NATURAL RESOURCES

INACTIVE AND ABANDONED MINE LANDS— Bodie Mine, Wauconda Mining District, Okanogan County, Washington

by Fritz E. Wolff,
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and David K. Norman

WASHINGTON
DIVISION OF GEOLOGY
AND EARTH RESOURCES
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Contents

FIGURES

TABLES

Inactive and Abandoned Mine Lands—Bodie Mine, Wauconda Mining District, Okanogan County, Washington

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INTRODUCTION

The Washington State Department of Natural Resources (DNR), Division of Geology and Earth Resources (DGER), is building a database and geographic information system (GIS) coverage of major mines in the state. Site characterization was initiated in 1999 (Norman, 2000). Work is funded through interagency grants from the U.S. Forest Service (USFS), Region 6. Other agencies sharing in the project are the U.S. Bureau of Land Management (BLM), the U.S. Environmental Protection Agency (EPA), and the Washington Department of Ecology (DOE).

More than 3800 mineral properties have been located in the state during the last 100 years (Huntting, 1956). Many are undeveloped prospects of little economic importance. Therefore, in considering the population to include in the Inactive and Abandoned Mine Lands (IAML) inventory, we have identified approximately 60 sites that meet one of the following criteria: (a) more than 2000 feet of underground development, (b) more than 10,000 tons of production, (c) location of a known mill site or smelter. This subset of sites includes only metal mines no longer in operation.

We have chosen to use the term *inactive* in the project's title in addition to the term *abandoned* because it more precisely describes the land-use situation regarding mining and avoids any political or legal implications of surrendering an interest to a property that may reopen with changes in economics, technology, or commodity importance.

The IAML database focuses on physical characteristics and hazards (openings, structures, materials, and waste) and water-related issues (acid mine drainage and/or metals transport). Accurate location, current ownership, and land status information are also included. Acquisition of this information is a critical first step in any systematic approach to determine if remedial or reclamation activities are warranted at a particular mine. Reports such as this one provide documentation on mines or groups of mines within specific mining districts or counties. The IAML database may be viewed by contacting Fritz Wolff (360-902-1468). IAML reports are online at http://www.dnr.wa.gov/geology/pubs/.

SUMMARY

The Bodie property is a partially mined and partially explored auriferous ore deposit located on the east bank of Toroda Creek, 12 miles north of Wauconda (Fig. 1). The property consists of five contiguous patented claims (see Fig. F4, p. 22). A number of companies owned or leased the mine beginning with its discovery in 1897. Almost all development took place during two periods of production: 1902–1907 (Bodie Mining Co., Inc.) and 1934–1945 (Northern Gold Co., Inc.). The current owner is

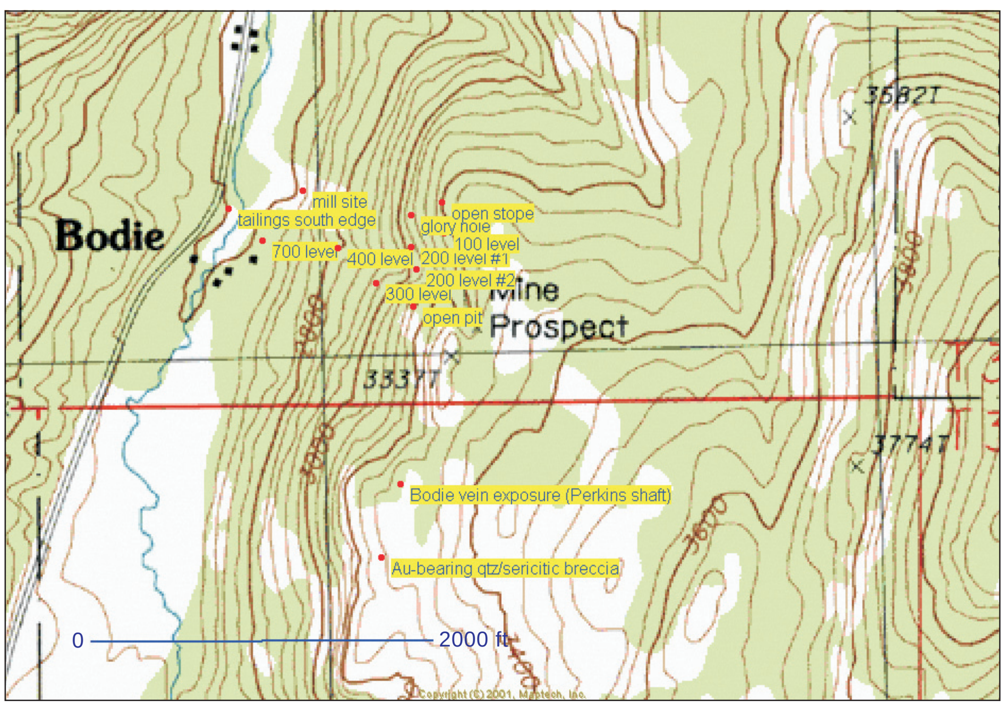

Figure 1. Map showing the general location of the Bodie mine in Okanogan County (above), and a more detailed map of the mine site (below).

Geo-Mineral Exploration, Inc., Seattle, Wash. The estimated dollar value of production at historic metal prices is $410,000 from 50,000 to 70,000 tons of ore. Conditions at the mine, particularly in the vicinity of the Bodie vein development, are precarious, and it should not be entered.

Some cabins and a former bunkhouse located on the Little George claim are all that remain of the Bodie camp and settlement, which is on the register of the Okanogan Historical Society. (See Appendix F.)

The ore consists of microscopic particles of free gold and/or electrum, gold selenide, and gold-bearing sulfides found in a banded quartz vein 5 to 22 feet wide that strikes N to N16°E and dips 60 to 80°W. The average extent of the underground development along strike is approximately 700 to 800 feet, but the vein crops out at various points for 6000 feet or more along strike. The structure most often referred to as the Bodie vein is a series of parallel quartz stringers or veinlets separated by narrow bands of highly altered and pyritized andesite/dacite (Chamberlain, 1936). In some places, the quartz is chalcedonic in structure; in others, it is crustiform and contains late-stage calcite. The ore body displays many characteristics of an epithermal hot-springs type deposit, similar in age and structure to those found at Republic and Orient, Wash. The vein is continuous in the mine workings from the surface to the bottom of a winze, a vertical distance of about 450 feet.

An extensive unit of pyroclastic breccia surrounds both sides of the Bodie vein near the mine workings and crops out south of the mine in places free of colluvium. Several large-scale surface sampling programs were directed at determining the areal distribution and tenor of potential economic mineralization of the breccia in the 1970s and 1980s. They indicate a significant tonnage of low-grade precious metals may exist, but were inconclusive as to calculated ore reserves (Appendix E). Moen (1980) estimated that the breccia "…might exceed 50 million tons of sparsely mineralized gold and silver." Available information indicates that the deposit has not been explored to any degree along strike to the north, nor did we find any reference to past core-drilling programs.

DGER personnel visited the site in August 2001 and June 2002 and 2007, as well as June 1997 in conjunction with the Dept. of Ecology (DOE) (Raforth and others, 2000). We located six of the seven adits reported to have been driven at the mine: the 100, 200 (two portals), 250, 300, 400, and 700 levels. The 100-level adit was driven along the vein; the other adits are crosscuts bearing east at right angles to the vein. The 700-level adit stopped short of the vein's downward extension. Exhausting cold air from the other portals suggests that the crosscuts are at least partly connected to stopes that daylight on the mine ridge. One feature that appears to be a glory hole was discovered near the northernmost open stopes but offset 250 feet to the west. It may represent a branching of the Bodie vein. An open pit was gouged out of the steep western slope of the mine ridge on strike, about 250 feet southeast of the 300-level portal. The exposures here present an excellent opportunity to view the mineralized structure(s), but could not be safely examined because of rockfall and because the vein's hanging wall is collapsing into the pit and into openings underneath the foot trail.

The mill site is marked by crusher and ball mill foundations. The building burned in 1962. The remains of an office/superintendent's house lie a few feet south of the mill site. Aerial tram cables span part of the distance from the former primary ore bin to the 400-level dump, also the site of a small machine shop.

Figure 2. Massive andesite exposure at the 700-level portal. Platy fragments are spalling around opening. View is to the east.

The extremely fine-grained nature of the precious metal and sulfide mineralization has led to considerable experimentation, especially regarding fineness of grind, to achieve high mill recoveries. The available information indicates that gold may occur as free gold or electrum, as a selenide, is attached to or included in metal sulfides, or some combination thereof. Recoveries reported with stand-alone amalgamation, gravity separation, cyanidation, and flotation suggest that all three modes of occurrence are possible. No specific silver minerals have been identified (DGER mine file).

Approximately 35,000 cubic yards of mill tailings overlie a flat 6.5-acre area along the east bank of Toroda Creek. A grab sample taken at the surface by DGER met the state standards for unrestricted and industrial/commercial land use for cadmium, copper, lead, and zinc listed in WAC 173-340-900, the Model Toxics Control Act (MTCA)(see Tables 3 and 4). However, the arsenic analysis exceeded this standard by a factor of three. A second sample taken from a depth of 48 inches was analyzed for free cyanide and mercury. Cyanide was not detectable, and the mercury content was well below the MTCA standard. Huchton (1997) found elevated levels of antimony, arsenic, and selenium in a composite sample taken from several waste rock dumps (see Table 3).

None of the adits at the Bodie mine discharged water. Toroda Creek flows through the property from south to north. Although the stream cuts the west margin of the tailings, which are exposed on the other bank (see Fig. 14), sampling by DOE upstream and downstream indicates that the mine tailings have a negligible effect on water or stream sediment quality, both of which meet state standards (Raforth and others, 2000; see Table 6). The taxa DGER collected in a sample of benthic macroinvertebrates from Toroda Creek at the mine site are indicative of good water quality.

ACCESS

The mine and the historic settlement of Bodie are reached by following the paved Toroda Creek Road for approximately 12 miles north of Wauconda, Wash. Historic log structures can be seen on both sides of the road at this point (see Appendix F, Figs. F1 and F2). The mine lies approximately 1000 feet east of the settlement at elevations of 2750 to 3250 feet. A serviceable road switchbacks up the mountainside, connecting all the adits; unfortunately the entry point is blocked by a clearcut on the north end of the patented claims.

OWNERSHIP

The property consists of five en bloc patented lode claims: Bodie, Bodie No. 2, West Cliff, Crystal Bluff, and Little George. Most of the mine workings are on the south end of the Bodie claim in SE¼SW¼ sec. 34, T39N R31E; parts of Bodie No. 2 extend into NE¼NW¼ sec. 3, T38N R31E. The Bureau of Land Management (BLM), Washington Dept. of Natural Resources (DNR), and private parties own lands north and south of the mine. These claims were located in 1897 and surveyed for patent as Mineral Survey 721 in 1902 and 1903 (Appendix F, Fig. F4). Whether or not the original claim corners remain visible was not determined by DGER. Moen (1980) shows an approximate location of the claims with respect to the mill site and cabins. The present owner of record is Geo-Mineral Exploration, Inc., Seattle, Wash. (Okanogan County Assessor, written commun., 2006). The BLM LR2000 database shows no active unpatented claims in sec. 34 or sec. 3 (BLM, Nov. 2006).

The Toroda claim group is mentioned in historic reports (DGER mine file). Toroda 1, 2, and 3 were unpatented claims, now closed, which were contiguous end-to-end along strike, beginning at the south endline of Bodie No. 2.

HISTORY

The Bodie Mining Company was organized in 1902 to expand development of the original location. Under the leadership of C. M. Fassett of Spokane, a ten-stamp mill was erected that used mercury amalgamation and straight-leach cyanidation (Chamberlain, 1936). Early production mined near-surface zones of high-grade ore containing as much as 20 ounces per ton (opt) gold. Initial milling practice yielded marginal recoveries, leading to several turnovers in management and ownership. The first period of mining ended in 1916, prior to the start of World War I. During this period, the mine changed hands four times: Bodie Mining Co. (1902–1907), Bodie Mining and Transportation Co. (1907–1909), Duluth-Toroda Mining Co. (1910–1912), and Toroda Development Co. (1915–1916). (See Appendix C.) Moore (1934) reported that approximately 15,000 tons were mined during this 14-year period, with a value of about $130,000 with gold held at $20.67 per ounce.

Two companies, Cary Mining and Development Co. and Blue Stem Mining Co., leased or purchased the property between 1916 and 1922, but no production is reported in these years. Chamberlain (1936) stated that the mine was shut down until 1934, at which time Northern Gold Corp. began operations when the price of gold increased to $35 per ounce. Northern Gold rebuilt the mill in 1935, increased throughput to 70 tons per day (tpd), and added a trial flotation circuit that was suspended after only six months use. Recoveries were not completely successful until 1938 when cyanidation and a revised flotation circuit were added. Northern Gold ceased mining and milling operations in 1941 after the War Production Board issued Government Order L-208 closing industries considered nonessential during World War II, but remained active on the property until 1945. The company mined approximately 50,000 tons, valued at $280,000, until shut down. As many as 40 miners and mill men had been employed during Northern Gold's stewardship, working three shifts per day (Moen, 1980).

Geo-Mineral Exploration acquired title to the five patented claims in 1970. Activities by Geo-Mineral are unknown. However, a number of lease and option agreements were conducted for the purpose of sampling and exploration as the price of gold escalated in the late 1970s and early 1980s: Vieco Resources, Ltd., Vancouver, B.C. (1974); Malabar Mines, Ltd. (1980); Noranda Exploration, Inc., and Western Land and Resources, Inc. (1982); Freeport Exploration Co., Inc. (1984); and Crown Resource Corp. (1984, 1987). Some data reported by these companies are summarized in Appendices D and E. A list of principal companies holding title to the Bodie mine is shown in Appendix C.

GEOLOGIC SETTING

Gold mineralization at the Bodie mine is remarkably similar to and of the same age as epithermal (50– 200°C) hot-springs type gold deposits found at the First Thought mine in Stevens County and the Republic Mining District in Ferry County. Two host rocks, both in the upper Eocene Klondike Mountain Formation, surround the Bodie vein: a dense microcrystalline andesite flow grading to dacite in places, and one or more units of brecciated volcanic rock containing minor pyroclastic sediments. The andesite ranges in color from light green to dark purple and commonly displays a platy flow structure that dips into the hillside at moderate angles (Fig. 2).

Although the brecciated rocks contain widespread gold mineralization as discussed below, historical mining operations have concentrated on a persistent vein up to 22 feet wide, striking N to N16°E and dipping 60 to 80°W. The Bodie vein contains a series of thin porcelain-like quartz stringers or veinlets separated by narrow bands of highly altered andesite and dacite as shown in (Fig. 3).

Moen (1980) reported that the precious metal mineralization occurs as "dust-sized particles". The only readily identifiable sulfide mineral in our investigation was finely disseminated pyrite that is pervasive, both in the vein and the breccia. Propylite, sericite, and kaolinite are important alteration products; there is also widespread silica flooding (Chamberlain, 1936). Production records indicate that the vein produced some bonanza-type gold values exceeding 20 opt gold in the early mining, in particular from the surface to the 100 level. Stope mining from the 100 level down to the 300 level produced averages of 0.75 to 0.125 opt gold respectively, suggesting that grade diminishes with depth. This may not be an entirely accurate assumption because of inconsistent mining practices characterized by Woodbridge (1928) as "random high-grading of the deposit". In 1924, the mine superintendent made the comment that, "...near the bottom of the winze, 90 feet below the 400 level, the vein is 12 feet wide and assays $4.85 per ton (0.25 opt) in strong sulfides" (DGER mine file). A compilation of assays on the Bodie vein and its extension to the south is shown in Appendix D.

Recent chemical analyses of the Bodie ore indicate that the mineralization is more complex than previously thought. Huchton (1997) found elevated levels of antimony, arsenic, and selenium in a composite sample of several waste rock dumps. Moore (1934) reported the presence of gold selenide in the

Bodie ore. In addition, DGER found indications of arsenic, lead, and zinc minerals in a tailings sample (see Table 3). These findings are consistent with observations in the Republic Mining District made by Tschauder (1989) where mercury, iron, arsenic, antimony, and selenium were associated with chalcedonic gold/silver mineralization. In the absence of specifically identified silver minerals, an overall production gold/silver ratio of about 1:0.73 opt suggests electrum (a gold/silver solid solution containing 25–55% silver) may be present. Tests run by the U.S. Bureau of Mines in 1945 reported gold from a large sample of Bodie vein material had a fineness of 631 of a possible 1000, the balance being silver.

Significant low-grade gold and silver mineralization occurs in a large body of brecciated volcanic rocks on both sides of the of the Bodie vein in the upper levels of the mine and extending south along the mine ridge. As shown in Fig. 4, the breccia departs from the hanging wall of the vein below the 250 level due to faulting, but thickens at lower elevations (DGER mine file). Chamberlain (1936) identified this rock type as a highly silicified andesite breccia that was also encountered in drifts penetrating the vein's footwall to the east.

A comprehensive study of the breccia unit was conducted by McClaren (1980) for Malabar Mines Ltd., including geochemical sampling of the B soil horizon. Statements in the study pertinent to this report are as follows:

"The majority of the breccia is composed of andesitic fragments, however on the 400 level and near the glory hole, mudstone and clastic sediments form an integral part of the unit ....The breccia displays various degrees of hydrothermal alteration, ranging from intense silicification and argillic alteration to weak propylitic alteration. Both the breccia and alteration have been traced south of the main workings to Bodie Creek, a distance of approximately 6600 feet....The breccia trends north to northeasterly and generally parallels the strike of the vein except at the northern portion of the property where there is a split between the main breccia mass and the vein with massive andesites intervening. Where the breccia is silicified, the clasts form approximately 80 per cent of the mass (Fig. 5)....Areas that exhibit silicification features were found to be more likely to contain precious metal values. However, rocks showing intense argillic alteration also contain significant precious metal values." Assays taken at various times from the brecciated unit, including 37 samples from the foregoing study, are shown in Appendix E.

McClaren's sampling of the B soil horizon was set up on a grid with east–west cutlines (exact location unknown) spaced at 200 foot intervals along strike of the vein. In total, 273 samples were collected over a sampled distance of 25,000 feet. The normal gold background in the area was determined to be in the range of 0 to 50 ppb. Gold values considered anomalous in the study ranged from 100 to 7400 ppb in specific areas extending north several hundred feet from the main mine workings and 6000 feet south. Analyses for copper and silver taken at the same points as the gold analyses proved to be unreliable pathfinder elements. McClaren concluded, "The previously mined areas yielded geochemical responses that do not fully reflect the areal distribution of auriferous rock. The reason for the limited response may be due to the sample spacing and the size of gold particles in the soil. The gold geochemical results are best used to delineate areas of potential gold bearing lithologies, but cannot be reliably used to eliminate areas of lesser potential. This is best illustrated in the area of the Myrtle workings [~2000 feet S16°W of the mine] where rock analyses for gold contained in surface samples

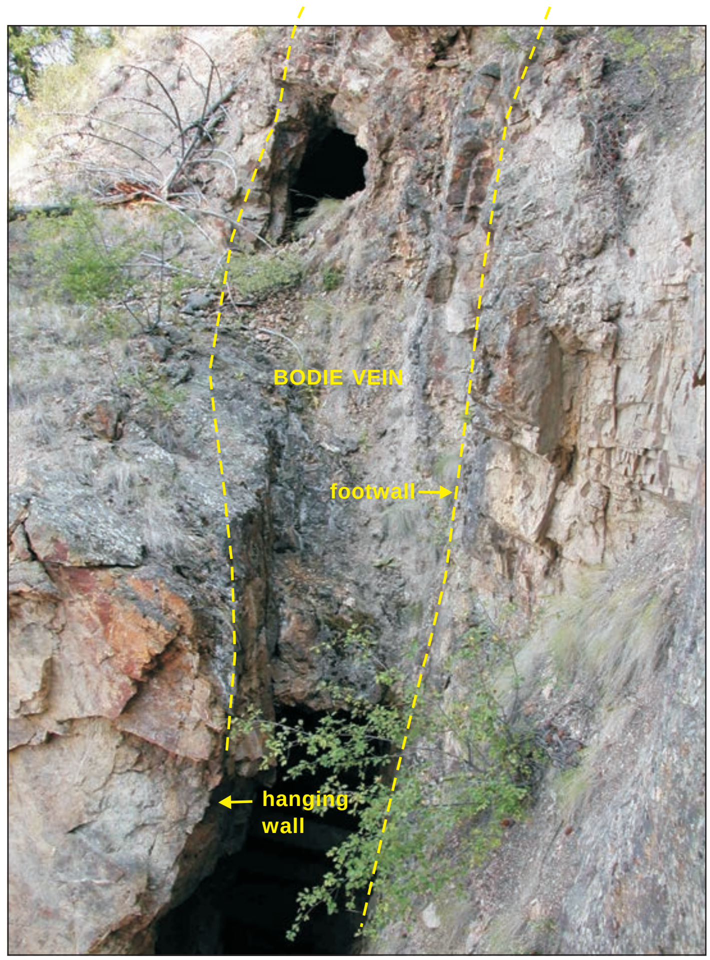

Figure 3. Bodie vein exposure and open stopes on the 100 level. View is to the north.

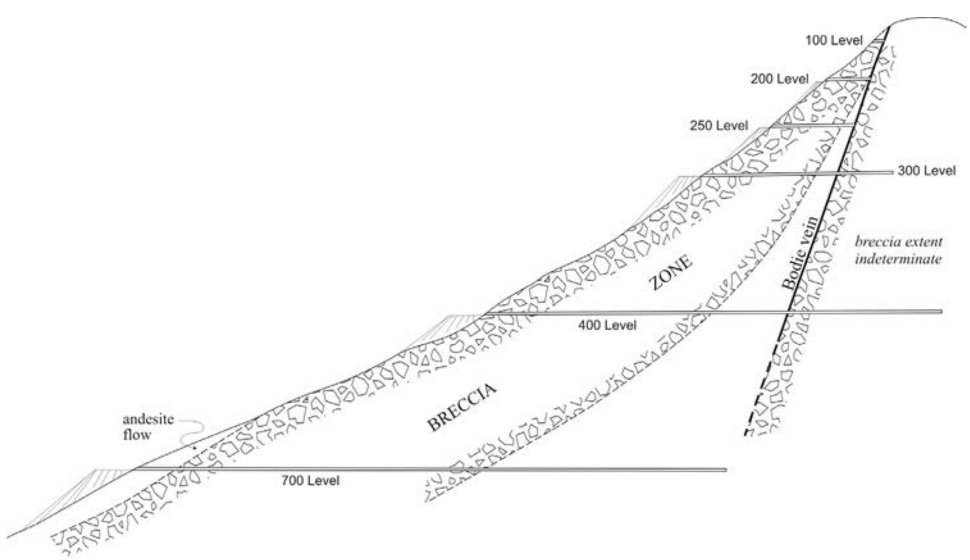

Figure 4. Cross section of the Bodie mine looking north. Levels are superimposed on one plane. (Modified from Moen, 1980.)

yielded favorable results, while soil samples taken from the same area failed to return anomalous results" (DGER mine file). Summary results of the soil sampling are shown in Appendix E.

OPENINGS

Total development at the Bodie mine is approximately 10,000 feet of adits, drifts, and stopes including a glory hole and an open pit. Six adits lying on the west-facing slope above the mill were driven east at right angles to the vein: the 200 (two adits), 250, 300, 400, and 700 levels. Figure 6 from Chamberlain's thesis shows the extent of underground development in 1936. The 100 level was driven along strike near the top of the mine ridge. Here, the stope is open in places and at others thinly bridged by the vein itself. The 750-foot-long 700-level crosscut is blind, stopping a few feet short of the vein's downward projection (Fig. 4). A cross section in Chamberlain (1936) indicates that some of the stopes were continuous from the surface to the 250-level elevation, a distance of about 180 feet. The raise/shaft shown in Figure 6 connected all levels down to the 400 crosscut, which acted as the main haulage way. Surface slough has obliterated the exact location of the raise collar.

All of the mine workings, underground and on the surface, are hazardous and should not be entered (Figs. 7 and 8). Most of the crosscutting adits are caved or partly caved. Cool air exhausting from the 200-, 300-, and 400-level portals indicates that they are open to some extent (see Table 2). We observed no air exhausting from the 700-level portal.

The longest horizontal development along the vein was approximately 1000 feet on the 400 level. The lowest vertical development is a 90-foot winze sunk from the 400 level giving a vertical extent of the vein's exposure within the mine of 450 feet.

Figure 6. Plan view of mine development circa-1936. Open pit is off-area to the southwest (after Chamberlain, 1936).

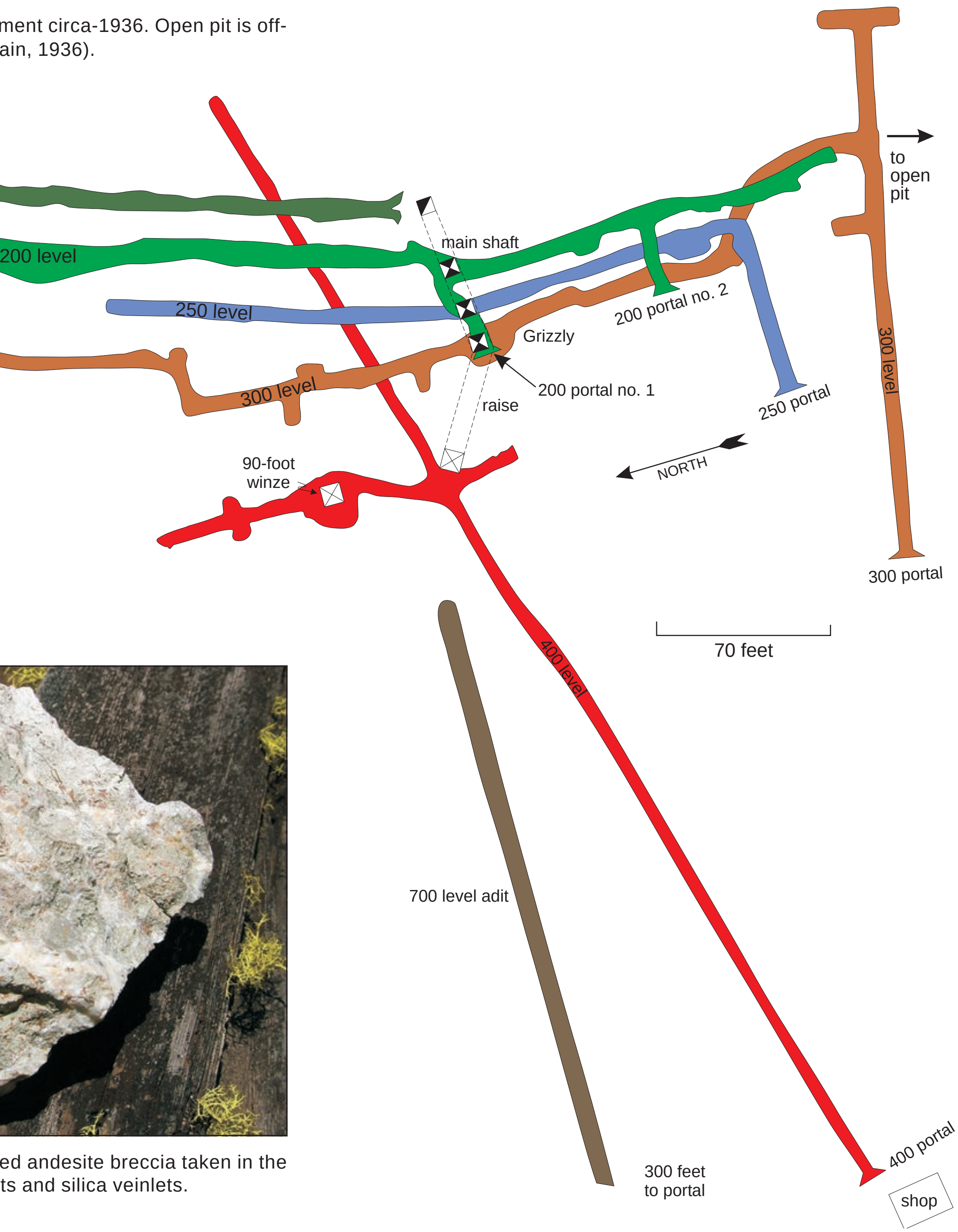

Figure 5. A 12-inch sample of silicified andesite breccia taken in the 400 level adit. Note pyritization in clasts and silica veinlets.

Figure 7. Open stopes along mine ridge. View is to the northeast.

Figure 9. Glory hole, ~50 feet in diameter by 40 feet deep. The Bodie vein is 250 feet to the east. View is to the south.

A feature that resembles a glory hole is approximately 40 feet deep with vertical sidewalls (Fig. 9). It does not appear to be a subsidence feature. It is located 250 feet west of the northern-most open stopes. As such, it either represents a branching of the vein or a pocket of economic gold mineralization in the breccia.

The headwall in an open pit located on strike ~250 feet southeast of the 300-level portal is about 100 feet in height with several adits and at least one raise entering the sidewalls (Fig. 10). The area could not be safely entered. The vein's hanging wall at the pit location is separating and falling into the opening, and caved beneath it during DGER site characterization (Fig. 11).

Allen's (1974) description of the physical condition of the openings more than 30 years ago indicates an advanced state of failure at that time: "100 level inaccessible...200 level caving and requires clearing and bridging...250 level open for ~100 feet along the vein and 35 feet wide with stopes above and below. The hanging wall appears mineralized, but could not be safely sampled."

Figure 8. Open stopes along mine ridge. View is to the northeast.

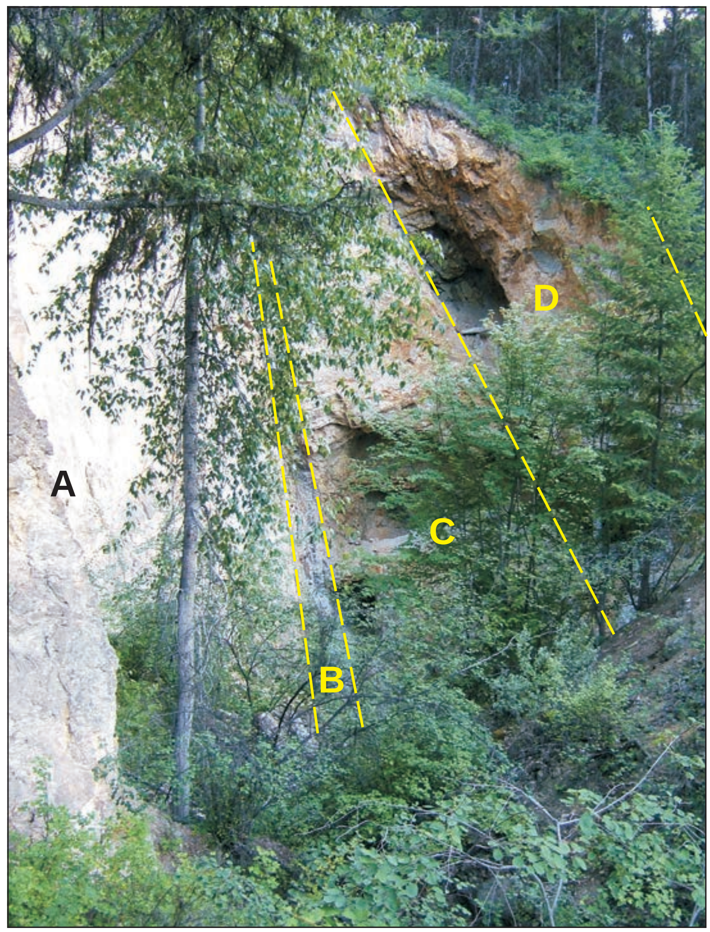

Figure 10. Different lithologies exposed in the open pit: A, fault plane or footwall; B, fault gouge (?); C, breccia unit (?); D, pyritized Bodie vein. View is to the south.

Figure 11. Ten-foot-deep cracks in the open pit hanging wall. Material is collapsing into the pit. View is to the south.

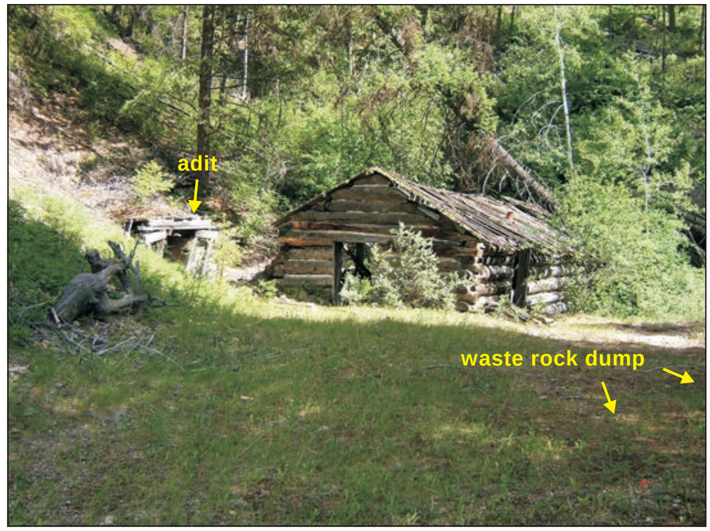

Figure 12. 400 level adit, waste rock dump, and shop. View is to the east.

MATERIALS AND STRUCTURES

The log structure on the 400-level dump is a maintenance shop (Fig. 12). It contains vestiges of a bit-sharpening forge a me circa-1930s drilling equipment. A frame building, probably an office or on-site residence, is located on a bench several hundred feet south of the mill footings. In the late 1930s, ore was transported via aerial tramway from the 400-level portal to the mill. The cables still span part of the distance, but the tail- and headworks are collapsed.

WATER

With the exception of a seep at the 700-level portal, which could not be sampled, none of the openings discharged water in August 2001 and June 2002. Toroda Creek flows through the property from south to north. DOE took samples ¼ mile upstream and downstream from the mill in order to bracket what, if any, effect the tailings have on water and stream sediment quality. Lead and zinc analyses increased by a factor of 5 from upstream to downstream sample sites. However, "...all other metals decreased in concentration in the downstream direction. At the concentrations detected, all metals meet state water quality standards. Metal concentrations do not exceed any of the sediment quality guidelines" (Raforth and others, 2000).

We collected a sample of benthic macroinvertebrates at a point where Toroda Creek cuts through the west margin of the tailings. This sample was "rich in species, containing the only caddisflies, only stoneflies, and the only pyralid moth in addition to numerous mayflies found across all the BMI samples [from six other eastern Washington mine sites]. In a water quality context, the Toroda Creek site had a species composition indicative of good water quality." (M. Hays, DNR biologist, written commun., 2002). In general, the Bodie mine and mill appear to have had a negligible effect on water and stream sediment quality (see Table 7).

MILLING OPERATIONS

The mill site is marked by the presence of crusher and ball mill foundations, but the mill burned in 1962 (Fig. 13). A photo taken in 1936 by Chamberlain shows the Northern Gold mill site, tramway, and ore bin (Appendix F, Fig. F3). The original ore mined in the 1890s was sufficiently high-grade to be direct shipped to a smelter. In 1902, Bodie Mining Co. installed a ten-stamp 20 tpd mill using mercury amalgamation and cyanidation. Precious metal recovery was poor considering the relatively high assays of the run-of-mine ore, resulting in the property changing hands several times until operations stopped altogether in 1916 (DGER mine file).

By 1934, all the mill equipment except a steam boiler had been removed. At this time, Northern Gold acquired the property and updated crushing and grinding equipment, added Wilfley shaking tables, and increased the capacity to 70 tpd. Free gold was recovered from mercury amalgam in a retort; the table concentrate was dried and sent to the smelter. The table tailings were passed over corduroy riffles, retorted, and recovered as dross. Material passed through the riffles went into the tailings pile. The company's first attempt with a flotation circuit was abandoned after only 6 months of operation in 1935 (Chamberlain, 1936). Moen (1980) reported that the mill was expanded to 125 tpd in 1938, with improved cyanidation treatment and a more successful flotation circuit. It is unlikely that active mining or milling operations were carried out after issuance of government order L-208, which closed industries, such as gold mining, that were not considered essential to World War II production.

The finely disseminated nature of the mineralization described by Chamberlain (1936) has complicated gold recovery in the past, leading investigators to agree that the ore must be ground to pass at least 150-mesh (0.004-inch opening) for acceptable liberation. Milling experiments conducted by Cham-

Figure 13. Mill site footing and tram cable to the 400-level adit. View is to the east.

Figure 14. Cut bank on Toroda Creek. Light brown tailings (between arrows) overlie the original land surface. Flow is right to left. View is to the south.

berlain (1936) and corroborated by Moen (1980), indicate that cyanidation alone may yield gold recovery in excess of 90 percent and silver recovery in the 70 to 87 percent range with optimization of key variables. In Chamberlain's study, flotation and cyanidation both yielded gold recoveries in excess of 90 percent; amalgamation approximately 40 percent. These results indicate that the Bodie ore contains gold-bearing sulfides or selenides in addition to free gold and possible electrum.

The tailings are exposed for 1500 feet along a cut bank on the east margin of Toroda Creek. They cover an area of 6.5 acres, 4 feet thick on the margins and about 8 feet thick closer to the mill site. Cottonwood trees up to 20 inches in diameter and a thick stand of grass have established on the surface (Fig. 14). The total volume is in the range of 30,000 to 40,000 cubic yards at a density of 1.65 tons per cubic yard.

Two grab samples of tailings material were taken. The first was from one foot below the surface and consisted of fine particle size representative of flotation practices. It was analyzed for arsenic, cadmium, copper, lead, and zinc. All analytes met the state standards for unrestricted and industrial/commercial land use for cadmium, copper, lead, and zinc listed in WAC 173-340-900, the Model Toxics Control Act (MTCA), except arsenic, which exceeded these standards by a factor of three (see Tables 3 and 4). Huchton (1997) reported similar arsenic content. A second sample was taken close to the mill site, 4 feet below the surface in coarser material more representative of the circa-1902 milling practices. No free cyanide was detected in this sample, and the mercury content was 1.9 mg/kg, well below the MTCA standard of 9.0 mg/kg.

Moen (1980) reported that a large scale sampling program conducted on the tailings in 1975 indicated a residual gold content of 0.031 opt and silver content of 0.158 opt. A comprehensive mineral identification study of the Bodie ore would be an invaluable precursor to any future evaluation of gold and silver recovery from the deposit.

WASTE ROCK DUMPS

Chamberlain (1936) reported that run-of-mine material from the Bodie vein was hand-sorted at the 400-level dump, then transferred via aerial tramway to the mill. Therefore the 400-level waste rock dump is composed of discarded vein material and andesite breccia developed as a result of driving the adit. The other dumps consist of breccia and fine-grained volcanic rock. The largest dumps of approximately 1500 tons are in front of the 300 and 400 levels. Huchton (1997) took a composite sample from all the waste rock dumps. Levels of antimony, arsenic, and selenium exceeded MTCA standards (see Tables 3 and 4).

GENERAL INFORMATION

Name: Bodie

MAS/MILS sequence number: 0530470766

Access: two-wheel drive

Status of mining activity: none

Claim status: Patented claims are: Bodie, Bodie No. 2, Little George, Crystal Bluff, and West Cliff; patented under mineral survey, M.S. 721

Current ownership: Geo-Mineral Exploration, Inc., Seattle, Wash., c/o Fritz Hanson

Surrounding land status: Bureau of Land Management, Washington State Department of Natural Resources, and private holdings

Location and map information: see Table 1

Directions: From the settlement of Wauconda on State Route 20, proceed approximately 12 miles north on the Toroda Creek Road. The Bodie bunkhouse and the log cabins of the camp lie on the highway. The mine and tailings are situated on the east bank of Toroda Creek.

Table 1. Location and map information.

Mine property	County	Location	Decimal latitude	Decimal longitude	1:24,000 quad.	1:100,000 quad.
Bodie	Okanogan	SW¼ sec. 34, T39N R31E; parts of Bodie No. 2 extend into NE¼NW¼ sec. 3, T38N R31E	48.830569	118.89055	Bodie	Republic

MINE OPERATIONS DATA

Type of mine: underground

Commodities mined: gold, minor silver

Geologic setting: A chalcedonic quartz vein, or veins, containing narrow ribbons of andesitic/dacitic wall rock strikes north to northeasterly at steep angles and transects massive volcanic breccias in the Eocene Klondike Mountain Formation.

Ore minerals: gold, pyrite; possible pyrrhotite and electrum

Non-ore minerals: quartz, calcite

Host rock: andesite breccia

Period of production: 1902–1916, 1934–1941

Development: ~10,000 feet total development (DGER mine file)

Production: 50,000 to 70,000 tons valued at approximately $410,000 at historic metal prices

Mill data: gravity separation, mercury amalgamation, cyanidation, and flotation; mill destroyed in 1962

PHYSICAL ATTRIBUTES

Features: see Table 2

Materials: none

Machinery: aerial tram cables

Structures: bunkhouse, cabins, superintendent's house, shop at the 400-level adit

Waste rock dumps, tailings impoundments, highwalls, or pit walls: six waste rock dumps, tailings of 30,000 to 40,000 cubic yards volume, 75 to 100 foot highwall at open pit, 40-foot-deep glory hole

Analysis of waste rock dumps: see Tables 3 and 4

Waste rock, tailings, or dumps in excess of 500 cubic yards: seven

Analysis of tailings and dumps: see Tables 3 and 4

Table 2. Mine features. – – –, no data; N/A, not applicable; *, data from Moen (1980); **, data from Chamberlain (1936).

Description	Condition	Total length (feet)	Distance to vein (feet)	Width (feet)	Height/ depth (feet)	True bearing	Elev. (feet)	Decimal latitude	Decimal longitude
tailings	cottonwood grove and grasses	1500	N/A	150	3–8	N/A	2600	48.83200	118.89624
mill (site)	foundations	N/A	N/A	N/A	N/A	N/A	2620	48.83206	118.89433
700-level portal	open	750*	0	5	7	E	2620	48.83122	118.89533
400-level portal	open	540**	350**	5	7	N80°E	2800	48.83108	118.89349
300-level portal	12 x 6-inch opening above sloughing	240**	160**	5	7	E	2950	48.83078	118.89234
250-level portal	did not find	100**	100**	– – –	– – –	– – –	~2990*	– – –	– – –
200-level portal no. 1	36 x 18-inch opening; hinged door inside portal	40**	40**	5	7	E	3010	48.83083	118.89175
200-level portal no. 2	36 x 30-inch opening; hinged door inside portal	20**	20**	5	7	E	3010	48.83107	118.89188
100 level and discontinuous open stopes	open	750	0**	5–20	40	N15°E	3160–3200	48.83183–48.83036	118.89086–118.89166
glory hole	open; fence wire around perimeter on ground; vertical walls	N/A	~250	40	40	N/A	3080	48.83170	118.89173
open pit floor	hanging wall collapsing; footwall vertical	150	0	50	75–100	N15°E	3125	48.83036	118.89166

Table 3. Soil Analysis. Metal concentrations are mg/kg; ≤, indicates metal was not detected; the number following is the practical quantitation limit above which results are accurate for the particular analysis method—the metal could be present in any concentration up to that limit and not be detected. – – –, no data; *, from Huchton (1997). Analyses in bold indicate levels which exceed one or more standard shown in Table 4.

Sample location	Antimony	Arsenic III	Cadmium	Copper	Cyanide	Lead	Mercury	Selenium	Zinc
fine tailings on flat; 12 inches below surface	– – –	**60.6**	1.13	15.9	– – –	7.7	– – –	– – –	130
coarse tailings on flat; 48 inches below surface	– – –	– – –	– – –	– – –	– – –	– – –	1.9	– – –	– – –
waste rock dumps*	**83.4**	**38.9**	– – –	77.8	– – –	14.0	7.1	**0.9**	76.7
tailings*	– – –	**44.8**	– – –	11.5	– – –	26.5	1.17	≤1.79	249

Table 4. Soil quality standards for unrestricted land use. WAC 173-340-900, Model Toxics Control Act, Table 749-2: Priority contaminants of ecological concern for sites that qualify for the simplified terrestrial ecological evaluation procedure (partial data). Concentrations are in mg/kgd.

Metals	Antimony	Arsenic III	Cadmium	Copper	Cyanide	Lead	Mercury	Selenium	Zinc	Gold
unrestricted land use	32	20	25	100	no std.	220	9 (inorganic)	0.8	270	no std.
industrial or commercial use	32	20	36	550	no std.	220	9 (inorganic)	0.8	570	no std.

Reclamation activity: none

VEGETATION

A thick stand of cottonwood trees and grasses cover the tailings. The mine area supports sparse fir and larch to 12 inches in diameter and inland shrubs and weeds.

WILDLIFE

Black bear (*Ursus americanus*) tracks and scat noted. See Table 5 for bat habitat information.

WATER QUALITY

Surface waters observed: Toroda Creek
Proximity to surface waters: 0 feet
Domestic use: grazing
Acid mine drainage or staining: none
Water field data: see Tables 6 and 7
Surface water migration: none

ACKNOWLEDGMENTS

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Table 5. Bat habitat information. N/A, not applicable.

Opening	Aspect	Air temp. (°F) at portal	Air flow: exhaust	Air flow: intake	Multiple interconnected openings	Bats or bat evidence observed
700-level adit	west	65	no	no	no	no
400-level adit	west	39	yes	N/A	yes	no
300-level adit	west	39	yes	N/A	yes	no
200-level adit	west	40	yes	N/A	yes	no
open stopes	NE–SW	60	no	faint	yes	no

Table 6. Surface water field data (Raforth and others, 2000).

Description	Flow (gpm)	Conductivity (μS/cm)	pH	Hardness	Temp. (°F)
Toroda Creek high flow, upstream from mine	19,740	313	7.84	142	51
Toroda creek high flow, downstream from mine	18,400	318	7.95	138	51
Toroda Creek low flow, upstream from mine	2468	393	7.88	184	42
Toroda Creek low flow, downstream from mine	2782	392	8.00	182	44

Table 7. Surface water analysis. Metal concentrations are in micrograms/liter (μg/L); hardness is in milligrams/liter (mg/L); ≤, analyte was not detected, but may be present at any level up to the figure shown; USEPA, U.S. Environmental Protection Agency; – – –, no data; **, standards for these metals are hardness dependent. Standards calculated for hardness values specific to Part 1 below are shown in Appendix B. Data below from Raforth and others (2000).

PART 1: ANALYSIS BY USEPA METHOD 6020, INDUCTIVELY COUPLED PLASMA/MASS SPECTROMETRY

Sample location	Arsenic	Cadmium**	Copper**	Iron	Lead**	Mercury	Zinc**	Hardness
Toroda Creek high flow, upstream from mine	≤1.5	0.026	1.2	181	0.029	0.0026	0.97	142
Toroda creek high flow, downstream from mine	2.0	0.022	1.1	71	0.077	≤0.002	5.7	138
Toroda Creek low flow, upstream from mine	1.2	≤0.02	0.79	– – –	0.14	0.0027	0.59	184
Toroda Creek low flow, downstream from mine	1.2	≤0.02	0.82	– – –	≤0.02	≤0.002	3.2	182

PART 2: APPLICABLE WASHINGTON STATE WATER QUALITY STANDARDS

Type of standards (applicable Washington Administrative Code)	Arsenic	Cadmium	Copper	Iron	Lead	Mercury	Zinc	Hardness
Surface water standards (WAC 173-201A, Standard for aquatic life in surface freshwater, chronic level maximums at 100 mg/L hardness)	190	**	**	none	**	0.012	**	100
Ground water standards (WAC 246-290, Washington State Department of Health, standards for ground water, domestic consumption)	50.0	none	1300	300 (cosmetic only)	15	2.0	5000	– – –

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Appendix A. Methods and field equipment

METHODS

We recorded observations and measurements in the field. Longitude and latitude were recorded with a global positioning system (GPS) unit in NAD83 decimal degree format. Literature research provided data on underground development, which was verified in the field when possible.

Soil samples from dumps or tailings were taken from subsurface material, screened to minus 12 mesh, and double bagged in polyethylene. Chain of custody was maintained.

Soil and water samples were analyzed for the metals listed in this report by inductively coupled plasma/mass spectrometry (ICP/MS) following USEPA (U.S. Environmental Protection Agency) Method 6010. Holding times for the metals of interest were observed. Mercury analysis is per EPA 7471A. Total cyanide analysis is per EPA 9012A.

Instrument calibration was performed before each analytical run and checked by standards and blanks. Matrix spike and matrix spike duplicates were performed with each set.

FIELD EQUIPMENT

barometric altimeter
binoculars
digital camera
flashlight
Garmin GPS 5, handheld GPS unit
Hanna Instruments DiST WP-3 digital conductivity meter and calibration solution
litmus paper, range 0–14, and 4–7
Oakton digital pH meter
Oakton digital electrical conductivity meter
Taylor model 9841 digital thermometer

Appendix B. Water quality standards for hardness dependent metals

Conversion formulae are given in WAC 173-201A at
http://www.ecy.wa.gov/pubs/wac173201a.pdf.
Chronic standard in micrograms/liter (μg/L)

Sample location	Hardness (mg/L)	Cd (μg/L)	Cu (μg/L)	Pb (μg/L)	Zn (μg/L)
Toroda Creek high flow	140	1.32	15.13	3.62	138.98
Toroda Creek low flow	183	1.61	19.02	4.82	174.39

Appendix C. Bodie mine ownership

Company	Period of activity	Registered in Washington?	Date registered with Sec. of State	Date stricken or dissolved	Comment	Place of business
Bodie Mining Co., Inc.*	1902–1907	yes	April 1898	Aug. 1909	– – –	Spokane
B. and J. Mining Co.*	1907–1909	no	– – –	– – –	– – –	– – –
Duluth-Toroda Mining Co., Inc.*	1910–1916	yes	July 1900	Aug. 1912	– – –	Chesaw
Cary Mining and Development Co.*	1916–1922	no	– – –	– – –	– – –	– – –
Blue Stem Mining Co.*	1922–1926	no	– – –	– – –	– – –	– – –
Northern Gold Co., Inc.	1930–1944	yes	July 1934	July 1945	fees paid 1935–1942	Spokane
Geo-Mineral Exploration, Inc.	1970–present	yes	July 1970	July 1982	last year registered, 1980; UBI: D-206557	Seattle

* Huntting (1956)

Appendix D. Gold and silver assays from the Bodie vein at various locations

Location	Date	Sample Type	Source	Au (opt)	Ag (opt)
100 level to surface	1902–1916	production average	Moen (1980)	1.0+	0.73
100 to 200 level	1902–1916	production average	Moen (1980)	0.4	– – –
200 to 250 level	1902–1916	production average	Moen (1980)	0.75	0.60
250 to 300 level	1902–1916	production average	Moen (1980)	0.13	0.09
winze 96 feet below 400 level	1924	channel	Moore (1924)	0.25	– – –
Bodie no. 4 claim tunnel	unknown	3-foot channel	Allen (1974)	0.36	– – –
Toroda no. 1 claim, "Perkins tunnel"	1934	25-foot channel	Moore (1934)	0.30	– – –
Toroda no. 2 claim (1040 feet south of open pit)	1934	8-foot channel from 40-foot incline	Moore (1934)	0.95	– – –
Toroda no. 2 claim, vein material in dump	1934	grab	Moore (1934)	0.5	– – –
Toroda no. 3 claim	1934	2.5-foot channel from open cut	Moore (1934)	0.32	– – –

Appendix E. Gold and silver assays from the Bodie breccia at various locations

Location	Date	Sample type	Source	Au (opt)	Ag (opt)
200-level crosscut wall rock	1938	40-foot channel	DGER mine file (Anaconda Mining Co.)	0.17	– – –
400-level crosscut wall rock	1973	50-foot chip from south wall	DGER mine file (E. A. Magill)	0.02	0.18
400-level crosscut wall rock	1973	200-foot chip from south wall	DGER mine file (E. A. Magill)	0.015	0.23
~1600 feet north of mine workings to 2400 feet south, along east–west cutlines	1979	37 of 107 chip samples	DGER mine file (McClaren, 1980)	0.041	0.089
mine workings to 7500 feet south	1981	273 soil samples	DGER mine file (Noranda Exploration, Inc.)	trace–0.168	trace–1.56
"top of mine ridge"	1935	30-foot channel	DGER mine file (Sunshine Mining Co.)	0.20	

Appendix F. Historic information

Figure F1. Some cabins and a former bunkhouse located on the Little George claim are all that remain of the Bodie camp and settlement, which is on the register of the Okanogan Historical Society (note marker). View is to the south.

Figure F2. Former bunkhouse. View is to the south.

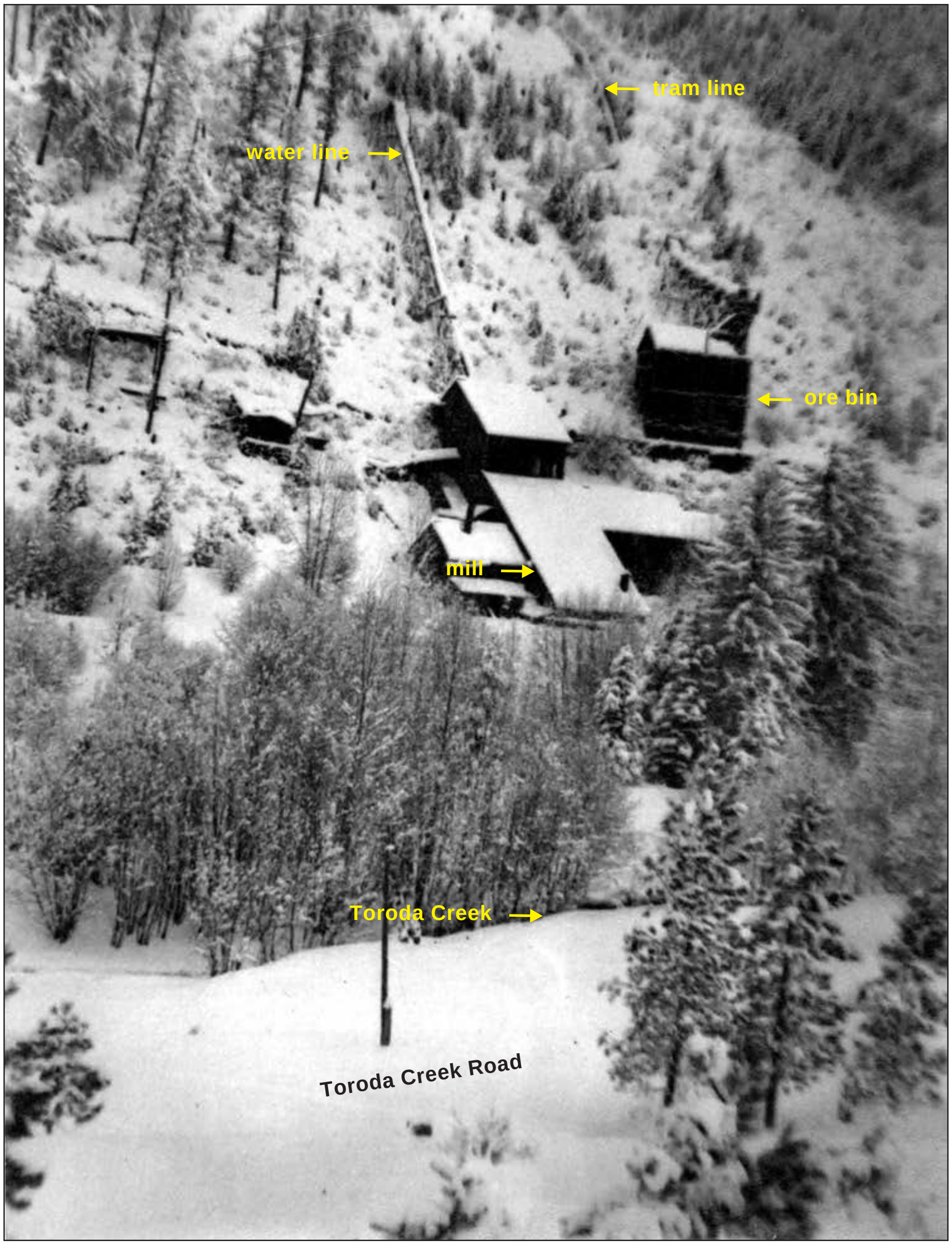

Figure F3. Mine site circa-1936 (after Chamberlain, 1936). View is to the east.

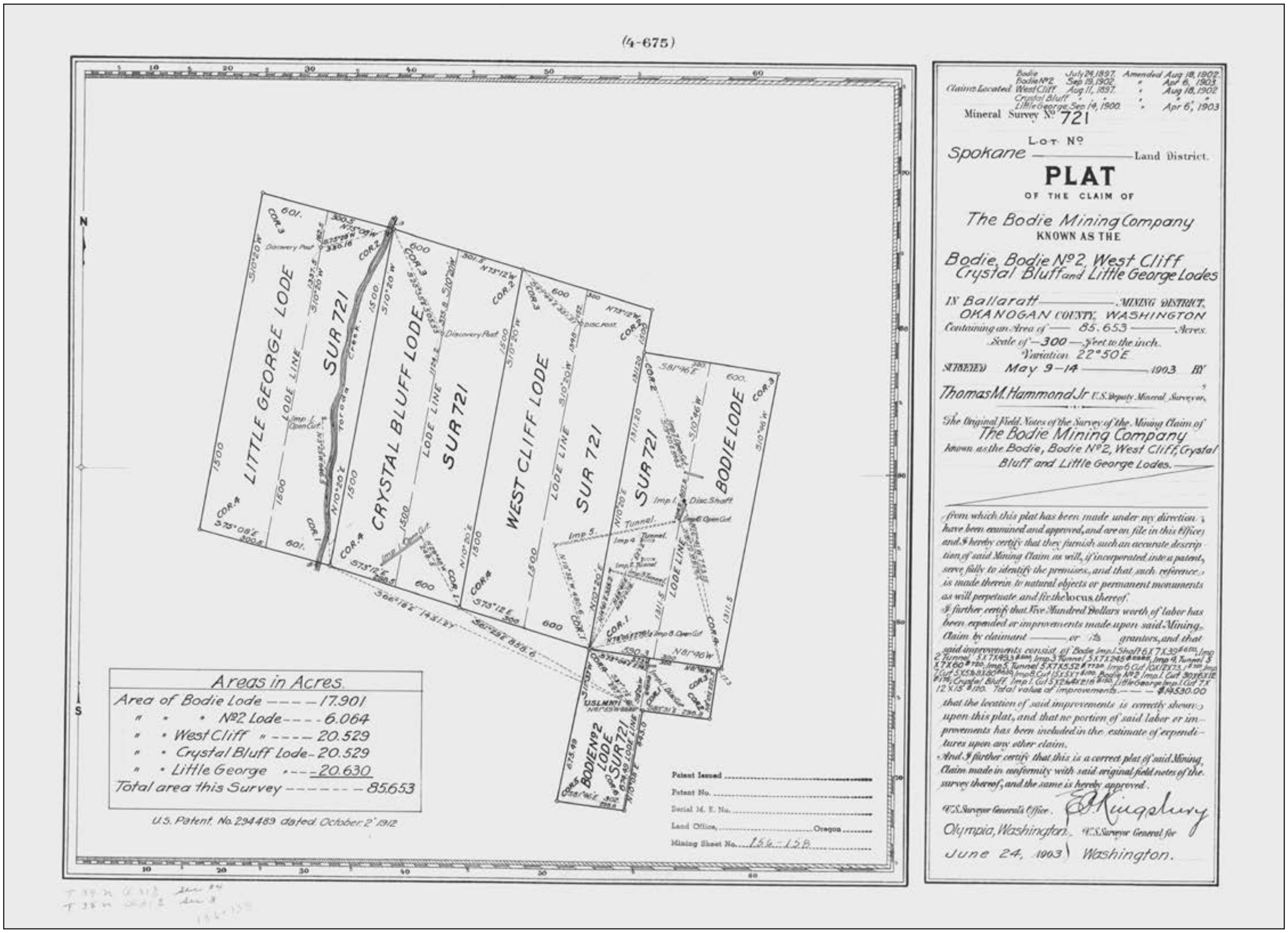

Figure F4. Bodie patented claim(s) survey, M.S. 721.