Geology of the Vienna Mineralized Area, Blaine and Camas Counties, Idaho

By J. Brian Mahoney and Michael C. Horn

Prepared in cooperation with the Idaho Geological Survey,
Idaho State University, and the University of Idaho

Bulletin 2064-DD

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
Gale A. Norton, Secretary

U.S. Geological Survey
Charles G. Groat, Director

U.S. Geological Survey, Reston, Virginia: 2005

Posted online April 2005, version 1.0

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Suggested citation:
Mahoney, J.B., and Horn, M.C., 2005, Geology of the Vienna mineralized area, Blaine and Camas Counties, Idaho: U.S. Geology Survey Bulletin 2064–DD, 9 p.

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Metric Conversion Factors

Multiply	By	To obtain
tons	1.016	metric tons
short tons	0.907	metric tons
troy ounces	31.103	grams
ounces	28.35	grams

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Abstract

The Vienna mineralized area of south-central Idaho was an important silver-lead-producing district in the late 1800s and has intermittently produced lead, silver, zinc, copper, and gold since that time. The district is underlain by biotite granodiorite of the Cretaceous Idaho batholith, and all mineral deposits are hosted by the biotite granodiorite. The granodiorite intrudes Paleozoic sedimentary rocks of the Sun Valley Group, is overlain by rocks of the Eocene Challis Volcanic Group, and is cut by numerous northeast-trending Eocene faults and dikes.

Two mineralogically and texturally distinct vein types are present in a northwest- and east-trending conjugate shear-zone system. The shear zones postdate granodiorite emplacement and joint formation, but predate Eocene fault and dike formation. Ribbon veins consist of alternating bands of massive vein quartz and silver-sulfide (proustite and pyrargyrite) mineral stringers. The ribbon veins were sheared and brecciated during multiple phases of injection of mineralizing fluids. A quartz-sericite-pyrite-galena vein system was subsequently emplaced in the brecciated shear zones. Both vein systems are believed to be the product of mesothermal, multiphase mineralization. K-Ar dating of shear-zone sericite indicates that sericitization occurred at 80.7±2.8 Ma; thus mineralization in the Vienna mineralized area probably is Late Cretaceous in age.

Introduction

The Vienna mineralized area of south-central Idaho is at the southwest end of the Stanley Basin, approximately 60 km north of Ketchum, Idaho (fig. 1). The area is in the northern Smoky Mountains, at the south end of the Sawtooth Mountains, in Blaine and Camas Counties, Idaho. It includes the drainages of Smiley, Frenchman, Johnson, Emma, and Beaver Creeks and part of the headwaters of Alturas Lake Creek (Jake and Eureka Gulches).

The Vienna mineralized area, as described in this paper, encompasses parts of the Vienna, Sawtooth, Skeleton Creek, and Big Smoky mining districts (Van Noy and others, 1986; Federspiel and others, 1987, 1992). The majority of mining activity and ore production has been from the headwaters of Smiley and Beaver Creeks, in the Vienna and Sawtooth mining districts, although a number of small mines and prospects are in the surrounding drainages (Umpleby, 1915; Van Noy and others, 1986; Federspiel and others, 1987). The level of erosion may be an important factor to the discovery of economic deposits because most successful workings are in deep glacial cirques that face northeast.

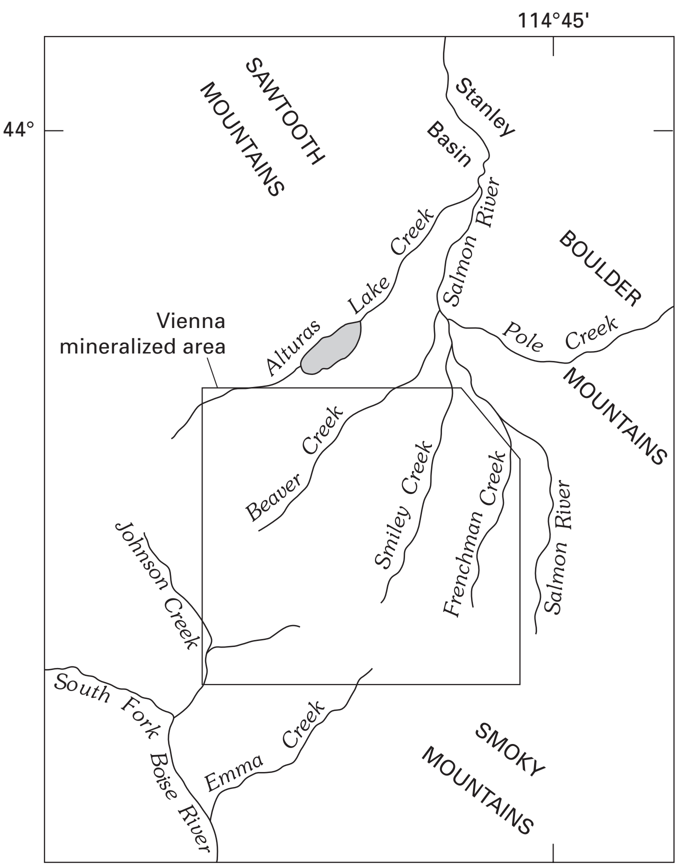


Figure 1. Location of Vienna mineralized area, Blaine and Camas Counties, Idaho.

Historical Perspective

The Vienna and Sawtooth mining districts were discovered in 1879, and the majority of mining activity occurred between 1880 and 1888. The largest producers were the Webfoot, Vienna, Silver King, and Pilgrim mines (fig. 2). Approximately two million dollars (historical prices) of silver ore was removed from the districts during this initial period of activity (Umpleby, 1915); significant production has not occurred since that time. Exploration has been intermittent since the late 1800s, including brief flurries of activity in the 1930s and early 1940s and in the late 1960s to early 1970s, when 79 claims were filed in the Vienna mining district (Van Noy and others, 1986). A small amount of production occurred in the early 1980s when material from existing mine dumps was processed by a custom mill along Warm Springs Creek, approximately 70 km south of the Vienna mining district. The Vienna and Sawtooth mining districts currently (1992) contain 55 patented claims and 170 current claims (Federspiel and others, 1992). Exploration, including a drilling program, was being conducted in 1992 at the Webfoot property in the headwaters of Smiley Creek; production is anticipated but is contingent on precious-metal prices.

Previous Work

The Vienna mining district and adjoining districts were important metal-producing areas in south-central Idaho during the late 1800s and have been the subject of numerous geologic investigations. Umpleby (1915) compiled a brief reconnaissance report of the district during mapping of the Sawtooth 30-minute quadrangle. Ballard (1922) discussed the district in a detailed report on the ore deposits of the Alturas 30-minute quadrangle. Ross (1927) conducted a detailed investigation of the surficial and subsurface geology of the Vienna mining district. Shannon (1971) mapped the district in detail, and conducted an extensive geochemical survey (stream sediment) in order to evaluate the use of geochemistry as an exploration tool. There are also numerous unpublished mining company reports of the area. The Vienna mineralized area was discussed as part of the northern addition to the South Boise Yuba study area (Federspiel and others, 1987). Mahoney and Horn (1989) reviewed the geologic setting and mineral deposits of the Vienna mineralized area, and the present report is a reevaluation of findings presented in that report. Federspiel and others (1992) evaluated mines and prospects in the area during a mineral resource investigation of the Smoky Mountains.

Geologic Setting

Lithology

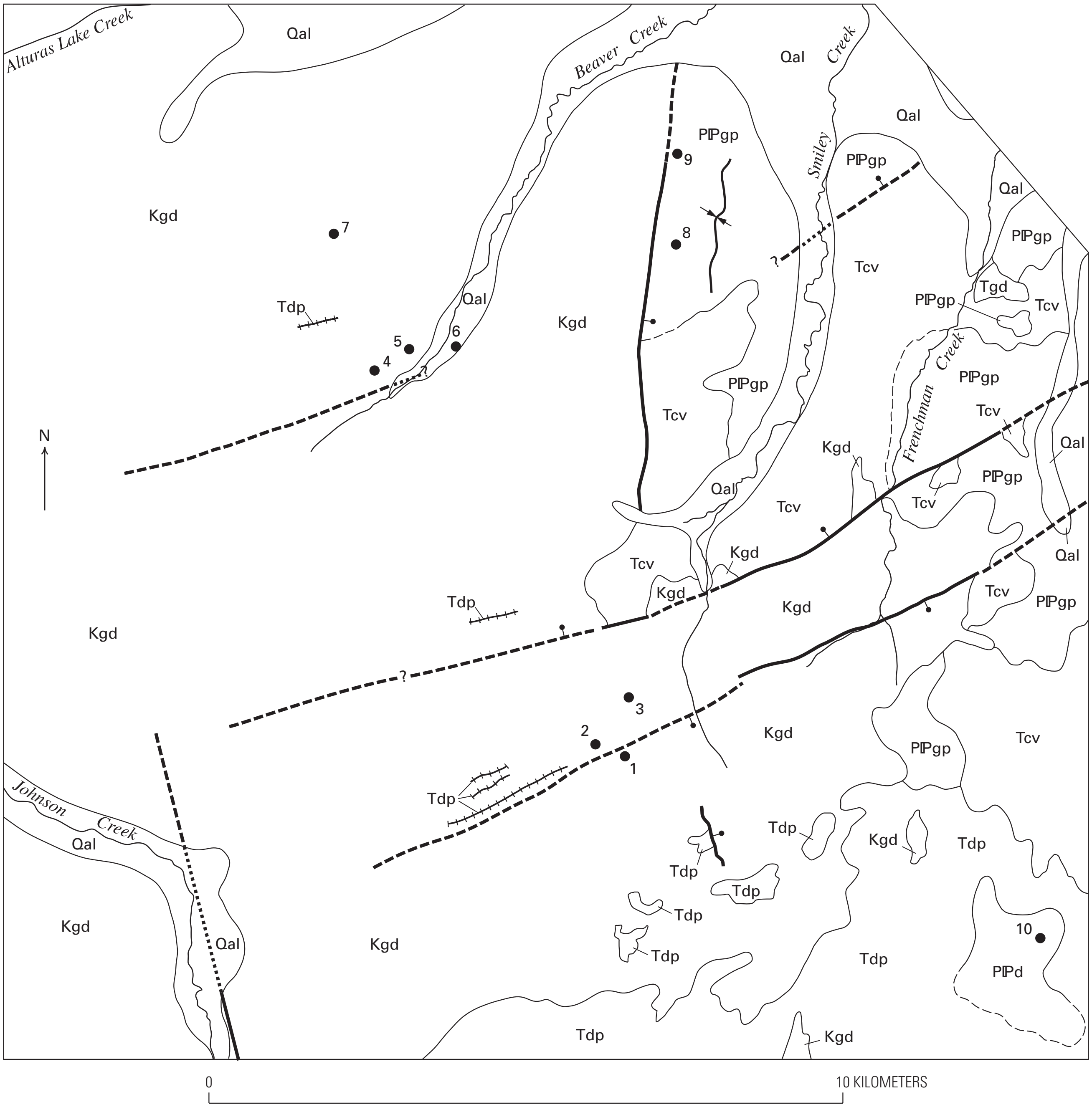
The Vienna mineralized area is on the southeast edge of the Atlanta lobe of the Cretaceous Idaho batholith (Kiilsgaard, Lewis, and Bennett, 2001). Biotite granodiorite to quartz monzonite of the batholith underlies most of the area. Mineral deposits in the area, with the exception of two small sediment-hosted skarn deposits west of Smiley Creek (Ura group and P&D claims) and one sediment-hosted replacement and polymetallic vein deposit (Mountain King claim), are hosted by the biotite granodiorite (fig. 2).

The biotite granodiorite is medium to coarse grained and composed of quartz, plagioclase, microcline, and biotite, and accessory magnetite, zircon and sphene. It is locally porphyritic, containing alkali feldspar phenocrysts as long as 8 cm; the porphyritic nature of the biotite granodiorite is believed to be the result of potassium metasomatism (Johnson and others, 1988). Cataclastic textures are visible in thin section, and in outcrop the biotite granodiorite locally displays an incipient gneissic texture, particularly northwest of Beaver Creek (fig. 2). Thin (2–20 cm), randomly oriented aplite and pegmatite dikes locally cut the granodiorite. The origin of the aplite and pegmatite dikes is uncertain: they may be a late-stage differentiate of the Cretaceous batholith. It is also possible that they are related to the Tertiary biotite (pink) granite of the Sawtooth batholith, exposed 8 km to the north, or to the Prairie Creek stock, a smaller Tertiary biotite (pink) granite intrusion, exposed 5 km to the south.

The biotite granodiorite intrudes micritic sandstone, siltstone, and sandy limestone of the Middle Pennsylvanian to Lower Permian Grand Prize Formation of the Sun Valley Group in the east half of the Vienna mineralized area (Mahoney and others, 1991) (fig. 2). The Grand Prize Formation in this area has been contact metamorphosed to calc-silicate hornfels and locally contains abundant wollastonite, diopside, and tremolite. The metamorphosed Grand Prize Formation hosts antimony-, silver-, and tungsten-rich skarn deposits (Ura group and P&D claims) on the north edge of the Vienna mineralized area, west of Smiley Creek, and silver-lead polymetallic veins and replacement deposits on Mule Creek, in the southern part of the area (fig. 2). Small roof pendants of sedimentary rock are exposed along ridges in the northeastern part of the mineralized area.

Andesitic to dacitic lavas and associated volcaniclastic sedimentary rocks of the Eocene Challis Volcanic Group unconformably overlie both the Cretaceous granodiorite and the Pennsylvanian-Permian Grand Prize Formation in the eastern part of the mineralized area (fig. 2). The volcanic rocks comprise a section more than 500 m thick of andesitic to dacitic flow rocks, tuff breccias, and volcanogenic

Figure 2 (following page). Generalized geology of the Vienna mineralized area, Blaine and Camas Counties, Idaho.



EXPLANATION

- Qal — **Alluvium (Quaternary)**
- Tgd — **Granodiorite (Tertiary)**
- Tdp — **Dacite porphyry (Tertiary)**
- Tcv — **Challis Volcanic Group (Eocene)**
- Kgd — **Granodiorite (Cretaceous)**
- PIPd — **Dollarhide Formation (Lower Permian to Middle Pennsylvanian)**
- PIPgp — **Grand Prize Formation (Lower Permian to Middle Pennsylvanian)**

- **Contact—**Dashed where approximately located
- ? **Fault—**Dashed where approximately located; dotted where concealed; queried where uncertain
- **Fault—**Bar and ball on downthrown side
- **Dike**
- **Syncline**
- **Historically productive mine or claim—**Shown by number: 1, Vienna; 2, Solace; 3, Webfoot; 4, Pilgrim; 5, Beaver Bidwell; 6, Silver King; 7, Ruby; 8, Ura group; 9, P&D claims; 10, Mountain King

sandstone and siltstone. The volcanic rocks are locally in fault contact with the granodiorite where they are preserved in downthrown fault blocks adjacent to north- and northeast-trending normal faults.

Northeast-trending Eocene dacite porphyry dikes cut the biotite granodiorite throughout the Vienna mineralized area. The pervasive northeast trend and the spatial relationship between northeast-trending faults and dacite porphyry dikes suggest that dike emplacement was structurally controlled. Chilled contacts within the dikes and minor alteration zones in the country rock characterize the intrusive contact between the dike rocks and the granodiorite, but no evidence of mineralization associated with Eocene dike emplacement was identified. Eocene dacite porphyry dikes reportedly cut mineralized veins at depth, although we could not confirm this.

Thin (0.2–0.4 m) lamprophyric dikes of uncertain age locally cut the biotite granodiorite. These dikes are inferred to be Cretaceous in age elsewhere in the region, although no absolute dates exist. Lamprophyric dikes apparently cut mineralized veins in the Webfoot mine ("diabase" of Ballard, 1922; Ross, 1927), but on the surface the highly altered nature of the dikes makes the exact relationship between these dikes and mineralized structures ambiguous.

Structure

The Cretaceous biotite granodiorite contains a prominent joint system that is exposed in the headwaters of Beaver Creek. The dominant joint set strikes N. 35°–50° W. and dips steeply to the north. This orientation roughly parallels the east edge of the batholith, suggesting that the dominant joint system represents contraction joints parallel with the batholith margin. The geometry of the joint set varies markedly, however, from planar, parallel joint sets to curvilinear joint patterns. Previous workers have suggested that mineral veins in the Vienna mineralized area are confined to the joint sets (for example, Ballard, 1922), but it is now recognized that the vein system is subparallel with the joint sets and clearly postdates them. Joint sets are locally mineralized adjacent to crosscutting subparallel mineralized shear zones.

Mineralized rock in the Vienna mineralized area occurs along shear zones that cut the granodiorite. The shear zones approximate a conjugate fracture set in which one set trends about N. 60° W. and the second set trends east-west. The shear zones are generally near vertical or dip steeply to the north. On the surface, the shear zones are iron oxide stained (limonite) and locally brecciated; below ground, breccia is common within shear zones, and intense chloritic and sericitic alteration extends for 1–3 m from the shear zones. Evidence of shearing and brecciation is more pronounced along the east-trending shear zones (Ballard, 1922). Both sets of shear zones are mineralized, although the east-trending set is normally of higher grade. Ore shoots are present locally at shear zone-joint and shear zone–shear zone intersections. Vein material is commonly sheared and brecciated, and small offsets from one to tens of meters of veins attest to syntectonic vein emplacement (figs. 4, 5).

The most pronounced structures in the Vienna mineralized area are northeast-trending (N. 50°–75° E.) normal faults that have displacements ranging from tens to hundreds of meters. These high-angle normal faults cut the Paleozoic Grand Prize Formation, the Cretaceous biotite granodiorite, and the Eocene Challis Volcanic Group (fig. 2) and are believed to be associated with the Eocene trans-Challis fault system (Bennett, 1986). The faults apparently controlled emplacement of the Eocene dacite porphyry dikes and must therefore be coeval with or slightly older than the Eocene dikes. The brittle nature, prominent surficial expression, large offset, lack of hydrothermal alteration, and lateral extent of these normal faults make them different from the more subdued mineralized shear zones previously discussed. There is a strong correlation between the trend of the normal faults and the location of mines and prospects in the Vienna mineralized area, and the faults may structurally control the location of mineral deposits. Three large economic deposits in the Vienna mineralized area (Webfoot, Solace, and Vienna mines) are apparently in a horst block bounded by Eocene normal faults at the head of Smiley Creek; deeper, more highly mineralized levels of the biotite granodiorite may have been uplifted along these Eocene structures. The relationship at depth between the northeast-trending Eocene faults and mineralized structures is unknown.

A prominent north-trending normal fault downdrops andesitic flow rocks of the Challis Volcanic Group against Cretaceous biotite granodiorite west of Smiley Creek (fig. 2). The fault is almost vertical and has an offset of least 500 m, based on the thickness of the volcanic rocks on the downthrown eastern block of the fault. The fault apparently cuts shear zones in the granodiorite and is believed to be associated with basin and range extension. This north-trending normal fault is subparallel with the Sawtooth fault to the north, which is the eastern bounding fault of the Sawtooth batholith horst block, and may be an extension or splay to the Sawtooth fault (Tschanz and others, 1986).

Mineral Deposits

Two distinct types of mineralized veins are present in the Vienna mineralized area: shear-zone-hosted silver-sulfide ribbon veins and shear-zone-hosted quartz-sericite-pyrite-galena veins. The veins are spatially associated but are mineralogically and texturally distinct. Crosscutting relations indicate that formation of the ribbon veins preceded emplacement of the quartz-sericite-pyrite-galena veins. Samples obtained from the principal mines in the mineralized area (Pilgrim, Webfoot, Solace, Vienna) were assayed; results are listed in table 1.

Both types of veins in the Vienna mineralized area are classified in the regional descriptive model of Worl and Johnson (1995) as polymetallic quartz veins and lodes; the

Table 1. Analytical data from selected samples of the Vienna mineralized area, Blaine and Camas Counties, Idaho.

[Selected assay results from numerous mines and prospects throughout the Vienna mineralized area are listed. Samples are grouped by property and listed by drainage. Proprietary restrictions prevent the disclosure of individual sample locations. Assays were selected specifically to provide a representative description of mineral deposits in the area. Sample types: Rock samples were fire assayed for gold and silver and analyzed for a 15-element or 12-element geochemical suite using atomic absorption or inductively coupled plasma (ICP) spectrometry. Gold analysis by fire assay with atomic absorption finish or by ICP of one assay ton of material; silver analysis by fire assay; copper, lead, zinc analysis by ICP. All samples analyzed by the U.S. Bureau of Mines. Samples stored at U.S. Bureau of Mines, Western Field Operations Center, Spokane, Wash.]

Sample Number	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)	Lead (percent)	Zinc (percent)	Sample type	Drainage	Description
3036	0.365	0.10	0.0002	0.0007	0.028	Chip	Beaver Creek	Vein/dike
3744	0.135	7.6	0.046	0.220	0.80	Select	Beaver Creek	Stockpile
3746	0.116	1.52	0.002	0.0036	0.01	Chip	Beaver Creek	Banded quartz
3033	0.142	0.29	0.0013	0.0012	0.006	Chip	Beaver Creek	Banded quartz
2997	0.05	12.83	0.0095	0.061	0.078	Select	Beaver Creek	Mill tailing
3718	0.127	7.62	0.017	0.115	0.065	Select	Beaver Creek	Shear zone
2474	0.127	29.6	0.052	1.05	0.120	Chip	Smiley Creek	Banded quartz
2475	0.118	56.1	0.0585	0.2460	0.1	Chip	Smiley Creek	Banded quartz
2498	0.861	0.65	0.003	0.015	0.006	Select	Smiley Creek	Shear zone
2490	0.169	47.5	0.051	0.086	0.226	Chip	Smiley Creek	Shear zone
2497	0.089	9.05	0.001	1.10	0.395	Chip	Smiley Creek	Shear zone
1657	0.282	18.1	0.0285	0.0315	0.048	Grab	Smiley Creek	Dump grid
1676	0.111	9.35	0.128	0.255	0.24	Grab	Smiley Creek	Dump grid
2469	0.08	6.21	0.002	0.211	0.005	Select	Smiley Creek	Quartz vein
1689	0.054	3.22	0.0067	0.0395	0.014	Grab	Smiley Creek	Dump grid
1696	0.079	3.82	0.008	0.1625	0.022	Grab	Smiley Creek	Dump grid
2472	0.115	3.95	0.0053	0.026	0.015	Select	Smiley Creek	Quartz vein

silver-sulfide ribbon veins belong to the silver variety and the quartz-sericite-pyrite-galena veins to the base-metal variety. Similar crosscutting relationships between these two varieties are documented elsewhere in the region (Worl and Johnson, 1995).

Quartz-Silver-Sulfide Ribbon Veins

The quartz-silver-sulfide ribbon veins consist of roughly defined bands of massive white vein quartz and aphanitic dark-gray silver-sulfide minerals, primarily pyrargyrite and proustite (figs. 3, 4). Aphanitic minerals are present as thin (<0.5 cm) stringers in thicker (≈0.7–2 cm) white quartz veinlets, which are present as anastomosing ribbons separated by elongate blebs of highly altered wallrock. Tetrahedrite, ruby silver, argentian stibnite, and argentite ("black metal") are locally abundant (Ballard, 1922; Shannon, 1971). The arsenic and antimony contents of the deposits vary considerably across the district (Shannon, 1971; Federspiel and others, 1992) but are highest in the Silver King mine, which represents the deepest level of exposure in the district (fig. 2). Pyrite and arsenopyrite are common in the altered wallrock and in the gangue of shear zones but are notably absent in the competent ribbon veins.

The ribbon veins pinch and swell along strike and locally form tabular ore lenses. Veins range in width from 0.1 to 2 m, and alteration zones extend from 1 to 3 m from the veins. The ribbon vein system is parallel to subparallel with shear zones; wallrock fractures are commonly parallel with the ribbon veins and are best developed in the east-trending shear zones. Brecciation and folding of the ribbon veins are common (fig. 5). Alteration adjacent to the veins consists of intense sericitization close to the veins and chloritization and kaolinitization near the outer edges of the altered zones to a distance of 1–3 m from the veins.

Figure 3. Photograph of silver-sulfide ribbon ore, Vienna mineralized area, Idaho. Note sericitic and chloritic alteration surrounding silver sulfide and quartz veinlets.

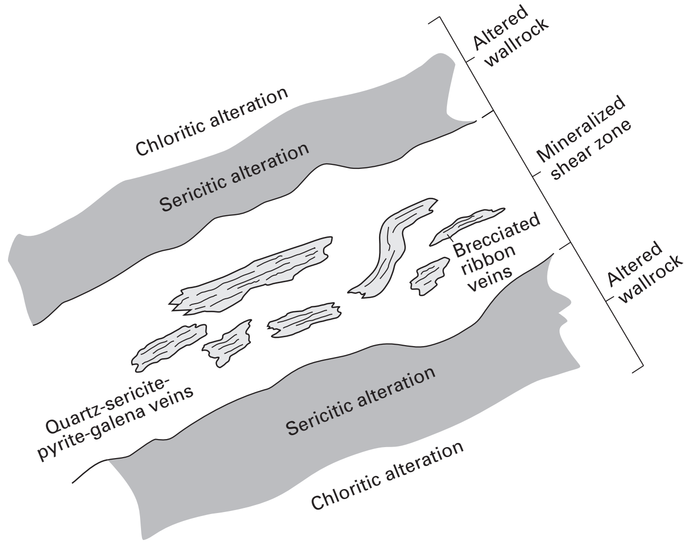


Figure 4. Schematic diagram of mineralized shear zone typical of Vienna mineralized area, Idaho. Note brecciated ribbon veins overprinted by quartz-sericite-pyrite-galena veins and alteration halos surrounding shear zone. Host rock is biotite granodiorite country rock.

The ribbon veins represent a hypogene mineralization event characterized by repeated pulses of quartz deposition and deposition of aphanitic sulfide minerals, as indicated by the development of ribbon structures and the presence of vein-parallel inclusions of intensely altered wallrock (J.S. Lee, unpub. data). Sulfide mineral paragenesis and the primary alteration features associated with the ribbon veins are difficult to determine because of subsequent shearing and brecciation during late-stage and post-mineralization tectonism.

Quartz-Sericite-Pyrite-Galena Veins

The quartz-sericite-pyrite-galena vein system consists of galena, sphalerite, and arsenopyrite and minor stibnite and argentite in a quartz, sericite, siderite, and pyrite gangue (fig. 6). The arsenopyrite contains minor amounts of gold (Shannon, 1971), and disseminated gold is presented in the alteration zones (J.S. Lee, unpub. data). Pyrite, and to a lesser extent, arsenopyrite are disseminated throughout the shear zone and surrounding altered wallrock. The sulfide minerals are present as irregular patches within the intensely sheared gouge zone, and open-space-filling textures are locally evident. Sulfide minerals locally form massive lenses as long as 3 m, particularly near shear zone–joint and shear zone–shear zone intersections. The gangue material consists primarily of irregular, elongated grains of quartz and abundant sericite and siderite. Andorite and other sulfosalts are locally important (J.S. Lee, unpub. data).

Sericite from a northwest-trending shear zone in the headwaters of Beaver Creek yielded a K-Ar date of 80.7±2.8 Ma that indicates mineralization in the Vienna mineralized area

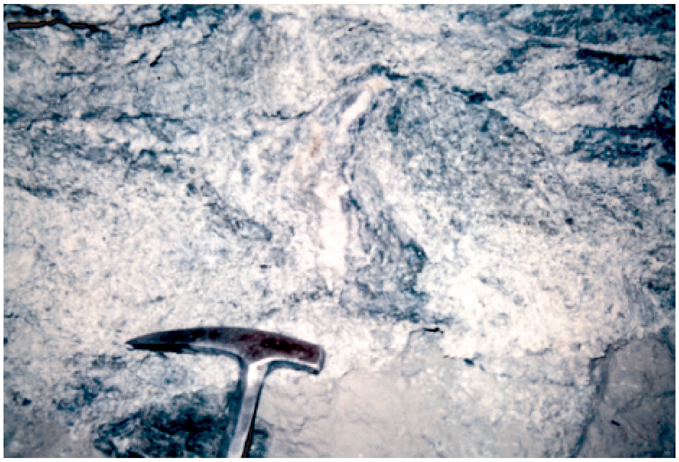


Figure 5. Photograph of mineralized shear zone in the Pilgrim mine, Vienna mineralized area, Idaho. Note folded and brecciated ribbon veins. Hammer head shown for scale.

to be Late Cretaceous (D. Runkle and J. Herckel, University of British Columbia Geochronology Lab, unpub. data). This date agrees with field relations, which indicate that mineralization occurred following emplacement of the Cretaceous biotite granodiorite and development of the joint system, yet prior to intrusion of the crosscutting Eocene dacite porphyry dikes. This age of mineralization corresponds with the earliest Late Cretaceous–Paleocene mineralization episode suggested by Snee and Kunk (1989).

Quartz-sericite-pyrite-galena veins are present in the same shear zones as the ribbon veins and significantly overprint the early phase of mineralization. The ribbon veins are strongly sheared and brecciated, although small unsheared segments of the ribbon veins are present as inclusions within the intensely sheared and mineralized gouge zone (figs. 4, 5). The gouge zone contains abundant sericite and minor chlorite, and the wallrock is chloritized and sericitized as far as 1–3 m from the shear zone. Quartz-sericite-pyrite-galena mineralized rock is present along both shear-zone systems in the Vienna mineralized area, and ore shoots of this assemblage locally are present at shear-zone intersections. Minor mineralized rock also is present along joint planes near joint–shear zone intersections.

Genesis of Mineral Deposits

The two vein types in the Vienna mineralized area are mineralogically and texturally distinct but are spatially and genetically related. The quartz-sericite-pyrite-galena veins postdate the ribbon veins, as shown by (1) brecciation and shearing of the ribbon ore within the highly sericitized and mineralized shear zones and (2) dissemination of pyrite and arsenopyrite throughout the gouge and alteration zones but absence of those minerals in the more competent (impermeable) ribbon veins. Ribbon veins are concentrated near the center of shear zones, whereas the quartz-sericite-pyrite-galena veins are present throughout the gouge and alteration zones, as well as in ore shoots at shear zone and shear zone–joint intersections.

Mineralization in the Vienna mineralized area is believed to be the result of multiphase injection of mineralizing fluids along a conjugate shear system during the Late Cretaceous. Structural control on the conjugate shear set is unclear; the shear zones may be the result of hydrostatic stress associated with the late-stage hydrothermal system or may have formed from post-intrusion, pre-mineralization tectonic stress.

The two vein systems probably formed as the result of changes in hydrostatic pressure, temperature, and fluid composition during a mesothermal mineralization event of multiple phases. This event was characterized by emplacement and continued brecciation of the ribbon ore, followed by deposition of the quartz-sericite-pyrite-galena system along the same shear zones. The ribbon vein system is mesothermal in origin and was emplaced during several stages of quartz injection, sericitization, and mineralization, as suggested by the ribbon nature of the veins, alternating brecciation and ribbon vein formation, and inclusion of altered wallrock within the shear zones. The quartz-sericite-pyrite-galena system was subsequently deposited along the sheared and brecciated shear zones. This vein system displays open-space textures characteristic of an epithermal origin, but such textures also develop in mesothermal systems in void spaces created by brecciation and at the intersections of shear zones and shear zone and joints (C. Godwin, consulting geologist, oral commun., 1990).

The paragenetic sequence is believed to progress from deposition of silver-sulfide minerals to deposition of galena, sphalerite, arsenopyrite, and pyrite, and probably is the result of changes in ore fluid composition related to depletion and the interaction between evolving ore fluid and granodiorite wallrock. The metal-bearing fluids are probably a late-stage hydrothermal system associated with Cretaceous biotite granodiorite; however, lead-isotope analysis suggests that the

Figure 6. Photograph of brecciated quartz and silver sulfide ribbon veins in an oxidized quartz-sericite-pyrite-galena matrix, Vienna mineralized area, Idaho.

ultimate source of the metals may be related to Precambrian upper crustal rocks (Sanford and Wooden, 1995).

Crosscutting field relations (dikes and faults cutting veins), a lack of associated silver-lead deposits in adjacent Eocene rocks, the mesothermal nature of the ribbon veins, and K-Ar dating of shear-zone sericite suggest that mineralized rock in the Vienna mineralized area is primarily hosted by biotite granodiorite of the Cretaceous Idaho batholith and is of Late Cretaceous age. Eocene emplacement of northeast-trending faults and dacite porphyry dikes may have caused minor remobilization of the Cretaceous ore minerals but did not contribute new ore material. Mines and prospects of the mineralized area are in uplifted fault blocks and in deeply eroded glacial cirques, suggesting that mineralization is more prevalent at depth. Mineralogical zonation of the deposits of the Vienna mineralized area is suggested by a higher proportion of argentian stibnite and galena in deeper workings (such as Silver King). Additional mineral deposits may be present at depth in the Vienna mineralized area, particularly in areas characterized by higher level surficial exposures, such as the headwaters of Johnson Creek and Emma Gulch.

Acknowledgments

We thank Earl Waite, Jr., and the Rothschild Corporation for access to the Webfoot mine and for the numerous discussions about the area. Frank Federspiel of the U.S. Bureau of Mines provided the sericite sample and is greatly appreciated for his discussions and a review of the manuscript. The assistance of Jody Robb and the ladies at the Smiley Creek Lodge is gratefully acknowledged. We thank Dita Runkle and Joe Herckel of the University of British Columbia Geochronology Laboratory for providing the critical sericite age date. This manuscript benefited from reviews by Frank Federspiel, Gary Winkler, Jeff Jones, Ron Statelmayer, and Ron Worl.

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