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GEOCHEMICAL REPORT NO. 11

A Geochemical Investigation of Stream Sediments In the Elliott Highway Area, Alaska

By

W. M. Burand

Juneau, Alaska

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A GEOCHEMICAL INVESTIGATION OF STREAM SEDIMENTS IN THE ELLIOTT HIGHWAY AREA, ALASKA

By

W. M. Burand

INTRODUCTION AND SUMMARY

This report presents information obtained from a geochemical investigation of sediments of springs, creeks, and rivers accessible to the Elliot Highway, running from Fairbanks to Manley Hot Springs. The study was made during June 22 through July 20, 1965 in an attempt to find indications of mineralized areas favorable for prospecting.

The country rock in this region was intruded by masses of diorite and quartz-diorite during Mesozoic time and by masses of monzonite and quartz-monzonite during Tertiary time. Some of the intrusives were accompanied by mineralization, the source of much of the placer gold, lode gold, and other metals found in this region.

Field tests and laboratory analyses for trace quantities of metal were made on 146 sediment samples. Eighteen samples were found to contain anomalous amounts of copper, lead, zinc, or molybdenum. Three of the anomalies were supported by field tests, but most of the high field tests were not confirmed by laboratory analyses. Follow-up work in this region should include laboratory analyses of all stream sediments.

Two anomalies were found in streams draining a mineralized area in Dome Creek Valley in the Fairbanks District.

Four anomalies were found in streams draining a mineralized zone that crops out on the north side of Amy Dome between Money Knob and Gold Stream Valley in the Tolovana District. Three anomalies were found in small streams about 6 miles north of this mineralized zone. One of these samples, number 77 contained 325 parts per million copper, 35 parts per million lead, 225 parts per million zinc, and 26 parts per million molybdenum. This is the largest molybdenum content reported to date in stream sediments collected during geochemical investigations in the Yukon-Tanana Region by the Division of Mines and Minerals.

One anomaly was found in a stream draining a mineralized shear zone that crops out on Eureka Dome in the Hot Springs District; however, all streams that cut this zone contain near-anomalous amounts of copper.

LOCATION AND ACCESSIBILITY

The report area, comprising 250 square miles, is in the southwestern part of the Yukon-Tanana Region, Alaska between 150°40' and 147°30' west longitude and between 65°35' and 64°55' north latitude.

The Elliott Highway, an improved dirt and gravel road, winds 160 miles westward from Fairbanks across the Southern edge of the Great Central Plateau Province of Alaska to Manley Hot Springs. From Fairbanks, the highway provides access to the Dome Creek mining area and Olnes in the Fairbanks District; to Livengood in the Tolovana District; to Eureka, Manley Hot Springs, and Tofty in the Hot Springs District; to the head of Minook Creek in the Rampart District; and to trails leading to the Tolovana and Hutlinana Hot Springs.

GENERAL FEATURES

The region between Fairbanks and Manley Hot Springs is one of diversified topography and drainage. The Tanana River flows through a broad, poorly-drained, alluvium-filled valley, ranging from 440 feet elevation near Fairbanks to 255 feet elevation near Manley Hot Springs. This valley controls the base level of erosion for southerly-flowing streams draining the report area. The two major streams draining this area, and tributary to the Tanana River, are the Tolovana River and Baker Creek. The Tolovana River is the larger of the two streams and its major tributaries are the Chatanika River, Washington Creek, Tatalina River, Livengood Creek, and the West Fork of the Tolovana River. The major tributaries of Baker Creek are the Hutlinana Creek and the Eureka Creek.

The northern wall of the Tanana Valley rises in a series of gentle to steep slopes to the flat topped ridges of the plateau, which ranges from 1,000 to 2,000 feet elevation. Hills, knobs, and ridges rise above the plateau to 2,400 feet elevation and mountain masses rise to elevations in excess of 4,600 feet.

A diverse drainage pattern has evolved in this region. The drainage is controlled by regional structure, by changes in elevation of the Tanana River, by superposition of present streams upon ancient drainage systems, and by differential erosion. Changes in regional structure have altered the courses of several streams including the Tolovana River, which now flows for 12 miles in a westerly direction before turning sharply southward again to its junction with the Tanana River. Remanents of ancient stream channels are found in places on ridges, in benches along the upper walls of some valleys and buried in alluvium-filled valleys. Asymetric valleys have been developed through processes of differential erosion. Soilfluction is usually greater on southerly-facing slopes where frost and sun combine to develop a thicker mantle of frost-riven material than on northerly-facing slopes. This flow of detrital material may cause the stream to be crowded to the opposite side of the valley where the slope is steeper.

Timberline is generally limited to elevations under 2,300 feet, but local conditions may cause it to be higher or lower. In trunk valleys and on some favored slopes, especially where bedrock is limestone, the timberline may be over 3,000 feet elevation. Under unfavorable conditions, as in places where basic and ultrabasic bedrock is present, timberline may be under 2,000 feet elevation.

GEOLOGY

The geology of the Fairbanks, Tolovana, and Hot Springs Districts is described in the following U.S. Geological Survey Reports: Bulletin 872, THE YUKON-TANANA REGION, ALASKA by J.B. Mertie, Jr.; Bulletin 849-B LODE DEPOSITS OF THE FAIRBANKS DISTRICT, ALASKA by J.M. Hill; Bulletin 520, MINERAL DEPOSITS OF ALASKA IN 1911 by A.H. Brooks and others; and Bulletin 662, MINERAL RESOURCES OF ALASKA IN 1916 by A.H. Brooks and others.

Placer gold, lode gold, and other metal deposits found in the report area are believed to be derived from mineralization accompanying the Mesozoic and Tertiary granitic intrusions. Four hot springs issue from the country rock near contacts with Tertiary monzonite and quartz-monzonite.

From Fox to Aggie Creek-Wickersham Creek Divide the country rock is composed of Birch Creek schist and undifferentiated meta-igneous rocks of pre-Cambrian(?) age. The meta-sediments include quartz-mica schist, carbonaceous schist, and quartzite interbedded with thin beds of impure limestone. Intermixed with the sediments are meta-igneous rocks that include granitic and dioritic gneisses, amphobolite and hornblende schist, and sericite and chlorite schist. This whole assemblage of rocks has been affected by several periods of diastrophism.

From the Aggie Creek-Wickersham Creek Divide to the Tatalina River, the country rock is comprised of red and green slaty shale, black argillite, chert, quartzite, phyllite, quartzose sandstone, and limestone of pre-Middle Ordovician age. These have been slightly metamorphosed so that a platy cleavage has been developed in some of the shale and argillite. A band of Tolovana limestone, 5 miles long by 1 mile wide, strikes N 60° E across the Ordovician sediments north of Globe Creek. This massive white, semi-crystaline, silicified limestone is of Silurian age.

North of the Tatalina River the country rock is comprised of undifferentiated sedimentary rocks of Devonian age. These include beds of sandstone, quartzite, shale, slate, graywacke, schist, and argillite that are interbedded in places with finely crystalline, dark to light-gray limestone. These were intruded near Livengood by Tertiary monzonite and quartz monzonite.

Livengood chert of lower-Mississippian age forms a band of rocks 6 miles long by 8 miles wide which extends N 60° E from the Sawtooth Mountains to Beaver Creek Valley. These rocks also cross Livengood Creek near the mouth of Gertrude Creek and crop out in Goldstream Valley at the dam site (figure 6). This band of rocks is comprised of light-gray to black laminated chert and brecciated chert recemented with a chalcedonic quartz that is in places interbedded with unsilicified argillite and limestone. The chert fragments in the brecciated chert range in color from light-gray to black; in places the chert is red from the oxidation of included iron.

The highway traverses Quaternary alluvium from Livengood southwest to Rosebud Creek, where it crosses a ridge comprised of Livengood chert into the West Fork of the Tolovana River Valley. From the westerly banks of the river the road traverses ultra-basic and basic greenstones of Devonian age. These extend southwestward from the West Fork for ten miles and then give place to Devonian sedimentary rocks comprised of phyllite, argillaceous shale, graywacke schist, and quartzite--possibly an extension of the Devonian sediments that crop out between Livengood and the Tatalina River.

The Devonian rocks give place to Cretaceous sedimentary rocks south of the mouths of Moose and Starvation Creeks. The Cretaceous rocks extend in a S 60° W direction, from the Sawtooth Mountains to the Tanana River Valley in a band about 20 miles wide by 70 miles long. These rocks are comprised of quartzite, sandstone, slates, argillites, and shales that are intruded by masses of Tertiary monzonite and quartz-monzonite on Elephant Mountain, Eureka Dome, Roughtop Mountain, and the Hot Springs Dome southwest of Manley Hot Springs. The Cretaceous sediments are overlain with unconsolidated sediments of Quaternary age in the Baker Creek and Patterson Creek valleys and in the Tanana Valley near Fish Creek.

MINERALIZATION

Gold and other metal deposits found in the Pedro Dome area and in Dome Creek Valley (figure 1) are related to the Mesozoic diorite that crops out on Pedro Dome. The diorite lies within a mineralized zone that extends southwestward from the head of Fairbanks Creek, across the head of Cleary Creek, through Pedro Dome, and into Dome Creek Valley beyond the head of Moose Creek--a tributary of Dome Creek. This mineralized zone lies along the axis of an anticline and is structurally controlled by fracturing and shearing along the crest and limbs of this anticline.

Most of the mineralized quartz veins in this area are nearly vertical and strike from N 60° W to west. A few, however, strike N 25° E to N 45° E and dip to the south. Many of these veins have been subjected to three or more periods of quartz deposition. The third period carried silica with substantial amounts of iron, arsenic, antimony, sulfur, lead, gold, silver, and some bismuth. Where sulfides accompany the free gold, the quartz veins are fine grained and grayish-white in color -- free gold also occurs without sulfides in white quartz. The lode-gold quartz in the Fairbanks District is inclined to be porous, show crystal faces, and to be stained by iron oxides and a greenish-yellow oxide of arsenic and antimony.

The Soo Mine at the head of Dome Creek produced gold worth $165,000 from a gold lode comprised of a grayish-white quartz with sulfides and visible free gold. This mine was operated for short invervals between 1912 and 1933.

Concentrates from placer mines in the Fairbanks District have contained silver, gold, antimony, galena, pyrite, arsenopyrite, some scheelite, and a little cassiterite.

Gold and other metal deposits in the Livengood Creek area are derived chiefly from the mineralization which accompanied the monzonite and quartz-monzonite that intruded the country rock of Amy Dome. A small portion of the gold may be related to earlier periods of mineralization that may have accompanied other earlier intrusions in this area. Tributaries of Goldstream Creek (the south fork of the Hess River), Livengood Creek and its southerly tributaries which have cut the mineralized zone, produced rich gold placer deposits, whereas northerly tributaries of Livengood Creek did not.

A weathered outcrop of granitic rock between the heads of Olive and Lillian Creeks contains some cinnabar. Assays of samples of this outcrop are reported to have ranged from trace amounts to 0.02% mercury.

Olive, Lillian, and Ruth Creeks (which head on Money Knob) have produced placer gold. On a spur west of Ruth Creek, at about 1400 feet elevation, a mineralized zone is exposed that extends several hundred feet to the top of the spur. Quartz veins in this area are numerous and range from a fraction of an inch to 3 inches, strike S 20° E to S 60° E and have near-vertical dips. This zone is comprised of hard, greenstained rock composed of a mixture of dolomite, quartz, calcite, and sulfides. The green stain is derived from many fine grains of chromite disseminated through the rock.

The mineral zone in the vicinity of Livengood Creek appears to be closely related to the regional structure, which trends in a N 60° E direction. In this area a marked flexure in the rock formations has developed a well-defined cross structure that trends N 60° W. The ridge west of Amy Dome reflects this structure by its direction of elongation. The effects of this structure are also shown by the strike of the quartz veins, N 20° W to N 60° W, and by the shearing of the mineralized country rock in a northwesterly direction.

Chromite and picotite, in the Livengood District, are associated with serpentine of Devonian age. This may be interpreted as evidence that Paleozoic volcanism took place in this area. If this is true, then it is possible that a zone of weakness has existed, localized in this area, for geologic ages. It is therefore possible that the Livengood mineralization is composite and is representative of more than one period of intrusion and deposition.

GEOCHEMICAL STUDIES

Field tests were made on 146 samples of sediment taken from springs, creeks, and rivers accessible to the Elliott Highway. The tests were made by the method outlined in the University of Alaska's Mining Extension Bulletin No. 2, ELEMENTARY GEOCHEMICAL PROSPECTING METHODS, by Leo Mark Anthony, except that petroleum spirits paint thinner was used in place of "Blazo" (white gasoline) as a solvent for the dye solution. The samples were dried, screened to minus 80 mesh, and sent to Rocky Mountain Geochemical Laboratories, Salt Lake City, Utah, for analyses for trace quantities of copper, lead, zinc, and molybdenum.

Map numbers have been substituted for field test site numbers to provide continuity. Sample sites are shown on the maps (figures 1 through 14) by numbered circles and anomalies are indicated by solid circles with chemical symbols. The chemical symbols used are "Cu" for copper, "Pb" for lead, "Zn" for zinc, and "Mo" for molybdenum.

The results of field tests and chemical analyses are recorded in table 1 by sequence of map numbers. The results of the field tests are reported in milliliters (ml) of dithizone dye solution used and the results of geochemical analyses are recorded in parts per million (ppm) of metal content. Frequency distribution graphs were prepared for copper, lead, zinc, and molybdenum from the results of chemical analyses recorded in table 1. The graphs compare the frequency with which the various concentrations of metal occur. They are also used to determine the mode, i.e., the concentration of metal found most frequently in the sediments, and to determine anomalous concentrations of metal, i.e., the concentrations of metal considered great enough to indicate the probable presence of a mineralized zone.

DISCUSSION OF RESULTS

An anomaly in a stream sediment does not necessarily indicate that an ore deposit is present upstream. It may indicate a high metal content in the country rock, a deposit too low in grade or too small to be mined, or a highly-fractured, weakly-mineralized zone being leached by ground waters. The intensity of an anomaly in a stream sediment or in a drainage area is a function of the total amount of metal that has been leached from the catchment basin less the amount that has been precipitated before water enters the surface drainage.

A high ratio of cold extractable (field test) to total extractable (lab analysis) metal may indicate a hydromorphic anomaly 1/, i.e., an anomaly caused by the leaching of metal from a mineralized zone by ground water and then transported and precipitated from the ground water into the overlying soils or directly into the stream bed. A low cold extractable to total extractable metal ratio may indicate a residual anomaly 1/, i.e., an anomaly caused by the mechanical erosion of a mineralized soil or zone and the dispersion of that metal without leaching.

Samples 61, 62, and 63, which required more than five milliliters of dithizone dye solution, were also found to be anomalous by laboratory methods. The other field tests indicating anomalous amounts of metal were not supported by laboratory results.

Follow-up work on anomalies reported should include laboratory analyses of all stream sediment samples taken. Soil tests should be made in areas above the uppermost stream sediment sample found to be anomalous in a stream, and soil samples should be analyzed by laboratory methods as a check on the field tests.

Figure 1, Samples 8 & 10

Samples 8 and 10 contained anomalous amounts of lead. These were taken from streams cutting the mineralized zone that extends through Pedro Dome into Dome Creek Valley. At the head of Dome Creek are a number of gold quartz veins that also carry silver, stibnite, galena, arsenopyrite scheelite, cassiterite, and minor amounts of bismuth.

Figure 2, Samples 19 & 23

Sample 19 contained an anomalous amount of lead. This sample was taken from a small hillside spring or seep. Follow-up work here should include taking sediment samples from the stream northeast of sample 19. Sample 23 contained an anomalous amount of molybdenum. This anomaly may indicate the presence of a small body of granite or possibly limestone above the sample site.

1/ GEOCHEMISTRY IN MINERAL EXPLORATION by H.E. Hawkes and J.S. Webb, p. 276 Copyright 1962.

Figure 3, Samples 27, 28, & 29

Sample 28 contained anomalous amounts of copper, lead, and zinc. Samples from other streams nearby do not appear to support this anomaly; however, samples 27 and 29 contained 20 parts per million copper, and over 100 parts per million zinc. These two streams are within a half a mile of sample 28, which was taken from a small creek or spring.

Figure 6, Samples 60, 61, 62, & 63

Samples 60, 61, and 63 had anomalous amounts of zinc; samples 62 and 63 had anomalous amounts of lead, and 62 also had an anomalous amount of molybdenum. A mineralized weathered granite containing some cinnabar crops out between the heads of Olive and Lillian Creeks. A small stringer of stibnite was exposed and reburied on Ruth Creek by placer miners. Concentrates of placers in the Livengood Creek area contained gold, silver, picotite (a chrome mineral), stibnite, galena, cinnabar, and small amounts of scheelite.

Figure 6, Samples 75, 76, & 77

The spillway at the northeast end of Goldstream Dam has been washed out and several small streams or soil seeps flow down the northeast wall of this spillway. Sediment samples 76 and 77 were taken from two of these streams and both contained anomalous amounts of copper, zinc and molybdenum. Sample 77 contained 325 parts per million of copper, 35 parts per million lead, 225 parts per million zinc and 26 parts per million molybdenum. This is the largest molybdenum content reported to date in stream sediments collected by the Division of Mines and Minerals in the Yukon-Tanana Region. Sample 75, taken below the dam, contained 85 parts per million copper and only 4 parts per million molybdenum. The bedrock in this area is Livengood chert. Follow-up work should include the sampling of streams cutting the hill northeast of the dam. Soil tests, if made, should be checked by laboratory analyses.

Figure 7, Samples 84 & 86

Sample 84 contained anomalous amounts of copper, zinc, and molybdenum and was taken from a small sluggish stream. Sample 86 was taken from a small spring above the road. J.B. Mertie, Jr., shows the rock here to be ultrabasic and basic greenstones. Follow-up work here should include the sampling of streams heading on the north side of the ridge drained by the anomalous streams.

Figure 8, Sample 91

Sample 91 contained anomalous amounts of copper, zinc, and molybdenum. Follow-up work here should include the sampling of streams that head in the ridge above sample 91

Figure 11, Samples 108, 109, & 110

Sample 108, taken from Cairo Creek near its mouth, contained an anomalous amount of zinc, 20 parts per million copper, and 25 parts per million lead. Sample 110 was taken from the Hutlinana Hot Spring and contained 35 parts per million copper, 15 parts per million lead, and 115 parts per million zinc. The spring water is clear and has a slight hydrogen sulfide odor, though the gas bubbling through the water is odorless. The water has a pleasant taste and is lukewarm. Iron pipes and vessels left in the water corrode. In U.S. Geological Survey Water Supply Paper 418, MINERAL SPRINGS OF ALASKA, Gerald A. Waring reported the spring's temperature to be 114°F. The reason for the change in temperature since that time is not known.

Figure 12, Sample 131

The Eureka mining area is shown in figure 12. Placer gold mines are indicated by crossed pick and shovel symbols. Placer concentrates from this mining area have been found to contain pyrite, picotite, galena, cinnabar, and small amounts of scheelite. Sample 131 contained 35 parts per million copper, 15 parts per million lead and an anomalous amount of zinc. A mass of monzonite or quartz monzonite crops out at the head of Rhode Island Creek. Follow-up work here should include taking samples above sample site 131 at various intervals up to the head of the creek.

Figure 13, Sample 139

Sample 139 contained an anomalous amount of molybdenum, but contained only minor amounts of the other metals. It is probably related to granitic rock in the area above the sample site.

Figure 14, Sample 144

Sample 144 was taken from Karshner Creek below the two hot springs. The two hot springs, about 50 yards apart, issue from separate rock basins. The temperature of the water from the westerly spring is 125°F. The temperature of the easterly spring is 136°F. The present owner has used the spring water to heat green houses, his own home, and to furnish hot water for a small bath house. The water has no noticeable odor or taste but does corrode iron pipes and iron vessels.

TABLE 1

Analyses of Stream Sediments
in the Elliott Highway Area

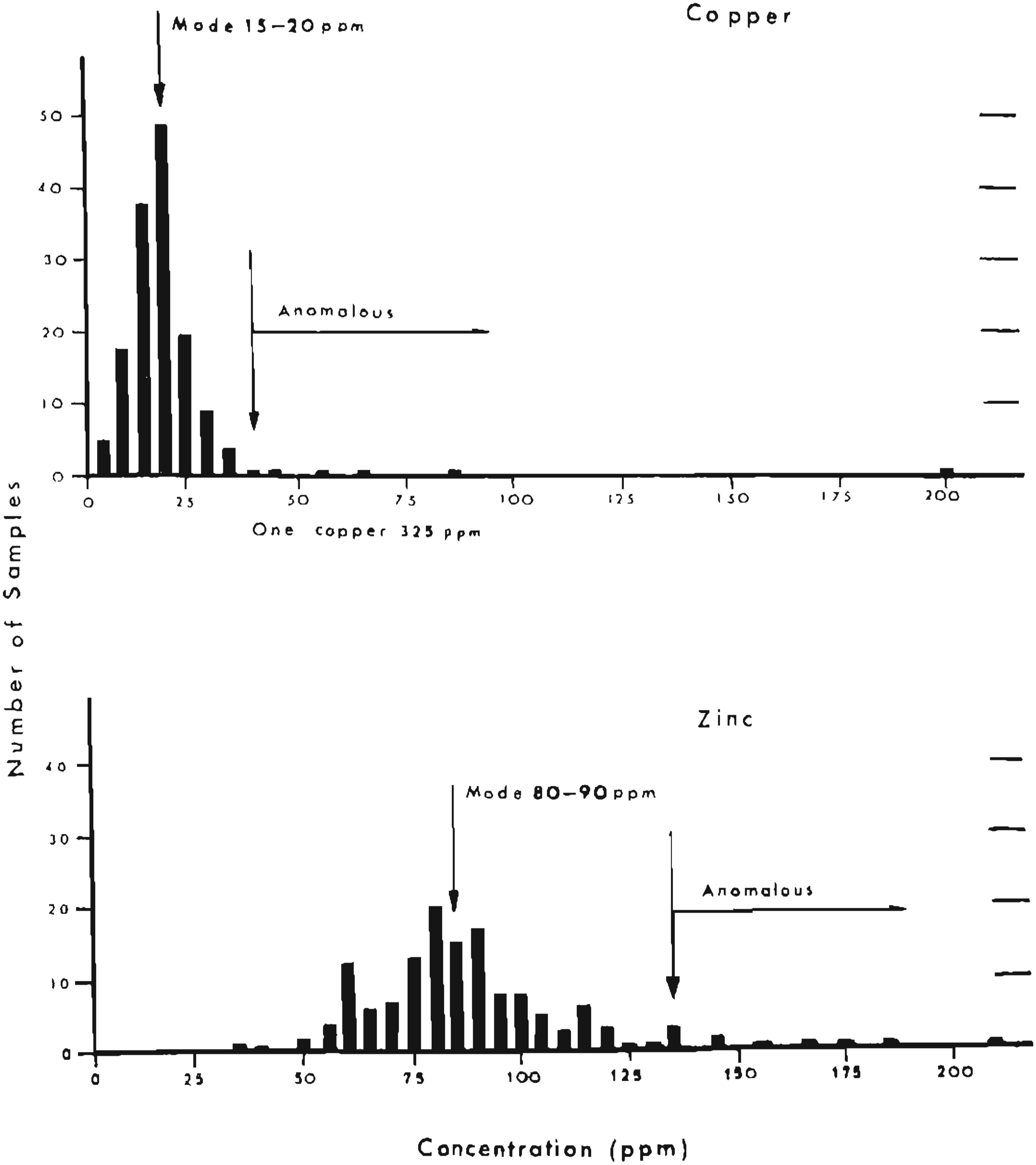
Sample Numbers		Field Test	Laboratory Analyses*			
Map	Field #5K	ml of Dye	Copper	Lead	Zinc	Molybdenum
1	101	1	10	10	65	3
2	102	17	15	15	95	3
3	105	2	20	15	95	3
4	106	1	20	10	55	4
5	104B	5	15	10	60	4
6	103	3	10	15	105	3
7	112	1	15	20	75	3
8	113	2	15	70	120	3
9	114	1	20	20	125	3
10	115	1	15	30	85	3
11	116	10	15	15	85	4
12	117	20	20	15	80	2
13	118	20	20	20	95	3
14	119	20	20	15	90	2
15	124	2	15	10	70	3
16	120	2	15	10	60	2
17	121	1	15	10	75	4
18	123	2	5	10	40	4
19	125	3	10	60	60	3
20	126	4	10	10	70	2
21	127	20	20	15	85	4
22	128	20	25	10	90	4
23	129	2	15	10	75	5
24	130A	1	15	15	80	4
25	130B	1	20	20	85	3
26	131	1	15	20	80	3
27	133	1	20	15	115	3
28	134	2	45	30	135	3
29	135	1	20	15	100	3
30	136	1	15	10	80	4

*Anomalous amounts of metal are underlined.

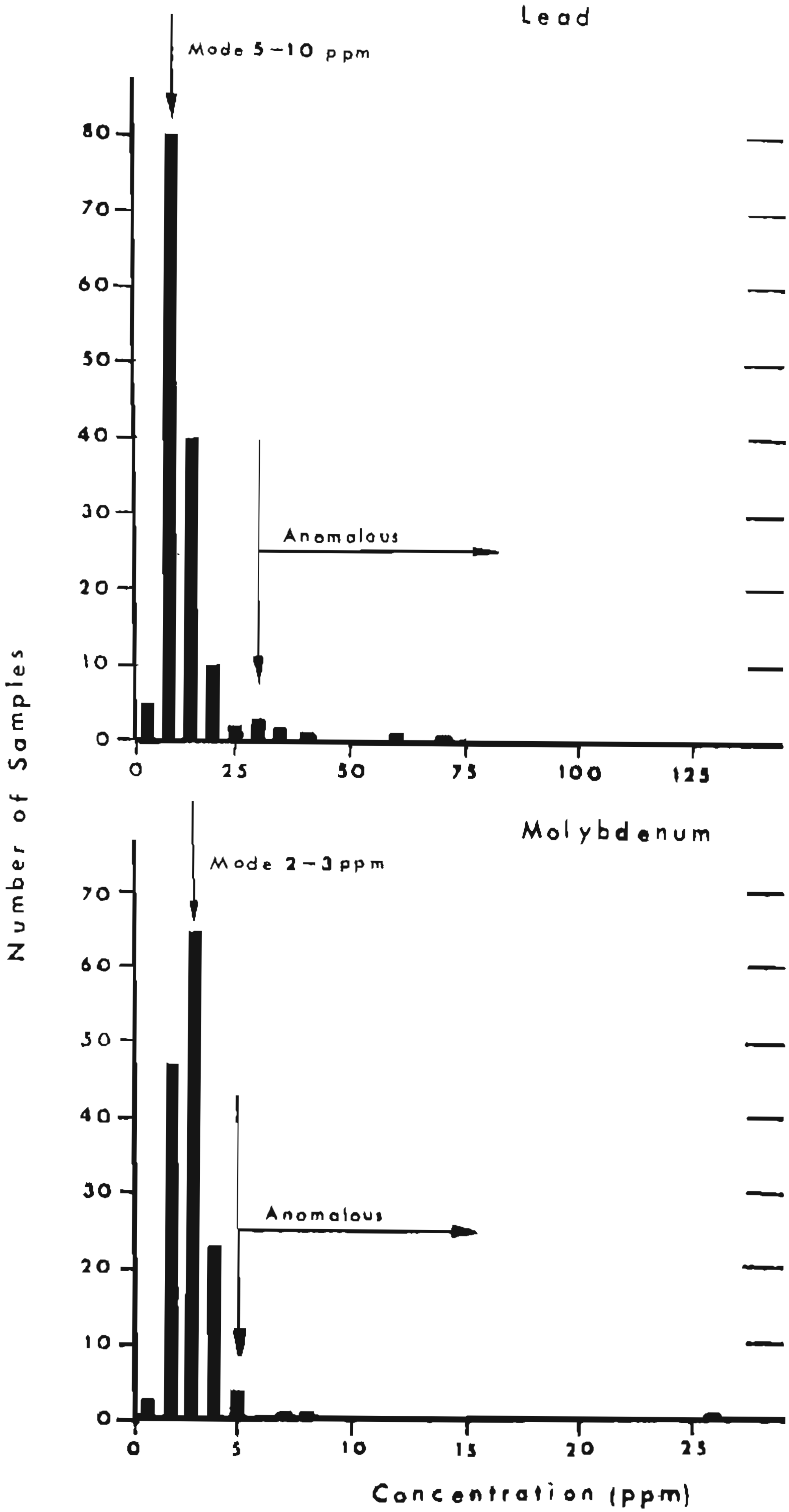
Map	Field #5K	Ml of Dye	Copper	Lead	Zinc	Molybdenum
31	137	1	15	10	80	4
32	167	1	15	15	80	3
33	166	1	20	15	70	2
34	138	2	20	10	105	3
35	139	2	5	10	60	2
36	140	2	10	10	65	2
37	141	2	15	10	75	2
38	142	2	20	15	90	4
39	143	1	20	15	105	3
40	144	2	15	10	70	4
41	157	4	10	10	60	3
42	145	5	15	10	90	2
43	146A	2	20	10	60	2
44	146B	2	15	10	70	4
45	147	3	25	15	95	3
46	148	3	25	15	115	3
47	149	2	30	10	105	2
48	151	20	15	10	75	2
49	152	20	20	10	80	2
50	153	5	15	10	90	3
51	154	2	30	25	145	4
52	155	17	10	10	80	2
53	156	4	20	10	95	3
54	185	2	10	15	85	2
55	158	20	20	10	100	2
56	187	3	5	10	55	2
57	189	20	15	10	85	1
58	188	1	20	15	100	3
59	159	1	30	15	100	1
60	160	1	30	20	145	3
61	161	11	30	20	185	2
62	183	13	15	40	130	5
63	184	6	25	35	135	4
64	190	2	25	15	35	2
65	181	2	20	15	110	2
66	182	7	20	10	90	3
67	180	3	15	10	70	2
68	179	3	20	15	90	2
69	178	2	20	10	85	2
70	177	3	20	15	95	3

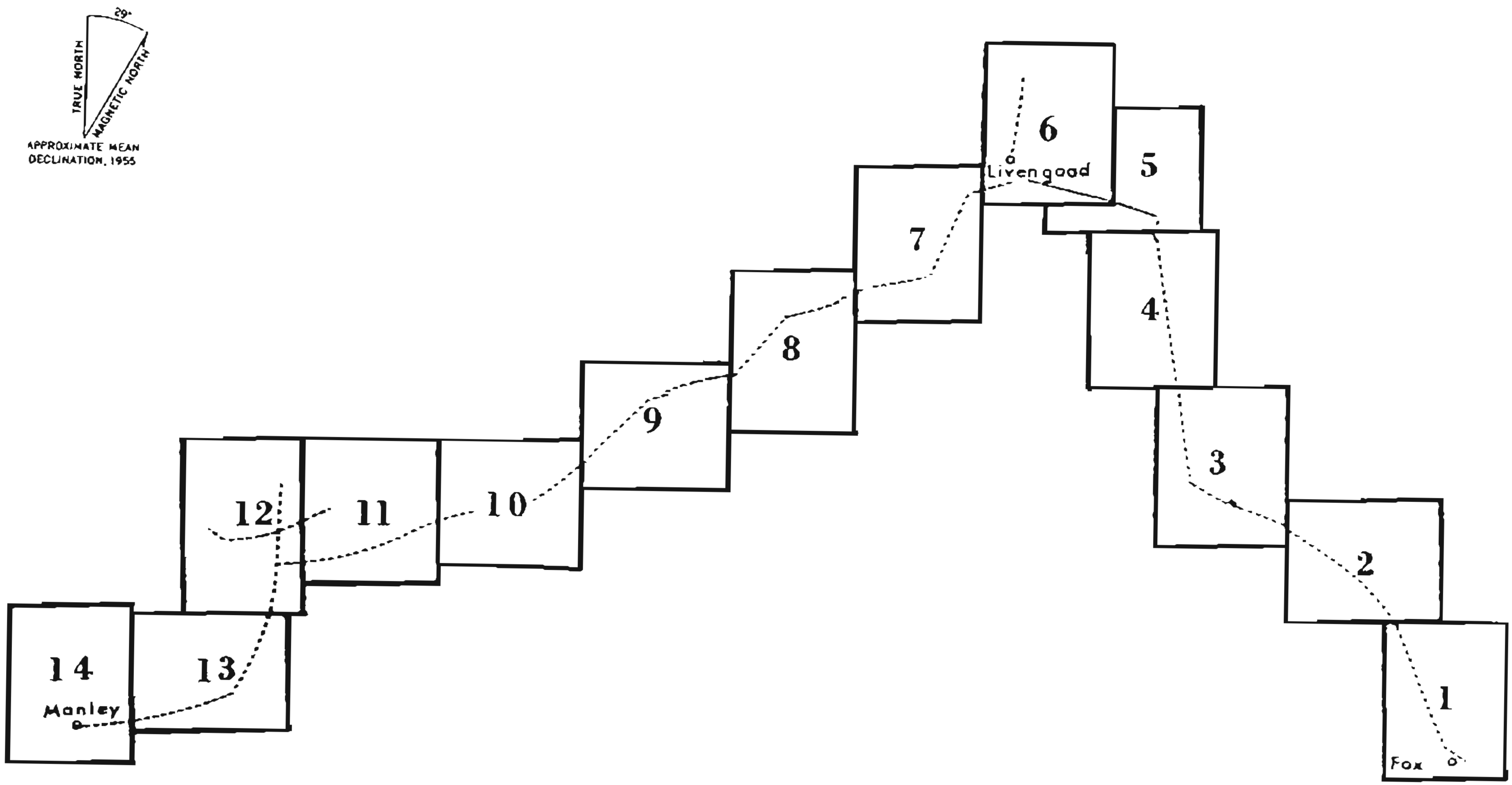
Map	Field #5K	Ml of Dye	Copper	Lead	Zinc	Molybdenum
71	176	3	20	15	90	3
72	175	17	20	10	65	3
73	163	1	10	10	85	2
74	170	3	15	10	70	2
75	174	2	85	15	90	4
76	171	2	200	30	105	8
77	172	4	325	35	225	26
78	173	4	25	15	80	2
79	162	2	15	10	75	3
80	163	18	25	15	100	3
81	164	8	10	10	90	1
82	165	2	15	10	80	2
83	191	1	20	10	120	2
84	192	2	40	15	135	5
85	193	7	25	15	115	2
86	194	2	65	20	210	3
87	195	1	20	20	100	3
88	196	2	30	15	120	3
89	197	3	20	15	85	3
90	198	3	20	10	85	2
91	199	3	55	20	165	7
92	249	1	15	10	115	3
93	252	1	15	5	75	2
94	251	1	20	10	90	2
95	250	1	15	5	80	3
96	200	2	5	10	50	3
97	201	2	15	10	75	4
98	202	2	20	10	80	3
99	203	1	10	10	60	2
100	204	2	20	15	75	3
101	244	2	20	10	85	3
102	243	1	15	10	80	3
103	240	4	25	10	85	3
104	241	1	15	10	80	3
105	242	2	15	10	80	3
106	217	2	10	10	80	3
107	218	1	10	10	90	4
108	219	3	20	25	175	2
109	220	4	25	15	90	4
110	222	2	35	15	115	2

Map	Field #5K	ml of Dye	Copper	Lead	Zinc	Molybdenum
111	221	2	15	10	75	2
112	223	2	20	10	75	2
113	224	1	20	10	90	2
114	205	2	10	10	60	2
115	206	2	10	10	75	2
116	208	1	5	10	75	3
117	209	2	20	10	85	4
118	215	2	25	10	85	3
119	216	2	20	10	90	2
120	214	1	20	10	90	3
121	213	1	20	15	100	3
122	212	2	20	10	80	2
123	211	3	15	10	80	3
124	210	2	20	10	95	3
125	321	2	30	5	110	2
126	322	1	35	5	115	3
127	323	1	35	10	110	2
128	324	2	25	5	80	1
129	226	1	25	15	65	3
130	227	2	30	10	100	3
131	231	2	35	15	155	3
132	230	1	20	10	65	3
133	228	1	20	10	80	3
134	229	1	20	10	65	4
135	232	8	20	15	85	3
136	233	6	25	10	90	2
137	234	5	30	15	95	4
138	235	2	25	10	55	4
139	236	2	15	10	60	5
140	237	2	20	10	55	3
141	238	2	20	10	60	4
142	239	3	10	10	50	3
143	248	1	10	10	60	3
144	247	2	10	10	50	2
145	246	1	5	20	35	2
146	245	2	15	15	60	3



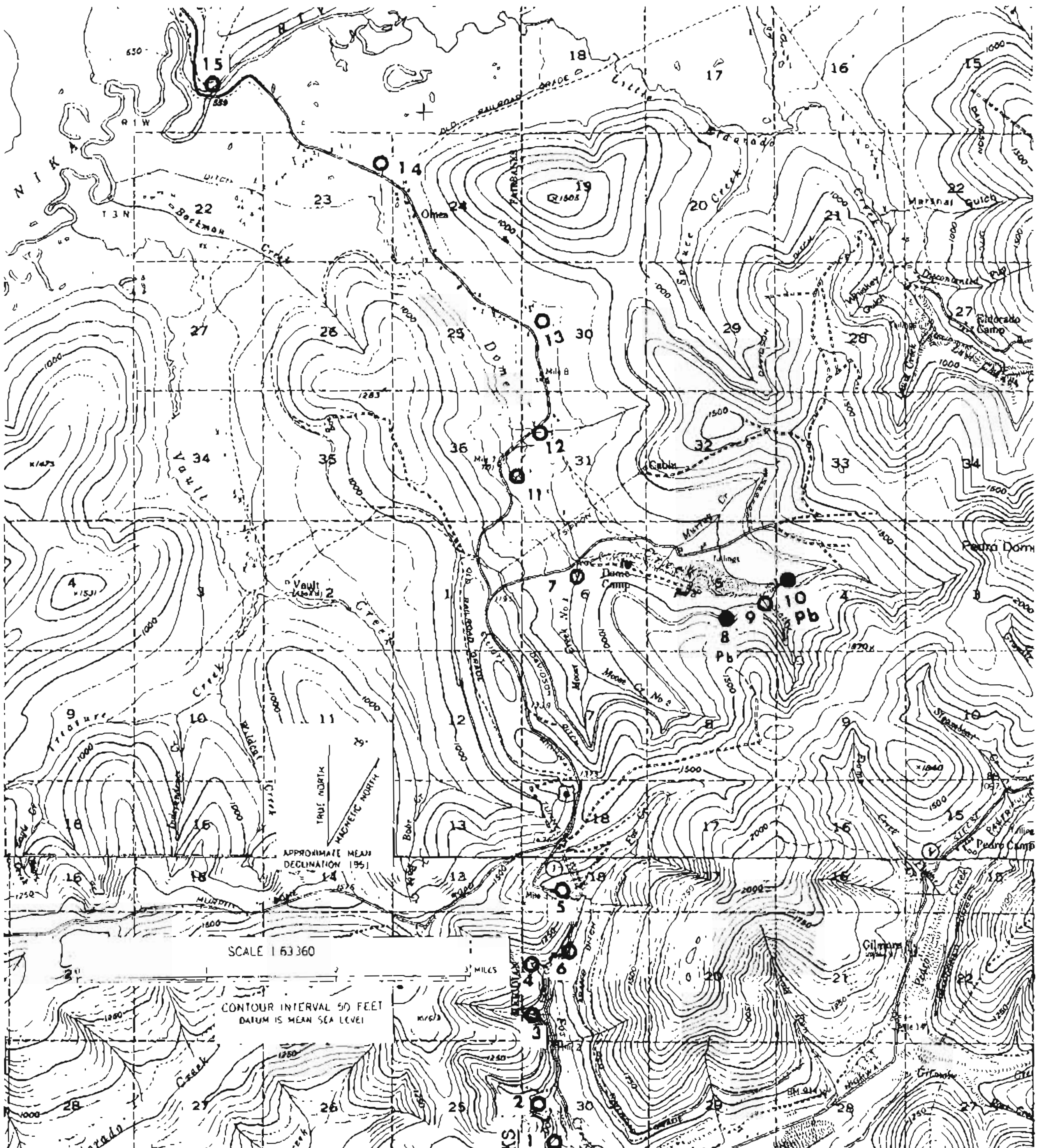
Frequency distribution graphs for copper, lead, zinc, and molybdenum


Lead
Mode 5–10 ppm
80
70
60
50
40
30
20
10
0
Anomalous
0
25
50
75
100
125
Number of Samples
Molybdenum
Mode 2–3 ppm
70
60
50
40
30
20
10
0
Anomalous
0
5
10
15
20
25
Concentration (ppm)



Maps-figure 1-14; Adapted from U.S. Geological Survey quadrangle maps of Fairbanks, Livengood, and Tanana. Scale 1:63,360

DIAGRAM
Showing Layout of
Figs. 1 — 14


SCALE 1:63360
MILES
CONTOUR INTERVAL 50 FEET
DATUM IS MEAN SEA LEVEL
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1951
Dome Camp
Eldorado Camp
Pedro Dome
Pedro Camp
Vault
Tailings
FAIRBANKS
Tungsten Hill
Pb
Vault Creek
Treasure Creek
Wildcat Creek
Murray Cr
Moose Cr No 2
Big Eldorado Creek
Silver Creek
Steamboat Creek
Whiskey Gulch
Marshal Gulch
Ester Cr
Bobs Cr
Gilmore
Sourdough Creek
Dome Creek
Little Eldorado Creek
Beckman Creek
R 1 W
T 3 N
FIG. 1

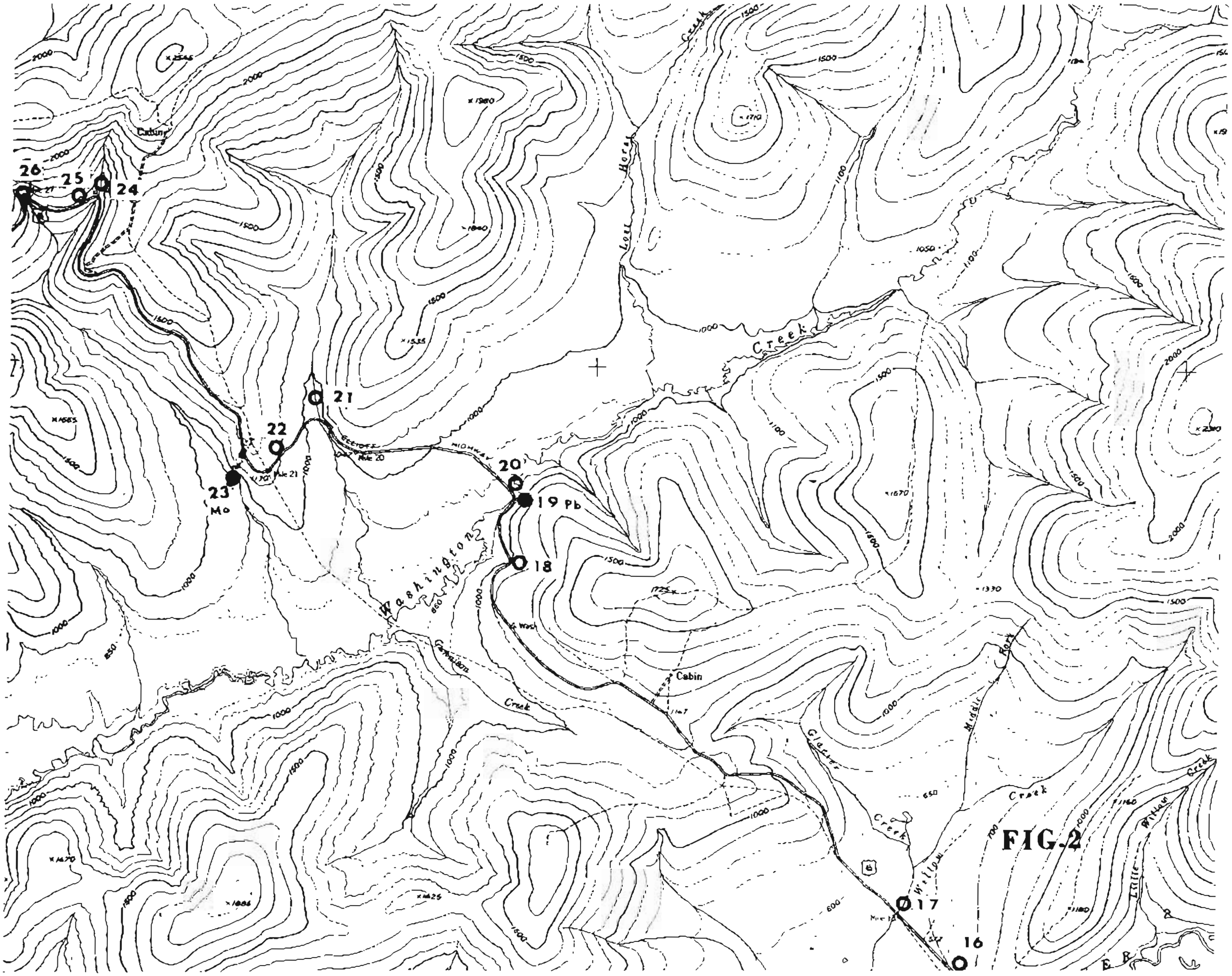

26
25
24
Cabin
21
22
23
Mo
20
19 Pb
18
17
16
Washington
Creek
Cabin
Glacier
Creek
Middle
Fork
Willow
Creek
Lost
Horse
Highway

FIG.2

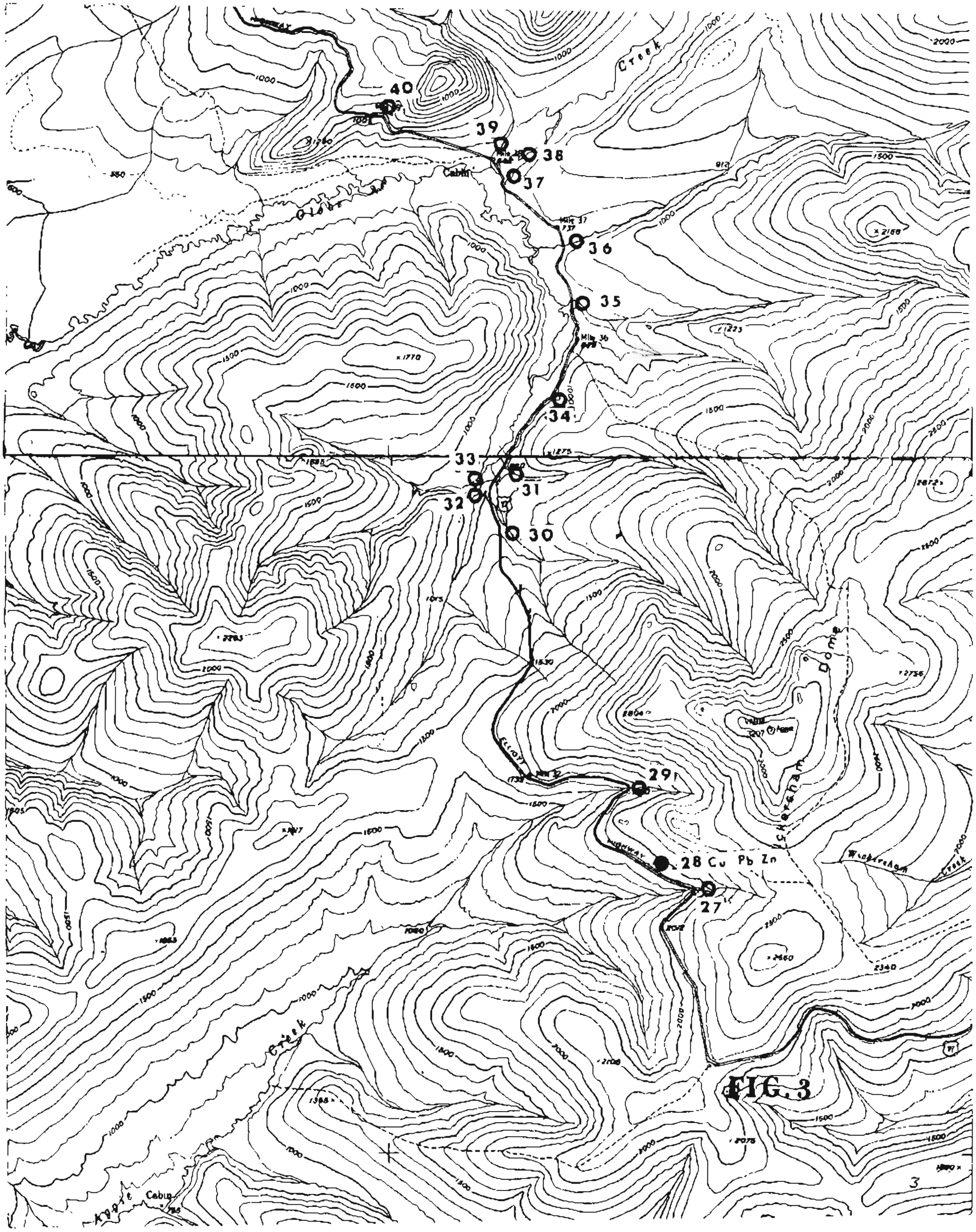
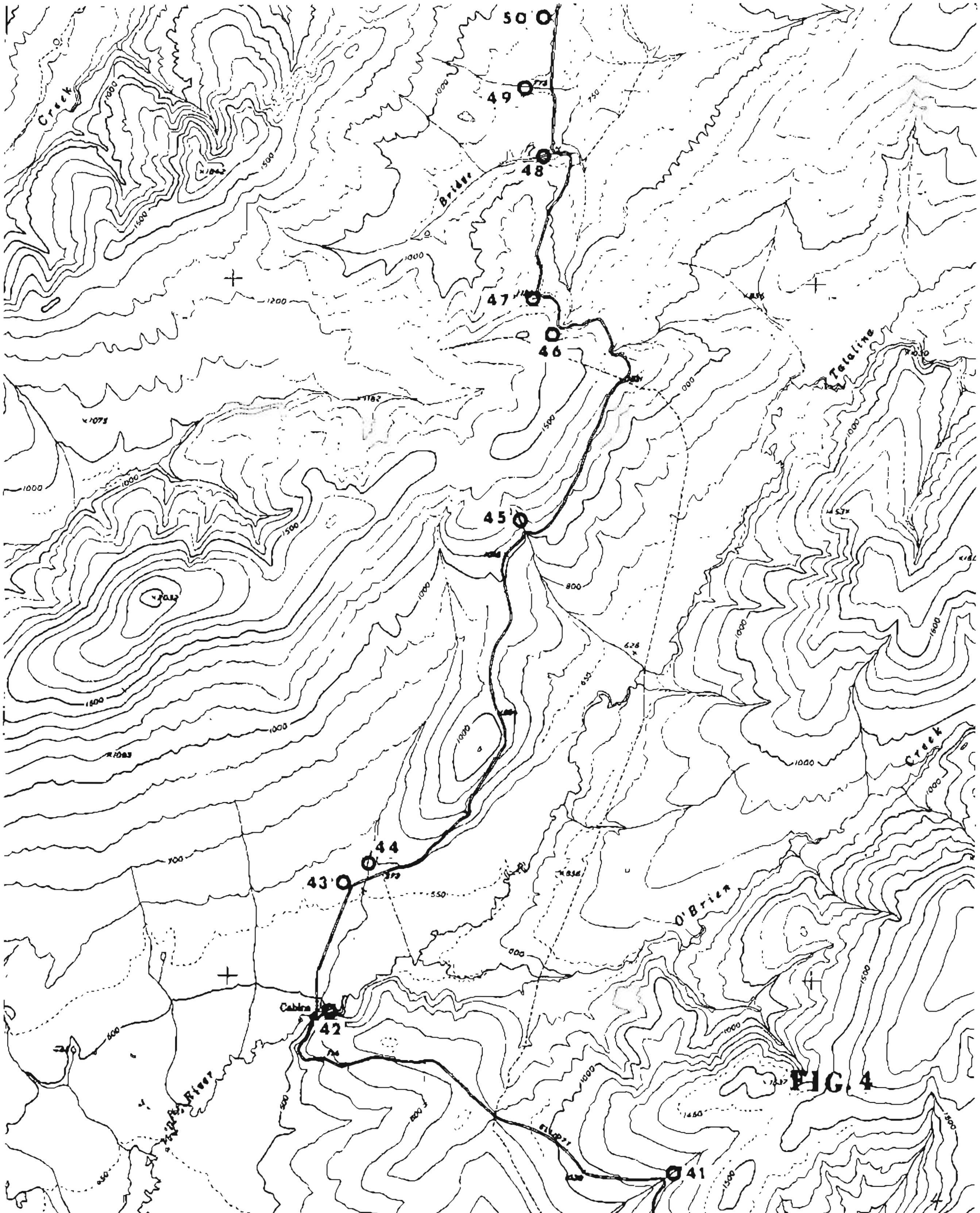


FIG. 3



50
49
48
47
46
45
44
43
42
41
Cabins
Creek
Bridge
Tatalina
Creek
O'Brien
River

FIG. 4

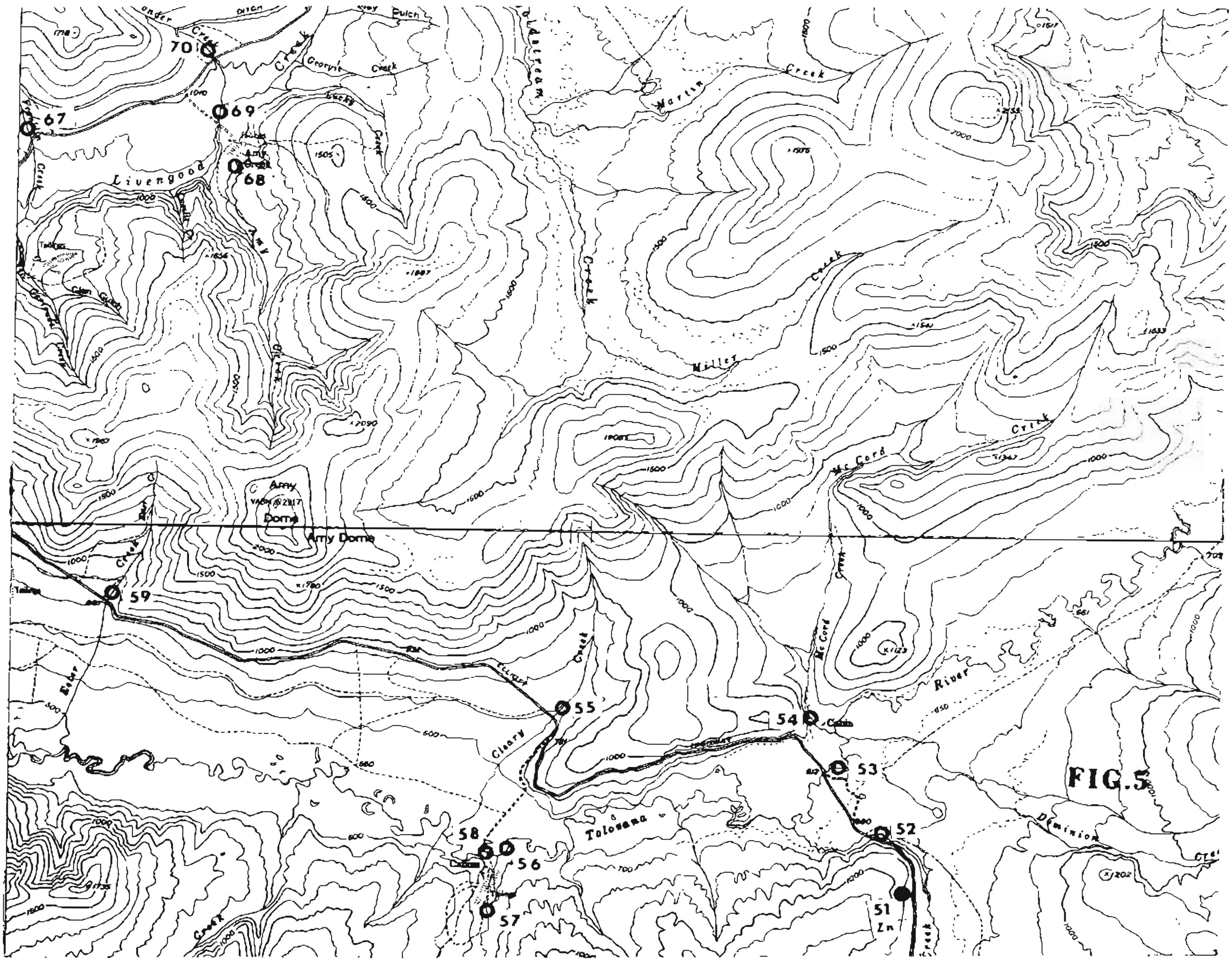


FIG.5
Livengood
Amy Dome
Army Dome
Miller
Creek
Martin Creek
McCord Creek
River
Cleary Creek
Tolovana
Dominion
Eldor
Glen Gulch
Lucky Creek
51
52
53
54
55
56
57
58
59
67
68
69
70

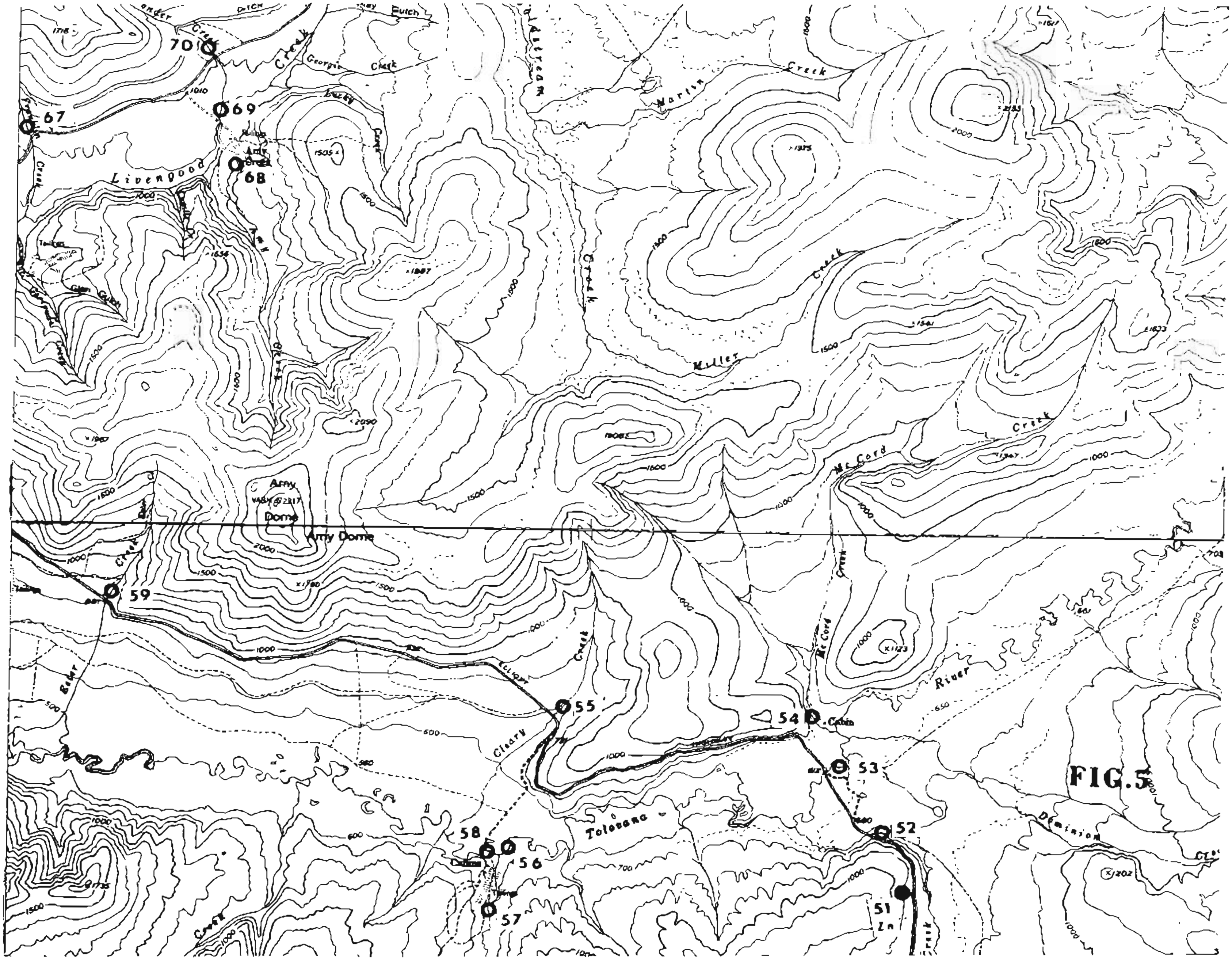
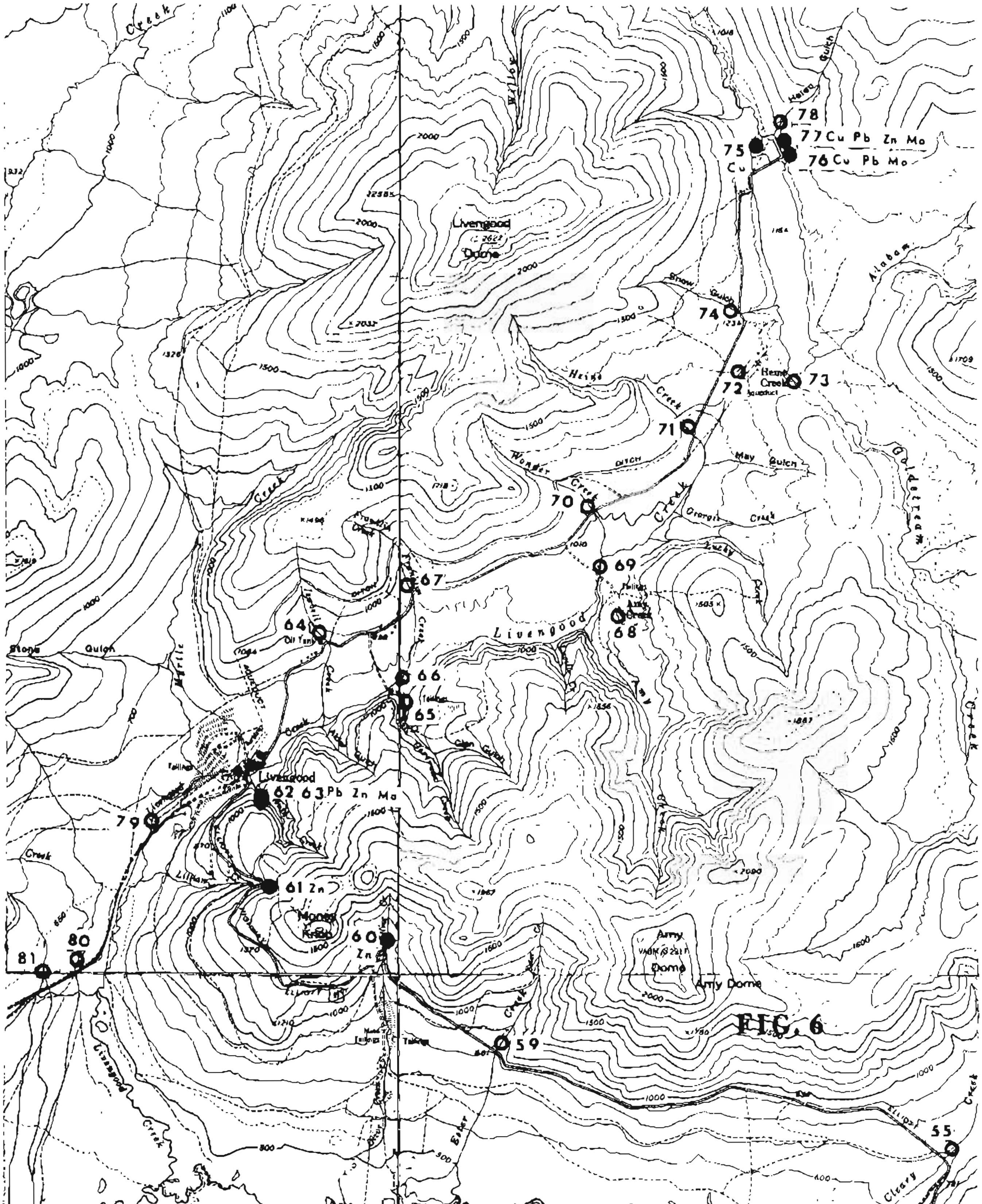

Livengood
Amy Dome
Cleary
Tolovana
River
Miller
Creek
Martin
Mc Cord
Dominion
Cabin
67
68
69
70
59
55
54
53
52
51
56
57
58

FIG.5



Livengood Dome
Livengood
62 63 Pb Zn Mo
61 Zn
60 Zn
59
55
64
65
66
67
68
69
70
71
72
73
74
75 Cu
76 Cu Pb Mo
77 Cu Pb Zn Mo
78
79
80
81
Amy Dome
Money Knob
Wonder Creek
Heine Creek
May Gulch
Snow Gulch
Stone Gulch
Helen Gulch
Livengood Creek
Amy Creek
Cleary Creek
Lucky Creek

FIG. 6

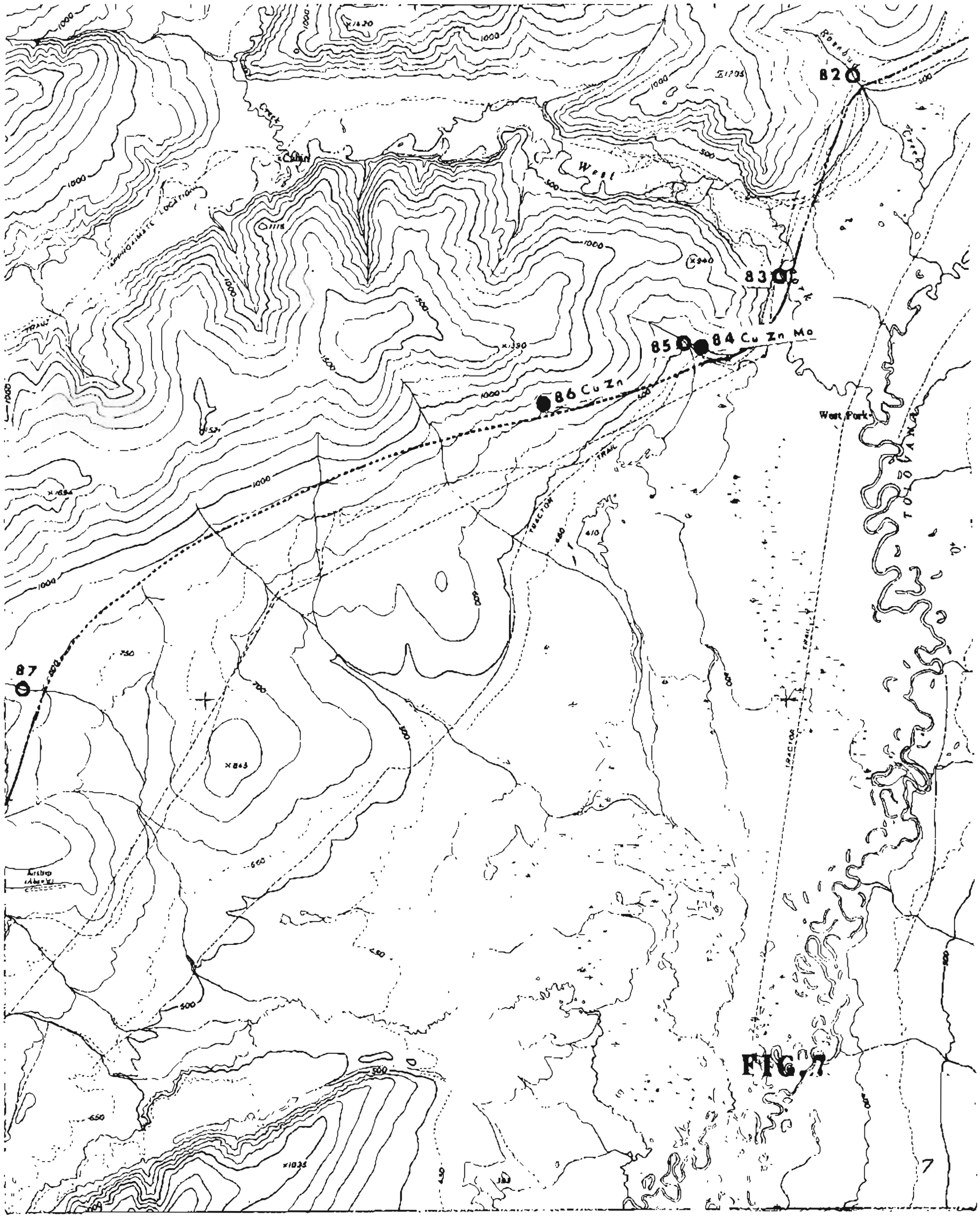

82
83
84 Cu Zn Mo
85
86 Cu Zn
87
West Fork
Cabin
West Park
TOLOVANA
TRACTOR TRAIL
APPROXIMATE LOCATION

FIG. 7

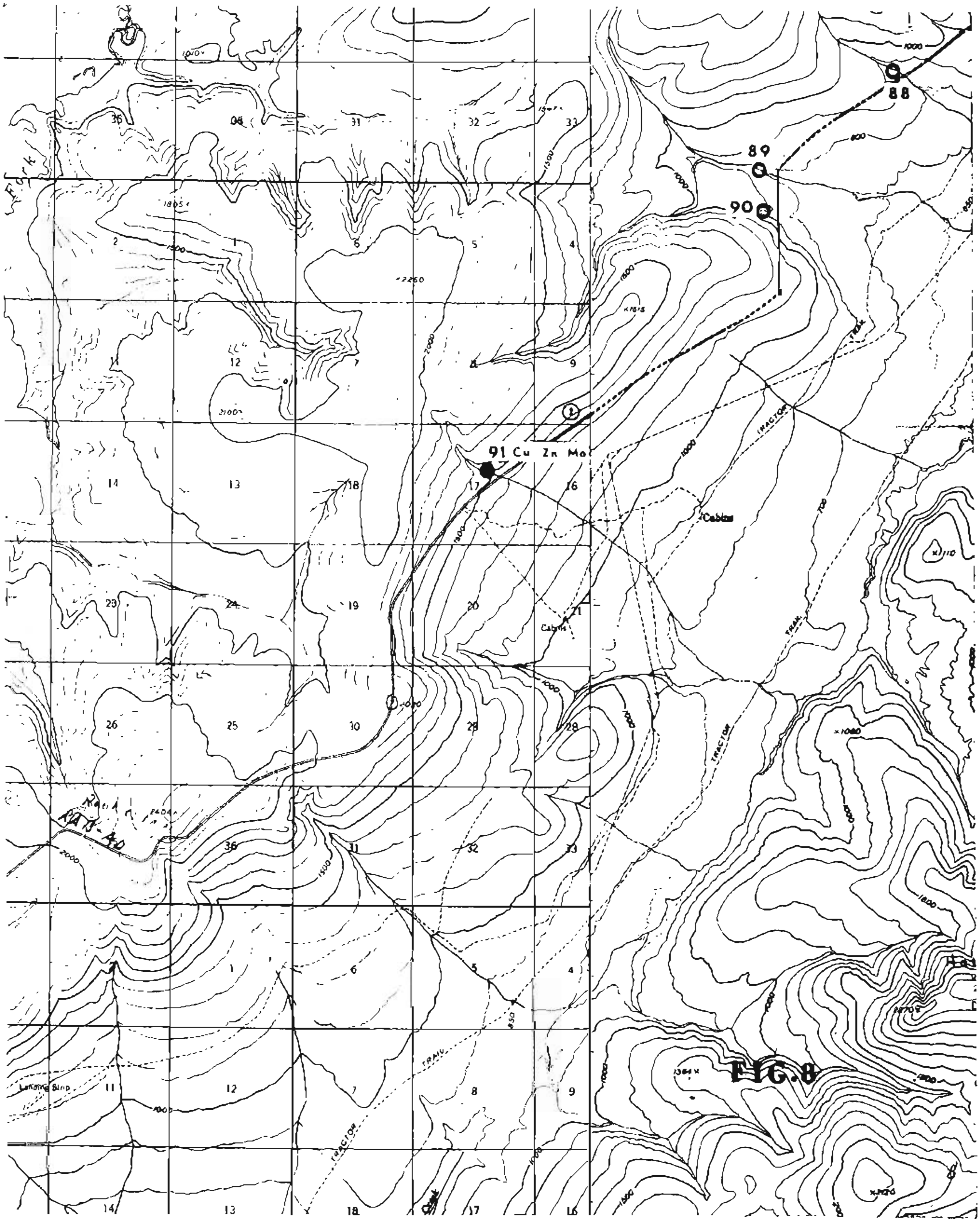


FIG. 8

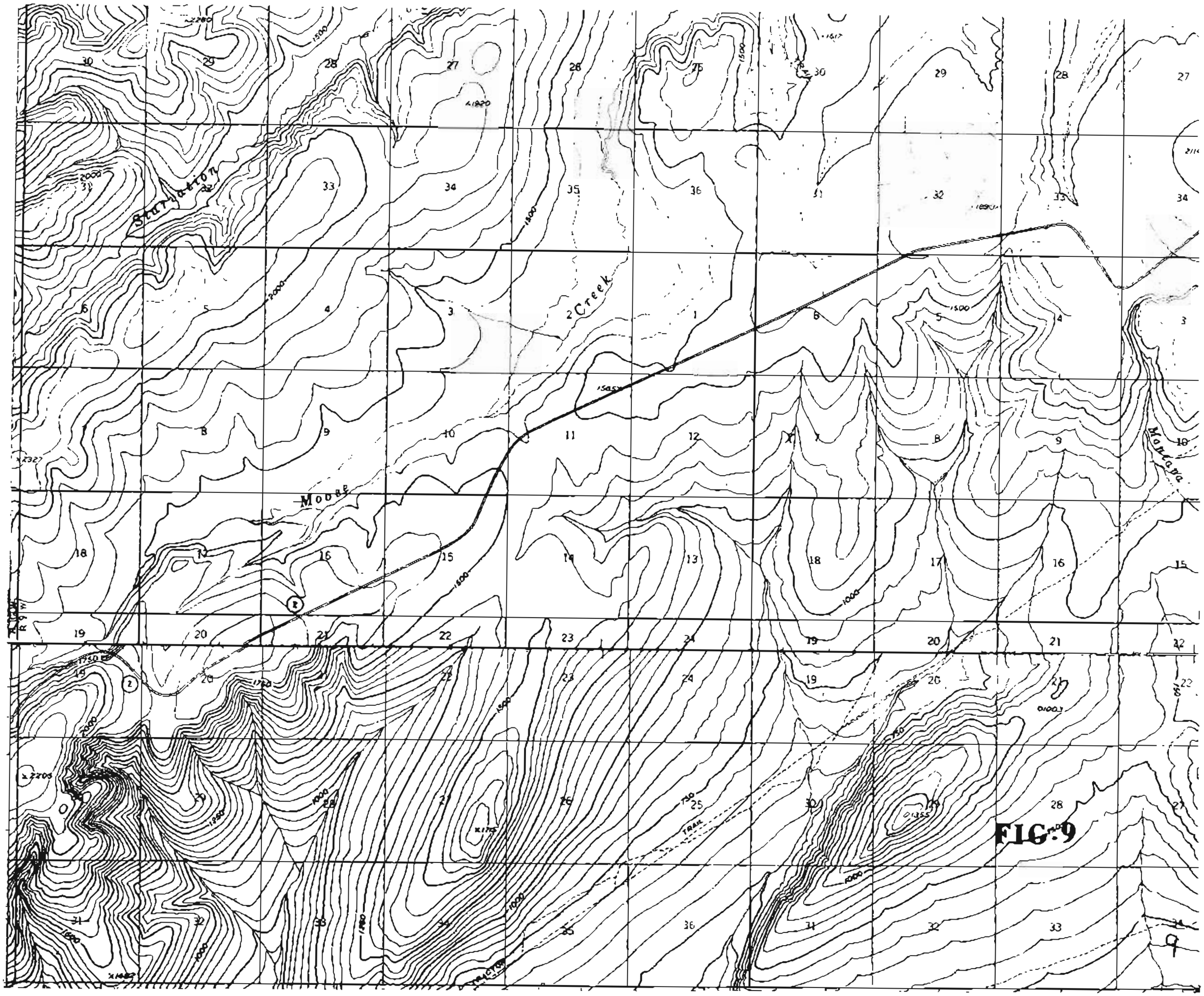


FIG. 9

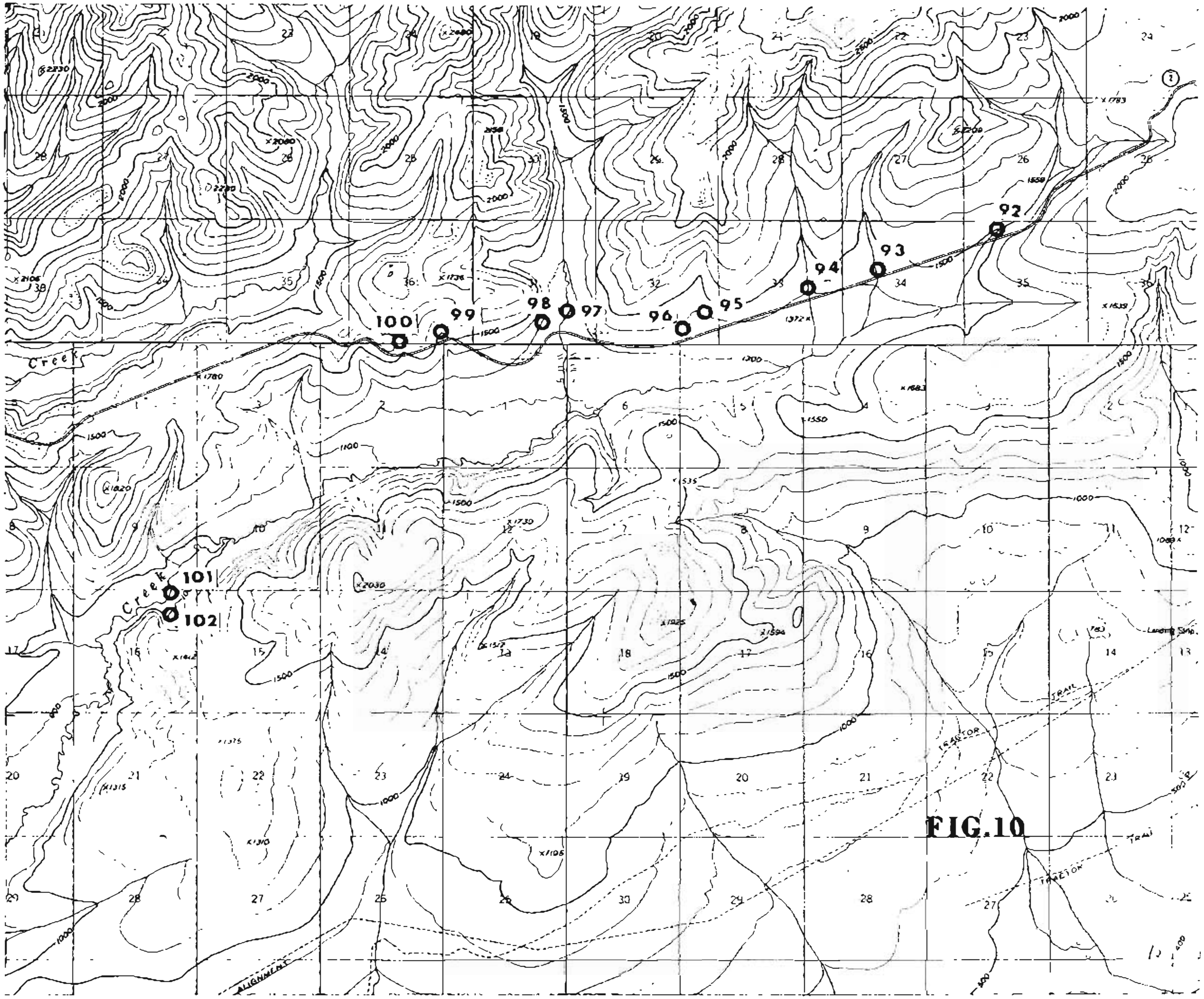


FIG.10

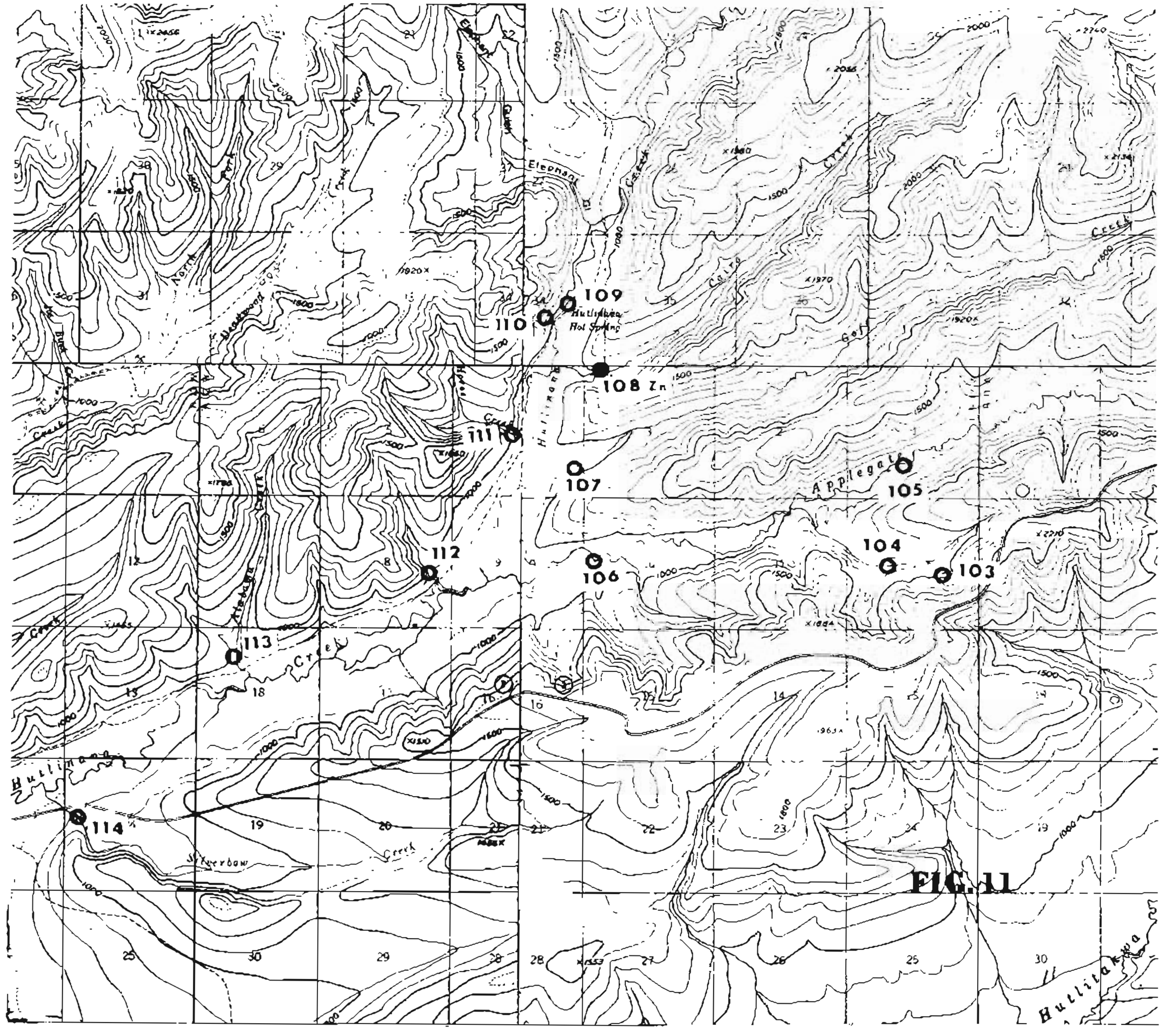
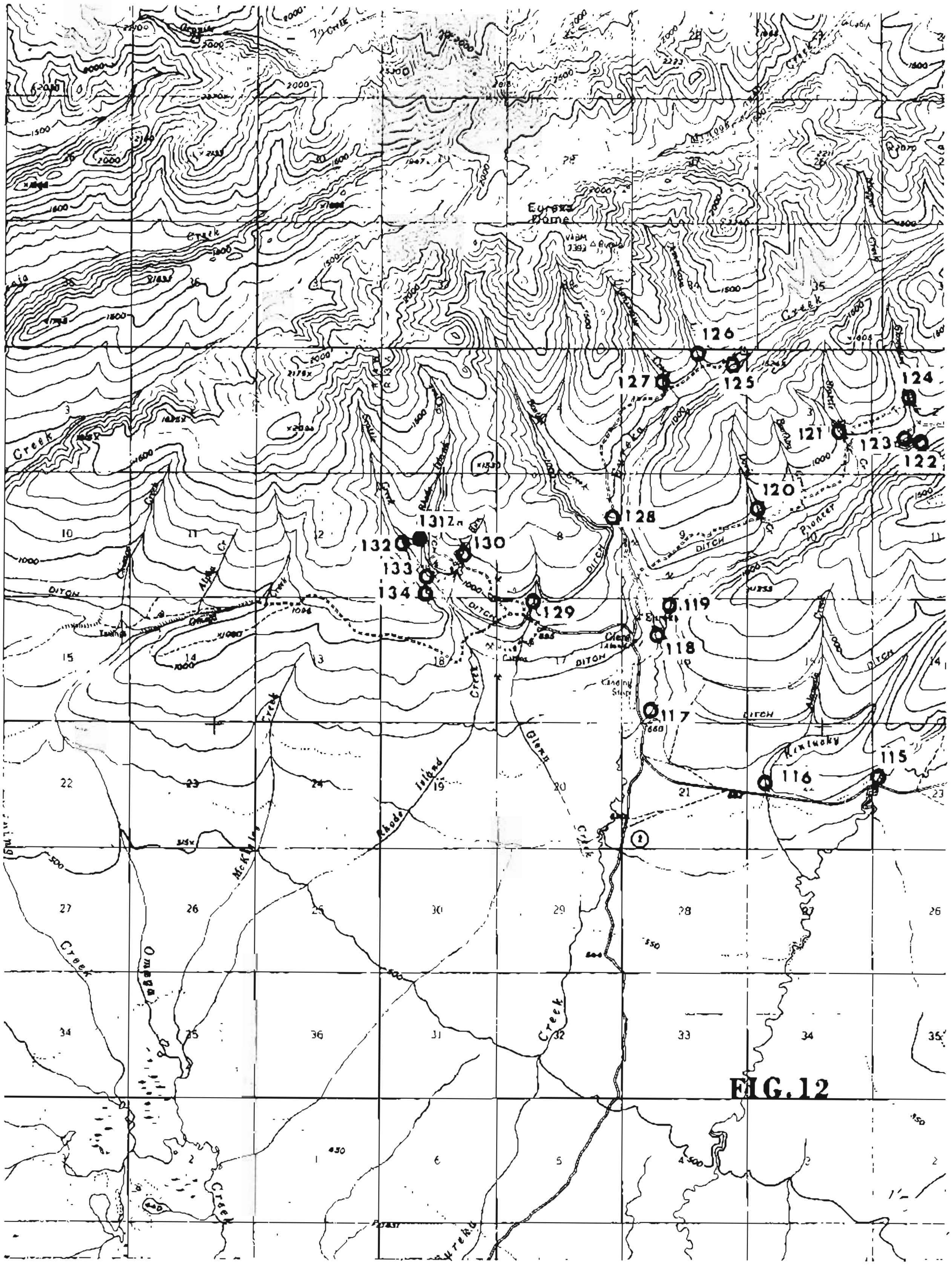
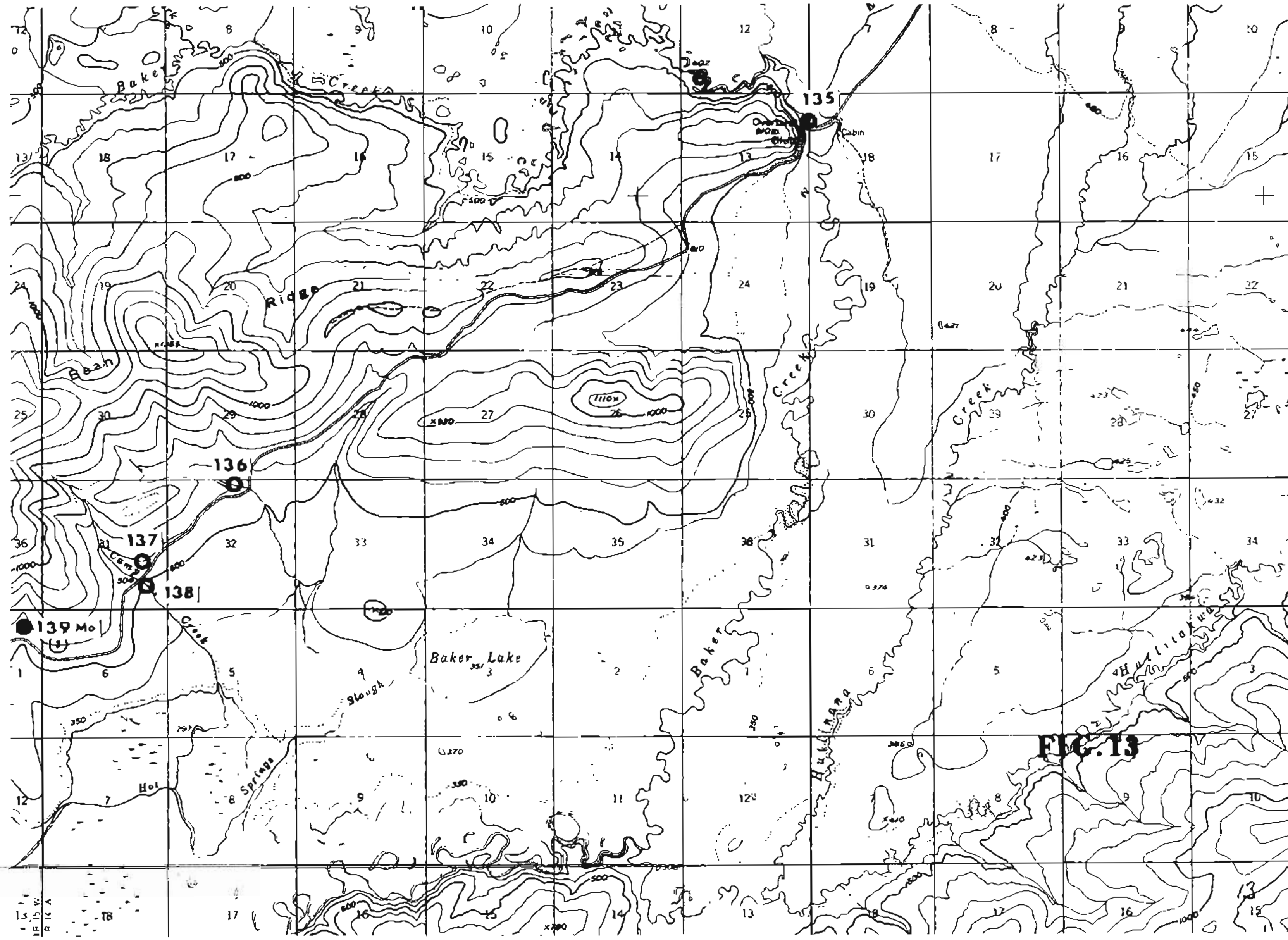

103
104
105
106
107
108 Zn
109
110
111
112
113
114
Applegate
Elephant
Creek
Hot Spring
Hutlinana
Silverbow
North Fork

FIG. 11



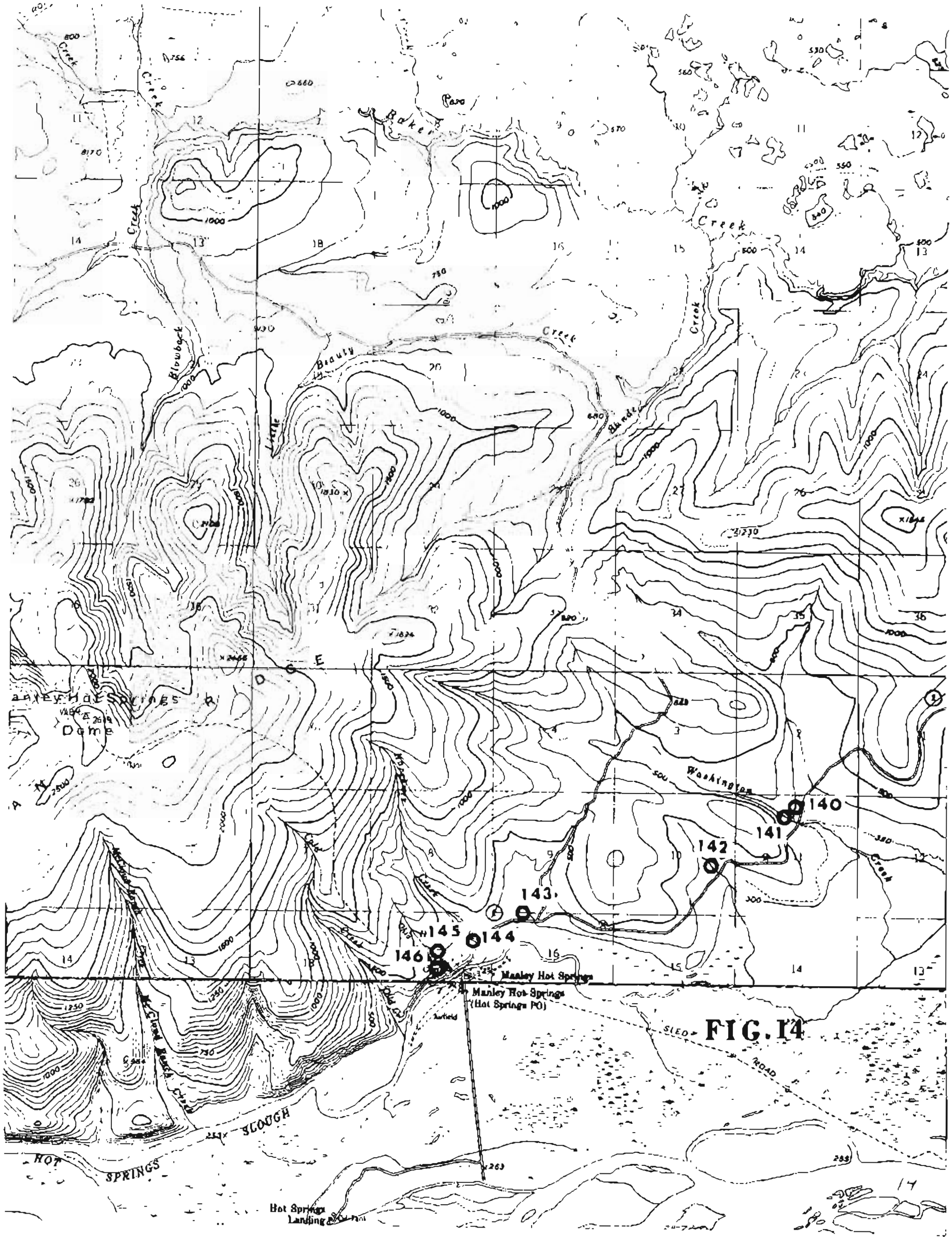
Eureka Dome
Creek
DITCH
Pioneer
Kentucky
Glenn
Rhode Island
Omega
126
127
125
124
121
123
122
120
128
131
132
130
133
134
129
119
118
117
116
115

FIG. 12



Baker Creek
Bean Ridge
Baker Lake
Slough
Springs
Hot
Creek
Baker Creek
Hulliana
Cabin
Camp
135
136
137
138
139 Mo

FIG. 13



Baker
Creek
Blowback Creek
Beauty Creek
Little
Washington
Creek
Manley Hot Springs Dome
R I D G E
Manley Hot Springs
Manley Hot Springs (Hot Springs PO)
Airfield
SLED ROAD
HOT SPRINGS SLOUGH
Hot Springs Landing
140
141
142
143
144
145
146

FIG. 14