Metamorphism of Argillaceous and Schistose Rocks of the Bellevue Wedge, Elkhorn Mountains, Northeastern Oregon

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INTRODUCTION

The Elkhorn Mountains in northeastern Oregon are part of the Blue Mountains province, which is composed of four distinct pre-Tertiary tectonostratigraphic terranes which were accreted to the North American continent via convergent plate processes during the Mesozoic and Cenozoic (Coney *et al.* 1980, Vallier *et al.* 1977). One of these terranes, the Baker Terrane, is composed of metagabbro, melange, and the Elkhorn Ridge Argillite (ERA), a unit of relatively coherent oceanic sediments. During the late Jurassic - early Cretaceous, granitic plutons intruded the area; one of these plutons was the 450 km^2 Bald Mountain Batholith (BMB), which Taubeneck (1995) characterized as having evolved from hot and relatively dry tonalitic magmas. This study focuses on rocks from the Bellevue Wedge, a "peninsula" of anomalously intense metamorphism in the contact aureole of the BMB. The Bellevue Wedge is located between the central portion of the BMB and a limb of the BMB which Hewett (1931) called the Monumental Salient, between 6-12 km northeast of Granite, Oregon (Figure 1).

While extensive work has been done characterizing the BMB (Taubeneck, 1957 and 1995), the age and sedimentary environment of the ERA in its type locality (Coward, 1983; Ave Lallemant *et al.*, 1980), and related argillaceous and schistose rocks of the Baker Terrane (Bishop, 1995; Gilluly, 1937; Vallier *et al.* 1977), little has been done on the effects of either regional or contact metamorphism of the ERA. In the field, rocks of the Bellevue Wedge are commonly gneissic but also include cherty argillite and fine-grained foliated phyllites, particularly in the western portion of the Bellevue Wedge. In the interior of the Bellevue Wedge, massive coarse-grained gneisses with mesoscopic isoclinal folds and a locally penetrative schistosity suggest high-temperature deformation within the Bellevue Wedge (Figure 2). This observation is at odds with the suggestion that the source of high temperature metamorphism was the adjacent undeformed BMB. Textures indicative of static grain growth associated with high temperature contact metamorphism are apparent in optical and electron microprobe analyses. This study examines the discrepancy between outcrop scale and microscopic appearances of Bellevue Wedge rocks and provides constraints on the P-T evolution of those rocks.

METHODS

Eighty-seven samples of ERA and igneous rocks associated with the BMB were taken both from within the Bellevue Wedge and from areas .05 km to >2 km to the west and northwest, with particular attention being paid to those outcrops which were most gneissic in appearance. Sample collection was mostly limited to roadcuts and ridges, but samples were well-distributed over an approximately 20 km^2 area within the Crawfish Lake, Mount Ireland, Trout Meadows, and Granite quadrangles. Sample locations within the Bellevue Wedge ranged from 0 km to >2 km from the surficial contact with the BMB. Sixty-four samples were studied in hand sample, twenty-four of which were examined in thin section. Mineral compositions from ten of these were analyzed using an electron microprobe (SEM/EDS).

RESULTS AND DISCUSSION

The ERA in the Bellevue Wedge contain four distinct mineral assemblages. Schistose rocks in the western portion of the Bellevue Wedge at the greatest distance from the central lobe of the BMB and between 1 to 2 km from the Monumental Salient have the assemblage quartz + K-feldspar + biotite + chlorite + garnet + plagioclase ± ilmenite ± apatite ± pyrite. In the central portion of the Bellevue Wedge, between 1 to 2 km from the BMB, where the rocks have a more gneissic appearance, the assemblage is quartz + K-feldspar + biotite + andalusite + cordierite + plagioclase ± zircon ± barite ± pyrite ±ilmenite. Within 800 m of the surficial contact with the BMB in the southeast portion of the Bellevue Wedge, a calc-silicate rock contains the assemblage quartz + K-feldspar + biotite + clinopyroxene + orthopyroxene + actinolite + plagioclase ± sphene ± rutile ± ilmenite ±

apatite. In the southern portion of the Bellevue Wedge within 200 m of the contact with the BMB, schistose rocks have the assemblage quartz + K-feldspar + biotite + garnet + andalusite + plagioclase ± ilmenite ± apatite.

Grain size is highly variable across the Bellevue Wedge. The largest quartz grains (>1 cm) are found in rocks in the eastern section, closest to the BMB, whereas much smaller grains (≈50 μm) are found in rocks in the western section of the Bellevue Wedge at a distance of >2 km from the surficial contact with the BMB. Biotite grain size is also quite variable, ranging from ≈1 cm in the matrix of rocks within 1 km of the surficial contact of the BMB to very small (≈30 μm) inclusions in relict minerals of one sample. Muscovite is not present in any samples, except for some relict grains in two of the samples from the central portion of the Bellevue Wedge. Typically, however, mineral grains in Bellevue Wedge rocks display equilibrium textures with smooth grain boundaries, and near-120° angles between quartz grains, indicating post-deformation heating.

The distribution of the different mineral assemblages throughout the BW is consistent with contact metamorphic effects from the BMB, since the highest-grade assemblages are located within 800 m of the BMB while lower-grade assemblages are found at greater distances from the BMB. With the exception of relict muscovite in two samples, the minerals seem to be in textural equilibrium. Thus the assemblages can be used to constrain the P-T conditions of contact metamorphism.

To the west, farthest from the BMB, the equilibrium AFM assemblage is bio + gar + chl. The next highest-grade rocks to the east-northeast (assemblage bio + and + cord) are separated by the reaction:

chlorite → cordierite + andalusite + biotite

Even closer to the BMB, south of the bio + and + cord rocks, the assemblage is bio + and + gar. This assemblage is stable at similar temperatures as the bio + and + cord assemblage, but continues to be stable at higher temperatures as well. This difference in AFM mineral assemblages at different distances could be a function of grade and/or a change in bulk composition.

The equilibrium assemblage found in a calc-silicate rock of the ERA close to the BMB is bio + Cpx + Opx + Ca-amphibole. This is consistent with the diopside zone in the typical metamorphic evolution of calc-silicates in contact aureoles, and corresponds roughly to the sillimanite - K-feldspar zone in pelites.

CONCLUSIONS

The unique gneissic textures of rocks of the Bellevue Wedge are a consequence of contact metamorphism associated with the BMB overprinting an earlier low-temperature, high-pressure deformation episode. The coexistence of andalusite with relatively high-temperature AFM assemblages indicates that the metamorphic event occurred at low pressure (≈1-2 kb). Nearest the BMB, the presence of cordierite indicates that temperatures were at least 650°C. Farthest from the BMB, the presence of garnet indicates that temperatures were between 350°C and 550°C; this temperature is harder to constrain due to the low slope of the reaction curve at such low pressure. More analysis, including geothermobarometry and a more extensive analysis of relict textures in two samples, is being conducted to put better constraints on the P-T conditions which created these textures and assemblages.

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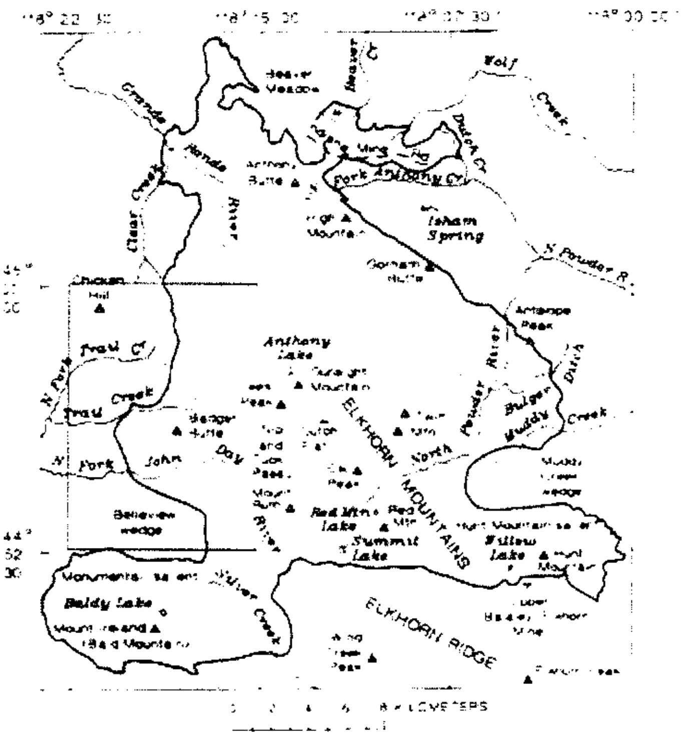

Figure 1: The Bellevue Wedge is located between the main limb of the Bald Mountain Batholith and the Monumental Salient (both shaded). The rectangular outline shows the area of the Crawfish Lake quadrangle (modified from Taubeneck, 1995).

Figure 2: Gneissic textures visible in the ERA in the central portion of the Bellevue Wedge. Hammer for scale.

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