INTERIM REPORT

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INTRODUCTION

This interim report is the first in a series of quarterly reports designed to keep the Stearns County Park Department informed on the progress of geologic research carried out on Granite Quarry Park property. The purpose of the report is to provide assistance in the preparation of reports submitted to the LCMR as a part of the required communications related to the grant. The major effort thus far has been collecting data on the depths of individual quarries. That effort is now largely completed and a description of that work is included in this interim report.

Discussions have been held with personnel from the U.S. Bureau of Mines, which represents a major potential resource for Granite Quarry Park. There are four main areas that have so far been identified as possible cooperation areas: 1) testing geophysical equipment; 2) blasting experiments; 3) reclaimation and environmental protection; and 4)public outreach/education. Jim Jessop, who continues to be our most helpful contact person, has suggested that the county make a general presentation on the park site at the Twin Cities Research Center in St. Paul; this would help identify other areas in the Bureau that might be curious about the park. Then for interested Bureau personnel, a follow-up visit to the site this fall would help solidify specific plans. Also, a memorandum of agreement regarding access to the site and any initial work done by Jessop's group will have to be drawn up. The seismic work originally planned for this fall will probably have to be put off until spring.

Initial contacts have also been made with the Minnesota Geological Survey and the Minnesota Department of Natural Resources; both agencies are involved in the County Geologic Atlas which is currently being prepared. The project leader in the Minnesota Geologic Survey is a specialist in glacial geology. A brief meeting has been held with the geologist responsible for mapping the crystalline bedrock. The park project was explained to him and more follow-through meetings will be necessary. Only preliminary contacts have been made with the DNR Division of Waters. Their regional seismic work will probably be mainly in the western part of the county and that planning depends on the distribution

of subsurface control identified by the Minnesota Geological Survey. The liaison effort with all of these agencies is a long-term and on-going aspect of the work on the Granite Quarry Park project.

This interim report consists of two main parts. First, a "preliminary literature survey" is provided to give an historical perspective on geologic investigations in central Minnesota. And second, the "quarry survey" will be described.

PRELIMINARY LITERATURE SURVEY

Background

The geology of central Minnesota can be subdivided into three generalized layers (Figure 1) which correspond with three broad subdivisions of geologic time. The youngest material is unconsolidated clay, sand, and gravel which forms a continuous blanket over the surface. This material was deposited by glaciers and streams during the Quaternary Period (about the last one million years) and is termed "drift". Sedimentary rocks including weathered residuum, shales, and sandstone constitute a rather discontinuous intermediate layer. These rocks were formed during the Cretaceous Period (about 70 to 140 million years ago and the Cambrian Period (about 500 to 550 million years ago). The deepest rocks are the oldest. Metamorphic and igneous rocks including granite, argillite, and graywacke were formed during the Precambrian (more than one billion years ago). Although it is these oldest crystalline rocks that will be emphasized in the Granite Quarry Park research, the other layers are also part of the geologic contest of the park property.

This literature survey is organized in accordance with the three geologic subdivisions described in the previous paragraph. After some general references are discussed in this "Background" section, the glacial drift, sedimentary rock, and crystalline bedrock will each be reviewed chronologically. Usually the older references are more generalized while the more recent references tend to be more focused and detailed. The intent of this preliminary literature survey is to establish the geologic contest of the Granite Park property. A more exhaustive review of the literature will probably be included in the County Atlas being prepared by the Minnesota Geological Survey.

Much of the early published information on the geology of central Minnesota was limited to state-wide compilations and discussions. For example, the area is shown only as igneous crystalline rocks on an old state map (MN Geological Survey, 1932); the chapter in Schwartz and Thiel's (1954) classic summary of Minnesota geology emphasizes the granite industry in central Minnesota. More recent state maps (Sims, 1970; Morey and others, 1982) show more complex geology and the chapter on central Minnesota in a newer summary of Minnesota geology (Ojakangas and Matsch,

1982) includes more discussion of the glacial drift and sedimentary rocks. Summaries of the geology of Stearns County are included in such project-specific reports as the hydrologic atlas for the Sauk and Mississippi watershed (Helgesen, Ericson, and Lindholm, 1975) and the comprehensive water plan for Stearns County. In the last few years, the geology of central Minnesota has been investigated using satellite-based technology (Shurr and Watkins, 1989) and has been reinterpreted in terms of plate tectonics (Southwick, Morey, and McSwiggen, 1988).

Quaternary Drift

The surface mantle of unconsolidated sediment consists of material deposited by glaciers which is called "till" and material deposited by glacial streams which is "outwash". Patterns of till and outwash are used to interpret the history of glacial and stream deposition and erosion. An early, fairly comprehensive history of the upper Mississippi included the St.Cloud area (Cooper, 1935). A more obscure reference (Ahlquist, 1955) described terraces along the Sauk River just to the west of Granite Quarry Park. Modern interpretations of regional glacial history (Wright and Ruhe, 1965; Wright, 1972) have included central Minnesota and have also focused on the area (Wright, 1973). The most comprehensive compilation of data on glacial till and outwash in central Minnesota is the report on sand plains in the St. Cloud area (Lindholm, 1980). It remains the primary source of information, although there are several recent investigations which warrant mention. Glacial landforms generally west and north of Stearns County have been summarized by Goldstein (1987). Glacial stratigraphy and structure near Powder Ridge, which is located in the St. Croix End Moraine south of Granite Quarry Park, has been recently described in detail (Danelski and others, 1993).

Cretaceous Sedimentary Rock

In the vicinity of the park property, only Cretaceous sedimentary rock is preserved. Cambrian sedimentary rock is located farther south (see Figure 1) and is not presently known to be found north of Wright County. Because the layer of Cretaceous sedimentary rock is discontinuous and buried beneath glacial drift, descriptions have only been recently completed. Outcrops in Stearns County are included in state-wide

compilations (Sloan, 1964; Parham, 1970). Stearns County is included in a regional summary of Cretaceous geology (Shurr and others, 1987b) and specific test borings in the vicinity of St. Cloud have been described (Setterholm and others, 1989). Physical properties of Cretaceous clays which may have economic potential are described by Toth and others (1990). Relationships between Cretaceous weathering residuum and lithology and structures in crystalline bedrock are discussed by Shurr and others (1991).

Precambrian Crystalline Bedrock

The majority of geologic literature that deals with the area of Stearns County is devoted to descriptions and interpretations of the Precambrian crystalline bedrock. It is these rocks which are extensively exposed and quarried in the eastern part of the county. Only scattered lithologic and geochemical descriptions were published before World War II; rocks quarried in central Minnesota were described by Bowles (1918) and by Thiel and Dutton (1935). The first systematic attempt to describe and map all the major rock types as well as interpret their relative ages and geologic history was carried out by Margaret Skillman Woyski (1949). She expanded earlier interpretations to include most Precambrian crystalline rocks as igneous in origin.

Radiometric dating of Precambrian rocks in central Minnesota was the next major technological advancement (Goldich and others, 1961; Hanson, 1968). Modern petrographic, geochemical, and geochronologic data are summarized in a chapter of the Centennial Volume of the Minnesota Geological Survey (Keighin, Morey, and Goldich, 1972); igneous origins are retained as interpretations for most of the major rock types. However, as more detailed studies became available, interpretations of metamorphic origins became progressively more important. This modification of interpretation began with the systematic description and naming of formal rock units (Morey, 1978), continued with the mapping of those units (Morey, Olsen, and Southwick, 1981), and culminated in a re-interpretated metamorphic origin for rocks previously thought to be igneous (Darcy, Himmelberg, and Morey, 1984). Coupled with the trend to interpret more rocks as metamorphic, there was a growing awareness of the importance of plate tectonics.

Several lines of structural (Holst, 1984) and geochemical (Horan, Hanson, and Spencer, 1987) evidence converged on a fundamental change in the interpretation of tectonics in central Minnesota. The 1981 geologic map was reinterpreted (Southwick, Morey, and McSwiggen, 1988) as a convergent plate margin and the geochemical implications of that reinterpretation were documented (Barovich and others, 1989). During approximately the same period of time from the mid to late 1980's, staff and students as St. Cloud State University's Department of Earth Sciences began publishing a series of abstracts which focused on the Precambrian geology of central Minnesota. Rocks specifically from the Granite Quarry Park area were described (Ronnie and others, 1985), the origin of a unique lithology was discussed (Watkins, 1987; Watkins, Anderson, and Erickson, 1987), and evidence was presented for previously unrecognized faults in central Minnesota (Shurr and others, 1987a). Zircon, a mineral critical in radiometric dating and in interpretation of metamorphism, has been described in detail (Belden, Anderson, and Watkins, 1989). Faults which are a logical consequence of the interpretation of a convergent margin have been documented (Watkins, Shurr, and Anderson, 1990) and it appears that these Precambrian faults have been recently reactivated to control the development of modern landforms (Johnson and others, 1991; Shurr, Johnson, and Watkins, 1992). The unique rapakivi lithology has also been described in more detail (Hellickson, Radzevicius, and Anderson, 1992; Radzevicius, Hellickson, and Anderson, 1992).

Some of the most recent and most detailed information on crystalline rocks near the Granite Quarry Park is contained in two reports on the geology (Shurr and others, 1991) and the geochemistry (Heine, 1991) of rocks in the Meridian Aggregates Quarry. The quarry was mapped at a scale of 1 in = 100 ft, geologic structures and lithologies were characterized, and a geologic history based on plate tectonic interpretations was summarized. It is anticipated that this study will provide a valuable analogue for the geology of Granite Quarry Park which is located approximately one mile south of the Meridian Aggregates Quarry.

QUARRY SURVEY

The basic data collection and analysis for the determination of quarry bathymetry was conducted during July and August of 1993. About 400 hours of time were spent in obtaining about 6000 data points, organizing these data points spatially on a map, contouring these data, and field checking the results.

The water depth values were obtained by floating an electronic sonar device across the quarries following a nylon rope marked with one meter intervals which was stretched between two known points on the quarry margins. The water depth at each mark along the rope was determined and recorded in a log book.

Each transect location was marked on an outline map of each quarry, with the water depth readings later recorded along each transect. Contour lines were then added using 10 foot contour intervals for most maps, with a 5 foot contour used for some of the shallow quarries. The zero datum was the surface of the water at the time the readings were completed.

After the completion of the basic maps, a field check process was conducted to obtain a more precise fitting for the contour lines, or to add detail to complex areas. This was done with the use of a canoe, the first draft map, and the sonar device. Where there were problem areas, more data points were collected so that a more refined contour map could be completed.

The outline of the quarries was drawn from available aerial photographs, refined in the field at the time of data collection, and could, in some cases, be improved by a more detailed image of the quarry, or one which does not have any dark shadows which obscure the margin.

Relative surface water elevations were also recorded during this time period for 10 different quarries at 11 different time intervals. These data represent the change in water level caused by inflow of surface water, evaporation from the water surface and flow of water from one quarry to another quarry through cracks and fractures. Because of the very heavy precipitation during July and August these values most probably do not define a typical summer pattern, and will need to be augmented with additional data.

CONCLUSIONS

The investigations on Granite Quarry Park property have begun. Fortunately, the quarry survey was essentially completed during the warm-weather months of the summer. The relatively minor refinements and simple drafting that remain to be done could easily be completed in the next few months. That phase of the project will then be finished.

Geologic investigations are just beginning. As an offshot of the completed literature survey, a review of the regional geology around the park property can be written. Data collection for the study of the nine square mile "neighborhood" of the park will be done this fall.

Although we are off to a staggering start, the research potentials on this project are excellent. The Bureau of Mines is interested in a long-term presence in the park. That will augment the continuing attention the area receives from the Department of Earth Sciences at St. Cloud State University.

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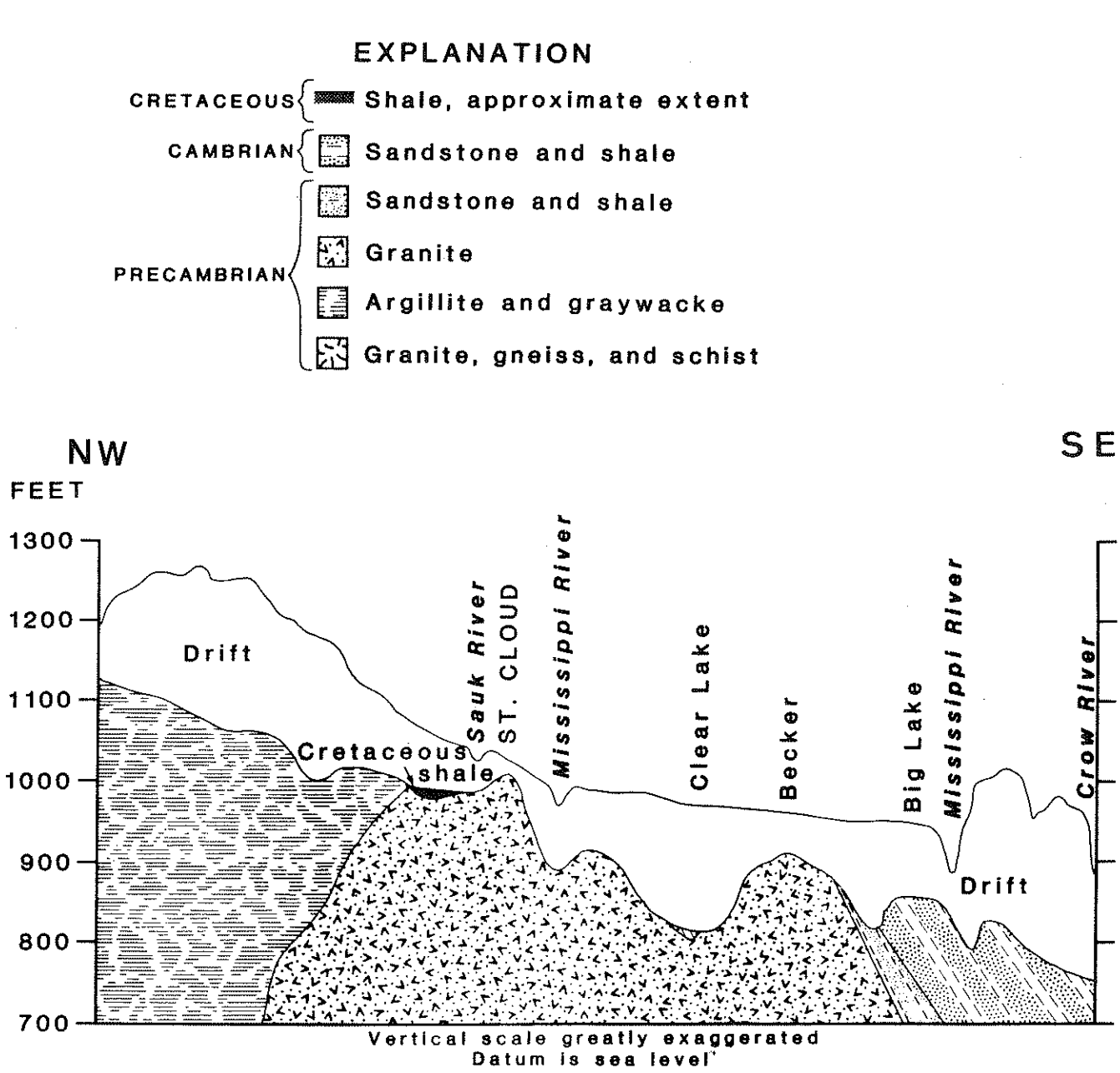

Figure 1---Simplified cross section of geologic layers along the Mississippi River near Granite Quarry Park. This side-view is taken from Lindholm (1980).