PRESSURE AND TEMPERATURE OF DEFORMATION OF THE WESTERN METAMORPHIC BELT, PRINCE RUPERT, BRITISH COLUMBIA

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INTRODUCTION

The northern coastal region of British Columbia is part of the accreted Insular superterrane, which according to the "Baja B.C." hypothesis was transported northward over 3000 km between 90 and 50 Ma (Cowan et al., 1997). Near Prince Rupert, the Insular Belt contains the Western Metamorphic Belt (WMB). Hutchinson (1982) mapped the WMB and believed these rocks to have been metamorphosed at the same time as the emplacement of the epidote-bearing Ecstall pluton, intruded 91 Ma ago at a pressure of 8 kbar (Butler et al., 2001). In this interpretation, rocks of the WMB should have equilibrated at pressures similar to those of the Ecstall. Crawford et al. (1999), however, contend that the Ecstall was instead thrust westward after emplacement over the shallower country rock; in this model, rocks of the western WMB should preserve lower pressures of metamorphism than the Ecstall.

The purpose of this project was to construct a detailed geologic map of the field area, analyze the petrology of the WMB rocks, and ascertain the P-T conditions of these units in order to determine the relationship of the WMB to the Ecstall.

METHODS

Geological mapping of the field area was performed over a four-week period in July and August of 2000 (Fig. 1). Outcrops are generally limited to shorelines, and a boat was utilized to give access to as many areas of the shore as possible. The study area is dominated by well-foliated garnet-bearing mica schists with some variations in mineralogy and lenses or minor layers of other rock types, as described in the geological map. Over 40 samples of all major rock types were collected in the field; thin sections were made of 26 of these for petrographic analysis. Of these, five samples were studied at Beloit College with a scanning electron microscope (SEM) using backscattered electrons, and mineral compositions for geothermometry and geobarometry calculations were obtained with an energy dispersion spectrometer (EDS).

PETROGRAPHY

Most samples in the study area can be described as garnet-bearing mica schists with well-developed foliation. Garnet and staurolite are the predominant porphyroblasts and are contained within a quartz + plagioclase + biotite + muscovite + ilmenite matrix. One sample from Digby Island, north of Figure 1, contains chloritoid porphyroblasts. Table 1 gives the mineral assemblages identified in thin section for each sample (see Fig. 1 for sample locations).

Garnet and staurolite appear to be syn-kinematic; biotite and muscovite define the foliation and wrap around the larger (up to 1 cm) garnets. Many garnets have quartz pressure shadows or mica tails, and show signs of rotation consistent with a predominantly sinistral sense of shear (Granger, this volume). Quartz grains are commonly recrystallized and display granoblastic texture. Ilmenite grains are irregularly shaped; in some cases they strictly follow foliation, but in others are randomly oriented.

Nearly all samples display little to moderate late chlorite retrograde overprint, commonly as a replacement of garnet, staurolite, or biotite. One sample (BCD-63) has primary epidote inclusions in garnet. Graphite-bearing rocks have a strong foliation marked by layers of finely-disseminated graphite throughout the sample, with graphite concentrated along the rims of porphyroblasts.

electron microprobe: deconvoluting multistage tectonic histories: Geology, v. 27, p. 1023-1026.

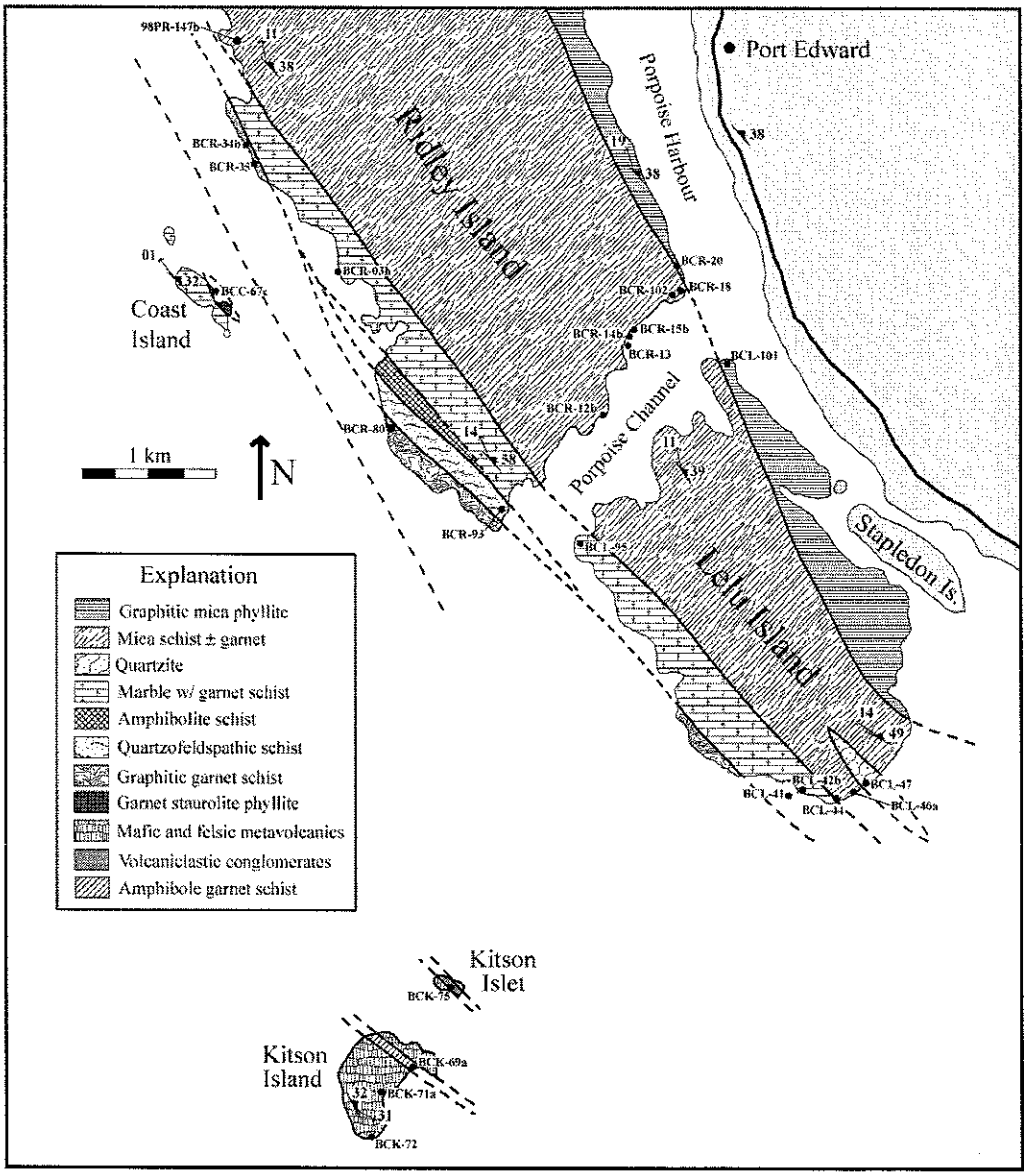

Figure 1 Geologic map of the field area. Sample locations are shown. Two samples used in P-T calculations (BCD-63 and BC-89) located north of this map area.

GEOTHERMOBAROMETRY

In all cases, garnets are almandine rich (X_{alm}= 2.01-2.75) and are weakly zoned with core compositions slightly more Ca-rich (ΔX_{gr}= 0.27). The spessartine composition is low in all cases (X_{sp}= 0.02-0.28). Opaque minerals are ilmenite (+ graphite in some samples).

The garnet-biotite geothermometer (Ferry and Spear, 1978) and garnet, biotite, plagioclase, muscovite geobarometer (Ghent and Stout, 1981) were used to determine the P and T for samples BC-89, BCR-80, and 98PR-147b. Sample BCD-63, contains chlorite and no biotite so the garnet-chlorite geothermometer (Dickenson and Hewitt, 1986) was used for this sample. Peak metamorphic temperatures and pressures for these rocks are shown in Figure 2; temperatures range from ~480-550°C and pressures from ~4-6.5 kbar; this is consistent with the occurrence of staurolite and garnet together in many of the rocks.

Table 1. Mineral assemblages from the Western Metamorphic Belt

Samples	Qtz	Plag	Bt	Ms	Gt	St	Amph	Chl	Ep	Ctd	Calcite	Tourm	Graph	Ilm
BCL-101	•	•	•	•									•	•
BCR-20	•	•	•	•								•	•	•
BCR-102	•	•	•	•									•	•
BCR-18	•	•	•	•								•		•
BCR-15b	•	•	•		•		•							•
BCR-14b	•	•	•				•				•			•
BCR-13	•	•	•	•	•									•
BCR-12B	•	•	•		•									•
BC-89	•	•	•		•								•	•
BCL-47	•			•								•		•
BCL-46a	•	•	•	•	•	•			•					•
BCL-95	•			•							•			•
BCL-44	•	•	•	•	•	•								•
BCL-42b	•	•	•	•	•			•				•		•
BCL-41	•	•	•						•					•
BCR-03b	•	•	•	•	•	•						•		•
BCR-34b	•	•	•	•	•									•
BCR-93	•	•	•				•	•						•
BCR-80	•	•	•	•	•	•		•					•	•
BCL-35	•	•	•	•	•	•		•					•	•
BCC-67c	•	•	•	•	•	•								•
BCD-63	•	•		•	•	•		•	•	•				•
BCK-75	•	•	•				•	•						•
BCK-69a	•	•	•	•	•	•	•							•
BCK-71a	•	•	•				•							•
BCK-72	•	•	•				•							•

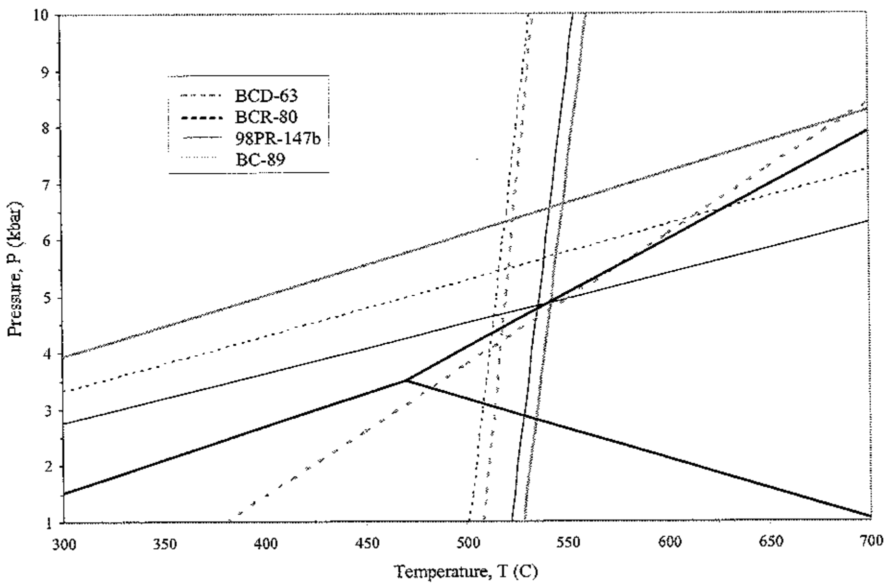

Figure 2. Pressure and temperature calculations for selected samples. Al_2SiO_3 phase diagram shown for reference.

DISCUSSION

Many samples throughout the study area contain staurolite and garnet, which constrains their temperatures of equilibration to between ~500-675°C (Fig. 3). Sample BCD-63 from Digby Island is further constrained in terms of temperature, as the assemblage chloritoid + staurolite + garnet restricts its temperature to between ~500-550°C. These general limitations are in accord with the P-T calculations which put the temperatures at ~480-550°C.

If Hutchinson's (1982) model of syn-metamorphic pluton emplacement were correct, one would expect the western WMB rocks to yield pressures of ~8 kbar, however this is not the case. Metamorphic pressures are significantly lower (4-6.5 kbar), indicating these rocks equilibrated at higher crustal levels than did the Ecstall pluton. The relationship between the WMB deformation and the emplacement of the Ecstall pluton is therefore more complex than Hutchinson's model. Crawford et al. (2000) and Butler et al. (2001) suggest that the Ecstall pluton was thrust westward across the Prince Rupert shear zone during or shortly after intrusion. However, kinematic indicators throughout the field area, and within their "Prince Rupert shear zone" give consistent left-lateral strike-slip movement during syn-tectonic metamorphism (Granger, this volume). Either thrusting did not occur here, or it was thoroughly overprinted by later left-lateral shearing.

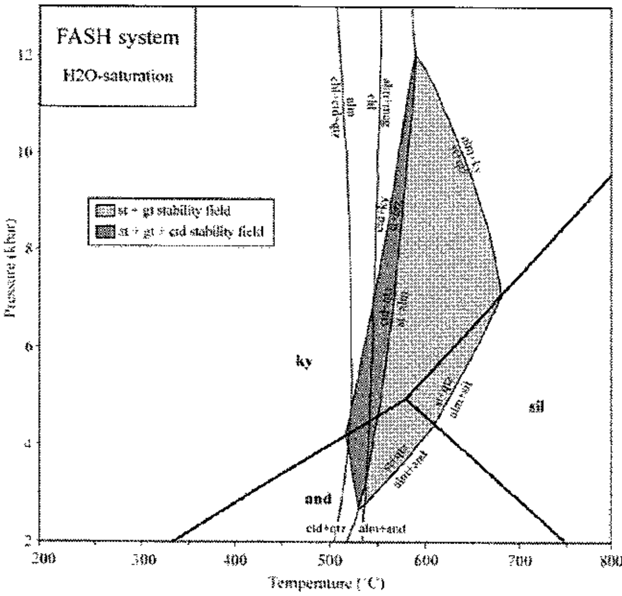

Figure 3. Fields of stability for st+gt and st+gt+ctd assemblages. Modified from Bucher and Frey, 1994.

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