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Final Report on Results of the Cordilleran Geochemistry Project:

A Comparative Assessment of Soil Geochemical Methods for Detecting Buried Mineral Deposits – 3Ts Au-Ag Prospect, Central British Columbia

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EXECUTIVE SUMMARY

Effective mineral exploration in the Nechako Plateau and adjoining regions of central British Columbia has been hindered for many years by thick forest cover, an extensive blanket of till and other glacial deposits and, locally, widespread Tertiary basalt cover. This report describes methods and results of a multimedia geochemical orientation survey conducted during June and July 2005 over the 3Ts epithermal Au-Ag prospect in the Interior Plateau region. This project, funded by Geoscience BC, investigates the surficial geochemical response in soils and Quaternary materials of epithermal Au-Ag mineralization at 3Ts. This region is highly prospective for the discovery of epithermal Au deposits, among other mineral deposit types, and the low-sulphidation 3Ts prospect is one of the more significant examples in central BC of this type.

The objective of this project is to determine and recommend the most effective field and laboratory geochemical methods for property-scale evaluation of buried mineral targets in drift-covered terrain, by 1) evaluating the most suitable soil media and horizons for field sampling, and 2) evaluating and comparing commercially available analytical methods. No similar publicly available comparative geochemical methodology studies have been conducted in the western Cordillera, and it is this vacuum that the project attempts to fill. This project also complements the parallel Geoscience BC research project on the effective use of halogen geochemistry of soils and vegetation for exploration (Dunn et al., 2006a, b).

New and intercomparable soil geochemical data are provided to help in answering exploration geochemical questions in this region. Brunisolic Bm horizon soils are commonly developed around the 3Ts property, primarily in basal and colluviated tills, which are the dominant glacial parent material in the area. They are also developed in rubbly near-bedrock colluvium, stabilized colluvium and minor glaciofluvial outwash sediments, underlining the importance of the proper identification of Quaternary deposits in interpreting source directions of any anomalous geochemical patterns. The mineral and organic soils sampled as part of this orientation study were analyzed for Au and other elements using a wide spectrum of commercially available analytical techniques. Inorganic analytical methods included total Au determinations (fire assay), near-total to partial determinations (aqua regia digestion) and several types of selective extractions (Enzyme Leach^{SM}, Mobile Metal Ion^{SM} and Na-Pyrophosphate leach), all employing an ICP-MS finish. Two less conventional techniques employing organic compounds in soils (Soil Gas Hydrocarbons^{SM} and Soil Desorption Pyrolysis^{SM}) were also tested. The B horizon soils were the object of all analytical techniques compared, with the exception of C horizon tills (aqua regia–ICP-MS and Au by fire assay) and Na-Pyrophosphate leach of humus.

Project objectives are, in part, to ascertain which of those partial and selective extraction methods undertaken here 1) delineate the presence of mineralization and 2) provide the greatest levels of geochemical contrast, over each of the Tommy and Ted veins at the 3Ts prospect. Project deliverables are the answers to the following questions:

- What are the most appropriate field sampling, preparation and analytical techniques for epithermal Au deposit exploration in this environment?
- Where and what should be sampled?
- Which analytical methods reflect the presence of buried Au mineralization and which do not?
- Which of the methods provide the greatest and most optimal geochemical contrast for property-scale exploration?

Answering these questions will assist mineral exploration companies in conducting more effective geochemical exploration programs for blind targets, thereby increasing the likelihood of discovery. Specific field sampling and analytical recommendations are provided for conducting the most effective property-scale geochemical surveys for similar epithermal gold deposits in the British Columbia Interior Plateau.

Most of the total, near-total to partial, and selective extraction analytical methods tested were successful, to varying extents, in highlighting the presence of Au mineralization at one or both of the mineralized quartz veins on the 3Ts property. Total and near-total to partial Au responses in soil and till by both aqua regia and fire assay methods are similar, with both methods returning substantially similar Au concentrations of 200 to 250 ppb in B horizon soils sampled above the Tommy vein. Both aqua regia (AR) and fire assay (FA) methods were similarly successful in highlighting the location of the Ted vein in both B

horizon soils and tills. With maximum Au concentrations of just over 40 ppb in B horizon soils by AR, the absolute magnitude of Ted vein Au results, however, is lower than those reported from the Tommy vein.

Results suggest that, for property-scale geochemical exploration, B horizon mineral soils and LFH horizon organic-rich humus offer similar levels of geochemical contrast for AR-digestible Au and Ag, with the B horizon soils offering a slightly superior contrast overall. Geochemical results vary slightly from vein to vein with variations in primary mineralogy, topography and surficial cover. In general, AR-digestible Au and Ag results at the Tommy vein show slightly greater geochemical contrast, as measured by response ratios, than those at the Ted vein. At the Tommy vein, Au response ratios for B horizon soil and humus over the vein are almost identical. Elevated values of Ag in humus provide a larger geochemical footprint, but Ag in the B horizon soils offers a slightly better anomaly contrast over the mineralization. Rubbly B horizon soils and LFH humus are developed directly over subcropping and outcropping quartz vein mineralization at the Tommy vein, and probably incorporate a significant component of near-residual mineralized fragments. Neither basal nor colluviated till is preserved directly over the vein; however, elevated values of Au and Ag in till immediately to the east are tentatively interpreted to represent, at least in part, glacially transported material that is locally derived from the Tommy vein. The location of the Tommy vein is also outlined by elevated levels of several base metals determined by AR digestion–ICP-MS in B horizon soil.

Concentrations of AR-digestible base metals, such as Zn, are even greater in B horizon soils overlying the Ted vein, which is reported to contain greater primary base metal concentrations than the Tommy vein. Surficial cover is more complex on the Ted orientation line. Localized glaciofluvial outwash sediments and more widespread stabilized near-surface colluvium are present in addition to basal and colluviated tills. As with the Tommy vein, B horizon mineral soils provide the best overall anomaly contrast for property-scale geochemical exploration. Gold and silver in humus, B horizon soil and till all reflect to varying degrees the presence of precious metal mineralization at the Ted vein, although the magnitudes of the geochemical responses are slightly less than those reported for the Tommy vein. In addition, highly elevated Au and Ag concentrations are present in both B horizon soil and C horizon till both above and down-ice from the vein.

Given the extensive historical use of B horizon soils in geochemical exploration in British Columbia, an assessment of the results of selective extraction procedures using these near-surface soils is a major part of this study. A comparison of response ratios for elements determined by aqua regia (AR), Enzyme Leach^{SM} (EL) and Mobile Metal Ion^{SM} (MMI) methods suggest that for many elements, particularly the base metals, EL and MMI provide superior levels of geochemical contrast over known Au mineralization at the Tommy and Ted veins. Mobile Metal Ion results showed positive responses for Au as well as several relevant base metals such as Zn, Pb and Cd in near-surface soils over both the Tommy vein and the Ted vein. Furthermore, MMI results displayed a good geochemical contrast relative to several other analytical methods in spite of field site variations inherent in the recommended ‘fixed depth’ sampling procedure. Although MMI Au concentrations in the study area are of a low magnitude, Au response ratios are 23 to 24 times line background over both the Tommy vein mineralization and a central anomaly of unknown origin. Similar results are reported from the Ted vein, where a Au response ratio of almost 75 times line background is superior to that for all other methods, including aqua regia. In the case of Ag, there was no anomalous response at the Tommy vein; however, a strong Ag MMI response ratio at the Ted vein (~23 times line median) is superior to that reported by all other methods, including aqua regia.

Contrast ratios indicate that precious metals response by EL is less effective relative to other inorganic analytical methods, since this leach extracts only minor amounts of Au and Ag and relies more heavily here on strong responses from pathfinder elements such as As and Sb. For example, the Au response in the Tommy vein soils, while present, is subdued relative to response ratios of other methods. There is no significant Au response at the Ted vein, and at neither vein does EL Ag in soil exceed analytical detection limits. Enzyme Leach results here are much stronger for a number of important base metals and precious metal pathfinder elements. As measured by calculated response ratios, strong As, Sb, Cu, Pb and Cd responses are present in B horizon soils by EL over the Tommy vein, and strong Sb, Zn, Pb and Cd responses are present over the Ted vein. The relative strengths of base metal responses by selective extractions vary from one element to another. For example, the Zn by MMI response in near-surface soils is superior to that of EL, highlighting all three features along the Tommy transect — the Tommy vein, the central anomaly, and the Larry vein — with response ratios of up to 15 times background values. In the case of the Tommy vein itself, elevated MMI response ratios for Zn are up to 10 times background, and are

present at three sites. By way of contrast, poorer although still impressive response ratios of 4 times background and 3 times background occur for EL Zn in soil and AR Zn in soil/humus, respectively, at the Tommy vein. In the case of Pb, both MMI and EL provide strong responses at Tommy vein, with EL response ratios up to 19 times background values, and those by MMI up to 11 times background. In the case of the Ted vein, both EL and MMI results provide substantially similar strong Zn results of 48 to 50 times background levels; however, the strong EL Pb response over the Ted vein, about 15 times background, is not matched by an anomalous MMI Pb response.

Soil Gas Hydrocarbon (SGH) and Soil Desorption Pyrolysis (SDP) studies yielded some positive results at 3Ts. Compound class signature results identified by an in-house evaluation of the B horizon SGH soil data by Activation Laboratories Ltd. identify the locations of known Au mineralization along both the Tommy and Ted transects. On the Tommy line, compound class signature results delineate the locations of the Tommy vein, the central anomaly and the Larry vein, albeit with fairly subtle results of only about 2 to 2.5 times line background values. Compound class signature results are much stronger at the Ted vein, at about 5 times line background at a single soil site over the vein. In the case of SDP results, one compound in particular, C_3H_5F, provides a subtle level of geochemical contrast in B horizon soils over Tommy vein mineralization, with two soil sites showing concentrations that are roughly 2.5 times median levels. Both of the organic compound methods yield 1) relatively poor contrast, particularly for SDP, between results from soils over mineralization compared to those from background areas, and 2) some ambiguity about which organic compounds, or groups of compounds, might be useful for which deposit styles. Anomalous responses for individual compounds, when present over epithermal mineralization, are generally subtle compared to those of either aqua regia or to selective extraction methods such as MMI or EL.

Some key outcomes and recommendations regarding specific field sampling and analytical procedures for conducting effective property-scale geochemical surveys for similar epithermal gold deposits include:

- Near-surface soils are more suitable than tills for detailed geochemical grid sampling at a property scale, in part for reasons of sampling cost but more critically because of their widespread availability. The optimum use of B horizon soils in geochemical surveys, however, is contingent upon samplers being capable of making suitable observations as to the type and origins of parent materials. Although not the focus of this study, till sampling remains the best choice for reconnaissance-level geochemical sampling, producing more comparable geochemical results that are largely unaffected by the pedogenic processes that cause such physical and geochemical variability in near-surface soils.
- Soil geochemical surveys should be considered an important component of property-scale exploration projects in this region.
- Both MMI-M and EL methods offer similarly strong geochemical responses and contrast ratios in near-surface and B horizon soils, respectively, for base metals at 3Ts. These, in some cases, yield geochemical contrast levels that are superior to those of AR digestions. These methods may be suitable substitutes for AR digestion–ICP-MS analyses in areas of concealed mineralization. The same holds true for the SGH and SDP methods using organic compounds, although their background-to-anomaly contrast is more subdued than either MMI or EL. For the near-surface mineralization targeted in this study, however, the AR digestion–ICP-MS multi-element analytical suite provides a more effective combination of 1) suitable geochemical contrast over the Tommy and Ted vein mineralizations and 2) a wide range of reported elements critical to this deposit style, including Au and Ag, precious metal pathfinders such as As and Sb, and relevant base metals such as Zn, Cu, Pb and Cd. In general, the selective extraction analytical suites tested in this project provide most, but not all, of the key elements needed for the detection of epithermal Au-Ag deposits beneath soil and till cover. Some elements are lacking in the selective extraction suites, or if present are at concentrations below stated analytical detection limits; examples include As-Sb (MMI-M suite) and Ag-Au (EL suite). Positive AR results are, however, strongly influenced by the relict lithological signature, in thin soils, of near-surface outcropping and subcropping of resistant quartz veins. The MMI, EL, SGH and SDP methods might prove more useful than AR for detecting more deeply-buried deposits, where such inherited lithological signatures are not present in surface soils. Now that this intermethod comparison is shown to be successful and has been quantified on known, near-surface, epithermal-style mineralization, testing of the technologies needs to be extended to

more deeply buried Au deposits in order to further evaluate their respective usefulness in the Interior Plateau environment of central British Columbia.