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Locating hidden channels for placer gold exploration in the Cariboo District, British Columbia, Canada: A case study

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ABSTRACT

During the past 150 years, most of the modern day creeks were the target of miners roaming the Cariboo Mountains, British Columbia, in the search for placer gold. In these days, the probability to locate new placer gold occurrence in recent river beds is therefore substantially reduced. New, promising exploration targets appear to be channels mostly buried under alluvial cover sediments. It is airborne geophysical methods that can reveal hidden channels fast and cost-effectively as these penetrate the sub-surface contactless and reflect physical properties of the sub-surface, such as electric conductivity and magnetic susceptibility or magnetization, respectively.

We applied the airborne geophysical exploration approach on four exploration areas in the Cariboo gold district. Helicopter-borne transient electromagnetic (TEM) and magnetic data were flown using the SkyTEM system. To our knowledge, it has been innovatory to apply high resolution, high density airborne geophysics in the search for placer gold deposited in pre-Holocene sedimentary channel fills of the Cariboo Mountains. A particular effort of our studies aimed at the Mary creek claims which straddle the boundary of the Quesnel and Kootenay terranes of the Canadian Cordillera and include the dormant Toop mine situated in the Mary creek area known for many finds of coarse nugget from the pre-glacial buried Toop channel. Our objective was to locate the southbound extension of the channel buried in Pleistocene sediments of the Toop plateau. Careful analysis of the airborne geophysical data sets provided indications from both the TEM and magnetic data sets favouring the existence of a hidden channel beneath the plateau.

The evaluation of seven reverse circulation (RC) drill holes sunk into a promising elongated narrow conductor beneath the plateau was not conclusive as not clearly showing the sedimentary pattern of a channel with gravels typically at its bottom. Only electric conductivity-depth sections compiled from the airborne TEM and 2D direct current (DC) multi-electrode resistivity ground survey data enabled the interpretation of the airborne TEM and magnetic responses recorded over the Toop plateau. The sections suggest that the electric conductor is generated by an upwarp of a conductive layer extending at the bottom of the Pleistocene sediments. Another feature separated by ≤100 m from the conductor line is reflected by low electric conductivity, but is rarely prominent through its neat magnetic signature. Fine accumulations of black minerals, i.e. magnetite grains, in sediments of the area are frequently met when panning material from the creeks. We therefore interpret this low conductivity, magnetic feature as expression of a gravel lense hosting accumulations of magnetite grains and possibly indicating the southbound extension of the Toop channel beneath the plateau.

Careful analysis of the airborne magnetic data set led to the result in that magnetite is not only wide-spread in present day rivers and creeks, but also in buried channels and palaeo precipitation run-off paths. Magnetic data proved to be very helpful in this project with regard of pursuing not only present day, but buried valleys and channels, in particular.

Our experience made on the Mary creek claims is summarized in a straightforward exploration concept for hidden, possibly gold-bearing channels in the Cariboo gold district.

1. Introduction

The Cariboo Mountains of central British Columbia, Canada, are a classic gold rush area of the 1850s where placer gold mining still continues. Production started in 1858 and by 1861 Barkerville was the

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largest town north of San Francisco and west of Chicago (see Fig. 1). Recent estimates state that approximately 6 million ounces of placer gold have been produced in British Columbia from 1858 to present and half of this amount stems from the Cariboo mining district (Roed, 1995; Brown and Ash, 2009).

Eyles and Kocsis (1988) describe several phases of placer mining in the Barkerville area between 1858 and today: Initially, prospectors worked the surface of lucrative post-glacial fluvial gravels and modern river bars. This was followed by a second phase characterized by the construction of deep shafts to penetrate till to attain buried interstadial gravels. Subsequent large-scale hydraulic operations involved the working of substantial volumes of low-paying sediment. Today, individual prospectors carefully look for small-volume but high-paying deposits in contrast to well-funded mining companies that look for large volume deposits even if these are buried beneath a cover of Holocene overburden. Many placers occur in late Pleistocene glacial facies deposited at or beneath the margins of a regional ice sheet, together with tertiary gravel deposits, or associated to interstadial and post-glacial sediments. In particular, buried palaeo channels and gulches that were incised in early glacial depositions by melting waters are presently a favourite target model for placer gold exploration.

Successful use of geophysical methods in mineral exploration implies a contrast of physical rock properties between target and host. Gold pockets mostly situated at the bottom of sedimentary channel fills are, however, expected to be too small in size to produce a response noticeable by geophysical device. We therefore have to focus on the contrast of physical properties between the younger channel fill and the older sediments where the channel is embedded. The electric conductivity of unconsolidated sand and gravel of the channel can vary between 0.1 and 20 mS/m and more consolidated sediments of the host, such as loam, till, silt or schist, can be expected to cover an even wider conductivity range of 0.01 to 30 mS/m (Seidel and Lange, 2007). Hence, the contrast in electric conductivity required for successful geophysical surveying largely depends on the difference of porosity and water content of the channel fill and host rock.

Little attention was initially given to magnetic properties of the glacial sediments until we became aware of local accumulations of mostly magnetic, heavy minerals in a number of river beds. This observation was useful as

- heavy mineral accumulations can host gold dust and nuggets and
- tiny weight percentage of magnetite grains in rock fabric considerably increases the magnetic susceptibility (Schön, 1996) enabling the detection of recent and palaeo channels with magnetic fill.

Developing a slightly magnetic target model (Table 1) and applying 2.5D magnetic modelling confirmed the power of airborne magnetic surveying for buried channel detection in the Cariboo mining district. During the interpretation stage of the airborne electric conductivity data, the magnetic data set proved to be of substantial assistance when locating recent and palaeo streams in the area of investigation, which has been a key experience of this project.

In north central Europe, the airborne geophysical approach to locate and characterize Quaternary fresh water bearing buried channels incised some hundred meters deep in Tertiary sediments is well introduced (Siemon et al., 2009). The younger, frequently very permeable sedimentary fills give rise to the formation of significant aquifers. Due to increasing fresh water demand in coastal zones of the North Sea, these aquifers are becoming more and more important for sustainable water management and have therefore been in the focus of geophysical research. In Germany, the helicopter-borne five-frequency electromagnetic system operated by the Federal Institute for Geosciences and Raw Materials (BGR) has been used for mapping and vertical detailing the channel fills (e.g. Gabriel et al., 2003; Siemon et al., 2004; Eberle and Siemon, 2006; Siemon et al., 2009; Wiederhold et al., 2009); to support hydrogeological investigations in Denmark, an airborne transient electromagnetic (TEM) system—now known as SkyTEM (Sorensen and Auken, 2004)—came into use for intense mapping of buried Quaternary valleys (e.g. Auken et al., 2009; Jorgensen and Sandersen, 2009). Within the EU supported BURVAL project, airborne electromagnetic surveying and data interpretation played a key role in contributing to sustainable

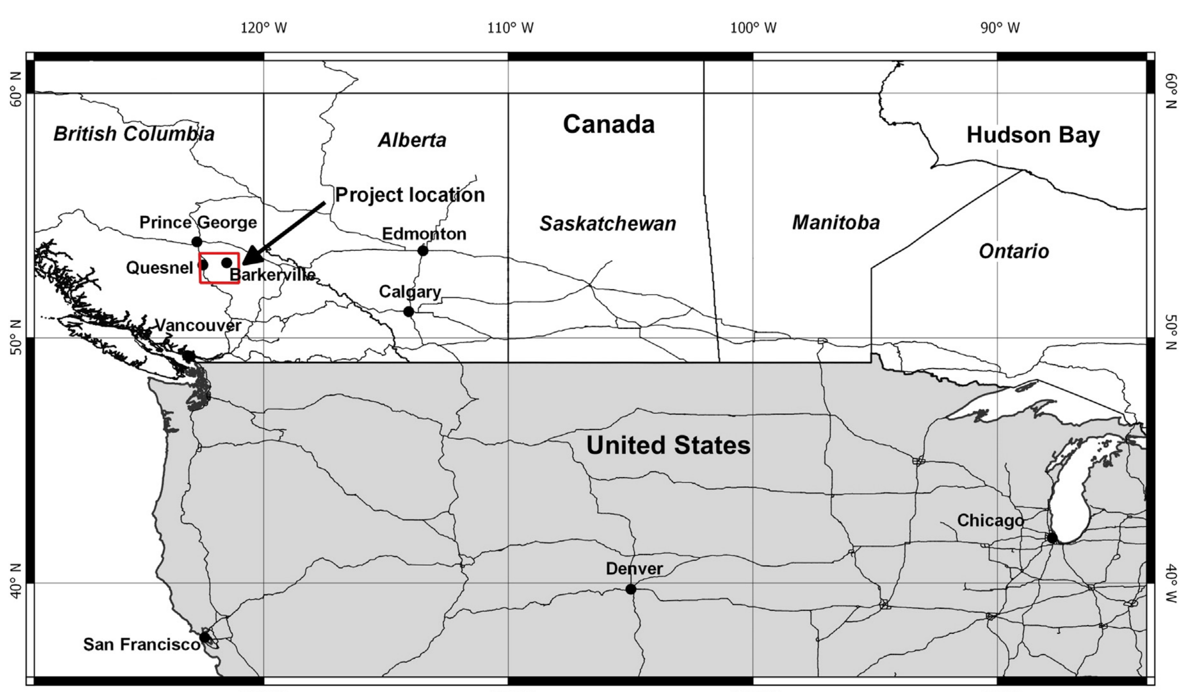

Fig. 1. Location map (modified after Cui et al., 2015).