

Idaho Mining and Exploration, 2016-2017

Virginia S. Gillerman
Earl H. Bennett
Alexis Clark
Mark Barton

Staff Report 21-02
June 2021

Idaho Geological Survey
Morrill Hall, Third Floor
University of Idaho
Moscow, Idaho 83844-3014

Idaho Mining and Exploration, 2016-2017

Virginia S. Gillerman
Earl H. Bennett
Alexis Clark
Mark Barton

*Staff Reports present timely information for
public distribution. This publication may not
conform to the agency's standards.*

Staff Report 21-02
June 2021

Idaho Geological Survey
Morrill Hall, Third Floor
University of Idaho
Moscow, Idaho 83844-3014

Contents

Introduction	4
Metal Mining	7
Phosphate Mining	10
Other Industrial Minerals	12
Energy	15
Mineral Exploration	21

Illustrations

Figure 1. Value of Idaho's non-fuel mineral production, 2010 - 2017.....	5
Figure 2. Location of active mining areas	6
Figure 3. Crew at bottom of Lucky Friday #4 shaft project.....	8
Figure 4. Core from 366FW vein, 4900 level, Galena mine	8
Figure 5. Golden Chest mine, Murray, overview.....	9
Figure 6. Map of Southeast Idaho Phosphate District.....	10
Figure 7. Mining at Panel G, Smoky Canyon mine, 2017.....	11
Figure 8. Reclamation at Panel A, North Rasmussen Ridge mine, 2017.....	12
Figure 9. Location map of industrial mineral operations, 2017.....	13
Figure 10. Splitting Oakley stone into sheets, Yukon Gold quarry.....	14
Figure 11. Hess pumice plant, Malad.....	15
Figure 12. Map of hydrocarbon wells, SW Idaho	19
Figure 13. Monthly production, Willow Field, 2016-2017	20
Figure 14. Location map of 2016 and 2017 exploration projects.....	22
Figure 15. Bunker Hill mine glory hole., 1907.....	23
Figure 16. Drilling at the RAM deposit, Idaho Cobalt Project, Fall, 2017.....	25
Figure 17. Final cover installation over heap leach pad, Beartrack mine, 2017.....	26
Figure 18. Map of Yellow Pine drill hole MGI-16-414 with assays, structure 2016.....	27
Figure 19. Geotechnical drilling, West End pit, Stibnite, 2017.....	28
Figure 20. Core with oxide copper in porphyry, Empire mine, 2017.....	29
Figure 21. Core of epithermal veins in Aspen Fm., Kilgore project, 2016	30
Figure 22. Aerial view, DeLamar mine in snow, date unknown, probably circa 2000...	31

Idaho Mining and Exploration, 2016-2017

Virginia S. Gillerman¹, Earl H. Bennett²,
Alexis Clark¹ and Mark Barton¹

INTRODUCTION

Idaho's mineral industry experienced a solid year in 2016. This was followed by limited growth and renewed exploration activity in 2017. This staff report summarizes the Idaho mining and exploration industry during the two calendar years, 2016 and 2017. Additional details and photographs may be found in the annual visual presentations available on the Mines and Minerals page of the Idaho Geological Survey (IGS) website: <https://www.idahogeology.org/geologic-resources/mines-minerals/current-historic-mining-activity>

The economic value of Idaho non-fuel mineral production is shown in Figure 1, as reported by the U.S. Geological Survey. Phosphate production is for raw ore only, but in Idaho, the in-state processing of phosphate rock adds a 4 to 5 times multiplier to the value. The relative proportion of metals is also shown. The sharp drop in metal value after 2014 reflects the termination of production at the large Thompson Creek molybdenum mine in December, 2014. In 2016, Idaho's total was \$ 592 million, and in 2017 it was \$ 551 million. The percent from metals in 2016 was about 29%, after a high of almost 75% in 2010. In both 2016 and 2017, leading Idaho commodities by value were phosphate rock, construction sand and gravel, crushed stone, lead and silver. In mid-2016, the mining sector employed about 2,460 people but that decreased about 10% to 2,216 persons in 2017, according to the Idaho Division of Financial Management July 2019 Idaho Economic Forecast. The location of Idaho's major mining areas is shown in Figure 2. Idaho receives royalties from mineral production on state land. The phosphate leases and aggregate leases provide approximately 85% of the annual royalties, which totalled just over \$ 1 million in 2017.

Commodity prices, including precious and base metals, were up significantly, particularly in the second half of 2016, and alloy metals, including molybdenum and cobalt, both of which are abundant in Idaho, rose 20% or more in price during the calendar year. In 2017, gold and silver prices were nearly flat, with gold hovering around \$1300 per troy ounce and silver at a healthier

¹Idaho Geological Survey.

²Idaho Geological Survey, retired.

\$17 per ounce. Lead and zinc prices climbed gradually in 2017, but cobalt spiked in early 2017 from about \$10 per pound to \$31 per pound in late November. That spike led to a furious staking rush in the Idaho Cobalt Belt, as discussed later. Cobalt is one of the components used in batteries for rechargeable electric vehicles and is listed among the “Critical Minerals” in the executive order 13817.

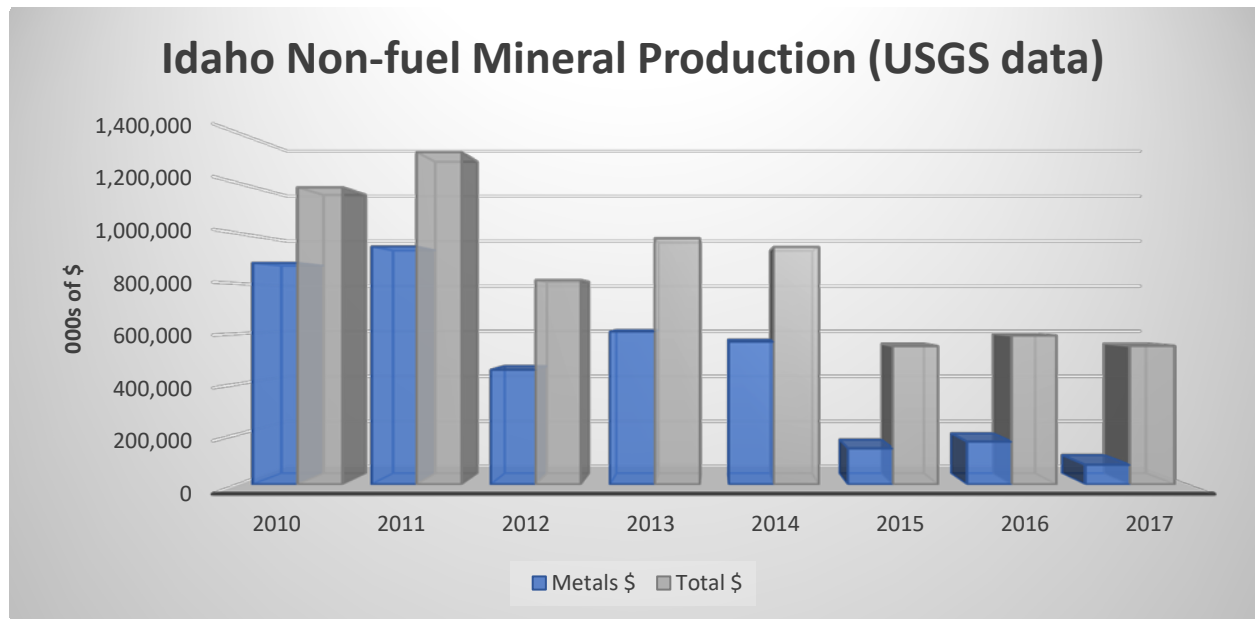


Figure 1. Value, in thousands of dollars, of Idaho’s non-fuel mineral production, 2010 – 2017. Data from U.S. Geological Survey.

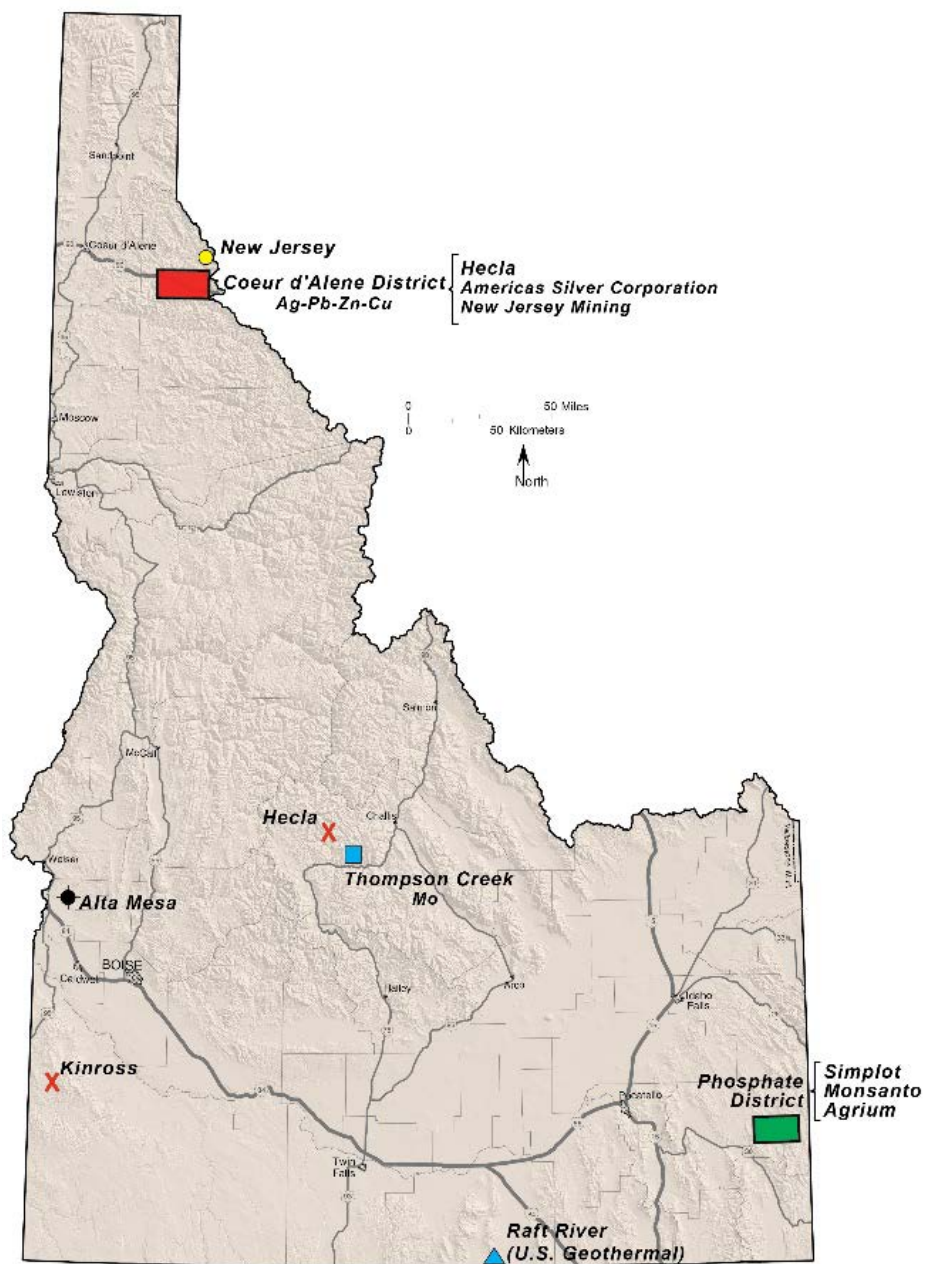


Figure 2. Location of mines and active plants in 2016 and 2017. The red X indicates a closed gold mine in reclamation. Yellow dots are small gold mines. The black cross hair is for oil and gas production, and the blue triangle indicates a geothermal plant.

METAL MINING

COEUR D'ALENE AND MURRAY DISTRICTS

North Idaho's Coeur d'Alene District, also known as the Silver Valley, has mined silver along with lead, zinc, copper and antimony, since 1884 from structurally controlled, quartz-siderite-sulfide veins in deformed Mesoproterozoic Belt Basin metasedimentary rocks. The world-class district is credited with over 1.24 billion troy ounces of silver. In 2016 – 2017 the north Idaho region was home to Idaho's only metal mining.

Hecla Mining Company, operator of the Lucky Friday mine at Mullan, celebrated its 125th birthday in 2016. Hecla started in the Silver Valley in 1891 and has a large property position in the district. In 2016, the company acquired the large Montanore and Rock Creek Ag-Cu deposits hosted by Belt Basin quartzites in Montana. In May, Hecla and contractor Cementation completed the #4 shaft at the Lucky Friday mine. The shaft bottom on the 8620 level is 9,587 feet below the ground surface (Fig. 3). The contractor spent the second half of the year installing the shaft lining, hoists, and other infrastructure. The mine had an excellent year in 2016, with most production from the 6250 to 6350 levels of the Gold Hunter vein system. As expected from the drilling, higher grades were encountered at depth from the silver-rich galena of the 30 vein. The Lucky Friday produced 3.6 million ounces of silver in 2016.

On March 13, 2017, USW Local 5114 went out on strike, effectively shutting down the Lucky Friday. The striking workers posted notices in the Spokane Spokesman-Review and elsewhere accusing Hecla management of unfair labor practices and unsafe conditions. A major issue was the miners' demand for control of their own work assignments and shifts. The acrimonious relations lasted throughout the year, and the strike was on-going at the end of 2017. Though the new #4 shaft was fully operational, the only production after the first quarter was a small amount of mining done by the salaried employees.

Americas Silver Corporation operated the Galena mine, and they graciously hosted a field trip for the Geological Society of America Rocky Mountain section meeting in May, 2016. Cost reductions implemented in the past few years, as well as rising metal prices were helpful to the bottom line. Production in 2016 was 1.4 million ounces of silver and 24 million pounds of lead. Exploration drilling and modelling focused on the "upper country" Ag-Pb veins above the 3000 level, as well as around the deeper Caladay lead zone and newly discovered veins.

In 2017, Americas Silver was mining the 2400 level and developing the lead zone, a set of sub-parallel, E-W trending narrow veins on the 3200 level, plus stopes at and below the 4900 level. The company worked hard to reduce costs by 50% since 2012, and exploration work increased reserves by 18%. The geologists were entering the historic geology into 3D models for mine planning and had a 20-hole drill program that intercepted high grade veins in 2017 (Fig. 4).



Figure 3. The bottom of #4 shaft at Lucky Friday mine, 2016.



Figure 4. Core from 366FW vein on 4900 level, Galena mine. Assayed 347 g/t Ag and 14% Pb over 2.8 meters.

At Murray, a former placer gold camp north of the Silver Valley, New Jersey Mining Company also hosted a field trip to their Golden Chest gold mine in May, 2016. The company resumed mining in the second half of the year. New Jersey discovered the new Stevens vein and expected to mine about 7,000 tons from the open pit, adjacent to the Idaho Fault. They were dewatering the underground workings. Ore was shipped to New Jersey's flotation mill at Kellogg.

In 2017, the open pit at the Golden Chest operated all year, with an average head grade of 4.11 g/t Au and a total of 3,525 troy ounces of gold produced in the year (Fig. 5). The mine exploits a series of quartz veins with ore shoots containing gold and spotty scheelite localized along the Idaho fault which cuts folded Belt rocks. Approximately 30,000 meters of modern drilling has been done and a new 43-101 compliant resource report was released in December. The company processed the ore at their 360-tonne per day flotation mill and cyanide leach plant, and they also worked on geologic modelling, a backfill system and underground development. Mining of the underground Skookum shoot stopes began in December. The company raised enough money to pay off the balance of the \$ 3.75 million purchase price and acquired full ownership of the Golden Chest late in 2017.



Figure 5. Golden Chest mine, Murray, with portal in lower center and open pit on top.

OTHER METAL MINING

The Thompson Creek molybdenum mine in Custer County mine remained on care and maintenance status with Mo oxide prices staying below \$10 per pound. Some toll milling of impure molybdenum concentrates was done and the clean product sent to the Langeloth, PA roaster to produce Mo oxide. Ironically, the Record of Decision which permits the Phase 8 expansion of the mine was signed by the Bureau of Land Management and U.S. Forest Service in 2016. In October, 2016, Thompson Creek Metals Company and Centerra Gold Inc. completed a Plan of Arrangement whereby Centerra acquired all the shares and ownership of Thompson Creek Metals.

PHOSPHATE MINING

Southeast Idaho's Phosphate District includes three large open pit mines and three processing plants, and all were in full operation (Fig. 6). The resource is part of the Meade Peak member of the Phosphoria Formation, a black phosphatic shale deposited over parts of Idaho, Wyoming, Utah and Montana in the Permian about 265 million years ago. The ore mineral is fluorapatite.

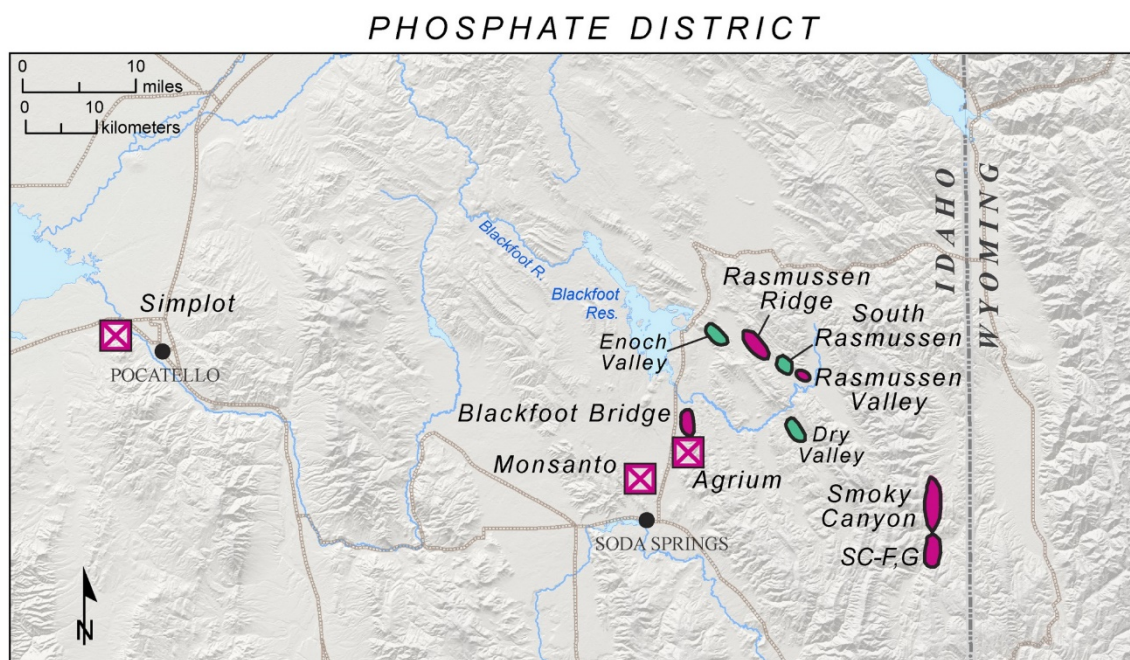


Figure 6. Location map of Phosphate District of southeast Idaho. Active open pit mines are in red ovals; green ovals are mines in reclamation; squares with red Xs are plants.

J.R. Simplot Company operated the Smoky Canyon mine near the Wyoming border. In 2016 they mined at Panel F, the Manning Creek lease, and at Panel G, the Deer Creek lease, on the south end of the property (Fig. 7). An 8-mile haul road connecting the two areas was finished and public roads rerouted around the Panel G pit. In November, 2016, Simplot completed an earth and bentonite cover barrier over 17 acres of Panel F backfill. In 2017, Simplot replaced three haul trucks and purchased a new shovel. Ore is crushed at the mine and sent through an 83-mile long slurry line to the Don fertilizer plant in Pocatello. The company was permitting the East Smoky pit extension and completed the final 18-foot lift on the tailings dam. They were also segregating waste rock to minimize environmentally harmful selenium-bearing waste, which is greatest in the middle shale unit.



Figure 7. Mining in 2017 at Simplot's Panel G, Smoky Canyon mine, with new Hitachi EX2600 shovel and CAT haul trucks.

Monsanto, and its subsidiary P4, operated the Blackfoot Bridge mine, which opened in 2013. They backfilled the North pit and reclaimed its external overburden pile, installing lysimeters and a Geosynthetic Clay Liner Laminate (GCLL) over the disturbed material in 2016. A problem with faulty drainage layer in the liner required additional work in 2017. The mine had a record year in 2017, extracting about 2 million tons of ore. Most of the Monsanto ore was trucked to their elemental phosphorus plant at Soda Springs, the only such plant in the western hemisphere, but in 2017, they sold about 25% to Agrium. In 2017 mining took place in the Mid pit at the Blackfoot Bridge mine. Reclamation was completed at the Enoch Valley mine, and Monsanto worked with EPA on legacy issues at the Ballard. The company was in merger negotiations with Bayer in 2017.

Agrium and subsidiary, NuWest Industries, mined phases 2 and 3 of Panel B at the North Rasmussen Ridge mine, while backfilling Panel A in 2016 (Fig. 8). They continued reclamation

at the South and Central Rasmussen Ridge properties. Ore was sent to their phosphoric acid fertilizer plant at Conda. In 2017, they built a new load-out facility at the plant. On January 13, 2017, a Record of Decision was signed by the Bureau of Land Management and cooperating agencies granting approval of the new Rasmussen Valley mine, a 500-acre project on mixed federal, state and private leases. Agrium was constructing haul roads, storm water management facilities and other needed earthworks during the second half of the year. They also announced an agreement on November 7, 2017, for Itafos to purchase Agrium's Conda phosphate operations for \$100 million.

In addition to approval and the construction start at Agrium's new Rasmussen Valley mine in mid-2017, other permitting for new mines was underway. Simplot and contractors were preparing an Environmental Impact Statement (EIS) for the East Smoky expansion, which would add 3-12 years of reserve, and an EIS for the 2,133-acre Dairy Syncline project, which would require moving all mine and mill facilities. Agrium received approval from the state in 2016 to mine the private Lanes Creek lease and started limited mining, but Agrium paused permitting and evaluation at their Husky/Dry Ridge property. Monsanto drilled at North Caldwell Canyon and submitted a mine plan for Caldwell Canyon to the BLM in 2016. The following year, Monsanto drilled 7 holes at Trail Creek and formally initiated the EIS process for Caldwell Canyon in March. Caldwell Canyon would have a 30-year life. Stonegate Agricom, later renamed Paris Hills Agricom, held the Paris Hills underground phosphate project near Preston and discussed permitting with the state but overall, the project was on hold. Fertoz USA, a newcomer to the state, had some interest at Dry Ridge in 2016, but they also were on hold.

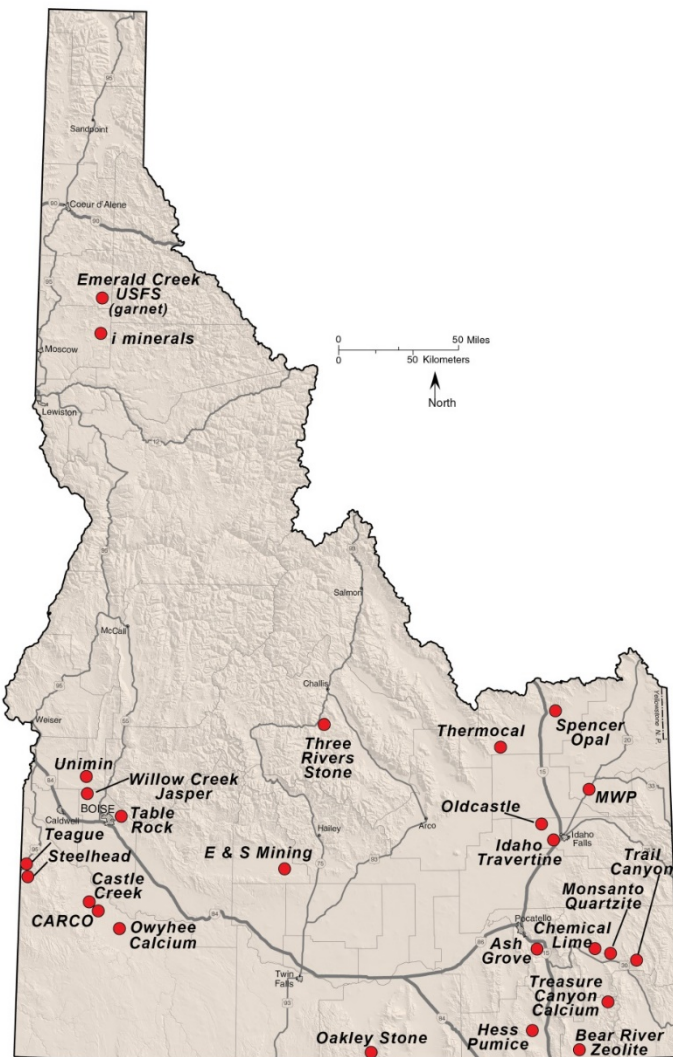


Figure 8. Agrium's reclamation at Panel A, North Rasmussen Ridge mine, 2017.

OTHER INDUSTRIAL MINERALS

Industrial mineral operations in 2016 and 2017 changed little from prior years (Fig. 9) as markets were fairly stable, though not stellar. Demand for decorative building stone was steady to slightly

higher as construction increased across the country. At least in southwest Idaho, demand seemed up somewhat for aggregate and construction sand and gravel. The smaller industrial minerals plants and quarries are important segments to local economies in rural areas. One change was the demolition of the Ash Grove cement plant at Inkom. Cement production there ended a few years earlier, and the facility had been used only as a shipping terminal.



INDUSTRIALS 2017

Figure 9. Locations of non-phosphate industrial mineral operations in 2017.

Emerald Creek Garnet, a subsidiary of Opta Minerals Inc., mined alluvial almandine garnets from the St. Maries River floodplain and Emerald and Carpenter Creek basins near Fernwood. The sized and sorted garnets are used in water jets, filtration, and abrasives. The deposits have

been producing since 1930. The U.S. Forest Service operates a park nearby where tourists can collect star garnets, Idaho's official gemstone.

The i-minerals' Bovill project at the historic Helmer-Bovill clay pits in Latah County submitted an operating and reclamation plan to the Idaho Department of Lands in mid-2016 for a mine and plant to produce four products: kaolin, halloysite, K-feldspar and quartz. They were also working on a Bankable Feasibility Study, which was completed in 2016, and seeking ways to reduce costs and optimize the design, possibly by increased production of higher-value products such as metakaolin and halloysite. An amended plan was finished in May, 2017. Markets are very competitive with the southeast U.S. being the largest clay producing area.

The center of Idaho's dimension stone industry is at Middle Mountain south of the town of Oakley and the location of several quarries of Oakley stone, an unusual micaceous quartzite which splits into large but thin sheets for use as a facing stone. The attractive colors range from gold to silver to gray (Fig. 10). Producers included Northern Stone Supply, Oakley Valley Stone, Sawtooth Stone, Scrivanich Stone and smaller operators. Markets were good with higher-end homes nationally using the durable stone as pavers, ledgerstone, facing stones and tiles. Sawtooth Stone permitted two new pits in 2017 and added rhyolite to its product collection.



Figure 10. Splitting Oakley stone into sheets, Yukon Gold quarry.

Other dimension stone producers included Table Rock Sandstone at Boise and Idaho Travertine with a cutting facility in Idaho Falls.

E & S Mining and Trucking extracted gold-colored pumice from the pit near Fairfield. CARCO mined clay at the Benjel clay mine in Owyhee County and processed it at a plant in Caldwell. Monsanto operated a quartzite quarry on state lease ground in Caribou County to provide high-purity silica for its phosphate plant.

Hess Pumice Products and its daughter companies, Hess Perlite (Idaho Minerals), U.S. Grout, and Hess Pozz, employ 80-100 people at the plant in Malad and Wrights Creek mine north of Malad (Fig. 11). Special shaking screens help to sizing and clean the pumice, which is shipped worldwide. Some markets slowed down but Hess aggressively continued to do market research and tested new applications for its specialty pozzolan that is made from the high-purity pumice.



Figure 11. Hess pumice plant, Malad, Idaho.

Bear River Zeolite, a subsidiary of U.S. Antimony, operated a clinoptilolite mine and plant near Preston. In 2016, they added a second screening line. Main markets are water filtration and agricultural products. About 14 people are employed at the operation.

ENERGY

GEOTHERMAL

High temperature geothermal activities for 2016-17 in Idaho included electrical generation or other industrial-scale applications. ‘High-temperature’ typically is regarded as subsurface

temperatures greater than 75°C (167°F), suitable for binary cycle geothermal power plant operation. Idaho continues to use its geothermal resources for low-to-moderate temperature applications (i.e., greater than 20°C or 68°F), including district and residential heating, aquaculture, greenhouses, and recreation.

Industry Production and Exploration

US Geothermal continued operation of the Raft River geothermal power plant in the Raft River basin in Cassia County. Phase II expansion plans, announced in 2017, were to increase output generation from 10 MW to 13MW through wellfield optimization and drilling projects.

A second production leg in existing production well RRG-2 was drilled in summer 2016, starting at approximately 1,067 meters (3,500 feet) below surface to a total depth of 1,708 meters (5,605 feet), targeting the predominant fracture zone between RRG-2 and RRG-1. Several permeable zones were identified in the second production leg, and the temperature stabilized to 136°C (277°F). US Geothermal attributed a 180 gpm reduction in total flow in the well compared to before drilling to scale damage in the original leg. The company reported normal production rates for the facility, attributing current production in RRG-2 to the second leg and indicated the original leg may be chemically treated in the future to restore production. Refer to 2/6/2017 US Geothermal press release at: <http://www.usgeothermal.com/static-files/ea22345c-1aad-45b3-afb1-a31c2a2186f7>, accessed 6/7/2020.

Well RRG-5 was brought online and began pumping 119°C (247°F) water in March 2017 at a rate of 1,100 gpm, resulting in a net power increase of 0.71 MW and no observed impacts to water levels measured in nearby wells. Details may be found in a 4/27/2017 US Geothermal press release: <http://www.usgeothermal.com/static-files/171bc6e7-2602-45b5-a315-a9678f383df0>, accessed 6/6/2020.

In a 12/13/2017 press release, US Geothermal announced it had reached an agreement to acquire 100 percent interest in the Raft River power facility, with plans for further expansion. Average generation increased by about 1.6 MW with the addition of production well RRG-5 earlier in 2017 and injection upgrades during 2017 (<http://www.usgeothermal.com/static-files/acc4116c-366a-40a5-9eca-dbd19bf57d09>, accessed 6/7/2020).

In a 2/6/2017 update, US Geothermal reported enhanced injection capacity in well RRG-9 of 1,200 gallons per minute (gpm), compared to the initial well injection capacity of 20 gpm, following thermal stimulation activities associated with the DOE-funded EGS demonstration project (<http://www.usgeothermal.com/static-files/ea22345c-1aad-45b3-afb1-a31c2a2186f7>, accessed 6/7/2020).

In 2016 Walker Ranch Energy, LLC (under parent company Agua Caliente) submitted to BLM a utilization plan and 13 geothermal drilling permit applications to the BLM with the intent to construct a 25 MW geothermal power plant in the Raft River basin in Cassia County. For more details visit BLM's website at: <https://eplanning.blm.gov/eplanning-ui/project/45742/510> (accessed 6/7/2020) and summary available at: <https://www.thinkgeoenergy.com/blm-gives-go-ahead-for-walker-ranch-geothermal-project-in-idaho/>, accessed 6/7/2020.

Agua Caliente conducted a 3D seismic reflection survey over the Walker Ranch area. Open EI provides 3D seismic images and amplitude-depth slice (<https://openei.org/doe-opendata/dataset/walker-ranch-3d-seismic-images>, accessed 6/7/2020).

Ormat Technologies applied for the rights to use hot water from Panther Creek Hot Springs for development of a 10-20 MW power generation facility in Lemhi County. In December 2017, final Environmental Impact Statement (EIS) and draft Record of Decision (ROD) documents were issued on the proposed Big Creek Geothermal Leasing Project on 5,600 acres in Lemhi County. https://www.fs.usda.gov/nfs/11558/www/nepa/84254_FSPLT3_4112462.pdf, accessed 6/7/2020. Draft ROD documentation is available at: https://www.fs.usda.gov/nfs/11558/www/nepa/84254_FSPLT3_4112433.pdf, accessed 6/7/2020.

Government and Academic Geothermal Studies

Phase 1 of the U.S. Department of Energy (DOE) Frontier Observatory for Research in Geothermal Energy (FORGE) project, awarded summer 2015, generated extensive reporting and data submission on the Geothermal Data Repository in 2016, including site characterization data, conceptual model, and well data for USGS-142, WO-2, and INEL-1 (<https://www.energy.gov/eere/forge/idaho-national-laboratory>, accessed 6/3/2020).

The DOE-funded Project HOTSPOT evaluation of potential geothermal resources in the western Snake River Plain beneath Mountain Home Air Force Base continued with evaluation of borehole MH-2, advanced in 2011 to 1,821 meters (5,974 feet) along the southwest extent of a gravity anomaly. Flowing artesian, 150°C (302°F) conditions were encountered at 1,745 meters (5,725 feet) in a hydrothermally altered basalt system. The study incorporated available core logs, fracture and fault logs, and slip indicators to better understand the structural basin model and fracture network system (Kessler and others, 2017).

Glen and others (2017) collected high-resolution gravity and ground magnetic data, magnetotelluric data, and seismic reflection data in three areas within west and southcentral Idaho near Mountain Home, Bostic, and Camas Prairie. Data was used to characterize intra-basin and basin-bounding faults, basin geometry, fault interactions, and areas for favorable hydrothermal flow conditions. The study found favorable conditions for potential high-temperature geothermal resources at all three locations.

Conrad and others (2016) reported isotopic analysis of over 40 samples collected from thermal springs and wells within the Eastern Snake River Plain (ESRP) in southern Idaho in conjunction with multi-component chemical geothermometry and ³He/⁴He analysis. Results suggested favorable areas in the Twin Falls and Camas Prairie vicinities.

Geothermal References

Conrad, M.E., Dobson, P.F., Sonnenthal, E.L., Kennedy, B. M., Cannon, C., Worthing, W., Wood, T., Neupane, G., Mattson, E., and McLing, T., 2016, Application of isotopic approaches for identifying hidden geothermal systems in southern Idaho, *in* Proceedings 41st Workshop on

Geothermal Reservoir Engineering, SGP-TR-209, 9 p. Available at:
https://pangea.stanford.edu/ERE/db/IGAstandard/search_results.php?showmax=99&CONFERENCE=Stanford%20Geothermal%20Workshop&SortField=Last1&SortOrder=Ascend&Find=Star%20Search&Year=2016 (accessed June 5 2020).

Kessler, J.A., Bradbury, K.K., Evans, J.P., Pulsipher, M.A., Schmitt, D.R., Shervais J.W., Rowe, F.E., and Varriale, J., 2017, Geology and In Situ Stress of the MH-2 Borehole, Idaho, USA: Insights into Western Snake River Plain Structure from Geothermal Exploration Drilling: *Lithosphere*, v. 9, no. 3, p. 476-498. Available at:
<https://pubs.geoscienceworld.org/gsa/lithosphere/article/9/3/476/207894/Geology-and-in-situ-stress-of-the-MH-2-borehole> (accessed June 5 2020).

Glen, J.M.G., Liberty, L., Gasperikova, E., Siler, D., Shervais, J., Ritzinger, B., Athens, N., and Earney, T., 2017, Geophysical investigations and structural framework of geothermal systems in West and Southcentral Idaho; Camas Prairie to Mountain Home, *in* Proceedings 42nd Workshop on Geothermal Reservoir Engineering, SGP-TR-212, 13 p. Available at:
<https://pangea.stanford.edu/ERE/pdf/IGAstandard/SGW/2017/Atkinson.pdf> (accessed June 8 2020).

OIL AND GAS

In 2016, Idaho completed its first full year of commercial oil and gas production, making it the 31st US state to produce hydrocarbons. Production is concentrated in the southwestern part of the state where conventional accumulations of condensate, gas, and oil, have been encountered beneath the western Snake River Plain. The deposits occur within fault-bounded structures and stratigraphic traps associated with the evolution and filling of a NW trending rift basin during the late Miocene to early Pliocene. All the production is currently from the Willow Field which is operated by Alta Mesa Holdings (Fig. 12). Alta Mesa acquired the asset in 2012 from Bridge Resources who drilled the initial discovery well (ML Investment 1-10) in 2010. Since acquiring the asset, Alta Mesa has spent over 160 Million USD in the collection of several 3D seismic surveys and the construction of infrastructure needed to process and transport the produced fluids and gases.

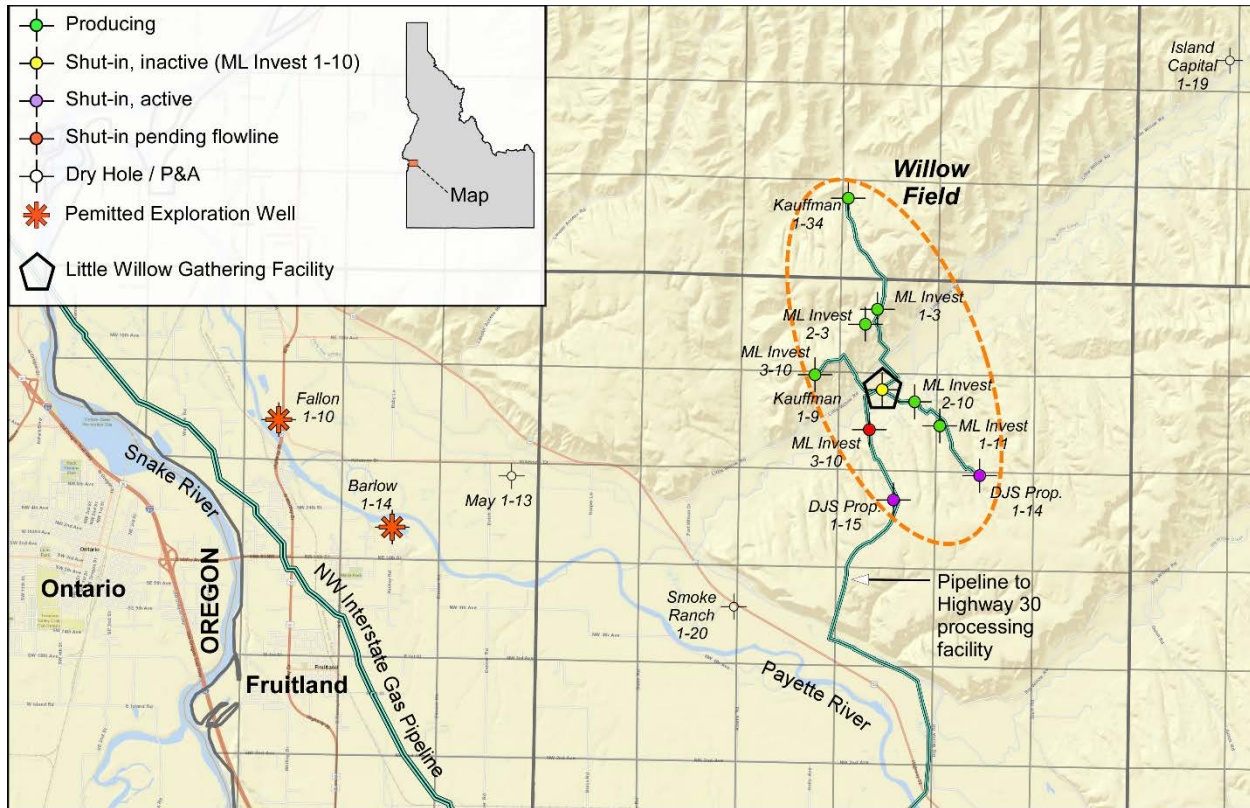


Figure 12. Map showing status of well drilled in SW Idaho since 2010 to 2017.

Development and Production Activities

Pay zones within the Willow Field occur at subsurface depths of 3,800 to 4,300 ft with thicknesses ranging from 30-150 ft. Several of the wells; the ML Investment 2-10, ML Investment 1-11, and Kauffman 1-9, produce from multiple zones. Recently drilled development wells include the ML Investment 2-3, completed in January of 2016, and the ML Investment 3-10, completed in November 2017. Between January of 2016 and December of 2017, production from the Willow field was over 2,000,000 BOE (Fig. 13) with about 30 percent of the production coming from a mixture of oil, condensate, and natural gas liquids (NGL's). Peak production from the field occurred in May 2016 (117,000 BOE) and has been in decline since due to natural depletion and issues with water breakthrough that has led several of the wells to be shut-in and recompleted. The ML Investment 1-10 well is currently shut-in with no plans at this time to recomplete and resume production. Production from the recently drilled ML Investment 3-10 is pending construction of a flowline that is expected to be finished and operational in early 2018.

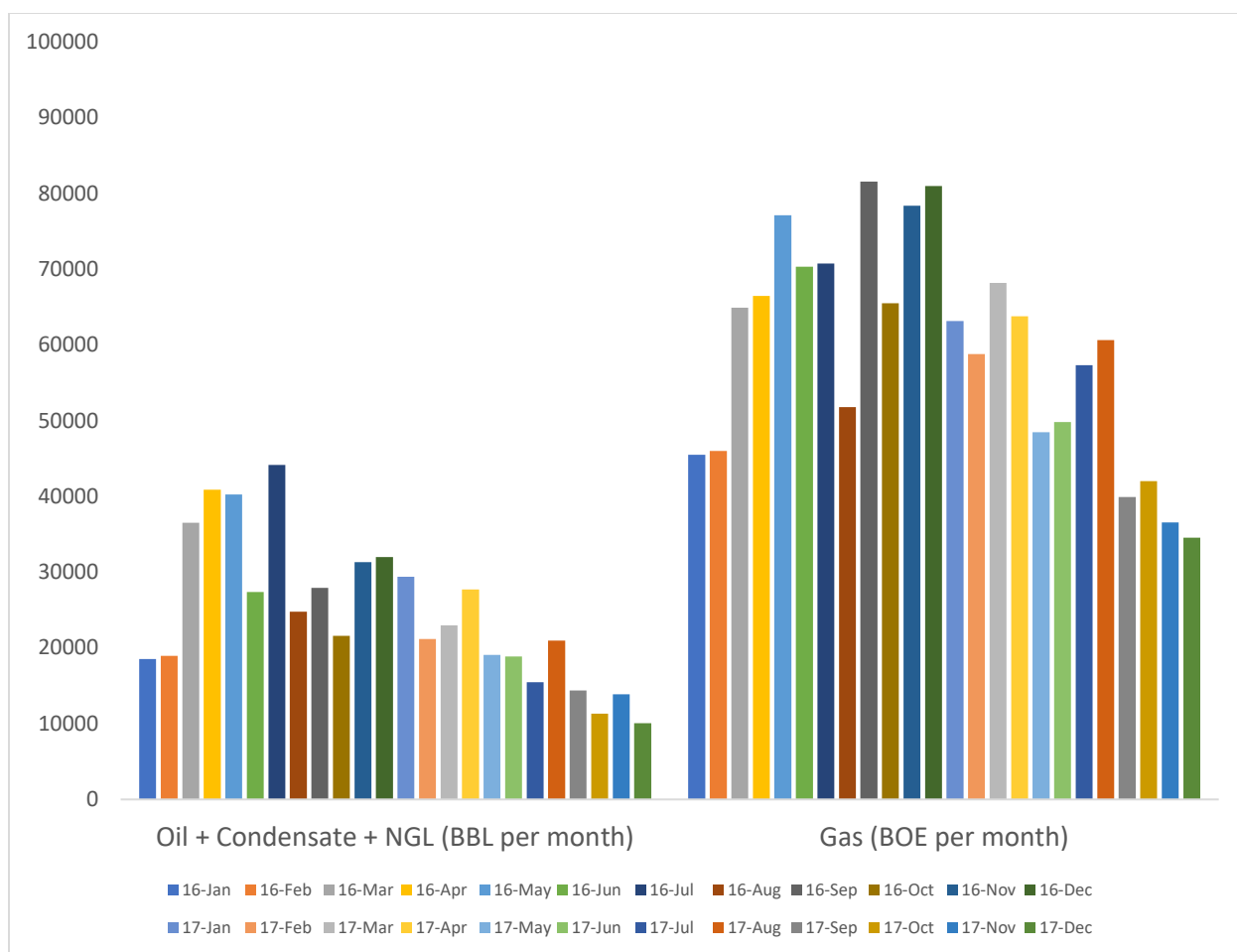


Figure 13. Monthly production data from Willow Field, SW Idaho, 2016 to 2017.

Exploration and Leasing Activities

In October of 2017, Alta Mesa Holdings received permits to drill two exploration wells, the Fallon 1-10 and the Barlow 1-14, in Payette County (Fig. 12). The wells are located about 6 miles to the west of the Willow Field with target intervals in the lower Chalk Hills and Payette Formations at depths ranging from 3,500-5,500 ft. Drilling is planned to begin in March, 2018 and finish in about a month. In southeast Idaho, CPC Minerals, completed drilling Federal 20-3 to a depth of 7,052 ft in late November, 2017 (Fig. 14). The well targeted natural gas within the Upper Jurassic Preuss and Stump sandstones that are part of the fold and thrust belt. No hydrocarbon shows were reported, and the well was plugged and abandoned in December of 2017. At this point, no wells have produced commercial hydrocarbons in the southeastern part of the state, but exploration is ongoing with CPC Minerals indicating that future drilling is possible.

Idaho Department of Lands (IDL) conducts oil and gas lease sales when eligible lands are available for lease and nominated by the public Auctions are public, advertised, and awarded based on an oral bonus bid/acre. Public lease size is restricted to all the state lands in one section

or about 640 acres. Private leasing is unregulated. In October of 2016, the Idaho Department of Lands auctioned 4,462 acres of state-owned mineral estates in 225 leases from seven counties distributed across the southwestern, south-central, and southeastern portions of the state. Alta Mesa Holdings was the principal bidder acquiring 209 leases. A summary of the auction can be found at: <https://www.idl.idaho.gov/wp-content/uploads/sites/116/news-media/2016-releases/10-19-2016-idaho-auctions-thousands-more-acres-for-oil-gas-development.pdf>. In South-central Idaho, 34,595 acres were nominated for lease in Twin Falls and Owyhee Counties in 2015, but were withdrawn in February 2016. The region has potential for discoveries similar to those in northern Nevada (Oil and Gas Journal, June 2, 2014, p. 42), but no exploration activities have been conducted yet.

MINERAL EXPLORATION

Mineral exploration in Idaho in 2016 is shown in Fig. 14. Concern about the sage grouse and its highest quality habitat, referred to as sagebrush focal areas (SFAs), dominated discussions of mineral and hydrocarbon exploration across the West. The Idaho Geological Survey used its in-house mines and prospects database to illustrate the overlap of numerous mineralized areas with proposed SFAs (sagebrush focal areas), considered critical habitat for the bird. The proposed withdrawal plan, initiated in 2015, affected over 3.8 million acres in Idaho, and work started on an Environmental Impact Statement (EIS). IGS assisted with the Idaho Alternative compromise proposal formulated by the Governor's office during 2016. Resource extraction and land access on millions of acres in adjoining states were also at stake. Politics intervened with the election of a new president in November, 2016. In October, 2017, the new Secretary of Interior and the Bureau of Land Management issued a formal notice of cancellation of the withdrawals and a termination of the EIS for the 10 million acres of SFA lands in Idaho, Montana, Nevada, Oregon, and Wyoming.

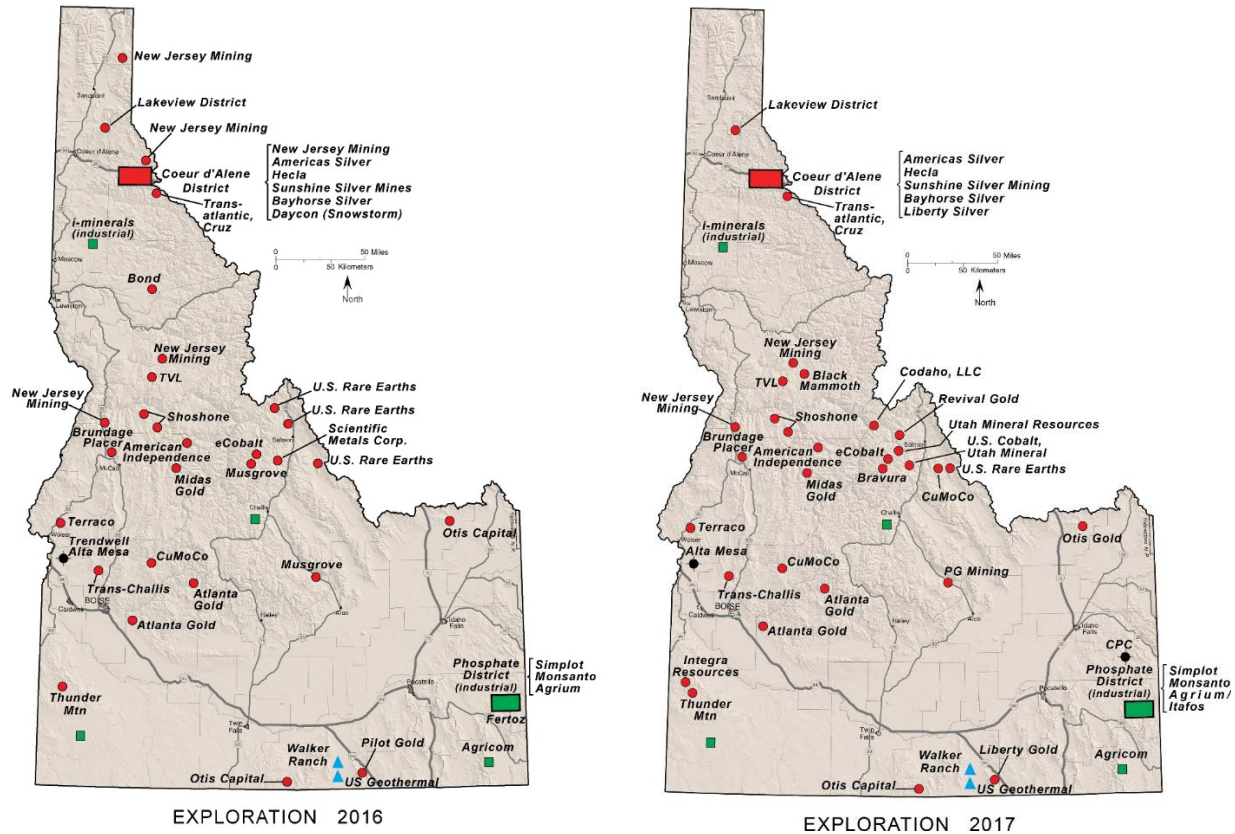


Figure 14. Locations of 2016 and 2017 exploration projects. Green boxes indicate industrial minerals, red symbols are metals, and blue triangles indicate geothermal projects. Black is for hydrocarbons.

2017 saw a significant upturn in minerals exploration in Idaho (Fig. 15). There were a number of reasons, in addition to the policy change on the withdrawals. Metal prices improved in 2017 over the previous year, particularly in the precious metals, but also cobalt and base metals. The new federal government was perceived by many as being less rigid on environmental and regulatory matters, and global financing for mining improved. Grass roots projects returned to the state as well as more on-the-ground activity at advanced projects. Exploration activity for the two-year period is covered below, starting in the north.

NORTH IDAHO

Active exploration in 2016 in north Idaho was mostly limited to the operating mines of the Coeur d'Alene and Murray Districts, as covered in the prior section. Bayhorse Silver mobilized a drill rig to test the Crown Point/Silver King vein structures near Smelterville. Other small companies held property but had little activity.

In August, 2017, a newly-formed company, Liberty Silver Corporation, signed a letter of intent with owner Placer Mining Corporation to pay \$ 30 million for a lease-purchase option on the historic Bunker Hill mine. The large lead-zinc producer is on the west end of the Coeur d'Alene

district (Fig. 2) and produced about 38 million tons of ore between 1885 and 1981 (Fig. 15). In late November, Liberty changed their name to the Bunker Hill Mining Corporation. The company was negotiating with the Environmental Protection Agency (EPA) to resolve water quality issues at the cleaned-up site with a plan for Bunker Hill to pay the EPA \$ 1 million per year and to assume responsibility for operation of the plant if the purchase option was concluded. Consultants for Bunker digitized the historic workings and drill data into a 3D model. The company was raising money with the intent to upgrade resources of the Quill zone and other areas. At its peak, the old Bunker Hill Company operated the mine, a lead smelter and refinery and an electrolytic zinc reduction plant, cadmium plant, zinc fuming plant, sulfuric acid plant, and even a phosphoric acid plant at Kellogg.

Black Mammoth Metals Corporation conducted surface exploration at its Blanco Creek property southeast of Elk City in 2017; the area had not seen activity since the early 1990s. Three historic underground mines, the Alberta, Hercules, and Pasadena mines, lie along a northeast-trending shear zone, and rock chip samples returned high grade Au and Ag assays. The company filed a plan to drill the next year. Other small companies that held properties in north Idaho included Bayhorse Silver, Transatlantic, and the Brundage placer. TVL and Premium's property at Orogrande was inactive, as the companies were having corporate difficulties.



Figure 15. Bunker Hill glory hole, 1907.

SALMON AREA AND COBALT BELT

In 2016, the Musgrove Creek gold property was optioned to Bravura Ventures who staked an additional 38 claims. The property was not active in 2017.

CuMoCo explored the Calida gold property in Mormon Canyon in Lemhi County in 2017. Several old mines exploited veins and shears with copper, gold, and silver, with the last exploration in 1983. Cumoco drilled 24 holes, encountering visible chalcopryrite.

In 2016, exploration in the Salmon area was essentially confined to the Idaho Cobalt Belt, and principally to the long-lived Idaho Cobalt Project. Formation Capital Corporation, who discovered the RAM deposit there in 1997, and subsequently succeeded in permitting, but not opening, an underground Cu-Co-Au mine, changed its name to eCobalt Solutions, Inc. The name change reflected the growing interest in cobalt use in rechargeable batteries. The price of cobalt rose about 30% in the last half of the year. The project is on the periphery of the Blackbird mining district, and the ore horizons are likely continuations of the stratigraphy from the Blackbird mine, once held by Noranda. eCobalt was raising money to complete a new feasibility study and maintain the existing earthworks at the site. Late in 2016, Scientific Metals acquired the Iron Creek property, and Cruz Capital picked up the Idaho Star prospect.

By 2017, the spike in cobalt prices had precipitated a full-scale staking rush in the Idaho Cobalt Belt (ICB) of Lemhi County. Cobalt is classified as a critical mineral and Idaho has the country's only primary deposits and reserve. The northwest-trending belt is about 30 miles long by 5 miles wide and defined by a near linear zone of stratabound cobalt occurrences and past producing mines, all hosted in specific Mesoproterozoic metasedimentary rocks of the Apple Creek Formation, which was formerly designated as the Yellowjacket. The ore-hosting strata are siltites, argillites and in the more metamorphosed strata at the structurally complex Blackbird mine, schists and biotitites of unknown origin. The latter may represent rift-related exhalative zones or hydrothermal alteration. Ore metals are copper and cobalt with local gold and anomalous rare earths. Ore minerals include cobaltite, chalcopryrite, gold, pyrite and cobaltian pyrite in the southeast, and local pyrrhotite and magnetite. Models of the deposit origins are controversial, though the deposits bear resemblance in gross age, host rocks and metal signatures to the African Copper Belt. Metamorphism increases to the northwest along the ICB. Noranda had defined a reserve of about 18 million tons at the Blackbird mine in the 1970s just before cobalt prices collapsed, and the district later became a remediation site. The old tailings pond was reclaimed and a permanent water treatment plant erected.

eCobalt Solutions, Inc., was optimizing designs for the mine and a cobalt production facility and updating the feasibility study for their permitted mine on the RAM Cu-Co-Au deposit, which is peripheral to the patented Blackbird property. The company also purchased industrial property adjacent to the railroad in Blackfoot for a potential processing facility. They drilled additional holes in the fall to move resources into the proven category and did pre-construction work on site (Fig. 16). A positive feasibility study (at \$26 per pound Co) was released in September, 2017, with a 12-year mine life and exploration potential. Cobaltite is the main mineral, and the deposit carries a gold credit.

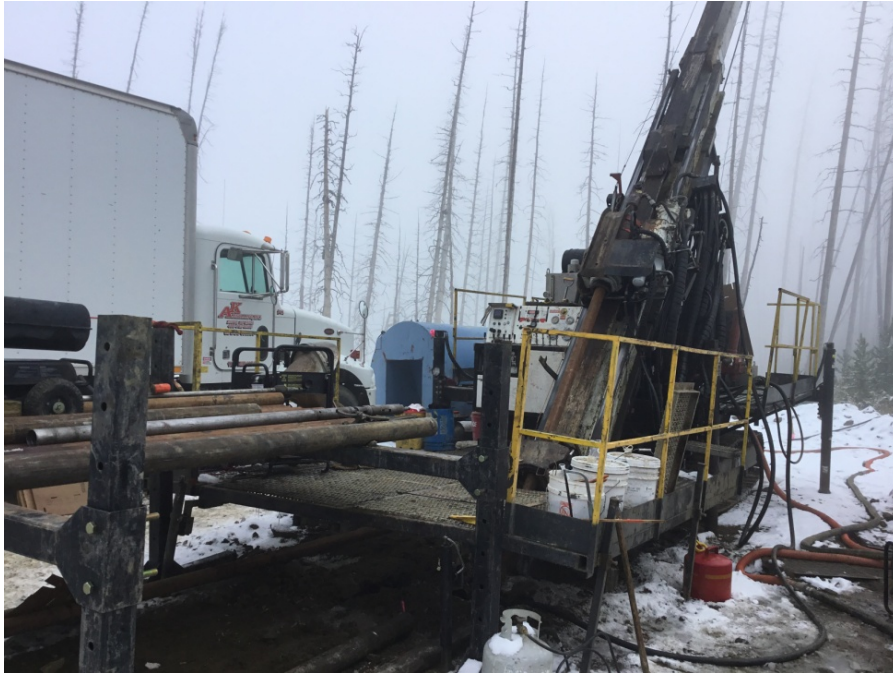


Figure 16. Drilling on the RAM deposit, Idaho Cobalt Belt, Fall, 2017.

US Cobalt formerly Scientific Metals, had a very aggressive program at the partly patented Iron Creek property during the second half of 2017. The cobalt deposit, located in the No Name zone and Jackass zones, is exposed in the No Name adit, on the southeast end of the ICB. It hosts a historic resource of 1.3 million tons at 0.59% Co, based on Noranda work in the 1980s. The main ore mineral is cobaltian pyrite with chalcopyrite present in separate horizons. The company drilled a total of about 35,000 feet in the 40-hole diamond drill program. They also rehabilitated the #1 adit, conducted channel sampling, and started metallurgical and mineralogic studies.

Elsewhere in the ICB, Utah Mineral Resources picked up the CAS property further north on Iron Creek in March, with a purchase agreement and 1-year work commitment. The 1967 discovery has been explored principally by geophysics and trenching; historic hole IC03-04 intersected 4.6 meters of 0.334% Co and 8 g/t Au. Utah also acquired the Sweet Repose prospect near the Blackbird district. An Australian company, Codaho, acquired the Salmon Canyon Copper property on the far northwest end of the belt. Host rocks there are high grade sillimanite-garnet-quartz-biotite gneisses with chalcopyrite and cobaltian arsenopyrite (glaucodot). Claim-staking in the ICB continued until the end of 2017.

Gold was the target elsewhere in Lemhi County. Meridian Gold installed a final cover over the former heap leach pad at the Beartrack mine (Fig. 17), a former open pit gold operation that produced about 600,000 ounces and closed in 2000 at a time of low gold prices. In August, 2017, Revival Gold acquired the Beartrack property and also nearby Arnett Creek, which was explored

in the 1990s by AGR and has large placer workings at the Haidee and other areas. Revival conducted surface sampling and mapping at Arnett, where 37 of 107 rock chip samples assayed over 1 ppm Au. At the Beartrack mine, Revival drilled 12 holes, totaling 3,024 meters, in the South Pit and Ward's Gulch areas. A prior Meridian hole hit a 71 g/t Au intercept in Ward's Gulch.



Figure 17. Cover installation over heap leach pad, Beartrack mine, 2017.

CENTRAL IDAHO

Midas Gold's project at historic Stibnite in the Yellow Pine mining district in Valley County was one of the largest efforts in the state in 2016 and 2017. The company went back to the original "Stibnite" name, after briefly referring to it as the "Golden Meadows" project. On September 21, 2016, Midas formally submitted a Plan of Restoration and Operations (PRO) to state and federal agencies. The Payette National Forest is the lead agency with the Idaho Department of Lands mainly involved on the state level. The PRO outlined the proposal for a new gold-antimony mine with three pits and subsequent mine closure including restoration of historic and new environmental impacts. Mining and construction would last over 15 years and be a major employment and economic benefit to the county. One feature of the PRO would be infilling and restoration of the Yellow Pine pit after mining to allow migration of anadromous fish up the East Fork of the South Fork of the Salmon River, which flows through the current pit. Midas started a drill program which extended into 2017 and worked on infrastructure, reclamation, safety closure and metallurgy. For example, Diamond hole MGI-16-414 intersected 200 meters of over 2 g/t Au with antimony. The angle hole was collared between the Meadow Creek Fault and the Hidden Fault (Fig. 18) and helped upgrade resources to reserves.

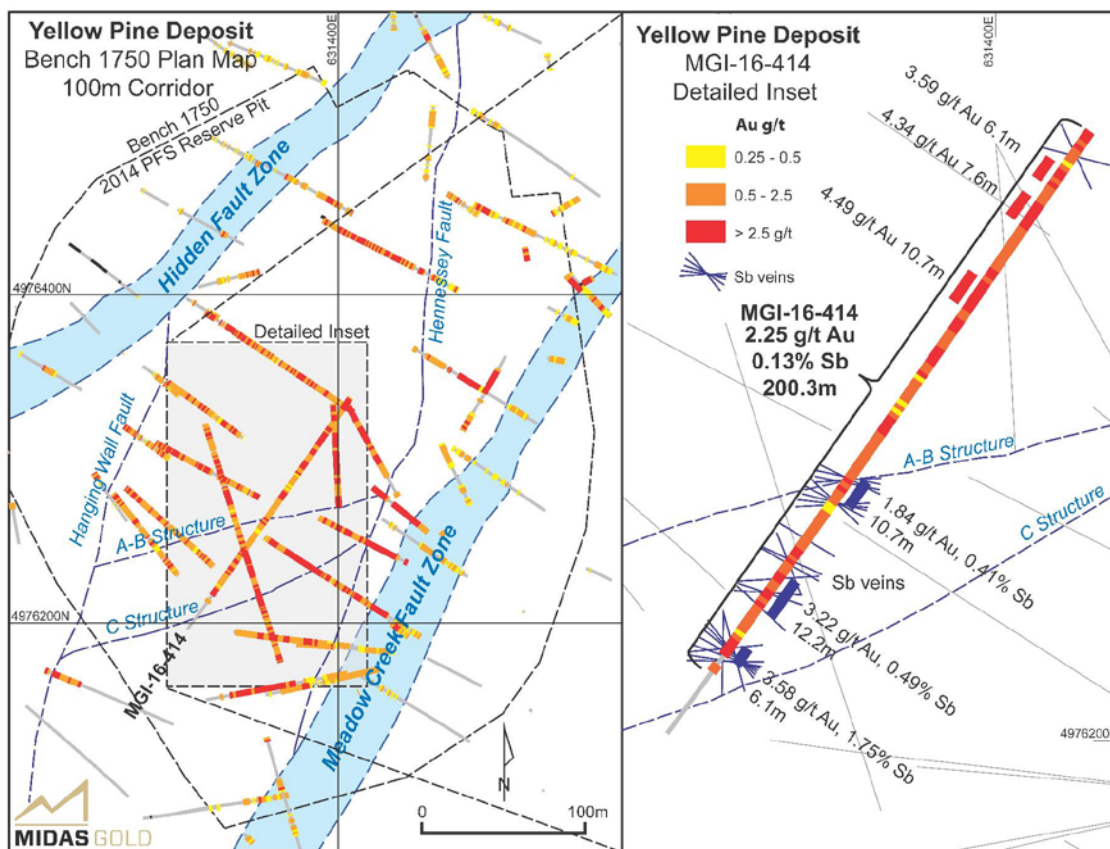


Figure 18. Yellow Pine drill hole MGI-16-414 map, Midas Press Release, November 30, 2016.

Drilling continued at Stibnite in 2017 with the exploration program of 20 holes, totaling 3,377 meters of core, principally in the Yellow Pine and Hangar Flats deposits. Midas also did geotechnical drilling, metallurgy, powerline and road studies and worked on a new feasibility study (Fig. 19). Public scoping meetings were started by the Forest Service as part of the EIS process. Midas had a large public relations and outreach program, giving over 30 tours of the site to 700 visitors and planting trees in riparian areas.



Figure 19. Geotechnical drilling, West End pit area, Stibnite project, 2017.

Near Mackay in Custer County, Phoenix Global Mining (PG Mining) was working at the Alder Creek mining district, home to the historic Empire mine. The copper and polymetallic skarns were explored in the 1990s and early 2000s by Cambior and others who defined an open pit oxide copper resource. PG Mining released a JORC-compliant resource of 19.3 million metric tons at 0.47% Cu with Ag, Au, and Zn credits in November, 2017, based on new infill drilling (Fig. 20). The company was working on a prefeasibility study for a 7,000 ton/year leaching and SX-EW operation.

In Boise County, CuMoCo continued to wrestle with financial and legal issues associated with permitting and plans for the giant Cumo molybdenum-copper deposit. In 2016, the 180,000-acre Pioneer fire burned half the site. Conservation groups challenged the exploration drilling program with litigation over the endangered plant, *Sacajawea's bitterroot*. Public scoping on a Supplemental Environmental Assessment of the drilling took place in late 2017.



Figure 20. Core with oxide copper mineralization in porphyry, Empire mine project, 2017.

SOUTHERN AND EASTERN IDAHO

Atlanta Gold did not do any work in the Atlanta District in 2016. In 2017, the company was cited for Clean Water Act violations related to discharge of As-bearing effluent from historic mine workings. The water treatment plant which the company had installed worked well except when overwhelmed during spring runoff. Atlanta Gold shifted its exploration attention to a private parcel in the Neal District of Elmore County, only a short distance southeast of Boise. An affiliate company, Mineral Point LLC, explored the quartz-pyrite veins in silicified granodiorite with minor drilling, sampling and stockpile tests on the 5-acre property. After being shut down by the state over an incomplete reclamation plan, a new state permit allowing removal of a 12,900-ton stockpile was issued in 2017.

Thunder Mountain Gold resolved legal issues related to its South Mountain property in Owyhee County in 2016, allowing work to move forward when feasible. Terracco's Idaho-Almaden property in Washington County remained inactive.

In southeastern Idaho, Pilot Gold acquired the Black Pine property, also called Mineral Gulch, from Western Pacific in July, 2016. Black Pine was an open pit, heap leach producer of about 435,000 ounces of gold from a Carlin-type system. The former Pegasus mine closed in 1997 after only five years production during a time of low gold prices. In 2017, Pilot changed its name to Liberty Gold, reviewed the historic data and geology and submitted a revised plan of operations for a large drill program to the Sawtooth National Forest.

Otis Gold was one of the few companies with a large drill program in 2016. They drilled 20 core holes and 20 RC holes, totaling 10,300 meters (34,000 feet), at the Kilgore project in Clark County. Some of the holes tested the Cretaceous Aspen Formation basement under the volcanic rocks and intersected good epithermal mineralization (Fig. 21). Better intercepts assayed 2 g/t Au over 300 feet with potassic alteration and silicification. The Aspen is a limey and carbonaceous sandstone to shale.



Figure 21. Epithermal veins in basal Aspen Formation, Kilgore property, 2016.

Otis continued drilling in 2017 with 24 diamond drill holes for 8,000 meters. They also did ground magnetics and collected 2,500 new soil, rock-chip, and stream sediment samples at Kilgore.

In November, 2017, Integra Resources Corporation purchased the largely patented DeLamar mine property in the Silver City district of Owyhee County. Integra bought the package from Kinross for Canadian \$ 7.5 million and stock, with a variable royalty retained by Kinross, the most recent past operator. Kinross mined at DeLamar and the Stone Cabin mine on Florida Mountain, but closed the property in 1998 when gold prices were at a low point (Fig. 22). Mining at Stone Cabin had barely started. The classic epithermal district, discovered in 1863 and studied by Lindgren around 1900, has historic and modern production of over 1.6 million ounces of gold and 100 million ounces of silver. Notable at DeLamar is the occurrence of silver selenide minerals, principally naumannite, in the ores. The property had a NI 43-101 resource of 2.7

million ounces of gold-equivalent (AuEq) at 0.3 g/t AuEq cutoff, based on Kinross' work. Integra was looking at unmined but known mineralization and untested high-grade targets at depth and planning an ambitious drill program for 2018. Mineralization is associated with a series of mid-Miocene rhyolitic domes and plugs.



Figure 22. Kinross DeLamar mine, looking southeast at snow-covered tailings impoundment. Date unknown, but prior to full closure and reclamation.