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GEOCHEMISTRY AND DESCRIPTION OF JASPEROID NEAR GROUSE, SOUTH-CENTRAL IDAHO

by

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A thesis submitted to the Faculty and the Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Master of Science (Geology)

Golden, Colorado

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ABSTRACT

Jasperoid bodies, in Paleozoic sedimentary rocks near Grouse, Idaho, range from massive and dense jasperoid showing original host rock textures to highly brecciated, quartz-healed jasperoid. Macroscopic and microscopic observation of the jasperoid bodies near Grouse indicate that the jasperoids are irregular replacements of carbonate-bank limestone sequences.

Fifty-four rock chip samples of jasperoid were collected from outcrops in the Grouse area and analyzed for sixteen elements: Ag, As, Au, Cu, Hg, Mo, Pb, Sb, Tl, Zn, Bi, Cd, Ga, Pd, Se, and Te. The suite of elements Ag, As, Au, Cu, Hg, Mo, Pb, Sb, and Zn was detected in a majority of jasperoid samples. Only a few of the samples had detectable amounts of Cd, Ga, and Tl. Although most of the samples did not have anomalous values for gold, trace elements often associated with gold, As, Sb, and Hg, were found in anomalous concentrations in some jasperoid samples. Element associations determined by correlation analysis include As-Sb-Hg and Pb-Ag. The suite of elements As-Sb-Hg is commonly associated with sediment-hosted disseminated precious-metal deposits. Lead and silver may have been locally derived from metalliferous sedimentary rocks, the McGowan Creek Formation, and could have been deposited under the same conditions that formed the jasperoid. Geochemical analyses of McGowan Creek Formation samples indicates that it may be locally enriched in Ag, Pb, and Zn.

A regional stream-sediment sampling program in the Grouse area indicates that the Mountain Springs Canyon and Rough Canyon areas have anomalous concentrations of As, Sb, and Hg, trace elements often associated with gold. This may indicate the presence of mineralized rock in these drainages. Both areas are downstream from north-trending faults that cut jasperoid bodies locally, suggesting that mineralization may have been fault-controlled.

These jasperoids are similar, geologically and geochemically, to jasperoid associated with sediment-hosted precious-metal deposits in the western United States. The jasperoids near Grouse probably formed by vein filling and replacement of carbonates by hydrothermal fluids. Many samples show multiple stages of brecciation and are cemented and veined with silica, indicating that more than one fluid was involved. The proximity of most of the jasperoids to faults indicates that deposition may be structurally controlled. The same hydrothermal fluids that formed the jasperoid may also have formed low-grade precious-metal deposits near the jasperoid bodies.

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1. INTRODUCTION

This investigation was designed to document the nature and extent of jasperoid bodies in Paleozoic sedimentary rocks near Grouse, Idaho. The lithology and geochemistry of Paleozoic sedimentary rocks were compared to the jasperoids in order to relate the alteration and geochemistry of the jasperoid to country rocks. These data were used to determine the degree of mineralization and to establish the potential for undiscovered gold deposits that might be associated with the jasperoid bodies. Jasperoid, as used in this paper, refers to "an epigenetic replacement of a previously lithified host rock" (Lovering, 1972).

This investigation was conducted by confirmation of previous geologic mapping, rock sampling for descriptive purposes and regional geochemical surveys. The regional geochemical survey included collection and analyses of rock-chip samples from outcrop, -80 mesh fraction of stream sediments, and heavy-mineral concentrates panned from stream sediments. Geochemical data were analyzed and interpreted with the aid of histograms and correlation analysis.

This study is part of a U.S. Geological Survey CUSMAP (Conterminous United States Mineral Assessment Program) project. Results of this report will be used to evaluate a part of the mineral resources of the Hailey 1° x 2° quadrangle and part of the Idaho Falls 1° x 2° quadrangle.

Location

The area studied is in south-central Idaho near the community of Grouse, in the northwest corner of the Idaho Falls 1° x 2° quadrangle. It is west of U.S. Highway 93 and northeast of the confluence of Cherry and Antelope Creeks (fig. 1). Most of the samples were collected on land administered by the U.S. Bureau of Land Management in the White Knob Mountain Wilderness Study Area. The area studied includes parts of two preliminary 7.5' topographic maps, the Mackay 4 (Grouse) NE and NW quadrangles, which cover the northern half of the Grouse 15' quadrangle. The topography of the study area is characterized by relatively steep terrane, with elevations ranging from about 5,990 feet along Antelope Creek to 7,995 feet north of Mountain Spring Canyon. Many intermittent streams drain the area and flow into Antelope Creek or Cherry Creek. The climate is semi-arid and the sparse vegetation includes sagebrush, juniper, pinon, and assorted grasses. Access is provided by unimproved dirt roads extending from improved roads along Antelope and Cherry Creeks.

Previous Work

Field area

The geology of the Grouse area was previously mapped by Nelson and Ross (1968; 1969a and b). Recent mapping by Skipp (1988; 1989) was used to locate jasperoid bodies near Grouse and is the basis for Plate 1 of the study area. Skipp and others (1979a) described the Mississippian and Pennsylvanian systems in Idaho. Link and others

(1988) discussed the stratigraphy and structure of Paleozoic sedimentary rocks in south-central Idaho. Sandberg (1975) named the McGowan Creek Formation, which crops out in the study area, for an argillite flysch sequence of Late Devonian and Lower Mississippian age in the Lost River Range of east-central Idaho. A study of the paleogeography of Mississippian turbidites in south-central Idaho by Nilsen (1977) included a discussion of the McGowan Creek Formation. Upper Paleozoic carbonate bank and forebank deposits including the Snaky Canyon and Bluebird Mountain Formations, present in the study area, were studied by Skipp and others (1979b).

The geology and mineral deposits of the Mackay area, near Grouse, were first described in a comprehensive report by Umpleby (1917), which includes a geologic map and short sections on the Alder Creek, Copper Basin, and Lava Creek Mining Districts. The mining history of south central Idaho was recorded by Ross (1963) and by Wells (1983). Worl and others (1989) assessed the mineral resource potential of the Challis National Forest which includes the Grouse area. Current research involving geology and mineral deposits of the Hailey and western Idaho Falls 1° x 2° quadrangles is in progress and preliminary results are discussed in Winkler and others (1989). This report includes an article by Soulliere and others (1989) on the geologic controls of mineralization in sedimentary rocks of the western Idaho Falls 1° x 2° quadrangle.

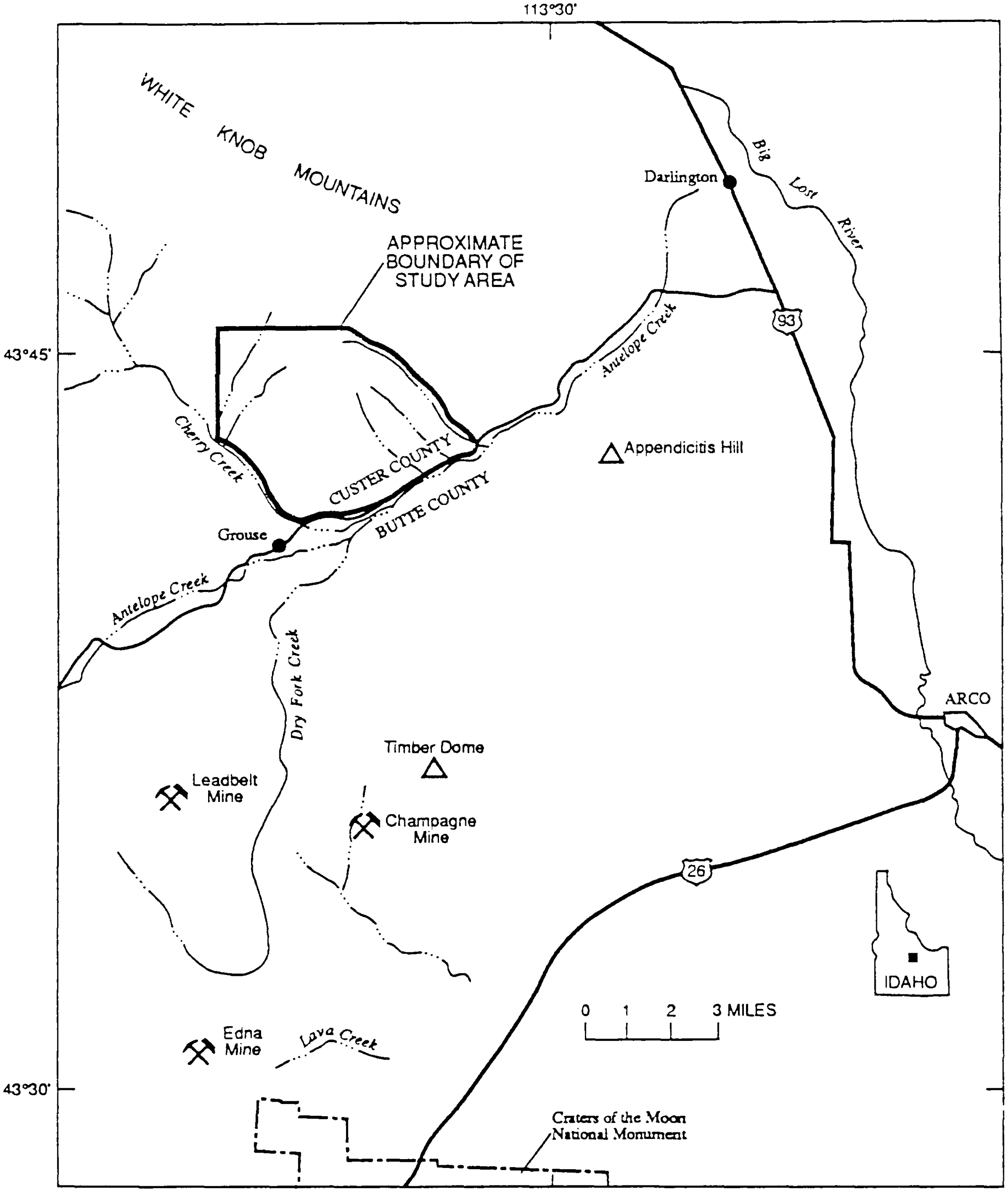


Figure 1 -- Index map of the Grouse area, south-central Idaho.

The geology and geochemistry of jasperoid rocks near Mackay were studied on a reconnaissance basis by Wilson and others (1988a and b) and Soulliere and others (1988). Data collected during these studies included results of the geochemical analysis of some samples collected for this thesis study. Results of studies by Wilson and others (1988) and Soulliere and others (1988) combined with information obtained during this thesis study will be used to evaluate the potential for sedimentary rock-hosted precious metal deposits in the western Idaho Falls 1x2 degree quadrangle.

Exploration geochemistry

Exploration geochemistry has proven to be an effective tool, when used in conjunction with geologic and geophysical information, for the exploration and assessment of undiscovered resources of large areas. Exploration geochemistry is based on established principles of the geochemical cycle and distribution of elements (Overstreet and Marsh, 1981). Textbook references on geochemical exploration include Beus and Grigorian (1977), Rose and others (1979), and Levinson (1980). Selected geochemical mineral exploration programs are described by Erickson and others (1964), Lovering and McCarthy (1978), Meyer and others (1979), Overstreet and Marsh (1981), Theobald (1981), and Hinkle (1988).

Most exposed or easily detected mineral deposits in the western United States have already been exploited. Therefore sophisticated geological and geochemical techniques are now needed to locate concealed deposits, including sedimentary-rock-hosted disseminated mineral deposits. The design of geochemical exploration programs for gold associated with sedimentary rock-hosted deposits is strongly influenced by new developments in ore deposit modeling. Studies specific to geochemistry and exploration for gold deposits include Lakin and others (1974), Barnes (1979), Boyle (1979), Roslyakov (1984), Boyle (1987), and Romberger (1988). Nichol and others (1989) address the issue of sample representivity in reference to gold exploration and outline stages for a successful exploration program. Govett and Nichol (1979) and Govett (1983) describe the successful use of lithogeochemistry, the most direct geochemical method used in mineral exploration. Crone and others (1984) and Nielson and Laskowski (1987) found that rock chip sampling and analysis is an effective medium in exploration for disseminated gold deposits.

Stream sediment sampling has become a widely used medium in reconnaissance mineral exploration (Overstreet and Marsh, 1981). Hinkle (1988) summarizes numerous exploration programs using geochemical sampling in arid environments, including stream-sediment and heavy-mineral panned concentrate sampling media. When using concentrate samples in evaluating potential for gold in an arid environment, Hinkle suggests that the sample media be analyzed for trace elements often associated with gold, such as arsenic, antimony, or mercury.

A broad spectrum of analytical techniques are available to obtain chemical information from sample media (Baedecker, 1987). Improved analytical instrumentation has provided rapid multi-element analyses, lowered the detection limit, and improved accuracy and precision for many elements of interest at lower unit costs (Church, 1981). Computer-aided data processing, including map plotting and multivariate statistial techniques, have aided interpretation of geochemical data.

Exploration for Sedimentary Rock-Hosted Disseminated Precious-Metal Deposits

Sedimentary rock-hosted disseminated deposits have been exploration targets since 1960 when the Carlin gold deposit was discovered in Nevada. This discovery, along with the increase in the price of gold and the development of heap-leach techniques for gold extraction, sparked interest in exploration for other sedimentary rock-hosted precious-metal deposits. These deposits originated from hydrothermal processes and do not contain visible gold in unoxidized ore nor are they known to contribute to placer deposits. Thus they are often termed "invisible gold" deposits and present unique challenges to exploration geologists. The fine grain size of the gold makes it difficult to detect by traditional means. Several publications describe the characteristics of known deposits and develop criteria for exploration (Hausen, 1967; Hausen and Kerr, 1968; Bagby and Berger, 1985; Tooker, 1985; Bagby and others, 1986; Berger, 1986; Romberger, 1986). A recent review of the characteristics of this deposit type may be found in a symposium volume on bulk mineable precious metal deposits of the western United States edited by Schafer and others (1988). In this volume, Percival and others (1988) review current models for origin and include descriptions of the physical and chemical characteristics of these deposits. The origin of sedimentary rock-hosted gold deposits is controversial.

Sedimentary rock-hosted gold deposits are currently thought to have been generated either in geothermal systems, up to 5 km depth, where gold was scavenged from host rocks by meteoric fluids (Radtke and Dickson, 1974; Percival and others, 1988; Hofstra and others, 1990) or contributed by magmatic fluids and deposited on the periphery of base and precious-metal districts several kilometers from intrusions (Sillitoe and Bonham, 1990).

Historically, the minute sub-micron size of gold in many of the sedimentary rock-hosted deposits prevented it from being detected in panning by early prospectors; the gold was too fine to be detected in panned concentrates. New methods for exploration involving the recognition of element associations and mineral associations were developed using characterization studies of known deposits. A series of papers by Radtke and others (1972, 1974, 1976, 1980), Dickson and others (1975, 1978), Dickson and Radtke (1977), and Radtke (1981, 1985) describe the type deposit at Carlin, Nevada in detail. These papers, along with studies by Marsh (1976) and Ikramuddin and others (1986) encouraged the use of pathfinder elements, As, Sb, Tl, and Hg, in geochemical exploration for new sedimentary rock-hosted disseminated mineral deposits. Nelson (1985), however, found that these elements commonly occur in anomalous concentrations in barren as well as mineralized systems. In a subsequent study that included jasperoid analyses, Nelson (1990) concluded that discriminant analysis and Q-mode factor analysis of geochemical data may be useful in distinguishing barren from mineralized terranes.

Geochemical Exploration Methods Involving Jasperoid

Jasperoid has been reported in more than 200 mining districts in the western United States (Lovering, 1972) and is often associated with sedimentary rock-hosted precious-metal deposits. Because of this spatial relationship to known deposits, recent geochemical exploration for gold has focused attention on jasperoid rocks as a means to identify new deposits.

Jasperoid bodies are also important because, as hydrothermal products, they reflect the geochemical nature of the fluids that produced them and they may offer some understanding of the ore-forming processes. Jasperoid forms during almost any stage in the development of a gold-bearing hydrothermal system, however, gold is not associated with all jasperoid rock. Because of this disparity many attempts have been made to distinguish barren from mineralized jasperoid.

Recent exploration for gold has discovered several exposed deposits using geochemical techniques involving rock, soil, and plant sampling. Sampling jasperoid for geochemical analyses is just one method used as a guide to locating ore and interpreting ore genesis. Studies have been made on the color, texture, mineralogy (Lovering, 1972), oxygen isotope composition (O'Neil and Bailey, 1979; Northrup and others, 1987; Holland and others, 1990), and fluid inclusion petrography (Nash, 1972; Hofstra and others, 1987 and 1990) of jasperoid - all in an attempt to establish criteria that will be useful in locating sedimentary rock-hosted disseminated gold deposits.

In general, published literature on the geochemistry of jasperoid associated with known sedimentary rock-hosted deposits is sparse. Most information is likely company proprietary information.

Early studies on jasperoid, conducted in the late 1940's and 1950's, concentrated on jasperoid associated with ore deposits at the Tintic mining district in Utah (Lovering, 1949; Howd, 1957; Duke and Howd, 1959; Bush and others, 1960). These studies used textural, mineralogical, and multi-element geochemical data in an attempt to identify jasperoid related to ore.

During the 1960's and early 1970's, most published research on jasperoid was by T.G. Lovering and his colleagues. In 1962, Lovering and Hamilton applied the same methods used in the early Tintic work to data on jasperoid associated with ore deposits from numerous mining districts in the western United States. Subsequent research added the geochemical analyses of tellurium, mercury (Lovering and others, 1966) and gold (Lovering and others, 1968) to the jasperoid data base. In 1972, Lovering summarized the results of the data base and established criteria to distinguish barren jasperoid from those associated with ore. Methods and criteria developed during this study were later used to evaluate mineralization in the Taylor mining district, Nevada (Lovering and Heyl, 1974).

From the 1970's to the present, published research involving jasperoid has steadily increased. Emphasis on the sampling and geochemical analyses of jasperoid continues to be a useful tool in the search for new sedimentary rock-hosted disseminated gold deposits. Because jasperoid often forms prominent outcrops that can be readily identified, rock-chip sampling of outcrop has become reliable sampling media (Nielson and Laskowski, 1987). Other media such a jasperoid float and stream cobbles were studied by Lovering (1981) and proved to be effective in identifying mineralized areas upstream from drainage basins.

Geochemical sampling and analyses of jasperoid associated with known sedimentary rock-hosted deposits are included in papers by Erickson and others (1966), McCarthy and others (1969), Hill and others (1986), Birak and others (1987), and Dean and others (1988). These papers, however, do not relate the geochemistry to ore forming processes. Lovering (1962) discussed the mechanisms of silica replacement of limestone and Fournier (1985) summarized the physical and chemical conditions necessary for silica replacement associated with gold deposition. Neither of these reports, however, related processes to analytical data.

Research by Nelson (1985, 1990) and Holland and others (1988) indicate that multivariate statistical analysis may be helpful in discriminating between barren jasperoid and jasperoid associated with mineral deposits. Nelson (1985) studied large geochemical data bases of 30 to 50 elements from several epithermal deposits in the western U.S. He first used discriminant analysis of raw geochemical data in order to separate barren from mineralized systems and then used R-mode factor analysis to reduce the data to principal components that could be interpreted in terms of factors, such as geologic processes. Holland and others (1988) also used Q-mode factor analysis and included oxygen isotope data as well as elemental geochemical data.

Objectives of Investigation and Presentation

The specific objectives of this geologic and geochemical study were: (1) to describe the lithology of the jasperoid bodies near Grouse, using hand samples collected in the field, observations during fieldwork, thin-section analysis, and geochemical analysis, (2) to document the relationship between jasperoid bodies and the surrounding sedimentary rocks, (3) to design, execute and interpret a stream-sediment and rock geochemical sampling program near Grouse, concentrating on gold and its trace elements, and (4) to discuss possible origin of jasperoid and any associated mineralization. This report summarizes the design, methods, results, and conclusions of the geochemical survey. Chapter 2 describes the mining history and geologic setting of the study area and Chapter 3 describes jasperoid lithology and petrography. Chapter 4 outlines the procedures followed in the geochemical survey, including sample design and collection, laboratory methods, data reliability, and data processing procedures. Chapter 5 presents the results of the geochemical survey and Chapter 6 summarizes the conclusions, discusses probable geologic interpretations regarding origin, and provides suggestions for future work.

2. REGIONAL GEOLOGY

Geologic setting

The study area is on the southwestern flank of the White Knob Mountains, adjacent to Antelope Valley (fig. 1). The area is underlain by Paleozoic rocks, mainly carbonates and clastics, and flows of Eocene Challis Volcanic Group (fig. 2; plate 1). In general, the Paleozoic sedimentary rocks dip gently to the east or northeast and are cut by north-to northwest-trending high-angle faults. Paleozoic rocks, mainly limestone, are locally silicified to jasperoid both along and away from faults (fig. 2; plate 1).

In south-central Idaho, several major thrust plates separate distinct stratigraphic rock sequences (Skipp and Hait, 1977; Skipp, 1987; Link and others, 1988). Paleozoic sedimentary rocks in the Grouse area are part of the Grouse plate, probably emplaced during eastward-directed thrusting in mid-Cretaceous time (Skipp, 1987). In the Grouse plate, Lower and Upper Mississippian carbonate bank and forebank deposits of the Middle Canyon, Scott Peak, South Creek, Surrett Canyon, Bluebird Mountain, and Snaky Canyon Formations (Skipp and others, 1979a) conformably overlie turbidites of the Lower Mississippian McGowan Creek Formation (Sandberg, 1975) (fig. 3). The Lower and Upper Mississippian carbonate bank and forebank deposits will be referred to collectively as "carbonate bank limestone" in this report. The McGowan Creek Formation was deposited in the eastern part of a foreland basin (Nilsen, 1977; Skipp and others, 1979b). The contact between the McGowan Creek Formation and the overlying Middle Canyon

Formation is gradational. The Mississippian Middle Canyon, Scott Peak, South Creek, and Surrett Canyon Formations represent carbonate bank and forebank deposits across which a flood of fine-grained sand transgressed (Upper Mississippian to Lower Pennsylvanian Bluebird Mountain Formation). The Snaky Canyon Formation (Lower Pennsylvanian to Lower Permian), mainly limestone and sandstone, represents a shallow-water carbonate bank deposit.

Challis Volcanic Group rocks are widespread in the Grouse area, where they unconformably overlie Paleozoic sedimentary rocks. Late Cretaceous and (or) early Tertiary uplift, erosion, and deposition of conglomerate preceded Eocene Challis volcanism. The volcanic rocks consist mainly of rhyolitic flows, pipes, and dikes and andesitic tuffs, breccias, and lava flows. Hypabyssal stocks and dikes accompanied Eocene volcanism northwest of the study area near Mackay. The study area is located a few miles southeast of the Eocene Mackay stock, a granitic intrusive complex. Aeromagnetic data indicate that the Mackay stock may be more extensive in the subsurface and that a low-density buried intrusive may be present about 3 miles south of Grouse (Kleinkopf and others, 1989).

High-angle faults are widespread in the area and formed during three periods of Tertiary extension (Skipp, 1989). East-west-trending normal faults represent a period of local north-south extension that followed Mesozoic thrusting and preceded Challis volcanism. North-trending rhyolite dikes were emplaced during extension in Challis time (Anderson, 1929; Skipp and others, 1990). Post-Challis extension is represented by north

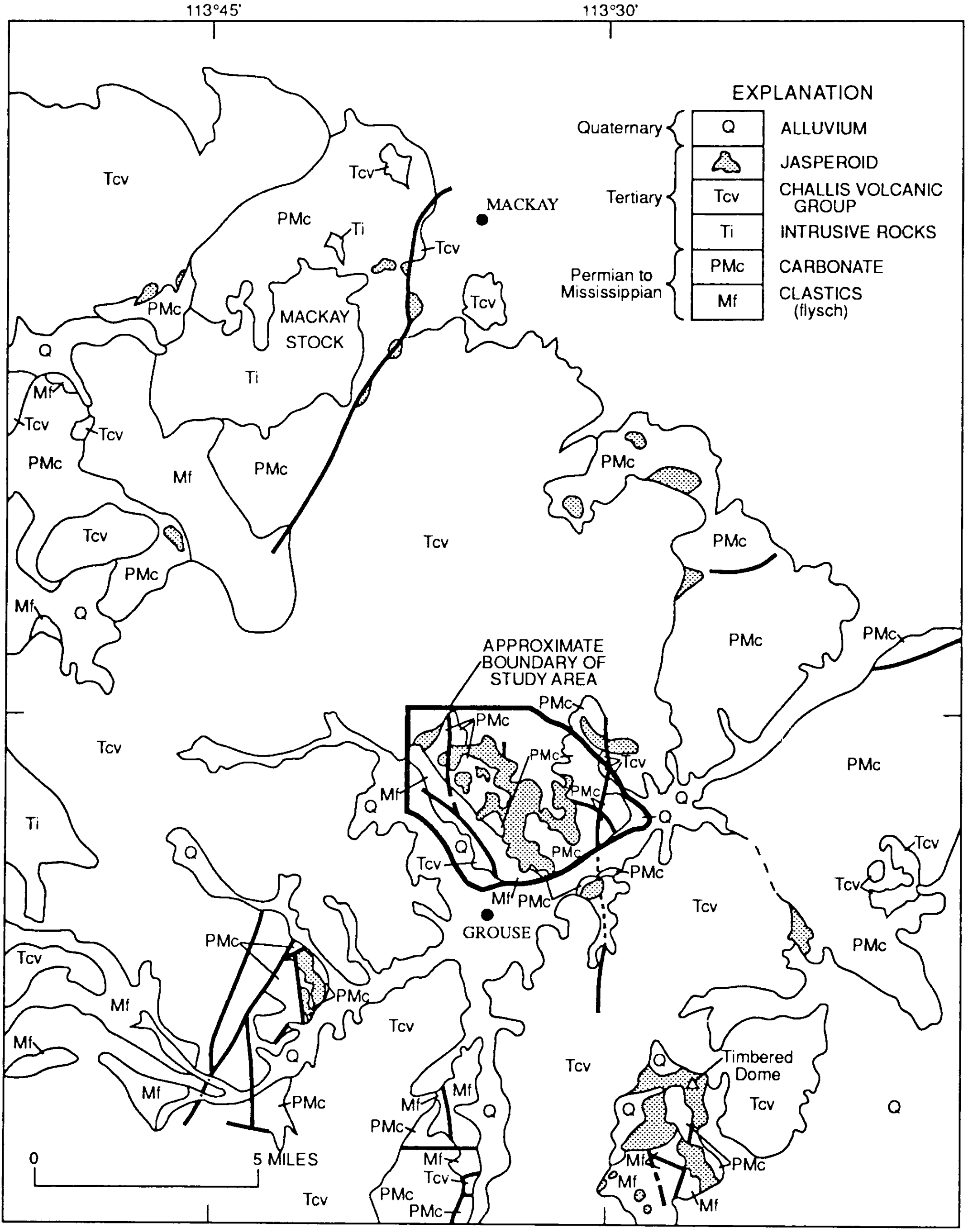


Figure 2 -- Regional geologic map of the Grouse and Mackay areas, south-central Idaho (modified from Wilson and others, 1988a).

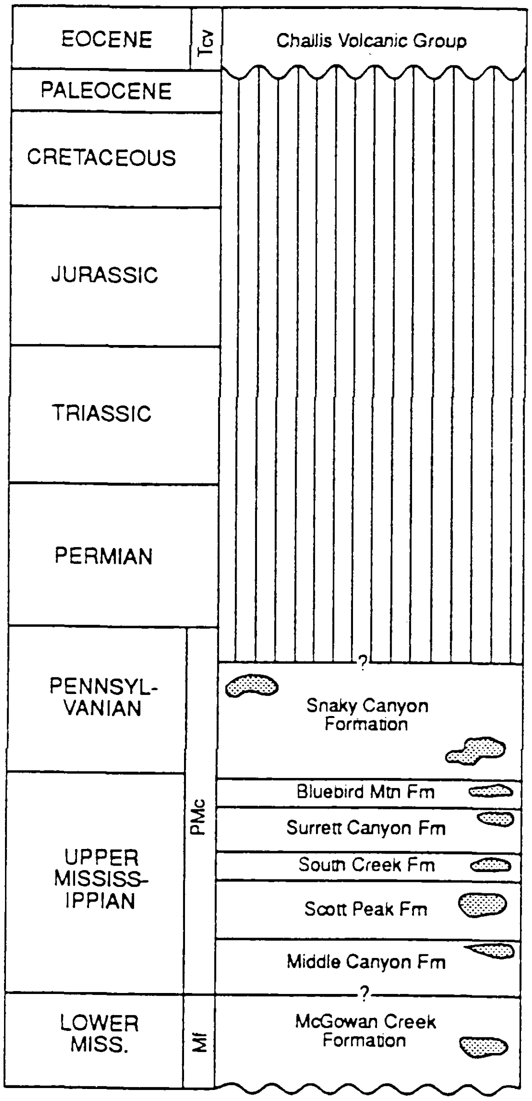


Figure 3 -- Stratigraphic column showing relationship and age of rock units from the Grouse area. Shaded bodies indicate jasperoid.

and northwest-trending faults. Most of the post-Challis faults are curved, have west sides down, and tilt the Challis volcanics to the east (Skipp, 1988). Major fractures and joints are related to post-Challis tectonics.

Description of Rock Units

The following descriptions of rock units exposed in the study area were summarized from Skipp (1988; 1989) and supplemented by observations by the author. The McGowan Creek Formation (Lower Mississippian) is the oldest unit exposed in the study area. The lower member (Mmgl, plate 1) has a minimum thickness of 575 feet near Cherry Creek and consists mainly of laminated siltstone, fine-to coarse-grained sandstone, and granule to pebble conglomerate deposited by turbidity flows. No fossils have been found in this unit (Skipp, 1988). The upper member (Mmgu), also deposited by turbidity flows, has a thickness of 1,265 feet at Cherry Creek. It consists of grayish-black to medium-gray, fissile mudstone with siltstone interbeds and calcareous sandstone and aphanitic limestone. Mudstones and siltstones are fossiliferous and contain mollusks, brachiopods, fish scales, trilobites, and the trace fossil Nerites. Contact with the lower member is gradational and is placed at the base of the stratigraphically lowest thick mudstone sequence (Skipp, 1988).

Most of the sedimentary rocks exposed in the study area are Upper Mississippian limestones that are fairly resistant to erosion and tend to form cliffs. For descriptive purposes these formations will be referred to collectively as "carbonate bank" rocks in this report. All of the carbonate bank formations have been locally silicified to jasperoid (Tj), which is considered to be Tertiary in age (Skipp, 1988).

The Upper Mississippian Middle Canyon Formation (Mmc) gradationally overlies the McGowan Creek Formation and consists of 610 feet of medium-gray silty limestone. The Scott Peak Formation (Ms), also Upper Mississippian in age, consists of medium- to dark-gray, variably cherty, fossiliferous, thin- to thick-bedded limestone with silty interbeds. Black to light gray chert nodules and lenses are locally abundant. The limestone tends to form cliffs and is about 1,550 feet thick in the study area. The Upper Mississippian South Creek Formation (Msc), which overlies the Scott Peak Formation, is poorly exposed and consists of medium-gray, thin-bedded, fossiliferous, silty limestone with minor chert.

The Surrett Canyon Formation (Msu; Upper Mississippian) is chiefly a pure, fossiliferous, variably cherty, thick-bedded limestone. It is gradational with the underlying South Creek Formation and is estimated to be about 1,300 feet thick (Skipp, 1988). The Bluebird Mountain Formation (Mb; Upper Mississippian) has an apparent gradational contact with the Surrett Canyon in the Grouse area. It consists of about 13 feet of very-light to medium-gray, fine-grained, calcareous sandstone and siltstone. The Bluebird Mountain Formation is overlain by the Bloom Member (PMsb) of the Snaky Canyon Formation (Upper Pennsylvanian to Upper Mississippian). The Bloom Member consists of medium-gray, chiefly impure, fossiliferous, variably cherty limestone with minor interbeds of calcareous sandstone and siltstone.

Tertiary volcanic rocks overlying the Paleozoic units are collectively known as the Challis Volcanic Group (Eocene) and consist of a basal conglomerate (Tc), andesite flows (Taf), tuffs (Tta; Tts) and pipes (Tp), rhyolite lavas (Trl), pipes (Trp), tuffs (Ttc) and dikes (Td). Quaternary alluvium (Qal) is present in stream drainages and along Antelope and Cherry Creeks. Alluvial fan (Qf) and landslide (Ql) deposits are also present locally.

Economic Geology

No mines are present within the study area, however three major mining districts and several mines and prospects are near Grouse (fig. 4). Three types of mineral deposits have been exploited in the area: skarn deposits, polymetallic veins in Paleozoic sedimentary rocks, and polymetallic veins in Challis volcanic rocks (Worl and others, 1989). These mineral deposits are thought to be Tertiary in age. Metals in these deposits may have been in part remobilized from Paleozoic sedimentary rocks. During Paleozoic time, there may have been metal-enriched deposition in deep restricted marine basins resulting in metal-enriched sedimentary rocks that would now be part of the Copper Basin and McGowan Creek Formations (Wilson and others, 1988a). Magmatic and hydrothermal activity during Tertiary time could have reconcentrated these metals into the present deposits. Hydrothermal systems in the late stages of volcanic and intrusive activity were probably responsible for the development of polymetallic vein deposits that are common throughout the area. These same hydrothermal systems probably formed some of the jasperoid bodies in the area, especially those aligned along

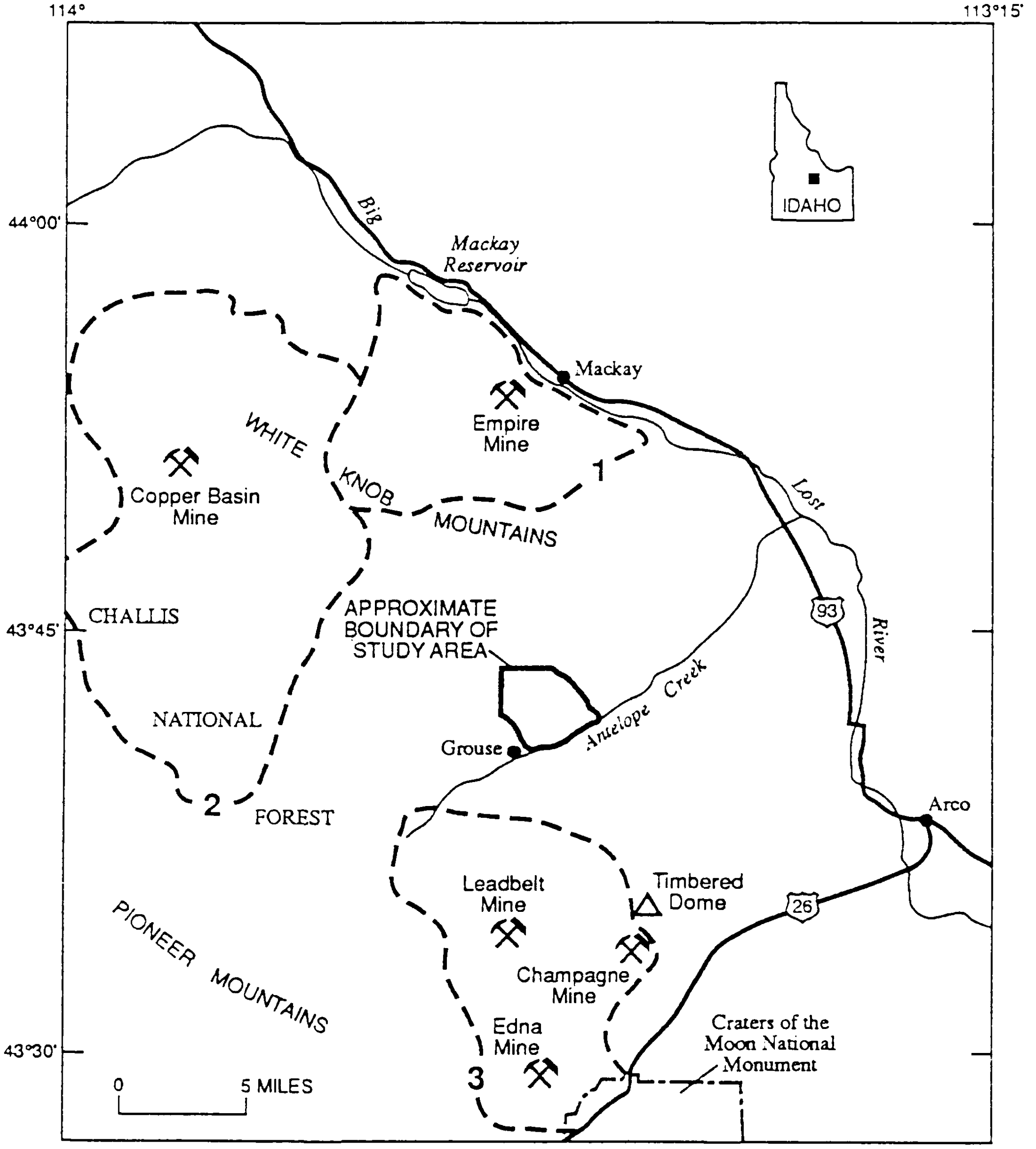


Figure 4 -- Map showing location of major mines and mining districts in the Grouse area. (1) Alder Creek Mining District, (2) Copper Mining District, (3) Lava Creek Mining District (modified from Wilson and others, 1988a).

high-angle faults (Wilson and others, 1988a).

Mining History

There are three major mining districts, Alder Creek, Copper Basin, and Lava Creek, and numerous other prospects near Grouse (fig. 4). Most of these deposits were discovered during the 1880's and early 1890's when rich silver-lead ores were being mined throughout central Idaho (Wells, 1983).

Alder Creek District The Alder Creek district is northeast of the study area, near Mackay (fig. 4). Most of the mines in this district exploited skarn and vein deposits. Copper was the main commodity mined, but the deposits also contained lead, zinc, silver, gold, tungsten, and molybdenum (Nelson and Ross, 1969a and b). The skarn deposits consist of chalcopyrite, pyrite, pyrrhotite, calcite, quartz, magnetite, fluorite, scheelite, molybdenite, sphalerite, and specularite in addition to calc-silicate skarn minerals (Umpleby, 1917). The Empire Mine, active intermittently from 1901 into the 1960's, was the major copper producer. As of July 1988, there was no active mining in this area.

Copper Basin District The Copper Basin mining district is northwest of the study area (fig. 4). Deposits of this district are similar to those in the Alder Creek district, mainly skarn and vein deposits. Ore was discovered here in 1888 and mining continued until the 1930's. The ore bodies are in quartzite and limestone intruded by aplite and granite porphyry, and are highly oxidized (Simons, 1981). Oxidized copper ore with some lead from the Copper Basin mine was assayed at 35-55% copper (Wells, 1983). Oxidized copper minerals are malachite, azurite, chrysocolla, cuprite, melaconite, and tenorite. Copper sulfides are rare at Copper Basin, however, some chalcopyrite, chalcocite, bornite, and pyrite may be found. As of 1988, the area had been staked and recent drilling by private companies was evident.

Lava Creek District The Lava Creek district is located about 6 miles south of Grouse (fig. 4). Ore deposits take the form of veins in sedimentary or volcanic rocks. Polymetallic fissure veins in sedimentary rocks are mainly in the Leadbelt area and ore minerals are mostly argentiferous galena with some sphalerite and chalcopyrite. Polymetallic fissure veins in volcanic rocks are found near Champagne Creek. These are epithermal deposits characterized by complex mineralogy and significant amounts of lead, silver, zinc, copper, iron, gold, tungsten, tin, antimony, arsenic, and bismuth (Anderson, 1947).

In 1988, the Bema Gold Corporation of Canada started a heap leach test at the Champagne mine, in the Lava Creek district (fig. 3). The company began production of gold and silver from an oxide ore body in Challis volcanic rocks in June 1989. They estimate that the deposit contains 2.4 million short tons of mineable precious-metal reserves and have begun further exploration for additional reserves (Engineering and Mining Journal, 1989). The ore deposits of the Champagne mine are shallow epithermal or hot spring deposits localized in north-trending siliceous veins and hydrothermal breccia zones (Moye and others, 1989).

Recent Exploration Activity

Recent exploration activity in the Grouse area has focused on searching for sedimentary rock- and volcanic-hosted disseminated precious-metal deposits. No deposits of this type have been discovered as yet. However, because of the known spatial relationship between jasperoid and deposits of this type, several claims have been staked around most outcrops of jasperoid in the area. Recent activity by private companies consists mainly of detailed mapping, geochemical sampling, and some local drilling.

3. JASPEROID GEOLOGY

During the summers of 1987 and 1988, fifty-four rock chip and fist-sized samples of jasperoid were collected from outcrops in the study area. These samples, along with observations in the field, were used to describe in detail the physical and chemical characteristics of the jasperoid. The physical characteristics are described in this chapter and the chemical characteristics are described in Chapter 4.

Jasperoid bodies are easily recognized in the Grouse area because they tend to be more resistant to erosion than the surrounding sedimentary rocks and therefore form prominent outcrops. Outcrops of jasperoid tend to be at higher elevations, on hill tops and slopes, rather than at lower elevations in valleys. One exception to this is the outcrop located in Waddoups Canyon (plate 1).

Jasperoid in the study area occurs as irregularly shaped bodies in Paleozoic sedimentary rocks, mainly carbonate bank limestone (plate 1). A few occur locally in carbonaceous clastic rocks of the upper member of the McGowan Creek Formation. Many have a close spatial relation to high-angle, north to northeast-trending faults (plate 1). Minor silicified fracture breccias and jasperoid stringers trend north to northeast in several outcrops. The Grouse jasperoids are inferred to be Eocene or younger Tertiary in age (Skipp, 1988).

Lithology

Jasperoid outcrops range from massive, hard and dense jasperoid with original textures preserved (chert nodules and layers, fig. 5) to highly brecciated, quartz-healed, gossan-stained jasperoid with angular clasts (fig. 6). Detailed descriptions of the physical characteristics of jasperoid samples collected from the Grouse area are in table 1 (Appendix A).

Jasperoid varies in color including maroon, buff, and shades of gray. Wind polished surfaces are common and have a waxy sheen. Most weathered surfaces are stained by iron oxides to various shades of brown, yellow, or red. Jarosite is also common on the surfaces of some samples, usually along fractures.

The majority of jasperoid samples are very brecciated, and many show multiple stages of brecciation and healing of fractures. The jasperoid breccias tend to have angular grain- to pebble-size clasts in a fine-grained matrix. Several samples have crosscutting veins of quartz and calcite, and a few have vugs. Jasperoids that are not brecciated are dense aphanitic quartz with original sedimentary structures, chert nodules, and fossils preserved. Jasperoid breccia and non-brecciated jasperoid were not distinguished on the geologic map in this report because jasperoid texture changed every few feet to inches. No alteration or zoning indicative of mineralization was noted in jasperoids. Jasperoid bodies show no mappable gradation of silicification, that is no zonation from jasperoid to silicified limestone to crystalized limestone to unsilicified limestone.

Petrography

Thin sections were prepared for eleven jasperoid samples and were examined petrographically (table 2; Appendix A). The examination revealed microtexture and accessory minerals not visible to the naked eye. Examination of thin-section samples also revealed a complex history, beginning with replacement of carbonate by silica, followed by brecciation, recementation, and veining, and ending with weathering and oxidation.

Most of the jasperoid samples are matrix-supported microquartz breccia with abundant veinlets and microfractures; a few are clast-supported (table 2, Appendix A). Quartz is the main constituent of jasperoid, although chalcedony and calcite are common, both as individual grains and as veinlets. The majority of quartz grains, in both the matrices and the clasts of jasperoid breccia, have irregular boundaries that are tightly interlocked like pieces of a jigsaw puzzle. This type of microtexture, suture or jigsaw-puzzle texture, is common in jasperoid and was described in detail by Lovering (1972). Visible accessory minerals include epidote and calcite. Rusty-red colored iron oxides coat individual grains and clasts as well as the matrices and surfaces of some jasperoid. Some samples contained silicified bioclasts. In one sample (88CCS34) coarse equant quartz grains had inclusions of carbonate and calcite, indicating silica replacement of the carbonate and calcite.

Relationship to sedimentary rocks

In the study area, contacts between jasperoid and sedimentary rocks were not

Figure 5 -- Photo showing jasperoid with original host-rock textures preserved - bedding and light-gray chert bands.

Figure 6 -- Photo showing highly brecciated, quartz-healed jasperoid.

exposed or were difficult to observe because of erosion. In general the contact between jasperoid and unsilicified limestone is considered to be gradational (Skipp, 1988). However, at one location in the study area (sample sites 88CCS23 and 24; plate 1), it was possible to observe in outcrop the contact between jasperoid and unsilicified limestone (fig. 7). Jasperoid from this area was brecciated near a fault and gradually graded into dense, unbrecciated jasperoid in sharp contact with unsilicified limestone (fig. 7).

Figure 7 -- Photo showing contact between jasperoid and unsilicified limestone. Hammerhead in unsilicified limestone, hammer handle in jasperoid.

4. JASPEROID AND STREAM-SEDIMENT GEOCHEMISTRY

Sampling Design

The objectives of geochemical sampling were: (1) to describe the chemical characteristics of the jasperoid bodies near Grouse, and (2) to assess the mineral potential of the Grouse area using a regional drainage geochemical sampling survey. Samples were analyzed for gold and its associated trace elements.

A geochemical survey was designed after examining the literature and geologic maps of the study area and case studies of similar environments. The design took into account the geological, physical, and climatic characteristics of the study area. For this survey, rock chips from outcrop, heavy-mineral concentrates from stream sediments, and the minus 80-mesh fraction from stream sediments were selected as sample media.

Rock-chip samples of jasperoid were selected because they have been effective in exploration for disseminated gold deposits (Crone and others, 1984; Nielson and Laskowski, 1987; Nelson, 1990). Jasperoid was also relatively easy to collect because it forms prominent outcrops in the study area and is readily accessible. Unaltered and unmineralized sedimentary rocks near jasperoid were also collected in order to provide background geochemical data for individual rock units. Rock-chip samples were collected from outcrop on a regional basis, with sample density averaging 3 to 4 samples per square mile.

The climate and physiography of the study area are conducive to both mechanical and chemical dispersion. Stream sediments provide an excellent medium for characterization of these types of dispersion. Stream sediments are easy to collect and "represent the best composite of materials from the catchment area upstream from the sampling site" (Levinson, 1980). Heavy-mineral concentrates and the minus 80-mesh (less than 0.18 mm) fraction of bulk sediments were selected, respectively, to detect the products of mechanical and chemical dispersion from mineral deposits. These sample fractions have been used concurrently in similar geochemical surveys (Meyer and others, 1979; Simons, 1981; Moye and Hall, 1988; Smith, 1989). Bulk stream-sediment samples were collected from drainages at a density of about one sample per square mile. This type of survey is one of the most widely used geochemical reconnaissance techniques where the objective is to locate mineral deposits and alterated areas (Levinson, 1980).

Inductively coupled plasma atomic emission spectroscopy (ICP) was chosen for analyses for all elements, except gold, of both the rock-chip and the stream-sediment samples. This method provides efficient, low cost, simultaneous, multi-element detection of most major, minor and trace elements at detection limits lower than, or comparable to, other routinely used methods, such as emission spectroscopy and atomic absorption (Levinson, 1980). The graphite furnace atomic absorption (GFA) method was chosen for gold analysis. This method provides the ability to detect gold at extremely low concentrations in samples of small size at relatively low cost and with a reduction in the likelihood of contamination (Levinson, 1980). All samples were analyzed by

Geochemical Services Inc. (GSI) of Sparks, Nevada, in order to have consistent data to compare with the results of other geochemical studies involving the Hailey and Idaho Falls CUSMAP project (Moye and Hall, 1988; Wilson and others, 1988a).

Sample Collection

Seventy-one rock-chip samples were collected from outcrops of jasperoid (54 samples), unaltered and unmineralized rocks of the McGowan Creek Formation (6 samples), and carbonate bank limestone (11 samples; plate 1). At each site, a five pound bag of rock chips and one or more hand samples were collected. Field observations regarding the physical appearance and exact location of each sample were recorded. In addition, factors present which might produce false anomalies, such as iron oxide coatings or visible metallic minerals, were also noted.

Stream-sediment samples were collected at twenty-five sites along intermittent stream drainages in the study area. No water flowed at any stream site. At each site, bulk sediment was collected from three or more points within the stream channel. Duplicate samples were collected at 5 sites to measure within site variation. Bulk sediment samples composed of approximately 25 ounces of stream sediment were collected from point bars or sections of low gradient. To obtain the heavy-mineral concentrate samples, about ten pounds of bulk stream sediment were collected from gravels at each site. Samples were then dry-sieved through a stainless steel screen (10 mesh) in order to remove large pebbles and unwanted organic debris. Using a steel gold pan, the bulk sediment was panned in order to reduce the amount of common rock-forming minerals, such as quartz and feldspar, and to create a concentrated sample. Approximately fifty percent quartz and feldspar remained in the concentrate. Water for panning was not available at the sample sites, so all samples were panned in the Big Lost River. Each sample was stored in a brown paper envelope and allowed to air dry.

Underlying lithology, float lithology, and a brief description of the stream channel were recorded at each sample site. Field observations of factors which might produce false anomalies, such as nearby prospects, human artifacts, and oxide coatings, were also noted.

Laboratory Procedures

Rock-chip samples

Rock-chip samples were prepared for inductively coupled plasma atomic emission spectroscopy (ICP) and graphite furnace atomic absorption (GFA) analyses at the USGS Branch of Central Mineral Resources laboratory. Each rock-chip sample was crushed and pulverized, then sieved to -100 mesh with U.S. Standard stainless steel sieves. Ceramic plates were used during crushing in order to avoid contamination that often occurs with metallic plates. Each sample was then analyzed for 15 elements (Ag, As, Bi, Cd, Cu, Ga, Hg, Mo, Pb, Pd, Sb, Se, Te, Tl, and Zn) by Geochemical Services, Inc. (GSI), Sparks, Nevada, using ICP methods. In addition, gold was analyzed using the GFA method by GSI. Details of the analytical procedures are considered proprietary information. The

GSI chemical analysis proceedure consists of single acid digestion of the sample followed by extraction of the metals of interest into an organic phase before analysis by ICP and GFA techniques.

Stream-sediment samples

In the laboratory, bulk stream-sediment samples were passed through 80-mesh stainless steel sieves to obtain the fine fraction for chemical analysis. The minus 80-mesh fraction of each sample was sent to GSI for analysis. Samples were analyzed by ICP for 15 elements using the same procedures outlined above for rock-chip samples; note that stream sediment samples were analyzed in 1991 and at that time GSI analysis package no longer included Pd.

Heavy-mineral concentrate samples

Each panned concentrate sample was dried and split in the laboratory by the author. Approximately half of the sample was analyzed by ICP and GFA and half was retained for mineralogical study. Samples were analyzed for 16 elements by GSI using the same procedures outlined above for rock-chip samples.

Data Reliability

The accuracy and precision of geochemical data aid in interpretation by establishing confidence in the data and revealing possible errors. The data control program for this investigation included the analysis of reference samples, analytical (sample splits) duplicates and field (within-site) duplicates. Results were assessed using data listings and one-way analysis of variance (ANOV) methods. Table 1 contains the results of analysis of variance for jasperoid samples.

Accuracy describes the extent to which the analysis reflects the true metal content of the sample. Acceptable accuracy limits for ICP and GFA were ±15% at the 95% confidence level (Rose and others, 1979). These acceptibility criteria are reasonable because the data generally showed a large regional variation so that anomalous concentrations could be readily distinguished from background concentrations. Three reference samples were run by GSI and all elements were acceptable at the 95% confidence level.

Precision refers to the reproducibility of the data. Reproducibility is probably more significant than accuracy in geochemical surveys where the recognition of the regional differences is more important than true metal content. Analytical and within-site precision were assessed using data from duplicate samples. To measure analytical precision, six rock samples and and six stream-sediment samples were split in the laboratory and analyzed in duplicate. Sample-site precision was assessed by analyzing six field duplicate samples.

For the stream-sediment samples analyzed by ICP, acceptable precision limits were ± 50% at the 95% confidence level (Rose and others, 1979). Within these limits, anomalous concentrations of elements could be distinguished from background concentrations. Data for elements not detected or rarely detected were not included in the precision control program. For the rock and stream-sediment samples these included Bi, Cd, Ga, Pd, Se, Te, and Tl. Based on examination of the data listings, the sample splits and field duplicate samples showed acceptable precision for all elements at the 95% confidence level. Examination of the data listings for the sample splits showed that analytical precision for rock samples was acceptable for all elements except Mo. Despite poor analytical precision, anomalous Mo concentrations are significantly greater than background concentrations and anomaly detection is not obstructed.

One-way analysis of variance (ANOV) was used to assess precision and to help determine the source of the variation. The ANOV technique is described in detail by Davis (1986). In this case, ANOV was used to distinguish regional and station sample variation from analytical variation. Results of ANOV indicate a significant variation between sample sites (regional variation) at the 95% confidence level. Within-site and analytical variation was not significant for all elements except Mo at the 95% confidence level. The poor precision for Mo may be due to the high regional variation and is considered insignificant.

Data Processing

The geochemical survey for this investigation provided three multivariate data sets for interpretation. Statistical programs and plotting routines were performed using the DEC-VAX computer at the U.S. Geological Survey. The Statistical Package (STATPAC) computer program (VanTrump and Miesch, 1976) was used to analyze data statistically.

The rock chip, stream-sediment, and heavy-mineral concentrate data sets were entered on the DEC-VAX. Duplicate samples were eliminated from the data sets. Raw data listings, basic statistics (mean, standard deviation, range), histograms and correlation matrices were used to classify the geochemical information and to examine the areal distribution of samples having anomalous element concentrations. The intent was to determine element concentrations and patterns of element associations that may reflect geologic processes or features, such as mineralization, lithology, and dispersion.

Table 1 -- Results of analysis of variance for jasperoid samples.

ELEMENT	REGIONAL VARIANCE V_R	STATION VARIANCE V_S	ANALY-TICAL V_A	F_1 TEST V_R/V_S	F_2 TEST V_S/V_A
Ag	89.5	8.9	1.6	18.7*	6.7
As	99.9	0.05	0.03	2650.1*	2.5
Cu	98.1	1.2	0.08	104.6*	2.5
Mo	97.4	2.6	0.0	76.9*	316.6*
Pb	96.1	3.2	0.7	50.5*	5.6
Sb	99.6	0.0	0.4	2211.6*	0.2
Zn	99.5	0.0	0.5	1196.7*	0.4

V_R = Regional (between site) variation component; expressed as a percent of total variance
V_S = Station (within site) variation component; expressed as a percent of total variance
V_A = Analytical variation component; expressed as a percent of total variance
F_1 = (19.30) critical value at 95% confidence level
F_2 = (6.94) critical value at 95% confidence level
* = Statistically significant at 95% confidence level

Sample locations and geology are shown on plate 1. A complete listing of raw data and summary statistics for the stream-sediment and rock samples is in Appendix C. Summary statistics, such as mean and standard deviation, were calculated using arithmetic data. Using this information, the data were screened to facilitate interpretation. Qualified values in the data sets are concentrations detected but less than the lower detection limit (L). For the rock and stream-sediment sample data, at least 90% of the values for Bi, Pd, and Te were at or below the limit of detection. These elements were eliminated from the statistical data sets and were evaluated individually. In addition, Se and Ga were eliminated from the carbonate bank data because 90% of their values were below the detection limit. Because the data are quantitative and more than 50% of the values for the remaining elements are unqualified, original values were used and no substitutions were made.

Histograms were constructed for all unqualified elements to display the data distribution and to distinguish class boundaries between background and anomalous values for single element plots. The separation of data into background and anomalous samples may be made by visual assessment of the histograms or by statistical manipulation of the data sets, assuming that the data sets approximate a known distribution (Rose, 1972). Normal or log-normal distributions are most often used in geochemical studies and statistical analyses using these distribution laws have assisted in data classification (Rose and others, 1979). However, many of the data from the Grouse area were not normally distributed and classification of samples had to be made by other means. Where there are a limited number of metal sources in a survey area, and where high trace element contrast exists between background and mineralized source materials, visual assessment of the histograms may be sufficient to separate background from anomalous samples (Closs and Sado, 1981). This is the case for the Grouse area and the classification of samples has been made on the subjective assessment of histograms. Selected histograms for trace elements (As, Sb, Hg, Mo, Ag, Pb, Cu, Zn) from the jasperoid data set are included in figures 8 and 9. Because the data sets for this investigation contain a large number of variables, a complete collection of single element plots and histograms is not included.

The association of pairs of elements (linear correlation) is another valuable tool used in the interpretation of geochemical data. Linear correlation may be mathematically evaluated using correlation analysis and is useful because the association of elements or geochemical suites so identified may be indicative of common geologic processes. From the data sets, correlation matrices were constructed in order to determine element associations specific to the Grouse area for comparison with data from other geographic areas (tables 2-6). In a correlation matrix, the coefficients are unitless numbers which range from +1 to -1; a correlation of +1 indicates a perfect direct relationship between two variables; a correlation of -1 indicates a perfect inverse relationship between the two variables; zero indicates no linear relationship at all (Davis, 1986, p. 38). The statistical significance of the correlation coefficients can be established at a specified level of confidence, traditionally at the 95% confidence level, given the number of samples in the data set (Davis, 1986).

Tie diagrams were constructed from the correlation matices in order to graphically display the single element associations and suggest groupings of elements or geochemical associations (figs. 10-14). Further analysis of the data, for example, factor analysis, was not attempted due to the reconnaissance nature of the study. The data are too sparse and incomplete to enable a valid multivariate analysis.

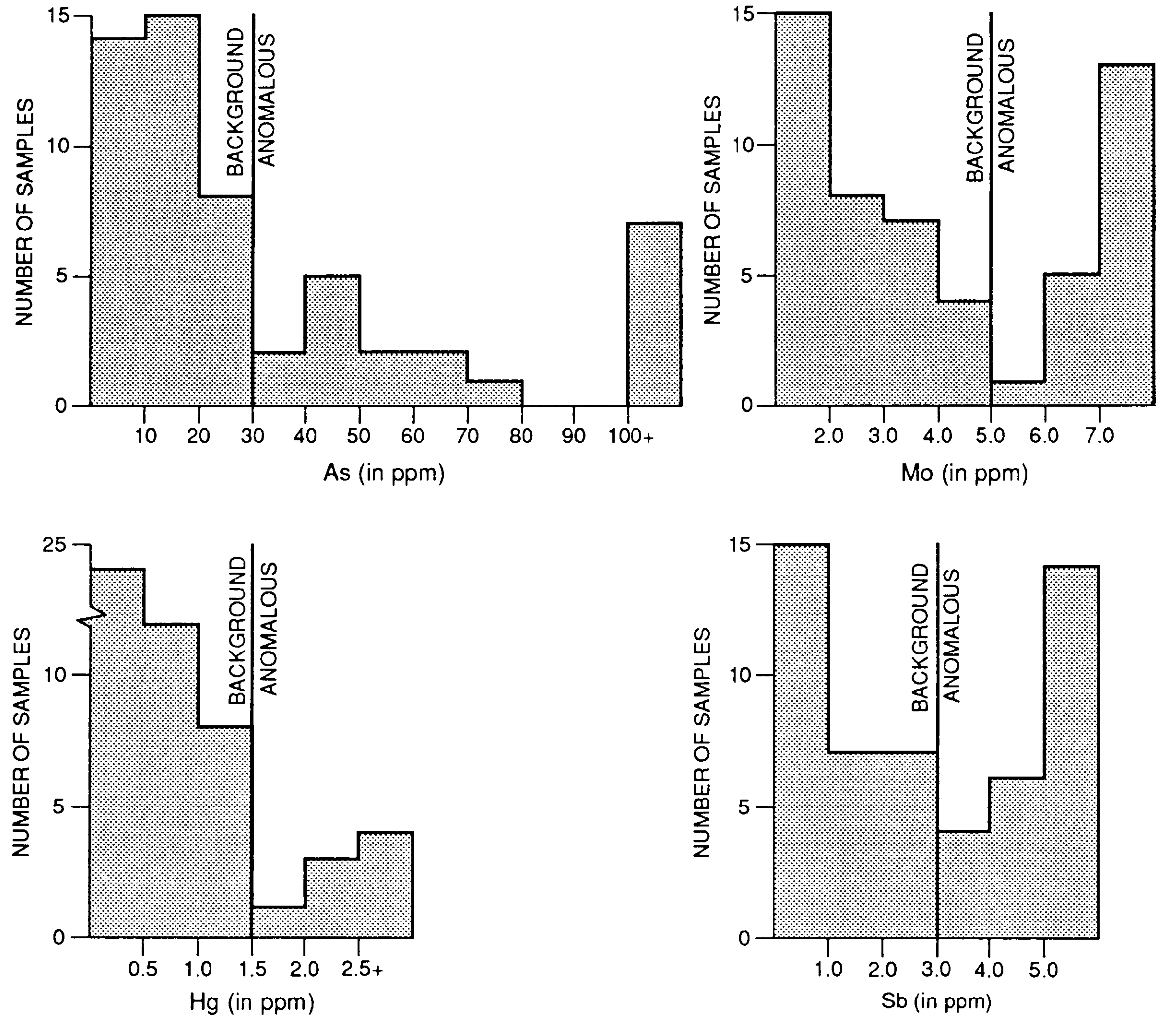


Figure 8 -- Histograms for As, Mo, Hg, Sb from jasperoid samples. Anomalous values determined by visual examination of the data.

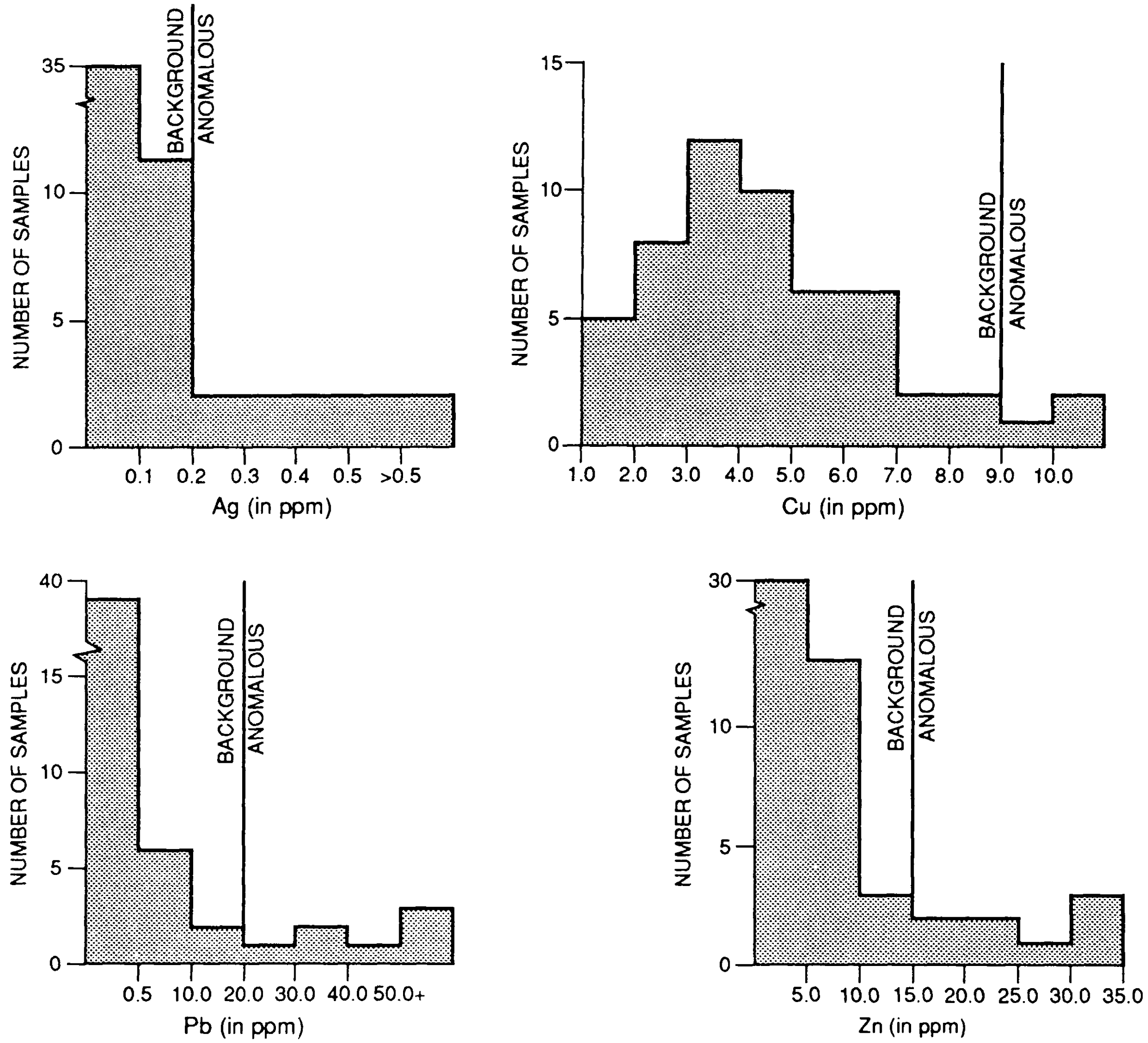


Figure 9 -- Histograms for Ag, Pb, Cu, and Zn from jasperoid samples. Anomalous values determined by visual examination of the data.

Table 2 -- Correlation coefficients for jasperoid rock data (n = 54). The minimum significant correlation coefficient is 0.27 at the 95% confidence level.

Jasperoid (54 samples)

Ag	1.00												
As	0.15	1.00											
Au	0.11	0.04	1.00										
Cu	0.17	0.28	0.03	1.00									
Hg	0.08	0.60	0.07	0.14	1.00								
Mo	0.03	0.11	0.19	0.04	0.12	1.00							
Pb	0.97	0.14	0.10	0.05	0.00	-0.02	1.00						
Sb	0.15	0.93	0.05	0.16	0.51	0.04	0.16	1.00					
Tl	0.11	0.81	0.07	0.04	0.28	0.07	0.15	0.89	1.00				
Zn	0.08	0.19	-0.08	0.18	0.22	0.12	-0.02	0.15	0.03	1.00			
Cd	0.07	0.29	0.11	0.06	0.29	0.08	0.07	0.22	0.08	0.53	1.00		
Ga	0.05	0.28	-0.09	0.20	0.50	0.07	-0.08	0.18	0.02	0.40	0.10	1.00	
Se	0.09	0.13	-0.11	0.17	0.13	0.28	0.07	0.00	-0.07	0.32	0.28	0.14	1.00
	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Cd	Ga	Se

Table 3 -- Correlation coefficients for McGowan Creek rock data (n = 6). The minimum significant correlation coefficient is 0.70 at the 95% confidence level.

McGowan Creek (6 samples)

Ag	1.00												
As	-0.12	1.00											
Au	-0.23	0.26	1.00										
Cu	0.56	0.09	-0.43	1.00									
Hg	-0.31	-0.25	-0.41	0.12	1.00								
Mo	0.98	0.03	-0.29	0.66	-0.33	1.00							
Pb	0.27	-0.15	-0.47	0.66	0.78	0.27	1.00						
Sb	-0.05	0.21	-0.43	0.24	0.82	-0.01	0.77	1.00					
Tl	-0.39	-0.26	-0.41	-0.38	-0.16	-0.36	-0.52	-0.35	1.00				
Zn	0.96	-0.30	-0.45	0.55	-0.22	0.93	0.29	-0.05	-0.16	1.00			
Cd	0.59	-0.27	-0.77	0.69	-0.11	0.66	0.27	-0.07	0.28	0.75	1.00		
Ga	-0.33	-0.25	-0.42	0.13	1.00	-0.36	0.77	0.80	-0.13	-0.24	-0.09	1.00	
Se	0.91	-0.11	-0.37	0.81	-0.25	0.94	0.37	-0.08	-0.29	0.91	0.80	-0.26	1.00
	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Cd	Ga	Se

Table 4 -- Correlation coefficients for Carbonate Bank rock data (n = 11). Minimum significant correlation coefficient is 0.55 at the 95% confidence level.

Carbonate Bank (11 samples)

Ag	1.00										
As	0.11	1.00									
Au	0.06	0.26	1.00								
Cu	0.48	0.51	-0.21	1.00							
Hg	0.08	1.00	0.26	0.51	1.00						
Mo	0.00	0.94	0.33	0.38	0.95	1.00					
Pb	0.35	-0.05	0.37	-0.22	0.07	0.16	1.00				
Sb	0.12	1.00	0.29	0.48	0.99	0.94	-0.04	1.00			
Tl	0.04	0.99	0.24	0.52	1.00	0.96	-0.09	0.99	1.00		
Zn	0.07	-0.13	-0.20	-0.05	-0.12	0.10	0.60	-0.11	-0.10	1.00	
Cd	-0.47	-0.30	-0.22	-0.15	-0.28	-0.14	0.07	-0.32	-0.26	0.66	1.00
	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Cd

Table 5 -- Correlation coefficients for panned-concentrate data (n = 22). Minimum significant correlation coefficient is 0.40 at the 95% confidence level.

Panned concentrate (22 samples)

Ag	1.00												
As	0.14	1.00											
Au	-0.05	0.00	1.00										
Cu	0.59	0.29	0.10	1.00									
Hg	0.60	0.56	-0.29	0.36	1.00								
Mo	0.30	0.76	-0.35	0.43	0.64	1.00							
Pb	0.47	0.86	-0.04	0.61	0.70	0.83	1.00						
Sb	-0.03	0.62	0.44	-0.05	0.04	0.07	0.37	1.00					
Tl	0.82	0.24	-0.14	0.35	0.79	0.34	0.49	0.03	1.00				
Zn	0.14	0.80	-0.14	0.50	0.33	0.81	0.77	0.26	-0.03	1.00			
Cd	0.88	0.43	-0.18	0.50	0.85	0.55	0.67	0.06	0.95	0.26	1.00		
Ga	0.79	0.32	-0.07	0.33	0.78	0.33	0.54	0.17	0.99	0.00	0.94	1.00	
Se	0.88	0.23	-0.12	0.43	0.77	0.33	0.51	0.02	0.99	0.00	0.96	0.98	1.00
	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Cd	Ga	Se

Table 6 -- Correlation coefficients for -80 mesh data (n = 22). Minimum significant correlation coefficient is 0.40 at the 95% confidence level.

- 80 Mesh stream-sediment (22 Samples)

Ag	1.00										
As	0.16	1.00									
Au	0.49	-0.07	1.00								
Cu	0.61	-0.09	0.64	1.00							
Mo	0.69	0.71	0.25	0.27	1.00						
Pb	0.09	0.04	0.02	0.06	0.09	1.00					
Sb	0.07	0.88	0.00	-0.14	0.66	0.00	1.00				
Zn	0.83	0.58	0.25	0.32	0.94	0.14	0.48	1.00			
Cd	0.76	0.58	0.16	0.21	0.86	0.13	0.51	0.92	1.00		
Ga	-0.61	-0.25	-0.55	-0.52	-0.47	0.28	-0.27	-0.46	-0.38	1.00	
Se	0.97	0.23	0.46	0.61	0.72	0.17	0.14	0.84	0.77	-0.61	1.00
	Ag	As	Au	Cu	Mo	Pb	Sb	Zn	Cd	Ga	Se

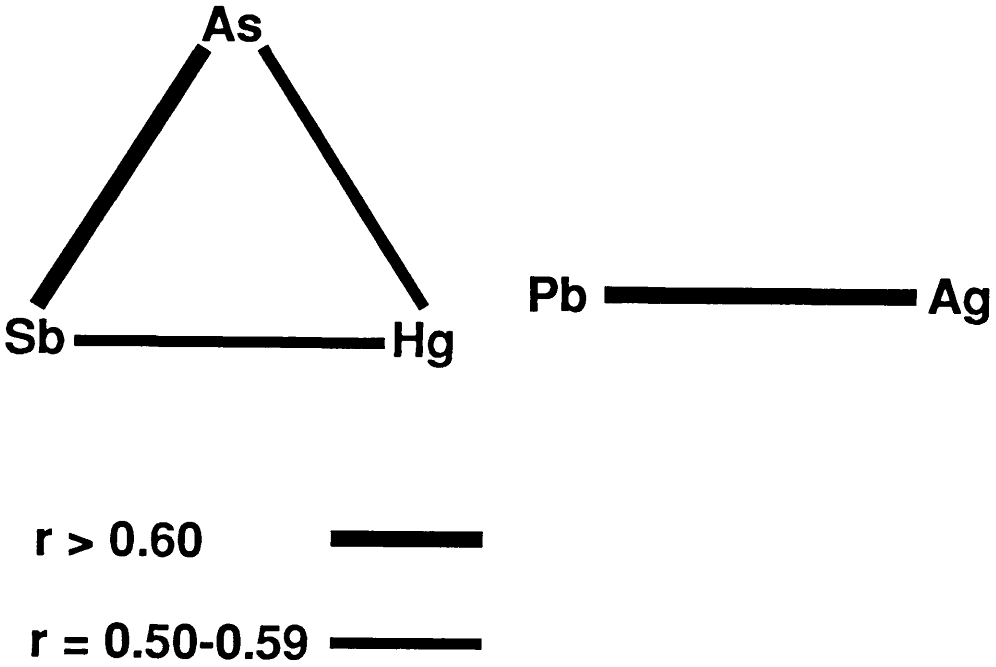


Figure 10 -- Tie diagram based on correlation coefficients, r, for jasperoid data.

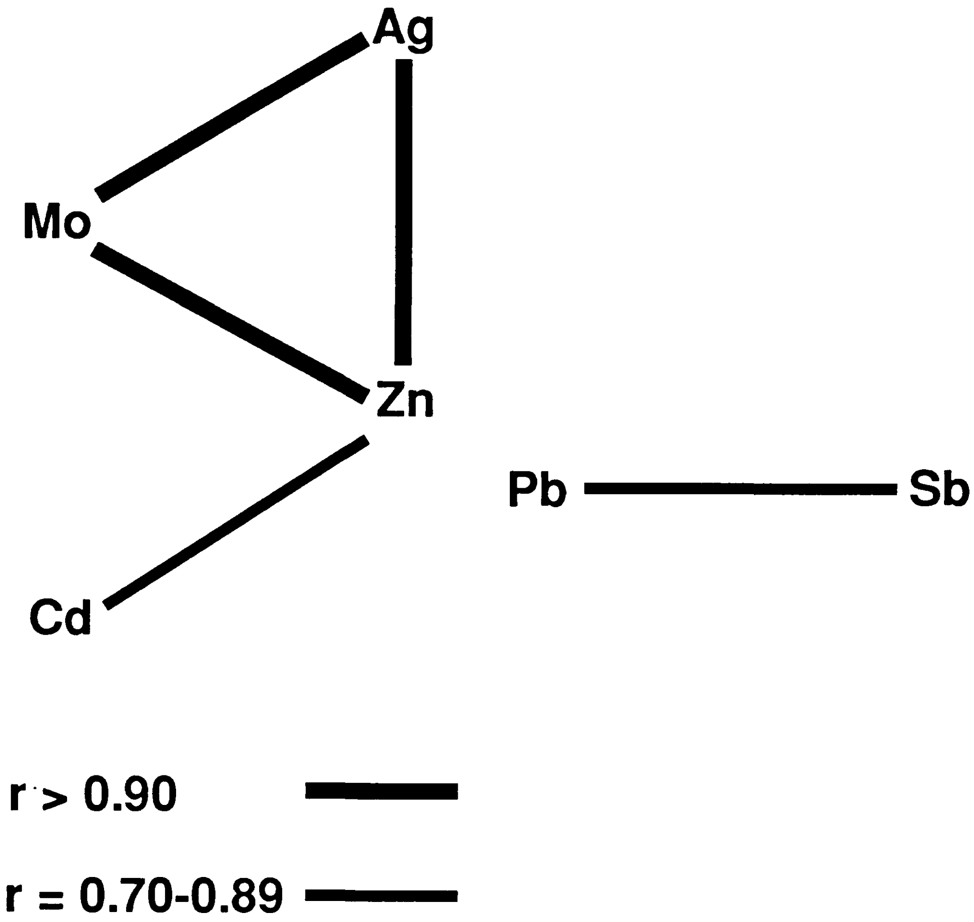


Figure 11 -- Tie diagram based on correlation coefficients, r, McGowan Creek samples.

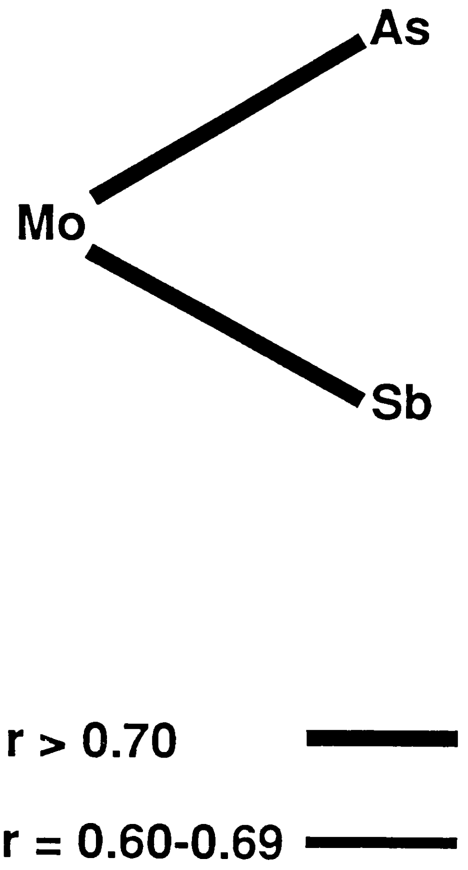


Figure 12 -- Tie diagram based on correlation coefficients, r, carbonate bank samples.

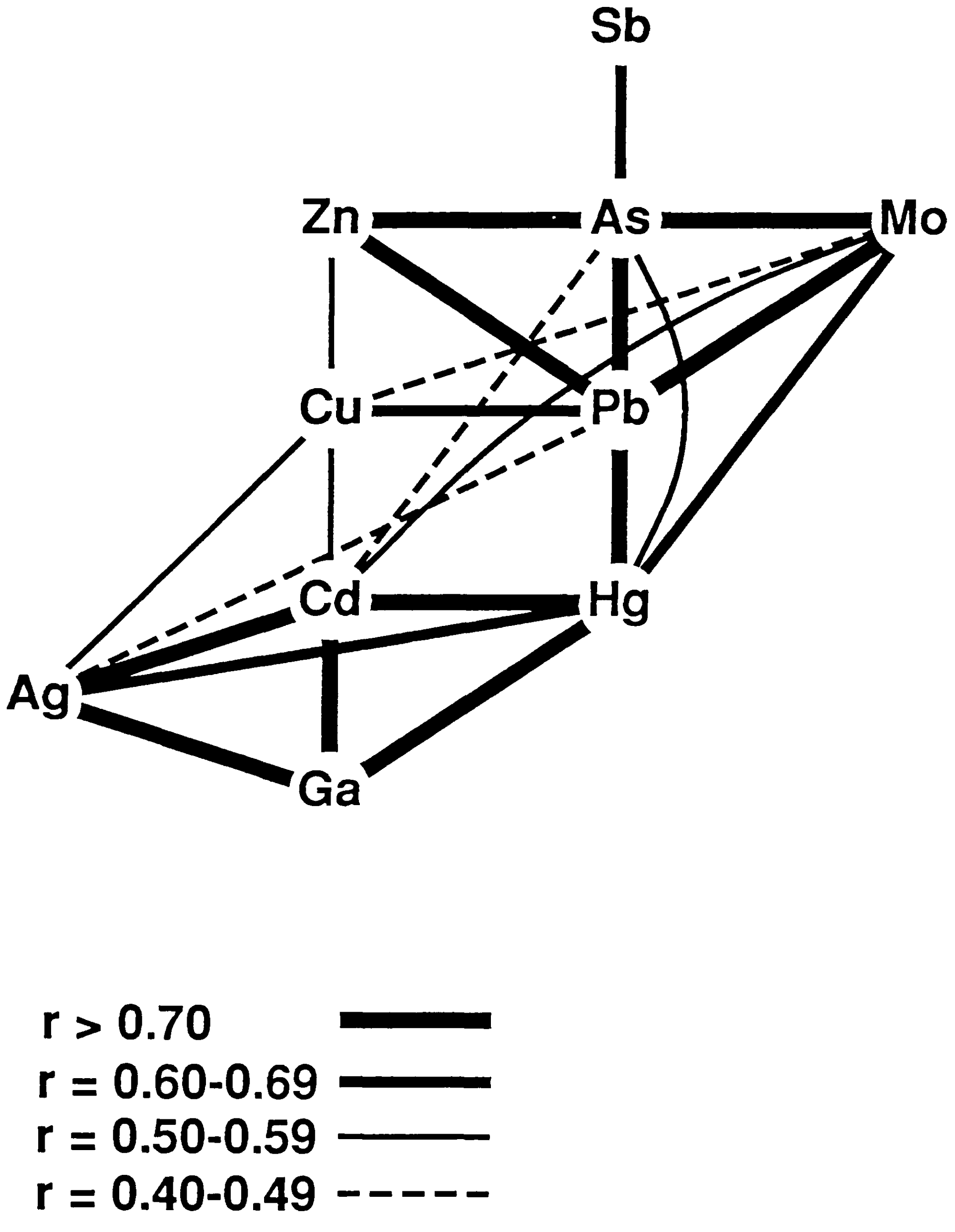


Figure 13 -- Tie diagram based on correlation coefficients, r, panned-concentrate samples.

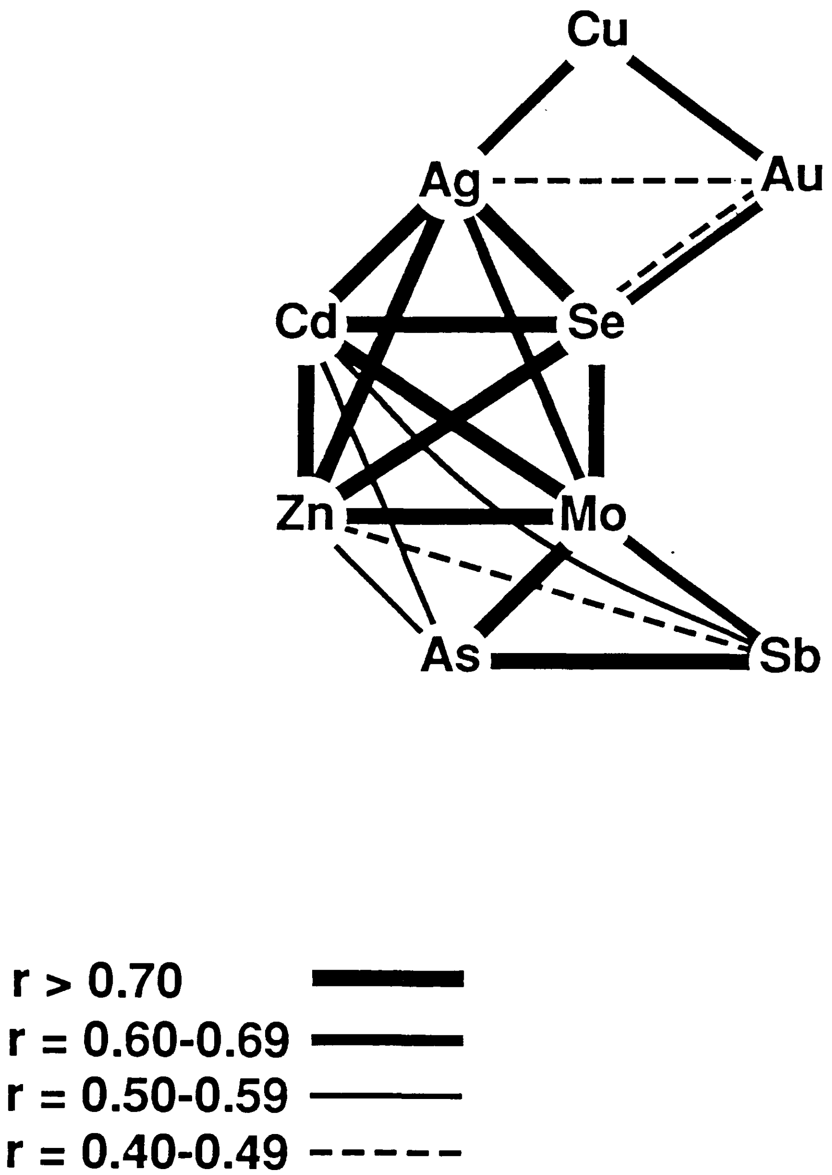


Figure 14 -- Tie diagram based on correlation coefficients, r, -80 mesh stream-sediment samples.

5. RESULTS

Rock Sample Geochemistry

Jasperoid Samples

The suite of elements Ag, As, Au, Cu, Hg, Mo, Pb, Sb, and Zn was detected in a majority of jasperoid samples. Only a few of the samples had detectable amounts of Cd, Ga, and Tl. Correlation analysis of the jasperoid defines several element associations (table 2 and fig. 10); the strongest associations are As-Hg-Sb and Pb-Ag (correlation coefficient >0.50). Table 7 lists the background and anomalous values for selected elements for all jasperoid samples. Anomalous values were determined by visual examination of the histograms (figs. 8 and 9). For example, the histogram for Ag reveals that a majority of the samples contain less than 0.2 ppm and are considered background for jasperoid samples (fig. 9). Samples with values of Ag greater than 0.2 ppm are considered anomalous for interpretational purposes. The majority of Au values ranged from less than 0.001 ppm to 0.004 ppm and only two values are considered anomalous (0.009 ppm and 0.019 ppm; Samples 87M-164 and 87M-167; fig. 15).

Sample 87M-150, located in the southernmost jasperoid body, had the highest concentration of As (515 ppm) and Sb (57.5 ppm). Sample 88CCS17, located near Richardson Spring (plate 1), had the highest concentration of Hg (8.02 ppm). The highest concentration of Au (0.019 ppm) came from sample 87M-167 collected from brecciated jasperoid south of Mountain Spring Canyon (plate 1). Sample 87M-151 had the highest concentration of Ag (2.15 ppm) and Pb (452 ppm) and sample 88CCS24A had the highest concentration of Zn (39.4 ppm) (plate 1).

Carbonate Bank Samples

Most jasperoid bodies in the Grouse area are replacements of carbonate bank limestone. The geochemistry of the unsilicified carbonate bank rocks is characterized by the detectable concentration of Ag, As, Au, Cu, Mo, Pb, Sb, Zn, and Cd. Correlation analysis of the carbonate bank samples shows a strong As-Sb-Mo association (correlation coefficient >0.70), and a Zn-Pb-Cd association (correlation coefficient >0.60; table 3). Sample 88CCS43 had the highest concentration of Ag (0.11 ppm) and Cu (5.73 ppm). Sample 88CCS57A had the highest concentrations of As (89.6 ppm), Hg (2.95 ppm), Mo (6.30 ppm), Sb (4.92 ppm), and Tl (6.44 ppm). Sample 88KLS20C had the highest Zn (125 ppm) and Cd (1.12 ppm) concentrations. Several samples had the highest Au concentration (0.001 ppm).

McGowan Creek Samples

Exposures of the McGowan Creek Formation were sparse and therefore few samples were collected in the study area to be used as background for the geochemical investigation. The geochemistry of unaltered McGowan Creek samples is characterized by detectable concentrations of Ag, As, Au, Cu, Hg, Mo, Pb, Sb, Zn, and Cd. Correlation

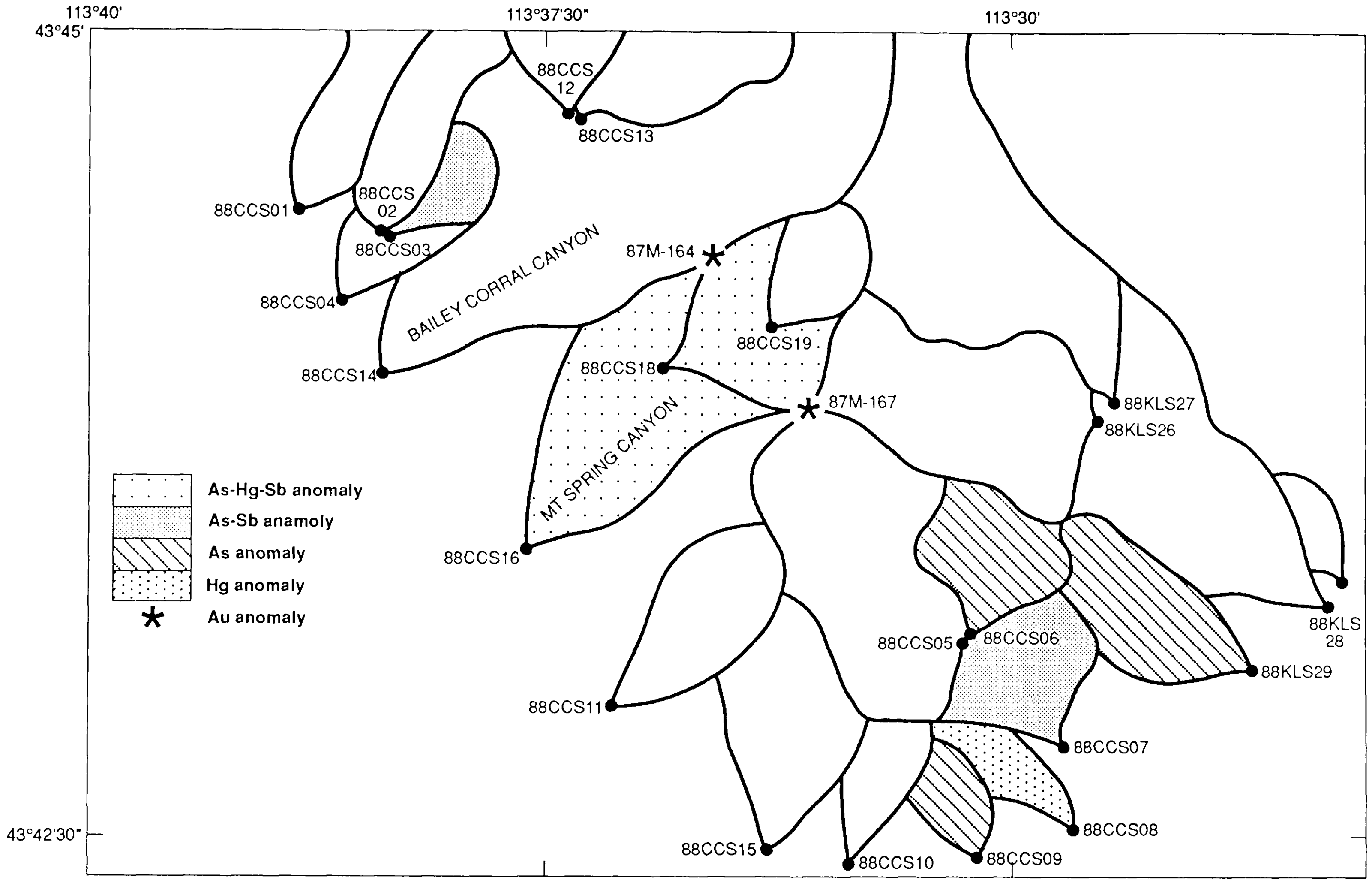


Figure 15 -- Map showing anomalous values for panned-concentrate samples. All anomalies are from jasperoid samples

analysis of the McGowan Creek samples shows a strong Mo-Ag-Zn-Cd association (correlation coefficient >0.90) and a Pb-Sb association (correlation coefficient >0.70) (Table 4). Sample 88CCS44, collected from fractured McGowan Creek Formation on a ridge between Bailey Corral Canyon and Rough Canyon (plate 1), had the highest concentration of Ag (2.79 ppm), Cu (26.5 ppm), Mo (5.74 ppm), Zn (152 ppm), Cd (0.97 ppm), and Se (8.15 ppm). The highest concentration of As (30.3 ppm) was from sample 88CCS66 and the highest Au (0.003 ppm) value was from sample 88CCS65. These samples were collected from small outcrops of McGowan Creek Formation in north-trending fractures; no large-scale faulting was noted in the area. Sample 88CCS31 had the highest concentration of Hg (1.19 ppm), Pb (11.4 ppm), Sb (4.74 ppm), and Ga (1.63 ppm).

Discussion

The trace-element association As-Au-Sb-Hg-Tl is characteristic of epithermal precious-metal deposits (Silberman and Berger, 1985). Values for trace elements from the Grouse jasperoids are within the range of those of known sedimentary rock-hosted disseminated precious-metal deposits (Table 8; Percival and others, 1988, p. 24). Lead and silver in the jasperoid samples may have been derived from the McGowan Creek Formation, which is locally metal-enriched (Table 9). The McGowan Creek samples had greater concentrations of zinc, silver, and copper than the jasperoid or carbonate bank samples. Jasperoid samples have greater concentrations of most trace elements than carbonate bank samples, with the exception of zinc.

Jasperoids near Grouse have lower concentrations of trace elements than jasperoids sampled throughout the Mackay area (Table 9). This variation may be due to several factors including lithology and chemistry of the host rocks, source and timing of the mineralizing fluids, distance from the source, pressure-temperature evolution of the fluids, flow rate and duration of fluids, and structural setting.

Stream-sediment Geochemistry

Results of the stream-sediment geochemistry found anomalous values for As-Hg-Sb in panned-concentrate samples collected in Mountain Springs Canyon (samples 88CCS16, 88CCS18; fig. 15 and plate 1). This drainage is downstream from a jasperoid body which is cut locally by a north-trending high-angle fault.

Anomalous values for As and Sb were also found for a panned-concentrate sample (88CCS03) collected in a drainage north of Bailey Corral Canyon (plate 1). This stream also drains an area in which a jasperoid body is cut by a north-trending fault. Panned-concentrate sample 88CCS07, collected in Ras Canyon, was also anomalous in As and Sb; no north-trending fault was found in this area.

All of the panned-concentrate samples had detectable concentrations of Ag, As, Au, Cu, Hg, Mo, Pb, Sb, Zn, Cd, and Ga. Sample 88CCS16, collected at the mouth of Mountain Spring Canyon, had the highest concentration of Ag (2.02 ppm), Hg (13.5 ppm), Tl (67.5 ppm), Cd (13.5 ppm), and Se (135 ppm). Sample 88CCS18, near the head of Mountain Spring Canyon, had the highest concentration of As (391 ppm), Pb (37.3 ppm), and Zn (563 ppm). The highest concentrations of Au (0.002 ppb) and Sb (328 ppm) were from sample 88CCS03, collected from a tributary of Rough Canyon. The headwaters of Mountain Spring and Rough Canyons are transected by north-trending faults (plate 1). Sample 88CCS07, collected from Ras Canyon, had the highest concentration of Mo (33 ppm).

Table 7 -- Background and anomalous values for selected elements in jasperoid samples. All values in parts per million (ppm).

ELEMENT	BACKGROUND	ANOMALOUS
Ag	<0.2	>0.2
As	<30	>30
Cu	<9.0	>9.0
Hg	<1.5	>1.5
Mo	<5.0	>5.0
Pb	<20.0	>20.0
Sb	<3.0	>3.0
Zn	<15.0	>15.0

Table 8 -- Trace element abundances in rock samples from the Grouse area (maximum value) and from selected rock samples from known sedimentary rock-hosted gold deposits in the western United States. Data from known deposits modified from Percival and others (1988). All elements reported in parts per million (ppm), unless otherwise noted. Au-Ag reported in ounces per ton for known gold deposits. NA, not analyzed.

SAMPLE	ELEMENT							
	Au	Ag	As	Hg	Sb	Cu	Pb	Zn
Jasperoid	0.019	2.15	515	8.02	57.5	41	452	39.4
McCowan Ck	0.003	2.79	30.3	1.19	4.74	26.5	11.4	152
Carbonate bank	0.001	2.79	30.3	2.95	4.92	5.73	2.43	125
Standard Deposit (J)*	0.016	0.01	19	5	NA	20	20	10
Santa Fe Deposit (J)*	0.067	2.91	240	12	280	35	1,300	30
White Caps Deposit (LS)*	50	NA	15%	NA	700	70	30	20
White Caps Deposit(J)*	0.380	0.12	3,100	15	93	NA	NA	NA
Relief Canyon	0.165	0.26	1,000	12	160	25	35	85
Chimney Creek (SS)*	0.368	0.45	320	30	390	40	650	385

* J=jasperoid, LS = limestone, SS = silicified sandstone

Table 9 -- Summary of analytical results of rock samples from the Grouse area. Arithmetic mean is given in parts per million. N -- number of samples.

SAMPLE	N	ELEMENT (MEAN CONCENTRATION)								
		Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Zn
Jasperoid	54	0.16	45.85	0.003	5.19	0.93	7.03	17.75	4.95	7.68
McGowan Creek	6	0.91	12.50	0.002	13.35	0.29	2.03	6.24	2.19	54.75
Carbonate bank	11	0.05	11.02	0.001	2.79	0.38	1.00	1.11	0.81	21.71
Mackay Jasperoid*	110	0.40	134.90	0.01	10.51	1.64	10.40	13.42	11.45	26.63

* Summary of analytical results of 110 jasperoid samples collected in the Mackay, Idaho area, from Wilson and others, 1988.

6. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Macroscopic and microscopic observation of the jasperoid bodies near Grouse indicate that the jasperoids are irregular replacements of carbonate bank limestone sequences. Values for trace elements from the Grouse jasperoids are within the range of those of known sediment-hosted disseminated precious-metal deposits (Table 1; Percival and others, 1988, p. 24). Field relations show that most of the Grouse jasperoid bodies are along fracture and fault systems that trend north to northeast. Silicified fracture breccias and jasperoid stringers also have a weak north to northeast trend. Jasperoids in the Grouse area may have formed from ascending hydrothermal solutions and were deposited along and adjacent to these fault and fracture systems. Skipp in Wilson and others (1988) suggests that some jasperoid near Mackay may have formed by meteoric water in karst zones as well as fault zones. No karst topography was noted in the study area. Most of the jasperoid bodies are brecciated and recemented and many are veined with silica, indicating repeated fluid influx. Multiple stages of brecciation indicate more than one episode of faulting. No gradation of the degree of silicification was observed and the jasperoids form a sharp boundary with unsilicified limestone. This may be the result of changes in permeability and fluid flow as a result of changes in pH, temperature, and pressure. Replacement of limestone by silica may cease as the result of: 1) an increase in pH of the solution at the replacement interface to the point where limestone is less soluble than silica, 2) an increase in the temperature of the whole rock body, 3) a decrease in the permeability due to deposition of silica (silicification armors the rocks from further migration of fluids, 4) depletion of silica, and 5) a decrease in pressure as solutions move into fracture zones (Lovering, 1972).

Tertiary igneous and hydrothermal activity with accompanying mineralization took place throughout the area during regional extension (Worl and others, 1988). Hydrothermal activity, beginning about 50 million years ago and continuing intermittently to the present, produced a variety of ore deposits including skarn, vein, and replacement deposits. Hydrothermal solutions moving along major high-angle fracture systems also formed large bodies of jasperoid, such as those near Grouse, in local shelf carbonate and black shale terranes. Jasperoid in the Grouse area are inferred to be Eocene or younger in age (Skipp, 1988).

The proximity of the Grouse jasperoids to known and inferred intrusive bodies supports an intrusion-related origin for the formation of the jasperoid bodies. The jasperoid bodies are located a few miles southeast of the Eocene Mackay stock, a granitic intrusive complex that formed skarn deposits at the Empire and Copper Basin mines (fig. 4). Aeromagnetic data indicate that the Mackay stock may be more extensive in the subsurface and that a low-density buried intrusion may be present about 3 miles south of Grouse (Kleinkopf and others, 1989). Silica may have been late stage fluids from these intrusions at depth.

In carbonate environments, jasperoid is formed when silica is deposited in response to the physical and chemical changes that occur as calcite is dissolved from limestone and silica is precipitated during cooling of a hydrothermal fluid. Silica replacement of carbonate rocks occurs at temperatures below 300°C (Fournier, 1985). At a constant partial pressure of CO_2, decreasing temperature increases the solubility of calcite and decreases the solubility of silica, quartz, and chalcedony (Fournier, 1989). Also, at constant temperature, calcite becomes less soluble as the partial pressure of CO_2 decreases (Ellis, 1959). This slow cooling of a hydrothermal fluid at near neutral pH promotes the replacement of limestone by silica resulting in formation of a jasperoid body. Silica deposition may also have occurred as a result of a sudden decrease in pressure resulting from brecciation along fault zones. The proximity of faults to most of the jasperoids at Grouse indicates that deposition was possibly structurally controlled. Textural evidence (brecciated jasperoid) suggests fault movement during silicification. Hydrothermal fluids moved along high-angle faults and other permeable areas before deposition. Anomalous concentrations of As, Sb, and Hg were found in stream-sediment samples from Rough Creek and Mountain Spring Canyon. Both areas are downstream from north-trending faults that cut jasperoid bodies, indicating that mineralization may also be fault controlled. North-trending faults predate Challis volcanic activity and are considered to be Mesozoic in age (Skipp, 1988). Mineral deposits at the Champagne mine, about 10 mi south of Grouse, occur in northerly-trending veins and stockworks related to the north-trending Mesozoic structural fabric (Skipp, 1990, written communication). East-west- and northeast-trending faults are also present in the Grouse area and are considered to be pre-

Challis volcanism (Skipp, 1988). Southworth (1988) recognized significant northeast- and northwest-trending lineaments at a local and regional scale in the Idaho Falls 1° x 2° quadrangle, including the Grouse area. He further noted that the northwest-trending faults are often offset by northeast-trending faults and that the intersection of these trends may be potential zones of mineralization. Although the jasperoid bodies at Grouse have low gold values, they have geological and geochemical properties that are similar to jasperoid associated with known sedimentary rock-hosted precious-metal deposits in the western United States (Percival and others, 1988): 1) Grouse jasperoids are replacements of limestone, carbonaceous limestone, and calcareous carbonaceous shales, 2) many jasperoid bodies show multiple generations of brecciation and silicification, 3) many are proximal to or along high-angle faults and fractures, 4) quartz and calcite veins are common, and minor jarosite is present, and 5) jasperoid geochemistry is characterized by anomalous amounts of Ag, As, Au, Cu, Hg, Mo, Pb, Sb, and Zn and scattered traces of Cd, Ga, and Tl.

Local intrusions probably produced hydrothermal systems responsible for silica deposition in the Grouse area. Intrusions at depth (Kleinkopf and others, 1989) may have been the source of a convective hydrothermal system that either supplied metals and/or acted as a heat source for transport of metals from sedimentary rocks. The suite of elements Ag, Au, As, Hg, and Sb are consistently present, commonly in anomalous concentrations, in rock samples from this study. This indicates that some of the hydrothermal fluids were metal-bearing. The same hydrothermal systems responsible for silica deposition may have scavenged metals from sedimentary host rocks and redeposited the metals locally. The fluids could have formed precious-metal deposits in unsilicified country rock near the jasperoid bodies, as is common for disseminated gold deposits in the western United States (Percival and others, 1988).

Recommendations

Results of the stream-sediment sampling indicate that trace elements associated with sedimentary rock-hosted precious-metal deposits, As-Sb-Hg, are present in anomalous concentrations from samples collected downstream from faulted jasperoid bodies. These anomalies may indicate the presence of mineralized rocks in the Rough Creek and Mountain Spring Canyon areas. These areas warrant further detailed exploration for precious-metal deposits. Further exploration including detailed sampling of the faulted bedrock should concentrate on these areas. The origin of sedimentary rock-hosted gold deposits is currently under debate and its outcome affects exploration for precious-metal deposits in the Grouse area. Hofstra and others (1990) propose that this type of gold deposit is the result of mixing of two meteoric fluids and sulfidization of iron while Sillitoe and Bonham (1990) propose a magmatic origin for the gold. Although this study suggests that the jasperoids near Grouse are hydrothermal in origin, the nature of the fluids is not known. During this study, thin sections of jasperoid samples were examined for fluid inclusions in an attempt to determine the origin and nature of fluids.

The intensely brecciated nature of the jasperoid samples made identification of fluid inclusions impossible. No isotopic research to date has been undertaken on the jasperoid rocks. Detailed studies of the isotopic composition of the jasperoid and surrounding country rocks are needed in order to the determine a meteoric or magmatic source for the silica and the metals.

REFERENCES CITED

Anderson, A.L., 1929, Geology and ore deposits of the Lava Creek district, Idaho: Idaho Bureau of Mines and Geology Pamphlet 32, 70 p.

Anderson, A.L., 1947, Epithermal mineralization at the Last Chance and Hornsilver mines, Lava Creek district, Butte County, Idaho: Geological Society of America Bulletin, v. 56, p. 451-482.

Baedecker, P.A., ed., 1987, Methods for geochemical analysis: U.S. Geological Survey Bulletin 1770, 143 p.

Bagby, W.C., and Berger, B.R., 1985, Geologic characteristics of sediment-hosted, disseminated precious-metal deposits in the western United States, in Berger, B.R., and Bethke, P.M., eds., Geology and geochemistry of epithermal systems: Society of Economic Geologists Reviews in Economic Geology, V. 2, p. 169-200.

Bagby, W.C., Menzie, W.D., Mosier, D.L., and Singer, D.A., 1986, Grade and tonnage model of carbonate-hosted Au-Ag deposits, in Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 175-177.

Barnes, H.L., 1979, Geochemistry of Hydrothermal Ore Deposits: New York, John Wiley and Sons, 708 p.

Berger, B.R., 1986, Descriptive model of carbonate-hosted Au-Ag deposits, in Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 175.

Beus, A.A., and Grigorian, S.V., 1977, Geochemical Exploration Methods for Mineral Deposits: Illinois, Applied Publishing Ltd., 287 p.

Birak, D.J., Mancuso, T.K., and Dahl, A.R., 1987, Sediment-hosted disseminated gold mineralization at Jerritt Canyon, Nevada I - jasperoids as the key to the time-space framework [abs.]: Geological Society of America Abstracts with Programs, v. 19, no. 7, p. 589.

Boyle, R.W., 1979, The geochemistry of gold and its deposits: Geological Survey of Canada Bulletin 280, 584 p.

Boyle, R.W., 1987, Gold, history and genesis of deposits: Van Nostrand Reinhold Company Inc., New York, 676 p.

Bush, J.B., Cook, D.R., Lovering, T.S., and Morris, H.T., 1960, The chief Oxide-Burgin area discoveries, East Tintic district, Utah: Economic Geology, v. 55, p. 1507-1540.

Closs, L.G. and Sado, E.V., 1981, Geochemistry of soils and glacial sediments near gold mineralization in the Beardmore-Geraldton area, District of Thunder Bay: Ontario Geological Survey Study 22, 65 p.

Church, S.E., 1981, Multi-element analysis of forty-four geochemical reference samples using inductively coupled plasma-atomic emission spectrometry: Geostandards Newsletter, v. 5, p. 133-160.

Crone, W., Larson, L.T., Carpenter, R.H., Chao, T.T., and Sanzolone, R.F., 1984, A comparison of iron oxide-rich joint coatings and rock chips as geochemical sampling media in exploration for disseminated gold deposits: Journal of Geochemical Exploration, v. 20, p. 161-178.

Davis, J.C., 1986, Statistics and Data Analysis in Geology, second edition: New York, John Wiley and Sons, 646 p.

Dean, W.E., Bostick, N.H., Bartel, A.J., Brandt, E.L., Davis, T.A., Doughten, M., Gent, C.A., Jaunaraja, S.R., Libby, B., Malcolm, M.J., Robb, E.C., Taggart, J.E., Threlkeld, C.N., Vuletich, A.K., Cunningham, C.G., Ashley, R.P., and Chou, I-M., 1988, Data on the geochemistry and thermal maturation of sedimentary rock-hosted disseminated gold deposits and associated rocks, southwestern Guizhou Province, People's Republic of China: U.S. Geological Survey Open-File Report 88-271, 22 p.

Dickson, F.W., and Radtke, A.S., 1977, The unique mineralogy of Hg-As-Sb-Tl sulfides at the Carlin gold deposit, Nevada, and implications as to the origin of the deposit: Mineralogical Society of America - Friends of Mineralogy Joint Symposium on Crystal Growth and Habit, 3rd, Tucson, Arizona, 1977, p. 13-14.

Dickson, F.W., Radtke, A.S. and Rye, R.O., 1975, Implications of the occurrence of barium minerals and their sulfur isotopic compositions of barite on late-stage processes in Carlin-type gold deposits (abs.): Geological Society of America Abstracts with Programs, v. 7, no. 5, p. 604-605.

Dickson, F.W., Rye, R.O., and Radtke, A.S., 1978, The Carlin gold deposit: Product of an ancient geothermal system that extracted ore and gangue components from sedimentary rocks (abs.): International Association on the Genesis of Ore Deposits (IAGOD) Symposium, 5th, Alta, Utah, Abstracts with Programs, p. 82.

Duke, D.A., and Howd, F.H., 1959, Jasperoid and ore deposits in the Tintic and East Tintic mining district, Utah [abs.]: Geological Society of America Bulletin, V. 70, p. 1593.

Engineering and Mining Journal, 1989, A toast to the Champagne Mine: v. 190, n. 8 (August), p. 15.

Erickson, R.L., Masursky, H., Marranzino, A.P., Oda, U., and Janes, W.W., 1964, Geochemical anomalies in the lower plate of the Roberts thrust, near Cortez, Nevada, in Geological Survey Research 1964: U.S. Geological Survey Professional Paper 501-B, p. B92-B94.

Erickson, R.L., Van Sickle, G.H., Nakagawa, H.M., McCarthy, J.H., and Leong, K.W., 1966, Gold geochemical anomaly in the Cortez district, Nevada: U.S. Geological Survey Circular 534, 9 p.

Fournier, R.O., 1985, Silica minerals as indicators of conditions during gold deposition, in Tooker, E.W., ed., Geologic characteristics of sediment-hosted disseminated gold deposits - Search for an occurrence model: U.S. Geological Survey Bulletin 1646, p. 15-26.

Govett, G.J.S., 1983, Rock Geochemistry in Mineral Exploration: Amsterdam, Elsevier, 461 p.

Govett, G.J.S., and Nichol, I., 1979, Lithogeochemistry in mineral exploration, in Hood, P.J., ed., Geophysics and geochemistry in the search for metallic ores: Geological Survey of Canada, Economic Geology Report 31, p. 339-362.

Harris, Michael, and Radtke, A.S., 1976, Statistical study of selected trace elements with reference to geology and genesis of the Carlin gold deposit, Nevada: U.S. Geological Survey Professional Paper 960, 21 p.

Hausen, D.M., 1967, Fine gold occurrence at Carlin, Nevada: New York, Columbia University, unpub. Ph.D. thesis, 166 p.

Hausen, D.M., and Kerr, P.F., 1968, Fine gold occurrence at Carlin, Nevada, in Ridge, J.D., ed., Ore deposits of the United States, 1933-1967: New York, American Institute of Mining, Metallurgical, and Petroleum Engineers, v. 1, p. 908-940.

Hill, R.H., Adrian, B.M., Bagby, W.C., Bailey, E.A., Goldfarb, R.J., and Pickthorn, W.J., 1986, Geochemical data for rock samples collected from selected sediment-hosted disseminated precious-metal deposits in Nevada: U.S. Geological Survey Open-File Report 86-107, 30 p.

Hinkle, M.E., 1988, Geochemical sampling in arid environments by the U.S. Geological Survey: U.S. Geological Survey Circular 997, 26 p.

Hofstra, A.H., Landis, G.P., Leventhal, J.S., Northrup, H.R., Rye, R.O., Doe, T.C., and Dahl, A.R., 1990, Genesis of sediment-hosted disseminated gold deposits by Canyon, Nevada, in Geological Society of Nevada and U.S. Geological Survey, Geology and ore deposits of the Great Basin: Great Basin Symposium, Abstract with Programs, p.55

Hofstra, A.H., and Rowe, W.A., 1987, Sediment-hosted disseminated gold mineralization at Jerritt Canyon, Nevada II - jasperoid paragensis and occurrence [abs.]: Geological Society of America Abstracts with Programs, v.19, no, 7, p. 704.

Holland, P.T., Beatty, D.W., and Snow, G.G., 1988, Comparative elemental and oxygen isotope geochemistry of jasperoid in the Northern Great Basin: Evidence for distinctive fluid evolution in gold-producing hydrothermal systems: Economic Geology, v. 83, n. 7, p. 1401-1419.

Holland, P.T., Beatty, D.W., and Snow, G.G., 1989, Comparative elemental and oxygen isotope geochemistry of jasperoid in the Northern Great Basin: Evidence for distinctive fluid evolution in gold-producing hydrothermal systems - a reply: Economic Geology, v. 84, p. 1707-1712.

Howd, F.H., 1957, Hydrothermal alteration in the East Tintic mining district: Geological Society of Utah Guidebook 12, p. 124-134.

Ikramuddin, M., Besse, L., and Nordstrom, P.M., 1986, Thallium in Carlin-type gold deposits: Applied Geochemistry, v. 1, p. 493-502.

Jones, B.K., and Leveille, R.A., 1989, Comparative elemental and oxygen isotope geochemistry of jasperoid in the northern Great Basin: evidence for distinctive fluid evolution in gold-producing hydrothermal systems - a discussion: Economic Geology, v. 84, p. 1705-1707.

Kleinkopf, M.D., Bankey, Viki, and McCafferty, A.E., 1989, Gravity and magnetic anomaly patterns applied to mineral resource exploration, Hailey 1° x 2° quadrangle, Idaho, in, Winkler, G.R., Soulliere, S.J., Worl, R.G., and Johnson, K.M., Geology and mineral deposits of the Hailey and western Idaho Falls 1°x2° quadrangles, Idaho: U.S. Geological Survey Open-File Report 89-639, p. 26-32.

Lakin, W.H., Curtain, C.G., Hubert, A.E., Shacklette, H.T., and Doxtader, K.G., 1974, Geochemistry of gold in the weathering cycle: U.S. Geological Survey Bulletin 1330, 80 p.

Levinson, A.A., 1980, Introduction to Exploration Geochemistry, 2nd edition: Applied Publishing, 942 p.

Link, P.K., Skipp, B.A., Hait, M.H., Jr., Janecke, Susanne, and Burton, B.R., 1988, Structural and stratigraphic transect of south-central Idaho: a field guide to the Lost River, White Knob, Pioneer, Boulder, and Smoky Mountains, in Link, P.K., and Hackett, W.R., eds., Guidebook to the geology of central and southern Idaho: Idaho Geological Survey Bulletin 27, p. 5-42.

Lovering, T.G., 1962, The origin of jasperoid in limestone: Economic Geology, v. 57, p. 861-889.

Lovering, T.G., 1972, Jasperoid in the United States - its characteristics, origin, and economic significance: U.S. Geological Survey Professional Paper 710, 164 p.

Lovering, T.G., 1981, Jasperoid float and stream cobbles as tools in geochemical exploration for hydrothermal ore deposits: Journal of Geochemical Exploration, v. 14, p. 69-81.

Lovering, T.G., and Hamilton, J.C., 1962, Criteria for the recognition of jasperoid associated with sulfide ore, in Short papers in geology and hydrology, articles 60-119, Geological Survey Research 1962: U.S. Geological Survey Professional Paper 450-C, p. C9-C11.

Lovering, T.G., and Heyl, A.V., 1974, Jasperoid as a guide to mineralization in the Taylor mining district and vicinity near Ely, Nevada: Economic Geology, v. 69, p. 46-58.

Lovering, T.G., Lakin, H.W., and Hubert, A.E., 1968, Concentration and minor element association of gold in ore-related jasperoid samples: U.S. Geological Survey Professional Paper 600-B, P. B112-B114.

Lovering, T.G., Lakin, H.W., and McCarthy, J.H., 1966, Tellurium and mercury in jasperoid samples: U.S. Geological Survey Professional Paper 550-B, p. B138-B141.

Lovering, T.G., and McCarthy, J.H., Jr., 1978, Conceptual models in exploration geochemistry, the basin and range province of the western United States and northern Mexico: Journal of Geochemical Exploration, v. 9, no. 2/3, p. 115-271.

Lovering, T.S., 1949, Rock alteration as a guide to ore - East Tintic district, Utah: Economic Geology Monograph 1, 65 p.

Marsh, S.P., 1976, Geochemical prospecting for Carlin-type gold deposits: U.S. Geological Survey Open-File Report 76-335, 9 p.

McCarthy, J.H., Jr., Learned, R.E., Botbol, J.M., Lovering, T.G., Watterson, J.R., and Turner, R.L., 1969, Gold-bearing jasperoid in the Drum Mountains, Juab and Millard Counties, Utah: U.S. Geological Survey Circular 623, 4 p.

Meyer, W.T., Theobald, P.K., Jr., and Bloom, H., 1979, Stream sediment geochemistry, in Hood, P.J., ed., Geophysics and Geochemistry in the Search for Metallic Ores: Geological Survey of Canada, Economic Geology, Report 31, p. 411-434.

Moye, F.J., Hackett, W.R., Blakely, J.D., and Snider, L.G., 1988, Regional geologic setting and volcanic stratigraphy of the Challis volcanic field, central Idaho, in Link, P.K., and Hackett, W.R., eds., Guidebook to the geology of central and southern Idaho: Idaho Geological Survey Bulletin 27, p. 87-97.

Moye, F.J., and Hall, L.F., 1988, Epithermal precious metal deposits, southeastern Challis volcanic field, central Idaho: Exploration potential: Geological Society of America Abstracts with Programs, v. 20, n. 6, p. 434.

Moye, F.J., Sanford, R.F., Erdman, J.A., and Johnson, K.M., 1989, Volcanic-hosted and intrusion-related mineral deposits in the Hailey and Idaho Falls quadrangles, Idaho, in Winkler, G.R., Soulliere, S.J., Worl, R.G., and Johnson, K.M., eds., Geology and mineral deposits of the Hailey and western Idaho Falls 1°x2° quadrangles, Idaho: U.S. Geological Survey Open-File Report 89-639, p. 70-71.

Nash, J.T., 1972, Fluid-inclusion studies of some gold deposits in Nevada: U.S. Geological Survey Professional Paper 800-C, p. C15-C19.

Nelson, C.E., 1985, Applications of multivariate analysis to precious metal exploration in the western U.S. (abs.): Geological Society of America, Abstracts with Programs, v. 17., p. 675.

Nelson, C.E., 1986, A comparative geochemical study of barren and mineralized Carlin-type gold deposits (abs.): Assoc. Explor. Geochem. and Cordilleran Section, Assoc. Canada, p. 66.

Nelson, C.E., 1990, Comparative geochemistry of jasperoids from Carlin-type gold deposits of the western United States, in, Hedenquist, J.W., White, N.C., and Siddeley, G., eds., Epithermal Gold Mineralization of the Circum-Pacific: Geology, Geochemistry, Origin, and Exploration II: Journal of Geochemical Exploration, v. 36, p. 171-195.

Nelson, W.H., and Ross, C.P., 1968, Geology of part of the Alder Creek Mining district, Custer County, Idaho: U.S. Geological Survey Bulletin 1252-A, 30 p.

Nelson, W.H., and Ross, C.P., 1969a, Geology of the Mackay 30-minute quadrangle, Idaho: U.S. Geological Survey Open-File Report 1385, 161 p.

Nelson, W.H., and Ross, C.P., 1969b, Geologic map of the Mackay quadrangle south-central Idaho: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-580, scale 1:125,000.

Nichol, Ian, Closs, L.G., and Lavin, O.P., 1989, Sample representivity with reference to gold exploration, in Garland, G.D., ed., Proceedings of Exploration '87: Third Decennial International Conference on Geophysical and Geochemical Exploration for Mineral and Groundwater: Ontario Geological Survey Special Volume 3, p. 609-624.

Nielson, R.L., and Laskowski, E.R., 1987, Rock chip geochemical values of mineralized samples from Nevada mining districts - An exploration tool?, in Schafer, R.W., Cooper, J.J., and Vikre, P.G., eds., 1988, Bulk Mineable Precious Metal Deposits of the Western United States Symposium Proceedings: Geological Society of Nevada, p. 62.

Nilsen, T.H., 1977, Paleogeography of Mississippian turbidites in south-central Idaho, in Stewart, J.H., Stevens, C.H., and Fritsche, A.E., eds., Paleozoic paleogeography of the western Untied States: Society of Economic Paleontologists and Mineralogists Pacific Section, Pacific Coast Paleogeography Symposium I, p. 275-299.

Northrup, H.R., Rye, R.O., Landis, G.P., Lusterwerk, R., Jones, M.B., and Daly, W.E., 1987, Sediment-hosted disseminated gold mineralization at Jerritt Canyon, Nevada V - stable isotope geochemistry and a model of ore deposition [abs.]: Geological Society of America Abstracts with Programs, v. 19, n. 7, p. 791.

O'Neil, J.R., and Bailey, G.B., 1979, Stable isotope investigation of gold-bearing jasperoid in the central Drum Mountains, Utah: Economic Geology, V. 74, no. 4, p. 852-859.

Overstreet, W.C., and Marsh, S.P., 1981, Some concepts and techniques in geochemical exploration: Economic Geology, 75th Annual Volume, p. 775-805.

Percival, T.J., Bagby, W.C., and Radtke, A.S., 1988, Physical and chemical features of precious-metal deposits hosted by sedimentary rocks in the western United States, in Schafer, R.W., Cooper, J.J., and Vikre, P.G., eds., 1988, Bulk Mineable Precious Metal Deposits of the Western United States Symposium Proceedings: Geological Society of Nevada, p. 11-34.

Radtke, A.S., 1981, Geology of the Carlin gold deposit, Nevada: U.S. Geological Survey Open-File Report 81-97, 154 p.

Radtke, A.S., 1985, Geology of the Carlin gold deposit, Nevada: U.S. Geological Survey Professional Paper 1267, 124 p.

Radtke, A.S., and Dickson, F.W., 1976, General features of disseminated replacement gold deposits of the Carlin-type (abs.), in Geology and exploration aspects of fine-grained, Carlin-type gold deposits: Geological Society of Nevada and Mackay School of Mines Symposium, Reno, Nevada, 1976, Preprints with Program, p. 1-2.

Radtke, A.S., and Dickson, F.W., and Rytuba, J.J., 1974, Genesis of disseminated gold deposits of the Carlin type (abs.): Geological Society of America Abstracts with Programs, v. 6, No. 3, p. 239-240.

Radtke, A.S., Heropoulos, Chris, Fabbi, B.P., Scheiner, B.J., and Essington, Mel, 1972, Data on major and minor elements in host rocks and ores, Carlin gold deposit, Nevada: Economic Geology, v. 67, n. 7, p. 975-978.

Radtke, A.S., Rye, R.O., and Dickson, F.W., 1980, Geology and stable isotope studies of the Carlin gold deposit, Nevada: Economic Geology, v. 75, no. 5, p.641-672.

Rogers, Michael, 1987, Rare earth element analysis as an indicator for economic Au mineralization of Nevada jasperoid samples by inductively coupled plasma spectroscopy, in Geological Society of Nevada Symposium, Bulk mineable precious metal deposits of the western United States, April 6-8, 1987, Abstracts with Programs, p. 59-60.

Romberger, S.B., 1986, Ore deposits no. 9, disseminated gold deposits: Geoscience Canada, v. 13, n. 1, p. 23-31.

Romberger, S.B., 1988, Geochemistry of Gold in Hydrothermal Deposits, in Shawe, D.R., Ashley, R.P., and Carter, L.M.H., Geology and resources of gold in the United States - Introduction to geology and resources of gold, and geochemistry of gold: U.S. Geological Survey Bulletin 1857, p. A9-A22.

Rose, A.W., 1972, Statistical interpretation techniques in geochemical exploration: Society of Mining Engineers of American Institute of Mining, Metallurgical and Petroleum Engineers Transactions, v. 252, n. 3, p. 233-239.

Rose, A.W., Hawkes, H.E., and Webb, J.S., 1979, Geochemistry in Mineral Exploration, 2nd edition: Academic Press, 657 p.

Roslyakov, N.A., 1984, Zonality of gold forms in the surficial environment as criterion for buried gold deposits: Journal of Geochemical Exploration, v. 21, p. 333-340.

Ross, C.P., 1963, Mining history of south-central Idaho: Idaho Bureau of Mines and geology pamphlet 131, 29 p.

Sandberg, C.A., 1975, McGowan Creek Formation, a new name for Lower Mississippian flysch sequence in east central Idaho: U.S. Geological Survey Bulletin 1405-E, p. E1-E11.

Schafer, R.W., Cooper, J.J., and Vikre, P.G., eds., 1988, Bulk Mineable Precious Metal Deposits of the western United States Symposium Proceedings: Geological Society of Nevada, 755 p.

Simons, F.S., 1981, A geological and geochemical evaluation of the mineral resources of the Boulder-Pioneer Wilderness Study Area, Blaine and Custer Counties, Idaho: U.S. Geological Survey Bulletin 1497-C, p. 87-180.

Sillitoe, R.H., and Bonham, H.F., Jr., 1990, Sediment-hosted gold deposits - Distal products of magmatic-hydrothermal systems: Geology, v. 18, n. 2, p. 157-161.

Skipp, Betty, 1987, Basement thrust sheets in the Clearwater orogenic zone, central Idaho and western Montana: Geology, v. 15, p. 220-224.

Skipp, Betty, 1988, Geologic map of the Mackay 4 (Grouse) NE quadrangle, Butte and Custer Counties, Idaho: U.S. Geological Survey Open-File Report 88-923, scale 1:24,000.

Skipp, Betty, 1989, Geologic map of the Mackay 4 (Grouse) NW quadrangle, Butte and Custer Counties, Idaho, scale 1:24,000.

Skipp, Betty, and Hait, M.H., Jr., 1977, Allochthons along the northeast margin of the Snake River Plain, Idaho: Wyoming Geological Association Twenty-ninth Annual Field Conference Guidebook, p. 499-515.

Skipp, Betty, Hoggan, R.D., Schleicher, D.L., and Douglass, R.C., 1979a, Upper Paleozoic carbonate bank in east-central Idaho - Snaky Canyon, Bluebird Mountain, and Arco Hills Formations and their paleotectonic significance: U.S. Geological Survey Bulletin 1486, 78 p.

Skipp, Betty, Kuntz, M.A., and Morgan, L.A., 1990, Geologic map of Mackay 4 (Grouse) SE quadrangle, Idaho: U.S. Geological Survey Open-File Report 89-431, scale 1:24,000.

Skipp, Betty, Sando, W.S., and Hall, W.E., 1979b, The Mississippian and Pennsylvanian (Carboniferous) systems in the U.S. - Idaho: U.S. Geological Survey Professional Paper 1110-AA, p. AA1-AA42.

Smith, C.L., 1989, Geochemical characterization of some mineralized terranes in the Hailey 1°X2° quadrangle, Idaho, in Winkler, G.R., Soulliere, S.J., Worl, R.G., and Johnson, K.M., Geology and mineral deposits of the Hailey and western Idaho Falls 1°x2° quadrangles, Idaho: U.S. Geological Survey Open-File Report 89-639, p. 23-25.

Soulliere, S.J., Wilson, A.B., Moye, F.J., and Rhea, K.P., 1988, Analytical results and sample locality map of jasperoid samples from Mackay, Idaho: U.S. Geological Survey Open-file Report 88-589, 21 p.

Soulliere, S.J., Wilson, A.B., and Skipp, Betty, 1989, Geologic controls for mineralization in sedimentary rocks, western Idaho Falls 1°x2° quadrangle, Idaho, in Winkler, G.R., Soulliere, S.J., Worl, R.G., and Johnson, K.M., Geology and mineral deposits of the Hailey and western Idaho Falls 1°x2° quadrangles, Idaho: U.S. Geological Survey Open-File Report 89-639, p. 128-135.

Southworth, C.S., 1988, Preliminary lineament map of the Hailey, Idaho and west half of the Idaho Falls, Idaho 1°x2° quadrangles, with inset of regional image mosaic and geologic structures: U.S. Geological Survey Open-File Report 88-640, scale 1:250,000.

Theobald, P.K., Jr., 1981, One Man's View of a Research Gap: Presidential Address of the Association of Exploration Geochemists: Journal of Exploration Geochemistry, v. 15, p. 1-20.

Tingley, J.V., and Bonham, H.F., eds., 1986, Sediment-hosted precious-metal deposits of northern Nevada: Nevada Bureau of Mines and Geology Report 40, 103 p.

Tooker, E.W., ed., 1985, Geologic characteristics of sediment- and volcanic-hosted disseminated gold deposits - Search for an occurrence model: U.S. Geological Survey Bulletin 1646, 150 p.

Umpleby, J.B., 1917, Geology and ore deposits of the Mackay region, Idaho: U.S. Geological Survey Professional Paper 97, 129 p.

VanTrump, George, Jr., and Miesch, A.T., 1976, The U.S. Geological Survey RASS-STATPAC system for management and reduction of geochemical sata: Computers and Geosciences, v. 3, p. 844-873.

Wells, M.W., 1983, Gold camps and silver cities, nineteenth century mining in central and southern Idaho: Idaho Department of Lands, Bureau of Mines and Geology Bulletin 22, 165 p.

Wilson, A.B., Soulliere, S.J., Skipp, Betty, Worl, R.G., and Rhea, K.P., 1988a, Geology and geochemistry of jasperoid near Mackay, Idaho, in Link, P.K., and Hackett, W.R., eds., Guidebook to the geology of central and southern Idaho: Idaho Geological Survey Bulletin 27, p. 183-192.

Wilson, A.B., Soulliere, S.J., Skipp, Betty, Worl, R.G., and Rhea, K.P., 1988b, Geology and geochemistry of jasperoid from Mackay, Idaho: Geological Society of America Abstracts with Programs, v. 20, no. 6, p. 474.

Winkler, G.R., Soulliere, S.J., Worl, R.G., and Johnson, K.M., 1989, Geology and mineral deposits of the Hailey and western Idaho Falls 1°x2° quadrangles, Idaho: U.S. Geological Survey Open-File Report 89-639, 140 p.

Worl, R.G., Wilson, A.B., Smith, C.L., Kleinkopf, M.D., and Sykes, R.C., 1989, Mineral resource potential and geology of the Challis National Forest, Idaho: U.S. Geological Survey Bulletin 1873, 101 p.

APPENDIX A

Rock Descriptions

Table A.1. -- Description of rock samples from the Grouse area.

JASPEROID SAMPLES (59)

Sample Number	Description
87M149	Jasperoid, gray to pinkish-gray, in McGowan Creek Formation, Fe stained
87M150	Silicified limestone, maroon to orange-yellow color
87M151	Silicified limestone, with crinoid stem
87M152	Jasperoid, gray to pinkish-gray
87M153	Jasperoid breccia
87M154	Jasperoid breccia
87M155	Jasperoid breccia, dark gray color
87M156	Jasperoid breccia, dark-gray to tan to pink color, Fe stained surface
87M157	Jasperoid breccia, light to dark gray color, Fe stained surface
87M158	Silicified limestone breccia, dark gray color, fossiliferous
87M159	Jasperoid breccia, light to dark gray, Fe stained surface
87M160	Silicified limestone, gray to white, gossan-stained
87M161	Jasperoid breccia in fault zone
87M162	Jasperoid breccia, gray, in fault zone
87M163	Silicified limestone, gray
87M164	Silicified limestone, light gray to brown-orange color
87M165	Jasperoid, dark gray, Fe stained surface
87M166	Silicified limestone, dark gray, Fe stained surface
87M167	Silicified limestone breccia
88CCS17	Jasperoid breccia, gossan-stained, maroon to light pink color, clasts are angular to subrounded, pebble-size
88CCS21	Jasperoid breccia, with very angular, gray-colored, pebble to cobble size clasts, gossan-stained red to reddish-orange colored on weathered surface
88CCS23	Jasperoid breccia, light-gray color on fresh surface, weathers orange-yellow
88CCS24A	Silicified Surrett Canyon Formation, light- to medium-gray color, weathers pinkish-gray
88CCS25	Jasperoid breccia maroon to orange-red matrix, angular to subrounded, medium-gray to white clasts, clasts range from pebble to grain size
88CCS27	Jasperoid breccia, light-gray to reddish-orange colored matrix, angular, dark gray, grain-size clasts
88CCS28	Jasperoid breccia, large angular, gray clasts, very fine, light tan colored matrix
88CCS29	Jasperoid breccia, medium-gray colored, angular clasts, light-gray colored, fine matrix, weathers pink to maroon
88CCS30A	Jasperoid breccia, maroon to light-yellow color, grain-size angular clasts
88CCS30B	Jasperoid breccia, yellow to buff color, grain to pebble size angular clasts
88CCS33	Jasperoid breccia, medium-gray matrix, dark-gray, angular clasts, matrix weathers to light-brown color
88CCS34	Jasperoid breccia, gossan-stained, medium-gray, angular clasts with fine yellowish-brown matrix
88CCS34R	Jasperoid breccia, gossan-stained, medium-gray, angular clasts with fine yellowish-brown matrix, analytical duplicate sample
88CCS35	Jasperoid breccia, gossan-stained, bright red-orange weathered surface

(continued)

Table A.1 (Continued)

Sample Number	Description
88CCS36	Jasperoid breccia, light- to medium-gray angular clasts, weathers yellow-tan
88CCS38	Jasperoid breccia, medium-gray, angular clasts, weathered surface is reddish-orange
88CCS39	Jasperoid breccia, medium-gray, angular clasts with fine light-gray matrix, some maroon-colored matrix crosscuts sample and may represent another period of brecciation
88CCS40	Jasperoid, medium- to light-gray, slightly brecciated
88CCS40R	Jasperoid, medium- to light-gray, slightly brecciated, analytical duplicate sample
88CCS41	Jasperoid, medium- to light-gray, slightly brecciated
88CCS42	Jasperoid, dark gray color, very finely sheared and brecciated
88CCS46	Jasperoid breccia, gossan-stained, rusty-red-orange color on weathered surface, medium-gray on fresh surface
88CCS47	Jasperoid, white to medium-gray color, with white quartz veinlets, not brecciated but outcrop was sheared in places, weathers yellow to buff color
88CCS49	Jasperoid, medium to dark gray, with light-gray quartz veinlets
88CCS50	Jasperoid breccia, light-gray, angular clasts with maroon colored matrix
88CCS51	Jasperoid, gossan-stained, medium to light-gray color, with quartz veinlets, vuggy texture
88CCS52	Jasperoid breccia, light-pink, rounded clasts, with maroon colored matrix
88CCS52R	Jasperoid breccia, light-pink, rounded clasts, with maroon colored matrix, analytical duplicate sample
88CCS55	Very brecciated jasperoid, gossan-stained, light- to medium-gray colored, angular clasts with fine orange-yellow matrix, vuggy texture
88CCS56	Very brecciated jasperoid, slight gossan stain, probably more than one period of brecciation, light- to medium-gray clasts, buff to yellow-orange matrix, vuggy texture
88CCS57B	Jasperoid breccia, very weathered, gossan stained, light-gray to yellow color, vuggy texture
88CCS58	Jasperoid breccia, angular to subrounded, pebble-size clasts, pink to light-gray color
88CCS59	Jasperoid breccia, grain size, light- to dark-gray angular clasts, weathers yellow-buff color
88CCS60	Jasperoid, light to medium-gray, weathers yellow-orange
88CCS61	Jasperoid breccia, slightly sheared, white to light-gray color, weathers yellow-buff color
88CCS62	Jasperoid breccia, rounded, buff to tan colored clasts, yellow-brown matrix
88CCS62R	Jasperoid breccia, rounded, buff to tan colored clasts, yellow-brown matrix, analytical duplicate sample
88CCS63	Jasperoid, medium-gray, massive, dense
88CCS64	Jasperoid, dark-gray, dense, massive
MCGOWAN CREEK SAMPLES (7)	
88CCS31	Pebble conglomerate, rounded pebble-size clasts, light-to dark-gray color
88CCS32	Calcareous shale, fissile, dark-gray color, slightly laminated, weathers light-gray to buff
88CCS44	Shale, fissile, black, fissile, and sandy brown shale
88CCS48	Shale, fissile, black to dark-gray color, weathers brown
88CCS65	Brecciated, sheared dark-gray, sandy siltstone, weathers yellow, some gossan stain

(continued)

Table A.1 (Continued)

Sample Number	Description
88CCS65R	Brecciated, sheared, dark-gray, sandy siltstone, weathers yellow, some gossan stain, analytical duplicate sample
88CCS66	Sandy siltstone, dark-gray color, weathers light-gray
CARBONATE BANK SAMPLES (12)	
88CCS20	Limestone, Scott Peak Fm., massive-bedded, medium to light-gray color, with calcite veins and brachiopod shell, weathers light-gray to white
88CCS24B	Unsilicified Surrett Canyon Formation, light- to medium gray color
88CCS37	Limestone, Scott Peak Fm., massive-bedded, light-gray, with crinoid fossils
88CCS43	Limestone, light- to medium-gray
88CCS45	Limestone, Snaky Canyon Fm., very light-gray, fossiliferous
88CCS53	Limestone, Snaky Canyon Fm., light- to medium-gray, massive-bedded, with calcite veinlets, some brachiopod shells
88CCS54	Limestone, Snaky Canyon Fm., light- to medium-gray, with brown chert nodules and calcite veinlets
88CCS57A	Limestone, Snaky Canyon Fm., cherty, medium-gray color
88CCS67	Limestone, medium-gray
88CCS67R	Limestone, medium-gray color, analytical duplicate sample
88CCS68	Limestone, Surrett Canyon Fm., Medium-gray, thin- to massive-bedded, with calcite veinlets up to 3 in wide
88CCS69	Limestone, South Creek Fm., light- to medium-gray

Table A.2. -- Description of thin sections of jasperoid samples from Grouse, Idaho.

Sample Number	Description
88CCS60	Matrix-supported microquartz breccia with angular clasts, clasts and matrix have suture or jigsaw-puzzle texture; some chert clasts and silicified bioclasts present; chalcedonic quartz prevalent; iron oxide coatings on grains in matrix and surrounding clasts; abundant micro-fractures with random orientation cut clasts and matrix; minor epidote
88CCS17	Matrix-supported microquartz breccia with angular clasts and calcite veinlets, abundant secondary iron oxide coatings on grains and some calcite veinlets; calcite veinlets show evidence of strain (undulatory extinction); more than one period of brecciation is evident; abundant epidote; some chert present, mainly as fracture fill
88CCS58	Matrix-supported microquartz breccia showing several periods of brecciation; suture or jigsaw-puzzle texture is prevent in matrix and angular clasts; sparse secondary calcite grains and some quarts veinlets also present; sparse iron oxide coatings on some grains; bioclast replaced by silica; minor epidote; chert clasts
88CCS38	Matrix-supported microquartz breccia with angular clasts and visible bioclasts replaced by silica; jigsaw-puzzle or suture texture prevalent in matrix and clasts; iron oxide coatings on some clasts; some calcite veinlets present, both oxidized and unoxidized; minor chalcedonic quartz (indicating pore-filling?); microfractures prevalent
88CCS34	Matrix-supported microquartz breccia with angular clasts; some coarse equant quartz (macroquartz) with carbonate/calcite inclusions (indicative of replacement); minor chalcedonic quartz; minor iron oxide coatings on some clasts and in matrix; jigsaw- puzzle texture prevalent in clasts; silicified bioclasts
88CCS30A	Clast-supported microquartz breccia with angular clasts that have jigsaw-puzzle texture; abundant quartz veinlets; some chert clasts; more the one period of brecciation evident
88CCS57A	Matrix-supported microquartz breccia with angular to subangular clasts; clasts have jigsaw-puzzle texture; contains bundant bioclasts that have been silicified; abundant chert clasts; very minor iron-oxide coatings on some clasts
88CCS62	Clast-supported macroquartz breccia with angular clasts; contains several silicified bioclasts and abundant chert fragments
88CCS24A	Matrix-supported microquartz breccia with angular clasts; come chert clasts and chalcedonic quartz; iron oxide coatings on most grains
88CCS30B	Matrix-supported microquartz breccia with angular to subrounded clasts; more than one period of brecciation evident; abundant epidote and iron oxide coatings on clasts
88CCS56	Clast-supported microquartz-breccia with angular clasts; minor epidote and iron oxide coatings on grains; minor chert clasts

APPENDIX B

Analytical Procedures

Table B.1 -- List of elements analyzed and their limits of detection. Gold determined by graphite furnace atomic absorption analyses. All other elements determined by inductively coupled plasma atomic emission spectroscopy. [All values in ppm, parts per million, except for lower Au limit which is in ppb, parts per billion]

Element	Lower Limit	Upper Limit
Ag	0.015	12,500
As	1.0	25,000
Au	0.5 ppb	6,250
Bi	0.25	12,500
Cd	0.25	12,500
Cu	0.025	50,000
Ga	0.50	12,500
Hg	0.10	6,250
Mo	0.10	12,500
Pb	0.25	2,500
Pd	0.10	2,500
Sb	0.25	12,500
Se	1.0	100
Te	0.5	12,500
Tl	0.5	12,500
Zn	1.0	50,000

APPENDIX C

Data Listings
and
Summary Statistics

Table C.1 -- Results of geochemical analyses of rock samples from Grouse, Idaho. [All values in ppm (parts per million); L indicates a value less than the detection limit]

JASPEROID SAMPLES

SAMPLE	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn
87M149	0.581	64.7	0.004	4.20	0.468	3.72	113.0	4.01	1.19	6.44
87M150	0.438	515.	0.004	8.05	2.35	7.73	104.	57.5	17.7	7.9
87M151	2.15	31.7	0.004	6.61	0.563	4.77	452.	4.12	0.693	6.30
87M152	0.181	13.0	0.004	3.72	1.00	5.43	35.7	5.45	1.08	3.87
87M153	0.142	30.3	0.004	5.60	1.08	6.12	43.5	2.22	1.24	4.49
87M154	0.307	10.2	0.004	4.27	0.693	4.10	29.0	1.09	0.917	4.60
87M155	0.172	8.41	0.004	6.49	0.220	4.66	15.9	0.933	0.549	4.61
87M156	0.192	11.1	0.004	4.35	2.58	8.65	35.2	1.04	0.796	21.8
87M157	0.098	46.4	0.004	3.82	1.54	2.77	7.27	3.06	1.82	2.88
87M158	0.075	5.24	0.004	3.38	0.347	3.97	7.27	0.513L	0.703	1.85
87M159	0.067	14.6	0.004	3.05	0.477	46.7	5.35	2.06	0.959	0.949L
87M160	0.097	76.4	0.003	6.30	1.06	7.29	4.48	3.06	1.86	5.21
87M161	0.112	44.9	0.003	6.20	1.44	7.55	5.86	7.94	2.24	5.76
87M162	0.219	107.	0.004	8.83	1.74	79.6	11.5	5.84	1.38	15.7
87M163	0.085	27.4	0.008	3.60	0.627	3.23	5.55	2.53	0.620	6.8
87M164	0.072	9.91	0.009	3.83	0.508	3.48	5.56	1.40	0.480	7.93
87M165	0.312	167.	0.007	7.23	3.78	11.9	4.67	16.1	3.29	12.2
87M166	0.08	24.9	0.008	3.97	0.487	7.14	2.85	2.91	0.730	3.47
87M167	0.09	10.9	0.019	4.19	0.532	9.06	3.51	1.07	0.660	2.35
88CCS17	0.093	312.000	0.001	9.760	8.020	2.240	3.380	23.400	2.250	8.200
88CCS21	0.070	21.700	0.001L	4.650	0.211	8.860	1.820	1.850	0.470L	3.110
88CCS23	0.056	18.000	0.001	1.990	0.271	2.070	1.520	4.280	1.170	1.540
88CCS24A	0.091	120.000	0.002	5.700	1.410	6.970	3.510	16.200	2.280	39.400

(continued)

Table C.1 (Continued)

JASPEROID SAMPLES

SAMPLE	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn
88CCS25	0.105	5.670	0.001L	3.690	0.593	0.152	3.590	2.150	0.657	7.310
88CCS27	0.019	17.800	0.001L	3.620	0.133	4.550	1.350	0.927	0.465L	2.700
88CCS28	0.062	4.050	0.001	2.790	0.097L	0.247	0.924	0.243L	0.485L	4.500
88CCS29	0.018	23.500	0.001L	2.750	0.099L	14.400	0.986	0.956	0.495L	6.930
88CCS30A	0.037	15.000	0.001L	6.000	0.710	0.416	0.869	0.944	0.488L	1.650
88CCS30B	0.182	66.000	0.007	4.740	2.320	34.700	3.150	7.700	2.910	16.500
88CCS33	0.091	15.100	0.001L	5.170	0.093L	2.350	2.210	0.656	0.466L	25.900
88CCS34	0.055	103.000	0.001L	5.370	0.160	3.110	2.320	4.890	0.490L	22.200
88CCS34R	0.044	102.000	0.002	4.900	0.170	3.060	2.080	4.890	0.497L	20.800
88CCS35	0.028	2.690	0.001L	2.270	0.092L	2.360	2.280	0.636	0.459L	2.090
88CCS36	0.122	25.200	0.001L	4.050	1.080	7.370	2.930	6.800	0.562	3.940
88CCS38	0.087	21.500	0.007	3.760	0.687	2.780	3.050	8.680	0.725	5.280
88CCS39	0.067	9.010	0.001L	2.130	0.092L	6.710	1.440	0.348	0.462L	0.924L
88CCS40	0.088	10.700	0.002	5.310	0.096L	15.200	1.090	0.254	0.480	0.960L
88CCS40R	0.106	12.400	0.001	4.980	0.097L	17.200	1.360	0.375	0.485L	1.120
88CCS41	0.045	8.270	0.001L	2.250	0.094L	6.500	1.030	0.635	0.468L	1.480
88CCS42	0.050	6.020	0.001L	4.700	0.093L	1.350	1.060	0.232L	0.465L	14.600
88CCS46	0.424	48.700	0.001L	10.400	2.460	6.920	1.760	4.870	0.799	33.400
88CCS47	0.037	2.650	0.001L	1.980	0.166	0.896	0.348	0.584	0.491L	0.982L
88CCS49	0.057	1.130	0.001	7.710	0.098L	0.294	1.390	0.401	0.490L	3.030
88CCS50	0.058	11.800	0.005	4.640	1.460	1.180	1.410	2.380	0.492L	2.650
88CCS51	0.104	21.300	0.001	4.020	0.537	0.524	1.170	3.400	0.483L	31.400
88CCS52	0.120	9.490	0.001L	2.830	0.100L	0.372	1.540	1.830	0.666	3.270
88CCS52R	0.131	10.700	0.002	3.750	0.102	0.428	2.000	1.990	1.130	3.920
88CCS55	0.070	58.900	0.001	6.300	0.399	3.380	1.500	2.980	0.467L	12.800

(continued)

Table C.1 (Continued)

JASPEROID SAMPLES

SAMPLE	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn
88CCS56	0.061	12.000	0.002	2.840	0.802	1.280	2.270	3.270	0.491L	2.680
88CCS57B	0.184	47.500	0.001L	5.470	3.600	1.720	2.410	4.550	0.467L	4.960
88CCS58	0.051	5.380	0.001L	3.420	0.093L	2.700	2.490	0.580	0.466L	5.810
88CCS59	0.142	21.600	0.002	3.930	0.606	1.550	2.370	6.510	0.497L	1.860
88CCS60	0.038	7.640	0.002	1.870	0.095L	3.300	1.780	1.440	0.475L	1.350
88CCS61	0.079	13.100	0.001	2.320	1.080	0.717	1.690	14.300	1.680	4.330
88CCS62	0.043	40.800	0.001	1.280	0.658	2.970	0.491	8.870	7.540	1.300
88CCS62R	0.042	39.300	0.001L	1.940	0.640	2.820	0.520	8.540	7.280	1.490
88CCS63	0.084	50.400	0.002	1.960	0.094L	0.226	2.050	0.852	0.470L	1.800
88CCS64	0.286	99.200	0.003	41.000	0.092L	1.500	3.130	5.980	0.460L	8.860

SAMPLE	Bi	Cd	Ga	Pd	Se	Te
87M149	0.482	0.242L	0.484L	0.097L	0.969L	0.484L
87M150	0.304	0.243	0.580	0.097L	0.971L	0.485L
87M151	1.35	0.233	0.466L	0.093L	0.933L	0.466L
87M152	0.235L	0.235L	0.47L	0.094L	0.94L	0.47L
87M153	0.245L	0.245L	0.49L	0.098L	0.98L	0.49L
87M154	0.245L	0.245L	0.489L	0.098L	0.978L	0.489L
87M155	0.238L	0.238L	0.476L	0.095L	0.952L	0.476L
87M156	0.234L	0.234L	0.468L	0.094L	0.936L	0.468L
87M157	0.247L	0.247L	0.494L	0.099L	0.988L	0.494L
87M158	0.233L	0.233L	0.466L	0.093LL	0.931L	0.466L

(continued)

Table C.1 (Continued)

JASPEROID SAMPLES

SAMPLE	Bi	Cd	Ga	Pd	Se	Te
87M159	0.237L	0.237L	0.474L	0.095L	0.949L	0.474L
87M160	0.218L	0.218L	0.436L	0.087L	0.873L	0.436L
87M161	0.23L	0.23L	0.567L	0.092L	0.919L	0.46L
87M162	0.239L	0.239L	0.677L	0.096L	1.44	0.478L
87M163	0.238L	0.238L	0.725	0.095L	0.951L	0.475L
87M164	0.223L	0.223L	0.787	0.089L	0.893L	0.446L
87M165	0.219L	0.219L	0.532	0.87L	0.874L	0.437L
87M166	0.234L	0.234L	0.468L	0.094L	0.936L	0.468L
87M167	0.231L	0.231L	0.480	0.092L	0.924L	0.462L
88CCS17	0.241L	0.428	1.740	0.482L	0.963L	0.482L
88CCS21	0.235L	0.094L	0.974	0.470L	0.940L	0.470L
88CCS23	0.250L	0.100L	0.702	0.499L	0.998L	0.499L
88CCS24A	0.239L	0.742	0.479L	0.479L	1.300	0.479L
88CCS25	0.243L	0.097L	0.486L	0.486L	0.973L	0.486L
88CCS27	0.232L	0.093L	0.650	0.465L	0.929L	0.465L
88CCS28	0.243L	0.097L	0.485L	0.485L	0.971L	0.485L
88CCS29	0.248L	0.099L	0.495L	0.495L	0.990L	0.495L
88CCS30A	0.244L	0.098L	0.488L	0.488L	0.977L	0.488L
88CCS30B	0.245L	0.216	0.994	0.490L	0.980L	0.490L
88CCS33	0.233L	0.227	0.466L	0.466L	0.933L	0.466L
88CCS34	0.245L	0.228	1.180	0.490L	0.980L	0.490L
88CCS34R	0.249L	0.208	1.020	0.497L	0.994L	0.497L
88CCS35	0.229L	0.092L	0.459L	0.459L	0.917L	0.459L
88CCS36	0.227L	0.154	0.700	0.455L	0.909L	0.455L
88CCS38	0.237L	0.095L	0.473L	0.473L	0.947L	0.473L

(continued)

Table C.1 (Continued)

JASPEROID SAMPLES

SAMPLE	Bi	Cd	Ga	Pd	Se	Te
88CCS39	0.231L	0.092L	0.462L	0.462L	0.924L	0.462L
88CCS40	0.240L	0.096L	0.480L	0.480L	0.960L	0.480L
88CCS40R	0.243L	0.097L	0.485L	0.485L	0.971L	0.485L
88CCS41	0.234L	0.094L	0.468L	0.468L	0.936L	0.468L
88CCS42	0.232L	0.129	0.465L	0.465L	0.929L	0.465L
88CCS46	0.245L	0.220	2.450	0.490L	0.980L	0.490L
88CCS47	0.246L	0.098L	0.491L	0.491L	0.982L	0.491L
88CCS49	0.245L	0.131	0.490L	0.490L	0.980L	0.490L
88CCS50	0.246L	0.145	0.492L	0.492L	0.984L	0.492L
88CCS51	0.241L	0.360	0.501	0.483L	0.965L	0.483L
88CCS52	0.249L	0.120	0.498L	0.498L	0.996L	0.498L
88CCS52R	0.235L	0.132	0.471L	0.471L	0.942L	0.471L
88CCS55	0.234L	0.880L	0.467L	0.467L	0.935L	0.467L
88CCS56	0.246L	0.155	0.491L	0.491L	0.982L	0.491L
88CCS57B	0.234L	0.165	0.467L	0.467L	0.935L	0.467L
88CCS58	0.233L	0.183	0.466L	0.466L	0.931L	0.466L
88CCS59	0.249L	0.099L	0.497L	0.497L	0.994L	0.497L
88CCS60	0.238L	0.095L	0.475L	0.475L	0.951L	0.475L
88CCS61	0.230L	0.092L	0.460L	0.460L	0.921L	0.460L
88CCS62	0.239L	0.096L	0.479L	0.479L	0.958L	0.479L
88CCS62R	0.235L	0.094L	0.471L	0.471L	0.942L	0.471L
88CCS63	0.235L	0.094L	0.470L	0.470L	0.940L	0.470L
88CCS64	0.230L	0.092L	0.605	0.460L	0.921L	0.460L

(continued)

Table C.1 (Continued)

MCGOWAN CREEK SAMPLES

SAMPLE	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn
88CCS31	0.184	7.960	0.001L	15.400	1.190	0.588	11.400	4.740	0.486L	28.400
88CCS32	0.151	7.690	0.001L	7.740	0.099L	0.765	2.680	1.020	0.813	43.100
88CCS44	2.790	11.400	0.001L	26.500	0.093L	5.740	8.870	1.980	0.463L	152.000
88CCS48	1.880	8.450	0.002	6.580	0.130	3.150	5.100	2.060	0.456L	95.800
88CCS65	0.096	9.180	0.003	11.100	0.097L	0.263	4.440	0.387	0.484L	1.880
88CCS65R	0.093	8.760	0.003	11.400	0.096L	0.246	4.230	0.391	0.482L	2.890
88CCS66	0.357	30.300	0.002	12.800	0.105	1.650	4.920	2.960	0.476L	7.290

SAMPLE	Bi	Cd	Ga	Pd	Se	Te
88CCS31	0.243L	0.320	1.630	0.486L	0.973L	0.486L
88CCS32	0.248L	0.601	0.495L	0.495L	0.990L	0.495L
88CCS44	0.231L	0.967	0.463L	0.463L	8.160	0.463L
88CCS48	0.228L	0.176	0.456L	0.456L	2.470	0.456L
88CCS65	0.242L	0.097L	0.484L	0.484L	0.967L	0.484L
88CCS65R	0.241L	0.096L	0.482L	0.482L	0.963L	0.482L
88CCS66	0.238L	0.138	0.476L	0.476L	0.952L	0.476L

(continued)

Table C.1 (Continued)

CARBONATE BANK SAMPLES

SAMPLE	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn
88CCS20	0.015L	2.100	0.001L	2.040	0.099L	0.429	0.611	0.269	0.494L	30.300
88CCS24B	0.054	13.4	0.001L	2.32	0.334	0.337	1.51	0.942	0.486L	15.5
88CCS37	0.021	2.120	0.001L	2.400	0.100L	0.100L	0.668	0.294	0.498L	19.100
88CCS43	0.109	2.740	0.001L	5.730	0.097L	0.256	1.480	0.242L	0.484L	29.900
88CCS45	0.061	1.450	0.001	2.630	0.095L	0.095L	0.567	0.239L	0.477L	14.800
88CCS53	0.036	1.000L	0.001	3.900	0.100L	0.352	0.795	0.250L	0.500L	15.900
88CCS54	0.066	2.160	0.001L	2.700	0.100L	0.166	0.630	0.448	0.499L	18.300
88CCS57A	0.059	89.600	0.001	5.250	2.950	6.300	0.963	4.920	6.440	18.300
88CCS67	0.063	3.830	0.001	1.910	0.094L	0.158	1.160	0.655	0.471L	19.500
88CCS67R	0.062	3.920	0.001L	1.970	0.099L	0.159	1.160	1.140	0.494L	20.100
88CCS68	0.053	1.660	0.001	1.110	0.099L	1.960	2.430	0.421	0.497L	48.300
88CCS69	0.030	1.110	0.001	0.740	0.097L	0.850	1.380	0.242L	0.484L	8.960

SAMPLE	Bi	Cd	Ga	Pd	Se	Tl
88CCS20	0.247L	1.100	0.494L	0.494L	0.988L	0.494L
88CCS24B	0.248L	0.361	0.496L	0.496L	0.498L	0.499L
88CCS37	0.249L	0.639	0.498L	0.498L	0.996L	0.498L
88CCS43	0.242L	0.482	0.484L	0.484L	0.967L	0.484L
88CCS45	0.239L	0.501	0.477L	0.477L	0.954L	0.477L
88CCS53	0.250L	0.835	0.500L	0.500L	1.000L	0.500L
88CCS54	0.250L	0.330	0.499L	0.499L	0.998L	0.499L
88CCS57A	0.248L	0.326	0.496L	0.496L	0.992L	0.496L
88CCS67	0.235L	0.349	0.471L	0.471L	0.942L	0.471L
88CCS67R	0.247L	0.354	0.494L	0.494L	0.988L	0.494L
88CCS68	0.249L	0.969	0.497L	0.497L	0.994L	0.497L
88CCS69	0.242L	0.246	0.484L	0.484L	0.967L	0.484L

Table C.2 -- Summary of analytical results (in ppm) of rock samples from Grouse, Idaho. [Min. = minimum value detected; Max. = maximum value detected; V = number of uncensored values; L = detectable but below stated detection limits]. Note: univariate statistics for ALL data.

UNIVARIATE STATISTICS

JASPEROID (54)

	Min.	Max.	Mean	Deviation	V	L
Ag	0.02	2.15	0.16	0.30	54	0
As	1.13	515.	45.85	82.81	54	0
Au	<0.0005	0.019	0.003	0.003	37	17
Cu	1.28	41.	5.19	5.36	54	0
Hg	<0.09	8.02	0.93	1.32	40	14
Mo	0.15	79.60	7.03	12.76	54	0
Pb	0.35	452.	17.75	63.98	54	0
Sb	<0.23	57.50	4.95	8.63	51	3
Tl	0.46	17.70	1.33	2.53	30	24
Zn	0.92	39.40	7.68	8.72	50	4
Bi	<0.22	1.35	<0.26	0.15	3	51
Cd	<0.09	0.88	0.20	0.14	16	38
Ga	<0.44	2.45	0.60	0.374	17	37
Pd	<0.087	<0.50	<0.34	0.19	0	54
Se	0.00	1.44	<0.87	0.31	2	47
Te	<0.44	<0.99	<0.53	0.15	0	54

(continued)

Table C.2 Continued

	McGOWAN CREEK FORMATION (6)					
	Min.	Max.	Mean	Deviation	V	L
Ag	0.10	2.79	0.91	1.14	6	0
As	7.69	30.30	12.50	8.82	6	0
Au	<0.001	0.003	0.002	0.001	3	3
Cu	6.58	26.50	13.35	7.21	6	0
Hg	0.09	1.19	0.29	0.44	3	3
Mo	0.26	5.74	2.03	2.10	6	0
Pb	2.68	11.40	6.24	3.24	6	0
Sb	0.39	4.74	2.19	1.54	6	0
Tl	<0.46	0.81	0.53	0.14	1	5
Zn	1.88	152.	54.75	58.34	6	0
Bi	<0.23	<0.25	<0.24	0.008	0	6
Cd	<0.097	0.97	0.38	0.34	5	1
Ga	<0.46	1.63	0.67	0.47	1	5
Pd	<0.46	<0.495	<0.48	0.015	0	6
Se	<0.95	8.16	2.42	2.88	2	4
Te	<0.46	<0.495	<0.48	0.015	0	6

(continued)

Table C.2 Continued

	CARBONATE BANK LIMESTONE (11)					
	Min.	Max.	Mean	Deviation	V	L
Ag	0.015	0.11	0.05	0.03	10	1
As	1.00	89.60	11.02	26.30	10	1
Au	<0.001	0.001	0.0009	0.0003	6	5
Cu	0.07	5.73	2.79	1.57	11	0
Hg	0.09	2.95	0.38	0.85	2	9
Mo	0.095	6.30	1.00	1.84	9	2
Pb	0.57	2.43	1.11	0.57	11	0
Sb	0.23	4.92	0.81	1.38	7	4
Tl	<0.47	6.44	1.03	1.79	1	10
Zn	8.96	48.30	21.71	10.79	11	0
Bi	<0.24	<0.25	<0.25	0.005	0	11
Cd	<0.25	1.10	0.56	0.290	11	0
Ga	<0.47	<0.50	<0.49	0.01	0	11
Pd	<0.47	<0.50	<0.49	0.01	0	11
Se	<0.94	<1.00	<0.98	0.02	0	11
Te	<0.47	<0.50	<0.49	0.01	0	11

Table C.3 -- Results of geochemical analyses of panned-concentrate samples from Grouse, Idaho. [All values in ppm (parts per million); L indicates a value less than the detection limit]

SAMPLE	AG	AS	AU	CU	HG	MO	PB	SB	TL	ZN
88CCS01	0.027L	15.700	0.001L	6.090	2.210	5.520	11.400	1.750	0.914L	92.900
88CCS02	0.033L	13.000	0.001	6.860	0.415	1.760	7.290	1.450	1.080L	53.500
88CCS03	0.025	318.000	0.002	7.610	0.654	5.000	22.700	328.000	0.590L	234.000
88CCS04	0.021	15.700	0.001L	3.780	0.923	2.140	5.510	9.460	0.536L	44.500
88CCS05	0.064	84.100	0.001L	9.870	0.526	15.300	10.400	16.200	0.643	152.000
88CCS06	0.088	106.000	0.001L	11.800	1.070	12.600	11.600	10.800	0.493L	165.000
88CCS07	0.080	219.000	0.001L	18.900	3.610	33.000	27.800	42.600	0.826L	336.000
88CCS08	0.052	85.500	0.001L	6.740	6.450	10.300	7.550	16.100	0.487L	128.000
88CCS09	0.060	101.000	0.001L	7.600	0.654	9.980	6.350	21.000	0.665	153.000
88CCS10	1.370	24.900	0.001	45.100	0.125L	7.990	14.300	3.050	0.627L	289.000
88CCS11	0.261	43.800	0.002	62.300	0.606	6.940	17.500	9.260	0.614L	139.000
88CCS12	0.017L	7.080	0.001L	5.770	0.848	1.180	8.440	0.999	0.567L	47.400
88CCS13	0.015L	14.100	0.001L	3.420	0.262	1.590	5.640	1.920	0.490L	29.300
88CCS13R	0.018	19.300	0.001	4.320	0.135	1.590	6.540	2.240	0.520L	35.300
88CCS14	0.018L	31.400	0.001L	8.090	0.724	3.230	7.520	2.870	0.590L	66.800
88CCS15	0.225	27.100	0.001L	45.500	0.298	4.760	11.200	4.730	0.543L	148.000
88CCS16	2.020L	200.000	0.001L	45.900	13.500L	23.900	33.700	33.700L	67.500L	135.00L
88CCS18	0.087	391.000	0.001L	40.800	7.780	31.600	37.300	38.800	0.653L	563.000
88CCS19	0.014L	4.170	0.002	0.743	0.319	0.412	3.500	0.515	0.471L	17.500
88KLS26	0.019	51.500	0.001	10.000	0.673	4.240	11.700	9.840	0.560L	128.000
88KLS26R	0.015L	50.000	0.001	10.400	0.805	6.610	12.900	7.930	0.484L	143.000
88KLS27	0.015	8.020	0.001	4.380	0.337	0.785	6.070	0.785	0.481L	50.600
88KLS28	0.014L	9.200	0.001	4.950	0.09	1.220	4.860	0.863	0.459L	49.300
88KLS29	0.058	124.000	0.001L	24.100	0.428	19.500	15.700	11.500	0.541L	357.000

(continued)

Table C.3 Continued

SAMPLE	BI	CD	GA	PD	SE	TE
88CCS01	0.457L	0.261	3.960	0.914L	1.820L	0.914L
88CCS02	0.543L	0.304	1.720	1.080L	2.170L	1.080L
88CCS03	0.295L	0.882	11.100	0.590L	2.270	0.590L
88CCS04	0.268L	0.203	2.020	0.536L	1.070L	0.536L
88CCS05	0.267L	1.210	1.490	0.534L	1.080	0.534L
88CCS06	0.246L	1.180	1.000	0.493L	0.986L	0.493L
88CCS07	0.413L	2.080	2.430	0.826L	1.650L	0.826L
88CCS08	0.244L	0.965	0.683	0.487L	0.974L	0.487L
88CCS09	0.252L	1.030	0.505L	0.505L	1.000L	0.505L
88CCS10	0.314L	3.140	0.768	0.627L	16.300	0.627L
88CCS11	0.307L	0.651	1.800	0.614L	5.890	0.614L
88CCS12	0.284L	0.130	2.790	0.567L	1.130L	0.567L
88CCS13	0.245L	0.136	0.864	0.490L	0.979L	0.490L
88CCS13R	0.260L	0.172	0.830	0.520L	1.040L	0.520L
88CCS14	0.295L	0.295	1.790	0.590L	1.170L	0.590L
88CCS15	0.272L	0.659	0.943	0.543L	8.230	0.543L
88CCS16	33.700L	13.500L	67.500L	67.500L	135.000L	67.500L
88CCS18	0.326L	3.280	2.760	0.653L	2.550	0.653L
88CCS19	0.235L	0.094L	0.485	0.471L	0.942L	0.471L
88KLS26	0.280L	0.854	1.810	0.560L	1.110L	0.560L
88KLS26R	0.242L	0.851	2.540	0.484L	0.967L	0.484L
88KLS27	0.240L	0.121	2.210	0.481L	0.962L	0.481L
88KLS28	0.229L	0.264	1.180	0.459L	0.917L	0.459L
88KLS29	0.270L	1.510	1.720	0.541L	1.680	0.541L

Table C.4 -- Summary of analytical results (in ppm) of panned-concentrate samples (n = 22) from Grouse, Idaho. [Min. = minimum value detected; Max. = maximum value detected; V = number of samples with detectable values]

UNIVARIATE STATISTICS

	Min.	Max.	Mean	Deviation	V	L
Ag	<0.01	2.02	0.21	0.50	14	8
As	4.17	391.	86.10	106.47	22	0
Au	<0.001	0.002	0.0008	0.0005	8	14
Cu	0.74	62.30	17.29	18.09	22	0
Hg	0.09	13.50	1.93	3.28	20	2
Mo	0.41	33.	9.23	9.75	22	0
Pb	3.5	37.30	13.09	9.39	22	0
Sb	0.515	328.	25.74	68.66	21	1
Tl	<0.46	<67.50	3.65	14.26	2	20
Zn	17.50	563.	153.6	132.55	21	1
Bi	<0.23	<33.70	<1.82	7.12	0	22
Cd	<0.09	13.50	1.49	2.83	20	2
Ga	<0.485	<67.50	5.07	14.11	20	2
Pd	<0.46	<67.50	<3.64	14.26	0	22
Se	<0.92	135.	8.63	28.45	7	15
Te	<0.46	<67.50	<3.64	14.26	0	22

Table C.5 -- Results of geochemical analyses of -80 mesh fraction stream-sediment samples from Grouse, Idaho.
[All values in ppm (parts per million); L indicates a value less than the detection limit]

SAMPLE	AG	AS	AU	CU	HG	MO	PB	SB	TL	ZN
88CCS01	0.274	5.73	0.006	24.0	0.092L	1.78	12.8	0.896	0.458L	102.
88CCS02	0.135	3.09	0.004	29.8	0.096L	1.12	22.5	0.928	0.478L	75.6
88CCS03	0.291	19.1	0.003	21.8	0.092L	2.73	21.2	4.85	0.458L	123.
88CCS03R	0.303	20.3	0.004	21.0	0.095L	2.54	15.7	4.67	0.473L	115.
88CCS04	0.584	10.3	0.003	28.3	0.093L	2.23	12.7	1.47	0.465L	138.
88CCS04R	0.600	7.92	0.004	29.6	0.092L	2.21	13.5	1.61	0.460L	142.
88CCS05	0.149	29.9	0.001	21.6	0.302	5.39	17.0	6.66	1.15	206.
88CCS06	0.173	36.8	0.005	23.7	0.353	6.85	20.0	6.86	0.989	210.
88CCS07	0.168	38.1	0.001	21.8	0.106	5.87	14.8	5.99	0.582	161.
88CCS08	0.174	35.0	0.002	21.9	0.340	5.91	19.2	6.12	0.891	183.
88CCS08R	0.189	32.6	0.001	21.2	0.100	5.96	18.1	5.66	1.07	178.
88CCS09	0.168	39.3	0.003	17.7	0.118	3.91	13.8	8.48	0.707	145.
88CCS10	3.96	31.2	0.006	48.0	0.093L	11.1	20.2	4.31	0.463L	439.
88CCS11	0.638	15.8	0.007	46.9	0.094L	2.36	10.9	3.01	0.469L	85.1
88CCS11R	0.730	18.7	0.007	51.6	0.137	2.99	13.1	3.79	0.491L	103.
88CCS12	0.051	4.88	0.001	24.5	0.096L	0.879	24.3	1.05	0.480L	72.6
88CCS13	0.084	8.98	0.003	25.3	0.098L	1.06	24.5	1.21	0.491L	92.1
88CCS13R	0.097	7.14	0.006	27.5	0.097L	1.28	21.7	1.26	0.487L	86.4
88CCS14	0.237	6.13	0.0009	27.1	0.094L	1.30	13.8	1.21	0.518	104.
88CCS15	0.743	18.9	0.004	56.1	0.093L	3.97	16.8	3.42	0.619	152.
88CCS16	0.162	27.9	0.0005L	18.5	0.297	3.30	13.2	4.26	0.684	125.
88CCS18	0.185	51.6	0.0010	24.3	0.145	4.18	20.2	4.90	0.635	185.
88CCS19	0.080	6.95	0.001	18.2	0.094L	1.30	13.9	1.16	0.470L	70.8
88KLS26	0.108	18.5	0.002	21.1	0.102	1.69	14.4	3.50	0.595	114.
88KLS27	0.087	6.55	0.002	28.7	0.097L	1.06	18.4	1.33	0.487L	88.9
88KLS27R	0.100	7.65	0.002	26.1	0.091L	0.906	16.6	1.14	0.456L	81.8
88KLS28	0.171	9.43	0.001	19.7	0.099L	2.55	12.7	1.96	0.493L	120.
88KLS29	0.189	19.1	0.0006	19.9	0.099L	3.64	13.7	2.31	0.494L	167.

(continued)

Table C.5 (Continued)

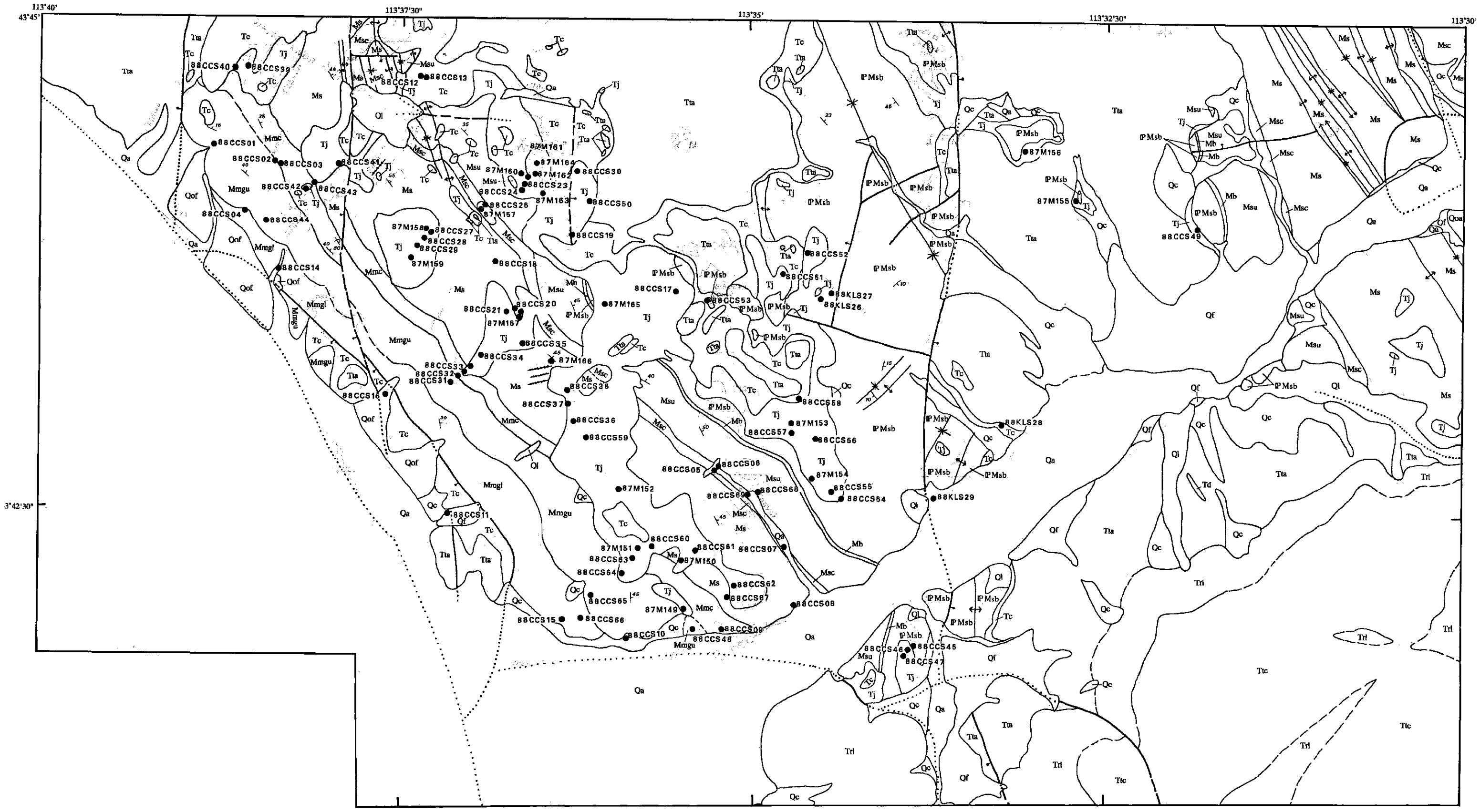
SAMPLE	BI	CD	GA	SE	TE
88CCS01	0.229L	1.11	3.07	1.43	0.458L
88CCS02	0.239L	0.604	3.79	0.956L	0.478L
88CCS03	0.229L	1.86	3.15	1.35	0.458L
88CCS03R	0.237L	1.62	2.65	0.947L	0.473L
88CCS04	0.232L	1.51	3.47	1.56	0.465L
88CCS04R	0.230L	1.53	3.42	2.48	0.460L
88CCS05	0.259	2.12	3.90	0.912L	0.456L
88CCS06	0.238L	2.42	3.29	1.76	0.475L
88CCS07	0.236L	1.97	4.03	1.05	0.473L
88CCS08	0.241L	2.49	4.60	1.35	0.482L
88CCS08R	0.326	2.26	4.35	0.988L	0.494L
88CCS09	0.244L	1.79	2.57	1.94	.487L
88CCS10	0.231L	4.82	1.33	12.2	.463L
88CCS11	0.235L	1.20	2.09	1.24	.469L
88CCS11R	0.246L	1.27	2.81	2.17	.491L
88CCS12	0.240L	1.39	3.96	0.960L	.480L
88CCS13	0.246L	1.17	5.15	1.31	.491L
88CCS13R	0.244L	1.06	3.88	1.03	.487L
88CCS14	0.235L	1.31	3.84	0.940L	.470L
88CCS15	0.267	1.57	2.23	4.29	.466L
88CCS16	0.246L	1.87	2.88	1.65	.491L
88CCS18	0.350	2.13	3.73	1.41	.490L
88CCS19	0.235L	1.16	3.72	0.940L	.470L
88KLS26	0.230L	2.67	4.06	0.919L	.460L
88KLS27	0.244L	1.39	5.94	0.975L	.487L
88KLS27R	0.228L	1.10	5.39	0.912L	.456L
88KLS28	0.247L	1.40	3.66	0.986L	.493L
88KLS29	0.247L	1.79	4.00	0.988L	.494L

Table C.6 -- Summary of analytical results (in ppm) of -80 mesh fraction stream-sediment samples (n= 22) from Grouse, Idaho. [Min. = minimum value detected; Max. = maximum value detected; V = number of samples with detectable values]

UNIVARIATE STATISTICS

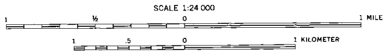
	Min.	Max.	Mean	Deviation	V	L
Ag	0.05	3.96	0.40	0.82	22	0
As	3.09	51.60	20.15	13.98	22	0
Au	0.0005	0.007	0.003	0.002	21	1
Cu	17.70	56.10	26.77	10.27	22	0
Hg	0.092	0.35	0.14	0.09	8	14
Mo	0.88	11.10	3.37	2.48	22	0
Pb	10.90	24.50	16.86	4.10	22	0
Sb	0.90	8.48	3.45	2.31	22	0
Tl	0.46	1.15	0.59	0.19	10	12
Zn	70.80	439.	143.6	78.47	22	0
Bi	0.23	0.35	0.25	0.03	3	19
Cd	0.60	4.82	1.81	0.84	22	0
Ga	1.33	5.94	3.57	1.01	22	0
Se	0.91	12.2	1.87	2.42	13	9
Te	0.46	0.49	0.48	0.01	0	22

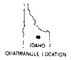
PLATE 1



Base from U.S. Geological Survey, 1:24,000,
Grouse, Miller Peak, provisional editions, 1991

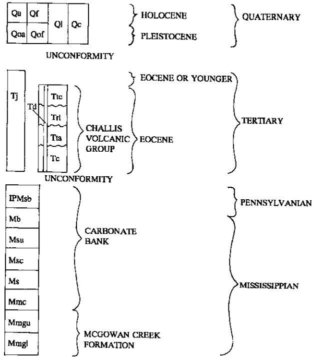
Geology modified from Skipp (1988 and 1989)





EXPLANATION

CORRELATION OF MAP UNITS



LIST OF MAP UNITS

Qa	Alluvium (Holocene)
Qoa	Old alluvium (Pleistocene)
Qf	Alluvial-fan deposits (Holocene and Late Pleistocene)
Ql	Landslide deposits (Holocene and Pleistocene)
Qc	Colluvium (Holocene and Pleistocene)
Qof	Old landslide deposits (Pleistocene)
Tj	Jasperoid (Eocene or younger Tertiary)
Td	Rhyolite dikes (Eocene)
Ttc	Tuffs of Little Chokecherry Canyon, Challis Volcanic Group (Eocene)
Trl	Rhyodacite lavas, Challis Volcanic Group (Eocene)
Tta	Tuffs of Antelope Creek, Challis Volcanic Group (Eocene)
Tc	Basal conglomerate, breccia, and sandstone, Challis Volcanic Group (Eocene)
IPMsb	Snaky Canyon Formation, Bloom Member (Lower Pennsylvanian to Upper Mississippian)
Mb	Bluebird Mountain Formation (Upper Mississippian)
Msu	Surrett Canyon Formation (Upper Mississippian)
Msc	South Creek Formation (Upper Mississippian)
Ms	Scott Peak Formation (Upper Mississippian)
Mmc	Middle Canyon Formation (Upper Mississippian)
Mmgu	McGowan Creek Formation, upper member (Lower Mississippian)
Mmgl	McGowan Creek Formation, lower member (Lower Mississippian)
——	Contact
·····—•—--	Fault, ball and bar on downthrown side, dotted where concealed; dashed where inferred
✳	Syncline
↕	Anticline
⊥40	Strike and dip
++++++	Calcite Vein
88CCS06 ●	Sample site and number

PLATE 1 -- SAMPLE LOCALITY AND GEOLOGIC MAP OF THE GROUSE AREA, SOUTH-CENTRAL IDAHO

1992

PLATE 1

SANDRA SOULLIERE

T-4317