KATSTIC SINKHOLE SEDIMENTS OF DOLOSTONE IN THE UPPER MIDWEST'S DRIFTLESS AREA, USA

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ABSTRACT

Analysis of one sinkhole, the Dodgeville sinkhole, developed in Ordovician dolostones in the Driftless Area of Wisconsin in the Upper Midwest'd Driftless Area reveals homogenous clayey sediment fills reflecting a range of dissolutional processes during the Quaternary or Pre-Quaternary. Granulometric analysis, graphical moments statistics, carbonate minerals, and sand grain lithology were used to differentiate sinkhole sediment sources and modes of accumulation.

Sediments in the dolostone sinkholes developed by dissolution. Sediments contain two major types of sediments: residual redish clay(autogenic sediments) and aeolian silt (allogenic sediments). The massive clay is generated from the weathered dolostone bedrocks as a in situ materials. The loessial silt is mostly derived from transportation of the surrounding surface materials, with some evidences of penetrated deposition.

Unlike the collapsed sandstone sinkholes (Oh et al., 1993), dolostone sinkholes reveal homogenous, autogenic clay materials, and a geochemical composition indicative of in situ autogenic karstification.

Dolostone sinkhole silts (26.9%) and sands (34.9%) are derived from weathered Platteville-Galena dolostones, and contain high carbonate(37.5%), chert (57.2%) and lead ore (.̃ 3%).

Graphical mom nts statistics for sorting, skewness, and kurtosis indicate that sand grains from dolostones were derived entirely from local bedrock by in situ dissolution. Upper sinkhole sediments are pedogenically very young as carbonate is unleached.

Materials of the sinkhole sediment are definetely inherited from internal dolostones by dissolution and weathering, because not only a granulomatric comparison of dolostone and sandstone sediments demonstrates that they have heterogeneous paticle size distributions, but also lithologic analyses displays they differ completely.

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I. INTRODUCTION

The southwestern Wisconsin karst is part of a larger karst region in the Upper Mississippi Valley (Day, Reeder, and Oh, 1989). The karst is formed in Paleozoic sedimentary rocks (Lower Silurian and Ordovician in age), and contains over 200 caves, more than 10,000 springs, at least 250 sinkholes, and thousands of dry valleys (Day and Reeder, 1989)(Figure 1).

There are two different sinkhole types in this region: solutional dolostone sinkholes and collapsed sandstone sinkholes. They are completely different genetic patterns and sediment properties (Oh,1992).

Dolostone sinkholes contain vertical solutional cavities, rock shafts, and collapsed sinkholes connected to cave systems (Day and Reeder, 1989). Many small solutional sinkholes appear to be buried in loessial soils. One such sinkhole, the Dodgeville sinkhole, is investigated in this study.

The study area, Dodgeville Sinkhole, is located in the southwestern Wisconsin Driftless Area in Grant County (Figure 1). South of the Wisconsin River in Grant County, upland sinkholes are developed on Upper and Middle Ordovician and Lower Silurian-aged dolostones. Sinkhole sediments and their potential sources should be heterogeneous because of the range of available materials. Likewise, sinkhole sediment properties may show significant physiographic variation developed during the Quaternary or pre-Quaternary.

The sinkhole sediments in southwestern Wisconsin may be of importance because they may provide a record of the complex Quaternary physiographic history of the upper Midwest (Day, Reeder, and Oh, 1989), and perhaps a history of pre-Quaternary karst landscape evolution. This research is based on the source investigation of the sinkhole sediments in southwestern Wisconsin by Oh (1990d) (Table 1).

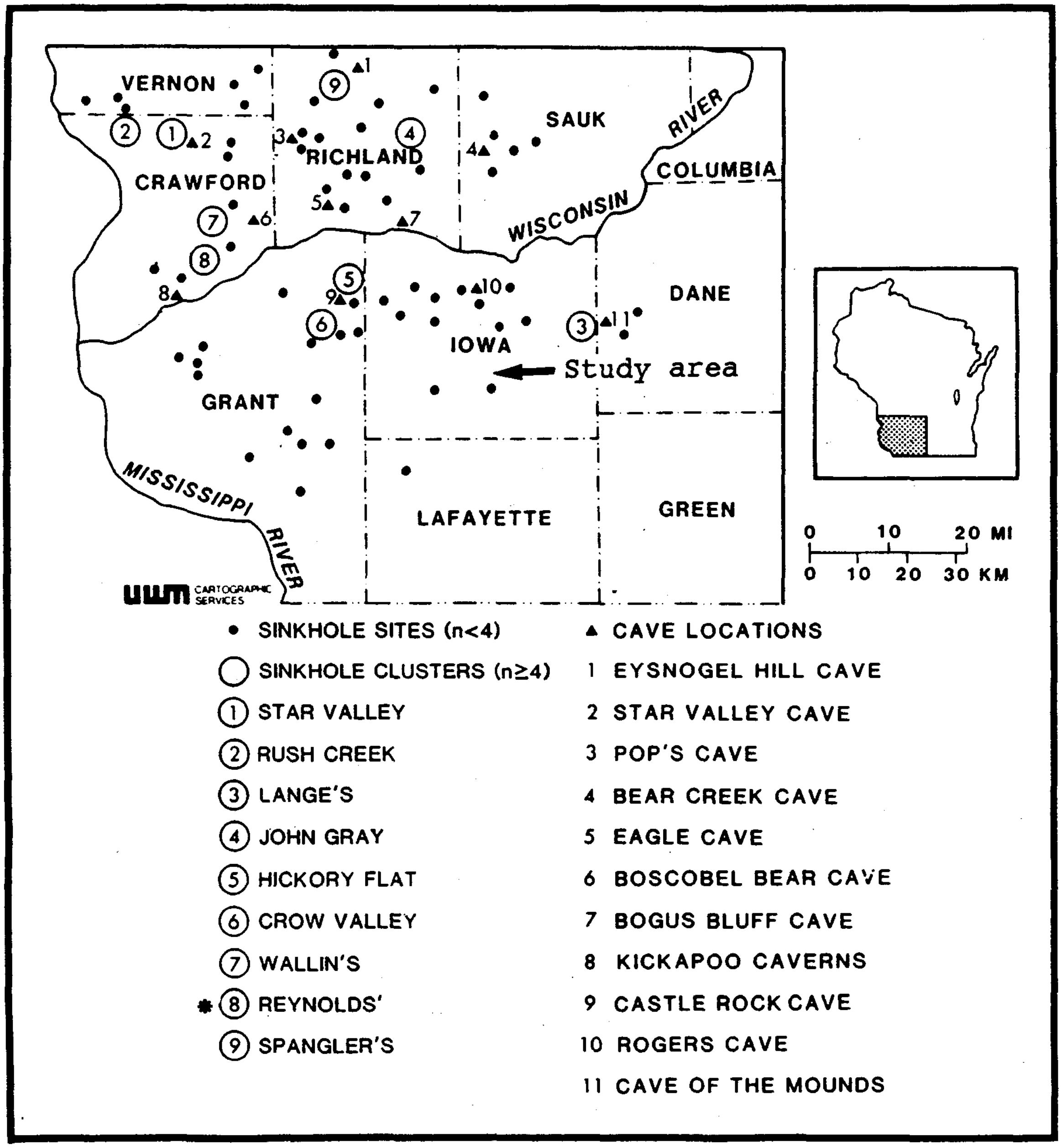


Figure 1. Study area with karstic feature distributions in southwestern Wisconsin. Source, Oh and Day, 1991.

Table 1. Potential sources of sinkhole sediments in the southwestern Wisconsin karst system.

Potential sources	**Major sources**	**Sub-sources**
Bedrock units	Lower Silurian	Niagara dolostone
	Upper Ordovician	Maquoketa shale
	Middle Ordovician	Galena dolostone Decorah dolostone Platteville dolostone St. Peter sandstone
	Lower Ordovician	Prairie du Chien
Weathered Materials	Insoluble residue Red clay residuum	Non-dissolved matter Reddish-brown clay
Exotic materials	Aeolian silt Windrow formation	Loessial soils Paleo-fluvial gravels

Source, Oh, 1992.

Bedrock lithology, Quaternary climatic variations, and colluvial and other slope process are critical contributors factors to sinkhole sediment variation in the Driftless Area of Wisconsin. The bedrock of the study area in southwestern Wisconsin consists dominantly of three different lithologic sequences: Ordovician sedimentary rocks contain combinations of dolostones, shale, and sandstone, and the Lower Silurian-aged bedrock is predominantly dolostone (Table 2). These different bedrocks may produce different sinkhole sediment properties which depend mainly on landscape position (Oh and Day, 1991).

Table 2. Simplified Silurian and Ordovician geologic column for southwestern Wisconsin.

System	Series	Formation or Group	Avg.Thicknessis in meters
Silurian	Lower/ Middle	Niagara Dolostone	60
Ordovician	Upper	Maquoketa Shale	37
	Middle	Platteville/Galena Dolostone	103
		St. Peter sandstone	12
	Lower	Prairie du Chien Group Dolostone	91

source, Agnew et al., 1956.

The objective is to investigate the geomorphic linkages between the potential source materials and sinkhole sediments to determine their erosional, transportational and depositional correlations. This objective involves five major types of analysis: stratigraphic interpretation, particle size analysis, sand grain lithologic identification, and carbonate mineral determination.

To achieve this objective considerable data were required in order to understand the geomorphic development including correlation between provenance and sinkhole deposits.

II. METHODS USED

Field sampling of potential sources and sinkhole sediments was focused in Grant County in the southwestern Driftless Area. This site was selected because: 1) the Dodgeville sinkhole can be a typical karstic disslutional sinkhole of the upland Driftless Areas. 2) weathered residuum is exposed on the flat ridge crests developed on the carbonates.

Field work involved collecting samples to evaluate correlation between potential sources and sinkhole sediments. For the investigation of potential sources, samples of area dolostones were collected in order to compare to the sinkhole sediment grain differences. Loess data compiled from Frolking (1985), Knox (1987), Oh and Day (1989b, 1991), Leigh (1991), and Brown (1992) were used to complete the data base for this study. These data were compared with the results of the sand fractionation from sinkhole sediments.

Dodgeville sinkhole sediments were collected from exposed road-cut outcrops. Sediment samples of exposed units were taken by cutting out at regularly spaced intervals (10 to 30cm) and at clear stratigraphic boundaries. Sediment samples from the outcrops were analyzed in four phases: stratigraphic interpretation; lithologic analysis; geophysical and geochemical analysis. Sedimentary stratigraphy is important since it facilitates correlation with geologic strata and other sources and permits correlation among sinkholes. Lithologic identification may display a correlation of surficial landform evolution of the Driftless Area between source rock units and properties of sinkhole sediments.

Geophysical and geochemical analyses will provide additional supporting details to delineate the characteristics of the sinkhole sediment properties.

Analyses of texture, structure, and other criteria follow the methods outlined by the Soil Survey Staff(1990). Particle size analysis may elucidate transportational mechanisms and depositonal environments of sinkholes and potential source materials. This analysis may distinguish textural differences between materials from weathered source rocks(dolostones, sandstones and shale) and may identify mechanisms of sediment translocation. The measurements involved a combination of the hydrometer method of Gee and Bauder(1986) and mechanical methods of Lindholm(1987). The hydrometer method reveals the percent clay(<2 m), silt (>2 m to <6.25 m), and sand (>6.25 m). Fractionation of silt particles was divided at one (phi) interval.

Graphical moments statistics, descriptive statistics using graphically-derived granulometric data, for sorting(uniformity or dispersion), skewness (asymmetry), and kurtosis(peakness)(Folk and Ward, 1957, p.13-15) provide fundamental properties of sedimentary materials in the context of transportational and depositional conditions. The graphical-computational technique is to draw a cumulative percentage curve on probability paper to get the phipercentiles: 5th, 16th, 25th, 50th, 75th, 84th, and 95th values.

Interpretation of the granulometric results was undertaken using Griffiths's method(1967, p.78~87). Fractions of sand particles were collected by wet sieving(sieve mesh # 230) from the hydrometer cylinders and were then dried, and dry sieved with sieve mesh # 10, 18, 35, 60, 120, and 230, and then divided in one interval.

Sand grain lithologies were determined and counted by identifying samples using the binocular microscope method introduced by Lucas et al. from the Iowa Geological Survey(1978). Sand grain lithology is useful in discriminating different potential source materials for the sinkhole sediments. In order to get a clear optical identification of the rock fragments, collected from the dry sieving, free iron oxides were removed by the digestion method (Jefferies, 1941 and 1945).

Carbonate minerals (calcite and dolomite) were determined by the gasometric method with the Chittick apparatus (Dreimanis, 1962). Computation of the percentage of calcite and dolomite from the Chittick apparatus data is illustrated by Dreimanis (1962, p.525). Calcite and dolomite minerals were measured from the amount of gas generated in the first 30 seconds and in the first 20 minutes of the reaction. Carbonates are an indication not only of pedogenic conditions but also sources since carbonates may be inherited from calcareous parent materials(calcite and dolomite) or from loess.

Organic matter(%) was determined by the digestion method as provided by the Soil Science Department of the University of Wisconsin(1980. p.8-9). Samples were oxidized with sodium dichromate-sulfuric acid(3 N $Na_2 Cr_2O_7$ in 10 N H_2SO_4), and the organic matter was measured using a Coleman Model 21 Flame Photometer. Organic matter reflects vegetation cover, climatic variations, and geomorphic development based on stable and unstable conditions.

Soluble salts were determined by solution extraction using the conductivity meter(Radiometer Copenhagen Type CDM 3d) method of the Soil Science Department of the University of Wisconsin(1980. p.18). Salinity represents the dryness of exposed surficial conditions, and provides a sedimentary property distinction between sinkhole environments.

Ⅲ. RESULTS

A. Physical Setting

The Dodgeville sinkhole, a vertical dissolutional crevice(conduit), is located on an interfluve in the east-central part of the Driftless Area, Iowa County, Wisconsin(Plate 1).

Plate 1. Study site on the solutional karstic depressions in the southwestern Wisconsin upland. Source, the author.

The sinkhole is on the "Dodgeville Erosional Surface" of Trowbridge(1921). The land surface in this region is relatively less dissected with a flatter mesa-like dissolutinal karstic upland topography(Oh, 1992) than the deeper dissected valleys north of the Wisconsin River. Elevation of the surrounding interfluival ridges is 379-402 meters(1232-1320') above mean sea level. Elevation of the sinkhole is 381 meters(1250').

Table 3. General outline of the sampled sinkhole in the southwestern Wisconsin karst.

Sampled Sinkhole	Dodgeville Sinkhole
Location, County	Iowa
Sinkhole Types	Open pit
Orientation (360°)	335/155°
Landscape Position	Ridge Crest
Elevation	381 meters
Bedrock of sinkholes	Dolostone
Slope Angles	1.5°
Cite Landuse (surrounding)	Road Cut and Crop field
Sinkhole Depth	700 centimeters
Sampled Sediment Depth	340 centimeters
Sinkhole Slope Angle	90.0°
Max. Sinkhole Length	200 centimeters
Min. Sinkhole Length	150 centimeters
Sinkhole Base Length	110 centimeters
Max. age of fill	Apploximately 30,000-30 million (Hole, H1976)

Source, Oh (1992).

The bedrock around the Dodgeville sinkhole is the lead- bearing Ordovician Plattville-Galena dolostone which is one of the dominant cave and karst forming rocks in southwestern Wisconsin(Day, 1986). However, many karst features are not distinct since they have been buried by loess. Information of the sampled sinkhole is shown in Table 3.

This vicinity is characterized by humid prairie soils represented by the Tama Silt Loam and associated deep silt-loams of former prairies on the Military Ridge and similar uplands(Hole, 1976). The main parent material for the upland soils is Peorian loess of late-Wisconsinan age(around 25,000-10,000 B.P.) which was derived from the Mississippi River floodplain (Hogan and Beatty, 1963). Reddish-brown cherty clays, derived from the weathered carbonates are blanketed by the aeolian silts(Hole, 1956). Loess-derived materials in the upper horizons and carbonate residual reddish-brown clays in the lower horizons constitute the typical pedosequences of the Platteville-Galena bedrock regions(Frolking, 1985).

B. Stratigraphy Interpretation

Sediment in the Dodgeville sediment outcrops is illustrated in Figure 2, which shows two different massive depositional units, distinguished both by depositional characteristics and textural properties. The culturally disturbed upper unit(0-100cm) reflects sediment derivation from the surrounding upland soils and debris from the construction of the road. The unit displays very angular broken chert, dolostone debris, and mixed soil materials.

Sediments in the lower unit(100-340cm) were apparently derived from weathered carbonate residue, as reflected by the high clay content(54.4%) and the uniformity of the sedimentary structure. The Dodgeville sinkhole appears completely different in sediment origin and accumulation from the other sandstone sinkholes. Conspicuous properties include the highest percent clays (55.7%), carbonate fractions(46.9%) and chert fractions(49.3%); lead ores (3.8%); soluble salts(1.82mm MHO), and alkalic sediments(pH 8.0); however, it has the lowest percent of organic matter (0.3%) and silt (26.9%) (Figure 2).

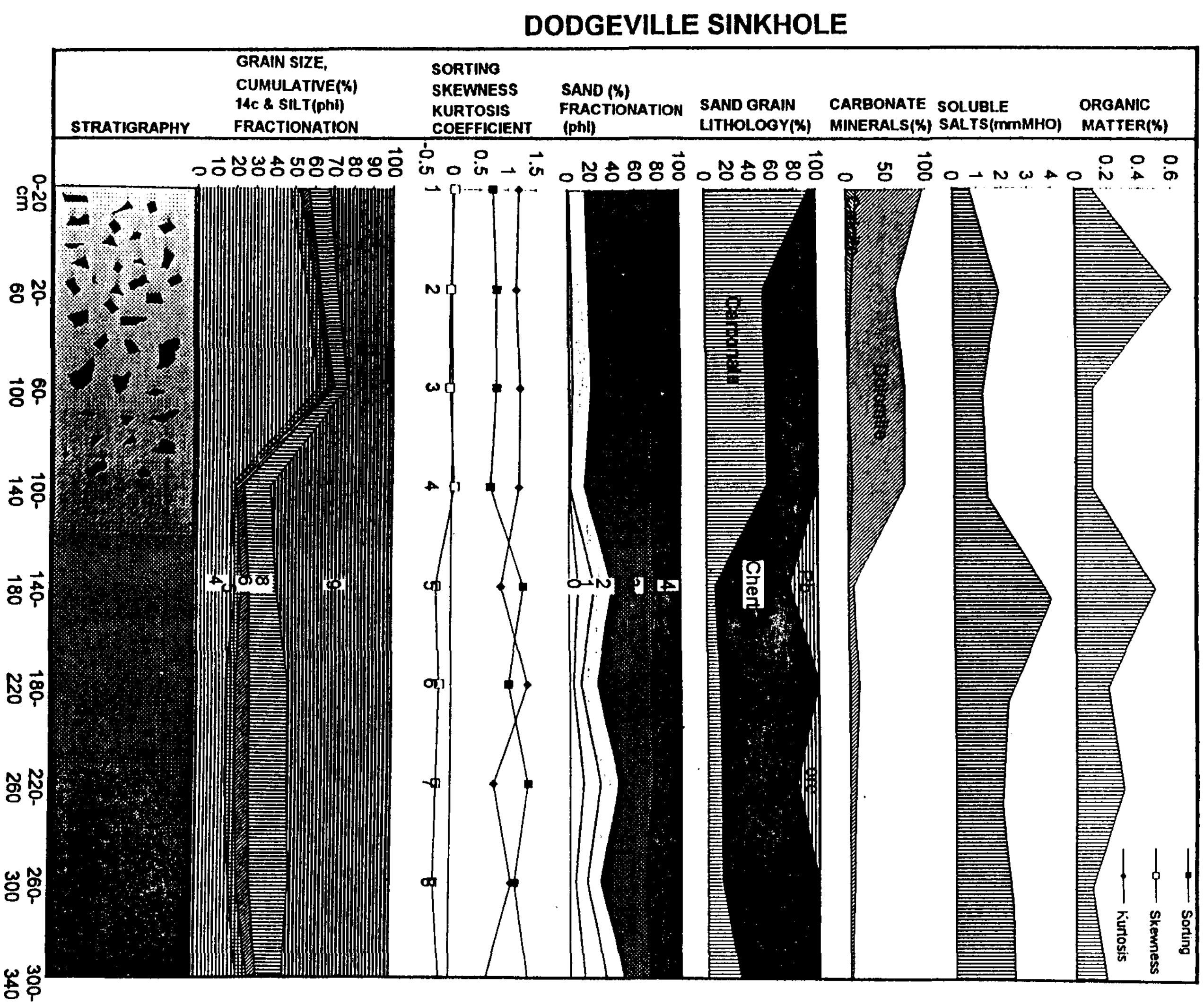


Figure 2. Sediment properties for the Dodgeville sinkhole (Fractionation unit: phi; vertical numbers: selected sampling numbers for the examination). Source, Oh, 1992.

a. Lower Unit

The massive, undisturbed, and homogeneous lower unit(100-340cm) consists mostly of yellowish brown(10 YR 5/8) to dark yellowish brown clays(10 YR 4/4, 5/6) with significant quantities of cherty sands(17.6%) and broken carbonate and chert debris(3-5 centimeters diameter). Sand/silt/clay percentages of the undisturbed sediments are 17.5/54.4/28.0. Sand fraction analysis shows that cherty fractions are dominant (76.4%) indicating that sediment composition is predominantly influenced by the local carbonate lithology (Figure 3).

There are two different approaches to measuring the carbonate contents of the sediments; 1) lithological study reveals 14.8% of carbonates; and 2) a gasometric method shows 9.0% of carbonate minerals. Mean carbonate content (11.9%) of this unit of the sediment is much less than in the upper unit(74.8%), suggesting the lower unit contains largely decomposed and leached clay sediments. The clay sediments represent a typical autogenic karstic deposit which does not contain other lithologies(Oh, 1992). According to Frolking(1982), clays of the dolostone bedrock in southwestern Wisconsin were produced neither solely by weathering of dolostone nor by loess deposition, but rather through pedogenesis in the dissolution zone of the carbonates. The clay unit appears to be a massive unstratified sedimentary structure comprised of clay with in situ depositional characteristics.

The age of the clay sediment is unknown but residual soils in the southwestern Wisconsin Driftless Area range from 3,000 to 30 million years B.P. (Hole, 1976). Karst studies of the Upper Mississippi River Valley by Lively and Alexander(1985) revealed that "Abandoned solution cavities and caves at different elevations combined with ages that range to >350,000 years..." (p.32). Thus, most sediments of the dolostone cavities including the Dodgeville Sinkhole appear to be older materials than the sandstone sinkhole sediments in southwestern Wisconsin(Oh, 1992).

Clays or other insoluble residuum from the carbonate bedrock produce residual

FREQUENCY AND CUMULATIVE CURVES OF DODGEVILLE SINKHOLE

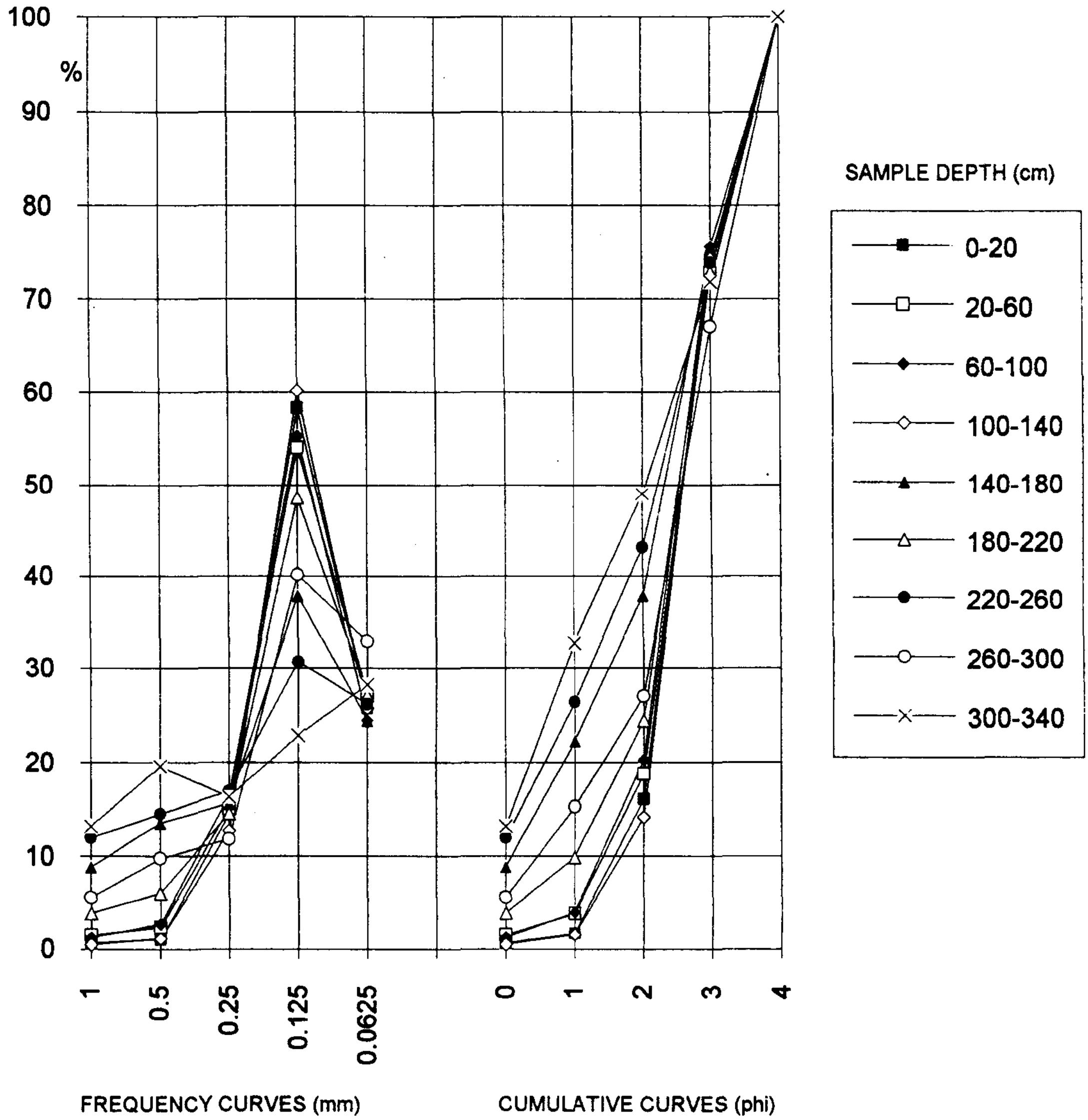
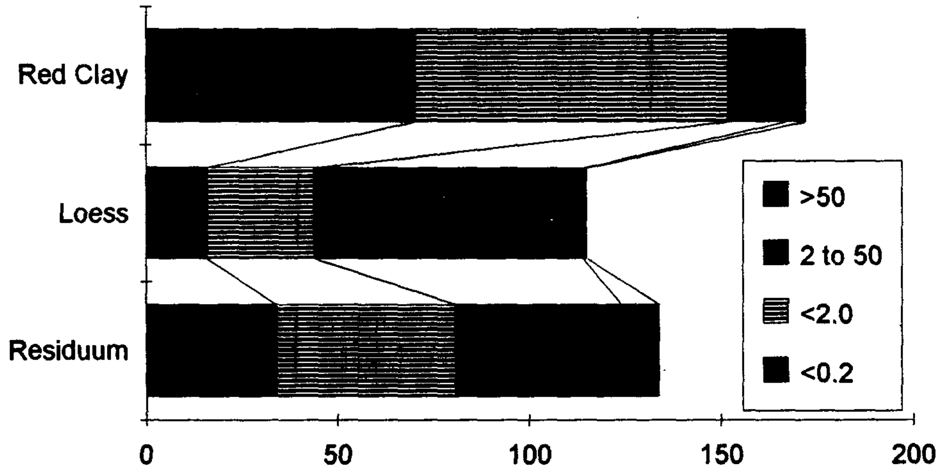


Figure 3. Sand grain frequency and cumulative curves of the Dodgeville sinkhole sediments. Source, Oh, 1992.

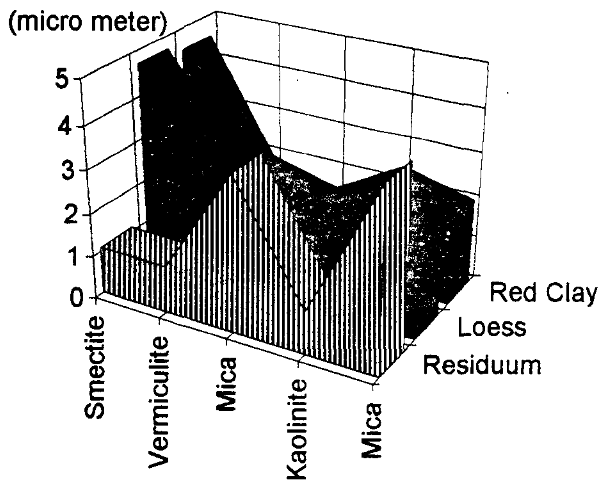
soil generated by weathering and dissolutional processes in southwestern Wisconsin described by Black(1970), Frolking(1983), and Palmquist(1965). The residuum has strong brown to yellowish red colors, a clayey texture, and a strong angular blocky structure(Frolking, 1983). Frolking classifies the grain size of the residuum together with that of loess and red clay. Carbonate residuum particles are finer than loess particles, but not as fine as red clay particles. A comparison of the grain size of residuum with loess and red clay in southwestern Wisconsin is given in Figure 4.

Figure 4. Grain size distribution of unlithified materials in southwestern Wisconsin. Source Frolking, 1983 p.818.



The residuum in southwestern Wisconsin is not widely exposed but some localities on ridge crests contain about 60 to 120 centimeters of residuum sequences. Residuum occurs on the highest and flattest remnants of the Galena-Platteville and Prairie du Chien dolostones, or in karst pockets(Black, 1970). Only the flattest surfaces or karst depressions contain residuum due to rapid erosion rates, periglacial processes, glacial ice erosion(?), wind(Black, 1970), and solifluction or creep(Palmquist, 1965). Residuum may contain a mixture of clays derived from leaching of loess, transported clays from the shales, and residual clays from carbonate rocks(about 2% clay contents) (Frolking, 1983). Clay mineralogy of the loess, red clay, and residuum indicates characteristics of weathering stages and mineral composition(Figure 5).

Figure 5. Clay mineralogy *(scale 1-5) of residuum, loess, and red caly, (feldspar and chlorite <5%),



Mineralogy represents an averaging of mineral composition for the <0.2 to 2 micro meter fractions based on XRD peak area, where 5=>50%, 4=5 1=<5%. Source Frolking, 1983 p.818.

The sediment shows no evidence of alluvial or colluvial processes in terms of the graphical moments statistics; the sand is poorly sorted, and phi-distributions of the grain sizes are somewhat platykurtic and leptokurtic and negatively skewed about the median(Figure 3). The angular sand fractions are dominated by fine sand(35.4%) and very fine sand(27.4%). The sand percentage ratios for the sinkhole sediments(2/3-phi: 14.9/35.4%) and bedrock(2/3-phi: 18.8/44.77%) (Figure 6) are nearly identical. However, there is much less very fine sand in the sediment than in the bedrock(44.8%), indicating differential erosional conditions. Finer sands in the unit appear to have been weathered over a long period from the cherty dolostone. The unit has much more very fine silt (9-phi: 62.1%) than medium silt(6-phi: 19.2%)), which may be related to the long duration of weathering processes.

b. Upper Unit

The upper unit(0-100 cm) consists of disturbed mixed brownish yellow(10 YR 6/8) and yellowish brown(10 YR 5/6, 5/8) sediments including sands, clays and broken rock fragments. These mixed materials suggest that the upper unit was disturbed by construction activities. The unit displays irregular depositional sequences and is modern in age, because the unit appears to be mixed with materials from road construction. Sinkholes in Wisconsin have considerable anthrogenic alterations(Oh and Day, 1989).

In terms of particle size distribution, the unit contains much sand(45.5%), which suggests mechanical weathering of friable cherty dolostones. The sand consists mostly of carbonate(64.7%) and chert fractions(34.5%) (Figure 3) and the surrounding bedrock contains characteristic sequences of chert and dolostone. Unleached sediments and undissolved carbonate debris contributed a significant percentage of the carbonates. The result of gasometric analysis of the carbonates verified the significant amount of the carbonates in the sediments(75.2% by unit), which implies that the unit consists about 1/3 of noncarbonate sediments from cherty rocks and clay minerals. Dolomite content (69.2%) is higher than the calcite content(6.0%): this is characteristic of impure carbonate bedrocks. Results indicate that the sediments derived from dolostones contain a considerable amount of weathered carbonates of in situ origin, but also noncarbonate local materials(chert, clay minerals, and galena).

In the sand fraction the dominance of fine sand(56.7%) is unexpected. Fine sand exceeds medium sand(14.6%) by 3.9 times, but both the lower unit and bedrock have ratios about 2.4:1. The fine sand probably is anthropogenic in origin. The disturbed sediments also have an elevated fine silt fraction (56.0%) that represents carbonate-derived silt finer than that derived from loess.

Statistical results of granulometric analysis indicate that the sand is not derived from fluvial processes because it is poorly sorted and the phi-distributions of the grain sizes are somewhat leptokurtic and nearly symmetrical about the median (Figure 3).

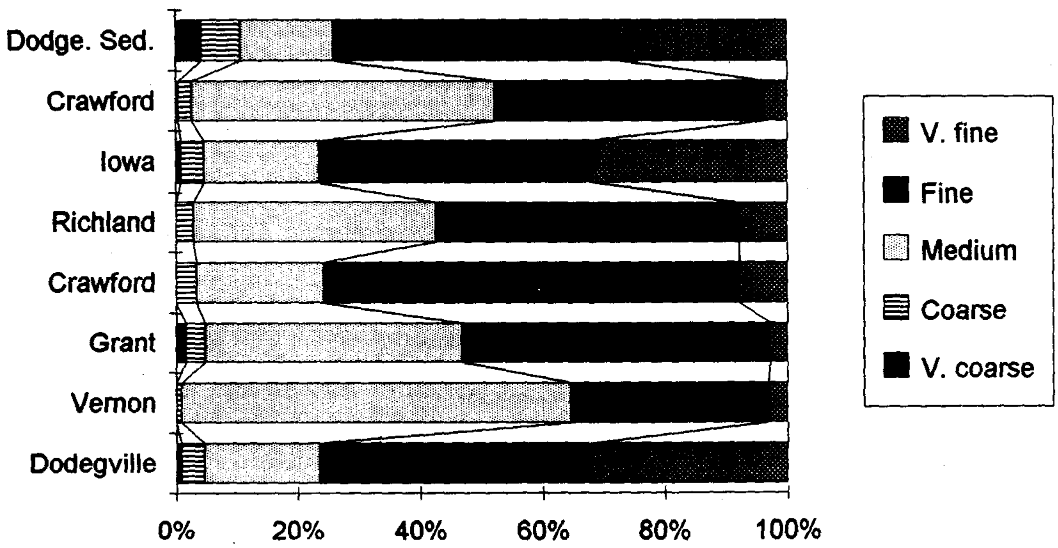
The sediments of the Dodgeville sinkhole are completely different from the sandstone sinkhole sediments in southwestern Wisconsin. In terms of the particle size distribution, the undisturbed homogeneous clay unit has more clay(55.7%) and less sand(17.5%) representing sediments formed over long periods of time. The undisturbed clay unit has more coarse sand fractions that(8.6%) is difficult to explain. The undisturbed unit has more fine silt(9-phi: 62.1%) than the disturbed top unit(56.0%), which implies that sediments affected by long term weathering have finer fractions than those subjected to short-term weathering. Sedimentation rates in the sinkhole are probably very low and reflect the long-period of carbonate weathering.

From lithologic analysis of the sinkhole sediments, three heterogeneous rock fractions were identified: carbonate(36.1%), chert(58.6%), and galena(5.3%). In terms of provenance it is probable that the fractions were entirely derived from the carbonate rocks. Surface frosted and rounded silica quartz grains are absent, indicating that none of the sand is from the St. Peter sandstone.

Of the sinkholes studied(Oh, 1992, Oh, Day, and Gladfelter, 1993), the Dodgeville sinkhole has the least organic matter(0.2%), the most soluble salts (1.82 mm MHO), the highest pH(8.0), and the most carbonates(37.4%). The similar percentages of carbonate fractions(36.1%) and chert fractions (58.6%) represent the carbonate rocks, which are cherty dolostones. Weathering and corrosion of the bedrock has contributed directly and exclusively to the sinkhole sediments, and the immediate surrounding lithology controls sinkhole sediment composition.

Sand grain fractions from the above bedrock are compared to the sand from the Dodgeville sinkhole sediments shown in Figure 6.

Figure 6. Sand fractionation of sampled bedrocks and the Dodgeville sediments. Source the author, 1992.



This graph presents that sizes of the dolostone sand fraction of Dodgeville sinkhole sediments are finner than other sandstone bedrock fractions, It is identical fraction ratio of bedrock fraction sizes 'Iowa Co.' and sinkhole sediments sizes "Dodgeville sinkhole', so that provenance of grains of the sinkhole is in situ dolostone bedrocks. Fractions of loess from the southwestern Wisconsin uplands and silts of the sinkhole sediments are shown in Figure 7.

Figure 7. Silt fractionation of three sampled loess sites from Grant County and the Dodgeville sediments. Source the author, 1992.

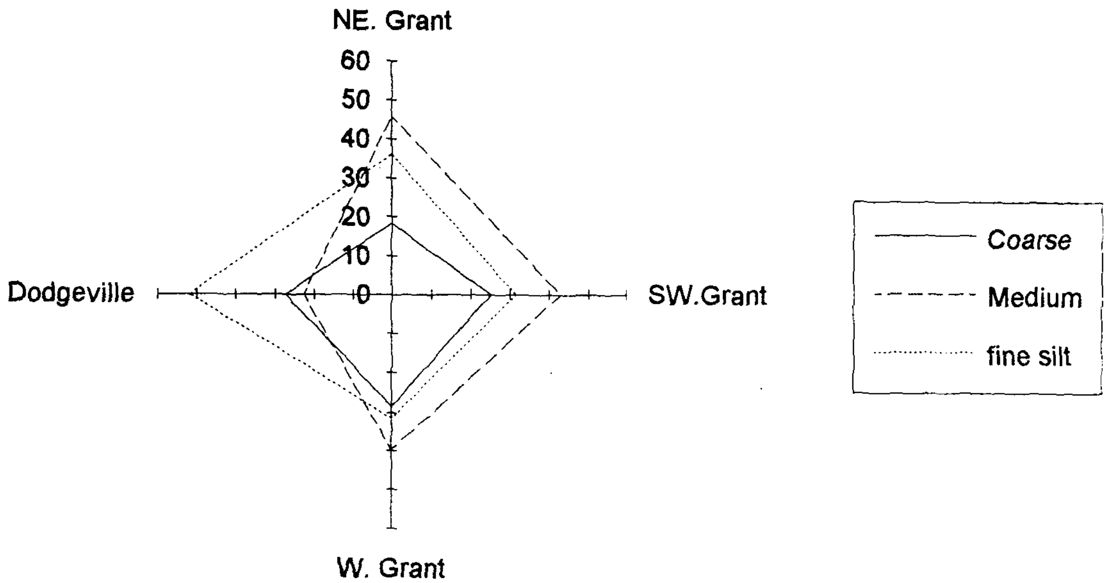
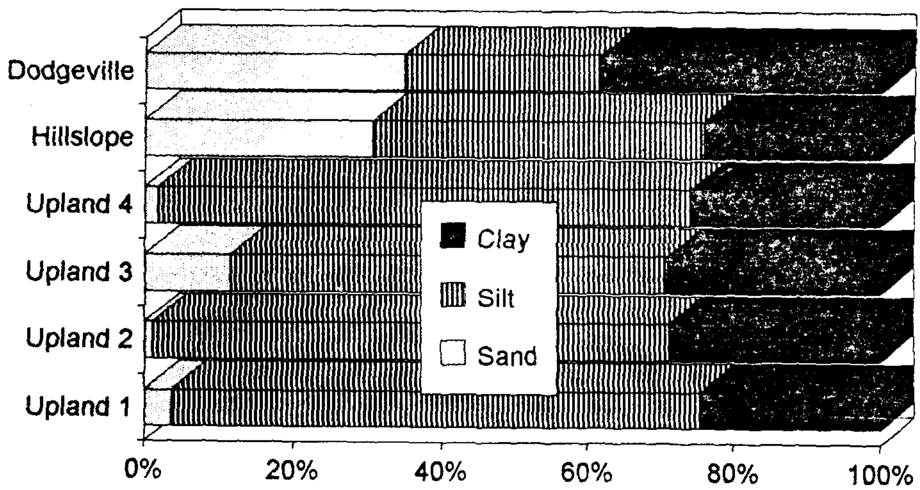


Figure 8. Texture of sampled upland loessial soils and Dodgeville sediments. Source, the author, 1992.



This curve demonstrates that grain sizes of silt of the sinkhole is completely different from that of loessial soil of this region.

Texture of sinkhole sediment was compared to upland loesses and hillside soils in Figure 8. It dispalys that texture of sinkhole sediments is similar to slope soil's, but different from loesses. In result, sand and clay of the sinkhole sediments are much greater in percentages than loesses.

Ⅳ. DISCUSSION AND CONCLUSIONS

Research on the karst sediments in southwestern Wisconsin(Oh and Day, 1989b; 1991) suggests that sediment environments depend on three physical conditions: Bedrock unit, Landscape position, and Sinkhole origin.

1) Bedrock units: composition of sinkhole sediment depends on the host Ordovician sedimentary rock. Calcite and dolomite are the major constituents of the dolostone. Clay minerals in the karst sediments may have derived from either carbonate residuum, aeolian silts, and/or weathered shalely bedrock(Maquoketta shale: uppermost Ordovician unit). Weakly cemented St. Peter sandstone fractions are mostly silicious quartz grains. With reworked organic loess and weathered local debris, karst sediments contain considerable sand(range 17-85%) that could be derived either from sandstone outcrops by backwasting(Oh and Day, 1990b) or from carbonate rocks by weathering and slope processes.

Sediment in sinkholes adjacent to sandstone bedrock contains much sand, particularly from the friable St. Peter sandstone(Oh and Day, 1991). Sediment in sinkholes formed in dolostone bedrock or shalely bedrock may also have a high clay content since the sediment source is the weathered residuum which overlies carbonate bedrock.

2) Landscape position: most sinkholes are located on mid slopes(50%) and ridge crests(45%) (Day and Reeder, 1989). Some sinkholes are connected to cave systems, and some are formed as vertical conduits by dissolution. Most sinkholes display a closed-depression topography(Day, Reeder, and Oh, 1989). Sinkholes on ridge tops contain mostly thin accumulations of loess with local residue from inwash processes. Sinkholes on the hillsides contain a mixture of loess and local particles reworked by slope processes (Oh, 1990c).

3) Origin of sinkholes: sediments in closed sinkholes demonstrate accretional and stratified features. Sediments in collapsed sinkholes which are connected to subterranean cave systems contain a mixture of materials derived from bedrock

by collapse, vadose cave sediments, and reworked organic loess from the surface.

Previous investigations suggest that the variable types of unconsolidated materials in the southwestern Driftless Area have been removed by erosion, and could be potentially preserved in the karst system: residuum lies in small karst pockets(Black, 1970); red clays remain in karst depressions(Frolking, Jackson and Knox, 1983); gravel deposits of the Windrow formation are distributed in caves and crevices(Knox, 1981); glacial sediments may have been preserved in paleo-surface depressions of karstic collapse features(Effland, 1990); and paleo-organic soils may be buried in the sediments at the bottom of sinkholes(Oh and Day, 1991). Previous research, however, does not provide precise identification of the materials in terms of provenance.

An autogenic sediment in the Dodgeville sinkhole consists entirely of carbonate rock-derived materials: dolostone sand and silt fractions, reddish clays, cherty particles, and lead ore. This indicates that the dolostone sinkhole consists almost entirely of in situ carbonate weathering materials.

Dolostone sinkhole sediments in the Driftless Area provide evidence for sinkhole genesis, sources and transport of infill materials and Quaternary environmental changes. Major conclusions are as follows:

1) Upper portion of the material in the sinkhole is of historic origin, reflecting European land use practices, but the lower portion of the sediments is of typical karstified autogenic sediment infills.

2) Sand and silt of the sinkhole sediments are finner than that of loess, however, sand and clay fractions are coarser than loess.

3) Materials of the sinkhole sediment are definetely inherited from internal dolostones by dissolution and weathering, because Figure 6 and 7 demonstrate heterogeneous paticle size distributions between sandstone bedrocks and dolostone bedrocks with dolostone sediments.

4) The Dodgeville sinkhole sediments present autogenic karstic features.

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