Thermal evolution of the Central Gneiss Complex, British Columbia, constrained by garnet geochronology

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Abstract

The western Canadian Cordillera and Coast Mountains of British Columbia were assembled through terrane accretion during the Jurassic and Cretaceous. These allochthonous units have been correlated with the Alexander, Yukon-Tanana and Taku terranes, as well as rocks of the Gravina basin (Crawford et al. 2000). A continuous metamorphic gradient exists, from chlorite-grade rocks on islands in west (Hutchison 1970; Hollister 1975; Hollister 1977; Crawford et al., 1979) to the late Cretaceous and Paleogene granulite-facies core of the orogen (Hollister 1977; Selverstone and Hollister 1980; Hollister and Andronicos 1997). These rocks are intruded by a suite of plutons that progress from Jurassic age in the west and Eocene age in the east (Crawford and Hollister 1982; Hutchinson 1982; Klepeis et al. 1998; Andronicos et al. 1999). Medium to high pressure (8-9 kbars) metamorphic rocks (Crawford et al. 1979) on the west are separated by the Coast shear zone from migmatites and assemblages indicating higher temperatures (>700 C) but lower pressures on the east (Hollister 1977; Selverstone and Hollister 1980).

Samples were collected from the Central Gneiss Complex (CGC) of British Columbia, located between lat 54^o and 55^o N (Figure 1) for garnet geochronology. The CGC is the exhumed middle crust of a continental magmatic arc (Hollister and Andronicos 1997). Lithologies within the CGC are primarily orthogneiss, rusty-weathering migmatite, luecogneiss, amphibolite, and minor calc-silicate gneiss; all metamorphosed to upper-amphibolite and medium pressure granulite facies (Hollister, 1982; Hutchinson 1982a). Regional metamorphism induced partial melting at temperatures in excess of 750^o C at mid-crustal pressures (6-7 kbar) (Hollister 1982). The region is intruded by the Quottoon Pluton (59 Ma U-Pb zr) and the Kasiks Sill Complex (53 Ma U-Pb zr) (Andronicos et al. 2003; Gehrels et al. 2009).

Five samples of syn-tectonic garnet from the Central Gneiss Complex were dated using Lu-Hf and one using Sm-Nd (Figure 2). Sample GMO was collected north of the Skeena River adjacent to the Quottoon Pluton. Rocks at this locality are composed of garnet-sillimanite-biotite-plagioclase-quartz gneiss, and produced a Lu-Hf garnet age of 66.0±3.2 Ma and an Sm-Nd garnet age of 53.0±3.5 Ma. Kwinitsa Quarry is a garnet-bearing tonalite gneiss located on the north shore of the Skeena River, 1 km south of the bottom of the Kasiks Sill. The sample from Kwinitsa had a Lu-Hf garnet age of 67.2±0.8 Ma. The other three samples were collected on the south side of the Skeena River, between Spinel Peak and Sillimanite Needle. These units were migmatitic gneisses. Sample 09B-06 contained grt+bt+plag+qtz+oxides had a Lu-Hf

age of 66.8±0.6 Ma; 09B-15 contained grt+cordierite+sil+bt+plag+qtz+oxides with a Lu-Hf age of 70.0±0.8; and 09B-34 contained grt+bt+plag+qtz and gave a Lu-Hf age of 66.3±2.7.

Utilizing multiple isotopic systems with varied closure temperatures, a thermal history can be assembled (Figure 3). Prograde garnet growth took place as units were heating up to >650^o C between 70.4±3.3 Ma and 66.0±3.2 (2σ). P-T estimates and regional geochronology support that the crust remained at a high temperature (>750^o C) from the late Cretaceous to the early Eocene (Andronicos et al., 2003). The first record of cooling below many isotopic systems' closure temperature occurs at 53 Ma, with U-Pb zircon, U-Pb sphene, and Sm-Nd garnet. The closure of these systems was soon followed by Ar-Ar hornblende and Ar-Ar biotite, which supports rapid exhumation at rates of 2 mm/yr during the late Paleocene and early Eocene (Hollister 1982). This cooling was related to rapid uplift of middle and deep crustal rocks (Hollister 1982; Kenah and Hollister 1983) and termination of large-scale batholith formation within the Coast Plutonic Complex (Armstrong 1988; van der Heyden 1992). The entire width of the high-grade core of the orogen cooled at essentially the same time, as recorded by the consistency in Ar-Ar hornblende ages (Figure 3). The variations in ages are a function of elevation, with the oldest ages occurring at the highest elevations (Andronicos et al 2003).

Units in the Central Gneiss Complex record a long-lived granulite facies metamorphic event, from 70-52 Ma. The Lu-Hf system retained information on prograde garnet growth despite metamorphic conditions in the surrounding crust at upper-amphibolite to granulite-facies conditions for 18 million years. This indicates that the Lu-Hf system in garnet is extremely robust and a useful geochronologic tool for deciphering metamorphic ages despite complex thermal histories.

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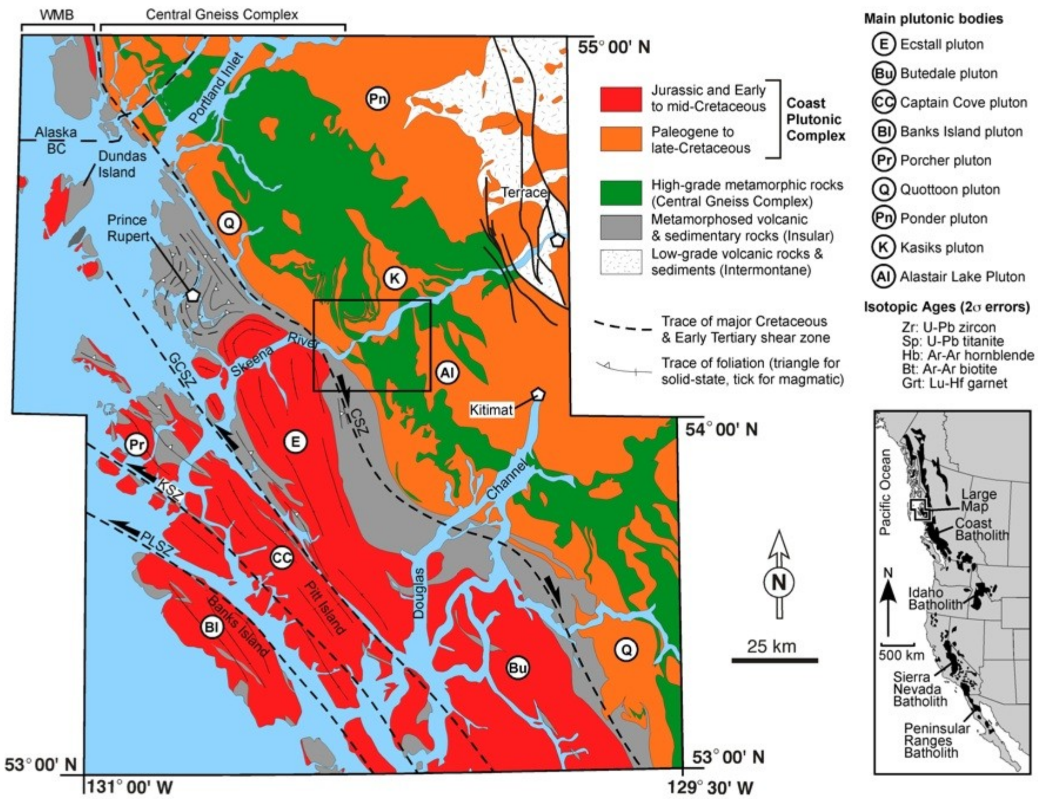

Figure 1. Simplified geologic map of the central Coast Mountains, British Columbia. Red and gray units are the Gravina Belt, Alexander and Wrangelia Terranes. Orange and green units are the Stikine Terrane. The Central Gneiss Complex is an Eocene metamorphic core complex. Area of figure 2 indicated by the black box.

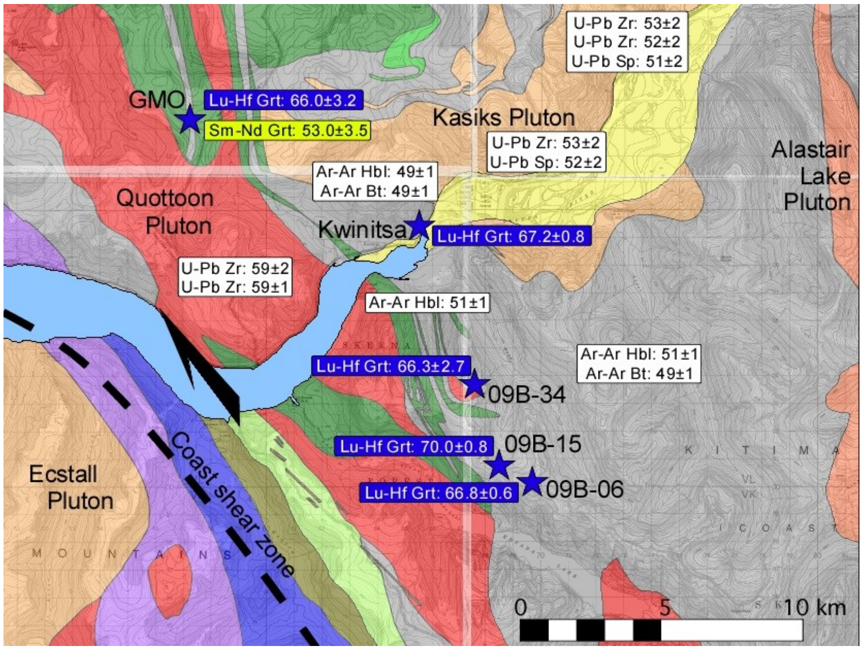

Figure 2. Geologic map of the study area. Lu-Hf garnet ages in blue and Sm-Nd garnet ages in yellow were collected at Washington State University by Wolf (*this study*). White boxes are ages of various systems from Andronicos *et al.* (2003) and Gehrels *et al.* (2009). All errors are 2σ.

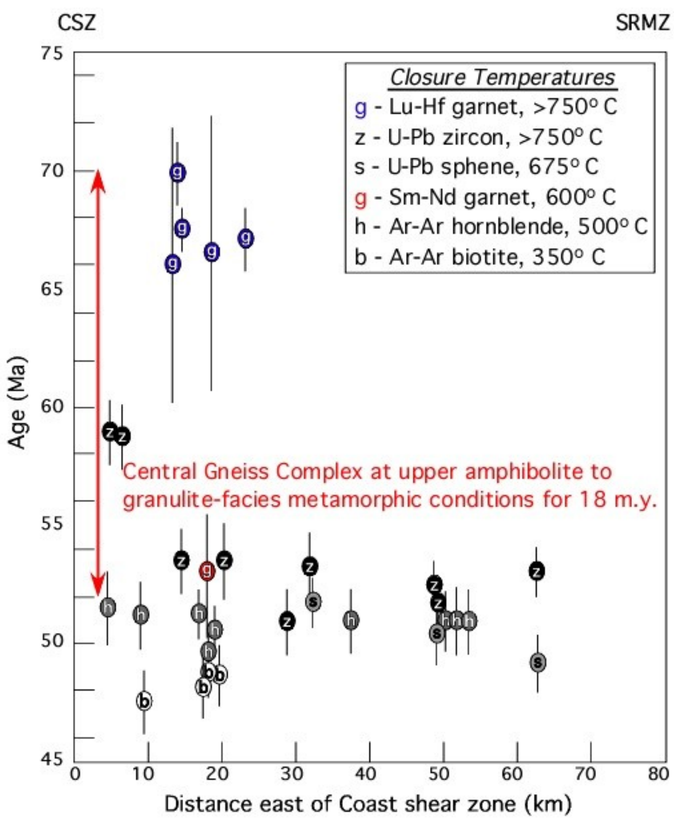

Figure 3. Plot of age versus distance from the Coast shear zone (CSZ), towards the Shames River Mylonite (SRMZ). Garnet data from this study, other data from Andronicos *et al.* (2003) and Gehrels *et al.* (2009).