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# MINNESOTA MINERAL DIVERSIFICATION

Ten Year Plan

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## MINNESOTA MINERALS COORDINATING COMMITTEE

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MDNR

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## **EXECUTIVE SUMMARY**

Minnesota has a long history of iron ore and taconite production but there is now the need to stimulate statewide development of other mineral commodities. At the same time, the state must support existing industries, including taconite, and examine the possibilities for added value processing for Minnesota mineral commodities.

The benefits to the state of mineral diversification include private investment in exploration activity; regional stability from a diversity of mineral products and increased employment; and greater returns to all levels of government through taxes and royalties.

Surface deposits of glacial material hide most of the bedrock in Minnesota. Nevertheless, current geological information indicates highly favorable conditions for the occurrence of a wide range of mineral deposits. These range from precious metals through non-ferrous and strategic metals to industrial minerals and construction materials. Minnesota is also attractive to mining companies because of our existing, mining related infrastructure.

To encourage mineral diversification the legislature has provided support for mineral programs in state agencies and the university. Current and future programs will be focused on three broad objectives:

Objective 1 - To improve and extend Minnesota's iron industry Objective 2 - To increase the probability of nonferrous metallic mineral discoveries Objective 3 - To enhance Minnesota's industrial minerals industry

The programs under each of these principal objectives will provide information and technology that will encourage mineral companies to come to Minnesota.

Mineral resource development is a lengthy and complex undertaking. Short-term gains from state initiatives to stimulate mineral development cannot be expected in all areas. On the other hand, a steady, long-term commitment will lead to significant economic growth. The best results will be obtained with continuing stable funding over several biennia.

The Mineral Diversification Plan describes an effective framework for mineral diversification over 10 years. In addition, the plan provides for detailed biennial plans to be submitted to the Legislature each biennium. The planning process includes wide interdisciplinary involvement, opportunities for public and industry input, and careful prioritization of projects. The Minerals Coordinating Committee, a legislatively mandated body, is responsible for the planning process and the outcomes of the programs selected.

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## BACKGROUND

Mineral industries contribute significantly to Minnesota's economy. During the last ten years, Minnesota has ranked between first and sixth, nationally, in total non-fuel mineral production, and has been consistently first in iron ore and taconite production. In 1985, Minnesota's industrial mineral rankings were: 7th in peat, 10th in sand and gravel, 11th in industrial sand and dimension stone, 18th in lime, 29th in crushed stone, and 40th in clay.

Within the minerals industry, the mining and processing of taconite has been the primary source of employment and other economic benefits, including some 2300 Minnesota businesses that supply it with goods and services. Currently, Minnesota's mineral economy is dominated by taconite and is strongly affected by the fluctuations of the steel industry. Minnesota's taconite industry is mature; it doesn't need further exploration and development. However, it does need research and product development support to maintain and enhance its competitive position, and to explore production of added-value products (such as hot metal or slabs) near existing mines. Cost reductions and improved pellet quality can make Minnesota taconite more competitive at Great Lakes ports. The production of added-value products from taconite would allow Minnesota to capture the production revenues that are presently enjoyed by lower lakes industries that use our shipped raw material.

While we can plan for continued benefits from the iron ore industry, economic stability in much of rural Minnesota must be tied to Minnesota's excellent potential for diversification into other minerals. These include gold, silver, platinum, titanium, manganese, copper, nickel, and cobalt. There is also potential to further develop industrial minerals such as clay, stone, and carbonates. Thus, every region of the state possesses potential for mineral development of some kind (see figure 1).

The probability that mineral diversification will succeed in Minnesota is high. Geologists have believed for many years that the geology of Minnesota shows high potential for development of a non-ferrous metals mining industry. Ontario, with similar geology, mines a variety of metallic minerals. Ontario's total annual mineral product value is over four billion dollars (more than twice Minnesota's), and its mining employment is over four times Minnesota's. Eleven different minerals each contribute more than \$100 million per year to Ontario's economy.

Mineral production values in Minnesota and Ontario were equal thirty years ago, but Ontario's industry was more diverse. The province successfully encouraged diversification through:

- Strong encouragement of mineral discovery and development;
- Administrative and legislative commitment;
- A commitment to making lands available for exploration;



## RECENT EXPLORATION ACTIVITY BY COMMODITY

Arrows leading to patterned rock units do not indicate a specific site. A deposit could occur at any location within these areas.

The indicated potentials are those currently being considered by industry but do not include all possibilities.

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- The sharing of development risk through generous taxation policies and incentives;
- The adoption of efficient regulatory policies and procedures; and
- Support for increasing the level of geologic and mineral potential knowledge.

Several of these program elements exist to some degree in Minnesota, but they need further emphasis and development.

## THE NEED FOR DIVERSIFICATION

What is the goal of the Mineral Diversification Plan? To stimulate development of Minnesota's mineral resources. The plan emphasizes exploration and development of new minerals, but also includes research and product development to reduce costs for the state's taconite industry and encourage production of higher-valued products within the state.

<u>What is mineral diversification</u>? Expansion of the mineral base of Minnesota's economy. It is the discovery and development of a variety of metallic minerals such as gold, silver, platinum, copper, nickel, cobalt, and titanium. It also includes expanded use of industrial minerals, such as clays, dimension stone, and silica sand. Geologic studies have shown that these minerals have a high probability of occurrence in Minnesota. Diversification also includes processing minerals into higher-value, semifinished or finished products (e.g., steel production, or clay processed for the paper industry).

<u>Why is it needed</u>? To maintain and enhance the state's mineral economy. Minnesota's mineral economy is tied primarily to taconite pellet production, and fluctuates with the steel industry. Diversifying into other types of mineral mining, along with value-added processing of taconite pellets and other commodities, will result in a growing, more stable, statewide mineral economy. And, it will result in employment, local taxes and royalties throughout the state. As indicated in the report of the Governor's Commission on the Economic Future of the State, "diversification" and "development of adequate levels of income and jobs for the population" are two main state policy goals. For minerals specifically, the state should "...identify new mineral products...undertake a more comprehensive mineral's survey, and...develop a more comprehensive mineral's development policy".

In two recent conferences hosted by the Blandin Foundation, representatives of industry, government, academia, and environmental groups spoke in accord about the importance of a forward-looking mineral economy <u>and</u> environmental protection.

How will Minnesota benefit? The benefits of mineral diversification include:

1. Increased private expenditures in Minnesota by exploration companies;

- 2. Increased potential for discovering economically viable mineral resources;
- 3. Greater regional stability through developing a range of mineral resource industries;
- 4. Increased employment in rural areas through job creation in exploration, mining, and processing industries;
- 5. Increased indirect employment in service and support industries; and
- Greater returns to local and state governments through taxes and royalties. (All state school districts benefit from the revenues earned in the Permanent School Trust, about 80% of which is from mineral taxes and royalties.)

## WHY IS DIVERSIFICATION A STATE ROLE?

Discovery and development of "new" mineral resources is a lengthy, complex and costly process. Minnesota is in worldwide competition to attract industry expenditures and development. The state must demonstrate that it is willing to encourage these activities.

What is an appropriate state role? The state's role has three components: 1) to provide the geologic and mineral potential data that serve as a framework to attract exploration; 2) technical research; and 3) to provide a political, regulatory and economic climate that makes development predictable and attractive. This role does not include exploration itself, which is appropriately left to private industry.

## THE ROLE OF THE LEGISLATURE

The state legislature has two key roles in mineral diversification: it can establish and support policies that promote environmentally sound exploration and development, and appropriate the funding needed to implement diversification programs.

The legislature has declared it state policy "To provide for the diversification of the state's mineral economy through long-term support of mineral exploration, evaluation, development, production, and commercialization" (Minn. Stat. sec. 93.001).

What policies are needed to promote diversification? Pro-active mineral policies include:

- Minimizing multiple agency obstacles to permitting
- Developing appropriate business incentives
- Maintaining equitable mineral industry taxation laws

- Promoting environmental and reclamation research
- Supporting technical research programs
- Supporting programs for mineral information gathering and dissemination
- Supporting University basic training and research related to mineral resources.

<u>Can state funding accelerate mineral development</u>? State agency and university efforts positively impact mineral development activities. Leasing by mineral exploration companies has increased as a direct response to the identification and disclosure of chrome, platinum and gold occurrences. In 1980, the state had 21 non-ferrous mineral leases covering 5,248 acres, held by three companies. In 1987, the state had over 600 leases covering more than 250,000 acres, with active exploration efforts conducted by 26 companies.

## THE ROLE OF THE MINERALS COORDINATING COMMITTEE

Minerals programs have been implemented historically in the Department of Natural Resources and the University of Minnesota. This plan does not call for the creation of new organizations, but focuses on expanding and making optimal use of existing facilities. The programs proposed in this initiative will be managed and coordinated through the Minerals Coordinating Committee (MCC). The Committee includes the directors of: the Minerals Division of the Department of Natural Resources (MDNR), the Minnesota Geological Survey (MGS), the Mineral Resources Research Center (MRRC), and the Natural Resources Research Institute (NRRI). The MCC was organized in 1975 by the Legislative Commission on Minnesota Resources (LCMR) to coordinate proposals and set priorities for minerals-related LCMR funding requests. It was formally established by state law in 1987, with the MDNR representative as chair.

It is important to delineate the roles of the MCC members, and their responsibilities in implementing this plan. Areas of cooperation between the MCC member agencies are summarized in Appendix 1.

The Minerals Division, now part of the MDNR, was formed in 1889. It manages the state's 12 million acres of mineral rights, 3 million acres of peatland, and has statewide regulatory responsibility on public and private land. It leases state minerals and manages programs to encourage exploration and development, and to enhance the value of Minnesota minerals. These activities generate income for trust funds, general fund, local governments, etc. To encourage leasing, it conducts mineral potential surveys to develop regional target areas, and provides data for land management decisions. With the exception of reclamation studies, it is not a research organization. It has, however, a strong interest in setting research priorities.

The university members are primarily educational and research organizations, with varying capabilities and missions. The NRRI was established in 1983, the MRRC in 1911, and the MGS in 1872.

The NRRI's mission is to foster the environmentally sound use of Minnesota's natural resources through research, technology and business development, and through information transfer. The capabilities of the Institute's Minerals Division include: 1) mineral processing, process assessment, and process development; 2) geologic studies emphasizing geochemistry, ore deposit modeling, and resource evaluation; 3) mining, with an emphasis on mine planning, economics, and evaluation, and 4) a growing research capability in industrial minerals and remote sensing/biogeochemistry.

The MRRC has a legislative mandate for education and research related to the wise development of mineral resources. Research functions range from mineral characterization to process metallurgical engineering. Much of its work is oriented toward identifying processing methods and developing new ways to extract value from mineral occurrences. While it has primary interest in Minnesota's resources, its mission covers fundamental aspects of mineral science and engineering that contribute to national and international knowledge. Its research program also serves as a training medium for the development of skilled mineral engineers. In 1978, MRRC was designated the Minnesota Mining and Mineral Resources Research Institute in the federal Mineral Institute Program.

The mission of the MGS is to undertake and promote the scientific study of Minnesota's geology, and to make the results available to the public. As a research and service arm of the University of Minnesota, MGS conducts basic and applied earth sciences research to elucidate the geology of Minnesota for the benefit of its citizens. MGS works to provide a scientifically sound geologic framework for the state that can be used to further investigations in mineral resources, engineering geology, and environmental geology. This objective is accomplished mainly through the preparation of reports and geologic maps at various scales, using data and interpretive insights from direct field study, geophysics, geochemistry, and test drilling.

Private industry also maintains research facilities in Minnesota to work on specific projects, and contributes to program priority and selection. Although the Minnesota Iron Ore Cooperative Research Program is based on industry-state cost sharing, it is also possible to develop federal cost sharing through the U.S. Geological Survey, U.S. Bureau of Mines and federal Mineral Institute Program for cooperative research and other areas in the Diversification Plan.

## THE MINERAL DIVERSIFICATION PLAN

The legislature directed the Minerals Coordinating Committee to prepare and adopt a ten-year plan for mineral diversification. The plan includes strategies to: 1) increase the knowledge of the state's mineral potential;

- 2) stimulate the development of mineral resources in the state; and
- 3) promote basic minerals research.

These strategies are based on a need to increase the level of knowledge of Minnesota's mineral potential and designed to achieve the goal of stimulating the development of Minnesota's mineral resources within a reasonable amount of time. Ten years is a short period of time for a significant mineral development to occur in that it commonly takes more than five years to develop a mine following discovery. Benefits from exploration and development activities do occur immediately, but the full benefit of diversifying Minnesota's mineral economy requires a long-term commitment.

The plan is organized in three major objectives or program areas within which projects are described and prioritized. Objective One concerns maintenance and growth within the existing iron ore and taconite industry. It focuses on process innovation to increase production efficiency and on the development of added value products. Objective Two is directed at non-ferrous metallic minerals, especially those of current highest interest: gold, platinum, titanium, cobalt and others. The focus is on the generation of geologic information to attract private exploration efforts. Objective Three focuses on the promotion of industrial minerals industries based on Minnesota's sand, gravel, and clay resources and on potential for discovery of diamonds and other more valuable industrial mineral commodities.

The Diversification Plan encompasses ten years, the first biennium of which is underway. The recommended program areas for the ten-year plan, and the fiscal year 1988-89 budget are found in Appendix 2. The planning process will update and set priorities for each biennium. This recognizes the emergence of new priorities as work accomplished produces results. For example, the discovery of a significant precious metal ore deposit may call for reclamation or process technology research. However, the basic framework for the ten-year plan will remain unchanged.

Within the diversification planning process is a mechanism to support basic research; projects of the type that lay the foundation for later work to stimulate Minnesota's mineral economy. In recognition of the importance of such research, the Minerals Coordinating Committee delegated to the University a basic research project review and funding mechanism with the initiation of the Diversification program. A portion of legislative diversification funding (this biennium \$200,000) is allocated to the University's Earth Resources subcommittee, an arm of the University Council for Natural Resources. The subcommittee is charged to solicit proposals for minerals basic research from both the University and other Minnesota academic institutions. Proposals are given peer review and, if recommended for funding, forwarded to the MCC for final review. Currently, seven projects (which will be discussed in the appropriate sections of the plan) have been initiated through this process.

The Mineral Diversification Plan, designed cooperatively by the mission-oriented agencies, has a high probability of producing substantial economic benefits in the long term. The rate of progress depends on both the level and continuity of funding. The best results will be obtained with stable funding over several biennia. While the projects are listed separately, it should be pointed out the activities are interrelated and directed toward a common goal.

## PUBLIC INVOLVEMENT IN MINERAL DIVERSIFICATION PLANNING

Public involvement in minerals planning will take several forms. Some sources of input can provide technical competence and will be solicited directly; the Iron Ore Cooperative Research Committee is an example. There are other groups and agencies whose contributions are primarily technical. Examples include professional groups such as the American Institute of Mining Engineers and various geological societies. The MCC will also solicit input from groups and agencies that have general interest in the progress of mineral diversification. Examples include local governments, civic, and environmental groups. The Minerals Coordinating Committee has identified over 20 sources of planning input of all kinds (see Appendix 3).

In addition to the Iron Ore Cooperative Research Committee, at least two other advisory groups will be established by the Minerals Coordinating Committee: to advise concerning non-ferrous minerals, and to assist industrial minerals planning.

Fostering better communication and understanding of minerals issues will be an ongoing emphasis. The Blandin Foundation's sponsorship of recent minerals conferences and Congressman Oberstar's Minerals Forum (January, 1988) are examples.

## **OBJECTIVE 1 - To Improve and Extend Minnesota's Iron Industry.**

## **Discussion of Objective:**

The Minnesota Mesabi Range is one of the largest non-fuel mineral producing regions in the world and in a continuous production effort spanning over 100 years has produced over 3.5 billion tons of iron ore raw materials for the U.S. steel industry.

In recent times, demand for iron ore has declined globally; current Minnesota taconite pellet production is somewhat more than half of previous peak levels. Industry's response has been to reduce costs and improve quality. Some cost reductions have been achieved by improving efficiency (cutting labor requirements). Thus, the regional economy has suffered the double impact of lower production and decreased employment.

It is estimated that current taconite pellet production levels (in the range of 30 to 40 million tons per year) will remain stable. Even at this reduced level, Minnesota ranked first in the United States in 1985 and second in 1986 in state non-fuel mineral product value.

Iron ore production in Minnesota is thus of critical importance to both the state and the nation. An appropriate level of research support is necessary to:

- a) ensure continued production of taconite pellets at internationally competitive costs;
- b) identify additional markets for iron ore-derived specialty materials, and
- c) explore the development of added value products.

## **Related Issues:**

#### COST EFFECTIVENESS:

Since the mid 1950's, a global iron ore industry of vast capacity has developed. Two nations, Australia and Brazil, are in the forefront. Together, these two countries possess substantial proven resources of easily-mined, high grade ore that can be shipped directly to processors. This confers significant cost advantages. By contrast the taconite industry must mine extremely hard taconite rock, containing approximately two-thirds waste material, and employ complex processing operations to extract the taconite and produce high grade pellets.

Since the early 1980's, an increasing share of U.S. iron ore consumption has been imported. For Minnesota to retain its domestic steel markets, it is of critical importance to address all possible ways to reduce costs.

## MARKET ACCESS:

Both Michigan and Canada may be considered competitors for lower Great Lakes

markets. In 1985, Canadian imports were 8.6 million tons, Michigan production was 12.5 million tons and Minnesota production was 33.4 million tons. To maintain this share of the market, Minnesota must continue to reduce costs.

## WORLD DEMAND:

Global demand for steel (and, consequently, iron ore raw materials) has declined in recent years and there is an international excess of iron ore production capacity. This excess is a driving force for cost reduction that will extend well into the future.

## NEW APPLICATIONS:

Although the tonnages involved in the primary iron ore/steel industry are vast, the potential for additional uses of taconite concentrates should be explored even if at much smaller tonnages. Some areas of potential interest are use in the coal cleaning industry and in combustion systems.

## QUALITY AND SPECIFICATIONS:

In the steel industry it is possible that cost benefits can be achieved by improvements in pellet quality and modification of pellet product specifications. Areas of active interest are lower silica content and fluxed pellets. Partially reduced pellets may also be attractive to the steel industry. These are areas that require continued research and development.

## ADDED VALUE:

Currently, all "added value" is generated outside of Minnesota for the nation's steel industry. Direct reduction, direct smelting and local slab production are all possibilities for Minnesota. Their economic potential should be fully assessed with respect to product, markets, and production scale. Continued research is required to identify viable market opportunities and to develop advanced technology that could provide an economic edge. Fluxed pellets and partially reduced pellets are also added value products since they reduce blast furnace operation costs.

## AVAILABILITY OF TECHNOLOGY:

The development of "added value" technology has been addressed more aggressively overseas than in North America and there are several direct smelting technologies of potential interest, e.g., COREX, PLASMASMELT, INRED, etc. However, none of these have been developed for or adapted to the site specific conditions in Minnesota. Opportunities exist for research and development that optimize process design with respect to local raw materials and energy sources (e.g., low-cost western coal).

#### LABOR ISSUES:

Although labor costs are a significant proportion of taconite pellet costs, productivity has doubled in recent years and labor costs have been dramatically reduced. The major potential for cost improvement by reducing labor costs has been achieved.

#### **ENERGY ISSUES:**

The two main energy sources for taconite plants are electricity and fossil fuel. In recent

years power contracts have been renegotiated to correct high demand costs established when plants were operating close to full capacity. Although there is little that state supported research can contribute to electric power cost schedules, there are significant areas of research available aimed at reducing power consumption.

The other major energy source is fossil fuel used for induration (fire hardening). Firing systems based on a range of fuels have been developed and flexibility needs to be maintained since the relative costs of different fuels change with time. There are also technical problems associated with the lowest cost fuels that afford significant research and development opportunities.

#### **ENVIRONMENTAL ISSUES:**

Minnesota has a paramount interest in maintaining environmental quality. New technologies must meet environmental standards and should also be directed toward replacing "dirty" processes with cleaner ones.

## **Discussion of Issues:**

Several areas present issues we can influence either directly or indirectly. Areas of direct influence include cost effectiveness and product quality for current production, the development of new uses for current products, and added value technologies and products.

However, because industry controls user specifications and developments in blast furnace practices, the development of improved pellets (low silica, fluxed, partially reduced, etc.) can only be partially influenced.

## **Program Areas and Strategies**

**Program Area One:** Technological Research for Current Operations <u>Discussion</u>: Technological research for current operations covers all mineral and process engineering areas applicable to current flowsheets and practices and also to the development of new processes, operating practices, and control systems. There are three primary research areas: mining, concentration and induration.

Technical expertise and interest in these activity areas lie primarily in industry, the University of Minnesota, and the U.S. Bureau of Mines (USBM). In 1985, the state established a Cooperative Industry Research program managed by DNR with project evaluation and selection by a committee with membership from DNR, the University, USBM, and each of the companies. To date, projects in this program have focused on concentration and induration.

From the perspective of developing a Mineral Diversification Plan, projects addressing technological research for current operations can be subdivided into the basic programmatic areas as follows:

Computer Applications
Economic Analysis
Systems Analysis
Drilling and Blasting
Materials Handling and Mine Transportation Systems
Rock Mechanics/Fragmented Slope Stability
Selective Mining
Comminution
Mineral Separation
Process Analysis and Control
Flowsheet Development
Process Development
Product Development
Agglomeration Chemistry and Physics
Fuels and Energy
Product Quality Control

## Sample Projects:

- New product development
- Development of lower cost drilling systems
- Development of blasting procedures for controlled finer primary rock size distribution
- Identification of safety limits for fragmented rock piles
- Feasibility of mining selected horizons at given sites
- Transportation studies
- Grinding circuit optimization
- Improved iron recovery
- Development of on-stream analysis and improved process control
- Evaluation of circuit modification using process modeling
- Application of fine screening for improved product quality
- Application of flotation for silica reduction
- Development of organic binder application
- Slagging combustion for reduced fuel costs
- Dynamic modeling for improved induration control
- Development of fluxed pellet compositions to meet specific blast furnace requirements
- Improved high-temperature pellet quality

## Relationship of Projects to Overall Strategy and Issues:

The above list identifies typical projects in each area. There is a very large number of candidate projects; funding and other constraints will permit the execution of only a few. In addition to funding constraints, there are also limitations to the number of projects that can be effectively managed by the available technical expertise. Thus, it is also important to use the research program as a training medium for the development of the skilled mineral engineers Minnesota will need in the future.

In order to develop a rational procedure for the selection of projects and the allocation of limited resources, a thorough analysis of current systems and determination of current costs are necessary. From this information, areas for maximum impact can be identified and research projects established to address those most critical. The Iron Ore Cooperative Research Committee will continue to be important in the selection process.

## Program Area Two: Value Added Processing

<u>Discussion</u>: An important research area here is the basic study of direct reduction technology with the objective of identifying and developing processes that are specific to Minnesota. Once identified, these technologies would permit the production of a molten iron product that could be refined in Minnesota to a higher value product.

Therefore, economic evaluation of slab production and the possibility of alloy production are areas that must be included in studies concerning added value processing.

## Sample Projects:

- Thermodynamic and kinetic studies of iron ore reduction related to both pelletized and unpelletized taconite concentrates
- Development of heat and mass balance estimates for projected new reduction processes
- Experimental verification of reduction process routes
- Evaluation of feasibility for production of specialty steels
- Feasibility studies for ferroalloy production
- The COREX project
- Exploratory studies for the production of new materials based on iron ore concentrates

## Relationship of Projects to Overall Strategy and Issues:

Any added value product involving iron must be based on the reduction of iron ore and the most economic process will be the result of an optimal combination of the underlying thermodynamics and kinetics and innovative process engineering. A direct smelting process that produces pig iron as a final product may be feasible in Minnesota, but not as economically sound as it would be with an added value component. Thus, production of slabs and alloy steel should be thoroughly evaluated.

## Program Area Three: Basic Ferrous Minerals Research

<u>Discussion</u>: The Mesabi Range has provided sources for iron ore production in the following categories: direct shipping ore, gravity concentrates, wash ore, and taconite concentrates. Current operations are essentially confined to the production of taconite concentrates.

To optimize production of Minnesota ores there is the need for detailed characterization of geology, mineralogy and process performance at specific sites. Also, basic minerals research is required to determine the composition of the vast residues of earlier mining operations, anticipating their potential for modern mineral processing technologies to yield inexpensive or specialized iron ore raw materials.

The three basic research areas are: Applied Process Mineralogy, Fine Particle Technology, and Mineral Processing.

## Sample Projects:

- Characterization of taconite minerals as a function of ore horizon:
  - -Basic Mineralogy
  - -Mineral Associations
  - -Liberation Characteristics
  - (all need to be carried out on a site-by-site basis)
- Examination of potential to produce higher grade products
- Studies of size/liberation/grade relationship for different ore sources
- Relationship of fine particle characteristics to separation performance in different mineral processing operations
- Comprehensive inventory for all waste materials: their mineralogy, and grade and tonnage estimates
- Recovery of CaO and/or MgO units from tailings or slatey horizons for fluxed pellet production
- Evaluation and development of improved mineral processing unit operations

## Relationship of Projects to Overall Strategy and Issues:

The importance of applied mineralogy to overall process performance cannot be overemphasized since it provides the basic data to which process and quality improvements are fundamentally related.

The highest priority areas are projects to enhance current taconite production and to develop mineralogical data that will aid in cost reduction and quality improvement.

This information is also necessary for studies related to new process development for added value products.

Fine particle technology is concerned with the properties of fine particles and their relationship to separation processes. This information is necessary for both cost reduction and quality improvements in concentration processes.

Mineral processing concerns the variables in particle separation and the development of mechanical systems to achieve optimal separation. These three programmatic areas form the nucleus of basic minerals research and relate to nonferrous and industrial minerals as well as the iron ore industry, to which the above sample projects apply. They are all necessary components in an overall program for cost reduction and quality improvements in the taconite industry.

## **Performance Indicators**

Measurable Indicators:

- 1. Adoption by industry
  - improvement of cost effectiveness
  - capital investment as an indicator
  - "accepted" in some other way

**Estimated Indicators:** 

- 1. Prove or disprove effectiveness of technology
- 2. Company involvement in cooperative research

## **OBJECTIVE 2 - To Encourage Exploration and Development of Non-ferrous Metallic Minerals**

## Discussion of Objective:

Minnesota is in worldwide competition to attract exploration expenditures and mineral development. Corporate decisions on where to initiate an exploration and development program are based on a number of criteria, among them:

1. Mineral commodity of interest;

2. Mineral potential of the area;

3. Availability of regional and detailed local geologic information;

4. Local political, economic, and environmental considerations;

5. Availability of land for exploration, and

6. Regional infrastructure and mining tradition.

Pursuit of new mineral resources usually occurs in areas with the highest probability for discovery. Geologists have known for many years that Minnesota has high potential for development of non-ferrous metals (e.g., gold, the platinum group minerals, titanium, copper, and others). However, mineral exploration in most of Minnesota has been hindered by lack of detailed geologic maps, particularly in areas with few outcrops and a thick cover of glacially deposited sand, silt, and gravel.

To attract exploration and development, Minnesota must develop geologic and mineral potential data and provide the administrative and economic climate that makes development predictable and attractive. This translates directly to a program that encompasses geologic and mineral potential mapping using a variety of techniques, as well as leasing and technical information programs.

Geologic mapping in the drift-covered parts of the state is difficult. Fortunately, aeromagnetic mapping and related investigations funded by the Legislative Commission on Minnesota Resources have provided regional data of exceptional quality to guide geologic interpretations. In addition there are sophisticated new tools available:

- high-speed computers for processing geophysical data,
- advanced geochemical techniques,
- better ore deposit modeling for Minnesota geologic settings,
- improved theoretical approaches incorporating plate tectonics and ore deposit models.

These tools improve the chances of a discovery by helping to develop a detailed regional geologic framework that exploration companies can use to efficiently select targets for investigation. It is the role of the Minerals Coordinating Committee to provide a regional, contemporary interpretation of Minnesota's geology and regional evaluations of mineral potential. Mineral exploration, however, is best left to private industry.

Through the implementation of the ten program areas discussed here, the attractiveness of Minnesota to exploration companies will be materially enhanced. Increased exploration activity promotes the chances of a major mineral deposit discovery and the development and jobs that would accompany it. But it is particularly critical for the state to take the long-term view-- not only to concentrate on mineral targets that are the object of private industry exploration today, but to provide for diversification in the future by developing information relevant to the occurrence of other commodities. We must keep the long range goals of the state in mind, rather than focusing on the particular commodity or deposit model that seems most attractive this year.

## **Program Areas and Strategies**

## Program Area One: Mapping

<u>Discussion</u>: The most effective way to increase the probability of a nonferrous metallic mineral discovery is to attract exploration companies to a variety of exploration targets. The state can do this by preparing and publishing geologic maps and reports that provide background on the regional geology of Minnesota. Exploration companies use these maps to develop target concepts and exploration models and as a basis for more detailed geologic mapping.

#### Sample projects:

- Bedrock geologic mapping
- Surface and subsurface stratigraphic mapping

## Relationship of Projects to Overall Strategy and Issues:

One of the state's most important roles is to acquire and publish regional geologic maps. These have direct utility for mineral exploration, are basic to geologic research, and are fundamental to many aspects of land-use planning. These projects include both conventional bedrock mapping and newer subsurface mapping techniques. Surface and subsurface mapping programs go hand-in-hand. How well we understand the geology of the covered areas is directly dependent on how well we understand the geology of the exposed areas. This is because mapping extends from the known and exposed bedrock into areas of covered bedrock.

Bedrock geologic mapping is needed both in unmapped areas, and in areas that have been mapped but where new data and geologic concepts allow a new interpretation of existing geologic maps. Examples of unmapped areas include: 1) northeastern Itasca County (gold); 2) Beaver Bay-Silver Bay area, Lake and Cook Counties (platinumgroup minerals); 3) Virginia Horn near the cities of Eveleth and Virginia, St. Louis County (gold); 4) Northwest Angle, Lake of the Woods County (gold); and 5) various areas in Pipestone, Rock, and Cottonwood Counties (gold, manganese, uranium).

Areas for which existing maps must be revised include: (1) the Vermilion and Rainy Lake districts of St. Louis and Koochiching Counties, where extensive exploration has produced considerable new data; and (2) the Hibbing and New Ulm regions where new high-resolution aeromagnetic data permit new geologic interpretations.

## **Program Area Two:** Geophysics

<u>Discussion</u>: Because most of Minnesota's bedrock is covered with glacial drift, geophysical methods must be used to reveal the state's geological framework. These studies, which include magnetic, seismic, electrical and gravitational methods, are useful in "sensing" through the drift, thereby allowing geologists to make educated guesses about concealed bedrock geology.

This work is not designed to locate economic mineral deposits, but to unravel Minnesota's complex bedrock geology.

The cornerstone of the geophysical effort has been a low-altitude, high-resolution aeromagnetic survey, which began in 1979 with support of the LCMR. Statewide coverage should be complete by 1991. An important supplement to the aeromagnetic data has been a ground-based gravity data network, which includes stations spaced 1-2 miles apart in all accessible areas of the state. The Planning Information Center's computer enhancement and graphic display capabilities have greatly increased the utility of these data.

#### Sample projects:

- Interpretation and synthesis of aeromagnetic and gravity data
- Ground-based geophysical studies
- Upgrading of well logging system
- Improved software and hardware capabilities
- Expansion of rock property files

## Relationship of Projects to Overall Strategy and Issues:

Geophysics, combined with drilling, provide the understanding of geology in three dimensions. An understanding of overall crustal structure is needed to explain the geologic evolution of an area, and to locate likely sites of economic mineralization. Seismic and magnetotelluric investigations are particularly useful for studying crustal structure.

Aeromagnetic surveys have enormously advanced understanding of Minnesota's bedrock, but much more can be learned. Interpretation and synthesis of the aeromagnetic and gravity databases have barely begun. Over the next ten years, these data will

be processed, interpreted, and combined with control from outcrop and regional drilling to produce new bedrock maps.

State-sponsored geophysical studies help define a regional geologic framework, but geophysical methods for orebody prospecting are too specialized and expensive to employ on a statewide scale. Ground-based geophysical studies (gravitational, magnetic, electromagnetic, seismic, etc.) can be used to answer specific geologic questions at a given site. These detailed studies are left to exploration companies, once they have been guided to a favorable area by the state's regional-scale data.

## **Program Area Three:** Geochemistry

<u>Discussion</u>: Improvements in analytical methods and computational capacity over the past two decades have made regional geochemical surveys possible. Although exploration companies have surveyed relatively restricted target areas, regional surveys are rare. However, regional geochemical surveys of large areas have been conducted by governmental agencies in Scandinavia and Canada and their work shows that data can provide a framework within which exploration companies can target their efforts in Minnesota. Surface and subsurface stratigraphic studies provide the basis for understanding the significance of geochemical findings. The recently completed glacial till geochemical survey sponsored by the LCMR is an example of an evaluation technique successfully adapted for Minnesota from Canadian and Finnish methods.

## Sample projects:

- Glacial till sampling
- Bedrock sampling in Archean greenstone belts and the Duluth Complex
- Geochemistry of iron-formation and associated rocks of the Cuyuna District
- Biogeochemistry

## Relationship of Projects to Overall Strategy and Issues:

Geochemical analyses are an integral part of the geologic evaluation of an area. In addition to providing direct indications of economic mineral potential, they contribute important information to the overall geologic framework and further help attract exploration interest.

Glacial till sampling has been applied in pilot areas of northern Minnesota, and has located interesting gold anomalies. To achieve optimum results, sampling efforts should be expanded and should proceed hand-in-hand with stratigraphic studies of glacial deposits. This method has been used with gold, but is also being tested under the LCMR Strategic Mineral Geochemical program for application in evaluating cobalt, titanium, and the platinum-group elements in the Duluth Complex.

Archean greenstone belts and the Duluth Complex may contain valuable metal deposits, but have not been surveyed systematically from the viewpoint of exploration geochemistry. Such surveying has occurred on an ad hoc basis in conjunction with geologic mapping and petrologic studies, but it should be expanded, standardized, and

entered into an interactive data base. This should be done in cooperation with industry to assure augmentation rather than overlap, and should be integrated with regional drilling programs.

The rocks of the Cuyuna District are known to contain sub-economic amounts of manganese and to have other unique but unevaluated geochemical traits. Available drill core from the district will be subjected to broad-spectrum geochemical study. The results should be interpreted in terms of new geochemical models for concentrating metals in marine environments similar to those in which the Cuyuna rocks were deposited.

Biogeochemistry, another geochemical method, examines the concentrations in plants of heavy and precious metals. Plants located near ore deposits can show the effects of the heavy and precious metals in two ways. First, some plants are bioconcentrators and will accumulate heavy metals in leaves, bark, roots, or branches. These anomalous concentrations can be detected by the use of geochemical techniques. Second, concentrations of heavy and precious metals in plants can cause a spectral shift in emitted radiation due to plant stress. These spectral changes can be detected by satellite and high altitude aerial photography. Both of these techniques are mineral exploration methods that are currently being used by the exploration industry in arid and semi-arid regions. However, their utility has not been fully evaluated in Minnesota. If these techniques can be successfully applied here, they offer another way to "see through" the glacial overburden.

## Program Area Four: Bedrock drilling

<u>Discussion</u>: Bedrock drilling is an essential component of the geologic mapping process in areas where bedrock outcrops are sparse or lacking. For those areas (some Minnesota counties have no surface outcrops) it provides verification of rock types and structures present, and geologic proof for more abstract geophysics work. Two types of drilling are needed: regional shallow test drilling (bedrock penetrations of 3 to 6 meters) to verify geophysical data, and deeper stratigraphic test drilling (bedrock penetrations of 150 to 300 meters) in limited areas to provide data on rock sequences.

## Sample projects:

- Test drilling in the northern Itasca County greenstone belt (75 shallow and 2 deep holes)
- Test drilling in southwestern Minnesota: to better understand its varied geology and to assess manganese potential
- Test drilling in the southern and central Duluth Complex, St. Louis and Lake Counties

## Relationship of Projects to Overall Strategy and Issues:

Because much of Minnesota lacks outcrops, and therefore cannot be mapped geologically by conventional surface methods, subsurface mapping methods are required. Test drilling, in combination with geophysical methods, yields regional-scale (1:250,000) maps of bedrock geology. These maps provide the basis for industry to establish efficient regional mineral exploration programs.

## Program Area Five: Ore Deposit Modeling

<u>Discussion</u>: Modeling is an important tool in the search for ore deposits. An ore deposit model consists of a description of the essential attributes of a class of mineral deposits. It may relate the attributes to the natural origin of the ores, or it may be descriptive, consisting of a list of the various attributes that are recognized as essential to the occurrence of deposits. Use of these models can substantially increase mineral exploration by calling attention to the potential for types of deposits not currently being sought.

## Sample projects:

- Technical workshops on ore deposit models applicable to Minnesota
- Publication of workshop recommendations
- Creation of ore deposit models

## Relationship of Projects to Overall Strategy and Issues:

The state will work with the U.S. Geological Survey and others to hold mineral deposit modeling workshops. The emphasis will be new models that have not been applied to Minnesota's geology. For example, workshops will consider the potential for gold deposits of types other than the shear zone model of Archean gold deposits, which currently receives greatest emphasis by industry.

The state will summarize the results of ore deposit modeling in a document that can be used by non-scientists who need to know about minerals that might be found in economic quantities in Minnesota.

Program Area Six: Environmental Research, Regulation and Coordination

<u>Discussion</u>: The state must be prepared to regulate non-ferrous metallic mineral development. A well-prepared regulatory agency can efficiently issue permits that protect environmental quality and enable development to proceed in a reasonable timeframe. Work should be done <u>before</u> industry requests operating permits to ensure that regulatory agencies have good technical data on which to make permitting decisions.

## Sample Projects:

• Impact mitigation studies

-Process chemicals -Heavy metals -Acid mine drainage

• Regulatory information and coordination

## -Advance preparation for mining proposals -Cooperative agreements

## Relationship of Projects to Overall Strategy and Issues:

Process chemicals, heavy metals, and acid mine drainage can be by-products of nonferrous metallic mining that must be mitigated. Mitigation techniques must be carefully evaluated to determine: 1) how effectively they protect the environment, and 2) how much they cost (for industry feasibility analysis).

Basic information will be needed by the regulatory agencies to determine effective methods to mitigate residual process chemicals associated with disposal of tailings and leached ore. Heavy metals will be associated with stockpiles and tailings basins, and methods to mitigate their release must be developed. It is also likely that metallic minerals in Minnesota will be found in sulfide mineralized rocks. Sulfides in tailings and stockpiles can be a source of acid drainage, which must be mitigated during and after mining.

A variety of state, local, and federal agencies have regulatory authority over metallic mineral development. It will be necessary to eliminate duplication in permitting, and determine areas of leadership among them. Coordination between agencies is needed for a regulatory process to be effective and efficient. Regulatory agencies must work together to develop information needed to regulate non-ferrous mining. Cooperative agreements between agencies should be developed that better define roles and responsibilities.

## **Program Area 7:** Resource Evaluation

Discussion: Resource evaluations define the resource potential of a given area for a specific commodity or commodities. They are based on: 1) using existing ore deposits within an area to predict mineral potential; and 2) ore deposit modeling to predict ore deposits that may occur in an area. The evaluations also estimate the resource potential within the area. It is appropriate for the state to evaluate potential on a regional scale; detailed work on specific areas is the province of industry.

State sponsored resource evaluations help industry determine the economic feasibility of putting a mineral deposit into production. This includes economic studies that concern the effects of taxes, royalty rates, and local construction costs. Resource evaluations also benefit the state by defining its potential to be competitive with other areas.

Industry itself conducts pre-development drilling, development drilling and rock property studies, ore reserve calculations, mine design and planning, pilot ore extraction studies, mill design and planning, reclamation/environmental requirements and costs, and marketing (potential customers, market price of metals, etc.).

Industry conducts a detailed evaluation to determine whether a deposit is feasible to mine. The economic feasibility of any ore deposit is based on four parameters: 1) grade of ore; 2) tons of ore present; 3) whether the mine will be open pit or underground;

and 4) the current value of a ton of ore based on the metals to be recovered. This initial or "prefeasibility" study determines whether the next phase (engineering, milling, and other studies) of the project will be started. This information can be used as the basis for future work as the economics of mineral commodities change.

Sample projects:

- Regional resource evaluation studies
- Economic feasibility analyses
- Three-dimensional graphics development

## Relationship of Projects to Overall Strategy and Issues:

Regional and local resource evaluations will illustrate Minnesota's resource potential and the economic feasibility of mining in Minnesota. These studies can estimate the mineral potential (grade and tons) for a given area (e.g., gold and massive sulfides in the Archean greenstone belts). More detailed economic evaluations for specific deposits must be funded by industry.

Sufficient data are available on many of the copper-nickel deposits to determine the threshold price of copper and nickel that would make these resources economically attractive. The previous work on copper/nickel should be updated to incorporate current economic conditions. Ore reserves will be recalculated using new geostatistical techniques (such as krieging). These data will be used with the geologic data to identify the mining methods and related operating and construction expenses, and tax and royalty costs.

Three-dimensional graphics programs are useful in evaluating the short and long term economic feasibility of mining different ore deposits in Minnesota. Ore grade, geology, and other mining parameters will be displayed in three dimensions. The data will be interactively linked to changing economic parameters.

## **Program Area Eight:** Mineral Resource Services

<u>Discussion</u>: A variety of mineral related services aid both industry, by providing the foundation and framework for mineral development, and the state in making informed decisions on mineral matters.

Conducting basic mineral processing and metallurgical research along with economic evaluations of Minnesota's competitive position in the world mineral market are critical activities. These functions develop expertise applicable to known and newly discovered resources.

#### Sample Projects:

Database management system

• Mineral services

- Information dissemination/promotion
- Metallurgical/mineral processing research
- Mineral economic evaluations

## Relationship of Projects to Overall Strategy and Issues:

A wealth of information is available in a variety of locations. Making these data easily accessible by computer will increase their usefulness. Using what is already known about the state's excellent mineral potential and known mineral resources to aggressively promote mineral opportunities will attract more exploration to Minnesota and encourage future development.

## Program Area Nine: Leasing, Land Availability, and Mineral Ownership

<u>Discussion</u>: A key to successful mineral development is making land available for exploration. Regular lease sales of state-owned minerals are critical. This enables industry to obtain substantial lease holdings with a minimum of time and expense. Leasing of state minerals generates both exploration activity and revenues. This, in turn, yields geologic and mineral potential data (which must be submitted to the state), local jobs, and state and local taxes.

Mineral ownership in many parts of Minnesota is complex. This is due to the large number of past severances of mineral and surface estates. The Severed Minerals Interest Law (Minn. Stat. secs. 93.52-93.58) will help alleviate this problem by requiring owners of severed minerals to register their interests. The state, however, must now determine which parcels of land have unregistered severed minerals.

## Sample Projects:

- Regular state mineral lease sales
- Informing public on mineral leasing procedures and options
- Severed mineral ownership research
- Improved mineral ownership records

## Program Area Ten: Basic Non-Ferrous Minerals Research

<u>Discussion</u>: Minnesota's non-ferrous metallic mineral potential is high but, for many minerals of this class, basic research is required to set the stage for exploration, mine development and production. This is particularly true for mineral commodities such as diamonds, manganese, and platinum.

#### Sample Projects:

- Development of a model for mineral resource appraisal
- Examination of manganese ores in the Cuyuna Range
- Evaluation of extraction methods for platinum-group minerals of the Duluth Complex.

- Evaluation of fire assay techniques for assessment of precious metals from the Duluth Complex and Minnesota's greenstone
- Identification of diamond bearing kimberlites in Minnesota

## Relationship of Projects to Overall Strategy and Issues:

The development of industries based on Minnesota's non-ferrous metallic minerals is a focus of this plan. Because these minerals have not had the attention historically given iron ore and taconite nor the production history of some of the industrial minerals, basic research plays a very important role. Some of the basic research projects listed above, if successful, will attract the interest of mining companies and further stimulate exploration.

## **Performance Indicators**

## Measurable Indicators:

- 1. Number of exploration companies active in Minnesota
- 2. Number of acres of state land under lease
- 3. Number of exploration drill holes
- 4. Number of metal occurrences tested through the feasibility stage

## **Estimated Indicators:**

- 1. Number of acres of private land leased
- 2. Number of total geophysical grids used as guides for site drilling
- 3. With the current level of exploration activity, it is reasonable to expect that mineral resources will be discovered in Minnesota. Industry must determine if these resources are economic to mine. If such a resource is discovered and determined to be economic, at least one non-ferrous metallic mineral mine could be developed in Minnesota during the time frame of this plan.
- 4. With the present level of interest and exploration, it is reasonable to expect that, within two years, industry will conduct feasibility studies of non-ferrous mineral resources to determine if they can be profitably mined.

## **OBJECTIVE 3 - To Enhance Minnesota's Industrial Minerals Industry**

## Discussion of Objective:

A variety of industrial rocks and minerals are mined and processed in Minnesota. Examples include clay (used for brick, tile, and cement) and limestone (used as aggregate and dimension stone). These commodities supply local (sand and gravel), regional (clay) and national (granitic dimension stone) markets. Most of Minnesota's industrial minerals are used in construction. To diversify its industrial minerals industry, Minnesota must identify other useful rocks and minerals (e.g., sandstone, carbonates, high tech ceramics, diamonds, and others) and develop additional uses and markets for them.

To expand opportunities for industrial minerals in Minnesota, five main issues must be addressed:

- 1. Geological Resource Assessment
  - commodity identification
  - physical, mineralogical, and chemical properties of industrial minerals
  - general (regional) deposit characterization
- 2. Product Development
  - develop products using Minnesota resources
  - identify and demonstrate benefits of using Minnesota resources in existing products (e.g., clays for paper making or cat litter)
- 3. Industrial Mineral Markets
  - identification of local, regional, national, and international markets
  - current and near future market supply and demand
  - transportation variables
  - product specifications
  - identification of current and potential competitors
  - property/use relationships and potential alternative uses

## 4. Technical Requirements

- mining characteristics and methods
- processing characteristics and methods
- conventional and novel technology applications
- technical feasibility assessment
- 5. Government Requirements
  - tax/royalty structure and industry implications
  - permits drilling, mining, reclamation, etc.
  - environmental impacts and requirements
  - roles of local, regional, state and federal agencies

Although the issues are interrelated, each is critical to the expansion of Minnesota's industrial minerals base. It is impossible to identify markets, transportation factors, competition, production costs, and governmental requirements without knowing the extent, location and quality of an industrial mineral.

## **Program Areas and Strategies**

## Program Area One: Resource Assessment

<u>Discussion</u>: Minnesota's industrial minerals base currently consists of peat, sand, gravel, clay, limestone, dolomite, basalt aggregate, quartzite aggregate, and dimension stone. There is potential to develop clay for paper and paints, diamonds, titania for pigment, refractories, rare-earth elements and phosphate from carbonatites and shale-related products. A comprehensive data base is needed that encompasses the distribution, quantity, and physical and chemical characteristics of each industrial mineral. This information is useful in targeting specific markets for particular industrial minerals, and should also be provided to local governments and individuals to assist them in evaluating development.

## Sample Projects:

- Regional resource inventory
- Statewide mapping of industrial mineral occurrences
- Regional and local clay studies
- Aeromagnetic and gravity modeling to identify environments favorable for kimberlites (diamonds), phosphates, etc.
- Regional silica studies (applications in glass, ceramics, abrasives, drilling, etc.)
- Regional carbonate studies (applications for paper, aggregate, cement, waste collection, etc.)

## Relationship of Projects to Overall Strategy and Issues:

The projects will provide: 1) the distribution of industrial mineral resources; 2) local resource assessments; 3) resource characteristics and quality; and 4) a basic assessment of mining and processing requirements on a regional scale. These initial studies will provide basic information for product development research and detailed mining and processing. The information can also be used to define market areas (potential consumers, transportation requirements, etc.) and assist various governmental units in providing adequate and timely environmental assessments and permitting. More directly, industrial minerals resources. State-provided information has served this function in evaluating peat projects, for example.

## Program Area Two: Product Development

<u>Discussion</u>: An important element in the development and enhancement of Minnesota's industrial minerals industry is the matching of Minnesota's resources with products. There are two areas that should be considered. The first is the identification of products that use Minnesota resources directly without process or other technological development. The second is the development of new or existing products in which Minnesota resources can be used.

## Sample Projects

- Clay products development
- Stone and aggregate products development
- Waste material utilization

## Relationship of Projects to Overall Strategy and Issues:

These projects have high potential for success. Minnesota clay resources are being assessed by current projects. The next step is product assessment and development. Stone and aggregate are presently produced in Minnesota, but other products, for example, lightweight aggregates, should be explored. Waste material, such as mine tailings, might also be successfully marketed. Currently, the MDNR sells construction materials taken from waste dumps on the Iron Range.

## **Program Area Three:** Marketing and Economic Feasibility

<u>Discussion</u>: The feasibility of producing a certain industrial mineral depends on availability and access to markets. Fundamental marketing information will help producers of Minnesota's industrial minerals to identify new local and regional markets and, perhaps, national and international markets.

The availability of transportation is another important aspect of feasibility. Many industrial minerals have a low unit value; production and, especially, transportation costs determine their market area. Only if the physical and chemical specifications of a particular industrial mineral are unique or in high demand can the market area for an industrial mineral be expanded. These and other market factors must be identified to make Minnesota's industrial minerals more competitive.

## Sample Projects:

- Current industrial mineral consumer-producer index
  - emphasis on Minnesota, neighboring states, Great Lake states, Mississippi River access, and Ontario, Canada
  - potential industrial mineral consumers for new resources
- Current product specifications and possible alternative uses
- Estimation of mining and processing costs including environmental mitigation

- Impact of taxes and royalties on industrial minerals
- Transportation study costs and routes

## Relationship of Projects to Overall Strategy and Issues:

These projects and others will allow industrial mineral producers to better assess the feasibility of producing an industrial mineral for a particular market area. For example, the costs and markets for diamonds (high value/national and international markets) versus sand and gravel (low value/local markets) are very different. However, the market areas are limited by transportation and production costs. Substitutability is another factor that affects the marketing of industrial minerals. The identification of such factors will be important to expanding markets.

**Program Area Four:** Technical Requirements, and Process and Mining Research and Technology

<u>Discussion</u>: Minnesota's industrial minerals will become more valuable both through: 1) the application of current technologies not yet employed here; and 2) the development and use of new technologies for processing and mining. For example, in the past, Minnesota's kaolin clay deposits have been tested for paper-grade quality with little success. However, current projects will assess new separation techniques that could enhance that resource and its application in paper making. Product identification and determination of basic physical and chemical parameters will identify some of the barriers to producing a useful and competitive product.

#### Sample Projects:

- High-tech ceramics, e.g., ceramic engines
- Limestone and dolomite for fluxed pellets for the steel industry
- Limestone and dolomite as sulfur sorbents for coal-fired electrical plants
- High purity limestone for the paper industry
- Titanium dioxide for the pigment industry

## Relationship of Projects to Overall Strategy and Issues:

These projects will make Minnesota's industrial minerals more competitive by determining better methods for extraction and refinement. New refining techniques can increase market size by producing a higher-value mineral product desired by consumers in a larger geographic area. These processes may allow Minnesota's raw materials to be substituted for those the state currently imports (for example, kaolin clay from Georgia). Production may lead to value added products in addition to current raw material sales.

## Program Area Five: Government Requirements

<u>Discussion</u>: Industrial minerals are important economic commodities in Minnesota. However, one key to their continued development is clearly defined and equitable taxes, royalties, and permits that pertain to the exploration and mining of industrial minerals. This is important at all levels of government: local, state, and federal.

## Sample Projects:

- Develop a handbook for industrial mineral producers that outlines state, local, and federal regulations that apply to production in Minnesota
- Evaluate, and revise as necessary, current regulation of industrial minerals production

## Relationship of Projects to Overall Strategy and Issues:

These efforts will help insure the timely startup of industrial minerals operations. This is important, relative to higher-value minerals commodities, to make industrial minerals competitive over a larger market area by lowering startup costs.

## **Basic Research in Industrial Minerals**

<u>Discussion</u>: The need for basic research in this area is highest in product development and in technical requirements. Product development requires long-term basic research in the fields of materials science and in new ceramics applications (e.g., engine parts). Basic research efforts are also needed in developing new processing techniques that will make currently unexploited resources valuable. An example is process technology for Minnesota clays to make them suitable for the paper industry.

## **Performance Indicators**

## Measurable Indicators:

- 1. Number of requests by local governments for information relating to the occurrence, mining, production, and environmental requirements, etc., related to industrial minerals
- 2. Development of new or expanded industrial mineral mines (within 10 years)
- 3. Feasibility studies by industry (within 2 years after completion of a major study)
- 4. Requests from the industrial minerals industry for additional information relating to state agency industrial mineral studies

## **Estimated Indicators:**

- 1. Increased production of industrial minerals for local use and exportation
- 2. Increased leasing activity
- 3. Increased capital investment

These indicators will provide a measure of the success of state studies related to industrial minerals. Not every indicator will apply in every case, because of the wide variety and occurrence of industrial minerals in Minnesota. However, these indicators will show the usefulness of the studies and their effectiveness in creating increased employment and revenues. Relatively small, local area developments have large secondary economic impacts.

APPENDICES



## APPENDIX 1 - Areas of Cooperation Between MCC Member Agencies

## FY 1988

	DNR	MGS	MRRC	NRRI
Aeromagnetic Survey - 5th Phase		Х		
Glacial Till Geochemistry Surveys	Х	X		
Geologic Drilling and Mapping		Х		
LMIC Minerals Data Base	Х	Х	х	Х
Drill Core Examination and Assay	х			
Industrial Minerals Characterization	х	Х	х	Х
and Research				
Bedrock Geochemistry		Х		Х
Non-ferrous Research			х	х
(e.g., titanium and manganese)				
Reclamation Studies	х			
Mineral Resource Economic Evaluation				х
Improved Geophysical and Remote	х	Х		Х
Sensing Base				
Sample Analysis/Equipment	х	Х	х	Х
Determination of Mineral Rights	Х			
Ownership				
Ferrous Minerals Research			х	Х
Mineral Occurrence Resource	Х		X	
Evaluation				
Value-added Process Evaluation			х	Х
Ore Deposit Modeling		х		Х
Minerals Basic Research		Х	х	Х

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## **APPENDIX 2 - Program Areas and Budget**

A tabulation of program or project areas that need to be included in a comprehensive state minerals plan has been assembled by the Mineral Coordinating Committee and is shown in the following. Since funding is constrained it is not possible to be active in every program area. The prime responsibility of the Coordinating Committee is to identify the top priority areas at a given time and ensure the wise use of the funding allocated by the state. Projects funded for FY 1988 are shown at the end of this appendix and are cross-referenced to the programs listed. Total state funding for FY 1988 was \$1.6 million and was distributed 18.1% to the existing industry, 75.6% to non-ferrous minerals, and 6.3% to basic research. It is clear that only a small number of program areas can be addressed with current funding. A significant increase is needed in future years.

By comparison with provincial programs in Canada, an annual budget approaching \$5 or \$6 million would be quite modest for Minnesota. The Coordinating Committee is charged with presenting a budget to the legislature for consideration in odd years and will present the second biennial budget to the 1989 Legislature based on information gathered in 1988. Consistent with the need for mineral diversification, a significant increase in funding will be requested.

In reviewing the current program it is considered that an increase in the percent of funds allocated to existing industry and basic research would be appropriate. The proposed approximate percentage allocation of funding over the ten year plan is shown below. This assumes gradually increased funding over the 10 year period.

Fiscal Year	88/89	90/91	92/93	94/95	96/97	
ore industry	18.4	2Ø	20	20	20	
minerals	57.Ø	55	55	55	55	
minerals	18.4	15	15	15	15	
Basic research	6.2	10	10	10	10	
	100	100	100	100	100	

#### PROPOSED PERCENTAGE ALLOCATION OF FUNDS

## MINNESOTA MINERALS PLAN PROGRAM AREAS

- 1. Existing Iron Ore Industry
  - 1.1 process technology
  - 1.2 reduction processes
  - 1.3 steel and ferro alloys
  - 1.4 novel products
  - 1.5 ferrous minerals research
- 2. Non-Ferrous Minerals
  - 2.1 mapping

  - 2.2 geophysics 2.3 geochemistry 2.4 drilling 2.5 ore deposit modeling
  - 2.6 resource assessment

  - 2.7 regulations
    2.8 access to minerals
  - 2.9 economic analysis
  - 2.10 information systems
  - 2.11 mineral research
  - 2.12 process technology
- 3. Industrial Minerals
  - 3.1 geological resource assessment
  - 3.2 product development

  - 3.3 markets
    3.4 technology
  - 3.5 government regulations
- Basic Minerals Research 4.
  - 4.1 geology
  - 4.2 mineralogy
  - 4.3 exploration 4.4 mining

  - 4.5 mineral processing
  - 4.6 extractive metallurgy
  - 4.7 mineral economics
  - 4.8 analytical systems
  - 4.9 computer applications
  - 4.10 process analysis and control

## MINNESOTA MINERALS COORDINATING COMMITTEE

## Mineral Projects FY 1988

Project Number	t Project Title	Budget (\$,000)		Program Area
1	Aeromagnetic Survey Phase 4	392*	2.2	GEOPHYSICS Air-Borne Data Acquisition
2	Strategic Minerals Geochemistry	98*	2.3	GEOCHEMISTRY Bedrock
3	Glacial Till Geochemistry	75	2.3	GEOCHEMISTRY Glacial Till
4	Clay Deposit Evaluation	196 <sup>*</sup>	2.4 2.6 2.7 2.9 2.11	DRILLING (35) RESOURCE ASSESSMENT (49) REGULATIONS (10) ECONOMIC ANALYSIS (14) MINERAL RESEARCH (88)
5	Geologic Drilling and Mapping	150	2.1 2.4	MAPPING (75) DRILLING (75)
6	LMIC Minerals Data Base	25	2.10	INFORMATION SYSTEMS Data Base
7	Drill Core Examination and Assay	50	2.4	DRILLING Drill Core Analysis
8	Industrial Minerals Characteri- zation Carbonate Project	100	2.6	RESOURCE ASSESSMENT Mineral Characterization
9	Bedrock Geochemistry	50	2.3	GEOCHEMISTRY Bedrock
10	Non-Ferrous Minerals Research	75	2.11	MINERAL RESEARCH Extractive Metallurgy
11	Ferrous Minerals Research	50	1.5	FERROUS MINERALS RESEARCH
12	Minerals Basic Research	100	4.	BASIC MINERALS RESEARCH
13	Iron Ore Cooperative Research	245	1.1	PROCESS TECHNOLOGY
 T(	otal Expenditures	1.606		

\* LCMR

## **APPENDIX 3 - Public Involvement in Mineral Diversification Planning**

The Minerals Coordinating Committee has identified sources of planning assistance from various public groups, industries, and academic and technical communities. Some of those, listed below, are consulted regularly now and some are new sources. Mineral diversification planning is improved and strengthened with the involvement of the groups listed below.

## 1. Sources of Direct Planning Input

- The Cooperative Research Committee
- Special conferences (eg: the Blandin Minerals Forum)
- AIME (including the formation of special advisory groups)
- Mine manager meetings
- Annual Fall Activities Forum
- MCC membership
- Industry and trade groups
- Rural Development Board
- Greater Minnesota Corporation

## 2. Sources of General Planning Input

- Lake Superior Industrial Bureau
- Open houses/regional meetings
- Public meetings
- Local government meetings
- NEMDA
- Legislative tours
- Regional Development Commissions

- 3. Sources of Technical Planning Assistance
  - Professional meetings
  - Consulting and academic communities
  - United States Geological Survey
  - United States Bureau of Mines
  - Environmental review process
  - Lake Superior Industrial Bureau
  - Open Houses/Regional Meetings
  - Public Meetings, as needed
  - MCC informational bulletins
  - Local government meetings
  - NEMDA