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RECONNAISSANCE GEOCHEMICAL SURVEY OF THE AL JURDHAWIYAH AND WADI AL JARIR QUADRANGLES, SHEETS 25/42 D AND 25/42 C, KINGDOM OF SAUDI ARABIA

by

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ABSTRACT

A reconnaissance wadi-sediment geochemical survey was conducted in the Al Jurdhawiyah (sheet 25/42 D) and Wadi al Jarir (sheet 25/42 C) quadrangles in order to identify anomalies potentially related to mineralized rock. Sieved bulk-sediment fractions and pan concentrates were created from the original samples collected from wadis in the two quadrangles. A semiquantitative 30-element spectrographic analysis was completed on both the sieved bulk-sediment fraction and the pan concentrate of each sample. The results were statistically analyzed in an attempt to identify anomalous regions. Anomaly threshold values were calculated for most elements; the threshold value of an element in a data set is defined as the geometric mean value plus two standard deviations.

The Baid al Jimalah West tin-tungsten deposit (MODS 02661) in the southern part of the Al Jurdhawiyah quadrangle was identified by one pan-concentrate sample containing anomalous concentrations of tin and tungsten. Samples near the Baid al Jimalah East ancient lead-zinc-silver mines (MODS 00960) contain strongly anomalous concentrations of tin and lead and to a lesser extent of tungsten and copper. Both of these regions and other regions containing anomalous concentrations of certain elements are recommended for additional studies. A comparison of results obtained from sieved bulk-sediment fractions and pan concentrates indicates that the latter is the better medium for these geochemical investigations.

1/ U.S. Geological Survey Saudi Arabian Mission

INTRODUCTION

During Rabi al Thani and Jumad al Thani 1400 AH (February and March 1980), a reconnaissance geochemical survey of wadi sediments was made in the Al Jurdhawiyah and Wadi al Jarir quadrangles (sheets 25/42 D and 25/42 C), Kingdom of Saudi Arabia. These areas were studied to identify geochemical anomalies potentially related to mineralized rock and to provide geochemical information in support of the resource-assessment and geologic mapping projects.

Mineral localities referred to in this report are recorded in the Mineral Occurrence Documentation System (MODS) data bank and are identified by a unique five-digit locality number. Data regarding analyses of geologic material are recorded in the Rock Analysis Storage System (RASS) data bank, and each sample is identified by a unique six-digit number. Inquiries regarding either data bank may be made through the Office of the Technical Advisor, Deputy Ministry for Mineral Resources, Jiddah, Saudi Arabia.

The work on which this study is based was performed in accordance with a cooperative agreement between the U.S. Geological Survey (USGS) and the Saudi Arabian Ministry of Petroleum and Mineral Resources.

Location

The Al Jurdhawiyah quadrangle lies between lat 25°00' and 25°30' N. and long 42°30' and 43°00' E., in the northeastern part of the Arabian Shield (fig. 1). The quadrangle is in a relatively densely populated area that contains about a dozen villages including Al Jurdhawiyah, Jarrar, Ar Rigna, and Al Mushrifa. The main physiographic features are the massive granitic hills of Aban al Ahmar in the northern part, Jabal Kutayfah in the southeastern part, and Jabal Shawfan in the southwestern part of the quadrangle. The Nafud Kutayfah is in the southeastern part and the dunes of the Nafud al Urayk are in the western part of the quadrangle.

The Wadi al Jarir quadrangle lies between lat 25°00' and 25°30' N. and long 42°00' and 42°30' E. (fig. 1). The area is mainly of low relief and drains north-northeast toward Wadi ar Rimah through Wadi al Jarir and its tributaries. The eastern part of the quadrangle is covered by eolian sand in the Nafud al Urayk. The area is not so densely populated as the Al Jurdhawiyah quadrangle but contains a few villages including At Tarafiyah, Al Batah, and Motrabah.

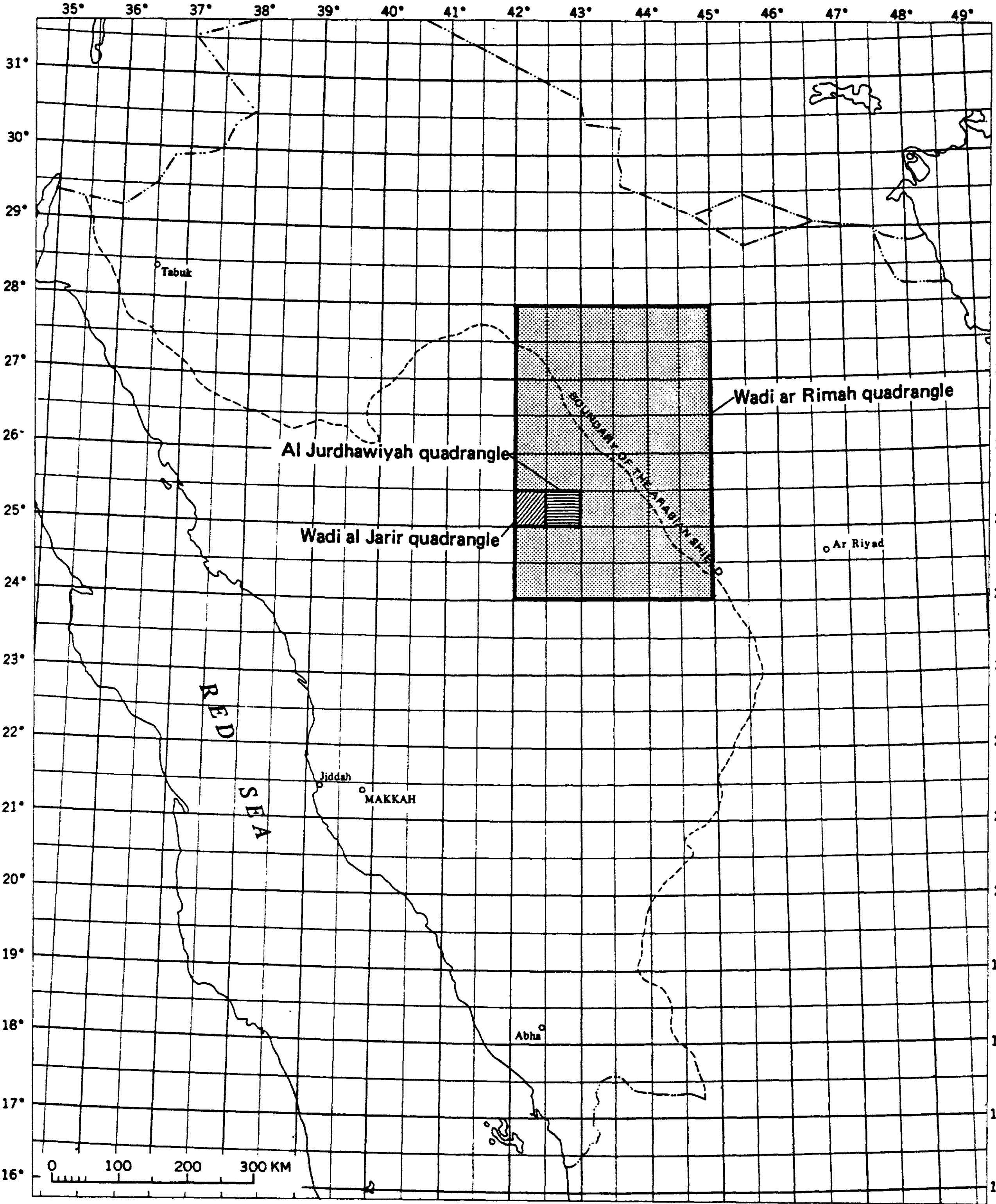


Figure 1.--Index map of western Saudi Arabia showing the location of the Al Jurdhawiyah and Wadi al Jarir quadrangles (1:100,000 scale), sheets 25/42 D and 25/42 C, and the Wadi ar Rimah quadrangle (1:500,000 scale).

Previous work

Mytton (1970) conducted a geochemical reconnaissance of the Wadi ar Rimah 1:500,000-scale quadrangle (lat 24° to 28° N., long 42° to 45° E.) that included 49 wadi-sediment samples collected from the main wadis that drain the Al Jurdhawiyah quadrangle. Neither the -30+80 mesh fraction samples nor the heavy-mineral pan concentrates indicated any significant anomalies. Muller (1975) subsequently conducted geological mapping and mineral exploration programs in the Al Jurdhawiyah area, and as part of a study of pyrite-bearing silicic volcanic rocks, he collected 100 wadi-sediment samples from a 25-km2 area around Jabal Jarrar, but no geochemical anomalies were identified. Geologic maps at 1:100,000 scale have been published for the Al Jurdhawiyah (Cole, 1981) and the Wadi al Jarir (Young, 1982) quadrangles.

ACKNOWLEDGEMENTS

I would like to thank U.S. Geological Survey geologists James C. Cole, who supplied much of the geologic data for the two quadrangles, and Edward A. du Bray, who provided technical advice. I would also like to thank field assistants Abdi Issa Abdullah and Ali Muhammed Jaberti (USGS) for their diligence during sample preparation and panning, sometimes in temperatures as high as 43°C.

FIELD AND LABORATORY PROCEDURE

In the Al Jurdhawiyah quadrangle, 416 sites were sampled, and in the Wadi al Jarir quadrangle, 243 sites were sampled (plate 1). Samples were collected in almost every square kilometer of area except in areas covered by eolian sand or lacking a well-developed drainage net. Sample location maps are archived in base-data file USGS-DF-02-5 available at the Jiddah office of the U.S. Geological Survey.

The two RASS sample number series, the first three digits of which are 149 and 159, are parallel number series, that is, for example, samples 149321 and 159321 are from the same location: 149321 is the sieved bulk fraction and 159321 is the pan concentrate.

At each sample site approximately 10 kg of unconsolidated material were collected at a depth of about 20 cm. Natural drop-out sites in wadis, where heavy minerals tend to collect, were sampled when possible. Care was taken to avoid sites where windblown material was excessive.

Each sample was passed through a -10 mesh sieve and mechanically split; approximately one-quarter of the -10 mesh material was sieved to separate the -30+80 mesh fraction; this fraction is defined as the sieved bulk fraction. The remaining three-quarters of the -10 mesh material was panned using standard gold panning techniques; this fraction is defined as the pan concentrate. The sieved bulk fraction was selected because studies by both Overstreet (1978) and Elliott (in press) indicated that this fraction is the most informative for analysis of bulk wadi-sediment samples.

The sieved bulk-fraction and pan-concentrate samples were analyzed by the DGMR-USGS chemical laboratory in Jiddah. The samples were first pulverized and passed through a -160 mesh sieve; then a 30-element semiquantitative emission spectrographic analysis was completed on each sample. Four of the thirty elements (iron, calcium, magnesium, and titanium) are in most samples in large amounts, generally in excess of 1,000 parts per million (ppm). Because they are not pathfinder elements for trace-element geochemical anomalies, these four elements are not considered further in this report. The remaining 26 trace elements and their detection limits are listed in tables 1 and 2.

DATA ANALYSIS AND PRESENTATION OF RESULTS

All analytical results and sample locations are archived in RASS. The data were statistically analyzed using the STATPAC package routines developed by the U.S. Geological Survey (Sower and others, 1971).

The geometric mean and standard deviation were computed for the sample population by element. Because frequency-distribution studies show that elements in geologic materials are lognormally distributed in many cases (Ahrens, 1954, 1957), geometric means are more applicable than arithmetic means. The geometric mean was calculated using Cohen's method (Miesch, 1967), which provides an estimate of the geometric mean for censored or qualified distributions (in this case for sample sets in which some values are qualified by L, less than). The analytical data are semiquantitative and are arbitrarily reported as the midpoint of class intervals established on the basis of a logarithmic scale.

The anomaly threshold value is defined for most elements as the geometric mean value plus two standard deviations ($\bar{x} + 2\sigma$) following the recommendation of Overstreet (1978). However, because gold, silver, arsenic, cadmium, antimony, tungsten, and zinc are so infrequently detected by semiquantitative analysis, any detected amount is regarded as anoma-

Table 1.—*Geometric mean, standard deviation, and threshold value for sieved bulk-fraction samples by element*

[All data are in parts per million. Leaders indicate not calculated due to insufficient number of unqualified values. N = number of unqualified values]

Element	Lower limit of detection	N	Geometric mean $\bar{X}$	Standard deviation σ	Computed threshold value $\bar{X} + 2\sigma$	Selected histogram threshold (fig. 2)
Manganese	10	676	428	148	700	700
Silver	0.5	0	-	-	-	0.5*
Arsenic	200	0	-	-	-	200*
Gold	10	0	-	-	-	10*
Boron	10	446	17	7	30	30
Barium	20	676	554	181	1000	700
Beryllium	1	49	1	1	3	3
Bismuth	10	0	-	-	-	10*
Cadmium	20	0	-	-	-	20*
Cobalt	5	147	6	1	10	7
Chromium	10	676	209	91	300	300
Copper	5	674	32	30	100	70
Lanthanum	20	41	23	6	30	30
Molybdenum	5	0	-	-	-	25
Niobium	20	2	30	-	-	-
Nickel	5	675	22	11	50	30
Lead	10	165	21	43	100	30
Antimony	100	0	-	-	-	100*
Scandium	5	234	6	2	10	10
Tin	10	8	100	0	-	-
Strontium	100	669	197	67	300	300
Vanadium	10	676	71	31	100	100
Tungsten	50	1	200	-	-	50*
Yttrium	10	318	13	5	20	20
Zinc	200	0	-	-	-	200*
Zirconium	10	674	199	180	500	500

* Lower limit of detection taken as threshold for elements with no uncensored (unqualified) values (see text).

Table 2.--*Geometric mean, standard deviation, and threshold value for pan-concentrate samples by element*
[All data are in parts per million. Leaders indicate not calculated due to insufficient number of unqualified values. N = number of unqualified values]

Element	Lower limit of detection	N	Geometric mean $\overline{x}$	Standard deviation σ	Computed threshold value $\overline{x} + 2\sigma$	Selected histogram threshold (fig. 2)
Manganese	10	580	2,411	1,132	5,000	5,000
Silver	0.5	0	-	-	-	0.5*
Arsenic	200	0	-	-	-	200*
Gold	10	0	-	-	-	10*
Boron	10	284	16	6	30	30
Barium	20	645	185	110	500	300
Beryllium	1	295	4	2	10	7
Bismuth	10	0	-	-	-	10*
Cadmium	20	0	-	-	-	20*
Cobalt	5	633	16	8	30	30
Chromium	10	650	1,087	619	2,000	2,000
Copper	5	649	69	45	150	150
Lanthanum	20	591	45	21	100	100
Molybdenum	5	59	9	4	15	15
Niobium	20	96	24	9	50	30
Nickel	5	650	31	16	70	50
Lead	10	435	27	149	300	50
Antimony	100	0	-	-	-	200*
Scandium	5	261	18	10	30	30
Tin	10	87	24	26	70	30
Strontium	100	541	222	123	500	300
Vanadium	10	650	514	308	1,000	1,000
Tungsten	50	1	200	-	-	50*
Yttrium	10	650	65	37	150	100
Zinc	200	0	-	-	-	200*
Zirconium	10	114	875	220	1,500	1,000

* Lower limit of detection taken as threshold for elements with no uncensored (unqualified) values (see text).

lous. Of these 7 elements, only tungsten was detected in any of the 674 samples. The geometric mean, standard deviation, and threshold value for each element are presented in table 1 for the sieved bulk-fraction samples and in table 2 for the pan-concentrate samples. Computed threshold values ($\bar{x}+2\sigma$) have been rounded down to the nearest spectrographic reporting interval value for the purpose of defining the anomaly threshold for each detected element (tables 1 and 2). Frequency-versus-concentration histograms for all trace elements in the sample population except silver, gold, arsenic, bismuth, cadmium, antimony, tungsten, and zinc are plotted in figure 2.

Samples containing greater-than-threshold concentrations for any element except iron, magnesium, titanium, and calcium, which were not statistically analyzed, are located on plate 1, and values for the anomalous elements are indicated. Samples anomalous in one or two elements were obtained from many sites. Because samples from these localities do not include extreme values and are not part of regional anomalies, their anomalous character may be an artifact of panning or the result of localized geochemical variation. Although these samples may have significance and are recorded on plate 1, they are not considered further in this report.

Regions that contain a group of samples anomalous in a single element are usually underlain by rock types geochemically atypical of the study area; they appear anomalous because of a peculiar source-terrain composition and probably not because of mineralized rock. For example, the pan concentrates collected from areas draining metasandstones and metasiltstones in the northwestern corner of the Wadi al Jarir quadrangle are enriched in vanadium (pl. 1) but not in any element of potential economic significance. The fact that many localities on plate 1 are characterized by samples anomalous in nickel, scandium, cobalt, vanadium, or chromium is attributable to greater-than-normal accumulations of oxide and ferromagnesian minerals in samples from these localities. These anomalous samples are lithologically controlled by mafic or magnetite-rich source rocks. Anomalous regions are those that share an anomalous-element suite.

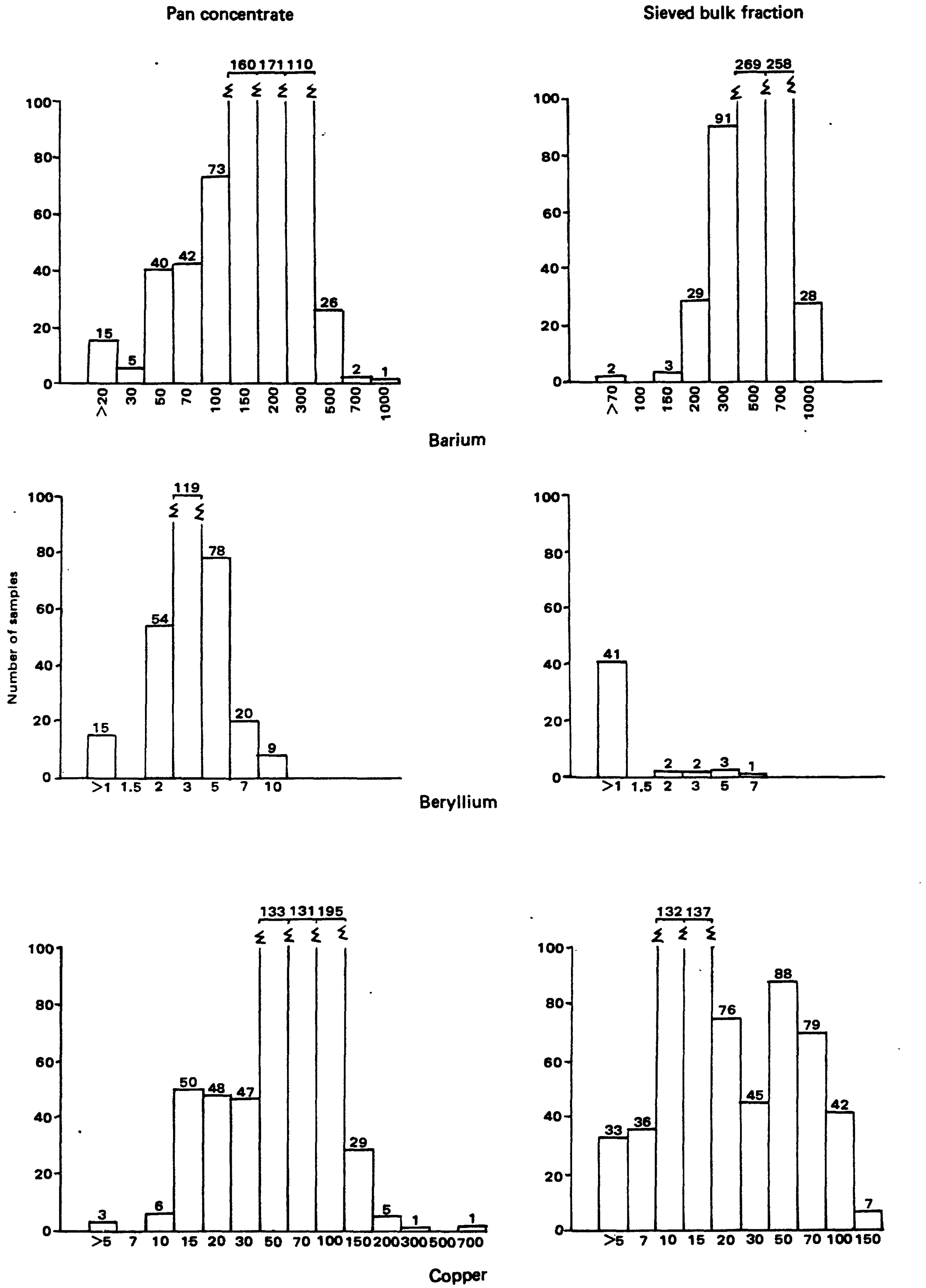


Figure 2.--Frequency-versus-concentration histograms for elements for samples collected in the Al Jurdhawiyah and Wadi al Jarir quadrangles. Only samples having unqualified values are plotted; see text for discussion. Concentrations are in parts per million.

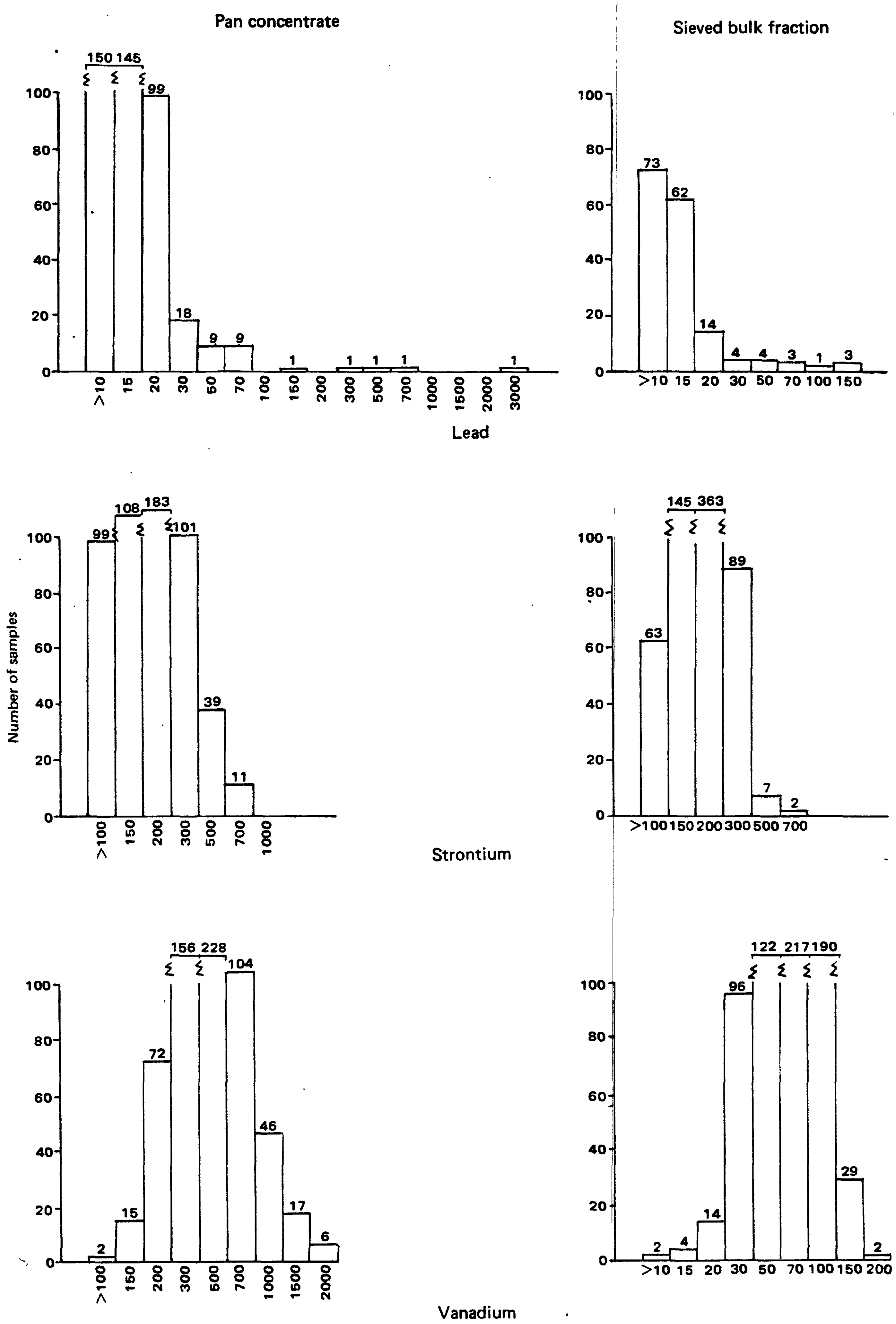
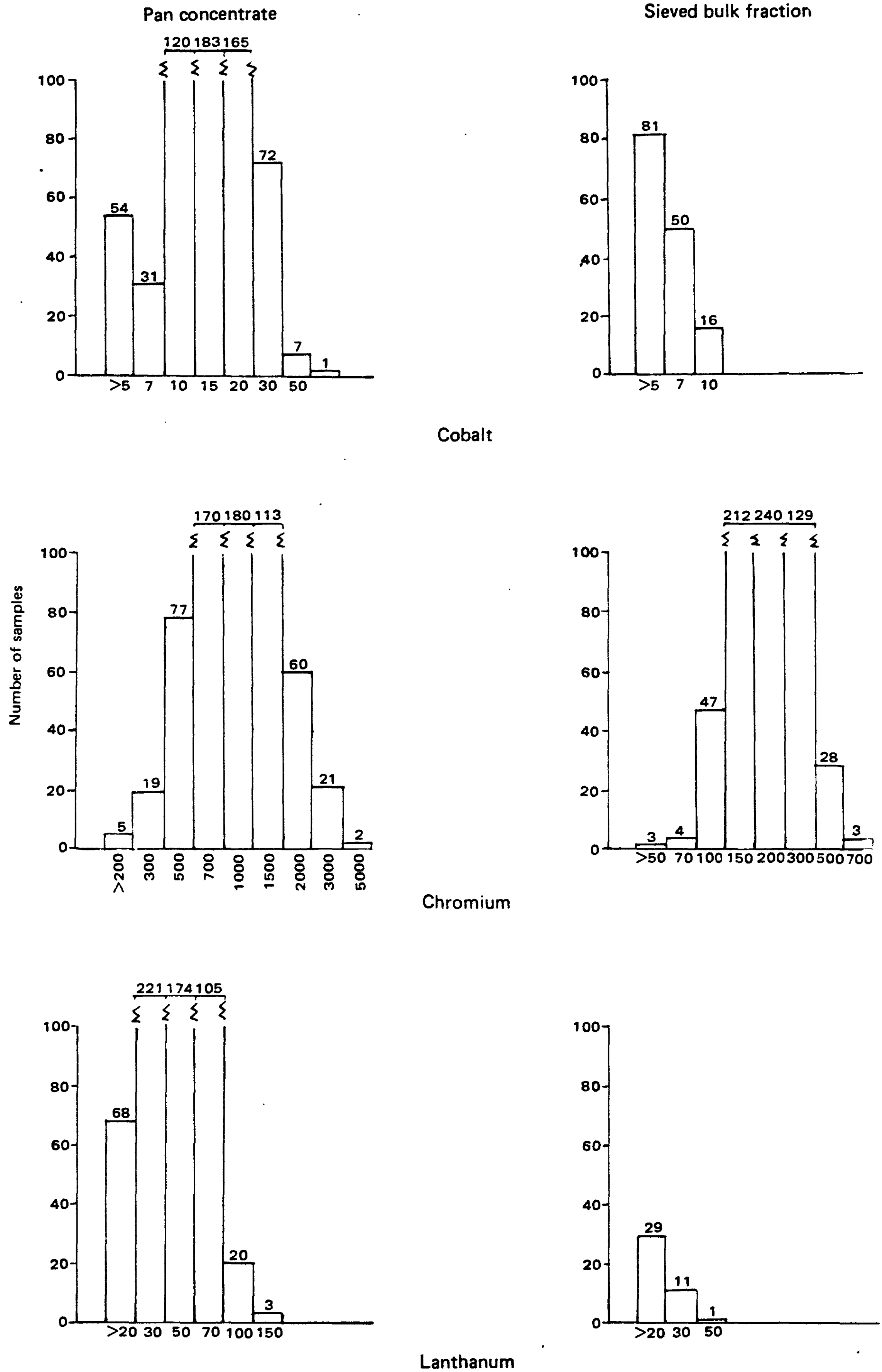


Figure 2.--Continued



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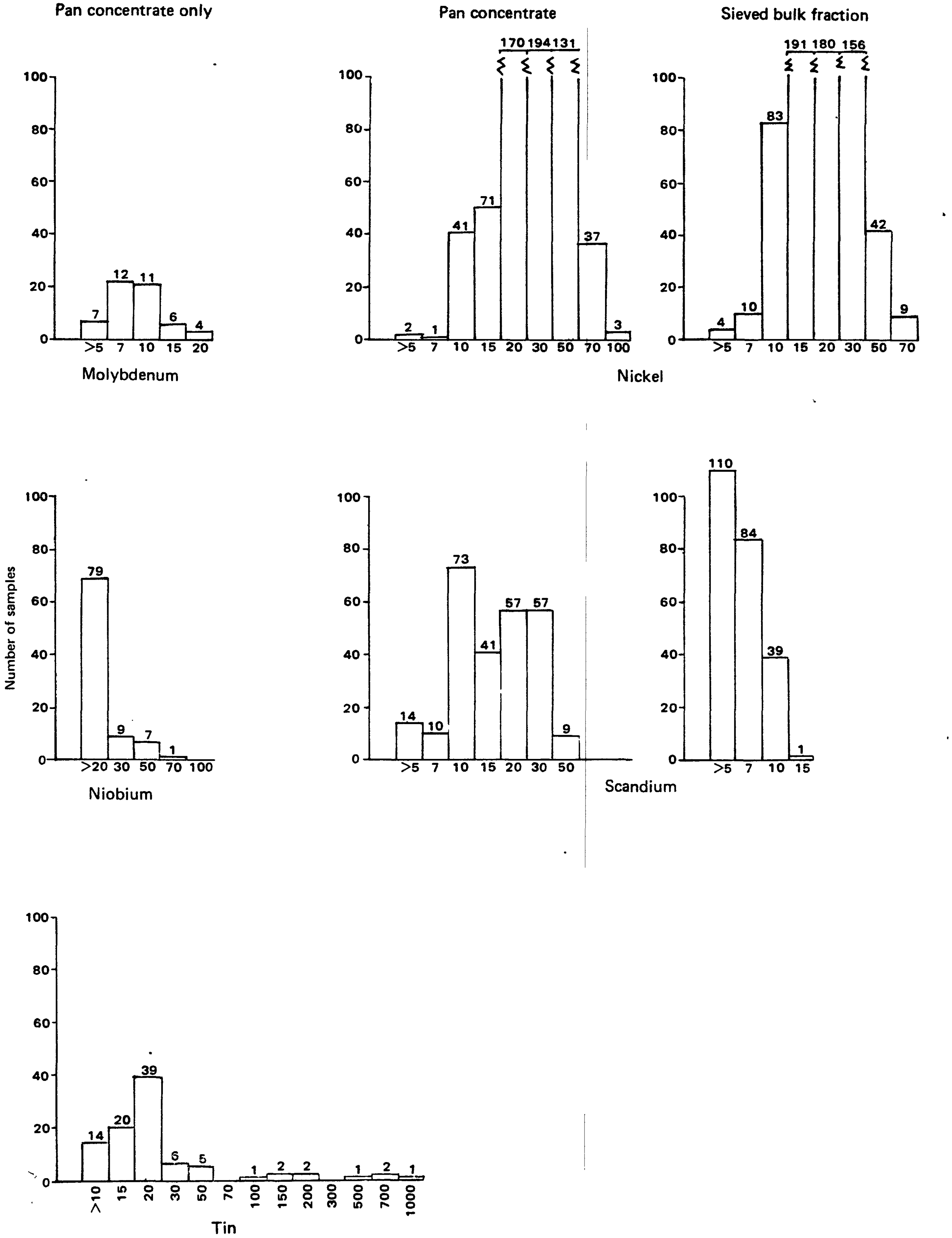

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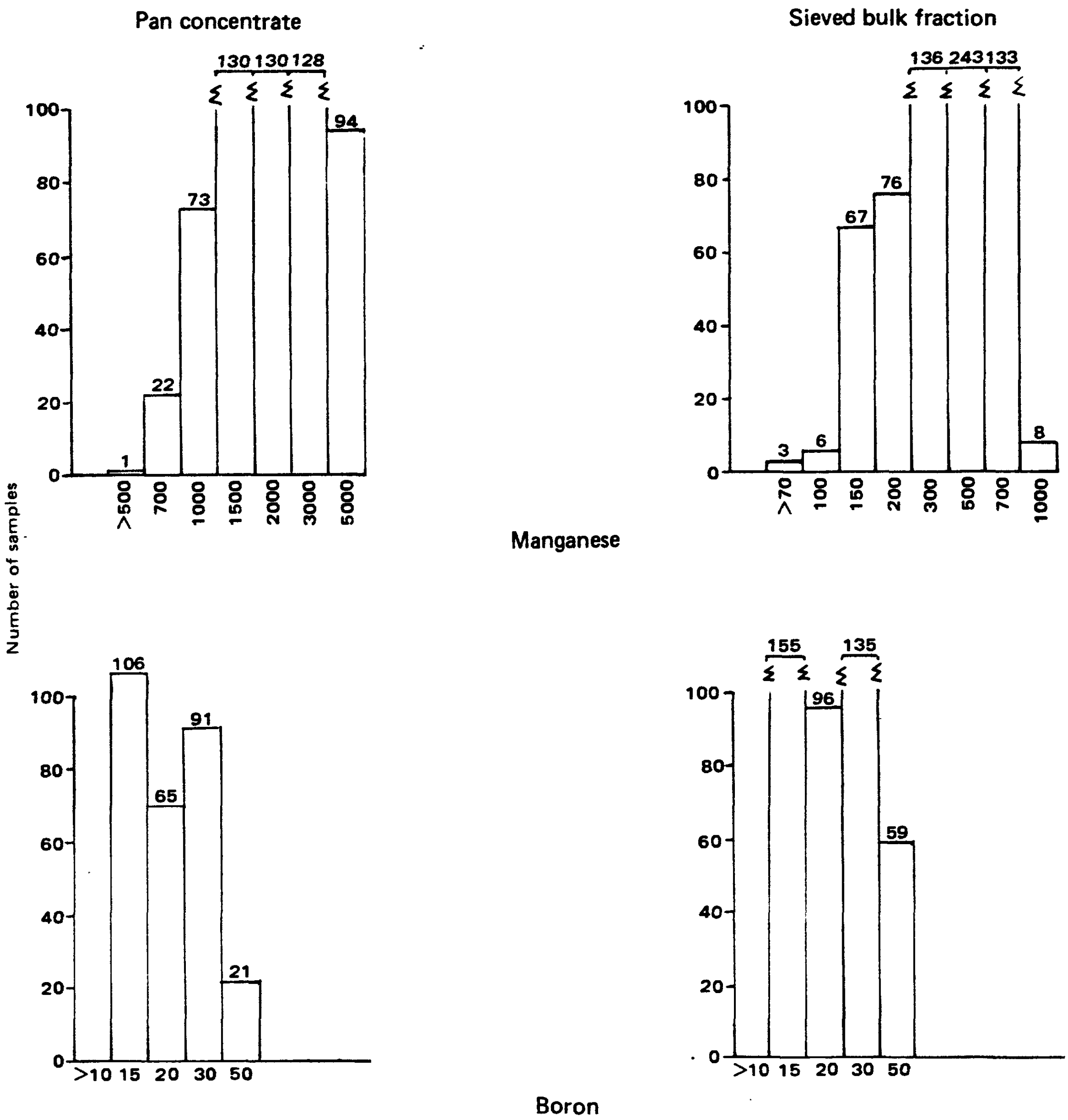

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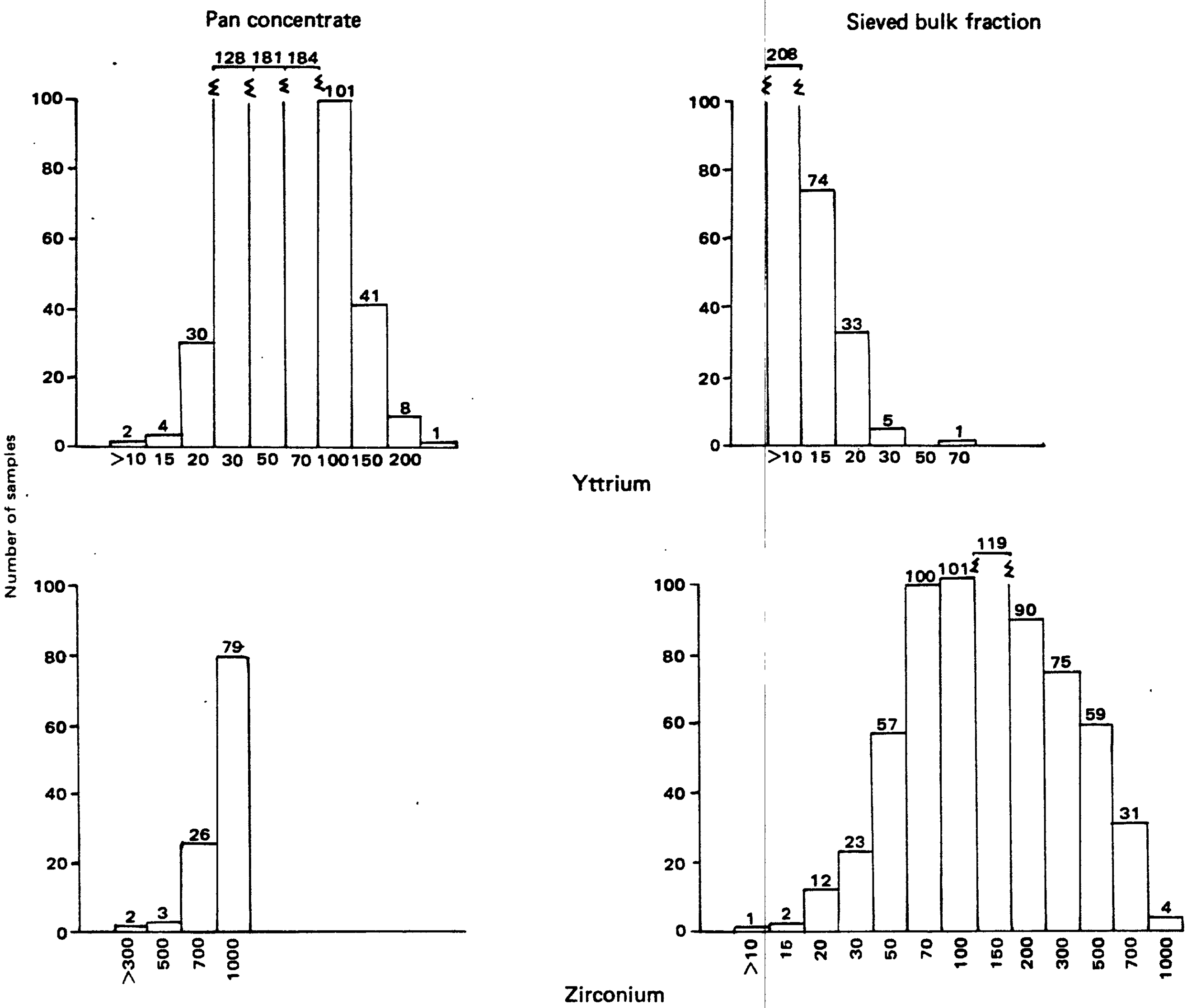

Figure 2.--Continued

DISCUSSION OF RESULTS

Sieved bulk-fraction samples

The Baid al Jimalah West tungsten and tin deposit (Cole and others, 1981; MODS 02661) in the southern part of the Al Jurdhawiyah quadrangle was detected in this study by one sample (RASS 149321) containing 200 ppm tungsten. The ancient mines at Baid al Jimalah East (MODS 00960) were detected by one sample (RASS 149305) containing 150 ppm lead. A copper and chromium anomaly north of Shaib ad Dath in the eastern part of the quadrangle is probably attributable to andesitic layers within the volcanic conglomerate because the copper content in mafic rocks is typically much greater than in felsic rocks. A small beryllium anomaly is coincident with Aban al Ahmar in the northern part of the Al Jurdhawiyah quadrangle. Aban al Ahmar consists of peralkaline granite that is typically enriched in several trace elements including beryllium (Drysdall, 1980). Anomalous nickel concentrations throughout the quadrangle are probably associated with the mafic rocks in the area.

Anomalous copper values are common throughout the Wadi al Jarir quadrangle, but the higher values are mainly in the southern part (pl. 1). These anomalous values are probably attributable to mafic dikes.

Pan-concentrate samples

The presence of the Baid al Jimalah West tungsten and tin deposit in the Al Jurdhawiyah quadrangle is suggested by one sample (RASS 159321) containing 1,500 ppm tungsten and 1,000 ppm tin (pl. 1). Several samples collected near Baid al Jimalah East ancient mines contain from 500 to 3,000 ppm lead and 200 ppm copper, and one sample (RASS 159317) anomalous in tin (100 ppm) was collected north of the Baid al Jimalah East ancient mines (pl. 1). Samples collected near Sumr al Jurdhawiyah contain anomalous concentrations of beryllium, lanthanum, and chromium. A sample (RASS 159684) containing 700 ppm copper was also obtained from this area. This anomalous area is near the contact between granodiorite and volcanic conglomerate that is interlayered with andesite. The anomalous-element suite in this area includes elements characteristic of both felsic and mafic terranes, probably because the wadi system draining the area is underlain by both felsic and mafic rocks.

Samples collected south of Aban al Ahmar contain anomalous concentrations of beryllium, lanthanum, niobium, and yttrium. These anomalous concentrations are probably attributable to the peralkaline granite of Aban al Ahmar, which is enriched in such trace elements (Drysdall, 1980).

The anomalous nickel concentrations in the Al Jurdhawiyah- and Murdama-group rocks are probably due to the presence of mafic rocks. Greater-than-normal accumulations of oxide and ferromagnesian minerals probably caused the vanadium anomaly in the northeastern part of the quadrangle.

In the Wadi al Jarir quadrangle, two samples collected from the southern part contain anomalous concentrations of tin of 150 ppm (RASS 159288) and 200 ppm (RASS 159324) (pl. 1).

FOLLOWUP INVESTIGATIONS

During Jumad al Awal 1401 AH (March 1981), additional wadi-sediment sampling was conducted in two parts of the Al Jurdhawiyah quadrangle. West of Sumr al Jurdhawiyah, near the locality from which the sample containing 700 ppm copper was collected, four wadi-sediment samples were collected (RASS 164722, 164723, 164724, 164725). The samples were processed as described above, and the pan concentrates were submitted to the DGMR-USGS chemical laboratory for semiquantitative spectrographic analysis. None of the samples contained anomalous copper concentrations.

Additional sampling was also conducted in the area around Baid al Jimalah East ancient mines and the area from which a sample containing 100 ppm tin was collected. The six samples collected were processed as described above, and the pan concentrates were submitted for analysis. The following values (in ppm) for tin, lead, and tungsten were obtained (see also plate 1)(leaders indicate not detected at lower limit of detection; see table 1):

Sample number	Tin	Lead	Tungsten
164721	20	-	-
164726	200	10	-
164727	500	-	-
164728	700	10	100
174210	100	3,000	-
174211	30	300	-
174212	700	500	-

These results indicate a zone anomalous in tin, lead, and tungsten east of the Baid al Jimalah West tin-tungsten deposit. The source and significance of this anomaly will be determined by work currently in progress by the USGS and the Riofinex Geological Mission under subprojects 3.12.05 and 3.12.19.

CONCLUSIONS AND RECOMMENDATIONS

The Baid al Jimalah West tungsten-tin deposit would have been discovered as a result of this geochemical survey had the source for alluvial tin and tungsten not already been located by Cole (1981) prior to the receipt of analytical results for wadi-sediment samples. Because of the difficulty of discovering deposits like Baid al Jimalah West, a program of wadi-sediment sampling should be conducted in each quadrangle as it is geologically mapped. Thorough wadi-sediment sampling should increase the likelihood of detection of areas of mineralized rock.

Most elements are more frequently detected in the pan-concentrate samples than in the sieved bulk-fraction samples. Ancient mines and areas of known mineralized rock are more clearly defined by the pan-concentrate samples. In the future, as du Bray (1981) also determined, only pan concentrates need to be analyzed.

The following areas are recommended for additional studies:

1. The tin, lead, and tungsten anomaly near Baid al Jimalah East ancient mines in the Al Jurdhawiyah quadrangle.

2. The area near Sumr al Jurdhawiyah in the Al Jurdhawiyah quadrangle from which the sample containing 700 ppm copper and the samples showing anomalous concentrations of nickel, cobalt, chromium, beryllium, and lanthanum were collected.

3. The two areas in the southern part of Wadi al Jarir quadrangle from which the two samples containing 150 ppm and 200 ppm tin in the pan-concentrate fraction were collected.

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