Structural Controls on Regional Geomorphology
At Potter Mountain, Massachusetts

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Introduction: The Taconic Mountains form a series of ridges which trend generally 10° east of north in western New England. According to many models, the Taconic Mountains are the eroded remains of a major thrust sheet (e.g. Stanley and Ratcliffe, 1985). Thrusting occurred during the Ordovician Taconian Orogeny approximately 480 to 460 Ma (Karabinos et al., 1993). The ridges in the Taconic Mountains are composed primarily of a dark gray, silver, and green phyllite, the Nassau Formation. In the project area, the Nassau Formation lies above the Walloomsac and Stockbridge Formations. These formations were derived from continental shelf sediments, whereas the overlying Nassau Formation represents continental slope and rise sediments (Friedman, 1989). The Walloomsac and Stockbridge Formations are exposed in major valleys which parallel major ridges.

Our study area is centered on Potter Mountain which lies just northeast of Hancock, Massachusetts, in the Stephentown Center, New York, Massachusetts 71/2 by 15' Quadrangle. Potter Mountain is composed of three ridges trending at 070°, 022°, and 352° which meet at Widow White's Peak at an elevation of 742m. The entrance to the Jiminy Peak Ski Area lies at an elevation of only 361 m approximately 2 kilometers to the northwest of the summit. Our major goals in the study include examining in detail the structural features of bedrock in our area, determining what structures might be controlling the orientation of streams, and attempting to arrive at a clear understanding of the structural control of large scale valleys within the Taconic Range.

Methods: Our primary means of data collection was through intensive field work. While in the field, we focused on collecting measurements of joint and foliation orientations because we believed that these were the major structural features which might be controlling stream orientation. Once we completed our field work, we plotted rose diagrams and stereograms of joint set and foliation orientations. We then measured the orientations of 250 m long stream segments from base maps. We then plotted rose diagrams of these data to compare with the orientations of joint sets and foliation. We also plotted the orientation of drumlinoid features in order to get an idea of regional ice flow direction. Finally, using lithologic and structural data gathered in the field, we constructed a cross section demonstrating what we believe to be the large scale bedrock structures beneath Potter Mountain.

Data: The orientations of foliation in the rock units of Potter Mountain were remarkably consistent throughout the area of study. Foliation strikes ranged from 010° to 040° with the major peak between 020° and 030°(Figure 1). Field measurements of 185 joints revealed two major jointing directions in the bedrock of Potter Mountain (Figure 2). The first set has an average strike and dip of 215°, 75° NW and the second has an average orientation of 102°, 84° SW. In order to avoid masking variations in data across our field area, we chose to divide our joint data into separate sets for the eastern and western portions. In the western portion of our field area the major north-south joint set has a strike of 200° to 210° while those in the east strike at 220°. Similarly the strikes of the east-west joint set fall between 090° and 110° in the western portion and at 120°-130° in the eastern portion.

By measuring stream orientations on the Stephentown Quadrangle map, we constructed a rose diagram which indicated that most streams in our field area flow between 000° and 010° on the north side of Potter Mountain and between 180° and 190° on the south side. Since the presence of glacial till at lower elevations in our field area seemed likely to have an effect on stream orientations, we subdivided our stream data into an upper portion (encompassing all data from above 450 m) and a lower portion. At high elevations, the strike of the north-south joint set and the average orientation of the streams both fall between 000°-010°, and in the lower reaches of the area the stream orientation and strike of the north-south joints lie between 010°-020°(Figures 3-6).

Although our primary concern in the field was collecting measurements of structural features related to regional deformation, we also noted changes in lithology and major lithologic contacts. The primary rock type observed in our area of study is the green, chlorite-rich unit in the Nassau Formation. A fairly broad belt of silver gray phyllite, also part of the Nassau Formation, occurs at intermediate elevations, especially in the western portion of the study area (Figure 7). Along the eastern flank of Potter Mountain, a narrow band of Walloomsac Formation lies in contact with the Stockbridge Formation. The contact in this area is fairly complex with the Stockbridge Formation overlying the Walloomsac Formation in some locations.

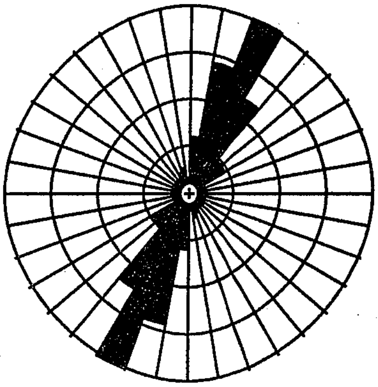


Figure 1. Total Foliation Data for Potter Mountain N=158

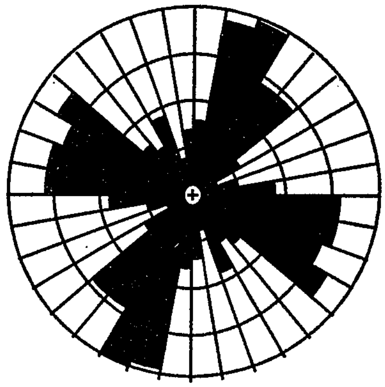


Figure 2. Total Joint Data N=185

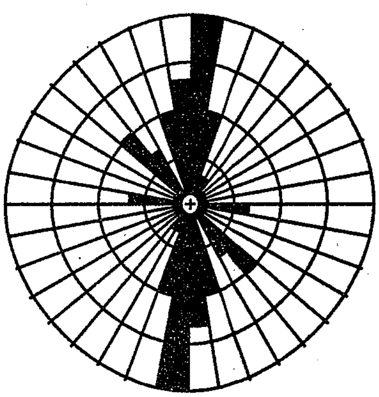


Figure 3. Stream Orientations Above 450m N=25

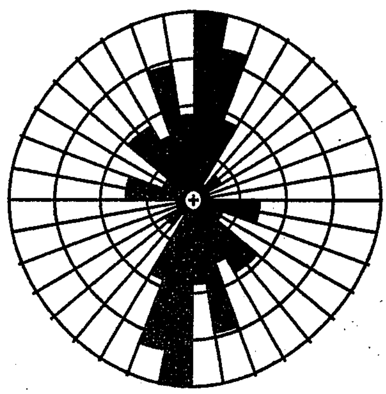


Figure 4. Joint Orientation Above 450m N=71

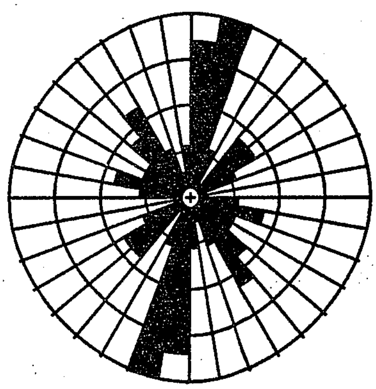


Figure 5. Stream Orientations Below 450m N=44

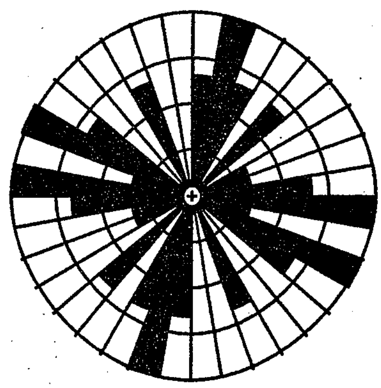
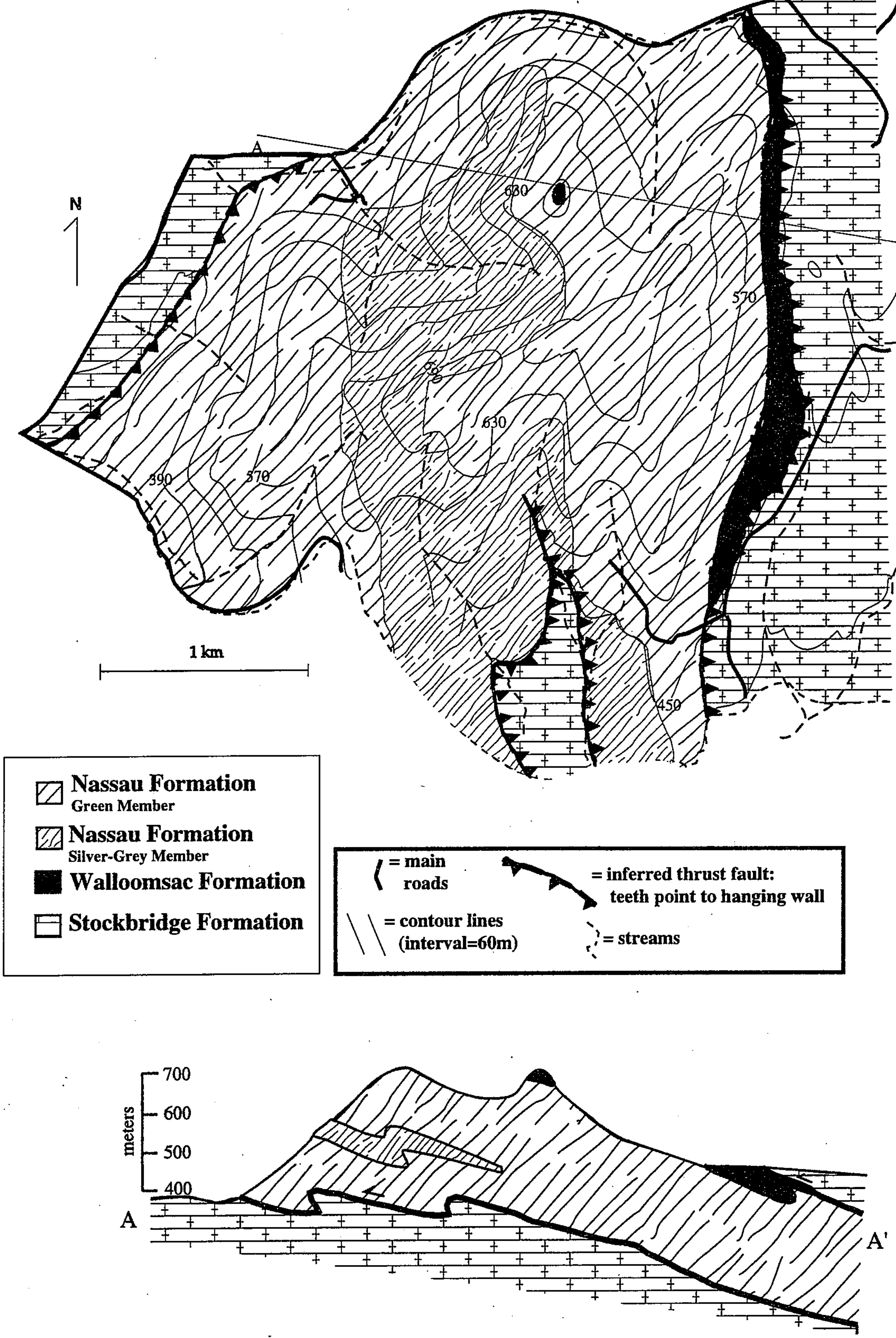


Figure 6. Joint Orientation Below 450m N=24

Figure 7. Geologic Map
and Cross Section of Potter Mountain



Indeed, these formations are repeated several times. Just up-slope from this area, at an elevation of approximately 480 m, Zen et al. (1983) have mapped a major fault contact between the Nassau and Walloomsac Formations (Figure 7).

Discussion: The striking correlation between the orientation of the major north-south joint sets and the stream flow direction throughout our field area suggests that the streams are exploiting the planes of weakness provided by the north-south joint surfaces. The elevation of our field area combined with its masked location south-east of the Taconic Crest and south of Brodie Mountain suggests that the advancing glaciers of the Wisconsinan Ice Sheet probably did not deposit a thick till blanket over the bedrock of Potter Mountain (D. DeSimone personal communication). Consequently, the effects of glaciation on the stream morphology seem fairly limited. However, the east-west striking joint set does not seem to influence stream orientation. There seem to be two possible explanations for this observation. First, the stream orientations we measured were fairly large scale, and it is possible that some exploitation of the east-west joints exists on a smaller scale. In other words, small portions of the streams may jog east or west along the second plane of weakness provided by this second joint direction. The second possibility relates to the fact that the only streams flowing for any distance below 450m lie on the south side of Potter Mountain. Since the south flanks of Potter Mountain lie on the lee side of the ridge from the advancing ice sheet, the till blanket was much thicker here than anywhere else in the study area (D. DeSimone personal communication). The presence of till in this area may have masked the bedrock control on the stream orientation until after the streams had cut deep gullies and were no longer able to migrate easily in new directions. Consequently, although the streams in this area were observed flowing on bedrock, the ability of these streams to migrate along the east-west joint direction may be limited because they first formed following the till gradient.

The eastern portion of our field area may provide us with another model for the orientation of streams in the Potter Mountain study area. The repetition of lithologic units here suggests that several thrust faults cut through this area. Furthermore, the presence of the Walloomsac Formation observed as high as 692 m suggests that faults may penetrate into the Nassau Formation (Figure 7). We believe that these thrusts are part of a series of imbricate thrust faults which cut beneath Potter Mountain. In the highly faulted eastern area, Secum Brook (the easternmost stream in our area) defines a fairly broad lowland as it flows south. In addition, the brook appears to follow the trace of the thrust faults. The size of the Secum Brook lowland suggests that streams which exploit areas weakened by faulting may develop large scale valleys. If this is indeed the case, the regional picture of parallel ridges and valleys might be the result of streams exploiting the relatively weakened areas surrounding major faults. Further correlation of streams and fault traces may help us arrive at a clearer understanding of the regional geomorphology of the Taconic Mountains.

Conclusions: We believe that three major conclusions can be drawn from the data presented above:

1) The orientation of first and second order streams on the flanks of Potter Mountain is primarily controlled by the prominent north-south jointing direction in the bedrock over which they flow.

2) The presence of repeated lithologic units on the eastern slope of Potter Mountain is evidence of a system of imbricate thrust faults which strike north-south.

3) The major north-south jointing direction combined with the north-south trending faults may be the avenues along which higher order streams have eroded through the Taconic thrust sheets generating the regional parallel ridge and valley system.

Works Cited:

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