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3D IP/Resistivity Characterization of the Hasbrouck Peak Epithermal Gold System: Establishing a District Exploration Signature

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ABSTRACT

The known mineralization at the Hasbrouck epithermal gold-silver deposit in Nevada was used as a test site to determine its geophysical signature and to establish optimal geophysical system parameters to be used in the exploration for similar deposits within the district. Mapping of the property with omnidirectional 3D resistivity and 3D IP E-SCAN revealed a close correlation between the gold-silver mineralization and the areas identified by the 3D survey as having relatively high resistivity. The 3D IP confirms the 3D resistivity pattern and distribution, but adds no significant exploration information to what is made apparent by the 3D resistivity patterns alone. The resistivity anomaly has high ratio-to-background values, and this relatively simple, strong and obvious signature does not require a close station spacing for definition, as long as the survey utilizes dense, uniformly distributed and truly omnidirectional sampling. This supports the use of lower-cost reconnaissance-scale 3D E-SCAN resistivity in this geological setting—a concept that was tested with a larger-scale survey to the southeast of the Hasbrouck deposit. This second survey easily mapped similar shallow high resistivity areas, but also imaged a more subtle anomaly, a pattern visually suggesting a deep feeder structure and fluid up-flow. In the exploration for epithermal gold deposits, accurate imaging of such a pattern with true 3D data provides a most likely position for the deeper fluid feeder system, whose underlying structures are not directly detectable by geophysical methods due to their small size and often resistive nature, but nonetheless represent inferential targets for the potential discovery of deeper bonanza-grade gold.

INTRODUCTION

The Hasbrouck deposit is a low-sulfidation epithermal gold–silver deposit, located in the western portion of the Divide Mining District, eight kilometres south of Tonopah, Nevada, between Reno and Las Vegas. The measured and indicated resource is 811,000 ounces Au and 18,149,000 ounces Ag (Wilson, 2014). The deposit lies below Hasbrouck Peak (Figure 1) which represents an erosional remnant of a hot spring geothermal system associated with an early Miocene caldera. The geology is relatively simple, consisting of layered Tertiary volcanics, with a strongly silicified unit capping the mountain.

This paper describes how the E-SCAN system was used to determine a geophysical signature for this deposit, and how this can be used in the exploration for similar deposits in the district. In addition, the merits of deep geophysical investigation are discussed.

THE E-SCAN SYSTEM

The E-SCAN system is a distributed-array 3D induced polarization (IP) and 3D resistivity acquisition and imaging system, which is typically used in the pole-pole configuration. A few of the important features of the system, especially as it was applied to the project described in this paper, are: its ability to handle any type of terrain due to its simple and flexible wiring requirements; its ability to easily change scale from closely-spaced stations for near-surface detail work to very widely-spaced stations for deep penetration; and its lack of directional bias by rejecting the line-based approach of data collecting and instead insisting on true omnidirectional readings throughout the grid, with high-density, uniform sampling of the earth both laterally and to depth.

Figure 1: Hasbrouck Peak, viewed facing west.

DATA COLLECTION AND ANALYSIS

A plan view of Hasbrouck Peak is provided in Figure 2 which also shows the mapped faults in the ore zone of gold-silver mineralization and shows Hwy 95 immediately to the west. This map is used as a base for some of the other figures in this paper.

The E-SCAN survey grid was draped over the entire Hasbrouck Peak complex using a 300 ft by 300 ft station spacing between electrodes, and resulting in 225 grid stations in total. Measurement of 50 to 60 omnidirectional resistivity and IP values from each of the 225 stations produced a large, high density, uniformly-distributed 3D data set which was inverted

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using 75 ft square mesh elements (UBC 3D DCIP inversion code).

Figure 2: Plan view showing fault zones and Hwy 95 to the west.

The result of the inversion is a 3D block of earth mesh elements which can be viewed in multiple plan and section slices. The plan view can also be draped on topography, at a chosen depth below the topographic surface. Figure 3 shows the 3D inverted resistivity model in the form of one plan, draped 150 ft below surface and four section views through the mineralized area.

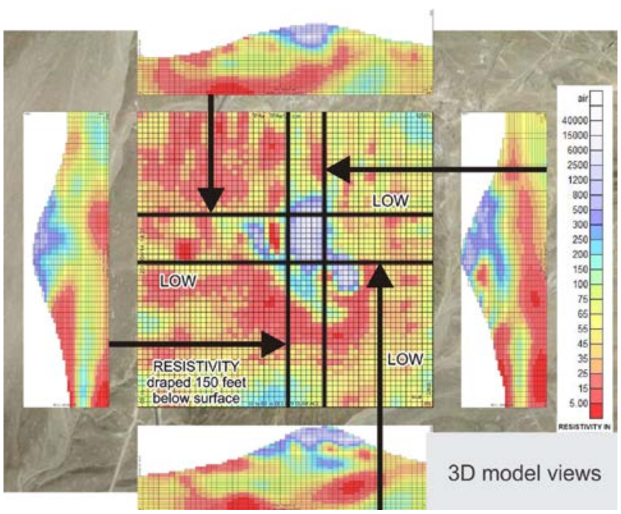

Figure 3: 3D inverted resistivity in draped plan and four sections.

Since these cell element views show the unmodified inversion output values for each cell, it is useful to work with these until a first pass set of observations and conclusions is made, after which the somewhat subjective application of gridding and contouring can be applied for additional resolution of pattern subtleties.

The plan view in Figure 3 shows a strong resistivity anomaly, at 20-times background, near the centre of the grid. This view is at a depth below topography of 150 ft, and shows that there is an absence of adjacent shallow anomalies across the 4200 ft by 4200 ft survey area.

There is a close lateral correlation between the elevated resistivity and the gold-silver resource as shown in Figure 4. The geologic process responsible for the high resistivity is understood to be silicification, a process of sealing off connected open spaces that represent the main pathways for electrical conduction throughout the host volcanic units.

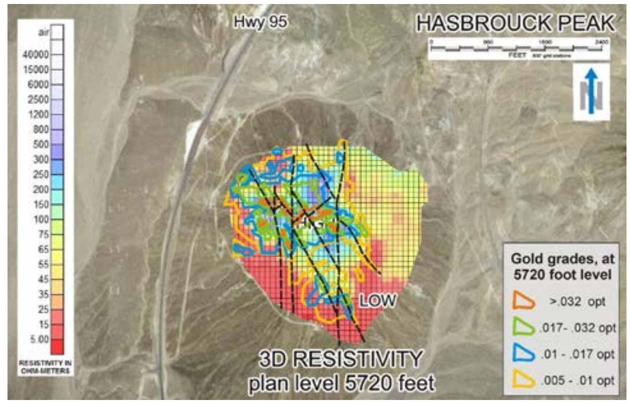

Figure 4: Gold grades superimposed on resistivity inversion model.

The 3D IP data set reveals no significant chargeability anomalies over the survey area. Typical IP values are less than 1.5%, which is nominally "background" (see Figure 5). The mineralized areas actually display IP values that are anomalously lower than background due to silica encapsulation. The same process that caused the elevated resistivity also encapsulates the gold-associated sulphides in resistive silica, so that the sulphides are isolated from any electrical IP reaction. The 3D IP values confirm the 3D resistivity pattern and distribution, but add no significant exploration information to what is made apparent by the 3D resistivity patterns alone.

The resistivity correlation is confirmed in the vertical sense, where again we see close correlation between high resistivity and known ore mineralization in section views. Figure 6a is a true vertical section through the 3D resistivity model and extends 1500 ft below the peak. Areas of elevated resistivity are outlined and these areas are superimposed on gold grades in Figure 6b. The correlation between the main ore zone and the distinct, 20-times background resistivity anomaly is obvious, but there are also two subtle resistivity anomalies at 5-times background and 3-times background (labelled "A" and "B" respectively).

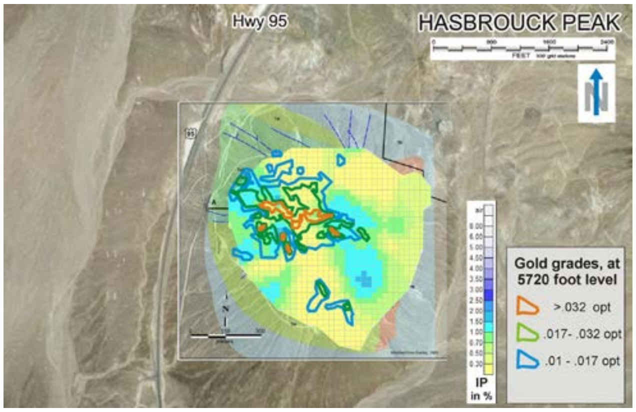

Figure 5: Gold grades superimposed on IP inversion model.

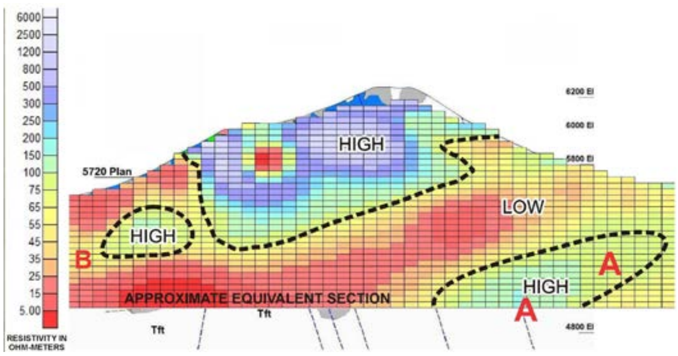

Figure 6a: Inverted resistivity in section.

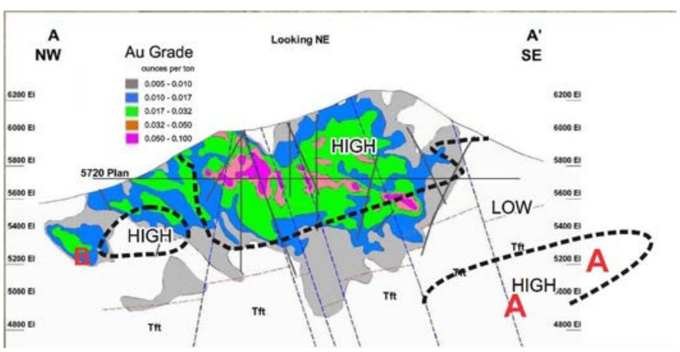

Figure 6b: Gold grades in approximately the same section as Figure 6a, with superimposed high resistivity zones.

A review of historic drilling suggests no testing in the area of anomaly A at lower right, recognized as a site requiring investigation. The lesser-ratio (3x) anomaly at B confirms that significant grades can be associated with intermediate (modest) levels of anomalous resistivity, making anomaly A even more interesting. In relatively undisturbed, layered volcanic host regimes, unexplained (but data-verifiable) anomaly patterns of any relative intensity may warrant investigation; absolute values are historically non-diagnostic for grade. Follow-up of subtle E-SCAN anomalies has proven to be justified elsewhere due to the true 3D nature of the data set with its high-density, all-directional measurements, and uniformly distributed sampling of the earth both laterally and to depth, which effectively precludes the generation of sparse-data or line-data processing artefacts.

DISTRICT EXPLORATION

The single high-ratio resistivity anomaly within Hasbrouck Peak's quiet background mode confirms an opportunity for extended survey coverage at wider, more economical survey grid spacing. For example, a step-out true 3D resistivity survey at almost double the grid station spacing (500 ft by 600 ft vs 300 ft by 300 ft) was undertaken between Hasbrouck Peak and Klondyke Peak to the southeast (area B in Figure 7). Banking on the fact that the Hasbrouck anomaly can be recognized from decimated data at a station spacing of 600 ft and even 900 ft, this new survey confidently covered 2.8-times the area of the original Hasbrouck 3D survey (area A in Figure 7), at one-third the cost per square mile.

The new survey mapped elevated resistivity anomalies that are similar to those at Hasbrouck, but in flat land. Two vertical sections through the resistivity inversion model for area B are shown in Figure 7 as well, directly to the right of the section lines drawn on the plan view. The southern section passes through an unmistakable high ratio anomaly labelled "D", similar to the one on Hasbrouck Peak, which is also clearly seen in the plan view. The northern section passes through a more subtle low ratio anomaly, labelled "C", which is enhanced in the section by manipulating the colour bar to better illuminate the weak pattern.

The peak resistivity for anomaly C is only 160 ohm-m, compared to values greater than 1000 ohm-m for anomaly D, but it is the anomalous pattern, regardless of its intensity or ratio, that is diagnostic of an unexplained feature that demands follow-up investigation. The pattern of interest here is closely reminiscent of that which has been observed, and drill-confirmed, on the Hollister NV property (Shore, 2015) where a mid-depth silica-sealed resistive aquitard overlies the *geophysically-undetectable* (i.e. inferred) Gwenivere and Clementine vein systems, which together contain in excess of 1 million ounces of high grade gold. Although gold mineralization can also occur in and above the resistive cap feature in these settings, the potential to (directly or indirectly) locate and then drill test the related deep feeder conduit system is an exploration advantage that is provided specifically through the routine speculative application of Very Large Scale (VLS) 3D E-SCAN overview resistivity mapping.

Prospective volcanic host conditions extend in an area up to 8 miles wide from Three Hills near Tonopah, south toward Goldfield. The geology and terrain are shown to be amenable to the use of lower cost, wider spacing 3D resistivity mapping with a station spacing of 600 ft by 600 ft, which could quickly cover the entire area from Tonopah to Goldfield. Such mapping could deliver a multi-targeting true 3D assessment of this volcanic regime from the near-surface to effective depths of a mile or two below surface when the optional VLS extra-deep "context mapping" data are routinely gathered.

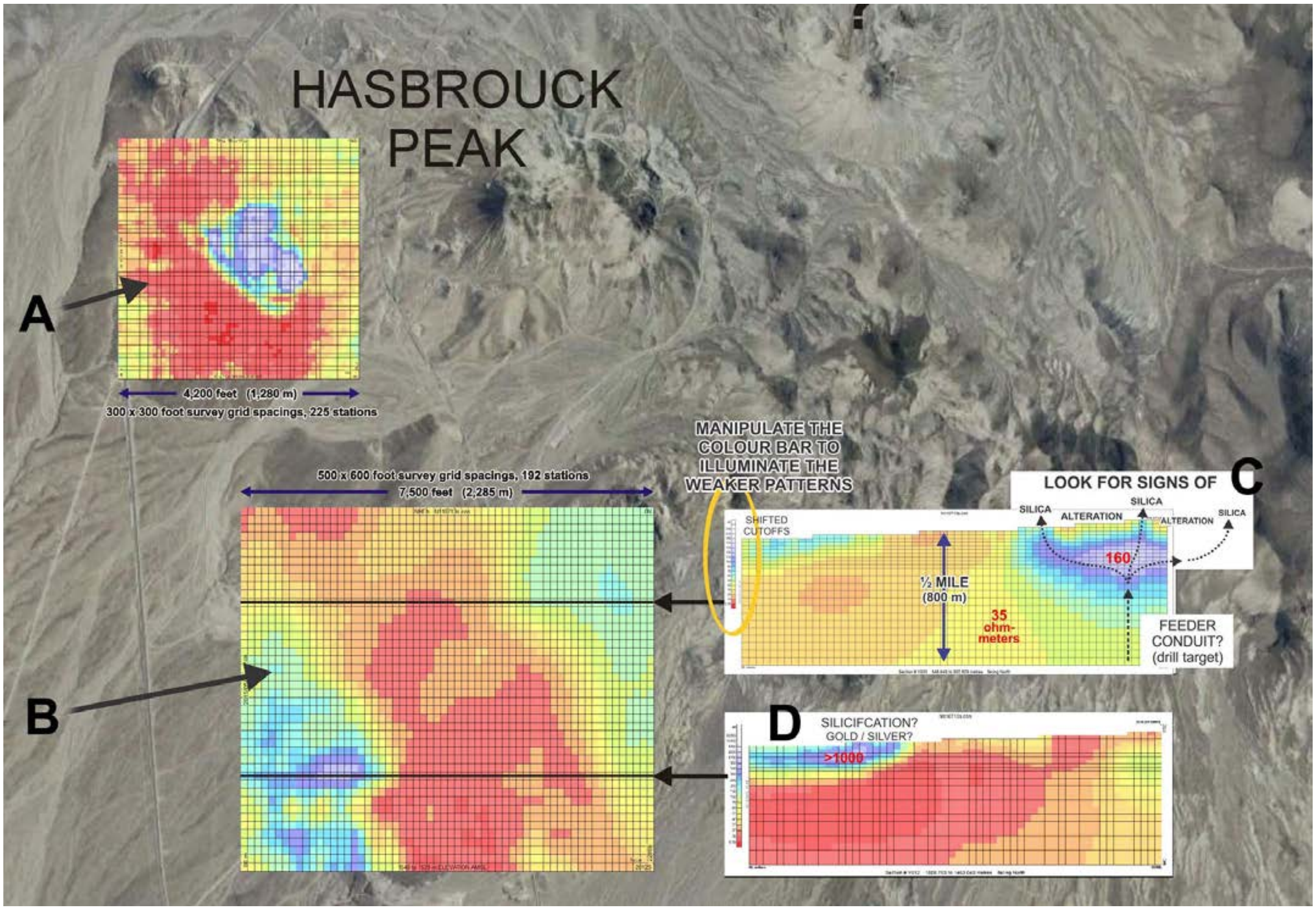

Figure 7: Larger-scale survey area (B) southeast of the Hasbrouck grid (A). Anomalies C and D were detected.

The overview VLS imaging capability allows direct or inferential mapping through the large vertical range (3000 ft to 5000 ft) that is typical of volcanic-hosted epithermal systems. Within areas exhibiting multiple hot-spring and sinter manifestations at surface, this deep overview imaging presents the possibility of linking adjacent surface manifestations to observed or inferred locations of common deep fluid-source structures or zones, i.e. deep drill targets, even when the connected sinters or hot-spring zones may be located a few hundred metres apart (at Hollister) to several kilometres apart, as in New Zealand (Shore, 2015).

The area already hosts two economic gold-silver epithermal ore systems, at Hasbrouck Peak and at Three Hills. While the detection and 3D imaging of look-alike systems would be the primary survey objective, we don't know what other types of shallow or deep economic mineralization might be imaged in the course of a single true 3D mapping survey pass, for example the potential deep, high grade feeder system pattern that is imaged at C of Figure 7.

While any survey array could cover the area, the resistive nature of the primary target, and the expected more subtly resistive nature of deep feeder structure patterns such as at anomaly C, both require true 3D data sets to ensure recognition of these resistive-end anomaly patterns, and to avoid the creation of the misleading or obscuring artefact patterns that often result from 3D inversion of sparse or directionally-biased (non-3D) field survey data sets.

CONCLUSIONS

3D E-SCAN IP and resistivity mapping at Hasbrouck Peak reveals a distinct 3D resistivity anomaly pattern that closely correlates with the known ore-grade gold-bearing epithermal silicification, within its volcanic host. The resistivity imagery alone delivers an unambiguous resource targeting signature for reference in the exploration of the surrounding area of similar volcanic terrane.

On this property, 3D IP data contribute very little to the exploration program: pervasive gold-associated sulphides have been encapsulated by silica and are consequently isolated from any electrical IP reaction.

The relatively featureless background resistivity signature of the host volcanic units confirms the potential for effective application of low cost, reconnaissance-scale 3D E-SCAN resistivity (no IP) survey across the covered areas that extend in all directions, including north to Three Hills (outskirts of Tonopah), where similar ore mineralization can be expected to yield similar 3D resistivity anomaly signatures.

The optional inclusion of simultaneous VLS 3D E-SCAN mapping deep below the near-surface regime may provide additional views or inferences of deep plumbing system elements that would identify subsurface linkages between adjacent surface hot-spring manifestations, and then reveal the (possibly offset) most-likely location to drill to test for deep conduit-related high-grade "bonanza" gold mineralization.

REFERENCES

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