PERIGLACIAL GEOMORPHOLOGY OF THE APPALACHIAN HIGHLANDS AND INTERIOR HIGHLANDS SOUTH OF THE GLACIAL BORDER — A REVIEW*

G. MICHAEL CLARK and EDWARD J. CIOLKOSZ

Department of Geological Sciences, The University of Tennessee, Knoxville, TN 37996-1410 (U.S.A.)
Department of Agronomy, The Pennsylvania State University, University Park, PA 16802 (U.S.A.)

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Abstract


Many features reported in the Appalachian region have been assigned a paleoperiglacial origin based on field relationships and their similarities with analogs active in present day actuoperiglacial environments. These forms include, but are not limited to, sorted and nonsorted varieties of patterned ground, grès litées, block fields, block slopes, and block streams, cryoplanation terraces, and hillslope and river terrace landscapes. Although very small-scale features (generally less than 1 m in plan or section dimension) and some larger forms on steep hillslopes are known to be at least sporadically active today, the large-scale features discussed here are interpreted as either inactive or truly fossil periglacial phenomena. Thus they have implications for paleoclimatic reconstruction and significance as indicators of relative landscape stability since the time(s) of their development. This paper briefly reviews the historical dimension of early researchers’ work, presents selected examples of recent research results, and gives the authors’ conclusions.

Introduction

As documented by Péwé (1983) certain unglaciated areas south of the continental ice sheets in the conterminous United States had periglacial climates during the cold phases of Wisconsinan time. During glacial cold-phase maxima, large areas of the Appalachian Highlands were above the forest limit (Delcourt and Delcourt, 1981). The Appalachian Highlands and Interior Highlands (Thornbury, 1965) provided broad spectra of rocks and soils, topography and biota that fostered a wide range of periglacial environments. On the regional basis (Fig. 1), trends of the fold-belt mountain and plateau systems permitted development of a wide variety of landforms and deposits at varying distances and topographic settings from the ice sheet margins. As most reports are from the Appalachian Highlands, this geomorphic division receives preponderant coverage.

There is little present evidence on the nature of the Early and Mid Quaternary environments in the study region. For the Late Quaternary, however, Eyles and Westgate (1987) argue that, in early Wisconsinan time, Laurentide ice extent was restricted and never extended beyond at least the eastern Great Lakes basins (Fig. 1).
Detailed paleovegetation data are available for the last 40 ka (Delcourt and Delcourt, 1981). During the last glacial cold-phase maximum (23–16.5 ka), tundra and boreal forest vegetational assemblages existed south of the glacial margin. Moran (1972, p. 102) estimated a glacial-age July temperature for the highest elevation (ca. 2025 m) in the Great Smoky Mountains of ca. 6.5°C. Shafer (1984, p. 88) concluded that Flat Laurel Gap (35°24' N; 82°45' W; 1475–1500 m) may have had an average annual air temperature as low as −7.0°C at 18 ka BP. Kutzbach and Wright (1985) simulated the climate of 18 ka BP and then compared the results with the North American geologic record of that time. They concluded that the jet stream was split by the North American ice sheet, and that the southern branch was intensified over the southeastern United States. July average temperatures may have been 5 to 15°C lower than now, and in most parts of the study region (Fig. 1) annual precipitation was decreased markedly (10–30%).

In the Late Wisconsinan, Late Glacial Interval (16.5–12.5 ka), spruce-rich forests replaced tundra in the higher valleys, ridges, and plateaus. During Holocene time (12.5–0 ka), closed boreal forests have persisted at the highest elevations, and closed hardwood forests have dominated over other forest types in the remainder of the region (Delcourt and Delcourt, 1986).

At the present there are only a few published reports of Pleistocene paleoperoiglacial features indicative of permafrost (Walters, 1978; Cronce and Ciolkosz, 1986; Marsh, 1987). The search for such forms, however, is still in its infancy.

Extant climates are extremely varied due to differences in elevation, latitude, topography, distance from water bodies, and other factors.
Mean annual air temperatures range from ca. 6.6 to 15.6°C. Soil temperature regimes are thermic in the Piedmont province south of Maryland, and in the Ridge and Valley province south of Virginia. In other areas there are mesic, or at high elevations frigid, soils (Buol, 1973; Carter and Ciolkosz, 1980; Springer and Elder, 1980; Lietzke and McGuire, 1987). Cryic soils are unknown, although frost pockets may exist. For example, Balch (1900) reported several occurrences of glaciers in the region in scree. Periglacial features discussed here occur primarily in areas with mesic or frigid soils. Temperate deciduous forest cover is the predominant natural vegetation (Braun, 1950). Average Appalachian summit temperatures can be estimated reliably (Leffler, 1981), and all of the mountain summits are well below the computed forest limit. In addition, even in the coldest winters, under natural forest conditions with snow cover, the soil is frozen to a depth of less than 25 cm (Carter and Ciolkosz, 1980).

We understand the term “periglacial” (Lozinski, 1909), to mean cold climatic environments (with or without permafrost) and their landform elements, landforms, and landscapes produced directly and indirectly through the process effects of strong frost action, intensive mass wasting, and solifluction operating on land that is seasonally snow free (Black, 1966, p. 329; Washburn, 1980, p. 2). Fluvial processes and landforms are also of great importance (French, 1976; Worsley, 1984; Clark, 1988), and differ from their humid temperate region counterparts especially as they are affected by both ground frost and surface ice and snow.

Periglacial studies are divided into research on fossil forms, or paleoperiglacial investigations, and actuoperiglacial geomorphology, the study of active forms and their genesis (Karte, 1982). Of course this dichotomy neglects the existence of inactive phenomena, which may lie dormant for many years and then reactivate during short episodes of climatic cooling, but it is useful in a general sense to separate historical reconstructions from field and laboratory process studies. Scale is an important aspect of periglacial feature research, because forms which differ in size may have disparate origins and chronologies. Empirical observations suggest that the three general groupings: micro-, meso- and macroforms constitute a useful hierarchy (Karte, 1982). Microforms on several size scales include the different types of patterned ground, as well as features that are commonly seen in cross-sectional exposures. Mesoforms are features that blanket first-order landforms such as block streams in valley depressions and block fields, block slopes and cryoplanation terraces on side slopes. Periglacial macroforms include larger landscape elements as hillslopes, valleys and various domal and planar relief features that collectively comprise periglacial landscapes (French, 1976, chapters, 7-8; French and Karte, 1988; Lewkowicz, 1988). Following suggestions from Washburn (1956, 1980, 1985) the outline used here is descriptive and nongene- netic because the genesis of many active features is poorly understood and the interpretation of inactive and fossil analogs is even more tenuous. Also, the complexity of periglacial phenomena renders any ordering scheme exceedingly difficult. This format is intended only for organizational purposes; we hope that it will be replaced by a much more meaningful future arrangement.

To shorten treatment, we exclude several complex topics. These subjects include loess and other aeolian deposits, alpine debris flow and slursh and snow avalanche deposits (Rapp, 1985), karst phenomena, and aspects of speleology that may contribute some information on paleoperiglacial environmental conditions. The published and unpublished information on involutions is also so scattered and fragmented that it will require separate treatment. The discussion of included topics is necessarily brief. For example, expansions on paleoperiglacial environments and their chronologies, and on the origins and ages of both colluvial features
and river terraces could stand on their own as future treatises.

We make no attempt to give equal treatment either on an equal-area basis or by geomorphic subdivisions within the region. For example, although there are relict mass movement deposits and landforms in southeastern Ohio (Pomeroy, 1987) that may be of paleoperciglacial genesis, we have not attempted a synthesis because there are so many modern-day occurrences that give rise to similar features. Truly diagnostic surface evidence of paleoperciglacial activity in southeastern Ohio is not known (K.R. Everett and S.E. White, pers. commun., March 1988). In particular, age dating and correlation of deposits is a major problem. Where given, dates are from cited works, and some may require revision. Although eventual correlation with both marine and continental glacial records is of utmost priority, the current state of understanding is in flux (Eyles and Westgate, 1987) and much additional work is needed.

**Historical perspective**

*Appalachian Highlands major geomorphic division*

Several early researchers in the Appalachians recognized the significance of Late Cenozoic landforms and colluvial and alluvial deposits, which they attributed to former "frost" climates despite the present humid temperate environments and the presence of a dense forest cover. If their interpretations subsequently prove to be less than exact, it is understandable in the light of increasingly complex field relationships that current studies are exposing.

Early observations by Kerr (1881) in the Piedmont and Blue Ridge provinces of North Carolina (Fig. 1, several selected locations shown, and Table 1) were incorporated into field sketches and written descriptions that clearly identify the colluvial origin of soils and their parent materials. Kerr noted the variable thicknesses, crude stratifications, unconformable relations with underlying residua and bedrock units, and the multiple nature of colluvial episodes. Kerr even adumbrated the necessity of deep erosional events and topographic reversals following the emplacement of colluvial fills that he concluded were of "frost drift" origin.

Eargle (1940) clearly identified the colluvial origin of soils in the Spartanburg County area, South Carolina (Fig. 1). Deposits of organic matter up to 4 m in thickness and rich in spruce and fir pollen are overlain by up to 7 m or more of colluvium. Eargle noted that the great thickening of colluvium downslope implies that the local relief has been decreased by lowering of upland areas and filling in of lowland sites. Following Eargle (1940), Bryan (1940) supported the conclusions of Kerr (1881), with observations of his own on unspecified locations in North Carolina. He noted as additional evidence the widespread distribution of faceted and striated terrace gravels reported by Wentworth (1928) and later by Petty (1930).

Much closer to the glacial border and at higher elevations, Wherry (1923) and Ashley (1933) described features now thought to be of periglacial origin (Fig. 1). In particular, Ashley (1933) noted rock cities composed of massive sandstone layers separated by expanded joint surfaces. He also pictured and described several presently well known block deposits in Pennsylvania south of the glacial border. Smith and Smith (1945) called attention to the existence of unforested block accumulations in the Blue Ridge of Maryland (Fig. 1). This study significantly expanded the known geographic range of these features. Smith (1953a) presented the first geologic study of the Hickory Run deposit (Fig. 1), and concluded that it developed under a periglacial environment. Smith (1953b) also attributed the origin of rock cities of southwestern New York (Fig. 1), to periglacial frost wedging. With few exceptions, however, these types of features seem to have been regarded more as scenic geological curiosities than as objects of serious research. A number of short