COBALT DATABASE OF UTAH

by Jake Alexander and Stephanie E. Mills

OPEN-FILE REPORT 749
UTAH GEOLOGICAL SURVEY
UTAH DEPARTMENT OF NATURAL RESOURCES
2023

Blank pages are intentional for printing purposes.

Cobalt Database of Utah

by

Jake Alexander and Stephanie E. Mills

Cover photo: *Bieberite ($CoSO_4 \cdot 7H_2O$) disseminated mineralization at the contact of the Moenkopi Formation and the Shinarump Member of the Chinle Formation at Colt Mesa mine, Circle Cliffs mining district, Garfield County, Utah (from Proctor and Proctor, 2021).*

Suggested citation:

Alexander, J. and Mills, S.E., 2023, Cobalt database of Utah: Utah Geological Survey Open-File Report 749, 5 p., 1 plate, https://doi.org/10.34191/OFR-749.

OPEN-FILE REPORT 749
UTAH GEOLOGICAL SURVEY
UTAH DEPARTMENT OF NATURAL RESOURCES
2023

STATE OF UTAH
Spencer J. Cox, Governor

DEPARTMENT OF NATURAL RESOURCES
Joel Ferry, Executive Director

UTAH GEOLOGICAL SURVEY
R. William Keach II, Director

PUBLICATIONS
contact
Natural Resources Map & Bookstore
1594 W. North Temple
Salt Lake City, UT 84116
telephone: 801-537-3320
toll-free: 1-888-UTAH MAP
website: utahmapstore.com
email: geostore@utah.gov

UTAH GEOLOGICAL SURVEY
contact
1594 W. North Temple, Suite 3110
Salt Lake City, UT 84116
telephone: 801-537-3300
website: geology.utah.gov

BACKGROUND AND PURPOSE

This report and accompanying database collate known cobalt mineral occurrences and geochemical data for the state of Utah. These data were compiled from the Utah Geological Survey's Utah Mineral Occurrence System database (UMOS), the National Uranium Resource Evaluation Hydrogeochemical and Stream Sediment Reconnaissance program (NURE-HSSR; U.S. Geological Survey, 2004) geochemical database, the U.S. Geological Survey National Geochemical Database (NGDB; U.S. Geological Survey, 2016), and the Utah Geochemistry Database (UGDB; unpublished internal Utah Geological Survey database). UMOS mineral occurrence data identifies known historical workings in which a cobalt-bearing mineral is described as a commodity at either a major, minor, or occurrence level. These minerals include erythrite ($Co_3(AsO_4)_2 \cdot 8H_2O$), cobaltzippeite ($Co(UO_2)_2(SO_4)O_2 \cdot 3.5H_2O$), skutterudite/smaltite ($CoAs_3$), cobalt-bearing psilomelane ($CoBa_2Mn_5O_{10}$), and bieberite ($CoSO_4 \cdot 7H_2O$). Geochemical data was filtered by concentration of cobalt, and a cut-off grade of 0.05 wt. % (500 ppm) was established as a threshold for cobalt anomalism. The mineral occurrence and geochemical data are presented "as is" from the original data source and no independent quality assurance or quality control has been conducted to verify accuracy (e.g., site visits, independent geochemical analyses, etc.). The database in both spreadsheet (MS Excel) and GIS geodatabase (.gdb) formats can be downloaded from: https://ugspub.nr.utah.gov/publications/open_file_reports/ofr-749/ofr-749.zip. A description of database fields for both mineral occurrence and geochemical data is given below and in the spreadsheet.

COBALT IN UTAH

Cobalt is classified as a critical mineral by the U.S. Department of the Interior due to the mineral's necessity to the United States' economic and national security and the vulnerability of the commodity to supply chain disruption (Slack and others, 2017; Burton, 2022). Cobalt consumption in the United States is primarily for superalloys used in the manufacture of turbine engines for both jet aircraft and domestic energy production. Secondary uses include wear-resistant tool components, metallurgical alloys, and various chemical applications (Mills and Rupke, 2023). As the United States moves toward more sustainable and green energy initiatives, cobalt demand will continue to increase. Future consumption of cobalt is closely linked to the domestic production of electric vehicles, namely the manufacture of lithium-cobalt-nickel-oxide cathode components in rechargeable batteries.

Globally, cobalt is most commonly produced as a co- or by-product of copper and nickel extraction in various ore deposits. These deposit types, with corresponding location and concentration ranges, include sediment-hosted copper deposits (Congo and Zambia, 0.026–1.08% Co), nickel laterites (Australia and Cuba, 0.078%–0.13% Co), and magmatic sulfide deposits (Australia and Canada, 0.05–0.1% Co) (Horn and others, 2021). For reference, the average upper crustal abundance of cobalt is 0.001% (Halley and others, 2015).

Utah's diverse geology and the presence of favorable deposit types suggests cobalt co- or by-product potential may exist; however, potential production is likely tied to the economics of a primary economic mineral(s) (e.g., copper). Plate 1 of this Open-File Report displays locations of both geochemical data with anomalous cobalt concentrations and known occurrences of cobalt-bearing minerals. Known cobalt occurrences exist within Utah's sediment-hosted copper and/or uranium-vanadium deposits of the Colorado Plateau. Isolated occurrences of cobalt can be found in base-metal and polymetallic vein deposits in the Big Cottonwood mining district, in association with iron deposits in the southern Uinta Mountains, and in anomalous, understudied occurrences identified across the Basin and Range Province in western Utah.

EXPLANATION OF DATABASE FIELDS

1 – UTMineralOccurrences_Co

MIN_OCC_ID – unique ID assigned to each UMOS cobalt mineral occurrence for this database.

PLATE_ID – unique ID assigned to each UMOS cobalt mineral occurrence for use in the map figure.

SITE_NAME – most recent or most well-known name of site.

DISTRICT – mining district (after Krahulec, 2018).

COMMODITY – listing of commodities present at the site; commodities are generally listed in order of importance.

MAJOR – major commodities produced.

MINOR – minor commodities or byproducts produced.

OCCURRENCE – commodities found at site but with no current or known economic significance.

COBALT – cobalt commodity significance at site based on mineral occurrence data.

TYPE – classification of primary commodity produced.

AGE_MA – age of mineralization in millions of years.

DEP_MODEL – genetic model of mineralization.

PRODUCTION – relative amount of production from site.

DEP_SIZE – relative size of deposit.

ORE_MINERALS – economic minerals produced.

NON_ORE_MINERALS – non-economic (gangue) minerals present.

ALTERATION – type and degree of alteration in host rocks.

DEP_TYPE – brief description of deposit type.

DEP_FORM – description of geometric form of deposit.

WORKINGS – category of workings.

WORK_DEPTH_FT – depth of workings in feet.

EXPLOR_COMMENTS – comments on exploration at location.

WORK_DESCRIPTIONS – description of workings.

LOCAL_STRUCTURE – local structural observations.

STRIKE – orientation of strike of bed.

DIP – angle and orientation of dip direction.

HR_AGE – age of host rock, qualitative.

HR_FORMATION – name of formation or member name and formation name.

HR_TYPE – classification of host rock.

IGNEOUS_AGE – age of igneous rock, qualitative.

IGNEOUS_NAME – classification of igneous rock.

IGNEOUS_TYPE – detailed classification of igneous rock.

MINERAL_AGE – age of mineralization, qualitative.

ORE_CONTROL – observations on controls of ore genesis.

COMMENTS – geological, historical production, and general comments.

LAND_STATUS – land jurisdiction of mineral rights.

OWNER – name of owner.

OPERATOR – name of operator.

REFERENCE1 – first reference.

REFERENCE2 – second reference.

REFERENCE3 – third reference.

REFERENCE4 – fourth reference.

TECTONIC_SETTING – related geological province within Utah.

REGIONAL_STRUCTURE – related regional geologic structure.

DISCOVERED – year of discovery.

DISCOVERY - type of discovery.

DISCOVERER – name of discoverer.

LOCATION – directional description of site location.

COUNTY – county name.

QUADRANGLE_24000 – U.S. Geological Survey 1:24,000-scale quadrangle name on which site is located.

AGENCY – Utah Geological Survey.

DATE – date of compilation into UMOS (YYYY MM).

REPRESENTATIVE – name of staff compiler.

UTM_E_NAD83 – Easting coordinate of site in UTM (Universal Transverse Mercator) meters.

UTM_N_NAD83 – Northing coordinate of site in UTM (Universal Transverse Mercator) meters.

UTM_ZONE – UTM Zone.

2 – UTGeochemistry_Co

SAMPLE_ID – unique ID assigned to each sample in UGDB.

PLATE_ID – unique ID assigned to each sample for use in the map figure.

SAMPLE_NAME – sample ID or name from original publication or report.

DATA_SOURCE – source of data.

Ag_ppm – concentration of silver in ppm.

Al_PCT – concentration of aluminum in weight percent.

As_ppm – concentration of arsenic in ppm.

Au_ppm – concentration of gold in ppm.

B_ppm – concentration of boron in ppm.

Ba_ppm – concentration of barium in ppm.

Be_ppm – concentration of beryllium in ppm.

Bi_ppm – concentration of bismuth in ppm.

Ca_PCT – concentration of calcium in weight percent.

Cd_ppm – concentration of cadmium in ppm.

Ce_ppm – concentration of cerium in ppm.

Co_ppm – concentration of cobalt in ppm.

Cr_ppm – concentration of chromium in ppm.

Cs_ppm – concentration of cesium in ppm.

Cu_ppm – concentration of copper in ppm.

Dy_ppm – concentration of dysprosium in ppm.

Er_ppm – concentration of erbium in ppm.

Eu_ppm – concentration of europium in ppm.

F_ppm – concentration of fluorine in ppm.

Fe_PCT – concentration of iron in weight percent.

Ga_ppm – concentration of gallium in ppm.

Gd_ppm – concentration of gadolinium in ppm.

Ge_ppm – concentration of germanium in ppm.

Hf_ppm – concentration of hafnium in ppm.

Hg_ppm – concentration of mercury in ppm.

Ho_ppm – concentration of holmium in ppm.

In_ppm – concentration of indium in ppm.

K_PCT – concentration of potassium in weight percent.

La_ppm – concentration of lanthanum in ppm.

Li_ppm – concentration of lithium in ppm.

Lu_ppm – concentration of lutetium in ppm.

Mg_PCT – concentration of magnesium in weight percent.

Mn_ppm – concentration of manganese in ppm.

Mo_ppm – concentration of molybdenum in ppm.

Na_PCT – concentration of sodium in weight percent.

Nb_ppm – concentration of niobium in ppm.

Nd_ppm – concentration of neodymium in ppm.

Ni_ppm – concentration of nickel in ppm.

P_PCT – concentration of phosphorus in weight percent.

Pb_ppm – concentration of lead in ppm.

Pr_ppm – concentration of praseodymium in ppm.

Rb_ppm – concentration of rubidium in ppm.

Re_ppm – concentration of rhenium in ppm.

S_PCT – concentration of sulfur in weight percent.

Sb_ppm – concentration of antimony in ppm.

Sc_ppm – concentration of scandium in ppm.

Se_ppm – concentration of selenium in ppm.

SiO2_PCT – concentration of silicon dioxide in weight percent

Sm_ppm – concentration of samarium in ppm.

Sn_ppm – concentration of tin in ppm.

Sr_ppm – concentration of strontium in ppm.

Ta_ppm – concentration of tantalum in ppm.

Tb_ppm – concentration of terbium in ppm.

Te_ppm – concentration of tellurium in ppm.

Th_ppm – concentration of thorium in ppm.

Ti_PCT – concentration of titanium in weight percent.

Tl_ppm – concentration of thallium in ppm.

Tm_ppm – concentration of thulium in ppm.

U_ppm – concentration of uranium in ppm.

V_ppm – concentration of vanadium in ppm.

W_ppm – concentration of tungsten in ppm.

Y_ppm – concentration of yttrium in ppm.

Yb_ppm – concentration of ytterbium in ppm.

Zn_ppm – concentration of zinc in ppm.

Zr_ppm – concentration of zirconium in ppm.

DISTRICT – mining district (after Krahulec, 2018).

PROPERTY – most recent or well known site name.

NOTES – description; citation; organization.

UTM_E_NAD83 – Easting coordinate of site in UTM (Universal Transverse Mercator) meters.

UTM_N_NAD83 – Northing coordinate of site in UTM (Universal Transverse Mercator) meters.

UTM_ZONE – UTM Zone.

ACKNOWLEDGMENTS

Preparation of this report and accompanying database was funded, in part, by a U.S. Geological Survey National Geological and Geophysical Data Preservation Program grant (GS22AS00033).

Data contributions to UGDB provided by Western Cobalt LLC and CoCo Resources LLC (see Mendenhall and Ure, 2019 and Proctor and Proctor, 2021).

REFERENCES

Burton, J., 2022, U.S. Geological Survey releases 2022 list of critical minerals: Online, https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals, accessed April 2023.

Halley, S., Dilles, J.H., Tosdal, R.M., 2015, Footprints—Hydrothermal alteration and geochemical dispersion around porphyry copper deposits: SEG Newsletter, no. 100, p. 11–17, https://doi.org/10.5382/SEGnews.2015-100.fea.

Horn, S., Gunn, A.G., Petavratzi, E., Shaw, R.A., Eilu, P., Tormanen, T., Bjerkgard, T., Sandstad, J.S., Jonsson, E., Kountourelis, S., and Wall, F., 2021, Cobalt resources in Europe and the potential for new discoveries: Ore Geology Reviews, v. 130, 25 p., https://doi.org/10.1016/j.oregeorev.2020.103915.

Krahulec, K., 2018, Utah mining districts: Utah Geological Survey Open-File Report 695, 196 p., 1 plate, https://doi.org/10.34191/OFR-695.

Mendenhall, A. and Ure., M., 2019, Cobalt One–Vernon Hills, Utah: Utah, unpublished consultant's report for Western Cobalt LLC, 6 p.

Mills, S.E. and Rupke, A., 2023, Critical minerals of Utah, second edition: Utah Geological Survey Circular 135, 47 p., https://doi.org/10.34191/C-135.

Proctor, D. and Proctor, N., 2021, Colt Mesa Project—Garfield County, Utah: Utah, unpublished consultant's report for CoCo Resources LLC, 8 p.

Slack, J.F., Kimball, B.E., and Shedd, K.B., 2017, Cobalt, chap. F of Schulz, K.J., DeYoung, J.H., Jr., Seal, R.R., II, and Bradley, D.C., editors, Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply: U.S. Geological Survey Professional Paper 1802, p. F1–F40, https://doi.org/10.3133/pp1802f.

U.S. Geological Survey, 2004, National uranium resource evaluation (NURE) hydrogeochemical and stream sediment reconnaissance data: Online, https://mrdata.usgs.gov/nure/, accessed February and March 2023.

U.S. Geological Survey, 2016, National geochemical database: Online, https://mrdata.usgs.gov/ngdb/, accessed February and March, 2023.

UTAH GEOLOGICAL SURVEY
a divison of
Utah Department of Natural Resources

Plate 1
Utah Geological Survey Open-File Report 749
Cobalt Database of Utah

Cobalt Occurrences in Utah

2023

Jake Alexander

Scale 1:1,000,000

Modified from: Krahulec, K., 2018, Utah mining districts: Utah Geological Survey Open-File Report 695, 196 p., 1 plate, https://doi.org/10.34191/OFR-695.

0 20 40 60 80 100 Km

0 20 40 60 80 100 Miles

Regional Geologic Feature

Geologic Province Boundary

Mining District

District Name (Primary Commodities)

Cobalt Occurrence Type

Hydrothermal Replacement/Vein

Sediment Hosted

Cobalt Geochemistry

Co (ppm) 500-1500

Co (ppm) 1500-3000

Co (ppm) >3000

1 **Cobalt Mineral Occurrences:** 1-Dyer Mine, 2-Colt Mesa Mine, 3-Happy Jack Mine, 4-Newman and Afton Groups Mines, 5-Rainy Day Mine, 6-Cobalt #1, 7-Cobolt #1, 8-Paint Mine, 9-Emma Mine, 10-Iron Mountain Mine, 11-Ferry Iron Mine, 12-Little Erma Mine, 13-King Edward Mine, 14-Avalanche #13, 15-Spanish Trails, 16-Ryan 101, 17-Granite Canyon Adit, 18-Castle Peak Draw Prospect, 19-Great Basin East, 20-Lucky Strike #2 Mine.

(1) **Cobalt Geochemistry (ppm):** 1- 860, 2- 2000 3- 510, 4- 500, 5- 500, 6- 621, 7- 578, 8- 1295, 9- 1500, 10- 1000, 11- 2010, 12- 2000, 13- 24254, 14- 904, 15- 721 , 16- 500, 17- 500, 18- 500, 19- 500, 20- 700, 21- 3630, 22- 2740, 23- 830, 24- 810, 25- 6060, 26- 4230, 27- 3750, 28- 1420.