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COUNTY ATLAS SERIES
ATLAS C-10, PART A
Plate 7—Geologic Resources

GEOLOGIC RESOURCES

By

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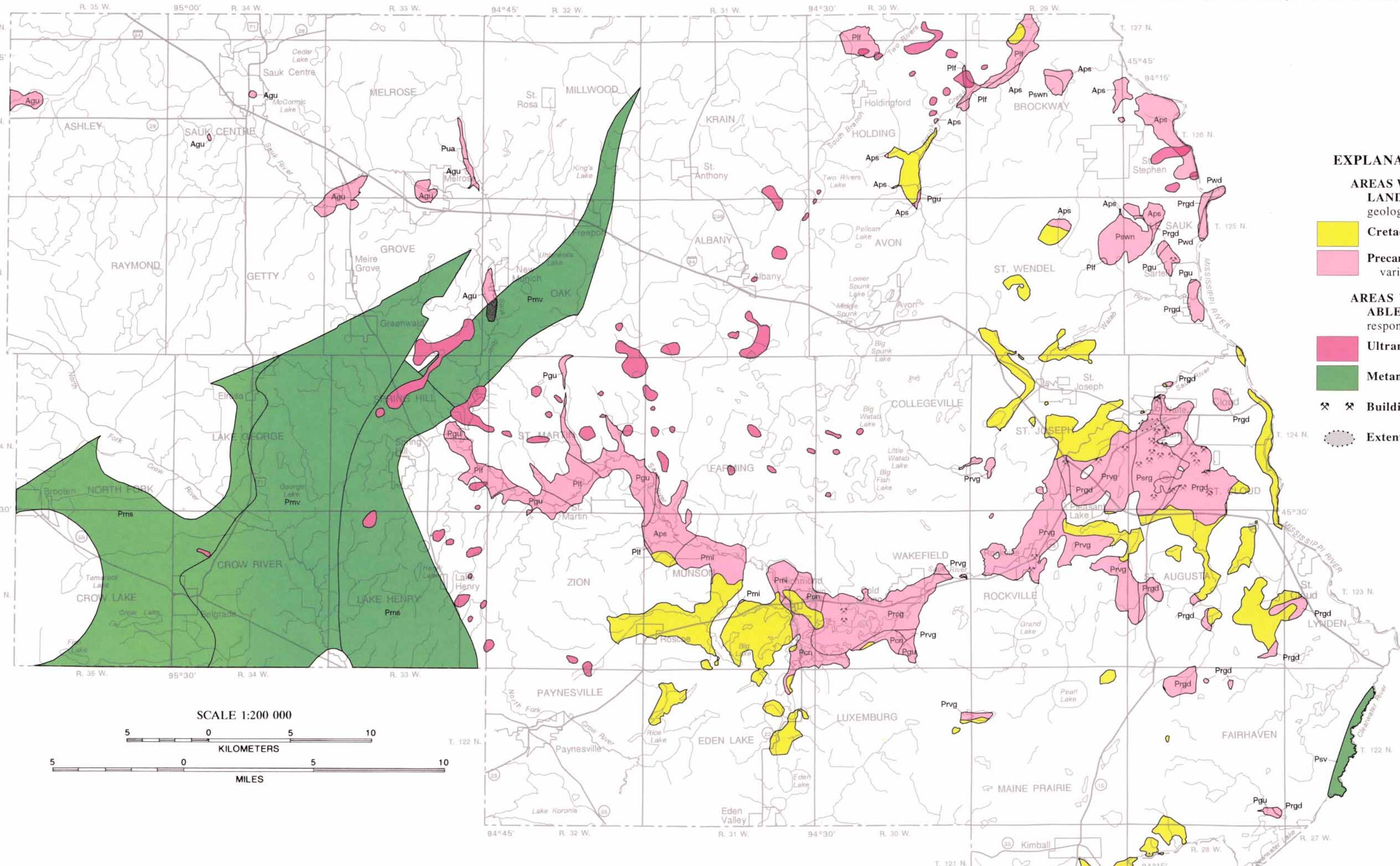
1995



Map A. Bedrock Resources

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

Township and range lines digitized from 1:24,000-scale U.S. Geological Survey topographic maps

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

Compiled by Terrence J. Boerboom and Dale R. Setterholm

Cartography by Brian Pedrotty, Philip Heywood, and Joyce Meints.

EXPLANATION TO BEDROCK RESOURCES MAP

AREAS WHERE BEDROCK IS LESS THE 50 FEET BELOW LAND SURFACE—Unit labels correspond to the bedrock geologic map units on Plate 2.

Cretaceous sedimentary rocks.

Precambrian crystalline rocks—Commonly overlain by highly variable thicknesses of weathered residuum.

AREAS WHERE PRECAMBRIAN BEDROCK IS FAVORABLE FOR MINERAL EXPLORATION—Unit labels correspond to the bedrock geologic units on Plate 2.

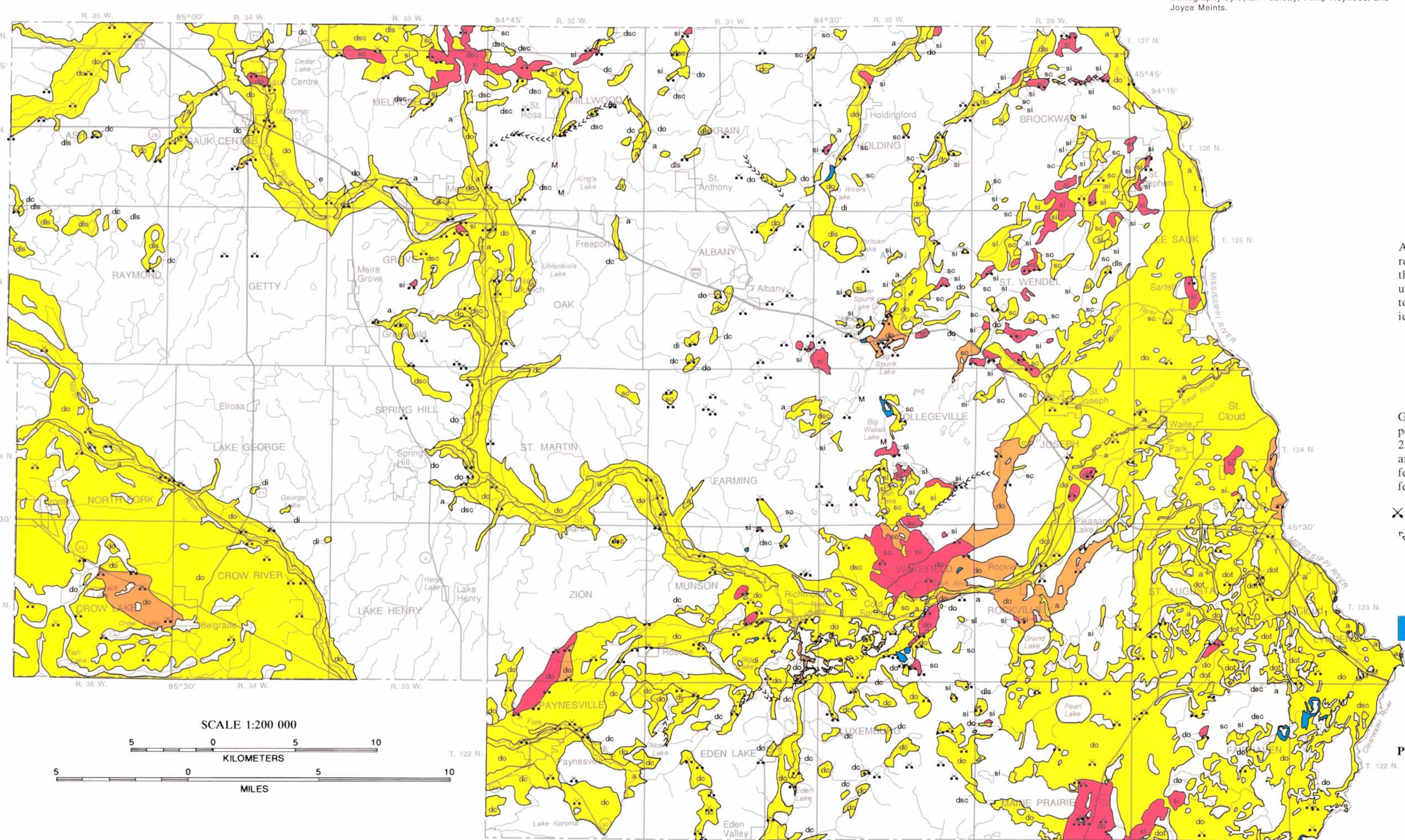
Ultramafic intrusive rocks.

Metamorphosed volcanic and sedimentary rocks.

Building stone quarries—Active; selected inactive.

Extent of active crushed-stone quarry.

LOCATION DIAGRAM



Map B. Surficial Resources

Compiled by Gary N. Meyer

Cartography by Brian Pedrotty, Philip Heywood, and Joyce Meints.

EXPLANATION TO SURFICIAL RESOURCES MAP

SAND AND GRAVEL RESOURCES

Areas shown in color are considered to have potential for aggregate resources, but reliable subsurface information is very limited beyond the confines of existing pits. Unit labels for Quaternary geologic units are from Plate 3 of this atlas; selected units are unlabeled owing to a lack of space (refer to the surficial geologic map on Plate 3 for identification of unlabeled units).

Primary

Water table >20 feet deep

Water table <20 feet deep

Generally more than 35 weight percent gravel (particles larger than 2 millimeters in diameter); sand and gravel deposits more than 20 feet thick; generally less than 10 feet of cover.

Secondary

Less than 35 weight percent gravel-size material; or deposit less than 20 feet thick; or more than 10 feet of cover. A high water table may also be a limiting factor. Some areas mapped as secondary may contain pockets of primary resources.

Gravel pits—Active and intermittently active; inactive.

Esker—Sinuous ridge of sand and gravel that may be covered by ten feet or more of till. Inferred flow direction indicated. Eskers with inferred directional flow to the south and west are interpreted to be of Superior lobe origin (unit **si**); the rest are attributed to the Des Moines lobe (unit **di**).

OTHER SURFICIAL GEOLOGIC RESOURCES

Marl deposits (unit **m**, Plate 3).

M **Selected marl deposits too small to show in color.**

T **Sites where till (unit wt, Plate 3) has been mined for manure-pit liner.**

GEOLOGIC ORIGIN OF SAND AND GRAVEL

These units are from the surficial geologic map on Plate 3.

Postglacial Deposits

e **Eolian sand**—No gravel in the deposit itself, although gravelly sand outwash may be present at depth in places.

a **Alluvium**—Deposits along the Mississippi River can be quite gravelly in places, but alluvium elsewhere in Stearns County is generally gravel poor. Owing to a high water table, to be utilized, most deposits must be dredged.

t **Terrace deposits**—Mostly sand to gravelly sand, although gravel may be present at depth. Spall content and LAR values are both probably low.

Des Moines lobe deposits

dls **Lake sand and silt**—If gravel is present at all, it is fine and restricted to the margins of the deposit. Spall content and LAR values are both probably relatively high.

do **Outwash**—This deposit is the most widespread and utilized aggregate source in the county. The coarser and better quality deposits are found in the vicinity of, and consist largely of, reworked Superior lobe deposits. The decrease in LAR values (Table 2) from west to east reflects increased incorporation of Superior lobe deposits. Shale content also decreases somewhat to the east: a single pit each among those sampled within two areas—Cold Spring to St. Cloud, and south of St. Cloud—are responsible for increasing the average values (Table 1)

dot **Outwash over Superior lobe deposits**—In general too thin and gravel poor to be mapped as a primary resource. However, good quality aggregate may be present at depth in places where the outwash is thin over Superior lobe sand and gravel.

di, dc **Ice-contact deposits**—Both units **di** and **dc** contain sand and gravel deposited in close proximity to glacial ice. The sand and gravel is thus quite variable over short distances, and is commonly interbedded or overlain by till. Unit **di** in general contains more and thicker beds of sand and gravel. Shale-clast content (Table 1) is generally higher than in outwash deposits, with smaller deposits in particular having shale-rich beds.

dsc **Till over Superior lobe sand and gravel**—Till overburden is commonly greater than 10 feet thick, so this unit was mapped as a secondary aggregate resource. However, in places the till cover is thin to absent, and thick, good quality gravel is readily accessible.

Superior Lobe Deposits

sl **Lake sand**—Most of these deposits are gravel poor, although gravel lenses occur in places, particularly at the margin. A high water table in most deposits also limits the unit's value as a source of aggregate.

so **Outwash**—The large deposit north of Cold Spring is mapped as a primary aggregate resource on the basis of well records, a few shallow exposures, and comparison with Superior lobe outwash deposits outside the county. Spall content and LAR values should be similar to those of Superior lobe ice-contact deposits in the Avon area (Tables 1 and 2).

si, sc **Ice-contact deposits**—Both units **si** and **sc** contain sand and gravel deposited in close proximity to glacial ice. The sand and gravel is thus quite variable over short distances, and is commonly interbedded or overlain by till. Unit **si** in general contains more and thicker beds of sand and gravel, and in places exceeds 100 feet. Unit **sc** is mapped as a secondary aggregate resource owing to the unpredictable presence of interbedded or overlying till. Unit **si** deposits are mapped as a secondary resource where they are gravel poor in the upper part. LAR values increase to the west and south (Table 2), primarily due to increasing incorporation in those directions of relatively soft carbonate clasts derived from underlying older Pleistocene deposits.

Unmapped Minor Deposits

Pockets of sand and gravel are present in places within areas mapped as till on Plate 3, particularly in Superior lobe stagnation moraine (unit **stp**). Lenses of sand and gravel in Des Moines lobe till are generally thin and of poor quality, whereas those in Superior lobe till can contain some good quality gravel. A few pits have been opened in Rainy lobe ice-contact deposits where accessible along steep-sided meltwater channels in the western part of the county. Spall content in Rainy lobe deposits is low (Table 1), whereas LAR values are moderate (Table 2), due to moderate amounts of carbonate clasts.

INTRODUCTION

The principal geologic resources in Stearns County are Precambrian granite, which is cut for building stone and crushed for aggregate, and Quaternary sand and gravel, also used for aggregate. Principal uses for aggregate are railroad ballast; concrete for buildings, bridges, and road pavement; road base and fill; bituminous road pavement. Aggregate is also used for riprap and in landscaping. This plate describes these and other geologic resources and shows where there is potential to extract them in the future.

The maps on this plate reflect only geologic criteria. Urban development and zoning regulations obviously have a major impact on the availability of resources for mining. However, a map that attempted to take these factors into account would soon be outdated. That kind of rapidly changing demographic information is best portrayed and managed with a computerized Geographic Information System (GIS).

MAJOR RESOURCES

Building Stone

Stearns County has provided stone for the building trade since 1875 and continues to do so today. Building stone must have strength, durability, workability, color, beauty, and be in demand by potential users. Exposure of the rock at the land surface and widely spaced vertical and horizontal joints, such that large blocks can be obtained, are also necessary conditions. Building stone has been quarried at almost 100 sites in Stearns County (Nelson and others, 1990), and these sites correlate almost perfectly with the distribution of outcrops. That is, almost every outcrop, or group of outcrops, has been quarried at some time. Presently, there are four quarries actively producing building stone. One of these is mining the Reformatory granodiorite; the other three are mining the Rockville Granite. Various trade names have been used for the different shades of stone that have come out of the quarries, such as Charcoal Gray, Rockville Pink, and Rockville White.

The inactive status of a building-stone quarry does not necessarily indicate the depletion of the resource, but rather that mining conditions or changes in the demand for a particular color or texture make other sources more attractive. Inactive quarries are sometimes reopened. Our understanding of the geology does not suggest that previously unknown varieties of stone exist. It is likely that stone of good quality exists near enough to the land surface to be quarried, but there is no evidence to suggest that it would be superior to existing sources, and the cost of stripping overburden is a strong deterrent to exploration. However, these buried sources may become economically viable building-stone sources in the future if or when the present quarries become depleted or if demand for a certain variety of stone rises.

Crushed Stone

Crushed stone is a significant aggregate resource in Stearns County. This material, used for railroad ballast and other construction purposes, is currently mined from a quarry that contains both the St. Cloud Granite and Reformatory granodiorite, but other Precambrian bedrock units may also be suitable sources. In some states, specifications for higher quality road-building materials have increased the demand for this type of product.

Unlike dimension-stone quarries, closely spaced fractures do not detract from the usefulness of the rock. Because this is not a concern, the feasibility of utilizing buried rock that is close to the surface is greatly enhanced. A number of areas where depth to Precambrian bedrock is less than fifty feet have this potential resource; they are shown on Map A, Bedrock resources.

Sand and Gravel

Sand and gravel is used mostly for road construction—for road base and in mix for concrete and bituminous pavements and on unpaved roads. It also is used in general construction. Historic production of sand and gravel in Stearns County is shown in Figure 1. In addition to sufficient thickness and gravel content, and minimum of cover, a relatively wide range in size from sand to gravel is desirable in a deposit, because different size mixtures are required for different uses. The sand and gravel resources depicted on Map B, Surficial resources, are further distinguished by geologic units, because the quality of the resource is influenced by its origin. For example, gravel originating from the Des Moines lobe commonly has at least some shale, whereas Superior lobe gravel deposits contain very little shale (Table 1). The content of iron oxide clasts tends to be higher in Des Moines lobe deposits as well, although much of the relatively high content of iron oxide in deposits of southern Stearns County, including the Superior lobe deposit near Kimball, was probably derived through reworking of local Cretaceous deposits. LAR values (Table 2) tend to be higher for Des Moines lobe deposits because of their higher content of soft shale and carbonate fragments.

MINOR AND POTENTIAL RESOURCES

Clay

Potentially useful clay is available from the weathered residuum of the Precambrian crystalline rocks, and from the Late Cretaceous sedimentary rocks. The upper parts of the weathered residuum are rich in kaolinitic clays. One of these clays, from the residuum on the St. Cloud Granite, has been characterized and extensively tested by Toth and others (1990). They concluded that this clay would have commercial value if appropriate mining and processing techniques were used. The composition and physical characteristics of a bedrock unit strongly affect the thickness and properties of the clay that forms as the bedrock weathers. For that reason, the weathering products of each bedrock unit (and each compositional variation within it) must be evaluated separately for commercial use. However, it is reasonable to assume that the weathering products of some of the other bedrock units in Stearns County, and especially the granites, will have similar commercial utility. An active mine that exploits kaolinitic weathered residuum deposits in southern Minnesota demonstrates the feasibility of utilizing this resource in Stearns County. Additional information on residual weathering deposits in Stearns County is available in Setterholm and others (1989) and Shurr and others (1991).

The Cretaceous strata that in many places overlie the weathered residuum have also been shown to have potential for commercial uses. Toth and others (1990) have described and tested ball-clay samples from Richmond and Avon for use in production of hand-thrown clayware. They report that the Avon deposit has been used for this purpose for many years. Mapping of the Cretaceous strata for this atlas suggests that the Avon deposit is a thrust block of Cretaceous strata within the Quaternary section. Areas where Cretaceous strata are within 50 feet of the land surface are shown in Map A, Bedrock resources.

Quaternary glacial till and lake clays were used in the past in a number of places across the county (Nelson and others, 1990) for the manufacture of brick and tile. Two pits in southeastern St. Cloud Township were apparently still in operation in the 1950s, mining lake clay below outwash sand (unit **dlc**, Plate 3). However, due to changes in the construction industry, brick making is not likely to resume in Stearns County. Loam-textured till (unit **wt**, Plate 3) is being mined from a few sites in northeastern Stearns County (and possibly elsewhere) to line manure pits. These deposits may become increasingly valuable in this part of the county where clayey deposits are scarce.

Marl

Composed largely of calcium carbonate, marl is used for improving soil for agriculture. The large deposit south of Cold Spring is currently being mined for this purpose. In general, the lighter the color, the higher the calcium content of a marl deposit. Stearns County has many thick marl deposits; those shown on Map B, Surficial resources, were compiled from the county soil survey (Sutton, 1985) and Stauffer and Thiel (1933). Many other marl deposits are concealed below thick peat.

Mineral Resources

Although the economically important dimension- and crushed-stone quarries in Stearns County are well established, very little exploration for metallic and nonmetallic mineral resources has been done here relative to other parts of Minnesota. This is due in large part to the generally thick glacial deposits that cover the bedrock in most of the county. Although mineral exploration becomes increasingly difficult as the thickness of the glacial cover increases, modern geophysical data and methods can delineate targets for drilling with sufficient accuracy to permit exploration. Explorationists elsewhere in the state routinely drill through one hundred or more feet of overburden to reach their drill targets, and, thus, glacial cover should not be a deterrent to exploration in Stearns County. Perhaps the main reason for the general lack of interest is that in the past most of the county had been mapped as Archean gneisses, which generally do not host significant mineral deposits and thus are not attractive for mineral exploration. The reinterpreted bedrock geology shown on Plate 2, which extends the previously unrecognized Mille Lacs Group (units **Pmv** and **Pms**) into Stearns County, may lead to future interest by mineral explorationists. Although little is known about these rocks, they may contain many of the same attributes of volcanic and clastic terranes elsewhere that host volcanogenic or sedimentary-exhalative types of massive sulfide deposits and, possibly, shear-zone-hosted or stratabound gold deposits. In general, mineral exploration interests in Stearns County are likely to be rather low-key, but the newly recognized attributes may lead to a slight increase in exploration activity, depending largely on the market prices of the various metallic and nonmetallic commodities.

The small, pluglike ultramafic intrusions on Map A, Bedrock resources (and mapped as unit **Pggu** on the Bedrock geologic map, Plate 3), have been drilled in the past with two different commodities in mind. One of the plugs was drilled in a search for diamonds, because common targets of diamond exploration are small, ovoid intrusions that are delineated by their magnetic anomalies. Two other plugs were drilled, not for diamonds but base metals. These abundant, small pipelike intrusions show up well geophysically, making them easily identifiable targets that are likely to see continued exploratory drilling in the future.

Peat

Peat deposits, which are mapped on Plate 3 (unit **p**), are widespread in the county. Peat is mined elsewhere in Minnesota, primarily for horticultural purposes.

ACKNOWLEDGMENTS

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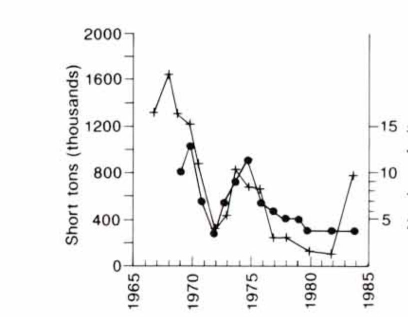

FIGURE 1. *Production from gravel pits (+; left axis) and the number of reporting pits (•; right axis). Data from U.S. Bureau of Mines Mineral Yearbooks, 1965–1985.*

TABLE 1. *Summary of spall* material content for sand and gravel aggregate, Stearns County.*

[Values are percentage of total weight. Numbers in parentheses following values indicate the number of samples on which the values are based; T, trace amount; –, not counted. Source: Minnesota Department of Transportation gravel pit sheets.]

Deposit	Shale	Iron oxide	Unsound chert	Sites sampled
Des Moines lobe outwash				
Ashley Township	0.3 (7)	0.2 (7)	–	2
Sauk Centre to Melrose	1.8 (19)	0.5 (17)	0.4 (1)	9
Brooten to Belgrade	0.3 (19)	0.3 (19)	0.0 (5)	6
Paynesville to Richmond	0.3 (11)	0.7 (9)	0.2 (2)	6
Avon area	0.3 (20)	0.4 (20)	–	3
Cold Spring to St. Cloud	0.3 (22)	1.0 (21)	0.1 (15)	7
Kimball area	0.6 (12)	0.8 (11)	0.4 (4)	4
North of St. Cloud	0.0 (3)	0.2 (3)	–	1
South of St. Cloud	0.4 (15)	0.7 (14)	0.4 (10)	6
Des Moines lobe ice contact				
Paynesville to Richmond	0.6 (11)	0.4 (9)	0.1 (3)	4
Superior Lobe ice contact				
Greenwald-Melrose area	0.3 (30)	0.1 (30)	T (4)	9
Avon area	T (29)	0.3 (28)	0.1 (27)	6
Kimball area	0.1 (4)	1.5 (3)	0.2 (1)	1
Rainy Lobe ice contact				
Ashley Township	0.1 (2)	0.2 (2)	–	1

*Spall materials are rock particles that will cause a pop-out in hardened concrete or bituminous pavement. Maximum permissible spall materials in coarse aggregate for concrete used in highway construction, by weight percent of total sample, are: 0.7 percent shale, 0.3 percent soft iron oxide particles, and total spall materials (shale and iron oxide plus unsound chert, coal, and clayey limestone) not more than 1.5 percent. Maximum permissible total spall materials in bituminous pavement is 5.0 percent.

TABLE 2. *Summary of Los Angeles Rattler (LAR)* tests for sand and gravel aggregate, Stearns County.*

[Source: Minnesota Department of Transportation gravel pit sheets.]

Deposit	Mean LAR Value	Range	No. of Tests	Sites Sampled
Des Moines lobe outwash				
Ashley Township	25.6	24.3–28.2	10	2
Sauk Centre to Melrose	25.2	21.4–27.3	16	6
Brooten to Belgrade	24.9	20.4–28.7	26	5
Paynesville to Richmond	23.8	20.9–27.2	15	5
Avon area	17.7	12.5–25.0	35	2
Cold Spring to St. Cloud	24.2	18.1–28.3	33	6
Kimball area	23.4	18.3–25.9	13	4
North of St. Cloud	18.4	16.4–20.1	3	1
South of St. Cloud	20.4	17.9–24.5	7	2
Des Moines lobe ice contact				
Paynesville to Richmond	24.6	22.4–27.8	15	4
Superior Lobe ice contact				
Greenwald-Melrose area	23.4	20.9–28.2	39	7
Avon area	19.6	14.7–24.2	39	6
Kimball area	23.1	20.0–26.8	6	1
Rainy Lobe ice contact				
Ashley Township	24.5	22.3–25.9	3	1

*LAR is a standard method for testing resistance of aggregate to abrasion. Coarse aggregate is rotated in a steel cylinder with steel balls for a specified time. The percentage of fine material abraded from the coarse aggregate originally put in the cylinder, expressed as percentage of loss, is the LAR value. The more resistant the aggregate, the lower the value. Maximum permissible loss for aggregate used in highway pavement construction (total sample) is 40 percent.