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DEPARTMENT OF REGISTRATION AND EDUCATION
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DIVISION OF THE
STATE GEOLOGICAL SURVEY
JOHN C. FRYE, *Chief*
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REPORT OF INVESTIGATIONS 179

GEOCHEMICAL PROSPECTING IN THE ZINC-LEAD DISTRICT OF NORTHWESTERN ILLINOIS

BY

J. C. BRADBURY

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GEOCHEMICAL PROSPECTING IN THE ZINC-LEAD DISTRICT OF NORTHWESTERN ILLINOIS

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J. C. BRADBURY

ABSTRACT

The rapid dithizone method of geochemical prospecting was investigated as an aid to ore search in the zinc-lead district of northwestern Illinois. Twelve traverses were made across known ore bodies to explore conditions of topography, bedrock formations, and ore depth. Four traverses were run in nonmineralized areas. The method does not appear to be effective in locating ore bodies in the district, but may indicate areas of mineralization by high readings of valley silts.

INTRODUCTION

An increasing amount of interest has been shown during the past few years in prospecting for zinc ore by geochemical methods. Various techniques have been tried, but the one which has attained the greatest popularity is the testing of soils for heavy metals by use of dithizone (diphenylthiocarbazone) as a colorimetric indicator. The method as originally outlined (Huff, 1951) is to digest the soil sample by boiling it in acid, but recently a "cold" method has been devised (Bloom, 1953) which allows immediate testing of the sample with considerably greater rapidity.

The speed and convenience of the method and reports of its successful use suggested the desirability of a preliminary evaluation of its worth as an aid to prospecting in the zinc-lead district of northwestern Illinois. During the summer of 1954 the method was explored with respect to different conditions of topography, bedrock formations, and depth to ore. Twelve traverses of varying length and sample depth were made across four known ore bodies, and four traverses were run in two areas in which drilling had shown there was virtually no mineralization.

LOCATION, TOPOGRAPHY, AND GEOLOGIC SETTING

The main zinc-bearing area of northwestern Illinois lies in the northwest quarter of Jo Daviess County. The topography is for the most part maturely dissected with rounded hills and well-developed valleys, but changes gradually from rugged near the Mississippi River to gently rolling in the northeast part. As the principal mineralized belt lies within the Driftless Area, there is no glacial till, but a cover of loess is general and varies in thickness from zero on rocky slopes to more than 15 feet on inter-stream and upland areas.

A residual clay has been developed on the surface of the dolomite bedrock. It is generally 12 to 18 inches thick, seldom exceeding 2 feet. As the bedrock strata are essentially flat-lying, the Galena dolomite is overlain by the Maquoketa shale in the topographically higher parts of the area.

The zinc ore bodies are primarily open-space filling in zones of fracturing. Depth to ore varies in general from about 50 feet to more than 200 feet, depending on topography and thickness of the ore body, but may be as little as 20 feet.

SAMPLE PREPARATION AND ANALYTICAL PROCEDURE

Samples were taken with a 1¼″ soil auger, with the two "curls" of the material in the bottom inch or two of the auger serving as the sample. Spacing of sample stations was 50 feet on one traverse and 100 feet on all the others. On at least one traverse across each ore body and on a traverse of one barren area, samples were taken at a depth of 1 foot and at vertical intervals of 3 feet thereafter until bedrock or the 15-foot limit of the soil auger was reached. On the remaining traverses samples were taken only at a depth of 1 foot, as a time-saving measure as well as to test the feasibility of shallow, rapid sampling. No surface samples were taken because of the possibility of contamination by the sludge from churn drill prospect holes and by mine chats used as agricultural limestone.

The method used with most of the samples was to allow them to dry and then partially crush them with a rolling pin. The fine fraction was sampled by means of a lucite scoop of 0.1 gm. capacity. During the last week a wet sampler was tried, consisting of a lucite plate with a hole of 0.1 gm. capacity drilled through it and a lucite plunger to extract the packed-in sample. Use of the wet sampler allows immediate testing of a sample, an important factor if full advantage is to be taken of the flexibility offered by the "cold" method.

The analytical procedure used was that outlined by Bloom (1953). The soil sample is given a 5-second shaking in an ammonium citrate–water solution with a dithizone-xylene solution as the color indicator. Results of the tests are recorded as the number of milliliters of dithizone needed to titrate to a blue end-point. Zero signifies no change from the original green color, and ½ indicates a blue green in the first milliliter of dithizone.

SIGNIFICANCE OF DEPTH OF SAMPLES

Although the samples of soil taken at the top of the bedrock generally give the strongest readings, it was found that the maximum depth to which augering need be carried in areas of thick overburden is about 4 feet. The four traverses on which depth to bedrock was 10 feet or greater showed that the 4-foot samples indicate the presence and position of the halo of soil metallization as clearly as the deeper samples. Figure 1 demonstrates the adequacy of the 4-foot depth on a traverse across ore body A.

Samples taken at a depth of 1 foot on twelve traverses across four ore bodies gave little indication of the presence of the halos, but did frequently give high readings in dark-colored valley silts. Shallow sampling may thus prove useful in suggesting areas where mineralization may be found.

TRAVERSES IN AREAS CONTAINING ORE

Indications of mineralization were usually encountered on the traverses within the areas containing ore bodies, but the actual location of an ore body was suggested only under favorable conditions, such as those surrounding ore body B (fig. 2). Across the main valley, which is parallel to the ore body, profile A-B furnishes strong readings from the dark brownish-gray silt adjacent to the stream in the 1-foot sample and from the dark-brown silts of the flood plain in the samples at bedrock, indicating an area of mineralization nearby. The upper index limit of 11, exceeded at three stations, was the capacity of the apparatus then in use. In the tributary valley from the east (profile C-D), the strong to moderate values from the residual clay and the valley silts on and just off the topographic nose indicate that the source of the high values may be under the hill to the east of the main valley. Furthermore, the fact that the residual clay and not the valley silts on pro-

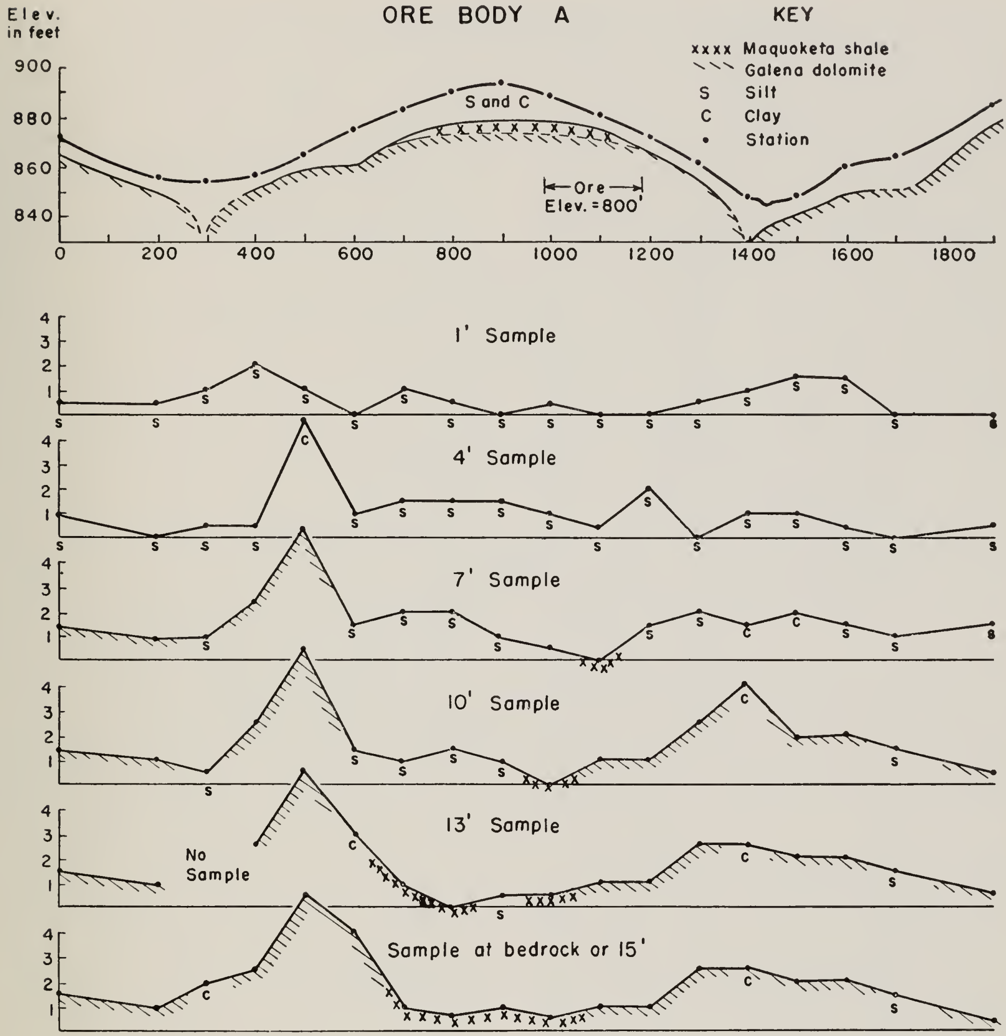

FIG. 1.—Topographic profile of one traverse across ore body A and dithizone tests showing adequacy of 4-foot sample depth. Numbers on abscissae represent strength of heavy metal concentrations. Lithologic symbols on dithizone test curves identify sample material at each sample station.

file C-D gives the strong reading suggests that the source is not far from that sample station.

The favorable circumstance of a tributary valley cutting across the ore body was augmented in this instance by the fact that the tributary cuts across a high part of the ore body. Drill records show that ore is only 20 feet below the surface and that traces of zinc mineralization extend up to the top of the bedrock. The usual depth to ore in the district is about 100 feet.

Under profile A-B the top of the ore is nearly 200 feet down and the highest zinc mineralization is 100 feet down. Consequently, no indication of the position of the ore body is given in the auger borings. The samples which gave the high readings in the profile for samples taken at the top of the bedrock are all valley silts, and the first residual clay up the hill slope gives a weak 1.

In the same profile the high reading on the other side of the main valley is believed

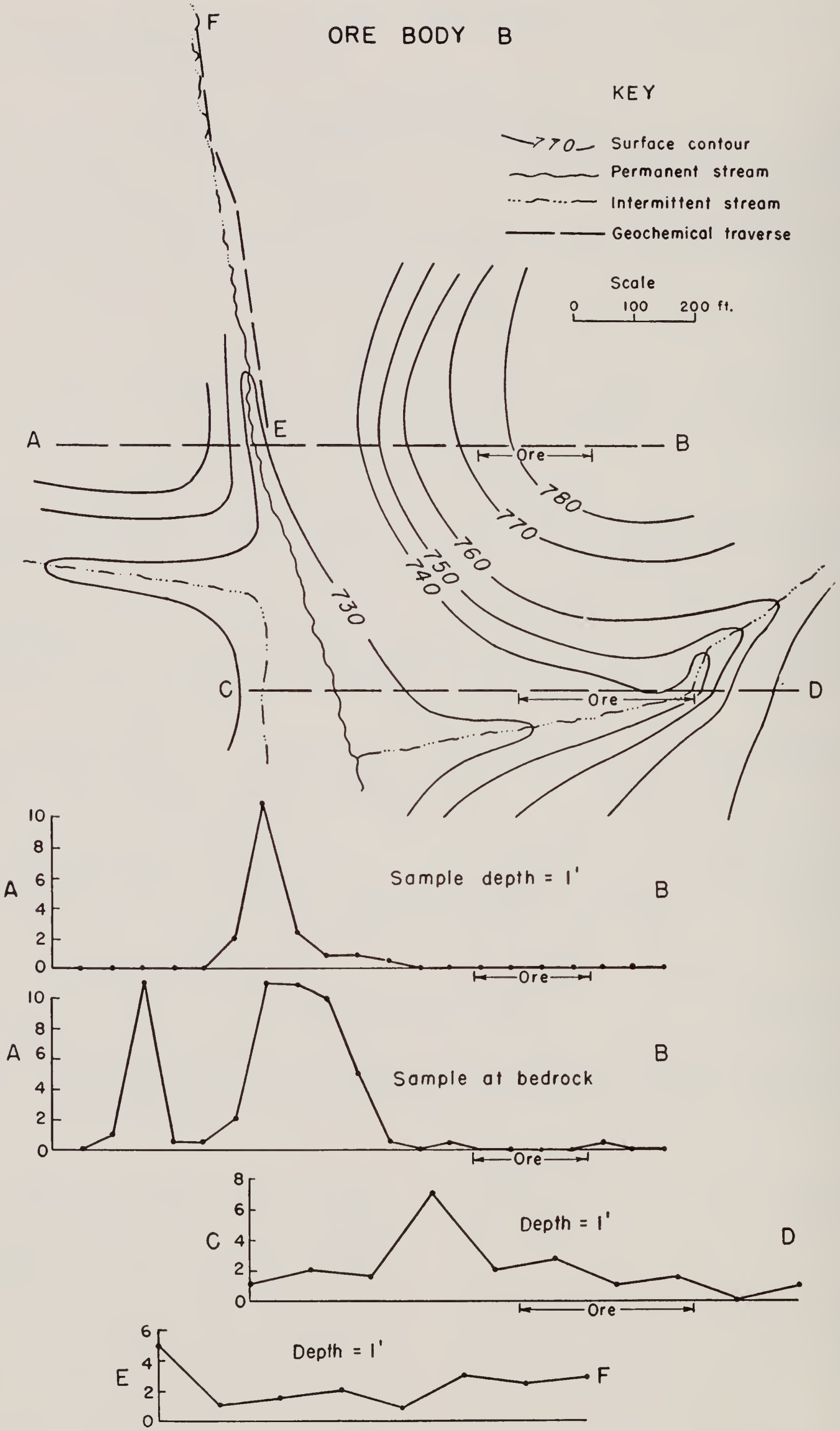

Fig. 2.—Surface topography and dithizone tests on three traverses in vicinity of ore body B. Numbers on abscissae represent strength of heavy metal concentrations.

to be due to a lead-bearing crevice, a shallow deposit fairly common throughout the district. Such crevices would undoubtedly give trouble in any program of geochemical prospecting for the deeper large zinc ore bodies. Because many of these small crevice deposits contain zinc and the larger zinc ore bodies occasionally contain abundant lead, even specific tests for lead or zinc would be of no help in determining the type of mineralization encountered.

Profile E-F demonstrates that samples from a valley that drains an area of noncommercial low-grade mineralization can give moderately strong readings. The northern part of the profile extends well upstream from the north end of the ore body and yet values above 2 persist. The metals in this portion of the valley probably come from the low-grade mineralization which has been encountered in prospect drilling in a wide area to the north.

The increase in values in the northern portion of the profile E-F coincides with the shifting of the traverse line from the flood plain to the dry stream channel. In order to determine whether the higher values were caused by a property inherent in the channel or were due to a new source of mineralization, a sample (not shown in fig. 1) was taken from the channel just west of the last flood-plain sample. The reading obtained was 3, the same order of magnitude as shown by the other channel stations and considerably more than the 1 of the companion flood-plain sample, indicating a stronger concentration of heavy metals in the channel silt.

Below a surface topographically similar to that over ore body B, a large ore body 100-200 feet deep was investigated by three traverses at right angles to the ore trend. The only high readings came from the silts in the cross-cutting tributary valley; as mine water has been flowing in this valley for a number of years, considerable doubt is thrown on the significance of the high values. The main valley, which contained a wide flood plain and a major stream, showed only weak values; it is probable that dilution is taking place. The traverses across the upland under which the ore body lies gave little indication of mineralization.

A different set of conditions surround ore body A, one profile across which is shown in figure 1. In an area of relatively gentle slopes, a valley parallels the ore body on each side, and there is no cross-cutting tributary. Depth to the ore is 80 to 90 feet. As has been pointed out, the 1-foot samples give only a slight indication of the nearby ore body, but the 4-foot samples suggest the possibility of commercial mineralization and the direction in which it may lie. The higher readings are from the lower slopes of the central ridge and indicate that there may be ore under the ridge. The lack of high values in the valley silts may be explained by the fact that the end of the ore body lies only a short distance in the upstream direction.

A traverse was run across the south part of ore body A where the ore has little vertical extent and lies more than 200 feet below ground surface. No valleys were crossed and no indication of the ore body was found.

The possibility of detecting an ore body under relatively thick Maquoketa shale was tested on a gently rolling upland. Depth to the ore was around 300 feet. Three traverses were run across the ore body at successively lower positions down a gentle slope. All dithizone readings were low, but the third traverse showed a grouping of values of 1 and 1½ near and over ore. Otherwise, values of 0 and ½ were typical, with an occasional 1. However, with only generally weak readings as guides, the method does not appear definitive enough to be of use in areas where there is a Maquoketa shale cover.

TRAVERSES IN AREAS WITHOUT MINERALIZATION

In an effort to find the maximum value that a dithizone test may show in a nonmineralized area, four traverses were run in two areas in which drilling had shown that there was virtually no mineralization. In addition, it was desired to know if the high values encountered in valleys in mineralized areas are significant. It was feared that such concentrations might merely represent normal accumulations of metals from the trace amounts generally present in the "nonmineralized" rocks of the district or from mill tailings which may have been used as agricultural limestone on nearby fields.

Areas which contained a medium-sized valley with a flood plain no larger than that of the main valley in the area of ore body B were chosen. The traverses were run at right angles to the main valley. Samples were taken to bedrock on one traverse and at a depth of 1 foot on the other three. For each traverse there was always one sample station that was located within a few feet of the stream, where previous work had shown that the strongest concentration of heavy metals can be expected.

The tests showed a slight concentration near the stream in both areas, but no values above 1 were encountered. Elsewhere on the flood plain and on the slopes and uplands values of ½ were the maximum.

SIGNIFICANCE OF DITHIZONE VALUES

Values of 2 or greater, if encountered on uplands or interstream areas, appear to be indicative of commercial mineralization. If encountered in a valley flat, a value of 2 or 3 signifies the presence of mineralization in the general vicinity but not necessarily in commercial amounts. Because of a tendency for the heavy metals to concentrate in valleys, and especially near the present channels, a reading there of at least 4 or 5 appears to be the minimum value that can be regarded as suggesting the possibility of nearby ore. Values of 2 and 3 in valleys should not be disregarded, but low-grade, noncommercial mineralization can cause readings of 3, as shown by the north end of profile E-F in figure 1.

Four traverses in two areas thought to be barren of mineralization showed a concentration of metal in valleys but gave no index numbers above 1.

Values of 1½ are indefinite. They apparently indicate presence of mineralization but have been encountered several hundred feet away from an ore body and apparently not connected with the ore body, as shown by both ends of the 7-foot profile of figure 1. However, if such values are grouped they may be useful in indicating the direction in which an ore body may lie from a single strong value, as in the 4-foot profile of ore body A in figure 1.

APPLICABILITY OF METHOD

The preliminary testing program showed that the method is not generally effective in locating ore bodies in northwestern Illinois, probably because of their depth below the bedrock surface (generally around 100 feet) and the lack of strong fracturing in the rock above the ore bodies.

Areas of mineralization may be indicated by samples from medium and small valleys. The silts on the flood plains, especially near the streams, and in dry channels give relatively high values in mineralized areas and low values in barren areas. If the ore is less than 100 feet below the top of the bedrock, some indication of the location of the ore body may be gained by sampling the valley slopes. A sample depth of 1 foot is adequate near streams, but a depth of the order of 4 feet is necessary on slopes in areas of thick overburden.

Shallow, small lead deposits are common in northwestern Illinois and may be expected to give misleading anomalies.

The method apparently has little value in areas in which the Galena dolomite is overlain by the Maquoketa shale.

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