CROSS SECTION OF THE PALEOZOIC ROCKS OF NORTHEASTERN ILLINOIS: IMPLICATIONS FOR SUBSURFACE AGGREGATE MINING

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Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

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Cover photo: Material Service Corporation's Thornton quarry in southern Cook County.

ABSTRACT

Today, construction aggregate is a major component of Illinois' stone production, an industry that has been important in northeastern Illinois for more than 150 years. Securing a continuous supply of aggregate is critical for the metropolitan construction industry, which faces constraints from urban expansion and geologic factors. Many quarries in the Chicago area cannot be expanded laterally and have limited reserves of stone. As sources of aggregate obtainable by surface quarrying are exhausted, underground mining will have to be considered. To expand quarries by underground mining requires comprehensive knowledge about the bedrock geology of the region.

This preliminary study used new data from two major geologic investigations in the Chicago area: the Superconducting Super Collider (SSC) project, encompassing parts of Du Page, Kane, De Kalb, and Kendall Counties, and the Tunnel and Reservoir Plan (TARP) of the Metropolitan Sanitary District of Greater Chicago (now the Metropolitan Water Reclamation District of Greater Chicago), covering most of Cook County. The SSC and TARP projects produced substantial data derived from bedrock cores and geophysical logs on most of the local Paleozoic stratigraphic sequence, a major source of aggregate in northeastern Illinois. This study was the first to incorporate data from both projects.

A west-east stratigraphic cross section of the Paleozoic rocks in northeastern Illinois was constructed. Data indicate that underground mining of the Galena-Platteville can be considered for the following situations. In areas where the Silurian is thick, inclines could be constructed through the shaly basal Silurian and Maquoketa sediments when the expansion of existing quarries is no longer possible. In the western part of the study area where the Silurian is thin or absent, an incline could be constructed through the basal shaly Silurian and the Maquoketa. In the northern part of the study area where Quaternary sediments are thick, an inclined shaft could be sunk through the unconsolidated sediments to mine the Silurian or, if the Silurian is too thin or poor in quality, through the Silurian and the Maquoketa to mine the Galena-Platteville directly. In sharp contrast to the resources available for surface mining, suitable resources for underground mining appear to be evenly distributed throughout the study area.

INTRODUCTION

Paleozoic carbonate rocks (primarily dolomite)—an important source of aggregate in northern Illinois—are part of a thick sequence of sedimentary rocks underlying all of northeastern Illinois (Cook, De Kalb, Du Page, Kane, Kankakee, Kendall, Lake, McHenry, and Will Counties). Our understanding of the lithostratigraphic sequence and depositional environment of these rocks is limited by the paucity of surface exposures and the small amount of subsurface information. Most of what we do know is derived from scattered quarry exposures or water-well cuttings, which provide limited data for most of the stratigraphic section.

Located in a major metropolitan area, the Paleozoic rocks are important for economic, engineering, and environmental reasons. A large valuable stone industry has thrived in the Chicago metropolitan area since its early settlement. Initially, lime and building stone were the major products. Today, construction aggregate is the focus of industrial mineral production (Mikulic 1989). Securing a continuous supply of aggregate is critical for the metropolitan construction industry as it faces increasing pressure from urban expansion and geologic constraints (Mikulic and Goodwin 1986). To deal with the constraints on aggregate production, comprehensive knowledge about the bedrock geology of the region is required.

During the last 25 years, geologic studies conducted in the Chicago area have produced a substantial amount of data, derived from bedrock cores and geophysical logs, on parts of the Paleozoic stratigraphic sequence. The two most important of these studies are the Superconducting Super Collider (SSC) project, embracing parts of Du Page, Kane, De Kalb, and Kendall Counties, and the Tunnel and Reservoir Plan (TARP) of the Metropolitan Sanitary District of Greater Chicago (MSDGC, now termed the Metropolitan Water Reclamation District of Greater Chicago, or MWRDGC), covering much of Cook County (fig. 1). Numerous contract reports published in conjunction with these projects pertain mostly to site-specific engineering and

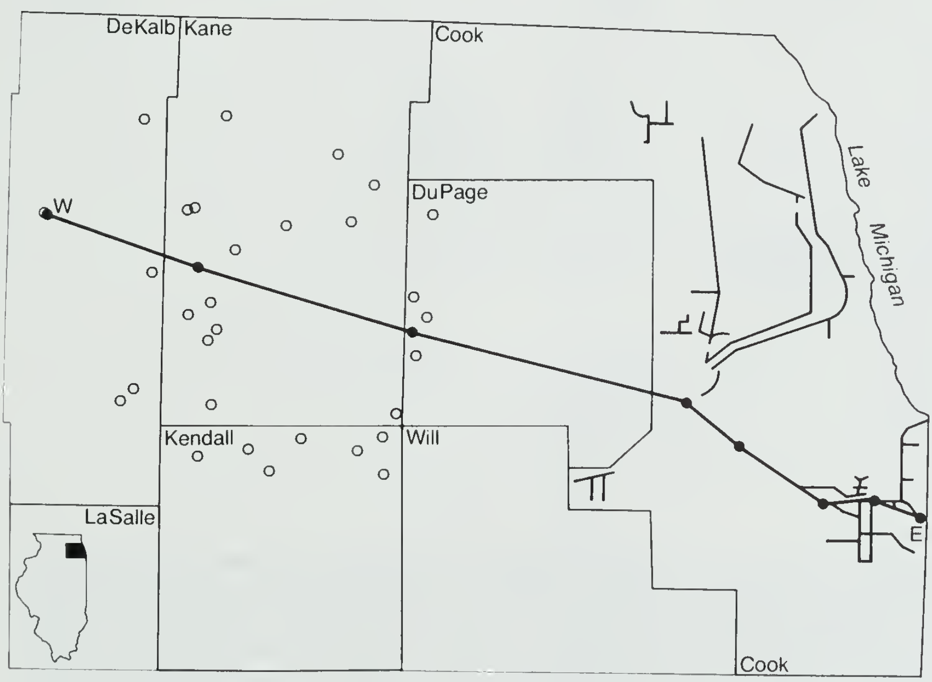


Figure 1 Locations of core holes drilled for the proposed SSC (open circles) and proposed and constructed TARP tunnels (thin lines) in northeastern Illinois (from Buschbach et al. 1982 and Graese et al. 1988). Line W–E shows location of cross section in figure 2.

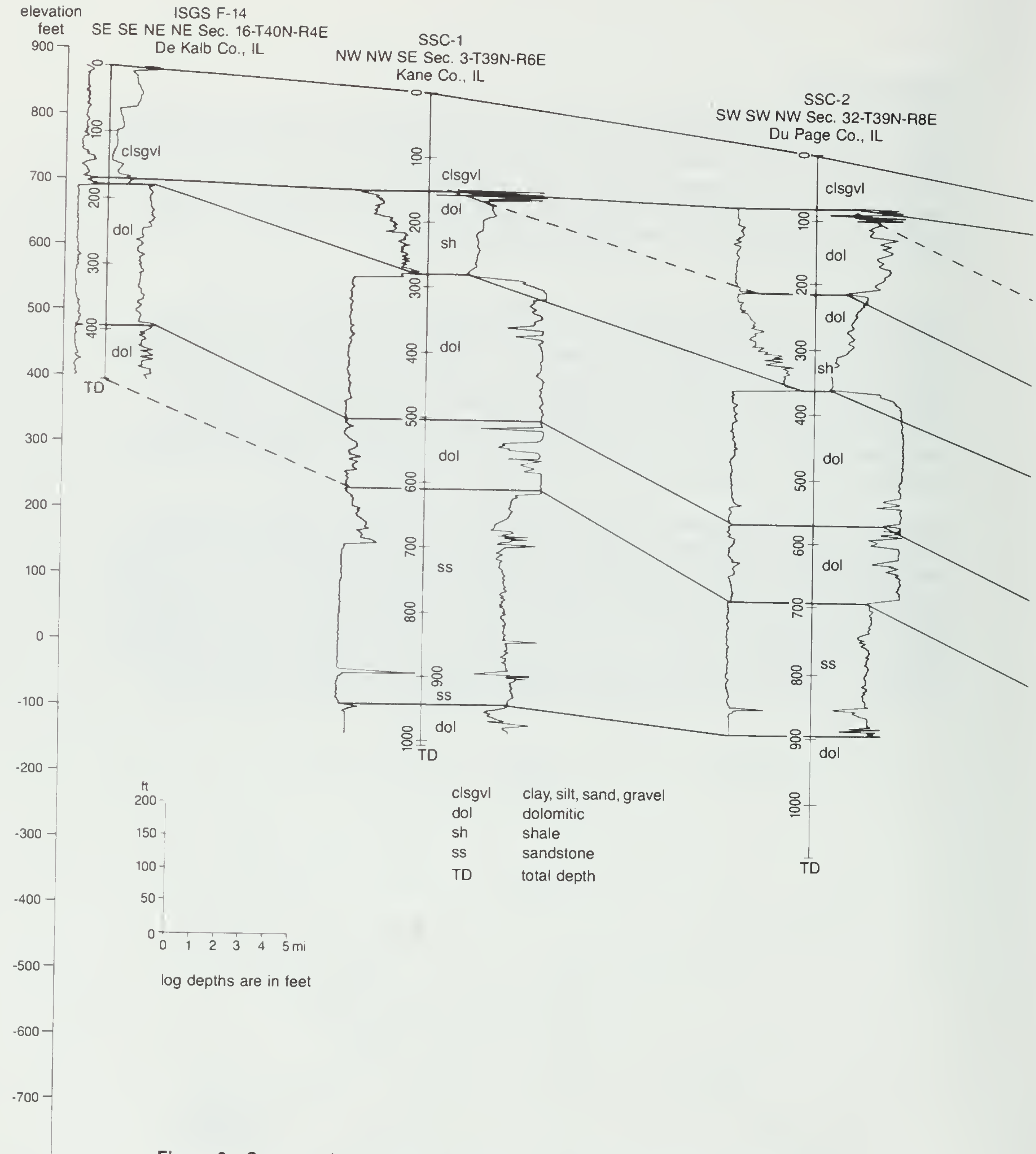
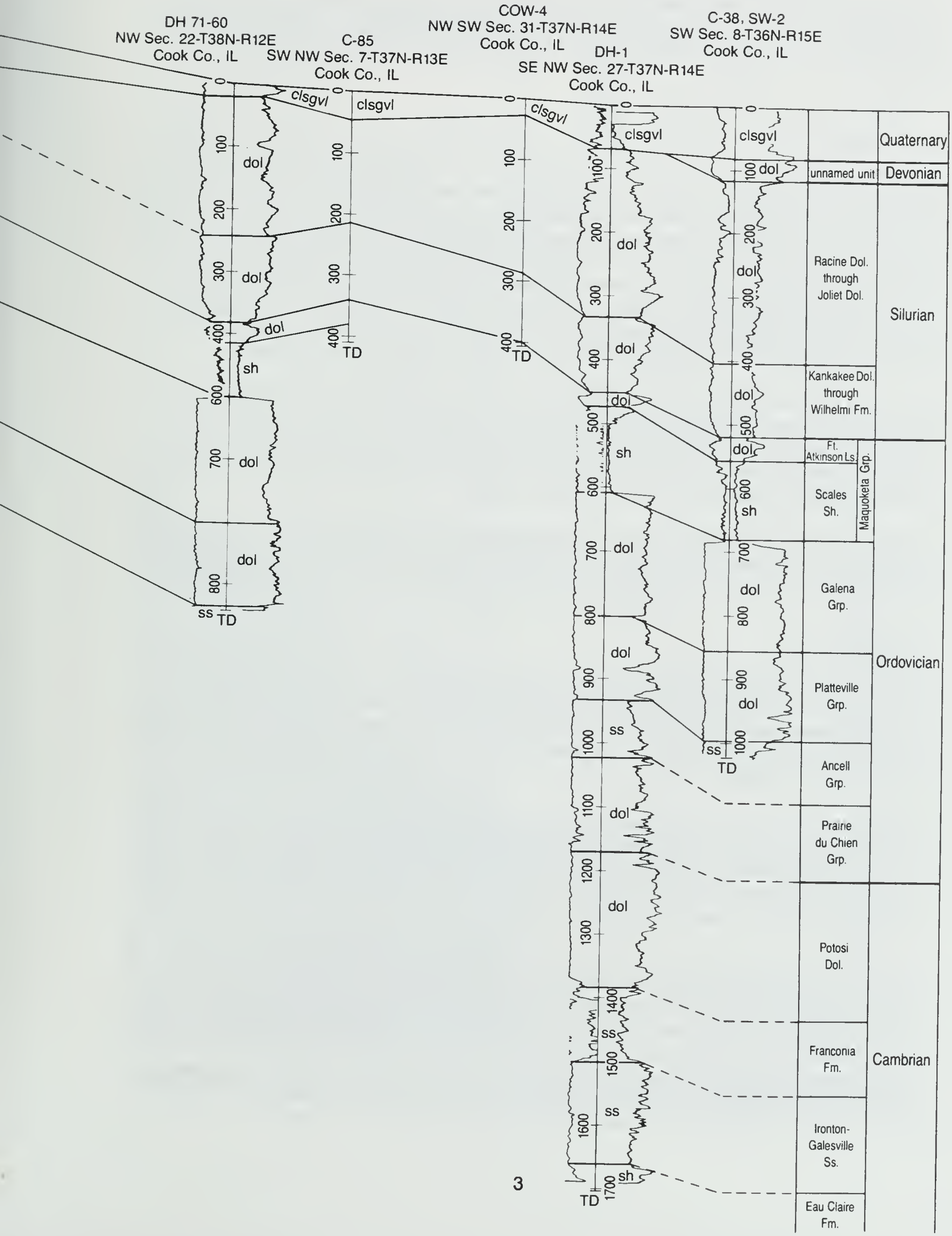


Figure 2 Cross section correlating Paleozoic rock units in northeastern Illinois from De Kalb County (west) to the Indiana border (east). Data points are based on core distribution and available geophysical logs from SSC cores F-14, SSC-1, and SSC-2, and TARP cores DH71-60, C-85, COW-4, DH-1, and C-38 in combination with SW-2. Stratigraphic boundaries in SW-2 below the base of the Silurian and DH-1 were derived from information on file with the MSDGC. Stratigraphic boundaries for SSC cores are from logs in Vaiden et al. (1988) and Kempton et al. (1987). Ground surface topography between data points is not shown.



DH 71-60
NW Sec. 22-T38N-R12E
Cook Co., IL
C-85
SW NW Sec. 7-T37N-R13E
Cook Co., IL
COW-4
NW SW Sec. 31-T37N-R14E
Cook Co., IL
DH-1
SE NW Sec. 27-T37N-R14E
Cook Co., IL
C-38, SW-2
SW Sec. 8-T36N-R15E
Cook Co., IL
clsgvl
dol
sh
ss
TD
Quaternary
unnamed unit
Devonian
Racine Dol. through Joliet Dol.
Silurian
Kankakee Dol. through Wilhelmi Fm.
Ft. Atkinson Ls.
Scales Sh.
Maquoketa Grp.
Galena Grp.
Platteville Grp.
Ordovician
Ancell Grp.
Prairie du Chien Grp.
Potosi Dol.
Franconia Fm.
Cambrian
Ironton-Galesville Ss.
Eau Claire Fm.

environmental matters. No detailed regional stratigraphic synthesis using the geologic data from both the SSC and TARP studies was attempted.

This preliminary study uses data from the SSC and TARP projects to construct a west-east stratigraphic cross section of the Paleozoic rocks in northeastern Illinois (fig. 2). The potential for underground mining for aggregate in the Chicago area is then discussed in terms of stratigraphic information.

DATABASE

Subsurface data have been derived from investigations of the Chicago area bedrock geology over the last 25 years. The largest of these studies was the TARP program of the MSDGC. Approximately 500 bedrock cores were drilled, starting in the late 1960s, and totaled more than 170,000 feet (51,000 m). Drilling took place along the proposed routes of a deep sewer tunnel system in Cook County (Buschbach et al. 1982). Most of the cores penetrated the entire Silurian section (fig. 2), and several extended into the upper parts of the Cambrian. Extensive engineering and environmental studies were conducted, and 110 drill holes and water wells were logged geophysically. A seismic survey of a large part of Cook County was also executed. Additional data were obtained during tunnel construction, which is still in progress.

More recently, geologic investigations for the SSC project generated 30 cores from Du Page, De Kalb, Kane, and Kendall Counties (Graese et al. 1988) (fig. 1). The cores penetrate part of the Ordovician rock sequence and some of the Silurian section. Extensive engineering and environmental testing and geophysical logging were completed for each drill hole (Kempton et al. 1987a, 1987b, Curry et al. 1988, Vaiden et al. 1988).

Some smaller projects, mostly private investigations for stone resources, have produced cores and other data for scattered locations in the area. These projects in combination with quarries and natural exposures provide the Silurian and upper Ordovician database for the region.

STRATIGRAPHY

The general geology of the Chicago region has been discussed by Bannister (1868), Alden (1902), Bretz (1939), and Willman (1971). Typically, the bedrock surface is covered by a thick (100 feet, 30 m) blanket of glacially and fluvially derived Quaternary sediments. Bedrock rarely occurs near the surface; exposures are confined primarily to drainage channels, such as the Des Plaines River valley.

Major structural features of this region comprise the Wisconsin Arch on the west, the Kankakee Arch on the south, and the Michigan Basin on the east. Paleozoic strata dip an average of 10 to 15 feet per mile away from the arches and eastward into this basin (Willman 1971). The dip combined with erosional truncation produces a pattern: rocks at the bedrock surface become increasingly older from east to west (figs. 2 and 3).

As much as 5,000 feet (1,500 m) of Cambrian, Ordovician, and Silurian sedimentary rocks overlie the Precambrian basement rocks in the area. Devonian sediments fill fissures within Silurian rocks in widely scattered localities in Cook County (Weller 1899, Kluessendorf et al. 1988). Newly discovered Middle Devonian carbonates occur in Cook County along the Indiana border (figs. 3 and 4). Pennsylvanian strata occur to the southwest in Grundy, Kankakee, and Will Counties and fill solution features in Will and Kankakee Counties (Bretz 1940). Possible Devonian, Mississippian, and Pennsylvanian strata fill the Des Plaines disturbance (Willman 1973), a meteorite impact site in northern Cook County (McHone et al. 1986).

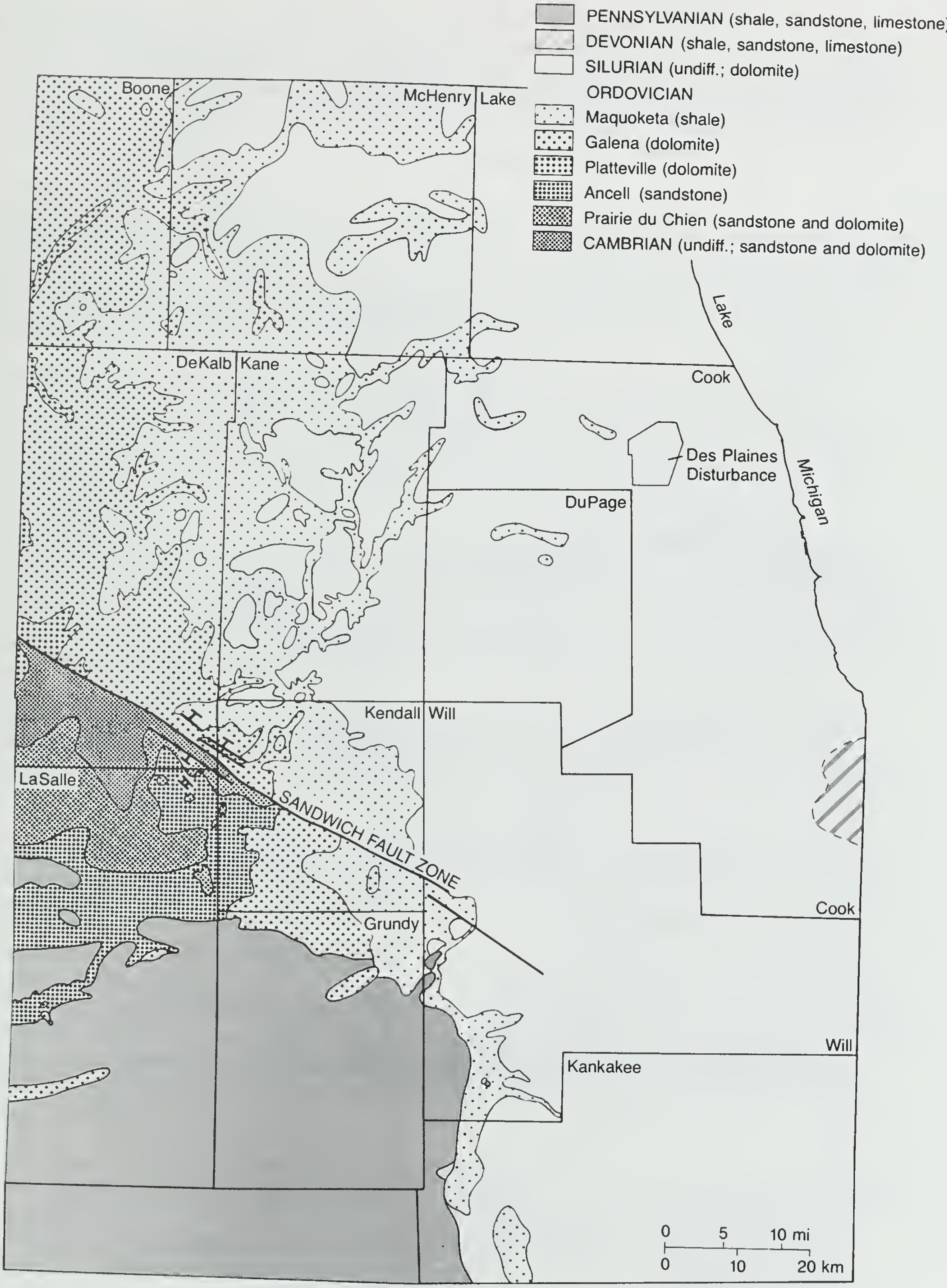


Figure 3 Bedrock surface geologic map of study area (from Willman 1971 and Graese et al. 1988).

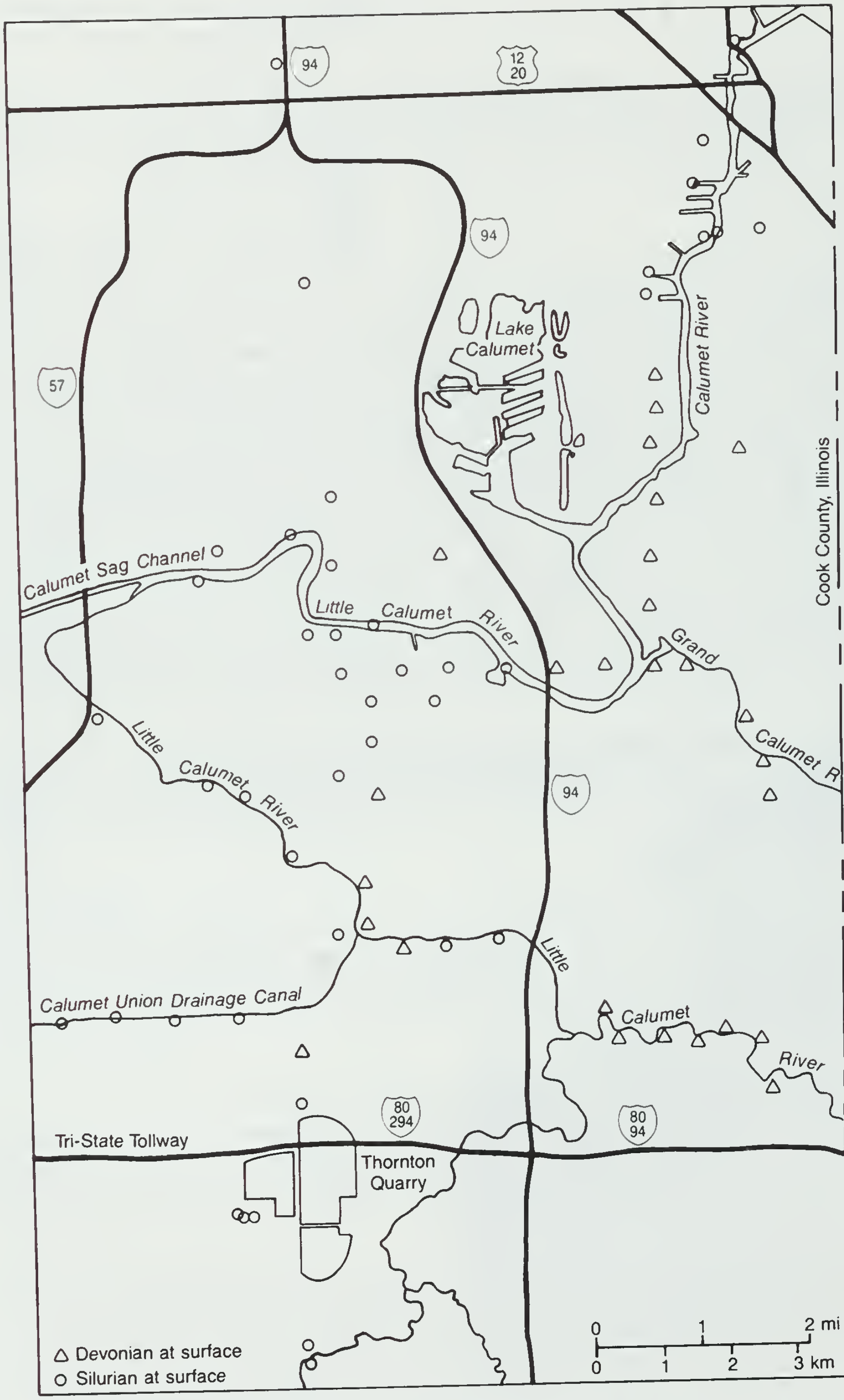


Figure 4 TARP core locations that show Devonian or Silurian rocks at the bedrock surface in southeastern Cook County.

Cambrian

Upper Cambrian strata that unconformably overlie Precambrian rocks are the oldest Paleozoic rocks in northeastern Illinois. They are poorly known, having been only partially penetrated by a few cores and water-well logs. These strata consist primarily of sandstone with some dolomite and siltstone beds at the top of the sequence and are as much as 4,000 feet (1,200 m) thick (Willman 1971).

Ordovician

Prairie du Chien Group The Prairie du Chien Group overlies Cambrian strata throughout the Chicago area except where it was eroded prior to Ancell deposition. As much as 300 feet (90 m) thick (fig. 2), this unit consists primarily of dolomite with some sandstone intervals (Willman 1971). The deep burial and the limited subsurface information available for these rocks precludes any economic potential for them in northeastern Illinois in the foreseeable future.

Ancell Group The Ancell Group is composed primarily of sandstone with shales and dolomites at the top. Its base marks a prominent erosional unconformity with the underlying Prairie du Chien Group and the unit varies from 100 to 400 feet (30 to 120 m) thick (fig. 2) (Buschbach et al. 1982). The Ancell Group forms an important aquifer in this area and is a major source of silica sand where exposed at the bedrock surface, west of the study area.

Galena-Platteville Groups The Galena-Platteville (figs. 2 and 5) underlies the Maquoketa Group throughout the entire Chicago metropolitan area and constitutes a major potential source of aggregate. In De Kalb and Kendall Counties in the western part of the region, where Silurian and Maquoketa strata have been completely removed by erosion, the Galena Group occurs at the bedrock surface (fig. 3). It has been quarried in Kendall, De Kalb, and Boone Counties, and from there west to the Mississippi River.

The uppermost Galena Group, ranging from 170 to 225 feet (52 to 68 m) thick, consists of thick-bedded, pure dolomite (or limestone locally). A cherty interval 5 to 10 feet (1.5 to 3 m) thick occurs at the top of the Dunleith Formation in the western part of the study area (Graese et al. 1988, Willman and Kolata 1978, Buschbach et al. 1982).

The Platteville Group, which underlies the Galena, ranges from 140 to 150 feet (42 to 45 m) thick (Graese et al. 1988). Typically a dolomite (limestone locally), it contains some chert and shaly parts.

Maquoketa Group The general unsuitability of Maquoketa rocks as a source for aggregate constitutes an important geologic constraint on the regional stone industry. They underlie the Silurian strata throughout northeastern Illinois, marking the lowest possible depth to which most quarries can be developed (fig. 6). At the erosional western edge of Silurian strata, the Maquoketa occurs at the bedrock surface (fig. 3). The Maquoketa also thins westward as a result of erosional truncation (fig. 2), reflecting the prevailing eastward dip of Paleozoic strata into the Michigan Basin.

The Maquoketa Group in northeastern Illinois is divided into four formations (fig. 5) (Buschbach 1964, Kolata and Graese 1983). The uppermost formation, the Neda, which ranges from 0 to 15 feet (0 to 4.5 m) thick, is present only locally in widely scattered areas. The Neda is a ferruginous, oolitic, reddish mudstone that is found only where the Maquoketa reaches its maximum thickness. Underlying the Neda is the Brainard Formation, primarily a greenish mudstone containing thin carbonate interbeds, ranging from 0 to 160 feet (0 to 48 m) thick. The Fort Atkinson Formation, which underlies the Brainard, ranges from 0 to 60 feet (0 to 18 m) thick (average 20 to 40 feet, 6 to 12 m) and consists predominantly of dolomite with some shaly

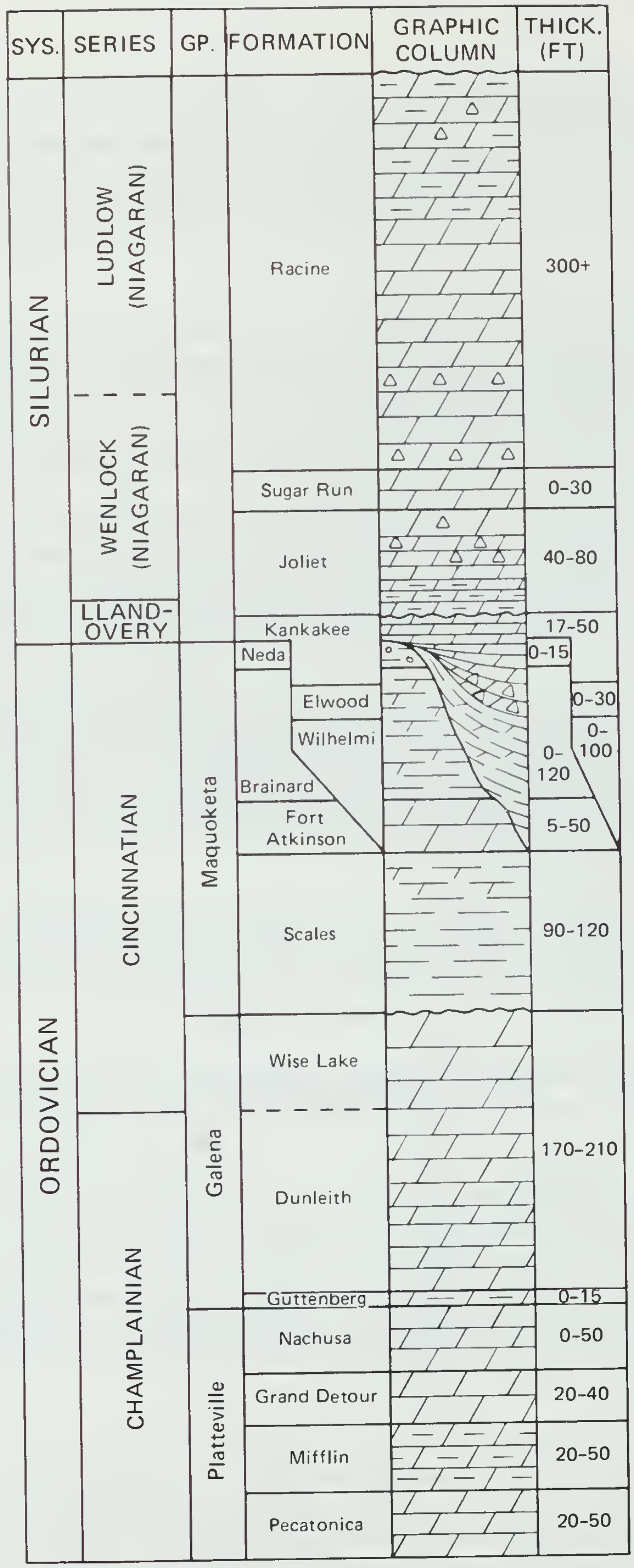


Figure 5 General stratigraphic column of Ordovician and Silurian rocks in northeastern Illinois (from Willman 1971 and Mikulic et al. 1985).

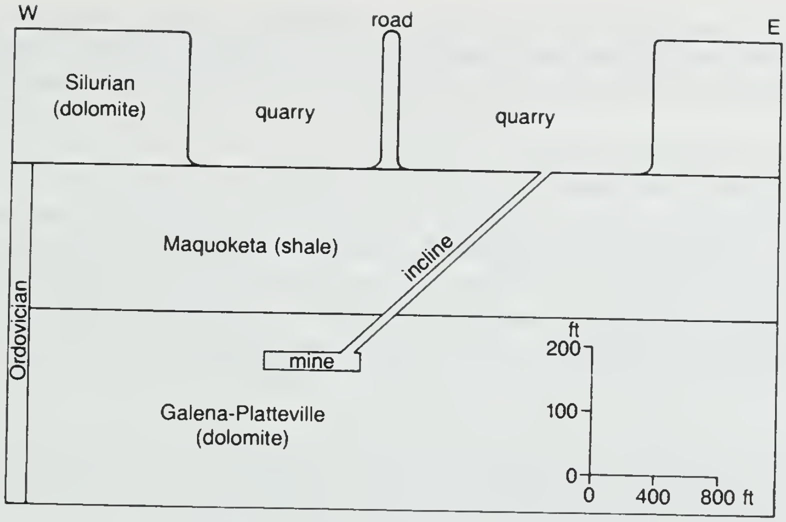


Figure 6 Cross section of underground mine at Elmhurst-Chicago Stone Company, Elmhurst, Du Page County, Illinois.

partings. This unit has been quarried in the Channahon area where it crops out, at North Aurora, in the National Quarry at Joliet, and at Garden Prairie, where it was uncovered after the overlying Silurian was quarried through. Underlying the Fort Atkinson is the Scales Formation, a dark mudstone ranging from 40 to 135 feet (12 to 40.5 m) thick. The Scales Formation overlies the Galena Group unconformably.

This four-part lithologic division of the Maquoketa varies locally as a result of increasing carbonate content of the Scales Formation in northwestern Kane and eastern Du Page Counties and of the Brainard Formation in northeastern Kane, northwestern Cook, southern Lake, and southeastern McHenry Counties (Kolata and Graese 1983).

Thickness of the lower Silurian rocks varies inversely with thickness of the Maquoketa Group. Extensive erosion of the Maquoketa surface prior to deposition of Silurian sediments produced a series of broad hills and valleys. As a result of this erosion, the Brainard Formation varies considerably in thickness (fig. 5); in some locations it has been removed entirely. In a few places, the underlying Fort Atkinson Formation has been eroded as well.

Silurian

The Silurian rocks compose the bedrock surface throughout much of the study area and represent the primary stone resource in the region. Reaching a maximum thickness of 500 feet (150 m) along the Illinois-Indiana border in Cook County, these rocks thin and disappear towards the west (fig. 2). Descriptions of the Silurian rocks in the area are in Willman (1971, 1973), Buschbach et al. (1982), Mikulic et al. (1985), and Mikulic and Kluessendorf (1985).

Kankakee, Elwood, and Wilhelmi Formations The Kankakee, Elwood, and Wilhelmi Formations, which comprise the lowermost Silurian strata in northeastern Illinois (fig. 5), are exposed in Kane, Kendall, western Will, western Kankakee, western McHenry, and eastern De Kalb Counties (fig. 3). They vary considerably in thickness from 20 to 150 feet (6 to 45 m).

The Kankakee Dolomite, ranging from 20 to 30 feet (6 to 9 m) thick, is a crystalline dolomite with common discontinuous argillaceous partings. The Kankakee is the lowermost Silurian rock unit that is typically quarried in the Chicago area; the basal few feet contain some chert.

The underlying Elwood Dolomite is an argillaceous dolomite containing abundant chert. The lowest Silurian unit, the Wilhelmi, is characteristically argillaceous, becoming shaly downward; chert occurs near its top. All three of these units are Llandoverian in age (Mikulic et al. 1985).

The considerable variation in thickness of these units is largely controlled by the thickness of the underlying Ordovician Maquoketa Group. At the end of the Ordovician, the Maquoketa was weathered and eroded, resulting in a series of broad hills and valleys with as much as 200 feet (30 m) of relief. Thicknesses of the Maquoketa and the three Silurian units vary inversely (fig. 5). Where the Brainard Formation is thinnest or absent, the Kankakee to Wilhelmi interval is thickest, and the Fort Atkinson Formation may underlie the Silurian directly. Where the Brainard Formation is thickest, the Neda Formation may occur at the top of the Ordovician, the lower Silurian interval is thin, and the Elwood and Wilhelmi Formations may be absent.

Sugar Run-Joliet Dolomites The Sugar Run-Joliet Dolomites, which underlie the Racine, are an economically important interval that has been quarried throughout northeastern Illinois (fig. 5). The Sugar Run Dolomite, which is as much as 30 feet (9 m) thick, consists of slightly argillaceous, well-bedded dolomite; chert may be present. This unit was quarried extensively for high-quality building stone during the late nineteenth century at Joliet, Lemont, and Lockport.

The Joliet Dolomite, which ranges from 40 to 80 feet (12 to 24 m) thick, is subdivided into three lithologically distinctive members. The uppermost member, the Romeo Member, is a very pure, porous, thick-bedded to massive dolomite that has been quarried for lime and flux, although locally it may contain chert. The middle member, the Markgraf Member, is lithologically similar to the Sugar Run Dolomite, and it too has been quarried for building stone at Joliet and along the Fox River. The lowermost member, the Brandon Bridge Member, is a conspicuous pinkish to greenish, thin-bedded, highly argillaceous dolomite. At some localities, the Brandon Bridge is shaly and reddish or bluish gray. This member sits atop an unconformable surface that denotes one of the best stratigraphic marker horizons in the Silurian of this region. As determined by conodont studies, the Brandon Bridge ranges from late Llandoverian to early Wenlockian (Mikulic et al. 1985).

Racine Dolomite The Racine Dolomite, the thickest unit in the Silurian of northeastern Illinois, has been a primary source for aggregate in this region. The Racine is thickest at the border between Illinois and Lake Michigan-Indiana and thins to the west (fig. 2). As best as can be determined, the erosional limit of the Racine runs through central Du Page County and west-central Will and Kankakee Counties. At its thickest, the Racine is as much as 350 feet (150 m) thick (fig. 5). This maximum thickness corresponds to erosion-resistant, reef-controlled bedrock hills, such as the Thornton, Stony Island, and Torrence Avenue reefs (Mikulic and Kluessendorf 1985). However, these reefs are limited in geographic extent, and the more typical interreef Racine is generally around 200 feet (60 m) thick along the east edge of the study area.

Reef and nonreef Racine vary substantially in composition and economic potential. Historically, reefs have been quarried preferentially for two reasons: (1) they are a source of high-quality stone used initially for lime burning and later for construction aggregate, and (2) the reef-controlled, erosion-resistant bedrock hills of the Lake Chicago Plain account for most of the exposures available for quarrying near the center of Chicago. Although differing in size, shape, and thickness, Racine reefs are fairly uniform in stone quality. In some areas, such as east-central Cook County, lithologically similar strata form barrier reeflike features of thick-bedded to massive carbonates. Groups of small reefs and reef-influenced interreef strata occur in the McCook-Lyons area of Cook County, where they yield high-quality aggregate.

The more pervasive Racine interreef strata have seldom been quarried because they rarely crop out as a result of their low resistance to erosion, and their high argillaceous content makes them unsuitable for lime burning or aggregate production. Where the interreef Racine is thickest, the upper part comprises highly argillaceous dolomite or dolomitic mudstone. These strata succeed alternating intervals of porous dolomite, argillaceous dolomite, and dense, nonporous, argillaceous dolomite containing chert nodules locally.

Devonian

Recently, Devonian rocks have been recognized in MSDGC cores drilled east and south of Lake Calumet (figs. 3 and 4) (Mikulic, in preparation). Previously, Late Devonian sediments had been reported from widely scattered fissure fills within reefs of the Silurian Racine Dolomite and in fault blocks within the area of the Des Plaines disturbance (Weller 1899, Kluessendorf et al. 1988). The strata at the bedrock surface in the vicinity of Lake Calumet appear to be Middle Devonian, as indicated by rare conodonts recovered from core samples (R. Norby 1990, personal communication). Core recovery of these Middle Devonian strata is poor, but the following generalizations may be made. As much as 30 feet (9 m) of coarse-grained, brown, sandy, laminated dolomite with some argillaceous or shaly intervals is present. The Devonian unconformably overlies the Silurian Racine Dolomite and thins from east to west. These strata occur at an elevation lower than nearby Silurian reef-controlled bedrock hills, a fact that indicates a pre-Middle Devonian erosional relief on the Silurian surface. Lithologically, these rocks are similar to the Middle Devonian Thiensville Formation of the Milwaukee, Wisconsin, area to the north and to the Detroit River Formation of northwestern Indiana. The limited distribution and thickness of the Devonian rocks preclude their having any value as an aggregate source in northeastern Illinois.

AGGREGATE PRODUCTION AND UNDERGROUND MINING

Stone production has been an important industry in northeastern Illinois for more than 150 years (Mikulic and Goodwin 1986, Mikulic 1989). Geologic constraints determine where stone can be quarried. The locations where quarries can be operated economically are restricted by the thickness of Quaternary overburden, the limited number of rock exposures, and the thickness of aggregate sources of suitable quality.

Most natural exposures have been developed into quarries in the past, and the reserves of high-quality aggregate in these quarries have been exhausted. Most operators are unable to expand existing quarries laterally because of urban encroachment, and few potential quarry sites are available to supply the demands of the greater Chicago area (Mikulic 1989). Underground mining in existing quarries may be the key to alleviating some of these problems (Mikulic and Goodwin 1986).

To date, the Chicago metropolitan stone industry has been based primarily on the quarrying of Silurian rocks. Many quarries in the Chicago area were forced to close when they reached the shaly basal Wilhelmi Formation or underlying Ordovician Maquoketa Group strata and lateral expansion was impossible. These closures resulted in fewer quarry sites in the center of Chicago where demand for stone is high.

The Elmhurst-Chicago Stone Company pioneered an alternative to abandonment at their Elmhurst quarry. By 1980, the entire Silurian in this quarry had been removed to a depth of more than 200 feet (60 m), exposing the top of the Ordovician Maquoketa Group, a mudstone of no economic value. Lacking potential for lateral quarry expansion and confronting a Maquoketa section too thick to remove economically, the company decided to mine the Ordovician Galena Group dolomites lying 240 feet (72 m) below the existing quarry floor (Rukavina 1987) via an incline that was constructed through the Maquoketa (fig. 6).

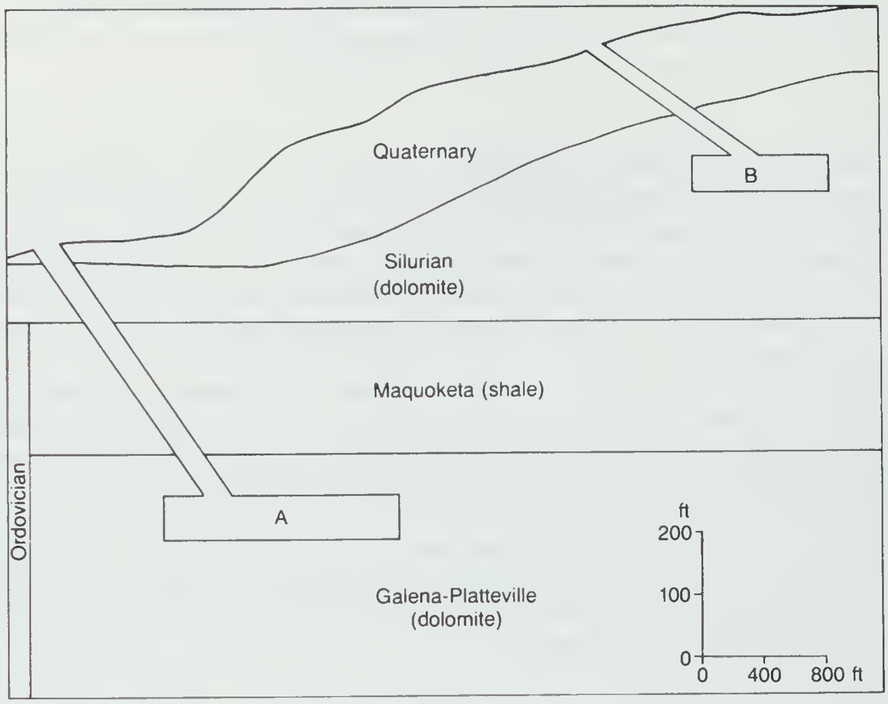


Figure 7 Cross section of another possible development of underground mines for northeastern Illinois. Mining of (A) Galena-Platteville where unconsolidated Quaternary sediments are thin and a thin sequence of basal Silurian rocks occurs, and (B) thick sequence of Silurian where overlain by a thick sequence of unconsolidated Quaternary sediments.

Underground mining of the Galena-Platteville at other locations could be considered in the following geological situations. In areas where the Silurian is thick (primarily eastern part of the study area), inclines could be constructed through the shaly basal Silurian and Maquoketa sediments when the expansion of existing quarries is no longer possible (fig. 6). In the western part of the study area, where the Silurian is thin or absent, an incline could be constructed through the basal shaly Silurian and the Maquoketa (fig. 7A). In the northern part of the study area (Lake and McHenry Counties) where Quaternary sediments are thick, an inclined shaft could be sunk through the unconsolidated sediments in order to mine the Silurian (fig. 7B), or if the Silurian is too thin or poor in quality, through the Silurian and the Maquoketa to mine the Galena-Platteville directly.

Successful underground mining depends on a variety of factors such as potential market and proximity to competitive surface quarry operations. Underground mining offers some advantages, including the continued production of aggregates from sites where quality stone is no longer accessible to surface mining methods. Operators could mine larger areas in the more uniform Galena-Platteville than at the surface where the younger rocks are uneven in quality or beneath land otherwise unavailable because of space needed for plant operations.

As sources of aggregate obtainable by surface quarrying are exhausted in the Chicago metropolitan area, underground mining will become an increasingly important source of stone. Geological factors in the area indicate that suitable resources for underground mining are evenly distributed throughout the area—a situation in sharp contrast to the resources available for surface mining.

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