Structural and Geomorphological Controls on Stream Valley Orientation in the vicinity of Misery Mountain in Berkshire County, Massachusetts and Rensselaer County, New York.

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Introduction and Goals

The study area is located in Berkshire County, Massachusetts and Rensselaer County, New York, along the crest and flanks of the Taconic Range near Misery Mountain. The geologic history of this area includes the Ordovician Taconian Orogeny and the advance of Wisconsinan Ice Sheet. The Taconian Orogeny is responsible for the rise of the Taconic Range. The Wisconsinan Ice Sheet began its advance through this part of New England about 24,000 years ago. The ice began its retreat around 18,000 years ago and exposed the study area along the Massachusetts/New York border around 15,000 years ago (DeSimone 1989). This part of the Taconic region has major north-south oriented valleys underlain predominantly by marble and ridges composed of phyllite. Tributary streams flowing off the ridge axis to the east do not follow the direction of the regional gradient of approximately 100°. Instead, they flow more southeasterly with an average orientation of 120°. With these observations in mind, the project objective is to gather and analyze data that could lead to an explanation of why the major valleys and ridges are located where they are and oriented at approximately 010° and why the tributary streams deviate from the regional gradient.

Methods

The field work consisted of ten days of traverses across the hollows of the Taconic Range in the vicinity of Misery Mountain. These traverses were designed to maximize coverage of tributary hollows and existing hiking trails. Each traverse involved the collection of the strike and dip of foliation, joint orientation, and lithological data.

For the purpose of analysis, the field area was divided into east and west sections. The strike and dip of foliation and joints were plotted onto maps in each sub-region. Computer generated rose diagrams and stereograms of foliation, joint and stream orientation were compiled and correlated.

Map analysis entailed gathering stream orientation data, determining the local stream gradient, and estimating ice flow direction by measuring rock drumlin and drumlinoid orientations. Using rose diagrams, correlations were made between the stream orientation and structural data. A geologic map (Fig. 1) and cross section (Fig. 2) was compiled from field data and some information was adapted from Zen et al. (1983).

Stratigraphy and Lithology

The bedrock of the Misery Mountain study area is composed of three units of the Nassau Formation. The first unit, identified as the "green member", is a green-gray to dark green phyllite with quartz veins. The second unit denoted as the "silver member", is a light green to slate gray phyllite. The third unit called the "dark gray member", is a dark gray to black phyllite and is flaky in hand sample. Weathered surfaces of this unit are rusty black. The Nassau Formation is Late Proterozoic to Cambrian in age, (Zen et al. 1983). Above the Nassau Formation, deposits of Pleistocene till can be found (DeSimone 1989).

East and West Structural Orientation and Stream Flow

The average foliation for the study area is 006° 38° SE. The average on the west side is 006° 36° SE and on the east side the average is 002° 31° SE. Figure 3 compares the strike of joint sets and the direction of upper and lower tributary stream flow for the east and west sides. The average strike of the dominant joint set on the western side is 094°. The average direction of the western tributary stream flow is 262°, while the direction of the regional gradient on the west side is 269°. On the east side, the average strike of the dominant joint set is 098°. The direction of the regional gradient on the east side is 104°, while the average direction of tributary stream flow is 121°.

The tributary streams of this study area flow over till and bedrock. Field observation reveals that where the local stream gradient is the highest, at the higher elevations, the stream is flowing over bedrock and that in places where the local stream gradient is low the stream is flowing mostly over till. Therefore, the stream bedrock interface is critical in determining bedrock joint control on tributary stream flow. This transition occurs at an average elevation of 450 meters for both the east and the west sides.

As shown in Figure 3, the direction of flow for the lower elevation west tributary streams is the same as the direction of flow for the upper elevation west tributary streams. The direction of flow for the upper tributary streams is essentially the same as the strike direction of the dominant joint set on the west side (Fig. 3). On the east side, the direction of flow in the upper tributary streams is different from the flow of the lower tributary streams. Since the upper tributary streams of both the west and the east side flow over bedrock the orientation of these streams is influenced by the jointing of the bedrock as shown in Figure 3.

Rock Drumlin Orientation and Ice Flow

Ice flow indicators exist as the long axes of rock drumlin and drumlinoid landforms and have been used in other studies of the Taconic Range (DeSimone 1989). Map analysis of 27 higher elevation drumlin and drumlinoid orientations revealed that the regional ice flow over the Misery Mountain area was at 165°, consistent with the findings of a southward expansion of the Hudson-Champlain ice lobe over the Taconic range. As the ice retreated from the region it left in its wake a nonuniform blanket of till (DeSimone 1989).

Model for Southeasterly Stream Orientation on the east side of Misery Mountain

Based on the direction of regional ice flow and glacial history, the following model (Fig. 4) can be proposed for explaining how joint control in the higher elevation streams began and the southeasterly orientation of the streams of the east flank ensued;

1. Till deposition by advancing glaciers.
2. Deglaciation, accompanied by thinning ice cover exposed till-veneered hills, and left active ice tongues to be nourished by the waning ice sheet (DeSimone 1989).
3. Stagnant ice in tributary stream valleys and the Hancock valley ice tongue defined the tributary stream hollows on the lee side of Misery Mountain.
4. Meltwater, runoff and spring flows erode away the till layer where it is thinnest and the local stream gradient is the highest, cutting into the bedrock sooner at the higher elevations.

Conclusions

Stream segments on Misery Mountain above 450 meters demonstrate an orientation that correlates with bedrock jointing of the area, while stream segments at the lower elevations are partly determined by prevailing direction of the till gradient and the nature of the underlying material. As the stream cuts through the till and into the bedrock, its course may be influenced by prominent joint sets. If the proposed model is true, the overall stream flow control for the east flank at lower elevations is most likely glacial in origin.

Recommendation.

Clearly, the rate of stream flow and rate of erosion are two major factors in determining the flow of water over any landscape. To clearly define the controls of stream flow in the study area all variables should be identified. This study only examined the bedrock structures and the local stream gradients and glacial history. To provide more evidence for the model proposed in this paper, the location of stagnant ice needs to be more closely examined. DeSimone (1989) located the Hancock Valley tongue and projected stagnate ice blocks into the future locations of Rathburn and Gardener Hollow and Jones and Whitman Brook. To prove the past existence of the stagnant ice blocks, regions along these hollows should be examined for isolated ablation till and ice contact stratified sediments which may be locally preserved in these hollows.

References

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Zen, E-An, ed., Goldsmith, Richard, Ratcliffe, N.M., Robinson, Peter, and Stanley, R.S., compilers, 1983, Bedrock geologic map of Massachusetts: U.S. Geological Survey and the Commonwealth of Massachusetts, Department of Public Works, and Sinnot, J.A., State Geologist.

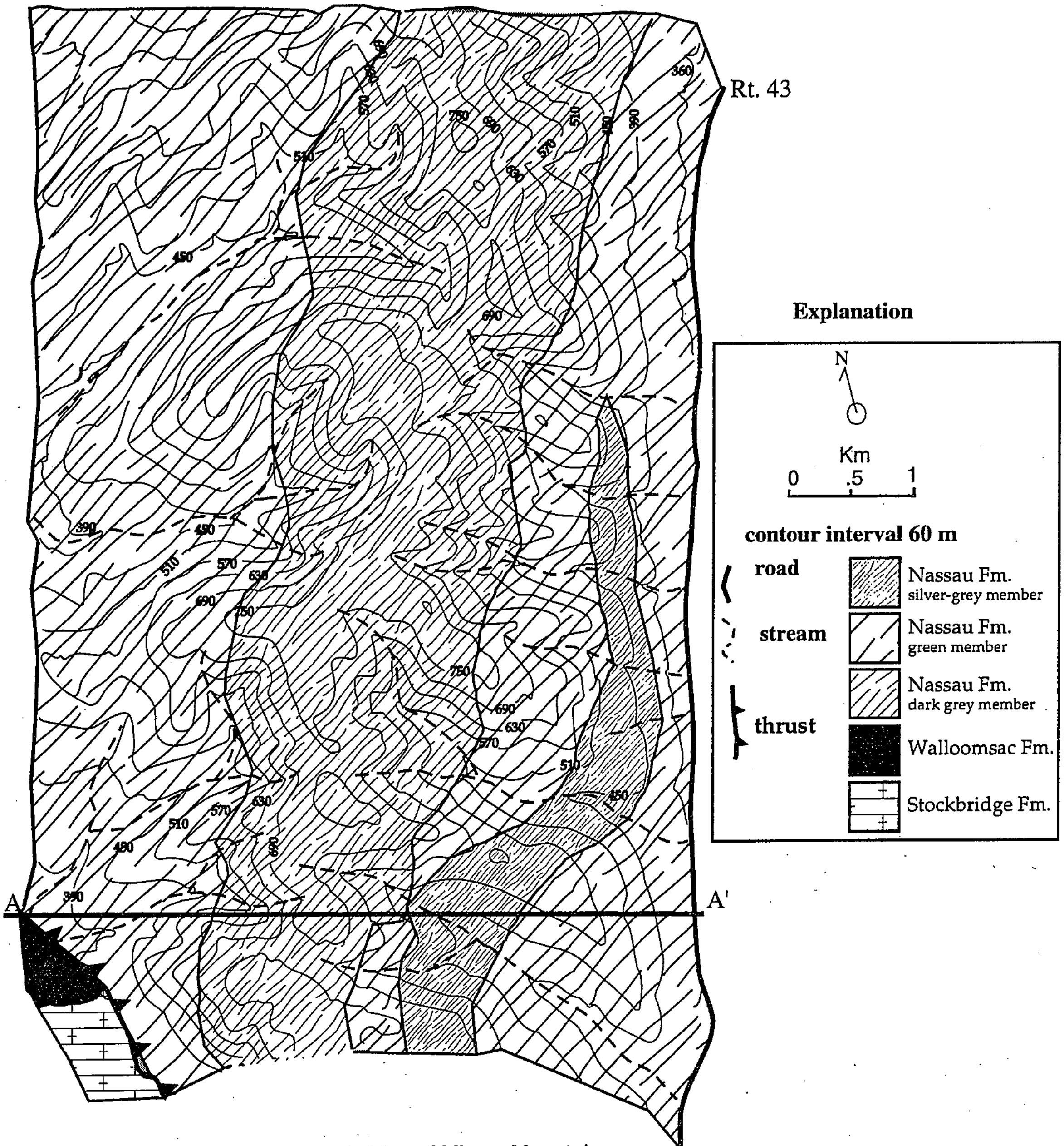

Figure 1. Geologic Map of Misery Mountain

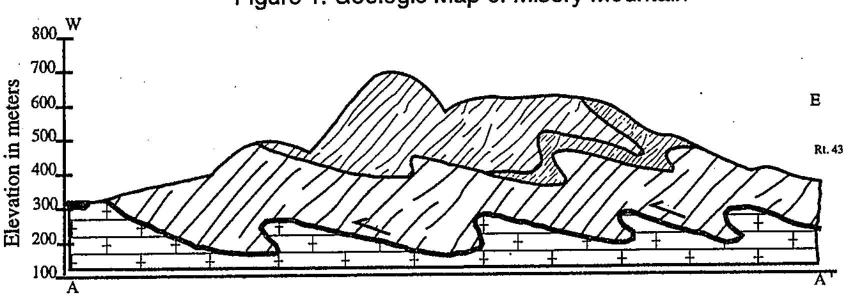

Figure 2. CrossSection of Misery Mountain

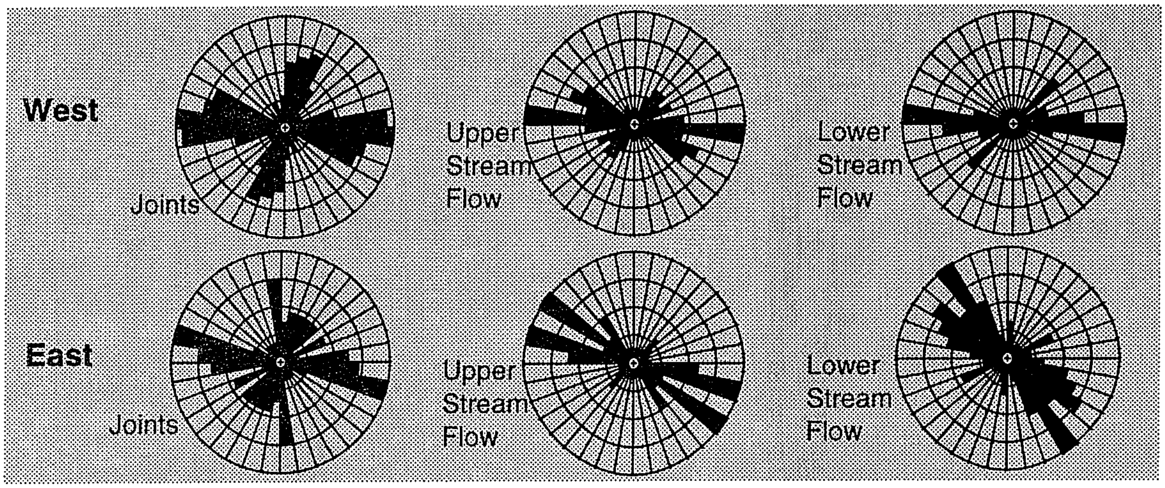

Figure 3. Comparason of joints and upper and lower stream orientation.

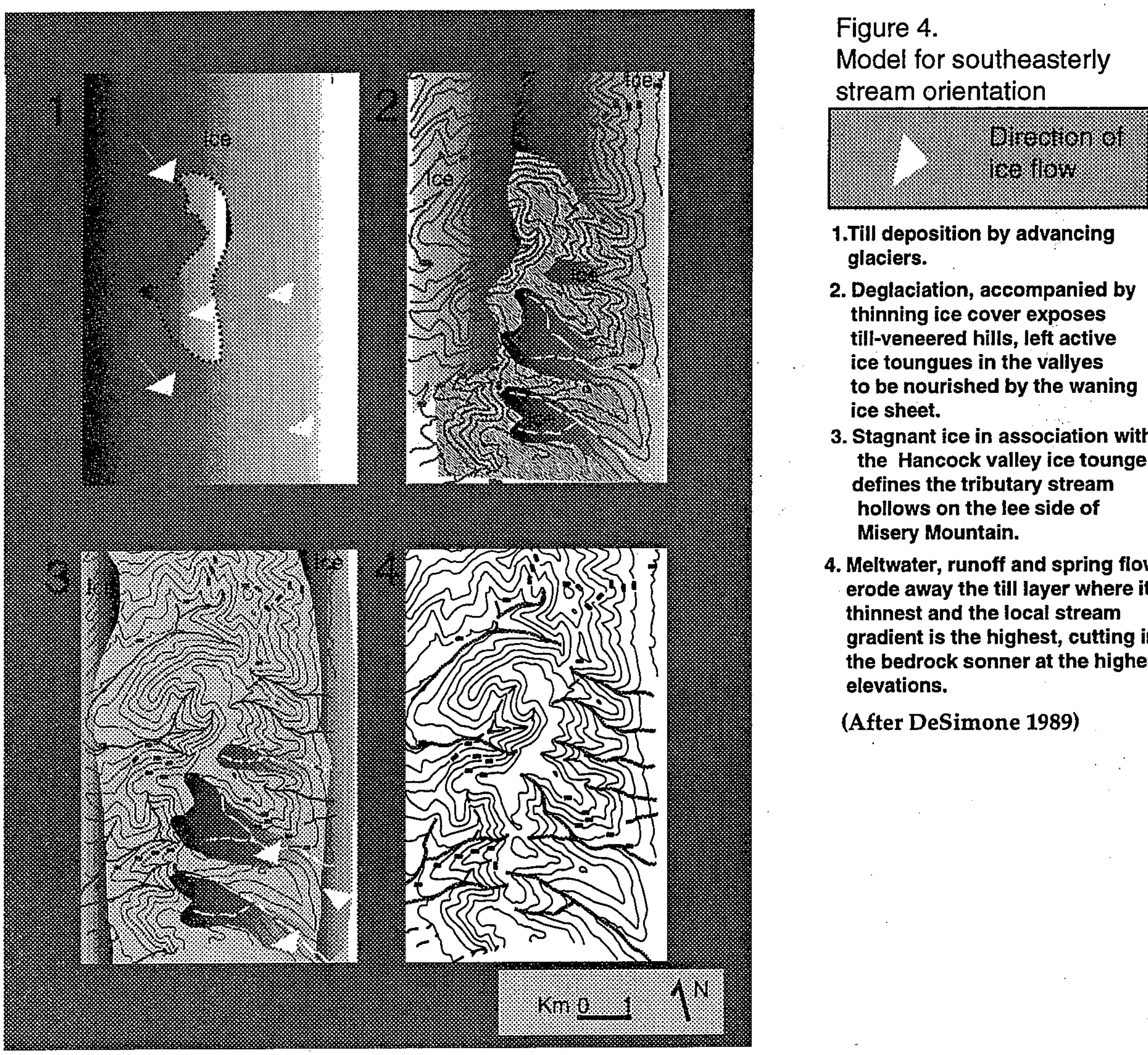

Figure 4.
Model for southeasterly stream orientation

1. Till deposition by advancing glaciers.

2. Deglaciation, accompanied by thinning ice cover exposes till-veneered hills, left active ice toungues in the vallyes to be nourished by the waning ice sheet.

3. Stagnant ice in association with the Hancock valley ice tounge defines the tributary stream hollows on the lee side of Misery Mountain.

4. Meltwater, runoff and spring flows erode away the till layer where it is thinnest and the local stream gradient is the highest, cutting into the bedrock sonner at the higher elevations.

(After DeSimone 1989)