

BRITISH COLUMBIA New U-Pb Geochronological Data and their Significance for Diamond Exploration

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ABSTRACT

Seven new U-Pb zircon ages for this area are reported for samples of drill cuttings. Samples B5 (1854±6 Ma) and B25 (minimum age 1.75Ga; inherited zircon 1.89 - 2.23 Ga) are located within but near the edge of Nova terrane as currently defined. Sample B2 plots within the Kiskatinaw terrane and samples B11 (1994±7 Ma), B12 (1993±7 Ma) and B14 (1993±7 Ma) plot within the Ksituan terrane. Sample B34 (1859±10 Ma), located near the British Columbia - Yukon Border. occurs within the Fort Simpson terrane. The samples from the Nova terrane returned Paleoproterozoic ages and thus did not confirm the popular interpretation that assigns Archean age to Nova terrane. The age indicated by the inherited zircon from sample B25 is similar to 2.0 and 2.3 Ga ages previously reported for the Buffalo Head terrane, which is believed to be reworked Archean basement. This finding is important from the exploration point of view since the Buffalo Head terrane in neigbouring Alberta hosts diamondiferous kimberlites.

INTRODUCTION

The Diamond potential of British Columbia was summarized in terms of "Diamondiferous Mantle Root Model" (DMS Model) and "Eclogite Subduction Zone model" (ES Model) by Simandl (2004). The DMR (Figure 1) explains the origin of diamond deposits in the classical diamond producing areas within ancient stable cratons (Figure 2). The Canadian Cordillera has been located in an oceancontinent boundary since the supercontinent called Rodinia started to rift apart between 530 and 570 Ma ago (Price and Monger, 2000; Colpron et al., 2002). The Precambrian basement rocks of similar age and nature as those that underlie the diamondiferous kimberlites occurrences east of the Alberta-BC border and Northwest Territories described by Carlson et al. (1999) do extend into eastern BC (Figure 4). For example, Archean Nova Terrane is commonly interpreted as a fragment of the Slave Craton. There are also other reasons suggesting that a "deep keel" may have underlain parts of BC's and Alberta's basement in the past, but it has been destroyed since. For example, before the breakup of Rodinia, the west coast of North America was probably joined or adjacent to Siberia (Price and Sears 2003) and could have been underlain by a mantle root at this time. In southeastern BC the remnants of the keel probably persisted in a modified form at least until the Triassic (the Cross Kimberlite Rb/Sr dates on phlogopite are 240-250 Ma, according to Smith et al., (1988). In summary, independently of the paleo-tectonic continent matching scenario the DMR model can be applied to eastern parts of BC, where Archean or Proterozoic basement can be extrapolated from Alberta and Northwest Territories by a combination of geology and geophysics (Figure 4). Therefore radiometric dating studies such as this one enhance our understanding of the Precambrian basement and indirectly of the diamond potential within northeastern British Columbia.

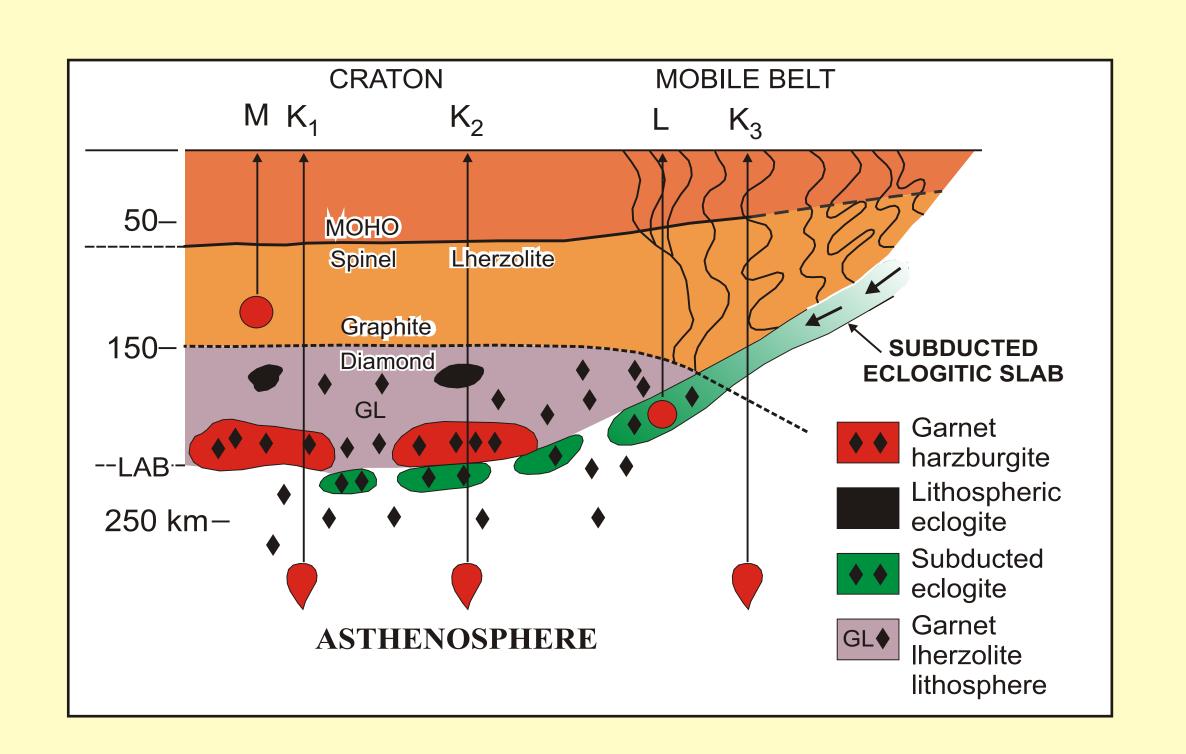


Figure 1. Diamondiferous Mantle Root Model showing accretion of a mobile belt against Archean craton (Mitchell, 1991). L- lamproite, M- Melilitic magma, K- kimberlite, LAB lithosphereasthenosphere boundary. K1 will contain carry peridotitic garnets, K2 and L will possibly carry peridotitic and eclogitic garnets and K3 will be barren.

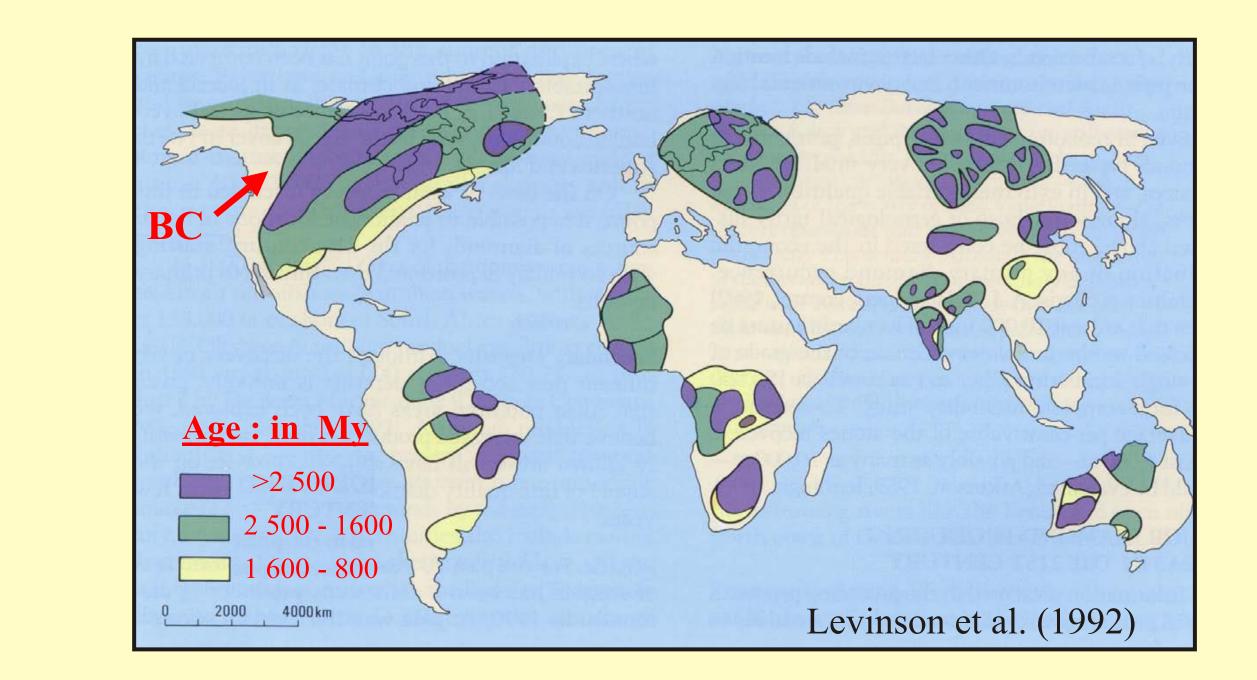


Figure 2. Areas of kimberlite magmatism are largely restricted to the regions of continental crust underlain by Archean (>2.5 b.y.) cratons, which are surrounded by younger metamorphic terrains commonly referred to as "mobile belts" (Clifford, 1996). Up to now most, if not all, kimberlites containing economic diamond concentrations were found in "on-craton" settings. Most of the generalized maps, such as this one depict British Columbia in "off-craton setting".

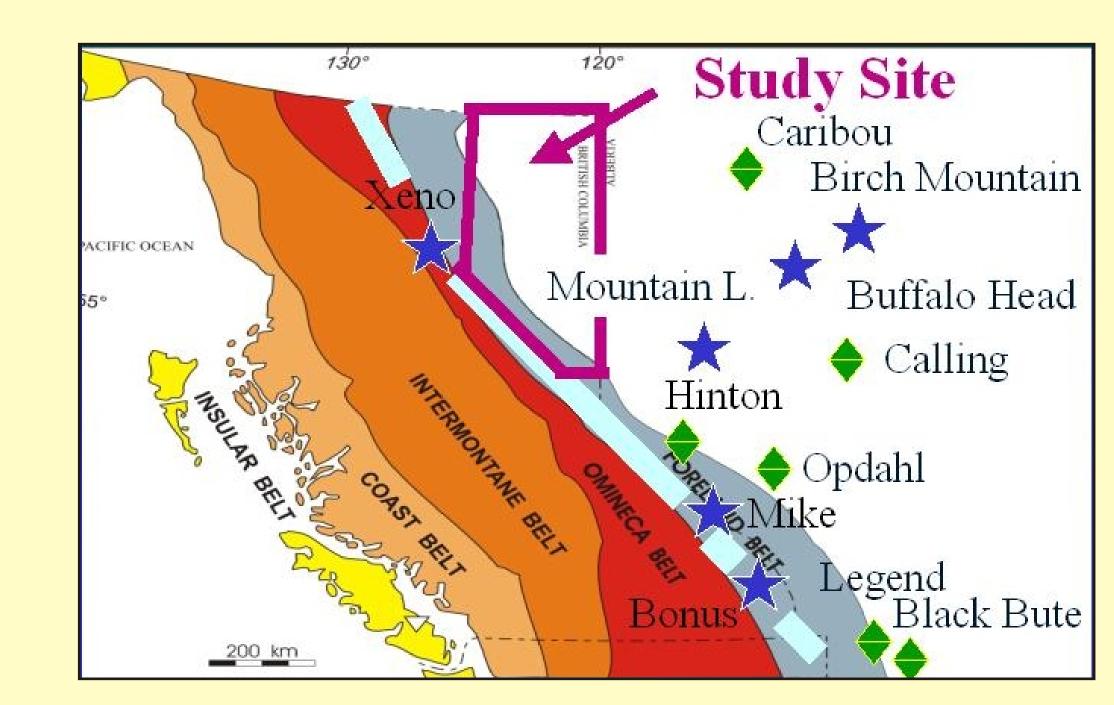


Figure 3. Compilation of BC and Alberta diamond occurrences. In situ diamond occurrences are identified by stars. Diamond shapes represent alluvial occurrences (From Simandl, 2004).

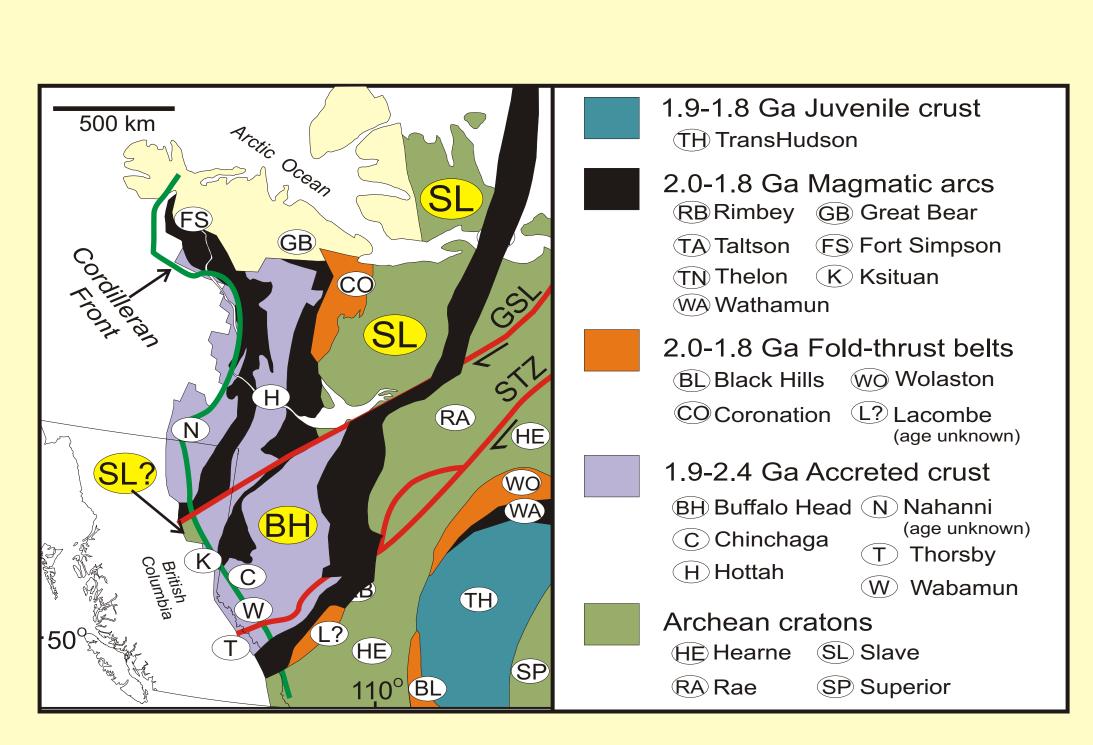


Figure 4. Generalized tectonic map of Alberta Basin, showing projections of Proterozoic basement rocks from Alberta to British Columbia. Note also that a portion of the Slave Craton (Archean) may have been displaced along the Great Slave Lake shear zone all the way to the British Columbia Cordilleran Front is shown in green and major lineaments in Red. GSL - Great Slave Shear Zone. From: Gehrels and Ross (1998).

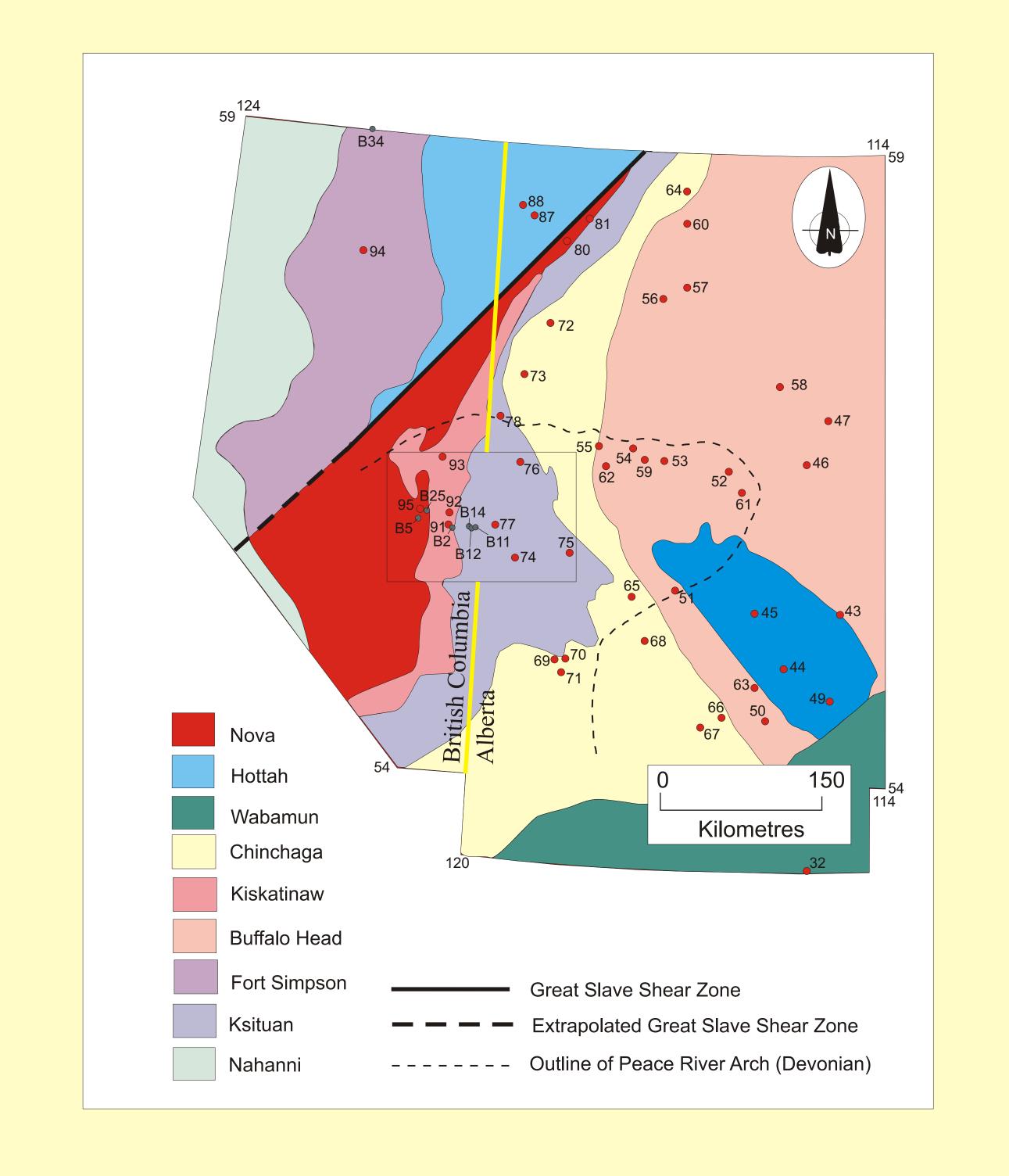
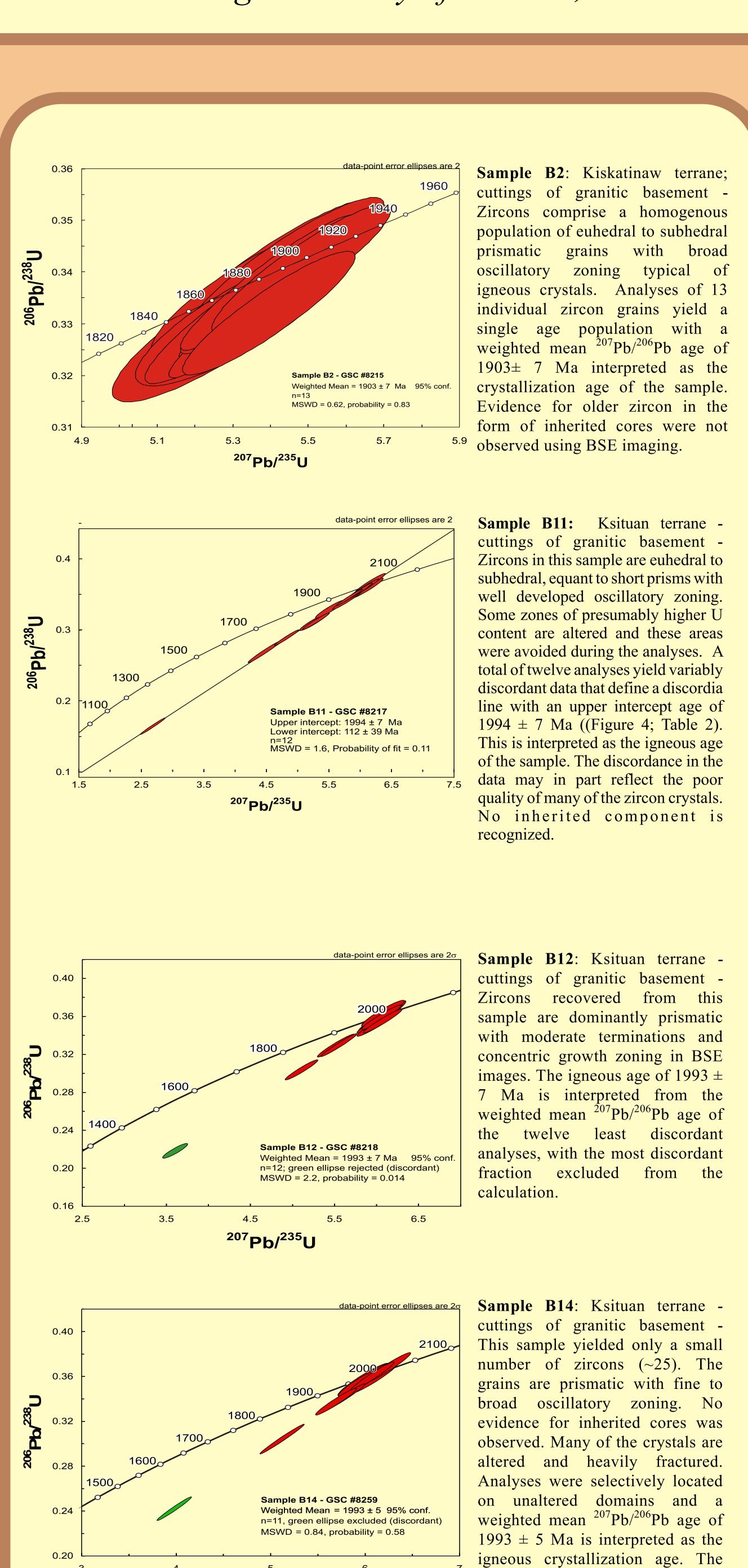


Figure 5. Generalized tectonic map of basement in NE British Columbia and adjacent Alberta. Nova is commonly interpreted as a sliver of Archaean Slave craton. From: Villeneuve et al. (1993). Samples that were submitted for age dating, and discussed in the text are identified by numbers B2, B5, B11, B12, B14, B25 and B34. Age dates for the remaining sample locations are given by Villeneuve et al. (1993).

SAMPLING / ANALYTICAL PROCEDURES

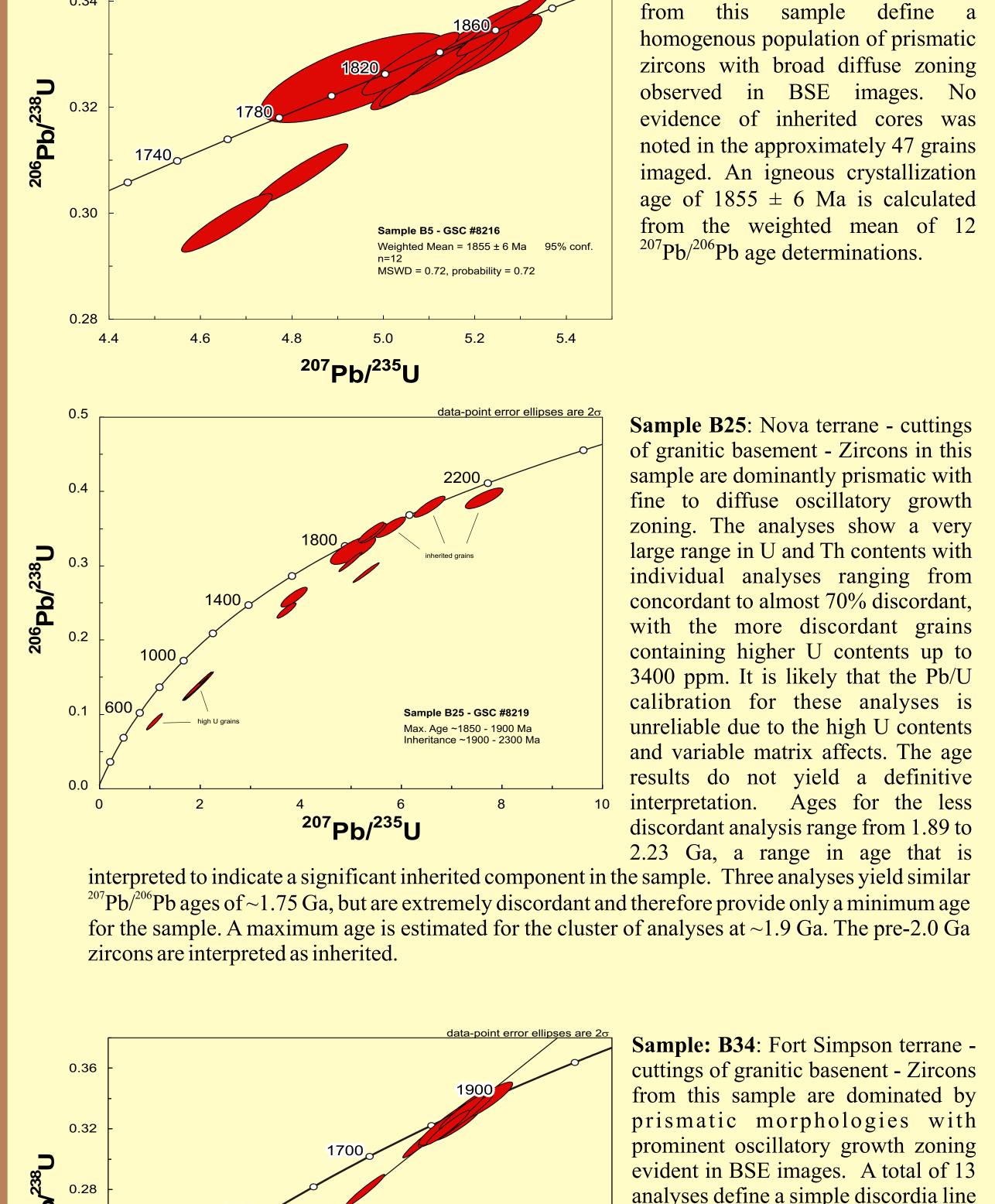
Basement cuttings were collected from oil and gas exploration boreholes and handpicked to avoid cavings (contamination) from overlying shale and limestone units, crushed, and the heavy mineral fraction separated using heavy liquids and magnetic separation using a FrantzTM isodynamic separator. Zircons were recovered from seven of the nine samples processed. The U-Pb ages of the zircons were determined using the Sensitive High Resolution Ion MicroProbe (SHRIMP) at the J.C. Roddick Ion Microprobe Laboratory, Geological Survey of Canada Analytical procedures followed those described by Stern (1997), with standards and U-Pb calibration methods following Stern and Amelin (2003). Briefly, zircons were cast in 2.5 cm diameter epoxy mounts (GSC #333) along with fragments of the GSC laboratory standard zircon (z6266, with 206 Pb/ 238 U age = 559 Ma). The mid-sections of the zircons were exposed using 9, 6, and 1 µm diamond compound, and the internal features of the zircons (such as zoning, structures, alteration, etc.) were characterized with cathodoluminescence (CL) and backscattered electrons (BSE) utilizing a Cambridge Instruments scanning electron microscope. Mount surfaces were evaporatively coated with 10 nm of high purity Au. Analyses were conducted using an ¹⁶O primary beam, projected onto the zircons at 10 kV. Two different sized spots were used for analysis, one ca. 25 µm in diameter, and another ca. 16 µm in diameter with a beam current of ca. 9 and 1.6 nA respectively. The count rates of ten isotopes of Zr⁺, U⁺, Th⁺, and Pb⁺ in zircon were sequentially measured over 7 scans with a single electron multiplier and a pulse counting system with deadtime of 35 ns. Off-line data processing was accomplished using customized in-house software. The 1σ external errors of 206Pb/238U ratios reported in the accompanying data table incorporate a 1.4 to 2.0 % (for larger spot and smaller spot respectively) error in calibrating the standard zircon (see Stern and Amelin, 2003). No fractionation correction was applied to the Pb-isotope data; common Pb correction utilized the measured 204Pb and composition of the surface gold coating (Stern, 1997). Isoplot v. 3.00 (Ludwig, 2003) was used to generate concordia plots and calculate weighted means.

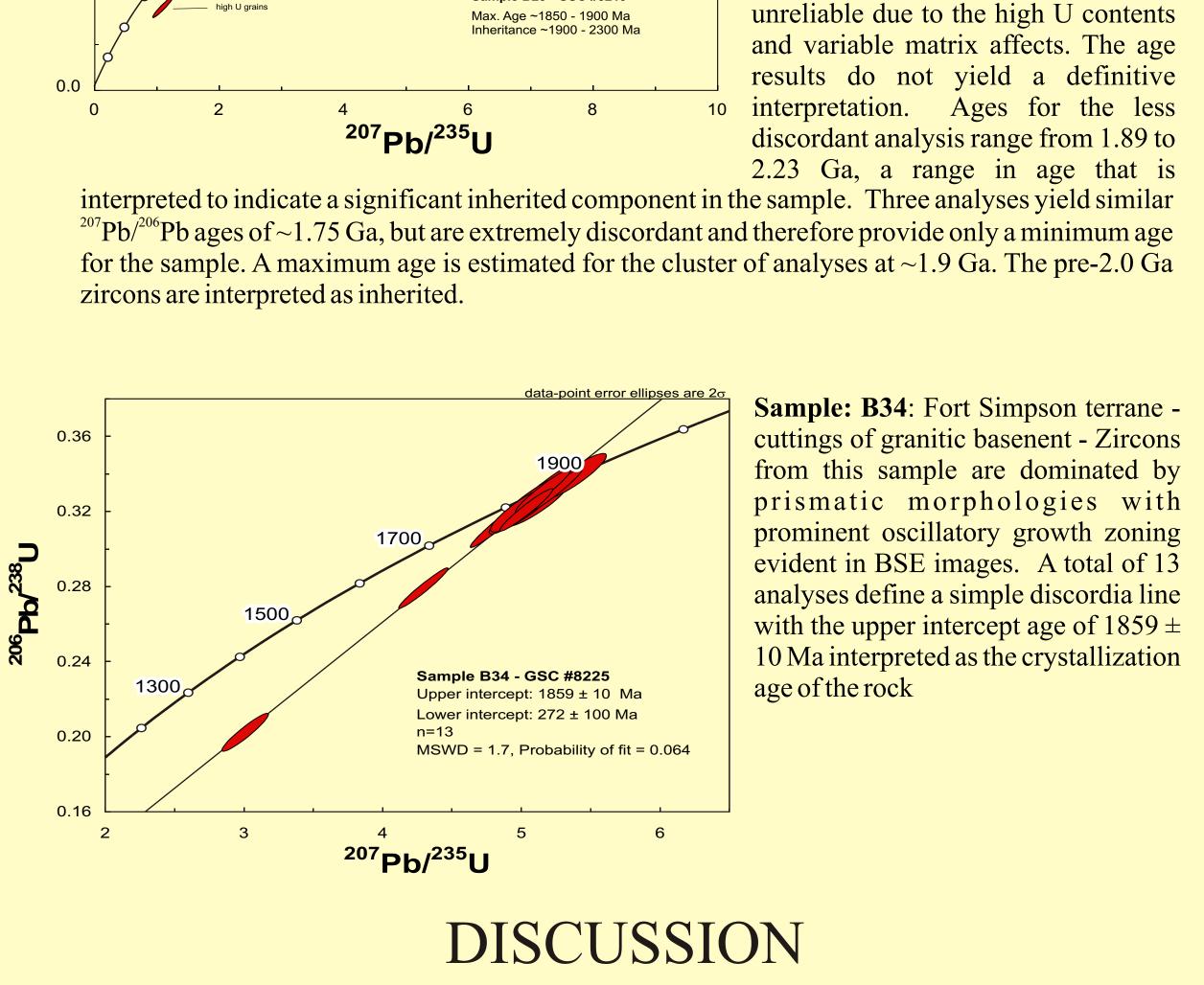


²⁰⁷Pb/²³⁵U

most discordant analysis was

excluded from the calculation.





granitic rock - Zircons recovered

Six of the seven samples yield reliable age information with Paleoproterozoic ages that fall within three age groupings: ~1990; ~1900, and ~1850 Ma. Although sample B25 did not yield a reliable age estimate, it is most likely Paleoproterozoic, and most significantly, contains zircon that indicates interaction with $\sim 2.0 - 2.3$ Ga crust.

Sample B34 is from within the area of the Fort Simpson Terrane (Figure 5), which is defined mainly as a magnetic high and interpreted as a calc-alkaline plutonic belt. The age of the sample at 1859 ± 10 Ma is older than a previously published age of 1845 ± 1 Ma for the Fort Simpson Terrane in British Columbia (locality 94; Villeneuve et al. 1993). Two dates of Fort Simpson Terrane, reported in the Northwest Territories, indicate ages of 1.84 and 1.85 Ga (Villeneuve et al. 1991 and Ross et al., 2000). Result for sample B34 supports previous geophysical interpretations that extend the Fort Simpson terrane from Northeastern British Columbia all the way to Northwest Territories (e.g. Aspler et al.

Samples B11, B12 and B14 are located within the Ksituan terrane. The three samples give consistent ages of 1994 ± 7 , 1993 ± 7 and 1993 ± 5 Ma. These ages are slightly older than to the results of Ross and Eaton (1900 to 1986 Ma, 2004), but still within the proposed range because of associated uncertainties. Dates in Ksituan terrane are in the same range as Kiskatinaw dates reported by Villeneuve et al.(1993), and there is no distinction in age between these terranes. Samples B5 and terrane. The 1854 ± 6 Ma age for the B5 sample is similar to Kiskatinaw ages previously reported by Villeneuve et al. (1993).

Sample B25 provided an unexpected result and is extremely important. Three highly discordant analyses yield similar 207 Pb/ 206 Pb ages of ~ 1.75 Ga, and constrain the minimum age for this sample. The most concordant analyses range in age from 1.89 to 2.23 Ga, indicating a significant inherited component in the sample. A maximum age is estimated for the cluster of analyses at ~1.9 Ga. This result suggests that rocks within at least a portion of the Nova terrane contain zircons with similar characteristics to those of the Buffalo Head and Chinchaga terranes. Buffalo Head terrane is believed to consist mainly of Paleoproterozoic rocks (2.0 to 2.3Ga) intruded by a magmatic event at ~1.96 Ga (Villeneuve et al. 1993). Archaean magmatic ages are not documented in the diamondiferous kimberlite-bearing Buffalo Head terrane, as they have in the Nova terrane in Alberta (Ross and Eaton, 2002). However, upper U-Pb intercept ages in some Buffalo Head rocks

The difference between the B25 sample and B5 samples is striking, and also requires additional consideration. Our results do not support the hypothesis that Nova terrane is a sliver of the Archaean Slave craton (Figure 2), basement samples located centrally within the Nova terrane are lacking, so some caution should be exercised. Other approaches such as Nd isotopic analyses could be used to further compare the sample B25 with existing data from the Buffalo Head and Chinchaga terranes in Alberta where Nd data suggest that these terranes formed on a foundation consisting of Archaean

CONCLUSION

This study confirms the presence of Precambrian basement throughout the Northeastern British Columbia study area. The dates of 1993±5, 1993±7 and 1994±7 Ma within the Ksituan terrane represent the timing of igneous activity and these rocks must have intruded older basement, the age of which remains undetermined. Interpretation of ²⁰⁷Pb/²⁰⁶Pb zircon ages on studied samples does not confirm the presence of Archaean basement within the projected area of the Nova terrane, although it does not entirely eliminate that possibility. Sample B25 located within, but near the edge of Nova terrane contains inherited zircon of ~2.0-2.2 Ga, similar in age to rocks from the Buffalo Head and Chinchaga terranes. This is significant, because Buffalo Head terrane hosts diamondbearing kimberlites in neighboring Alberta. This result indicates that basement of BHT age is present much farther west than previously proposed. Based on similarities with diamond kimberlite-hosting BHT terrane in Alberta, portions of NE British Columbia should be considered as legitimate, but speculative diamond exploration areas.

FUTURE WORK

Additional work including Nd isotope analysis could potentially establish additional similarities or differences between Buffalo Head terrane in Alberta and Nova terrane in BC. A key question is whether Nova terrane rocks were derived through recycling of Archean material. Additional dating and detailed geophysical interpretation are required to reconcile existing data.

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