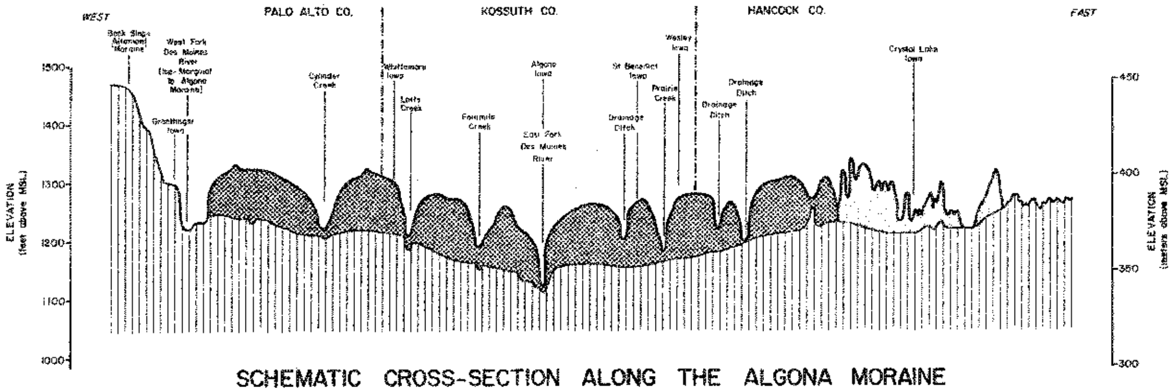
GLACIAL SEDIMENTATION AND THE ALGONA MORAINE IN IOWA



SCHEMATIC CROSS-SECTION ALONG THE ALGONA MORAINE

GEOLOGICAL SOCIETY OF IOWA
1981 FALL FIELD TRIP

GUIDEBOOK 36

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GLACIAL SEDIMENTATION AND THE ALGONA MORAINE IN IOWA

A review of recent research on glacial sedimentation and its application to the glacial deposits of the Des Moines Lobe (Late Wisconsinan) in Iowa, and a study of changing glacial landforms and sedimentation along the Algona Moraine.

Led by

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Those portions of the guidebook dealing with the review of till sedimentation and with the discussions for Stops 1 and 2 are derived wholly or in part from Kemmis, Hallberg, and Lutenegger (1981). My thanks to these authors for permission to use their materials for this report.

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INTRODUCTION

Glacial geology, like many other disciplines in geology, has undergone rapid and important changes in concepts and procedures during the past 15 years. The results of investigations during this period have been as important to glacial geology as plate tectonic theory has been to other disciplines in geology. With this as background, the field trip has a number of objectives:

1. To review current concepts in glacial sedimentation. Only fifteen years ago there was but a rudimentary understanding of the actual *processes* of till sedimentation. Recent studies on existing glaciers have provided us with important new concepts of the many ways in which till-like sediments (diamictons) can be deposited in the glacial environment. Consequently, on the field trip we would like to review these new concepts.
2. To show how these new concepts of glacial sedimentation can be applied to the deposits of the Des Moines Lobe in Iowa.
3. To point out the implications of this new understanding of glacial sedimentation to the classification of glacial landforms.
4. To see changes in both glacial landforms and sedimentation along a *single* moraine or ice-marginal position, the Algona Moraine in Iowa.

FIELD TRIP PLAN

The field trip can be divided into two parts. Part 1 is a review of current concepts in glacial sedimentation and their application to glacial deposits on the Des Moines Lobe. The best field locations to do this are at Stops 1 and 2, Weaver Construction Company's Alden and Dows Quarries. Unfortunately, these two stops are located a long way from the Algona Moraine. Nonetheless, they are excellent localities to show the properties and sedimentary structures indicative of different glacial sedimentation processes. The perspective gained from these two stops will be very helpful later as we traverse the Algona Moraine area where we will be limited to looking at cores and relatively small exposures.

Part II, which includes Stops 3 through 7, is a traverse along the Algona Moraine from Wesley through to the Lake Mills, Iowa area. Along the way we will view changes in topography along the "moraine," and at select locations we will look at cores and outcrops, noting the nature of glacial sedimentation in these areas. By day's end we will see that there is a dramatic change in topography along this "moraine," and that this change is the result of changes in glacial sedimentation which took place along the former ice front.

It is hoped that this field trip will give you an idea of the complexity of the glacial environment, as well as an idea of the complexity of areal variations in glacial sedimentation and processes on the Des Moines Lobe. Perhaps you will also realize that classic maps of moraines in the Midwest tell you virtually nothing about either the landscape or the glacial sediments along the moraine fronts. Neither do they give any indication of regional variations in glacial sedimentation.

PART 1. CURRENT CONCEPTS IN TILL SEDIMENTATION AND THEIR APPLICATION TO DEPOSITS OF THE DES MOINES LOBE

This section consists of 1) a brief literature review of the processes of till deposition; and 2) a discussion for Stops 1 and 2, stops where it will be demonstrated how recent studies on the processes of glacial sedimentation can be applied to the deposits of the Des Moines Lobe.

Till Sedimentation

Till-like materials are the dominant component of most upland landforms on the Des Moines Lobe. Until recently, the *processes* by which till deposition takes place were poorly understood. Recent studies, particularly in the past two decades, have concentrated on the factors which affect the occurrence and mechanics of glacial processes. Although our understanding of glacial depositional processes is far from complete, many major aspects are now satisfactorily understood.

It has long been recognized that till-like deposits may form by deposition in two grossly different environments: subglacially, beneath the ice, and supraglacially, at the upper surface of the ice (figure 1). Until recently, however, there was only a rudimentary understanding of both the depositional processes in these two environments and the sedimentological character and sequence of the till-like materials which resulted. We now recognize that till-like deposits (diamictons) can be genetically differentiated on the basis of properties inherited from the depositional processes. Tables 1 and 2, for instance, designate the type and properties for till-like sediments deposited by various processes from land-based glaciers as recognized respectively by Boulton (1976) and Lawson (1979).

Till-dominated glacial landforms are obviously built up as a result of glacial deposition through time. When trying to understand the genesis

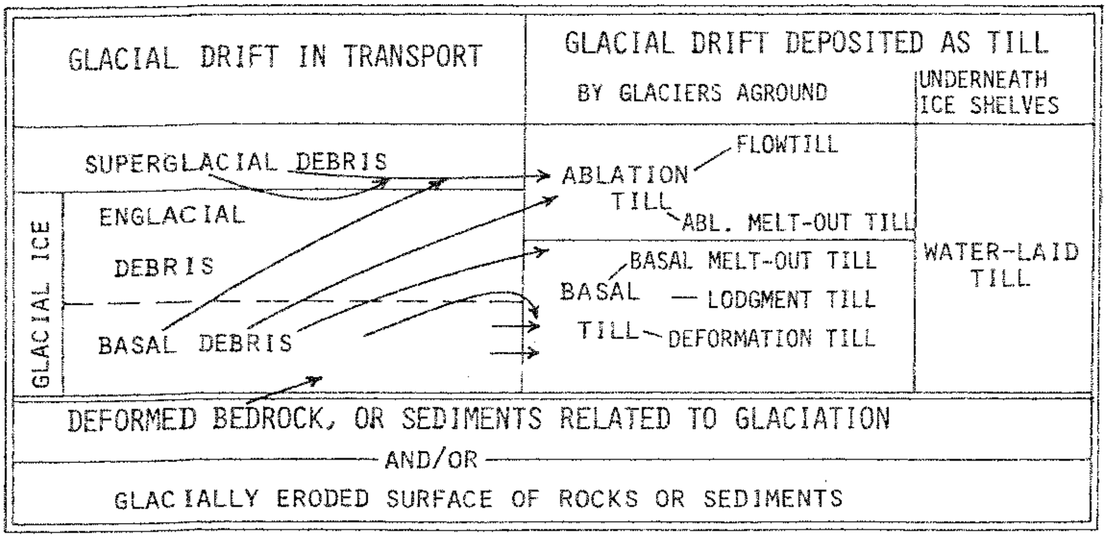


Figure 1. Dreimanis' genetic classification of tills and their relationship to glacial debris in transport (after Dreimanis, 1976).

of various glacial landforms it is thus extremely critical that one understand till sedimentational processes. The following sections provide a brief summary from recent studies on till depositional processes in the subglacial and supraglacial environments.

Subglacial Sedimentation

Subglacially-deposited till has classically been called lodgement till. It is now recognized that till may be deposited subglacially by three different processes: lodgement, regelation melt-out, and basal melt-out, rather than by just a single process of lodgement.

Lodgement is largely a mechanical process whereby frictional forces between a particle in traction and the bed become greater than the traction exerted by the moving ice, and the particle becomes "lodged" or deposited on the bed. Boulton (1974, 1975) provides a comprehensive theoretical treatment of lodgement including an analysis of the various factors involved (particle size, ice velocity, normal stress between the particle and the bed, etc.) and their influence on the kind and rate of subglacial processes taking place. Lodgement is probably most important for clast size particles, as opposed to matrix size particles, because these larger particles are capable of generating greater frictional forces relative to the tractive forces of the ice.

Table 1. Boulton's criteria for distinguishing tills of different origin (from Boulton, 1976).

Properties	Flow Till	Melt-out Till	Lodgement Till
Nature of sequence and position of tills within it	Topmost of a sequence of tills. Often occurs directly above ice-contact outwash sediments. May coat hummocky terrain as a thin veneer. Sediment lenses of all sizes occur within the flow till	Occurs directly above lodgement till or eroded surface. Always overlain by sediment overburden	Occurs at the base of a sequence of sediments derived from glacier retreat
Grain size composition and its spatial variation	Often shows considerable variations in grain size composition. Local enrichment and depletion in fines due to sub-aerial washing on till surface	Relative small spatial variation in grain size composition	Relatively small spatial variation in grain size composition. May show boulder clusters of glacitectonic inclusion from underlying beds
Banding	Shows both sedimentary banding and shear banding. The former due to water sorting on the till surface, the latter due to streaking out during flow	Absence of banding	Absence of sedimentary banding but shear banding due to inclusion and streaking out of sub-till sediment
Clast orientation fabrics largest commonly occurring clast should be selected as the most reliable	Transverse and parallel to flow direction. Often parallel and transverse to ice flow direction, but not necessarily. Large within site fabric variability	Little studied, but well-defined transverse and parallel orientations probably tend to develop. a - b planes tend to lie in plane of bed. Highs within site fabric consistency	Tendency for the development of strong parallel fabric peaks with an up-glacier dip, except for those tills where postdepositional deformation has occurred, such as in flutes or folds transverse to flow. Here, transverse peaks may develop. Strong within site and between site correlation
Folding and faulting	Intra-formational folding due to flow, commonly seen asymmetric overturned or flat-lying isoclinal folds common. Anticlinal and synclinal fold noses preserved. Frequently overlie stratified sediments which show gentle folding and high angle faulting indicative of collapse over melting stagnant ice	No internal folding	Folding may be apparent when underlying beds have been incorporated. Folds generally isoclinal with flat-lying axial planes. Anticlinal fold noses rarely preserved. Synclines facing up glacier commonly found. Fold noses often completely streaked out. Folding in underlying beds similar to that in the till, though it may be less extreme. Structures reflect subglacial shearing
Geotechnical properties	Wide variation in index properties from the same site. Deviations to both sides of T-line. Reflects sorting processes	Relatively little within-site variation in index properties. Points fall on T-Line	Relatively little within-site variation in index properties. Points fall on T-line
Jointing	Joints primarily reflect drying out (vertical, polygonal in plan), and freezing (closely spaced 2 cm, and parallel to the surface)	Rarely jointed	Joints primarily reflect unloading (parallel to the surface, more widely spaced than joints due to freezing), and shearing (sub-parallel lenticular joints sets, or vertical conjugate sets)
Surface expression (geomorphology)	May occur below a low relief slightly irregular surface, or below an irregular hummocky ridged surface, or a series of ridges lying parallel to the glacier margin. The ridges may be composed primarily of flow till or of stratified outwash capped by flow till	Never exposed at surface	Almost invariably fluted and or drumlinised in the direction of ice movement. May have transverse pushed ridges superimposed, or an irregular pattern of till squeezed up in crevasses
Till thickness	Extremely variable, from very thin to very thick. Average thickness unlikely to the order of 1 - 2 m	Thin, unlikely to exceed 2 m	Any thickness. Average thickness may be large

Table 2. Some characteristics of the deposits, terminus region, Matanuska Glacier, Alaska (after, Lawson, 1979).

		Internal organization					
Process	Deposit	General	Structure	Pebble fabric	Contacts-basal surface features	Geometry-maximum dimensions	Miscellaneous properties
Lodgement at glacier sole	Lodgement till	Clasts randomly dispersed to clustered in matrix.	Massive; shear foliation, other "tectonic" features.	Strong; unimodal(?) pattern; orientation influenced by ice flow and substrate; low angle of dip.	Image of substrate	Discontinuous pockets or sheets of variable thickness and extent.	Usually dense compact.
Buried ice melt	Melt-out till	Clasts randomly dispersed in matrix	Massive; may preserve individual or sets of ice strata.	Strong; unimodal parallel to local ice flow; low angle of dip.	Upper sharp, may be transitional; sub-ice probably sharp.	Sheet to discontinuous sheet; km² to m² in area, m thick.	Internal contacts of strata are diffuse; loose.
Sediment flow	Sediment flow						
	Type I	Clasts dispersed in fine-grained matrix.	Massive.	Absent to very weak; vertical clasts.	Non-erosional, conformable contacts; contacts indistinct to sharp; load structures.	Lobe; maximum of 1000 m² in area, 2.5 m thick.	Dense, compact.
	Type II	Plug zone; clasts dispersed in fine-grained matrix;	Massive; intraformational blocks.	Absent to very weak; vertical clasts.	Non-erosional, conformable contacts; contacts indistinct to sharp.	Lobe; maximum 600 m² in area; 1.5 m thick; sheet of coalesced deposits.	Dense, compact.
		Shear zone; gravel zone at base, upper part may show decreased silt-clay and gravel content; overall, clasts dispersed in fine-grained matrix.	Massive; deposit may appear layered where shear and plug zones distinct in texture.	Absent to weak; bimodal or multimodal; vertical clasts.			
	Type III	Matrix to clast dominated; lack of fine-grained matrix possible; basal gravels.	Massive; intraformational blocks occasionally.	Moderate, multimodal to bimodal parallel and transverse to flow.	Non-erosional, conformable contacts; contacts indistinct to sharp.	Thin lobe; 200 m² in area; 0.5 m thick; fan wedge; 2000 m² in area; 3.5 m thick rarely; sheet of coalesced deposits.	Dense to loose.
	Type IV	Matrix, except at base, where granules possible.	Massive to graded (distribution, coarse tail).	Absent.	Contacts conformable; indistinct.	Thin sheet; 200 m² in area, 0.3 m thick; fills surface lows of irregular size and shape.	Loose.
Spall	Slope colluvium	Clasts dispersed randomly in matrix to clast supported.	Massive to intraformational blocks in massive material.	Absent; vertical clasts.	Conformable to former surface, non-erosional.	Irregular cross sections; band parallel to former slope of variable length, 2 m thick.	Loose; chaotic intraformational block orientations.
Slump	Slump	Clasts dispersed randomly in matrix.	Massive to undisturbed blocks over slip plane.	Absent, except in some blocks.	Shear plane may occur; conformable contacts.	Irregular; hundreds of m² in area, 2.5 m thick.	Loose to dense.
Ablation	Ice slope colluvium	Clasts dispersed in matrix to clast supported.	Massive.	Weak; parallel to trend of ice slope; low to high angle of dip.	Conformable to former surface; non-erosional.	Discontinuous thin sheets to wedge of variable area; 3.5 m thick.	Loose to dense.
Meltwater flow	Meltwater sheet and rill deposits.	Matrix.	Parallel stratification; deltaic cross stratification; massive to graded.	Parallel to flow; downslope dip.	Conformable to non-conformable; erosional to non-erosional.	Thin sheets; wedges, lenses; 1000 m² in area; 0.5 m thick.	Dense; associated with sediment flow deposits commonly.

Particles within the basal ice may also be deposited during regelation melt-out. Where ice is at the pressure melting point and sliding over the bed, debris may be passively deposited by melt-out during the melting portion of the regelation process. This process is probably effective primarily for smaller sized debris, particularly the matrix size materials which dominate Midwestern tills. The limitation for the size of debris deposited by this process is related to the size of the obstructions causing regelation melting and the thickness of the regelation water film.

Basal melt-out is the name given to material melted out from the basal ice by geothermal heat and the heat produced by glacier movement (deformation and sliding, where sliding is taking place). In many glacier situations, these two heat sources are sufficient to melt out till on the order of 1-3 cm in thickness annually (Boulton, 1970; Mickelson, 1973; Sugden and John, 1976). There is still some confusion exactly under what conditions basal melt-out occurs. Basal melt-out is certainly important in stagnant-ice conditions (figure 2) or where debris-rich ice has stagnated in hollows on the glacier bed, being overridden by cleaner, active ice. However, strict basal melt-out may be rare at the interface between the bed and actively moving ice which is at the pressure melting point. The reason for this is that the available heat may promote enhanced melting by regelation rather than by basal melt-out on the bed as a whole (i.e., melting may be concentrated at obstacles on the bed, rather than uniform melting over the whole bed). However, at present there is still a great need to understand the relationship between regelation melt-out and basal melt-out at the base of active ice at the pressure melting point.

It should be noted that of the three subglacial depositional processes, lodgement and regelation occur primarily particle by particle (or in some instances, small aggregates of particles). Basal melt-out, however, may include deposition of sizeable aggregates, such as lenses of till or other sediments in the ice, such as stratified sand, gravel or silt (Lawson, 1979).

Subglacial depositional processes may inherit fabric largely from the parent ice (Boulton, 1971, 1976; Lawson, 1979) with only partial reorientation as the interstitial ice melts out. Since subglacially deposited tills are deposited beneath ice loads, they often become overconsolidated (in the geotechnical sense) and consequently have relatively high density. Subglacially-deposited tills may contain lenses of meltwater deposits. These deposits may originate as: 1) meltwater deposits eroded by the ice and subsequently deposited with the till; or 2) meltwater deposits in subglacial or englacial channels. In general, however, meltwater deposits volumetrically constitute only low proportions of subglacially-deposited sediments in active ice situations.

Dreimanis (1976) gives the generic name "basal till" to tills deposited subglacially (figure 1). Basal till is a useful term because it is not always possible to determine which depositional process may have taken place, and used in this sense, the term recognizes or implies that there

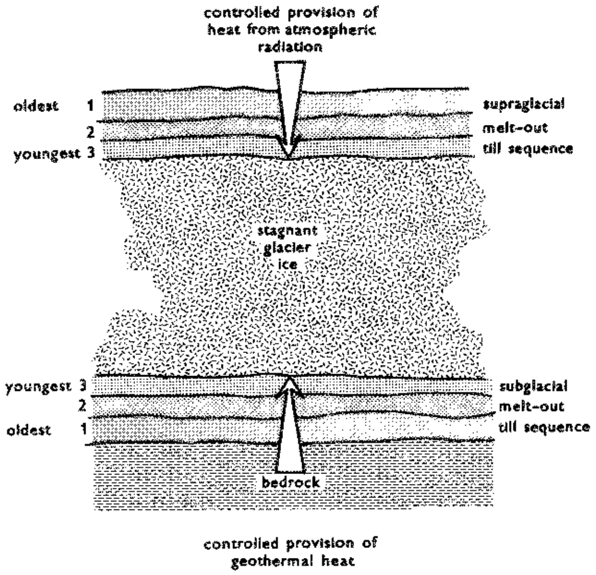


Figure 2. Melt-out till sequences in supraglacial and subglacial situations, showing the age relationships of the layers added (from Sugden and John, 1976, p. 221).

may be more than one process of subglacial till deposition. More detailed discussions of subglacial sedimentation occur in Boulton (1972, 1976), Dreimanis (1976), Goldthwait (1971), Lawson (1979), Mickelson (1973), and Sugden and John (1976).

Supraglacial Sedimentation

Sedimentation in the supraglacial environment may be extremely complex (figure 3). More extensive discussions of sedimentation in the supraglacial environment can be found in Boulton (1972, 1976), Lawson (1979), Sugden and John (1976), and references cited in these publications.

Supraglacial sediments may consist of three basic types: 1) supraglacial melt-out till (figure 2), which largely inherits its properties from the parent ice; 2) resedimented deposits (Lawson, 1979) or flow till (Hartshorn, 1958; Boulton, 1972), which consist of deposits which have been subject to flow, reworking and resedimentation on and/or next to the ice surface, and which derive their sedimentologic properties from the resedimentation processes; many of these deposits are till-like (diamictons) in appearance; and 3) supraglacial meltwater deposits, which represent resorted deposits in supraglacial channels and pools.

Supraglacial sedimentation begins quite simply with the melt-out of debris from the ice. In continental ice sheets, this debris originates either as basally-derived debris which, as a result of ice dynamics, has been transported up to an englacial or supraglacial position or may simply be debris-rich basal or englacial ice which has become exposed near the

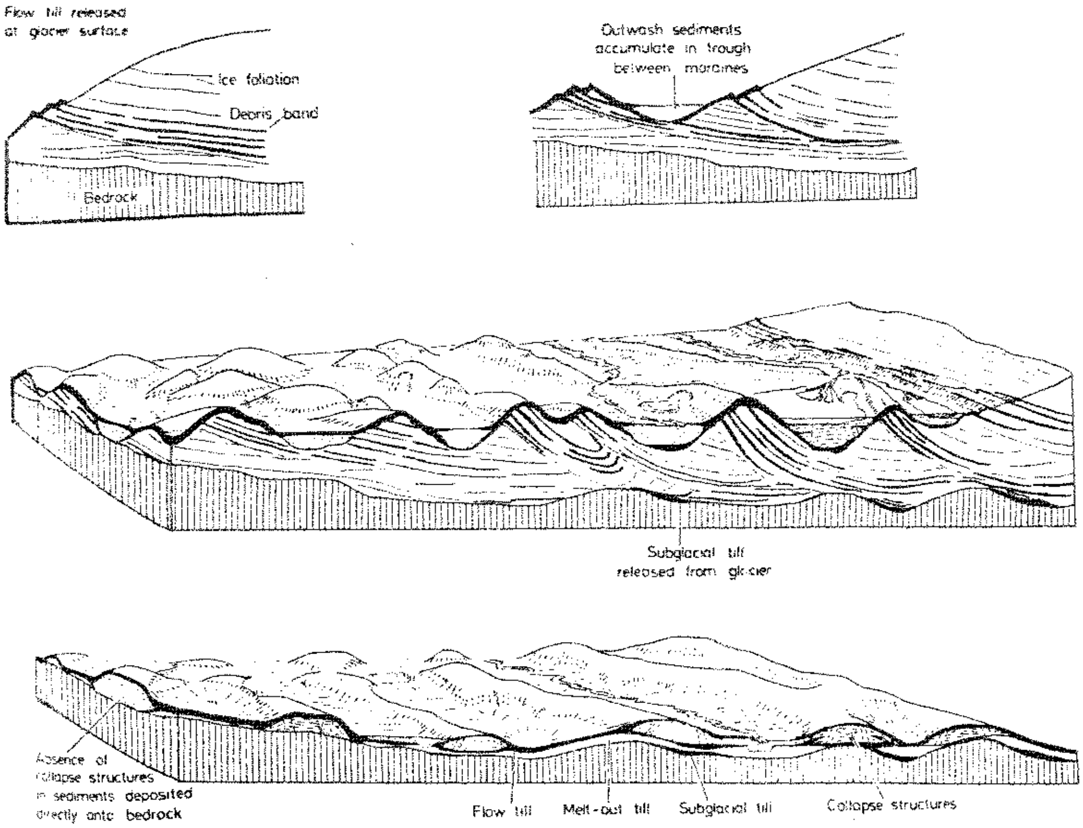


Figure 3. Schematic diagrams illustrating the complexity of sedimentation in the supraglacial environment (from Boulton, 1972).

terminus as the ice surface is lowered by ablation. The heat for this supraglacial melt-out is supplied ultimately by solar radiation, but other factors, such as heat from meltwater streams and ponds, etc., may contribute to the melting. Since the debris in the ice is generally poorly-sorted, passive melt-out of the debris may result in a till-like deposit. After the debris has been melted out, a number of options may occur depending on the local conditions. In the simplest case, the material may simply be let down with virtually no disturbance. Till deposited in this manner is probably the true supraglacial melt-out till (Sugden and John, 1976). Alternatively, fines may be removed by meltwater on the ice surface, leaving a coarse-textured, poorly-sorted lag. This is the simplistic concept of ablation till, as used for many years by Flint, (1957, 1971; see figure 4). In both of the above cases, the material was simply let down as the underlying ice melted out.

The supraglacial debris may just as well have been subject to flow and resedimentation as described by Boulton (1972) and Lawson (1979). Lawson's study is the most comprehensive to date and will be used to briefly illustrate the resedimentation processes which may occur in the supraglacial environment. Till-like deposits may result from the following resedimentation processes:

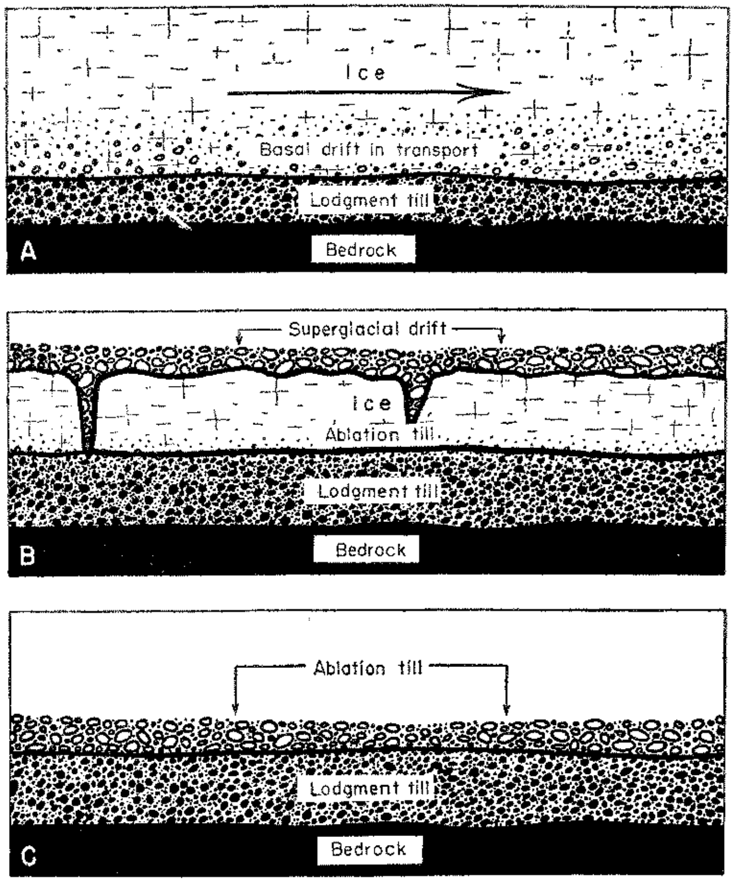


Figure 4. Origin of lodgment till and ablation till envisaged by Flint, 1957, p. 121. A. Basal drift in transport lodges over bedrock to form lodgment till. B. Later, thin ice near the glacier margin wastes away beneath a cover of superglacial drift, from which trickling water has removed the finer particles. Ablation till is being deposited from basal zone of ice. C. Postglacial condition. The superglacial drift forms thin layer of ablation till over the lodgment till.

1. Sediment flow: deposits resulting from the flow of supraglacial sediments. Both Boulton (1972, 1976) and Lawson (1979) recognize that there are several different flow types which differ in the mode of flow and in the properties of the resulting sediments (Tables 1 and 2).

2. Ice slope colluvium: deposits formed when debris melts out onto a sloping ice surface and accumulates at the base of the slope. These deposits may be transitional to melt-out till in some situations.

3. Slope colluvium: deposits formed when supraglacial sediments collapse by spall off a steep ice wall.

4. Slump deposits: deposits formed when supraglacial material is subjected to slumping.

Supraglacial meltwater sediments are deposited in meltwater streams and ponds on the glacier surface. The texture of the meltwater deposits is largely a function of the particle sizes available for transport and the sorting which has taken place.

The supraglacial environment, in contrast to the subglacial environment, is one in which meltwater may play an important part. Certainly, the potential for meltwater activity is great. The effect of the meltwater is three-fold: 1) it may promote mass wasting of supraglacial sediments by various processes of sediment flow or slumping; 2) it may physically alter the constituency of till-like deposits by flow, winnowing, etc.; and 3) it may result in the complete reworking with the subsequent sedimentation of supraglacial fluvial and lacustrine sediments.

In addition to these single processes of sedimentation it should be realized that the supraglacial environment is a dynamic one: near the terminus considerable amounts of debris may be released out onto the ice surface as the ice melts downward. Both differential melting and collapse (the latter resulting from the collapse or undercutting of sub- supra- or englacial meltwater channels) cause the supraglacial surface to be an ever changing one. Debris subject at one period to flow, may later be subject to several periods of resedimentation before all of the underlying ice melts out. Supraglacial channels or ponds may in turn be drained suddenly by the collapse of adjacent or underlying ice, or clogged by the influx of sediment flows or slumps from adjacent higher slopes. Consequently, supraglacial sediments commonly consist of resedimented till-like materials interbedded with meltwater deposits. The till-like materials commonly show evidence for flow or some degree of reworking by meltwater but this need not always be the case. The supraglacial sediment assemblage may also show evidence for some sort of collapse or flow. Consequently, the sediment sequence and character of supraglacially-deposited sediments may differ recognizably from subglacially-deposited sediments.

Stop 1. Alden Section

Weaver Construction Company Quarry; described section located on the south side of U.S. Highway 20 in the NE¼, of the NW¼, of the NW¼ of sec. 20, T. 89N., R. 21W., Hardin Co. Elevation 1150 feet (350 m). The Alden Section is in a moderate relief "minor moraine" area, with local modification by stream dissection.

Objectives: There are three primary objectives at this stop;

1. Examine the character of the basal till of the Des Moines Lobe:

    a. Note the uniformity in morphology and texture of the basal till both vertically and laterally. The till is almost devoid of any interbedded stratified deposits.

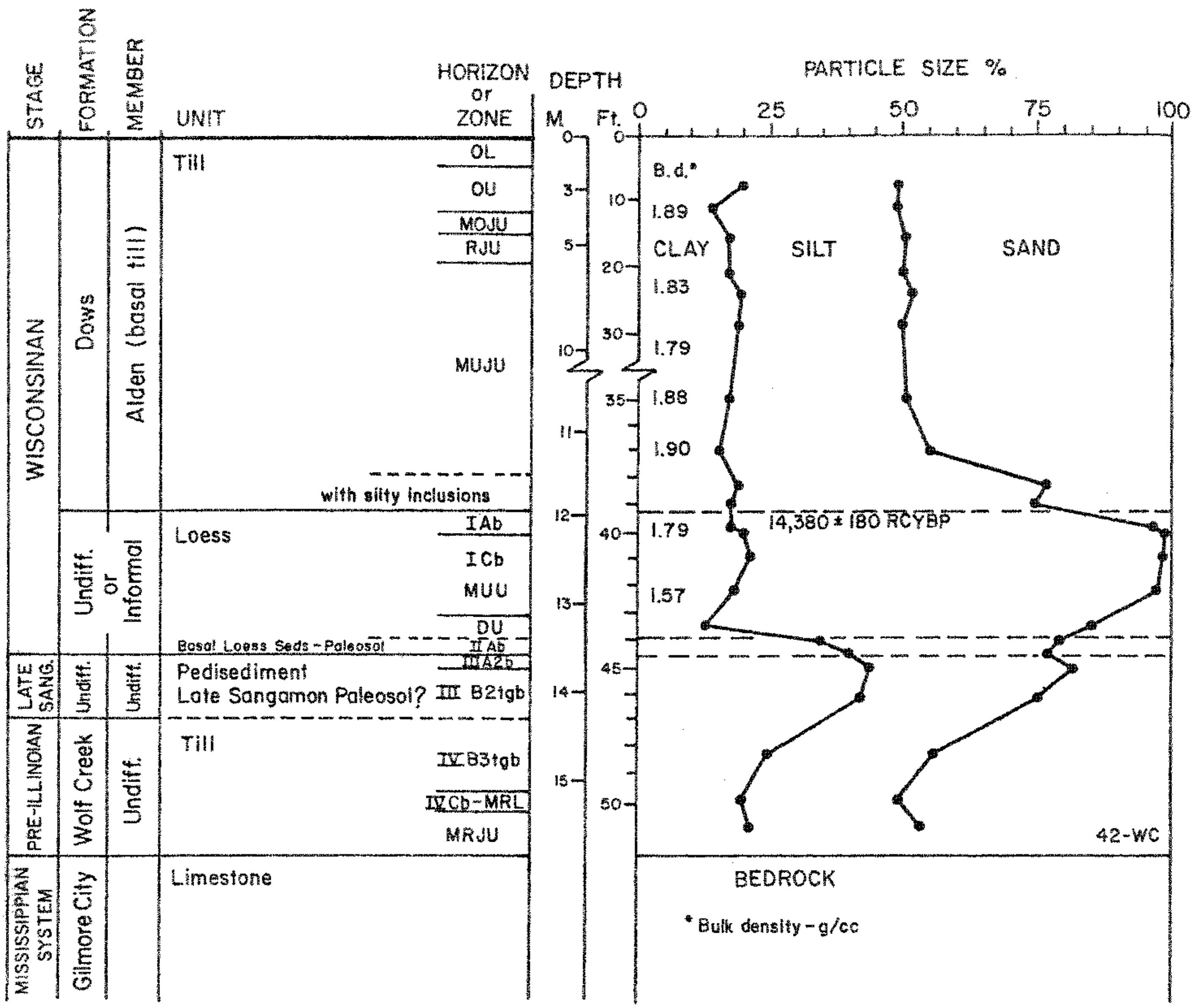


Figure 5. Stratigraphy, particle-size and bulk density data for the Alden Section.

b. Note that the only exception to this uniformity is at the bottom of the till where the local substrate (loess) has been incorporated into the lower 0.3 m of the till.

2. Note the stratigraphic setting of the Des Moines Lobe deposits; i.e., the basal till lies on Wisconsinan loess and older Quaternary sediments, not bedrock.

3. Look at the nature of Late-Wisconsinan (post-glacial) and Holocene changes to the landsurface demonstrated by the presence of stone lines and thin overlying hillslope sediments.

The stratigraphy of the Alden Section, as originally described and sampled in 1976 by George Hallberg of the Iowa Geological Survey, is shown in figure 5. The accompanying mineralogy data for this section is given in Table 3. In brief the section is comprised of about 12 m of Late Wisconsinan basal till of the Des Moines Lobe which overlies about 1.5 m of Wisconsinan loess. The loess in turn overlies a well-developed paleosol developed in pre-Wisconsinan sediments resting on Mississippian age underburden.

The principal features of basal till of the Des Moines Lobe in Iowa are illustrated at this section. The basal till contains virtually no interbedded meltwater deposits within it. It is also dense and very uniform in its textural, mineralogical, and morphological properties throughout the exposure (figure 5, Table 3). The uniformity found for the basal till at this exposure is also found regionally (figure 6, Table 4). Thus, although till as a sediment is poorly sorted, in certain glacial settings, such as here in Iowa, its matrix texture and composition can be remarkably uniform with a relatively narrow range of values for each property. This is of great practical value to us as it allows us to map different till units as rock stratigraphic units. Previous studies of the lithologic characteristics of tills in Iowa include Van Zant (1974), Hallberg (1980) and Hallberg, ed. (1980).

Mineralogically, a conspicuous feature of the till of the Des Moines Lobe is the presence of clasts of Upper Cretaceous shale (Table 3). These clasts can readily be seen in the till at this outcrop.

The only major exception to the remarkable uniformity of the basal till occurs in a zone located at the bottom of the till. The lowermost 0.3 m (1-2 feet) of the basal till is enriched in silt content as shown on figure 5. There is a gradational change upward in particle-size distribution from till which is high in silt content (near the loess contact) to the uniform till texture typical of the basal till both at this site and regionally. Zones of this type are common in the basal till; only infrequently have a few small, discrete block inclusions of loess been discernible in the till. Generally it appears that loess has been incorporated and dispersed throughout the till matrix, and that these locally-derived materials have been progressively diluted upward in the section. This dilution may likely be caused by repeated regelation at the base of the ice. Kemmis (1981) hypothesizes that such zones in the lower increments of basal till are related to erosion-transportation-deposition resulting from recurrent regelation in the basal ice as it moved over an unlithified sediment bed (in this case loess). Where these zones occur, local substrate materials, such as the loess, may have been eroded particle-by-particle during regelation freezing, diluting the normal, farther-travelled debris load. Thus with time the character of the basal till would change: initially, local materials, such as the loess, would dominate the composition of the till matrix, but progressively these local materials would form lower and lower proportions of the matrix materials as more of the local substrate became covered up. Finally, after the local source was completely covered up, the farther-travelled, better homogenized material would constitute the till matrix.

Table 3. Mineralogy data, Alden Section.

			Clay Mineralogy %			Sand-Fraction Lithology %				
Depth M(ft.)		Horizon or Zone	Ex.	Ill.	K+C	T.C.	Sh.	T.X.	Q.-F.	T.X.
			LATE-WISCONSINAN (Cary)							
			DOWS FORMATION							
					Alden Member (basal till)					
2.4	(8.0)	OU	72	17	11					
3.4	(11.0)	OU	65	22	13	34	6	42	48	58
5.0	(16.5)	RJU	70	18	12					
6.6	(21.5)	MUJU	71	16	13	27	13	41	52	59
7.3	(24.0)	MUJU	74	14	13					
9.0	(29.5)	MUJU	65	20	15	31	10	42	50	58
10.7	(35.0)	MUJU	64	24	12					
11.3	(37.0)	MUJU	60	24	16	28	8	39	57	61
11.7	(38.5)	MUJU	69	16	15	30	6	36	57	64
11.9	(38.9)	MUJU	62	24	14					
			WISCONSINAN							
			Loess undiff.							
12.0	(39.5)	IAb	58	28	14					
12.2	(40.0)	MUU	62	24	14					
12.5	(41.0)	MUU	63	24	13					
13.3	(43.5)	MUU	70	23	8					
			PRE-ILLINOIAN							
			WOLF CREEK FORMATION							
					Till Undiff. (Hickory Hills Till Mem?)					
15.4	(50.5)	MRJU	61	19	20					
15.6	(51.1)	MRJU	62	17	21	31	1	34	54	65

Ex. - expandable clay minerals

Ill. - Illite

K+C - Kaolinite plus chlorite

Q.-F. - quartz-feldspar

T.C. - total carbonate grains

Sh. - shale

T.S. - total sedimentary grains

T.X. - total crystalline grains

The upper part of the basal till at this site and elsewhere has been subject to late Wisconsinan ("post glacial") and Holocene slope development and possibly some minor eolian activity. Across the high points on the landscape surficial sediments, commonly 15-20 cm (6-8 inches) thick, overlie a stone line. Downslope, the stone line grades into a thicker zone of pebbles and cobbles in minor drainageways, and the overlying sediments may thicken to approximately 1 m (3 feet). It is important to recognize that these sediments are related to the post-glacial, subaerial modification which these landforms have undergone, and that they should not be confused with supraglacial sediments.

At this stop we should also note the relationship of the Des Moines Lobe deposits to the underlying strata. Beneath the basal till in the described section, a weak A/C soil profile occurred at the top of the Wisconsinan

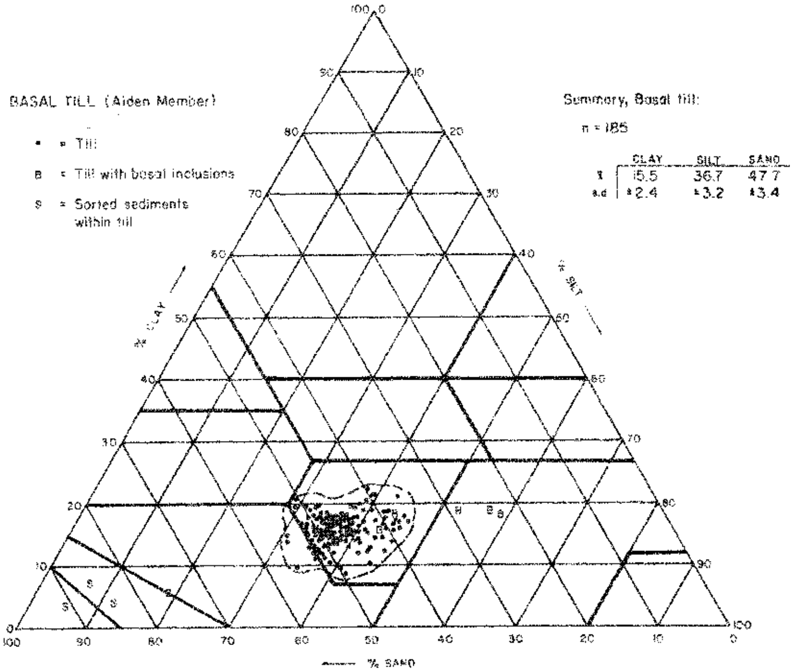


Figure 6. Textural values for basal till of the east-central Des Moines Lobe area.

loess. The A-horizon in the loess was 15-25 cm (6-10 inches) thick, and was leached of carbonates. The leaching extended 5-8 cm (2-3 inches) into the underlying C-horizon. At the contact between the till and the paleosol several broken logs occurred. Four different log fragments have been identified; 2 were larch and 2 were spruce (Larix undiff., and Picea undiff., Dr. Dwight Bensend, Dept. of Forestry, Iowa State University, and Dr. Frances B. King, Illinois State Museum, pers. comm.). One of these logs from the contact was radiocarbon dated at 14,380 ± 180 RCYBP (I-9765). This dates the advance of the Des Moines Lobe ice in this area.

The loess in turn overlies a strongly developed paleosol formed in Pre-Wisconsinan sediments and till. This till is correlated with the Wolf Creek Formation of Pre-Illinoian age (Hallberg, 1980) and overlies Mississippian bedrock.

Since the original sampling in 1976, the quarry operation has expanded significantly, and the face of the Quaternary deposits has been moved more than 30 m (100 feet). The Wisconsinan section is still very similar to that described (figure 5). However, beneath the loess the paleosol which occurs is now seen to be developed in fine-textured pre-Wisconsinan alluvial sediments which in turn overlie bedrock. Note that across the quarry, the basal till of the Des Moines Lobe does not lie on bedrock but on older Quaternary sediments. Thus, in analyzing the sub-Des Moines Lobe surface, one *cannot* deal with just the bedrock surface. In fact, since only a very small percentage of the Des Moines Lobe deposits in

Table 4. Summary mineralogic data for basal till of the east-central Des Moines Lobe area.

CLAY MINERALOGY - %
n = 94

Alden Member - basal till

	Ex.	Ill.	K+C
mean	69	19	12
s.d.	4	3	3
range	56-78	14-26	8-18

SAND-FRACTION LITHOLOGIES - %

Alden Member - basal till
n = 62

	C/D (ratio)	T.C.	Sh.	T.S.	Q.-F.	T.X.
mean	3.8	27	14	42	50	58
s.d.	6.3	6	8	9	8	9
range	0.6-NoD	19-33	1-39	24-72	28-68	28-76

MATRIX CARBONATES - %

Alden Member - basal till
n = 38

	C/D	Cal.	Dol.	T.C.
mean	0.29	3.5	12.3	15.8
s.d.	0.13	1.4	2.0	2.5
range	0.11-0.43	0.6-5.2	5.5-15.8	6.1-19.2

KEY

Ex. - expandable clay
Ill. - illite
K+C -kaolinite plus chlorite

C/D - calcite/dolomite ratio
T.C. - total carbonate
Sh - shale
T.S. - total sedimentary grains
Q.-F. - quartz-feldspar grains
T.X.-total crystalline grains (Q.-F. plus igneous and metamorphic)
Cal. - calcite
Dol.-dolomite
MATRIX CARBONATES determined using Chittick apparatus after methods of Walter and Hallberg, 1980

Iowa rest on bedrock, one must be extremely cautious in using the configuration of the bedrock topography as the basis for inferring the flow regime of the Des Moines Lobe ice.

Stop 2. Dows Quarry Section

Weaver Construction Company Quarry located on the west side of the gravel road in the NE¼ of the SE¼, sec. 30, T. 91N., R. 22W., Franklin Co. Elevation 1160 feet (353 m). The Dows Quarry Section is on the flank of the high-relief Altamont I ridge complex.

Objectives: There are several items which we want to observe and emphasize at this site:

1. The nature of the supraglacial sediments. At this site we can observe a number of features indicative of deposition in the supraglacial environment.

2. The contrast between the supraglacial sediment sequence and the dense, uniform basal till.

3. The nature of "block inclusions" which occur in basal till. Block inclusions are blocks of local substrate which have been eroded and deposited intact within the basal till.

4. One of the subglacial deformational structures, slickensides, which have developed in a paleosol that occurs just beneath the basal till of the Des Moines Lobe deposits.

5. The stratigraphic relationship between the Des Moines Lobe deposits and the underlying materials. This site, as at Stop 1, consists of Des Moines Lobe deposits which overlie a complex sequence of older Quaternary sediments, not bedrock.

In brief, the sequence at this location consists of approximately 13 m (40 feet) of Des Moines Lobe deposits (Dows Formation) of which the upper 8 m (25 feet) consists of supraglacially-deposited tills, diamictons, and associated meltwater deposits (Morgan Member) while the lower 5 m (15 feet) consist of basal till (Alden Member; figure 7). The Des Moines Lobe deposits stratigraphically overlie an older Wisconsinan till, the "Tazewell" till (figure 8), which in turn overlies a well-developed paleosol developed in pre-Wisconsinan sediments that rest on a third till of Pre-Illinoian age (figure 9). The combined thickness of the pre-Wisconsinan sediments and the third till in the sequence is approximately 5 m (15 feet) across the section. These units in turn rest on Mississippian age limestone.

The Des Moines Lobe deposits at this site consist of a thick sequence of supraglacially-deposited sediments over basal till. This section exposes one of the best sequences of supraglacial sediments in the state. A number of features indicative of supraglacial sedimentation are present including interbedded till-like sediments and meltwater deposits which show various structures indicative of collapse of adjacent and underlying ice. The described section includes 8 m (25.0 feet) of supraglacial sediments which include a transition upward from melt-out till (figure 2) to deformed sediment flows (till-like deposits) and interbedded meltwater deposits. The scenario envisaged for the deposition of these supraglacial sediments is shown on figure 3.

The supraglacial sediments are variable in texture and in thickness across the section. The great variability in the supraglacial sediments across the section makes sampling difficult. To present the section and data for documentation we have simply sampled one vertical section as an example of the variability present (figure 7). The variability in texture for the supraglacially-deposited diamictons is related to resedimentation processes (flow, slump, meltwater reworking, etc.) which can take place in the supraglacial environment (figure 3; Lawson, 1979). The matrix texture of supraglacially-deposited till-like sediments is highly variable (figure 10), in sharp contrast to the uniform matrix texture of the basal till. Although one would always like to be able to reconstruct the exact sequence of events that have occurred at a site, this may not always be possible in a sequence of supraglacially-deposited sediments, even when they are as well or convincingly exposed as at this section. The reason for this is because of the dynamic nature of the supraglacial environment. This mixture of till-like sediments and meltwater deposits has likely been subjected to more than one period of post-depositional flow and collapse as the underlying ice melted out, obscuring the record. The result of these multiple periods of deformation would be to produce a chaotic mixture of till-like sediments and meltwater deposits. For instance while the boundaries of one till flow might be easy to recognize, if subsequent flow or collapse involves only a portion of that flow, reconstructing the sequence of events becomes significantly more difficult. Imagine what the difficulty becomes if parts of this flow were subject to several such deformational events.

This section provides one of the principal correlation sections between landforms and sediments on the Des Moines Lobe. Thick supraglacial sediments tend to occur in the hummocky, high relief areas. The Dows Quarry Section in this case is located on the back side of a hummocky, high relief ridge system, the Altamont I Moraine, which is part of the eastern, lateral ice-marginal position of the Altamont Moraine. We will see a similar setting of thick supraglacial sediments, but in a core, along the lateral portion of the Algona Moraine, Stop 6.

The supraglacial deposits at this site overlie typical basal till, till which is dense (Table 5) and uniform in composition (Table 6, figure 7) and has essentially no interbedded meltwater deposits: a strong contrast to the overlying supraglacial sediments. The basal till at the described section (figure 7) is 5 m (16.5 feet) thick. This is about the thickest area of basal till in the exposure. In other places across the exposure, the basal till may thin to as little as 0.5-1.0 m (2-3 feet). Two pieces of spruce wood from the lower 0.8 m of the basal till have been dated at 13,525 ± 95 RCYBP (Beta-1076) and 13,400 ± 130 RCYBP (DIC-1651).

The Des Moines Lobe deposits at this site overlie either an earlier Wisconsinan till, presently correlated as the "Tazewell" till, or where the Tazewell till has been truncated they overlie a paleosol, the Yarmouth-Sangamon Paleosol, developed in pre-Wisconsinan sediments. The Tazewell till is oxidized (yellowish brown color) over much of the exposure, and as a consequence, the abrupt contact with the unoxidized (dark greenish gray) basal till of the overlying Dows Formation is pronounced. The Tazewell till is truncated at the very north end of the Dows Quarry exposure. Elsewhere, the till varies from 1-3 m (2-9 feet) in thickness and is comprised primarily of basal till.

Correlation of the Tazewell till is based on the lithology and physical features of the till, radiocarbon dating, and relative stratigraphic

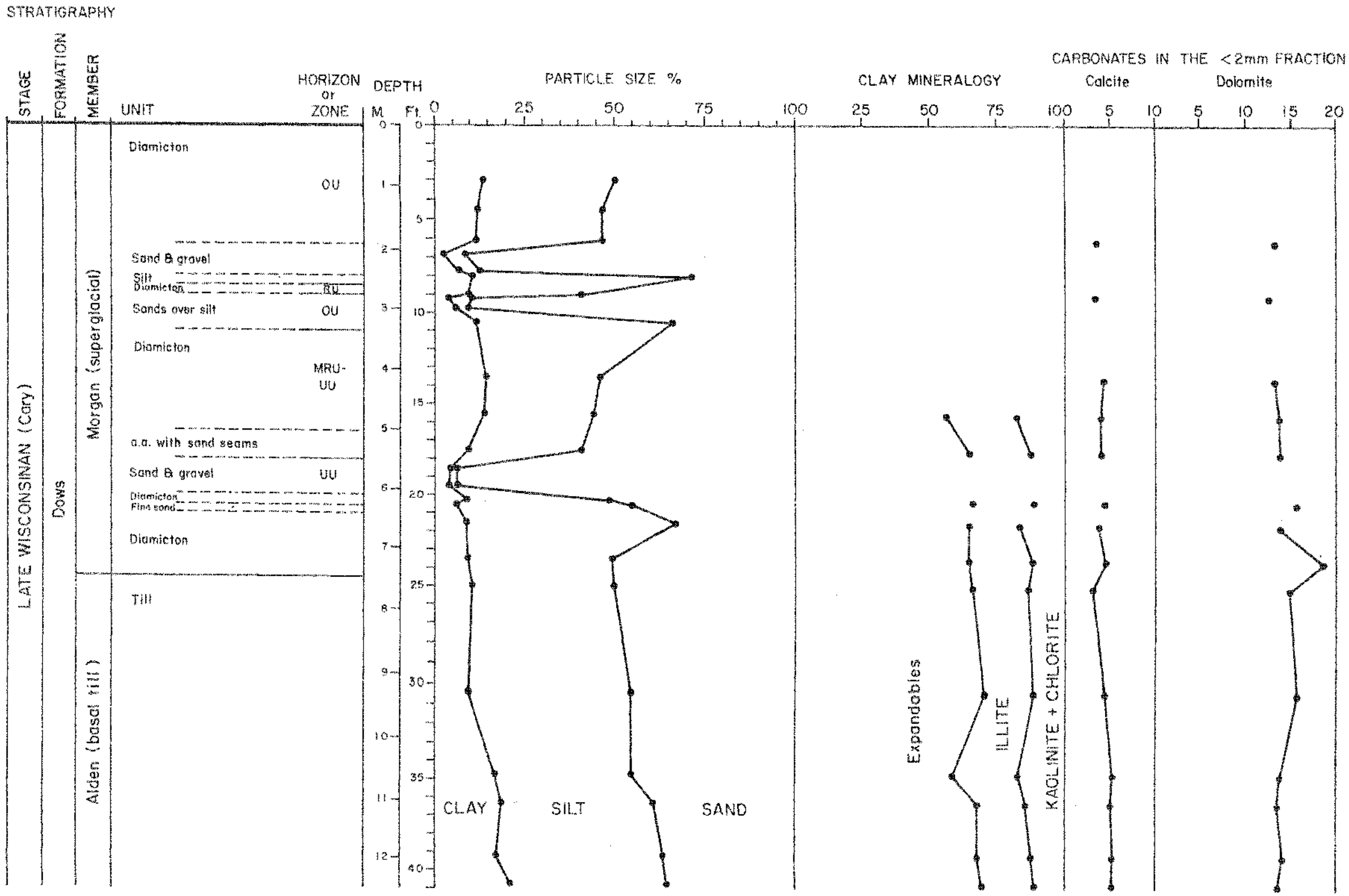


Figure 7. Stratigraphy, particle-size and mineralogy data for the Dows Formation, Des Moines Lobe deposits at the Dows Quarry Section.

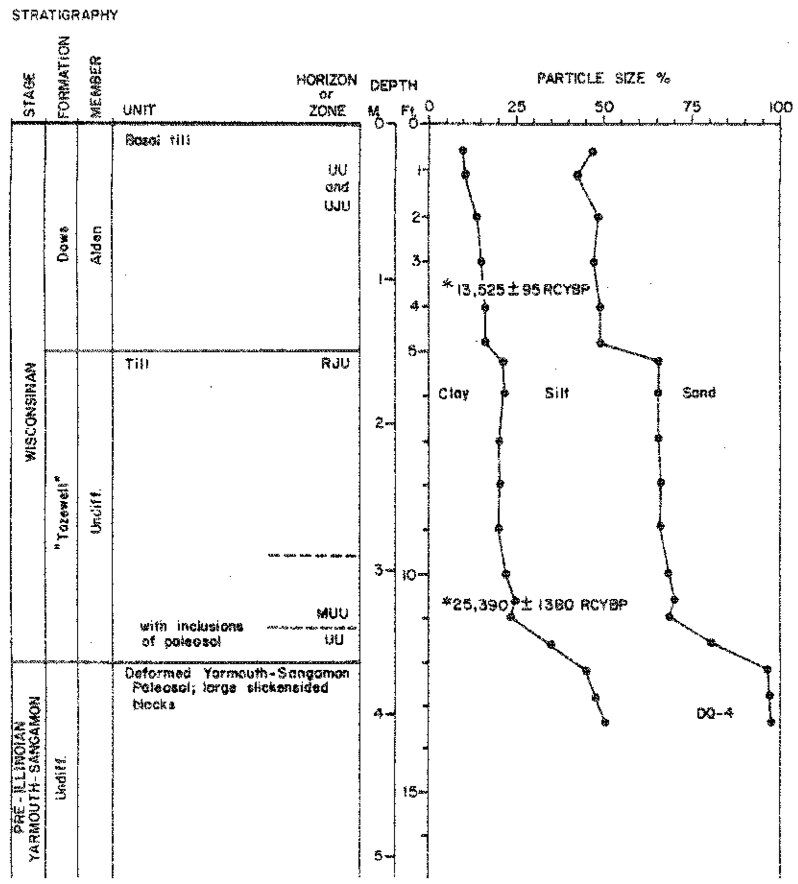


Figure 8. Stratigraphy and particle size data for a portion of the stratigraphic sequence exposed in Dows Quarry. Note the uniformity in matrix texture for the basal till of the Des Moines Lobe (Dows Fm., Alden Mem.) and the basal till of the "Tazewell" till. Note also the contrast in texture between the two tills.

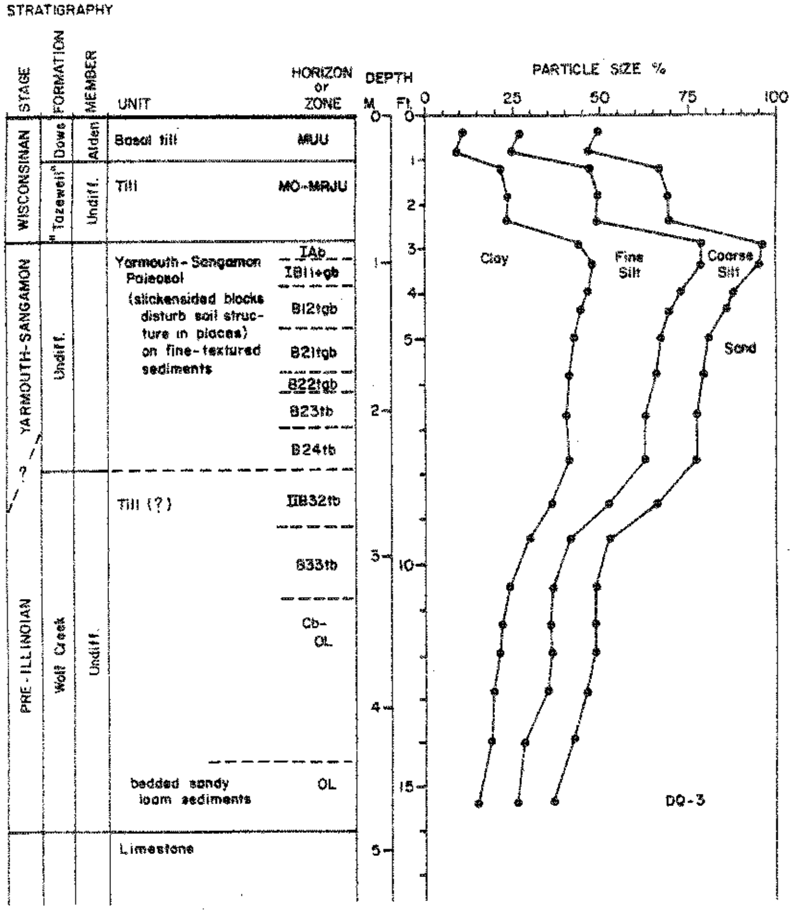


Figure 9. Stratigraphy and particle size data for the lower portion of the Quaternary sequence exposed in Dows Quarry.

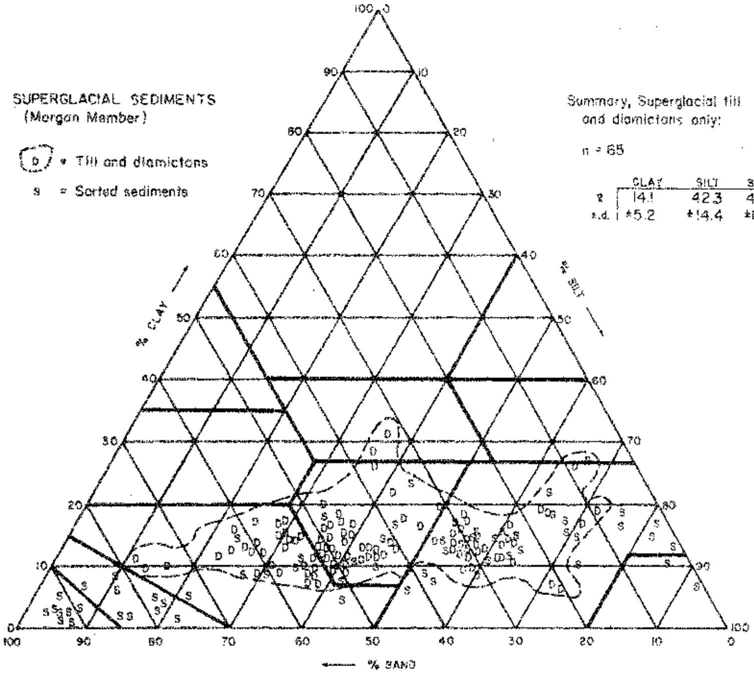


Figure 10. Textural data for supraglacially-deposited sediments in the east-central Des Moines Lobe area. Contrast the wide range of textural values for the supraglacial till-like sediments (denoted by the symbol D on the diagram) with the narrow range of values for basal till (figure 6).

position. The "Tazewell" till at this site is loam textured, but, in contrast to the Des Moines Lobe basal till, the silt content is greater than the sand content (figure 8). The clay mineralogy shows a high expandable content with illite slightly higher than kaolinite, and the matrix carbonate data show a relatively high total carbonate content and a C/D ratio between 0.3 and 0.4 (Table 7). These lithologic data contrast with data for Pre-Illinoian age tills in east-central Iowa (Hallberg, 1980; Hallberg, Wollenhaupt and Wickham, 1980), but are very similar to data on the "Tazewell till" in northwest Iowa (Hallberg and G.A. Miller, unpublished data). In outcrop, the Tazewell till also has physical features different from those typically found for Pre-Illinoian age tills in the area. It does not have the pervasive jointing often found in the Pre-Illinoian tills, and what joints are present lack the strong secondary alteration found along joints in Pre-Illinoian age tills in Iowa. The Tazewell till, although oxidized across most of the section, is not oxidized to the bright yellowish-brown and reddish brown colors typically found for the Pre-Illinoian age tills. One discrepancy between this till and typical "Tazewell" till, however, is in the content of shale clasts. The "Tazewell" till at this site contains only about 2% Cretaceous shale clasts in the ½-1 inch pebble fraction. Cretaceous shale clasts in the "Tazewell" till of northwest Iowa are much more conspicuous and occur in higher percentages (Van Zant, 1974). Even so, we tentatively correlate this till with the "Tazewell" till.

Table 5. Density data for subglacially and supraglacially deposited Des Moines Lobe deposits at Dows Quarry.

	Bulk Density g/cc	Void ratio e	Moisture Content %	Saturation %	Notes
	Supraglacial deposits - (Morgan Member) - oxidized and unleached mottled - oxidized and unleached				
	1.69	0.57	11.5	54	Till-like, with interbedded sands; Near Fabric Site.
	1.85	0.43	11.0	67	
	1.75	0.52	11.5	59	Till-like
	1.67	0.59	12.2	55	Silty-diamicton
	1.71	0.55	14.2	76	Till-like
	Till Bed? mottled-oxidized; mottled-reduced to mottled-unoxidized and unleached.				
	1.83	0.45	10.4	61	Till, near Fabric Site
	1.77	0.49	10.4	56	
	1.85	0.43	11.8	73	MR-MUU till
1.	2.00	0.32	10.0	83	1) UU - MUU Block within MRU
2.	1.79	0.48	10.5	59	till 2.)
	1.73	0.53	11.0	54	MRU till with silty inclusions overlying next two samples:
	Till Bed? or Basal till				
	1.85	0.43	11.8	73	MUU till
	1.91	0.39	10.0	68	MUU till
	Basal till deposits (Alden Member all unoxidized and unleached uniform till				
	2.01	0.32	11.0	92	Near fabric site
	1.98	0.34	12.0	96	
	1.94	0.37	14.0	100	
	1.95	0.36	13.6	100	Below fabric site in "Till Bed"
	2.02	0.31	12.0	100	
	2.00	0.32	12.0	100	Just above contact with "Tazewell" till.

Table 6. Clay mineralogy data for the Des Moines Lobe deposits at Dows Quarry.

		Clay Mineralogy %		
Depth M(ft.)	Horizon or Zone	Ex	Ill.	K+C
LATE WISCONSINAN (Cary)				
	DOWS FORMATION			
		Morgan Member (supraglacial deposits)		
4.7 (15.5)	UU	56	26	18
5.3 (17.5)	UU	64	23	13
6.1 (20.0)	UU	66	22	12
6.6 (21.5)	UU	64	18	18
7.2 (23.5)	UU	64	24	12
		Alden Member (basal till)		
7.6 (25.0)	UU	66	20	14
9.1 (30.0)	UU	70	18	12
10.7 (35.0)	UU	61	21	18
11.0 (36.0)	UU	67	18	15
11.9 (39.0)	UJU	67	20	13
12.5 (41.0)	UJU	69	19	12

Small wood fragments, painstakingly separated from the base of the Tazewell till at this site by George Hallberg, were radiocarbon dated at 25,390 ± 1380 RCYBP (Beta-1764). This date is somewhat older than the 20,000 RCYBP dates reported by Ruhe (1969) for the Tazewell till in northwestern Iowa.

At the north end of the exposure "block inclusions" are present within the Tazewell till. They consist of blocks of underlying substrate which have been eroded and deposited intact within the basal till. The block inclusion which we will see is a block of the underlying paleosol. The color and texture contrast between the gleyed paleosol and the oxidized basal till of the Tazewell till is pronounced, making these block inclusions easy to recognize.

The Tazewell till rests on a paleosol developed in pre-Wisconsinan sediments that in turn rest on a Pre-Illinoian age till. Where the Tazewell till is truncated the Des Moines Lobe deposits rest on the truncated paleosol. The total thickness of the pre-Wisconsinan sediments and the Pre-Illinoian age till is approximately 5 m (15 feet) across the section. The Pre-Illinoian till is poorly exposed over most of the exposure. It is probably thickest at the north end of the quarry, reaching thicknesses of a few feet. To the south it appears to thin while the overlying sediments thicken to comprise nearly all of this interval. Based on mineralogic data, the till correlates with the Pre-Illinoian age Wolf Creek Formation described by Hallberg (1980).

Table 7. Clay and carbonate mineralogy of the "Tazewell" till at the Dows Quarry Section.

Clay Mineralogy

Horizon or Zone	Ex.	ILL.	K+C
RJU	61	19	20
RJU	65	18	17
UJU	58	17	15

Matrix Carbonate
%

C/D	Cal.	Dol.	T.C.
0.41	5.3	13.0	18.3
0.41	5.7	13.9	19.6
0.37	5.3	14.2	19.5
0.38	6.1	16.1	22.2
0.40	5.8	14.5	20.3

At the north end of the quarry exposure the paleosol in the pre-Wisconsinan sediments has been partially truncated and is directly overlain by the basal till of the Des Moines Lobe deposits. The truncated paleosol has been strongly deformed by the overriding ice of the Des Moines Lobe and exhibits well-expressed slickensides on large shear faces of varying orientation. This is a good exposure to see these features resulting from subglacial deformation of unlithified sediments.

PART II. THE ALGONA MORAINE AND VICINITY

The second part of the field trip will examine a variety of different landscapes and materials in the vicinity of the Algona Moraine (figure 11): 1) glacial lake sediments overlying Des Moines Lobe till in front of the Algona Moraine (Stop 3); 2) the sediments and landscape features of the frontal portion of the Algona Moraine (Stop 4); 3) the sediment sequence and landscape features of the lateral portion of the Algona Moraine (Stops 5 and 6); and 4) the sediment sequence in a former supraglacial lake in part of the Bemis-Altamont Moraine Complex adjacent to the lateral portion of the Algona Moraine (Stop 7).

Stop 3. Corwith Core 2, Glacial Lake Jones

Core taken from the west side of Iowa Route 17 in the SE¼, NE¼, SE¼ sec. 36, T. 95N., R. 26W., Kossuth Co. Elevation 1177 feet (359 m). The Corwith Core 2 site is located in a very low relief, multi-leveled area in front of the Algona Moraine.

Soil survey investigations over the past few years have revealed that glaciolacustrine sediments are present over surprisingly large areas on the Des Moines Lobe. The objective of this stop is to view a core of these sediments from a site that is part of an extensive glaciolacustrine area (250 to 500 km^2) just in front of the Algona Moraine.

The Corwith Core 2 site, originally sampled in November, 1979, consisted of over 5.5 feet (1.7 m) of glaciolacustrine sediments overlying till (figure 12). The glaciolacustrine sediments are dominantly fine-grained (silt loam, silty clay loam and loam textured). In other cores in this area, fine-grained sediments dominate the upper part of the glaciolacustrine sequence, while the base of the sequence consists of stratified sands, and in some cases, fine gravels, interbedded with fine-grained sediments.

The Corwith Core 2 site lies in an area which we are presently informally referring to as Glacial Lake Jones. A great deal of work remains to be done on Glacial Lake Jones: what is its extent, what variations are there in sediment types and thicknesses, what was the origin of the lake (or lakes)? Because of the large area involved, Glacial Lake Jones would be a good area for a Ph.D. dissertation involving sedimentology and Quaternary geology, although portions of the area might be selected for a detailed Master's thesis.

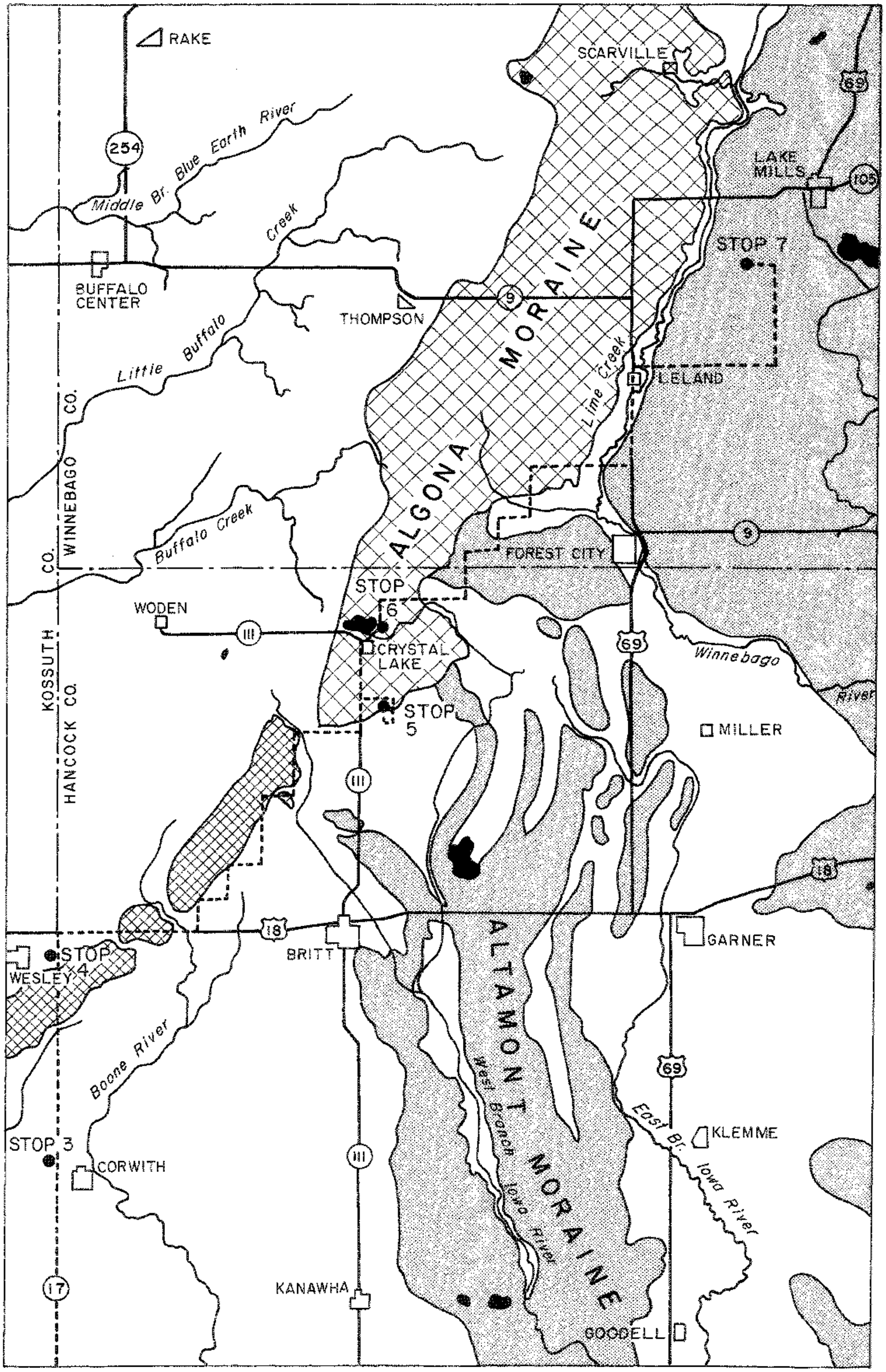
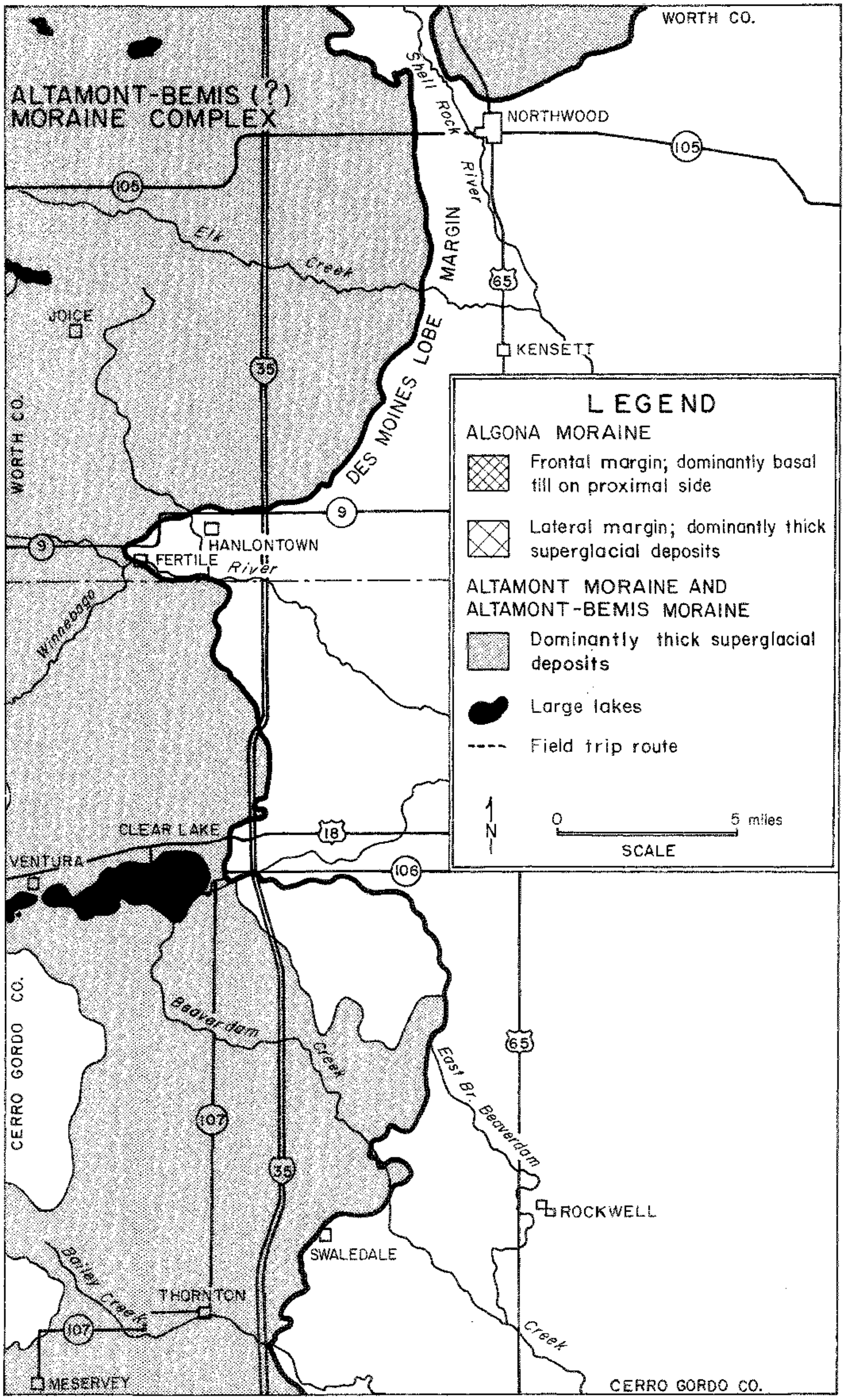


Figure 11. Generalized map of moraine boundaries, northeast Des



Moines Lobe in Iowa.

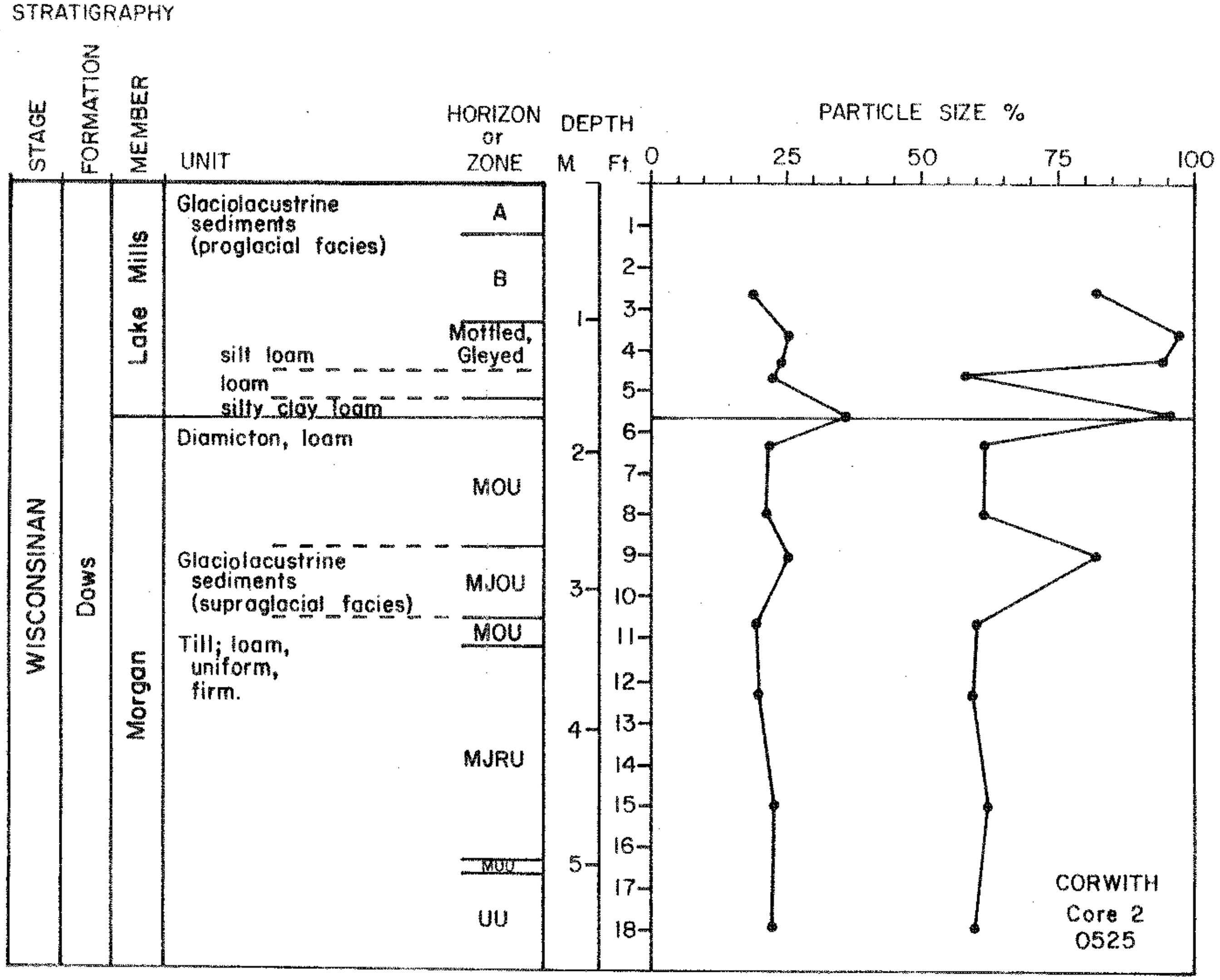


Figure 12. Stratigraphy and particle size data for the Corwith Core 2 site.

At present we have a poor understanding of Glacial Lake Jones. The lake sediments display a distinctive air photo pattern, which is of great assistance in mapping their distribution. There also seem to be the classic relations of outwash fans and valley trains leading out into the "lake" area. However, there are a number of problems remaining to which there are no simple answers: 1) how does the lake area relate to the East Fork of the Des Moines River which cuts deeply through the lake area; and 2) how does one explain that the lake sediments extend up over low ridges which are higher than till landscapes to the south (i.e., what constituted the southern margin of the lake basin)? This area promises to be one for interesting research in the future.

A final note about the name: Glacial Lake Jones is named for Bob Jones, party leader in charge of the U.S.D.A. Soil Conservation Service soil survey of Kossuth, Hancock, and Winnebago Counties. Bob has devoted his career to mapping soils in Iowa. Although his job has not been one that would bring widespread recognition, he has done a fine job, establishing several important new soil series, training many young men as soil scientists, and has been eager to show us geological problems which he has encountered during his investigations. Glacial Lake Jones is one of those problems.

Stop 4. The Frontal Margin of the Algona Moraine, Wesley, Iowa

Cores taken from the west side of Iowa Route 17 in the SE¼, SE¼, NE¼ sec. 36, T. 96N., R. 27W., Kossuth Co. Elevation 1260 feet (384 m). The Wesley cores are located on a low relief area just behind the crest of the Algona Moraine.

In the short drive from Stop 3 we have traversed up over the frontal margin of the Algona Moraine. Note the character of the Algona Moraine here. It is marked by a steep, non-hummocky front over 100 feet (30 m) high, with a well-defined crest which drops down 20 to 30 feet (6 to 9 m) to a different, low-relief landscape (figure 13). The moraine boundaries shown on figure 13 differ from those classically given for the Algona Moraine (see Ruhe, 1969) which extended the moraine nearly all the way to Minnesota. The boundaries shown on figure 13 are mapped, however, using criteria for moraines generally applied elsewhere in the Midwest. The character of the Algona Moraine seen here is the same seen all along the frontal margin of the Algona Moraine from the junction of the moraine with the West Fork of the Des Moines River in Palo Alto Co. on the west to near Crystal Lake northeast of here: a steep, prominent front with a well-defined crest 1 to 3 miles (1.5 to 4.5 km) wide. This ridge marks the former ice margin, the Algona End Moraine. We will cross the Algona Moraine again near Hutchins, Iowa on our way to the next stop, and then skirt along the front of the moraine, noting very little change from what we have seen here until we come near Crystal Lake.

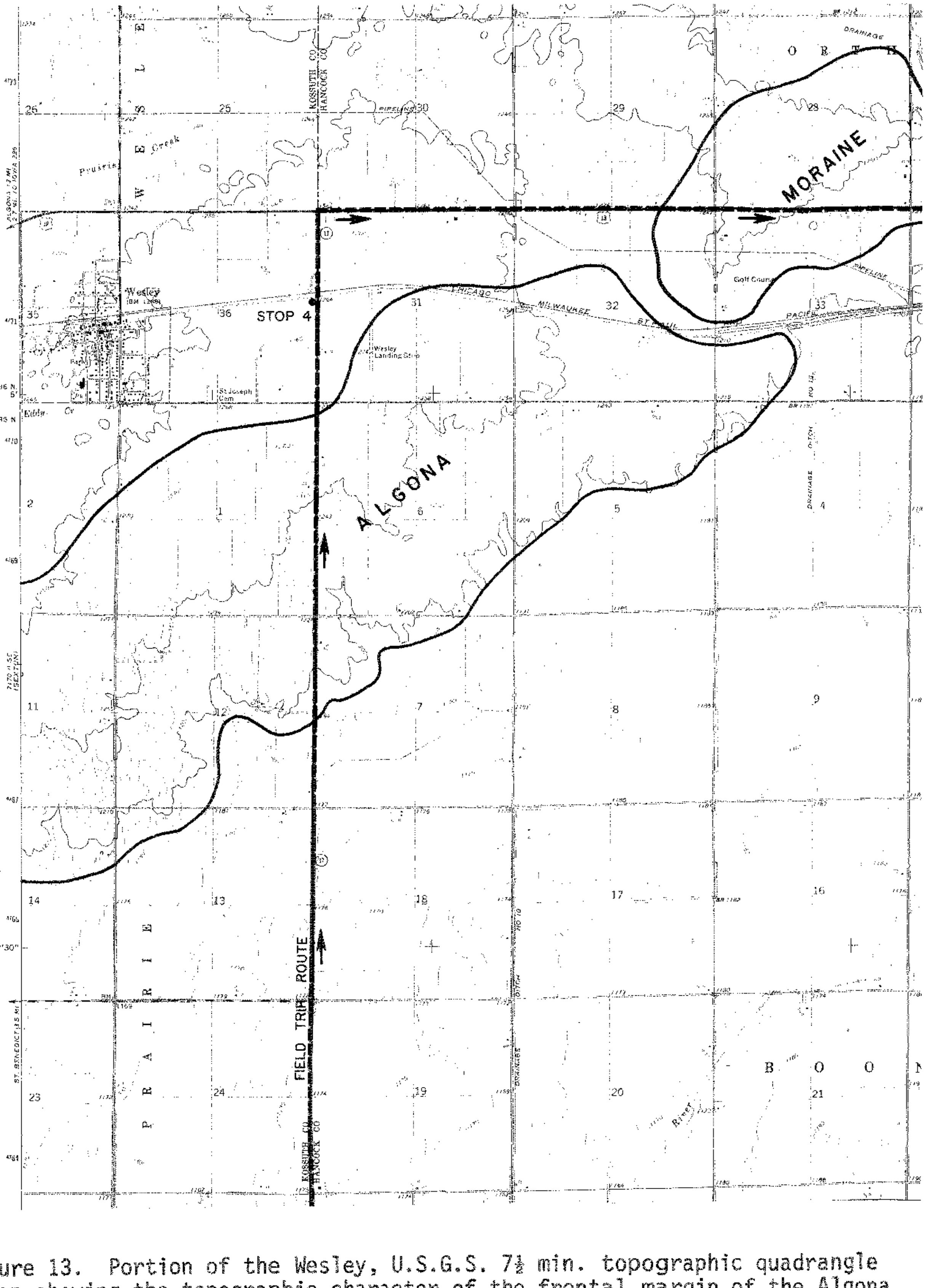
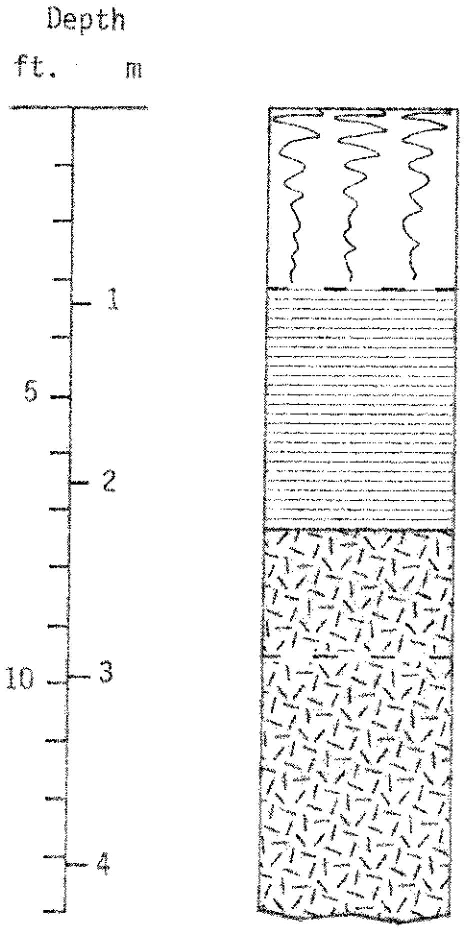


Figure 13. Portion of the Wesley, U.S.G.S. 7½ min. topographic quadrangle map showing the topographic character of the frontal margin of the Algona Moraine near Stop 4.

WESLEY CORE 1



Modern soil profile; developed in fine-grained stratified sediments.

Fine-grained stratified sediments; mottled, reduced, unleached.

Till, loam texture; uniform; mottled, reduced, jointed, unleached.

As above, but unoxidized, jointed, unleached.

Figure 14. Generalized log of Wesley Core 1.

Figure 14 shows the sediment sequence in Wesley Core 1. Glaciolacustrine sediments 7.3 feet (2.2 m) thick overlie a thick sequence of uniform loam till. The glaciolacustrine sediments are not extensive in this area, and according to Bob Jones, this is one of the few known sites behind this part of the Algona Moraine where the sediments have been found. Wesley Core 2, taken approximately 100 feet south of Core 1, differs somewhat in that the surficial sediments are thinner (2.5 feet or 0.8 m), and the till from 8.5 to 13 feet (2.6 to 4 m) contains numerous laminations and thin lenses of stratified silt and sand. The till sequence at this site appears to be dominantly basal till and melt-out till.

There are three outcrops in the city of Algona just behind the moraine front (figure 15), which we will not be able to see today because of time limitations. At these sites thick sequences of uniform basal till can also be seen (figure 16), similar to the till sequence shown in Wesley Core 1. At this stage of investigations on the Des Moines Lobe it appears that sedimentation along the frontal margin of the Algona Moraine was by active ice with deposition of lodgement and melt-out tills dominant.

Textural and mineralogical data for Algona Sites 1 and 2 (figure 16, Table 8) show that the basal till there differs from the basal till farther south in the east-central portion of the Des Moines Lobe (figure 6, Table 4). The textural data at Algona, for example, fall at the very edge of the range of values for basal till in the east-central portion of the lobe. The sand fraction lithologies are dramatically different, with very high mean shale values at Algona (47%) compared to values in the east-central Des Moines Lobe area (14%). At present, there is a great need for textural and mineralogical sampling of deep cores in the north-central Des Moines Lobe area. When such data become available, we may be able to determine whether the lithological values of the Algona sites represent part of a systematic *facies change* in the composition of basal tills on the Des Moines Lobe or whether the basal till of the Algona advance is lithologically distinct and perhaps represents a distinct rock-stratigraphic unit.

Stop 5. A Kame Comprising Part of the Algona Moraine Complex Near Crystal Lake

A sand and gravel pit located in the NW¼, SW¼, NE¼ sec. 27, T. 97N., R. 25W., Hancock Co. Elevation 1290 feet (393 m). The site is located on a prominent knob on a hummocky, high-relief ridge constituting part of the lateral margin of the Algona Moraine.

The map for the Crystal Lake area (figure 17) shows a dramatic change in topography from that found along the frontal margin (figure 13).

The Algona Moraine from here northward extends in a roughly N-NE direction (figure 11). The "moraine" here is not comprised by a single, narrow,

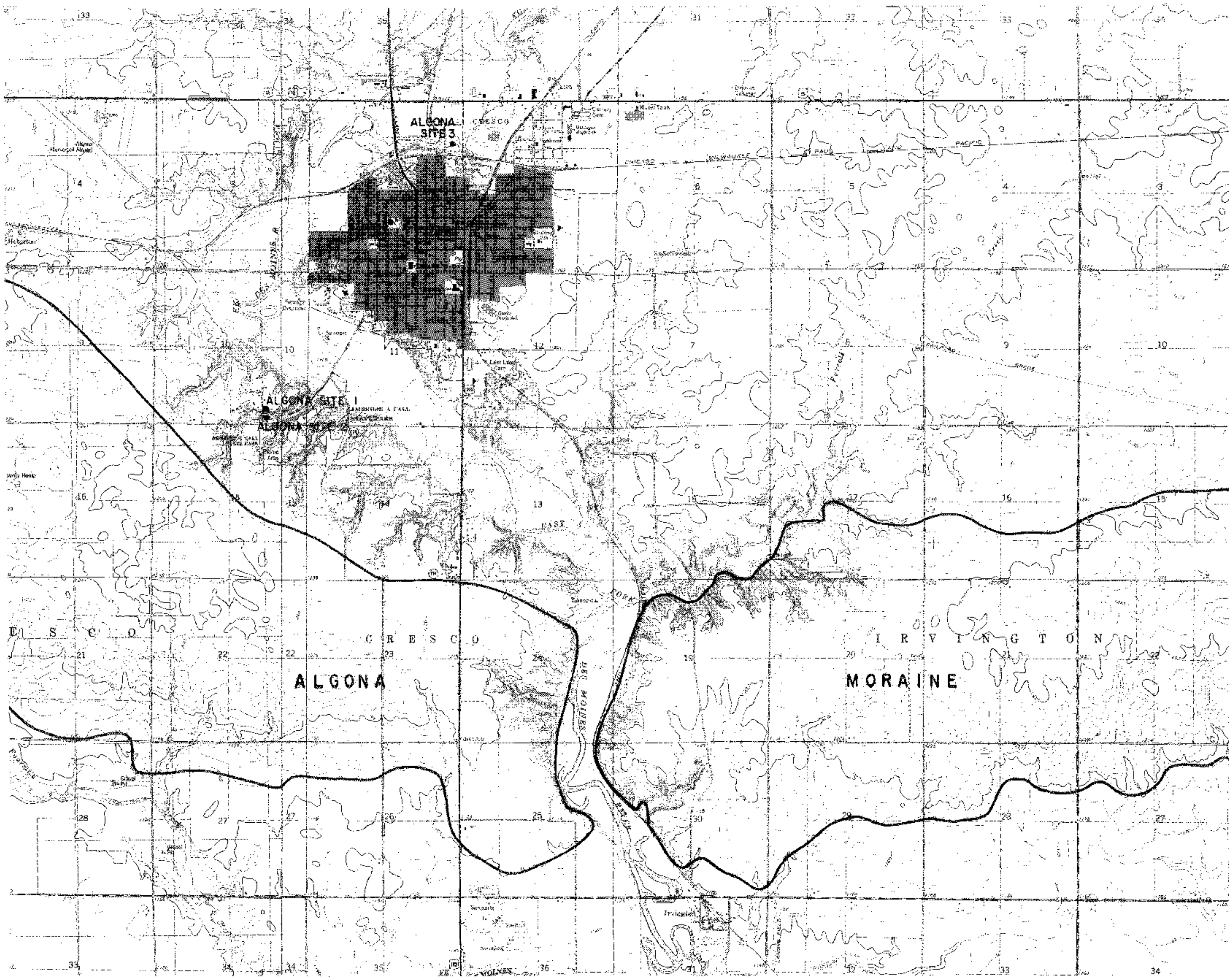


Figure 15. Portions of the Algona and Hobarton, U.S.G.S. 7½ min. topographic quadrangle maps showing the character of the Algona Moraine front and the location of sites Algona 1, 2, and 3.

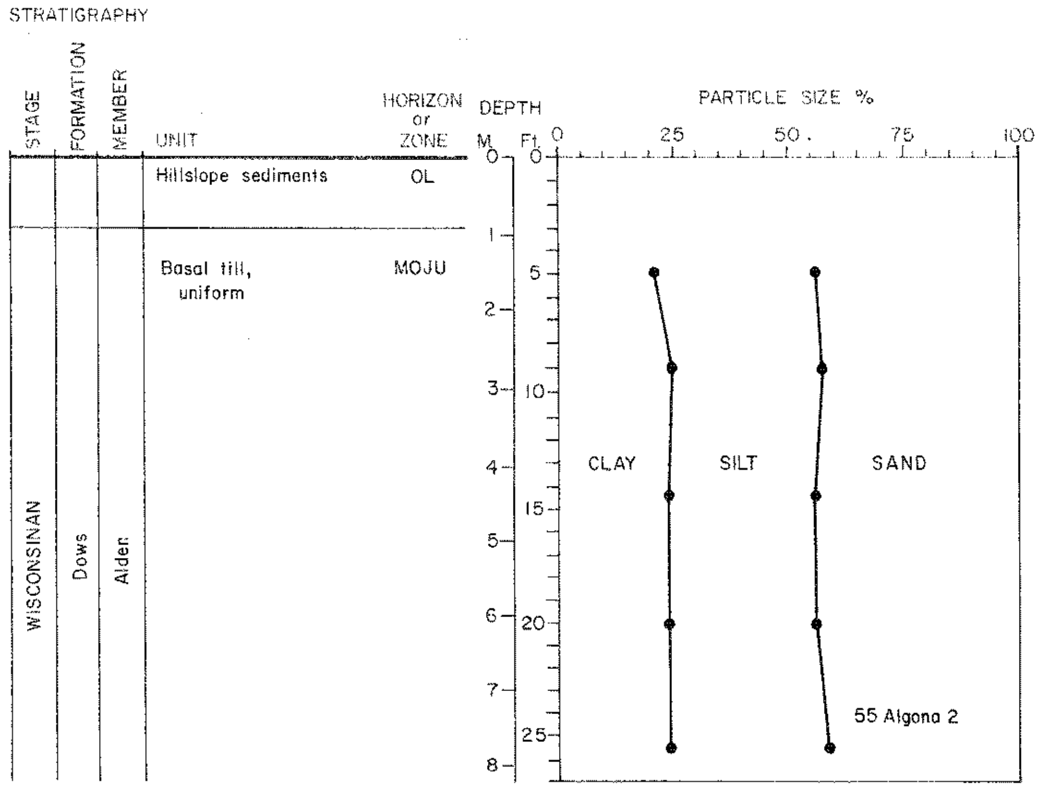


Figure 16. Stratigraphy and particle size data for site Algona 2.

Table 8. Textural and mineralogic data for sites Algona 1 and 2.

MATRIX TEXTURE -%
N = 8

	Sand	Silt	Clay
mean	41.5	36.6	21.9
s.d.	3.0	5.3	2.6
range	36.2-44.8	31.1-44.3	18.6-24.6

SAND FRACTION LITHOLOGY - %
N = 3

	C/D (ratio)	T.C.	Sh.	T.S.	Q.-F.	T.X.
mean	0.98	30	47	78	22.0	22.3
s.d.	0.61	6.5	6.4	2.1	1.7	2.1
range	0.50 - 1.67	24-37	40-52	76-80	20-23	20-24

MATRIX CARBONATES - %
N = 8

	C/D	Cal.	Dol.	T.C.
mean	0.27	3.5	12.7	16.3
s.d.	0.7	0.9	1.1	1.3
range	.16-.36	2.2-4.3	11.4-14.7	14.7-19.0

prominent, non-hummocky ridge as we saw along the frontal portion of the moraine, but by a broad belt of high relief hummocks. At this and the following stop we want to see that not only is there a change in topography, but there is also a basic change in glacial sedimentation as well. Whereas the frontal portion of the moraine at Algona and Wesley is dominated by basal till, the lateral portions of the moraine from here northward are dominated by supraglacial sediments. This stop will be a brief one. It is a good place for photos of the hummocky, high relief topography which constitutes this part of the moraine and to see the coarse sand and gravel deposits in a kame-like knob which constitutes part of the "moraine" front here.

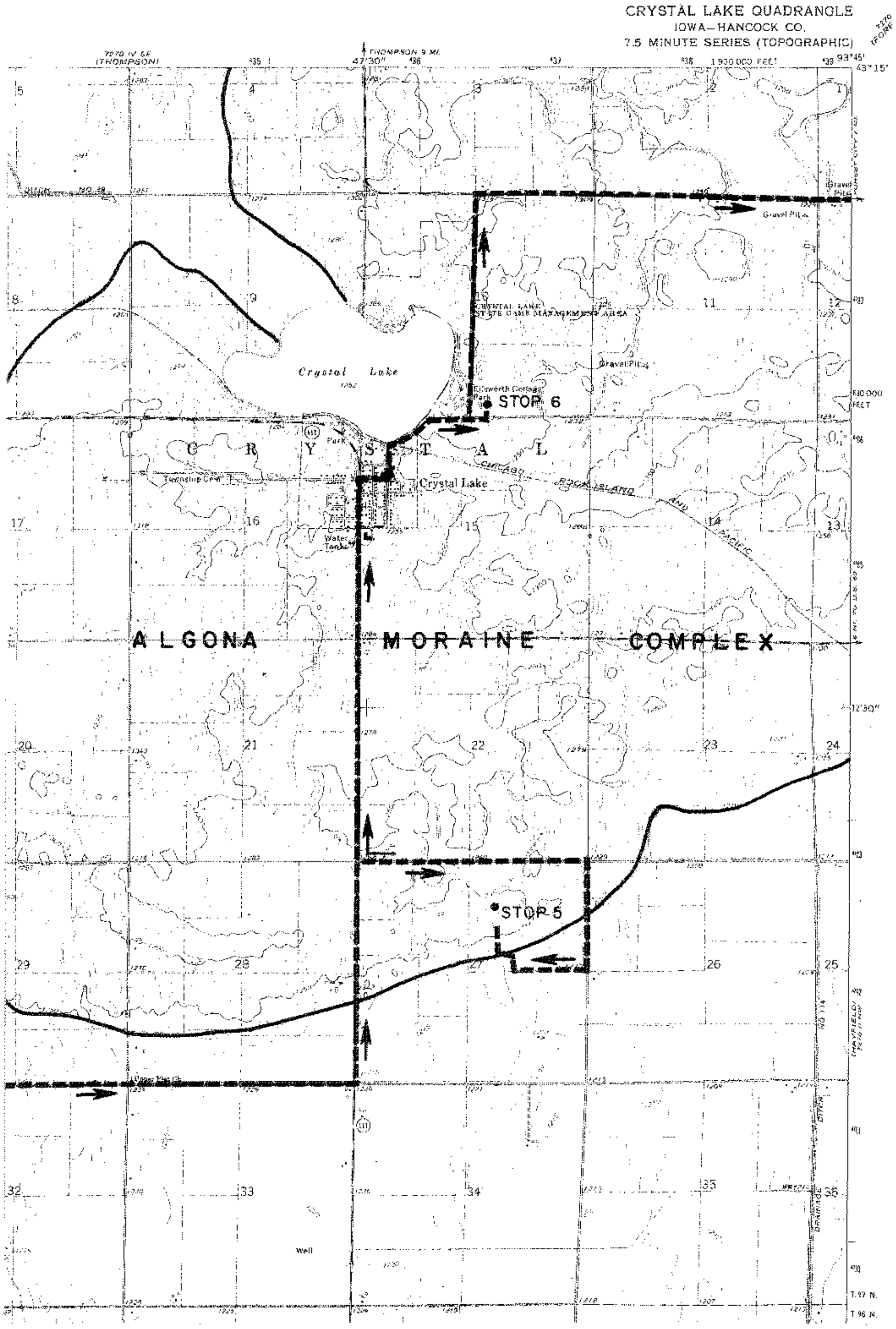


Figure 17. Portion of the Crystal Lake, U.S.G.S. 7½ min. topographic quadrangle map showing the hummocky topography constituting the lateral margin of the Algona Moraine Complex, and the location of Stops 5 and 6.

Stop 6. Cores in the Algona Moraine Complex Near Crystal Lake

Cores from sites located in the NW¼, NE¼, sec. 15, T. 97N., R. 25W. (Cores 1 and 2, figure 17) and the SW¼, SW¼, SE¼, sec. 10, T. 97N., R. 25W., (Core 3, figure 17) Hancock Co. Elevations: Core 1, 1284 feet (391 m); Core 2, 1264 feet (385 m); and Core 3, 1293 feet (394 m). The core sites are on various knobs in the hummocky, high relief areas constituting the lateral margin of the Algona Moraine.

These three cores, only superficially logged during drilling, exemplify the kind of variations one can find in relatively short distances in this area. Core 1 (figure 18) consisted of just over 3 feet (1 m) of till-derived sediments (probably hill-slope sediments) over 11+ feet (3.3+ m) of till-like sediments (diamictons). The diamictons appear to be mostly loam-textured. They appear to be stratified in the sense that there are subtle variations in particle size distribution, most notably in the pebble size fraction. There are virtually no sorted sands, gravels, or silts in the core except for a thin interval between the depths of 9 and 9.2 feet (2.7 to 2.75 m).

Core 2 is only 6 feet (1.8 m) deep. The drilling rig was stopped on something, possibly a boulder. We tried other sites within a few feet of this hole, and every time we were stopped at the same depth. The sediments consisted of diamictons interbedded with numerous sand lenses. Do these sediments remind you of the upper part of the section at Dows Quarry?

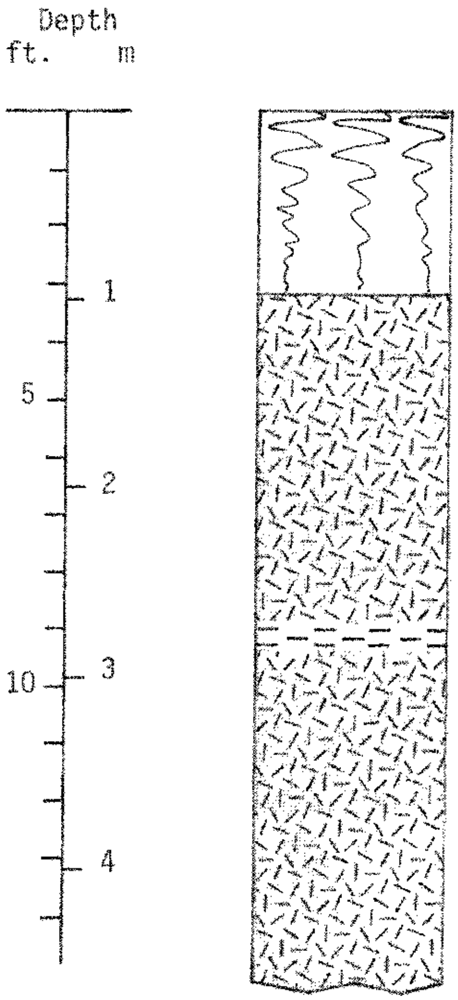
Core 3 consisted of about 9 feet (2.7 m) of bedded diamictons and sand (figure 19) overlying about 6 feet (1.8 m) of stratified sands. The bedding and the presence of appreciable amounts of meltwater deposits are more indicative of supraglacial sedimentation and locally stagnant ice. This sequence contrasts with the uniform till and dominantly active ice, subglacial deposition which probably took place along the frontal margin of the moraine.

Stop 7. The Lake Mills Section

A roadcut located in the SE¼, SW¼, SW¼ sec. 16, T. 99N., R. 23W., Winnebago Co. Elevation: 1300 feet (396 m).

The Lake Mills Section is located right in the heart of the high relief hummocky area, dominated by thick supraglacial sediments, which comprise the Altamont-Bemis(?) Moraine Complex (figure 20). The section is located at a road cut through the flat, plateau-like top of a broad, high relief hummock. A veneer of glaciolacustrine sediments occurs along the top of the "plateau," but is absent on the sideslopes which are composed of till-like sediments. The glaciolacustrine sediments are bedded in the lower part and there is a general fining upward sequence (figure 21). The base of the glaciolacustrine sediments is undulating and marked

CRYSTAL LAKE CORE 1



Modern soil profile developed in till-derived sediments (probably pedisediment).

Diamictons, subtle variations in particle-size distribution, particularly pebble size and percentage, with depth; sand seams in the interval from 9 to 9.2 ft. (2.7 to 2.75 m), oxidized, jointed, unleached.

Figure 18. Generalized log of Crystal Lake Core 1.

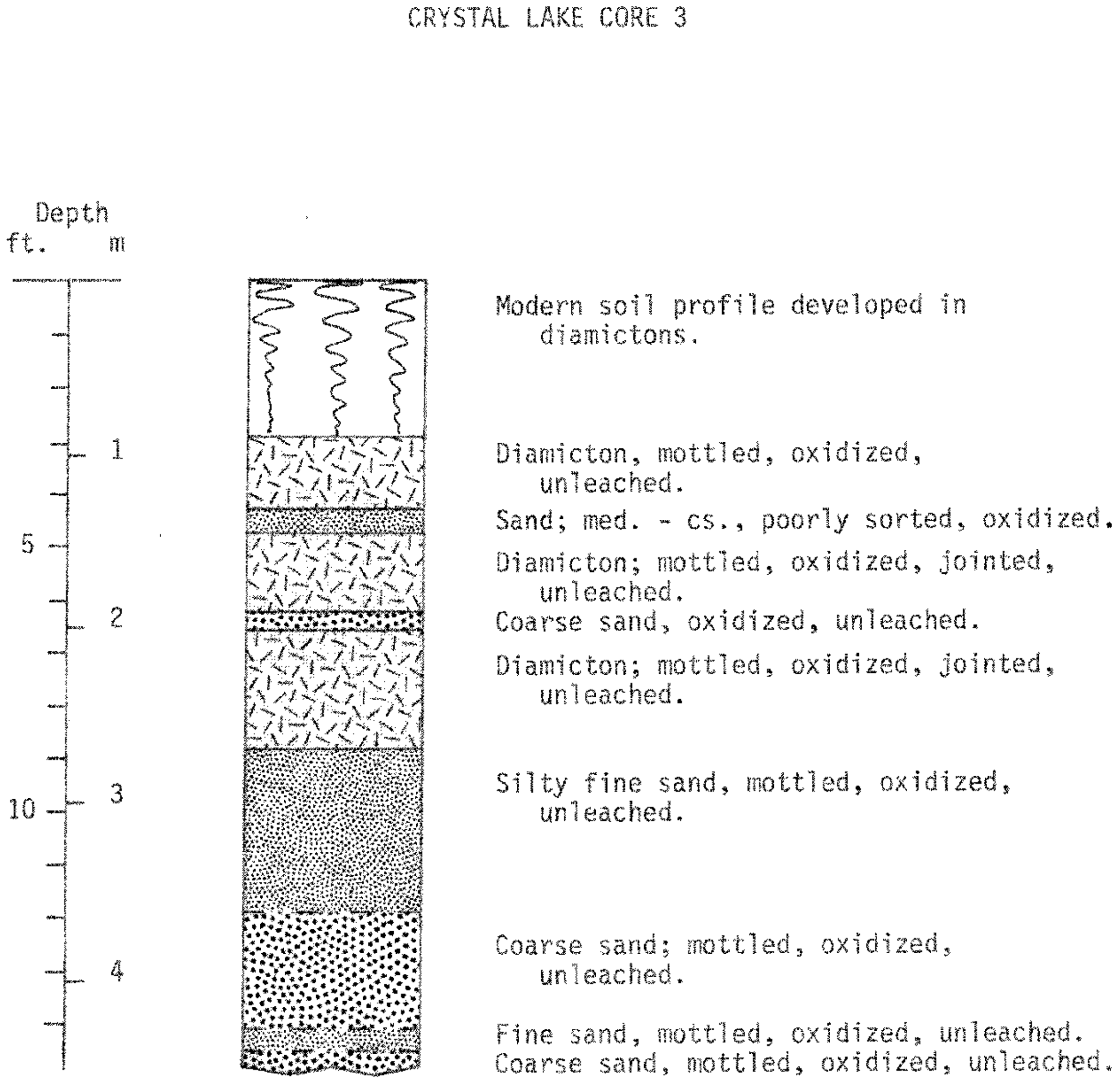


Figure 19. Generalized log of Crystal Lake Core 3.

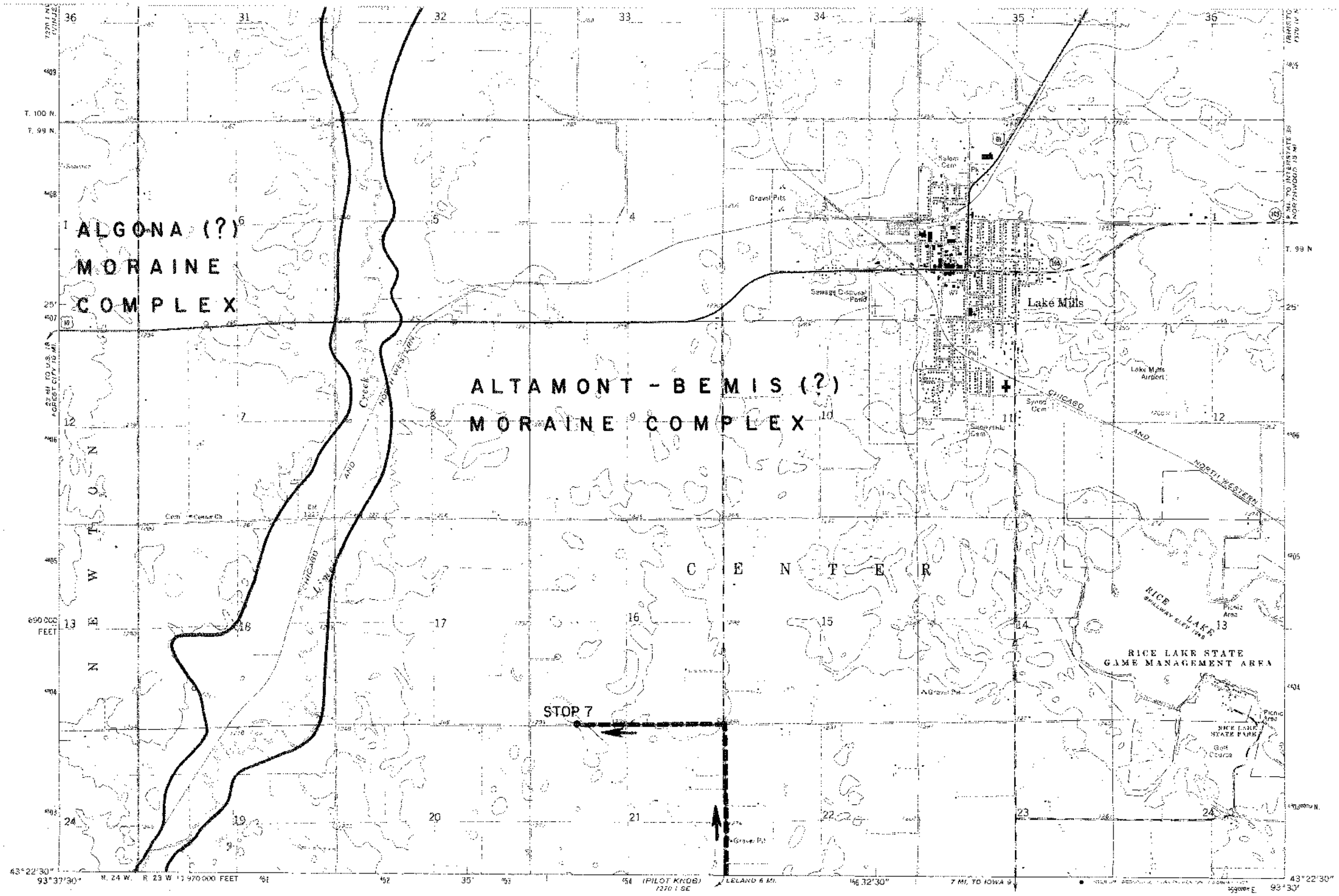


Figure 20. Portion of the Lake Mills, U.S.G.S. 7½ min topographic map showing the hummocky topography constituting the Algona and the Altamont-Bemis (?) Moraine Complexes and the location of Stop 7.

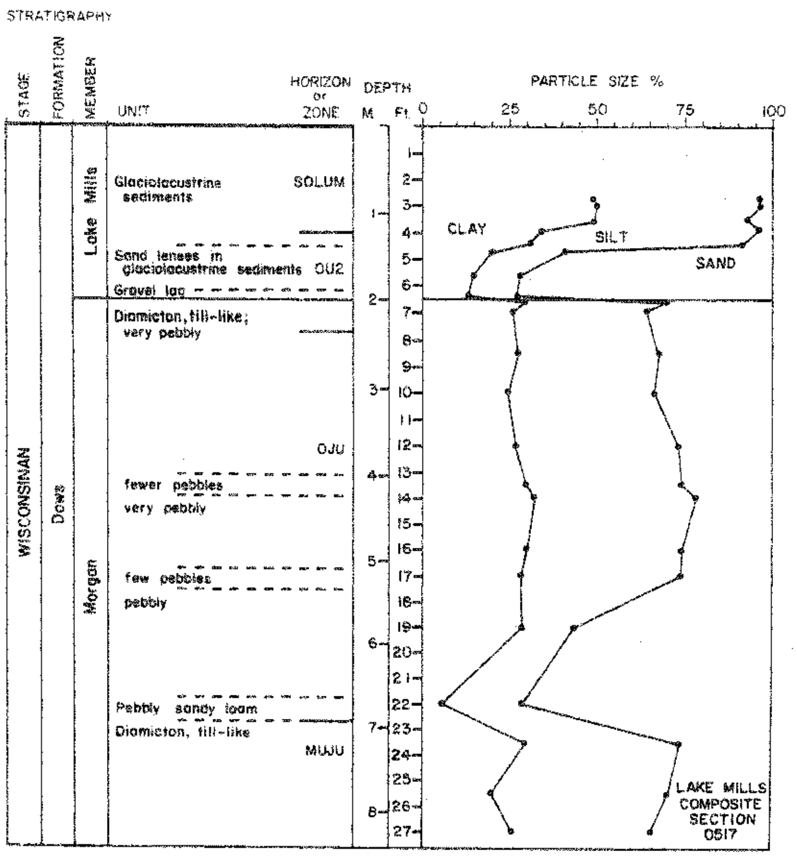


Figure 21. Stratigraphy and particle size data for the Lake Mills Section.

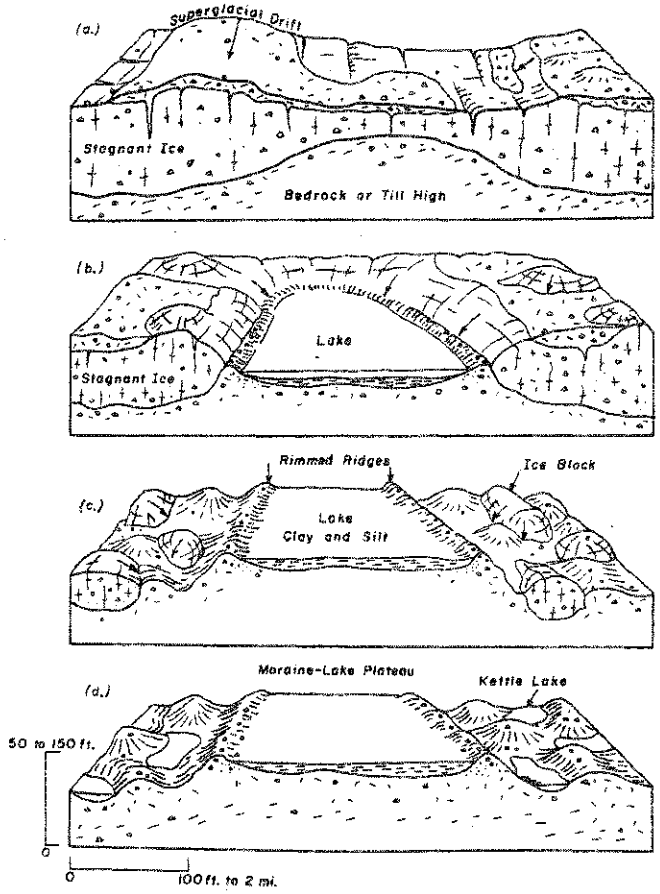


Figure 22. Block diagram showing inferred origin and topographic inversion of lacustrine sediments at the Lake Mills Section, Stop 7 (from Parizek, p. 66).

by a gravel lag on top of till-like sediments of the Morgan Member. The gravel lag is succeeded upward by thinly bedded sands. At the sampled section, the bedded sands are overlain by apparently massive "silts" which contain small, discontinuous, contorted lenses of sand. This interval, which is less than 2 feet (0.6 m) thick, is overlain by apparently massive, fine-grained glaciolacustrine sediments which contains the modern soil profile in the top, and is as heavy-textured as clay in places (figure 21). The till-like sediments underlying the glaciolacustrine deposits are variable in texture (figure 21), contain occasional sand lenses, and in the core there was noticeable variations in pebble content in the till with depth. Some intervals of the "till" or "diamicton" contained very abundant pebbles, other intervals had few pebbles, while still others had moderate,"normal" concentrations of pebbles.

The interpretation for this section is shown on figure 22. The till-like sediments are interpreted to have been deposited supraglacially. The glaciolacustrine sediments are also interpreted to have been deposited supraglacially in ice-walled or ice-floored lakes (figure 22).

Fine-grained ice-walled or ice-floored glaciolacustrine deposits such as exposed at this stop occur extensively in circular or crudely rounded flat-topped knobs or "plateaus" throughout this part of the Altamont-Bemis(?) Moraine Complex, and can be distinguished on soil maps. These ice-contact deposits in Iowa have received little study to date, but they would be a fine thesis topic. Work could be done on the distribution of the deposits, their sedimentology, variations in thickness, texture, lake bottom topography, etc.

EPILOGUE

We have seen in our traverse along the Algona Moraine that there has been a change in both topography and in the character of the glacial deposits along the moraine front. This suggests that there were distinctly different sedimentational environments along a *single* ice margin. What would cause such differences? Are there any analogies which can be made between existing glaciers and the Des Moines Lobe during the Algona advance? The sedimentational patterns along the Algona Moraine are similar to those of many valley glaciers. At the time of the Algona advance the Des Moines Lobe appears to have been moving as a lobe down a broad trough (cover illustration). This type of flow would have been characterized by higher velocity, active ice along the axis of the lobe and much slower moving, nearly stagnant ice along the lateral margins. In addition, ice flow along the lateral margins would be upslope, promoting compressive flow in the glacier and causing the basally-derived debris to be carried up into englacial and supraglacial positions where it would most likely be deposited supraglacially. In contrast, along the axis of the lobe, flow would be down the regional slope, there would be little compressive flow, and deposition would largely be subglacial.

An aim of geomorphology, rightly or wrongly, has always been that landform names convey both something about the land form and about the materials or origin of the landform. In the case of the Algona Moraine, the term "moraine" clearly fails to convey these two messages. The term "moraine" certainly should remain in the literature as a term for ice-marginal drift deposits. In the future, however, let us hope that more effort will be made in designating what kind of glacial sedimentation took place along various ice margins, or moraines. As it stands now, classic moraine maps of the Midwest tell nothing of the sedimentational conditions which occurred along those ice margins, and they provide no information on the important differences in sedimentation which took place regionally.

For the last few miles of the field trip we have traversed a broad area composed of hummocky, high-relief landforms comprised dominantly of supraglacial sediments. These landforms occur in no definite arrangement. Previous authors have subdivided the area into areas of Bemis, Altamont and Algona Moraines. At best these subdivisions were simple guesses. At this time it seems more fruitful to this author that the area be designated as a "moraine complex" where extensive supraglacial sedimentation took place over a broad belt at or near a former ice margin. Further south, where the broad belt narrows down and distinct, continuous ridges develop which can be traced around the lobe to the classic Bemis and Altamont Moraines, it seems worthwhile to delineate these as separate moraines.

The Altamont-Bemis(?) "Moraine Complex" may have resulted because slow moving, nearly stagnant glacial ice was continuously present in the northeastern portion of the Des Moines Lobe in Iowa (remember, this was a period of only 1,000 to 2,000 years!) while farther south there were greater oscillations of the ice front.

Over the field trip we have reviewed the complexity of sedimentation in the glacial environment and its application to deposits on the Des Moines Lobe. I hope the field trip has been an interesting introduction to you of the patterns in glacial sedimentation on the Des Moines Lobe which we are now beginning to comprehend.

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