Age, geochemical and metallogenic investigations of Cretaceous intrusions in southeastern Yukon and southwestern NWT: A preliminary report

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ABSTRACT

The geochronology and geochemistry of Cretaceous intrusions and associated mineralization in southeastern Yukon and southwestern NWT is the focus of a new research project. The objective is to investigate the southeastern extension of well-established plutonic suites currently recognized in central and western Yukon. Here we report five new U-Pb zircon ages from the study area that indicate that at least three distinct ages of intrusions are present. Two bodies (Bennett Creek pluton and an unnamed body west of Tungsten) give ages of ~91 Ma and are correlated with the Tombstone Plutonic Suite. Two phases of the Coal River batholith give ages of ~96 Ma and are considered to be part of the Tay River plutonic suite. Finally, the Mt. Billings Batholith east of Tuchitua Junction gives an age of ~106 Ma, and is correlated with the Anvil plutonic suite. Compositionally, the intrusions range from monzogranite to granodiorite and most contain at least minor amounts of biotite ± hornblende ± magnetite. Also, they are dominantly peraluminous to slightly metaluminous, subalkalic, relatively oxidized, and appear to span I-, S-, and A-type (within-plate) fields on various lithogeochemical discriminant plots. These new data will help constrain genetic and exploration models for a wide variety of Cretaceous intrusion-related gold and base metal mineral deposit types in the study area.

RÉSUMÉ

La géochronologie et la géochimie d'intrusions d'âge Crétacé et de la minéralisation associée, dans le sud-est du Yukon et le sud-ouest des T.N.-O., font l'objet d'un nouveau projet de recherches. L'objectif de cette étude est de déterminer l'extension sud-est de suites plutoniques bien établies qui sont actuellement reconnues dans le centre et l'ouest du Yukon. Nous présentons ici cinq nouvelles datations au U-Pb du zircon, provenant de la région à l'étude, qui indiquent la présence d'au moins trois périodes intrusives d'âges distincts. Deux masses intrusives (le pluton de Bennet Creek et un pluton sans nom situé à l'ouest de Tungsten) datent d'environ 91 Ma et on peut les corréler avec la Suite plutonique de Tombstone. Deux des phases du pluton de Coal River datent de 96 Ma et on considère qu'elles appartiennent à la suite plutonique de Tay River. Enfin, le Batholite du mont Billings, situé à l'est de Tuchitua Junction, date de 106 Ma et on peut le corréler avec la suite plutonique d'Anvil. La composition des intrusions varie du monzogranite au granodiorite et la plupart contiennent au moins de petites quantités de biotite ± hornblende ± magnétite. De plus, ils sont surtout hyperalumineux à légèrement méta-alumineux et subalcalins, relativement oxydés et, sur divers graphiques de discrimination lithogéochimique, paraissent chevaucher les champs des types I, S et A (intraplaques). Ces nouvelles données vont aider à définir les modèles génétiques et d'exploration pour une grande variété de types de minéralisations aurifères et de métaux communs qui sont associées aux intrusions d'âge Crétacé qui sont présentes dans la région à l'étude.

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INTRODUCTION

Recent investigations within the Tintina gold belt (TGB) in central and western Yukon, conducted primarily by the Mineral Deposit Research Unit at UBC and the Yukon Geology Program, has led to the identification of numerous distinct plutonic suites (Fig. 1). Individual suites are distinguished based on their lithological, geochemical, and geochronological characteristics, as well as their metallogenic associations. The aim of this project is to investigate extensions of the plutonic suite designations, as currently defined, into the much less studied eastern and southern extent of the TGB in southeastern Yukon and southwestern NWT (Fig. 1). The study area comprises most of map sheets 95 D (Coal River), 95 E (Flat River), 95 L (Glacier Lake), 105 A (Watson Lake), 105 H (Frances Lake) and 105 I (Nahanni).

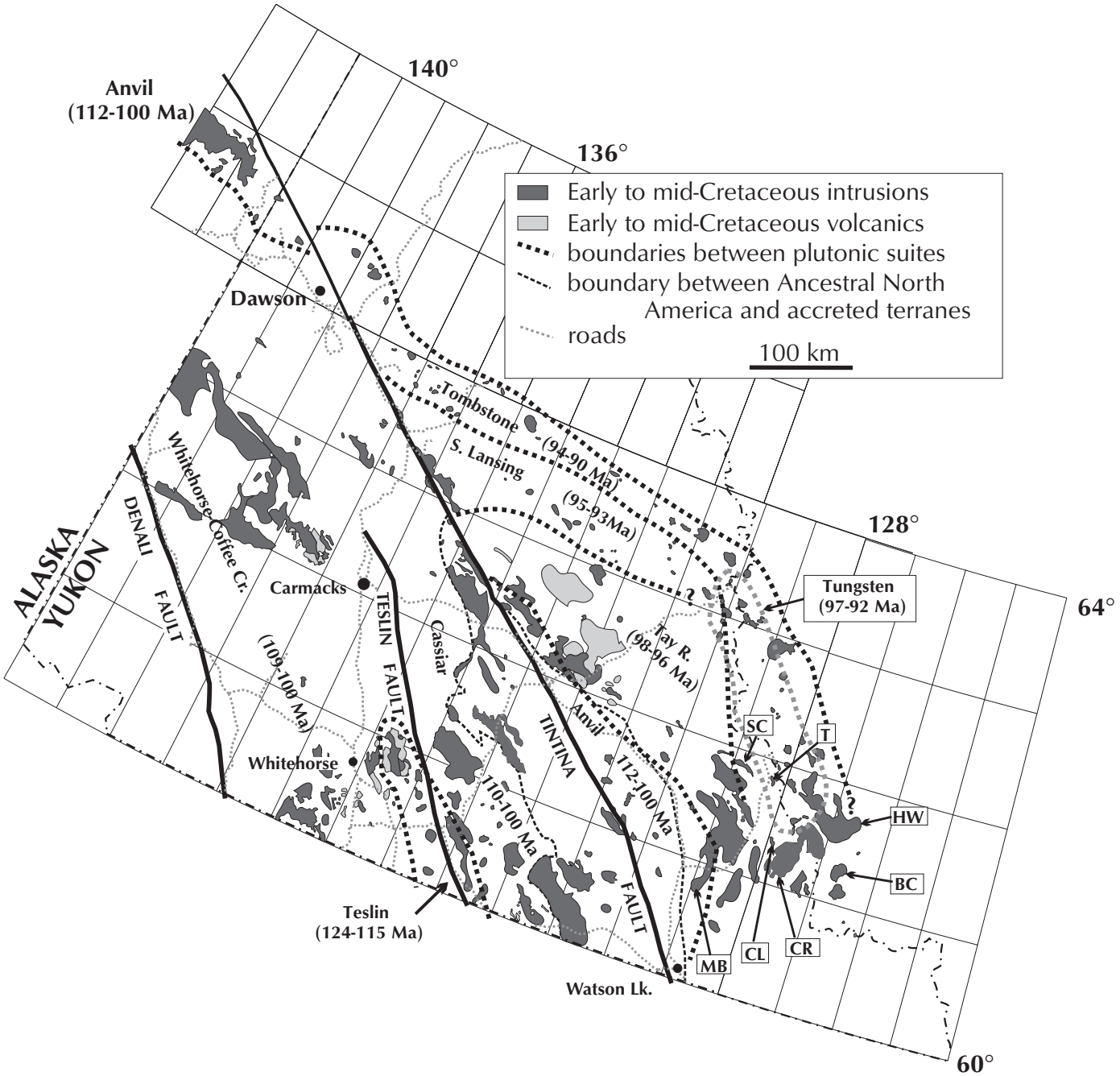

Figure 1. *Regional map showing the distribution of Early and mid-Cretaceous plutons and volcanic rocks (modified from Wheeler and McFeely, 1991). Individual plutons referred to in the text include: MB = Mt. Billings; CR = Coal River; SC = Shannon Creek; BC = Bennett Creek; T = Tuna stock; CL = Caesar Lakes; HW = Hole-in-the-Wall.*

The study area contains a wealth of mineral deposits and occurrences that are likely intrusion-related, including a wide variety of base and precious metal-bearing skarn, carbonate-replacement, porphyry and vein occurrences. Previous exploration efforts in the area, however, have been hampered by a lack of information concerning the age and geochemistry of plutonic rocks, and the relationship between intrusions and mineralization. In this paper we report initial geochronological and geochemical data for samples collected from separate intrusions and/or phases of composite intrusions. Many of the intrusions in the study area are unnamed, and in this report we use informal names (shown in Fig. 1) for simplicity.

TEXTURE AND LITHOLOGY

Three distinct textural varieties are observed within the intrusions in the study area, based on hand sample and initial petrographic examination (Table 1). Most intrusions show an equigranular texture in which grain size can vary greatly, ranging from coarse (~1 cm) to very fine (<1 mm). Equigranular textures are typical of the larger intrusions in the area, such as the Coal River and Mt. Billings batholiths. Megacrystic textures with K-feldspar phenocrysts up to 4 cm in length are less abundant, and are present in some of the smaller bodies such as the Bennett Creek and Caesar Lakes plutons. Distinctly foliated textures have thus far only been observed in the Shannon Creek pluton.

The intrusions all contain roughly subequal amounts of quartz, plagioclase, and K-feldspar, and cluster between the monzogranite and granodiorite fields on a standard Q-A-P (IUGS) granitoid discrimination diagram. All samples contain varying amounts of biotite ± hornblende ± magnetite. The Tuna stock contains a very minor amount (<1%) of muscovite; however it differs from Gordey and Anderson's (1993) 'two-mica plutons' as defined in the Nahanni map area in that it also contains a small amount of hornblende.

GEOCHRONOLOGY

Five new U-Pb zircon ages have been obtained from intrusions in the study area. Results are summarized in Table 1. Zircons from the three smaller plutons (Bennett Creek, Shannon Creek, and Caesar Lakes plutons) show very simple U-Pb systematics, in contrast with the larger intrusive bodies (Mt. Billings and Coal River batholiths) which display much more complex U-Pb zircon systematics, with evidence for a large amount of inherited zircon. U-Pb dating of titanite from several of the intrusions will be undertaken in order to constrain the emplacement ages of these bodies.

The results indicate that intrusions of several ages are present. The southeasternmost intrusion (Bennett Creek) and the northwesternmost intrusion (Shannon Creek) give ages of 91.0 ± 03 to 92.5 ± 04 Ma, suggesting that they represent a southeastern continuation of the Tombstone Plutonic Suite (~92 Ma). Samples from two different phases of the Coal River batholith give ages of ~96 Ma. This age and the mineralogy of the samples support correlation with the Tay River plutonic suite

Table 1. *Summary of sample locations, textural characteristics and U-Pb ages.*

Sample #	Intrusion Name	Easting	Northing	NTS Map Sheet	U-Pb Age (Ma)	Texture/Fabric
SH-99-001	Shannon Creek pluton	511410	6860975	105H15	92.5 ± 0.4	foliated
SH-99-002	Shannon Creek pluton	510575	6861110	105H15	n/a	foliated
SH-99-006	Coal River batholith	569700	6796900	95E/05	96.9 ± 0.4	equigranular
SH-99-007	Coal River batholith	571000	6798125	95E/05	n/a	equigranular
SH-99-008	Coal River batholith	574000	6803635	95E/05	95.6 ± 0.3	equigranular
SH-99-009	Coal River batholith	581700	6824250	95E/11	n/a	equigranular
SH-99-010	Bennett Creek pluton	628757	6799292	95E/07	n/a	megacrystic
SH-99-011	Bennett Creek pluton	624400	6789175	95E/02	91.0 ± 0.3	megacrystic
SH-99-012	Bennett Creek pluton	621528	6794800	95E/07	n/a	megacrystic
SH-99-013	Caesar Lakes pluton	559500	6799200	95E/05	n/a	equigranular
SH-99-014	Caesar Lakes pluton	556750	6802500	95E/05	n/a	equigranular
SH-99-015	Caesar Lakes pluton	555870	6800680	95E/05	n/a	equigranular
SH-99-016	Tuna stock	541644	6855058	105H16	n/a	megacrystic
SH-99-022	Mt. Billings Batholith	507300	6757200	105A15	106.4 ± 0.4	equigranular

to the northwest. The Mt. Billings Batholith is the westernmost body that was dated, and gives a somewhat older age (~106 Ma). This intrusion is therefore considered to be a part of the Anvil plutonic suite.

GEOCHEMISTRY

Geochemical analyses have been obtained from 14 samples from 6 individual intrusions in the study area. Preliminary interpretations of the geochemical data are presented below, and the data are shown on various geochemical discriminant plots in Figure 2. The intrusions are predominantly peraluminous to slightly metaluminous (Fig. 2a), subalkalic with SiO_2 contents ranging from 65 to 75% (Fig. 2b), and are at least slightly oxidized, based on Fe_2O_3/FeO ratios. The primitive-mantle-normalized rare earth element (REE) diagram (Fig. 2c) shows that all intrusions have experienced some degree of feldspar fractionation, as evidenced from the slight to moderate negative Eu anomalies. There is also a less consistent negative Tm anomaly present in the samples, but this is more than likely the result of analytical error as heavy rare earth elements (HREE) tend not to completely dissolve during the analytical process (S. Piercey, pers. comm., 1999). On tectonic discriminant plots (Fig. 2d), it is apparent that these intrusions do not show any particular affinity towards a single, clearly isolated tectonic environment; instead they tend to overlap the boundaries between 'within-plate' (A-type) granites, syncollisional (S-type) and volcanic-arc (I-type) granites.

MINERAL POTENTIAL

A variety of intrusion-hosted and intrusion-related deposits and occurrences are known in the eastern Selwyn Basin. These include W (± base metal) skarns such as Mactung, Cantung, and

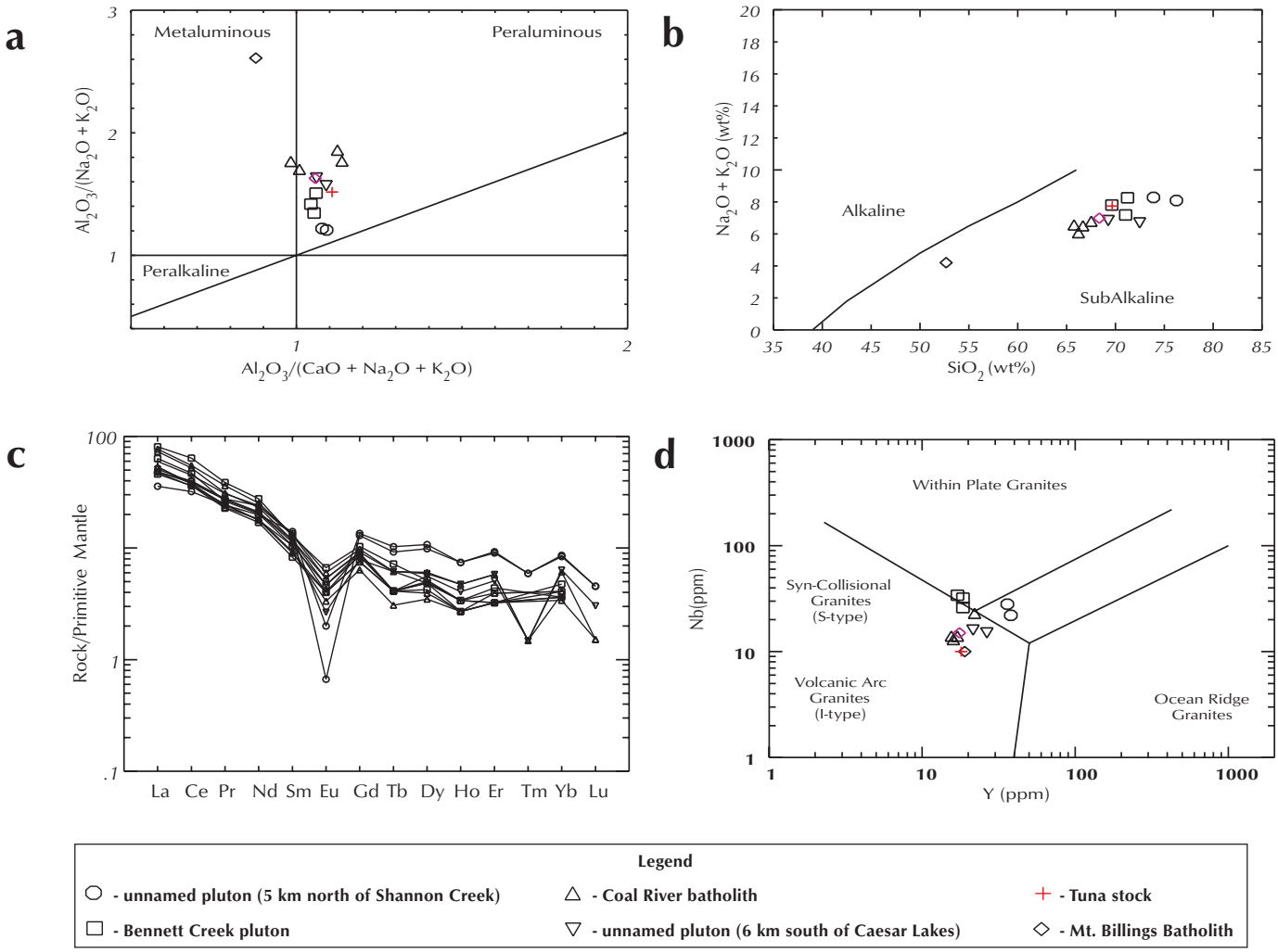

Figure 2. *Geochemical plots from whole rock analyses of granitoid rocks: a) Shand Index (after Maniar and Piccoli, 1989) depicting the dominantly peraluminous nature of the intrusions. b) Total alkalies versus silica plot (Irvine and Barager, 1971). c) Primitive-mantle-normalized REE diagram (values from Sun and McDonough, 1989). d) Nb versus Y diagram (Pearce et al., 1984).*

Lened; Ag-rich base metal skarns and mantos such as Sa Dena Hes; gold-bearing sheeted quartz veins (e.g., within the Mactung intrusion); distal, apparently structurally controlled deposits such as Hyland; and massive sulphide replacement deposits such as Macmillan. Indeed, at least 45% of the 325 Minfile occurrences listed for the six map sheets that comprise the study area are definitely or arguably intrusion-related (Yukon Minfile, 1997). This has led to a considerable amount of interest from exploration companies in the mineral potential of this region. In particular, Hudson Bay Exploration & Development and Viceroy Resources/Novagold Resources have had on-going exploration programs in the region over the past two years, and additional work is likely.

DISCUSSION

Initial results from this study indicate that intrusions in the southeastern part of the TGB show at least subtle differences from intrusions elsewhere in the TGB in the Yukon (as described by Lang et al., in press). Intrusions in the study area have slightly elevated average SiO_2 content, are typically more peraluminous, have significantly larger negative Eu anomalies, and show more of an affinity with A-type ('within-plate') granites. Our results indicate that various intrusions in the study area can be correlated with the Tombstone, Tay River and Anvil plutonic suites, but the Tombstone and Tay River equivalents show complete spatial overlap (Fig. 1).

Future investigations will include:

- additional sampling of intrusions in the study area to complete the lithogeochemical and geochronological coverage;
- radiogenic isotope studies (Nd, Sr, and Pb) to gain a better understanding of the underlying basement rocks within the region;
- sampling of known mineral occurrences for mineralogical and Pb isotopic studies (probably in conjunction with geologists from the Yukon Geology Program); and
- a modest amount of mapping of selected intrusive complexes.

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