Text and references to accompany Nevada Bureau of Mines and Geology Map 172

Geologic Map of the Wood Hills, Elko County, Nevada

by

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INTRODUCTION

The Wood Hills are a structurally complex terrain of metamorphosed and unmetamorphosed Paleozoic strata and Cenozoic surficial, volcanic, and volcaniclastic rocks. These rocks form a gentle structural and topographic dome (Thorman, 1970) with no known range-bounding normal faults. Structurally, rocks within the Wood Hills record deep tectonic burial and metamorphism during the Mesozoic and ductile to brittle extension that accommodated exhumation of metamorphosed strata during the Cenozoic. The purpose of this map and accompanying text is to describe and discuss structures in the Wood Hills. More regional tectonic and structural interpretations that integrate geologic data discussed herein from the Wood Hills are presented elsewhere (e.g., Camilleri and Chamberlain, 1997; Camilleri and McGrew, 1997; Camilleri, 1998; Camilleri, 2009).

The Wood Hills are structurally divided into two plates separated by a low-angle normal fault, the Wood Hills fault (figs. 1 and 2). This fault separates unmetamorphosed Paleozoic and Cenozoic strata in its hanging wall from regionally metamorphosed and polydeformed Paleozoic strata in its footwall. For simplicity, the description of the structure in the Wood Hills is divided into three main parts. The first and second parts focus on the markedly different structures within rocks in the footwall and hanging wall of the Wood Hills fault, respectively. The third part discusses high-angle normal faults that occur in both the hanging wall and footwall of the Wood Hills fault.

PREVIOUS WORK AND METHODS

Thorman (1970) was the first to recognize and correlate Paleozoic strata in the Wood Hills with the Cordilleran miogeocline, and he was the first to define major structures. This work builds upon Thorman's (1970) fundamental contribution by dividing and refining the stratigraphy, by mapping metamorphic isograds, and by strain analyses of the metamorphic rocks. These new data resulted in a more detailed picture of the structural and metamorphic character of the Wood Hills.

Mapping of the Wood Hills was conducted from 1988 to 1992. U.S. Geological Survey 1:24,000-scale topographic quadrangles served as base maps. Tertiary units and Quaternary surficial units were mapped principally by using 1:24,000-scale color aerial photographs.

REGIONAL FRAMEWORK

The Wood Hills form part of a large terrain of Paleozoic strata that underwent tectonic burial and Barrovian metamorphism in the Cretaceous, broadly synchronous with convergence in the Sevier fold and thrust belt to the east (fig. 1; Camilleri and Chamberlain, 1997). This terrain includes the Pequop Mountains to the east and the East Humboldt Range–Ruby Mountains to the west. The Paleozoic section within this terrain ranges from unmetamorphosed to the east and progressively increases in metamorphic grade to upper amphibolite facies in the west (fig. 1). An increase in metamorphic pressure accompanies the northwest increase in metamorphic grade and consequently progressively deeper levels of the Mesozoic crust are exposed from southeast to northwest (fig. 1). The Wood Hills form an intermediate grade, mid-crustal part of the terrain. The Barrovian metamorphic pattern within this terrain has been attributed primarily to tectonic burial during the Mesozoic (Camilleri and Chamberlain, 1997).

Exhumation of the metamorphic terrain in the Wood

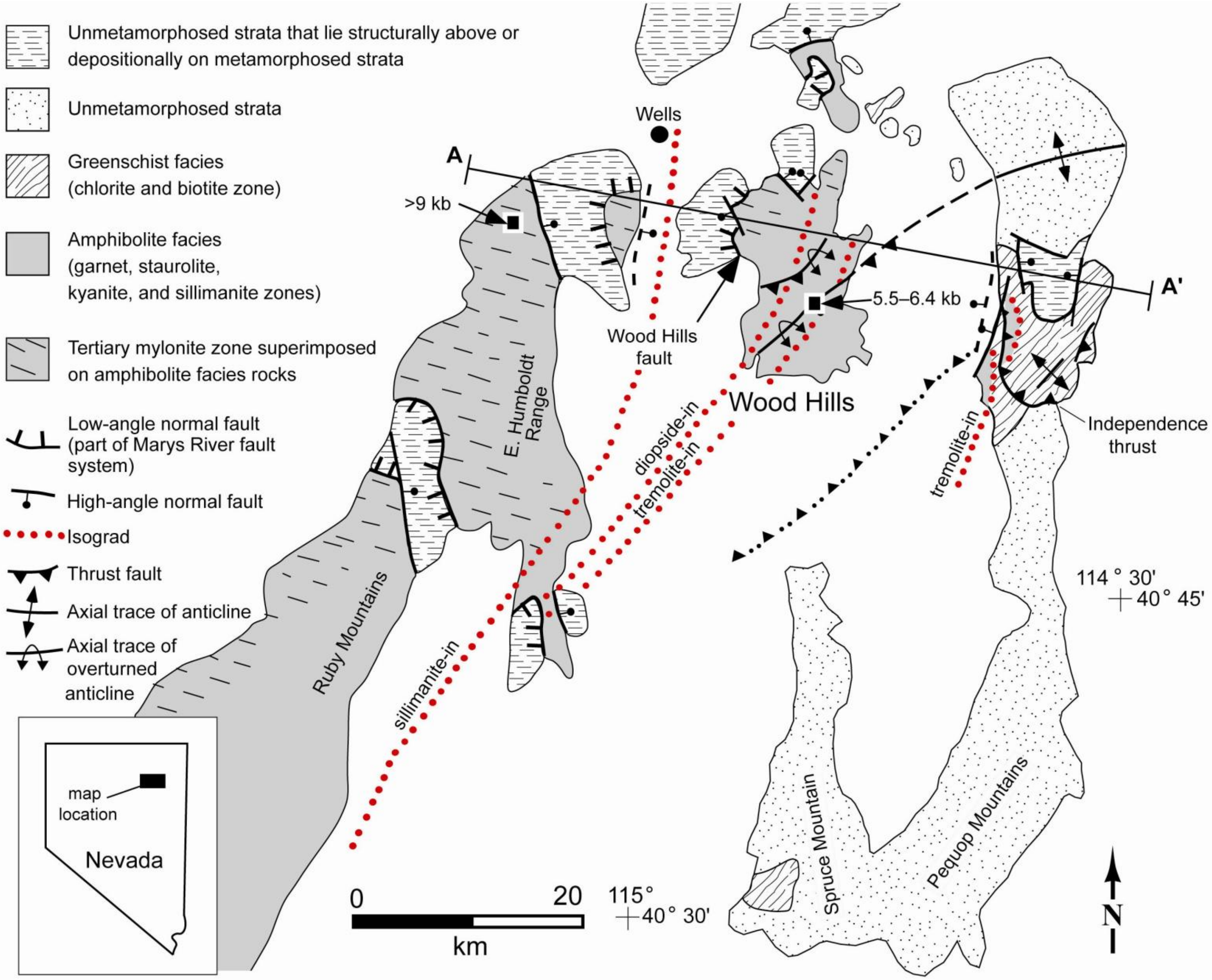


Figure 1. Metamorphic map of the Wood Hills and vicinity. Map is modified after Camilleri and Chamberlain (1997). Barometric data shown in the Wood Hills are from Hodges et al. (1992) and in the East Humboldt Range from McGrew et al. (2000). Diopside- and tremolite-in isograds are for calc-silicate rocks and the sillimanite-in isograd is for metapelite. A–A' is line of section shown schematically in figure 10c.

Hills and East Humboldt Range was accomplished largely by the Cenozoic top-to-the-west-to-northwest Marys River normal fault system (e.g., Mueller and Snoke, 1993a and b). This normal fault system is manifest regionally as a series of low-angle normal faults that lie atop a related normal-sense mylonitic shear zone superimposed on the metamorphic rocks (fig. 1). One fault segment related to this system is the Wood Hills fault, which is exposed in the northwestern corner of the Wood Hills (fig. 1). The hanging walls of the low-angle normal faults associated with the Marys River fault system characteristically contain fragments of an east-dipping, unmetamorphosed Paleozoic section that is depositionally overlain by Eocene-Oligocene volcanic rocks and by the Miocene Humboldt Formation. The Humboldt Formation represents synextensional basin fill deposited as a consequence of slip along the Marys River fault system (Mueller and Snoke, 1993a and b).

STRATIGRAPHY

Rocks within the Wood Hills are divisible into three distinct groups: 1) rocks comprising the footwall of the Wood Hills fault, 2) rocks in the hanging wall, and 3) Tertiary to Quaternary surficial deposits. The three groups are briefly discussed here; however, more complete lithologic descriptions are given in the description of map units.

The footwall of the Wood Hills fault is composed of regionally metamorphosed Cambrian to Upper Devonian strata and Cretaceous (?) granitic dikes and pods. Paleozoic strata are predominantly marble with minor quartzite and metapelite, and are ductilely deformed and variably attenuated. Comparison of thicknesses of metamorphosed units in the Wood Hills with undeformed but correlative units in adjacent ranges suggests that units are attenuated by as much as 50 percent (Camilleri, 1994). Exposures of granitic intrusions in the Wood Hills tend to be small, commonly less than 4 m^2, and are sparse but appear to be more abundant in the northwestern part of the range. Although only a few intrusions were mapped in this study, Thorman's (1970) map of the Wood Hills highlights the relative northwest increase in granite intrusions.

Rocks in the hanging wall of the Wood Hills fault contrast sharply with footwall rocks. Hanging wall rocks consist of unmetamorphosed Devonian to Permian carbonate and clastic strata, Eocene volcanic rocks, and the Miocene Humboldt Formation. Moreover, hanging wall rocks are unfoliated and lack intrusions.

The youngest units in the Wood Hills consist of Tertiary? to Quaternary surficial deposits that cover strata in the footwall and hanging wall of the Wood Hills fault. These deposits include modern and older alluvium and pluvial sediment. All of these deposits mantle an extensive pediment surface surrounding the topographically dome-shaped Wood Hills. Pluvial sediment (unit Qla) was deposited up to a Pleistocene shoreline, and the contact between Qla and alluvium (Qau) represents this shoreline as well as the lake's high stand. Older alluvium (unit QTs) is prominent, mantling metamorphic rocks on the west-central flank of the Wood Hills. In addition, in a few places, well-rounded pebbles of unmetamorphosed and metamorphosed Paleozoic strata were found atop some of the highest ridges in the Wood Hills and these may be remnants of older alluvium. The occurrence of these pebbles suggests that the Wood Hills were previously overlain by a veneer of alluvial debris that has been largely eroded away.

STRUCTURES AND METAMORPHISM IN THE FOOTWALL OF THE WOOD HILLS FAULT

The footwall of the Wood Hills fault contains several overprinting structures. The most pronounced and pervasive structural features are a prograde metamorphic fabric and overprinting map-scale northwest-vergent folds (Thorman, 1970). Additional prominent, but localized, structural features include a brittle low-angle fault in the southernmost part of the range; a folded low-angle normal fault in the central part of the range; and a zone of mylonitization structurally beneath the Wood Hills fault in the northwestern part of the range (fig. 2). The relative ages of these structural features, in order of decreasing age, are inferred to be (1) folded low-angle normal fault, (2) regional metamorphic fabric, (3) northwest-vergent folds, and (4) mylonite zone and brittle low-angle fault. For simplicity, metamorphism and the northwest-vergent folds are discussed before the more localized structural features.

Metamorphism

Paleozoic strata beneath the Wood Hills fault record a single, prograde Barrovian type metamorphic event. Metamorphism was accompanied by the development of a single foliation (S_1) and in places a lineation (L_1). Metamorphic mineral assemblages indicate that the rocks are amphibolite facies and that metamorphic grade increases from southeast to northwest. A general increase in grain size of the metamorphic rocks accompanies the northwest increase in metamorphic grade. The timing of peak metamorphism in the Wood Hills is inferred to be ca. 84 Ma (Late Cretaceous) based on U-Pb data from sphene derived from the Wood Hills and adjacent Pequop Mountains (Camilleri and Chamberlain, 1997).

Mineral assemblages in metamorphosed pelite and siliceous dolomite define both metamorphic grade and lateral variations in grade within the Wood Hills. A discussion of these assemblages is presented first and is followed by a discussion of the character of the metamorphic fabric and ductile flow that accompanied its development.

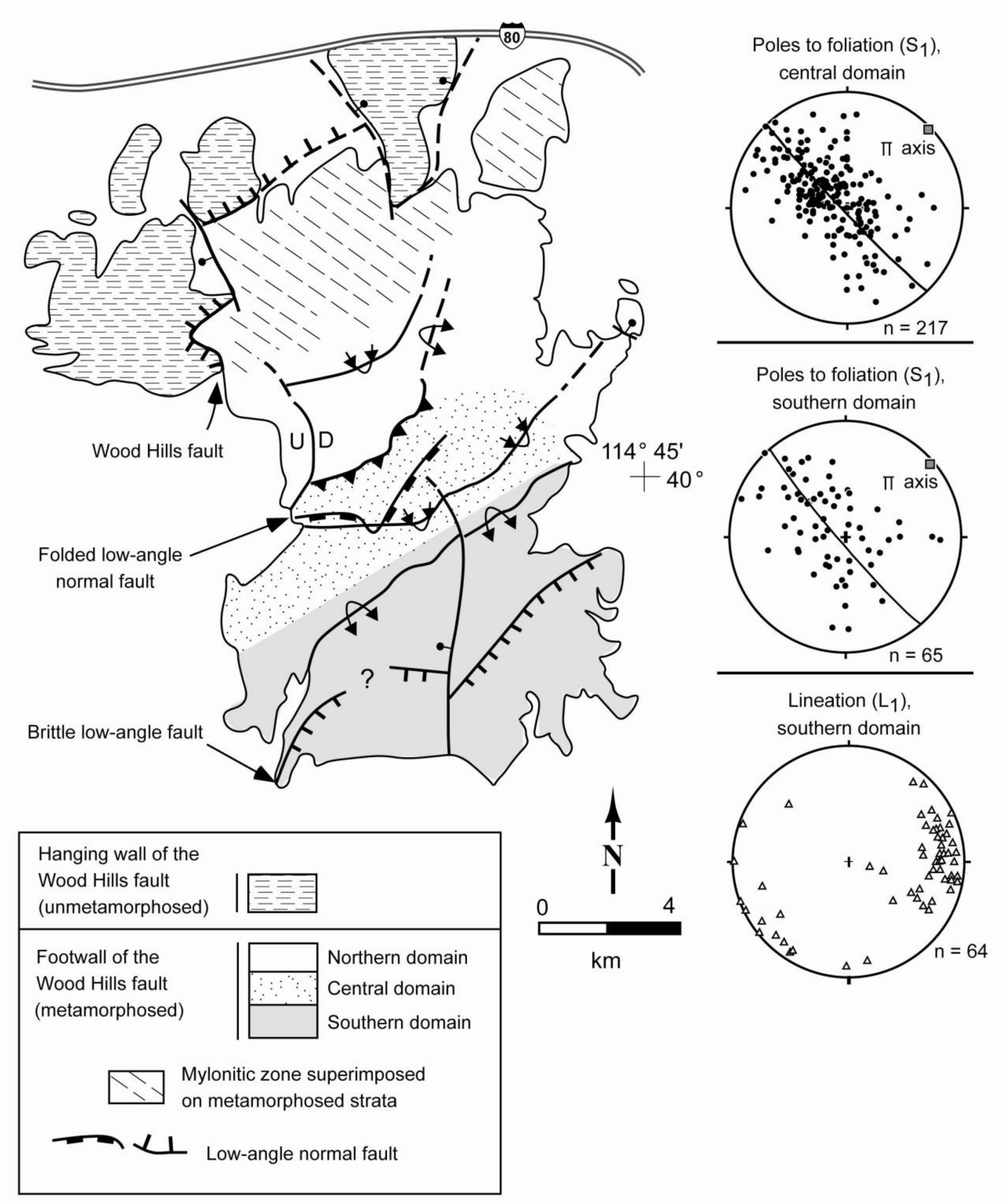


Figure 2. Simplified tectonic map of the Wood Hills. Stereograms (π diagrams) for the central and southern domains show poles to foliation and a best fit great circle to the poles. Assuming the folds in the Wood Hills are roughly cylindrical, the pole (π axis) to the great circles defines the general trend and plunge of the fold axes.

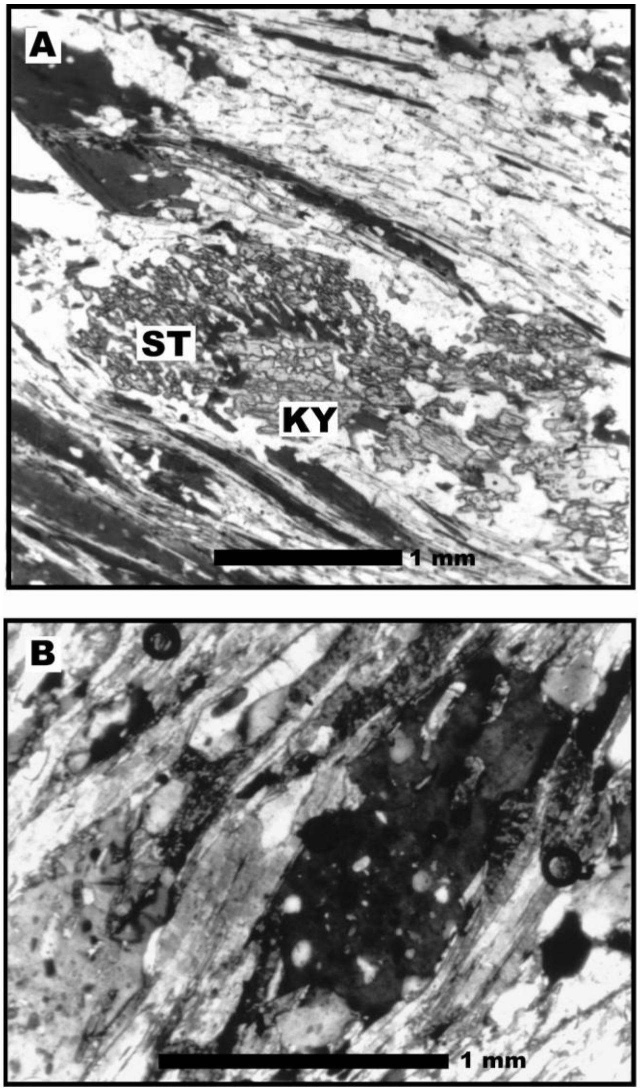


Figure 3. A) Plain light photomicrograph of kyanite-bearing Dunderberg Shale [schist] showing the reaction: staurolite ---> kyanite + biotite. The dark mineral between the staurolite and kyanite grains is biotite. **B)** Photomicrograph of Kanosh Shale [schist] in crossed polars. Elliptical, extinct grain in the center is feldspar. Feldspar is surrounded by coarse-grained biotite and muscovite. Mineral abbreviations are given in appendix B.

Metamorphism of Pelitic Units

Metapelites constitute a minor percentage of the metamorphic rocks, but they are the only rocks that yield diagnostic assemblages for assessing metamorphic grade. The Cambrian Dunderberg Shale and the Ordovician Kanosh Shale are the only prominent metapelitic units in the Wood Hills. The Dunderberg Shale is included in Unit Cdm, and the Kanosh Shale forms the top of unit Opc. The metapelites texturally range from phyllite to schist and are mineralogically variable. However, all metapelites contain biotite and none were observed to contain prograde metamorphic chlorite. The lack of prograde chlorite in all metapelites is suggestive of amphibolite facies metamorphism.

The Dunderberg Shale is the stratigraphically lower exposed metapelitic unit in the Wood Hills. Typical assemblages in the Dunderberg Shale [schist], in order of decreasing abundance, are BI-MU-Q-PL-ALL-TOUR ± CC, BI-MU-KY-ST-Q-PL-ALL, and BI-ST-KY-GT-MU-Q-PL-ALL-RT-IL (a list of mineral abbreviations is given in appendix A). Textural relationships indicate that kyanite in the assemblage BI-ST-KY-GT-MU-Q-PL-ALL-RT-IL is a byproduct of the breakdown of staurolite by a reaction such as Q + MU + ST = BI + GT +KY (fig. 3a). The kyanite-staurolite-bearing schists are sparse and were found in only two localities (fig. 4), but are important because they record the transition from the Barrovian staurolite to kyanite zones and indicate upper amphibolite facies metamorphism. Moreover, Hodges et al. (1992), on the basis of thermobarometric analysis, reported metamorphic pressures of 5.5–6.4 kb (or depths of ~ 18 to 24 km) and temperatures of ~ 540–590 °C for the Dunderberg Shale in the easternmost kyanite locality (fig. 4). Because the Dunderberg shale, prior to metamorphism, was probably at a stratigraphic depth of ~ 8 km, or pressure of ~ 2.2 kb, the barometric data imply that metamorphosed strata in the Wood Hills were subjected to pressures that are ~ 3 to 4 kb in excess of pressures at stratigraphic depths (Camilleri and Chamberlain, 1997). Such excessive pressures are likely a consequence of tectonic burial.

The Kanosh Shale is the younger metapelitic unit and its mineral constitution does not vary significantly (fig. 4). It contains a typical equilibrium assemblage of BI-MU-Q-FS-TOUR-ALL (fig. 4). The association of this mineral assemblage with the kyanite-bearing schists of the Dunderberg Shale indicates that the Kanosh assemblage is stable in the kyanite zone. The Kanosh Shale is not a true pelite in the sense that within the amphibolite facies it does not yield high-aluminum metamorphic minerals. Despite the lack of variance in mineral assemblage, the Kanosh Shale exhibits pronounced textural changes with respect to fabric and the growth of porphyroblastic feldspar. The Kanosh Shale is a phyllite in the southeastern corner of the Wood Hills and is a schist to the northwest (fig. 4). Within phyllitic rocks incipient feldspar porphyroblasts form clots that consist of a mesh of biotite, muscovite, quartz, and feldspar with diffuse grain boundaries. Within schistose rocks, feldspar porphyroblasts are well-formed with minor inclusions and have sharp grain boundaries (fig. 3b).

Metamorphism of Siliceous Dolomite

Mineral assemblages in metamorphosed siliceous dolomite vary spatially and consequently allow approximate placement of calc-silicate isograds. The metamorphic rocks are divided into talc, tremolite, and diopside zones separated by approximately located northeast-trending tremolite- and diopside-in isograds. Talc zone rocks comprise the southeastern part of the range, tremolite zone the central sector, and diopside zone rocks the western part of the range (fig. 5). Although the

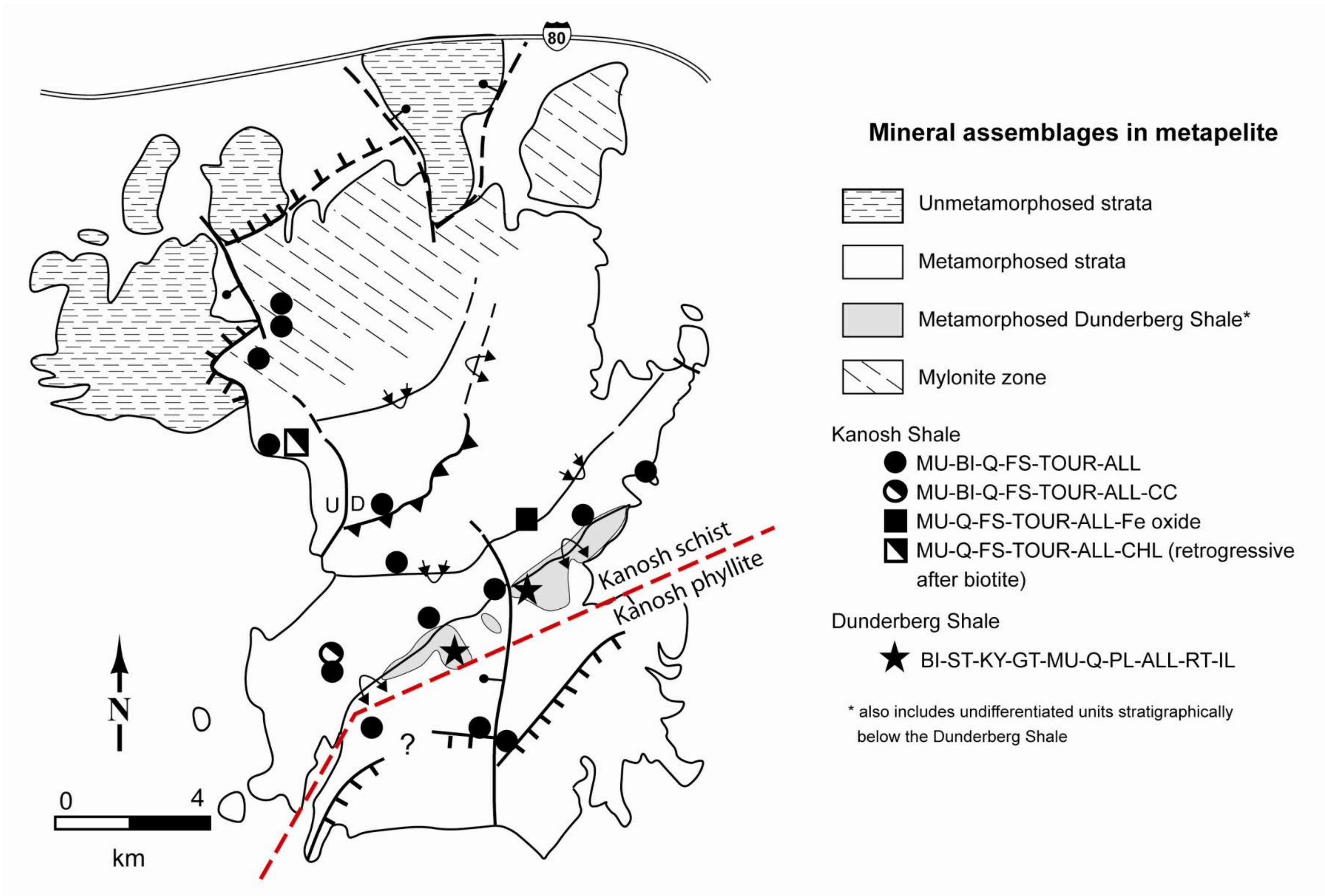
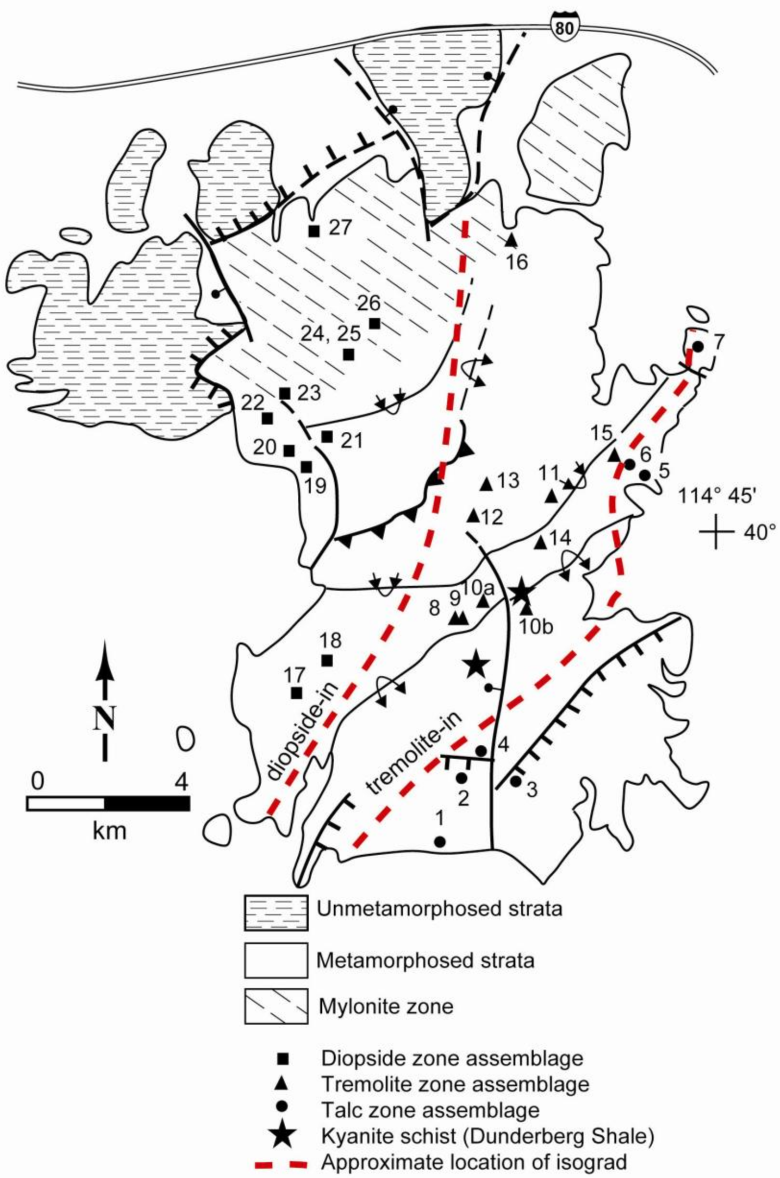


Figure 4. Metamorphic map showing locations of, and assemblages in, the Kanosh and Dunderberg Shales. Dashed line in the southern Wood Hills represents the approximate textural boundary between Kanosh phyllite and schist. Mineral abbreviations are given in appendix B.



Mineral assemblages in calc-silicate rocks

Talc zone

(1) Simonson Dolomite, Q-DO
(2) Fish Haven Dolomite, Q-DO
(3) Fish Haven Dolomite, Q-DO
(4) Quartzite in the Pogonip Group, CC-DO-Q
(5) Quartzite in the Pogonip Group, CC-DO-Q-TLC
(6) Simonson Dolomite, CC-DO-Q-TLC
(7) Roberts Mountains Formation, CC-DO-Q-TLC

Tremolite zone

(8) Notch Peak Formation, TR-CC-DO
(9) Notch Peak Formation, TR-CC-DO
(10a) Notch Peak Formation,TR-CC-DO-Q
(10b) Notch Peak Formation,TR-CC-Q
(11) Simonson Dolomite, Q-DO
(12) Field observation of tremolite, no thin section
(13) Field observation of tremolite, no thin section
(14) Field observation of tremolite, no thin section
(15) Field observation of tremolite, no thin section
(16) Field observation of tremolite, no thin section

Diopside zone

(17) Quartzite in the Pogonip Group, DI-CC-Q
(18) Quartzite in the Pogonip Group, DI-TR-CC-Q
(19) Quartzite in the Pogonip Group, DI-DO-Q
(20) Roberts Mountains Formation, DI-TR-CC
(21) Simonson Dolomite, DI-DO-Q
(22) Roberts Mountains Formation, DI-CC-DO
(23) Roberts Mountains Formation, DI-CC-Q

Diopside zone rocks overprinted in the mylonite zone

(24) Simonson Dolomite, various reactions breaking down DI to TLC, Q, CC, DO
(25) DI --> TR-CC-Q
(26) Simonson Dolomite, DI reacted out and pseudomorphed by TLC-DO-Q
(27) Quartzite in the Pogonip Group, DI --> TR-CC-Q

Figure 5. Metamorphic map showing locations of, and assemblages in, calc-silicate rocks. Map is modified after Camilleri and Chamberlain (1997). Mineral abbreviations are given in appendix B.

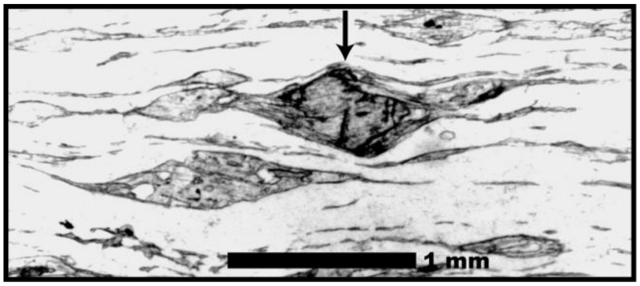


Figure 6. Plain light photomicrograph of a diopside porphyroclast in a mylonitic quartzite from the Ordovician Pogonip Group (unit "Opa"). The diopside porphyroclast (dark high-relief grain at top and center, see arrow) has recrystallized tails of tremolite and calcite, which are a byproduct of the breakdown of diopside. The other porphyroclasts in this photomicrograph are tremolite. Sense of shear is top-to-the-west-northwest (to the right in the photo).

diopside zone encompasses the entire western part of the Wood Hills, most of the diopside zone rocks in the northwestern part of the range are overprinted in the mylonite zone. Overprinted rocks mineralogically reflect metamorphic conditions during mylonitization rather than diopside zone metamorphism. For example, diopside is not a stable phase within mylonitic rocks (see fig. 5). Diopside in mylonitic rocks typically forms porphyroclasts with asymmetric tails of TR-CC-Q that record the reaction DI + H_2O + CO_2 = TR + CC + Q (fig. 6).

The positions of the calc-silicate isograds indicate a northwest increase in metamorphic grade within the Wood Hills. The presence of kyanite in metapelites within the tremolite zone indicates that the tremolite zone, and, by inference, the diopside zone is within the kyanite zone or upper amphibolite facies. Precise correlation of the talc zone with metapelitic metamorphic zones is not possible because no metapelites with diagnostic assemblages crop out within this zone. However, the presence of chlorite-absent biotite schists of the Kanosh Shale within the talc zone suggests amphibolite facies conditions.

Metamorphic Fabric

The metamorphic rocks range from unfoliated in the extreme southeastern part of the Wood Hills to penetratively foliated in the central and northwestern parts of the range. Metamorphosed strata constitute rocks with a foliation only (S tectonite), rocks with a foliation and a lineation (S-L tectonite [S_1 and L_1]), and sparse rocks with a static fabric (no foliation or lineation). Foliation is approximately parallel to bedding. Lineation is defined by porphyroblasts in polymineralic rocks or grain shape in monomineralic rocks and trends vary from east-northeast to east-southeast (fig. 2). In the highest grade rocks, in the northern part of the Wood Hills, metamorphic rocks contain sparse outcrop-scale isoclinal folds with axial surfaces parallel to foliation. These folds are interpreted to have formed during metamorphism because they lie within the plane of foliation and they do not deform the foliation.

Foliation is penetrative in the northern and central part of the Wood Hills but dies out within southeast-dipping Ordovician to Devonian strata in the southernmost part of the Wood Hills. Foliation within the Ordovician-Devonian section becomes increasingly partitioned stratigraphically above the Eureka Quartzite and eventually disappears upwards within unit DOu. This is reflected on the geologic map by the presence of bedding symbols in units DOu and Ds in the southeastern part of the Wood Hills. Although most rocks in unit DOu lack macroscopic fabric elements, metamorphism in these rocks is evident by the presence of microstructures indicative of recrystallization (e.g., grain boundary migration).

Development of fabric elements during metamorphism appears to be a product of dominantly coaxial ductile flow (Camilleri, 1998). This inference is based on the observation that microstructures in the metamorphic rocks lack evidence for a significant component of noncoaxial flow and on analysis of preferred orientation of quartz crystallographic c-axes in quartzite (Camilleri, 1998). The quartz data suggest that predominantly coaxial plane strain to flattening accompanied at least the peak of metamorphism (fig. 7a). Consequently, the attenuation of stratigraphic section is likely a product of flow with a dominant coaxial component during metamorphism (Camilleri, 1998).

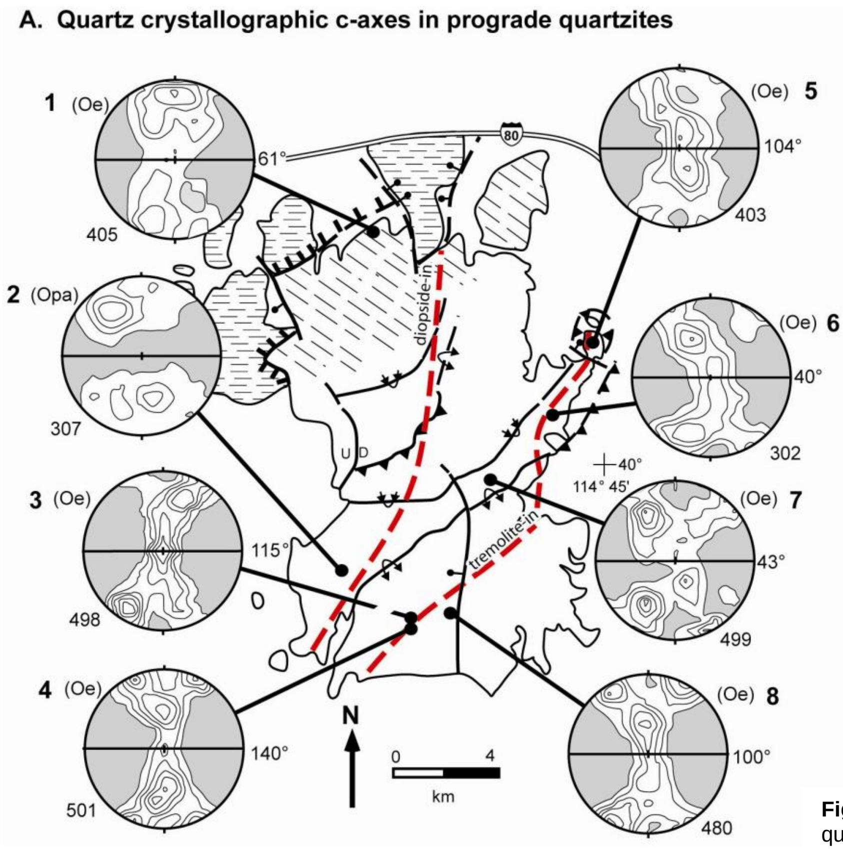
Summary

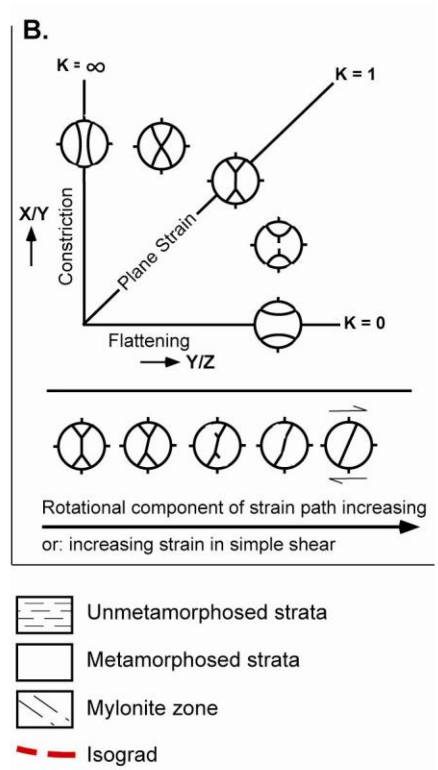
Metamorphic rocks in the footwall of the Wood Hills fault constitute amphibolite facies S and S-L tectonites that record pressures that exceed premetamorphic pressures at stratigraphic depths by about ~ 3 to 4 kb. Metamorphism was accompanied by attenuation of stratigraphic units accommodated by dominantly coaxial deformation.

Northwest-Vergent Folds

The most pronounced structural feature in the footwall of the Wood Hills fault is a series of overturned northwest-vergent folds cored by small-displacement thrust faults. Both S_1 and L_1 are folded by the folds, and construction of pi diagrams suggests that fold hinges plunge gently to the northeast (fig. 2). A weak axial-planar grain-shape foliation or crenulation that overprints S_1 is common along fold hinges, and outcrop-scale parasitic folds that fold S_1 are present in places along fold limbs (fig. 8). In addition, analysis of quartz crystallographic c-axes from a quartzite overprinted in the hinge of the southernmost anticline indicates top-to-the-northwest shear accompanied flow in the folds core (see sample 5 in fig. 7), consistent with the vergence of the fold.

Deformation and folding of S_1 and L_1 indicates that the northwest-vergent folds postdate development of the metamorphic fabric (Thorman, 1970). There is, however, a lack of evidence for metamorphic retrogression in rocks deformed by the folds. This suggests that folding occurred





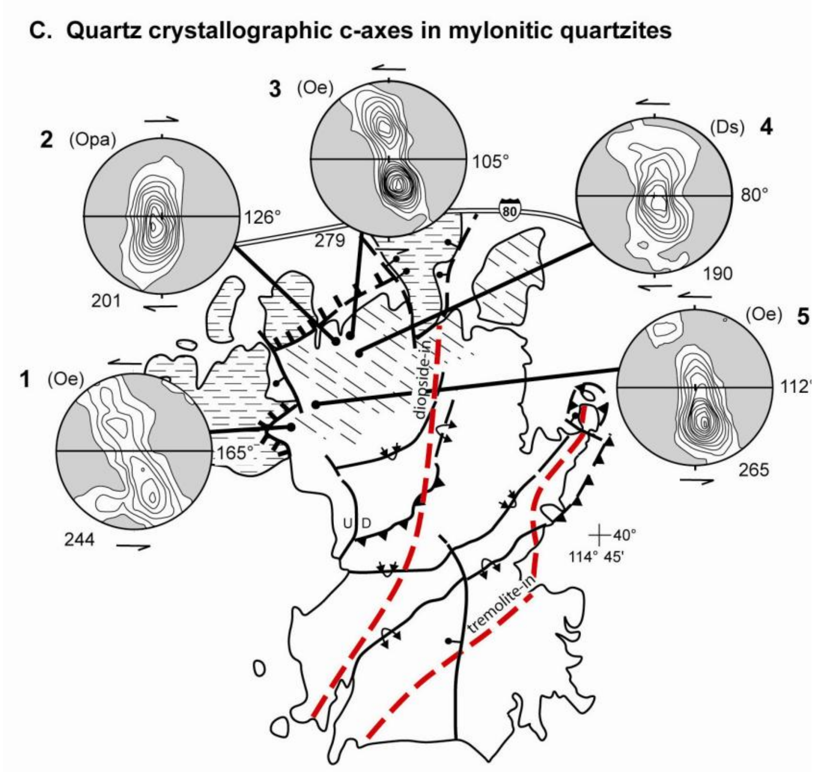


Figure 7. A) Crystallographic preferred orientation (CPO) of quartz c-axes in prograde metamorphic quartzites (modified after Camilleri, 1998). **B)** Geometry of CPO of c-axes in quartzites expected for coaxial deformation (on the Flinn plot) and progressive noncoaxial deformation (modified after Schmid and Casey, 1986). On the stereograms, X is horizontal, Y is perpendicular to the page, and Z is vertical. **C)** CPO of c-axes in mylonitic quartzites. CPOs displayed in figure 7A reflect dominantly coaxial deformation. Specifically, samples 4, 5, and 6 reflect coaxial plane strain; sample 2, coaxial flattening; and samples 1 and 7, strain that is transitional between coaxial flattening and plane strain. Sample 3 exhibits a component of top-to-the-southeast noncoaxial flow and sample 5, a component of top-to-the-northwest noncoaxial flow. Sample 5, however, is overprinted in, and from the core of, a northwest-vergent fold, and consequently the quartz data reflect strain imposed during folding rather than metamorphism. The evidence for overprinting in sample 5 is sparse crenulated muscovite grains. CPOs displayed in figure 7C reflect strong noncoaxial deformation. All patterns indicate a top-to-the-west to -northwest sense of shear with the exception of sample 2, which yields a top-to-the-southeast sense of shear. Oe=Eureka Quartzite; Ds=quartzite in the Simonson Dolomite; Opa=quartzite in unit A of the Pogonip Group. Data in figures 7A and 7C are plotted on equal area nets and contoured by the Kamb method (Kamb, 1959) with a 2-sigma contour interval. Number of data points is indicated at the bottom, and trend of lineation to the right, of the stereogram. In each stereogram, foliation is vertical and lineation is horizontal; both are represented by a horizontal line transecting the center of the stereonet with the eastward direction on the right. Stratigraphic up is on the top of the stereogram. Orientations of c-axes were obtained by standard methods on a universal stage. For samples with greater than 400 data points, orientations of c-axes were measured in two sections, both cut perpendicular to foliation but one parallel and one perpendicular to lineation. Data from the section cut perpendicular to lineation were rotated and added to data from the section cut parallel to lineation. In all cases rotated-fabric patterns yielded the same pattern as the lineation-parallel sections. Orientations of c-axes for samples with less than 400 data points were obtained from a single section cut perpendicular to foliation and parallel to lineation.

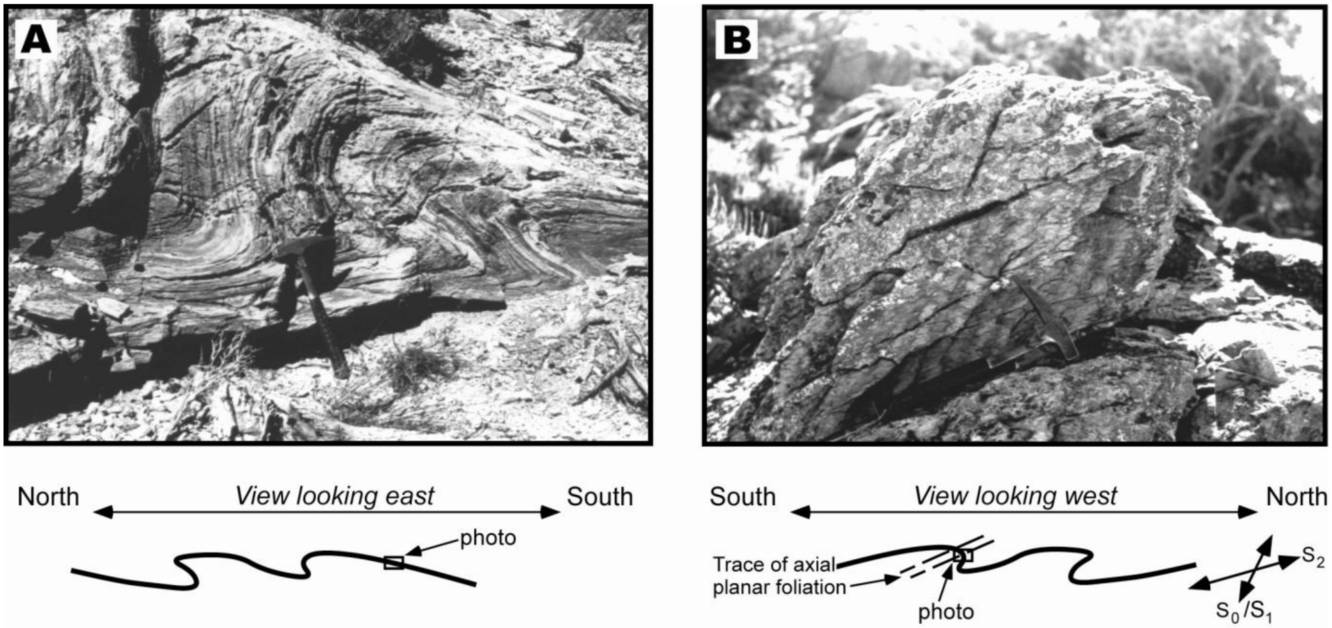


Figure 8. Photographs of scarce small-scale structures associated with the map-scale northwest-vergent folds. Hammers for scale. The structural position of the photos are shown in schematic sketches of the folds. **A)** Photograph of a parasitic northwest-vergent fold in Ordovician Pogonip Group strata. This fold is on the upright, south-dipping limb of the overturned anticline in the southern Wood Hills. The fold is defined by S_1 and does not have an axial planar foliation. The thickening and thinning of layers along hinges and limbs evident in this photograph is more apparent than real because of the orientation of the outcrop face relative to fold orientation. **B)** Axial planar grain-shape foliation (S_2) in Pogonip Group strata from the overturned limb in the hinge zone of the northwest-vergent anticline in southern Wood Hills. S_2 in the Wood Hills is scarce and restricted to hinge zones of the folds.

at pressure and temperature conditions similar to that attained during metamorphism. The Dunderberg Shale along the hinge line of the southernmost anticline provides the best evidence of the lack of retrogressive metamorphism. In this area S_1 is heavily overprinted and the Dunderberg Shale comprises an L-tectonite reflecting constrictional strain in the core of the fold. Lineation is defined by stretched porphyroblasts and hinges of crenulations. Thin-section observations of the L-tectonite revealed kinked kyanite and staurolite and biotite porphyroblasts that are recrystallized, kinked, or pulled apart without establishment of retrogressive phases, which indicates that amphibolite facies metamorphic conditions were established before, and possibly continued during folding. The only evidence for neomineralization during folding is coarse-grained muscovite that grew in pull-apart zones within biotite. Therefore, on the basis of thin-section observation, there is no direct evidence that folding accompanied a dramatic change in metamorphic conditions.

Folded Normal Fault in the Central Part of the Wood Hills

The central part of the Wood Hills contains a low-angle normal fault that emplaces Devonian over Ordovician rocks (fig. 2). This fault is folded by the northwest-vergent folds and hence predates folding. Although the fault surface is not exposed, map relations indicate that the fault is at a low angle to foliation (which is approximately parallel to bedding) and consequently, if unfolded, this fault geometrically constitutes a low-angle normal fault. Whether or not the fault formed at a low angle depends on its age. If the fault predates metamorphism, then it was probably a higher angle fault that rotated to a lower angle during the up to 50% attenuation of strata that accompanied metamorphism (fig. 9). If the fault postdates the metamorphic foliation, then it probably formed at a low angle. Several observations suggest that the fault predates metamorphism. First, S_1 does not appear to be overprinted adjacent to the fault contact, suggesting that S_1 postdates the fault. Second, field observations of rocks along the fault trace suggest that footwall and hanging wall units are probably mildly interdigitated. Apparent interdigitation is most likely a consequence of ductile flow during metamorphism and implies that the fault existed before metamorphism (e.g., fig. 9). Therefore, the fault is tentatively inferred to predate metamorphism. The age of this fault, if assumed to be premetamorphic, is bracketed between Devonian (the youngest rocks cut by the fault) and Late Cretaceous (age of peak metamorphism).

Zone of Mylonitization

A partitioned top-to-the-west- to -northwest zone of mylonitization overprints S_1 in the northern part of the Wood Hills (fig. 2). Mylonitization produced variable and localized grain size reduction. Consequently, although there is a general northwest increase in grain size of the

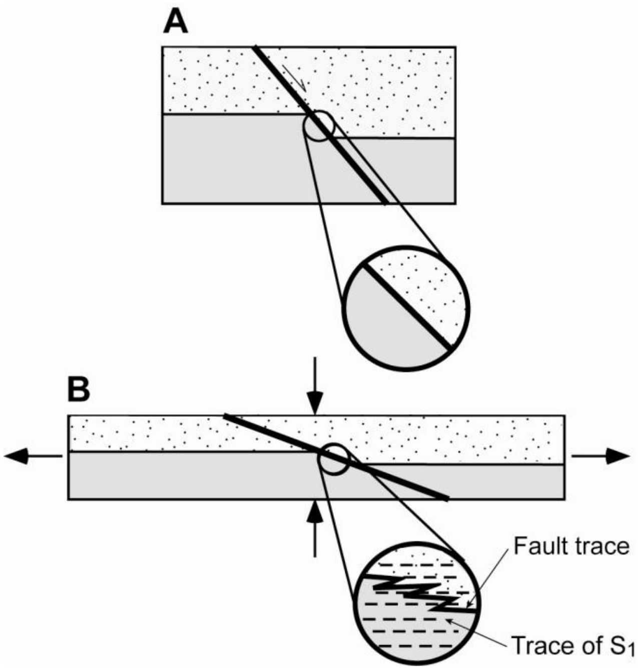


Figure 9. Schematic cross sections illustrating the inferred evolution of the folded low-angle normal fault prior to folding. **A)** Cross section of the fault prior to metamorphism. **B)** Cross section of the fault just prior to northwest-vergent folding. Shortening perpendicular to bedding, and consequent attenuation, during metamorphism results in rotation of the fault to a lower angle and interdigitation of contrasting units juxtaposed along the fault. Foliation transects, without deflection, units in the hanging wall and footwall of the fault.

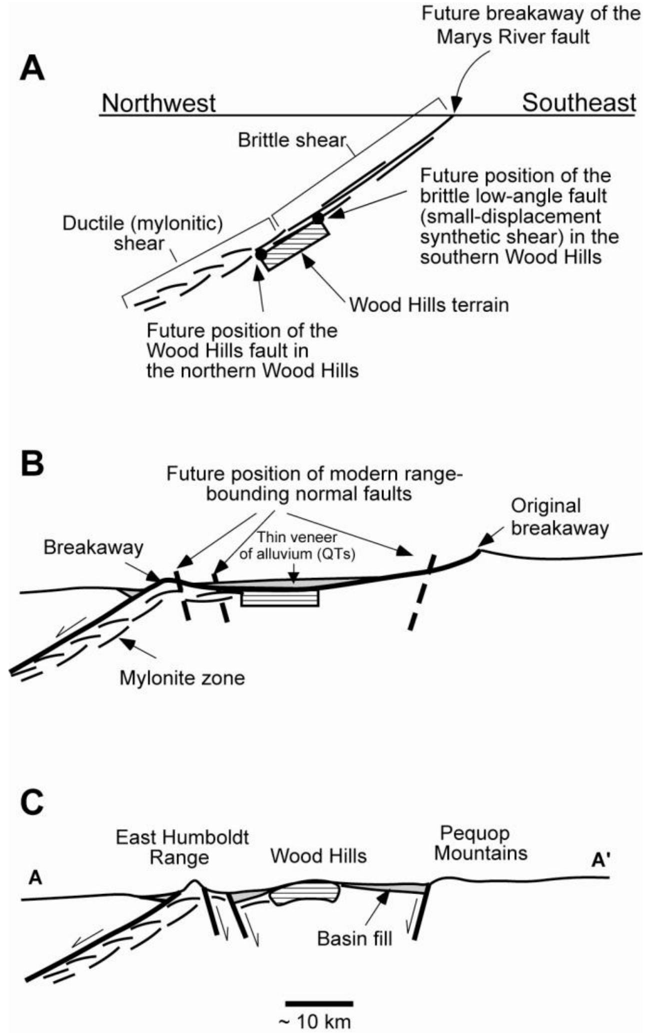


Figure 10. Schematic cross sections illustrating exhumation of the metamorphic rocks in the Wood Hills. The location of the cross section depicted in figure 10C is shown in figure 1.

metamorphic rocks within the Wood Hills, some mylonitic rocks are very fine grained and have lost their regional metamorphic appearance. Mylonitic deformation ranges from outcrop-scale shears to much larger shear zones that produce mappable displacements of stratigraphic units (e.g., the ductile low-angle normal faults on the map). Overall, zones of mylonitization are partitioned, but the mylonitic fabric is more abundant in the extreme northwestern corner of the range.

Observations of microstructures in polymineralic mylonitic rocks revealed porphyroclasts that yield a consistent top-to-west- to -northwest sense of shear (fig. 6). Analysis of preferred orientations of quartz crystallographic c-axes in five quartzite samples indicates noncoaxial flow accompanied mylonitization with a predominant sense of shear that is equivalent to that manifest by porphyroclasts in other rocks (fig. 7C). There is, however, one exception of a mylonitic quartzite whose c-axis pattern yielded on opposite sense of shear (sample 2 in fig. 7C).

The partitioned zone of mylonitization in the Wood Hills is kinematically similar to the penetrative top-to-the-west-northwest Tertiary mylonite zone exposed due west in the East Humboldt Range (fig. 1; see Snoke and Lush [1984] for discussion of shear zone). Moreover, the mylonitic shear zones in both the East Humboldt Range and Wood Hills underlie a fault associated with the Marys River fault system. Therefore, I interpret the zone of mylonitic deformation in the Wood Hills to be an eastern extension of the shear zone in the East Humboldt Range.

Brittle Low-Angle Fault in the Southern Wood Hills

The brittle low-angle fault in the southern Wood Hills cuts Middle Ordovician to Silurian strata and dips gently to the south. A klippe of Ordovician strata (unit Ou) in the central part of the Wood Hills may be a remnant of this fault (Thorman, 1970). The fault in the southern Wood Hills is demonstrably brittle (Thorman, 1970), characterized by intense brecciation of rocks immediately above and below the fault. In fact, exposures of klippen composed mostly of brecciated rock up to several meters thick (unit SObx) are common features north of the trace of the fault. Much of the fault's trace is shown mapped as approximately located on the southwestern flank of the Wood Hills. The reason the fault is approximately located is because it projects into undistinctive Silurian and Devonian dolomite units that lack stratigraphic contrast. Consequently, it is difficult to delineate the fault's position precisely.

Overall, the fault omits a minor amount of stratigraphic section and is at a low-angle to bedding and foliation in its hanging wall and footwall. Lack of piercing points makes sense of slip difficult to determine; however, the geometry of offset units suggests that hanging wall transport was directed in the general domain of north to west-southwest. The amount of slip is probably in the range of tens of meters to a few kilometers. The precise age of this fault is unknown but because it cuts the metamorphic fabric, it can be assumed to be Late Cretaceous or younger. The fault has a sense of slip that is similar to the Marys River fault system and consequently, it may be a normal fault related to the Marys River system that has been rotated by isostatic rebound of the metamorphic rocks (see fig. 10 and related discussion in "Summary and Discussion" section).

Timing of Emplacement of Granitic Intrusions

The timing of emplacement of granitic intrusions is not precisely constrained but can be inferred to have occurred during and/or after the time of peak metamorphism (Late Cretaceous) but before Tertiary mylonitization. This inference is based on several observations. First, the granitic intrusives lack the strong S_1 metamorphic fabric suggesting they were emplaced after the fabric was well established, i.e., during or after peak metamorphic conditions. Second, intrusives within the mylonite zone are visibly deformed by small-scale shears, and therefore emplacement is inferred to predate Tertiary mylonitization. South of the mylonite zone, intrusive bodies do exhibit sparse but mild ductile deformation in outcrop and, in thin section, minor plastic deformation of quartz and feldspar is evident in most intrusives. This deformation could have taken place during peak metamorphism as a late-stage but mild product of the strain field responsible for the development of S_1. Alternatively, the deformation could have been superimposed during northwest-vergent folding and/or after folding. Unfortunately, the age of intrusives relative to the northwest-vergent folds is not constrained. In summary, granite intrusion may have begun during peak metamorphism but appears to have been completed prior to mylonitization.

WOOD HILLS FAULT AND THE STRUCTURE OF ROCKS IN ITS HANGING WALL

The Wood Hills fault dips gently to the west and juxtaposes unmetamorphosed Tertiary and middle to upper Paleozoic rocks on top of upper amphibolite facies, lower to middle Paleozoic rocks. Two klippen of pervasively fractured and brecciated Devonian Guilmette Formation exposed to the east of the trace of the Wood Hills fault are inferred to be part of its hanging wall. Paleozoic strata in the hanging wall of the fault are deformed by small-scale folds and thrust faults but have an overall eastward dip. Tertiary strata in the hanging wall of the fault are poorly exposed but inspection of aerial photographs indicates that they dip moderately to steeply east. Moreover, outcrops near Interstate 80 reveal an easterly dip of ~ 35 to 57° (Thorman, 1970; his data are shown on the map). Although the contact between Tertiary and Paleozoic rocks in the hanging wall of the Wood Hills fault is either faulted or not exposed, Tertiary rocks are inferred to have been unconformably deposited on the Paleozoic strata. This inference is based on the observation that in the hanging walls of other faults associated with the Marys River fault system (e.g., Mueller and Snoke, 1993a, b), Eocene volcanic rocks lie depositionally atop Paleozoic strata and Miocene Humboldt Formation lies atop the volcanic rocks.

There are no direct age constraints on the Wood Hills fault but its age can be inferred by assessing the age of the Humboldt Formation in its hanging wall, which was deposited during slip along the fault (Mueller and Snoke, 1993a, b). A tuff in the upper member of the Humboldt Formation yielded an 11.6 $\pm$ 1.2 Ma zircon fission track age. This tuff lies stratigraphically just above conglomerate that contains the first appearance of metamorphic clasts derived from the Wood Hills. Assuming the tuff has not been reworked, this age indicates that the Wood Hills metamorphic terrain was exhumed by at least late middle to early late Miocene, and it suggests that the Wood Hills fault, a segment of the Marys River fault system, was active at this time.

HIGH-ANGLE NORMAL FAULTS

Rocks in both the hanging wall and footwall of the Wood Hills fault are transected by predominantly west- to north- trending nearly vertical to high-angle normal faults. These faults are brittle and have minor displacements. Several of the faults transect rocks in both the hanging wall and footwall of the Wood Hills fault suggesting that collectively the high-angle faults constitute the youngest structures in the Wood Hills. In fact, some of the faults may be as young as Quaternary. For example, on the western side of the Wood Hills, one of the high-angle faults is shown cutting Quaternary alluvium. The existence of this fault is based on aerial photographs that reveal a conspicuous scarp that appears to offset the pediment surface.

SUMMARY AND DISCUSSION

Structures in the Wood Hills are broadly divisible into four main phases of deformation. The oldest is extensional, occurred between the Devonian and Late Cretaceous, and is presently manifest as the folded low-angle normal fault. The second phase of deformation involved Barrovian metamorphism of the Paleozoic section. Metamorphism was accompanied by dominantly coaxial ductile flow that resulted in attenuation of units and production of S and S-L tectonites. Subsequently, after the metamorphic fabric was established and without an apparent dramatic change in metamorphic conditions, the Paleozoic section was thrust-faulted and folded about northeast-trending axes. The northwest-vergent folds have been inferred to be back folds in the hanging wall of the Independence thrust, a thrust that projects beneath the Wood Hills and that is exposed in the adjacent Pequop Mountains to the east (Camilleri and Chamberlain, 1997; fig. 1). Structures formed during the youngest and fourth phase of deformation include the high-angle normal faults, the brittle low-angle fault in the southern Wood Hills, the mylonite zone, and most importantly, the Wood Hills fault, which is part of the Marys River fault system. These features collectively manifest protracted uplift and extensional exhumation of metamorphic strata in the Wood Hills. Figure 10 schematically illustrates exhumation of the Wood Hills terrain from a time before initiation of slip along the Marys River fault (fig. 10A), to a time just prior to the formation of the modern range-bounding normal faults (fig. 10B), to the present (fig. 10C). In figure 10B, slip along the Marys River fault has resulted in isostatically induced rotation and rebound of its footwall and exhumation of the Wood Hills terrain. The mylonite zone exposed in the northern part of the Wood Hills is interpreted to be a deeper part of the Marys River fault and the brittle low-angle fault in the southern Wood Hills (not shown in fig. 10) is interpreted to be a small-displacement synthetic shear of a structurally shallower level of the Marys River fault. Deposition of older alluvium (unit QTs on the map) atop the Wood Hills terrain is inferred to have occurred just prior to, or during the initial stages of, formation of the modern range-bounding faults, i.e., at around the time represented in figure 10B. The alluvial debris is inferred to have been shed from topographically higher areas surrounding a topographically depressed Wood Hills (fig. 10B). Figure 10C shows the current structural configuration of the Wood Hills. The Wood Hills define a domed graben between the topographically higher East Humboldt Range and the Pequop Mountains. The high-angle faults in the Wood Hills are probably related to doming (i.e., flexure) and reflect extension above a neutral surface at depth. Flexure may be a product of isostatic rebound and/or related to rollover along the east- and west-dipping normal faults bounding the East Humboldt and Pequop Mountains, respectively.

DESCRIPTION OF MAP UNITS

Quaternary and Tertiary Surficial Units

Qau Alluvium, undivided (Quaternary) —Unconsolidated gravel, sand, and silt deposited in intermittent streams and on pediments and alluvial fans.

Qa Alluvium (Quaternary) —Unconsolidated gravel, sand, and silt deposited in intermittent streams.

Qla Lacustrine deposits and alluvium, undivided (Quaternary) —Pluvial lacustrine deposits of gravel, sand, and silt and alluvial deposits of gravel, sand, and silt deposited in intermittent streams.

QTs Sedimentary rocks (Quaternary and Tertiary?) —Light-gray to tan conglomerate, breccia, sandstone, tuffaceous sandstone, and siltstone. Gravel in conglomerate includes clasts derived from unmetamorphosed middle to upper Paleozoic miogeoclinal carbonates with no apparent source in the Wood Hills as well as metamorphic clasts derived from rocks units in the Wood Hills. The source for unmetamorphosed middle Paleozoic clasts was likely to the east or north of the Wood Hills (see fig. 10)

Unmetamorphosed Rocks in the Hanging Wall of the Wood Hills Fault

Humboldt Formation (Miocene) divided into the following units:

Th Upper member and lower member of the Humboldt Formation, undivided–Unit shown in cross section only.

Thu Upper member of the Humboldt Formation–Tan limestone, siltstone, sandstone, and conglomerate in the lower part of the upper member and conglomerate, siltstone, sandstone, and white vitric tuff in the upper part of the upper member. One of the tuff beds yielded a zircon fission track age of ~12 Ma (see appendix B and map for location). Clasts within the upper member are predominantly derived from unmetamorphosed upper Paleozoic carbonate and clastic strata. However, sparse metamorphic clasts similar to rock units in the Wood Hills occur stratigraphically just below as well as above, the 12 Ma tuff. The upper member is at least 1,560 feet thick.

Thl Lower member of the Humboldt Formation–Pervasively fractured and silicified megabreccias composed of unmetamorphosed upper Paleozoic strata, and sparse conglomerate. The lower member is estimated to be at least 630 feet thick.

Tv Volcanic rocks (Eocene)–Reddish-brown rhyolitic to dacitic volcanic rocks. Brooks et al. (1995a, b) report an $^{40}Ar/^{39}Ar$ age of 39.7 + 0.1 Ma from biotite in an ash flow tuff.

PPfe Ferguson Mountain Formation (Permian) and Ely Limestone (Permian and Pennsylvanian), undivided–Interbedded light-gray limestone, cherty limestone, and silty limestone.

Mu Chainman Shale, Diamond Peak Formation, and Tripon Pass Limestone undivided (Mississippian)–Unit is shown in cross section only.

Mdpc Chainman Shale and Diamond Peak Formation, undivided (Mississippian)–Tan to light-gray shale, argillite, siliceous shale, siltstone, and chert-pebble conglomerate.

Dg Guilmette Formation (Devonian)–Light-gray limestone.

Metamorphic Rocks in the Footwall of the Wood Hills Fault

Note: structural thicknesses are given only for formations whose bottoms and tops are exposed and whose thicknesses can be geometrically calculated from the map. These thicknesses are estimates. The structural thicknesses of any particular formation is variable because it defines pinch-and-swell structure. Moreover, in places, some units are thinned so much that they structurally pinch out.

Dg Guilmette Formation (Devonian)–Alternating light-gray to gray-green very fine- to coarse-grained calcite marble with sparse dolomite marble.

DOu Simonson Dolomite (Devonian), Lone Mountain Dolomite (Devonian and Silurian), Roberts Mountains Formation (Silurian), Laketown Dolomite (Silurian), and Fish Haven Dolomite (Ordovician), undivided–Dark-gray cherty dolomite marble at the base with overlying light- to medium-gray dolomite marble and sparse red-brown- to light-gray-weathering dolomitic quartzite and quartzite. Upper part of unit in the northernmost part of the Wood Hills contains sparse gray-green calcite marble. Note: a sliver of this unit also occurs in the hanging wall of the Wood Hills fault due east of section 1, T36N, R62E.

Ds Simonson Dolomite (Devonian)–Laminated light-gray to black dolostone in the southernmost Wood Hills and light- to medium-gray dolomite marble with sparse gray-green calcite marble in the central and northern parts of the Wood Hills. Red-brown- to light-gray-weathering dolomitic quartzite and quartzite occur at the base of the formation throughout the Wood Hills.

Srm Roberts Mountains Formation (Silurian)–Light- to medium-gray-green calcite marble and minor dolomite marble with sparse chert lenses. In places, the Roberts Mountains Formation structurally pinches out, and locally it attains a maximum structural thickness of at least 385 feet. This formation is only mappable in the central and northern parts of the Wood Hills. From north to south in the central part of the Wood Hills, the percentage of dolomite marble in the formation increases and the percentage of calcite marble decreases to zero. In the south-central part of the Wood Hills, the stratigraphic interval occupied by the Roberts Mountains Formation is composed of dolomite marble that becomes indistinguishable from overlying and underlying dolomite marble. Thus, in the southernmost Wood Hills, the stratigraphic interval occupied elsewhere in the Wood Hills by the Roberts Mountains Formation is comprised of dolomite that is not distinguishable as a mappable unit. This northward change from dolomite marble to calcite marble is consistent with Silurian lithofacies patterns to the east of the Wood Hills in Nevada and Utah. The lithologic change in the Wood Hills is along strike with a change from shelf dolostones to the south to calcareous slope deposits to the north in strata to the east of the Wood Hills (see Sheehan, 1979). Note: a sliver of this unit also occurs in the hanging wall of the Wood Hills fault due east of section 1, T36N, R62E.

SObx Brecciated Laketown Dolomite (Silurian), Fish Haven Dolomite (Ordovician) and (or) Eureka Quartzite (Ordovician), undivided–Brecciated quartzite and dolomite in the southernmost part of the Wood Hills.

Ou Eureka Quartzite and Pogonip Group (Ordovician), undivided

Oe Eureka Quartzite (Ordovician)–White quartzite with sparse gray streaks. In places, the Eureka Quartzite structurally pinches out, and locally it attains a maximum structural thickness of at least 400 feet.

Pogonip Group (Ordovician) divided into the following units:

Opl Lehman Formation–Light-gray-green calcite marble and micaceous calcite marble. In places, the Lehman Formation structurally pinches out, and locally it attains a maximum structural thickness of at least 400 feet.

OPlc Lehman Formation and Unit C, undivided

Opc Unit C–Phyllite or schist with lesser light-gray to light-gray-green calcite and micaceous calcite marble in uppermost part of unit; marble and micaceous calcite marble in the middle part; grayish-yellow-weathering quartzite in the basal part. Phyllite or schist and calcite marble in uppermost part of unit A are correlative with the Kanosh Shale. In places, Unit C structurally pinches out, and locally it attains a maximum structural thickness of at least 575 feet.

Opb Unit B–Light-gray to light-gray-green micaceous calcite marble, calcite marble, and minor phyllite or schist. In places, Unit B is at least as thin as 210 feet, and locally it attains a maximum structural thickness of at least 690 feet.

Opa Unit A–Light-gray, white, or cream-colored cherty, micaceous, calcite marble. Unit A can be distinguished from Unit B by the presence of chert and its generally lighter color. In places, Unit A is at least as thin as 230 feet, and locally it attains a maximum structural thickness of at least 920 feet.

Notch Peak Formation (Early Ordovician and Late Cambrian)–divided into the following units:

OCnpu Upper member–Light gray-blue dolomite marble, with subordinate white dolomite or calcite marble and light-gray-blue calcite marble. Marble contains sparse chert lenses. In places, the upper member is at least as thin as 150 feet, and locally it attains a maximum structural thickness of at least 270 feet.

OCnpl Lower member–Light-gray-blue calcite marble with sparse chert lenses. In places, the lower member is at least as thin as 320 feet, and locally it attains a maximum structural thickness of at least 920 feet.

Cdm Dunderberg Shale (Late Cambrian), Oasis Formation (Late Cambrian), Shafter Formation (Late and Middle Cambrian), Decoy Limestone (Middle Cambrian), and Morgan Pass Formation (Middle Cambrian), undivided–Schist and light-gray to white to cream-colored calcite marble and micaceous calcite marble in uppermost part of unit (= Dunderberg Shale) and underlying light-gray to gray-green to light-gray-blue calcite marble and micaceous calcite marble with minor tan dolomite marble.

CZms Metasedimentary rocks (Late Cambrian to Proterozoic)–Unit shown in cross section only. Unit consists of formations comprising unit Cdm and unexposed formations stratigraphically below unit Cdm. Unexposed formations included in this unit are: Clifside Limestone (Middle Cambrian), Toano Limestone (Middle Cambrian), Killian Springs Formation (Lower [?] and Middle Cambrian), and Prospect Mountain Quartzite (Late Proterozoic and Early Cambrian).

Intrusive Rocks in the Footwall of the Wood Hills Fault

Kg Granite (Late Cretaceous?)–Muscovite- ± garnet-bearing pegmatitic granite dikes or pods.

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APPENDIX A: MINERAL ABBREVIATIONS

ALL	allanite	GT	garnet	ST	staurolite
BI	biotite	FS	feldspar	TLC	talc
CC	calcite	IL	ilmenite	TOUR	tourmaline
CHL	chlorite	MU	muscovite	TR	tremolite
DI	diopside	PL	plagioclase	KY	kyanite
DO	dolomite	RT	rutile	Q	quartz

APPENDIX B: FISSION TRACK ANALYSIS*

White vitric tuff in the upper member of the Humboldt Formation (sample location is indicated on the map)

Mineral: Zircon

Standard track density: 175000 t/cm ^{2} 2623 (tracks counted)

Zeta factor: 324.65 Glass standard: SRM962

Grain	#Fossil tracks	#Induced tracks	Uranium ppm	Age (Ma)	Error 2s (Ma)
1	71	228	292	7.00	1.9
2	92	225	590	11.61	2.9
3	41	99	163	11.75	4.4
4	78	155	275	14.28	4.0
5	147	275	609	15.17	3.1
6	41	128	130	9.09	3.3
7	44	128	130	9.09	3.3
8	61	129	229	13.42	4.2
TOTAL	575	1404	275	11.62	1.2

Fossil track density: 1.59e+6 t/cm ^{2}

Induced track density: 7.76e+6 t/cm ^{2}

CHI ^{2} = 26.8011 7 degrees of freedom

Probability = 3.60875e-4

*Fission track analysis done by P.K. Cerveny at the University of Wyoming (contract work)

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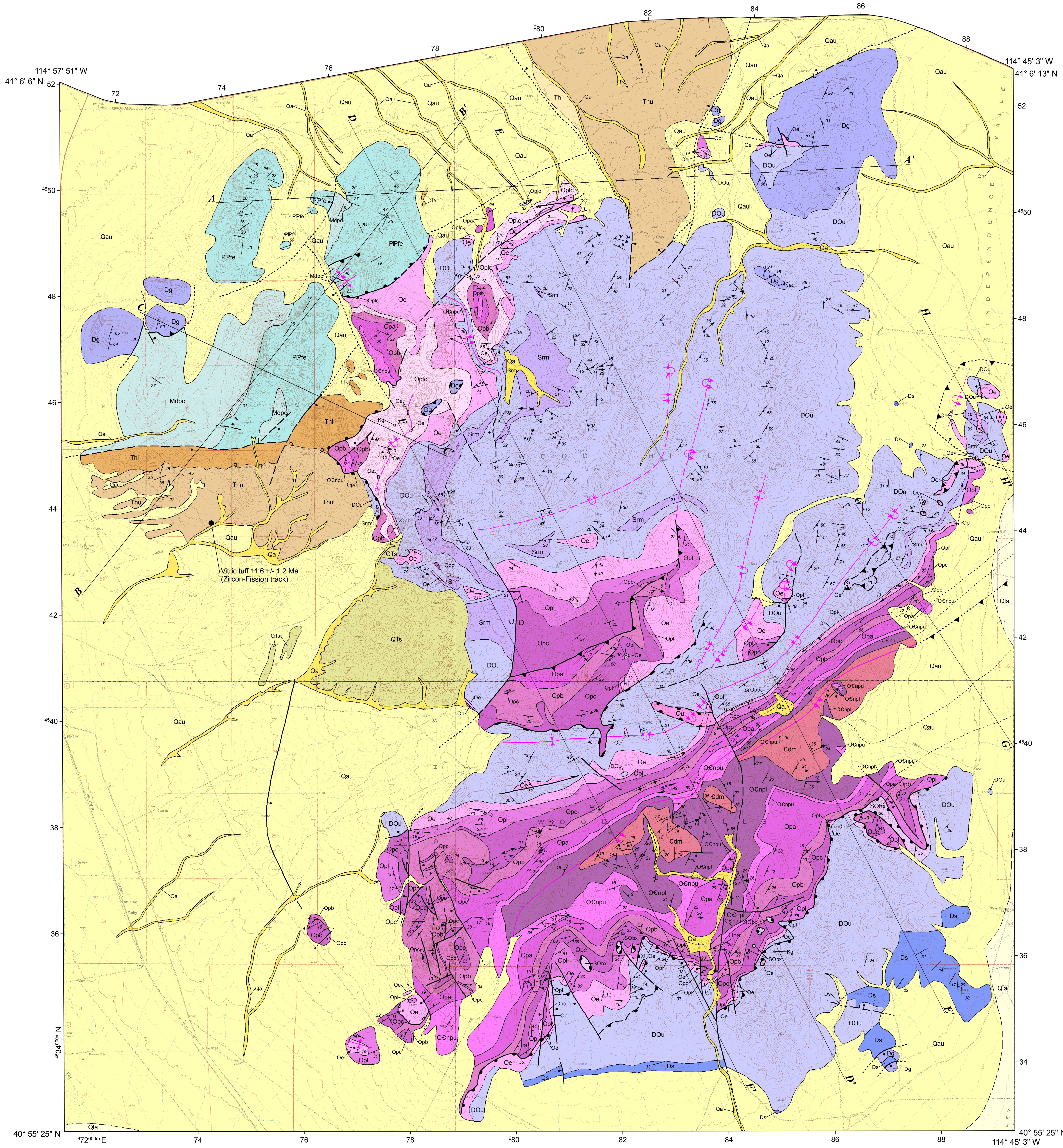


GEOLOGIC MAP OF THE WOOD HILLS, ELKO COUNTY, NEVADA

Phyllis Camilleri

Department of Geosciences, Austin Peay State University

2010

Quaternary and Tertiary Surficial Units

- Qau — Alluvium, undivided
- Qa — Alluvium
- Qla — Lacustrine deposits and alluvium, undivided
- QTs — Sedimentary rocks

Unmetamorphosed Rocks in the Hanging Wall of the Wood Hills Fault

- Th — Upper member and lower member of the Humboldt Formation, undivided
- Thu — Upper member of the Humboldt Formation
- Thl — Lower member of the Humboldt Formation
- Tv — Volcanic rocks
- PIPfe — Ferguson Mountain Formation and Ely Limestone, undivided
- Mu — Chainman Shale, Diamond Peak Formation, and Tripon Pass Limestone, undivided (unit shown in cross section only)
- Mdpc — Chainman Shale and Diamond Peak Formation, undivided
- Dg — Guilmette Formation

Metamorphic Rocks in the Footwall of the Wood Hills Fault

- Dg — Guilmette Formation
- DOu — Simonson Dolomite, Lone Mountain Dolomite, Roberts Mountains Formation, Laketown Dolomite, and Fish Haven Dolomite, undivided
- Ds — Simonson Dolomite
- Srm — Roberts Mountains Formation
- SObx — Brecciated Laketown Dolomite, Fish Haven Dolomite and (or) Eureka Quartzite, undivided
- Ou — Eureka Quartzite and Pogonip Group, undivided
- Oe — Eureka Quartzite

POGONIP GROUP

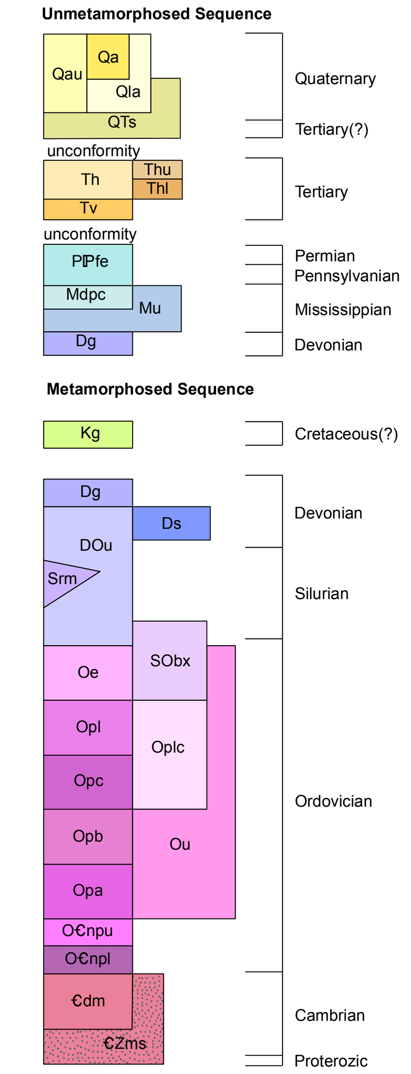
- Opl — Lehman Formation
- Oplc — Lehman Formation and unit C, undivided
- Opc — Unit C
- Opb — Unit B
- Opa — Unit A

- O€npu — Upper member of the Notch Peak Formation
- O€npl — Lower member of the Notch Peak Formation
- €dm — Dunderberg Shale, Oasis Formation, Shafter Formation, Decoy Limestone, Morgan Pass Formation, undivided
- €Zms — Metasedimentary rocks (unit shown in cross section only)

Intrusive Rocks in the Footwall of the Wood Hills Fault

- Kg — Granite

See accompanying text for full unit descriptions, references and figures for this map.



Symbology (per FGDC-STD-013-2006)

Contact Solid where certain and location accurate, long-dashed where approximate, dotted where concealed; queried if identity or existence uncertain.

Normal faults Solid where certain and location accurate, long-dashed where approximate, dotted where concealed; queried if identity or existence uncertain. Ball on downthrown side.

Vertical or near-vertical faults Solid where certain and location accurate, long-dashed where approximate, dotted where concealed; queried if identity or existence uncertain. U on upthrown block, D on downthrown block.

Low-angle normal fault (brittle) Solid where certain and location accurate, long-dashed where approximate; queried if identity or existence uncertain. Half circles are on hanging wall.

Low-angle normal fault (ductile) Solid where certain and location accurate, long-dashed where approximate; queried if identity or existence uncertain. Half circles are on hanging wall.

Thrust fault Solid where certain and location accurate, long-dashed where approximate, dotted where concealed. Sawteeth on hanging wall.

Folded low-angle normal fault Solid where certain and location accurate, long-dashed where approximate. Rectangles are on hanging wall.

Anticline Solid where certain and location accurate.

Syncline Solid where certain and location accurate, long-dashed where approximate.

Overturned anticline Solid where certain and location accurate, long-dashed where approximate, short-dashed where concealed; queried if identity or existence uncertain.

Overturned syncline Solid where certain and location accurate, long-dashed where approximate; queried if identity or existence uncertain.

Strike and dip of bedding
41 Inclined; 37 Overturned

Strike and dip of foliation (S_1)
Arrow shows trend and plunge of lineation (L_1)
47 25 Inclined

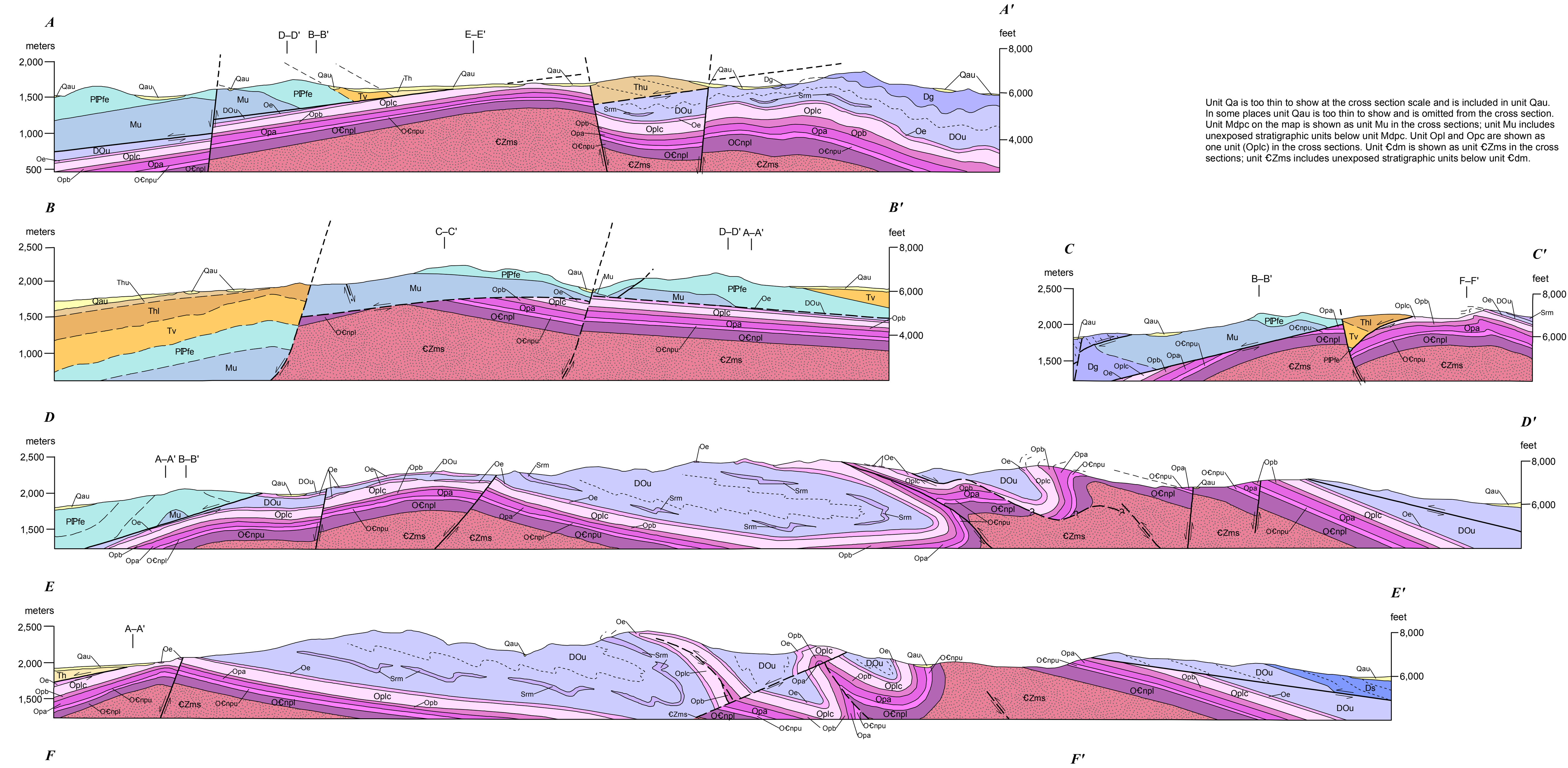
Strike and dip of foliation
Vertical

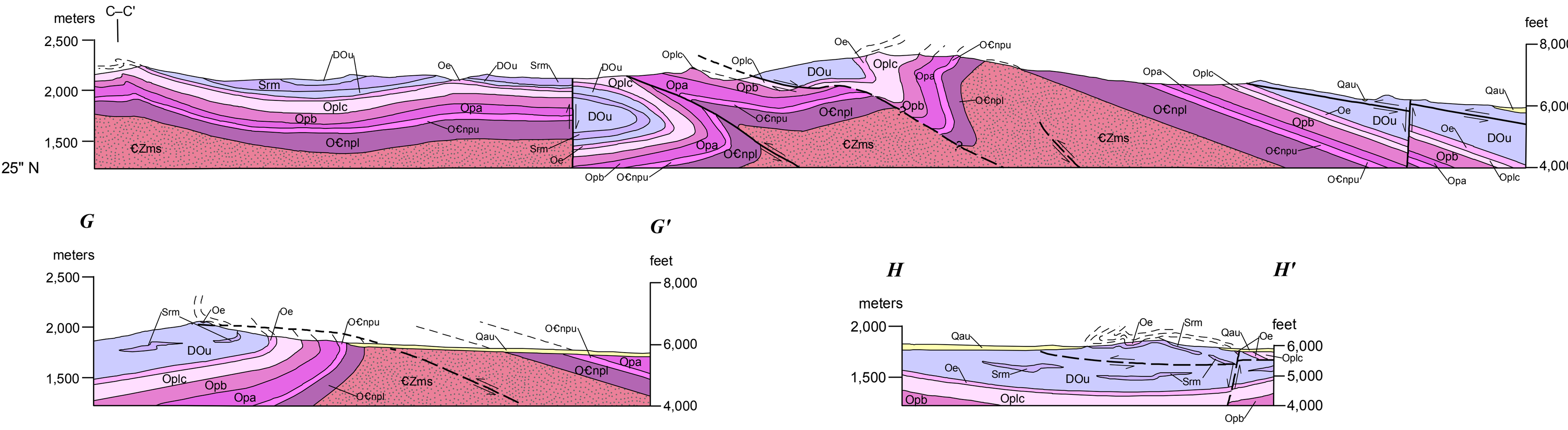
Trend and plunge of elongation lineation (L_1)
33 Inclined

Trend of horizontal lineation
Horizontal

Line of cross section
A *A′*

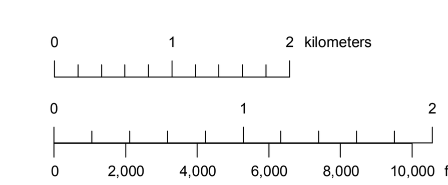
Sample location
Vitric tuff





Unit Qa is too thin to show at the cross section scale and is included in unit Qau. In some places unit Qau is too thin to show and is omitted from the cross section. Unit Mdpc on the map is shown as unit Mu in the cross sections; unit Mu includes unexposed stratigraphic units below unit Mdpc. Unit Opl and Opc are shown as one unit (Oplc) in the cross sections. Unit €dm is shown as unit €Zms in the cross sections; unit €Zms includes unexposed stratigraphic units below unit €dm.

Scale 1:48,000

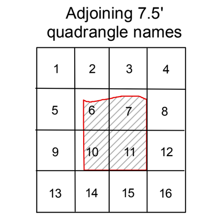


CONTOUR INTERVAL 20 FEET

Projection: Universal Transverse Mercator, Zone 11, North American Datum 1927 (m)

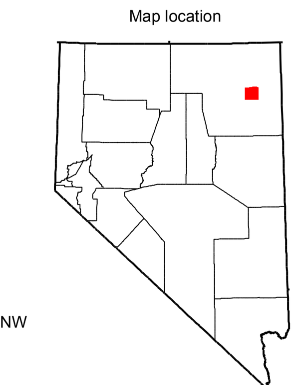
Base map: U.S. Geological Survey
Wells 7.5' quadrangle (1968, photorevised 1982)
Moor Summit 7.5' quadrangle (1968, photorevised 1982)
Tobar 7.5' quadrangle (1968, photorevised 1982)
Snow Water Lake NE 7.5' quadrangle (1968, photoinspected 1982)

Adjoining 7.5' quadrangle names



1 Metropolis
2 Oxley Peak
3 Wells Peak
4 Holborn
5 Welcome
6 Wells
7 Moor Summit
8 Pequop Summit SW
9 Humboldt Peak
10 Tobar
11 Snow Water Lake NE
12 Independence Valley NW
13 Gordon Creek
14 Snow Water Lake
15 Ventosa
16 Independence Valley SW

Map location



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PEER-REVIEWED MAP
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Field review by Christopher D. Henry (NBMG) and Jim Trexler (University of Nevada, Reno)

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