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STRUCTURE CONTROL ON CIRQUE-LIKE FEATURES IN SOUTH-EAST NEW YORK STATE, U.S.A.

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ABSTRACT. Cirque-like features, occurring on the western flank of Shawangunk Mountain in south-east New York State, are unique in the area. Though these topographic forms are apparently the product of periglacial and glacial processes, their initiation and subsequent development were dependent to a considerable extent on a specific set of jointing and bedding attitudes and differential lithologies.

RÉSUMÉ. *Contrôle structurel de formes resemblant à des cirques dans le Sud Est de New York State, U.S.A.* Des formes ressemblent à des cirques, observables sur le flanc Ouest des Shawangunk Mountain dans le Sud Est de New York State, sont uniques dans la région. Bien que leur forme topographique soit apparemment le produit de processus glaciaires et périglaciaires, leur création et leur développement ultérieurs résultent dans une très large mesure d'un ensemble spécifique de pendages concourants et couches et de différences lithologiques.

ZUSAMMENFASSUNG. *Strukturbedingungen für Kar-ähnliche Erscheinungen im Südosten des New York State, U.S.A.* Kar-ähnliche Erscheinungen, die an der Westflanke des Shawangunk Mountain im Südosten des New York State auftreten, sind in diesem Gebiet einmalig. Obwohl diese topographischen Formen sichtlich das Ergebnis periglazialer und glazialer Prozesse sind, war ihre Einleitung und darauffolgende Entwicklung doch weitgehend von einer spezifischen Folge von Verbindungs- und Lagerungsvorgängen und von differentierten Gesteinsschichten abhängig.

INTRODUCTION

Most valley heads on the western slope of Shawangunk Mountain in the area of Ellenville in south-east New York State display a semi-spherical outline similar to that of cirques. Though the terminus of the Wisconsin ice sheet extended beyond Shawangunk Mountain (Fig. 1), such topographic features are unusual for south-east New York State; definite cirques only occur at higher elevations in the Catskill Mountains region further north (Rich, 1935). Not only are these cirque-like valley forms atypical for the region but also they are anomalous with respect to orientation. Cirques are often more prevalent on cooler, east-facing slopes, where firn accumulations are preserved for longer periods during the summer and physical weathering is more intense (Derbyshire and Evans, [c1976]). Thus, the origin of these cirque-like forms may not be solely attributable to glacial activity. This study was undertaken to examine the influence of special geologic factors that may have contributed to their development.

GENERAL GEOLOGY

In the area studied (Fig. 1); Shawangunk Mountain forms a conspicuous ridge trending 25° to 30° east of north. The western slope is supported by the Silurian Shawangunk Formation which dips to the west-north-west. Three lithologic units comprise this formation. In upward stratigraphic succession they are: (a) a resistant quartzitic conglomerate, (b) a relatively weak middle member, consisting predominantly of siltstone and shale, and (c) a resistant quartzitic sandstone. The eastern part of the ridge is underlain by the thin-bedded, generally fine-clastic Ordovician Martinsburg Formation, which forms an east-south-east-facing, relatively undissected, erosional escarpment. Fractures within the ridge show distinct preferred orientation; most prominent is a set of strike joints; subsidiary dip joints are also present.

The valleys on the western slope of the ridge are parallel to the dip joints, all trending west-north-westerly. Unsorted glacial and mass-wasted debris is found within the valleys.

DISCUSSION

Certainly, the topographic prominence and contrasting slope lithologies, as well as the structural fabric of Shawangunk Mountain, existed prior to the onset of Pleistocene climatic conditions. The contrast in distinct channel development that exists between the western dip slope and the eastern erosional escarpment of Shawangunk Mountain is probably, in large measure, a pre-glacial feature as well. Unlike the east-facing erosional escarpment of Shawangunk Mountain, where extensive exposure

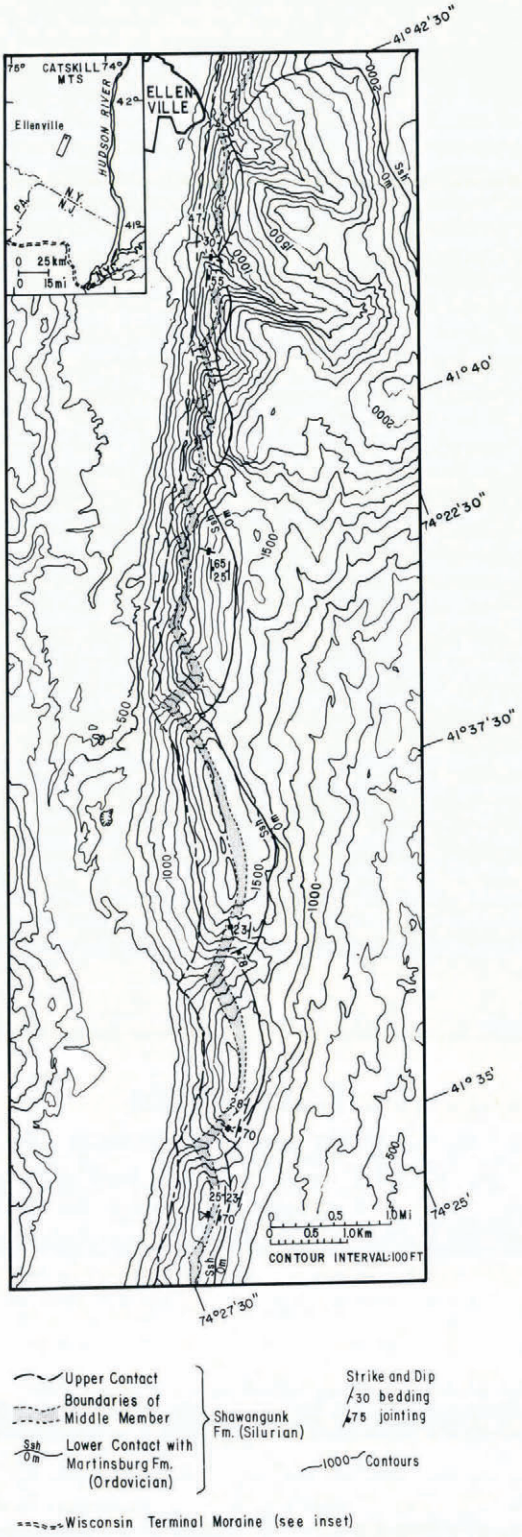

Fig. 1. Shawangunk Mountain in the vicinity of Ellenville, New York State. The small rectangle in the map inset shows the relationship of the area to the surrounding region. The geology is based on personal observation and Fisher and others (1971).

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of Martinsburg shale in strike favored parallel westward retreat of the entire escarpment by active undercutting of the Shawangunk conglomerate cap rock, the west-facing slope was geologically predisposed to experience the development of distinct and confined valleys. Sheet wash would have been ineffective in eroding the dip slope underlain by the quartzitic sandstone of the Shawangunk Formation except along the particular zones of weakness provided by dip joints. Without this structurally and lithologically controlled predisposition toward distinct channeling on the western slope, cirque-like forms would likely not have developed. Nevertheless, without the interplay of a number of geologic factors, the valleys would have remained essentially narrow and linear features.

The sequential development of the valleys, following their initial dissection, to the present curved morphology is envisioned to have proceeded along the following stages:

1. Lateral erosion and consequent broadening of the valleys in strike as channel erosion encountered the middle, weak member of the Shawangunk Formation. The lower reaches of the channels would remain confined by the resistant uppermost quartzitic sandstone. With time, the valleys would assume a "pear-shaped" form with the upper part and head of the valleys becoming rather open and broad.
2. Under Pleistocene climatic conditions, permanent or semi-permanent accumulations of snow, firn, and ice would have filled the more open upper reaches of the valleys. Under these conditions, valley sides and headwalls would have been more actively degraded by frost action than would downcutting have deepened valley floors. Further, at the time that Shawangunk Mountain was covered by the ice sheet, ice flow, concentrated within the valleys, would have accentuated lateral broadening of the valley walls by plucking of elongate slab-like blocks delineated primarily by bedding planes, and the more prevalent strike-oriented joints. Concomitantly, eastward extension of headwalls would have been promoted by movement of slabs down westward-dipping bedding planes.

Where pre-glacial erosion had cut down through the Shawangunk Formation and into the Martinsburg shale, cirque-like broadening of the valleys would have developed within the Martinsburg shale.

In summary, without the influences of frost action and glacial plucking, the valleys would probably have remained essentially "V"-shaped and, except for tributaries dissecting channels in strike along the weak middle member, would have retained their linear aspect. Thus, it may be concluded that the valley heads on the western slope of Shawangunk Mountain owe their cirque-like morphology to periglacial and glacial activity. Nevertheless, it is clear that their initial development and subsequent evolution very much depended on pre-existing topographic features, rock structure, and lithologic contrasts.

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