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GEOLOGICAL SURVEY CIRCULAR 680

Gold Anomaly in Soil of the West End Creek Area, Yellow Pine District, Valley County, Idaho

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ABSTRACT

A gold anomaly recently found by soil sampling near the Yellow Pine mine is accompanied by a silver anomaly and by conspicuous though minor mercury, antimony, arsenic, and tungsten anomalies. The anomalies are not completely delimited by the sampling, but preliminary results indicate that a gold anomaly extends 600 feet along one fault and 500 feet along a fault that intersects it. The gold content of 128 soil samples ranges from less than 0.05 ppm (part per million) to 8.0 ppm; the median value is 0.70 ppm. Within the area in which gold in the soil samples is equal to or greater than 1 ppm, 23 samples have as the mean 2.91 ppm, equivalent to 0.085 troy ounce of gold per ton. The gold anomaly in soil helps define an attractive exploration target for low-grade gold ore in this area, which overlaps that of the West End Creek gold prospects described by J. R. Cooper in 1951 in U.S. Geological Survey Bulletin 969–F (p. 151–197).

INTRODUCTION

A gold anomaly in the West End Creek area, Yellow Pine district, Valley County, Idaho, was found by soil sampling carried out by the U.S. Geological Survey in 1972. The gold anomaly (fig. 2) is accompanied by a silver anomaly (fig. 3) and by conspicuous though relatively minor mercury, antimony, arsenic, and tungsten anomalies (figs. 4–7). The anomalies are not completely delimited by the sampling, but the preliminary results clearly indicate that a gold anomaly extends 600 feet along the fault zone paralleling West End Creek and 500 feet along the West End fault itself. The gold anomaly helps define an attractive exploration target for low-grade gold ore in this area, which overlaps that of the West End Creek gold prospects.

The West End Creek prospects, 0.8 mile northeast of the inactive Yellow Pine antimony-gold-tungsten mine, were discovered by the Bradley Mining Co. in 1943 and described by Cooper (1951, p. 189–190; prospects near 32,000 N., 24,700 E., pl. 38). Cooper concluded that the prospects "may contain a substantial tonnage of ore averaging a little less than 0.1 ounce of gold per ton."

Two holes were diamond-drilled at the prospects about 1946. The site of DDH WEC–1 (fig. 1) is marked by the remains of the drilling platform. The site of DDH WEC–2 and the orientation of both holes are inferred from an oral description given me by Mr. Ernest Oberbillig, mining engineer.

Mining claims in the area of the gold anomaly were reportedly held by Electronic Metals, Inc., Boise, Idaho in 1972. In 1971 and 1972, bulldozing and sampling of the Electronic Metals claims were carried out under the supervision of Mr. Oberbillig.

SAMPLING

Samples taken by Leonard at sites east and southwest of DDH WEC–1 (fig. 1) in July 1972 assayed 3.0 and 7.0 ppm (parts per million) Au, respectively, and ≈1.5 and 3 ppm Ag.[1] The assays confirmed the occurrence of gold in the area. To estimate the extent of gold mineralization, 128 samples of soil were collected later in July by John Schloderer and volunteer William C. Leonard of the Survey field party. Results of the sampling are shown

[1] Analyses by U.S. Geological Survey; Au determined by fire assay plus atomic absorption method by W. D. Goss, A. W. Haubert, and J. A. Thomas; Ag determined by semiquantitative spectrographic analysis by R. G. Havens.

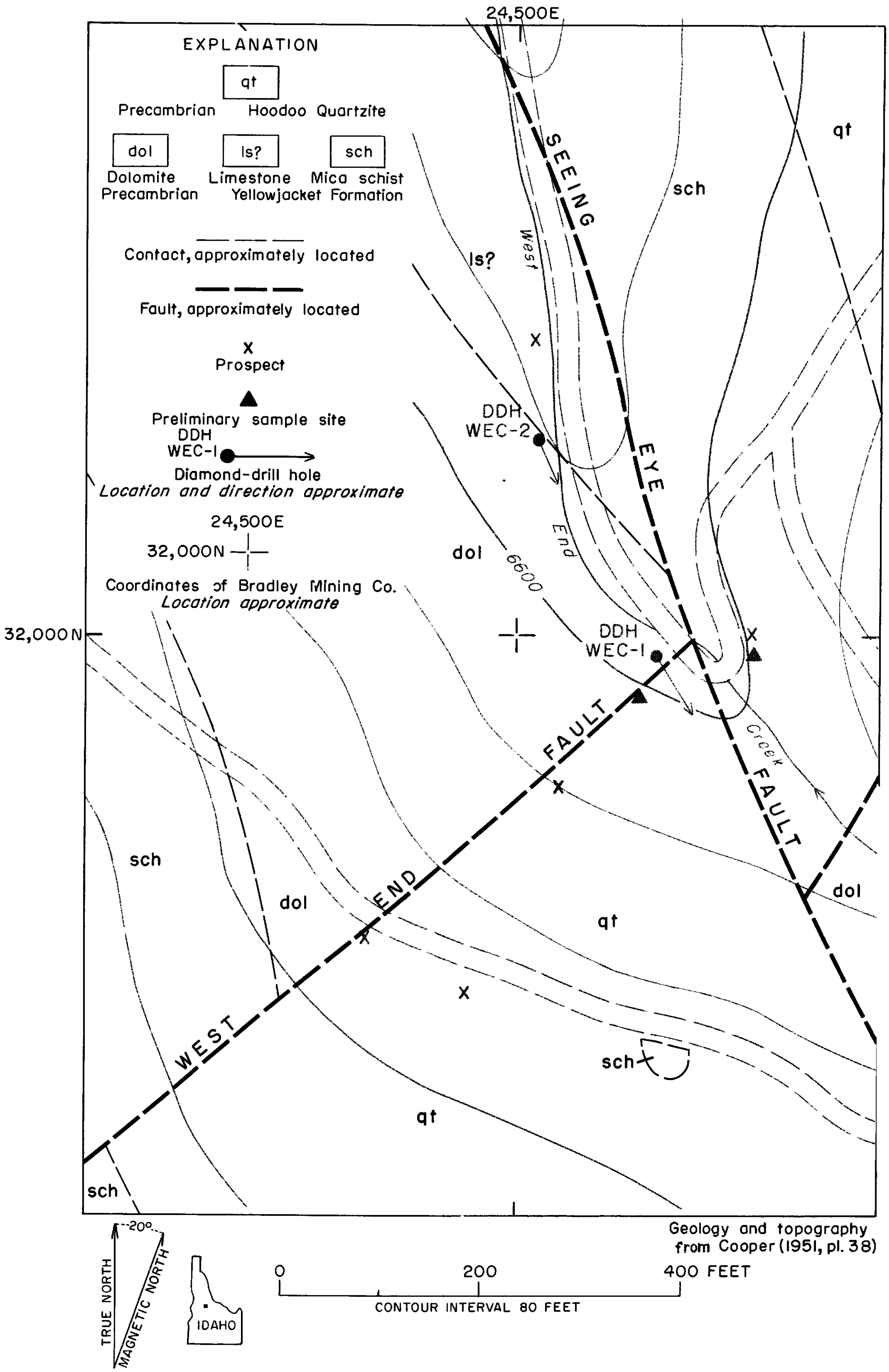

FIGURE 1.—Geologic map of the West End Creek area.

in figures 2–7 and in table 1. The soil samples were taken at depths of 4 to 6 inches, where possible at intervals of 25 feet on traverses 100 feet apart. The samples represent colluvium from which organic debris and larger rock fragments were rejected. Most of the sample material would pass through the loosely held fingers of the sampler's hand. The whole of each sample was crushed to minus 4-mesh, split, finely ground, and analyzed. The bulk sample, not merely the fines, was chosen for analysis because it represents what might be mined at shallow depth from this deposit.

Slopes in the sampled area are generally steep (fig. 1); the vegetation is varied. The slope north of West End Creek is bare, supports small grasses, or has widely spaced conifers. The rest of the area is covered with dense brush and conifers, and the forest floor is littered with mull. Banister's (1970, fig. 2) geochemical sampling of mull in the West End Creek area ended approximately where our sampling of soils began.

GEOLOGY

The geology of the West End Creek area is complex. Regional geologic mapping shows that the area is a jumble of fault blocks of metamorphic rock related to the inner ring-fracture system of a large Tertiary cauldron whose central feature is the Thunder Mountain caldera of Challis Volcanics. (For a brief description of the cauldron and its ore deposits, see U.S. Geological Survey, 1971, p. A36.) Metamorphic rocks of the West End Creek area are dolomite, limestone, mica schist, and quartzite (Cooper, 1951, pl. 38; this report, fig. 1). The metamorphic rocks are interpreted here as Precambrian; the carbonate rocks are correlated with the Yellowjacket Formation, the quartzite with the stratigraphically higher Hoodoo Quartzite, and the mica schist either with a part of the Yellowjacket beneath the carbonate rocks or with the lower part of the Hoodoo. A metavolcanic unit (Leonard, 1962) that occurs elsewhere at the top of the Yellowjacket is missing from the West End Creek area. The mica schist is interpreted as a muscovite-rich retrograded equivalent of the sillimanite-biotite schist of the district. The metamorphic rocks of the West End Creek area form northwest-trending belts that are parts of isoclinal, locally recumbent folds paralleled by and crosscut by faults of various ages and senses of movement. In places, the metamorphic rocks are cut by alaskite of the Idaho batholith suite.

Cooper (1951, pl. 38; this report, fig. 1) showed three faults in the West End Creek area. He interpreted the apparent horizontal offset of metamorphic rock belts on opposite sides of the West End fault[2] as indicative of right-lateral movement along the fault. A similar movement sense may be inferred along the fault that underlies West End Creek, here named the Seeing Eye fault for its southeast strike. The Seeing Eye fault is partly exposed as a zone of slumped gouge visible in roadcuts along West End Creek. This fault, and probably the neighboring faults as well, marks a zone of deformation, not a single, sharp break.

The southwestward increase in apparent horizontal offset along the West End fault and the steepening of the dip of foliation in homolo-

[2] The West End fault was named many years ago. Note that the West End fault does not coincide with West End Creek. The name of the fault, though confusing, is too well established to change.

TABLE 1.—*Distribution of gold, silver, and some associated elements in 128 soil samples, West End Creek area*

[Values in parts per million, unless otherwise noted. 1 ppm Au or Ag is equivalent to 0.029 troy ounce per short ton. Analyses by U.S. Geological Survey. Au and Ag determined by atomic absorption analysis: Au by E. Welsch and J. D. Hoffman, Ag by R. B. Carten and R. M. O'Leary. Hg determined by R. Turner. As, Sb, W, and Fe determined by semiquantitative spectrographic analysis by D. Siems and B. Crim. L, detected but below limit of determination]

	Limit of determination	Range	Mode	Median	Mean [1]
Au	0.05	<0.05– 8.0	L(0.05)	0.70	0.69
Ag	.5	<.5 – 17.0	1.0	4.0	1.6
Hg	.01	.08– 5.8	0.10–0.19	.52	.90
As	200	<200 –2,000	<200	200	(2)
Sb	100	<100 – 300	<100	L(100)	(2)
W	50	<50 – 150	<50	<50	(2)
Fe (in percent)	.05	.7 – 5	3	3	2.6

[1] Values at and below limit of detection counted as zero.
[2] Not significant; too many values below limit of detection.

gous rock units north of the fault are consistent with a reinterpretation of the fault as a hinge fault of the radial fracture system of the Thunder Mountain caldera. In this reinterpretation, the hinge point of the West End fault is at its intersection with the Seeing Eye fault; relative motion along the West End fault swings the north side up, and the total angular displacement is about 23°, or—if the angular displacement was equal in magnitude and opposite in sense—about 11° up for the north block and about 11° down for the south block.

DESCRIPTION OF ANOMALIES

The gold anomaly shown by soil sampling is mainly along West End Creek and west of its confluence with the gully underlain by the West End fault (fig. 2). A lobe of the anomaly extends southwestward, parallel to the West End fault and about 100 feet southeast of it. Minor gold highs are present at the southwest corner of the sampled area. A conspicuous gold high, incompletely mapped, is present at the southeast corner of the sampled area. This high is near the intersection of the Seeing Eye fault and a north-northeast-striking fault mapped by Cooper. The preliminary sampling merely shows a target for additional exploration; it does not fully define the area that may be favorable for the occurrence of gold.

The silver anomaly (fig. 3) is nearly coincident with the gold anomaly in outline, but the highs do not all correspond with each other. Moreover, the southwest lobe of the silver anomaly passes across the trace of the West End fault. The relations of the distribution of silver and gold in the soil samples are better seen in figure 8, a plot of the Ag-Au ratios.

Mercury, antimony, arsenic, and tungsten (figs. 4–7), as well as copper (not illustrated; maximum concentration 100 ppm), give minor anomalies similar in outline to those of gold and silver. Accordingly, any of the five minor elements might have served as a pathfinder for gold and silver at this site, but none of them was essential. Statistically, none of the five minor metals correlates well with gold or silver; spatially, all five indicate the gold and silver target.

Tin, an element rarely detected in spectrographic analyses of rocks of the region, gives a weak anomaly near the southeast corner of the area sampled. The peak value is only 15 ppm.

Iron gives a minor anomaly similar in orientation to the gold anomaly but differing in details of shape. Broad iron highs generally coincide with the mica schist belt. A narrow, weak high coincides with the trace of the West End fault. Iron lows coincide with areas of quartzite and carbonate rocks. These relations are only of local significance, for in some places in the region, carbonate rocks characteristically break down to terra rossa, a red, iron-rich soil. The iron anomaly in the West End Creek area is too trivial to show as a text figure, but the distribution of iron is summarized in table 1. The element is of interest because iron oxide minerals are conspicuous in much of the soil in the West End Creek area, and gold is associated with them. Nevertheless, it is the mineralogy of the soils, rather than their total Fe content, that is significant.

The following additional elements were sought by semiquantitative spectrographic analysis: B, Ba, Be, Bi, Ca, Cd, Co, Cr, La, Mg, Mn, Mo, Nb, Ni, Pb, Sc, Sr, Ti, V, Y, Zn, Zr. Among these, Mo is present in slightly anomalous concentrations (5–7 ppm) in three samples. The other elements detected spectrographically behave as common rock-forming elements and show no anomalous concentrations.

SILVER-GOLD RATIOS

Gold and silver are the only elements of the table 1 suite that show a moderately good correlation by statistical test, in spite of the wide range of Ag-Au ratios. The ratios range from 0.5 to 40.0 (mostly from 1 to 7), the mode is 2 (by class intervals 0–0.9, 1.0–1.9, . . .), the median 3.0, and the mean 4.8, based on 73 sample pairs for which the values of both Ag and Au are above the limit of determination. The ratio of 0.5 is given by a single, erratic, gold-rich sample containing 4 ppm Ag and 8 ppm Au. If this erratic sample is disregarded, the coefficient of determination, r^2, is 0.70. The quality of the correlation is only fair; 1.00 would represent a perfect correlation.

A map of the contoured Ag-Au ratios (fig. 8) shows that the attempt to correlate all the determinable ratios is destined for limited success because the ratios are distinctly zoned.

Low ratios (<3.0) form a trough flanked by higher ratios. The axis of the trough coincides in most places with the higher gold values. By inverting the ratio, the relation can be stated another way: high Au-Ag ratios generally accompany the higher Au values; or, the higher the gold assay, the greater the apparent fineness of the gold. The relation is a common one in many gold deposits.

Once the zoning is recognized, the Ag-Au ratios of the trough and flanking areas can be compared separately. For the trough, Ag:Au <3.0 for 27 samples, the coefficient of determination, $\bar{r}^2$, corrected for the small number of samples, is 0.85. The line of regression is defined by the equation

$$Y_c = 1.975X - 0.061,$$

and the scatter or standard error of estimate, σ_{s_y}, is 1.33 ppm. This means that, within about 1 ppm, the calculated value of Ag (taken as the dependent variable) is roughly twice the value of Au. For the flanking areas that are well defined, Ag:Au >3.0 for 17 samples, the coefficient of determination, $\bar{r}^2$, corrected for the small number of samples, is 0.89. The line of regression is defined by the equation

$$Y_c = 5.266X + 0.466,$$

and the standard error of estimate, σ_{s_y}, is 1.07 ppm. That is, within about 1 ppm, the calculated value of Ag is roughly five times the Au value plus 0.5 ppm. Thus the correlations are good when the zonal distribution of the metals is taken into account.

MINERALOGY OF SELECTED SAMPLES

Five samples selected because of their high gold, high silver, and median gold content were cleaned ultrasonically and separated in methylene iodide by James R. Jacobs. The sized heavy and light fractions were examined microscopically.

More than 70–80 percent of each sample consists of the common rock-forming minerals of the mica schist and quartzite that underlie most of the area sampled.

No particles of native metal, unoxidized sulfides, or unoxidized sulfosalts were detectable in the plus 325-mesh fractions or in the washed minus 325-mesh fines. Goethite and hematite are common oxidation products, and clays are moderately abundant. Some of the goethite is pseudomorphous after minute pyritohedra of pyrite; the rest is granular, fibrous, or formless. Hematite is present as plates of specularite, as black grains, and as earthy red grains, in part intergrown with goethite. A trace of jarosite(?) was detected in one X-ray powder photograph of goethite.

The clays are colorless to dark brown. X-ray powder diffractograms show them to be a mixed assemblage. Illite is present in all five samples and dominant in most. In most samples, illite is accompanied by kaolinite, montmorillonite, or both minerals. Chlorite and an unidentified clay-size mineral are present in several samples. No goethite, lepidocrocite, or jarosite was detectable in the clay fraction.

Samples of the heavy fractions and of the untreated soil samples were mounted in cold-setting plastic and polished by various methods. Owing to the porosity and fragility of the hematite-goethite intergrowths and, in the untreated samples, to the abundance of clay, the samples were difficult to polish. After repeated trials, work was concentrated on the minus 60, plus 100-mesh heavy fraction of a sample for which analysis of the original unseparated soil sample gave 6.0 ppm Au and 14.0 ppm Ag. This atypical sample was chosen because of the reasonable likelihood of identifying gold particles in it.

The polished section of the heavy fraction of this atypical sample showed 50 grains of iron oxides, most of them cellular aggregates of minute hematite plates intergrown with very fine grained goethite. A few of the aggregates resemble pseudomorphs after pyrite. Scanned at $\times$ 320 with a dry objective, 14 grains (28 percent) showed minute pips of a bright metallic mineral within the iron oxide aggregates, generally as a single recognizable pip within each aggregate grain. The diameter of measurable pips is < 1 to 2.2 microns. The pips, examined at $\times$ 480 with an oil-immersion objective, are equant to shredlike, bright, very pale yellow to almost white, well polished, and softer than the hematite within which most of them are enclosed. In addition to the single pips visible at $\times$ 320, several to a dozen bright particles < 1 micron in diameter are visible in oil in each grain of the iron oxide aggregate. The minute size of all the pips makes it impossible to measure their physical properties.

Electron-microprobe scanning of the pips and their oxide host grains also fails to identify the pips but does indicate the site of some gold and silver in the sample. George A. Desborough, the probe analyst, reports that the pips do not contain measurable Au, Ag, Hg, As, S, Sb, Se, or Te. In contrast, pits as much as 5 microns long within the oxide host show a high concentration of Ag, subordinate Au and S, and no detectable Hg, As, Sb, Se, or Te. The proportions of Ag and S suggest that the pits contain acanthite, but failure of these areas to polish leaves the identification of acanthite in doubt. For eight areas, the ratio of Ag to Au within the pits ranges from 1.2 to 13.5 and averages 6.2. The high mean Ag-Au ratio in the pits contrasts strongly with the ratio of 2.3 found by assay of the original soil sample. Probe scans of a polished mount of the soil sample itself and of a typical soil sample assaying 0.70 ppm Au and 2.0 ppm Ag showed a slight concentration of Ag at the contacts of micron-size particles of iron sulfides identified optically and by probe as pyrite and pyrrhotite. The iron sulfides in the unseparated soil samples are inclusions within rock-forming silicates and are most likely accessory minerals of the unmineralized country rock.

In summary, a careful mineralogical reconnaissance of representative samples shows that some of the Ag—perhaps much of it—is present as a sulfide (acanthite?); that the silver sulfide areas contain some Au, whose form is unknown; and that Hg is neither concentrated in the silver sulfide areas nor locatable elsewhere by microprobe study of these samples. Silver sulfide areas definable by microprobe are confined to the hematite-goethite aggregates, within which they occur as unpolished areas only a few microns long. The Ag-Au ratio is considerably higher in the silver sulfide areas than in the corresponding bulk sample; therefore, some Au of unspecifiable site is also present. Particles of native gold and silver have not been identified.

The small particle size of the precious-metal-bearing areas and the absence of identifiable particles of native gold or electrum are consistent with the statement of Cooper (1951, p. 190) that low-grade ore from the West End Creek prospects cyanides readily, the implication being that the ore treated was not free milling.

SUMMARY AND INTERPRETATION

A major gold anomaly nearly coincident with a major silver anomaly is present in soils of the West End Creek area. The gold anomaly, though incompletely mapped, is a favorable target for further exploration. The principal area in which gold values exceed 1 ppm measures about 100 by 450 feet. Several smaller areas having Au >1 ppm are present south and southwest of the main part of the anomaly. The limits of the isolated highs have not been established. Gold in soils is not limited to the immediate neighborhood of the West End fault, along which most of the earlier prospecting was concentrated. Instead, the principal gold anomaly mapped so far is along West End Creek itself.

Within the area in which gold values are equal to or greater than 1 ppm, 23 samples have as the mean 2.91 ppm Au, 6.00 ppm Ag, and Ag:Au=2.06. The mean gold content of these soil samples, equivalent to 0.085 troy ounce per ton, is remarkably close to "a little less than 0.1 ounce of gold per ton," the average reported by Cooper (1951, p. 190) for a substantial tonnage of ore at the West End Creek prospects.

The distribution of gold, silver, and minor metals in the soils is most reasonably interpreted as related to the West End and Seeing Eye faults and to a third fault that strikes north-northeast. The widespread occurrence of gold and silver in the soils suggests a diffuse sort of mineralization, accompanied by little gangue except clay minerals and iron oxides. The field aspect of the iron oxides suggests weathering, but these oxides and their hydrates might equally well have been formed by a low-temperature hypogene process attendant on deposition of the gold. The zoning of gold and silver values might be either hypogene or supergene; in other areas, both processes have led alike to the development of gold-rich zones in which the gold is enriched at the expense of silver. The gold-rich zones here are not confined to gullies and creek bottoms, where surface water is seasonally plentiful; and upslope areas do not characteristically show silver depletion, as one might expect if leaching of the more soluble element, silver, had been effected by ground water. Rather, the zonal distribution of gold and silver in the soils seems more reasonably interpreted as a primary feature of the underlying deposit. Nothing in the distributional pattern is suggestive of eluvial or ancient placer concentration or of a lithogene source of the gold and silver.

No other investigations of gold and silver anomalies in soils of the district are available to guide an economic interpretation of the results of this sampling. Nevertheless, the preliminary results reported here seem adequate to encourage further exploration of the area for low-grade gold ore.

ACKNOWLEDGMENTS

I am indebted to Mr. T. C. Jarrett of the T. C. Jarret Co. for suggesting a method of embedding that made it possible to polish the fragile iron oxide aggregates, to Mr. Ernest Oberbillig, Electronic Metals, Inc., for information on drill sites, to my associate George A. Desborough for microprobe analyses of selected samples, to James R. Jacobs for the separation of samples, to Glen Izett and C. S. Venable Barclay of the Geological Survey for access to special X-ray equipment, and to the chemists of the Geological Survey for providing the abundant analytical data on which this report is based.

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FIGURES 2-8

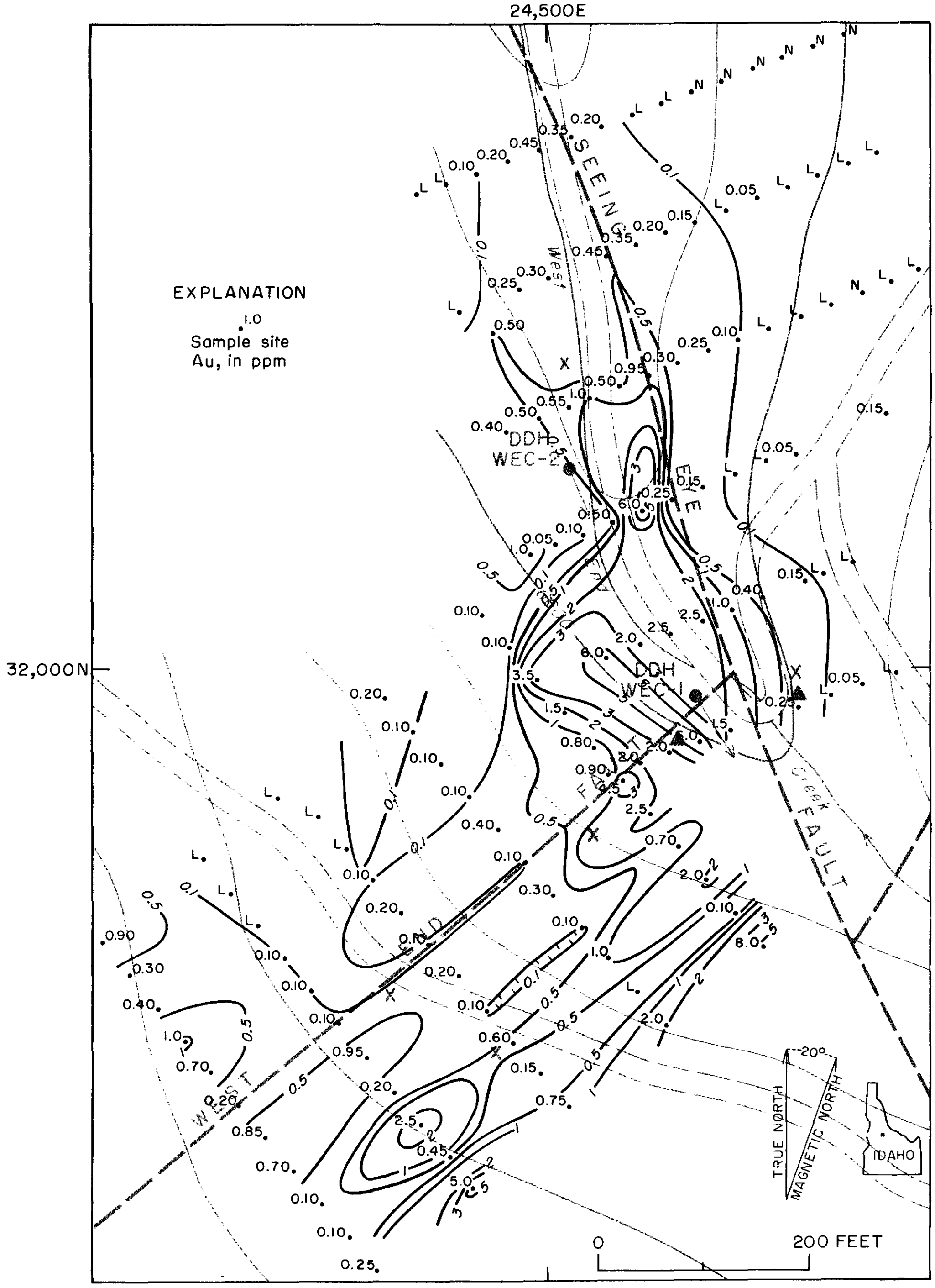

FIGURE 2.—Gold anomaly in soil, West End Creek area. Contours 0.1–0.5–1–2–3–5 ppm. N, not detected; L, detected but below limit of determination (0.05 ppm).

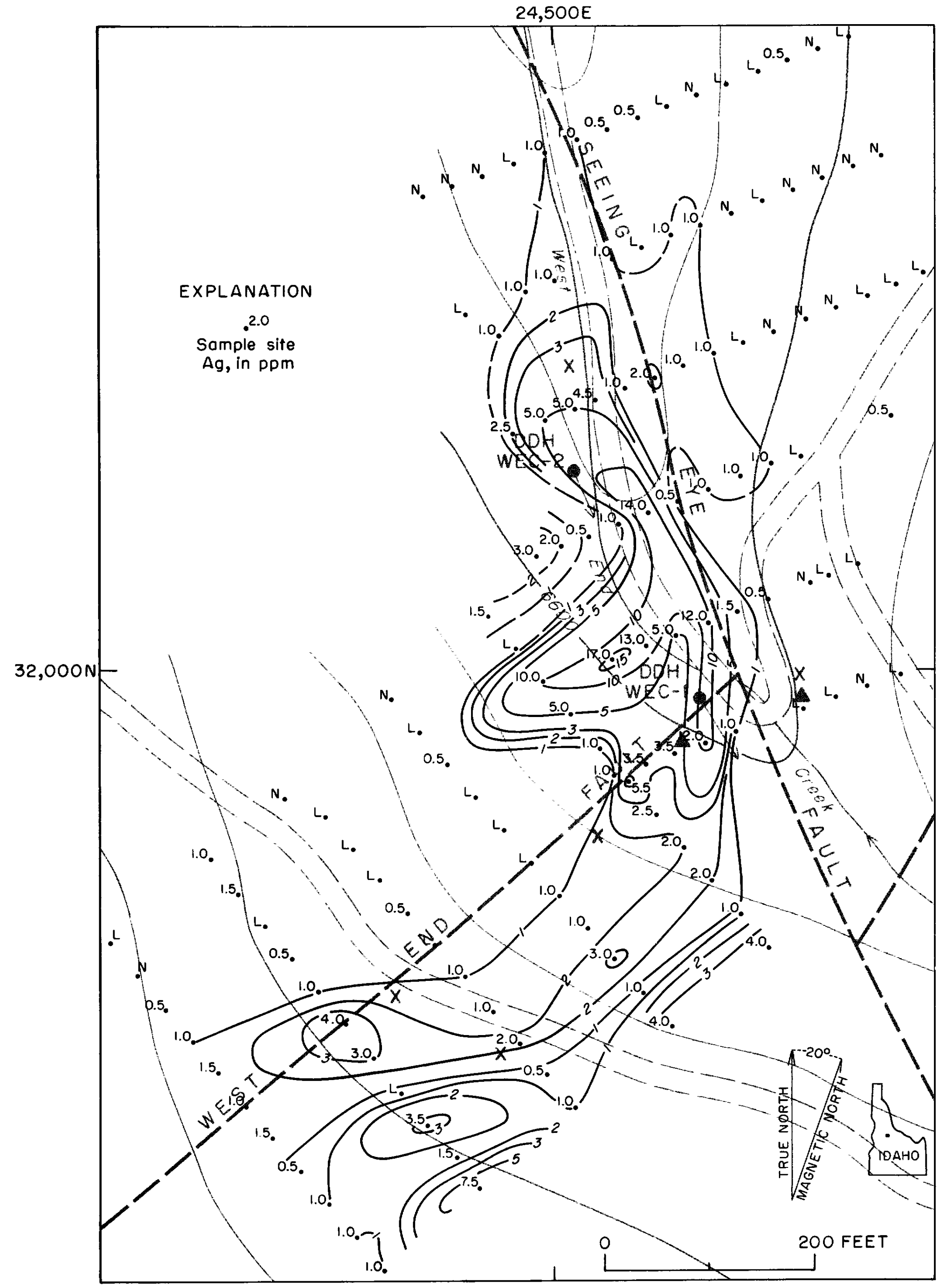

FIGURE 3.—Silver anomaly in soil, West End Creek area. Contours 1–2–3–5–10–15 ppm. N, not detected; L, detected but below limit of determination (0.5 ppm).

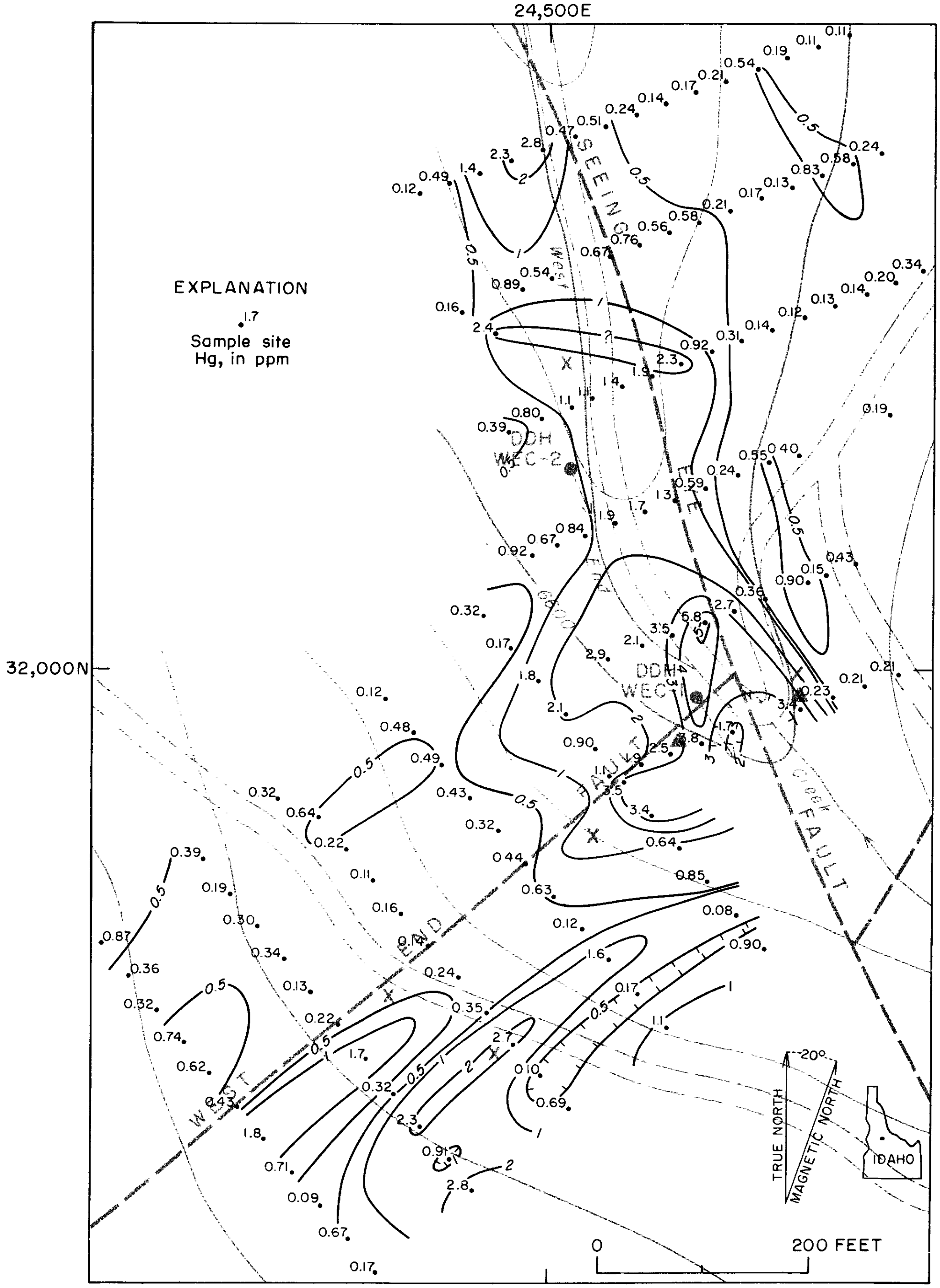

Figure 4.—Mercury anomaly in soil, West End Creek area. Contours 0.5–1–2–3–4–5 ppm.

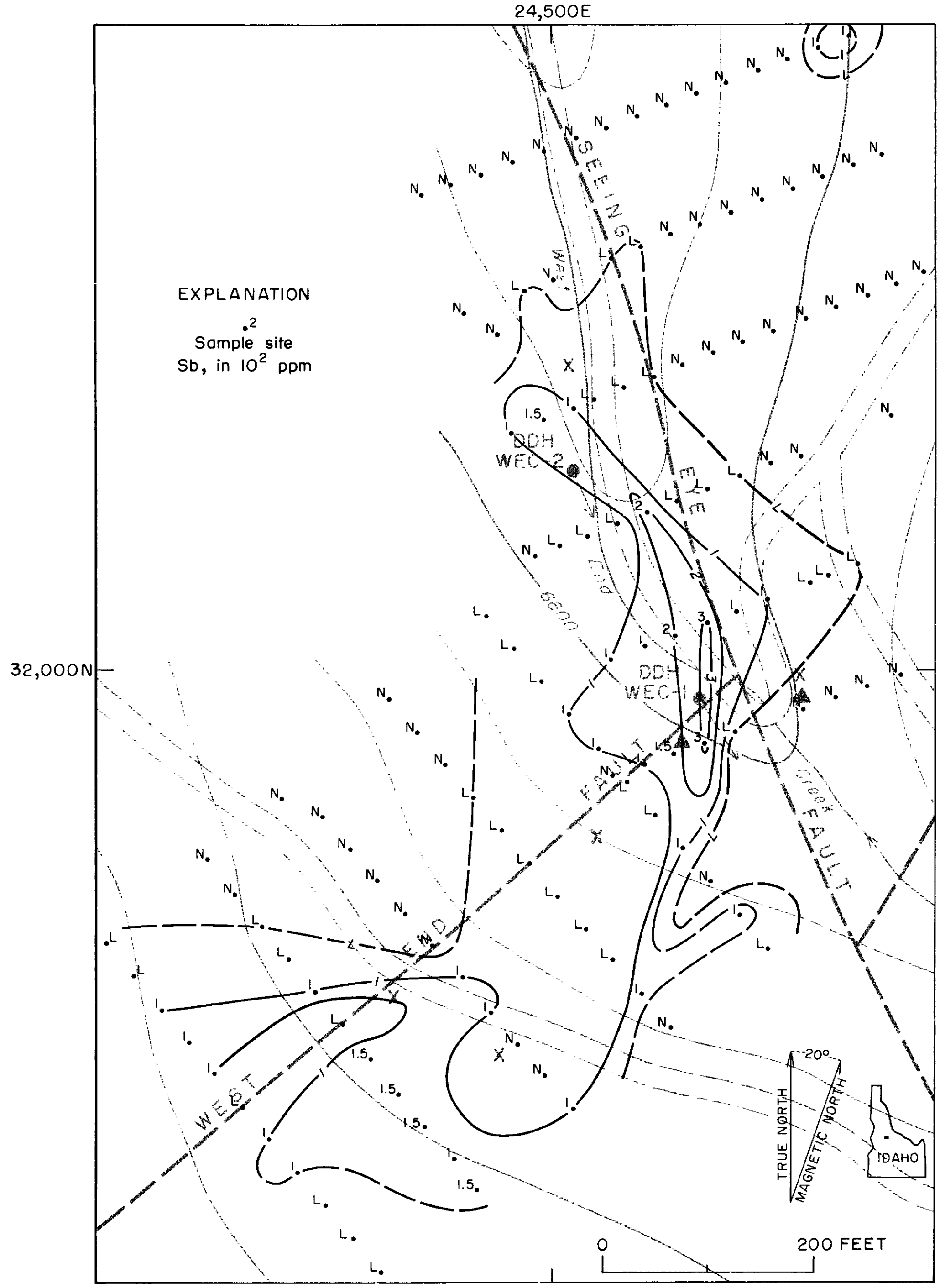

FIGURE 5.—Antimony anomaly in soil, West End Creek area. Contours L–1–2–3×10² ppm. N, not detected; L, detected but below limit of determination (100 ppm).

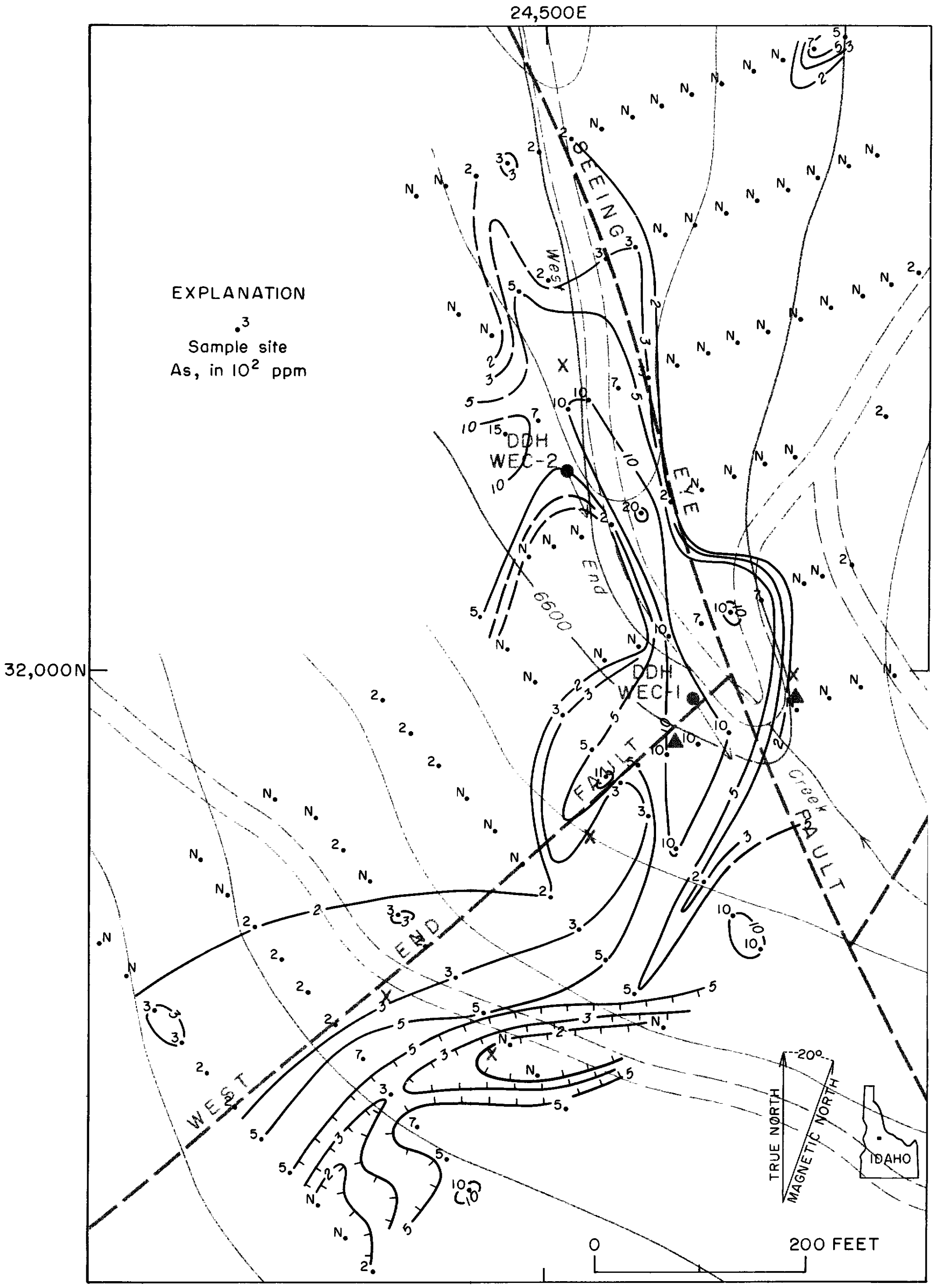

FIGURE 6.—Arsenic anomaly in soil, West End Creek area. Contours 2–3–5–10–20×10^2 ppm. N, not detected at 200 ppm.

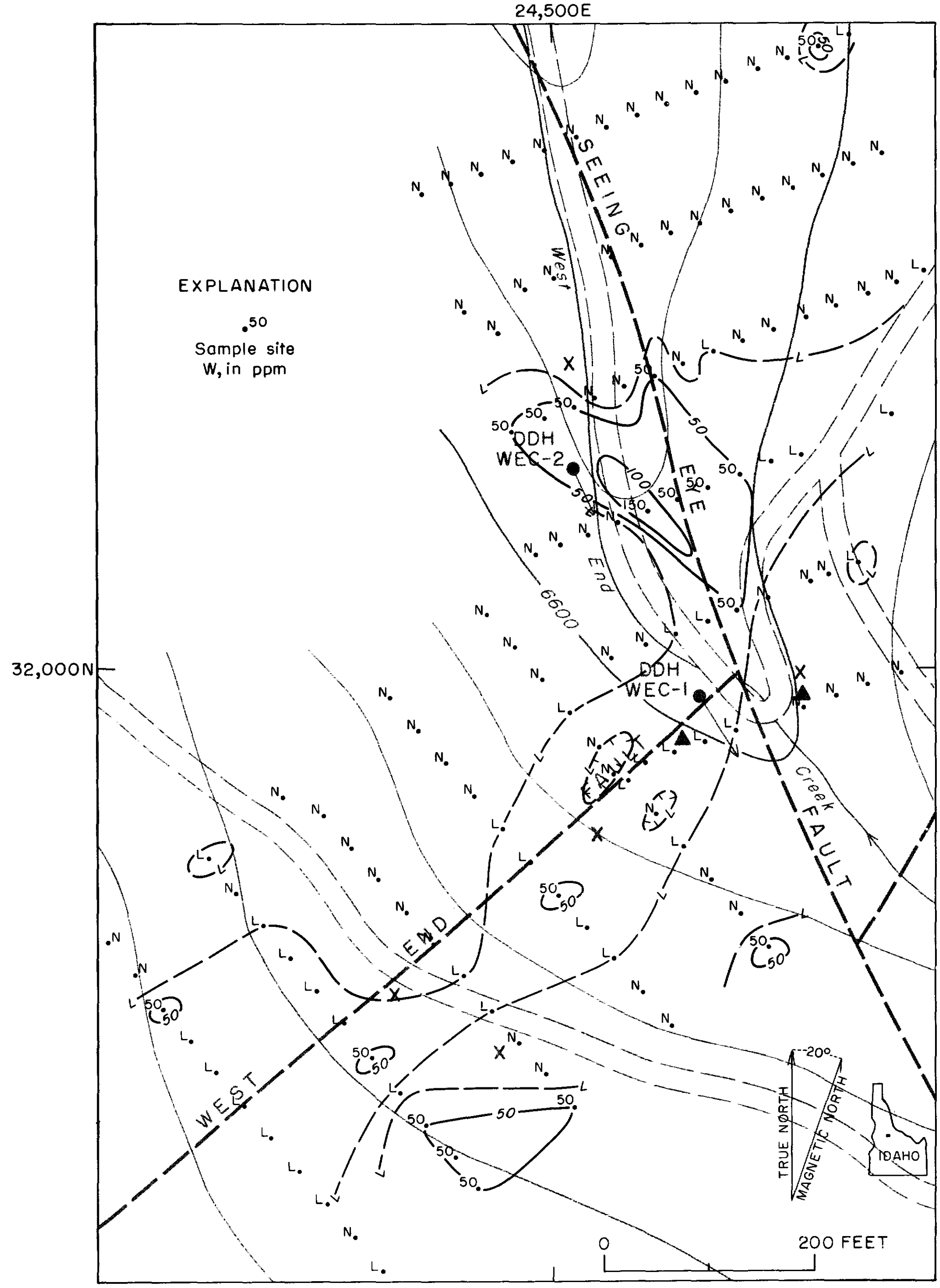

FIGURE 7.—Tungsten anomaly in soil, West End Creek area. Contours L–50–100 ppm. N, not detected; L, detected but below limit of determination (50 ppm).

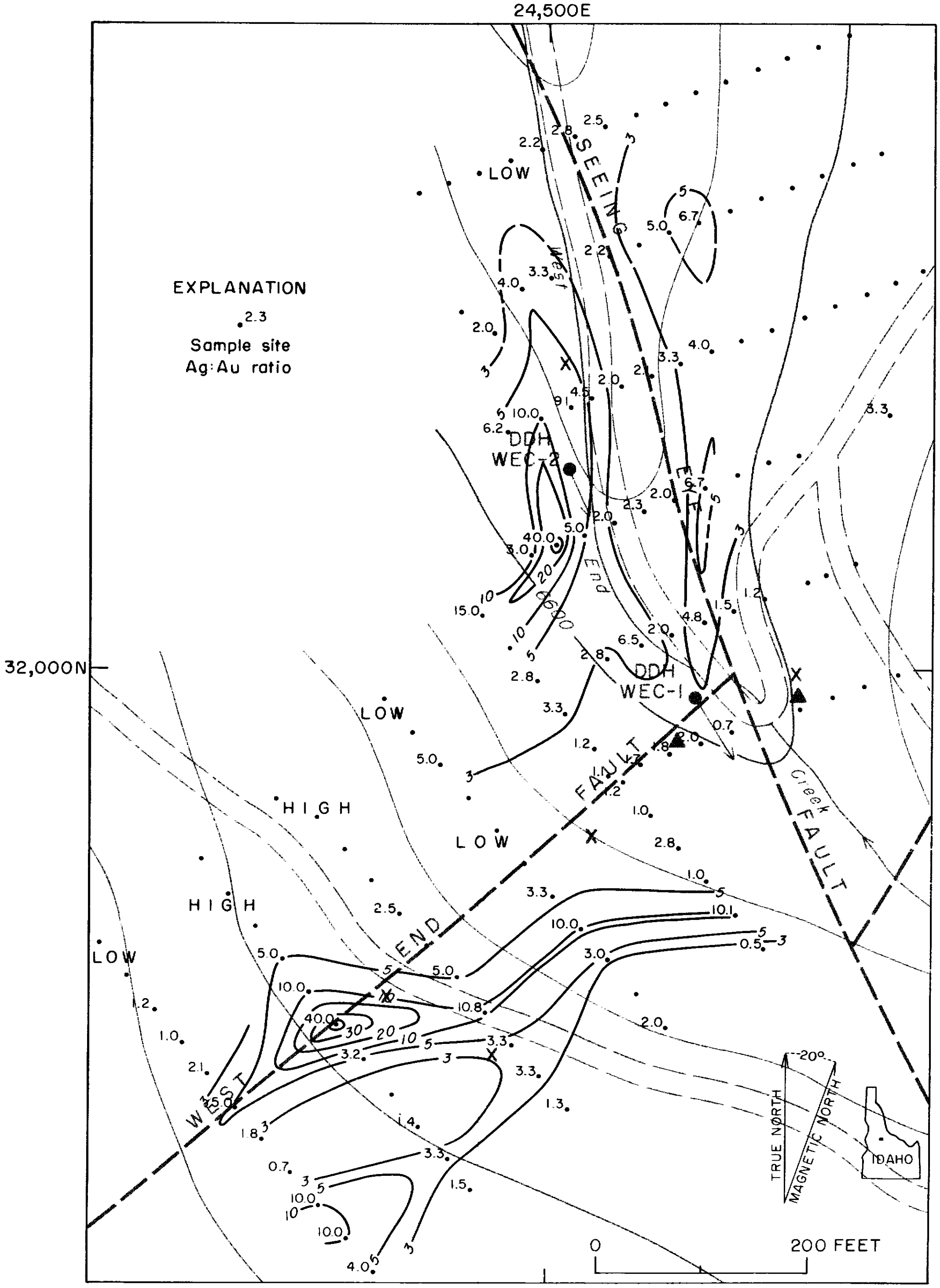

Figure 8.—Silver-gold ratios in soil, West End Creek area. Contours 3–5–10–20–30–40.