MINNESOTA GEOLOGICAL SURVEY

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THE BASIS FOR A CONTINENTAL DRILLING PROGRAM IN MINNESOTA

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INTRODUCTION

The use of drill holes for the direct sampling and measurement of materials and properties beneath the earth's surface is the only really effective method of solving many basic scientific and practical problems. Although two to three million holes have been drilled in North America, they are concentrated in oil producing regions or in sedimentary rock. Comparatively few holes have been drilled in igneous and metamorphic rock, and many areas of scientific interest but less obvious economic importance have not been drilled at all. A select committee at a workshop on continental drilling held June 10-13, 1974 at Ghost Range, Abiquiu, New Mexico (Shoemaker, 1975) has proposed a 10-year program, aimed at the systematic exploration of the North American plate in much the same way that the Deep Sea Drilling Project has attacked the problems of the ocean basin. This program calls for the drilling of many shallow holes (30-300 m) and a few intermediate to deep holes (300-9,000 m). The impact of the results of deep sea drilling on geologic thought already has profound implications for future development of the earth's resources and should justify similar research on the continents.

Specifically, the Ghost Ranch Group hopes to increase the understanding of the mechanism of faulting and earthquakes, hydrothermal systems and active magma chambers, heat flow and thermal structure of the crust, the state of ambient stress in the North American Plate, and the extent, regional structure, and evolution of the crystalline continental crust. The latter is of particular interest to us in Minnesota because one of the proposed drilling targets is the gneissic terrane typically exposed in the Minnesota River Valley. This terrane was selected by the Ghost Ranch Group because it contains some of the oldest rocks (perhaps as much as 3,800-3,900 m.y.) known on the North American plate. The Group suggests that the materials obtained from the Minnesota River Valley would result in data pertinent to some of the most ancient chemical and rock-forming processes we know on earth. In turn, these data would provide important controls for models of the early evolution of the planet.

An undertaking of the scope and size proposed by the Ghost Ranch Group requires a substantive geological data base for each area to be investigated and expertise in the areas of scientific planning, information and data management, and the logistics of accessing data. The Minnesota Geological Survey over the years has supported numerous geological, geochemical, and geochronological studies in the Minnesota River Valley and has, through these studies, developed substantive knowledge of the geological problems unique to the area. In addition it also maintains a number of computer-based data-managment systems, particularly in the areas of storing and retrieving geological data and materials. The following discussion briefly reviews some of the geological, geochemical and geochronological data pertinent to the gneissic terrane exposed in the Minnesota River Valley, summarizes our current knowledge regarding the inferred distribution of the gneissic terrane beyond the limits of the Minnesota River Valley, and enumerates facilities and programs relating to the Minnesota River Valley that are applicable to a continental drilling program.

EXTENT AND GENERAL GEOLOGIC RELATIONSHIPS OF THE MINNESOTA RIVER VALLEY TERRANE

The Ghost Ranch Group recommended that the gneissic terrane in the Minnesota River Valley be studied by a two-phase drilling program (Shoemaker, 1975, p. 27): (1) A limited series of preliminary, shallow holes (100-300 m) through overlying younger materials to explore the areal distribution of the ancient gneissic rocks; and (2) a deep hole (10 km) to establish the nature of the deep crust as it developed during the very early stages of continental evolution. This drilling program was based on the assumption (p. 27) that the total areal exposure of the old gneissic rocks " ... is limited to a few square miles of low relief in the valley floor" and that "...an area several hundred times larger may be underlain by this ancient complex." The Ghost Ranch Group considerably underestimated the areal extent of the gneissic terrane and treated it more or less as a single point (e.g., see fig. 6, p. 28). Consequently, they did not take into account any of the problems that can be expected in siting specific targets, both to delineate the areal extent of the terrane and to locate the placement of a single deep hole which would yield maximum scientific data. This does not negate in any way the value of drilling in the Minnesota River Valley, but it does emphasize one important role of the Minnesota Geological Survey -- that of providing geologic criteria for selecting specific targets.

The 1:1,000,000 bedrock geologic map of Minnesota (Sims, 1970) shows in a general way the inferred distribution of Precambrian rocks in Minnesota. A new compilation of the bedrock geology of Minnesota is shown in Figure 1. It adds new data to the 1970 map by Sims and incorporates significant changes in interpretation. It is important to remember that at least 80 percent of Minnesota is covered with glacial drift, and heavy reliance has been placed on aeromagnetic and gravity maps to augment limited subsurface data, particularly in the western half of the State.

Weiblen and others, (1975) and Walton and others (in press) have shown that the Precambrian rocks of Minnesota are divisible into five terrane units. We believe that three of these terranes are fundamental blocks or plates of the craton, separated from each other by major crustal rifts or sutures. Two are supracratonal features, essentially basins of subsidence and sedimentation formed on the more fundamental blocks.*

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*In our initial presentation of the terrane concept for classifying the major Precambrian components of Minnesota (Weiblen and others, 1975), we identified three fundamental and three supracratonal terranes. We now propose to combine two of these supracratonal terranes as follows (Walton and others, in prep).

PRECAMBRIAN TERRANES

	Terrane Number	
	Original	Revised
Ancient gneiss block, Minnesota River Valley, southern Minnesota	I	I
Superior Province greenstone and granite block, northern Minnesota	II	II
Pre-Animikie supracratonal basin east-central Minnesota	III	IIIa

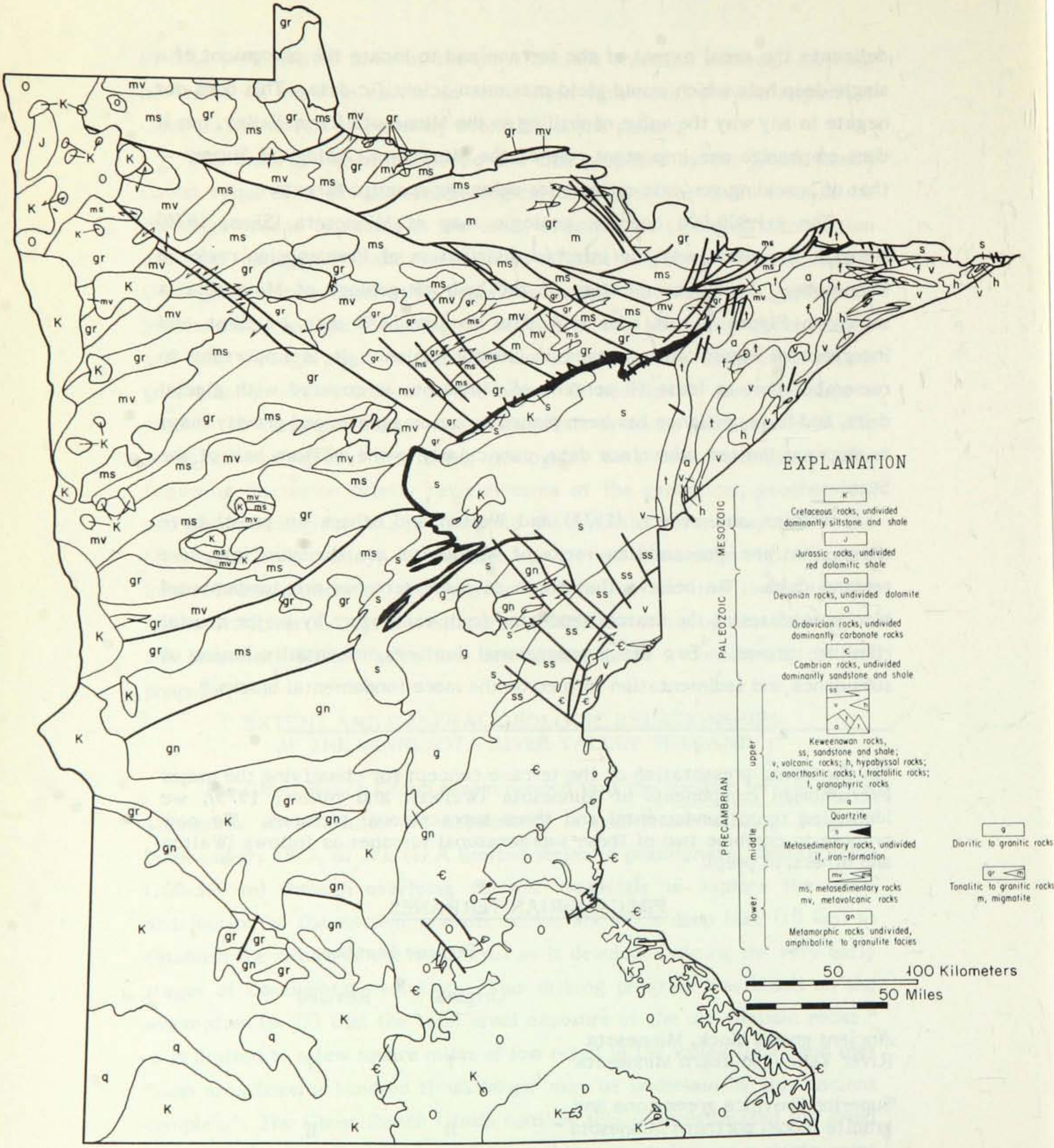

FIGURE 1 -- Generalized geologic map of Minnesota. Compiled from various sources by G.B. Morey, 1976.

If the supracratonal rocks are removed, the geologic map of the fundamental cratonal blocks of Minnesota is relatively simple (Figure 2). The chronology of major petrogenetic events which formed the three fundamental terranes is tabulated in Figure 3. They are defined as follows:

Terrane I, the ancient gneisses of southwestern Minnesota: Feldspathic, amphibolitic, and ultrabasic gneisses including relict components with whole rock Rb-Sr and U-Pb ages of 3,800 to 3,900 m.y. Intense deformation and amphibolite to granulite facies metamorphism occurred 3,600 and perhaps again at 3,000 m.y. Granitic masses of batholithic dimensions were emplaced with little or no additional deformation about 2,500 to 2,600 m.y. A major metamorphic event that affected at least part of the gneiss terrane also may have occurred at about that time. Major plutonism also occurred at 1,700 to 1,800 m.y. when at least parts of the terrane were reactivated, deformed and metamorphosed.

Terrane II, the greenstone terrane of northern Minnesota: Basaltic to rhyo-dacitic volcanic rocks, including pillow lavas, volcanogenic sedimentary rocks, banded iron-formations, and hypabyssal intrusions, invaded by large granitic plutons 2,750 to 2,700 m.y. Blocks of supracrustal strata on the order of 100 km in length and tens of km in thickness are tilted to near vertical and metamorphosed to the greenschist to lower amphibolite facies. Moderate folding and near-vertical lineations are coupled with the diapiric rise of major granitic plutons.

Terrane V, the Keweenawan rocks of eastern Minnesota. Basaltic to rhyolitic volcanic rocks, hypabyssal dikes and sills, large ultrabasic and gabbroic to granophyric intrusions, and clastic sedimentary rocks formed during a major period of intracontinental rifting at approximately 1,100 m.y.

Animikie Group supracratonal basin, east-central Minnesota	IV	IIIb
Sioux Quartzite supracratonal basin, southwestern Minnesota	V	IV
Keweenawan rift zone block, northeastern Minnesota	VI	V

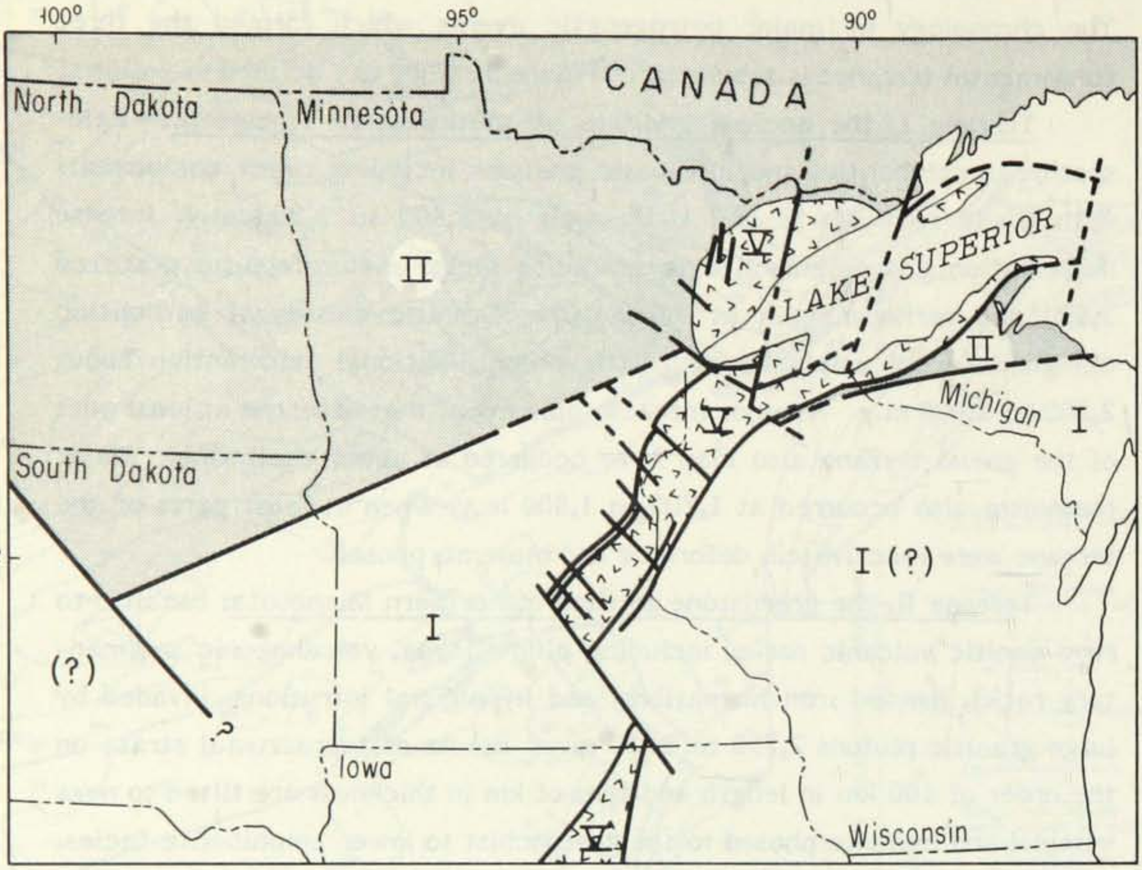

FIGURE 2 — Geologic map showing the Precambrian terranes that form the fundamental basement blocks of Minnesota as the region would appear if all basins and veneers of sedimentary rock were stripped away (modified from Walton and others, in prep.).

Time Years x 10^{-9}	I MINNESOTA RIVER VALLEY CONTIGUOUS GNEISS TERRANE	II SUPERIOR PROVINCE GREENSTONE TERRANE	V KEWEENAWAN MID-CONTINENT RIFT TERRANE
~ 05			
~ 11	Rifting to form Terrane V	Rifting to form Terrane V	HYPABYSSAL PLUTONISM VOLCANISM MAJOR RIFTING
~ 147 (Sioux Quartzite)	Deposition of Terrane IV sedimentary rocks		
~ 17 (Penokean)	MAJOR PLUTONISM METAMORPHISM		
~ 19 (Animikie and Pre-Animikie)	Deposition of Terrane III sedimentary rocks	Deposition of Terrane III sedimentary rocks	
~ 25 – ~ 27	MAJOR PLUTONISM, METAMORPHISM	MAJOR PLUTONISM, WEAK METAMORPHISM SEDIMENTATION VOLCANISM	
~ 32	REGIONAL METAMORPHISM Amphibolite to Granulite Facies DEFORMATION		
~ 36 – ~ 38	VOLCANISM SEDIMENTATION - ?- -?- -?- -? -		

FIGURE 3 -- Table of Precambrian geological events that formed or affected the fundamental basement terranes of Minnesota (Walton and others, in prep.). Primary geological events or processes which formed the terranes are capitalized. Superposed or subsequent events are listed in lower case. Shading indicates the time-spans of primary events in each terrane.

It is especially important to note that terrane I, with the earliest evidences of crustal development spans a very long period of time involving repeated tectonic, magmatic, and metamorphic activity. In contrast terrane II was formed within a very short span of time and once formed was little affected by subsequent geologic events. The substrate on which both the early Precambrian terranes formed is entirely conjectural. Space for terrane V was made by the rifting of earlier terranes with the upwelling of basaltic magma to form a block of new crust as the rift widened.

The fundamental Precambrian terranes are separated from each other at present by sharp lines of demarcation, major rifts or sutures. However, very little is known about the early nature and origin of the boundary between the two old terranes. Regardless of how this boundary originally formed, it is clear that today it is an active fault zone as evidenced by three earthquakes of moderate magnitude which have occurred along the boundary over a span of approximately 125 years. Two of these earthquakes, however, have occurred within the last 25 years.

Obviously, terrane V formed as a rift analogous to an an incipient ocean floor spreading movement. The origin of terranes I and II cannot be explained so readily. Morey and Sims (1976) concluded that the gneisses comprised all or part of a protocontinent that existed at the time of formation of the greenstone terrane in northern Minnesota and adjacent areas (2,700 m.y.). They emphasized, however, that the old gneisses are not interpreted as a protocrust, because as Goldich and others (1970) have noted, the available evidence, although fragmentary, indicates that the gneisses evolved through processes similar to those recognized in many other rocks of younger ages. It is tempting to suggest that the boundary separating terranes I and II formed originally by the opening or closing of oceanic rifts, but nothing that we now know or believe about Minnesota geology has provided an answer to this question.

SITE SELECTION CRITERIA FOR A SHALLOW-HOLE DRILLING PROGRAM

The recognition of two apparently discrete lower Precambrian crustal blocks in Minnesota has important implications for the siting of a shallow-hole drilling program designed to elucidate the distribution of the old gneissic terrane. A comprehensive understanding of the location and nature of the boundary separating the two terranes is an important prerequisite to an overall understanding of the early crustal evolution of the North American Plate.

Because much of terranes I and II are covered by a considerable thickness of Cretaceous and Pleistocene materials, the areal extent and the position of the boundary separating them has been inferred in east-central Minnesota (Morey, in prep.) and from geophysical data.

Although there is no geochronologic evidence that lower Precambrian gneisses exposed in east-central Minnesota are as old as those in the Minnesota River Valley, the rocks in the two areas have similar structural styles and apparently have had comparable tectonic histories. Similarly, the rocks in both areas were metamorphosed under granulite or upper amphibolite facies metamorphic conditions at or, more probably, before 2,700 m.y. ago. Consequently, Morey and Sims (1976) concluded that they are integral parts of the same segment of early crust. Using these observations and geophysical data, Morey and Sims (1976) inferred that the north edge of the gneissic terrane extends from about $45^{\circ}30'$N latitude at the western boundary of the State, northeastward to the vicinity of Duluth on Lake Superior, as indicated in Figure 4. According to Morey and Sims (1976), the boundary at the western border of Minnesota is about 25 km northwest of Odessa, where high-grade biotite gneiss and granitic rocks are exposed. At Duluth the boundary is truncated and displaced to the southeast by a transform fault that separates two segments of terrane V, a structural feature of Late Precambrian (about 1,100 m.y.) age.

Since the publication of Morey and Sims' original interpretation, Sims (in prep.) has suggested that the boundary is approximately 40 kilometers to the north of that originally proposed where it corresponds to a second northeast-trending fault zone (fig. 1). In accordance with geologic observations in northern Michigan and Wisconsin, Sims suggests that the rocks between the two fault zones in Minnesota may be the reactivated and cataclasized equivalents of less severely deformed rocks south of the southern fault zone. Substantive geologic evidence bearing on this interpretation is lacking. Granitic rocks similar to those in the greenstone terrane are exposed locally, but the nature of the rocks into which the

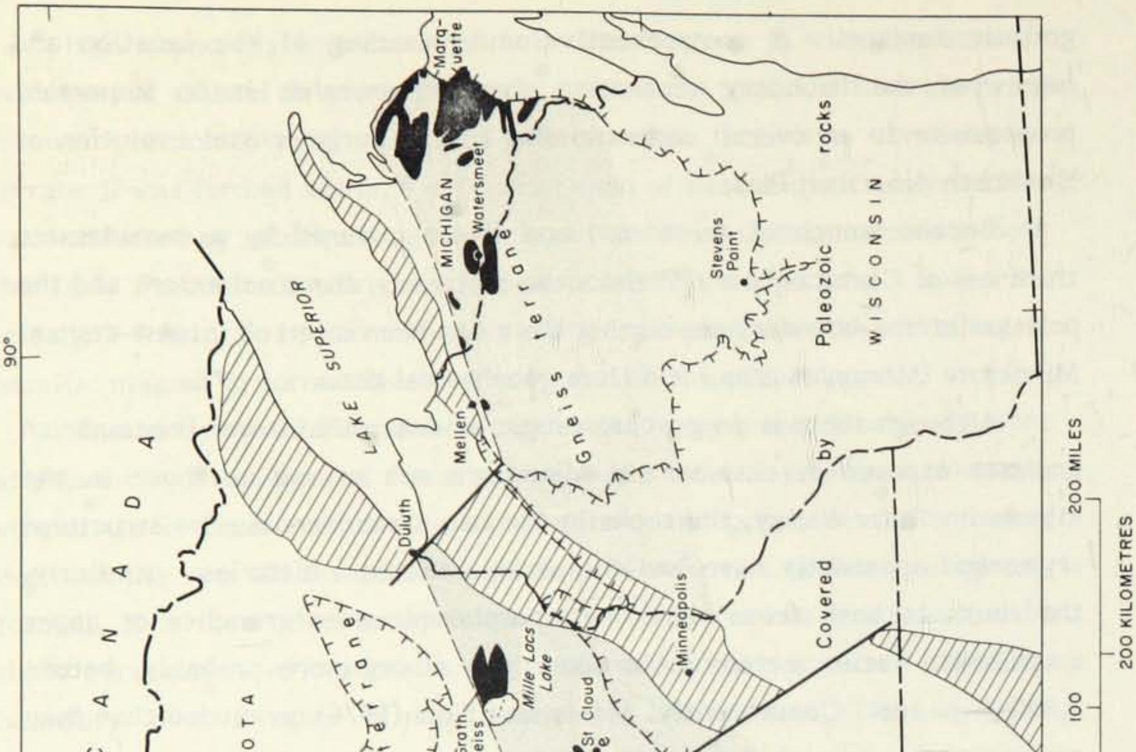

FIGURE 4 — Map of Lake Superior region showing the approximate distribution of Lower Precambrian greenstone-granite and gneiss as proposed by Morey and Sims (1976). Areas of exposed granitic gneisses known or inferred to be 2,700 m.y. old shown in black. Stipple pattern indicates probable minimum extent of gneissic terrane.

granites were intruded is debatable. Scattered water wells have penetrated what has been described as "schistose sedimentary" rocks. Although these rocks could just as well be cataclasized and metamorphosed gneissic rocks, the Minnesota Geological Survey provisionally classifies them as metasedimentary rocks associated with terrane II (fig. 1).

Geophysical and subsurface geologic data reported by Lidiak (1971), suggests the boundary zone between terranes I and II extends southwestward into South Dakota for a distance of about 210 km, where it appears to terminate against northwest-trending magnetic and gravity anomalies that imply a northwest structural trend in the basement rocks. To the west of this geophysical discontinuity, the rocks generally have a northwest-trending grain comparable to that observed in the Precambrian rocks exposed in the core of the Black Hills uplift in western South Dakota (Lidiak, 1971; Goldich and others, 1966). The inferred structural discontinuity in the basement rocks of South Dakota is interpreted (Sims and Morey, 1972, fig. 1-1) as being analogous to the Churchill-Superior province boundary, in Canada, which was formed about 1,800 m.y. ago (Stockwell, 1973, table 1), approximately at the same time as the Penokean orogeny (Goldich, 1972a) in the Lake Superior region. Thus, the crustal segment containing these old gneissic rocks has an inferred length of at least 900 km and a width, in southern Minnesota, of at least 160 km, as shown on Figure 2. If lithologically similar gneisses exposed in northern Wisconsin and Michigan are a part of this terrane, as Morey and Sims (1976) suggest, the width exceeds 210 km.

The old gneiss terrane is inferred to form the basement for part of terrane III (a & b) in east-central Minnesota (Morey, 1973) and all of terrane IV in southwestern Minnesota. It probably also forms the basement for most of the middle Precambrian strata in Wisconsin (Sims, in prep.) and Michigan (Fig. 4). If these inferences -- based on the apparent geologic coherence of the separately exposed gneisses throughout the region -- are correct, the old gneiss terrane (Terrane I) has an areal extent of at least 150,000 km^2 and probably much more.

To delineate more accurately the position and nature of the boundary in Minnesota between terranes I and II requires extensive geophysical and

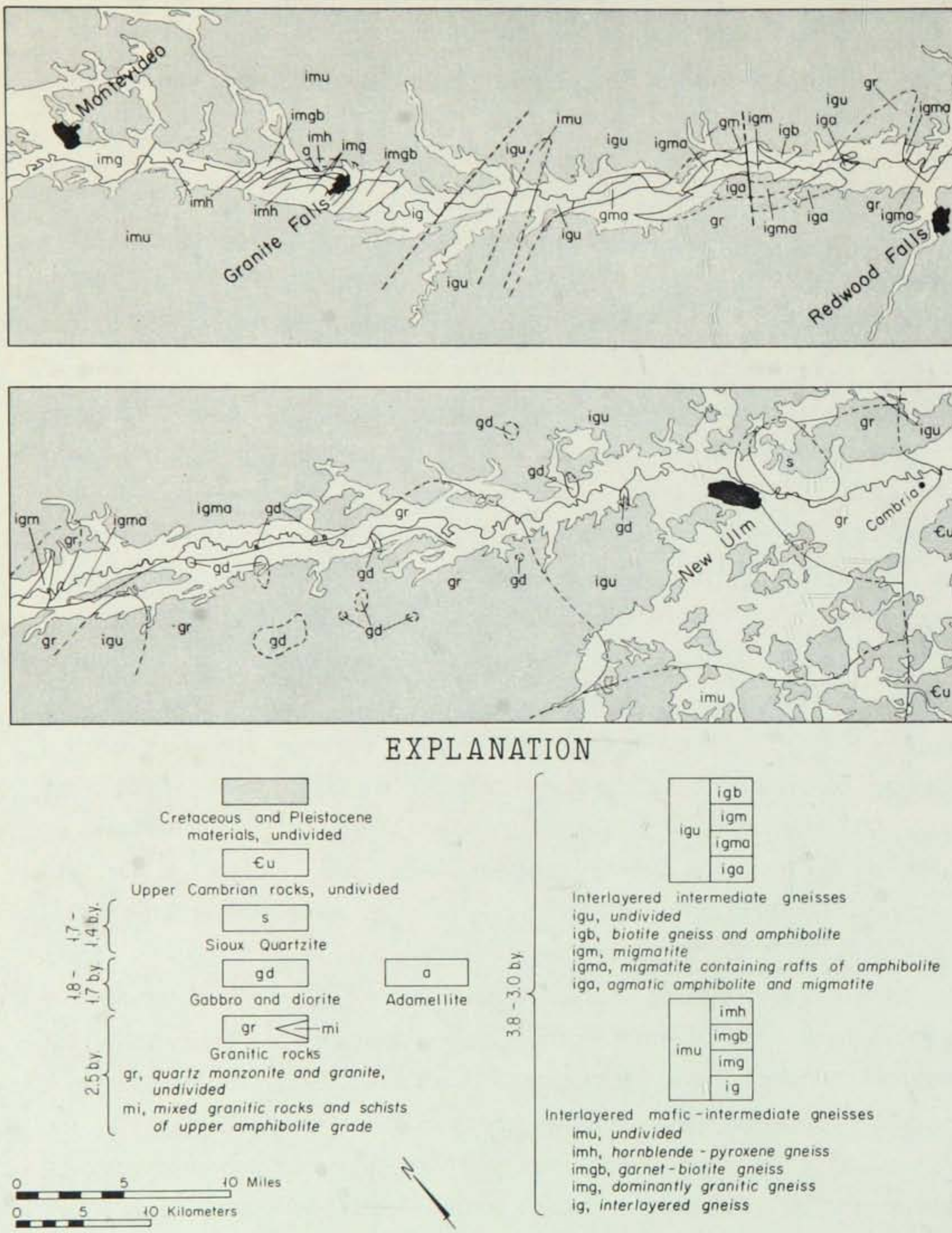

FIGURE 5 -- Geologic map of Precambrian rocks exposed in the Minnesota River Valley (modified from Austin and others, 1970).

subsurface geologic studies. Although aeromagnetic maps are available at various scales for the entire State (see Zeitz and Kirby, 1970; Sims, 1972), the only published gravity data are those of Craddock and others (1970). This map, at a scale of 1:1,000,000 is not detailed enough to be of more than general use in locating the boundary. Gravity data on a one-mile grid are currently being collected in the area of the inferred boundary. These data, when compiled in map form, will be of considerable value in refining the geologic configuration of Precambrian rocks units in the vicinity of the inferred boundary. Nonetheless, any definitive conclusions regarding the geologic significance of the boundary must await the completion of a shallow-hole drilling program designed to test many of the inferences outlined above.

SITE SELECTION CRITERIA FOR A DEEP-HOLE DRILLING PROGRAM

Although old gneissic rocks are inferred to underlie a large part of southern Minnesota, they are exposed at only a few scattered localities beyond the limits of the Minnesota River Valley. Consequently, the inferred distribution of rock types within the gneiss terrane is based primarily on geologic observations within the valley itself and on geophysical data, including a preliminary Simple Bouguer Gravity map of the New Ulm sheet (Minnesota Geological Survey open-file map). Although the bedrock geologic map of the New Ulm Sheet at a scale of 1:250,000 (Austin and others, 1970) illustrates many of the complexities associated with the gneiss terrane, it is not sufficiently detailed to materially aid in selecting potential sites for a deep hole.

Grant has mapped at scales of 1:48,000 or 1:62,500 much of the bedrock geology within the Minnesota River Valley between Odessa, to the northwest, and Cambria, to the southeast (unpub. Ms. maps in the files of the Minnesota Geological Survey). This work, in conjunction with the earlier studies of Lund (1956), demonstrates that the terrane consists of a grossly interlayered sequence of highly deformed migmatitic granitic gneiss, amphibolitic gneiss and pelitic gneiss which is intruded by a variety of younger granitic rocks (Fig. 5).

Although gneissic rocks crop out sporadically throughout the Minnesota River Valley, they have been studied extensively only in the Granite

Falls-Montevideo and Morton-Sacred Heart areas. The major emphasis of these studies has been to obtain a detailed knowledge of the metamorphic and deformational history and to "look beyond" the metamorphism to determine the pre-metamorphic character and origin of the gneisses.

In the Granite Falls-Montevideo area the bedrock consists mainly of granitic gneiss (the Montevideo gneiss of Goldich and others, 1970), hornblende-pyroxene gneiss, and garnet-biotite gneiss which have mineral assemblages characteristic of the lower granulite-upper amphibolite metamorphic facies (Himmelberg and Phinney, 1967). Each type of gneiss constitutes mappable units 300 to 2,000 meters thick (Himmelberg, 1968). The granitic gneiss contains discontinuous lenses of hornblende-pyroxene gneiss and is intruded by leucocratic granite. Modes and chemical analyses (Goldich and others, 1970; Goldich, 1972b) indicate that the granitic gneiss ranges in composition from granite to granodiorite.

A possibly major east-trending fault south of Granite Falls is inferred to separate the rocks exposed between Granite Falls and Montevideo from those exposed in the vicinity of Morton and Sacred Heart (Grant, 1972, fig. III-80).

In the Sacred Heart-Morton area, mappable units within the gneisses are less distinct than in the Granite Falls-Montevideo area, but four units constituting a succession a few thousand meters thick have been delineated (Grant, 1972). The lower three units are quartzofeldspathic gneisses that contain varying amounts of amphibolite; the upper unit is a biotite-rich pelitic gneiss which contains cordierite-anthophyllite and sillimanite-K-feldspar assemblages (Grant, 1972).

The Morton gneiss, as used by Goldich and others (1970) is considered by Grant (1972) to be a variant of one of the quartzofeldspathic units that contains rafts of amphibolite. It is a migmatitic rock consisting of amphibolite, a gray phase having the composition of trondhjemite (Goldich, 1972b, p. 27) and a pink granitic or pegmatitic phase. The gneissic rocks in this area were intruded and possibly metamorphosed by a generally coarsed-grained granite, the Sacred Heart Granite of Goldich and others (1970).

The gneissic rocks, at least between Montevido and Granite Falls, have been subjected to several periods of folding. Geologic mapping by Lund (1956) and Himmelberg (1968) defined a broad antiformal structure in the vicinity of Granite Falls plunging gently to the east and having an axial plane dipping steeply to the south. Subsequently Bauer (1974) delineated two periods of folding which are younger than the major antiformal structure, and one period of folding that may be older. The earliest folding is represented by small, isoclinal, recumbent folds that are coaxial with the major antiforms. These folds may be remnants of a very early period of folding or they may have formed during the early development of the major antiformal structure. Folds younger than the major antiformal structure include small to large parasitic folds whose orientations are generally consistent with that of the major antiform, and minor folds whose axial planes trend in a northwesterly direction and are inclined to the northeast. Bauer (1974) suggests that the latter period of folding may be much younger than the main period of folding.

Structural elements in the gneissic terrane exposed to the northwest of Montevideo and to the southeast of Granite Falls have been described in a general way by Grant (1972). He has suggested that the various structural elements in these areas are consistent with the antiformal structure recognized near Granite Falls. However, later deformation involving minor folding, warping, shearing, and faulting is evident throughout the valley and particularly in the area south of Granite Falls.

Grant (1972, p. 196) suggested that the major period of folding and the granulite-facies metamorphism took place contemporaneously with the emplacement of the major plutonic rocks (Sacred Heart Granite of Goldich and others, 1970). The precise timing of the folding and metamorphism remains equivocal, but it is clear that much of the terrane evolved prior to plutonism at 2,500 m.y.

In general, the field studies summarized above, and their contained references, have provided the geologic framework for the detailed geochronological and geochemical studies of S.S. Goldich and his colleagues (Goldich and others, 1961; Goldich and Hedge, 1962; Catanzaro, 1963; Stern and others, 1964; Goldich and Gast, 1966; Goldich and Hedge, 1966; Goldich and others, 1966; Hanson, 1968; Goldich and others, 1970; Goldich, 1972a &

b; Goldich and Hedge, 1974; Goldich and others, 1975; Wooden and others, 1975). These studies summarize the results of what probably is the most extensive and thorough geochronological and geochemical study of any area in North America or the World.

Although still far from complete, the geochronological studies have demonstrated that the gneissic terrane is much more complex than the geologic observations so far obtained would seem to indicate. Despite the imperfect nature of the data, three general conclusons seem valid: (1) Various tonalitic components of the gneissic terrane may be as much as 3,800 to 3,900 m.y. old (Goldich and Hedge, 1974, 1975; Goldich and others, 1975); (2) The old rocks may have been metamorphosed at 3,650 m.y. (Wooden and others, 1975) and again metamorphosed or intruded by a granitic magma at 3,000 m.y. (Goldich and Hedge, 1975); (3) The gneissic rocks were subsequently affected by a period of plutonism and possibly metamorphism at approximately 2,500 m.y. and by a much younger thermal event at 1,700 to 1,800 m.y. (Goldich and others, 1970).

It is clear that the old gneissic terrane has been repeatedly affected by a variety of complex and as yet incompletely understood geological processes. Consequently, there is no published geological model which accounts for all of the observations, and in fact there is no general agreement as to the geological significance of the geochronological data so far obtained (e.g. Farhat, 1975; Farhat and Wetherill, 1975). Currently, Goldich and several colleagues have an extensive petrologic, geochemical, and geochronological program underway which will provide a considerable amount of new data. These studies will provide valuable input into the site selection of a deep hole, but the initiation of a drilling program cannot be predicated on completion of current studies. The drilling is badly needed as input into the studies, and major advances can be anticipated the sooner a drilling program is integrated with current research. In a very real sense current research awaits input from drilling to perhaps a greater degree then drilling site selection awaits results from current work.

RELATIONSHIP OF THE CONTINENTAL DRILLING PROJECT TO EXISTING AND PROPOSED PROGRAMS OF THE MINNESOTA GEOLOGICAL SURVEY

The Minnesota Geological Survey has long recognized the scientific and practical importance of geologic studies in the Minnesota River Valley. Consequently, it has supported and will continue to support such studies and to encourage "all-comers" interested in the geology of the Minnesota River Valley. However, the valley is only a small part of a much larger terrane which is mostly covered by a considerable thickness of Mesozoic and Cenozoic materials. A comprehensive understanding of the geology of the entire terrane will require a subsurface geological exploration program much like the shallow-hole investigative program proposed by the Ghost Ranch Group. The scientific aspects of such a program require a closely coordinated effort involving exploratory drilling, and various geophysical, petrological, and geochemical disciplines. The Minnesota Geological Survey has designed such a program and a bill to fund it at a level of $250,000/year is before the Minnesota Legislature. The bill has not yet been enacted, but if it were to be passed, the Minnesota Geological Survey would proceed immediately to implement a drilling program. Undoubtedly the boundaries between the various fundamental Precambrian terranes referred to above would be among the first targets. It is not possible to assess the probability of obtaining this funding. It is probably not strong in the immediate future, but would be enhanced if matched by outside funds.

In anticipation of a comprehensive subsurface exploration program, the Minnesota Geological Survey also has designed and now maintains a computer-based data storage and retrieval system which is compatible with the U.S. Geological Survey CRIB system. This data display and retrieval system utilizes a direct access, permanent file on the Univeristy of Minnesota Control Data CYBER 74 computer with a time-sharing terminal in the Survey offices. The file is designed to store a basic inventory of all wells drilled in Minnesota. It also includes summaries of geological logs and other pertinent geologic and engineering data. At the present time the system contains approximately 8,500 wells, mostly from the Seven County Metropolitan Area which includes Minneapolis and St. Paul.

The Survey also maintains an in-house repository of well cuttings from throughout the State. Much of the information derived from these cuttings is cross-referenced into the computer-based storage and retrieval system. In addition, the Survey maintains more than 100,000 feet of diamond drill core which currently is being stored at the core storage facilities, U.S. Bureau of Mines, Twin Cities Research Center. The Survey recently has completed a Bureau of Mines sponsored project which permits relatively easy access -- within mutually compatible guidelines and procedures -- to this material by all interested scientists and other qualified individuals. At the present time, the Survey is considering alternative methods of integrating data pertaining to these materials into a useable storage and retrieval system.

All of these facilities provide a rational basis for the management of considerable amounts of data acquired before, during, or after any specific drilling project. As such the facilities are completely compatible with the data-management needs outlined by the workshop on continental drilling. Should a continental drilling project be undertaken, the Minnesota Geological Survey will propose a site selection, data collection and management program for Minnesota, to which it will anticipate making a significant cost-sharing contribution.

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