STRUCTURAL CONTROLS ON THE ORIENTATION AND LOCATION OF MAJOR RIDGES AND VALLEYS IN THE TACONIC RANGES, WESTERN NEW ENGLAND AND EASTERN NEW YORK

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Introduction

The Taconic Ranges in western New England and eastern New York are dominated by major ridges and valleys trending between 0° to 30°. In western Berkshire County, Massachusetts, and eastern Rensselaer County, New York, elevation differences of up to 850 m over a horizontal distance of less than 5 km results in very rugged topography. Ridges are dominantly composed of slates, phyllites, and schists of the Late Proterozoic to Middle Ordovician Taconic sequence, that were deposited on the continental slope and rise of ancient North America (represented by the Nassau Formation in the study area). Valleys are dominantly underlain by Early Cambrian to Early Ordovician marbles deposited on the continental shelf (Stockbridge Formation). Rocks of the Taconic sequence were thrust westward over the carbonate shelf rocks during the Ordovician Taconian orogeny. Middle Ordovician syn-orogenic flysch (Walloomsac Formation) was deposited on both rocks of the carbonate shelf and the Taconic sequence and is found in valleys and at intermediate elevations on the slopes of ridges.

Ice sheets of the Pleistocene Wisconsinan glaciation created till deposits, mainly at lower elevations, and probably removed surfical material from ridge crests. Ice flow was approximately 160°, at an oblique angle to the major ridges and valleys.

Marbles are much more susceptible to chemical weathering than the aluminum rich rocks of the Taconic sequence. The greater extent of chemical weathering promotes more rapid erosion of marble than the phyllite and schist found in the study area. Thus, it is not surprising that the valleys are dominantly underlain by marble. However, if Taconic sequence rocks were emplaced over carbonate shelf rocks as an imbricate stack along a basal sole thrust, erosion must have removed the more resistant phyllites before the marbles were exposed. We searched for a structural explanation of why the major valleys formed where they did and why they are oriented approximately north-south.

Data

The study area is located along the New York-Massachusetts border (Fig. 1). Major valleys typically trend approximately north-south; east-west trending valleys are uncommon. Tributary streams tend to flow down the regional gradient between ridges and valleys on the west side of ridges and at higher elevations on the east side of ridges. However, tributary stream flow deviates significantly from the regional gradient at lower elevations on the east side of ridges (Fig.1).

Outcrops along the ridges are mostly composed of phyllite of the Nassau Formation (Fig. 2), part of the Taconic sequence. A strongly developed crenulation cleavage dominates the fabric of the rock. Bedding is rarely recognizable but an earlier folded cleavage is commonly visible. The strong crenulation cleavage is axial-planar to the tight folds of this early cleavage. With few exceptions, the crenulation cleavage strikes between 350° and 30°, and it unfailingly dips to the east (Fig.1). Statistically,

there is no difference in dip angle or dip direction between the east and west side of ridges (Fig. 3). The strike of the cleavage is approximately parallel to the local trend of the major ridges and valleys (Fig. 1).

Throughout the area, two prominent sets of steeply dipping joints are present in all rock types. One strikes between 0° and 40° and the other strikes between 80° and 130° (Fig. 1). One joint set is approximately parallel to the dominant cleavage and the major ridges and valleys. The other joint set is approximately perpendicular to the major ridges and valleys but is similar in orientation to tributary streams on the west side of ridges and at higher elevations on the east side of ridges.

Marble outcrops of the Stockbridge Formation are scarce and located in valleys, mostly in roadcuts. Bedding is commonly preserved and cleavage is only developed in micaceous beds. Where exposure is good, bedding in the marble clearly outlines folds and faults in the Stockbridge Formation and the orientation of these structures is consistent with formation during thrusting of the Taconic sequence rocks over the carbonate shelf rocks. Field data and information from well logs suggests that the Stockbridge Formation is not everywhere structurally lower than the Nassau Formation and separated from it by a basal sole thrust. Rather, in the Route 43 and Route 7 valleys the Stockbridge Formation appears to be bounded to the west and east by east dipping thrust faults. Rocks of the Walloomsac Formation also appear to be located in fault bounded slivers

Interpretations

The remarkable similarity between the orientation of the major ridges and valleys and the strike of the dominant cleavage and one of the two prominent joint sets suggests that the planar structures provided a direction of weakness which has been exploited by streams in forming the major valleys. Similarly, the tributary streams flowing from major ridge crests to valleys may take advantage of the other prominent joint set, at least where till cover is thin and streams flow over bedrock. The influence of this joint set on the course of tributary streams is, however, difficult to evaluate because the streams flow down the regional gradient, which happens to be approximately parallel to the strike of the joints. Till cover is thickest in the major valleys and on the lower portions of the eastern side of ridges. The southeasterly course of many tributary streams on the eastern side of ridges at lower elevations is probably controlled by the pattern of till deposition by glaciers which flowed obliquely over the ridges in an average direction of 160°. The till deposits fill pre-existing tributary valleys at lower elevations and the gradient of the surface of the deposits trends more southeasterly than the original valleys did.

The location of major valleys is controlled by the fault bounded slivers, or horses, of marble. The slivers formed when the imbricate thrust stack of Taconic sequence rocks overrode the carbonate shelf rocks and large portions of the foot-wall became accreted to the hanging-wall. The present location of these slivers between thrust sheets of the Taconic sequence rocks indicates that the imbricate faults were active during westward transport along the basal sole thrust. The accreted carbonate slivers were faulted into position along the pre-existing imbricate splays which separated Taconic sequence rocks. The same process explains the existence of isolated carbonate slivers along Taconian thrust faults west of the study area which have been erroneously used as evidence for an eastward younging of thrust fault propagation.

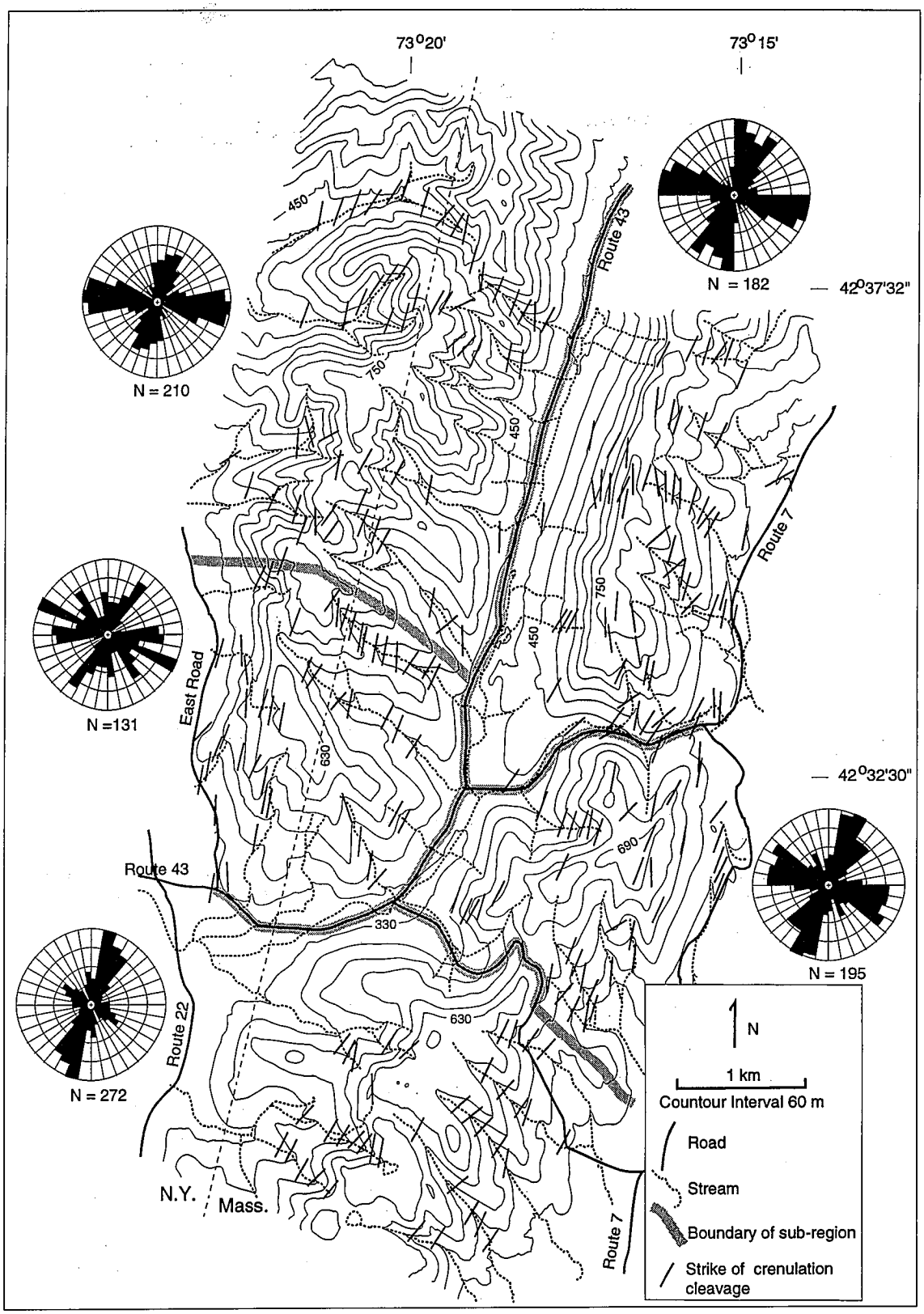

Figure 1. Map of study area showing strike of the dominant crenulation cleavage (all east dipping) and rose diagrams of the strike of joints.

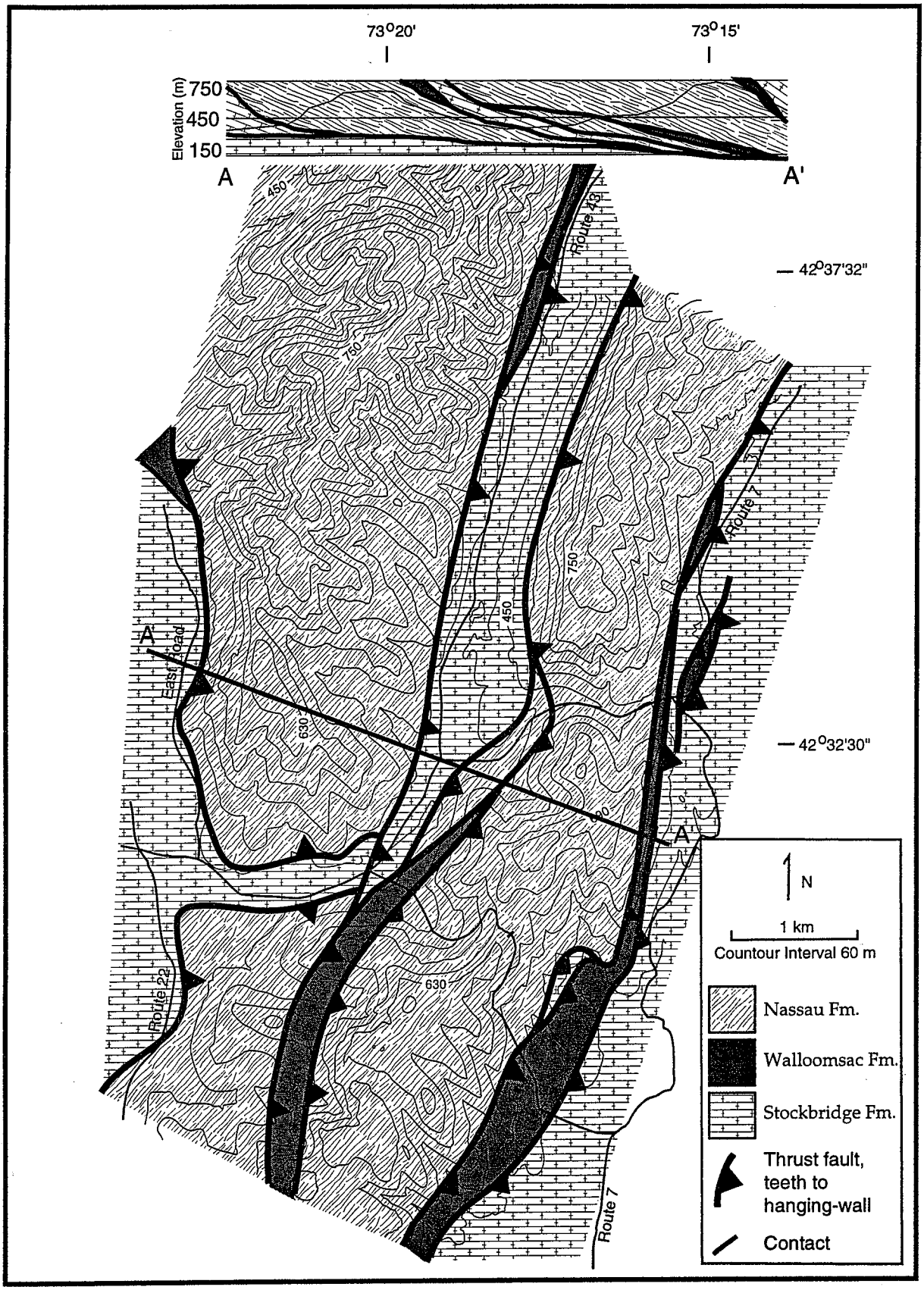

Figure 2. Geologic map and cross section of study area. Based, in part, on information from Zen et al. (1983).

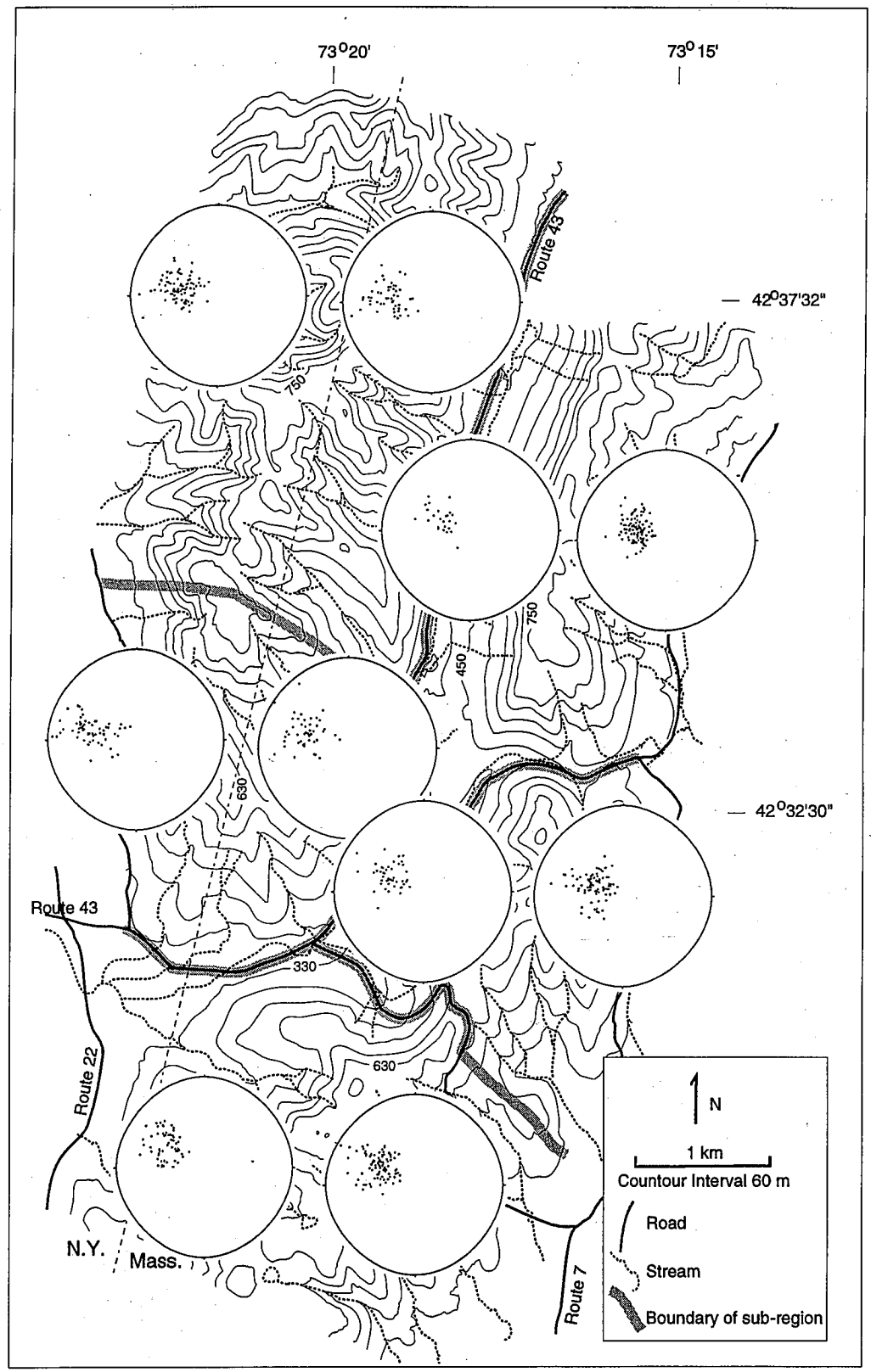

Figure 3. Map of study area showing stereograms of poles to dominant crenulation cleavage from the east and west sides of ridges in each of five sub-regions.