

MAP SHOWING SAMPLE LOCATIONS AND RECONNAISSANCE GEOLOGY OF THE SOUTHWEST QUARTER OF THE STEPHENSON MOUNTAIN 30- BY 60-MINUTE QUADRANGLE,
JEFFERSON AND CROOK COUNTIES, OREGON
1986

- Qa Alluvial deposits**--Unconsolidated silt, sand, and gravel of fluvial origin. Includes channel, flood-plain, and terrace deposits, alluvial fan debris, slope wash, loess deposit, and pediment deposits
- Qls Landslide deposits**--Chaotic masses of angular blocks, chiefly mixtures of basalt and tuffaceous sedimentary rocks. Includes debris flows and large talus piles
- QTb Basalt**--Intracanyon dike-tuffaceous olivine basalt flows filling channels cut in rocks of the Deschutes and John Day Formations. Flows are 3-9 m thick, crudely jointed, and sparsely vesicular. Lower parts of many flows are brecciated. Flows form accumulations as much as 30 m thick
- QTV Basaltic shield volcano**--Small shield volcanoes marking vents from which flows of unit **QTb** were erupted. Locally includes minor accumulations of basaltic cinders
- Igneous rocks of unknown or uncertain age**
- Tr Rhyolite flow and dome**--Sparingly porphyritic to nonporphyritic, flow banded, often lithophyal. Includes some associated tuff and lapilli tuff. Flows typically rest on rocks of the Clarno Formation with small angular or erosional unconformity
- Tai Silicic intrusive rocks**--Chiefly nonporphyritic rhyolite and dacite; includes rocks intrusive into rocks of Clarno and John Day Formations. Many bodies mark vents for flows of unit **Tr**
- Twt Welded tuff**--Light-brown porphyritic welded tuff with autaxitic structure
- Td Deschutes Formation**--Moderately to well-bedded cross-bedded tuffaceous siltstone and sandstone with some conglomerate composed of pebbles and cobbles of basalt. Includes some thin layers of tuff and lapilli tuff
- Tcr Basalt of Columbia River Basalt Group**--Flows of Yakima and Picture Gorge Basalts
- John Day Formation**
- Tji Member i**--Weakly welded basal ash-flow tuff overlain by thick-bedded tuffaceous claystones and air-fall tuffs. Basal tuff is coarse grained, moderately autaxitic, and sparsely porphyritic. Generally grayish brown with numerous fragments of black glass
- Tjh Member h**--Medium- to thick-bedded tuff with minor lapilli tuff overlying a basal ash-flow sheet. Basal ash-flow tuff has 2-3 percent crystals, chiefly oligoclase and quartz, and is typically fine grained and sparsely porphyritic; locally autaxitic and lithophyal
- Tig Member g**--Basal ash-flow sheet overlain by medium- to thick-bedded tuff and lapilli tuff. Basal ash-flow tuff is markedly porphyritic with 10-20 percent of quartz and soda-rich sanidine crystals; locally autaxitic and lithophyal
- Tjf Member f**--Light gray thin- to thick-bedded tuff, lapilli tuff, and tuffaceous sedimentary rocks
- Tje Member e**--Light-brown aphanitic densely welded nonporphyritic welded tuff with abundant lithophysae. Two cooling units can be locally recognized
- Tjd Member d**--Thin-bedded white tuff and lapilli tuff; moderately to poorly indurated; unit ranges from 0-30 m thick
- Tjc Member c**--Fine-grained flow-banded reddish-gray rhyolite with 2-3 percent crystals, chiefly oligoclase
- Number b**
- Tjb Trachyandesite flows**--Black fine-grained trachyandesite flows with minor interbeds of tuffaceous sedimentary rocks. Trachyandesite is sparsely vesicular, sparsely porphyritic, and relatively fresh. Breaks into fist-size angular fragments
- Tjbi Trachyandesite plug**--Possible intrusive body of trachyandesite that may mark a vent for some of the flows
- Tja Number a**--Two welded ash-flow sheets separated by approximately 30 m of lapilli tuff. Basal ash-flow sheet is 15-30 m thick and consists of two cooling units; strongly autaxitic and porphyritic with 5-10 percent of quartz, sanidine, and oligoclase crystals and traces of green hornblende. Rests unconformably on lavas and tuffs of Clarno Formation. Upper ash-flow sheet is light gray to reddish gray, aphanitic, and nonporphyritic with less than 2 percent of crystals. Upper tuff much less extensive than lower tuff
- Clarno Formation**
- Tcl Andesite flows, domes, and flow breccias**--Gray to greenish-gray andesite flows, domes, and flow breccias with lesser basalt flows; some tuffs, tuffaceous sedimentary rocks, and saprolites too small to include in unit **Tcl**
- Tct Bedded volcanoclastic rocks**--Includes tuff, lapilli tuff, ash-flow tuff, and epiclastic sandstone, siltstone, and conglomerate. Volcanic lava flows and flow breccias locally present
- Tcrt Rhyolite and dacite flows and domes**--Reddish-gray flow-banded silicic flows and domes with minor pumice lapilli tuff. Includes only those rocks interlayered with rocks of Clarno character. Includes some "post-Clarno" rocks of Horse Heaven area
- Tcmi Mafic intrusive rocks**--Plugs, dikes, and irregular intrusive bodies of mafic andesite, basaltic andesite, and basalt similar in composition to lava flows of the Clarno Formation. Some bodies may be younger than the Clarno Formation
- pT Phyllite and sedimentary rocks**--Includes phyllite at Muddy Ranch and slate and graywacke southeast of Hay Creek Ranch. Unit is unconformably overlain by Clarno Formation
- ¹Modified from Robinson, P.T., 1975, Reconnaissance geologic map of the John Day Formation in the southwestern part of the Blue Mountains and adjacent areas, north-central Oregon: U.S. Geological Survey Miscellaneous Investigation Series Map I-872, scale 1:125,000.
- SAMPLE-SITE SYMBOLS**
- (Numbers correspond to those in Plate 5)
- 415** Stream-sediment (silt and panned concentrate)
- X** Rock-chip



ELEMENT ABUNDANCE MAPS:
GOLD, SILVER, AND ARSENIC

G O L D

SILT-SEDIMENT SAMPLES	ROCK-CHIP SAMPLES
A ≥ 0.03 parts per million	1 ≥ 0.03 parts per million
C 0.005 to 0.029	2 0.005 to 0.029
	4 0.003 to 0.0049

Circles indicate silt-sediment and rock-chip sample sites with anomalous values (see text)

S I L V E R

SILT-SEDIMENT SAMPLES	ROCK-CHIP SAMPLES
A ≥ 0.18 parts per million	1 ≥ 1.16 parts per million
B 0.14 to 0.17	2 0.44 to 1.15
C 0.11 to 0.13	3 0.22 to 0.43
D 0.09 to 0.10	4 0.16 to 0.21

Circles indicate silt-sediment and rock-chip sample sites with anomalous values (see text)

A R S E N I C

SILT-SEDIMENT SAMPLES	ROCK-CHIP SAMPLES
A ≥ 10 parts per million	1 ≥ 220 parts per million
B 7 to 9.9	2 4.3 to 219
C 6 to 6.9	3 32 to 42
D 5 to 5.9	4 19 to 31

Circles indicate silt-sediment and rock-chip sample sites with anomalous values (see text)

See text discussion under "Element Abundance Maps" for explanation of intervals

By Jerry J. Gray and Gary L. Baxter, Oregon Department of Geology and Mineral Industries, and Robert O. Van Atta, Portland State University

Field work conducted in 1984 and 1985

SCALE 1:100,000



CONTOUR INTERVAL 40 METERS

Base map from U.S. Geological Survey-Stephenson Mountain, Oregon, 30- by 60- minute quadrangle

ELEMENT ABUNDANCE MAPS:
COPPER, MERCURY, AND MOLYBDENUM

COPPER

SILT-SEDIMENT SAMPLES	ROCK-CHIP SAMPLES
A ≥ 59 parts per million	1 ≥ 82 parts per million
B 49 to 58	2 70 to 81
C 41 to 48	3 57 to 69
D 35 to 40	4 37 to 56

Circles indicate silt-sediment and rock-chip sample sites with anomalous values (see text)

MERCURY

SILT-SEDIMENT SAMPLES	ROCK-CHIP SAMPLES
A ≥ 1.23 parts per million	1 ≥ 24 parts per million
B 0.25 to 1.22	2 4.19 to 23
C 0.18 to 0.24	3 0.52 to 4.18
D 0.12 to 0.17	4 0.2 to 0.51

Circles indicate silt-sediment and rock-chip sample sites with anomalous values (see text)

MOLYBDENUM

SILT-SEDIMENT SAMPLES	ROCK-CHIP SAMPLES
A ≥ 2 parts per million	1 ≥ 32.5 parts per million
B 1 to 1.9	2 17.6 to 32.4
D 0.7 to 0.9	3 8.6 to 17.5
E 0.4 to 0.6	4 5.7 to 8.5

Circles indicate silt-sediment and rock-chip sample sites with anomalous values (see text)

See text discussion under "Element Abundance Maps" for explanation of intervals

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Field work conducted in 1984 and 1985

SCALE 1:100,000



CONTOUR INTERVAL 40 METERS

Base map from U.S. Geological Survey-Stephenson Mountain, Oregon, 30- by 60-minute quadrangle

ELEMENT ABUNDANCE MAPS: LEAD AND ZINC

LEAD

SILT-SEDIMENT SAMPLES	ROCK-CHIP SAMPLES
A ≥ 10 parts per million	1 ≥ 26 parts per million
B 8 to 9	2 18 to 25
C 7 to 7.9	3 15 to 17
D 6.5 to 6.9	4 13 to 14

Circles indicate silt-sediment and rock-chip sample sites with anomalous values (see text)

ZINC

SILT-SEDIMENT SAMPLES	ROCK-CHIP SAMPLES
A ≥ 98 parts per million	1 ≥ 168 parts per million
B 85 to 97	2 116 to 167
C 73 to 84	3 101 to 115
D 60 to 72	4 78 to 100

Circles indicate silt-sediment and rock-chip sample sites with anomalous values (see text)

See text discussion under "Element Abundance Maps" for explanation of intervals

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Field work conducted in 1984 and 1985

SURFACE AND SUBSURFACE STATUS MAP

Mineral estate administered by the Federal government

Surface estate administered by the Federal government

Information regarding land status and minerals owned by the Federal government from U.S. Bureau of Land Management, 1981

NOTE TO MAP USERS

The surface and minerals management status overprints are published as general planning and management tools. Some of the lands, surface and mineral rights, may have been shown as patented lands due to the lack of information available to BLM with respect to the nature of acquisition. Tracts less than 40 acres are usually omitted because of the map scale. Access through private lands may be restricted. The official land records in the respective offices of the Bureau of Land Management or other responsible Federal agencies should be checked for up-to-date status on any specific tract of land. Inadequacies in the BLM maps should be reported to the respective Bureau of Land Management offices from which the maps were obtained.

SCALE 1:100,000

CONTOUR INTERVAL 40 METERS

Base map from U.S. Geological Survey-Stephenson Mountain, Oregon, 30- by 60-minute quadrangle

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MOUNTAIN 30- BY 60-MINUTE QUADRANGLE, JEFFERSON AND CROOK
COUNTIES, OREGON

by Jerry J. Gray and Gary L. Baxter, Oregon Department of
Geology and Mineral Industries, and Robert O. Van Atta,
Portland State University

NOTICE

The Oregon Department of Geology and Mineral Industries is publishing this paper because the subject matter is consistent with the mission of the department. To facilitate timely distribution of information, this paper has not been edited to our usual standards.

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4. Lead and zinc element abundance maps; surface and subsurface land status map
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INTRODUCTION

General

This study, which covers an area of about 425 square miles (sq mi), is mainly a geochemical survey, with emphasis on the possibility that hot-spring gold deposits may exist within the study area. The study is one of several geochemical surveys that have been published by the Oregon Department of Geology and Mineral Industries (DOGAMI) since 1969, including those by Bowen (1969), Oregon Department of Geology and Mineral Industries (1976), Munts (1981), Ferns and Brooks (1983), Gray and Berri (1983), Gray and others (1983), and Ferns and others (1984). This particular area was picked for study because (1) gold has been produced from the Oregon King Mine just north of the study area, and (2) within the study area, gold mineralization has been reported from the Axehandle Mine, mercury has been produced from the Horse Heaven and Axehandle Mines, jasperoid is currently being mined by rockhounds, and types of rocks favorable to the hosting of gold mineralization occur. Industrial minerals were not included in this study.

Objectives

The objectives of the study were to (1) systematically collect and chemically analyze stream-sediment and rock-chip samples to determine the type of mineralization that occurs in the study area, (2) study the mineralogy of the heavy and light fractions of gold pan concentrates to see if they indicate mineralization, (3) delineate mineralized areas within the study area, (4) compile a geologic map (scale 1:50,000) of the study area, and (5) release the geologic map and resource data to the public in a DOGAMI publication.

Geologic Setting

The area covered by this study is east of Madras, Oregon, and extends 15.5 miles (mi) from north to south and 27.5 mi from east to west (Figure 1). Two physiographic provinces are represented within the study area. The northwest corner of the study area is part of the Deschutes-Umatilla Plateau, which is a subsection of the larger Columbia Plateau. The rest of the study area is in the Ochoco Mountains, which are a part of the Blue Mountains province.

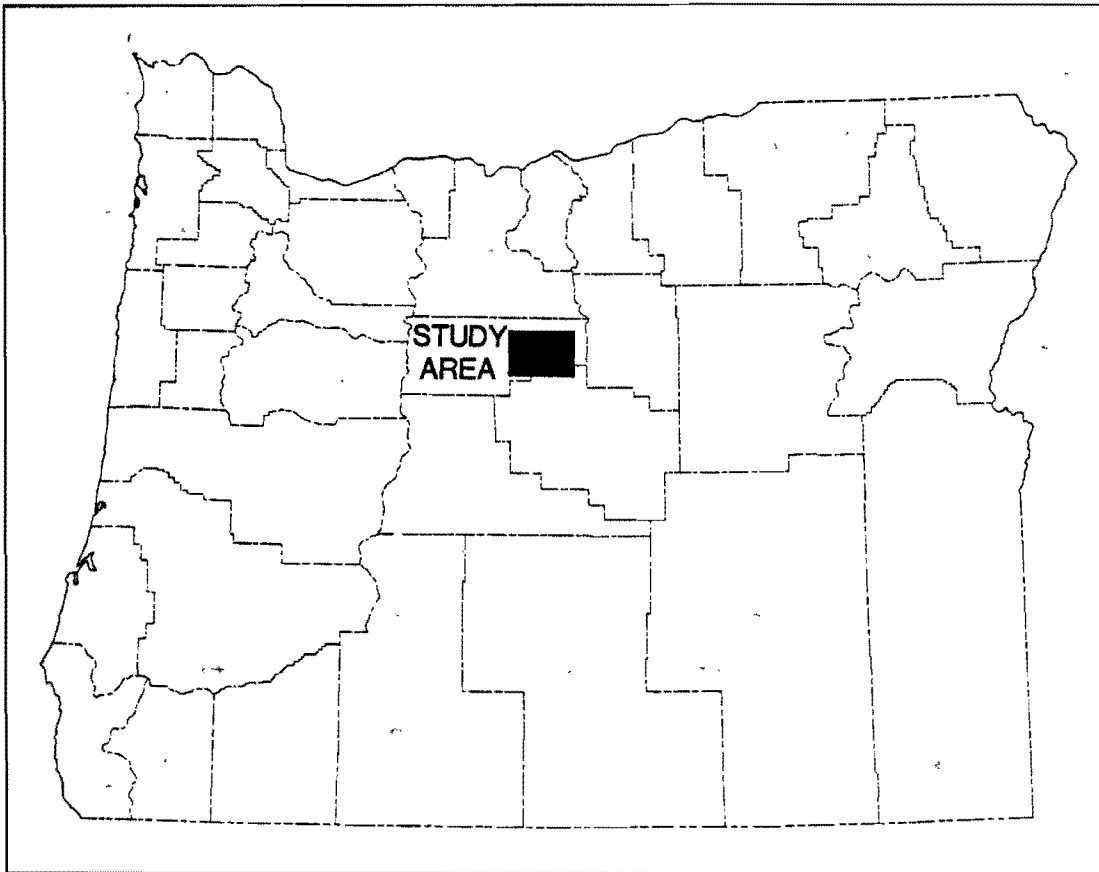


Figure 1. Index map showing location of study area.

Mercury, coal, and jasperoid for rockhound material have been produced within the area. Gold, silver, copper, and lead have been produced from the Oregon King Mine, which lies a few miles to the north of the area.

Published geologic studies (Waters and others, 1951; Peck, 1964; Swanson and Robinson, 1968; Swanson, 1969; Robinson, 1975), previous and current mineral production, and rock units occurring in the area seem to fit the gold and silver epithermal (hot spring-fumarolic) mineral-deposition model (Berger and Eimon, 1983).

Geologic units occurring within the study area (see Plate 1) include, from oldest to youngest, pre-Tertiary rocks (phyllite and sedimentary rocks), the Clarno Formation, the John Day Formation, basalt of the Columbia River Basalt Group, the Deschutes Formation, igneous rocks of unknown or uncertain age, basaltic shield volcanoes, basalt, landslide deposits, and alluvial deposits (Robinson, 1975). Units of particular interest to this study are discussed below.

The pre-Tertiary rocks crop out in the southwest portion of the study area. According to Peck (1964), the rocks of this unit are slates, graywacke locally cut by thin discontinuous quartz veins, chert-granule conglomerate, and meta-andesite. One meta-andesite that crops out at the forks of intermittent streams in sec. 25, T. 11 S., R. 15 E., has been altered to an aggregate of oligoclase, a carbonate mineral, clinozoisite, quartz, and sericite (see Tables 1 and 2 [Plate 5] for data from silt samples 257 and 287 and rock-chip sample 258).

The Clarno Formation occurs on about two-thirds of the eastern and southern portions of the geologic map. This unit is composed of andesite and rhyolite flows, domes, and flow breccias; bedded volcanoclastic rocks; and mafic intrusive rocks.

Rocks of the John Day Formation are found in the area covered by the northeastern third of the geologic map. According to Peck (1964), the John Day Formation, which may be about 4,000 feet (ft) thick, is composed of a sequence of welded rhyolitic ash flows, massive ash-fall tuffs, and water-laid tuff. In the lower part of the formation, local rhyolite flows derived from rhyolite dome complexes occur.

Flat-lying basalt flows of the Columbia River Basalt Group are exposed in a small area in the northeastern corner of the map.

The igneous rocks of unknown or uncertain age shown on the geologic map include rhyolite flows and domes and

silicic intrusive rocks. Geochemical surveying conducted for this study suggests that these rocks may have some special significance in terms of the mineralization that occurs within the study area. Although metal element anomalies were found in all formations exposed in the study area, the distribution of the anomalies suggests they may occur more frequently at contacts between the igneous rocks of unknown or uncertain age and the other formations in the area.

Epithermal (Hot Spring/Fumarolic) Gold and Silver Model

Epithermal mineral deposits, including gold and silver, form at low to moderate temperatures at or near the surface of the ground. A low-temperature epithermal deposit is generally characterized by the presence of low-temperature minerals such as cinnabar (mercury), stibnite (antimony), realgar (arsenic), gold, and silver, plus silica in the form of jasperoid (Berger and Eimon, 1983). Examples of epithermal mineral deposits are the three mines already mentioned. The most important deposits are found as veins and replacements in volcanic rocks and as replacements in sedimentary rocks. The epithermal (hot spring/fumarolic) model of gold and silver deposition starts with a heat source, a plumbing system, and a supply of water. Downward-percolating ground water is heated by the heat source and forced upward along the plumbing system. The heat source may be a cooling magma body, and the plumbing system may be breccia pipes or open fractures that become veins when filled. As ground water percolates downward and is heated, it changes chemically and is able to dissolve metal from the rock through which it passes. Eventually the fluid reaches the plumbing system and travels upward. If it boils and/or encounters cold water, carbon, an oxidant, or a carbonate that changes the pH, then gold, silver, and/or other metals and nonmetals may be deposited. Specific sequences of deposition also depend greatly on the specific composition of the migrating fluid.

Deposition of silica in the form of jasperoid is a major indicator of hot-spring activity. In this report, the term "jasperoid" is used interchangeably with "silicification" and includes the rockhound's jasper, agate, and thundereggs. The term "jasperoid" is defined as a rock composed dominantly of silica, most commonly in the form of cryptocrystalline quartz, that is formed largely by epigenetic replacement. According to Lovering (1972):

"Although jasperoid in the United States is most abundant in limestone and dolomite, it also occurs in shale, mudstone, extrusive rocks, and metamorphic

rocks. Most bodies of jasperoid are localized along faults, fracture zones, and shear zones, and they spread laterally from such conduits through beds of favorable lithology or permeability, or beneath, impermeable caprocks.

"Large masses of jasperoid characteristically form prominent rugged outcrops that shed a talus of angular broken blocks. They tend to be strongly brecciated and recemented by younger quartz. The rock is fine grained to aphanitic in texture; the coarse varieties resemble fine-grained quartzite, and the finer varieties resemble chert. Vugs are commonly abundant and conspicuous. Jasperoid in most outcrops is oxidized and is stained by iron oxides in various shades of brown, yellow, and red. Unoxidized jasperoid is predominantly gray or black. Some jasperoid retains both the color and texture of the host rock....".

More detailed descriptions of these systems are given by Lovering and McCarthy (1978), Boyle (1979), Worthington and others (1980), Eimon (1981), and Berger and Eimon (1983).

Mining History

The metallic mining history of the study area is mainly the history of three mines. The Oregon King Mine, which is 3 mi northeast of Ashwood and 2 mi north of the study area, was discovered in 1898. According to Brooks and Ramp (1968), between 1898 and 1965, mine production totaled at least 3,700 oz of gold, 290,000 oz of silver, 30 tons of copper, and 55 tons of lead. At today's (May 13, 1986) prices of gold (\$345/oz), silver (\$5.25/oz), copper (\$1,400/ton), and lead (\$380/ton), the total value of the mine's output would be \$2,863,000. The mine is in Clarno-age rocks that have been intruded by silicic rocks of unknown age.

About 10 mi to the east in the northeast corner of the study area, another mine, the Horse Heaven Mine, is located. This mine, a mercury producer, was discovered in 1933. According to Brooks (1963), total production between 1933 and 1958 was 17,214 flasks. At today's (May 13, 1986) prices of \$270/flask, the output value would be \$4,648,000. According to Robinson (1975), the mine is located in Clarno-age rhyolite and dacite flows or domes that have also been intruded by silicic rocks of unknown age. A thick clay horizon on an angular unconformity may have played a major role in localizing the mercury ore bodies.

The Axehandle Mine, the smallest producer of the three, is located between the other two mines. Its production was 150 flasks of mercury (Brooks, 1963), with a total value of \$41,000 at today's (May 13, 1986) prices of \$270/flask. According to Brooks (1963), the ore bodies are found (1) along the contact zone between an andesite plug and extrusive andesites that were penetrated by the plug and (2) in shear zones that cut the extrusive andesite. All of the rocks are of Clarno age. Waters and others (1951) and Ramp and others (1975) report a gold occurrence near the Axehandle Mine.

Since the 1930's, the study area has been a mecca for rockhounds. Every year, many pounds of agates, thundereggs, jasper, and petrified wood are produced from the large number of collecting sites contained within its boundaries. Visitors from other parts of the United States and the rest of the world come to this area to obtain cutting materials. The abundance of cutting material is indicated by the fact that almost all of the rock-chip sample sites listed in this report contain cutting-grade jasperoid. Sample site 221 is an unworked petrified wood locality.

Also in the 1930's, small amounts of coal were produced from two adits (map numbers 291 and 294, Plate 1). According to local ranchers, the coal mining was not successful because the coal had a high ash content.

Acknowledgments

All the landowners in the study area were extremely helpful in allowing access to their lands. Michael L. Cummings, Portland State University (PSU), and Donald A. Hull, DOGAMI, formally reviewed the report. Other DOGAMI staff members who worked on the report include Beverly F. Vogt, publications manager; Klaus K.E. Neuendorf, editor; Paul E. Staub, cartographer; and Anne E. Bradley and Angie M. Karel, typists. Jerry J. Gray had primary responsibility for field surveying and writing of the report. Analytical work was performed by Gary L. Baxter, DOGAMI. The study of heavy minerals was conducted by Robert O. Van Atta, PSU.

MAPS

Base Maps

The base map used for this study is the southwest quarter of the U.S. Bureau of Land Management's (USBLM) Stevenson Mountain 30- by 60-minute quadrangle map (scale 1:100,000). The base map was enlarged to 1:50,000 for the geology/sample location map (Plate 1). The computer-generated element abundance maps (Plates 2, 3, and 4) and the Federal land ownership map (Plate 4) are printed on the original 1:100,000-scale base map.

Geology/Sample Location Map

The geology shown on the map on Plate 1 was taken from a portion of Robinson's (1975) reconnaissance geologic map of the area. Robinson's map was published at a scale of 1:125,000, and the portion that was covered by this study was enlarged to 1:50,000 to be used for the geologic map. Because Robinson's base map was different from the base map used for this study, the geologic contacts and the topographic contours do not always match. Therefore, the geologic map should be viewed only as a generalized geologic map on which mineralization patterns and geochemical trends and anomalies can be observed.

The sample-site locations were plotted on the geologic map (Plate 1). The square symbol represents silt and heavy mineral samples; the X's represent rock-chip samples.

Federal Land Ownership Map

The land ownership within the study area is very complex because the surface owner may not own the subsurface. The last map (scale 1:100,000) on Plate 4 shows those lands that are totally or partially owned by the Federal government (USBLM and U.S. Forest Service [USFS]). The patterned areas indicate Federal surface ownership, and the shaded areas show subsurface Federal ownership, most of which is open for location if a valid discovery is made (USBLM, 1981). If the surface is in private ownership and the subsurface is open for location, the prospector has the right to prospect and to stake mining claims. However, it is best to work out an agreement with the surface owner as well.

GEOCHEMICAL AND MINERALOGICAL SURVEY

Introduction

Previously cited studies suggest that the study area is favorable for the occurrence of mercury, precious metals (gold and silver), and base metals (copper, lead, and zinc) in high-grade veins. A sampling program was undertaken to delineate suspected or previously unknown mineralization outside of the Gold King-Axehandle-Horse Heaven mining district. The 416 samples (sample number 333 is a void number) listed on Tables 1 and 2 (Plate 5), which were collected in the course of this study, were assayed for gold, silver, arsenic, copper, mercury, molybdenum, lead, and zinc. Computer programs were used (1) to store, retrieve, summarize, and print both the site and analytical data; and (2) to plot element abundance maps.

Sample Collection

Samples were collected during the 1984 and 1985 field seasons. In general, three types of samples were collected. Two types of samples were collected at each stream-sediment site: (1) a stream-deposited sediment (frequently termed "silt" in this report) and (2) a heavy mineral concentrate panned from stream sediments (Table 1, Plate 5). The third type of sample, which was a rock-chip sample, was collected where there was field evidence of mineralization (the presence of jasper or other silicification, bleaching, iron staining, and metal sulfides or oxides). In addition, one soil sample (silt sample 55) and one loess (wind-deposited) sediment sample (silt sample 321, taken from a road right-of-way) were collected.

To minimize the effects of ranching, farming, road building, or other human activities, samples were taken on the upstream sides of culverts and barns. The distribution of anomalies identified in this study indicates that previous mining did not affect the stream-sediment assays, because most of the anomalies occurred in areas where there had been no mining. The silt samples were collected by filling two 1-pound (lb) paper sacks and allowing the samples to air dry.

The heavy-mineral concentrate was obtained by sieving stream gravels and sands to yield two full gold pans (diameter of 15-inches [in.]) of minus 1/4-in. material. Panning then reduced the volume of the sample to less than 100 milliliters (ml) and removed most lighter rock chips and

minerals. The concentrate was transferred to 50-ml centrifuge bottles.

At mineralized sites, rock-chip and some hand samples were taken. The rock chips were collected in cloth bags for shipment to the laboratory. Thin sections were made from a few of the hand samples.

Sample Numbering

As each sample was collected and a computer form was filled in, a field number was assigned to the sample. Each sample was also assigned a laboratory number when it reached the laboratory. For the final report, a map number was also assigned to the sample. All three numbers for each sediment sample are listed in Table 11 (Appendix 1); the numbers for the rock-chip samples are listed in Table 12 (Appendix 1).

Computer System

A spreadsheet software package (Lotus 1-2-3) was used to enter raw geochemical data into an IBM microcomputer. Software that is available at no cost from the U.S. Geological Survey (USGS, 1984) was used to store, retrieve, and statistically analyze the geochemical data and to plot histograms and element abundance maps.

Laboratory Support

The DOGAMI laboratory had two responsibilities: (1) to oversee, from the analytical standpoint, the taking, handling, and storage of samples, and (2) to perform the analyses for gold (Au), silver (Ag), copper (Cu), lead (Pb), molybdenum (Mo), and zinc (Zn).

Chemex Laboratories, Ltd., North Vancouver, British Columbia, Canada, provided analyses for arsenic (As) and mercury (Hg) and provided quality-control check analyses for the six elements analyzed in the DOGAMI laboratory.

Barringer Laboratories, Inc., Wheatridge, Colorado, performed the heavy liquid separations for the panned concentrates.

Robert O. Van Atta, Earth Science Department, Portland State University, Portland, Oregon, provided the mineralogical analyses of the light- and heavy-mineral fractions of the panned concentrates.

A summary of the decomposition and analytical methods and detection limits is given in Table 3. A more detailed description of the laboratory procedures for geochemistry appears in Appendix 2. Appendix 3 provides details of the laboratory procedures employed in the mineralogy study of the panned concentrates.

Table 3. SILT AND ROCK-CHIP SAMPLE ANALYTICAL METHODS

Element		Detection limit (ppm)	Decomposition method*	Analytical method
Gold	(Au)	0.002	Fire assay preconcentration, Nitric acid (HNO_3), Hydrochloric acid (HCl)	Atomic absorption (AA)
Silver	(Ag)	0.02	HCl, potassium chlorate (KClO_3) organic solvent extraction	AA
Lead	(Pb)	0.2	Same as for Ag	AA
Copper	(Cu)	<10	HCl, HNO_3 with KCl	AA
Zinc	(Zn)	<10	Same as for Cu	AA
Arsenic	(As)		HNO_3 , perchloric acid (HClO_4)	Hydride/AA
Molybdenum	(Mo)	0.2	Same as for Cu	AA
Mercury	(Hg)	0.005	HNO_3 , HCl	Cold Vapor/AA

* Hydrofluoric acid was also used for Ag, Pb, Cu, Zn, and Mo in rock samples.

Geochemical Data

General

The computer system described earlier was used to (1) print raw data, frequency tables, histograms, and correlation statistics, and (2) plot element abundance maps.

Raw Data

Table 1 (Plate 5) contains the data for the 305 sediment samples collected for this study. Included in the first section of the table are (1) sample numbers corresponding to numbers plotted on geology/sample location map (Plate 1); (2) sample-site location data consisting of county, quadrangle, legal subdivisions, and UTM grid numbers; and (3) geologic symbols from the geologic map, which is based on work by Robinson (1975), of geologic units that could have contributed to the sample, starting with the formation at the site and continuing in order up stream. The second section on the table contains assay data for silt samples, which were tested for gold, silver, arsenic, copper, mercury, molybdenum, lead, and zinc. The third section contains gold pan concentrate data.

Table 2 (Plate 5), which contains raw data for the rock-chip samples, consists of the same type of data as listed in the first two sections of Table 1.

Sample Assay Statistics

USGS software cited previously was used to generate the range, mean, standard deviation, histograms, and least-square correlations for both the silt samples and rock-chip samples. Assays that were below the detection limits were not used in generating statistics.

Summary Statistics: Table 4 lists the number of assays above the detection level, those below the detection level, the range, mean, standard deviation, the mean plus two standard deviations, the geometric mean, the geometric standard deviation, and the geometric mean plus two geometric standard means for each of the elements assayed. The table has separate statistics for silt and rock-chip samples.

Table 4. SUMMARY ASSAY STATISTICS FOR BOTH SILT AND ROCK-CHIP SAMPLES

Silt sample assay statistics										
Element	Number of samples with valid assays	Number of samples with values below detection limit	Minimum	Range Maximum	Mean	Standard deviation	Mean plus two standard deviations	Geometric mean	Geometric standard deviation	Geometric mean plus two geometric standard deviations
Au	176	128	0.002	0.090	0.013	0.012	0.253	0.009	2.1	4
Ag	282	22	0.01	0.32	0.07	0.04	0.15	0.056	1.8	4
As	304	0	1	22	4	2	8	3	1.8	7
Cu	304	0	7	75	28	10	48	26	1.4	29
Hg	304	0	0.01	17	0.19	1	2	0.08	2.3	5
Mo	295	9	0.1	2	0.5	0.4	1.3	0.4	2.0	4
Pb	304	0	3	13	5	2	9	5	1.3	8
Zn	304	0	15	750	53	43	139	49	1.4	52
Rock-chip sample assay statistics										
Au	48	63	0.002	0.060	0.013	0.015	0.43	0.007	3.1	6
Ag	111	0	0.02	5.9	0.21	0.61	1.43	0.11	2.3	5
As	111	0	1	800	27	93	213	8	3.2	14
Cu	111	0	5	102	26	21	68	20	1.9	24
Hg	111	0	0.01	100	4	16	36	0.12	5.8	12
Mo	111	0	0.3	97	7	13	33	4	2.5	9
Pb	111	0	1	90	9	11	31	6	2.4	11
Zn	111	0	4	507	54	58	170	38	2.3	42

Frequency Tables and Histograms: A USGS computer program (BASTAT) (USGS, 1984) was used to generate frequency tables and histograms. Both raw data and data converted to logarithms were used to generate tables and histograms. The data in logarithms gave more obvious bell-shaped histograms (Tables 5 and 6), and these histograms were used to determine anomaly thresholds for each of the elements. The anomaly thresholds were placed where there was a major change in the length of the histogram bars (shown as X's in Tables 5 and 6). In most cases, this threshold was fairly close to the 95th percentile. This anomaly threshold is underlined across the histograms and frequency tables. For comparison, the anomaly values obtained from the mean plus two standard deviations and from the geometric mean plus two geometric standard deviations are included at the bottoms of Tables 5 and 6.

Table 5. SILT SAMPLE ASSAY FREQUENCY TABLES,
HISTOGRAMS, ANOMALY THRESHOLDS, AND TWO OTHER
STANDARDS FOR COMPUTING THE ANOMALY THRESHOLDS
FOR EIGHT ELEMENTS

Histogram for gold assay concentrations (ppm) in log 10 from silt samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
0.083 - 0.126	1	304	0.3	100.0	0.105	
0.055 - 0.083	2	303	0.7	99.7	0.069	
0.036 - 0.055	5	301	1.6	99.0	0.046	
0.024 - 0.036	13	296	4.3	97.4	0.030	Anomaly x threshold
0.016 - 0.024	25	283	8.2	93.1	0.020	xx
0.011 - 0.016	1	258	0.3	84.9	0.013	
0.007 - 0.011	75	257	24.7	84.5	0.009	xxxxxxx
0.005 - 0.007	26	182	8.6	59.9	0.006	xx
0.003 - 0.005	15	156	4.9	51.3	0.004	x
0.002 - 0.003	13	141	4.3	46.4	0.0025	x
Below detection limits	128	128	42.1	42.1	--	

Anomaly value obtained by using the mean plus two standard deviations is 0.253.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 4.

Histogram for silver assay concentrations (ppm) in log 10 from silt samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
0.32 - 0.45	1	304	0.3	100.0	0.38	
0.22 - 0.32	0	303	0.0	99.7	0.27	
0.16 - 0.22	14	303	4.6	99.7	0.19	x Anomaly
0.11 - 0.15	16	289	5.3	95.1	0.14	x threshold
0.08 - 0.11	62	273	20.4	89.8	0.10	xxxxx
0.06 - 0.08	53	211	17.4	69.4	0.07	xxxxx
0.04 - 0.06	74	158	24.3	52.0	0.05	xxxxxxx
0.03 - 0.04	39	84	12.8	27.6	0.034	xxx
0.02 - 0.03	22	45	7.2	14.8	0.024	xx
0.014 - 0.02	0	23	0.0	7.6	0.017	
0.010 - 0.014	1	23	0.3	7.6	0.012	
Below detection limits	22	22	7.2	7.2		

Anomaly value obtained by using the mean plus two standard deviations is 0.15.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 4.

Table 5. SILT SAMPLE ASSAY FREQUENCY TABLES,
HISTOGRAMS, ANOMALY THRESHOLDS, AND TWO OTHER
STANDARDS FOR COMPUTING THE ANOMALY THRESHOLDS
FOR EIGHT ELEMENTS -- Continued

Histogram for arsenic assay concentrations (ppm) in log 10 from silt samples

Limits		Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
Lower	Upper						
20	- 27	1	304	0.3	100.0	23	
15	- 20	2	303	0.7	99.7	17	
11	- 15	0	301	0.0	99.0	13	
8	- 11	9	301	3.0	99.0	10	x Anomaly
6	- 8	8	292	2.6	96.1	7	x threshold
4.5	- 6	54	284	17.8	93.4	5	xxxx
3.3	- 4.5	66	230	21.7	75.7	3.9	xxxxxx
2.5	- 3.3	80	164	26.3	53.9	2.9	xxxxxxxx
1.8	- 2.5	43	84	14.1	27.6	2.1	xxxx
1.3	- 1.8	0	41	0.0	13.5	1.6	
1.0	- 1.3	41	41	13.5	13.5	1.2	xxx

Anomaly value obtained by using the mean plus two standard deviations is 8.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 7.

Histogram for copper assay concentrations (ppm) in log 10 from silt samples

Limits		Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
Lower	Upper						
70	- 88	1	304	0.3	100.0	79	
56	- 70	9	303	3.0	99.7	63	x
44	- 56	8	294	2.6	96.7	50	x Anomaly
35	- 44	40	286	13.2	94.1	40	xxx threshold
28	- 35	82	246	27.0	80.9	31	xxxxxxx
22	- 28	63	164	20.7	53.9	25	xxxxxx
18	- 22	65	101	21.4	33.2	20	xxxxxx
14	- 18	27	36	8.9	11.8	16	xx
11	- 14	5	9	1.6	3.0	13	
9	- 11	2	4	0.7	1.3	10	
7	- 9	2	2	0.7	0.7	8	

Anomaly value obtained by using the mean plus two standard deviations is 48.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 29.

Table 5. SILT SAMPLE ASSAY FREQUENCY TABLES,
HISTOGRAMS, ANOMALY THRESHOLDS, AND TWO OTHER
STANDARDS FOR COMPUTING THE ANOMALY THRESHOLDS
FOR EIGHT ELEMENTS -- Continued

Histogram for mercury assay concentrations (ppm) in log 10 from silt samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
16 - 33	1	304	0.3	100.0	24	
8 - 15	0	303	0.0	99.7	12	
4 - 8	1	303	0.3	99.7	6	
1.7 - 4	2	302	0.7	99.3	3	
0.8 - 1.7	2	300	0.7	98.7	1	
0.4 - 0.8	4	298	1.3	98.0	0.6	Anomaly
0.2 - 0.4	13	294	4.3	96.7	0.3	x threshold
0.09 - 0.2	89	281	29.3	92.4	0.14	xxxxxxx
0.04 - 0.09	126	192	41.4	63.2	0.07	xxxxxxxxxxx
0.02 - 0.04	48	66	15.8	21.7	0.03	xxxx
0.01 - 0.02	18	18	5.9	5.9	0.015	x

Anomaly value obtained by using the mean plus two standard deviations is 2.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 5.

Histogram for molybdenum assay concentrations (ppm) in log 10 from silt samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
2.0 - 2.7	11	304	3.6	100	2.3	x
1.5 - 2.0	2	293	0.7	96.4	1.7	
1.1 - 1.5	3	291	1.0	95.7	1.3	
0.8 - 1.1	35	288	11.5	94.7	1.0	Anomaly xxx threshold
0.6 - 0.8	22	253	7.2	83.2	0.7	xx
0.45 - 0.6	65	231	21.4	76.0	0.5	xxxxx
0.33 - 0.45	44	166	14.5	54.6	0.38	xxxx
0.25 - 0.33	49	122	16.1	40.1	0.28	xxxx
0.18 - 0.25	45	73	14.8	24.0	0.21	xxxx
0.13 - 0.18	0	28	0.0	9.2	0.16	
0.10 - 0.13	19	28	6.3	9.2	0.12	xx
Below detection limits	9	9	3.0	3.0		

Anomaly value obtained by using the mean plus two standard deviations is 1.3.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 4.

Table 5. SILT SAMPLE ASSAY FREQUENCY TABLES,
HISTOGRAMS, ANOMALY THRESHOLDS, AND TWO OTHER
STANDARDS FOR COMPUTING THE ANOMALY THRESHOLDS
FOR EIGHT ELEMENTS -- Continued

Histogram for lead assay concentrations (ppm) in log 10 from silt samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
11 - 13	2	304	0.7	100.0	12	
10 - 11	2	302	0.7	99.3	11	
8 - 10	9	300	3.0	98.7	9	x Anomaly
7 - 8	14	291	4.6	95.7	8	x threshold
6.2 - 7	37	277	12.2	91.1	7	xxx
5.4 - 6.2	63	240	20.7	78.9	5.8	xxxxx
4.7 - 5.4	101	177	33.2	58.2	5.0	xxxxxxxxx
4.0 - 4.7	0	76	0.0	25.0	4.3	
3.5 - 4.0	63	76	20.7	25.0	3.8	xxxxx
3.0 - 3.5	13	13	4.3	4.3	3.2	x

Anomaly value obtained by using the mean plus two standard deviations is 9.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 8.

Histogram for zinc assay concentrations (ppm) in log 10 from silt samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
508 - 752	1	304	0.3	100.0	630	
344 - 508	0	303	0.3	99.7	426	
232 - 344	0	303	0.0	99.7	288	
157 - 232	0	303	0.0	99.7	195	
106 - 157	2	303	0.7	99.7	132	
72 - 106	28	301	9.2	99.0	89	xx Anomaly threshold
49 - 72	114	273	37.5	89.8	60	xxxxxxxxx
33 - 49	135	159	44.4	52.3	41	xxxxxxxxxxxxx
22 - 33	19	24	6.3	7.9	28	xx
15 - 22	5	5	1.6	1.6	19	

Anomaly value obtained by using the mean plus two standard deviations is 139.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 52.

Table 6. ROCK-CHIP SAMPLE ASSAY FREQUENCY TABLES,
HISTOGRAMS, ANOMALY THRESHOLDS, AND TWO OTHER
STANDARDS FOR COMPUTING THE ANOMALY THRESHOLDS
FOR EIGHT ELEMENTS

Histogram for gold assay concentrations (ppm) in log 10 from rock-chip samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
0.055 - 0.083	1	111	0.9	100.0	0.069	
0.036 - 0.055	6	110	5.4	99.1	0.046	x Anomaly
0.024 - 0.036	2	104	1.8	93.7	0.030	threshold
0.016 - 0.024	5	102	4.5	91.9	0.020	x
0.011 - 0.016	0	97	0.0	87.4	0.013	
0.007 - 0.011	10	97	9.0	87.4	0.009	xx
0.005 - 0.007	3	87	2.7	78.4	0.006	x
0.003 - 0.005	5	84	4.5	75.7	0.004	x
0.002 - 0.003	16	79	14.4	71.2	0.0025	xxxx
Below detection limits	63	63	56.8	56.8		

Anomaly value obtained by using the mean plus two standard deviations is 0.43.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 6.

Histogram for silver assay concentrations (ppm) in log 10 from rock-chip samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
5 - 10	1	111	0.9	100.0	8	
3 - 5	0	110	0.0	99.1	4	
1.5 - 3	2	110	1.8	99.1	2	
0.8 - 1.5	1	108	0.9	97.3	1.2	
0.4 - 0.8	1	107	0.9	96.4	0.6	Anomaly
0.2 - 0.4	5	106	4.5	95.5	0.3	x threshold
0.13 - 0.2	29	101	26.1	91.0	0.18	xxxxxxx
0.07 - 0.13	48	72	43.2	64.9	0.10	xxxxxxxxxxx
0.04 - 0.07	21	24	18.9	21.6	0.05	xxxxx
0.02 - 0.04	3	3	2.7	2.7	0.03	x

Anomaly value obtained by using the mean plus two standard deviations is 1.43.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 5.

Table 6. ROCK-CHIP SAMPLE ASSAY FREQUENCY TABLES,
HISTOGRAMS, ANOMALY THRESHOLDS, AND TWO OTHER
STANDARDS FOR COMPUTING THE ANOMALY THRESHOLDS
FOR EIGHT ELEMENTS -- Continued

Histogram for arsenic assay concentrations (ppm) in log 10 from rock-chip samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
759 - 1585	1	111	0.9	100.0	1172	
363 - 759	2	110	1.8	99.1	560	
174 - 363	1	108	0.9	97.3	268	
83 - 174	1	107	0.9	96.4	129	
40 - 83	2	106	1.8	95.5	61	Anomaly
19 - 40	14	104	12.6	93.7	29	xxx threshold
9 - 19	14	90	12.6	81.1	14	xxx
4 - 9	35	76	31.5	68.5	7	xxxxxxxxx
2 - 4	34	41	30.6	36.9	3	xxxxxxxxx
1 - 2	7	7	6.3	6.3	1.5	xx

Anomaly value obtained by using the mean plus two standard deviations is 213.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 14.

Histogram for copper assay concentrations (ppm) in log 10 from rock-chip samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
79 - 112	5	111	4.5	100.0	96	x Anomaly
56 - 79	7	106	6.3	95.5	68	xx threshold
40 - 56	7	99	6.3	89.2	48	xx
28 - 40	10	92	9.0	82.9	34	xx
20 - 28	19	82	17.1	73.9	24	xxxxx
14 - 20	22	63	19.8	56.8	17	xxxxxx
10 - 14	32	41	28.8	36.9	12	xxxxxxxxx
7 - 10	7	9	6.3	8.1	9	xx
5 - 7	2	2	1.8	1.8	6	

Anomaly value obtained by using the mean plus two standard deviations is 68.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 24.

Table 6. ROCK-CHIP SAMPLE ASSAY FREQUENCY TABLES,
HISTOGRAMS, ANOMALY THRESHOLDS, AND TWO OTHER
STANDARDS FOR COMPUTING THE ANOMALY THRESHOLDS
FOR EIGHT ELEMENTS -- Continued

Histogram for mercury assay concentrations (ppm) in log 10 from rock-chip samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
91 - 251	3	111	2.7	100.0	171	x
33 - 91	0	108	0.0	97.3	62	
12 - 33	3	108	2.7	97.3	23	x
4 - 12	0	105	0.0	94.6	8	
1.6 - 4	4	105	3.6	94.6	3	x
0.6 - 1.6	2	101	1.8	91.0	1.1	Anomaly
0.2 - 0.6	8	99	7.2	89.2	0.4	xx threshold
0.08 - 0.2	31	91	27.9	82.0	0.14	xxxxxxx
0.03 - 0.08	52	60	46.8	54.1	0.05	xxxxxxxxxxxxx
0.01 - 0.03	8	8	7.2	7.2	0.02	xx

Anomaly value obtained by using the mean plus two standard deviations is 36.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 12.

Histogram for molybdenum assay concentrations (ppm) in log 10 from rock-chip samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
52 - 99	3	111	2.7	100.0	76	x
27 - 52	3	108	2.7	97.3	40	x
14 - 27	3	105	2.7	94.6	21	x Anomaly
8 - 14	4	102	3.6	91.9	11	x threshold
4 - 8	33	98	29.7	88.3	6	xxxxxxx
2 - 4	40	65	36.0	58.6	3	xxxxxxxxx
1 - 2	21	25	18.9	22.5	1.6	xxxxx
0.6 - 1	1	4	0.9	3.6	0.8	
0.3 - 0.6	3	3	2.7	2.7	0.4	x

Anomaly value obtained by using the mean plus two standard deviations is 33.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 9.

Table 6. ROCK-CHIP SAMPLE ASSAY FREQUENCY TABLES,
HISTOGRAMS, ANOMALY THRESHOLDS, AND TWO OTHER
STANDARDS FOR COMPUTING THE ANOMALY THRESHOLDS
FOR EIGHT ELEMENTS -- Continued

Histogram for lead assay concentrations (ppm) in log 10 from rock-chip samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
57.5 - 95.5	2	111	1.8	100.0	76.5	
34.7 - 57.5	0	109	0.0	98.2	46.1	Anomaly
20.9 - 34.7	4	109	3.6	98.2	27.8	x threshold
12.6 - 20.9	19	105	17.1	94.6	16.7	xxxxx
7.6 - 12.6	24	86	21.6	77.5	10.1	xxxxxx
4.6 - 7.6	29	62	26.1	55.9	6.1	xxxxxxx
2.8 - 4.6	13	33	11.7	29.7	3.7	xxx
1.7 - 2.8	12	20	10.8	18.0	2.2	xxx
1.0 - 1.7	8	8	7.2	7.2	1.3	xx

Anomaly value obtained by using the mean plus two standard deviations is 31.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 42.

Histogram for zinc assay concentrations (ppm) in log 10 from rock-chip samples

Limits Lower - Upper	Obs. frq.	Obs. cum. frq.	Per. frq.	Per. cum. frq.	Class midpoint	Histogram
470 - 798	1	111	0.9	100.0	634	
277 - 470	0	110	0.0	99.1	373	
163 - 277	2	110	1.8	99.1	220	Anomaly
96 - 163	12	108	10.8	97.3	129	xxx threshold
57 - 96	22	96	19.8	86.5	76	xxxxxx
33 - 57	27	74	24.3	66.7	45	xxxxxxx
20 - 33	23	47	20.7	42.3	26	xxxxxx
12 - 20	14	24	12.6	21.6	16	xxx
7 - 12	5	10	4.5	9.0	9	x
4 - 7	5	5	4.5	4.5	5	x

Anomaly value obtained by using the mean plus two standard deviations is 170.

Anomaly value obtained by using the geometric mean plus two geometric standard deviations is 11.

Least-Squares Correlations: The computer program (STATCOR) (USGS, 1984) used for the least-squares correlations could not change raw data to logarithms. The correlations would have been higher if the data could have been converted to logs. Least-squares correlations determine which elements show sympathetic variation with other elements--and how closely the variations in one element are matched by variations in other elements. Table 7 lists the least-squares correlations between each element and every other element. The values in the table are R² values for each of the least squares correlations. The number "1.0000" that appears diagonally across Table 7 illustrates that an element is 100 percent correlated with itself. If the values for two elements are closely correlated (high R²), then one element can serve as a pathfinder for the other element.

The highest R² for gold and any other element in the rock-chip samples is the value of 0.2906 for lead. This number indicates that as the amount of lead increases in samples, so does the amount of gold. It also shows that 71 percent of the variance in gold assay values cannot be explained by the variance in lead assay values. An R² correlation of 0.2906 is not considered to be a very high correlation.

Table 7. SILT AND ROCK-CHIP LEAST-SQUARES CORRELATIONS (R^2) BETWEEN ELEMENT ASSAYS

SILT SAMPLES								
Elements	Au	Ag	As	Cu	Hg	Mo	Pb	Zn
Au	1.0000	0.0987	0.1698	-0.0102	0.0266	-0.1352	0.1059	0.0207
Ag		1.0000	0.2346	0.1934	0.0998	-0.0917	0.2833	0.1239
As			1.0000	0.1176	0.2831	-0.0980	0.3315	0.0999
Cu				1.0000	0.0664	-0.0996	-0.1284	0.1253
Hg					1.0000	0.0040	0.0865	-0.0067
Mo						1.0000	0.2284	-0.0271
Pb							1.0000	0.0293
Zn								1.0000

ROCK-CHIP SAMPLES								
Elements	Au	Ag	As	Cu	Hg	Mo	Pb	Zn
Au	1.0000	0.1397	-0.0033	0.0103	0.0906	-0.0826	0.2906	0.1338
Ag		1.0000	0.0537	0.0388	0.1631	-0.0559	0.3848	-0.0239
As			1.0000	-0.0283	-0.0252	0.6907	0.0085	-0.0254
Cu				1.0000	0.3833	-0.0480	0.1340	0.3323
Hg					1.0000	-0.0622	0.4107	0.0302
Mo						1.0000	-0.0584	-0.0735
Pb							1.0000	0.2182
Zn								1.0000

Element Abundance Maps

A USGS program (MAP---\$) (USGS, 1984) was used to produce the element abundance maps shown on Plates 2, 3, and 4. The assay values of an element were divided into up to seven groups. The program then assigned a letter (silt samples) or number (rock chip) samples to each of the groups. The letter "A" and the number "1" were used for the categories containing the highest values for silt and rock chip samples, respectively. The program then divided the map area into squares the size of the two symbols. The program caused a dot matrix printer to print the appropriate symbol for the squares that had assay values. If the printer encountered a square that contained two assays within its boundaries, it printed the symbol for the first assay it came to within that square, even though the second assay might be higher in value.

Frequency tables and histograms (Tables 5 and 6) were used to determine which groups of assay values were anomalous (see section entitled "Frequency Tables and Histograms"). The program produced 16 element abundance maps, eight of which were for silt samples and eight for rock chips. The silt and rock-chip maps for each element were combined into a total of eight maps. Symbols for assay values that were not classed as anomalous were deleted from the maps except for the symbol for the assay value that was immediately below the anomaly threshold. The element abundance maps were printed over the same topographic base as the geology/sample location map, only at a scale of 1:100,000, instead of at a scale of 1:50,000, which is the scale of the geology/sample location map. In those cases where both silt and rock-chip samples were taken at the same locations, the silt-sample letter was printed on the left and the rock-chip number on the right.

The anomaly thresholds for all elements are listed in Table 8. The computer programs used to generate the data for Tables 5 and 8 do not handle the raw data in the same manner. Thus, the threshold values in the two tables vary slightly.

Table 8. ANOMALY THRESHOLDS

Element	Silt sample (ppm)	Rock-chip sample (ppm)
Gold	0.03	0.03
Silver	0.11	0.22
Arsenic	6	43
Copper	41	57
Mercury	0.18	0.52
Molybdenum	0.7	8.6
Lead	7	15
Zinc	73	101

Because of the way that the maps were generated, the locations are not exact. Furthermore, because the computer program does not include data from a second sample in a square on the map, data can be lost. Therefore, to maximize the value of this report, the user should study the raw data table as well as the maps to identify areas of interest.

Gold Pan Concentrate Mineralogy

General

At all but 16 of the stream-sediment sites, two gold pans of minus 1/4-in. material were panned to produce a concentrate of mostly heavy minerals. This material was screened (20-mesh) in the lab, and the magnetic material was removed. The remaining material was treated with a heavy liquid to produce two fractions: a light fraction of specific gravity less than 3 and a heavy fraction of specific gravity greater than 3. A glass slide was made from each concentrate that was studied. These slides are archived at DOGAMI's Portland office. The raw data from these studies appears in the left half of Table 1 (Plate 5). Laboratory procedures are described in Appendix 3.

The following ore minerals and two high-temperature minerals were identified in the heavy fraction: arsenopyrite, azurite, cerussite, cinnabar, malachite, andalusite, and garnet.

Four minerals of interest identified in the light fraction were potassium feldspar (adularia, microcline, and sanidine), sericite, azurite, and malachite.

Because of funding limitations, only 60 percent of the concentrates could be selected for grain-count studies, and maps showing mineral distribution could not be generated.

Light-Mineral Fraction Results

A simple, cursory examination of the light-mineral fraction was made to determine whether or not the following components were present: potassium feldspar (stained canary yellow) in the form of adularia, microcline, and/or sanidine; plagioclase feldspar (twinned and unstained); sericite; chlorite; rock fragments; and quartz. Rock fragments that were stained yellow were noted as "potassic rock silicates." Malachite, azurite, and limonitic rock fragments were contaminants in a few splits of light minerals, and their presence was also noted. The results of this examination are summarized in Table 9. The raw data appear in Table 1 (Plate 5).

Table 9. SUMMARY OF MINERALOGY OF THE LIGHT FRACTION OF THE GOLD PAN CONCENTRATES

Mineral	Number of samples containing mineral	Percentage of samples containing mineral
Potassium feldspar (adularia, microcline, and/or sanidine)	70	38.7
Chlorite	4	2.2
Sericite	119	65.6
Rock fragments	180	100.0
Potassic rock silicates	111	61.3
Plagioclase	180	100.0
Quartz	2	1.1
Malachite	34	18.8
Azurite	3	1.7
Chrysocolla	1	0.6
Limonitic rock	4	2.2

Heavy-Mineral Fraction Results

The percentages of minerals found in the heavy-mineral fraction are summarized in Table 10. Raw data appear in Table 1 (Plate 5).

Fluorescent Mineral Results

The results of the fluorescent mineral examination are given in Table 1. In only eight cases was the color of fluorescence noted, and that information is included in "Comments" in Table 1 (Plate 5).

Table 10. SUMMARY OF HEAVY-MINERAL COMPOSITION OF THE GOLD PAN CONCENTRATES

Mineral	Percentage of samples containing mineral	Percentage of samples with a given abundance rank *						Abundance rel. to all samples (180)
		T	R	M	C	A	F	
Amphibole (hornblende + actinolite)	100	18.8	72.4	6.1	0.6	2.2	0.0	T-R
Basaltic hornblende	100	32.3	60.0	8.3	0.0	0.0	0.0	T-R
Andalusite	2.2	100	0.0	0.0	0.0	0.0	0.0	T
Apatite	77.3	84.3	15.0	0.7	0.0	0.0	0.0	T-R
Augite	97.8	24.9	44.6	23.7	5.1	1.1	0.0	R-C
Aegerine (+aegerine augite)	34.3	96.8	3.2	0.0	0.0	0.0	0.0	T
Arsenopyrite	6.6	100	0.0	0.0	0.0	0.0	0.0	T
Azurite	0.6	100	0.0	0.0	0.0	0.0	0.0	T
Cerussite	3.9	100	0.0	0.0	0.0	0.0	0.0	T
Chlorite	0.0	---	---	---	---	---	---	-
Chromite	44.2	100	0.0	0.0	0.0	0.0	0.0	T
Cinnabar	7.2	100	0.0	0.0	0.0	0.0	0.0	T
Clinoenstatite	33.7	93.5	4.9	1.6	0.0	0.0	0.0	T
Clinozoisite	7.7	100	0.0	0.0	0.0	0.0	0.0	T
Diopside	27.1	100	0.0	0.0	0.0	0.0	0.0	T
Enstatite	9.4	94.1	5.9	0.0	0.0	0.0	0.0	T
Epidote	35.9	98.5	1.5	0.0	0.0	0.0	0.0	T
Fluorite	0.0	---	---	---	---	---	---	-
Garnet	10.5	89.5	10.5	0.0	0.0	0.0	0.0	T
Hematite	96.1	29.3	62.7	8.0	0.0	0.0	0.0	R
Hypersthene	100	0.0	0.0	0.0	0.0	0.0	100.0	F
Ilmenite	96.1	74.8	26.4	0.0	0.0	0.0	0.0	T-R
Limonite	100	29.3	60.2	9.9	0.6	0.0	0.0	R
Limonitic rock	90.6	58.8	38.4	1.8	0.0	0.0	0.0	T-R
Leucoxene	58.6	93.4	6.6	0.0	0.0	0.0	0.0	T
Magnetite	100	5.0	32.6	54.1	6.6	1.7	0.0	R-C
Mica	0.0	---	---	---	---	---	---	-
Malachite	1.1	100	0.0	0.0	0.0	0.0	0.0	T
Monazite	2.8	100	0.0	0.0	0.0	0.0	0.0	T
Olivine	62.4	95.6	4.4	0.0	0.0	0.0	0.0	T
Pyrite	28.7	100	0.0	0.0	0.0	0.0	0.0	T
Rutile	64.6	91.6	8.5	0.9	0.0	0.0	0.0	T
Sphene	5.0	100	0.0	0.0	0.0	0.0	0.0	T
Spinel	1.1	100	0.0	0.0	0.0	0.0	0.0	T
Staurolite	2.2	100	0.0	0.0	0.0	0.0	0.0	T
Zircon	79.6	74.5	20.0	5.5	0.0	0.0	0.0	T-R
Zoisite	3.9	100	0.0	0.0	0.0	0.0	0.0	T
Plagioclase**	33.1	95.0	5.0	0.0	0.0	0.0	0.0	T

* T = Trace = 1 or 2 grains; R = Rare = 1%; M = Minor = 1-5%; C = Common = 5-10%

A = Abundant = 10-50%; F = Flood = 50% or more.

** Contaminant.

ANOMALIES

General

Clues to mineralization may take several forms. The clues are usually something different from the ordinary and could be something as simple as a topographic low, as subtle as the difference between two clays, or as obvious as a rock chip sample with an arsenic value of 800 ppm. In this report, these types of clues are all called "anomalies." The clues--or anomalies--fall into four main categories: (1) Information found in a geological library where reports on mines and prospects are stored. (2) Observations made in the field, such as the presence of jasperoids and breccias, field-observed mineralization, and topographic highs and lows. (3) Anomalies revealed by analysis of samples. (4) Minerals found in gold pan concentrates.

Library Anomalies

Many anomalies can be identified in a geologic library through research of reports of mines and prospects (see "Selected References"). The Gold King, Axehandle, Oregon Queen, and Horse Heaven Mines form a mineralized zone that lies at the top of the northeast corner of the geology/sample location map (Plate 1). Other anomalies that have been described in the literature include the jasperoid deposits that have been mined or are currently being mined from the Richards and Hay Creek Ranches (Oregon Department of Geology and Mineral Industries, 1973). Another anomaly that was listed in DOGAMI's unpublished files is the Grizzly Mountain limestone deposit.

Field Anomalies

During the field surveying, mineralization was observed and sampled, including mines and prospects, thunderegg (jasperoid) beds, silicified ash flow tuffs, jasperoid breccias, hot spring sinter, iron staining to massive limonite, clay zones that may be hydrothermal in origin around breccia pipes, red soil, and garnets in the gold pan concentrates.

During the two field seasons, 111 rock-chip samples were collected. Each one of these is regarded as an anomaly because only those outcrops and float that showed some kind of mineralization were sampled. One soil sample was taken and is listed as sample 55 (Table 1, Plate 5). The sample was taken at the site of a small excavation because the soil

was colored bright red. The sample was anomalous in six of the eight elements under the silt sample standards and would be anomalous for two elements under the rock-chip standards.

Larger scale anomalous features that were found during the field season include hot spring breccia pipes such as those at rock-chip sample sites 133, 136, 137, 150, and 151 (see geology/sample location map, Plate 1). The breccia pipe at sample site 151 is a good example of a hydrofractured breccia pipe in the bedded rock of the Clarno Formation that has been fractured several times and has a strong clay zone around it. Two other areas that had much hot spring activity were the area around sample sites 222, 223, 224, 225, and 231 and the area around sample sites 270, 271, and 272. The first area has a jasperoid cap, sinter, massive limonite, and a jasperoid that is composed of quartz fragments that are cemented together with secondary silica. The second area is the Grizzly Mountain limestone site. The limestone consists of a pod of hydrothermal calcite that before being mined was 40 ft long and 10 ft wide. The fresh-plowed wheat field to the northeast is lighter in color than the rest of the fields nearby because it contains cobbles that have a coating of secondary calcite. When broken, these cobbles are yellow from iron oxide.

Geochemical Anomalies

General

Element abundance maps, which are a form of anomaly maps, were computer generated for this study to highlight locations of special interest. As described in the section entitled "Computer System," letters were used on the maps to indicate different silt sample values, and numbers were used to indicate different rock-chip values, with "A" and "1" the highest values for silt and rock-chip samples, respectively. In addition, to highlight samples of special interest, a circle was drawn around each letter and number categorized as anomalous on the basis of the histograms and statistical data listed in Tables 5 and 6.

It should be emphasized that these circles, while based on geochemical and statistical data, are still basically interpretative. An element value for a silt sample is the net result of mineralization upstream and may or may not be related to the value of a silt sample from a nearby drainage.

Gold

Exploration firms consider any gold value over 0.030 ppm to be anomalous. For two reasons, this author (Gray) believes that gold values at and above 0.005 ppm should be considered anomalous in the study area until additional evidence suggests otherwise: (1) Gold may not occur at the top of a hot-spring system (Berger and Eimon, 1983), and (2) some gold anomalies may be traced only short distances downstream.

Other Elements

The anomalies for other elements should be compared to those on the gold element abundance map. All of the maps show anomalous values in the area around silt sample site 253. One of the reasons that the entire study area was originally selected for study is that the contacts between pre-Tertiary, Clarno Formation, and John Day Formation rocks might have clay or saprolite zones that might form barriers to mineralizing solutions. All three rock units and their contacts are present within the area surrounding sample 253.

Although not shown on the geology/sample location map, the contact between the Clarno and John Day Formations is also exposed at sample site 79. Six of the elements are anomalous in the general area surrounding this site.

The gold anomaly occurring in the general area around sample sites 37 to 46 is not duplicated by the other elements, except for lead. The Ashwood Butte-Axehandle Mine-Horse Heaven Mine zone is clearly indicated by an east-west-trending line of silver, arsenic, and mercury anomalies. The same general trend is followed by a smaller number of gold anomalies.

The southeastern corner of the molybdenum map contains a large number of molybdenum anomalies that may be due to a higher molybdenum background caused by the Tertiary rhyolite flows. However, samples 360 and 364 have anomalous gold values. The high arsenic and molybdenum values occurring at rock-chip sample sites 133 (365 ppm As and 32 ppm Mo), 136 (220 ppm As and 52 ppm Mo), and 137 (800 ppm As and 97 ppm Mo) qualify this area to be defined as anomalous. Samples 136 and 137 were taken at a prospect adit into a breccia pipe. Sample 133 was collected at a breccia pipe. Gold pan concentrate sample 134, which was taken upstream from rock-chip samples 136 and 137, had a trace of arsenopyrite.

The silver, copper, and molybdenum anomalies at sample site 230 are not duplicated by gold. This may be due to the fact that gold may not be present at the top of a hot spring system. Sample 230 is taken at the mouth of a drainage containing hot-spring sinter, jasperoid cap rock, massive limonite, and a jasperoid rock that had to have formed in the throat of a hot spring. The gold pan concentrates for sample 230 contain arsenopyrite (arsenic), cerussite (lead), cinnabar (mercury), and malachite (copper).

Minerals in Gold Pan Concentrates

Nine different ore minerals were found in pan concentrates: arsenopyrite (arsenic); azurite, chalcocite, chrysocolla, cuprite, and malachite (copper); cinnabar (mercury); cerussite (lead); and erythrite (cobalt). The distribution of these minerals is shown on small-scale maps (Figures 2, 3, 4, and 5) in the text. The distribution of these minerals does not match the silt sample anomalies, indicating the importance of assaying pan concentrates along with silt samples in a geochemical survey of this type.

Two types of alteration minerals (sericite and jarosite) are plotted on the gold anomaly map (Figure 6). Again there does not appear to be a correlation between the minerals present in the gold pan and the gold anomalies. These two minerals may be part of an alteration halo around a mineralized zone.

Two high-temperature minerals (andalusite and garnet) were plotted on another copy of the gold anomaly map (Figure 7). There was no correlation between the minerals and anomalies. The presence of these high-temperature minerals in an epithermal system is difficult to explain. Joseph Levay (personal communication, 1986) has identified similar garnets in a steam-explosion pebble dike crosscutting a jasperoid cap over an epithermal system in Baker County, eastern Oregon.

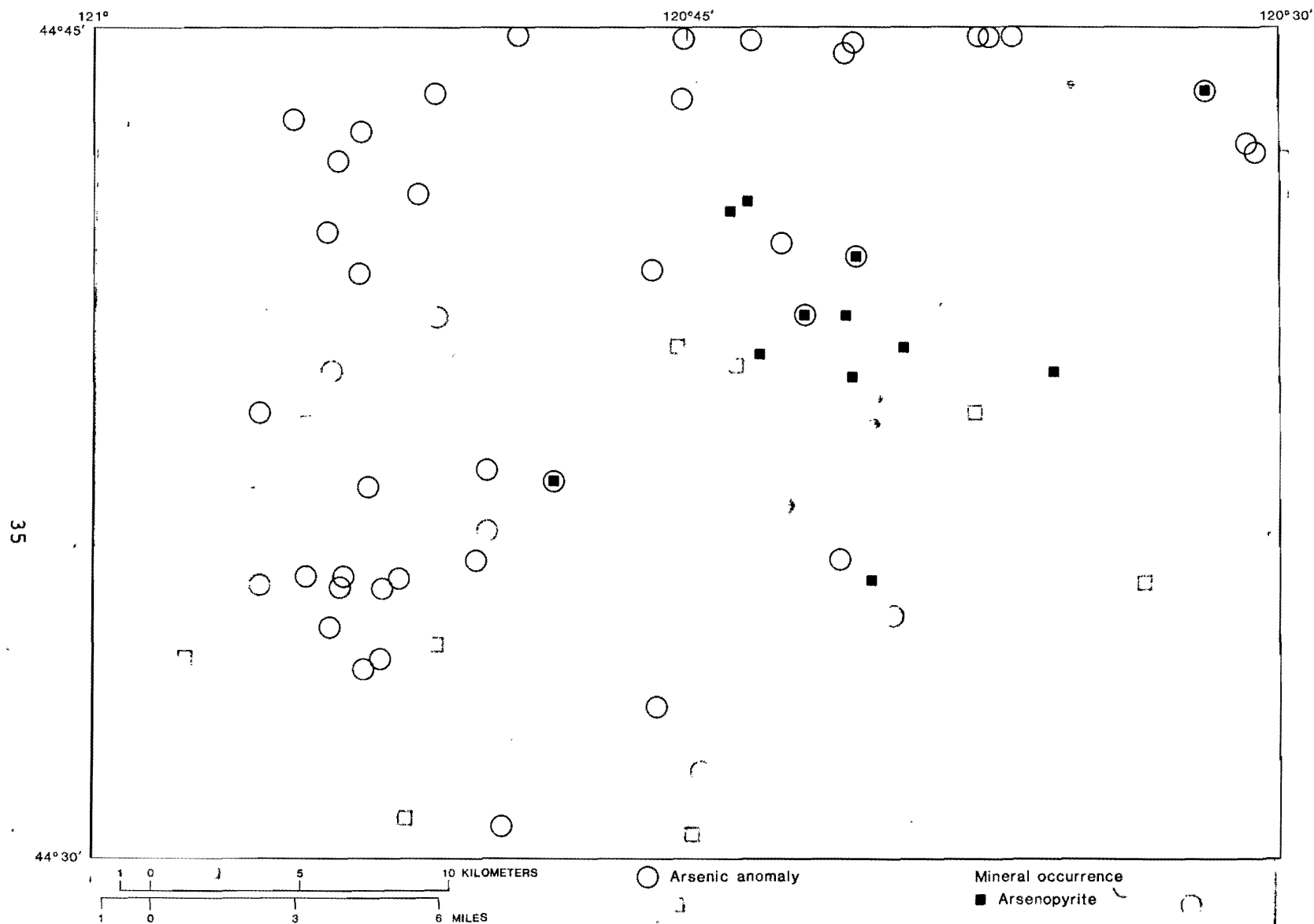


Figure 2. Map showing the relationship of the arsenopyrite gold pan occurrences to arsenic anomalies.

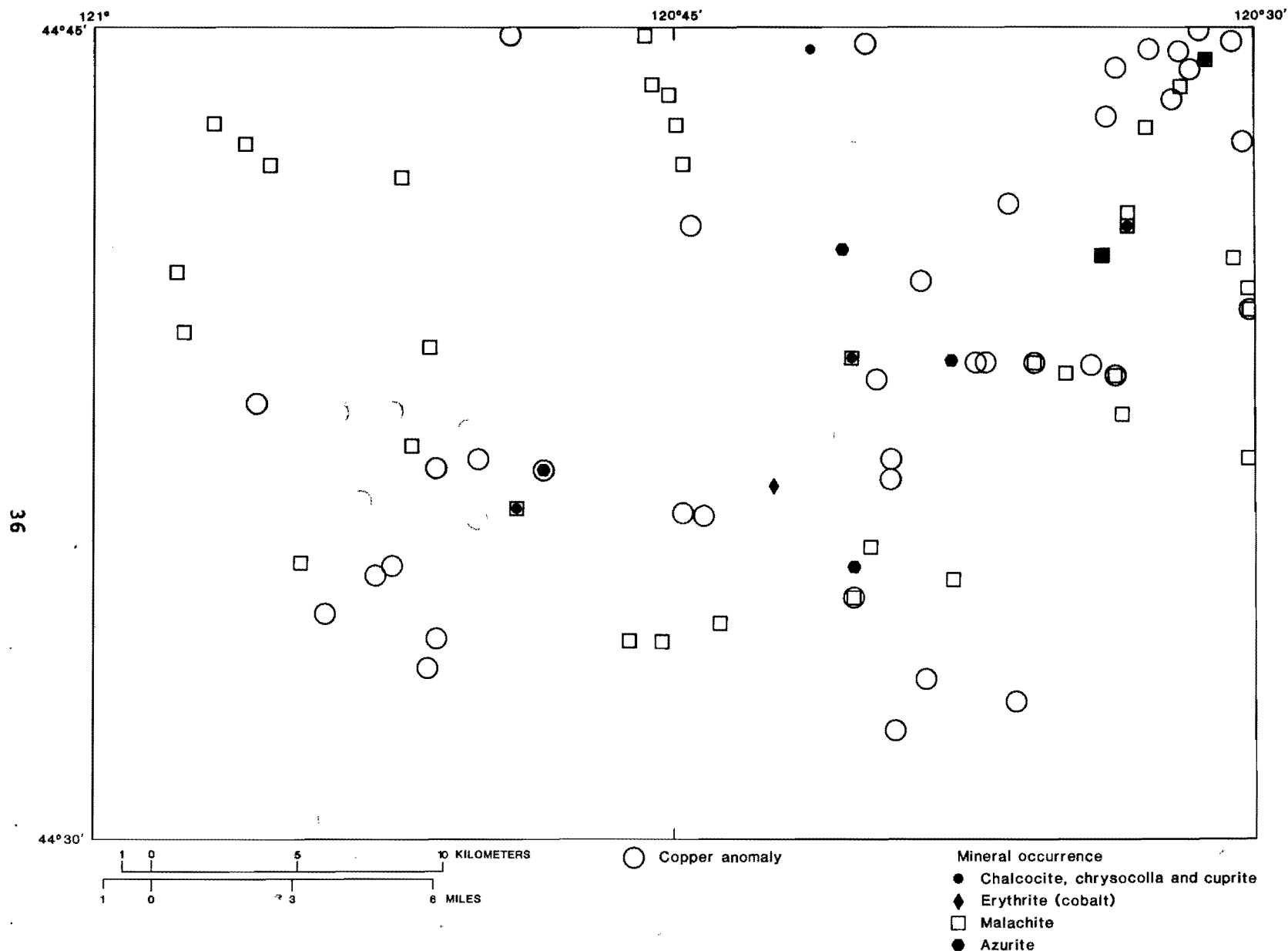


Figure 3. Map showing the relationship of the azurite, chalcocite, chrysocolla, cuprite, erythrite, and malachite gold pan occurrences to copper anomalies.

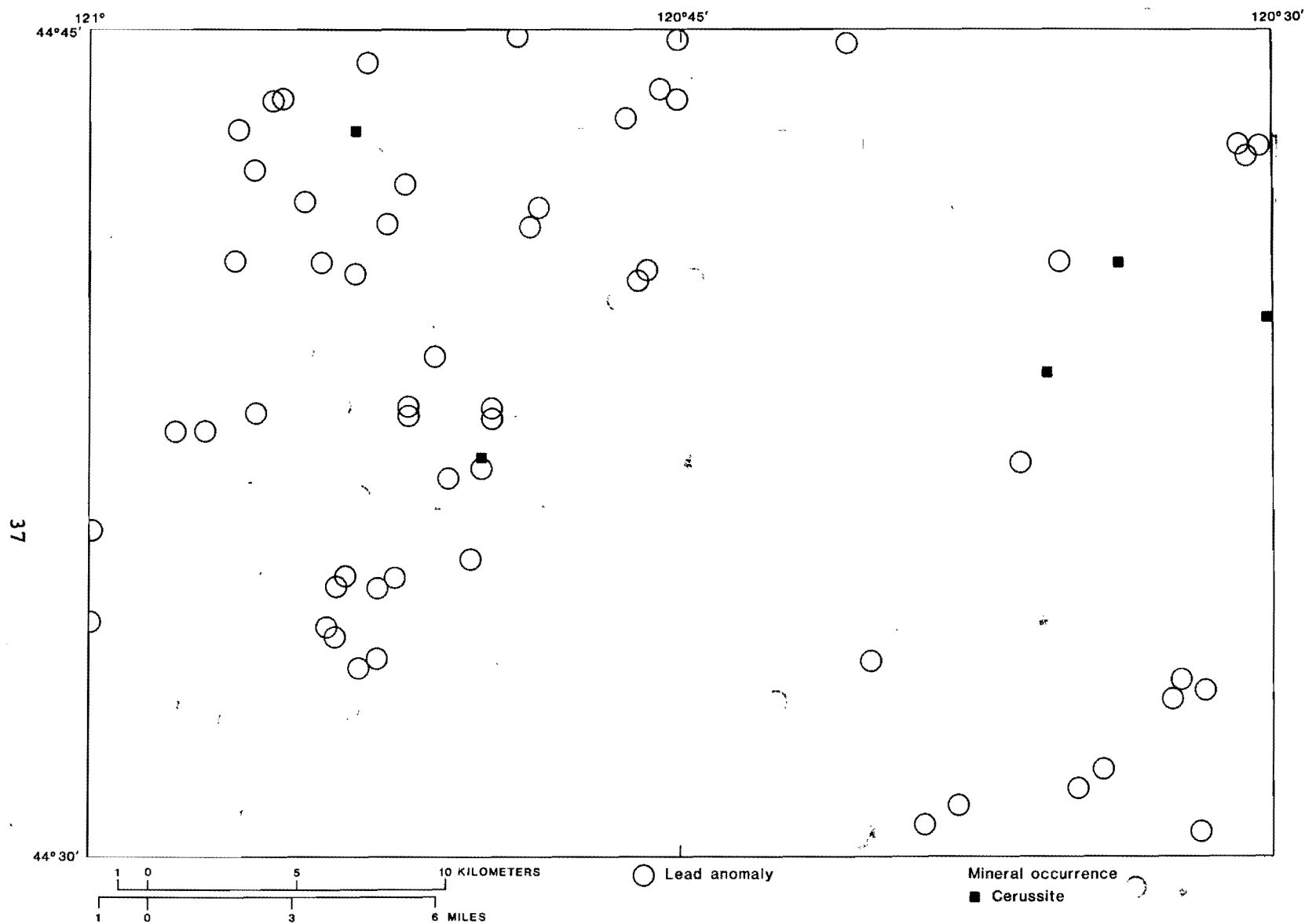


Figure 4. Map showing the relationship of the cerussite gold pan occurrences to lead anomalies.

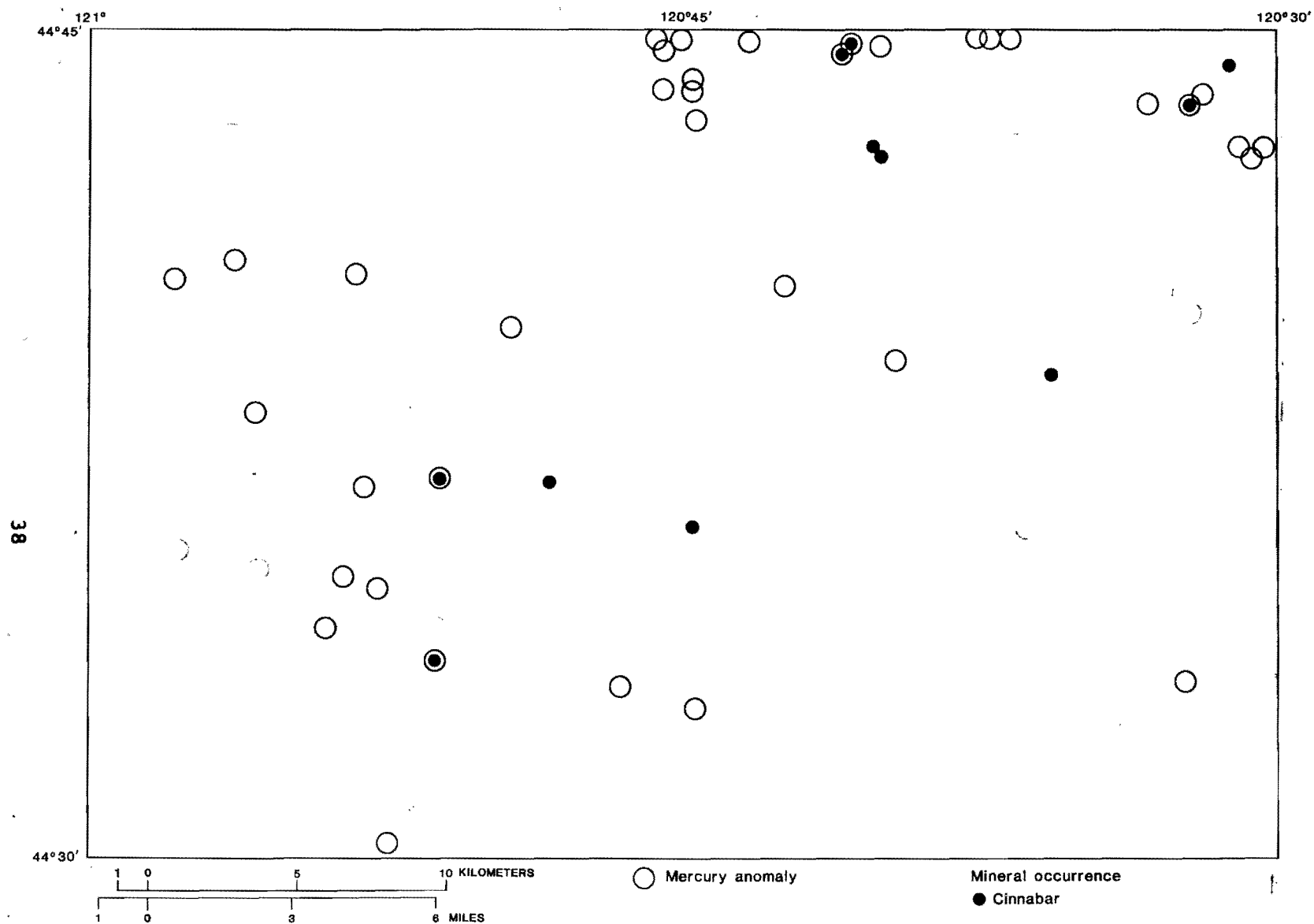


Figure 5. Map showing the relationship of the cinnabar gold pan occurrences to mercury anomalies.

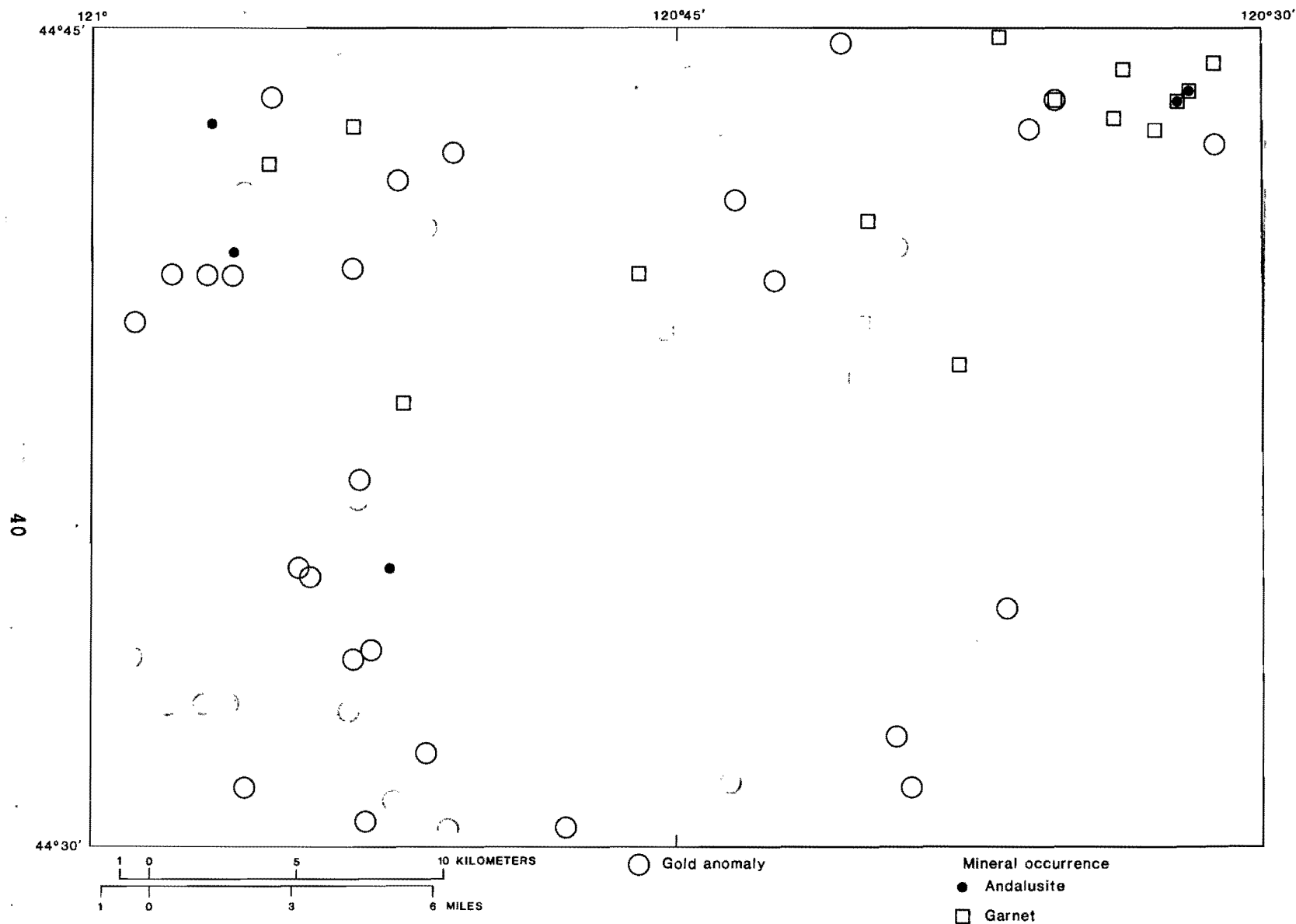


Figure 7. Map showing the relationship of the andalusite and garnet occurrences to gold anomalies.

MINERAL OCCURRENCES

This study was mainly concerned with the possibility of discovering economic hot-spring gold deposits. Jasperoid was sampled and assayed as a pathfinder. It must be noted that most of the rock chips sampled represent rockhound cutting-grade material. One such sample, sample 221 (NW 1/4 sec. 32, T. 10 S., R. 18 E.); was collected from a deposit that contained petrified wood 2 ft across and that appeared never to have been mined.

Two outcrops of perlite were found. The first was sampled (sample 374, NE 1/4 sec. 14, T. 11 S., R. 18 E.); the second was not sampled but was located near sample 373 (on the line between secs. 15 and 16, T. 11 S., R. 18 E.).

The Grizzly Mountain limestone was located and visited in the course of this study. The hydrothermal calcite had been mined out and could not be sampled. Because of its hydrothermal origin, however, nearby mineralized jasperoid was sampled (samples 270 and 271, NE 1/4 sec. 21, T. 12 S., R. 15 E.; and sample 272, NW 1/4 sec. 22, T. 12 S., R. 15 E.).

Two adits in Clarno-age rocks (NE 1/4 and SW 1/4 sec. 6, T. 12 S., R. 16 E.) that had been opened for a coal seam were found. The coal mine apparently had not proven to be economic. Samples 291 and 294 were taken from coal found on the dumps of the two mines. Sample 293 was from the black shale above the coal seam. The three samples were all anomalous in arsenic, and the two coal samples were anomalous in molybdenum. The black shale had 0.004 ppm in gold, 23 ppm in arsenic, and 4.4 ppm in molybdenum.

RECOMMENDATIONS

The data included in this report lead to the following recommendations:

1. The unsampled areas should not be treated as having negative geochemical values.
2. Drainages above areas containing element anomalies should be studied.
3. The original field work was done on 7-1/2-minute quadrangle maps. These maps are archived at the Portland office of the Oregon Department of Geology and Mineral Industries (DOGAMI). If additional detailed geochemical surveying is to be done, a set of topographic quadrangle maps should be obtained, and the geochemical data should be hand plotted on the appropriate maps.
4. About 40 percent of the gold pan concentrates were not studied because of a lack of funding. These should be studied as the other 60 percent were studied.
5. The silt samples were assayed for only eight elements, and the gold pan concentrates were not assayed at all. More assaying should be done on the samples. Of particular interest would be analyses for antimony, fluorine, and thallium.
6. DOGAMI has silt sample splits and concentrates available for assaying.
7. Isolated sample sites with anomalies in only one element should not be rejected for study.
8. Areas with low or below-detection-limit gold values but with other anomalous values should not be rejected for study. Field work indicates that in many areas it appears that only the very tops of hot-spring systems have been exposed by erosion.

SUMMARY

The main objectives of this report were to conduct a geochemical survey, to present a geologic map, to integrate the resource data and the geologic map, to delineate mineralized areas, and to determine if hot-spring gold mineralization is present in the study area.

All of the above objectives of the study were met. The data given in this report suggest that the study area contains hot-spring gold deposits. This study has laid the ground work for others to follow.

Each of the rock-chip samples flags a mineralized area. The anomalies shown on the element abundance maps point to areas where more detailed work should be done and which could be possible exploration targets.

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APPENDIX 1. KEY TO SAMPLE NUMBERS USED IN THIS STUDY

Table 11. MAP , LABORATORY , AND FIELD SAMPLE NUMBERS FOR SEDIMENT SAMPLES

Map	Lab	Field	Map	Lab	Field	Map	Lab	Field	Map	Lab	Field
2	75	P0111F01	119	166	P0225F01	236	238	P0335F01	341		B0206F01
3	73	P0108F01	120	169	P0230F01	237	235	P0332F01	342		B0205F01
4	74	P0109F01	121	168	P0228F01	238	211	P0282F10	343		B0204F01
5	66	P0100F01	123	172	P0233F01	239	212	P0283F01	345		B0123F01
6	63	P0091F01	124	162	P0221F01	240	28	P0045F01	346		B0124F01
7	64	P0092F01	125	163	P0222F01	241	29	P0046F01	348		B0027F01
8	24	P0041F01	126	165	P0224F01	242	30	P0047F01	349		B0025F01
9	9	P0022F01	128	143	P0200F01	243	40	P0387F01	350		B0026F01
10	25	P0042F01	129	170	P0231F01	244	55	P0082F01	351	119	P0163F01
15	70	P0104F01	131	133	P0185F01	245	43	P0066F01	352		B0126F01
16	69	P0103F01	134	139	P0195F01	246	42	P0065F01	353		B0029F01
17	68	P0102F01	135	140	P0196F01	247	31	P0048F01	354		B0125F01
18	67	P0101F01	138	138	P0193F01	249	36	P0059F01	355		B0028F01
19	72	P0107F01	139	137	P0192F01	253	32	P0053F01	356	234	P0329F01
20	65	P0095F01	140	161	P0220F01	255	33	P0056F01	357	233	P0328F01
23	26	P0043F01	141	132	P0184F01	257	34	P0057F01	358	230	P0321F01
24	27	P0044F01	142	155	P0214F01	259	57	P0084F01	361		B0121F01
28	52	P0076F01	144	141	P0198F01	260	56	P0083F01	362		B0120F01
29	53	P0077F01	145	142	P0199F01	261	38	P0061F01	365		B0202F01
30	4	P0017F01	146	159	P0218F01	262	39	P0062F01	366		B0201F01
34	59	P0086F01	147	158	P0217F01	263	44	P0067F01	367		B0022F01
37	1	P0002F01	148	160	P0219F01	264	45	P0068F01	368		B0020F01
39	76	P0112F01	149	157	P0216F01	265	79	P0117F01	369		B0021F01
40	7	P0020F01	152	131	P0183F01	266	80	P0118F01	370	239	P0336F01
41	8	P0021F01	154	121	P0171F01	268	49	P0072F01	371	237	P0334F01
42	6	P0019F01	156	153	P0212F01	269	46	P0069F01	372	236	P0333F01
43	5	P0018F01	158	154	P0213F01	273	47	P0070F01	375	210	P0280F01
45	54	P0081F01	159	130	P0182F01	274	48	P0071F01	376	209	P0279F01
47	77	P0113F01	160	128	P0180F01	275	15	P0028F01	377	202	P0272F01
48	78	P0114F01	161	129	P0181F01	279	16	P0029F01	378	203	P0273F01
49	2	P0014F01	163	122	P0173F01	280	17	P0030F01	379	204	P0274F01
50	3	P0015F01	164	123	P0174F01	281	19	P0032F01	380	205	P0275F01
53	50	P0074F01	167	184	P0251F01	282	18	P0031F01	381	206	P0276F01
54	51	P0075F01	168	243	P0343F01	283	22	P0039F01	382	207	P0277F01
55	19	P0013D01	169	244	P0344F01	284	23	P0040F01	383	107	P0147F01
56	41	P0064F01	170	242	P0342F01	285	82	P0121F01	384	106	P0146F01
57	191	P0258F01	171	241	P0341F01	286	83	P0122F01	385	104	P0144F01
59	229	P0308F01	175	251	P0353F01	287	35	P0058F01	386	105	P0145F01
61	227	P0306F01	176	240	P0386F01	289		B0032F01	387	208	P0278F01
62	176	P0240F01	177	250	P0350F01	290		B0210F01	388		B0209F01
65	226	P0303F01	178	266	P0378F01	292	37	P0060F01	389		B0032F01
67	201	P0271F01	179	267	P0379F01	295	101	P0140F01	390		B0210F01
70	228	P0307F01	180	246	P0346F01	296	100	P0139F01	391		B0033F01
71	225	P0302F01	181	245	P0345F01	297	99	P0138F01	392		B0132F01
72	224	P0301F01	182	247	P0347F01	298	98	P0137F01	393		B0131F01
73	175	P0239F01	183	186	P0253F01	300	102	P0141F01	394		B0133F01
74	200	P0270F01	184	185	P0252F01	301	103	P0142F01	395		B0135F01
75	173	P0234F01	186	254	P0357F01	302	84	P0123F01	396		B0023F01
76	62	P0090F01	188	253	P0355F01	303	89	P0128F01	397		B0024F01
79	61	P0088F01	189	252	P0354F01	304	87	P0126F01	398		B0203F01
80	60	P0087F01	190	248	P0348F01	305	86	P0125F01	399	232	P0327F01
81	199	P0269F01	191	249	P0349F01	306	85	P0124F01	400		B0207F01
82	192	P0261F01	192	189	P0256F01	307	90	P0129F01	401		B0208F01
83	194	P0263F01	193	188	P0255F01	308	95	P0134F01	402		B0031F01
84	193	P0262F01	194	187	P0254F01	309	96	P0135F01	403		B0030F01
86	58	P0085F01	195	190	P0257F01	310	91	P0130F01	404	231	P0325F01
87	195	P0265F01	196	264	P0375F01	311	92	P0131F01	405		B0211F01
89	198	P0268F01	198	265	P0376F01	312	93	P0132F01	406		B0034F01
90	197	P0267F01	203	263	P0372F01	313	94	P0133F01	407		B0122F01
91	196	P0266F01	204	262	P0371F01	314	152	P0211F01	408		B0130F01
92	135	P0190F01	209	256	P0362F01	315	144	P0201F01	409		B0134F01
93	134	P0189F01	210	259	P0367F01	316	146	P0203F01	412		B0127F01
94	136	P0191F01	211	261	P0369F01	318	145	P0202F01	413		B0129F01
95	12	P0025F01	212	260	P0368F01	319	151	P0209F01	414		B0128F01
96	14	P0027F01	213	222	P0299F01	321	---	P0210C01	415		B0233F01
97	13	P0026F01	215	258	P0364F01	322	147	P0204F01			
99	11	P0024F01	216	257	P0363F01	323	148	P0205F01			
100	10	P0023F01	217	221	P0298F01	324	150	P0207F01			
101	20	P0033F01	218	223	P0300F01	325	149	P0206F01			
102	21	P0034F01	219	126	P0177F01	327	115	P0159F01			
105	177	P0242F01	220	125	P0176F01	329	113	P0153F01			
106	178	P0243F01	226	220	P0297F01	330	112	P0152F01			
107	180	P0245F01	227	124	P0175F01	331	111	P0151F01			
108	179	P0244F01	228	127	P0179F01	332	110	P0150F01			
110	181	P0248F01	229	218	P0295F01	334	109	P0149F01			
111	182	P0249F01	230	219	P0296F01	336	116	P0160F01			
112	183	P0250F01	232	216	P0288F01	337	117	P0161F01			
115	174	P0235F01	233	215	P0287F01	338	114	P0158F01			
115	174	P0235F01	234	213	P0285F01	339	108	P0148F01			
116	164	P0223F01	234	213	P0285F01	340	118	P0162F01			
118	167	P0226F01	235	214	P0286F01						

Table 12. MAP , LABORATORY , AND FIELD SAMPLE NUMBERS FOR ROCK-CHIP SAMPLES

Map	Lab	Field	Map	Lab	Field	Map	Lab	Field	Map	Lab	Field
1	47	P0110R01	88	85	P0264R01	199	4	P0005R01	291	49	P0115R01
11	42	P0096R01	98	32	P0063R01	200	5	P0005R02	293	50	P0116R01
12	45	P0099R01	103	24	P0038R01	201	115	P0359R01	294	51	P0116R02
13	44	P0098R01	104	79	P0238R01	202	120	P0370R01	299	55	P0155R01
14	43	P0097R01	109	3	P0004R01	205	121	P0373R01	317	73	P0203R03
21	17	P0011R01	113	77	P0236R01	206	118	P0365R01	320	74	P0208R01
22	18	P0012R01	114	78	P0237R01	207	116	P0360R01	326	54	P0154R01
25	41	P0094R01	117	75	P0227R01	208	117	P0361R01	328	57	P0157R01
26	40	P0093R01	122	81	P0246R01	214	119	P0366R01	335	56	P0156R01
27	16	P0010R01	127	76	P0229R01	221	65	P0178R01	344	105	P0330R01
31	20	P0016R01	130	68	P0187R01	222	89	P0289R01	347	106	P0331R01
32	15	P0009R01	132	66	P0185R03	223	90	P0290R01	359	99	P0319R01
33	14	P0008R01	133	67	P0186R01	224	91	P0291R01	360	100	P0320R01
35	35	P0078R01	136	70	P0194R01	225	92	P0292R01	363	98	P0318R01
36	36	P0079R01	137	71	P0194R02	231	93	P0294R01	364	97	P0317R01
38	1	P0001R01	143	72	P0197R01	248	25	P0049R01	373	88	P0284R01
44	13	P0007R01	150	59	P0166R01	250	26	P0050R01	374	87	P0281R01
46	37	P0080R01	151	58	P0165R01	251	27	P0051R01	410	103	P0324R01
51	33	P0073R01	153	63	P0170R01	252	28	P0052R01	411	101	P0322R01
52	34	P0073R02	155	64	P0172R01	254	30	P0055R01	416	104	P0323R01
58	83	P0259R01	157	60	P0167R01	256	29	P0054R01	417	104	P0326R01
60	96	P0308R02	162	62	P0169R01	258	31	P0057R03			
63	94	P0304R01	165	61	P0168R01	267	108	P0338R01			
64	95	P0305R01	166	82	P0247R01	270	110	P0340R01			
66	80	P0241R01	172	111	P0351R01	271	107	P0337R01			
68	86	P0271R03	173	112	P0352R01	272	109	P0039R01			
69	84	P0260R01	174	113	P0352R02	276	23	P0037R01			
77	39	P0090R03	185	123	P0377R01	277	22	P0036R01			
78	38	P0089R01	187	114	P0356R01	278	21	P0035R01			
85	69	P0188R01	197	122	P0374R01	288	52	P0120R01			

APPENDIX 2. LABORATORY PROCEDURES FOR SEDIMENT AND ROCK GEOCHEMISTRY

In general, the word "sample" has two meanings in this study: (1) the raw or field sample taken, and (2) the analytical sample prepared from the field sample. The latter samples were analyzed to produce the composition data included within this report. The analytical samples for stream silt sediments were the minus 80-mesh fraction of the raw samples. (As indicated earlier, the term "silt" is used frequently in reference to stream sediments. It should be understood that the term "silt," as used in this report, includes sand, silt, and clay fractions and does not refer to the narrow particle size range normally defined by the term "silt." For rock chips, the minus 80-mesh material (pulp) produced by grinding constituted the analytical samples.

Sample Preparation (DOGAMI)

The silt samples were air dried and then ground lightly using a disc pulverizer with discs set at about 1/8-in. separation. Each sample was then screened in all-stainless-steel sieve sets. The minus 80-mesh (177-micron) fraction was homogenized by rolling on a rubber cloth, split into two or more portions, and bagged. The oversize portion was then discarded.

After air drying, the rock samples were crushed and then ground to minus 100-mesh (149-microns) in a disc pulverizer. Each sample was homogenized by rolling as described above, split into two or more portions, and bagged.

DOGAMI's Analytical Procedures--Silt

1. Copper-Zinc (Cu-Zn): A 5-gram (g) sample was treated with 25 milliliters (ml) of hydrochloric acid (HCl), 5ml of nitric acid (HNO₃) and, after reaction had slowed, with 5 ml of a 5-percent solution of potassium chlorate (KClO₃). After this dissolution was complete, the unfiltered mixture was made to volume with deionized water in a 250-ml volumetric flask. The solution was used to determine Cu and Zn by flame atomic absorption (AA).
2. Molybdenum (Mo): A 100-ml aliquot (via graduated cylinder) of the above solution was taken to dryness and then redissolved with 5 ml of HNO₃, 2 ml of HCl,

and 2 ml of 5-percent KClO_3 . The unfiltered mixture was transferred to a graduated 50-ml plastic centrifuge tube, 5 ml of glacial acetic acid was added, and the volume was brought to 25 ml with deionized water. The solution was used to determine Mo by flame AA.

3. Silver-Lead (Ag-Pb): The method developed by Viets (1978) was used to determine these two elements. In general, the method employs KClO_3 -HCl digestion, addition of ascorbic acid and potassium iodide (KI), selective extraction of the elements with tricaprylmethylammonium chloride-methylisobutylketone (MIBK), and flame AA determination of these two elements in the organic phase.

The method was modified as follows:

- (a) 50-ml plastic centrifuge tubes (Falcon type) were used for the digestion/extraction.
 - (b) 2 g of sample rather than 1 g were used.
 - (c) The samples were ashed at 450°C . prior to dissolution. Excessive foaming during the acid dissolution was encountered and is, according to Viets, due to organic debris and/or carbonates. Ashing of the samples until very little black carbon residue was left was effective in reducing the foaming. There was no apparent loss of Ag or Pb in this limited time-at-temperature ashing, as determined by "before and after" tests on several samples.
4. Gold (Au): Fire assay was used to collect, in 1 milligram (mg) of Pd, the gold in a 25-g portion of each sample. The resulting bead was first treated with 0.5-ml of HNO_3 and then with 1.5-ml of HCl. The solution was allowed to sit overnight to outgas, and Au was determined by flame AA.

DOGAMI's Analytical Procedures--Rock Chips

The methods used for sediments were used for the rock samples with these modifications: (1) Except for Au, the methods for the other elements involved dissolution with HF and its removal by taking to dryness as a preliminary step. For Ag-Pb, the HF treatment of Viets (1978) was followed. (2) Ashing was required for the four coal-bearing samples.

Detailed procedures on the chemical preparation of the sediment and rock samples are available from the DOGAMI laboratory.

Notes on Atomic Absorbtion Analyses Performed by DOGAMI

The instrument employed was a Perkin-Elmer model 4000 AA. Perkin-Elmer "cookbook" conditions were used.

Prior to analysis of the samples, replicate determinations of each element were made in the standards used for instrument calibration. Absorbances and concentrations were plotted in order to obtain the range of linearity for each element and to determine if each element curve started at zero absorbance and zero concentration. This procedure also allowed detection of incorrectly made standards. For each element, one high-concentration standard within the linear range was chosen for the blank-and-one-standard calibration method recommended by Perkin-Elmer.

1. Au--242.8 nanometer (nm): The standards used were in the same acid matrix as the samples but without added Pd. The blank used was Pd carried through the fire assay process and dissolved in the same manner as the samples. Absorbance readings were obtained in the following order: a Pd blank, five (or fewer) samples, and a Pd blank. The average Pd blank absorbance was subtracted from sample absorbances, and the corrected sample absorbances were converted to concentrations.

The practical detection limit was 0.002 parts per million (ppm) for 25-g samples (as concentrated and collected in Pd via fire assay) in 2-ml solution. Close attention to flame conditions was necessary to maintain this limit. Somewhat higher detection limits were obtained where the sample available was limited.

2. Ag--328.1 nm (background correction); Pb--283.3 nm (background correction): The standards and blank were prepared by Viets' (1978) method. Both elements were read directly in the concentration mode using one standard calibration.

The practical detection limits were 0.02 ppm for Ag and 0.2 for Pb. These values are comparable to those given by Viets.

3. Cu--324.8 nm; Zn--213.9 nm; Mo--313.3 nm (nitrous oxide/acetylene, background correction): Even though the standards were in highly concentrated solutions (2 g/100 ml for Cu and Zn, 8 g/100 ml for

Mo), the aqueous standards were effective in producing acceptable results. This was evidenced by the favorable correspondence of the standard reference material data obtained in this study with their "certified" concentrations. Concentrations were read directly using one-standard calibrations.

The detection limits for Cu and Zn were well below the standard concentrations obtained, and no estimates of the practical detection limits were made. The practical detection limit for Mo was generally 0.2 ppm. Close attention to flame conditions and frequent restandardization were necessary to maintain this limit for Mo.

Chemex's Analytical Procedures

1. Gold: For low-grade samples and geochemical materials, a 10-g sample was fused in litharge, carbonate, and siliceous flux with the addition of 10 mg of Au-free silver and cupelled. The silver bead was parted with dilute HNO_3 and analyzed for Au on an AA spectrophotometer. The detection limit was 0.005 ppm.
2. Silver, copper, molybdenum, lead, and zinc: A 1.0-g portion of the sample was weighed into a calibrated test tube. The sample was digested using hot 70-percent HClO_4 and concentrated HNO_3 . Digestion time was 2 hours. The sample volume was adjusted to 25 ml using demineralized water. Sample solutions were homogenized and allowed to settle before being analyzed by AA procedures. Detection limits using the Techtron A.A.5 AA unit were as follows: Ag=0.2 ppm; and Cu, Mo, Pb, and Zn=1 ppm. Ag and Pb values were corrected for background absorbtion.
3. Arsenic: A 1.0-g sample was digested with a mixture of HClO_4 and HNO_3 to strong fumes of HClO_4 . The digested solution was diluted to volume and mixed. An aliquot of the digest was acidified, reduced with KI, and mixed. A portion of the reduced solution was converted to arsine with NaBH_4 , and the As content was determined using flameless AA. Detection limit was 1 ppm.
4. Mercury: The sample was digested with HNO_3 plus a small amount of HCl . Following digestion, the resulting clear solution was transferred to a reaction flask connected to a closed system absorption cell. Stannous sulfate was rapidly added to reduce Hg to its elemental state. The Hg was then flushed out of the reaction vessel into the absorption cell where it was measured by cold vapor AA methods with a Varian

spectrophotometer. The absorbance of samples was compared with the absorbance of freshly prepared Hg standard solutions carried through the same procedure. Detection limit was 5 ppb.

Additional Notes

The analytical methods used in-house for this project have been used in other recent DOGAMI projects (see Ferns and Brooks, 1983; Gray and Berri, 1983; and Gray and others, 1983).

Sufficient material remains from nearly all the samples for the analytical determination of other path-finder elements. Tribromoethylene-separated light- and heavy-mineral fractions are also available for chemical analysis.

Although manganese (Mn) was not included in the analytical format for this study, considerable Mn was observed during the chemical dissolution of some of the rock samples. After the end of the sampling phase of the project, psilomelane, ranging in size from pebbles to boulders, was found in a field 1 mi west of sample sites 164 and 263 (Mud Spring Creek drainage).

Quality-Control Notes

Chemex Laboratories, Ltd., was asked to provide data on samples designated as quality-control samples for comparison with DOGAMI results. Although Chemex used different dissolution methods for Ag, Cu, Pb, Zn, and Mo, its results were generally close to in-house replicate analyses. Chemex's detection limits were somewhat greater for Au, Ag, Pb, and Mo.

DOGAMI's chemical preparation of the standard reference materials selected for measurements of accuracy was done with somewhat greater care than with the samples. Filtration and more accurate volumetric measurements were employed for the standards.

Accuracy

A number of standard reference materials (SRM's) were analyzed in order to evaluate the analytical methods employed with the samples. The correspondence of the element concentrations of the SRM's obtained by these methods with their certified concentrations allows a measurement of the accuracy of the data obtained by these methods.

The data obtained represents "total" element concentrations, and accuracy measurement is therefore applicable only to the rock samples. There are no standards available for "extractable" element concentrations, and measurement of accuracy in the sediment samples was not possible.

GOLD

No standards were available.

SILVER ppm

<u>Standard</u>	<u>This Study</u>	<u>"Certified"</u>			
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
USGS AGV-1	0.095	0.11	0.11	---	---
USGS BCR-1	0.045	0.036	0.03?	---	---
USGS G-2	0.050	0.049	---	---	---
USGS W-1	0.085	0.081	0.081	---	---
NBS 330	1.36	---	---	1.51	---
NBS 331	0.325	---	---	0.243	---
CSRM KC-1	1048.	---	---	---	1140
CSRM MP-1	54.1	---	---	---	57.9

COPPER ppm

<u>Standard</u>	<u>This Study</u>	<u>"Certified"</u>			
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
USGS AGV-1	63.6	59.7	63	---	---
USGS BCR-1	20.6	18.4	19	---	---
USGS DTS-1	9.4	7.0	7	---	---
USGS G-2	13.4	11.7	11	---	---
USGS W-1	121.	110	110	---	---
NBS 329	1376.	---	---	1320	---
NBS 331	907.	---	---	910	---
CSRM KC-1	1190.	---	---	---	1140
CSRM HV-1	4820.	---	---	---	5200

LEAD ppm

<u>Standard</u>	<u>This Study</u>	<u>"Certified"</u>	
		<u>1</u>	<u>2</u>
USGS AGV-1	36.4	35.1	36
USGS BCR-1	13.7	17.6	15
USGS G-2	31.1	31.2	29
USGS W-1	6.4	7.8	8

ZINC ppm

<u>Standard</u>	<u>This Study</u>	<u>"Certified"</u>		
		<u>1</u>	<u>2</u>	<u>5</u>
USGS AGV-1	92.4	84	84	---
USGS BCR-1	131.4	120	120	---
USGS DTS-1	36.3	45	45	---
USGS G-2	86.3	85	85	---
USGS W-1	87.1	86	86	---
BCS 183/3	31,900.			32,500

MOLYBDENUM ppm

<u>Standard</u>	<u>This Study</u>	<u>"Certified"</u>			
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
USGS AGV-1	3.2	2.3	3?	---	---
USGS BCR-1	1.8	1.1	3?	---	---
USGS DTS-1	<0.1	0.2	---	---	---
USGS G-2	0.2	0.36	1?	---	---
USGS W-1	0.5	0.57	0.6?	---	---
NBS 331	26.5	---	---	22.	---
CSRM HV-1	559.	---	---	---	580
CSRM MP-1	143.	---	---	---	140

1. Flanagan, F. J. 1976, Description and analyses of eight new USGS rock standards: U.S. Geological Survey Professional Paper 840, p. 171-172.

2. Abbey, S. 1973, Studies in "standard samples" of silicate rocks and minerals--Part 3: Extension and revision of "usable" values: Geological Survey of Canada Paper 73-36, 25 p.

3. National Bureau of Standards (NBS)
NBS 329: Zinc Concentrate
NBS 330: Copper Ore Mill Heads
NBS 331: Copper ORd Mill Tails
4. Canadian Standard Reference Materials (CSRM)
CSRM HV-1: Copper-Molybdenum Ore
CSRM KC-1: Zinc-Lead-Tin-Silver Ore
CSRM MP-1: Zinc-Tin-Copper-Lead Ore
5. British Chemical Standards (BCS)
BCS 183/3: Leaded Gunmetal (CU base alloy)

Reproducibility

The following tables list replicate results for those elements determined in the DOGAMI lab. The average values listed are the average of DOGAMI results. The values under the heading "Chemex" were determined by Chemex Laboratories, Ltd., and are quality-control check analyses. The quality-control data are summarized in the following tables: Table 13 contains silt sample data for gold and silver, and Table 14 has similar data for rock-chip samples. Table 15 contains silt sample data for copper and molybdenum, and Table 16 has similar data for rock-chip samples. Table 17 contains silt sample data for lead and zinc, while Table 18 has similar data for rock-chip samples.

Chemex provided original analyses for As and Hg; therefore replicate results and quality-control check analyses were not obtained for these elements. Silt sample 56 was used by the field geologist as a blind sample. Assays were conducted for each of the eight elements at least eight times. The results of these assays are shown in Table 19.

Table 13. QUALITY-CONTROL ASSAYS OF SILT SAMPLES FOR GOLD AND SILVER*

Map sample no.	Gold [ppm]				Average	Chemex	Silver [ppm]					Average	Chemex
	Analyses						Analyses						
2	0.039	LO.002	--	--	0.020	--	--	--	--	--	--	--	--
4	0.022	LO.002	--	--	0.011	--	--	--	--	--	--	--	--
8	0.009	LO.004	--	--	0.004	--	--	--	--	--	--	--	--
9	0.016	0.006	--	--	0.011	--	--	--	--	--	--	--	--
10	0.017	0.008	--	--	0.012	--	--	--	--	--	--	--	--
15	0.066	LO.002	--	--	0.033	--	--	--	--	--	--	--	--
16	LO.004	0.008	0.004	--	0.003	LO.005	0.047	0.030	--	--	0.04	--	--
17	0.004	LO.004	--	--	0.003	--	0.025	0.090	0.095	0.033	0.019	0.05	0.1
18	LO.004	LO.004	--	--	LO.004	--	--	--	--	--	--	--	--
19	LO.004	0.004	--	--	0.002	--	--	--	--	--	--	--	--
20	0.004	LO.004	--	--	0.002	--	--	--	--	--	--	--	--
23	0.012	LO.004	LO.002	LO.002	0.003	--	--	--	--	--	--	--	--
24	0.032	0.004	LO.002	--	0.012	--	--	--	--	--	--	--	--
30	0.034	0.002	--	--	0.018	--	--	--	--	--	--	--	--
37	0.038	0.024	--	--	0.031	--	--	--	--	--	--	--	--
39	0.054	0.004	0.003	LO.002	0.015	--	--	--	--	--	--	--	--
40	0.084	LO.002	--	--	0.042	--	--	--	--	--	--	--	--
41	0.012	0.005	--	--	0.008	--	--	--	--	--	--	--	--
42	0.016	LO.002	--	--	0.008	--	--	--	--	--	--	--	--
43	0.058	0.002	--	--	0.030	--	--	--	--	--	--	--	--
47	0.030	LO.004	0.002	LO.002	0.008	--	--	--	--	--	--	--	--
48	0.030	0.002	--	--	0.016	--	--	--	--	--	--	--	--
49	0.026	0.032	0.029	0.030	0.029	--	0.016	0.028	--	--	0.02	--	--
50	0.030	0.005	--	--	0.018	--	--	--	--	--	--	--	--
53	0.013	0.018	--	--	0.016	LO.005	0.026	0.090	0.090	0.057	--	0.07	0.1
56	0.004	0.004	--	--	0.004	--	--	--	--	--	--	--	--
57	--	--	--	--	--	--	0.036	0.039	0.028	0.030	--	0.03	0.1
62	0.002	LO.002	--	--	LO.002	--	0.068	0.054	0.034	0.030	--	0.05	--
67	--	--	--	--	--	--	0.064	0.055	0.024	0.054	--	0.05	--
71	--	--	--	--	--	--	0.066	0.065	0.060	0.135	--	0.08	--
73	LO.002	LO.002	--	--	LO.002	--	0.025	0.036	0.017	--	--	0.02	--
74	LO.004	0.066	0.014	--	0.027	LO.005	0.047	0.097	0.035	--	--	0.06	0.1
75	LO.002	0.017	0.031	--	0.016	--	--	--	--	--	--	--	--
76	0.012	LO.004	--	--	0.006	--	--	--	--	--	--	--	--
80	0.040	0.018	--	--	0.029	LO.005	0.040	0.075	0.098	0.065	--	0.07	0.1
81	LO.002	LO.002	LO.002	--	LO.002	--	--	--	--	--	--	--	--
87	--	--	--	--	--	--	0.026	0.043	0.035	--	--	0.04	--
90	--	--	--	--	--	--	0.053	0.108	0.069	--	--	0.08	--
91	0.025	LO.002	--	--	0.012	--	0.031	0.037	0.031	0.030	--	0.03	--
93	--	--	--	--	--	--	0.030	0.034	0.031	0.037	--	0.03	--
94	0.009	LO.004	--	--	0.004	--	0.049	0.051	0.031	0.061	--	0.04	--
95	0.011	LO.002	--	--	0.006	--	--	--	--	--	--	--	--
97	0.016	0.002	--	--	0.009	--	--	--	--	--	--	--	--
99	0.015	LO.002	--	--	0.008	--	--	--	--	--	--	--	--
100	0.014	LO.002	--	--	0.007	LO.005	0.063	0.137	0.135	0.092	0.019	0.09	0.1
101	0.010	LO.004	0.003	LO.002	0.003	LO.005	0.110	0.140	0.136	0.096	0.130	0.12	0.1
102	0.033	0.003	LO.002	--	0.012	--	--	--	--	--	--	--	--
105	LO.002	LO.002	--	--	LO.002	--	--	--	--	--	--	--	--
106	0.003	0.003	0.015	--	0.007	--	--	--	--	--	--	--	--
107	0.046	0.074	--	--	0.060	LO.005	0.073	0.138	0.052	--	--	0.09	0.2
108	LO.002	0.002	0.046	--	0.016	--	--	--	--	--	--	--	--
110	--	--	--	--	--	--	0.050	0.057	0.033	0.030	--	0.04	--
115	LO.002	0.037	--	--	0.018	--	--	--	--	--	--	--	--
118	LO.002	0.004	--	--	0.002	--	--	--	--	--	--	--	--
119	LO.002	0.050	--	--	0.025	--	--	--	--	--	--	--	--
120	LO.002	0.002	--	--	LO.002	--	--	--	--	--	--	--	--
121	LO.002	LO.002	--	--	LO.002	--	--	--	--	--	--	--	--
123	LO.002	LO.002	--	--	LO.002	--	--	--	--	--	--	--	--
125	0.060	0.006	--	--	0.033	--	--	--	--	--	--	--	--
129	0.014	0.006	0.005	--	0.008	LO.005	0.134	0.151	0.032	--	--	0.11	0.1
135	0.010	0.017	--	--	0.014	LO.005	0.035	0.101	0.087	0.058	0.017	0.06	0.1
140	0.056	LO.002	--	--	0.028	--	--	--	--	--	--	--	--
147	0.005	LO.002	--	--	0.002	--	--	--	--	--	--	--	--
148	0.007	0.032	LO.004	--	0.020	LO.005	0.169	0.094	0.055	0.072	0.029	0.08	0.1
149	0.002	LO.002	--	--	0.007	--	--	--	--	--	--	--	--
154	0.014	LO.002	--	--	0.007	--	--	--	--	--	--	--	--
159	LO.004	0.012	--	--	0.006	LO.005	0.021	0.085	0.091	0.042	0.153	0.08	0.1
160	--	--	--	--	--	--	0.027	0.025	0.019	--	--	0.02	--
163	--	--	--	--	--	--	0.018	0.018	0.022	--	--	0.02	--
176	LO.002	LO.002	--	--	LO.002	LO.005	0.098	0.029	0.015	0.021	0.025	0.04	0.1

Table 13. QUALITY-CONTROL ASSAYS OF SILT SAMPLES FOR GOLD AND SILVER -- Continued

Map sample no.	Gold [ppm]					Silver [ppm]					Average	Chemex
	Analyses				Average	Analyses				Average		
177	LO.002	0.004	LO.002	LO.002	LO.002	LO.005	0.115	0.115	0.029	0.023	0.07	0.1
178	---	---	---	---	---	---	0.033	0.035	0.031	0.125	0.06	---
179	LO.002	0.003	---	---	0.002	LO.005	0.085	0.095	0.025	---	0.06	0.1
181	---	---	---	---	---	---	0.036	0.044	0.120	0.055	0.07	---
183	---	---	---	---	---	---	0.026	0.031	0.023	0.029	0.03	---
184	---	---	---	---	---	---	0.019	0.030	0.027	---	0.03	---
195	LO.004	0.006	---	---	0.003	LO.005	0.037	0.121	---	---	0.08	0.1
198	---	---	---	---	---	---	0.285	0.026	0.012	0.101	0.11	---
212	0.002	LO.002	---	---	0.002	LO.005	0.081	0.152	0.027	---	0.09	0.2
226	LO.004	0.010	0.034	---	0.015	LO.005	0.118	0.111	0.043	---	0.09	0.1
227	---	---	---	---	---	---	0.032	0.038	0.080	0.047	0.05	---
228	0.002	LO.002	---	---	0.011	---	---	---	---	---	---	---
232	---	---	---	---	---	---	0.054	0.062	0.050	---	0.06	---
233	---	---	---	---	---	---	0.041	0.046	0.029	0.034	0.04	---
237	---	---	---	---	---	---	0.036	0.030	0.012	0.086	0.04	---
238	---	---	---	---	---	---	0.042	0.044	0.015	0.039	0.04	---
240	0.024	LO.004	0.003	LO.002	0.007	---	---	---	---	---	---	---
241	0.024	LO.004	LO.002	LO.002	0.008	---	---	---	---	---	---	---
242	0.060	0.014	LO.004	LO.022	0.024	LO.005	0.024	0.081	0.099	0.074	0.06	0.1
243	0.026	0.017	0.082	---	0.042	LO.005	0.058	0.113	0.114	0.078	0.09	0.1
246	0.008	0.004	---	---	0.006	---	---	---	---	---	---	---
247	0.038	LO.004	LO.002	0.078	0.029	---	---	---	---	---	---	---
249	0.014	0.030	---	---	0.022	---	---	---	---	---	---	---
253	0.034	0.003	LO.002	---	0.012	---	---	---	---	---	---	---
255	0.054	LO.002	LO.002	---	0.018	---	---	---	---	---	---	---
257	0.022	LO.002	LO.002	---	0.007	---	---	---	---	---	---	---
261	0.034	LO.002	---	---	0.017	---	---	---	---	---	---	---
262	0.022	LO.002	---	---	0.011	---	---	---	---	---	---	---
265	0.026	0.033	---	---	0.030	---	---	---	---	---	---	---
266	0.038	0.016	0.042	---	0.032	LO.005	0.020	0.131	0.141	0.092	0.09	0.1
268	0.041	0.006	---	---	0.024	---	---	---	---	---	---	---
273	0.057	LO.002	---	---	0.028	---	---	---	---	---	---	---
279	0.041	LO.002	---	---	0.020	---	---	---	---	---	---	---
280	0.025	LO.002	LO.002	---	0.008	---	---	---	---	---	---	---
281	0.015	LO.004	---	---	0.008	---	---	---	---	---	---	---
283	0.017	LO.004	---	---	0.008	---	---	---	---	---	---	---
284	0.029	LO.002	0.004	---	0.011	---	---	---	---	---	---	---
285	0.027	LO.002	---	---	0.014	---	---	---	---	---	---	---
287	0.038	0.003	LO.002	---	0.014	---	---	---	---	---	---	---
289	0.019	0.004	---	---	0.012	---	---	---	---	---	---	---
290	LO.004	LO.004	---	---	LO.004	---	0.025	0.044	0.022	---	0.03	---
292	0.050	LO.002	0.008	---	0.019	---	---	---	---	---	---	---
296	LO.004	0.060	0.038	LO.002	0.024	LO.005	0.041	0.125	0.135	0.083	0.08	0.2
297	---	---	---	---	---	---	0.058	0.057	0.022	0.036	0.04	---
298	LO.004	LO.004	---	---	LO.004	---	0.041	0.040	0.025	0.024	0.03	---
302	0.087	0.006	0.003	---	0.032	---	---	---	---	---	---	---
303	0.004	LO.004	---	---	0.002	---	---	---	---	---	---	---
307	0.048	0.064	0.010	---	0.041	LO.005	0.023	0.098	0.107	0.062	0.07	0.1
308	LO.004	LO.004	---	---	LO.004	---	---	---	---	---	---	---
309	LO.004	LO.004	---	---	LO.004	---	---	---	---	---	---	---
310	LO.004	LO.004	---	---	LO.004	---	---	---	---	---	---	---
311	LO.004	LO.004	---	---	LO.004	---	---	---	---	---	---	---
312	LO.004	LO.004	---	---	LO.004	---	---	---	---	---	---	---
314	0.045	0.002	---	---	0.024	---	---	---	---	---	---	---
324	0.004	0.012	0.026	---	0.014	LO.005	0.110	0.119	0.055	0.072	0.09	0.1
327	---	---	---	---	---	---	0.096	0.069	0.023	0.051	0.06	---
329	---	---	---	---	---	---	0.177	0.003	---	---	0.09	---
330	0.034	LO.002	---	---	0.017	---	0.084	LO.001	---	---	0.04	---
331	---	---	---	---	---	---	0.094	0.025	---	---	0.06	---
332	0.004	0.009	---	---	0.006	LO.005	0.081	0.093	0.112	0.061	0.06	0.1
334	0.016	0.002	---	---	0.009	---	---	---	---	---	---	---
338	---	---	---	---	---	---	0.106	0.031	---	---	0.07	---
340	---	---	---	---	---	---	0.106	0.001	---	---	0.05	---
358	0.007	LO.002	---	---	0.004	LO.005	0.120	0.109	0.067	---	0.10	0.2
375	0.005	0.040	0.014	---	0.020	LO.005	0.070	0.130	0.067	---	0.09	0.2
380	---	---	---	---	---	---	0.038	0.040	0.018	0.013	0.03	---
381	---	---	---	---	---	---	0.051	0.060	0.017	0.030	0.04	---
385	0.114	LO.002	---	---	0.057	---	0.035	0.092	0.030	---	0.05	---
386	---	---	---	---	---	---	0.027	0.052	0.010	0.030	0.03	---

* L= Below detection limit, which is the value listed.

Table 14. QUALITY-CONTROL ASSAYS OF ROCK-CHIP SAMPLES FOR GOLD AND SILVER*

Map sample no.	Gold [ppm]					Silver [ppm]						
	Analyses				Average	Chemex	Analyses				Average	Chemex
14	--	--	--	--	--	--	5.70	6.20	--	--	5.90	--
26	0.002	0.002	--	--	0.002	0.010	0.059	0.049	--	--	0.05	0.1
31	L0.002	L0.002	0.036	--	0.012	0.010	0.039	0.041	--	--	0.04	0.1
32	0.038	0.005	--	--	0.022	--	--	--	--	--	--	--
38	0.074	0.005	--	--	0.040	--	--	--	--	--	--	--
44	--	--	--	--	--	--	1.80	1.93	--	--	1.87	--
46	0.116	0.003	--	--	0.060	--	--	--	--	--	--	--
66	L0.002	L0.002	--	--	L0.002	0.005	0.169	0.097	0.145	--	0.14	0.2
77	0.074	0.002	--	--	0.038	--	--	--	--	--	--	--
78	0.024	0.006	0.003	--	0.011	--	--	--	--	--	--	--
136	L0.002	L0.002	--	--	L0.002	0.005	0.065	0.053	--	--	0.06	0.1
157	L0.002	L0.002	0.003	--	L0.002	0.010	0.078	0.045	--	--	0.06	0.1
166	0.032	0.018	--	--	0.025	--	--	--	--	--	--	--
172	0.030	0.003	--	--	0.016	--	--	--	--	--	--	--
173	0.003	L0.002	--	--	L0.002	--	--	--	--	--	--	--
174	0.020	L0.002	--	--	0.010	--	--	--	--	--	--	--
185	L0.002	L0.002	--	--	L0.002	--	--	--	--	--	--	--
187	0.004	L0.002	--	--	0.002	--	--	--	--	--	--	--
197	0.002	0.051	--	--	0.026	--	--	--	--	--	--	--
199	--	--	--	--	--	--	2.10	2.15	--	--	2.13	--
200	0.024	0.003	--	--	0.014	--	--	--	--	--	--	--
201	L0.002	L0.002	--	--	L0.002	--	--	--	--	--	--	--
202	L0.002	L0.002	L0.002	0.002	L0.002	L0.005	0.070	0.054	0.030	0.025	0.035	0.1
205	0.003	L0.002	--	--	0.002	--	--	--	--	--	--	--
223	L0.002	L0.002	0.004	--	L0.002	0.015	0.094	0.011	0.065	--	0.06	0.1
248	0.076	L0.002	--	--	0.038	--	--	--	--	--	--	--
254	L0.002	0.002	--	--	L0.002	0.005	0.145	0.204	--	--	0.17	0.1
270	0.008	L0.002	L0.002	--	0.003	L0.005	0.098	0.032	0.055	--	0.06	0.1
293	L0.002	L0.002	0.012	--	0.004	0.010	0.199	0.042	0.060	0.035	0.09	0.1
326	--	--	--	--	--	--	0.091	0.108	--	--	0.10	--
344	0.002	0.004	--	--	0.003	--	--	--	--	--	--	--
360	0.003	0.076	--	--	0.040	--	0.123	0.028	0.060	--	0.07	0.2
364	L0.002	0.106	--	--	0.053	--	--	--	--	--	--	--
417	0.005	0.012	--	--	0.008	--	--	--	--	--	--	--

* L= Below detection limit, which is the value listed.

Table 15. QUALITY-CONTROL ASSAYS OF SILT SAMPLES FOR COPPER AND MOLYBDENUM

Map sample no.	Copper [ppm]				Molybdenum [ppm]			
	Analyses		Average	Chemex	Analyses		Average	Chemex
16	14.9	16.6	16	14	0.4	0.5	0.4	1
53	21.9	21.6	22	22	0.2	0.2	0.2	1
74	16.6	19.0	18	16	0.5	0.2	0.4	1
80	20.9	20.4	21	21	0.2	0.4	0.3	1
100	24.4	24.8	25	24	0.6	0.7	0.6	1
101	27.0	26.9	27	24	0.2	0.5	0.4	1
107	24.4	23.8	24	24	0.5	0.8	0.6	1
129	41.5	41.8	42	43	0.4	0.4	0.4	1
135	22.6	26.8	25	20	0.4	0.4	0.4	1
148	25.7	29.0	27	30	0.4	0.4	0.4	1
159	32.4	38.9	36	33	0.3	0.3	0.3	1
176	41.4	43.8	43	40	0.4	0.4	0.4	1
177	37.2	32.7	35	37	0.4	0.5	0.4	1
179	36.3	39.6	38	36	0.6	0.7	0.6	1
195	28.7	34.0	31	28	0.4	0.4	0.4	1
212	29.4	25.8	28	25	0.3	0.3	0.3	1
226	44.4	40.8	43	37	0.4	0.4	0.4	1
242	16.9	17.6	17	14	0.2	0.3	0.2	1
243	36.2	33.8	35	31	0.4	0.3	0.4	1
266	35.3	44.0	40	36	0.6	0.5	0.6	1
296	25.8	22.8	24	27	0.3	0.1	0.2	1
307	25.2	31.4	28	29	0.2	0.2	0.2	1
324	30.0	30.4	30	27	0.2	0.3	0.2	1
332	23.3	24.5	24	27	0.3	0.3	0.3	1
358	44.8	38.0	41	42	0.5	0.3	0.4	1
375	32.4	39.4	36	37	0.4	0.3	0.4	1

Table 16. QUALITY-CONTROL ASSAYS OF ROCK-CHIP SAMPLES FOR COPPER AND MOLYBDENUM

Map sample no.	Copper [ppm]				Molybdenum [ppm]			
	Analyses		Average	Chemex	Analyses		Average	Chemex
26	17.6	18.0	18	12	6.0	4.3	5.2	6
31	8.3	8.9	9	6	65.9	64.1	65.0	41
66	25.2	27.0	26	26	1.6	1.5	1.6	3
136	23.2	26.4	25	25	45.4	57.1	51.3	34
157	28.2	28.8	28	27	2.7	2.8	2.8	3
202	14.1	14.1	14	12	14.4	15.8	15.1	4
223	17.5	17.7	18	15	4.5	4.0	4.2	4
254	17.6	19.0	18	13	57.1	57.6	57.4	33
270	20.4	20.0	20	13	1.9	1.7	1.8	1
293	37.7	39.8	39	33	5.3	3.6	4.4	1
360	55.5	58.0	57	45	0.5	0.5	0.5	1

Table 17. QUALITY-CONTROL ASSAYS OF SILT SAMPLES FOR LEAD AND ZINC

Map sample no.	Lead [ppm]							Zinc [ppm]				
	Analyses						Average	Chemex	Analyses		Average	Chemex
15	6.58	4.39	--	--	--	--	5	--	--	--	--	--
16	4.28	4.42	4.36	4.44	--	--	4	1	64.9	69.3	67	68
53	6.22	6.22	6.28	5.85	--	--	6	2	49.0	48.2	49	60
74	5.21	5.29	--	--	--	--	5	2	47.2	53.4	50	49
80	6.76	6.74	6.95	6.47	--	--	7	3	47.8	46.2	47	60
90	5.76	5.61	--	--	--	--	6	--	--	--	--	--
100	6.87	6.98	6.84	6.37	--	--	7	6	47.3	43.9	46	70
101	7.92	7.16	7.25	7.10	7.14	--	7	6	74.0	75.1	75	75
107	6.95	7.19	--	--	--	--	7	3	59.8	60.0	60	65
129	4.66	4.55	--	--	--	--	6	1	55.8	56.0	56	62
135	2.02	2.76	2.75	2.77	3.03	--	3	1	116.0	125.0	120	55
148	4.60	4.40	4.58	4.50	--	--	5	3	44.0	49.8	47	55
159	4.43	4.23	4.26	4.06	4.56	--	4	2	48.6	57.8	53	58
176	4.35	5.74	--	--	--	--	5	3	55.8	59.2	58	65
177	6.90	4.99	--	--	--	--	6	2	44.6	39.7	42	57
179	4.40	4.65	--	--	--	--	5	3	37.0	39.3	38	54
195	5.38	5.50	--	--	--	--	5	3	41.3	49.8	46	52
212	3.54	3.80	--	--	--	--	4	3	70.6	62.3	66	52
226	3.42	3.45	3.12	--	--	--	3	2	70.8	60.0	65	58
242	4.54	4.35	4.38	4.36	--	--	4	2	39.7	43.8	42	40
243	6.10	5.88	6.18	5.58	--	--	6	3	59.8	54.5	57	75
266	6.99	6.80	6.68	7.06	--	--	7	3	76.0	97.2	87	88
296	3.90	3.86	4.08	3.96	--	--	4	1	51.1	44.3	48	50
307	4.53	4.69	4.56	4.45	--	--	5	2	43.8	56.1	50	53
324	4.76	4.72	4.93	4.92	--	--	5	2	61.0	65.3	63	63
327	4.31	4.22	--	--	--	--	4	--	--	--	--	--
329	4.04	2.91	--	--	--	--	3	--	--	--	--	--
330	4.53	4.20	--	--	--	--	4	--	--	--	--	--
331	3.66	2.45	--	--	--	--	3	--	--	--	--	--
332	3.38	3.38	3.53	3.63	3.70	--	4	1	82.0	89.8	86	85
338	5.90	6.22	--	--	--	--	6	--	--	--	--	--
340	4.66	3.36	--	--	--	--	4	--	--	--	--	--
358	5.86	6.09	--	--	--	--	6	4	80.0	68.3	74	82
375	5.09	5.09	--	--	--	--	5	3	40.2	48.5	44	54
385	4.28	2.87	--	--	--	--	4	--	--	--	--	--
386	3.92	3.70	--	--	--	--	4	--	--	--	--	--

Table 18. QUALITY-CONTROL ASSAYS OF ROCK-CHIP SAMPLES FOR LEAD AND ZINC

Map sample no.	Lead [ppm]							Zinc [ppm]				
	Analyses						Average	Chemex	Analyses		Average	Chemex
26	4.41	5.04	--	--	--	--	5	1	14.8	15.2	15	14
31	1.30	1.58	--	--	--	--	1	1	4.4	3.8	4	5
66	10.32	11.40	9.05	--	--	--	10	3	42.3	43.9	43	50
136	9.21	9.22	--	--	--	--	9	1	27.7	29.9	29	32
157	3.45	2.91	--	--	--	--	3	1	73.8	74.4	74	80
202	2.62	2.35	2.20	2.85	--	--	3	1	18.2	18.2	18	24
223	1.16	1.14	1.15	--	--	--	1	1	12.4	12.5	12	18
254	20.32	21.46	--	--	--	--	21	15	80.0	80.4	80	84
270	1.60	1.80	1.30	--	--	--	2	1	23.4	23.1	23	20
293	2.14	2.50	3.10	1.85	1.45	2.75	2	1	21.6	22.4	22	26
326	6.50	6.09	--	--	--	--	6	--	--	--	--	--
360	5.36	4.95	4.65	--	--	--	5	1	78.8	76.9	78	75

Table 19. REPRODUCIBILITY OF ASSAYS FOR MAP
SAMPLE 56, WHICH WAS USED AS A
BLIND SAMPLE

Laboratory no.	Analyses							
	Gold	Silver	Arsenic	Copper	Mercury	Molybdenum	Lead	Zinc
41	0.004	0.06	4	20	0.09	0.2	6	45
71	0.004	0.06	5	16	0.10	0.4	6	38
88	L0.004	L0.02	9	18	0.12	L0.1	6	42
88	0.004	--	--	--	--	--	--	--
120	L0.004	0.16	9	18	0.08	0.4	5	43
120	0.012	0.10	--	17	--	0.5	6	40
120	--	0.10	--	--	--	--	--	--
120	--	0.06	--	--	--	--	--	--
120	--	0.01	--	--	--	--	--	--
120	--	0.03	--	--	--	--	--	--
156	L0.004	0.06	4	22	0.08	0.3	5	54
171	0.002	0.04	5	17	0.07	0.2	5	43
171	L0.002	0.04	--	--	--	--	--	--
171	--	0.03	--	--	--	--	--	--
171	--	0.02	--	--	--	--	--	--
217	L0.004	0.22	4	15	0.06	0.5	5	39
255	L0.002	0.03	4	17	0.03	0.3	5	39
255	--	0.04	--	--	--	--	--	--
255	--	0.02	--	--	--	--	--	--
255	--	0.04	--	--	--	--	--	--
255	--	0.10	--	--	--	--	--	--
Average	0.003	0.06	5	18	0.08	0.4	5	43
Chemex 120	L0.005	0.2	--	19	--	1	2	60

* L = Below detection limit, which is the value listed.

APPENDIX 3. LABORATORY PROCEDURES FOR GOLD PAN CONCENTRATES

In brief, the preparation of the gold pan concentrates began with the separation of the magnetic portion of the concentrates from the nonmagnetic portion and then the separation of the nonmagnetic concentrate into two fractions--a lighter fraction with a specific gravity less than 3 and a heavier fraction with a specific gravity greater than 3.

For this study, 180 samples of both light and heavy fractions were selected for study by petrographic microscope and long- and short-wavelength ultraviolet (UV) light.

The procedures are described below:

1. DOGAMI:

- a. Each concentrate was sieved, and the minus 20-mesh material was spread on 8-1/2- by 11-in. paper. The oversize was discarded.
- b. Magnetite and minerals intergrown with magnetite were removed with a hand magnet covered with 6- by 6-in. S and S weighing paper. Magnetic material was carried to and deposited on a second piece of 8-1/2- by 11-in. paper. The process was repeated until little additional intergrown magnetite could be picked up. (Note: It was not necessary to spend excessive time trying to remove the intergrown material. "Plowing through" and "patting the surface" of the spread-out material proved to be effective techniques.)
- c. The magnetic material was spread out and treated again as in step b (above) and deposited on a third piece of paper. This procedure was done to remove the nonmagnetic material entrained in the magnetic material.
- d. The magnetic material was transferred to a coin envelope previously marked with the sample identification number. The sample was then catalogued and placed in storage.

2. Barringer Laboratories:

- a. The nonmagnetic material was transferred to a 50-

ml plastic culture tube and separated with tetrabromoethane (TBE).

- b. After nonmagnetic material was separated with TBE and then washed to remove the TBE, the fraction with a specific gravity less than 3 was returned to the culture tubes and the fraction with a specific gravity greater than 3 was placed in appropriate-size glass bottles.

3. Van Atta:

- a. Heavy-mineral separates were each run through a sample splitter to obtain a representative split of 1,000-1,500 grains.
 - (1) The split of the heavies was mounted in Lakeside 70 (a thermoplastic) on a microscope slide and covered with a cover slip.
 - (2) The mounted split of the heavies was examined in transmitted plane and polarized light and under reflected light with a polarizing microscope.
- b. The light fraction of each sample was run through a sample splitter to obtain a representative split of 1,000 to 1,500 grains.
 - (1) The split of the lights was mounted in Lakeside 70 on a microscope slide, and the mount was ground down to expose most of the grains at the surface.
 - (2) The ground mount was stained to reveal the presence of potassium feldspar. This was done by etching the mount with hydrofluoric acid for 30 to 45 seconds and immersing it in a saturated solution of sodium cobaltinitrite for 30 to 45 seconds. Potassium-bearing minerals and rock fragments were stained canary yellow.
- c. The heavy-mineral fraction was examined by traversing the entire mounted split on a polarizing microscope with a mechanical stage. Successive lines of traverse were selected so that they overlapped slightly. In this manner, every grain in the mount was observed. Examination of the entire mounted split made it possible to determine the relative abundance of each species of heavy grain. The relative abundance of each species was characterized by one of the following

terms: Trace--one or two grains seen; rare--1 percent; minor--1 to 5 percent; common--5 to 10 percent; abundant--10 to 50 percent; flood--greater than 50 percent.

- d. The stained mount of the light split was examined with a polarizing microscope under reflected light. All the grains in each mount were examined by the method described in step c (above).
- e. Fluorescent mineral grains were examined under both short- and long-wavelength UV light. The sample was scattered on an inclined stainless steel sheet and crimped at one end to direct the mineral grains on the sheet into the sample bottle. The grains on the sheet were "stirred" with a camel's-hair brush to expose all grains to the UV light.