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Tills of Kidder County, North Dakota

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Abstract

Kidder County, located in south-central North Dakota, is completely covered by drift of the Wisconsin stage. Irregular preglacial topography, large amounts of confusing "stagnation" moraine, and a blanket of outwash over much of the county make differentiation of tills of different glacial advances difficult. The purpose of this report is finding ways of lithologically differentiating the tills of the different glacial advances in the county.

Kidder County is covered by drift of two major advances of the Mankato substage, A-1 and B-1 of Flint's South Dakota designation. A dark brown, sandy, loesslike material covering much of the county probably is the same material overlying carbon 14 dated wood in the southeast part of the county. Yellow loess is exposed in at least four places in the county.

Grain analyses on 55 samples of till from throughout the county showed no significant differences in the size composition of tills of the A-1 and B-1 advances. Fifteen pebble counts failed to show any differences between tills of the two advances. The field appearances of tills of the two advances do not differ appreciably. However, where two tills crop out in one exposure in the southern part of the county, the lower till is yellower, stickier, and harder than other tills in the county and has small irregular joints coated with iron

and manganese oxide. This till is thought to be Tazewell in age. In a second exposure two tills are separated by a gravel concentrate which is overlain by less than a foot of loess. These two tills probably belong to the Long Lake and Twin Buttes loops of the A-1 advance of the Mankato substage.

The only way to differentiate tills within the Mankato substage in the end moraine complex of south-central North Dakota is by the topographic expression and stratigraphic relationships of the till sheets. In some cases Mankato and Tazewell tills may be differentiated by secondary changes such as the degree of oxidation and joint coatings. The percentages of sand and the percentages of shale in the coarse sand fraction of samples of till collected from the county were not found to vary appreciably for 15 miles on either side of the contact between the Fox Hills sandstone and the Pierre shale. This helps to strengthen the belief of other workers that only 20-30% of till is locally derived.

Introduction

During the summer of 1959 the author worked with a North Dakota Geological Survey party which mapped the glacial geology of Kidder County, N. Dak. During mapping, the problem came up of differentiating tills of different ice advances. There is a special set of problems in the study area--the effect of preglacial topography and the large blanket of outwash masking the end moraines. Thus differentiation on the basis of landforms is difficult. The purpose of this report is finding ways of lithologically differentiating the tills of the glacial advances.

Kidder County is located in the Coteau du Missouri in the glaciated Missouri Plateau section of the Great Plains province (Fenneman, 1938) of south-central North Dakota. The elevation of the county varies from 1700 to 2300 feet above sea level. The county has a short grass native vegetation and lies near the east edge of the Chestnut soil zone (U. S. Department of Agriculture, Yearbook 1941, p. 117).

Flint's "Pleistocene Geology of Eastern South Dakota" is the most complete work on the glacial geology of the end moraine complex in this general area (Kidder County is 50 miles from the South Dakota boundary). Considerable reference will be make to it. Age designations are from Lemke and Colton (1958, table 1 and fig. 3). (See table 1 and appendix I.) Except for size analyses of five till samples (C-71, 76, 97, 106, and 114) made by James Chmelik, all field observations and laboratory analyses were made by the author. The generalized glacial map of the county (fig. 1) is taken in part from the unpublished work of Dr. Jon L. Rau, Wallace E. Bakken, James C. Chmelik, and Barrett J. Williams, members of the Survey mapping party.

During six weeks in June and July of 1959, 125 spot samples of till and loess were collected in the county. Figure 2 is a location map of 55 samples on which size analyses were made by means of a slightly modified American Society for Testing Materials (1958, p. 83-93) hydrometer procedure D422-54T. The coarse sand (Wentworth scale) fractions separated during the size analyses were studied and the percentages of shale grains recorded. Color was determined by comparing the samples with the Munsell soil color charts. Differential thermal analysis was used to detect dolomite and gypsum in two samples.

Summary of the glacial geology of Kidder County

The glaciers of the Wisconsin stage advanced from northeast across North Dakota over older drift and nearly 200 miles of Pierre shale. The ice advance came to a halt after moving over the escarpment just east of the Coteau du Missouri. In Kidder County the topography of the end moraine complex was even more complicated by the irregular badland topography developed on bedrock of Fox Hills sandstone. What appears to be end Moraine is often only an irregular preglacial topography covered with a thin blanket of drift. Till behind the end moraines is often in the form of confusing "stagnation" or "dead ice" moraine (Lemke and Colton, 1958, fig. 5). Much of the till is covered with one of the largest outwash bodies in the United States (Flint and others, 1959). Therefore true relationships between the tills of different glacial advances are often difficult to determine ~~from~~ using only the geomorphology of the till sheets.

The till of the end moraines on the northern and eastern sides of the county (fig. 1) belongs to the post-Cary advance number 1 of Lemke and Colton, which corresponds to Flint's B-1 Mankato advance in South

From Lemke and Colton, 1958, table 1.	Lemke and Colton (1958, fig. 3) in N. Dak.	Flint in S. Dak. (Lemke and Colton, 1958, fig. 3.)	This report.
Valders substage			
Two Creeks interstadial			
Mankato substage	Post-Cary	B-1 and later Mankato advances	B-1 Mankato advance
	Post-Tazewell - pre-Two Creeks	A-1 Mankato advance	A-1 Mankato advance
Interstadial			
Cary substage	Not present	Cary	Cary (See appendix I)
Interstadial			
Tazewell substage	Tazewell(?)	Tazewell	Tazewell
Interstadial			
Iowan substage	Iowan(?)	Iowan	

Table 1.--Classification of the Wisconsin stage.

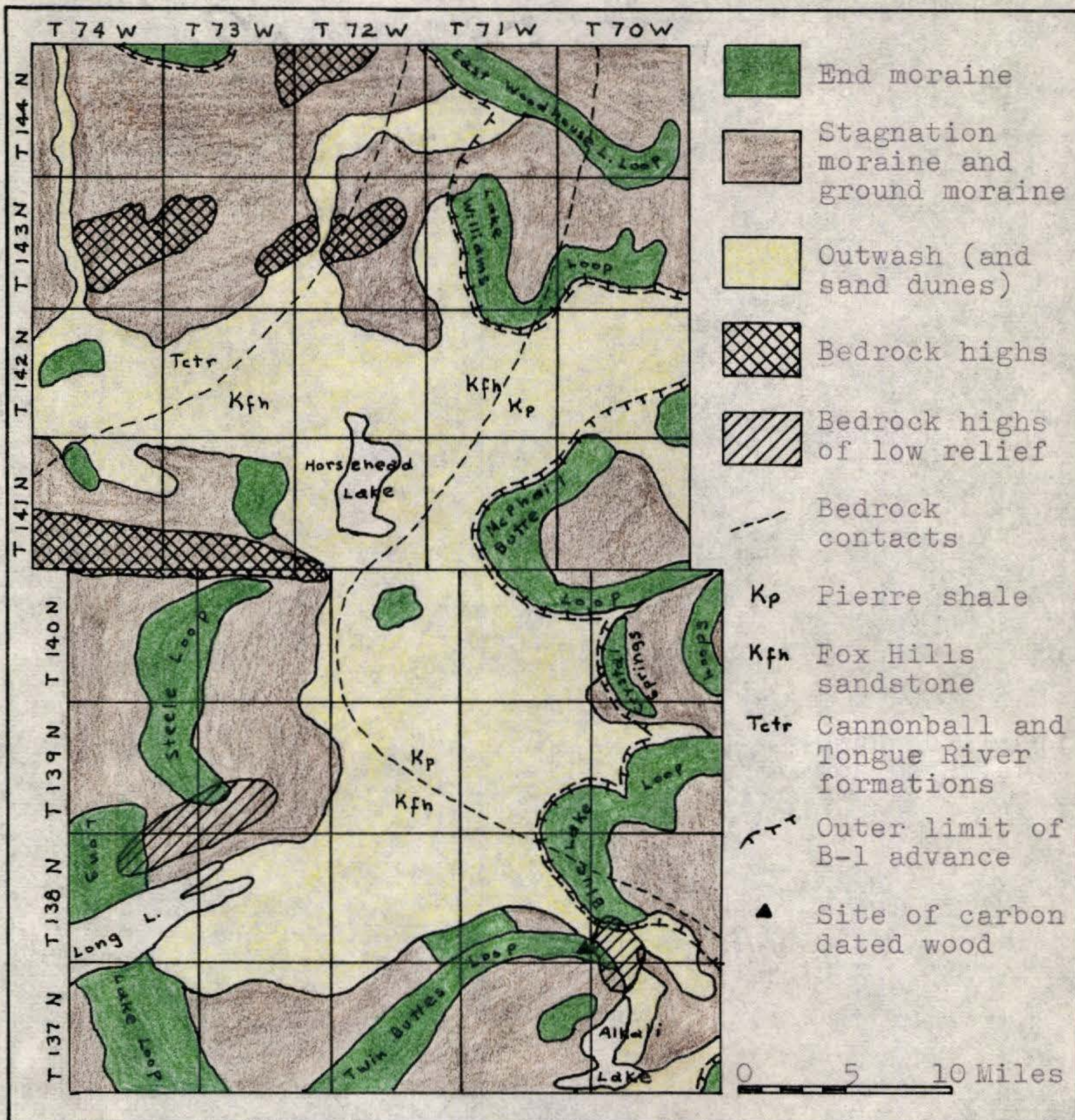

Figure 1.--Generalized map of surface geology of Kidder County, N. Dak.

Dakota. The rest of the county is covered by till of the post-Tazewell - pre-Two Creeks substage, which corresponds to Flint's A-1 Mankato advance. For convenience, they will be referred to as the A-1 and B-1 advances. Some till of the Tazewell drift sheet may be exposed in the county. (See p. 20.)

The end moraine of the B-1 advance has strongly arcuate loops with closely spaced subparallel ridges of high relief. The "Twin Buttes" loop of the A-1 advance has high relief but few strongly arcuate subparallel ridges. The rest of the end moraine in the central and west part of the county has low relief and wider spaced subparallel ridges; in the central part of the county much of it is covered with outwash from the B-1 advance. Not only does this outwash hide much of the glacial geology of the county, but part of it was probably incorporated into the advancing ice, making the resultant till more heterogeneous.

Yellow loess or loesslike material was observed in at least four localities in the county:

1. Roadcut 6½ mi north of Tappen, a half mile south of the northwest corner of sec. 2, T. 140 N., R. 71 W.; 3 ft of loess under a half foot of gravelly till.
2. Near south shore of Lake Isabel, 4 mi south of Dawson, in the SE¼SW¼ sec. 34, T. 139 N., R. 72 W.; 7 ft of loesslike matterial interbedding downward into laminated lake clay; sample Cl-7; histogram fig. 3b.
3. Roadcut 2 mi east of Alkali Lake, a half mile south of the northeast corner of sec. 12, T. 137 N., R. 70 W.; 20 ft of loess partially surrounded

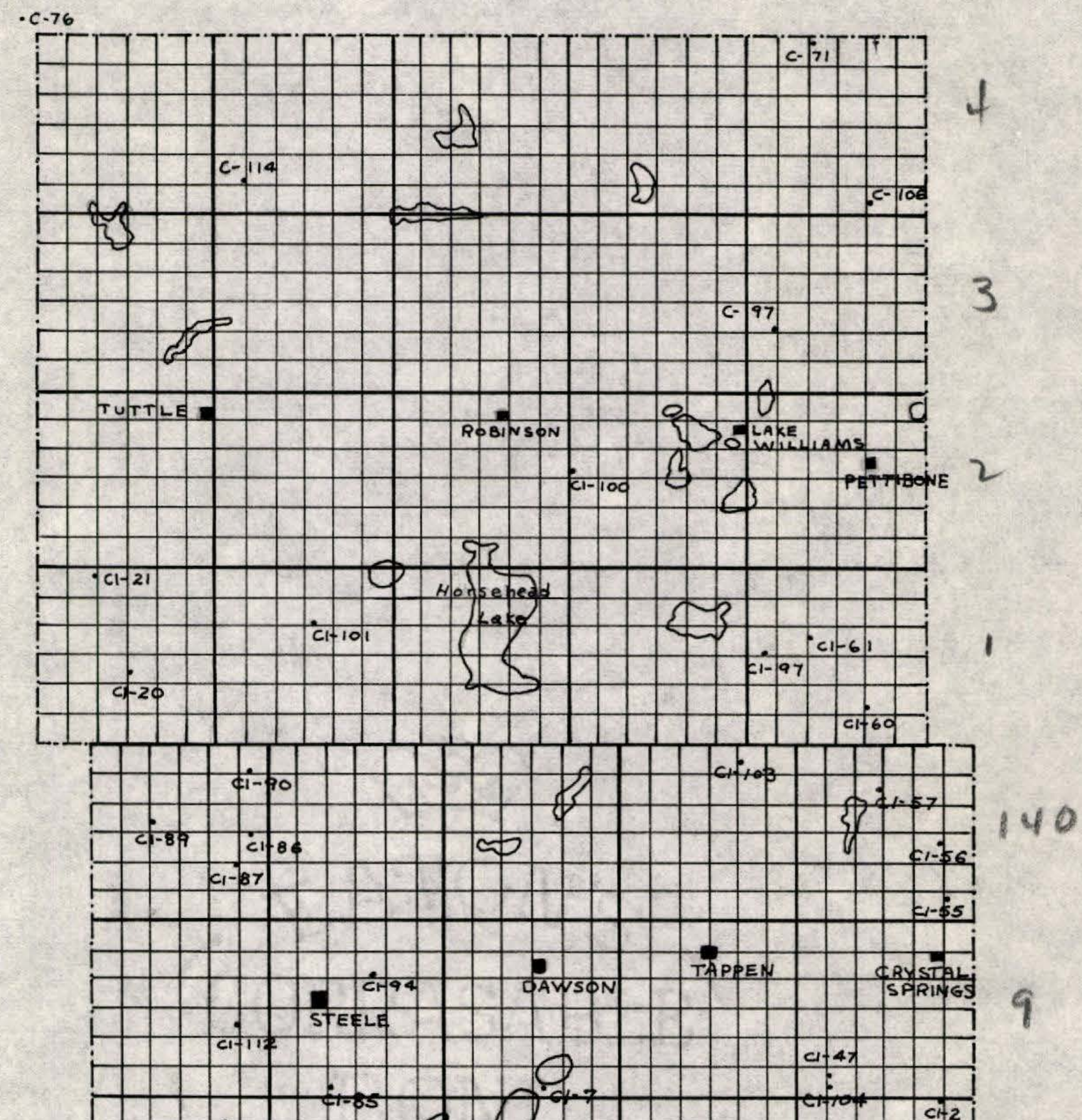

Figure 2.--Location of samples on which size analyses were made.

by outwash; sample C1-52; histogram fig. 3c.

4. Roadcut described on page 19.

From ½ to 3 feet of post-Mankato loesslike material covers much of the outwash and till in the south half of the county. It contains mostly fine sand the same size as that in active dunes in the south-central part of the county, but it is genetically the same as loess. (See fig. 4a, b, and c.) It is generally dark brown, contains much organic material, is not bedded and is fairly well consolidated. (See Flint, 1955, p. 128.) This is probably the same material found above the spruce wood (in Twin Buttes loop) that was radiocarbon dated

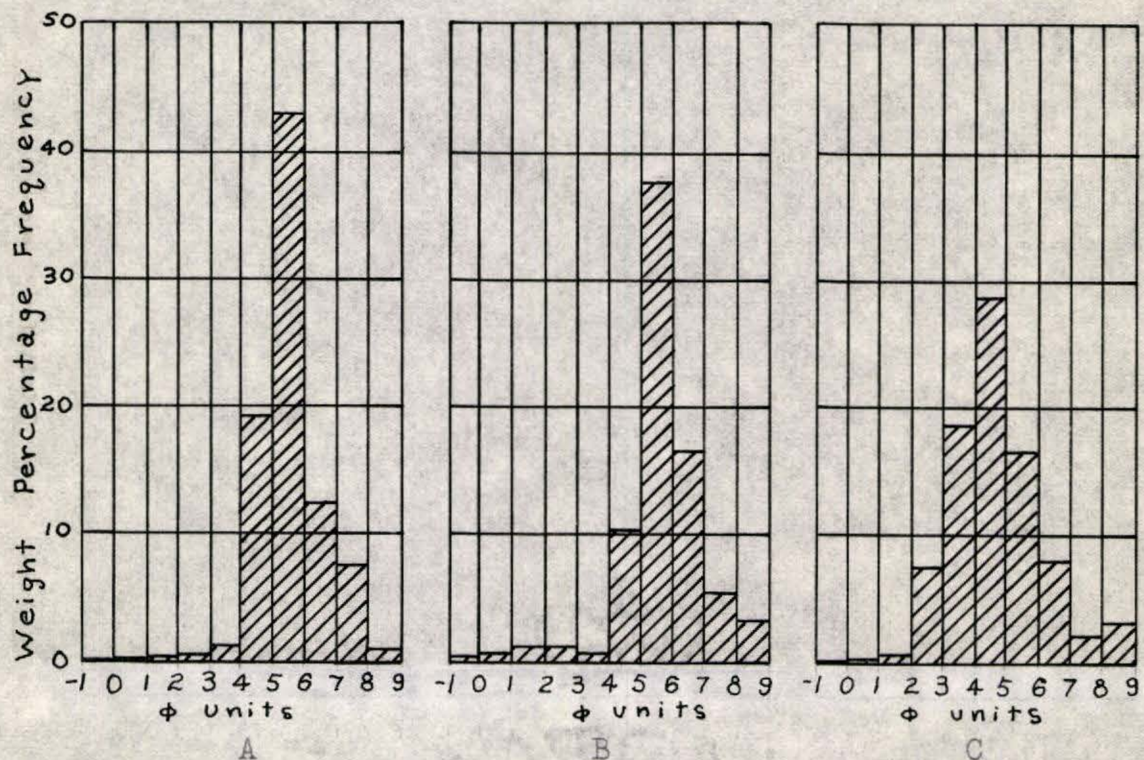

Figure 3.--Histograms showing grain-size frequencies in three samples of Mankato loess. A, C1-37-D; B, C1-7; C, C1-52.

at 11,480 ± 300 years B. P., which corresponds to the Two Creeks interstadial (Moir, 1958, p. 109-110). Lemke and Colton (1958, p. 49) stated that "because of the present lack of knowledge of the stratigraphic relations of the deposits overlying the radiocarbon dated material [in the Twin Buttes moraine], it cannot now be ascertained whether [the drift of the B-1 advance] antedates or post dates the Two Creeks interstadial."

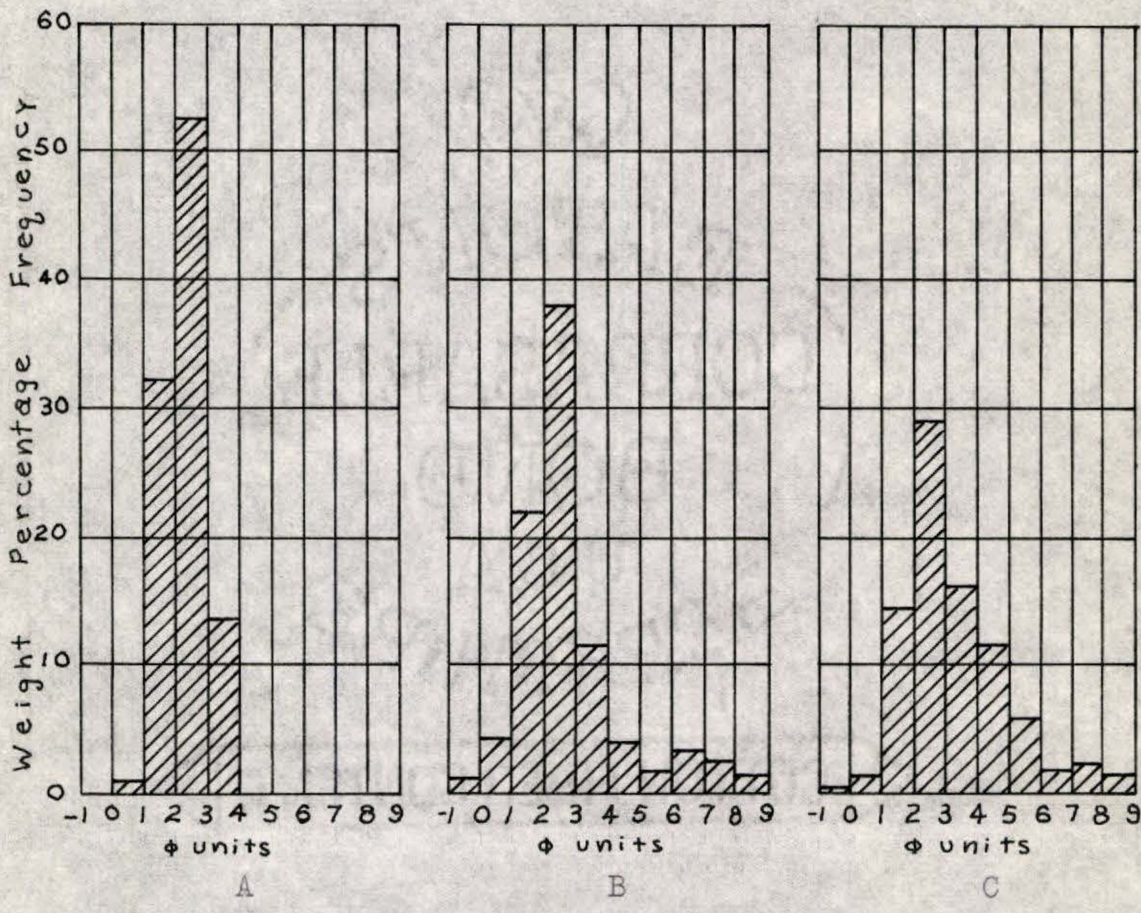

Figure 4.--Histograms showing grain-size frequencies in two samples of post-Mankato loesslike sand and one sample of dune sand. A. Cl-8, dune sand from NW¼ sec. 15, T. 138 N., R. 72 W.; B, Cl-35, loesslike sand from 0.2 mi S of NE corner sec. 29, T. 138 N., R. 71 W.; C, Cl-32, loesslike sand from 0.3 mi W of SE corner sec. 6, T. 137 N., R. 71 W.

Otherwise, this loesslike sand has no stratigraphic importance.

Results

Field appearance.--No significant difference in color exists between the tills of the A-1 and B-1 advances. On the Munsell scale it is generally 2.5Y-5Y 5-7/2-4 when dry and 2.5Y-5Y 4-5/2-4 when wet. The wet color can generally be described as olive or olive brown. Most of the till has reddish-yellow spots, probably caused by the oxidation of fragments of iron oxide concretions from the Pierre shale, and a white mottling, due to an irregular concentration of calcium carbonate. In several places in the southwest corner of the county the till contains "geodes" filled with crystals of gypsum one-eighth inch long. Also observed within the till in the southwest corner were salmon-colored dolomitic lenses and sheets (as in the northwest corner of sec. 30, T. 137 N., R. 74 W.; and three miles into Burleigh County, 0.1 mile north of the southeast corner of sec. 28, T. 139 N., R. 75 W.). Horizontal fissility was noted at a few exposures. Except for one exposure (described on page 18), the tills have no significant visual differences that might be used for correlation.

Grain size analysis.--Shepps (1953, p. 35) made size analyses on about 75 till samples from Tazewell, early Cary, and late Cary till sheets in several counties in

Table 2.--Location and size composition of 47 samples of till.

No.	Location	Percent		
		Sand	Silt	Clay
Cl-2	NE corner sec. 2, T. 138 N., R. 70 W.	36.8	25.5	37.7
Cl-9	0.2 mi N of SE corner sec. 33, T. 138 N., R. 72 W.	27.8	30.7	41.5
Cl-10-A	0.3 mi N of SE corner sec. 16, T. 137 N., R. 72 W.	31.0	38.5	30.5
Cl-10-B	do.	25.0	45.0	30.0
Cl-10-C	do.	34.4	35.0	30.6
Cl-20	0.4 mi N of SW corner sec. 22, T. 141 N., R. 74 W.	30.8	30.4	38.8
Cl-21-A	0.2 mi S of NE corner sec. 5, T. 141 N., R. 74 W.	57.5	13.3	29.2
Cl-30	NE corner sec. 2, T. 137 N., R. 72 W.	28.2	35.4	36.4
Cl-31	0.2 mi N of SE corner sec. 2, T. 137 N., R. 72 W.	28.3	31.7	40.0
Cl-36	0.2 mi S of NW corner sec. 21, T. 138 N., R. 71 W.	25.4	27.8	46.8
Cl-37-A	0.3 mi N of SW corner sec. 22, T. 138 N., R. 71 W.	48.1	21.8	30.1
Cl-37-B	do.	36.2	30.8	33.0
Cl-37-E	do.	28.4	28.4	43.2
Cl-40	0.1 mi N of SE corner sec. 25, T. 138 N., R. 72 W.	55.9	25.2	18.9
Cl-47-B	0.2 mi S of NW corner sec. 32, T. 139 N., R. 70 W.	26.1	43.6	30.3
Cl-48-A	0.3 mi S of NE corner sec. 19, T. 138 N., R. 70 W.	47.0	25.1	27.9
Cl-49	0.5 mi W of NE corner sec. 34, T. 138 N., R. 70 W.	28.0	29.4	42.6
Cl-50	NE corner sec. 4, T. 137 N., R. 70 W.	26.0	30.4	43.6
Cl-51	0.2 mi N of SE corner sec. 16, T. 137 N., R. 70 W.	27.5	31.1	41.4
Cl-53	0.4 mi N of SE corner sec. 21, T. 137 N., R. 71 W.	24.8	29.7	45.5
Cl-54	SW corner sec. 10, T. 137 N., R. 71 W.	28.3	37.5	34.2
Cl-55	0.3 mi S of NW corner sec. 36, T. 140 N., R. 70 W.	41.3	35.3	23.4
Cl-56	0.3 mi S of NE corner sec. 23, T. 140 N., R. 70 W.	43.0	34.6	22.4
Cl-57	0.5 mi N of SE corner sec. 9, T. 140 N., R. 70 W.	28.0	27.0	45.0
Cl-60	0.1 mi N of SW corner sec. 26, T. 141 N., R. 70 W.	7.9	53.8	38.3

No.	Location	Percent		
		Sand	Silt	Clay
C1-61	0.4 mi S of NW corner sec. 16, T. 141 N., R. 70 W.	24.0	33.0	42.1
C1-85-A	0.4 mi N of SW corner sec. 33, T. 139 N., R. 73 W.	1.0	22.0	77.0
C1-87	NE corner sec. 26, T. 140 N., R. 74 W.	25.7	29.4	44.9
C1- 89	0.4 mi N of SW corner sec. 16, T. 140 N., R. 74 W.	38.7	29.4	31.9
C1-90	0.3 mi E of SW corner sec. 1, T. 140 N., R. 74 W.	29.2	30.1	40.7
C1-94	0.4 mi W of SE corner sec. 10, T. 139 N., R. 73 W.	25.0	34.8	40.2
C1-97	0.5 mi W of SE corner sec 18, T. 141 N., R. 70 W.	33.8	33.0	33.2
C1-100	0.1 mi N of SW corner sec. 18, T. 142 N., R. 71 W.	32.6	34.3	33.1
C1-101	0.2 mi E of SW corner sec. 10, T. 141 N., R. 73 W.	58.5	21.5	20.0
C1-103	0.3 mi N of SW corner sec. 2, T. 140 N., R. 71 W.	34.4	29.9	35.7
C1-104	0.2 mi N of SW corner sec. 32, T. 139 N., R. 70 W.	32.7	29.8	37.5
C1-105	0.2 mi E of SW corner sec. 7, T. 139 N., R. 70 W.	39.5	27.0	33.5
C1-107	SE corner sec. 15, T. 137 N., R. 74 W.	35.6	32.2	32.2
C1-108	SE corner sec. 34, T. 137 N., R. 74 W.	27.4	42.3	30.3
C1-109	SE corner sec. 18, T. 137 N., R. 73 W.	31.4	29.6	39.0
C1-112	0.5 mi N of SE corner sec. 23, R. 139 N., R. 74 W.	27.0	37.2	35.8
C1-113	0.5 mi W of SE corner sec. 2, T. 138 N., R. 74 W.	26.5	39.1	34.4
C-71	NW¼ sec. 4, T. 144 N., R. 70 W.	25.0	26.7	48.3
C-76	SE¼NE¼ sec. 32, T. 145 N., R. 74 W.	40.5	24.8	34.7
C-97	SE corner sec. 19, T. 143 N., R. 70 W.	38.6	24.4	37.0
C-106	0.6 mi S of NW corner sec. 35, T. 144 N., R. 70 W.	28.9	29.8	41.3
C-~~C1~~-114	SE¼SE¼ sec. 30, T. 144 N., R. 74 W.	46.2	29.8	24.0

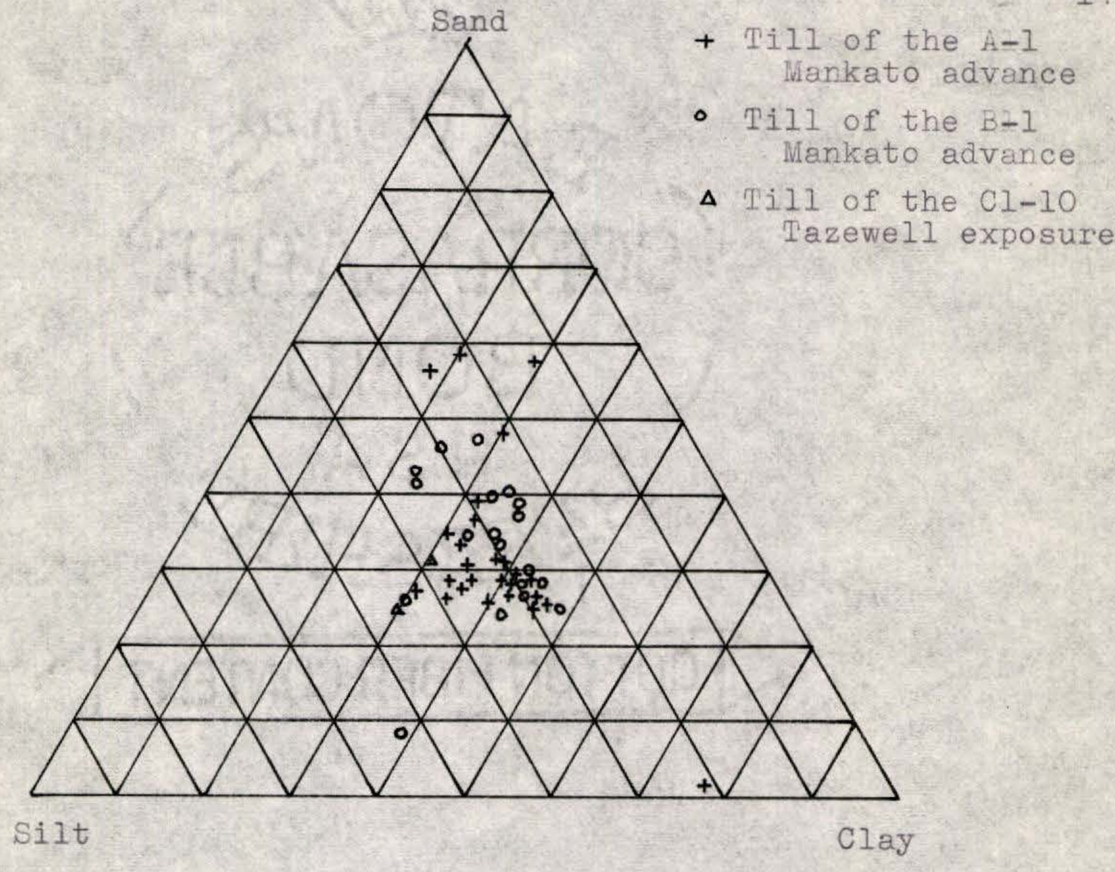

Figure 5.--Triangular diagram of sand-silt-clay composition of 47 samples of Mankato and Tazewell till.

northeast Ohio. He found that the sand-silt-clay ratios plotted on a triangular diagram were very useful in correlating the till sheets. Triangular plots of 47 samples of till from Kidder County are shown in figure 5 and the locations of these samples in figure 2 and table 2. Histograms of representative samples are given in figure 6. No major difference exists between the size compositions of the A-1 and B-1 tills. Most plots fall within a small area on the triangular diagram. The very clayey sample, Cl-85-A, is probably contaminated by lake clay. Nearly all the samples that have greater

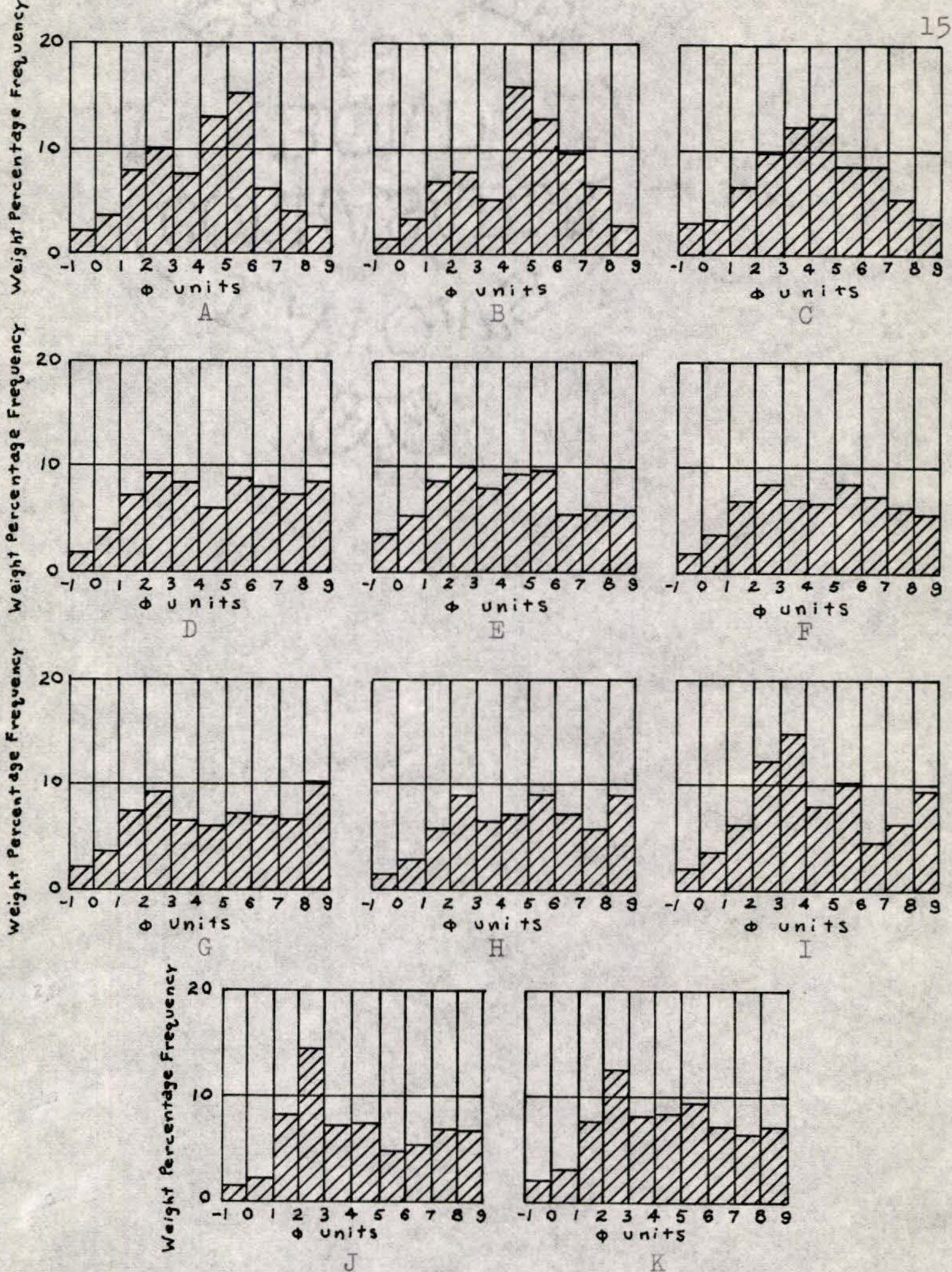

Figure 6.--Histograms showing grain-size frequencies in two samples of Tazewell till and nine samples of Mankato till. A. Cl-10-A; B. Cl-10-B; both Tazewell till; and C, C.-10-C; D, Cl-20; E, Cl-37-B; F, Cl-37-E; G, Cl-57; H, Cl-87; I, Cl-89; J, Cl-97; K, Cl-107.

than average percentages of sand have been contaminated with outwash. For example, samples C1-55 and C1-56 are from a 2½ to 3 foot blanket of till overlying outwash behind the western part of the Crystal Springs loop.

Nine out of eleven till histograms in figure 6 have peaks in the fine sand grade. This size grade also has the greatest frequency in the wind blown sand covering much of the county. (See fig. 4a, b, and c.) The peak in this grade size in the till is probably the result of incorporation of much wind blown sand into the till. The peaks in eight out of eleven till histograms in the medium silt grade probably have similar relationships with the peak in the medium silt grade in loess such as that shown in figure 3a and b.

An attempt was made to plot the sand and clay percentages on two different isopleth maps (Krumbein and Pettijohn, 1938, p. 201). But only a random distribution of the sand and clay percentages was noted. Closer spaced sampling, however, might show significant relationships between outcrops of Fox Hills sandstone, outwash deposits, and the amount of sand in the till. It might be expected that the till west of the contact of the Fox Hills sandstone and the Pierre shale would have a higher percentage of sand. However the difference is not great: 14 samples east of the contact average 31% sand, and 33 samples west of the contact average

33% sand.

Stone counts.--Stone counts have been used to differentiate till sheets by determining differences in provenance. Flint (1955, p. 136-137) made stone counts at 34 localities in South Dakota and found no significant differences in composition of stones in different glacial advances. Fourteen pebble counts were made on A-1 and B-1 tills and no significant differences were noted in pebble composition of the tills of the two advances. (See fig. 7.)

Flint noted (1955, p. 137) that the true percentage

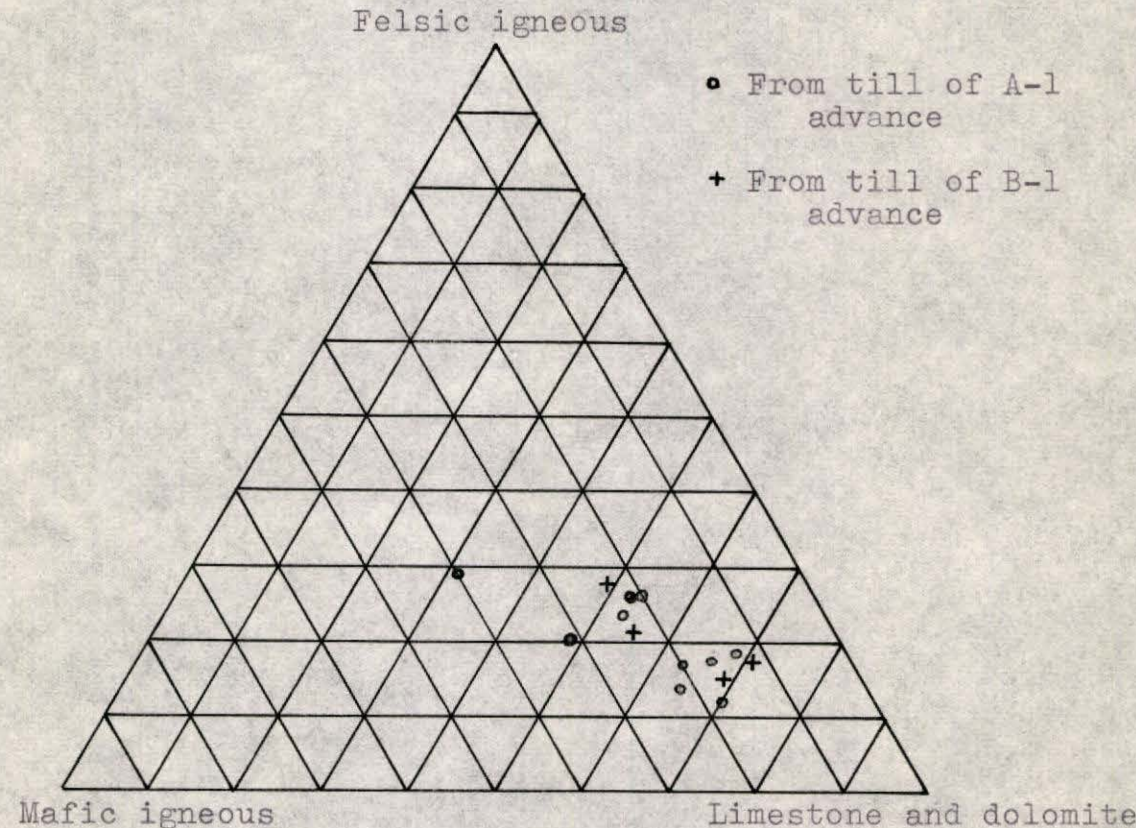

Figure 7.--Triangular diagram of ratios of three most abundant rock types in pebbles in till of A-1 and B-1 advances.

of shale in pebbles is hard to derermine because the shale pebbles disintegrate easily. The coarse sand fractions separated during size analysis were saved and the percentages of shale grains determined. Again no significant trends were noted. It would be expected that the till east of the contact of the Fox Hills sandstone and Pierre shale would have a higher percentage of shale grains. However, shale averaged 27% of the coarse fraction in samples from east of the contact, while west of the contact, shale averaged 31% of that fraction. This is probably due to the large amount of outwash incorporated into the till of these three loops east of the contact.

Stratigraphy.--At least two localities were observed in the county that had more than one till exposed. In a road cut 8½ miles south of Tappen, 0.3 mile north of the southwest corner of sec. 22, T. 138 N., R. 71 W., the following section was observed:

	Feet
6. Fine sand, dark brown; fine grained; wind blown; loesslike, with silt matrix........	1.9
5. Till, pale olive (5Y 6/3) when dry; 5 mm iron oxide spots; 1 ft thick lime concentration near middle; sample Cl-37-E; histogram, fig. 6f. (Probably corresponds to till of Twin Buttes loop, of the A-1 Mankato advance.)..	3.8

Feet

Sharp contact.

4. Loess, pale yellow (5Y 7/4) when dry; inconspicuous vertical jointing; with tube shaped ferruginous concretions, 2 mm in diameter; sample Cl-37-D; histogram, fig. 3a.................................. 0.2-0.8

Sharp contact.

3. Gravel, with a few boulders up to 1 ft in diameter................................ 0.2

Sharp contact.

2. Till, pale olive (5Y 6/3) when dry; 5 mm iron oxide spots; 0.1 ft thick lime concentration at top; well compacted; sample Cl-37-B; histogram, fig. 6e. (Probably corresponds to till of the recessional of the Long Lake loop of the A-1 Mankato advance.) 5.0

Concealed interval................................ 7.0

1. Till, pale yellow (5Y 7/3) when dry; 5 mm iron oxide spots. (May be the same as unit 2.) 2.0

Base concealed.

20.7

Flint noted tube shaped ferruginous concretions in many South Dakota loesses (1955, p. 39, 97). They probably developed around roots of the plants that caught the wind-blown loess. Lemke and Kaye (1958, p. 94) found a lime concentration associated with a boulder concentration between two tills in north-central North Dakota. If Lemke and Colton were correct in saying that both the Twin Buttes and Long Lake loops belong to the A-1 advance of the Mankato, the interval represented by the gravel concentrate and loess must be fairly short. (See Appendix I.)

The second exposure with two tills is 13 miles south of Dawson, 0.3 mile north of the southeast corner of sec. 16, T. 137 N., R. 72 W., an either side of State highway 3:

	Feet (estimated)
3. Till, pale yellow (5Y 7/3) when dry; 5 mm iron oxide spots; lime mottling; contains Fox Hills sandstone boulders; contains more pebbles than unit 2; sample C1-10-C; histogram, fig. 6c. (A-1 advance of Mankato.)................................	3.0-8.0
Sharp irregular unconformity.	
2. Till, pale yellow (2.5Y 7/4) when dry; very sticky when wet, hard when dry; iron and manganese oxide coatings on the faces of small, irregular, 1 in. spaced joints; samples C1-10-A (1 ft below top) and C1-10-B (6 ft below top); histograms, fig. 6a and b. (Tazewell.)...............	10.0

	Feet (estimated)
Contact gradational.	
1. Till, similar to unit 2 but greyer. (Probably the unoxidized equivalent of unit 2.)..	5.0
Base concealed. maximum	25.0

The till of unit 2 is the only one seen in the county that differs conspicuously from all the others. Iron and manganese oxide on small irregular joint faces was also noted in the older (Iowan or Tazewell) of two tills described by Lemke and Kaye (1958, p. 95). It was also noted by Flint (1955, p. 35) on joint surfaces of Iowan till in South Dakota. Because this till is considerably different from other tills in the county, it is probably not of the A-1 or B-1 Mankato advances, but is Tazewell in age (known Tazewell is exposed 30 miles southwest of this exposure). Flint found that most pre-Wisconsin till is more prominently jointed.

Another till that is sticky when wet (samples Cl-49 and 50) is exposed 10 miles south of Crystal Springs, 0.4 mile west of the northeast corner of sec. 4, T. 137 N., R. 70 W. Other than its stickiness, this till isn't remarkably different from other tills in Kidder County.

Conclusions

Tills of different glacial advances in the end moraine complex in south-central North Dakota are difficult to differentiate by lithology alone. Little difference exists between tills of the A-1 and B-1 advances of the Mankato subatage. If the major direction of glacial flow in the different substages had varied, the till lithologies might have been different. In northwestern North Dakota, where the ice approached from more than one major direction, Howard (1956) outlined the contact between two different tills by using stone counts. Stone counts also might be used in south-central North Dakota to differentiate substages. (Stone counts were only made on Mankato till in Kidder County.) However, the major glacial movements were probably all southwest, over nearly 200 miles of a single bedrock formation.

Secondary changes, such as oxidation and iron and manganese oxide on joint faces, may be of considerable help in distinguishing between Mankato and Tazewell tills. (And very strong jointing would suggest pre-Wisconsin till.) Except for the geomorphology of the till sheets, stratigraphic relationships, where they can be observed, are the most helpful.

A second conclusion that was reached concerns Shepps' statement (1953, p. 46-47) that the importance of the local source of till has been overestimated. (Flint (1955, p. 138) emphasizes the importance of the local source in South Dakota.) He thinks only 20 to 30% of till in northeastern Ohio has been locally derived. If by local is meant an area the size of Kidder County, the same conclusion can probably be reached for the tills of Kidder County. Except for the thin tills with much incorporated outwash, little significant difference was seen in the percentage of shale in the coarse sand fraction of samples taken from up to 15 miles on either side of the contact of the Fox Hills sandstone and Pierre shale. And, except for the influence of outwash, the percentages of sand, silt, and clay doesn't vary significantly on either side of the contact. If the local source were important, more sand should be found in tills west of Fox Hills-Pierre contact and more clay east of it.

Appendix I

Probable Cary drift in Kidder County

This report has been written with the assumption that Lemke and Colton's age designations were correct (fig. 8a). However, it is probable that the outer edge of Flint's A-1 Mankato advance correlates with the Twin Buttes loop in Kidder County, and the remainder of Lemke and Colton's A-1 Mankato advance to the norhtwest belongs to the Cary maximum (fig. 8b). The reasons for believing this are as follows:

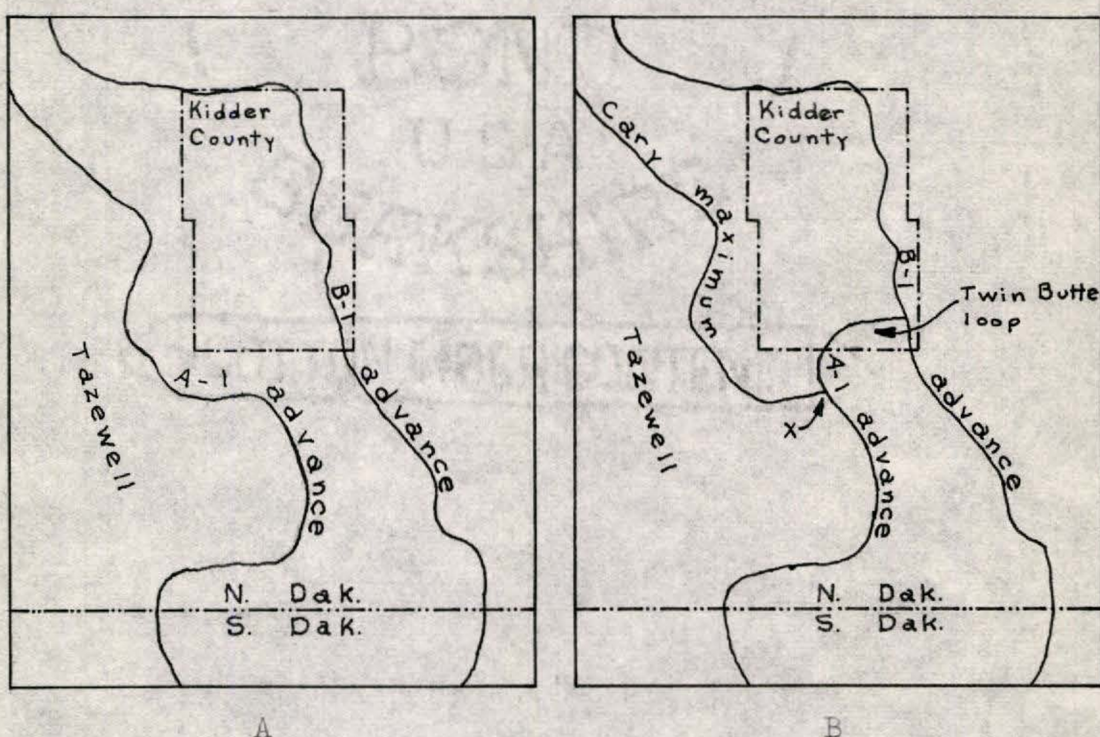

Figure 8.--Age of till sheets. A, according to Lemke and Colton (1958, fig. 3). B, a more probable interpretation.

1. The topography of the Twin Buttes loop resembles that of the end moraines of the B-1 advance much more than it does that of the end moraines of Lemke and Colton's A-1 advance northwest of the Twin Buttes loop (see p. 7).

2. The Twin Buttes loop overlaps at right angles the recessional of the Long Lake loop (fig. 1).

3. Flint (1955) makes no mention of loess between till of minor advances of the Mankato substage. However, there is loess between till of the Twin Buttes loop and the recessional of the Long Lake loop (see p. 19).

4. Lemke and Colton did most of their correlating with aerial photographs. At the critical point on the aerial photograhps (x, fig. 8b), there is little evidence that the A-1 advance should be as in figure 8a, rather than as in figure 8b.

The main conclusions of the report are not altered by this change in age designations. Not only tills of the A-1 and B-1 advances, but also tills of the Cary and Mankato substages are lithologically indistinguishable in Kidder County. Flint (1955, p. 110) says the tills of these two substages are also indistinguishable in South Dakota. If the till of western Kidder County is Cary rather than Mankato, the loess of unit 4 on page 19 is post-Cary - pre-Mankato rather than "inter-A-1 Mankato".

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