DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1523-D
SHEET 2 OF 2

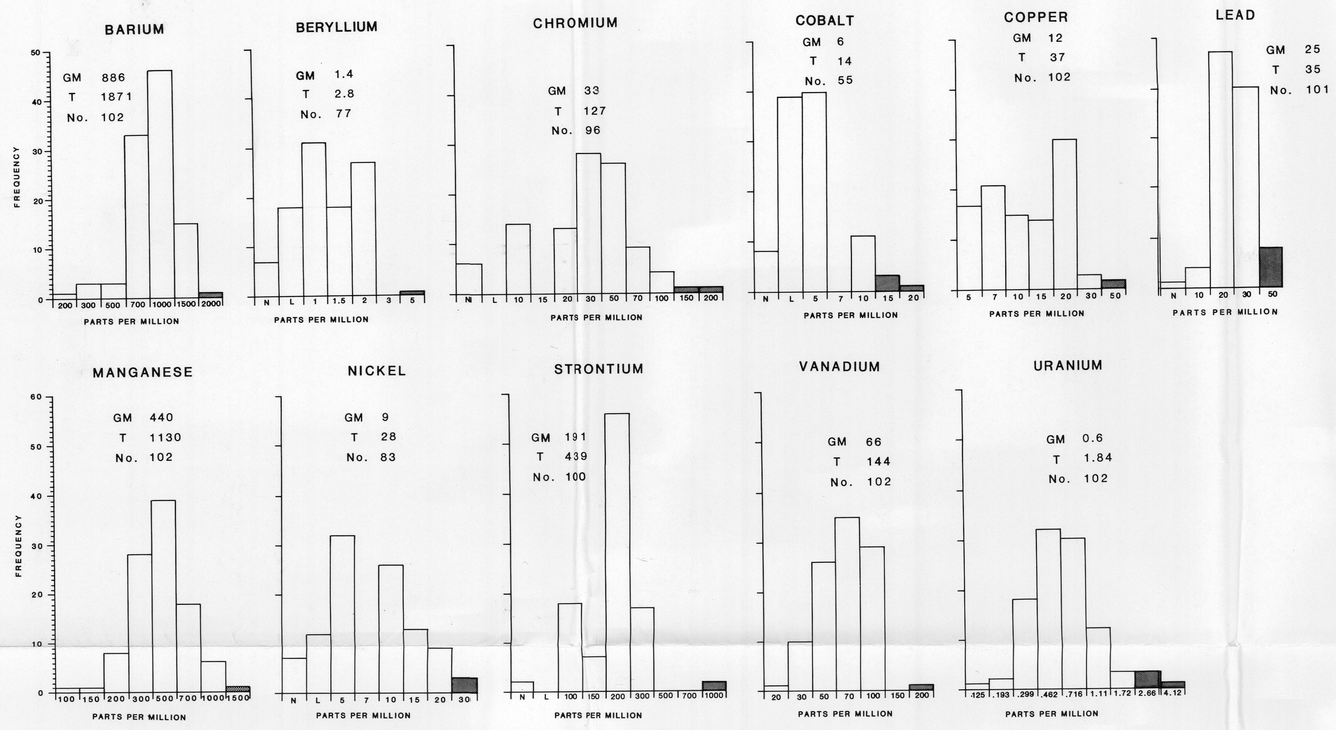


Figure 1. Histograms showing distribution of selected elements in 102 stream-sediment samples. Shading indicates analytical classes that are above the calculated threshold value. GM, geometric mean; T, calculated threshold value; No., number of samples used to calculate the geometric mean and threshold values; N, looked for, but not detected; L, detected, but below the limit of detection.

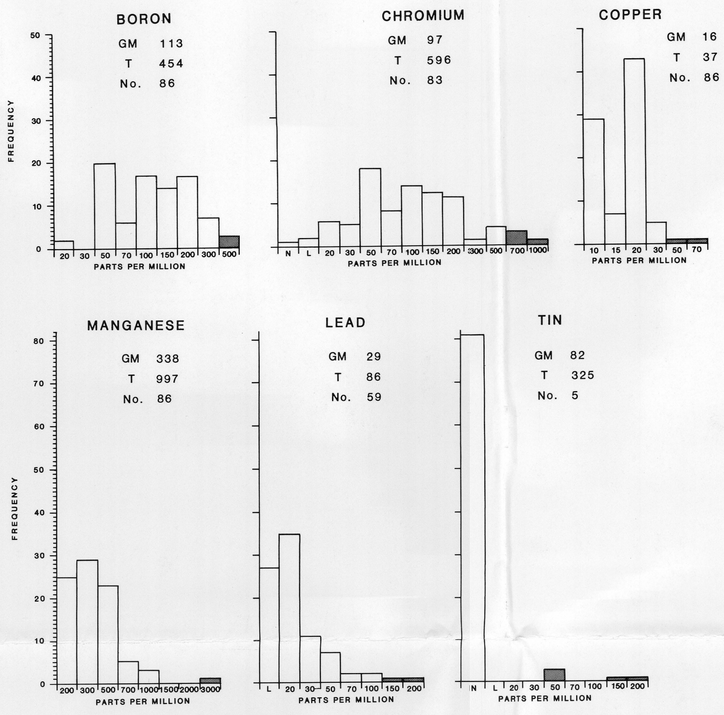


Figure 2. Histograms showing distribution of selected elements in 86 panned-concentrate samples. Shading indicates analytical classes that are above the calculated threshold value. GM, geometric mean; T, calculated threshold value; No., number of samples used to calculate the geometric mean and threshold values; N, looked for, but not detected; L, detected, but below the limit of detection. All tin values were considered anomalous.

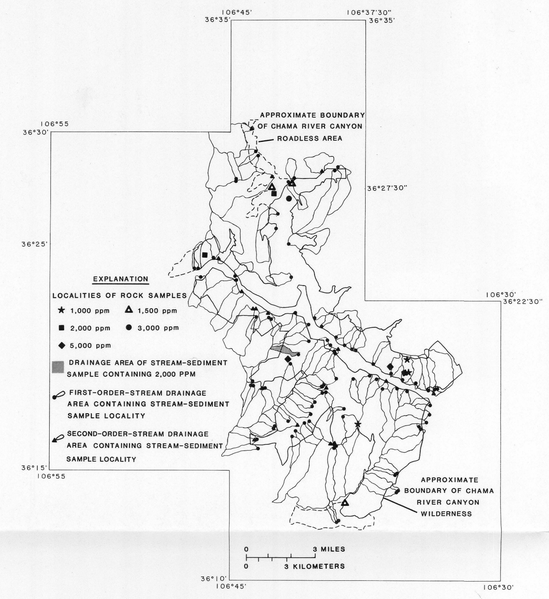


Figure 3. Distribution of samples containing anomalous concentrations of barium in the Chama River Canyon Wilderness and contiguous Roadless Area.

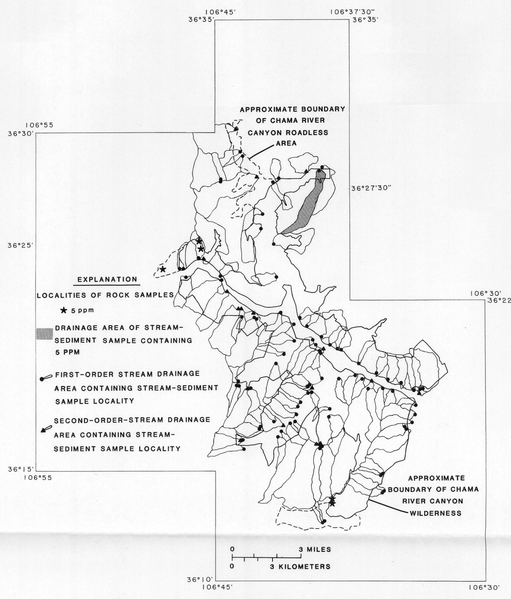


Figure 4. Distribution of samples containing anomalous concentrations of beryllium in the Chama River Canyon Wilderness and contiguous Roadless Area.

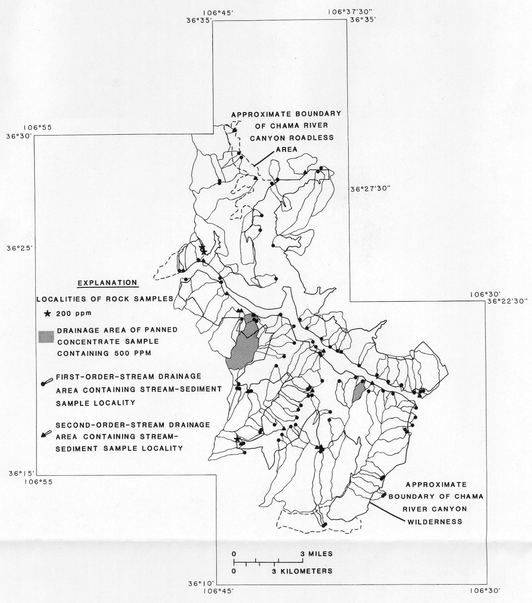


Figure 5. Distribution of samples containing anomalous concentrations of boron in the Chama River Canyon Wilderness and contiguous Roadless Area.

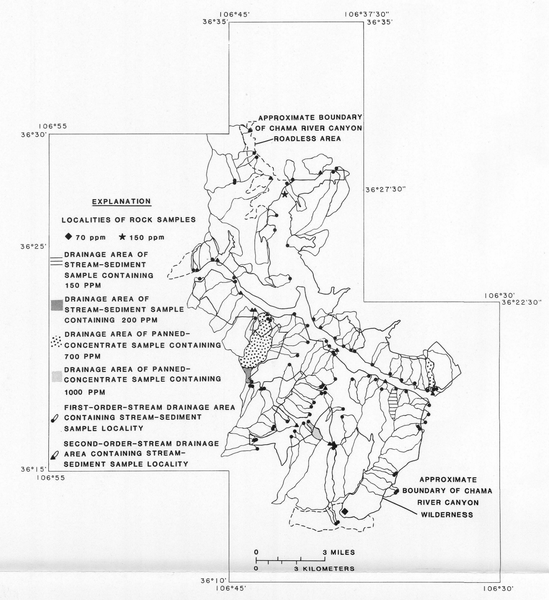


Figure 6. Distribution of samples containing anomalous concentrations of chromium in the Chama River Canyon Wilderness and contiguous Roadless Area.

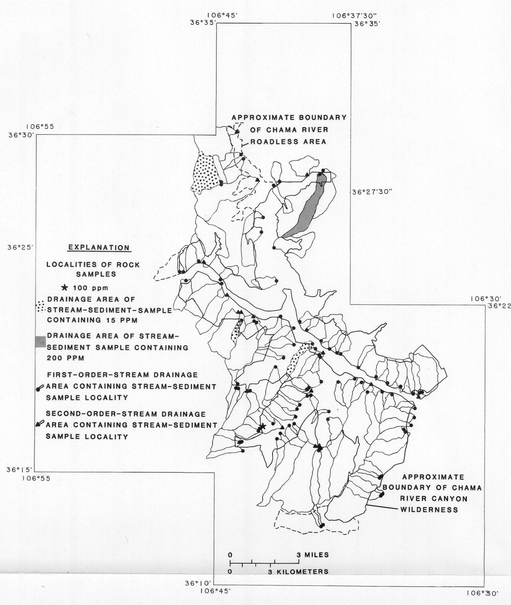


Figure 7. Distribution of samples containing anomalous concentrations of cobalt in the Chama River Canyon Wilderness and contiguous Roadless Area.

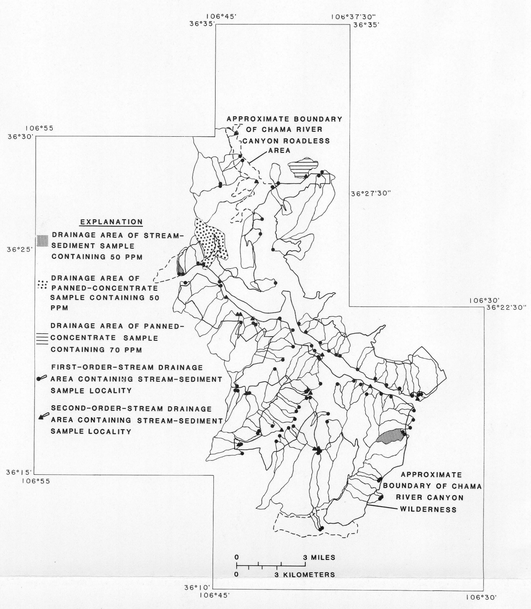


Figure 8. Distribution of samples containing anomalous concentrations of copper in the Chama River Canyon Wilderness and contiguous Roadless Area.

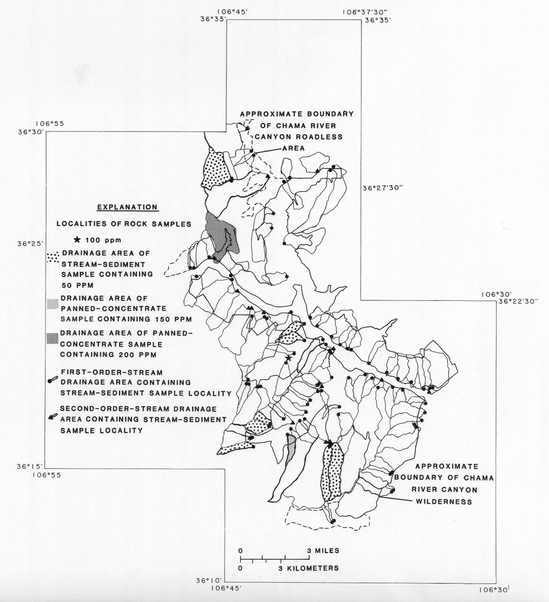


Figure 9. Distribution of samples containing anomalous concentrations of lead in the Chama River Canyon Wilderness and contiguous Roadless Area.

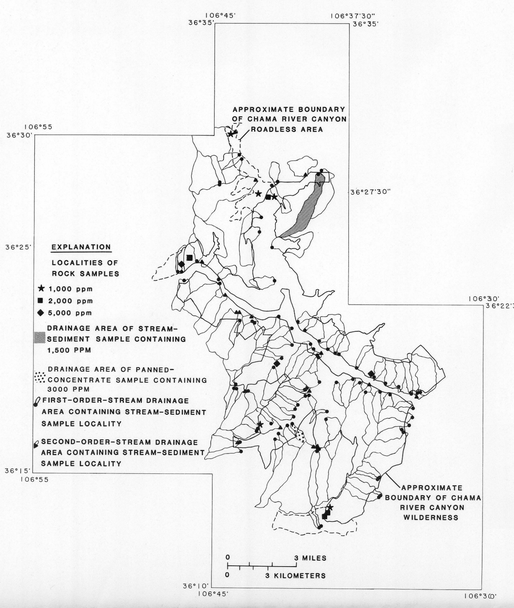


Figure 10. Distribution of samples containing anomalous concentrations of manganese in the Chama River Canyon Wilderness and contiguous Roadless Area.

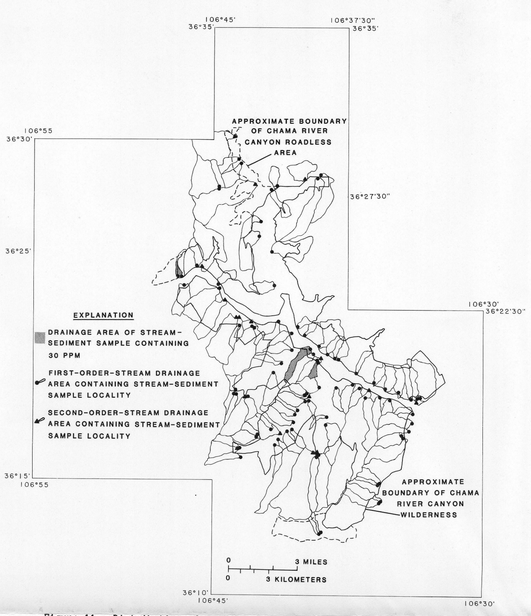


Figure 11. Distribution of samples containing anomalous concentrations of nickel in the Chama River Canyon Wilderness and contiguous Roadless Area.

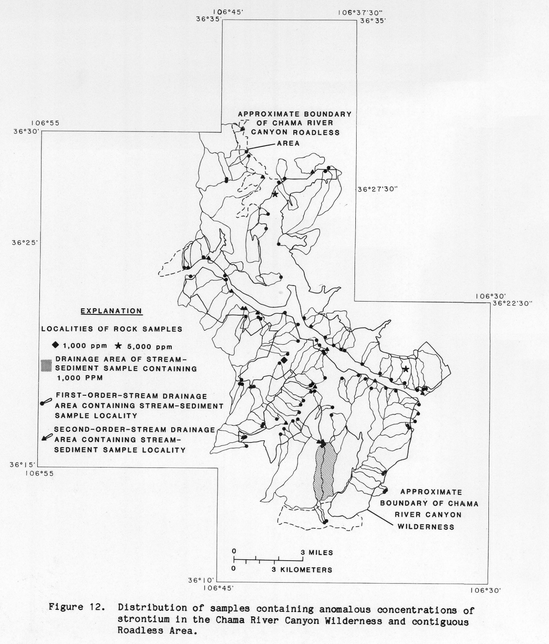


Figure 12. Distribution of samples containing anomalous concentrations of strontium in the Chama River Canyon Wilderness and contiguous Roadless Area.

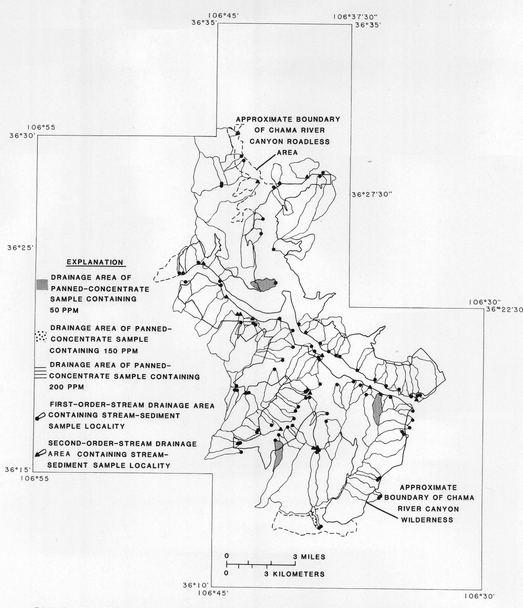


Figure 13. Distribution of samples containing anomalous concentrations of tin in the Chama River Canyon Wilderness and contiguous Roadless Area.

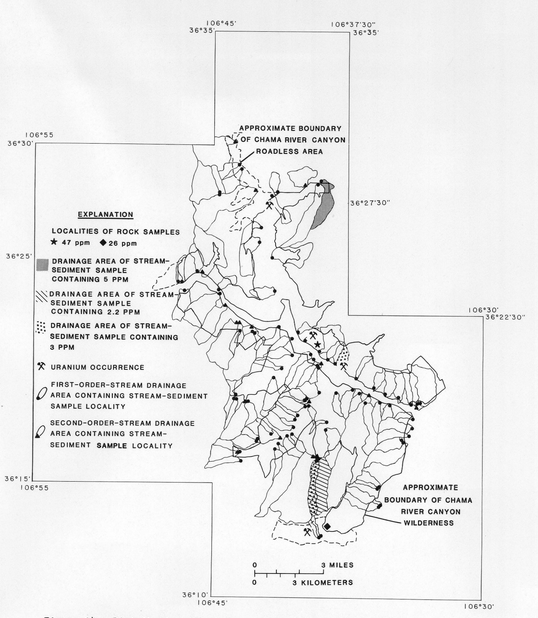


Figure 14. Distribution of samples containing anomalous concentrations of uranium in the Chama River Canyon Wilderness and contiguous Roadless Area.

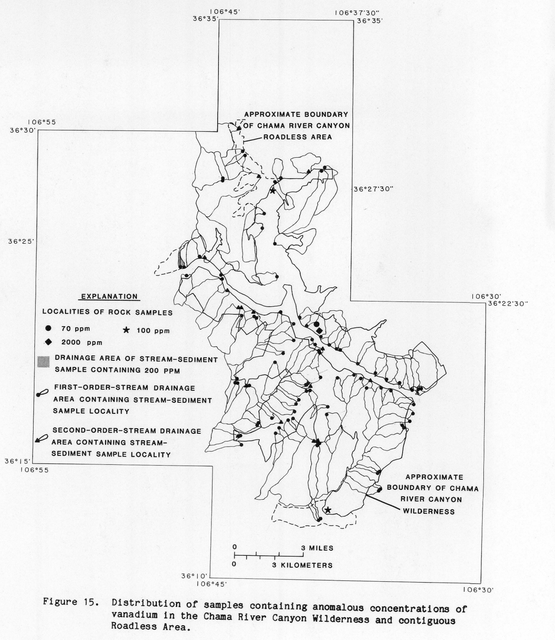


Figure 15. Distribution of samples containing anomalous concentrations of vanadium in the Chama River Canyon Wilderness and contiguous Roadless Area.

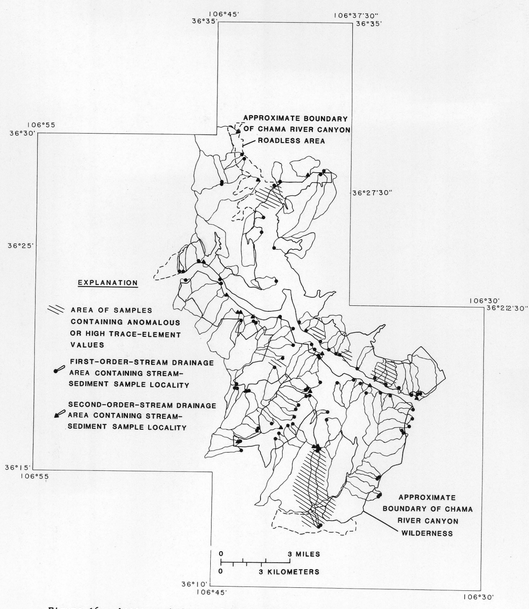


Figure 16. Areas containing clusters of samples having anomalous or high trace-element values that are or may be associated with minor mineralization.

Manganese

In the study area, anomalous concentrations of manganese, as manganese oxide, were found mainly in rock samples (fig. 10, table 1). Many of the anomalous sample localities are clustered in two areas in the Morrison Formation (table 1, samples 58, 59, and 63, and samples 109, 116, and 121). Two anomalous samples are from the central part of the study area, from a distinctive grayish-green grit-size sandstone (samples 1 and 46) in the upper part of the Chinle Formation. Other scattered anomalous samples are from the Cutler (sample 93), Chinle (sample 79), Morrison (sample 130), and Burro Canyon(?) (sample 9) Formations. The concentration of manganese considered to be anomalous differed for each formation. Anomalous values shown in figure 10 range from 1,000 to 5,000 ppm, which are well above the average values reported in similar rocks by Turekian and Wedepohl (1961) (table 2). Anomalous concentrations of manganese were also detected in stream-sediment sample 225 and panned concentrate sample 159P from two widely-spaced localities.

Nickel

Nickel values were not unusually high in most samples. Only three stream-sediment samples (fig. 11; table 1, samples 136, 140, 211) contained anomalous amounts of nickel. Sample 211 also contained anomalous vanadium (fig. 15), and sample 136 also contained anomalous cobalt (fig. 7).

Strontium

Anomalous amounts of strontium were found in several samples from widely spaced localities (fig. 12). Two limestone samples (table 1, samples 43, 111) from the Todilto Limestone contained more than 5,000 ppm strontium. This amount is much greater than that in average carbonates or deep-sea carbonates (Turekian and Wedepohl, 1961; table 2). One sandstone sample (table 1, sample 1) from the Chinle had 1,000 ppm strontium, a value greater than the amount in average sandstone (Turekian and Wedepohl, 1961, table 2). This sample also contained anomalous concentrations of barium (fig. 3), lead (fig. 9), and manganese (fig. 10). Anomalous strontium was also detected in stream-sediment samples 173 and 175, which are from adjacent first- and second-order streams. Both of these samples also contained anomalous lead (fig. 9) and uranium (fig. 14). Strontium, lead, and uranium are commonly associated with and enriched near uranium deposits in the San Juan basin, west of the study area (Spirakis and others, 1981).

Tin

Anomalous concentrations of tin are commonly found in rocks of igneous origin, although placer tin also has been reported (Vanderburg, 1939). No evidence for any igneous activity was seen in the study area. The tin-bearing minerals in panned-concentrate samples 142P, 155P, 190P, 201P, and 229P are not known, but they were probably incorporated in the original sediments by fluvial or other sedimentary depositional processes. Several samples containing tin anomalies also contained other element anomalies. Sample 142P also contained boron and chromium; sample 155P also contained lead. The distribution of anomalous tin is shown in figure 13.

Uranium

Uranium values reported for all samples represent only part of the amount actually present, as the fluorimetric extraction method used to analyze for uranium extracts only readily soluble uranium. Anomalous amounts of uranium were detected in two rock samples and four stream-sediment samples (fig. 14; table 1, samples 18, 54, 149, 173, 175, 224). The southernmost of the two rock sample localities was in the Todilto Limestone, about 1 mi east of a known uranium occurrence in the Todilto (fig. 14; Hilpert, 1969; Light, 1983). The uranium enrichment at both the sample locality and the known occurrence is probably related to the same mineralizing system. The other rock sample (18, table 1) was from the Chinle Formation and contained anomalous amounts of both uranium and vanadium. This sample locality is not near any known uranium prospect.

Several rock samples had high uranium values, when compared with uranium values in other rocks of the same formation (table 1). However, these values, overall, are not abnormal for the rock types. These samples need to be analyzed by the delayed-neutron method to further evaluate their actual uranium content. Additional data on uranium content in rock samples from known prospects in the study area is found in Light (1983).

Three of the stream-sediment samples (173, 175, 224) containing uranium anomalies were from streams that drain only the Dakota Sandstone and Burro Canyon(?) Formation. Both of these formations contain local uranium anomalies in areas peripheral to the study area. Stream-sediment sample 149 was from a stream that cuts through the upper part of the Chinle Formation. The Chinle in this area contains a small uranium prospect (Hilpert, 1969; Light, 1983).

Vanadium

Concentrations of vanadium were found in samples from scattered localities in the study area (fig. 15). Rock samples 26 and 111 (table 1) from the Todilto Limestone contained anomalous vanadium ranging from 70 to 100 ppm; sample 18 from the Chinle Formation had 2,000 ppm vanadium; and sample 56 from the Wanakah Formation contained 100 ppm vanadium. All three localities are near known uranium occurrences (Chenoweth, 1974; Hilpert, 1969; and Light, 1983).

Only stream-sediment sample 211 contained anomalous vanadium. This sample was from a stream that drains primarily the Chinle and Entrada. The Chinle has a relatively high background level of vanadium and may be the source of the vanadium in this particular sample, which also contained anomalous copper, nickel, and strontium.

GEOCHEMICAL PATTERNS

The anomalous trace-element distributions shown in figures 3-15 appear to be random in some areas; in other areas, several of these elements occur together in a pattern that may indicate some type of mineralizing system. Areas showing several anomalous trace-element concentrations that may be associated with minor mineralization are shown in figure 16. In these areas, several rock, stream-sediment, and panned-concentrate samples contained more than one trace-element anomaly that are commonly found enriched near sedimentary uranium and stratabound copper-uranium deposits (Spirakis and others, 1981; Spirakis and Pierson, 1983; and Tourtelot and Vine, 1976).

Spirakis and others (1981) have shown that organic carbon, beryllium, uranium, vanadium, molybdenum, selenium, lead, manganese, magnesium, iron, barium, yttrium, copper, and possibly sulfur, arsenic, and mercury have been enriched in primary uranium ore deposits in the Grants uranium region of the southern part of the San Juan basin. Aluminum, uranium, vanadium, selenium, manganese, calcium, strontium, copper, iron, carbonate carbon, and barium are enriched in secondary uranium deposits in the same area (Spirakis and others, 1981).

The associated anomalies shown in figure 16 include at least several of the following: barium, chromium, manganese, lead, strontium, uranium, and vanadium. As noted above, most of these elements are enriched in sedimentary uranium deposits. Several of the clustered anomalies are associated with known uranium occurrences; others are not. The distribution of the barium and vanadium anomalies are of particular interest, as they offer some promise as geochemical prospecting tools.

Several samples that contained high or anomalous concentrations of barium were collected near known uraniferous rocks (figs. 3 and 14; Light, 1983). Although none of the barium-rich samples have anomalous amounts of uranium, several appear to have more than background amounts of uranium (table 1). Spirakis and Pierson (1983) noted barium anomalies, as haloes, near uranium deposits in the Grants uranium region of the southern part of the San Juan basin. They proposed that barium, as barite, is a postore alteration product that formed during the oxidation of iron sulfides that are associated with the uranium deposits. Spirakis and Pierson further suggested that the barium anomalies might be useful prospecting guides for partly oxidized uranium deposits. Inasmuch as barite can form under other circumstances, additional sampling and study are needed to evaluate this premise.

Vanadium also may be a useful geochemical prospecting guide. Throughout the Colorado Plateau anomalous concentrations of vanadium are associated with uranium and copper-uranium deposits. The association of vanadium with uranium in the Todilto Limestone is of particular interest. Hilpert (1969) has demonstrated that in the Todilto, vanadium concentration tends to increase, although somewhat irregularly, as uranium deposits are approached. Thus the vanadium seems to form haloes of different concentrations around the uranium deposits. The increase in vanadium appears to be partly concentrated in the clays in the Todilto, based on scanning electron microscope observations; away from the uranium deposits the clays are not vanadiferous (Ridgley, unpub. data, 1982).

The following examples suggest that increases in vanadium concentration in the Todilto in the study area are similarly associated with uranium anomalies. In the northern part of the study area, uranium has been detected in the Todilto (Chenoweth, 1974) and overlying Wanakah Formation (Hilpert, 1969; Light, 1983), but the concentrations were low and the occurrences have a spotty distribution. Although no anomalous uranium was detected in any Todilto sample in this study, anomalous vanadium was detected in one sample (fig. 15).

In the central part of the study area, a sample from the Todilto contained an anomalous concentration of vanadium; uranium concentration in this sample was higher than in other samples of the Todilto, but was not anomalous. This particular sample locality is approximately 0.5 mi east of a reported uranium occurrence in the Todilto (fig. 14; Hilpert, 1969). Float fragments of the Todilto from this occurrence contained 0.1-3 percent uranium (Hilpert, 1969); the vanadium content is not known.

In the southern part of the study area, anomalous concentrations of uranium were found in samples from two localities about 1 mi apart (fig. 14; Chenoweth, 1974; Hilpert, 1969). At the uranium claim in the roadless area, the uranium, in concentrations of as much as 0.37 percent $U_3O_8$ (Hilpert, 1969), is associated with anomalous vanadium (Light, 1983). A slightly elevated level of vanadium (50 ppm) was detected from the other locality, although it was not from the sample that contained the uranium anomaly.

Just south of the study area, a small uranium deposit in the Todilto was mined. This deposit contained 0.10 percent $U_3O_8$ (Chenoweth, 1974) and was reported to have a uranium-vanadium ratio of 1 (Hilpert, 1969).

These examples suggest that vanadium in the Todilto is associated with uranium and that the vanadium may be concentrated in haloes around uranium occurrences. By examining changes in vanadium concentration and uranium-vanadium ratios of both outcrop whole rock and clay-mineral fractions it might be possible to delineate haloes that could indicate buried uranium deposits.

GEOCHEMICAL EVALUATION

Several methods were used to evaluate the geochemical data. The data were visually examined for high values, plotted on histograms, or statistically treated to identify anomalous concentrations of elements. Rock-sample data were grouped by rock type within a formation or member of a formation before being evaluated. Most formations or members had too few samples, when grouped by rock type, to permit a valid statistical study. Thus, rock data were only visually examined for anomalous concentrations of elements and were compared to average abundances of elements in similar rocks as determined by Turekian and Wedepohl (1961). Stream-sediment and panned-concentrate sample data were also visually examined for element anomalies. These data sets, however, had enough samples to be statistically treated. The data were converted to logarithms and the geometric mean, geometric deviation, and threshold value were calculated for each element from the logarithmic data. Only data that were not qualified by ">" (greater than a certain concentration), "N" (looked for but not detected), or "L" (detected but below the limit of detection) were used in the evaluation. The threshold value was obtained by multiplying the geometric mean by the square of the geometric deviation (Lepeltier, 1969). An individual value was considered to be anomalous if it exceeded the calculated threshold value for that element. The threshold value actually represents the value at the 97.5th percentile of a cumulative frequency curve that is derived by plotting the logarithmic data versus probability.

Histograms of element concentrations were also prepared for the stream-sediment and panned-concentrate data. The histograms were examined for the presence of possible multiple populations, indicated by separate groups of data, as well as for obvious anomalous concentrations. Some elements did show distinct groupings of data. These groupings could result from analytical error or might actually represent distinct populations resulting from erosion of specific rock units by streams.

In evaluating element anomalies in panned-concentrate samples it is important to remember that only the nonmagnetic heavy fraction was analyzed. One of the main reasons for collecting panned-concentrate samples is to locate and identify concentrations of placer minerals that might represent potential resources.

Gold, silver, arsenic, cadmium, antimony, bismuth, and tungsten were not detected in any sample. However, of the samples collected by Light (1983), three samples of the Todilto Limestone had detectable arsenic, and one stream-sediment sample had detectable silver.

Several trace elements were selected for further evaluation because their presence in anomalous concentrations in stream-sediment, rock, and, to a lesser extent, panned-concentrate samples could indicate undiscovered mineral deposits. In sedimentary rocks, like those exposed in the study area, the most likely trace-element anomalies are those that are associated with sedimentary copper and uranium mineral deposits or occurrences. Histograms of the concentrations of these elements in stream-sediment and panned-concentrate samples are shown in figures 1 and 2.

The distribution of anomalous concentrations of the elements studied in rock, stream-sediment, and panned-concentrate samples are shown in figures 3-15. The geochemical distribution pattern of each of these elements is discussed separately below.

Barium

Anomalous concentrations of barium were found in one stream-sediment (sample 151) and twelve rock samples (table 1). Several of the anomalous samples were from two localities; the remaining samples were from widely spaced localities (fig. 3). Rock units containing anomalous concentrations of barium include the Cutler (sample 92), Chinle (samples 1, 45), Entrada (sample 44), Wanakah (sample 41), Morrison (samples 63, 119, 120, 121, 124), and Dakota (samples 15, 29) Formations. The concentration of barium considered to be anomalous was different for each formation. The anomalous values shown in figure 3 are substantially higher than averages found by Turekian and Wedepohl (1961) in similar rock types (table 2).

Beryllium

Anomalous concentrations of beryllium were found in one stream-sediment and several rock samples (fig. 4; table 1). Four rock samples (61, 62, 83, 100) were claystone or argillaceous sandstone of the Brushy Basin Member of the Morrison Formation; two samples (90, 91) were shale from the lower part of the Dakota Sandstone; and one sample (128) was an argillaceous sandstone of the Burro Canyon(?) Formation. The beryllium in these rocks is probably in the clay fraction because beryllium can replace aluminum in the clay structure. Some clays, such as those of the Dakota and Brushy Basin, are of volcanic origin, which is likely the source of the beryllium. The source of the beryllium anomaly in stream-sediment sample 225 is probably the clays derived from the Burro Canyon(?) or Dakota. The stream from which this anomalous sample came drains only the Dakota and Burro Canyon(?) Formations.

Boron

The boron content of most samples is not unusually high; however, anomalous amounts were detected in several rock and stream-sediment samples (fig. 5; table 1). Two rock samples (90, 91) were mudstones from the lower part of the Dakota. These samples also contained anomalous amounts of beryllium (fig. 4). The other rock sample (4) is from the lower member of the Morrison Formation. Boron anomalies in panned-concentrate samples 142P, 182P, and 200P probably reflect the amount of tourmaline in the nonmagnetic heavy fraction. Petrographic examination of sample 182P revealed a greater proportion of tourmaline than in other samples.

Chromium

Most of the localities of samples containing anomalous concentrations of chromium appear to be randomly distributed, except in the western part of the study area where anomalous chromium is present in three contiguous drainage basins (fig. 6; table 1). The anomalous chromium occurs in stream-sediment sample 131 and panned-concentrate samples 142P and 182P in this area. The panned-concentrate samples are from adjacent first- and second-order streams. Anomalous chromium was also detected in stream-sediment sample 201 and panned-concentrate samples 159P and 194P from separate localities. The anomalous amounts of chromium in sandstone samples 56 and 107 of the Wanakah Formation are from two to four times the amount present in average sandstone (Turekian and Wedepohl, 1961; table 2). The mineral or minerals containing the chromium in the samples described is not known.

Cobalt

Anomalous amounts of cobalt are limited to a few stream-sediment samples (table 1, samples 135, 136, 219, 225) from widely-spaced localities, and one rock sample (9) (fig. 7). The rock sample was an argillaceous sandstone of the Burro Canyon(?) Formation and contains 100 ppm cobalt. This amount is substantially greater than the amount reported for average sandstone (Turekian and Wedepohl, 1961; table 2) and for other rocks collected from the study area.

Copper

The distribution of samples containing anomalous copper values is shown in figure 8. The anomalous stream-sediment samples (table 1, samples 206, 211) are from streams that drain primarily Triassic rocks. These rocks are known to contain copper occurrences in several areas peripheral to the study area; however, no anomalous concentrations of copper were detected in any rock samples collected from the study area. The anomalous copper values observed in the two panned-concentrate samples (table 1, samples 212P, 223P) are not considered to indicate resources because rock formations in these drainage basins are not known to contain copper deposits. These rock formations are from Late Jurassic to Cretaceous in age.

Lead

The lead content of most samples is not unusually high. Anomalous concentrations detected in rock, stream-sediment, and panned-concentrate samples are shown in figure 9 and table 1. Most of the anomalous localities are clustered in two areas. Anomalous concentrations of lead (table 1, samples 1, 141, 152) in the central part of the study area, and at the northernmost anomalous locality (table 1, sample 219), are in stream-sediment samples from streams that drain primarily Triassic rocks. According to Hilpert (1969), Triassic rocks of the Colorado Plateau have a high content of some base metals, including lead. Thus at least some of the lead may be of nonradiogenic origin. The lead in these samples was not associated with particularly high concentrations of uranium.

Samples from the southwestern cluster of localities (table 1, samples 134, 168, 169) are from streams that drain the Morrison to Dakota stratigraphic interval. Several of these samples contain high, but not anomalous, amounts of uranium. Lead is, however, associated with anomalous amounts of uranium in stream-sediment samples 173 and 175 from the southern part of the study area. Because of the association of lead anomalies with high and anomalous uranium values in these areas, at least part of the lead may be of radiogenic origin. The mineral containing the anomalous lead in panned-concentrate samples 155P and 212P is not known as no excess sample was available for mineralogic evaluation. Sample 155P also contains an anomalous concentration of tin (fig. 13), and sample 212P also contains an anomalous concentration of copper (fig. 8).

Table 2.--Concentration of elements in average sedimentary rocks
[Expressed in parts per million. X, only order of magnitude estimate could be made. From Turekian and Wedepohl, 1961].

| | Ba | Be | B | Cr | Co | Cu | Pb | Mn | Ni | Sr | U | V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shale | 580 | 3 | 100 | 90 | 19 | 45 | 20 | 850 | 68 | 300 | 3.7 | 130 |
| Sandstone | X0 | .X | 35 | 35 | .3 | X | 7 | X0 | 2 | 20 | .45 | 20 |
| Carbonate rock | 10 | .X | 20 | 11 | .1 | 4 | 9 | 1,100 | 20 | 610 | 2.2 | 20 |

DISTRIBUTION MAPS OF SELECTED TRACE ELEMENTS

# GEOCHEMICAL MAP OF THE CHAMA RIVER CANYON WILDERNESS AND CONTIGUOUS ROADLESS AREA, RIO ARRIBA COUNTY, NEW MEXICO

By

Jennie L. Ridgley

1986

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1986

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