S U M M A R Y

In 2008 Geotech flew a regional scale 24,675 line-km survey covering a 25,000 km² area (1 km line spacing) in the Selwyn Basin. The survey footprint straddles east-central Yukon and overlaps into the western Northwest Territories. In March 2013 Yukon Geological Survey purchased the survey data, and in November 2013, released the data publicly. The Selwyn Basin area is prospective for SEDEX-style Pb-Zn-Ag mineralization and the ZTEM survey data provide insights into regional structures and plutons in the region. The Howard’s Pass SEDEX deposits at the southeastern edge of the Selwyn Basin survey area host a combined ~250 million tonne resource with ~4.5% Zn and ~1.5% Pb.

Major NW-SE to ESE and minor NNW-SSE linear conductive trends correlate with known regional geologic, structural and inferred mineral trends. Circular conductive anomalies surrounding resistivity highs reflect por-rich hornfels surrounding intrusive plutons. 2D-3D computer inversions reveal a correlation between enhanced conductivity along strike and the clustering of deposits at Howard’s Pass.

Key words: Airborne, ZTEM, electromagnetics, magnetics, 2D-3D inversion, Selwyn Basin, SEDEX.
sedimentary cover, based on resistivity contrasts (M. Zang, ESL, pers. comm., 2008).

The Selwyn Basin is a northwest trending Paleozoic deep water sedimentary basin mainly composed of black shales and cherts that host SEDEX and stratiform barite deposits (Figure 1-2). The three SEDEX base metal districts that occur in the Selwyn Basin of Yukon (Anvil, Macmillan Pass and Howard’s Pass - Fig. 1) are related to major episodes of mafic volcanism. SEDEX deposits occur in fault-bounded grabens and formed in reduced sulphur-rich settings from hydrothermal vents located along extensional faults. Except for stratiform barite, the other mineral deposits in the Selwyn Basin (see Fig. 2) postdate its deposition and are related to Mesozoic and Cenozoic tectonic and related intrusive events (Goodfellow, 2007).

The Howard’s Pass SEDEX deposits were discovered in 1972 using regional stream sampling for lead-zinc. Extensive soil sampling, trenching, mapping and drilling continue to guide exploration. The local geology in Howards Pass consists of Hadrynian to Cambrian basement phyllites and coarse clastics units that outcrop to the southeast of the property. These are followed by a thick sequence of Cambrian-Ordovician age Rabbitkettle limestones and calcareous mudstones. These are overlain by the Ordovician to Silurian Road River Group black shales that consist of Howard’s Pass Fm carbonaceous mudstones at the base, and flaggy and siliceous mudstones at the top. The Howard’s Pass Fm. includes the sulphide-rich Active Member unit that contains all the known zinc and lead mineralization at Howard’s Pass (see Fig. 3). The Road River Group is overlain by Devonian to Mississippian Lower and Upper Earn Group mudstones. The rocks have been intruded locally by Cretaceous felsic intrusions. The geology can be structurally complex, with the deposits to the southeast lying on the south limb of a large ~N-300° trending regional syncline, whereas to the northwest they lie on a steeply dipping NW-trending contact, as shown in Figure 3b (Burgoyne, 2005; O’Donnell, 2009; Kirkham et al., 2012).

The mineralized horizon at Howard’s Pass, referred to as the “zinc corridor”, trends NW-SE and extends for 37.5km, with the 15 drilled deposits and zones that are offset/separated by interpreted faults. The Active Member is generally 20-30m thick and consists of laminated, fine-grained sphalerite and galena with minor pyrite. Higher grade zones, like XY Central (45.1 Mt indicated @ 5.17% Zn & 2.49% Pb) and Don (36.90 Mt indicated @ 5.63% Zn & 2.11% Pb), are coarser grained, exhibit sulphide-resemblization, contain multiple lenses and occur near the base of the Active Member (Goodfellow, 2007; Kirkham et al., 2012).

Figure 3: Howard’s Pass geological cross-sections at Don East (A) and Don deposits (B), showing complex structure, drillholes, and geologic units across HP valley (modified after O’Donnell, 2009).

PASSIVE AEM AND MAGNETIC RESULTS

The ZTEM passive AFMAG (Labson et al., 1985) helicopter EM and aeromagnetic survey at Selwyn Basin was flown between May to October, 2008 (Witherly, 2013). It consisted of 24,675 line-kilometres of coverage using 10,000 line-spacing and 500m in-fills along N-035° oriented survey lines (Fig. 2). ZTEM tipper data (Tzx in-line & Tzy cross-line) were acquired at 5 frequencies (30-360Hz). Readers can refer to Legault et al., (2012) for additional descriptions of the ZTEM system and theory.

REGIONAL SURVEY RESULTS

The regional ZTEM and magnetic results in Selwyn Basin were presented by Carne et al. (2013) and Witherly (2014). Figure 5 presents the total divergence (DT; Lo and Zang, 2008) image of the ZTEM In-phase tipper at 90Hz. The DT image highlights resistive (blue) and conductive
features over intrusions, stratigraphy and other geology. Component, highlighting low (blue) and high (red) resistivity along Howard’s Pass de-posit area than previously seen in slightly less uniform and more variably conductive trend along the Howard’s Pass SEDEX deposits. It shows a narrower, 2012) across a 35x50km model region that is centred on obtained from 2D ZTEM inversions (ref. Legault et al., 2012) over a smaller 70x80km area that focuses on the Howard’s Pass, highlighting conductive lineament and HP drill holes, known deposits and 2D-3D model region discussed below.

Figure 4: ZTEM total divergence (DT) for 90Hz In-phase component, highlighting low (blue) and high (red) resistivity features over intrusions, stratigraphy and other geology.

HOWARD’S PASS SURVEY RESULTS

The ZTEM total divergence image from Figure 4 is shown over a smaller 70x80km area that focuses on the Howard’s Pass SEDEX region in Figure 5. It highlights a thin, NW-SE trending conductive lineament that extends through the >37km long “zinc-corridor” deposit area as defined by drilling. Each of the 15 known SEDEX deposits, defined by dhd clusters and labelled by name (ref. Kirkham et al., 2012), overlie the Howard’s Pass (HP) ZTEM conductor. Because the mineralized Active Member is thin (<30m), the HP conductor must also encompass the surrounding Howard’s Pass Fm. black shales units to be resolvable in the AEM results. As shown, the HP ZTEM conductor flanks the southwest edge of a broader, 1-2km wide, high resistivity unit (carbonates), that is in turn flanked by another thin conductive lineament (barren shale units) on its north-eastern edge. The conductive band that hosts HP is the most prominent in the area and extends for ~70km - pinching to the northwest, just outside the focus area, and terminating to the SE where basement rocks outcrop (ref, Gordey and Makepeace, 1999).

Figure 6 presents a resistivity-depth slice at 300m obtained from 2D ZTEM inversions (ref. Legault et al, 2012) across a 35x50km model region that is centred on the Howards Pass SEDEX deposits. It shows a narrower, slightly less uniform and more variably conductive trend along Howard’s Pass de-posit area than previously seen in the raw ZTEM data images. Interestingly, most of the deposits appear to be grouped/clustered within areas of higher conductivity along strike (see Fig. 6), in particular the larger tonnage deposits at Anniv, Don-Don East and XY. Similar on-strike conductivity variations are observed in the 3D inversion (not shown) obtained using UBC MT3dinv code (ref. Holtham and Oldenburg, 2008). This suggests possible enhanced mineralization in areas of thicker black shale sub-basins that are being defined with AEM. Alternately, this might simply reflect separation of the mineralized and shale horizons by fault-displacement. Both inversions show better strike continuity at greater depths (>500m).

Figure 7 compares the 3D ZTEM resistivity and 3D magnetic susceptibility (mag-susc.) sections, obtained using UBC Mag3d (Li and Oldenburg, 1996), over the Don deposit, one of the higher tonnage and more deeply explored at Howard’s Pass, with many drillholes extending below 800m depths, as shown in Figure 3. Figure 8a highlights the shallow buried but >500m wide resistivity low that matches the known width of the Don deposit and extends to similar depths. Resistivity highs on either side coincide with flanking carbonate units. Figure 8b shows a buried, weak but visible mag-susc. high that correlates with the deposit and extends to depth. Higher mag-susc. values at 1.5-2km depth likely reflect the deeper basement metamorphic units.

CONCLUSION

Regional ZTEM and magnetic survey data over a 23,000 km2 area of Selwyn Basin reveal major NW-SE to ESE and minor NNW-SSE linear conductive trends that correlate with known regional geologic, structural and inferred mineral trends. In addition, circular conductive anomalies surrounding resistivity highs reflect po-rich hornfelses surrounding intrusive plutons. The ZTEM and magnetic results at Howard’s Pass SEDEX district have been analysed at the property and deposit scale using 2D-3D computer inversion to better define their relation to geology. Their study appears to reveal a correlation.
between enhanced conductivity along strike and the clustering of deposits at Howard’s Pass. This could be explained either by enhanced mineralization in areas of thicker black shale sub-basins or simply separation of the mineralized and shale horizons by fault-displacement.

**ZTEM – 2D RESISTIVITY DEPTH-SLICE (300m)**

Figure 6: ZTEM Resistivity depth-slice (z=300m) from 2D Inversion (Tzx In-line) over detailed grid at Howard’s Pass, highlighting conductive lineament over deposits and location of L4730 model section in Fig. 7.

**REFERENCES**


