

Alaska's Mineral Industry 2016

Special Report 72



State of Alaska
Department of Natural Resources
Division of Geological & Geophysical Surveys

STATE OF ALASKA

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Suggested citation:

Athey, J.E., and Werdon, M.B., 2017, Alaska's mineral industry 2016:

Alaska Division of Geological & Geophysical Surveys Special Report 72.

<http://doi.org/10.14509/29748>



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Alaska's Mineral Industry 2016

Jennifer E. Athey¹ and Melanie B. Werdon¹

Special Report 72

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Cover. Drilling at the Palmer project in southeast Alaska. The property is adjacent to a paved Alaska state highway, with access to year-round deep-sea port facilities in Haines, Alaska. Photo provided by Liz Cornejo, Constantine Metal Resources Ltd.

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EXECUTIVE SUMMARY

This summary of the status of Alaska's mineral industry for 2016 is the 36th such annual report produced by the Department of Natural Resources, Division of Geological & Geophysical Surveys and partner agencies. Published for more than one-third of a century, the annual report endeavors to provide a consistent, factual snapshot of mineral industry activity in Alaska. It also serves as the authoritative, historical record of mining in the state.



The **total reported value** of Alaska's mineral industry likely increased in 2016 to **\$2.83 billion**. The total value for 2016 is a composite of the year's expenditures on exploration and development plus the revenue to the operators from the commodities produced. Because mining revenue in 2016 is not directly comparable with the theoretical first market value in 2015, the amount of the increase is unknown. The theoretical first market value was used to estimate the gross production value in previous years.

Exploration and production trends reversed the declines reported in 2015; both exploration expenditures and production values increased in 2016.

***Mining Revenue** realized by operators likely increased to **\$2.5 billion** in 2016, since metal production and the theoretical first market value of commodities produced climbed more than 9 percent in 2016.

Zinc was the top metal produced in 2016, accounting for almost **44 percent of Alaska's total metal production by value**. Gold followed at 39 percent, along with silver at 8.6 percent and lead at 8.5 percent.

Development expenditures in Alaska fell 30 percent in 2016, to **\$217.4 million**. Development expenditures at Alaska's major mines accounted for more than 90 percent of total development expenditures.

Mineral exploration expenditures rose slightly in 2016 to **\$58.9 million**, up less than one percent from the 2015 level of \$58.3 million. Almost half of the State's exploration spending (49 percent) was conducted by the major mines.

Mining claims and prospecting sites covered approximately **2.6 million acres** of Alaska in 2016, with 5,656 active Federal and 31,190 active State mining claims. While the total area of the State held by mining claims decreased in 2016, the area of new claims increased by 22 percent. The number of new State 40-acre and 160-acre claims increased by more than 19 percent in 2016, new State prospecting sites remained flat, and new Federal claims decreased by almost 48 percent.

Mineral industry **employment** in 2016 is estimated at **3,232 full-time-equivalent jobs**, an overall increase of about 331 jobs (11 percent) from 2015. The number of exploration jobs increased by almost 38 percent to 160 jobs in 2016, and combined production and development jobs saw a 10 percent gain as 287 new jobs were reported.

Estimated **revenues** to the State of Alaska and municipalities from mineral-industry-specific fees, rent, sales, royalties, and taxes amounted to almost **\$69.5 million** in 2016.

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INTRODUCTION

Alaska's mineral potential is evident from its historically significant production: placer gold from the Fairbanks and Nome mining districts, copper from the Kennecott area, lode gold from the Alaska-Juneau (A-J) and Treadwell mines near Juneau, and placer platinum from the Goodnews Bay mining district. Alaska's major deposits currently in production include Red Dog, Greens Creek, Pogo, Fort Knox, Kensington, and Usibelli Coal mines (photo 1). Promising advanced-exploration and development projects include Pebble, Donlin Gold, Livengood, Niblack, Palmer, Arctic, and Bornite deposits. These collectively represent a significant proportion of United States domestic gold, copper, and base-metal resources and indicate that there are still extremely large mineral deposits to be developed in Alaska. Significant resources of other commodities, including the Graphite Creek graphite deposit and the Bokan Mountain rare-earth-element deposit, promise domestic sources of critical raw materials needed for twenty-first-century technologies. Without a doubt, Alaska holds other mineral deposits yet to be discovered.

It is the policy of the State of Alaska to encourage the settlement of its land and the development of its resources by making them available for maximum use consistent with the public interest. Alaska, in its strategic Pacific Rim location, offers prospective land, sanctity of title, State-sponsored geological and geophysical mapping, a reasonable permitting process coordinated among agencies, a capable workforce, exploration incentives, and innovative infrastructure equity-sharing programs. More than 190

million acres of Federal, State, and Native-owned lands are open for mineral-related activities and mining. This allows the minerals industry to be a driving force in the State's economy through significant local employment, infrastructure, and government revenue. For purposes of this report, Alaska has been divided into seven geographic regions, shown in figure 1.

Availability of the Large Mine Permitting Team to provide guidance helps attract investment to Alaska.

—An exploration company, Manager²

Alaska's exploration activity, an indicator of industry interest and future production values, showed signs of life in 2016. Exploration expenditures were up slightly (1 percent), from \$58.3 million in 2015 to \$58.9 million in 2016, and the area of new mining claims and prospecting sites staked statewide increased by 22 percent, even as worldwide nonferrous exploration budgets experienced a 21 percent decline (table 1). Alaska had the third largest exploration budget of the U.S. states after Nevada and Arizona³. Development expenditures in Alaska totaled \$217.4 million in 2016, down 30 percent from \$309.9 million in 2015. The sale of commodities mined in Alaska brought more than \$2.5 billion in revenue to companies in 2016. Comparable mining revenue figures are not available for 2015 and prior years, as discussed below. Estimated revenue to industry is inferred to have increased over the 2015 figure, since the theoretical first market value for 2016 of \$3.01 billion increased more than 9 percent from \$2.76 billion in 2015.

²Jackson, Taylor, and Green, K.P., 2017, Fraser Institute Annual Survey of Mining Companies, 2016: Vancouver, BC, Fraser Institute, 70 p. <https://www.fraserinstitute.org>

³S&P Global Market Intelligence, 2017, Worldwide Mining Exploration Trends 2016: A special report from S&P Global Market Intelligence for the PDAC International Convention, 16 p. http://mineralsmakelife.org/wp-content/uploads/2017/04/Worldwide_Mining_Exploration_Trends_2017.pdf

TRACKING ALASKA'S MINERAL INDUSTRY: ESTIMATED REVENUE TO INDUSTRY VERSUS THEORETICAL FIRST MARKET VALUE

This report begins a new method of tracking the value of Alaska's mineral production. Starting with calendar year 2016, estimated revenue to industry, as reported by mining companies, along with theoretical first market values will be used in place of the 'estimated first market value' tabulated in previous years (note column name change to 'theoretical first market value'; table 1). The new 'estimated revenue to industry' figure accounts for actual sales (stockpiling for sales, hedging by locking in a future selling price, and the price at the time of sale accounting for deductions because of other valuable metals or impurities in the concentrate), including smelting and refining charges for the removal of impurities and transportation of the final product, whereas the 'theoretical first market value' figure simply reflects the total amount of each commodity produced in the State multiplied by the average price for that year and is a hypothetical value of the fully refined final product. Under the prior method of accounting, the theoretical first market value of minerals produced in Alaska increased 9 percent from \$2.8 in 2015 to more than \$3.0 billion in 2016. The simplicity of the former approach meant that the theoretical first market value figure could significantly overstate the revenue realized by the operators. For example, there is almost a \$500 million difference between estimated revenue received by operators in 2016 and the theoretical first market value for 2016. When actual revenue values are either not available or must be withheld for reasons of confidentiality, theoretical first market values will be used instead (note that this will be true for any mine that does not report actual revenue). In the "Government Revenues from Alaska's Mineral Industry" section, gross income from mining operations as reported on Alaska Mining License Tax returns and explanatory text are also available for comparison with the estimated revenue to industry value.



Photo 1, left. Hecla Mining Company's silver proof for 2016. Greens Creek produced 9.25 million ounces of silver in 2016, the mine's highest silver production level in 10 years. Photo from Hecla Mining Company, <http://www.hecla-mining.com/greens-creek/>, last accessed January 13, 2017.

Figure 1, below. Regions of mineral activity as described in this report.

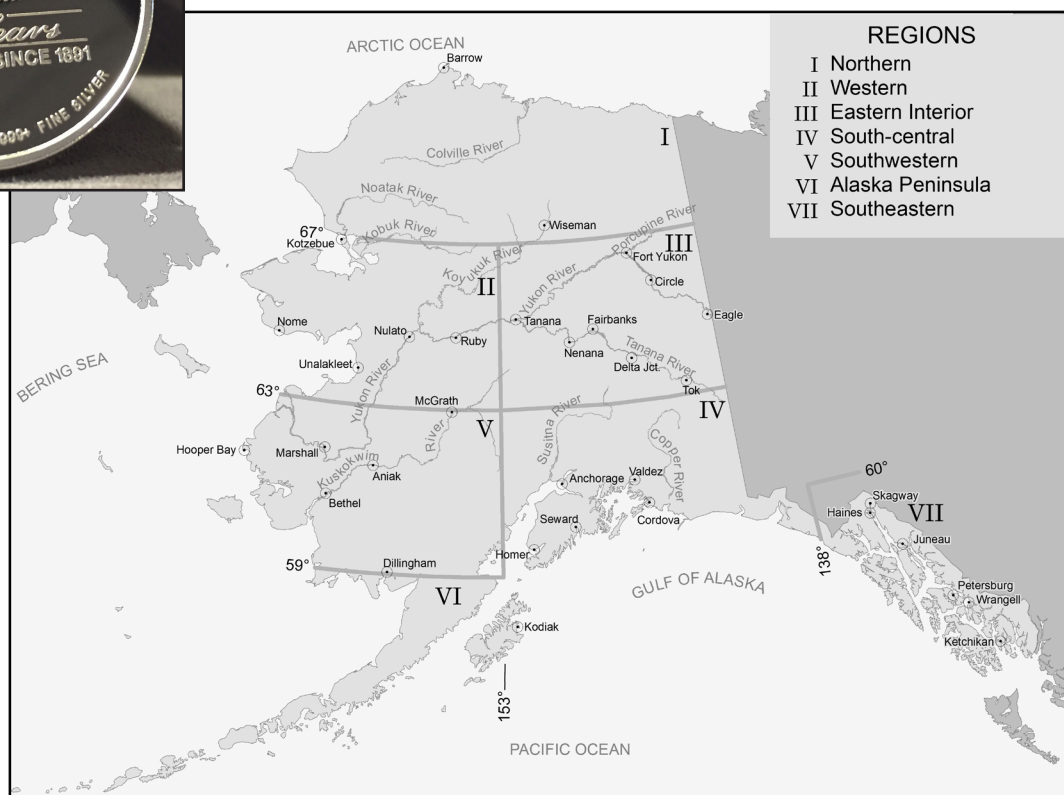


Table 1. Reported annual exploration and development expenditures of the mineral industry, the theoretical first market value of mineral production in Alaska, and estimated revenue to the mineral industry from the sale of those commodities (in millions of dollars), 1981–2016. Average annual values are given for 1981–1985, 1986–1990, 1991–1995, and 1996–2000; individual year totals are provided for 2001–2016.

Year	Exploration Expenditures (\$ millions)	Development Expenditures (\$ millions)	Theoretical First Market Value (\$ millions) ^a	Estimated Revenue to Industry (\$ millions) ^b
1981–1985	\$37.5	\$36.3	\$204.7	--
1986–1990	\$36.2	\$109.6	\$288.6	--
1991–1995	\$33.2	\$55.3	\$520.1	--
1996–2000	\$49.4	\$158.7	\$917.4	--
2001	\$23.8	\$81.2	\$917.3	--
2002	\$26.5	\$34.0	\$1,012.8	--
2003	\$27.6	\$39.1	\$1,000.7	--
2004	\$70.8	\$209.1	\$1,338.7	--
2005	\$103.9	\$347.9	\$1,401.6	--
2006	\$178.9	\$495.7	\$2,858.2	--
2007	\$329.1	\$318.8	\$3,367.0	--
2008	\$347.3	\$396.2	\$2,427.1	--
2009	\$180.0	\$330.8	\$2,455.6	--
2010	\$264.4	\$293.3	\$3,126.8	--
2011	\$365.1	\$271.9 ^c	\$3,507.7	--
2012	\$335.1	\$342.4	\$3,436.1	--
2013	\$175.5	\$358.8	\$3,418.7	--
2014	\$96.2	\$281.7	\$3,282.1	--
2015	\$58.3	\$309.9 ^c	\$2,759.2	--
2016	\$58.9	\$217.4	\$3,012.6	\$2,536.6

Exploration, development, and production figures are provided in Alaska's Mineral Industry reports published annually by DGGIS and sister agencies.

^aTheoretical first market value is calculated by multiplying reported commodity amounts produced for a calendar year by the average yearly price per unit. This figure may significantly overestimate the value of the commodity, because it assumes that the commodity is a pure, final product and the operator has incurred no additional charges during its production.

^bEstimated revenue to industry is compiled from 1) revenue figures reported for the calendar year by major mine operators (accounting for actual sale prices and including smelting and refining charges and transportation costs), except a theoretical first market value is substituted when actual mine revenue is unavailable; 2) calculated value of industrial materials (rock, sand, and gravel) produced from some State and Federal lands (table 11); and gross operating income of placer mining operations from Mining License Tax forms as reported by the Department of Revenue (table 12).

^c2011 and 2015 total missing significant expected data

-- = Not reported

Definitions, for the purposes of this report:

Exploration—the search for economic mineral deposits.

Development—the building of infrastructure or activities that facilitate production of mineral products, including such sustaining expenditures as equipment replacement and rebuilding, facility upgrades, and other expenses that must be amortized or depreciated according to tax law.

Production—a commodity produced and reported in actual unit values or average values, for example, metal values computed from weekly averages on the London Metal Exchange.

The exploration, development, and production values used in this report are compiled from past-year statements issued by companies, including press releases and corporate annual and financial reports, as well as phone interviews, replies to questionnaires, and news media articles. Average metal prices used in the first market value calculations that are incorporated into estimated mining revenues and estimated commodity values are based on average daily prices on the London Metal Exchange. Coal prices are estimated from average coal prices for similar grade material around the Pacific Rim. Industrial materials prices are based on regional rates provided by some operators. Due to incomplete reporting, the numbers compiled in this report are likely minimum estimates of the importance of Alaska's mineral industry to the State's economy, although estimates of commodity values and company revenue may also likely be overinflated by theoretical first market values.

This report is a cooperative project led by the Alaska Division of Geological & Geophysical Surveys (DGGS) in the Department of Natural Resources (DNR), with support from the DNR Division of Mining, Land & Water (DMLW), the Department of Labor and Workforce Development (DLWD), and the Department of Revenue (DOR). The agencies involved in producing this report are committed to producing a reliable annual commentary on mineral industry activity in Alaska, which is vital for informed decision-making by State and local governments, the Legislature, land managers, industry, Native corporations, and the public.

EMPLOYMENT

Total mineral industry employment in 2016 is estimated at 3,232 full-time-equivalent jobs, an overall increase of about 331 jobs (11 percent) from 2015 (table 2). The exploration sector added an estimated 44 jobs, up 38 percent from 2015 despite flat exploration spending. Development lost 143 jobs while production gained 430, for a net gain of 287 positions (10 percent). This shift parallels the trends of increased mine production and decreased spending on development, down 30 percent in 2016. Note that most large operators do not differentiate production

from development employment, and since 2014, development and production employment, when not specifically provided by the operator, have been estimated for large operations based on their reported ratio of production to development expenditures. Full-time-equivalent positions are based on a 260-day work year and 10-hour work day unless actual average annual employment numbers are provided.

This report relies on a variety of sources to tabulate mineral industry employment, including publicly available company documents, personal communications, and questionnaires sent out by the DNR. Many exploration companies and mine operators voluntarily responded to questionnaires with 2016 employment information. Additional employment information was obtained from the Mine Safety and Health Administration (MSHA)⁴. These additional datasets and sources represent a minimum estimate and an incomplete picture of mineral industry employment in Alaska, but the values that are available add to the statewide mining employment total and provide a more complete estimate of the impact of mining to the State's workforce and wealth-generation potential. In particular, MSHA data indicate that materials production (rock, sand, and gravel) employment apparently increased by 46 percent, although State records of material-sale volumes decreased slightly in 2016. While the industrial materials sector is still underreported, the MSHA dataset captures its employment more completely than past voluntary reporting through questionnaires. Affidavits of Annual Labor and Applications for Permits to Mine in Alaska (APMAs) were not used to collect 2016 employment data.

Employment in placer mining and exploration is challenging to quantify, due to the large number of small or seasonal operations and incomplete reporting. Placer mining employment in 2016 was estimated from the number of placer mines that reported gross operating income on Mining License Tax returns, a new methodology fully explained in table 12. The new placer employment calculations estimate this sector more completely than MSHA data, which was the original source of the 2015 estimate. Employment for ten lode exploration projects

⁴Mine Safety and Health Administration, (MSHA); <http://arlweb.msha.gov/OpenGovernmentData/OGIMSHA.asp>, dataset 9. Last accessed May 3, 2017.

Table 2. Estimated Alaska mineral industry employment, 2006–2016^a, as compiled from public documents, MSHA reporting^b, personal communications, and other sources. The total employment number for an operation may be divided among exploration, development, and production activities based on the reported expenditures in those categories.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Gold/silver mining											
Placer	242	208	282	399	405	439	477	432	241	224 ^e	222
Lode	704	808	739	832	1,008	1,085	1,206	1,176	1,054	1,047	1,253
Polymetallic mining	245	276	317	321	350	364	386	390	287	303	306
Base metals mining	457	457	475	413	550	586	530	550	446	475	526
Recreational mining	45	54	30	36	35	41	52	55	7	--	--
Industrial minerals										173	253
Sand and gravel	337	284	277	286	313	307	424	565	30	--	--
Rock	104	124	93	83	11	28	60	19	65	--	--
Coal ^c	95	102	110	117	140	140	144	120	115	112	100
Peat ^{c,d}	11	11	7	--	3	3	4	--	<1	--	--
Tin, jade, soapstone, ceramics, platinum	--	--	--	--	--	--	--	1	1	--	--
Production (total of above categories)	2,240	2,324	2,330	2,487	2,815	2,993	3,283	3,308	2,246	2,230	2,660
Mineral development	848	735	516	371	537	422	535	358	468	555	412
Mineral exploration	435	499	546	422	520	535 ^f	548	385	253	116	160
TOTAL	3,523	3,558	3,392	3,280	3,872	3,950	4,366	4,051	2,967	2,901	3,232

^aReported man-days are calculated on a 260-day work year and 10-hour work day to obtain average annual employment unless actual average annual employment numbers are provided.

^bMSHA data: <http://arlweb.msha.gov/OpenGovernmentData/DataSets/MinesProdYearly.zip>

^cCoal and peat employment numbers are combined in 2009.

^dThis figure does not include all of the man-days associated with peat operations; most of those man-days are included in sand and gravel numbers.

^eValue was updated to estimate calculated from Department of Revenue data. See table 12 for information on placer employment calculations.

^fAverage of 520–550 range reported for 2011.

-- = Not reported

See Exploration, Development, and Production sections for further details.

that did not report employment was estimated using their reported exploration expenditures and an employment-per-dollar-spent ratio averaged from 18 projects that reported complete employment and expenditure data.

The Alaska Department of Labor and Workforce Development (DLWD) provided 2016 mining employment and wage statistics based on 104 reporting units (companies) consisting of 50 metal ore, 33 coal and nonmetallic-mineral quarrying, and 21 mining-support-activity units. Among companies in

2016, mining and support activities provided 2,945 jobs, down slightly (1 percent) from 2,984 jobs in 2015. Although the number of companies providing support activities remained the same, annual average employment in this sector decreased 11 percent from last year. DLWD data show that nonmetallic mineral-product manufacturing provided 257 jobs, which includes an average of 252 jobs in cement and concrete manufacturing for 2016. Primary metal manufacturing provided 16 jobs, while metal and mineral merchant wholesalers provided an average of 109 jobs during 2016⁵.

⁵State of Alaska Department of Labor and Workforce Development (DLWD), Research and Analysis Section, Quarterly Census on Employment and Wages (QCEW); last accessed September 24, 2017; <http://live.laborstats.alaska.gov/qcew/ee16.pdf>

According to DLWD data, 18 boroughs or census areas reported non-oil-and-gas mining employment in 2016. Juneau, Anchorage, and Fairbanks area (combined Fairbanks North Star Borough and Southeast Fairbanks Census Area) each had more than 100 mining jobs. The greater Fairbanks area had the highest number of jobs in mining (1,209) with the City and Borough of Juneau ranking second with 771 jobs⁵.

Average wages for mining-sector jobs are some of the highest among major industries in Alaska, with a 2016 annual average wage of \$108,627, more than twice as much as the average \$52,151-per-year private-sector wage in Alaska. Total wages paid by non-oil-and-gas mining firms in 2016 were \$302,851,861, down slightly (less than 1 percent) from 2015. Total wages paid by mining-support firms in 2016 were \$12,508,843, a 13 percent decrease from 2015. DLWD employment is based on wage records and includes part-time jobs but does not include the self-employed and working family members not covered under unemployment insurance. The majority of placer operators are self-employed and are therefore not counted in the DLWD data. Employment data may not include jobs in the exploration and development phases of mining at geological and engineering consulting firms, which are categorized in the engineering, environmental, or construction industries. Consequently, mining's contributions to employment and earnings in Alaska are likely understated by DLWD's dataset⁵.

Alaska Miners Association's 2016 economic impact report stated that Alaska's mining industry provided 4,350 direct mining jobs and an additional 4,250 indirect jobs, with \$675 million total paid in wages⁶. Mining companies strengthen Alaska's local economies by employing Alaska residents from local communities and by purchasing supplies and services from hundreds of Alaska businesses.

GOVERNMENT REVENUES FROM ALASKA'S MINERAL INDUSTRY

In 2016 government revenue from Alaska's mineral industry totaled \$69.5 million (table 3). The 40 percent decrease from \$116.5 in 2015 is due primarily to decreased revenues from Alaska Corporate Income Tax and Mining License Tax, which are reported for the State fiscal year (July 2015 – June 2016). Table 3 provides an itemized listing of estimated revenues paid to the State and municipalities. These revenues are incomplete and serve only as a minimum. Changes to the table include the addition of receipts from the Large Mine Permit Coordination program and deletion of bond pool payments, which are reclamation financial assurance, not considered State revenue, and may only be used to reclaim sites disturbed by mining activities. DNR reported that \$57,825 was received in bond pool payments in 2016. The negative 2013 Mental Health Trust material sales number is due to a deposit incorrectly shown as revenue in 2009. The deposit was corrected in 2013 and then refunded to the customer.

Gross income for 2016 of \$1,902 million is compiled from the Mining License Tax returns filed by all taxed mining operators in Alaska and indicates the income received for commodities sold during the tax year (December 2015 – November 2016; table 4). For comparison, 2016 'estimated revenue to industry' of \$2,537 million in table 1 is compiled for the calendar year and includes some theoretical first market values of mineral production that may not have been sold during that time period, as well as the value of untaxed sand and gravel products. Note that table 4 excludes royalty-only taxpayers; royalty-only taxpayers are typically landowners who receive revenue solely from a royalty share, with no gross income from mining operations. All six major mines in Alaska earn gross income from mining operations and their income is included in the table's values.

⁶Alaska Miners Association, The Economic Benefits of Alaska's Mining Industry, January 2017; last accessed August 24, 2017; <https://www.dropbox.com/s/ouji67uc6qu1ygo/2016%20McDowell.pdf?dl=1>

Table 3. Reported and estimated revenues paid to the State of Alaska and municipalities by Alaska's mineral industry, 2009–2016. The figures in this table will change as data are reviewed and updated; the table has been significantly updated to reflect Department of Natural Resources and Department of Revenue reporting for previous years. See footnotes for reporting sources and dates.

	2011	2012	2013	2014	2015	2016
State mineral rents and royalties^{a,b}						
State claim rentals	8,498,314	7,951,003	7,507,976	6,740,816	6,920,029	7,327,630
Production royalties ^c	5,416,473	8,982,259	9,808,575	7,004,376	4,608,137	2,816,884
Annual labor	760,884	357,500	542,588	389,807	321,419	331,986
Subtotal	\$ 14,675,671	17,290,762	17,859,139	14,134,999	11,849,585	10,476,500
State coal rents and royalties^b						
Rents	446,415	186,204	324,393	315,398	351,724	347,324
Royalties ^c	2,616,629	2,921,491	2,757,444	2,514,532	2,430,267	2,237,777
Bonus	--	3,025,000	--	38,005	111,000	--
Subtotal	\$ 3,063,044	6,132,695	3,081,837	2,867,935	2,892,992	2,585,101
State material Sales						
Mental Health	90,116	11,876	-7,854	115,493	69,163	25,130
Division of Land ^b	1,239,747	1,735,404	4,965,386	10,559,857	11,293,545	6,412,271
State Pipeline Coordinator's Office	309,600	30,746	340,786	105,330	197,644	121,994
Subtotal	\$ 1,639,463	1,778,025	5,298,318	10,780,680	11,560,352	6,559,395
State mining miscellaneous fees^b						
Filing fees	1,395	6,274	3,350	3,350	2,100	9,650
Bid Bonus	3,319,323	465,850	--	93,767	--	193,963
Penalty fees	238,115	532,959	205,453	122,035	43,307	95,677
Exploration incentive app filing fee	--	--	--	--	--	--
Surface mine investment interest	25,890	20,491	5,772	7,802	7,801	19,690
Surface coal mining app fee	7,534	2,200	22,800	1,300	21,700	7,218
APMA mining fees	30,741	45,055	32,953	26,511	24,302	21,627
Subtotal	\$ 3,622,998	1,072,829	270,329	254,764	99,210	347,826
Other Fees						
AIDEA - Facilities use fees ^d	13,500,000	12,600,000	11,986,000	11,986,000	11,356,000	10,709,000
State Fuel Taxes ^e	741,071	585,034	951,852	Not reported	Not reported	2,066,313
State corporate income tax ^f	81,790,274	15,020,036	26,812,498	15,215,598	17,320,051	1,636,850
Mining License Tax ^g	49,588,119	40,695,833	46,787,690	23,457,300	38,665,209	11,137,900
Large Mine Permit Coordination Program Receipts ^h	1,913,906	2,614,863	2,238,589	1,919,659	1,725,021	1,364,952
STATE TOTAL	\$ 170,534,545	97,790,077	115,286,252	80,616,934	95,468,420	46,883,837
Payments to Municipalities ⁱ	20,378,242	21,529,472	29,412,224	18,525,615	21,041,152	22,656,383
TOTAL	\$ 190,912,787	119,319,549	144,698,476	99,142,549	116,509,572	69,540,220

^aIncludes upland lease and offshore lease rentals. Figures are reported by calendar year by the Alaska Department of Natural Resources.

^bFigures are reported by calendar year by the Alaska Department of Natural Resources.

^cReported on a cash basis; payments actually received during the given year.

^dAIDEA user fees for use of the State-owned roads and ports: the De Long Mountain Transportation System by Teck Alaska Inc., operator of the Red Dog Mine; and for use of the Skagway Ore Terminal by Minto Explorations Ltd., a subsidiary of Capstone Mining Corp. (formerly Sherwood Copper Corp.). AIDEA figures are reported by fiscal year.

^eIn 2013, calculated on Fuel and Oil Expenditures from Mining Licenses Tax Form/Department of Revenue, assuming Alaska average fuel cost of \$6.09, <https://www.commerce.alaska.gov/web/dkra/researchanalysis/fuelpricesurvey.aspx>. 2016 value was reported by the major operating mines, less their fuel tax refund.

^fOnly subchapter C corporations pay income tax. This report may not reflect 100% of the returns received in a year. The amount of corporate income tax reported in each fiscal year is the amount of tax actually received and may not agree with the amount reported on a corporation's tax return. This is due primarily to timing differences.

^gIncludes metals, coal, and material for 2011. In 2012 and later, Mining License Tax was not collected on materials. <http://www.tax.alaska.gov/programs/programs/reports/Annual.aspx?60610&Year=2016>

^hThe DNR, Office of Project Management and Permitting (OPMP) recovers costs from applicants for large mine permit coordination, per AS 38.05.020(b)(9) and AS 37.05.146(b)(3).

ⁱPayments to Municipalities include property taxes, payments in lieu of taxes (PILT), and severance taxes. Data should be considered a minimum estimate. Data were primarily provided by the major operating mines.

Table 4. Mining tax analysis by tax bracket for 2014–2016, based on Mining License Tax returns. Analysis excludes royalty-only taxpayers—those with positive royalties received but zero gross income from mining operations. Information provided by the Alaska Department of Revenue. The figures in this table will change as data are reviewed and updated.

2014 (December 2013 – November 2014)									
Bracket	Marginal rate	No. of tax-payers	Gross income from mining operations	Net taxable income*	Net income as percentage of gross	Total tax liability	Average gross income	Average taxable income	Average tax liability
Under \$0	0%	194	\$225,708,606	\$ -65,853,227	-29%	\$0	\$1,163,446	-\$339,450	\$0
\$0 to \$40,000	0%	222	\$10,029,137	\$934,556	9%	\$0	\$45,176	\$4,210	\$0
\$40,001 to \$100,000	3%, 5%	20	\$3,823,854	\$951,405	25%	\$29,896	\$191,193	\$47,570	\$1,495
Over \$100,000	7%	15	\$2,194,531,323	\$470,191,692	21%	\$32,868,418	\$146,302,088	\$31,346,113	\$2,191,228
TOTAL		451	\$2,434,092,920	\$406,224,426		\$32,898,314			
2015 (December 2014 – November 2015)									
Bracket	Marginal rate	No. of tax-payers	Gross income from mining operations	Net taxable income*	Net income as percentage of gross	Total tax liability	Average gross income	Average taxable income	Average tax liability
Under \$0	0%	191	\$181,380,675	\$ -48,850,623	-27%	\$0	\$949,637	-\$255,762	\$0
\$0 to \$40,000	0%	228	\$9,051,119	\$785,831	9%	\$0	\$39,698	\$3,447	\$0
\$40,001 to \$100,000	3%, 5%	8	\$2,594,126	\$539,304	21%	\$19,018	\$324,266	\$67,413	\$2,377
Over \$100,000	7%	10	\$2,306,213,104	\$570,733,654	25%	\$39,921,356	\$230,621,310	\$57,073,365	\$3,992,136
TOTAL		437	\$2,499,239,024	\$523,208,166		\$39,940,374			
2016 (December 2015 – November 2016)									
Bracket	Marginal rate	No. of tax-payers	Gross income from mining operations	Net taxable income*	Net income as percentage of gross	Total tax liability	Average gross income	Average taxable income	Average tax liability
Under \$0	0%	196	\$196,280,847	\$ -73,021,851	-37%	\$0	\$1,001,433	-\$372,560	\$0
\$0 to \$40,000	0%	259	\$5,992,664	\$855,765	14%	\$0	\$23,138	\$3,304	\$0
\$40,001 to \$100,000	3%, 5%	7	\$2,627,609	\$433,192	16%	\$14,724	\$375,373	\$61,885	\$2,103
Over \$100,000	7%	13	\$1,697,029,520	\$172,391,009	10%	\$9,306,567	\$130,540,732	\$13,260,847	\$715,890
TOTAL		475	\$1,901,930,640	\$100,658,115		\$9,321,291			

*Net income taxable under the Mining License Tax

Note: The 3% bracket (income \$40,000 to \$50,000) and the 5% bracket (\$50,000 to \$100,000) are combined for this analysis because of confidentiality issues that would arise if each bracket were reported separately. Taxpayers with negative income (under \$0) are not a separate bracket, but are reported separately to distinguish between large money-losing operations and small operations with zero or positive income.

Mining License Tax collections were significantly impacted by a sharp decline in mineral prices during the first half of FY2016 (July 1, 2015 – January 1, 2016), resulting in a 71 percent decrease in taxes collected. Zinc, which began a precipitous drop in price during May 2015, lost 27 percent of its price. Though the price recovered before June 30, 2016, the damage to taxable income (and thus, the amount of tax collected) was already done. The Department of Revenue (DOR) reported that 475 taxpayers submitted Mining License Tax returns in 2016, of which

20 (4 percent) were liable for taxes on net taxable income from mining in the amount of \$172.8 million (table 4). Almost 200 taxpayers reported negative net taxable incomes from mining at an average loss of \$372,560 per taxpayer.

According to DOR, the 90.5 percent drop in revenue from corporate mining taxes on the mining sector also stemmed from the precipitous drop in mineral prices during the year. The fall in mining profits coincided with the maturity of several large

tax credits and overpayments. Lower tax assessments and larger refunds combined to result in the significant decline.

While State government revenue from minerals and mining activity dropped considerably over recent years, it is important to note that historical yearly collections have fluctuated and 2016 numbers can be viewed more appropriately as part of the general trend. Despite revenue and payment declines to

State governments in 2016, revenue to municipalities remained strong. In Juneau, Fairbanks, and the Northwest Arctic Borough, revenue from mining-related activity was among the largest contributors to municipal and borough budgets. In addition, the mining industry paid more than \$123.5 million to Native organizations. Alaska communities also received \$1.4 million in charitable donations. More information about various sources of revenues is available from individual agencies (appendix A).

MINERALS-RELATED GOVERNMENT ACTIVITIES

THE U.S. GEOLOGICAL SURVEY

The U.S. Geological Survey (USGS) Mineral Resources Program conducted multiple projects focused on the geologic framework and mineral resources of Alaska in 2016. Alaska Science Center research staff in Anchorage coordinated field-based studies of the tectonic and metallogenic evolution of 1) the Lake Clark and Neacola Mountains region, south-central Alaska, and 2) the Yukon-Tanana uplands, eastern Alaska. USGS also funded a new airborne magnetic survey, contracted through DGGS, of the eastern Colleen and Black River quadrangles of northeastern Alaska. Research staff at the Crustal Geophysics and Geochemistry Science Center and Central Mineral and Environmental Resources Science Center in Denver field tested hyperspectral remote sensing to characterize surficial materials, geology, and potential mineral resources in Alaska. This project seeks to define the hyperspectral-geologic footprint of select mineral deposits and to regionally extrapolate this knowledge to areas not well characterized.

Additionally, Alaska Science Center research staff, in cooperation with DGGS, evaluated the mineral potential for selected deposit models across Alaska through a new GIS-based analysis of existing, geospatially referenced datasets (for example, stream sediment and rock geochemistry, and lithology). The resulting maps show both the estimated potential and the confidence of that estimate for a given group of mineral commodities or deposit types. Estimated mineral resource potential and certainty were mapped for: (1) rare earth elements, (2) placer and paleoplacer gold, (3) platinum group elements, (4)

carbonate-hosted copper, (5) sandstone uranium, and (6) tin-tungsten-molybdenum-fluorspar. These groups include most of the strategic and critical elements of greatest interest in current exploration. Results of this study covering the entire State of Alaska were published in USGS Open-File Report 2016-1191. The USGS continues to improve and adapt this method, now focusing on the statewide potential for sediment-hosted copper and various styles of lode gold, including porphyry, reduced intrusion-related, epithermal, and orogenic gold deposits.

DIVISION OF MINING, LAND & WATER

The Division of Mining, Land & Water (DMLW) supervises Alaska's mineral (including coal) and water resources, managing the State's mineral exploration, development and leasing programs on the 96 million acres of State lands available for mineral exploration and mining, and administers the State's Surface Coal Mining Control and Reclamation Act. The Division allocates and manages the State's water resources on all lands in Alaska, adjudicates water rights, provides technical hydrologic support, and assures dam safety.

In 2016 the Division's Large Mine Permitting Team (LMPT) coordinated the permitting activities of large mines in the state, including Red Dog, Fort Knox, Pogo, Kensington, Greens Creek, and Nixon Fork mines. The LMPT also consulted with owners of active potential development projects Graphite One, Chuitna Coal, Donlin Gold, Niblack, and Pebble, as well as engaged in the review of large hard rock mining projects in Canada that have the potential to affect Alaska's interest's dependent upon transboundary rivers.

On July 7, 2016, the Alaska District Court issued an order remanding the Office of Surface Mining Reclamation and Enforcements (OSMRE) decision concerning the Wishbone Hill Mine back to the agency for reconsideration. During 2016, there were two concurrent processes being addressed by the State of Alaska concerning Wishbone Hill. The first was the Department of Law's (DOL) activity concerning the case Castle Mountain Coalition (CMC) v. OSMRE and the second was DMLW work responding to OSMRE's action to address the remand order for the two Ten Day Notices.

On May 3, 2016, U.S. District Court Judge Sharon Gleason, ruled (Case No. 3:12-cv-00114-SLG)

that the United States had acted in bad faith in litigation concerning ownership of the lands underlying the Mosquito Fork River in the Fortymile area. Based on that bad faith, Judge Gleason ordered the United States to reimburse the State of Alaska nearly \$600,000 in litigation costs. This decision was the culmination of a dispute that lasted several decades concerning State issued mining claims on the Mosquito Fork of the Fortymile River.

In 2016 Mining Section staff participated and provided input into the development of the U.S. Bureau of Land Management's (BLM) Revegetation and Wildlife Habitat Criteria and Site Assessment Procedures for Upland and Floodplain Mine Reclamation on BLM-managed public lands in Alaska. Staff worked closely with the Placer Mining Subcommittee members of the Alaska Resource Advisory Council in providing State perspectives on revegetation for placer mining reclamation.

DMLW staff continued the review of the CERCLA 108 (b) proposed regulations and provided comment to the Alaska Department of Law and the interstate Mining Compact Commission on the potential effects of the proposed regulation on the mining industry in Alaska.

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

Alaska Geologic Materials Center

The Alaska Geologic Materials Center (GMC), maintained by DGGs, is the State's largest and most comprehensive archive of geologic samples. It is the key entity directed to support the knowledge of Alaska geology through the acquisition and preservation of physical collections, which assist in the discovery of mineral and energy resources. The GMC



houses drill core from numerous Alaska mineral prospects, as well as DGGs rock samples and the Alaska collections of the U.S. Geological Survey, the

former U.S. Bureau of Mines, and other agencies.

In 2016, the GMC completed its first full year of operation at the newly renovated 100,000-square-foot facility at 3651 Penland Parkway in Anchorage (photo 2). The new facility features more than 5,000 eight-foot-wide industrial steel shelves (photo 3), as well as viewing areas with roller tables and high-lumen overhead lighting. As part of the facility's relocation, the GMC instituted a new barcode-based online information system to track the more than 580,000 samples in the collection's inventory. The browser-based search interface (maps.dggs.alaska.gov/gmc) allows users to build simple to complex queries through text- or map-based searches.

Mineral industry clients donated significant volumes of mineral core to the GMC in 2016. Major donations were received from Pure Nickel, Inc., Millrock Resources Inc., Riversdale Alaska LLC, Alaska Energy Authority, Online Exploration

Photo 2, above. The new Geologic Materials Center (GMC) facility in Anchorage, Alaska. The GMC collection holds more than 354,000 linear feet of diamond-drilled, hard-rock mineral core representing more than 2,100 exploratory and geotechnical drill holes and a state-wide collection of 350,000 surface rock and sediment samples. Photo by Kurt Johnson, DGGs.

Services, Inc., and Kinross Gold Corporation, which added more than 2,800 core boxes representing 16 prospects with 66 boreholes.

Minerals Resource Section Activities

The DGGs Mineral Resources section uses its expertise in mineral deposit geology, geophysics, and geochemistry to evaluate State land for its potential to host undiscovered mineral resources (table 5).

Section staff conduct geophysical surveys, geologic mapping, mineral-resource assessments, and ore deposit research; they also track mineral industry exploration and discoveries, development, and production. Additionally, the Section's expertise and knowledge are sought to review other Departmental actions including State land selection conveyance prioritization, land-use plans, land disposal actions, review of Federal actions, and infrastructure planning.



Photo 3. Samples from Geologic Materials Center shelves may be displayed in public or private viewing rooms with roller tables and high-lumen overhead track-lighting. Rooms include extra counter and table space, sinks, LED stereoscopes, digital balances (+/- 0.1g), and other advanced equipment. Photo courtesy of Chris Arend, photoguy@alaska.net.

Table 5. New DGGs publications in 2016.

GEOLOGIC MAPS, REPORTS, AND GEOCHEMICAL DATA

- Livengood area geologic map: <http://doi.org/10.14509/29665>
- Bonnifield bedrock geologic map: <http://doi.org/10.14509/29661>
- Bonnifield rock geochemical data: <http://doi.org/10.14509/29653>
- Tok area mineral occurrences summary: <http://doi.org/10.14509/29605>
- Tok area stream sediment geochemical data: <http://doi.org/10.14509/29688>
- Tok area rock geochemical data: <http://doi.org/10.14509/29685>
- Bering Straits heavy mineral concentration: <http://doi.org/10.14509/29666>
- Windy Fork peralkaline pluton REE/zirconium: <http://doi.org/10.14509/29667>
- Clearwater Mountains U-Pb zircon age data: <http://doi.org/10.14509/29663>
- Ray Mountains area U-Pb zircon age data: <http://doi.org/10.14509/29662>
- Tyonek Quadrangle geochemical data: <http://doi.org/10.14509/29651>
- Strategic & Critical Minerals (digital compilation of historical PGE geochemical data): <http://doi.org/10.14509/29474>
- Strategic & Critical Minerals (digital compilation of historical REE geochemical data): <http://doi.org/10.14509/29473>
- Areas with critical-minerals potential in Alaska (USGS-DGGs cooperative project): <http://dx.doi.org/10.3133/ofr20161191>
- Geochemical atlas of Alaska (USGS-DGGs cooperative project): <http://dx.doi.org/10.3133/ds908>
- Alaska's mineral industry 2015 (report): <http://doi.org/10.14509/29687>
- Alaska's mineral industry 2015 (presentation): <http://doi.org/10.14509/29598>
- Alaska's mineral resources 2015 (poster): <http://doi.org/10.14509/29558>

GEOPHYSICAL SURVEYS

- Updated Bonnifield geophysical survey: <http://doi.org/10.14509/29557>
- Sub-regional, merged, gridded airborne geophysical data: <http://doi.org/10.14509/29555>

The geophysical, geological, and resource surveys conducted by the Mineral Resources section not only inventory the potential for mineral resources, but add value to the State's current and future revenue.

Since 1993 the data products of the Airborne Geophysical/Geological Mineral Inventory (AGGMI) program have been an important component of successful resource-exploration programs; products have contributed to the private-sector discovery of more than 22 million ounces of gold in the Salcha River–Pogo and Livengood areas (figure 2). State budget cuts impacted the AGGMI program, resulting in the loss of a permanent staff position in the Mineral Resources section and its annual funding for data collection and publication. New geophysical surveys now rely on ad-hoc funding from external sources (table 6) or the State of Alaska's capital budget.

Geophysical Datasets

The Alaska Mental Health Trust Land Office contracted DGGs to manage a detailed airborne magnetic survey for the Icy Cape area, near Yakutat,

as part of their Icy Cape Gold and Industrial Heavy Minerals project. This survey will be published by DGGs after a 5-year confidentiality period expires. In 2016 the DGGs AGGMI program's Bonnifield geophysical dataset was upgraded to modern digital standards and re-released to provide better access to and preserve these data. Additionally, publication DDS-12 (doi.org/10.14509/29555) was created to host DGGs' collection of sub-regional, merged, gridded airborne geophysical data. Three merged datasets along the Tintina Gold belt were added in 2016, and more data will be added in FY2018. A portion of the DGGs AGGMI program's VHS-format flight videos, collected as part of historical geophysical surveys, were converted into mp4 files to enable digital archiving, and will be published with their associated surveys starting in FY2018.

Strategic & Critical (SCM) Assessment

The DGGs Strategic and Critical Minerals (SCM) Assessment project is designed to evaluate Alaska's potential to contribute domestically produced stra-

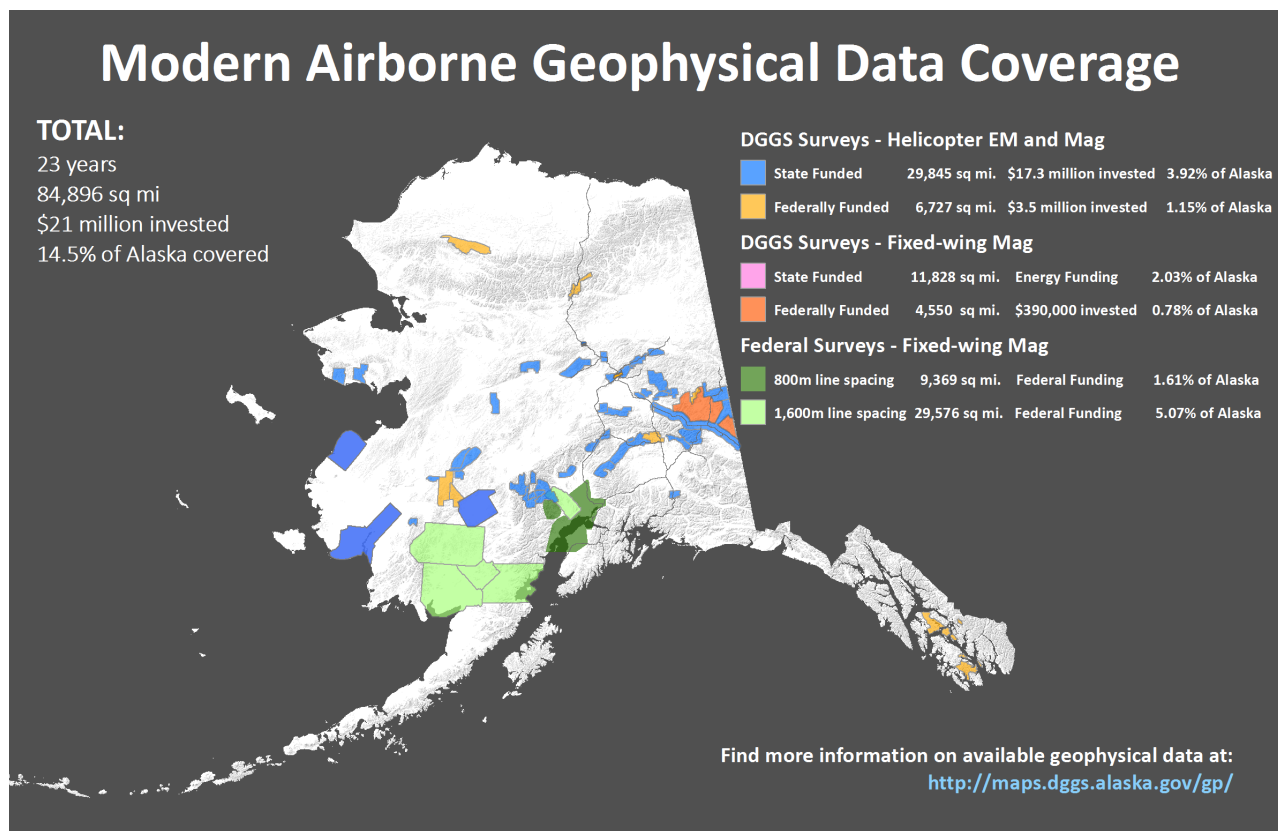


Figure 2. Modern airborne geophysical data coverage of Alaska, managed by Alaska Division of Geological & Geophysical Surveys and the U.S. Geological Survey over the past 23 years. Survey data is available from the division's website: <http://maps.dggs.alaska.gov/gp/>.

tegic and critical minerals that are required to meet the nation's needs for military and civilian high-tech equipment and electronics, as well as conventional- and green-energy technologies. In 2016 DGGs digitally compiled and published geochemical data and locations for approximately 27,000 SCM-related historical samples. As part of a cooperative agreement between the DGGs and the USGS, both agencies conducted a statewide, GIS-based identification of areas that have resource potential for critical minerals in six selected groups of deposit types in Alaska. This collaboration also resulted in the creation of a geochemical atlas of Alaska. Other SCM-related publications include evaluation of rare-earth-elements and zirconium associated with the Windy Fork pluton in southwestern Alaska, and heavy mineral concentrate transport in the Bering Straits (table 5).

Geologic Mapping and Geochemical Sampling

The DGGs Mineral Resources section filled gaps in Alaska's detailed geologic map coverage by publishing maps of the Livengood area and Bonnifield mining district in 2016. The Livengood map and report, centered on International Tower

Hill's 20-million-ounce Livengood gold deposit and Freegold Venture's Shorty Creek exploration project, incorporate multiple years of fieldwork by DGGs, supporting rock and ore geochemical data, radiometric ages, and industry surface and drill-hole data. The Bonnifield geologic map and report cover the Bonnifield volcanogenic massive sulfide (VMS) belt as well as Au–Ag–As–Sb vein prospects in the northern Alaska Range (table 5).

In 2016 DGGs conducted a major detailed geologic mapping and geochemical sampling project in the Tok River area. Field work in summer 2016 covered 480 square miles of the eastern Alaska Range just south of Tok (photo 4). DGGs evaluated the mineral-resource potential of the Tok River area; adjacent lands host VMS base metal deposits, copper–gold skarns, and structurally controlled gold-bearing veins. Within the project area, there are intrusion-related copper–gold prospects, base-metal prospects of uncertain origin, and placer gold occurrences. DGGs documented 20 mineral occurrences not previously part of the public record and published rock and stream-sediment geochemical data for the Tok area. Publication of the geologic map and report is planned in 2017.

Table 6. DGGs-managed, Federally funded detailed airborne geophysical survey work as of December 2016^a.

Survey Area			Survey Size	Resulting Products
Wrangell/Stikine ^b			1,111 sq. miles	Airborne geophysical survey
Koyukuk/Wiseman			533 sq. miles	Airborne geophysical survey
Ketchikan ^c			805 sq. miles	Airborne geophysical survey
Aniak			1,240 sq. miles	Airborne geophysical survey
Delta River			603 sq. miles	Airborne geophysical survey
Sleetmute			641 sq. miles	Airborne geophysical survey
Howard Pass–Misheguk Mountain			1,447 sq. miles	Airborne geophysical survey
Western Fortymile			250 sq. miles	Airborne geophysical survey
Tanacross ^d			4,550 sq. miles	Airborne geophysical survey
Total	10 years	\$4.3 million	11,180 sq. miles	1.9% of Alaska's total area

^aProjects funded mainly by U.S. Bureau of Land Management with contributions from DGGs, local and state governments, and private corporations. Projects concentrate mainly on federal land. Data are released through DGGs.

^bMajor funding provided by BLM and the City of Wrangell.

^cMajor funding provided by BLM and Ketchikan Gateway Borough. Sealaska Corp., Alaska State Mental Health Land Trust Office, the City of Coffman Cove, and the City of Thorne Bay also contributed funds. Sealaska Corp. also contributed previously acquired geophysical data.

^dFunding provided by U.S. Geological Survey.



Photo 4. Photo of Alicja Wypych during the 2016 Tok River geologic mapping project in the Tanacross A-6 quadrangle of the Eastern Alaska Range. The Dry Tok River lies in the valley behind Alicja to the north, and metasedimentary and metavolcanic rocks of Devonian-Mississippian(?) age form the highly folded outcrop and ridge behind her in the Delta District. Photo by Karri R. Sicard, DGGs.

EXPLORATION

Mineral exploration expenditures in Alaska totaled \$58.9 million, up one percent from 2015 and down 84 percent from 2011, the peak of recent exploration expenditures (table 7; figures 3, 4, and 5). Prior to 2016, Alaska's exploration collapse outpaced global trends, as did exploration throughout the U.S. as a whole. In 2016 however, exploration spending in Alaska stabilized while worldwide activity fell 21 percent and U.S. exploration dropped an additional nine percent³.

Thirty individual exploration projects, some managed by the same company, reported activity in 2016. Alaska's five operating metal mines conducted almost half of all exploration in 2016, spending a combined \$28.6 million, or almost 49 percent, of the statewide total. Combined, five of the six advanced-stage exploration projects spent almost 21 percent of the statewide exploration total. Many of

Alaska's advanced projects have reached a stage of decreased exploration investment, focusing instead on optimization studies, permitting, or the search for additional financing. Excluding the operating mines, six projects spent more than \$1 million, down from 8 projects in 2015. An additional 14 projects individually spent more than \$100,000, compared to 6 projects in 2015, showing that early-stage projects were better able to find investor funding in 2016.

The total area of the State covered by mining claims and prospecting sites in 2016 continued to decrease from the total acreage in the late 2000's; about 2,906,320 acres in 2015 dropped to about 2,552,120 acres in 2016 (a decrease of more than 12 percent; table 8). The total area of new State 40-acre and 160-acre claims staked in 2016 increased by almost 23 percent.

Table 7. Reported exploration expenditures in Alaska by commodity, 1981–2016. Exploration expenditures were estimated for five projects using their reported employment or drilling footage and a project-cost ratio averaged from 18 and 9 projects, respectively, with reported, complete data.

	Base metals	Polymetallic ^a	Precious metals ^b	Industrial minerals	Coal and peat	Other ^c	Total
1981	\$ 28,262,200		\$ 35,273,200	\$ 10,300,000	\$ 2,341,000	\$ 127,000	\$ 76,303,400
1982	31,757,900		10,944,100		2,900,000	15,300	45,617,300
1983	9,758,760		20,897,555	2,068,300	1,338,454	70,000	34,133,069
1984	4,720,596		14,948,554	270,000	2,065,000	279,500	22,283,650
1985	2,397,600		6,482,400		270,000		9,150,000
1986	1,847,660		6,107,084	170,000	790,000		8,914,744
1987	2,523,350		11,743,711	286,000	1,150,000	31,000	15,734,061
1988	1,208,000		41,370,600	160,200	2,730,000		45,468,800
1989	3,503,000		43,205,300	125,000	924,296	5,000	47,762,596
1990	5,282,200		57,185,394	370,000	321,000	97,000	63,255,594
1991	4,789,500		34,422,039	92,000	603,000	2,000	39,908,539
1992	1,116,000	3,560,000	25,083,000	25,000	425,000	0	30,209,000
1993	910,000	5,676,743	23,382,246	163,500	0	125,000	30,257,489
1994	600,000	8,099,054	18,815,560	225,000	2,554,000	810,000	31,103,614
1995	2,770,000	10,550,000	20,883,100	100,000	0	3,000	34,306,100
1996	1,100,000	11,983,364	31,238,600	400,000	0	0	44,721,964
1997	1,700,000	22,347,000	32,960,500	80,000	720,000	0	57,807,500
1998	1,000,000	13,727,000	42,441,000	12,000	87,000	0	57,267,000
1999	3,869,000	3,168,000	44,891,000	1,000	0	410,000	52,339,000
2000	8,545,000	3,933,000	21,579,000	58,500	0	736,100	34,851,600
2001	4,810,000	1,977,000	15,820,000	50,000	10,000	1,106,000	23,773,000
2002	1,700,000	5,162,000	17,342,000	185,000	0	2,113,000	26,502,000
2003	262,000	7,081,000	19,726,000	0	0	533,000	27,602,000
2004	3,100,000	40,237,000	26,954,000	213,000	50,000	258,000	70,812,000
2005	1,764,000	54,271,000	46,255,000	142,000	0	1,463,000	103,895,000
2006	5,069,000	81,073,000	89,793,000	20,000	2,394,000	580,000	178,929,000
2007	38,888,000	123,487,500	155,601,400	42,500	7,675,000	3,447,000	329,141,400
2008	30,116,000	163,030,000	134,885,000	0	0	19,238,000	347,269,000
2009	3,862,715	85,871,529	84,020,531	17,850	0	6,193,518	179,966,143
2010	6,392,519	122,955,321	125,364,382	19,000	6,520,200	3,104,199	264,355,621
2011	7,730,891	160,880,974	186,255,005	--	3,250,000	6,962,325	365,079,195
2012	18,161,211	150,339,009	152,444,311	--	W	14,129,838	335,074,369
2013	8,122,810	103,524,782	60,977,949	22,762	W	2,840,713	175,489,016
2014	8,310,433	29,836,240	51,759,541	32,221	W	6,300,413	96,238,848
2015	6,199,064	25,171,955	26,907,877	--	--	--	58,278,896
2016	7,820,283	25,295,705	24,857,804	--	--	912,510	58,886,302
TOTAL	\$ 269,969,692	\$ 1,263,238,176	\$ 1,762,817,743	\$ 15,650,833	\$ 39,117,950	\$ 71,892,416	\$ 3,422,686,810

^aPolymetallic deposits considered a separate category for the first time in 1992.

^bApproximately \$0.94 million spent on platinum-group-element (PGE-Ni-Cu) exploration during 2014, included in the polymetallic category. Prior to 2013, PGE exploration was included in the precious metal exploration total.

^cIncludes rare-earth elements, magnetite sands, rock, gemstones, and graphite.

N/A = Not available

-- = Not reported

W = Withheld; data included in "Other" column

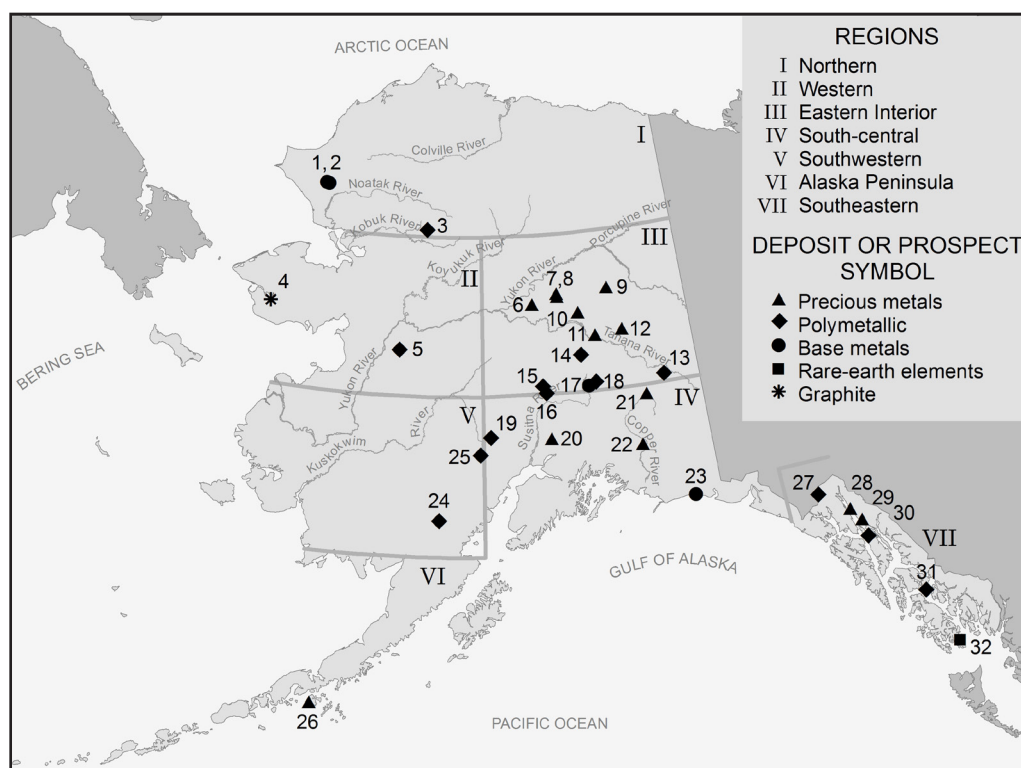


Figure 3. Selected exploration projects in Alaska, 2016.

EXPLORATION

I. Northern Region

1. Lik—Zazu Metals Corp.
2. Noatak—Teck Alaska Inc.
3. Upper Kobuk (Arctic and Bornite)—Trilogy Metals Inc.

II. Western Region

4. Graphite Creek—Graphite One Resources Inc.
5. Round Top—Western Alaska Copper & Gold

III. Eastern Interior Region

6. Elephant Mountain—Endurance Gold Corporation
7. Livengood—International Tower Hill Mines Ltd.
8. Shorty Creek—Freegold Ventures Ltd.
9. Circle-area claims—Kinross Gold Inc.
10. Fairbanks District
 - a Fort Knox and district—Fairbanks Gold Mining Inc.
 - b Golden Summit—Freegold Ventures Ltd.
 - c Treasure Creek—Treasure Creek Partnership
 - d Amanita—Avidian Gold Inc.

11. Richardson mining district
 - a Richardson and Hilltop—Northern Empire Resources Corp.
 - b Sam—Great American Minerals Exploration Inc.
12. Goodpaster mining district
 - a Pogo area—Sumitomo Metal Mining Pogo LLC
 - b Skippy, Fog—Stone Boy Inc
 - c LMS—Gold Reserve Inc.
 - d Goodpaster—Millrock Resources Inc.
13. Tetlin—Peak Gold LLC
14. Red Mountain—White Rock Minerals Ltd.
15. Golden Zone—Avidian Gold Inc.
16. Honolulu—Honolulu Prospect Corp.
17. Caribou Dome—Coventry Resources Ltd.
18. Stellar—Millrock Resources Inc.

IV. South-central Region

19. Whistler—Brazil Resources Inc.
20. Willow Creek—Miranda Gold Corp.
21. Chisna—Millrock Resources Inc.
22. Opal—Ben Porterfield
23. Icy Cape—Alaska Mental Health Trust Land Office

V. Southwestern Region

24. Pebble—The Pebble Limited Partnership
25. Copper Joe—Kiska Metals Corp.

VI. Alaska Peninsula Region

26. Unga-Popov—Redstar Gold Corp.

VII. Southeastern Region

27. Palmer—Constantine Metal Resources Ltd.
28. Kensington/Jualin—Coeur Alaska Inc.
29. Herbert Gold—Grand Portage Resources Ltd.
30. Greens Creek Mine—Hecla Greens Creek Mining Company
31. Zarembo Island—Zarembo Minerals Co. LLC
32. Bokan Mountain/Dotson Ridge—Ucore Rare Metals Inc.

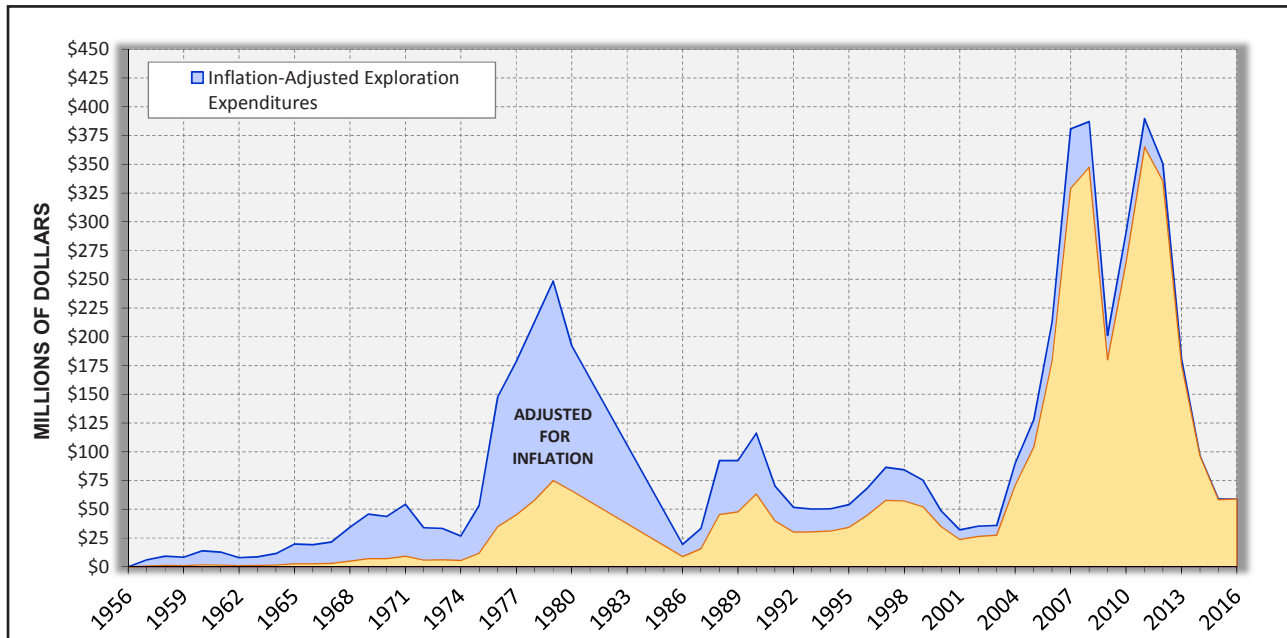


Figure 4. Alaska mineral exploration expenditures, 1956–2016. Curve in background is adjusted for inflation to 2016 dollars.

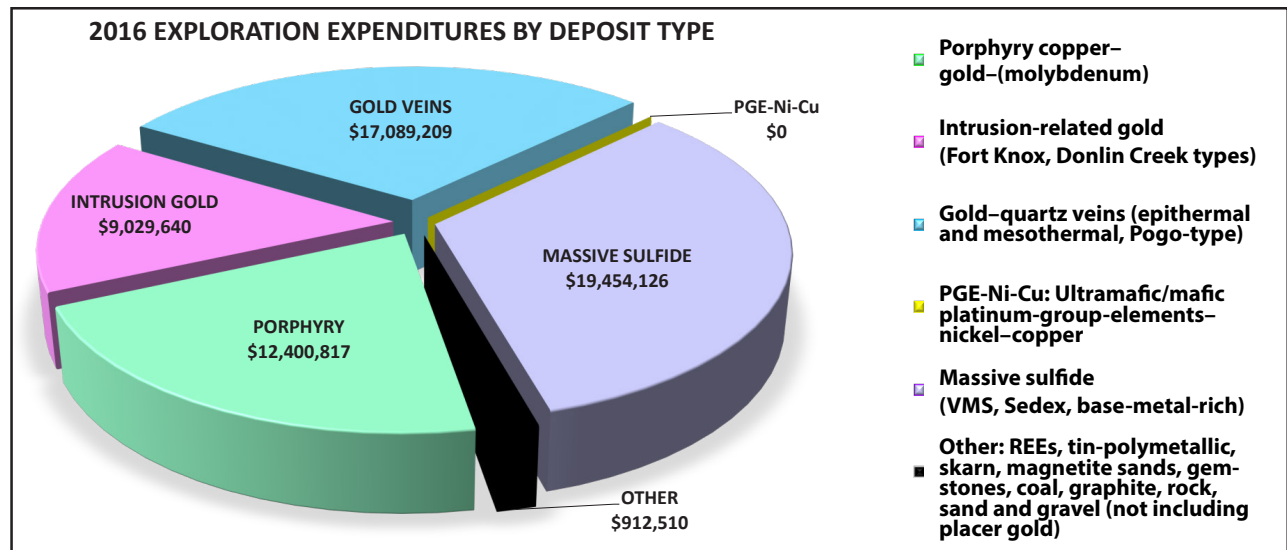


Figure 5. Exploration expenditures by deposit type, 2016.

Table 8. Summary of claim activity by acres, 1991–2016.

Year ^a	State Claims				State Prospecting Sites (160 acres)		Federal Claims (20 acre sites)	
	New (Active) 40 acre ^b	New (Active) 160 acre	Total (Active) 40 acre ^b	Total (Active) 160 acre	New	Total	New	Total
1991	3,277	0	37,862	0	747	1,723	1,299	23,222
1992	2,640	0	36,250	0	454	1,472	695	20,254
1993	2,120	0	34,340	0	1,412	2,259	601	9,298
1994	4,057	0	34,400	0	802	2,378	341	8,495
1995	4,512	0	30,464	0	1,030	2,725	376	7,766
1996	9,489	0	36,602	0	2,082	3,687	681	9,346
1997	8,678	0	42,836	0	2,480	5,305	1,872	11,320
1998	9,786	0	49,816	0	3,194	7,148	427	11,033
1999	11,978	0	56,107	0	1,755	7,600	308	10,176
2000	4,560	614	54,393	614	1,143	5,675	523	7,805
2001	858	907	49,627	1,503	27	3,091	464	8,248
2002	745	826	44,056	2,179	61	2,138	261	8,100
2003	856	2,603	38,076	4,387	101	1,857	676	8,424
2004	1,070	3,533	34,380	7,719	59	1,484	66	8,313
2005	806	4,502	34,066	11,551	128	1,612	411	7,826
2006	1,111	5,747	33,864	16,249	103	1,646	457	8,068
2007	576	6,031	31,305	20,208	57	1,625	933	8,872
2008	1,333	2,565	23,033	13,519	24	651	3,001	11,732
2009	1,142	2,793	24,340	16,381	40	335	1,057	10,431
2010	1,446	6,132	24,805	20,389	88	441	332	8,413
2011	1,932	4,893	24,319	21,970	180	273	284	8,438
2012	1,638	3,478	24,673	20,810	202	409	632	--
2013	1,622	2,155	24,883	17,347	28	209	289	6,916
2014	1,219	677	25,479	15,250	19	197	69	6,003
2015 ^c	1,014	711	22,537	11,735	21	36	71	6,074
2016	1,164	893	21,303	9,887	21	31	37	5,656

Information provided by Alaska Department of Natural Resources and U.S. Bureau of Land Management. Figures are updated as new information becomes available.

^aAfter 2010, State claim and prospecting site totals are not directly comparable to previous years. Claim totals comprise Mining Claims (including "River Bottom Navigable" subtype) and Leasehold Locations whose claimants filed an Annual Affidavit of Labor, and claims initiated on State-selected land. There were 127 active 40-acre claims and 43 active 160-acre claims on State-selected land in 2016, as compared with 209 active 40-acre claims and 136 active 160-acre claims on State-selected land in 2015.

^bIncludes claim fractions varying from 1 to 39 acres.

^cIncludes updated State claim numbers.

-- = Not reported

NORTHERN REGION

Teck Alaska Inc. continued to explore for sediment-hosted massive sulfides on their Noatak project about 8 miles northwest of its existing Red Dog mine in northwest Alaska in 2016. The project area includes the Anarraaq–Aktigiruk deposits, where Teck drilled a total of 29,800 feet. These high-quality targets continued to yield good drill results.

Zazu Metals Corporation (operating partner) and 50-percent joint-venture partner Teck Resources currently hold the Lik property, a zinc–lead–silver sediment-hosted massive sulfide deposit near the Red Dog mine in northwest Alaska. Zazu has the right to increase its ownership to 80 percent by meeting certain spending commitments by 2018. The most-recent resource estimate for Lik is stated in Zazu Metals' December 2013 preliminary economic assessment report (see appendix D). In 2016 Zazu conducted work required to maintain data for

permitting applications, including completion of an acid-rock-drainage study, and continuation of environmental, mine design, and metallurgical studies in preparation for permitting.

In 2016 Trilogy Metals Inc. (formerly NovaCopper Inc.) drilled a total of 10,033 feet in 13 holes at their Arctic volcanogenic massive sulfide deposit, one of their assets in the Upper Kobuk Mineral Projects in the southern Brooks Range (photo 5). The holes were selected for geotechnical, hydrological, waste-rock characterization, metallurgical studies, and further resource-definition purposes. Significant results include Hole AR16-0148, which intersected four mineralized intervals, including 70 feet of 3.79 percent copper, 0.025 ounce of gold per ton, 2.02 ounces of silver per ton, 0.99 percent lead, and 5.78 percent zinc. In 2016 Trilogy Metals also conducted aquatic, avian, habitat, archaeological, and wetlands-delineation surveys, continued ongoing



Photo 5. Trilogy Metals Inc. spent \$5.5 million on their Upper Kobuk Minerals Projects in 2016, part of which funded drilling at the Arctic volcanogenic massive sulfide deposit, an advanced-stage exploration project in the southern Brooks Range. Photo provided by Erin Workman, Trilogy Metals Inc.

baseline environmental data collection, and completed a LiDAR survey for the project area, which was initiated in 2015. Arctic resources are tabulated in appendix D.

On April 19, 2016, Trilogy Metals Inc. released an updated resource estimate, and on May 16, 2016, filed a NI 43-101 technical report for the Bornite carbonate-hosted copper-replacement deposit in the southern Brooks Range, another one of their assets in the Upper Kobuk Mineral Projects. The updated resource resulted in contained copper in indicated resources increasing from 334 to 913 million pounds, constituting a 173 percent increase in contained metal. Total contained copper in inferred resources decreased from 5,696 to 5,450 million pounds copper (1,768 million pounds in-pit at 0.5 percent copper cut-off grade; 3,683 million pounds below-pit at 1.5 percent copper cut-off grade), which constitutes a 4 percent decrease in contained metal due principally to moving in-pit inferred resources to the indicated category. Bornite resources are tabulated in appendix D. The update incorporated a new three-dimensional lithology, alteration, and structural model for the Bornite deposit, as well as results from previously un-sampled or partially sampled historical Kennecott drill core. Trilogy continued environmental baseline data collection, but no exploration or drilling was conducted in 2016.

WESTERN REGION

Located 34 miles north of Nome, Graphite One Resources, Inc.'s Graphite Creek project hosts the United States' largest large-flake graphite deposit (photo 6). Graphite Creek is an advanced-stage exploration project progressing towards the evaluation phase. In 2016 the company conducted a comprehensive product-development program. Test results exceeded graphite-purity threshold requirements, producing premium-grade spherical graphite (SPG) from purified graphite and achieving almost 75 percent conversion of Spheroidal, Thin, Aggregate, and eXpanded (STAX) naturally-occurring morphologies present in graphite sourced from the Graphite Creek deposit to SPG in the size range suitable for electric vehicle applications. This exceeds typical industry yields of 30 to 40 percent. Results also show successful, near-theoretical-limit discharge-capacity tests on coated and uncoated spherical graphite. Together, these results demonstrate the potential to produce products that will effectively compete in the high-end battery market (for both electric vehicles and power storage) as well as other markets for purified graphite and graphite byproducts. The company is nearing completion of preliminary test work on a mineral-processing circuit for producing high-grade graphite concentrate. Although Graphite One Resources did not conduct any exploration

Photo 6. The Graphite Creek large-flake graphite deposit in Alaska's Seward Peninsula is hosted in high-grade metamorphic rocks of the Kigluaik Group. Graphite occurs as semi-massive to massive segregations in the schistose rocks. Photo from Graphite One Resources, <http://www.graphiteoneresources.com/projects/photos/#&gid=1&pid=2>, last accessed on October 6, 2017.



work during 2016, they continued environmental baseline studies and plan to release Graphite Creek's inaugural PEA, including a refined resource estimate, in February 2017. Graphite Creek's resources as of April 2015, based on 48 drill holes, are tabulated in appendix D. The deposit remains open along strike in both the east and west directions, as well as down dip.

In 2016 Western Alaska Copper & Gold Co. conducted exploration drilling at their Round Top property in western Alaska (photo 7), a combined porphyry, copper-molybdenum skarn, and lead-zinc-silver carbonate-replacement deposit. The six-hole, 4,791-foot-total-length drill program tested historical drilling by Anaconda, as well as soil-geochemical anomalies and geophysical targets. Total dimensions of the Round Top mineralizing system remain untested. It extends a minimum of 1,960 feet in the north-south direction as defined by drilling, and geologic features, soil geochemistry, IP-resistivity, and aeromagnetic anomalies suggest a north-south dimension of greater than 8,000 feet. The deposit is open in the east-west direction, but copper-in-soil geochemistry and an aeromagnetic anomaly suggest a target area of about 8,000 feet east-west. The vertical extent of copper mineralization is open at depth, but extends to at least 1,100 feet. In 2016 Western Alaska discovered second-

ary chalcocite beneath the East Lobe Porphyry, including 128 feet of 0.50 percent copper within a 246-foot-long interval of 0.31 percent copper. Other highlights include a 0.94 percent copper assay at 971 feet in drill hole RT-11, with mineralization continuing to the bottom of the hole. Recognizing chalcocite as a primary source of copper at Round Top is considered by Western Alaska to potentially be the single most-important discovery of their 2016 program. Secondary copper mineralization, primarily in the form of chalcocite, likely will be a critical element in future value considerations because chalcocite is acid soluble and can be extracted using the more cost-effective, solution-extraction electro-winning recovery method.

EASTERN INTERIOR

Peak Gold, LLC, a joint venture between Contango ORE Inc. and Royal Alaska, LLC (a wholly owned subsidiary of Royal Gold, Inc.), continued to explore the Tetlin project area south of Tok (photo 8). The area contains the Peak and North Peak polymetallic gold-silver-copper skarn deposits, as well as other prospects and prospective targets. Royal Alaska has the option to invest up to \$30 million through October 2018 to earn up to a 40 percent interest in the joint venture; through December 31, 2016, Royal Alaska has earned a 20.6 percent interest. With a budget of \$11 million aimed at expanding the gold-



Photo 7. Kit Marrs and Gary Jones at the Round Top discovery outcrop in western Alaska, a combined Cu-Mo-Ag porphyry system with skarn and carbonate-replacement mineralization. The Round Top porphyry system is composed of two distinctive Late Cretaceous to Early Tertiary felsic intrusives hosted by a Paleozoic quartz-mica schist. Photo provided by Shane Lasley, Data Mine North.

Photo 8. Curt Freeman and Royal Gold, Inc. representatives standing on an outcrop overlooking the Peak and North Peak polymetallic gold–silver–copper skarn deposits at Peak Gold LLC’s Tetlin project in eastern Interior Alaska. Photo provided by Curt Freeman, Avalon Development Corporation.



and copper-rich skarn deposits at Tetlin, Peak Gold conducted Alaska’s largest exploration program for 2016. Peak Gold completed a three-phase drilling program: 19 core holes drilled in Phase I, 62 holes in Phase II, and 37 holes in Phase III, for a total of 67,322 feet. The 2016 drilling traced a roughly 6,500-foot-long arc of contiguous, high-grade skarn mineralization, which is about three times the footprint of the Peak deposit described in Contango’s 2014 initial resource. One hole drilled in the 2016 expansion area cut three gold-rich intercepts, including 127.6 feet averaging 1.506 ounces of gold per ton from a depth of 47.6 feet, which was the best intercept at Tetlin in terms of high grades over broad widths. The North Peak area remains open to expansion to the northwest and southeast, as the

last holes drilled were still in gold-bearing skarn. Contango’s 2014 Tetlin project area report states indicated and inferred resources (based on 52,526 feet of core in 78 of 130 holes, assuming prices of \$1,318 per ounce of gold, \$21.55 per ounce of silver, and \$3.25 per pound of copper) of 10.8 million tons containing 52.4 million pounds of copper, 921,000 ounces of gold, and 3,881,000 ounces of silver (appendix D). An updated resource estimate is expected in mid-2017, which will incorporate an additional 143 drill holes covering over 98,425 feet since the initial resource was completed in 2014.

To ensure continued mining into the future, Sumitomo Metal Mining Pogo LLC invested \$10 million in exploration at Pogo mine in 2016, following \$15

million in 2015. At least five high-grade gold zones (Liese, East Deep, North, Fun, and South Pogo) have been discovered within one mile of the mill; these zones are currently contributing ore to the mill, or are expected to in the near future. Pogo is permitted to operate through 2019, but extensive exploration efforts are underway to identify additional ore resources and reserves. The nearby 4021 and Keri/Spring vein systems hosted by the Pogo shear are not clearly defined yet, but create the possibility to extend the life of the mine.

In 2016 Kinross Gold Corporation's exploration expenditures were forecast to be more than \$3.9 million at its open-pit Fort Knox mine, operated by subsidiary Fairbanks Gold Mining, Inc., and surrounding brownfield properties about 20 miles north of Fairbanks; they are continuing to look for ways to further extend the mine's operation. Exploration drilling of the east and south wall of the existing open pit returned positive results, and additions to the inferred resource are anticipated during 2017. In 2016 a total of 7,500 feet were drilled into the east and south walls of the open pit mine. The 15-hole, HQ3-diameter-core drilling program tested the existing geologic-resource model for a potential mineral-resource addition and refined the granite-schist contact. Mineralization was intersected in every hole drilled; highlights include 95 feet of 0.029 ounce of gold per ton, 45 feet of 0.054 ounce of gold per ton, 120 feet of 0.019 ounce of gold per ton, 115 feet of 0.029 ounce of gold per ton, and 80 feet of 0.058 ounce of gold per ton. Kinross also conducted grassroots exploration in 2016 on several of its claim blocks in the Circle mining district. In 2017 Kinross will prioritize exploration drilling at Fort Knox to target opportunities for mineral-resource additions.

Freegold Ventures Limited's 2016 drilling program at their intrusion-related Shorty Creek property included seven holes totaling 9,966 feet; two holes were drilled in the "Hill 1835" area, and five holes were drilled in the "1710" area to test copper-molybdenum targets. "Hill 1835" mineralization is spatially associated with a magnetic high defined by State of Alaska-funded airborne geophysical surveys and industry-funded ground-based surveys. Drilling highlights include 1,426 feet averaging 0.57 percent copper-equivalent, and 1,344 feet averaging 0.41 percent copper-equivalent. In the "1710" area, five

drill holes totaling 6,627 feet tested a copper-molybdenum soil anomaly and magnetic high. Drill hole SC 16-07 intersected 0.11 percent copper and 0.011 percent molybdenum from zero to 521.7 feet, including an interval of quartz-feldspar porphyry from zero to 232.3 feet that averaged 0.15 percent copper and 0.009 percent molybdenum. The entire 1,300-foot-long drill hole averaged 0.08 percent copper and 0.006 percent molybdenum. Additionally, Freegold conducted new ground-based geochemical sampling, geophysical surveys, and claim staking in 2016, and identified the new Quarry and Steel Creek target areas.

Freegold Ventures Limited released a preliminary economic assessment (PEA) and technical report for their intrusion-related Golden Summit gold property near Fort Knox mine north of Fairbanks in 2016. Freegold's initial development scenario for Golden Summit includes a proposed heap-leach operation focused on the existing oxide portion of the resource, with a staged approach to a larger milling scenario. At a 0.010 ounce of gold per ton cut-off, the combined sulfide and oxide resources within the conceptual pit are 67.8 million tons indicated, averaging 0.020 ounce of gold per ton (1,363,000 contained ounces of gold, 345,00 in oxide), plus 78.8 million tons inferred, averaging 0.020 ounce of gold per ton (1,584,000 contained ounces of gold, 183,000 in oxide; appendix D). Using \$1,300 per ounce of gold, the PEA evaluated a two-phase, 24-year, open-pit mine generating two gold streams, each operating at 11,000 tons per day to produce 2,358,000 ounces of doré over the life of the mine; processing operations for the oxide and sulfide mineralized materials are heap leach and bio-oxidation, respectively. In 2016, 717 soil samples were collected; they delineate a gold-in-soil geochemical anomaly west of the current Dolphin deposit. Previously completed shallow rotary air-blast drilling was composited and indicates better-grade oxide material may be present to the north.

In October 2016, International Tower Hill Mines Ltd. (ITH) released an optimized prefeasibility study for its intrusion-related Livengood gold project located 70 miles northwest of Fairbanks. The revised plan calls for a scaled-back, 52,600 ton-per-day mill circuit (a 2013 feasibility study proposed a 100,000 ton-per-day operation), followed by a gravity gold

circuit and a conventional carbon-in-leach circuit. The prefeasibility study's mine plan is estimated to provide sufficient ore (life-of-mine head grade of 0.021 ounce of gold per ton) to support an average annual production rate during years 1–5 of 378,300 ounces of gold per year, and an annual production rate of approximately 294,100 ounces of gold per year over an estimated 23-year mine life. Life-of-mine production would total approximately 6.8 million ounces of gold. The project's mineral resource is based on 783 drill holes, totaling 717,435 feet, and a gold price of \$1,230 per ounce (photo 9; appendix D). On December 28, 2016, ITH announced the closing of a non-brokered, private-placement financing of \$22.0 million. The company intends to use the net proceeds of the private placement for full satisfaction of the final payment due in January 2017

for acquisition of certain mining claims and related rights in the vicinity of the Livengood gold project (approximately \$14.7 million), continuation of optimization studies to further improve and de-risk the project, required environmental baseline studies, and for general working capital purposes.

Coventry Resources Ltd.'s 2016 program at the sediment-hosted Caribou Dome copper project in south-central Alaska, formerly known as Denali Copper, included 22 drill holes for a total of 21,400 feet. Near-surface, high-grade mineralization was extended for greater than 400 feet along strike and for a depth greater than 1,000 feet to the northeast. Coventry better defined the extents of very-high-grade, shallow mineralization and identified an area for a potential starter open-pit mine. Coventry

Photo 9. Drilling at Money Knob area of the Livengood gold project, an advanced-stage exploration project north of Fairbanks, Alaska. This topographic high and the adjoining ridge lines have been considered by many to be the lode gold source for the adjacent placer gold deposits. The placer deposits have been actively mined since 1914 and produced more than 500,000 ounces of gold. Photo from International Tower Hill, http://www.ithmines.com/project/photo_gallery/, last accessed October 6, 2017.



delineated multiple new high-priority induced-potential targets over 4.3 miles of strike. Soil sampling defined a new, three-mile-long, copper-in-soil anomaly at the Senator Prospect, located seven miles from the Caribou Dome deposit. Follow-up rock-chip sampling revealed sediment-hosted copper mineralization with assays up to 12.1 percent copper. A total of 845 rock-chip, soil, till, and scree geochemistry samples were collected property wide, and Coventry completed 32 lines of three-dimensional IP geophysical surveying. Coventry also conducted an initial metallurgy test for Lens 4/5/6 and Lens 7/8, which indicates greater than 99 percent recoveries; concentrates grading greater than 27.4 percent copper were achieved. An economic assessment and scoping study are underway and scheduled for completion in early 2017. Coventry is evaluating their project's potential to develop into a low-capital-expenditure, starter high-grade mining operation.

Elephant Mountain, an early stage exploration project in Interior Alaska, is centered on a Cretaceous reduced intrusion-related gold system. In

2016 Endurance Gold Corporation drill-tested soil anomalies with greater than 100 parts per billion gold; three holes were drilled in the South Zone and one hole in the North Zone, for a total of 1,962 feet (photo 10). Highlights of South Zone drilling include 0.119 ounce of gold per ton over 15 feet, including 0.595 ounce of gold per ton over 2 feet, spatially associated with a 3,300-foot-long by 800-foot-wide gold–arsenic–antimony soil anomaly. Highlights of North Zone drilling include 0.012 ounce of gold per ton over 483 feet, including 0.018 ounce of gold per ton over 158 feet, spatially associated with a 0.4-square-mile surface-alteration zone with disseminated pyrite and arsenopyrite in a pervasively silica–sericite–clay-altered granodiorite and a gold–arsenic soil anomaly. The Central Zone target, an area of no outcrop and deeper cover, is located between the North and the South Zones and is spatially associated with the east–west-trending Elephant Mountain fault, which is interpreted to traverse the entire Elephant Mountain intrusion. The area is overlain by anomalous gold values in soil. The recessive Central Zone target remains untested by diamond drilling.

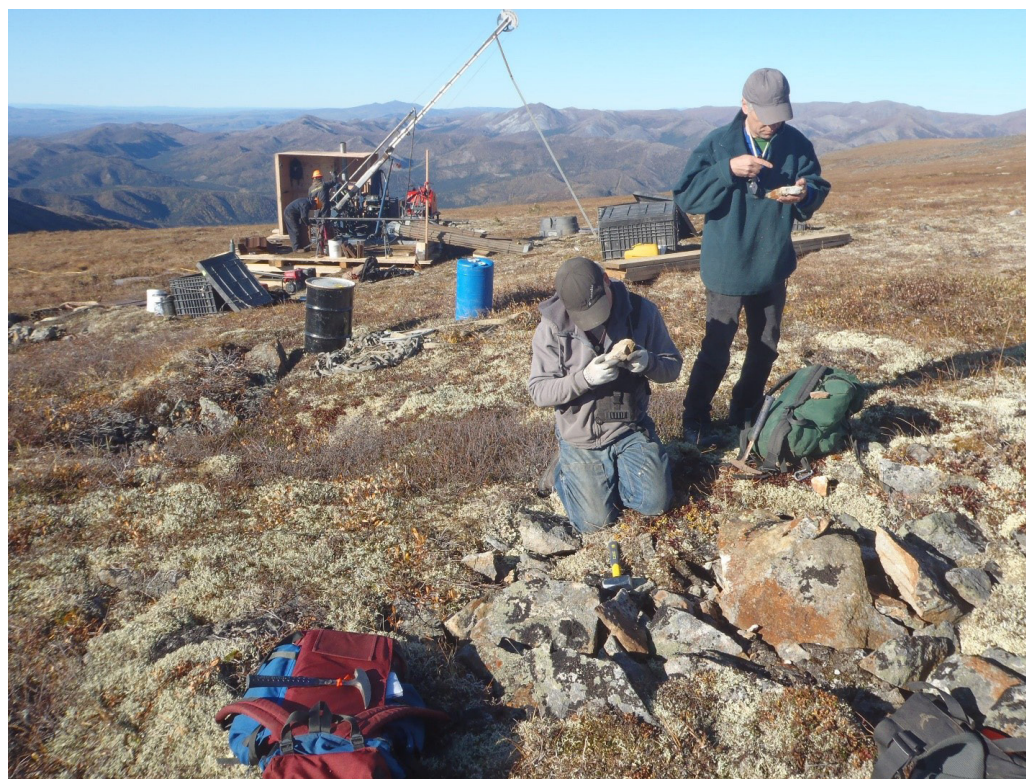


Photo 10. Drilling and prospecting at the Elephant Mountain project. The property comprises at least six targets which are interpreted to be part of the family of reduced intrusion-related gold systems similar to the Fort Knox and other Tintina Gold belt deposits. Photo provided by Robert T. Boyd, Endurance Gold Corporation.

In February 2016, White Rock Minerals Ltd. announced the proposed acquisition of the Red Mountain polymetallic volcanogenic massive sulfide (VMS) project in the north-central Alaska Range, with two known deposits: Dry Creek (101 historical drill holes for a total of 45,380 feet) and West Tundra Flats (26 historical drill holes for 17,550 feet). White Rock executed a Heads of Agreement relating to a proposal to acquire 100 percent of Atlas Resources Pty Ltd, a company that holds an option to acquire a 100 percent interest in the Red Mountain project by way of a share-for-share exchange. The acquisition of Atlas Resources was completed in April 2016, and the option to acquire the Red Mountain project from Metallogeny Inc. was exercised in May 2016, giving White Rock 100 percent ownership of the property. In March 2016, White Rock Minerals Ltd. staked 85 new mining claims in the Bonnifield district. In June through August 2016, White Rock focused on identifying high-priority magnetic, conductivity, and geochemical targets for future follow-up work utilizing geochemical vector analysis, detailed geologic maps published by DGGs, and interpretation of a DGGs airborne magnetic and electromagnetic survey of the area by Condor Consulting, Inc. The resulting integrated assessment led to an additional 114 claims being staked and prioritization of the Dry Creek West, ReRun, West Tundra Flats, Smog, and Glacier target areas as highly prospective for additional VMS deposits, which are included within 30 geochemical-geophysical targets classified as of high interest.

In 2016 Northern Empire Resources Corp. conducted exploration on their Richardson property, which hosts multiple intrusion-related as well as low- and high-angle fault-hosted lode gold prospects with gold \pm silver \pm arsenic \pm antimony \pm bismuth geochemical signatures. The property has geologic similarities to the Fort Knox and Pogo gold mines. The project area includes the historical Democrat lode gold mine hosted by a 90 million-year-old, quartz-feldspar-porphyry dike. In 2016 Northern Empire Resources Corp. collected rock chip-channel samples at 3 foot intervals across 430 feet of the exposed face at Democrat. One 105-foot-long sample returned 0.167 ounce of gold per ton and 0.869 ounce of silver per ton, including 20 feet of 0.535 ounce of gold per ton and 1.428 ounces

of silver per ton. Another sample collected about 200 feet away returned 0.075 ounce of gold per ton and 1.146 ounces of silver per ton across 20 feet. Northern Empire also collected 1,298 geochemical samples across the Richardson property and conducted trenching, prospecting, 172 line-miles of ground-magnetic geophysical surveys, identified structures in airborne geophysics, re-logged historical core holes, and delineated future drill targets. Work to date has identified a 1.2-mile-long, north-northeast-trending gold-in-soil anomaly with a coincident geophysical structural signature. Additionally, 1.2 miles of the geophysical signature is poorly covered by soil data. A second northwest-trending mineralized structure was identified with coincident elevated gold-in-soils over a 3,300-foot strike length; an additional 3,300 feet remain to be evaluated by geochemical sampling.

Stone Boy Inc. conducted exploration on their Skippy and Fog gold properties in the Big Delta quadrangle in 2016. Property and exploration details are not publicly available.

The LMS Gold Project hosts a structurally controlled, possibly intrusion-related gold prospect located in the Goodpaster mining district 90 miles southeast of Fairbanks. Gold is present within a folded, stratabound tabular zone consisting of silicified graphitic quartzite breccia and within narrow, high-grade veins. The main prospect, the Camp Zone, is situated at the southeast end of a 3.7-mile-long, northwest-trending zone of aligned surface geochemical samples containing anomalous gold, arsenic, and lesser silver and copper; it remains open along strike and at depth. Although no exploration activities were conducted on the LMS property in 2016, Gold Reserve Inc. released an updated resource estimate (appendix D) and NI 43-101 technical report for the project in February. In March 2016, Gold Reserve Inc. completed a purchase-and-sale agreement with Raven Gold Alaska Inc., a wholly-owned subsidiary of Corvus Gold Inc., to acquire the project.

Millrock Resources Inc., in a joint venture with Vista Minerals Pty Ltd., collected seven lines of induced polarization (IP) measurements over the Zackly copper-gold skarn in the Alaska Range in 2016. Zackly is part of the company's Stellar project.

Coincident chargeability anomalies and copper-in-soil geochemical anomalies together appear to extend the strike length of the skarn to both the east and west.

In October 2016, Millrock Resources Inc. announced that it has assembled a 39,159-acre land position covering high-potential gold targets in the Goodpaster mining district near the Pogo gold mine through a series of purchase-and-option agreements and claim staking. The claims cover soil geochemical anomalies, many of which are untested. Several targets have previous drill intercepts that returned anomalous gold. Millrock conducted core re-logging, surface geologic mapping, and soil and rock sampling in 2016. This work defined a north-east-southwest-trending corridor of anomalous gold values, several east-west-trending quartz vein systems, and a small low-angle, northwest-dipping quartz vein with similar characteristics to the tabular bodies at Pogo. Millrock also collected over 930 short-wave infrared spectra from both core and surface samples.

In 2016 the Treasure Creek Partnership consolidated three properties in the Treasure and Any Creek watersheds north of Fairbanks that potentially host plutonic-related, lode-gold mineralization contained in three shear zones over a seven-mile-long strike length. Exploration activity in 2016 included conducting field work, confirming the location of mineralized lode-gold sites, and reviewing and updating 1990's-era exploration information. Historical records indicate trench and drill intercepts contain assays near or greater than 0.032 ounce of gold per ton over widths of 65 feet.

Great American Minerals Exploration Inc. (GAME) reached an agreement with Stone Boy Inc. to consolidate exploration of its 26,639-acre Uncle Sam property with Stone Boy's adjacent Monte Cristo property. GAME's Sam project, as it is now known, is located about 40 miles west of the Pogo mine. Stone Boy discovered the Monte Cristo project's Naosi gold-silver-antimony deposit in 2008, and from 2008 through 2012 Stone Boy drilled 79 holes to outline a mineralized zone about 5,000 feet along strike and to a depth of about 1,600 feet. Results included 26.0 feet of 0.228 ounce of gold per ton, 0.575 ounce of silver per ton, and 0.1 percent

antimony; and 74.9 feet grading 0.123 ounce of gold per ton, 1.40 ounces of silver per ton, and 0.17 percent antimony.

The Golden Zone intrusion-related gold property in south-central Alaska hosts a number of high-grade gold occurrences with silver and copper (\pm lead, \pm zinc). In 2016 Avidian Gold Inc. purchased Hidefield Gold PLC's 29.4 percent interest outright and entered into a purchase agreement with Chulitna & Mines Trust to acquire the remaining 70.6 percent interest in Golden Zone. Avidian released an NI 43-101-compliant indicated resource totaling 267,400 ounces of gold and 1.4 million ounces of silver in 6.1 million tons of ore (appendix D) at a cut-off grade of 0.015 ounce of gold per ton. This resource is amenable to open pit mining and remains open for expansion. The company conducted reconnaissance prospecting of the property, compiled a large amount of historical data, and completed minor amounts of camp and road maintenance.

In 2016 Avidian Gold Inc. acquired the 5.6-square-mile Amanita gold project located immediately adjacent to the Fort Knox gold mine north of Fairbanks. Avidian entered a lease-to-purchase option spanning a 15-year period. The Amanita property hosts a structurally controlled, intrusion-related gold system with geological, structural, and alteration similarities to the Fort Knox mine. The main mineralized zone is defined by a 1.2-mile by 1.9-mile gold-in-soil anomaly. Historical drilling highlights include: 15 feet at 0.335 ounce of gold per ton, 75 feet at 0.029 ounce of gold per ton, 40 feet at 0.067 ounce of gold per ton, and 45 feet at 0.088 ounce of gold per ton. Avidian conducted reconnaissance prospecting, rock and soil sampling, and historical data compilation during 2016.

The Honolulu property, located five miles east of the Parks highway, hosts a structural zone with anomalous silver, lead, zinc, copper, and gold. In 2016 Honolulu Prospect Corp. conducted a multi-phase exploration program that included 16 drill holes and the collection of 1,505 sediment and 124 rock samples. The company defined a mineralized structural zone with multiple mineralized fault splays containing continuous high-grade mineralization along a 1,000-foot strike length and across a zone up to 200-feet wide. The company also identified four new areas with anomalous silver, copper,

and gold. The 16 holes were drilled from five pads for a total of 8,645 feet. Select hand samples include: sheeted arsenopyrite veins from Tiki Chute with 0.17 ounce of gold per ton and 1.35 ounces of silver per ton; disseminated arsenopyrite in drusy quartz from Bertram Gulch with 0.03 ounce of gold per ton and 7.3 ounces of silver per ton; and oxidized sulfide veins from Tempest with 8.26 percent lead, 6.47 percent zinc, and 223.8 ounces of silver per ton.

SOUTH-CENTRAL REGION

The late-exploration-stage Willow Creek project, located 75 miles north of Anchorage in the Willow Creek mining district, is an orogenic gold vein system currently being planned for development through a joint-venture partnership between Miranda Gold Corp. and Gold Torrent Inc. Gold Torrent has agreed to earn a 70 percent equity interest through the funding of the first \$10 million in development costs. In March 2016, Miranda and Gold Torrent announced an updated resource estimate for the Willow Creek project of 121,500 ounces of gold (measured plus indicated; appendix D). All estimated resources are based on a cut-off grade of 0.146 ounce of gold per ton, a long-term gold price of \$1,265 per ounce, and assumed metallurgical recoveries of 80 percent. Improved understanding of the geologic controls on mineralization resulted in a significant increase in the mineral-resource estimate for the Willow Creek project. In total, mineral resources at the Willow Creek project include eight veins in the Coleman area and two veins in the Lucky Shot area; they are based on information from 174 drill holes (photo 11). Potential exists to increase the mineral resources through drilling down-dip extensions of the Coleman and Lucky Shot area, as well as exploration targets in the War Baby and Murphy areas along strike to the east.

In June 2016, a newly completed NI 43-101 preliminary feasibility study for the Willow project reported proven plus probable mineral reserves of

87,500 ounces of gold (appendix D). The preliminary feasibility study includes a proposed mine plan and cost estimate with annual gold production of approximately 25,000 ounces of gold per year (after pre-production and build-up) at an underground mining rate of 220 tons per day. Their proposed mine plan includes a total of 87,612 ounces gold contained in 192,400 tons and a recovery plant head grade of 0.46 ounce of gold per ton at an all-in sustaining cash cost of \$675 per ounce of gold produced. The proposed gold recovery plant utilizes gravity-only gold recovery methods, without chemical treatment, and produces no toxic tails. The proposed plant is designed to capture coarse gold contained in the mesothermal quartz vein material by crushing and screening the material into multiple size fractions and then separating the gold using jigs, spirals, and tables.

Brazil Resources Inc. (now GoldMining Inc.) is currently evaluating the Whistler-area copper–gold–silver porphyry deposits 90 miles west of Anchorage; the company acquired the properties from Kiska Metals Corporation in 2015. Although no work was performed on-site in 2016, Brazil Resources Inc. released a new technical report announcing the first resource estimates for the Raintree West and Island Mountain deposits, largely based on drilling

Photo 11. Photo of the Coleman historical underground workings of the Lucky Shot mine. The Coleman block is the westernmost faulted segment of the gold-bearing quartz zone that comprises the Willow property in south-central Alaska. Photo from Miranda Gold Corp., http://www.mirandagold.com/i/pdf/43-101_Willow-Creek.pdf, last accessed on October 6, 2017.



22/06/2013

by Kiska Metals Corporation between 2009 and 2011 (appendix D). Island Mountain is estimated at 125 million tons (indicated plus inferred) grading 0.05 percent copper, 0.013 ounce of gold per ton, and 0.053 ounce of silver per ton at a cut-off grade of 0.009 ounce of gold-equivalent per ton, based on 41,562 feet of drilling in 34 holes. Raintree West is estimated to contain 92 million tons (inferred) averaging 0.08 percent copper, 0.017 ounce of gold per ton, and 0.127 ounce of silver per ton based on 23,222 feet of drilling in 14 holes. Their report also re-stated the resource estimate for the Whistler gold-copper deposit initially released in 2015, based largely on the resource estimate completed by Kiska Metals Corporation in March 2011 (appendix D). Metal recoveries reported for the Whistler deposit resource estimate, and assumed for the Raintree West deposit, include 85 percent for copper, 75 percent for gold, and 75 percent for silver.

In April 2016, Corvus Gold Inc. announced that its wholly owned Alaskan subsidiary, Raven Gold Alaska Inc. signed an agreement to sell the Chisna project to Millrock Resources Inc. The property hosts a known porphyry copper-gold occurrence as well as many other promising targets. Ownership of the project is being sold for \$25,000 cash at closing, and Corvus is granted a retained net-smelter-return royalty of one percent on precious metals and one percent on base metals. No exploration work was conducted in 2016.

The Opal prospect near Chitina, being evaluated by Ben Porterfield, contains gold-bearing, polymetallic quartz veins hosted in a white mica-altered, 52 million-year-old tonalite sill. High gold grades of up to 4 ounces of gold per ton are reported. Visible gold is common, and it is associated with galena, sphalerite, pyrite, and arsenopyrite. In 2016 exploration was conducted on high-angle shear zones cutting the sill and on pods at the wall-rock contact at the top of the sill.

In 2016 Alaska Mental Health Trust Land Office (TLO) field crews collected more than 4,000 pounds of heavy mineral (HM) concentrates for laboratory studies on their Icy Cape placer/beach property located 75 miles northwest of Yakutat. In the contracted HM laboratory, samples were processed by industry-specific methods and standards to produce

mineral concentrates for industrial testing, application, and marketing. The TLO also contracted for a low-altitude, high-resolution aeromagnetic survey over the coastal sediments of their Icy Cape property. Results show patterns consistent with the TLO's geologic and deposit models.

SOUTHWESTERN REGION

The Pebble porphyry copper-gold-molybdenum deposit in southwest Alaska is currently the world's largest undeveloped resource of both copper and gold, with a total endowment of 81.8 billion pounds of copper and 107.9 million ounces of gold contained in 12 billion tons of ore grading 0.34 percent copper, 0.023 percent molybdenum, 0.009 ounce of gold per ton, and 0.043 ounce of silver per ton. In 2016 Northern Dynasty Minerals Ltd. (currently sole owner of The Pebble Limited Partnership) and the Environmental Protection Agency (EPA) filed a joint notice in federal court stating their intent to enter into mediation to resolve ongoing litigation of the Pebble project.

In 2016 First Quantum Minerals funded a single, 2,644-foot-long exploratory drill hole at Kiska Metals Corp.'s Copper Joe porphyry copper property in southwest Alaska (photo 12). The hole tested the Evening Star target, a 0.9-mile-wide magnetotelluric anomaly with coincident favorable geological, geochemical, and geophysical indicators. The drill hole intercepted more than 1,300 feet of hydrothermal breccia with strong phyllic alteration, abundant pyrite, sparse early quartz veins, magnetite-anhydrite-pyrite-chalcopryrite veins, and banded molybdenite veins. No significant copper grades were intersected but extensive brecciation and strong alteration suggest a robust hydrothermal porphyry system; additional drilling is required to determine if ore-grade mineralization exists. First Quantum Minerals withdrew from the project at the end of the season. In December 2016, AuRico Metals Inc. announced a definitive agreement to acquire Kiska Metals, subject to customary closing conditions including Kiska shareholder approval.

SOUTHEASTERN REGION

Exploration at Hecla Mining Company's Greens Creek mine in Southeast Alaska in 2016 focused along the trend of numerous underground volcano-

Photo 12. Photo of Hades Creek in the southeastern corner of the Copper Joe prospect, looking southwest at ferricrete benches overlaying strongly quartz-sericite-pyrite-altered quartz monzonite. Photo from Kiska Metals Corp., Copper Joe Executive Summary, by Mike Roberts, January 2015.



genic massive sulfide ore bodies, but the company also explored its highly prospective 23-square-mile surface land package (photo 13). Definition and exploration drilling continues to replace and add new reserves, keeping reserves well ahead of production. Exploration work in 2016 increased reserves for the 9A and NWW zones where approximately 8.3 million ounces of silver, 46,500 ounces of gold, and an unknown amount of base metals were added. Measured and indicated resources were increased with additions in the 9A, NWW, SW, and Gallagher zones, as well as the newly established Upper Plate resource. At the NWW Zone, inferred resources decreased due to conversion to reserves and indicated resources; all other zones, except 200 South, showed increases in inferred resources.

In 2016, exploration drilling was concentrated on the Gallagher Zone and the Mine Syncline, a new exploration target area where the ore horizon has been identified in the north and south-central parts of the Greens Creek mine. Drilling of the NWW Zone's southern extension continues to define mineralization along the lower fold, spanning from the

fold nose and along the upper limb. Mineralization is represented by multiple distinct bands of massive ore and mineralized argillites in proximity to the mine contact and has similar geometry and dimensions to the current resource model. Assay results include 45.4 ounces of silver per ton, 0.20 ounce of gold per ton, 19.0 percent zinc, and 10.3 percent lead over 18.6 feet, and 51.7 ounces of silver per ton, 0.20 ounce of gold per ton, 11.2 percent zinc, and 4.8 percent lead over 10.0 feet. Drilling also targeted the Upper Southwest Zone (USW) around previously mined levels and identified mineralization that extends down to the upper limb of NWW. Assay results from USW include 46.8 ounces of silver per ton, 0.03 ounce of gold per ton, 10.9 percent zinc, and 6.1 percent lead over 10.2 feet. The drilling also identified shallow mineralization east of the Kahuna fault. Recent drilling of the lower 9A Zone has generally confirmed and upgraded the resource model. Initial definition drilling of the East Ore Zone shows that overall the mineralization is thinner than expected compared to the model, but this drilling is advancing into stronger mineralized portions of the

resource. Exploration drilling of the Gallagher Zone targeted a new flat-lying zone above the 4211 Drift that may define a mine contact that steepens to the east near the Gallagher fault. Deep exploration drilling of the Mine Syncline shows the mine contact continues steeply down dip from the NWW Zone and could define a broad syncline below the current mine infrastructure that could host mineralization. Drilling of this same syncline in the central part of the mine shows the mine contact is the down-dip extension of the lower limb of the NWW Zone. This early stage drilling has shown there are some large prospective areas below current mining that contain the mine horizon.

Coeur Alaska, Inc.'s 2016 exploration expenditures totaled \$6.2 million (\$3.5 million expensed; \$2.7 million capitalized) at their Kensington mine north of Juneau. Coeur's accelerated surface and

underground exploration program was focused on potential resource conversion and expansion within the Kensington Main ore body, nearby Raven vein, and newly discovered resources at the high-grade Jualin deposit (photo 14). Exploration also sought to extend several new veins in the district discovered through surface-sampling programs. Exploration drilling at Kensington Main included four zones (lower Block M, and zones 12, 41, and 44) focusing on the potential expansion of the Kensington resource down-dip and to the south of the current resource model. One drill hole in this zone returned 12 feet of 1.21 ounces of gold per ton. Drilling at Raven targeted the down-plunge extension of a high-grade ore shoot.

Development of the Jualin decline (64 percent complete at year end) is allowing better exploration drilling access. Exploration of the high-grade Jualin

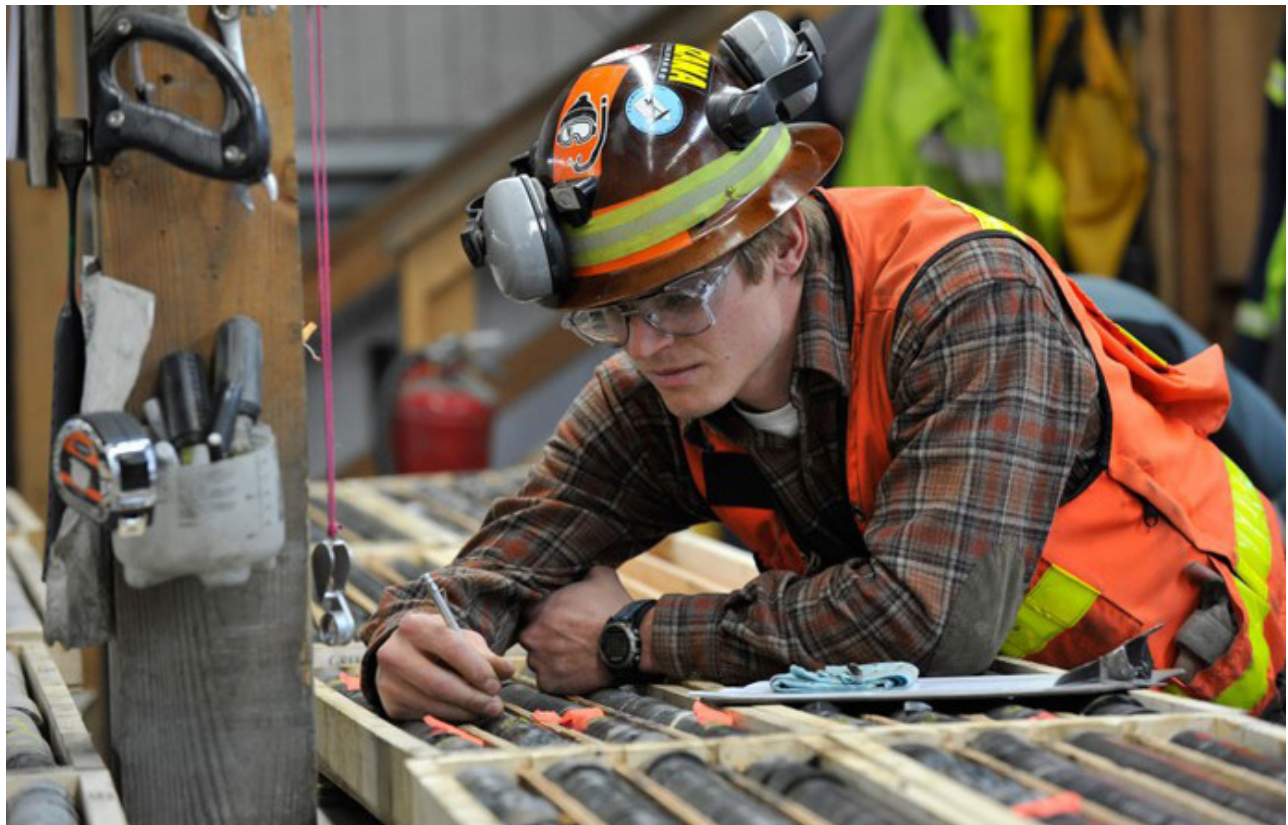


Photo 13. Core logging at Greens Creek mine in southeast Alaska. In 2016 exploration drilling footage consisted of 3,094 feet of surface exploration and 24,720 feet of underground exploration. Photo from Hecla Mining Company, <http://www.hecla-mining.com/greens-creek/>, last accessed January 13, 2017.



deposit accelerated following development of a new exploration station; three drill holes targeting the potential upgrade and expansion of the Jualin resource were completed. Surface drilling twinning historical Jualin drill holes began in August 2016, and this drill program had six planned holes for a total of 11,000 feet budgeted. A surface-based winter drilling program followed the twinning program and focused on potential expansion of the Jualin #4 vein, which remains open at depth and extends about 1,000 feet to the south. Currently, the Jualin #4 vein (1 of 5 known veins) contains a resource of 179,000 ounces of gold at 0.619 ounce of gold per ton and a new resource estimate is in preparation. Vein #5 sits 300 feet below Vein #4 and has similar grade and thicknesses in five out of six holes drilled to this depth.

At the Palmer volcanogenic massive sulfide project near Haines, Constantine Metal Resources Ltd. has delineated an inferred resource of 8.9 million tons grading 1.41 percent copper, 5.25 percent zinc, 0.925 ounce of silver per ton, and 0.009 ounce of

gold per ton (appendix D). In 2016 Dowa Metals and Mining Co., Ltd. completed its \$22 million earn-in and has exercised its option to participate as a joint-venture partner on the Palmer project. Constantine owns 51 percent participating interest and Dowa 49 percent. In 2016 Dowa funded a \$3.7 million exploration program. Two holes totaling 1,952 feet were drilled at the CAP prospect; they intersected semi-massive pyrite, and intervals with anomalous silver and other pathfinder elements (photo 15). Constantine also sampled rocks at the CAP, Nunatak, Gullies, MHC, Jag, Waterfall, Boundary, and Tsirku prospects and obtained many promising assays. Constantine completed environmental assessment work for the U.S. Bureau of Land Management and began construction of its Glacier Creek access road, which will connect the resource area to the Haines highway, enhancing safety to support ongoing exploration work and technical studies.

Although no exploration work was conducted in 2016, Ucore Rare Metals Inc. conducted mineral-separation tests on ore from their advanced-ex-

Photo 14, above. Three miners at Kensington mine. Photo from Coeur Alaska, Inc., <http://www.coeur.com/mines-projects/mines/kensington-alaska>, last accessed January 16, 2017.

Photo 15, opposite. Drilling at the advanced-exploration-stage Palmer project in southeast Alaska near the community of Haines. Mineralization at Palmer is hosted in the same belt of rocks as Hecla's Greens Creek mine near Juneau, Alaska. Photo provided by Liz Cornejo, Constantine Metal Resources Ltd.

ploration-stage, plutonic-related, Bokan-Dotson Ridge rare-earth-element (REE) project in Southeast Alaska. The first batch of pregnant leach solution (PLS) derived from Bokan ore was treated by the SuperLig®-One Molecular Recognition Technology plant at IBC Advanced Technologies, Inc.'s Utah facility. Successful separations include: 1) separation of REE from gangue metals in the PLS; 2) greater than 99 percent purity of separation of light REE from heavy REE at greater than 99 percent recovery; 3) greater than 99 percent purity of separation and recovery of the sub-groups samarium-dysprosium (Dy sub-group) and holmium-lutetium (Ho sub-group) from the heavy REE class consisting of samarium and lutetium; and 4) greater than 99 percent separation of dysprosium from the Dy sub-group. Resources from Ucore Rare Metals' 2013 preliminary economic assessment (PEA) report for the Bokan property are tabulated in appendix D. The PEA proposes a 1,650 ton-per-day underground mine, an 830 ton-per-day mill utilizing magnetic-separation sorting, and a state-of-the-art processing facility.

In July 2016, Grande Portage Resources Ltd. announced it entered into an agreement to acquire Quaterra Resources Inc.'s 35 percent participating interest in the Herbert Gold project, an orogenic gold-vein system located near Juneau. Grande Portage will issue to Quaterra 1,182,331 common shares, and pay Quaterra \$250,000 upon either: (a) delivery of a feasibility report establishing that the Herbert Gold property can be profitably placed into commercial production, or (b) the change of control of Grande Portage or the sale of the Herbert Gold property. As a result, Grande Portage will own 100 percent interest in the Herbert Gold property, subject to a 5 percent net-smelter-returns royalty reserved to an underlying lessor, plus minimum annual advance royalties of \$20,000 due November 1, 2016 and 2017 and increasing to \$30,000 in subsequent years. No exploration work was conducted in 2016. Herbert Gold project resources are tabulated in appendix D. Drilling to date has intersected the mineralized vein over a strike length of 1,200 feet and to a depth of more than 650 feet. The vein can be traced at surface over a strike length of 3,300 feet.



The Zarembo Island property near Wrangell in Southeast Alaska contains widespread lead–zinc–silver–gold anomalies; the historical Frenchie prospect on the property has mineralogical similarities to volcanogenic massive sulfide ores at the Greens Creek mine and is hosted by the same rock package. In 2016 Zarembo Minerals Co. LLC focused on better defining the grade and distribution of gold by conducting metallic-sieve analyses; results indicate 92 percent of the gold in re-analyzed samples is in the coarser, plus-80-mesh size fraction, which is normally discarded in a standard gold fire assay. A previously sampled, 16-foot-thick section of outcrop now has revised grades of 0.128 ounce of gold per ton, up to four percent zinc, and minor lead and silver.

ALASKA PENINSULA REGION

Redstar Gold Corp. conducted two phases of exploration in 2016 on their Unga project, which includes the Shumagin, Apollo, Centennial, Orange Mountain, Zachary Bay, Amethyst, and Aquila epithermal gold–silver prospects. The Shumagin

trend parallels the historically mined Apollo–Sitka vein system, which between 1886 and 1922 produced approximately 150,000 ounces of gold at a grade of approximately 0.292 ounce of gold per ton. In June 2016, Redstar’s Phase I surface program included classifying alteration assemblages and conducting other geologic work to identify drill targets. From October through November, Phase II’s drilling program tested the down-dip and along-strike expansion potential of high-grade vein/breccia mineralization within the Shumigan Gold Zone. A total of 4,938 feet were drilled in seven holes spaced over approximately 2,500 feet of strike length. All drill holes intersected the target structure, which includes multi-generational phreatomagmatic breccias, hydrothermal breccias, and late breccias and veins with colloform–crustiform–to cockade-textured quartz–adularia–carbonate (\pm rhodochrosite, \pm green clay). Select intervals from drill holes 16SH019 and 16SH020 include three feet at 0.436 ounce of gold per ton and 3.8 feet at 0.330 ounce of gold per ton, respectively.

DEVELOPMENT AND PRODUCTION

This section combines development and production narratives; however, we continue efforts to tabulate development expenditures separately. Over the last 10 years the majority of development work has been conducted at mine sites, with development activities being integral to the mining operations. Additionally, there have been few purely development-stage projects. The development sector of the mining process refers to building infrastructure or conducting activities that facilitate production of mineral products. Development expenditures reflect actual expenditures at mines as well as sustaining capital. Sustaining capital includes equipment replacement and rebuilding, facility upgrades, and other expenditures that must be amortized or depreciated in accordance with tax laws; thus, they are frequently reported as distinct line items in securities filings. Development activities, whether to build a new mine or make improvements to an existing mine, are often precursors to increased annual production or extended mine life. Production expenditures include those costs directly related to the production of metals.

Development and production estimates in this report are compiled from a variety of online sources, including annual reports, 10-K reports, and news releases by producers. They are supplemented by questionnaires returned to DGGS by mining companies, as well as personal communications such as phone calls and emails.

Average metal prices used in this report are based on the average daily London Metal Exchange (LME) price (table 9). Some respondents reported actual unit values received for production; in cases where actual values were available, they were used in place of the average values. This report uses revenue as

reported by producers to quantify production values. If unavailable or confidential, the theoretical first market value (estimated gross value of a pure mineral product at first wholesale) is used instead to approximate the value of production; it does not represent actual sales or gross income of producers, does not take into account shipping, smelting, refining, and other costs incurred by the producer, and may significantly overestimate the actual value of the material.

Table 9. Average metal prices, 1996–2016.

Year	Gold \$/oz	Silver \$/oz	Copper \$/lb	Lead \$/lb	Zinc \$/lb
1996	387.60	5.19	1.03	0.37	0.49
1997	330.76	4.91	1.03	0.28	0.59
1998	293.88	5.53	0.75	0.24	0.46
1999	278.70	5.20	0.71	0.23	0.49
2000	279.10	4.96	0.82	0.21	0.51
2001	271.04	4.37	0.71	0.22	0.40
2002	310.06	4.61	0.41	0.21	0.35
2003	363.38	4.88	0.81	0.23	0.38
2004	409.72	6.67	1.29	0.40	0.47
2005	444.74	7.32	1.61	0.43	0.63
2006	603.46	11.55	3.02	0.58	1.47
2007	695.39	13.38	3.24	1.17	1.47
2008	871.96	14.99	3.12	0.94	0.84
2009 ^a	972.35	14.67	2.35	0.78	0.75
2010 ^a	1,224.53	20.19	3.42	0.97	0.98
2011 ^a	1,571.52	35.12	3.99	1.09	0.99
2012 ^a	1,668.98	31.15	3.61	0.93	0.88
2013 ^{a,b}	1,411.23	23.79	3.32	0.97	0.87
2014 ^{a,b}	1,266.40	19.78	3.11	0.95	0.98
2015 ^{a,b}	1,160.06	15.68	2.50	0.81	0.88
2016 ^{a,b}	1,250.74	17.14	2.16	0.81	0.92

^a2009–2016 gold and silver prices from Kitco cumulative average London PM fix; 2009–2012 copper, lead, and zinc from British Columbia Ministry of Energy and Mines.

^b2013–2016 copper, lead, and zinc prices from U.S. Geological Survey Mineral Commodity Summaries, based on London Metal Exchange (LME), and LME average daily settlement.

DEVELOPMENT AND PRODUCTION DISCUSSION

Reported and estimated development expenditures in 2016 were 30 percent less than in 2015, with eight projects spending a total of approximately \$217.4 million. Projects that reported significant development expenditures are shown in figure 6; Red Dog, Fort Knox, Pogo, Kensington, and Greens Creek mines together spent more than \$195.8 million, 90 percent of the total. Precious-metals projects

Fort Knox, Pogo, and Kensington comprised 61 percent of the development expenditures in both 2015 and 2016 (table 10). In the past 10 years, precious metals have been the impetus behind almost two-thirds of annual development investment.

The total mining revenue from the sale of commodities in Alaska during 2016 is estimated at \$2.54 billion (table 1). This metric is new and largely based on confidential data; it is not directly comparable to numbers reported in prior years. The estimated

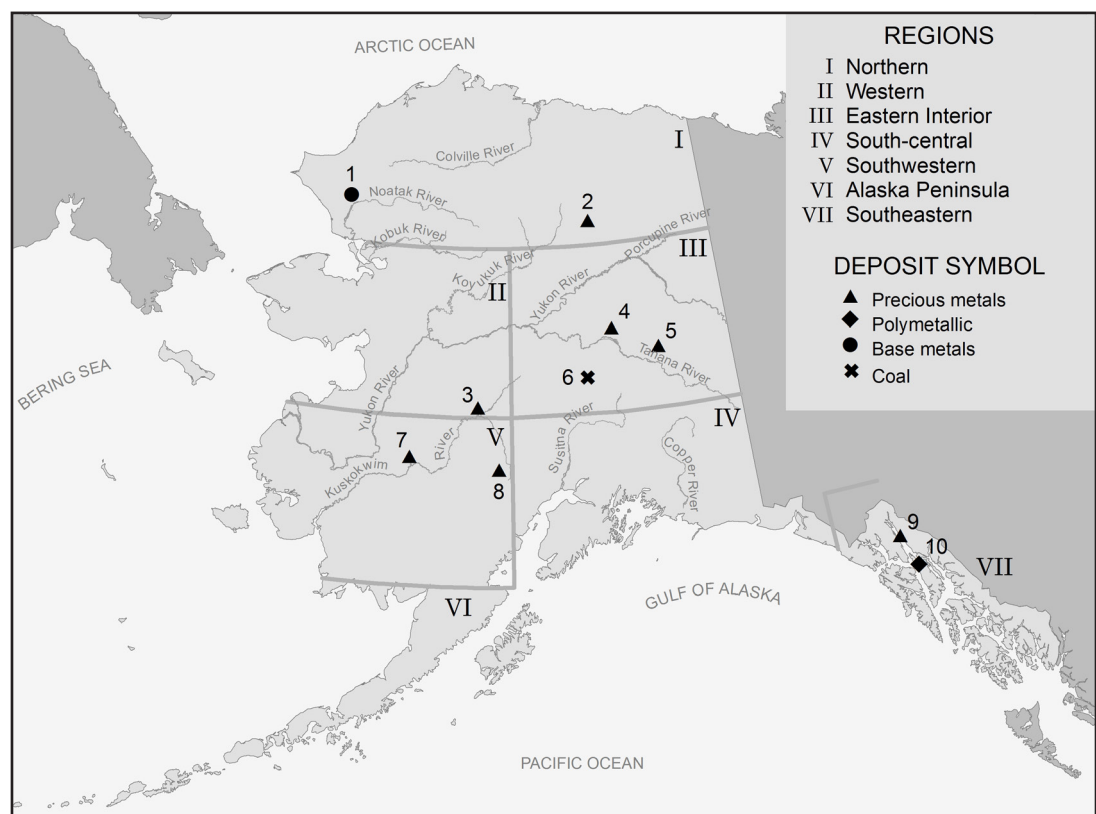


Figure 6. Selected development projects in Alaska, 2016.

Production & Development	
I. Northern Region 1. Red Dog Mine—Teck Alaska Inc. 2. Chandalar placer gold project—Goldrich NyacAu Placer LLC	IV. South-central Region
II. Western Region 3. Nixon Fork—Mystery Creek Resources Inc.*	V. Southwestern Region 7. Donlin Gold project—Donlin Gold LLC* 8. Terra—WestMountain Gold Inc.
III. Eastern Interior Region 4. Fort Knox Mine—Fairbanks Gold Mining Inc. 5. Pogo—Sumitomo Metal Mining Pogo LLC 6. Usibelli Coal Mine—Usibelli Coal Mine Inc.	VI. Alaska Peninsula Region
	VII. Southeastern Region 9. Kensington—Coeur Alaska Inc. 10. Greens Creek Mine—Hecla Greens Creek Mining Company
*Development activity only	

Table 10. Reported mineral development expenditures in Alaska by commodity, 1982–2016.

Year	Base Metals	Polymetallics ^a	Precious Metals	Gemstones ^b	Industrial Minerals	Coal and Peat	Total
1982	10,270,000		19,320,000		4,251,000	7,750,000	41,591,000
1983	19,500,000		7,112,500		1,000,000	250,000	27,862,500
1984	10,710,500		15,058,555		579,000	27,000,000	53,348,055
1985	13,000,000		16,890,755		1,830,000	2,400,000	34,120,755
1986 ^a	3,260,800	8,000,000	12,417,172		124,000	530,000	24,331,972
1987	38,080,000	48,000,000	13,640,848		188,000	342,000	100,250,848
1988	165,500,000	69,000,000	40,445,400		--	--	274,945,400
1989	118,200,000	411,000	6,465,350		7,000,000	2,196,000	134,272,350
1990	--	4,101,000	7,136,500		30,000	3,079,000	14,346,500
1991	--	8,000,000	14,994,350		262,000	2,318,000	25,574,350
1992	80,000	4,300,000	23,151,300		404,000	1,655,000	29,590,300
1993	--	10,731,136	15,103,000		433,500	1,400,000	27,667,636
1994	10,000,000	5,000,000	27,392,850		5,000	2,545,000	44,942,850
1995	11,200,000	9,590,000	127,165,750		426,000	200,000	148,581,750
1996	60,000,000	60,100,000	273,042,000		495,000	400,000	394,037,000
1997	133,880,000	7,300,000	26,299,000		500,000	410,000	168,389,000
1998	28,000,000	5,600,000	15,602,000		5,355,000	850,000	55,407,000
1999	12,500,000	2,500,000	15,864,000		400,000	2,575,000	33,839,000
2000	100,000,000	16,400,000	24,699,000		611,000	--	141,710,000
2001	43,800,000	3,300,000	32,719,000		300,000	1,040,000	81,159,000
2002	--	5,700,000	26,655,000		250,000	1,450,000	34,055,000
2003	--	--	38,839,332		315,000	--	39,154,332
2004	17,700,000	6,215,000	177,440,081		4,991,434	2,760,000	209,106,515
2005	28,000,000	16,700,000	301,011,469		856,500	1,350,000	347,917,969
2006	31,200,000	26,183,280	420,759,203		1,566,000	15,985,000	495,693,483
2007	41,374,880	30,766,902	239,931,040		1,320,500	5,385,000	318,778,322
2008	45,000,000	24,000,000	319,702,594		205,113	7,260,000	396,167,707
2009 ^b	29,000,000	17,500,000	277,020,142	225,250	270,000	6,800,000	330,815,392
2010	42,000,000	16,300,000	225,793,300	200,000	--	9,000,000	293,293,300
2011	48,590,865	41,657,000	170,931,851	250,000	902,480	9,560,000	271,892,196
2012	35,234,500	62,184,000	235,642,406	--	5,290,870	4,021,544	342,373,320
2013	W	57,119,121	258,130,353	295,000	1,831,369	W	358,775,844
2014	W	W	199,909,824	700,000	756,495	--	281,735,787
2015 ^c	W	W	188,226,940	--	--	--	309,938,884
2016	W	47,046,279	133,243,900	--	--	W	217,376,728
TOTAL	\$ 1,096,081,545	\$ 613,704,718	\$ 3,947,756,765	\$ 1,670,250	\$ 42,749,261	\$ 120,511,544	\$ 6,103,042,045

^aPolymetallics category added in 1986.^bGemstone development category added in 2009.^cDevelopment expenditures were underreported for precious metals in 2015.

-- = Not reported

W = Figures withheld for confidentiality purposes. Expenditures are incorporated into the state total.

value of mineral production in Alaska, including theoretical first market values substituted for confidential data, increased more than five percent, from \$2.8 billion to \$2.9 billion (table 11). Gross mining income for tax purposes declined from \$2.5 in 2015 to \$1.9 billion in 2016, a decrease of 24 percent.

Metals (gold, silver, lead, and zinc) account for \$2.86 billion (more than 98 percent of the total), coal adds up to \$32.6 million, and industrial minerals account for \$17.3 million. Alaska's major mines added 430 employees to their production workforce in 2016, which corresponds with increased amounts of all metals produced.

Table 11. Estimated mineral production in Alaska, 2014–2016^{a,b}.

Metals	2014	2015	2016	2014	2015	2016
Gold (ounces)	948,547	873,984	909,242	\$1,201,239,753	\$1,013,875,933	\$1,119,280,480
Silver (ounces)	15,388,901	15,147,249	16,621,035	304,392,456	237,508,864	246,109,759
Copper (tons)	--	--	--	--	--	--
Lead (tons)	155,183	151,247	155,409	294,847,225	245,126,547	241,931,352
Zinc (tons)	716,781	686,938	700,376	1,404,890,368	1,204,315,037	1,250,186,440
Platinum (ounces)	--	--	--	--	--	--
Subtotal				\$3,205,369,802	\$2,700,826,381	\$2,857,508,031
Gemstones and semi-precious stones						
Gemstones and semi-precious stones				\$120,000	\$0	\$0
Subtotal				\$120,000	\$0	\$0
Industrial Minerals						
Sand and gravel (million tons) ^c	0.5	5.7	6.1	\$6,837,950	\$17,176,622	\$17,258,291
Rock (million tons)	1.1	--	--	17,218,014	--	--
Subtotal				\$24,055,964	\$17,176,622	\$17,258,291
Coal and Peat						
Coal (tons) ^d	1,500,000	1,177,390	930,987	\$52,500,000	\$41,208,650	\$32,584,545
Peat (cubic yards) ^d	2,461	--	--	36,915	--	--
Subtotal				\$52,536,915	\$41,208,650	\$32,584,545
TOTAL				\$3,282,082,681	\$2,759,211,653	\$2,907,350,867

^aProduction data from DGGs questionnaires, Internet research, interviews with operators, DOT&PF, and municipalities, regional corporations, and Federal land management agencies.

^bValues for selected metals, coal, and industrial minerals production are based on average prices for each year unless public values were provided by the operator. Total value does not match the Estimated Revenue to Industry in Table 1 due to the incorporation of confidential data in the statewide total.

^cIndustrial minerals (rock, sand, and gravel) values are combined into the sand and gravel category in 2015 and 2016.

^dCoal and peat production values are combined in 2012 and 2013.

Zinc maintained its place as the State's leading mineral product, with a production value of \$1.25 billion in 2016 (a four percent increase from 2015). Zinc accounted for 43 percent of Alaska's production value (figure 7). The annual value of zinc production has exceeded that of gold since 2014 (appendix B). The value of gold production has decreased 28 percent to \$1.12 billion in 2016 since 2013's record value of \$1.55 billion.

Gold production from lode mines in the Eastern Interior and Southeastern regions totaled 909,242 ounces in 2016, of which 75 percent was produced from the Fort Knox and Pogo gold mines in the Eastern Interior region (figure 8). Kensington gold and Greens Creek polymetallic mines in southeastern Alaska, the third and fourth largest gold producers, accounted for the remainder of lode gold production. Placer gold production in 2016 is

estimated to be 51,812 ounces or 6 percent of the total gold produced in Alaska (table 12). Total employment related to gold production in 2016 is 1,475 full-time-equivalent jobs (table 2).

The value of Alaska industrial minerals (rock, sand, and gravel) is at least \$17.3 million in 2016. This figure is based on production data from State lands, the U.S. Bureau of Land Management, and the U.S. Forest Service; it does not include Mental Health Trust lands or lands managed by the State Pipeline Coordinator's Office (figure 9 and appendix C). The total estimated volume of industrial minerals sold is 5.4 million tons for the three DNR land offices (table 13), of which the Northern region accounted for 81 percent of industrial minerals sold in the State. MSHA reported 253 full-time-equivalent jobs in the industrial materials sector in 2016. The 2016 production volume, value, and employment

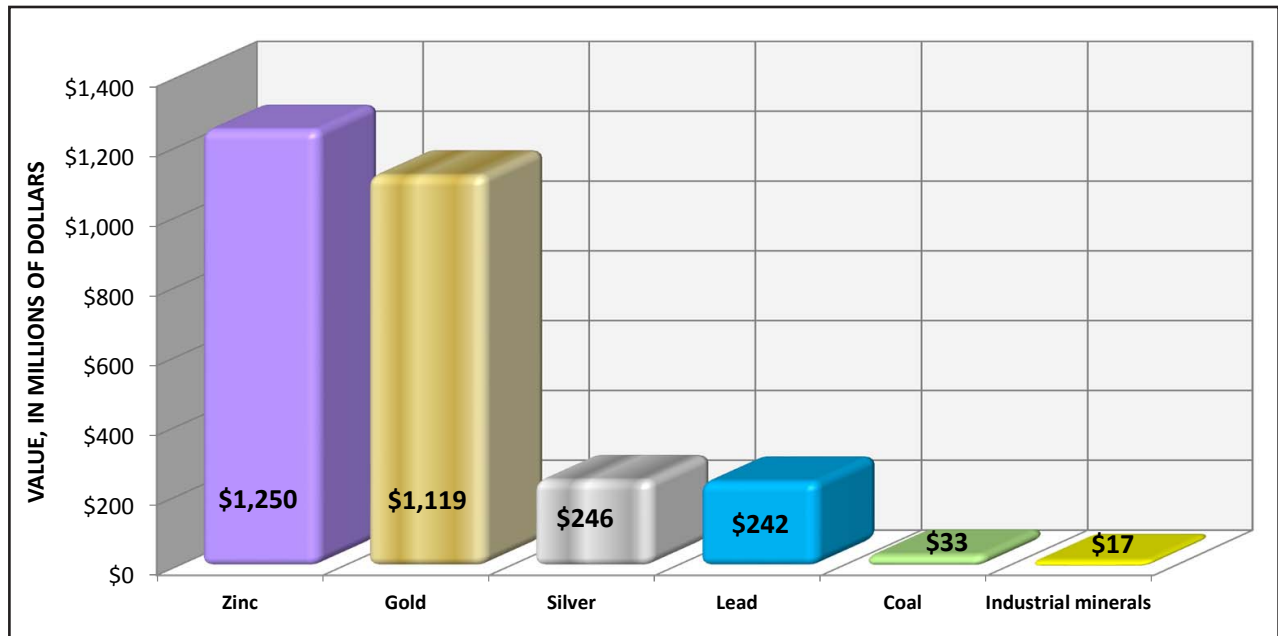


Figure 7. Estimated 2016 mineral production in Alaska by commodity.

figures should be considered minimum estimates due to reporting shortfalls. These figures do not account for significant production of industrial minerals on private, Native, and other Federal lands.

Alaska's Office of International Trade reported that Alaska shipped mineral ores and concentrates, metal ores and concentrates, and coal to more than 11 countries in Europe, North America, and the

Asia-Pacific region in 2016. The Alaska 2016 export value was \$1.55 billion, up almost five percent from 2015 (table 14). Total exports include copper-gold concentrates from the Minto Mine in Yukon Territory, Canada, which were shipped through the AIDEA-owned terminal in Skagway, and coal exported through the Alaska-Railroad-owned coal-loading facility in Seward. Coal production de-

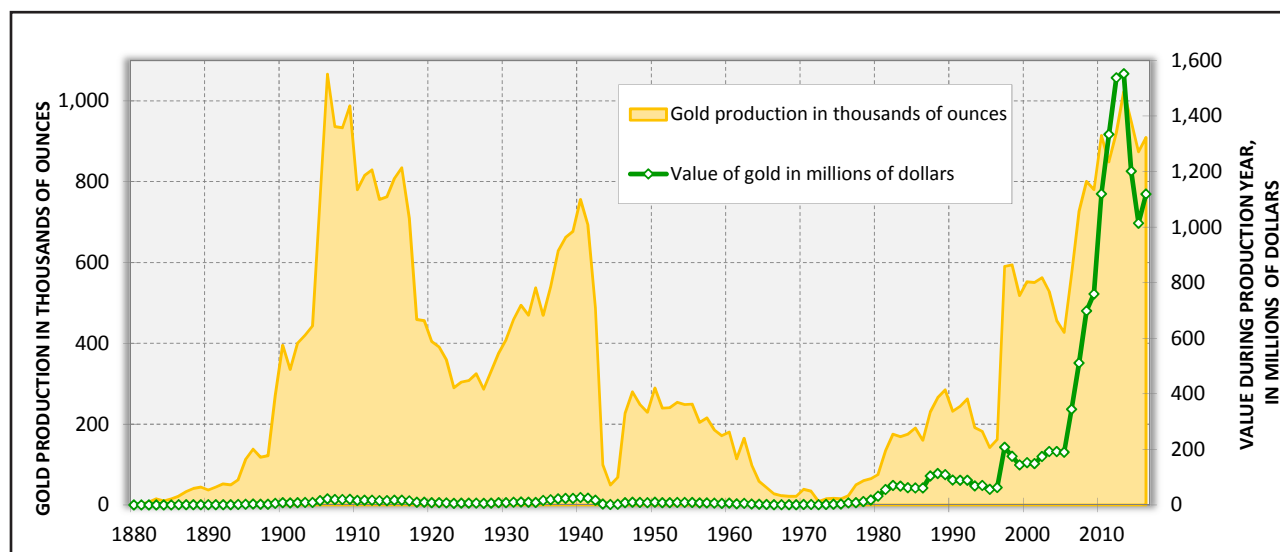


Figure 8. Historical gold production in Alaska, 1880–2016, and corresponding market value.

Table 12. Production and employment estimates for Alaska placer gold mines, 2014–2016.

	2014	2015	2016
Number of placer operations reporting gross operating income ^a	229	238	236
Total gross operating income reported ^a	\$104,994,998	\$78,200,155	\$64,803,637
Average yearly price of gold ^b	\$ 1,266.40	\$ 1,160.06	\$ 1,250.74
Estimated number of gold ounces produced ^c	82,908	67,410	51,812
Estimated number of full-time-equivalent employees ^d	216	224	222

^aValues provided by the Department of Revenue.

^b2014–2016 gold prices from Kitco cumulative average London PM fix.

^cEstimated number of gold ounces produced is calculated by dividing the total gross income by the average price of gold. This yearly estimate does not take into account gold stockpiled, sold in other years, or paid as wages.

^dEstimated number of employees is calculated by multiplying the number of placer operations by 4 workers per mine, a factor determined for the October 2014 report *The Economic Impacts of Placer Mining in Alaska* prepared by McDowell Group, <https://www.dropbox.com/s/wly4yrnmlop59on/AMA%20Placer%20Final%20Report%202011.15.pdf?dl=0>. The factor takes in account unpaid family members and workers paid directly in gold. Full-time-equivalent jobs were calculated by multiplying the total number of workers by a ratio of 86 placer miner working-days per year/365 days. The number of placer miner working-days per year was determined by McDowell Group for the October 2014 report.

clined by approximately 246,400 tons or 21 percent in 2016 (figure 10), primarily due to a reduction in coal exports. In the past decade, the value of coal exports has decreased 93 percent from the high of \$33 million in 2009 to \$2 million in 2016. The Usibelli Coal Mine section contains additional information about the decrease in exports and ramifications for the mine.

RED DOG MINE

Red Dog mine, a sediment-hosted massive sulfide deposit in northwest Alaska operated by Teck Alaska Inc., is an open-pit, truck-and-loader operation using conventional drill and blast mining methods. On-site mineral-processing facilities employ conventional grinding and sulfide-flotation methods to

produce zinc and lead concentrates. In 2016 Teck Alaska mined from the Aqqaluk deposit portion of their Red Dog deposit. Zinc production increased to 1.29 billion pounds, compared with 1.25 billion pounds in 2015, primarily due to increased mill throughput as softer ores were processed (table 15). The zinc grade was 17.1 percent and the rate of recovery was 82.8 percent. Lead production in 2016 rose to 269.6 million pounds, compared to 259.2 million pounds in 2015, primarily due to higher mill throughput. The lead grade was 4.9 percent and the rate of recovery was 56.0 percent. In 2016 Teck Alaska employed 600 staff (including contractors), mined 15,106,000 tons of material, and milled 4,684,823 tons. Teck Alaska sold 1.323 billion

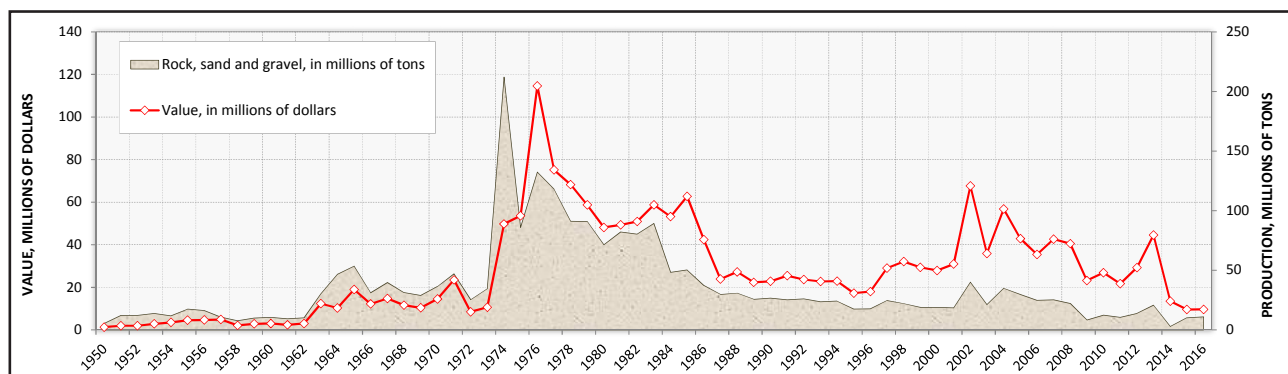


Figure 9. Rock, sand, and gravel production in Alaska, 1950–2016.

Table 13. Material (rock, sand, and gravel) sale volumes (in tons) by region reported on State-owned land, excluding Mental Health Trust lands or lands managed by the State Pipeline Coordinator's Office, for 2011–2016. These volumes do not include material produced from private, Native, or Federal lands, which are significant amounts. These figures serve as minimum amounts of material produced.

Region	2011	2012	2013	2014	2015	2016
Northern (Fairbanks office)	2,890,304	3,501,387	4,991,349	9,247,223	3,559,580	4,989,855
South-Central (Anchorage office)	70,410	1,035,450	235,050	433,433	2,115,750	396,657
Southeast (Juneau office)	77,940	56,115	69,866	62,559	50,211	13,268
Total	3,038,654	4,592,952	5,296,265	9,743,214	5,725,541	5,399,780

Source: Department of Natural Resources, Division of Mining, Land and Water Southeast Regional Office (SERO), South-Central Regional Office (SCRO), and Northern Regional Office (NRO) Material Sale Tracking Spreadsheets. Prepared by Zoya Ponomareva.

DNR material sales volumes and revenues do not correlate, as volumes are attributed to the calendar year in which material was extracted while revenues are tracked on a cash basis (when received), which could be in the subsequent calendar year.

Table 14. Alaska international mineral export values (in millions of dollars).

Year	Mineral Ores and Concentrates ^a	Canada Copper Ores Through Skagway Terminal ^b	Precious Metals ^c	Coal ^d	Total Value of Mineral Exports
1996	\$249	--	> \$1	\$27	\$276
1997	369	--	> \$1	26	395
1998	317	--	> \$1	8	325
1999	359	--	> \$1	15	374
2000	293	--	1	16	310
2001	329	--	3	17	349
2002	380	--	47	9	436
2003	413	--	84	4	501
2004	505	--	110	14	629
2005	511	--	132	14	657
2006	1,094	--	110	10	1,214
2007	1,269	16	132	5	1,406
2008	691	103	144	23	858
2009	853	64	153	33	1,039
2010	1,336	37	214	25	1,575
2011	1,809	199	267	31	2,107
2012	1,502	169	84	31	1,617
2013	1,495	150	22	27	1,543
2014	1,762	186	11	17	1,790
2015	1,468	99	7	5	1,480
2016	1,523	146	26	2	1,551

Sources: 1996–2013, U.S. Census Bureau, Origin of Movement Series; 2014–2016, Alaska Office of International Trade. Figures are updated as new information becomes available.

^aHS 26 Mineral Ores: Zinc ores and concentrates, lead ores and concentrates, copper ores and concentrates, silver ores, gold ores and concentrates, zirconium ore (only in 2009), and miscellaneous ores.

^bValue of Canada copper ores moving through Skagway that are included in Mineral Ores and Concentrates values

^cHS 71 Precious Metals: Gold doré, precious stones, and wrought jewelry

^dHS 27 Coal

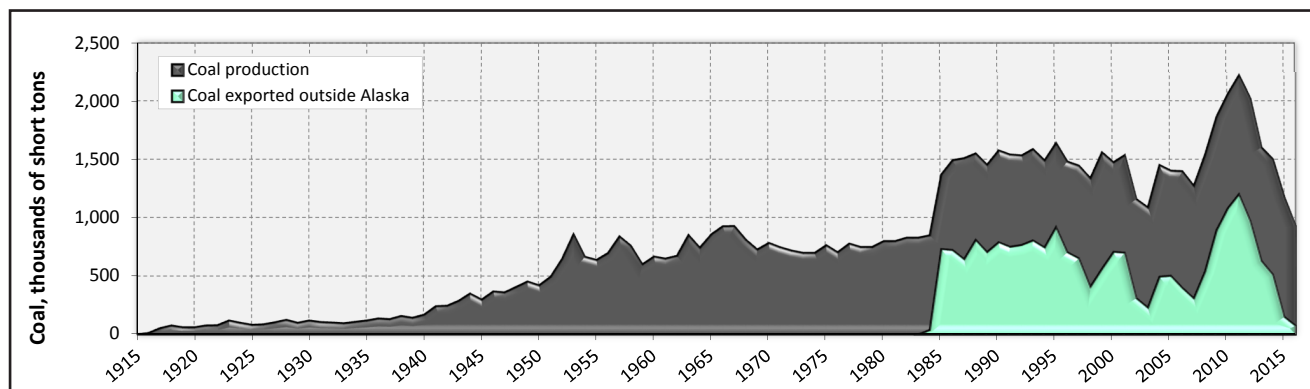
**Figure 10.** Alaska coal production and exports, 1915–2016.

Table 15. Red Dog Mine production statistics, 1989–2016^a.

Year	Tons Milled	Ore Grade			Total Tons Concentrate Produced ^b	Contained Tons Zinc	Contained Tons Lead	Million Ounces Silver ^c	Employees
		Zinc (%)	Lead (%)	Silver (oz/ton)					
1989	33,300	20.4	7.6	3.6	8,532	--	--	--	228
1990	996,700	26.5	8.5	3.6	443,600	191,981	31,187	1.6	350
1991	1,599,300	22.5	6.6	2.8	521,400	234,510	43,815	1.46	331
1992	1,582,000	19.9	6.0	2.9	474,900	231,363	15,960	1.38	349
1993	1,874,600	18.4	5.7	2.8	539,800	255,149	24,788	1.51	376
1994	2,339,500	18.8	5.7	2.8	658,000	328,160	32,775	1.84	391
1995	2,485,900	19.0	5.8	2.8	753,600	358,676	55,715	3.62	397
1996	2,312,600	18.7	5.0	2.8	765,300	357,680	65,886	4.3	417
1997	2,127,000	20.3	5.2	2.9	799,400	373,097	69,284	4.27	479
1998	2,752,587	21.4	5.2	2.7	1,015,773	490,461	80,193	5.2	466
1999	3,282,788	21.3	5.2	2.7	1,207,160	574,111	97,756	6.21	539
2000	3,365,508	21.0	4.7	2.5	1,211,539	585,030	91,557	5.84	536
2001	3,560,430	19.8	5.0	2.5	1,215,837	570,980	105,000	5.9	559
2002	3,489,600	21.1	5.4	2.7	1,366,480	637,800	118,880	6.75	560
2003	3,476,689	21.7	6.2	3.1	1,410,892	638,569	137,679	7.7	388
2004	3,249,613	22.0	6.0	3.0	1,337,545	610,900	128,970	7.22	508
2005	3,402,831	21.7	5.6	3.0	1,330,717	626,112	112,766	1.97	449
2006	3,569,280	20.6	6.1	3.0	1,378,384	614,538	136,135	7.62	457
2007	3,726,910	20.2	6.1	3.1	1,428,014	633,511	146,152	11.55	459
2008	3,306,934	20.1	6.0	3.1	1,273,885	567,911	135,143	7.5	475
2009	3,729,119	20.9	5.9	3.1	1,445,870	642,096	144,954	8.12	413
2010	3,937,456	18.2	5.4	3.1	1,300,694	593,043	121,144	6.78	550
2011	4,048,000	19.1	5.0	3.0	1,182,060	572,208	84,033	5.19	586
2012	3,941,000	18.2	4.6	3.0	1,134,415	529,157	95,282	5.89	530
2013	4,243,899	17.0	3.9	NA	1,271,221	607,704	106,594	6.1	550 ^d
2014	4,739,302	16.6	4.4	NA	1,409,511	656,971	135,032	7.56	639 ^d
2015	4,437,950	14.1	2.9	NA	1,351,221	625,004	129,630	6.7	630 ^d
2016	4,684,823	17.1	4.9	NA	1,411,029	642,647	134,813	7.34	600
TOTAL	86,295,619				29,646,779	13,749,369	2,581,122	147.12	

^aRevised slightly from Special Report 51, *Alaska's Mineral Industry 1995*, based on new company data.^bTotals for years 1990 through 1995 include bulk concentrate. Total for 2013 estimated from total metal produced for 2013.^cEstimate calculated at 56 ounces per ton of lead metal produced from 1990 to 2004 and 2006; as reported credit for 2005, net of treatment charges; calculated at 3.1 ounces per ton of ore for 2007; estimated as proportional with increase in zinc and lead in 2013; as reported in 2014 and 2016; calculated based on recoverable silver from reported lead concentrate recovered in 2015.^dValue reported by Department of Natural Resources

-- = No concentrate produced

NA = Not available

pounds of zinc and 289.9 million pounds of lead from Red Dog mine in 2016. Teck Alaska spent \$46 million in sustaining capital at Red Dog, gross profits before depreciation and amortization were \$749 million, and final gross profits were \$537 million. In 2016 Teck began development of its Qanaiyaq deposit, a near-surface deposit located immediately south of the mined-out Red Dog Main pit. This high-grade deposit hosts 8.2 million tons of reserves averaging 24.7 percent zinc and 6.9 percent lead; production at Qanaiyaq is scheduled to begin in early 2017. Red Dog reserves and resources for the Aqqaluk and Qanaiyaq deposits as of March 2016 are tabulated in appendix D.

In accordance with the operating agreement governing the Red Dog mine between Teck and NANA Regional Corporation, Inc. (NANA), Teck pays a 30 percent royalty on net proceeds of production to NANA. This royalty increases by 5 percent every fifth year to a maximum of 50 percent, with the next adjustment to 35 percent occurring in October 2017. The NANA royalty charge in 2016 was \$213 million. A payment in lieu of taxes (PILT) agreement between Teck Alaska and the North West Arctic Borough (the last regional municipality) expired December 31, 2015. Teck Alaska and the Borough have subsequently reached a new agreement. Teck

Alaska leases road and port facilities from the Alaska Industrial Development and Export Authority, through which it ships all concentrates produced at the Red Dog operations. The lease requires Teck to pay a minimum annual user fee of \$18 million for the next 14 years and \$6 million for the following nine years.

FORT KNOX MINE

The Fort Knox plutonic-hosted gold mine located 20 miles north of Fairbanks is operated by Fairbanks Gold Mining, Inc., a wholly owned subsidiary of Kinross Gold Corporation. The open-pit and truck-and-shovel operation uses carbon-in-pulp, heap leach, and gravity processes to recover gold. Fort Knox celebrated its 20th anniversary of operation and poured its 7-millionth ounce of gold in 2016; gold production for the year totaled 409,845 ounces (table 16, photo 16). Production increased slightly compared with 2015, mainly as a result of record production from the heap leach, but this was partially offset by lower mill grades. Fort Knox's 2016 production cost of sales was \$741 per equivalent ounce of gold sold. In 2016 Kinross employed 660 people, mined 34,998,000 tons of ore, processed 14,570,000 tons of ore through the mill, and processed 32,124,000 tons of ore on the heap



Photo 16. Fort Knox gold pour. Photo from Fairbanks Gold Mining, Inc., <http://www.kinross.com/operations/default.aspx#americas-fortknox>, last accessed October 6, 2017.

Table 16. Fort Knox Mine production statistics, 1996–2016.

Year	Tons Mined (Ore + Waste)			Tons Milled (Ore)			Tons Placed on Heap Leach ^b	Ounces Gold Produced	Employees
	Fort Knox	True North ^a	Total	Fort Knox	True North ^a	Total			
1996	16,684,000	0	16,684,000	769,700	0	769,700		16,085	243
1997	32,380,000	0	32,380,000	12,163,151	0	12,163,151		366,223	249
1998	33,294,000	0	33,294,000	13,741,610	0	13,741,610		365,320	245
1999	30,350,000	0	30,350,000	13,819,010	0	13,819,010		351,120	253
2000	35,600,000	0	35,600,000	15,000,000	0	15,000,000		362,929	253
2001	25,957,900	8,448,400	34,406,300	13,282,614	2,377,386	15,660,000		411,220	360
2002	24,583,500	11,461,000	36,044,500	11,887,200	3,371,800	15,259,000		410,519	360
2003	30,597,940	12,707,100	43,305,040	11,473,000	3,611,682	15,084,682		391,831	316
2004	44,187,000	3,763,000	47,950,000	12,917,966	1,675,854	14,593,820		338,334	427
2005	63,248,000	0	63,248,000	14,384,842	0	14,384,842		329,320	411
2006	51,070,000	0	51,070,000	14,839,297	0	14,839,297		333,383	406
2007	45,940,000	0	45,940,000	14,021,400	0	14,021,400		338,459	399
2008	46,300,000	0	46,300,000	15,110,000	0	15,110,000		329,105	449
2009	27,585,000	0	27,585,000	17,884,000	0	17,884,000		263,260	500
2010	42,400,000	0	42,400,000	14,560,000	0	14,560,000		349,729	525
2011	34,550,000	0	34,550,000	14,880,000	0	14,880,000		289,794	522
2012	63,120,000	0	63,120,000	14,550,000	0	14,550,000		359,948	565
2013	63,280,000	0	63,280,000	13,960,000	0	13,960,000		428,822	629
2014	49,240,000	0	49,240,000	14,920,000	0	14,920,000	28,500,000	387,285	649
2015	60,860,000	0	60,860,000	14,820,000	0	14,820,000	27,700,000	401,553	657
2016	65,240,000	0	65,240,000	14,570,000	0	14,570,000	32,124,000	409,845	660
TOTAL	886,467,340	36,379,500	922,846,840	283,553,790	11,036,722	294,590,512	192,724,000	7,234,084	

^aTrue North Mine started production in 2001 and suspended production in 2004.

^bWalter Creek Heap leach facility started production in 2009, but was not tracked until 2014. Total includes 104.4 million tons placed on heap leach from 2009 through 2013.

leach pad at Fort Knox. Mill grade averaged 0.022 ounce of gold per ton with an 83 percent recovery rate, and the heap leach grade averaged 0.009 ounce of gold per ton. Capital expenditures were \$70.2 million, and depreciation, depletion, and amortization expenses totaled \$88.7 million. Fort Knox paid \$8.3 million in property taxes during 2016. Fort Knox mine reserves and resources as of December 31, 2016 are tabulated in appendix D. Termination of open pit mining at Fort Knox is currently scheduled for 2019. In May 2016, the U.S. Bureau of Land Management announced it is considering a proposal to relinquish 709 acres of National Oceanic and Atmospheric

Administration land immediately west of the phase-8 expansion of Fort Knox, as this land is no longer needed to fulfill its mission. Access to this land could add to the mine's life.

POGO MINE

The Pogo mine in Interior Alaska is owned and operated by Sumitomo Metal Mining Pogo LLC, a joint venture between 85 percent owner Sumitomo Metal Mining Co., Ltd. and 15 percent owner Sumitomo Corporation. The deposit consists of a set of structurally controlled, gold-bearing quartz veins that are being mined underground with a cut-and-

fill operation, with gravity, flotation, and cyanide leaching processes used to recover gold. Pogo mine celebrated its 10th anniversary of production in 2016 (table 17). Pogo mine produced 269,342 ounces of gold for the year from 941,856 tons of ore milled. The company mined 1,515,117 tons of ore and waste material and placed 12,812,069 cubic feet of paste backfill in the underground workings. The ore grade was 0.331 ounce per ton at a recovery rate of 86.1 percent. Sumitomo paid \$43.9 million in wages in 2016 and employed 470 workers, including contractors. Pogo mine reserves and resources as of year-end 2016 are tabulated in appendix D.

USIBELLI COAL MINE

Usibelli Coal Mine Inc. is a local, family-owned coal mining company with 112 full-time-equivalent employees. The company has been in production since 1943, mining coal from the Miocene Suntrana Formation from leases on State-owned lands in the Healy area. Usibelli's main leases are in the Hoseanna Creek and Jumbo Dome areas. There are four

active and past coal resources. Poker Flats produced about 27 million tons of coal beginning in the 1970s, and the site is now fully reclaimed. Gold Run Pass is nearing completion of its mining life, with four of five reclamation stages complete. More than 10 million tons of coal are planned to be mined from Two Bull Ridge, which has 3.5–5 cubic yards of overburden for each ton of coal, and multiple seams. The number 3 seam averages 18 feet thick, number 4 seam is up to 32 feet thick, and number 6 seam averages 21 feet thick. Finally, the Jumbo Dome mine region contains approximately 250 million tons of coal, about 80 million tons of which have been permitted for mining. Number 4 seam averages 40 feet thick with 25 to 75 feet of overburden above it, and number 3 seam averages 30 feet thick with 35 feet of overburden between it and number 4 seam. Stripping ratios are 0.5 cubic yards of overburden per one ton of coal. All of the coal is subbituminous, low-ash, and extremely low in sulfur.

Table 17. Pogo Mine production statistics, 2006–2016.

Year	Tons Ore Mined	Tons Ore Milled	Ounces of Gold Recovered	Recovery (%)	Head Grade Gold (oz/ton)	Employees ^a
2006	447,129	338,000	113,364	85.0	0.395	477
2007	715,665	715,400	259,820	84.4	0.430	339
2008	882,400	818,237	347,219	83.8	0.506	285
2009	944,823	930,836	389,808	88.2	0.475	272
2010	900,585	947,189	383,434	89.6	0.452	300
2011	892,725	929,020	325,708	89.6	0.392	310
2012	815,922	875,351	315,886	89.7	0.402	335
2013 ^b	963,229	875,351	337,393	90.2	0.395	320
2014	972,406	967,230	342,147	89.0	0.396	320
2015 ^c	--	--	283,000	--	--	350
2016 ^c	1,515,117	941,856	269,342	86.1	0.331	470
TOTAL	9,050,001	8,338,470	3,367,121			

^aIncludes contract employees, if known.

^bSilver production of 32,000 ounces was reported in 2013.

^cSome production figures as reported by DNR, last accessed on 10/6/2016. <http://dnr.alaska.gov/mlw/mining/largemine/pogo/>

-- = Not reported

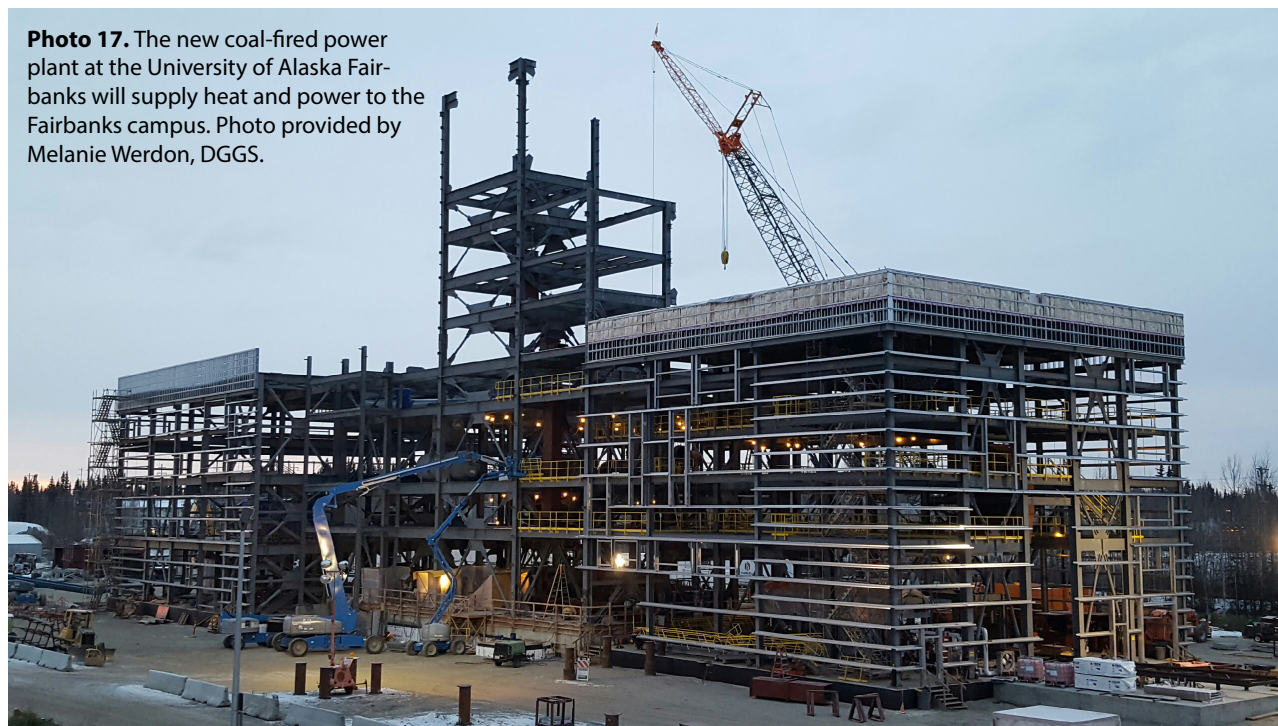
In 2016 Usibelli produced nearly 80 percent of its coal from its new Jumbo Dome mine, with lesser amounts from its Two Bull Ridge mine. Total production was 930,987 tons of coal, down from 1.177 million tons in 2015; 75,000 tons of 2016's production were exported to Japan in July through the Alaska Railroad Corporation's export facility in Seward. This facility is operated by Aurora Energy Services LLC, a subsidiary of Usibelli. Subsequently, exports were halted and the coal-loading facility was put into temporary closure status. Company officials attribute low-export demand to a strong U.S. dollar, cheap natural gas, and lower-priced coal from Indonesia and Australia. The majority of Usibelli's coal is used for in-state electrical power generation at seven Interior Alaska coal-fired power plants. The University of Alaska Fairbanks is adding a new boiler and 17-megawatt turbine generator (photo 17), Eielson

Air Force Base is upgrading multiple boilers, and Golden Valley Electric Association is in the process of commissioning the Healy Number 2 power plant, a 50-megawatt coal-fired electrical plant at the mouth of the Usibelli mine. Healy Number 2 is projected to use about 200,000 tons of coal per year. This increase in coal demand will be partially offset by an expected 55,000-ton decrease in coal consumption by the U.S. Air Force as they phase out their coal-fired power plant in Clear.

KENSINGTON MINE

Kensington mine's structurally controlled orogenic-gold veins (Kensington Main, Jualin, Raven) are located 45 miles north of Juneau in Southeast Alaska. The mine is operated by Coeur Alaska, Inc., a wholly owned subsidiary of Coeur d'Alene Mines Corporation. Kensington employs long-hole stoping

Photo 17. The new coal-fired power plant at the University of Alaska Fairbanks will supply heat and power to the Fairbanks campus. Photo provided by Melanie Werdon, DGGs.



and drift-and-fill underground mining methods, followed by flotation processes to recover gold. The mine's 2016 production of 124,331 ounces of gold was near the high end of the company's guidance range (table 18). In 2016 Coeur Alaska, Inc. employed 331 people, and processed 620,209 tons of material through the mill at an average grade of 0.21 ounce of gold per ton with a 94.7 percent recovery rate. Coeur Alaska, Inc. sold 121,688 ounces of gold for metal sales of \$146.6 million. Costs applicable to sales were \$96.7 million, adjusted average cash costs applicable to sales for the year were \$790 per ounce of gold, and total sustaining and development capital expenditures were \$36.8 million. Development of the Jualin decline continues on schedule with 64 percent completed as of year-end 2016. Coeur's 2015 technical report forecasts gold production to reach 149,000 ounces of gold per year in 2018, the first full year of production from Jualin. Kensington mine reserves and resources as of December 31, 2016 are tabulated in appendix D.

GREENS CREEK MINE

The Greens Creek underground, volcanogenic massive sulfide mine in Southeast Alaska is operated by Hecla Mining Company (photo 18). For 2016 Hecla reported production of 9,253,543 ounces of silver from Greens Creek, the highest since Hecla acquired 100 percent of the mine in 2008 (table 19). Silver production showed an increase of 9.5 percent over the prior year, but gold production fell by 11.0 percent to 53,912 ounces. The increase in silver

production resulted from higher grades and higher recovery, while gold production was lower due to slightly lower ore grades. The mine also produced 41.19 million pounds of lead and 115.46 million pounds of zinc. The mill operated at an average of 2,229 tons per day for the year, milling a total of 815,639 tons. Mining and milling costs per ton were \$69.48 and \$31.99, respectively. Ore grades milled were 14.55 ounces of silver per ton, 0.10 ounce of gold per ton, 3.11 percent lead, and 8.08 percent zinc. The cost of sales and other direct production costs and depreciation, depletion, and amortization for 2016 was \$191.3 million. The cash cost, after byproduct credits, was \$3.84 per ounce of silver, a decrease from \$3.91 in 2015. Hecla Mining Company had 414 employees at Greens Creek in 2016. Definition drilling at Greens Creek in 2016 refined the resources of the 9A, Southwest Bench, East Ore and NWW zones. Greens Creek mine reserves and resources as of December 31, 2016 are tabulated in appendix D.

CHANDALAR PLACER MINE

The Chandalar placer gold mine in the southern Brooks Range near the Dalton highway is owned by Goldrich NyacAU Placer, LLC, a joint venture between Goldrich and project manager NyacAU (photo 19). Production in 2016 totaled 10,209 ounces of alluvial gold (8,227 ounces of fine gold), at an estimated cost of approximately \$960 per ounce. The plant operated approximately 15 hours per day at a processing rate of 183 bank-cubic yards per hour. In

Table 18. Kensington Mine production statistics, 2010–2016.

Year	Ore (tons milled)	Ore grade gold (ounce/ton)	Gold Recovery (%)	Gold produced (ounces)
2010 ^a	174,028	0.28	89.9	43,143
2011	415,340	0.23	92.7	88,420
2012	394,780	0.22	95.6	82,125
2013	553,717	0.21	96.6	114,821
2014	635,960	0.20	94.1	117,823
2015	659,786	0.20	94.9	128,865
2016	620,209	0.21	94.7	124,331
TOTAL	3,453,820			699,528

^aProduction started July 3, 2010

2016 Goldrich NyacAU surveyed the area beyond Line 11 and received a permit to mine Lines 11 to 18 in addition to permits already received to mine Lines 1 to 11.

TERRA

In 2016 WestMountain Gold Inc. conducted small-scale surface mining and milling operations as part of a bulk-sampling program at Terra, a structurally controlled, high-grade gold-silver vein system located approximately 125 miles west-northwest of Anchorage. In late summer, a landslide buried the surface bulk-sampling area; no injuries or equipment damage occurred. By mid-September, WestMountain Gold had processed 890 tons of material from the high-grade gold vein at Terra, and had another 1,470 tons of stockpiled material available that was mined prior to the landslide. Due to reduced revenue caused by the landslide, the company stated they will most likely be unable to

fund future operational costs, including planning and commencement of any potential underground mine development.

DONLIN GOLD PROJECT

Donlin Gold is a proposed, large open-pit gold mine located in southwest Alaska owned by Donlin Gold, LLC, a 50/50 partnership between Barrick Gold Corp. and NOVAGOLD Resources Inc. The project has proven and probable reserves of 34 million ounces of gold grading 0.061 ounce of gold per ton. Donlin Gold's preferred design for the Donlin project anticipates a throughput of approximately 59,000 tons per day. The company's proposal to power the mine includes a 14-inch-diameter, 315-mile-long natural gas pipeline starting in Beluga, Alaska, passing north through the Alaska Range, and continuing to the mine site. Donlin Gold estimates the project would take 3 to 4 years to construct and would have a projected mine life of



Photo 18. Aerial view of Greens Creek mine near Juneau, Alaska. The operation is accessed by boat and served by 13 miles of road, and consists of the mine, an ore concentrating mill, a dry stacked tailings facility, a ship-loading facility, camp facilities, and a ferry dock. Photo from Hecla Mining Company, <http://www.hecla-mining.com/greens-creek/>, last accessed January 13, 2017.

Table 19. Greens Creek Mine production statistics, 1989–2016.

Year	Tons Milled	Tons Concentrate	Tons Zinc	Metal Produced				Employees
				Tons Lead	Tons Copper ^a	Ounces Gold	Ounces Silver	
1989	264,600	--	187,007	9,585	--	23,530	5,166,591	235
1990	382,574	--	37,000	16,728	--	38,103	7,636,501	265
1991	380,000	--	41,850	16,900	--	37,000	7,600,000	238
1992	365,000	113,827	40,500	16,500	--	32,400	7,100,000	217
1993 ^b	77,780	--	9,500	3,515	--	7,350	1,721,878	217
1994 ^c	--	--	--	--	--	--	--	--
1995 ^c	--	--	--	--	--	--	--	--
1996 ^b	135,000	43,000	9,100	4,200	193	7,480	2,476,000	265
1997	493,000	--	46,000	19,000	1,300	56,000	9,700,000	275
1998	540,000	--	58,900	22,700	1,300	60,572	9,500,000	275
1999	578,358	--	68,527	25,503	1,400	80,060	10,261,835	275
2000	619,438	--	84,082	31,677	1,400	128,709	12,424,093	275
2001	658,000	--	63,903	22,385	1,400	87,583	10,900,000	275
2002	733,507	217,200	80,306	27,582	1,600	102,694	10,913,183	262
2003	781,200	--	76,200	24,800	--	99,000	11,707,000	295
2004	805,789	--	69,115	21,826	--	86,000	9,707,000	265
2005	717,600	--	58,350	18,600	--	72,800	9,700,000	265 ^d
2006	732,176	--	59,429	20,992	--	62,935	8,865,818	245 ^e
2007	732,227	--	62,603	21,029	--	68,006	8,646,825	276 ^f
2008	734,910	--	58,224	18,562	--	67,269	7,145,711	336 ^g
2009	790,871	--	70,379	22,253	--	67,278	7,459,170	321 ^h
2010	800,397	--	74,496	25,336	--	68,838	7,206,973	343 ⁱ
2011	772,069	--	66,050	21,055	--	56,818	6,498,337	364 ^j
2012	789,569	--	64,249	21,074	--	55,496	6,394,235	386 ^k
2013	805,322	--	57,614	20,114	--	57,457	7,448,347	390 ^l
2014	816,213	--	59,810	20,151	--	58,810	7,826,341	415
2015	814,398	--	61,934	21,617	--	60,566	8,452,153	418
2016	815,639	--	57,729	20,596	--	53,912	9,253,543	414
TOTAL	16,135,637	--	1,622,857	514,280	8,593	1,596,666	211,711,534	

^aNo copper credits in 1989–1993 and 2003–2016.^bPartial-year production.^cNo production in 1994 and 1995 due to mine closure.^dFifteen of these employees were assigned to development effort.^eFifty employees were assigned to development and reported in that section's employment.^fForty-five employees were assigned to development and reported in that section's employment.^gNineteen employees were assigned to development and reported in that section's employment.^hEighty-five employees were assigned to development and reported in that sector's employment.ⁱSeventy-nine employees were assigned to development and reported in that sector's employment.^jNineteen employees were assigned to development and reported in that sector's employment.^kThirty-nine employees were assigned to development and reported in that sector's employment.^lAll employees were assigned to the production sector.

-- = Not reported

approximately 27.5 years. It would produce an estimated average of approximately one million ounces of gold per year.

As part of its mine-development effort, in 2016 Donlin Gold applied to install a number of structures and facilities on State lands and also requested to restrict public easements. The State of Alaska's Department of Natural Resources, Southcentral Regional Office (SCRO) conducted a public scoping notice from August 31 to October 17, 2016 to make the public aware of the applications received and to solicit public input that will be considered during the adjudication process. In its 2016 year-end financial report and project update, NOVAGOLD listed major milestones that include advancement of the permitting and technical work at the project. These include the completion of a six-month public comment period on the draft Environmental Impact Statement (EIS) completed by the U. S. Army Corps

of Engineers, and completion of public working sessions attended by all cooperating agencies to address comments on key topics and how to address them in the final EIS, which is planned for completion in early 2018. Other permitting applications and submissions have been concurrently advanced with State and Federal agencies.

NIXON FORK

The Nixon Fork underground mine is a copper-gold skarn deposit located 32 miles northeast of McGrath and operated by Mystery Creek Resources, Inc., a wholly owned subsidiary of Titan Resources, Ltd. The last reported resources are approximately 145,000 tons, containing 136,000 ounces of gold. In August 2016, Mystery Creek submitted notification to the Department of Natural Resources to restart the mine, which has been idle since 2007, and in September 2016 the company received a certificate of approval to operate a dam.



Photo 19. Footprint of Chandalar placer gold mining operation located 190 miles north of Fairbanks. Photo from Goldrich NyacAU Placer, LLC,

<http://www.goldrichmining.com/chandalar-gold-district/photo-gallery.html>, last accessed October 6, 2017.

DRILLING

Eleven companies publicly reported significant drilling programs in Alaska in 2016 (table 20). Total 2016 drilling on 16 projects across all sectors was 644,512 feet, down 31 percent from almost a million feet of drilling in 2015 (table 21). Exploration drilling totaled 428,520 feet in 2016, 60,950 feet less than drilled in 2015 (photo 20). About 253,626 feet or 39 percent of exploration drilling was conducted by lode mines looking to increase their reserves and extend mine life. Development drilling totaled 122,847 feet, and production drilling totaled 93,145 feet.

Drilling footage was primarily compiled from questionnaires, public company reports, and online information, and represents a minimum amount for 2016. Placer exploration drilling in 2016 was not compiled, and development and production drilling is also likely underreported. Blast-hole drilling during production at Alaska’s large lode mines was not tracked.

Table 20. Companies publicly reporting significant drilling programs in Alaska in 2016.

Coeur Alaska Inc.
Contango ORE Inc.
Coventry Resources
Freegold Ventures Ltd.
Hecla Greens Creek Mining Company
Honolulu Prospect Corp.
Kinross Gold Corp. (Fairbanks Gold Mining Inc.)
Trilogy Metals Inc.
Redstar Gold Corp.
Teck Alaska Inc.
Western Alaska Copper & Gold Co.

Table 21. Drilling footage reported or estimated in Alaska, 1982–2016.

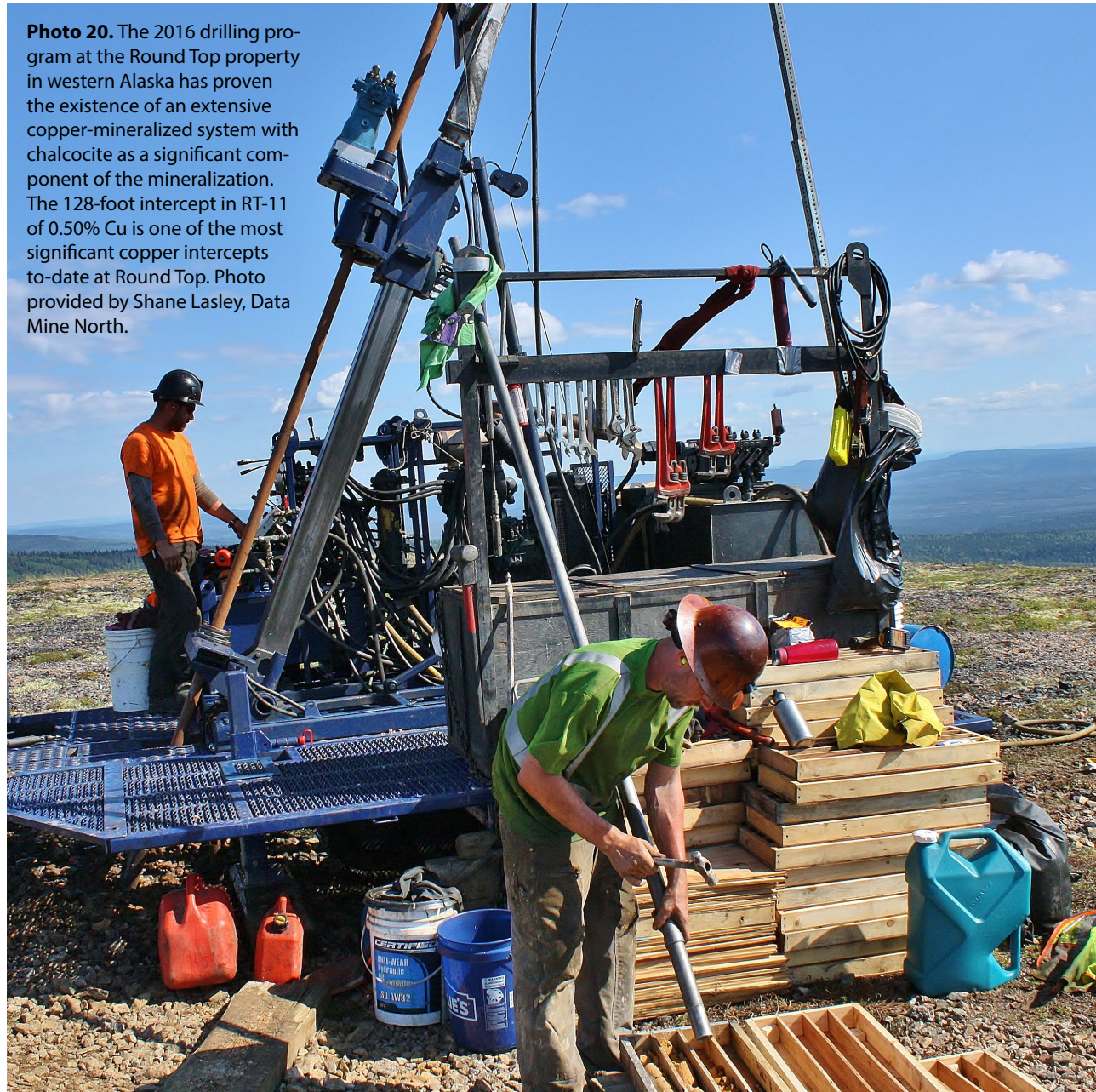
Year	Placer Exploration	Placer Thawing	Total Placer	Total Coal	Hardrock Core ^a	Hardrock Rotary ^a	Total Hardrock	Total Feet Drilled
1982	30,000	94,000	124,000	80,000	--	--	200,000	404,000
1983	23,000	30,000	53,000	12,000	--	--	180,500	245,500
1984	31,000	98,000	129,000	25,700	--	--	176,000	330,700
1985	46,000	34,000	80,000	8,700	--	--	131,700	220,400
1986	32,400	227,000	259,400	28,800	--	--	50,200	338,400
1987	50,250	130,000	180,250	19,900	95,600	19,500	115,100	315,250
1988	152,000	300,000	452,000	26,150	223,630	130,230	353,860	832,010
1989	97,250	210,000	307,250	38,670	242,440	89,790	332,230	678,150
1990	78,930	105,000	183,930	18,195	648,600	112,355	760,955	963,080
1991	51,247	130,000	181,247	16,894	205,805	110,850	316,655	514,796
1992	6,740	65,000	71,740	12,875	211,812	148,022	359,834	444,449
1993	25,216	--	25,216	--	124,325	127,990	252,315	277,531
1994	21,000	--	21,000	8,168	347,018	91,692	438,710	467,878
1995	27,570	--	27,570	--	363,690	51,795	415,485	443,055
1996	61,780	--	61,780	8,500	524,330	134,527	658,857	729,137
1997	38,980	--	38,980	13,998	523,676	180,834	704,510	757,488
1998	33,250	--	33,250	2,300	505,408	45,670	551,078	586,628
1999	6,727	--	6,727	--	369,863	78,934	448,797	455,524
2000	15,480	--	15,480	--	418,630	127,638	546,268	561,748
2001	1,100	--	1,100	36,151	240,318	75,750	316,068	353,319
2002	1,250	--	1,250	--	385,290	103,612	488,902	490,152
2003	10,108	--	10,108	2,000	270,456	100,178	370,634	382,742
2004	107,526	--	107,526	--	415,628	36,024	451,652	559,178
2005	3,360	--	3,360	--	592,497	41,780	634,277	637,637
2006	8,759	--	8,759	7,500	765,363	54,173	819,536	835,795
2007	19,575	--	19,575	50,539	830,478	268,112	1,098,590	1,168,704
2008	1,216	--	1,216	26,869	874,634	250,278	1,124,912	1,152,997
2009	1,244	--	1,244	W	403,275	260,059	663,334	664,578
2010	10,427	--	10,427	11,601	688,911	216,768	905,679	927,707
2011	3,150	--	3,150	W	883,272	175,181	1,058,453	1,061,603
2012	13,282	--	13,282	7,704	1,082,439	14,182	1,096,621	1,117,607
2013	17,986	--	17,986	W	933,194	17,800	950,994	968,980
2014	7,227	--	7,227	W	487,106	9,736	496,842	504,069
2015	--	--	--	W	923,324	12,795	937,769	937,769
2016	--	--	--	--	644,512	W	644,512	644,512

^aCore and rotary drilling not differentiated prior to 1987.

-- = Not reported

W = withheld for confidentiality; included in hardrock rotary or core.

Photo 20. The 2016 drilling program at the Round Top property in western Alaska has proven the existence of an extensive copper-mineralized system with chalcocite as a significant component of the mineralization. The 128-foot intercept in RT-11 of 0.50% Cu is one of the most significant copper intercepts to-date at Round Top. Photo provided by Shane Lasley, Data Mine North.



ACKNOWLEDGMENTS

The authors thank the companies, agencies, and individuals that responded to emails or phone calls and provided information about their activities and operations. Without their voluntary and timely information, this report would not be possible. The authors particularly thank Karen Matthias (Council of Alaska Producers) for her thoughtful comments on the content and format of the report. In addition to operational information, members of the public provided photographs and images used in this report. These contributions are greatly appreciated. The authors specifically acknowledge Robert T. Boyd (Endurance Gold Corporation), Liz Cornejo (Constantine Metal Resources Ltd.), Curt Freeman (Avalon Development Corporation), Shane Lasley (Data Mine North), and Erin Workman (Trilogy Metals Inc.) for providing photos. Where appropriate, contributors have been acknowledged in the text.

The production of this publication depends upon the collaboration of many agencies and organizations. Listed here are staff from the major agencies and organizations who provided mining-related information. Alyssa Rodrigues (Department of Labor and Workforce Development) provided updated mining employment and wage information. Paul Strickler and Curtis Warren (Alaska Department of Revenue), Yulia Ellsworth (Alaska Industrial

Development and Export Authority), Kyle Moselle [Department of Natural Resources (DNR)/Office of Project Management and Permitting], Cristin Cowles-Brunton (DNR/Support Services Division), and Annette Ziegman (Denali Borough) provided government revenue data. Chollada Jarupakorn [DNR/Division of Mining, Land & Water (DMLW)], Jeff Jasper (DNR/Information Resources Management), and Melody Smyth (Bureau of Land Management) provided claim information. Zoya Ponomareva (DMLW) provided information on the industrial minerals sector, as well as Robert Ellefson, Edward Klimasauskas, and Joseph Galluzzi (U.S. Bureau of Land Management) and Steve Hohensee (U.S. Forest Service). Deborah Morgan (Alaska Governor's Office/Office of International Trade) provided commodity export information. Jamey Jones (U.S. Geological Survey), Mitch Henning (DMLW), and Kurt Johnson and Gina Graham (DGGS) provided information on government activities in Alaska in 2016. Jennifer Athey and Melanie Werdon (DGGS) compiled the data and prepared the body of the text, tables, and appendices; Evan Twelker (DGGS) reviewed the text and tables and updated the graphic illustrations. The booklet's design, layout, and cover are by Kristen Hendricks (DGGS); Ken Papp and Steve Masterman (DGGS) edited the final version.

APPENDICES

APPENDIX A Resources Related to the Minerals Industry in Alaska



Department of Natural Resources

- Recording Fees | http://dnr.alaska.gov/ssd/recoff/fees_RO.cfm
- Public Information Center | <http://dnr.alaska.gov/commis/pic>
- State Uniform Commercial Code (UCC) Documents Search | <http://dnr.alaska.gov/ssd/recoff/>

Division of Mining, Landing & Water

- Mining Applications and Forms | <http://dnr.alaska.gov/mlw/forms/>
- Fact Sheets | <http://dnr.alaska.gov/mlw/factsht/>
- Annual Placer Mining Application (APMA) 2015 | <http://dnr.alaska.gov/mlw/forms/14apma/>
- Annual Rental | http://dnr.alaska.gov/mlw/factsht/mine_fs/annualre.pdf
- Leasing State Land | http://dnr.alaska.gov/mlw/factsht/land_fs/lease_land.pdf
- Land Leasing & Contract Payment Information | http://dnr.alaska.gov/mlw/factsht/land_fs/lease_contract_payment_info.pdf
- Production Royalty | http://dnr.alaska.gov/mlw/factsht/mine_fs/producti.pdf
- DNR Production Royalty Form | http://dnr.alaska.gov/mlw/forms/mining/royalty_fm.pdf
- Exploration Incentive Credit Program | http://dnr.alaska.gov/mlw/factsht/mine_fs/explore.pdf



Division of Geological & Geophysical Surveys

- Publications On-Line | <http://dggs.alaska.gov/publications/>
- Interactive Maps | <http://maps.dggs.alaska.gov/>
- Geologic Maps of Alaska: Online Map Search Tool | <http://maps.dggs.alaska.gov/mapindex/>
- Unpublished Geology-Related Data (Alaska Geologic Data Index) | <http://maps.dggs.alaska.gov/agdi/>
- Geologic Materials Center | <http://dggs.alaska.gov/gmc/>
- Geochemical Sample Analysis Search (WebGeochem) | <http://www.dggs.alaska.gov/webgeochem/>
- Minerals Report Questionnaire | http://www.dggs.alaska.gov/minerals_questionnaire

Alaska's Minerals Data & Information Rescue in Alaska (MDIRA) Project Websites

- MDIRA Portal Home Page | <http://akgeology.info/>
- Alaska Mining Claims Mapper | <http://akmining.info/>
- Land Records Web Application | <http://dnr.alaska.gov/Landrecords/>
- State Recorder's Office Search | <http://dnr.alaska.gov/ssd/recoff/searchRO.cfm>
- Alaska Resource Data Files | <http://ardf.wr.usgs.gov/>
- USGS Alaska Geochemical Database (NURE, RASS, PLUTO...) | <http://pubs.usgs.gov/ds/637/>
- Guide to Alaska Geologic and Mineral Information | <http://doi.org/10.14509/3318>
- Alaska State Geo-Spatial Data Clearinghouse | <http://www.asgdc.state.ak.us/>



Department of Commerce, Community, and Economic Development

- Minerals Information | <https://www.commerce.alaska.gov/web/ded/dev/mineralsdevelopment>
- Community and Regional Information | <https://www.commerce.alaska.gov/web/dcra/ResearchAnalysis>
- Alaska Industrial Development and Export Authority (AIDEA) | <http://www.aidea.org>
- AIDEA Supports Mining | www.aidea.org/Programs/ProjectDevelopment/30YearsofMiningSupport

Department of Revenue

- Mining License Tax | <http://www.tax.alaska.gov/programs/programs/index.aspx?60610>
- Motor Fuel Tax Claim for Refund | <http://www.tax.alaska.gov/programs/programs/forms/index.aspx?60210>
- Alaska Motor Fuel Tax Instructions | <http://www.tax.alaska.gov/programs/documentviewer/viewer.aspx?5086f>



APPENDIX B

Primary Metals Production in Alaska, 1880–2016^a

Year	Gold ^b		Silver		Mercury		Antimony		Tin	
	(oz)	(m\$)	(oz)	(t\$)	(flask ^c)	(t\$)	(lb)	(t\$)	(lb)	(t\$)
1880–99	1,153,889	\$23.9	496,101	\$329.0	--	--	--	--	--	--
1900–09	6,673,173	137.9	1,324,580	779.5	--	--	--	--	304,000	\$112.2
1910–19	7,209,094	149.0	7,058,235	5,107.5	--	--	2,760,000	W	1,640,000	805.9
1920–29	3,373,336	69.8	6,407,375	5,160.8	117	\$7.6	W	W	317,800	163.9
1930–39	5,345,205	150.8	3,250,173	1,889.8	31	2.3	1,616,000	\$228.3	1,024,400	502.1
1940–49	3,137,447	109.8	794,842	577.0	3,094	724.3	2,062,080	311.1	319,200	230.3
1950–59	2,297,827	80.6	321,669	292.9	18,185	4,370.0	2,663,520	3,697.6	1,144,000	1,310.5
1960–69	751,870	26.6	59,300	70.7	13,996	3,098.0	228,800	267.8	--	--
1970–79	324,906	55.8	54,700	250.5	4,040	1,694.0	1,473,000	1,714.0	166,000	949.0
1980	75,000	32.0	7,500	111.0	--	--	--	--	120,000	984.0
1981	134,200	55.2	13,420	111.3	W	W	--	--	106,000	700.0
1982	175,000	69.9	22,000	198.0	--	--	--	--	198,000	1,365.0
1983	169,000	67.6	33,200	332.0	--	--	22,400	45.0	215,000	1,100.0
1984	175,000	62.1	20,000	159.0	5	1.5	135,000	225.8	225,000	400.0
1985	190,000	61.2	28,500	171.0	27	10.0	65,000	98.0	300,000	650.0
1986	160,000	60.8	24,000	134.4	12	2.8	45,000	67.5	340,000	890.0
1987	229,707	104.5	54,300	391.0	--	--	--	--	288,000	460.0
1988	265,500	112.8	47,790	282.0	W	W	--	--	300,000	950.0
1989	284,617	108.7	5,211,591	27,300.0	--	--	--	--	194,000	672.0
1990	231,700	89.2	10,135,000	50,675.0	--	--	--	--	57,000	200.0
1991	243,900	88.3	9,076,854	39,110.0	--	--	--	--	6,800	22.1
1992	262,530	88.5	9,115,755	34,913.0	--	--	--	--	1,500	5.9
1993	191,265	68.6	5,658,958	24,333.0	--	--	--	--	21,000	50.6
1994	182,100	70.3	1,968,000	10,391.0	--	--	--	--	--	--
1995	141,882	56.0	1,225,730	6,655.0	--	--	--	--	--	--
1996	161,565	62.6	3,676,000	19,078.0	--	--	--	--	--	--
1997	590,516	207.3	14,401,165	70,710.0	--	--	--	--	--	--
1998	594,191	174.6	14,856,000	82,154.0	--	--	--	--	--	--
1999	517,890	144.3	16,467,000	85,628.0	--	--	--	--	--	--
2000	551,982	154.1	18,226,615	90,404.0	--	--	--	--	--	--
2001	550,644	149.3	16,798,000	73,408.0	--	--	--	--	--	--
2002	562,094	174.3	17,858,183	82,326.0	--	--	--	--	--	--
2003	528,191	191.9	18,589,100	95,300.0	--	--	--	--	--	--
2004	456,508	192.3	16,947,270	113,056.9	--	--	--	--	--	--
2005	427,031	189.9	11,670,000	85,382.0	--	--	--	--	--	--
2006	570,129	344.1	16,489,394	190,415.9	--	--	--	--	--	--
2007	726,933	511.1	20,203,985	270,402.1	--	--	--	--	--	--
2008	800,752	698.2	14,643,735	219,496.4	--	--	--	--	--	--
2009	780,657	759.1	15,617,436	229,159.3	--	--	--	--	--	--
2010	914,462	1,119.8	13,991,297	282,523.5	--	--	--	--	--	--
2011	848,945	1,334.1	11,683,967	410,340.9	--	--	--	--	--	--
2012	921,240	1,537.5	12,313,877	383,573.6	--	--	--	--	--	--
2013	1,022,987	1,551.9	13,453,367	320,121.0	--	--	--	--	--	--
2014	948,547	1,201.2	15,388,901	304,392.5	--	--	--	--	--	--
2015	873,984	1,013.9	15,147,249	237,508.9	--	--	--	--	--	--
2016	909,242	1,119.3	16,621,035	246,109.8	--	--	--	--	--	--
Other ^e	--	--	--	--	1,438	--	--	--	--	--
TOTAL	47,636,639	\$14,830.7	377,453,149	\$4,101,215.3	40,945	\$9,910.5	11,070,800	\$6,655.1	7,287,700	\$12,523.5

t\$ = thousands of dollars

m\$ = millions of dollars

-- = Not reported

W = withheld

^aFrom published and unpublished state and federal documents. Where state and federal figures differ significantly, state figures are used. Please refer to previous editions of this appendix for year-to-year production information for years 1900 to 1979.

^bGold production adjusted to be consistent with mining district production totals. Value for 2015 does not include placer gold production.

^c76-lb flask.

^dCrude platinum; total production of refined metal is about 575,000 oz (page 58).

^eNot traceable by year.

APPENDIX B

Primary Metals Production in Alaska, 1880–2016^a

Year	Lead		Zinc		Platinum ^d		Copper		Chromium	
	(tons)	(t\$)	(tons)	(t\$)	(oz)	(t\$)	(lb)	(m\$)	(tons)	(t\$)
1880–99	250	\$17.0	--	--	--	--	--	--	--	--
1900–09	369	32.8	--	--	--	--	29,549,486	\$4.8	--	--
1910–19	3,565	470.2	--	--	914	\$116.5	515,253,817	109.9	2,200	W
1920–29	7,961	1,084.1	--	--	5,750	484.9	643,576,929	93.3	--	--
1930–39	10,791	914.3	--	--	102,615	5,427.1	184,522,000	19.5	--	--
1940–49	3,096	405.2	678	\$0.5	225,285	12,623.3	433,700	0.2	7,409	\$250.9
1950–59	177	38.6	--	--	107,927	9,403.9	106,000	0.1	21,442	1,975.8
1960–69	40	9.9	--	--	111,556	13,618.5	352,000	0.1	--	--
1970–79	20	8.0	--	--	41,604	6,826.0	--	--	8,000	1,200.0
1980	31	29.0	--	--	--	--	--	--	--	--
1981	--	--	--	--	900	200.0	--	--	--	--
1982	--	--	--	--	W	W	--	--	--	--
1983	--	--	--	--	W	W	--	--	--	--
1984	--	--	--	--	W	W	--	--	--	--
1985	--	--	--	--	--	--	--	--	--	--
1986	--	--	--	--	W	W	--	--	--	--
1987	--	--	--	--	W	W	--	--	--	--
1988	--	--	--	--	25	13.8	--	--	--	--
1989	9,585	7,700.0	19,843	29,400.0	--	--	--	--	--	--
1990	44,220	30,954.0	181,200	253,680.0	--	--	--	--	--	--
1991	69,591	33,403.7	278,221	278,221.0	15	5.3	--	--	--	--
1992	68,664	31,585.0	274,507	301,957.7	--	--	--	--	--	--
1993	38,221	13,759.6	268,769	236,516.7	3	1.2	--	--	--	--
1994	36,447	25,512.9	329,003	296,102.7	5	2.1	--	--	--	--
1995	58,098	34,428.6	359,950	345,552.0	1	0.4	--	--	--	--
1996	70,086	52,284.0	366,780	361,646.0	2	0.8	780,000	0.8	--	--
1997	88,560	49,593.0	419,097	494,888.0	--	--	3,440,000	3.5	--	--
1998	102,887	49,386.0	549,348	505,400.0	--	--	3,800,000	2.9	--	--
1999	125,208	57,596.0	643,642	630,769.0	--	--	4,200,000	3.0	--	--
2000	123,224	51,754.0	669,112	682,494.0	--	--	2,800,000	2.3	--	--
2001	127,385	56,049.0	634,883	507,907.0	--	--	2,800,000	2.0	--	--
2002	146,462	61,514.0	718,103	502,674.0	--	--	3,200,000	2.3	--	--
2003	162,479	64,279.0	714,769	536,348.0	--	--	--	--	--	--
2004	150,796	120,636.8	680,015	651,432.2	--	--	--	--	--	--
2005	131,366	115,230.0	684,462	862,108.0	--	--	--	--	--	--
2006	157,128	183,629.3	673,967	2,002,971.4	--	--	--	--	--	--
2007	167,181	389,532.2	696,115	2,048,451.6	--	--	87,627	0.3	--	--
2008	153,705	287,428.4	626,135	1,055,220.1	--	--	--	--	--	--
2009	167,204	260,838.2	712,496	1,068,744.0	--	--	--	--	--	--
2010	146,480	284,171.2	667,539	1,212,390.3	--	--	--	--	--	--
2011	113,649	247,755.2	696,793	1,379,649.2	5,000	8,609.3	1,058	0.0	--	--
2012	126,234	234,795.2	647,481	1,139,566.6	--	--	14,327	0.0	--	--
2013	126,707	245,811.6	665,318	1,157,653.3	--	--	77,240	0.3	--	--
2014	155,183	294,847.2	716,781	1,404,890.4	--	--	--	--	--	--
2015	151,247	245,126.5	686,938	1,204,315.0	--	--	--	--	--	--
2016	155,409	241,931.4	700,376	1,250,186.4	--	--	--	--	--	--
Other ^e	--	--	--	--	71,946	17,091.9	--	--	--	--
TOTAL	3,199,706	\$3,774,541.0	15,282,321	\$22,401,135.1	673,548	\$57,333.1	1,394,994,184	\$245.3	39,051	\$3,426.7

t\$ = thousands of dollars

m\$ = millions of dollars

-- = Not reported

W = withheld

^aFrom published and unpublished state and federal documents. Where state and federal figures differ significantly, state figures are used. Please refer to previous editions of this appendix for year-to-year production information for years 1900 to 1979.

^bGold production adjusted to be consistent with mining district production totals. Value for 2015 does not include placer gold production (page 57).

^c76-lb flask (page 57).

^dCrude platinum; total production of refined metal is about 575,000 oz.

^eNot traceable by year.

APPENDIX C

Production of Industrial Minerals, Coal, and Other Commodities in Alaska, 1880–2016^{a,b}

Year	Coal		Sand and Gravel ^c		Rock ^d		Barite		Other ^e
	short tons	m\$	short tons	m\$	short tons	m\$	short tons	t\$	
1880–1899	19,429	\$0.1	--	--	7,510	\$0.0	--	--	--
1900–1909	33,214	0.2	--	--	15,318	0.2	--	--	\$246,403
1910–1919	210,806	1.2	--	--	50,014	0.3	--	--	2,014,788
1920–1929	937,860	5.2	--	--	494,417	2.7	--	--	2,523,754
1930–1939	1,222,797	5.5	42,332	\$0.0	689,676	2.8	--	--	899,767
1940–1949	3,189,026	20.2	1,758,504	0.7	286,341	1.3	--	--	27,124,158
1950–1959	6,632,641	59.7	65,804,686	55.1	1,843,560	5.2	--	--	25,443,427
1960–1969	7,849,000	58.8	163,315,000	176.7	2,034,000	4.2	225,000	\$1,200.0	34,143,000
1970–1979	7,405,000	89.0	489,522,000	1,004.9	47,930,000	137.4	502,000	8,217.0	77,501,000
1980	800,000	16.0	40,000,000	86.0	3,700,000	15.4	50,000	2,000.0	97,500
1981	800,000	17.6	46,000,000	88.2	4,200,000	19.3	--	--	256,000
1982	830,000	18.0	45,000,000	91.0	3,400,000	15.6	--	--	150,000
1983	830,000	18.0	50,000,000	105.0	5,270,000	25.0	--	--	242,000
1984	849,161	23.8	27,000,000	95.0	2,700,000	16.0	--	--	875,875
1985	1,370,000	39.7	28,184,080	112.1	2,500,000	12.0	--	--	559,000
1986	1,492,707	40.1	20,873,110	75.8	4,200,000	20.3	--	--	384,800
1987	1,508,927	42.4	16,696,374	42.7	1,805,000	11.6	--	--	388,400
1988	1,551,162	44.3	17,264,500	48.8	3,600,000	24.7	--	--	389,000
1989	1,452,353	41.5	14,418,000	39.9	2,914,000	20.3	--	--	1,492,000
1990	1,576,000	45.0	15,013,500	40.8	3,200,000	22.1	--	--	400,000
1991	1,540,000	39.0	14,160,011	45.5	3,000,000	22.5	--	--	462,000
1992	1,531,800	38.3	14,599,746	42.2	2,900,000	23.0	--	--	430,000
1993	1,586,545	38.1	13,162,402	40.6	3,561,324	26.2	--	--	465,000
1994	1,490,000	36.8	13,518,321	41.0	3,843,953	27.0	--	--	459,500
1995	1,640,000	41.3	9,847,550	30.9	2,811,152	22.1	--	--	182,500
1996	1,481,000	38.0	9,890,463	32.2	3,000,045	23.6	--	--	200,000
1997	1,446,000	38.1	13,800,000	51.9	3,200,000	20.0	--	--	217,000
1998	1,339,000	35.2	12,363,450	57.3	1,636,200	14.0	--	--	215,000
1999	1,560,000	41.1	10,600,000	52.4	1,640,000	18.0	--	--	190,000
2000	1,473,355	38.8	10,600,000	49.9	5,200,000	36.6	--	--	203,000
2001	1,537,000	48.1	10,360,000	55.2	3,091,000	27.2	--	--	205,000
2002	1,158,000	37.4	22,412,000	120.7	3,152,000	31.4	--	--	200,000
2003	1,088,000	38.1	11,868,001	64.1	861,382	10.4	--	--	175,000
2004	1,450,000	50.8	19,576,092	101.5	7,312,050	106.2	--	--	2,732,554
2005	1,402,174	49.1	16,620,009	76.5	2,803,172	22.6	--	--	809,642
2006	1,397,500	48.9	13,953,465	63.4	2,369,738	23.8	--	--	1,057,500
2007	1,273,004	44.6	14,163,676	76.1	2,211,954	25.5	--	--	1,085,500
2008	1,538,000	53.8	12,461,685	72.4	2,485,820	39.5	--	--	1,159,502
2009	1,861,714	65.2	7,072,037	41.4	1,837,090	27.2	--	--	3,678,930
2010	2,061,000	72.1	6,977,297	48.0	290,852	4.3	--	--	2,303,950
2011	2,220,000	77.7	5,862,851	38.7	499,722	6.4	--	--	3,200,000
2012	2,018,759	70.7	7,799,994	52.3	1,050,762	15.8	--	--	--
2013	1,600,000	56.0	11,622,045	79.6	364,632	5.5	--	--	1,900,000
2014	1,500,000	52.5	526,509	6.8	1,147,869	17.2	--	--	120,000
2015	1,177,390	41.2	5,725,541	17.2	--	--	--	--	--
2016	930,987	32.6	6,123,896	17.3	--	--	--	--	--
Other	--	--	--	--	2,300,000 ^f	W	79,000	W	--
TOTAL	79,861,311	\$1,809.4	1,336,559,126	\$3,437.7	153,410,553	\$952.5	856,000	\$11,417.0	\$196,782,450

^a From published and unpublished state and federal documents. Where state and federal figures differ significantly, state figures are used.

^b Please refer to previous editions of this appendix for year-to-year production information for years 1900 to 1979.

^c As of 2015, rock, sand, and gravel are reported as a combined commodity.

^d Building-stone production figures for 1880–1937 are for the southcentral and interior regions of Alaska only.

^e Includes 2.4 million lb U₃O₈ (1955–1971); 505,000 tons gypsum (1905–1926); 286,000 lb WO₃ (intermittently, 1916–1980); 94,000 lb asbestos (1942–44); 540,000 lb graphite (1917–1918 and 1942–1950); and undistributed amounts of zinc, jade, peat, clay, soapstone, miscellaneous gemstones, and other commodities (1880–present).

^f Marble quarried on Prince of Wales Island, southeastern Alaska (1900–1941).

m\$ = millions of dollars

t\$ = thousands of dollars

-- = not reported

W = withheld

APPENDIX D

Identified Mineral Resources of Alaska Deposits

DEPOSIT — Type — Metal Suite	PHASE	CATEGORY	SHORT TONS OF RESOURCE	Cu %	Cu thousand pounds	Pb %	Pb thousand pounds	Zn %	Zn thousand pounds	Au oz/ton	Au thousand ounces	Ag oz/ton	Ag thousand ounces	Mo %	Mo thousand pounds
KENSINGTON — Gold veins — Precious metals (gold)	Production	Proven	1,133,000							0.194	219.8				
	Production	Probable	1,483,000							0.187	277.3				
	Production	Measured	1,297,000							0.261	338.5				
	Production	Indicated	1,828,000							0.292	533.8				
	Advanced Exploration	Inferred	1,579,000							0.276	435.8				
	Total		7,320,000							0.247	1,805.2				
LMS — Gold veins — Precious metals (gold)	Exploration (0.5 g/t Au cut-off, open pit)	Inferred	9,170,000							0.032	267.0				
	Total		13,594,000							0.366	4,973.0				
<i>Note: Values have not been updated for 2015.</i>															
TERRA — Gold veins — Precious metals (gold, silver)	Exploration (5 g/tonne Au cut-off)	Indicated	128,913							0.387	49.8	0.88	112.7		
	Exploration (5 g/tonne Au cut-off)	Inferred	811,286							0.456	369.8	0.81	653.9		
	Total		940,199							0.446	419.6	0.82	766.6		
HERBERT GOLD — Gold veins — Precious metals (gold)	Exploration (unknown Au cut-off)	Indicated	905,100							0.202	182.4				
	Exploration (unknown Au cut-off)	Inferred	56,900							0.225	12.8				
	Total		962,000							0.203	195.2				
GOLDEN ZONE — Gold veins — Precious metals (gold, silver)	Exploration (0.5 g/tonne Au cut-off)	Indicated	4,615,377							0.064	267.4	0.332	1,397.8		
	Exploration (0.5 g/tonne Au cut-off)	Inferred	1,491,427							0.027	35.9	0.082	111.4		
	Total		6,106,804							0.055	303.3	0.271	1,509.2		
WILLOW (Lucky Shot) — Gold veins — Precious metals (gold)	Development (7 g/tonne cut-off)	Proven	75,729							0.605	41.7	0.065	4.5		
	Development (7 g/tonne cut-off)	Probable	116,514							0.432	45.8	0.045	4.8		
	Exploration (5 g/tonne Au cut-off)	Measured	63,824							0.858	49.9	0.080	4.7		
	Exploration (5 g/tonne Au cut-off)	Indicated	163,803							0.480	71.6	0.051	7.4		
	Exploration (5 g/tonne Au cut-off)	Inferred	65,036							0.592	35.1	0.048	2.9		
	Total		484,906							0.553	244.1	0.055	24.2		
SHOTGUN — Gold veins — Precious metals (gold)	Exploration (0.015 ounce of Au/ton cut-off)	Inferred	22,860,000							0.031	706.0				
	Total		22,860,000							0.031	706.0				
DONLIN — Intrusion gold — Precious metals (gold)	Development	Proven	8,468,971							0.068	573.0				
	Development	Probable	547,984,194							0.061	33,276.0				
	Development	Measured	52,910							0.074	53.0				
	Development	Indicated	40,210,802							0.065	5,104.0				
	Development	Inferred	101,649,697							0.059	5,993.0				
	Total		698,366,574							0.061	45,000.0				
FORT KNOX — Intrusion gold — Precious metals (gold)	Production	Proven	29,741,426							0.014	406				
	Production	Probable	85,658,305							0.013	1,100				
	Production	Measured	8,070,012							0.014	114				
	Production	Indicated	96,675,894							0.014	1,326				
	Production	Inferred	14,369,713							0.013	193				
	Total		234,515,350							0	3,139				
GOLDEN SUMMIT — Intrusion gold — Precious metals (gold)	Exploration (Dolphin oxide deposit; 0.30 g/tonne cut-off)	Indicated	17,834,397							0.021	345.0				
	Exploration (Dolphin oxide deposit; 0.30 g/tonne cut-off)	Inferred	10,604,235							0.019	183.0				
	Exploration (Dolphin sulfide deposit; 0.30 g/tonne cut-off)	Indicated	49,912,656							0.022	1,018.0				
	Exploration (Dolphin sulfide deposit; 0.30 g/tonne cut-off)	Inferred	68,211,024							0.022	1,401.0				
	Total		146,562,312							0.022	2,947.0				
MONEY KNOB (Livengood) — Intrusion gold — Precious metals (gold)	Advanced Exploration (part of meas./Indic./Infer. resource)	Proven	416,287,867							0.023	8,620.0				
	Advanced Exploration (part of meas./Indic./Infer. resource)	Probable	15,443,381							0.023	353.0				
	Advanced Exploration	Measured	548,223,507							0.022	10,840.8				
	Advanced Exploration	Indicated	30,908,809							0.022	620.3				
	Advanced Exploration	Inferred	58,202,037							0.021	1,127.2				
	Total		637,334,353							0.022	12,588.4				

Data in this table were collected from publicly available company reports and company press releases.

APPENDIX D Identified Mineral Resources of Alaska Deposits, continued

DEPOSIT—Type—Metal Suite	PHASE	CATEGORY	SHORT TONS OF RESOURCE	Cu %	Cu thousand pounds	Pb %	Pb thousand pounds	Zn %	Zn thousand pounds	Au oz/ton	Au thousand ounces	Ag oz/ton	Ag thousand ounces	Mo %	Mo thousand pounds
NIXON FORK — Intrusion gold (skarn) — Precious metals (gold)	Indicated		270,430							0.481	130.0				
	Inferred		118,000							0.512	60.5				
	Total		388,430							0.491	190.5				
VINASALE — Intrusion gold — Precious metals (gold)	Indicated		3,760,000							0.043	162.0				
	Inferred		55,340,000							0.031	1,703.0				
	Total		59,100,000							0.032	1,865.0				
ANARRAAQ-AKTIGIRUQ — Massive sulfide — Base metals (lead, zinc, silver)	Indicated		19,000,000			4.8	1,824,000	15.8	6,004,000			2.10	39,300		
	Inferred														
	Total														
ARCTIC — Massive sulfide — Polymetallic (copper, lead, zinc, gold, silver)	Indicated		26,287,650	3.26	1,713,000	0.76	400,900	4.45	2,338,000	0.021	550.0	1.55	40,800		
	Inferred		3,707,035	3.22	239,000	0.58	43,200	3.84	285,000	0.017	60.0	1.21	4,500		
	Total		29,994,685	3.25	1,952,000	0.74	444,100	4.37	2,623,000	0.020	610.0	1.51	45,300		
BORNITE — Massive sulfide — Polymetallic (copper)	Indicated		44,643,555	1.02	913,000										
	Inferred		92,704,271	0.95	1,768,000										
	Total		137,347,826	0.98	2,681,000										
DELTA — Massive sulfide — Polymetallic (copper, lead, zinc, gold, silver)	Indicated		9,400,000	0.4	75,200	1.75	329,000	4.61	866,680	0.047	441.9	1.85	17,402		
	Inferred		5,900,000	0.4	47,200	2.1	247,800	4.6	542,800	0.050	292.9	2.07	12,232		
	Total		15,300,000	0.4	122,400	1.9	576,800	4.6	1,409,480	0.097	734.8	3.92	29,634		
GREENS CREEK — Massive sulfide — Polymetallic (lead, zinc, gold, silver)	Indicated		18,570,000			2.70	1,003,000	8.04	2,986,000			1.463	27,170		
	Inferred		490,000			2.77	27,000	10.03	98,000			1.723	840		
	Total		19,060,000			2.73	1,030,000	8.04	3,084,000			1.489	27,910		
LIK — Massive sulfide — Base metals (lead, zinc, silver)	Indicated		18,570,000			2.70	1,003,000	8.04	2,986,000			1.463	27,170		
	Inferred		490,000			2.77	27,000	10.03	98,000			1.723	840		
	Total		19,060,000			2.73	1,030,000	8.04	3,084,000			1.489	27,910		
NIBLACK — Massive sulfide — Polymetallic (copper, zinc, gold, silver)	Indicated		6,215,039	0.95	118,085					0.051	318.0	0.86	5,357		
	Inferred		2,612,000	0.73	38,135					0.041	108.0	0.63	1,650		
	Total		8,827,039	0.84	156,220					0.032	37.0	0.48	545		
PALMER — Massive sulfide — Polymetallic (copper, zinc, gold, silver)	Indicated		8,956,269	1.41	252,567							0.925	8,281		
	Inferred														
	Total		8,956,269	1.41	252,567										
RED DOG — Massive sulfide — Base metals (lead, zinc, silver)	Indicated		62,400,000			4.1	5,117,000	14.6	18,221,000			2.15	134,470		
	Inferred		220,000			3.8	17,000	11.5	51,000			2.23	490		
	Total		62,620,000			4.1	5,134,000	14.6	18,272,000			2.15	134,960		
SUN — Massive sulfide — Polymetallic (copper, lead, zinc, gold, silver)	Indicated		1,994,000	1.53	60,843	1.07	50,585	4.30	171,337	0.006	14.0	1.66	3,315		
	Inferred		10,842,000	1.19	258,541	1.46	315,503	4.24	918,295	0.007	77.0	2.27	24,549		
	Total		12,836,000	1.36	319,384	1.53	366,088	4.54	1,089,632	0.006	91.0	2.93	28,864		
TANANARIVU — Massive sulfide — Polymetallic (copper, lead, zinc, gold, silver)	Indicated		1,997,000	1.14	292,671	0.9	35,745	2.17	86,652	0.006	13.0	2.12	4,227		
	Inferred														
	Total		1,997,000	1.14	292,671	0.9	35,745	2.17	86,652	0.006	13.0	2.12	4,227		

Data in this table were collected from publicly available company reports and company press releases.

APPENDIX D

Identified Mineral Resources of Alaska Deposits, continued

DEPOSIT—Type—Metal Suite	PHASE	CATEGORY	SHORT TONS OF RESOURCE	Cu %	Cu thousand pounds	Pb %	Pb thousand pounds	Zn %	Zn thousand pounds	Au oz/ton	Au thousand ounces	Ag oz/ton	Ag thousand ounces	Mo %	Mo thousand pounds
PEBBLE — Porphyry — Polymetallic (copper, gold, silver, molybdenum)	Measured		580,912,100	0.33	3,830,000					0.010	5,930.0	0.0485	28,300	0.0178	210,000
	Advanced Exploration (0.3 CuEq cut-off)		6,516,797,600	0.41	53,420,000					0.010	64,620.0	0.0485	315,500	0.0245	3,200,000
	Indicated		4,916,258,000	0.25	24,550,000					0.008	37,325.0	0.0347	170,490	0.0222	2,180,000
	Inferred		12,013,967,700	0.34	81,800,000					0.009	107,875.0	0.0429	514,290	0.0223	5,750,000
Total															
PYRAMID — Porphyry — Polymetallic (copper, gold, molybdenum)	Measured		103,616,200	0.4	104,000					0.003	276.0			0.02	40,000
	Advanced Exploration (0.21% CuEq cut-off)		87,081,700	0.3	87,000					0.002	212.0			0.02	34,000
	Indicated		190,697,900	0.4	191,000					0.003	488.0			0.02	74,000
	Inferred														
Total															
TETLIN — Skarn — Polymetallic (copper, gold, silver)	Measured		6,580,000	0.25	32,900					0.101	664.8	0.32	2,113		
	Advanced Exploration (0.5 g/tonne Au cut-off)		4,240,000	0.23	19,504					0.060	256.3	0.42	1,768		
	Indicated		10,820,000	0.24	52,404					0.085	921.1	0.36	3,881		
	Inferred														
Total															
RAINTREE WEST — Porphyry — Polymetallic (copper, gold, silver)	Measured		34,921,181	0.06	41,910					0.012	409.0	0.157	6,320		
	Advanced Exploration (above 250m)		57,055,566	0.1	114,130					0.020	1,130.0	0.109	6,224		
	Indicated		91,976,746	0.085	156,040					0.017	1,539.0	0.127	12,544		
	Inferred														
Total															
ISLAND MOUNTAIN — Porphyry — Polymetallic (copper, gold, silver)	Measured		34,259,795	0.06	41,120					0.014	485.0	0.032	1,099		
	Advanced Exploration		90,411,466	0.05	90,430					0.014	1,237.0	0.030	2,690		
	Indicated		124,671,261	0.053	131,550					0.014	1,722.0	0.030	3,789		
	Inferred														
Total															
WHISTLER — Porphyry — Polymetallic (copper, gold, silver)	Measured		87,300,000	0.17	302,000					0.015	1,280.0	0.057	5,030		
	Advanced Exploration		160,700,000	0.15	467,000					0.012	1,850.0	0.051	8,210		
	Indicated		248,000,000	0.16	769,000					0.013	3,130.0	0.053	13,240.0		
	Inferred														
Total															
QUARTZ HILL — Porphyry — (Molybdenum)	Measured		444,000,000											0.219	978,851,280
	Advanced Exploration		1,360,000,000											0.136	2,998,283,200
	Indicated		1,804,000,000											0.156	3,977,134,480
	Inferred														
Total															
BOKAN MOUNTAIN — Other (Intrusion hosted) — Other (rare-earth elements)	Measured		5,278,000												
	Advanced Exploration		1,157,000												
	Indicated		6,435,000												
	Inferred														
Total															
GRAPHITE CREEK — Other — Other (graphite)	Measured		19,790,000												
	Advanced Exploration		170,150,000												
	Indicated		189,940,000												
	Inferred														
Total															
BOKAN MOUNTAIN — Other (Intrusion hosted) — Other (rare-earth elements)	Measured		5,278,000												
	Advanced Exploration		1,157,000												
	Indicated		6,435,000												
	Inferred														
Total															
GRAPHITE CREEK — Other — Other (graphite)	Measured		19,790,000												
	Advanced Exploration		170,150,000												
	Indicated		189,940,000												
	Inferred														
Total															

Data in this table were collected from publicly available company reports and company press releases.

APPENDIX E

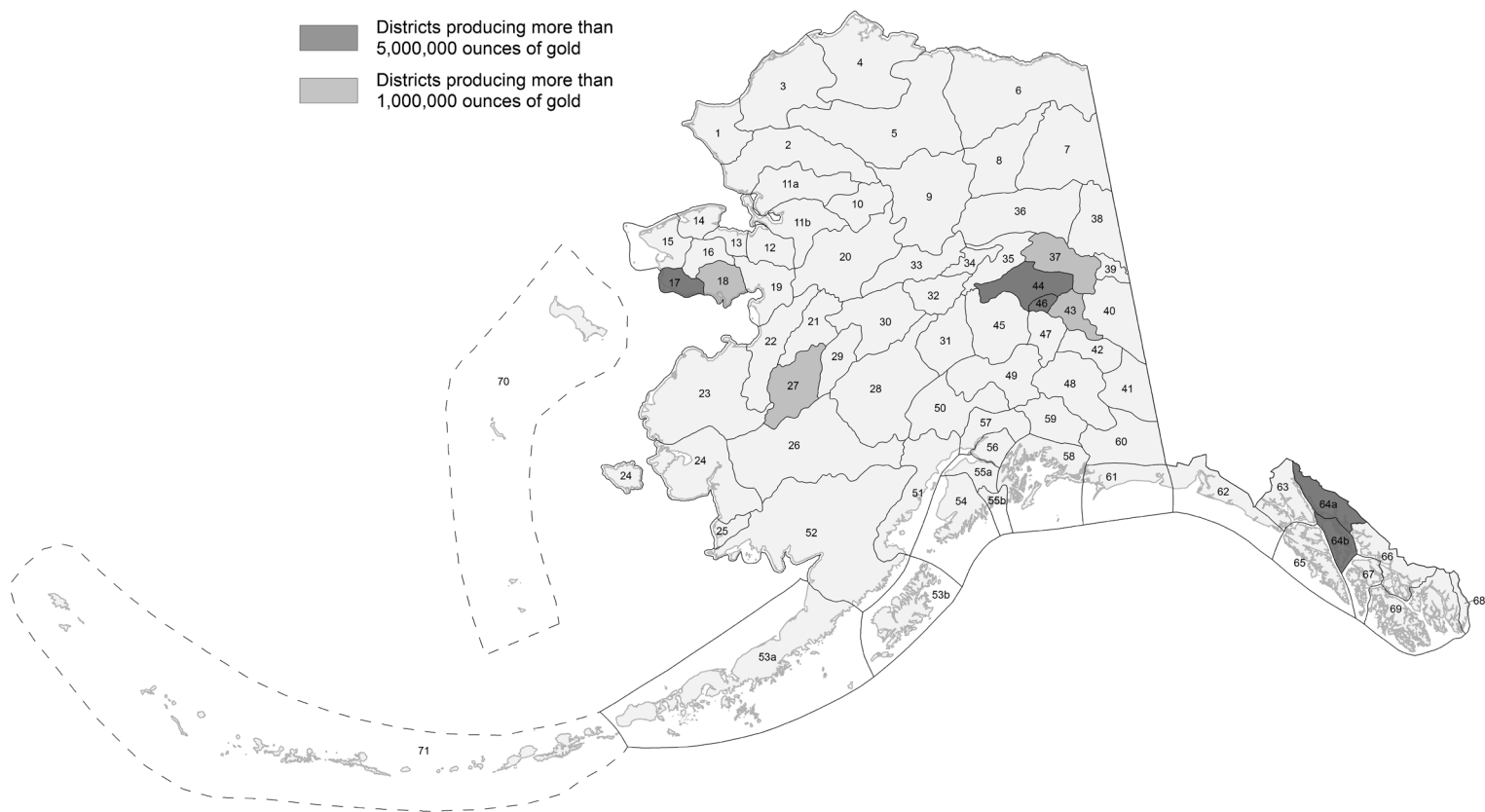
Conversion Chart, U.S. Customary Units/Metric Units

<i>To convert from:</i>	<i>to:</i>	<i>multiply by:</i>
WEIGHT/MASS/ORE CONTENT		
ounces (avoirdupois)	grams	28.3495
ounces (troy)	grams	31.1035
pounds	kilograms	0.4536
short tons	metric tons (tonnes)	0.9072
grams	ounces (avoirdupois)	0.03527
grams	ounces (troy)	0.03215
kilograms	pounds	2.20462
metric tons (tonnes)	short tons	1.10231
parts per million (ppm)	parts per billion (ppb)	1,000
parts per million (ppm)	ounces per ton	0.0292
parts per million (ppm)	grams/metric tons (tonnes)	1.00
LENGTH		
miles	kilometers	1.60934
miles	yards	1,760
miles	meters	1,609.34
yards	meters	0.9144
feet	meters	0.3048
feet	centimeters	30.48
feet	millimeters	304.8
inches	centimeters	2.54
inches	millimeters	25.4
kilometers	miles	0.621371
meters	yards	1.09361
meters	feet	3.28084
millimeters	feet	0.00328
millimeters	inches	0.03937
centimeters	inches	0.3937
TEMPERATURE		
<i>To convert from:</i>	<i>to:</i>	<i>do this:</i>
degrees Fahrenheit	degrees Celsius	subtract 32, multiply by 5, divide by 9
degrees Celsius	degrees Fahrenheit	multiply by 9, divide by 5, add 32
AREA		
square miles	square kilometers	2.59
square miles	acres	640
acres	square meters	4,046.86
acres	hectares	0.40486
square yards	square meters	0.836127
square feet	square meters	0.092903
square inches	square centimeters	6.4516
square inches	square millimeters	645.16
square meters	acres	0.000247105
square kilometers	acres	247.105
square kilometers	square miles	0.386102
square meters	square feet	10.7639
square meters	square yards	1.19599
hectares	acres	2.47105
hectares	square meters	10,000
square centimeters	square inches	0.155
square millimeters	square inches	0.00155
VOLUME		
cubic yards	cubic meters	0.764555
cubic feet	cubic meters	0.0283168
cubic inches	cubic centimeter	16.3871
cubic meters	cubic yards	1.30795
cubic meters	cubic feet	35.3147
cubic centimeters	cubic inches	0.0610237
gallons (U.S.)	liters	3.78541
liters	gallons (U.S.)	0.264172
milliliters	ounces (fluid)	0.033814
ounces (fluid)	milliliters	29.5735

Source: www.google.com/unitconverter

Mining districts ^a	Production (in refined troy ounces)		
	Total	Placer	Lode
1 Lisburne district	0	0	0
2 Noatak district	7,800	7,800	0
3 Wainwright district	0	0	0
4 Barrow district	0	0	0
5 Colville district	0	0	0
6 Canning district	0	0	0
7 Sheenjek district	0	0	0
8 Chandalar district	70,278	52,878	17,400
9 Koyukuk district	378,075	378,075	0
10 Shungnak district	15,000	15,000	0
11 Kiana & Selawik districts	40,607	40,607	0
12 Fairhaven district (Candle subdistrict)	254,265	254,265	0
13 Fairhaven district (Inmachuk subdistrict)	349,975	349,975	0
14 Serpentine district	4,536	4,536	0
15 Port Clarence district	42,358	42,358	0
16 Kougarak district	191,712	191,712	0
17 Nome (Cape Nome) district	5,043,465	5,043,465	0
18 Council district	1,047,042	1,020,042	27,000
19 Koyuk district	84,462	84,462	0
20 Hughes district	403,671	403,671	0
21 Kaiyuh district	149,703	5,400	144,303
22 Anvik district	7	7	0
23 Marshall district	124,506	124,506	0
24 Bethel district	42,953	42,953	0
25 Goodnews Bay district	31,202	31,202	0
26 Aniak district	613,407	613,407	0
27 Iditarod district	1,565,226	1,562,296	2,930
28 McGrath district	364,672	133,307	231,365
29 Innoko district	757,219	757,063	156
30 Ruby district	478,023	478,023	0
31 Kantishna district	99,307	91,401	7,906
32 Hot Springs district	604,926	604,926	0
33 Melozitna district	14,630	14,630	0
34 Rampart district	204,845	204,845	0
35 Tolovana district	547,556	547,556	0
36 Yukon Flats district	0	0	0
37 Circle district	1,125,341	1,125,341	0
38 Black district	2	2	0
39 Eagle district	52,166	52,166	0
40 Fortymile district	602,758	602,758	0
41 Chisana district	144,521	78,021	66,500
42 Tok district	288	288	0
43 Goodpaster district	3,369,472	2,051	3,367,421
44 Fairbanks district	15,814,447	8,282,595	7,531,852
45 Bonnifield district	108,983	102,283	6,700
46 Richardson subdistrict of Fairbanks district ^b	121,828	119,528	2,300
47 Delta River district	11,732	11,732	0
48 Chistochina district	186,604	186,604	0
49 Valdez Creek district	533,167	531,586	1,581
50 Yentna district	204,980	204,980	0
51 Redoubt district	105	105	0
52 Bristol Bay Region	1,570	1,570	0
53 Kodiak district (53b)—Alaska Peninsula Region (53a)	112,409	4,809	107,600
54 Homer district	17	17	0
55 Hope & Seward districts	135,252	70,252	65,000
56 Anchorage district ^c	460	460	0
57 Willow Creek district	667,841	58,841	609,000
58 Prince William Sound district	137,802	102	137,700
59 Nelchina district	15,016	15,016	0
60 Nizina district	148,500	148,500	0
61 Yakataga district	18,041	18,041	0
62 Yakutat district ^d	13,200	2,200	11,000
63 Juneau district (partial)	82,540	82,540	0
64 Juneau (64a) & Admiralty (64b) districts	10,086,645	82,390	10,004,255
65 Chichagof district	770,000	0	770,000
66 Petersburg district	15,000	15,000	0
67 Kupreanof district	0	0	0
68 Hyder district	219	219	0
69 Ketchikan district	62,002	4,002	58,000
70 Bering Sea Region	0	0	0
71 Aleutian Islands Region	0	0	0
Unknown (undistributed) ^e	119,251	119,251	0
TOTAL (refined Troy ounces)	48,193,586	25,023,617	23,169,969
(1,499 metric tons)			

Total Gold Production in Alaska by Mining District, 1880–2016



^aMining district names and boundaries revised slightly from those defined by Ransome and Kerns (1954) and Cobb (1973). Sources of data: U.S. Geological Survey, U.S. Bureau of Mines, and Alaska Territorial Department of Mines records 1880–1930; U.S. Mint records 1930–1969; State of Alaska production records 1970–2016. Entries of "0" generally mean no specific records are available.

^bNot included in total for Fairbanks district.

^cMost placer gold production included in Willow Creek district.

^dIncludes lode production from Glacier Bay area and placer production from Lituya Bay area.

^eProduction that cannot be credited to individual districts due to lack of specific records or for reasons of confidentiality. Beginning in 2015, placer production is not compiled for individual mining districts, but is instead included in the 'Unknown' category.



Geologists working at the Palmer property in southeast Alaska. Photo provided by Liz Cornejo, Constantine Metal Resources Ltd.



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