations.

DISCUSSION

The high concentrations in these alkaline waters of rare earth elements La, Ce, Pr, Nd, Tb, Yb, and Lu indicate that the REE-bearing minerals are soluble in water. Most REE-bearing minerals are refractory, such as monazite, xenotime, or cerite, and are generally insoluble in waters, except under extreme acid conditions. The most likely mineral that is the source for the REE metals in the alkaline waters in the Three Rivers area is bastnasite, a REE-bearing fluorocarbonate. Bastnasite is an important ore mineral for REE deposits such as Mountain Pass, California. Bastnasite occurs along with copper and fluorite in the Gallinas Mountains, about 40 miles to the north of Three Rivers. The deposits, which are small in size, are associated with a trachyte laccolith, and consist of low-temperature epithermal veins and breccia fillings in the Yeso Formation (Perhac, 1970).

The results of the stream sediment survey in the Three Rivers area indicate that gold mineralization as well as REE mineralization may be present. Highly anomalous concentrations of gold occur at site S01 as well as weakly anomalous concentrations of Au, Pb, and Zn at other sites (Fig. 4 and Table 3).

A belt of alkalic intrusive rocks (Kelly and Thompson, 1964) occur to the north and east

**Table 2. Average concentration of stream
waters from Turekian (1969)**

Element	Concentration (ppb)
La	0.2
Ce	0.06
Pr	0.03
Nd	0.2
Tb	0.008
Yb	0.05
Lu	0.008

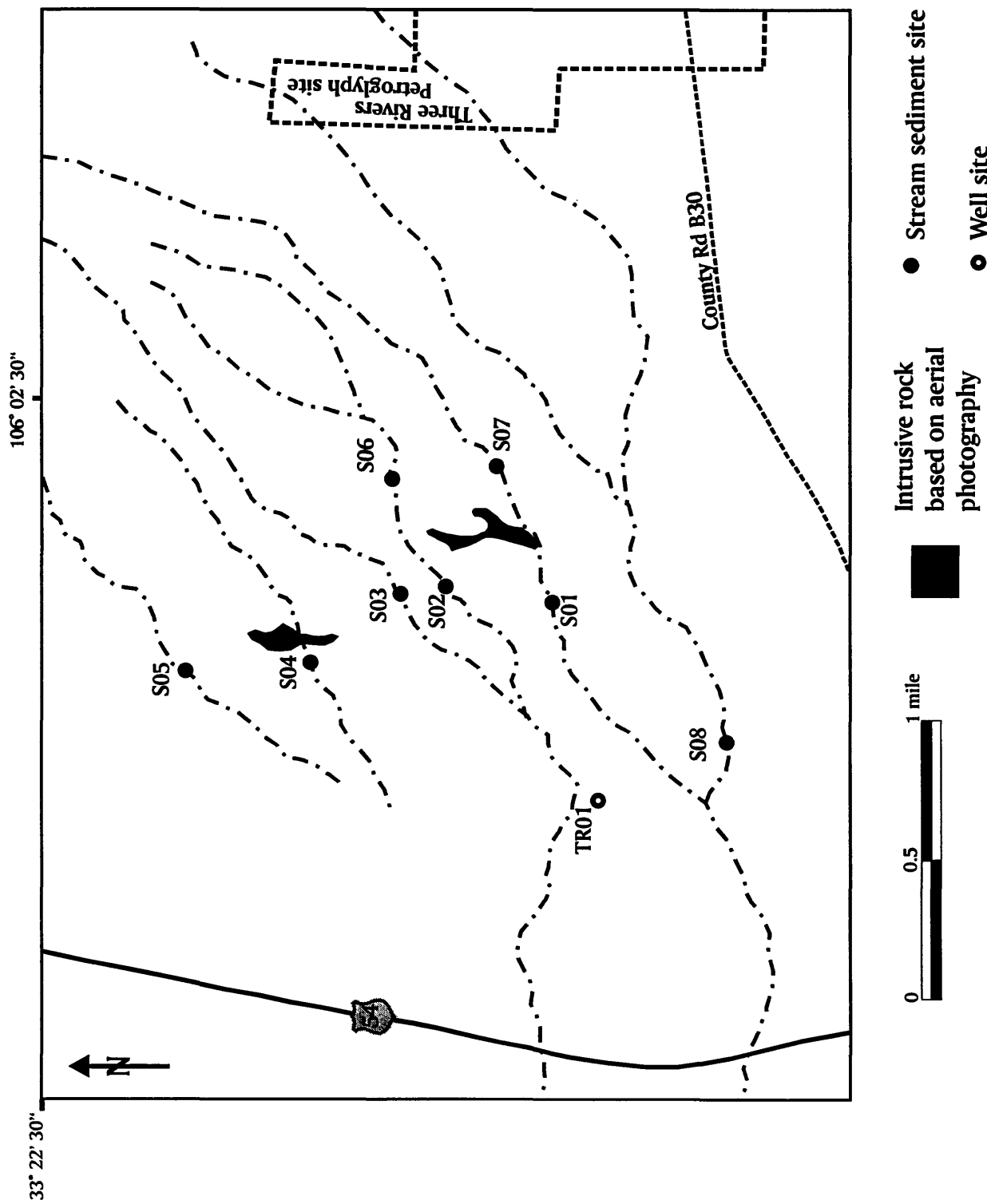


Figure 4. Map showing locations of steam sediment sample, Three Rivers area, New Mexico

Table 3. Chemical analyses of stream sediments collected in the Three Rivers area. Metals in ppm.

Site	Cu	Pb	Zn	Co	Cr	Ni	Au	Sb	As	Cd	Ce	Nd	Sm	U
S01	<1	22	88	10	49	19	0.4	0.4	2	3.8	62	26	3.3	2.8
S02	<1	33	51	7	30	6	0.007	0.4	2.1	2.8	55	24	2.9	2.9
S03	2	9	35	4	15	5	<.002	0.3	1.4	1.8	47	19	2.5	2
S04	<1	43	131	13	53	19	0.012	0.6	2.8	6.6	78	28	4.3	2.4
S05	5	9	35	4	12	7	0.009	0.4	1.9	1.2	46	19	3.2	1.7
S06	1	13	82	6	22	11	0.005	0.5	2.5	3.1	36	13	2.8	2.6
S07	<1	15	83	9	41	9	0.006	0.4	2.3	3.4	48	18	3.5	2.6
S08	<1	8	84	8	34	6	<.002	0.4	1.6	3.9	42	16	2.9	2.3

of the study area. This belt is part of an early to mid-Tertiary alkalic igneous province extending from west Texas to central-northern Montana. Rocks consist of silica-undersaturated to silica-saturated rocks with associated mineralization, particularly gold deposits (Woodward, 1991).

REE metals and precious metal deposits occur to the north of the Three Rivers area as intrusive breccia-pipe deposits and epithermal veins at Nogal and White Oaks districts in Lincoln county (McLemore, 1991). If REE and Au mineralization is present in the Three Rivers area, it is likely that the age and occurrence is similar to these districts to the north.

CONCLUSIONS

The anomalous concentrations of REE metals in the water samples and the anomalous concentration of Au in stream sediments is permissive evidence for moderate potential for REE and gold mineralization in the Three Rivers area. The bedrock in the study area is mostly covered with coalesced alluvial fans. Only a few small outcrops of intrusive rock are present. The intrusive rocks appear to be lamprophyric sills and dikes striking approximately north-south. The intrusive rocks are probably associated in age with the Sierra Blanca igneous complex. Based only on cursory look, the intrusive rocks show no obvious signs of hydrothermal alteration at the surface. Well site TR01 is probably less than 200 feet depth and contains water which is anomalous REE. This suggests that the mineralization is probably in the shallow subsurface.

It should be noted that this anomaly is based on scant evidence and further studies, particularly subsurface drilling, are needed in order to confirm or deny the presence of subsurface mineralization.

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