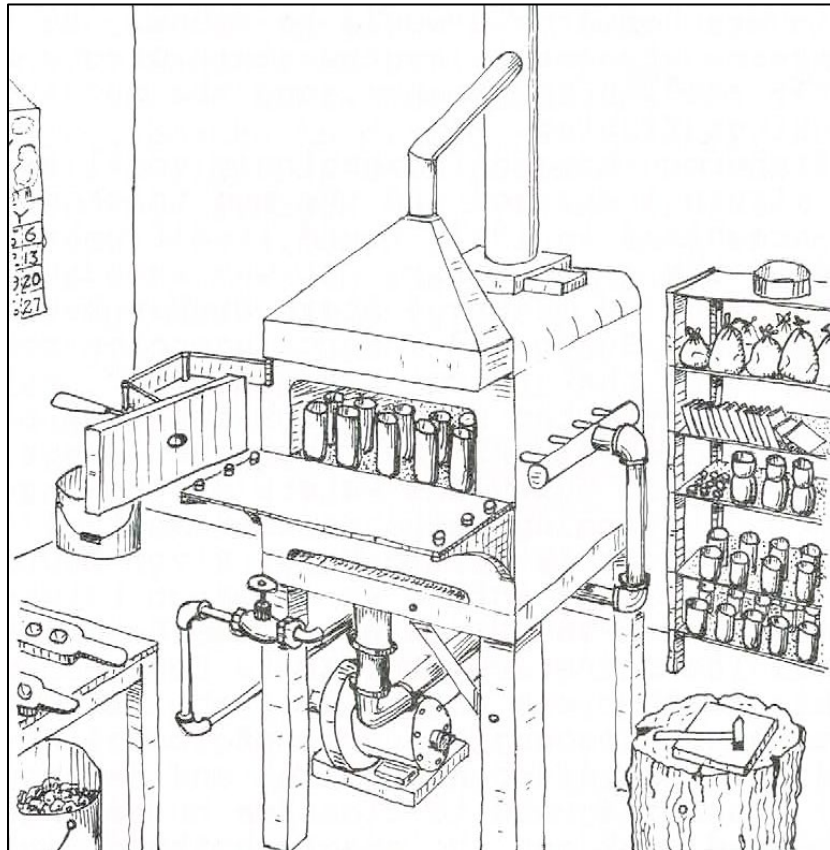


State of Oregon
Oregon Department of Geology and Mineral Industries
Ruairi J. Day-Stirrat, State Geologist

DIGITAL DATA SERIES MILO-4

MINERAL INFORMATION LAYER FOR OREGON, RELEASE 4 (MILO-4)

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2026

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WHAT'S IN THIS REPORT?

MILO-4 is a geospatial database that stores and manages information regarding Oregon's mineral occurrences, prospects, and mines. The database is the primary way the state of Oregon extracts, researches, and displays available historical mining and mineral resource information at local to statewide scales.

Cover image: Sketch of an early DOGAMI fire assay furnace. Credit: Ralph S. Mason, former State Geologist of Oregon, 1977.



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GEOGRAPHIC INFORMATION SYSTEM (GIS) DATA

*See the digital publication folder for files. Geodatabase is Esri® version 10.7 format.
Metadata is embedded in the geodatabase and is provided as separate.xml format files.*

MILOv4.gdb:

Feature dataset: MineralInformation

feature class:

MILO

Feature class:

AssayPointLocations

LargeFormatMapPoints

Tabular data:

AssayReturns

CountyMineRecords

LargeFormatMaps

Relationship classes:

AssayReturnsRC

CountyMineRecordsRC

LargeFormatMapsRC

Metadata:

MILO.xml

LargeFormatMapPoints.xml

AssayPointLocations.xml

AssayReturns.xml

CountyMineRecords.xml

LargeFormatMaps.xml

UNITS OF MEASUREMENT

The intended audience for this report is the government, industry, academia, and the public. Therefore, we selected U.S. Customary units as the primary units. A conversion table for U.S. Customary units to SI (International System) Metric units is included for easier conversion where needed.

SI Metric to U.S. Customary Units			
	Multiply	By	To obtain
length:	millimeter (mm)	0.039	inch (in)
	centimeter (cm)	0.394	inch (in)
	meter (m)	3.281	foot (ft)
	meter (m)	1.094	yard (yd)
	kilometer (km)	0.621	mile (mi)
area:	square kilometer (km ²)	0.386	square mile (mi ²)
volume:	cubic meter (m ³)	35.315	cubic ft (ft ³)
	cubic meter (m ³)	1.308	cubic yard (yd ³)
	cubic kilometer (km ³)	0.24	cubic mile (mi ³)
mass	kilogram (kg)	2.205	pound (lb)
	gram (g)	0.035	ounce (oz)
	metric ton	1.102	US ton

U.S. Customary Units to SI Metric Units			
	Multiply	By	To obtain
length:	inch (in)	25.4	millimeter (mm)
	inch (in)	2.54	centimeter (cm)
	foot (ft)	0.305	meter (m)
	yard (yd)	0.914	meter (m)
	mile (mi)	1.609	kilometer (km)
area:	square mile (mi ²)	2.59	square kilometer (km ²)
volume:	cubic ft (ft ³)	0.028	cubic meter (m ³)
	cubic yard (yd ³)	0.765	cubic meter (m ³)
	cubic mile (mi ³)	4.168	cubic kilometer (km ³)
mass	pound (lb)	0.454	kilogram (kg)
	ounce (oz)	28.350	gram (g)
	US ton	0.907	metric ton

EXECUTIVE SUMMARY

The Mineral Information Layer for Oregon, release 4 (MILO-4), is a geospatial database that stores and manages information regarding Oregon's mineral occurrences, prospects, and mines. It is the primary way the state of Oregon extracts, researches, and displays available historical mining and mineral resource information. MILO-4 lists 24,664 mineral occurrences, prospects, and mines, containing information for commodities, including metals (elements and metallic oxides), industrial minerals (nonmetallic minerals and materials, including gemstones), mineral fuel (coal and oil shale), and aggregate (sand, gravel, and stone). Early versions of MILO (MILOC, MILO93, MILO-2) established the dataset as a statewide tabular and spatial mineral database that linked mineral occurrences, prospects, and mines with available commodity information, added geospatial capabilities, and made the data easily accessible on the Oregon Department of Geology and Mineral Industries (DOGAMI) website. MILO-3 significantly enhanced the usability of MILO, adding capabilities to browse geography and discover and cross-reference individual, post-1860s DOGAMI mining collections by spatially linking published literature, historical mining documents, and large-format maps with mineral occurrences, prospects, and mines statewide. MILO-4 continues the enhanced-usability heritage of earlier versions by adding 1,348 new mineral occurrences, prospects, and mines. It adds a new feature class to organize, spatialize, and search 15,405 analytical results obtained from DOGAMI's in-house fire assay, chemical, and spectrograph laboratories which operated between 1937 and 1985.

MILO-4 is the definitive source of Oregon's mineral background information and answers the fundamental question: ***Where are mineral resources found in Oregon?*** It also provides key information needed to: 1) build a comprehensive understanding of geologic and mineral system relationships across Oregon using geospatial analysis; 2) determine probable exploration targets within geologically permissive areas and guide efforts to locate undiscovered resources; 3) highlight areas that may have hazardous abandoned mine land features and inform land-use decisions; and 4) identify areas of mineralized rock where undesirable health outcomes are known to be associated with long-term exposure to naturally occurring elements, minerals, and materials that may pose health hazards through their physical properties.

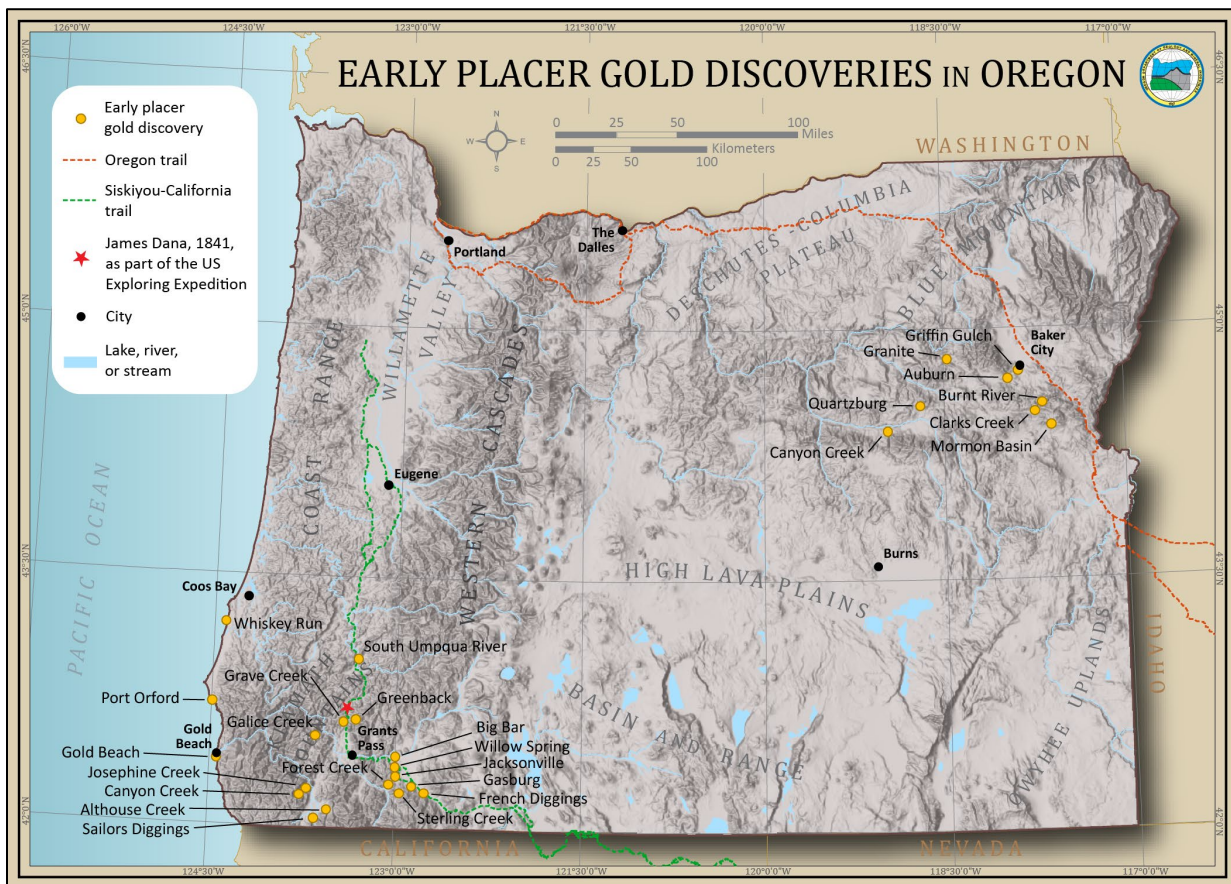
Oregon has a rich mineral exploration and mining heritage dating back to the mid-19th century. Gold and silver mining were the foundation of Oregon's early mining industry, with major fields focused in the Coast and Klamath Mountains of southwest Oregon, the Western Cascades, and the Blue Mountains of eastern Oregon. Mining of traditional high-value metals was replaced after World War II by the production of other metals, aggregate, and industrial minerals. In the 21st century, worldwide demand for clean energy technology is growing. Federal strategies aim to increase economic prosperity and support the national security and energy independence of the United States by building a resilient supply chain of domestic critical minerals and materials needed for modern technologies. Spatial analysis of MILO-4 commodity data, cross-referenced with published data, historical mine records, and legacy mine maps shows that 29 critical minerals identified by the U.S. Geological Survey and U.S. Department of Energy are present in Oregon. Fourteen additional elements, not listed as commodities in MILO-4, are reported with quantitative and/or qualitative results in analytical data compiled from DOGAMI's fire assay, chemical, and spectrograph laboratories. Making legacy mining information available in a digital format like MILO-4, is a cost-effective first step toward a comprehensive statewide evaluation of Oregon's mineral resource potential.

1.0 INTRODUCTION

1.1 Cataloging Oregon’s Exploration and Mining Heritage

Oregon has a rich heritage of mineral exploration dating back to 1841, with the first recognition of the prospect of gold in the territory by members of the United States Exploring Expedition of 1838 to 1842, led by U.S. Naval Lieutenant Charles Wilkes. On September 23, 1841, noted mineralogist James Dwight Dana, as part of the expedition traveling the Siskiyou-California Trail between the Oregon Country’s Willamette Valley and San Francisco Bay in Mexican California, observed quartz veins midway between the South Fork of the Umpqua and Rogue rivers (**Figure 1-1**; Wilkes, 1845, p. 231). Dana (1849, p. 637 to 638) noted that “the talcose and allied rocks of the Umpqua and Shasty (Rogue River) districts resemble[d] in many parts the gold-bearing rocks of other regions”. Following California gold discoveries in 1848 and sufficiently impressed by the geology of the area, Dana expressed little doubt that “the gold district will be found to have very wide limits” and future discoveries would follow in southwest Oregon (Dana, 1849, p. 638). Remarkably, the area of Dana’s first observation of quartz veins in southwest Oregon laid within 5 miles (mi) of what would become the Greenback Mine in 1897, regarded as the largest producing lode gold mine in southwest Oregon in the early 1900s (**Figure 1-1**; Diller, 1914, p. 31).

Figure 1-1. Early placer gold discoveries in Oregon. Map cartography by Jon J. Franczyk.



Early placer gold encounters in southwest Oregon were motivated by the discovery of the rich Yreka Dry Diggings on California's Shasta River in 1851, a decade after Dana's first geologic observations in the region. Rich placer deposits were reported on tributaries of the Illinois River in 1851 and 1852, including finds along Josephine, Canyon, and Althouse creeks, and at Sailor Diggings on East Fork Illinois River (**Figure 1-1**; Raymond, 1870; DOGAMI, 1942b; Brooks and Ramp, 1968). Other notable finds in southwest Oregon, adjacent to the Siskiyou-California Trail, were made between 1851 and 1859 on the South Umpqua River, Grave Creek, Galice Creek, Rogue River at Big Bar, Willow Spring, Jacksonville, Forest Creek, Gasburg, Sterling Creek, and French Diggings (**Figure 1-1**; Raymond, 1870; Brooks and Ramp, 1968). Coastal prospects began to be worked between 1851 and 1853 at several well-known sites at Gold Beach, Port Orford, and Whiskey Run (**Figure 1-1**; Raymond, 1870; Brooks and Ramp, 1968).

In 1861 the search for gold expanded to northeast Oregon, where placers at Griffin Gulch, Auburn, and the Burnt River began to be worked along the Oregon Trail (**Figure 1-1**; Raymond, 1870; Lindgren, 1901; Brooks and Ramp, 1968). Early in 1862, the historically most productive placer gold deposits were discovered 80 mi southwest of Auburn at Canyon Creek, near present-day John Day-Canyon City (**Figure 1-1**; Brooks and Ramp, 1968; Brooks, 2007). At the close of 1863, most placer districts in northeast Oregon had been worked and mining camps assembled at Canyon City, Auburn, Quartzburg, Granite, Clarksville, and Mormon Basin (**Figure 1-1**; Brooks, 2007).

These initial strikes of gold, and numerous additional discoveries, were the reason for the emigration to and population of both northeastern and southwestern Oregon—the two regions where the principal gold fields were found (**Figure 1-1**; Brooks and Ramp, 1968). Since the earliest days of statehood in 1859, gold, silver, other minerals, and the geologic landscape itself have remained valuable natural resources in the state (Spreen, 1939; DOGAMI, 1939, unpublished, 1940, 1941, 1942a, b, c; Brooks and Ramp, 1968; Brooks, 2007). The Oregon Legislature, recognizing the importance of the mining industry to Oregon's well-being and prosperity, created the Oregon Bureau of Mines and Geology in 1911. Between 1911 and 1922 the Oregon Bureau of Mines and Geology operated at Oregon Agricultural College (now Oregon State University), publishing 14 bulletins describing Oregon's geology and mineral occurrences (**Figure 1-2**). In 1923 the Oregon Bureau of Mines and Geology was disbanded due to a lack of funding, and all files were turned over to the college.

In 1937, more than seven years into the Great Depression, the Oregon Legislature created the Oregon Department of Geology and Mineral Industries (DOGAMI). Seeking renewed opportunities for employment and mineral development, DOGAMI was assigned statutory duties to study the mineral resources of the state, provide information to the public about those resources, and support and promote mineral resource exploration and mining activities (Oregon Revised Statutes, 2023, i.e., ORS 516.030 and 516.035). As part of DOGAMI's organic statutes, the agency provided free or subsidized fire assay, chemical, and spectrograph analyses between 1937 and 1985, offered grubstake funds to prospectors, tested Oregon mineral occurrences to determine the best ore processing steps and identify new markets, and published mineral-resource assessments. Oversight of the state's mineral production, minimizing impacts of mineral extraction, and enhancing reclamation of mined lands became key parts of DOGAMI's statewide mineral portfolio in 1972 with the creation of the Mineral Land Regulation and Reclamation Program (MLRR; see Oregon Revised Statutes, 2023, i.e., ORS 517).

DOGAMI and its predecessor, the Oregon Bureau of Mines and Geology, have collected and maintained mine-related documents created from the 1860s to the present day. These documents include commodity files, historical mine maps, letters, reports from mining companies and individuals, analytical reports, mining and minerals-related data, and publications. In recent years, many of these paper mining records

have been transferred to digital formats and preserved on the DOGAMI website, making them more accessible to a larger audience (<https://www.oregon.gov/dogami/milo/Pages/ohmi.aspx>).

An essential component of DOGAMI's statutory mission is advanced with Release 4 of the Mineral Information Layer for Oregon (MILO-4). MILO-4 is a geospatial database system that stores and manages Oregon's mining-resource information and spatially displays where mineral resources are found. It is the primary way the state of Oregon extracts, researches, and displays available historical mining and mineral resource information. The dataset contains information for the following commodities: metals (elements and metallic oxides), industrial minerals (nonmetallic minerals and materials, including gemstones), mineral fuel (coal and oil shale), and aggregate (sand, gravel, and stone) (Figure 1-3). MILO-4 continues the enhanced-usability heritage of earlier MILO versions by displaying 24,664 mineral occurrences, prospects, and mines in Oregon, linked with commodity information, 4,587 historical mining documents, and 995 large-format maps. An additional feature class added to this release organizes 15,405 fire assay, chemical, and spectrograph records from DOGAMI's in-house laboratories into a spatially searchable tabular format. The MILO-4 geodatabase and this report are accompanied online by a Geographic Information System (GIS) based interactive web map with filtering capacity (<https://gis.dogami.oregon.gov/maps/milo/>).

Figure 1-2. Oregon Bureau of Mines and Geology field geologists conducting a mineral resource evaluation in Oregon circa 1922.

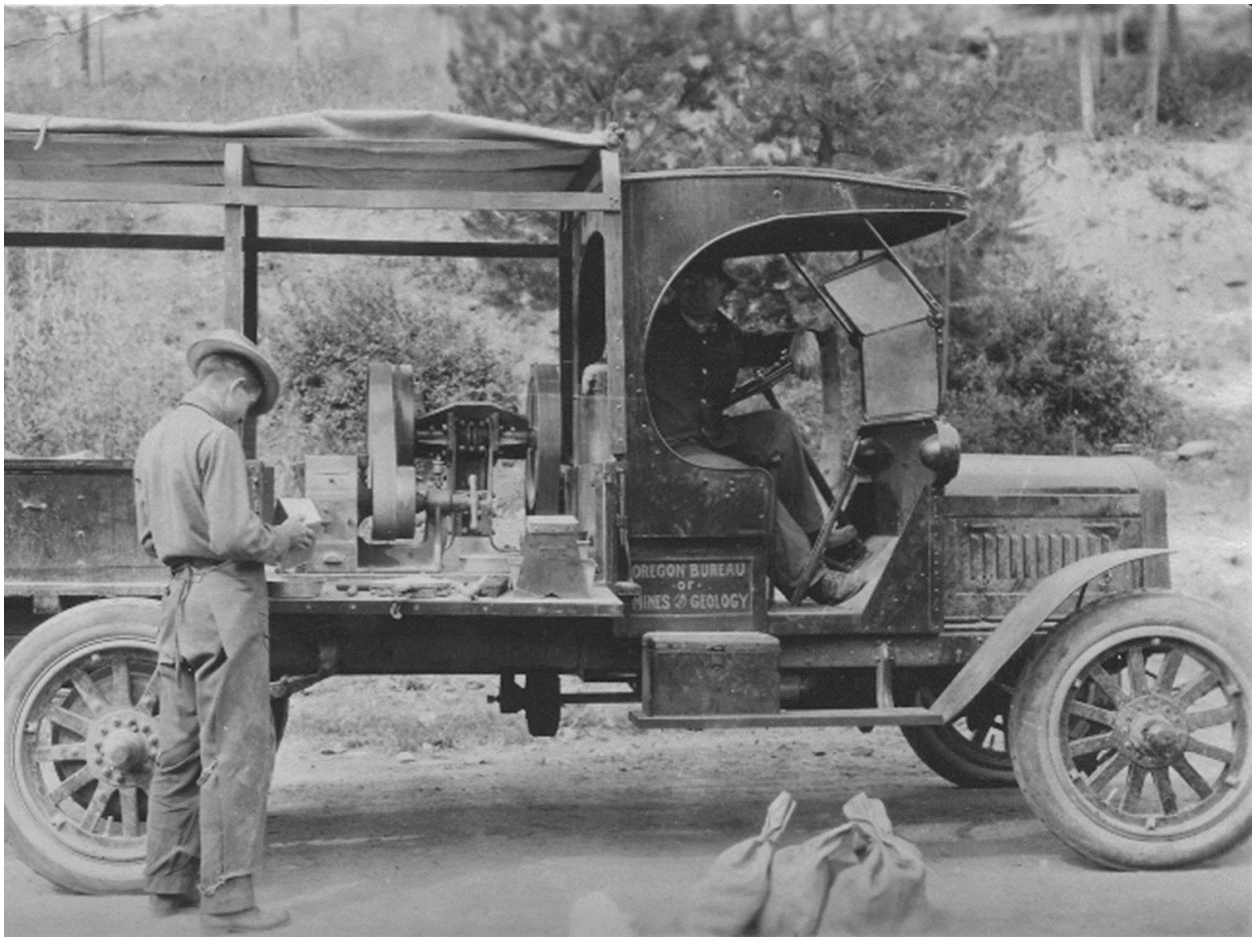
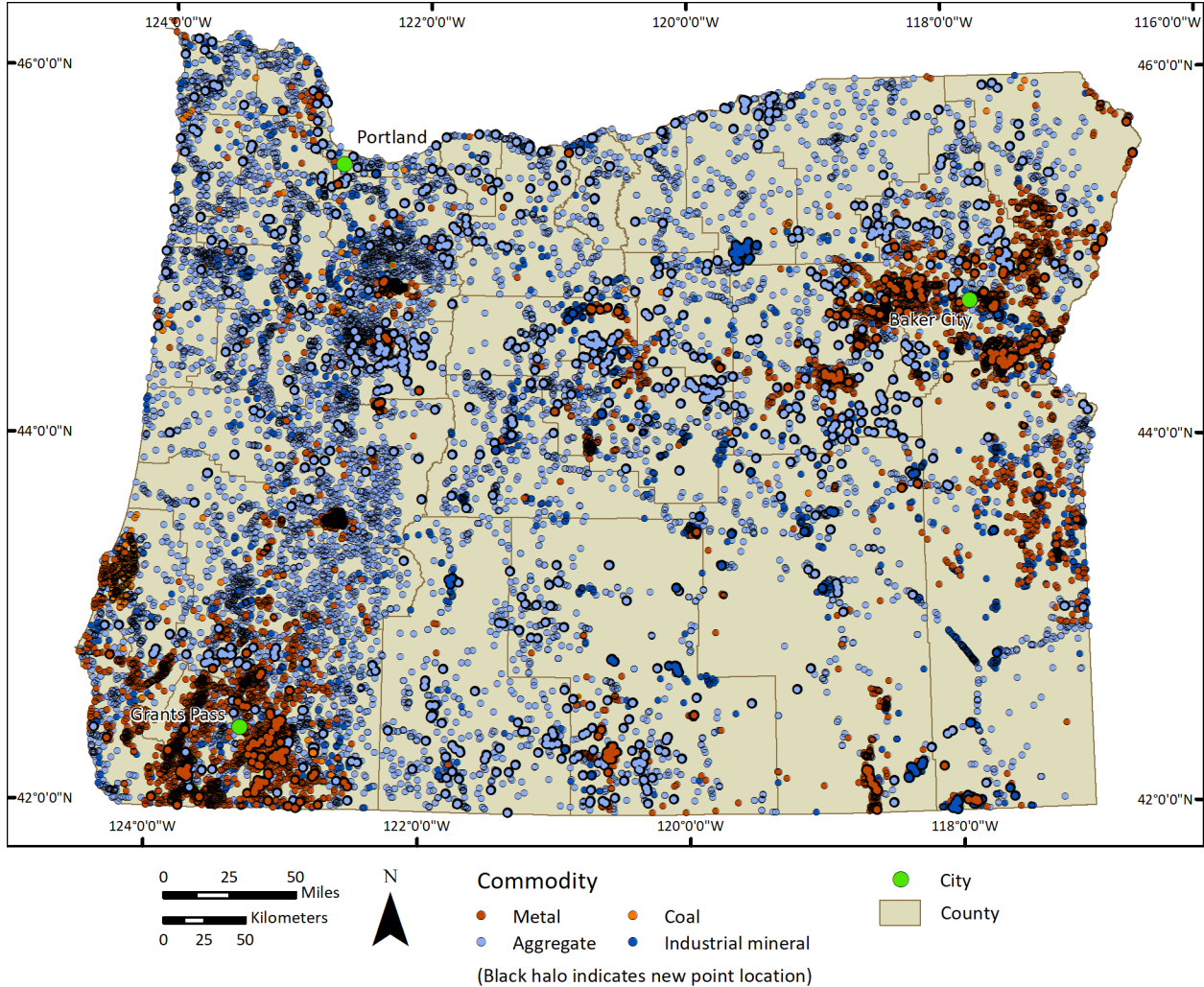


Figure 1-3. Map showing the 24,664 mineral occurrence, prospect, and mine points in Oregon and included in MILO-4. Each point includes information about its site name, location, mining district, commodities, rock type, and other historical mining records. MILO-4 points are colored according to commodity (aggregate, coal, industrial mineral, metal). The new mine and prospect points added to MILO-4 are highlighted by a black halo. Map cartography by Jon. J. Franczyk.



1.2 History of the Mineral Information Layer for Oregon

MILO was first created to provide the state of Oregon with a mineral resource database (Gray, 1991, 1993). The predecessor and foundation for MILO was a 1991 database version referred to as the Mineral Information Layer for Oregon by County (MILOC; Gray, 1991, 1993). MILOC was created in dBASE III+ format. Information for location, commodity, and other data for 7,899 mineral occurrences, prospects, and mines statewide was included. MILOC was later converted to a GIS format and renamed MILO-1 (i.e., MILO Release 1). The GIS-based MILO-1 database was not released to the public.

Release 2 (MILO-2) was published in 2010 establishing an updated statewide tabular and spatial mineral database (Niewendorp and Geitgey, 2010). Drawing on the legacy of Oregon's available mineral-

related published and unpublished data, MILO-2: 1) added 13,202 mine and prospect sites; 2) linked mine-site locations with available commodity information; 3) added GIS capabilities allowing for spatial queries; and 4) made the data easily accessible online. MILO-2 listed 21,101 mineral occurrences, prospects, and mines (Niewendorp and Geitgey, 2010). The substantial increase in sites displayed in MILO-2 was chiefly the result of data extracted from several sources:

- The U.S. Geological Survey (USGS) Mineral Resources Data System (MRDS), Computerized Resources Information Bank (CRIB), and U.S. Bureau of Mines Mineral Industry Location Subsystem mainframe databases. The inclusion of these datasets resulted in the addition of ~700 records not presented in MILOC/MILO-1 (U.S. Geological Survey, 2005);
- Two unpublished datasets from the Oregon Department of Transportation (ODOT). These datasets listed aggregate sources and quality tests for ~2,000 sites not originally in MILOC/MILO-1; and
- Mining-related marks and symbols on maps (e.g., aggregate site[s], borrow pits, quarries, gravel pits, and mine/prospect site[s]) from the ~1,866 USGS 1:24,000-scale, 7.5-minute topographic quadrangle series covering Oregon. Visual inspection and heads-up digitizing of topographic quadrangle maps added nearly 9,000 sites to MILO-2.

Release 3 (MILO-3) advanced previous releases by adding 2,215 mine and prospect records and spatially linking scanned historical large-format mine maps (1,954 Adobe® Portable Document Format [PDF] files), mine records and reports (4,637 Adobe® PDFs), and published literature with mine and prospect points statewide (McClaghry and others, 2020; [Figure 1-4](#); see [Appendix Table 9-1](#)).

Integrating historic mine maps and records with mine sites in MILO-3 significantly enhanced a user's ability to browse geography, discover, and cross-reference individual DOGAMI mining collections. MILO-3 data were also migrated to a single geodatabase, conforming to the U.S. Geological Survey's (USGS) National Cooperative Geologic Mapping Program (NCGMP) GeMS, standard Version 2.7 (U.S. Geological Survey, 2020), and added new feature classes for the Oregon Geologic Data Compilation (OGDC-7; Franczyk and others, 2020; superseded by Darin and others, 2025; [Appendix Table 9-1](#)). DOGAMI has implemented the GeMS schema as the database standard for all geologic mapping and mineral inventory projects to meet NCGMP requirements, support the construction of standardized nationwide geologic content, and streamline future updates, data creation, and data maintenance.

Release 4 (MILO-4) lists 24,664 mineral occurrences, prospects, and mines; 1,348 points have been added beyond the 23,316 locations shown in MILO-3 ([Figure 1-3](#); McClaghry and others, 2020). The notable increase in sites displayed in MILO-4 is chiefly the result of data extracted from the following sources:

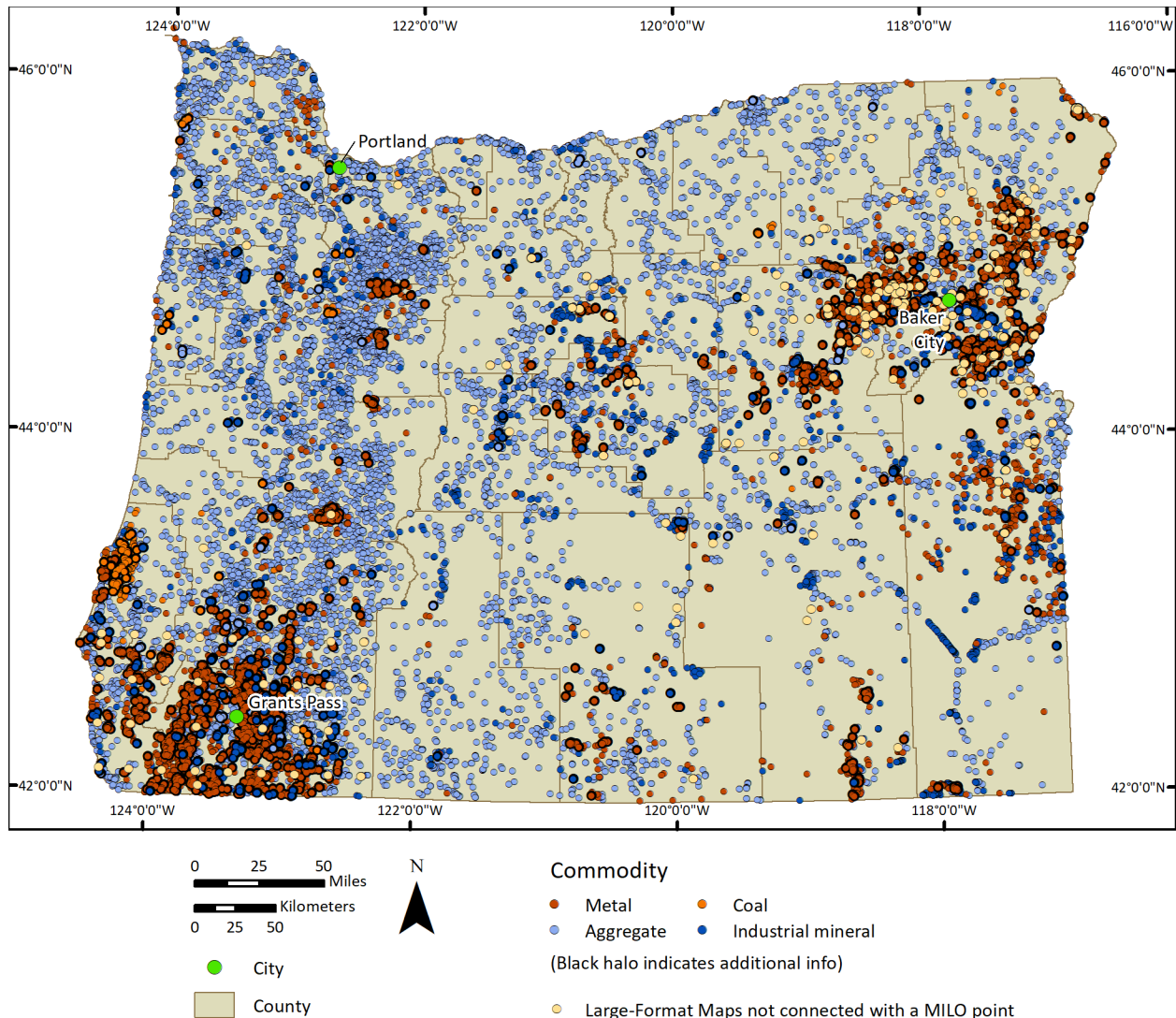
- Mining-related marks and symbols from Version 3.0 of the USGS_TopoMinesSymbols_24k_Points (Horton and San Juan, 2023)
- Visual inspection and heads-up digitizing of high-resolution 1-m lidar imagery for abandoned mine land features (e.g., adits, shafts, prospect pits, trenching) in and around the North Santiam, Quartzville, Blue River, and Bohemia mining districts in the Oregon Cascades ([Figure 1-3](#))
- USGS Mineral Resource Data System, MRDS-fUS41 dataset (U.S. Geological Survey, 2005)

The MILO-4 geodatabase has been modified to delete the MILO-3 column **OperatingStatus**, as it is not maintained. The **ElevationFeet** attribute was recalculated for the dataset with 3.2-ft lidar data where available, and secondarily with a 32.8-ft digital elevation model. The geometry for the **Latitude** and **Longitude** columns was recalculated for the entire point dataset. All points were attributed with up-to-date statewide geologic information using OGDC-8 of Darin and others (2025).

A new feature class named **AssayPointLocations** and database table **AssayReturns**, related through the **AssayReturns** relationship class has been added to MILO-4. It stores analytical results obtained from DOGAMI's in-house fire assay, chemical, and spectrograph laboratories between 1937 and 1985 (**Figure 1-4**). The feature class and database table include 15,405 individual scanned analytical records as PDF files. Records are located by township-range-section grid if the samples were collected from surveyed areas and by county and/or state of Oregon if the samples were obtained from areas not surveyed.

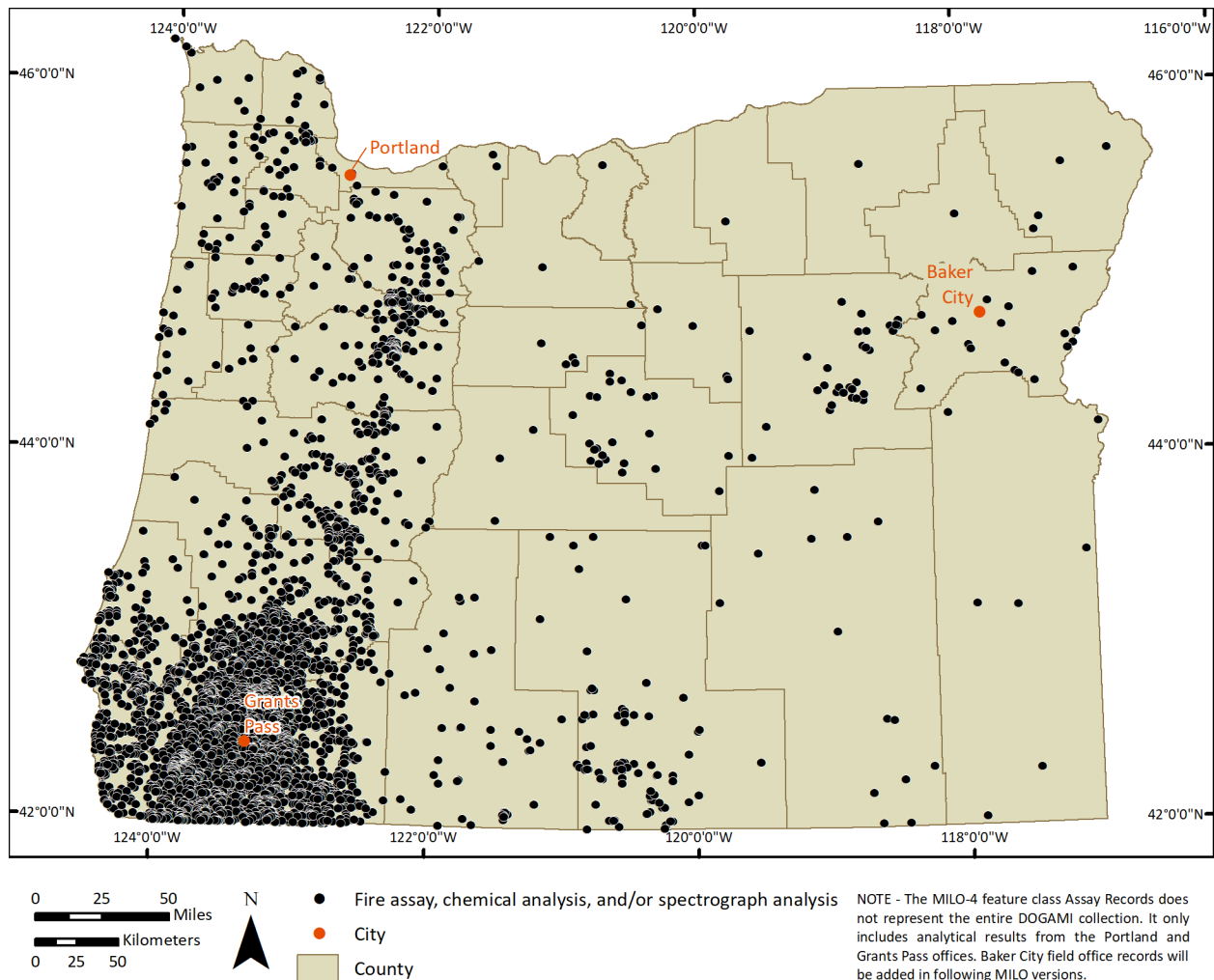
The data entries and analytical records (**AssayPointLocations**, **AssayReturns**) in MILO-4 only partially account for the entire DOGAMI collection and represent those records obtained through the Portland and Grants Pass (now closed) offices (**Figure 1-5**). Approximately 15,000 Baker City field-office records remain to be scanned, tabulated, and added to a future release of MILO.

Figure 1-4. Map showing MILO-4 mineral occurrence, prospect, and mine points associated with additional mine and map records in Oregon. Black halos show sites related to published and unpublished hardcopy mining maps, records, and documents. Tan points are locations of large-scale mine maps not related to a MILO point. Map cartography by Jon J. Franczyk.



Although the data for MILO-4 are statewide in extent, coverage varies from county to county (Figure 1-3). The breadth of this dataset makes it probable that some errors exist in the MILO-4 attribute table. However, internal quality control and assurance procedures have been employed to prevent duplications and omissions within the table attributes and between the databases compiled for it. Mine-site data presented in MILO-4 are subject to change as new data are obtained and are updated internally. MILO-4 supersedes all previous MILO versions, including MILOC (Gray, 1991), MILOC93 (Gray, 1993), MILO-2 (Niewendorp and Geitgey, 2010), and MILO-3 (McClaghry and others, 2020).

Figure 1-5. Distribution of 15,405 scanned, tabulated, and located DOGAMI fire assay, chemical, and spectrograph results in Oregon obtained through the Portland and Grants Pass offices and displayed in the feature class AssayPointLocations. Points are related to records in the database table AssayReturns through the AssayReturns relationship class. Map cartography by Jon J. Franczyk.



2.0 OREGON DOGAMI MINING RECORDS

2.1 Large-Scale Mine Maps and County Mining Records

The Oregon Historical Mining Information collection on the DOGAMI website hosts digital scans of published and unpublished hardcopy mining maps, records, and documents originally held in collections at the Portland, Baker City, and former Grants Pass offices. Hardcopy material was scanned and saved as Tagged Image File Format (tiff) files. Tiffs were then converted to PDF file format. Large-format maps in the DOGAMI collection include 1,468 maps and sketches, plans of underground workings, vertical sections, drill-hole maps, mining-claim plat maps, and regional mine-location maps (Figure 2-1, Figure 2-2). Large-format maps were digitized at the National Mine Map Repository in Pittsburgh, Pennsylvania, and by staff at the DOGAMI Baker City office between 2015 and 2018. Mining records in the DOGAMI collection include maps, letters, news clippings, photographs, and reports (Figure 2-3, Figure 2-4). Documents were scanned into single PDFs by mine site, between 2007 and 2010. This digital collection can be accessed by downloading the MILO-geodatabase accompanying this report (<https://pubs.oregon.gov/dogami/dds/p-MILO-4.htm>), using the MILO-4 interactive web map, or through DOGAMI's Oregon Historical Mining Information website page, where the collection is organized by county and district (<https://www.oregon.gov/dogami/milo/Pages/ohmi.aspx>).

Figure 2-1. Example large-format map in MILO-4. Geologic map of the No. 1 tunnel, Standard Mine, Grant County, Oregon. The No. 1 tunnel shown here corresponds to the lower part of Figure 3-2. Concentrations for gold, silver, copper, and cobalt are shown along the strike of the tunnel. An original draft of the map was created in 1926; it was redrawn in 1970.

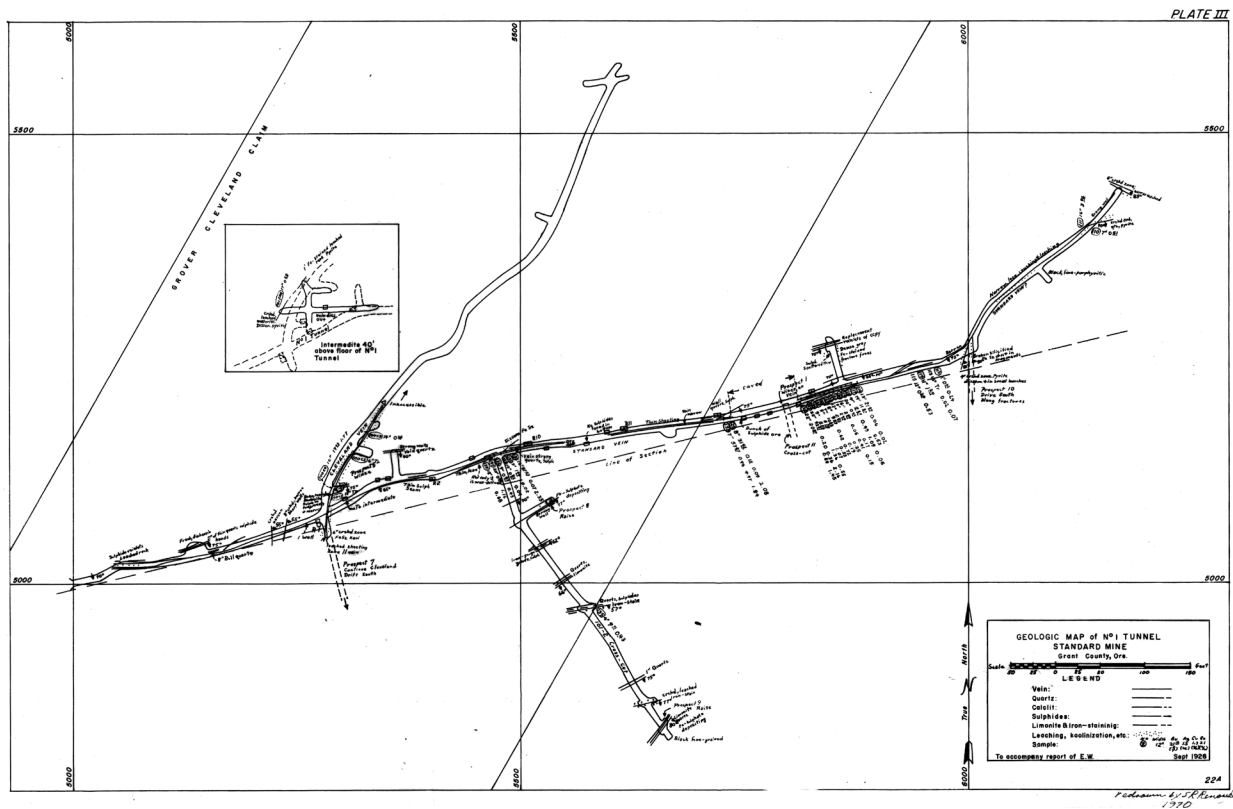


Figure 2-2. Example large-format map accessible in MILO-4. Map of a vertical section along the Standard Vein at the Standard Mine, Grant County, Oregon. The profile shows concentrations for occurrences of gold, silver, copper, and cobalt along tunnels. An original draft of the profile was created in 1926; it was redrawn in 1970.

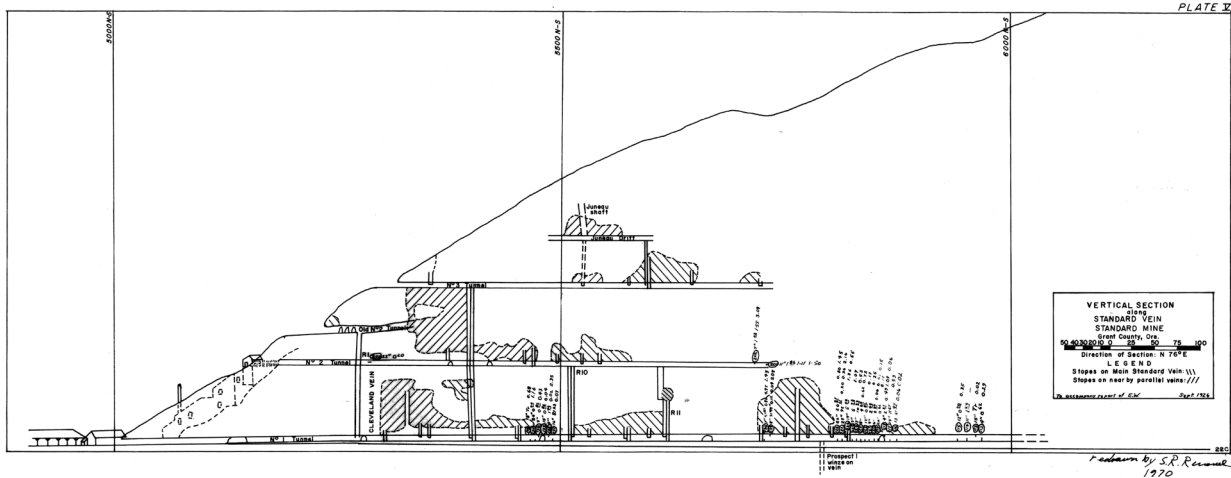


Figure 2-3. Example historical mining record accessible in MILO-4. Excerpt page from an August 3, 1958, DOGAMI memorandum describing the Standard Mine in the Quartzburg District of Grant County, Oregon.

State Department of Geology and Mineral Industries

1069 State Office Building
Portland 1, Oregon

Quartzburg District
Grant County

Standard Mine

Location: T. 12 S., R. 33 E., Section 12.

General: Ore originating from several places in the Standard Mine, but principally from a Mexican stoppe (underhand) on the lowest level, was milled during 1958 thru the mill belonging to the Standard Milling Company, Inc. Most of the time a bulk concentrate was made but for a while the ore was concentrated into two fractions. The fractional products consisted of a copper concentrate and a cobalt-gold concentrate, a general average for each of which is as follows:

Copper Concentrate

Copper - 27%
Gold - 3.0 ounces
Cobalt - .067%

Cobalt-Gold Concentrate

Cobalt - 15% plus
Nickel - 7% plus
Gold - 10.0 ounces plus
Copper - 0.10%

Approximately two tons of copper concentrates were recovered to one of cobalt. The ratio of concentration was 7:1 for the copper and 12 to 14:1 for the cobalt.

A flow sheet of the Standard Milling Company, Inc.'s mill is appended herewith. All information, both flow sheet and concentrate data, was furnished by Mr. Vernon Jacobson, M. E. who is one of the company principals.

Memorandum report: NSW, Aug. 3, 1958

Figure 2-4. Example historical mining record accessible in MILO-4. Certificate of Assay for the Standard Mine, recorded on May 4, 1961. Analysis of eight samples reported results for gold, silver, lead, copper, and cobalt.

PHONE NUMBER 4-1267

To: Sheep Creek Mines Ltd.,
6 - 190 Baker St.,
Nelson, B.C.

E
Certificate of Assay
G. S. ELDRIDGE & CO. LTD.
ASSAYERS METALLURGISTS CHEMISTS
INSPECTION AND TESTING ENGINEERS
633 HORNBY ST. VANCOUVER, CANADA

CABLE ADDRESS "ELDRICO"
FILE NO. 5022
DATE May 4, 1961

MEMBERS OF
CANADIAN INSTITUTE OF CHEMISTRY
CANADIAN INSTITUTE MINING AND METALLURGY
AMERICAN SOCIETY FOR TESTING MATERIALS
AMERICAN SOCIETY FOR METALS
AMERICAN CHEMICAL SOCIETY
ASSOCIATION OF OFFICIAL REFINING CHEMISTS
NATIONAL ASSOCIATION OF CORROSION ENGINEERS

We Herby Certify that the following are the results of assays made by us upon submitted ORE samples.

MARKED	GOLD		SILVER		LEAD (Pb)		COPPER (Cu)		COBALT (Co)		TOTAL VALUE PER TON (2000 LBS.)
	OUNCES PER TON	VALUE PER TON	OUNCES PER TON	VALUE PER TON	PER CENT.	VALUE PER TON	PER CENT.	VALUE PER TON	PER CENT.	VALUE PER TON	
332	0.10	3.50	0.2	\$	COARSE ORE CN		2.95		0.07		
333	13.24	463.40	1.3		JIG 0.05		0.83				
334	1.80	63.90	1.3		COPPER CONC		19.03		1.51		
335	0.10	3.50	0.2		TAILINGS POND		0.51		0.12		
336	2.36	82.60	0.5		FLOOR #1 LEVEL 14ft		0.88		2.30		
337	2.16	75.60	0.4		NEAR FACE 4.5 210ft		2.16		2.09		
338	0.02	0.70	1.0		PREPARE DINE PITAL #6		0.33		0.03		
339	0.02	0.70	0.3		NEAR FACE #3 50ft		2.33		0.04		

1. The assays conducted on my samples
9 assays for lead, copper, silver, gold, etc.

Gold calculated at \$ 3.50 per ounce. Calculated at _____ cents per lb.
Silver calculated at _____ per ounce. Calculated at _____ cents per lb.

NOTE: Rejects retained one week.
Pulps retained three months.
Pulps and rejects may be stored for a maximum of one year by special permission.

H. S. Eldridge President

2.2 DOGAMI Assay and Chemical Analysis Services

"The department shall make, or cause to be made, quantitative determinations of ores and minerals when submitted for the purpose by citizens of the state, and shall mail to the sender the results obtained within 10 working days after receipt of samples; said service shall be performed by the department without charge to the sender and shall be rendered in exchange for information for the records of the department, stating the name and residence of the sender together with a history of the ore or mineral, giving as nearly as possible the location from which the sample was taken, including the name of the county, and any other matters that may be beneficial touching the same."

1937—Oregon Revised Statutes (2023, i.e., 516.040)

The legislation that created DOGAMI in 1937 also established within the agency, through Oregon Revised Statute (ORS) 516.040, fire assay and chemical analysis services. These services operated in the main Portland office, Baker City, and former Grants Pass field offices. All three offices provided fire assay and chemical analysis services between 1937 and 1943. Grants Pass and Baker City furnaces operated until

1943 when, as a World War II conservation measure, they were consolidated and moved to the main Portland Office. Fire assay services analyzed the precious metals gold and silver, platinum-group metals, and the base metals copper, lead, and zinc (Hoagland and Matthews, 1959). The chemical laboratory provided information for at least 60 elements found in rocks and minerals in Oregon. The most requested chemical determinations were those for chrome, iron, silica, mercury, alumina, nickel, copper, lead, and zinc. DOGAMI's fire assay and chemical analysis services were designed to encourage the prospector to search for mineral deposits and determine if the ore and related prospect were worth developing, or to aid residents who were interested in the analysis of rocks, minerals, or ores of the state (Hoagland and Matthews, 1959; Wagner, 1966).

The law governing these services entitled any individual or group of two or more people working together to submit two samples from mines and prospects within the state per month for free laboratory analysis of grade and/or identity (Hoagland and Matthews, 1959; Wagner, 1966). Samples originating from mine occurrences undergoing active development, mining, milling, or where ore was being shipped from the prospect were not allowed. Mining engineers sampling mine occurrences professionally for evaluation purposes were also prohibited from submitting samples.

Samples to be analyzed were either brought in or mailed to DOGAMI's offices in Portland, Grants Pass, or Baker City. Each sample submitted was accompanied by a *Request for Sample Information* form with handwritten information for client information (e.g., name, address, citizenship), sample location information (e.g., county, mining district, township, range, section, the analysis desired), and sample type (e.g., channel, grab, description; nature of sample or mineralization) (Figure 2-5). Required sample location data was to be recorded by the applicant using a map showing the legal subdivision grid in the prospect area (Figure 2-5; Wagner, 1966). This information could be obtained from all Oregon areas surveyed per standard General Land Office practices. Available sources of location information were: maps showing the legal subdivisions for each county, on file in the recorder's office at individual county courthouses; the township-range-section grid shown on all topographic quadrangle maps issued by the USGS; most land maps available from the U.S. Bureau of Land Management, the U.S. Forest Service, and other federal and state agencies focusing upon land use; and commercially-issued county and township maps available for purchase in most cities and many smaller towns (Wagner, 1966). While most of Oregon had been surveyed by 1937, some fire assay and chemical samples were obtained and submitted from nonsurveyed areas where location maps were unavailable. Applicants submitting samples from these areas were asked to describe the location as clearly as possible with reference to conspicuous landmarks, emphasizing distances and directions (Wagner, 1966). As a publicly funded service, all information submitted regarding the prospect and all laboratory results were considered open to public inspection and available to be published (Figure 2-5, Figure 2-6). A detailed account of ORS 516.040 was printed on the back of the Sample Information Form that was required to accompany each sample submission (Figure 2-7).

Hoagland and Matthews (1959) described the sample preparation and methodology employed by the fire assay and chemical analysis laboratory. Sample preparation is summarized here and shown in Figure 2-8.

- Information received with each sample accepted for analysis or fire assay was copied into a logbook. Samples were to represent the whole rock material and have a minimum weight of at least 1.1 pounds (lbs) to ensure accurate analytical results.
- A permanent DOGAMI Prime ID number was assigned to each sample and its corresponding *Request for Sample Information* form (e.g., ADG-5, P33474).

- A DOGAMI geologist examined the samples. The rock type and principal minerals were noted on the *Request for Sample Information* form in the space marked *Description* (Figure 2-7).
- Samples were subsequently crushed to 0.25 inches (in) and sorted through a Jones Riffle Splitter.
- A 0.2 lb split of the sample was then pulverized to the extent that 95% of the split would pass through a 100-mesh screen (0.006 in openings). The pulverized split (pulp) was then ready for chemical analysis or fire assay.
- The nonpulverized splits, or rejects, were sacked and checked for radioactivity using a sensitive Geiger counter.
- After testing, pulps and rejects were held in department storage for no longer than one year before being permanently discarded.

There was no charge for DOGAMI's fire assay and chemical analysis services. All that was asked in exchange for the free analytical data was the information provided on the *Request for Sample Information* sheet (Figure 2-5, Figure 2-6). This information was placed on file by DOGAMI, could be examined by the public if desired, and was used to enhance the overall knowledge of the state's mineral resources. These free public services were continued until ended by the legislature in July 1971 with the passage of House Bill 2040 (Oregon Revised Statutes, 2023, repealed by 1971 c.441 §6). Analytical services continued following this legislative action, on a for-charge basis, and the two-sample restriction per month was removed. Fire assay and chemical analysis services became further restricted starting on January 1, 1981, whereafter analytical facilities at DOGAMI were reserved for in-house staff program and project research (Oregon Department of Geology and Mineral Industries Editor, 1981). This was done to better focus lab work on samples and projects that would increase mineral-resource development in Oregon (e.g., Ferns and Brooks, 1983; Gray and others, 1983, 1986). Public samples submitted to DOGAMI for routine assays and chemical analyses were sent offsite to an approved list of private commercial analytical laboratories on an annual bid basis (Oregon Department of Geology and Mineral Industries Editor, 1981). DOGAMI's geochemical analytical laboratories permanently shut down on June 30, 1993, when the Oregon Legislature curtailed funds and directed the agency to end the in-house services (Oregon Department of Geology and Mineral Industries Editor, 1993).

Figure 2-5. Example of a DOGAMI unpublished public historical assay record from July 6, 1948. Analysis of two samples reported results for gold, copper, cobalt, and nickel. The sample is associated with the Gold Hill mining district in Jackson County in southwest Oregon. The location is given in township, range, and section. This record is included as part of MILO-4.

IG-138 + 139
Au, Co, Cu, Ni
Grants Pass

STATE DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
ASSAY LABORATORIES
SAMPLE INFORMATION REQUESTED

Baker

The law passed by the Legislature, governing the free assaying and analyzing of samples sent to the State Assay Laboratories, provides that certain information be furnished the Laboratory regarding samples sent for assay, etc. A copy of this law will be found on the back of this blank. Please read the law carefully. Will you please fill in the information called for on the following blank, as far as possible and return the same to the nearest State Assay Laboratory along with your sample? If you have made out a blank, this copy is for your future use. Keep a copy of the information on each sample for your own reference.

Your name in full . . . *A. D. Wolfe*

Postoffice address . . . *OFFICE*

Are you a citizen of Oregon? *YES*. Date on which sample is sent *6-17-48*.

Name (or names) of owners of the property. . . *R. D. SEMON*

Name of particular claim and date of location. . . *SHAMROCK - 1902*

Location of property or source of sample (describe as accurately as possible below):
 (1) County *Jackson* (2) Mining district *Gold Hill*.
 (3) Township *3.45* (4) Range *2W* (5) Section *20* (6) Quarter Section

How far from passable road? . . . *on Rd*

For what minerals or elements do you wish the sample analyzed? *Ni, Cu, Co, Au*

(Unless other minerals or elements are specifically named this sample will be assayed for gold and silver only.)

Type of sampling: Channel (length) *5'* . . . Grab Pipe

Report mailed Called for

IMPORTANT: A sample, to be of value, should be taken in an even channel across the vein from wall to wall. Its position in the workings should be marked and the width measured. Assays of unlocated samples, without widths, are of little value; they create little interest in the minds of experienced investors and engineers.

(signed) *A. D. Wolfe*

DO NOT WRITE BELOW THIS LINE--FOR OFFICE USE ONLY -- USE OTHER SIDE IF DESIRED

Description *#1 - 3' Channel taken across oxidized material of ore body 15' down from collar of old shaft. #2 - Grab sample from dump--*

sulphides.

Sample Number	GOLD		SILVER		COBALT Percent	COPPER Percent	NICKEL Ni
	oz./ T	Value	oz./ T	Value			
P-7274 IG-138	Nil	--	---	--	0.18%	2.60%	1.73%
P-7275 IG-139	Nil	--	---	--	0.34%	0.80%	2.71%

Report issued(*7-6-48*) Card filed()

Figure 2-6. Example of a DOGAMI unpublished government historical assay record from July 9, 1949. Analysis of two samples reported results for gold, silver, copper, uranium, thorium, and cobalt. The sample is associated with the Standard Mine in the Quartzburg mining district in Grant County in northeast Oregon. The location is given in township, range, and section. This record is not included as part of MILO-4 but will be added in a future release.

STANDARD MINE QUARTZBURG GRANT
 STATE OF OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
 ASSAY LABORATORY
 REQUEST FOR SAMPLE INFORMATION

The State law governing free analysis of samples sent to State Assay Laboratories requires that certain information be furnished the Laboratory regarding samples sent for assay or identification. A copy of the law will be found on the back of this blank. Please fill in the information called for as completely as possible, and submit it along with your sample. Keep a copy of the information on each sample for your own reference.

Your name in full Baker Office

Post office address _____

Are you a citizen of Oregon _____ Date on which sample is sent July 9, 1949

Name (or names) of owners of the property _____

Name of claim sample obtained from Standard Mine

Location of property or source of sample (describe as accurately as possible below):
 (If legal description is not known, give location with reference to known geographical point)

County Grant Mining district Quartzburg

Township 12 S Range 33 E Section 12 Quarter section _____

How far from passable road _____

For what minerals or elements do you wish the sample(s) analyzed Au, Co, Cu, U₃O₈, Radioactivity

	Channel (length)	Grab	Pipe	Description
Sample no. 1				#1 Single piece of heavily mineralized ore.
Sample no. 2				#2 Composite sample of miscellaneous fragments (Samples for assay should be at least 1 pound in weight; clay samples for ceramic testing, at least 5 pounds.)

IMPORTANT: A vein sample should be taken in an even channel across the vein from wall to wall. Location of sample in the workings, together with the width measured, should be recorded.

(Signed) _____

DO NOT WRITE BELOW THIS LINE - FOR OFFICE USE ONLY - USE OTHER SIDE IF DESIRED

Description The Atomic Energy Commission has found a small amount of U₃O₈ in samples which the owners state showed less mineralization and less radioactivity on their counter than do these. A cobalt concentrate was produced from this mine years ago. - refer to letter to Libbey for further details.

Sample number	GOLD		SILVER		COPPER	URANIUM	THORIUM	COBALT
	oz./T.	Value	oz./T.	Value	Percent	Percent	Percent	Percent
P-8843	0.78		1.20		4.20%	Nil	0.01-0.1%	3.44%
P-8844	0.28		0.30		0.90%	Nil	Trace	1.11%

Report issued _____ Card filed _____ Report mailed _____ Called for _____

SIR-5

Figure 2-7. 1937 Oregon law relating to the free analysis of rocks, ores, and minerals.**LAW RELATING TO FREE ANALYSIS OF ORES, MINERALS, ETC.****CHAPTER 179, Section 10, Oregon Laws 1937.**

The department shall make, or cause to be made, quantitative determinations of ores and minerals when submitted for the purpose, that are from original prospects or properties within the state of Oregon, and shall mail to the sender the results obtained within 10 working days after receipt of samples; said service shall be performed by the department without charge to the sender and shall be rendered in exchange for information for the records of the department, stating the name and residence of the sender together with a history of the ore or mineral, giving as nearly as possible the location from which the sample was taken, including the name of the county, and any other matters that may be beneficial touching the same. All determinations shall be performed under the following rules and regulations and subject to the following restrictions:

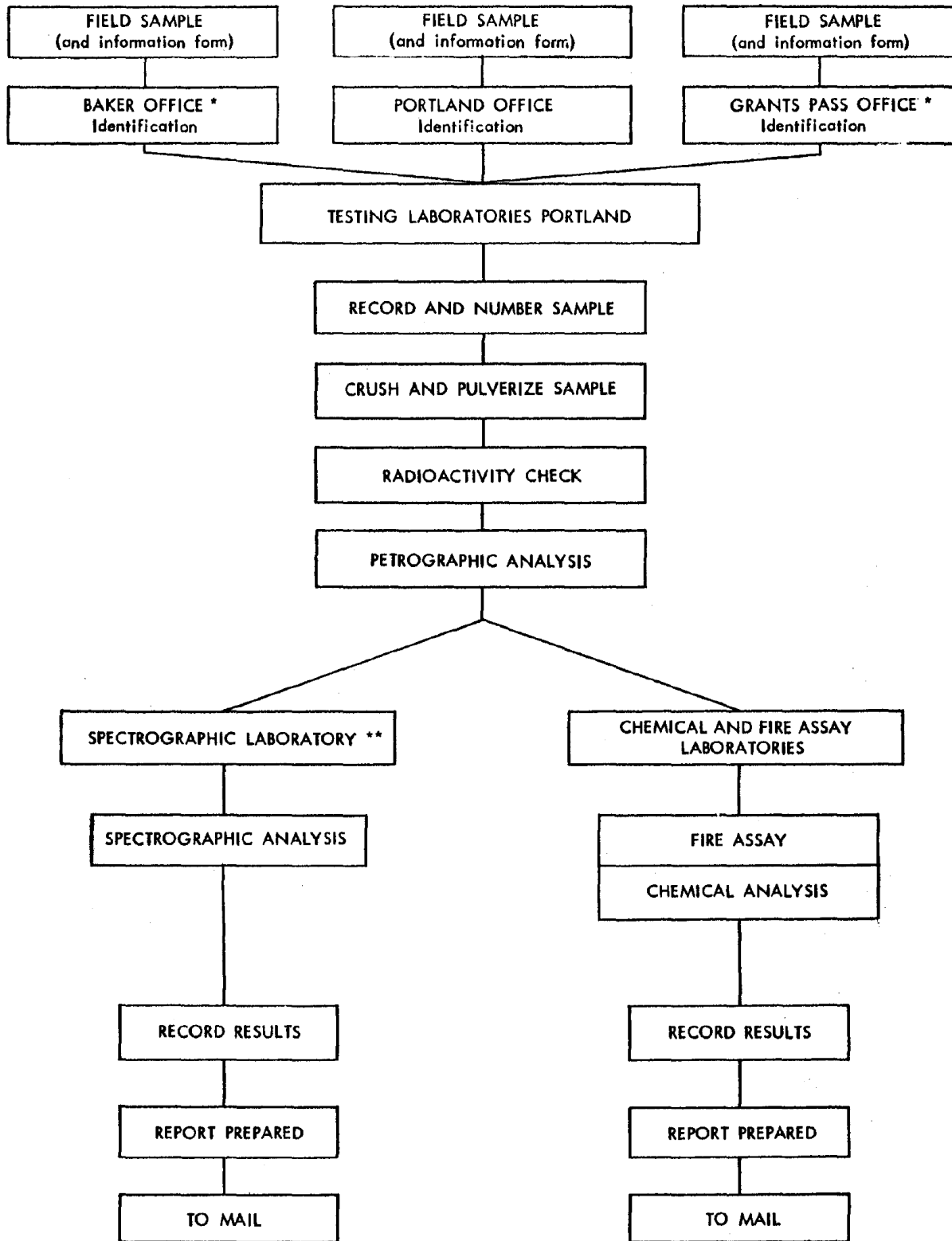
(a) No sample submitted by engineers sampling prospects or mines for the purpose of evaluation, or submitted by operating mines milling or shipping ore, or hiring labor, shall be accepted by the department for assay and/or analysis, except they be taken in the field by members of the department's staff in conducting the work of the department within the scope of this act.

(b) The number of samples which any single person or group of persons may submit shall be limited to two in any 30-day period and all samples shall be assayed or analyzed by the department in the order received, as far as possible.

(c) All information received and results of determination sent out shall be open to public inspection and may be published by the department.

(d) Before any work is done on the material submitted, all information required must be possessed by the department and the 10-day limit for reports will count from the time such data are received by the department.

Figure 2-8. Routing procedure for submitting samples to the DOGAMI fire assay, chemical, and spectrograph laboratory. The figure is from Hoagland and Matthews (1959).



2.3 Spectrograph Services

In 1941, the legislature appropriated funds to DOGAMI through ORS 516.050, 516.060, and 516.070 to establish, equip, and operate a first-of-its-kind spectrographic laboratory in the Pacific Northwest (Oregon Revised Statutes, 2023). A Baird three-meter-grating, wide-range spectrograph (1,800 to 21,000 Å) was purchased and began operating in January 1942. The chief use of the spectrograph was qualitative and estimated quantitative determinations of 66 major, minor, and trace elements in a sample (Hoagland and Matthews, 1959). The spectrograph was often employed to discover which metallic elements were present before investing efforts into more detailed chemical analyses. Samples were allowed from all persons, regardless of where the samples were obtained or whether they were residents of the state of Oregon. According to the statute, the spectrographic laboratory operated under a fee schedule for samples from the public. Spectrographic determinations requested by any state department, institution, or other agency were performed without charge. Oregon citizens could obtain a 20% discount if they verified that the sample originated in Oregon and signed the bottom of the form submitted with the sample.

Operational details and sample preparation for the spectrographic laboratory were described by Hoagland and Matthews (1959).

- Each sample was accompanied by the pricelist for spectrographic analysis, giving the name and address of the sender and indicating the type of analysis desired. The form included a list of all elements that could be identified by the laboratory.
- Samples were to represent the whole rock material and have a minimum weight of at least 1.1 lb to ensure accurate analytical results. Samples as small as 0.00004 ounces (oz) were acceptable. However, a small sample size limited the accuracy of the analysis and the ability to obtain quantitative results.
- A DOGAMI Prime ID number was assigned to each sample (e.g., ADG-5, P33474) for record-keeping and future correspondence.

Prospectors, miners, industry, and public agencies all valued the services of the spectrographic laboratory. Hundreds of routine analyses were performed by DOGAMI staff working on ferruginous bauxite, nickel laterites, and similar projects, where prompt results helped to determine the course of day-to-day fieldwork. Over time, other spectrographs were purchased in the Pacific Northwest and demands on DOGAMI equipment declined. DOGAMI's outdated spectrograph was retired in 1976 as different types of modern analytical equipment were used to solve developing geologic problems (Oregon Revised Statutes, 2023, i.e., ORS 516.050 and 516.060 were repealed by 1993 c.260 §12).

2.4 Public Value

DOGAMI's in-house fire assay, chemical, and spectrograph laboratories were popular with the public. In June 1938, the Grants Pass and Baker City assay offices had nearly 1,200 visitors, accepted more than 450 samples for assay, and produced 2,250 analyses. The number of analyses requested on each sample varied from one to six, with an average of more than two per sample. Between 1943 and 1959, 24,000 samples were received in the fire assay and chemical laboratories (Hoagland and Matthews, 1959). DOGAMI's Grants Pass sample ledger indicates 19,261 samples were submitted to fire assay, chemical, and spectrograph laboratories between 1937 and 1988 resulting in 40,752 discrete analyses (**Table 2-1**). Records tallied in **Table 2-1** exclude samples and analyses from Baker City office records, which will be added to future MILO data releases.

Table 2-1. Log of samples and analyses from Grants Pass fire assay, chemical, and spectrograph laboratories between 1937 and 1988.

Year	Number of Samples	Number of Analyses
1937	677	1,316
1938	1,730	3,220
1939	1,554	3,011
1940	1,963	3,457
1941	1,720	2,704
1942*	843	1,259
1943	276	523
1944	83	189
1945	342	602
1946	238	518
1947	286	627
1948	295	736
1949	396	905
1950	295	738
1951	683	1,807
1952	542	1,269
1953	479	1,096
1954	528	1,299
1955	411	1,030
1956	438	1,162
1957	580	1,521
1958	336	908
1959	324	823
1960	351	756
1961	301	717
1962	216	538
1963	308	771
1964	216	533
1965	229	577
1966	227	609
1967	237	607
1968	218	570
1969	258	707
1970	256	676
1971 [†]	117	295
1972	96	164
1973	108	231
1974	142	259
1975	153	297
1976	78	170
1977	85	195
1978	118	266
1979	92	191
1980	92	187
1981 [‡]	22	45
1982 [¥]	76	239
1983 [¥]	27	65
1984 [¥]	25	61
1985 [¥]	80	99
1986 [¥]	109	197
1987 [¥]	2	4
1988 [¥]	3	6
Totals	19,261	40,752

*Mining industry stopped by World War II

[†]Free public services discontinued[‡]Services reserved for DOGAMI in-house research.[¥]DOGAMI analyses only, no public records. The table includes samples submitted through the Portland and Grants Pass offices only. No Baker City records are included in the table.

3.0 MILO COMPILATION METHODS

3.1 MILO-3 Updates

The main emphasis for updating and publishing MILO-3 was to add new mineral occurrences, prospects, and mines to the MILO feature class, to move the legacy MILO database to a format consistent with the USGS NCGMP GeMS standard, to link the geodatabase to the OGD-7 (Franczyk and others, 2020; superseded by Darin and others, 2025), and to spatially link digital historical large-format maps and mining records and reports with specific mine sites ([Appendix Table 9-1](#)). The following section describes the procedure for adding these data to MILO-3.

3.1.1 Transferring MILO-2 to the MILO-3 GeMS database schema

The conversion of MILO-2 (Niewendorp and Geitgey, 2010) to the USGS NCGMP GeMS geodatabase standard (U.S. Geological Survey, 2020) was completed by McLaughry and others (2020) following the internal methodology described in the following sections. Although one of the primary goals of the MILO-3 project was schema conversion, adjustments and additions were made to the spatial data to improve the data's integrity and provide better feature representation. However, the methodology was developed to keep the source data true to the original studies. The MILO-2 feature class was converted into the USGS NCGMP GeMS database schema in the following manner:

- Sections of the attribute table were standardized to follow specific USGS NCGMP GeMS database schema rules.
- Field names were converted to Pascal Case (the first letter of each word is capitalized), and any spaces or special characters were removed.
- Any field names that contained “_ID” were reserved for primary keys.
- A field was added that contained an identifier (ArcJoinID) to spatially correlate it back to a specific geologic unit defined by its study citation and map unit label in the MapUnitPolys feature class in OGD-7 (Franczyk and others, 2020).

3.1.2 Assigning county mining records to MILO-3 mine locations

A Fuzzy Lookup (Microsoft® Excel®) and GIS-based (Esri® ArcMap™) approach was used to associate historical mining records with MILO mine points.

- Unique IDs: A unique identification was created for each MILO mine point (e.g., ID_00001) in the MILO feature class attribute table, so joins could be created between other datasets and then linked back to the original data (see [Appendix Table 9-2](#)). A unique ID was created for each of the 4,587 historical documents (e.g., HD_0001) in the historical mining records table so joins could be made with MILO mine points.
- Matching approach: When a MILO mine point was found to be related to a historical document, the MILO mine point unique ID was recorded in the historical mining record's table row. That way, they could be linked to each other using the IDs.
- Initial matching process: Prior to the matching process, spelling errors were corrected and attributes were modified for consistency in the CommodityAbbreviation, SiteName, Synonym, MiningDistrict, and Owner fields in the MILO feature class. The MILO mine point or subject field in

the historical mining records table was compared to the SiteName in the MILO attribute table using the Fuzzy Lookup Add-In for Microsoft® Excel®. Microsoft® Research developed the Fuzzy Lookup Add-In and performs fuzzy matching of textual data in Microsoft® Excel®. It was used to fuzzy join similar rows between two different tables. The matching process is susceptible to a wide variety of errors, including spelling inconsistencies, inconsistent use of abbreviations and synonyms, and added or missing data. For instance, it might detect that the rows “Mr. Andrew Hill,” “Hill, Andrew R.,” and “Andy Hill” all refer to the same underlying entity, returning a similar score along with each match. Many MILO mine points in the MILO attribute table were not identified with a specific SiteName. For example, “prospect,” “gravel pit,” and other generic descriptions were not considered. Therefore, in preparation for Fuzzy Lookup, a modified list of 11,203 MILO mine sites with a specific SiteName, was generated. The process of Fuzzy Lookup, considering the modified list of 11,203 MILO mine sites, generated 14,074 matches with a similarity score of 75% or greater and a limitation of 20 matches of MILO mine points to each historical mining record. The modified list was then trimmed down to 4,695 likely matches where the mining record county matched the county that the MILO mine point fell within. This final step was taken to avoid mismatches, where mine names matched but the records referred to similarly named mines in different parts of the state.

- Matching process: A combination of visual inspections matched historical mining records and MILO mine points using Esri® ArcMap™ and Adobe Bridge. Specific features examined to assign possible matches as good, neutral, or bad were mine name, document name, district, Public Land Survey System (PLSS) location, and commodity. This examination included looking at the MILO mine points spatially in Esri® ArcMap™, looking in the attribute tables for matching information in Esri® ArcMap™, and viewing documents in Adobe Bridge to get identifying information from the actual document. Appropriate MILO mine-point IDs were manually added when a good match with nearby MILO mine points was verified. After the first pass, all neutral-assigned matches were given a second look and assigned either as a good or bad match.
- Historical mining records table: The attribute table fields for these historical mining records were exported to a geodatabase table (CountyMineRecords) and formatted with the following fields: CountyMineRecords_ID, District, DocumentName, and Hyperlink (see [Appendix Table 9-2](#)).
- Duplicate checks: There was no check for duplicates in the MILO point data. There were no duplicates found in the county mine-records dataset.

3.1.3 Assigning large-format maps to MILO-3 mine locations

The list below gives a general description of the data inputs and geospatial processing applied to the large-format maps to link them to specific mine point(s) in MILO-3, the quadrangle(s) covered by the map, or mining district. [Table 3-1](#) lists the certainty level of the matching process (using Esri® ArcMap™ and Adobe® Bridge™).

- Created unique IDs: A unique identification was created for each mine point (e.g., ID_00001) in the MILO-3 feature class attribute table so joins could be created between other datasets to link back to the original data (see [Appendix Table 9-3](#)). A unique ID field (DOGAMI_No) was also created for each large-format map.
- Matching approach: When a large-format map was found to be associated with a MILO mine point (see matching process, below), that map’s unique ID was recorded in the MILO mine point’s attribute table row. Similarly, the MILO mine point’s unique ID was recorded in the large-format

map’s attribute table row. In this manner, the maps and mine points were linked to each other by using the IDs as either a primary or a foreign key. An Esri® ArcGIS™ Spatial Join tool was run (MILO mine points within 33 ft of large-format map points) to use proximity to establish an initial relationship between both sets of points.

- Established map scale: A scale was determined for each map where possible. However, not every large-format map contained scale information.
- Classed maps on the basis of characteristics: A level-of-certainty code, based on proximity, map scale, and other characteristics (Table 3-1) was established. Each map was assigned a code by matching the description of the level of certainty.

Table 3-1. Definition for levels of match potential and certainty of match between large-format maps and MILO-3 mine points.

Levels of Certainty	Description of Match Certainty
0	No details
1	Map w/in 33 ft of a mine (large format or no scale)
2	Scale <1:12,000 (large scale only)
3	1 and 2 (close and large-format map)
4	Regional study (small scale)
5	Scale >1:12,000 (small scale only)
9	Not in Oregon

- Matching process: Matching large-format maps to specific MILO mine points was accomplished by geospatially examining the proximity of map points to mine points and then comparing the mine names in MILO with the mine names displayed on the large-format maps. This process included looking at the map points and mine points spatially in Esri® ArcMap™, looking in the attribute tables for matching information in Esri® ArcMap™, and viewing individual map PDF files in Adobe Bridge® to get identifying information from the map. All maps in the collection were cross-checked and assigned a correlation status category (Table 3-2).
- Geologist review: After the maps had been sorted into a status category, some maps had ambiguous map locations or names. A DOGAMI geologist familiar with the MILO mine points and large-format maps examined these maps for a final matching decision (Table 3-2).

Table 3-2. Correlation status category table used when matching large-format maps to MILO-3 mine points.

Correlation Status	Description
1	Checked, no match with a MILO mine point
2	Checked, match with single MILO mine point
2	Checked, match with multiple MILO mine points
3	Checked, topology or USGS quadrangle map
3	Checked, geology map
3	Checked, large map without MILO mine point association
4	Checked, location is correct, but not enough information to link with MILO’s mine point
5	Checked, unknown location
6	Review by a geologist
7	Checked, location correct, associated with district centroid. Not enough information to link with MILO mine point(s)

- Maps that matched with a mine: 995 large-format maps were associated with at least one mine. The attribute table fields for these maps were exported to a geodatabase table (LargeFormatMaps) and formatted as Title, LargeFormatMap_ID, Hyperlink, Scale, Year (see [Appendix Table 9-2](#)).
- Maps that did not match with a mine: Although many maps were successfully correlated with a MILO mine point, 473 maps did not have a specific name, owner, or distinctive identifying information to link the map with a MILO mine point. [Figure 1-4](#) shows the locations of these maps. These maps (LargeFormatMapPoints) remained in their point feature class format. Their attribute table fields were formatted in the same way as the large-format map geodatabase table (see [Appendix Table 9-3](#)).
- Duplicate checks: The MILO mine point data were not checked for duplicates and the large-format maps dataset did not contain duplicates.

3.2 MILO-4 Updates

The main objective for updating and publishing MILO-4 was to add new mineral occurrences, prospects, and mines to the MILO feature class and to add a new feature class to organize, spatially display, and search analytical results obtained from DOGAMI's in-house fire assay, chemical, and spectrograph laboratories ([Figure 1-3](#), [Figure 1-4](#)). The following section describes the procedure for adding these data to MILO-4.

3.2.1 Creating the AssayPointsLocations feature class and AssayReturns database table for MILO-4

Individual PDF files were created from high-resolution scans of the original fire assay, chemical, and spectrograph *Logs* and *Request for Sample Information* paper files and stored on the DOGAMI file server system ([Figure 2-5](#)). MILO-4 includes records that were part of our Portland and Grants Pass collections. As a first step, we took 134 combined fire assay, chemical, and spectrograph PDF files and separated them into individual documents based on the DOGAMI Prime ID number assigned to an individual sample(s) at the original time of submittal ([Figure 2-5](#), [Figure 2-8](#)). Next, originally handwritten information from each assay record was entered into a master Microsoft® Excel® spreadsheet ([Figure 2-5](#)). This process resulted in 15,405 unique fire assay, chemical, and spectrograph records saved as standalone PDF files, with results parsed into a digital spreadsheet. The Microsoft® Excel® spreadsheet contains fields for client information (e.g., name, address, citizenship), sample location information (e.g., county, mining district, township, range, section, and the analysis desired), and sample type (e.g., channel, grab, description; nature of sample or mineralization), which were provided by the client at the time of submittal to DOGAMI ([Figure 2-5](#), [Figure 2-8](#)). The bottom of the form included analytical results determined in the DOGAMI laboratories. All data were entered “as-is” with no effort made to correct information other than ensuring that county and city names within Oregon were correct. The *Notes* field in the Microsoft® Excel® spreadsheet contains a *P* if a member of the public submitted the assay and contains *GO* if submitted by an employee of DOGAMI or other government agency. Most assay records did not include information for every data field; some clients may not have been able to provide this information, were reluctant to do so, or the handwriting was illegible. Fire assay, chemical, and spectrograph records also include geochemical and radioactivity results for the sample (e.g., Au oz/T [ounces per ton], Ag oz/T, Cr₂O₃ %, and water %), which were obtained by the lab via analysis ([Figure](#)

2-5, Figure 2-8). Most commonly, fire assay records include at least gold (Au oz/T) and silver (Ag oz/T) compositional data in oz/T and a monetary value that the lab calculated based on the value of that material at the time. Occasionally, the client asked for additional geochemical analyses, including but not limited to arsenic (As ppm [parts per million]), chromium (Cr%), mercury (Hg oz/T), uranium (U₃O₈% equivalent), copper (Cu%), lead (Pb%), manganese (Mn%), and zinc (Zn%); **Figure 2-5).**

Guidelines for the standardized method of populating the data fields were followed for fields included in the original database spreadsheet (see **Appendix Table 9-4, Table 9-5).** For example, if the analyst recorded “Trace” under “Gold oz/T”, then “L” was entered into the “Au oz/T” field in the database (**Appendix Table 9-5).** Records that included full qualitative spectrographic analysis were entered into the database with R1 to R6 values according to their assigned value in the guidelines (**Appendix Table 9-5).** If an assay record included a geochemical parameter that was not included in the original database, it was added as a new field and formatted similarly to preexisting fields. For example, a field already existed for mercury measured in pounds per ton (HG lb/T), but a new field needed to be added for analyses in which mercury was measured in parts per million (HG_PPM_S). The field title “HG_PPM_S” was formatted similarly to the pre-existing field for magnesium in parts per million “MG_PPM_S” for mercury measured in parts per million. On occasion, some assay records included quantitative data without specified units. In these cases, the units were inferred and recorded based on the magnitude of the number. For example, if a mafic volcanic unit had reported Calcium (Ca) of 9.5 with no units specified, it was inferred to be in weight percent and not parts per million because 9.5 ppm calcium in a mafic volcanic rock, though not impossible, is highly improbable. These data were included in the description for the few assays that included chromium-to-iron ratios (Cr:Fe). Data from the spectral analysis were missing for several assay records; these records were still added to the database spreadsheet, but the lack of geochemical data was noted.

3.2.2 Locating points in the AssayPointsLocations feature class

MILO-4 contains a new feature class called **AssayPointLocations** and database table **AssayReturns**, related through the **AssayReturns** relationship class (**Figure 1-4).** These data, developed using Esri® ArcPRO™ v. 3.3, contains fire assay, chemical, and spectrograph analytical results compiled from the Portland and Grants Pass offices. Unique Adobe® PDF analytical records each contain full or partial PLSS location information. The location information is used to link each analytical record with its corresponding PLSS geospatial data point, based on township, range, section, and quarter section information. Because the PLSS data was the most detailed location information on each assay, the Bureau of Land Management (BLM) OR Cadastral PLSS Second Division polygon dataset was downloaded from the BLM Geospatial Business Platform (BLM GBP Hub, <https://gbp-blm-egis.hub.arcgis.com/>) and used to designate assay point locations. The BLM OR Cadastral dataset was converted from polygons to points (centroids within), and a PLSS code was created within a field in the point attribute table. This field consists of the township and range down to the quarter-quarter section. This PLSS code format was replicated in the **AssayReturns** table using each record’s PLSS location information. The code information was a primary key for relating the cadastral point locations to the assay table records points that did not have corresponding PLSS information were associated with the Oregon county’s shapefile centroid. The final task was to assign locations for records that did not contain PLSS or county location information. These points were assigned to the Oregon shapefile centroid.

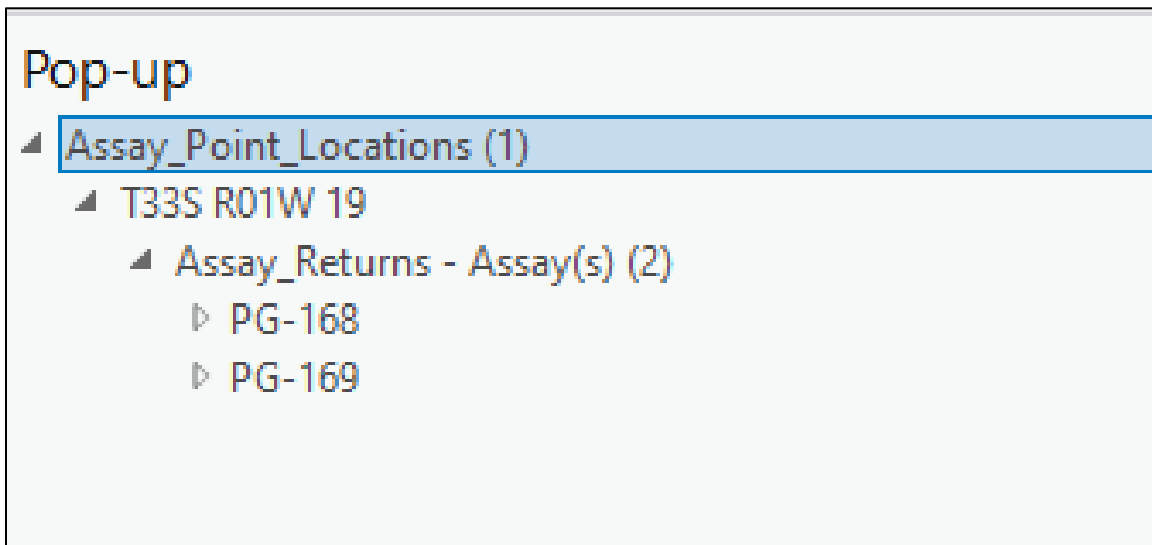
The location accuracy of records varies substantially by the location information provided in each analytical record. Location accuracy relies heavily upon the original submitter knowing and recording,

correct location information. However, this vital task was often imperfectly performed. Nominally, records located by a given PLSS location have the following location accuracy: ± 6.2 mi for those sites located by township and range; ± 0.6 mi for those assigned by township, range, and section; ± 0.3 mi for those assigned by township, range, section, and quarter section.

An extensive quality control process was done to prepare the data for publication. Multiple iterations of joining tests were undertaken to ensure each record was successfully and correctly joined to a PLSS point using the PLSS code. After performing a join test, the PLSS code for the records that did not match to a point was modified so that in the next test, they would potentially join successfully. This continued until all records were matched with a point location. Next, the dataset with PLSS points that matched at least one record was checked for duplicate points and/or points with duplicate PLSS codes. The duplicate points and codes were then removed.

The goal of relating the records with their appropriate PLSS point location is so that you can click on a point in a map, and the corresponding record for that location will be queried. This is considered a “one-to-many” relationship, so that one point can link to multiple records. The *Table to Relationship Class* tool in ArcPRO™ was used to create the relationship classes within the file geodatabase. For this process, the “origin table” was the PLSS point locations, the “destination table” was the AssayReturns table, and an “intermediate table” was created that defined the relationship between the primary key fields (PLSS code and the DOGAMI Prime ID number). **Figure 3-1** is an example of a PLSS point query showing one point (T33S R01W 19) associated with multiple assay records (PG-168, PG-169). The same type of stacked query is true for the files located at the county and state centroid levels.

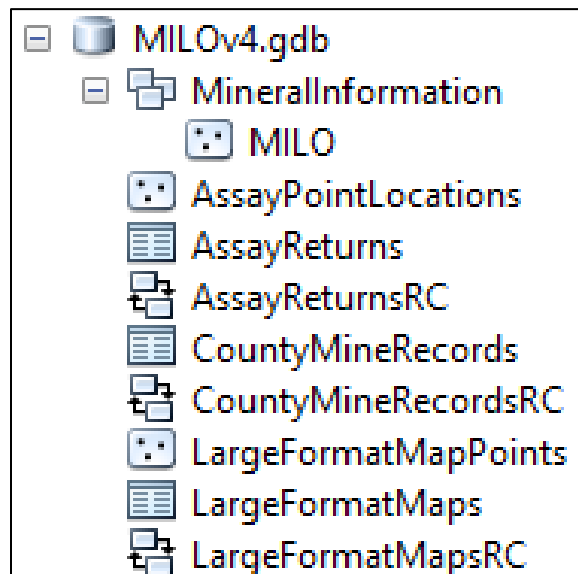
Figure 3-1. Feature classes, geodatabase tables, and relationship classes in the AssayPointLocations feature class.



3.3 Geodatabase, Map and Mine Record, and Assay Relationship Classes

The MILO-4 geodatabase contains the MILO mine point feature class, large-format maps feature class (not linked to a MILO mine point), large-format maps geodatabase table (linked to a MILO mine point), county mine records geodatabase table (linked to a MILO mine point), and AssayPointLocations feature class. **Figure 3-2** shows the feature classes, geodatabase tables, and relationship classes in the MILO-4 geodatabase. The relationship class is located in the geodatabase. An intermediate table is the connection between the MILO feature class and the large-format maps and county mine records attribute table. The MILO dataset is the origin of the large-format maps and the county mine records geodatabase tables is the destination.

Figure 3-2. Feature classes, geodatabase tables, and relationship classes (denoted as RC) in the MILO-4 geodatabase.



The intermediate tables (LargeFormatMapsRC, CountyMineRecordsRC) establish the relationships between the large-format maps, county mine records, and MILO mine point locations (MILO, CountyMineRecords, LargeFormatMaps; see [Appendix Table 9-1](#), [Table 9-2](#), [Table 9-3](#)). The intermediate relationship class tables contain the unique IDs of the MILO mine points (primary key) and unique IDs of the large-format maps or county mine records (foreign key). Please note that there may be multiple entries for a unique MILO mine point if that MILO mine point is associated with many unique large-scale maps. Likewise, there may be multiple entries for a unique large-format map if that MILO mine point is associated with many, unique large-format maps. The intermediate tables (LargeFormatMapsRC, CountyMineRecordsRC) were created in Microsoft® Excel® and imported into the MILO-3 geodatabase. Relationship classes in the intermediate tables were created using an ArcGIS™ tool (Data Management > Relationship Classes > Table To Relationship Class). Relationship class information can be accessed in the geodatabase through two methods:

- Method 1 – In an open ArcMap™ session, select a mine point in the MILO feature class using the Identify tool. The upper panel of the Identify window will display the feature class and any linked county documents (Figure 3-3). Not all MILO mine records are associated with large-format maps or county mine records. In cases where no records are linked with a particular mine site, the Identify tool will list the name of the LargeFormatMaps and CountyMineRecords tables; the tool queries the tables for associated records but will not return a link.
- Method 2 – Open the attribute table of the MILO feature class or the attribute tables for the large-format map (LargeFormatMaps,) or county mine record (CountyMineRecords). Use the “select related records” button in the tool ribbon at the top of the table to determine the relationship between county mine documents and MILO mine sites (Figure 3-4). Like Method 1, please note that every entry in a table (LargeFormatMaps, CountyMineRecords) has an associated mine, but not every mine has an associated large-format map or county mine record in a table.

Figure 3-3. Method 1 for selecting a MILO-4 mine point in Esri® ArcMap™ with the Identify tool and searching for linked maps and historical documents. Yellow circles are mine sites and prospects in the area of interest. The solid blue circle is the selected Virtue Mine in the MILO feature class. The base map is a USA Topo Map from Esri®.

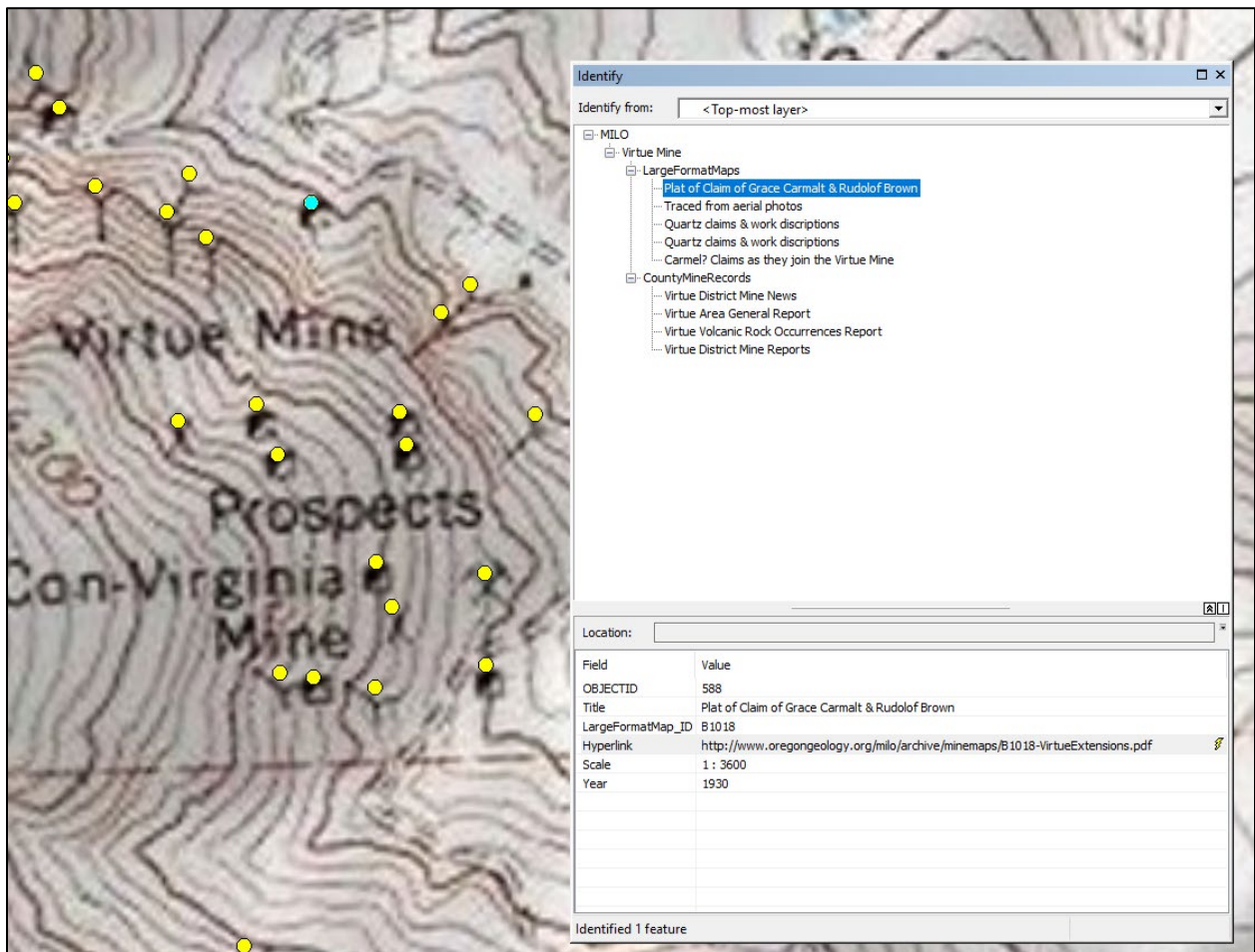
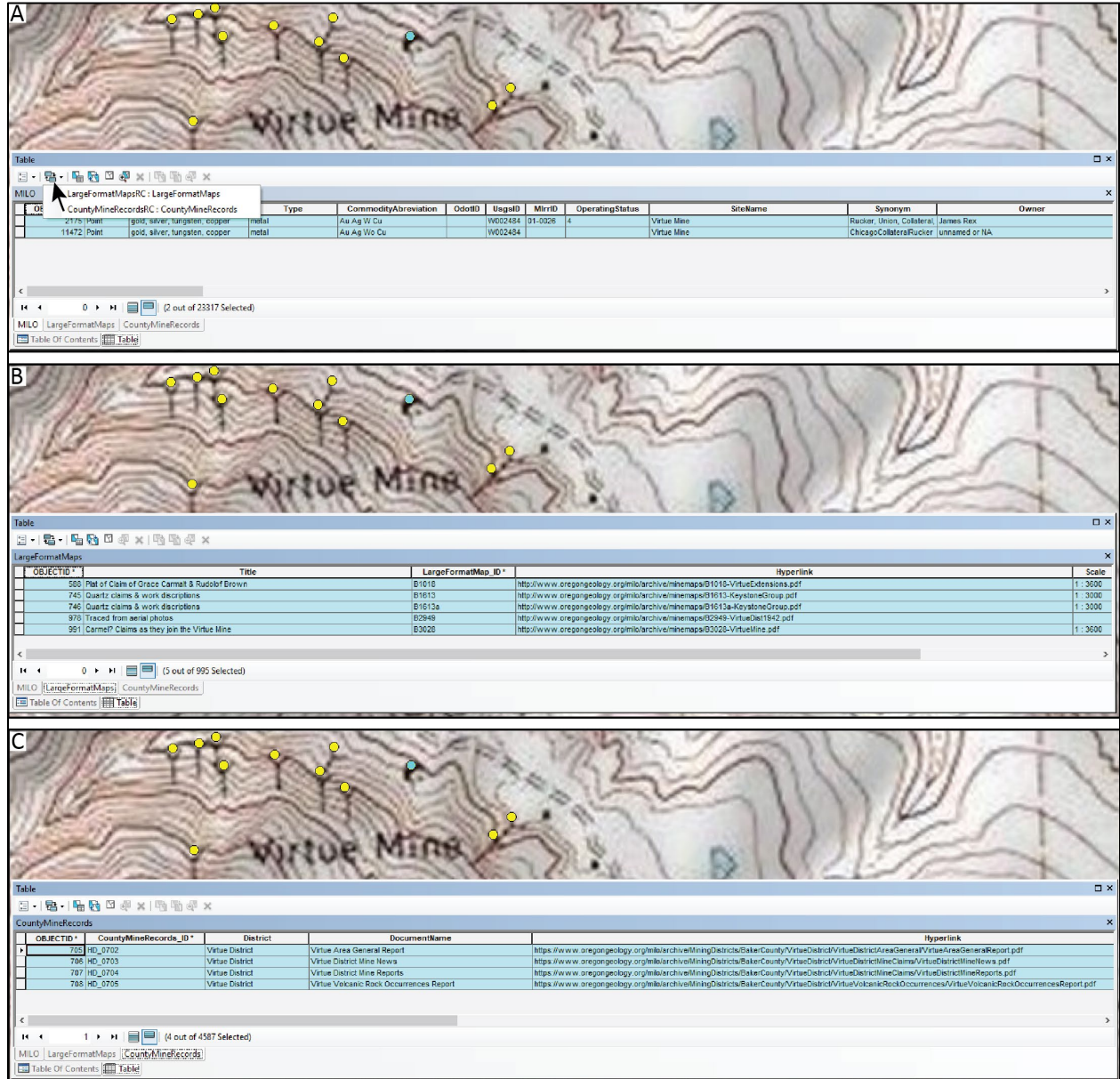


Figure 3-4. Method 2 in Esri® ArcMap for determining relationships between the MILO-4 feature class, large-format maps, and county mine records. (A) Attribute table of selected mine records for the Virtue Mine in Baker County. The black arrow in the upper left corner of the table window points to the “select related records” button. The dropdown field shows the related tables. (B) Related attribute table “LargeFormatMaps” listing large-format maps associated with the Virtue Mine points. (C) Related attribute table “CountyMineRecords” shows historical records associated with the Virtue Mine points. Hyperlinks in the LargeFormatMaps and CountyMineRecords tables connect to large-format map and county mine records hosted at <https://www.oregon.gov/dogami/milo/Pages/index.aspx>. Yellow circles are mine sites and prospects in A–C are the area of interest. The solid blue circle in A–C is the selected Virtue Mine site. The base map is a USA Topo Map from Esri®.



4.0 METADATA

Feature-class level metadata has been created for MILO-4, following the internal DOGAMI metadata standard v. 1.4; a more rigorous version of the FGDC *Content Standard for Digital Geospatial Metadata*, Version 2 (<https://www.fgdc.gov/metadata/csdgm-standard>). The DOGAMI internal metadata standard complies with the approved Oregon GIS Metadata Standard (currently Version 2.04), as the Oregon Geospatial Enterprise Office prescribes (Oregon Geospatial Enterprise Office, 2024). Each geodatabase record has exported fields augmented to item-level NGDPP metadata-compliant fields, allowing fast uploading of all record metadata to the USGS Registry of Scientific Collections (ReSciColl).

5.0 UPDATES

Updates to MILO-4 will occur upon the availability of new data and as staff resources and funding are available. To keep track of updates, we will use a primary release number, such as the current Release 4, along with a decimal number identifying the update (e.g., 4.1). When we apply major updates to the database, a new primary release number (e.g., 5) will be assigned. Future updates to MILO include:

- Editing, updating, and georeferencing incomplete and poorly located data using modern 3 ft lidar topography and orthophoto imagery;
- Adding mine locations digitized from literature, historical records, and 3 ft lidar topography;
- Adding fire assay, chemical, and spectrograph records currently housed in the Baker City field office ([Table 5-1](#));
- Spatial joining of additional mining records ([Table 5-1](#));
- Creation of a feature class representing the point/polygon locations of mining districts in Oregon;
- Adding specimen photographs available for MILO mine sites;
- Integrating MILO with other DOGAMI datasets, such as the Geochemical Information Layer for Oregon (GILO; Ferns and McConnell, 2005; Niewendorp and others, 2010) and the Geothermal Information Layer for Oregon (GTILO) (Niewendorp and others, 2012); and
- Integrating current and future DOGAMI MLRR records.

Table 5-1. DOGAMI mineral and mining collections to be added to the MILO and the Oregon Historical Mining Information collection in future updates.

Collection	Description	Volume	Web Resource URL	Availability
Baker County Historical Mining Claim Location Records	Placer and lode mining claim records from 1862 to 1964 held by the Baker County Recorder's Office; 22 books (1962–1964) remain to be scanned	110 PDFs	https://www.oregon.gov/dogami/milo/Pages/index-claim-records-BAKE.aspx	Available online
Commodities	83 commodity types, from abrasives to zinc	105 PDFs	https://www.oregon.gov/dogami/milo/Pages/index-commodities.aspx	Available online
Historical Societies: Gold Hill (25) and Josephine (132)	Geology-related records in historical society holdings	157 PDFs	https://www.oregon.gov/dogami/milo/Pages/index-historical-soc-records.aspx	Available online
Oregon DMA, DMEA, OME Dockets	Defense Minerals Administration (DMA), Defense Minerals Exploration Administration (DMEA), and Office of Minerals Exploration (OME) files	103 Oregon docket records	https://www.oregon.gov/dogami/milo/Pages/ORdockets.aspx ; linking to Oregon dockets: https://pubs.er.usgs.gov/publication/ds1004	Available online
"Gray" literature and publications (non-DOGAMI)	Unpublished reports and those published by the USGS	9 PDFs		Available online
Oil and gas well logs	Applications, site plans, gas analyses, logs, plugging records, permits, well summaries, etc.	4,700 PDFs	https://www.oregon.gov/dogami/mlrr/Pages/oilgas-logs.aspx	Available online
Mining-related series publications	DOGAMI, OBM, USBM, and USGS publications.	188 PDFs	https://www.oregon.gov/dogami/milo/Pages/publications.aspx	Available online
Field notebooks	—	—	—	Scanned; not currently publicly available
Oregon Bureau of Mines, DOGAMI Portland office	Microfiche of correspondence and mine records, 1911–1923	—	—	Scanned; not currently publicly available
Assay records and index to assay results from DOGAMI offices in Portland, Baker City, Grants Pass	DOGAMI fire assay, chemical, and spectrograph assay information from 1937 to 1980; Baker City Office assay card-file index; Grants Pass Office assay logbook	~17,900 assay records; ~8,220 index cards; 1 logbook	—	To be scanned in the future
Mining records, DOGAMI offices in Portland and Baker City offices	Mining production records, staff descriptions and letters, mine maps, workings maps, plat maps, newspaper clippings, other notes	~25,000 separate sheets in 120 file folders	https://www.oregon.gov/dogami/milo/Pages/index-miningrecords.aspx	To be scanned in the future

Collection	Description	Volume	Web Resource URL	Availability
Thin section, DOGAMI offices in Portland and Baker City	Thin sections and descriptive index cards	~2500 thin sections	—	To be scanned in the future
Historical photos, DOGAMI offices in Portland and Baker City	Historic mine photographs, department photographs, and slides.	15 large binders	—	To be scanned in the future
Bullion records, DOGAMI Baker City office	Descriptions of free gold shipments out of Baker County between 1890 and 1959	6 bound volumes	—	To be scanned in the future
Mercury and copper files, DOGAMI Baker City office	Statewide information about the commodities	2 large binders	—	To be scanned in the future
U.S. Bureau of Mines records	Mine maps, magnetics surveys, etc., on index card-sized microfiche	300–500 items	—	To be scanned in the future
Stream-sediment analyses and field notes, DOGAMI Baker City office	Stream-sediment analyses, field notes from sites in eastern Oregon	1 large binder	—	To be scanned in the future
BLM mineral plats (non-DOGAMI materials)	—	—	https://glorerecords.blm.gov/search/default.aspx#searchTabIndex=0&searchByTypeIndex=1	—

6.0 DISCUSSION

6.1 Critical Minerals in the 21st Century

Gold and silver mining underpinned Oregon mining until World War II, when in 1942, the industry was stopped by government order (Brooks and Ramp, 1968; **Table 6-1**). DOGAMI was directed during the war to support national defense by studying, encouraging, and assisting in the production of strategic and critical raw materials, principally chromite, manganese, mercury, platinum, copper, antimony, and zinc (Allen and others, 1938; DOGAMI, 1939, 1940, 1941, 1942a, b; Libbey and others, 1942; Wagner, 1944; Libbey, 1951; Brooks, 1957, 1963; Ramp, 1961; Munts, 1973; Madin and others, 2016). Oregon's gold and silver industry never recovered after the war. In the following Cold War era, DOGAMI investigated the statewide potential for chrome, mercury, limestone, clay, talc, silica, nickel, resources of radioactive minerals (uranium), and ferruginous bauxite (Libbey and others, 1942; Corcoran and Libbey, 1956; Schafer, 1956; Peterson, 1958; Brooks, 1963; Hook, 1976; Ramp, 1978; Mason, 1982; Gray, 1981; Ferns and Ramp, 1988; Brooks and Baxter, 1989; Geitgey, 1990; Madin and others, 2016; **Table 6-1**). Substantial amounts of ferronickel, the first in the United States to be produced from domestic ores, were produced at Nickel Mountain in southwestern Oregon between 1954 and the late 1990s (Gray, 1981). Absent a robust metal mining industry following the Cold War era, resource development in Oregon has been led by the production of aggregate in the form of sand and gravel, and crushed stone (**Table 6-1**). These commodities are the most valuable of the state's mineral resources currently produced and are increasing

in demand. The state has also had variable production in other commodities, including gemstones, limestone, bentonite, diatomite, emery, perlite, and pumice ([Table 6-1](#)).

Table 6-1. Listing of important Oregon mineral commodities in MILO-4.

Commodity	Symbol	Atomic Number	Type	Common Use(s)	Number of Sites in MILO-4	Assay Results
Gold	Au	79	Metallic	Aerospace, consumer electronics, dentistry and medicine, finances	6817	Qn/QI*
Silver	Ag	47	Metallic	Consumer electronics, photography, dentistry, medicine, finances	3201	Qn/QI
Chromite	Cr	24	Metallic	Stainless steel and other alloys	909	Qn/QI
Manganese	Mn	25	Metallic	Steelmaking and batteries	254	Qn/QI
Mercury	Hg	80	Metallic	Chemical catalyst, electrical uses, thermostats, medical devices	1191	Qn/QI
Platinum	Pt	78	Metallic	Catalytic converters	153	Qn/QI
Copper	Cu	29	Metallic	Energy technology, defense, consumer electronics	1829	Qn/QI
Antimony	Sb	51	Metallic	Lead-acid batteries and flame retardants	278	Qn/QI
Zinc	Zn	30	Metallic	Metallurgy to produce galvanized steel	1296	Qn/QI
Nickel	Ni	28	Metallic	Stainless steel, superalloys, rechargeable batteries	262	Qn/QI
Uranium	U	92	Metallic	Nuclear reactors, energy production, military applications	212	Qn/QI
Ferruginous bauxite	—	—	Aggregate, industrial	Aluminum production	15	—
Sand and gravel	—	—	Aggregate, industrial	Road construction, construction fill, construction materials	2961	—
Crushed stone	—	—	Aggregate, industrial	Road construction and maintenance, cement, chemical applications	8947	—
Dimension stone	—	—	Aggregate, industrial	Building facing, construction, decorative purposes	58	—
Borrow/fill topsoil	—	—	Aggregate, industrial	Road construction, construction fill	48	—
Gemstones	—	—	Aggregate, industrial	Jewelry, decorative objects	744	—
Limestone	—	—	Aggregate, industrial	Construction, agriculture	196	—
Bentonite	—	—	Aggregate, industrial	Lubricant for drilling and cutting tools, fertilizers, pesticides	264	—

Commodity	Symbol	Atomic Number	Type	Common Use(s)	Number of Sites in MILO-4	Assay Results
Diatomite	—	—	Aggregate, industrial	Insulation or as a filtering material, insecticide	157	—
Perlite	—	—	Aggregate, industrial	Agriculture, soil amendments, plant propagation, fireproofing	28	—
Pumice	—	—	Aggregate, industrial	Abrasive in cleaning, polishing, scouring compounds	112	—

* Qn: quantitative data reported; Ql: qualitative data reported

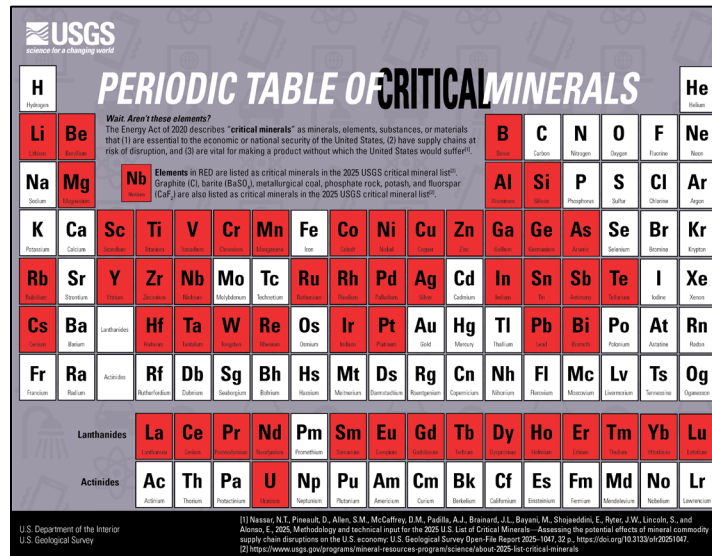
Critical minerals such as lithium and cobalt are vital for rechargeable batteries and play a key role in U.S. efforts to transition to renewable energy and achieve energy independence. The Energy Act of 2020, passed by bipartisan majorities in the United States House and Senate in 2020, directed the USGS to compile a list of critical minerals every three years (United States of America, 2020). In 2022, the USGS critical minerals list considered the following 50 as essential for all technologies: **aluminum, antimony, arsenic, barite, beryllium, bismuth, cerium, cesium, chromium, cobalt, dysprosium, erbium, europium, fluorspar, gadolinium, gallium, germanium, graphite, hafnium, holmium, indium, iridium, lanthanum, lithium, lutetium, magnesium, manganese, neodymium, nickel, niobium, palladium, platinum, praseodymium, rhodium, rubidium, ruthenium, samarium, scandium, tantalum, tellurium, terbium, thulium, tin, titanium, tungsten, vanadium, ytterbium, yttrium, zinc, and zirconium** (U.S. Geological Survey, 2022; [Figure 6-1](#), [Figure 6-2](#); [Table 6-2](#)). The list was updated by the USGS in 2025 to include 10 additional critical minerals, including **boron, copper, lead, metallurgical coal, phosphate, potash, rhenium, silicon, silver, and uranium**. These updates reflect a refined analysis of criticality, based on over 1200 disruption scenarios and possible changes in mineral commodity supply chains (both domestic and foreign), markets, and risks (U.S. Geological Survey, 2025; United States of America, 2025a,b; Nassar and others, 2025). The mineral commodities of **gallium, germanium, magnesium metal, niobium, potash, rhodium, tungsten**, and several rare earth elements, such as **samarium, lutetium, terbium, dysprosium, gadolinium, and yttrium** have the greatest risk of supply chain disruption (U.S. Geological Survey, 2025; United States of America, 2025b; Nassar and others, 2025).

The U.S. Department of Energy (USDOE) took a forward-looking global perspective of demand for clean energy technologies between now and 2035 and independently developed a complementary list of minerals, elements, substances, and materials in 2023. The 2023 USDOE critical materials list for energy includes: **aluminum, cobalt, copper, dysprosium, electrical steel (grain-oriented electrical steel, nongrain-oriented electrical steel, and amorphous steel), fluorine, gallium, iridium, lithium, magnesium, natural graphite, neodymium, nickel, platinum, praseodymium, terbium, silicon, and silicon carbide** (U.S. Department of Energy, 2023; [Figure 6-1](#), [Figure 6-2](#); [Table 6-2](#)). The USGS and USDOE critical minerals lists, and additional information is found at the following website: <https://www.criticalminerals.gov/>.

Spatial analysis of MILO-4 commodity data, cross-referenced with published data, historic mine records, and legacy mine maps, shows that 29 critical minerals identified by the USGS and USDOE are present in Oregon. Critical minerals listed as commodities in MILO-4 include: **aluminum, antimony, arsenic, barite, beryllium, bismuth, boron, chromium, cobalt, copper, fluorine, iridium, lead, lithium, manganese, nickel, palladium, platinum, rhodium, ruthenium, silver, tellurium, tin, titanium, tungsten, uranium, vanadium, zinc, and zirconium** ([Figure 6-1](#), [Figure 6-2](#); [Table 6-2](#)). Fourteen additional critical minerals, not listed as commodities in MILO-4, are reported with quantitative

and/or qualitative results in analytical data compiled from DOGAMI’s fire assay, chemical, and spectrograph laboratories (Table 6-2). These include: **barite, cerium, cesium, gallium, hafnium, indium, lanthanum, magnesium, potash, praseodymium, silicon, tantalum, ytterbium, and yttrium.** MILO-4 also notably includes former coal sites, with coal beds and the surrounding sedimentary units representing potential targets for undiscovered rare-earth elements (Figure 1-3). Additional information on mineral commodities in Oregon, including critical minerals, can be found on the listing of commodity reports on DOGAMI’s website, <https://www.oregon.gov/dogami/milo/Pages/index-commodities.aspx>.

Figure 6-1. Periodic table of the elements highlighting critical minerals included in the 2025 USGS Critical Minerals list. Image is from the USGS, <https://www.usgs.gov/media/images/periodic-table-2025-critical-minerals-full-color> (Nassar and others, 2025).



MILO-4 provides the fundamental information needed to begin a critical-mineral prospectivity analysis of Oregon and identify exploration targets within geologically permissive areas. DOGAMI has identified two areas of primary critical mineral occurrence and interest using MILO-4, in combination with historic mining data, records, and maps. The first area is McDermitt caldera, in southeast Oregon’s Malheur County, which lies within the USGS Earth Mapping Resource Initiative southeast Oregon lithium focus area (Figure 6-2). Mercury has been the best-known element of economic significance at McDermitt caldera and is the only one that has had significant mining (Brooks, 1957, 1963, e.g., Opalite and Bretz Mines). However, deposits or concentrations of several other elements, including lithium, gallium, zirconium, gold, and uranium are also known. Based on a combination of geologic investigations, mineral exploration, and current economics the caldera is now understood to have significantly more mineral potential than has been historically known (Henry and others, 2017). Lithium, a critical element fundamental to most batteries enabling portable power and electric vehicles, is particularly notable. McDermitt caldera hosts the only known lithium deposit in Oregon, associated with hectorite beds occurring in moat lake sediments (Benson and others, 2017). Recent mineral resource evaluation of the caldera indicates the largest lithium deposit in the U.S., reinforcing the significance of its potential for future supply to the rapidly growing U.S. battery manufacturing industry (Castor and Henry, 2020; Jindalee Resources Limited, 2021).

The second area is the Quartzburg mining district in northeast Oregon's Grant County (**Figure 6-2**). The Quartzburg mining district overlaps two USGS Earth Mapping Resource Initiative focus areas in the Blue Mountains: 1) a northeast Oregon-Idaho massive sulfide area; and 2) a northeast Oregon polymetallic gold-silver veins area. Historic mining in Quartzburg largely focused on the extraction of gold, with silver, copper, and cobalt also mined (Wagner, 1956; Vhay, 1960; Koschmann and Bergendahl, 1968; Johnson, 1975). Other mineral commodities were mostly discarded (Johnson, 1975). However, based on geologic mapping and mineral assessment by Brooks and others (1984) and MILO-4 data, other critical-mineral commodity occurrences for cobalt, zinc, nickel, antimony, arsenic, silver, manganese, and bismuth are recognized in the district. Chief among these may be cobalt. The Standard Mine produced and exported cobalt ore to Germany at the turn of the 19th to 20th century, achieving international fame (Blue Mountain American, October 5, 1901; Wagner, 1956; **Figure 2-1, Figure 2-2, Figure 2-3, Figure 2-4, Figure 2-6**). It was believed at that time to be the only cobalt mine in the United States and one of the few that operated in the United States through 1937, when the operation was destroyed by fire (Blue Mountain American, October 5, 1901; California Mining Journal, July 1937). The Standard Mine was later operated briefly by the U.S. Vanadium Corporation as a cobalt producer in 1940-1941, targeting massive lode deposits of gold-copper-cobalt (Wagner, 1956). Mining records in MILO-4 indicate similar polymetallic copper-cobalt mineral associations are present across the district. Surrounding districts in Grant and Baker counties are also host to occurrences of a range of critical-mineral commodities and other economic minerals, including antimony, chromium, platinum, and zinc (**Figure 6-2**).

Figure 6-2. Map showing the distribution of 29 critical minerals as commodities in MILO-4. Critical mineral commodities are listed alphabetically in the legend. Figure cartography by Jon J. Franczyk.

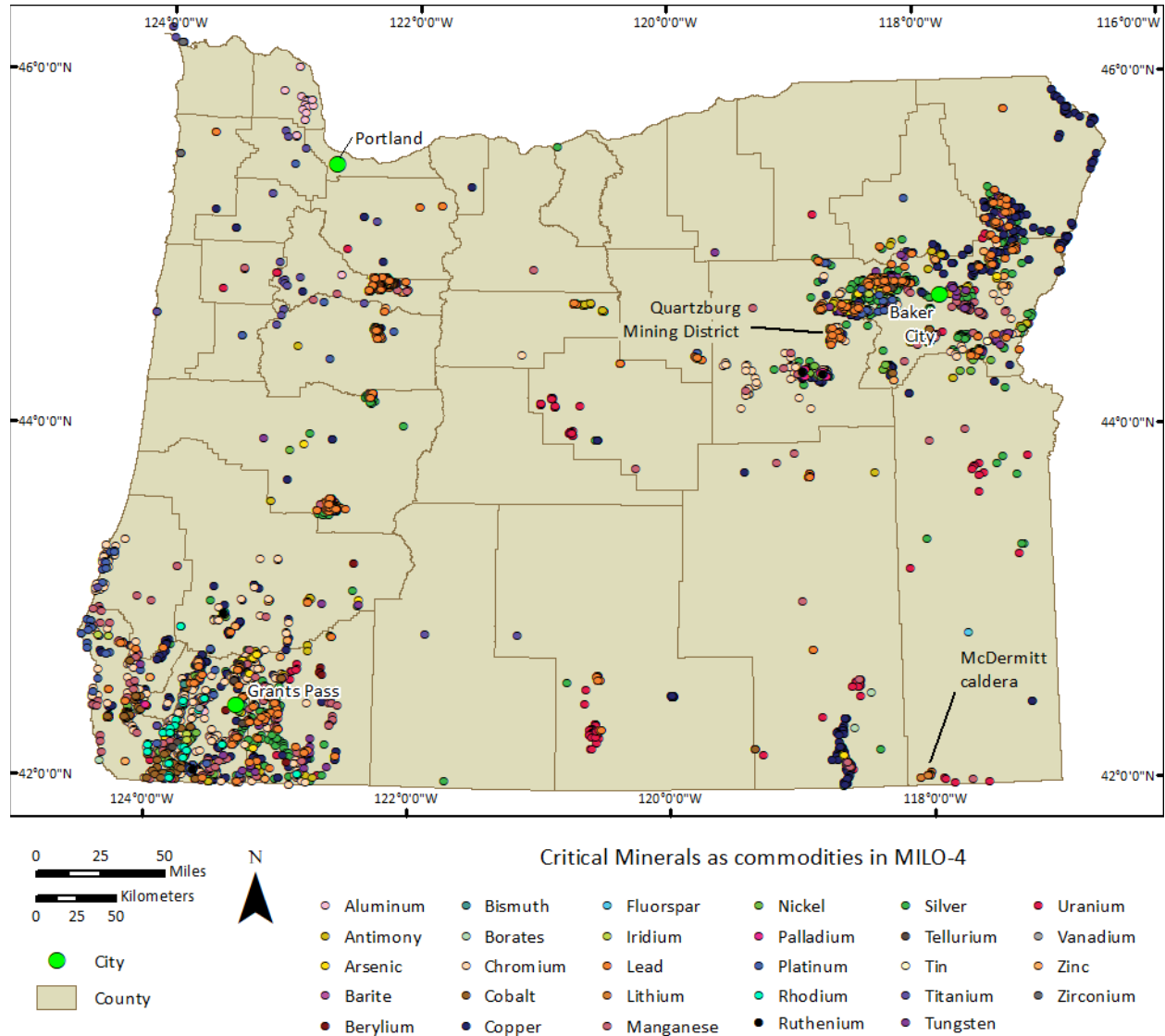


Table 6-2. Listing of USGS and USDOE critical minerals and materials for energy, including those in MILO-4.

USGS Critical Minerals 2025*	USDOE Critical Minerals and Materials*	Symbol	Atomic Number	Common Use(s)	Number of Sites in MILO-4	DOGAMI Assay Results
Aluminum	Aluminum	Al	13	Used in almost all sectors of the economy	16	Qn/Ql ^r
Antimony	—	Sb	51	Lead-acid batteries, flame retardants	278	Qn/Ql
Arsenic	—	As	33	Semi-conductors	293	Qn/Ql
Barite (mineral)	—	BaSO ₄	—	Hydrocarbon production	—	Qn
Beryllium	—	Be	4	Alloying agent in aerospace and defense industries	6	Qn/Ql
Bismuth	—	Bi	83	Medical and atomic research	13	Ql.
Boron	—	B	5	Steel hardener and glass and in nuclear energy	3	Qn/Ql
Cerium	—	Ce	58	Catalytic converters, ceramics, glass, metallurgy, polishing	—	Ql.
Cesium	—	Cs	55	Research and development	—	Ql.
Chromium	—	Cr	24	Stainless steel, other alloys	909	Qn/Ql
Cobalt	Cobalt	Co	27	Rechargeable batteries, superalloys	130	Qn/Ql
Copper	Copper	Cu	29	Energy technology, defense, consumer electronics	1829	Qn/Ql
Dysprosium	Dysprosium	Dy	66	Permanent magnets, data storage devices, lasers	—	—
—	Electrical Steel	—	—	Capacitors, inductors, relays, solenoids	—	—
Erbium	—	Er	68	Fiber optics, optical amplifiers, lasers, glass colorants	—	—
Europium	—	Eu	63	Phosphors and nuclear control rods	—	—
Fluorspar (mineral)	Fluorine	F	9	Manufacture of aluminum, cement, steel, gasoline, chemicals	1	Qn/Ql
Gadolinium	-	Gd	64	Medical imaging, permanent magnets, steelmaking	—	—
Gallium	Gallium	Ga	31	Integrated circuits and optical devices like leds	—	Qn/Ql
Germanium	-	Ge	32	Fiber optics and night vision applications	—	—
Graphite (min)	Graphite (min)	C	6	Lubricants, batteries, fuel cells	—	—
Hafnium	—	Hf	72	Nuclear control rods, alloys, high-temperature ceramics	—	Ql
Holmium	—	Ho	67	Permanent magnets, nuclear control rods, lasers	—	—
Indium	—	In	49	Liquid crystal display screens	—	Ql
Iridium	Iridium	Ir	77	Anodes for electrochemical processes, chemical catalyst	9	Qn/Ql
Lanthanum	—	La	57	Catalysts, ceramics, glass, polishing, metallurgy, batteries	-	Qn/Ql
Lead	—	Pb	82	Batteries, ammunition, glass and ceramics production	1254	Qn/Ql
Lithium	Lithium	Li	3	Rechargeable batteries	24	Ql
Lutetium	—	Lu	71	Scintillators for medical imaging, electronics, cancer therapies	—	—

USGS Critical Minerals 2025*	USDOE Critical Minerals and Materials*	Symbol	Atomic Number	Common Use(s)	Number of Sites in MILO-4	DOGAMI Assay Results
Magnesium	—	Mg	12	Alloy and for reducing metals	—	Qn/Ql
Manganese	—	Mn	25	Steelmaking and batteries	254	Qn/Ql
Metallurgic coal	—	—	—	Steel production	—	—
Neodymium	Neodymium	Nd	60	Permanent magnets, rubber catalysts, medical/industrial lasers	—	—
Nickel	Nickel	Ni	28	Stainless steel, superalloys, rechargeable batteries	262	Qn/Ql
Niobium	—	Nb	41	Steel and superalloys	—	—
Palladium	—	Pd	46	Catalytic converters and as a catalyst agent	28	Qn/Ql
Phosphate	—	PO ₄		Fertilizers	—	—
Platinum	Platinum	Pt	78	Catalytic converters	153	Qn/Ql
Potash	—	K	19	Fertilizers	—	Qn/Ql
Praseodymium	—	Pr	59	Magnets, batteries, aerospace alloys, ceramics, colorants	—	Ql
Rhenium	—	Re	75	High-performance jet engines and gas turbines	—	—
Rhodium	—	Rh	45	Catalytic converters, electrical components, catalyst	40	Qn/Ql
Rubidium	—	Rb	37	Research and development in electronics	—	—
Ruthenium	—	Ru	44	Catalysts, electrical contacts, and chip resistors	4	Qn
Samarium	—	Sm	62	Magnets, absorber in nuclear reactors, cancer treatments	—	—
Scandium	—	Sc	21	Alloys, ceramics, and fuel cells	—	—
Silicon	Silicon	S	8	Computer chips, solar cells, cement, semiconductors	—	Qn/Ql
—	Silicon Carbide	SiC	—	Finishing-polishing equipment, slicing of silicon wafers	—	—
Silver	—	Ag	47	Electrical circuits, batteries, solar cells, medical instruments	3201	Qn/Ql
Tantalum	—	Ta	73	Electronic components, mostly capacitors, superalloys	-	Qn/Ql
Tellurium	—	Te	52	Solar cells, thermoelectric devices, and as alloying additive	29	Ql
Terbium	Terbium	Tb	65	Magnets, fiber optics, lasers, and solid-state devices	—	—
Thulium	—	Tm	69	Various metal alloys and in lasers	—	—
Tin	—	Sn	50	Protective coatings and alloys for steel	4	—
Titanium	—	Ti	22	White pigment or metal alloys	36	Qn/Ql
Tungsten	—	W	74	Wear-resistant metals	89	Qn/Ql
Uranium	—	U	92	Nuclear fuel and medical applications	212	Qn/Ql
Vanadium	—	V	23	Alloying agent for iron and steel	2	Qn/Ql

USGS Critical Minerals 2025*	USDOE Critical Minerals and Materials*	Symbol	Atomic Number	Common Use(s)	Number of Sites in MILO-4	DOGAMI Assay Results
Ytterbium	—	Yb	70	Catalysts, scintillometers, lasers, and metallurgy	—	Qn/Ql
Yttrium	—	Y	39	Ceramic catalysts, lasers, metallurgy, and phosphors	—	Ql
Zinc	—	Zn	30	Metallurgy to produce galvanized steel	1296	Qn/Ql
Zirconium	—	Zr	40	High-temperature ceramics and corrosion-resistant alloys	2	Qn/Ql

*<https://www.criticalminerals.gov/>

†Qn: quantitative data reported; Ql: qualitative data reported

7.0 CONCLUSIONS

The historical actions and results of Oregon’s exploration and mining heritage are documented by MILO-4, which organizes 24,664 mineral occurrences, prospects, and mines, spatially linked with commodity information, 4,587 historical mining documents, and 995 large-format maps. An additional feature class organizes 15,405 fire assay, chemical, and spectrograph records from DOGAMI’s in-house laboratories into a spatially searchable tabular format.

MILO-4 is the definitive source of Oregon’s mineral background information and answers the fundamental question: **Where are mineral resources found in Oregon?** It also provides key information needed to: 1) build a comprehensive understanding of geologic and mineral system relationships across Oregon using geospatial analysis; 2) determine probable exploration targets within geologically permissive areas and guide efforts to locate undiscovered resources; 3) highlight areas that may have hazardous abandoned mine land features and inform land-use decisions; and 4) identify areas of mineralized rock where undesirable health outcomes are known to be associated with long-term exposure to naturally occurring elements, minerals, and materials that may pose health hazards through their physical properties (Niewendorp, 2011).

Indexing, cross-referencing, and publishing DOGAMI’s many collections of legacy mineral-occurrence and mining-related data in a single, modern, geospatial database format and GIS-based interactive web map provides unified and consistent access to researchers and the public. Feature-class level Federal Geologic Data Committee (FGDC) and USGS National Geological and Geophysical Data Preservation Program (NGGDPP) schema-conformant metadata, that are exported and uploaded to the Registry of Scientific Collections (ReSciColl), collectively make the data more discoverable. Compilation of these data into publicly available formats supports DOGAMI’s and the NGGDPP’s goals: 1) develop and maintain digital infrastructure supporting the preservation, archiving, and delivery of historical geological materials; and 2) the preservation and documentation of geochemical samples relevant to critical minerals assessment.

Gold and silver mining underpinned Oregon’s early mining industry until World War II. Mining of these traditional high-value metals was replaced in the post-war years by the production of other metals, aggregate, and industrial minerals. In the 21st century, worldwide demand for clean energy technology is growing. Federal strategies aim to increase the economic prosperity and national security of the United States by building a resilient supply chain of domestic critical minerals and materials needed for modern technologies. Spatial analysis of MILO-4 commodity data, cross-referenced with published data, historic

mine records, and legacy mine maps show that 29 critical minerals identified by the USGS and USDOE are present in Oregon (**Figure 6-1**; **Table 6-2**). Fourteen additional elements, not listed as commodities in MILO-4, are reported with quantitative and/or qualitative results in analytical data compiled from DOGAMI's fire assay, chemical, and spectrograph laboratories (**Table 6-2**). DOGAMI anticipates that interest in the exploration and extraction of critical minerals will increase in Oregon, driven by technology, developments in renewable energy, and efforts to reduce carbon emissions. Developing new and recycled sources of critical minerals will be paramount to meet this demand. Making legacy mining information available in a digital format like MILO-4, is a cost-effective first step toward a comprehensive statewide evaluation of Oregon's mineral resource potential.

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10.0 APPENDIX

10.1 MILO-4 Feature Class Fields

Table 9-1. MILO-4 feature class fields.

Field Name	Description
Commodity	All commodities listed in the literature for this site, major commodities present, a comma-separated list
Type	Commodity type: metal, industrial mineral, aggregate, coal
CommodityAbbreviation	Commodity abbreviation for major commodities present, a space-separated list
ODOTID	A unique identifier that references records of information pertaining to an ODOT-owned aggregate pit/quarry or private source
USGSID	A unique identifier that references records of information pertaining to a mineral property; USGS MRDS and CRIB
MLRRID	The permit or site number from the DOGAMI MLRR Program; the unique record number
OperatingStatus	Indicates the operating status of the site at the time of last modification: 1) mineral occurrence (no workings and/or production), 2) raw prospect (minor workings but no production), 3) developed prospect (workings but no production), 5) mine (present or past producer)
SiteName	The name of the mineral deposit or mining operation; place name on USGS quadrangle map or name referenced in various published and unpublished sources
Synonym	Other names the site has had over time, or in the case of placers, names of other gravel bars along a river segment for which one location was chosen for the site name; name referenced in various published and unpublished sources
Owner	Name of individual, company, or operator identified with the operation
County	County in Oregon where the site is found, single county entry
MiningDistrict	Mining district the mine record was assigned; some districts are formal, but most are informal
Location	Physical address or reference to topographic point or feature
PLSSSectionFraction	The letters or a single letter following the subdivision of the township, range, and section system; for example, section fraction NW NW NW indicates the northwest quarter of the northwest quarter of the northwest quarter of the section; a single letter such as N indicates the north half of the section
Section	PLSS section number; su= section unknown
Township	PLSS township number and direction (N S)
Range	PLSS range number and range character (E W)
Latitude	Latitude in decimal degrees or Y coordinates for the center point of each point
Longitude	Longitude in decimal degrees or X coordinates for the center point of each point
TopoMap24k	USGS 1:24,000-scale (24K) topographic map in Oregon, where the site is located
TopoMap100k	USGS 1:100,000-scale (100K) topographic map in Oregon where the site is located
ElevationFeet	Point of reference in feet; the site elevation obtained from 1-meter lidar imagery where available or a 15-minute digital elevation model
CommoditiesProduced	Commodities produced and sold or used
ProductSize	A broad characterization of the magnitude of production at the site; two different categorizations were used: a three-fold set based on magnitude (Small, Medium, Large) and a simple indicator (Yes or No), with some records showing <i>Undete</i> for unknown.
ProductInformation	Production information
OreMaterial	Ore material (valuable minerals or mineral material)

Field Name	Description
DepositType	General type of deposit or resource present at the site
WorkingsType	Type of workings
WorkingsDescription	Description of exploration and/or mine workings
YearOfDiscovery	Year the mineral discovery was made
YearProductionStarted	Year that mineral production started
FullReference1	Bibliographic reference provides information supporting the database record; reference #1
ShortReference1	Publication Series Information
Pages1	Page number of reference where the site is mentioned or described
FullReference2	Bibliographic reference provides information supporting the database record; reference #2
ShortReference2	Publication Series Information
Pages2	Page number of reference where the site is mentioned or described
FullReference3	Bibliographic reference provides information supporting the database record; reference #3
ShortReference3	Publication Series Information
Pages3	Page number of reference where the site is mentioned or described
FullReference4	Bibliographic reference provides information supporting the database record; reference #4
ShortReference4	Publication Series Information
Pages4	Page number of reference where the site is mentioned or described
FullReference5	Bibliographic reference provides information supporting the database record; reference #5
ShortReference5	Publication Series Information
Pages5	Page number of reference where the site is mentioned or described
DataSourceID	Data source identification is a foreign key to geologic maps; unique code for each original reference map, expressed as the first four letters of the first author's last name, first and middle initials, the year of publication, and a map identifier as needed
MapUnit	Reference map unit label symbol taken from the original geologic reference map
MapUnitName	Reference map unit name taken from the map legend or explanation of map units on the original geologic reference map
ThematicUnitLabel	Geologic Merge Unit Label in previous versions of OGDC (Smith and Roe, 2015); label (period delimited) assigned by area geologists that combines all the original map units into 7 different general geologic categories
ThematicRockType	General geologic rock type of the geologic merge unit label, expressed by the genesis of the unit in OGDC
ThematicAge	Age of geologic merge unit based on the geologic time scale in OGDC
ThematicTerraneGroup	Terrane or group name: stratigraphic name (formally or informally named) for the terrane or group in OGDC
ThematicFormation	Stratigraphic name (formally or informally named) for the geologic formation in OGDC
ThematicMember	Stratigraphic name (formally or informally named) for the member type in OGDC
ThematicUnit	Stratigraphic name (formally or informally named) for the unit type in OGDC
ThematicLithology	Characteristic lithology type name for the geologic merge unit label in OGDC
ArcJoinID	Concatenation of 'DataSourceID' and 'MapUnit' fields without a space in between; for use with joins or relates of data tables in ArcGIS™ or other GIS software
MILO_ID*	Primary key. Values = ID_1, ID_2, ID_3, etc. Values must be unique to the database

10.2 Large-Scale Mine Maps and County Mining Records Table Fields

Table 9-2. CountyMineRecords geodatabase table fields.

Field Name	Description
CountyMineRecords_ID*	Primary key; values = HD_0001, HD_0002, HD_0003, etc.; values may be repeated in the dataset
District	Mining district in which the county mine record was assigned; some districts are formal, but most are informal
DocumentName	Title assigned to the scanned document
Hyperlink	Hyperlink to the online document
MILOID	Foreign key; values = ID_00001, ID_00002, ID_00003, etc.; values may be repeated in the dataset

*Note the Field Name MILOID is part of the CountyMineRecordsRC table and corresponds to the primary key listed in the field CountyMineRecords_ID.

Table 9-3. LargeFormatMapsPoints feature class and LargeFormatMaps geodatabase table fields.

Field Name	Description
Title	Title of scanned document
LargeFormatMap_ID	Primary key; values = B0001, B0002, B0003, etc.; values may be repeated in the dataset
Hyperlink	Hyperlink to the online document
Scale	The scale of the map listed by the author reported as 1: [denominator]
Year	Year the document was published or created
MILOID	Foreign key; values = ID_00001, ID_00002, ID_00003, etc.; values may be repeated in the dataset

*Note the Field Name MILOID is part of the LargeFormatMapsRC table and corresponds to the primary key listed in the field LargeFormatMap_ID.

10.3 AssayReturns Database Table Fields

Table 9-4. AssayReturns feature database table fields.

Field Name	Description
DOGAMIPrime_ID	Primary key, first DOGAMI identification number
DOGAMISecond_ID	Second DOGAMI identification number
DOGAMIThird_ID	Third DOGAMI identification number
USGSPrime_ID	First USGS identification number
USGSSecond_ID	Second USGS identification number
Name	Name of person submitting sample for assay
Address	Address of person submitting sample for assay
City	City of the person submitting the sample for an assay
State	State of the person submitting the sample for an assay
Zipcode	Zip code of person submitting sample for assay
Date	Date sample was submitted
Mine	Name of mine sample was taken from
Claim	Name of claim sampled

Field Name	Description
PropertyOwner	Owner of the property where the sample was taken
County	County location
District	Mining district
Township	Township location
Range	Range location
Section	Section location
QuarterSection	Quarter section location
QuarterQuarterSection	Quarter section location
Directions	How far from the passable road? What is the name of the road?
Type	Type of sample taken
Location	Where the sample was taken from
Description	Description of sample
Gravity	Specific gravity
Radioactivity	Radioactivity
Ag_PPB	Silver, parts per billion
Ag_PPM_S	Silver, parts per million
Ag_oz_T	Silver, ounces per ton
Ag_Percent	Silver, percent
Al_Percent	Aluminum, percent
Al ₂ O ₃ _Percent	Aluminum oxide, alumina, percent
As_PPM_S	Arsenic, parts per million
As_Percent	Arsenic, percent
Ash_Percent	Ash, percent
Au_PPB	Gold, parts per billion
Au_PPM_S	Gold, parts per million
Au_oz_T	Gold, ounces per ton
Au_Percent	Gold, percent
B_PPM_S	Boron, parts per million
B_Percent	Boron, percent
Ba_PPM_S	Barium, parts per million
Ba_Percent	Barium, percent
BaO_Percent	Barium oxide, percent
BaSO ₄ _Percent	Barium sulfate, percent
Be_PPM_S	Beryllium, parts per million
Be_Percent	Beryllium, percent
BeO_Percent	Beryllium oxide, percent
Bi_PPM_S	Bismuth, parts per million
Bi_Percent	Bismuth, percent
Bo_Percent	Borate, percent
C_Percent	Carbon, percent
Ca_PPM_S	Calcium, parts per million

Field Name	Description
Ca_Percent	Calcium, percent
Calcium_Carbonate_Percent	Calcium carbonate, percent
CaO_Percent	Calcium oxide, lime, percent
CaCO ₃ _Percent	Calcite, calcium carbonate, percent
CaF ₂ _Percent	Calcium fluoride, percent
Cb_Percent	Columbium, percent
Cb ₂ O ₅ _Percent	Columbium pentoxide (columbic acid), percent.
Cd_PPM_S	Cadmium, parts per million
Cd_Percent	Cadmium, percent
Ce_Percent	Cerium, percent
Chromite_Percent	Chromite, percent
Co_oz_T	Cobalt, ounces per ton
Co_PPM_S	Cobalt, parts per million
Co_Percent	Cobalt, percent
Cr_PPM_S	Chromium, parts per million
Cr_Percent	Chromium, percent
Cr ₂ O ₃ _Percent	Chromium oxide, chrome, percent
Cs_Percent	Cesium, percent
Cu_oz_T	Copper, ounces per ton
Cu_PPM_S	Copper, parts per million
Cu_Percent	Copper, percent
F_Percent	Fluorine, percent
Fe_PPM_S	Iron, parts per million
Fe_Percent	Iron, percent
FeAlO ₃ _Percent	Available aluminum and iron oxides, percent
FeO_Percent	Wüstite (iron (II) oxide), percent
Fe ₂ O ₃ _Percent	Ferric oxide red, percent
Ga_PPM_S	Gallium, parts per million
Ga_Percent	Gallium, percent
Ge_Percent	Germanium, percent
H_Ions	Hydrogen ion
Hf_Percent	Hafnium, percent
Hg_Percent	Mercury, percent
Hg_cc_Per_Half_gm	Mercury, cubic centimeter per ½ gram
Hg_oz_T	Mercury, ounces per ton
Hg_lb_T	Mercury, pounds per ton
Hg_PPM_S	Mercury, parts per million
In_Percent	Indium, percent
Ir_Percent	Iridium, percent
K_Percent	Potassium, percent
K ₂ O_Percent	Potassium oxide, percent—not used yet
La_PPM_S	Lanthanum, parts per million

Field Name	Description
La_Percent	Lanthanum, percent
Li_Percent	Lithium, percent
Mg_PPM_S	Magnesium, parts per million
Mg_Percent	Magnesium, percent
MgCO ₃ _Percent	Magnesium carbonate, percent
MgO_Percent	Magnesium oxide, magnesia, percent
MgO_gmsPer1000cc	Magnesium oxide, magnesia, grams per 1000cc
Mn_PPM_S	Manganese, parts per million
Mn_Percent	Manganese, percent
MnO ₂ _Percent	Manganese dioxide, percent
Mo_oz_T	Molybdenum, ounces per ton
Mo_PPM_S	Molybdenum, parts per million
Mo_Percent	Molybdenum, percent
Na_Percent	Sodium, percent
Na ₂ O_Percent	Sodium oxide, percent
Nb_PPM_S	Niobium, parts per million
Nb_Percent	Niobium, percent
Nd_Percent	Neodymium, percent
Ni_oz_T	Nickel, ounces per ton
Ni_PPM_S	Nickel, parts per million
Ni_Percent	Nickel, percent
Os_Percent	Osmium, percent
P_PPM_S	Phosphorus, parts per million
P_Percent	Phosphorus, percent
PO ₄ _Percent	Phosphorus, percent
P ₂ O ₅ _Percent	Phosphorus oxide, percent
Pb_oz_T	Lead, ounces per ton
Pb_PPM_S	Lead, parts per million
Pb_Percent	Lead, percent
Pd_Percent	Palladium, percent
Pd_oz_T	Palladium, ounces per ton
Pr_Percent	Praseodymium, percent
Pt_Percent	Platinum, percent
Pt_oz_T	Platinum, ounces per ton
Ra_Percent	Radium, percent
Rh_Percent	Rhodium, percent
Rh_And_Pt_oz_T	Rhodium and platinum, ounces per ton
Ru_Percent	Ruthenium, percent
S_Percent	Sulfur, percent
SO ₃ _Percent	Sulfite, percent
SO ₄ _Percent	Sulfate, percent
Sb_PPM_S	Antimony, parts per million

Field Name	Description
Sb_Percent	Antimony, percent
Sc_PPM_S	Scandium, parts per million
Se_PPM_S	Selenium, parts per million
Se_Percent	Selenium, percent
Si_Percent	Silicon, percent
SiO ₂ _Percent	Silica, percent
SiO ₂ _InsolublePercent	Silica insoluble, percent
Sn_PPM_S	Tin, parts per million
Sn_Percent	Tin, percent
Sr_PPM_S	Strontium, parts per million
Sr_Percent	Strontium, percent
Stibnite_Percent	Stibnite, percent
Ta_Percent	Tantalum, percent
Ta ₂ O ₅ _Percent	Tantalum oxide, percent
Tb_Percent	Terbium, percent
Te_Percent	Tellurium, percent
Th_PPM_S	Thorium, parts per million
Th_Percent	Thorium, percent
Ti_PPM_S	Titanium, parts per million
Ti_Percent	Titanium, percent
TiO ₂ _Percent	Titanium oxide, percent
Tl_PPM_S	Thallium, parts per million
Tl_Percent	Thallium, percent
U_PPM_S	Uranium, parts per million
U_Percent	Uranium, percent
eU_Percent	Uranium equivalent, percent
U ₃ O ₈ _Percent	Uranium oxide, percent
V_PPM_S	Vanadium, parts per million
V_Percent	Vanadium, percent
V ₂ O ₃ _Percent	Vanadium trioxide, percent
W_PPM_S	Tungsten, parts per million
W_Percent	Tungsten, percent
WO ₃ _Percent	Tungsten oxide, percent
Y_PPM_S	Yttrium, parts per million
Y_Percent	Yttrium, percent
Yb_Percent	Ytterbium, percent
Zn_oz_T	Zinc, ounces per ton
Zn_PPM_S	Zinc, parts per million
Zn_Percent	Zinc, percent
Zr_PPM_S	Zirconium, parts per million
Zr_Percent	Zirconium, percent
ZrO ₂ _Percent	Zirconia oxide, percent

Field Name	Description
RareEarths	Rare earths
Petroleum_Percent	Petroleum, percent
Water_Percent	Water, percent
Others_Percent	Others, percent
Solids_gmsPer1000cc	Solids, grams per 1000cc
SolubleAlkalis_Percent	Soluble alkalis, percent
Soluble_Fe_Percent	Soluble iron, percent
SolubleMatter_Percent	Soluble matter, percent
Insoluble_Percent	Insoluble residue, percent
InsolubleAcid_Percent	Insoluble residue mixed with acid, percent
InsolubleWater_Percent	Insoluble residue mixed with water, percent
Insoluble_Hg_PPM	Insoluble residue mixed with mercury, parts per million
Moisture_Percent	Moisture, percent
MoistureAndIgnitionLoss_Percent	Moisture and ignition loss, percent
LossOnIgnition_Percent	Loss on ignition, percent
Notes	Additional information on record
PLSS_ID	Foreign key; values are listed as Township Range Section Quarter Quarter as available, otherwise county or state; example: T37S R09W 09 SENW

10.4 AssayReturns Database Table Dictionary

Table 9-5. AssayReturns database table dictionary.

Field Name	Description
SL	Slight trace
BL	Blank
L	Trace, some detected
N	Nil, none detected
Q	Qualitatively, found but not measured
P without #	Qualitative analysis
ND	Not Determined
*	After amount = value is approximate
(low)	After amount = on the low side (as in range)
Present	How much is unknown
-	In front of a number (-0.01) = less than that amount
+	After a number (20.00+) = slightly more than that amount
2 or 3 letters -#	Field lab
P - #	Petrographic analysis lab
S - #	Spectrographic lab
ID.	Identification (when someone wanted to know what type of rock they had)
Spec	Qualitative Spectrographic Analysis
R1	Qualitative Spectrographic Analysis; elements present in concentrations greater than 10%
R2	Qualitative Spectrographic Analysis; 10–1%
R3	Qualitative Spectrographic Analysis; 1–0.1%
R4	Qualitative Spectrographic Analysis; 0.1–0.01%
R5	Qualitative Spectrographic Analysis; 0.01–0.001%
R6	Qualitative Spectrographic Analysis; < 0.001%
P	Public Assay
GO	Government Assay