NATURAL RESOURCES

# INACTIVE AND ABANDONED MINE LANDS— Alder Mine, Twisp Mining District, Okanogan County, Washington


by Fritz E. Wolff,
Donald T. McKay, Jr.,
and David K. Norman



WASHINGTON
DIVISION OF GEOLOGY
AND EARTH RESOURCES
Open File Report 2004-16
July 2004



site location


WASHINGTON STATE DEPARTMENT OF
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**DISCLAIMER**





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# Contents



## FIGURES



## TABLES

# Inactive and Abandoned Mine Lands—Alder Mine, Twisp 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, Region 6. Other agencies sharing in the project are the U.S. Forest Service (USFS), U.S. Bureau of Land Management (BLM), the U.S. Environmental Protection Agency (EPA), and the Washington Department of Ecology (DOE).

Over 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 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. Open-File Reports (OFRs), such as this one, provide documentation on mines or groups of mines within specific mining districts or counties. The IAML database may be viewed with assistance from DGER personnel. IAML OFRs are posted online at http://www.dnr.wa.gov/geology/pubs/.

## SUMMARY

The original property contained 16 unpatented lode claims, two homestead entries, and three patented lode claims under mineral survey #989. As of December 2003, the patented lode claims and one homestead entry comprised the mine property. It is surrounded by the Wenatchee-Okanogan National Forest and covers portions of SW¼ sec. 25 and NW¼ sec. 36, T33N R21E (Fig. 1). From its earliest discovery and development prior to 1910 through May 1953 (the date of last production), the mine produced 86,600 tons of ore that contained 35,000 ounces of combined gold and silver, approximately 1.3 million pounds of copper, and 686,000 pounds of combined lead and zinc (Moen, 1973). The principal feature is an open pit 500 feet long, 75 feet wide, and 150 feet deep. Four adits accessed open stopes directly beneath the open pit, totaling 3000 feet of development. The mine's vertical extent is only 370 feet from the highest outcrop to the lowest mine level. Much of the early mining was carried out in an upper zone of oxidation where enriched values in gold and copper were encountered. Sampling and development performed on four mine levels indicate that both the gold and copper values decrease with depth. Mapping and sampling carried out by Leggat (1935) indicated that mineralization on level 4, also referred to as the Fargo level, was sparse to nonexistent. DGER visited the site on 10 June 2002.

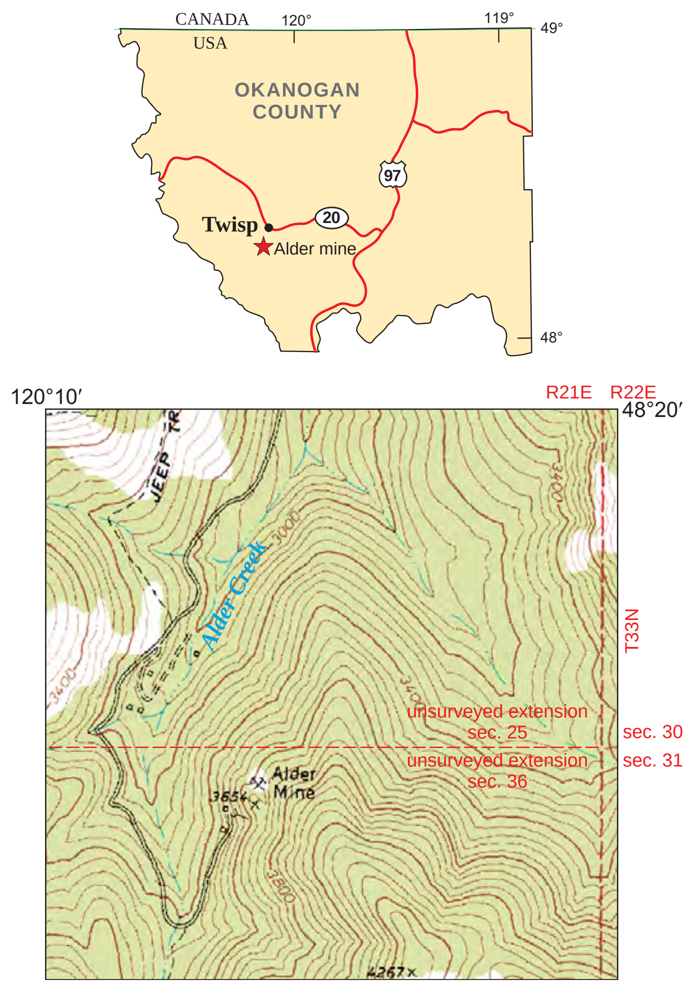


**Figure 1.** Map showing the general location of the Alder mine in Okanogan County (above), and a more detailed map of the mine site, scale 1:24,000 (below).

The mine is reached by following the Lookout Mountain road southwest of Twisp for about 6 miles to elevation 3400 feet (Fig. 2). The open pit and all other openings are extremely hazardous. We believe that the level 4 adit is oxygen-depleted due to lack of interconnections underground, rotting timbers, oxidation of sulfide ores, cave-ins, and acid mine drainage (pH = 3.0). Water discharging from this opening and level 3 (Methow) is toxic to human health and aquatic organisms (see Table 6). Water discharging into a pond from level 4 (Fargo) enters Alder Creek in periods of high runoff and has saturated forest soils with elevated levels of copper, cadmium, zinc, and selenium (Peplow, 1999). Wildlife and cattle use the pond.

This report covers only data obtained at the Alder mine. The 1950s-era Alder mill site near the southwest city limits of Twisp has been the site of remedial action by the owner, in cooperation with state and federal agencies, and is not addressed in this report. Prior to 1950, most of the mine's production was shipped directly to ASARCO's Tacoma smelter without milling. Several thousand tons of low-grade ore were concentrated at the former Red Shirt mill near the Twisp airport, owned at the time by Alder Group Mining and Smelting Co. (Mining World, 1939).


**Figure 2.** Overview of the Alder mine site. Disturbed area totals about 13 acres. View to the northeast.

**Figure 3.** Inside the Alder open pit. View to the north. Geologist atop iron-stained outcrop on the rim for scale.

## Ownership

The present owners, Alder Gold-Copper Company, Inc., of Portland, Oregon, purchased the property in 1947. The property consists of the three patented claims as described below, an adjacent homestead tract (H.E.S. 247, ~17 acres), and a mill site near Twisp (Okanogan Assessor, written commun., 2004).

## History

Gold and copper mineralization was first discovered in the Alder Creek area in 1896. The early history of the Alder Mine is sketchy, but the Alder Group Mining and Smelting Co. (Alder Group) acquired the property in 1903. Judging from the information and dates of various reports on the property, this company drove three adits into the ore zone, two of which were connected by a raise to a surface glory hole (Figs. 3 and 4). Three claims were patented in 1910. The original property included two homesteads and a number unpatented claims. Additional drifting but little mining was done from 1914 to 1916. The mine lay idle until 1928, at which time R. K. Magney, a Spokane mining engineer, negotiated a lease and formed a company later known as Alder Metals Corporation. The stock market collapse of 1929 and ensuing economic depression stopped further activity until 1939 (Malott, 1939). An article in *Mining Truth* (March 21, 1939, p. 3) reported an extremely complex situation regarding clouded title to the property: "Alder Group Mining Co., controlled in North Dakota, held title but its corporate existence was permitted to lapse after the property was sold under contract to Alder Metals. Twisp Mining and Smelting…took over the Alder Metals interest but did not go through with the contract. A new company…was then incorporated and offered the property to a concern called Methow Gold…but Alder Metals maintain[ed] there was no continuity of title. Another complication arises from the reputed sale of the [mine] by Twisp Mining and Smelting to Chelan Mining Company." The exact outcome of this 1939 litigation is not clear, but by November of that year, *Mining World* reported that the claims were "leased by the Alder Group Mining and Smelting Co. to the Methow Gold Corporation.

Methow Gold operated the mine from 1939 to 1941. During this period, 330 cars of crude ore and 38 cars of concentrate were shipped by rail from Pateros to the ASARCO smelter in Tacoma, totaling over $348,000 in gold, silver, and copper (DGER mine file). The mine was shut down in late 1941 by government order L-208 restricting mining operations to strategic minerals only. During this time, low-grade ore from the Alder was milled at the former Red Shirt mill under lease to Methow Gold. The Red Shirt mill is about 1 mile south of Twisp near the airport (Mining World, 1939).

Alder Gold-Copper Company, Inc., formerly of Spokane, now Portland, purchased the property in 1947. Alder Gold built a 300-ton per day flotation mill on the hill about 0.2 miles southwest of Twisp in 1950. The company continued operations on a full-time basis until May 1953 when the mine closed. There has been no known production since that date. The Alder mill site at Twisp was given a '1a' ranking by the Washington State Department of Ecology (DOE) due to the presence of toxic metal-bearing tailings and has been the site of remedial activity (R. Roeder, DOE, written commun., 2003).

## Geologic Setting

Descriptions of the Alder deposit's origin, the host rock, and its relationship to the mineralization have varied over the years depending on the accuracy of age dating and geologic mapping in the area and expanding theories on the genesis of certain kinds of ore deposits. All investigators agree in substance, but disagree or postulate on specific details.

The orebody can be described as a mineralized shear zone of heavily altered basic volcanic rock, "originally dacite, and perhaps andesitic tuffs and breccias…" (Burnet, 1976). In that sense, it is not specifically a 'vein' although that term has been applied. Kirkemo (1953) and others describe it as a replacement mass of quartz enclosed in metavolcanic rocks resembling andesite. Grant (1973) made the following observation: "Much of the zone shows intense crushing. Alteration consists of silicification, chloritization, and seritization." The ore-bearing elongated structure strikes N25W with a surface expression of 500 to 700 feet long by approximately 130 feet wide. The Alder Creek stock, a Tertiary quartz-diorite, intrudes Cretaceous metavolcanics of the Newby Group at the mine, forming a distinct footwall along the eastern margin of the mineralization (Fig. 4). Kirkemo (1953) describes the footwall as a "schistose, altered and bleached zone, 20 to 30 feet wide, of andesite". It is nearly vertical along most of its strike. Burnet (1976) identified the hanging-wall rocks as a quartz-sericite phyllite that he was able to trace north of the open pit along strike for over a mile. The hanging wall of the mineralized zone dips 85SW in the open pit, gradually sloping to 50SW on level 3, 130 feet below the outcrop. Kirkemo's (1953) surface geology map indicates that the western margin is bounded by granite porphyry and altered volcanics.

Ore minerals in the quartz are chalcopyrite, sphalerite, and argentiferous galena, with pyrite as gangue in the unaltered sulfide zone. In the surface oxidized zone, which extended about 100 feet downdip from the outcrop, the primary ore minerals were chalcocite, malachite, azurite, and zinc oxides and locally abundant gold (Kirkemo, 1953).

Structural controls dominate the mine landscape. According to studies done in the Methow Valley by Barksdale (1975), the Alder mine is located near the junction of two locally significant faults, the Smith Canyon fault and the Moccasin Lake fault. The 17-mile-long Smith Canyon fault passes through the western margin of the mine approximately 50 feet west of the level 4 portal and may have truncated the original deposit. Grant (1973) postulated that some surface evidence exists that the strike-slip movement of the Smith Canyon fault may have displaced the mineralized volcanics approximately 800 feet to the south.


**Figure 4.** Inside Alder open pit. Note footwall of Alder Creek stock and hanging wall of metavolcanics. View to the south.

Agreement is universal that an additional fault, running perpendicular to the deposit's long axis, cuts off the mineralization near the south end of the open pit. Burnet (1976) described this feature as follows: "The Alder ore zone is offset by a NE trending fault zone a few hundred feet south of the open pit". This feature's horizontal or vertical displacement, or some combination thereof, probably cannot be determined from the surface without substantial core drilling. No efforts have been made to explore for the deposit's extensions, although most investigators agree that a continuation is possible.

The northern limit of the open pit terminates in a heavily iron-stained zone extending approximately 50 feet west of the footwall (Fig. 3). Mining during the post-1939 operations would obviously have sampled this area extensively, leading to the supposition that the exposure was uneconomic. A surface geology map drawn by Kirkemo in 1951 (DGER mine map file) while employed by Alder Gold indicates that the footwall contact continues to the northwest from the iron-stained zone, but is obscured by dump material and overburden.

Most early investigators of the property believed that the close proximity of the mineralization to the diorite intrusive suggested a hydrothermal emplacement of the sulfides and precious metals. However, the deposit exhibits many characteristics of a volcanogenic massive sulfide (VMS) deposit rather than a true fissure vein deposit. Burnet (1976) reported "one sample of loose rock from the Alder open pit contains banded sulfides that may be stratiform. If the sulfides in the mine are volcanogenic, the strata may be overturned. The structural hangingwall is more altered…than the structural footwall; it contains more veins, sulfide minerals and perhaps more chalcopyrite. These characteristics are typical of *underlying* [author's italics] rock in volcanic-exhalative ore deposits. Massive sulfides, if they occur, should be within or stratigraphically above the tuffaceous zone in the footwall." The presence of marked seritization and chloritization associated with the Alder deposit also strongly suggests VMS origin: "Host rocks underlying VMS deposits are extensively altered. Sericite, chlorite and montmorillonite …are common alteration products in Kuroko-type deposits" (Derkey, 1994).

**Figure 5.** Intersection of level 2 raise with pit floor. View vertical (looking straight down).

## Openings

Underground workings at the Alder mine exceed 3500 feet, including four adits, an open pit, and a sublevel between levels 2 and 3. Kirkemo's 1951 map (DGER mine map file) indicates that the open pit incorporates levels 1 and 2, intercepting a vertical raise and timbers in the "H.W. Drift" 40 feet above level 3 (Figs. 5 and 6).

The collar of adit level 2 is obscured by dump material at elevation 3578 feet. It is located on a barely discernible bench opposite the open pit's short axis, 20 feet west of and a few feet below the main haul road. During spring runoff, small amounts of water discharge to the surface.

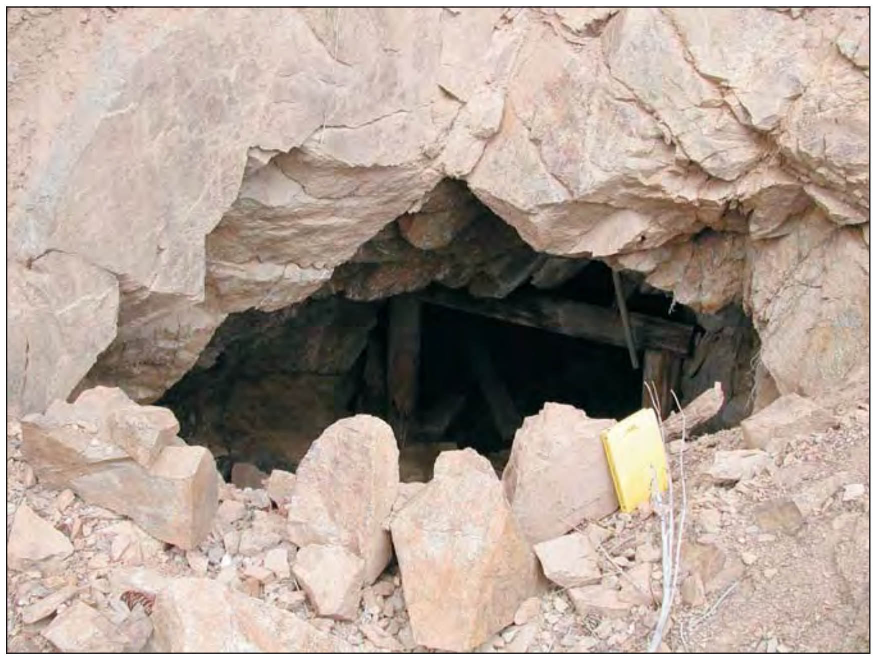

**Figure 6.** Sublevel drift that holes out into the open pit 40 feet above level 3 (Methow level). View to the west.

Level 3 is open and accessible. Various reports refer to it as the "Methow Level" driven by Methow Gold Co. circa 1939 at elevation 3478 feet (Fig. 7). Surface slough covers the entrance to within a few feet of the drift timber caps. Underground condition is unknown. Grant (1973) reported the tunnel open but "all the raises (10 in total) connecting to upper levels are plugged solid with muck." A trickle of water at 1 gpm discharged from the adit on the date of DGER visitation. A 10-inch-deep pool of standing water was impounded behind the portal slough. Exhaust air with a distinct sulfurous smell emanated from the portal at ~2 mph. This level does not show up on documentation written prior to 1939, therefore we conclude that it derives its name from the period of Methow Gold operations circa 1939 through 1941. Mine maps (DGER mine files) show that almost all the mineralized ground above level 3 has been stoped to within a few feet of the open pit floor.

Level 4 is the lowest development adit on the property. It was driven between 1906 and 1910 by the Alder Group in an unsuccessful effort to develop vertical depth on the orebody. The portal lies at elevation 3370 feet, approximately 380 feet below the original outcrop. Maps and reports refer to it as the "Fargo Level" after stockholders from North Dakota. Leggat (1935) examined this level when it was still open and represents the best available information regarding its condition and mineralization: "This tunnel…some 1200 feet long, with several branching drifts and crosscuts, rambles through the country in an aimless way and fails to find anything of importance. The vein, so feebly mineralized as to be unrecognizable as such, is crossed, several hundred feet through the footwall…and fruitlessly explored…." The tunnel has a wye at a point 175 feet from the portal. The left hand entrance was "caved tight" at the time of Leggat's investigation. From there it wanders southwest approximately 900 feet, passing directly underneath the upper levels and encountering only pyritized quartz, diorite, and black andesite. We detected noticeable amounts of hydrogen sulfide in the air exiting the portal, which is open but badly deteriorated. Crawford (1928) reported "The air in this tunnel was so bad… that only a very hurried inspection was possible." This level, which discharges a small amount of toxic water as described below, should be considered an extreme hazard to human health. The portal is caved almost to the drift caps (Figs. 8 and 9).

### Materials and Structures

Photographs taken in 1963 show a sheet-metal snow shed extending outward from the portal of level 3 to the dump, an ore storage bin above the access road at elevation 3434 feet, and a dry house, sawmill, and miscellaneous shops clustered nearby. The buildings and snow shed are gone, and the ore bin has collapsed (Fig. 10). Figure 11 shows the same location circa-1940, the time of Methow Gold's operation. The mine camp on the flat below the property is gone.

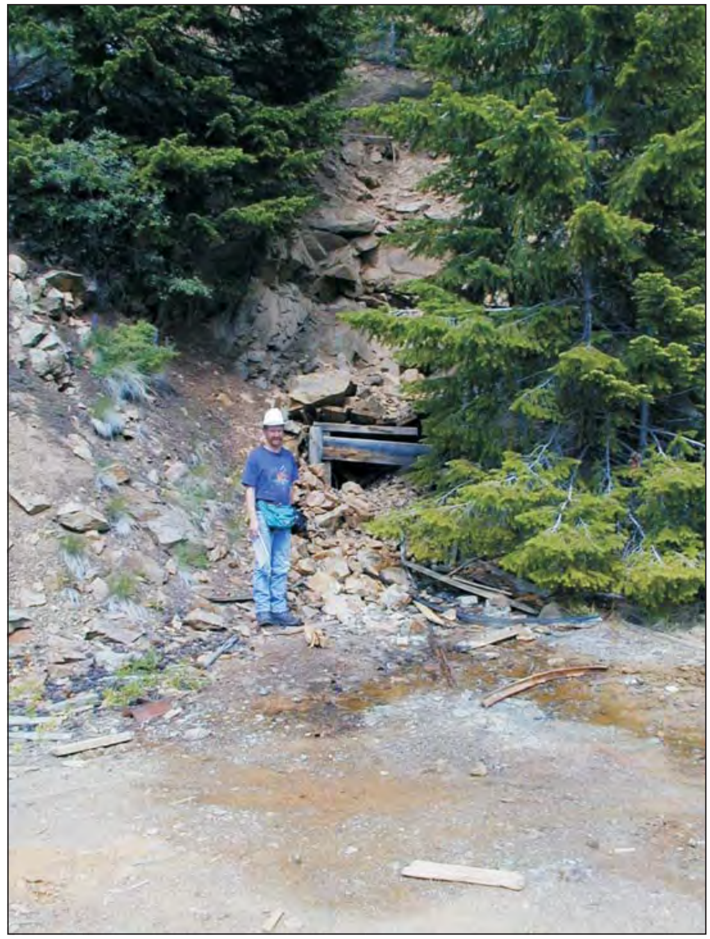

**Figure 7.** Level 3 adit (Methow level). Note sheet flow discharge in front of geologist. View to the east.

### Water

On 10 June 2002, 1 gpm of water discharged from the level 3 (Methow) portal and infiltrated the dump material within 30 feet. The discharge was clear with crusts of white precipitate on the margins. Field tests gave a pH of 4.4 and conductivity of 1400 mhos/cm.

Water discharged at a rate of 4 gpm from level 4 (Fargo) about 600 feet north and 100 feet below level 3 (Methow). We observed a 12-inch-deep impoundment of mine water behind surface slough at the portal, migrating by sheet flow to a pond 12 inches deep, 25 feet long, and 15 feet wide about 50 feet west of the portal. The area between the portal and the pond is covered with a thick mat of dark green algae. The water is clear, but the sediment bed is stained bright orange (Figs. 12 and 13). The electrical conductivity meter pegged at 2000 mhos/cm maximum scale, and pH measured 3.0. Wildlife and cattle use the pond. Peplow's (1999) data regarding Alder Mine impact on Alder Creek indicates water from this pond reaches Alder Creek at a point directly below the pond, probably during periods of heavy rainfall or spring runoff. In addition to direct water-laden transport, Peplow estimated, "Over 90% of the more than 11,000 kg of metals discharged annually from the mine tunnels are retained by the forest soils between the mine and creek making soil the principal reservoir for the deposition of elements delivered to the environment."

**Figure 8.** Entrance to level 4 (Fargo level). View to the east. Water impounded behind colluvium slough is discharging in foreground.

Water samples taken by DGER at both locations exceed Washington State standards for drinking water and chronic effects to aquatic life for cadmium, copper, and zinc by several levels of magnitude (see Table 6). The discharges should be considered extremely toxic to humans. We expected to see anomalous arsenic content in these samples as a result of the recent public health issues raised about the area around the former Alder mill near Twisp. However, no arsenic was detected in the level 3 discharge, and analysis of level 4 discharge showed 10 $\mu$g/L. No arsenic was detected in the level 4 grab sample of dump material.

Analyses and field observations conducted by Raforth (Raforth and others, 2000) at the level 4 impoundment agree with our 2002 investigation. Results of sampling done upstream and downstream of the mine area in Alder Creek are shown in Table 6. DGER personnel looked for benthic macroinvertebrates without success at a point in Alder Creek immediately west of the mine site. Peplow (1999) conducted a more thorough evaluation of this indicator of water quality: "Surber samples were collected to compare the community structure of benthic macroinvertebrates (BMI) below the mine with samples from reference sites not impacted by the mine [above in Alder Creek and Poorman Creek as a reference stream]. The density and diversity of BMI were less below the mine than above.... A strong relationship was established between the discharge of metal-laden mine waste from the abandoned Alder Mine, elevated levels of Cd, Se, and Zn in Alder Creek, and the condition of the benthic community of Alder Creek." Peplow's thesis provides significant data of metal concentration in Alder Creek in terms of geographical distribution [upstream and down], and as a function of time [high flow 6/30/98 through low flow 9/5/98].

### Milling Operations

Most of the 26,000 tons mined between 1939 and 1942 were shipped to the Tacoma smelter via rail from Pateros. This amounted to 330 carloads of run-of-mine ore and 38 carloads of concentrate processed at the Red Shirt mill near the Twisp airport. In 1950/51, the Alder Gold-Copper Co. constructed a 300 tpd selective flotation mill southwest of Twisp. Approximately 60,000 tons of ore were mined and processed at this latter mill site between 1950 and the mine's closure in 1953 (DGER mine files). Alder Gold-Copper Co. has removed the mill. EPA and DOE have plans to mitigate the tailings impoundments (R. Roeder, DOE, written commun., 2004).

### Waste Rock Dumps

A veneer of waste rock covers almost the entire mine site west of the open pit hanging wall (Fig. 2) and continues around the north end for some distance. This material covers the original location of the level 2 portal and is so pervasive that we consider any attempt to reconstruct the undisturbed geologic units in this area as problematic. The open pit floor and walls are littered with talus accumulated since the last activity in 1953.

## GENERAL INFORMATION

**Name:** Alder mine

**MAS/MILS sequence number:** 0530470333

**Access:** two-wheel drive road

**Status of mining activity:** none

**Claim status:** As of January 2004, property held by the Alder Gold Copper Co., Portland, Oregon, consisted of three patented claims (Twisp Lode, Methow Lode, Alder Creek

**Figure 9.** Overview of level 4 adit, water discharge, and pond (pH 3.0).

**Figure 10.** Remains of the ore-loading bunker. View to the north.

**Table 1.** Mine features. – – –, no data; **, data from DGER mine map file

| Description | Condition | Fenced (yes/no) | Length (feet) | Width (feet) | Height/depth (feet) | True bearing | Elev. (feet) | Decimal longitude | Decimal latitude |
|---|---|---|---|---|---|---|---|---|---|
| open pit | talus material caving from footwall and hanging wall; 6 x 6-foot raise holes through at pit bottom next to top of stope or drift | no | 640 | 120 | 150 | N25°W | 3578–3728 | 120.15949 | 48.32235 |
| level 2 adit | caved | no | 600 | – – – | – – – | N60°E** | 3578 | – – – | – – – |
| level 3 adit (Methow) | open, condition unknown; 10 inches of standing water behind colluvium at portal | no | 1000 | 5 | 7 | N60°E | 3478 | 120.15997 | 48.32152 |
| level 4 adit (Fargo) | open, bad air exhausting, caving inside, toxic water discharge | no | 1500 | 5 | 7 | S85°E | 3370 | 120.16046 | 48.32337 |

Lode) and homestead entry 247, 17.42 acres. Contact the Okanogan County Assessor's Office for additional information. There are no longer any unpatented claims attached to the mine.

**Current ownership:** Alder Copper Gold Co., Portland, Ore.

**Surrounding land status:** Okanogan National Forest

**Location and map information:**

| Mine name | County | Mine location | Decimal latitude | Decimal longitude | 1:24,000 quad. | 1:100,000 quad. |
|---|---|---|---|---|---|---|
| Alder | Okanogan | secs. 35, 36, T33N R21E | 48.32207 | 120.15797 | Twisp West | Twisp |

**Directions:** The mine is reached by following the Lookout Mountain road (USFS Road 200) southwest of Twisp for about 6 miles to elevation 3400 feet. The mine is visible to the east of Alder Creek from the road.

## MINE OPERATIONS DATA

**Type of mine:** underground and open pit

**Commodities mined:** copper, lead, zinc, silver, gold

**Geologic setting:** dacitic-andesitic metavolcanics of the Jurassic–Cretaceous Newby Group, probably deposited along or proximal to an island arc (Bunning, 1990)

**Ore minerals:** chalcopyrite, chalcocite, malachite, azurite, sphalerite, gold, galena

**Non-ore minerals:** quartz, pyrite, arsenopyrite

**Period of production:** 1902–1910, 1939–1941, 1950–1953

**Development:** open pit excavation and more than 3000 feet of drifts and stopes

**Production:** 86,634 tons of ore that included 15,000 ounces of gold, 19,000 ounces of silver, 1.3 million pounds of copper, 38,000 pounds of lead, and 648,000 pounds of zinc

**Mill data:** Alder Gold Copper Co. constructed a selective flotation mill near the Twisp city limits in 1950. The mill was used until 1953. The owner has dismantled it. EPA plans remedial work on the lower tailings impoundment (R. Roeder, DOE, written commun., 2004). DOE has dismantled the nearby Red Shirt mill, formerly leased by Methow Gold for milling low-grade ore from the Alder mine circa 1939–1942.

## PHYSICAL ATTRIBUTES

**Features:** see Table 1

**Materials:** none

**Machinery:** none

**Structures:** none

**Waste rock dumps, tailings, impoundments, highwalls, or pit walls:** Waste rock dumps in excess of 50,000 cubic yards; no mill tailings on site; water impounded behind level 3 adit, possibly behind levels 2 and 4. Near-vertical highwall at open pit is approximately 150 feet high.

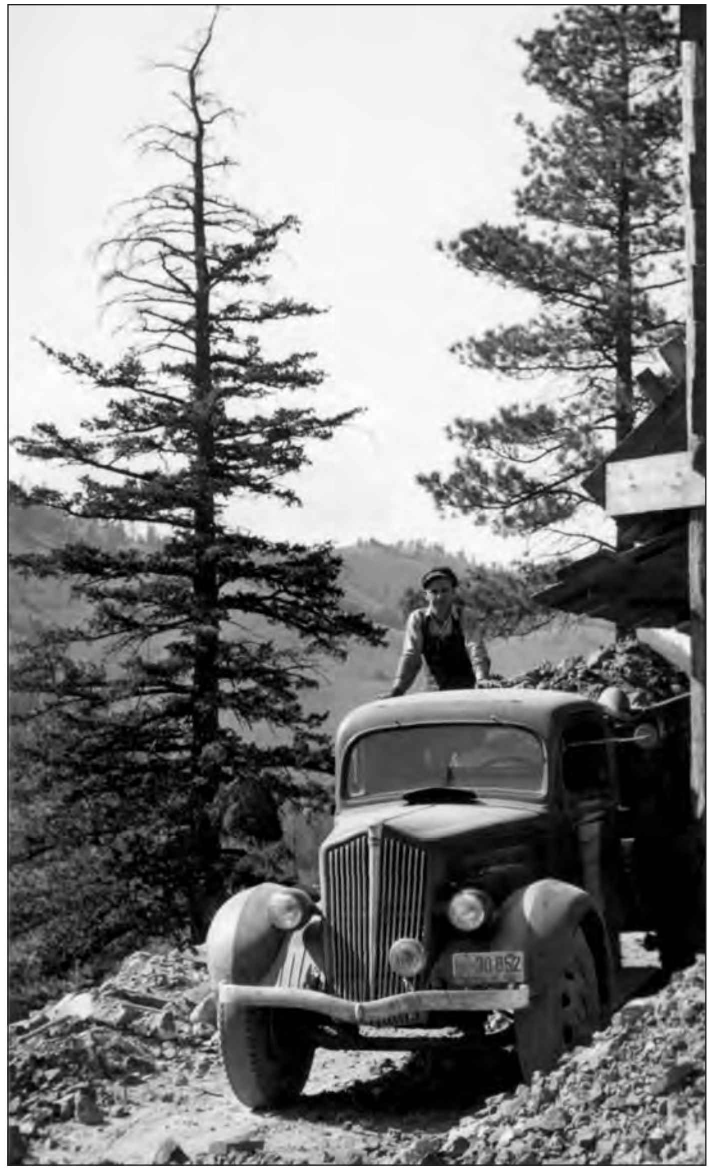

**Figure 11.** Loading ore at bunker circa 1940. Photo from Methow Gold Co.

**Table 2.** 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; **, tailings from the Alder mine processed at the Red Shirt mill 1939–1942. Analyses in bold indicate levels that exceed standards shown in Table 3

| Sample location | Arsenic | Cadmium | Copper | Iron | Lead | Mercury | Zinc | Gold |
|---|---|---|---|---|---|---|---|---|
| level 4 (Fargo) dump grab sample | 8.1 | <1.0 | **363** | 39,400 | 164 | – – – | 137 | – – – |
| Red Shirt mill tailings at DOE well site** | **29.8** | <1.0 | **173** | 24,600 | 28.4 | – – – | 207 | – – – |
| Red Shirt mill tailings 100 feet east of DOE well site** | **21.6** | <1.0 | **130** | 18,300 | 21.6 | – – – | 126 | – – – |

**Table 3.** 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 mg/kg. Levels shown for unrestricted land use. Levels for silver, gold, and iron are not specified

| Metals | Arsenic III | Cadmium | Copper | Lead | Mercury | Zinc |
|---|---|---|---|---|---|---|
| mg/Kg | 20 | 25 | 100 | 220 | 9 | 270 |

**Analysis of tailings and dumps:** see Tables 2 and 3

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

**Reclamation activity:** none

## VEGETATION

Sparse fir, willow, grass, algae, and stressed pine at level 4 portal. Waste rock dumps are barren, as is the open pit excavation. Xeric landscape.

## WILDLIFE

See Table 4

## WATER QUALITY

**Surface waters observed:** Alder Creek

**Proximity to surface waters:** 1000 feet

**Domestic use:** cattle grazing; pond at level 4 adit used by cattle and wildlife

**Acid mine drainage or staining:** yes

**Water field data:** see Table 5

**Surface water migration:** seasonal discharge from portal of level 4

**Figure 12.** Site of water sample at level 4 (Fargo level) adit (pH 3.0). View to the east.

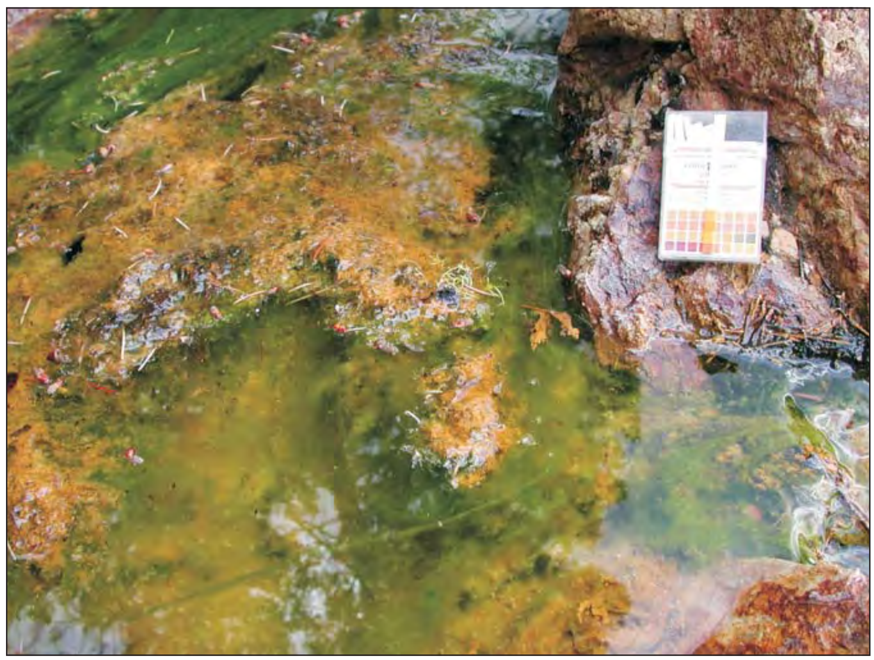

**Figure 13.** Algae growth in discharge from level 4 adit.

**Table 4.** Bat information

| Opening | Aspect | Air temp. at portal | Air flow: exhaust | Air flow: intake | Multiple interconnected openings | Bat evidence |
|---|---|---|---|---|---|---|
| Level 3 portal | SW | 70°F | yes, sulfurous | | yes | no |
| Level 4 portal | NW | 70°F | yes, sulfurous | | yes | no |

## ACKNOWLEDGMENTS

The authors thank our editor Jari Roloff for helpful suggestions on the layout and content of this report. Additional appreciation goes to USFS Region 6 personnel Bob Fujimoto and Dick Sawaya and Bob Raforth of the Washington State Department of Ecology.

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**Table 5.** Surface water field data. *, data collected by Robert L. Raforth, Washington Department of Ecology, Water Quality Division (Raforth and others, 2000). – – –, no data

| Description | Flow (feet/second) | Conductivity ($\mu$S/cm) | pH | Bed color | Temp. (°F) | Elev. (feet) | UTM N | UTM E |
|---|---|---|---|---|---|---|---|---|
| Level 3 portal | 1 | 1400 | 4.4 | copper salts precipitate | 45 | 3578 | 710524 | 535594 |
| Level 4 portal | 4 | >2000 (limit of instrument) | 3.0 | orange | 70 | 3370 | 710480 | 535614 |
| Alder Creek, upstream, high flow* | 45 | 673 | 8.0 | – – – | 46 | – – – | – – – | – – – |
| Alder Creek, middle high flow* | – – – | 2650 | 4.9 | – – – | 41 | – – – | – – – | – – – |
| Alder Creek, downstream, high flow* | 900 | 578 | 8.1 | – – – | 45 | – – – | – – – | – – – |
| Alder Mine, north adit (level 4)* | – – – | 3060 | 3.5 | – – – | 43 | – – – | – – – | – – – |
| Alder Creek, upstream, low flow* | 5 | 739 | 8.3 | – – – | 40 | – – – | – – – | – – – |
| Alder Creek, middle downstream, low flow* | 45 | 782 | 6.9 | – – – | 41 | – – – | – – – | – – – |
| Alder Creek, downstream, low flow* | 100 | 642 | 8.4 | – – – | 45 | – – – | – – – | – – – |
| Alder Mine, north adit (level 4)* | – – – | – – – | – – – | – – – | – – – | – – – | – – – | – – – |

**Table 6.** Surface water analysis. Metal concentrations are $\mu$g/L; hardness is in mg/L. ≤ 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; *, data collected by Robert L. Raforth, Washington Department of Ecology, Water Quality Division (Raforth and others, 2000). **, standards for these metals are hardness dependent. Conversion formulae are shown in http://www.ecy.wa.gov/pubs/wac173201a.pdf. Standards calculated for hardness values specific to Part 1 below are shown in Appendix B. Numbers in bold indicate analyses that exceed one or more of the water standards shown in Part 3 below

**PART 1: ANALYSIS BY USEPA METHOD 6010, INDUCTIVELY COUPLED PLASMA**

| Sample location | Arsenic | Cadmium | Copper | Iron | Lead | Mercury | Zinc | Hardness |
|---|---|---|---|---|---|---|---|---|
| Level 3 adit (Methow) | <10.0 | **1330** | **32,400** | 759 | 4 | – – – | **92,200** | – – – |
| Level 4 adit (Fargo) | 10.2 | **32,900** | **11,500** | 4910 | **146** | – – – | **203,000** | 1430 |

**PART 2: ANALYSIS BY USEPA METHOD 6020, INDUCTIVELY COUPLED PLASMA/MASS SPECTROMETRY**

| Sample location | Arsenic | Cadmium | Copper | Iron | Lead | Mercury | Zinc | Hardness |
|---|---|---|---|---|---|---|---|---|
| Alder Creek upstream, high flow* | <1.5 | <0.04 | 0.8 | 62 | 0.08 | <0.002 | 1.9 | 365 |
| Alder Creek middle, high flow* | – – – | – – – | – – – | – – – | – – – | – – – | – – – | – – – |
| Alder Creek downstream, high flow* | <1.5 | 9.5 | 3.0 | 40 | 0.07 | <0.002 | 484 | 298 |
| Alder Mine north adit, high flow* [level 4 adit, Fargo] | 3.5 | **3980** | **20,800** | 18,500 | **414** | <0.002 | **321,000** | 1430 |
| Alder Creek, upstream, low flow* | 1.3 | <0.02 | 0.9 | – – – | 0.02 | 0.0023 | 0.93 | 424 |
| Alder Creek, middle, low flow* | 0.9 | 2.2 | 3.9 | – – – | 0.17 | <0.002 | 289 | 387 |
| Alder Creek, downstream, low flow* | 1.0 | 2.6 | 1.0 | – – – | 0.06 | <0.002 | 116 | 354 |

**PART 3: 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

We recorded observations and measurements in the field. Longitude and latitude were recorded in NAD83 decimal degree format. Literature research provided data on underground development, which was verified in the field when possible.

All water samples were collected as simple grab samples in pre-cleaned 500 mL HDPE bottles with preservative and kept on ice for transport to Sound Analytical Services, Inc. (SAS). Soil samples from dumps or tailings were taken from subsurface material and double bagged in polyethylene. Chain of custody was maintained.

Water and soil samples were analyzed for arsenic, cadmium, copper, iron, lead, and zinc by inductively coupled plasma/mass spectrometry (ICP/MS) following USEPA Method 6010. Samples were analyzed for mercury by cold vapor atomic absorption (CVAA), USEPA Method 7470 (water), and Method 7471 (soil).

Holding times for the metals of interest were observed (28 days for mercury, 180 days for other metals). 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 III+, 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

WAC 173-201A. Chronic standard ($\mu$g/l). Hardness data from Robert L. Raforth (Wash. Dept. of Ecology, Water Quality Divn., written commun., 2003)

| Sample location | Hardness (mg/l) | Cd ($\mu$g/l) | Cu ($\mu$g/l) | Pb ($\mu$g/l) | Zn ($\mu$g/l) |
|---|---|---|---|---|---|
| Alder Level 4 adit (Fargo) | 1430 | 7.3 | 110.2 | 38 | 104.5 |