GEOSCIENCE PARTNERSHIPS IN THE TOODOGGONE RIVER AND MCCONNELL CREEK MAP AREAS, NORTH-CENTRAL BRITISH COLUMBIA[1]

(PARTS OF TOODOGGONE RIVER NTS 094E/2, 3, 6, 7, 10, 11 AND MCCONNELL CREEK NTS 94D/8,9,15)

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INTRODUCTION

The Toodoggone geoscience partners are investigating the magmatic and structural evolution [of the Toodoggone mining camp] and the intertwined development of hydrothermal systems associated with epithermal, porphyry and skarn mineralization. This partnership involves a consortium of five mining exploration companies - Stealth Minerals Ltd., Northgate Exploration Ltd., Finlay Minerals Ltd., Bishop Resources Inc. and Sable Resources Ltd., in addition to the B.C. Geological Survey (BCGS), the Geological Survey of Canada (GSC), and The University of British Columbia.

In 2003, government programs comprised 1:20 000 bedrock mapping and an airborne multiparameter geophysics survey, both using operating funding derived from the Federal-Provincial Targeted Geoscience Initiative-II (2003-2005) and mining company participants. Regional mapping conducted by the B.C. Geological Survey focussed on two regions, the northerly of these surveys located between the Finlay and Toodoggone rivers in the central Toodoggone River map area **(Figure 1).** The southern survey area, near Johanson Lake in the McConnell Creek map area, was mapped by Schiarizza and is reported upon separately (2004, this volume). This brief report introduces the components of field programs conducted in the Toodoggone River area.

The Toodoggone River area is currently the focus of some of the most active mineral exploration in British Columbia. The region hosts several gold-enriched porphyry copper deposits (including Kemess North and Kemess South) and past-producing, low sulphidation epithermal gold mines (Chappelle-Baker, Lawyers, Shasta and Al). The premier deposit in the Toodoggone area is Kemess South, an open-pit mine with proven reserves of 109.4 million tonnes (Mt) of ore grading 0.71 grams gold and 0.23% copper, or 2.5 million contained ounces (oz) of gold. Approximately 6 km to the north is the Kemess North porphyry deposit, which has an estimated 4 million oz gold resource contained in 369 Mt of material grading 0.34 grams per tonne gold and 0.18% copper.

BEDROCK MAPPING

The emphasis of bedrock mapping in the Toodoggone region is on Early Jurassic volcanic and plutonic rocks, since they are the predominant host rocks for past gold production from high-level epithermal systems (Lawyers, Shasta, and Bonanza-Al), and current production from deeper porphyry deposits, as at Kemess South. Over the past several years mining exploration has shifted east and north beyond areas where the BCGS established a geological framework for gold-enriched porphyry and epithermal prospects (Diakow *et. al*., 1993 and 2001). This adjacent, poorly understood area has large gossans and a number of potential exploration targets highlighted by a B.C. Regional Geochemical Survey (Jackaman, 1997). Grassroots prospecting has been an important component of recent exploration programs, leading to new epithermal and porphyry discoveries in this frontier area by Stealth Minerals Limited and other companies.

The enhanced exploration activity has provided added impetus for additional regional mapping. During the past summer, the BCGS embarked on a two-year initiative to complete detailed mapping within a region covering roughly 1000 km^2 (Figure 1). This region is considered to be highly prospective in terms of mineral potential, but lacks the geologic context and timing constraints established through detailed mapping and geochronometry elsewhere in the Toodoggone region.

Fieldwork in 2003 resulted in 1:20 000 map coverage of approximately 215 km^2 in the Swannell Mountains between the Finlay and Toodoggone Rivers. The Shasta

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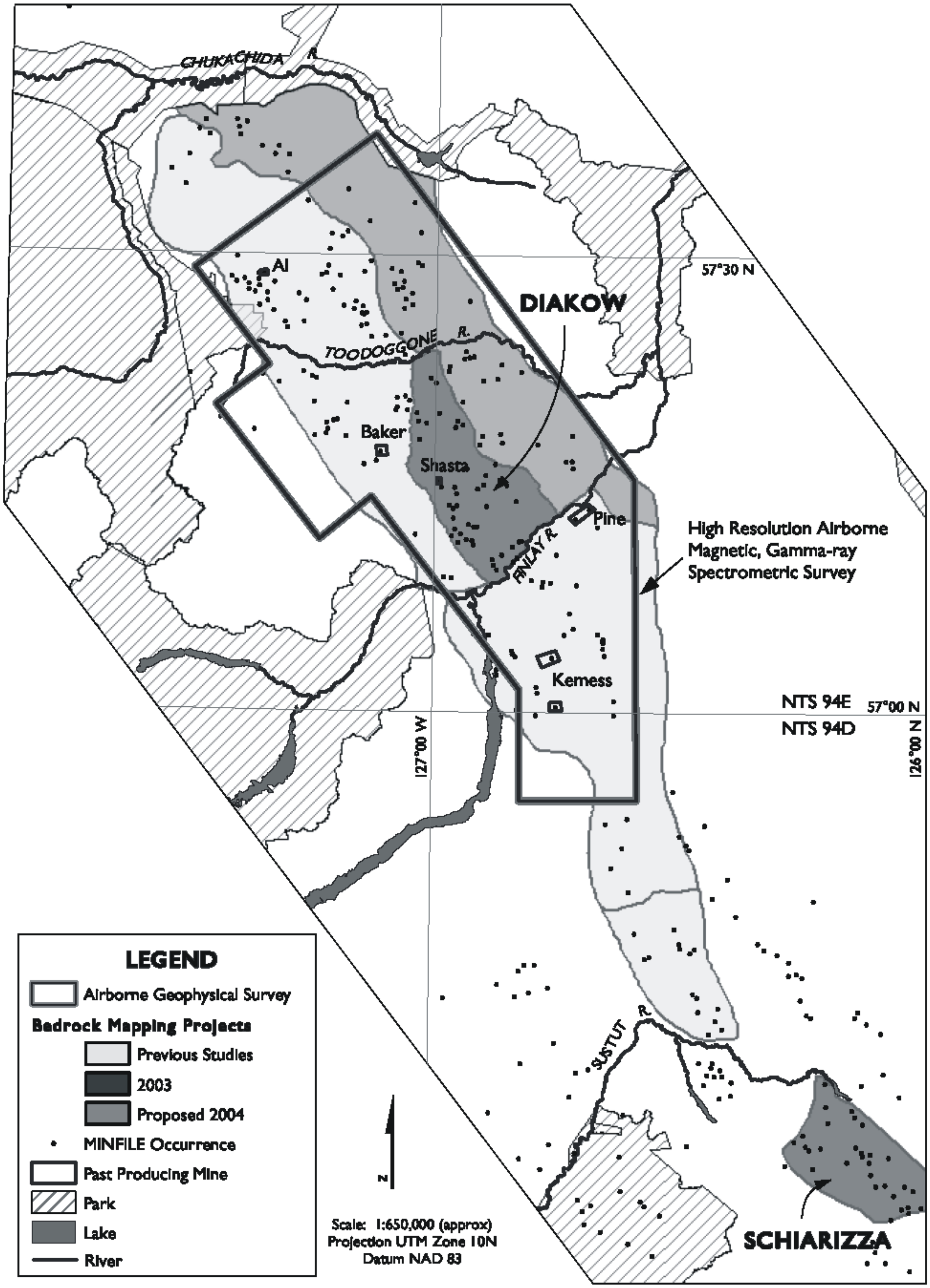

Figure 1. Location of government-mining company funded bedrock mapping and airborne gamma-ray spectrometric and magnetic total field surveys in the Toodoggone River (parts of NTS 094E/2,6,7) and McConnell Creek (parts of NTS 094D/8,9) map areas. The airborne survey covers over 2200 km^2 of Early Jurassic rocks that contain the majority of mineral prospects (shown as dots) and mines in the Toodoggone mining camp. Northgate Exploration Ltd funded an extension to the original survey, south of the Kemess South mine.

and Baker gold vein deposits are situated near the western boundary of the project area, and the porphyry prospects Brenda and Pil North, situated along the eastern boundary. Part of this region has been previously mapped at reconnaissance scale (Diakow *et. al*, 1985). The current study will produce a map, and upgrade the regional stratigraphy and structural interpretation, and provide additional timing constraints for magmatic and mineralizing events.

GEOLOGICAL HIGHLIGHTS

- Three major stratigraphic units exposed between the Finlay and Toodoggone rivers are consistent with those mapped in adjacent areas of the Toodoggone magmatic belt. Listed from oldest to youngest, they consist of: the Asitka Group, the Takla Group and the Toodoggone Formation of the Hazelton Group. In the study area, distribution of the oldest rocks, assigned to the Late Carboniferous to Early Permian Asitka Group, and the overlying Late Triassic Takla Group, reflect uplift associated with high-level emplacement of the Early Jurassic Duncan pluton. In general these rocks occupy differentially uplifted blocks, presently dislocated by faults oriented subparallel to the northwest-trending margin of the Duncan pluton, and they crop out as relatively thin pendants resting directly on the pluton. The Asitka Group is subdivided into a lower unit composed of subaerial pyroclastic rocks of andesite to dacite composition, and an upper unit composed of recrystallized limestone, with or without relatively thin mudstone, siltstone and sandstone sections. Skarns carrying primarily chalcopyrite and magnetite, and occasionally anomalous gold concentrations, are common in the vicinity of Drybrough Peak within contact metamorphosed pendants in calcareous rocks of the Asitka Group. Notable examples are those being explored at the VIP and Dry Pond prospects. The Late Triassic Takla Group overlies the Asitka Group above a non-erosive contact. The Takla Group is generally composed of thick, monotonous augite-phyric and comparatively rare, bladed plagioclase porphyritic basalts and basaltic andesites. Pyroxene-rich sandstones and siltstone, evidently derived from the mafic flows are scattered in the low-lying terrain adjacent to the Finlay River. In the Toodoggone region, limestone is rarely observed within the Takla Group, however, several kilometres southeast of Black Lake, it occurs as discrete lenses, between 0.5 and 5 metres thick, enclosed by volcanic rocks. These limestones provide evidence for restricted basins within the predominately subaerial volcanic pile, which comprises most of the Takla Group.

  The Early Jurassic Toodoggone Formation is the sole stratigraphic subdivision of the Hazelton Group in the Toodoggone River map area. It depositionally overlies Triassic volcanic rocks above an erosional unconformity, which in the 2003 study area is marked by deposits of conglomerate. This conglomerate is exposed at four main localities with the unconformable contact traceable intermittently over a distance of 7 kilometres. Without exception, all localities are characterized by crudely bedded cobble conglomerate dominated by rounded clasts of fine-grained "crowded" hornblende-plagioclase porphyritic andesite and interlayered locally with lesser sandstone. The clast lithology is unlike any observed rocks found locally in the underlying Takla Group. The conglomerate is therefore interpreted to represent some of the earliest extrusive products of the Toodoggone Formation eroded a short time after eruption.

  The Toodoggone Formation is a compositionally uniform, subaerial volcanic succession composed of quartz, biotite, hornblende and titanite-bearing high-silica andesite to dacite pyroclastic rocks and lesser trachyandesite lava flows (Diakow *et. al.,* 1993). Map units, composed predominantly of pyroclastic rocks exposed throughout much of the 2003 study area, are believed to be representative of those mapped near the bottom and top of the formation in adjacent areas. Trachyandesite lava flows predominate in the southeast part of the area. They correlate with rocks stratigraphically lower in the Toodoggone succession.

- Stocks and smaller plutons of the Early Jurassic Black Lake suite are temporally and probably genetically related to extrusive rocks of the Toodoggone Formation. Typical Black Lake intrusions consist mainly of biotite, hornblende and titanite-bearing granodiorite with a medium to coarse-grained equigranular texture. These plutons differ compositionally from those associated with gold-copper porphyry mineralization at the Kemess deposits, where they are more mafic and consist of monzodiorites and medium to coarse grained monzonite porphyries. These “mafic” plutons also have a distinctly tabular geometry, and in the case of the Maple Leaf pluton at Kemess South, emplacement appears to be at a sub-volcanic crustal level. A new finding this summer is that the Black Lake monzonite intrusions also are related to mineralization in the present study area. For example, at the "Pil North" porphyry prospect, widespread propylitic and argillic alteration zones are centred over monzonite porphyry that is flanked by an older biotite-hornblende granodiorite. Nearby at the "Brenda" porphyry target, a swarm of monzonite dikes are interpreted to be the near surface expression of a deeply seated pluton. Additionally, recently discovered vein mineralization at the "10 K" prospect adjacent to the Finlay River, and gold-bearing copper-magnetite skarn at "Dry Pond" near Drybrough Peak are both related to monzonitic dike emplacement. The association of copper-gold mineralization with hypabyssal monzonitic bodies is observed at multiple localities in the Toodoggone region, and the distinctiveness of these plutons and their field relationships suggest they represent a distinct magmatic pulse(s) in the Black Lake suite.

- Regional geological and metallogenic studies of the Toodoggone River map area conducted over the past 20 years, mainly by the BCGS, demonstrate that the porphyry and epithermal styles of mineralization formed 200 to 190 million years ago. This mineralizing epoch coincides in space and time with a suite of earliest Jurassic granitoids shallowly emplaced within a contemporaneous subaerial volcanic succession. Their distribution is confined to an elongate syn-volcanic extensional trough.
- Unravelling the history of magmatic and mineralizing events is a key objective of the Toodoggone program. Presently, age dating of 20 samples is in progress to determine ages for various mineralized monzonites, and to directly date alteration associated with epithermal and porphyry mineralization.

HELICOPTER-BORNE NATGAM SURVEY (GAMMA-RAY SPECTROMETRIC AND MAGNETIC TOTAL FIELD)

In late summer, a combined, high-resolution airborne gamma-ray spectrometric and magnetic survey was completed in the Toodoggone region (Figure 1). This survey provides new public domain gamma ray data and higher resolution aeromagnetic data for the entire Toodoggone mining camp, within a broader GSC-industry funded aeromagnetic survey published in 1999. The principal objective of the new survey is to provide a consistent geophysical and geochemical (via radioactive elements; K, U,Th) framework to supplement regional bedrock mapping by the B.C. Geological Survey and ongoing property-scale exploration. The surveyed region has clear economic potential, demonstrated by the Kemess South Mine, the gold-copper porphyry deposit at Kemess North, several past-producing mines and numerous gold epithermal prospects. Hydrothermal alteration minerals associated with porphyry and epithermal mineralization in the Toodoggone are known to respond well to these airborne techniques, and have been shown to respond to ground gamma ray surveys in the Shasta deposit area (Shives, unpublished data).

Gamma ray spectrometry (surface geochemical information) and magnetic total field measurements (deeper-looking geophysical information) are complementary, as features with low magnetic response are commonly enriched in radioactive elements, and vice versa. Excellent bedrock exposure throughout most of the survey area will optimize detection of known and new mineral prospects, broad zones of hydrothermally altered rocks, bedrock lithologic contrasts and structures.

AIRBORNE SURVEY

The survey boundaries were designed by theBCGS in consultation with industry partners and the GSC. Funding was provided, in part, by Stealth Minerals Ltd., Northgate Explorations Ltd., Finlay Minerals Ltd., Bishop Resources Inc. and Sable Resources Ltd. The GSC provided contract preparation, tendering, evaluation and, on July 24th, awarded the contract through Public Works and Government Services Canada to Fugro Airborne Surveys of Mississauga, Ontario.

The GSC (Radiation Geophysics Section and Regional Geophysics Section) is responsible for overall quality control, including system calibrations, conducted in Ottawa prior to mobilization, and field checks to ensure specifications and procedures adhere to well-established NATGAM national standards.

The survey overlies a topographic transition from eastern Spatsizi Plateau into relatively subdued mountains of the Swannell Ranges. The mountainous terrain required a helicopter survey to maintain a nominal terrain clearance of 135 m, with no more than 30 m difference between traverse line and magnetic control line elevations. The helicopter used was a Eurocopter AS350B2. Flight speed averaged 120 kph. A total of 6214 line kilometres were flown, covering 2214 km^2, with flight lines oriented 055^o, spaced at 400 m intervals and magnetic control lines oriented at 321^o, spaced at 4000m intervals.

Gamma ray spectrometric measurements were made using an Exploranium GR820 spectrometer to record 256 channel spectra every second, from 33.6 liters of downward-looking and 4.2 liters of upward-looking sodium iodide detectors. The detector boxes were carried inside the helicopter and in a cage mounted outside **(Figure 2)**. Prior to mobilization, system-specific correction factors were determined using GSC portable

Figure 2. Gamma-ray spectrometric system includes two sodium iodide detector boxes mounted inside (orange box) and outside (in white cage, lower right) the helicopter, linked to spectrometer console in the system rack, behind pilot.

calibration pads at Ottawa airport and the GSC calibration test strip in Breckenridge, Quebec. In the field, daily calibration checks were completed using Cs^{137} and Tl^{208} sources and a test line was established and flown daily to monitor reproducibility of all measured variables.

Standard energy windows were used to record the gamma ray counts. These are 1370-1570 keV for potassium, 1660-1860 keV for uranium, 2410-2810 keV for thorium and 400-2810 keV for total radioactivity. Several corrections are applied to the raw window counts prior to conversion to standard concentration units, including: system dead time; background activity from cosmic radiation, the aircraft and atmospheric radon decay products; spectral scattering in the ground, air and detectors; deviations of altitude from the planned terrain clearance; temperature and pressure variations.

Magnetic total field measurements were made using a cesium split-beam sensor sampling at 10Hz, with an in-flight sensitivity of 0.01 nT, housed in a bird towed 30 m below the helicopter **(Figure 3**).

Figure 3. Cesium split-beam magnetometer is housed in a "bird" (foreground), towed 30 m below the helicopter.

The system was calibrated using the Bourget, Ontario magnetic test range prior to mobilization, to determine heading effects and lag on the magnetic measurements. In the survey area, ground magnetometer stations continuously recorded diurnal magnetic variations to monitor variation in the earth's magnetic field.

Positional information was provided by a dual frequency Ashtech differential GPS system, monitoring up to twelve satellites, and yielding a positional accuracy of approximately 2-3 m after post-flight differential correction.

AIRBORNE SURVEY STATUS

The Toodoggone survey commenced August 19, 2003 and was completed on September 17. The preliminary data covering mineral claims owned by the respective industry partners was distributed on December 1, 2003, after Fugro had completed preliminary corrections to the raw magnetic and radiometric data, and subdivided the data into property blocks. Additional corrections will be applied and final digital data and colour maps for the entire survey will be delivered to the GSC by mid-February. The geophysical data for all areas covered by claims held by other companies or individuals or available for staking will be realeased to the public along with the company partner information in late March 2004.

2004 TOODOGGONE TGI PROGRAM

Next year is anticipated to be an active one for mineral exploration in the Toodoggone region, and the GSB will continue to aid this work by providing a geological framework at a scale of 1:20 000. Mapping completed this season in the Swannell Mountains will be expanded to the east, thereby completing geologic coverage between the Finlay and Toodoggone rivers and the mapping in the Johannsen Lake area expanded (see 2004 mapping in Figure 1). The new Griz-Sickle epithermal vein system, discovered by Stealth Minerals Ltd. in 2003, is near the centre of the northern mapping area for 2004. This program will then shift north westward into remote terrain bridging the Toodoggone and Chukachida rivers, a region containing the north easternmost extent of prospective Early Jurassic rocks in the Stikine Terrane.

Initiation of several detailed mineral deposit studies involving graduate students from the Department of Earth and Ocean Sciences at The University of British Columbia, under the guidance of Dr. Steve Rowins, are planned with mining company partners in 2004. These studies will focus on aspects of porphyry copper-gold and epithermal gold styles of mineralization, and although the timing of these projects will carry on beyond the duration of TGI-II, the results will ultimately be integrated with those of the regional bedrock program leading to a better understanding of the metallogeny of the Toodoggone mining camp.

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