Hope Bay gold deposits
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Abstract

Hope Bay gold deposits are located in West Kitikmeot region of Nunavut territory, Canada and consist of several world-class gold deposits including Doris North, Madrid (Naartok) and Boston, which are porphyry-type deposits situated in a greenstone belt and are currently turned into producing mines. In 2015 a large part of Hope Bay field was surveyed with SkyTEM system in order to gather additional information about geology of the area. The data were severely affected by IP to such degree, that some 40% of the coverage were not suitable for interpretation. The data were further transferred to Aarhus Geophysics, ApS in order to carry out multiparametric inversion with simultaneous extraction of four Cole-Cole parameters, including improved and corrected electrical resistivity ($\rho$), chargeability ($m_0$), relaxation time ($\tau$) and frequency parameter ($c$).

Introduction

The gold deposits of Hope Bay (Figure 1) are hosted in Hope Bay volcanic belt. The deposits were found in early 90’s and yield altogether 17 MT of ore with average gold content of 6 g/T.

In 2015 a SkyTEM survey was flown over the prospect. SkyTEM data were subject to heavy IP effects. The data were initially inverted by the data provider (Auken and Christiansen, 2004), however due to severe IP effects, resulting in negative recorded voltages in data (Figure 2), the inversion was very challenging.

Figure 2. Example of SkyTEM transient (high moment and low moment) affected by IP. Grey: raw transients, blue: processed transients.

It became evident, that up to 40% of the data cannot be inverted using this classical 1D approach and therefore over 8000 line km of data (or the entire northern half) were further transferred to Aarhus Geophysics for inversions in IP mode (Fiandaca et al., 2012).

Spatially Constrained Inversion of SkyTEM data

SkyTEM data were inverted using Spatially Constrained Inversion algorithm (SCI, Viezzoli et al., 2008), modified as per Fiandaca et al. (2012) to accommodate Cole-Cole modelling. The multiparametric inversion algorithm allows to simultaneously extract four Cole-Cole parameters.

Prior to the inversion, the data had to be post-processed in order to eliminate noisy data, while retaining those data, affected by IP. This procedure is thoroughly discussed in Kaminski and Viezzoli, 2017. As an example of such processing, Figure 2 is showing original transients delivered by data provider drawn in grey colour and the post-processed transients drawn in blue colour.
The inversion was carried out over 20-layered model with simultaneous recovery of four Cole-Cole parameters: electrical resistivity ($\rho$), chargeability ($m_0$), relaxation time ($\tau$) and frequency parameter ($c$). Due to excessive amounts of data, the inversion had to be split up in four tiles, with each tile not exceeding 40,000 stations. Each inversion has converged to target misfit and was compared to the original 1D inversion, carried out by the data provider (Figures 3 -5).

In Figure 3 a comparison is shown between a conventional 1D inversion carried out by the data provider (left) and an SCI inversion in IP mode, carried out by Aarhus Geophysics. As it can be seen in the figure, in case with conventional inversion there are some blanks, which correspond to those areas, where negative data had to be excluded from the inversion. Such blanks compose up to 40% of the area.

In general, the calculated misfit is greater in other areas, compared to the SCI inversion with IP modelling, which can be attributed to poor data fit for those data, severely affected by IP, but not showing negative voltages in transient, which had to be deleted in the conventional 1D approach.

Figure 3. Comparison of inversion misfits. Left: conventional 1D inversion carried out by the data provider. Right: SCI inversion with IP modelling carried out by Aarhus Geophysics.
Case studies:  
Hope Bay gold deposits

In Figure 4 a comparison is provided between electrical conductivity distributions, as recovered by conventional 1D inversion approach, calculated by data provider (left) vs SCI multiparametric inversion approach with IP modelling provided by Aarhus Geophysics (right). In general, the SCI inversion yields better coverage, as well as more interpretable results. Some conductive structures, which are consistent with known geology can be clearly interpreted from the SCI results, as opposed to conventional 1D results, where the conductive response from structures may be either missing or severely deteriorated (Figure 5). In this figure there are three examples shown of conductive structures, which are present in the SCI Cole-Cole inversion and are either absent or deteriorated in the conventional inversion results.

Figure 5 does not constitute any valid drill targets and is shown only as example of inversion quality. Inversion in IP mode has generally proven to provide more correct results in electrical resistivity domain, including porphyry gold deposits (Kaminski et al., 2016).

In addition to corrected and more complete coverage of recovered electrical conductivities, the SCI inversion yields recovery of chargeability (Figure 6), along with other Cole-Cole parameters, which may be used for more advanced interpretation, especially in complicated geologies, such as porphyry deposits in volcanic belt with resistive background (Oldenburg et al., 1997; Kaminski et al., 2016).
Case studies:
Hope Bay gold deposits

Figure 5. Close-up of electrical conductivity distribution comparison around Madrid deposit. (a) Conventional 1D inversion. (b) SCI Cole-Cole inversion.
Case studies:
Hope Bay gold deposits

Figure 6. Chargeability recovered as a result of SCI inversion in IP mode over Hope bay prospect, Nunavut.
Discussion

A cross-section of recovered electrical resistivity and chargeability was drawn over Madrid deposit (Figure 7). In these cross-sections, there is indication of interpretable structures, which may be in control of ore deposition. The chargeability cross-section (Figure 7 lower) is however provided without any calculations of the depth of investigation (DOI), which in this case is not estimated to exceed 50 m depth for the chargeability.

Conclusions

The comparison of inversion methods provided in current case study is suggesting that in cases with strong IP effect present in heliborne time-domain data, the classical inversion techniques may be not only responsible for providing distorted values of electrical resistivities, but also completely missing the targets, otherwise interpretable from physical properties recovered by multiparametric inversion in IP mode. In some extreme cases, when entire transients show negative voltages (as in case with 40% of coverage over Hope bay prospect) the conventional inversion may be incapable of recovering electrical resistivity distribution whatsoever.

References


