NATURAL RESOURCES

INACTIVE AND ABANDONED MINE LANDS—GERMANIA MINE, CEDAR CANYON MINING DISTRICT, STEVENS COUNTY, WASHINGTON

by Fritz E. Wolff,
Bryan T. Garcia,
Donald T. McKay,
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WASHINGTON
DIVISION OF GEOLOGY
AND EARTH RESOURCES

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INTRODUCTION

The Washington State Department of Natural Resources (WADNR), 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). The work has been funded in the past by interagency grants from the U.S. Forest Service (USFS), Region 6, and is currently funded by WADNR. The project results are shared with the U.S. Bureau of Land Management (BLM), the U.S. Environmental Protection Agency (EPA), and the Washington Department of Ecology (WADOE).

More than 3,800 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 2,000 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 re-open 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. These reports state what we believe to be the known facts at the time of publication. Changes brought about by future events should be taken into account by the reader.

IAML reports are available online through our Publications List at http://www.dnr.wa.gov/Publications/ger_publications_list.pdf. Look under Information Circulars (2005–present) and Open File Reports (2001–2004).

SUMMARY

The Germania Mine is located in the SW¼ sec. 13 and NE¼ sec. 23, T29N R37E, about 9 miles southeast of Fruitland in Stevens County, in the Cedar Canyon Mining District (Fig. 1). The total documented output from the Germania Mine is 88,350 tons of tungsten ore and 723 tons of tungsten trioxide (WO_3) concentrate, representing 70 percent of the state's output through date of publication. Tungsten's unique properties have classified it as a strategic material for manufacturing, and stockpiles have been maintained at various times by the U.S. Department of the Interior (*see* Appendix D). The mine was one of, if not the largest, single producer of tungsten in the U.S. during the ten-year period preceding World War I (WWI), and again between 1930 and 1935. We estimate the dollar value of the mine's production (at metal prices at the time mining took place) to be in the range of $1.0 to $1.5 million. The last year of active mining on the property was 1956.

The first claims on the Germania vein system in 1894 were staked for their gold content, which is not reported in any of the sources cited below. Wolframite mineralization was viewed as a form of tin at that time. Around 1900, however, there was new interest in the deposit as knowledge of tungsten's use in tool steels and arms manufacture began to spread. German nationals initiated the first serious mining operation in 1904 and shipped concentrate to the

Krupp AG steel works in Essen, Germany, up until the outbreak of WWI. An administrator authorized by Congress, known as the Alien Property Custodian, seized the property in 1917, but taxes went unpaid and the mine lay idle until 1930. Tungsten Producers, Inc., built a new mill and developed more than 6,000 feet of drifts and stopes in a generally successful operation. The Incandescent Lamp Division of General Electric Co., Inc., purchased the mine in 1936 and continued operations until 1941. During a search for strategic minerals between 1951 and 1952, sponsored by the Defense Minerals Exploration Administration (DMEA), Tungsten Mining and Milling Co., Inc., rehabilitated the 400 level and partly explored an extension of the main or Exodus vein northeast of the mine. Funds for this work were expended before the program's objectives could be met and the work was abandoned. Penticton Tungsten Ltd. acquired rights to the property in 1955 with the intent of reclaiming a stockpile of vein talus previously brought to the millsite. The discovery of uranium on the Spokane Indian Reservation cut the effort short, and Penticton merged with Tungsten Uranium Mines, Inc. Uranium mineralization found in the Germania vein proved uneconomic at 0.05 percent (U_3O_8) and the program was abandoned. This is the last known activity at the mine.

All production at the Germania Mine came from the Exodus vein, which is the westernmost of nine subparallel, steeply dipping quartz veins that crop out in a band approximately 3,600 feet wide and 2 miles long. The veins fill joint fissures in a late-Cretaceous quartz monzonite stock and strike N20–40E (Fig. C1). The Exodus vein is traceable intermittently southwest to northeast along strike for a distance of about 9,000 feet; the segment mined at the Germania is about 2,000 feet long. Wolframite $(Fe,Mn)WO_4$ is the primary tungsten mineral in addition to secondary scheelite ($CaWO_4$). The tungsten minerals occur as clusters in a quartz vein that pinches and swells from 1 or 2 inches to 24 inches in width. Pyrite is the most abundant sulfide, followed by chalcopyrite and galenobismutite. Soil samples indicate the presence of arsenopyrite and sphalerite. Two bismuth molybdates previously unreported in Washington, koechlinite and kamiokite, were identified during DGER site characterization. A random sample of wolframite-bearing vein material confirmed the presence of gold in the deposit. Autunite, a complex uranyl phosphate, is present in small quantities. The principal gangue mineral is quartz, which contains fluorite and tourmaline in addition to the ore minerals. On the deepest level, some 500 feet below the surface, the vein walls become less distinct and molybdenite supersedes wolframite as the major ore mineral.

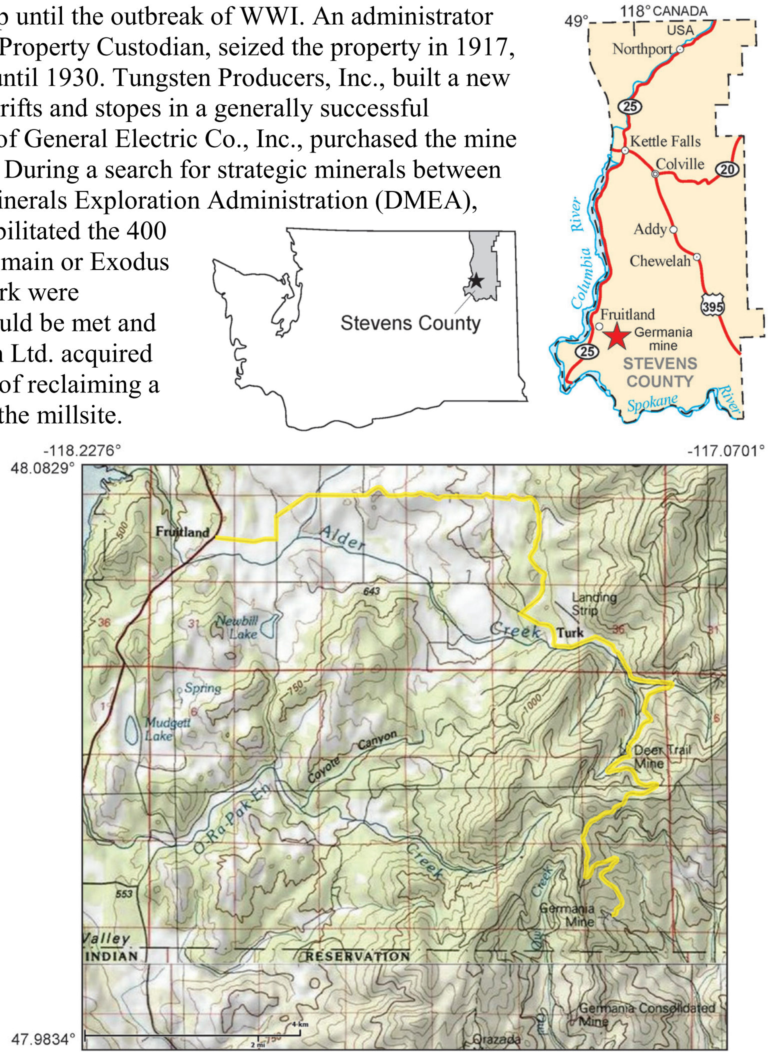

Figure 1. Topographic map of the Germania Mine area and maps showing its location within Washington State (upper left) and Stevens County (upper right). Yellow highlight shows route to the mine.

The mine was developed by three southwest-trending adits on the ridgeline above the mill, as well as two sublevels. The 400 level served as the main haulageway; its final length was 2,000 feet from the portal and it daylights just above the mill [ruins]. There is only one stope, dipping 85 degrees to vertical. It is 1,700 feet long and open to the surface from the top of the ridge to the mill site, a slope distance of about 1,600 feet (Figs. C3 and C4), and there is also some visible downdip caving. The original 100-level and 200-level adits appear to have been excised by the stoping. The stope should be considered an extreme hazard. Total development in drifts and raises is approximately 7,400 feet.

Fire destroyed the first 40-ton-per-day (tpd) gravity mill at Germania in 1914, prior to the start of WWI. The second mill, of 100-tpd capacity, was built in 1931 and was operable as late as 1955. The milling equipment has been removed and the structure is collapsed. The tailings, estimated at 90,000 to 100,000 tons, were dumped in chaotic piles in the Sand Creek drainage east of the mill. Arsenic and selenium levels in a grab sample taken by DGER and shown in Table 3 exceed standards shown in Table 4 for unrestricted and industrial or commercial use (WAC 173-340-900, Model Toxics Control Act). Minor amounts of copper, lead, zinc, and silver are present. Douglas fir with trunks less than 8 inches in diameter cover most of the pile.

The 400-level adit discharges mine water at about 2 gallons per minute (gpm); it infiltrates the tailings crest in the Sand Creek ravine east of the mill by sheet flow. Water emerges from the tailings toe at 5 gpm. Table 7 shows that chemical analyses for metals at both locations meet the applicable standards shown for Ground Water (WAC 246-290) and Surface Water (WAC 173-201A). The discharge is neutral (pH 7.4). With the exception of a slight increase in copper content, metal concentrations and hardness decreased at the lower location.

Although the People's Republic of China has supplied approximately 80 percent of world demand for tungsten since 1985, this figure appears to be dropping due to increasing internal manufacturing demand. If this trend continues, it raises the possibility of a resurgence in the North American supply from deposits in Canada and the U.S. that have been shut down since 1994. The remote location of the Germania Mine is a detriment to potential future development, but the extension of the Exodus vein to the northeast contains tungsten mineralization and has been only minimally explored, as have the other subparallel veins in the area. In addition, comprehensive sampling of the waste rock dump, tailings, and vein talus stockpile, estimated in total to exceed 200,000 tons, may indicate economically recoverable tungsten and gold values.

ACCESS

Before attempting to access the Germania Mine site, contact the Spokane office of the Bureau of Land Management (BLM) for permission to enter agency land through the locked gate described below. From Fruitland (Fig. 1), follow the Valley Road east approximately 8 miles to the abandoned settlement of Turk. Continue uphill along the Cedar Canyon Road. At 1 mile, the Deer Trail Mine appears on the righthand side. Continue on switchbacks, arriving at a four-way crossroads on the ridge crest in the center of sec. 12, T29N R37E. Take the southwest-bearing road from this point until meeting a locked gate in a few hundred yards. After the gate, continue south 2.4 miles and turn left at a sharp hairpin turn leading north and east to find the Germania site in 1 mile. Four-wheel drive capability is required. The route is shown on the USGS Adams Mountain 7.5-minute quadrangle.

OWNERSHIP

With the exception of one privately owned 20-acre parcel covering part of the tailings and former mine camp, all the lands formerly claimed or owned in fee simple as part of the Germania Mine are administered by the BLM (Fig. C2).

HISTORY

The Germania Mine is sometimes confused with the Germania Consolidated Mine (Fig. 1), given that they appear to be on the same vein with identical mineralization, and both properties had mills. They have, however, always been separate operations. The latter property is located on tribal land about 1 mile south of the Germania. Almost all production from the Germania Mine took place during two periods: 1906 to 1913 and 1931 to 1941. The last operation of any kind took place circa-1955-56 in an effort to rework the mill tailings; this attempt was cut short by an influx of offshore concentrates that caused the price to plummet from $63 to $12 per statute ton unit (stu)(equal to 20 pounds).

Very little is known about the property in the decade following its location as a gold-bearing quartz vein in 1894 by J. S. McLean, a local rancher. About 1900, the unique properties of tungsten as an alloying element in the manufacture of armaments and tool-steels became generally known, and demand skyrocketed in this country and Europe.

Canadian interests formed the Roselle Mining Co., Inc., in 1904 and began developing the mine based on its tungsten content. Roselle shipped 1,647 tons of hand-sorted wolframite ore to the Krupp AG steel works in Essen, Germany. This material captured the interest of German capitalists who apparently financed the activities of a German citizen, Wilhelm Scheck, living in Spokane. Scheck located three claims surrounding the Roselle property and was appointed general manager of the Germania Mining Co., Inc., which registered as a corporation with the State in 1907. Germania Mining contested Roselle's ownership and after several years of litigation, emerged with title to the property and built a 24-tpd gravity concentration mill in the fall of 1909. Germania Mining merged into another entity in 1912—American Tungsten Consolidated, Inc.—with the same board of directors and head offices

Figure 2. Stockpiles of cobble-sized vein talus at the mill level. The tailings repository in Sand Creek draw is hidden by forest at the top of the photo. View is to the east.

in New York, although the Minerals Yearbook for the years 1910 through 1914 collected no production figures for the mine, Weaver (1920) stated that the total output, including the Roselle operation, was approximately 5,000 tons of ore from which 140 tons of 64 percent tungstic oxide concentrate had been recovered and shipped to Essen. A few months prior to Germany's entry into WWI in July 1914, the mill was burned and the adits blasted shut by Scheck or his procurists (DGER mine file).

Congress created a position called the Alien Property Custodian as part of the 'Trading with the Enemy Act' in 1915. The custodian formally seized the property in 1917, but neglected to pay real estate taxes on the patented claims. Stevens County sold it at a sheriff's sale in 1921 for $250 to McLean and a group of former employees (Bunning, 1985).

In 1931, J. A. Scollard formed Tungsten Producers, Inc., and initiated a period of profitable systematic operations. The company constructed a new mill of 50-tpd capacity and invested in raises and chutes that greatly facilitated stope production. The Minerals Yearbook (1935) reported "Tungsten Producers made the largest shipment ever recorded from the mine [162 tons of concentrate], and the '600' level was started by sinking a 150 ft. winze from the main haulage way." At this time, the Germania Mine was the largest single producer of tungsten concentrate in the U.S. In total, Tungsten Producers mined 26,155 tons of ore and shipped 374 tons of concentrate averaging 70 percent WO_3. Sulfides of copper and lead from the run of mine ore were discarded in the tailings (Anderson and Puffett, 1954).

In October 1936, the Incandescent Lamp Division of General Electric Co., Inc. (GE), purchased the property for $300,000. GE expanded the mill capacity to 100 tpd over the next five years and mined 57,200 tons of ore averaging 0.4 percent WO_3; additionally 32,900 tons of tailings from previous operations that averaged 0.13 percent WO_3 were reworked. A large tonnage of outcrop talus, estimated at 100,000 tons by Hollister (1952), was moved by scrapers and dozers down to the mill level as shown in Figure 2. Not all of this material was recovered, but the 11,500 tons that were treated by the mill averaged about 1 pound per ton WO_3 or 0.05 percent (Page, 1941). GE closed the operation in October 1941 and sold the lands and the mill equipment to a Spokane real estate broker in 1943.

Tungsten Mining and Milling Co., Inc., of Spokane acquired the property in 1947 and qualified for a $50,000 Reconstruction Finance Corporation (RFC) loan in 1951, followed by a Defense Minerals Exploration Administration (DMEA) loan of $34,000 in 1952. The funds were to be used for exploring the commercial possibilities of the Exodus vein, which continues in the slope northeast of the 400-level adit; for rehabilitating the mill for processing approximately '120,000 tons of tailings'; and for rehabilitating as much of the 400 level as possible to sample vein material left in place by previous operators (Anderson and Puffett, 1954).

Work under the terms of the loans began in February 1952 and was terminated September 15, 1953, by mutual agreement between the government and the operator. During that period, 1,850 feet of the 400 level was rehabilitated. "Three separate veins spaced at intervals of nearly 130 feet in an east-west direction and trending along a general strike of N20-25E were exposed by trenching under the DMEA contract. The widest vein exposed for a length of 40 feet averaged nearly 13 inches wide in a trench at an altitude of 3,760 feet, some 1,200 feet north of the 400 level portal. This vein appears to be the northward projection of the mine's Exodus vein. A 250-foot drift was driven along this exposure. . . . Promising quantities of wolframite were seen in nearly all the veins exposed by the trenches. The wolframite was concentrated in small bunches similar to occurrence of the wolframite in the vein in the mine. It is estimated that in some locations the veins contained up to 5% WO_3" (Anderson and Puffett, 1954). The approximate location of this exploration activity is shown in Table 2. Some mill equipment was restored, but funds from both loans had been depleted when the contract was terminated.

Penticton Tungsten Mining Co., Ltd., undertook the last activity at the mine between 1955 and 1956. By this time it had become apparent that a mineral concentrate clean enough to meet specifications for the Defense Minerals Administration (DMA) purchasing program (1950–1959) could not be obtained by simple gravity separation alone, due to the increasing molybdenum content in the ore. The company installed a flotation circuit and ran about 1,000 tons of talus material stockpiled by GE through the mill (*Mining Industrial News*, July 1954). It is not known if these concentrates were purchased under the DMEA program, but the effort was apparently uneconomic. The company changed its name and focus to Penticton Uranium-Tungsten Co., Ltd., in 1955 (Bunning, 1985). Although Huntting (1956) reported an "area of high radioactivity on the property", it appears that the company found no commercial quantities of uranium mineralization at the time. (See discussion of autunite below.)

Figure 3. Euhedral wolframite crystal in glassy vein quartz and granitic host rock.

The Germania vein as presently developed is considered mined out from the 400-level portal south to the Spokane Indian Reservation boundary. All former corporate entities operating specifically as mining companies were dissolved at certain intervals by the Secretary of State for non-payment of fees. The total documented production from the Germania Mine is 88,350 tons of ore (U.S. Minerals Yearbook, 1902–1941). In total, 723 tons (72,300 stu) of tungstic oxide concentrate were produced, including values from 32,900 tons of reworked tailings and 11,500 tons of vein talus. This figure represents 70 percent of the state's output through date of publication. It is more than likely that this figure represents only the material actually milled, and therefore is a reasonably close approximation of the amount of tailings remaining. However, the waste rock dump and the vein talus stockpiles are estimated to total well over 100,000 tons combined. Table 1 illustrates the apparent decreasing tungsten content of the vein with increasing depth.

Table 1. Mine production over time vs. WO_3 content. *, reported by Mineral Resources of the U.S. and U.S. Minerals Yearbook (U.S. Geological Survey/U.S. Bureau of Mines, 1902–1941); **, estimate by Weaver (1920).

Production period	Company	Tons mined	Percent WO_3
1904 to 1907	Roselle Mining Co., Inc.	1,647*	3.5
1910 to ~ 1913	Germania Mining Co., Inc./American Tungsten Consolidated, Inc.	3,350**	1.9
1931 to 1936	Tungsten Producers, Inc.	26,155*	1.0
1936 to 1941	General Electric Co., Inc.	57,202*	0.4

GEOLOGIC SETTING

A series of quartz veins striking N20-40E and dipping vertically or steeply to the southeast cut through the center of a quartz monzonitic stock (Fig. C1). The zone is about 3,600 feet wide and roughly parallels the elongation of the stock. It continues for at least a mile northeast of the Germania Mine. The Exodus vein is the westernmost of the group, consisting of about nine veins in all (Culver and Broughton, 1945). The stock intrudes a small roof pendant of Precambrian argillite about 0.5 mile southeast of the Germania Mine, obscuring most of the veins, which appear to continue beneath it. Minor post-ore faulting indicated on General Electric's mine map (DGER mine map file), seems to have had little effect on the overall trend of the veins. The host rock is a late-Cretaceous biotite-rich quartz monzonite intrusive occupying an area of 8 to 10 square miles (Howd, 1956).

Howd (1956) stated that the chief structural feature of the intrusive is a set of steeply dipping elongated joints striking northeasterly, roughly parallel to its long axis. The joint set and veins have essentially the same strike and dip, suggesting that the mineralization may have occurred along related stress fractures. Du (1979) made the following observations after a study of joints, quartz veins, and aplite dikes in the area: "Comparison of the three pole diagrams shows that the orientation of the dikes and quartz veins are closely related to jointing. The coincidence of the patterns . . . suggests that structural control of the hydrothermal ores is the repeated reopening of old joint fractures."

Figure 4. Typical surface expression of the stoped-out Exodus vein. The walls are 6 to 8 feet apart. View is S25W.

The tungsten mineralization precipitated in silica-rich hydrothermal solutions as a result of late-stage magmatic segregation and subsequent drops in temperature and pressure. The amount of erosion in the area is not great and for this reason it appears that the veins occur near the top, or cupola, of the intrusive (Culver and Broughton, 1945). The attributes of the Germania deposit are in close agreement with comments on tungsten-bearing vein deposits made by Hobbs and Elliott (1973): "Tungsten ore shoots in quartz veins range from small isolated pockets of scheelite or wolframite to nearly continuously mineralized vein material that may measure a thousand feet or more on strike and downdip. Such extensive deposits are the exception in the United States, however, and most individual shoots have a vertical range of less than 500 feet . . . . The average grade of all productive tungsten veins in this country is probably close to 1 percent." Recent geothermometric studies indicate that the crystallization temperature of the vein material at the mine falls in the range of 300° to 450°C and possibly higher: 300°C for glassy quartz, 400°C for milky quartz, and 450° to 700°C for tourmaline (Guilbert and Park, 2007). Post-mineral, steeply dipping normal faults crosscut the vein at a number of places, but the lateral displacements are on the order of 5 feet or less, with the northeast side generally down-dropped.

Of the 16 tungsten minerals known to exist, only four are of commercial importance, and three of these minerals form an isomorphous series with huebnerite ($MnWO_4$) as one end member and ferberite ($FeWO_4$) as the other. Wolframite [$(Fe,Mn)WO_4$] is approximately intermediate in composition. One or more of these minerals may occur at the Germania Mine—they all appear in the field as black, tabular, striated crystals similar to the wolframite crystal shown in Figure 3. In the early stages of mining, particularly on the upper level, wolframite was found in crystalline masses with little or no gangue material (Bancroft and Lindgren, 1914). Here the average grade was about 2.5 percent WO_3. Scheelite ($CaWO_4$) is common as a secondary mineral and occurs as thin veinlets in and around wolframite crystals. Scheelite at the Germania Mine fluoresces a brilliant blue color under ultraviolet light. Other minerals reported but not recovered in the milling process are galenobismutite ($PbBi_2S_4$), molybdenite, chalcopyrite, and arsenopyrite. Pyrite was a major constituent in ore above the 200 level and decreased with depth. Quartz is the predominant gangue mineral, followed by accessory fluorite, black tourmaline, and chlorite. The quartz occurs as two mappable phases: glassy translucent crystals and milky-white masses. A grab sample chosen at random from the vein talus, consisting of about equal parts wolframite, quartz, and wall rock, contained 220 ppm gold when analyzed by ICP/MS. This analysis is probably atypical, but confirms the presence of gold in the deposit; the metal's occurrence could be associated or in solid solution with the tungsten minerals.

Du (1979) reported that traces of autunite, a secondary uranium phosphate, occur as thin crystals along joint planes within the mine. Kamiokite ($Fe_3Mo_3O_8$) and koechlinite (Bi_3MoO_8), two minerals not previously found in Washington, were identified by scanning electron microscope (SEM) in the process of DGER site characterization (G. Mustoe, Western Wash. Univ., written commun., 2012)(Fig. D2).

Although the vein appears essentially frozen to the walls in most places, Howd's (1956) study indicated that hydrothermal alteration is present, but confined to within a few inches of the vein walls. In places, plagioclase has been completely argillized, and zones of sericitic alteration 2 to 3 inches thick were observed on the 200 level where they created a parting plane between the granite and the vein, leading to caving.

A former superintendent at the mine reported that tungsten mineralization begins to lens out below the 400 level and is increasingly replaced by molybdenite (MoS_2). As this occurs, both wolframite and molybdenite, formerly in the vein, become sparsely disseminated in the underlying granite (Purdy, 1954). In addition, Bunning (1985) suggested “. . . it is possible that the mined-out tungsten veins are the upper expression of a porphyry molybdenum system hidden at depth.” The extensive ore deposit at Climax, Colorado, is zoned in a similar manner, where a halo of tungsten mineralization overlies the primary stockwork molybdenum veining (Hobbs and Elliott, 1973). If the tungsten/molybdenum interface is indeed at about the level of the main haulageway, as it appears to be, exploration of the Exodus vein to the northeast at elevations above 3,500 feet should be considered for developing additional reserves.

Figure 5. Probable location of former 200 level with ~60 foot highwall above. Overall excavation is 100 feet long on strike. View to the west.

DEVELOPMENT

The four production levels total approximately 6,000 feet of lateral development, and more than 1,400 feet of raises and winzes were driven (Fig. C3). The Exodus vein crops out continuously along the ridgeline of a north-facing slope (Fig. C4).

By 1914, the 100 and 200 levels had been driven and the 400 level started. The 100 level was a prospect drift. The 200 level (Roselle) was 750 feet long and the Exodus vein was about 9 inches wide. The only appearance of a second vein occurs on this level 50 feet east of the main vein. It was followed for about 400 feet by a crosscut. The 400 level or main haulageway was extended by Tungsten Producers, Inc., in the early 1930s. It is 2,050 feet long; the initial 1,300 feet of the vein averaged 16 inches in width and assayed about 2 percent WO_3. Approximately 80 percent of the vein from the 400 level up through the 200 and 100 levels has been stoped. At the 1,300-foot point on the haulageway, the vein splits in two: the left hand or east branch of the drift continues for 150 feet and narrows to 3 inches, and the west branch continues 750 feet to the heading where it steadily decreases in width from 12 inches to about 2 inches (DGER mine map file). The lowest or 600 level does not daylight. It was developed by a winze from the 400 level, passing through a small stope and a short sublevel at 80 feet. The vein averaged about 6 inches in width and was 1,250 feet long. Culver and Broughton (1945) stated that about 800 feet had been stoped up to the 400 level.

DGER’s site characterization (2013) confirms the geomorphology shown on Anderson and Puffett’s 1954 map, in that the linear near-vertical stope is open to the surface from the top of the ridge at elevation 3,957 feet to the mill site, with vertical openings of 400 feet to 40 feet, depending on location along the ridgeline. Figures 4 and 5 are typical of the surface expression. It appears that the 100 and 200 levels no longer exist *per se*; that is, no feature resembling an adit can be seen. The location of the 200 level was probably as shown in Figure 5 because of the size of the excavation, mine rail, and an overgrown road leading into the site.

In the course of rehabilitating the 400 level, it was discovered that the sill had been removed during stoping from the level below. As a result, the drift traverses an opening 6 feet wide by 75 feet long, 80 feet above the next lower level. DGER considers the mine to be caved, in view of our field observations and Anderson and Puffett’s (1954) statement that at the time of their examination, “Except for a major portion of the main haulage level, . . . most of the workings were inaccessible.”

MATERIALS AND STRUCTURES

The mill and camp buildings are collapsed. The approximately 3,000-gallon water tank is demolished.

WATER

Two water samples were taken during site characterization: (1) The 400-level adit discharged about 2 gallons per minute (gpm). The pH was neutral to slightly basic (7.4) and electrical conductivity (EC) was 570 μS/cm. The discharge was clear and the bed appeared natural (Fig. 6). The flow crossed the access road above the mill and infiltrated the top of the tailings pile in a spring-fed ravine of a Sand Creek tributary. (2) Water emerged from the base of the tailings 100 feet in elevation below the 400-level adit at a rate of ~5 gpm, forming a year-round stream. The pH was 7.0 and the EC measured 380 μS/cm. The water was clear, and the bed was stained light orange-brown. Chemical analyses for metals at both locations met the applicable standards shown in Table 7 for Ground Water (WAC 246-290) and Surface Water (WAC 173-201A). Contrary to expectation, hardness level and metal concentrations decreased (with the exception of a slight increase in copper), after the water flowed through the tailings.

Figure 6. Caved 400 level portal at upper right showing water discharge. View is to the northwest.

MILLING OPERATIONS

In August 1914, the original mill of 40-tpd capacity was reported destroyed by arson and the 200-level portal blasted shut (*Northwest Mining*, July 1936). The second mill of 100-tpd capacity shown in Figure 7 is the structure most commonly associated with the Germania Mine. It was built by Tungsten Producers, Inc., in 1931 and expanded to 200-tpd capacity by General Electric in 1938. Power for the mill was supplied by 440-volt 75-Kw diesel or gasoline generators. The mill building has collapsed (Fig. 8).

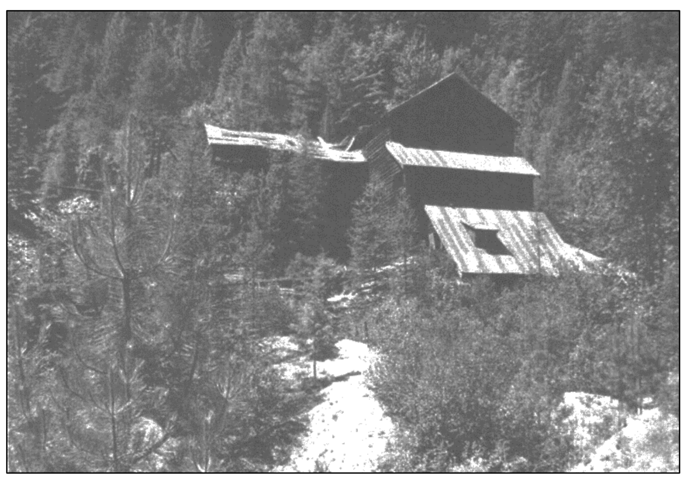

Figure 7. Germania mill circa 1985 (from Bunning, 1985). View is to the north.

WASTE ROCK DUMP AND TAILINGS

In all probability, the mining method used would have been underhand stoping in slusher drifts: the minimum stope width would have been at least 3 feet. Given the fact that in many areas the vein was considerably less, day-to-day production would of necessity have generated a considerable proportion of granitic host rock as overbreak. We believe the overbreak and quartz without visible tungsten mineralization was hand-sorted before primary crushing and transferred to the waste rock dump shown in Figure 9 by a stiff-leg boom that appears in newspaper photographs (*Spokane Daily Chronicle*, 6/29/1954). DGER did not attempt to sample the dump for metals because of its irregularity and its volume, estimated to exceed 75,000 tons. Our visual estimate of its composition was 75 percent granitic waste rock and 25 percent quartz.

The only available information we have on the grade of the stockpiled vein talus shown in Figure 2 is from the 11,528 tons run through the mill between April and October 1940, which yielded 1 pound per ton of WO_3 or 0.05 percent (Page, 1941). We estimate that the stockpile contains a minimum of 100,000 tons.

The tailings are deposited in chaotic piles filling about 700 lineal feet in the Sand Creek tributary ravine located east of and adjacent to the mill. Based on the documented mill output, we estimate 90,000 to 100,000 tons of minus ⅜-inch material remain (Fig. 10). Analyses for metals from a grab sample taken at one location are shown in Table 3. Levels of arsenic and selenium in this sample exceed soil standards shown in Table 4.

GENERAL INFORMATION

Names: Germania, Roselle

MAS/MILS sequence number: 0530650002

Access: four-wheel drive from Fruitland; intermittently locked gates on BLM land

Status of mining activity: none

Claim status: no patented or unpatented claims at time of publication

Current ownership: see "Ownership" discussed above; contact Stevens County Assessor's Office for current status

Surrounding land status: BLM

Map information: Adams Mountain [1:24,000] and Nespelem [1:100,000] quadrangles

MINE OPERATIONS DATA

Type of mine: underground

Commodities mined: tungsten

Geologic setting: mineralized quartz veins filling joints in granitic intrusive rock

Ore minerals: wolframite, scheelite; present but not recovered: autunite, chalcopyrite, galenobismutite, koechlinite, kamiokite, gold

Non-ore minerals: quartz, tourmaline, chlorite, pyrite, arsenopyrite (Huntting, 1956)

Host rock: biotite quartz monzonite of Cretaceous age

Period of production: 1904–1914, 1930–1941, 1956

Development: ~7,400 feet

Production: as shown in Table 1, plus undocumented tonnage of vein talus

Mill data: two gravity concentration mills: 40-tpd capacity, circa-1906; 100-tpd capacity, 1931

Figure 8. Mill ruins circa 2013. View is to the east.

Figure 9. Waste rock dump at photo center. Crest continues to the west behind the trees. Vein-talus stockpile in foreground. View is to the west.

Figure 10. Typical tailings exposure.

Table 2. Mine features. – – –, no data; *, data from IAML file; n/a, not applicable.

Description	Condition	Fenced (yes/no)	Length (feet)	Width (ft)	Height/ depth (ft)	True bearing	Elev. (ft)	Decimal latitude	Decimal longitude
400 level	caved	no	2050	5	7	S25W	3,518	48.0082	118.1009
200 level (Roselle), approximate location	no floor or back; drift is stoped out above and below	no	750	n/a	n/a	S25W	3,725	48.0066	118.1033
100 level	same as above	no	125	5*	7*	S25W	3,890	48.0057	118.1042
trench on vein at the ridge crest	open	no	100	20	20	N25E	3,957	48.0053	118.1044
mill	ruins	no	n/a	n/a	n/a	n/a	3,500	48.0083	118.1008
lowest extent of tailings in Sand Creek drainage	n/a	no	n/a	n/a	n/a	n/a	3,381	48.0072	118.0987
upper extent of tailings in Sand Creek drainage	n/a	no	n/a	n/a	n/a	n/a	3,495	48.0086	118.1007
southern extent of transported vein talus cobbles	n/a	no	n/a	n/a	n/a	n/a	3,478	48.0077	118.1003
1950s prospect tunnel north of mill (approximate)	– – –	– – –	250*	5*	7*	N25E	~3,760*	~48.0118*	~118.0976*

Table 3. Soil analysis. Analyses in bold indicate levels that exceed one or more of the standards shown in Table 4. Metal concentrations are mg/kg; ≤, indicates metal was not detected. The number following is the reporting 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. *, safe concentration limits have not been established for antimony, silver, and thallium.

	As^{+3}	Sb*	Be	Cd	Cr	Cu	Hg (inorganic)	Pb	Ni	Se	Ag*	Tl*	Zn
Tailings	**47**	3.9	0.80	≤0.42	4.7	39	0.49	150	0.59	**7.6**	3.5	≤4.2	20

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 milligrams/kilogram. **, safe concentration limits have not been established.

Land use/metals	As^{+3}	Sb	Be	Cd	Cr	Cu	Hg (inorganic)	Pb	Ni	Se	Ag	Tl	Zn
Unrestricted land use	20	**	25	25	42	100	9	220	100	0.8	**	**	270
Industrial or commercial use	20	**	**	36	135	550	9	220	1,850	0.8	**	**	570

PHYSICAL ATTRIBUTES

Features: see Table 2

Materials: none

Machinery: unknown/inaccessible

Structures: mill ruins

Waste rock dumps, tailings impoundments, highwalls, or pit walls: one waste rock dump, one tailings repository; prospect pits

Analysis of waste rock dumps: see Tables 3 and 4

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

Reclamation activity: none

VEGETATION

Vegetation is primarily inland fir, pine, grasses, and shrubs.

WILDLIFE

See Table 5 for bat habitat information.

WATER QUALITY

Surface waters observed: Sand Creek tributary

Proximity to surface waters: 100 feet

Domestic use: none

Acid mine drainage or staining: no

Water field data: see Tables 6 and 7

Surface water migration: mine discharge by sheet flow across mine access road into Sand Creek drainage at top of tailings pile

Table 5. Bat habitat information.

Opening	Aspect	Air temp. (°F) at portal	Air flow: exhaust	Air flow: intake	Multiple interconnected openings	Bats or bat evidence
Continuous open stope on ridgeline	NE	85	yes	no	yes	no
400 level adit, caved	E	85	no	no	no	no

Table 6. Surface water field data.

Description	Flow (gpm)	Conductivity (μS/cm)	pH	Bed color	Temp. (°F)
Discharge from 400 level adit	2	570	7.4	natural	45
Discharge at toe of tailings in Owl Creek ravine	5	380	7.0	light brown-orange	47

Table 7. Surface water analysis. Metal concentrations are in micrograms/liter (µg/L); hardness is in milligrams/liter (mg/L). USEPA, U.S. Environmental Protection Agency; *, standards for these metals are hardness dependent; **, standard not determined; ≤ indicates metal was not detected—the number following is the reporting 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. Standards calculated for hardness values specific to Part 1 below are shown in Appendix B.

PART 1: ANALYSIS BY USEPA METHOD 6020, INDUCTIVELY COUPLED PLASMA/MASS SPECTROMETRY												
Sample location	**As***	**Sb**	**Be**	**Cd***	**Cr^{+6}**	**Cu***	**Pb***	**Ni***	**Se***	**Tl**	**Ag**	**Zn***
400 level adit discharge; hardness = 270 mg/L	4.6	0.7	4.0	1.4	≤2	1.7	2.6	≤15	≤5	≤5	≤2	86
Discharge from tailings toe into Sand Creek drainage; hardness = 82 mg/L	≤3.8	0.4	1.8	0.4	≤2	3.2	≤2	≤15	≤5	≤5	≤2	34
PART 2: APPLICABLE WASHINGTON STATE WATER QUALITY STANDARDS												
Type of standards (applicable Washington Administrative Code)	**As***	**Sb**	**Be**	**Cd***	**Cr^{+6}**	**Cu***	**Pb***	**Ni***	**Se***	**Tl**	**Ag**	**Zn***
Surface water standards (WAC 173-201A, Standard for aquatic life in surface freshwater, chronic level maximums at 100 mg/L hardness)	190	**	**	2.15	10	497	7.28	304	5	**	**	104
Ground water standards (WAC 246-290, Washington State Department of Health, standards for ground water, domestic consumption)	10.0	6	4	5	100	1,300	15	100	50	2	100	5,000

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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 and double bagged in polyethylene. Chain of custody was maintained.

Soil and water samples were analyzed for the metals listed in this report by following USEPA (U.S. Environmental Protection Agency) Method 6020 inductively coupled plasma/mass spectrometry (ICP-MS Metals), or Method 6010B (ICP-Metals). Holding times for the metals of interest were observed.

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

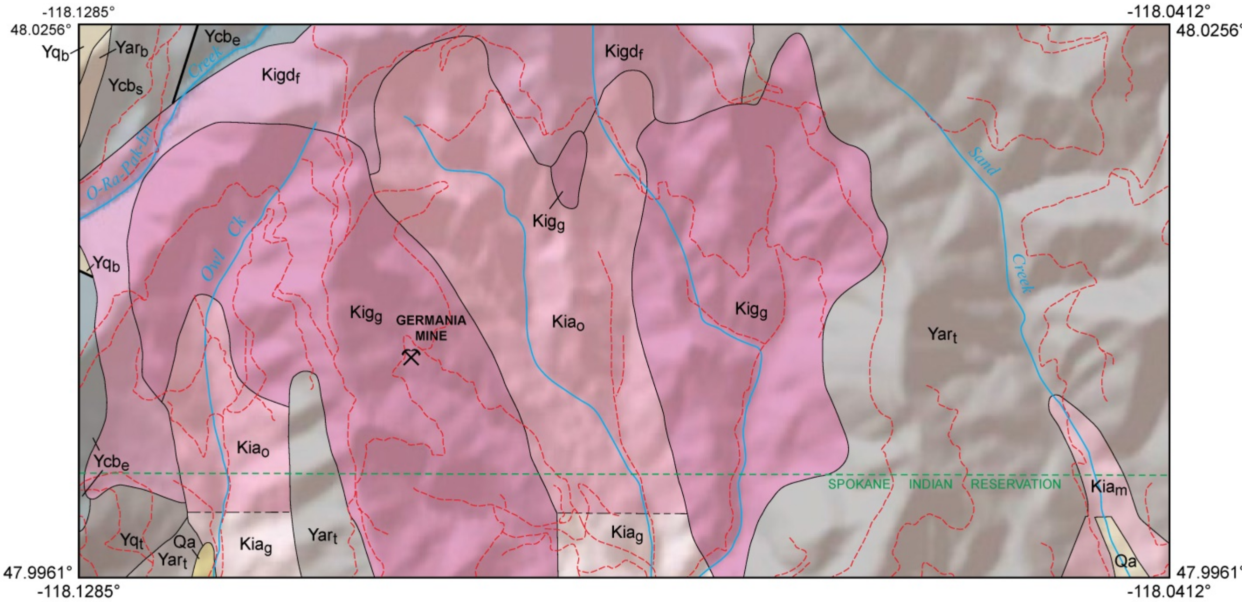
digital camera
flashlight
Garmin GPS III+, handheld GPS unit
Hanna Instruments DiST WP-3 digital conductivity meter
and calibration solution
Oakton digital pH meter
Oakton digital electrical conductivity meter
Taylor model 9841 digital thermometer

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)	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Se (µg/L)	Zn (µg/L)
400 level adit	270	190	2.15	497	304	7.28	5	242
Discharge in Sand Creek draw at toe of tailings pile	82	190	0.89	179	111	2.03	5	88

Appendix C. Maps and Land Status



Unconsolidated Sediments

Qa	Pleistocene continental glacial, glaciolacustrine, and outburst flood deposits (glacial drift), Fraser-age

Intrusive Igneous Rocks

Kia_g	Cretaceous acidic (felsic) intrusive; granite near the Germania Mine
Kia_m	Cretaceous leucocratic monzogranite and granite; pluton near Midnight Mine
Kia_o	Cretaceous acidic (felsic) intrusive rocks; porphyry near Owl Creek
$Kigd_f$	Cretaceous granodiorite; granodiorite near Fruitland
Kig_g	Cretaceous granite; granite near the Germania Mine

Metasedimentary and Metavolcanic Rocks (Greenschist Facies and Lower)

Yar_b	Middle Proterozoic argillite (low grade); Buffalo Hump Formation, Deer Trail Group dolomite
Yq_b	Middle Proterozoic quartzite (low grade); Buffalo Hump Formation, Deer Trail Group dolomite
Ycb_s	Middle Proterozoic metacarbonate; Stensgar Dolomite, Deer Trail Group
Ycb_e	Middle Proterozoic metacarbonate; Edna Dolomite, Deer Trail Group
Yar_t	Middle Proterozoic argillite; Togo Formation, Deer Trail Group
Yq_t	Middle Proterozoic quartzite (low grade); Togo Formation, Deer Trail Group

Geologic Symbols

- Contact—Identity and existence certain, location accurate
- Scratch contact—Indicates a difference of opinion on the identity of a unit between two adjacent maps
- Fault, unknown offset—Identity and existence certain, location accurate
- Logging road

Figure C1. Geologic map of the study area. Geology from the 1:100,000-scale layer of the Washington State Geologic Information Portal [http://www.dnr.wa.gov/geologyportal].

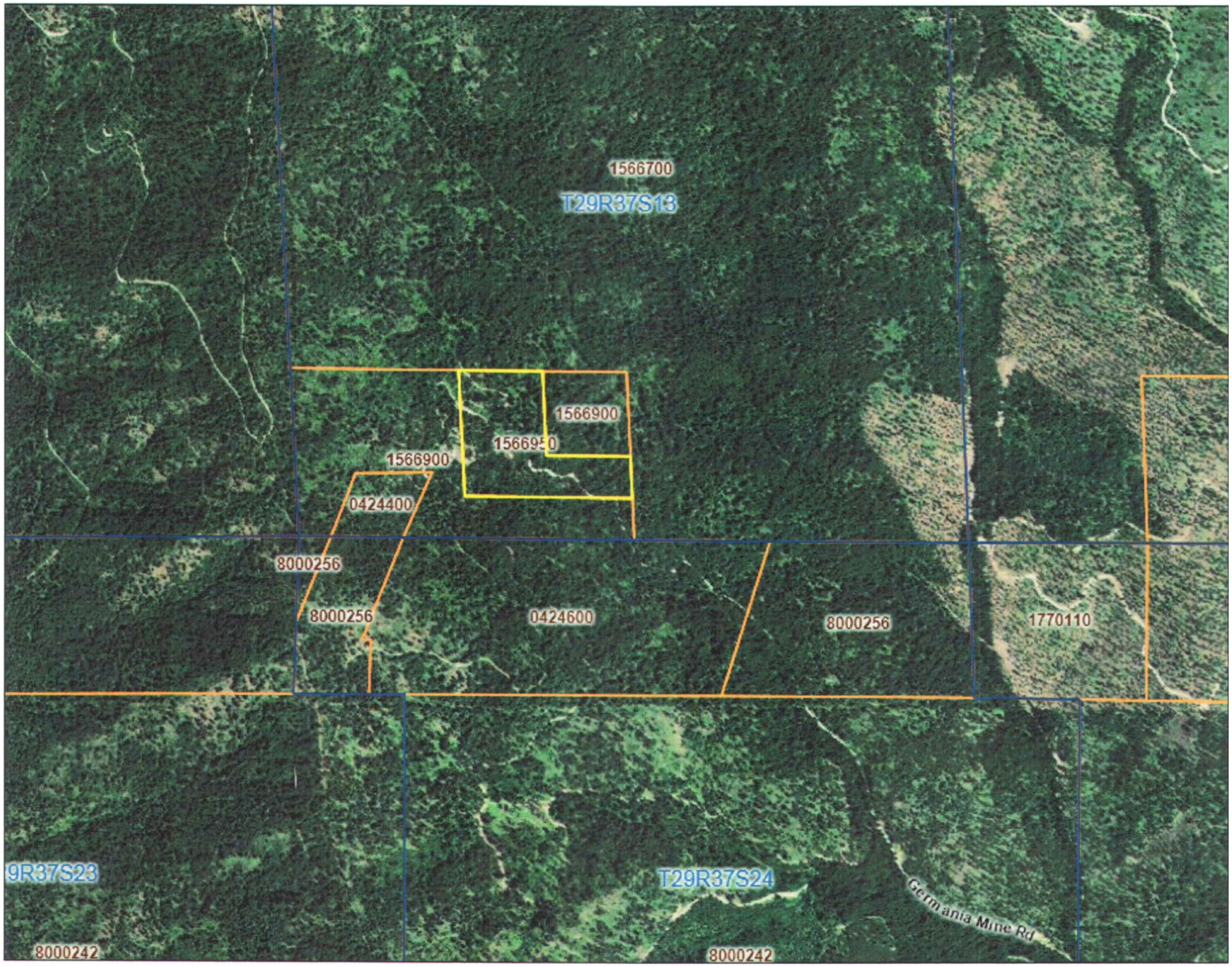


Figure C2. Land status. Former claims are marked by orange boundary lines with black claim numbers inside. The yellow 10-acre parcel is privately held. All other lands above the Spokane Indian Reservation boundary (lowest horizontal orange line), including the Exodus claim (angular parcel), are held by the Bureau of Land Management (Stevens County Assessor). Dark blue lines and blue numbers indicate township and range.

Figure C3. Composite plan and longitudinal section of the Germania Tungsten Mine circa 1952.

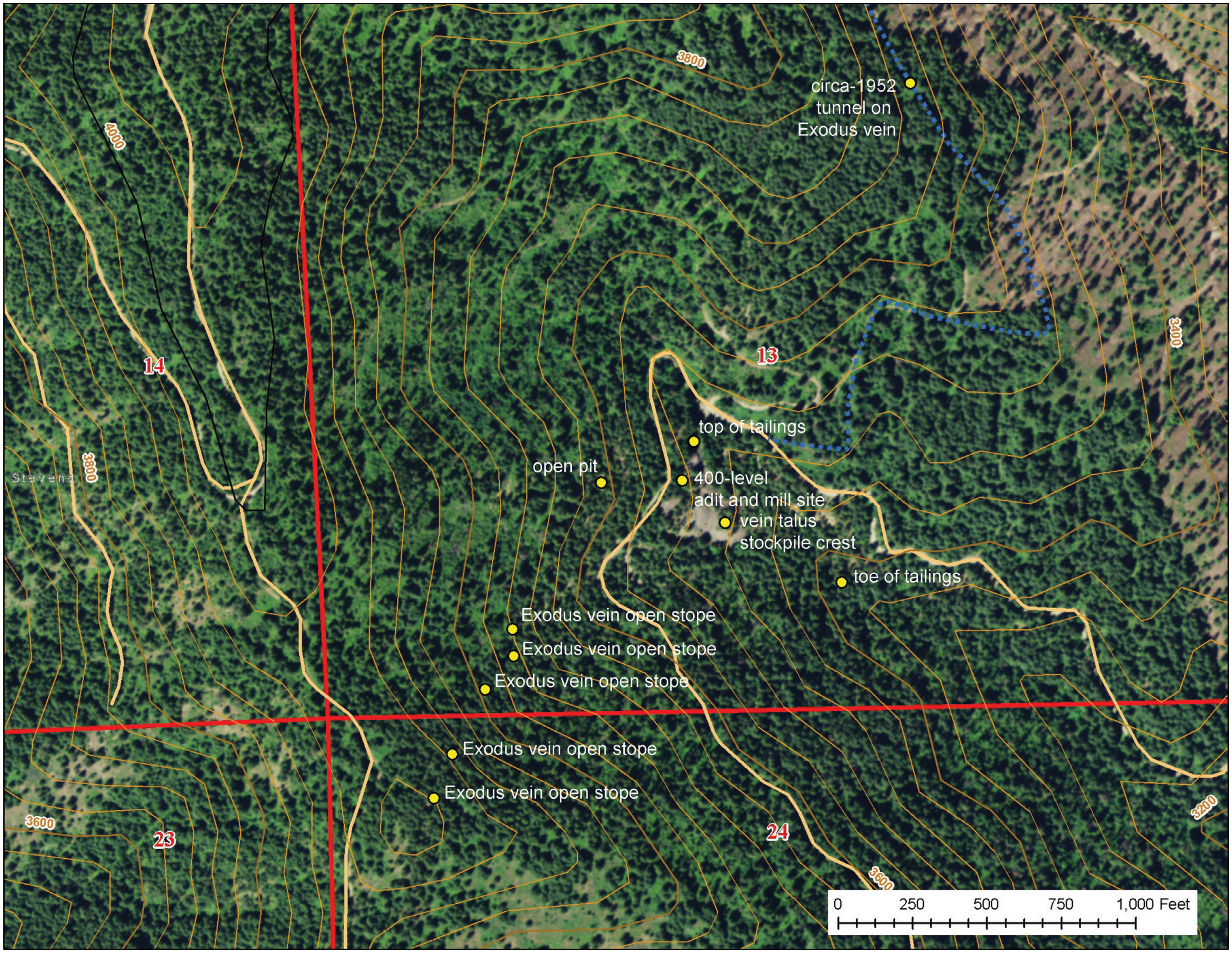


Figure C4. Aerial photo of mine features. The trace of the Exodus vein and open stopes is in the lower center. There is a small open pit on the vein near the center of the photo. To the right are the top of the tailings, the 400-level adit and mill site, and the crest of the vein talus stockpile. The point labeled 'toe of tailings' marks the re-emergence of water in the Sand Creek draw, discussed in text. In the upper right is the circa-1952 tunnel on the Exodus vein extension.

Appendix D. Tungsten Properties and Marketing

Tungsten has several properties that place it in a unique position among the elements: its melting point of about 6,200°F is second only to carbon; it has the lowest thermal expansion coefficient of all metals; its hardness is close to that of diamond; and it has excellent high temperature electrical and mechanical properties. For these reasons, it is not only a critical element in the manufacture of cemented carbide cutting tools and wear-resistant products, but also tool steels and high-strength, high-temperature alloys. The U.S. and other countries maintain stockpiles of tungsten as a strategic commodity. Tungsten is considered to be environmentally inert, although arsenic, lead, and copper minerals are almost always present in ore deposits as accessories and may create toxic soil or water conditions. Tungsten assays are reported in percent tungsten trioxide (WO_3), rather than percent tungsten. Tungsten is traded internationally on the basis of metric ton units (mtu) of 10 kg, or in the U.S. as short ton units (stu) of 20 pounds. Today, ammonium paratungstate (APT) has replaced wolframite or scheelite concentrate as the most desirable form of raw material purchased by end users. Using wolframite or scheelite concentrate as a starting point, APT is an upgraded secondary step using a complex ion-exchange process that produces a fine powder that is amenable for use in a wide variety of tungsten-bearing products, especially tungsten carbide, which accounts for 50 percent of world tungsten usage. APT commands a price two to three times that of mineral concentrate. Mineral concentrates are still quoted, however, and find use as direct blast furnace additives in steel production. They are offered in different grades, but specifications require a minimum tungsten trioxide content of 60 to 70 percent, depending on end use, and ‘not-to-exceed’ specifications for impurities like molybdenum and manganese among others.

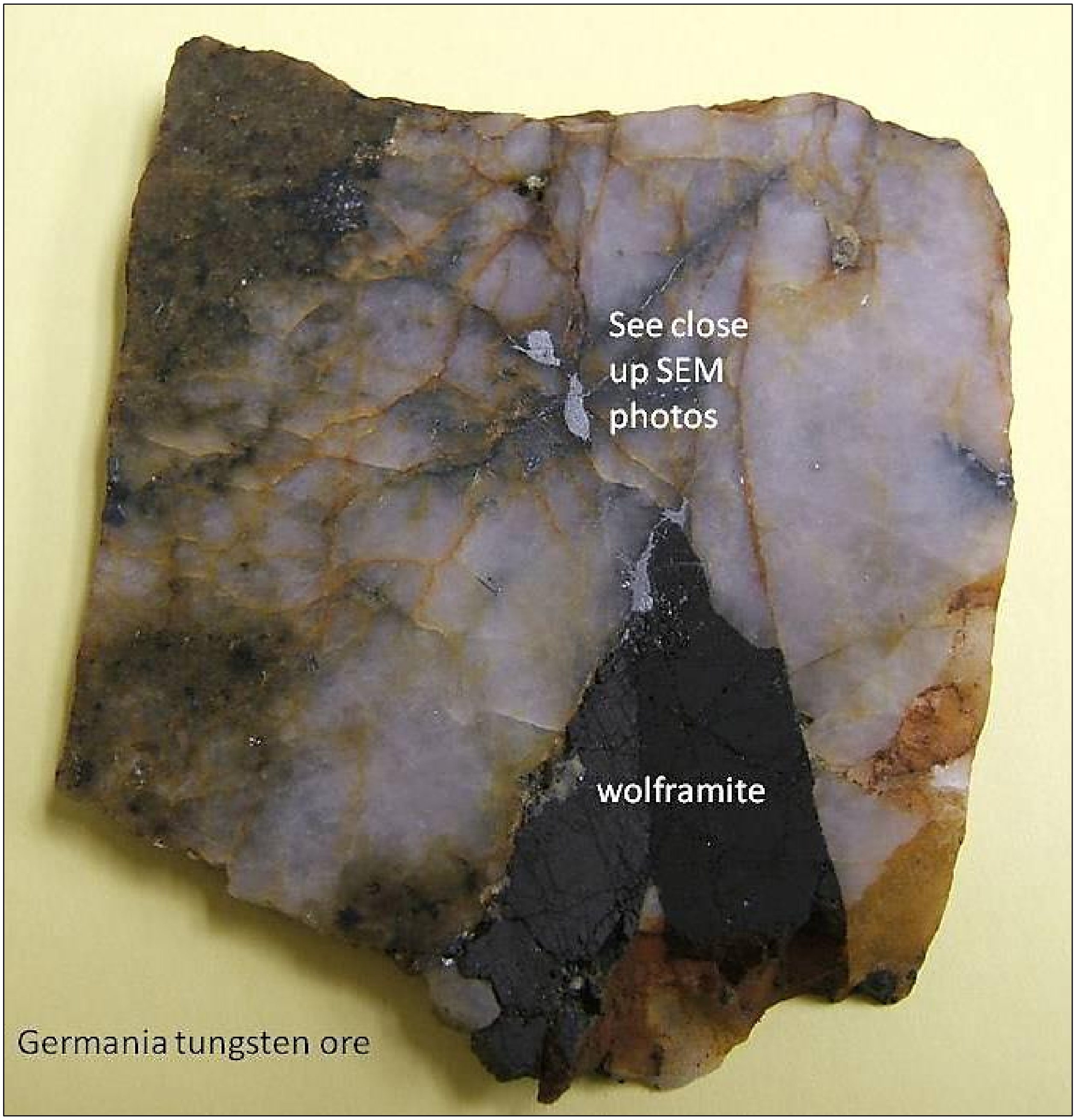


Figure D1. Sample of vein quartz with tungsten and molybdenum mineralization. Photo courtesy of George Mustoe (Western Wash. Univ., 2012).

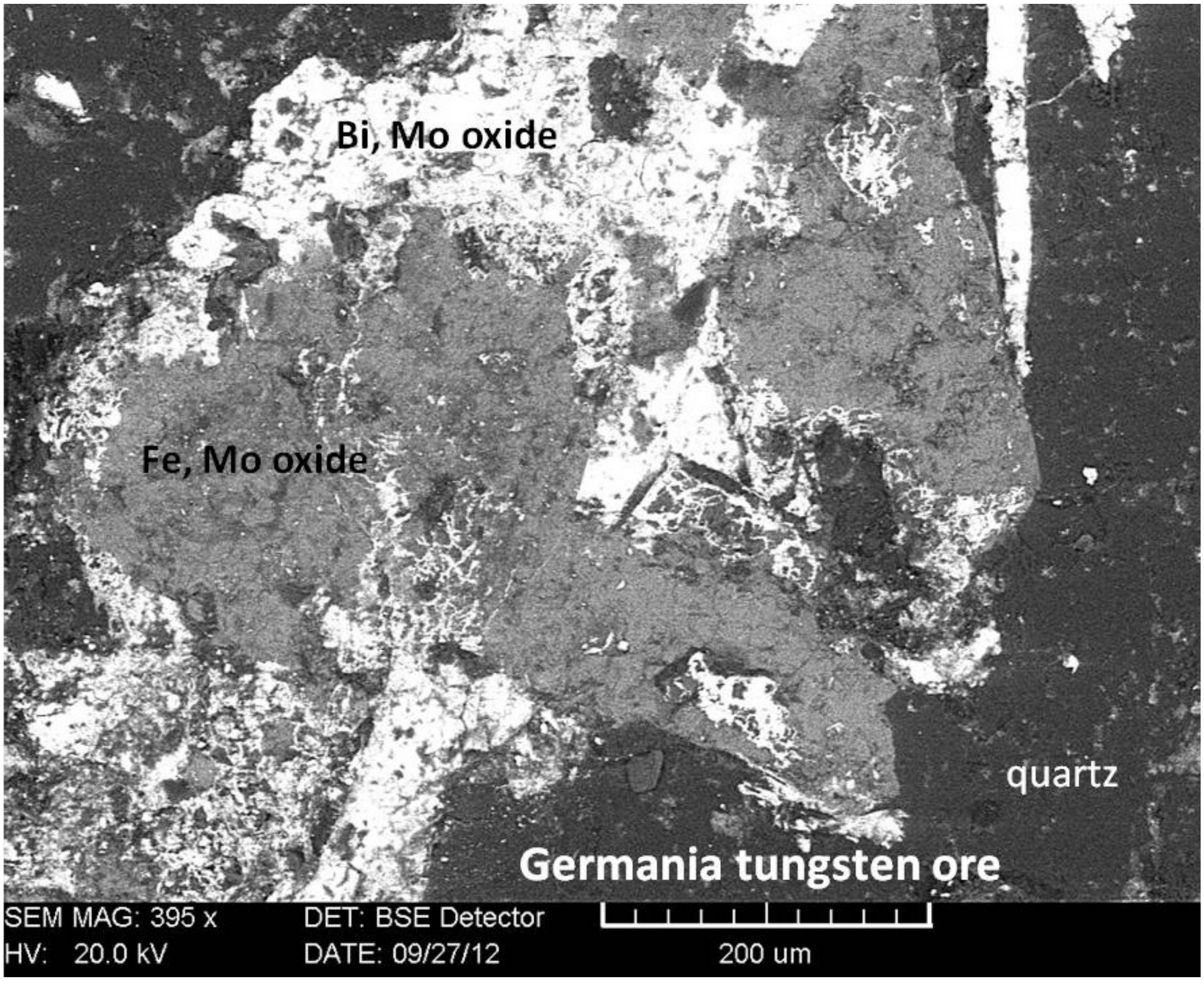


Figure D2. SEM photo showing koechlinite (Bi_3MoO_8) and kamiokite ($Fe_3Mo_3O_8$). Photo courtesy of George Mustoe (Western Wash. Univ., 2012).