KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 71-9

GEOCHEMICAL PROSPECTING FOR ORE DEPOSITS: BIG JUMBO LEAD MINE, LINN COUNTY, KANSAS

by

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Geochemistry
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The Big Jumbo Lead Mine is located 1.5 miles southeast of Pleasanton, Kansas in eastern Linn County. 70 miles to the south is the Tri-State Lead and Zinc District. The history of Big Jumbo is sketchy. Presumable, the location of the shaft was determined by the finding of galena samples on the surface. A shaft was sunk to 250 feet in the late 1870's. The 1899-1904 lead boom resulted in the enlargement of the mine and subsequent extraction of 15 tons of lead ore and a little zinc ore. In 1940 the mine was still in operation but ceased shortly thereafter (Schoewe, 1959).

Presently the mine is a circular, water-filled pit; 117 feet in diameter and 40-80 feet deep (Figure 1). Several prospect holes exist in the immediate area and a few other lead and zinc mines occur in eastern Linn County.

Most ore from Big Jumbo was found in the Fort Scott Limestone and adjacent Pleasanton Shales, of Pennsylvanian age, at a depth of 180 feet. That Big Jumbo ores come from Pennsylvanian strata is unique in that ores of the Tri-State area are obtained from strata of Mississippian age (Schoewe, 1959).

A peculiarity of the mine is a "chimney"-like hole surrounded by undisturbed strata in which most of the ore occurred. No evidence of igneous activity is present in the Pleasanton area and hence, a plutonic hypothesis is not tenable. According to Siebenthal (1915), the ore bearing circles of the Tri-State area owe their origin to solution resulting in the formation of sinkholes in the

Mississippian and collapse of the overlying Pennsylvanian. The displacement resulted in the shattering and brecciation of the overlying rocks, rendering them accessible to circulating artesian or surface waters affording favorable sites for deposition of the metallic ores. Siebenthal was of the opinion that the Linn County circles were analogous in origin to those of the Tri-State area (Schoewe, 1959).

Supporting evidence for these findings lies in previous studies and in statements made by former owners of the mine. According to one owner, drilling in the circular area was much easier than outside of it. The rocks were broken, displaced and occurred in brecciated masses. At present the strata in the mine appears disturbed, tilted and fractured (Schoewe, 1959).

Gravimeter tests done at the mine by Dr. Harold Yarger (1971) reveal low instead of high gravity readings (Figure 2), as expected from the high specific gravity of galena. The gravity lows reveal that the ore occurs with brecciated, low-density rocks. Solutional effects are evident in the fetwork nature of the limestone and striations on the ore surfaces (Schoewe, 1959).

Results of investigations by the Kansas Geological Survey (1971), based on the Pb206/Pb207 ration from selected areas in the Mid-Continent area, reveal that the ratios obtained from northwest Kansas are considerably higher than those of the Tri-State District. Specimens from the Big Jumbo mine yield a lead isotopic ratio essentially the same as those from the Tri-State samples, which suggests possible large potential lead and zinc deposits in the Pleasanton area. This close ratio further suggests the origin of the Pleasanton and Tri-State ores may be analogous and their source may underlie the entire Pleasanton - Tri-State area.

The Biochemical Investigation

Biochemical investigation refers to the use of plant indicators as a prospecting guide to underlying mineral concentrations (Harbaugh, 1950). The purpose of this investigation is to determine if alteration in leaf physiology caused by their metallic content and derived from underlying ore concentrations, can be detected from aerial photographs.

The use of vegetation in interpreting geologic phenomena is becoming an important tool in the search for ore deposits buried under a thick cover of soil or layers of unmineralized rock. Previous studies indicate that hidden ore deposits can be located by chemical analysis of leaves and stems, by mapping the distribution of species, and by observing toxic effects caused by an excess of metals in plants (Cannon, 1971). The use of aerial photography for biochemical investigations has, to my knowledge, never been attempted.

Causes of alterations in leaf physiology are precipitations of minor amounts of metals from mineralized solutions which have risen from the main ore zones during mineralization, rendering the overlying rocks and subsequently the weathered derivatives enriched with heavy elements which may be taken up by the trees, local chemical or lithological variations in the rocks or soil not related to mineralization, local variations in surface drainage producing differential leaching or concentration of metals in the soil, precipitation of minor amounts of metals that have been leached and carried upward from mineralized zones by ground waters subsequent to ore deposition and actual contact of tree roots with shallow mineralized zones (Harbaugh, 1950).

A metal chelate is a compound with a metal ion joined to two or more electron donor groups of a single organic molecule. The donors, normally Sulfur, Nitrogen, and Oxygen, require di- and trivalent ions for selective substitution into the organic molecule, depending on availability.

Metal ions serve as catalysts or as mediators in electron transfer, essential for growth, in plants. Just as the lack of an essential metal in the soil will cause cessation of growth, an excess of a toxic metal will cause changes in plant growth.

Changes in plants by abnormal quantities of metals in the nutrient supply are variations in vitality, completeness of the developmental cycle, growth and flowering cycles, growth abnormalities an changes in physical form.

Premature yellowing of leaves is noted in areas containing excess amounts of Ni, Cu, Pb, Cr, Co, Zn, and Mn. These elements interfere with assimilation of iron, essential for the production of chlorophyll (Burstrom, H., 1963).

Big Jumbo Lead Mine is located at 94°41' west and 38°9' north on the Pleasanton quadrangle (Figure 3) in east-central Kansas. The reason for selection of this particular mine is that it has not been operative for 30 years, thus providing an excellent location for the study of new methods of biochemical prospecting for ore deposits, including a dense forest cover for aerial photography purposes. The mine was also accessible to the University of Kansas for which those people involved in the investigation are employed.

Other areas of study included two control areas: 3 miles NE of the mine at 94°41' west and 38°12'30" north and 2 miles SE at 94°38' west and 38°8' north.

The hope was to find control areas containing the same tree species under similar environmental controls, yet lacking the ore contamination of those in the mine area. Similar drainage, similar elevations and lack of ore deposits and contamination were the criteria for locating the control areas.

The study also included a lead and zinc mine near Prescott, Kansas, 7 miles southeast of Big Jumbo at 94°38' west and 38°3'30" north.

The equipment involved in the study, in order of dates used, were October 5, 1971 - Cessna 170 provided and piloted by Dr. E.J. Zeller, Professor of Geochemistry, a Polaroid camera with two rolls of black and white film, Pleasanton quadrangle and a Kansas City aerial sectional.

October 15, and 23, 1971 - Kansas State Geology cars October 29, 1971 - Cessna 182 and pilot, provided by Erhart Flying Service, Lawrence, Kansas, 3 baggage compartment mounted 70mm., Hasselblad cameras equipped with 40 and 100mm. lenses, camera mountings and film including color infrared, color and black and white, provided by the Remote Sensing Dept.

November 29 - December 10, 1971 - Light tables in the Remote Sensing Laboratories and Scanning tables from the Physics Department.

Three cameras, each loaded with a different type of film, were used in the aerial photography of the Big Jumbo Mine Area. The film types included black and white for mapping purposes, color for tree identification and leaf color differences and color infrared for temperature differences. Of the three, the color infrared was expected to yield the most diagnostic results.

Every physical object on earth continually emits electromagnetic radiation in proportion to its temperature because of oscillations of atoms and molecules. Though thermal radiation does not lie in the visible part of the electromagnetic spectrum, infrared sensitive instruments can detect even subtle changes in temperature (Willow Run Laboratories, 1971).

Several trips to the mine were made previous to the aerial photography. Hand-held photos were taken during a flight made by Dr. Zeller and myself, October 5, 1971, to determine the aerial photography flight plan (Table 1). A trip was make October 15, 1971 to locate and identify indicator trees and collect rock samples form the mine area for later determination of lead and zinc content. Dr. Zeller, Dr. Harold Yarger, Dr. Phillip Wells and Gerry James, from the Geophysics, Botany, and Geochemistry Depts. respectively, made this trip. A final visit was made October 23, 1971 by Dr. Zeller's Geochemistry class to locate faults and visit the Prescott lead and zinc mine to collect galena samples for later lead isotope composition purposes.

The aerial photographs were taken October 26, 1971 following the flight plan in Table 1. Finally the photos were analyzed using light tables and scanning tables provided by the Remote Sensing and Physics Depts. respectively.

Results

Analysis of the 10,000 and 5,000 feet photographs was done by plotting the surface extent of each photo on the Pleasanton quadrangle and comparing crucial photos as to differences in color and density of the forest cover between the mine area and the control areas. The 1,000 feet photographs of the mine area were mosaiced and analyzed for intermine area correlation to the low-gravity anomalies.

The density of the forest cover in Control Area #1 (see Pleasanton quadrangle), appeared low to moderate while the infrared photos yielded a homogeneous deep-red to purple cover with a very few light-pink patches.

Control Area #2 yielded a very sparse forest cover appearing essentially homogeneous green with a few pinkish patches.

The density of the Experimental Area ranged from very sparse to very dense, the sparse areas essentially green with a few yellow and red patches; and in the dense areas the colors of the forest cover included green, deep-red, pink and yellow occurring either intermixed or concentrated in patches.

The analysis of the mosaiced 1,000 feet aerial photographs was done by projecting the enlarged photographs on a screen using a light projector. The intermine area correlation of the aerial photographs to the gravity anomalies was done by comparing the anomalies to the Tree Distribution (Figure 4), Trees With Early Fall Colors (Figure 5), and the Color Differentiation of the Color Infrared Photos (Figure 6).

Analysis of Figure 4 - Low-Gravity Anomalies vs. Forest Cover Distribution

Special attention was given to the low-gravity anomaly north of the mine. It is presumed this anomaly corresponds to a high lead concentration. Other than this anomaly, no correlations can be made. It appears the presence of this high lead concentration may have restricted growth in this anomaly. Absence of tree cover adjacent to the mine is due to the early shed of leaves from cottonwoods which typically encroach a mine area.

Analysis of Figure 5 - Low-Gravity Anomalies vs. Trees with Early Fall Colors

The trees which have already assumed their fall coloration, orange and yellow in photos, appear to occur associated with the low-gravity anomalies. A trend extending NE of the mine, the anomaly north of the mine and the anomaly SE of the mine all have greater numbers of "dead leaf" trees than the areas containing normal gravity reading.

Analysis of Figure 6 - Low-Gravity Anomalies vs. Tree Color Distribution (Color I.R.)

This figure has plotted both tree cover distribution and "off color" trees using color infrared film.. "Off color" refers to deviation from red and green in the photo. As in figure 4, the only trend seems to be that of the anomaly north of the mine. The presence of the leafless cottonwoods adjacent to the mine again depicts the barren area of the photo.

Analysis of dark crystals occurring in sandstones near the mine by X-Ray Diffraction methods yielded a pattern diagnostic of quartz. It was presumed these dark crystals were either galena or spallerite.

Results of isotopic analysis of galena samples taken from the Prescott Mine, south of Big Jumbo, are pending. It is hoped the Pb206/Pb207 ration will be the same as that obtained from the Big Jumbo mine.

Results of leaf and stem analysis from locations within the mine area and in the control areas are also pending. Within the mine are the leaves and stems of several tree species are hoped to contain high and low concentrations of lead and zinc corresponding to low and normal gravity anomalies respectively. Leaf and stem analysis from the control area are hoped to have much lower lead and zinc concentrations.

A major goal in economic geology is the detection and subsequent identification of surface and subsurface mineral deposits. One new technique is to correlate plant life or tree characteristics with mineral environment.

The use of plant indicators in identifying ore bodies by leaf and stem analysis is well established, but to detect these indicators from aerial photographs would prove extremely valuable in the search for ore deposits.

The analysis of the 10,000 and 5,000 feet aerial photographs reveal the mine area to have greater density and more heterogeneity in leaf color. If this ore body is associated with a dense forest cover, the abundance of ground water flowing through the brecciated rock, where, according to Yarger and Siebenthal, the ores occur, could explain the added nutrition lacking in the control areas. The heterogeneity of leaf color in the mine area as opposed to homogeneous color in the control area could be explained by premature yellowing by chlorosis due to the concentration of Lead and Zinc.

Although speculative, the mosaiced 1,000 feet photographs reveal restricted growth and premature yellowing associated with the low-gravity anomalies. Assuming ore concentrations occur in these anomalies, the higher concentrations of lead and zinc could be associated with these growth abnormalities.

Since no previous studies were located involving the use of aerial photography in detecting plant indicators as guides to underlying ore concentration, no guidelines were available for this study. The altitudes of aerial photography in this study led to unavoidable consequences such as haze in the high altitude photos, rendering the 10,000 feet photos nearly worthless. Although the 1,000 feet photos led to great detail, the problems of mosaicing and the se of scanning tables would favor higher altitude, 2,000 to 3,000 feet; photos resulting in a very slight loss in detail but a wider scope of undistorted view.

The time of year was another point not mentioned in previous studies. Although the development of a mature forest cover is a prerequisite to aerially observable detection of abnormalities in leaves, the advent of Fall results in a normal heterogeneous forest cover, therefore distorting results. A homogeneous forest cover would therefore yield results more nearly indicative of the effect of high ore concentration on plant abnormality.

The purpose of collecting galena samples from the Prescott mine, south of Big Jumbo, was because of the close Pb206/Pb207 ratios obtained from the Tri-State and Pleasanton ores. Data on the ratios obtained from areas intermediate between the two deposits would be a determining factor in correlating the two mines to the same source. Presuming the two mines had the same source, there would be a good possibility that this underlying source could give rise to "big ore" deposits intermediate between the two mines.

List of Illustrations

List of References

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Figure 1

Big Jumbo Lead Mine; Linn County, Kansas

View of Big Jumbo From 2500 Feet

Looking North - Mine in Center

View of Big Jumbo From 3500 Feet

Looking East - Mine in Center

Ground View of Big Jumbo Mine

From West Bank of Mine

Ground View of Big Jumbo Mine

From Slag Pile West of Mine

Figure 2.--- Low-Gravity Anomalies; Big Jumbo Lead Mine

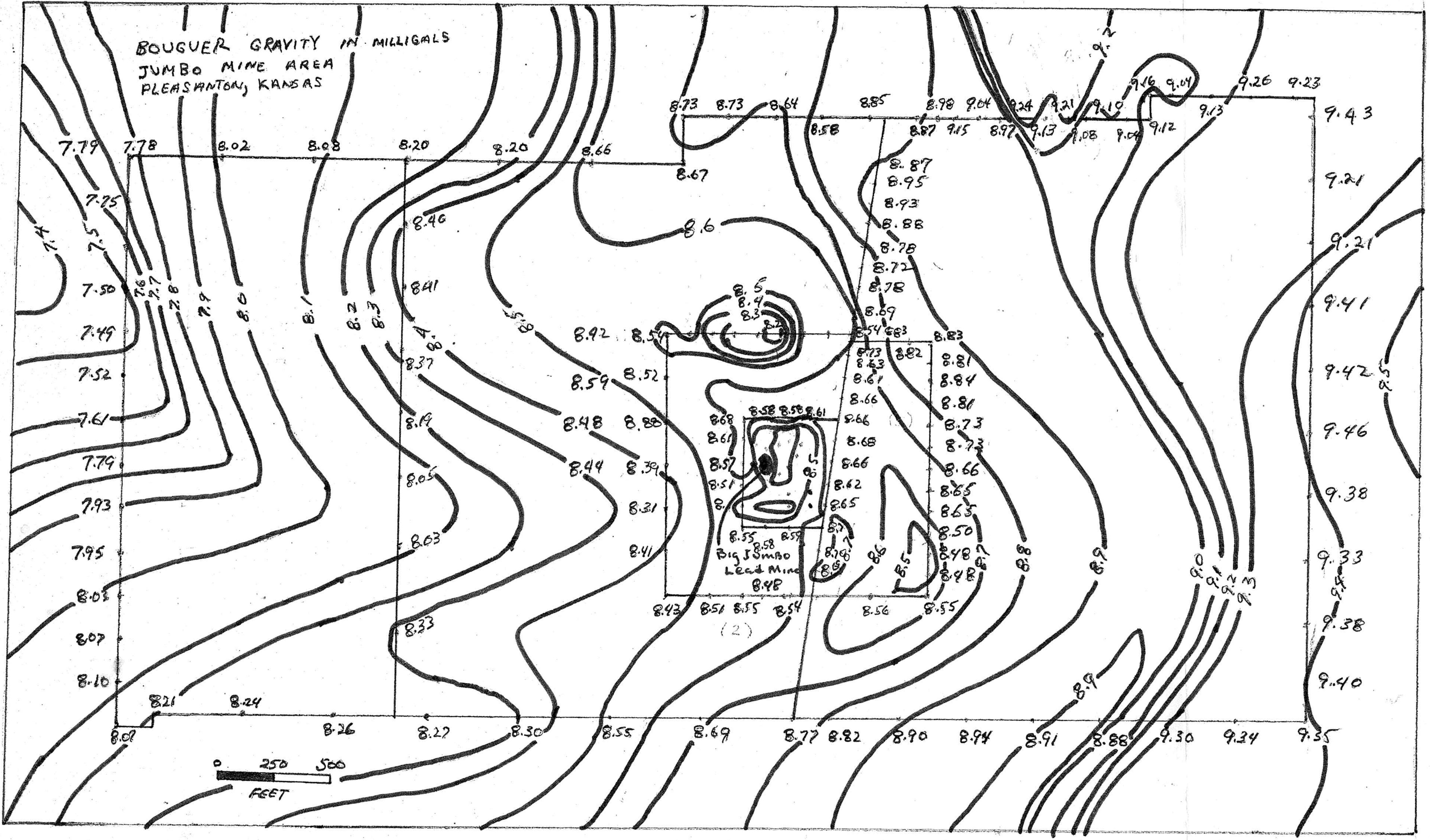
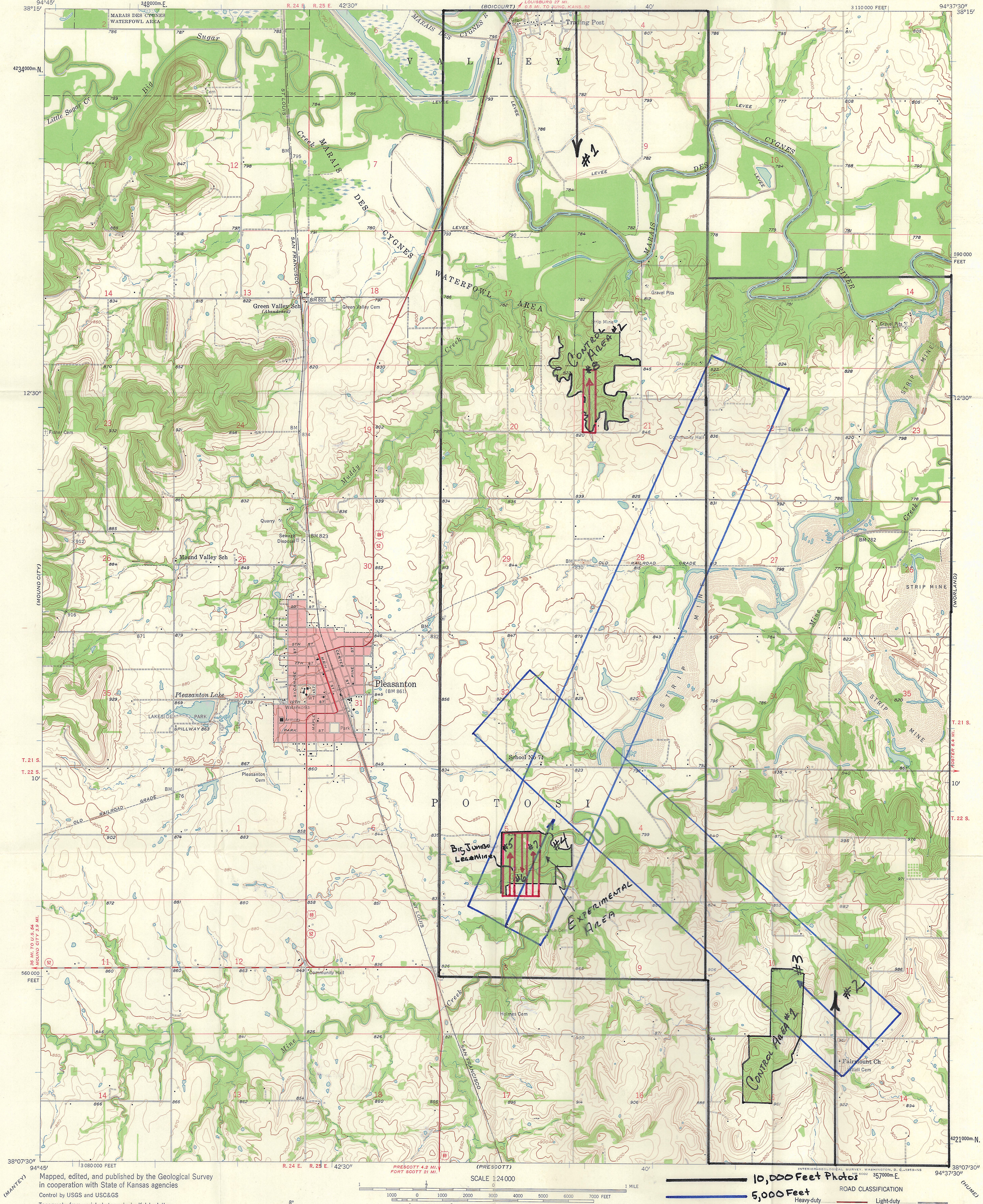


Figure 3 — Pleasanton Quadrangle Showing extent of Aerial Photographs*

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF KANSAS

PLEASANTON QUADRANGLE
KANSAS—LINN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1959—NS
MR 6002

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Control by USGS and USC&GS

Topography from aerial photographs by Kelsh plotter
Aerial photographs taken 1957. Field check 1958

Polyconic projection. 1927 North American datum
10,000-foot grid based on Kansas coordinate system, south zone
1000-meter Universal Transverse Mercator grid ticks,
zone 15, shown in blue

Red tint indicates area in which only
landmark buildings are shown

8°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN
DECLINATION, 1958

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER 2, COLORADO OR WASHINGTON 25, D. C.
AND BY THE STATE GEOLOGICAL SURVEY, LAWRENCE, KANSAS
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

▬	10,000 Feet Photos
▬	5,000 Feet
▬	1,000 Ft.

ROAD CLASSIFICATION

Heavy-duty	▬	Light-duty	═
Medium-duty	▬	Unimproved dirt	=========
U. S. Route		State Route	○

KANSAS
QUADRANGLE LOCATION

*-Flight Line represented
by arrow

PLEASANTON, KANS.
N3807.5—W9437.5/7.5
1958

Kansas Geological Survey
Open-file Report 71-9
Figure 3

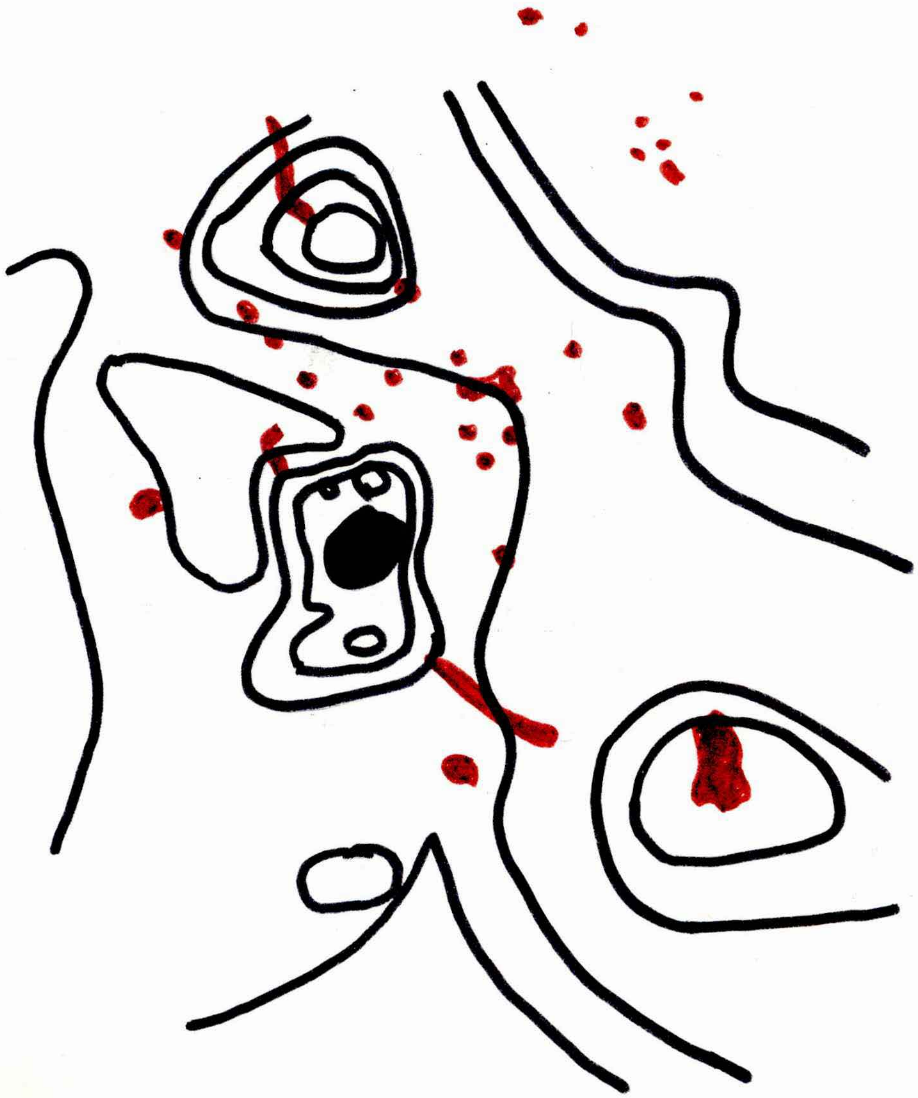
Figure 4
Low-Gravity Anomalies v. Tree Distribution*

Low-Gravity Anomalies - Black

Tree Distribution - Green

*mine represented by solid black area

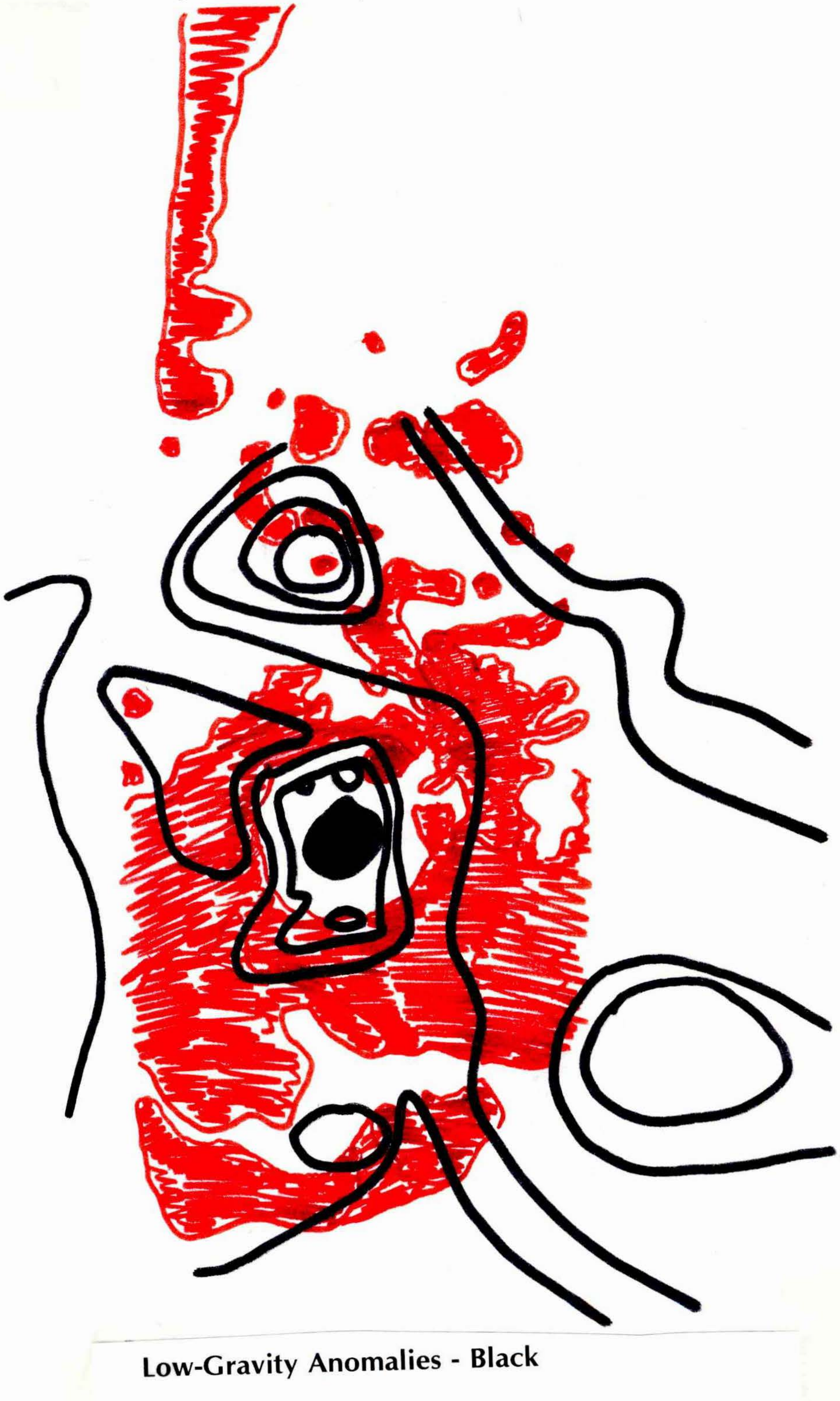
Figure 5
Low-Gravity Anomalies vs. Trees with Early Fall Coloration



Low-Gravity Anomalies - Black

Trees with Early Fall Coloration - Brown

Figure 6
Low-Gravity Anomalies vs. Tree Color Distribution (Color Infrared)



Low-Gravity Anomalies - Black

Tree Color Distribution (Infrared) - Red

Table 1

Aerial Photography Flight Plan

October 26, 1971

Depart from Lawrence Municiple Airport in Cessna 182 with 3, baggage compartment mounted, 70 mm., Hasselblad cameras

Climb to 10,000 feet in route to Pleasanton, Kansas 10,000 feet - 13 frames - 2 flights - 40mm. lens

Flight #1 - North-South - 8 miles - 7 frames

Flight #2 - South-North - 8 miles - 6 frames

Drop to 5,000 feet - 100mm. lens 5,000 feet - 24 frames - 2 flights - 100mm. lens

Flight #3 - control Area #1 to Experimental Area (Big Jumbo Lead Mine) - 14 frames

Flight #4 - Experimental Area to Control Area #2 - 10 frames

Drop to 1,000 feet

1,000 feet - 22 frames - 4 flights - 100mm. lens

Flight #5 - Experimental Area - South-North - 1/2 mile - 6 frames

Flight #6 - Experimental Area - North-South - 1/2 mile - 6 frames

Flight #7 - Experimental Area - South-North - 1/2 mile - 6 frames

Flight #8 - control Area 32 - south-North - 1/3 mile - 4 frames