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Geochemical Soil Studies in the Cotter Basin Area, Lewis and Clark County, Montana

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GEOCHEMICAL SOIL STUDIES IN THE COTTER BASIN AREA, LEWIS AND CLARK COUNTY, MONTANA

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Abstract

Geochemical sampling in an area of abnormal vegetation in the Cotter basin area, Lewis and Clark County, Montana, shows anomalously high concentrations of Cu, Pb, Ag, Zn, and Au in the soil. The singular presence of a particular plant species growing in the highly anomalous zone merits further investigation for its potential use as an indicator plant for base-metal deposits, buried at shallow depth.

INTRODUCTION

The Cotter basin prospect area is located about 8 miles (13 km) north of Lincoln, Montana, and about 1.5 miles (2.4 km) north of Stonewall Mountain in the Stonewall Mountain quadrangle, northwest Montana (fig. 1). The area contains adits and opencuts along a ridge and on a steep northwesterly facing slope above the upper reaches of Cotter Creek. The workings are accessible via an unpaved road that connects with a Forest Service road along the Copper Creek. The Forest Service road is a continuation of a road that intersects Montana Highway 200 about 7 miles (11 km) east of Lincoln, Montana, and follows the Landers Fork of the Blackfoot River to Copper Creek.

The area was investigated by the U.S. Geological Survey and the U.S. Bureau of Mines during the summer of 1974 in connection with mineral resource evaluation studies of the proposed Arrastra-Stonewall Wilderness candidate area, Helena National Forest. The prospect area is about 0.5 mile (1 km) to the north of the northern boundary of the wilderness candidate area.

The present studies consist of detailed mapping and sampling of the workings by the U.S. Bureau of Mines, and a geochemical soil and plant survey by the U.S. Geological Survey. In addition, a geologic sketch map was prepared from an enlarged photo and compiled at a scale of 1 inch equals 400 feet (fig. 2) in order to determine the geologic setting of the area, and to assist in the interpretation of the analytical data.

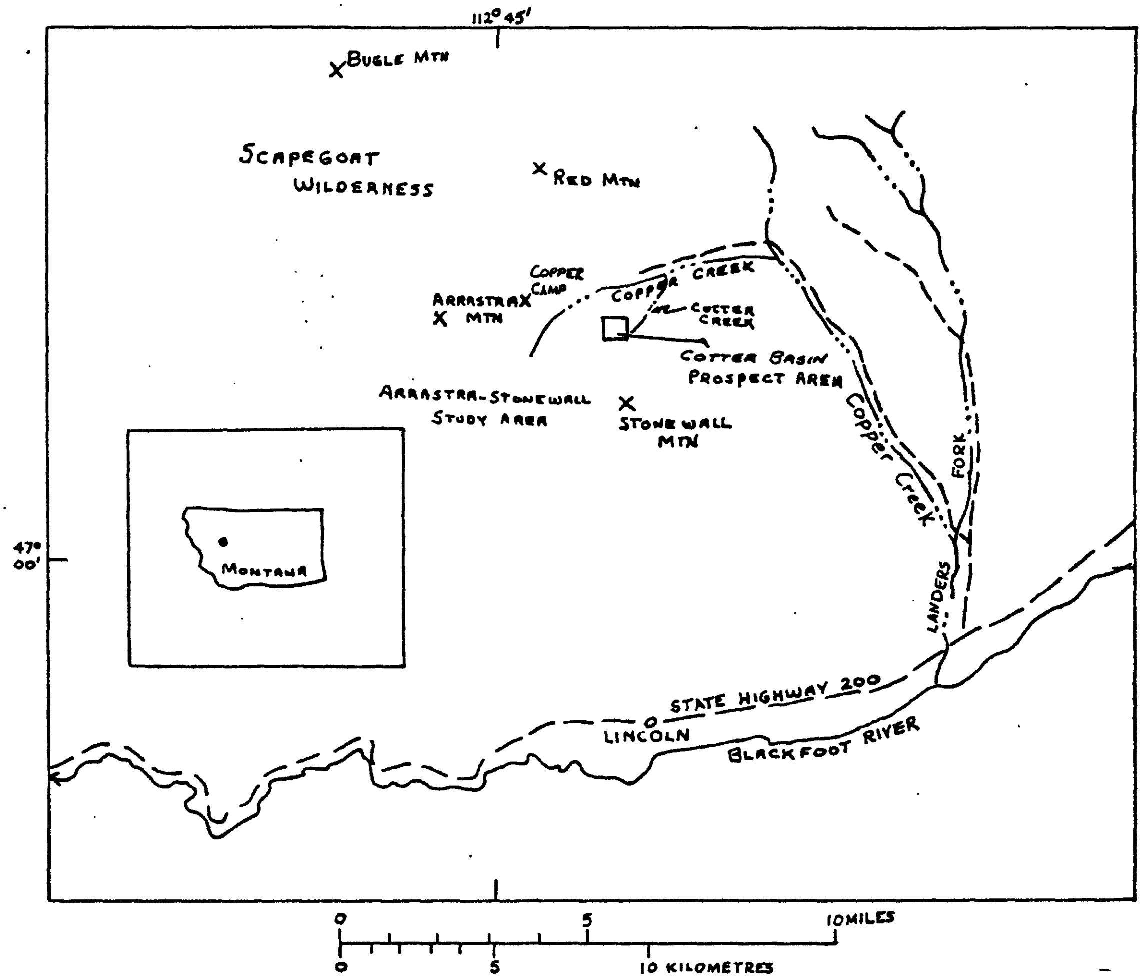
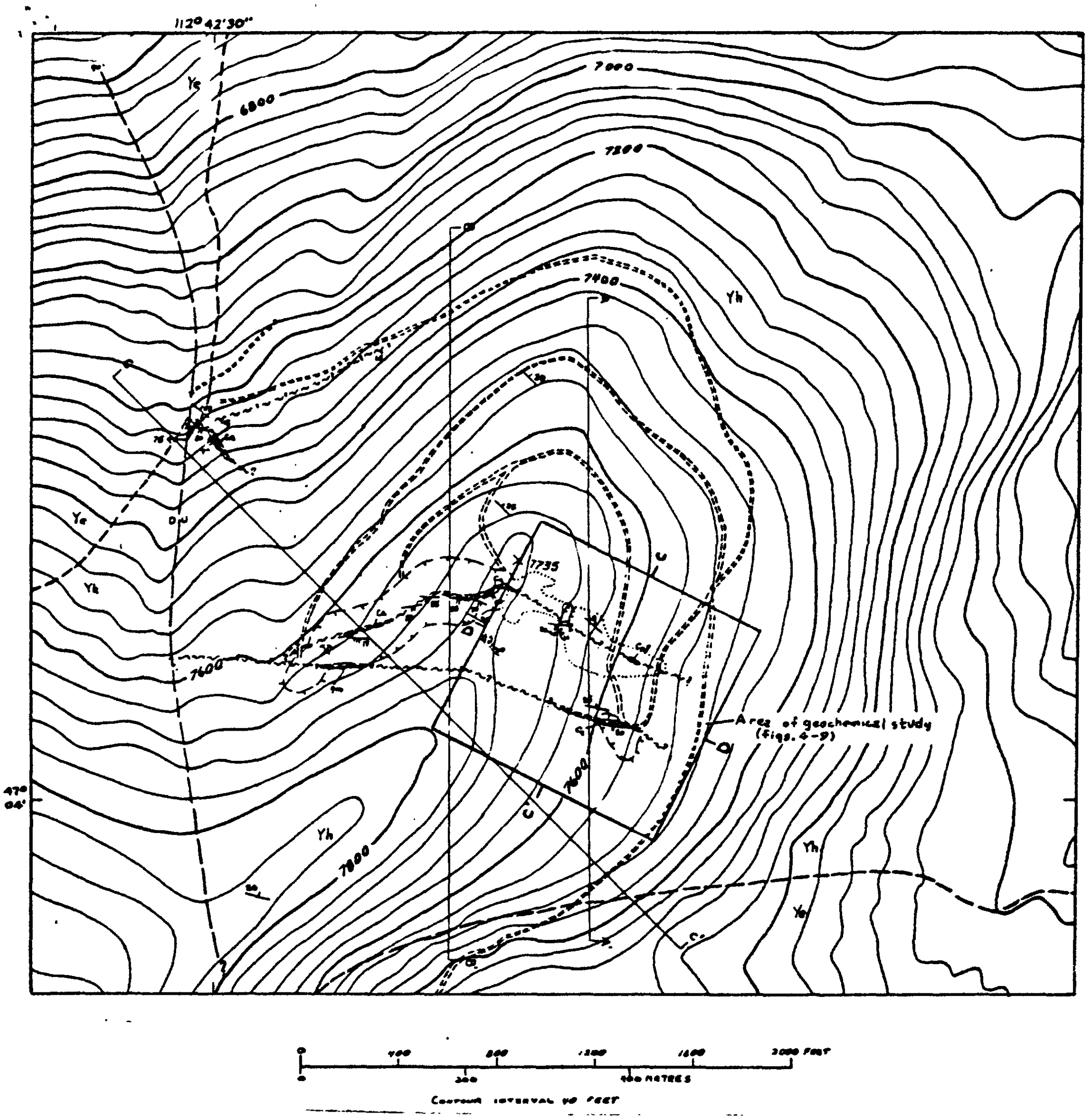


Figure 1.--Index map of the Cotter basin prospect area.



EXPLANATION

CENOZOIC (?)
- ca — Calcite vein
- qm — Quartz-monzonite porphyry

PRECAMBRIAN Y
- Yh — Helena Formation
- Ye — Empire Formation

- Inferred contact
- 28 — Strike and dip of beds
- 50 — Strike and dip of vein or mineralized shears measured at surface
- 70 — Strike and dip of vein measured in adit
- 75 ? — Fault--Showing dip of fault plane. Dashed where inferred; queried where doubtful
- ca ? — Shear zone--Dashed line shows approximate limits of shear zone where calcite veins are included. Queried where doubtful
- Open cut
- Adit
- Access road
- A A' — Line of cross section--Figure 3
- Area of Eriogonum cover

Figure 2.--Geologic map of the Cotter basin prospect area, Lewis and Clark County, Montana. Geology mapped by R.L.Earhart, 1974. Base compiled from aerial photographs, U.S. Geological Survey Stonewall Mountain 1:24,000 topographic quadrangle, and from survey control by L.Y. Marks, U.S. Bureau of Mines.

GEOLOGICAL SETTING

The sedimentary rocks in the area are, from youngest to oldest, the Helena and Empire Formations, both in the Belt Supergroup of Precambrian Y age. They strike northwesterly, dip gently to moderately northeast, and are cut by shear zones that mostly strike westerly and dip gently to moderately south. Locally the shear zones contain veins and pods of calcite with associated copper minerals, and at one locality a shear zone is intruded by a quartz-monzonite dike(?). One prominent shear zone along a fault in the western part of the map area (fig. 2) strikes northerly and dips steeply west.

Approximately 600 feet (183 m) of lowermost Helena Formation is present in the area. The Helena consists of thin to medium beds of gray dolomite and limestone with some interbeds of calcareous and dolomitic siltite. A few thin beds of greenish-gray siltite occur near the lower contact. The contact between the Helena and Empire Formations is gradational over about 50 feet (15 m) and is placed at the top of the first thick green siltite bed.

Only the uppermost part of the Empire Formation is exposed in the immediate area. But in the nearby Arrastra-Stonewall area, where the formation is better and more extensively exposed, it consists mostly of green siltite that is locally argillitic and contains thin beds of argillite. Gray quartzite beds 1-3 feet (0.3-0.9 m) thick are locally interbedded in the siltite, and limestone beds 1-2 feet (0.3-0.6 m) thick occur in the Empire especially near the upper contact.

Quartz monzonite porphyry was observed in the opencut above the upper adit shown near the 7,640-foot contour (fig. 2). This rock type was not observed elsewhere in the area; however, Mr. George Kornec, a developer of the property, reported a "porphyry dike" exposure a short distance northwest of the workings. Where exposed, quartz-monzonite porphyry is highly kaolinized and consists of a fine-grained gray groundmass and light-gray feldspar phenocrysts as long as 4 mm. The small monzonite body that is exposed appears to be a dike that intruded a shear zone. It seems possible that the quartz monzonite dike may have intruded along a shear zone from a stock at relatively shallow depth (fig. 3). If such a stock exists the magnetic reflection that it would be expected to give would likely be distorted by the magnetite-bearing Precambrian sills that are present a short distance to the west. The aeromagnetic map of this area (Mudge and others, 1968) shows a strong magnetic anomaly over the sills and this may distort the magnetic effect caused by a small, concealed quartz-monzonite stock.

The gravity map that accompanies the aeromagnetic map shows a strong gravity maximum trending west-northwesterly over the prospect area. A secondary anomaly along this maximum occurs a short distance north of the prospect area and may reflect the presence of a small stock.

The age of the quartz monzonite porphyry is not known; however, it is of somewhat similar appearance to quartz monzonite near the Mike Horse mine about 16 miles (26 km) east of the area, which is assumed to be of Late Cretaceous-early Tertiary age.

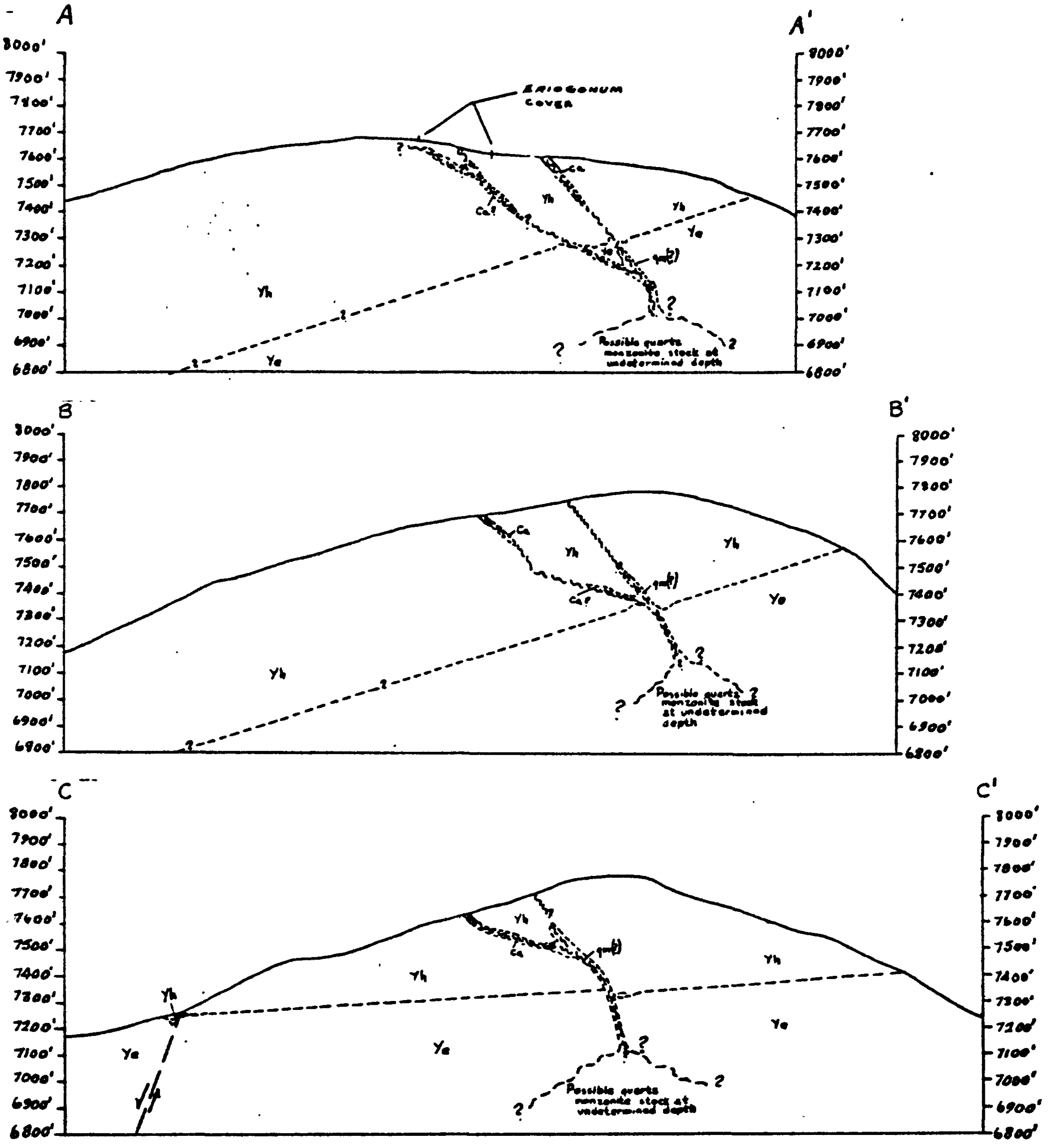


Figure 3.--Idealized geologic cross sections, Cotter basin area. Lines of sections and explanation of symbols shown on figure 2.

Cupriferous carbonate veins, 4 inches to 3 feet (10 cm-0.9 m) thick, occur locally along northwesterly striking shear zones. The veins are mostly calcite with minor quartz and varying amounts of copper and lead sulfide minerals and their oxidation products. The veins pinch and swell and appear to be discontinuous along the shear zones. The strike and dip of the veins is also somewhat erratic; at most localities the veins appear to occupy the hanging-wall portion of the shear zone, but locally rolls in the veins and abrupt strike deviations change the relative position of the vein in the shear zone. The vein system appears to be a southeasterly extension of the cupriferous carbonate veins reported at Copper Camp and in the Scapegoat Wilderness, most notably at Bugle Mountain (Mudge and others, 1974). The presence of the carbonate veins and the quartz-monzonite porphyry dike in the same shear zone indicates that they may be genetically related.

The main structural features in the area are west- to northwest-striking normal faults; slickensides along some shear planes indicate a southerly downward vertical movement of as much as a few tens of feet. Only the more prominent of the many shear zones in the area are shown on figure 2.

MINERALIZATION

Copper minerals occur in carbonate veins, shear zones and along fractures in the adjacent host rocks. The copper minerals are, in order of decreasing abundance, bornite, chalcocite, azurite, malachite, and chalcopyrite. Brochantite and cuprite may be locally present in the more highly oxidized parts of the veins. The veins contain, in addition to copper, localized occurrences of galena with minor sphalerite and pyrite. Silver is also present and is most abundant in the chalcocite-rich and galena-rich parts of the veins; the silver mineral has not been identified.

The cupriferous veins are commonly 1 to 1 1/2 feet (0.3-0.4 m) below the hanging wall of the host shear zone. Where the veins are highly mineralized, the adjacent shear zone also contains abundant copper minerals. Where the veins are weakly mineralized or absent, only minor copper minerals are found in the shear zones. The wall-rocks are limestone, dolomite, limy or dolomitic siltite, and siltite of the lower Helena Formation.

GEOCHEMICAL STUDY

The geochemical survey was prompted by the observation of a southeast-facing slope near the ridgetop, barren of vegetation except for a small, uncommon plant identified as *Eriogonum* sp. (H. T. Shacklette, oral commun., 1974). The survey was conducted to study the geochemistry of the soils supporting the *Eriogonum* growth in relation to the potential use of this plant as an indicator for concealed base-metal deposits.

During this survey 181 soil samples were collected on 700- to 1,000-foot (213-305 m) extending traverses northeast to southwest across the study area (fig. 4).

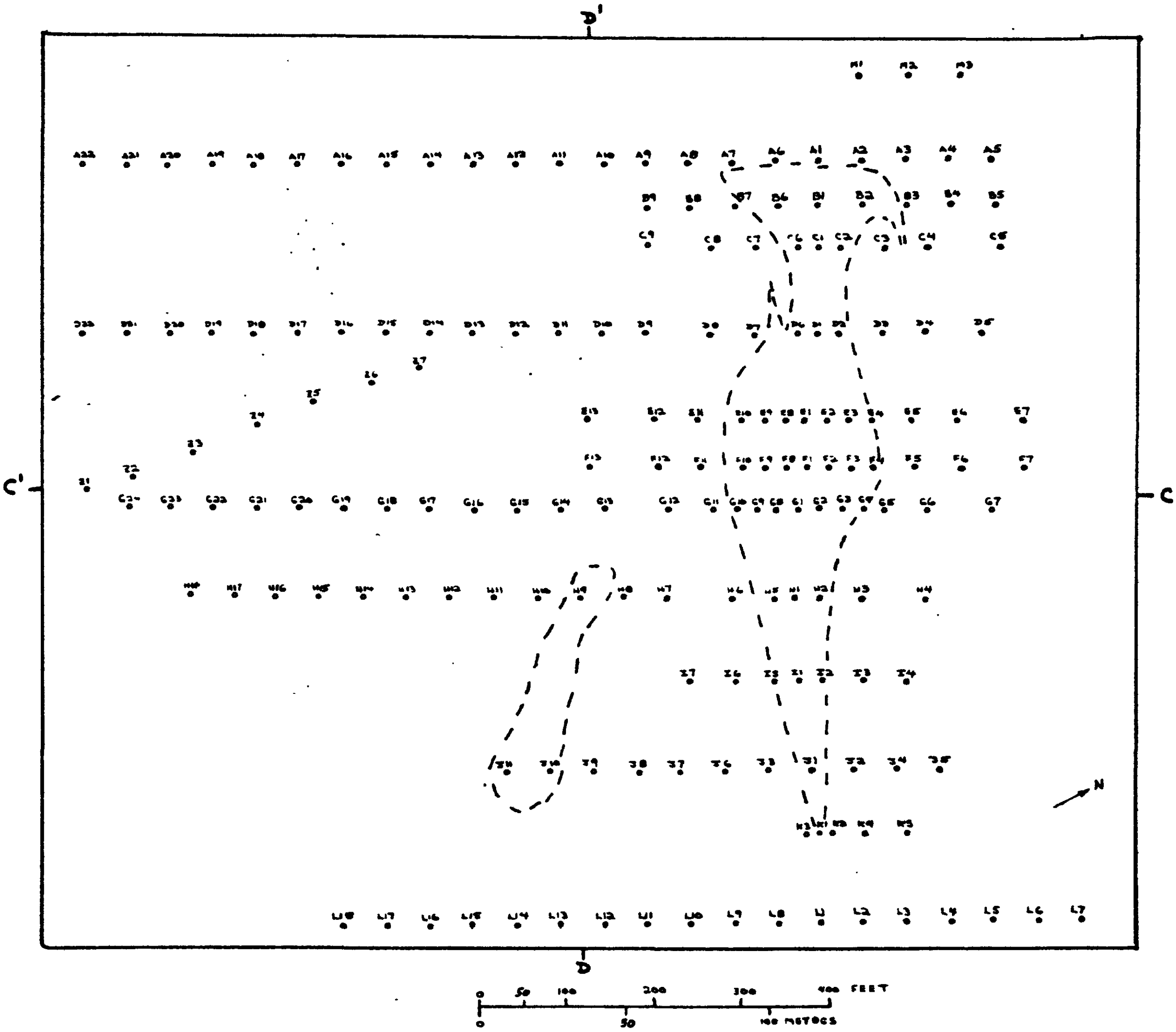


Figure 4.--Soil-sample localities and numbers. Dashed lines delimit areas of sparse vegetation. Location of area shown on figure 2.

MATERIAL SAMPLED AND ANALYTICAL METHODS

In the area covered by normal vegetation, the A-horizon is 3 to 6 inches (7.6-15.2 cm) thick with yellowish-gray to gray ash-textured soil. The area of abnormal vegetation has no developed A-horizon. The B-horizon, 8 to 16 inches (20.3-40.6 cm) thick, is characterized by fine- to medium-grained yellowish-brown soil. All samples were collected at a depth of 8 to 10 inches (20.3-25.4 cm) or where the color change to the B-horizon was apparent.

The soil samples were dried in ovens at 80°C, sieved to minus 80-mesh, ground in a vertical pulverizer with ceramic plates to approximately minus 150-mesh and analyzed by the following techniques: copper, lead, and silver by optical emission spectroscopy (Grimes and Marranzino, 1968); gold and zinc by atomic absorption spectroscopy (Ward and others, 1969). The results of the analyses are given in table 1. The sample preparation and analytical work were performed in the field in the mobile laboratories of the U.S. Geological Survey.

RESULTS

The geochemical data from the soil samples were entered into the U.S. Geological Survey DEC-10 computer via a key to tape machine and, using existing programs, histograms showing the percent frequency distribution and perspective maps for each element were obtained (figs. 5-9). An interactive cathode ray tube terminal was used to display these maps as viewed from various points in space. When the desired perspective was developed on the screen a copy of the image was made. The concentration contours appearing on the perspectives are equal to approximately 1/12 the difference between the minimum and maximum reported values of each element. From these computer-generated geochemical maps and histograms the following observations are made:

1. There is high correlation between the anomalous concentrations of Cu, Pb, Ag, and Au in the soils (figs. 5, 6, 7, 9) and the area of abnormal vegetation (fig. 4). These metals also define the strike of two prominent shear zones in the area as projected on the geologic map (fig. 2).
2. The Zn anomaly is not as clearly defined and the concentration range is much smaller (fig. 8) probably due to the greater mobility of Zn in the zone of oxidation.
3. The relationship of the *Eriogonum* sp. to anomalous concentrations of several metals in the soil as well as the plant's usefulness as an indicator of concealed base-metal deposits will require further study in various geochemical environments.

Figure 5. Histogram and perspective maps of Cu distribution in B-horizon soils. Location of area shown on figure 2.

Figure 6. Histogram and perspective maps of Pb distribution in B-horizon soils. Location of area shown in figure 2.

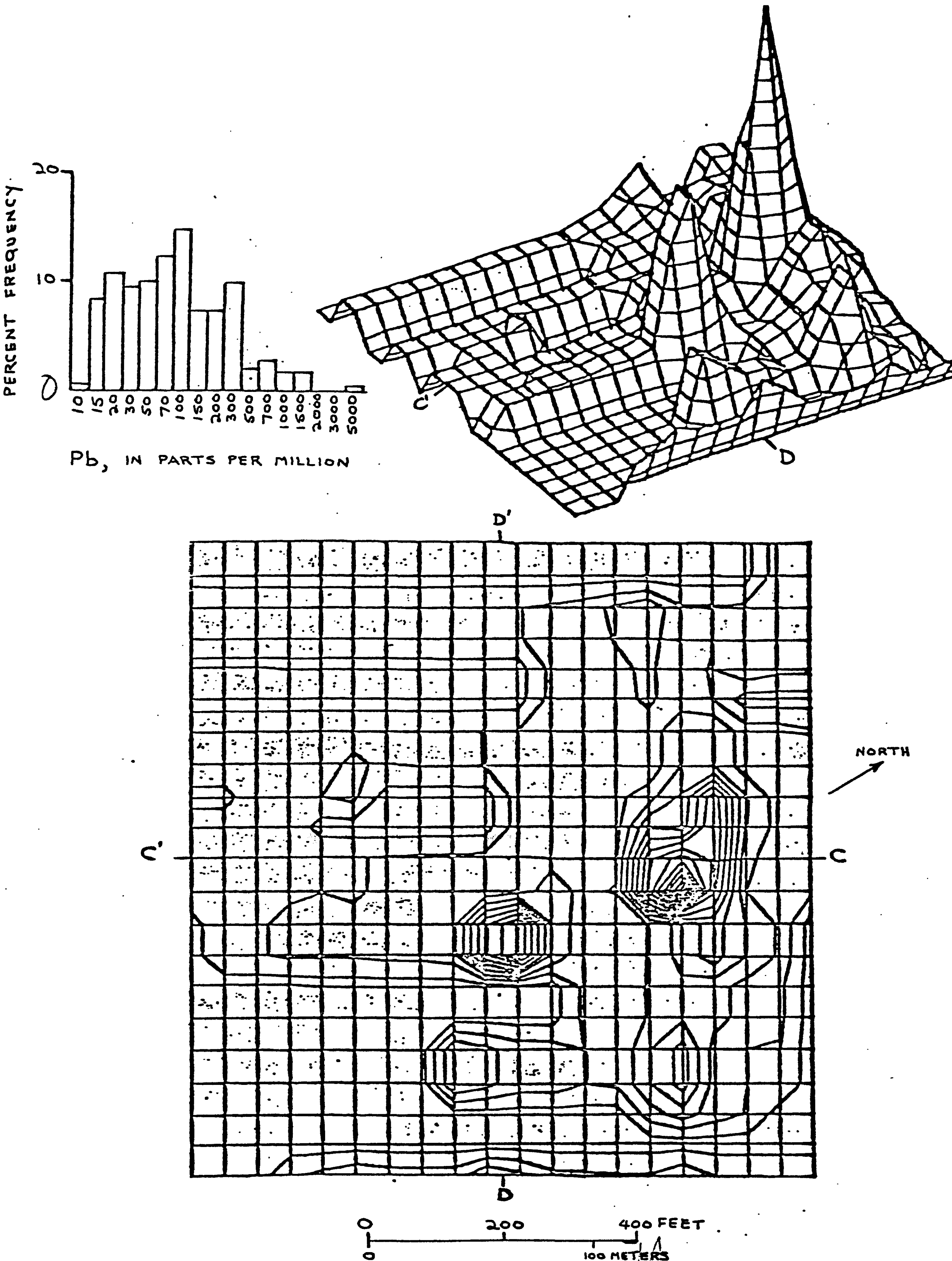


Figure 6. — Histogram and perspectives of Pb distribution

Figure 7. Histogram and perspective maps of Ag distribution in B-horizon soils. Location of area shown in figure 2.

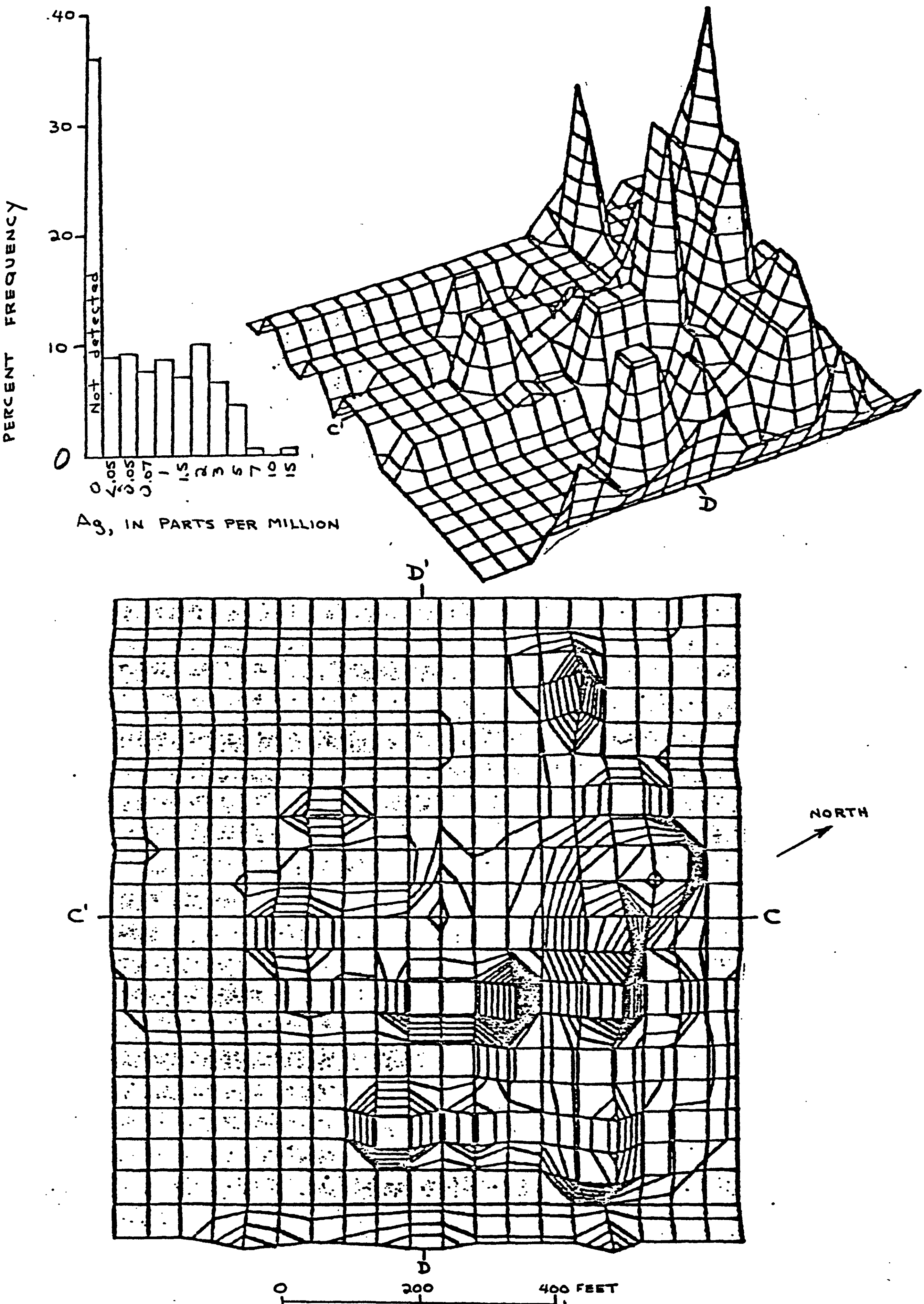


Figure 7 .- Histogram and perspective of Ag distribution

Figure 8. Histogram and perspective maps of Zn distribution in B-horizon soils. Location of area shown on figure 2.

Figure 9. Histogram and perspective maps of Au distribution in B-horizon soils. Location of area shown in figure 2.

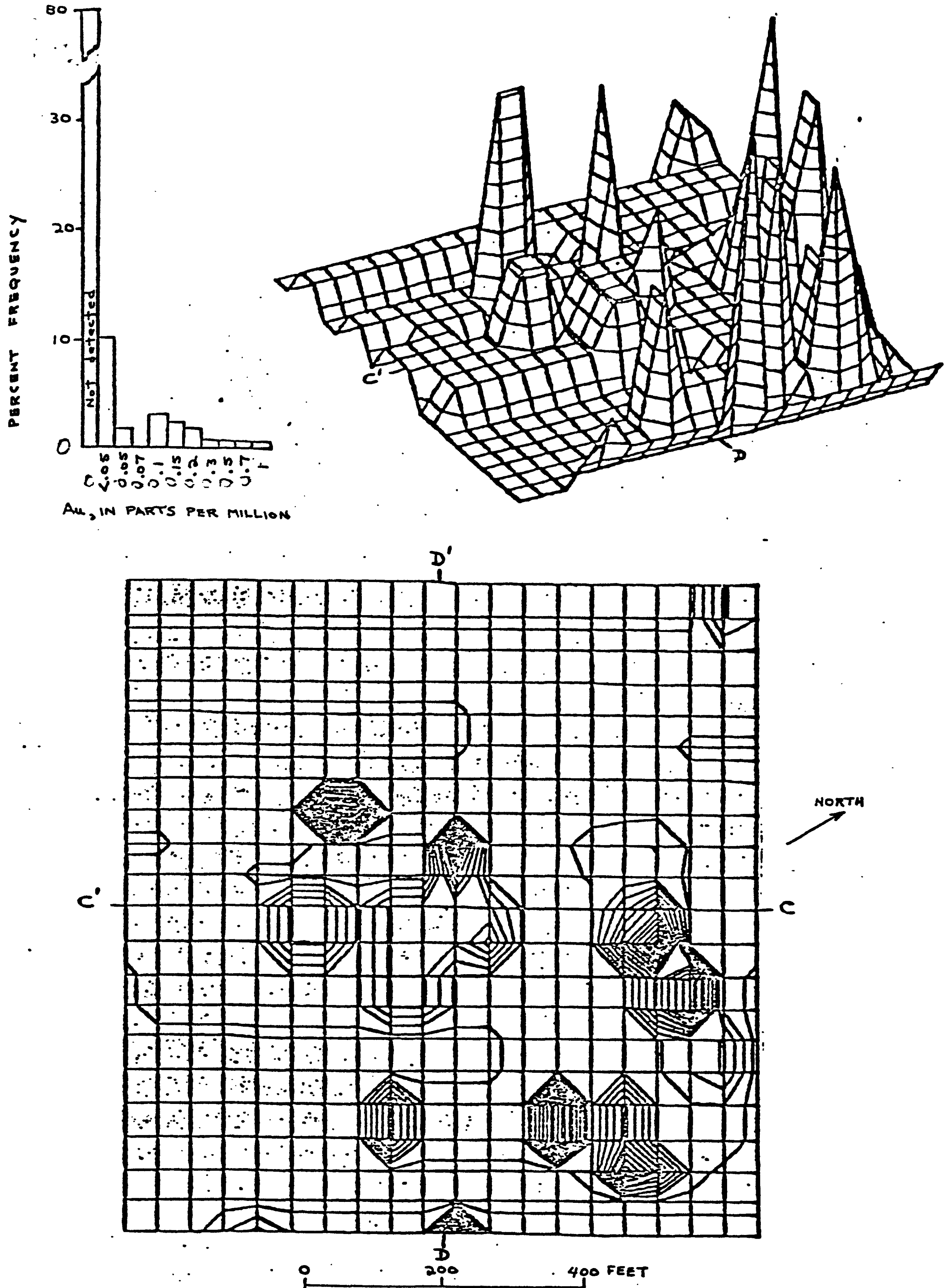


Figure 9. - Histogram and perspective of Au distribution

Table 1.--Analyses of soil samples from the Cotter Basin area, Lewis and Clark County, Montana

[Cu, Pb, and Ag analyses by semiquantitative emission spectrographic methods; Au and Zn were analyzed by atomic absorption. N indicates not detected; L indicates detected but below limit of determination. Number in parentheses indicates determination limit of method used in parts per million: Cu (5), Pb (10), Ag (0.5), Zn (5), and Au (0.05). Where the limits of determination differ from those indicated, their values are shown in brackets. Analyst: D. J. Grimes]

Sample No.	Base and precious metals, in parts per million				
	Cu	Pb	Ag	Zn	Au
A1	3,000	300	1.5	90	N
A2	700	100	N	180	N
A3	500	100	L	380	L
A4	500	50	N	130	L
A5	70	50	N	120	N
A6	500	70	0.5	110	L
A7	500	70	0.5	110	N
A8	30	150	N	140	N
A9	30	50	N	80	N
A10	30	30	N	120	N
A11	20	20	N	120	N
A12	20	30	N	210	N
A13	15	20	N	200	N
A14	70	20	N	110	N
A15	30	20	N	40	N
A16	20	15	N	60	N
A17	15	15	N	80	N
A18	15	15	N	70	N
A19	30	20	N	80	N
A20	20	20	N	90	N
A21	20	30	N	90	N
A22	30	20	N	90	N
B1	7,000	200	5.0	150	N
B2	3,000	150	0.5	210	N
B3	100	50	N	140	N

Table 1.--Analyses of soil samples from the Cotter Basin area, Lewis and Clark County, Montana--Continued

Sample No.	Base and precious metals, in parts per million				
	Cu	Pb	Ag	Zn	Au
B4	100	15	N	60	N
B5	100	30	N	140	N
B6	1,500	150	0.5	130	N
B7	1,000	70	L	140	N
B8	70	70	N	140	N
B9	50	70	N	120	N
C1	3,000	300	1.5	280	N
C2	1,500	100	0.5	150	N
C3	1,000	100	L	400	N
C4	500	70	N	170	N
C5	70	30	N	100	N
C6	700	150	L	100	N
C7	500	100	N	110	N
C8	500	100	N	150	N
C9	50	50	N	90	N
D1	5,000	500	3.0	140	N
D2	3,000	200	1.0	200	N
D3	300	100	0.5	120	N
D4	300	100	N	200	L
D5	200	70	N	110	N
D6	2,000	200	1.0	90	N
D7	5,000	70	0.7	110	N
D8	500	100	N	90	N
D9	50	50	N	70	N
D10	20	20	N	90	N
D11	300	50	L	200	L
D12	30	15	N	120	L
D13	100	15	L	80	L
D14	300	15	L	100	0.05
D15	30	15	N	80	L
D16	20	20	N	80	N
D17	15	10	N	60	N
D18	15	15	N	100	N
D19	15	15	N	80	N
D20	15	15	N	100	N

Table 1.--Analyses of soil samples from the Cotter Basin area, Lewis and Clark County, Montana--Continued

Sample No.	Base and precious metals, in parts per million				
	Cu	Pb	Ag	Zn	Au
D21	20	15	N	80	N
D22	30	20	N	130	0.05
E1	7,000	700	3.0	130	N
E2	5,000	200	2.0	140	N
E3	7,000	1,500	3.0	300	N[0.1]
E4	10,000	500	7.0	180	N
E5	1,000	150	0.5	200	N
E6	500	70	L	170	L
E7	200	70	N	180	N
E8	7,000	200	3.0	120	0.1
E9	7,000	300	2.0	140	0.05
E10	3,000	200	1.5	120	N
E11	700	50	0.7	100	N
E12	1,500	100	L	100	N
E13	700	100	0.7	130	0.25
F1	7,000	700	3.0	150	N
F2	15,000	700	3.0	200	N
F3	7,000	1,500	5.0	240	N
F4	10,000	300	5.0	220	N
F5	1,000	200	0.7	320	N
F6	500	100	0.5	110	N
F7	200	100	L	190	N
F8	10,000	200	5.0	130	N
F9	5,000	1,500	5.0	110	L
F10	1,000	150	2.0	80	N
F11	700	70	1.0	70	N
F12	1,000	100	1.0	80	N
F13	1,000	100	2.0	120	0.1
G1	7,000	300	3.0	140	N
G2	10,000	1,000	2.0	150	0.9
G3	7,000	1,000	1.5	210	N
G4	3,000	200	1.0	190	N
G5	700	150	0.7	130	N
G6	300	100	L	90	N
G7	300	70	N	210	N

Table 1.--Analyses of soil samples from the Cotter Basin area, Lewis and Clark County, Montana--Continued

Sample No.	Base and precious metals, in parts per million				
	Cu	Pb	Ag	Zn	Au
G8	10,000	5,000	15.0	140	N
G9	3,000	300	2.0	110	L
G10	1,500	300	2.0	90	N
G11	1,000	100	1.5	80	L
G12	1,000	150	1.0	70	N
G13	700	200	1.0	90	0.15
G14	500	70	1.5	40	N
G15	1,500	70	1.0	80	0.15
G16	1,000	30	1.0	70	N
G17	1,000	70	L	80	N
G18	1,000	15	3.0	110	0.2
G19	200	30	L	70	N
G20	20	20	N	60	N
G21	20	20	N	60	N
G22	15	15	N	70	N
G23	20	20	N	150	N
G24	15	15	N	70	N
H1	10,000	300	5.0	110	N
H2	5,000	700	1.5	160	N
H3	5,000	300	2.0	170	N[0.25]
H4	700	150	0.5	190	N
H5	10,000	300	5.0	140	N
H6	700	50	1.0	70	N
H7	700	70	5.0	50	N
H8	1,500	300	2.0	60	N
H9	5,000	1,000	2.0	80	N
H10	700	700	2.0	160	N[0.1]
H11	500	100	0.5	210	.1
H12	300	70	0.5	180	N
H13	300	70	0.7	150	N
H14	150	50	0.5	140	N
H15	50	50	L	130	N
H16	20	50	N	80	N
H17	15	20	N	70	N
H18	15	20	N	70	N

Table 1.--Analyses of soil samples from the Cotter Basin area, Lewis and Clark County, Montana--Continued

Sample No.	Base and precious metals, in parts per million Cu	Pb	Ag	Zn	Au
I1	5,000	300	1.5	80	N
I2	2,000	300	1.5	150	N
I3	700	150	1.0	150	N
I4	300	70	0.7	130	.1
I5	1,000	200	3.0	80	N
I6	700	150	1.0	80	N
I7	500	70	1.5	50	N
J1	5,000	500	3.0	130	.15
J2	300	100	1.0	70	N
J3	1,000	300	2.0	90	N
J4	70	30	L	70	L
J5	50	15	N	130	N
J6	500	50	1.0	100	.25
J7	300	30	0.7	90	N
J8	500	100	1.5	100	N
J9	500	100	0.5	80	N
J10	2,000	200	2.0	140	L
J11	2,000	300	2.0	160	.15
K1	2,000	300	3.0	110	N
K2	2,000	300	2.0	100	.7
K3	500	100	2.0	50	N
K4	150	50	0.7	90	N
K5	200	20	N	90	L
L1	1,000	150	2	130	N
L2	150	30	0.5	70	N
L3	30	20	N	40	N
L4	50	30	0.5	120	N
L5	30	30	L	100	N
L6	30	30	N	90	N
L7	30	20	N	80	N
L8	150	50	0.7	80	L
L9	300	50	0.7	90	N
L10	300	70	0.7	70	N
L11	300	70	0.7	80	N
L12	1,000	200	1.5	80	.35

Table 1.--Analyses of soil samples from the Cotter Basin area, Lewis and Clark Country, Montana--Continued

Sample No.	Base and precious metals, in parts per million				
	Cu	Pb	Ag	Zn	Au
L13	1,500	300	1.5	150	N
L14	300	100	1.0	100	N
L15	200	100	0.7	190	N
L16	300	100	0.5	220	N
L17	500	150	1.0	180	N
L18	500	100	2.0	110	.1
M1	1,500	100	N	150	N[0.1]
M2	1,500	50	0.5	180	N
M3	100	50	N	90	N
Z1	20	30	N	100	N
Z2	20	20	N	100	N
Z3	20	20	N	80	N
Z4	20	30	N	210	L
Z5	30	30	N	110	N
Z6	30	70	N	160	N
Z7	1,000	30	3.0	150	.5

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