Subsurface variation in the high-calcium Dolbee Creek Limestone in western Illinois

Mark Cloos and James Baxter

Illinois Institute of Natural Resources
STATE GEOLOGICAL SURVEY DIVISION
Jack A. Simon, Chief

ILLINOIS MINERAL NOTES 78
January 1981

Cloos, Mark
Subsurface variation in the high-calcium Dolbee Creek Limestone in western Illinois / Mark Cloos and James Baxter. – Champaign, Ill. : State Geological Survey Division, 1981.

23 ; 28 cm. – (Illinois mineral notes ; 78)

1. Limestone–Illinois. 2. Dolbee Creek Limestone. I. Baxter, James. II. Title. III. Series.

Printed by authority of the State of Illinois/1981/2500

Subsurface variation in the high-calcium Dolbee Creek Limestone in western Illinois

Mark Cloos and James Baxter

ILLINOIS STATE GEOLOGICAL SURVEY
Natural Resources Building
615 East Peabody Drive
Champaign, IL 61820

ILLINOIS MINERAL NOTES 78
January 1981

CONTENTS

FIGURES

TABLES

Subsurface variation in the high-calcium Dolbee Creek Limestone in western Illinois

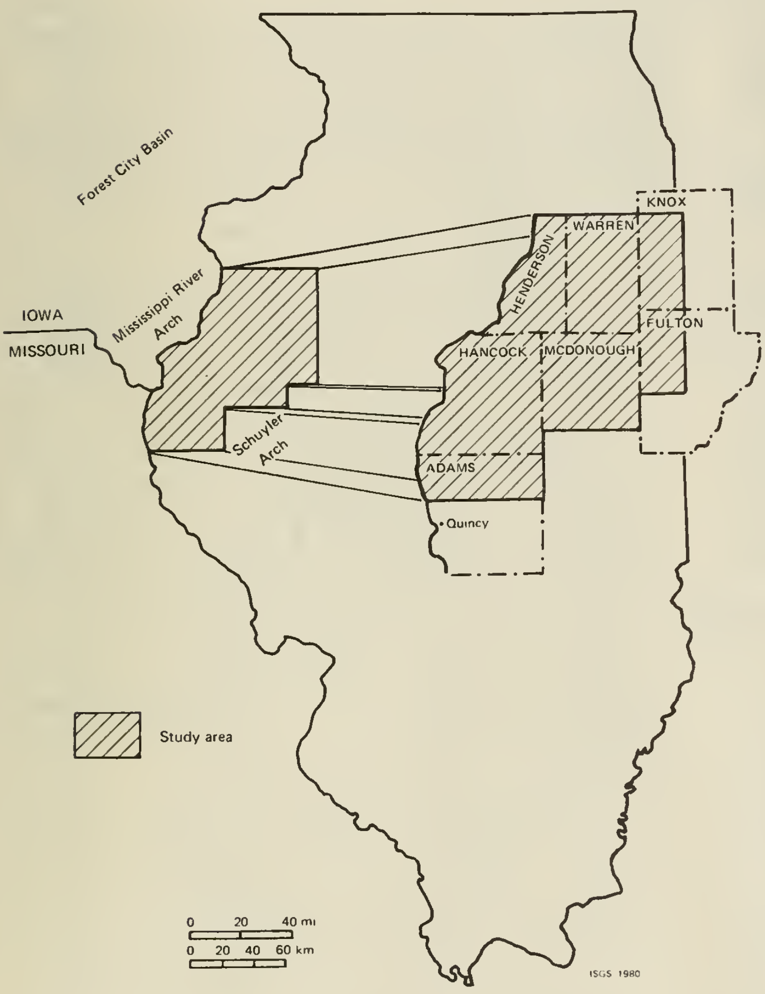


Figure 1. Study area.

ABSTRACT

High-calcium limestone in the lower Burlington "Quincy Beds," now assigned to the Dolbee Creek Member of the Burlington Limestone, has been quarried and mined for over 100 years near Quincy in Adams County, Illinois. Mining has been conducted primarily through adits in the bluffs of the Mississippi River. This report presents data on stratigraphic, lithologic, and chemical variations over a wide area of the shallow subsurface north and northeast of Quincy in central-western Illinois, where the Dolbee Creek Member occurs at depths that are accessible to mining only by shafts or inclines. Our report is based on the study of diamond drill borings in Adams, Fulton, Hancock, Henderson, Knox, McDonough, and Warren Counties.

Chemical analyses indicate that the Dolbee Creek Member does not maintain its high-calcium character north of Adams County. Although portions remain relatively chert free, the $MgCO_3$ content increases. This dolomitic stone, however, could be used as agricultural limestone and may be more suitable for aggregate than the soft, coarse-grained, crinoidal limestones now worked at Quincy.

INTRODUCTION

Very pure, almost chert-free limestone has been quarried or mined from adits since the mid-1800s near Quincy in Adams County, Illinois. The limestone, worked mainly for the production of lime and fine-ground products, occurs in a unit 10 to 25 feet thick (3 to 8 m). Previously referred to as the "Quincy Beds," "Quincy Lime," or basal Burlington, this limestone is now assigned to the Dolbee Creek Member of the Burlington Limestone Formation (Goodwin and Harvey, 1980). Published analyses have broken this limestone down into its components as follows: more than 97 percent $CaCO_3$, under 1.5 percent $MgCO_3$, and less than 0.5 percent SiO_2 (Lamar, 1957). Limestones that contain more than 95 percent $CaCO_3$ are generally classified as high-calcium stone; however, for chemical, metallurgical, and other special industrial purposes, limestones with 97 to 99 percent $CaCO_3$ are generally required. Although Illinois is a major producer of limestone and dolomite rock products, relatively few deposits can support sustained production of high-calcium limestone.

In 1969, the New Jersey Zinc Company drilled 61 diamond drill core holes north and northeast of Quincy in western Illinois as part of a regional exploration program. Most of these cores started in the Mississippian or Pennsylvanian bedrock and bottomed in the Ordovician. The recent release of data from these cores provides an opportunity to evaluate the economic potential of the Dolbee Creek Member (which was penetrated by 39 of the cores) in the shallow subsurface over all or parts of seven counties, including Adams, Fulton, Hancock, Henderson, Knox, McDonough, and Warren (fig. 1).

Because of the rapid increase in demand for high-calcium limestone, the paucity of suitable surface deposits, and environmental restraints on open pit quarry operations (Baxter, 1980), the subsurface potential of limestone units that have a high degree of purity in their outcrops (such as the Dolby Creek) needs to be evaluated. The Dolbee Creek is essentially chert-free throughout much of southeastern Iowa (Harris and Parker, 1964) and occurs at shallow depths north of Quincy. Detailed information on the quality of the stone in the Illinois subsurface was not available before the release and subsequent study of New Jersey Zinc's drill cores. The distribution of the coring sites used is shown in figure 2; detailed locations are given in table 1.

The primary purpose of this report is to delineate the distribution, thickness, depth, and chemical character of the Dolbee Creek Member of the Burlington, and of various carbonate units with low chert contents that are locally subjacent to the Dolbee Creek. Strata overlying the Dolbee Creek have generally high chert contents and were not analyzed.

GEOLOGIC SETTING

Areal geology

The study area is in western Illinois and includes counties adjacent to the Mississippi River. Paleozoic bedrock formations that crop out and/or occur at relatively shallow depths range in age from the Kinderhookian (lower Mississippian) Hannibal Shale to the Desmoinesian (middle Pennsylvanian) Carbondale Formation (fig. 3). Mesozoic strata of Cretaceous age crop out locally, but are not known to extend far into the subsurface.

Rocks of Mississippian age are at the bedrock surface in the western part of the area and crop out along major streams farther east. Pennsylvanian rocks are largely confined to the eastern parts of the area, but occur in small erosional remnants to the west (Willman et al., 1967). A major unconformity separates rocks of Pennsylvanian age from the underlying Mississippian strata in Illinois (Bristol and Howard, 1971). The effect of the long period of erosion associated with this unconformity combined with regional and local uplift led to the removal of Mississippian rocks. As a result, strata of Pennsylvanian age locally overlie units as old as the Hannibal Shale (fig. 3). The age of the uppermost Mississippian formations at any one place depends largely upon the depth of erosion at the sub-Pennsylvanian unconformity. The distribution of the various Mississippian formations and the extent of Pennsylvanian strata are shown in figure 4.

The Baylis Formation, of Cretaceous age, is limited to a small area in northern Adams County, mostly in T. 1 N., R. 8 W., where it overlies rocks of Mississippian age (Frye, Willman, and Glass 1964; Willman et al., 1967). Deposits of Cretaceous age were not recognized and probably were not encountered in the New Jersey Zinc cores. The entire area is covered by a surficial veneer of unconsolidated glacial deposits of Quaternary age.

Structure

The study area is situated along the eastern limb of the Mississippi River Arch (Howell, 1935; Willman et al., 1967), which is a broad upfold that separates the Illinois Basin from the Forest City Basin of Iowa. In western Hancock and Adams Counties, the axis of the arch is roughly parallel to the Mississippi River. The general rise of the Paleozoic strata from east to west, seen on structure contour maps (Stevenson and Whiting, 1967) follows the eastern limb of the Arch.

A glauconite zone marks the base of the Haight Creek Member of the Burlington Limestone (top of the Dolbee Creek; fig. 3). This glauconite was deposited on a horizontal plane and represents a synchronous or nearly synchronous depositional event. It is a convenient datum for structure-contour mapping. Structural mapping of the glauconite in Iowa has revealed a series of northwest-trending anticlines (Bentonsport, Skunk River, Burlington, and Sperry) superimposed upon the Mississippi River Arch (Harris and Parker, 1964). The axes of the anticlines have variable plunges; where the crests are at higher elevations, the overlying Dolbee Creek tends to thin. Extensions of these structures can be traced for short distances in Illinois and Iowa, but they apparently die out in parts of Warren, Henderson, McDonough, and Hancock Counties.

The distribution and depths of formations of the Kinderhookian North Hill Group are partially controlled by elements of structure not reflected in the overlying rocks of Valmeyeran age. These older formations—the Starrs Cave Limestone, Prospect Hill Siltstone, and McCraney Limestone, and the Kinderhookian Hannibal Shale—are on

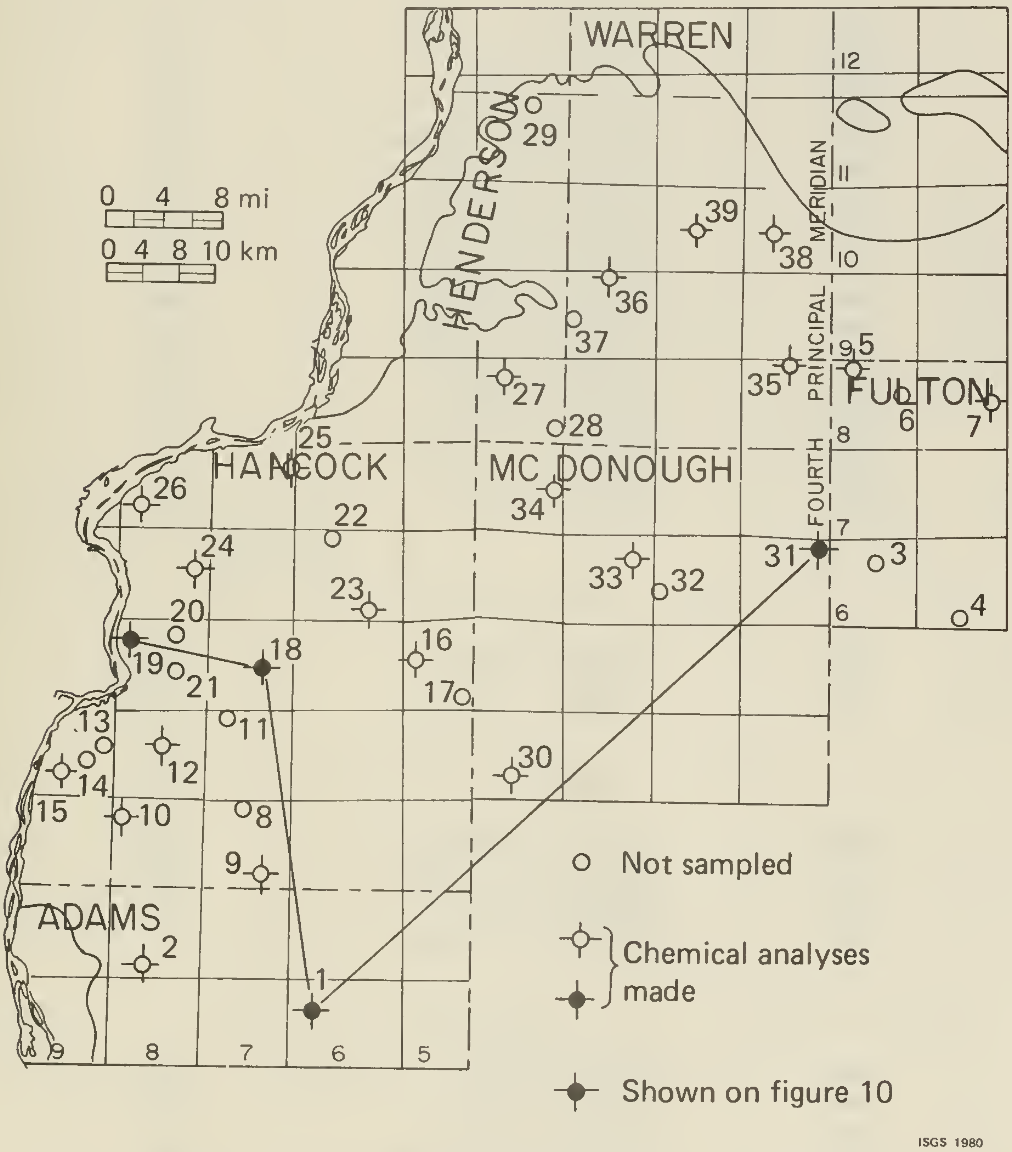
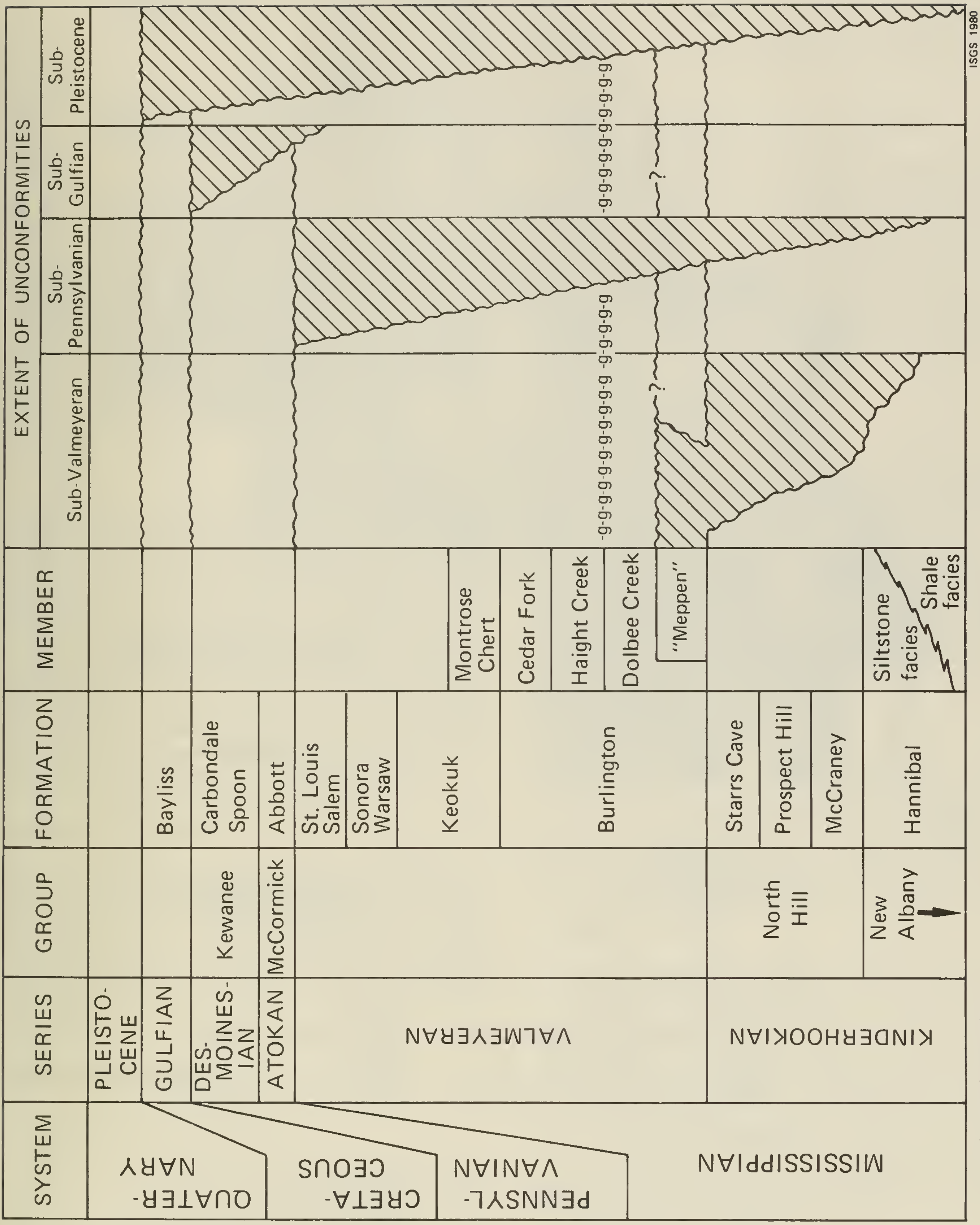


Figure 2. Distribution of cores penetrating the Dolbee Creek Member (for exact locations see table 1).

TABLE 1. Location and elevation of core holes and depth to Dolbee Creek Limestone Member

Well location no.	Core no.	Location	Elevation (ft)	Depth to Dolbee Creek (ft)
		Adams County		
1	7894	NE/c NE NE 17-1N-6N	629	260
2	7879	NW NE NW SW 33-2N-8W	637	239
		Fulton County		
3	7865	SW SE SW 10-6N-1E	626	419
4	7884	NW NW SW 34-6N-2E	651	480
5	7608	C SL NW SE 5-8N-1E	643	147
6	7870	SW NE SW NW 13-8N-1E	656	288
7	7864	NW/c SW NE SW 13-8N-2E	637	259
		Hancock County		
8	7896	NE/c NW NE SE 4-3N-7W	575	255
9	7606	C N/2 NE NW 35-3N-7W	646	329
10	7895	NW NE SW 7-3N-8W	657	286
11	7885	SE/c NE SW 5-4N-7W	649	308
12	7838	NE/c SW SW SW 15-4N-8W	688	251
13	7607	NW NE SE SE 13-4N-9W	689	287
14	7883	NE/c SW SE 23-4N-9W	663	312
15	7603	C EL SE SW SE 28-4N-9W	482	123
16	7881	NW/c SW SW 16-5N-5W	629	211
17	7873	NW SE SW NE 36-5N-5W	510	115
18	7845	NW SE NW 23-5N-7W	686	297
19	7609	C SL SE NE 7-5N-8W	647	265
20	7867	SW SE SE NW 11-5N-8W	683	284
21	7888	SE NW SW 23-5N-8W	618	199
22	7880	NE NE NE 4-6N-6W	647	244
23	7869	NW/c NE SW 36-6N-6W	550	195
24	7886	SW/c NW NW NW 13-6N-8W	678	249
25	7846	SE NE NE 13-7N-7W	601	185
26	7868	NW NE SW 29-7N-8W	582	191
		Henderson County		
27	7875	SE SW SW 9-8W-4W	737	159
28	7890	SE/c SE SE 36-8N-4W	768	277
29	7836	NE NW SW 2-11N-4W	769	53
		McDonough County		
30	7866	SW SW SE 28-4N-4W	530	104
31	7882	NE/c SE SE SE 1-6N-1W	598	275
32	7874	SW SE SW SW 19-6N-2W	653	Absent
33	7892	NE NE SE 11-6N-3W	711	262
34	7893	NE SE NE NE 24-7N-4W	?	314
		Warren County		
35	7889	NE SW NE 3-8N-1W	687	168
36	7887	SW/c SW SW 3-9N-3W	713	167
37	7860	NE NE SW 19-9N-3W	670	88+
38	7610	SW NW NW SW 21-10N-1W	740	227
39	7935	NW/c SW SW NW 22-10N-2W	769	171



-g- = glauconite marker

Figure 3. Rock units and stratigraphic relationships.

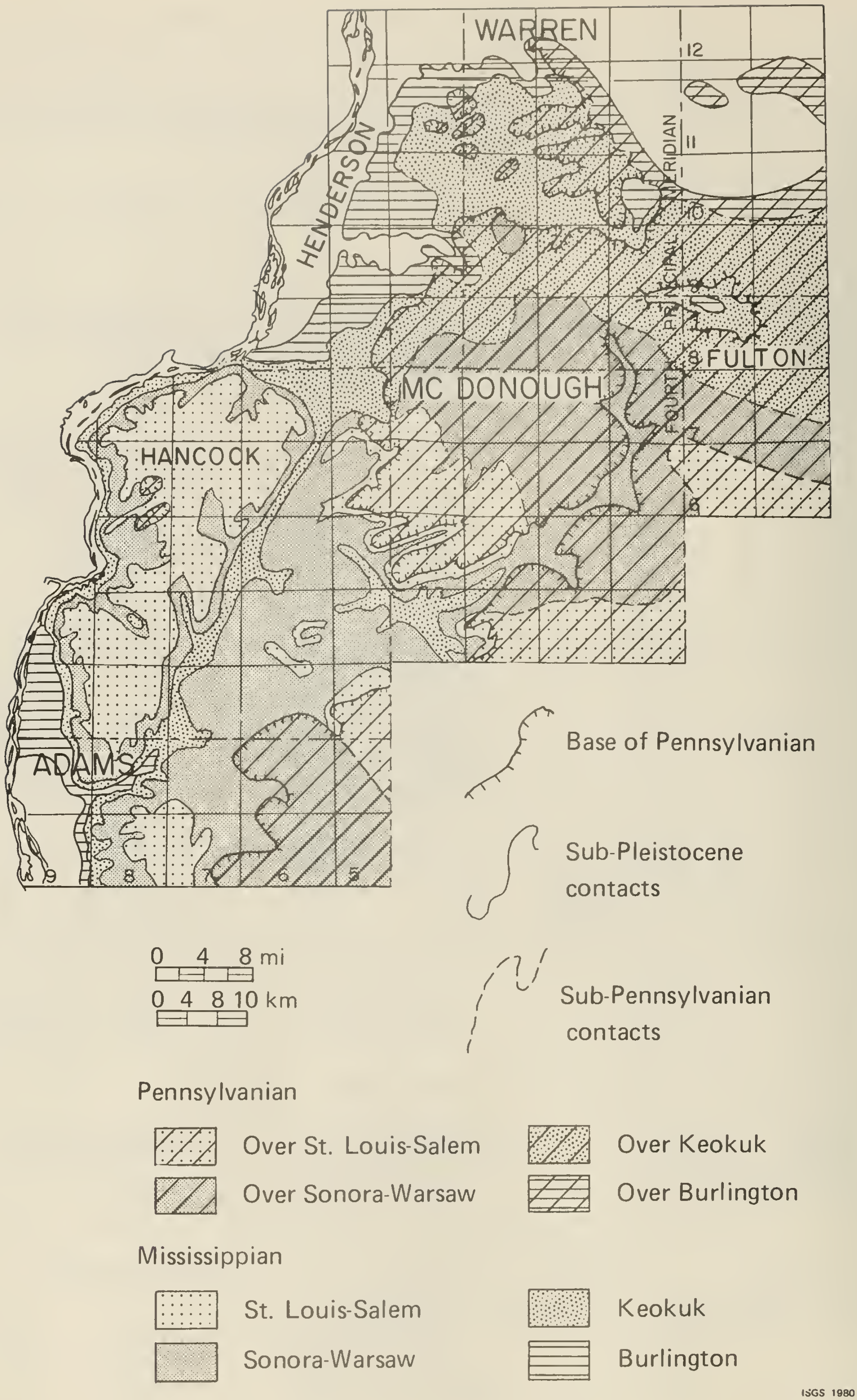


Figure 4. Extent of Mississippian age rocks.

the northwest flank of the Schuyler Arch (Workman and Gillette, 1956), the axis of which trends northeast through Schuyler County just east of the study area. The Schuyler Arch apparently formed after North Hill deposition and was truncated during a period of erosion that occurred before the deposition of Valmeyeran age rocks. As a result, the Dolbee Creek directly overlies each of the formations of the North Hill Group and the Hannibal Shale along relatively narrow belts in western Adams and Hancock Counties (fig. 5).

■ STRATIGRAPHY

The Dolbee Creek Member of the Burlington Limestone is overlain by variable thicknesses of younger Mississippian, Pennsylvanian, and Quaternary sediments (table 2). The distribution and lithologic character of these strata will be important if further drilling is needed to evaluate limestone resources, and if shafts or inclines need to be planned, should mining prove feasible.

Quaternary System

Unconsolidated sediments in the Quaternary System include surficial deposits of Pleistocene age. Glacial till and outwash deposited by glaciers of the Kansan and Illinoian Stages generally overlie all of the bedrock formations. A thin layer of loess, which consists of windblown silt and clay derived from the floodplains of the Mississippi River during Wisconsinan glaciation, blankets the whole area. Holocene alluvium occurs along the flood plains of the present streams. No record of the unconsolidated materials penetrated by the drilling is available, but the total thickness of such sediments exceeds 200 feet (60 m) in some places and averages about 75 feet (23 m) in the core holes.

Pennsylvanian System

Strata of Pennsylvanian age are predominantly shale, siltstone, and sandstone, with thin layers of limestone and coals. The thickness of rocks of the Pennsylvanian System varies from 0 to 367 feet (0 to 112 m) in the drilling, and average about 90 feet (27 m). The Abbott, Spoon, and Carbondale Formations are represented, but are not differentiated for this report.

Mississippian System

ST. LOUIS-SALEM LIMESTONE

Limestone and/or dolomite of the St. Louis Limestone and perhaps, in part, assignable to the Salem Limestone are present in approximately one-third of the drill holes. The St. Louis consists predominantly of buff to gray, fine-grained limestone that is ordinarily brecciated and commonly has variable amounts of green shale either as thin beds or interstitial to breccia fragments. The relationship of the St. Louis to the Salem in western Illinois is fairly complex; for our purpose, differentiation is not practical. The St. Louis-Salem unit in the drill cores varies from 0 to 54 feet (0 to 16.5 m) thick and averages about 19 feet (6 m) (table 2).

SONORA FORMATION-WARSAW SHALE

The combined thickness of the Warsaw Shale, and the siltstone, dolomitic siltstone, and sandstone of the Sonora Formation varies from 0 to 93 feet (0 to 2.8 m), depending upon the amount of pre-Pennsylvanian and/or pre-Quaternary erosion (table 2). Where overlain by beds of the St. Louis-Salem unit, the average thickness is about 65 feet (20 m). The Warsaw consists of gray dolomitic shale that contains beds of argillaceous limestone. Quartz geodes are common.

KEOKUK LIMESTONE

The Keokuk Limestone varies from 0 to 108 feet (0 to 33 m), but where overlain by the Warsaw Shale, it has a minimum thickness of about 62 feet (19 m) and averages about 84 feet (25 m) (table 2). The Keokuk consists of coarse, crinoidal limestone with interbedded, fine-grained limestone, argillaceous dolomite, and calcareous gray shale. The amount of shale increases upward through a gradation into the overlying Warsaw Shale. The lower part, 30 or more feet (9.0 m) thick, is very cherty; it is the Montrose Chert Member.

BURLINGTON LIMESTONE

In the study area, the Burlington Limestone can be divided into three units that correspond to members recognized in the type area in Iowa by Harris and Parker (1964): the Dolbee Creek Member at the base, the Haight Creek Member, and the Cedar Fork Member at the top (Collinson, 1964). These member names facilitate discussion of the Burlington Limestone.

Cedar Fork Member. The Cedar Fork Member (table 2) varies from 0 to 58 feet (0 to 18 m) in thickness, being completely absent in a few holes because of periods of post-Mississippian erosion. The Cedar Fork has a minimum thickness of about 8 feet (2 m) and averages about 17 feet (5 m) where overlain by the Keokuk Limestone. It is composed of light-gray, crinoidal limestone with less chert than the overlying Montrose Member of the Keokuk, and less chert and dolomite than the underlying Haight Creek. Stylolites are common, and grains of glauconite, disseminated in some beds, are diagnostic.

Haight Creek Member. The Haight Creek Member overlies the Dolbee Creek, and, in the cores, ranges in thickness

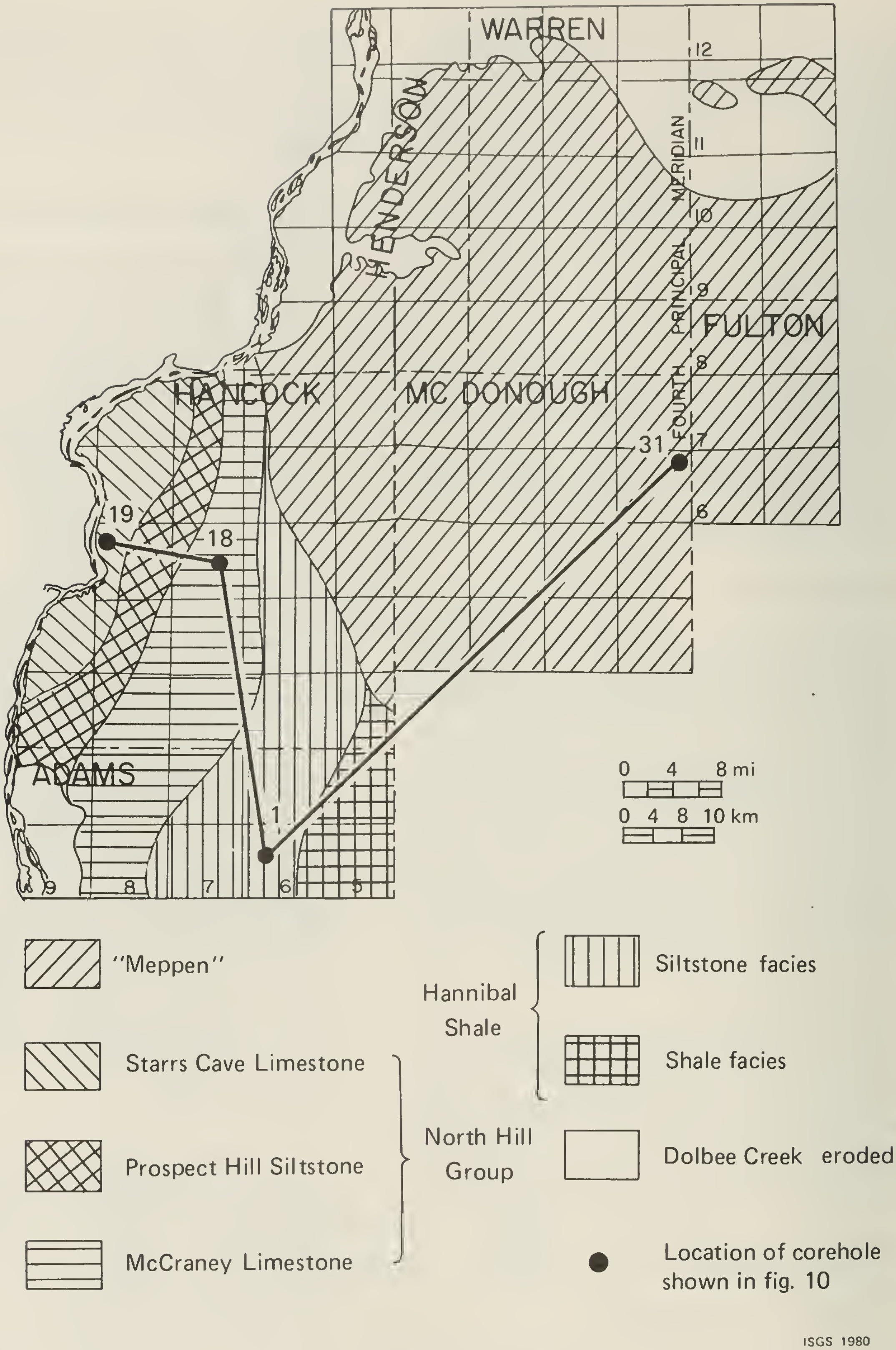


Figure 5. Distribution of formations underlying the Dolbee Creek Limestone Member.

TABLE 2. Thicknesses of stratigraphic units in the cores

Location no.	Quaternary (ft)	Pennsylvanian (ft)	St. Louis/ Salem (ft)	Sonora/ Warsaw (ft)	Keokuk (ft)	Burlington: Cedar Fork (ft)	Burlington: Haight Creek (ft)	Burlington: Dolbee Creek (excluding "Meppen") (ft)	Burlington: "Meppen" (ft)	Starrs Cave (ft)	Prospect Hill (ft)	McCraney (ft)
Adams County												
1	34	–	8	57	62	58	41	33	–	–	–	–
2	18	–	8	48	108	15	42	25	–	–	–	41
Fulton County												
3	34	126	40	93	80	9	37	47	15	–	–	–
4	233	11	22	79	89	10	36	45	16	–	–	–
5	115	–	–	–	–	–	32	38	9	–	–	–
6	90	95	–	–	64	16	23	37	16	–	–	–
7	62	120	–	–	32	8	37	36	16	–	–	–
Hancock County												
8	30	–	9(?)	50(?)	103	9	54	6	–	–	–	16
9	75	34	–	59	108	14	39	23	–	–	–	7
10	42	–	22	63	104	16	39	14	–	–	29	47
11	183	–	–	–	66	16	43	20	–	–	–	24
12	134	–	–	–	65	19	33	15	–	–	18	28
13	72	–	12	70	77	10	46	15	–	5	30	49
14	53	–	54	54	99	14	38	14	–	10	31	59
15	113	–	–	–	–	–	10	16	–	8	40	69
16	144	–	–	–	–	23	44	24	15	–	–	–
17	99	–	–	–	–	–	16	27	12	–	–	–
18	80	2(?)	26(?)	44	89	18	38	26	–	–	–	15
19	47	–	14	63	59	35	47	14	–	8	30	49
20	60	–	–	71	95	17	41	17	–	–	23	19
21	22	–	–	28	92	21	36	19	–	–	23	19
22	39	–	–	72	79	18	36	19	2(?)	–	–	–
23	32	–	–	30	80	26	27	25	10	–	–	–
24	39	–	6	73	74	14	43	17	–	2	21	18
25	30	–	–	20	77	31	27	22	–	–	–	17
26	51	–	–	–	83	20	37	22	–	2	23	33

TABLE 2. *Continued.*

Location no.	Quaternary (ft)	Pennsylvanian (ft)	St. Louis/ Salem (ft)	Sonora/ Warsaw (ft)	Keokuk (ft)	Burlington: Cedar Fork (ft)	Burlington: Haight Creek (ft)	Burlington: Dolbee Creek (excluding "Meppen") (ft)	Burlington: "Meppen" (ft)	Starrs Cave (ft)	Prospect Hill (ft)	McCraney (ft)
Henderson County												
27	39	29	—	—	45	17	29	24	15	—	—	—
28	82	68	—	6	73	21	27	30	14	—	—	—
29	21	—	—	—	—	14	18	15	12	—	—	—
McDonough County												
30	27	—	—	—	15	21	41	25	22	—	—	—
31	34	57	6	83	84	9	36	39	17	—	—	—
32	48	27	—	54 ft of undifferentiated Mississippian (brecciated, siliceous limestone), possibly a fault zone					9(?)	—	—	—
33	97	38	—	11	65	9	42	22	20	—	—	—
34	60	111	—	16	74	8	45	22	28	—	—	—
Warren County												
35	86	—	—	—	32	8	42	35	11	—	—	—
36	39	7	—	12	72	13	24	30	13	—	—	—
37	88	—	—	—	—	—	—	23	14	—	—	—
38	104	27	—	—	—	—	8	28	8	—	—	—
39	85	25	—	—	23	7	31	25	13	—	—	—

from 8 to 54 feet (2.4 to 17 m) (table 2). Where it has not been eroded, it has a minimum thickness of 18 feet (5.5 m) and averages about 37 feet (12.0 m).

The Haight Creek is a buff to brown dolomite or dolomitic limestone that is interbedded with coarse, buff to white, crinoidal limestone in layers up to 3 feet (0.3 m) thick; it can also contain minor amounts of shale. The dolomite or dolomitic limestone is finely granular to finely crystalline and varies from slightly porous to dense. White to gray nodular chert or massive chert is present in variable amounts within the member. Stylolites tend to be poorly developed, but stylolitic partings with amplitudes up to one-half inch (1.3 cm) occur. The base of the Haight Creek is characterized by the presence of abundant glauconite in dark-green, well-rounded grains that occur in thin laminae or are irregularly disseminated in the basal 3 to 36 inches (7.6 to 91.4 cm) of the member.

Dolbee Creek Member. The Dolbee Creek Member consists of crinoidal limestone with some interbedded microgranular layers up to 3 inches (8 cm) thick. Several feet of the uppermost layers commonly contain considerable amounts of light-gray chert and are locally dolomitic. A middle portion, the "Quincy beds," is high-calcium limestone, at least in portions of Adams County. In the Quincy area, a few feet at the base are primarily microgranular and more or less dolomitic.

The interval between the post-Kinderhookian unconformity and the base of the Haight Creek Member of the Burlington increases from less than 10 feet (3 m) locally in south central Hancock County to more than 60 feet (20 m) in central Fulton County (fig. 6). A basal portion of this thickened sequence is predominantly fine-grained dolomitic limestone that yields conodonts indicative of correlation with the Meppen Formation of Calhoun and

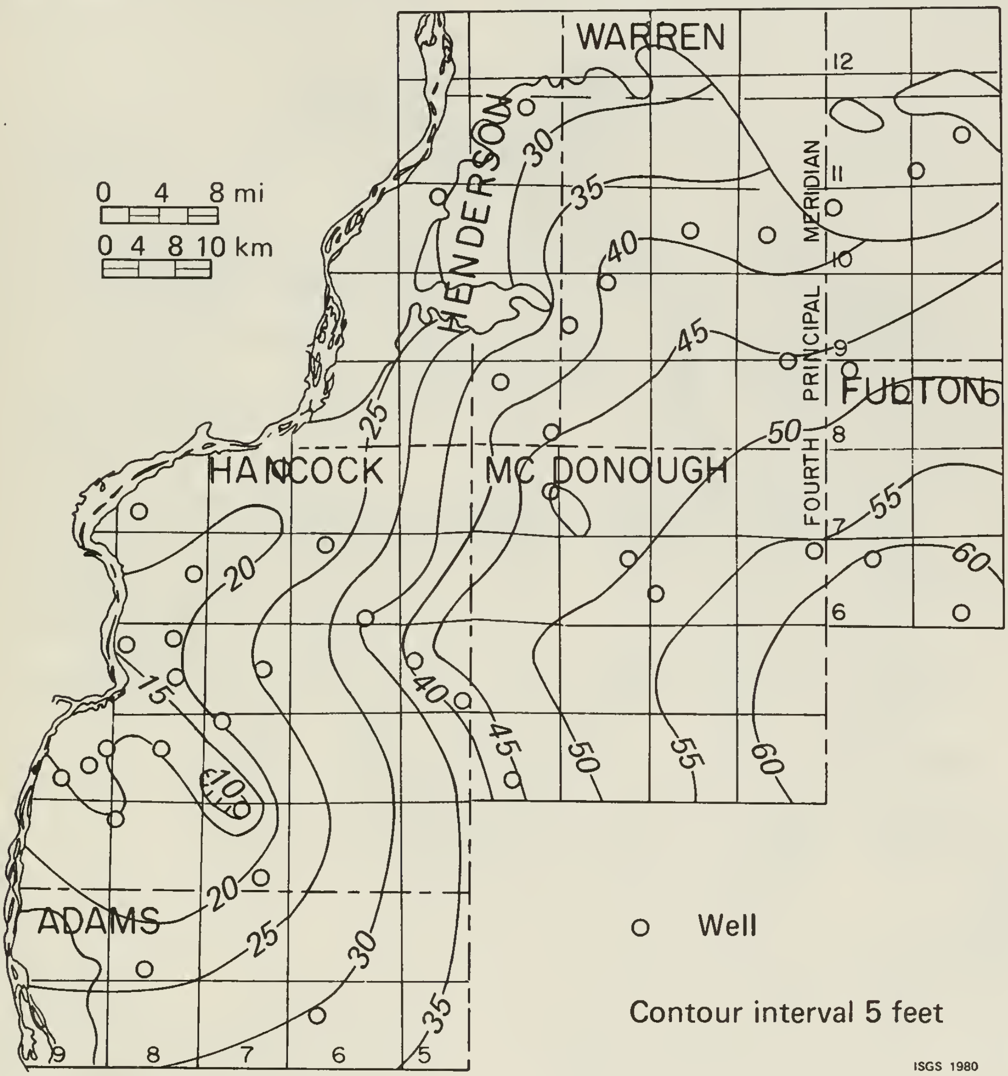


Figure 6. Thickness of the Dolbee Creek Member, including the "Meppen."

Jersey Counties, Illinois (Rodney Norby, personal communication). Detailed lithologic and paleontologic study of the basal Valmeyeran will be required before formal restriction of the Dolbee Creek and recognition of a pre-Dolbee Creek lithostratigraphic unit are justified. In our study, however, "Meppen" is used to denote this basal Valmeyeran dolomitic limestone unit.

The Dolbee Creek extends throughout the subsurface in the study area, except where it was removed by erosion along the northern and southwestern margins. In general, it thickens to the southeast (fig. 6) and, excluding "Meppen," it ranges from a minimum of 6 to a maximum of 47 feet (1.8 to 14.3 m) (fig. 7). The average thickness is about 24 feet (7.3 m) in the drilling (table 2).

The depth to the Dolbee Creek Limestone varies from 53 to 480 feet (16.2 to 146.3 m) in the New Jersey Zinc drilling (table 1). The depth at any place is determined by the ground-surface elevation and its relationships to the elevation of the top of the Dolbee Creek. Structure contour maps used in conjunction with the appropriate topographic sheets can assist in estimating the depth of the Dolbee Creek beneath any particular groundpoint.

The portion of the Dolbee Creek that seems equivalent to the "Meppen" is a light-brown to gray, fine-grained dolomite or dolomitic limestone that underlies more calcitic portions of the Dolbee Creek in the northeastern part of the area (fig. 5). Coarse-grained limestone layers up to 1 foot (0.3 m) thick are sometimes found interbedded with the dolomite. White nodular chert makes the unit distinctive, but the amount of chert varies considerably.

The "Meppen" varies from 0 to 28 feet (0 to 8.5 m) in thickness within the study area (table 2), reaching its greatest thickness in McDonough County (fig. 8).

The full extent and relationships of the "Meppen" in western Illinois have yet to be determined, but some observations are pertinent. The pattern of distribution is discordant with that of strata of the North Hill Group and hence discordant with the Schuyler Arch. In the study area, recognizable thicknesses of "Meppen" are restricted to an

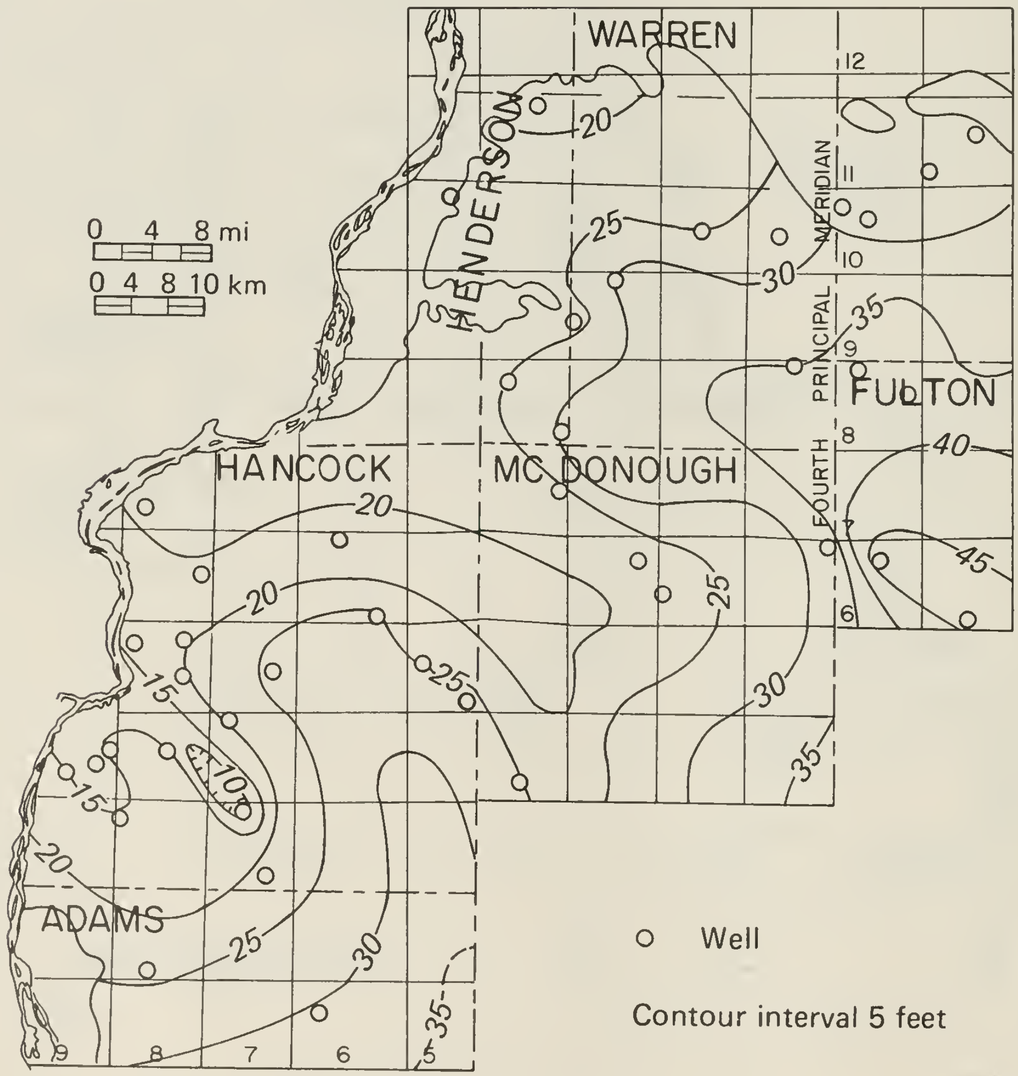


Figure 7. Thickness of the Dolbee Creek Member, excluding the "Meppen."

area in which it is underlain by the Hannibal Shale and in which the thickest accumulation appears to be situated astride the Schuyler Arch where the Kinderhookian is thin. It is assumed that "Meppen" beds at one time had greater lateral extent, but their absence in parts of Adams and Hancock County may be due to nondeposition rather than erosion. In the southwestern part of the study area, typical Dolbee Creek is in contact with formations of the North Hill Group or the Hannibal Shale, and the contact is nonconformable. In the latter cases, the Meppen equivalent appears to be absent.

STARRS CAVE LIMESTONE

The Starrs Cave Limestone is present only in western Hancock County, where it is subjacent to the Dolbee Creek along a narrow belt near the Mississippi River (fig. 5). It is composed of white to light-gray oolitic limestone that commonly contains abundant fossils and locally has abundant light-gray, shaly laminae. Figure 9 shows the thickness of the Starrs Cave, which ranges in the cores (table 2) from 2 to 12 feet (0.6 to 3.7 m).

PROSPECT HILL SILTSTONE

The Prospect Hill Siltstone consists of argillaceous, brown to gray, partly bioturbated siltstone with some interbedded, silty, blue to green shale. It underlies the Starrs Cave throughout the extent of that formation but directly underlies the Dolbee Creek along a narrow belt just east of the Starrs Cave (fig. 5).

McCRANEY LIMESTONE

The McCraney Limestone is a buff, lithographic to sublithographic limestone alternating with layers of brown, silty and dolomitic, fine-grained limestone up to 3 inches (7.6 cm) thick and spaced 2 inches to 2 feet (5 to 61 cm) apart. The brown, dolomitic limestone layers commonly

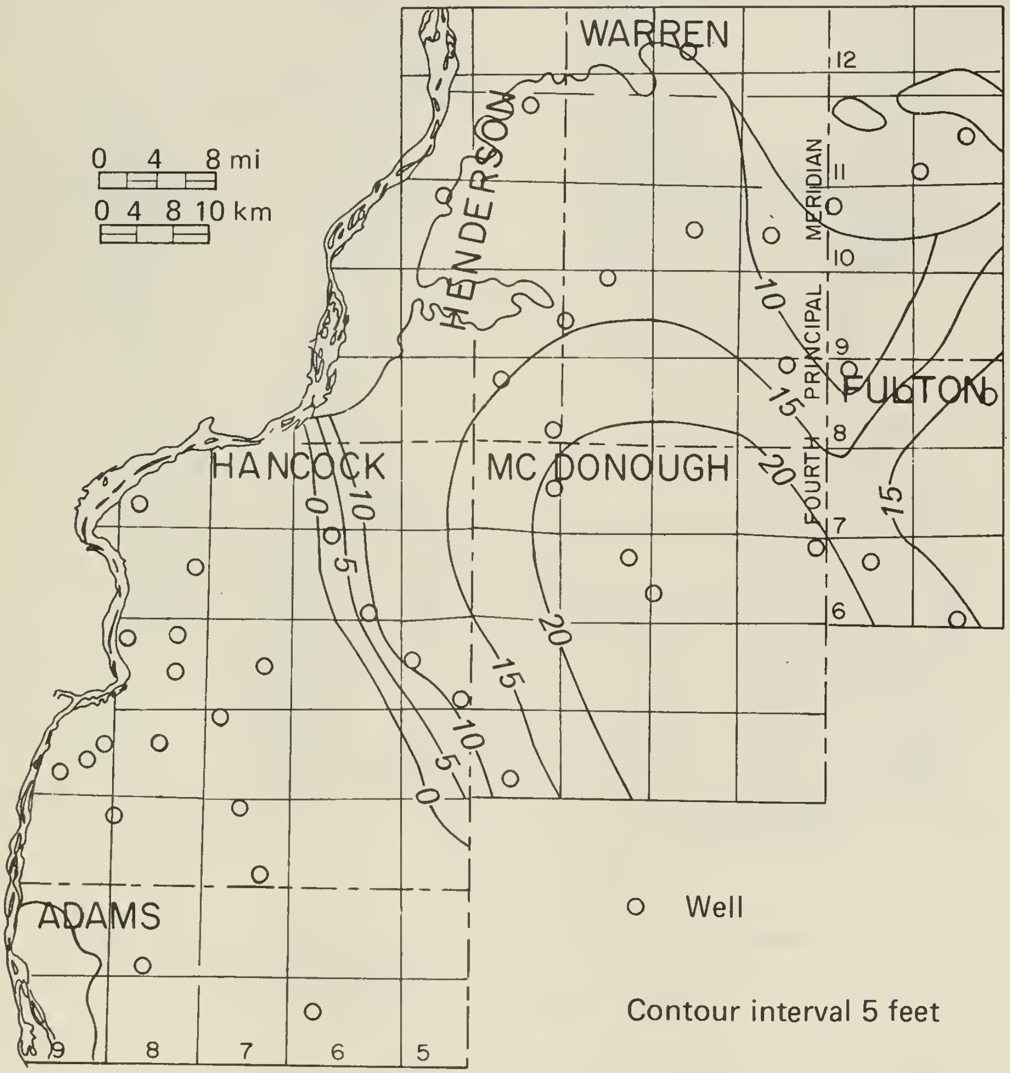


Figure 8. Thickness of the "Meppen."

contain fragments of buff, lithographic limestone.

Figure 9 shows a thickness map constructed for the McCraney Limestone. The patterned region on the map indicates the area where the Dolbee Creek Limestone unconformably overlies the McCraney. The McCraney reaches a maximum thickness of 69 feet (21 m) in western Hancock County (table 2); in the area where the McCraney is directly overlain by the Dolbee Creek, the thickness in the cores does not exceed 41 feet (12.5 m). The McCraney overlies the Hannibal Shale.

■ LIMESTONE RESOURCES

The Dolbee Creek Member of the Burlington Limestone is a primary potential source of limestone in western Illinois, especially for high-calcium limestone. The Dolbee Creek is directly underlain by carbonate units of the North Hill Group (Starrs Cave and McCraney) in parts of Hancock and Adams County; a mainly calcitic portion of the Dolbee Creek is underlain by dolomitic beds of Meppen equivalency in counties to the northeast (fig. 5).

The relationships of the Dolbee Creek to underlying limestone and dolomite rock units are illustrated through graphic logs from selected diamond drill cores (fig. 10). Where they are of sufficient thickness, of acceptable quality, and directly subjacent to minable thicknesses of Dolbee Creek, these units would represent additional reserves that could be recovered in conjunction with operations involving the lower part of the Burlington. Where the strata are thin or of unacceptable quality, the relationships of these strata to the basal Burlington would be an important consideration in the selection of a floor for the quarry or mine. Mining of the high-calcium limestone in Adams County could profitably involve selective mining of a face of best quality and subsequent extraction of subfloor strata for agricultural limestone and other products not requiring high-calcium contents. Sampling of the cores was guided by this consideration.

High-calcium limestone of the Dolbee Creek is locally underlain by siltstones of the Prospect Hill or of the upper part of the Hannibal (fig. 5). The identification and differentiation of these units will be important in any future exploration or development in Adams County. The differentiation would be of special interest in planning drilling programs designed to test the feasibility of mining the

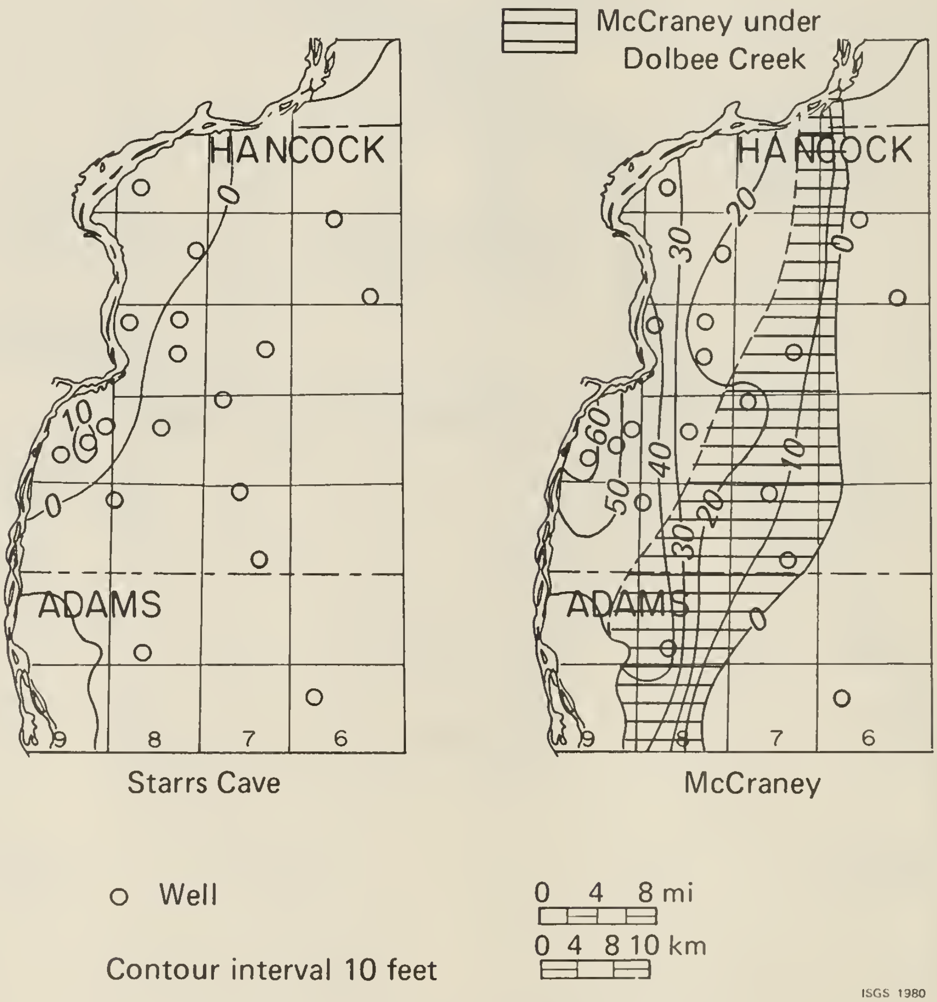


Figure 9. Extent and thickness of the Starrs Cave and McCraney Limestones.

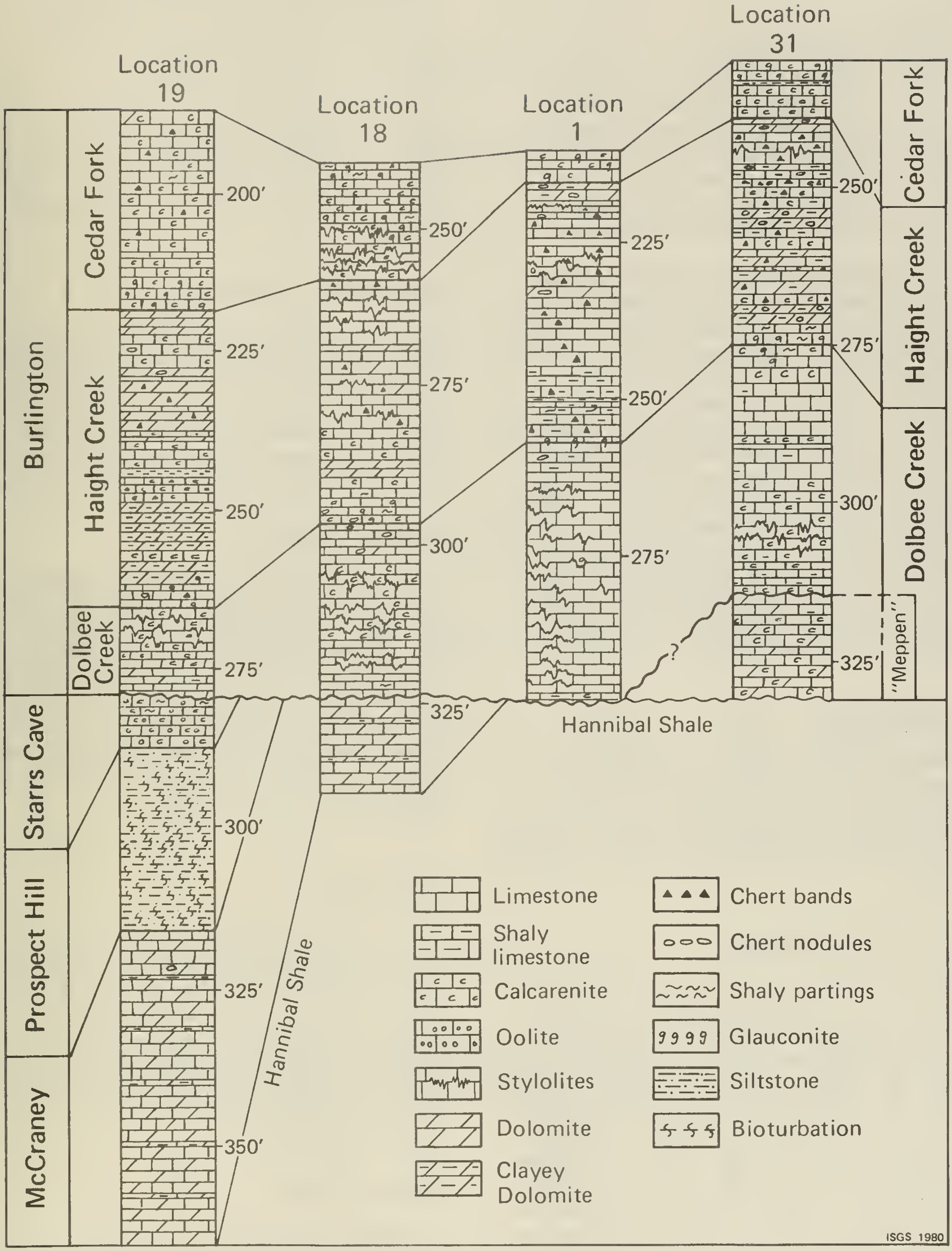


Figure 10. Lithologic character of the Burlington Limestone and subjacent rock units (for locations see fig. 2 and table 1).

McCraney Limestone in conjunction with the Dolbee Creek.

Sampling procedures

Twenty-four cores were sampled for chemical analyses by quartering the cores in the interval containing the Dolbee Creek and associated underlying limestone. Quartering was done by sawing two cuts halfway through the core at right angles to each other. Masses of solid chert were not quartered but a volumetrically proportionate quantity was removed with a hammer and added to the quartered limestone.

Representative samples were prepared for distinct lithologic units within the Dolbee Creek, Starrs Cave, and McCraney intervals. Altogether there were 87 samples of Dolbee Creek from 24 cores, 4 samples of Starrs Cave from 4 cores, and 4 samples of McCraney from 4 cores.

Individual samples were crushed to produce fragments up to 2 cm in diameter, and approximately 500 grams split off. A subsequent crushing and splitting yielded samples of 50 to 70 grams and particles up to 5 mm in size. These yields were passed through a 25-mesh screen, and the particles that failed to pass were crushed in a Plattner diamond mortar to pass the screen. This procedure helped to minimize the loss of chert during fine grinding. Each sample was fine-ground by mortar and pestle to pass a 100-mesh screen, then analyzed chemically by x-ray emission spectrograph and wet chemical methods.

Chemical analyses

The results of chemical analyses of the Dolbee Creek and subjacent limestone units (table 3) provide accurate quantitative evaluation of the chemical composition of the samples from the cores. In addition, these data can be used for determining vertical and lateral variations within the study area.

DOLBEE CREEK SAMPLES

The Dolbee Creek Member, excluding the "Meppen," was divided into 2 to 5 subunits for chemical analysis. The units were based on significant lithologic variations observed in the cores, particularly the presence of chert and dolomite. The chemical data (table 3) clearly show that the Dolbee Creek does not maintain a high-calcium character throughout the study area. Two cores from northern Adams County have appreciable thicknesses of limestone with calcium carbonate contents in the 97 to 98 percent range. North of Adams County, intervals with relatively low silica contents have thicknesses that range from about 12 to 20 feet (3.7 to 6.1 m). North of Adams County, magnesium contents are such that, except in portions of southern Hancock County, the calcium carbonate contents rarely exceed 95 percent, and even in those exceptional cases where they do, the thicknesses of high-calcium stone are diminished. The $CaCO_3$ content of samples ranged from 47 to 99 percent, the $MgCO_3$ content ranged from 1 to 27 percent, and the silica content ranged from <0.01 to 36 percent.

The "Meppen" equivalent was divided into two subunits in some of the cores that were analyzed. The $CaCO_3$ content of individual lithologic units varied from 54 to 98 percent, the $MgCO_3$ content varied from 2 to 33 percent, and the SiO_2 content varied from <0.05 to 22 percent (table 3). The average $CaCO_3$ content is approximately 74 percent.

STARRS CAVE SAMPLES

The contents of the Starrs Cave Limestone can be broken down in this way: approximately 87 to 98 percent $CaCO_3$, 2 to 8 percent $MgCO_3$, and 0.3 to 2.5 percent SiO_2 (table 3). Generally, this limestone has higher calcium contents where it is oolitic and less than 2 feet (0.6 m) thick, and increased magnesium contents where it is thicker. The average $CaCO_3$ content of the Starrs Cave is 91.2 percent.

McCRANEY SAMPLES

Samples of the McCraney Limestone were taken only from those cores in which the limestone was directly overlain by the Dolbee Creek—that is, at localities in Adams and Hancock Counties. The McCraney is a predominantly dolomitic limestone whose contents can be broken down into: approximately 73 to 79 percent $CaCO_3$, about 14 to 22 percent $MgCO_3$, and about 3 to 6 percent SiO_2 (table 3). The average $CaCO_3$ content of the McCraney is about 75 percent for all samples and for the 41-foot-thick (12.3 m) section penetrated in Adams County.

Possible uses

Illinois limestones and dolomites are used for a variety of constructional, chemical, and industrial purposes (Lamar, 1961). Chemical analyses indicate the possibilities for and limitations on the use of the Dolbee Creek and subjacent formations for purposes which have chemical specifications. Although there are no data on the physical characteristics of the stone, certain tentative conclusions can be made based on the history of use and performance of similar rocks in Illinois.

CHEMICAL STONE

The Dolbee Creek in Adams County, based on analyses from two cores and the history of the "Quincy Beds," seems suitable for a variety of purposes, including agricultural limestone and whiting, and the manufacture of lime and calcium carbide. Calcium Carbonate Company, a division of J. M.

TABLE 3. Chemical analyses of the Dolbee Creek Limestone Member and underlying carbonate rocks

Location no.	Core no.	Interval (ft)	Thickness (ft)	Formation (ft)	$CaCO_3$* (%)	$MgCO_3$* (%)	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	MnO (%)	CaO (%)	MgO (%)	CO_2 (%)	Miscellaneous† (%)
						Adams County								
1	7894	264.5-270.4	5.9	Dolbee Creek	94.66	1.15	4.06	0.48	0.02	100	53.03	0.55	41.65	S, 0.02; K_2O, 0.02
		270.4-282.0	11.6	" "	97.69	2.13	0.64	0.01	0.38	160	54.73	1.02	42.87	S, 0.01
		282.0-292.8	10.8	" "	99.57	2.43	0.27	0.24	0.12	120	55.78	1.16	42.29	S, 0.07
		292.8-297.4	4.6	" "	98.44	1.28	<0.01	0.39	0.44	160	55.15	0.61	43.33	S, 0.21
2	7879	236.5-245.0	8.5	Dolbee Creek	95.57	3.87	1.09	0.11	0.01	110	53.54	1.85	42.90	S, 0.03
		245.0-261.0	16.0	" "	98.50	1.90	<0.01	0.04	0.01	80	55.20	0.91	43.56	S, 0.03
		261.0-301.8	40.8	McCraney	74.95	22.06	2.91	0.47	0.37	110	41.99	10.55	43.82	S, 0.04; K_2O, 0.09
						Fulton County								
5	7608	147.0-154.4	7.4	Dolbee Creek‡	88.02	10.14	1.77	0.73	0.74	210	49.31	4.85	42.44	S, 0.10
		154.4-160.8	6.4	" "	74.22	7.99	20.07	<0.01	0.35	160	41.58	3.82	32.78	S, 0.05
		160.8-167.2	6.4	" "	91.69	6.88	1.01	0.34	0.33	110	51.37	3.29	43.49	S, 0.07
		167.2-185.0	17.8	" "	81.79	14.14	1.63	0.20	1.19	630	45.82	6.76	44.10	S, 0.10
		185.0-194.0	9.0	"Meppen"	82.50	17.44	0.23	<0.01	1.08	670	46.22	8.34	43.19	S, 0.09; Na_2O, 0.07
7	7864	257.7-272.0	14.3	Dolbee Creek‡	57.31	16.50	24.75	0.28	0.75	80	32.14	7.89	33.63	S, 0.07; Na_2O, 0.01; K_2O, 0.07
		272.0-294.0	22.0	" "	81.31	12.13	5.33	0.67	0.40	290	45.55	5.80	42.05	S, 0.04; Na_2O, 0.01
		294.0-302.3	8.3	"Meppen"	58.80	26.43	13.57	0.16	1.15	300	32.94	12.64	39.07	S, 0.10; Na_2O, 0.01
		302.3-310.2	7.9	"	85.13	12.46	0.70	<0.01	0.71	440	47.69	5.96	43.12	S, 0.12; Na_2O, 0.01
						Hancock County								
9	7606	326.0-335.0	9.0	Dolbee Creek	67.51	14.09	18.03	0.28	0.27	250	37.82	6.74	36.39	S, 0.04; K_2O, 0.11
		335.0-349.2	14.2	" "	94.05	5.33	0.33	0.01	0.21	60	52.69	2.55	43.88	S, 0.05
		349.2-356.0	6.8	McCraney	78.81	13.84	6.09	0.05	0.50	130	44.15	6.62	41.70	S, 0.09; K_2O, 0.12
10	7895	289.0-292.3	3.3	Dolbee Creek	75.63	19.45	3.86	0.73	0.42	160	42.37	9.30	42.56	S, 0.05; K_2O, 0.07
		292.3-300.2	7.9	" "	94.50	5.04	0.41	0.03	0.08	260	52.94	2.41	43.61	S, 0.03
		300.2-303.3	3.1	" "	95.00	5.37	<0.01	<0.01	0.34	50	53.22	2.57	43.63	S, 0.04
12	7838	221.5-225.4	3.9	Dolbee Creek	68.26	10.66	21.02	0.32	0.11	200	38.24	5.10	35.30	S, 0.05; Na_2O, 0.01; K_2O, 0.02
		225.4-231.3	5.9	" "	90.98	8.47	0.68	0.31	0.30	240	50.97	4.05	43.62	S, 0.13; Na_2O, 0.01
		231.3-234.8	3.5	" "	80.97	17.86	0.54	0.02	0.28	250	45.36	8.54	44.40	S, 0.04; Na_2O, 0.01
		234.8-238.3	3.5	" "	93.75	5.60	<0.01	0.11	0.05	240	52.52	2.68	43.48	S, 0.04; Na_2O, 0.01

TABLE 3. *Continued.*

Location no.	Core no.	Interval (ft)	Thickness (ft)	Formation (ft)	$CaCO_3$* (%)	$MgCO_3$* (%)	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	MnO (%)	CaO (%)	MgO (%)	CO_2 (%)	Miscellaneous† (%)
15	7603	124.0-128.2	4.2	Dolbee Creek	93.09	5.10	1.01	0.10	0.30	150	52.15	2.44	43.25	S, 0.05; K_2O, 0.03
		128.2-138.7	10.5	" "	93.80	5.50	0.63	<0.01	<0.01	420	52.53	2.63	43.62	S, 0.03; Na_2O, 0.04; K_2O, 0.03; TiO_2, 0.05
		138.7-147.0	8.3	Starrs Cave	87.47	8.24	2.42	0.52	0.34	110	49.80	3.94	42.45	S, 0.18; K_2O, 0.06
16	7881	211.0-221.2	10.2	Dolbee Creek‡	72.61	4.85	20.94	0.47	0.70	220	40.68	2.32	33.57	S, 0.21; K_2O, 0.03
		221.2-235.0	13.8	" "	94.11	5.44	0.38	0.21	0.26	110	52.72	2.60	43.63	S, 0.05
		235.0-247.4	12.4	"Meppen"	72.67	13.65	11.55	1.33	1.05	230	40.71	6.54	38.31	S, 0.05
		247.4-250.5	3.1	"	94.19	3.64	0.51	0.31	0.92	220	52.77	1.74	42.78	S, 0.32
18	7845	300.7-307.7	7.0	Dolbee Creek	47.03	16.77	35.69	0.79	0.37	170	26.35	8.02	27.74	S, 0.03; Na_2O, 0.14; K_2O, 0.08
		307.7-317.2	9.5	" "	89.82	6.80	4.01	0.10	0.14	150	50.32	3.25	42.17	S, 0.02
		317.2-327.2	10.0	" "	76.97	15.89	6.74	0.01	0.50	170	43.12	7.60	41.63	S, 0.05; K_2O, 0.04
		327.2-342.2	15.0	McCraney	73.63	19.89	4.34	0.40	0.63	360	41.25	9.51	42.72	S, 0.06; Na_2O, 0.03; K_2O, 0.16; TiO_2, 0.36
19	7609	261.4-272.5	11.1	Dolbee Creek‡	94.52	5.90	0.21	<0.01	0.29	80	52.95	2.82	43.54	S, 0.16
		272.5-275.5	3.0	" "	77.11	19.20	1.92	0.99	0.73	90	43.20	9.18	43.34	S, 0.10; Na_2O, 0.12; K_2O, 0.14
		275.5-283.7	8.2	Starrs Cave	92.18	5.85	1.49	0.75	0.36	190	51.64	2.80	42.45	S, 0.25; Na_2O, 0.01; K_2O, 0.10
23	7869	195.0-200.2	5.2	Dolbee Creek	67.24	9.60	23.90	<0.01	0.32	330	37.67	4.59	34.08	S, 0.05; Na_2O, 0.01
		200.2-206.5	6.3	" "	79.40	11.61	8.06	0.02	0.34	310	44.48	5.55	40.80	S, 0.03; Na_2O, 0.01; K_2O, 0.02
		206.5-219.7	13.2	" "	95.27	4.67	1.17	<0.01	0.19	300	53.37	2.23	42.44	S, 0.05; Na_2O, 0.01
		219.7-224.2	4.5	"Meppen"	65.56	31.43	<0.01	0.21	3.16	620	36.73	15.03	45.12	S, 0.04; Na_2O, 0.01
		224.2-230.0	5.8	"	56.17	20.32	22.09	0.09	2.01	500	31.47	9.72	34.35	S, 0.10; Na_2O, 0.01
24	7886	248.8-254.7	5.9	Dolbee Creek	47.0	18.65	33.59	1.14	0.38	100	26.33	8.92	29.36	S, 0.03; K_2O, 0.09
		254.7-262.5	7.8	" "	92.30	6.92	0.19	<0.01	0.60	110	51.71	3.31	43.69	S, 0.08
		262.5-266.2	3.7	" "	82.93	13.42	2.12	0.53	0.69	200	46.46	6.42	43.59	S, 0.08; K_2O, 0.08
		266.2-268.2	2.0	Starrs Cave	95.64	2.74	0.69	0.52	0.22	70	53.58	1.31	43.42	S, 0.20; K_2O, 0.01

TABLE 3. *Continued.*

Location no.	Core no.	Interval (ft)	Thickness (ft)	Formation (ft)	$CaCO_3$* (%)	$MgCO_3$* (%)	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	MnO (%)	CaO (%)	MgO (%)	CO_2 (%)	Miscellaneous† (%)
25	7846	185.0-195.0	10.0	Dolbee Creek	75.56	20.93	2.04	0.45	1.16	270	42.33	10.01	43.68	S, 0.08; K_2O, 0.09
		195.0-198.0	3.0	" "	97.46	2.38	<0.01	0.30	0.01	160	54.60	1.14	43.62	S, 0.03
		198.0-201.9	3.9	" "	97.66	2.43	<0.01	0.10	0.01	150	54.71	1.16	42.98	S, 0.01
		201.9-206.6	4.7	" "	80.27	18.88	0.57	0.18	0.82	220	44.97	9.03	44.33	S, 003; K_2O, 0.02
		206.6-223.2	16.6	McCraney	74.76	20.93	2.63	0.48	0.93	240	41.88	10.01	43.65	S, 0.05; K_2O, 0.07; TiO_2, 0.05
26	7868	194.5-202.2	7.7	Dolbee Creek	97.14	1.88	0.83	0.49	0.16	450	54.42	0.90	42.89	S, 0.07; P_2O_5, 0.04
		202.2-205.7	3.5	" "	79.06	13.36	3.13	2.00	2.22	320	44.29	6.39	40.44	S, 0.53; K_2O, 0.28
		205.7-216.4	10.6	" "	88.80	7.63	2.02	<0.01	0.59	260	49.75	3.65	42.14	S, 0.20, K_2O, 0.28; TiO_2, 0.30
		216.4-218.4	2.0	Starrs Cave	98.26	2.17	0.32	0.38	0.35	100	55.05	1.04	43.00	S, 0.22
						Henderson County								
27	7875	159.6-165.5	5.9	Dolbee Creek‡	66.54	5.35	27.52	0.45	0.16	160	37.28	2.56	31.82	S, 0.05
		165.5-174.0	8.5	" "	85.70	7.80	5.22	0.87	0.19	70	48.01	3.73	41.25	S, 0.15
		174.0-184.2	10.2	" "	92.61	7.28	0.15	<0.01	0.34	110	51.88	3.48	43.76	S, 0.21
		184.2-188.6	4.4	"Meppen"	63.15	25.64	9.38	0.55	1.67	390	35.38	12.26	40.04	S, 0.12, K_2O, 0.06
		188.6-199.2	10.6	"	90.27	8.53	0.15	0.49	1.07	210	50.57	4.08	43.28	S, 0.19
						McDonough County								
30	7866	104.1-114.5	10.4	Dolbee Creek‡	64.88	11.56	23.46	0.17	0.27	130	36.35	5.53	34.24	S, 0.02; K_2O, 0.03; P_2O_5, 0.05
		114.5-128.3	13.8	" "	95.23	3.81	0.29	0.36	0.24	70	53.35	1.82	43.80	S, 0.02
		128.3-147.0	18.7	"Meppen"	82.07	4.24	14.56	0.37	0.18	160	45.98	2.03	36.76	S, 0.03
		147.0-152.9	5.9	"	98.26	1.99	0.49	<0.01	0.28	170	55.05	0.95	43.24	S, 0.05
31	7882	275.0-279.0	4.0	Dolbee Creek‡	88.89	8.25	2.90	0.13	0.09	40	49.80	3.95	42.92	S, 0.02
		279.0-305.7	26.7	" "	89.27	7.95	2.43	0.16	0.17	280	50.01	3.80	42.73	S, 0.02; Na_2O, 0.01
		305.7-319.5	13.8	"Meppen"	68.15	20.81	10.11	0.13	0.70	460	38.18	9.95	40.43	S, 0.02; Na_2O, 0.01
		319.5-330.4	10.9	"	80.91	17.48	1.00	0.21	0.90	670	45.33	8.06	44.16	S, 0.08; Na_2O, 0.01
33	7892	261.5-270.0	8.5	Dolbee Creek‡	54.25	15.12	29.70	0.03	0.55	140	30.39	7.23	31.69	S, 0.10; K_2O, 0.03
		270.0-283.0	13.0	" "	92.71	7.65	0.14	0.27	0.27	140	51.94	3.66	43.61	S, 0.03
		283.0-300.7	16.3	"Meppen"	87.63	10.62	1.97	0.39	0.56	160	49.09	5.08	42.79	S, 0.03
		300.7-304.8	4.1	"	82.15	9.97	6.05	1.45	1.28	330	46.02	4.77	40.21	S, 0.16; K_2O, 0.02

TABLE 3. *Continued.*

Location no.	Core no.	Interval (ft)	Thickness (ft)	Formation (ft)	$CaCO_3$* (%)	$MgCO_3$* (%)	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	MnO (%)	CaO (%)	MgO (%)	CO_2 (%)	Miscellaneous† (%)
34	7893	306.0-316.7	10.7	Dolbee Creek‡	55.26	26.54	17.11	0.40	0.60	120	30.96	12.69	37.84	S, 0.03; K_2O, 0.01
		316.7-328.0	11.3	" "	92.98	7.13	0.38	0.20	0.14	110	52.09	3.41	43.61	S, 0.03
		328.0-356.0	28.0	"Meppen"	54.00	32.72	11.32	0.47	1.04	220	30.25	15.65	40.67	S, 0.07; Na_2O, 0.09, K_2O, 0.08
						Warren County								
35	7889	160.0-165.5	5.5	Dolbee Creek‡	79.11	19.11	2.04	0.37	0.81	400	44.32	9.14	42.97	S, 0.06; Na_2O, 0.01
		165.5-175.5	10.0	" "	68.29	9.83	22.67	0.03	0.38	600	38.26	4.70	33.78	S, 0.15; Na_2O, 0.01
		175.5-194.5	19.0	" "	85.93	13.17	0.69	<0.01	0.59	440	48.14	6.30	44.28	S, 0.04; Na_2O, 0.01
		194.5-205.1	10.6	"Meppen"	62.55	24.55	10.94	0.37	1.55	700	35.04	11.90	39.94	S, 0.13; Na_2O, 0.01; K_2O, 0.01
36	7887	167.3-179.8	12.5	Dolbee Creek‡	77.81	7.36	14.47	0.22	0.15	310	43.59	3.52	37.86	S, 0.04
		179.8-197.8	18.0	" "	92.73	7.46	0.05	0.31	0.17	80	51.95	3.57	43.79	S, 0.04
		197.8-201.2	3.4	"Meppen"	68.17	27.12	5.52	0.05	1.09	280	38.19	12.97	41.99	S, 0.10; K_2O, 0.04
		201.2-210.8	9.6	"	90.86	7.72	0.35	0.63	0.58	170	50.90	3.69	43.10	S, 0.27; Na_2O, 0.08; K_2O, 0.01
38	7610	139.5-154.0	14.5	Dolbee Creek‡	66.97	13.36	16.05	1.79	1.38	330	37.52	6.39	35.81	S, 0.07
		154.0-157.7	3.7	" "	63.96	29.61	2.73	0.33	1.94	590	35.83	14.61	43.82	S, 0.13; P_2O_5, 0.09
		157.7-167.7	10.0	" "	83.29	14.28	0.03	0.45	1.35	540	46.66	6.83	43.93	S, 0.10
		167.7-176.0	8.3	"Meppen"	77.68	19.89	0.67	<0.01	2.27	940	43.52	9.51	43.67	S, 0.26
39	7835	171.5-175.8	4.3	Dolbee Creek‡	69.10	27.45	3.05	0.07	0.66	400	38.71	13.13	43.44	S, 0.09, Na_2O, 0.01
		175.8-180-8	5.0	" "	94.03	4.93	0.53	<0.01	0.13	430	52.68	2.36	43.71	S, 002; Na_2O, 0.38
		180.8-196.0	15.2	" "	69.95	20.22	8.94	0.07	0.64	520	39.19	9.67	40.82	S, 0.06
		196.0-208.6	12.6	"Meppen"	60.90	32.62	5.68	0.19	1.18	640	34.12	15.61	42.45	S, 0.14; Na_2O, 0.01; K_2O, 0.03

*Calculated from CaO and MgO.
† Includes S, TiO_2, Na_2O, K_2O, and P_2O_5. Not listed if in amounts less than 0.01.
‡ Excluding "Meppen."

appear to have minable thicknesses of high-calcium stone, and areas east and south of Quincy remain as possible targets for future exploration. Limestone of the Starrs Cave and dolomitic limestone beds of the McCraney locally underlie the Dolbee Creek, but do not contain appreciable thicknesses of high-calcium stone. Where these formations are minable in conjunction with high-calcium operations, they could provide material for other purposes, such as agricultural limestone. Core drilling designed to evaluate limestone resources would be required to determine specific sites for mining in favorable areas.

REFERENCES

Baxter, J. W., 1980, Factors favoring expanded underground mining of limestone in Illnois: Mining Engineering, v. 32, no. 10, p. 1497-1504.

Bristol, H. M., and R. H. Howard, 1971, Paleogeologic map of the sub-Pennsylvanian Chesterian (Upper Mississippian) surface in the Illinois Basin: Illinois State Geological Survey Circular 458, 16 p.

Collinson, C. W., 1964, Western Illinois: 28th Annual Tri-State Field Conference: Illinois State Geological Survey Guidebook Series 6, 30 p.

Frye, J. C., H. B. Willman, and H. D. Glass, 1964, Cretaceous deposits and the Illinoian glacial boundary in western Illinois: Illinois State Geological Survey Circular 364, 28 p.

Goodwin, J. H., and R. D. Harvey, 1980. Limestone resources of Adams and Brown Counties, Illinois: Illinois State Geological Survey Circular 512, 20 p.

Harris, S. E., and M. C. Parker, 1964, Stratigraphy of the Osage Series in southeastern Iowa: Iowa Geological Survey Report of Investigations 1, 52 p.

Harvey, R. D., R. R. Frost, and Josephus Thomas, Jr., 1974, Lake marls, chalks, and other carbonate rocks, with high dissolution rates in SO_2-scrubbing liquors: Illinois State Geological Survey Environmental Geology Notes 68, 22 p.

Howell, J. V., 1935, The Mississippi River Arch: Kansas Geological Society Guidebook, 9th Annual Field Conference, p. 386-389.

Illinois Department of Transportation, Division of Highways, 1973, Standard specifications for road and bridge construction: State of Illinois: State of Illinois, Department of Transportation, Division of Highways, 752 p.

Illinois Department of Transportation, 1977, Sources and producers of aggregates for highway construction in Illinois: IDOT, Division of Highways, Bureau of Materials and Physical Research, Bulletin 23, revised October 1, 1977, Springfield, Illinois, 113 p.

Lamar, J. E., 1957, Chemical analyses of Illinois limestones and dolomites: Illinois State Geological Survey Report of Investigations 200, 33 p.

Lamar, J. E., 1961, Uses of limestone and dolomite: Illinois State Geological Survey Circular 321, 41 p.; 2nd printing with addenda, 1965.

Stevenson, D. L., and L. L. Whiting, 1967, Geologic structure of the Devonian-Silurian Hunton Megagroup in Illinois: Illinois State Geological Survey Illinois Petroleum 87, 5 p.

Willman, H. B., and others, 1967, Geologic map of Illinois, 1:500,000.

Workman, L. E., and Tracey Gillette, 1956, Subsurface stratigraphy of the Kinderhook Series in Illinois: Illinois State Geological Survey Report of Investigation 189, 46 p.

Huber Corporation, operates an underground mine in a 25- to 35-foot thickness of basal Burlington at Quincy, to produce filler, coloring agents, and specialty products such as animal feed supplements and poultry grit. The calcium carbonate content of essentially chert-free portions of Dolbee Creek in two cores in northern Adams County is comparable to that of the "Quincy bed." Reflectance values, shown as an average of four measurements made on separate briquettes pressed from -200 mesh powders, are lower for the cores than those for samples from Quincy (table 4). This may be because the core samples include more stratigraphic intervals than the especially "white" zone mined at Quincy.

High-purity stone of the Dolbee Creek may also prove to be suitable for use in the evolving environmental technology that concerns absorption of sulfur gases given off at coal-fired power plants. Research at the Illinois State Geological Survey (Harver, Frost, and Thomas, 1974) indicates that the efficiency of high-calcium limestone as a control of SO_2 in flue gases depends not only on purity and degree of comminution, but also on intercrystalline and intracrystalline porosity and permeability, which increase the effective surface area. Tests made on fine-ground limestones of various lithologies and geologic ages show that high-calcium limestones vary widely in effective surface area. Samples from the Dolbee Creek fall about midway through the range, indicating that compared to other available limestones with similar calcium contents, this material would be of intermediate affectiveness for SO_2 abatement (Harvey et al., 1974, tables 1 and 2). If used in processes designed especially for high-calcium limestone, increased amounts of magnesium in the mineral dolomite would require proportionately greater bulk charges and result in more wastes.

North of Adams County, the amount of dolomite will restrict the possibility of using the Dolbee Creek in limestone scrubbers and other chemical processes demanding high-calcium contents. Except for thin local occurrences within the Starrs Cave Limestone, carbonate rocks that underlie the Dolbee Creek in the cores do not contain high-calcium stone, and the exceptions do not approach minable thicknesses. Dolomitic limestones of the Dolbee Creek, however, including that of the "Meppen," may be useful as aglime and in desulfurization processes that specify or allow dolomitic limestone.

CONSTRUCTIONAL STONE

The high-calcium, crinoidal limestone of the Dolbee Creek is generally too soft to make products suitable for class A quality (concrete) aggregate, but find some market in class D (base and surface aggregate), and more limited use in class C and B (bituminous) aggregate (Illinois Department of Transportation, 1973; 1977). It is possible that the McCraney, and dolomitic facies of the Dolbee Creek (including "Meppen")—being less crystalline and finer grained than the high-calcium, crinoidal limestone—may have more desirable physical properties, but this possibility needs to be confirmed by testing procedures.

■ CONSIDERATIONS OF UNDERGROUND MINING

There are a number of geological factors that must be evaluated to determine the feasibility of mining. These include how deep the limestone is buried, its lateral variations in thickness and quality, the relationships of bedding characteristics to the choice of a substantial roof and a serviceable floor, local ground-water conditions, and character of the overlying rock column that would be penetrated by shaft or incline. A complete evaluation of these factors and of economic considerations such as potential markets and available transportation systems is beyond the scope of this investigation, and must be pursued on an individual site basis. To assist in such an evaluation, the descriptions of the cores are on open file at the Illinois State Geological Survey in Urbana, and the cores are available for inspection.

Depth of burial

Various maps, tables, and diagrams in this report provide information on the depth to the Dolbee Creek and the underlying carbonate rocks. The structure contour maps can be used to estimate the depth to the Dolbee Creek beneath a known elevation on the ground.

TABLE 4. Carbonate analysis, C.C.E., and reflectance of the Dolbee Creek Member in Adams County drill core compared to "Quincy Lime" at Quincy (from Goodwin and Harvey, 1980)

Location no.	Sample	Depth (ft)	Thickness (ft)	$CaCO_3$ (%)	$MgCO_3$ (%)	CCE (%)	Reflectance
1	Drill core C7894	270.4-297.4	27	98.57	2.11	101.07	75.8 ±0.06
2	Drill core C7879	236.5-261.0	24.5	97.48	2.58	100.55	75.7 ±0.24
	Quincy Black White Quarry NF564	outcrop	24	98.44	1.94	100.74	88.12±0.13

Presently, there are no shaft mines for the production of limestone in Illinois. With the exception of a single mine using an incline that is located near Alton in Madison County, underground limestone workings are confined to areas that can be entered through adits in bluffs or in faces developed by earlier open-pit methods. Limestone shaft mines, however, operate in nearby states at depths as great as 2,000 feet (610 m). The maximum depth of the Dolbee Creek in the area of drilling described here, 480 feet (146 m), does not appear to be prohibitive for mining, provided there is an adequate deposit, and market and other economic conditions are favorable.

VARIATIONS IN THICKNESS AND QUALITY

We have already discussed specific details of the variations in thickness and quality of the Dolbee Creek and associated subjacent limestone and dolomite. The implications of these data are that future prospecting and eventual underground mining will probably be limited to areas south of the north line of Adams County. The extent of the high-calcium beds, down dip, east of Quincy, is not well known; this area may be a candidate for further exploration drilling.

Choice of roof and floor

The lithologic columns (fig. 10) show the character of the target units and the overlying and underlying rock units. These columns also include information on bedding types that could help in the choice of a roof and floor.

The basal beds of the Haight Creek Member of the Burlington have locally conspicuous shale partings or thin layers of shale. These were noted in cores from Sec. 34, T. 6 N., R. 2 E.; Sec. 1, T. 6 N., R. 1 W.; and Sec. 11, T. 5 N., R. 8 W. Where present, these beds could cause roof problems if the complete Dolbee Creek was mined; however, the upper few feet of the Dolbee Creek are usually cherty and perhaps could be left to form the roof.

The choice of a mine floor would depend on local thickness, quality, and bedding plane characteristics. In Adams County, the character of the basal portion of the Dolbee Creek strata, which lies below the beds of highest purity, should be considered when evaluating a floor and the practicability of extracting subjacent stone. The basal 2 feet vary and their character depends upon the formation on which the Burlington lies. Where it overlies the Prospect Hill Siltstone or siltstone at the top of the Hannibal, the basal interval is silty and argillaceous and could be left in the floor to maintain product quality and provide better footing than the underlying siltstone. Contacts between the Dolbee Creek and the McCraney are sometimes difficult to pick, especially in areas where both are composed of micro-granular limestone. In western Hancock County, thin shale laminae are usually at the base of the Burlington where it overlies the Starrs Cave. The two feet (0.6 m) of the Dolbee Creek overlying the "Meppen" are often dolomitic and/or cherty.

Ground-water conditions

A complete appraisal of the ground-water conditions that may affect underground mining operations in the basal portion of the Burlington is beyond the scope of our investigation, but we can make some generalizations. The Burlington and the overlying Keokuk Limestone are major aquifers where they occur near the surface in western Adams County and throughout much of Hancock County—especially where they form the subcrop directly below the glacial drift (fig. 4). Production of up to 25 gallons per minute has been reported for wells in these areas, but 10 to 12 gallons is average. Local yields of 3 to 5 gallons per minute are not uncommon, especially where shale covers these units. Heavy pumping for dewatering large underground mines must be evaluated in terms of the possible effects of drawdowns on wells in the surrounding area.

The production of water is mainly related to fracture systems in the rock and solution development in the upper portion of the limestone subcrop. As a result, local ground-water conditions can vary greatly. In general the potential for ground water can be expected to decrease with increasing depth below the bedrock surface in areas where the Keokuk or Burlington constitute the subcrop beneath the drift. These limestones are not particularly cavernous; therefore, grouting to lessen the drainage of water into mines may be feasible. In some areas, however, such as southwestern McDonough County, upper portions of the Burlington-Keokuk are largely devoid of ground water. A major source of ground water lies in the Burlington at 160 to 180 feet below the top of the Keokuk, possibly in the Dolbee Creek. Mining downdip from the Burlington subcrop, with dewatering, will present few problems with respect to the quality of water to be discharged, but in areas 5 to 10 miles from the subcrop, especially where thick Pennsylvanian sediments constitute the upper portion of the bedrock column (fig. 4), there is a serious deterioration in water quality that may present environmental problems related to disposal of mine water.

A comprehensive study of ground-water conditions should be included in any future exploration directed toward site selection for underground mining. Minor water problems would be partially alleviated by mining updip, thus avoiding excessive accumulation of mine water at the advancing face, and facilitating pumping operations.

CONCLUSIONS

The high-calcium "Quincy Beds" now assigned to the Dolbee Creek Member of the Burlington Limestone do not maintain their purity in the subsurface north and northeast of Adams County; they become dolomitic along strike in that direction. Two cores in northern Adams County