Stirling Mine, Spring Mountains, Clark County Nevada

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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 my own observations. 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 a 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.

LOCATION (MRDS, 2011)

T.17S R.53E Sec 12	36.49108	-115.9586

The Stirling mine is within the Johnnie mining district (Tingley, 1998).

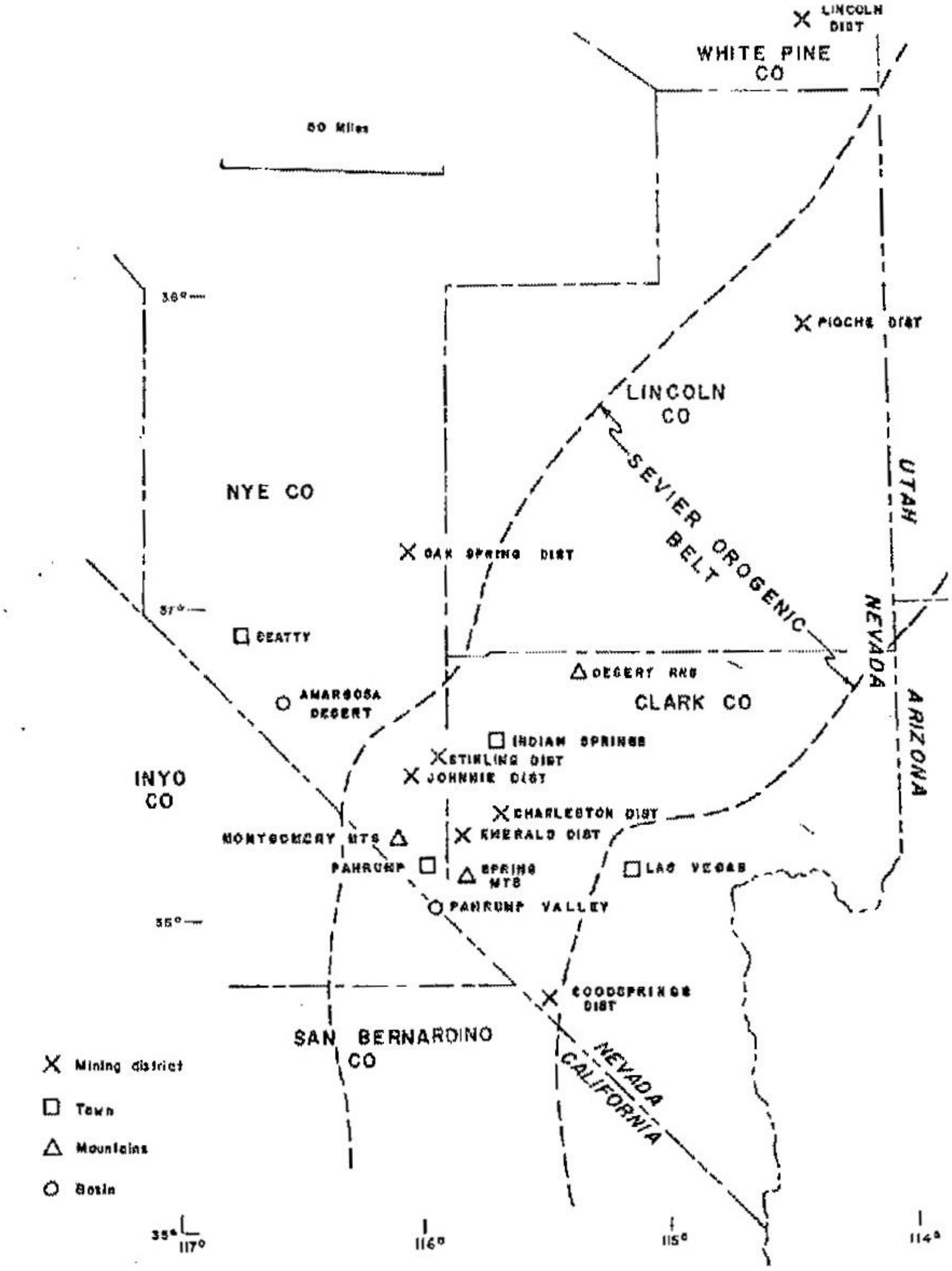


Figure 1. Index map of southern Nevada and adjacent areas showing locations of areas discussed in this report. Position of Sevier orogenic belt after Armstrong (1968) and Fleck (1970).

Figure 1. Location map of the mines in the Sevier Orogenic Belt. From Ivosivic, 1976, p. 2. Open source for educational purposes, no copyright.

PREVIOUS NAMES

HISTORY AND OWNERSHIP

REGIONAL GEOLOGY

The regional geology of the central Spring Mountains is described in the overview paper for this report series. It can be accessed at

http://www.greggwilkerson.com/spring-mnts-central.html

STRATIGRAPHY

Icosevic’s 1976 stratigraphic tables for the Johnnie District are reproduced from the Nevada Bureau of Mines website below:

Table 1. Stratigraphic units present in the Johnnie district showing, in parentheses, subdivisions recognized by Stewart (1966, 1970).

Age	Name		Thickness (feet)	Character
Holocene		Alluvium	0-20 ± (0-6 m)	Colluvium, talus, stream bedloads
Late Pleistocene to Holocene		Younger fanglomerate	0-100 + (0-30 m)	Inactive alluvial fans of compact sand and gravel
Late Pliocene to Middle Pleistocene		Older fanglomerate	0-200 + (0-60 m)	Dissected, consolidated to caliche-cemented sandy gravel; includes a 50'-thick unit of volcanic sediments
		Megabreccia unit	300 ± (90 m)	Tabular body of slabs of upper unit of Wood Canyon Formation, quartz-veined Zabriskie Quartzite, and lower part of Carrara Formation
		Unconformity		
Middle Cambrian	Bonanza King Formation	Papoose Lake member	1,200 ± (365 m)	Massive dolomite with lamellar texture
Early and Middle Cambrian		Carrara Formation	700-1,300 (210-400 m)	Thin- to medium-bedded shaly rocks near base; thick-bedded limestone predominates near top
Early Cambrian		Zabriskie Quartzite	115-240 (35-73 m)	Medium-bedded to massive quartzite

Table 1. (continued)

Late Precambrian and Early Cambrian	Wood Canyon Formation	Dolomite bearing unit (upper member, in part)	175-310 (53-94 m)	Medium-bedded dolomite and thin-bedded quartzite and siltstone
		Lower unit (lower member; middle member; upper member, in part)	1,680 (510 m)	Medium-bedded quartzite and siltstone with some dolomite
Late Precambrian	Stirling Quartzite	Upper unit (C member; D member; E member)	2,160 (659 m)	Medium-bedded quartzite and dolomitic quartzite; shale at base; thick, massive quartzite near top
		Lower unit (A member; B member)	2,080 (634 m)	Medium-bedded to massive quartzite; thick, massive unit near base
	Johnnie Formation	Upper unit (middle unit, in part; Rainstorm Member)	850-1,300 (260-395 m)	Thin- to medium-bedded shale and quartzite with several layers of brown-weathering dolomite and dolomitic quartzite
		Lower unit (lower unit; middle unit, in part) - base not exposed	2,900-3,300 (800-1002 m)	Medium- to thick-bedded shale and quartzite; layer of gray dolomite 650' below top

The main units in the area of the Stirling Mine are:

Lower and Middle Cambrian Carrara Formation (€c)
Cambrian and Proterozoic Wood Canyon Formation (€p€w)
Lower Cambrian and Late Proterozoic Woods Canyon Formation (€Zw)

MINE GEOLOGY

At least two main quartz veins up to 10 ft thick strike northeast, have various dips, and are traceable for at least 1,000 ft in metasedimentary rocks, probably of the Cambrian Wood Canyon Formation. The quartz veins are parallel and about 800 ft apart. The quartz is locally brecciated, iron-oxide stained, and contains traces of malachite, chalcopyrite, and galena. Nolan (1924) stated that the main quartz vein is traceable for several miles (Conyac, 1985, Table 1, Map No. 1).

[In the Johnnie District] *The gold occurs in prominent and persistent quartz veins along faults in sandstone , shale, and limestone of the Wood Canyon and Carrara Formations. The largest ore shoots are in the Johnnie mine, where the vein follows a fault between the two formations* (Corwall, 1972:38).

Mapping by Workman and others (2002, Figure 17 this report) shows the Johnnie, Overfield north and Overfield south mines as lying along a fault that marks a bedding plane between the Cambrian Bonanza King Formation (€b) and Proterozoic and Lower Cambrian Woods Canyon Formation (€Zw).

Stanley Wayne Ivosevic's abstract for the Jonnie District is reproduced below:

The Johnnie district, in the northeastern Spring Mountains, Nye County, Nevada, may have produced a little under 100,000 troy oz of gold, since the discovery of the district in 1890 (Ivosevic, 1976, p. ii).

An approximately 13,000-ft-thick (4,000 m) section of east dipping upper Precambrian through Middle Cambrian miogeosynclinal clastic and carbonate rocks is exposed in the district. The strata are, in order of decreasing age, the Johnnie Formation, Stirling Quartzite, Wood Canyon Formation, Zabriskie Quartzite, and Carrara and Bonanza King Formations. These are overlain by Cenozoic units which include an older unit and a younger unit of fanglomerate, the older containing a megabreccia deposit, and Quaternary alluvium (Ivosevic, 1976, p. ii).

The rocks were deformed by the Late Cretaceous Sevier orogeny and by subsequent tectonic events, which include Basin-and-Range faulting, of Miocene age, The oldest structures, formed in conjunction with Sevier tectonism, are disharmonic folds in the Johnnie Formation, which folds underwent rotation by later (Sevier orogeny) eastward tilting of the district during larger scale folding. Simultaneously with the later folding, competent rocks were translated across less competent ones along zones of tectonic *readjustment; the most notable zone is at the top of the Johnnie Formation in the western part of the district. High-angle fractures--in extension, conjugate, and pressure-release orientations--developed at about the same time and were the ancestors for most younger high-angle structures, including quartz veins* (Ivosevic, 1976, p. ii,iii).

Longitudinal faulting occurred at the end of the Sevier orogeny; and concurrently, the related Congress low-angle normal fault developed. The district was dropped down to the west along the Grapevine fault system during Basin-and-Range normal faulting at the west face of the Spring Mountains. Throughout the structural development of the district, displacement occurred along transverse faults in secondary readjustment to displacement along other features and also low-angle faults transposed younger rocks across older ones (Ivosevic, 1976, p. iii).

Some of the tectonism caused local carbonatization of the Bonanza King Formation (Ivosevic, 1976, p. iii).

The district was eroded in a series of stages during Basin-and-Range faulting. Finally, sometime between latest Miocene to middle Pleistocene times, pediments developed at the edges. of the resultant basins, then were buried by bajadas of older fanglomerate. Later, parts of the pediments were exhumed by erosion (Ivosevic, 1976, p. iii).

High-angle and concordant quartz-bearing structures were emplaced during hydrothermal activity, probably between the Paleocene and early Miocene epochs High-angle quartz veins, the average of which strikes ENE and dips north, dominate and are the hosts for most economic, mesothermal mineralization in the district. Three ore mineralogic suites ·are present: gold-chalcopyrite-pyrite, chalcopyrite-galena, and galena-calcite. Additionally, chalcopyrite occurs with specularite in stratabound quartz-poor lodes of apparent hydrothermal origin; these oxidize to low-grade malachite deposits. Placer gold deposits formed in the older fanglomerate during post Basin-and-Range faulting erosion of the district. The characteristic wall-rock alteration mineralogic suites in the hypogene deposits are sericite and pyrite in clastic rocks and also sericite, alone, in dolomite; the alteration minerals, chlorite, calcite, and specularite, occur locally. ***The ore mineralogic suites define a district-wide pattern of hypogene mineralogic zonation about gold centers at the Johnnie and Congress mines, the main producers in the district*** (Ivosevic, 1976, p. iii,iv).

The fundamental control which admitted the hydrothermal fluids into the district is obscure. However, trains of quartz veins are concentrated within 2.5-mi-long (4 km), ENE-trending principal mineralized structures which lie astride an inferred 13-mile·long (21 km) N.-35°-E. trending major longitudinal structure, which may be a manifestation of the fundamental control. The gold mineralization is localized in the Zabriskie Quartzite and the dolomitic rocks near the top of the Wood Canyon Formation, in part, by the retention of hydrothermal fluids beneath a blanket of shaly rocks at the base of the Carrara Formation. The base of the dolomitic rocks is also the base of the Cambrian section, which is recognized as a favorable stratigraphic site for ore deposition at other places in the southern Great Basin (Ivosevic, 1976, p. iv).

Although this report develops a theme in which the hydrothermal fluids were introduced from a remote source below the district, as the broad concepts of ore genesis change with time, it may become accepted that many of the constituents of the hydrothermal fluid were derived from local, syngenetic sources (Ivosevic, 1976, p. iv).

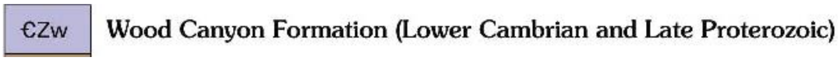
MAPPING

1:250,000

1:250,000

Workman and others (2002) mapped the area of the Stirling mine as being at a fault junction where a north-south trending fault and another fault the trends west-southwest to east-northeast. The latter fault a fault marks a contact between ***Lower Cambrian and Late Proterozoic Woods Canyon Formation (€Zw) to the south and Lower and Middle Cambrian Carrara Formation*** **(€c)** to the north.

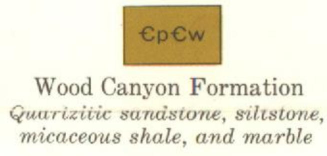
€c Carrara Formation (Middle and Lower Cambrian)



€Zw Wood Canyon Formation (Lower Cambrian and Late Proterozoic)

1:100,000

Cornwall (1972) mapped the area of the Stirling Mine as being in a block of Cambrian and Proterozoic Wood Canyon Formation (€p€w) that lies south of a normal fault. This fault curves from striking west-east to the west to striking southwest-northeast to the east.



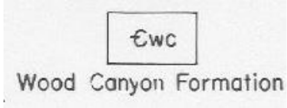
€p€w

Wood Canyon Formation

Quartzitic sandstone, siltstone, micaceous shale, and marble

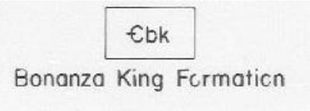
1:62,500

Burchfiel and others (1974) produced a composite map of the Spring Mountains. Their map shows the Stirling Mine to be hosted at the surface by Cambrian Woods Canyon Formation near a fault intersection between a north-south striking fault and a southwest to northeast trending one. To the north and east of these faults is Cambrian Bonanza King Formation.



€wc

Wood Canyon Formation



STRUCTURE

S.W. Ivosevic produced a map of the Johnnie Mining District that does not include the Stirling mine and his report does not discuss it.

Because the Stirling mine is included in Joseph V. Tingley's 1998 map and summary about the Johnnie Mining District, Ivosevic's 1976 structural maps and cross sections and mineralogical descriptions of the Johnnie District are reproduced below:

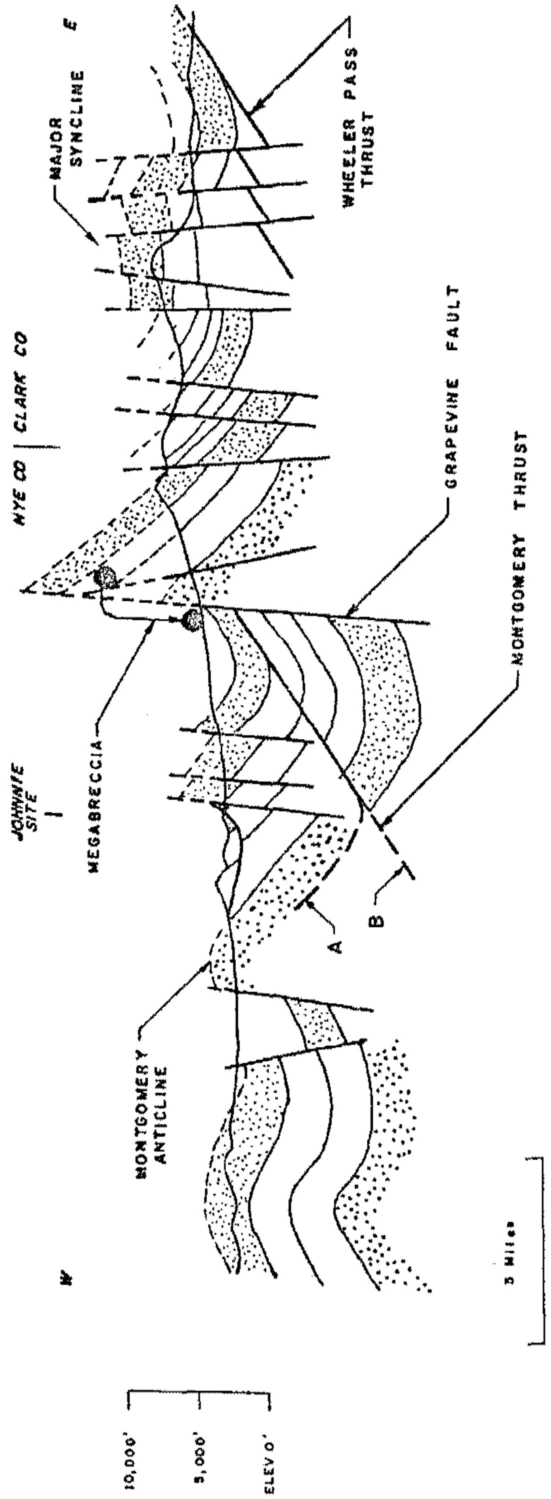


Figure 3. Geologic section - locally diagrammatic - through northwestern Spring Mountains along 18th parallel S., M. D. B. & M. showing large-scale folding, some possible thrust relations (A and B) beneath the Johnnie district, and probable origin of megabreccia deposit. Heavy stipple -- Johnnie Formation; light stipple -- Bonanza King Formation and younger Cambrian rocks. Compiled from Longwell and others (1965), Hamil (1966), Cornwall (1972), and mapping, this report.

Figure 2. Geologic section through the Spring Mountains (Ivosevic, 1972). Open source for educational purposes. No copyright.

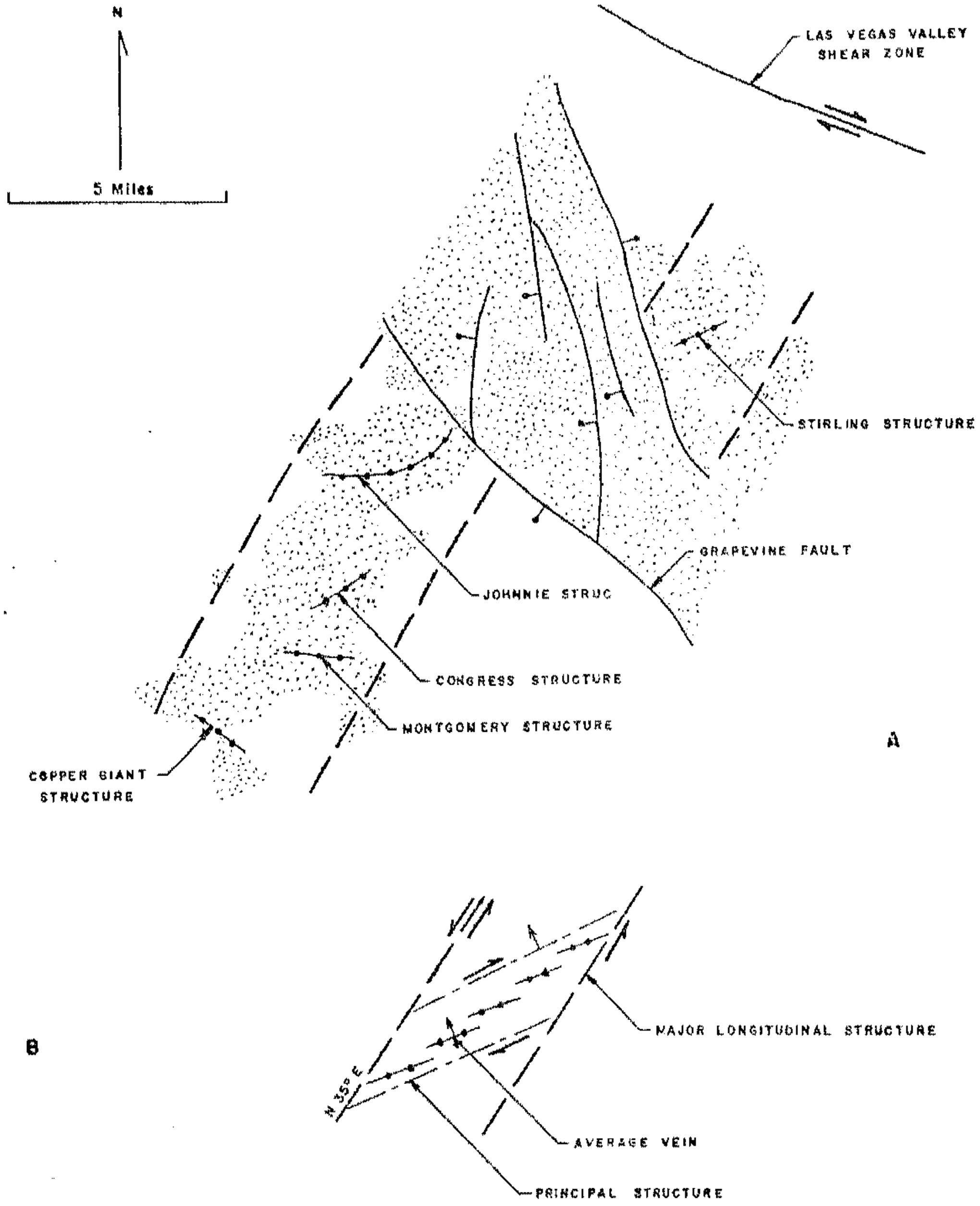


Figure 20. (A) Map of principal structures, showing inferred offset of major longitudinal structure (broken line). Faults from Cornwall (1972, pl. 1); ball on downthrown side. (B) Diagram illustrating relations among mineral localizing structures, showing inferred directions of strike separation.

Outcrop areas in (A) stippled.

Figure 3. Map of principal structures. From Ivosevic, 1976, p. 119. Open source for educational purposes. No copyright.

Hydrothermal activity was distributed in all or parts of each of the following geologic features:

(1) The Johnnie, Congress,and Hontgomery structures.
(2) The Zabriskie Quartzite and rocks immediately below.
(3) The contact of the Johnnie Formation and Stirling Quartzite. and the sole. of the Congress low-angle normal fault.
(4) Moderate to profuse, usually sub-map-scale quartz veinlets occur in all exposures of the Johnnie Formation in the Johnnie district. They are localized along bedding-related structures, particularly in fissile rocks, and in high-angle joints and small fractures.

When considered in three dimension this distribution was a consequence of the hypogene plumbing (Ivosevic, 1976:123).

MINERALOGY

[In the Johnnie District there are] *three ore mineralogic suites are present: gold-chalcopyrite-pyrite, chalcopyrite-galena, and galena-calcite. Additionally, chalcopyrite occurs with specularite in stratabound quartz-poor lodes of apparent hydrothermal origin; these oxidize to low-grade malachite deposits. Placer gold deposits formed in the older fanglomerate during post Basin-and-Range faulting erosion of the district (Ivosevic, 1976, p. iii).*

Ivosevic identified replacement of dolomite and brecciation as primary textures related to hydrothermal mineralization:

The product of replacement of dolomitic rocks by quartz adjacent to fissure fillings of vein quartz becomes part of the vein. This is very common in the Congress vein, particularly in the hanging wall where thicknesses up to 5 ft (1. 5 m) are added (pl. 10); and it occurs locally in the veins at the Johnnie and Overfield mines (Ivosevic, 1976:91).

Microscopically, replacement of dolomite occurs by invasion of vein quartz along fractures and between breccia fragments and involves embayment by the dissolution of dolomite along highly irregular boundaries. With advanced replacement dolomite appears to migrate toward the replacement front, evident because residual detrital quartz veins in quartzitic dolomite become more numerous toward the front. With continued replacement: these residual quartz grains anneal at points of contact in partially replaced rock; or the grains are engulfed by vein quartz and incorporated into its structure in completely replaced dolomitic rock (Ivosevic, 1976:91).

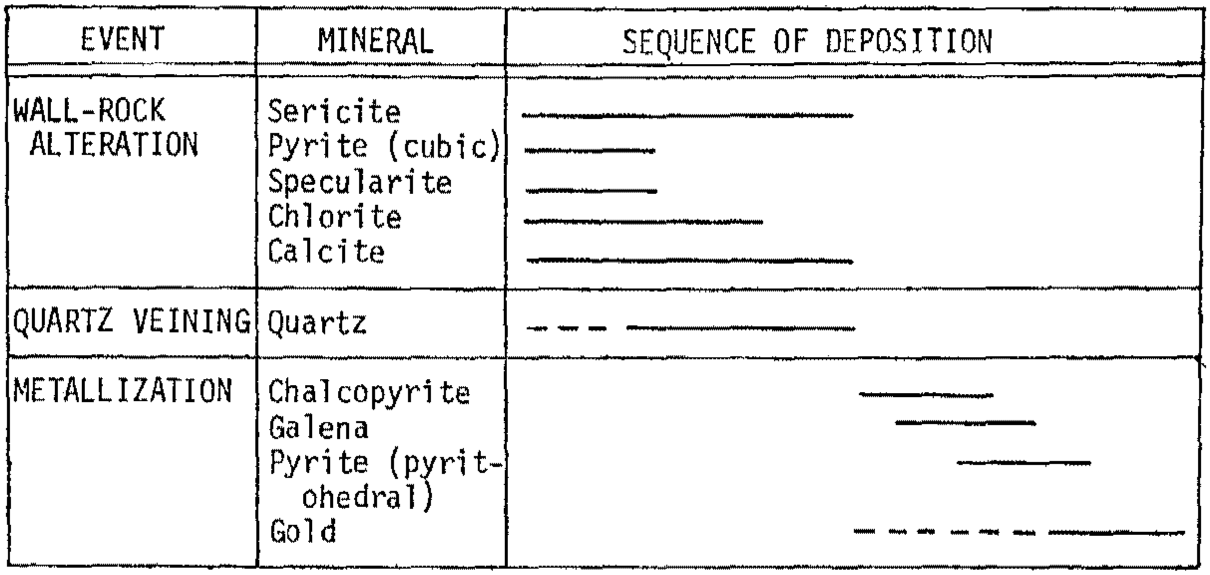
The resultant vein quartz contains numerous inclusions of apparent iron oxide less than 2.5 microns in diameter and also contains larger inclusions of unreplaced dolomite. These inclusions impart the characteristic red color to the ore from the Congress mine (Ivosevic, 1976:91).

There is a gold-producing center of hypogene mineralogic zonation which encompasses the Johnnie, Overfield, Broadway, and Doris mines (Ivosevic, 1976:97 and Figure 19, page 114).

Conyac's 1985 report for the Mount Stirling Wilderness Study area said the following about the Stirling Mine:

A total of 38 samples were taken; 35 were from small stockkpiles and from veins exposed in pits, and 3 were from the adit. All samples were of either massive or brecciated vein quartz with iron- and manganese-oxide stains. The three chip samples of vein quartz from the adit contained trace, 0.01, and 0.09 oz/ton gold. Four select samples contained: U.05 oz/ton gold with 0.1 oz/ton silver, 0.08 Ol/ ton gold with 0.5 ol/ton silver, 0.18 oz/ton gold with 0.3 oz/ton silver, and 0.10 oz/ton gold. A trace of gold was found in 17 other samples and a trace of silver was found in two samples. Eleven samples assayed for copper, lead, and linc contained from trace to 0.29% copper, trace to 0.26% lead, and trace to 0.02% zinc. Nine samples had no significant mineral values (Conyac, 1985, Table 1, Map No. 1).

Ivosevic's mineralogical paragenesis interpretation for the Johnnie District is reproduced from the Nevada Bureau of Mines and Geology below:



EVENT	MINERAL	SEQUENCE OF DEPOSITION
WALL-ROCK ALTERATION	Sericite Pyrite (cubic) Specularite Chlorite Calcite	
QUARTZ VEINING	Quartz	
METALLIZATION	Chalcopyrite Galena Pyrite (pyritohedral) Gold	

Figure 15. Paragenesis of hypogene ore deposits in the Johnnie district.

Figure 4. From Ivosevic, 1976, p. 84. Open source for educational purposes. No copyright.

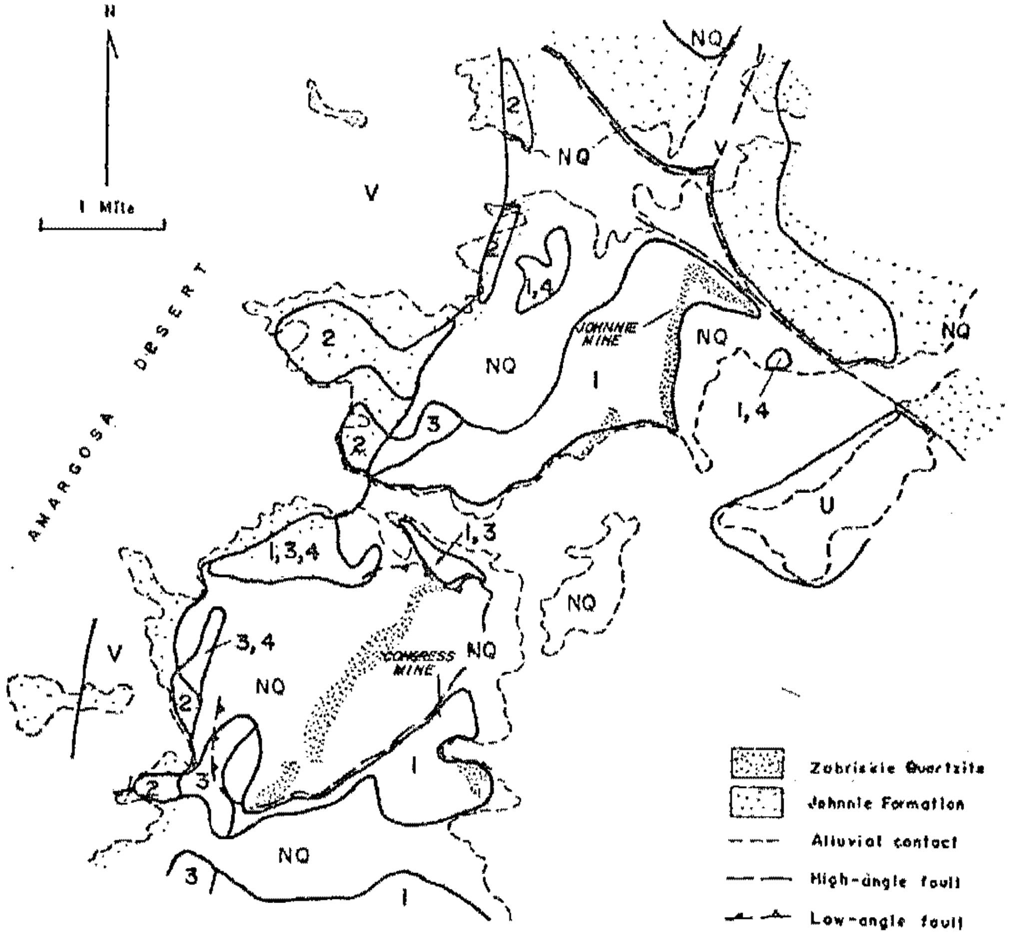


Figure 16. Map showing areas of hydrothermal activity and distribution of types of quartz-bearing structures in the Johnnie district.

1-4, outcrop areas of quartz-bearing structures: (1) high-angle quartz veins; (2) concordant quartz veins; (3) concordant quartz stringer lodes; (4) concordant quartz-poor lodes.

V, area of small outcrops containing numerous quartz veinlets.

U, allochtonous megabreccia deposit; type of quartz-bearing structure not classified.

NQ, areas essentially devoid of quartz-bearing structures.

Figure 5. Map of hydrothermal activity. From Ivosevic, 1976, p. 89. Open source for educational purposes. No copyright.

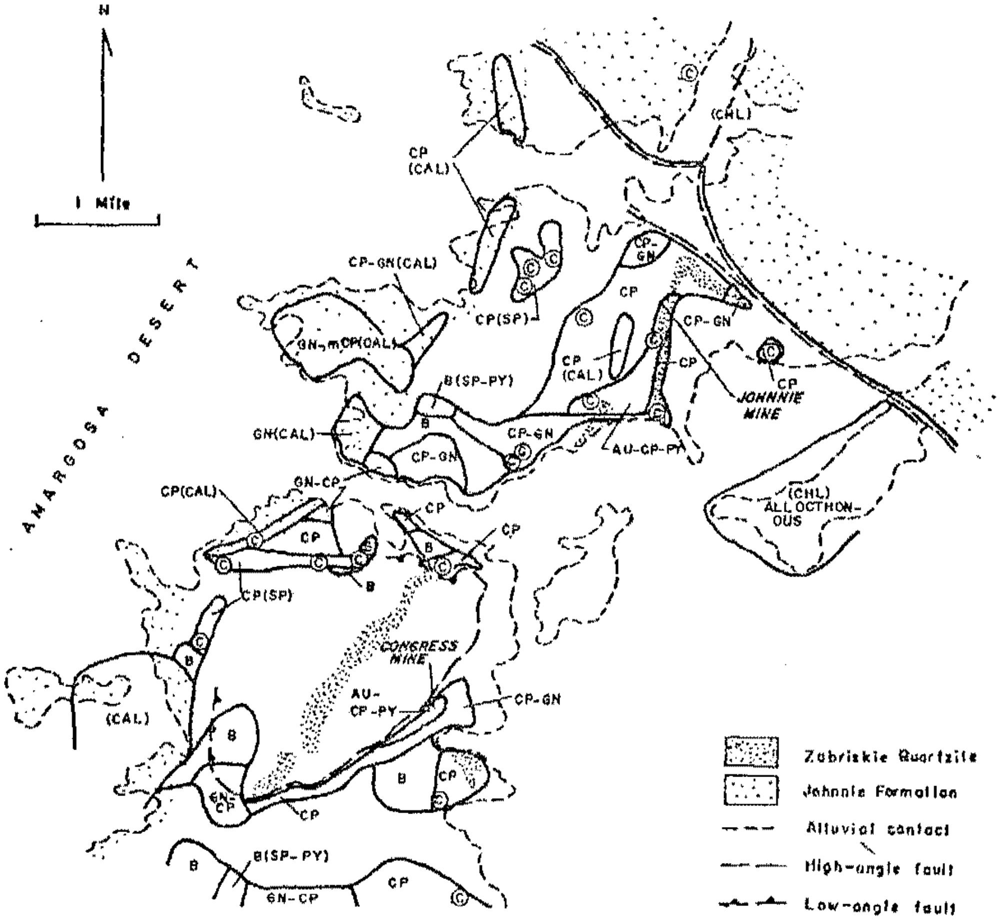


Figure 17. Map showing distribution of hydrothermal minerals in the Johnnie district, literally portraying areas in which ore minerals occur and locally showing general regions in which some gangue minerals occur (chlorite east of Grapevine fault; calcite in southwest part of district). Sub-zones with characteristic gangue minerals shown in parentheses.

Au-Cp-Py, gold-chalcopyrite-pyrite; Cp, chalcopyrite; Cp-Gn, chalcopyrite with subordinate galena; Gn-Cp, galena with subordinate chalcopyrite; Gn-mCp, galena with minor chalcopyrite; Gn, galena; Sp, specularite; Py, pyrite; Cal, calcite; Chl, chlorite; B, area of barren quartz veins.

(©), malachite deposit or group of closely spaced malachite deposits.

Based upon data from approximately 210 locations.

Figure 6. . Mineralogic distribution map. From Ivosevic, 1976, p. 93. Open source for educational purposes. No copyright.

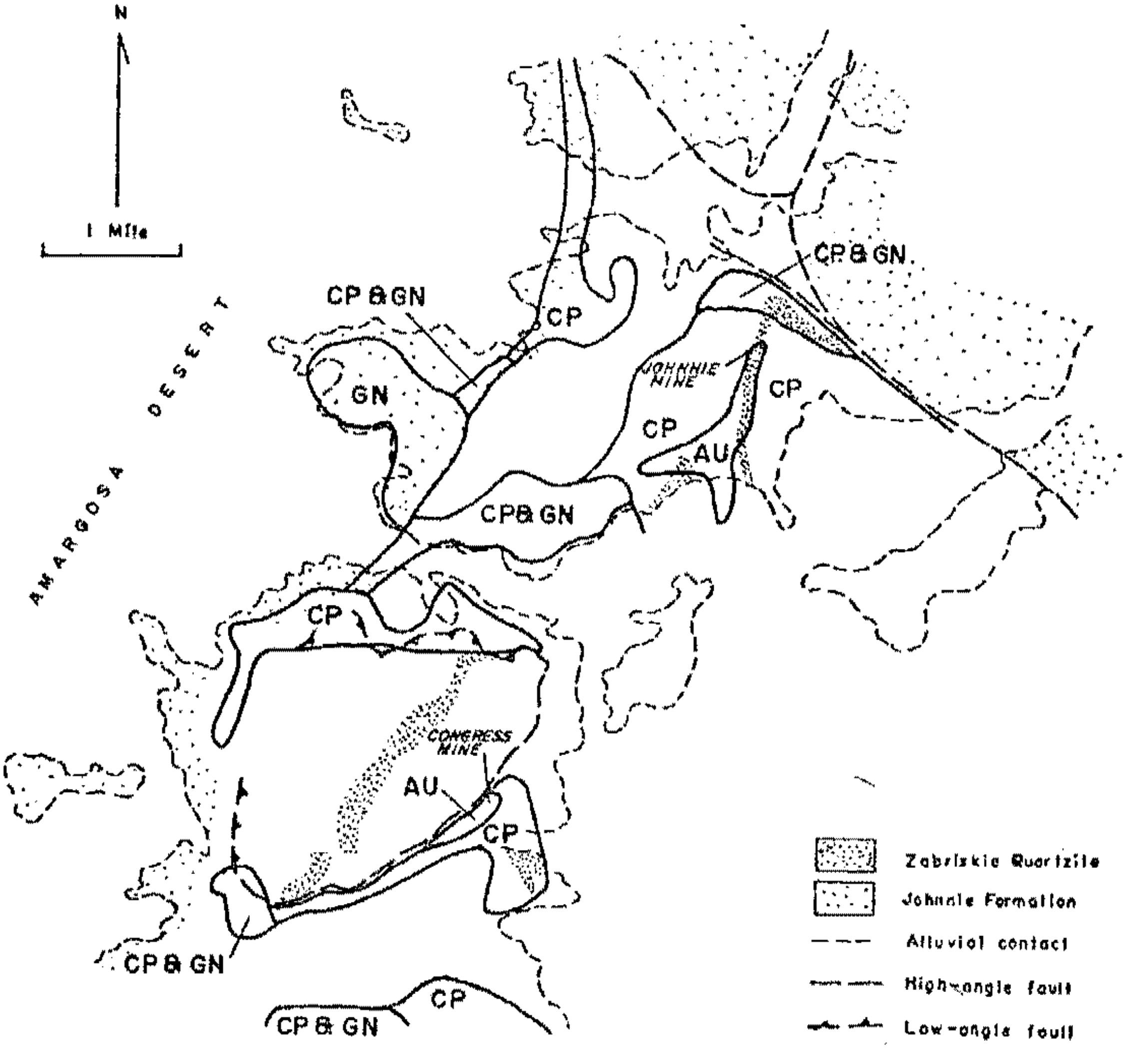


Figure 18. Map showing restricted interpretation of hypogene mineralogic zonation in the Johnnie district.

Au, gold zone; Cp, chalcopyrite zone; Cp and Gn, chalcopyrite-galena zone; Gn, galena zone.

Figure 7. Mineralogic zonation. From Ivosevic, 1976, p. 112. Open source for educational purposes. No copyright.

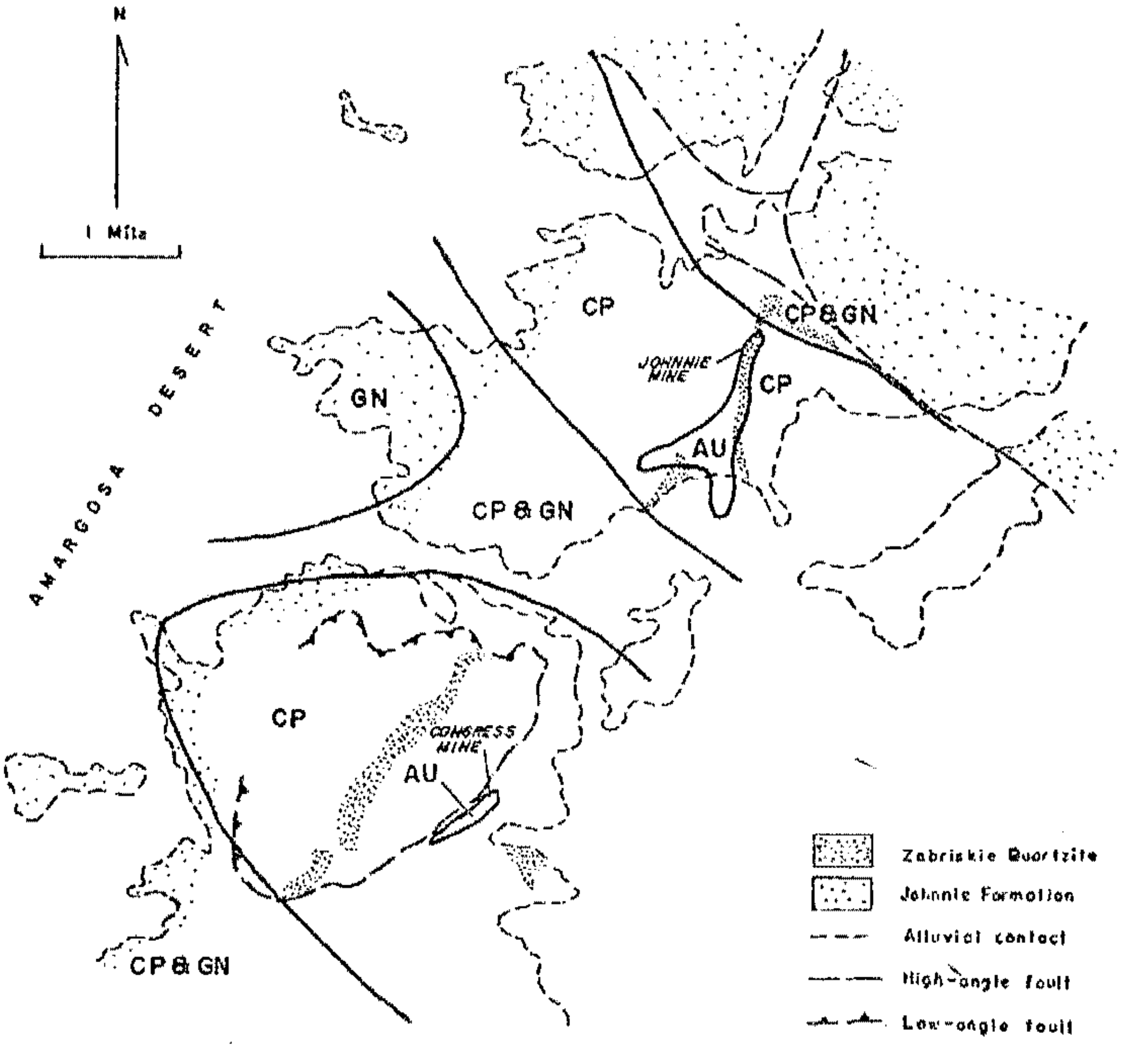


Figure 19. Map showing broad interpretation of hypogene mineralogic zonation in the Johnnie district.

Au, gold zone; Cp, chalcopyrite zone; Cp and Gn, chalcopyrite-galena zone; Gn, galena zone.

Figure 8. Generalized map of mineralogic zonation. From Ivosevic, 1976, p. 114. Open source for educational purposes. No copyright.

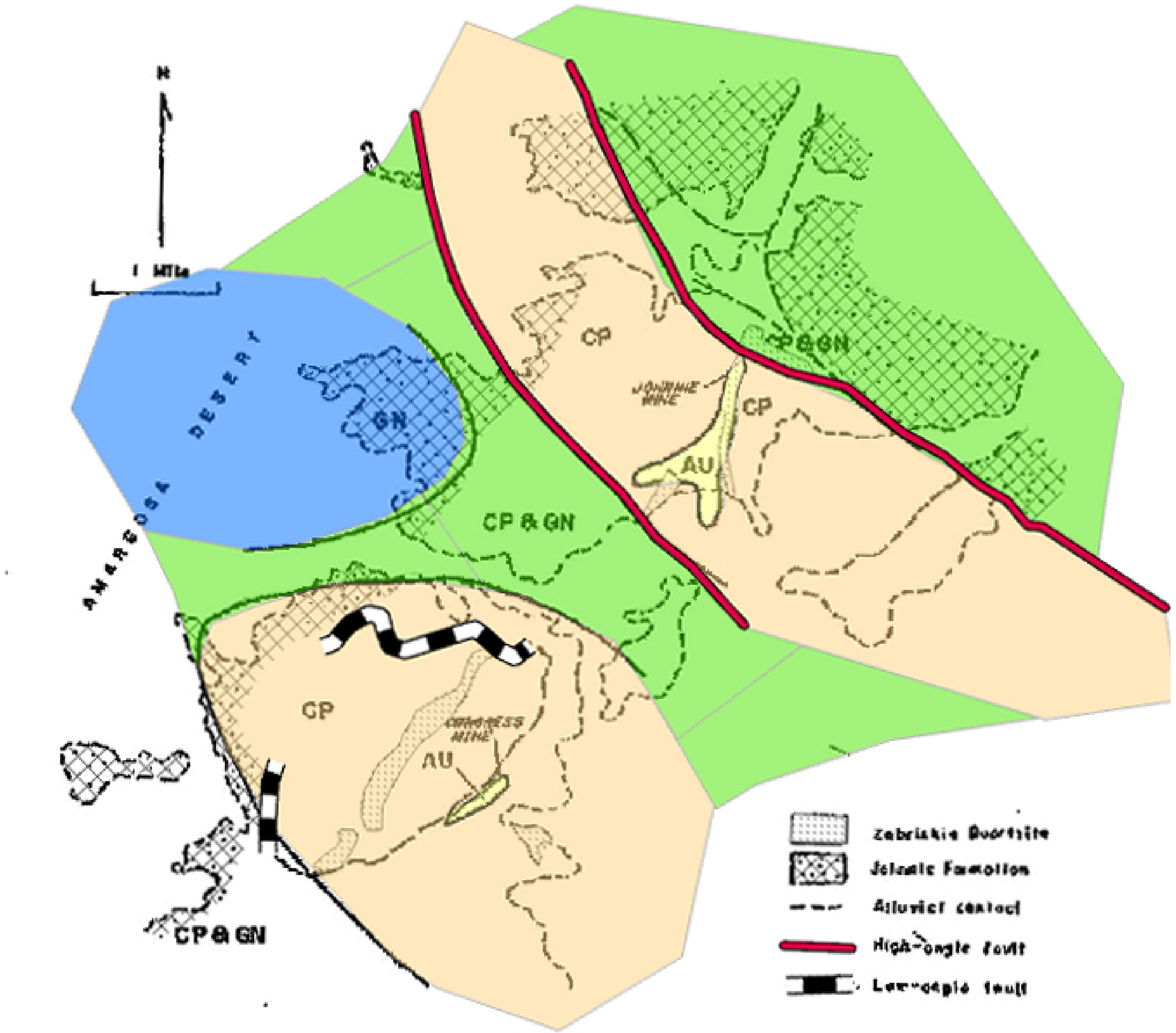


Figure 19. Map showing broad interpretation of hypogene mineralogic zonation in the Johnnie district.

Au, gold zone; Cp, chalcopyrite zone; Cp and Gn, chalcopyrite-galena zone; Gn, galena zone.

Figure 9. Modified from Ivosevic, 1976, p. 114. This map shows that high grade gold mineralization is associated with chalcopyrite.

ALTERATION

The main wall-rock alteration products are widely distributed sericite and pyrite. Locally, specularite, chlorite, and calcite occur as alteration products or as cogenetic gangue minerals in uncommon host rocks whose original mineralogies [sic] *furnished the* *reactants necessary to produce these three products. This permits the further subdivision of the hypogene mineralogic zones on the basis of gangue mineralogy. Thus, the chalcopyritic lodes, apparently inherent to the ferruginous parts of the Stirling Quartzite, include specularite.; and the major galena-quartz veins, simultaneously falling in the galena zone and the dolomitic upper part of the Johnnie Formation, characteristically contain calcite* (Ivosevic, 1976:71).

Wall-rock alteration, at temperatures below 200°C, added hydrogen, potassium, aluminum, iron, and sulfur to the rocks; and CO_2, sodium, magnesium, and calcium were released to the hydrothermal fluid. Quartz veining removed silica from the fluid; and metallization, at temperatures around 250°C, required the addition of gold, copper, lead, iron, and sulfur, from the hydrothermal fluid (Ivosevic, 1976:72).

ORIGIN

The main gold-chalcopyrite-pyrite-quartz veins and most other prominent veins in the [Johnnie] *district are localized in the Zabriskie Quartzite and underlying dolomitic rocks near the top of the Wood Canyon Formation. This was caused by a combination of mechanical and chemical qualities intrinsic to these rocks and by ponding of hydrothermal fluids beneath an impermeable blanket of sericitized shale gouge at the base of the Carrara Formation above the Zabriskie Quartzite. Significantly, correlative rocks, at the presently recognized base of the Cambrian section, host important ore deposits in other mining districts in the southern Great Basin* (Ivosevic, 1976:71-72).

Quartz veins and most other quartz-bearing structures in the Johnnie district are in trains within ENE-trending, north-dipping principal mineralized structures into which were funneled, through a series of other structures, hydrothermal fluids ascending from depth. These principal mineralized structures, four--or possibly five--in number, are aligned within a 15-mi-long (24 km) inferred major longitudinal structure, which trends N. 35° E. and also dips north. The major longitudinal structure, if real, is probably the surface .. expression of the fundamental control which guided heat and, maybe, metal-bearing hydrothermal fluids into the area to localize the Johnnie district (Ivosevic, 1976:72).

The hydrothermal fluids may have originated from lower crust or upper mantle sources or were derived from interstitial connate brines in the miogeosynclinal rocks in or below the district. In either case, the metals in the fluids then could have been leached from the miogeosynclinal rocks transgressed by the fluids (Ivosevic, 1976:72).

The term "fissure" is used hereforward as a convenience in discussing various aspects of quartz-bearing structures. I do not believe that open voids, as such, existed at any time. Widening of the fissures, by means such as those described in Vein Configuration and Localization of Ore Shoots, was accompanied simultaneously by filling by quartz (Ivosevic, 1976:72).

The chalcopyritic precursors of the malachite deposits developed in concordant quartz-poor lodes in porous host rocks in areas where quartz veins are thin and sparsely distributed and possibly were under compression at the time of chalcopyrite mineralization. This deprived the copper-bearing hydrothermal fluids of established conduits of migration and of dilatant fractures in quartz veins for the precipitation of chalcopyrite. The relatively porous coarser grained, lightcolored (hence, pure) quartzites in both the Stirling Quartzite and the Wood Canyon Formation offered suitable alternative conduits for the passage of hydrothermal fluids, favoring formation of quartz-poor lodes rather than quartz veins. These quartzites are porous because they contain many interstitial spaces incompletely filled with diagenetic quartz overgrowths and lack closely packed shaly matrix minerals (Ivosevic, 1976:104).

Therefore, quartz-poor chalcopyritic lodes developed in preference to the chalcopyrite-quartz veins which are the characteristic hosts for copper mineralization in the rest of the Johnnie district. The chalcopyritic lodes in the area south of Route 16 facing the Amargosa Desert are transitional northward along strike into the more typical quartz vein type of deposit (Ivosevic, 1976:104).

The most prominent malachite deposits occur in beds within the B member of the Stirling Quartzite throughout an interval which also contains most of the specularite-quartz veins in the district. The deposition of the specularite, as well as sericite, as wall-rock alteration products were doubtlessly triggered by the passage of the hydrothermal fluid through local iron-rich, dark-colored shaly quartzite beds in the B member. Analyses show that these rocks normally contain an average of 3 percent iron, 100 times more than do the light-colored quartzites nearby (Ivosevic, 1976:104-105).

Significant amounts of pyrite are lacking from the areas where malachite lodes occur; but, pyrite is present as a wall-rock alteration product in the specularite-bearing quartz stringer lodes and quartz veins in two areas where chalcopyrite is absent (fig. 17)…. Consequently malachite was precipitated near its hypogene source; because, during supergene leaching, the absence of pyrite in the chalcopyrite lodes inhibited the production of excess sulfuric acid required to disperse the dissolved copper (Ivosevic, 1976:105).

The role of sericite in malachite precipitation was not clarified during this study. The sericite-filled fractures in the host rocks of the malachite lodes in the Stirling Quartzite provided porous conduits for the migration of supergene solutions and may have provided free surfaces for the deposition of malachite. In 'addition, possible reaction of the copper laden supergene solutions with the surfaces of the sericite grains may have facilitated the nucleation of malachite crystals there in preference to the apparently less reactive surfaces of quartz grains. A reaction on the surfaces of minerals of sericitic affinity is suggested in the apparent preferential deposition of malachite on shaly rocks elsewhere in the stratigraphic section (Ivosevic, 1976:105).

These deposits are intriguing, because three observations suggest that they are syngenetic, bedded copper deposits rather than being epigenetic as has been implied *so far: (1) the deposits are concordant; (2) most are apparently confined to a single stratigraphic interval within the basal clastic series of a stratigraphic assemblage; and (3) they are widespread laterally throughout that interval. From personal observations and discussion, I know or infer that similar deposits are situated on the Copper Giant property (Appendix D; fig. 2), in the Stirling district (figs. 1 and 2), and maybe elsewhere in the region. At least some of the similar deposits are in the same stratigraphic Interval* (Ivosevic, 1976:106).

Bedded copper sulfide deposits with affiliated iron oxides occur in Idaho, Montana, and British Columbia (Wedow, 1975) in the Belt-Purcell Supergroup (McGill, 1970) of younger Precambrian age (Obradovich and Peterman, 1968). The Belt-Purcell Supergroup is a lowest or, pre-, miogeosynclinal sequence of sedimentary rocks, which is stratigraphically equivalent to the pre-Johnnie Formation sedimentary rocks in southern Nevada and southern California (Crittenden and others, 1971) (Ivosevic , 1976:106).

The syngenetic appearance of the chalcopyritic lodes in the Johnnie district may be misleading. The stratigraphic restriction of these may have resulted from the presence of iron required for the hydrothermal formation of the specularite which is allied with the chalcopyrite and from the presence of the apparently unique local imbalance between fracture dilatancy and rock porosity, which imbalance was conducive to the formation of quartz-poor lodes. The diverse mineralogic and morphologic types of ore deposits in the Johnnie district are united by their mutual commonality of origin. To ascribe a syngenetic, hence uncommon, origin to a particular type of deposit is a departure from the rationale of unity, which departure further argues against there being syngenetic deposits here (Ivosevic, 1976:106-107).

The possibility is broached in later sections that the ore deposits in the Johnnie district originated by a combination of syngenetic and epigenetic events. So, it may be that the chalcopyritic lodes are syngenetic deposits modified by later hydrothermal activity (Ivosevic, 1976:107).

Summary of Ore Genesis

Hydrothermal activity and attendant ore deposition occurred in the Johnnie district during early to middle Tertiary times after the structural preparation of the area by the Late Cretaceous Sevier orogeny and subsequent tectonism of lesser magnitude. The subsequent tectonism included inception of movement on the ancestral Grapevine fault system. After hydrothermal activity, the district was disturbed by Basin-and- Range normal faulting which offset some veins and thoroughly fractured the quartz in all of them. Although some erosion probably preceded hydrothermal activity, the remainder, most after Basin-and-Range faulting, exposed the district at its present level in a series of geomorphologic events culminating in the deposition of gold placers. (Ivosevic, 1976:155).

The sources of the heat, water, and contained elements in the hydrothermal system were not established by this study; but they probably came from some combination of remote and local sources. (Ivosevic, 1976:155).

The Basin and Range province is an area of high heat flow which was considerably higher in the Miocene (DeAngelo, 1922). This high flow of 6 degrees per hundred feet (25°C/km) can create hydrothermal fluids without volcanism in hydrological systems only a few thousand feet deep. There are not many volcanic or plutonic rocks in the central Spring Mountains.

Hydrothermal activity occurred at estimated temperatures of 150°C, later having risen to 250°C, and pressures of approximately 1,000 atm. The depth of burial corresponding to this is 15,000 ft (4,600 m) (Ivosevic, 1976:150).

This hydrothermal event occurred in Paleocene to early Miocene time (Ivosevic, 1976:156).

The hydrothermal fluid may have been derived from a remote source in the upper mantle or lower crust or from a pluton (considered remote for discussion purposes) emplaced at depth below the district. Alternatively, the source could have been local: connate water expelled from the miogeosynclinal rocks in or below the district during or after diagenesis; groundwater transported downward along the ancestral Grapevine fault system; or water in wet surficial or near surface materials overridden by the upper plate of the Montgomery thrust (Ivosevic, 1976:155).

The heat, only, of the hydrothermal system may have been derived from remote sources or the heat was generated locally by the geothermal gradient. In either case, hydrothermal convection of local fluids, if such was their source, would have resulted (Ivosevic, 1976:155-156).

The hydrothermal fluid, with its metals and silica, could have originated from a remote source or, the metals and silica originated by the leaching action of a hydrothermal fluid, from any source, migrating through the miogeosynclinal rocks in or below the district. If the fluid was a connate brine it would have provided the halogens considered necessary to enter into the complexes required to transport some of the metals, or the halogens carne from evaporite units, since removed by leaching, in the miogeosynclinal stratigraphic section (Ivosevic, 1976:156).

The hydrothermal fluid probably ascended along a gravity-controlled pressure gradient within a tabular, vertical dilatant zone now manifest as the inferred major longitudinal structure and/or the principal mineralized structures. The fluid either entered this zone by migrating directly from a remote upper mantle, lower crust, or plutonic source or by migrating essentially laterally from a local source. Fluid from a remote source may have migrated directly along the major longitudinal structure, if it is the upward propagation of a basement ligament; or the fluids from a remote source migrated from depth along a poorly defined front until they were collected and canalized along the Montgomery thrust *or Grapevine fault system to ultimately enter the major longitudinal structure or principal mineralized structures* (Ivosevic, 1976:156).

Whether the major longitudinal structure exists or not, once the hydrothermal fluid entered the mineralized area it was canalized at the base of the Stirling Quartzite, by the sole of the Congress low-angle normal fault, and possibly canalized by the Grapevine fault system and Montgomery thrust. From those sites, the fluid was diverted into the principal mineralized structures, which were the loci of fractures and faults made dilatant, by shear, under the influence of the local stress system in effect at the time. Finally in the fractures and faults, the hydrothermal fluids caused--sequentially--wall-rock alteration overlapped by quartz veining, and--after minor fracturing of the quartz-- metallization (Ivosevic, 1976:156-157).

A Fanciful Hypothesis for Ore Genesis

I. am fascinated by the possibility that the hydrothermal ore deposits in the Johnnie district originated from syngenetic materials in the vicinity (Ivosevic, 1976:157).

Concepts of ore genesis change with time. The once popular belief that all of the components of ore fluids originate' from magmatic sources has been modified greatly, in the last decade, by studies demonstrating that the aqueous phase of the fluids can arise from a variety of non-magmatic sources (for example, Gross, 1975; Guy, 1975; Skall, 1975). Another trend, which has roots in the same studies, points to examples (such as Carpenter and others, 1974; Gross, 1975) of the enrichment of metals in potentially hydrothermal subsurface waters in which the metals have been concentrated by solution of trace elements from country rock. As this trend takes conceptual form in terms of ore genesis, it will not be unreasonable to interpret the origins of deposits, such as those in the Johnnie district where there is no obvious magmatic source, in terms of lateral secretion (Ivosevic, 1976:157).

Among other phenomena, the apparent affinity of some metals for certain stratigraphic horizons in the Johnnie district may be more than a series of coincidences; the affinities are galena in the upper unit of the Johnnie Formation, chalcopyrite in the B member of the Stirling Quartzite, gold in the Zabriskie Quartzite, and the affinity of concordant quartz stringer lodes for particular stratigraphic horizons. The lack of an obvious magmatic source for the hydrothermal system and lack of obvious relations between the ore deposits and deeper structures cause one to seek alternate interpretations for their origins (Ivosevic, 1976:157-158).

Perhaps unimaginatively, this report explains these features on structural and lithologic grounds in light of currently prevailing concepts of ore genesis. However, if contradicting details of current concepts of ore genesis--which concepts are, in part, the outgrowth of contemporary geologic prejudices--are ignored, a case could be made for a syngenetic method of origin modified by lateral secretion processes (Ivosevic, 1976:158).

This report demonstrates…that, although not necessarily true, most of the constituents of the hydrothermal fluid could have been derived from local sources. Perhaps the profusion of quartz veinlets in the Johnnie Formation does not represent the paths of hydrothermal fluids ascending across a broad front, from below, before canalization into overlying structures to form quartz veins; perhaps the profuse veinlets are a system of collectors of hydrothermal fluids migrating laterally from adjacent rocks (Ivosevic, 1976:158).

Then all that is required for a lateral secretion origin is a lateral temperature and pressure differential to initiate hydrothermal activity and concentrate it along the controlling structures. The requisite heat could have been generated by the geothermal gradient, and the necessary low pressure conditions would have prevailed along the controlling structures at the time of the dilatancy which permitted the ingress of hydrothermal fluids (Ivosevic, 1976:158-159).

The following speculation, one of a number possible, is appealing because it unites a lot of observations. If, conveniently, the Johnnie district is above a narrow, longitudinal basin or basinal sequence of younger Precambrian sedimentary rocks below the base of the Paleozoic miogeosynclinal section, as suggested earlier in this report, several aspects of the district can be accounted for: (1) the ore deposits would lie within an elongate, northerly trending area; (2) ignoring the ramifications of thrust faulting for simplicity, the geothermal gradient might have been higher than in adjacent rocks, localizing hydrothermal convection and negating the requirement for a magmatic source; (3) high lithostatic pressures (Secor, 1962, 1965) -would have localized hydraulic fracturing and the simultaneous collection of connate fluids within these fractures, thus making it, at least in part, a case of lateral secretion (Ivosevic, 1976:159).

Additional isotope studies are necessary to: determine the source of the aqueous phase and other components of the hydrothermal fluid in the Johnnie district; and to define the temperature and age of ore deposition, which incidentally permits the deduction of depth and pressure. These studies, along with ones meant to prove or disprove the regionality--suggested here--of possible syngenetic copper deposits, would contribute greatly to assessing the validity of this fanciful hypothesis in the district and might give new direction to mineral exploration in the region (Ivosevic, 1976:159).

DEVELOPMENT

The main workings [of the Stirling Mine], *at the eastern end of the southern vein, include a 23-ft·long adit in quartz and a 58-ftdeep shaft. The shaft was inaccessible but appeared to have drifts at two levels. Also on the southern vein are 16 small surface pits. Two shafts, 13 and 28 ft deep, and 11 small pits are on the northern vein. Stockpiles of a few hundred pounds of quartz are near most of the pits* (Conyac, 1985, Table 1, Map No. 1).

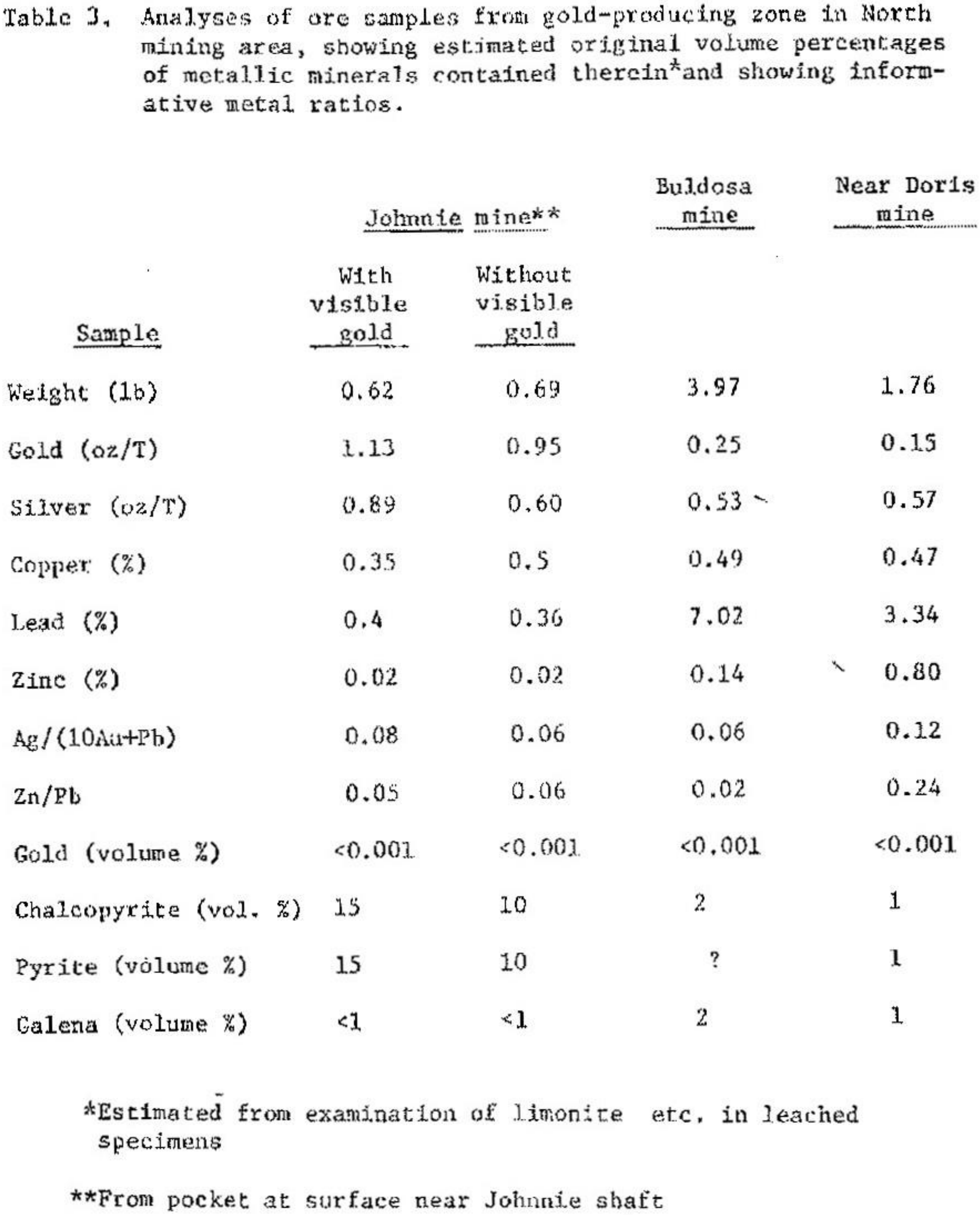


Table 3. Analyses of ore samples from gold-producing zone in North mining area, showing estimated original volume percentages of metallic minerals contained therein*and showing informative metal ratios.

	Johnnie mine**		Buldosa mine	Near Doris mine
Sample	With visible gold	Without visible gold		
Weight (lb)	0.62	0.69	3.97	1.76
Gold (oz/T)	1.13	0.95	0.25	0.15
Silver (oz/T)	0.89	0.60	0.53	0.57
Copper (%)	0.35	0.5	0.49	0.47
Lead (%)	0.4	0.36	7.02	3.34
Zinc (%)	0.02	0.02	0.14	0.80
Ag/(10Au+Pb)	0.08	0.06	0.06	0.12
Zn/Pb	0.05	0.06	0.02	0.24
Gold (volume %)	<0.001	<0.001	<0.001	<0.001
Chalcopyrite (vol. %)	15	10	2	1
Pyrite (volume %)	15	10	?	1
Galena (volume %)	<1	<1	2	1

*Estimated from examination of limonite etc. in leached specimens

**From pocket at surface near Johnnie shaft

Figure 10. From Ivosevic, 1976, p. 97.

REFERENCES AND BIBLIOGRAPHY

Averett, W.R., 1962, Directory of southern Nevada place names: Las Vegas, Nevada, Walter R. Averett, 114 p. See p. 71 Johnnie Mine.

Bonham, H. F., 1967a, Gold producing districts of Nevada, Nevada Bur. Mines and Geology Map 32.

Bonham, H. F., 1967b, Silver producing districts of Nevada, Nevada Bur. Mines and Geology Map 33.

Burchfiel, B.C., R. J. Fleck, D. T. Secor, R. R. Vincelette, and G. A. Davis, 1974, Geology of the Spring Mountains, Nevada, Geological Society of America Bulletin, (1974) 85 (7): 1013-1022. See https://doi.org/10.1130/0016-7606(1974)85<1013:GOTSMN>2.0.CO;2

Bradley, W. G., 1932, Methods and costs of mining and crushing gypsum at the mine of the Blue Diamond Corporation, Ltd., Arden, Nevada: U.S. Bur. Mines Information Circular 6615.

Carpenter, A. B., Trout, M. L., and Pickett, E. E., 1974, Preliminary report on the origin and chemical evolution of lead-and-zinc-rich oil field brines in central Mississippi: Economic Geology, v. 69, p. 1191-1206.

Carr, Michel D., 1980, Upper Jurassic to Lower Cretaceous(?) synorogenic sedimentary rocks in the southern Spring Mountains, Nevada, Geology, Geological Society of America, (1980) 8 (8): 385-389. See https://doi.org/10.1130/0091-7613(1980)8<385:UJTLCS>2.0.CO;2

Carr, Michel. D., 1978, Structure and stratigraphy of the Goodsprings district, southern Spring
Mountains, Nevada: Ph.D. dissertation, Rice University, Houston, Texas, 155p.

Carr, Michel D., 1980, Upper Jurassic to Lower Cretaceous(?) synorogenic sedimentary rocks in the
southern Spring Mountains, Nevada: Geology, v. 8, p. 3&5-389.

Carr, Michel D., 1983, Geometry and structural history of the Mesozoic thrust belt in the Goodsprings district, southern Spring Mountains, Nevada, Geological Society of America Bulletin, (1983) 94 (10): 1185-1198. See https://doi.org/10.1130/0016-7606(1983)94<1185:GASHOT>2.0.CO;2

Carr, M.D., 1992, Bedrock geologic map of the Blue Diamond NE 7.5' quadrangle, Clark County, Nevada: U.S. Geological Survey, Open-File Report OF-92-363, scale 1:24,000.

Carr, M.D., and Donnell-Canan, Cheryl, 1992, Bedrock geologic map of the Blue Diamond SE 7.5' quadrangle, Clark County, Nevada: U.S. Geological Survey, Open-File Report OF-92-177, scale 1:24,000.

Carr, Michael D and John C. Pinkerton, 1987, Geologic Map of the Goodsprings District, Southern Spring Mountains, Clark County, Nevada, U.S. Geological Survey, Map MF 1514.

Carr, M.D., McDonnell-Canan, Cheryl, and Weide, D.L.,2000,Geologic map of the Blue Diamond SE quadrangle, Nevada, Nevada Bureau of Mines and Geology, Map 123, 1:24,000

Cornwall, H.R., 1967, Preliminary geological map of southern Nye County, Nevada: U.S. Geological Survey, Open-File Report OF-67-68, scale 1:200,000.

Cornwall, Henry R., 1972, Geology and mineral deposits of southern Nye County, Nevada, Nevada Bureau of Mines and Geology Bulletin 77, 57 p. with maps; Scale 1:250.000. See p.38 Johnnie Mine.

Crittenden, M.D., Jr., Schaeffer, F. E., Trimble, D. E., and Woodward, L. A., 1971, Nomenclature and correlation of some upper Precambrian and basal Cambrian sequences in western Utah and southeastern Idaho: Geological Society of America Bulletin, v. 82, p. 581-601.

DeAngelo, J., Burns, E.R., Gentry, E., Batir, J.F., Lindsey, C.R., Mordensky, S.P., 2022, Heat flow maps and supporting data for the Great Basin, USA: U.S. Geological Survey data release, https://doi.org/10.5066/P9BZPVUC.

Engineering and Mining Journal, 1921, News by mining districts-Nevada (Johnnie district]: Eng. and Mining Journal, v. 112, p. 633.

Gross, W. H., 1975, New ore discovery and source of silver-gold veins,Guanajuato, Mexico: Econ. Geology, v. 70, p. 1175-1189.

Guy, B. P., 1975, Stratiform copper mineralization in dolomites of Northwestern Queensland, Australia: v. 70, p. 1414-1425

Hamil, G. S., IV, 1966, Structure and stratigraphy of the Mt. quadrangle, Nye County, Nevada, Inyo County, California: Ph.D dissertation, Rice University. 83 p.

Hewett, D. F., 1931, Geology and ore deposits of the Goodsprings quadrangle, Nevada: U. s. Geol. Survey Prof. Paper 162, 172 p.

Hewett, D. F., 1956, Geology and mineral resources of the Ivanpah quadrangle, California and Nevada: U. S. Geol. Survey Prof. Paper 275, 172 p.

Hewett, D. F., Callaghan, Eugene, Moore, B. N., Nolan, T. B., Rubey, W. W., and Schaller, W. T., 1936, Mineral resources of the region around Boulder Dam: U.S. Geol. Survey Bulletin 871.

Hill, J.M., 1912, The mining districts of the western United States: U.S. Geological Survey Bulletin 507, 309 p. See p. 222.

Ivosevic, S.W., 1972, Field Examination of the Five Star Lead Property, Emerald District, Clark County, Nevada, Nevada Bureau of Mines and Geology, Mining District Open Files.

Ivosevic, S.W., 1976, Geology and ore deposits of the Johnnie District, Nye County, Nevada, University of Nevada, Reno, series unknown, 1:24,000.

Jones, J.C. and E.W Stone, 1920, Arden, in Stone, R. W., and others, 1920, Gypsum deposits of the United States: U.S. Geological Survey Bulletin 697:155-158.

Kral, V. E., 1951, Mineral resources of Nye County, Nevada, Nevada University Bulletin, v. 45, no. 3, Geology and Minerals Series No. 50. See p.86 Johnnie Mine.

Labbe, C. H., 1921, The placers of the Johnnie district, Nevada, Engineering and Mining Journal, v. 112, p. 895-896.

Labbe, C. H., 1935, 1935, Sinking a 200-ft prospect shaft for $3,000: Engineering and Mining Journal, v. 126, p. 131.

Labbe, C. H., 1960, Rocky trails of the past: Published privately in Las Vegas, Nevada, p. 186-189.

Lincoln, F. C., 1923, Mining districts and mineral resources of Nevada: Nevada Newsletter Publishing Company, Reno, Nevada. See p. 172.

Longwell, C. R ,1945, Low-angle normal faults in the Basin-and-Range province: American Geophysical Union Transaction, v. 26, p. 107-118.

Longwell, C. R., Pampeyen, E. H., Bowyer, B., Roberts, R. J., 1965 , Geology and Mineral Deposits of Clark County, Nevada, Nevada Bureau of Mines and Geology, Bulletin 62, p. 186

Lotz, T. A., 1934, Biennial report of the Surveyor General and State Land Register for the period July 1, 1932, toJune 30, 1934, inclusive: Carson City, Nevada, State Printing Office, p. 16-24. See p.22.

Ludington, Steve, 2006, Mineral resource assessment of selected areas in Clark and Nye counties, Nevada, U.S. Geological Survey, Scientific Investigations Report 2006-5197, McGill, G. E., 1970, Belt Supergroup correlation, Helena to Glacier National Park, Montana: American Association of Petroleum Geologists Bulletin,v. 54, p. 349-352

Minobras, 1973, Nevada Industrial Minerals, 1973, p.10, 12, 35.

Moore, B. N.,1936, Arden, in Hewett, D. F., Callaghan, Eugene, Moore, B. N., Nolan, T. B., Rubey, W. W., and Schaller, W. T., 1936, Mineral resources of the region around Boulder Dam: U.S. Geol. Survey Bulletin 871.

Murphy, Thomas D, 1954, Silica resources of Clark County, Nevada, Nevada Bureau of Mines and Geology Bulletin 55, 43 p. See p. 5 and Fig. 2.

Nevada Division of Mines Inspection (NDM), 1991, Directory of Nevada Mine Operations Active During Calendar Year 1990, 60 p.

Nolan, T. B., 1924, Geology of the northwest portion of the Spring Hountains, Nevada: Ph.D. dissert., Yale Univ., 125 p,

Obradovich, J. D., and Peterman, Z. E., 1968, Geochronology of the Belt Series, Montana: Canadian Jour. Earth Sci., v, 5, p. 737-747.

Page, W.R., Lundstrom, S.C., Harris, A.G., Langenheim, V.E., Workman, J.B., Mahan, S.A., Paces, J.B., Dixon, G.L., Rowley, P.D., Burchfiel, B.C., Bell, J.W., and Smith, E.I., 2005, Geologic and geophysical maps of the Las Vegas 30' x 60' quadrangle, Clark and Nye Counties, Nevada, and Inyo County, California, U.S. Geological Survey, Scientific Investigations Map SIM-2814.

Paher., S. W., 1.970, Nevada ghost towns and mining camps: Howell-North Books. 492 p.

Secor, D. T. , Jr., 1962, Geology of the central Spring Mountains,Nevada: Ph.D. dissert., Stanford Univ., 152 p.

Secor, D. T. , Jr., 1965, The role of fluid pressure in jointing: American Journal of Science,v. 263, p. 633-646.

Skall., H., 1975, The paleoenvironment of the Pine Point lead-zinc district: Economic Geology, v. 70, p. 22-47.

Slate, J.L., Berry, M.E., and Menges, C.M., 2009, Surficial geologic map of the Death Valley Junction 30' x 60' quadrangle, California and Nevada, U.S. Geological Survey, Scientific Investigations Map SIM-3013, 1:100,000

Stoddard, C., 1932, Metal and nonmetal occurrences in Nevada: University of Nevada Bulletin, Bulletin of Nevada State Bureau of Mines and Mackay School of Mines, v. 26, no. 6 (Nevada Bureau of Mines and Geology Bulletin 16), 131 p. See p.68.

Tingley, Joseph V., 1998, Mining Districts of Nevada, Second Edition, Nevada Bureau of Mines and Geology, Report 47, Plate 1 with digital report of unnumbered pages.

U.S. Bureau of Mines (USBOM), 1932, Information Circular 6615, 11 p.

U.S. Bureau of Mines (USBOM), 1937, Information Circular 6964, pp. 1-15, 73, 81

U.S. Bureau of Mines (USBOM), 1950, Information Circular 7555, 21 p.

U.S. Bureau of Mines (USBOM), 1985, Open File Report MLA 41-85, 1985, TABLE 1,NO.

Vanderburg, W. 0., 1936a, Placer mining in Nevada: Nevada Bureau of Mines Bulletin 30, 178 p.Revised discussion of placer operations. Includes three localities previously unreported.

Vandenberg, 1937, Reconnaissance of mineral districts in Clark County, Nevada, USGS Information Circular 6964, P. 54

Wheeler, G.M., 1872, Preliminary report concerning explorations and surveys principally in Nevada and Arizona: Washington, D.C., U.S. Army Corps. of Engineers, 96 p., map, scale 1:1,500,000 (approx.). See p.52.

Wedow, Helmuth, Jr., copper deposits region (abstract): 1975, The potential for stratabound disseminated in the Cambrian sandstones of the Appalachian Econ. Geology, v. 70, p. 252.

Wilkerson, Gregg, 2019, Southern Spring Mountains (a.k.a. Goodsprings) Mining District, Clark County, Nevada and San Bernardino County, California. In David Miller, editor, Exploring ends of eras in the eastern Mojave Desert, Proceedings of the 2019 Desert Symposium, Desert Symposium Inc., pp. 104-112.

Wilkerson, Gregg, 2024a, Geology and Mining History of the Central Spring Mountains, Clark County, Nevada; http://www.greggwilkerson.com/spring-mnts-central.html

Wilkerson, Gregg, 2024b, Geologic Mosaic for the Central Spring Mountains, Clark County, Nevada;
http://www.greggwilkerson.com/geological-mosaic.html

Wilkerson, Gregg and Larry Vredenburgh, 2024, Railroads and mining in the Mojave Desert and southwestern Great Basin, California and Nevada, in Get your kicks:Trails across the Mojave, David M. Miller and Stephen M. Rowland, editors, 2024 Desert Symposium Field Guide and Proceedings April 2024, Desert Symposium, Inc.; p. 47-69.

Workman, J.B., Menges, C.M., Page, W.R., Taylor, E.M., Ekren, E.B., Rowley, P.D., Dixon, G.L., Thompson, R.A., and Wright, L.A., 2002, Geologic map of the Death Valley ground-water model area, Nevada and California, U.S. Geological Survey, Miscellaneous Field Studies Map MF-2381-A, 1:250,000

MAPS

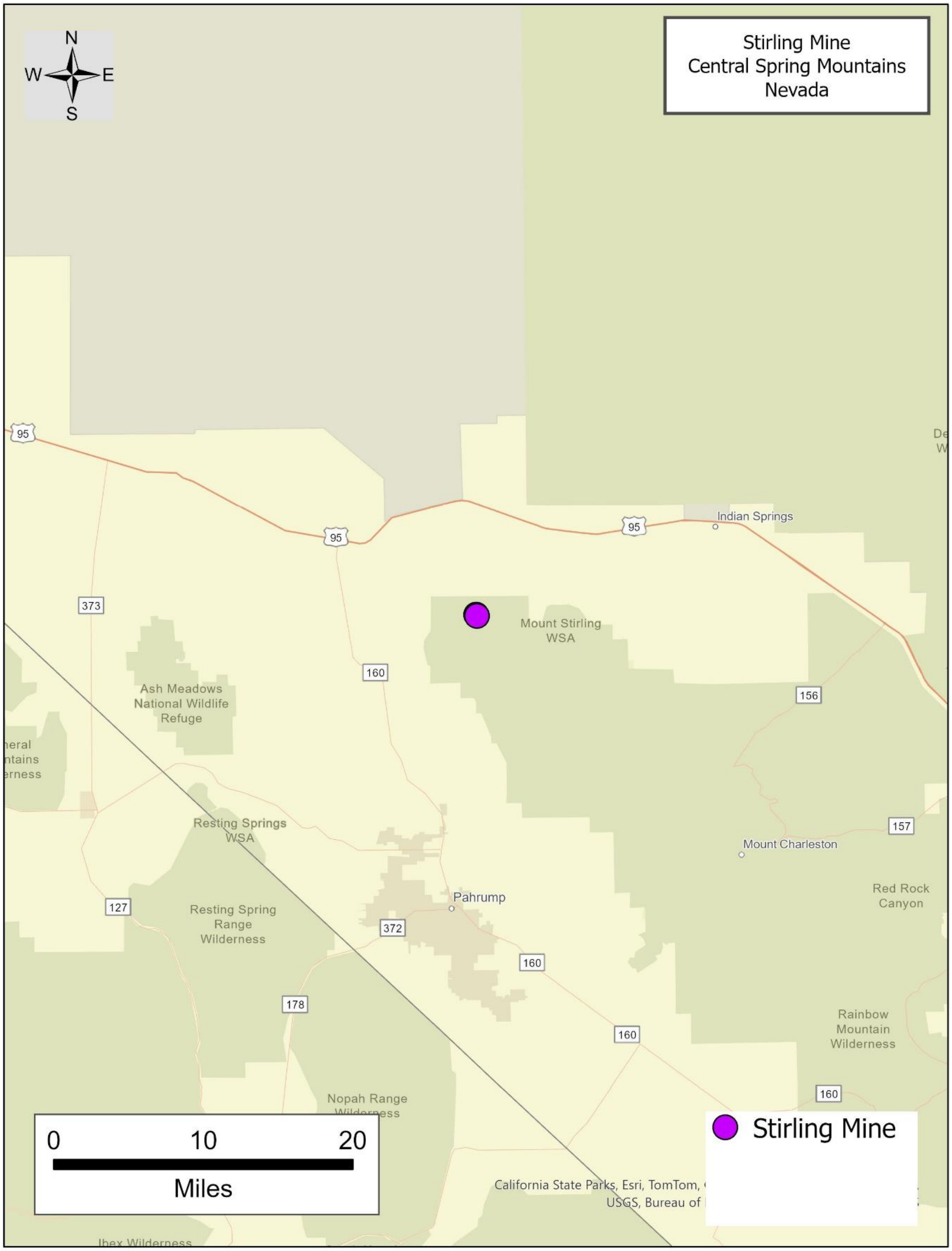


Figure 11. Location map for the Stirling Mine. Open source for educational purposes, no copyright.

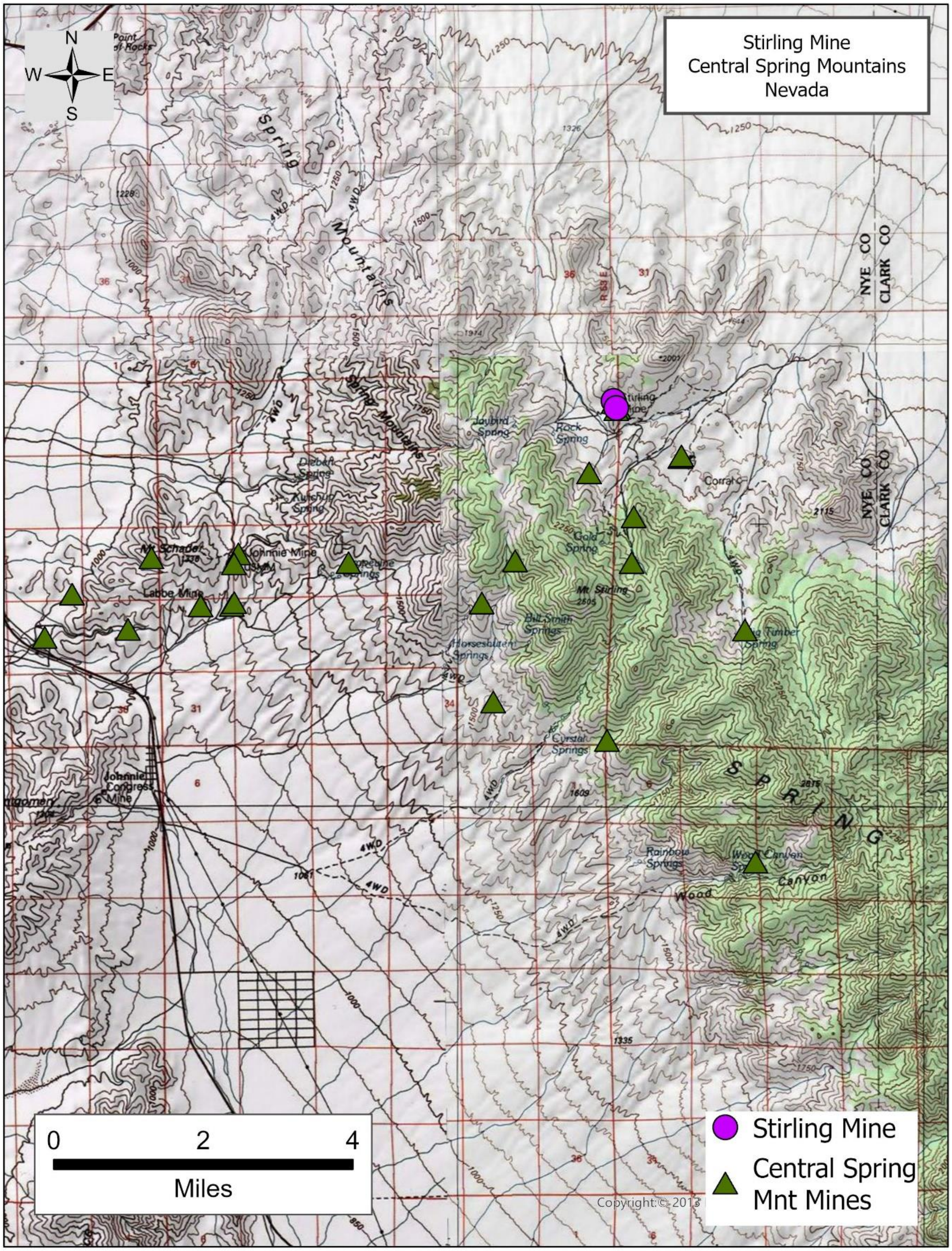


Figure 12. Regional topographic map of the Stirling Mine. Open source for educational purposes, no copyright.

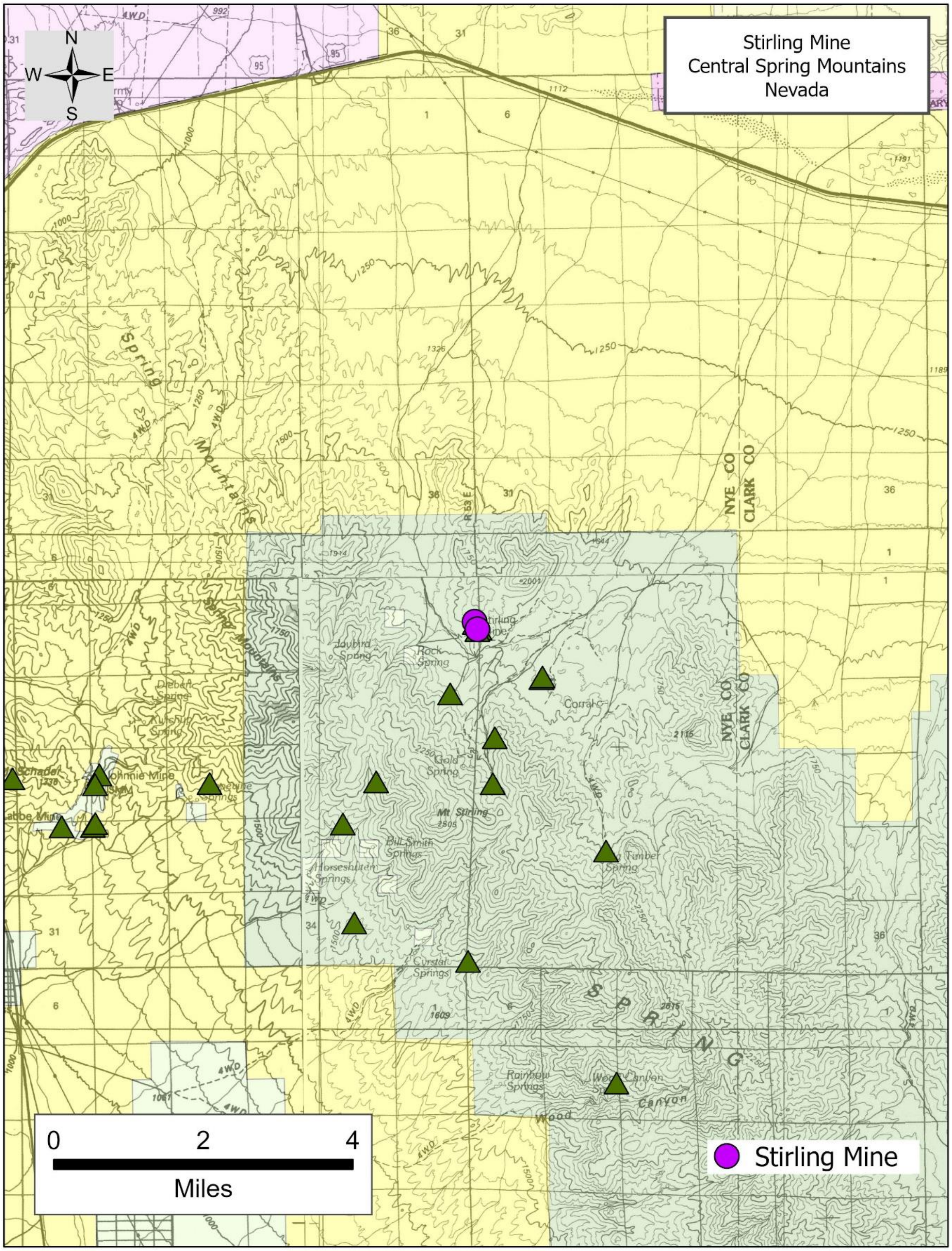


Figure 13. Land status map of the Stirling Mine. Green is U.S. Forest Service. Yellow is U.S. Bureau of Land Management. Blue is private land. Purple is military lands. Open source for educational purposes, no copyright.

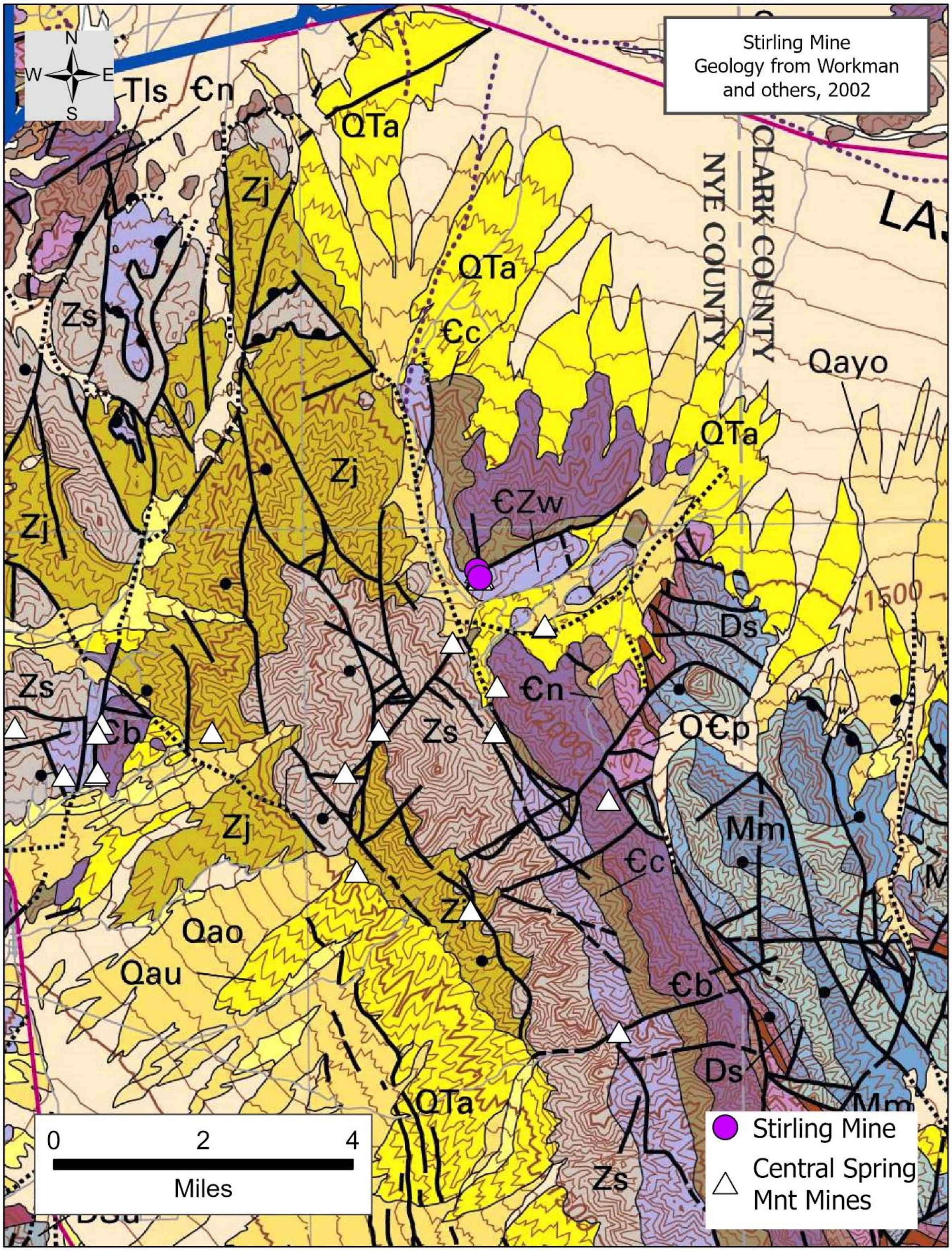


Figure 14. Regional geologic map of the Stirling Mine and surrounding areas. Open source for educational purposes, no copyright.

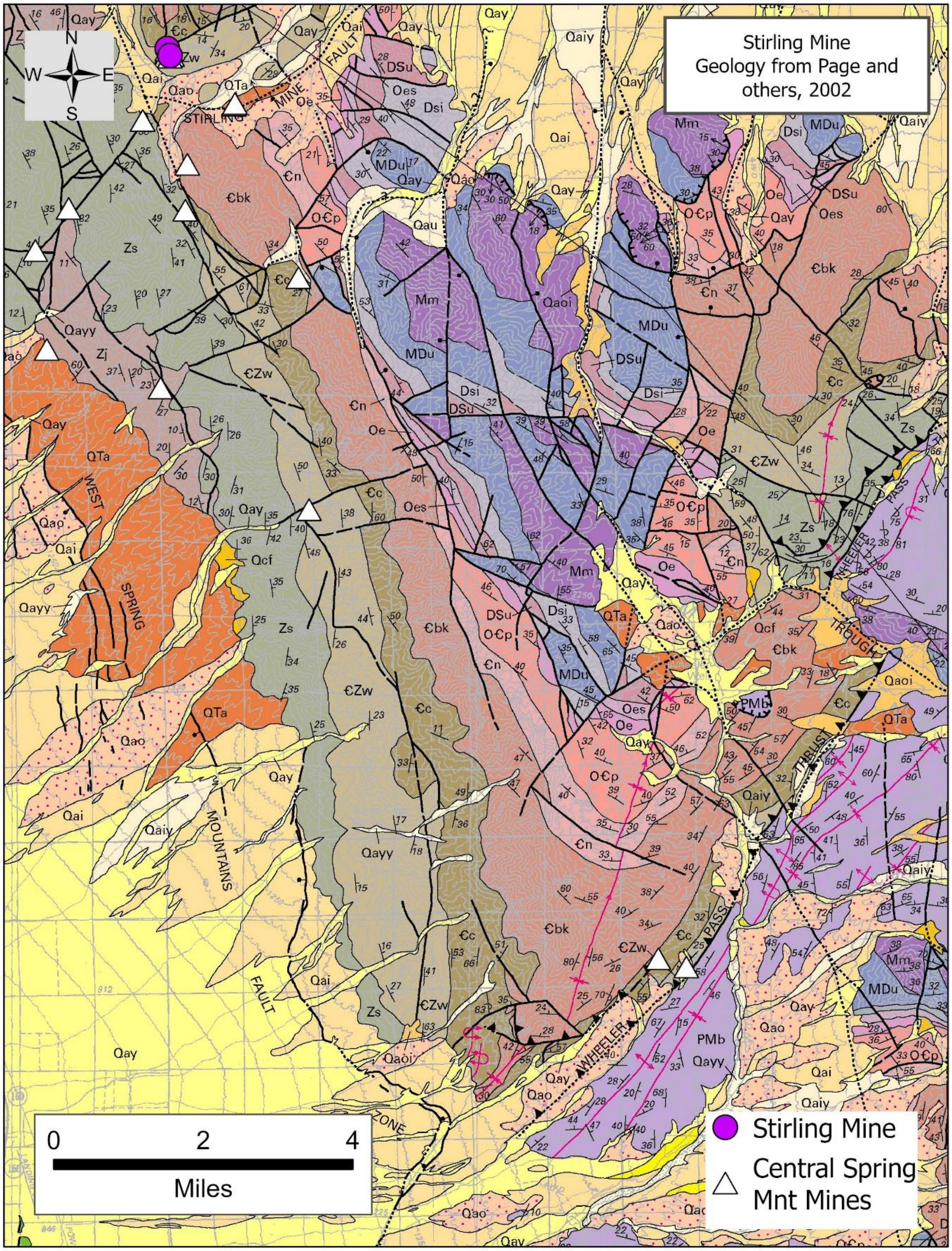


Figure 15.Regional geologic map of the Stirling Mine and surrounding areas. Open source for educational purposes, no copyright.

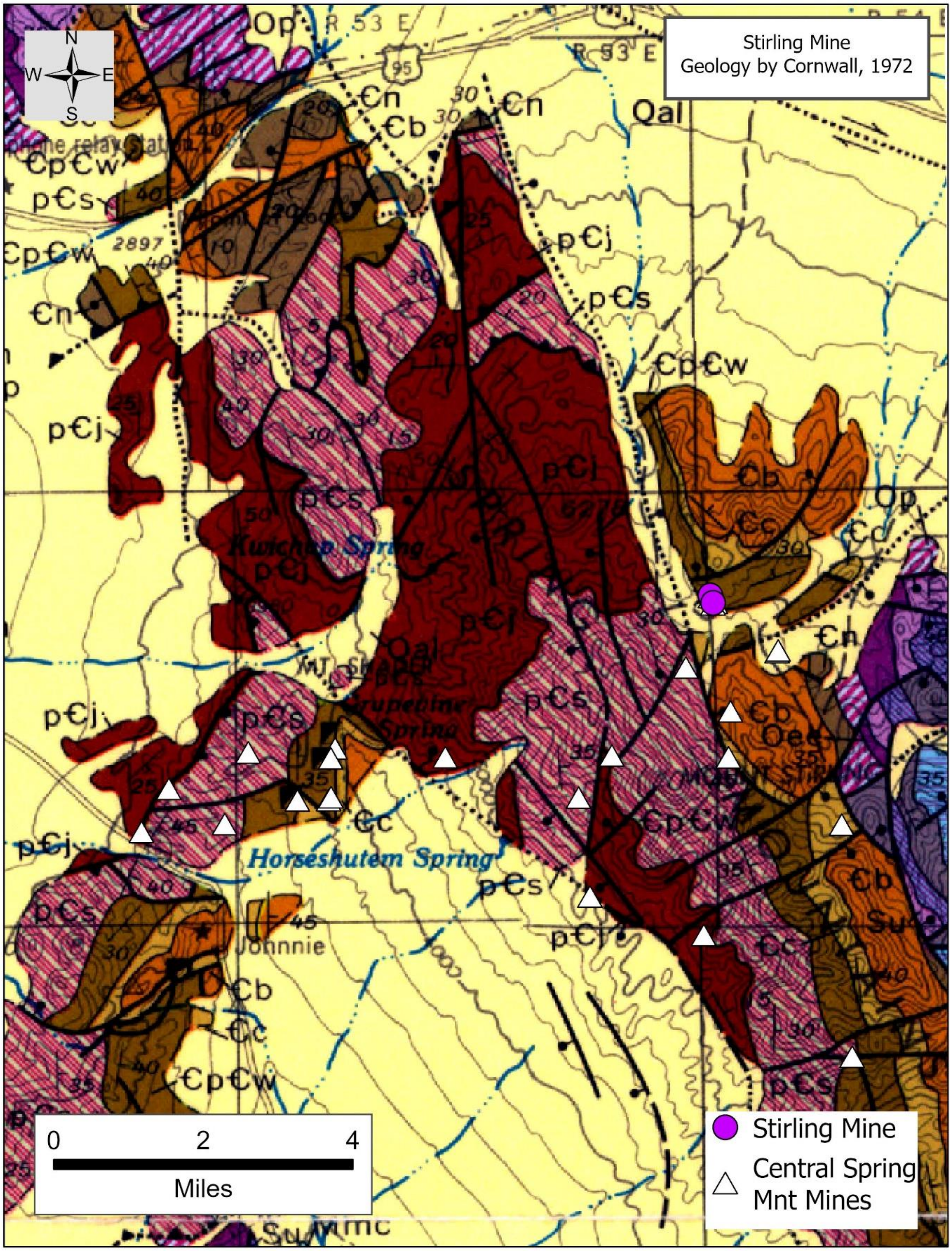


Figure 16. Regional geologic map of the Stirling Mine and surrounding areas. Open source for educational purposes, no copyright.

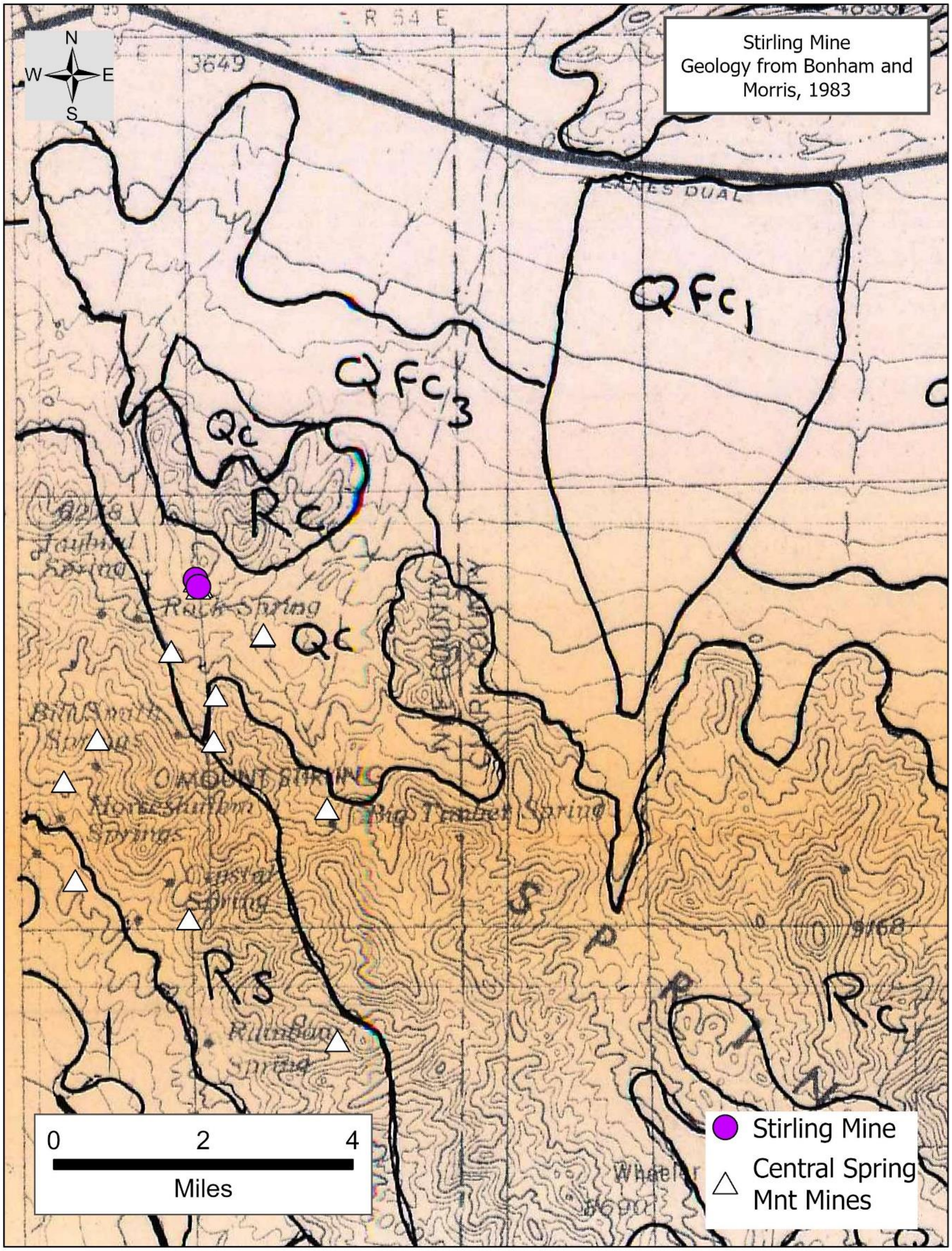


Figure 17. Regional geologic map of the Stirling Mine and surrounding areas. Open source for educational purposes, no copyright.

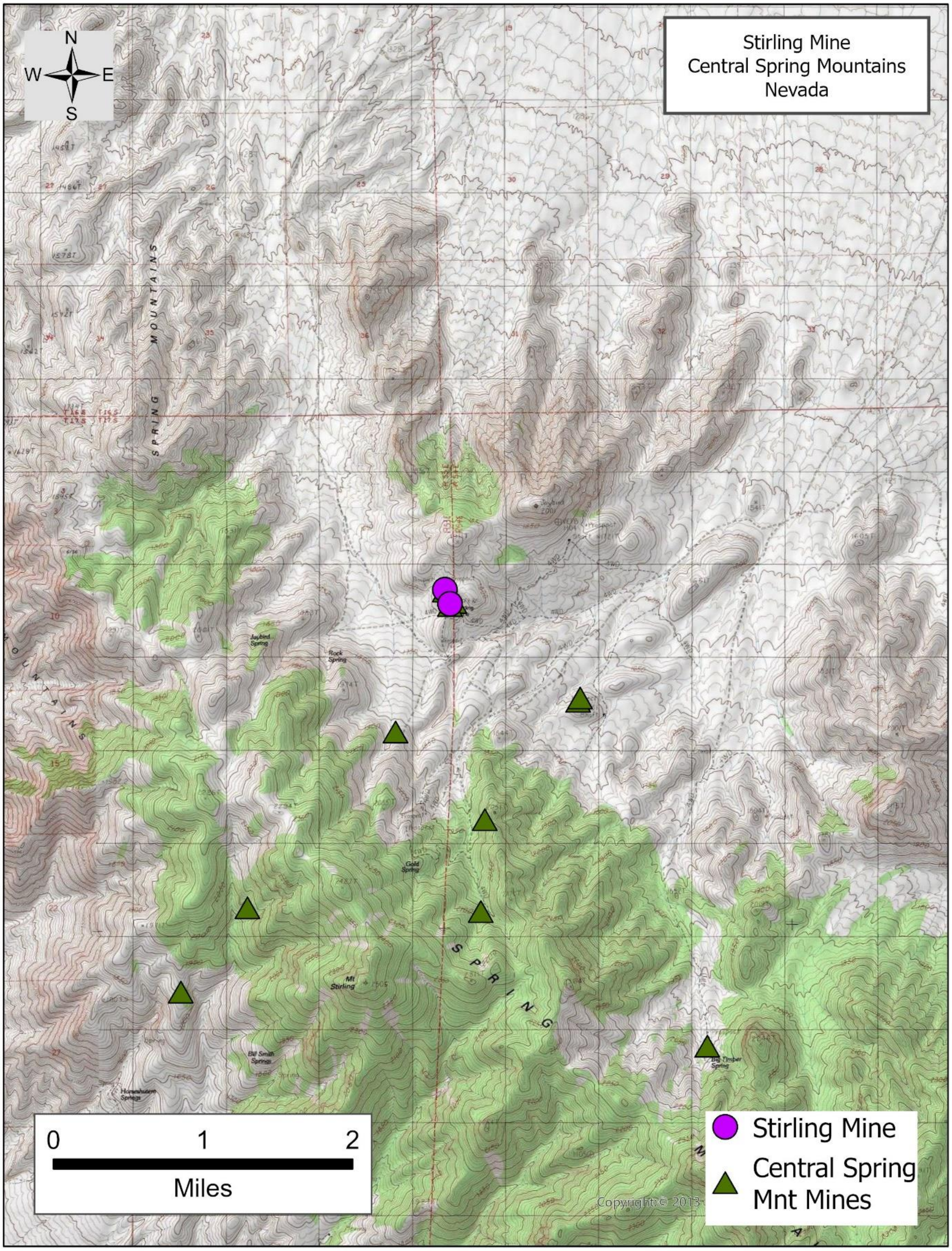


Figure 18. Figure 18. Area topographic map of the Stirling Mine. Open source for educational purposes, no copyright.

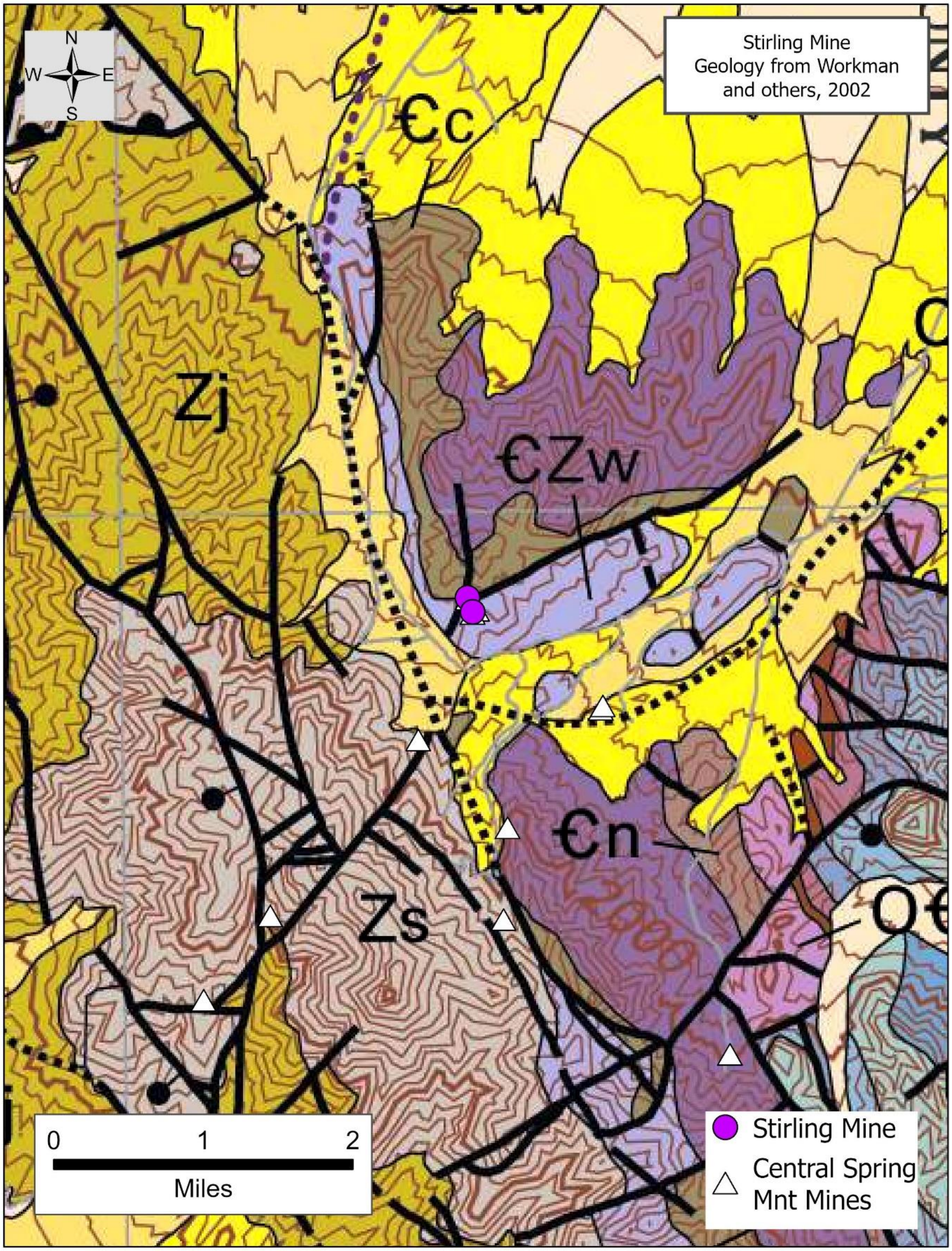


Figure 19. Area geologic map of the area surrounding the Stirling Mine. Open source for educational purposes, no copyright.

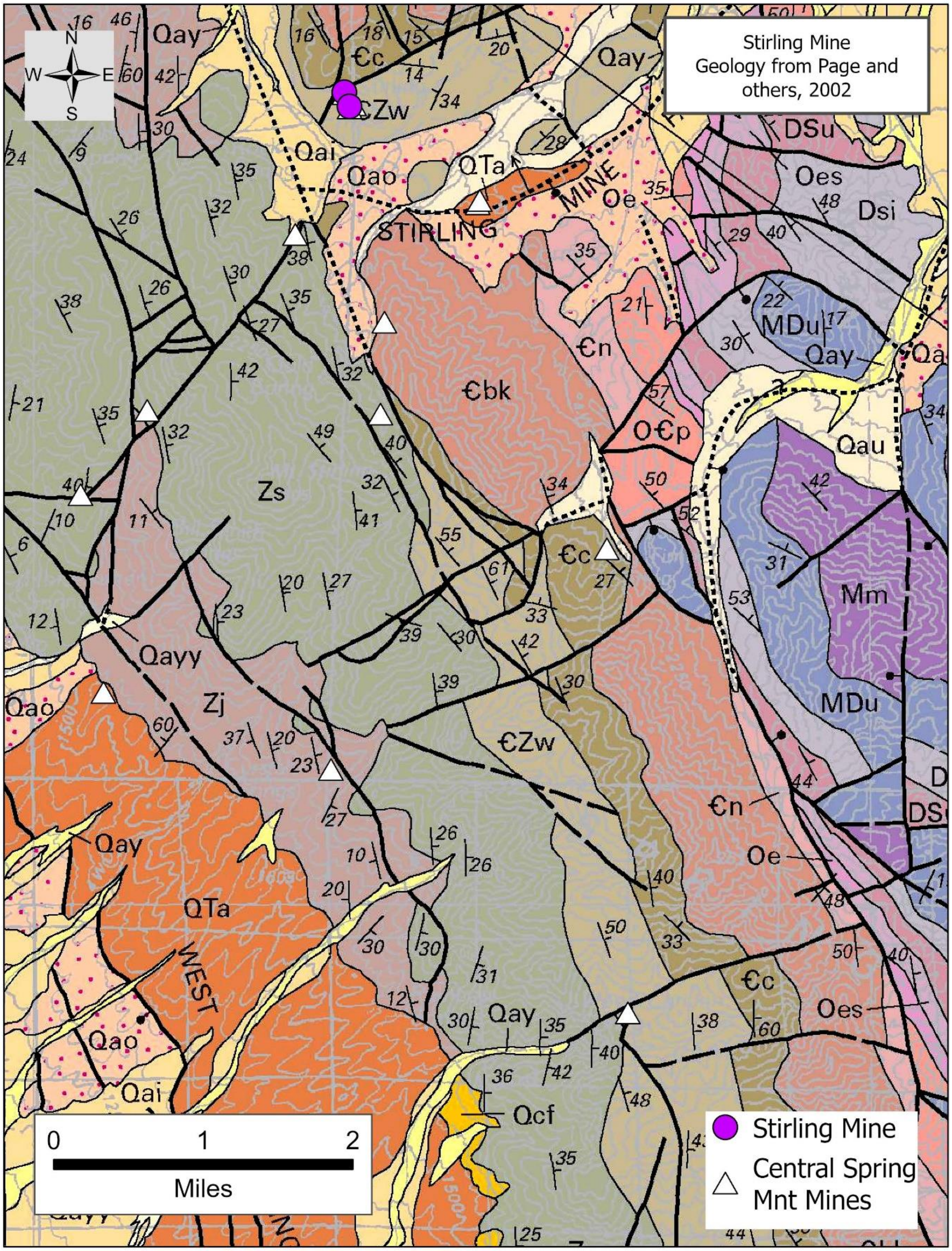


Figure 20. Area geologic map of the area surrounding the Stirling Mine. Open source for educational purposes, no copyright.

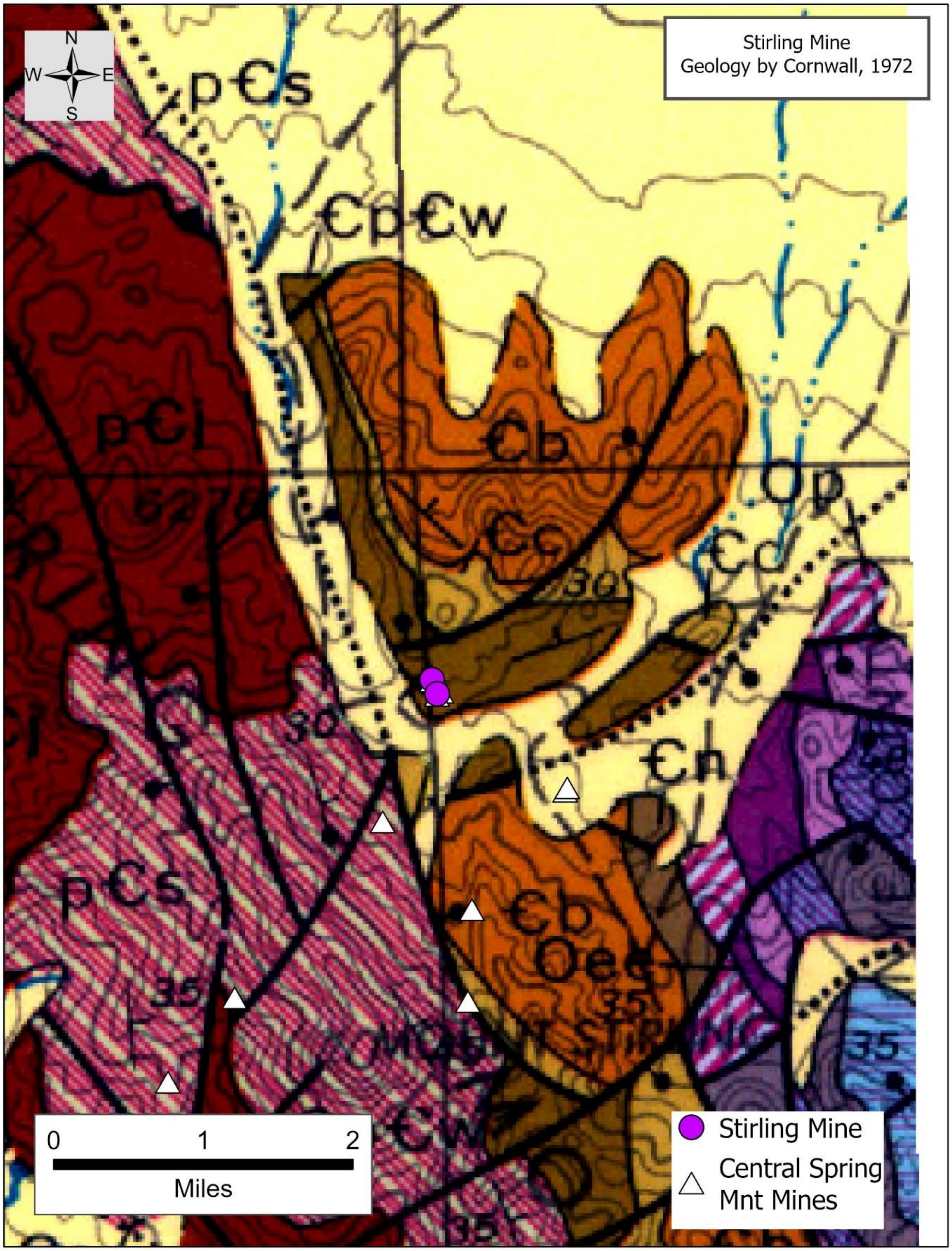


Figure 21. Area geologic map of the area surrounding the Stirling Mine. Open source for educational purposes, no copyright.

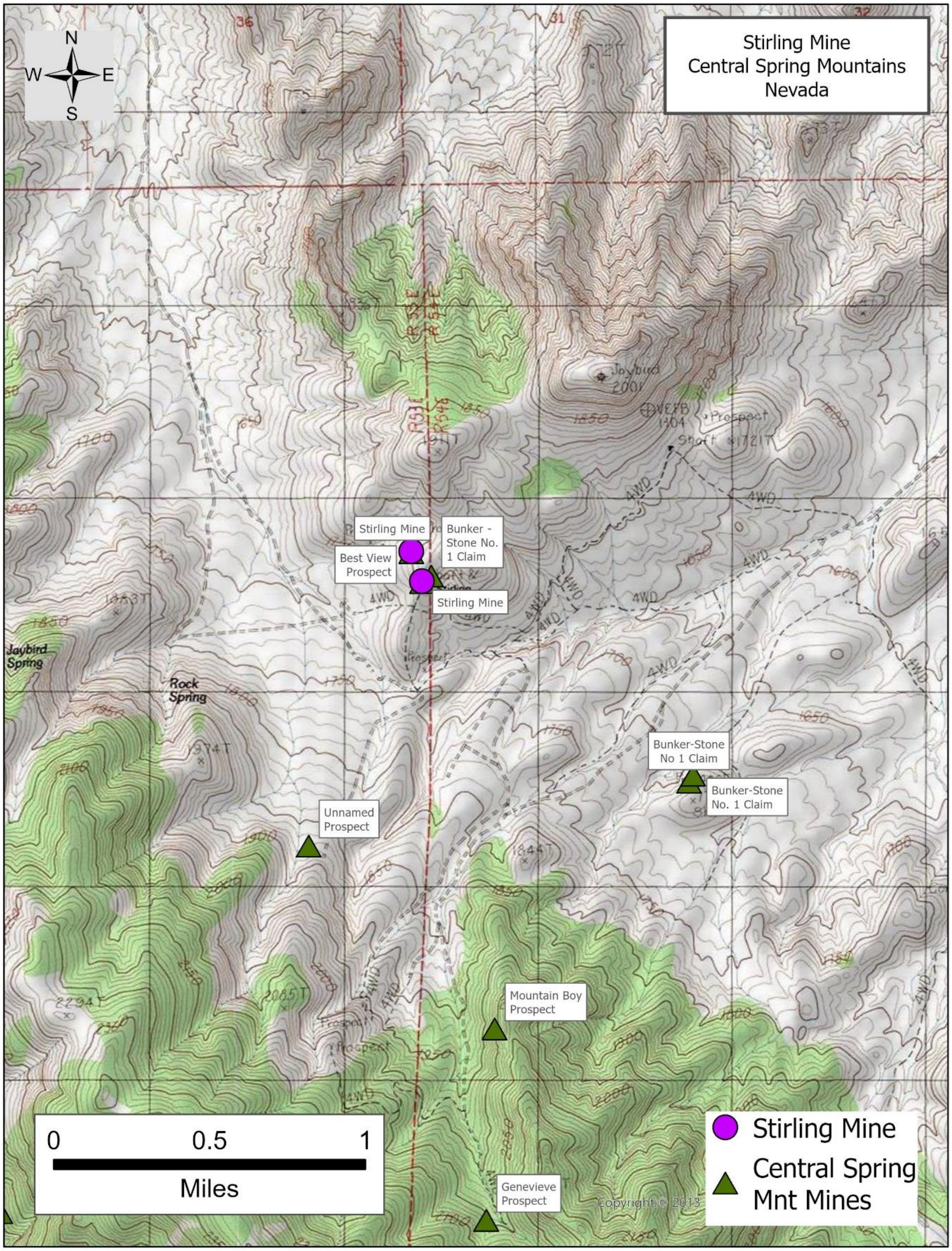


Figure 22. Site topographic map of the Stirling Mine and surrounding areas. Open source for educational purposes, no copyright.

Figure 23. Site geologic map of the Stirling Mine and surrounding areas. Open source for educational purposes, no copyright.

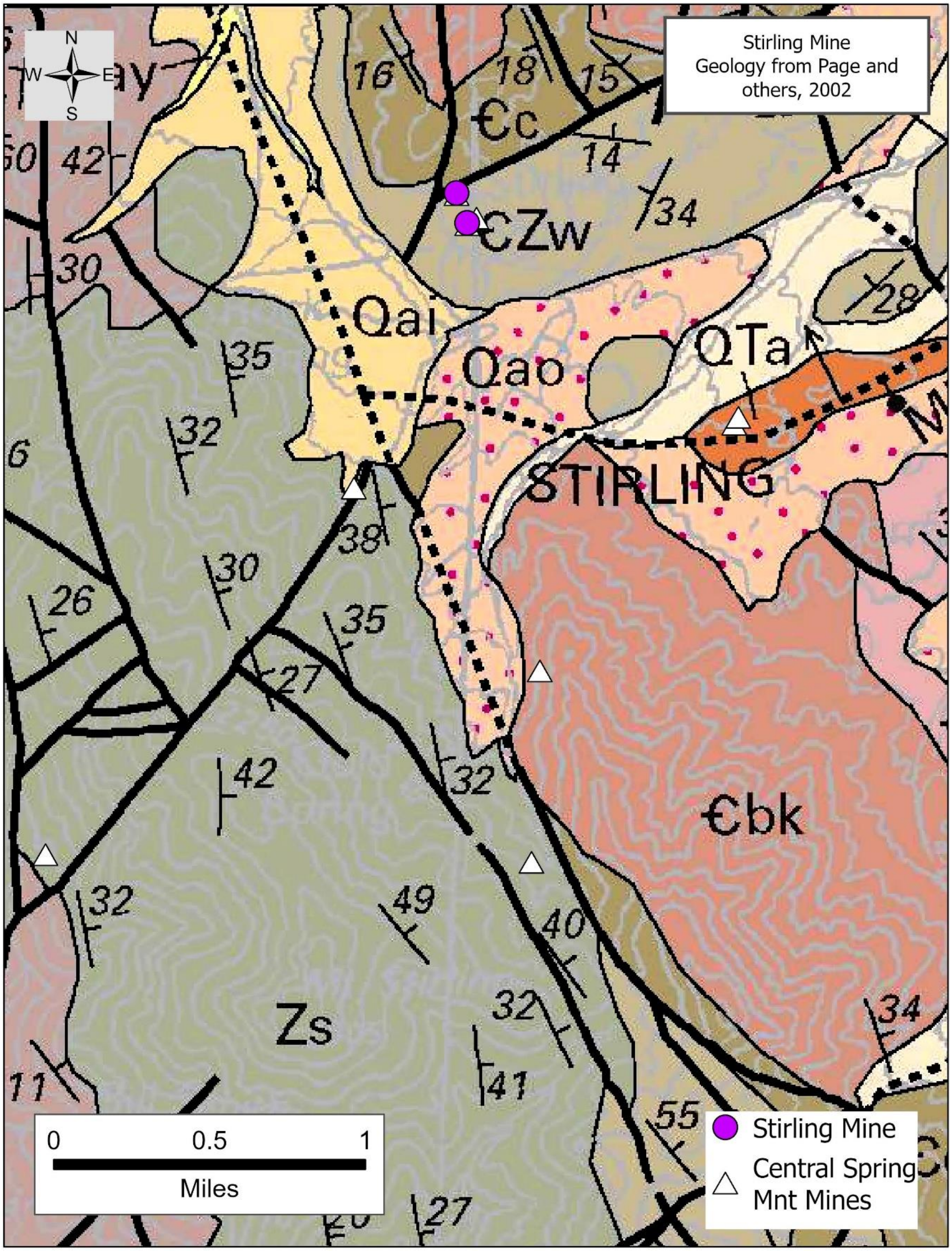


Figure 24. Site geologic map of the Stirling Mine and surrounding areas. Open source for educational purposes, no copyright.

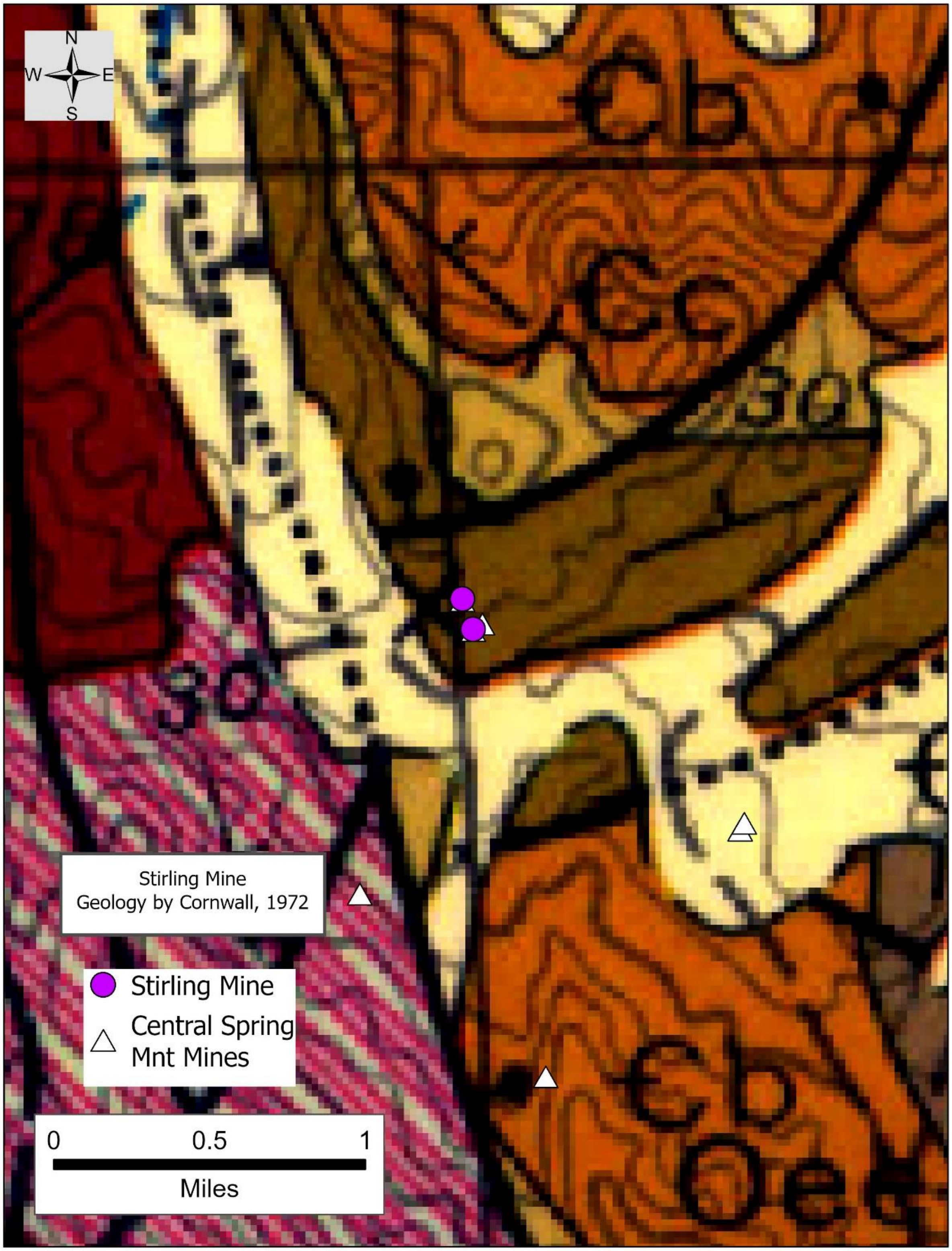


Figure 25. Site geologic map of the Stirling Mine and surrounding areas. Open source for educational purposes, no copyright.

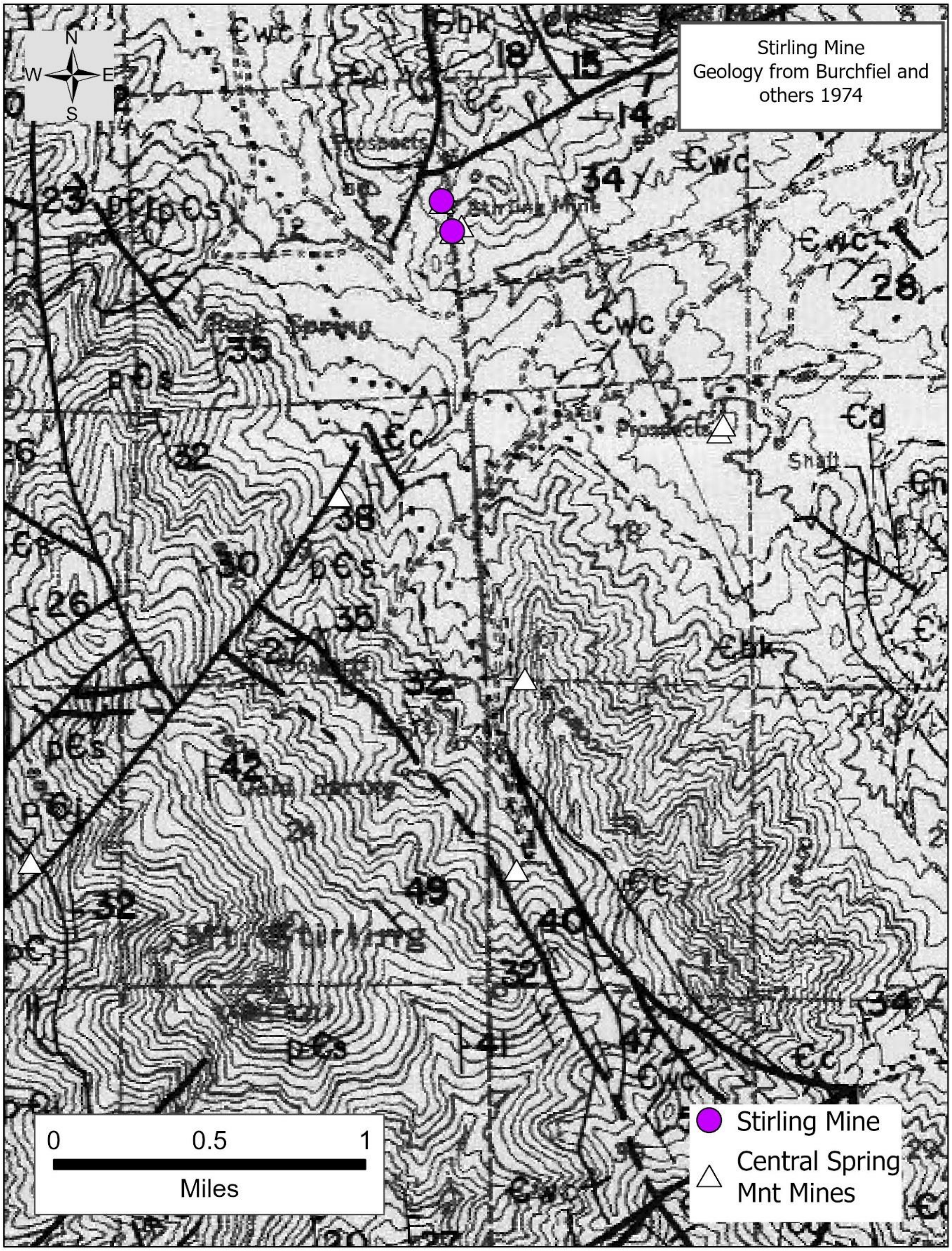


Figure 26. Site geologic map of the Stirling Mine and surrounding areas. Open source for educational purposes, no copyright.

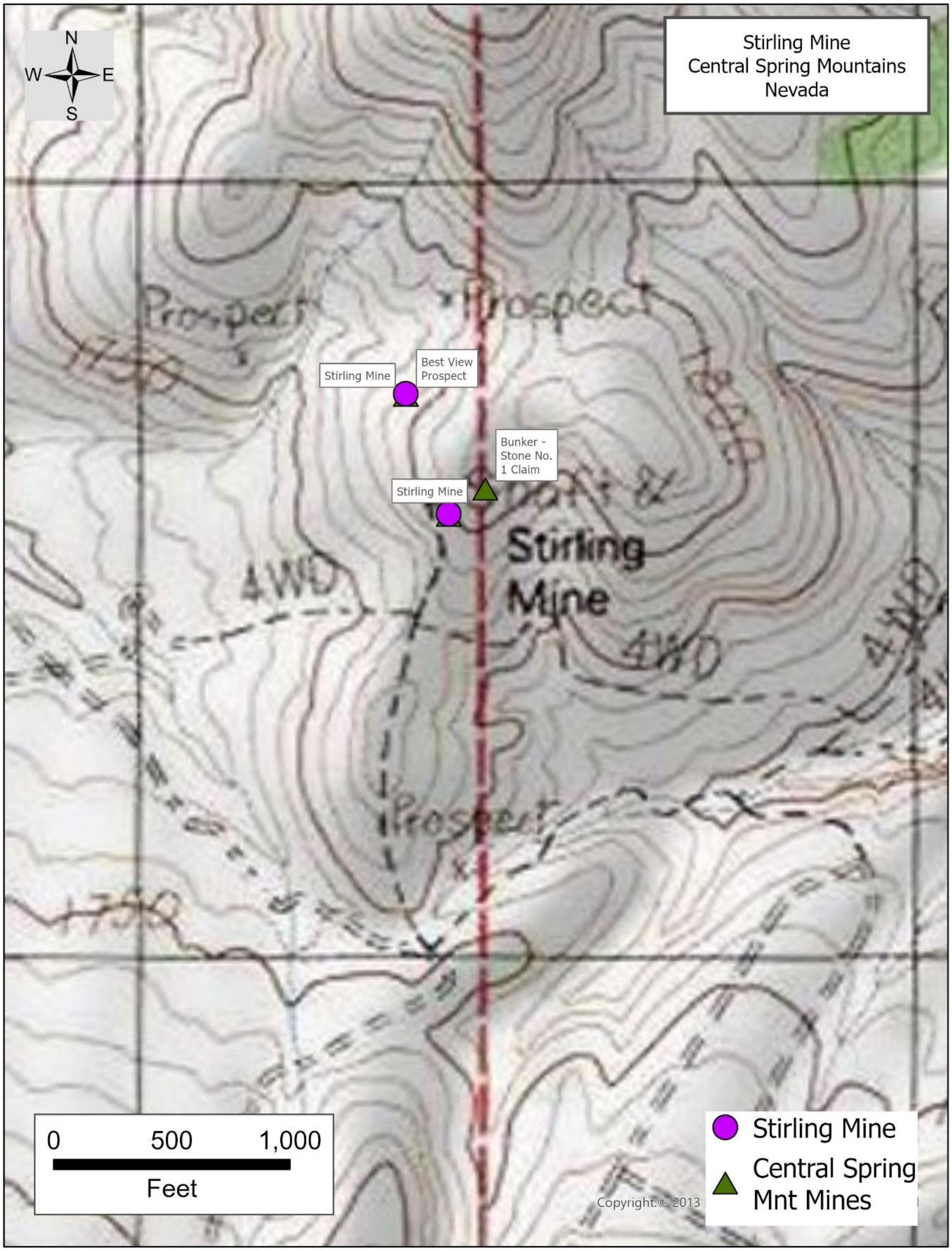


Figure 27. Topographic map of the Stirling Mine and surrounding areas. Open source for educational purposes, no copyright.

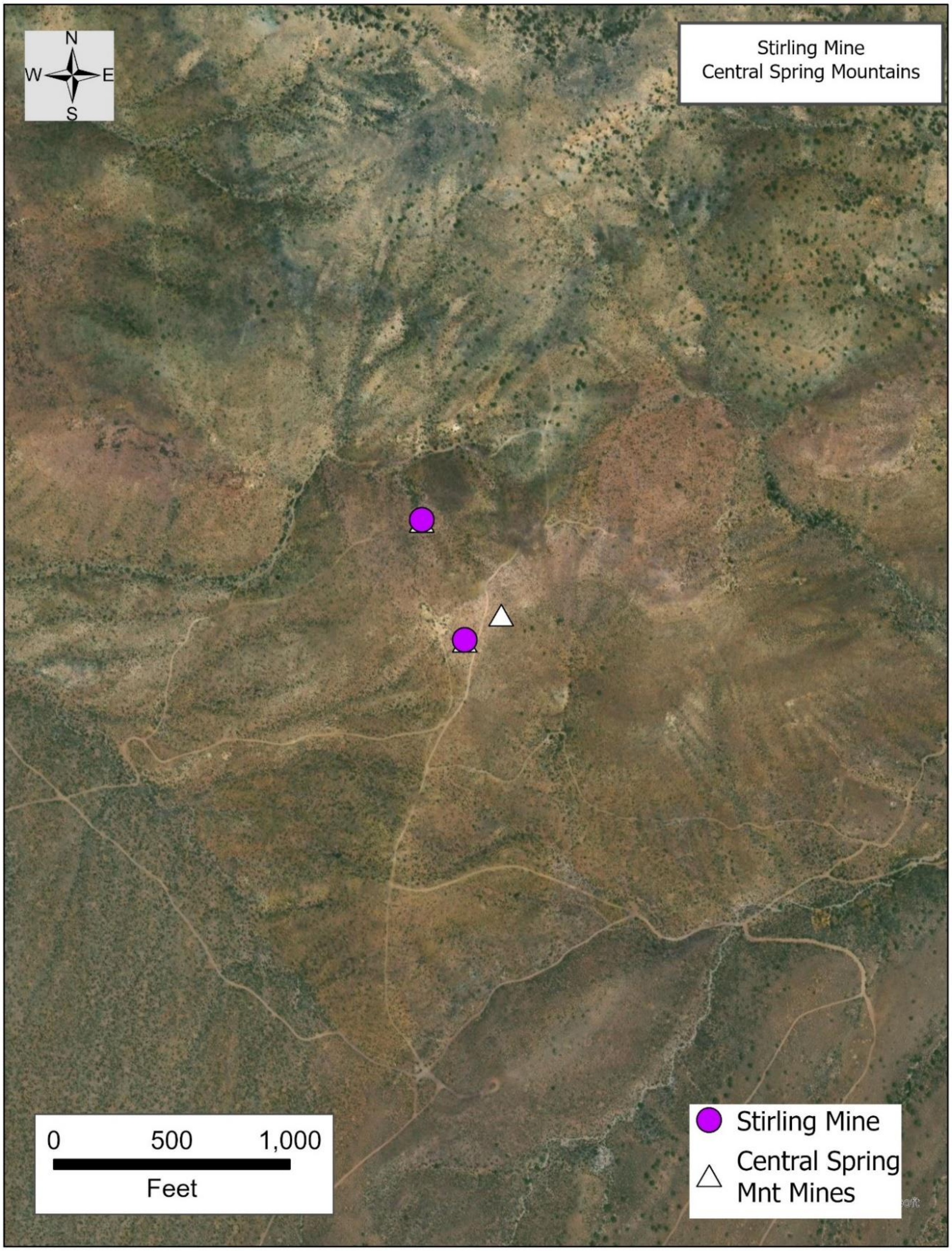


Figure 28. Aerial photo of the Stirling Mine and surrounding areas. Open source for educational purposes, no copyright.