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The Burnsville Fault: Determining the Southwest Extension and Relation to the Hayesville Fault

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Abstract

The Appalachian orogen records a complex multi-event history, including three mountain building events associated with the assembly of Pangea: the Ordovician Taconic, Silurian-Devonian Acadian, and the late Paleozoic Alleghanian orogenies. The Burnsville fault in western North Carolina (NC) is a dextral strike slip fault. The Burnsville fault runs through western NC and is the only Acadian structure in western NC. It was previously mapped between Asheville and Spruce Pine, NC. The Burnsville fault separates the Eastern Blue Ridge (EBR)–including the Ashe Metamorphic Suite (AMS)–which is present east of the Burnsville shear zone, and the Western Blue Ridge (WBR), which includes ~1 billion year old Grenville basement rocks. This boundary formed during the Taconic orogeny and was reactivated during the Acadian orogeny as the Burnsville fault. The southwest extension of the Burnsville fault is unclear. The Hayesville fault to the southwest of Asheville has previously been reported as a Taconic structure that, like the Burnsville fault, separates the EBR from the WBR. There is a level of uncertainty regarding the relationship between the Burnsville and Hayesville faults due to similar metamorphic conditions during the Taconic and Acadian as well as Alleghanian overprinting. There are three hypotheses for the Burnsville fault continuation southwest of Asheville: 1) it continues along the Chattahoochee-Dahlonega fault and does not overprint the Hayesville fault, 2) the Chattahoochee-Dahlonega fault connects to the Fries fault, in which case the Burnsville fault is truncated by the Chattahoochee-Dahlonega and Fries faults and does not continue south along the Hayesville fault, or 3) the Burnsville fault overprints the Hayesville fault and continues to the southwest. The Chattahoochee-Dahlonega and Fries faults are both Alleghanian structures. For this study, hypothesis three was tested by mapping the Hayesville fault in Haywood County, NC in the southwest corner of the Clyde 7.5 minute quadrangle. Shear sense indicators, vertical to slightly southeast dipping mylonite trending ~N45°E, and a shallow to horizontal plunging stretching lineation indicate ductile dextral strike slip faulting. Temperatures obtained from dynamic quartz recrystallization that occurred during deformation showed temperatures of ~500° C with slight overprinting from temperatures of less than 400° C. Findings for this shear zone are consistent to what has previously been documented in the Burnsville shear zone to the northeast. Detailed field mapping and microstructure analysis demonstrates that, at least locally, the Burnsville fault possibly continues along the northwest extension of the Hayesville fault.

1. Introduction

1.1. Tectonic setting and geologic background

The formation of supercontinent Pangea occurred from the culmination of three orogenies: the Ordovician Taconic, Silurian-Devonian Acadian, and ending with the late Paleozoic Alleghanian[1-5]. Discriminating the rock deformation that resulted from the Taconic and Acadian events is difficult because they are overprinted by Alleghanian deformation and the Taconic and Acadian orogenies occurred under similar metamorphic conditions. Within the southern Appalachians, this complicated history, and limited Acadian deformation, has resulted in a finite amount of information on the Acadian orogeny[6]. The Burnsville fault in western North Carolina (NC) (Fig.1) has been documented to be Acadian and therefore provides a unique opportunity to further understand the Acadian orogeny within the southern Appalachians.

The Burnsville fault in western NC, documented north of Asheville northeast to north of Spruce Pine, NC, is a dextral strike slip fault (Fig. 1) that separates rocks of two major lithotectonic terranes: EBR, which includes the Ashe Metamorphic Suite (AMS), which is present east of the Burnsville shear zone, and the WBR, which includes ~1 billion year old Grenville basement rocks (Fig. 1)[5, 7-9]. The AMS consists of amphibolite-facies schist, gneiss and amphibolite intruded by Silurian-Devonian granitic rocks and includes the units *Zamb* (amphibolite and biotite gneiss), *Zas* (aluminous schist), and *Ymy* (mylonite) [8, 10, 11]. The WBR predominantly consists of a series of thrust sheets composed of amphibolite to granulite facies Grenville basement, which are intruded by rifting related mafic dikes, granitic rocks and gabbro, and overlain locally by sedimentary rocks[8, 11]. The Eastern-Western Blue Ridge boundary was formed by episodic thrusting and collision of oceanic fragments and accretionary island arcs upon Laurentian basement rock[5,8].

The Burnsville fault was previously mapped as a Taconic thrust fault[12] that emplaced the Ashe Metamorphic Suite (AMS) onto the basement rocks. However, more recent studies have demonstrated the fault is an Acadian strike-slip fault that likely overprinted a Taconic thrust fault between 360 and 377 million years ago (mya)[6-9]. Near Asheville and Burnsville, NC, the Burnsville fault is observed with having a ~2 mile wide, vertical shear zone, with near-horizontal lineations, and is present within the AMS at the contact with basement rocks. This shear zone is recorded to have had temperatures of ~550° C and age dating from within the shear zone shows shearing took place 360-377 mya during the Acadian orogeny[8, 9]. The Burnsville fault provides an opportunity to constrain and understand the Acadian orogeny in the southeast Appalachians as it is one of the only documented Acadian structures within western NC. Previous studies have questioned if the Burnsville fault continues south along the Chattahoochee-Dahlonega fault or the Hayesville fault (Fig. 1) or if the Fries fault and Chattahoochee-Dahlonega fault are connected and truncate the Burnsville fault[5, 8]. The Fries fault is a major structure that is mapped as a thrust fault from central western NC to the northeast and northeast of the Grandfather Mountain Window to near Roanoke, Virginia, and as documented as being Alleghanian in age. The Chattahoochee-Dahlonega fault is also an Alleghanian structure and is documented having sheared Paleozoic granite after 335 mya and is attached to the Dahlonega shear zone in Northeast Georgia[8, 13]. With these existing questions, the crustal architecture of western NC is unclear.

West and southwest of Waynesville NC, and in Northern Georgia, the Taconic Hayesville fault has been thought to define the boundary between the EBR and the WBR southwest of Asheville[5, 14]. The Hayesville fault is similar to the Burnsville fault in that they both separate the EBR from the WBR. Because of this they are often correlated[8]. The Hayesville fault to the southwest of Asheville is documented as a thrust fault that emplaced the Hayesville thrust sheet over Grenville basement rocks (Fig. 1). The Hayesville thrust sheet includes the Copper Hill Formation (undivided), which is part of the Great Smoky group, marked as *Zchu* (Fig. 2, and Fig 3), on top of the Cartoogechaye terrane, which includes *Yr* biotite gneiss, *Yrg* Graywacke, *Yrf* felsic gneiss, *Yra* amphibolite, and *Yrm* migmatite in western NC (Fig. 1, 2, and 3). The Hayesville fault has been interpreted as a metamorphic suture of an island arc, now part of the EBR, thrust upon the WBR Laurentian basement rocks[1, 5] and as an amalgamation of terrane suturing faults with somewhat different histories[6]. There is considerable ambiguity regarding the exact location, characteristics, and history of the Hayesville fault within western NC due to the lack of evidence and possible reactivation from Acadian and Alleghanian overprinting[5, 6, 8]. Several studies suggest reactivation of the Hayesville fault, and a proposed northeastward extension by Acadian and/or Alleghanian orogenies along the Burnsville or Fries faults[1, 6, 15-18]. In addition to being a terrane bounding fault, the EBR-WBR boundary has also been hypothesized to be a middle Paleozoic or Silurian-Devonian and, documented within the Burnsville section of the boundary, to be a Silurian-Devonian dextral fault zone[5, 8, 9].

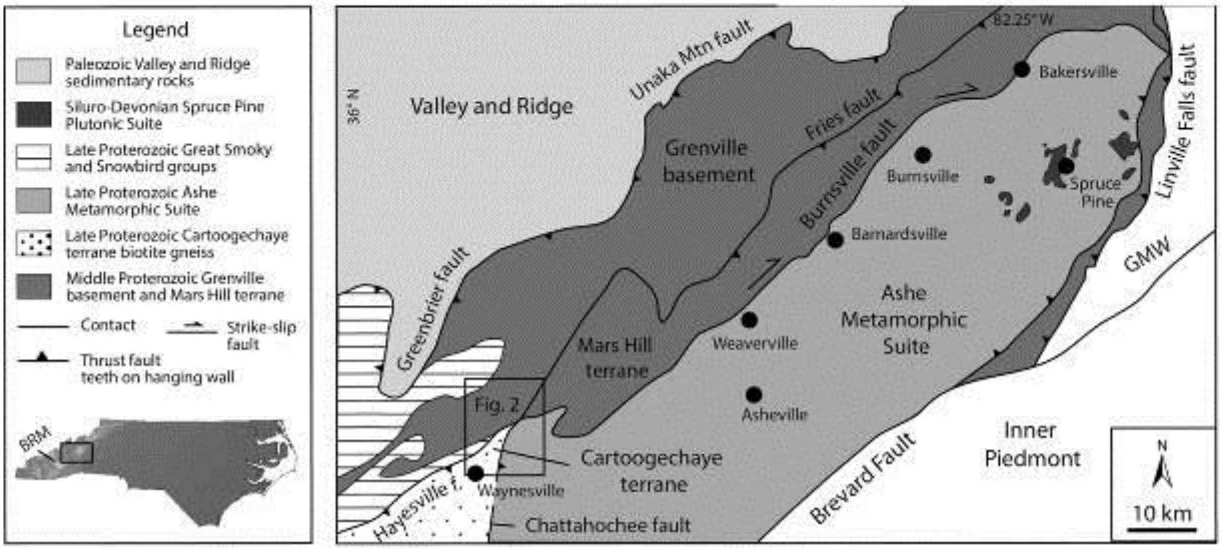

Figure 1. Simplified tectonic map of the southern Appalachians within NC. BRM, Blue Ridge Mountains; GMW, Grandfather Mountain Window. From *Stewart et al*. (1997) modified to include the Asheville area[19].

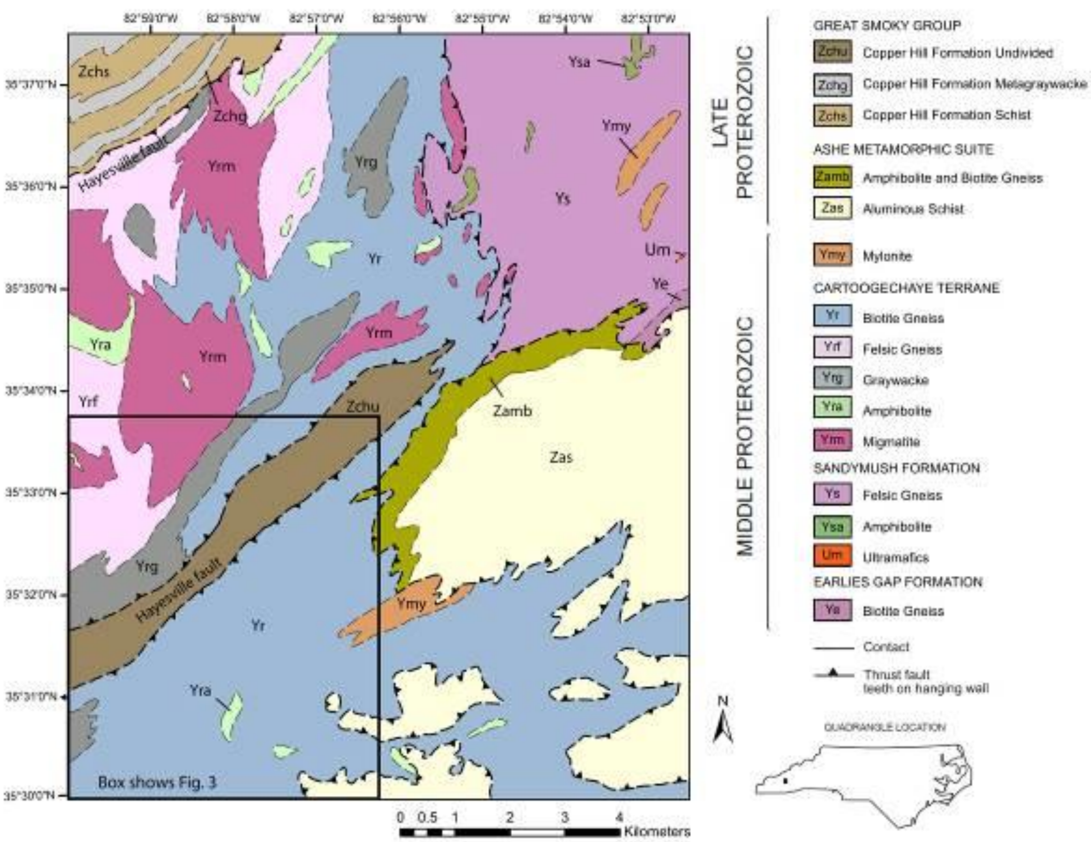

Figure 2. Previously published bedrock geologic map of the Clyde 7.5 minute quadrangle, NC[11]. Lineations and shear sense were not reported in the original publication of this map. The southwest quarter of this quadrangle was remapped for this project (Fig. 3).

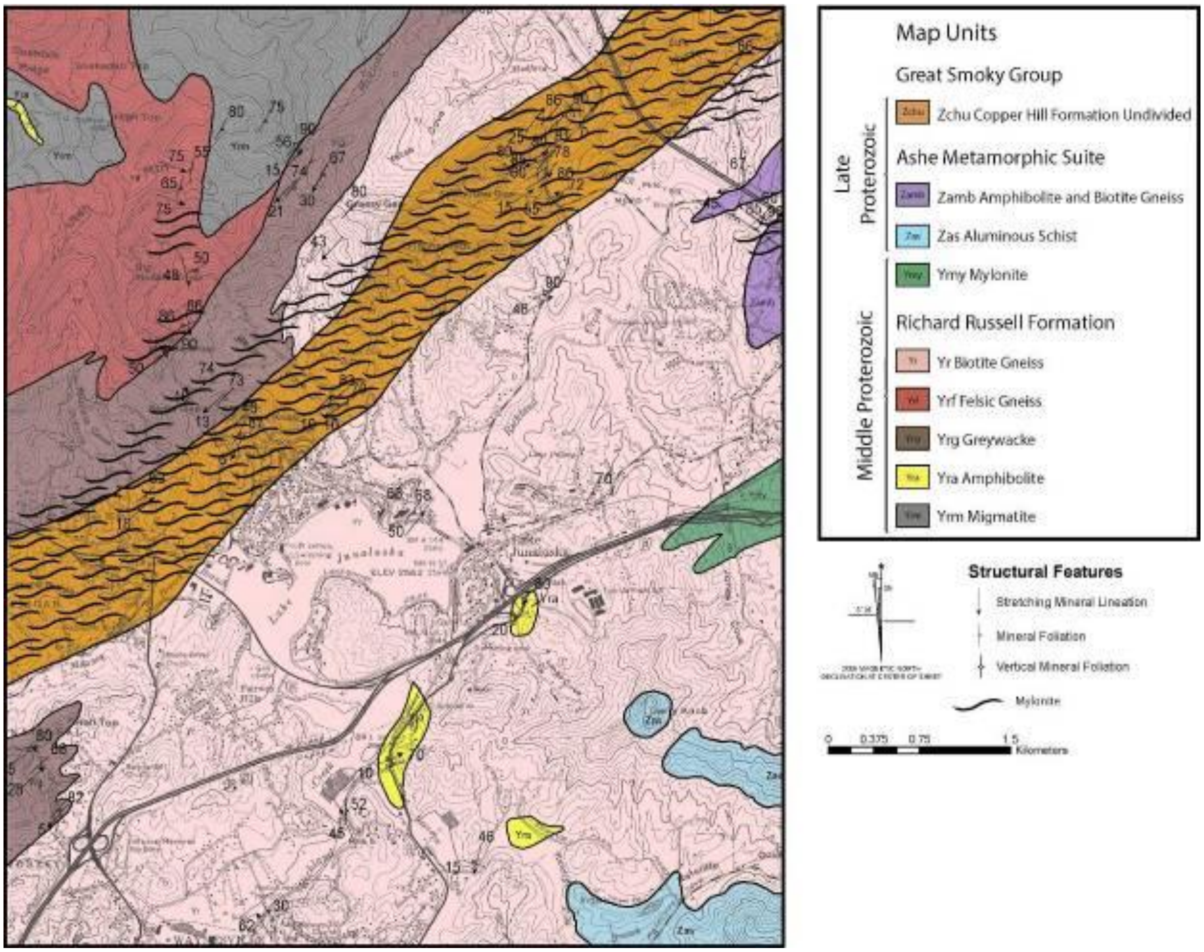

Figure 3. The southwest quarter of the Clyde 7.5 minute quadrangle NC, remapped in this study. This map shows the shear zone documented in this study. Measurements for stretching mineral lineation plunge are given at the bottom left of the symbol, while measurements for mineral foliation dip are given to the top and right of symbol.

1.2. Objective

By mapping the Hayesville fault through the geologic mapping of primarily the southwest quarter of the Clyde Quadrangle, near Waynesville, NC, and through thin section analysis for temperature constraints through quartz dynamic recrystallization identification, this study collected data through detailed geological field mapping and from microstructure analysis of rocks for the hypothesis that the Burnsville fault overprints the Hayesville fault and continues to the southwest (Fig. 1). The field area covers the northeast end of the Hayesville thrust fault, which makes it an ideal place to test hypothesis three. The Alleghanian orogeny has recorded temperatures of <400° C and the dextral strike slip Acadian and northwest thrusting Taconic orogeny has recorded temperatures of ~500° C[5, 6, 8, 9]. Determining temperature and shear sense allows for differentiation between Taconic, Acadian, and Alleghanian deformation. Identifying the southward extension of the Burnsville fault is critical for interpreting the architecture of the Appalachian mountains and for constraining the deformation history.

2. Methods

2.1. Field mapping and hand sample collection

Geologic mapping was conducted in the southwest quarter of the Clyde 7.5-minute quadrangle, NC (Fig. 2), which is located in central Haywood County, NC[11]. At each stop the rock type was mapped and documented. Field observations of the rocks such as rock texture, hardness, color, and mineralogy were documented. Any macroscopic shear sense indicators such as asymmetric boudins, shear folds, S-C fabrics, and rotated porphyroclasts were documented (Fig. 4 and 5). At every stop, geographic location, foliation, and lineation, when visible in the field.

2.2. Microstructural and deformation temperature constraints

It is often difficult to determine shear sense in the field because macro shear sense indicators often are not present or do not clearly display shear directions. For micro analyzation, thin section billets were first prepared by cutting select hand samples perpendicular to foliation and parallel to lineation and were then polished. Microstructures were observed in thin section with a polarizing light microscope exhibit shear sense indicators that may not be visible in hand sample. Some shear sense indicators that are micro in size that show shear sense include: mineral fish, micro orientation patterns such as S-C fabrics (Fig. 6C-6E), δ and σ porphyroclasts (Fig. 6A-D), and quartz lattice preferred orientation[9]. When present, these micro shear sense indicators were documented.

Temperatures during deformation can be estimated from quartz deformation textures visible in thin section using a microscope. Quartz is an incredibly common mineral and recrystallizes in a predictable manner during deformation based on temperature. At lower temperatures during ductile deformation, quartz recrystallization occurs through bulging recrystallization (BLG) at 280-400° C. With an increase in temperature, and therefore depth, subgrain rotation (SGR) occurs between 400-500° C (Fig. 6). Grain boundary migration (GBR) occurs at temperatures from 500-600° C. The temperature constraints given by recrystallization identification and can be used to calculate depth estimates at an assumed rate of 30° C per kilometer of depth. The temperatures given by quartz recrystallization were used to determine whether Acadian (~500° C) or Alleghanian (<400° C) temperatures were present.

3. Results

3.1. Field observations

The basement rock location and mineral foliation planes reported by *Merschat and Wiener*[11] (Fig. 2) appears to mostly align with the finding of this study. It was seen in the field that *Zchu* does not likely extend as far north as previously documented, and that a pocket of migmatic *Yra* amphibolite, part of the Richard Russell Formation, is present 0.6 km east of Lake Junaluska (Fig. 3). Pockets of granite about 0.5-4 m across were also present within the *Zchu.* Granite was not previously observed as being present within *Zchu*.

Vertical to near-vertical dipping, southwest to northeast trending (~N45°E) mylonite was documented primarily within *Zchu* that extended ~0.35 km to the north of *Zchu* in *Yrg* and *Yr* and ~0.12 km to the south in *Yr* along the northeast extension of the Hayesville fault (Fig. 3) showing strike slip motion with minor thrusting. This mylonite contained horizontal to near-horizontal mineral stretching lineations (Fig. 7A). The shear direction of deformed minerals within all the mylonite of this shear zone were consistent with strike slip faulting documented to the northeast near Asheville and Burnsville, NC. The width of the mylonite zone was ~1.4 km wide. Within this shear zone there were blocks of rock that were sheared to lesser degrees and in one case appeared microscopically unsheared. The largest unsheared block observed was measured to be 20 m or wider. Determining the full width of this block was not possible because rock visibility was limited to road cuts and occasional outcrops. This block was present within *Zchu* and contained granite and gneiss. The petrology of this block macroscopically looked closer in appearance to *Yr* than *Zchu*. Two thinner zones of unsheared or lesser sheared, crystalline rock, one with a width of ~5 m, and another thinner, ~1 m block were documented ~10 m apart, with mylonite between, and were present within the *Zchu*. A block of unknown width of lesser sheared rock was present 0.15 km to the north of *Zchu* within *Yrg*. The blocks of lesser or unsheared rock that were present in the shear zone were harder and more crystalline with less mica than the rocks that were sheared.

The *Yr* bedrock south of the shear zone appeared to contain more muscovite and appeared more schist like. This is consistent with the description of the Ashe metamorphic suite. There is a possibility that the Cartoogechaye Terrane is only present to the north of the Hayesville fault/hypothesized continuation of the Burnsville fault shear zone and that the Ashe metamorphic suite is present to the south. Further mapping to the southwest, and better documentation is needed to conclude whether the Ashe metamorphic suite, part of the EBR, is present directly south of the fault, or if the current interpretation of the presence of *Yr* is correct.

Shearing was also found at the contact of *Yrf* and *Yrg*, and within *Yrf*. Due to lack of evidence and similarities, these sheared rocks were not thought to be associated with the Burnsville fault. This location had mylonite which showed southeast to northwest trend, along N105°E, with steep, 48° to vertical, lineations trending north to south. Folds here showed top to south thrusting motion.

The stretching mineral lineations seen within rocks in the Hayesville fault shear zone all trended northeast to southwest, along N45°E (Fig. 7A), and dipped slightly or were horizontal. The highest concentration horizontal lineations were seen within the *Zchu*, along the Hayesville fault suggesting strike slip movement with some thrusting motion. Mineral lineations for the rest of the field area did not shown the same trend or plunge consistency and were generally not as strong. Mineral lineations, given in trend and plunge, for shear zone can be seen in Fig. 7A and for the remaining field area to the North, in Fig. 7B, and to the South, in Fig. 7C.

Most foliation measurements taken in the field orient northeast to southwest and dip to the Southeast (Fig. 7A-C). Within *Zchu* bedrock foliation strike and dip measurements were even more consistent with a generally steeper dip, usually close to vertical (Fig. 7A). Vertical foliation is consistent with strike slip faulting seen to the northeast along the Burnsville shear zone.

Figure 4. (A) Near vertical mylonite present in *Zchu* consistent with what has previously been documented to the northeast in the Burnsville shear zone. (B) Mylonite present in *Zchu* with porphyroclasts (shown with blue arrows) and a lesser sheared crystalline block (denoted by the red arrow). Both images were taken looking southeast towards 230°.

Macro and micro dextral shear sense indicators were present within the study area. Macro shear sense indicators that were present included augans, boudins, shear folds, and rotated and stretched porphyroclasts (Fig. 4 and 5). They were seen most commonly within *Zchu*. Shear sense indicators were also consistently present within 0.35 km to the north and 0.12 km south of the *Zchu* within the *Yr* and *Yrg*. Most of the shear sense indicators present showed dextral strike slip movement with horizontal to somewhat heterogeneous lineations, though some boudins within the shear zone showed some thrusting motion (Fig. 3B). Several sheared quartz veins were observed, some with shear folds, or rotations showing dextral motion when viewed from the top (Fig. 4). Macro and micro shear sense indicators were not seen farther from the *Zchu* except for at the contact of *Yrf* and *Yrg* and within *Yrf* 2.2 km northwest of Lake Junaluska and within a previously mapped contact 3.1 km northeast of Lake Junaluska between *Yr* and Zamb. This contact of *Yr* and *Zamb* was previously interpreted as a possible continuation of the Burnsville fault as part of the Chattahoochee-Dahlonega fault[6]. Some rotated porphyroclasts and augans showed a thrusting motion here. No clear micro shear sense indicators were seen at this location (Fig. 6F).

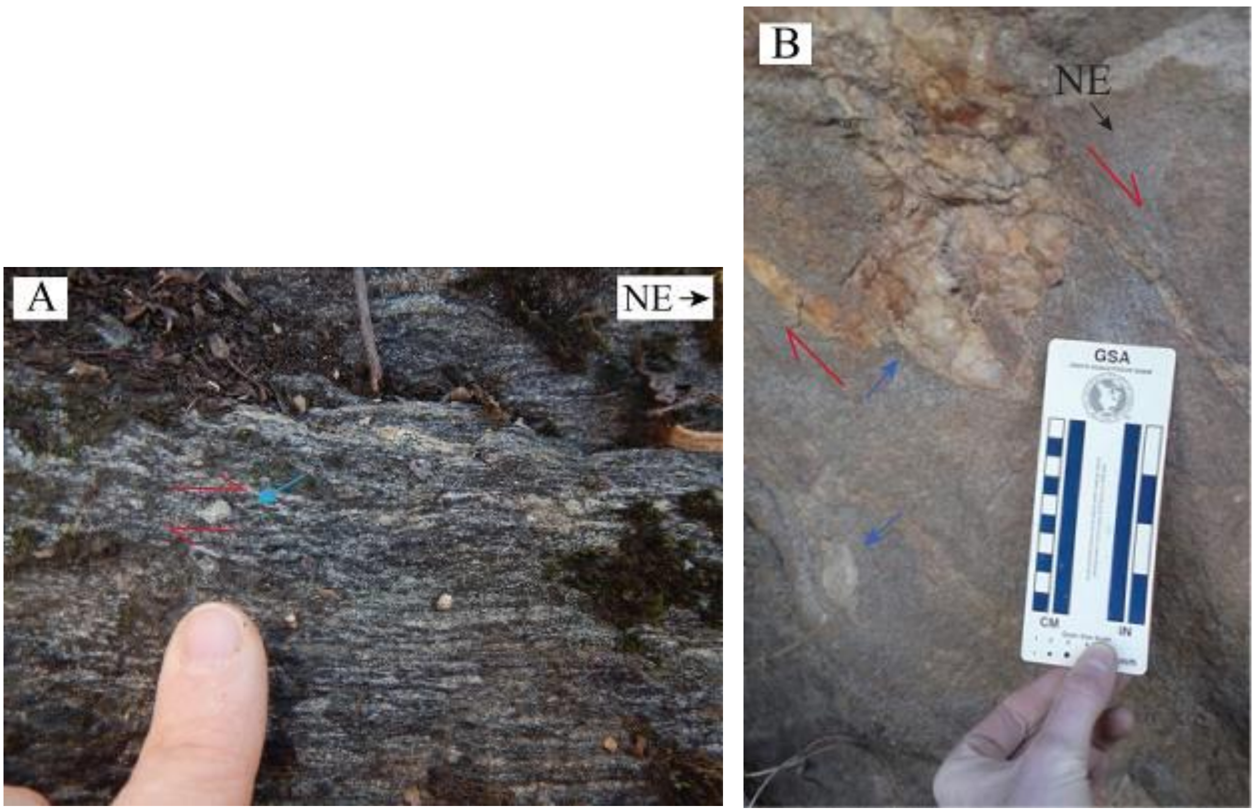

Figure 5. (A) Dextraly sheared *Yrg* containing porphyroclasts with tails located on the northern edge of shear zone. (B) Sheared quartz with tails. The blue arrows show porphyroclasts and the red arrows show shear sense in both images. Both images were taken looking down at the top of the rock.

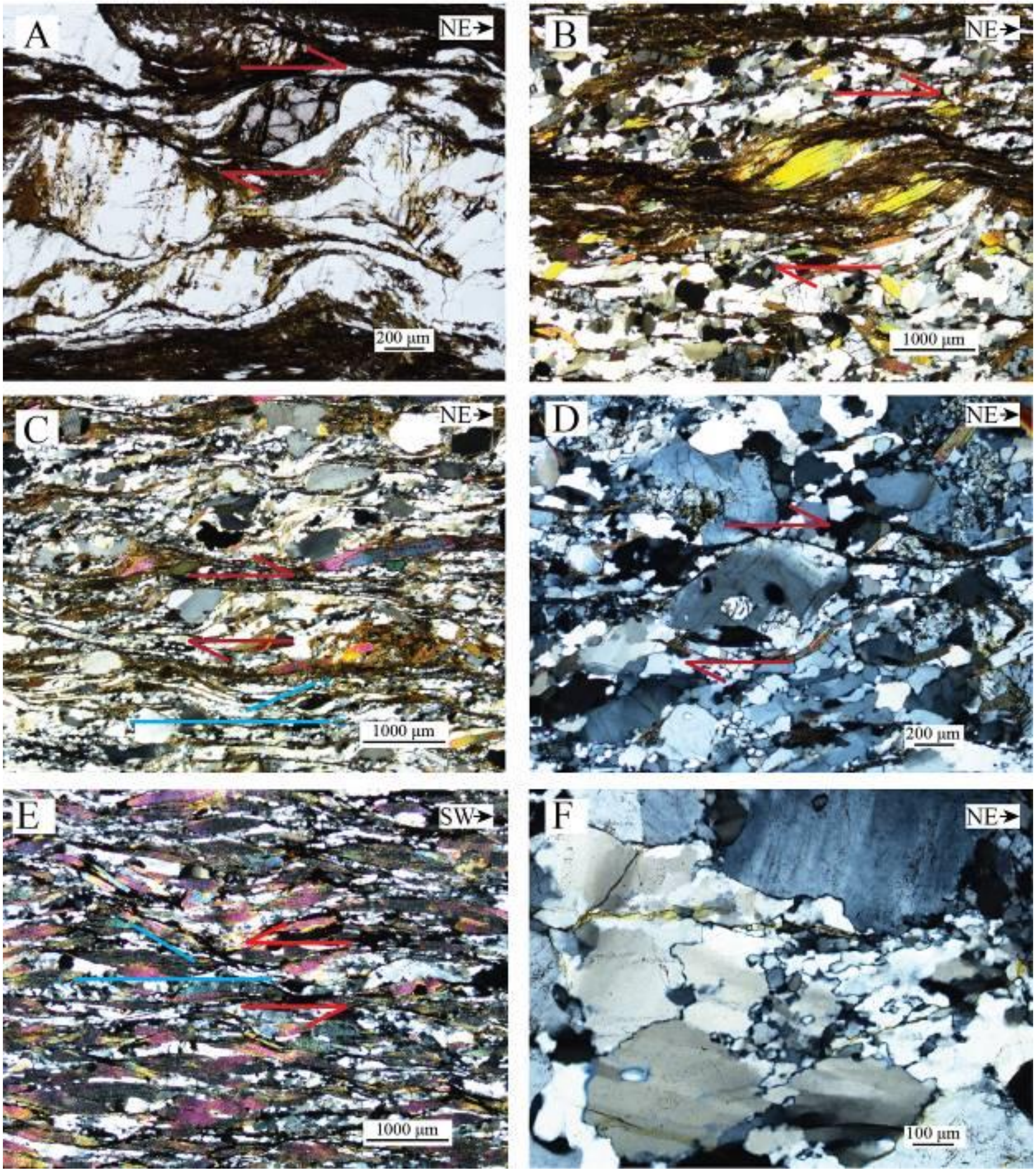

Figure 6. Microstructure shear sense indicators and dynamic quartz recrystallization documented through a transmitted light microscope. (A) Rotated garnet and quartz porphyroclasts with tail under plane light. (B) Dextral shear fabric and SGR quartz recrystallization under cross polarized light. (C) Dextral S-C fabric with sheared feldspars and quartz with SGR and a small amount of BLG quartz recrystallization under cross polarized light. (D) Dextrally sheared feldspar with quartz SGR and BLG. (E) S-C fabric which when oriented is dextral. Viewed under cross polarized light. (F) BLG and SGR quartz recrystallization under cross polarized light. All samples were collected from *Zchu* except for 10.F which was taken 3.1 km northwest of Lake Junaluska at the contact of *Zamb* and *Yr*.

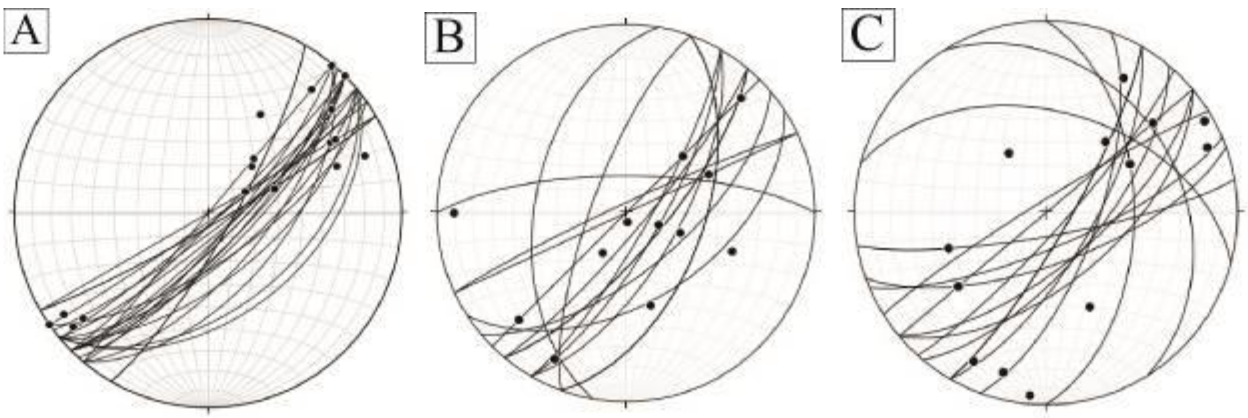

Figure 7. (A) Mineral foliations and stretching mineral lineations for the Hayesville fault in Haywood County, NC and possible local continuation of the Burnsville shear zone (Fig. 3). (B) Mineral foliations and stretching mineral lineations for the field area north of the shear zone. (C) Mineral foliations and stretching mineral lineations for the field area south of the shear zone.

3.2. Laboratory Observations

Micro shear sense indicators that were seen include mineral fish, lamellae, δ and σ porphyroclasts, and micro orientation patterns such as S-C fabrics, shear folds, and lattice preferred orientations (Fig. 6). Rotated porphyroclasts, shear folds, and S-C fabrics all showed dextral movement in all but one sample, that showed no movement, taken within *Zchu* (Fig. 8). The sample that did not show movement was likely part of an unsheared block within the shear zone.

SGR was the most common type of recrystallization and was seen in every sample in, and outside of the shear zone. The temperatures shown from dynamic quartz recrystallization show that SGR is the most common level of dynamic recrystallization which suggests temperatures of ~500° C and depths of 17 km. Some *Zchu* samples within the shear zone showed some BLG overprinting SGR (Fig. 6C and 6D) suggesting possible uplifting to depths of 13 km. Some samples in the *Yrg* basement show GBM overprinted by SGR overprinted by BLG. BLG was not present in every sample along the hypothesized shear zone, and when present was not very strong.

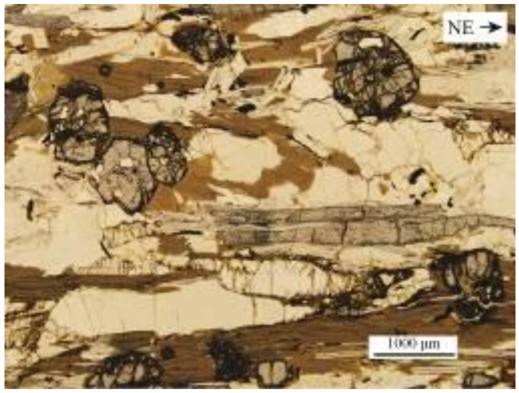

Figure 8. Only sample that did not show shearing from all samples collected from *Zchu.* Sample taken from a block of lesser sheared rock within *Zchu*. Thin section viewed under plane light.

4. Discussion

The Hayesville fault system is complex with uncertainties and assumptions resulting from possible overprinting, reactivation and a variety of tectonic models[5, 20]. This study indicates through findings from field mapping and micro analysis that it is possible the Hayesville fault, at least locally, was reactivated during the Acadian orogeny as the Burnsville fault. To the northeast, the Burnsville fault reactivated the contact between AMS and basement rocks. It is possible that reactivation of the Hayesville fault occurred within the field area for this study.

A ~1.4 km shear zone was documented mostly within the *Zchu*, at the northeast extension of the Hayesville fault, that extended slightly to the north and south into *Yr* and *Yrg*. To the northeast near Asheville, the Burnsville fault is documented with having a ~2 km wide shear zone within the AMS adjacent to basement rocks[9]. The vertical to slightly southeast dipping, and trending southwest to northeast, foliation of the feldspar mylonite found shows horizontal ductile shearing. This is consistent with strike slip faulting and with the Burnsville shear zone to the northeast. The horizontal with some heterogeneous plunge angles, trending southwest to northeast, stretching mineral lineation documented suggests strike slip movement with the possibility of minor thrusting motion. This matches previously documented areas along the Burnsville fault shear zone. The southwest to northeast foliations found within the area of study are very similar and almost the same as the foliation found where the Burnsville fault has previously been mapped (Fig. 7A). The similarities seen between the foliation in the field area for this study and previously mapped area of the Burnsville fault show an extremely close similarity in trend direction and dip angle. The foliations and mineral lineations were not as consistent elsewhere in the field area (Fig. 7B and 7C). Macro and micro shear sense indicators also consistently showed dextral movement. The presence of the Burnsville fault predominantly within *Zchu* is also supported from the possibility that strain partitioning occurred in the weaker rock. *Zchu* contains more muscovite and was likely able to shear easier than the surrounding *Yr* and *Yrg*. This type of opportunistic fault behavior is seen in the Burnsville fault near Asheville[9]. Temperatures of ~500° (Fig. 6), consistent with Acadian temperatures, along with dextral shear sense (Fig. 5) support the possibility of an Acadian age for this shear zone.

The Hayesville fault separates the EBR from the WBR to southwest of the field area[5]. To the northeast, the Burnsville fault is documented with separating the EBR and WBR[8]. If the Hayesville fault is connected to the Burnsville fault, the EBR and WBR boundary could be defined as one fault. The location of the Burnsville fault as the reactivated Hayesville fault also geometrically makes sense as it allows for the Burnsville fault to continue in a cohesive direction, which is consistent with strike slip faulting. These findings support an interpretation that the Burnsville fault does not continue along the Chattahoochee-Dahlonega fault, but rather suggests the possibility that the northeastward extension of the Hayesville fault, at least locally within this field area, was reactivated as the continuation of the Burnsville fault (Fig. 2 and Fig. 3).

The commonality of SGR shows temperatures of ~500° C which closely matches the temperatures already documented along the shear zone to the northeast, north of Asheville NC. The samples, which showed BLG overprinting SGR within the shear zone, suggest a slightly lower temperature for some samples than temperatures observed north of Asheville and Burnsville NC along the shear zone. Because the BLG is not very developed in any of the samples from this shear zone, and is only present in some of the samples, it is not possible that movement continued for very long after temperatures reached 400° C.

The temperatures found north of Asheville NC by *Corradino*[9] are somewhat cooler, showing SGR, than the temperatures reported by *Trupe*[8] further to the northeast near Burnsville NC, where mostly GBM was documented[8, 9]. The lower temperatures found in this study area and lower temperatures documented north of Asheville NC, compared to what was documented near Burnsville NC, possibly suggest that there is a trend in which the temperatures along the fault zone cools slightly further to the southeast, although more detailed mapping is needed to support this. *Trupe*[8] suggests that strike-slip movement had to stop by 362 mya, from cooling ages within the shear zone near Burnsville, NC. Slightly cooler temperatures within the field area for this project, suggests that deformation could have continued past 362 mya. The sample taken from the Chattahoochee-Dahlonega shear zone (Fig. 6F) 3.1 km northeast of Lake Junaluska showed the most BLG of any sample, which is less consistent with the Burnsville shear zone (Fig. 6A-6E). This also matches the Alleghanian temperatures of less than 400° C.

The possibility of the existence of the Burnsville fault continuing as a dextral strike slip through Haywood County as the Hayesville fault—past the Fries and Chattahoochee-Dahlonega faults—pulls into question the existing tectonic configurations for these faults within Haywood County. Several studies have previously suggested reactivation of the Hayesville fault, and a proposed northeastward extension by Acadian and/or Alleghanian orogenies[1, 6, 15-17].

If indeed the Burnsville fault does not continue along the Chattahoochee-Dahlonega fault, then the continuation of the Chattahoochee-Dahlonega fault is unknown. As the Chattahoochee-Dahlonega and Fries faults are both clearly documented as being Alleghanian structures, it is not possible for the Burnsville fault to have overprinted and truncated either of these faults[13]. It is unclear how far southwest the Burnsville fault continues. *Massey and Moecher*[5] mapped the Hayesville fault roughly twelve kilometers to the southwest of the study's field area, defined as the boundary of the EBR and WBR, and did not see dextral shearing along the boundary. They did encounter two small dextral zones fault, one 5 m wide located roughly 1 km north of the Hayesville fault and another roughly 5 km to the north[5]. These thin shear zones somewhat match what was observed in this study's field area, though lack of any further shear zones, and evidence that these events were separate, calls into question this assumption[5]. Further field mapping is needed to document the southward extension of the Burnsville fault.

5. Conclusion

This study mapped the northwest extension of the Hayesville fault to test for the location of the southward extension of the Burnsville fault. The presence of a roughly ~1.4 km wide dextral strike slip shear zone with many similarities to previously documented sections of the Burnsville fault suggests that the Burnsville fault continues along the Hayesville fault in the location of this study. This shear zone records temperatures which suggest Acadian to slightly post-Acadian shearing, and exhibits macro and micro dextral shear sense indicators, horizontal with some heterogeneous plunging mineral lineations, and vertical to slightly southeastward dipping mylonitic rocks. These data suggest that the Burnsville fault does not continue along the Chattahoochee-Dahlonega fault. Further mapping is needed to document the location of the Burnsville fault south of this study as well as the intersection with the Fries and Chattahoochee-Dahlonega faults.

6. Acknowledgments

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