Soils and landforms on the loess mantled karst uplands in southwestern Wisconsin, USA

오종우 (JONGWOO OH)*

Ⅰ. INTRODUCTION

Slope soil formation and its attributes in southwestern Wisconsin are potentially important due to its origin, landscape position and karstic backgrounds (Oh, 1990). Since French explorers and missionaries reached in southwestern Wisconsin in the 1830's, the

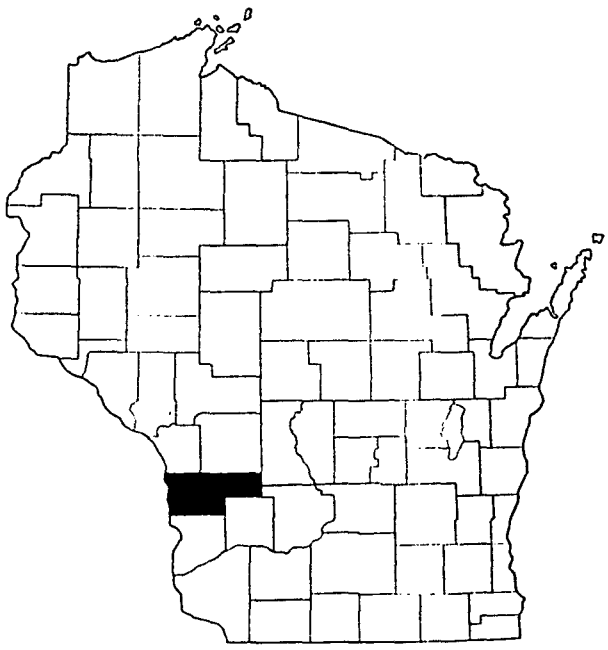

Figure 1. Study area in the southwestern Wisconsin karst.

* 경희대학교 강사, 이학박사

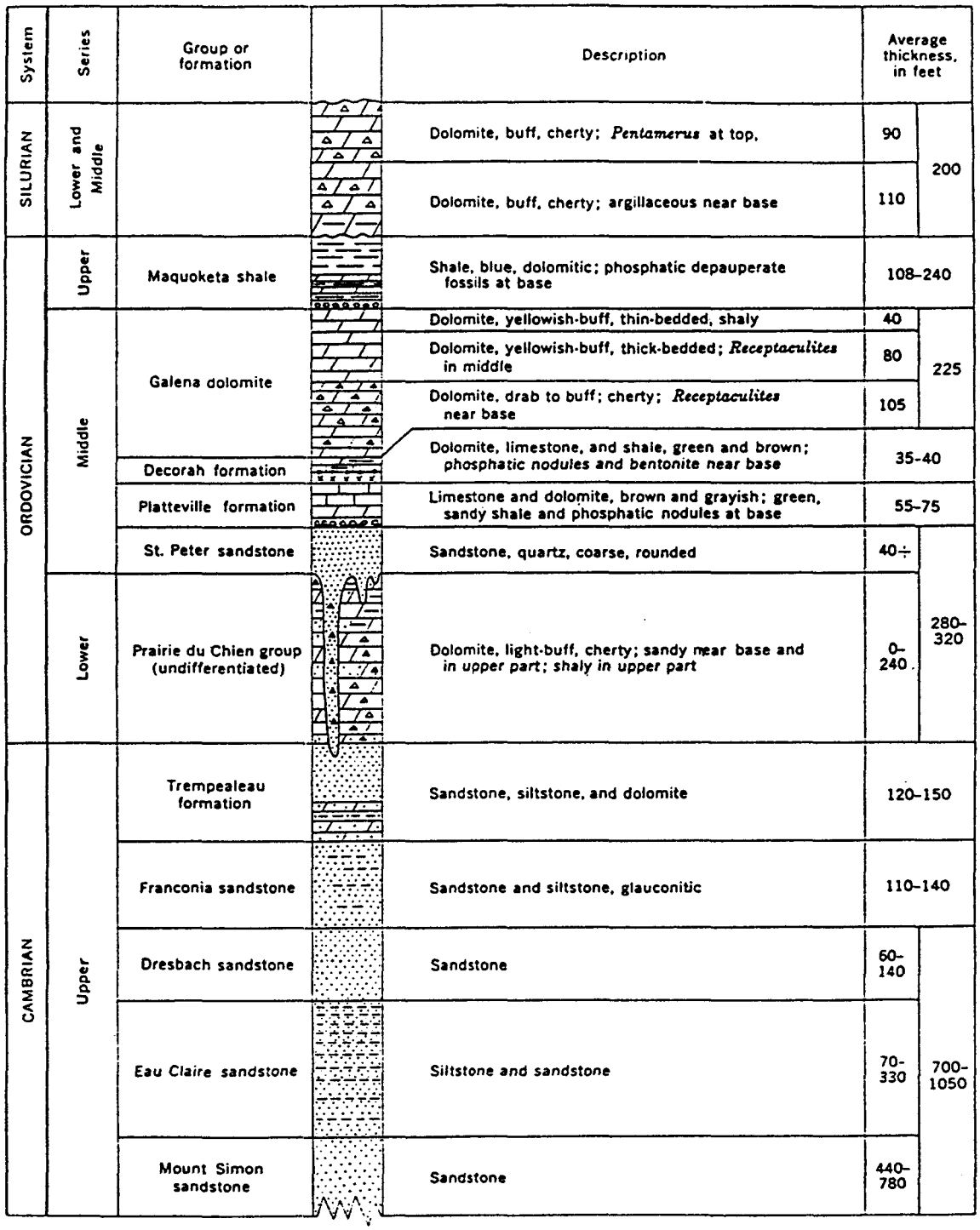

Figure 2. Stratigraphy of Middle and Lower Paleozoic sedimentary rocks in the Driftless Area. After Agnew et al. (1965).

loess mantled karst upland surfaces, consisted of forests: timberland, oak openings, and prairie, had been cultivated. At present, nearly 90% of the ridge land is in farms. Karst soils are usually reddish clayey features (Oh and Day, 1989).

Purpose of this study is to compare soil characteristics between ridge-tops and hillsides of the southwestern Wisconsin Driftless Area. These two soil characteristics will be different due to physical factors, such as landscape positions, bedrocks, and slope processes. The study area is a soilscape of Vernon County in the southestern Wisconsin Driftless Area (Figure 1).

Ⅱ. GEOLOGY AND PHYSIOGRAPHY

Most upper ridges are widely composed of carbonate rock, Prairie du Chein dolostone, and minor St. Peter sandstone (Figure 2). The

Figure 3.

hillsides have a combination of dolostone and PreCambrian sandstone between aeolian parent materials and dolostone bedrock. The St. Peter sandstone is a very friable mechanism (Winfree and Dott, 1983).

The landscape of southwesterbn Wisconsin is deeply and thoroughly dissected, and shows narrow ridges (mostly north of the Wisconsin River) and steep-sided hellslopes (Figure 3).

The elevation ranges in Vernon County from a low of 190m to a high of 405m, thus difference in elevation between stream bottom and ridge-tops range from 60 to 165m. Four main streams in the drainage pattern of County are the Kickapoo River, the Bad Axe River, Coon creek, and the Baraboo River.

Drainage ways of the Rivers flow either into the Mississippi River and Wisconsin River. Dry valleys in the Driftless Area has a complex history in surficial, hydrological and subterranean dnvironments. Approximate age of soil materials in Wisconsin presents in table 1.

Table 1 . Approximate age of soil initial materials in Wisconsin. Hole (1976

Period or System	Material	Age[a] (years before present)
Quaternary	Alluvium (surficial layers)	1 to 1,000
	Peat and muck	1 to 13,000
	Loess (surficial layers)	5,000 to 30,000
	(Peorian)[b]	(5,000 to 22,000)
	(Farmdale)[b]	(28,000 to 70,000)
	Glacial outwash and ice-contact deposits	5,000 to 30,000
	Glacial till (Wisconsinan)	11,000 to 70,000
	(Valderan)	(5,000 to 11,000)
	(Woodfordian: Mankato, Cary, Tazewell, Iowan)	(12,500 to 22,000)
	(Altonian: Farmdale)	(28,000 to 70,000)
	Residuum and duricrusts on bedrock	30,000 to 30 million
Devonian	Dolomites and shales	400 to 413 million
Silurian	Dolomites	413 to 425 million
Ordovician	Maquoketa (shales with dolomite) Sinnipee (dolomites with limestones and shales) Ancell (sandstone with shale and conglomerate) Prairie du Chien Group	425 to 475 million
Upper Cambrian	Sandstones with dolomites and shales	475 to 500 million
Precambrian Groups	Igneous and metamorphic rocks	600 million to 3.5 billion

[a]Note that the age of the initial (parent) material is almost always much greater than the age of the soil (see text). These estimates are based on Black and Rubin (1968), Hogan and Beatty (1963), Dury and Knox (1971), Wascher et al., (1971), and Dott and Batten (1971).

[b]The boundary between these two loesses has not been distinguished in the field in Wisconsin.

Ⅲ. SOILS ON THE RIDGE TOPS

A. Downs Series

The Downs series consists of deep, well drained, silty soils and red clays on broad upland ridges (Figure 4).

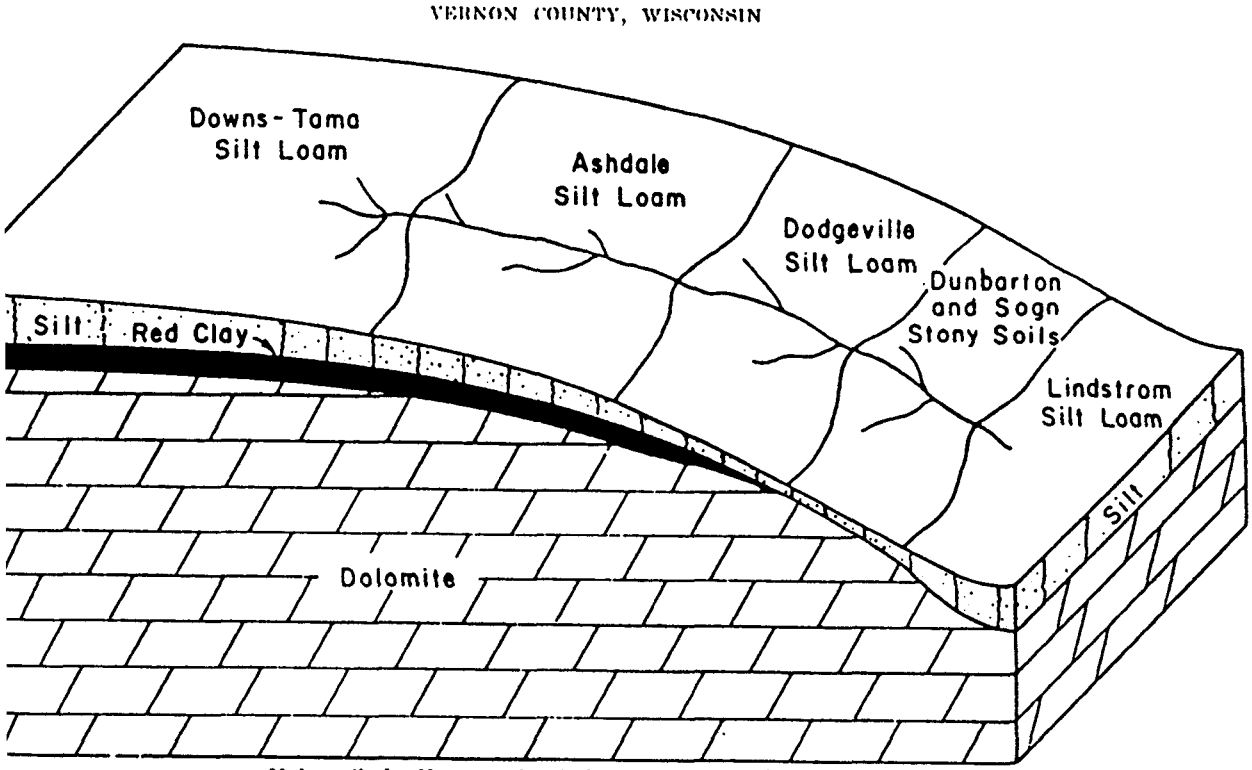

Figure 4.—Major soils, landforms, and underlying material on uplands underlain with dolomite

Table 2 Chemical composition of the potential source materials of sinkhole sediments in southwestern Wisconsin. (Oh, 1992).

Sources	SiO_2	Al_2O_2	Fe_2O_2	CaO	MgO	Others	Location	Num.
Clays:								
Loess[1]	76.5	12.0	2.3	0.9	0.7	7.6	Vernon Co.	n=2
	73.1	11.6	4.1	0.8	0.2	10.5	Trempeleau	n=1
Mean	74.8	11.8	3.2	0.9	0.5	9.1	SW. Wis.	n=3
Shale[2]	49.0	10.3	15.9	5.5	1.5	7.8	Grant Co.	n=2
Residual Clay[3]	62.9	17.9	5.6	0.6	2.7	10.3	Jackson Co.	n=9

Sources, 1: Ries, 1906 p. 145-150, 2: Steidtmann, 1924 p. 192, 3: Steidtmann, 1924 p. 192,

These soils formed in a mantle of wine-blown silt(loess) more than 120cm thick, under prairie grass and hardwoods. Downs soils are members of a fine-silty mixed mesic family of Mollic Hapludalfs (USDA, 1968) (Table 3). The bedrock is mostly friable dolostone but it is weathered sandstone in some places. Downs soils have a thicker (150cm) slightly darker colored surface layer than Fayette soils and a less strongly developed subsoil (Hole, 1980). They are intermingled with Tama soils and generally have a thinner, somewhat lighter colored (10 YR 3/1) surface layer.

The red clay beneath the Downs soils is weathered carbonate residual soils called residuum generated from the dolostones (Black, 1970). The red clay, in situ soils, is generally not thicker than loessial soils. Their chemical compositions and characteristics differ from loessial soils (Table 2).

B. Ashdale Series

The Ashdale series consists of well-drained, silty soils on the broad upper slopesides near ridges. These soils formed partly in loess 75-125cm thick and partly in the underlying one-third of the solum formed in the red clay of dolostone. The original vegetation was prairie grass. Ashdale soils are members of a fine-silty, mixed, mesic family of typic Argiudalls (USDA, 1968). Ashdale soils have a thicker and darker surface layer than Palsgrove, and are lock an E horizon. Ashdale soils differ from Dodgeville soils in having more of the solum formed in loess, and from Tama soils in having the lower part of the solum at a depth of less than 125cm formed in red clay residuum.

Table 3. Characteristics fo the ridge top soilscape of the upland karst in southwestern Wisconsin, USA. (Data compiled from USDA, 1968).

Soil types and features	SOILS ON THE RIDGE TOPS		
	Downs Series	Ashdale Series	Dodgeville Series
Landscape position	Ridge crest	Upper hillside	Intermittent hillside
Slope types	Convex	Convex	Convex
Bedrocks	Dolostone with minor sandstone	Dolostone with sandstone	Dolostone and sandstone
Texture	Well draind silty soils	Well drained silty soils	Well drained silty soils
Depth (cm)	Deep : 120	Thick: 75-125	Shallow-moderate: 37-75
Soil family and types	Fine silty mixed mesic Mollic Hapludolfs	Fine silty mexed mesic Typic Argiudalls	Fine silty mixed mesic Typic Argiudalls
Solum features (horizons)	A: dark colored B: weak developed	A: dark colored E: lack <125cm: red clay residuum	A: dark colored B: ⅓-⅔ red clay residuum C: yellowish red
Vegetation covers	Prairie grass & hardwoods	Prairie grass	Prairie grass

C. Dodgeville Series

The Dodgeville series consists of well-drained silty soils that are mostly on the broad lower hillsides of ridges. These soils are shallow to moderately deep over clay residuum. They formed partly in loess 37 to 75cm thick and partly in the underlying clayey residuum of

dolostone. Dodgeville soils are members of a fine-silty over clayey, mexed, mesic family of Typic Argiudolls (USDA, 1968). In uncultivated areas, the A horizon is generally black color due to organics. The B horizon, or about one-third to two-thirds of the solum, formed in red clay. In some places the C horizon is yellowish red. Dodgeville soils have a darker colored, thicker (150cm) surface horizon than Dubuque soils. They are associated with Ashdale soils but formed in shallower silt due to its landscape position, generally less than 50cm thick.

Ⅳ. SOILS ON THE HILLSIDES

D. Dunbarton Series

Slope soils in the Driftless Area associate with the Quaternary climatic alterations and landscape evoloution specially karstification (Oh, 1992). The Dunbarton series consists of well-drained soils underlain by dolostone bedrock at a depth of less than 50cm. The lower part of the solum formed in mixture of loess and red clay residuum . These soils are members of a clayey, montmorillonitic, misic family of Lithic Hapludalfs (USDA, 1968) (Table 4). The solum ranges from 30 to 50cm in thicknesses which is shallow than ridge crest soils due to its soilscape position. The color of the surface soil is either grayish brown or dark grayish brown. The texture of the residuum ranges from clay loam to silty clay. Dunbarton soils are closely associated with Sogn soils.

E. Sogn Series

The Sogn series consists of well-drained, stony soils that are shallow over dolostone (Hole, 1976). These soils formed in a thin mantle of loess over weathered and fissured dolostone. Most areas have convex slopes and are near the upper breaks of escarpments and on

narrow, sharp ridges. The original vegetation consisted of prairie grass and hardwood trees. Sogn soils are members of a loamy, mixed, mesic family of Lithic Hapludolls (USDA, 1968). Sogn soils formed in a thinner mantle (±30cm) of loess than Dubuque and Dodgeville soils and lack the textural B horizon and the red clay residuum of those soils.

Tabll 4. Charaeteristics of the hillsides of the uplane karst in southwestern Wisconsin, USA (Data compiled from USDA, 1968).

Soil types and features	SOILS ON THE HILLSIDES		
	Dunbarton Series	Sogn Series	Lindstrom Series
Landscape position	Lower hillside	Lower hillside	Bottom hillside
Slope types	Convex	Convex	Concave
Bedrocks	Dolostone	Dolostone	PreCambrian sandstone & dolostone
Texture	Well drained clay loam, silty clay	Well drained stoney soils	Well drained silty soils
Depth(cm)	Shallow: 30-50	Shallow: ±30	Deep: 150
Soil familly and types	Clay montmorillo-nitic mesic Lithic Hapludalfs	Loamy mesic Lithic Hapludalfs	Fine silt mixed mesic Cumulic Hapludolls
Solum features (horizons)	A:grayish brown or dark grayish brown	B:lack * mostly red clay residuum	A:sandier(10YR2/1 B:weak C:coarser
Vegetation covers	Prairie grass & hardwoods	Prairie grass & hardwoods	Prairie grass/ scattered oaks

F. Lindstrom Series

The Lindstrom series consists of deep, well-drained, silty soils that formed in deep deposits (150cm) of loess on concave hillslopes. The prime vegetation consisted of prairie grass and a few scattered oaks. These soils sre widely scattered throughout the County and are more commonly on south-facing hillslopes. Lindstrom soils are members of a fine-silty, mixed, mesic family of cumulic Hapludolls (USDA, 1968). In some places PreCambrian sandstone and dolostone fragments occur throughout the solum, and the A horizon is sandier (Milfred, 1966). Lindstrom and Fayette soils formed in similar politions and in parent material, but Lindstrom soils have a thicker, darker (10YR 2/1) A horizon. Lindstrom soils are similar to Tama soils, which are on ridge-tops, but generally have slightly less structural development in the B horizon. They also have a somewhat coarser textured subsoil and substratum than Tama soils.

V. CONCLUSIONS

Soils in Vernon County in southwestern Wisconsin associate with a mixture of wind-blown silt(loess) and carbonate residual soils. During the Quaternary climatic fluctuation periods, substential amounts of rerddish clay over the dolostone bedrocks were eroded away(Black, 1970), and then loess covered on the hilly uplands. This new earth dust left new parent soil materials which were pedogenically well-developed in the study area.

The soil thickness depends mainly on landscape positions due to its colluvial processes(Oh, 1990). The upper and midslope soils have thiner soil thicknesses due to its degradational, transportational zone than the lowslope soil thicknesses due to its aggregational zone. Therefore, correlation between soils and landfomrs will be the major factors fo surficial environments, since soilscapes differ along the regional landform positions.

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