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Structural analysis of mylonitic rocks in the Cougar Creek Complex, Oregon–Idaho using the porphyroclast hyperbolic distribution method, and potential use of SC′-type extensional shear bands as quantitative vorticity indicators

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ABSTRACT

Mylonitic rocks of the Cougar Creek Complex of northeastern Oregon and west-central Idaho provide an opportunity to document the deformational structures produced during general non-coaxial shear within quartz-feldspar mylonites and to explore the potential role of SC′-type extensional shear bands in vorticity analysis. Well-developed feldspar porphyroclasts within six mylonite zones were utilized to estimate bulk kinematic vorticity (W_k) using the porphyroclast hyperbolic distribution (PHD) method. W_k values for the Cougar Creek mylonites range from $W_k = 0.26$ to $W_k = 0.37$. Synthetic and antithetic shear band inclinations were measured relative to observed shear zone boundaries within five mylonite zones with estimated W_k values and compared to the non-coaxial flow field geometries and eigenvector orientations. In each mylonite zone, synthetic SC′-type shear band populations exhibit a range of inclination with maximum inclination lying approximately parallel to the acute bisector (AB) of the eigenvectors. Similarly, antithetic shear band populations show a range of inclination near the obtuse bisector (OB) of the eigenvectors. We infer that SC′-type extensional shear bands form initially parallel to AB and OB and rotate towards the flow plane with progressive deformation, decreasing their inclination relative to the shear zone boundary. AB and OB have significance in the strain field in that they represent orientations of maximum angular strain rate. Thus, planes perpendicular to AB and OB are mechanically favorable for small zones of localized simple shear (shear bands) within the heterogeneous bulk strain of the mylonite. Orientation analysis of populations of SC′-type shear bands may provide a direct, quantitative means of estimating W_k.

1. Introduction

Quantitative structural analysis may provide valuable information regarding the kinematic vorticity of deformation within mylonitic rocks (e.g., Passchier and Simpson, 1986; Passchier, 1987; De Paor, 1988; Wallis, 1995; Beam and Fisher, 1999; Klepeis et al., 1999; Bailey and Eyster, 2003; Giorgis et al., 2003; Law et al., 2004). The relative contributions of the pure and simple shear end-members present during general non-coaxial progressive deformation may be inferred by utilizing the porphyroclast hyperbolic distribution (PHD) method (Simpson and De Paor, 1993, 1997). In addition, the orientations of SC′-type extensional shear bands, measured oblique to the shear zone boundary (Passchier and Trouw, 1998, p. 111), may provide a method of determining bulk kinematic vorticity. The geometric relationship between SC′-type shear bands and their associated flow field has been described differently in the past. Some previous workers have observed and interpreted SC′-type shear band orientations as being coincidental with the direction of maximum angular shear strain rate (i.e., bisecting the acute and obtuse angles between eigenvectors; Simpson and De Paor, 1993, 1997; Klepeis et al., 1999; Law et al., 2004). Conversely, SC′-type shear bands have been interpreted as being oriented parallel to the inclined or unstable eigenvector (Bobyarchick, 1986).

Ductile shear zones within the Cougar Creek Complex (CCC) in the Blue Mountains Province (BMP) of northeastern Oregon and west-central Idaho (Fig. 1) provide an opportunity to evaluate the structural development of quartz-feldspar rocks at mid-crustal levels of the Wallowa island arc system. Mylonitic rocks from the CCC exhibit characteristics which make them suitable for PHD analysis: (1) simple mineralogy; and (2) well-developed and easily recognized deformational textures and fabrics (i.e., the presence of

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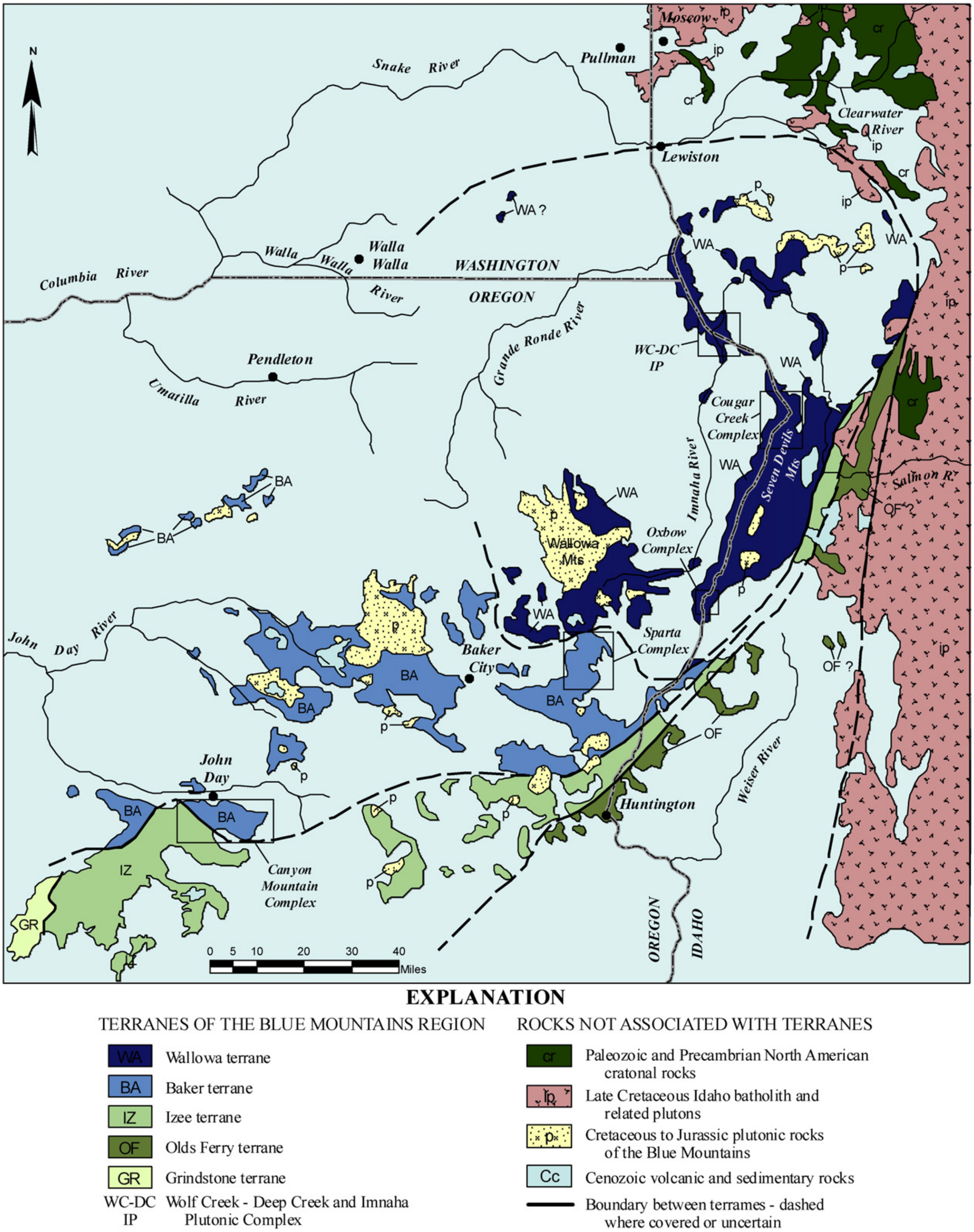

Fig. 1. Blue Mountains province terrane map.Regional geologic map of the Blue Mountains Province, northeastern Oregon, west-central Idaho, and southeastern Washington (After Vallier, 1995).

well-developed porphyroclasts and SC′-type extensional shear bands.

2. Regional geologic context

The CCC is one of five basement complexes within the BMP, and is exposed along a 10-km section of the Snake River within Hells Canyon, between Temperence Creek, Oregon and Pittsburg Landing, Idaho. Similar igneous complexes are located in several parts of the Salmon and Snake River canyons, including: (1) along the Snake River near Oxbow, Oregon, (the Oxbow Complex); (2) near the confluence of the Snake and Salmon rivers (the Wolf Creek–Deep Creek and Imnaha Plutonic Complex); and (3) along the Salmon River between Lucile and White Bird, Idaho (Fig. 1).