# Full 3D Acquisition and Modelling with the Quantec 3D System - The Hidden Hill Deposit Case Study

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## SUMMARY

This abstract will detail Quantec's 3D system, a proprietary 3D DC/IP and MT acquisition developed by Quantec Geoscience Ltd., Canada by means of a case study over the Hidden Hill Deposit in central Nevada, USA.

An integrated data acquisition, modelling and interpretation of the DC, IP, and MT surveys over a complex geological setting embedding a known epithermal gold and silver-bearing deposit are presented. The survey and interpretation are based on a true 3D acquisition and inversion of the geophysical data.

The results show a very close correlation between the geophysical resistivity and chargeability signatures and the location of the known mineralization. The extremely large data volume collected in an omni-directional current source proved to be essential for a detailed and reliable imaging of the subsurface.

**Key words:** 3D acquisition, 3D inversion DC/IP, MT, gold-silver deposit

## INTRODUCTION

Over the past years, the development of DC/IP and MT acquisition systems, processing software and workflows have all been advancing towards full 3D acquisition and imaging capabilities of the subsurface.

This abstract will detail the advancement of a 3D acquisition system owned and operated by Quantec Geoscience Ltd. of Toronto, Canada. Improvements over traditional acquisition systems are illustrated with examples over the Hidden Hill Deposit in Central Nevada.

Quantec's 3D system, as its 2D equivalent Titan-24, is a combined DC/IP and MT distributed array acquisition system (Sheard, 1997) and has the capability to image the subsurface up to great depth (750 m for DC/IP and 1500 m for the MT under favourable conditions). A survey has been completed over the Hidden Hill deposit in south-central Nevada, USA in 2011 and these results will be used to showcase the Quantec 3D technology in this abstract.

## METHOD AND RESULTS

The Quantec 3D system is operated as an array of individual data receiver modules (DRM), continuously recording time series of the electrical and magnetic fields as autonomous units. Each module (DRM) is also equipped with a GPS clock which is used in the processing to distinguish between different MT events or current injections (in case of the DC/IP reading).

During the DC/IP acquisition a geophysical operator deploys the current injection pole (typical acquisition geometry for this 3D system is pole-dipole) at different locations along a predetermined survey grid. The time series of the injection current is also recorded by a current monitor in the recording truck. Following a day of acquisition the signal recorded at the current monitor together with the GPS timestamp is used to parse the day long time series recorded by each acquisition module. Separate injections and typical DC/IP parameters are calculated (electric potential (V) and Phase (mrad)) from the processed signal.

For the MT component of the real 3D system, a remote MT site is used to reference the data acquired on site. Synchronisation between the remote MT station and the survey location is achieved via GPS clocks, in a similar fashion as the parsing of the DC/IP data. Sets of magnetic coils are buried at several locations across the survey area and several runs are measured, each centred around a specific frequency range, resulting in a dataset with a frequency range between 320 Hz and 0.01 Hz. Processing software calculates the MT impedances from the recorded time series which are subsequently used for further modelling of the data.

### The Hidden Hill Deposit and 3D Survey Geometry

The Hidden Hill deposit is covered by about 35 m of alluvium and is generally circular in plan with a diameter of approximately 230 m (Ristorcelli and Christensen, 2009). The zone is associated with the Confidence Mountain rhyolite flow dome and its detrital apron. The Hidden Hill deposit area was strongly affected by the later high-sulfidation alteration style, which may obscure earlier low-sulfidation veins (Figure 1). The deposit has been mapped before with geochemical and geophysical testing, geologic investigations, and diamond and reverse circulation percussion drilling.

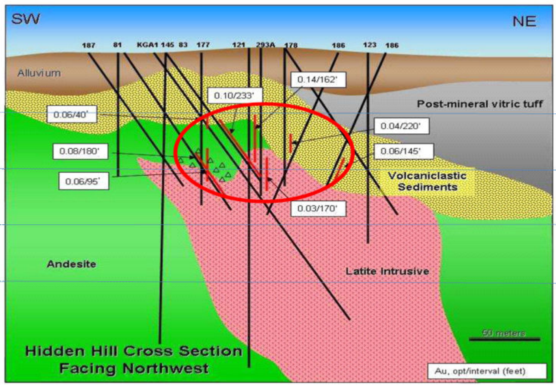


**Figure 1: Simplified geology of the Hidden Hill deposit**

The Hidden Hill deposit is located in the Golden Arrow property. The Golden Arrow property is situated along the northeastern margin of the Walker Lane Structural Belt, a geologic terrain dominated by northwest-striking, right-lateral transcurrent faulting. The district is also located along the western rim of the Kawich Range volcanic caldera. The property is underlain by a suite of Oligocene to Miocene-age andesitic to rhyolitic volcanic and volcaniclastic lithologies erupted from the Kawich volcanic center. The oldest rocks exposed are andesite, andesite volcanic breccia and andesite volcaniclastic sedimentary rocks. The andesite is overlain by a thick sequence of rhyolite ignimbrite sheets, which are intruded by rhyolite domes and associated phreatomagmatic diatremes. These rocks are overlain by rhyolitic maar volcaniclastic sedimentary rocks. Gold and silver mineralization was temporally associated with this rhyolitic igneous episode. All of these units are overlain by Pliocene-age basalt flows and Quaternary alluvial deposits. Faulting associated with late caldera collapse and later Walker Lane deformation cuts all rock units. Gold and silver bearing mineralization is typical of both volcanic-hosted low-sulfidation epithermal mineral systems and hot-springs-type, high-sulfidation epithermal mineral systems. Precious metal enrichments are associated with multi-episodic quartz-sulfide (±adularia ±ankerite ±sericite ±barite) veins, veinlets and stockwork zones within high-angle fault zones. Disseminated and stockwork mineralization also occurs within a section of rhyolitic volcaniclastic maar sedimentary rocks. The Golden Arrow mineralization is best described as consisting of low-sulfidation epithermal quartz and precious metal veins overprinted by hot-springs-style, high-sulfidation epithermal alteration and precious metal mineralization.

A 10x7 grid of DRM Sites was chosen as the survey geometry, with a spacing of 300 m in the north-south and east-west directions (Figure 2).

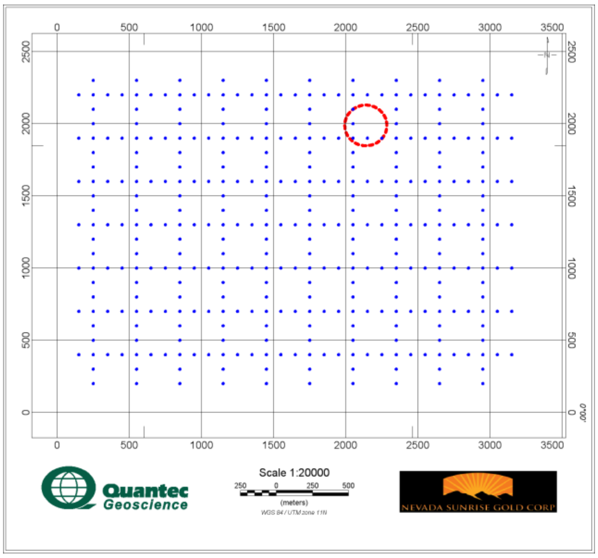


**Figure 2: Acquisition geometry. The solid dots show the electrode locations and the dashed circle depicts the approximate location of the Hidden Hill deposit.**

Each DRM site was connected to six electrode dipoles, three oriented north-south and three east-west. A total of 420 receiver diploes were deployed simultaneously. Current injections for the pole-dipole survey geometry of the DC/IP component were completed every ~100 m in east-west and north south directions. Additional current injections were taken outside the survey grid. In total 596 injection points were completed over the course of a 10 day survey campaign. The DC and IP datasets contain more than 280,000 measurement points over the survey area. This large dataset represents a very dense sampling of the subsurface by the 3D survey design. A volumetric illustration of the data density and data location plotted as pseudo-depth is given in Figure 3.

A roll-along approach, similar to that of seismic surveys, was used in this survey. This allows coverage of a large area with a limited number of receiver modules. Initially, a 49-unit grid was deployed and then partially moved, according to the roll-along principle, from the western side of the grid to the east. The current injection sequence was designed so that it provides enough overlaps between the initial and the roll-along areas.

For the MT measurement, 70 North-East and South-West dipole pairs along with magnetic sensors were used at each receiver site. The MT measurements were conducted over a 12-hour period.

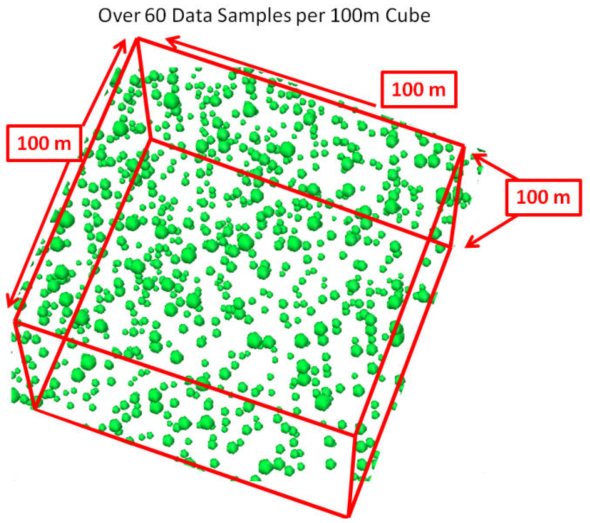


**Figure 3: Example of data density and pseudo data location across the survey area.**

### 3D inversion modelling (DC/IP)

Modelling of the DC/IP data was completed using the DCIP3D routines from the GIF-inversion facility of the University of British Columbia, Vancouver (Li & Oldenburg, 2000).
An inversion mesh was created with 50x50 m cells in a horizontal direction and a vertical mesh starting with 15 m thick cells and increasing thickness with depth. All 596 current injection poles were used in the inversion, and approximately 80% of the acquired receiver dipoles were used (more than 200,000). Thanks to the wealth of the data points only high quality data were allowed in inversion process.

### 3D inversion modelling (MT)

The 3D MT inversions were completed with the WSINV3DMT code (Weerachai Siripunvaraporn, 2005). The Data were inverted as Zxy and Zyx impedances, and 16 frequencies were included from 320 Hz to 0.01 Hz.
The inversion mesh was chosen at 106x106 m cells in the horizontal and 50 m thickness in the vertical direction, increasing with depth. As a starting model a 100 Ω·m half space was used.

### 3D inversion results

The following sections will describe the inversion results obtained from this data set. The colour scale of each model image will be kept constant in this abstract. The resistivity models are displayed in a logarithmic scale of 3 Ω·m in purple to 200 Ω·m in white. The chargeability models are presented in a linear scale where blue denotes 0 mrad and pink 20 mrad.

The IP chargeability and the DC and MT resistivity inversion models are displayed in Figure 4, Figure 5, and Figure 6, respectively. The models are displayed from 300 m depth and location of the Hidden Hill deposit is shown. For clarity, windowed images of the DC and IP inversion models trimmed along the Hidden Hill deposit are also shown in Figure 7 and Figure 8, respectively.

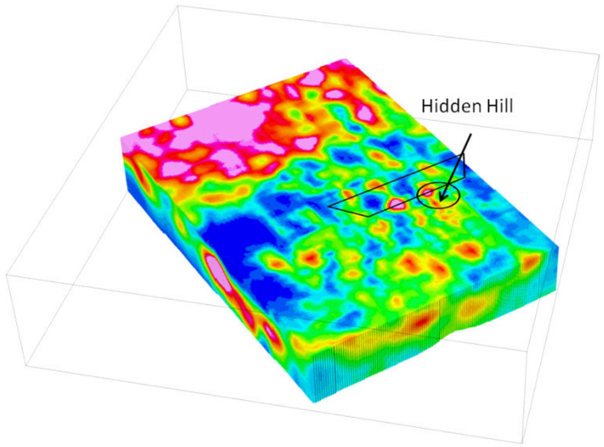


**Figure 4: 3D IP inversion results, displayed from 300 m depth. The box outlines the windowed image area and the circle depicts the approximate location of the Hidden Hill deposit.**

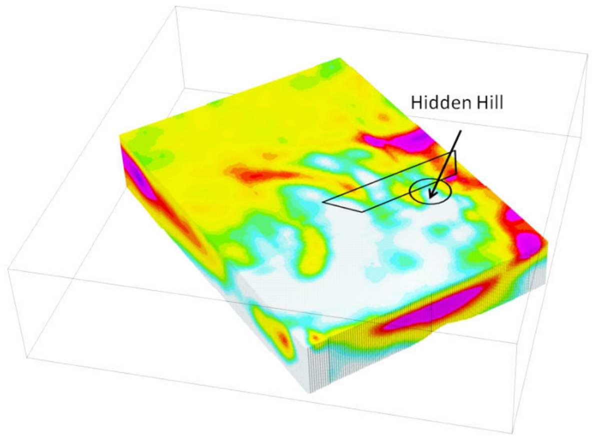


**Figure 5: 3D DC inversion results, displayed from 300 m depth. The box outlines the windowed image area and the circle depicts the approximate location of the Hidden Hill deposit.**

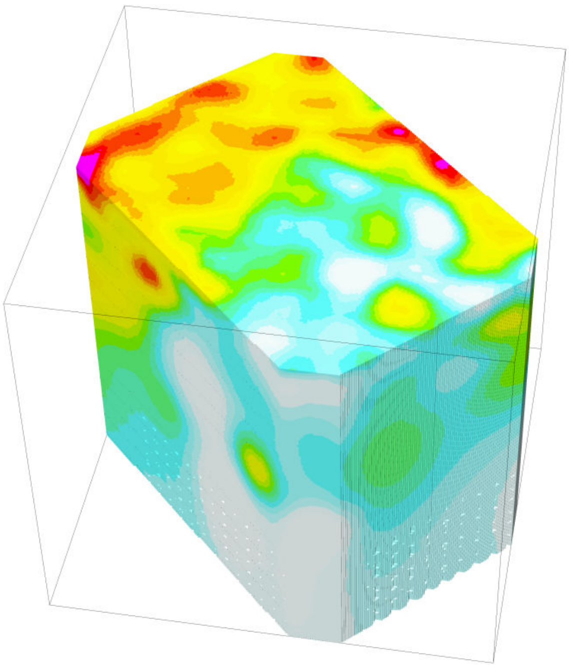

Figure 6: 3D MT inversion results, displayed from 300 m depth.

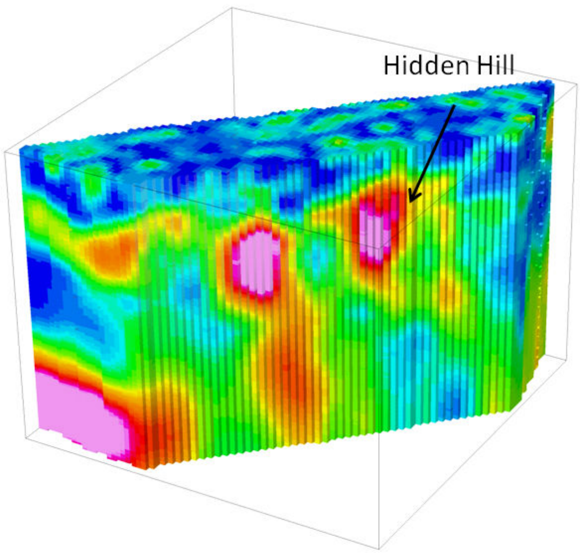


Figure 7: Trimmed 3D IP inversion model along the Hidden Hill deposit (see Figure 4).

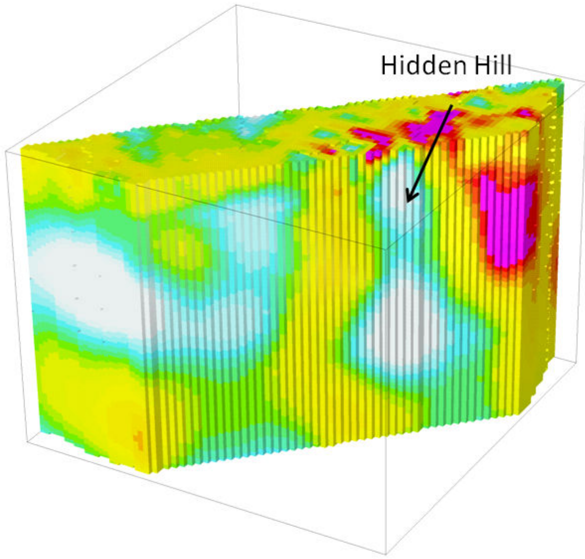


Figure 8: Trimmed 3D DC inversion model along the Hidden Hill deposit (see Figure 5).

Both DC and MT resistivity models display a resistive zone associated with the location of the Hidden Hill mineralization zone (Figure 5 and Figure 6). Additionally, a high chargeability anomaly is observed in this area (Figure 4). Geometry of the resolved resistive and chargeable anomalies in this area is better illustrated in the trimmed images along the mineralization zone (Figure 7 and Figure 8). A Latite Intrusion is mapped as a subvertical resistive anomaly with a resistivity of more than 200 Ω·m. The location of the chargeability anomaly observed in this area appears to coincide with the top of the resistive anomaly. This observation is in agreement with the Hidden Hill mineralization style. In Hidden Hill, gold mineralization is disseminated in brecciated zones with intense clay-pyrite alteration surrounding intrusive latite dikes (Ristorcelli and Christensen, 2009). Additionally, mineralization is concentrated in sub-horizontal stratabound lenses within the volcaniclastic maar sediment. The gold deposit style in Hidden Hill explains the location and relationship of the resolved chargeability and resistivity anomalies.

The Hidden Hill mineralization zone has been subject to a large amount of drilling to map and evaluate gold-silver mineralization grades. The existing drill-holes and their gold assay grades projected on to the chargeability and resistivity cross-sections in Hidden Hill area are illustrated in Figure 9 and Figure 10, respectively. It is evident that the high grade gold area displays a close correlation with the elevated chargeability zone. This correlation in conjunction with the resistivity anomaly associated with the Latite Intrusive dike provides a guideline to identify locations with similar geophysical signatures across the survey area as potential targets. In Figure 9 and Figure 10 a few potential targets of this kind have been marked for further exploration.

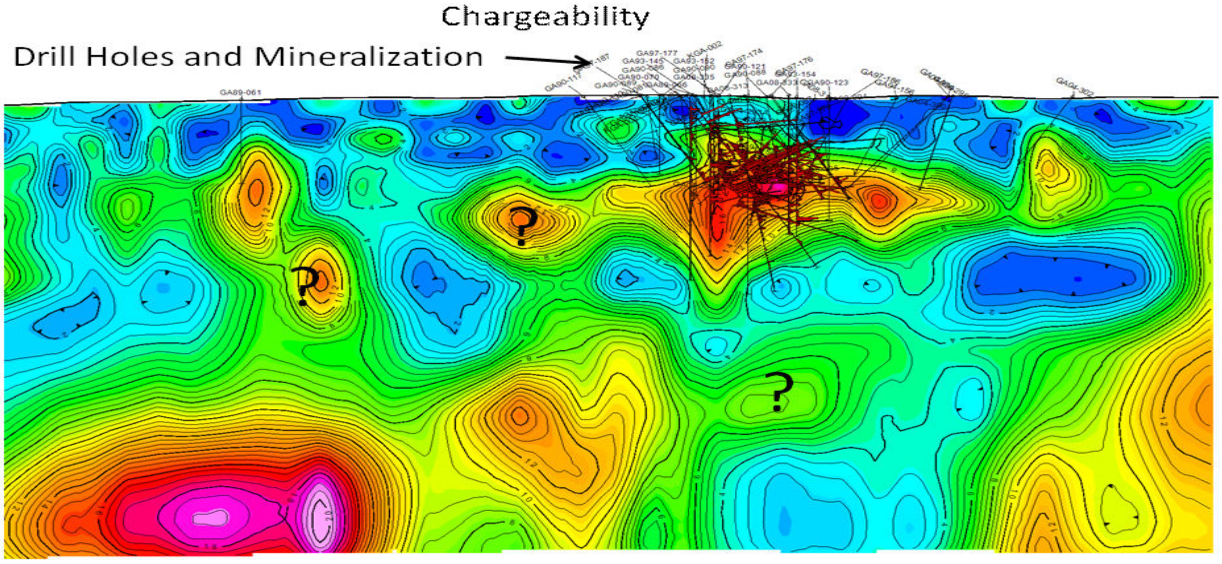


**Figure 9: Drill-holes and gold mineralization assay (ppb) superimposing cross-section of the chargeability 3D inversion model in Hidden Hill.**

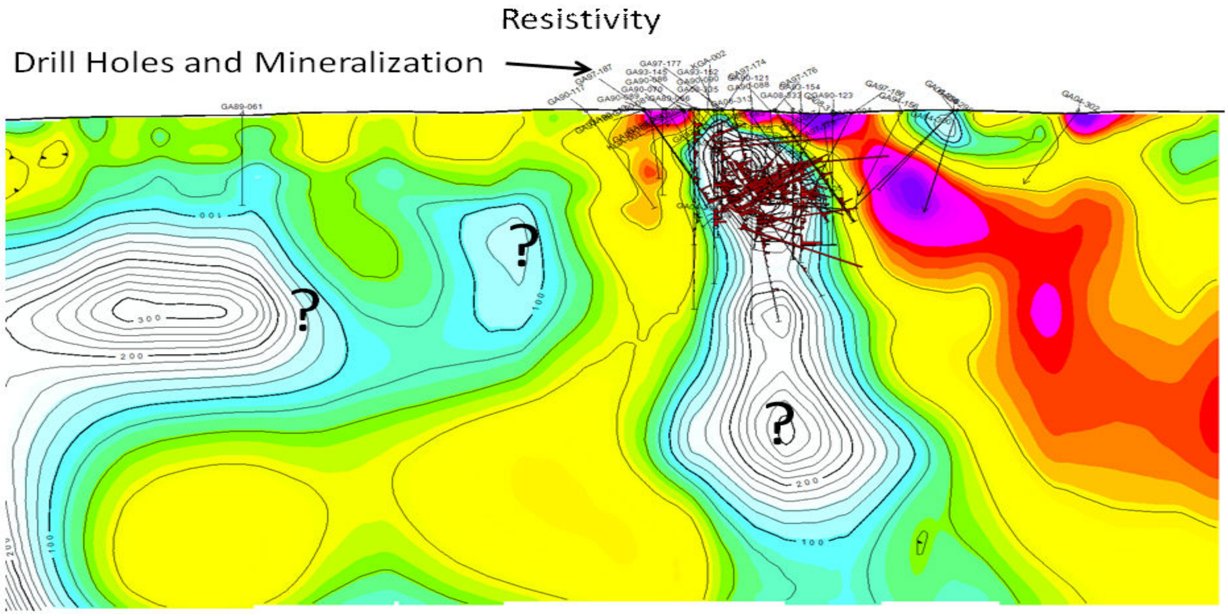


**Figure 10: Drill-holes and gold mineralization assay (ppb) superimposing cross-section of the resistivity 3D inversion model in Hidden Hill.**

## CONCLUSIONS

Deployment of a large distributed acquisition unit array like Quantec's proprietary Quantec 3D system is proven to be logistically and economically feasible. The large amount of data collected can be used to generate a detailed 3D image of the subsurface.

The additional information obtained in the larger data volume and an omni-directional DC current source allows for a more detailed imaging of the subsurface when compared with pseudo-3D, offset injection, and conventional 2D surveys.

The 3D DC/IP/MT survey using the Quantec 3D acquisition system successfully mapped the known Hidden Hill mineralization zone in the Golden Arrow property in detail. Additionally, the resistivity and chargeability models identified a number of localities in the subsurface with similar geophysical signature as that of the Hidden Hill deposit. These locations are considered as potential targets and are candidate for further exploration.

## ACKNOWLEDGMENTS

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