UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
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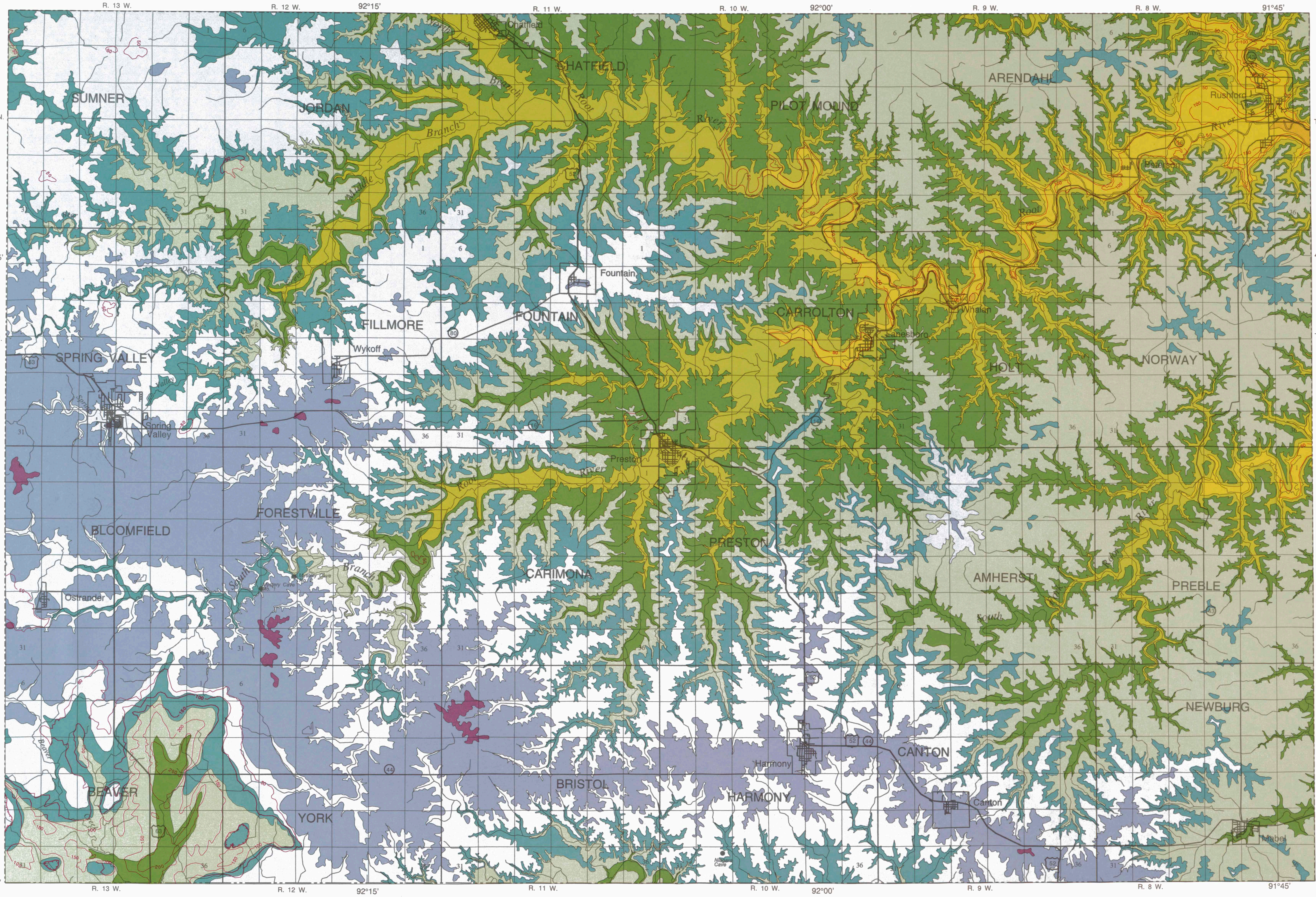
COUNTY ATLAS SERIES
ATLAS C-8, PART A
Plate 4—Depth to Bedrock & Bedrock Topography



Digital base modified from 1990 Census TIGER/Line Files of U.S. Bureau of the Census (source scale,1:100,000); digital base annotation by Minnesota Geological Survey

Universal Transverse Mercator Projection, grid zone 15
1927 North American Datum

SCALE 1:100 000

Cartography by Joyce Meints, Kimberly Esser, and Philip Heywood

DEPTH TO BEDROCK AND BEDROCK TOPOGRAPHY

By

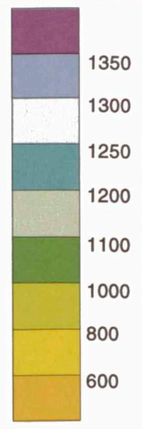
John H. Mossler and Howard C. Hobbs

1995

DESCRIPTION OF MAP SYMBOLS

Bedrock Topography

The1200–1250 foot interval is omitted where it is too thin to portray at the map scale; in these areas the color for the 1250–1300 foot interval includes the 1200–1250 foot interval



Depth to Bedrock

150

Measured in feet below land surface; contour interval 50 feet

INTRODUCTION

The surface topography of Fillmore County formed through a long and complex interaction of deposition and erosion. The bedrock surface was once overlain by thick and extensive unconsolidated glacial deposits; today it is covered only by a thin mantle of such deposits. The topography of the land surface largely reflects the configuration of the bedrock surface. The exception is in the southwestern corner of the county where thick glacial deposits fill an ancient valley cut in the bedrock.

MAP PREPARATION

The topography of the bedrock surface must be mapped before depth to bedrock can be determined. Several sources provide information on the elevation of the bedrock surface. Bedrock outcrops serve as control points. Geomorphic features on topographic maps, such as prominent steep rocky bluffs, rock-cored mesas, and areas of karst (indicated by sinkholes, blind valleys, and sinking streams), indicate shallowly buried bedrock (less than 50 feet and generally less than 25 feet of overburden). Soil maps delineate areas where bedrock is within five feet of the land surface (Farnham, 1958). Information on the subsurface, especially that provided by water-well records and refraction seismic soundings, gives additional control points in areas lacking bedrock exposures. Contour intervals are more generalized where the overburden is more than 100 feet thick, because there are few points of known bedrock elevation.

After the elevations of the bedrock surface have been contoured to show the bedrock topography, those contours are subtracted from corresponding land-surface topographic contours where the respective contours cross or intersect. The resulting values are contoured, along with depth to bedrock values taken from water wells and seismic lines, to create a map that depicts the interpreted depth to bedrock across the county. Accuracy of depth to bedrock for a particular area is dependent on knowledge of bedrock topography.

GEOMORPHOLOGY

The manner in which different rock formations respond to weathering and erosion is the chief influence on topography in Fillmore County. Weakly cemented sandstones and shales are easily eroded by flowing water; they also are subject to mass movement along near-vertical slopes. Limestones and dolostones are resistant to physical erosion but susceptible to solution in slightly acidic ground water. The flat uplands, or plateaus, in the county are mostly underlain by resistant limestones and dolostones, as are the flat-topped mesas and the long ridges that extend beyond the Galena–Cedar Valley plateau. High cliffs and bluffs along entrenched streams crossing the plateau also are composed of dolostone or limestone.

The escarpment between plateaus, sides of mesas and ridges, and floors and lower parts of valley walls along deeply entrenched streams is composed of weak sandstone and shale. The carbonate rocks underlying the plateaus, and particularly the Galena–Cedar Valley plateau, commonly are pockmarked by sinkholes and possess blind valleys and other landforms related to chemical dissolution of underlying carbonate rock. Gradients of streams are steepest where streams cross from resistant carbonate rocks to less resistant sandstones.

The bedrock in Fillmore County is characterized by two thick sequences of limestone and dolostone that are separated by a weakly cemented sandstone formation and shaly formations. The Galena–Cedar Valley plateau, also called the upper carbonate plateau, of western and southern Fillmore County (Fig. 1a) is composed of resistant carbonate bedrock units of the Galena Group, Dubuque and Maquoketa Formations, and the Wapsipinicon and Cedar Valley Groups. Interbedded thin, nonresistant beds do not affect topography. The escarpment that forms the outer margin of the Galena–Cedar Valley plateau is composed of, from bottom to top, the St. Peter Sandstone, Glenwood and Platteville Formations, Decorah Shale, and Cummingsville Formation (Fig. 1b). These formations are exposed in meander scars where streams incise the escarpment. As the escarpment retreats, it leaves fingerlike ridges capped by carbonate rocks of the more resistant Cummingsville and Platteville Formations. Continued erosion of these ridges ultimately results in the development of mesas, or small, flat-topped hills, of St. Peter Sandstone that are capped by erosional remnants of resistant Platteville limestone and isolated from the main body of the escarpment. Once the Platteville is removed by erosion, the round to elliptical hills of St. Peter Sandstone that remain form slightly hummocky terrain.

The carbonate uplands of the Galena–Cedar Valley plateau (Fig. 1a) are partially drained through the subsurface. Dry and blind valleys, caves, and resurgent springs form major parts of the near-surface ground-water system, and subsurface dissolution of carbonate by ground water is an important factor in the erosion process. In one area of the county (Forestville karst basin in western Fillmore County), dissolution of limestone and dolostone by ground water corresponds to a surface lowering of about five centimeters per 1000 years averaged across the entire drainage basin (Grow, 1986). Even flowage of main or trunk streams, such as the South Branch Root River near Mystery Cave 1 and 2, is diverted by underground drainage (Palmer and Palmer, 1993). Karst development is commonly most extensive nearest the periphery of the plateau—in the basal Dubuque Formation, and the Stewartville and Prosser formations of the Galena Group. The Devonian formations and the Maquoketa Formation generally are on flat uplands away from incised streams, and karst is less developed.

The gradient of the South Branch Root River is steepest by Mystery Cave 1 and 2, across the escarpment of the Galena–Cedar Valley plateau (Palmer and Palmer, 1993, p. 56). The steepening is caused in part by the massive and resistant nature of the Stewartville Formation, which caps the outermost edge of the plateau. It also is enhanced by the low resistance to erosion of the underlying bedrock units, particularly the Cummingsville and Decorah formations, which are easily eroded by running water and subject to significant mass wastage. The escarpment has the most rugged relief on the bedrock surface countywide.

Karst development is much less pronounced on the Prairie du Chien plateau, which is situated on less soluble dolostone and sandstone of the Prairie du Chien Group in northwestern Fillmore County (Fig. 1c). The dolostone of the Prairie du Chien contains a considerable amount of insoluble material that includes chert, clay, sand, and cavity linings of drusy quartz. Although many sinkholes have developed on the bedrock surface, most of them are filled with sediment and do not form depressions on the land surface. The Prairie du Chien plateau, unlike the Galena–Cedar Valley plateau, is not bordered by an escarpment. However, it is crossed by streams that are deeply entrenched into or through the Prairie du Chien dolostones, most notably the Root River from Lanesboro to Rushford.

GEOLOGIC HISTORY

Although the landscape of Fillmore County is interpreted to be youthful (in a geologic sense), it contains remnants of a much older landscape that may date to the Late Cretaceous. The Windrow Formation of Cretaceous age is preserved at many localities in the county at elevations from 1215 to 1375 feet above sea level. Iron Hill, the lower member of the Windrow Formation, is an iron-rich residuum that formed over a karsted surface of carbonate rocks. It developed principally in those carbonate units most susceptible to dissolution and karsting, such as the Stewartville and Spillville Formations. The residuum may have accumulated in a humid subtropical climate, with the iron being further concentrated by stream processes (Witzke and others, 1983). The upper part of the Windrow, the Ostrander Member, was deposited mostly in streams. Preservation of outliers of Windrow Formation fluvial deposits along high drainage divides indicates aggrading Cretaceous fluvial systems occupied a different position relative to modern fluvial systems. The bedrock bottom of the Mississippi River Valley at Winona is approximately 500 feet above sea level, indicating about 715 to 875 feet of post-Cretaceous downcutting. During the Cretaceous the general direction of regional fluvial transport also was different, toward the west and southwest, rather than east and southeast as at present.

Most of the karst features in the region are related to the geologically very young Quaternary landscape (Hallberg and Bettis, 1985; Lively and Alexander, 1985). There is no evidence that active karst dates from the Cretaceous or Tertiary. However, Cretaceous paleokarst is preserved in outcrops near St. Peter and Mankato on the Minnesota River Valley northwest of Fillmore County (Humphrey, 1958). Sloan (1964) reports that the Iron Hill Member of the Windrow Formation typically occurs on a karst topography in Fillmore County, primarily as fillings in enlarged joints and sinkholes or caves. These occurrences are no long exposed, though they were during iron mining.

Although little is preserved from the Tertiary landscape, at the beginning of the Quaternary there probably was a well-integrated dendritic network of streams draining a region of moderate relief that was mantled with residuum derived from underlying bedrock. Some of the residuum overlying Paleozoic bedrock in eastern Fillmore County (cherty, clay-rich terra rossa over the Oneota Dolomite; iron-stained, sandy residuum over the New Richmond Member) may be Tertiary in age.

A southward-draining, buried stream-valley system of pre-Quaternary age in southwestern Fillmore County is separated from a similar system of northward-draining preglacial buried valleys in Olmsted County (Olsen, 1988) by a regionally high (more than 1300 feet above sea level) divide in western Fillmore County and adjoining eastern Mower County. Much of western Fillmore County lay along this major watershed divide.

The modern stream network in Fillmore County shows no trace of the earlier network, probably because preglacial streams were not as deeply incised as their successors (Hobbs, 1985). Subsurface information does not indicate preservation of any pre-Quaternary valleys in Fillmore County other than the one in the southwest corner of the county. During the Quaternary the valleys of the Root River, the South Fork Root River, and their tributaries began to entrench into Paleozoic bedrock by headward erosion, which in turn was caused by the deep entrenchment of the Mississippi River.

The entrenched Mississippi River valley was cut during the earliest Pleistocene, concurrently with the earliest extensive glaciation. The gorge of the Mississippi was incised by meltwater from this glaciation, which occurred more than 788,000 years ago and possibly 2.14 million years ago (Matsch and Schneider, 1986). Because Mystery Cave 1 and 2 owe their origin mainly to underground diversion of the South Branch Root River, the caves formed only after the streams in the area entrenched into the limestone in which the caves now lie (Palmer and Palmer, 1993). Presence of speleothems more than 350,000 years old in Mystery Cave 1 and 2, and the necessity that the river be entrenched before the cave could form, push the origin of the caves and entrenchment of the South Branch Root River to the middle Quaternary period, more than 500,000 years ago (Palmer and Palmer, 1993).

ACKNOWLEDGMENTS

Partial funding for this project was approved by the Minnesota Legislature (M.L. 91, Ch. 254, Art. 1, Sec. 14, Subd. 4[F], and M.L. 93, Ch. 172, Sec. 14, Subd. 11[g]) as recommended by the Legislative Commission on Minnesota Resources from the Minnesota Environment and Natural Resources Trust Fund.

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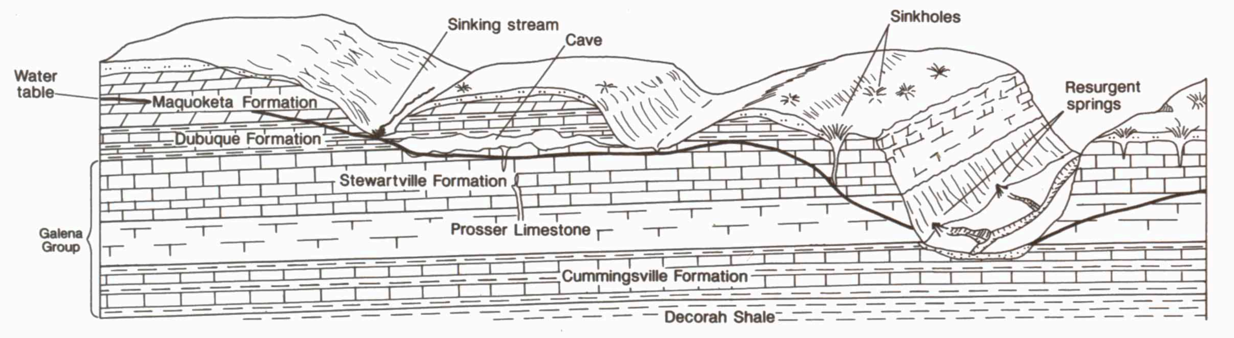
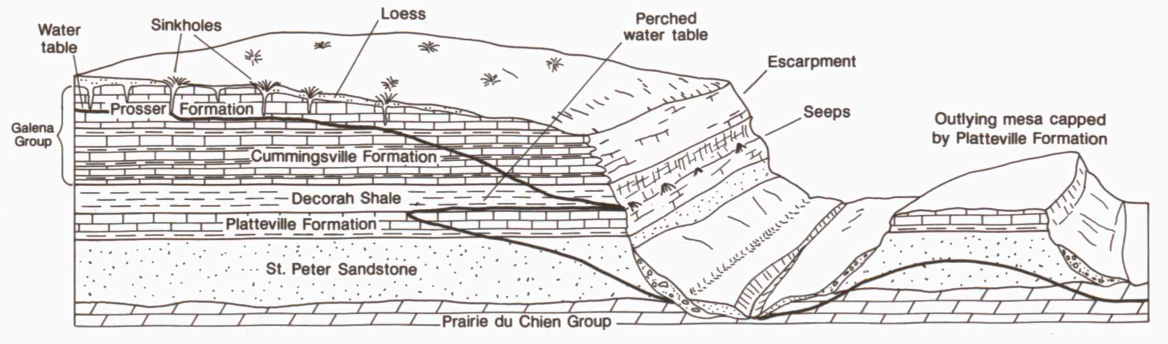
LOCATION DIAGRAM



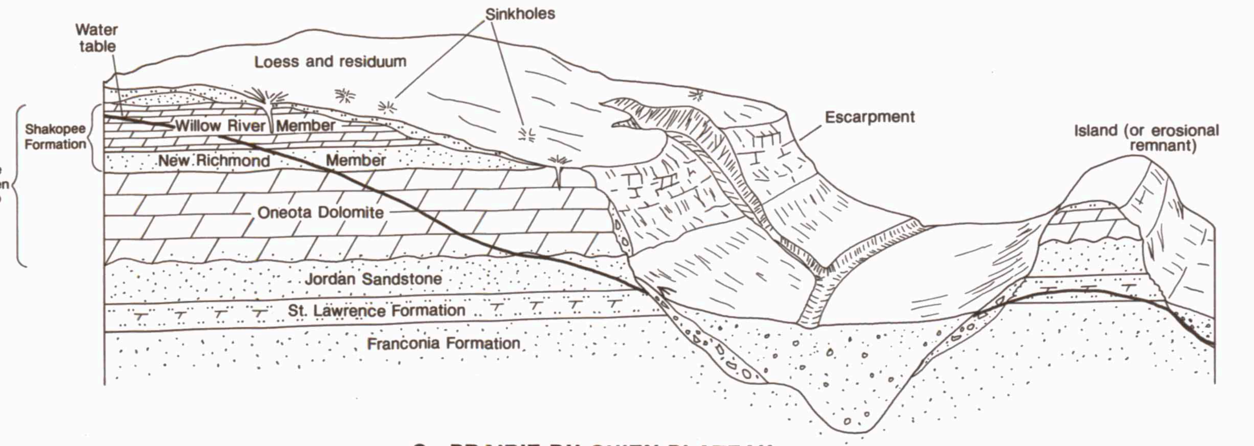
A. GALENA-CEDAR VALLEY PLATEAU

The plateau is composed of resistant carbonate bedrock units of the Galena Group, Dubuque, and Maquoketa Formations, and, locally, the Wapsipinicon and Cedar Valley Groups. Drainage is largely subsurface by way of sinking streams and sinkholes that debouch through resurgent springs. Some caves (for example, Mystery Cave 1 and 2; see Palmer and Palmer, 1993) formed through subsurface erosion when water was diverted from surface streams. Other caves were created when surface infiltration of water was channeled underground at discrete points through sinkholes (for example, Niagara Cave). The Stewartville and Prosser Formations commonly form cliffs along the stream valleys incising the plateau. Springs at the base of cliffs generally debouch near the top of the Cummingsville Formation.



B. ESCARPMENT AT FRONT OF GALENA–CEDAR VALLEY PLATEAU

The escarpment is composed of less resistant rock formations, chiefly shale and sandstone. The top of the escarpment is capped in most places by the Prosser Formation or, less typically, the Stewartville, and the formations generally thin gradually toward the edge of the escarpment without forming a prominent cliff. The plateau surface near the escarpment is commonly highly pitted with sinkholes. Springs or seeps issue above impermeable layers in the Decorah and Platteville Formations. Extensive wet, boggy areas may form below the seeps. The Glenwood Formation, although present beneath the Platteville, is too thin to show at the illustration scale.



C. PRAIRIE DU CHIEN PLATEAU

The plateau is situated on dolostone and sandstone of the Prairie du Chien Group. Streams are entrenched into Prairie du Chien rocks or through them into underlying sandstones. Many streams have incised meanders. Valley walls along lower reaches of streams are commonly edged by cliffs of Oneota dolostone. Tops of cliffs are generally underlain by New Richmond sandstone. Willow River dolostone generally is the first bedrock beneath unconsolidated overburden on the plateau. Karst is less extensive beneath this plateau owing to the lower solubility and higher insoluble content of the dolostone compared with values in carbonate rocks of the Stewartville and Prosser formations of the Galena Group. Springs along valley walls commonly emanate from the Jordan Sandstone. In the upper reaches of streams springs can also come out of the Oneota or the New Richmond.

FIGURE 1. *Bedrock geomorphology of Fillmore County.*