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Mineralogy and morphological properties of buried polygenetic paleosols formed in late quaternary sediments on upland landscapes of the central plains, USA

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ABSTRACT

East central Kansas is largely comprised of alternating, level beds of Permian shale and limestone of the Central Plains, USA. Polygenetic upland soils of east central Kansas have been formed though multiple and likely different sets of soil forming factors. Upland soils in this region have a complex genesis, often contain one or more paleosols, and form in multiple parent materials including loess, locally reworked loess or colluvium, and residuum. The depth to bedrock rarely exceeds 2 m. Upland hillslope soils commonly contain one or more paleosols, and can be observed on a variety of hillslope positions on the landscape. Generally, the lower paleosols are recognized by strongly expressed structure, thick continuous clay coatings on all faces of peds, and strong reddish color with either 7.5YR or 5YR hues. Soil textures of the paleosols often feel less clayey than the overlying horizons in field determinations. At first, this was attributed to a decrease in clay content, stickiness, and plasticity. However, subsequent laboratory characterization revealed that the clay content was usually highest in the lower paleosol horizons, and that the clay mineralogy of the modern soil was dominated by smectite, while the paleosols contained a mixed suite of minerals. Therefore, the perceived decrease in clay content was caused by a change in clay mineralogy, a feature that can be exploited in future field descriptions in order to more accurately distinguish between stratigraphic units in these thin, welded polygenetic soils. The age of the paleosols sampled in this study were typical for the late Quaternary-aged Severance formation, clustering in two age ranges, which were ≈19,000 to 20,000 and ≈22,500 to 27,700 uncalibrated ^{14}C yr BP. The results from this study illustrate that although they might be thin, truncated, and welded, late Quaternary-aged loess-derived soils and paleosols occur in regular, predictable patterns on many upland hillslopes in the Bluestem Hills Major Land Resource Area, and this region should be included in future regional investigations of the Central Plains.

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1. Introduction

The Bluestem Hills (Fig. 1) are underlain by alternating, level beds of Permian shale and limestone, some of which are quite cherty. Differential weathering of the shale and limestone features has created a repeating bench-and-slope topography, and as such, relatively stable landforms exist up and down the larger, steep hillslopes. Upland soils in the Bluestem Hills Major Land Resource Area (MLRA 76) are thought to have a long and complex genesis, to contain multiple parent materials, and to have formed under tallgrass prairie in an area that is transitional between udic and ustic moisture regimes. Parent materials were historically described as clayey sediments, such as residuum, although recent investigations have described a more complicated and polygenetic suite of parent materials for the modern soil and underlying paleosols (Wehmueller, 1996; Glaze, 1998). Thick loess deposits (>2 m) are not recognized in this portion of Kansas, although thicker loess units are recognized in other adjacent areas of the Central Plains. Although loess was likely deposited in this region, it is generally held that most of the loess has eroded from the upland hillslopes.

Loess–paleosol sequences of the Quaternary Period are present throughout much of the plains. Loess units widely recognized in the Central Plains include the Loveland (deposited approximately 500,000 to 100,00 yr BP), Gilman Canyon Formation (deposited approximately 41,000 to 20,000 yr BP), and Peoria Loess (deposited approximately 25,000 to 11,000 yr BP). Frye and Leonard (1952) estimated that one-third of Kansas has Peoria loess at the surface. Later, Welch and Hale (1987) used a combination of sources including geologic maps and county soil surveys to estimate that approximately 65% of the state was covered with Pleistocene loess. According to Welch and Hale (1987), widespread loess deposits are not recognized in east-central and southeastern Kansas, which includes the southern two-thirds of the Bluestem Hills MLRA.

On upland landscapes in east central Kansas, including the study area, buried paleosols with preserved A horizons are rare. It is much more common to find the modern soil superimposed (e.g.,welded) almost seamlessly onto the Bt horizon of one (or more than one)

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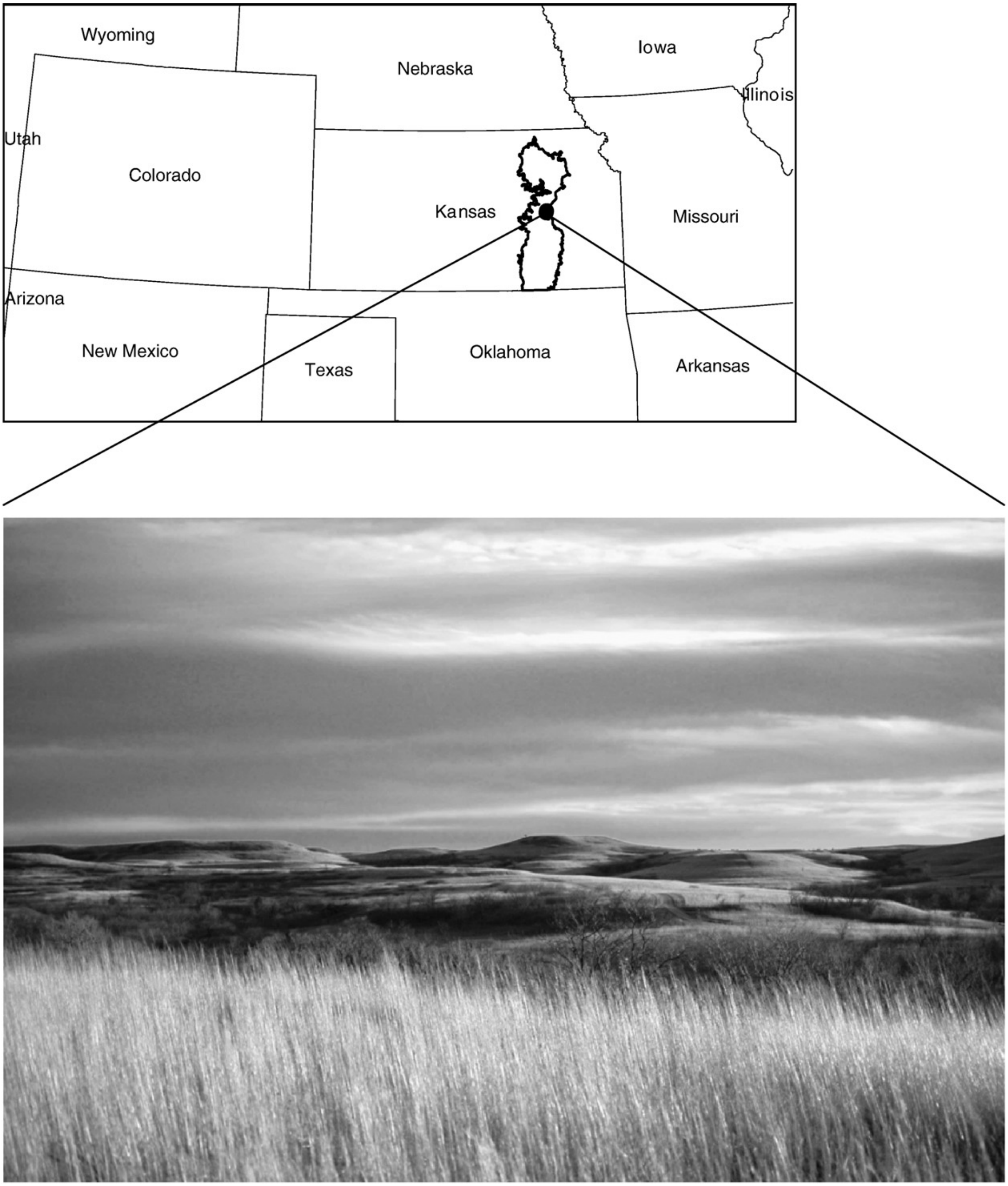

Fig. 1. Location of Bluestem Hills Major Land Resource Area in Kansas, and example of the landscape and vegetation of the study area.

paleosol. Also, it is common to see a dark red soil that is located above bedrock, and beneath the upper material (loess). This red paleosol sharply contacts interbedded Permian limestones and shales, and is commonly regarded by soil scientists as being derived mostly from residuum from these bedrock members. The soil matrix is often dark red in color with hues of 5YR or 7.5YR (or redder) and values and chromas of 4 or less. This material is very clayey and dense, with strongly expressed structure, thick clay films, and rock fragments that may or may not be similar to the underlying bedrock. Many soil scientists agree that this is a paleosol, but differ in opinions as to the parent material and age of the paleosol and/or sediments.

We hypothesize that although the upland soils of east central Kansas lack buried A horizons that are preserved, they are polygenetic and often contain two paleosols. In addition, these upland soils occur on hillslope locations across the landscape and can be recognized by subtle differences in morphology as well as differences in mineralogical composition. Therefore, the objective of this study was to use morphology as well as laboratory characterization including mineralogy to identify the stratigraphy and features of soil development within polygenetic soil profiles that are mapped on hillslopes. The secondary objectives were to confirm field observations of paleosols and subtle differences noticed between paleosols, which are often difficult to distinguish in thin loess-derived soils due to welding of the thin units via pedogenesis (Jacobs and Mason, 2007; Johnson et al., 2007), and to relate these thin, predominately loess-derived soils to the current body of knowledge on Great Plains loess and paleosol sequences.

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