Re-thinking the Comstock:

Volcanic Domes and Arcuate Structures

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ABSTRACT

GoldSpring, Inc. is currently developing the Comstock Mine Project, located near Virginia City, Nevada, in the immediate vicinity of the historic Comstock lode district. Geologic field mapping and geo-referencing of historic underground workings, combined with inspection of aerial and satellite images have identified numerous kilometer scale arcuate structures and lineaments spatially related to precious metal mineralization. Peripheral and central to specific arcuate structures are volcanic domes and dikes which played a role in channelizing magmas, hydrothermal fluids and meteoric waters. Reconciliation of historic underground workings illustrated that many of the bonanza grade stopes that averaged greater than 0.50 gold ounces/ton (14.6 gold g/tonne) and primary production levels were found to be positioned parallel to apparent arcuate structures, or located at projected intersections of interpreted arcuate structures.

Economic gold resources are locally enhanced by structural intersections of northeast and east-west vein swarms. The structural controls are dominated by a series of sub-parallel northwest striking faults collectively referred to as the Silver City fault zone. The western boundary of the current economic deposit is the foot wall of the Silver City fault zone and the eastern flank of Hartford Hill (interpreted as a rhyolite dome).

KEYWORDS

Virginia City, Comstock lode, Silver City lode, Silver City fault zone, arcuate structures, structural intersections, volcanic domes, precious metal mineralization

INTRODUCTION

Historically, the Comstock Mining District which includes the Comstock lode, Silver City lode and adjacent Occidental vein systems has been recognized as a world class epithermal precious metals district. The discovery of the first lode deposit in 1859 was located in Gold Canyon just south of present day Gold Hill, Nevada. The Comstock and Silver City mineralized systems collectively produced in excess of eight million two hundred thousand (8,200,000) ounces of gold and one hundred and ninety two million (192,000,000) ounces of silver from the mid-1800's to 1965 (Bonham, 1969), which equates to over $12 billion in today's metal prices. The mineralized zone of the Comstock District has a strike length of 4 miles (6.4 km) and production depths exceeding three thousand feet (914 m). Extensive production from the numerous mines in the area was concentrated from 1860 to 1892. In the early part of the 20th century, external events overtook the Comstock. The 1906 San Francisco earthquake destroyed the market for Nevada gold. World War one, the great depression, and World War 2, with its War Act curtailing precious-metals mining, each limited or eliminated mining activity. After the war, several intermittent pulses of mining activity occurred, during the 1950's, late 1970's, early 1980's and mid 1990's to the present.

The Comstock and the Silver City lodes are epithermal low-sulfidation Ag-Au deposits that include numerous historic bonanzas and recently evaluated deposits (e.g., Big Bonanza, Chollar-Potosi, Crown Point, Belcher, and Woodville) (Fig 1) hosted in early to middle Miocene volcanic rocks related to calc-alkaline magmatism generated during the oblique subduction of the Farallon plate beneath the North America plate. The historic precious metals production of the Comstock Mining District that includes the Comstock (N 05° to 15°E) and Silver City (N 30° to 40°W) lodes has been primarily concentrated in two major sets of quartz±adularia±sulfide-bearing fault-controlled vein systems. Adularia $^{40}Ar/^{39}Ar$ ages collected from these structural zones bracket the mineralization between 14.06 to 14.17 Ma (Hudson et al., 2009).

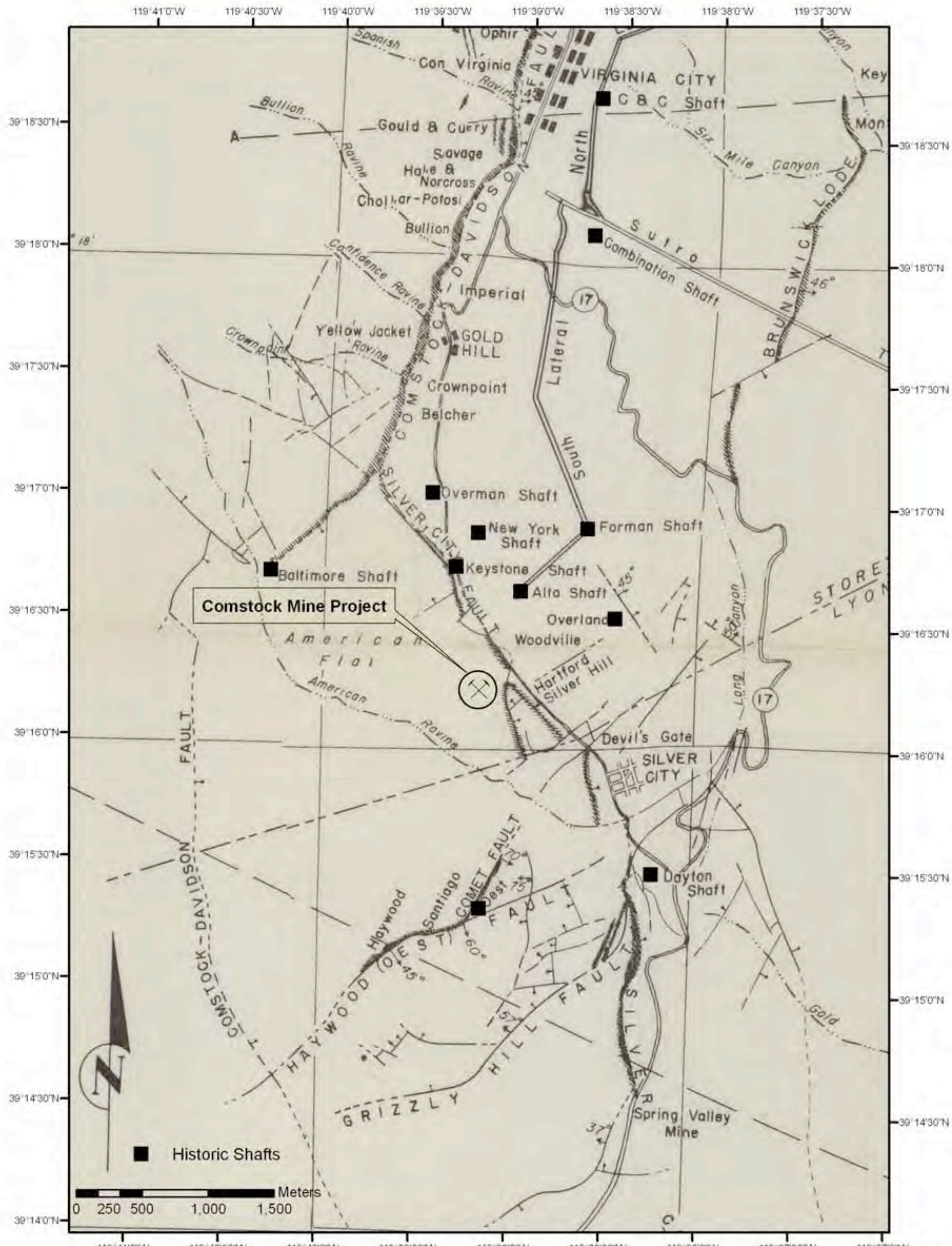

FIGURE 1. Historic Map of the Comstock and Silver City Lodes, from Stoddard and Carpenter (1950)

GoldSpring, Inc. has acquired significant land holdings in the Comstock Mining District, collectively known as its Comstock Mine Project (Fig.2). These include, among others, the Con-Imperial Pit, Crown Point, New York mine, Keystone, Justice, Woodville, Lucerne, and Billie the Kid, which was last mined in 2006. A development drilling program, conducted during 2007-2009, was centered in the historic Lucerne pit indicated that significant Au-Ag mineralization is present. Gold and silver mineralization in the Lucerne area occurs in quartz±adularia and calcite±iron and manganese oxides filled stock work fractures, hydrothermal breccia zones, and fault zones. The primary mineralized resource is structurally controlled by a series of sub-parallel, easterly dipping faults that are now collectively referred to as the Silver City fault zone. These faults are now interpreted as being related to a major arcuate structure that includes the Comstock and Silver City lodes. Often the mineralization is enhanced at lithologic contacts in association with respective hanging walls of the individual faults.

Similar low-sulfidation deposits in the Pah Rah and Virginia ranges (e.g. Olinghouse, Gooseberry, Talapoosa, Como) provide an excellent example of the interplay among volcanism, normal faulting, and hydrothermal activity that, synergistically, generated economic concentrations of precious metals. Despite the past economic interest and exploration potential, most of the scientific work has been done with the major effort done at clarifying its volcanic stratigraphy and structure.

In this work, the authors discuss the possible role of the arcuate structures in hosting precious metal mineralizations. We then present an overview of the main geological characteristics of the Comstock Mining District and the Comstock Mine Project. These data are then used to develop a geological framework for the Comstock Mine Project, which was used to build a resource model of the deposit.

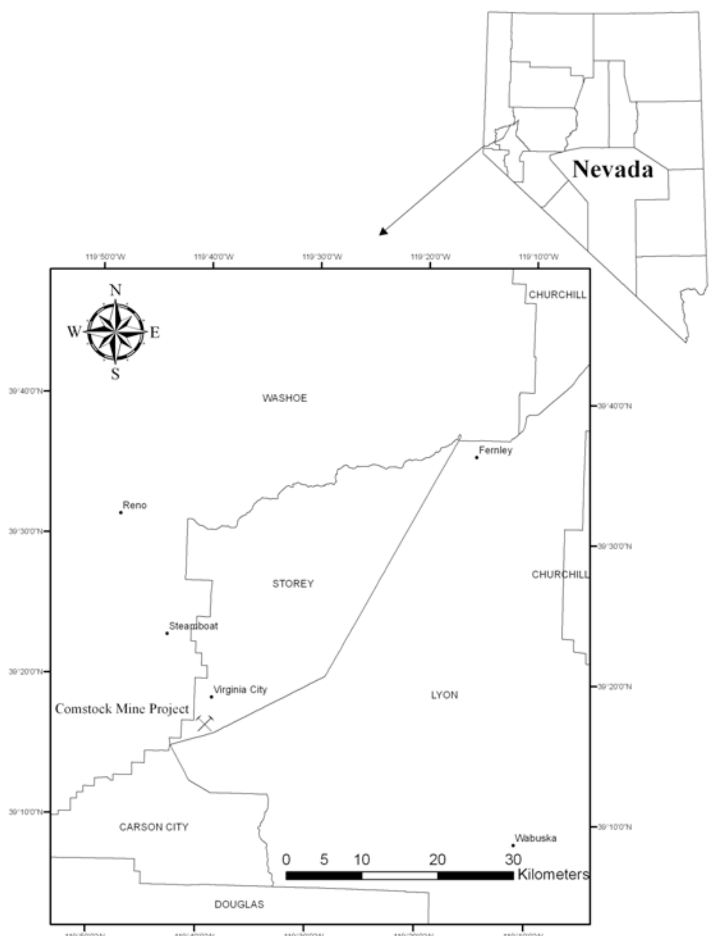

FIGURE 2. Location map of the Comstock Mine Project (Storey County, Nevada).

ARCUATE FEATURES: STRUCTURAL CONTROL FOR MINERALIZATION

General references on arcuate structures, also known as circular features, abound in the geological literature; however, studies combining the structural framework of arcuate structures with ore mineralization are limited. Early ideas of Eggers (1979), who pointed out that Mo-Cu mineralizations in the South Island region (New Zealand) might be spatially related to arcuate structures, have also been suggested by several authors elsewhere. For example, Dietrich et al. (2005) reported the presence of prominent circular features in the Selene mining district (Peru), with its long axis parallel to the NE-trending vein systems (σ_1 –direction was trending NE during mineralization) thus forming during the same field stress.

Similarly, Wallace (1975) and Hudson (1977) mentioned a large circular feature in the Dogskin Mountain, wherein the Wedekind and Peavine mine districts are located along the south margin. Both authors conclude that the lack of caldera structures favors a tectonic linkage between the circular structure and the Walker Lane. On the contrary, Anguita et al. (2001) suggested a caldera collapse scenario for more than two hundred circular and elliptical features in the Trans-Mexican Volcanic Belt. Lastly, Ponce and Glen (2002) presented a possible link between the Yellowstone hot spot and large-scale arcuate fractures and epithermal deposits in northern Nevada. Briefly, supported by gravity and magnetic data, these authors concluded that middle Miocene and younger epithermal deposits in northern Nevada are spatially and temporally linked with these regional arcuate structures that channelized hydrothermal fluids related to rifting.

Reviewing historic mining reports and reconciliation of digitized historic underground workings in the Comstock and Silver City lode (Fig 3), the authors recognized three main types of structurally controlled ore shoots: (1) dense development of stopes positioned parallel or along apparent arcuate/ring structures, (2) development of underground workings following the rake of mineralized structural intersections, and (3) concentrations of underground development along structural intersections among arcuate structures, lineaments, and normal faults.

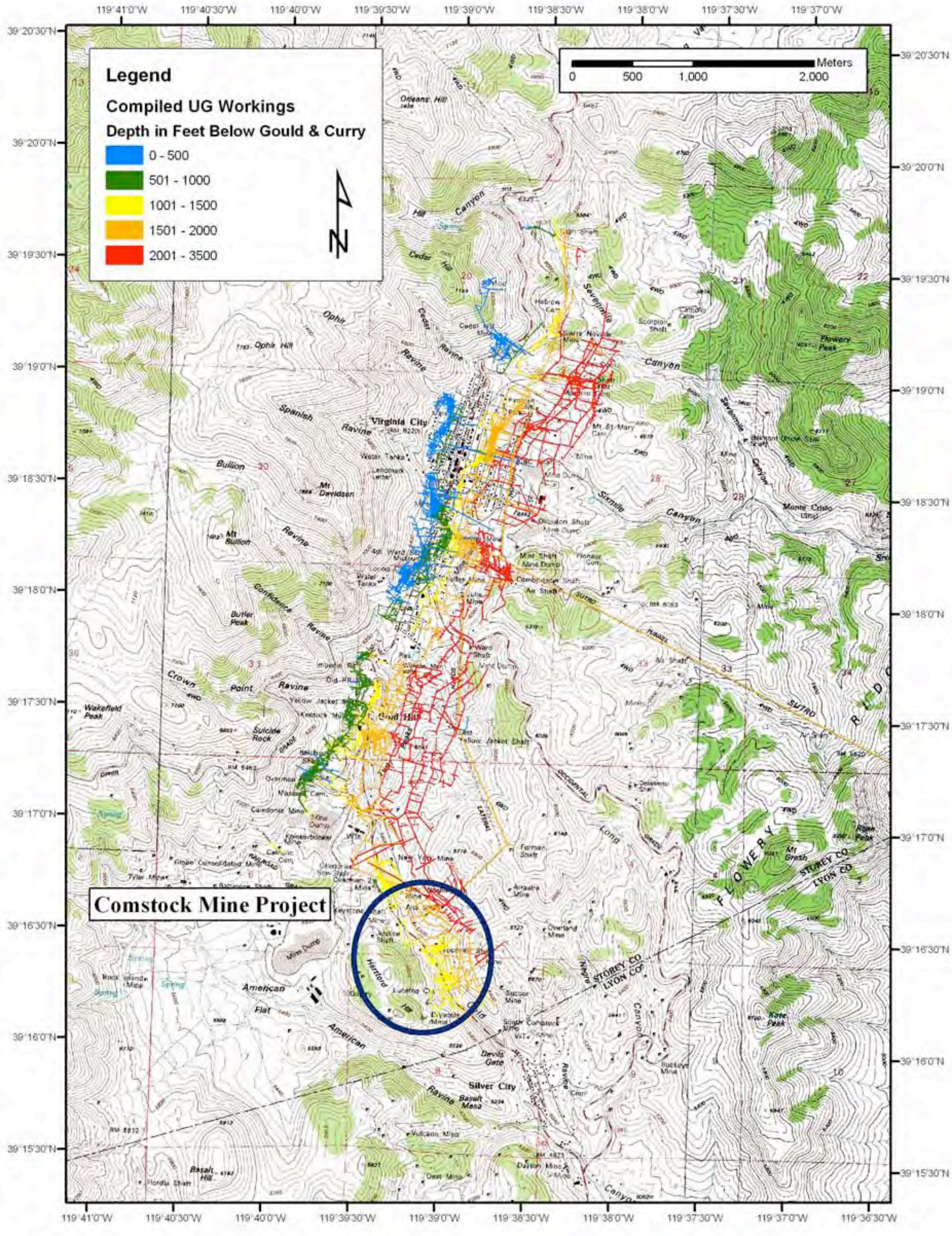

FIGURE 3. Generalized map of the Comstock Lode district with underground workings.

Arcuate structural control of ore concentration has received little attention in the Comstock's historic literature. An exception is Rae Gold's geologic staff, who recognized the importance of arcuate features during their evaluation of the Brunswick (Occidental) lode (Rae Gold, 1983). In this paper, we argue that localization of precious metal mineralization in the Comstock Mine Project, and elsewhere in the district, can be understood in terms of mesoscopic arcuate structures, which are first order structural traps for ore deposition. This interpretation is based upon field mapping combined with aerial and satellite images, review of historic stopes and mine levels, and the general spatial distribution of andesitic dikes. This led to the interpretation of the Comstock and Silver City lodes as lying on the same kilometer scale arcuate structure (Fig. 4).

This combination of data shows the prominent topographic and geological expression of arcuate structures revealed through stream patterns, historic mine workings and andesitic dikes density along the interpreted rims. The general distribution of the andesitic dikes along the arcuate structure in the project area could be interpreted as segmented ring-dikes, which may have intruded into the structure(s) during the Flowery Peak volcanic suite.

Similarly, intense hydrothermal alteration assemblages are spatially associated with interpreted arcuate structures. These are characterized by selvages of moderate to strong, argillic to sericitic alteration zones, producing the rock color anomalies easily spotted on aerial images.

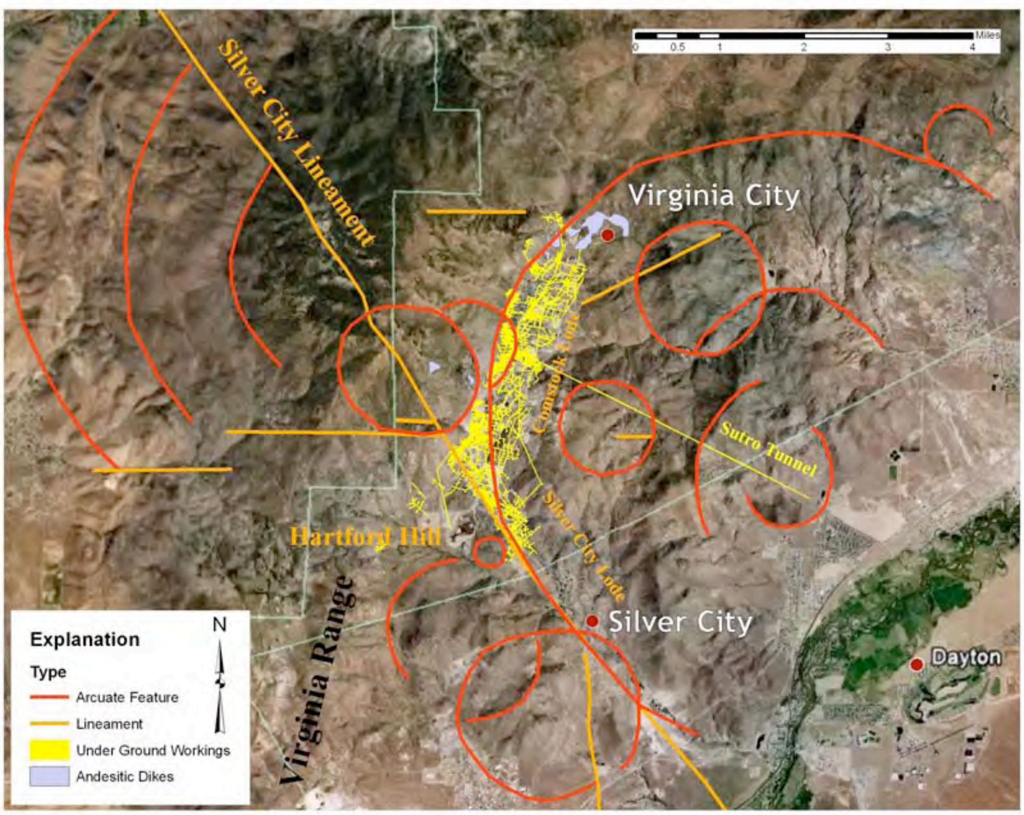

FIGURE 4: Satellite photo with interpreted arcuate features

DISTRICT GEOLOGY

The Comstock lode lies in the Virginia Range (Washoe Range) between Reno and Carson City, Nevada, where block faulting of the Basin and Range Province is prevalent. The block faulting produces downthrown graben blocks and upthrown horst blocks that have displaced and offset mineralized trends. The Comstock District is located within a series volcanic centers formed during the Miocene period, characterized by eruptions of rhyodacite ash flow tuffs and events of extrusive and intrusive rhyolite (quartz porphyry) followed by andesitic lava flows, dikes, pyroclastic flows and lahars. Below the Miocene volcanic sequence is an unconformable contact with Mesozoic and locally plutonic intrusions (cf. Gianella, 1936; Hudson, 2003; Castor et al., 2005). In this section, the main volcanic stratigraphy and structural characteristics between Gold Hill and Silver City, Goldspring's Comstock Mine Project, are described..

The Tertiary volcanics lie unconformably upon Mesozoic metaigneous rocks, which are well exposed along the haul road to the Billie the Kid pit and the highwalls of the Lucerne pit. The metaigneous rocks are dark greenish, weakly magnetic, metagabbro (iridescent labradorite) and porphyritic meta-andesite. The metaigneous rocks are poorly mineralized within the project area. Drill holes indicate that these rocks are also present toward the east (Succor mine area), where they are locally intruded by a quartz monzonite.

The Tertiary volcanic rocks are made up of several magmatic suites erupted between ~27 Ma to ~14.9 Ma (Castor et al., 2005; Hudson et al., 2009), apparently along a NW-SE volcanic trend. Within the project area, the oldest volcanic unit is the ~23 Ma Santiago Canyon Tuff, Gianella's Hartford Hill rhyolite, (Hudson et al., 2009). Conspicuous 2-4mm equant quartz phenocrysts characterize the light gray to beige, hard, crystal-poor Santiago Canyon ash flow tuff. Dense welding is common in surface croppings. Clear quartz micro-veinlets are also common, probably due to deuteric cooling. From bottom to top, this cooling unit grades from strongly welded to poorly welded. Mineralized quartz veins are mostly contained through the strongly welded tuff, suggesting a correlation between the grade of welding and vein development.

According to Bingler (1979), the Santiago Canyon Tuff is late Oligocene to early Miocene ca. 20.5 to 21.8 Ma and sourced from six to twelve miles to the south. The Santiago Canyon Tuff well exposed in the Billie the Kid pit walls, is the eastern boundary of the arcuate feature interpreted as the Hartford Hill rhyolite dome.

Stratigraphically below the Santiago Canyon tuffs, an apple greenish lithic to crystal rich ash flow interval is exposed in the Billie the Kid pit. The tuff is moderately welded with conpiscuous quartz grains and altered biotite. From drill hole data, the rhyodacite tuff unconformably overlies the metaigneous rocks with a thickness of about 70 feet (21 m).

The next magmatic stages are interpreted to have resulted from a stratovolcano and/or composite volcano tectonomagmatic settings (Castor et al., 2005; Hudson et al., 2009). The Silver City (17.7-18.3 Ma) and Virginia City (15.2-15.9 Ma) volcanic suites are volumetrically important through the region, and host the major ore deposits. The andesitic Alta Formation erupted during both magmatic suites chiefly as lava flows. It is distinctive by its porphyritic nature with large (0.2 to 1 cm) plagioclase and hornblende phenocrysts. In the Billie the Kid, Lucerne, and Justice pits the Alta Formation is in the hanging wall section of the Silver City fault zone, strongly hydrothermally altered and mineralized with economic gold and silver grades.

Finally, a variety of felsic to intermediate dikes (no radiometric ages are available within the project area) were emplaced along fractures of several orientations. The dikes are porphyritic with large, elongate plagioclase laths producing a conspicuous magmatic foliation in the field. Although the degree of hydrothermal alteration varies from weak to strong, the original rock fabric is fairly preserved. Small, non-mineralized N60°W-striking quartz veins cut these dikes in the Lucerne pit; however, similar dikes in the Succor mine area host N40°E-striking quartz ± sulfides veins with high-grade (gold grades greater than 0.1 opt) mineralization. Their $^{40}Ar/^{39}Ar$ ages are constrained at 14.5 Ma from similar dikes far north of the project area (Hudson et al., 2009) and field observations suggest that the andesitic dikes were extruded during the Flowery Peak magmatic suite sometime between 14.2-14.9 Ma (Castor et al.,2005).

LOCAL GEOLOGY

The Comstock Mine Project property is on the mid-southern end of the Comstock Mining District, in an area identified with the northwest striking Silver City fault. Historic economic mineralization that was exploited along the Silver City fault was described by Becker (1882) and Church (1879) as West lode (foot wall) and East lode (hanging wall) mineralized zones of the Silver City fault. In this area, newly-recognized, multiple sub-parallel, moderate to high angle brecciated zones (faults) are now collectively referred to as the Silver City fault zone (Fig. 5). These faults are now interpreted as ring faults associated with a major arcuate structure that includes both the Comstock lode and the Silver City lode.

FIGURE 5. Photograph of the Silver City fault zone, looking toward the southeast. Billie the Kid and Lucerne pits are in the background.

The newly recognized series of faults dominate the primary structural geology of the Billie the Kid/Lucerne deposit. The currently-mapped individual faults occupying the northwesterly trending Silver City fault zone are: the Gold Canyon fault (GC), the Silver City fault (SC), the Billie the Kid fault (BK) and the Drysdale fault (DR). The faults are sub-parallel, with the Gold Canyon fault making up the eastern edge of the Silver City fault zone. The Silver City fault is west of the Gold Canyon fault; the Billie the Kid fault is west of the Silver City fault; and the Drysdale fault makes up the western edge of the Silver City fault zone. However, it is likely that future detailed mapping and drilling will identify additional faults in the set. In the Lucerne and Justice pits, slickensides show rakes of about 60°SE, implying a right-lateral sense of movement for this fault zone.

The individual faults have a lateral periodicity spacing of approximately 150 feet (46 m). Thicknesses of the mineralized zones occurring along individual faults range from 40 to 120 feet (12 to 37 m). These zones are enhanced in grade and volumes by crosscutting

East-West and Northeast-striking structures. Within areas of intersecting structural zones, thicknesses of the individual mineralized zones that ranged from 40 to 120 feet (12 to 37 m) geometrically appear to be stacked zones resulting in apparent mineralized envelopes exceeding thicknesses of 500 feet (152 m).

Precious metal mineralization within the Billie the Kid/Lucerne deposit not only is structurally controlled by the Silver City fault zone, but has recently been recognized to have an apparent spatial occurrence with an east dipping quartz porphyry intrusive dike. Through detailed geologic logging of the drill holes and construction of cross sections, the intrusive dike follows the moderate to low angle structures of the Silver City fault zone. The trace of the dike geometrically appears to have been intruded along a single structure then either by post dike fault movement or post fault intrusion crosses into the next low angle structure up-gradient.

In addition to the intrusive event are a series of northerly striking (N 5º E) and northeast striking (N 50º E and N 70º E) vein filled structures that cross the Silver City fault zone. Multiple episodes of mineralization are characterized by differing ratios of silver to gold, and have been superimposed onto each other. One mineralizing event is associated with the cross cutting, northeasterly striking structures and intrusive dikes, and another event is sourced and structurally controlled by the Silver City fault zone. The crosscutting structures enrich the gold and silver grades and enhance the volumetric development of mineralization in the overlying Alta Andesite and other receptive host rocks.

HARTFORD COMPLEX

The Hartford Complex contains diversely oriented vein zones within complexly faulted rock. In the Billie the Kid pit, NS- and NE-striking quartz veins host higher grades and numerous diversely-oriented vein zones (stock works) contributed to the ore mineralization. The eastward down-dip extensions of the Lucerne pit and more northerly, wide spaced drilled Justice surface pit both have NW- and NE-dipping vein zones and enhanced ore grade mineralization at intersections with the Silver City fault zone.

As previously mentioned, structural ground preparation was paramount to mineralization in the project area, as it was throughout the Comstock Mining District. The volcanic-hosted setting of the Hartford Complex area was favorable for epithermal fissure-vein style, hydrothermal breccia development and micro to macro stock-work mineralization within lithologic units amenable to mineral deposition. Disseminated mineralization within respective units has been identified following lithological bedding orientations at locations of complex structural intersections. The majority of the stock-work style of mineralization located in the resource area, specifically in the Lucerne pit, is hosted within in the Alta andesitic units and the quartz porphyry.

Mineralization is hosted in fault zones associated with the northern Comstock lode and the southern Silver City lode. Current exploration and development drilling has been concentrated upon the resource area which includes the historic Billie the Kid and Lucerne open pits. Mineralization in the resource area is typically composed of late stage manganiferous calcite-quartz±adularia vein and drusy quartz fillings deposited in faults, fractures, and breccia zones.

Veined, brecciated and silicified Tertiary volcanic rocks are the prominent host rocks for economic mineralization. Recent deep drilling (greater than 600 feet (183 m) from surface) has identified structurally controlled mineralization hosted within older volcanic rocks. Triassic metaigneous rocks crop out toward the west within the footwall of the east-dipping Silver City fault zone. Intrusive volcanic rocks, including the Kate Peak formation have been identified as dikes.

The local geologic map summarizes many of the primary faults and rock units presently identified from surface expressions (Fig 6). In conjunction with the surface geologic mapping, a comprehensive study was initiated to review and compile historic and recent geologic data. The study included multiple specific tasks each requiring a disciplined approach.

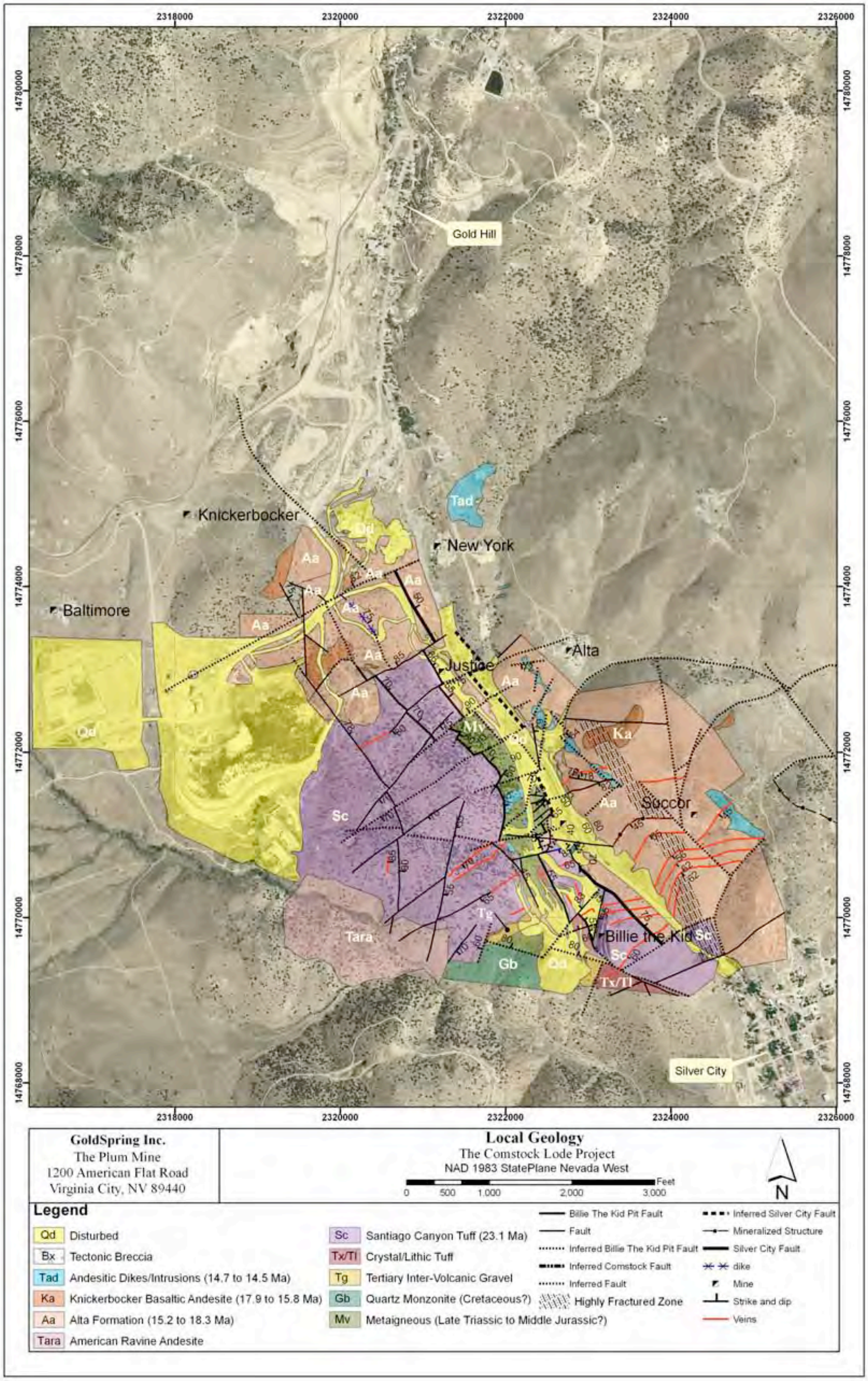

FIGURE 6. Geologic map of the Goldspring's Comstock Mine Project.

NUMERICAL MODELING

A numerical modeling effort was conducted on the project, using Techbase software, concurrently with the field mapping and the 2007-2009 drilling program. As an independent effort, the modeling was controlled by a mineralized envelope drawn on each section to approximate the Silver City fault zone. These limits were guided by the gold grades, faulting, veining, and alteration logged in the drill holes, as well as the presence of historical underground workings, projected onto each section.

Three-dimensional variograms were calculated using gold and silver samples within the mineralized envelope. The direction of greatest continuity was found to be north 65º east, with a plunge of 60º, essentially down the dip of the Silver City fault zone. The orthogonal direction with the next-greatest continuity was found to be north 25º west, along the strike of the zone, with the third direction, at north 65º east, inclination 30º, perpendicular to the plane of the fault zone.

The directions of continuity for silver were found to be the same as for gold, although it is interesting to note that the down-dip continuity for silver is significantly greater. One interpretation for this finding is that the silver mineralization is more related to the east-west and northeast trending faults, rather than the Silver City fault zone. Another interesting finding can be seen on the plot for the gold variogram. After reaching the sill, the variogram plot drops to a valley, then rises again. This suggests a hole-effect model, with a periodicity close to 150’, which is roughly the spacing between the sub-parallel faults making up the Silver City fault zone. This finding is especially interesting because the variograms were modeled independently, based on the drill hole data, before the geological team finalized the current interpretation for that zone.

Gold and silver grades were estimated for a block model covering the resource area, and then plotted on cross sections and level plans. When the block cross sections are compared to the sections with detailed geological interpretation, it is clear that the patterns of the block grades support the independently-derived interpretation.

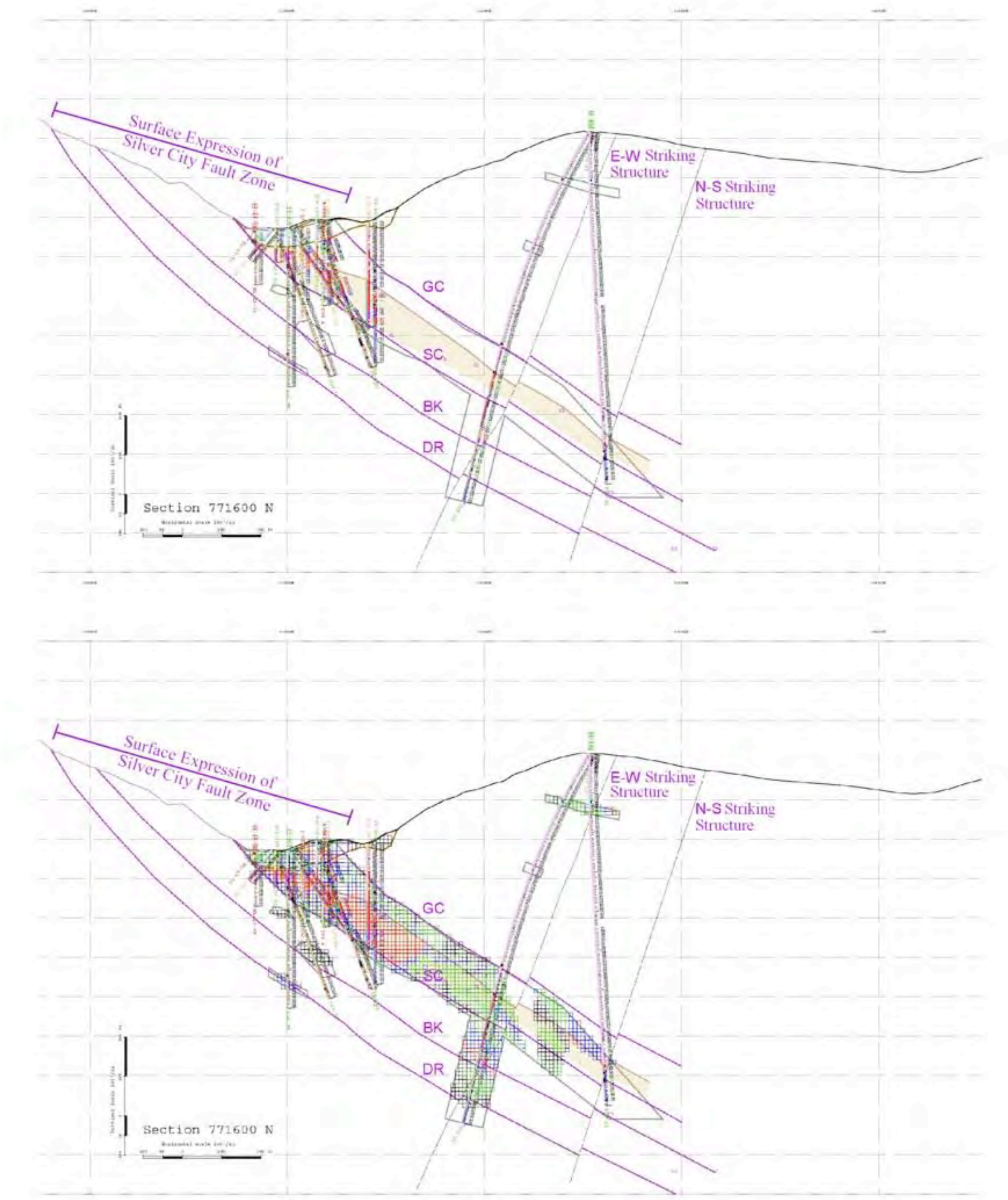

FIGURE 7. Geologic cross-section (top) and Block cross-section through the Silver City fault zone, showing sub-parallel northwesterly trending faults (GC: Gold Canyon fault, SC: Silver City fault, BK: Billie the Kid fault, DR: Drysdale fault).

SUMMARY

In summary, perhaps the most intriguing feature of the Virginia Range and the Comstock Mining District is the existence of numerous arcuate features that played a significant role in the genesis and deposition of epithermal precious metal mineralization. This realization has already provided valuable insights, which have guided the exploration and development, as well as the numerical modeling of GoldSpring's Comstock Mine Project.

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