Bruce and Silver Spoon Mines, Darwin Mining District, Dawin Hills, Inyo County, California

Gregg Wilkerson, 2024

Acknowledgement and Disclaimer

The information in this paper is taken largely from published and public sources. I have reproduced this material and present it pretty much as we found it, not trying to harmonize discrepancies in mine or geologic descriptions. I have changed verb tenses for readability and have used some paraphrase. I have expanded abbreviations or special characters with full text (e.g. feet instead of ft., inches instead of ") Italics indicate quotations. Authors of the original information are indicated at the end of each paragraph. Paragraphs without a citation are our own materials. The maps in this report have been compiled and rectified from digital and paper copies of original sources that were made at different scales and in different geographic projections. Therefore, many of the maps had to be adjusted or stretched. They do not fit perfectly. Most are accurate to within 100 feet, but reproduction and projection errors can be as much as 300 feet for some maps. PLSS means Public Land Survey System. That survey data was obtained from the U.S. Bureau of Land Management website.

MRDS, 2011, Mineral Resources Data System, U.S. Geological Survey, https://mrdata.usgs.gov/mrds/. This database relies on records that, in many cases, are inaccurate or imprecise. For example, if a report describes a mine as being in "Section 9", with no other information, MRDS plots the mine location in the center of the section. If a mine is reported in "SW ¼" of a section, MRDS plots the mine in the center of that SW quarter-section. Where I could confidently adjust an MRDS location of a mineral deposit to features identifiable in aerial photographs or topographic maps, I did so.

Help me make this report better. If you have any photographs, memories or reports for this mine that you can share, please send them to yosoygeologo@gmail.com so that I can incorporate that information and material into this paper.

Italics are quotations.

Location:

Bruce	T19S, R41E, Sec. 18 MDM:	36.28107	-117.5823
Silver Spoon:	T19S, R41E, Sec. 30 MDM:	36.24967	-117.5673

The Bruce and Silver Spoon Mines are in the Darwin Mining District. The Bruce mine is in the central Darwin Hills. The Silver Spoon is in the southern part of the Darwin Hills. The Bruce and Silver Spoon Mines are in the Darwin District. They are southeast of Owens Lake and north of the Coso Mountains.

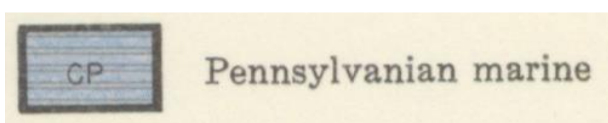
Darwin Mining District:

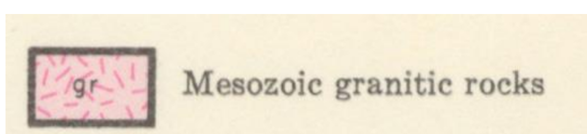
A recent compilation of information on the Darwin Mining District was made by Wilkerson (2021). Below is a summary of that work:

The Darwin lead-silver-zinc district comprises the area of the Darwin Hills within the Darwin Plateau of west central Inyo County, California. The district has a long and colorful history. The district was explored in the 1860's and discovered in 1875. Silver was mined from galena skarns and veins pre-WWI During WWI it was an important lead zinc producer. During WWII it was a principal supplier of silver for aerial photography. The mine then began exploring for tungsten. In 1982 Anaconda took concentrates with 60% tungsten to the Pine Tree mine northwest of Bishop, California for processing. In the 1990's Anaconda considered a large open pit low grade heap leach operation at Darwin. This idea was thwarted by the lack of enough water (75 million gallons per year) to sustain such an operation. Today the mine produces precious and base metals (mainly zinc) and tungsten with by-product germanium, tellurium and indium. The district has produced over $29 million in lead, silver, zinc, tungsten, and copper. Ore bodies occur as structurally controlled replacement and fissure filling deposits within a contact metamorphic calc-silicate aureole. This aureole developed within Keeler Canyon Formation limestones surrounding the intrusive Darwin quartz monzonite stock. While there were many mines and prospects within the Darwin District, most of the district's production has come from the larger and more important workings on the west side of the Darwin Hills which were ultimately consolidated and operated by the Anaconda Company as the Darwin Mine. These included the Bernon, Defiance, Essex, Independence, Intermediate, Rip Van Winkle and Thompson workings. Paleozoic rocks on the east side of the Darwin Hills also harbor several smaller tungsten deposits which have been sporadically developed in years past. The district is zoned and reflects its production history: silver, then lead, then zinc, then tungsten. Anaconda geologists believed the epithermal hydrothermal mineralization was related to a deep tungsten porphyry and explored it with a 2,200-foot-deep core drilling program. This core revealed a zone 188 feet averaging 3.6% zinc and another 20 ft zone averaging 10% zinc. The origin of the deposits was initially interpreted as skarn deposits due to the spatial association of ore bodies to the Darwin Stock. Later studies showed the stock was much older than the mineralization. Many deposits are formed through replacement and some are related to breccia pipes. The spatial association with the Darwin Stock is explained as early ground preparation through creation of a calk-alkaline contact metamorphic aureole. The aureole was later preferentially cut by faults and mineralizing breccias to form a wide variety of ore body types. Currently the Darwin Mine is expanding its workings to develop hydrozincite ores from areas of the mine that were avoided during earlier mining phases because of the difficulty in beneficiating them. They currently have a 5 ton per day pilot plant for testing various beneficiation scenarios. As mining continues deeper ore tenor is 50 to 170 ppm Au and Ag and lead values decrease while zinc values increase. Ore in fault zones is dry and crumbly. It falls out of the veins like powder. This powder is hand-processed and put into barrels. Ore is ground to 80 mesh and placed is a tank with 13% sulfuric acid. The acid extracts 90%of the zinc in 30 minutes. Tailings from the mill are mainly calcite and silica. Germanium stays with the silver. The leachate is then put through a membrane filter at 250 psi to recover water. The Zinc sulphate solution is 12.5% to 14.0% zinc. It is recovered in a spray dryer for fertilizers. By products are processed by Umicor to extract germanium, tellurium, vanadium, indium and zinc oxides from materials that include spodumene. The ores also contain 380 ppm manganese, and these are refined by World Industrial Minerals to produce a 24% product. Outside of the Darwin breccia pipes there are 15 million tons of proven zinc ores. Beneficiation includes a Damler 2426 duplex jig from which bulk gravity concentrates are produced that run 5 to 13 pounds of tungsten per ton. The tungsten concentrates are re-ground to a finer size for flotation. In the floatation cells, barite is separated. Tungsten remains in the vat. The zinc oxides are not floated. They have a 70% recovery, and only account for a small portion of the current production. Tailings are dewatered and returned underground as dry compacted backfill. The Darwin Mine has plans to commission a new plant to process 150 tons per day oxide ores and 350 tons per day sulfide ores. Their process manufactures sulfuric acid and excess heat. That heat will be converted to electricity through a heat exchanger and turbine to power the mine and plant. This operation, when approved, could employ 350 people. The projected profit margin for the present operation is 78%. The present operation acquired permits to operate after three decades of regulatory oversight. The main regulatory concerns for re-opening the mine, which is mostly on patented land, were the impacts that would accrue to historic mining structures and artifacts. Those concerns were satisfied when the current operator agreed to place its modern beneficiation equipment inside restored historic buildings.

Area Geology

The Darwin Hills are composed of Pennsylvanian marine rocks that are intruded by Mesozoic granite (Jennings, 1958):

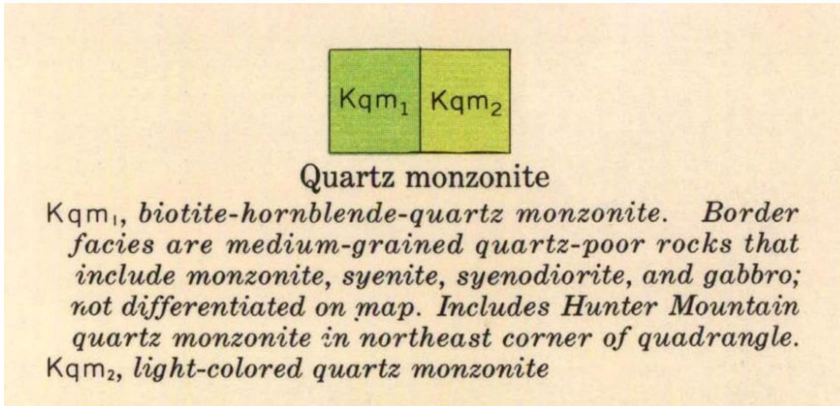


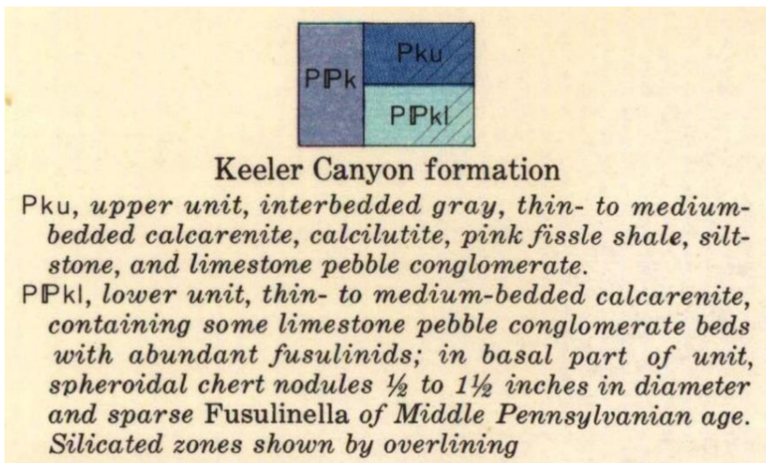


Mine Geology

Bruce Mine

Hall and MacKevette (1962) mapped the area of the Bruce Mine as near a contact between Cretaceous Quartz Monzonite and Permian-Pennsylvanian Keeler Formation. The mine location is controlled at this contact by a east-west striking fault.





Silver Spoon Mine

The Silver Spoon Mine is at the southern edge of Hall and MacKevette's (1962) map of the Darwin Quadrangle. That map indicates that the Silver Spoon Mine is located within the Keeler Canyon formation at the contact between the upper and lower units of that formation. Jayco's 1:100,000 scale map of the Darwin Quadrangle shows it to be at the north side of a Jurassic-Cretaceous granite intrusive.

Mineralogy

Mindat.org (2024) describes ore minerals at Darwin:

Supergene Minerals:

The Darwin ores are largely oxidized to considerable depth except where they are protected by a shallower impermeable layer. Extensive near surface leaching of zinc, sulfur, and iron from the primary *argentiferous galena and sphalerite ores have produced high grade oxidized ore that occurs in a crumbly porous mass composed of limonite, hemimorphite, cerussite, anglesite, plumbjarosite with some altered and unaltered relicts of galena. Anglesite forms a thin alteration halo around much of the galena. Native silver, cerargyrite, and sooty argentite also occur. Some of the early near surface oxidized ore in the Darwin District is said to have run 950 ounces of silver per ton. In the Defiance workings, the ore was almost completely oxidized to the 400 foot level with both oxide and primary ore extending from the 400 foot level to below the 1,000 foot level. In the Lucky Jim Mine, only small relicts of primary sulfides were found in the deeper workings below 900 feet. Secondary copper minerals accompany the secondary lead and zinc minerals and include aurichalcite, azurite, bronchantite, cledonite, chrysocolla, linarite, and malachite.*

Hypogene ore minerals

The hypogene ore and sulfide minerals consist principally of galena, sphalerite, pyrite, pyrrhotite, and chalcopyrite with minor tetrahedrite, scheelite, andorite, franckeite, and stannite. Argentiferous galena is the chief lead and silver ore mineral. It ranges in texture from fine to coarsely crystalline masses. Corroded inclusions of tetrahedrite, pyrrhotite, and chalcopyrite are common. Sphalerite is the chief zinc ore mineral and often occurs in coarse crystalline masses with cleavage faces 1-2 inches in diameter. Pyrite is abundant in both the lead-zinc deposits and throughout the country rock. Pyrrhotite is most common in the deep levels of the Thompson workings where it often occurs in a banded structure with galena and sphalerite. Chalcopyrite is a minor constituent of the ore and occurs as corroded inclusions in sphalerite and galena (Minedat.org, 2024).

Minerals that Bruce Bridenbecker and I found at the accessible mine dumps and workings are:

malachite
epidote
calcite
iron oxides
jasper
No sulfides

A list of all minerals known to be at Darwin is found in Appendix A.

Origin

The origin of the Darwin deposits was initially interpreted as skarn deposits due to the spatial association of ore bodies to the Darwin Stock. Later studies showed the stock was much older than the mineralization. Many deposits are formed through replacement, and some are related to breccia pipes. The spatial association with the Darwin Stock is explained as early ground preparation through creation of a calk-alkaline contact metamorphic aureole. The aureole was later preferentially cut by faults and mineralizing breccias that introduced ore fluids into the system to form a wide variety of ore body types.

Development

Both the Bruce and Silver Spoon were developed by shafts and trenches. At the Silver Spoon there are several surviving underground workings with ladders.

PHOTOGRAPHS

Bruce Mine

Figure 1. Bruce Mine. Photo by Gregg Wilkerson, February 2024.


Figure 2. Ore specimen, Bruce Mine. Photo by Gregg Wilkerson, February 2024.

Figure 3. Oxidized boxsworks formation, Bruce Mine. Gregg Wilkerson, February 2024.

Figure 4. Jasperoid materials, Bruce Mine. Gregg Wilkerson, February 2024

Silver Spoon Mine

Figure 5. Ruins of the Silver Spoon Mine. Gregg Wilkerson, February 2024

Figure 6. Underground workings of the Silver Spoon Mine. Gregg Wilkerson, February 2024.

Figure 7. Calcite and quartz specimen from the Silver Spoon Mine. Gregg Wilkerson, February 2024.

Figure 8. Breccia with cerargyrite (?), Silver Spoon Mine. Gregg Wilkerson, February 2024

Figure 9. Unidentified minerals at the Silver Spoon Mine. Gregg Wilkerson, February 2024.

Figure 10.Ore shoot and ruins of the Silver Spoon Mine. Gregg Wilkerson, February 2024.

Figure 11. Adit at the Silver Spoon Mine. Gregg Wilkerson, February 2024

REFERENCES AND BIBLIOGRAPHY

Greene, Linda I., 1989, U.S. National Park Service, Historic Preservation Branch, Pacific Northwest/Western Team, Denver Service Center, Death Valley – Historic Resource Study – A History of Mining, Volume I (Parts 1 and 2): part 2: III.C.2.g).

Hall, W.E., 1958, Structure and ore deposits of the Darwin quadrangle, Inyo County, California: U.S. Geological Survey, Open-File Report OF-58-42, scale 1:40,000; https://ngmdb.usgs.gov/Prodesc/proddesc_7944.htm

Hall, W.E. and MacKevett, E.M., 1958, Economic geology of the Darwin quadrangle, Inyo County, California, California Division of Mines and Geology, Special Report 51, 73 p. For Talc Hills see p. 67-72.

Hall, W.E., and MacKevett, E.M., 1962, Geology and ore deposits of the Darwin quadrangle, Inyo County, California: U.S. Geological Survey, Professional Paper 368, p. 80, scale 1:48,000; https://ngmdb.usgs.gov/Prodesc/proddesc_4363.htm

Jayko, A.S., 2010, Surficial geologic map of the Darwin Hills 30' x 60' quadrangle, Inyo County, California: U.S. Geological Survey, Scientific Investigations Map SIM-3040, scale 1:100,000; https://ngmdb.usgs.gov/Prodesc/proddesc_93779.htm

Jennings, C.W., 1958, Geologic map of California: Death Valley sheet: California Division of Mines and Geology, Geologic Atlas of California GAM-04, scale 1:250,000.

Merriam, Charles Warren, 1963, Geology of the Cerro Gordo mining district, Inyo County, California, U.S. Geological Survey Professional Paper 408, Plate 2: Southern part of the New York Buttes Quadrangle.

Mindat.org, 2024, Darwin District. https://www.mindat.org/loc-23498.html

MRDS, 2011, Mineral Resource Data System, U.S. Geological Survey; https://mrdata.usgs.gov/mrds/

Murdoch, Joseph and Robert W. Webb,1966, Minerals of California, Centennial Volume (1866-1966): California Division Mines & Geology Bulletin 189: 280.

National Park Service, 2024, Death Valley: Historic Resources Study, Section III, Inventory of Historical Resources the West Side; https://www.nps.gov/parkhistory/online_books/deva/section3a7.htm accessed March 4, 2024.

Norman, L.A., and Stewart, R.M., 1951, Mines and mineral resources of Inyo County: California Journal of Mines and Geology, v. 47, no. 1, p. 114-121.

Page, Ben M., 1951, Talc Deposits of Steatite Grade, Inyo County, California, California Division of Mines and Geology, Special Report 8, p. 1-19..

Pemberton, H. Earl, 1983, Minerals of California; Van Nostrand Reinholt Press, p. 417.

Rapp. J.S., M.A. Silva, C.T. Higgins, R.C. Martin and J.L. Burnett, 1990, Mines and Mineral Producers Active in California 1988-1989, California Division of Mines and Geology, Special Publication103, 160 p. and map.

Sampson, E., 1923, U. S. Geological Survey, Mineral Resources for1920, part II, pp. 203 - 204. Describes the talc and its technology.

Stone, Paul, Dunne, G.C., Stevens, C.H., and Gulliver, R.M., 1989, Geologic map of Paleozoic and Mesozoic rocks in parts of the Darwin and adjacent quadrangles, Inyo County, California: U.S. Geological Survey, Miscellaneous Investigations Series Map I-1932, scale 1:31,250; https://ngmdb.usgs.gov/Prodesc/proddesc_485.htm

Stone, Paul, Stevens, C.H., and Orchard, M.J., 1991, Stratigraphy of the Lower and Middle(?) Triassic Union Wash Formation, east-central California [Darwin area]: U.S. Geological Survey, Bulletin 1928, scale 1:29,000; https://ngmdb.usgs.gov/Prodesc/proddesc_22144.htm

Streitz, Robert, and Stinson, M.C., 1974, Geologic map of California: Death Valley sheet: California Division of Mines and Geology, Geologic Atlas of California GAM-04, scale 1:250,000.

Tucker, W. B., 1938, California Division of Mines Report 17, pp. 300-30. Gives geological notes. Refers to mine as Simonds Talc mine.

Tucker, W. B., 1926, California Division of Mines Report 22, pp. 523-524, 1926. Two paragraphs on geology and development.

Tucker, W. B., and Sampson, R. J., 1938, California Division of Mines Report 34, pp. 492-495. Very brief statement.

U.S. Geological Survey (2005), Mineral Resources Data System (MRDS): U.S. Geological Survey, Reston, Virginia, Local File ID 10252247.

Larry M. Vredenburgh, Larry M, Gary L. Shumway, Russell D. Hartil, Desert Fever, The Living West, Canoga Park, 323 p.

Waring, C. A., and Huguenin, E., 1919, California Division of Mines Report15, pp. 126-127. Report includes a reconnaissance geologic map of Inyo County

Wilkerson, Gregg, 2022, Geology and Mining History of the Darwin District Inyo County California: A compilation; https://www.academia.edu/88441633/Geology_and_Mining_History_of_the_Darwin_District_Inyo_County_California_A_compilation

Whitmarsh, R.S., 1998, Geologic map of the Coso Range [including Cactus Peak, Centennial Canyon, Coso Junction, Coso Peak, Haiwee Reservoir, Little Lake, Louisiana Butte, Petroglyph Canyon, Talc City Hills, Upper Centennial Flat, Vermillion Canyon, and Volcano Peak quadrangles, Inyo County, California]: Geological Society of America, scale 1:24,000; https://ngmdb.usgs.gov/Prodesc/proddesc_99995.htm

MAPS

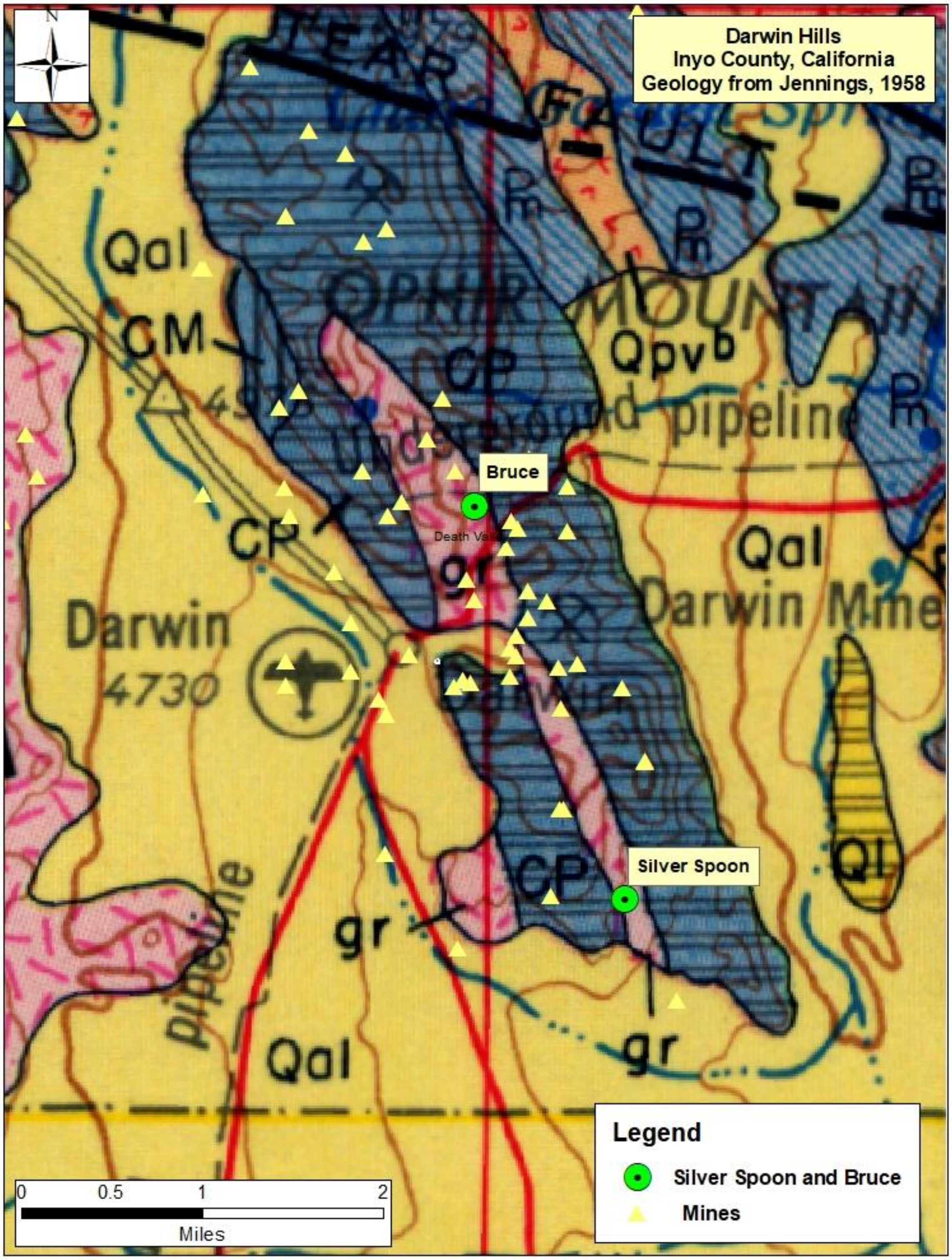


Figure 12. Geologic map of the Darwin Mining District.

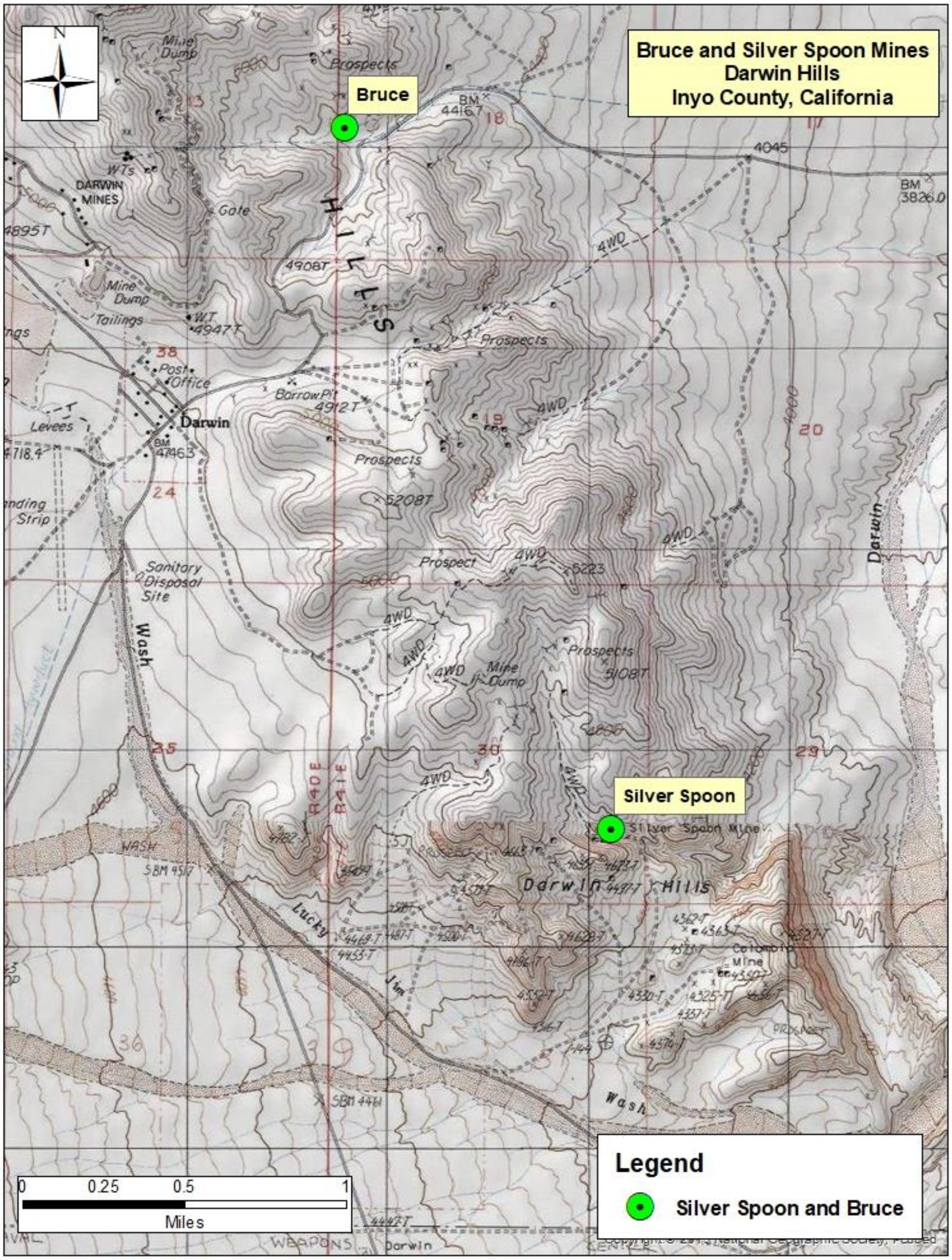


Figure 13. Topographic map of the Darwin Mining District showing locations of the Bruce and Silver Spoon Mines.

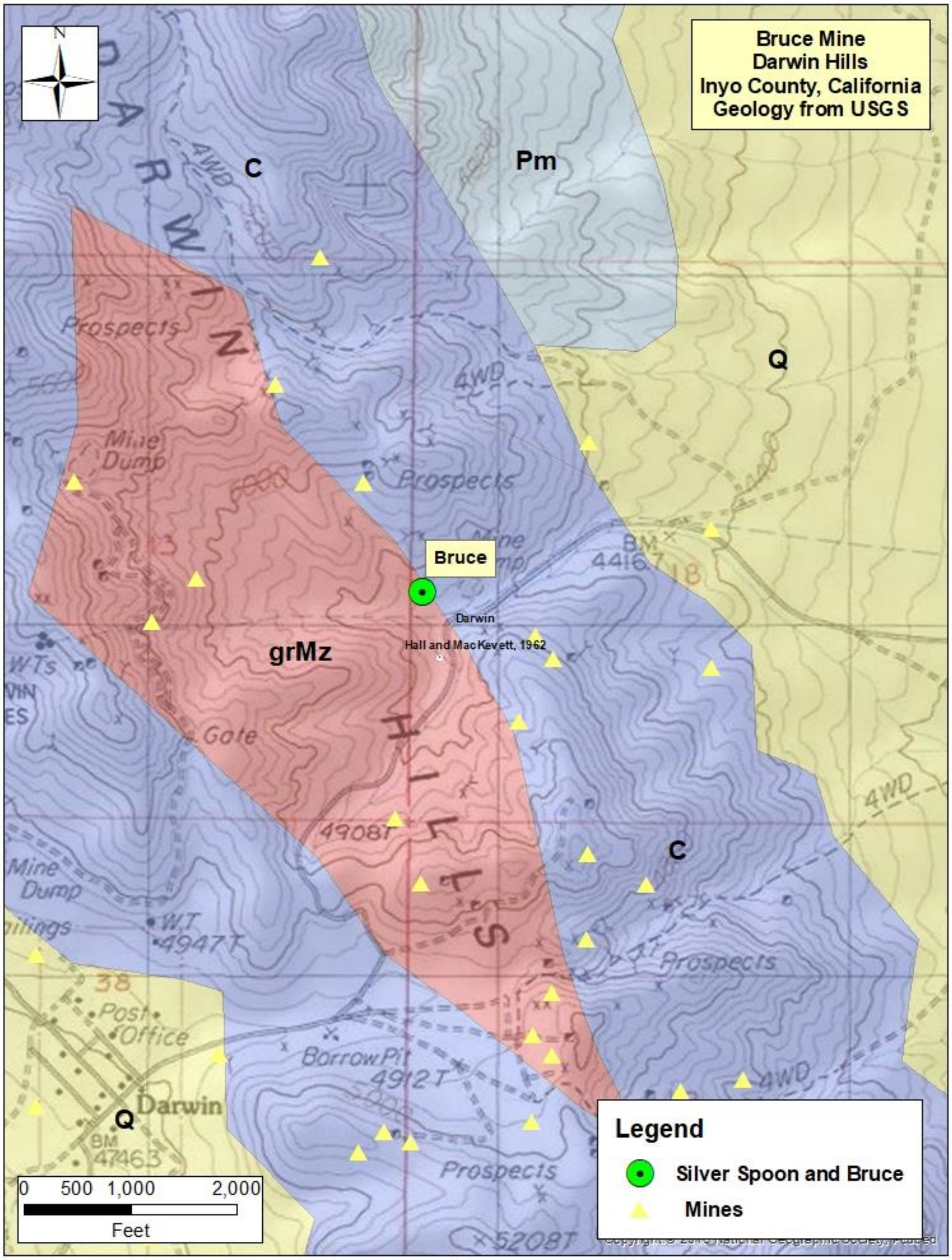


Figure 14. Generalized geologic map of the Bruce Mine and surrounding areas.

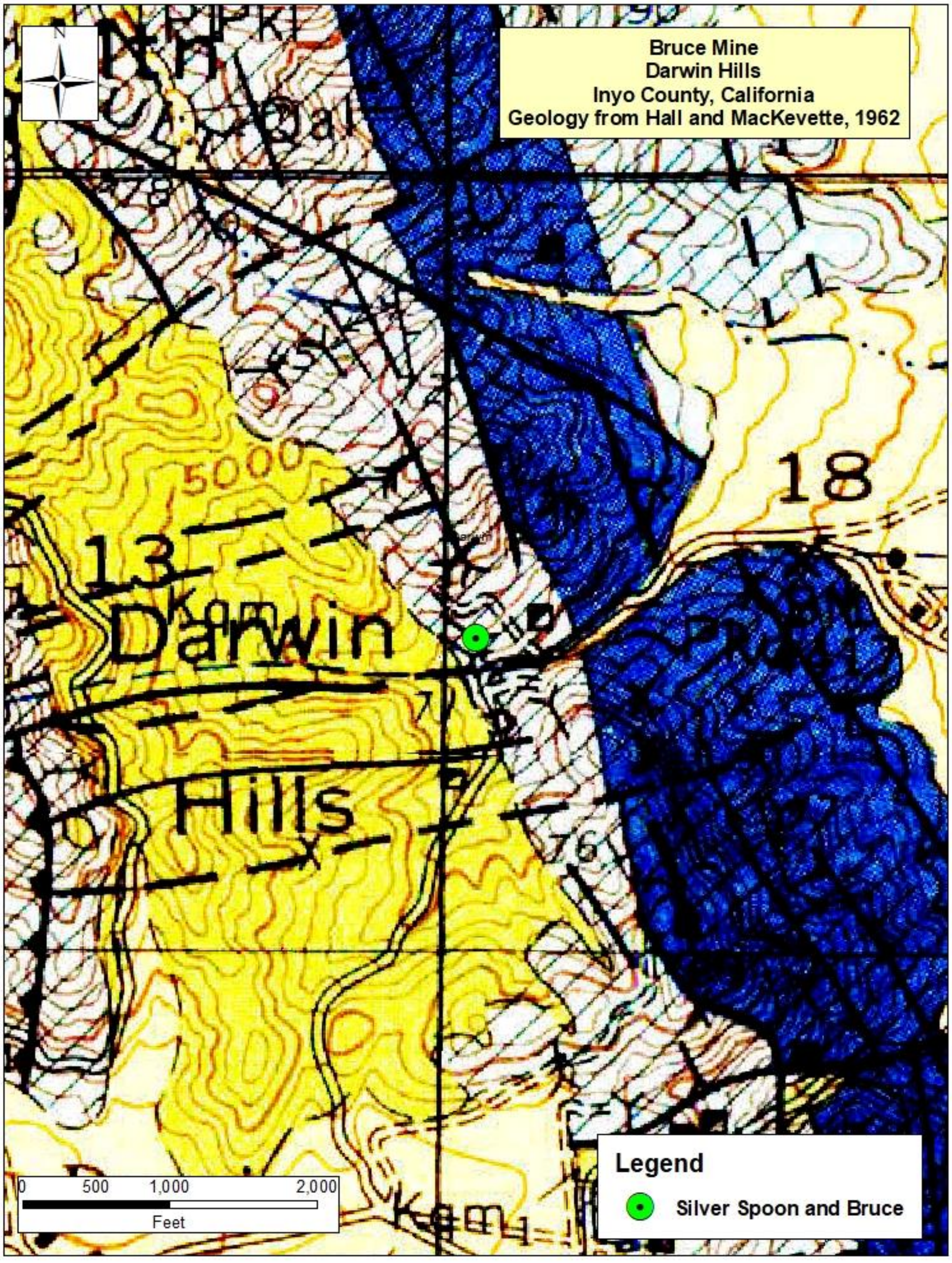


Figure 15. Geologic map of the Bruce Mine and surrounding area.

Figure 16. Aerial photo of the Bruce Mine.

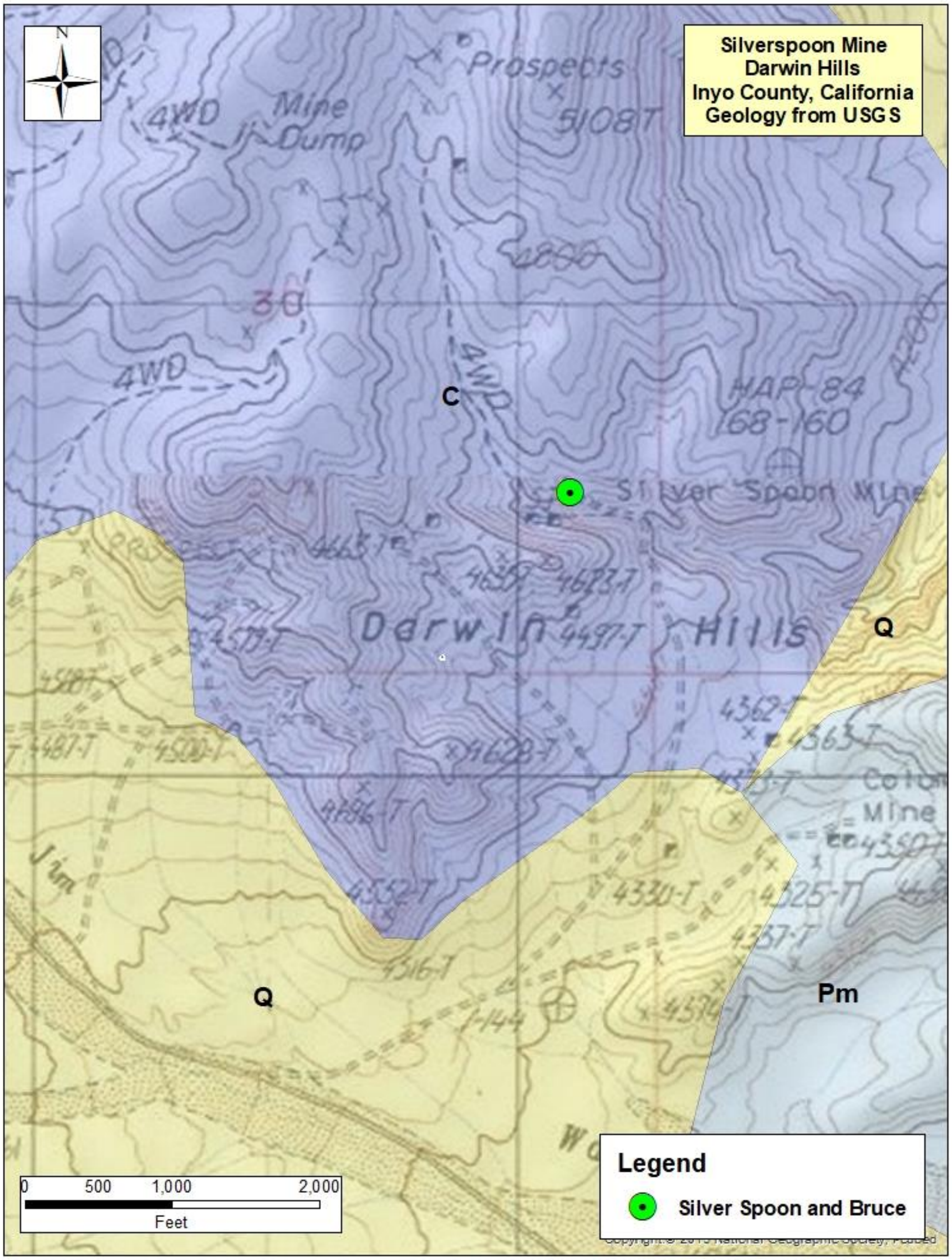


Figure 17. Generalized geologic map of the Silver Spoon Mine and surrounding area.

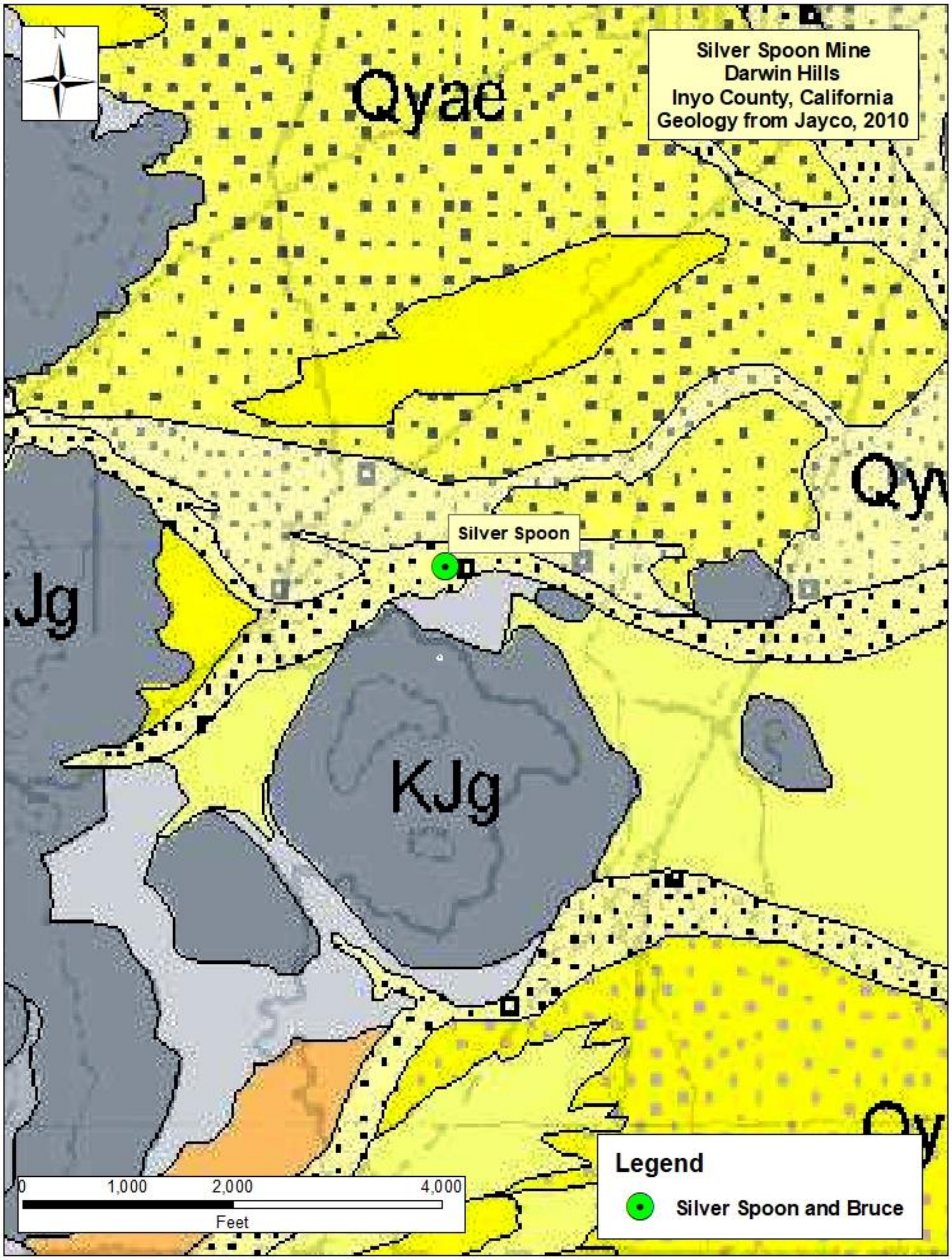


Figure 18. Geologic map of the Silver Spoon Mine.

APPENDIX A: Darwin Minerals

Acanthite
Andorite'
Andradite
Andradite-Grossular Series'
Anglesite
Anhydrite
Antlerite
Apatite'
Aragonite
Arsenopyrite
Augite
Aurichalcite
Autunite
Azurite
Baryte
Bindheimite'
Bismuth
Bismuthinite
Bismutite
Bornite
Boulangerite ?
Braunite
Brochantite
Calcite
var. Iceland Spar
Caledonite
Cerussite
Cervantite
Chalcanthite
Chalcocite
Chalcopyrite
Chlorargyrite
Chrysocolla
Chrysotile
Clausthalite
Clay minerals'
Clinochrysotile'
Clinozoisite
Conichalcite
Copper Stain'
Cosalite
Covellite
Creedite
Crocoite
Cuprite
Cupropavonite
Deweylite'
Diopside
Enargite
Epidote
Eskimoite
Famatinite
Fluorite
Franckeite
Friedrichite
Galena
var. Silver-bearing Galena
Galenobismutite
Garnet Group'
Gehlenite
Geocronite
Goethite
Gold
var. Electrum
Goslarite
Grossular
Guanajuatite
Gustavite
Gypsum; var. Selenite
Hematite
Hemimorphite
Heyrovskýite
Hydrohalloysite
Hydrozincite
Jarosite
Jasper'
Junoite
Kettnerite
Krupkaite
Larnite
Leadhillite
Limonite
Linarite
Litharge
Luzonite
Magnetite
Malachite
Massicot
Matildite
Melanterite
Metacinnabar
Mimetite
Minium
Montmorillonite
Muscovite
var. Sericite
Neyite
Opal
var. Opal-AN
Orthoclase
Pavonite
Plumbojarosite
Powellite
Pseudomalachite
Pyrite
Pyrolusite
Pyromorphite
Pyrrhotite
Quartz
Rickardite
Rosasite
Scheelite
Schirmerite'
Selenium
Senarmontite
Serpierite
Siderite
Silver
Smithsonite
Sphalerite
Spurrite (TL)
Stannite
Stibiconite'
Stibnite
Stolzite
Sulphur
Tennantite Subgroup'
Tenorite
Tetradymite
Tetrahedrite Subgroup'
Titanite
Tourmaline'
Tremolite
Tungstite
UM1975-21-Te:BiPbSSe'
Valentinite
Vanadinite
Vesuvianite
Vikingite
Vivianite
Wollastonite