Reports

Glaciated Appalachian Plateau: Till Shadows on Hills

Abstract. *North slopes are twice as steep as south slopes on the hills of central New York. This asymmetry is caused by unequal till thickness—3.6 meters on north slopes and 27.6 meters on south slopes. Previous workers interpreted the hills as being of bedrock sculptured by glacial erosion, with till 0.9 to 3 meters thick.*

My purpose is to reexamine and reinterpret some of the topographic and glacial features of hills in part of the glaciated Appalachian Plateau (Fig. 1). Von Engeln (*1*) discussed this area under the heading "Roches-moutonnées Fields"; he captioned an oblique aerial photograph, "Glacially rounded rock hills of the Appalachian Plateau. . . ." Charlesworth (*2*) described the area as a " . . . vast sea of roches moutonnées on the hills and plateaux of central New York." Tarr (*3*) stated, " . . . the till cover is only a few feet thick, probably averaging less than 10 feet [3 m]." Lounsbury (*4*) reported ". . . . a shallow soil mantle averaging not much more than 3 feet in thickness over the bedrock"; and, "This soil . . . at a depth ranging from 2 to 3 feet, rests on rock." In discussing Tioga County, immediately west of Broome County, Lounsbury stated, "The entire area . . . is covered by a thin layer of glacial till 3 to 10 feet thick" (*5*).

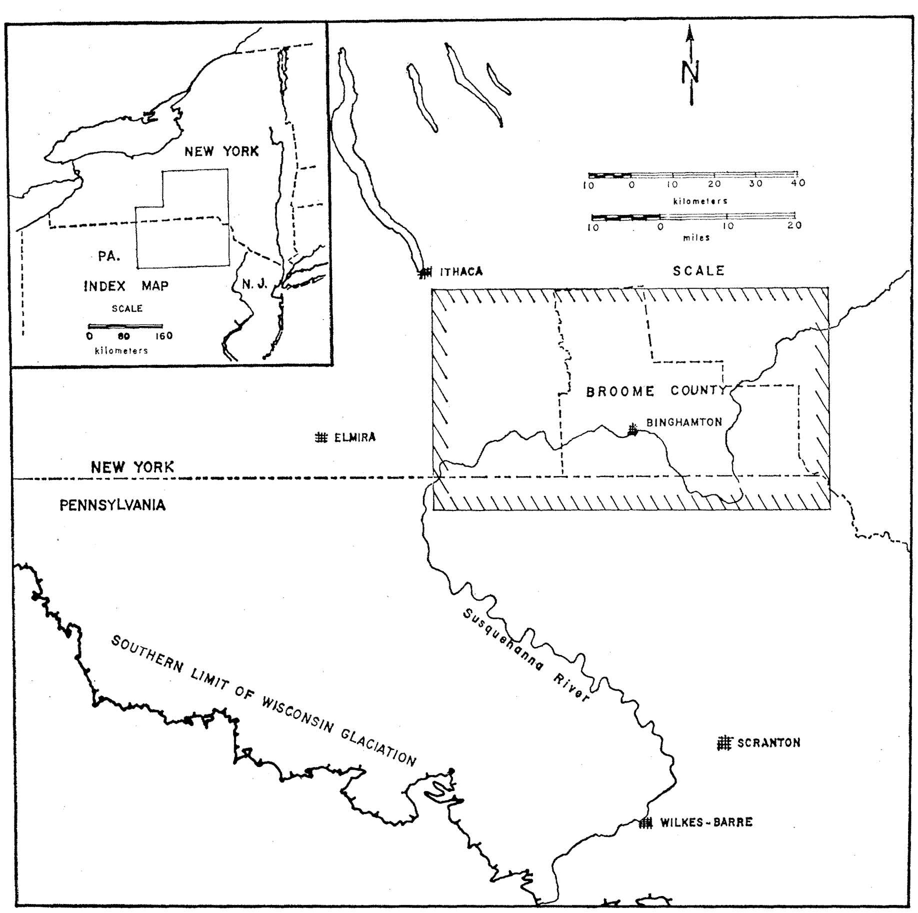

Fig. 1. Location of the portion (hatched) of the Appalachian Plateau covered by the report.

Bedrock in central New York consists of Middle and Upper Devonian clastics, largely marine shales and siltstones. Some terrigenous sandstones cap the higher hills south and east of Binghamton. The rocks dip about 6 m/km in a S25°W direction. The entire region was glaciated during Wisconsin time, but deposits from earlier glaciations are unknown. Although maximum relief is more than 450 m, local relief usually is less than 300 m. The Susquehanna River drainage system is the dominant hydrologic feature.

During the last 5 years I have made field-mapping studies of the geology and geomorphology of the area (Fig. 1) and collected information on 2000 water wells. For this report 400 bedrock wells located on 107 different hills were selected for analysis. The following criteria were developed in an attempt at uniformity and to minimize the influence of extraneous land forms and geological processes: (i) Hills are rounded topographic forms that exceed a height of 75 m; (ii) hills must be separate and distant from the flood plains of major rivers; (iii) hills must have elongation ratios (length/width) of less than 5.0. A deliberate attempt was made to select hills representing a variety of axial trends (Table 1). For the sampling of wells, 100 wells were chosen for each of the four compass quadrants: north, south, east, and west. Except for wells on north slopes, the location of the wells represents a uniform distribution for all slope elements of a quadrant; the middle part of most north slopes is made uninhabitable by steepness, so that distribution of the 100 north wells is bimodal in that most are located near either the top or the bottom of the slope. The materials comprising the north slopes also differ from the compositions of slopes in other directions: northern soils are stony silt loams, whereas the other slopes are of silt loams and gravelly silt loams (*4, 5*). The main bulk of surficial deposits on north slopes is till and colluvium that is less homogeneous and contains more and larger rock fragments than the lodgment-type till developed on other slopes.

The average thickness of unconsolidated material above bedrock is at least 18 m—more than six times the thickness cited in the literature. This new depth is derived by correlating field

Table 1. Directional trends of long axes and elongation ratios of 107 hills in central New York.

Directional trend of long axes	Number of hills	Elongation ratio (length/width)
North	52	1.64
East	17	1.97
Northeast	18	1.82
Northwest	20	2.23

studies with the data of Table 2. The depths to rock for south, east, and west slopes, 28.1, 15.8, and 18.9 m, respectively, represent actual thicknesses of glacial drift on these slopes. The figure of 6.7 m for north slopes, however, does not accurately represent north slopes throughout the region; by use of a method of weighted averaging and by integration with field studies of outcrop-distribution patterns, the thickness of unconsolidated materials on north slopes is calculated to be 3.6 m.

When this figure is compared with the 28.1-m thickness of materials on south slopes, the till asymmetry is even more pronounced. Till is generally thinnest at the hilltop and thickest at the bottom, but many south slopes deviate from this rule. The thickest till on south slopes (Fig. 2), >45 m, occurs not at the base but at a position about one-fifth the distance to the hilltop. Thus a cross section would show till thickening progressively from the top of the hill downslope to a position one-fifth from the bottom, where there is maximum thickness of up to 75 m, and thence thinning toward the base. This notch in the bedrock is interpreted as the position of the preglacial stream channel that was formerly at the base of the slope; obliteration of the old drainage by the till forced postglacial streams to adopt a course south of the former channel.

My data require reevaluation of the terminology used to describe hills in central New York. I suggest that the facts do not fit the criteria for this area to be classified as a roches-moutonnées field, as to either bedrock conditions or shape and orientation of hills. If a plane is drawn through the base of a hill and the volumes of materials are calculated, bedrock composes less than 70 percent of the total volume of the hill. Furthermore, the diversity of hill trends and the nature of the topographic asymmetry are contrary to the roches-moutonnées developmental process; that is, elongation of hills may be athwart glacial motion, and the steepest slopes are developed on the stoss—not on the lee sides. A shale-and-siltstone lithology is not an appropriate rock type for the production of roches moutonnées.

An alternative nomenclature may be possible: the hills may be described as some form of drumlin or rock drumlin. If judgment is based on hill size, physical setting, and axial-trend relations, central New York hills do not qualify as typical New York drumlinoid features. Most New York drumlins are less than 50 m high, are located on otherwise featureless plains, and possess streamline forms interpreted as paralleling glacial movement. Since the hills of this report are two to three times as high as most drumlins, are located in a region having preglacial relief of 300 to 450 m, and contain a wide scatter of long-axes orientation (see Table 1; one-third of the 107 hills have long axes transverse to the southwesterly moving ice sheet), such hills seem to be poorly suited for descriptions as drumlinoid.

The description that most clearly reflects the genetic character of the hills is "crag-and-tail topography." Thickness of deposition of till in central New York has been largely influenced by bedrock form, and the hills have been gently smoothed on the lee sides where the deposits accumulated. Despite the diverse orientations of hill axes, the till is always thickest on south and southwest slopes; indeed, thickening of till on such slopes is parallel with glacial transport as determined by striae and till-fabric analysis of the region, so that the direction of till thickening may provide an additional tool for determination of ice-sheet movements in similar areas. This part of the Appalachian Plateau, however, lacks cores of resistant rock, consistently aligned hill axes, and well-developed "tails" of the typical crag-and-tail topography defined in the literature and in geology texts. Under such circumstances it may be more appropriate and informative to label the features I have described "till-shadow hills."

One conclusion is that published descriptions of these hills as of bedrock sculptured by glacial erosion and covered by a thin veneer of till are incorrect.

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Table 2. Characteristics and topographic relations of 400 water wells (100 on each of four hill slopes) in central New York. All calculations are averages.

Site on slope	Well: Depth (m) To rock	Well: Depth (m) Total	Well: Elevation (m)	Hill: Elevation (m)	Hill: Height (m)	Hill: Topographic slope (%)	Hill: Elongation ratio (length/width)
North	6.7	46	410	468	116	24	1.77
South	28.1	47	395	472	109	12	1.90
East	15.8	58	435	483	102	18	2.06
West	18.9	43	415	478	110	15	1.82

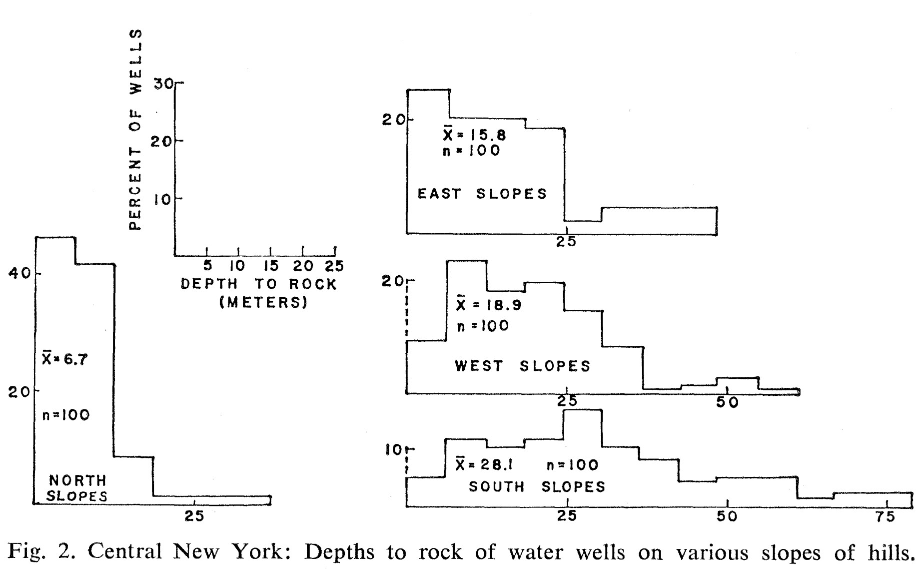

Fig. 2. Central New York: Depths to rock of water wells on various slopes of hills.

References and Notes

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3. R. S. Tarr, in H. S. Williams, R. S. Tarr, E. M. Kindle, *U.S. Geol. Surv. Geol. Atlas 169* (1909), p. 16.
4. C. Lounsbury, A. H. Hasty, D. F. Kinsman, J. H. Baran, *Soil Survey of Broome County, New York* (U.S. Dept. Agr., 1932), pp. 13–14.
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Methyl Radicals: Preparation and Stabilization

Abstract. *Methyl radicals were prepared by photolysis of methyl iodide in porous glass and were stabilized for days at room temperature. Their reactivity was investigated.*

Gomberg (*1*) isolated in 1900 a complicated free radical, triphenyl methyl, and opened up a new discipline in organic chemistry—the chemistry of free radicals. The simplest of the free radicals, methyl, could not be produced and stabilized at room temperature. Paneth (*2*) in 1929, using a flow system and a metallic film detection scheme, inferred the transient existence of methyl radicals with lifetimes from 20 to 100 msec. Since then methyl radicals have been produced and stabilized at low temperatures (42° to 77°K) either by embedding them in a frozen matrix or by adsorbing them, after gamma irradiation, on silica and alumina (*3, 4*). Herzberg and Shoosmith measured, at 2140 Å, absorption spectra of CH_3 and CD_3 in gas phase (*5*).

We now report the preparation and stabilization for days at room temperature of methyl radicals. The methyl radical was produced by the photolysis of methyl iodide adsorbed on porous Vycor glass. The corresponding deuteromethyl and C^{13}-methyl have also been produced. The radicals were identified by their characteristic electron-spin resonance (ESR) spectra. We studied the reactivity of the methyl radical with hydrogen, deuterium, oxygen, nitric oxide, and other gases using the change of ESR spectra to monitor the concentration of the methyl radical.

The methyl iodide and other alkyl iodides were degassed either in a vacuum system or by a purified helium flush; CD_3I and $C^{13}H_3I$ (50 percent) were obtained from Merck, Sharpe and Dohme of Canada, Limited. Helium (General Dynamics grade A) was purified by passing it over activated alumina cooled at liquid-nitrogen temperature. Oxygen (General Dynamics, industrial grade) was used without further purification. The other gases such as H_2, D_2, NO, CH_4, C_2H_6, and n-C_4H_{10} (Matheson) were either CP grade or prepurified grade and were used from lecture-size gas cylinders without purification.

The Vycor porous glass (Corning Glass No. 7930, 96 percent SiO_2 and 3 percent B_2O_3) was treated in oxygen at 600° to 650°C to remove the organic material usually absorbed on it from the contaminants present in the laboratory atmosphere. It was cooled to room temperature in helium and stored in a stoppered glass bottle. After this treatment the Vycor changed its color from yellow-brown to water-white. Vycor glass rods, 25 by 4 mm, weighing 0.5 g, were used. The surface area, as determined by the Brunauer-Emmett-Teller method of nitrogen adsorption at liquid-nitrogen temperature, was 144 m^2/g.

In the flow system a purified helium gas stream was passed through a saturator containing the alkyl iodide. The partial pressure of the alkyl iodide in the gas stream was controlled by the temperature of the saturator. The helium stream then passed over the Vycor porous glass placed in a quartz tube (6.5 mm outside diameter, 5.0 mm inside diameter) which was inserted into the flow system with polyethylene tube connections. The exit end of this quartz tube was also connected to a rotary vacuum pump. The helium was passed over the sample at a high flow rate at a pressure greater than atmospheric. The sample was irradiated outside of the cavity and, after irradiation, was transferred to another portion of the sample tube since a signal developed in the quartz sample tube on irradiation. The system was then evacuated with the rotary pump, and pure helium was passed over the sample. With helium flowing, the exit end of the sample tube was disconnected, was inserted into the microwave cavity, and again connected to the original flow line. For the measurement of the interaction of methyl radicals with other gases, the sample was evacuated after stopping the helium flow. The interacting gas at a certain pressure was introduced from another flow line, and the change in ESR signal was observed under static conditions.

In static experiments, a previously cleaned Vycor glass rod was evacuated at 500°C in a quartz tube (special purity, General Electric Co., 5 mm outside diameter, 4 mm inside diameter) which had a quartz-pyrex graded seal for attachment to a conventional vacuum

Table 1. Characteristics of methyl and deuteromethyl radicals. RT, room temperature; LN, liquid nitrogen; VG, Vycor glass; HFS, hyperfine splitting (separation between individual lines composing spectrum).

Condition	Total spread (gauss) Calc.	Total spread (gauss) Obs.	HFS (gauss) Calc.	HFS (gauss) Obs.	Line width (gauss)	Ratio of line intensities at peak
Methyl radical						
CH_3I Matrix at LN	68	68.8	22.4	23.2	3.6	1.0|2.8|2.9|1.0
Adsorbed on VG at RT		67.8		22.7	1.0	1.0|3.0|3.3|1.1
Adsorbed on VG at LN		68.8		22.9	0.8	1.0|3.7|4.1|1.3
Deuteromethyl radical						
Adsorbed on VG at RT		21.2		3.5	1.8	1.0|3.3|6.8|7.8|6.5|3.2|1.4

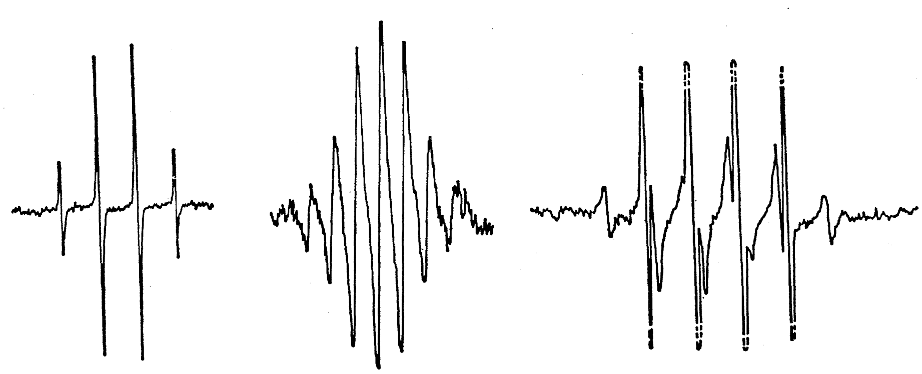

Fig. 1. ESR absorption derivative spectra of methyl (left) and deuteromethyl (center) and C^{13}-methyl (right) radicals at room temperature.