CIRCULAR 85

Mercury Content of Stream Sediments A Geochemical Survey of the Magdalena Mining District, New Mexico

by *FAZLOLLAH MISSAGHI*

STATE BUREAU OF MINES AND MINERAL RESOURCES
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Introduction

The geochemical survey of the Magdalena mining district is one in a continuing series of similar studies made by the New Mexico Bureau of Mines and Mineral Resources. In this study, an attempt has been made to establish the presence of mercury and the extent of its anomalies in stream sediments. It is known that dispersion of mercury above some hydrothermal ore deposits can be used as an aid in prospecting (Saukov, 1946; Hawks and Webb, 1962). Most studies of mercury dispersion are conducted by sampling the bedrock and, in some instances, by running soil analyses. A concurrent analysis of samples for this survey for lead, zinc, molybdenum, and copper was necessary to trace any possible relationship between anomalies of mercury and other metals of the district. The data thus obtained can be used in probing the area adjacent to the Magdalena district.

A geochemical bedrock traverse survey of the district was undertaken to establish the local threshold of lead, zinc, copper, molybdenum, and mercury in bedrock.

Although an improvement in the detecting technique of mercury was not planned at the beginning, it became necessary to make some improvements in the process of analysis in order to obtain more accurate results.

LOCATION AND ACCESSIBILITY

The Magdalena mining district lies in Socorro County in the central part of New Mexico about 65 miles south of Albuquerque and 28 miles west of Socorro (fig. 1). The investigated area is near the north end of the Magdalena Mountains, lying mostly on the west slope. The mining camp of Kelly was adjacent to the most productive area and was the largest camp in the district. The town of Magdalena is 3 miles from the principal mines and at the end of the branch line of the Atchison, Topeka, and Santa Fe Railway which leaves the main line at Socorro.

Access to the district is provided by U.S. Highway 60 which passes through the town of Magdalena.

Elevation of the district ranges from 6025 feet at its northeast corner to 9650 feet at the southeast corner on the crest of the range.

PREVIOUS WORK

U.S. Geological Survey Professional Paper 200 (Loughlin and Koschman, 1942) is a detailed study of the geology and ore deposits of the Magdalena mining district. Unfortunately, this work is out of print; a brief description of the geology of the area is given in connection with the present study. Lasky 'and Wootton (1933) compiled production records for the district from its earliest days through 1932. Their work was revised by Anderson (1957), who provided production data from 1932 through 1954. The most recent figures on production of the Magdalena district were compiled by the U.S. Geological Survey (1965).

GEOLOGY

There are four main groups of geologic formations in the district: argillite and granite of Precambrian age forming the core of the Magdalena Mountains; limestones, shales, and quartzites of Mississippian, Pennsylvanian, and Permian ages overlying the core and dipping westward; extrusive and intrusive igneous rocks of Tertiary age overlying the late Paleozoic sedimentary rocks and predominant in the southern and northwestern parts of the district; and landslides and alluvial deposits of Pleistocene to Recent age. Faults are numerous and are important structural features of the area. The principal mineralization is confined to a zone in the sedimentary rocks; it is adjacent to and above or below the "Silver Pipe" member of the Kelly Limestone. Secondary oxidized ores derived from the primary ores occur near the surface.

Since the geologic map of the district (Loughlin and Koschmann) is out of print, the distribution of faults and a simplified geology were adapted from previous work and used in the geochemical base map.

HISTORY OF MINING

The Magdalena mining district produced 325 million pounds of zinc, 73,000 short tons of lead, 5500 short tons of copper, 4 million ounces of silver, and less than 10,000 ounces of gold from 1866 through 1963. Mining activity in this district began with the discovery of oxidized lead ore, and the discovery of zinc carbonate in 1903 resulted in a marked increase in mining operations. Silver and gold are minor constituents of the lead and zinc ores. The production has been intermittent and fluctuating with metal prices. The ores of this district are classified as pyritic, pyritic copper, zinc, lead, and mixed sulfide, or zinc-lead. The mixed ores predominate and are in the form of local lenticular sheets. Almost all the known ore bodies are of the replacement type.

ACKNOWLEDGMENTS

Field work in the Magdalena mining district was conducted during the summer and fall of 1964. In this work, the author was assisted by Dominador Uy and Robert Chamberlin, part-time field assistants. The Rocky Mountain Geochemical Laboratories, Prescott, Arizona, did the geochemical analysis for lead, zinc, copper, and molybdenum. The preliminary analysis of samples for mercury was conducted by Dominador Uy, and the final determination of mercury by improved techniques was done in the Bureau's laboratory by

Jackie H. Smith under the supervision of Dr. Dexter H. Reynolds.

Field aid and technical advice by Mr. George B. Griswold and Dr. Frank E. Kottlowski, New Mexico Bureau of Mines and Mineral Resources, is gratefully acknowledged.

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Editorial work was done by Miss Teri Ray, and Mrs. Helen Waxier and Mrs. Betty Houston typed the manuscript. William E. Arnold drafted the illustrations. All are of the Bureau staff.

Geochemical Studies of the District

ANALYTICAL METHODS

All the rock and stream sediment samples were analyzed by the Rocky Mountain Geochemical Laboratories for lead, zinc, copper, and molybdenum content. The Type S Mercury Detector (Lemaire Instruments, Reno, Nevada) designed for the detection of mercury was adapted to laboratory conditions to improve its accuracy and to obtain permanent records of the assays. Figure 2 shows the standard equipment of the mercury detector. In principal, the instrument operates on the absorption by mercury vapor of ultraviolet light at 2537 Angstrom units (Ballard and Thornton, 1941). The modified equipment used for mercury analysis in this study is shown in Figure 3; here a small electric furnace replaces the propane burner and a recorder is connected to the microammeter circuit of the detector. Thus, the deviation of the microammeter is recorded and evaluated with higher precision. The rock samples collected for mercury vapor tests were ground and screened down to —40 mesh. The stream sediment samples were dried and screened to the same size. One gram of the sample was heated in a steel sample-heating bulb that is connected to the Mercury Detector. The mercury content of the sample was evaluated from the curve reproduced by the recorder.

ROCK SAMPLING SURVEY

Geologic cross sections of the Magdalena mining district (Loughlin and Koschmann) were chosen for geochemical traverse surveys. Aggregate samples of rock chips were taken along the cross sections and analyzed for lead, zinc, copper, molybdenum, and mercury content. These samples represent the outcrop of the formations along the profile. Some samples were taken from both sides of a dislocation or from the common border of the adjacent formations. Traverses 1 through 7 show the simplified geologic cross sections of the Magdalena district, the location of the samples, and the fluctuation of metal contents along the traverses. Table 1 describes the rock formation represented by each sample and gives the assay values of lead, zinc, copper, molybdenum, and mercury. Figures 4, 5, 6, 7, and 8 show the frequency distribution of lead, zinc, copper, molybdenum, and mercury in the rock samples.

The following values were chosen as threshold contents for the traverse survey: lead, 70 ppm; zinc, 100 ppm; copper, 30 ppm; molybdenum, 2 ppm; and mercury, 50 ppb.

A comparison of lead, zinc, copper, or molybdenum anomalies with anomalies of the mercury content in rock samples reveals the following:

Total number of lead, zinc, copper or molybdenum anomalies	66
Total number of mercury anomalies	33
Mercury anomalies coinciding with lead, zinc, copper, or molybdenum anomalies	23

This means that 50 per cent of the lead, zinc, copper, or molybdenum anomalies is confirmed by the mercury anomalies and that 70 per cent of the total mercury anomalies corresponds to those of the other metals.

A further breakdown of mercury anomalies shows the following relationship:

4 per cent of the mercury anomalies confirmed by the anomalies of other metals corresponds to the anomalies of four metals;

18 per cent of the mercury anomalies confirmed by the anomalies of other metals corresponds to the anomalies of three metals;

21 per cent of the mercury anomalies confirmed by the anomalies of other metals corresponds to the anomalies of two metals;

57 per cent of the mercury anomalies confirmed by the anomalies of other metals corresponds to the anomalies of one metal.

STREAM SEDIMENT SURVEY

There are no permanent streams within the area studied. "Stream" sediment samples were taken along the main valleys and the arroyos of the district (pl. 1). Some arroyos, no doubt, are contaminated by existing waste dumps, but these are easy to spot. Table 2 gives the assay values of lead, zinc, copper, molybdenum, and mercury in stream sediment samples. The frequency distribution of stream sediment sample analysis is shown in Figures 9, 10, 11, 12, and 13.

The following values were chosen as threshold contents for stream sediment survey: lead, 200 ppm; zinc, 150 ppm; copper, 60 ppm; molybdenum, 3 ppm; and mercury, 150 ppb.

A relationship between mercury anomalies and anomalies of the other metals can be established from the following:

Total number of lead, zinc, copper, or molybdenum anomalies	116
Total number of mercury anomalies	63
Mercury anomalies coinciding with lead, zinc, copper, or molybdenum anomalies	50

In other words, 54.3 per cent of the lead, zinc, copper, or molybdenum anomalies is confirmed by the mercury anomalies and 79.3 per cent of the total mercury anomalies corresponds to those of the other four metals.

A further breakdown of the data shows that in stream sediment samples most of the mercury anomalies correspond to the anomalies of four and three other metals.

38 per cent of the mercury anomalies confirmed by the anomalies of other metals corresponds to the anomalies of four metals;

38 per cent of the mercury anomalies confirmed by the anomalies of other metals corresponds to the anomalies of three metals;

14 per cent of the mercury anomalies confirmed by the anomalies of other metals corresponds to the anomalies of two other metals;

10 per cent of the mercury anomalies confirmed by the anomalies of other metals corresponds to the anomalies of one other metal.

Conclusions

Although the mercury halo method was primarily devised to discover hidden ore bodies, it can be used in geochemical stream sediment surveys. The present study indicates that 76 per cent of the mercury anomalies confirmed by the anomalies of lead, zinc, copper, or molybdenum in stream sediments corresponds to the anomalies of all four or three out of four of the other metals. In the traverse survey (that is, rock sampling), only 22 per cent of the mercury anomalies belongs to this category.

Portable equipment for mercury detection used in this study is useful in preliminary work, but a more reliable and sensitive instrument must be used for quantitative determination of mercury content (McCarthy and Vaughn, 1964).

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TABLE 1. ASSAY RESULTS FROM ROCK SAMPLING.

SAMPLE NO.	ROCK—LOCATION	LEAD (ppm)	ZINC (ppm)	COPPER (ppm)	MOLYBDENUM (ppm)	MERCURY (ppb)
1	Argillite (T1)	**110**	85	**140**	1	30
2	Argillite/Kelly limestone (T1)	30	55	25	1	24
3	Kelly limestone (T1)	**205**	**+1000**	20	**4**	**120**
4	Kelly limestone/Lower limestone (T1)	**+1000**	**+1000**	**185**	**2**	**120**
5	Lower limestone (T1)	**70**	45	15	—1	**54**
6	Lower limestone/Shale (T1)	**300**	**105**	**40**	1	**50**
7	Shale (T1)	**190**	**180**	**230**	**3**	16
8	Shale/Upper limestone (T1)	**250**	60	20	**2**	20
9	Upper limestone (T1)	10	20	10	**3**	**64**
10	Upper limestone/Upper quartzite (T1)	20	15	10	**3**	30
11	Rhyolite porphyry (T1)	**110**	50	25	—1	12
12	Upper latite tuff (T1)	**80**	45	20	—1	**100**
13	White rhyolite dike (T1)	45	10	15	—1	12
14	Lower andesite (T1)	35	80	**50**	**2**	**110**
15	Lower latite tuff (T1)	65	70	20	—1	48
16	White felsite tuff (T1)	55	45	15	1	24
17	Madera limestone (T1)	**75**	20	15	**6**	8
18	Madera limestone/Upper quartzite (T1)	45	35	15	**5**	16
19	Upper quartzite (T1)	40	10	10	—1	40
20	Granite (T5)	**230**	**180**	**50**	—1	24
21	Granite/Kelly limestone (T5)	65	95	10	—1	16
22	Kelly limestone (T5)	**145**	35	—5	**3**	32
23	Kelly l./Lower quartz/Kelly l. (T5)	**90**	**350**	10	**2**	**82**
24	Kelly limestone (T5)	25	20	5	—1	34
25	Lower quartzite (T5)	**85**	95	10	1	30
26	Lower limestone (T5)	35	70	20	**5**	**64**
27	Middle quartzite (T5)	55	40	20	**8**	**50**
28	Shale (T5)	**85**	**145**	20	**27**	30
29	Upper quartzite (T5)	30	55	20	1	20
30	Madera limestone (T5)	30	10	15	**3**	10
31	Lower limestone (T5)	40	25	15	—1	10
32	Lower quartzite (T5)	**240**	**250**	**70**	**8**	24
33	Lower limestone (T5)	50	70	15	—1	24
34	Madera limestone (T5)	25	30	15	—1	—5
35	Lower limestone (T5)	40	45	15	**2**	20
36	Shale and Upper quartzite (T5)	**400**	**330**	30	1	30
37	Madera limestone (T5)	50	50	25	1	**76**
38	Rhyolite porphyry (T5)	40	**125**	20	1	16
39	Banded rhyolite (T5)	45	50	10	**2**	40
40	Kelly limestone (T4)	**550**	**220**	15	**2**	10
41	Lower quartzite (T4)	**70**	40	15	1	30
42	Lower limestone (T4)	**160**	**160**	15	—1	**52**
43	Shale (T4)	50	**500**	**35**	1	**156**
44	Madera limestone (T4)	**350**	**140**	10	1	10
45	Rhyolite porphyry (T4)	45	30	25	1	10
46	Monzonite (T4)	20	40	10	1	24
47	Granite (T4)	50	65	20	—1	**50**
48	Argillite (T4)	45	75	**105**	**2**	24
49	Kelly limestone (T4)	50	**105**	10	1	**82**
50	Lower quartzite (T4)	10	**125**	15	1	22
51	Lower limestone (T4)	10	40	25	—1	48
52	Shale (T4)	25	**115**	25	—1	46
53	Upper quartzite (T4)	10	80	**35**	1	**130**
54	Madera limestone (T4)	10	40	15	1	26
55	Argillite (T4)	30	70	**35**	1	26
56	Granite (T6)	35	75	20	—1	**64**
57	Kelly limestone (T6)	65	75	15	—1	—5

A minus sign (—) is to be read "less than" and a plus sign (+) "greater than".
Anomalous values are given in boldface numbers (for example, **2**, **180**, **50**).
*T=Traverse.

TABLE 1. ASSAY RESULTS FROM ROCK SAMPLING (Cont)

SAMPLE NO.	ROCK—LOCATION	LEAD (ppm)	ZINC (ppm)	COPPER (ppm)	MOLYBDENUM (ppm)	MERCURY (ppb)
58	Lower quartzite (T6)	15	**105**	15	—1	18
59	Lower limestone (T6)	10	55	10	—1	6
60	Middle quartzite (T6)	35	55	15	—1	12
61	Shale (T6)	40	60	25	—1	**122**
62	Upper limestone (T6)	15	30	10	1	**104**
63	Kelly limestone (T6)	**+1000**	**310**	25	**11**	24
64	Granite (T6)	60	**100**	30	1	**68**
65	Kelly limestone (T6)	50	35	15	**11**	26
66	Granite (T6)	**230**	**230**	**40**	1	8
67	Diabase dike (T6)	55	70	**75**	—1	**60**
68	Kelly limestone (T6)	**125**	70	15	**2**	32
69	Lower quartzite/Upper quartzite (T6)	**110**	**145**	30	**3**	18
70	Madera limestone (T6)	20	15	15	**3**	20
71	Abo sandstone (T6)	10	20	10	1	14
72	Pink rhyolite/Rhyolite porphyry (T6)	50	45	20	1	16
73	Red andesite (T6)	40	15	30	1	10
74	Red rhyolite (T6)	25	25	30	—1	34
75	Latite porphyry (T6)	50	30	25	—1	36
76	Abo sandstone (T6)	25	25	30	—1	46
77	Purple andesite (T6)	30	25	**35**	—1	30
78	Granite (T3)	**70**	70	**55**	1	**90**
79	Kelly limestone (T3)	**+1000**	**+1000**	**400**	**3**	15
80	White rhyolite dike (T3)	**225**	85	**80**	1	36
81	Madera limestone (T3)	**90**	**300**	**35**	—1	**196**
82	Shale (T3)	35	—5	25	1	40
83	Upper latite tuff (T3)	50	25	**200**	**4**	**136**
84	Upper latite flow (T3)	40	50	**40**	—1	**128**
85	Rhyolite porphyry (T3)	45	25	**40**	—1	10
86	Monzonite (T3)	40	20	**50**	1	**66**
87	Kelly limestone (T7)	**+1000**	**130**	**75**	**35**	36
88	Lower quartzite (T7)	40	70	25	—1	**50**
89	Middle quartzite (T7)	20	10	20	—1	**70**
90	Lower limestone (T7)	15	55	20	—1	**96**
91	Lower quartzite (T7)	**80**	65	20	1	8
92	Kelly limestone (T7)	30	45	10	—1	10
93	Argillite (T7)	**400**	**425**	25	**6**	10
94	Madera limestone (T7)	10	—5	25	1	20
95	Purple andesite (T7)	15	25	30	—1	42
96	Latite porphyry (T7)	35	15	15	—1	8
97	Purple andesite (T7)	30	20	25	—1	42
98	Banded rhyolite (T7)	30	5	20	—1	38
99	Red andesite (T7)	30	30	25	—1	**64**
100	Upper andesite (T7)	25	35	**40**	—1	40
101	Pink rhyolite (T7)	40	5	30	—1	24
102	White rhyolite dike (T2)	35	10	20	—1	**68**
103	Lower andesite (T2)	30	50	30	—1	18
104	Upper latite tuff (T2)	20	25	**45**	1	10
105	Rhyolite porphyry (T2)	25	15	25	—1	30
106	Augite andesite (T2)	20	55	**75**	1	**62**
107	Granite (T2)	25	40	**70**	1	**52**
108	Granophyre (T2)	**540**	85	**185**	**5**	30
109	Granite (T3)	15	10	**75**	—1	16
110	Felsite (T7)	20	20	**35**	—1	40

A minus sign (—) is to be read "less than" and a plus sign (+) "greater than".
Anomalous values are given in boldface numbers (for example, **2**, **180**, **50**).
*T=Traverse.

TABLE 2. ASSAY RESULTS FROM STREAM SEDIMENT SAMPLING

SAMPLE NO.	LEAD (ppm)	ZINC (ppm)	COPPER (ppm)	MOLYBDENUM (ppm)	MERCURY (ppb)
SM-1	50	45	15	—1	60
SM-2	60	45	10	—1	20
SM-3	**220**	130	35	2	40
SM-4	**215**	**150**	45	2	20
SM-5	195	115	40	1	60
SM-6	145	75	35	1	**124**
SM-7	185	120	45	**10**	**44**
SM-8	**250**	105	45	1	**42**
SM-9	**400**	120	40	**3**	**48**
SM-10	**225**	120	40	**4**	75
SM-11	**290**	**155**	45	2	**34**
SM-12	**260**	**155**	50	**3**	35
SM-13	85	70	30	2	60
SM-14	185	**165**	45	1	20
SM-15	**320**	130	40	—1	**34**
SM-16	130	70	30	1	20
SM-17	155	100	55	2	30
SM-18	120	75	30	2	30
SM-19	195	85	40	1	20
SM-20	185	70	50	1	20
SM-21	100	60	30	1	—5
SM-22	95	70	35	—1	70
SM-23	150	130	50	**3**	24
SM-24	145	120	55	1	26
SM-25	125	80	45	1	10
SM-26	45	30	40	1	30
SM-27	40	40	35	1	40
SM-28	95	65	40	—1	4
SM-29	150	90	**60**	2	28
SM-30	**550**	100	50	**11**	18
SM-31	**205**	70	35	1	18
SM-32	105	55	25	1	100
SM-33	120	80	45	2	**156**
SM-34	100	70	35	2	70
SM-35	110	90	55	**3**	**156**
SM-36	120	70	55	1	**116**
SM-37	**+1000**	**+1000**	**200**	**14**	**220**
SM-38	100	55	30	2	40
SM-39	125	80	40	2	**182**
SM-40	95	40	30	1	24
SM-41	120	45	30	—1	**360**
SM-42	110	45	30	1	**190**
SM-43	145	**230**	**105**	2	20
SM-44	140	**200**	**90**	1	24
SM-45	190	**180**	**125**	**3**	110
SM-46	**220**	**330**	30	**3**	**954**
SM-47	**215**	**260**	40	2	**440**
SM-48	**270**	**300**	**65**	1	**432**
SM-49	**250**	**270**	50	—1	**132**
SM-50	**270**	**250**	50	—1	**190**
SM-51	**+1000**	**+1000**	**320**	—1	**450**
SM-52	**+1000**	**+1000**	**160**	—1	**230**
SM-53	185	**220**	**120**	1	—5
SM-54	**900**	**210**	**140**	1	**220**
SM-55	**+1000**	**380**	**105**	2	16
SM-56	**1050**	**400**	**120**	2	150
SM-57	**+1000**	**475**	**100**	1	110
SM-58	**+1000**	**450**	**140**	**10**	**180**

A minus sign (—) is to be read "less than" and a plus sign (+) "greater than".
Anomalous values are given in boldface numbers (for example, **220**, **3**, **155**).

TABLE 2. ASSAY RESULTS FROM STREAM SEDIMENT SAMPLING (Cont)

SAMPLE NO.	LEAD (ppm)	ZINC (ppm)	COPPER (ppm	MOLYBDENUM (ppm)	MERCURY (ppb)
SM-59	**+1000**	**+1000**	**+1000**	**6**	**290**
SM-60	**425**	**340**	**110**	1	20
SM-61	195	135	35	—1	140
SM-62	155	95	30	—1	**150**
SM-63	**350**	**300**	**75**	1	20
SM-64	**220**	**230**	**60**	1	80
SM-65	125	70	25	—1	30
SM-66	90	60	15	—1	—5
SM-67	**525**	**360**	**90**	—1	**310**
SM-68	**+1000**	**+1000**	**180**	**9**	**414**
SM-69	**+1000**	**525**	**85**	**11**	**210**
SM-70	120	**230**	**120**	**3**	5
SM-71	**+1000**	**+1000**	**110**	**3**	**290**
SM-72	185	**340**	**75**	1	50
SM-73	195	**425**	**75**	2	140
SM-74	175	**390**	**65**	1	**662**
SM-75	150	**400**	**65**	1	130
SM-76	90	**220**	40	—1	140
SM-77	60	90	35	—1	52
SM-78	65	95	30	1	52
SM-79	**205**	110	35	1	10
SM-80	165	**175**	30	**5**	54
SM-81	95	95	30	—1	10
SM-82	120	100	30	1	60
SM-83	**300**	**360**	50	—1	100
SM-84	40	70	20	2	8
SM-85	20	55	20	2	8
SM-86	30	45	25	—1	24
SM-87	20	50	15	1	—5
SM-88	**+1000**	**+1000**	**+1000**	**14**	**1200**
SM-89	**+1000**	**+1000**	**+1000**	**10**	**540**
SM-90	**+1000**	**+1000**	**+1000**	**5**	88
SM-91	**+1000**	**+1000**	**+1000**	**18**	**650**
SM-92	**+1000**	**+1000**	**+1000**	**5**	**380**
SM-93	**225**	**500**	**95**	—1	**860**
SM-94	**200**	**390**	**75**	1	**648**
SM-95	**250**	**450**	**75**	1	**520**
SM-96	**+1000**	**850**	**160**	1	30
SM-97	**+1000**	**950**	**215**	1	12
SM-98	**+1000**	**500**	**140**	—1	6
SM-99	**+1000**	**+1000**	**900**	3	70
SM-100	**+1000**	**750**	**135**	2	6
SM-101	**300**	**340**	**105**	—1	20
SM-102	30	70	15	—1	22
SM-103	35	85	15	1	30
SM-104	35	75	25	—1	20
SM-105	25	70	20	1	50
SM-106	170	**330**	**90**	2	**290**
SM-107	**330**	**750**	**95**	—1	**1270**
SM-108	**225**	**330**	**200**	1	**370**
SM-109	190	**350**	**150**	1	**190**
SM-110	140	**185**	55	2	**184**
SM-111	150	**200**	55	2	40
SM-112	120	145	35	1	54
SM-113	90	110	20	—1	22
SM-114	100	135	55	2	100
SM-115	80	105	35	2	80
SM-116	70	85	30	—1	30

A minus sign (—) is to be read "less than" and a plus sign (+) "greater than".

Anomalous values are given in boldface numbers (for example, **220**, **3**, **155**).

TABLE 2. ASSAY RESULTS FROM STREAM SEDIMENT SAMPLING (Cont)

SAMPLE NO.	LEAD (ppm)	ZINC (ppm)	COPPER (ppm)	MOLYBDENUM (ppm)	MERCURY (ppb)
SM-117	**500**	**+1000**	**65**	1	50
SM-118	**+1000**	**+1000**	**250**	2	40
SM-119	**+1000**	**+1000**	**220**	2	**228**
SM-120	120	125	30	2	94
SM-121	**650**	115	**75**	**3**	**230**
SM-122	185	70	25	**3**	**206**
SM-123	**475**	55	25	1	140
SM-124	**200**	75	30	2	**170**
SM-125	85	45	35	1	100
SM-126	**525**	105	**65**	**3**	110
SM-127	**210**	55	30	**3**	50
SM-128	90	55	35	2	**196**
SM-129	50	50	35	1	30
SM-130	50	55	30	1	10
SM-131	65	45	35	—1	140
SM-132	60	65	35	2	32
SM-133	**+1000**	**1050**	**140**	**4**	**150**
SM-134	**800**	**550**	**85**	**4**	120
SM-135	**850**	**900**	**145**	**3**	58
SM-136	**475**	**450**	**85**	2	32
SM-137	**340**	**290**	**60**	—1	20
SM-138	60	45	30	—1	**240**
SM-139	65	55	25	1	74
SM-140	50	45	15	—1	80
SM-141	55	40	40	—1	**282**
SM-142	50	40	30	—1	100
SM-143	80	40	35	1	**184**
SM-144	50	35	30	—1	110
SM-145	**625**	50	25	1	**174**
SM-146	25	55	20	—1	**166**
SM-147	**+1000**	**+1000**	**+1000**	35	**858**
SM-148	30	30	15	1	**310**
SM-149	80	45	20	1	**190**
SM-150	**320**	**425**	**75**	—1	110
SM-151	**+1000**	**+1000**	**+1000**	**40**	**264**
SM-152	**340**	**290**	55	**5**	100
SM-153	165	110	35	1	**760**
SM-154	**+1000**	**270**	**105**	**5**	110
SM-155	**525**	115	30	2	100
SM-156	**675**	135	25	2	60
SM-157	**350**	130	25	**3**	**250**
SM-158	**550**	**170**	45	2	**430**
SM-159	105	110	25	—1	100
SM-160	**+1000**	**+1000**	**500**	**19**	140
SM-161	**900**	**400**	**75**	**4**	**240**
SM-162	**+1000**	**340**	**60**	**3**	110
SM-163	**+1000**	**250**	**70**	**3**	112
SM-164	**550**	**290**	**60**	1	**220**
SM-165	105	80	30	1	140
SM-166	**+1000**	**+1000**	**+1000**	**11**	139
SM-167	**+1000**	**+1000**	**1000**	**6**	**720**
SM-168	**+1000**	**+1000**	**+1000**	**8**	**296**
SM-169	**850**	**250**	**65**	1	30
SM-170	**550**	**155**	30	1	44
SM-171	**900**	**180**	45	**3**	**250**
SM-172	**950**	**230**	50	**3**	**212**
SM-173	**240**	**150**	30	—1	70
SM-174	140	85	30	—1	—5

A minus sign (—) is to be read "less than" and a plus sign (+) "greater than".
Anomalous values are given in boldface numbers (for example, **220**, **3**, **155**).

TABLE 2. ASSAY RESULTS FROM STREAM SEDIMENT SAMPLING Wont 1

SAMPLE NO.	LEAD (ppm)	ZINC (ppm)	COPPER (ppm)	MOLYBDENUM (ppm)	MERCURY (ppb)
SM-175	75	60	35	—1	124
SM-176	155	135	55	1	116
SM-177	25	55	35	—1	40
SM-178	50	85	35	—1	30
SM-179	**900**	**370**	**75**	**3**	**590**
SM-180	+**1000**	**400**	**90**	**6**	**530**
SM-181	**850**	**260**	**75**	**3**	106
SM-182	+**1000**	**350**	**85**	**2**	**200**
SM-183	**600**	**310**	**85**	—1	**396**
SM-184	+**1000**	+**1000**	+**1000**	**10**	**1100**
SM-185	+**1000**	+**1000**	**950**	**50**	70
SM-186	+**1000**	+**1000**	**550**	**13**	118
SM-187	+**1000**	**195**	50	**3**	60
SM-188	+**1000**	+**1000**	+**1000**	**55**	80

A minus sign (—) is to be read "less than" and a plus sign (+) "greater than".
Anomalous values are given in boldface numbers (for example, **220**, **3**, **155**).

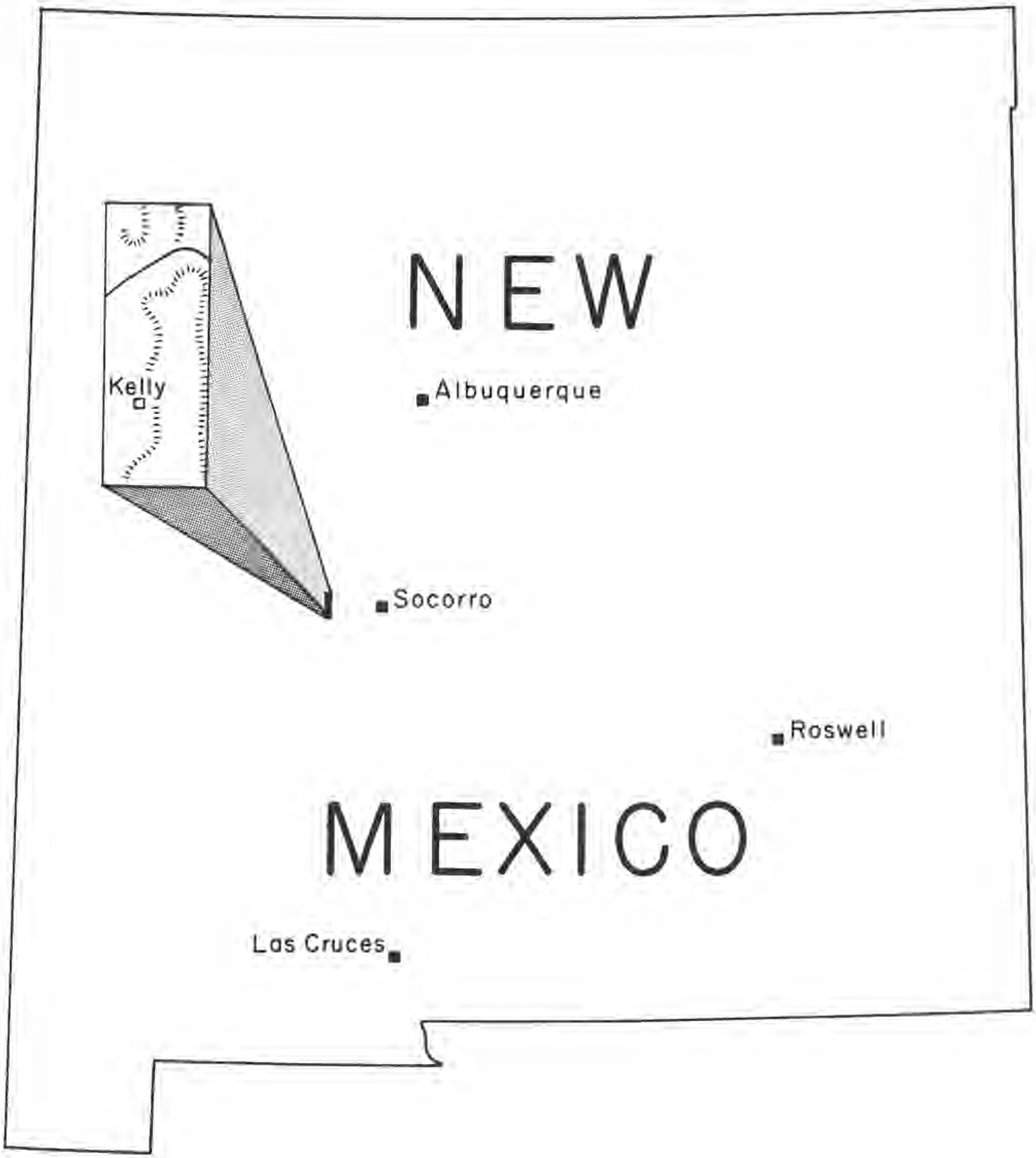


Figure 1
INDEX MAP SHOWING LOCATION OF MAGDALENA MINING DISTRICT

Figure 2

STANDARD EQUIPMENT OF THE TYPE S MERCURY DETECTOR

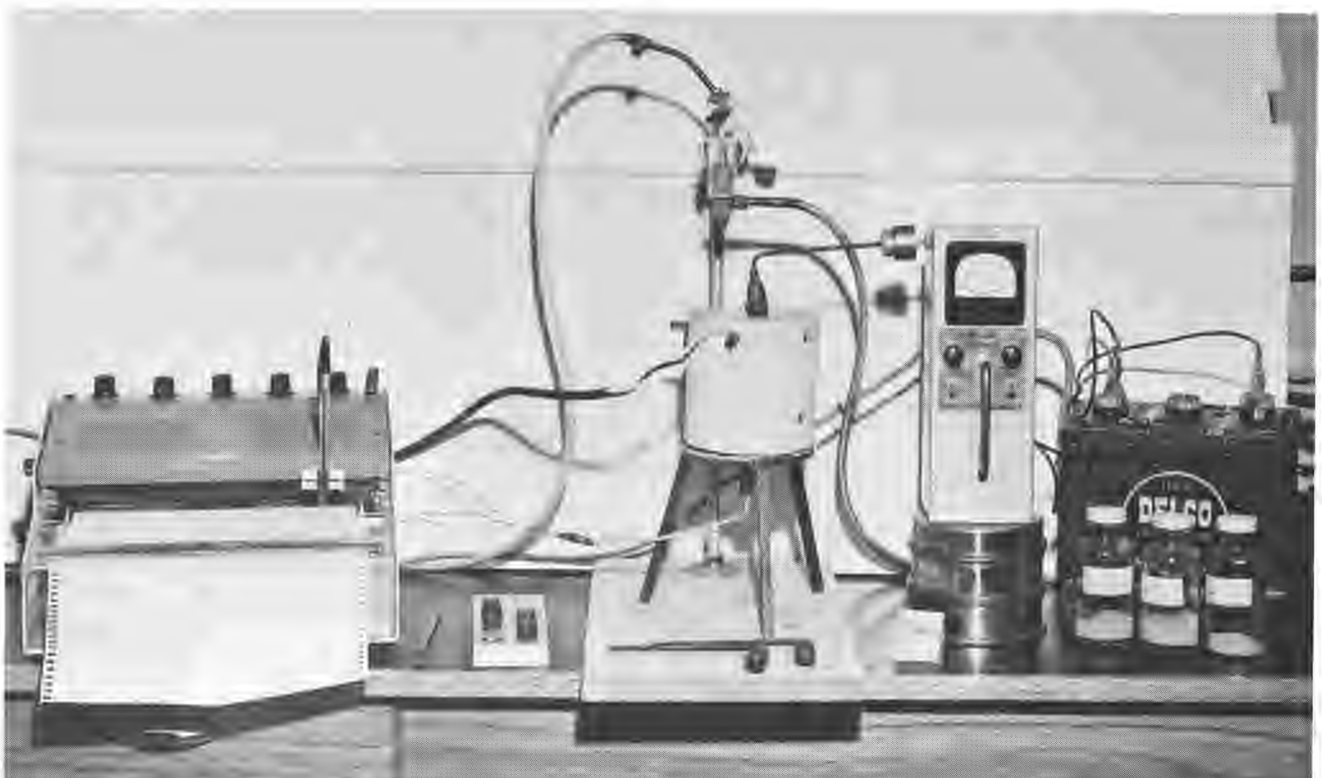


Figure 3

MODIFIED EQUIPMENT OF THE TYPE S MERCURY DETECTOR FOR LABORATORY WORK

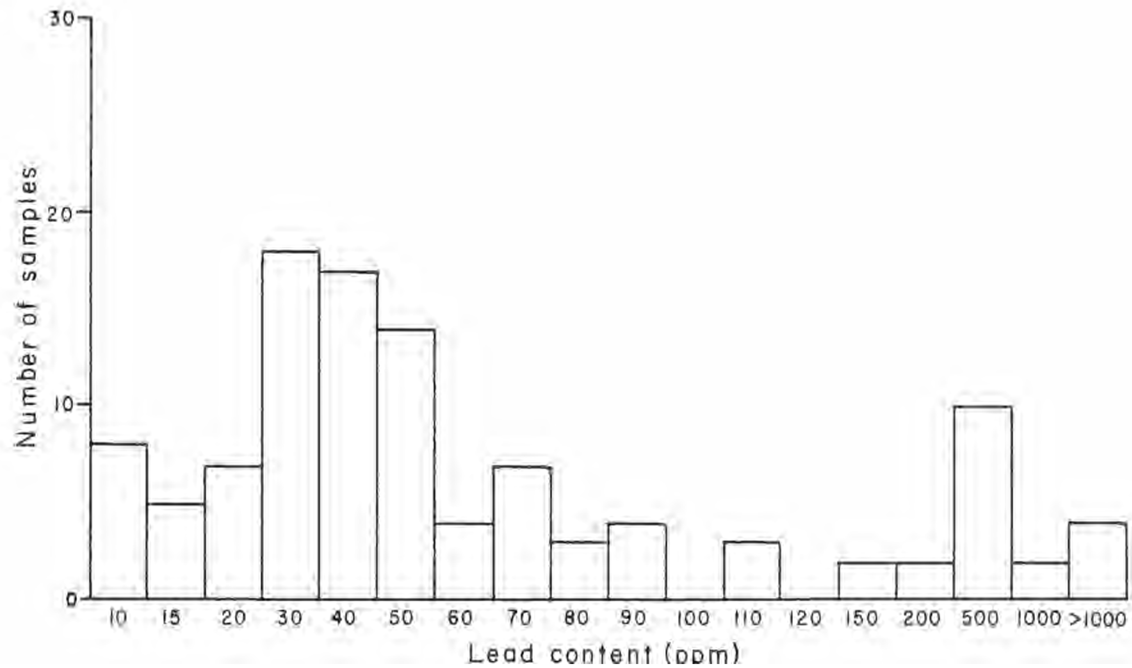


Figure 4
FREQUENCY DISTRIBUTION OF LEAD IN TRAVERSE SURVEY, ROCK SAMPLES

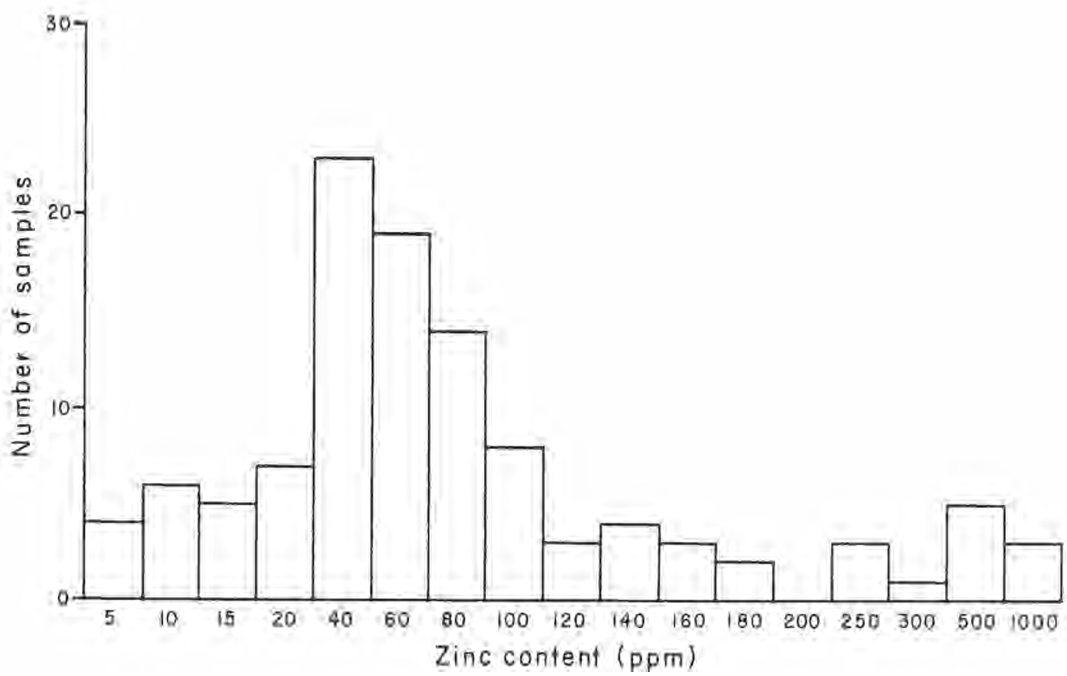


Figure 5
FREQUENCY DISTRIBUTION OF ZINC IN TRAVERSE SURVEY, ROCK SAMPLES

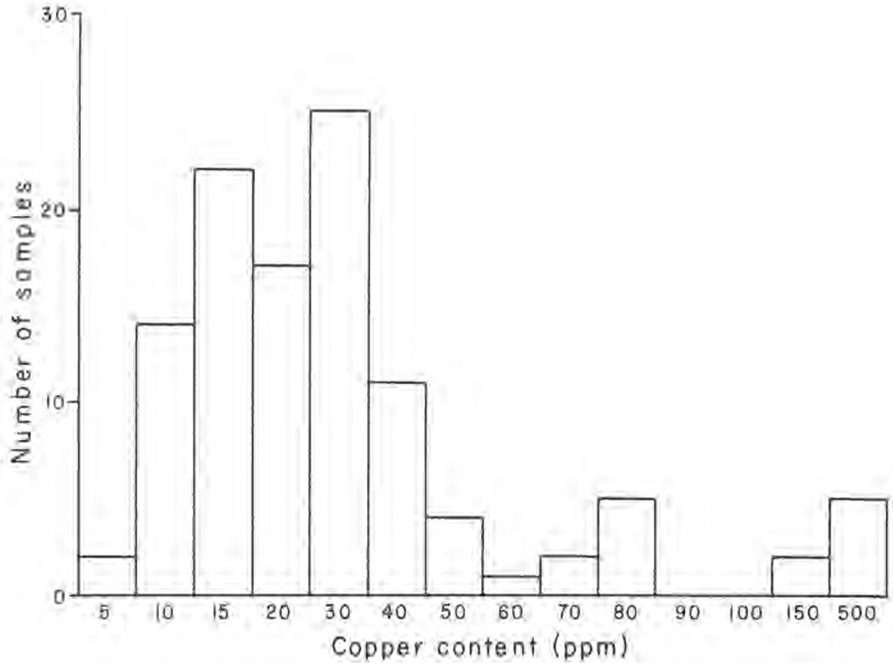


Figure 6

FREQUENCY DISTRIBUTION OF COPPER IN TRAVERSE SURVEY. ROCK SAMPLES

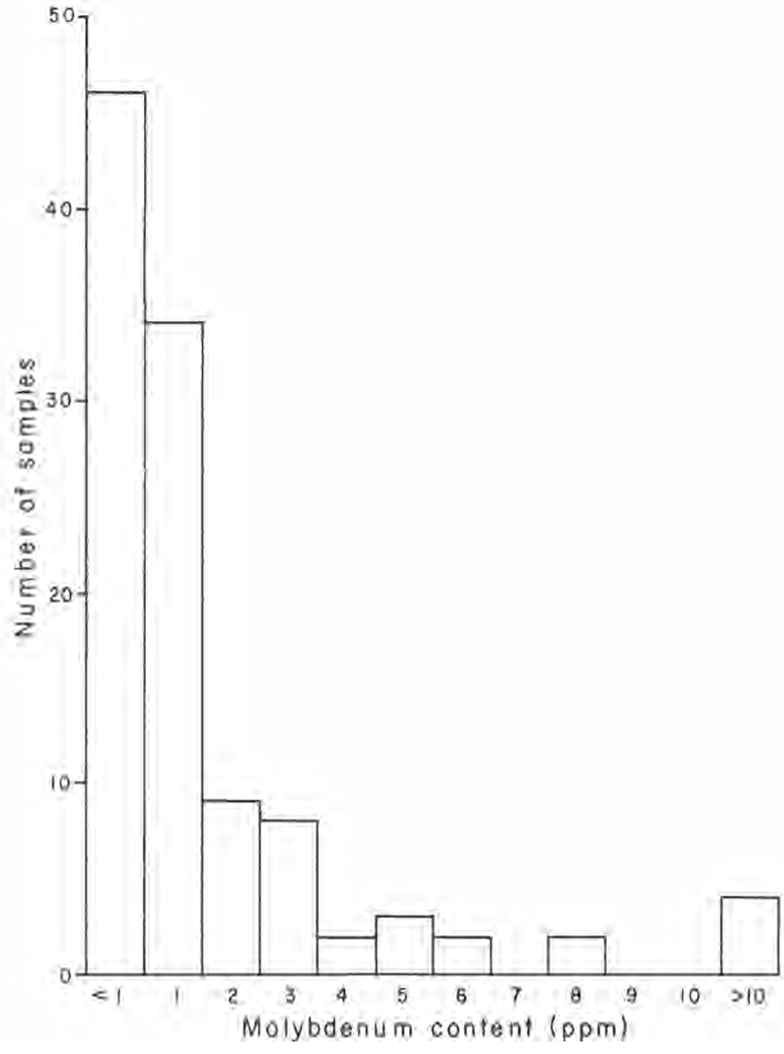


Figure 7

FREQUENCY DISTRIBUTION OF MOLYBDENUM IN TRAVERSE SURVEY, ROCK SAMPLES

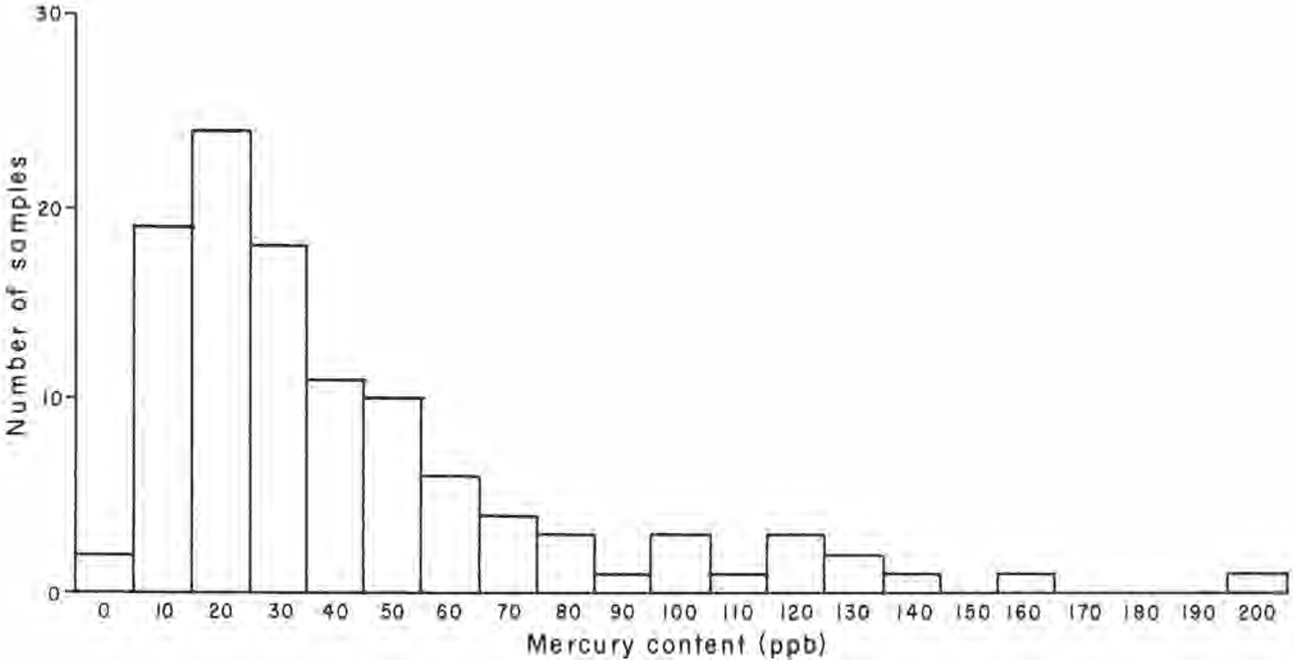


Figure 8

FREQUENCY DISTRIBUTION OF MERCURY IN TRAVERSE SURVEY, ROCK SAMPLES

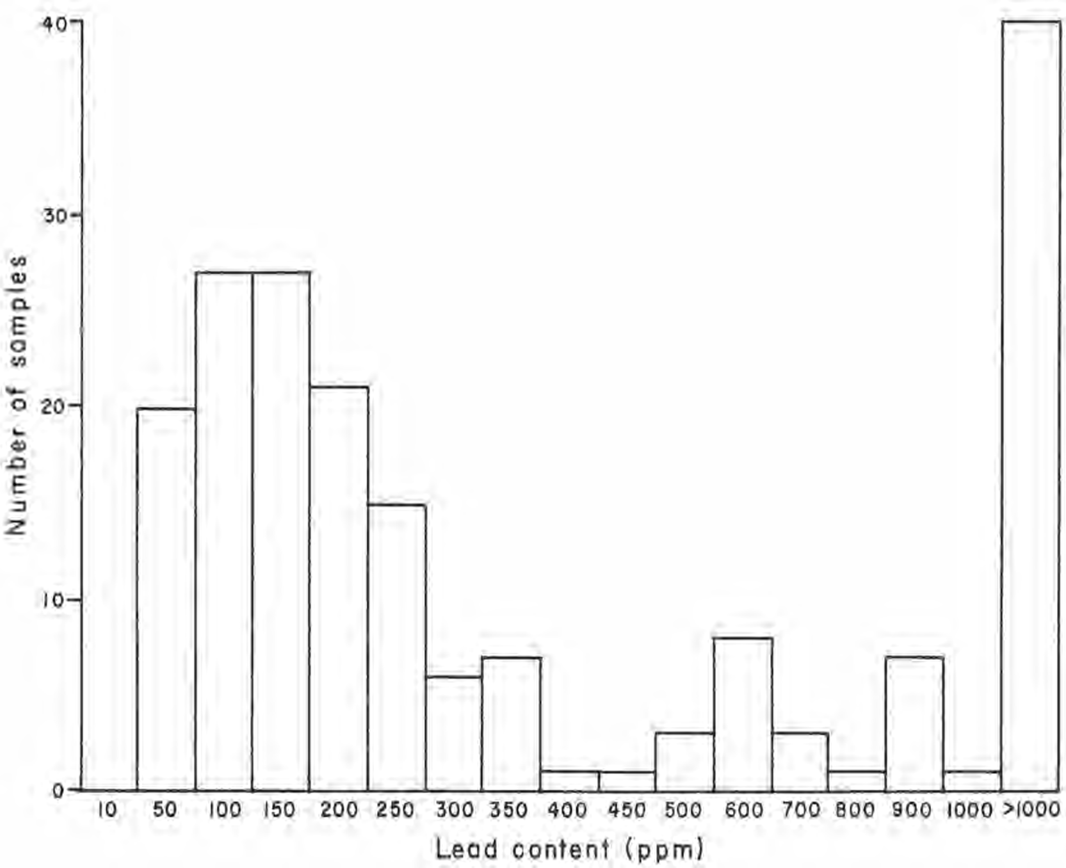


Figure 9

FREQUENCY DISTRIBUTION OF LEAD IN STREAM SEDIMENT SURVE

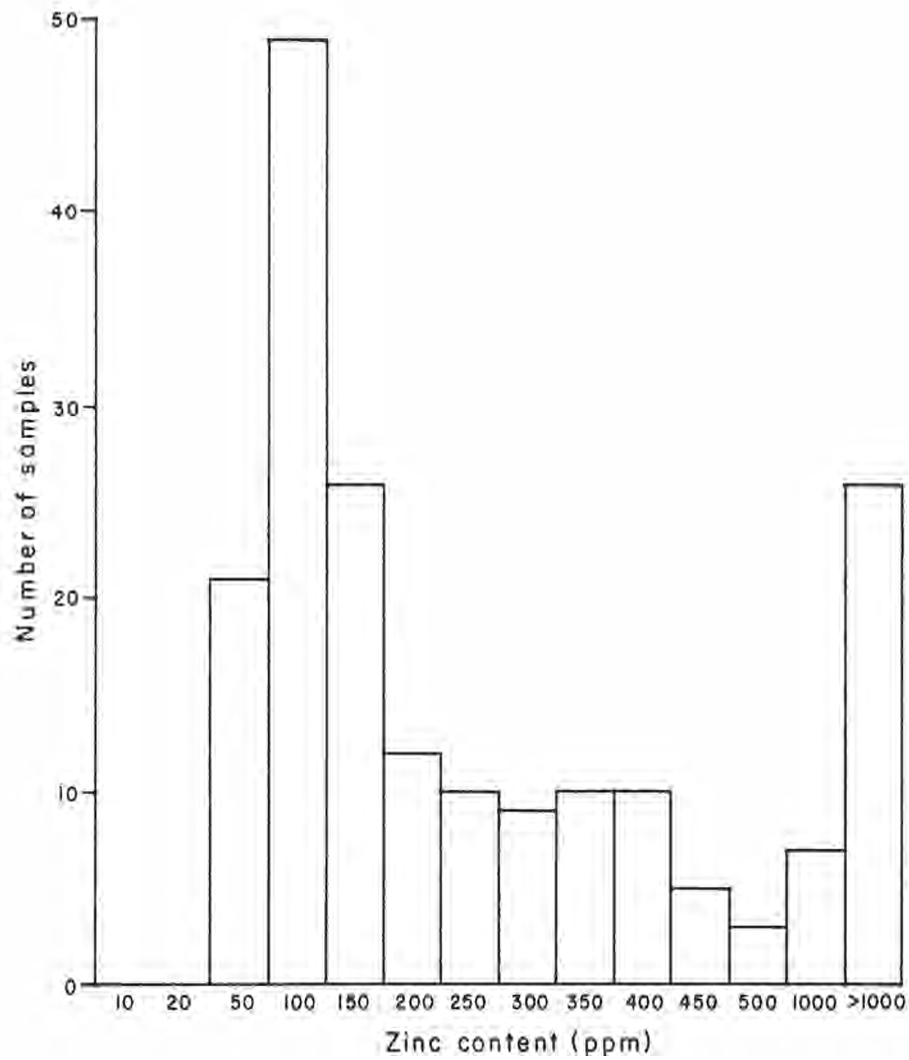


Figure 10

FREQUENCY DISTRIBUTION OF ZINC IN STREAM SEDIMENT SURVEY

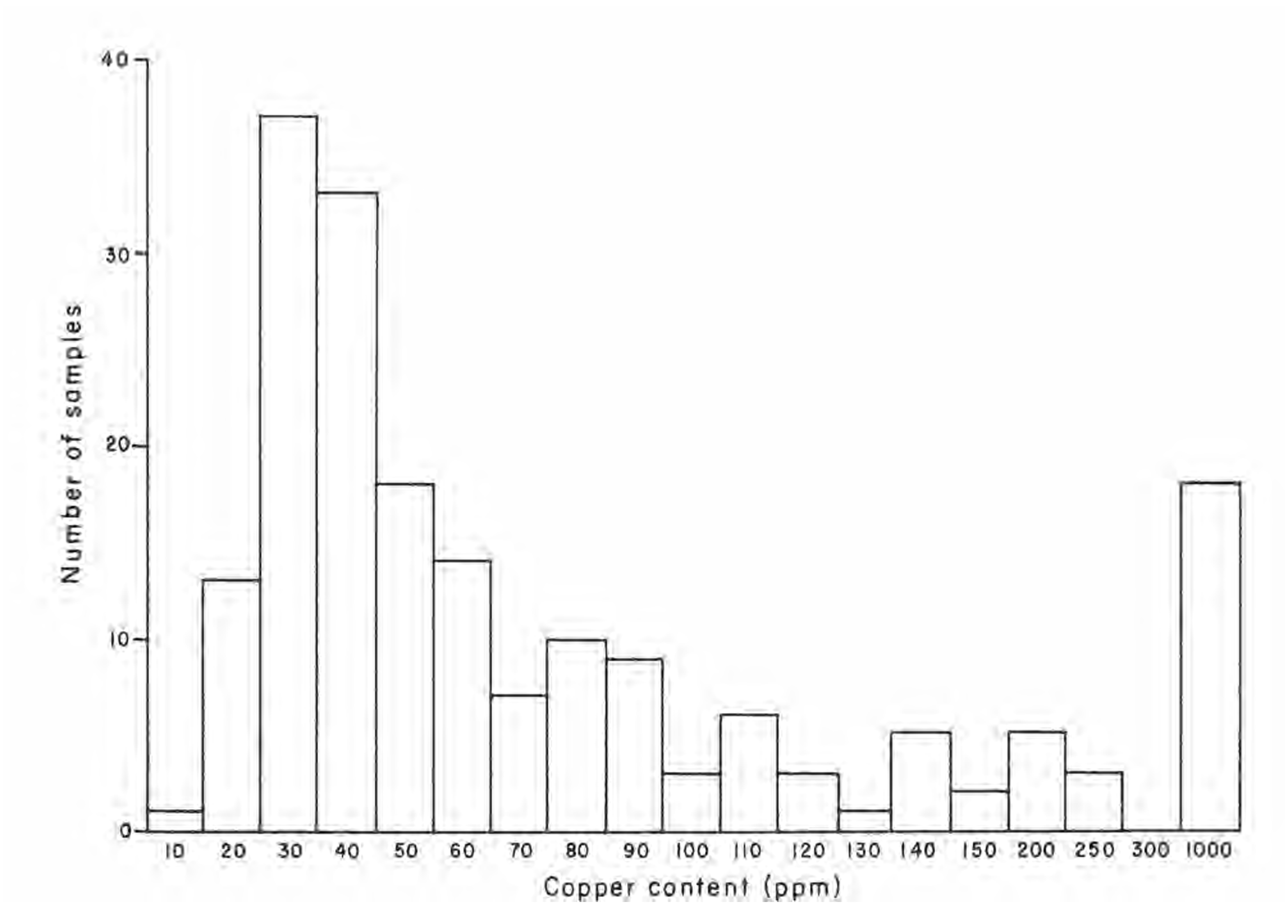


Figure 11

FREQUENCY DISTRIBUTION OF COPPER IN STREAM SEDIMENT SURVEY

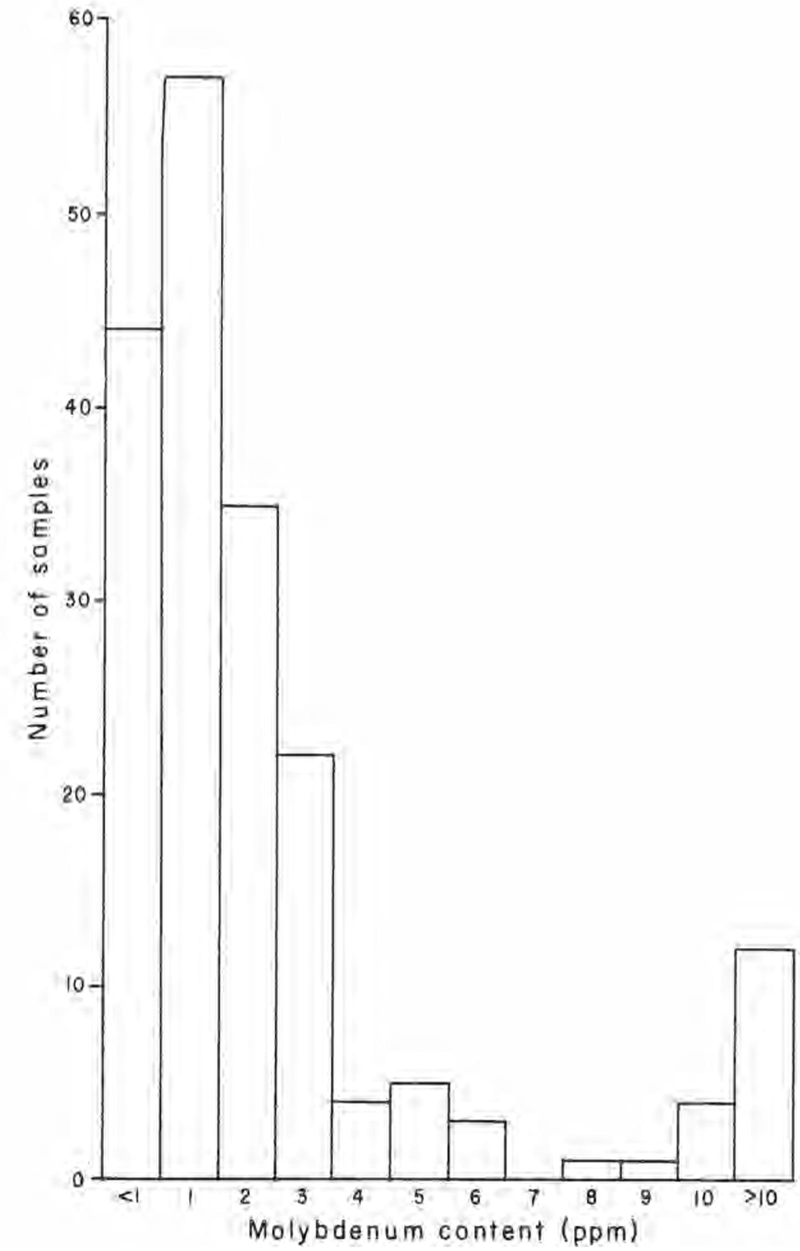


Figure 12
FREQUENCY DISTRIBUTION OF MOLYBDENUM IN STREAM SEDIMENT SURVEY

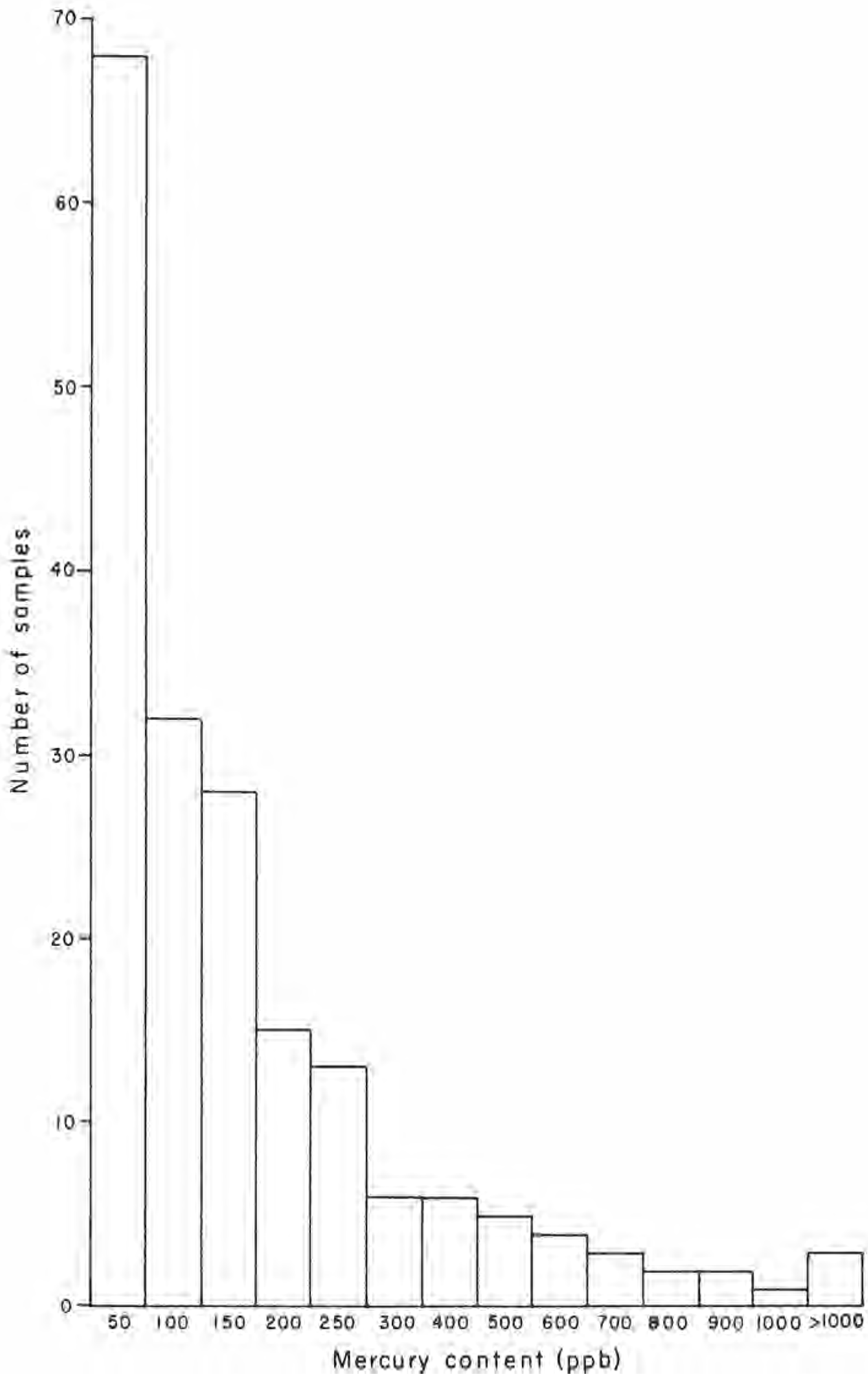
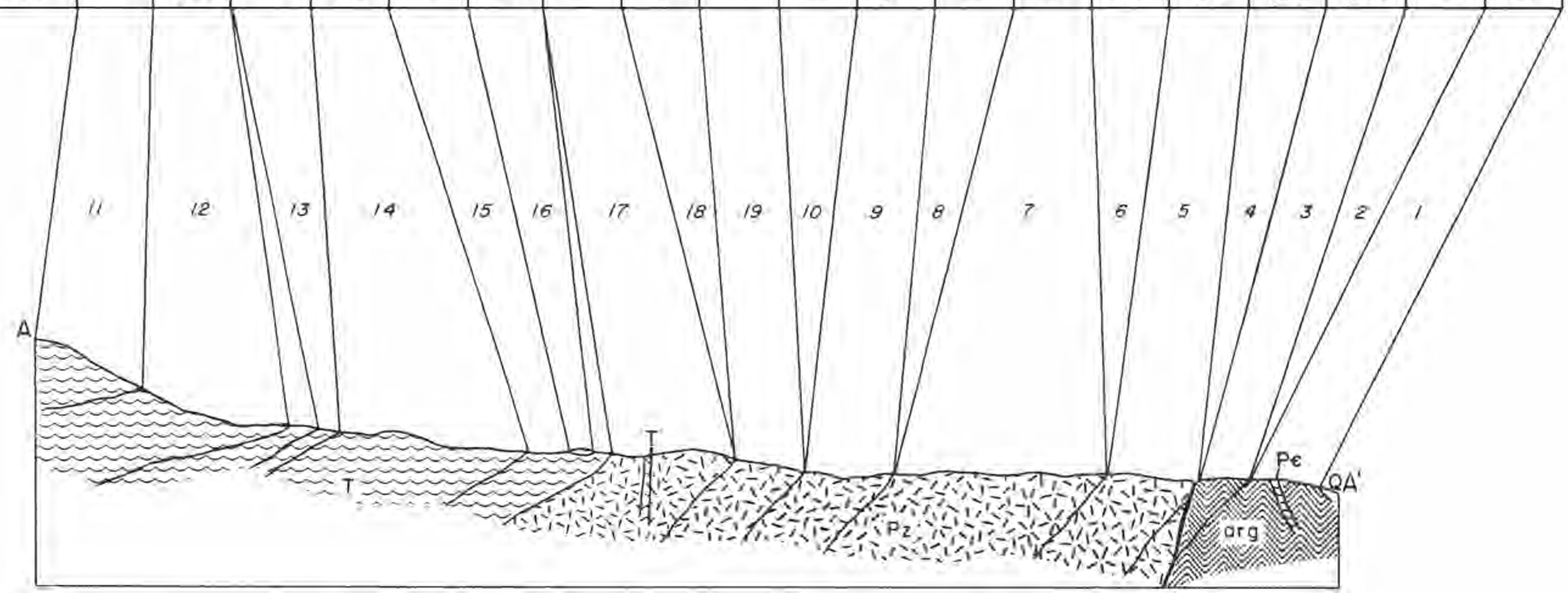


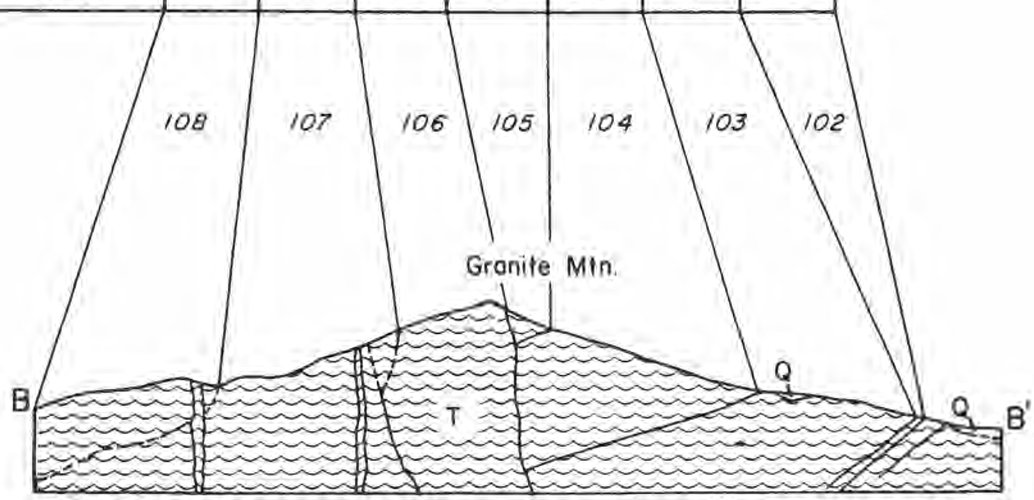
Figure 13
FREQUENCY DISTRIBUTION OF MERCURY IN STREAM SEDIMENT SURVEY

LEAD	110	80	45	35	65	55	75	45	40	20	10	250	190	300	70	+1000	205	30	110
ZINC	50	45	10	80	70	45	20	35	10	15	20	60	180	105	45	+1000	+1000	55	85
COPPER	25	20	15	50	20	15	15	15	10	10	10	20	230	40	15	185	20	25	140
MOLYBDENUM	-1	-1	-1	2	-1	1	6	5	-1	3	3	2	3	1	-1	2	4	1	1
MERCURY	12	100	12	110	48	24	8	16	40	30	64	20	16	50	54	120	120	24	30



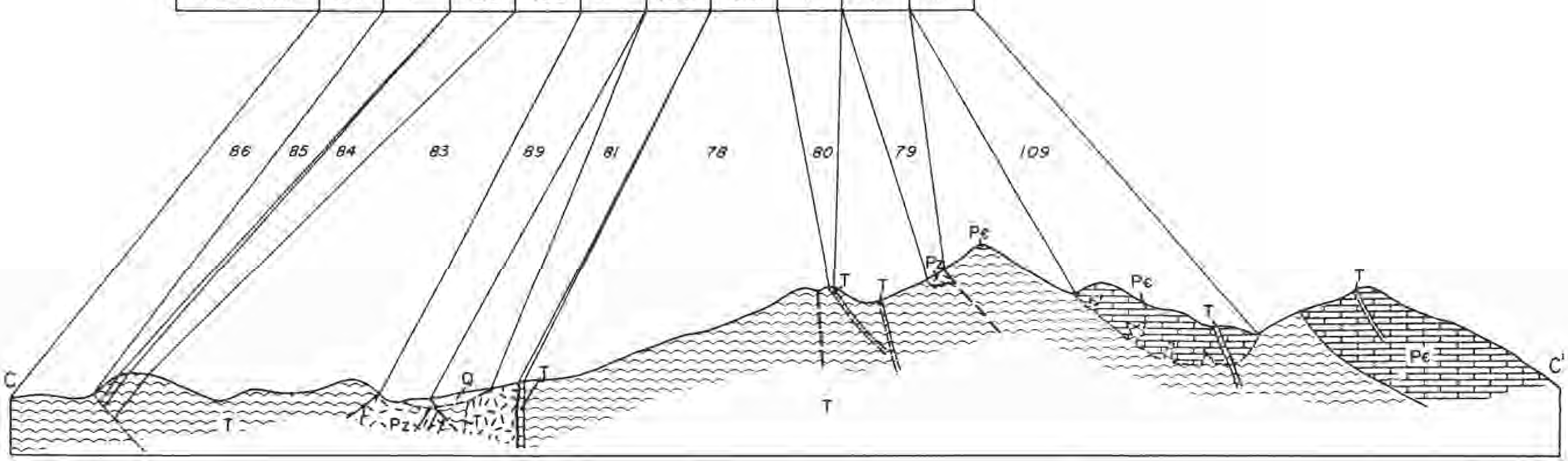
Traverse I. Rock sampling and geochemical profile

LEAD	540	25	20	25	20	30	35
ZINC	85	40	55	15	25	50	10
COPPER	185	70	75	25	45	30	20
MOLYBDENUM	5	1	1	-1	1	-1	-1
MERCURY	30	52	62	30	10	18	68



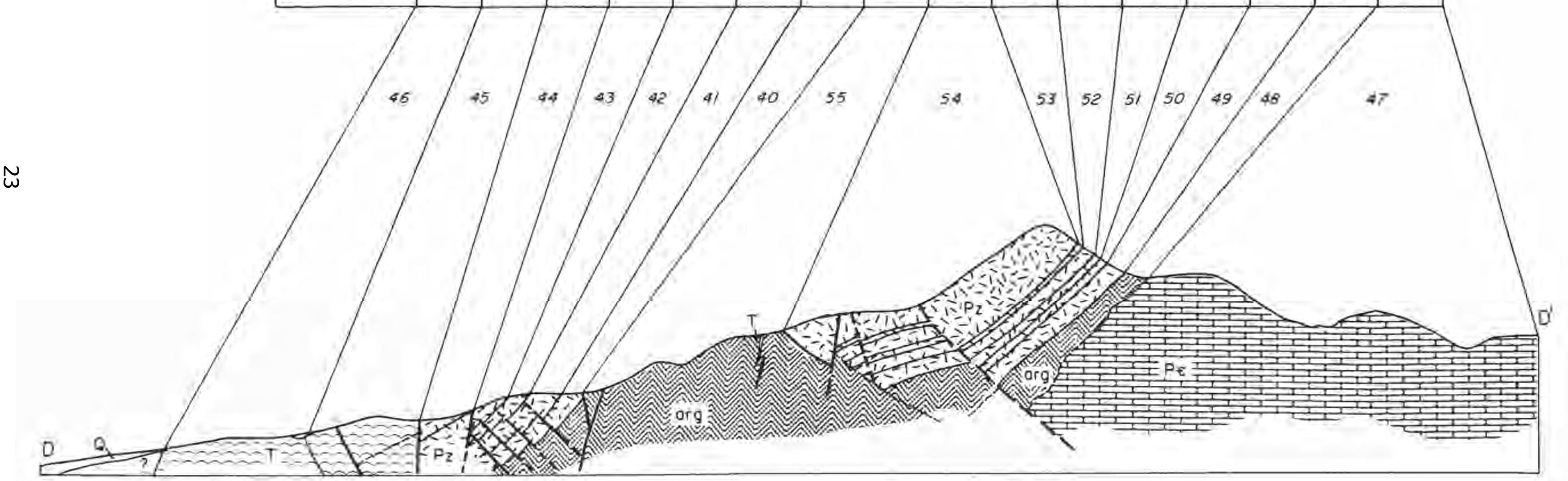
Traverse 2. Rock sampling and geochemical profile

LEAD	40	45	40	50	35	90	70	225	+1000	15
ZINC	20	25	50	25	-5	300	70	85	+1000	10
COPPER	50	40	40	200	25	35	55	80	400	75
MOLYBDENUM	1	-1	-1	4	1	-1	1	1	3	-1
MERCURY	66	10	128	136	40	196	90	36	15	16



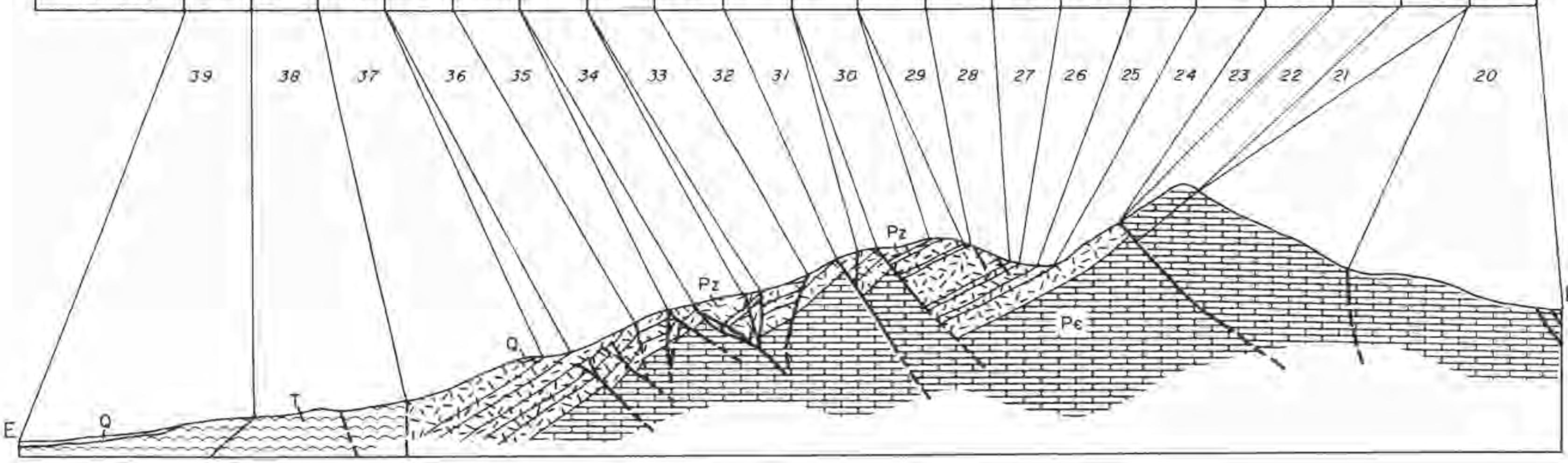
Traverse 3. Rock sampling and geochemical profile

LEAD	20	45	350	50	160	70	550	30	10	10	25	10	10	50	45	50
ZINC	40	30	140	500	160	40	220	70	40	80	115	40	125	105	75	65
COPPER	10	25	10	35	15	15	15	35	15	35	25	25	15	10	105	20
MOLYBDENUM	1	1	1	1	-1	1	2	1	1	1	-1	-1	1	1	2	-1
MERCURY	24	10	10	156	52	30	10	26	26	130	46	48	22	82	24	50



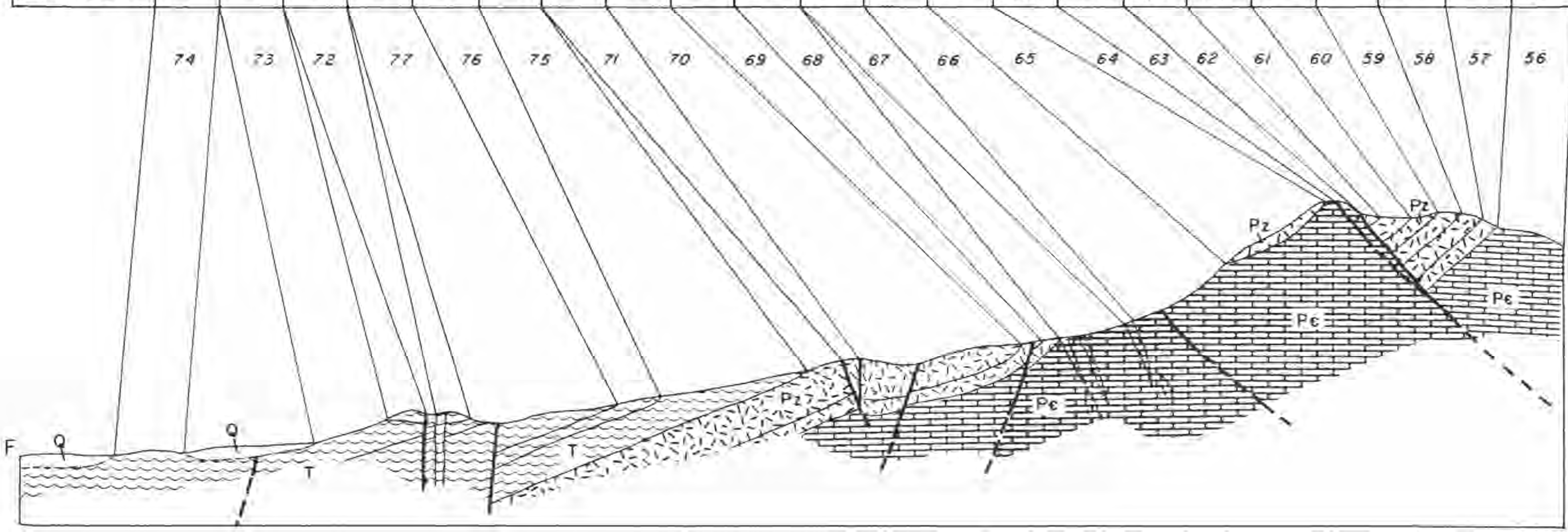
Traverse 4. Rock sampling and geochemical profile

LEAD	45	40	50	400	40	25	50	240	40	30	30	85	55	35	85	25	90	145	65	230
ZINC	50	125	50	330	45	30	70	250	25	10	55	145	40	70	45	20	350	35	90	180
COPPER	10	20	25	30	15	15	15	70	15	15	20	20	20	20	10	5	10	-5	10	50
MOLYBDENUM	2	1	1	1	2	-1	-1	8	-1	3	1	27	8	-5	1	-1	2	-3	-1	-1
MERCURY	40	16	76	30	20	-6	24	24	10	10	20	30	50	64	30	34	82	32	16	24



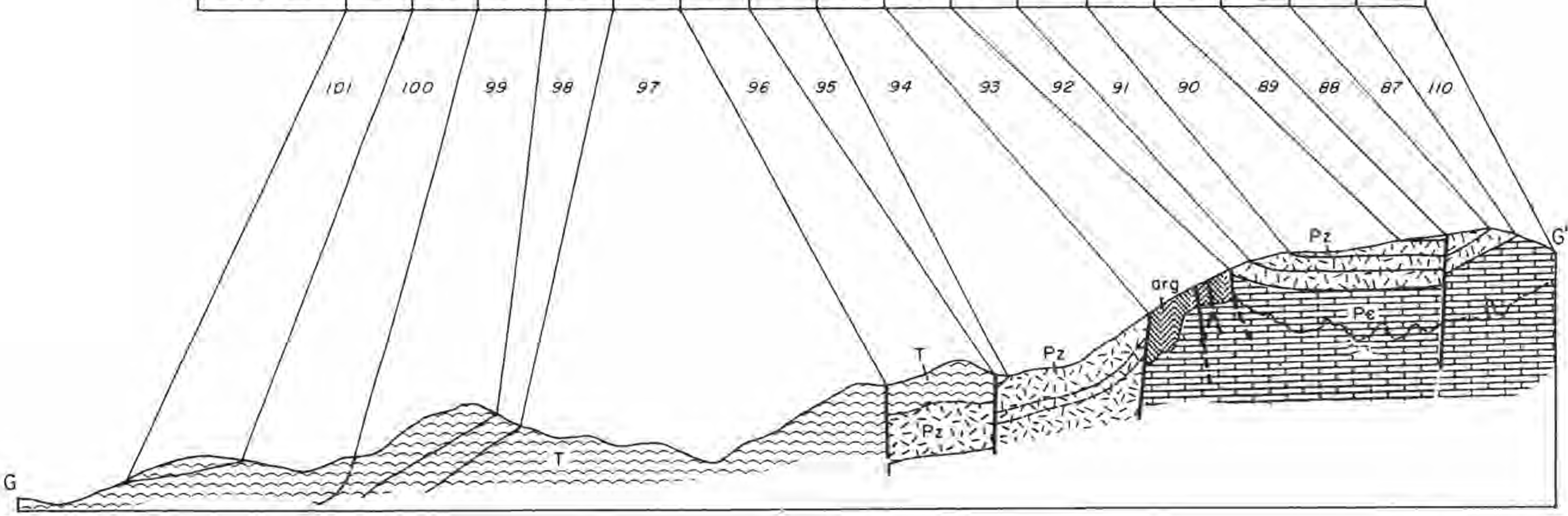
Traverse 5. Rock sampling and geochemical profile

LEAD	25	40	50	30	25	50	10	20	110	125	55	230	50	60	+1000	15	40	35	10	15	65	35
ZINC	25	15	45	25	25	30	20	15	145	70	70	230	35	100	310	30	60	55	55	105	75	75
COPPER	30	30	20	35	30	25	10	15	30	15	75	40	15	30	25	10	25	15	10	15	15	20
MOLYBDENUM	-1	1	1	-1	-1	-1	1	3	3	2	-1	1	11	1	11	1	-1	-1	-1	-1	-1	-1
MERCURY	34	10	16	30	46	36	14	20	18	30	60	8	26	68	24	104	122	12	6	18	-5	64

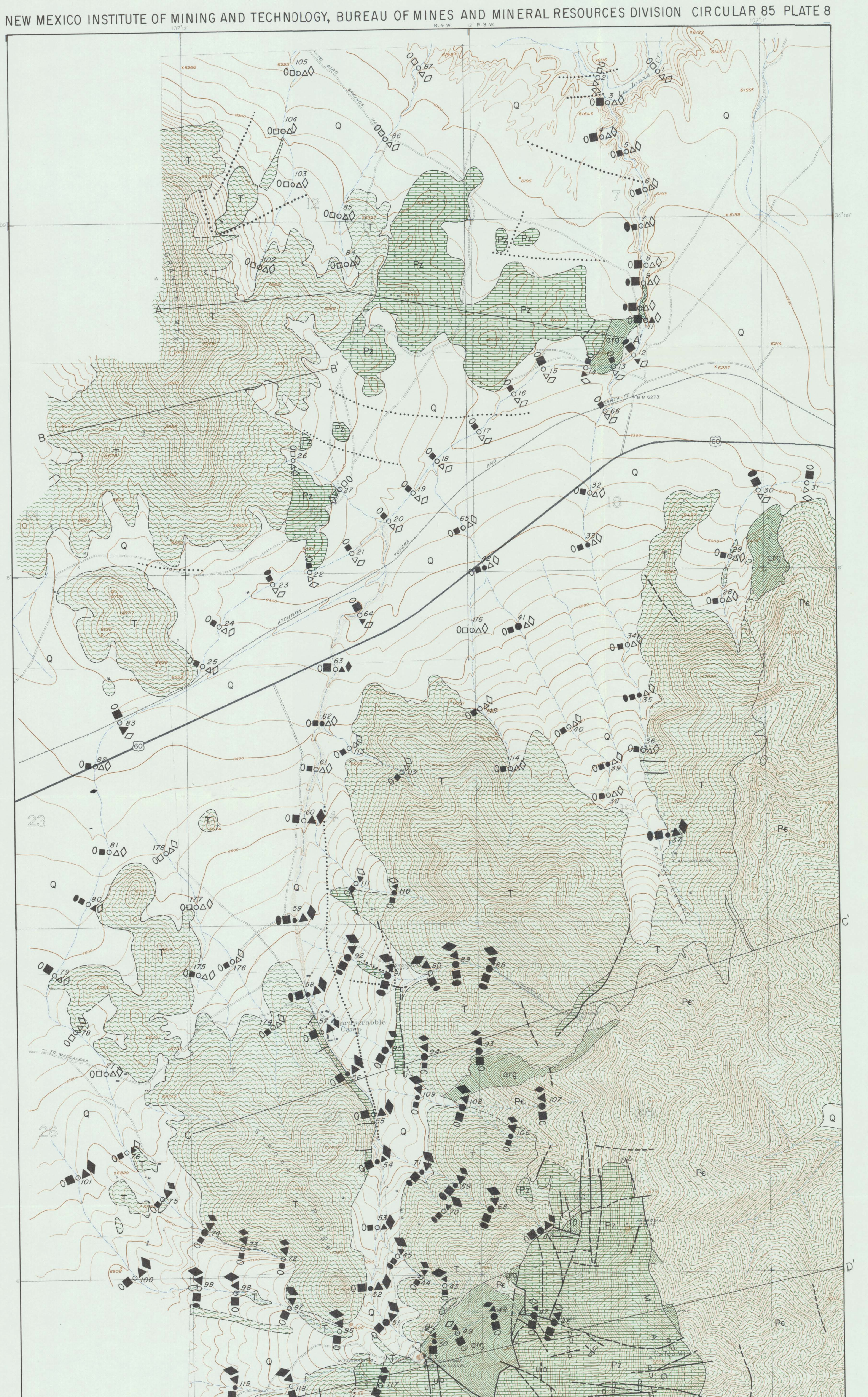


Traverse 6. Rock sampling and geochemical profile

LEAD	40	25	30	30	30	35	15	10	400	30	80	15	20	40	+1000	20
ZINC	5	35	30	5	20	15	25	-5	425	45	65	55	10	70	130	20
COPPER	30	40	25	20	25	15	30	25	25	10	20	20	20	25	75	35
MOLYBDENUM	-1	-1	-1	-1	-1	-1	-1	1	6	-1	1	-1	-1	-1	35	-1
MERCURY	-24	40	64	38	42	8	42	20	10	10	8	96	70	50	36	40



Traverse 7. Rock sampling and geochemical profile



Base from U.S. Geological Survey
Magdalena District N. M.

Geology simplified and adapted from G.F. Laughlin, 1916, A. H. Koschmann, and V. L. Stringfield, 1928-1929.
Geochemistry by Fazlollah Missaghi, 1965.

GEOCHEMICAL MAP OF THE MAGDALENA MINING DISTRICT
SOCORRO COUNTY, NEW MEXICO

Contour interval 20 feet
Datum is mean sea level

EXPLANATION

STREAM SEDIMENT SURVEY

0 Mo, □ Pb, ○19 Hg, △ Zn, ◊ Cu

The number is the sample number
Assay values are given in table 2

Hg: 150, 300 parts per billion

Pb: 70, 200 parts per million

Zn: 150, 300 parts per million

Cu: 60, 100 parts per million

Mo: 2, 5 parts per million

SIMPLIFIED GEOLOGY

SEDIMENTARY ROCKS

Talus
Alluvium
Landslides
} Q Quaternary

UNCONFORMITY

Abo Sandstone — Permian
Madera Limestone
Sandia Formation
Upper quartzite
Upper limestone
Shale
Middle quartzite
Lower limestone
Lower quartzite
— Pennsylvanian
Kelly Limestone — Mississippian
Pz Upper Paleozoic

UNCONFORMITY

Argillite ("greenstone") — arg Precambrian

IGNEOUS ROCKS

INTRUSIVE

White rhyolite dikes
Lamprophyre dikes
Pitchstone dike
Granophyre
Granite
Monzonite aplite dike
Monzonite
Augite andesite
Hornblende andesite
Rhyolite porphyry
Latite porphyry

EXTRUSIVE

White felsite tuff
Pink rhyolite
Upper andesite
Red rhyolite
Red andesite
Banded rhyolite
Purple andesite
Upper latite tuff
Lower andesite
Lower latite tuff

T Tertiary

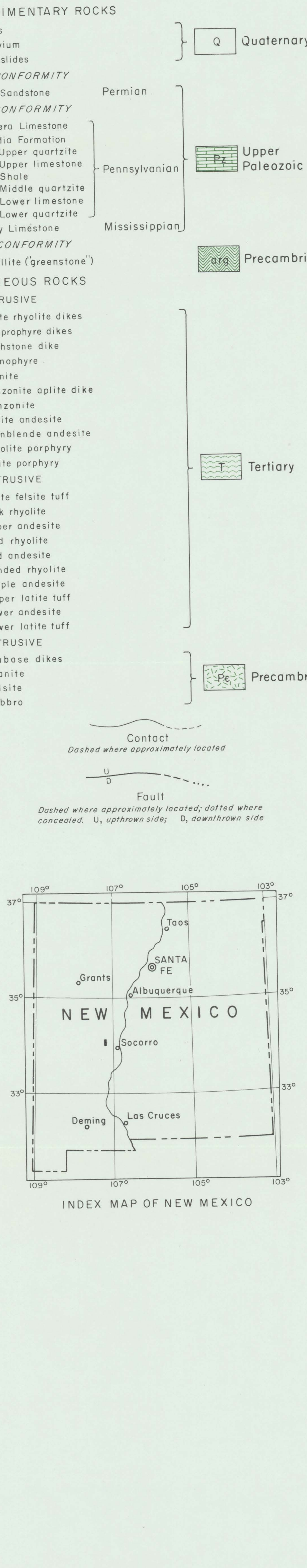
INTRUSIVE

Diabase dikes
Granite
Felsite
Gabbro

p€ Precambrian

Contact
Dashed where approximately located

Fault
Dashed where approximately located; dotted where concealed. U, upthrown side; D, downthrown side



INDEX MAP OF NEW MEXICO