

**Mining History, Geology, and Economic Potential of the  
King Tonopah Vein System, northern Tonopah District  
Nye County, Nevada**

for

**Tonogold Resources, Inc.  
5771 La Jolla Boulevard, Suite 100  
La Jolla, California 92037**

by

**Donald G. Strachan, Geologist, MSc CPG  
P.O. Box 2940, Gardnerville, Nevada 89410  
[www.geostrachan.com](http://www.geostrachan.com)**

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## Abstract

Tonogold Resources Inc. (“Tonogold”) has acquired a significant land position in the northern Tonopah District, Nevada, including an area around the historic King Tonopah shaft. The central Tonopah District produced 174 million ounces of silver and 1.8 million ounces of gold between 1901 and 1935. Average historic grade of the Central Tonopah District was 0.23 opt gold and 23 opt silver.

The northern Tonopah District was recognized as having a similar resource potential as early as 1935. Drill discoveries in the late 1940’s were followed by minor production from the King Tonopah vein at grades similar to those of the central Tonopah District. Drilling in the late 1970’s defined multiple Tonopah-type structures along with lithologies, alteration, and mineralization around the King Tonopah workings, at the center of a similar area large enough to duplicate the central Tonopah District.

Drill holes in the northern Tonopah District have encountered four steep vein structures in addition to the near-vertical King Tonopah vein. A gentle west-dipping, concave-upward, fault-vein system similar to the Tonopah Fault in the central District is indicated below the steep veins of northern Tonopah. The Tonopah Fault was a major source of production in the central District. Tonogold’s exploration goals include delineation of the indicated low-angle fault-vein system.

Tonogold has designed a two-phase drill program to define a resource potential similar in size and grade to the central Tonopah District. Phase One goals be acquisition of additional small property segments around the existing Tonogold holdings, compilation of all data, surface prospecting and mapping, and drill exploration. Rehabilitation of the King Tonopah workings, as an access alternative and for underground drilling, is included in the Phase One budget. When Phase One is completed, the extent of the King Tonopah resource should be determined, veins on existing and new structures should be found, and a Phase Two drill development plan for the northern Tonopah District should be viable.

Phase One will consist of surface drill exploration extended over a three to four-year period. A maximum of 20 vertical and angle surface RC holes will have an average length of 1,500 feet for a total of 30,000 feet. Estimated drilling cost, at \$24 per foot with assays: \$717,000. Estimated cost of underground access, sampling, and man-way rehabilitation in the King Tonopah shaft: \$153,800. Geologist and expenses: \$135,000. Contingency: \$100,000. Estimated Phase One costs: \$1,102,000. Substituting core for RC drilling will increase Phase One costs by 25%.

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## Introduction

### ***Purpose***

Nolan (1935) suggested the northern Tonopah District was favorable for additional Tonopah-type ore bodies after completing an underground map and three-dimensional model of the central Tonopah District. In 1947 and 1948, the King Tonopah vein was discovered as a direct result of Nolan's suggestion. Metal prices remained low in the years following the discovery, exploration was curtailed, and King Tonopah's production was limited to a single year's production.

This paper reports upon the geology of the King Tonopah mineralization and that of other vein intercepts in the immediate area, and provides a summary of drill hole descriptions, assay intervals, and production data from the King Tonopah vein. The potential of the northern Tonopah District is compared with the central Tonopah District, which produced 1,861,200 oz. gold and 174,152,628 oz. silver between 1901 and 1935 (Bonham and Garside, 1979, p. 109). Recommendations and cost estimates for developing the potential of the northern Tonopah District are given.

### ***Property description and ownership***

The King Tonopah vein system is centered in Sections 25 and 26, of Township 3 North and Range 42 East, Mt. Diablo meridian, about one mile north of the productive limits of the central Tonopah Mining District (Figure 2a). Ownership of the potential area is about evenly divided between patented and unpatented lode claims (Figure 4b). Unpatented claims are either owned outright by Tonogold or held under favorable lease terms. Patented claims are held by a single-owner Nevada company. The area within and surrounding Tonogold's present position is available for leasing or staking.

### ***Exploration and mining history***

From 1901 through the mid-1950's, the central Tonopah District produced 8,750,000 tons of ore averaging 0.23 opt gold and 23 opt silver (\$267/ton today), for 1,861,200 oz. gold and 174,152,628 oz. silver (Bonham and Garside, 1979, p. 109) and a total value at today's metal prices of \$2,070,000,000. Peak annual production in 1913 totaled 574,542 tons of 0.22 opt Au and 20 opt silver (\$241/ton today). At least 95% of Tonopah's historical production came from a zone one mile east-west, 1,200 feet north-south, and over 2,000 stratigraphic and vertical feet (Figures 2 and 3) directly beneath the town of Tonopah.

The King Tonopah shaft was sunk about 1905 for exploration purposes to test the outcropping Mizpah Formation in the northern Tonopah District. The Mizpah andesites are host for much of the ore taken from the central Tonopah District. No ore was encountered by the King Tonopah shaft, no lateral workings were undertaken, and the shaft was terminated just below the 300 foot level (elevation 5,885 feet). After exhaustive underground study of the Tonopah District, Nolan (1935) speculated on several areas for further exploration. He judged "the region to the north" to be the most favorable area. This "region" centered on the area of the King Tonopah shaft.

In 1947, Calumet & Hecla's field geologists followed up on Nolan's (1935) speculation. After finding quartz-adularia-sericite vein material on the dump of the King

Tonopah prospect shaft, they recommended exploration core drilling in the vicinity of the King Tonopah workings. This work was carried out by Tonopah Development Company. The fourth drill hole (ADH-4) was vertical, and intercepted two veins with typical Tonopah-type alteration and mineralization. The upper vein, the Q vein has not been developed or produced from, but the lower vein, the King Tonopah vein, produced ore in 1953 and 1954.

The first intercept of ADH-4 (Q vein), at an elevation of 5,405 feet (Figure 5), assayed 0.058 opt Au and 5.3 opt Ag over 9.0 feet. The second intercept (King Tonopah vein) at an elevation of 5,330 feet assayed 0.098 opt Au and 9.6 opt Ag over 13.3 feet. The sixth Calumet & Hecla hole (ADH-6) also had two intercepts: the first (Q vein) at an elevation of 5,395 feet graded 0.066 opt Au and 12.0 opt Ag over 4.0 feet, and the second (King Tonopah vein) at an elevation of 5,365 feet graded 0.119 opt Au and 22.7 opt Ag over 16.5 feet. Two more holes were drilled by Calumet & Hecla before the property was optioned to Asarco. Four additional holes were drilled by Asarco (ADH-9 through ADH-12) in 1948 before the property was returned to Calumet & Hecla.

In 1952, Summit King & Homestake joint ventured the King Tonopah property from Calumet & Hecla, refurbished the shaft to the 300 Level, and drove a cross-cut 900 feet to the north. In April, 1952, Summit King-Homestake the crosscut encountered five feet of “high grade” argentite-pyrargyrite vein (the King Tonopah vein) with the “traditional Tonopah ratio of 100 parts silver to 1 part gold” (Tonopah Times-Bonanza, April 22, 1952). By December, 1952, Summit King-Homestake had drifted 300 feet east and west on the 300 Level. They encountered offsetting faults at both faces and began to develop the King Tonopah vein at depth with an internal winze. Summit King-Homestake did not attempt to develop or explore the Q vein.

On January 2, 1953 (Tonopah Times-Bonanza), Summit King-Homestake declared the fault offsetting the east end of the King Tonopah vein was a “Halifax-style fault dipping 35° to the northeast”. The west end of the exposed King Tonopah vein terminated against a northeast-striking vertical fault. Of the 300 feet developed between the two faults, “260 feet were vein matter with good values” (Tonopah Times, 2 Jan. 1953). By October 23<sup>rd</sup>, 1953 (Tonopah Times-Bonanza), the Summit King winze had reached the 650 Level (elevation 5,335 feet). An “ore width” of four feet was encountered on the 550 Level. About 15,000 tons averaging about 0.3 opt Au and 30 opt Ag was blocked and mined between the faults and the 550 and 200 Levels by July 1954. Summit King-Homestake then returned their lease to Calumet & Hecla (Bonham & Garside, 1979, page 120). Wilkins (1986, page 4), in some conflict, states 30,000 tons grading 0.02 opt Au and 20 opt Ag were mined at this same time.

Summit King-Homestake did not explore beyond the offsetting faults to the east and west, nor did they develop the King Tonopah vein below the 550 Level, deciding instead to take what profit they could during a prolonged period of low metal prices. All of the Summit King-Homestake production came from approximately 50% of the faulted segment of the King Tonopah vein between the 550 and 200 levels, most of which was four to five feet wide.

Calumet & Hecla gave several leases to local miners between 1954 and 1958, who reported shipping ores valued at \$40 per ton to the smelter at McGill, Nevada. The

last reported attempt to fully develop the King Tonopah vein occurred in 1958 and 1959, when the directors of U.S. Milling and Minerals (Silverpeak mill) formed the Tonopah King Mining Company and leased the King Tonopah mine and surrounding claims. First shipment was made in December, 1958 (Tonopah Times-Bonanza), and periodic shipments continued from 1958 to 1962, when the Silverpeak mill closed after a series of fatal accidents. The King Tonopah shaft and headframe burned in the late 1960's.

Summa Corporation and Hughes Tool Company consolidated ownership of patented and unpatented claims within the Tonopah Mining District in the late 1960's. After acquisition, Summa focused exploration and development capital in the central Tonopah District. They did not explore the northern Tonopah District, including the area around the King Tonopah mine.

In 1977, Houston Oil and Minerals ("Houston") acquired all of Summa's Nevada mineral properties, including the now-consolidated patented and unpatented claims in the Tonopah Mining District. Houston's priorities for developing the Tonopah District during rising metal prices included: 1) exploitation of the considerable values already at the surface in the historical waste dumps and tailings, 2) development of open-pittable reserves in the central Tonopah District, and 3) exploration of potential new underground resources, especially in the northern Tonopah District. Houston concluded Tonopah's surface resources could be brought into production, and potential subsurface resources could be developed as experience was gained and exploration proceeded within the District. In 1979, Houston was purchased by Tenneco Inc., resulting in eventual cancellation of many of Houston's new exploration and development projects. Houston completed geologic mapping surveys, surface geochemical surveys, dump sampling surveys, and some drill programs prior to cancellation of the Tonopah project.

Houston's drill program in the northern Tonopah District consisted of thirteen core holes (HT-1 to HT-13). Extensions of the King Tonopah and Q veins, and six new vein or vein stringer zones, were discovered by Houston, with vein intercepts assaying up to 3.4 feet of 0.295 opt Au and 16.3 opt Ag (Table 1 and Figure 5). One of the six possible vein-bearing structures was an 11-foot wide quartz-sulfide stringer zone encountered 1,200 feet north of the King Tonopah vein. This interval, in vertical core hole HT-11 at an elevation of 5,340 feet (Figure 5) with an assay of 0.10 opt Au and 2.5 opt Ag, was an indication of additional Tonopah-type veins in the northern Tonopah District. The other three vein and stringer intercepts away from the original King Tonopah and Q veins (HT-5, HT-7, HT-13) are equally good indicators. Follow-up drilling of these intercepts or of the indicated vein system was not undertaken by Houston or its successor Tenneco.

### ***Workings***

Three prospect shafts were sunk in the northern Tonopah District: King Tonopah, Belle of Tonopah, and Umatilla (Figure 4b). The King Tonopah workings (1952-1960) leading away from the bottom of the King Tonopah shaft (5,885 feet elevation) are the latest underground development in the Northern Tonopah district. They consist of Summit King-Homestake's 900-foot crosscut north at the 300 Level, two 300-foot drifts along the King Tonopah Vein at the 300 and 550 levels, an internal winze from the 300

Level to the 650 Level, and several stopes between the 200 and 550 levels resulting from the 1953-54 ore shipments.

The Belle of Tonopah shaft is 470 feet deep and located about 1,620 feet west-southwest of the King Tonopah shaft. No workings or drifts away from the Belle of Tonopah are known.

The Umatilla shaft is over 1,200 feet deep and located about 3,035 feet west-southwest of the King Tonopah shaft. Sometime before World War II, a north-south crosscut at the 1,200 Level (4,940 feet elevation) was driven about 435 feet northeast of the Umatilla shaft, and 2,025 feet south (Figure 4b). No geological or assay records of these working have been found.

### ***Drilling***

Prospecting shafts first explored the subsurface of the Northern Tonopah district in the early part of the 20<sup>th</sup> Century, followed by twelve core holes by Calumet-Hecla and Asarco in the late 1940's (ADH holes), and thirteen core holes by Houston Oil and Minerals in 1978 and 1979 (HT holes, Table 1).

Five vertical reverse circulation holes were drilled on unpatented claims north and east of the King Tonopah shaft during the 1980's (Table 1). Locations of these latter holes are not known with certainty. Depths ranged from 525 to 875 feet. Veinlet and silicified zones were encountered in two holes, but drill returns were poor. Further compilation work may allow some geologic conclusions from this last known drill sequence.

## **Northern Tonopah district geology**

### ***Stratigraphy***

Pre-Tertiary basement does not outcrop beneath the caldera-associated Tertiary volcanic rocks of the Tonopah Mining District. The surrounding districts are characterized by early Paleozoic shale, siltstone, and minor chert and limestone and Mesozoic granitics. These same basement units are undoubtedly at depth beneath Tonopah. Tonopah's Tertiary volcanic rocks vary greatly in thickness and areal extent, a characteristic of the caldera environment. Thicknesses mentioned here may be regarded as average, but are variable locally. All units are often separated by profound unconformities.

| <b>Table 1 - Surface drill intercepts, North Tonopah (see Figure 5)</b>                            |              |                |             |                   |                   |                        |               |              |               |
|----------------------------------------------------------------------------------------------------|--------------|----------------|-------------|-------------------|-------------------|------------------------|---------------|--------------|---------------|
| <b>Drill</b>                                                                                       | <b>Drill</b> | <b>Angle</b>   | <b>TD</b>   | <b>Intcpt</b>     | <b>Thkns.</b>     | <b>Grade</b>           | <b>Grade</b>  | <b>Ag/Au</b> | <b>Vein</b>   |
| <b>Hole</b>                                                                                        | <b>type</b>  | <b>degrees</b> | <b>feet</b> | <b>feet</b>       | <b>feet</b>       | <b>opt Au</b>          | <b>opt Ag</b> | <b>ratio</b> | <b>name</b>   |
| ADH-1                                                                                              | core         | 90             | 1,621       | none              | none              | none                   | none          | none         |               |
| ADH-2                                                                                              | core         | 90             | unknown     |                   | no data available |                        |               |              |               |
| ADH-3                                                                                              | core         | 90             | 1,160       | none              | none              | none                   | none          | none         |               |
| ADH-4                                                                                              | core         | 90             | 1,483       | 5,420             | 9.0               | 0.058                  | 5.3           | 91           | King T. Vein  |
| *                                                                                                  | *            | *              | *           | 5,385             | 13.3              | 0.098                  | 9.6           | 98           | Q Vein        |
| ADH-5                                                                                              | core         | 60 SW          | 801         | none              | none              | none                   | none          | none         |               |
| ADH-6                                                                                              | core         | 60 E           | 953         | 5,395             | 4.0               | 0.066                  | 22.7          | 344          | King T. Vein  |
| *                                                                                                  | *            | *              | *           | 5,365             | 4.2               | 0.119                  | 12.0          | 101          | Q Vein        |
| ADH-7                                                                                              | core         | 55 W           | 1,200       | none              | none              | none                   | none          | none         |               |
| ADH-8                                                                                              | core         | 55 E           | unknown     |                   | no data available |                        |               |              |               |
| ADH-9                                                                                              | core         | 50 S           | 1,012       | 5,830             | no data available |                        |               |              | King T. Vein? |
| *                                                                                                  | *            | *              | *           | 5,810             | no data available |                        |               |              | Q Vein?       |
| ADH-10                                                                                             | core         | 58 NE          | 1,008       | 5,410             | 5.0               | 0.011                  | 1.0           | 91           | Q Vein?       |
| ADH-11                                                                                             | core         | 60 S           | unknown     |                   | no data available |                        |               |              |               |
| ADH-12                                                                                             | core         | 60 N           | unknown     |                   | no data available |                        |               |              |               |
| HT-1                                                                                               | core         | 60 N           | 736         | 5,845             | 3.4               | 0.295                  | 16.3          | 55           | King T. Vein  |
| *                                                                                                  | *            | *              | *           | 5,800             | 4.9               | 0.055                  | 7.5           | 136          | Q Vein        |
| HT-2                                                                                               | core         | 55 N           | 1,182       | 5,330             | 4.5               | 0.050                  | 3.7           | 74           | King T. Vein  |
| *                                                                                                  | *            | *              | *           | 5,300             | 7.5               | 0.008                  | 1.0           | 125          | Q Vein        |
| HT-3                                                                                               | core         | 50 N           | 928         | 5,580             | 6.0               | stringers, qtz-gal-sph |               |              | King T. Vein? |
| HT-4                                                                                               | core         | 50 N           | 1,385       | 5,285             | 2.0               | 0.023                  | 2.5           | 109          | King T. Vein? |
| *                                                                                                  | *            | *              | *           | 5,250             | 2.0               | 0.022                  | 3.5           | 159          | Q Vein?       |
| HT-5                                                                                               | core         | 45 N           | 1,746       | 5,840             | 5.5               | 0.039                  | 5.5           | 141          | King T. Vein? |
| *                                                                                                  | *            | *              | *           | 5,750             | 1.0               | 0.045                  | 9.6           | 213          | Q Vein?       |
| *                                                                                                  | *            | *              | *           | 5,420             | 100+              | stringers, qtz-gal-sph |               |              | Vein #4       |
| HT-6                                                                                               | core         | 60 N           | 1,034       | 5,330             | 40.0              | stringers, qtz-gal-sph |               |              | King T. Vein? |
| *                                                                                                  | *            | *              | *           | 5,290             | 1.0               | 0.021                  | 1.5           | 71           | Q Vein?       |
| HT-7                                                                                               | core         | 50 N           | 1,080       | 6,040             | 1.0               | 0.048                  | 15.7          | 327          | Vein #3       |
| HT-8                                                                                               | core         | 55 N           | 960         | no data available |                   |                        |               |              |               |
| HT-9                                                                                               | core         | 90             | 585         | 5,645             | 0.0               | 0.015                  | 2.5           | 167          | Q Vein        |
| HT-10                                                                                              | core         | 45 N           | 850         | 6,090             | 10+               | stringers, qtz-gal-sph |               |              | Vein #4?      |
| *                                                                                                  | *            | *              | *           | 6,010             | no data available |                        |               |              | King T. Vein? |
| *                                                                                                  | *            | *              | *           | 6,000             | no data available |                        |               |              | Q Vein?       |
| HT-11                                                                                              | core         | 90             | 942         | 5,340             | 13.0              | 0.010                  | 2.5           | 250          | Vein #6       |
| HT-12                                                                                              | core         |                | unknown     | no data available |                   |                        |               |              |               |
| HT-13                                                                                              | core         | 75 S           | 855         | 5,550             | 1.0               | 0.026                  | 3.8           | 146          | Vein #5       |
| 85-4                                                                                               | RC           | 90             | 650         | none              | none              | none                   | none          | none         | Loc. Unknown  |
| 85-6                                                                                               | RC           | 90             | 525         | 515-525           | no data available |                        |               |              | Loc. Unknown  |
| 86-1                                                                                               | RC           | 90             | 740         | 655-660           | 5.0               | n/a                    | 2.0           | n/a          | Loc. Unknown  |
| 87-1                                                                                               | RC           | 90             | 835         | 720-740           | 20.0              | stringers, qtz-py      |               |              | Loc. Unknown  |
| 87-2                                                                                               | RC           | 90             | 875         | none              | none              | none                   | none          | none         | Loc. Unknown  |
| ET-1                                                                                               | RC           | 60 N           | unknown     | 5590              | no data available |                        |               |              | Vein #5?      |
| ET-6                                                                                               | RC           | 60 N           | unknown     | no data available |                   |                        |               |              |               |
|                                                                                                    |              |                |             |                   |                   |                        |               |              |               |
| <b>Notes:</b>                                                                                      |              |                |             |                   |                   |                        |               |              |               |
| 1) Calumet-Hecla and Asarco drilled the ADH holes in 1948 and 1949; a total of about 14,000 feet . |              |                |             |                   |                   |                        |               |              |               |
| 2) Houston Oil and Minerals drilled the HT holes in 1978 and 1979; a total of about 13,300 feet    |              |                |             |                   |                   |                        |               |              |               |
| 3) The 85, 86, 87, and ET holes were drilled by Production Exploration. Records are incomplete.    |              |                |             |                   |                   |                        |               |              |               |

The basal Tonopah Formation is Oligocene, 1,000 feet thick, and consists of orange to pink to grey partially welded lithic ashflow tuff, volcanic breccias, and banded rhyolite domes and flows. The Tonopah rhyolites are unconformably overlain by the Mizpah Formation, the earliest Miocene unit in the district. The Mizpah Formation is 2,000 feet thick, and consists of purplish-brown to black, porphyritic andesite to trachyandesite flows, breccias, and minor dacite intrusions. Feldspar phenocrysts are often white and euhedral. The Mizpah andesites are unconformably overlain by the Fraction Tuff.

Locally more than 600 feet thick, the Miocene Fraction Tuff consists of two or more rhyolite cooling units with lithic ashflow tuffs, tuff breccias, and minor interbedded siltstone and sandstone. The Heller Tuff is a geographically constrained but mappable, crystal-rich, quartz latite ashflow tuff above the Fraction Tuff. The Heller and Fraction tuffs are unconformably overlain by the Seibert Formation, a district-wide sedimentary unit locally greater than 300 feet thick consisting of poor to well-sorted volcanic siltstone, sandstone, and conglomerate.

The Tonopah rhyolites and Mizpah andesites are hosts for Tonopah-type quartz-adularia-sericite epithermal gold-silver vein systems in the central and northern portions of the Tonopah Mining District. The Seibert Formation is host to high-level to paleosurface epithermal gold-bearing stockworks and breccias at Divide, Hasbrouck Mountain, and Three Hills, with additional minor occurrences elsewhere.

### ***Intrusions and flow-domes***

The West End Rhyolite and Extension Breccia are coeval lithologies emplaced as sills along the gently west-dipping Tonopah Fault. The West End Rhyolite is a light green, fine to medium grained, “crowded” quartz porphyry rhyolite. Wilkins (1986) refers to the West End Rhyolite as “a typical Climax-type moly rhyolite”. The Extension Breccia is a red, coarse grained autobreccia developed adjacent to, and during intrusion of, the West End Rhyolite. Both intrusive units were emplaced along the lower portions of the Tonopah Fault while Tonopah-type quartz-adularia-sericite veins were forming along the upper portions of the same low-angle fault. Both units appear to be differentiated, up-dip extensions from a deeply buried molybdenum porphyry west of Tonopah (Wilkins, 1986).

Oddie Rhyolite dikes and sills, common throughout the Tonopah Mining District, consist of pink to grey, porphyritic rhyolite. Oddie domes and flow-domes occur wherever Seibert Tuff has been preserved, especially in the southern Tonopah District and adjacent Divide District. Banding, brecciation, and marginal alteration and mineralization are common features of the Oddie Rhyolite domes. Brougner Rhyolites are younger than Oddie rhyolites, and are banded, grey to light brown, and porphyritic. Brougner domes occur throughout the Tonopah and Divide districts, but are usually not brecciated or associated with alteration or mineralization.

### ***Structure***

Fault geometry and timing was crucial to Tonopah-type quartz-adularia-sericite vein emplacement. The Tonopah Fault is concave-down, is elongate east-west, and dips gently west. The West End Rhyolite and Extension Breccia intrude the deeper, western

portions of the Tonopah Fault. The central Tonopah veins developed during the rhyolite breccia intrusion along the up-dip, eastern portions of the Tonopah Fault and in steep fractures in the hangingwall of the Tonopah Fault. The steep veins generally strike parallel to the east-west long axis of the Tonopah Fault, in the hangingwall of, and normal to, the concave-downward plane of the Tonopah Fault. The steep veins were higher grade but seldom more than five feet wide. Stope widths (thicknesses) up to 40 feet were encountered along the gently-dipping Tonopah Fault in the central Tonopah District.

Similar structural geometry is indicated for the northern Tonopah District. The King Tonopah vein fills a near-vertical fault striking east-west. Other east-west veins and stringer veinlet zones occur in the King Tonopah workings and nearby drill holes, all indicative of an underlying low-angle, west-dipping, concave-down fault beneath the Northern Tonopah district similar in geometry to the Tonopah Fault.

Post-vein faults offset the steep east-west veins and the gentle west-dipping veins of the central Tonopah District. The most prominent post-mineral fault in the central District is the Halifax fault (Figure 3), a north-northwest to northwest striking, moderately east-dipping normal faults. The Halifax Fault offsets the eastern extensions of the Tonopah Fault in the central Tonopah District, dropping the associated veins down several hundred feet to the east. Houston's eastern Tonopah District drilling program encountered Tonopah-style veins and grades at depth in the hangingwall of the Halifax fault (F. Saunders, personal communication).

In the northern Tonopah District, several post-mineral faults offset the King Tonopah vein system. One or more early, steep northeast-striking faults offset the west side of the King Tonopah vein. The northwest-striking, moderately northeast dipping Halifax Fault was encountered at the east end of the King Tonopah's 300-level drift. The King Tonopah workings also expose relatively young, normal faults striking north and dipping steeply west.

### **Alteration**

Hydrothermal alteration of Mizpah andesites is concentrically zoned in the vicinity of Tonopah-type veins. A potassium-silica flooded zone may be as wide as twenty feet immediately around the vein, followed by an argillic zone up to 100 feet wide consisting of an inner zone of kaolin-halloysite with minor quartz and an outer argillic zone of montmorillonite with minor kaolin and sericite. The outermost alteration zone associated with specific vein formation is a greenish-grey propylitic assemblage consisting of calcite-sericite replacing albitized plagioclase, chlorite-rutile-pyrite replacing biotite, and chlorite-albite-calcite-orthoclase replacing the groundmass.

Alteration of the Tonopah Rhyolite units is a more silicic counterpart to the Mizpah alteration assemblage. Critical to exploration is recognition of thin quartz-adularia-chlorite veinlets in propylitized rock within 300 feet of Tonopah-type veins. Of equal exploration importance is the observation that mineralized, Tonopah-type quartz-adularia-sericite veins terminate upwards into quartz-calcite-pyrite stringer zones "containing little or no silver or gold". Propylitic alteration extends 600 feet vertically above vein tops (Bonham and Garside, 1979, page 111).

### **Mineralization**

The predominant assemblage of hypogene ore minerals in Tonopah-type veins is chalcopyrite-galena-sphalerite-argentite-polybasite-pyrargyrite-pyrite-wolframite-electrum. Some of these minerals will occur in better-developed stringer zones immediately above or close beside vein lodes.

### **Geochemistry**

Fresh rock trace element geochemistry of Tonopah-type hypogene alteration and mineralization has not been compiled to date. Outcrop geochemistry of the region was compiled by Bonham & Garside (1982) but is of little value in evaluating and comparing drill results.

### **Geophysics**

Abundant metallic refuse has been scattered over the northern Tonopah landscape during the last 100 years, creating potential impediments to geophysical investigations. Looking for silicic veins with EM-resistivity gear will also be impeded by the numerous, pyrite-bearing, silicic, Oddie dikes and sills intruding faults and fractures throughout the district. Geophysical funds are probably better spent on drilling or geochemistry in this case.

## **Discussion**

The mining and exploration history of the northern Tonopah Mining District benefited first from Nolan's (1935) analysis, and later from the experience of Calumet & Hecla's and Summit King-Homestake's geologists and miners working in the King Tonopah vein. Choosing not to explore beyond the reserves already blocked out, Summit King-Homestake mined 15,000 tons grading 0.30 opt Au and 30 opt Ag, returning the property to Calumet & Hecla in 1954 (Bonham & Garside, 1979, page 120). Wilkins (1986, page 4), in some conflict, states King Tonopah production totaled 30,000 tons grading 0.02 opt Au and 20 opt Ag. This early work led to the hypothesis that the character of mineralization in the King Tonopah vicinity is equivalent to mineralization in the central Tonopah District.

Houston Oil and Minerals drilled thirteen core holes in 1978 and 1979 within 1,200 feet of the King Tonopah workings. A total of four new vein or veinlet stringer structures were delineated, indicating the north-south width of the vein mineralized area is at least as wide (north-south) as the productive zone in central Tonopah District. Including the King Tonopah and Q veins, at least six, apparently steeply-dipping structures with quartz-adularia-sericite veins or mineralized vein stringers are known in the northern Tonopah District.

## **Conclusions**

Multiple Tonopah-type veins, with favorable mineralization, alteration, and structure occur in the northern Tonopah District over an area large enough to duplicate central Tonopah's 1901-1935 production. Average historic grade was 0.23 opt gold and 23 opt silver. Drill holes in the northern Tonopah District have encountered four steep vein structures in addition to the near-vertical King Tonopah vein. A gentle west-

dipping, concave-upward, fault-vein should occur below the steep veins, but has not yet been encountered in north Tonopah drill holes. One of the goals of Tonogold's exploration and drilling program will be delineation of the indicated, low-angle, fault-vein system beneath the northern Tonopah vein structures. Once located, this fault-vein system will confirm the structural model of the King Tonopah area and may contain an extensive, thick, gently dipping, and readily mined lode zone.

## Recommendations

Tonogold intends to implement a two-phase exploration and drilling program for the northern Tonopah District, including the area around the King Tonopah Mine. The overall goal of these two phases will be to define a resource potential similar in size and grade to the central Tonopah District. Phase One goals be acquisition of additional small property segments around the existing Tonogold holdings, compilation of all data, surface prospecting and mapping, and drill exploration. Rehabilitation of the King Tonopah workings, as an access alternative and for underground drilling, is included in the Phase One budget. When Phase One is completed, the extent of the King Tonopah resource should be determined, veins on existing and new structures should be found, and a Phase Two drill development plan for the northern Tonopah District should be viable.

## Proposed Phase One budget

Phase One will consist of surface drill exploration extended over a three to four-year period. A maximum of 20 vertical and angle surface RC holes will have an average length of 1,500 feet for a total of 30,000 feet. Estimated drilling cost, at \$24 per foot with assays: \$717,000. Estimated cost of underground access, sampling, and man-way rehabilitation in the King Tonopah shaft: \$153,800. Geologist and expenses: \$135,000. Contingency: \$100,000. Estimated Phase One costs: \$1,102,000. Substituting core for RC drilling will increase Phase One costs by 25%.

| <b>Phase One Budget, King Tonopah</b> |                              |       |           |            |              |
|---------------------------------------|------------------------------|-------|-----------|------------|--------------|
|                                       |                              | units | unit cost |            |              |
| Data compilation                      |                              |       |           |            |              |
|                                       | Project geologist & misc     | 2     | \$ 13,500 | \$ 27,000  |              |
|                                       | subtotal                     |       |           |            | \$ 27,000    |
| Drilling                              |                              |       |           |            |              |
|                                       | Project geologist & misc     | 6     | \$ 13,500 | \$ 81,000  |              |
|                                       | Drill contractor (all costs) | ##### | \$ 22     | \$ 660,000 |              |
|                                       | Assays (50%)                 | 3,000 | \$ 19     | \$ 57,000  |              |
|                                       | subtotal                     |       |           |            | \$ 798,000   |
| Underground rehab                     |                              |       |           |            |              |
|                                       | Project geologist & misc     | 2     | \$ 13,500 | \$ 27,000  |              |
|                                       | Assays                       | 200   | \$ 19     | \$ 3,800   |              |
|                                       | Mine contractor              | 1,500 | \$ 100    | \$ 150,000 |              |
|                                       | subtotal                     |       |           |            | \$ 177,000   |
|                                       | Total                        |       |           |            | \$ 1,002,000 |
|                                       | Contingency                  | 10%   |           |            | \$ 100,200   |
|                                       | Grand total                  |       |           |            | \$ 1,102,200 |

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