THE RELATIONSHIPS BETWEEN MORPHOSTRATIGRAPHY, ROCK STRATIGRAPHY, AND ASPECTS OF TILL FABRIC IN CENTRAL ILLINOIS

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This is to certify that the

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Rock Stratigraphy, and Aspects of Till Fabric
In Central Illinois

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David Allan Castillon

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of the requirements for

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ABSTRACT

THE RELATIONSHIPS BETWEEN MORPHOSTRATIGRAPHY, ROCK STRATIGRAPHY, AND ASPECTS OF TILL FABRIC IN CENTRAL ILLINOIS

By

David Alan Castillon

This thesis is concerned with the relationship between selected morphostratigraphic units and aspects of rock stratigraphy including pebble orientation in central Illinois. Investigations were made to determine the nature of the areal relationships between rock stratigraphy and morphostratigraphy of the Woodfordian end moraines in central Illinois. Included in these investigations was an analysis of long-axis pebble orientation of the till fabric. The nature of the sedimentary contact zone deposited by two lobes of Woodfordian glacial ice was studied to determine if morphostratigraphic units in an interlobate area could be delineated by the use of pebble orientation data or rock stratigraphy. Analysis of the pebble lithology of elongate stones was made to determine if a discernible difference in lithologic composition exists between delineated morphostratigraphic units or between delineated rock-stratigraphic units.

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Thirty-eight analysis sites within the till of the Bloomington, Champaign, Eureka, and Normal Morphostratigraphic Units were selected. At each of these sites a random fifty-pebble sample was examined by established methods of till-fabric analysis. The pebbles' long-axis orientation was measured to the nearest five degrees and the dip strength was recorded. These same pebbles were classified lithologically in the laboratory. A sample of the till matrix surrounding the fifty pebbles was collected and analyzed by the laboratory of the Illinois State Geological Survey providing data on grain size, clay mineral composition, and carbonate content. Data on the color of the till matrix were provided by the author. These data were used to identify and correlate rock stratigraphic units.

The findings of this study indicate that the Eureka and Normal Morphostratigraphic Units should be mapped as a single unit identified as the Eureka-Normal Moraine (Drift). The physical characteristics of the till within the Eureka-Normal Moraine (Drift) indicate that this morphostratigraphic unit has a single rock-stratigraphic unit surface till which can be correlated with the Malden Till of the Wedron Formation. Pebble-orientation data from analysis sites along the trend of the Eureka-Normal Moraine (Drift) reveal that the long axis of elongate pebbles within the Malden Till prefer a perpendicular alignment to the trend of the moraine. These orientations indicate a Lake Michigan Lobe source. Pebble

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lithology data show that a lower percentage of crystalline pebbles and a larger percentage of carbonate pebbles are embedded in this till than were found in tills from the other morphostratigraphic units of this study.

The data from analysis sites within the till of the Champaign Moraine (Drift) indicate that this morphostratigraphic unit is well defined topographically and that the surface till of this unit can be correlated with the Snider Till of the Wedron Formation. This same rock-stratigraphic unit was correlated with the till on the eastern flank of the interlobate region. This portion of the interlobate region adjoins and can be associated with the Champaign Moraine (Drift) of this study. The long-axis pebble orientations of the Champaign Moraine (Drift) tend to be orthogonal to the trend of the morphostratigraphic unit outside of the interlobate, then become parallel to the trend of the landform in the associated interlobate region. An Erie Lobe source can be postulated for the Snider Till from these orientation findings. Pebble lithology data from the Champaign Moraine (Drift) and associated interlobate area indicate that pebbles within till from an Erie Lobe source have approximately 9 per cent fewer carbonate pebbles when compared with pebble lithology data from the Eureka-Normal Moraine (Drift) which has a Lake Michigan Lobe source.

The findings of this study reveal that the Bloomington Moraine (Drift) is very complex. Three distinct surface ills wi

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tills within this morphostratigraphic unit can be delineated: the Tiskilwa, Malden, and Shamrock Till Members. The latter was named and defined in this study. As was the case with the other units investigated in this study, the long axis of pebbles embedded in these tills preferred a perpendicular alignment to the trend of the moraine outside of the interlobate area. In the interlobate region associated with the Malden Till of the Bloomington Moraine (Drift) pebble-orientation data once again reveal a strong tendency for pebbles to align themselves parallel to the trend of the landform.

Because the relationships between morphostratigraphy, rock stratigraphy, and till fabric did not complement one another within the area of the Bloomington Moraine (Drift) as they did on the other units of this study, an alternate interpretation of the morphostratigraphy was investigated. An alternate interpretation must account for three distinct rock-stratigraphic units and also account for an ice source region that will explain its fabric. An analysis of the topography of the Bloomington Moraine (Drift) indicates that it is not necessarily one morphostratigraphic unit. Instead, it may represent a situation where three units of different age converge on one another. The oldest unit identified by the presence of Tiskilwa Till, which is the surface till west of Bloomington, Illinois, and exists over a wide area in the subsurface, was deposited by an ice advance from the north. The Shamrock Till, whose fabric orientations suggest it was eposi

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deposited by a western advance, possibly of the Erie Lobe, was deposited and overlies the Tiskilwa Till. A third and younger till unit which is the surface till within the moraine everywhere east of the Kickapoo Creek Valley and also the surface till on a part of the proximal slopes to the west of this stream was deposited contemporaneously with the Snider Till of the Champaign Moraine (Drift) forming the interlobate moraine. The time-stratigraphic correlation of Malden and Snider Tills suggested by the fabric orientations in the interlobate region, which are parallel to the ice-contact zone, and the similar physical characteristics of these two till members suggest that the landform associated with this region be named the Champaign-Bloomington Interlobate Moraine (Drift).

Of general interest to the area of glacial geomorphology is the finding of this study that morphostratigraphic units exist and can be useful geomorphically when sedimentary parameter data complement the landform unit.

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By

David Alan Castillon

A THESIS

Submitted to

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for the degree of

DOCTOR OF PHILOSOPHY

Department of Geography

1972

Dedicated to

Joanne
Cindy, Kim, Linda, Laura,
and David Alan II

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I wish to express my thanks to my committee, which was chaired by Dr. H. A. Winters and consisted of Dr. J. R. Harman, Dr. G. Higgs, and Dr. H. D. Foth; to the Illinois State Geological Survey and in particular to Dr. C. Collinson, P. Perkins, Dr. H. D. Glass, Dr. H. B. Willman, Dr. J. P. Kempton, Dr. D. L. Gross, and Dr. J. C. Frye of the Illinois State Geological Survey for their help and assistance; to my typist Sandy Aper for a fine job; and finally a special thanks to my wife Joanne, my daughters Cindy, Kim, Linda, and Laura, and my son David Alan II for their patience, understanding, and encouragement during the writing of this thesis.

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Chapter 1

INTRODUCTION

Statement of Problem

This thesis is concerned with the relationships between selected morphostratigraphic units and aspects of rock stratigraphy including pebble orientation in central Illinois.[1] Several specific matters, listed below, were investigated in an effort to determine these relationships. (1) The nature of the relationship between rock stratigraphy and morphostratigraphy of the Woodfordian end moraines in central Illinois was investigated. (2) The nature of the relationship between the pebble orientations of the till fabric and morphostratigraphy of the Woodfordian end moraines in central Illinois was investigated. (3) Investigations of the contact zone between two glacial lobes of the Woodfordian glacial ice were made to determine if morphostratigraphic units in an interlobate area could be delineated by the use of pebble-orientation data or rock stratigraphy. And (4) investigations were made to determine if a discernible difference in pebble lithology of the collected orientated stones exists between delineated morphostratigraphic units, or between delineated rock-stratigraphic units.

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[1]The study area is defined on page two and illustrated in Figure 1.

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Study Area

The study area selected in central Illinois contains one of the best examples in North America of arcuate-lobate end moraines with good topographic expression that merge into what appears to be an interlobate area. The study area has an approximate east-west extent of 40 miles (73 kilometers) and north-south extent of 30 miles (48 kilometers), and includes parts of Champaign, Ford, McLean, Piatt, and Woodford Counties in Illinois. The study area is delineated in Figure 1, a map of Illinois.

The literature describing various aspects of all or part of this area is extensive. An early work, very comprehensive for its time and entitled "The Illinois Glacial Lobe," was written in 1899 by Frank Leverett. This monograph describes the Pleistocene landforms of the state of Illinois and has served since its publication as a primary reference for glacial geology studies in the state. Leverett's interpretation of the glacial landforms of the study area was modified only slightly during the first thirty years following publication. He revised some of his interpretations in 1929 and again in 1932. These revisions included minor changes in both the delineation of moraines (Leverett, 1932) and the interpretation and terminology regarding substages of the Wisconsin glacial stage (Leverett, 1929). From 1932 to the present, changes in the interpretation of the Wisconsin glacial stage have continued. Two of the more

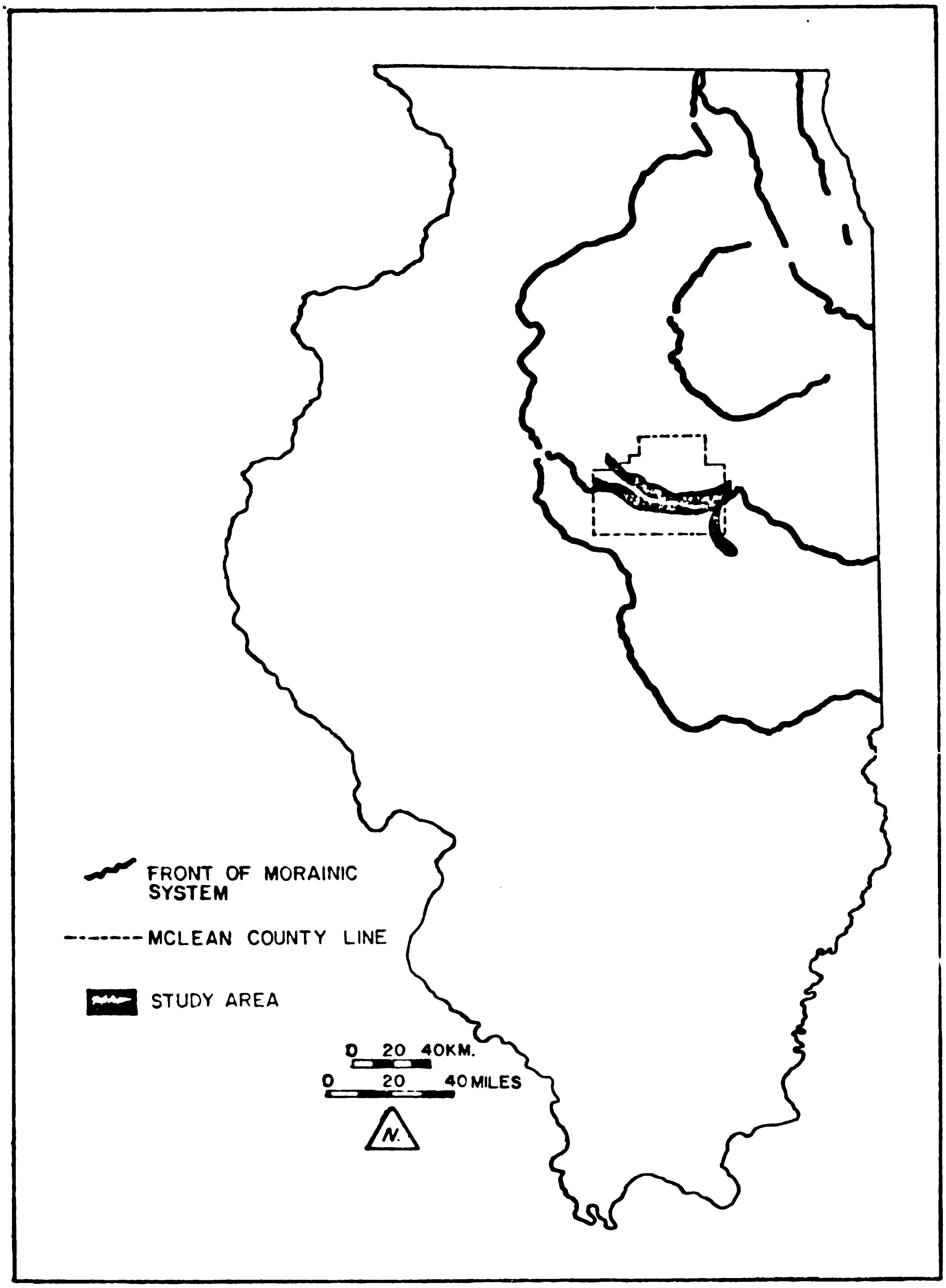

Figure 1 Map of Illinois illustrating study area

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important works concerned with the chronology of the Wisconsin glacial stage in Illinois were made by Leighton (1958) and Frye and Willman (1960).[2]

Many other publications describing various characteristics of the Wisconsinan glacial drift of Illinois were published in the 1960's. To cite a few of the more important works: Frye, Glass, and Willman (1962) published a study on the stratigraphy and mineralogy of the Wisconsinan loess; Willman, Glass, and Frye (1963, 1966) wrote on the mineralogy and weathering profiles of glacial till; and Piskin and Bergstrom (1967) described the thickness and character of the glacial drift of Illinois.

Two recent publications describing the study area were written by Willman and Frye (1970) and Kempton, DuMontelle, and Glass (1971). The former, Bulletin 94 of the Illinois State Geological Survey entitled "Pleistocene Stratigraphy of Illinois," is general in nature and covers the entire state whereas the latter is specific and focuses on till units in McLean County.

Bulletin 94 is useful because Willman and Frye review the principles of stratigraphic classification for Pleistocene deposits. Four different types of stratigraphy may be recognized: (1) time stratigraphy, (2) morphostratigraphy, (3) rock stratigraphy, and (4) soil stratigraphy. The study area for this thesis is a part of the Woodfordian time

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[2]Hereafter in this study the term "Wisconsinan" will be used for Wisconsin when referring to the glacial stage as suggested by Frye and Willman (1960).

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stratigraphic unit, the morphostratigraphic units broadly defined by the Peoria Sublobe of the Lake Michigan Lobe and the Decatur Sublobe of the Erie Lobe, the Wedron Formation rock-stratigraphic unit, and the Jules Soil soil-stratigraphic unit (see Figure 2). This study is concerned with certain relationships between morphostratigraphy and rock stratigraphy.

The Kempton, DuMontelle, and Glass (1971) work on the stratigraphy of Woodfordian tills in McLean County is useful because it defines five till units, three of which are surface tills in the study area of this thesis.

Morphostratigraphy

A morphostratigraphic unit is defined "as a body of rock that is identified primarily from the surface form it displays; it may or may not be distinctive lithologically from contiguous units; it may or may not transgress time throughout its extent" (Frye and Willman, 1960, 1962). Morphostratigraphic units were proposed in an effort to explain the relationship and significance of topographic forms to rock, soil, and time-stratigraphic units. The term "Drift" is attached to a named morphostratigraphic unit and is used to connote the deposit of glacial till and outwash associated with a moraine and traceable from it into the ground moraine, outwash apron, and beneath younger drifts (Willman and Frye, 1970). In this study the term "Moraine" will be retained to include the landform which is discernible by its topographic expression and the term "Drift" when included in parentheses following Moraine

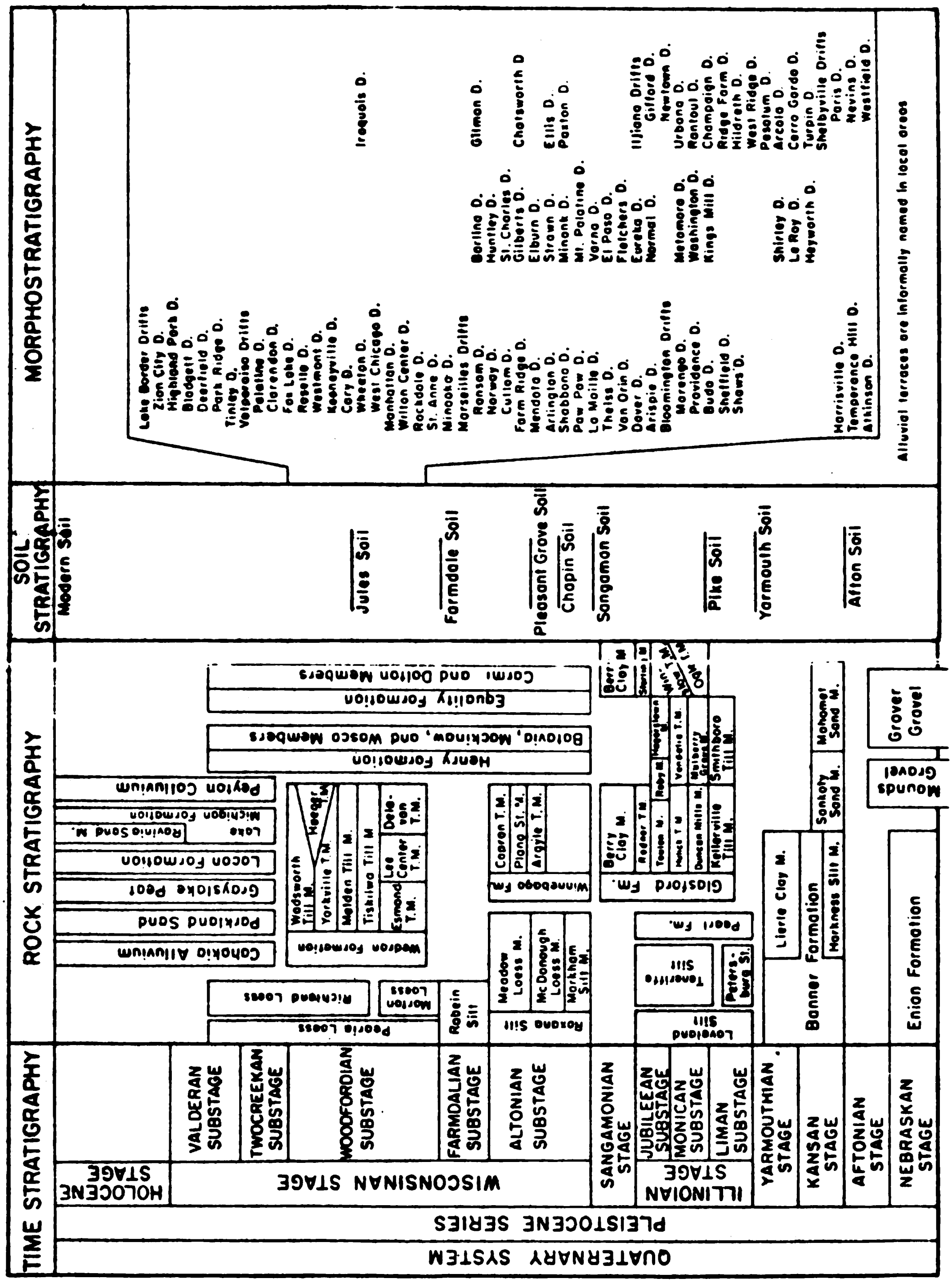

Figure 2 Stratigraphic classification of the Pleistocene deposits of Illinois (after Willman and Frye, 1970)

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is interpreted to be at least partially representative of the morphostratigraphic unit as defined by Willman and Frye (1970).

During the Woodfordian Substage two lobes of glacial ice covered approximately one-third of the northeastern sector of the state of Illinois (see Figure 3). The Erie Lobe had only one sublobe in Illinois called the Decatur Sublobe (Frye and Willman, 1970). The Lake Michigan Lobe had six sublobes (Frye and Willman, 1970). This study is concerned with some of the deposits of both the Peoria Sublobe of the Lake Michigan Lobe and the Decatur Sublobe of the Erie Lobe. These two sublobes deposited a sequence of Drifts that form the basis of the morphostratigraphy of the study area (Frye and Willman, 1970). The map entitled "Woodfordian Moraines of Illinois" (see Figure 4, in pocket) is included in this dissertation by permission of the Illinois State Geological Survey and shows all mapped Woodfordian morphostratigraphic units in the state.

The individual morphostratigraphic units defined as Drifts by Willman and Frye (1970) and selected for investigation in this study are based on part of the Bloomington and Eureka Moraines and all of the Normal Moraine of the Peoria Sublobe and part of the Champaign Moraine of the Decatur Sublobe. The drifts of this study from the Peoria Sublobe merge with the drift of the Decatur Sublobe to form the interlobate area (see Figure 4, in pocket).

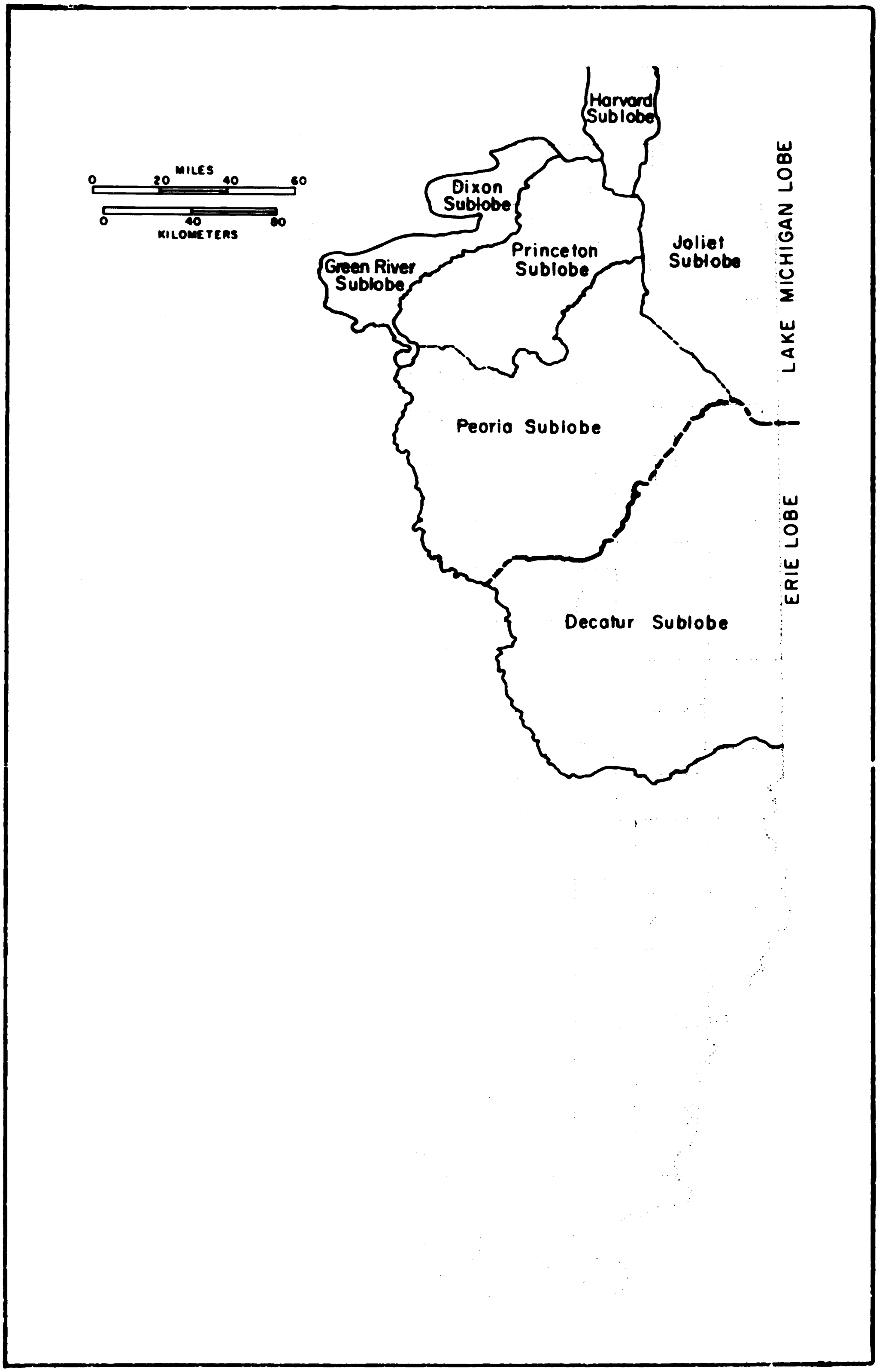

Figure 3 Woodfordian lobes and sublobes in Illinois (after Willman and Frye, 1970)

Rock Stratigraphy

The American Commission on Stratigraphic Nomenclature Code (1961, page 649) defines a rock-stratigraphic unit as follows:

> A rock-stratigraphic unit is a subdivision of the rocks in the earth's crust distinguished and delimited on the basis of lithologic characteristics....Rock-stratigraphic units are recognized and defined by observable physical features rather than by inferred geologic history.

The study area for this thesis lies entirely in the rock-stratigraphic unit named the Wedron Formation (see Figure 5). The Wedron Formation consists of glacial tills, outwash sands and gravels associated with the glacial tills, and silt deposited in Illinois during the Woodfordian Substage of the Wisconsinan Stage (Frye et al., 1968; Willman and Frye, 1970). The formation is bounded below by the Morton Loess or older deposits and above by the Richland Loess (Frye et al., 1968). Its type section is the Wedron Section, Wedron Silica Company pit, SE SW Sec. 9, T.34 N., R.4 E. (Willman and Frye, 1970).

Willman and Frye (1970) differentiated eight till members in the Wedron Formation in Illinois. Kempton, DuMontelle, and Glass (1971) defined five till units in the Wedron Formation in the McLean County region. And Johnson, Follmer, Gross, and Jacobs (1972) recognized four till members in the Wedron Formation in east-central Illinois. Figure 5 gives the areal distribution of the named till members as published in Guidebook Series 9 of the Illinois State Geological

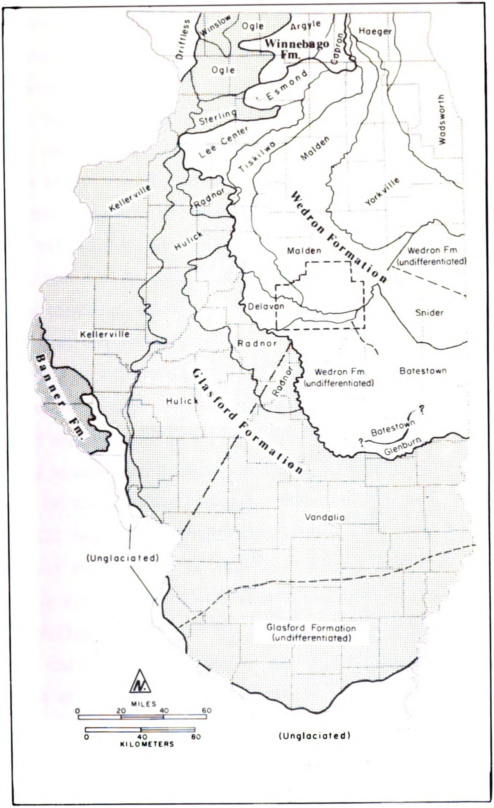

Figure 5 Areal distribution of till formations and members in Illinois (after Johnson et al., 1972, and others)

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Survey (Johnson et al., 1972). The reader should note that the five till units of Kempton, DuMontelle, and Glass (1971) have not been incorporated into the information on this map.

On the basis of works by Willman and Frye (1970); Kempton, DuMontelle, and Glass (1971); Johnson, Gross, and Moran (1971); and Johnson et al. (1972) the defined or correlated surface units for the study area of this thesis are (1) the Tiskilwa and Malden Till Members of Willman and Frye (1970); (2) Till Units 1, 2, and 4 of Kempton, DuMontelle, and Glass (1971); and (3) the Glenburn, Snider, and Batestown Till Members of Johnson, Gross, and Moran (1971).

According to Willman and Frye (1970) the Tiskilwa Till Member is the uppermost till of the western part of the Bloomington Moraine (Drift) in the study area. The western part of the Bloomington Moraine (Drift) is here defined as the drift west of Bloomington, Illinois. The type section for the Tiskilwa Till Member is a roadcut in Bureau County known as the Buda East Section. It is located in the SE SE SW Sec. 31, T.16 N., R.8 E., 5 miles (8 kilometers) northwest of Tiskilwa (Frye and Willman, 1965, page 96, unit 1). In the opinion of the author the Tiskilwa Till Member can be correlated areally with Unit 4 of Kempton, DuMontelle, and Glass (1971). Unit 4 is correlated with the Glenburn (Johnson, Gross, and Moran, 1971).

The Glenburn Till Member, which has a possible correlation with the Tiskilwa Till, is named for the town of Glenburn and

its type section is the Emerald Pond Section NE SW SW Sec. 33, T.20 N., R.12 W., Vermillion County (Johnson, Gross, and Moran, 1971, page 211). Radiocarbon dates indicate that this unit may be pre-Woodfordian (Johnson et al., 1972).

The Malden Till Member is the uppermost till of the eastern part of the Bloomington Moraine (Drift) and is the uppermost till of the Eureka and Normal Moraines (Drifts) in the study area (Willman and Frye, 1970). The type section for the Malden Till Member is in the Malden South Section, SW SE SE Sec. 5, T.16 N., R.10 E., roadcuts 2 miles (3 kilometers) south of Malden (Willman and Frye, 1970, pages 185-86). The Malden Till Member is differentiated into two units (Kempton, DuMontelle, and Glass, 1971). Unit 2, broadly defined, represents the uppermost till of the eastern part of the Bloomington Moraine (Drift), and Unit 1 is the uppermost till of the Eureka and Normal Moraines (Drifts) (Kempton, DuMontelle, and Glass, 1971).

The Batestown Till Member is correlated with the uppermost till of the Champaign Moraine (Drift) in the study area (Johnson et al., 1972). The type section for the Batestown Till Member is the Emerald Pond Section in Vermillion County, NE SW SW Sec. 33, T.20 N., R.12 W., (Johnson, Gross, and Moran, 1971, page 211). Unit 3 of Kempton, DuMontelle, and Glass (1971) was not shown to exist in the study area of this thesis. However, it has been suggested that the Batestown Till Member correlates with Unit 3 (Johnson, Gross, and Moran, 1971; Johnson et al., 1972). Previously the Batestown Till was called

Tazewell by Eveland (1952), and Cerro Gordo and Champaign by Ekblaw and Willman (1955).

The Snider Till Member was not previously recognized or correlated with any of the tills in the study area of this thesis, but the data collected in this study suggests a possible correlation (see Chapter 4). In the Danville region the Snider Till is the youngest till and is separated from the Batestown Till Member below by stratified drift and is named for the town of Snider, Illinois (Johnson, Gross, and Moran, 1971). The Emerald Pond Section in NE SW SW Sec. 33, T.20 N., R.12 W., Vermillion County is the type section (Johnson, Gross, and Moran, 1971, page 211).

Unit 5 of Kempton, DuMontelle, and Glass (1971) is reported to exist in the study area only as a subsurface till and was correlated by Johnson et al. (1972) with the Oakland Till Member of Ford (in preparation).

Figure 6 summarizes the relationship between Till Members or Till Units with suggested possible correlations.

Eveland (1952)	Ekblaw Willman (1955)	Willman Frye (1970)	Kempton DuMontelle Glass (1971)	Johnson Gross Moran (1971)	Johnson et al. (1972)
			1	Snider	Snider
	Champaign	Malden	2	Batestown	Batestown
Tazewell	Cerro Gordo		3		
		Tiskilwa	4	Glenburn	Glenburn
			5		Oakland

Figure 6 Correlated till members and till units

Till Fabric

Holmes (1939) defined till fabric as the space relations among the component rock and mineral fragments in undisturbed till and used a quantitative interpretation of these space relationships in an attempt to explain the direction of glacial ice movement. The technique established by Holmes to determine fabric has not been modified significantly over the past thirty years, but refinements in methods of analysis have been described during this period of time. Examples include Harrison (1957a), Kauranne (1960), and Andrews and Shimizu (1966). Practical uses for till-fabric analysis have expanded to include determination of the speed of glacial ice movement (Harris, 1968), stratigraphic variation in tills (Rains, 1969), reorientation of till by readvancing ice (MacClintock and Dreimanis, 1964), and correlation with landforms such as drumlins (Wright, 1957) and moraines (Hoppe, 1952). Also variability of till fabrics both horizontally and vertically has been studied by West and Donner (1957) and Young (1969).

The only till-fabric studies performed near the study area of this thesis are included in papers by Harrison (1957b), Smith (1970), and Lineback (1971). The results of the studies by Smith and Lineback are summarized in Guidebook Series 9 of the Illinois State Geological Survey (Johnson et al., 1972). Orientation findings for the Glenburn and Batestown Till Members of the Wedron Formation in the Danville, Illinois region show the Glenburn Till Member to have a southwest

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The till-fabric analysis for this study utilizes the technique of Holmes (1941). Both dip and strike were measured while the pebbles were in place in the till. Pebbles were then removed, measured to the nearest millimeter, and classified according to shape and lithology. The field and laboratory procedure of the till-fabric analysis is described in Chapter 2.

Till Matrix Composition

The till matrix was analyzed for grain size, clay mineral composition, and carbonate content by the laboratory of the Illinois State Geological Survey in Urbana, Illinois. Their help and cooperation is gratefully acknowledged. The laboratory procedures used to analyze the till matrix are described in Chapter 2.

The Illinois State Geological Survey classifies gravel as particles larger than 2.0 millimeters, sand as particles between 2.0 and 0.062 millimeters, silt as particles between 0.062 and 0.004 millimeters, and clay as particles smaller than 0.004 millimeters.

The clay mineral composition is determined by X-ray diffraction of oriented aggregates for clay-size particles. Three categories--expandable clays, illite, and chlorite plus kaolinite--are separated by this technique. The X-ray diffraction process is also used to determine the carbonate

content. Carbonates are measured in counts per second giving either calcite or dolomite depending on the angle of analysis.

The till matrix was also described according to color. Till samples were moistened and a Munsell Soil Color Number was determined, and a verbal notation of the dry color was determined.

Data and Analysis Sites

In this study till-fabric and till-matrix composition analyses were performed on samples collected at 4 to 5 mile intervals (6 to 8 kilometers) along the trend of the moraines and at approximately 2 mile (3 kilometers) intervals in the interlobate area. A discussion on analysis site selection is presented in Chapter 2.

A total of thirty-eight analysis sites were selected with thirteen of these in or near the interlobate area. For each analysis site data collected includes (1) location of the site; (2) elevation; (3) type of exposure (roadcut, pipeline trench, etc.); (4) depth of sample; (5) topography of the area including location of site with regard to the outline of the moraine (proximal, distal, or central); (6) till-pebble data which includes the size, shape, long-axis orientation, and lithology of each pebble; and (7) till-matrix composition data which includes the till color, grain-size distribution, clay mineral composition, and carbonate content. The data for all thirty-eight analysis sites are included in the Appendix of this thesis.

The relationship between landforms and sedimentary parameters can be found extensively in the literature of glacial geomorphology. For example, Hoppe (1952) carefully described the location of each of his till fabrics in terms of its location with respect to the outline of the moraine or hummock from which it was taken. Such descriptions made it possible for him to state certain relationships between sediments and landforms. Rains (1969) used the sedimentary parameters of till-fabric analysis to confirm the existence of two till units stratigraphically at a particular location. Anderson (1955) used the sedimentary parameter of pebble lithology and reports that pebble lithology is determined largely by the position and distance of the source area relative to the direction of ice movement and can be used to distinguish tills from different ice lobes. Willman and Frye (1970) used sedimentary parameters to differentiate the rock-stratigraphic units defined in Illinois.

The purpose of this thesis is to analyze and describe the relationships that exist between certain sedimentary parameters and landforms. The landform unit in this thesis is the morphostratigraphic unit (end moraine). The sedimentary parameters are pebble orientation, pebble lithology, and till-matrix composition. This thesis will analyze and describe the relationships between four morphostratigraphic units in central Illinois and certain sedimentary parameter data gathered from thirty-eight analysis sites along these units.

Justification for the Study

Till-fabric analysis and till-matrix composition analysis have proved to be important and meaningful field and laboratory techniques in glacial geomorphology. In addition to adding to knowledge of the glacial geomorphology of an area, they may reveal especially significant relationships between landforms and sediments. The writer knows of no till-fabric studies that apply the concept to interlobate areas. Such application may make it possible to determine at least in part ice behavior in interlobate areas and to better understand the nature of deglaciation in such regions. Finally, the area selected in Illinois is especially favorable for this analysis because the topography has been carefully mapped and the landforms are a part of one of the best understood Midwestern glacial landscapes.

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Chapter 2

FIELD WORK AND LABORATORY ANALYSIS

Selection of the Study Area

Introduction

The primary objective of this study is to determine relationships between morphostratigraphy and certain aspects of rock stratigraphy including pebble orientation, pebble lithology, and till-matrix composition. Such relationships would probably be most revealing (1) where the end moraines have good topographic expression both vertically and laterally, (2) where the proximal and distal boundaries of end moraines are reasonably well defined, (3) where the end moraines were formed by two distinct lobes of glacial ice, and (4) where the end moraines of two lobes merge into an interlobate area. An area that satisfies all these criteria is located in central Illinois, where the Eureka, Normal, and Bloomington Moraines (Drifts) merge with the Champaign Moraine (Drift) in what appears to be an interlobate area.

Study Area

Willman and Frye (1970) defined and delineated the Bloomington, Champaign, Eureka, and Normal Moraines (Drifts) (see Figure 4, in pocket). The study area for this thesis is shown on Figure 7 and can be delineated as follows: The Bloomington Moraine (Drift) was studied from the McLean County line on the west to the interlobate area in eastern

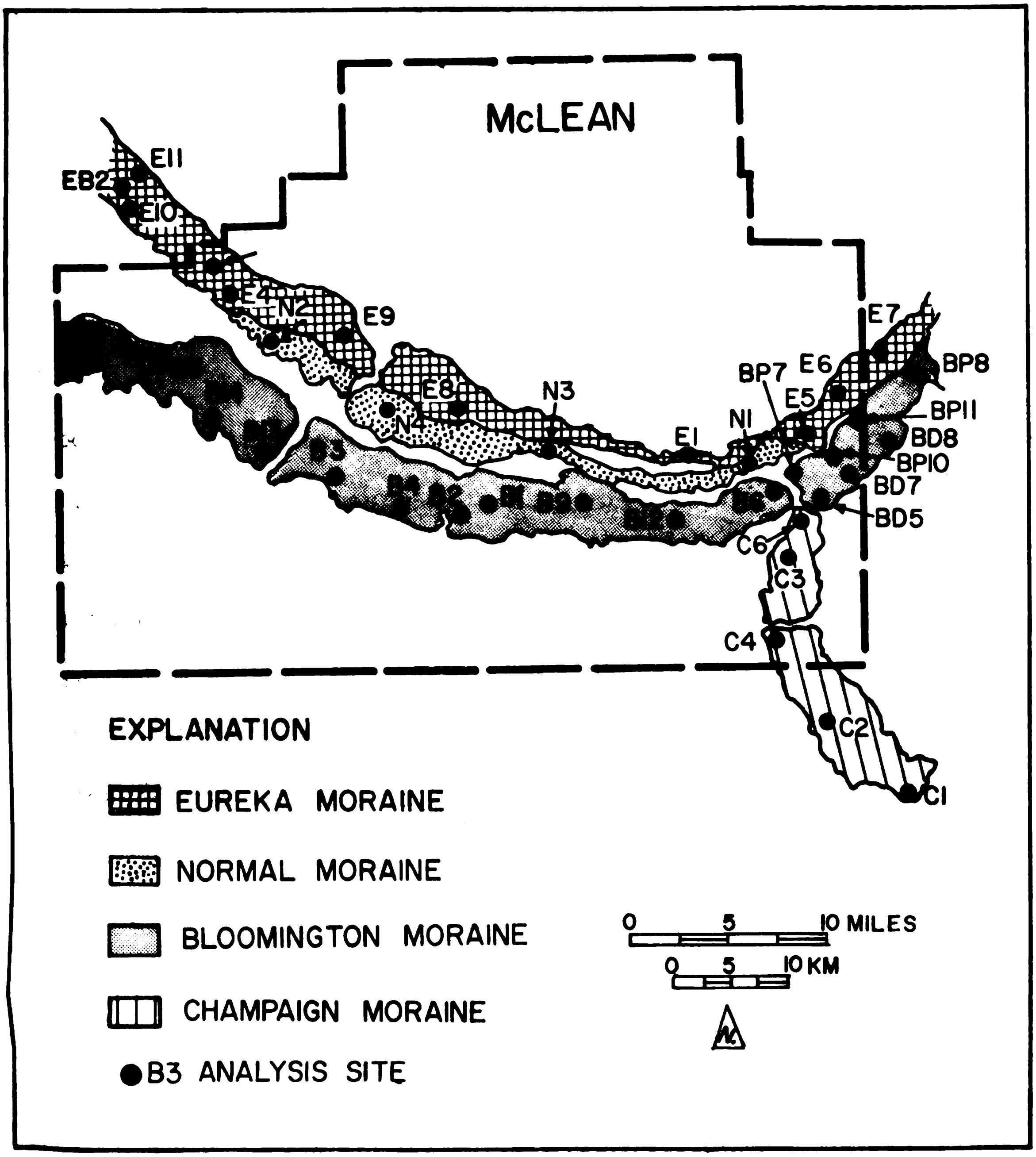

Figure 7 Morphostratigraphic units of the study area with general location of analysis sites

McLean County. The Champaign Moraine (Drift) was studied in the area between its two points of dissection by the Sangamon River approximately marked by analysis site locations C6 and C1. The Eureka Moraine (Drift) was studied from the area of its dissection by the Mackinaw River near analysis site EB2 to the interlobate area in eastern McLean County. And the Normal Moraine (Drift) was studied throughout its entire extent.

Selection of Analysis Sites

Introduction

The Map "Woodfordian Moraines of Illinois" (Figure 4, in pocket) summarizes more than seventy years of refinement in the mapping of the surficial landforms of the study area of this thesis. Leverett (1897, 1899) first mapped the Pleistocene landforms of this area, and the Bloomington Morainic System and Champaign Morainic System were named by him. Leighton and Ekblaw (1932) and Ekblaw (1941, 1959) revised and updated the mapping of Pleistocene deposits in the study area, adding the Normal Moraine. Further revisions by M. M. Leighton and J. A. Brophy (1961) altered the extent of the Normal Moraine. Willman and Frye (1970) defined the Eureka Moraine and established the extent of the Bloomington, Champaign, and Normal Moraines to their present positions.

Analysis Sites

Analysis sites were spaced 4 to 5 miles (6 to 8 kilometers) apart along the trend of the Bloomington and Champaign Moraines (Drifts), but because of the close and problematical relationship between the Eureka and Normal Moraines (Drifts) the 4 to 5 mile (6 to 8 kilometers) interval was alternated. The series of alternating sites appears justified in this area because according to Willman and Frye (1970) the Eureka and Normal Moraines (Drifts) are both part of the same rock-stratigraphic unit, the Malden Till Member. In the inter-lobate area where greater definition and refinement of relationships is sought, the interval between analysis sites was reduced to a 1 to 2 mile (1 to 3 kilometers) interval. A total of thirty-eight general analysis locations was selected along the moraines (see Figure 7).

Once a desirable general location for an analysis site was selected, two factors were considered before the specific location was determined. First only an exposure (such as a railroad cut, roadcut, pipeline trench, or borrow pit) within the moraine deep enough to reveal till below the zone of calcium carbonate ($CaCO_3$) leaching was considered to be a suitable location for analysis (see Figure 8). The surface till of the study area lies stratigraphically below the Richland Loess (Willman and Frye, 1970). The thickness of loess on top of the moraines of the study area ranged from less than 1 foot (0.3 meters) to approximately 8 feet (2.3 meters) in depth. Three feet (1 meter) of loess was very common. The surface of the calcareous zone was usually found to be about 4 feet (1.3 meters) and never exceeded 5 feet (1.5 meters) below the top of the cut or excavation.

Figure 8 Examples of analysis sites

Figure 8A Pipeline trench
Six foot deep trench in Malden Till at analysis site E7; (See Figure 7 for location)

Figure 8B Borrow pit
Borrow pit exposure of Shamrock Till along I-74 at analysis site B4; (See Figure 7 for location)

Figure 8A

Figure 8B

Figure 8 Examples of analysis sites

Figure 8C Roadcut with dig
Twelve foot roadcut exposure showing Richland Loess overlying Malden Till at analysis site N2

Figure 8D Close up of dig illustrating dip measurement
Brunton compass measuring dip of pebble embedded in Snider Till at analysis site BD7

Figure 8C

Figure 8D

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The average depth of till analysis was 8 feet (2.3 meters) below the original surface but this figure ranged from 4 to 25 feet (1.3 to 7.5 meters). A second factor considered in the selection of an analysis site was its location relative to the surrounding topography. Glen, Donner, and West (1957) suggest that, if care is taken to select deposits that do not appear to have been seriously disturbed since deposition, reorientation by gravitational movement can be minimized. When an exposure was selected as suitable, an attempt was made to locate the dig[3] in such a way that reorientation of the fabric by slides or mechanical movement was minimized. This was accomplished in most cases by selecting satisfactory exposures in the higher part of the moraine in the area of the analysis. By selecting such a location, the till under analysis could be assumed to have most likely remained unmoved or unaffected in any way by material that had moved as a result of gravitational mass wasting since its time of deposition. Thus, the fabric of the till would represent its original depositional environment.

Field Technique

Introduction

Most of the field data for this thesis was collected during the summer of 1971. The field procedure was initiated

[3] A "dig" is here defined to be the excavation into the side of an exposure necessary to create a suitable working surface for a till-fabric analysis (see Figures 8C and 8D).

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by the selection of an analysis site. Each location was identified by a field note number which was to identify the analysis site. The letter B was used to identify analysis sites along the trend of the Bloomington Moraine (Drift), C was used for Champaign Moraine (Drift), E for Eureka Moraine (Drift), and N for Normal Moraine (Drift). The letters EB refer to an analysis site located areally on the Eureka Morphostratigraphic Unit but in a lower rock-stratigraphic unit than the top till of the Eureka Moraine (Drift). In the interlobate area, which was defined by Willman and Frye (1970) as Bloomington Moraine (Drift), the letters BP and BD were used to identify analysis sites. BP denotes defined Bloomington Moraine (Drift) on the Peoria Sublobe side of the interlobate, and BD denotes Decatur Sublobe side of the same unit. The boundary between Peoria Sublobe side and Decatur Sublobe side of the interlobate is defined as a line connecting the upper limits of two intermittent streams as they bisect the interlobate (see Figure 9). Along with each letter designation is a number which identifies a specific location on the morphostratigraphic unit.

The identifying number, legal land description, elevation, type of exposure, depth of sample below the top of the exposure or cut, and topography were recorded for each analysis site (see the Appendix). Topography was described by slope development in the area of the analysis site and location with respect to the outline of the moraine. Slope development was

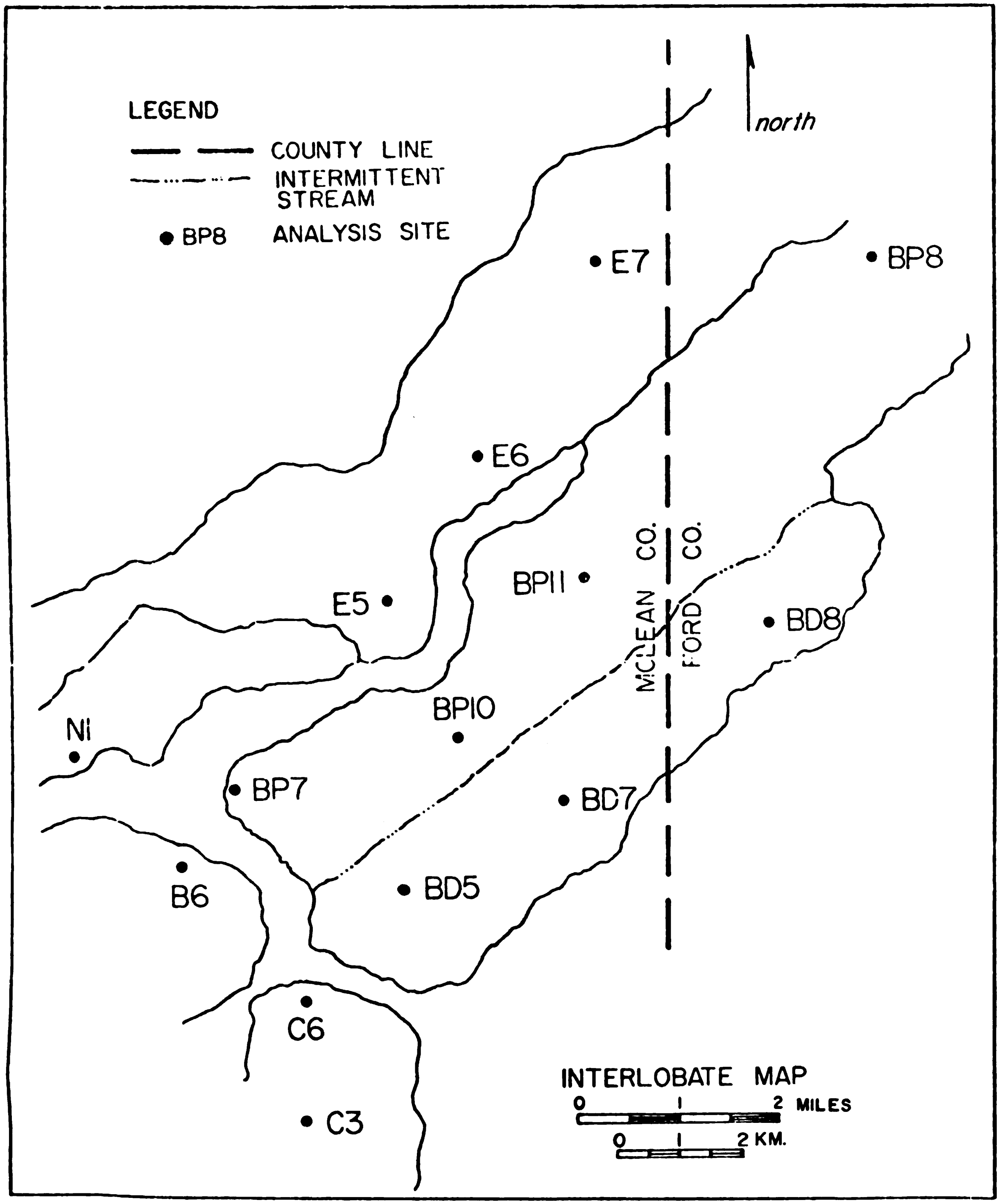

Figure 9 Interlobate map

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given by letter designation according to the scheme of the U.S.D.A. Soil Soncervation Service Soil Surveys (see Figure 10).

Slope	% Grade	Descriptive Terms USDA-SCS	(General)
A	0-2	Nearly level	(Level-flat)
B	2-6	Gently sloping	(Undulating)
C	6-12	Moderately sloping	(Rolling)
D	12-18	Strongly sloping	(Hilly)
E	18-25	Steep	(Steep)
F	25-35	Very steep	(Very steep)
G	Over 35	Very steep	(Rough)

Figure 10 Slope development classification

Location of the analysis site with respect to the outline of the moraine was described as proximal, distal, or central.

Till-Fabric Analysis

At each site selected a horizontal surface approximately 3 feet square (2500 square centimeters) was excavated (see Figure 8D). The surface was cleared and leveled with a mattock and brushed with a small broom to expose the top surface of any pebbles at that level. The matrix of till around each pebble was then carefully removed with a pocket knife in an effort to determine the long axis of the pebble. Approximately 4 pounds (1.8 kilograms) of the excavated till matrix was collected and bagged for later laboratory analysis as the pebbles were uncovered. While the pebble remained in place within the till matrix, the direction of the long axis was marked with a pencil line on the pebble. The Brunton compass was used to determine the direction of the pebble's ong axis

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long axis to the nearest 5 degrees in the 180-degree sector to the north of east-west. The clinometer measured the amount of dip of each pebble to the nearest 5 degrees (see Figure 8D). The measurement of pebbles to the nearest 5 degrees in the field was utilized because it appears to provide an acceptable degree of accuracy for till-fabric studies (Harris, 1969). Both measurements were recorded in the field notes (see the Appendix). The pebble was then removed, placed in an envelope, and filed for later laboratory analysis. After all pebbles of one layer had been measured, recorded, and filed, a second lower level was scraped clean and the process repeated until a random sample of fifty pebbles had been collected (see Figure 11). Harris (1969) illustrates statistically that a fifty-pebble sample is usually sufficient to show preferred orientation.

On occasions when the long axis of a pebble was vertical, the pebble's long axis orientation measurement (strike) is actually a measurement of the orientation of the pebble's second longest axis.[4] Pebble orientation data is presented in the Appendix and summarized graphically on Figure 14 (in pocket).

Laboratory Analysis of Pebbles

Introduction

Each pebble collected was analyzed in the laboratory. The laboratory procedure included (1) measuring the three

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[4]An example of a study that discusses pebbles with a vertical long axis orientation is Hoppe (1952).

Figure 11 Random sample of fifty pebbles
The fifty-pebble sample from analysis site N1 serves as an example to illustrate size and shape of pebbles for an analysis site location of this study.

Figure 12 Representative pebble shape categories
1 and 2 -- Tabular
3 and 4 -- Rhombohedroid
5, 6, and 7 -- Wedge-form
8 and 9 -- Ovoid

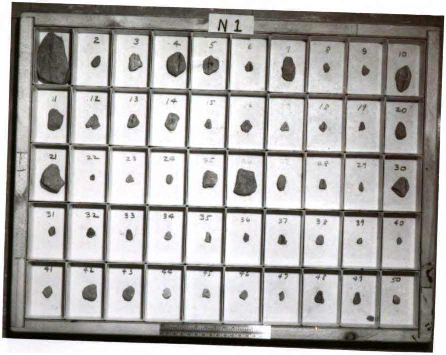

Figure 11

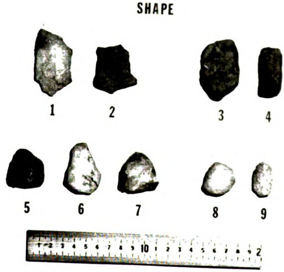

Figure 12

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dimensions of each pebble to the nearest millimeter, (2) classifying the pebble according to shape (see Figure 12), and (3) identifying and classifying each pebble's lithology. These laboratory data are presented in the Appendix and summarized in Tables 2, 5, and 7.

Pebble Shape

For this study pebble shape was divided into nine categories (see Figure 12). Holmes (1941) used six major forms and four categories of roundness to describe the shape of his pebbles. The six major forms were called discoid, ovoid, tabular, wedge-form, rhombohedroid, and varihedroid. The roundness classifications were called sharply angular, slightly rounded, moderately rounded, and well rounded. Holmes' (1941) categories were based on the work of Wentworth (1923, 1936), Wadell (1932, 1936), and Tester (1931). Wentworth (1936) used thirteen descriptive categories of shape to describe glacial pebbles from the Baraboo and Devil's Lake region of Wisconsin. Holmes (1941, plate 1, page 1355) illustrates seventeen of his twenty-four possible categories of form and roundness. Holmes (1941, page 1307) states: "tabular and discoid stones should be grouped together." For this reason and because it is very difficult to differentiate the sharply angular to slightly rounded varihedroid from the sharply angular to slightly rounded wedge-form, the discoid and varihedroid forms of Holmes (1941) were not used in this study. Four forms--tabular, rhombohedroid, wedge-form, and ovoid--we

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ovoid--were expanded into nine shape categories (see Figure 12). The first and second are tabular shapes, number one arrowhead in form, number two less pointed, but both flat. Rhombohedroid shapes were classified in two groups and numbered three and four. The number four was more elongated than number three. Three wedge-form shapes were recognized and numbered five, six, and seven, with the number six shape more elongated than five or seven. Numbers five and seven have basically the same shape but were differentiated on the basis of roundness. The number five shape would include all pebbles with a roundness classified as moderately rounded or well rounded, and the number seven shape would be more angular and include the roundness categories classified as slightly rounded or sharply angular (Holmes, 1941). The ovoid forms were assigned the numbers eight and nine and differ only in the ratio of the two longest dimensions, the latter being more elongated. The data on pebble size and pebble shape are included in the Appendix but will not be analyzed in this thesis.

Pebble Lithology

Classification of the lithology of glacial pebbles has been a research tool in glacial geomorphology for many years. Milthers (1942) studied the lithology of glacial pebbles in Norway and the Baltic region of Denmark; Holmes (1952) studied variations in glacial pebble lithology in New York;

and Anderson (1955) published an important work on the pebble lithology of the Marseilles till sheet in northeastern Illinois. More recently Ancin and Jacobs (in Johnson et al., 1972) classified the lithology of glacial pebbles from tills in east-central Illinois.

In this study only the elongate pebbles measured for orientation were classified lithologically. Thus, the sample was not a random sample. Since each sample of fifty pebbles in this study was biased by the same collection technique, they can effectively be compared lithologically. However, future investigators using the sedimentary parameter of pebble lithology should be aware of the restrictions placed on the pebble samples of this study which were classified lithologically.

Classification of each pebble's lithology was accomplished by fracturing each pebble to expose a fresh surface. The exposed fresh surface was then examined by hand lens and if necessary through a binocular microscope. Each pebble was identified and classified (see the Appendix). Five lithologic categories were recognized: crystalline, carbonate, noncarbonate clastic, chert-flint, and other. The crystalline pebbles were dominantly granites, basalts, and quartzites, but the category includes all igneous and metamorphic crystalline pebbles. Carbonate pebbles include limestone, dolomite, and all gradations between these such as limey dolomite, dolomitic limestone, and cherty dolomite. The noncarbonate clastic pebbles were dominated by shales and siltstones but included sandstones and all gradations between these three categories. The chert-flint group of pebbles includes only those lithologies. The lithologic classification of the remaining pebbles was diverse and statistically insignificant. These were placed together in the category termed other.

Laboratory Analysis of Till Matrix

Introduction

Laboratory analysis of the till-matrix samples collected at each analysis site was performed to characterize certain physical and compositional properties of the sediment. The laboratory analysis provided numerical data on grain size, percentage of sand, silt, and clay; clay mineral composition, percentage of expandable clay minerals, illite, and chlorite plus kaolinite; and carbonate content, counts per second of calcite and dolomite. Clay mineral composition and carbonate content was determined by X-ray diffraction analysis. The color of a moist sample of the till matrix for each analysis site was identified using the Munsell Soil Color Charts (1971), and in addition a descriptive color was recorded for a dry sample. The data from the laboratory analysis for each analysis site are given in the Appendix and summarized in Tables 1, 4, and 6.

Gross (1969, pages 33-37) has described the grain-size analysis and X-ray diffraction analysis techniques used by the Illinoi

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the Illinois State Geological Survey and has given permission (oral communication, June 1972) for use of a slightly modified version of his description in this thesis. The sections of this chapter, entitled Grain-Size Analysis and X-ray Diffraction Analysis which follow are largely the work of D. L. Gross.

Grain-Size Analysis

The grain-size distribution of the till-matrix samples was determined in the sedimentation laboratory of the Illinois State Geological Survey by a combined hydrometer and sieve analysis. This technique has been standardized by the Geological Survey so that the data may be compared with data from other parts of the state of Illinois.

Samples from each analysis site were first air-dried in the laboratory. The original sample was split into three subsamples, one for grain-size analysis, one for X-ray analysis, and one to be stored. Fifty-five grams of sample were used for grain-size analysis.

The sample was transferred to a milkshake mixer, 25 milliliters of 4 per cent sodium hexametaphosphate (Calgon) were added, and the mixer was filled with distilled water. After thirty minutes of mixing, the sample was transferred to a 1000 milliliter settling cylinder. After filling to 1000 milliliters with distilled water, the cylinder was vigorously shaken and placed in a water bath heated to 30 degrees Centigrade. After three hours, if no flocculation was observe

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was observed, the sample was reshaken for five minutes. A single hydrometer reading was taken after one hour and fifty-eight minutes. The hydrometers have been specially calibrated for this temperature so that they can be read directly in grams of clay present in the sample.

The sample was then wet-sieved through a 53-micron sieve to remove the sand. The sand was dried and sieved on a rotap machine for fifteen minutes to remove the greater-than-2.00-millimeters and the greater-than-62-micron fractions.

The original 55-gram sample weight was divided by the weight of the greater-than-2.00-millimeters-size fraction to give the percentage of gravel. The weight of the less-than-2.00-millimeters-size fraction was divided by the weight of the sand (2.00 millimeters to 0.062 millimeters) and the weight of the clay (less than .004 millimeters) to give the percentages of sand and clay respectively. The percentage of silt (0.062 to .004 millimeters) was obtained by subtracting the sum of the sand and clay percentages from 100 per cent. The sand, silt, and clay percentages total 100 per cent and are measurements of the less-than-2.00-millimeters fraction.

X-ray Diffraction Analysis

The composition of the clay mineral fraction and an indication of the relative abundance of calcite and dolomite were determined on oriented aggregates of the less-than-2-micron clay fraction by X-ray diffraction procedures. These analyses

were performed by Dr. H. D. Glass in the clay mineralogy laboratory of the stratigraphy section of the Illinois State Geological Survey.

Approximately 35 grams of the whole sample were placed in a 100-milliliter beaker and distilled water added. The beaker was vigorously stirred, and a small portion of the suspension was immediately decanted into another beaker. This procedure was repeated several times and the sand and gravel fractions discarded. The clay fraction was then dispersed. If flocculation occurred, the water was carefully decanted off, more distilled water added, and the beaker restirred. This was usually sufficient to disperse the sample, but occasionally a little sodium hexametaphosphate was added.

After settling for twenty minutes, a portion of the less-than-2-micron suspension was removed with a pipette, placed on a glass slide, and air-dried.

The oriented aggregate slides were analyzed with a General Electric XRD-5 diffraction unit coupled with a horizontal goniometer and a recording diffractometer. The slides were run after exposure to ethylene glycol vapor. Quantitative analysis of the percentages of expandable clay minerals, illite, and chlorite plus kaolinite, and relative abundance of calcite and dolomite has been standardized by the Geological Survey so that these data may be compared with data from other parts of the State of Illinois.

The expandable clay minerals are identified by the presence of a peak at approximately 17 Angstroms after treatment with ethylene glycol. These minerals include montmorillonite but are here principally formed by expandable vermiculite and chlorite as well as their mixed lattice intermediates.

Illite is identified by the presence of a 10 Angstrom peak, and is defined as a nonexpanding and noncollapsing 10 Angstrom clay mineral.

Chlorite plus kaolinite is calculated by the intensity of the 7.2 Angstrom reflection. Chlorite is the dominant mineral and is characterized by a 14 Angstrom periodicity. A trace of kaolinite was present in some samples. The first-order kaolinite reflection and the second-order chlorite reflection both occur at about 7 Angstroms, but the second-order kaolinite peak and the fourth-order chlorite peak could be observed separately and the presence of kaolinite thus noted.

To calculate the clay mineral percentages, a base line was drawn on the log-normal-diffraction chart. The differences in intensity, measured in counts per second, between this base line and the 7, 10, and 17 Angstrom peaks were then recorded. The counts noted for illite were multiplied by three, the counts noted for chlorite plus kaolinite were multiplied by two, and the counts for the expandable clay minerals were left unchanged in order to equalize the scattering difference between the different clay minerals. These ratios were then converted to 100 per cent.

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A diffraction intensity (DI) ratio was calculated by dividing the intensity of the illite peak, in counts per second, by the intensity of the chlorite plus kaolinite peak, in counts per second. This DI ratio is used as a numerical index of weathering. Illite is not appreciably weathered in the Woodfordian Substage of Illinois, but one of the very first effects of weathering is the alteration of chlorite to 14 Angstrom vermiculite and eventually to an expandable clay mineral at about 17 Angstroms (swelling chlorite). This loss of chlorite is reflected by a loss in intensity of the 7 Angstrom peak and causes the DI ratio to increase. The Diffraction Intensity ratio is most useful in a vertical section to compare samples within a profile. However, it should not be used as an "index fossil."

The relative abundance of calcite and dolomite was measured from the oriented slide. Calcite is measured in counts per second at 29.4 degrees 2-theta and dolomite is measured at 30.9 degrees 2-theta. These measurements reflect the percentage of the minerals present and also the particle size, crystallinity, and orientation of the minerals. Thus, the measurements are not true percentages. Preliminary results of work by Moran and Gross (oral communication, July 1972) indicate that calcite counts per second as determined by these X-ray methods correlate very well with true calcite percentages as determined with the Chittack apparatus (Driemanis, 1962). The correlation coefficient, based on

134 sets of duplicate analyses, for these two parameters is .90, which indicates a very high degree of correlation. The calcite counts per second should be divided by 3.6 (the slope of the regression line for the correlation) to get a true percentage of calcite. The correlation of dolomite counts per second to true per cent dolomite is not as good, with a .56 correlation coefficient. This relationship is almost one to one; the slope of the regression line is .97, which means that dolomite counts per second are approximately equal to true per cent dolomite.

This rapid clay mineral and carbonate X-ray procedure is particularly well suited for working with large numbers of samples. It is true that the numbers reported may not represent actual clay mineral percentages, but these are reproducible data which can be used for stratigraphic correlations.

Quantitative estimation of the amount of each clay mineral component present is difficult and an approximation at best. The procedure described above is based on the assumption that the greater the quantity of a particular mineral, the more intense the diffraction peaks of that mineral will be. However, other factors such as particle size, crystallinity, and the degree of orientation on the slide also influence the peak intensities and thus limit the preciseness of quantitative estimates. Therefore, it must be realized that the clay mineral data presented in this study are useful for stratigraphic correlation, but not necessarily as precise measurements of clay mineral content.

Color Analysis

The color of the till-matrix samples was determined by comparing a moist sample of the till matrix with the chips of Munsell Soil Color Charts. The Munsell Soil Color Book (1971) has seven charts containing 196 chips. The color of each chip has a three-variable description. The three variables are hue, value, and chroma. The hue notation of a color indicates its relation to red, yellow, green, blue, or purple; the value notation indicates its lightness; and the chroma notation indicates its strength or departure from a neutral of the same lightness (Munsell Color Company, 1971). An example of a Munsell color notation would be 7.5YR 5/6, with the 7.5YR representing the hue as a combination of yellow and red, 5 as the value, and 6 as the chroma.

The technique previously described in this study for X-ray diffraction analysis required the use of a slide that contains a dry sample of the clay fraction of the till-matrix sample. This slide was used to indicate a dry sample color because the slides can be compared for color easily. The descriptive words used included the following: yellow tan, gray brown, violet, peach, salmon, green gray, gray, olive, gray tan, tan, buff tan, and red brown.

Chapter 3

CHARACTERISTICS OF THE EUREKA-NORMAL MORPHOSTRATIGRAPHIC UNIT

Introduction

The individual morphostratigraphic units considered in Chapters 3, 4, and 5 of this thesis were delineated on the basis of definitions by Willman and Frye (1970). Portions of the Eureka, Champaign, and Bloomington Moraines (Drifts) and all of the Normal Moraine (Drift) were studied (see Figure 7). This chapter is concerned with the characteristics of the Eureka and Normal Moraines (Drifts).

By definition a morphostratigraphic unit is identified by the surface form it displays (Frye and Willman, 1960, 1962). A topographic boundary which delineates and separates the Eureka and Normal Moraines (Drifts) as two separate morphostratigraphic units is not apparent through field observation or map study except possibly in the area around Arrowsmith, Illinois. Therefore, these two morphostratigraphic units will be considered as one unit called the Eureka-Normal Moraine (Drift). Figure 13 (in pocket) is a Peoria 1:250,000 topographic contour map that may be referred to when altitudes associated with the study area are described. The distal base of the Eureka-Normal Moraine (Drift) in the study area is approximately marked by the 800 foot (243 meters) contour west of the city of Normal and by the 825 foot

(247 meters) contour east of the city. The proximal base of the Eureka-Normal Moraine (Drift) closely parallels the 800 foot (243 meters) contour except in the area where the Fletchers Moraine (Drift) exists (see Figure 4, in pocket). Here the proximal base of the moraine ranges from 800 feet (243 meters) to over 920 feet (276 meters) where the Eureka and Fletchers Moraines (Drifts) are adjoining.

The maximum relief in the study area is found in sections 7 and 18, T.23 N., R.6 E., where the crest of the Eureka-Normal Moraine (Drift) is 150 feet (45 meters) higher than the distal margin. At an altitude of approximately 950 feet (285 meters) this crest is the highest elevation in the study area. The rolling distal slopes are steeper than the more gradual gently sloping proximal slopes and the tops of the moraines are undulating. Within the moraine the more rugged topography is generally located in regions where streams have dissected or eroded the moraine. Thus, the present topography is the result of both glacial deposition and stream dissection. Possibly the best example of an area within the Eureka-Normal Moraine (Drift) that shows such effects is the Mackinaw River Valley (see Figure 13, in pocket). The Appendix contains a statement on the topography at each analysis site.

The trend of each moraine was determined to be a line connecting the crests of each morphostratigraphic unit as illustrated on Figure 14 (in pocket) and called the peak of the moraine. Fifteen analysis sites were selected along the trend of the Eureka-Normal Moraine (Drift) (see Figure 7). Six (E1, E3, E5, E6, E9, and EB2) were located in a central position on the moraine; two (E7 and E11) were located on the proximal slope; and seven (E4, E8, E10, N1, N2, N3, and N4) were located on the distal slope. The average altitude of the crests of the exposures used for analysis is 830 feet (248 meters). The average depth of analysis below these crests was 6 feet (2 meters). One analysis site (EB2) was stratigraphically below the top till of the Eureka Moraine (Drift). The stratigraphic relationships between the till at EB2 and the till at E10 will be discussed where the Congerville Section is described later in this chapter. Data from these fifteen analysis sites will be presented and analyzed in this chapter and later compared with comparable data from the other morphostratigraphic units under consideration so that the basic problem of relationships can be examined.

Physical Characteristics of the Till Matrix

The Eureka-Normal Moraine (Drift) represents some of the deposits of the Peoria Sublobe of the Lake Michigan Lobe (see Figure 3) deposited during the Woodfordian Substage of the Wisconsinan Stage in central Illinois (Willman and Frye, 1970). The Eureka-Normal Moraine (Drift) is a part of the Malden Till Member of the Wedron Formation (Willman and Frye, 1970) (see Figure 5). Willman and Frye (1970) describe the physical characteristics of the Malden Till Member as a silty, locally sandy, yellow gray to gray tan till bounded above by the Yorkville Till and below by the Tiskilwa Till.

This till can be correlated areally in McLean County with Unit 1 of Kempton, DuMontelle, and Glass (1971). These authors summarized the physical characteristics of Unit 1 as a tan or yellowish brown oxidized till or a gray or olive gray unoxidized till with average grain-size distribution of 15 per cent sand, 49 per cent silt, and 36 per cent clay, with average clay mineral composition of 2 per cent montmorillonite[5], 82 per cent illite and 16 per cent chlorite and kaolinite, and with a carbonate content of 10 counts per second calcite and 16 counts per second dolomite. The percentages given in the above description are based on thirty samples from McLean County. Willman and Frye (1970, Table 3, pp. 169-170) reported the results of similar analyses for four samples, two from the Eureka Moraine (Drift) and two from the Normal Moraine (Drift). Averages of the results of these four analyses show a grain-size distribution of 15 per cent sand, 41 per cent silt and 44 per cent clay, a clay mineral composition of 6 per cent expandable clays, 81 per cent illite, and 13 per cent kaolinite and chlorite, and carbonate content of 7 counts per second calcite and 23 counts per second dolomite. Location of the type section for the Malden Till Member can be found in Chapter 1 (see page 12).

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[5] Montmorillonite has been used by some I.S.G.S. authors in place of expandable clays. Data produced by X-ray diffraction analysis at the Illinois State Geological Survey on clay minerals is comparable for both categories. (H. D. Glass oral communication).

The physical characteristics of the Malden and Unit One Tills are described in terms of the same variables investigated in this study. Table 1 summarizes the data, on the physical characteristics of the till matrix for the Eureka-Normal Moraine (Drift), found in the Appendix. Data on color, grain size, clay mineral composition, and carbonate content for the fifteen analysis sites arranged from east to west along the trend of the Eureka-Normal Moraine (Drift) are included in this table (see Figure 7). Analysis site EB2 is included here because its location is in the area of the Eureka Moraine (Drift), but the till lies stratigraphically below the top till unit. The till overlying EB2 is described by the data for analysis site E10. A discussion of the stratigraphic relationship between these two till members is presented later in this chapter where the Congerville Section is described.

All till samples collected along the Eureka-Normal Moraine (Drift) were calcareous and oxidized. The average depth of leaching on well-drained level upland sites is about 4 feet (1.3 meters). The oxidation is reflected in the tan to buff tan color (2.5Y 5/4) that may grade into unoxidized till at a depth ranging from 12 to 15 feet (3.6 to 4.5 meters). Average depth of analysis for Eureka-Normal till samples was approximately 6 feet (2 meters) and ranged from 5 to 10 feet (1.5 to 3 meters) below the crest of the exposure.

The averages reported in Table 1 for all Eureka-Normal analysis sites, exclusive of EB2, are remarkably consistent with the averages for Eureka and Normal Moraine (Drift)

Table 1

Physical Characteristics of the Till Matrix--Eureka-Normal Till

Anal. Site	Color	Grain Size Distribution			Clay Mineral Composition			Carbonate Content	
		%Sand	%Silt	%Clay	%Exp. Clay	%Illite	%Chlor. & Kaol.	Counts Per Second	
								Calcite*	Dolomite
E7	2.5Y5/4	28	38	34	4	81	15	?	9
E6	2.5Y5/4	24	39	37	3	81	16	-	15
E5	2.5Y5/4	28	38	34	3	80	17	8	19
N1	2.5Y5/4	19	48	33	6	78	16	6	13
E1	2.5Y5/4	37	45	18	5	79	16	-	15
N3	10YR5/2	17	53	30	7	81	12	22	27
E8	2.5Y5/4	28	43	29	3	81	16	6	21
N4	2.5Y5/4	20	46	34	4	83	13	10	29
E9	2.5Y5/4	22	40	38	4	82	14	11	27
N2	2.5Y5/4	17	41	42	3	83	14	11	16
E4	2.5Y5/4	17	45	38	4	83	13	12	22
E3	2.5Y5/4	20	40	40	4	78	18	7	17
E10	2.5Y5/4	20	38	42	5	84	11	?	13
E11	2.5Y5/4	16	55	29	5	82	13	10	26
EB2	7.5YR5/4	27	41	32	14	70	16	22	26
Avg.#	2.5Y5/4	22	44	34	4	81	15	7	19

* ? questionable existence of calcite
- analyzed for calcite but none existed
both are considered zero for purpose of averaging calcite
Data for analysis site EB2 are not included in these averages

samples for the Malden Till Member of Willman and Frye (1970) and with the averages for Unit 1 of Kempton, DuMontelle, and Glass (1971). The only notable difference exists in the sand content of the grain-size distribution which shows sand content somewhat higher than the 15 per cent reported by both Willman and Frye (1970) and Kempton, DuMontelle, and Glass (1971). However, Willman and Frye (1970) described the Malden Till as a "silty locally sandy till" and the locally sandy condition appears to exist at analysis sites E1, E5, E6, E7, and E8 (see Figure 7). The till-matrix composition at analysis site N3 is somewhat anomalous, but the color difference and high calcite content are within the ranges for the Malden Till Member reported for these variables by Willman and Frye (1970). The averages of the numerical data in Table 1 for the Eureka-Normal till samples are also comparable to the numerical data presented for the Snider Till Member in the Danville, Illinois region (Johnson, Gross, and Moran, 1971; Johnson et al., 1972, Table 2, page 7). The relationship between Malden and Snider Till will be discussed in Chapters 4 and 5 of this thesis. Thus, the rock-stratigraphic unit to which the Eureka-Normal Moraine (Drift) in the study area of this thesis is assigned is the Malden Till Member of the Wedron Formation. This conclusion, which is consistent with the findings of Willman and Frye (1970), is based on the high degree of correlation between the physical characteristics of the till matrix reported in Table 1 and the description of the Malden Till.

Characteristics of Till Pebbles

Introduction

Data on pebble lithology, long-axis pebble orientation, size, and shape were collected for a fifty-pebble sample at each of the fifteen analysis sites along the trend of the Eureka-Normal Moraine (Drift) (see the Appendix and Figure 7). This study is concerned with the relationship between long-axis pebble orientation, pebble lithology, rock stratigraphy, and morphostratigraphy. Pebble size and shape data are included in the Appendix but will not be analyzed in this thesis.

Holmes (1941) was the first in this country to correlate long-axis pebble orientation with the direction of ice movement associated with an area of ground moraine in New York. He recognized both parallel and transverse patterns of long-axis pebble orientation and associated these with the direction of ice movement. Hoppe (1952) correlated the parallel and transverse patterns of long-axis orientation to ridge trends of hummocky moraines in Sweden but found little or no pebble orientation in the hollows between ridges. Wright (1962) correlated patterns of pebble alignment with the axes of drumlins in Minnesota and found them to parallel one another. Today most if not all investigators using the techniques of till-fabric analysis would agree that there is a strong tendency for the long axis of an elongated pebble within glacial till to be aligned either parallel to or perpendicular to the direction of ice flow if the till was deposited in association with active ice. Thus, in instances where associated landforms also bear a specific areal relationship to an active glacier pebble alignment and landform trend may be directly related. Possible realignment or reorientation of pebbles in glacial till resulting from events subsequent to deposition were reported by MacClintock and Dreimanis (1964) and by Ramsden and Westgate (1971). In Alberta, Canada, Ramsden and Westgate (1971) present evidence to support a till-fabric orientation change produced by the advance of a later glacier. Harrison (1957b) found that the clay till fabric of the Marseilles Moraine in northeastern Illinois (see Figure 4, in pocket) showed a greater tendency toward perpendicular than parallel orientation to the trend of the moraine but many fabrics appeared to have been reoriented slightly to an unpredictable alignment. It is worth noting at this time that the lobate form of the Marseilles Moraine is similar to that of the Eureka-Normal Moraine (Drift).

Another study which reports the findings of till-fabric analyses on lobate form moraines was written by Andrews and Smithson (1965). These authors describe four morainal forms called linear, hooked, s-shaped, and asymmetrical. The latter is a parabolic lobate form. The results of the Andrews and Smithson (1965) study reveal that the orientation and dip strength in asymmetrical form moraines is poorer than the orientation and dip strength in the other three forms. They also concluded the orientation strength was no different from proximal to distal slope and that dip strength was only slightly higher on the distal slope in asymmetrical form moraines.

These conclusions have special relevance to the discussion of pebble-orientation data described later in this chapter and in Chapters 4 and 5.

Till Pebble Orientation

The horizontal long-axis orientation of a fifty-pebble sample was determined in the field to the nearest five degrees (see Chapter 2 for a discussion of the field technique). Such data have been represented and analyzed in various ways. Holmes (1941) used rose and contoured diagrams in his analysis. Harrison (1957b) used rose diagrams and maps with preferred orientations indicated by arrows. Krumbein (1939), Kauranne (1960), and Andrews and Shimizu (1966) have all suggested statistical techniques for the analysis of orientation data but they also used orientation diagrams in these works to show associations. In this study it was concluded that pebble orientation could best be analyzed and compared by using rose diagrams centered at the location of each analysis site on a map of the study area showing the morphostratigraphic units (see Figure 14, in pocket).

Long-axis pebble orientation for the fourteen analysis sites in Malden Till along the Eureka-Normal Moraine (Drift) appear consistent with the findings of both Harrison (1957b), and Andrews and Smithson (1965). These works will be used for comparison in the remainder of this section as the findings of the till-fabric analyses of this study are reported.

Comparison of data from site E10 on the distal slope with that of site E11 on the proximal slope does show the distal orientation strength is somewhat better than the proximal orientation strength, but the consistency of this result is not demonstrated by the orientations at the remainder of the analysis sites on this moraine. The tendency for long-axis orientations to be parallel to the trend of the moraine exists at analysis sites E8, N4, E9, and N2 but is not as pronounced as the parallel tendency in the region near the interlobate area at analysis sites E5, E6, and E7 (see Figure 14, in pocket). A secondary mode orthogonal to the primary mode is present in the orientations at analysis sites N2 and N4. At all the remaining sites except N3, which is trimodal, the tendency of the long-axis orientation is toward a perpendicular to the trend of the moraine.

Both long-axis orientation and dip orientation and strength are considered in most till-fabric studies. These variables have a high degree of correlation and when used in combination strengthen the fabric representation. Holmes (1941), Harrison (1957a), West and Donner (1957), and others have used both measurements. Dip orientation and strength will be discussed in this study only when the rose diagram of the long-axis orientation shows a poor or unoriented pattern.

At analysis site N3, which has a trimodal long-axis orientation, and at analysis sites E11, E8, and N1 where the long-axis orientation is poor, dip orientation is considered an alternate fabric determinant. At N3, which has little or no

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no orientation, there exists a moderately strong dip orientation to the south-southeast. At N1, where there is a weak unimodal long-axis orientation to the north-northwest, the same moderately strong dip orientation to the south-southeast exists. The dip orientation is moderately strong to the west at E8 and weak to the northeast at E11. The dip orientation shows a tendency toward a perpendicular to the trend of the moraine except at E8 where it tends toward a parallel alignment to the trend of the moraine.

Figure 14 (in pocket) shows a greater tendency of fabric orientation toward a perpendicular than parallel alignment to the trend of the Eureka-Normal Moraine (Drift). However, careful examination reveals that a majority of the fabrics show a discrepancy between a perpendicular to the trend of the moraine and the actual pebble orientation. Harrison (1957b), in investigating the very arcuate Marseilles Moraine (see Figure 4, in pocket), and Andrews and Smithson (1965), in investigating the asymmetrical form moraines on Baffin Island, found their fabrics to be slightly askew from the perpendicular alignment to the moraine trend they expected. Harrison (1957b) suggested that these differences were the result of a till deformation process which altered the original depositional environment of the till. Andrews and Smithson (1965) associated the asymmetrical form of moraines to a process of pushing and overriding which altered and weakened the fabric strength. If Harrison (1957b) and Andrews and Smithson (1965) are correct regarding the relationship of the long-axis pebble orientation to the trend of a lobate form moraine, then the data of this study supports the contention that the original depositional environment of the pebbles in Eureka-Normal Moraine (Drift) was altered slightly in the formation of this moraine. As suggested by Glen, Donner, and West (1957), great care was taken to avoid locations for analysis sites in this study where alteration of till fabric as a result of gravitational forces would be a factor (see Chapter 2, selection of analysis sites). The processes by which such reorientation might take place can only be speculated on the basis of available information. However, it would appear that if a reorientation did take place it is most likely that the alteration was accomplished by a pulsation or slight readvance of the Woodfordian ice sheet after the original formation of much of the Eureka-Normal Moraine (Drift).

Till Pebble Lithology

The fifty pebbles measured for long-axis orientation at each analysis site were classified lithologically in the laboratory. Chapter 2 contains an account of the laboratory procedure and the resulting data can be found in the Appendix. The purpose of the investigation of pebble lithology was to show if a relationship exists between either pebble lithology and morphostratigraphy or pebble lithology and rock stratigraphy.

At this point it is appropriate to mention some of the deficiencies of the pebble lithology analysis of this study.

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The sample size of fifty pebbles appears too small, especially when pebbles without a long axis were not considered. Anderson (1955) used 100 pebbles for each sample location when studying the pebble lithology of the Marseilles Drift in northeastern Illinois (see Figure 4, in pocket) and found a great deal of variability both from proximal to distal side of the moraine as well as laterally. He also found local concentrations of particular lithologic types and his distribution of sample sites was more dense than the 1 to 5 mile spacing of analysis sites for this study. In spite of these deficiencies slight variations in pebble lithology, which appear worthy of consideration, did exist between both rock-stratigraphic units and morphostratigraphic units.

To accentuate these differences and facilitate analysis, the various pebbles were grouped into lithologic categories. The procedure involved first dividing the pebbles into crystalline and noncrystalline groups. Then the noncrystalline pebbles were separated into four groups: carbonate, noncarbonate clastic, chert-flint, and other (see Chapter 2 for lithologic types included in each group).

Lithologic characteristics of Eureka-Normal Moraine (Drift) pebbles are summarized in Table 2. Two general conclusions can be drawn about the lithologic composition of Eureka-Normal Moraine (Drift) pebbles in comparison to pebbles from till associated with other morphostratigraphic units treated in this study. First, the average number of crystalline pebbles is very low, and, second, the average number of

Table 2

Pebble Lithology--Eureka-Normal Till

Analysis	%Crystalline	NonCrystalline			
Site		%Carbonate	%NonCarbonate Clastic	%Chert Flint	%Other
E7	6	64	16	14	0
E6	12	52	24	12	0
E5	10	54	26	8	2
N1	26	42	14	14	4
E1	8	68	20	4	0
N3	6	72	18	4	0
E8	6	50	26	18	0
N4	24	54	12	10	0
E9	4	80	6	10	0
N2	6	64	22	8	0
E4	8	56	10	24	2
E3	10	70	14	6	0
E10	8	62	14	16	0
E11	8	64	16	12	0
EB2	20	62	12	4	2
Avg.#	10	61	17	11	1

#Average does not include data from analysis site EB2.

carbonates, the majority most probably Silurian dolomites, is very high. These conclusions were drawn after the data in Table 2 were compared with the data in Tables 5 and 7. However, an effective comparison of these data cannot be made until the characteristics of the Bloomington and Champaign Moraines (Drifts) have been discussed. Therefore, a more detailed discussion of pebble lithology will be presented in Chapters 4 and 5 where the lithology data for pebbles from these units are discussed.

Congerville Section

The Congerville Section is located areally on the Eureka Moraine (Drift) and is included in this chapter because of its location. The importance of this stratigraphic section is that it establishes the relationship between three Woodfordian units: the Richland Loess, the Malden Till, and the Tiskilwa Till.

Data on physical characteristics of this section can be found in Table 3. The upper two tills in this section are defined as Malden and Tiskilwa Till. The data for samples from this section are comparable to averages for samples from analysis sites defined to have these till units. A sharp line of demarcation between the Malden Till and Tiskilwa Till can be found in this section. A boulder line at the base of a thin zone of outwash clearly establishes the contact and stratigraphic relationship of these two till members.

Table 3

Physical Characteristics of the Congerville Section Samples

	Grain Size Distribution			Clay Mineral Composition			Carbonate Content		Long Axis Orient.
							Counts Per Second		
No.	%Sand	%Silt	%Clay	%Exp. Clay	%Illite	%Chlor. Kaol.	Calcite	Dolomite	
9	7	53	40	36	55	9	-	-	
8(E10)	19	50	31	4	82	14	10	23	N30E
7	45	33	22	7	81	12	14	19	
6(EB2)	28	36	36	18	67	15	24	32	N20W
5	44	41	15	6	81	13	7	12	
4	20	41	39	5	81	14	13	20	
3	10	64	26	5	78	17	9	10	
2	24	44	32	15	71	14	12	19	
1	29	37	34	18	65	17	13	20	

Table 3

Physical Characteristics of the Congerville Section Samples

	Grain Size Distribution			Clay Mineral Composition			Carbonate Content		Long
							Counts Per Second		Axis
No.	%Sand	%Silt	%Clay	%Exp. Clay	%Illite	%Chlor. Kaol.	Calcite	Dolomite	Orient.
9	7	53	40	36	55	9	-	-	
8(E10)	19	50	31	4	82	14	10	23	N30E
7	45	33	22	7	81	12	14	19	
6(EB2)	28	36	36	18	67	15	24	32	N20W
5	44	41	15	6	81	13	7	12	
4	20	41	39	5	81	14	13	20	
3	10	64	26	5	78	17	9	10	
2	24	44	32	15	71	14	12	19	
1	29	37	34	18	65	17	13	20	

Congerville Section

Measured in roadcuts in NE SE NE Sec. 3, T.25 N., R.1 W., Woodford County, Illinois, 1971, 1972.

	Thickness (ft)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Richland Loess	
9. Loess; tan to tan brown, leached; contains modern surface soil	2.0
Wedron Formation	
Malden Till Member	
Eureka Drift	
8. Till, silty, upper part leached; buff tan to light brown; oxidized	3.0
7. Sand and gravel, calcareous, dark tan, shape contact boulder line at base	0.5
Tiskilwa Till Member	
6. Till, sandy, pink to red brown, calcareous, compact angular blocky in upper part grading to unconsolidated near base, contains silt lenses	9.5
5. Sand and gravel, calcareous, yellow tan	2.0
Illinoian Stage	
Undifferentiated	
4, Till, silty, calcareous, buff tan to tan	2.0
3. Silt, yellow tan to lemon	0.5
2. Till, silty, olive to olive tan to pale green	1.0
1. Till, sandy, dark tan to gray to brown	9.5
Total	30.0

Long-axis pebble orientation data for the top two till units is also included in Table 3. The fabric of the Malden Till has a northeasterly orientation in this section and the fabric of the Tiskilwa Till has north-northwest orientation. The original depositional mode of Tiskilwa Till is believed to be represented by the fabric orientation at analysis site B15 (see Figure 14, in pocket). The long-axis pebble orientation at analysis site EB2 shows the reorientation effect that the glacial ice, which deposited the Eureka Drift, had on the Tiskilwa Till in the till plain behind the Bloomington Moraine (Drift) (see page 88 for a more detailed discussion).

The Woodfordian Units overlie a sequence of undifferentiated units believed to be Illinoian in age. The important aspect of the Congerville Section is that it clearly establishes the stratigraphic relationship between the Tiskilwa and Malden Till Members of this study.

Conclusions

The major conclusions of this chapter are the following: (1) The Eureka-Normal Moraine (Drift) is one morphostratigraphic unit. (2) Physical characteristics of the surface till within this unit indicate that it belongs to the Malden Till Member of the Wedron Formation. (3) Pebble orientation findings reveal that the long axis of elongate pebbles within this till prefer a perpendicular alignment to the trend of the moraine. These orientations indicate a Lake Michigan Lobe source. And (4) pebble lithology data indicates that a lower percentage of crystalline pebbles and a larger percentage of carbonate pebbles are embedded in this till than was found in tills from the other units of this study.

Chapter 4

CHARACTERISTICS OF THE CHAMPAIGN MORPHOSTRATIGRAPHIC UNIT AND ASSOCIATED INTERLOBATE AREA

Introduction

The Champaign Moraine (Drift) as delineated by Willman and Frye (1970) was studied between the two valleys of the Sangamon River which are approximated by analysis site locations C1 and C6 (see Figures 4 and 7). Near C6 the Sangamon River Valley separates the Champaign Moraine (Drift) from the interlobate section to the northeast, and near C1 the Sangamon River traverses the Champaign Moraine (Drift) and separates it into two segments.

The base of both the proximal and distal slope of the Champaign Moraine (Drift) in the study area is clearly defined topographically by the 750 foot (225 meters) contour (see Figure 13, in pocket). However, the topography of the Champaign Moraine (Drift) is more subdued than that of either the Bloomington or Eureka-Normal Moraines (Drifts). The distal slopes tend to be slightly steeper than the proximal slopes but both could be categorized as gently sloping to rolling (see Figure 10). In the study area the total local relief on the Champaign Moraine is approximately 80 feet (24 meters), but the average relief is less than 50 feet (15 meters) per square mile. A maximum altitude of about 830 feet (248 meters) is attained in a number of locations between Bellflower and Saybrook (see Figure 13, in pocket). Though the moraine is the least prominent in the study area, it is the best defined topographically in terms of both extent and boundaries.

Five analysis sites were selected along an 18 mile (29 kilometers) extent of Champaign Moraine (Drift) within the study area. Two analysis sites (C2 and C3) were in the central part of the moraine and three (C1, C4, and C6) were on the distal slope (see Figure 7). The average altitude of the exposures is 790 feet (237 meters) and the excavations average about 11 feet (3.3 meters) below the present land surface.

The associated interlobate area of the Champaign Moraine (Drift) is defined as the area of BD analysis-site locations, and the criterion used to establish this area is the same as that used to separate it from the area of BP analysis-site locations (see page 28 and Figure 9). The base of this area is approximated by the 750 foot contour (225 meters), and the altitude in the central part of this region is slightly more than 900 feet (270 meters). For purposes of discussion and analysis, the data from the three BD analysis sites are considered along with the data from the Champaign Moraine (Drift) so that the relationship between the interlobate area, which Willman and Frye (1970) refer to as Bloomington Moraine (Drift), and the Champaign Moraine (Drift) can be established.

Physical Characteristics of the Till Matrix

The Erie Lobe has been divided into sublobes including the Decatur which deposited a sequence of drifts (see Figure 4, in pocket) in east-central Illinois during the Woodfordian Substage of the Wisconsinan Stage (Willman and Frye, 1970) (see Figure 3). The Champaign Moraine (Drift) deposited by the Decatur Sublobe is a part of the Wedron Formation rock-stratigraphic unit that was undifferentiated by Willman and Frye (1970). Johnson, Gross, and Moran (1971) have studied the previously undifferentiated Wedron Formation in the Danville, Illinois region and have recognized three till members that they correlate with proposed units in the McLean County region of the study area.

Figure 6 illustrates the relationship between the Batestown, Unit 2, and Snider Tills. This figure also correlates these three units with tills that were named prior to the works in which the Batestown, Unit 2, and Snider Tills were defined. A discussion of the physical characteristics of the Batestown, Unit 2, and Snider Tills follows so that their relationships to the till of the Champaign Moraine (Drift) and associated interlobate area can be established.

The Batestown Till Member is described as a gray or dark gray often silty till which oxidizes to a characteristic light olive brown (Johnson et al., 1972). It is known to exist stratigraphically between the Snider and Glenburn Till Members in the Danville region (Johnson, Gross, and Moran, 1971). Some physical characteristics of the Batestown Till

Member are (1) a grain-size distribution of 28 per cent sand, 38 per cent silt, and 34 per cent clay; (2) a clay mineral composition of 3 per cent expandable clay, 80 per cent illite, and 17 per cent kaolinite and chlorite; and (3) a carbonate content of 5 per cent calcite and 19 per cent dolomite (Johnson, Gross, and Moran, 1971; and Johnson et al., 1972).

Unit 2 is described as a gray silty till, but a pinkish tint has been noted in some samples on the outer margin of the till (Kempton, DuMontelle, and Glass, 1971). The averages for 150 samples of Unit 2 till showed (1) a grain-size distribution of 27 per cent sand, 45 per cent silt, and 28 per cent clay; (2) a clay mineral composition of 3 per cent montmorillonite (see footnote 5, page 48), 79 per cent illite, and 18 per cent chlorite and kaolinite; and (3) a carbonate content of 14 counts per second calcite and 21 counts per second dolomite (Kempton, DuMontelle, and Glass, 1971).

The Snider Till Member is a gray brown to light olive brown till where oxidized and a dark gray where unoxidized (Johnson, Gross, and Moran, 1971). In comparison with the Batestown Till it contains less sand and slightly more illite (Johnson, Gross, and Moran, 1971; Johnson et al., 1972). Johnson, Gross, and Moran (1971) reported the average physical characteristics of the Snider Till Member to be (1) grain-size distribution 19 per cent sand, 45 per cent silt, and 36 per cent clay; (2) clay mineral composition 3 per cent expandables, 85 per cent illite, and 12 per cent kaolinite and chlorite; and (3) carbonate content 6 per cent calcite and 19 per cent dolomite.

With some of the physical characteristics of the Batestown, Unit 2, and Snider Tills established, a discussion of the data provided by analyses of till-matrix samples from the Champaign Moraine (Drift) and the associated interlobate area may be presented. These data are contained in the Appendix and summarized in Table 4. Averages for the BD locations and C locations are figured separately so that they may be compared. The data in the table are arranged in order from north to south along the trend of the moraine (see Figure 7).

Till samples from analysis sites C2 and C4 were from a depth of 15 feet (4.5 meters) and were an unoxidized gray. The till-matrix samples from locations C1 and C3 came from a depth of 9 feet (2.7 meters) and 5 feet (1.5 meters) respectively. Their colors were a greenish gray to olive gray, the characteristic oxidation colors for both the Snider and Batestown Till Members (Johnson et al., 1972). All the remaining samples listed in Table 4 came from shallow depth analysis sites, (see the Appendix for depths) were oxidized but calcareous, and have a tan color.

Comparison of the physical characteristics of the till samples of Champaign Moraine (Drift) with those from the BD locations in the interlobate area reveal no major consistent differences. From the numerical data in Table 4, it can be concluded that the till from BD locations on the interlobate and till from the analysis sites on the Champaign Moraine (Drift) are the same till.

Table 4

Physical Characteristics of the Till Matrix--
Champaign Till and Associated Interlobate Till

Anal. Site	Color	Grain Size Distribution			Clay Mineral Composition			Carbonate Content	
		%Sand	%Silt	%Clay	%Exp. Clay	%Illite	%Chlor. & Kaol.	Counts Per Second: Calcite*	Counts Per Second: Dolomite
BD8	2.5Y5/4	29	36	35	5	82	13	8	16
BD7	2.5Y5/4	22	40	38	3	85	12	7	16
BD5	2.5Y5/4	19	44	37	3	85	12	?	21
C6	2.5Y5/4	26	35	39	2	85	13	10	17
C3	2.5Y5/4	11	33	56	2	84	14	-	17
C4	2.5Y5/2	18	40	42	2	79	19	9	20
C2	2.5Y5/2	18	39	43	2	83	15	8	15
C1	2.5Y4/2	26	38	36	3	79	18	11	23
Avg.C	Variable#	20	37	43	2	82	16	7	18
Avg.BD	2.5Y5/4	23	40	37	4	84	12	5	18

\# Due primarily to various degrees of oxidation
* ? questionable existence of calcite
- analyzed for calcite but none existed
both are considered zero for purpose of averaging calcite

A comparison of the numerical data for physical characteristics of the Batestown Till Member and its correlative Unit 2 with the numerical data of Table 4 reveals two differences: (1) the Batestown Till and Unit 2 have a slightly sandier texture, and (2) the Batestown Till and Unit 2 have a little less illite. However, these differences are the same differences that separate the Batestown Till Member from the Snider Till Member. On this basis a correlation, though somewhat uncertain, may be drawn between the Snider Till Member and the various till samples whose physical characteristics are summarized in Table 4. This correlation of numerical data is strong enough that it can be concluded that the till on the Decatur Sublobe side of the Bloomington interlobate (see Figure 9) and the till of the Champaign Moraine (Drift) in the study area of this thesis are a part of the Snider Till Member of the Wedron Formation rock-stratigraphic unit. This conclusion is not inconsistent with the correlation drawn by Johnson, Gross, and Moran (1971), who correlated the Batestown Till with both Unit 2 and upper till in the Champaign-Urbana region of Kempton, DuMontelle, and Glass (1971), because the latter authors did not define the till in the section of Champaign Moraine (Drift) studied in this thesis. The correlation between the till described in Table 4 and the Batestown Till still remains a possibility on the basis of data from analysis sites BD8, C6, and C1 because of the sandier texture of the till at these locations. However, the high illite content in the clay mineral fraction at BD8 and C6 agree with the Snider Till correlation. Therefore, the till samples from analysis site C1 are the only ones which might be correlated with the Batestown Till. These findings are not inconsistent with the findings of Willman and Frye (1970) because the till of the Champaign Moraine (Drift) was not differentiated by them and because there still remains the possibility that the Malden Till Member, to which they assigned the interlobate region, can be correlated with the Snider Till Member (this correlation will be suggested later in this study).

Characteristics of Till Pebbles

Introduction

The purpose of this section is to discuss and analyze first, the relationships between long-axis pebble orientation, and both rock stratigraphy and morphostratigraphy; and, second, the relationships between the lithologic composition of pebbles and both rock stratigraphy and morphostratigraphy.

Data on pebble orientation, lithology, size, and shape for a fifty-pebble sample from each analysis site on the Champaign Moraine (Drift) and from each BD analysis site in the associated interlobate area can be found in the Appendix. Data on pebble size and shape were not analyzed in this study.

Till Pebble Orientation

Long-axis pebble orientation data for the analysis sites along the Champaign Moraine (Drift) and the BD locations in the associated interlobate region are illustrated on

Figure 14 (in pocket). Analysis sites C1, C4, and C6 are located on the distal side of the moraine while C2 and C3 are near the crest. The three analysis sites in the associated interlobate region would be on the proximal slope if this till was deposited by the Decatur Sublobe. However, Willman and Frye (1970) have mapped the drift of this segment as having been deposited by the Peoria Sublobe which, if correct, would place the analysis sites on the distal side of the Bloomington Moraine (Drift). Regardless of the interpretation selected, assuming Andrews and Smithson (1965) are correct, the position of analysis site with respect to the outline of the moraine makes very little difference in pebble orientation strength when asymmetrical (parabolic-lobate) form moraines are being considered. Therefore, the pebble orientation data from both the Champaign Moraine (Drift) and associated interlobate area will be discussed together and consideration of location with respect to outline of the moraine will not be included in a discussion of the interlobate area orientations.

Reasonably strong long-axis orientation patterns exist at seven of the eight locations studied (see Figure 14, in pocket). The one exception is at analysis site C1 where the long-axis orientation is bimodal and weak. The alternate measurement of dip strength is strong to the southwest for this location. Such an orientation at location C1 tends perpendicular to the trend of the moraine. The tendency towards a long-axis pebble orientation which is orthogonal to the trend of the moraine is more prevalent along the Champaign

Moraine (Drift) than along the Eureka-Normal Moraine (Drift) previously described. In the associated interlobate section, however, the tendency of the primary pebble fabric is to become parallel to the morainal unit with the secondary mode tending toward the perpendicular. This important relationship is also shown in the interlobate area associated with the Bloomington Moraine (Drift) and is elaborated upon in Chapters 5 and 6. Comparison of the actual long-axis pebble orientations as represented by the rose diagrams on Figure 14 (in pocket) with the true perpendicular to the trend of the moraine once again reveals a discrepancy. The orientations are slightly askew from a true perpendicular indicating, as was the case with the Eureka-Normal Moraine (Drift), that a pulsation or readvance of a retreating ice sheet may have reoriented the fabrics slightly from their original depositional environment. This possibility is based on the long-axis orientation findings of this study and the previous work of Harrison (1957b) and Andrews and Smithson (1965).

Till Pebble Lithology

The lithologic classification of each pebble from analysis sites along the Champaign Moraine (Drift) and the BD locations of the interlobate area can be found in the Appendix. These data are categorized and summarized in Table 5. A comparison of the data for C locations with the data for BD locations reveals a small difference in percentage of crystallines and a slightly larger difference for percentage of noncarbonate clastics. The latter difference can be

Table 5

Pebble Lithology--Champaign Till
and Associated Interlobate Till

Analysis Site	%Crystalline	NonCrystalline			
		%Carbonate	%NonCarbonate Clastic	%Chert Flint	%Other
BD8	16	48	20	14	2
BD7	8	60	22	10	0
BD5	12	46	26	16	0
C6	14	48	22	14	2
C3	18	50	24	8	0
C4	16	60	12	12	0
C2	24	52	12	10	2
C1	18	52	6	24	0
Avg.BD	12	51	23	13	1
Avg.C	18	52	15	14	1

attributed to a local concentration of shale pebbles in the area of the interlobate. Anderson (1955) believes that the sedimentary parameter of pebble lithology can be used to distinguish deposits from different lobes. Within the study area the only discernible differences in pebble lithology between the samples from the Peoria and Decatur Sublobes are reflected by the 9 per cent difference in carbonates. It appears that when the sample size is large (700 Eureka-Normal pebbles versus 400 Champaign-BD pebbles) that this degree of variation may be significant enough to provide a basis for determining primary source.

Conclusions

The major conclusions of this chapter are the following: (1) The till within the Champaign Moraine (Drift) and the till within the associated interlobate area are both correlated with the rock-stratigraphic unit named the Snider Till Member of the Wedron Formation. (2) The long-axis pebble orientations of the Champaign Moraine (Drift) tend to be orthogonal to the trend of the morphostratigraphic unit outside of the interlobate then become parallel to the landform in this area. These orientations indicate an Erie Lobe source for this till. And (3) the pebble lithology data from the Champaign Moraine (Drift) and associated interlobate indicate that pebbles within till from an Erie Lobe source have approximately 9 per cent fewer carbonate pebbles than pebbles within till from a Lake Michigan Lobe source.

Chapter 5

CHARACTERISTICS OF THE BLOOMINGTON MORPHOSTRATIGRAPHIC UNIT AND ASSOCIATED INTERLOBATE AREA

Introduction

The Bloomington Moraine (Drift) as defined by Willman and Frye (1970) was studied from the Tazewell-McLean County line on the west to the interlobate area just east of the Ford-McLean County line on the east (see Figure 4, in pocket). This section of the Bloomington Moraine (Drift) has the most massive topographic form of any of the morphostratigraphic units under consideration in this study (see Figure 13, in pocket). The local relief repeatedly exceeds 100 feet (30 meters) and the moraine varies in width from 1.5 to 4.5 miles (2.4 to 7.2 kilometers). The areal plan of the Bloomington Moraine (Drift) does not show the consistent arcuate lobate form that is exhibited by the Eureka-Normal and Champaign Moraines (Drifts) (see Figure 4, in pocket).

Topographically, it can be divided into three sections: (1) a section west of Bloomington, Illinois, which has its own small lobate form; (2) a central section which is almost linear in form; and (3) an interlobate section which has a form similar to the other moraines that merge to form this area. The western section is separated from the central section by the valley of the Sugar Creek (see Figure 13, in pocket). This western section has a distal base which is approximated by the 750 foot (225 meters) contour and a maximum altitude of 883 feet (265 meters). The central section is separated from the interlobate section by the valley of the Sangamon River. The central section has a distal base of approximately 800 feet (243 meters), and crest altitudes of over 900 feet (265 meters) are common in this part of the Bloomington Moraine (Drift) giving it a massive and prominent appearance (see Figure 13, in pocket). Here the proximal slopes are more gently rolling than the steeper distal slopes due in part to the higher altitude of the proximal base. This base is somewhat variable but generally parallels the 800 to 850 foot (243 to 265 meters) contour depending on location. The third section is the associated interlobate area of the Bloomington Moraine (Drift). This section is defined by the BP analysis site locations and the areal extent is illustrated on Figure 9. The base of this area is approximately 825 feet (260 meters) and the crest altitude exceeds 900 feet (265 meters).

At four places stream erosion has resulted in extreme dissection of the Bloomington Moraine (Drift) (see Figure 13, in pocket). Sugar Creek, Kickapoo Creek, and the Sangamon River traverse the Bloomington Moraine (Drift) while the North Fork of Salt Creek partially dissects this same moraine. The topography near their associated valleys is more rugged and very steep slopes are common (see Figure 10).

Fifteen analysis sites were selected for the purpose of collecting samples from the Bloomington Moraine (Drift) (see Figure 7). Two sites were on the proximal slope, four were in the central area near the crest, five were on the distal slope, and four were situated along the west flank of the interlobate section (see the Appendix for specific locations). Average depth of analysis below the top of the soil profile was approximately 9 feet (3 meters) with excavations ranging from 4 feet (1.3 meters) to 25 feet (7.5 meters) below the surface of the Bloomington Moraine (Drift). The surface of this drift above the analysis sites had an average altitude of 834 feet (250 meters). Data on physical characteristics of the till matrix, long-axis pebble orientation, and the lithology of pebbles collected from the fifteen analysis sites on the Bloomington Moraine (Drift) are contained in the Appendix. These data will be compiled, summarized, and presented in this chapter so that the basic question of relationships between morphostratigraphy, rock stratigraphy, pebble lithology, and pebble orientation can be answered.

Physical Characteristics of the Till Matrix

The Bloomington Moraine (Drift) in the study area of this thesis does not have the consistency found in the Eureka-Normal and Champaign Moraines (Drifts). Both Willman and Frye (1970) and Kempton, DuMontelle, and Glass (1971) recognized two till units in this part of the study area. Willman and Frye (1970) mapped the till on the Bloomington Moraine (Drift) west of Bloomington, Illinois, as belonging to the Tiskilwa Till Member and the till east of that same city as a part of the Malden Till Member (see Figure 5). The latter authors describe the till on the Bloomington Moraine (Drift) in McLean County to the west of Danvers,[6] Illinois, as Unit 4 Till and the till in McLean County to the east of the Danvers area as Unit 2 Till. These authors also postulated and mapped a third till named Unit 1 overlying the proximal slope of this moraine in places. The Malden Till and Unit 1 were previously described in Chapter 3, and Unit 2 was described in Chapter 4.

The Tiskilwa Till was described by Willman and Frye (1970) as a sandy, pink tan to reddish tan brown till (usually called pink) that is overlain by the Malden Till and may rest on the Delavan, Esmond, or Lee Center Till Members. Some of the physical characteristics of the Tiskilwa Till Member are represented by data from two samples of Bloomington Moraine (Drift) reported by Willman and Frye (1970) to contain this unit. Averages show (1) a grain-size distribution of approximately 29 per cent sand, 37 per cent silt, and 34 per cent clay; (2) a clay mineral composition of 18 per cent expandable clays, 68 per cent illite, and 14 per cent kaolinite and chlorite; and (3) a carbonate composition of 23 counts per second calcite and 36 counts per second dolomite. Kempton, DuMontelle, and Glass (1971) gave the following description of Unit 4 Till in McLean County:

> It is normally a reddish brown to pinkish gray till. Locally, this till grades to brownish gray. It can nearly always be differentiated from the upper three units in the region on the basis of color and clay mineral composition, particularly when one or more of the upper units are found in sequence with Unit 4. This till unit is slightly silty, averaging 30 per cent

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[6]The location of Danvers is approximated by analysis site B5 on Figure 7.

sand, 40 per cent silt, and 30 per cent clay. The average clay mineral content is 8 per cent montmorillonite, 70 per cent illite, and 22 per cent chlorite plus kaolinite. No significant change in clay mineral composition or grain size of the unit occurs with changes in color. Unit 4 contains the greatest amount of carbonate of all five units.

Numerical data describing certain physical characteristics of the till matrix for the fifteen analysis sites on the Bloomington Moraine (Drift) are summarized in Table 6 and arranged in this table in order from east to west along the trend of the moraine (see Figure 7). Because previous workers have recognized more than one rock-stratigraphic unit within the Bloomington Moraine (Drift) (Willman and Frye, 1970; Kempton, DuMontelle, and Glass, 1971), it may be more revealing if the samples are divided into as many groups as is meaningful on the basis of available data. The result is the recognition of three distinct till units within this part of the study area. For purposes of this discussion these are named Units A, B, and C to avoid confusion with the Kempton, DuMontelle, and Glass number system. Unit A is defined on the basis of data for till samples from analysis sites B13, B14, B5, and B15 (east to west); Unit B by till samples from sites B4 and B3; and Unit C by till samples from all the remaining analysis site locations whose data is summarized in Table 6 (see Figure 7 for locations).

Comparison of the averages of Unit A data reported in Table 6 with the average numerical physical characteristic data of the Tiskilwa Till Member (Willman and Frye, 1970) and also Unit 4 (Kempton, DuMontelle, and Glass, 1971) reveals

Table 6

Physical Characteristics of the Till Matrix--
Bloomington Till and Associated Interlobate Till

			Grain Size Distribution			Clay Mineral Composition			Carbonate Content	
	Anal. Site	Color	%Sand	%Silt	%Clay	%Exp. Clay	%Illite	%Chlor. & Kaol.	Counts Per Second Calcite*	Dolomite
Unit C	BP8	2.5Y5/4	25	42	33	6	81	13	10	14
	BP11	2.5Y5/4	20	42	38	6	81	13	12	19
	BP10	2.5Y5/4	22	40	38	7	78	15	?	15
	BP7	2.5Y5/4	24	36	40	5	83	12	7	17
	B6	2.5Y5/4	24	35	41	5	78	17	?	21
	B12	2.5Y5/4	16	36	48	3	87	10	8	14
	B9	2.5Y5/4	20	43	37	5	81	14	?	22
	B1	2.5Y5/4	22	40	38	6	81	13	?	20
	B2	2.5Y5/4	24	40	36	9	76	15	11	21
Un.B	B4	2.5Y4/2	29	38	33	5	71	24	26	35
	B3	2.5Y4/2	28	34	38	6	71	23	11	23
Unit A	B13	10YR5/4	20	46	34	17	67	16	6	32
	B14	7.5YR5/4	27	38	35	16	67	17	18	27
	B5	10YR5/3	27	37	36	14	72	14	24	34
	B15	7.5YR5/4	26	37	37	20	66	14	15	28
Avg.	Unit A	Pink	25	40	35	17	68	15	16	30
	Unit B	Gray	29	36	35	5	71	24	19	29
	Unit C	Tan	22	39	39	6	81	13	5	18

* ? questionable existence of calcite
- analyzed for calcite but none existed
both are considered as zero for purposes of averaging calcite

a high degree of similarity. This is especially well shown when comparing the low illite content, high carbonate content, and pink color. On this basis it is reasonable to conclude that the surface till on the Bloomington Morphostratigraphic Unit to the west of the city of Bloomington belongs to the Tiskilwa Till Member of the Wedron Formation rock-stratigraphic unit. This correlation is commensurate with the mapping of this unit by Willman and Frye (1970), but does not agree with the tentative boundary drawn between Unit 2 and Unit 4 by Kempton, DuMontelle, and Glass (1971). The findings of this study would suggest that this tentative boundary of Kempton, DuMontelle, and Glass (1971) be placed near the Kickapoo Creek Valley and that the distribution of Unit 1 till be restricted to the proximal slope of the Bloomington Moraine (Drift).

Unit B, the second of the three groups under discussion, can be differentiated from Units A and C on the basis of color and clay mineral composition. This unit is violet gray when unoxidized and a gray brown or tan when oxidized. The clay mineral composition of this unit has less expandable clay than Unit A and less illite than Unit C, producing a greater percentage of chlorite and kaolinite than either of the other units. Less significant differences exist in both texture, Unit B a little sandier than both Units A and C, and carbonate content, slightly more calcite in Unit B than Unit A and a great deal more calcite in Unit B than Unit C (see Table 6). Willman and Frye (1970) included the area defined by analysis sites B3 and B4 in the Malden Till Member, but findings of this study indicate that Unit B is clearly different from the Malden Till. Furthermore, Unit B cannot be correlated with Unit 4 Till, which was recognized and mapped in this area by Kempton, DuMontelle, and Glass (1971), because the differences between Unit B and Unit 4 Till are the same as the differences already described between Unit B and Unit A of this study. Thus, in the opinion of the author, Unit B should be treated as a separate and distinct till that has not been correctly correlated with any other rock-stratigraphic unit to this date. It should be pointed out, however, that the conclusion that Unit B Till has not been defined by previous investigators is based on the physical characteristic data from two analysis sites. Because data from only two sample sites may be judged insufficient for the purpose of naming a new till member, additional data were gathered from drill borings in McLean County. Data from drill borings McLean 10, 12, 13, 17, 18, 20, 21, and 25 support and extend the existence of this till unit. Figure 15 gives the location and elevation of these drill borings. At each of these drill-boring locations analyses of the clay fraction of split spoon samples reveal the existence of a till which is violet gray in color and has a clay mineral composition of approximately 7 per cent expandable clay, 70 per cent illite, and 23 per cent chlorite plus kaolinite. These data are on file in the geologic records section of the Illinois State Geological Survey in Urbana, Illinois. With the addition of this evidence the author proposes that Unit B be hereafter referred to as the Shamrock Till Member of the Wedron Formation. The suggested name is for the town of Shamrock in McLean County. The type section is an exposure in a borrow pit (see Figure 8B) on the north side of I-74 1.5 miles (2.4 kilometers) west of Shamrock, SE SE SW, Sec. 25, T.23 N., R.2 E. The name Shamrock Till will be used in the remainder of this paper to refer to Unit B Till, and the type section will be described later in this chapter.

McLean No.	Location	Elevation
10	NW SE Sec.22 T.23 N. R.2 E.	785
12	SE SE NW Sec.26 T.23 N. R.2 E.	849
13	NE NW Sec.36 T.23 N. R.2 E.	803
17	NW SW NE Sec.33 T.24 N. R.2 E.	774
18	SW NW NW Sec.5 T.23 N. R.2 E.	730
20	SE NW Sec.5 T.22 N. R.3 E.	747
21	NW NW Sec.5 T.22 N. R.3 E.	784
25	SE NW Sec.5 T.22 N. R.3 E.	748

Figure 15 McLean County drill boring locations

Unit C Till has very different physical characteristics from either Unit A or Unit B Till. The most noticeable differences are (1) finer texture, (2) high illite content, and (3) fewer carbonates. The averages reported in Table 6 for Unit C are from sample sites within both the Bloomington Moraine (Drift) and the associated interlobate area. The data in Table 6 indicates that the till samples from all analysis sites included in the Unit C group probably belongs to the same rock-stratigraphic unit. Comparisons of the numerical averages which represent the physical characteristics of Unit C Till described in the area shows that a strong similarity exists between Unit C Till and Malden Till. On the basis of this similarity it is probable that a correlation exists between Unit C and the Malden Till. This interpretation is consistent with the findings of Willman and Frye (1970). Kempton, DuMontelle, and Glass (1971) separated the Malden Till in the study area of this thesis into Units 1 and 2 mainly on the basis of texture. The results of the till-matrix investigations for this thesis do not provide a basis for the separation of the Malden Till into two units. There are some locally sandy places in the Unit C group, but, in the opinion of the author, the relatively small differences in texture do not provide an adequate basis for the recognition of more than one till member. Therefore, it is concluded that the till in Unit C is the equivalent of the Malden Till and is referred to as such in the remainder of this study.

Characteristics of Till Pebbles

Introduction

The purpose of this section is to present the data on long-axis pebble orientation and pebble lithology for 750 pebbles from analysis sites associated with Bloomington Moraine (Drift) (Willman and Frye, 1970). Orientation and lithologic data are contained in the Appendix and are summarized in Figure 14 (in pocket) and Table 7 respectively. The discussion of these data will be directed toward a clearer understanding of the relationship between the sedimentary parameter and associated landform unit.

Till Pebble Orientation

Due to the complexity in morphostratigraphic and rock-stratigraphic units within the Bloomington Moraine (Drift), long-axis pebble orientation data will be discussed in association with Units A, B, and C as previously described because a definite relationship can be shown to exist. The fabric orientations of pebbles measured in Unit A Till (Tiskilwa Till) exhibit a consistent tendency toward a perpendicular alignment to the trend of the moraine (see Figure 14, in pocket). The strong north-south alignment of pebbles at analysis site B15 probably best represents the original depositional mode of Tiskilwa Till because the Malden Till does not overlie the proximal slope of the moraine in this area. However, it appears likely that the till at locations B5, B13, and B14 may have been deformed slightly by ice that eventually constructed the Eureka-Normal Moraine (Drift) because Kempton, DuMontelle, and Glass (1971) report Unit 1 Till on the proximal slope of the Bloomington Moraine (Drift) in this area.

The Congerville Section previously described in Chapter 3 shows an exposure of Tiskilwa Till stratigraphically below the Malden Till. Pebble-orientation data from analysis site EB2 (see Figure 14, in pocket) reveal that a slight reorientation may have occurred in the ground moraine deposited in association with the Bloomington Moraine (Drift). The slight reorientation is illustrated by comparing the rose diagram associated with the pebble alignment at EB2 with the comparable diagram for B15 (see Figure 14, in pocket). A probable cause for this slight realignment is believed to be a result of subsequent ice movement that deposited the Malden Till.

Within the Bloomington Moraine (Drift) the Shamrock Till (Unit B), represented by analysis sites B3 and B4, can be separated topographically from the Tiskilwa Till on the west by the valley of the Sugar Creek, and from the Malden Till on the east by the valley of the Kickapoo Creek. These boundaries extend topographically to the south and incorporate parts of the Shirley and LeRoy Drifts (see Figures 4 and 13, in pocket). Data from drill boring McLean 17 (see Figure 15 for location) indicate that the Shamrock Till is stratigraphically overlain by the younger Malden Till and probably rests upon the older Tiskilwa Till in the subsurface. The long-axis pebble orientation data from Shamrock Till at analysis site B4 is the strongest orientation discovered in this study. Fifty-six per cent of the pebbles were oriented in a 30 degree sector around east-west and dip strength is to the east. Analysis site B3 from the same till also has an east-west fabric orientation with 28 per cent in the same east-west sector.

This strong east-west orientation of pebbles in Shamrock Till is clearly at variance to other nearby sites and suggests it formed in association with westward-moving ice. If this conclusion is correct, it is reasonable to suggest that the source of the Shamrock Till may well be from the Erie rather than the Lake Michigan Lobe. The Erie Lobe source for Shamrock Till is postulated under the assumption that certain pebbles tend to align themselves parallel to the direction of ice movement (Richter, 1932; Cailleux, 1938, and Lundquist, 1949), and supported by the fact that the Shamrock Till is unlike the drift in this area deposited by the Lake Michigan Lobe. However, because of the limited data and complexity of the drift, it is recommended that additional study be initiated regarding the Shamrock Till so that the conclusion of an Erie Lobe source for this till can be definitely confirmed or rejected.

Fabric orientations in Unit C (Malden Till) on the Bloomington Moraine (Drift) show a high degree of similarity to the fabrics of the Eureka-Normal Moraine (Drift) to the north, which has also been classified in this paper as Malden Till (see Chapter 3 and, Figure 14, in pocket). Strong perpendicular orientations to the trend of the moraine are found at analysis sites B1, B6, and B12. Locations B1 and B6 are on the proximal side of the moraine and B12 is near the crest. Unimodal but weak fabric orientations were found at analysis sites B2 and B9 both near the crest of the moraine. Dip strength, an alternate measure of orientation, is to the south at B9 and to the southeast at B2, giving both fabrics a weak preferred orthogonal alignment to the morainal trend.

The interlobate analysis sites on the Peoria Sublobe side of the interlobate section (see Figure 9) show a tendency toward a parallel alignment of pebble axis to trend of the topography. This tendency for pebbles to align themselves parallel to the landform is illustrated by the fabric diagrams at most BD and BP analysis sites as well as at the three E locations near the interlobate region (see Figure 14, in pocket) and is especially worthy of attention and explanation. Parallel alignment of pebble axis to landform trend is not unusual. The fabric of sediments associated with a drumlin often reveal such a relationship. Wright (1957), in his studies of drumlins in Minnesota, reports that almost all rose diagrams representing pebble alignment show a strong preference toward a parallel alignment with the landform trend. Glen, Donner, and West (1957) conclude that the mechanisms by which stones become oriented in till are most favorable to an alignment parallel to the direction of ice flow. Data from this study indicates that the long axis of pebbles prefer an orthogonal arrangement to the end moraine outside the interlobate area but changes to a tangental arrangement in the interlobate area. If Glen, Donner, and West (1957) are correct, then the pebble orientation data outside the interlobate area indicates ice flow perpendicular to the end moraine and the pebble orientation data in the interlobate area indicates that the ice flow associated with an interlobate landform is moving parallel to the ice-contact zone. It is reasonable to assume that the pressures produced at the contact between two glacial ice lobes could force the ice and its associated sediments to flow parallel to the contact zone. Therefore, it is a conclusion of this study that the sedimentary parameter data of pebble orientation may reveal the nature of ice behavior in an interlobate moraine and that the till fabric in areas believed to be interlobate landforms could possibly be identified using the data of this parameter.

Till Pebble Lithology

Table 7 contains a summary of the lithologic classification of pebbles from all B and BP analysis sites. The original data can be found in the Appendix. A discussion of the limitations in the use of this data and a discussion on the lithologic categories used in this analysis can be found in Chapter 2. In this section an attempt will be made to analyze and compare the data in Table 7 with the data in Tables 2 and 5. Results for data on lithologic composition of pebbles in Tables 2, 5, and 7 are not consistent. Crystalline percentages are highly variable between analysis sites. The same is true of noncarbonate clastic percentages. The only patterns that have become apparent in the study of pebble lithology for all units in the study area are these: (1) the percentage of carbonate pebbles for the entire interlobate area and the Champaign Moraine (Drift) is consistently low; and (2) the percentage of chert and flint pebbles in the

Table 7

Pebble Lithology--Bloomington Till
and Associated Interlobate Till

	Analysis Site	%Crystalline	NonCrystalline			
			%Carbonate	%NonCarbonate Clastic	%Chert Flint	%Other
Unit C	BP8	14	44	26	16	0
	BP11	14	56	16	14	0
	BP10	8	52	28	12	0
	BP7	28	54	12	6	0
	B6	16	52	26	6	0
	B12	20	54	22	2	2
	B9	20	60	10	8	2
	B1	18	64	12	0	6
	B2	12	64	18	4	2
Un.B	B4	12	62	12	10	4
	B3	12	66	16	4	2
Unit A	B13	10	56	26	6	2
	B14	16	60	16	6	2
	B5	18	62	14	6	0
	B15	8	56	28	4	4
	Unit A Avg.	13	58	21	6	2
	Unit B Avg.	12	64	14	7	3
	Unit C-B's	17	59	17	5	2
	Unit C-BP's	16	52	20	12	0
	Unit C Avg.	17	56	19	7	1

entire interlobate area and Champaign Moraine (Drift) is slightly higher than the comparable percentages for Eureka-Normal Moraine (Drift) pebbles and nearly double the percentage of chert and flint pebbles found in the Bloomington Moraine (Drift) exclusive of its associated interlobate analysis sites.

A comparison of lithologic composition between all interlobate analysis site locations (see Figure 9) reveals very little variation. The same is true in a comparison of the lithologic composition of pebbles from the C analysis sites with pebbles from both the BP and BD locations. Based on the data provided by analysis of the lithologic composition of elongate pebbles, it appears that the interlobate area of this study has a higher degree of similarity to the Champaign Moraine (Drift) (Snider Till) than to any other unit. However, the till-matrix composition data and pebble orientation data from the till within the interlobate area indicate the following: (1) The till found in the interlobate area associated with the Bloomington Moraine (Drift) (Malden Till) and the Champaign Moraine (Drift) (Snider Till) are very similar (see Tables 2 and 5); and (2) the pebble orientations within the till of the interlobate area indicate that the Malden and Snider Tills were probably deposited contemporaneously. Therefore, based on all the appropriate data, it is suggested that the landform defined in this study as the interlobate area, which was defined by Willman and Frye (1970) as Bloomington Drift, be named the Champaign-Bloomington Interlobate Moraine (Drift).

Shamrock Section

The Shamrock Section is the type section for a new suggested till member defined in this study. Analysis site B4 on Figure 7 marks the location of this section, and Figure 8B is a photo of the exposure. A description of this section follows.

Shamrock Section

Measured in a borrow pit in SE SE SW Sec. 25, T.23 N., R.2 E., McLean County, Illinois, 1971, 1972.

	Thickness (ft)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Richland Loess	
2. Loess; thin layer of tan to tan brown to black loess, locally coarse textured, leached modern surface soil grades into unit one below	2.5
Shamrock Till Member (type section)	
1. Till, tan to gray brown in upper part where oxidized to violet gray where unoxidized in lower part, compact angular blocky, silty till zones with very few pebbles irregularly spaced in profile	14.5
Total	17.0

The Shamrock Till physical characteristics are (1) a grain-size distribution of 30 per cent sand, 38 per cent silt, and 32 per cent clay; (2) a clay mineral composition of 7 per cent expandable clays, 70 per cent illite, and 23 per cent chlorite and kaolinite; and (3) a carbonate content of 18 counts per second calcite and 30 counts per second dolomite. Drill boring McLean 17 (NW SW NE Sec. 33, T.24 N., R.2 E.) to the north of the type section shows the stratigraphic position of the Shamrock Till as between the older Tiskilwa Till and the younger Malden Till. Kempton, DuMontelle, and Glass (1971) map the area defined in this study to have Shamrock Till as Unit 4 Till, which is correlated with the Tiskilwa Till. The Shamrock Till can be differentiated from the Tiskilwa and Unit 4 Till on the basis of color and clay mineral composition. The Shamrock Till is a tan or yellow tan till when oxidized and a gray or violet gray when unoxidized with the zone of oxidation at approximately 13 feet (4 meters) in the type section. The Tiskilwa Till has a salmon or peach color when oxidized and is pink to red brown where unoxidized. An easily discernible difference in clay mineral content separates these two units. The Shamrock Till has an average of 10 per cent less expandable clay than the Tiskilwa Till, and this difference is nearly balanced by the 8 per cent greater chlorite plus kaolinite content found in the Shamrock Till. In the Kempton, DuMontelle, and Glass (1971) paper these variables were not considered. Only illite content was considered, which is approximately the same for both the Shamrock and Unit 4 Tills. These differences clearly establish the necessity for defining a new till member. The till fabric data in the area of this type section confirm the need for a new unit. The long-axis pebble orientation data of this study indicate that the Shamrock Till could possibly have come from an Erie Lobe source because the fabric has a strong east-west orientation in the type section. The topography to the south of this type section indicates the possibility of a north-south trending landform which, if it did contain Shamrock Till, would strengthen the Erie Lobe source hypothesis. Analysis of the till and till fabric to the south of the Shamrock Till of this study is suggested for future investigation. The significance of the Shamrock Section is that it represents a significant exposure of till from the Bloomington Moraine (Drift) not previously defined.

Conclusions

The major conclusions of this chapter are the following: (1) The Bloomington Moraine (Drift) has three distinct surface tills in the study area: the Tiskilwa, Malden, and Shamrock Till Members. The latter was named and defined in this chapter. (2) Pebble-orientation data indicate that elongate pebbles prefer a perpendicular alignment to the moraine trend outside of the interlobate area but a parallel alignment to the landform is preferred in the interlobate area. And (3) the data of this study indicate that the interlobate area should be named the Champaign-Bloomington Interlobate Moraine (Drift).

Chapter 6

CONCLUSIONS AND IMPLICATIONS

Introduction

The purpose of this thesis is to establish the relationships that exist between certain sedimentary parameters of glacial till and particular glacial landforms. The sedimentary parameters investigated were long-axis pebble orientation, pebble lithology, and matrix composition. The glacial landforms studied were end moraines which represent recognized morphostratigraphic units. Two of the end moraines investigated merged into an interlobate moraine. Figure 16 summarizes the relationships between morphostratigraphic and rock-stratigraphic units established by this study. Also illustrated on this map is direction of ice flow as indicated by pebble-orientation data. Implications of the specific findings of this study have general application in geomorphology.

General Implications

The morphostratigraphic units of this study represent one interpretation of the glacial landforms in central Illinois that have been delineated mainly on the basis of topographic expression (see Figures 4 and 13, in pocket). Findings of this study indicate that morphostratigraphic units clearly exist, but a reevaluation of their forms and sedimentary associations may make them even more useful and meaningful as geomorphic

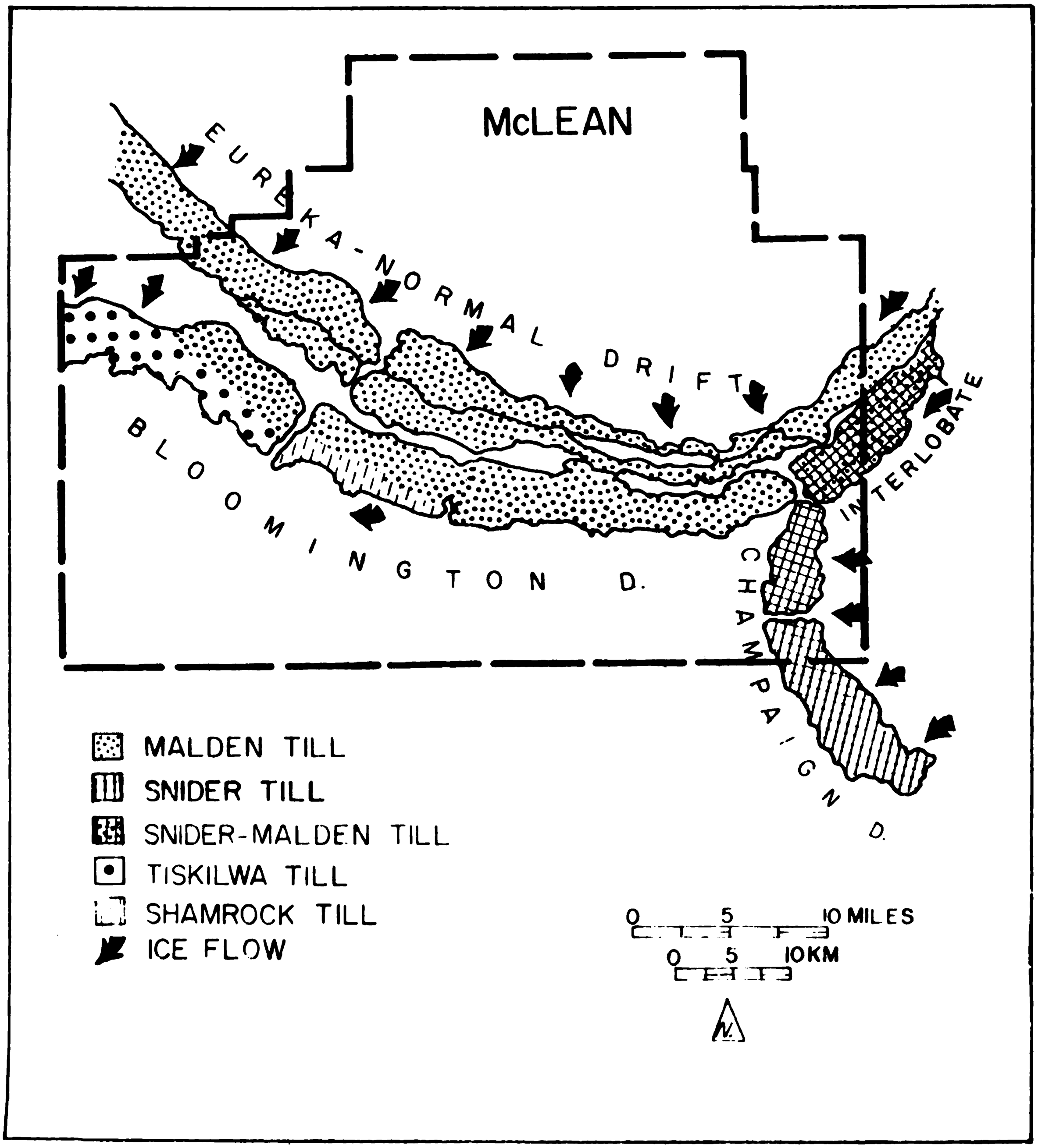

Figure 16 Relationships between morphostratigraphic units, rock stratigraphic units, and ice flow in the study area

units. Such reassessments were a major objective of this study, and the following are examples of findings or problems that have been recognized as a result: (1) the reinterpretation of the Eureka-Normal relationship as discussed in Chapter 3, (2) the variation in till associated with the Bloomington Moraine (Drift) which calls for a reassessment of that morphostratigraphic unit as discussed in Chapter 5 and to be discussed later in this chapter, and (3) the complexity and interrelationship within the interlobate area between the Bloomington and Champaign Moraines (Drifts) that indicate it was formed in association with an Erie-Lake Michigan Lobe ice contact as discussed in Chapters 4 and 5.

It is also important to recognize that certain problems are associated with any attempt to show relationships between morphostratigraphic units and sedimentary parameters. If two or more morphostratigraphic units merge, it may be impossible to understand their relationships without sedimentary parameter data and even that information may be insufficient for a reasonable interpretation. This problem is just one of the many difficulties that will present itself in studies that attempt to relate morphostratigraphy with associated sediments. However, the morphostratigraphic unit can be a very useful and meaningful unit when carefully mapped. The Champaign Moraine (Drift) of this study is a good example. This unit is easily delineated by its topographic expression. The surface till throughout its extent is a part of the same rock-stratigraphic unit. And the fabric complements its shape and depositional mode. This situation demonstrates that it is possible to define morphostratigraphic units which have positive relationships to their sediments and related fabrics.

Evaluation of the relationships between morphostratigraphic and rock-stratigraphic units, which is one of the stated purposes of this thesis, has revealed evidence that supports a reinterpretation of the morphostratigraphy of central Illinois. A proposed alternate interpretation of the morphostratigraphy in central Illinois is a major conclusion of this study and is discussed below.

An Alternate Interpretation of the Morphostratigraphy in Central Illinois

Figure 16 illustrates the relationship between morphostratigraphic units and the defined or correlated till members of this study. Ice-flow direction, which is suggested by the preferred long-axis orientation of each till member, is indicated with arrows on this map. A congruent relationship exists between the Eureka-Normal Moraine (Drift) and the Malden Till and also between the Champaign Moraine (Drift) and the Snider Till. Pebble-orientation data indicate that ice flow reflects a direct relationship to these end moraines. However, the relationships between the morphostratigraphic unit, rock-stratigraphic units, and ice flow for the Bloomington Moraine (Drift) do not complement one another.

Previous workers have recognized this situation but have not correlated rock stratigraphy with morphostratigraphy in this area. Any reinterpretation of the glacial geomorphology associated with the Bloomington Moraine (Drift) must account for three separate and distinct rock-stratigraphic units within a feature that has been mapped as one morphostratigraphic unit and also account for an ice source region that will explain its fabric. An analysis of the topography of the Bloomington Moraine (Drift) indicates that it is not necessarily one morphostratigraphic unit. Instead, it may represent a situation where three morphostratigraphic units of different age converge on one another. This is substantiated by the existence of three distinct rock-stratigraphic units.

The data of this thesis and the topography said to be associated with the present east-west trending LeRoy and Shirley Moraines (Drifts) indicate that these units could equally as well be explained by north-south trending moraines which extend to join the Heyworth Moraine (Drift) and portions of the Shelbyville Moraine (Drift) (see Figures 4 and 13, in pocket). By interpolating between sections of land outlined by the 750 foot (225 meter) contour, two or three north-south trending landform units take shape which intersect the Bloomington Moraine (Drift) at nearly right angles (see Figure 17).

This alternate interpretation of the morphostratigraphy can account for variations in the rock stratigraphy of the Bloomington Moraine (Drift) by assigning the western Tiskilwa Till to an east-west trending moraine, the eastern Malden Till

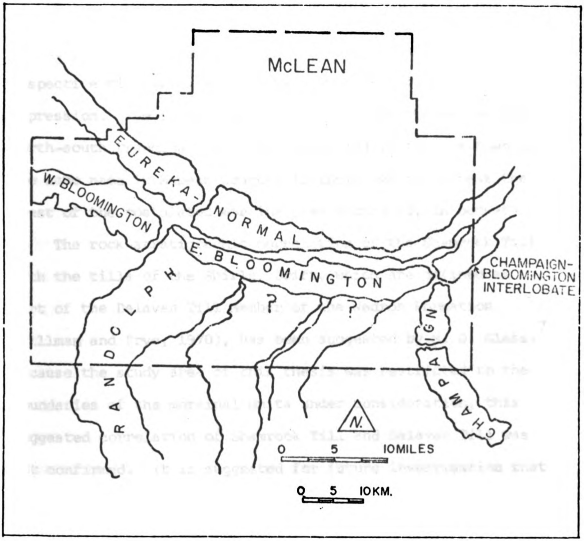

Figure 17 An alternate interpretation of the morphostratigraphy of Central Illinois

to a relatively younger unconformable moraine more closely associated with the Eureka-Normal Unit which contains this same rock stratigraphic till member, and the Shamrock Till to a previously unrecognized north-south trending moraine named in this paper the Randolph. These interpretations are supported by the preferred long-axis orientation of pebbles within each respective till and are consistent with topographic expression. The suggested name Randolph for the westernmost north-south trending unit (see Figure 17) is for the town of the same name in McLean County, Illinois, which is near the crest of the postulated moraine (see Figure 13, in pocket).

The rock-stratigraphic correlation of the Shamrock Till with the tills of the Shirley Drift, which are defined as part of the Delavan Till Member of the Wedron Formation (Willman and Frye, 1970), has been suggested by H. D. Glass.[7] Because the study area of this thesis was restricted to the boundaries of the morainal units under consideration, this suggested correlation of Shamrock Till and Delavan Till was not confirmed. It is suggested for future investigation that the tills of the LeRoy, Shirley, and Heyworth Drifts be studied and analyzed in an attempt to establish their relationship to the Shamrock Till.

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[7]H. D. Glass, Clay Mineralogist of the Illinois State Geologic Survey, in oral communication suggested this possible correlation.

Conclusions on the Glacial Geomorphology of Central Illinois

The morphostratigraphy, rock stratigraphy, and pebble-orientation data examined in this study suggest the following glacial chronology for central Illinois: (1) An ice advance, possibly even pre-Woodfordian from the north, deposited the Tiskilwa Till as a surface till on the Bloomington Moraine (Drift) to the west of the city of Bloomington, and this same till was deposited over a wide area because it is an extensive subsurface unit in the remainder of the study area. (2) An ice advance from the east or east-northeast overrode the Tiskilwa Till and deposited the Shamrock Till of the Randolph Moraine (Drift), with a north-south trending drift border. And (3) an ice advance from the north-northeast contemporaneous with an ice advance from the east-northeast deposited the Malden Till of the Bloomington Moraine (Drift) and Snider Till of the Champaign Moraine (Drift) respectively, forming an interlobate moraine named in this study the Champaign-Bloomington Interlobate Moraine (Drift) in the area of ice contact. The ice marginal retreat of the glacier to the north-northeast was marked by a slight readvance to form the Eureka-Normal Moraine (Drift).

Suggestions for Future Investigations

In a number of places in this thesis where data were limited or where there was doubt about findings and interpretations, recommendations were made for further investigation. The following is a summary of the suggestions for future investigation of the central Illinois region as indicated by the results of this study. (1) Of primary importance for further study is an analysis of the relationships between topography, till-matrix composition, and till-fabric orientation to the south of the Bloomington Moraine (Drift) of this study. An alternate interpretation of the morphostratigraphy of this region has been proposed. Additional investigation may provide evidence to support this proposed alternate interpretation. (2) The high degree of correlation between the morphostratigraphic unit termed the Eureka-Normal Moraine (Drift) and the rock-stratigraphic unit called the Malden Till Member has been established by this study. This relationship also exists between the Champaign Morphostratigraphic Unit and the Snider Till Member. However, some of the relationships between morphostratigraphy and rock stratigraphy along the Bloomington Moraine (Drift) remain unclear. For example, the lines of demarcation between till members are questionable and there is a need for further investigations of the till and till fabric of the Bloomington Moraine (Drift) to establish clearly the boundaries of the rock-stratigraphic units. And (3) future studies of interlobate moraines might well include an analysis of the till fabric in order to confirm or reject the hypothesis of this thesis that the long axis of pebbles embedded in the till of these landforms tends to prefer a parallel alignment to the associated ice-contact zone.

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APPENDIX

Explanation of Data in the Appendix

Depth of Analysis -	In feet below the crest of the exposure
Type of Exposure -	See Figure 8
Topography -	See Figure 10

TILL PEBBLE DATA:

Dimensions -	Longest dimension first, shortest dimension last; all dimensions in millimeters
Shape -	(See Figure 12) 1. Tabular-elongate 2. Tabular 3. Rhombohedroid 4. Rhombohedroid-elongate 5. Wedge-form-rounded 6. Wedge-form-elongate 7. Wedge-form-angular, subangular 8. Ovoid 9. Ovoid-elongate
Strike -	Orientation of the pebble's long axis
Dip -	Angle and direction of the pebble's dip
Misc. -	S - pebble shows glacial striations W - pebble was deeply weathered LAV - long axis was vertical, therefore strike data is for second longest axis

TILL MATRIX COMPOSITION DATA:

Grain-Size Distribution -	Sand .062-2.0 mm. Silt .004-.062 mm. Clay less than .004 mm.
Carbonates -	? the existence is questionable - none exists

Analysis Site Number B1 **Morphostratigraphic Unit** Bloomington

Location NE NE NE Sec. 25, T.33N., R.3E. **Quadrangle** LeRoy

Elevation 860' **Depth of Analysis** 7' **Type of Exposure** Roadcut (old)

Topography C and D slopes on proximal side of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	35	24	15	2	N25W	0	Dolomite	W
2	20	13	10	6	N5E	40S	Dolomite	
3	13	7	5	6	N20E	15SW	Dolomite	
4	21	16	14	5	N	20S	Dolomite	W
5	17	12	11	6	N	55S	Basalt	
6	15	8	1	1	N65E	15SW	Shale	
7	16	10	9	3	N80E	45W	Dolomite	
8	12	10	4	1	N25W	30W	Basalt	
9	16	12	10	6	N50W	0	Limestone	
10	16	6	5	6	N15E	5SW	Granite	
11	26	24	3	2	N20E	55NW	Shale	
12	15	10	10	5	N50W	10SE	Dolomite	
13	28	18	9	6	N60E	40SW	Basalt	
14	19	15	3	2	N	0	Shale	
15	23	16	10	6	N30E	10SW	Limonite	
16	23	17	15	5	N30E	10S	Dolomite	
17	18	12	9	6	N40E	0	Limonite	
18	28	21	14	6	N45E	15SW	Limestone	
19	19	10	8	6	N10E	0	Dolomite	
20	18	13	12	5	N65W	25SE	Limestone	
21	18	15	8	2	N75E	0	Limonite	
22	18	15	10	5	N20E	0	Siltstone	
23	22	12	8	6	N25E	10SW	Basalt	
24	12	10	7	5	N15W	20NW	Limestone	
25	45	25	18	5	N5W	35W	Limestone	
26	20	14	9	5	N20E	0	Shale	
27	35	21	20	9	N5W	15N	Limestone	W
28	16	13	6	1	E	0	Limestone	
29	10	7	7	3	N20W	0	Red Limestone	
30	10	7	5	9	N65E	25SW	Dolomite	
31	20	11	10	9	N35W	0	Dolomite	
32	17	10	10	4	N5W	10S	Dolomite	W
33	18	15	8	2	N5W	0	Limestone	
34	29	28	20	8	N20E	30W	Dolomite	
35	25	18	10	6	N	10S	Granite	
36	15	8	5	6	N10E	10SW	Dolomite	
37	13	11	7	5	N60E	30SW	Quartzite	
38	26	20	18	5	N10W	15SE	Dolomite	
39	10	5	5	6	N20E	20SW	Red Quartzite	
40	13	10	8	4	N70E	0	Limestone	
41	10	6	6	4	N75E	10SW	Granite	
42	13	10	8	6	N20E	15SW	Dolomite	
43	17	15	14	5	N70E	90	Dolomite	LAV
44	18	16	15	5	N25E	40NE	Limestone	
45	15	13	8	7	N5E	0	Dolomite	
46	22	8	5	6	N75W	40N	Limestone	
47	23	12	11	6	N50E	0	Dolomite	
48	27	13	5	1	N40W	10SE	Shale	
49	32	18	12	6	N20E	0	Limestone	
50	37	28	23	5	N70E	60S	Dolomite	

Till Matrix Composition Data: Color Yellow tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
22	40	38

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
6	81	13

Carbonates Cts./Sec	
Calcite	Dolomite
?	20

Figure 18 Data for analysis site B1

Analysis Site Number B2 **Morphostratigraphic Unit** Bloomington

Location NE NE SE Sec. 28, T.23N, R.3E. **Quadrangle** LeRoy

Elevation 820' **Depth of Analysis** 8' **Type of Exposure** Roadcut (old)

Topography D and E slopes near top center of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	21	16	14	5	N50W	15NW	Dolomite	
2	15	8	4	4	N70W	35SE	Dolomite	
3	23	22	10	2	N10E	30E	Chert	
4	26	12	10	6	N15E	65N	Siltstone	
5	23	20	14	7	N10E	10N	Dolomite	
6	22	18	15	5	N20W	0	Greenstone	
7	23	15	13	6	N75E	10S	Dolomite	
8	13	8	5	1	E	30S	Basalt	
9	16	15	11	3	N30E	0	Dolomite	
10	11	10	6	5	N25E	30SE	Limestone	
11	37	29	18	5	N60W	10N	Dolomite	
12	23	18	12	5	N30E	25SE	Dolomite	
13	24	20	11	2	N55W	40NW	Dolomite	
14	20	15	14	7	N85E	15S	Chert	W
15	22	14	11	3	N75E	45N	Dolomite	
16	14	11	8	9	N80E	0	Dolomite	
17	12	10	6	5	N85E	5W	Basalt	
18	21	17	15	8	N75E	15W	Limestone	
19	12	8	7	6	N30E	70NW	Dolomite	
20	20	14	10	5	N75E	0	Siltstone	
21	22	19	9	2	N45E	40NE	Dolomite	
22	19	14	11	5	N55W	20SW	Limestone	
23	22	14	7	1	N70W	10SE	Shale	
24	11	7	6	6	N50W	25SE	Dolomite	
25	19	9	7	9	N50E	15NE	Basalt	
26	43	25	18	1	N15W	0	Dolomite	
27	10	7	1	1	N85E	10E	Shale	
28	13	11	5	1	N35W	25NE	Dolomite	
29	12	10	7	3	N85W	0	Dolomite	
30	18	9	9	6	N25E	90	Dolomite	LAV
31	16	8	8	6	N	0	Dolomite	
32	30	24	16	3	N25E	35N	Dolomite	W
33	48	42	33	8	N30E	25NE	Dolomite	
34	18	11	9	3	N85W	40E	Granodiorite	
35	15	11	10	5	N55W	10NW	Dolomite	
36	10	8	5	9	N45E	40NE	Limestone	
37	13	10	5	5	N65W	10SE	Dolomite	
38	19	15	7	1	N5E	0	Limonite	
39	12	9	5	5	N10E	0	Siltstone	
40	10	8	5	5	N70E	0	Limestone	
41	9	7	5	2	N80E	0	Dolomite	
42	17	13	10	5	N55E	10NE	Shale	
43	9	6	5	6	N50W	10SE	Dolomite	
44	11	9	5	2	N85E	0	Granite	
45	13	9	7	9	N75W	5SE	Shale	
46	12	8	8	7	N55W	0	Dolomite	
47	16	12	5	1	N20E	45SE	Shale	
48	13	9	5	6	N	10S	Dolomite	
49	15	10	5	1	N10W	20E	Dolomite	
50	18	13	5	1	N5W	20E	Shale	

Till Matrix Composition Data: Color Yellow tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
24	40	36

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
9	76	15

Carbonates Cts./Sec	
Calcite	Dolomite
11	21

Figure 19 Data for analysis site B2

Analysis Site Number B3 **Morphostratigraphic Unit** Bloomington

Location SE NE SE Sec. 21, T.23N., R.2E. **Quadrangle** LeRoy

Elevation 850' **Depth of Analysis** 25' **Type of Exposure** Roadcut (new)

Topography C and D slopes on distal side of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	15	12	8	5	N85W	0	Dolomite	
2	22	21	13	5	E	10E	Limestone	
3	26	17	16	7	N80E	90	Dolomite	LAV
4	19	15	12	3	N80W	25E	Dolomite	
5	12	10	8	3	N35E	0	Limestone	
6	10	6	1	2	N40W	10SE	Shale	
7	23	20	12	2	N30E	10S	Dolomite	
8	35	32	16	2	N30W	40NE	Coal	
9	10	5	4	6	N35W	30NW	Dolomite	
10	13	8	6	4	N85E	35W	Dolomite	
11	15	11	8	6	N60W	0	Chert	
12	22	16	10	2	N30W	40SE	Muscovite Gneiss	
13	17	15	11	5	N15W	20S	Dolomite	
14	21	16	14	6	N30W	15SW	Limestone	
15	15	13	3	1	N20E	30E	Shale	
16	13	10	8	5	E	10S	Dolomite	
17	13	8	1	1	N40E	20SW	Shale	
18	27	18	18	5	N55E	35SW	Quartzite	
19	11	10	4	1	N55E	55SW	Dolomite	
20	16	8	6	6	N10W	20S	Dolomite	
21	19	15	7	1	E	45N	Shale	
22	17	12	6	6	E	30W	Shale	
23	11	8	5	6	N5W	30N	Quartzite	
24	13	9	4	1	N60W	0	Limestone	
25	12	10	7	5	N30E	30E	Basalt	
26	18	15	9	5	N85E	0	Basalt	
27	12	8	5	6	N	0	Dolomite	
28	16	10	7	6	N40W	25NW	Dolomite	
29	19	13	11	7	N40W	0	Chert	
30	16	11	5	1	N45W	50SW	Siltstone	W
31	13	10	3	1	N50W	90	Shale	LAV
32	23	17	8	1	N45W	65NE	Dolomite	
33	14	10	6	6	N50W	0	Dolomite	
34	28	21	11	1	N65E	30SW	Dolomite	
35	20	12	10	6	N20W	90	Dolomite	LAV
36	10	8	7	3	N85W	10W	Dolomite	
37	20	17	13	5	N80E	10W	Dolomite	
38	13	8	4	6	N	90	Limestone	LAV
39	19	15	10	3	E	90	Dolomite	LAV
40	16	15	7	2	N15W	60W	Dolomite	
41	26	16	16	5	N15E	0	Limestone	
42	23	20	10	1	N50E	45SW	Dolomite	
43	40	16	12	6	N30E	35S	Dolomite	
44	17	12	9	5	N25E	20SW	Limestone	
45	9	6	5	9	N15E	15S	Dolomite	
46	15	12	8	3	N40W	0	Dolomite	
47	15	13	5	1	N40E	30NE	Shale	
48	15	9	5	6	N35E	10SW	Dolomite	
49	23	18	10	1	N80W	40E	Dolomite	
50	23	14	14	7	N85W	45W	Basalt	

Till Matrix Composition Data: Color Gray brown Munsell Soil Color No. 2.5Y 4/2

Grain-Size Distribution		
Sand	Silt	Clay
28	34	38

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
6	71	23

Carbonates Cts./Sec	
Calcite	Dolomite
11	23

Figure 20 Data for analysis site B3

Analysis Site Number B4 **Morphostratigraphic Unit** Bloomington

Location SE SE SW Sec. 25, T.23N., R.2E. **Quadrangle** LeRoy

Elevation 830' **Depth of Analysis** 20' **Type of Exposure** Borrow Pit

Topography B, C, and D slopes on distal side of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	31	24	20	5	E	35E	Dolomite	W
2	17	9	7	6	N80E	[illegible]W	Dolomite	
3	15	10	8	3	N80E	20W	Shale	
4	14	12	8	5	N20E	90	Dolomite	LAV
5	9	5	5	5	N85W	25E	Dolomite	
6	9	7	4	7	N80W	90	Coal	LAV
7	13	6	1	1	N80W	10W	Shale	
8	7	5	2	1	N85E	90	Shale	LAV
9	12	7	6	6	N70W	35W	Dolomite	
10	8	6	1	1	E	65N	Shale	
11	8	6	4	6	N75E	90	Dolomite	LAV
12	18	12	9	7	E	90	Coal	LAV
13	11	10	7	5	N60W	0	Dolomite	
14	15	12	10	7	N70E	90	Chert	LAV
15	10	8	5	6	N70E	10E	Dolomite	
16	20	19	10	2	N85E	45E	Granite	
17	16	15	9	2	N85E	90	Dolomite	LAV
18	15	13	7	2	N70E	90	Limestone	LAV
19	8	4	3	6	N60E	20E	Dolomite	
20	10	7	7	3	N40E	40SW	Gabbro	
21	14	10	10	5	N60E	0	Dolomite	
22	10	6	4	6	N55E	10SW	Limestone	
23	9	7	5	7	E	55N	Chert	
24	8	5	3	6	N60E	35E	Quartzite	
25	12	8	7	5	N5E	45N	Limestone	
26	9	6	4	1	N60E	90	Limestone	
27	5	4	2	1	N85E	0	Shale	
28	10	7	3	1	N80E	90	Dolomite	
29	14	10	7	5	N75E	60NW	Dolomite	
30	22	15	9	1	N65E	55SE	Dolomite	
31	11	8	6	6	N75W	90	Dolomite	LAV
32	11	8	6	6	N75E	0	Dolomite	
33	35	17	15	7	N35E	45E	Chert	
34	24	15	14	7	N80W	25E	Dolomite	
35	9	8	5	5	N70W	90	Limestone	LAV
36	24	21	17	7	N80E	90	Dolomite	LAV
37	11	7	5	4	N75W	0	Limestone	
38	13	7	6	7	E	40E	Dolomite	
39	11	9	6	5	E	50N	Dolomite	
40	13	11	4	2	N80E	55N	Dolomite	
41	19	14	7	1	N80E	90	Chert	LAV
42	10	7	4	6	N85E	0	Chert	
43	19	16	9	1	E	55N	Dolomite	
44	14	10	9	5	N85W	90	Dolomite	LAV
45	14	13	3	1	N85E	90	Dolomite	LAV
46	12	8	7	7	N60E	50NE	Dolomite	
47	34	27	15	1	N50E	0	Shale	W
48	48	26	16	6	N60E	15SW	Basalt	
49	31	24	14	2	N70W	90	Quartzite	LAV
50	14	13	7	5	N85W	35W	Gabbro	

Till Matrix Composition Data: Color Violet Munsell Soil Color No. 2.5Y 4/2

Grain-Size Distribution		
Sand	Silt	Clay
29	38	33

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
5	71	24

Carbonates Cts./Sec	
Calcite	Dolomite
26	35

Figure 21 Data for analysis site B4

Analysis Site Number B5 **Morphostratigraphic Unit** Bloomington

Location NE NE NW Sec. 24, T.24N., R.1W. **Quadrangle** Danvers

Elevation 820' **Depth of Analysis** 9' **Type of Exposure** Roadcut (new)

Topography B and C slopes near top center of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	80	53	45	3	N20E	0	Quartzite	
2	10	6	4	6	N45E	10SW	Dolomite	
3	16	11	7	6	N85W	15E	Shale	
4	26	21	14	5	N80E	0	Dolomite	
5	21	14	10	6	N65W	45NW	Limestone	
6	11	8	3	2	N65W	25SE	Limestone	
7	24	15	11	7	N30E	10SW	Limestone	
8	24	18	8	1	N20W	25E	Gabbro	
9	15	8	5	6	N45E	25E	Dolomite	W
10	13	11	8	7	N70W	25SE	Chert	
11	18	11	9	7	N10W	25S	Dolomite	
12	94	55	47	4	N55W	10NW	Basalt	
13	50	33	20	6	N65E	25E	Dolomite	W
14	19	12	12	9	N70W	10NW	Diorite	
15	20	12	10	6	N45E	15NE	Dolomite	
16	21	13	9	6	N60E	10NE	Limestone	
17	16	9	2	1	N70E	50E	Shale	
18	17	13	7	2	N40E	30NE	Limestone	
19	25	18	15	7	E	0	Diorite	W
20	84	45	39	6	N80E	20E	Chert	
21	24	17	14	6	N30W	25N	Limestone	
22	22	11	9	6	N85W	0	Dolomite	
23	17	14	7	2	N20E	10SW	Dolomite	
24	15	12	3	1	N35W	10S	Dolomite	
25	21	13	15	5	N10W	90	Dolomite	LAV
26	29	17	14	4	N15E	15SW	Gabbro	W
27	9	7	4	5	N15E	0	Limestone	W
28	28	16	13	6	N	35S	Dolomite	
29	18	12	5	1	N80E	40S	Shale	
30	24	20	11	2	N50E	25SW	Dolomite	
31	19	18	10	2	N45W	0	Dolomite	
32	14	9	5	6	N20W	10S	Dolomite	
33	43	26	13	1	N25E	40S	Dolomite	
34	19	10	9	6	N30E	0	Limestone	W
35	10	6	5	6	N30E	10NE	Limestone	
36	24	18	16	5	N15E	0	Granite	W
37	12	11	8	5	E	10E	Limestone	
38	13	9	7	6	N20E	20NE	Shale	
39	12	7	6	6	N85E	0	Dolomite	
40	45	32	18	1	N5E	25N	Limestone	
41	16	10	8	6	N45E	20NE	Limestone	
42	18	13	9	5	N70W	20SE	Shale	
43	15	9	9	5	N15W	30S	Dolomite	
44	15	11	7	6	N70W	10SE	Chert	
45	31	28	18	5	N35E	25NE	Granite	
46	20	16	8	2	N85W	10E	Limestone	
47	19	14	5	1	N30W	20SE	Shale	
48	15	13	9	3	N60E	40S	Gabbro	
49	28	18	12	6	N5W	30N	Limestone	
50	26	23	8	1	N	0	Shale	

Till Matrix Composition Data: Color Peach **Munsell Soil Color No.** 10YR 5/3

Grain-Size Distribution		
Sand	Silt	Clay
27	37	36

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
14	72	14

Carbonates Cts./Sec	
Calcite	Dolomite
24	34

Figure 22 Data for analysis site B5

Analysis Site Number B6 **Morphostratigraphic Unit** Bloomington

Location NE SW SW Sec.20, T.23N., R.6E. **Quadrangle** Arrowsmith

Elevation 830' **Depth of Analysis** 5' **Type of Exposure** Pipeline Trench

Topography C and D slopes on proximal side of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	36	29	20	3	N65W	90	Siltstone	W
2	14	9	7	6	N45W	0	Basalt	
3	14	10	5	9	N45W	15NW	Quartzite	
4	13	7	5	6	N40W	15SW	Limestone	
5	13	11	10	7	N45E	90	Siltstone	LAV
6	13	8	6	3	N30W	10SE	Chert	
7	28	18	14	5	N50W	10E	Granite	
8	16	11	10	6	N45W	5E	Dolomite	
9	16	10	6	7	N75W	50S	Dolomite	
10	16	13	8	7	N40E	20SW	Limestone	
11	20	15	9	3	N80W	35W	Siltstone	
12	13	11	6	5	N50W	15NW	Shale	
13	10	7	7	3	N85W	0	Quartzite	
14	14	7	5	6	N35E	35SW	Limestone	
15	18	14	3	1	N55W	15NW	Shale	
16	18	12	9	5	N40W	0	Dolomite	
17	27	18	17	7	N50W	10SE	Dolomite	W
18	29	17	4	1	N60W	90	Shale	
19	15	9	5	6	N70W	10W	Limestone	
20	12	9	7	5	N45E	35NE	Dolomite	
21	27	15	4	1	N55W	50SW	Shale	
22	9	6	4	6	N25W	0	Dolomite	
23	13	10	6	7	N55W	20NW	Shale	W
24	24	15	15	3	N50W	20NW	Limestone	W
25	15	11	6	5	N	25E	Limestone	
26	15	10	7	6	N40W	0	Quartzite	
27	8	7	4	7	N55W	25E	Dolomite	
28	20	19	5	2	N15W	55SW	Dolomite	
29	23	15	11	5	N60E	15SW	Dolomite	
30	25	16	15	7	N5E	10SE	Dolomite	W
31	11	7	3	1	N30W	0	Shale	
32	9	5	4	6	N60W	0	Shale	
33	15	12	9	5	N50W	0	Dolomite	
34	15	12	8	5	N85W	35E	Dolomite	
35	13	11	8	5	N40W	45NE	Dolomite	
36	17	10	6	6	N25W	60SW	Chert	W
37	8	5	5	6	N50W	0	Dolomite	
38	11	6	6	6	N45W	25W	Shale	
39	18	11	10	3	N60W	50SE	Dolomite	
40	15	12	8	7	N40W	20NW	Limestone	
41	18	12	8	6	N40E	0	Chert	
42	15	10	8	7	N70E	40SW	Dolomite	W
43	18	16	11	5	N15E	30SE	Dolomite	
44	24	20	14	3	N40W	35SW	Limestone	
45	14	12	10	8	N50W	0	Shale	
46	10	8	2	2	N20W	30NE	Shale	
47	9	5	5	6	E	25S	Dolomite	
48	9	7	2	2	N25W	30NW	Quartzite	
49	10	5	2	6	N40W	20NW	Basalt	
50	12	10	5	7	N35W	20SE	Diorite	

Till Matrix Composition Data: Color Yellow tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
24	35	41

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
5	78	17

Carbonates Cts./Sec	
Calcite	Dolomite
?	21

Figure 23 Data for analysis site B6

Analysis Site Number B9 **Morphostratigraphic Unit** Bloomington

Location SW SE SW Sec. 27, T.23N., R.4E. **Quadrangle** Arrowsmith

Elevation 890' **Depth of Analysis** 5' **Type of Exposure** Roadcut (new)

Topography C and D slopes near top center of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	24	19	7	1	N35E	90	Dolomite	
2	13	9	5	6	N50E	15SW	Chert	
3	12	6	6	6	N45W	20SE	Basalt	
4	15	9	2	1	N45W	90	Shale	LAV
5	13	11	10	5	N40E	50SW	Limestone	
6	18	11	10	6	N65W	20SE	Flint	
7	18	12	6	7	N65W	90	Dolomite	
8	13	9	6	7	N5W	45E	Dolomite	
9	12	9	4	1	N70E	5W	Limestone	
10	9	6	3	6	N80E	0	Quartzite	
11	16	9	7	6	N70W	10SE	Dolomite	
12	18	5	3	6	N60W	10SE	Basalt	
13	12	8	7	6	N45E	10SW	Dolomite	
14	22	13	12	6	E	10S	Dolomite	
15	13	9	5	6	N35W	15SE	Dolomite	
16	9	7	6	5	N30W	10SE	Limestone	
17	14	10	6	7	N35E	45SW	Quartzite	
18	11	8	6	6	N60W	10NW	Basalt	
19	13	10	6	7	N65W	25S	Dolomite	
20	47	35	19	7	N45W	35NW	Dolomite	
21	14	12	7	3	N50E	0	Dolomite	
22	20	15	10	5	N85E	15E	Chert	
23	14	10	7	3	N40W	90	Basalt	LAV
24	14	8	6	6	N5E	30S	Basalt	
25	13	10	5	6	N40W	15SE	Basalt	
26	9	8	5	7	N75W	25E	Shale	
27	17	12	5	2	N65E	25SW	Limestone	
28	13	8	4	6	N50W	20SE	Limonite	
29	19	14	9	7	N25W	15SE	Dolomite	
30	12	8	5	6	N40E	20NE	Granodiorite	
31	11	7	5	6	E	15W	Chert	
32	11	10	4	1	N20E	25S	Dolomite	
33	21	18	12	7	N65W	35E	Dolomite	
34	16	10	9	4	N10E	20S	Dolomite	
35	13	9	4	1	N20W	15S	Dolomite	
36	20	13	12	6	N30E	40 W	Dolomite	
37	11	7	4	6	N30E	35NE	Dolomite	
38	16	12	9	5	N70W	45E	Dolomite	
39	12	10	7	5	N50E	15SW	Dolomite	
40	11	7	6	6	N85W	20W	Dolomite	
41	10	7	7	3	N35E	5NE	Dolomite	
42	13	10	2	1	N45E	35 W	Shale	
43	13	7	7	6	N55E	15[illegible]	Limestone	
44	18	13	10	7	N30E	65[illegible]	Diorite	
45	9	8	6	8	N75E	40[illegible]	Dolomite	
46	20	13	12	6	N70E	0	Sandstone	W
47	9	5	4	6	N75W	0	Dolomite	
48	11	10	3	1	N85E	20E	Shale	
49	15	12	8	5	N60E	10SW	Dolomite	
50	20	13	7	6	N20E	10N	Dolomite	

Till Matrix Composition Data: Color Yellow tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
20	43	37

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
5	81	14

Carbonates Cts./Sec	
Calcite	Dolomite
7	22

Figure 24 Data for analysis site B9

Analysis Site Number B12 **Morphostratigraphic Unit** Bloomington

Location NE NE SW Sec. 33, T.23N., R.5E. **Quadrangle** Arrowsmith

Elevation 880' **Depth of Analysis** 7' **Type of Exposure** Roadcut (old)

Topography B and C slopes near top center of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	127	88	51	6	N60W	10NW	Dolomite	S
2	20	15	9	7	N70E	25E	Dolomite	
3	15	8	5	9	N75E	30W	Quartzite	
4	11	10	5	7	N15W	30N	Shale	
5	20	15	7	1	N5E	25S	Limestone	
6	27	21	7	1	N20E	60N	Shale	
7	21	15	7	1	N70E	30E	Shale	
8	19	16	13	8	N55W	20SE	Limestone	
9	16	12	7	3	N20W	15N	Dolomite	
10	20	15	5	1	N10E	90	Shale	
11	41	25	22	6	N10E	90	Limonite	
12	12	8	6	6	N15E	0	Dolomite	
13	22	19	5	1	N10E	25N	Siltstone	
14	16	9	7	6	N15E	15N	Dolomite	
15	15	11	7	6	N30W	10NW	Dolomite	
16	14	10	8	5	N10E	20N	Dolomite	
17	20	15	10	7	N25W	20NW	Dolomite	
18	22	14	12	7	N25W	0	Dolomite	
19	13	10	7	5	N20W	30N	Dolomite	
20	13	8	3	1	N15W	90	Basalt	
21	45	28	25	6	N20E	50S	Granite	W
22	30	16	10	6	N30W	0	Limestone	
23	37	22	17	6	N20W	0	Limestone	
24	36	32	15	2	N15W	10S	Limestone	
25	15	7	5	6	N25E	5S	Chert	
26	15	12	10	5	N60E	20NE	Basalt	
27	30	18	12	7	N20W	0	Dolomite	
28	15	14	5	1	N25E	30NE	Shale	
29	35	25	21	5	N25W	25SE	Quartzite	
30	32	25	5	2	N40E	15NE	Shale	
31	10	8	5	8	N5W	10N	Limestone	
32	18	13	10	6	N	0	Dolomite	
33	36	30	12	7	N35W	20SE	Dolomite	W
34	19	13	5	1	N85W	90	Dolomite	
35	16	7	6	6	N50E	10SW	Shale	
36	12	10	4	1	N35W	10NW	Diorite	
37	12	10	6	3	N45E	10NE	Limestone	
38	25	17	15	3	N25W	90	Dolomite	LAV-W
39	11	7	6	4	N25E	0	Dolomite	
40	16	15	4	2	N35E	0	Shale	
41	14	9	8	6	N10E	0	Siltstone	W
42	12	6	5	6	N70E	10W	Dolomite	
43	10	7	6	5	N75W	5E	Dolomite	
44	10	8	3	1	E	20N	Limestone	
45	20	10	8	3	N80E	10W	Basalt	
46	12	7	7	6	N5W	10S	Quartzite	
47	15	9	8	6	N25W	40N	Granite	
48	10	8	5	2	N75E	0	Dolomite	
49	23	17	7	1	N10W	20N	Shale	
50	10	7	5	6	N50E	20SW	Quartzite	W

Till Matrix Composition Data: Color Yellow tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
16	36	48

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
3	87	10

Carbonates Cts./Sec	
Calcite	Dolomite
8	14

Figure 25 Data for analysis site B12

Analysis Site Number B13 **Morphostratigraphic Unit** Bloomington

Location NW NW NE Sec.14, T.23N., R.1E. **Quadrangle** McLean

Elevation 790' **Depth of Analysis** 8' **Type of Exposure** Roadcut (old)

Topography C and D slopes on distal side of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	23	15	9	6	N10W	50N	Siltstone	
2	27	20	14	5	N15W	60N	Basalt	
3	22	14	7	6	N40W	10SE	Dolomite	
4	23	21	13	3	N85W	10W	Limestone	
5	16	9	8	6	N5W	90	Limestove	LAV
6	13	9	9	6	N5E	90	Limestone	LAV
7	14	11	4	1	N70W	90	Limestone	LAV
8	19	16	12	7	N65E	30E	Limestone	W
9	20	14	13	5	N75E	90	Siltstone	W
10	12	10	9	3	E	90	Dolomite	
11	45	35	25	5	N10E	45N	Limestone	
12	19	17	6	1	N10E	90	Shale	LAV
13	16	12	5	2	N65W	90	Shale	LAV
14	20	12	9	6	N50E	35SW	Dolomite	
15	19	15	14	7	N50E	25NE	Siltstone	
16	16	12	7	6	N10W	40N	Gabbro	
17	12	10	5	2	N65E	60N	Chert	
18	31	27	22	7	N60E	0	Dolomite	
19	30	20	16	5	N20E	50N	Chert	
20	57	31	4	1	N15W	25N	Limestone	
21	30	20	18	5	N15W	45N	Limestone	
22	23	18	6	2	N20W	90	Siltstone	
23	26	18	4	1	N70E	40N	Limestone	
24	33	18	10	1	N	15N	Shale	
25	28	11	3	1	N30E	45NW	Shale	
26	17	[illegible]	10	5	E	0	Siltstone	
27	15	8	5	5	N85E	90	Dolomite	LAV
28	14	9	6	7	N55E	30SW	Dolomite	
29	11	10	5	8	N70E	40NE	Dolomite	
30	18	15	10	7	N80E	0	Chert	
31	18	7	4	6	N50W	10NW	Shale	
32	13	11	9	7	N85E	90	Basalt	LAV
33	37	23	16	6	N60E	30E	Limestone	
34	22	14	4	1	N35E	90	Shale	
35	21	15	13	3	N5E	35N	Dolomite	
36	18	10	4	1	N10W	90	Limestone	LAV
37	24	18	10	7	N40W	45NW	Dolomite	
38	14	13	3	2	N85W	10E	Basalt	
39	25	19	9	1	N70E	90	Dolomite	LAV
40	40	15	4	1	N85W	0	Shale	
41	49	19	3	1	N20E	10N	Shale	
42	20	16	9	5	N10E	20N	Granite Gneiss	W
43	28	23	13	5	N85W	90	Dolomite	LAV
44	15	10	10	5	N5E	20N	Dolomite	
45	24	15	10	4	N25E	10NE	Dolomite	
46	20	13	11	5	N75E	20W	Dolomite	
47	25	20	14	7	N	90	Limonite	LAV
48	12	11	8	5	N80W	90	Dolomite	
49	14	13	5	1	N25E	0	Dolomite	
50	17	15	7	1	N20E	15N	Dolomite	

Till Matrix Composition Data: Color Peach Munsell Soil Color No. 10YR 5/4

Grain-Size Distribution		
Sand	Silt	Clay
20	46	34

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
17	67	16

Carbonates Cts./Sec	
Calcite	Dolomite
6	32

Figure 26 Data for analysis site B13

Analysis Site Number B14 **Morphostratigraphic Unit** Bloomington

Location NE NE NE Sec.5, T.23N., R.1E. **Quadrangle** McLean

Elevation 800' **Depth of Analysis** 6' **Type of Exposure** Roadcut (old)

Topography B and C slopes on distal side of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	15	12	8	6	N25E	25SW	Limestone	
2	17	10	7	4	N5E	25E	Limestone	
3	25	19	14	7	N75W	15SE	Dolomite	
4	17	10	4	6	N60E	15SW	Shale	
5	50	34	24	3	N30W	25SE	Dolomite	
6	58	39	19	6	N20W	25NW	Limestone	
7	29	23	16	5	N50W	10NW	Dolomite	
8	30	17	3	4	N40W	45NW	Shale	
9	11	7	7	6	N35E	20E	Basalt	
10	18	14	8	6	N20E	40S	Limestone	
11	12	7	4	6	N65E	90	Siltstone	W-LAV
12	23	13	10	6	N70E	90	Dolomite	LAV
13	11	7	3	6	N10W	0	Basalt	
14	9	7	4	6	N60E	90	Dolomite	
15	10	9	4	7	N89W	90	Quartzite	LAV
16	11	10	9	8	N75E	80W	Quartzite	
17	12	10	5	7	N75E	80W	Dolomite	
18	25	18	8	7	N80W	90	Shale	LAV
19	13	12	7	5	N20W	90	Limestone	LAV
20	11	8	3	1	N80W	90	Basalt	
21	14	7	5	7	N80E	0	Chert	
22	13	10	3	1	N80W	90	Dolomite	LAV
23	38	30	26	3	N25W	0	Dolomite	
24	15	14	9	5	N65W	10NW	Quartzite	
25	28	12	6	4	N35E	45SW	Shale	
26	18	13	10	5	N55E	0	Dolomite	
27	14	10	7	6	N70E	30	Dolomite	
28	12	8	7	5	N10W	40S	Limestone	
29	15	12	8	5	N15W	25N	Quartzite	
30	11	10	6	7	N35W	90	Dolomite	LAV
31	14	12	3	2	N55E	90	Shale	
32	11	9	8	5	N40E	90	Dolomite	LAV
33	11	8	7	5	N60E	90	Dolomite	LAV
34	12	11	10	5	N70E	90	Chert	LAV
35	11	9	5	2	N20E	90	Shale	
36	13	9	5	2	N20W	90	Dolomite	LAV
37	10	8	3	2	N20E	20S	Dolomite	
38	13	9	7	7	N80W	0	Dolomite	
39	23	21	7	1	N30W	15SE	Dolomite	
40	11	10	5	7	N60W	10SE	Dolomite	
41	12	8	8	3	N15W	90	Dolomite	LAV
42	9	8	5	5	N70E	10SW	Diorite	
43	16	13	7	5	N10W	15S	Limestone	
44	15	13	4	1	N80E	80S	Dolomite	
45	35	20	12	2	N20W	35S	Limonite	
46	11	7	3	1	N30E	90	Chert	LAV
47	17	10	5	1	N25E	90	Shale	LAV
48	18	14	9	3	N50W	30NW	Dolomite	
49	20	14	9	7	N50W	0	Dolomite	
50	25	18	10	7	N40W	20NW	Dolomite	

Till Matrix Composition Data: Color Salmon **Munsell Soil Color No.** 7.5YR 5/4

Grain-Size Distribution		
Sand	Silt	Clay
27	38	35

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
16	67	17

Carbonates Cts./Sec	
Calcite	Dolomite
18	27

Figure 27 Data for analysis site B14

Analysis Site Number B15 **Morphostratigraphic Unit** Bloomington

Location SE NW NE Sec.19, T.24N., R.1W. **Quadrangle** Mackinaw

Elevation 790' **Depth of Analysis** 7' **Type of Exposure** Roadcut (old)

Topography C and D slopes on distal side of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	43	24	19	6	N	25N	Dolomite	S
2	24	14	4	1	N25W	40NW	Shale	
3	22	13	3	1	N10W	5S	Shale	
4	10	6	5	6	N85E	5W	Dolomite	
5	6	4	2	2	N25W	40NW	Shale	
6	33	17	8	2	N5W	30N	Chert	
7	14	9	7	5	N65E	20SW	Limestone	
8	13	10	3	2	N10W	25N	Shale	
9	13	10	7	5	N50E	20NE	Dolomite	
10	15	13	6	1	N60W	15NW	Dolomite	
11	59	50	33	3	N20E	60N	Limestone	
12	9	6	5	3	N5W	70N	Chert	
13	11	9	9	5	N50E	35NE	Dolomite	
14	24	15	7	2	N20W	20NW	Basalt	S
15	21	17	14	7	N5E	90	Dolomite	
16	18	15	8	5	N20W	50NW	Shale	
17	24	19	15	7	N15W	15N	Limestone	
18	13	10	8	6	N15E	5N	Dolomite	
19	11	8	7	5	N10E	20N	Dolomite	
20	15	10	8	7	N35W	15NW	Limestone	
21	10	5	3	4	N5W	45N	Dolomite	
22	12	7	6	6	N15W	30N	Dolomite	
23	19	9	7	4	N5E	50N	Dolomite	
24	13	12	6	2	N	0	Dolomite	W
25	21	15	12	6	N15E	25N	Dolomite	
26	[illegible]	10	5	[illegible]	[illegible]	90	Quartzite	[illegible]
27	27	17	16	7	N20E	10NE	Dolomite	
28	14	6	4	4	N15E	15N	Dolomite	
29	24	18	11	3	N20W	50W	Dolomite	
30	62	30	17	6	N20W	25NW	Dolomite	
31	30	18	16	6	N30W	15NW	Dolomite	
32	37	25	15	6	N75W	30W	Limonite	
33	50	35	25	5	N45W	0	Dolomite	
34	25	18	7	1	N40W	15NW	Siltstone	
35	22	16	14	7	N60E	15NE	Dolomite	
36	19	18	10	5	N	90	Quartzite	LAV
37	23	17	3	1	N	90	Shale	LAV
38	20	14	7	5	N40W	10SE	Shale	
39	20	11	4	1	N5E	15N	Shale	
40	15	9	7	7	N20E	40N	Limestone	
41	17	15	10	5	N5E	50N	Siltstone	
42	20	16	10	5	N50E	0	Sandstone	W
43	16	14	13	7	N5W	0	Dolomite	
44	28	20	17	9	N70E	10E	Quartzite	
45	32	19	15	6	N40E	45NE	Limonite	
46	34	23	5	1	N10W	10S	Shale	
47	10	8	6	5	N70E	10E	Siltstone	
48	11	6	5	6	N15W	20N	Shale	
49	11	8	8	5	N30W	10SE	Dolomite	
50	24	16	13	5	N65W	0	Limestone	

Till Matrix Composition Data: Color Salmon Munsell Soil Color No. 7.5YR 5/4

Grain-Size Distribution		
Sand	Silt	Clay
26	37	37

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
20	66	14

Carbonates Cts./Sec	
Calcite	Dolomite
15	28

Figure 28 Data for analysis site B15

Analysis Site Number C1 **Morphostratigraphic Unit** Champaign

Location NW NE SW Sec.9, T.20N., R.7E. **Quadrangle** Mahomet

Elevation 780' **Depth of Analysis** 9' **Type of Exposure** Roadcut (new)

Topography B and C slopes on distal side of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	20	13	6	8	N50E	15NW	Limestone	
2	21	15	14	5	N30W	0	Basalt	
3	29	22	16	3	N15E	20NE	Dolomite	S
4	16	11	9	5	N55W	25SE	Limestone	
5	20	12	10	6	N50E	10SW	Dolomite	S
6	28	20	5	1	N55E	15SW	Shale	
7	17	13	3	1	N55W	20S	Chert	
8	14	11	8	8	N65W	30SW	Dolomite	
9	18	13	8	5	N30E	55S	Gabbro	W
10	28	16	15	6	N25W	15NW	Limestone	
11	17	12	7	7	N60W	20E	Dolomite	
12	20	14	11	6	N85E	25SW	Dolomite	
13	13	10	8	3	N45E	30N	Dolomite	
14	34	22	16	5	N5E	60S	Dolomite	
15	15	10	9	6	N35E	0	Dolomite	
16	15	13	8	3	N60W	10N	Chert	
17	24	20	12	5	N25E	40S	Chert	
18	18	14	10	8	N35E	30SW	Dolomite	
19	21	14	13	5	N45W	30SE	Dolomite	
20	25	18	11	3	N60W	0	Diorite	W
21	36	32	7	1	N	35SW	Basalt	W
22	15	12	7	5	N20W	20SW	Dolomite	
23	34	25	14	7	N30W	10NE	Dolomite	
24	17	12	10	5	N15E	35S	Chert	W
25	22	17	9	5	N75E	30SE	Dolomite	
26	16	12	10	5	N20E	30S	Quartzite	
27	24	20	9	2	N45W	75SW	Chert	
28	27	26	15	5	N20W	20S	Dolomite	
29	22	20	12	8	N40W	15NE	Dolomite	
30	14	11	7	4	N30W	0	Dolomite	
31	15	9	8	6	N25W	20NW	Chert	
32	17	14	7	8	N75E	0	Quartzite	
33	19	14	13	5	N65E	30SW	Chert	
34	12	8	6	6	N45E	0	Dolomite	
35	14	13	7	5	N25E	30SW	Dolomite	
36	9	7	5	6	N40E	35SW	Quartzite	
37	26	19	14	5	N75E	35SW	Dolomite	
38	13	10	4	1	N85E	0	Granite	
39	21	16	14	5	N25E	20SW	Dolomite	
40	14	10	5	5	N45W	30SE	Chert	
41	42	18	17	4	N5W	20S	Dolomite	
42	13	10	2	2	N	0	Chert	
43	18	13	9	6	N5W	0	Chert	
44	21	12	8	6	N35E	25SW	Basalt	
45	14	10	8	6	E	0	Dolomite	
46	14	9	6	7	E	0	Chert	
47	13	9	6	5	N75W	10E	Dolomite	
48	27	26	5	2	N65E	40SE	Shale	
49	26	21	4	2	N65E	40SE	Shale	
50	22	13	10	6	N60E	30NE	Chert	

Till Matrix Composition Data: Color Green gray Munsell Soil Color No. 2.5Y 4/2

Grain-Size Distribution		
Sand	Silt	Clay
26	38	36

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
3	79	18

Carbonates Cts./Sec	
Calcite	Dolomite
11	23

Figure 29 Data for analysis site C1

Analysis Site Number C2 **Morphostratigraphic Unit** Champaign

Location NE NW NW Sec. 26, T.21N., R.6E. **Quadrangle** Gibson City

Elevation 790' **Depth of Analysis** 15' **Type of Exposure** Railroadcut (old)

Topography B and C slopes near top center of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	23	17	7	2	N80E	0	Dolomite	
2	20	12	12	6	N85E	10E	Dolomite	
3	22	13	8	4	N65W	10N	Limestone	
4	13	9	7	6	N60W	10S	Dolomite	
5	17	15	10	5	N20E	0	Dolomite	
6	16	8	7	4	N70E	30SW	Dolomite	
7	16	15	7	5	N80E	25NE	Basalt	
8	14	10	5	5	N	35N	Limestone	
9	15	9	7	4	N75W	30N	Chert	
10	29	20	13	6	N50E	40NW	Dolomite	S
11	37	26	23	5	N40W	10NE	Dolomite	
12	28	23	10	7	N40E	50NW	Basalt	
13	25	23	13	8	N55W	10NE	Dolomite	
14	20	12	10	6	E	0	Quartzite	
15	27	18	4	1	N5E	35S	Shale	S
16	26	15	5	1	N75E	20NE	Shale	
17	14	11	3	1	N10E	40SW	Shale	
18	16	12	11	5	N85E	30W	Diorite	
19	28	22	9	5	N70E	15NE	Limestone	
20	10	7	4	8	N25W	0	Quartzite	
21	22	18	9	5	N20E	25N	Limonite	S
22	19	16	7	5	N85E	15N	Shale	
23	17	12	8	6	N60E	25NE	Granite	
24	19	16	11	5	N75W	0	Dolomite	
25	19	15	14	7	N45W	20NW	Gabbro	
26	37	24	12	6	N30W	55SW	Dolomite	
27	22	17	5	7	N60W	20W	Chert	
28	35	23	22	5	N60E	50NW	Dolomite	
29	28	19	5	1	E	15N	Shale	
30	25	13	8	6	N65E	20NE	Chert	
31	21	11	9	6	E	20SW	Dolomite	
32	17	14	9	3	N80W	45N	Chert	
33	17	12	11	5	N65E	45NW	Dolomite	
34	35	20	17	6	N85W	10E	Gabbro	
35	21	20	12	5	N75E	30NE	Dolomite	
36	30	20	10	6	N25W	30SE	Siltstone	
37	30	27	27	8	N20E	0	Basalt	
38	29	21	15	8	N75E	10SW	Dolomite	
39	80	65	43	3	N	35S	Dolomite	
40	36	31	13	1	N5W	20S	Dolomite	S
41	16	10	6	4	N85E	15E	Limestone	
42	16	11	10	6	N50W	35SE	Greenstone	
43	13	9	7	5	N50E	30SW	Dolomite	
44	26	17	15	5	E	0	Dolomite	
45	16	15	10	7	N85W	20W	Dolomite	
46	41	26	25	6	N40W	0	Granite	
47	36	23	22	6	N45E	40S	Basalt	
48	12	11	5	7	N65E	10NE	Chert	
49	20	10	10	6	N60E	0	Dolomite	
50	11	8	5	8	N55E	0	Dolomite	

Till Matrix Composition Data: Color Gray Munsell Soil Color No. 2.5Y 5/2

Grain-Size Distribution		
Sand	Silt	Clay
18	39	43

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
2	83	15

Carbonates Cts./Sec	
Calcite	Dolomite
8	15

Figure 30 Data for analysis site C2

Analysis Site Number C3 **Morphostratigraphic Unit** Champaign

Location NW NE NW Sec.9, T.22N., R.6E. **Quadrangle** Arrowsmith

Elevation 820' **Depth of Analysis** 5' **Type of Exposure** Roadcut (old)

Topography B and C slopes near top center of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	37	27	3	2	N	30E	Shale	
2	15	9	7	6	N75E	30E	Dolomite	
3	24	10	8	4	N75E	10E	Shale	
4	10	7	5	5	N5E	0	Dolomite	
5	8	7	5	6	N20W	0	Dolomite	
6	20	12	9	4	N30W	0	Basalt	
7	27	17	3	1	N85E	40S	Shale	
8	17	10	7	6	N5E	25SE	Siltstone	W
9	17	11	9	6	N70W	25SE	Dolomite	
10	13	7	3	2	N30E	20NW	Shale	
11	13	10	7	5	N65E	25SW	Dolomite	
12	24	15	8	6	N45W	30SW	Basalt	
13	14	11	10	3	N30E	0	Gabbro	
14	62	46	25	5	N55E	10N	Dolomite	
15	12	6	6	6	N45E	0	Limestone	
16	14	9	7	4	N40W	0	Dolomite	
17	17	12	8	6	N65E	35NE	Dolomite	
18	35	25	20	5	N85W	55E	Limestone	
19	20	10	5	6	N50E	10NE	Limestone	
20	26	20	10	7	N10W	15S	Limestone	
21	35	23	22	6	N	30S	Granite	
22	14	8	4	1	N65W	0	Shale	
23	14	11	10	8	N	0	Dolomite	
24	16	8	7	4	N5W	10S	Limestone	
25	11	6	6	7	N45E	25NW	Dolomite	
26	26	13	12	4	N80W	20W	Quartzite	
27	9	5	4	6	N80W	0	Dolomite	
28	18	14	6	2	N70W	15SW	Chert	
29	13	9	6	6	N85E	15NE	Basalt	
30	31	19	8	1	N55W	25NE	Dolomite	
31	10	8	4	8	N35W	0	Quartzite	
32	10	9	4	8	N20W	0	Dolomite	
33	22	16	14	6	N45W	0	Chert	
34	15	12	6	7	E	10W	Dolomite	
35	15	10	2	1	N80W	15S	Shale	
36	17	11	3	1	N5W	35SE	Shale	
37	16	15	6	7	N70W	50S	Siltstone	
38	12	8	5	6	N60E	0	Quartzite	
39	11	10	3	2	N80W	50N	Shale	
40	10	4	2	4	N40E	0	Limestone	
41	15	9	6	6	N20W	20NW	Limestone	
42	23	17	4	2	N15W	30W	Siltstone	
43	20	11	8	6	N45W	35SE	Dolomite	
44	18	14	2	2	N35E	30E	Shale	
45	17	12	8	7	N55W	30SE	Dolomite	
46	14	7	6	6	N	0	Chert	
47	11	7	4	6	E	25NW	Limestone	
48	22	10	7	6	N10W	0	Basalt	S
49	49	38	11	7	N75W	0	Chert	
50	61	36	24	4	N50W	40NE	Dolomite	W

Till Matrix Composition Data: Color Olive **Munsell Soil Color No.** 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
11	33	56

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
2	84	14

Carbonates Cts./Sec	
Calcite	Dolomite
-	17

Figure 31 Data for analysis site C3

Analysis Site Number C4 **Morphostratigraphic Unit** Champaign

Location SW SW NW Sec.32, T.22N., R.6E. **Quadrangle** Arrowsmith

Elevation 760' **Depth of Analysis** 15' **Type of Exposure** Railroadcut (old)

Topography B and C slopes on distal edge of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	25	15	14	9	N5E	55S	Dolomite	
2	11	8	6	6	N55W	10NW	Dolomite	
3	19	18	11	3	N75W	55S	Limestone	
4	12	8	6	9	N65W	30NW	Greenstone	W
5	14	8	8	7	N50E	30W	Flint	
6	15	10	4	1	N75E	20W	Dolomite	
7	19	15	5	2	N50E	0	Shale	
8	36	26	19	6	N40E	20NE	Limestone	
9	14	12	2	2	N55E	30S	Shale	
10	14	10	6	6	N20E	10N	Basalt	
11	19	12	10	6	N10E	30N	Granite	
12	17	14	8	8	N60W	0	Dolomite	
13	26	19	4	1	N55W	65NE	Shale	
14	11	8	6	6	N50E	15W	Limestone	
15	13	11	6	5	N5W	0	Dolomite	
16	16	15	10	5	N80E	20E	Dolomite	
17	18	12	4	1	N45E	90	Siltstone	
18	15	12	6	3	N30E	0	Chert	
19	37	18	12	6	N25E	10SW	Dolomite	S
20	14	9	8	5	N25E	10SE	Dolomite	
21	14	11	6	5	N65E	0	Dolomite	
22	17	12	8	8	N65W	10W	Dolomite	
23	13	7	4	6	N	70N	Limestone	
24	14	11	6	7	N10W	15S	Limestone	
25	15	12	6	7	N40E	15NE	Dolomite	
26	13	7	3	1	N65E	30E	Shale	
27	18	9	3	1	N60W	90	Shale	LAV
28	16	12	6	8	N30W	90	Limestone	LAV
29	18	14	11	5	N40W	90	Dolomite	LAV
30	44	35	18	5	N40E	50S	Chert	
31	19	15	13	3	N50W	90	Granite	LAV
32	37	23	21	7	N80E	20SW	Dolomite	
33	23	16	15	5	N45E	30E	Chert	
34	20	12	9	4	N75W	30E	Limestone	S
35	24	21	13	5	N30E	0	Quartzite	
36	31	20	18	5	N55W	0	Diorite	W
37	16	10	10	7	N50W	10NW	Dolomite	
38	15	11	7	5	N15E	30S	Limestone	
39	11	7	5	6	N65W	30S	Quartzite	
40	15	8	6	4	N50E	20NE	Chert	
41	14	10	7	5	N85E	10W	Limestone	
42	20	16	8	5	N25E	60E	Dolomite	S
43	22	13	8	6	N	0	Dolomite	
44	11	8	5	5	N20W	0	Dolomite	
45	13	12	6	7	N55E	55S	Basalt	S
46	12	10	8	7	N60E	10NE	Dolomite	
47	10	6	6	6	N65E	0	Limestone	
48	19	10	9	4	N25E	30SW	Dolomite	S
49	15	10	10	5	N55W	40S	Chert	
50	16	9	8	5	N80W	20E	Dolomite	

Till Matrix Composition Data: Color Gray Munsell Soil Color No. 2.5Y 5/2

Grain-Size Distribution		
Sand	Silt	Clay
18	40	42

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
2	79	19

Carbonates Cts./Sec	
Calcite	Dolomite
9	20

Figure 32 Data for analysis site C4

Analysis Site Number C6 **Morphostratigraphic Unit** Champaign

Location SE NE NW Sec.33, T.23N., R.6E. **Quadrangle** Arrowsmith

Elevation 800' **Depth of Analysis** 4' **Type of Exposure** Roadcut (old)

Topography B and C slopes on distal edge of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	24	22	13	5	N85E	5W	Dolomite	
2	19	17	10	5	N75E	30NW	Dolomite	
3	17	10	9	4	N65W	15NW	Dolomite	
4	10	8	3	2	N60W	0	Chert	
5	22	21	11	3	N70W	10SE	Chert	
6	17	13	8	3	N85E	15N	Flint	
7	26	14	10	6	N40W	15SE	Dolomite	
8	13	8	4	6	N60W	10NW	Limestone	
9	12	10	8	5	N	0	Dolomite	
10	19	14	12	3	N45W	10SE	Limonite	
11	17	14	11	5	N65E	10SW	Dolomite	
12	17	15	9	7	N75W	20NW	Dolomite	
13	15	13	7	5	N40W	10SE	Basalt	
14	32	20	17	6	N30W	30NW	Siltstone	
15	14	10	9	5	N55W	20NW	Limestone	
16	18	10	9	6	N60W	10SE	Basalt	
17	17	8	5	6	N85W	10NW	Shale	
18	22	12	9	6	N45W	10SE	Limestone	
19	13	12	7	1	N45W	20SE	Chert	
20	18	13	11	6	N75E	10W	Gabbro	
21	17	11	10	6	N85W	45W	Limestone	
22	22	10	7	6	N80W	40N	Shale	
23	22	14	11	6	N75W	5W	Dolomite	
24	27	20	8	1	N65W	10NW	Shale	
25	13	11	9	5	N65W	15SE	Basalt	
26	30	22	15	7	N30E	30NE	Shale	
27	15	10	6	6	N75E	0	Dolomite	
28	15	10	5	6	E	20W	Siltstone	
29	20	16	6	5	N	20W	Siltstone	
30	17	16	4	1	N40E	15NE	Shale	
31	12	10	6	6	N70W	20NW	Chert	
32	20	12	7	6	N85W	45S	Siltstone	
33	17	11	9	6	N55W	15SE	Dolomite	
34	14	9	5	6	N75W	10W	Siltstone	
35	11	9	9	7	N80E	10W	Dolomite	
36	14	9	8	7	N30E	10SW	Chert	
37	14	10	8	6	N25E	0	Dolomite	W
38	36	32	15	2	N50W	30SE	Dolomite	
39	15	12	10	5	N70W	0	Dolomite	
40	10	7	4	6	N75W	35W	Dolomite	
41	25	13	10	6	N30E	25SW	Granite	W
42	16	12	7	5	N65W	10W	Dolomite	
43	41	18	10	5	N75W	30W	Limestone	
44	16	12	10	6	N75W	0	Quartzite	
45	16	12	2	1	N15E	10N	Shale	
46	10	7	6	6	N80W	0	Dolomite	
47	20	18	12	5	N60W	20NW	Dolomite	
48	36	28	18	6	N70W	10W	Quartzite	
49	13	11	6	7	N70E	15W	Chert	
50	13	11	5	2	N5E	15S	Dolomite	

Till Matrix Composition Data: Color Gray tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
26	35	39

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
2	85	13

Carbonates Cts./Sec	
Calcite	Dolomite
10	17

Figure 33 Data for analysis site C6

Analysis Site Number E1 **Morphostratigraphic Unit** Eureka

Location NW NW NW Sec. 15, T.23N., R.5E. **Quadrangle** Arrowsmith

Elevation 910' **Depth of Analysis** 6' **Type of Exposure** Roadcut (old)

Topography B and C slopes near top center of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	60	27	26	6	N	10S	Dolomite	
2	29	18	17	9	N10E	40S	Basalt	
3	52	32	25	5	N30E	20SW	Siltstone	W
4	23	20	14	7	N25W	20SE	Dolomite	
5	25	18	10	1	N25W	20SE	Siltstone	
6	35	24	15	9	N15W	10N	Limestone	W
7	24	13	13	6	N40E	20SW	Basalt	
8	26	18	10	1	N35W	20SE	Siltstone	
9	16	14	8	5	N55E	20SW	Limestone	
10	15	11	5	7	N45E	25SW	Chert	
11	40	24	16	6	N60E	20W	Dolomite	
12	15	11	7	5	N35E	20SW	Limestone	
13	32	23	15	6	N45E	15SW	Dolomite	W
14	44	29	19	7	N40E	15SW	Dolomite	
15	54	28	22	6	N10W	35S	Dolomite	S
16	54	32	29	6	N	40S	Dolomite	
17	20	16	5	1	N75E	0	Dolomite	
18	19	13	11	5	N45W	30NW	Dolomite	
19	24	18	10	1	N15W	20W	Syenite	
20	62	35	30	4	N45E	55SW	Dolomite	
21	27	18	15	6	N45E	0	Dolomite	
22	27	19	7	1	N60E	40N	Shale	
23	23	20	8	1	N15W	25S	Shale	
24	19	16	10	8	N20W	35S	Dolomite	
25	30	20	17	3	N5W	30S	Dolomite	
26	27	23	12	2	N25W	0	Dolomite	
27	32	17	10	1	N	10N	Dolomite	
28	14	10	5	5	N50W	20NW	Dolomite	
29	22	15	12	5	N20W	0	Dolomite	W
30	27	19	16	3	N30W	15N	Limestone	
31	45	28	25	9	N55E	40SW	Dolomite	
32	38	35	20	7	N30W	35SW	Dolomite	
33	44	25	21	6	N5W	20S	Dolomite	
34	20	14	9	6	N	10S	Siltstone	
35	28	25	18	5	N65E	0	Dolomite	W
36	19	17	11	5	N65E	90	Dolomite	LAV
37	17	12	4	2	N60W	70S	Dolomite	
38	18	15	12	5	N10W	20S	Dolomite	
39	15	17	11	8	N15W	10S	Dolomite	
40	19	13	12	7	N10W	20N	Siltstone	
41	15	11	5	2	N70E	60N	Siltstone	
42	26	17	5	1	N45E	40NW	Shale	
43	20	13	12	3	N10W	40N	Flint	
44	38	25	21	3	N15W	15N	Limestone	
45	50	37	26	3	N10W	25S	Dolomite	
46	28	19	12	6	N5W	30S	Dolomite	
47	17	15	5	2	N5W	50S	Shale	
48	38	31	17	7	N10E	50S	Dolomite	
49	35	21	14	6	N15E	45S	Dolomite	
50	23	15	10	6	N20W	90	Basalt	LAV

Till Matrix Composition Data: Color Tan **Munsell Soil Color No.** 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
37	45	18

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
5	79	16

Carbonates Cts./Sec.	
Calcite	Dolomite
-	15

Figure 34 Data for analysis site E1

Analysis Site Number E3 **Morphostratigraphic Unit** Eureka

Location NE NW NW Sec.28, T.25N., R.1E. **Quadrangle** Danvers

Elevation 830' **Depth of Analysis** 5' **Type of Exposure** Roadcut (new)

Topography B and C slopes near top center of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	15	11	5	1	N	5N	Dolomite	
2	9	8	5	5	N55W	25SE	Dolomite	
3	28	25	8	1	N20E	15N	Limestone	
4	11	9	3	1	N75W	50S	Dolomite	W
5	16	11	9	6	N20E	15SW	Dolomite	
6	19	17	13	5	N5E	15S	Dolomite	
7	9	5	5	4	N30W	15NW	Dolomite	
8	18	10	7	4	N35E	10E	Limestone	
9	24	7	6	4	N5E	5N	Shale	
10	19	18	6	1	N10W	25S	Dolomite	
11	11	7	4	7	N	0	Chert	
12	16	14	7	5	N45W	20S	Limestone	
13	20	16	15	3	N50W	15NW	Chert	
14	18	14	9	3	N80W	10W	Granite	
15	13	7	5	6	N15E	15SW	Shale	
16	17	15	7	5	N	25S	Biotite Gneiss	W
17	20	17	7	2	E	25S	Siltstone	
18	17	12	10	3	N25W	25E	Dolomite	
19	15	11	10	7	N55W	90	Dolomite	LAV
20	23	20	4	2	N45E	0	Shale	
21	21	13	12	6	N45E	20S	Dolomite	W
22	16	10	10	6	N10E	0	Limestone	
23	14	9	4	1	N25E	20SW	Chert	
24	10	8	7	6	N35E	20NW	Quartzite	
25	28	18	15	7	N35W	25SE	Dolomite	
26	22	12	10	4	N5E	5N	Granite	
27	10	8	5	6	N60W	0	Limestone	
28	17	[illegible]	12	3	N50W	0	Dolomite	W
29	47	36	26	5	N75E	25W	Dolomite	W
30	16	12	8	3	N10E	5N	Dolomite	
31	17	12	8	7	N10E	20S	Limestone	
32	12	8	7	6	N40W	10SE	Siltstone	
33	23	12	8	6	N20E	10NE	Dolomite	W
34	21	16	13	5	N40W	0	Limestone	W
35	37	23	16	4	E	45S	Dolomite	
36	13	10	9	7	N15E	20NW	Dolomite	
37	15	10	8	5	N25E	0	Limestone	
38	12	9	8	5	N40E	10SW	Dolomite	
39	9	4	4	6	N35E	25NE	Quartzite	
40	22	15	12	5	N80W	0	Dolomite	
41	15	12	5	1	N10W	5N	Dolomite	
42	20	18	13	8	N10W	5S	Dolomite	W
43	13	7	6	4	E	15W	Dolomite	
44	19	7	6	6	N85W	0	Shale	
45	32	22	18	6	N50W	25NW	Dolomite	
46	15	11	4	1	N30E	20NE	Dolomite	
47	17	14	6	1	N80E	20E	Shale	
48	22	16	12	5	N35W	15SE	Limestone	
49	16	11	6	5	N85W	25SE	Dolomite	
50	19	12	9	6	N80E	25E	Dolomite	

Till Matrix Composition Data: Color Tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
20	40	40

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
4	78	18

Carbonates Cts./Sec	
Calcite	Dolomite
7	17

Figure 35 Data for analysis site E3

Analysis Site Number E4 **Morphostratigraphic Unit** Eureka

Location SE SW SW Sec. 34, T.25N., R.1E. **Quadrangle** Danvers

Elevation 840' **Depth of Analysis** 6' **Type of Exposure** Roadcut (old)

Topography B and C slopes on distal edge of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	46	37	20	5	N35E	90	Greenstone	
2	26	15	15	3	N70E	0	Flint	
3	15	13	8	7	N40W	35E	Dolomite	
4	61	44	32	7	N50W	90	Dolomite	LAV
5	10	5	3	4	N60E	10NE	Dolomite (?)	
6	12	11	5	7	N65W	35NE	Chert	
7	12	8	7	5	N40W	30NW	Flint	
8	11	7	6	6	N50E	0	Chert	
9	17	13	7	7	N75E	35NW	Limestone	
10	12	8	7	2	N85E	0	Dolomite	
11	12	8	6	6	N85W	40E	Siltstone	
12	18	12	9	4	N40E	60NE	Dolomite	
13	13	12	7	8	N65E	10SW	Dolomite	
14	15	13	9	5	N70E	10NE	Chert	
15	22	14	12	6	N55E	45NE	Basalt	
16	18	14	4	1	N65E	90	Shale	
17	14	9	9	5	N55E	0	Dolomite	
18	8	6	3	3	N50W	0	Limestone	
19	18	14	8	7	N5E	25S	Chert	
20	9	8	3	1	N45E	0	Red Shale	
21	32	27	5	1	N55E	90	Shale	LAV
22	15	11	9	5	E	20E	Chert	
23	30	24	3	1	N65E	45NW	Shale	
24	21	12	10	6	N35E	0	Dolomite	
25	11	7	4	2	N10E	10S	Granite	
26	16	12	11	5	N15E	10S	Dolomite	
27	12	8	7	6	N10E	15SW	Dolomite	
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Limestone	
29	13	9	6	6	N30E	10NE	Dolomite	
30	11	8	5	6	N	0	Chert	
31	16	14	13	5	N20E	25E	Dolomite	
32	12	8	4	6	N45E	30NE	Limestone	
33	10	6	3	4	N85W	30E	Limestone	
34	16	12	10	7	N	55S	Dolomite	
35	36	35	19	7	N	30N	Dolomite	
36	15	11	10	5	N45E	0	Granite	
37	16	11	7	6	N10E	25S	Dolomite	
38	12	11	7	7	N75W	0	Chert	
39	11	7	6	5	N75E	15SW	Dolomite	
40	10	8	5	5	N	10S	Dolomite	
41	15	10	8	6	E	15E	Flint	
42	13	11	5	7	N30E	90	Chert	
43	16	11	8	6	N85E	35W	Dolomite	
44	44	35	10	1	N45E	30NE	Dolomite	
45	11	6	5	4	N55E	10NE	Dolomite	
46	8	7	6	5	N75E	35NE	Chert	
47	11	6	5	6	N40E	0	Dolomite	
48	20	15	8	3	N10E	40S	Dolomite	
49	11	7	6	6	N30E	40NE	Dolomite	
50	22	15	14	5	N70E	15NE	Geode	

Till Matrix Composition Data: Color Tan **Munsell Soil Color No.** 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
17	45	38

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
4	83	13

Carbonates Cts./Sec	
Calcite	Dolomite
12	[illegible]

Figure 36 Data for analysis site E4

Analysis Site Number E5 **Morphostratigraphic Unit** Eureka

Location SE NW NW Sec.10, T.23N., R.6E. **Quadrangle** Arrowsmith

Elevation 900' **Depth of Analysis** 5' **Type of Exposure** Pipeline Trench

Topography B, C, and D slopes near top center of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	15	13	8	3	N65E	0	Limestone	
2	11	8	6	6	N20E	30E	Dolomite	
3	13	11	4	2	N45W	25SE	Dolomite	
4	11	6	6	6	N20E	15W	Limestone	
5	14	11	2	1	N80W	10E	Shale	
6	19	13	11	5	N30E	15W	Dolomite	
7	18	12	7	7	N45E	35W	Limestone	
8	15	11	3	1	N85W	25W	Shale	
9	13	11	4	2	N40E	35SE	Dolomite	
10	11	9	5	5	N5W	10E	Dolomite	
11	18	11	5	2	N35W	10NE	Dolomite	
12	15	12	11	5	N75E	0	Limestone	
13	9	5	4	4	N40E	10W	Limestone	
14	11	8	5	5	N40E	90	Quartzite	
15	12	10	9	9	N80E	30E	Gabbro	
16	11	5	5	4	N70E	20SE	Quartzite	
17	23	17	7	2	N	20E	Limestone	
18	45	34	28	5	N5E	90	Dolomite	LAV-S
19	43	32	28	5	N80W	0	Dolomite	
20	27	15	12	6	N55E	90	Dolomite	LAV-W
21	58	29	23	6	N35E	90	Conglomerate	W
22	22	15	8	6	N35W	55SE	Dolomite	
23	22	14	9	6	E	55E	Dolomite	
24	12	5	5	4	N5E	20E	Limestone	
25	20	17	10	7	N40E	45SE	Siltstone	
26	15	6	4	6	N45E	15SW	Shale	
27	19	18	14	7	N30E	55SE	Dolomite	
28	14	13	7	7	N30E	10SE	Limestone	
29	11	7	6	4	N25E	0	Shale	
30	15	13	9	7	N80W	10W	Chert	
31	21	10	3	1	N35E	10NE	Shale	
32	12	8	4	1	N80E	0	Siltstone	
33	15	10	7	6	N5W	20E	Chert	
34	16	14	8	5	N25W	10SE	Dolomite	
35	15	10	4	2	N85W	5E	Shale	
36	19	11	2	1	N10W	75E	Shale	
37	24	13	10	6	N80W	35E	Dolomite	
38	14	11	8	5	N35E	0	Quartzite	
39	37	25	16	6	N45E	90	Limestone	LAV
40	15	13	10	5	N25W	10NW	Quartzite	
41	32	17	16	9	N70W	40E	Dolomite	
42	15	10	5	1	N85W	45E	Dolomite	
43	21	18	11	5	N60W	40SE	Siltstone	
44	21	10	7	4	N70W	20SE	Dolomite	
45	13	12	2	1	N20W	90	Shale	
46	15	9	6	2	N75W	20W	Shale	
47	14	11	7	5	N20E	90	Dolomite	
48	16	10	10	7	N80W	30NW	Shale	
49	18	15	10	7	N65W	45E	Chert	
50	24	18	12	7	N40E	50NE	Chert	

Till Matrix Composition Data: Color Tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
28	38	34

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
3	80	17

Carbonates Cts./Sec	
Calcite	Dolomite
8	19

Figure 37 Data for analysis site E5

Analysis Site Number E6 **Morphostratigraphic Unit** Eureka

Location NE SW SW Sec. 35, T.24N., R.6E. **Quadrangle** Gibson City

Elevation 880' **Depth of Analysis** 5' **Type of Exposure** Pipeline Trench

Topography B and C slopes near top center of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	14	8	7	6	N5E	0	Dolomite	
2	31	24	13	2	N15E	10E	Dolomite	
3	30	20	10	1	N25E	15NE	Chert	
4	19	9	6	6	N60E	15SW	Dolomite	
5	16	11	4	2	N65E	40SW	Shale	
6	13	14	2	1	N85W	5W	Shale	
7	15	12	7	6	N80W	90	Chert	LAV
8	14	10	7	6	N5W	0	Diorite	
9	37	27	21	5	N55W	30SW	Dolomite	
10	11	9	8	5	N60W	25SE	Siltstone	
11	21	18	15	5	N50W	40NW	Chert	
12	19	11	8	6	N80W	0	Chert	
13	12	9	7	5	N40W	35SE	Dolomite	
14	14	12	8	5	N65E	0	Limestone	
15	10	8	6	6	N75E	20SW	Limestone	
16	10	7	4	4	N25W	35SE	Dolomite	
17	16	11	10	6	N5W	5S	Dolomite	
18	13	10	6	7	N45W	30N	Siltstone	
19	19	13	5	1	N60E	40SW	Siltstone	
20	17	13	12	3	N45W	25SE	Dolomite	
21	16	10	8	4	N35E	0	Limestone	
22	22	8	6	4	N15E	0	Shale	
23	13	8	7	7	N35E	25NW	Dolomite	
24	32	25	18	5	N10E	90	Dolomite	LAV-W
25	13	9	5	2	N20E	45SW	Dolomite	
26	20	13	11	7	N15E	10S	Shale	
27	16	14	10	7	N90E	0	Limestone	
28	12	9	8	5	N55W	25NW	Dolomite	W
29	15	13	7	7	N15E	90	Flint	
30	16	14	8	2	N15E	45W	Shale	
31	36	33	22	5	N75E	40N	Gabbro	
32	16	11	8	6	N5E	10N	Dolomite	
33	16	13	12	3	N15E	25S	Siltstone	
34	16	11	9	7	N85E	10E	Dolomite	
35	24	16	5	1	N35E	50SW	Siltstone	
36	16	11	3	1	N80E	25W	Shale	
37	12	8	2	2	N15E	80S	Shale	
38	12	9	5	6	N60W	25NW	Limestone	
39	13	11	9	7	N50E	90	Dolomite	LAV
40	13	9	8	6	N5E	15S	Basalt	
41	32	23	9	1	N10W	0	Dolomite	
42	16	10	8	6	N20W	0	Basalt	
43	43	40	16	7	N	50S	Chert	
44	66	36	28	6	N20W	20NW	Gabbro	S
45	33	23	13	3	N55W	30NW	Limestone	
46	9	7	4	2	N50W	10SE	Dolomite	
47	12	10	7	5	N	10S	Dolomite	
48	28	20	14	6	N55W	55NW	Dolomite	
49	23	18	12	7	N5W	15S	Dolomite	
50	12	9	9	5	N15E	25N	Granite	

Till Matrix Composition Data: Color Tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
24	39	37

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
3	81	16

Carbonates Cts./Sec	
Calcite	Dolomite
-	15

Figure 38 Data for analysis site E6

Analysis Site Number E7 **Morphostratigraphic Unit** Eureka

Location SW SE SW Sec. 24, T.24N., R.6E. **Quadrangle** Sibley

Elevation 810' **Depth of Analysis** 6' **Type of Exposure** Pipeline Trench

Topography B, C, and D slopes on proximal side of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	21	12	8	6	N5E	5N	Basalt	
2	26	17	10	6	N15W	[illegible]	Siltstone	
3	13	8	6	4	N20E	0	Dolomite	
4	20	16	9	7	N10W	55[illegible]	Chert	
5	14	11	8	5	N35W	10SW	Basalt	
6	12	9	6	5	N80E	20W	Chert	
7	17	12	10	3	N35E	35SW	Dolomite	
8	17	12	10	6	N25E	0	Dolomite	
9	56	50	17	2	N5E	90	Siltstone	LAV
10	16	12	11	5	N30E	20NE	Dolomite	
11	23	15	12	3	N30E	55NE	Siltstone	
12	14	7	7	6	N25W	10SW	Dolomite	
13	17	14	12	5	N15W	20[illegible]	Dolomite	
14	21	13	5	1	N15E	15N	Dolomite	
15	28	18	13	9	N70E	15E	Limestone	
16	11	6	4	6	N5E	10N	Dolomite	
17	18	15	10	7	N	10N	Dolomite	
18	16	12	8	6	N30E	0	Limestone	
19	36	22	9	1	N5E	70N	Dolomite	
20	20	14	10	3	N45E	10NW	Dolomite	
21	13	10	5	1	N15E	45W	Dolomite	
22	10	6	3	6	N70W	20W	Dolomite	
23	19	16	9	5	N5W	90	Dolomite	LAV
24	17	10	6	6	N10E	0	Shale	
25	11	7	3	6	N20E	0	Limestone	
26	11	8	5	6	N45E	10NE	Limestone	
27	10	6	4	6	N20E	40[illegible]	Dolomite	W
28	20	13	12	5	N20W	15NW	Dolomite	W
29	50	40	9	1	N55W	15N	Shale	
30	17	13	10	5	N10W	10N	Limestone	
31	22	16	12	5	N40W	20NW	Limestone	
32	15	11	8	3	N20W	10E	Dolomite	
33	10	9	4	1	N80W	15W	Limestone	
34	16	11	10	5	N80W	20E	Dolomite	
35	24	17	7	1	N25E	10S	Dolomite	
36	18	12	10	6	N25W	25SE	Limestone	
37	14	10	5	2	N70W	10E	Chert	
38	12	11	8	7	N60E	90	Chert	
39	12	10	6	5	N50E	35SW	Limestone	
40	18	12	8	7	N45E	0	Chert	
41	22	15	7	2	N25E	5NE	Chert	
42	12	10	4	1	N10E	35N	Chert	
43	10	4	2	4	N70E	15[illegible]	Shale	
44	30	20	16	3	N25W	0	Basalt	S
45	16	7	6	4	N75W	25W	Dolomite	
46	21	17	11	3	N20W	0	Dolomite	
47	21	12	9	6	N	15N	Dolomite	
48	13	9	6	6	N15E	20N	Shale	
49	18	14	8	6	N10W	45N	Shale	
50	36	30	22	8	N25E	35N	Limestone	S

Till Matrix Composition Data: Color Tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
28	38	34

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
4	81	15

Carbonates Cts./Sec	
Calcite	Dolomite
7	9

Figure 39 Data for analysis site E7

Analysis Site Number E8 **Morphostratigraphic Unit** Eureka

Location NW NW NW Sec. 3, T.23N., R.3E. **Quadrangle** LeRoy

Elevation 840' **Depth of Analysis** 5' **Type of Exposure** Roadcut (old)

Topography B and C slopes on distal side of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	10	4	4	4	N10E	15N	Dolomite	
2	12	10	7	6	N15W	10[illegible]	Dolomite	
3	13	7	6	4	N40W	35NE	Basalt	
4	8	5	4	6	N85W	[illegible]	Dolomite	
5	11	8	4	5	N55W	10NW	Shale (spores)	
6	25	22	12	7	N70W	[illegible]	Dolomite	
7	10	7	5	6	N10W	[illegible]	Dolomite	
8	10	7	4	6	N40W	[illegible]	Limestone	
9	37	23	12	7	N30W	[illegible]	Chert	
10	25	24	12	7	E	10W	Dolomite	
11	13	8	5	6	N	5N	Chert	
12	27	17	14	5	N60W	40NE	Dolomite	W
13	10	8	4	4	N80E	30E	Chert	
14	17	10	8	7	N15W	25S	Chert	
15	15	10	7	5	N70W	15W	Chert	
16	10	7	5	6	N80E	20W	Dolomite	
17	17	14	11	7	N5W	0	Shale	
18	19	11	10	6	N45W	15NW	Granite	
19	31	27	12	2	N30W	90	Siltstone	LAV
20	20	11	7	1	N55W	30NW	Chert	
21	15	11	10	5	N15W	90	Dolomite	
22	18	17	11	7	N	25W	Dolomite	
23	16	7	3	4	N30E	20SW	Shale	
24	16	11	7	8	N30E	20SW	Dolomite	
25	25	14	3	1	N85E	10W	Shale	
26	27	16	11	3	E	20W	Limestone	
27	29	24	19	5	N50W	45NW	Dolomite	
28	31	20	7	1	N60W	25NW	Shale	W
29	18	12	4	1	N75E	90	Shale	
30	31	22	10	2	N65E	35NE	Siltstone	
31	21	19	10	2	N55W	35NW	Dolomite	
32	17	12	4	2	N20W	20SE	Shale	
33	9	5	3	6	N40E	10SW	Dolomite	
34	17	10	6	6	N25W	20SE	Limestone	
35	25	20	8	1	N50W	25W	Limestone	
36	17	11	10	6	N40W	35SE	Chert	
37	26	19	15	3	N80E	20W	Chert	
38	14	11	10	7	N15W	15N	Chert	
39	15	13	6	8	N30W	20SE	Limestone	
40	59	18	5	1	N85W	10W	Shale	
41	28	13	12	6	N80W	10W	Limestone	
42	19	12	5	2	N75W	10W	Shale	
43	13	10	6	7	N80W	90	Limestone	
44	19	17	15	5	N45E	55NW	Dolomite	
45	28	24	10	2	N50W	90	Shale	LAV
46	26	17	8	7	N75E	25E	Dolomite	
47	22	15	10	6	N50W	90	Quartzite	
48	67	49	32	5	N5W	45S	Dolomite	
49	25	22	10	2	N35W	90	Limestone	
50	25	15	12	3	N70W	30W	Siltstone	

Till Matrix Composition Data: Color Tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
28	43	29

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
3	81	16

Carbonates Cts./Sec	
Calcite	Dolomite
6	21

Figure 40 Data for analysis site E8

Analysis Site Number E9 **Morphostratigraphic Unit** Eureka

Location NE SW SW Sec. 10, T.24N., R.2E. **Quadrangle** Normal

Elevation 840' **Depth of Analysis** 5' **Type of Exposure** Roadcut (new)

Topography C and D slopes near top center of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	42	28	23	6	N85W	25W	Dolomite	S
2	46	38	21	5	E	40N	Dolomite	
3	20	14	10	7	N65W	25SE	Chert	
4	22	17	11	3	N35E	15NW	Dolomite	
5	42	32	31	3	N80E	30W	Dolomite	
6	25	20	3	1	N80E	30E	Shale	
7	11	10	7	2	N80E	0	Dolomite	
8	10	4	3	6	N	15E	Dolomite	
9	46	28	28	6	N70E	25W	Dolomite	
10	17	4	1	1	N75E	15W	Dolomite	
11	15	14	8	5	N45W	90	Dolomite	
12	19	12	10	6	N15W	20N	Dolomite	
13	18	12	11	5	N60W	20NE	Dolomite	
14	25	20	18	5	N25W	0	Dolomite	
15	28	25	20	8	E	90	Dolomite	
16	28	20	14	6	N85E	10W	Dolomite	
17	20	13	11	4	N45E	35NE	Dolomite	
18	11	5	4	6	N45E	0	Limestone	
19	15	14	12	5	N60W	10SE	Dolomite	
20	13	10	7	5	N55E	10NE	Chert	
21	24	22	12	7	N75W	50NW	Dolomite	
22	26	15	10	6	N40E	90	Dolomite	LAV
23	15	12	10	5	N70W	10NW	Dolomite	
24	53	37	24	6	N70E	10E	Limestone	
25	31	25	14	5	N45W	30NE	Dolomite	
26	17	16	9	5	N75E	10W	Dolomite	
27	28	21	10	5	[illegible]	[illegible]	Dolomite	
28	41	32	24	8	N60E	20NE	Dolomite	
29	29	17	11	4	N80E	15E	Chert	
30	46	39	19	6	N10W	45N	Dolomite	
31	17	13	11	6	N75W	90	Dolomite	
32	45	44	20	3	N40W	0	Limestone	
33	22	18	14	3	N15E	45NW	Dolomite	
34	10	8	4	8	E	25E	Quartzite	
35	13	10	7	3	N20W	10S	Dolomite	
36	20	15	10	7	N10W	20N	Dolomite	
37	16	10	9	6	N50E	25NE	Limestone	
38	21	14	10	6	E	10W	Chert	
39	25	21	18	7	N65W	25NW	Dolomite	
40	22	15	10	3	N5W	40N	Limestone	
41	12	5	4	6	N50W	0	Dolomite	
42	17	14	9	5	N15W	10N	Limestone	
43	16	11	3	1	N60E	15NE	Shale	
44	18	10	10	7	N70W	30SE	Chert	
45	12	7	5	6	N50W	35SE	Limestone	
46	30	19	15	5	N70E	40E	Dolomite	
47	11	6	3	4	N30E	30NE	Basalt	
48	16	14	14	8	N50E	35NE	Dolomite	W
49	18	11	8	6	N	40N	Dolomite	
50	15	10	9	6	N80W	10W	Sandstone	W

Till Matrix Composition Data: Color Tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
22	40	38

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
4	82	14

Carbonates Cts./Sec	
Calcite	Dolomite
11	27

Figure 41 Data for analysis site E9

Analysis Site Number E10 Morphostratigraphic Unit Eureka

Location NE SE SE Sec. 3, T.25N., R.1W. Quadrangle Danvers

Elevation 770' Depth of Analysis 6' Type of Exposure Roadcut (new)

Topography C, D, and E slopes on distal side of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	15	12	8	3	N70E	90	Dolomite	LAV
2	13	9	7	6	N35E	10NE	Limestone	W
3	12	9	6	7	N45W	55NE	Chert	
4	45	23	13	1	N55E	20NE	Pink Dolomite	
5	14	10	6	7	N45W	35NW	Chert	
6	20	12	8	4	N10W	30N	Dolomite	
7	12	8	2	2	N70E	10E	Shale	
8	13	8	5	6	N25E	15SW	Dolomite	
9	16	15	5	2	N85W	20W	Limestone	
10	13	8	6	6	N30E	25SW	Limestone	
11	15	10	7	5	N40E	10SW	Dolomite	
12	14	11	8	5	N55E	0	Dolomite	
13	13	9	7	3	N	40N	Dolomite	
14	52	32	22	6	N70E	30W	Dolomite	
15	13	10	5	6	N20E	10SW	Dolomite	
16	21	17	15	8	N55W	90	Limestone	LAV
17	15	12	5	2	E	10W	Shale	
18	16	14	11	7	N20W	25S	Limestone	
19	17	13	10	5	N10E	30S	Limestone	
20	15	12	10	7	N25E	35SW	Quartzite	
21	14	12	9	5	N5E	30S	Quartzite	
22	18	14	13	5	N15W	40N	Dolomite	
23	24	20	10	5	N45E	45SE	Limestone	
24	14	10	9	5	N45E	10NE	Dolomite	
25	38	23	16	7	N35E	15NE	Dolomite	
26	19	17	10	5	N75E	10E	Basalt	
27	20	15	15	3	N10W	0	Limestone	
28	10	9	2	1	[illegible]	25N	Limestone	
29	12	10	5	5	N35E	20NE	Chert	
30	9	7	5	6	N85W	65E	Dolomite	
31	13	10	8	5	N10W	20N	Red Jasper	
32	18	14	6	5	N20E	30N	Dolomite	
33	21	14	13	6	N10E	30N	Chert	
34	17	10	8	3	N5W	15N	Dolomite	
35	15	10	5	1	N55W	20NW	Chert	
36	13	10	2	1	N45E	15NE	Shale	
37	14	10	8	5	N65E	0	Dolomite	
38	12	7	2	1	N85E	50W	Shale	
39	26	15	14	7	N55W	15NW	Chert	
40	12	7	5	6	N80W	30W	Dolomite	
41	15	7	6	6	N25E	20SW	Shale	
42	14	9	8	6	N50W	10SE	Dolomite	
43	13	12	4	1	N80W	20W	Shale	
44	13	12	9	7	N35E	10SW	Chert	
45	12	9	5	5	N35E	10NE	Dolomite	
46	14	11	7	6	N45E	5SW	Chert	
47	17	11	7	6	N25W	10SE	Dolomite	
48	19	12	9	6	N20E	25SW	Dolomite	
49	40	20	6	1	N5E	10N	Shale	S
50	12	10	6	3	N70W	15SE	Dolomite	

Till Matrix Composition Data: Color Buff tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
20	38	42

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
5	84	11

Carbonates Cts./Sec	
Calcite	Dolomite
?	13

Figure 42 Data for analysis site E10

Analysis Site Number E11 **Morphostratigraphic Unit** Eureka

Location SW NE SE Sec. 34, T.26N., R.1W. **Quadrangle** Danvers

Elevation 700' **Depth of Analysis** 6' **Type of Exposure** Roadcut (new)

Topography C, D, and E slopes on proximal side of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	10	7	5	4	N10E	0	Flint	
2	15	12	7	3	N80W	0	Chert	
3	16	13	9	6	N35E	15W	Siltstone	
4	12	10	7	5	N30E	35S	Dolomite	
5	21	13	6	1	N55W	20W	Limestone	
6	20	12	9	6	N85W	20	Limestone	
7	11	7	5	6	N55W	0	Shale	
8	7	5	4	3	N75E	0	Gabbro	
9	13	12	7	3	N25E	15NE	Dolomite	
10	13	9	8	5	N20E	40NE	Limestone	
11	17	10	7	6	N55E	15NE	Limestone	
12	13	10	9	5	N5W	0	Dolomite	
13	13	10	10	3	N55E	20NE	Limestone	
14	15	10	9	6	N30E	15N	Dolomite	
15	23	20	12	7	N5E	50N	Dolomite	
16	25	20	11	3	N45E	10NE	Limestone	W
17	15	12	8	5	N50E	45NE	Limestone	
18	16	7	4	1	N25W	15NW	Shale	
19	39	35	22	5	N15W	90	Dolomite	LAV
20	11	8	7	7	N30E	20SW	Dolomite	
21	17	8	7	6	N25W	10S	Dolomite	
22	15	12	10	8	N30E	20NE	Dolomite	
23	18	13	9	6	N5W	40NW	Dolomite	
24	13	11	7	5	N65W	25SE	Cherty Dolomite	
25	15	12	9	7	N20E	10NW	Limestone	
26	11	7	5	6	N25W	15NW	Dolomite	
27	14	13	8	5	N50W	10NE	Dolomite	
28	11	9	7	8	N40W	45NE	Quartzite	
29	27	17	9	4	N15W	5S	Limestone	
30	14	12	8	7	N50W	15NW	Dolomite	
31	12	7	6	6	N5W	10N	Dolomite	
32	12	7	5	6	N85E	15W	Chert	
33	10	7	6	5	N80W	5E	Dolomite	
34	43	24	13	1	E	20S	Shale	
35	24	18	15	5	N85W	90	Dolomite	LAV
36	62	52	33	3	N75W	0	Dolomite	
37	15	5	5	6	N65W	10W	Dolomite	
38	33	20	14	6	N65W	0	Siltstone	
39	10	8	4	6	N45W	0	Shale	
40	38	26	22	3	N25W	30NW	Dolomite	
41	26	16	11	4	N35W	20SE	Dolomite	
42	14	12	8	8	N75E	10W	Chert	
43	64	49	29	6	N	20N	Limestone	
44	18	14	10	3	N50W	10SE	Granite	
45	23	19	11	6	N60W	90	Chert	
46	35	21	7	1	N75E	15E	Shale	
47	16	12	3	1	N60E	10NE	Shale	
48	33	22	14	3	N20W	15N	Dolomite	
49	11	5	5	6	N70W	10SE	Quartzite	
50	24	11	8	6	N40W	10SE	Chert	

Till Matrix Composition Data: Color Tan **Munsell Soil Color No.** 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
16	55	29

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
5	82	13

Carbonates Cts./Sec	
Calcite	Dolomite
10	26

Figure 43 Data for analysis site E11

Analysis Site Number N1 **Morphostratigraphic Unit** Normal

Location NW SE NW Sec. 18, T.23N., R.6E. **Quadrangle** Arrowsmith

Elevation 830' **Depth of Analysis** 5' **Type of Exposure** Roadcut (old)

Topography B and C slopes on distal edge of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	73	51	35	5	N10E	15N	Dolomite	
2	17	12	10	6	N50E	35NE	Basalt	W
3	26	18	12	7	N50E	0	Coral Fossil	
4	32	27	20	8	N15W	25S	Granite	
5	26	22	12	8	N50E	20N	Dolomite	
6	14	11	6	5	N55E	10NE	Limestone	
7	34	20	18	6	E	0	Dolomite	
8	13	9	5	4	N25W	25NE	Limestone	
9	14	12	7	5	N85W	30S	Dolomite	
10	37	21	18	6	N45W	0	Limestone	
11	30	18	17	5	N15W	15S	Quartzite	
12	22	18	12	7	N15W	20N	Chert	
13	20	15	11	5	N40W	0	Quartzite	
14	24	15	12	5	N80W	25NE	Dolomite	
15	14	10	7	6	N55W	10NE	Limestone	
16	16	15	6	2	N80W	20NE	Shale	
17	14	12	4	1	N45E	15NE	Chert	
18	14	11	4	7	N75W	15NE	Chert	
19	12	8	8	7	N10W	15N	Quartzite	
20	24	15	14	6	N20W	10S	Basalt	
21	40	35	25	7	N5E	0	Dolomite	
22	8	6	6	5	N80E	15W	Flint	
23	12	11	5	1	N70E	10W	Limestone	
24	13	10	6	8	N10W	10W	Siltstone	
25	22	17	16	3	N10W	55S	Chert	
26	35	30	18	3	N15W	15S	Limestone	W
27	22	16	13	6	N45W	25SE	Limestone	
28	14	10	9	6	N60E	0	Shale	
29	13	7	6	6	N45W	10SE	Light Crystalline(?)	
30	28	26	19	5	N80E	0	Dolomite	
31	14	9	8	6	N10W	0	Basalt	
32	14	11	7	5	N	0	Basalt	
33	15	9	7	6	N80E	15E	Siltstone	W
34	13	12	6	7	N60W	40SW	Granite	
35	17	9	7	6	N30E	15NE	Limestone	
36	13	8	3	1	N30E	15SW	Shale	
37	15	13	5	1	N70E	20E	Limonite	
38	13	11	7	5	N55W	25SE	Shale	
39	9	8	3	1	N75E	25E	Limestone	
40	10	7	6	9	N80W	45SE	Quartzite	
41	16	14	9	7	N30E	10SW	Chert	
42	23	22	13	5	N10W	40W	Basalt	
43	20	18	12	5	N60E	20S	Dolomite	
44	15	12	7	8	N85E	15W	Dolomite	
45	14	11	6	7	N70E	30S	Limestone	
46	14	11	7	7	N70E	0	Dolomite	
47	13	7	5	4	N40W	20W	Dolomite	
48	19	13	8	6	N65W	0	Siltstone	
49	18	10	8	6	N25W	15S	Basalt	
50	13	10	9	5	N70E	15S	Chert	

Till Matrix Composition Data: Color Tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
19	48	33

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
6	78	16

Carbonates Cts./Sec	
Calcite	Dolomite
6	13

Figure 44 Data for analysis site N1

Analysis Site Number N2 **Morphostratigraphic Unit** Normal

Location SW NE NE Sec. 14, T.24N., R.1E. **Quadrangle** Danvers

Elevation 800' **Depth of Analysis** 10' **Type of Exposure** Roadcut (new)

Topography B and C slopes on distal edge of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	25	19	8	2	N80W	10E	Shale	
2	23	23	20	7	N85W	0	Limestone	
3	11	10	7	5	N85W	20W	Diorite	
4	22	13	3	1	N50W	30NW	Dolomite	
5	12	10	8	5	N75W	90	Chert	LAV
6	11	8	6	5	N85W	90	Dolomite	LAV
7	23	14	6	1	N55E	10NE	Dolomite	
8	30	23	20	3	N15E	30S	Chert	
9	17	13	9	8	N5E	50W	Dolomite	
10	15	13	7	7	N55E	45W	Shale	
11	13	10	10	5	E	45S	Dolomite	
12	18	16	8	5	N	40W	Dolomite	
13	13	8	6	6	N85W	20N	Dolomite	
14	30	23	5	1	N85E	40W	Shale	
15	27	19	17	3	N85W	0	Dolomite	
16	8	6	5	8	N80W	0	Dolomite	
17	10	6	5	5	E	10W	Limestone	
18	13	8	5	6	N80E	90	Dolomite	LAV
19	21	17	10	7	E	15W	Dolomite	
20	18	15	12	5	N75E	30W	Dolomite	
21	17	14	7	8	N80W	10E	Dolomite	
22	30	18	7	1	N50W	20NW	Shale	
23	16	14	9	8	N35W	55SW	Limestone	
24	12	8	7	5	N5E	20S	Dolomite	
25	56	46	20	5	N25E	55N	Siltstone	
26	16	13	10	5	N50E	90	Limestone	LAV
27	10	7	6	3	N40E	0	Dolomite	
28	18	13	9	6	N75W	15W	Dolomite	
29	20	14	7	1	N45W	90	Shale	
30	27	16	15	5	N70W	30W	Dolomite	
31	16	9	8	4	N30E	0	Dolomite	
32	18	9	9	6	N30E	15S	Dolomite	
33	42	31	23	5	N40E	0	Dolomite	
34	14	10	9	5	N30E	15N	Limestone	
35	31	20	13	6	N40W	25NW	Dolomite	
36	30	18	15	3	N15E	20S	Siltstone	
37	27	22	15	5	N65W	20W	Cherty Dolomite	
38	17	14	11	5	N60W	0	Chert	
39	21	17	10	5	N25W	10N	Siltstone	
40	32	30	15	5	N65W	30NW	Dolomite	
41	21	16	11	3	N15E	10S	Dolomite	
42	16	13	10	7	N80W	90	Chert	LAV
43	25	16	10	6	N20E	40N	Dolomite	
44	27	25	13	5	N20E	60N	Shale	
45	21	16	12	8	N60E	0	Dolomite	
46	45	31	24	3	N10E	40W	Dolomite	
47	19	15	9	3	N30W	35NW	Quartzite	
48	14	12	5	2	N40W	40NE	Shale	
49	41	28	27	3	N30E	0	Granite	
50	18	9	6	6	N15W	25NW	Shale	

Till Matrix Composition Data: Color Tan **Munsell Soil Color No.** 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
17	41	42

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
3	83	14

Carbonates Cts./Sec	
Calcite	Dolomite
11	16

Figure 45 Data for analysis site N2

Analysis Site Number N3 **Morphostratigraphic Unit** Normal

Location NE SE SE Sec. 8, T.23N., R.4E. **Quadrangle** LeRoy

Elevation 870' **Depth of Analysis** 6' **Type of Exposure** Roadcut (old)

Topography B and C slopes on distal edge of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	27	17	10	6	N5W	10S	Limestone	
2	28	27	21	5	N25E	0	Dolomite	
3	12	9	9	5	N65W	10NW	Limestone	
4	18	14	6	2	N50W	0	Shale	
5	12	8	6	6	N85W	0	Dolomite	
6	13	10	8	5	N70E	15NW	Limestone	
7	17	10	5	6	N70W	10 E q	Greenstone	
8	11	9	8	3	N65W	15SE	Dolomite	
9	11	8	5	6	N10W	0	Limestone	
10	35	23	19	3	N80E	10W	Dolomite	
11	26	20	14	7	N25W	25NW	Dolomite	
12	13	8	3	1	E	0	Limestone	
13	15	10	5	1	N10W	0	Dolomite	
14	10	7	6	3	N60W	10NW	Limestone	
15	13	10	3	1	N30W	40NE	Shale	
16	10	7	5	6	N35W	0	Dolomite	
17	13	7	7	8	N25W	35NE	Dolomite	
18	11	9	4	2	N85W	10W	Shale	
19	16	10	6	6	N70E	20N	Siltstone	
20	18	10	9	9	N65W	35SE	Limestone	
21	9	8	4	5	N70E	10W	Dolomite	
22	14	11	8	5	N65E	30S	Dolomite	
23	11	9	6	6	N5E	15S	Dolomite	
24	17	7	6	6	N55E	90	Dolomite	LAV
25	22	16	11	5	N45W	5NW	Dolomite	
26	13	6	5	6	N75E	0	Limestone	
27	14	8	8	6	N60E	0	Limestone	
28	16	10	8	8	N30W	35SE	Dolomite	
29	17	14	10	8	N40W	15SE	Dolomite	
30	12	9	7	3	N25E	90	Dolomite	LAV-S
31	30	25	20	3	N5W	35S	Siltstone	
32	15	11	5	1	N45W	0	Shale	
33	7	4	3	6	N35W	15SE	Gabbro	
34	9	7	6	7	N20W	10SE	Dolomite	
35	25	20	15	5	N30E	0	Limestone	
36	20	19	9	5	N60E	15NE	Limestone	
37	14	10	6	2	N	15S	Dolomite	
38	13	9	6	6	N10W	0	Limestone	
39	15	17	13	3	N90E	30S	Granodiorite	
40	12	9	5	5	N80E	35S	Siltstone	
41	18	14	3	1	N	5S	Shale	
42	12	10	6	5	N50E	20NW	Limestone	
43	9	6	4	6	N70W	30SE	Limestone	
44	21	10	7	6	N45W	10SE	Dolomite	
45	11	7	6	6	N60W	25SE	Dolomite	
46	11	6	6	6	N25W	0	Limestone	
47	11	6	6	6	E	10W	Dolomite	
48	10	8	5	5	N35W	30SE	Chert	
49	22	15	13	7	N35E	40NE	Siltstone	
50	20	15	12	5	E	10E	Chert	

Till Matrix Composition Data: Color Gray tan Munsell Soil Color No. 10YR 5/2

Grain-Size Distribution		
Sand	Silt	Clay
17	53	30

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
7	81	12

Carbonates Cts./Sec	
Calcite	Dolomite
22	27

Figure 46 Data for analysis site N3

Analysis Site Number N4 **Morphostratigraphic Unit** Normal

Location NE NW NW Sec. 1, T.23N., R.2E. **Quadrangle** LeRoy

Elevation 860' **Depth of Analysis** 5' **Type of Exposure** Roadcut (new)

Topography B and C slopes on distal side of moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	18	7	5	6	N80E	10E	Basalt	
2	31	22	18	3	N70E	15E	Sandstone	W
3	12	11	5	5	N85W	0	Chert	
4	14	9	4	2	N25E	20S	Shale	
5	13	10	6	6	N20W	90	Dolomite	LAV
6	9	6	5	5	N85E	10E	Limestone	
7	12	10	4	6	N10W	40S	Basalt	
8	18	14	13	5	N30W	0	Chert	
9	41	31	17	7	N70W	45S	Dolomite	
10	16	11	8	3	N40W	5NW	Granite	
11	12	9	5	5	N10W	10S	Dolomite	
12	18	14	9	5	N10W	25S	Dolomite	
13	16	14	10	3	N20W	55S	Dolomite	
14	11	7	3	6	N85E	0	Shale	
15	13	11	3	1	N30W	20W	Dolomite	
16	15	11	6	5	N60W	5W	Limestone	
17	18	15	10	5	N75W	45E	Diorite	
18	9	6	6	6	N80E	0	Limestone	
19	23	18	13	5	N60W	50SE	Limestone	
20	17	13	10	8	N10E	5S	Basalt	
21	14	11	6	6	N70W	15E	Chert	
22	15	10	9	5	N55W	90	Dolomite	W
23	22	12	8	6	N85W	40E	Dolomite	
24	21	14	3	1	N10E	20S	Shale	
25	16	11	6	5	N15E	10S	Limestone	
26	15	8	3	6	N45E	5NE	Granite	
27	49	34	25	6	N40E	5SW	Granite	W
28	11	7	4	6	N75E	10E	Shale	
29	31	25	15	5	N40E	10NE	Granite	
30	30	20	9	7	N85E	10E	Chert	
31	12	10	6	5	N80E	10E	Limestone	W
32	12	6	2	1	N75W	50S	Shale	
33	37	22	19	6	N35W	25NW	Dolomite	
34	18	8	8	6	N80W	0	Limestone	
35	12	8	5	6	N10E	20N	Dolomite	
36	11	10	5	8	N10E	25N	Granite	
37	11	6	5	6	N55W	0	Limestone	
38	20	15	9	7	N70E	20SW	Dolomite	
39	30	26	18	5	N60E	0	Dolomite	
40	24	14	8	6	N20E	15N	Basalt	W
41	26	16	13	6	N85E	0	Flint	
42	116	73	57	3	E	45E	Dolomite	
43	10	8	6	6	N20W	10S	Basalt	
44	25	15	14	5	N80W	20E	Dolomite	
45	12	9	5	6	N	10S	Dolomite	
46	15	11	10	5	N10W	0	Dolomite	
47	25	12	10	6	N85W	5W	Dark Crystalline (?)	
48	23	16	15	7	E	0	Limestone	
49	19	16	13	8	N75W	25W	Dolomite	
50	20	19	6	1	N50E	50NE	Dolomite	

Till Matrix Composition Data: Color Tan **Munsell Soil Color No.** 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
20	46	34

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
4	83	13

Carbonates Cts./Sec	
Calcite	Dolomite
10	29

Figure 47 Data for analysis site N4

Analysis Site Number BD5 **Morphostratigraphic Unit** Bloomington

Location SE SE SE Sec. 22, T.23N., R.6E. **Quadrangle** Gibson City

Elevation 840' **Depth of Analysis** 5' **Type of Exposure** Roadcut (old)

Topography B, C, and D slopes on interlobate moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	8	6	5	6	N5W	15N	Chert	
2	19	16	11	5	N50E	90	Dolomite	
3	10	7	6	6	N60E	10SW	Limestone	
4	8	6	5	6	N85E	0	Dolomite	
5	10	8	6	3	N70E	20E	Chert	
6	24	17	12	5	N55W	60NW	Limestone	
7	24	19	3	1	N85E	60N	Shale	
8	15	12	5	2	N65W	75SE	Chert	
9	12	11	6	8	N85W	15W	Limestone	
10	32	20	14	6	N25W	10SE	Dolomite	
11	11	8	6	6	N45W	40NE	Limestone	
12	11	8	6	6	N55W	40NW	Quartzite	
13	15	13	10	7	N55W	30NW	Dolomite	
14	8	6	2	1	N55W	10SE	Siltstone	
15	55	33	14	1	N5W	35W	Shale	W
16	32	22	3	1	N50E	55NW	Shale	
17	20	13	11	6	N55W	10NW	Dolomite	
18	9	4	1	6	N35E	20NE	Shale	
19	10	6	5	6	N70E	25SW	Dolomite	
20	15	12	7	5	N65E	35SW	Basalt	
21	30	18	14	9	N70W	35NW	Limestone	
22	10	6	6	6	N50E	20SW	Chert	
23	12	7	5	6	N50E	25SW	Dolomite	
24	7	5	4	5	N25W	0	Quartzite	
25	9	8	5	9	N60W	35NW	Quartzite	
26	29	21	12	5	N85W	40W	Siltstone	
27	8	4	4	6	N15E	25N	Quartzite	
28	10	9	8	5	N70E	10E	Dolomite	
29	6	5	3	5	N5E	0	Limestone	
30	14	9	8	6	N45W	20NW	Flint	
31	20	16	12	7	N25E	0	Chert	
32	40	27	23	5	N10W	30N	Dolomite	S
33	14	13	2	2	N	10N	Shale	
34	12	8	5	9	N60W	10SE	Limestone	
35	9	7	4	6	N25W	45SE	Limestone	
36	20	19	14	5	N5W	35W	Dolomite	
37	17	11	7	6	N55E	35SW	Chert	
38	7	5	3	5	N50E	0	Diorite	
39	14	7	5	6	N10W	45N	Dolomite	
40	10	5	4	6	N40E	20SW	Limestone	
41	11	8	5	6	N60E	20SW	Siltstone	
42	14	8	8	6	N45W	10NW	Siltstone	W
43	15	12	8	7	N45W	20NW	Chert	
44	10	7	7	6	N15E	15S	Limestone	
45	18	13	8	6	N30W	5NW	Dolomite	
46	12	10	8	5	N80W	0	Limestone	
47	9	8	4	7	N50W	20NW	Shale	
48	20	12	8	2	N10E	10N	Shale	
49	15	12	4	1	N80W	40W	Shale	W
50	72	50	37	3	N30W	10W	Sandstone	

Till Matrix Composition Data: Color Tan **Munsell Soil Color No.** 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
19	44	37

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
3	85	12

Carbonates Cts./Sec	
Calcite	Dolomite
2	21

Figure 48 Data for analysis site BD5

Analysis Site Number BD7 **Morphostratigraphic Unit** Bloomington

Location SW NW NW Sec.24, T.23N., R.6E. **Quadrangle** Gibson City

Elevation 820' **Depth of Analysis** 5' **Type of Exposure** Roadcut (old)

Topography C and D slopes on interlobate moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	44	36	32	5	N70W	55SE	Granite	
2	23	19	14	7	N40W	10NW	Limestone	
3	23	13	12	6	N40W	5SE	Siltstone	
4	13	8	8	6	N55E	10E	Dolomite	
5	24	15	9	4	N45W	5SE	Limestone	
6	14	11	7	8	N10W	10	Limestone	
7	32	30	19	5	N55W	90	Quartzite	
8	10	7	2	1	N20E	0	Shale	
9	30	24	17	5	N15E	20N	Limestone	
10	11	6	4	6	N35W	40SW	Dolomite	
11	25	24	3	2	N20E	0	Shale	
12	19	13	6	6	N00W	15SE	Shale	
13	24	18	13	6	N35E	40NW	Dolomite	
14	13	12	10	3	N45W	45E	Dolomite	
15	14	12	10	7	N20W	5NW	Dolomite	
16	15	10	7	6	N10W	15N	Dolomite	
17	27	23	15	6	N35E	40NE	Dolomite	
18	30	26	14	5	N30W	35NE	Shale	
19	10	9	7	8	N45W	10SE	Chert	
20	9	7	3	1	N45W	0	Limestone	
21	11	10	6	7	N30W	45NW	Limestone	
22	10	5	5	6	N5E	25N	Limestone	
23	15	13	9	5	N5E	20E	Dolomite	
24	23	15	5	1	N85E	20W	Shale	
25	10	6	4	6	N5W	0	Limestone	
26	13	10	8	7	[illegible]	[illegible]	Shale	
27	21	18	13	7	N20W	40N	Dolomite	
28	11	10	8	5	N	20E	Chert	
29	13	12	9	5	E	10W	Dolomite	
30	31	23	15	3	N80W	0	Limestone	
31	28	16	8	6	N85W	20E	Chert	
32	14	10	8	6	N30W	10SE	Limestone	
33	12	8	4	1	N35W	10SE	Chert	
34	11	8	6	7	N5E	60E	Chert	
35	15	12	9	5	N50E	0	Limestone	
36	11	5	3	6	N85W	10E	Shale	
37	13	11	6	5	N5E	50E	Shale	
38	25	18	15	5	N35W	0	Shale	
39	15	11	8	5	N80E	0	Dolomite	
40	24	19	13	5	N15E	40E	Dolomite	
41	15	14	9	5	N5E	10E	Dolomite	
42	11	6	3	1	N5E	10E	Shale	
43	9	8	6	6	N15E	0	Dolomite	
44	9	8	5	8	N15W	0	Quartzite	
45	25	18	17	3	N80W	0	Quartzite	
46	18	12	9	9	N50E	0	Limestone	
47	13	10	8	8	N60E	35SW	Dolomite	
48	11	7	4	2	N25E	30NE	Dolomite	
49	15	11	8	6	N30W	60NW	Dolomite	
50	40	25	21	6	N15W	40E	Dolomite	

Till Matrix Composition Data: Color Tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
22	40	38

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
3	85	12

Carbonates Cts./Sec	
Calcite	Dolomite
7	16

Figure 49 Data for analysis site BD7

Analysis Site Number BD7 **Morphostratigraphic Unit** Bloomington

Location SW NW NW Sec.24, T.23N., R.6E. **Quadrangle** Gibson City

Elevation 820' **Depth of Analysis** 5' **Type of Exposure** Roadcut (old)

Topography C and D slopes on interlobate moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	44	36	32	5	N70W	55SE	Granite	
2	23	15	14	7	N40W	10NW	Limestone	
3	23	13	12	6	N40W	5SE	Siltstone	
4	13	8	8	6	N55E	10E	Dolomite	
5	24	15	9	4	N40W	5SE	Limestone	
6	14	11	7	8	N10W	10	Limestone	
7	32	30	19	5	N55W	90	Quartzite	
8	10	7	2	1	N20E	0	Shale	
9	30	24	17	5	N15E	20N	Limestone	
10	11	6	4	6	N35W	40NW	Dolomite	
11	25	24	3	2	N20E	0	Shale	
12	19	15	6	6	N60W	15SE	Shale	
13	24	18	13	6	N35E	40NW	Dolomite	
14	13	12	10	3	N45W	45E	Dolomite	
15	14	12	10	7	N20W	5SW	Dolomite	
16	15	10	7	6	N10W	15N	Dolomite	
17	27	23	15	6	N35E	40NE	Dolomite	
18	30	26	14	5	N30W	35NE	Shale	
19	10	9	7	8	N45W	10SE	Chert	
20	9	7	3	1	N45W	0	Limestone	
21	11	10	6	7	N30W	45NW	Limestone	
22	10	5	5	6	N5E	25N	Limestone	
23	15	13	9	5	N5E	20S	Dolomite	
24	23	15	5	1	N85E	20W	Shale	
25	10	6	4	6	N5W	0	Limestone	
26	13	10	8	7	N50W	35SE	Shale	
27	21	18	13	7	N20W	40N	Dolomite	
28	11	10	8	5	N	20S	Chert	
29	13	12	9	5	E	10W	Dolomite	
30	31	23	15	3	N80W	0	Limestone	
31	28	16	8	6	N85W	20E	Chert	
32	14	10	8	6	N30W	10SE	Limestone	
33	12	8	4	1	N35W	10E	Chert	
34	11	8	6	7	N5E	60S	Chert	
35	15	12	9	5	N50E	0	Limestone	
36	11	5	3	6	N85W	10E	Shale	
37	13	11	6	5	N5E	50S	Shale	
38	25	18	15	5	N35W	0	Shale	
39	15	11	8	5	N80E	0	Dolomite	
40	24	19	13	5	N15E	40S	Dolomite	
41	15	14	9	5	N5E	10S	Dolomite	
42	11	6	3	1	N5E	10S	Shale	
43	9	8	6	6	N15E	0	Dolomite	
44	9	8	5	8	N15W	0	Quartzite	
45	25	18	17	3	N80W	0	Quartzite	
46	18	12	9	9	N55E	0	Limestone	
47	13	10	8	8	N60E	35SW	Dolomite	
48	11	7	4	2	N25E	30NE	Dolomite	
49	15	11	8	6	N30W	60NW	Dolomite	
50	40	25	21	6	N15W	40E	Dolomite	

Till Matrix Composition Data: Color Tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
22	40	38

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
3	85	12

Carbonates Cts./Sec	
Calcite	Dolomite
7	16

Figure 49 Data for analysis site BD7

Analysis Site Number BD8 Morphostratigraphic Unit Bloomington

Location SW SW NW Sec.8, T.23N., R.7E. Quadrangle Gibson City

Elevation 800' Depth of Analysis 8' Type of Exposure Roadcut (old)

Topography B and C slopes on interlobate moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	11	8	3	6	N35W	10NW	Basalt	
2	16	13	9	5	N45W	0	Dolomite	
3	19	8	7	6	N55E	90	Shale	LAV
4	22	10	5	1	N60W	10SE	Shale	
5	30	25	13	7	E	45S	Chert	
6	45	22	18	6	N75W	20S	Limestone	
7	13	12	7	8	N25W	10SE	Basalt	
8	33	20	14	3	N20W	20N	Dolomite	
9	17	14	9	5	N55W	10NW	Limonite	
10	28	22	10	5	N5E	90	Basalt	LAV
11	14	10	9	7	N85E	25E	Limestone	
12	21	12	8	6	N75W	20W	Dolomite	
13	18	5	5	6	N45E	10E	Quartzite	
14	15	10	9	6	N55E	90	Chert	LAV
15	11	7	6	6	N70W	40NW	Limestone	
16	15	12	8	6	N45W	35W	Dolomite	
17	14	11	6	5	N25E	60NE	Limestone	
18	12	10	8	6	N40E	35NE	Dolomite	
19	15	14	9	5	N50E	25NE	Dolomite	
20	14	10	6	6	N70E	20NE	Limestone	
21	11	9	6	7	N	40N	Dolomite	
22	13	10	5	2	N60E	25SE	Chert	
23	26	20	9	2	N70E	50N	Siltstone	
24	15	7	4	4	N70E	10SW	Shale	
25	14	10	3	1	N70W	90	Shale	
26	13	8	2	1	N20E	10NE	Shale	
27	44	25	17	6	N30E	20NE	Granite	W
28	15	10	10	7	N10E	0	Chert	
29	28	17	13	6	N50E	10NE	Dolomite	
30	39	19	17	6	N30W	90	Dolomite	LAV
31	57	44	37	5	N75E	10W	Dolomite	S
32	12	10	7	8	N40W	10SE	Quartzite	
33	16	10	7	6	N30E	30SW	Dolomite	
34	17	11	10	5	N40W	10NW	Limestone	
35	13	10	8	6	N70E	30NE	Siltstone	
36	17	10	7	4	N50W	40SE	Siltstone	
37	40	37	13	1	N25E	20NE	Dolomite	
38	13	12	6	5	N30W	50SE	Basalt	
39	12	7	6	6	N15E	15N	Chert	
40	12	10	9	7	N5W	10S	Chert	
41	11	8	5	9	N25E	25NE	Quartzite	
42	17	14	10	5	N70E	80SW	Dolomite	
43	15	10	9	6	N60E	20NE	Dolomite	
44	53	37	18	1	N35E	10SW	Shale	
45	13	9	7	6	N5E	5N.	Dolomite	
46	19	11	6	2	N45E	25SW	Limestone	
47	22	17	15	3	N70E	90	Dolomite	LAV
48	14	9	3	1	N25E	30NE	Shale	
49	22	15	10	5	N	50S	Dolomite	S
50	12	9	5	6	N25E	40NE	Chert	

Till Matrix Composition Data: Color Tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
29	36	35

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
5	82	13

Carbonates Cts./Sec	
Calcite	Dolomite
8	16

Figure 50 Data for analysis site BD8

Analysis Site Number BP7 **Morphostratigraphic Unit** Bloomington

Location SE NE NE Sec.20, T.23N., R.6E. **Quadrangle** Arrowsmith

Elevation 830' **Depth of Analysis** 5' **Type of Exposure** Pipeline Trench

Topography B and C slopes near edge of interlobate moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	70	53	28	7	E	55N	Granite	
2	15	10	6	7	N70E	25W	Limestone	
3	28	23	9	1	N10E	45N	Siltstone	
4	17	12	12	3	N20E	0	Granite	
5	15	9	7	4	N65W	15NW	Dolomite	
6	18	7	8	6	N65E	25SW	Chert	
7	17	10	6	6	N40W	10NW	Limestone	
8	16	11	7	4	N60E	20W	Dolomite	
9	22	9	9	4	N15W	55N	Dolomite	
10	10	8	5	2	N70W	15S	Dolomite	W
11	19	10	7	4	N75E	90	Quartzite	LAV
12	22	15	7	1	N80E	60S	Siltstone	
13	15	13	8	3	N45W	90	Quartzite	
14	13	10	7	6	N45W	30SE	Gabbro	
15	11	8	6	5	N30E	45NE	Dolomite	
16	29	13	10	6	N70W	0	Limestone	
17	17	16	10	7	N55E	0	Basalt	
18	20	17	12	5	N15E	20S	Dolomite	
19	55	45	25	5	N25E	0	Dolomite	
20	20	12	12	3	N25E	0	Dolomite	W
21	22	11	10	6	N70W	45E	Limestone	
22	22	20	15	5	N35W	90	Dolomite	LAV
23	22	12	10	4	N35E	0	Chert	
24	25	16	14	6	N25E	0	Dolomite	
25	39	27	25	3	N50W	25NW	Dolomite	
26	21	15	5	1	N60W	0	Siltstone	
27	16	12	6	1	N25E	[illegible]	Gabbro	
28	25	18	10	5	N85W	40W	Granite	
29	34	28	10	1	N55E	35SW	Dolomite	
30	13	7	4	6	N70W	35W	Granite	
31	15	10	7	7	N40W	15NW	Siltstone	
32	14	12	9	8	N20E	15S	Dolomite	W
33	28	15	13	5	N60E	0	Quartzite	
34	18	14	9	7	N65E	15SW	Greenstone	
35	14	10	9	3	N60W	5NW	Quartzite	
36	17	10	9	6	N55W	0	Chert	
37	24	19	12	3	N10W	10SE	Limestone	
38	45	44	25	5	N40E	15NW	Felsite	
39	17	7	4	6	N30W	10SE	Red Limestone	
40	20	16	10	5	N35W	30S	Diorite	
41	24	12	4	1	N60W	5SE	Siltstone	
42	49	32	32	3	N10E	20S	Dolomite	
43	13	9	6	6	N85E	0	Dolomite	
44	13	7	3	1	N30E	0	Limestone	
45	10	6	3	1	N30E	5SW	Dolomite	
46	8	7	5	3	N30E	15SW	Dolomite	
47	13	10	8	5	N10E	0	Dolomite	
48	31	21	14	6	N5E	55S	Dolomite	
49	13	9	7	5	N50W	20SE	Limestone	
50	19	10	2	1	N5E	15N	Shale	

Till Matrix Composition Data: Color Yellow tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
24	36	40

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
5	83	12

Carbonates Cts./Sec	
Calcite	Dolomite
7	17

Figure 51 Data for analysis site BP7

Analysis Site Number BP8 **Morphostratigraphic Unit** Bloomington

Location SE SW SW Sec. 21, T.24N., R.7E. **Quadrangle** Sibley

Elevation 810' **Depth of Analysis** 5' **Type of Exposure** Roadcut (old)

Topography C and D slopes on interlobate moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	27	20	15	3	E	90	Siltstone	
2	19	13	7	1	N45W	40NW	Shale	
3	9	5	4	6	N10E	0	Basalt	
4	10	6	5	6	N75E	25W	Quartzite	
5	15	9	4	6	N75E	0	Dolomite	
6	15	9	7	6	N70W	10W	Dolomite	
7	18	12	10	7	N10W	0	Chert	
8	18	17	9	7	N45W	40NW	Dolomite	
9	15	12	6	3	N40E	10NW	Dolomite	
10	15	10	4	1	N15E	5S	Shale	W
11	8	8	4	2	N65E	90	Siltstone	
12	14	7	1	1	N85E	90	Shale	
13	12	9	3	1	N15E	10S	Shale	
14	30	23	15	5	N75W	60NW	Dolomite	
15	7	4	3	6	N55W	0	Dolomite	W
16	8	6	4	3	N75E	0	Limestone	
17	8	7	5	6	N75E	0	Basalt	
18	13	11	2	1	N60E	5NE	Shale	
19	11	6	4	5	N30W	10N	Dolomite	
20	12	11	4	2	N70E	90	Shale	LAV-W
21	12	9	7	5	N30W	35S	Dolomite	
22	16	10	9	7	N55W	50NE	Dolomite	W
23	14	11	7	7	N60E	15NW	Chert	
24	12	10	5	8	N70E	20E	Quartzite	
25	24	21	12	5	N	25S	Dolomite	
26	19	14	6	1	N70E	35NE	Chert	
27	32	20	22	5	N60E	90	Chert	
28	18	14	13	5	N55E	90	Limestone	LAV
29	21	16	14	5	N50W	0	Dolomite	
30	10	10	4	1	N85W	90	Siltstone	
31	21	14	12	7	N75W	40NW	Dolomite	
32	15	10	5	2	N80E	90	Shale	
33	16	9	6	6	N20E	10N	Dolomite	
34	12	9	6	6	N30W	20NW	Quartzite	
35	29	17	6	1	N10E	45N	Shale	
36	29	20	9	2	N20W	5N	Dolomite	
37	14	13	9	5	N20W	25S	Limestone	
38	9	7	3	7	N75E	15W	Limestone	
39	15	12	8	7	E	10W	Chert	
40	12	10	5	7	E	20N	Chert	
41	16	10	5	6	N10E	0	Dolomite	W
42	14	8	3	1	N30W	0	Shale	
43	10	6	4	6	N25W	55SE	Basalt	
44	18	15	6	2	N30E	45NW	Dolomite	
45	7	6	3	2	N20E	35NE	Chert	
46	12	9	6	5	N35E	10NW	Limestone	
47	14	8	4	1	N45W	90	Basalt	
48	23	18	8	2	N20E	50SE	Shale	
49	15	12	8	5	N15E	90	Dolomite	
50	15	8	7	6	N45W	10NW	Chert	

Till Matrix Composition Data: Color Yellow tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
25	42	33

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
6	81	13

Carbonates Cts./Sec	
Calcite	Dolomite
10	14

Figure 52 Data for analysis site BP8

Analysis Site Number BP10 **Morphostratigraphic Unit** Bloomington

Location NW NW SW Sec. 14, T.23N., R.6E. **Quadrangle** Gibson City

Elevation 870' **Depth of Analysis** 4' **Type of Exposure** Roadcut (old)

Topography B and C slopes on interlobate moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	150	135	76	7	N10E	20N	Dolomite	
2	13	11	7	7	N55E	10SW	Chert	
3	13	10	6	6	N50E	10NE	Dolomite	
4	11	7	7	6	N75E	10E	Dolomite	
5	19	14	10	3	N60E	60SW	Dolomite	
6	19	14	10	6	N	0	Quartzite	
7	18	15	11	3	N15W	45S	Dolomite	
8	11	8	4	5	N20E	10N	Limestone	
9	11	9	6	5	N25E	0	Shale	
10	17	9	5	1	N50E	15SW	Dolomite	
11	13	8	3	1	N25W	25SE	Shale	
12	20	14	2	1	N40E	0	Shale	
13	12	7	3	2	N25W	15SE	Gabbro	
14	15	10	6	6	N20E	10S	Chert	
15	22	12	9	6	N55E	5NE	Sandstone	W
16	33	20	6	1	N50E	15SW	Shale	
17	15	8	3	1	N70E	90	Siltstone	
18	16	14	3	1	N65E	90	Shale	
19	17	14	4	2	N15W	20	Shale	
20	35	27	25	5	N10W	20S	Dolomite	W
21	31	22	8	1	N55E	20NE	Red Limestone	
22	12	11	3	1	N75E	20E	Shale	
23	16	10	8	3	N25W	10SE	Limestone	
24	22	16	12	5	N5W	45N	Chert	W
25	13	10	8	5	N	0	Dolomite	
26	19	15	4	1	N65E	35E	Shale	
27	14	10	6	7	N75E	0	Dolomite	
28	10	9	4	1	N25E	10SW	Shale	
29	11	7	5	6	N70E	10NE	Limestone	
30	15	13	6	5	N20W	40N	Dolomite	
31	13	8	6	6	N	10N	Limestone	
32	10	6	4	6	N15E	30N	Quartzite	
33	17	12	8	5	N55E	30SW	Chert	
34	15	12	7	6	N15E	15S	Dolomite	W
35	10	6	4	4	N15E	20S	Shale	
36	36	26	17	5	N45E	35S	Dolomite	W
37	17	12	10	5	N70E	20E	Limestone	
38	8	7	6	8	N65E	10NE	Chert	
39	12	9	6	6	N60E	15NE	Basalt	
40	12	7	6	4	N25E	10W	Dolomite	W
41	15	10	7	6	N40W	35SE	Dolomite	
42	20	17	9	7	N75W	90	Dolomite	
43	21	11	6	4	N75W	15E	Limestone	
44	13	9	8	5	N40E	10NE	Dolomite	
45	19	8	3	6	N25W	35S	Shale	
46	13	8	7	6	N55E	40NE	Limestone	
47	15	12	4	1	N60W	0	Shale	
48	14	10	3	1	N	35S	Chert	
49	12	9	8	5	N5E	30S	Dolomite	
50	16	11	8	3	N10E	20S	Dolomite	

Till Matrix Composition Data: Color Yellow tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
22	40	38

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
7	78	15

Carbonates Cts./Sec	
Calcite	Dolomite
?	15

Figure 53 Data for analysis site BP10

Analysis Site Number BP11 **Morphostratigraphic Unit** Bloomington

Location NW NE NW Sec. 12, T.23N., R.6E. **Quadrangle** Gibson City

Elevation 850' **Depth of Analysis** 10' **Type of Exposure** Roadcut (old)

Topography C and D slopes high on interlobate moraine

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	30	19	6	1	N30W	50SE	Siltstone	W
2	10	7	5	6	N50E	0	Dolomite	
3	11	5	3	4	N20E	10N	Dolomite	
4	13	11	9	7	N35E	20SW	Dolomite	
5	11	9	4	2	N50W	25SE	Chert	
6	10	9	7	7	N55W	35SE	Chert	
7	18	15	14	3	[illegible]	35E	Chert	
8	15	13	9	5	N60W	10SE	Dolomite	
9	12	7	6	4	N10E	10S	Dolomite	
10	12	10	5	2	N40E	10NE	Dolomite	
11	28	15	15	3	N10W	90	Dolomite	
12	28	4	9	2	N25W	15NW	Limestone	
13	11	7	3	1	N70W	10SE	Shale	
14	17	14	9	7	N40E	15SW	Dolomite	
15	38	32	17	5	N15E	30S	Limestone	
16	14	10	8	6	N60E	10SW	Dolomite	
17	10	6	5	6	N30E	30NE	Dolomite	
18	12	8	5	6	N20E	0	Basalt	
19	11	6	4	3	N	0	Limestone	
20	31	16	14	6	N50E	10SW	Basalt	
21	16	10	5	1	N15E	25N	Dolomite	W
22	22	16	4	1	N10E	25S	Granite	W
23	23	18	9	5	N45E	30S	Dolomite	
24	9	6	5	7	N15E	10S	Dolomite	
25	12	9	4	1	N25E	0	Limestone	
26	9	9	4	5	N	10N	Quartzite	
27	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	Shale	
28	21	13	11	3	N65E	0	Chert	
29	20	13	10	6	N25E	15NE	Dolomite	
30	20	17	9	7	N30W	10NW	Dolomite	
31	8	6	5	9	N10W	0	Red Limestone	
32	10	6	2	1	N40E	25NE	Dolomite	
33	15	13	9	7	N40E	90	Dolomite	LAV
34	20	13	10	7	N10W	25N	Chert	
35	17	10	9	6	N30E	30NE	Dolomite	W
36	13	10	8	7	N75W	40SE	Dolomite	
37	17	14	6	1	N10E	30N	Shale	
38	38	31	16	3	N25W	25NW	Quartzite	
39	24	14	11	6	N60W	15NW	Dolomite	
40	11	8	9	6	N15E	15N	Chert	
41	9	6	4	6	N30E	10NE	Quartzite	
42	22	13	12	6	N40E	20NE	Dolomite	
43	13	8	4	1	N35E	10SW	Siltstone	
44	16	15	7	5	N65W	25SE	Felsite	
45	16	10	3	1	N65E	0	Shale	
46	15	10	9	3	N55E	90	Dolomite	
47	10	8	5	5	N30E	10SW	Shale	
48	12	10	3	2	N65E	10NE	Shale	
49	14	9	6	6	N60E	0	Limestone	
50	13	9	7	3	N40W	25NW	Chert	

Till Matrix Composition Data: Color Yellow tan Munsell Soil Color No. 2.5Y 5/4

Grain-Size Distribution		
Sand	Silt	Clay
20	42	38

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
6	81	13

Carbonates Cts./Sec	
Calcite	Dolomite
12	19

Figure 54 Data for analysis site BP11

Analysis Site Number EB2 **Morphostratigraphic Unit** Eureka

Location NE SE NE Sec.3, T.25N., R.1W. **Quadrangle** Danvers

Elevation 750' **Depth of Analysis** 23' **Type of Exposure** Roadcut (new)

Topography ? (stratigraphically lower till unit, top till see E10)

Till Pebble Data:

No.	Dimensions			Shape	Strike	Dip	Lithology	Misc.
1	13	8	7	6	N10W	5N	Dolomite	
2	13	12	4	2	N5W	90	Dolomite	
3	43	31	17	6	N30W	90	Limestone	LAV
4	13	9	6	6	N25W	30NW	Granite	
5	13	7	5	4	N35W	30SE	Dolomite	
6	16	11	8	3	N20W	25SE	Dolomite	
7	22	16	15	3	N25W	45E	Quartzite	
8	12	8	6	3	N15W	10S	Limestone	
9	37	13	12	4	N50W	20NW	Dolomite	
10	18	15	10	5	N75E	45E	Limestone	
11	22	16	10	5	N35W	0	Limestone	
12	19	11	10	3	N5W	0	Siltstone	
13	11	10	5	5	N5W	25S	Greenstone	W
14	18	14	12	7	N5W	15N	Gabbro	
15	22	16	12	5	N10E	40S	Dolomite	
16	23	14	10	6	N5E	40W	Dolomite	
17	24	23	11	8	N25W	10SW	Dolomite	
18	24	13	6	1	N10W	70W	Limestone	
19	18	15	14	5	N5W	45S	Basalt	
20	30	21	16	3	N60W	10NW	Dolomite	
21	17	7	3	2	N	0	Coal	
22	20	16	10	5	N45W	20NW	Dolomite	
23	21	17	12	7	N50W	0	Chert	
24	19	13	9	7	N30E	35NE	Dolomite	
25	13	10	6	6	N35W	30SE	Dolomite	
26	22	17	12	5	N30W	35NW	Sandstone	W
27	20	18	5	1	N40W	90	Shale	
28	15	12	8	5	N45E	30NE	Limestone	
29	11	7	5	6	N25W	0	Limestone	
30	14	12	6	7	N20W	20S	Dolomite	
31	20	13	9	6	N55W	15NW	Basalt	
32	15	9	8	6	N10W	10N	Dolomite	
33	29	23	17	9	N35W	10NW	Basalt	
34	25	15	11	6	N60W	50N	Dolomite	
35	10	6	5	4	N75W	0	Dolomite	
36	12	10	6	5	N35E	25NE	Shale	
37	12	10	6	5	N55W	15SE	Granite	
38	13	10	8	5	N45W	90	Dolomite	LAV
39	13	10	6	5	N20W	15NW	Dolomite	
40	14	11	7	5	N	0	Dolomite	
41	14	12	10	7	N30W	90	Chert	LAV
42	15	11	8	6	N30W	25SW	Dolomite	
43	27	15	13	4	N10W	30N	Dolomite	
44	20	12	7	2	N35W	35SE	Dolomite	
45	14	11	4	2	N40E	30SW	Dolomite	
46	11	7	4	2	N5E	0	Dolomite	
47	15	7	7	6	N10W	15S	Basalt	
48	14	10	8	6	N35W	0	Granite	
49	27	22	8	1	N15W	90	Sandstone	
50	38	20	12	6	N30W	35SW	Shale	

Till Matrix Composition Data: Color Red brown Munsell Soil Color No. 7.5YR 5/4

Grain-Size Distribution		
Sand	Silt	Clay
27	41	32

Clay Mineral Composition		
Expandable Clay Minerals	Illite	Chlorite plus Kaolinite
14	70	16

Carbonates Cts./Sec	
Calcite	Dolomite
22	26

Figure 55 Data for analysis site EB2