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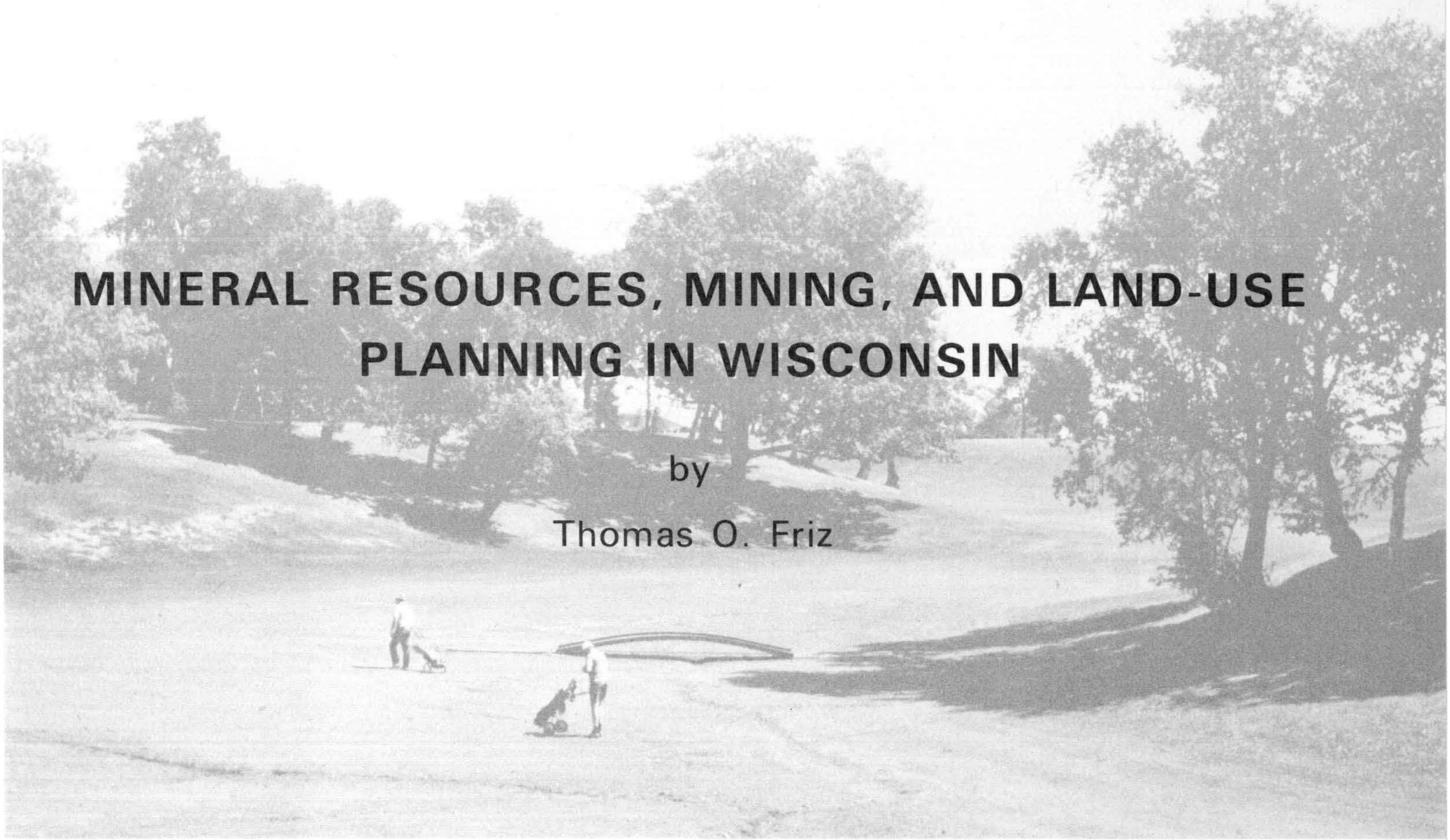
GEOLOGICAL AND NATURAL HISTORY SURVEY



# MINERAL RESOURCES, MINING, AND LAND-USE PLANNING IN WISCONSIN

by
Thomas O. Friz

A MINING INFORMATION PROJECT FUNDED BY THE

UPPER GREAT LAKES
REGIONAL COMMISSION

Cover photo: City of Racine golf course and picnic area developed from reclamation of clay pits of the former Hilker Brothers North Point brickyard in Shoop Park, Wind Point, Racine County.

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This investigation was accomplished with the financial assistance of the Upper Great Lakes Regional Commission, but the data, statements, findings, conclusions and recommendations do not necessarily reflect the views of the Commission.



University of Wisconsin - Extension
Geological and Natural History Survey
M.E. Ostrom, Director and State Geologist
February 1975

## AUTHOR

Dr. Friz received his B.S., M.S., and Ph.D. degrees in mining engineering from the University of Wisconsin - Madison and is a registered Professional Engineer in the state of Wisconsin. He has worked in the minerals industry in Wyoming and northern Michigan, was an instructor in the Minerals and Metals Engineering Department, University of Wisconsin - Madison and spent four years with the U.S. Bureau of Mines in Minneapolis and Washington, D.C. before joining the Conservation Division, U.S. Geological Survey in Reston, Virginia.

# PREFACE

Minerals, together with agricultural and forestry products, are the primary source of wealth produced in our state and nation. Although the production of minerals requires only a small fraction of the state's total land surface, as compared with either agriculture or forestry, mining activities generally are much more disruptive to the land surface, and rehabilitation is more costly.

The Upper Great Lakes Region has a long history of mining that predates discovery by European explorers. Although there have been periods of reduced activity, since about 1835 the intensity of mining in Wisconsin and throughout the Great Lakes Region has tended to increase. This increase is a reflection of increasing demand for mineral materials, of exploration that has yielded new deposits to supply these demands, and of advanced technology that has been applied to improve methods of prospecting, mining, and mineral processing.

Today, we are in the midst of what is described by some as a minerals crisis, namely, that our domestic and even world supply of minerals is not keeping pace with demands. Thus, one can expect that the search for minerals will continue to intensify and that mining activity will increase.

The sharp increase in mineral exploration and mining activity, especially over the past 10 to 15 years, has brought with it an increase in conflict over land use and an increase in land negotiations for purposes of mineral prospecting and mining. Although this condition is rather general throughout the Great Lakes Region, it is particularly true in Wisconsin where one rich deposit of copper and zinc with minor amounts of gold and silver has been located near Ladysmith, in Rusk County, and where the intensity of prospecting and land negotiations is at a very high level.

In addition, the general increase in production and consumption of nonmetallic minerals such as sand, gravel, and crushed stone, which are required by the construction industry, has created increased public concern over mining activities, especially where these activities occur in close proximity to urban areas. There is clear evidence to indicate that nearness of such mines to consumers has a major effect on holding materials prices down, and that it is possible to plan for and design mining activities in such a way that they are compatible with other activities and can thus be made a part of a multisequential land-use plan. Yet, in spite of this evidence, there is a general lack of knowledge regarding the importance of mining as the provider of basic and essential raw materials to supply society's constantly expanding and increasing mineral needs. In addition, this lack of knowledge extends to such matters as land and mineral rights negotiations, the character of mineral deposits and minerals, mineral economics, and land-use planning.

In response to these needs the Wisconsin Geological and Natural History Survey and the Environmental Resources Unit, University of Wisconsin-Extension, in 1973 submitted to the Upper Great Lakes Regional Commission a program proposal to develop informational materials on (1) zoning to provide for control of mining activities and to protect known mineral deposits, (2) metal or nonmetal prospecting agreements, mining leases, and alternative transactions, and (3) mineral rights. In addition, a list of consultants was to be prepared and a mining information hot line was to be made available to provide rapid response to questions relating to prospecting and mining.

This report, "Mineral Resources, Mining, and Land-Use Planning in Wisconsin" is one product of the mining information program. It is intended to provide general background information and answers to questions on minerals, mineral deposits, mineral economics, mineral production, mined land reclamation, and mining and mineral resources as a part of the land-use planning concept. Specifically, the report focuses on Wisconsin and discusses the nature, occurrence, and distribution of mineral deposits, the value of the mineral industry, how minerals are produced, the reclamation of mined land, and mining as a temporary use of the land which can be made a part of a multisequential land-use plan.

This information is intended for use by individuals, local and state governments, industry, and planning commissions in consideration of problems and concerns relating to prospecting and mining transactions, zoning for mineral extraction, and mineral resource policy issues. For specific information on zoning to regulate mining activity and to reserve known mineral deposits, refer to Wisconsin Geological and Natural History Survey Information Circular 24, "Model Mineral Reservation and Mine Zoning Ordinance."

M.E. Ostrom, Project Director

## ACKNOWLEDGMENTS

This investigation was accomplished with the financial assistance of the Upper Great Lakes Regional Commission, which is gratefully acknowledged.

The author wishes to express his special gratitude to Dr. M.E. Ostrom, State Geologist and Director of the Wisconsin Geological and Natural History Survey, for guidance and assistance in the development and preparation of this report, Robert Olmstead supervised preparation of the map illustrations and coordinated arrangements for final publication. Nico Brouwer and Susan Tolman assisted with drafting. These efforts of the cartographic unit of the Survey are greatly appreciated. The support and assistance of other Survey staff in the preparation of the report is also gratefully acknowledged.

Many other persons from state and local government agencies, the academic community, and the mineral industry contributed their time and knowledge in the review of this report. Editorial assistance was provided by the University of Wisconsin-Extension, Office of Editorial Services. The helpful assistance of these persons and agencies is greatly appreciated.

# CONTENTS

# ILLUSTRATIONS

Page

# TABLES

# ABSTRACT

This report provides background information that can be used by individuals, local and state governments, industry, and planning units as the basis for assessing concerns over matters such as rising mineral costs, mining methods, reclamation, and land-use conflicts.

It gives general background information and answers to questions on Wisconsin's minerals, mineral deposits, mineral economics, mineral production, mined land reclamation, and mining and mineral resources as related to land-use planning. It also describes the nature, occurrence, and distribution of mineral deposits, the value of the mineral industry, how minerals are produced, reclamation of mined land, and mining as a temporary use of the land which can be made a part of a multi-sequential land-use plan.

# INTRODUCTION

The role of minerals in our local, state, and national economies and the importance of the mineral industry as the provider of these materials is generally only poorly understood. The critical importance of minerals and the expanding use of and increasing demand for minerals have caused an increase in efforts to locate and produce them. At the same time, there has been increased concern over questions such as rising mineral costs, mining methods, reclamation, and land-use conflicts.

The purpose of this report is to provide background information for use by individuals, local and state governments, industry, and planning units in assessing some of these concerns. The report contains five chapters, which address the following questions: I. Where Do Wisconsin's Minerals Come From?; II. What is the Value of Wisconsin's Mineral Industry?; III. How are Minerals Produced in Wisconsin?; IV. What is Mined Land Reclamation and Sequential Land Use?; and V. How Does Mineral Extraction Fit Into Land-Use Planning? Although the report is concerned mainly with Wisconsin, the broader issues and concerns apply equally to many other states. For this reason, it should find broad application, especially in the Upper Great Lakes Region.

## Chapter I

## WHERE DO WISCONSIN'S MINERALS COME FROM?

### Introduction

Mining, agriculture, and forestry provide the basic materials and foods essential for human existence on earth. Each must be properly managed and must utilize an ever-improving technology in order to meet the increasing demands of our society.

Minerals used in Wisconsin come from all over the world. However, only a very small proportion of our total state mineral needs are supplied from deposits located within our borders. Those that are produced here are basic to a large segment of our construction and manufacturing industries and are a major reason why these industries have located in Wisconsin.

Mining is the process of extracting minerals from the earth. To understand mining and related activities, it is important to have at least a basic notion of the character and distribution of minerals in the earth, of economic influences on minerals and mining, and of mineral resources including metals, nonmetals, and mineral fuels. Two keys to the overall management of mineral resources are intelligent land-use planning for mineral extraction and concise, equitable regulations covering the undesirable effects of mineral extraction.

### Mineral Distribution

Throughout history people have relied on minerals found in the crust of the earth to sustain and improve living standards. The distribution of mineral materials, whether metals, nonmetals, or mineral fuels, is the result of natural geological processes that have acted on the crust during and since its formation. An estimated 99.1 percent of the earth's crust is composed of the 12 elements shown in Table 1, while all of the remaining elements comprise the other 0.9 percent.[1] If all elements were found in a uniform homogeneous mix, none of the elements necessary for our comfort and well-being could be economically extracted with our existing technology. Under such a hypothetical situation, human beings no doubt would have remained primitive animals.

Table 1. Distribution of elements in the earth's crust.

| | | | |
|---|---|---|---|
| Oxygen | 49.2% | Potassium | 2.4% |
| Silicon | 25.7% | Magnesium | 1.9% |
| Aluminum | 7.4% | Hydrogen | 0.9% |
| Iron | 4.7% | Titanium | 0.6% |
| Calcium | 3.4% | Chlorine | 0.2% |
| Sodium | 2.6% | Phosphorus | 0.1% |
| | | All others | 0.9% |

Source: Clarke, F.W., and Washington, H.S., The composition of the earth's crust. (See the References at the end of this circular for complete citation.)

1. Superscript numbers refer to items in the list of references at the end of this report.

Fortunately the earth's crust is not a homogeneous mass. Geologic processes have acted upon the rocks and minerals, breaking down the old to form new and concentrating certain elements at unique locations throughout the crust. Concentrations of minerals of economic value occur and can be profitably extracted from the earth only at certain rare locations. Such concentrations are called ore or mineral deposits. From the land-use planning aspect, the key parts of this definition are economic value to the community and the nation, rarity, and location. From the mineral production aspect, the key parts of this definition are concerned with economic value in the marketplace and whether or not the ore can be extracted from the earth at a profit.

## Economic Influences

A mineral deposit is a mineral-bearing rock from which a mineral or minerals can be extracted profitably with existing technology and under present economic conditions. Each mineral deposit is unique in location and character. Geologic processes that have operated throughout geologic time have determined the distribution of deposits, mineral associations, depth and thickness of deposits, grade of the ore, and various physical and chemical characteristics of the ore. By applying modern geologic science and technology, the minerals industry can locate some mineral deposits, determine the grade and quantity of ore, and establish the economics of extracting and processing the ore into usable materials. The market value of the product, location of markets, and the cost of mining, processing, and transporting the mineral materials determines the feasibility of profitable extraction.

Both the economic value and the profitability of extracting mineral materials are in a constant state of flux. Market prices increase and decrease depending upon supply and demand, and can lead to the opening or closing of mines which are operating on a narrow profit margin. Market specifications can change, making the products from certain mines using new processing techniques of more value than those from similar mines using different processing methods. Such market changes can often lead to the closing of older mines and the opening of new mines. Changes in technology can lead to profitable extraction of lower grade ores, with the result that what were formerly unusable low-grade concentrations of minerals can be mined profitably and thus can be classified as mineral deposits. Changes in processing technology may also create markets for a new form of mineral product, resulting in the abandonment of older mines where insufficient ore remains to warrant changing over to the new process or where the remaining ore is unsuited to the preferred new technology.

Specific examples of these factors can be seen in Wisconsin's mineral industry. A sand and gravel deposit located 40 miles from a market cannot compete with a sand and gravel deposit located 5 miles from the same market. Although the two deposits may be of comparable size and quality and be operated by the same management using the same equipment, one can be operated more profitably than the other because of the difference in transportation costs. Sand and gravel is a high-bulk, low unit value commodity. For this reason, transportation charges of about 10 cents per ton-mile in addition to loading charges form an economic barrier against the more distant deposit and thus prevent its development under existing market and economic conditions. Such deposits are considered to have potential for future development but do not qualify as mineral deposits under existing conditions because they cannot be mined, purchased, and sold at a profit in competition with other more suitably located deposits.

The zinc-lead deposits of southwestern Wisconsin are of low grade. A decrease in the market price of zinc or lead by a cent per pound, once the break-even level is reached, can result in the closing of mines. In like manner, an increase in the price of these metals over the critical level may lead to the reopening of older mines and the renewed search for new ore deposits.

Efforts to develop the low-grade iron resources and taconites in the Lake Superior Iron Region had two far-reaching results to the state of Wisconsin. Through the development of an economic technology, low-grade resources became ore deposits, thus expanding our exploitable reserves of iron ore. As a result, the iron resources near Black River Falls became profitable to mine and a new mine began production in 1969. In addition, the development of pelletizing equipment as an integral part of this overall technology led to a change in market specifications. Because pellets have a controlled composition and shape, they have the advantage that more iron can be produced per blast furnace charge. As more pellets came on the market, an economic advantage was gained by using pellets exclusively. This ultimately led to the closing of the direct shipping iron-ore mines on the Gogebic Range in Wisconsin and Michigan. The high cost of producing iron ore from these deep, underground mines did not allow for a profitable operation if the additional cost of pelletizing the ore to produce a competitive product was added to the mining and transportation costs. Thus the mines were closed and the ore deposits became potential deposits awaiting a shift in market conditions or improved technology to make them profitable once more.

Dictates of the marketplace gave rise to Wisconsin's clay mining and brick manufacturing industry in the late 1800s and early 1900s and also caused its ultimate decline. Clay pits and brick manufacturing facilities were generally located close to cities and towns, and they offered a lower cost substitute for scarce timber supplies. The industry declined as a result of the introduction of portland cement and subsequent cheaper concrete products.

Similar examples of the effect of changing marketplace conditions on the mineral industry can be cited for dimension stone, crushed stone, and peat, as well as certain other nonmetals, metals, and mineral fuels. Environmental protection costs, regulatory changes, and changing monetary situations can be expected to affect both the economic value and the profitability of extracting mineral materials.

## Potential Mineral Deposits

Because of the rarity of mineral deposits, the search for new deposits is a high-risk venture with but small probability of success. The search for copper and petroleum in Wisconsin are typical examples. Copper deposits have been continuously sought in both northern and southwestern Wisconsin since early historical times. The presence of copper mineralization in the state and the proximity of copper ore deposits in northern Michigan provided ample incentive to carry out the search. All of the time, effort, expense, and failure of past exploration activity did not discourage present exploration specialists. In 1968 Great Lakes Exploration Company, Inc., a subsidiary of Kennecott Copper Company, announced the discovery of a copper deposit near Ladysmith in Rusk County. This discovery can be regarded as the result of all prior exploration efforts to locate copper in Wisconsin beginning in the mid-1600s. Economic, engineering, and environmental studies of the proposed mine are presently under way. It is anticipated that Wisconsin's first copper mine will commence operation by 1976. The search for copper deposits is continuing in the northern portion of the state and may eventually lead to the discovery of additional deposits.

Petroleum and natural gas have been sought in the state since the early 1900s. Although geologic conditions are not conducive to the accumulation of petroleum, the existence of oil and gas seeps and the discovery of petroleum in Illinois and Michigan have provided ample incentive for wildcat drillers to search for petroleum. Thus far, this search has yielded no commercial production of oil or natural gas. Drilling for petroleum, however, continues in the state.

As the more readily accessable deposits of minerals have been used up, more sophisticated techniques have been developed to aid in the discovery of hidden deposits. Geophysical and geochemical techniques and the recent introduction of remote satellite sensing are all contributing to the discovery of new ore deposits. Increasingly detailed geologic mapping of bedrock formations is also contributing to the search for new mineral deposits. However, only 3.5 percent of the state has been so mapped. In addition, much of the bedrock is obscured by thick deposits of glacial material. The distribution of glacial deposits is shown in Figure 1 and the thickness of these deposits in Figure 2. Scattered outcrops of bedrock found throughout the state provided the first indications of the nature of the rocks underlying the state.

Drilling of water wells expands our knowledge of the bedrock and subsurface geology of Wisconsin, as do mineral exploration, drilling, and mine excavation. This data is constantly being accumulated and interpreted to increase our understanding of the geology of the state. Some areas of the state, such as the north central portion, are only poorly understood due to a lack of data. A generalized map indicating the present knowledge of the bedrock geology of the state is presented in Figure 3. The potential for finding new metal, nonmetal, and mineral fuel deposits in the state is dependent upon defining the location and extent of favorable host rocks, which requires detailed geologic and geophysical mapping. For example, zinc and lead deposits, some of which contain copper, barite, and pyrite, are associated with rocks of the Ordovician System as well as the Silurian and Cambrian systems, which are found in southwestern Wisconsin. New deposits of zinc and lead are expected to be found in such association in the area shown in Figure 4.

Development of Wisconsin's potential to continue to provide minerals essential for construction and the manufacturing industries, and without which these industries and our society would be severaly crippled, depends on the state's capability to identify these resources and to assist industry in their identifications. Such identifications require detailed geologic and geophysical mapping of the entire state, especially in those areas of rapid development in which land is being preempted for other, and often less critical, use.

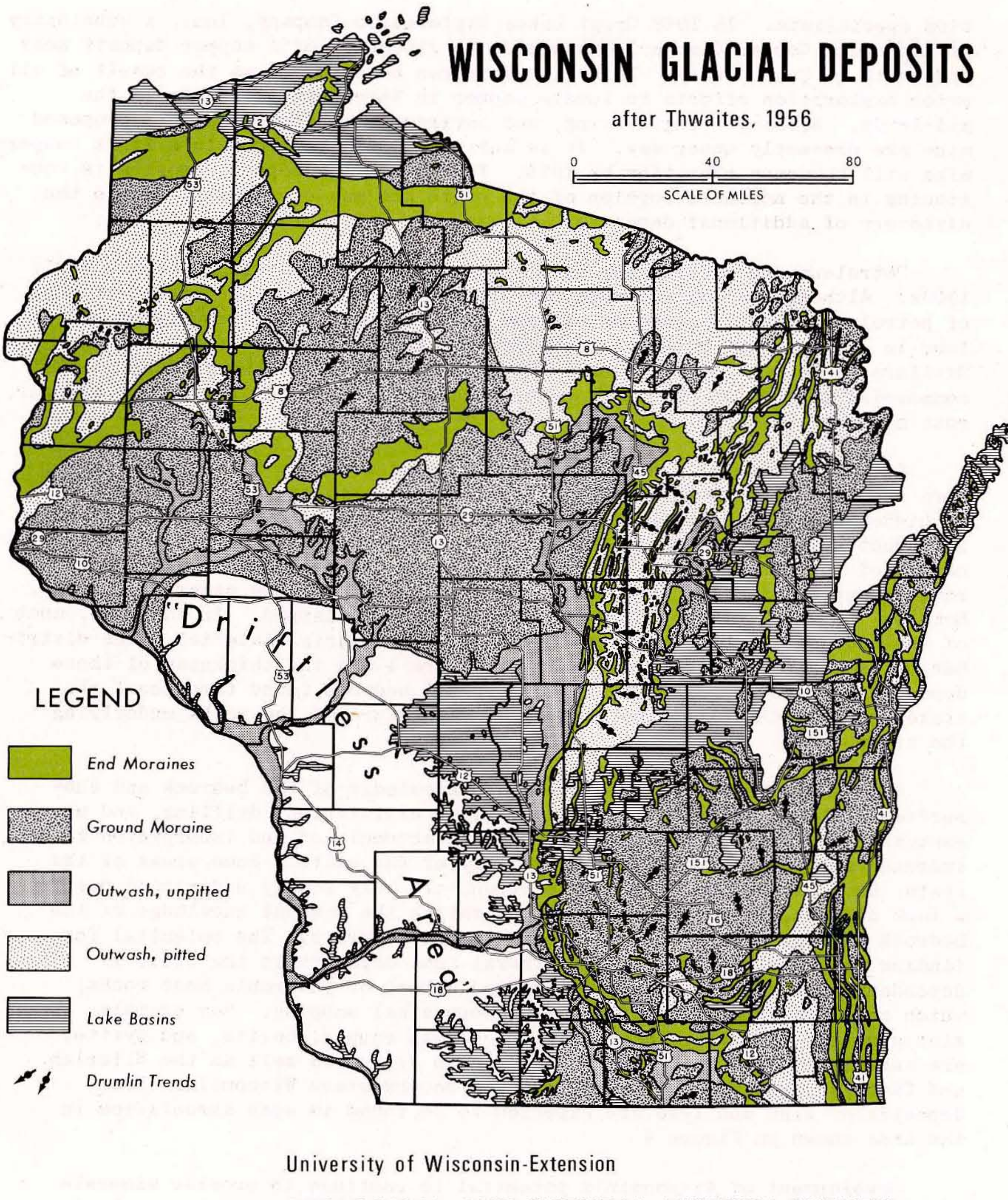



Figure 1. Wisconsin glacial deposits (after Thwaites, 1956).

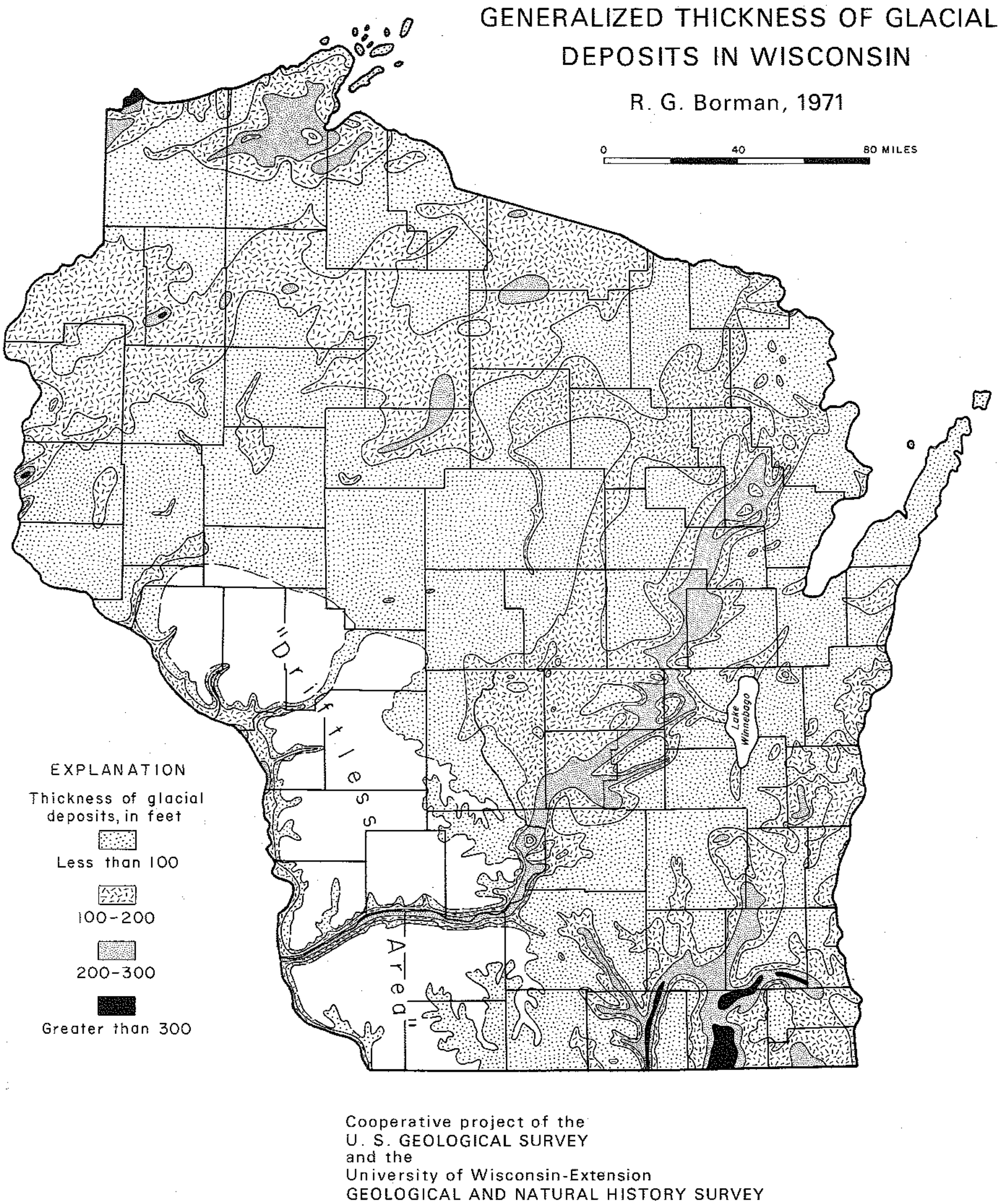



Figure 2. Generalized thickness of glacial deposits in Wisconsin.

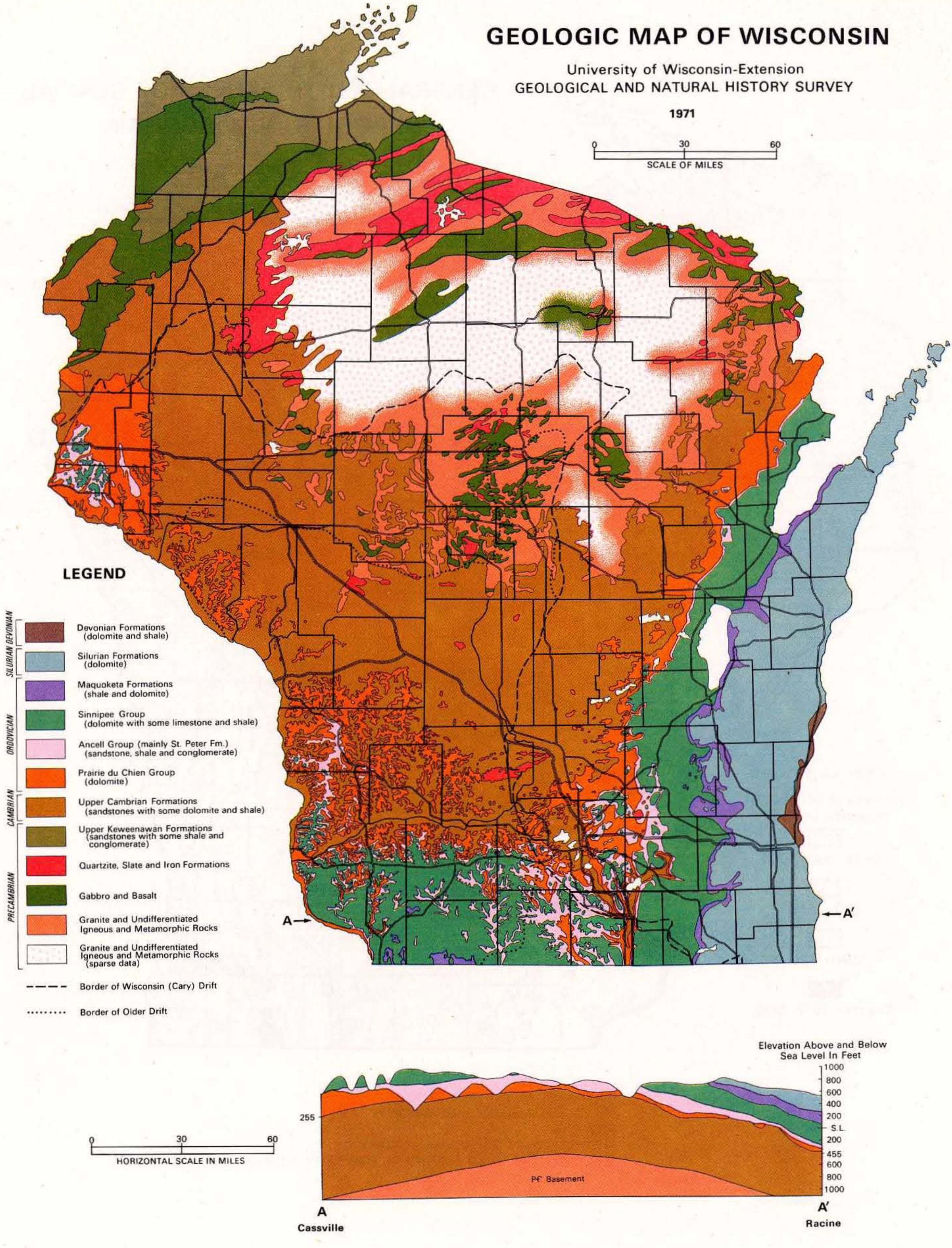



Figure 3. Geologic map of Wisconsin.

Metallics. Deposits of iron ore in Wisconsin are associated primarily with the iron formations of the Precambrian System. Those areas in which iron formation rocks occur and which have the potential for future development and discovery of ore bodies are indicated in Figure 4.

Copper, zinc, silver, gold, and nickel mineralization is associated with igneous rocks of the Precambrian System, primarily volcanic rocks. Although only one deposit, which contains copper, zinc, and minor silver and gold, has been discovered in these rocks to date, the potential for future discoveries exists. Potential areas of mineralization are shown in Figure 4.

Scattered occurrences of cerium, chromite, columbium, magnesite, molybdenite, and zircon have been reported from the Precambrian System rocks of northern Wisconsin.[2] None of these occurrences has led to the discovery of an ore deposit, and the potential for future discovery is remote but not impossible.

Nonmetallics. The known nonmetallic mineral resources of the state include essentially stone, sand and gravel, and clay.

Stone comprises one of the most important mineral resources of the state. It is mined from various bedrock formations and is processed for use as either dimension stone or crushed stone. Dimension stone is used for building and ornamental purposes and must be of sufficient beauty and durability to find a place in the market. Crushed stone is used as aggregate in concrete and for other construction purposes and must be of proper chemical composition, strength, and durability to compete with sand and gravel. Ground limestone is used for agricultural purposes as a soil treatment. The various dolomite formations of the Silurian System of rocks and of the Sinnipee and Prairie du Chien groups of the Ordovician System of rocks (Figure 3) are important sources of dolomite and limestone for both dimension and crushed stone usage. The Upper Cambrian formations are a source of dimension dolomite and sandstone. The Cambrian sandstones and the Ancell Group are important sources of silica sand. The Precambrian System is an important source of granite, rhyolite, basalt, and quartzite, which are used as both dimension and crushed stone.

Those areas in which rock types of value for dimension or crushed stone are found and where the glacial overburden may be sufficiently thin to allow quarrying to take place are shown in Figure 5. The potential for development of new stone quarries is great but is dependent upon market demands.

The extensive glacial activity that has shaped Wisconsin's landscape was also responsible for providing one of the most valuable mineral assets to the state, namely sand and gravel. Extensive deposits of sand and gravel are found in most counties of the state, principally in glacial outwash formations (Figure 1). Such formations may be at the surface or may be buried beneath subsequent glacial debris. In some cases drumlins, eskers, and river sediments also contain valuable deposits of sand and gravel. The potential for discovery of new sand and gravel deposits is great. However, discovery and utilization of new deposits close to major consuming markets is becoming more difficult, as many deposits have been exhausted or the lands

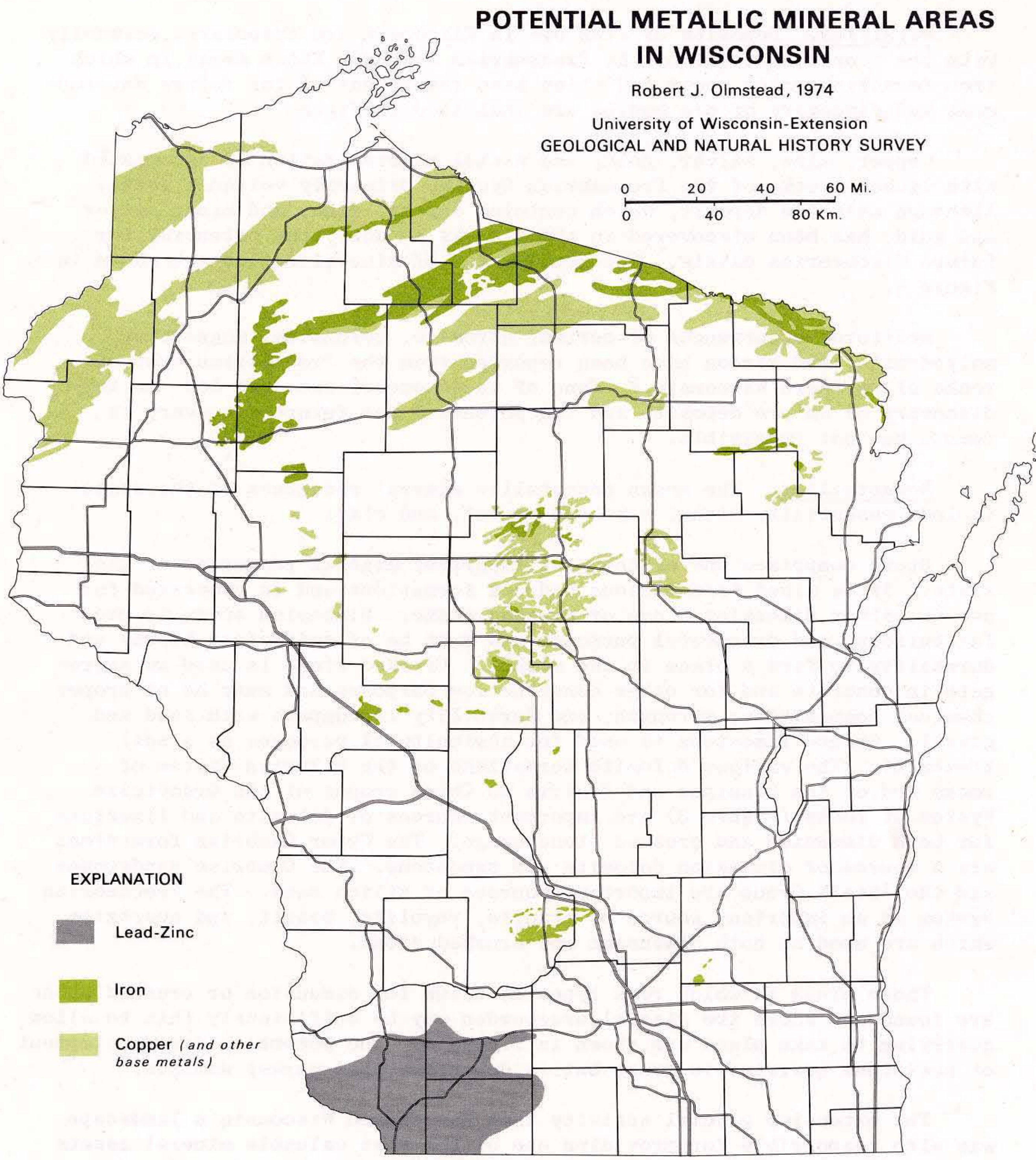



Figure 4. Potential metallic mineral areas in Wisconsin.

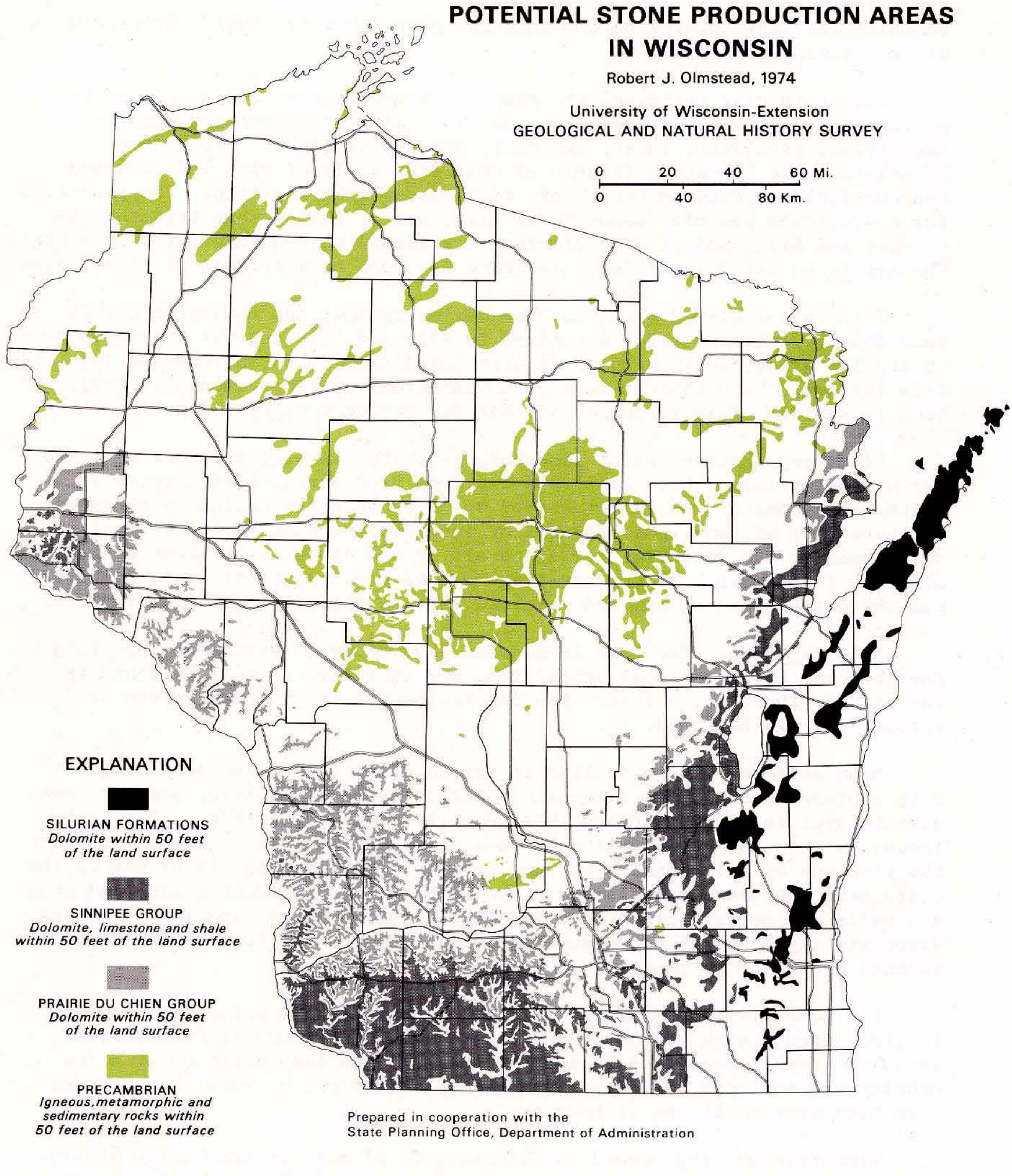



Figure 5. Potential stone production areas in Wisconsin.

on which they are located have been built over, thus precluding extraction of the mineral materials.

Wisconsin clay resources are found scattered throughout many counties of the state. These resources are mostly of glacial origin and occur as lacustrine, estuarine, loess, residual, and stream clays. The bedrock Maquoketa Shale Formation (Figure 3) consists mainly of clay and is mined near Oakfield in Fond du Lac County to produce brick and tile. The potential for discovering new clay deposits is high, but at the present time the use of clay for brick and tile manufacture has almost ceased to exist in the state. Changes in market demands indicate there may soon be a revival of clay mining.

Talc is associated with the Precambrian igneous and metamorphic rocks in Wood County. This material was mined in 1929 and 1930 but was abandoned due to the low grade, small size of deposits, and difficulty in removing impurities from the ore. With changes in market conditions or improvements in purification technology, this resource may some day become a mineral deposit.

Scattered occurrences of asbestos, graphite, marble, and rock suitable for use as abrasives have been reported from Precambrian System rocks in northern Wisconsin.[4] With the exception of those rocks useful as abrasives, all have been of low-grade material of insufficient quantity to warrant development. The potential for discovery of ore deposits of these nonmetallic minerals is unknown. As our knowledge of the geology of the state improves our chances of finding new and valuable mineral deposits will also improve.

Mineral Fuels. The rock formations that occur in Wisconsin were laid down before the age of coal deposition, and therefore no coal is found in the state. There is, however, the remote possibility that petroleum or natural gas may be found.

Some wells have been drilled in search of petroleum and natural gas in both southern and eastern Wisconsin. All of these wells have, however, been unsuccessful in locating producible quantities of hydrocarbons. The tens of thousands of water wells that have been drilled have also failed to indicate the presence of petroleum. The poor prospects for finding oil or gas in the state have not discouraged speculators from drilling wildcat wells, and even now wells are being drilled specifically in search of oil and gas. Perhaps Wisconsin may become a petroleum producing state in the future, but the chances are not very promising.

The potential for discovery of nuclear-fuel source materials is also limited, even though radioactive minerals have been found in Precambrian rocks at several locations within the state. With the exception of a few pebbles and boulders collected from glacial drift all of these occurrences have been very small and of poor grade.

Wisconsin has the second largest reserve of peat in the United States, some 2.5 billion tons on one million acres of land.[3] The deposits of moss, reedsedge, and humus peat, formed in swampy areas since the last glacial period, are distributed along the eastern one-half and northern one-third of the state. Peat was considered to be a source of low-quality fuel during the early 1900s, but use has shifted toward agricultural and soil conditioning purposes since that time. Continued expansion of these markets would result in an expansion of the peat-mining industry in the state.

## Chapter II

## WHAT IS THE VALUE OF WISCONSIN'S MINERAL INDUSTRY?

### Introduction

Minerals have been an important economic asset to the state of Wisconsin since early settlement days when the lead deposits of southwestern Wisconsin attracted prospectors and miners. Since those early days, the mineral industry has expanded and grown to include the production of lead, zinc, iron ore, clays, dimension stone, crushed stone, lime, sand and gravel, peat, and abrasives. The quantity and value of minerals produced in the state at 10-year intervals from 1910 through 1970 is presented in Table 3. Mineral production in 1971, the latest year for which U.S. Bureau of Mines statistics are available, was valued at $84,036,000[4], a slight decrease from the peak year of 1970.

### Lead

Lead was one of the first minerals produced in what was to become the state of Wisconsin. Galena, the principal lead mineral, was utilized for ornamental purposes in an unsmelted state by local Indian tribes prior to the coming of white explorers. Early French missionaries and explorers noted the presence of galena and extracted and smelted the ore to produce lead metal on a small scale during the period 1700-1800. The influx of settlers into the state during the early 1800s was primarily the result of the occurrence of galena. Sustained production of lead began in 1821 and reached its peak in 1845 and 1847, when more than 27,000 tons of lead was shipped from the mines.[5] Soon after statehood was granted in 1848 the value of the lead industry was recognized by the state legislature. Under a legislative act, a State Geological Survey was created on March 25, 1853. The act provided "that it shall be the duty of said state geologist to complete his survey of that portion of the state known as the 'lead mines' before commencing the survey of the remainder of the state."[6]

A summary of lead production since 1821 is presented in Table 2. Cumulative production is estimated to be about 723,000 tons of lead metal with a cumulative value of about $68,300,000. Lead continues to be produced in the state but as a subsidiary activity to the primary extraction of zinc minerals.

Table 2. Wisconsin lead production, 1821-1971.

| Years | Quantity Produced | Value |
|---|---|---|
| 1821-1851 | 294,941 tons [a] | |
| 1852-1881 | 295,034 tons [a] | $52,000,000 [a] |
| 1882-1911 | 45,492 tons [a] | |
| 1912-1941 | 48,048 tons [b] | $ 5,889,948 [b] |
| 1942-1971 | 39,384 tons [b] | $10,399,444 [b] |
| Total | 722,899 tons [b] | $68,289,392 [b] |

a Bain, H. Foster, Zinc and lead deposits of the Upper Mississippi Valley.

b Minerals yearbook, 1906-1971.

Table 3. Wisconsin mineral production, 1910-1970.

| | 1910 | | 1920 | | 1930 | | 1940 | |
|---|---|---|---|---|---|---|---|---|
| | Quantity | Dollar Value | Quantity | Dollar Value | Quantity | Dollar Value | Quantity | Dollar Value |
| Clay--tons | NA | $ 1,176,883 | NA | $ 1,413,255 | NA | $ 2,778,533 | NA | $ 326,000 |
| Iron ore-long tons | 1,149,551 | 3,609,139 | 1,067,159 | 4,333,307 | 1,148,277 | 3,179,175 | 1,227,840 | 3,290,389 |
| Lead--tons | 3,884 | 341,793 | 2,647 | 423,520 | 1,537 | 153,700 | 445 | 44,500 |
| Lime--tons | 248,238 | 959,405 | 144,590 | 1,539,027 | 64,989 | 598,739 | 65,632 | 542,749 |
| Peat--tons | 0 | 0 | NA | NA | 0 | 0 | 0 | 0 |
| Sand and gravel--tons | 1,451,758 | 425,563 | 2,422,689 | 1,553,622 | 7,082,063 | 2,801,713 | 6,742,882 | 2,304,197 |
| Stone--tons | NA | 2,644,518 | 1,564,940 | 3,729,236 | 3,370,750 | 5,100,266 | 4,330,360 | 5,030,263 |
| Zinc--tons | 20,952 | 2,133,216 | 27,285 | 4,420,170 | 12,558 | 1,205,568 | 5,770 | 727,020 |
| Miscellaneous | NA | 5,249,163 | NA | 497,360 | NA | 1,890,201 | NA | 734,885 |
| Total | -- | $12,504,977 | -- | $18,029,039 | -- | $17,711,394 | -- | $13,553,683 |

Table 3. Wisconsin mineral production, 1910-1970.--Continued.

| | 1950 | | 1960 | | 1970 | |
|---|---|---|---|---|---|---|
| | Quantity | Dollar Value | Quantity | Dollar Value | Quantity | Dollar Value |
| Clay--tons | 80,000 | $ 70,000 | 144,000 | $ 156,000 | 8,000 | $ 14,000 |
| Iron Ore--long tons | 1,702,000 | 8,814,000[b] | 1,502,000 | 16,222,000[a] | 806,000 | 10,308,000[b] |
| Lead--tons | 532 | 144,000 | 1,165 | 273,000 | 761 | 238,000 |
| Lime--tons | 124,530 | 1,448,000 | -- | --[a] | 247,000 | 4,503,000 |
| Peat--tons | 2,293 | 9,000 | 8,500 | 145,000[b] | 1,581 | 139,000[b] |
| Sand and gravel tons | 19,117,000 | 11,959,000 | 35,681,000 | 25,648,000 | 41,103,000 | 35,107,000 |
| Stone--tons | 7,000,000 | 14,495,000 | 16,486,000 | 22,302,000 | 17,577,000 | 25,167,000 |
| Zinc--tons | 5,722 | 1,625,000 | 18,410 | 4,750,000 | 20,634 | 6,322,000 |
| Miscellaneous | NA | 3,129,000 | NA | 7,675,000 | NA | 5,871,260 |
| Total | -- | $41,693,000 | -- | $77,171,000 | -- | $87,670,000 |

a Included under Miscellaneous
b Estimate
c Includes variously abrasive stones, barite, cement, marl, pyrites, sandline bricks, paint pigments, silica
NA Not Available
Source: Minerals yearbook, 1906-1971

## Zinc

Smithsonite and sphalerite, the primary zinc minerals, were considered worthless during early lead mining days. The establishment of a market for zinc in 1860 resulted in the mining and processing of zinc minerals.[5] Smithsonite, the zinc carbonate ore, was produced during the early period of zinc extraction. Since the late 1800s, sphalerite, the zinc sulfide ore, has been produced exclusively. Cumulative production of zinc in the state from 1860 to 1971 is presented in Table 4. Early production is presented in terms of ore, while later production is in terms of zinc metal contained. Converting the early ore production to contained metal yields an estimated cumulative production of 1,500,000 tons of zinc metal valued at about $253,000,000. Zinc continues to be produced in the state.

Table 4. Wisconsin zinc production, 1860-1971.

| Years | Production | Value |
|---|---|---|
| 1860-1905 | 450,000 tons carbonate and sulfide ore [a] | $ 10,000,000 [a] |
| 1906-1941 | 733,807 tons metal [b] | $110,674,613 [b] |
| 1942-1971 | 504,147 tons metal [b] | $132,546,030 [b] |
| Total | 1,500,000 tons metal [c] | $253,220,643 |

[a] Bain, H. Foster, Zinc and lead deposits of the Upper Mississippi Valley.

[b] Minerals yearbook, 1906-1971.

[c] Estimate.

## Iron Ore

Wisconsin's iron mining industry had its start in 1849 in the Mayville District in Dodge County. Most of the early mines produced limited quantities of ore for local blast furnaces. Large-scale iron mining on the Wisconsin portions of the Menominee and Gogebic ranges began in 1880 and 1885, respectively. A summary of production from the various Wisconsin iron districts is presented in Table 5. The value of total ore produced is not known but probably lies in the range of $500 million to $1 billion.

The closing of the last deep underground mine on the Gogebic Range in 1965 left the state without iron ore production until 1969, when a low-grade taconite deposit came into production near Black River Falls in Jackson County. The projected life of this mine is 20 years.

## Clay

The mining of clay for brick and tile manufacturing began on a small scale in the 1830s and reached its peak between 1900 and 1910, when as many as 157 plants were producing over 190 million bricks per year.[7] Production has continuously declined since this time until at present only two plants are operating within the state. Statistical data on clay production and value of manufactured clay products are incomplete. Recent data are concerned with the quantity and value of raw clay, while earlier statistical data reported the value of manufactured clay products. Clay products valued in excess of $1 million per year have, however, been reported for a number of years.

Table 5. Wisconsin iron ore production, 1849-1971.

| District | Years in Production | Quantity Produced (long tons) |
|---|---|---|
| Mayville District, Dodge County [a] | 1849-1928 | 2,580,000 |
| Ironton, Sauk County (bog ore) [b] | 1850-1873 | 25,000 |
| Florence District, Florence County [a] | 1880-1932 | 7,250,000 |
| Gogebic District, Iron County [a] [c] | 1885-1965 | 68,643,000 |
| Baraboo District, Sauk County [a] | 1904-1925 | 643,000 |
| Jackson District (concentrates), Jackson County [c] | 1969-present | 1,666,000 |
| | Total | 80,807,000 |

[a] Bean, E.F., Iron resources of Wisconsin: Paper presented at American Institute of Mining Engineers Meeting, Jan. 17, 1949.

[b] Strong, M., Geology of Wisconsin, Volume IV, 1873-1879, Part I, Geology of the Mississippi region north of the Wisconsin River: Beloit, Wis., 1882.

[c] Minerals yearbook, 1906-1971.

## Sand and Gravel

The sand and gravel industry dates from early settlement days when gravel was used for surfacing on roads. Statistical data on sand and gravel production are lacking prior to 1905, but since that year cumulative production of 1,012,842,198 tons with a value of $659,534,323 has been reported.[7] During 1970, the latest year for which county production statistics are available, there were 440 reported active sand and gravel operations, located in all but three counties of the state. Sand and gravel is produced and used within a short distance of the pit because of the low unit value of the material and high transportation costs. Since 1958, sand and gravel has been the single most valuable mineral commodity produced in the state. In 1971 Wisconsin ranked 7th among all states in production of sand and gravel.

## Stone

Wisconsin's stone industry produces both dimension and crushed stone from the sedimentary, igneous, and metamorphic rocks found in the state. The dimension limestone industry began prior to 1846 in Waukesha County, where limestone was quarried for use as a building material. In 1970, there were 39 active dimension limestone quarries in the state. Limestone is also produced and crushed for use as aggregate for the manufacture of lime and cement, and for agricultural limestone. In 1970, over 87 percent of the total state stone production was crushed limestone.

Sandstone was quarried as early as 1865 for use as dimension stone. Although the number of quarries producing dimension sandstone has declined over the years, there remained 18 active quarries in 1970 producing dimension sandstone, silica sand, and quartzite. High-purity silica sandstone is crushed for use as blast, molding, and special-use sands, while quartzite is crushed and used as abrasive grinding pebbles and as ballast.

The quarrying of igneous rocks such as granite, gabbro, and rhyolite for construction and monument usage began in 1880. In 1970, there were 15 active granite quarries. A small amount of crushed granite and basalt is also produced.

During 1970 a total of 436 active stone quarries were operating in 47 of the state's 72 counties, with 72 producing dimension stone and 364 producing crushed and broken stone. Cumulative production of stone, based on statistical data maintained since 1919, totals 397,886, 350 tons valued at $634,036,072.

## Peat

Peat is the only material classified as a mineral fuel that is produced in Wisconsin. Minor production of peat for fuel purposes occurred in the early 1900s, while production for agricultural purposes began in 1941. Two companies produced peat in 1970 from a humus peat deposit in Waukesha County and a moss and humus deposit in Lincoln County. Total production for 1970 was 1,581 tons. Although data are incomplete regarding cumulative peat production in the state, it is unlikely that this figure exceeds 75,000 tons. Some of the peat produced is of very high value due to special processing, packaging, and use as a seed inoculant.

## Minerals Consumption

An indication of the magnitude of the role of the minerals industry in our lives can be obtained by looking at our per capita consumption of mineral products. A random sampling of mineral consumption in the United States for the year 1970 is presented in Table 6. The greatest tonnages of material used are the construction and energy minerals, namely sand and gravel, crushed stone, and bituminous coal. Metal consumption amounts to but a few pounds of finished metal per person each year. The large tonnages of ore which must be processed to provide this metal are reflected in the statistics for bauxite (aluminum ore) and iron ore.

Metal ores produced in the state of Wisconsin are shipped outside of the state for processing into refined metals. In 1970 Wisconsin's metal ore production made up about 1 percent of the total U.S. iron ore production, about 0.1 percent of the U.S. lead production, and about 4 percent of the U.S. zinc production. Wisconsin's contribution to total U.S. consumption of these metals is even less due to imports of these metals. All other metals consumed by the people living in the state must be supplied by other states or by foreign imports.

The nonmetals produced in Wisconsin are for the most part consumed within the state. Sand and gravel and crushed stone are essentially utilized in-state for construction purposes. During 1970, some 18,608 pounds per person of sand and gravel were produced in the state and some 7,918 pounds per person of crushed stone were produced. This is more than twice the national per capita consumption of sand and gravel and slightly under the national average for crushed stone. Wisconsin's dimension stone is both used in-state and exported to other states. All other nonmetallic minerals must be imported from other states or foreign counties.

Table 6. National per capita consumption of selected mineral materials in 1970.

| Mineral Substance | Consumption per Person | Average Value per Person |
|---|---|---|
| Bauxite | 172 lb | $ 1.11 |
| Aluminum metal | 44 lb | $ 12.45 |
| Bituminous coal | 5088 lb | $ 15.90 |
| Copper metal | 20 lb | $ 11.70 |
| Iron ore | 1488 lb | $ 7.17 |
| Land metal | 13 lb | $ 2.10 |
| Phosphate rock | 116 lb | $ 0.31 |
| Sand gravel | 9291 lb | $ 5.49 |
| Crushed stone | 8592 lb | $ 6.79 |
| Zinc metal | 15 lb | $ 2.37 |
| Crude petroleum | 18 bbl | $ 58.19 |
| All minerals--U.S. production plus imports minus exports | | $155.02 |

Sources: U.S. Bureau of the Census, Census of population, 1970, and Minerals yearbook, 1970.

Wisconsin has no production of energy minerals. All of the petroleum natural gas, coal, and uranium used for production of energy must be obtained from outside of the state.

As the population of the state grows, our demands for mineral materials will increase even if our present consumptive levels remain constant. Recycling of materials can provide a portion of this demand. Some minerals, particularly the construction minerals sand and gravel and crushed stone, cannot be recycled at present. Continued production of these vital commodities is necessary to meet our future needs.

## Chapter III

## HOW ARE MINERALS PRODUCED IN WISCONSIN?

Minerals are extracted from the earth by a variety of mining methods, some relatively simple, others more complex. These mining methods fall into three broad categories: wells, surface methods, and underground methods.

### Wells

Wells are used for the extraction of petroleum, natural gas, sulfur, brines, hot water, steam, and potable water. Wells are small-diameter holes drilled into the earth's crust in search of a permeable rock reservoir that contains a valuable product. Minerals are extracted through the well bore by pumping or by natural flow due to pressure differential between the reservoir and the surface. Wells and related facilities occupy but a small area of the surface, generally a fraction of an acre for an individual well. Wells are used in Wisconsin to produce water. Holes drilled to explore for gas or oil have, so far, been unsuccessful. Such holes, together with exploration holes drilled to explore for other minerals are classified as test holes.

### Surface Methods

Surface mining methods are subdivided into three major groups--strip mines, open pit mines, and quarries--but the three have certain characteristics in common. All surface mines are operated to depths dictated by the thickness of the overburden and the value of the mineral material being extracted. As a general rule, surface mining is cheaper and safer than underground mining, with greater tonnages produced per unit of labor. Surface mining results in the recovery of nearly all of the mineral values present, while underground mining recovers much less of the deposit because of the need to support the workings with rock pillars that often contain ore. Surface mines tend to use large-scale earth-moving equipment, resulting in greater capital expenditures but lower production costs than for underground mines. In the short run, surface mines tend to disturb greater acreages of land than would comparable underground mines; however, subsidence of underground workings may lead to disturbance of the surface due to caging of the mine long after it has been abandoned. Reclamation of surface mines can be accomplished more easily and at less cost than reclamation of caving underground mines. Adequate preplanning of many surface mines can lead to rapid reclamation of disturbed lands.

Strip-mining is a term generally used to refer to the surface mining of coal. There is no strip-mining activity in Wisconsin and none is anticipated because of the absence of coal-bearing formations. Strip-mining involves the removal or "stripping" away of overburden materials to get at a mineral deposit which is generally and essentially flat-lying, occurs near the ground surface, and covers a large area. Due to the thinness of such deposits, mining at any one location is of short duration.

Strip-mining is commonly subdivided into area stripping, contour stripping, and auger mining. Area stripping refers to the progressive mining of coal beds from large acreages of land. This form of strip-mining results in the typical spoil peak topography shown in Figure 6. Contour stripping is practiced in areas of high topographic relief where the coal outcrops in the hillsides. Area stripping cannot be practiced at such locations due to increasing thickness of the overburden as the topography rises. Contour stripping follows the coal outcrop and progresses into the hillsides until the overburden becomes too thick for further economical stripping. An example of a contour strip mine is shown in Figure 7. Auger mining is a form of underground mining carried out by surface equipment and is used in conjunction with contour stripping. Once the contour pit has reached its final form, an auger is brought in to extract additional coal from the coal bed by drilling or augering into the seam from the strip pit. An example of auger mining is shown in Figure 8.

Open pit mining is a term usually applied to surface metal mines, while the terms pit and quarry are often used to refer to nonmetallic surface mines. Open pit mines are commonly characterized by limited surface extent, thick ore deposits and, thus, greater depths than other surface mines, and long-term production. Blasting is usually required to break the ore and waste rock prior to removal from the mine. In addition to the actual mine site, land surface is used to dispose of waste rock and overburden and to impound tailings generated during the concentration of valuable minerals from the ore. There is only one open pit metal mine in Wisconsin, the iron mine at Black River Falls (Figure 9). This mine is expected to occupy about 80 acres of land with waste rock dumps covering an additional 300 acres and tailings occupying about 240 acres of land. It is expected to be in continuous operation until at least 1989.

The terms pit and quarry are applied to nonmetallic surface mines. Pits are generally developed in unconsolidated materials such as sand and gravel. These mines tend to vary in size from small operations on a few acres of land to large excavations covering several hundred acres. The size of a pit is dependent upon the characteristics of the deposit and the location of property lines. If a deposit is uniform in grade, the active working face is often small. If the deposit is nonuniform, requiring blending to achieve a useful product, a number of widespread working faces may be maintained to furnish material necessary to produce the blended product. Pits are often of shallow depths and in many cases do not extend below the water table. When materials are to be removed from below the water table they may be removed either by dredging, or the use of drag lines and buckets, or by using pumps to lower the water level so that conventional machinery may be used.

The quantity of waste produced in pit mining is usually small. Often waste material is bypassed, or, if mined, is placed in worked-out portions of the pit. Washing or other separation processes may be necessary to produce a saleable product. The waste from such operations is placed in settling ponds and waste dumps. Such ponds and dumps may occupy unmined surface lands or may be confined to worked-out portions of the pit. Blasting is not normally required in pit mining operations as the mineral deposit is usually composed of unconsolidated materials. In Wisconsin, sand and gravel, clay, and peat are extracted by pit mining (Figures 10, 11, and 12).

Quarry is the term applied to surface mines developed in solid rock and from which stone is extracted and processed to produce either dimension or crushed stone. Quarries may be shallow or deep, tend to operate for extended periods of time at one site, and normally do not produce much waste material requiring surface disposal. To be economical, the amount of overburden must be relatively thin, (under 50 feet). Rock is removed from the quarry face by drilling and blasting. Light charges are used in dimension quarries and heavier charges are used in crushed stone quarries. Some dimension stone quarries cut and wedge the rock to remove it to prevent shattering caused by blasting. Quarries may be vertical excavations or may enter an outcrop horizontally. Representative examples of Wisconsin's stone quarrying operations are presented in Figures 13, 14, 15, and 16.

## Underground Methods

Underground mining methods are used to extract mineral materials from deposits that are too deep for surface mining. Because of the variety and complexity of underground mining methods, only a generalized discussion of these methods is presented.

All underground mining methods have certain basic characteristics and functions in common. They must provide support for the workings, particularly the entries, ventilation routes, and passageways such as the haulageways and manways. They must provide for the efficient and economical removal of the ore and movement of the ore to the surface. They must embody certain safety and health features to protect the underground working force.

An underground mine may be visualized as a community but with whole subdivisions stacked one on top of the other rather than spread out over the surface. Each subdivision represents one level in the mine, with the levels interconnected by vertical shaft openings. The streets of each subdivision are like the tunnels on each level of the mine. Each house is like a large body of ore. Repair shops, supply shops, sewer, water, compressed air, electricity, telephones, transportation, and other related facilities all must be provided in the mine just as similar facilities and services are required by a community.

Entry into underground mines is via vertical or inclined shafts or horizontal adits. These entries serve a number of functions, such as permitting entry of men and materials, removal of ore and waste rock, and ventilation of the workings. Each underground mine has one or more levels from which ore is extracted. On each level and between levels, a complex series of horizontal and vertical tunnels are excavated. These tunnels further extend the function of the mine entries--movements of men and materials, removal of ore and waste, and ventilation.

The ore is extracted from between mine levels by any one of a variety of extraction methods. The choice of extraction method to be used at any individual mine is based on the physical characteristics of the ore and waste as well as size and shape of the mineral deposit, value of the ore, and other engineering and economic considerations. Some mines require little support to keep the mine workings from collapsing, while others require extensive support to keep the workings open. Other extraction methods are based on the ability of the ore and waste to fracture and cave when undermined and utilize these properties under controlled conditions to extract the ore.

After extraction from a mine, the ore is brought to the surface. The desirable minerals in an ore are separated from undesirable materials by means of a process called concentration which is usually done in the vicinity of the mine. The ore concentration process generates waste called tailings, which require land surface for disposal. Waste rock from the mine is also brought to the surface for disposal in waste dumps that require land surface. In addition to tailings and waste disposal, surface structures such as head-frames, change house, offices, repair facilities, and other related structures occupy the land surface.

Two basic underground mining methods have been used in Wisconsin. The room and pillar method is used in the zinc-lead district of southwestern Wisconsin and was also used to extract sandstone at two mines located along the Mississippi River bluffs in Pierce County. In this method ore is extracted from an interconnected system of openings called "rooms". The rooms are separated by "pillars"--rock that is left in place to support the and prevent its collapse. The amount of pillar required to support the mine depends on the strength of the rock and weight it must support. Commonly, over 35 percent of the rock, much of which may contain ore, must be left behind in the form of pillars. The sublevel caving method was used in the iron mines of northern Wisconsin. This complex method involves mining several levels in the top of the ore body (sublevels) and then blasting out the supporting timbers which allows the overlying material to cave onto a timber flooring covering the underlying ore. Mining progresses downward with the timber support blasted out after two or three slices of ore have been removed.

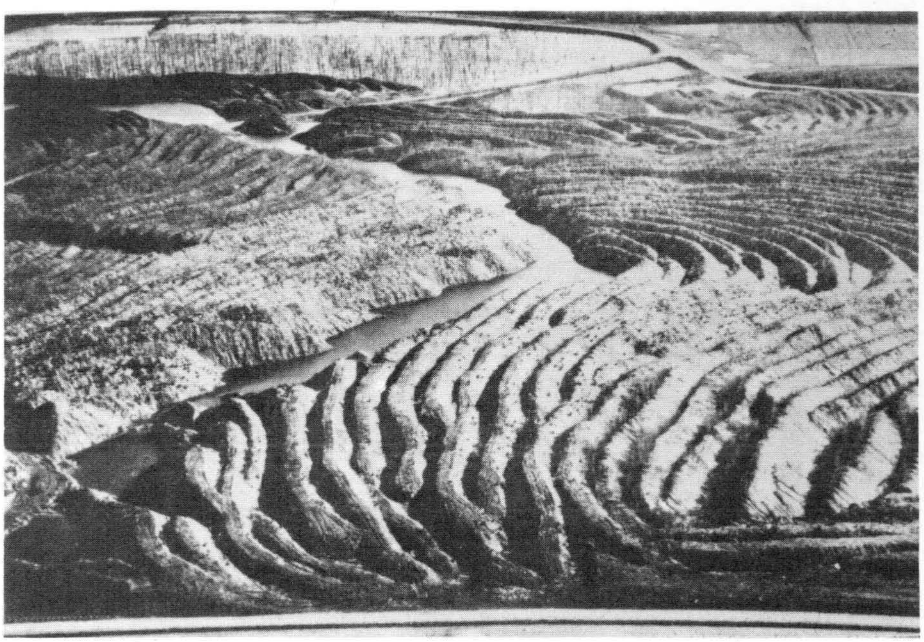


Figure 6. Typical spoil topography created by area strip-mining in Kentucky.

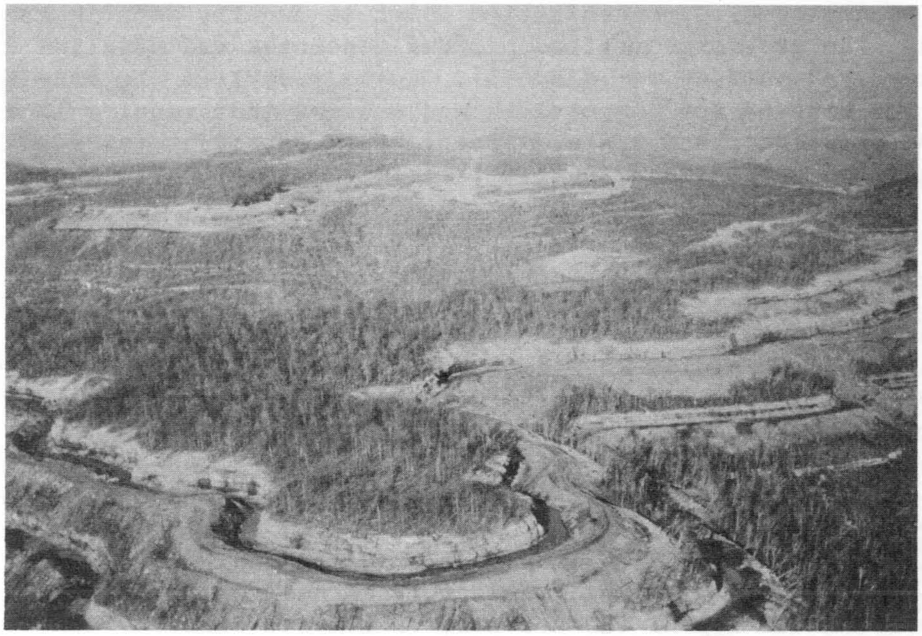


Figure 7. Contour strip mine in West Virginia.

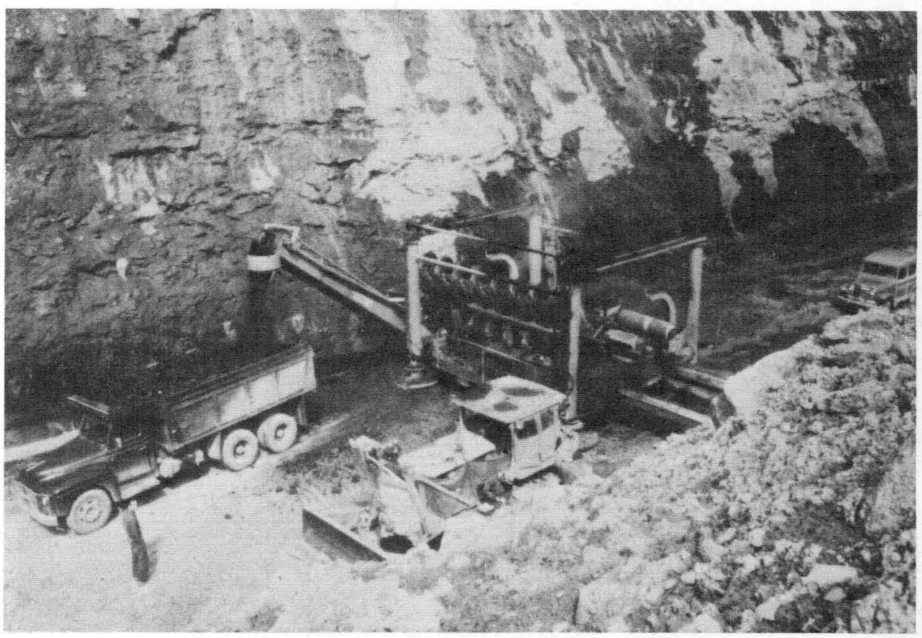


Figure 8. Auger mining operation in Kentucky.

Figure 9. Jackson County Iron Company open pit iron mine near Black River Falls, Jackson County.

Figure 10. Clay pit of the Oakfield Brick Works, Oakfield, Fond du Lac County.

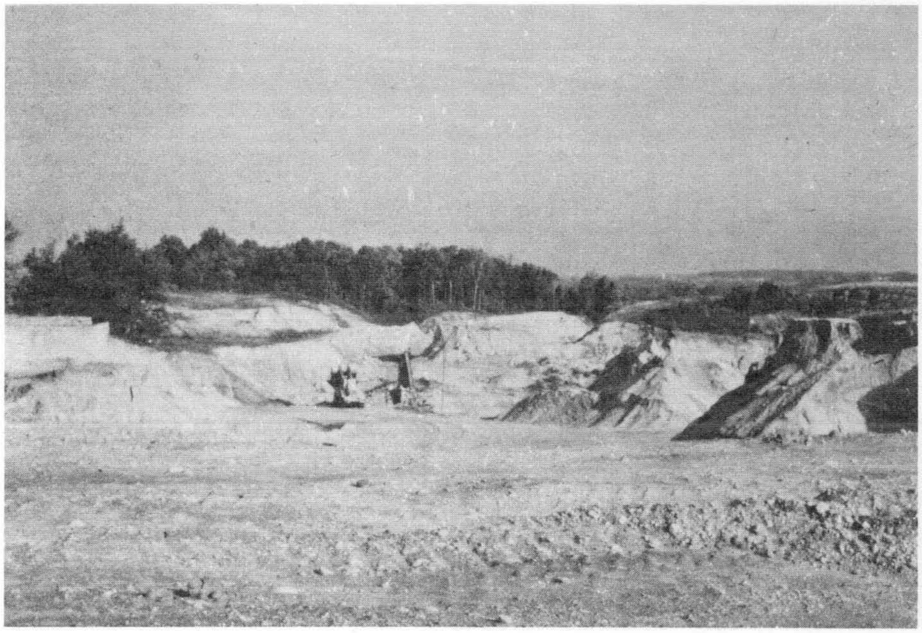


Figure 11. Sand and gravel pit, Cedar Lake Sand and Gravel Company, Washington County.

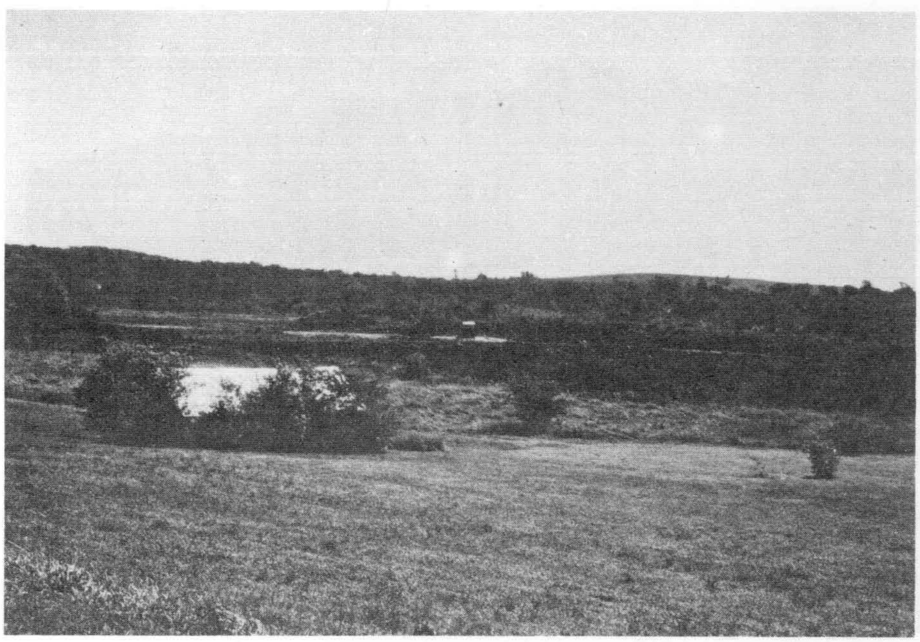


Figure 12. Peat pit of Demilco, Inc., near the city of Waukesha, Waukesha County.

Figure 13. Vertical crushed limestone quarry of Vulcan Materials Corporation near Sussex, Waukesha County.

Figure 14. Horizontal crushed quartzite quarry on Rib Mountain, Marathon County.

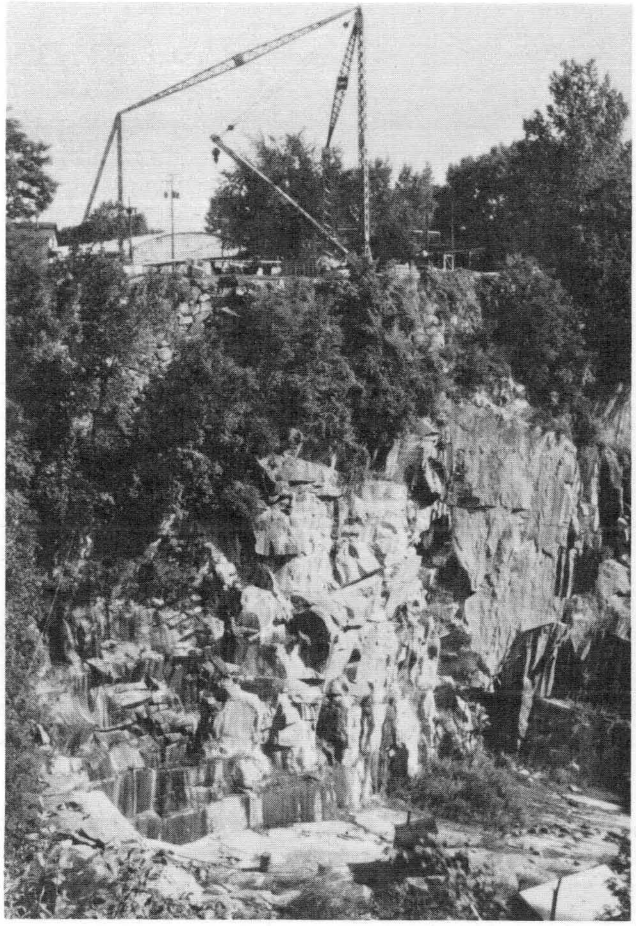


Figure 15. Dimension granite quarry of Montello Granite Company, at Montello, Marquette County.

Figure 16. Dimension limestone quarry of Wislanco, Inc. at Lannon, Waukesha County.

## Chapter IV

## WHAT ARE MINED LAND RECLAMATION AND SEQUENTIAL LAND USE?

Reclamation of lands affected by mining activity is the process of reducing the undesirable effects of mining to a more desirable state and includes the improvement of operating mines as well as rehabilitation of abandoned mine sites. The concept of sequential land use, as it applies to mined land, implies that mining is one of several uses which are planned to occur on a specified plot of land in a predetermined sequence. It provides that planned reclamation will take place and that the reclamation will be tailored to a specific end use of the land. In order to develop a workable sequential land-use plan for a mining operation, it is essential to know how mining affects the land and what are the alternatives for reclamation of mined lands.

### The Effect of Mining on the Land

Mineral extraction, whether by wells, surface mines, or underground mines, can affect the land surface in one of several ways. Extraction of mineral materials from open pit mines, pits, and quarries results in physical disturbance of the land surface and changes in surface configuration of the affected lands. An example of an unreclaimed pit is shown in Figure 17. Land such as this is removed from productive use until it is reclaimed and a sequential use established.

Extraction from underground mines may eventually lead to subsidence of the land surface due to failure or collapse of the workings. Caving of old stopes may also affect the land surface as shown in Figure 18. Failure to fill or seal shafts or adits upon abandonment of underground mines can create safety hazards and attractive nuisances, as shown in Figure 19. Subsidence, caving stopes, and open shafts can hinder or prevent future development and use of land.

Wells, surface mines, and underground mines require surface structures such as buildings and roadways to support the mineral extraction activities. Some of these structures may be readily converted to sequential use upon completion of mining activities. Others that cannot be converted for sequential use are often left standing, and gradually deteriorate with time. Structures such as the abandoned mill shown in Figure 20 occupy the land surface and should be removed during reclamation of the land.

Both surface and underground mines may produce waste rock and/or tailings which require disposal on the land surface. If waste dumps are not planned with an end use of the land in mind, they can pose a serious obstacle to future land use. Waste rock from the Montreal Mine on the Gogebic Range, as viewed from the community of Gile, is shown in Figure 21. Considerable reclamation work will be required to return such land to sequential use. Tailings ponds not only occupy the land surface but are often subject to water and wind erosion due to the fine size of the tailings (Figure 22). Tailings ponds, if not reclaimed, result in wasted land surface and can affect surrounding land uses due to the high erosion potential.

Without planned reclamation, land disturbed by mining activities may be rendered useless for extended periods of time.

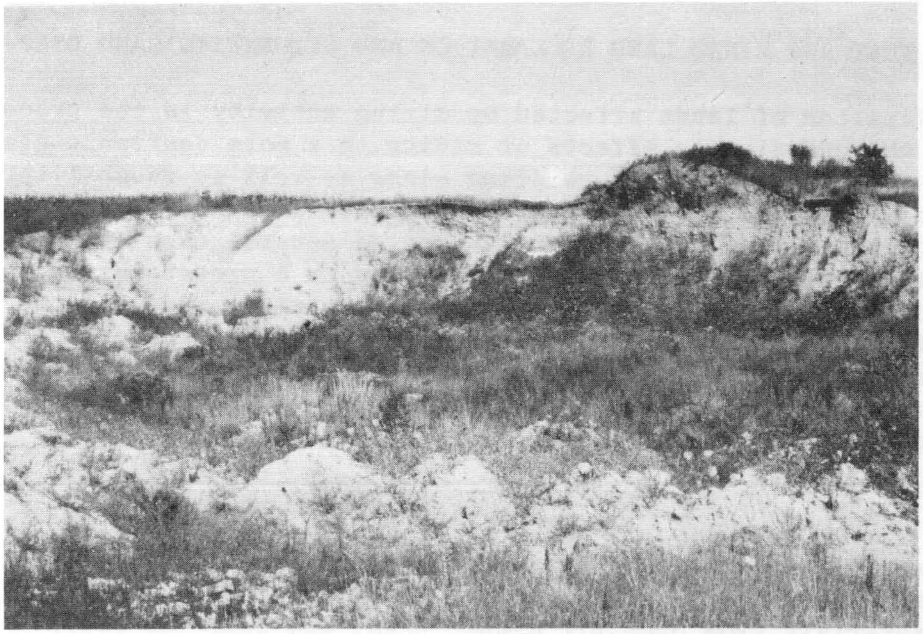


Figure 17. Abandoned sand and gravel pit, Dane County.

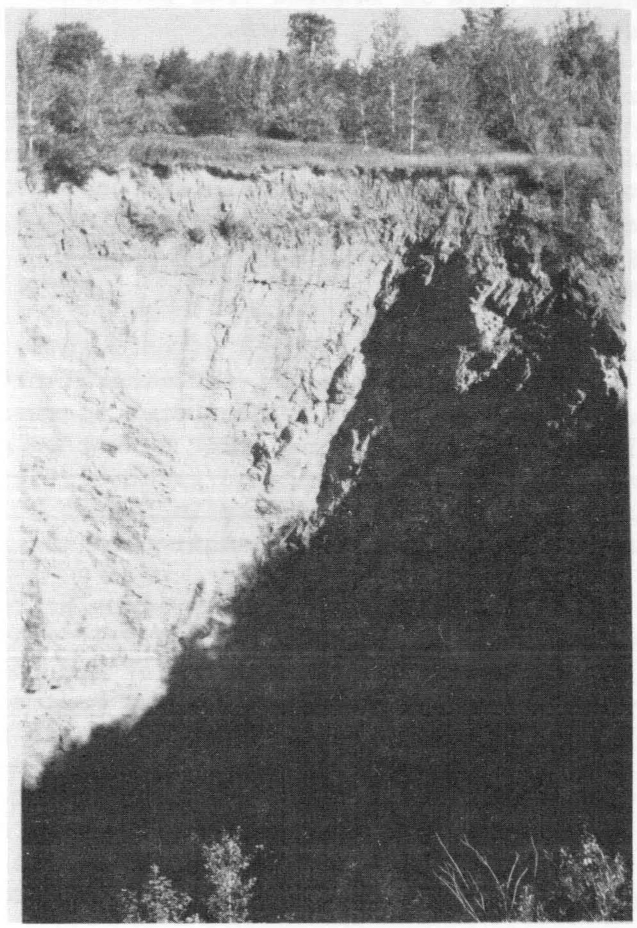


Figure 18. Caved stope from underground iron mining activity near Hurley, Iron County.

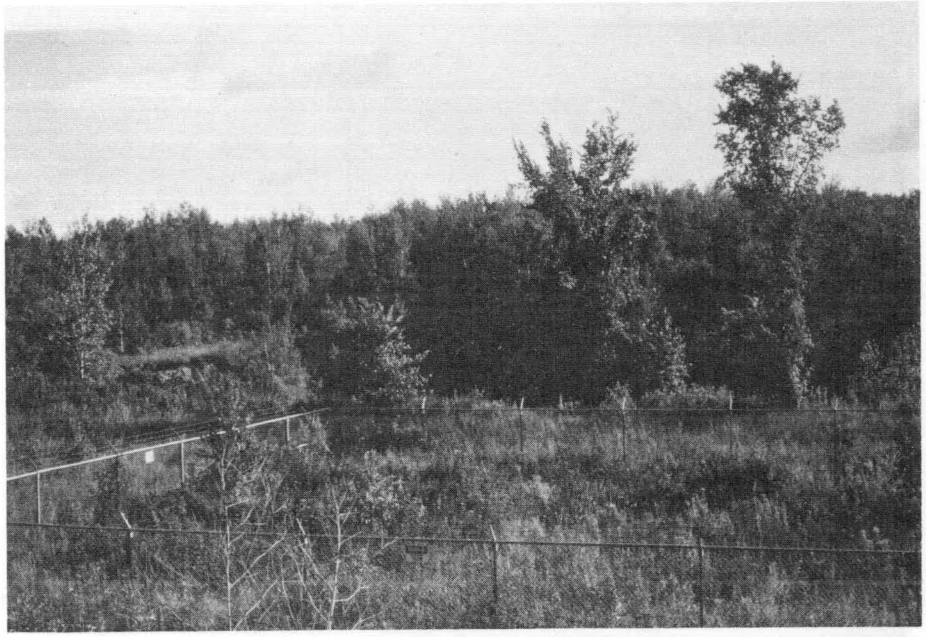


Figure 19. Open shaft of old iron mine, Montreal, Iron County.

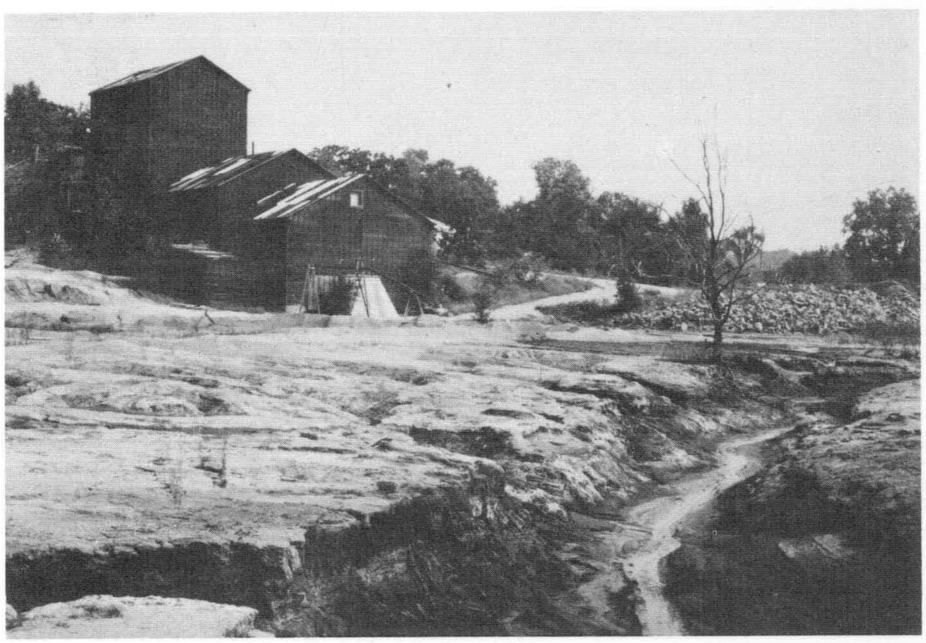


Figure 20. Old lead-zinc mill near Linden, Iowa County.

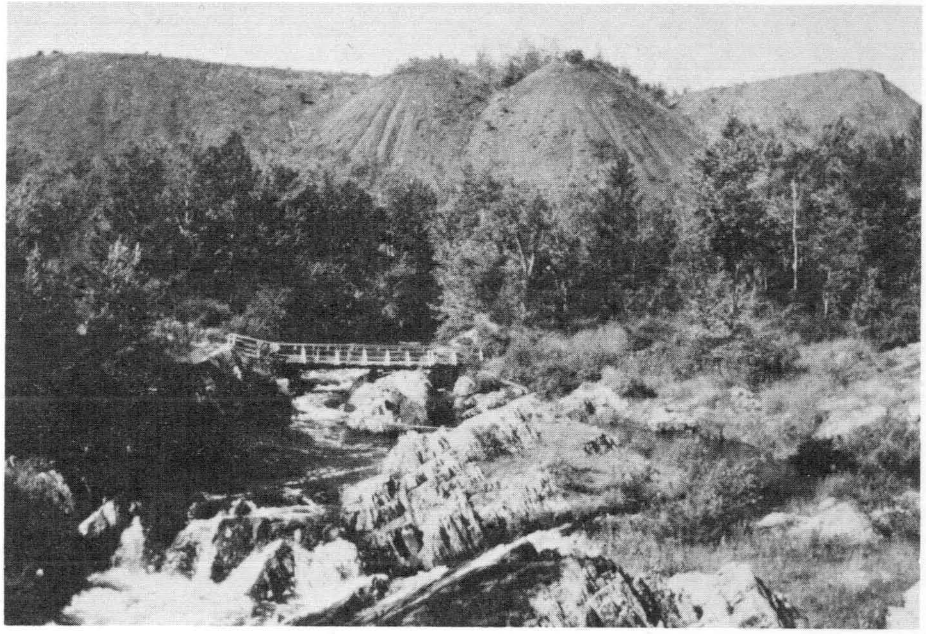


Figure 21. Waste rock dump from Montreal iron mine, Montreal, Iron County.

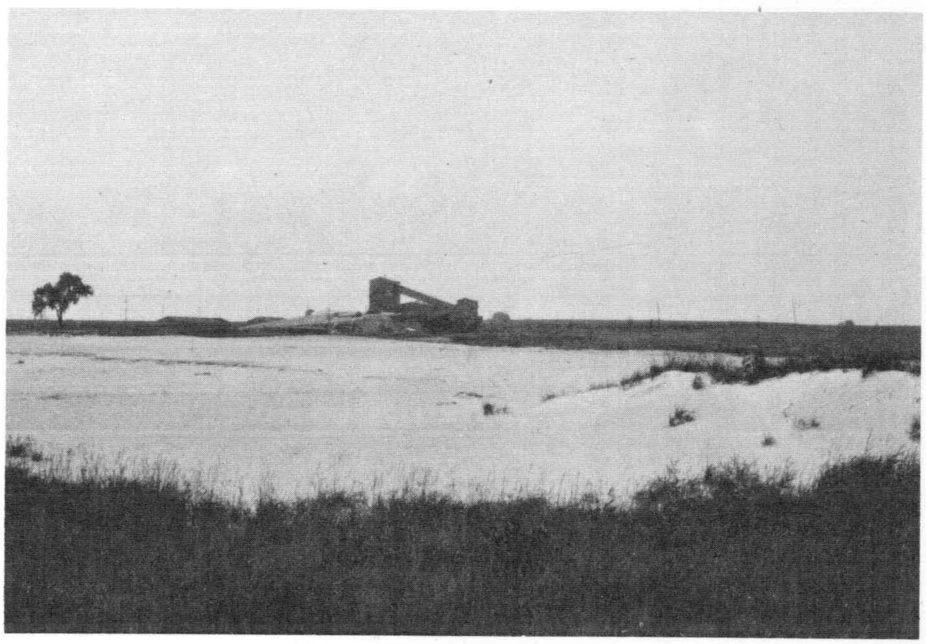


Figure 22. Tailings from concentration of lead-zinc areas near Elmo, Grant County.

## Reclamation of Mined Lands

The degree of success of reclamation varies with each mine site and depends on a number of factors. Climate, soil types, topography, water-table depth, type of mine, depth of mine, quantity of waste rock, surrounding land use, proximity to population centers, surrounding scenic values, regulatory controls, economics, and many other factors have a bearing on reclamation practices. Reclamation of mined land in Wisconsin is greatly enhanced because of the near ideal conditions of soils, climate, and topography, and by the types of mining activity conducted in the state.

Physical disturbance of the land surface and changes in land elevation resulting from well drilling and surface mining may be treated in a variety of ways. Reclamation of an exploratory oil or gas well, for example, can be readily accomplished by filling the well bore, removing surface equipment, covering and grading drill mud pits, and revegetating the disturbed surface. A planned reclamation program for a drill site can erase any trace of drilling activity within a single growing season. Because of the limited land area involved in a drilling site, the site is usually reclaimed for the same land use that existed before drilling commenced.

Pits are the easiest form of surface mine to reclaim. Grading of the land, replacement of topsoil, provided it has been segregated and stockpiled, and revegetation can prepare these lands for almost any type of sequential use. Pits that have been excavated below the water table are often reclaimed as lakes and are suitable for a variety of sequential uses. More complex reclamation practices can be applied to pits in order to prepare the land for such special use as a golf course, or sanitary landfill.

Open pit mines are often difficult to reclaim because of the depth and steepness of the excavation. Back filling of such mines is impractical due to high cost and lack of large volumes of fill material. Location and topography of surrounding land may indicate potential reclamation practices and sequential use of the land. Lakes often can be created in open pit mines in Wisconsin with surrounding mined land developed to complement lake usage. Reducing the angle of the rock above the water level is often necessary in the development of a lake.

Quarries with vertical faces are similar to open pit mines insofar as reclamation is concerned. Some vertical quarries fill with water and lend themselves to creation of a lake with surrounding lands reclaimed for water oriented use. Reduction of the vertical walls to more gentle slopes may be necessary to allow access to and use of the lake. Quarries that do not extend below the ground level elevation or that can be readily filled to ground level can be reclaimed for a variety of sequential uses ranging from residential to heavy industrial. Rock exposed in the quarry walls may be left in place or may be blasted to reduce the slope, covered with subsoil and topsoil, and revegetated.

Underground mining in Wisconsin has resulted in relatively minor damage to the land surface through subsidence, caving, or open shafts. The zinc-lead mines of southwestern Wisconsin are excavated in limestone that has proven to be very strong. Subsidence and caving are rare. The iron mines of northern Wisconsin used a method of mining that involved caving of the ground for extraction of the ore. Some of this caving has progressed to the surface. Open mine entries may be found in both the zinc-lead district and the iron ore district. Reclamation of subsided or caved ground and open mine entries may be accomplished by filling. After settling and compaction of the fill, the land may be returned to sequential use. Because of the potential hazard of additional subsidence or caving, sequential use for agriculture or recreational purposes is more desirable than use for residential purposes. Some shafts have been capped with concrete and fenced to prevent access. The small surface area involved is lost to sequential use with this method. Reclamation of land occupied by mine-related surface structures is readily accomplished either through use of the buildings directly for sequential use or through removal of the structures. Demolition of the buildings, filling of basements, grading, and revegetation can return the land to its premining condition. Sequential use of such buildings is often dependent upon the sequential use planned for the mined land. Additional grading or shaping of the land to compliment such use may be necessary.

Reclamation of waste dumps is most readily accomplished if the dumps are preplanned according to the sequential land use. Movement of waste rock is costly, particularly if it must be moved a second time. Reclamation of waste dumps includes grading of outslopes, covering the rock with soil, and revegetating. Benching of dumps to reduce erosion and contouring of dumps to blend into the surrounding topography can enhance the reclamation effort. Waste dumps can be useful for creating land forms suitable for various sequential uses. Tailings ponds when dewatered and drained can be reclaimed by replacement of soil and revegetating. Often tailings impoundments are placed in natural depressions, and the resultant land created by the tailings may be suitable for agricultural or other nonintensive sequential uses. Both waste rock and coarse tailings may be of value for local highway construction. This has been the case of waste rock from iron mining operations and both waste rock and coarse tailings from zinc-lead mines.

Reclamation techniques are constantly improving as the minerals industry gains experience in this area. Unreclaimed mined lands are readily recognized as such. Reclaimed mine lands normally do not show any indication of their former use for mineral production.

## Sequential Use of Reclaimed Mined Lands

Examples of reclaimed mined land that have been put to sequential use can be found in many areas of the state. In some cases the mined land was donated or sold to local or state government for development, other lands were sold to real estate companies for development, while other mined lands were reclaimed and put to sequential use by the mining companies.

Optimum utilization of mined land requires planning for sequential use prior to mining so that reclamation may be carried out in the most practical and efficient manner. The sequential use that is planned for a mining operation is limited only by certain physical constraints such as size of the property, depth of excavation, and quantity of waste, and by the imagination of those planning the reclamation and sequential use.

The pictorial review (Figures 23-33) of sequential use of mined land for residential, commercial, industrial, recreational, and agricultural purposes that follows represents but a few of the many examples that exist around the state.

Residential Use

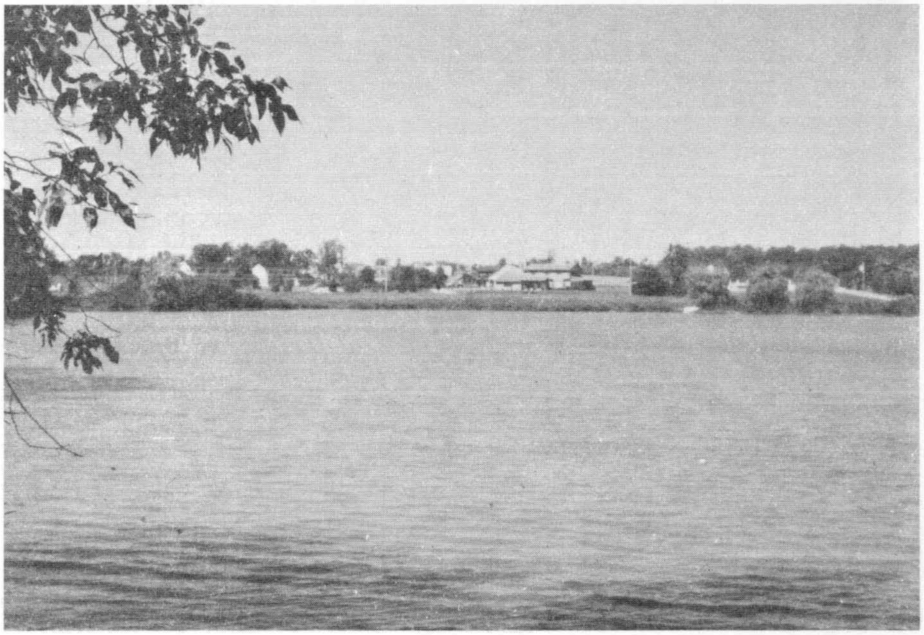


Figure 23. Sixty-acre private lake constructed in a former sand and gravel pit with residential development on surrounding land. Lac du Cours subdivision, city of Mequon, Ozaukee, County.

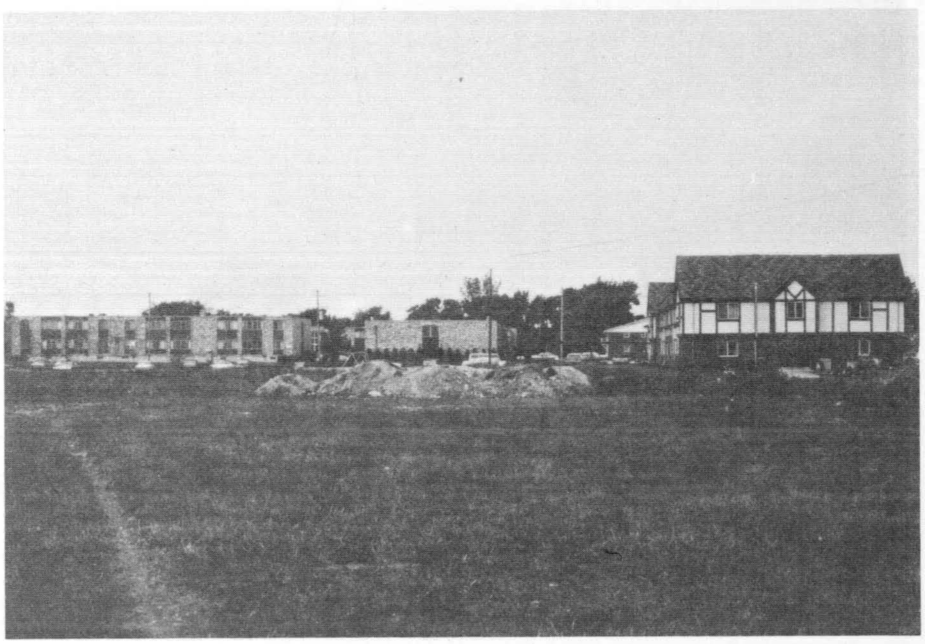


Figure 24. Former sand and gravel pit utilized for sanitary landfill site with apartment buildings constructed on the filled land in the city of Waukesha, Waukesha County.

Commercial Use

Figure 25. Former sand and gravel pit used for the Bay Shore Shopping Center in the city of Glendale, Milwaukee County.

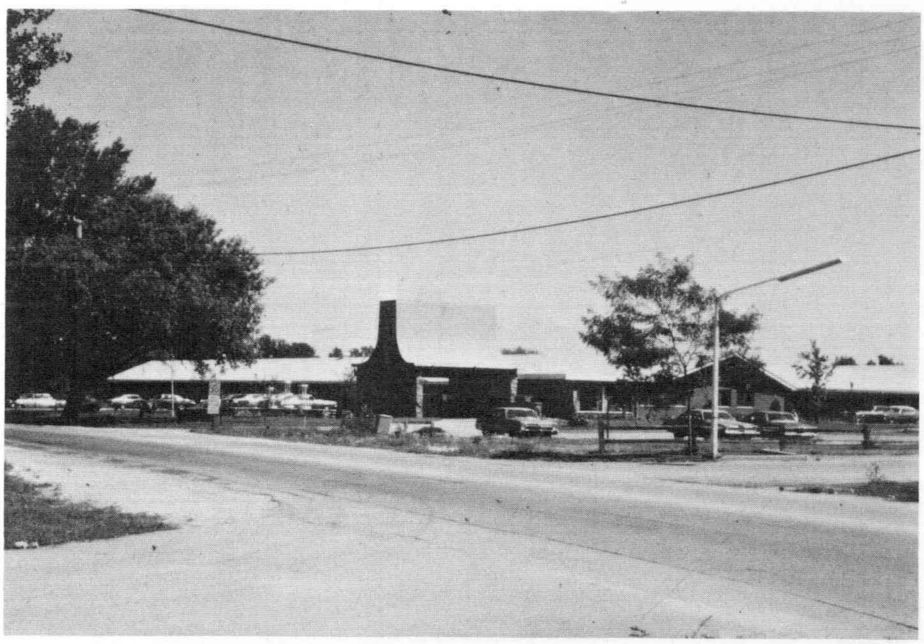


Figure 26. Former sand and gravel pit used for nursing home, in the city of Glendale, Milwaukee, County.

Industrial Use

Figure 27. Former quarry site filled to ground level and used for heavy industrial plants.

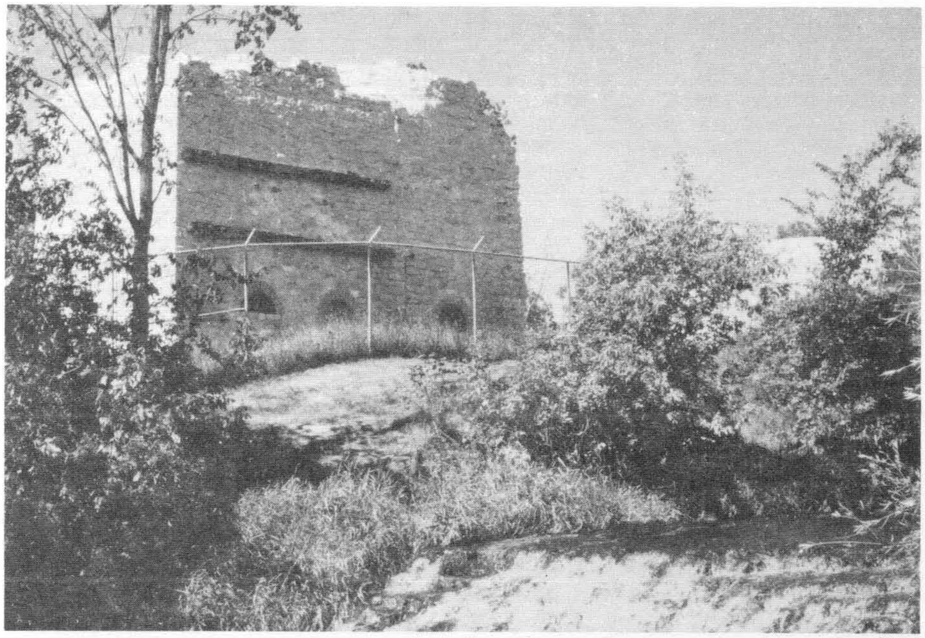


Figure 28. Conversion of historic lime manufacturing site into a community park. Lime Kiln Park, Menomonee Falls, Waukesha County.

Figure 29. Reclaimed dimension limestone quarry for swimming, picnicking, camping, and fishing. Menomonee Park, Waukesha County Park System, Waukesha County.

Figure 30. Reclaimed clay pits of the old Hilker Brothers North Point brickyard for city of Racine golf course and picnic area. Shoop Park, Wind Point, Racine County.

Figure 31. Highway borrow pits reclaimed for use as roadside parks.

Agricultural Use

Figure 32. Former sand and gravel pit reclaimed for agricultural purposes, Ozaukee County.

Figure 33. Former sand and gravel pit reclaimed for agricultural purposes, Fond du Lac County.

## Chapter V

## HOW DOES MINERAL EXTRACTION FIT INTO LAND-USE PLANNING?

### Introduction

Wisconsin's land and water resources must support a wide variety of uses to fulfill the wants and needs of the people. Agricultural, recreational, residential, industrial, transportation, mineral extraction, and a host of other uses compete for the land and water resources. In 1973 the use of land surface in the state, included 56.6 percent in farmland, 17 percent in public and state recreation, 11 percent in private woodlands, 6.5 percent in urban and built-up lands, and 2.8 percent in transportation[8]. Although our land and water resources are limited, large acreages with suitable characteristics are available to support these major uses. Planning for such usage is generally uncomplicated due to the availability of alternate sites.

Certain land uses rely on the unique characteristics and features of a site, such as the occurrence of unusual scenic features, historical or prehistorical sites, rare geological features, and wildlife or wilderness areas. Examples include:

1. Wisconsin Dells--a scenic 7-1/5 mile stretch of the Wisconsin River.

2. Aztalan--a 123-acre historical park containing an ancient indian village site.

3. Tower Hill--a 108-acre historical park containing a lead shot tower.

4. Point Beach State Forest--a 2,517-acre site containing fossil and scenic areas.

5. Kettle Moraine State Forests--three parks totaling 36,086 acres containing glacial geology features and of scenic value.

6. Horicon Marsh Wildlife Area--a 10,857-acre state wildlife area.

7. Horicon National Wildlife Refuge--a 20,796-acre federal wildlife area.

Many of these unique sites have been preserved under federal, state, county, or local governmental auspices. Substitute sites do not exist which embody similar characteristics, nor can we arbitrarily move such sites to more convenient geographic locations. Most of these sites occupy only minor land acreage and should be given use priority over more common uses for which substitute lands are more readily available.

Our mineral resources are also unique in that each deposit occupies a single unit under a relatively small land area. Land used for mineral production in 1971 totalled 2,284 acres, or .006 percent of the total area of the state. The average mineral productivity per acre of land used by the mineral industry in this same year was $36,793. Cumulative land surface used for mining operations between 1930 and 1971 totalled 46,880 acres, or 0.13 percent of the total area of the state. A summary of mineral land-use statistics is presented in Table 7.

Mineral deposits were emplaced during geologic times and must be extracted where they naturally occur if they are to be of benefit to man. Certain mineral materials are more plentiful than others, and their individual uniqueness is often overlooked. Certainly our zinc-lead, iron ore, and copper deposits are more unique than sand and gravel or stone deposits. Yet even sand and gravel and stone deposits are unique, particularly as we utilize large quantities of these minerals and deplete the total available supply.

Mineral extraction is, however, an industrial activity that often comes into conflict with other land uses. Mining in remote areas comes into conflict with recreational, wilderness, scenic, and wildlife uses, while mining near communities comes into conflict with intensive residential and commercial uses. Many mineral deposits have been lost to use because their locations and value were not recognized prior to the placement of buildings and structures on the lands that they occupy. Other mineral deposits have been rightfully lost because their use would conflict with even more unique land values.

The key to land-use planning for mineral extraction is two sided: We must have adequate knowledge of where our mineral deposits are located so that we may plan for extraction, sequential land use, and minimum of conflict; and we must provide for the creation of mineral reservation and extraction districts with adequate zoning regulations and controls to integrate mineral production with society's mineral demands and a community's land-use objectives and plans.

Table 7. Mineral land-use statistics for the state of Wisconsin.

| | |
|---|---|
| **1971** | |
| Number of mining operations | 769 |
| Acreage mined by surface mining methods | 1,301 acres |
| Total land surface used by mineral industry | 2,284 acres |
| Total surface area reclaimed by mineral industry | 1,603 acres |
| Total value of mineral production | $84,036,000 |
| Production per acre mined | $52,424 |
| Production per acre used | $36,793 |
| **1930-1971** | |
| Cumulative surface area used by mineral industry | 46,880 acres |
| Cumulative surface area reclaimed by mineral industry [a] | 12,400 acres |

Source: U.S. Bureau of Mines, Washington, D.C.
[a] Does not include lands reclaimed by private developers on orphaned lands.

## Basic Resource Data Collection

Acquisition and interpretation of geologic, soils, and hydrologic data is a basic ingredient for many land-use planning and management functions. Basic data on surface and bedrock topography, surface and bedrock geology, and surficial deposit thickness are vital to mineral resource planning. Collection, interpretation, and use of such data in mineral resource planning is discussed using example maps from Burke Township in Dane County. These maps were taken from a Wisconsin Geological and Natural History Survey publication (in process) by Perry G. Olcott, entitled, Land Use and The Geologic Environment for Burke Township, Dane County.

An index map showing the location of Burke Township is presented in Figure 34.

Land Surface Topography. Topographic maps are generally prepared from air photos using bench marks on the ground for elevation control. Topographic maps for many areas of the state have been prepared in this manner and published by the U. S. Geological Survey. These maps contain a wealth of basic planning data. The shape and elevation of the land surface is shown by lines of equal elevation, or contour lines with elevations measured from mean sea level. Topographic maps also show the location and elevation of bench marks and water features such as lakes, rivers, and wetlands as well as manmade objects like roads, railroads, buildings, and transmission lines.

The land surface topography for Burke Township is shown in Figure 35. This map contains only contour lines showing land elevation with a contour interval of 40 feet. Similar maps with a contour interval of 10 feet are available. Land elevations range from about 860 feet in the western portion of the township to 1,060 feet in the southeastern corner. A broad north-south trending valley is found in the western section, with rolling highlands and occasional knolls in the remaining areas.

Land surface topographic maps serve as a base for most subsequent surface mapping and planning activities and are particularly useful in preparing surficial geology, surficial deposit thickness, and hydrologic maps.

Bedrock Topography. Bedrock topography is often obscured by unconsolidated surficial materials such as sands and gravel. Direct measurement of the bedrock surface elevation can be obtained from outcrops, from exposures in excavations, road cuts, and quarries, and from well logs. Geophysical measurements can also provide information on the depth of the bedrock surface. Interpretation of bedrock surface elevations between data points is necessary to construct the bedrock topographic map. Such interpretive work is always subject to revision as additional data is acquired.

The bedrock topography for Burke Township is presented in Figure 36. This map depicts the relief of the bedrock surface by contour lines with a contour interval of 50 feet. Bedrock elevations range from 500 feet in the southwestern corner to over 1,050 feet in the southeastern corner.

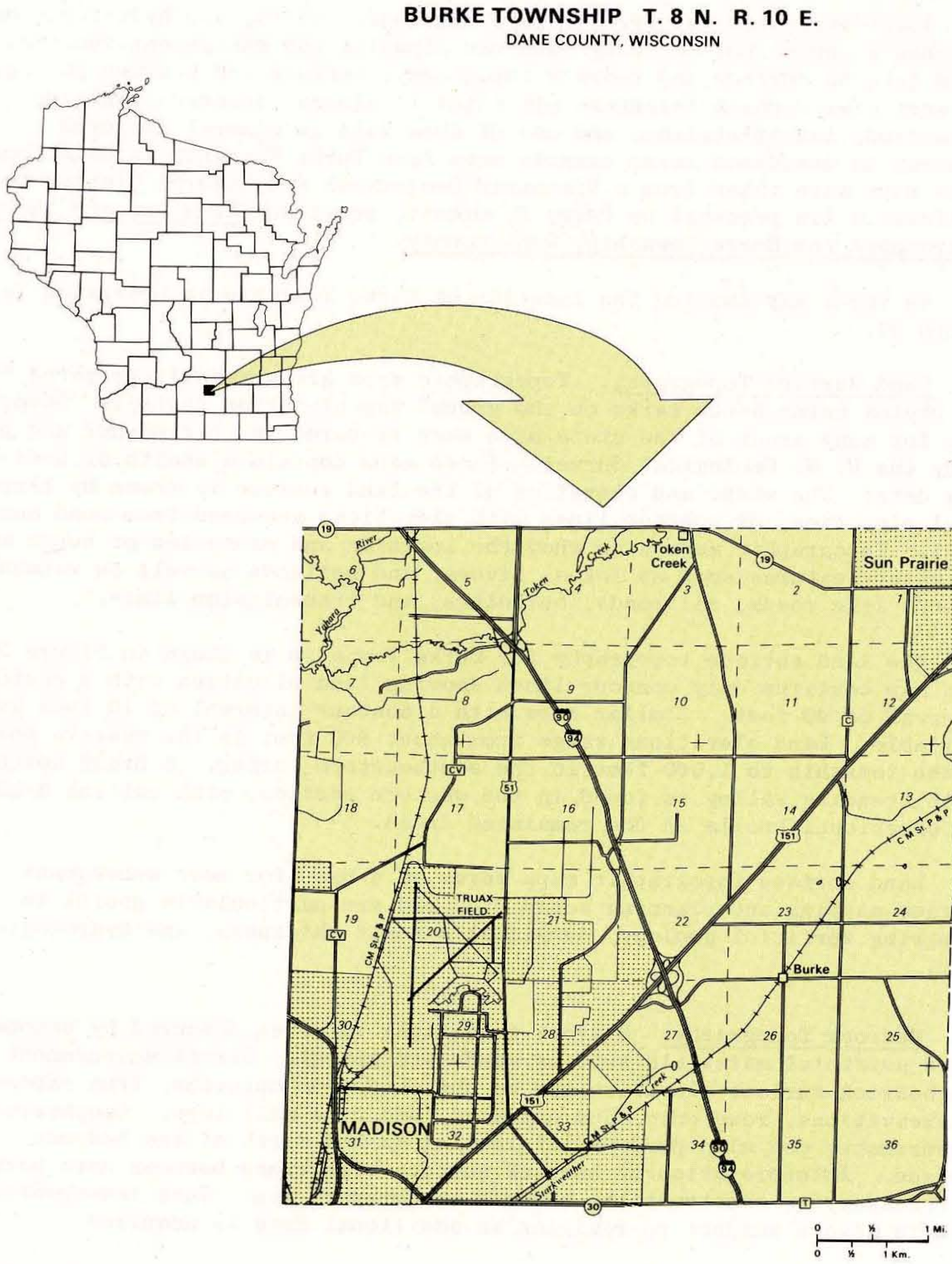
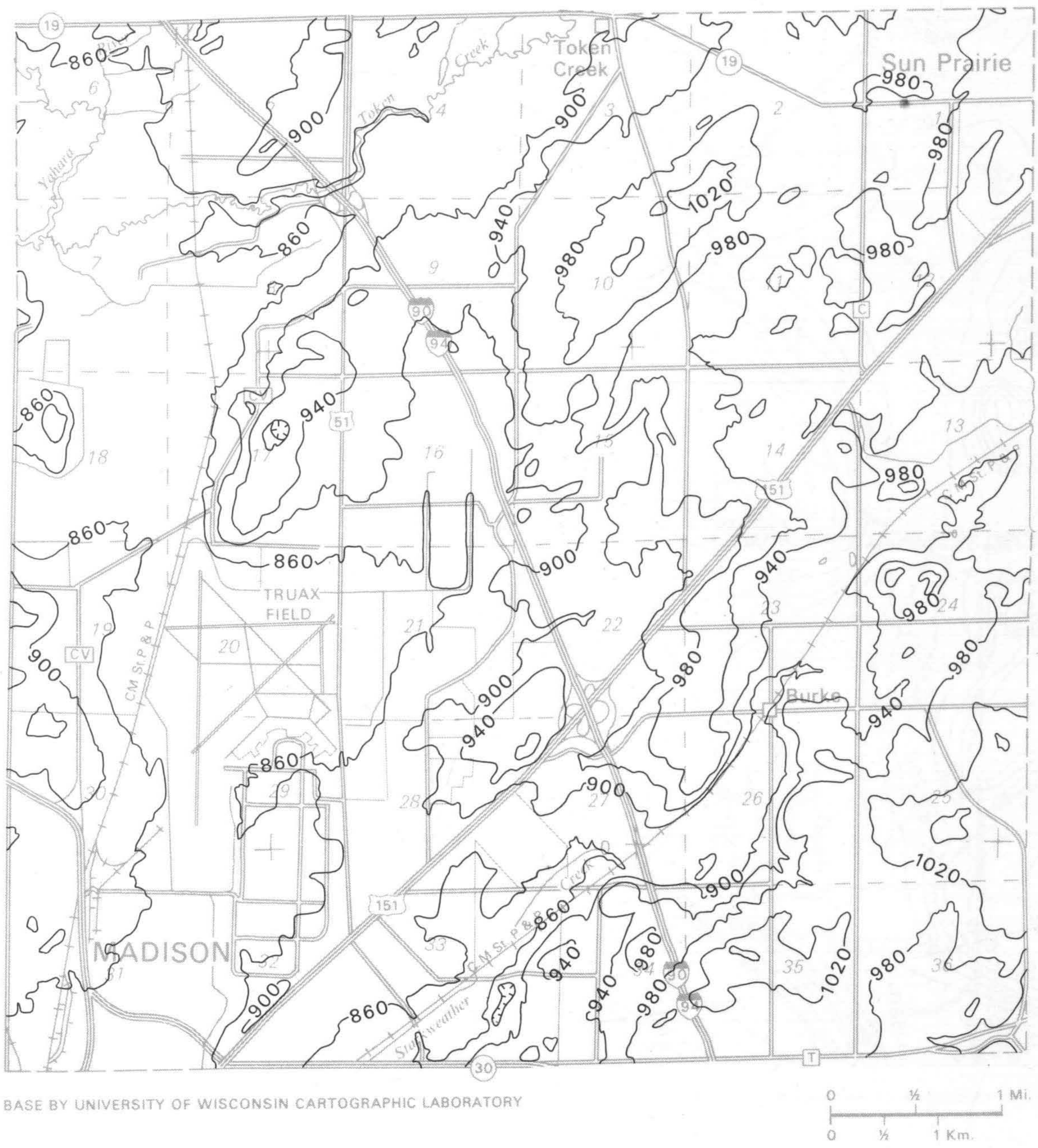



Figure 34. Location of Burke Township.

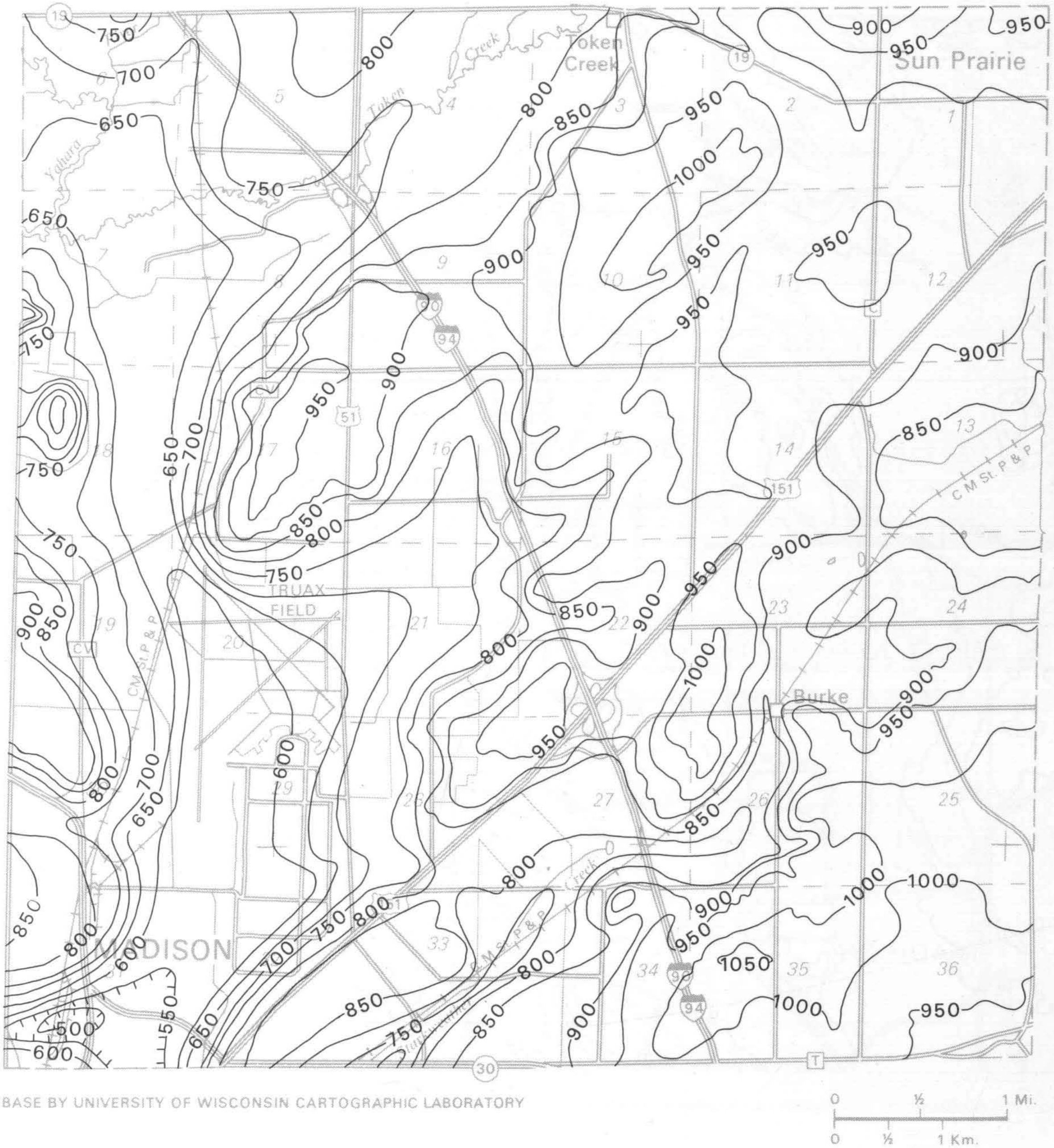



———900———

Line of equal elevation of the land-surface in feet above Mean Sea Level. Contour interval 40 feet.

Source: P. Olcott, 1973

Figure 35. Land-surface topography, Burke Township.




———700———

Line of equal elevation of the bedrock surface in feet above Mean Sea Level. Contour interval 50 feet.

Source: P. Olcott, 1973

Figure 36. Bedrock topography, Burke Township.

The most prominent feature is the deep north-south trending valley in the western portion of the township. Intersecting valleys have created steep sided bluffs along this valley system. Several high knolls are found in the eastern portion of the township.

The bedrock topographic map is used as a base for mapping and interpreting bedrock and surficial geology. It is also a necessary map for determining surficial deposit thickness and depth to bedrock and for interpreting ground water movement and other hydrologic data.

Bedrock Geology. The identification, analysis, and mapping of bedrock formations and structural geology features is accomplished by direct observation of outcrops and rock exposures and from data obtained during drilling of wells. In some cases geophysical measurements can be useful in determining formation thickness and rock type. Indirect data are obtained by correlation of known formation sequences from other areas with the formations under study. Bedrock geology is a part of the total geology of an area and is customarily separated from unconsolidated surficial deposits for clarity in presentation of the data.

The bedrock geology of Burke Township is presented in Figure 37, along with the stratigraphic sequence and lithology of the formations. Formation distribution is controlled by bedrock topography with successfully older Cambrian sandstone formations exposed in the deep valley and the youngest formation, the Platteville Formation, exposed in the highlands. The entire township is underlain by Precambrian crystalline rocks beneath the sedimentary formations.

The St. Peter sandstone is a difficult unit to map because it is highly variable in thickness and its contact with the underlying Prairie du Chien Group is unconformable and thus very uneven. The thickness of the sandstone varies inversely with the thickness of the Prairie du Chien Group, and one unit may be present to the exclusion of the other. As a result, the St. Peter contact is shown as an approximation with a dashed line. Two small faults of small displacement are shown. These could not be traced in the subsurface mapping but may be related to faulting south of the township.

The identification, mapping, and analysis of various bedrock formations is of particular importance to mineral resource planning. Certain formations in some areas of the world are known to host valuable mineral deposits. Entire formations may be of value because they are composed of high purity compounds such as salt, potash, or silica sand. Some formations are known to contain energy minerals, while others may be of value as sources of ornamental or crushed stone. Identification and mapping of any such formations delineates potential target areas for mineral exploration and development for the land-use planners and managers.

Unconsolidated Surficial Deposits. Unconsolidated surficial materials are located between the bedrock surface and the land surface. These materials consist of weathered and disintegrated bedrock and of glacial deposits of sand gravel and other materials. Surficial deposits may occur directly over the parent bedrock from which they were derived or may have been transported to and deposited at their present location by wind, water, or glacial action.

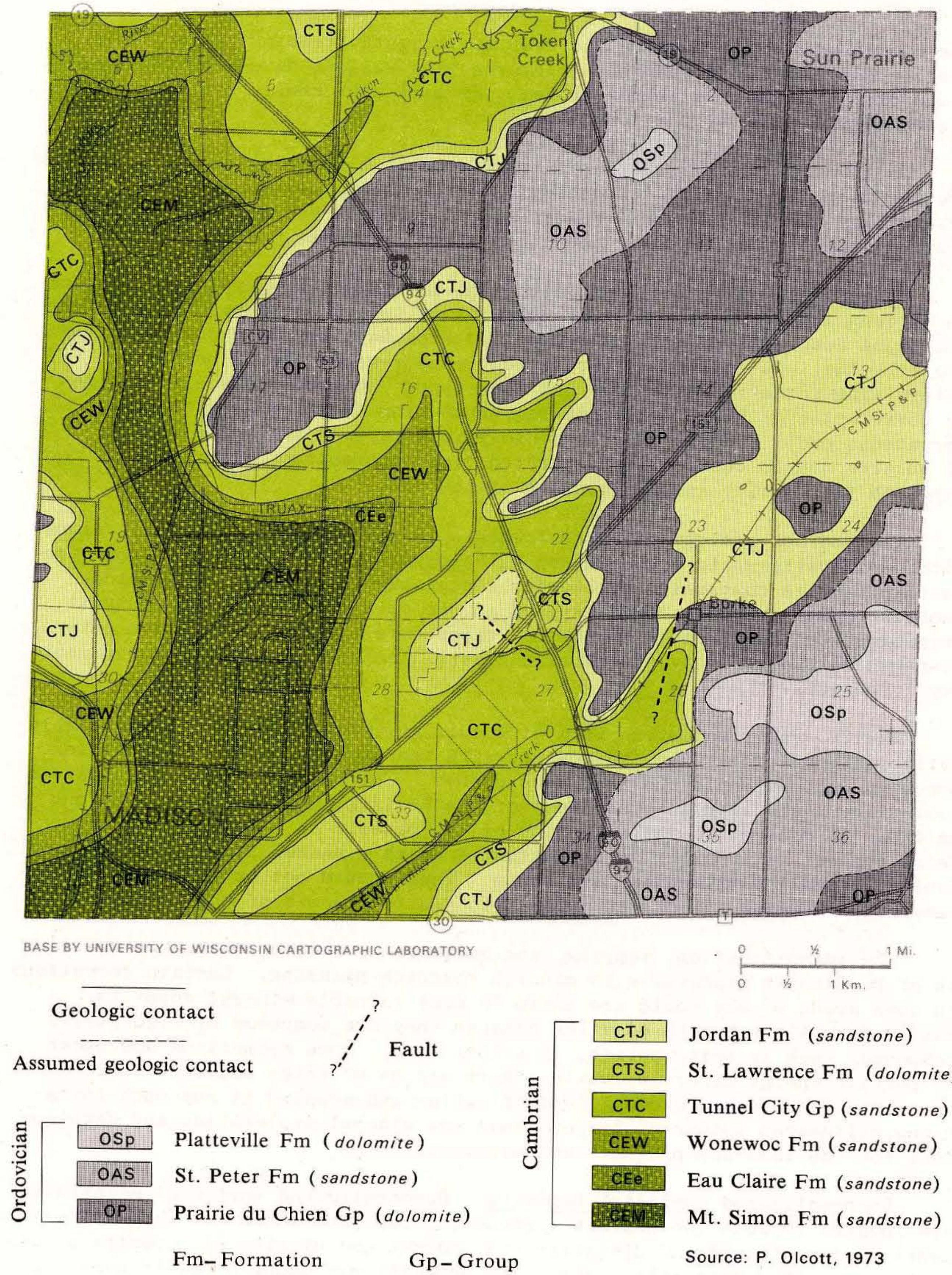



Figure 37. Bedrock geology, Burke Township.

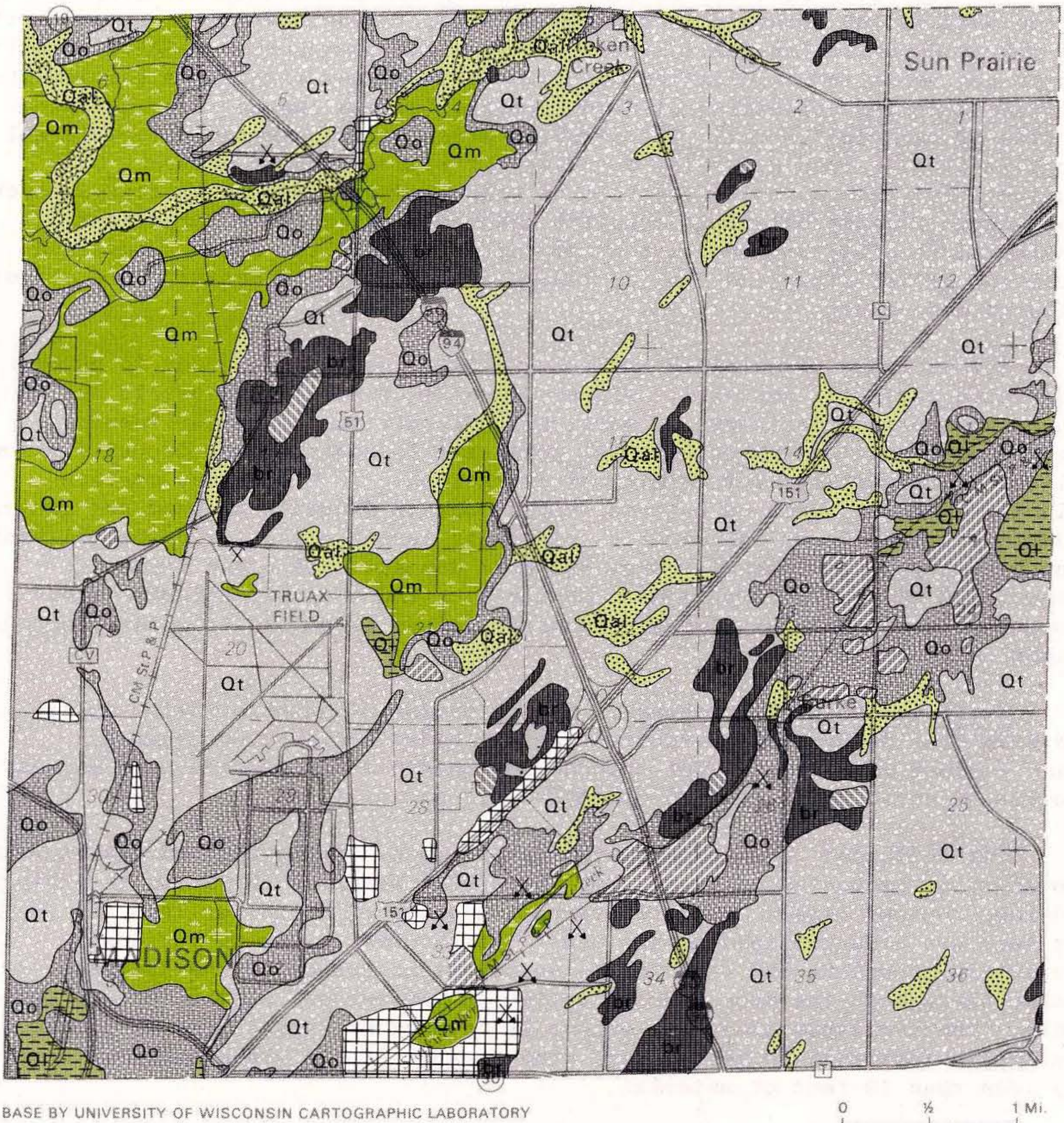
The surficial deposits of Burke Township are presented in Figure 38. A large part of the township is covered by till, a nonstratified unsorted mixture of debris deposited by glacial ice. Outwash was transported by glacial melt-water and deposited in drainage channels that carried water from the ice front. Outwash deposits contain stratified sorted materials and are a principal source of sand and gravel. The alluvium marsh and lacustrine materials all contain fine-grained particles deposited by wind and water action. Clay suitable for use in the manufacture of brick and tile may be present in such deposits. Organic materials are also associated with these formations, including possible commercial peat deposits. Landfills, dumps, reclaimed sand and gravel pits, and similar lands created by man's activity are classified as made lands.

A wide range of metallic and nonmetallic minerals may occur in unconsolidated surficial deposits. Placer deposits of metallic minerals may be found in specific drainages or particular depositional layers. Identification of formations which have the potential to contain such deposits allows planning for possible future mineral extraction. In Wisconsin, certain glacial features, such as outwash, often contain deposits of sand and gravel. Identification of outwash deposits pinpoints target areas for potential sand and gravel pit development. Clay and peat deposits are often found in lacustrine and marsh formations. Exploration and identification of these formations as potential mineral extraction areas is an aid to mineral resource planning and management.

Surficial Deposit Thickness. The thickness of unconsolidated surficial materials is determined by subtracting the bedrock elevation from the land surface elevation. The thicknesses obtained are plotted on a map and points of equal thickness are connected by contour lines.

The thickness of unconsolidated materials overlying the bedrock in Burke Township is presented in Figure 39. Surficial material thickness is shown by 50-foot contour lines. Shallow overburden areas of 5 feet or less and 10 feet or less are also outlined on the map. The thickest cover of surficial materials, reaching 350 feet in the southwestern corner of the township, is found throughout the deep bedrock valley in the western portion of the township. The highlands areas are generally covered by thin layers of surficial materials less than 50 feet thick. The bedrock knolls are frequently covered by less than 19 feet of material.

The surficial deposit thickness map is useful in determining those areas in which surface mining can economically take place. Surface mines are limited by the amount of overburden that must be removed before reaching the mineral deposit. Stone quarries are usually limited to areas with less than 50 feet of overburden. As the value of the mineral material increases, the thickness of overburden that can be economically removed also increases. In some metal mines, several hundred feet of overburden may be removed to reach a deposit.




Qt — Glacial till – ground and hilly moraine, clay, silt, sand, gravel, and boulders, unsorted and unstratified

Qo — Glacial outwash – outwash plains, terraces, deltas, and ice contact deposits, mainly silt, sand, and gravel, sorted and stratified

Qal — Alluvium – valley bottom and flood plain deposits, mainly silt and sand, sorted and stratified

Qm — Marsh – lowland drainageway and small depression deposits, organic peat and muck, some inorganic materials

Ql — Lacustrine deposits – mainly silt and fine sand

br — Bedrock – dolomite and sandstone

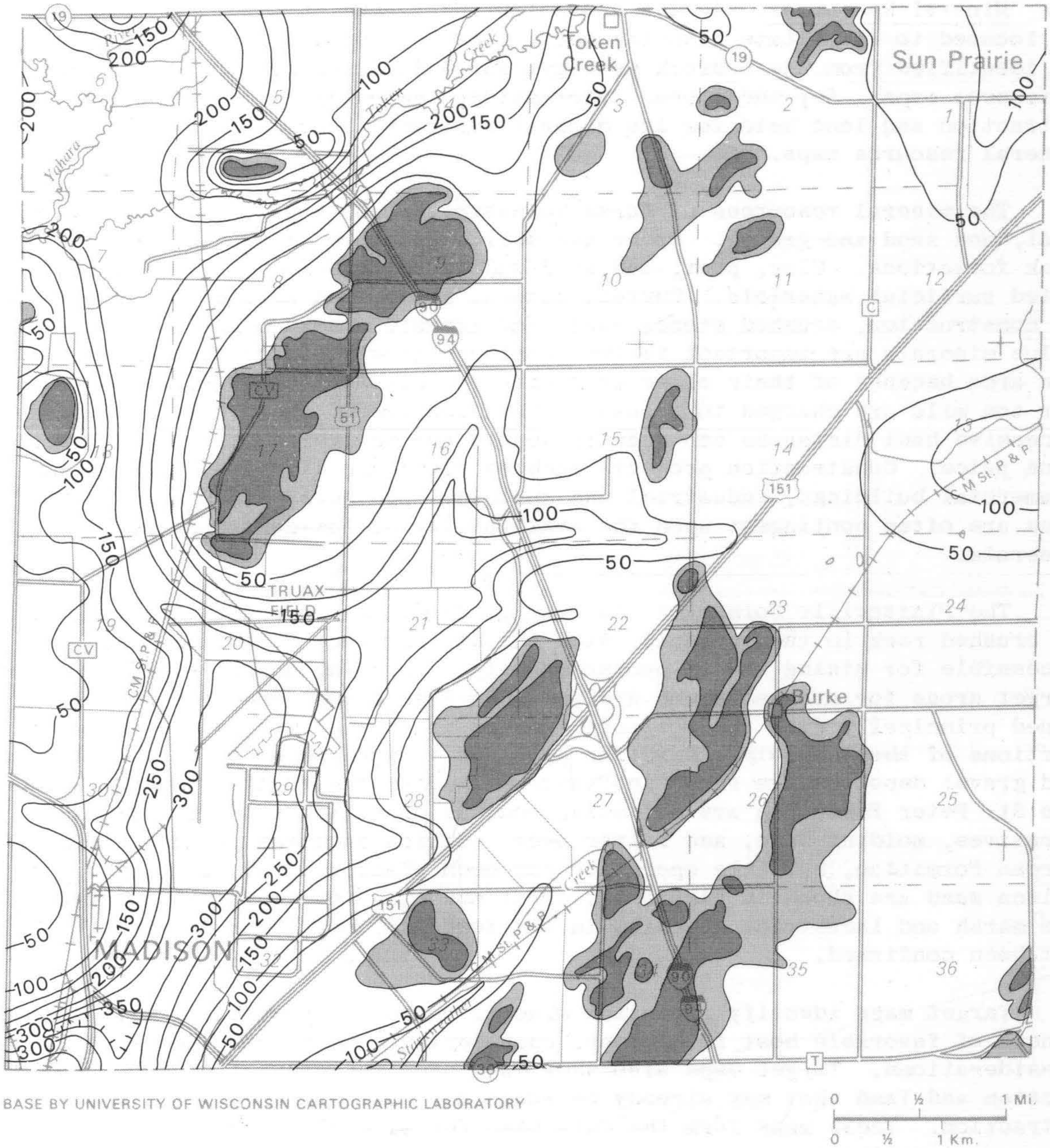
Made land, landfills, dumps, etc.

Gravel pit

Quarry

Source: P. Olcott, 1973

Figure 38. Surficial materials, Burke Township.




Areas where bedrock is 5 feet or less from land-surface
(Modified from USDA, SCS advanced field sheets)

Approximate areas where bedrock is 10 feet or less from land-surface

——100——

Line of equal thickness of unconsolidated materials
Contour interval 50 feet

Source: P. Olcott, 1973

Figure 39. Thickness of unconsolidated materials and areas of shallow bedrock, Burke Township.

Mineral Resources. Active and potential mineral production sites must be located to facilitate planning activities. Potential production sites can be identified from the bedrock geology, surficial geology, and overburden thickness maps. Any additional information, including lands zoned for mineral extraction and land held for its mineral reserves, should be included on the mineral resource maps.

The mineral resources of Burke Township include stone, silica sand, clay, peat, and sand and gravel. Stone and silica sand are extracted from the bedrock formations. Clay, peat, and sand and gravel are found in the unconsolidated surficial materials. Current mineral production is limited to the minerals of construction, crushed stone, sand, and gravel. These high-bulk, low-unit-value minerals are important to the continual growth of the Madison metropolitan area because of their close proximity to this market. Truck-loading costs per ton mile are charged to transport the minerals of construction to market.[9] Excessive haul distances can readily double the delivered price over the average mine price. Construction projects such as roads and highways, housing and commercial buildings, industrial and municipal projects, and a host of other uses are often contingent upon the availability of low-cost construction minerals.

The Platteville Formation and Prairie du Chien Group are the best sources of crushed rock in the township, with the St. Lawrence Formation being less accessible for mining and of poorer quality. Existing quarries and potential target areas for crushed stone are shown in Figure 40. Sand and gravel is mined principally from the outwash deposits in the eastern and southcentral portions of the township. Existing pits and target areas for potential sand and gravel deposits are shown in Figure 41. Both the Jordan Formation and the St. Peter Formation are potential sources of silica sand for use as abrasives, molding sand, and filter beds. Silica sand was produced from the Jordan Formation, but this operation has been abandoned. Target areas for silica sand are shown in Figure 42. Peat and clay resources may occur within the marsh and lacustrine deposits in the township, but their presence has not been confirmed.

Target maps identify potential mineral resource areas based upon occurrences of favorable host formations, engineering constraints, and economic considerations. Target maps also show land used for current mineral production and land that may already be zoned for mineral reservation and extraction. These maps form the data base for mineral resource planning and management activities.

Mineral Deposits. Target areas for various mineral materials can be determined from the basic resource data. Past and current mineral production sites can be determined from published records, air photos, and numerous other data sources. A critical data gap exists, however, in the location of actual mineral deposits within the target areas.

It is extremely difficult to plan for mineral reservation and extraction districts without precise knowledge on the location of potential future mineral production sites. Target areas for mineral materials include those

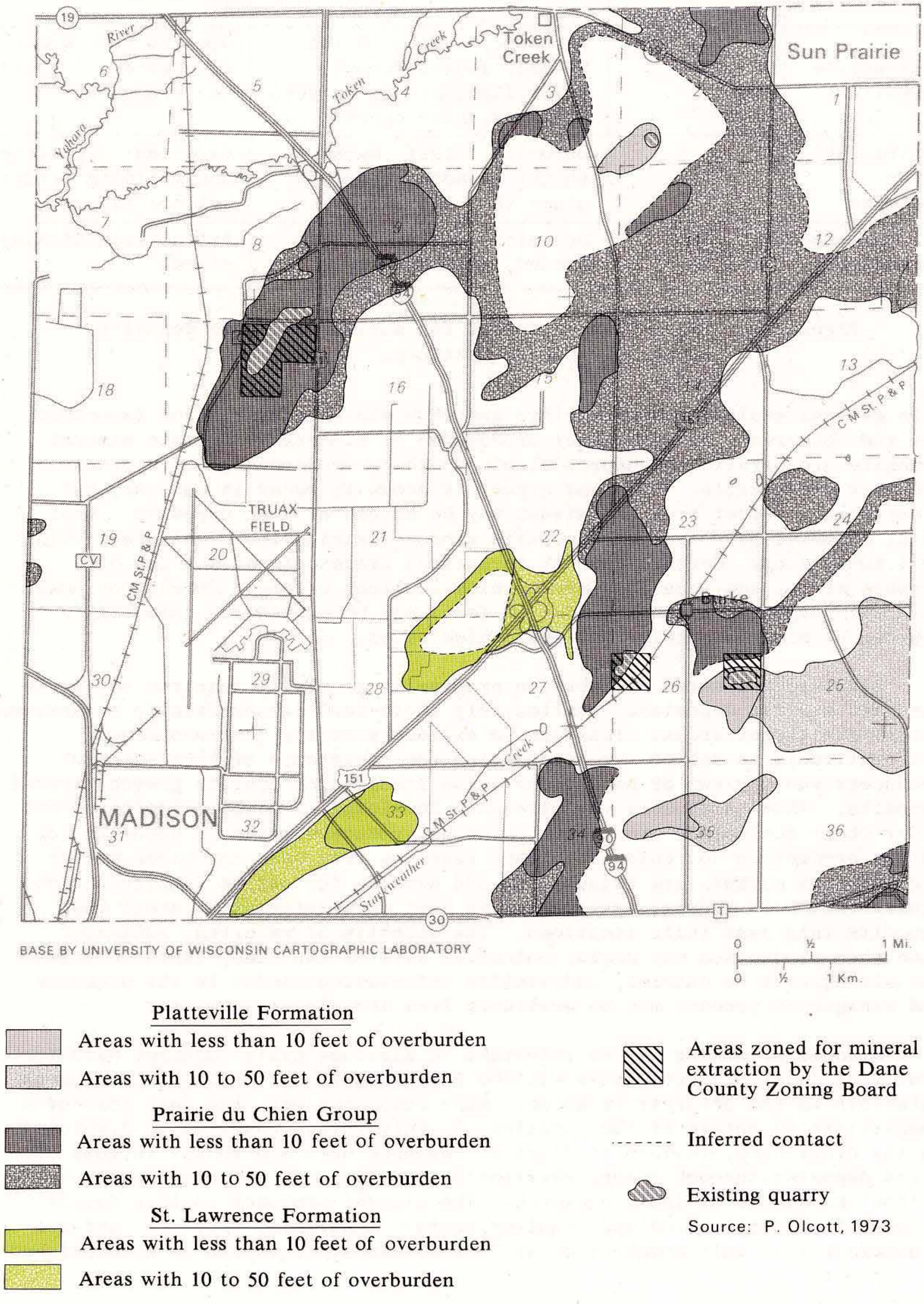



Figure 40. Areas with potential for shallow dolomite deposits, Burke Township.

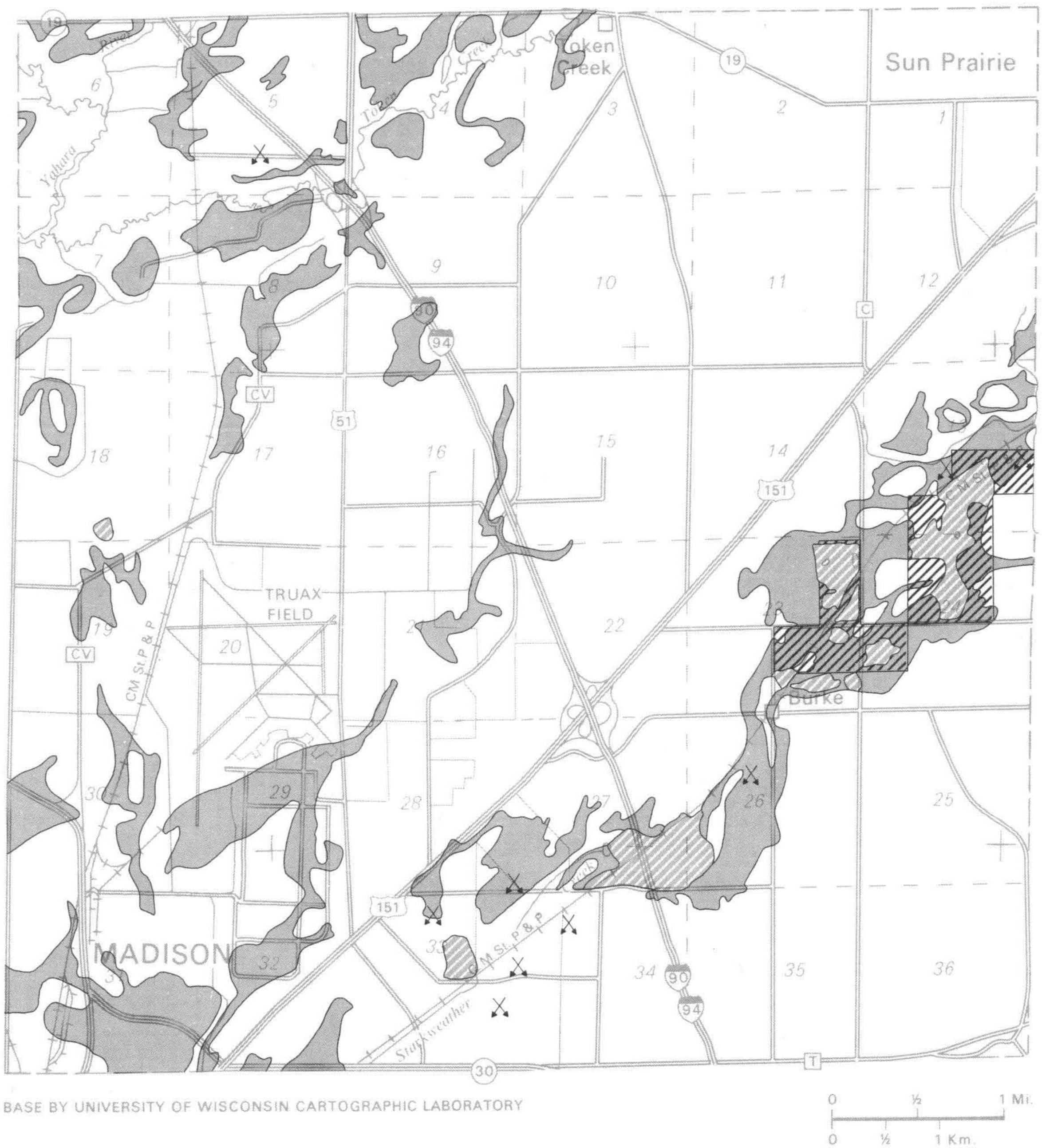
| Formation | Approximate Max. Thickness | Lithology | Potential Economic Uses |
|---|---|---|---|
| Platteville Formation | 25 | Dolomite, medium to thin bedded, fossiliferous, thin clay partings in some horizons, some chert | Good to poor grade aggregate and building stone; aglime |
| Prairie du Chien dolomite | 75 | Dolomite, algal, massive to thin bedded, cherty, minor thin clay layers | Excellent aggregate and building stone; aglime; rip-rap |
| St. Lawrence Formation | 25 | Dolomite, medium to thin bedded, glauconitic | Attractive building stone |

Figure 40. Areas with potential for shallow dolomite deposits, Burke Township.--Continued.

with general geologic, engineering, and economic characteristics favorable for the occurrence and potential production of minerals. Certain mineral deposits are erratic and unpredictable in their occurrence, while others are very predictable. Sand and gravel is known to occur in outwash, but a particular target area of outwash may be devoid of such deposits. Most metal deposits have even more erratic random distribution within favorable host formations. Certain bedrock formations are excellent sources of crushed stone, and locations where thick sections of these formations occur with thin overburden cover (under 10 feet) can be considered potential sources of mineral supply and, thus, mine sites.

A detailed mineral exploration program is generally required to locate specific mineral deposits. particularly those that are erratic in occurrence, within the target areas. This can be extremely costly. A recommended alternative is to enlist the cooperation and assistance of local mineral producers who may own or have under lease lands which contain proven mineral deposits. These producers may also have knowledge of deposit locations not under their control or ownership. Mineral producers may hold deposits for future production to replace depleted reserves from existing mines or for use when new markets are established and demands for output increase. Companies that hold mineral reserves often have more information about the deposits than just their locations. The quantity of reserves, estimated time when production may begin, potential life of the mine, depth to which the mining will be carried, and similar information useful in the planning and management process may be available from the mining companies.

Mineral producers may be reluctant to disclose basic resource data for fear that local property taxes will be increased if the presence of mineral materials on the property is known. Some companies may also fear loss of a competitive advantage if the location of their future reserves is disclosed. On the other hand, failure to disclose resource data may result in loss of these deposits through zoning restrictions or land-use planning developed without knowledge of their presence. The mineral producer is thus caught in a difficult situation and requires certain assurances from the land-use planners before full cooperation will be obtained. This can be accomplished



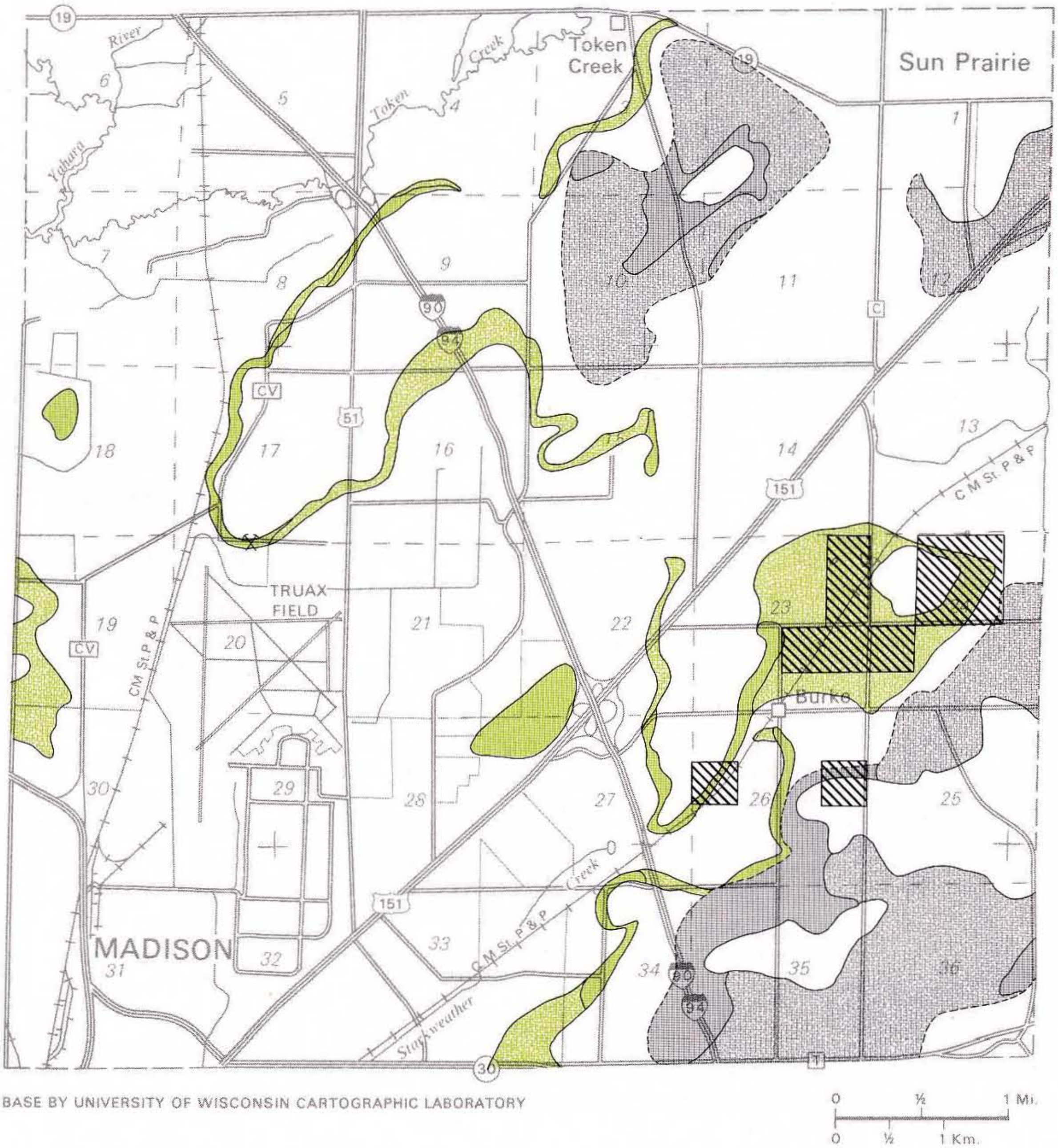

Areas with potential as a source of well sorted sand and gravel

Areas zoned for mineral extraction by the Dane County Zoning Board

Existing sand and gravel pit

Source: P. Olcott, 1973

Figure 41. Areas with potential for sand and gravel, Burke Township.




St. Peter Formation

Areas with less than 10 feet of overburden

Areas with 10 to 50 feet of overburden

Jordan Formation

Areas with less than 10 feet of overburden

Areas with 10 to 50 feet of overburden

Areas zoned for mineral extraction by the Dane County Zoning Board

------ Inferred contact

Existing quarry

Source: P. Olcott, 1973

Figure 42. Areas with potential for shallow sandstone deposits, Burke Township.

| Formation | Approximate Max. Thickness | Lithology | Potential Economic Uses |
|---|---|---|---|
| St. Peter Sandstone | 80 | Sandstone, medium to fine grained quartz sand, silica cement, friable | Molding sand; filter sand, abrasives |
| Jordan Sandstone | 40 | Sandstone, medium to very fine grained in upper part, coarse to fine grained in part, quartz sand with silica mud dolomite cement, friable, some glauconite | Molding sand; filter sand, abrasives |

Figure 42. Areas with potential for shallow sandstone deposits, Burke Township.--Continued.

if the local unit of government provides assurance that local property taxes will not be increased on lands with mineral potential because of the mineral potential discovered through the efforts and investments of the company. Once a property is opened for mineral production, the use of the property has changed and a change in tax rate can be justified. The local planning and management agency should inform producers of the goals, objectives, and benefits of the land-use planning program for mineral reservation and extraction to insure the full cooperation of the mineral producers. By including individual mineral producers or representatives from producer's associations in the planning activity, cooperation and valuable assistance can be obtained from the mineral industry.

## Providing for the Future

Mineral Extraction Districting. The establishment of mineral reservation and extraction districts through zoning should be a major concern to all people and in all areas where the future supply of minerals is critical to development and the general welfare. A wide variety of factors must be considered in establishing such districts for those lands known to contain mineral deposits and target areas with high potential for mineral production. The size and variety of the resource base, markets and demands for the resources, time sequence of development, land-use conflicts, and governmental boundary locations all influence establishment of reservation and extraction districts.

The size and variety of mineral deposits that make up the local mineral resource base often determine land-use priorities. A small resource base limited to a few deposits requires careful consideration in preserving all deposits for use. Considerable effort may be required to resolve conflicts and define extraction districts. A large resource base, particularly if only one or two mineral commodities are involved, may require little effort in identifying reservation and extraction districts. Large tracts of land free from conflicting uses and controversy may be available for inclusion within such districts. The resources so preserved may supply the needs of the area for many years. A large, diverse resource base may require considerable planning to assure adequate supplies of all available mineral materials.

Market location and demands for various mineral materials must be determined prior to a decision regarding the quantity of land to be included within reservation and extraction districts. Local and national dependence upon local mineral supplies must be analyzed in deciding this question. National dependence on most metal, nonmetal, and mineral fuel resources is significant. Many of these mineral materials are being rapidly exhausted within the country with increasing dependence on imported supplies. Shortages are reflected by increasing prices of most commodities. Wisconsin's lead, zinc, copper, and iron resources can be considered of national importance. The common nonmetallic minerals sand and gravel, stone, clay, and similar low-value, high-bulk commodities can be of critical local importance. Some local jurisdictions have exhausted or built over deposits of common minerals or prohibited mining under zoning regulations. Governmental units surrounding dependent markets must consider this dependency when establishing their mineral districts.

Failure to include sufficient reserves of minerals within reservation and extraction districts can result in exhaustion of local supplies and dependency on supplies from surrounding governmental units. Excessive cost for common minerals due to high transportation charges can result. Ideally, all mineral deposits should be preserved for use. Certain mineral deposits may be rapidly developed and worked out, and the land returned to sequential use. Other mineral deposits may support production for many years. The length of time lands will be held prior to production and the life of the mining operation before exhaustion of the deposit and reclamation of the land occurs have a significant influence on the inclusion of specific reserves within extraction districts.

Certain land uses seriously conflict with mining operations. Mineral lands that have been built over by residential, commercial, or industrial structures are normally lost to mineral production. Exceptions do occur, particularly if the deposit contains a scarce or high-value commodity. Surface lands may be purchased and the structures removed to allow surface mining. Underground mining methods may be used to extract minerals from beneath built-over areas without damage or disturbance to surface structures. Built-over lands must be identified, and if they occur within mineral target areas, the mineral lands may be excluded from consideration. The presence of unique scenic, historic, wildlife, or wilderness areas may also conflict with mining activities. Identification of unique areas within target mineral areas could eliminate these areas from inclusion within mineral districts.

The presence of residential developments on lands adjacent to mineral lands is of concern in establishing a reservation and extraction district. Surface mining activities and mine-related vehicle movement are normally not compatible with residential development. Residential developments within one-quarter mile of proposed mineral extraction districts should be identified and the potential conflicts analyzed. In some cases mineral development may be allowed or even desirable. Short-term mining activity employing modern techniques to eliminate the undesirable effects of mining may create lands that would enhance residential developments. In other cases traffic routings through residential zones or long-term mining operations may result in severe conflicts and continuous complaints.

Public opinion as voiced at public hearings or through canvassing of opinions from property owners may be of value in determining potential conflict areas.

The location of governmental boundaries in relationship to extraction districts also deserves consideration. Extraction districts adjacent to governmental boundaries may result in land-use conflicts with adjoining jurisdictions. Cooperation among planners from surrounding governmental units can help reduce potential conflicts or may result in expansion of mineral reservation and extraction districts in adjoining governmental units.

Numerous conflicts may arise during establishment of mineral districts. These potential conflicts must be weighed against the need for mineral materials and the degree of disruption resulting from mining activity. Public hearings offer one means of obtaining public opinion and participation in the decision-making process. Public hearings often result in emotional appeals rather than factual presentations. Public awareness of a program for mineral reservation and extraction districting and the goals of such a program can benefit the program and reduce emotional issues. Special considerations must be given to property owners whose land will be included within such districts. Consideration must also be directed to property owners immediately adjacent to a district. Establishment of a well-structured, enforceable zoning ordinance that provides for control of all undesirable aspects of mineral production can help insure public support of the program.

<u>Management of Mineral Reservation and Extraction Districts</u>. Mineral reservation and extraction districts require a certain degree of management to avoid conflicts and insure continuity of the planned program. Some management functions are a part of the planning phase during establishment of extraction districts while others occur after planning and districting are completed. Such management is a proper function of local government, which has been given zoning power by the state.

Mineral districts must be established as reservation zones to prevent conflicting land uses from encroaching upon mineral lands. They must also be industrial districts to allow extraction and processing of mineral materials. This dual purpose can lead to potential conflicts. The end use of the land must be carefully considered during the planning stage to avoid management problems. If the end use of the mineral lands is to be for residential development, management of the district must be aimed at preventing industrial or commercial encroachment except for industries related to production or to processing the minerals contained in the deposit. Upon exhaustion of the deposit, all mineral-related industries should be removed, land reclamation completed, and a change in use status initiated.

Management of land use prior to the start of active mining operations is also an area of concern. A number of years may pass before a particular deposit is opened to production. Various land uses may be allowed on mineral lands, provided they do not conflict or interfere with the primary purpose of the extraction district. Agricultural, open space, temporary parks or recreational activities, and similar uses may be allowed so long as these uses can be terminated and the land brought into mineral production when needed.

Buffer zones may be desirable around extraction districts, either as part of the extraction district or under a special land-use classification. This buffer zone can prevent noncompatible developments from progressing up to the deposit and will avoid future conflicts when the deposit is opened for production. A minimum of 500 feet of buffer lands should be included between the deposit and adjoining lands carrying a highler land-use status. Development on buffer zones must be controlled by the management agency to insure development compatible with mineral extraction.

A mechanism should be provided so that property owners can apply for mineral reservation and extraction district status after the initial districts are established. Occasionally new deposits maybe discovered on lands that were not considered in initial districts. These new discoveries should be considered after formal application and review of conflicts. The management agency, in cooperation with the planning group must resolve jurisdictional problems and prepare procedures to be followed in such cases.

Changing market conditions or technologies may affect mineral usefulness. Some deposits included within reservation and extraction districts may lose their commercial value, while other lands not included in these districts may become valuable for their minerals. The management agency must be aware of these potential changes and provide the mechanism for removing mineral district status and creating new mineral districts.

The management agency can also anticipate conflicts and complaints which might arise over district status, disturbing practices of the mine operations, traffic problems, requests for change of land status, and a myriad of other problems. In solving these conflicts and problems the management agency must always bear in mind the purpose for establishing mineral reservation and extraction districts, namely, to maximize the utilization of mineral and other resources which occur within its jurisdiction.

Wisconsin Geological and Natural History Survey Information Circular Number 24 describes a model mineral reservation and mine zoning ordinance which contains provisions to regulate mining activity and to reserve known mineral deposits.

## REFERENCES


1. Clarke, F.W., and Washington, H.S., The composition of the earth's crust: U.S. Geological Survey, Professional Paper 127, Washington, D.C., 1924.

2. Dutton, Carl E., and Bradley, Reta E., Lithologic, geophysical, and mineral commodity maps of precambrian rocks in Wisconsin: U.S. Geological Survey, Miscellaneous Geologic Investigations Map I-631, Washington, D.C., 1970.

3. Sheridan, Eugene T., and DeCarlo, Joseph A., Peat in the United States: U.S. Bureau of Mines, Information Circular 7799, Washington, D.C., 1957.

4. Minerals yearbook, 1971: U.S. Geological Survey, U.S. Bureau of Mines, Washington, D.C., 1972.

5. Bain, Foster H., Zinc and lead deposits of the Upper Mississippi Valley: Wisconsin Geological and Natural History Survey, Bulletin No. XIX, Economic Series No. 12, Washington, D.C., 1907.

6. Bean, E.F., State geological surveys of Wisconsin: Transactions of the Wisconsin Academy of Sciences, Arts, and Letters, Vol. 30, 1937, pp. 203-220.

7. Minerals yearbooks: U.S. Geological Survey, U.S. Bureau of Mines, Washington, D.C., 1906-1971 (annual publications).

8. Wisconsin resource projections preliminary report on land use: Department of Administration, Bureau of State Planning, Information Sciences Section, Madison, Wisconsin, 1970.

9. Wimphon, S., Letter to State Geologist of Wisconsin: U.S. Bureau of Mines, Washington, D.C., 1973.

10. Friz, Thomas O., Man and the minerals of construction: How they interrelate in the seven counties of southeastern Wisconsin: Ph.D. thesis, The University of Wisconsin, Madison, Wisconsin, 1970.

I. C. 26 MINERAL RESOURCES, MINING, AND LAND-USE PLANNING IN WISCONSIN 1975