Exploration07

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3D Geochemical and Mineralogical Model of the Sleeper Low Sulphidation Gold System, Nevada

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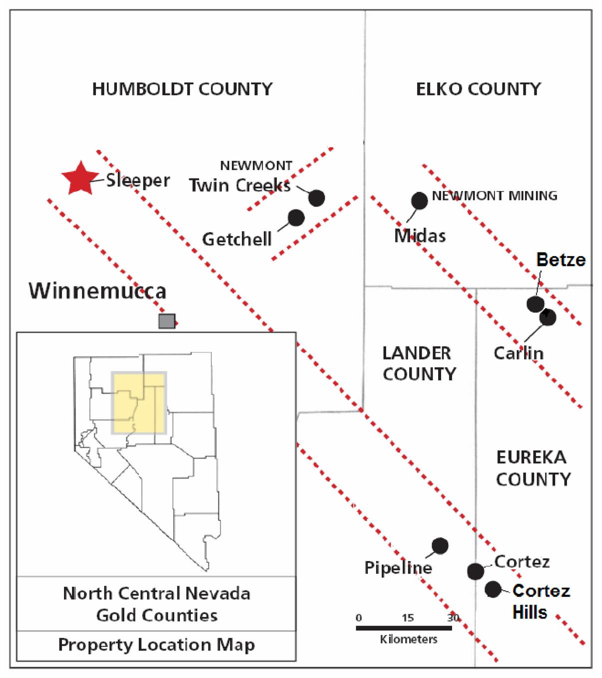
ABSTRACT

Hydrothermal mineral systems, including low sulphidation gold systems in Nevada, are zoned geochemically and mineralogically. This offers up the opportunity to use zonation relationships in surface and drill-hole data to vector from the periphery of a mineralized system to the location of a known ore-body within it and in larger systems, to undiscovered ore. The advent of inexpensive, multi-element geochemical analysis techniques with low detection limits have made it possible to identify zoned element associations and to map out their spatial relations to ore. The invention of the ASD (Analytical Spectral Device) now allows the identification and estimated relative abundance of often innocuous hydrothermal clay and other alteration minerals in near real time to provide additional vectors to the location of high grade mineralization within a system. The interpretation of these types of data characterized by voluminous variables, is facilitated by interpolating element or mineral distributions among drill holes using 3D gridding techniques to create 3D block models. In this form, data relationships and spatial patterns can be fully explored using 3D visualization exploration tools. Gocad 3D pattern recognition software provides a way to identify and illustrate zonation characteristics and to develop targeting vector criteria. The display of these features in relation to modeled and integrated 3D geology (lithologies, faults), 3D geophysical inversion data, and surface data can further aid in identifying new exploration targets. An example of the wealth of information that can be derived from data modeling and 3D visualization is presented using data from the Sleeper low sulphidation Au deposit located 26 miles northwest of Winnemucca, Nevada.



LOCATION

The Sleeper deposit is located 51 miles by road, NNW of the town of Winnemucca in Humboldt County, central Nevada (Lat. 41.336, Long. –118.051) on a NW extension of the Eureka, Cortez, Battle Mountain gold trend (Figure 2).

INTRODUCTION

The Sleeper deposit is a low sulfidation, bonanza gold vein ore body enveloped by bulk tonnage, low grade disseminated gold ore (Wood and Hamilton, 1991, Nash, *et.al*, 1995, 1994). It was a shallow, Nevada range-front, pediment discovery drilled by Amax in 1984 (Wood and Hamilton, 1991). Open pit mining took place from 1986 to 1996, originally centered on the Sleeper Vein itself. Successful exploration lead to the discoveries of the Wood, Office and West Wood Veins and the open pit was expanded to mine those ore bodies (Thomason, *et.al*., 2006, Wood and Hamilton, 1991) (Figure 1).

Recorded mine production was 1.682 Moz Au, 2.8 Moz Ag (Thomason, *et.al*., 2006

In 1996 X-Cal Resources, Ltd. (X-Cal) optioned the property from Amax, combined it with their contiguous land holdings and started exploration of the larger district-scale potential of the Sleeper gold system has recently been integrated and synthesized with the past mine data in 3D, utilizing Gocad pattern recognition software.

Datasets include: Au and Ag data from historic mine and recent exploration drill-holes; new multi-element, low detection ICP-MS data and spectral reflectance (ASD) mineralogical data on select holes; geophysical surveys (detailed air magnetics, pre-mine IP, CSAMT, gravity), and surface geochemistry (rocks, soils, soil gas).

The 3D modeling provides new insight into the Sleeper deposit, mineralization controls, alteration patterns and exploration potential. This paper presents a refined geologic framework for the Sleeper system and newly recognized multi element and alteration mineral zoning patterns related to gold mineralization.

GEOLOGY

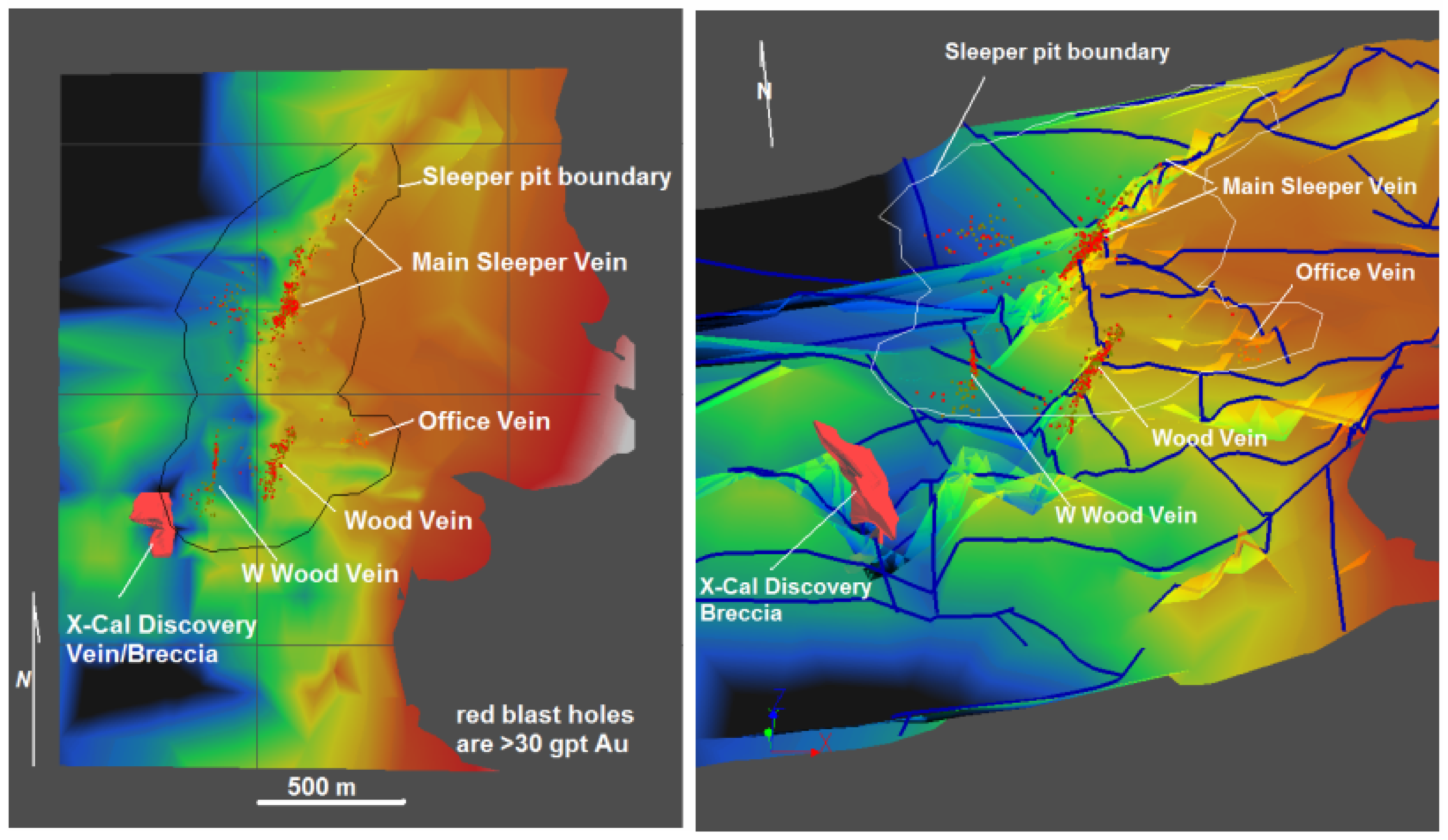
Principle host rocks of the Sleeper veins are Sleeper Rhyolite, part of a Miocene, bimodal volcanic sequence, interbedded with volcaniclastic rocks deposited in a fault controlled basin along the range-front (Wood and Hamilton, 1991, Nash, et.al., 1995, 1994). Metamorphic basement rocks of the Upper Triassic and Jurassic Auld Land Syne Group (Wilden, 1964) are locally mineralized.

Miocene host rocks are dated 16.5 Ma with mineralization and alteration in the range 14-16.5 Ma (Conrad, et.al., 1993).

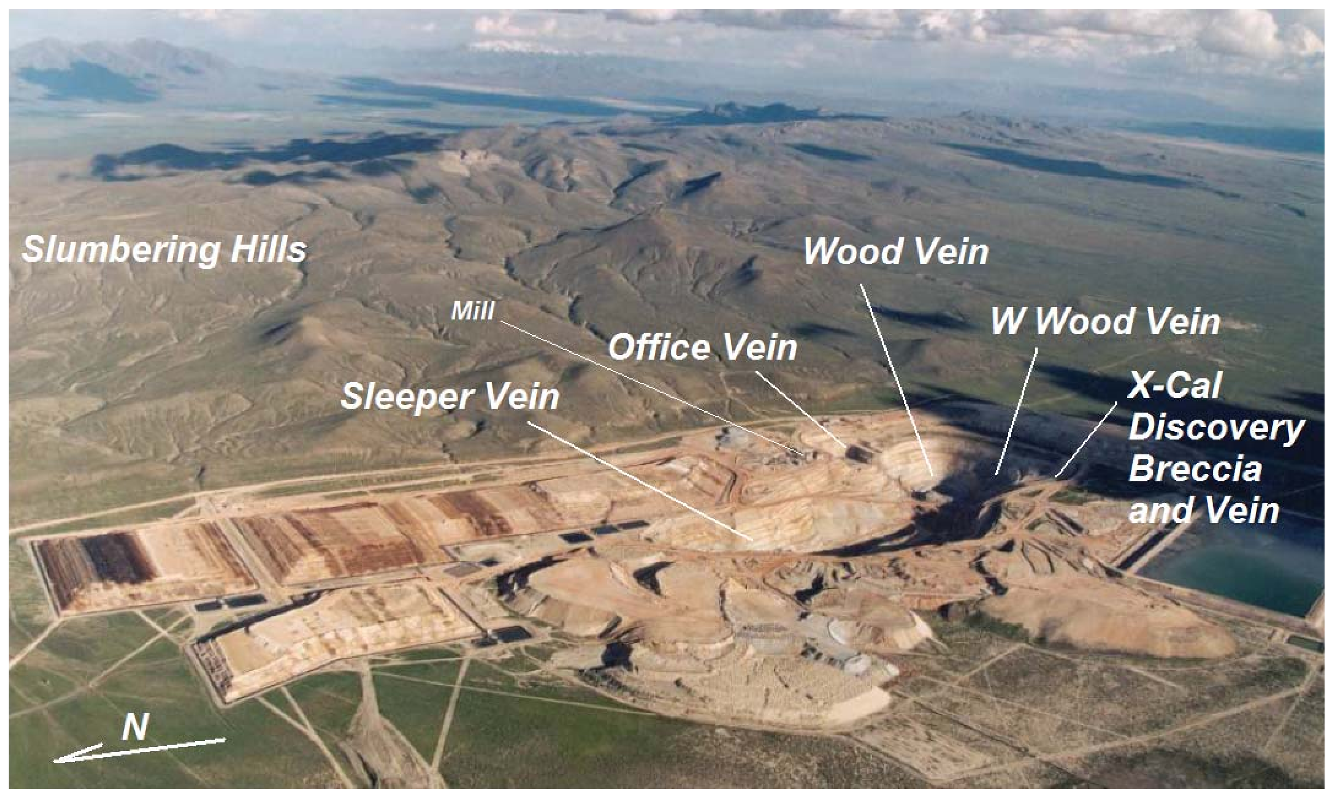
The Sleeper rhyolite has been interpreted as a flow dome complex (Nash, et.al., 1995, Conrad, et.al., 1993). A more recent interpretation based on logging of new holes and relogging of past holes is that the Sleeper rhyolite is either a sill or an intrusive cryptodome complex (laccolith-like) within tuffaceous rhyolites (Sillitoe, 2006).

A distinctive mafic marker unit (with pillow basalt) in the Miocene sequence is present beneath the Sleeper Rhyolite. Offsets on this contact provide evidence of the basin faults and recurrent faulting which controlled gold mineralization. Previous recognition of abundant and systematic relief on the hanging wall (HW) contact surface of the mafic marker unit (Blair, 2005, early cross sections of 0viedo, 1998, Nash, et.al., 1995, 1994) is clearly evident using 3D modeling (Figure 3). The geometry (relief) of the HW contact surface is interpreted to reflect composite horst and graben structures controlled by intersecting NS, NE, EW and NW trending normal faults. Sleeper rhyolite and other subsequent Miocene basin fill units were deposited into the horst, graben, range front basin and its associated sub-basins.

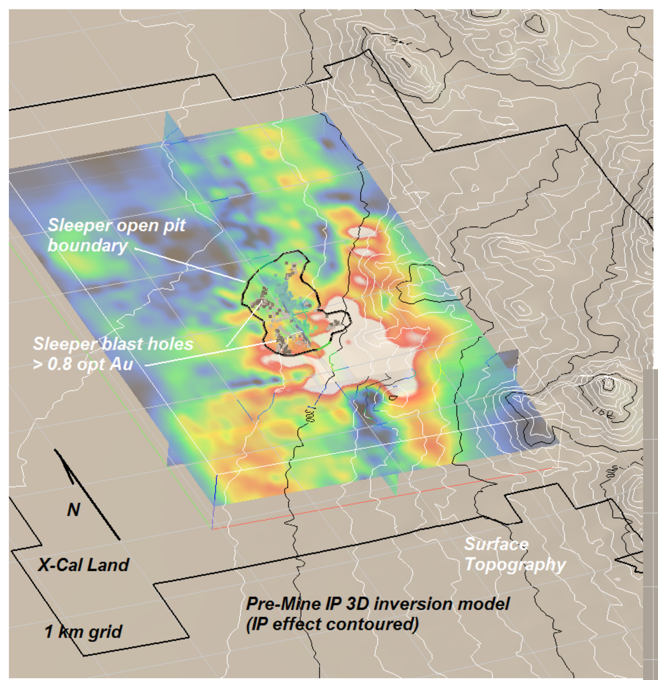
Gold vein, breccia and disseminated mineralization is present along reactivated, basin controlling normal faults. Known bonanza gold veins mimic the geometry of reactivated basin growth faults along composite graben boundaries (Figure 3).

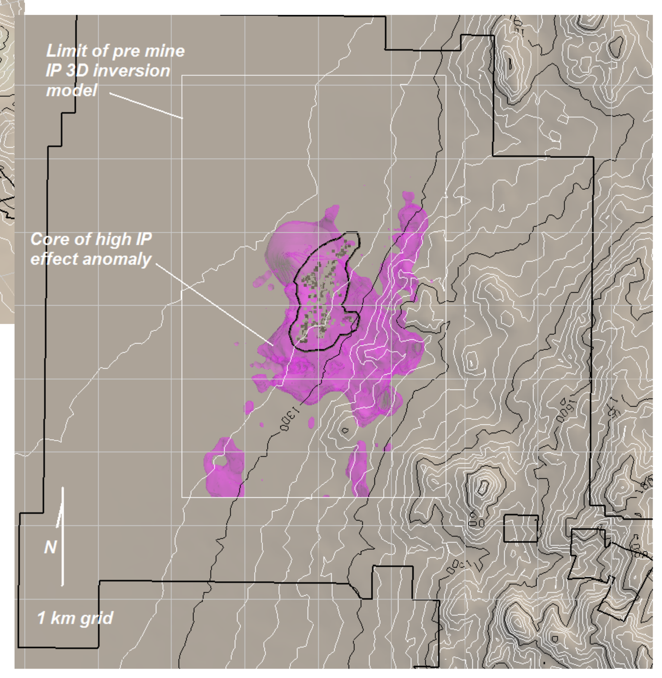


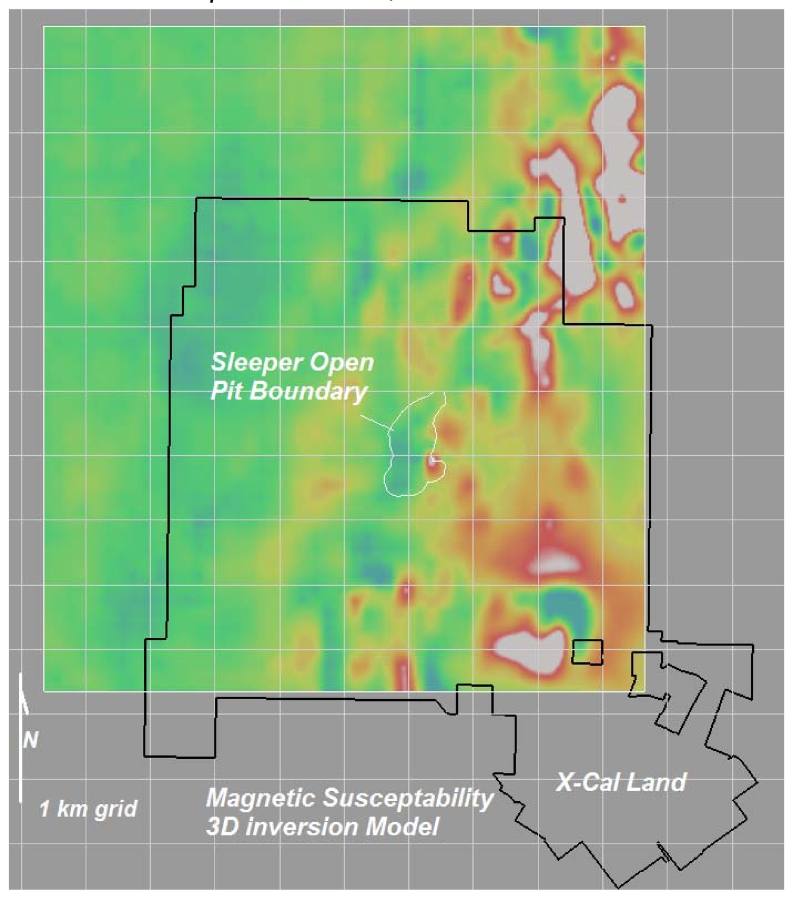
Left a: Structure contour map (colored by Z elevation) of modeled HW contact surface of basalt unit within host sequence beneath Sleeper rhyolite. High grade open pit blast holes defining veins and modeled surface of X-Cal Discovery Breccia are shown in red. Right b: Oblique view looking NNE illustrates the correlation of gold with interpreted graben bounding faults. The ore bodies are within Sleeper Rhyolite which overlays the modeled HW contact of the basalt unit of the mine host sequence.

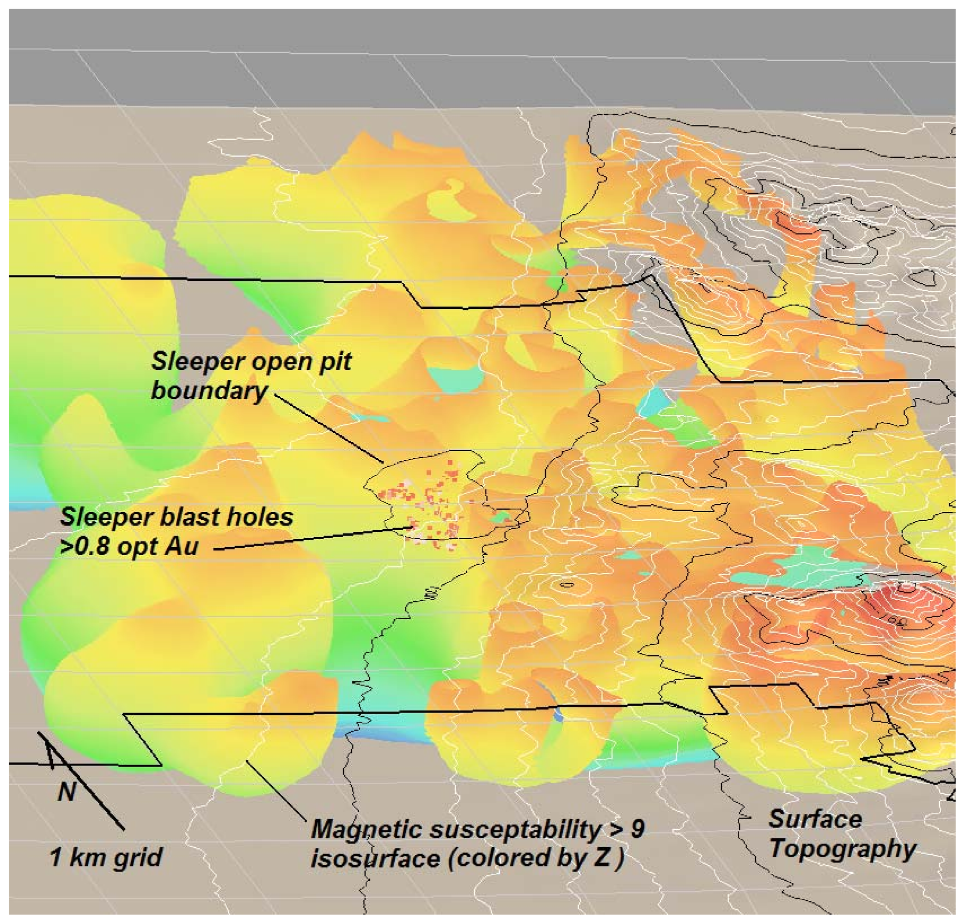


Arial view of the Sleeper open pit looking SE along the Cortez Gold Trend of Nevada









3D Spatial Integration of Data

Sleeper has a wealth of pre-mine IP, CSAMT and geologic drill hole data, as well as recent gravity, CSAMT, aero magnetics, surface soil gas and conventional soils survey data and exploration drill holes. We have used Gocad to integrate and synthesize the information for the first time, including 3D inversions of the geophysical data. Mine scale targets have been identified for drill testing.

We find that in the areas of bedrock exposure (the Sleeper open pit) and the drill holes, there are excellent correlations among the inverted geophysical results and geology. Protolith host units, alteration assemblages and various geochemical anomalies also correlation well with the geophysical inversion data, which is beyond the scope of this poster .

Several views of the inverted geophysics are presented here to add additional context to the recognized geological, geochemical and alteration patterns within the data.

The Sleeper deposit correlates with a distinctive magnetic low as illustrated. The magnetic low probably reflects a combination of host rocks protolith characteristics and alteration. In appears Sleeper is hosted within an altered range front graben active during Miocene volcanism and mineralization.

A recent 3D IP inversion of pre mine data indicates the Sleeper and associated presently known veins are present above a strong IP effect anomaly.

The geochemical and alteration patterns presented below also correlate with the geophysical patterns as you can see by comparing the figures.

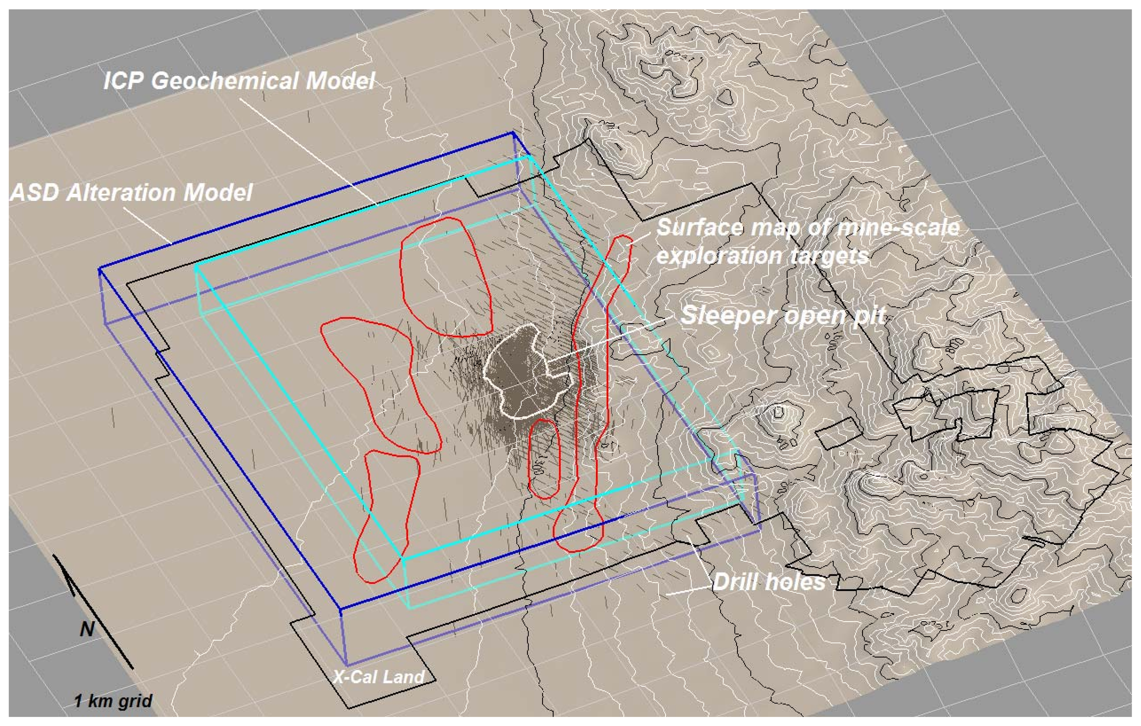


Figure 3. Oblique view of composite 3D data looking NE. Location and extent of ASD Alteration and ICP Geochemical models within X-Cal Resources land. Past drill holes were werhe generally analyzed only for gold and silver.

ANALYTICAL METHODS AND DATA PROCESSING

Drill-hole samples were analyzed using a near total 4-acid digestion and ICP-ES/ICP-MS determination. Partial digest aqua regia data for some drill-holes were incorporated into the database for elements that could be satisfactorily leveled with the total digest data. All analyses were completed at ALS-Chemex Ltd. The geochemical data were converted to log (base 10) units to facilitate display and spatial analysis.

The occurrence and relative abundance of alteration minerals were determined for selected samples using ASD (spectral reflectance) analysis.. Relative abundances were converted from presence or absence to numeric values of 1 and 0. Notations of trace, weak and strong were assigned values of 2, 3, and 4 respectively.

The down-hole data was gridded with GoCAD2.07 software to produce individual element block models (xyz cell dimensions of 50x50x5 m) using: 1) an inverse distance squared algorithm, 2) an unconstrained search radius of 150 m in all directions, and 3) a restriction of gridding to the region from the surface topography to a vertical depth of 30 m below the end of drill holes. The alteration minerals identified by ASD were gridded using a nearest neighbor categorical interpolation.

GEOCHEMICAL MODEL

(cross sections to the right illustrate the following relationships in order)

The Sleeper low sulphidation Au-Ag system is related to vertical plumes in Au, Ag, and As emanating from depth that trace out fluid pathways along high angle structures (Figure 4). Within the large system plume, there is a profile. general zonation east to west from more Ag dominated to more Au dominated. The basalts and, in some cases, the rhyolite, are altered in the area of the system plume as expressed in depletion of Na and other elements (Be, Ce, Hf, La, Nb, Pb, Ta, Th, Y, and Zr) east of the deposit; Ca-Mg depletion centered on the deposit and along a NW trending corridor; and enrichment in K and Rb on the outer margin of ore to the west . The high grade Au veins are located along the western fringe of the system plume at the boundary between K-Rb and Na-Ca-Mg alteration signatures. The distributions of anomalous Ag, As, Ge, S, Se, Te, and Tl are similar to that of the Ca-Mg depletion alteration. The distributions of Sb, Mo, Re, and W are more closely associated with the K-Rb enrichment alteration.

High grade mineralization appears to have a strong elevation control. The base of high grade mineralization coincides with the bottom of a flat-lying, saucer-shaped zone of Zn depletion. Above this boundary, Ba, Mo, U, and Se are enriched while below it, As, S, and Zn are enriched. This feature is interpreted to be the reflection of hypogene oxidation related to a boiling horizon. The highest grade Au and Ag intercepts are generally restricted to the oxidized portion of the profile.

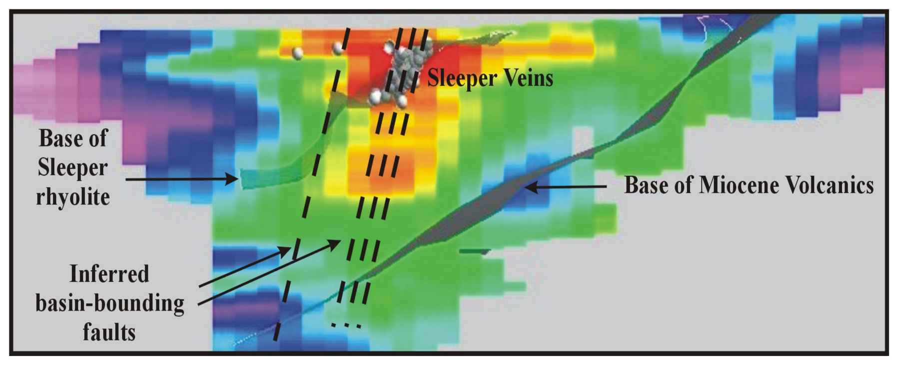


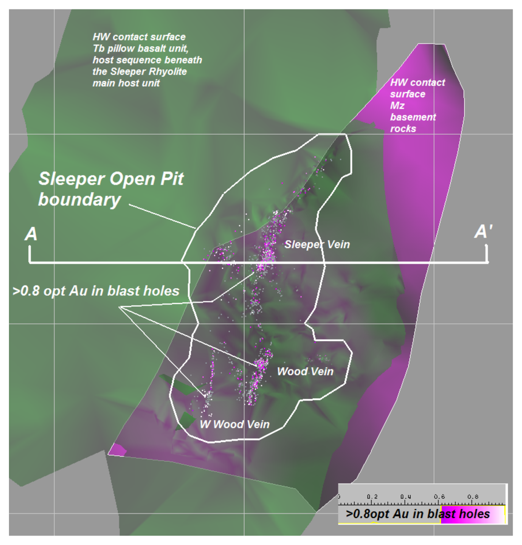
Figure 4: Gridded image of the Au distribution in an E-W section through the Sleeper Vein (yellow > 0.003 oz/ton). White spheres are Au assays > 3 oz/ton.

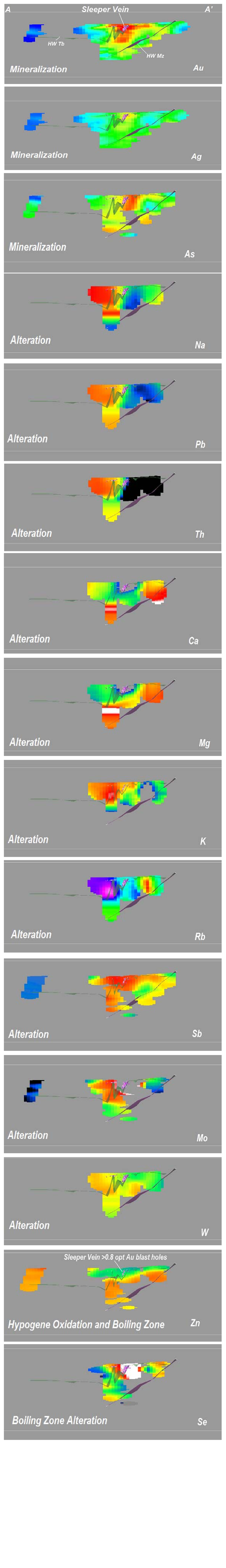
MINERALOGIC ALTERATION MODEL

A zoned sequence of clay minerals is present from east to west in the order of illite → kaolinite-buddingtonite-illite(NH4) → montmorillonite → nontronite (Jackson, 2007). The boundaries between the various zones are more or less vertical or steeply dipping to the west and are observed to cross-cut stratigraphy. The high grade veins are positioned within the buddingtonite-illite(NH4) halo within the larger kaolinite zone. The distribution of buddingtonite resembles that of 2 vertical plumes that flatten out at higher elevations to encompass the high grade veins (Figure 5). The location of at least one of these is spatially associated with a NW-trending structural corridor.

The distribution of silica (quartz, opal, chalcedony) forms an outer boundary to the gold system and, in some areas, underlies it. The eastern margin of the silica zone is located at approximately the same location as the eastern margin of the montmorillonite halo. Chalcedony is present within a NW structural corridor that cross-cuts the range-bounding structures whereas opal is distributed to the north and south of the chalcedony zone within the quartz halo.

Another zoned sequence is that of jarosite → gypsum → CO_3-bearing minerals. The distribution of jarosite is centered on the high grade veins to a depth of about 100 m below them, locally deeper. Gypsum is present in a halo marginal to the jarosite zone both laterally and beneath it. Samples with CO_3 spectra occur within the gypsum halo but exclusive to samples with gypsum. A long string of CO_3-bearing samples is located at depth between the 2 buddingtonite plumes.





The distribution of hematite is generally restricted to above the redox boundary. However, within the oxide zone, the distribution of abundant hematite is centered on the high grade veins with possible extensions along the NW structural corridor that intersects the range-bounding structures. This relationship is likely due to the higher concentration of sulphide surrounding the deposit that was subjected to oxidation. Associated with sulphide oxidation is the presence of alunite above the redox boundary in close proximity to the high grade veins.

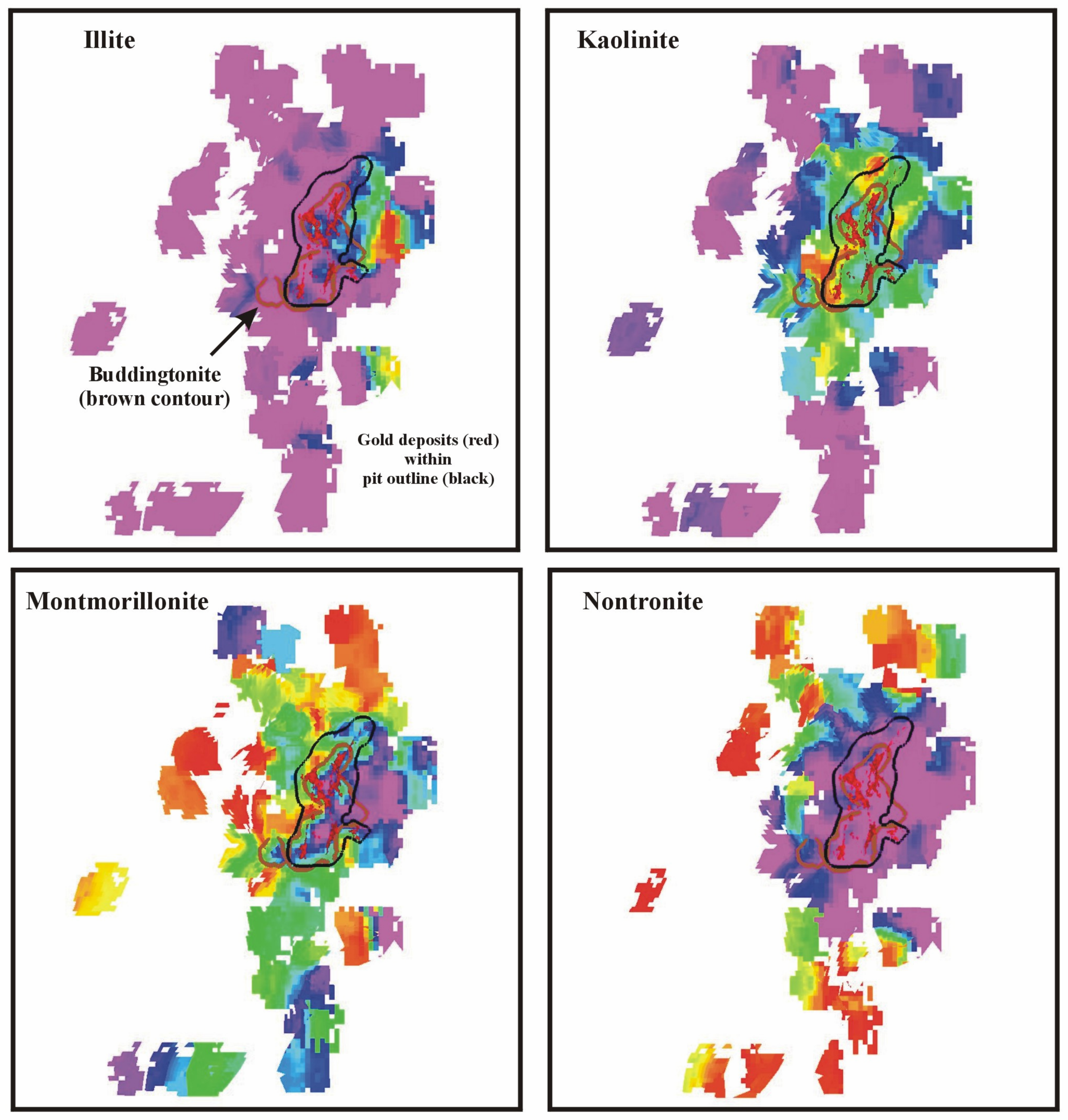
3D SPATIAL DATA INTEGRATION AND PATTERNS

The distribution of high grade Au and Ag appears to reflect the concurrence of 3 main features: 1) major lithologic contacts, 2) high angle structures, and 3) a redox gradient. The coincidence of the oxidized zone (boiling horizon) with open high angle structures developed at the rhyolite/basalt contact created conditions favourable for the formation of high grade Au veins.

Many of the alteration zones have a geochemical expression. The distribution of illite is most similar to that of Na depletion alteration. The relative abundance of illite is closely correlated with the intensity of Na depletion.

The distribution of jarosite with its peripheral zone of gypsum is similar to that of depletion in Ca and Mg and anomalous concentrations of Ag, As, Ge, S, Se, Te, and Tl. The kaolinite-buddingtonite zone is generally coincident with anomalous K, Rb, Sb, Mo, Re, and W. The opal-chalcedony zone is the host for anomalous Bi. The hematite zone is located within the shallow saucer-shaped feature defined by Zn depletion.

The Sleeper system lies within the boundary of a large magnetic low. In 3D, the limits of the Ca-Mg depletion anomaly correspond closely to the boundaries of the magnetic low. This suggests that the alteration process resulted in both mafic mineral and magnetite destruction.



Plan view of the intersection of the block model with a surface 50 m below top of bedrock.

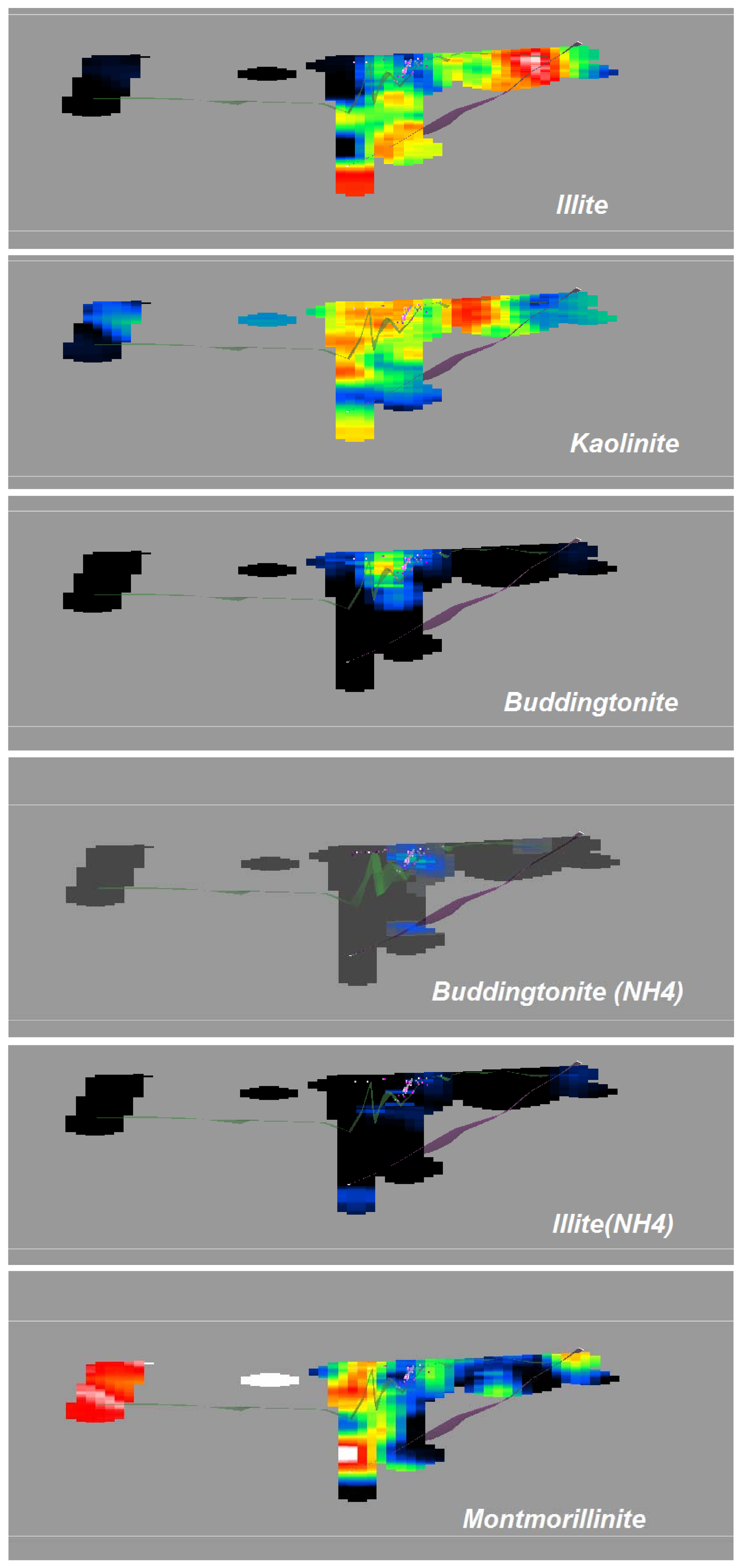
CONCLUSIONS

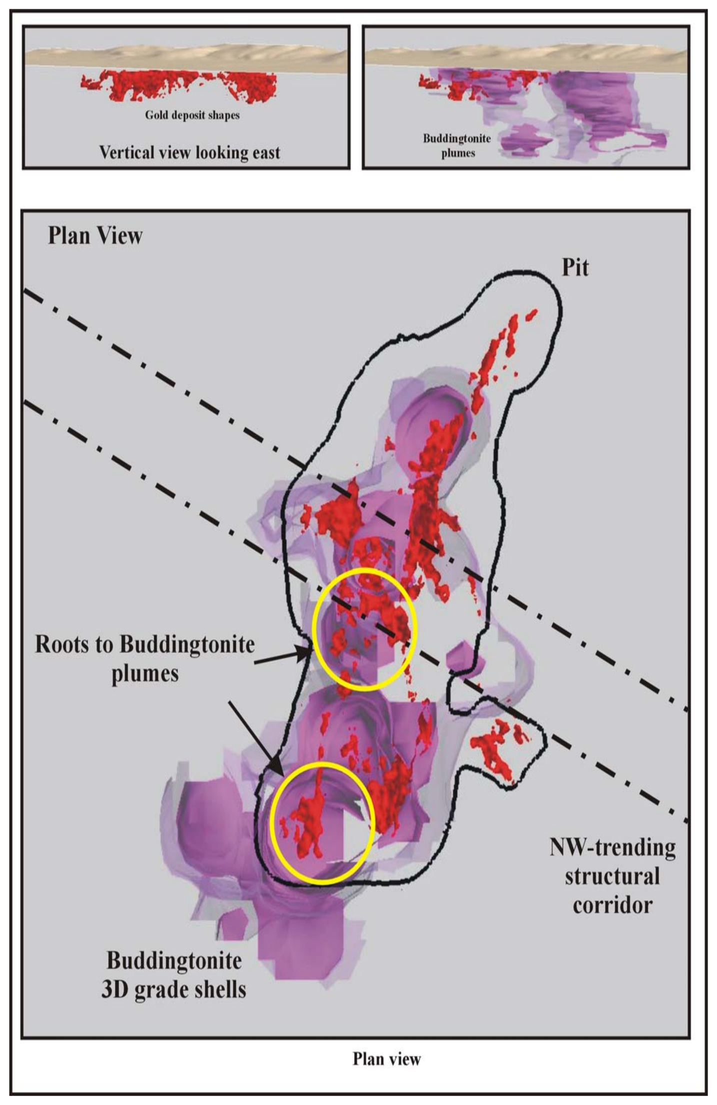
The full integration of all geologic, geochemical, and geophysical data in 3D space has contributed to a better understanding of the Sleeper mineral system including mineralization controls, alteration patterns, and exploration potential. An important component of this integration was 3D modeled down-hole geochemical data and mineralogic ASD data.

Some important observations include: 1) mineralization is focused along basin-bounding normal faults; 2) Au, Ag and alteration patterns are larger scale than the discreet veins and graben bounding fault controls 3) the Au core within the Sleeper graben grades eastward to a Ag rich zone beyond the pit boundary; 4) trace element signatures and alteration mineralogy are zoned in relation to the deposit in a very systematic and predictive fashion; 5) high grade gold mineralization is floored by a saucer-like zone of Zn depletion and other redox related signatures reflecting hypogene oxidation due to boiling; and 6) mineral trends and alteration signatures relate well to features in other data sets such as airborne magnetics, gravity, IP, and soils.

ACKNOWLEDGEMENTS

Shawn Kennedy, President of X-Cal, is the force behind the Sleeper District exploration with his vision to fully realize the gold potential of the Sleeper district with the development of multiple open pits within the range-front pediment. He has assembled a team of experienced consultants whose observations, interpretations, and ideas have significantly contributed to the current understanding of the system. These include geologists, Dr. Ken Snyder, Robert Thomason, Winthrop Rowe, Larry Martin, Larry Kornze, Keith Blair, and geophysicist, Jim Wright. Dr. Richard Sillitoe and Dr. Jeffrey Hedenquist provided key insights and interpretations with respect to the geology an mineral potential based on a site visits to the property.





Buddingtonite alteration plumes associated with the Sleeper Vein gold deposits. Distribution of gold mineralization shown in red as determined from blast hole data

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