SHALLOW SEISMIC SURVEY OF THE KANSAS STATE UNIVERSITY CAMPUS AREA

by

KENNETH E. MATHIAS

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Approved by:

Charles P. Walters

Major Professor

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INTRODUCTION

Purpose of Investigation

As of this time a complete study of the subsurface geology in the vicinity of the Kansas State University Campus has not been made. Previous subsurface investigations have been oriented toward the engineering geology for each specific building project. These investigations have shown that the geology of the underlying unconsolidated sediments and the bedrock configuration are quite complex.

This project was undertaken to determine the feasibility of using seismic techniques to determine more about the near surface geology of the area. In addition, techniques of seismic investigation were to be developed to determine the problems of identification of sediments at depth.

It is hoped that this investigation has significantly increased the assemblage of information of the subsurface geology of the campus area. Field work was started in the summer of 1971 and completed in the fall of 1971.

Area of Investigation

The principal area of investigation was the Kansas State University main campus, northwest of Manhattan, Kansas, and part of the Kansas State University Agronomy Research farm northwest of the main campus (Fig. 1). The boundaries of the main campus are Anderson Avenue on the south, North Manhattan Avenue on the east and Denison Avenue on the west. The boundaries of the Agronomy Research farm portion of the area surveyed are Kimball Avenue on the south, North Manhattan

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

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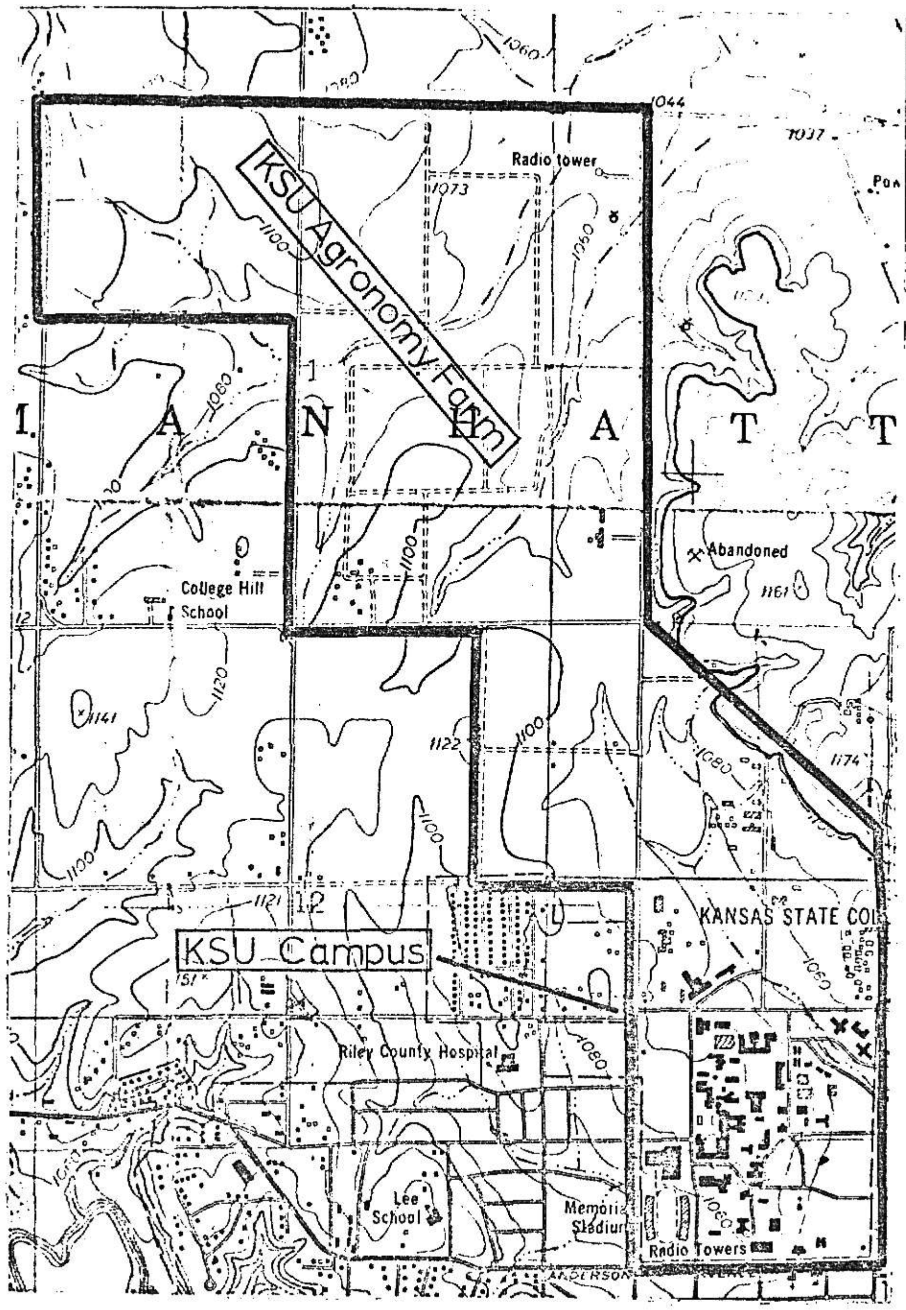

Fig. 1

Index Map showing area covered in this investigation (From Manhattan Quadrangle, U. S. G. S.)

Avenue on the east, Browning Avenue on the west and Marlatt Avenue on the north. Side traverses were made to the nearest rock outcrops to gain additional information.

Physiography and Topography

The area is in the Flint Hills Division of the Central Lowlands Physiographic Province. To the south is the eastward flowing Kansas River. To the east the Blue River flows southward toward its confluence with the Kansas River.

Relief in the area of investigation is approximately 90 feet with the lowest point being at elevation 1030 feet at the southeast corner of the campus and the highest at the corner of Browning Avenue and Marlatt Avenue with an elevation of 1120 feet.

Geology

The location is primarily in an area of alluvial stream-type deposits of Buck Creek Terrace origin of Illinoian Age (Beck, 1961). The Agronomy Research farm is in an area thought to be the filled channel of an ancient stream. Deposits on the farm and on the main campus consist of clay, silt, sand, gravel, chert gravel, and some boulders. A representative boring log is presented in Fig. 2. The outcrops near the former channel are rocks of the Permian System, Lower Permian Series, Gearyan Stage (Zeller, 1968). Rocks under the unconsolidated materials in the area are of the Council Grove Group. Rock strata in the area have a regional westward dip of approximately fifteen feet per mile.

Ground water levels are near the surface. Levels are as near as eight feet below the surface on the main campus south of Memorial Stadium and three feet be-

REPRESENTATIVE BORING LOG

Barnett-Stuart Consulting Geologists

Building: KSU Women's Dorms Unit C

Boring Number: 1

Water Level: Caved @ 1037.4

Date: 9/30/65

Elevation	Depth	Description
1071.4	0.0'	Top Hole
1069.2	2.2'	Topsoil
1061.4	10.0'	Brown sandy clay, damp
1051.1	20.3'	Brown sandy silt, damp
1039.4	32.0'	Tan very fine sand, silty, damp, wet @ 27'
1022.1	49.3'	Brown medium to coarse sand
1018.6	52.8'	Shale, blue-gray limy, very hard Bottom hole

Fig. 2

A representative boring log made on the Kansas State University Campus for Ford Hall low the surface at the Agronomy farm near Marlatt Avenue and the KSAC radio tower. Foundation construction and basement drainage problems are partly the result of the high water levels on the main campus while drain tile is needed in some areas of the Agronomy farm.

PREVIOUS INVESTIGATIONS

Previous published work has not related specifically to the Kansas State University campus area. However, work has been done relative to the glacial geology and history of the Blue and Kansas River Valley areas. Mention has been made in these works of the geology of the campus area. Following are some results of previous investigations.

Hays in 1892 was the first to recognize that the Kansan glacier may have dammed several river valleys and probably created several lakes. He was one of the first to define the limits of glaciation. These limits were said to be the Kansas River on the south and the Blue River on the west.

The first person to have recognized and named the largest lake was Smyth (1898) who named it Kaw Lake. It was described as extending west on the Kansas and Smoky Hill Rivers to Salina and north on the Blue River to Blue Rapids.

Todd stated in 1909 that the drainage of the Kansas River was once westward. Downwarping of the area because of great ice loading reversed flow direction.

At a later time, Todd (1918) went further to describe conditions during the ice age in the Manhattan area. In the first (1918a) of two articles he described an old river channel trending through the campus at Manhattan. It was believed by him that the old channel once contained the Kansas River where it flowed 150 to 175 feet higher than the present Kansas River. The river flowed through the campus and northward turning eastward near the intersection of Marlatt Avenue and Denison Avenue. He thought that the Kaw Lake retained waters as high as 1175 feet in elevation. Therefore the channel trending through the campus would have been under water.

In a second article in the same year, Todd (1918b) gave a further description of happenings in the Kaw Lake area. The Blue River, carrying a load from the west, deposited it in the underwater Manhattan area. The present filling in the area may partially be a preserved delta. Boulders in the material under the campus were probably rafted in on icebergs during the age of the lake.

The Quaternary geology of Riley County was investigated and presented in 1949 by Beck. Stratified sands were exposed at the excavation of the field house and were suggested to be glacial outwash deposits. He stated that the abandoned channel north of campus was once the channel of Wildcat Creek. When the stream was blocked to the east by the Kansan glacier an overflow across campus took place. Later Wildcat Creek was diverted into its present channel where it continued to flow. Some unconsolidated sediment in the campus area was reported to be water deposited after the Kansan Age due to overflows of the Kansas and Blue Rivers during heavy surface runoffs during the Illinoian and Wisconsin ages.

Mudge said in 1955 that the outwash on the KSU campus was of Kansan Age. Furthermore, he stated that the K-Hill and Bluemont Hills were connected at that time giving emphasis to the fact that the Kansas River flowed through the campus area.

In a paper concerning the buried valley north of Manhattan, Beck (1961) described the geology and history of the area. He did bedrock contour work from test holes in the area and concluded that the old channel trended north-eastward.

In an examination of the lithology of the various glacially associated deposits Moulthrop in 1963 wrote that the Buck Creek deposits (which are in the campus area) are a distinctive brown to brownish red, grade from silty clay and very fine sand and silt to medium sand and contain many layers of chert. He stated that the lithology is uniform throughout the Kansas River Valley and major tributary valleys.

Steeples (1970) showed in the neighboring Blue Valley, east of Manhattan, that the alluvial fill ranges from less than 10 feet to as much as 114 feet thick.

METHODS OF INVESTIGATION

The Seismograph

The model MD-1 portable engineering seismograph manufactured by Minnetech Laboratories of Minneapolis, Minnesota, was used primarily. Correlation with building foundation investigation borehole information was also used.

The field equipment includes a timing device, geophone with cable, hammer with cable and a steel striker plate one-inch thick.

As in any geophysical method, information about sub-surface conditions and material identification is obtained by measuring a physical property. In this case the seismograph measures velocities of shock waves transmitted in the several subsurface layers of the sediment mantle. The velocity in a layer is measured by creating a shock wave by a hammer blow and measuring the time for the longitudinal wave component to arrive at a particular point where a geophone receives the signal. Additional time-distance relationships are used to find the thickness and depth of layers differing in vibration transmitting qualities, by successively increasing the distance between the wave source and geophone. The use of these relationships is called seismic refraction surveying.

Refraction surveying calculations are based on several assumptions, all of which must be met to achieve results. Jakosky (1957) proposed these assumptions:

1. The velocity in successive strata increases as depth increases.
2. The sediments of the strata are such that the velocities in any direction are the same.
3. The strata are sufficiently thick.
4. The boundaries between the strata are planes.

To achieve penetration, condition one must be met. If all conditions are met, the travel time curve (Fig. 3) will have straight line segments with successively decreasing slopes. These conditions rarely exist in practice and the possibility that they do not exist must be kept in mind while surveying, to help explain erratic results.

In operation and theory the process of shallow refraction surveying is quite straightforward. A geophone is placed at point D (Fig. 4). A series of shock waves is made with hammer blows by moving outward from the geophone at 10 foot intervals. The travel time of the wave through the medium is registered at the timer for each blow of the hammer. At locations close to the geophone the wave will travel through the medium from A' to D with characteristic velocity of the medium which is V1 and is measured as the slope of segment 1 (Fig. 3). As the distance from the geophone is increased the wave will travel to the higher velocity layer (medium 2) with characteristic velocity V1 by path AB. It then proceeds to travel through medium 2 by path BC. Travel of the wave to the geophone from medium 2 is by path CD. The velocity in medium 2 is measured as the slope of the second time-distance curve. If a third layer is present its characteristic velocity will be depicted as the slope of segment 3.

From formulas supplied in the MD-1 Manual (Minnetech Labs, 1964) the following relationships were used to determine depth to velocity layer discontinuities.

$$D1 = \frac{X1}{2}\sqrt{\frac{V2 - V1}{V2 + V1}} \qquad \text{and} \qquad D2 = P \cdot D1 + \frac{X2}{2}\sqrt{\frac{V3 - V2}{V3 + V2}}$$

where

D1 - depth to the first horizontal discontinuity.

D2 - depth to the second horizontal discontinuity.

V1, V2, V3 - velocities in feet per second in mediums 1, 2, 3 respectively.

X1 - distance in feet read from the time-distance plot at the first velocity break in slope.

X2 - distance in feet read from the time-distance plot at the second velocity break in slope.

P - given by

$$P = \frac{\frac{V2}{V1}\sqrt{\left(\frac{V3}{V1}\right)^2 - 1} - \frac{V3}{V1}\sqrt{\left(\frac{V2}{V1}\right)^2 - 1}}{\sqrt{\left(\frac{V3}{V1}\right)^2 - \left(\frac{V2}{V1}\right)^2}}$$

Depths to the first discontinuity are approximately one-third of the value of X1. Therefore, if a first velocity break does not occur in the distance traversed, the depth of any higher velocity layer will be at least deeper than one-third of the distance traversed.

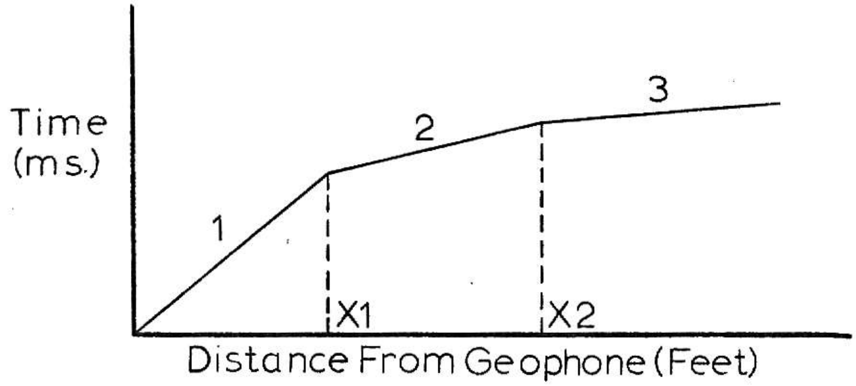

Fig. 3

Plot of wave travel time versus source distance from geophone

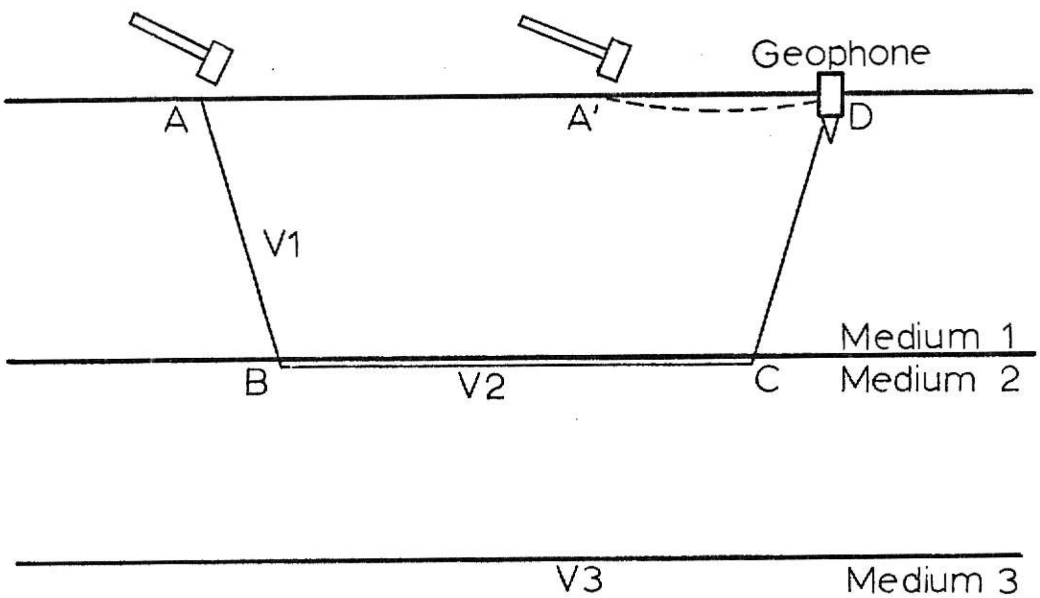

Fig. 4

Cross section showing wave travel relationships

The depth to the horizontal velocity boundary is the measure of the average depth over the middle two-thirds of the total traverse length for depth D1 and the middle one-third for D2.

For detailed work it is necessary to run separate traverses in two directions across a traverse location. In addition, traverses at right angles are useful in determining the dip of layers. More detailed theory and procedures appear in Jakosky (1957) and in Grant and West (1965).

The resultant velocity measurements may be used to indicate various mantle rocks. Table 1 lists the velocities of waves according to both material type and geological age. In shallow seismic work the energy source is not of great magnitude and usually the low velocity layers consisting of unconsolidated heterogeneous sediments 20 to 100 feet thick are measured. This zone is what the deep seismic surveyors try to avoid when setting their source charges. Velocities range from 550 to 2500 feet per second in this layer. Internal reflections cause reverberations and associated problems in distinguishing the first arrival signal in such sediments. In most cases the botton of the low velocity zone is closely associated with the top of the permanent ground water table (Jakosky).

Where porous materials are filled with moisture the modulous of elasticity is increased and improved wave transmission results in an increase of velocity at the water table. Consolidated sediments do not have a parallel effect with increasing water content. Sandstones, limestones, schists, and certain igneous rocks exhibit the property of reduction of velocity upon saturation (Jakosky). Therefore water saturation may bring the velocities of two completely different materials such as limestone and saturated clay into the same range of values. This effect makes the identification of buried materials from the velocity plot difficult. As in any geophysical survey it is necessary to have actual test-hole data for control and correlation purposes.

A major problem encountered in seismic work is that of outside disturbances masking the first arrival wave by the creation of extraneous noise. In shallow work with a wave source of low magnitude, increased difficulty is encountered the farther from the geophone the hammer stations are placed, the greater the magnitude of outside noise with relation to the shock signal. The geophone is usually placed in a shallow hole and covered to minimize wind disturbances. Placement of the geophone in firm ground away from trees, telephone and power poles, pipelines, streets, buildings and other structures that may transmit vibration is necessary for noise reduction. Bothersome sources of noise that prevent operation completely at times are aircraft, nearby automobile traffic, construction work, air conditioning units and power plants. The wind blowing across tall grass, weeds and trees also creates unwanted vibration.

Field Procedures

The MD-1 portable seismograph is designed for two-man operation. However it was modified for one-man operation by the addition of a shielded extension cable to the geophone. In this way the seismograph was moved by the operator who also used the hammer while the geophone remained in a fixed location.

Several trial traverses were made with the seismograph to check the equipment and to develop operator techniques. These were numbered traverses but the data were not used in this investigation. The actual survey began with traverse number 20.

The main campus survey was conducted so as to stay at a maximum possible distance from structures, pipes, steam tunnels and sidewalks. The procedure of running traverses at right angles and traverses in reverse was tried. Complicated corrections for topographic slope were required when running right angle traverses. Total time for running of one traverse of one hundred feet in one direction was approximately 45 minutes where hammer intervals were 10 feet apart with 5 to 10 blows of the hammer at each station. Each traverse was run in one direction along level ground because extreme detail was not wanted at each location. The calculated depths were the average depth over the middle two-thirds of the traverse for single layer cases and the average over the middle one-third of the traverse length for a two-layer case. Late night and early morning surveying was resorted to after initial traverses indicated too much noise interference from traffic for maximum traverse length and associated subsurface penetration. The procedure eliminated noise problems except in the area of the power plant where surveying closer than 200 to 300 feet did not give useful results.

The seismic investigation of the Agronomy farm was much more simple. Instead of selecting small areas favorable for surveying as on the main campus, the entire Agronomy farm was suitable for surveying. A grid of traverse locations was laid out and the work executed. Minimal noise problems resulted even though some farm machinery was working in the area.

Table 1

Approximate Range of Velocities of Longitudinal Waves
Representative of Materials Found in the Earth's Crust
(From Jakosky)

A. Classification According to Material

Material	Velocity (ft./sec.)
Weathered surface material	1000 - 2000
Gravel, rubble, dry sand	1500 - 3000
Sand (wet)	2000 - 6000
Clay	3000 - 9000
Water (depending on temp. & salt cont.)	4700 - 5500
Sea Water	4800 - 5000
Sandstone	6000 - 13000
Shale	9000 - 14000
Chalk	6000 - 13000
Limestone	7000 - 20000
Salt	14000 - 17000
Granite	15000 - 19000
Metamorphic Rocks	10000 - 23000
Ice	12050

B. Classification According to Geologic Age

Age	Type Rock	Velocity (ft./sec.)
Quaternary	Sediments	1000 - 7500
Tertiary	Consolidated Sediments	5000 - 14000
Mesozoic	Consolidated Sediments	6000 - 19500
Paleozoic	Consolidated Sediments	6500 - 19500
Archeozoic	Various	12500 - 23000

A base map supplied by the Kansas State University Development Office was used for location spotting and surface elevations of the traverses for the main campus. A portion of the Manhattan Quadrangle was photographed, enlarged, and used along with an aerial photograph for location and ground elevation data in the Agronomy farm area. The use of the hand level enabled further control for elevation determinations.

Outcrops of rock in the area fronting onto the filled valley were mapped to obtain further control and correlation.

After the completion of the Agronomy farm survey, some areas indicating shallow depths to velocity boundary layers were checked by use of the hand auger.

RESULTS

Treatment of Data

The time-distance relationships obtained from the seismograph traverses were plotted on graph paper to the nearest 1/2 millisecond and 1/2 foot so as to give the information needed for depth calculations. Some scattering of points from the straight line velocity relationships was considered a normal occurrence as indicated in references dealing with practical seismic analysis. In the practical case the medium was not homogeneous, and the velocity boundary layers were usually not planes. A straight line was constructed through the average of points. This was done with great care to insure accuracy. The slopes of the lines were calculated to yield velocity values to the nearest 250 feet per second. The velocity breaks were located to the nearest foot. Using this method the depths were calculated to the nearest one-tenth foot. The surface elevations were located to the nearest foot on the main campus and to the nearest two feet on the Agronomy farm. The final elevations of the higher velocity boundary layers were rounded off to the nearest foot. The MD-1 manual states that by following the above procedure, depth values may be obtained accurate to within 5 percent of the true depth to the higher velocity zone.

Bore-hole logs were examined and depths to the various layers and bedrock recorded.

Maps of 1:960 scale for the main campus and 1:6000 scale for the entire area including the Agronomy farm were used for plotting the resultant data. Bore-hole locations were plotted showing bedrock elevations to the nearest foot. All seismic traverse locations with characteristic velocities of 5000 feet per second or greater were plotted and the elevations of these layers noted. High velocity layers were not encountered in some traverses and it was noted on the maps that depths to a high velocity zone were of a value greater than one-third the length of the traverse. Both bedrock elevations and high velocity layer elevations were used in contouring, with the assumption that the high velocity layer surfaces were bedrock surfaces. The location and elevations of existing rock outcrops provided additional control at the edges of the map where little information was available. The outcrop of Long Creek Limestone at the horseshoe courts south of the Student Union was taken into consideration. The main campus was divided into sections for separate contouring and several versions of the map were made using the same data.

Thickness maps were then constructed from bedrock-high velocity layer maps, topographic maps, and drill data from Beck (1961).

Presentation of Results

The main campus bedrock-high velocity layer map (Plate III) illustrates contours of from 1000 feet elevation in the southeast portion of the campus to 1060 feet elevation in the central portion of the campus. The low bedrock areas of the southeast campus correlate with a low topographic elevation area and possible ancient stream channel. The central part of the campus is underlain with a cap rock of Long Creek Limestone of 1050 feet average elevation. In the area of campus in the vicinity of the football stadium is a buried channel trending southeast in direction. Seismic traverses in the area indicated a fairly shallow depth to a high velocity layer. Work in the same area with a hand auger showed water saturated material at about the same depth. Depths to higher velocity interface layers in the vicinity of the Chapel are also likely to be depths to water saturated zones as it is known from bore hole information that the bedrock drops off rather rapidly in that area. The same occurrence was evident in the stream area between Boyd Hall and the Waters Annex building. Although contours seemed to indicate subsurface conditions with drainage direction similar to topographic drainage, the depths to actual bedrock may be somewhat deeper than given by the seismograph. Close correlation with bore-hole depths to bedrock elsewhere on campus was obtained.

The traverses on the Agronomy farm (Plate IV) did not have the advantage of closely spaced bore-hole data for correlative purposes. High velocity interface layers were encountered at elevations from 1035 to 1110 feet. Contour lines indicated a buried valley trending north-eastward. Velocities ranged from 10,000 feet per second at locations 53 and 76 to near 5000 feet per second elsewhere. From seismic information it appeared that a divide exists between northeast drainage in the abandoned stream valley and southwest drainage through the campus area. This divide is along Kimball Avenue.

In work done by Smith in 1959 concerning ground-water studies in the Manhattan area, ground-water contours were presented in the Agronomy farm area in the shape of a valley trending northeastward. His contours were very nearly the same shape as those derived by the seismic survey except that they were generally twenty feet lower in elevation.

Bedrock contour work in the area presented in a paper by Beck in 1961 showed a northeastward trending valley based on bedrock elevations obtained by drilling in the area north of Manhattan. Although only one hole was drilled in the area investigated for this work, it correlated closely to a depth obtained seismically near traverse location 56. He did not show a buried drainage divide along Kimball Avenue but gave evidence of drainage toward the northwest from the main campus into the northeasterly trending channel.

A soil map of the Agronomy farm did not yield any correlation with seismic data either depthwise or with velocity studies. It had been previously suggested that evidence of a possible ancient lake deposit layer in the vicinity of the KSU stadium (O. W. Bidwell, personal communication, 1971) would be detected by a seismic survey

Field checking of near-surface high velocity interface layers with a hand auger showed water saturated clays. Auger location 1 (Plate II) showed a definite caliche zone. This may have been due to a recent or ancient water table fluctuation.

A map showing the thickness from the first velocity change to the bedrock as determined by Beck (1961) was constructed (Plate VI). This may be an indication of the thickness of water-saturated unconsolidated sediments on the Agronomy farm if the first velocity change is assumed to be the water table.

SUMMARY

Earlier workers provided general information pertaining to the area investigate This information was useful in planning and explaining some of the results of the seism work. Bore-hole information provided useful correlation in the main campus area. Ideal survey conditions were not met on the main campus area due to noise interferenc and many structures and buried pipes. Not all areas could be investigated. The existence of low velocity layers at depth possibly may have limited penetration. High velocity layers in some locations on campus and in a large part of the west two-thirds of the Agronomy farm were explained as ground-water levels.

Great difficulty was encountered in differentiating between bedrock and unconsolidated sediments. The characteristic velocity of known bedrock layers was near 10,000 feet per second and other velocities were near 5000 feet per second. The characteristic velocities of saturated unconsolidated sediments were about 5000 feet per second. Therefore, more drill information is required in some areas for complete knowledge of subsurface conditions.

Through the use of cross-section drawings it was found that the subsurface bedrock-high velocity layer shape followed the topographic form to some extent in the area surveyed.

The use of the seismograph for near surface exploration must be carefully coordinated with surrounding conditions and test-hole information. The presence of low velocity layers and water tables are the greatest source of confusion. Therefore, the seismic method is not suitable for use by itself and in all areas.

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ILLEGIBLE DOCUMENT

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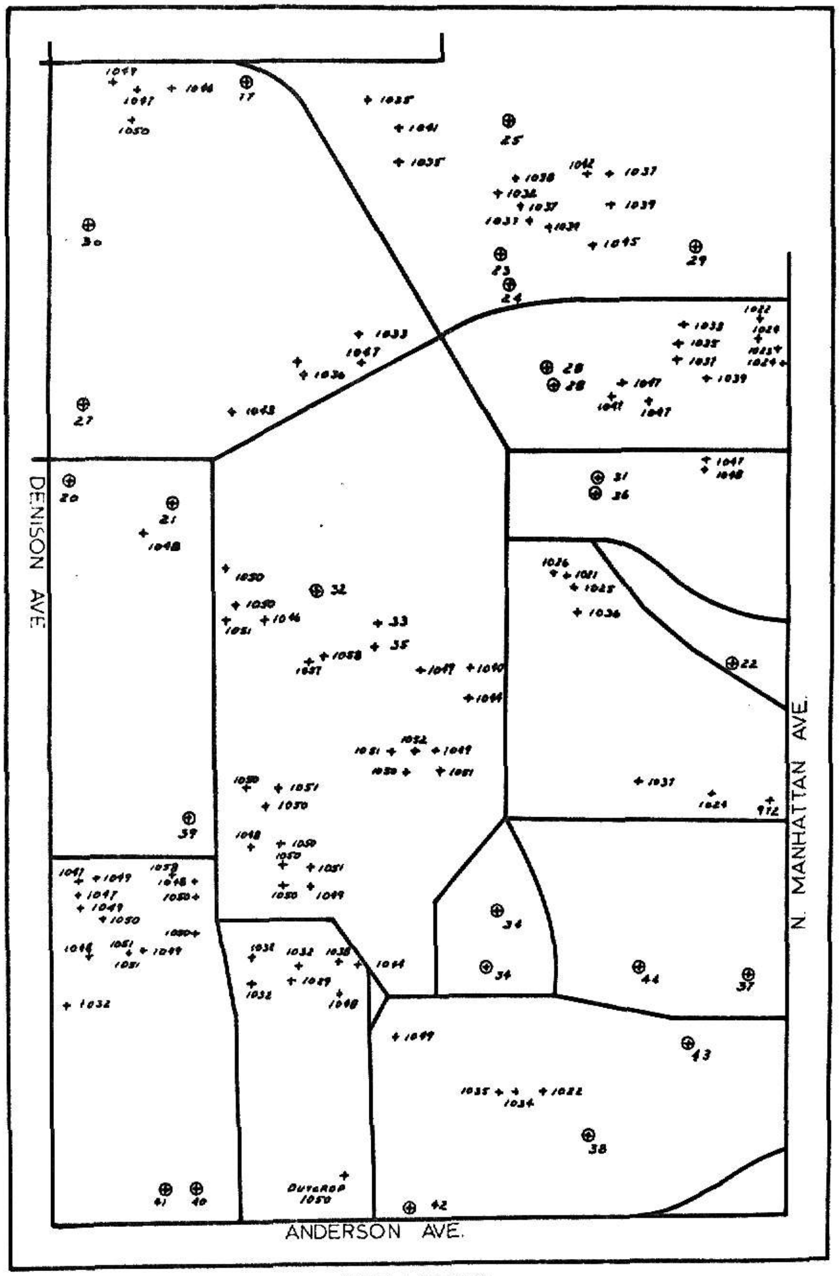
PLATE I
KSU CAMPUS
DATA MAP



EXPLANATION

+1050 DRILLED TEST HOLE AND BEDROCK ELEV
⊕ 21 SEISMOGRAPH LOCATION AND NUMBER

SCALE

0 200 400 1000 FEET

PLATE II
K.S.U. CAMPUS AREA
DATA MAP

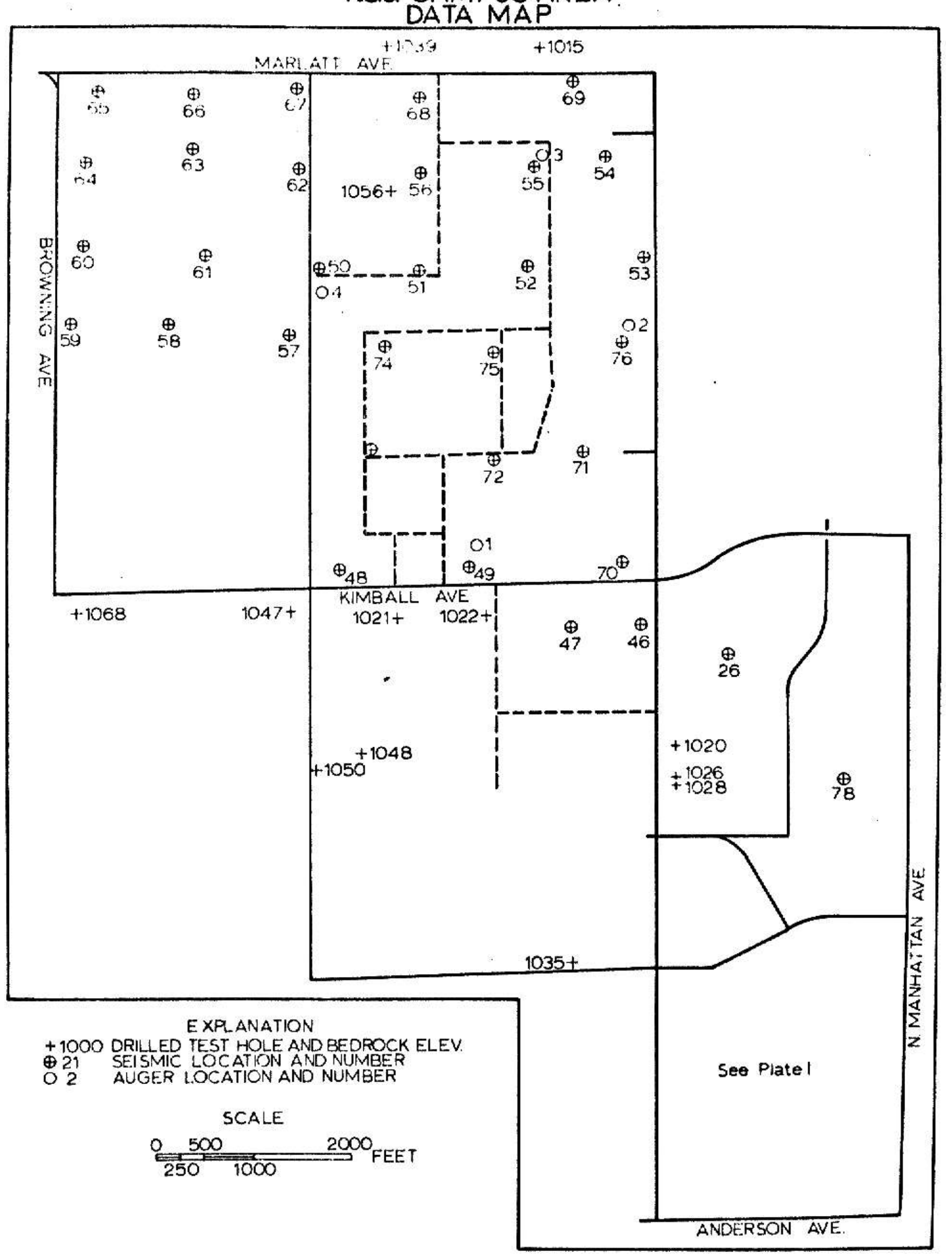
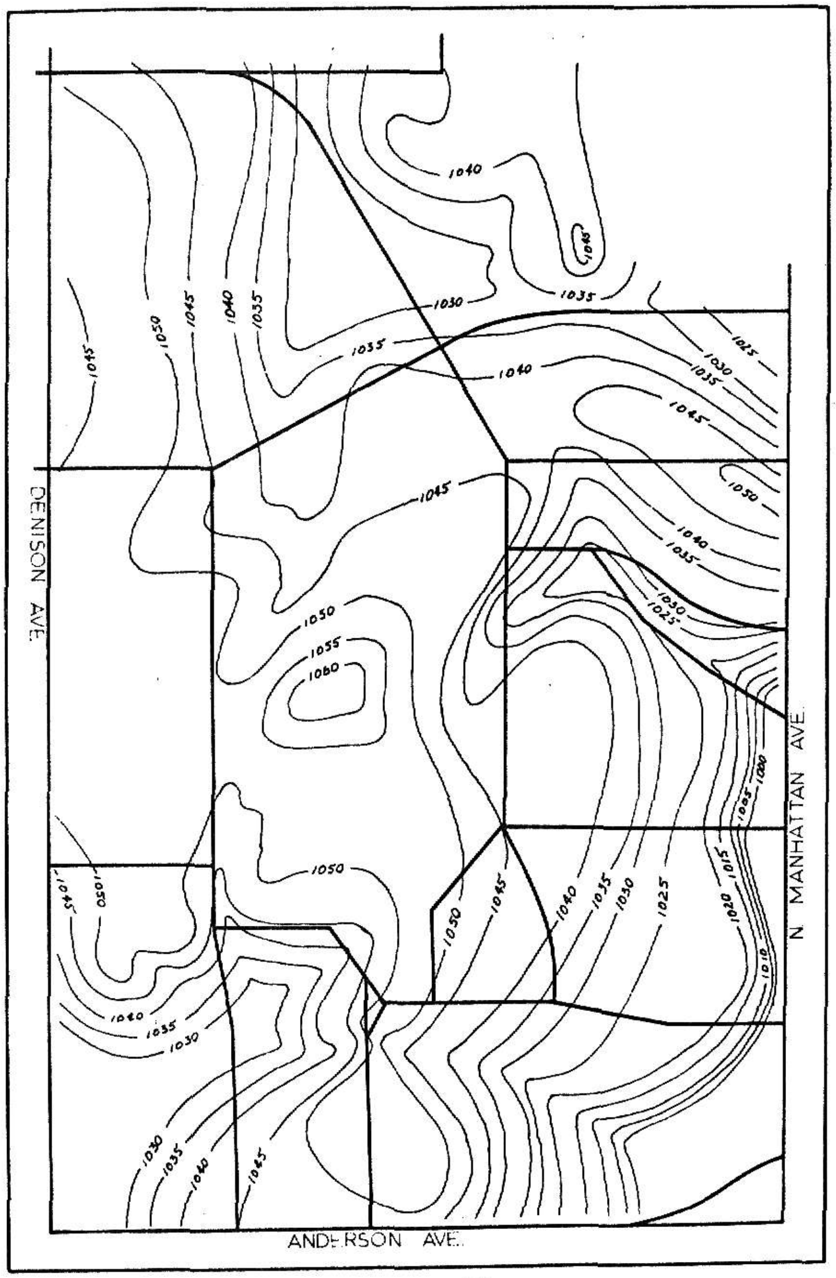


PLATE III
BEDROCK-HIGH VELOCITY LAYER CONTOUR MAP
KSU CAMPUS



EXPLANATION

—1100— BEDROCK HIGH VELOCITY LAYER CONTOUR
ROAD

SCALE

0 200 400 1000 FEET

PLATE IV
BEDROCK-HIGH VELOCITY LAYER CONTOUR MAP

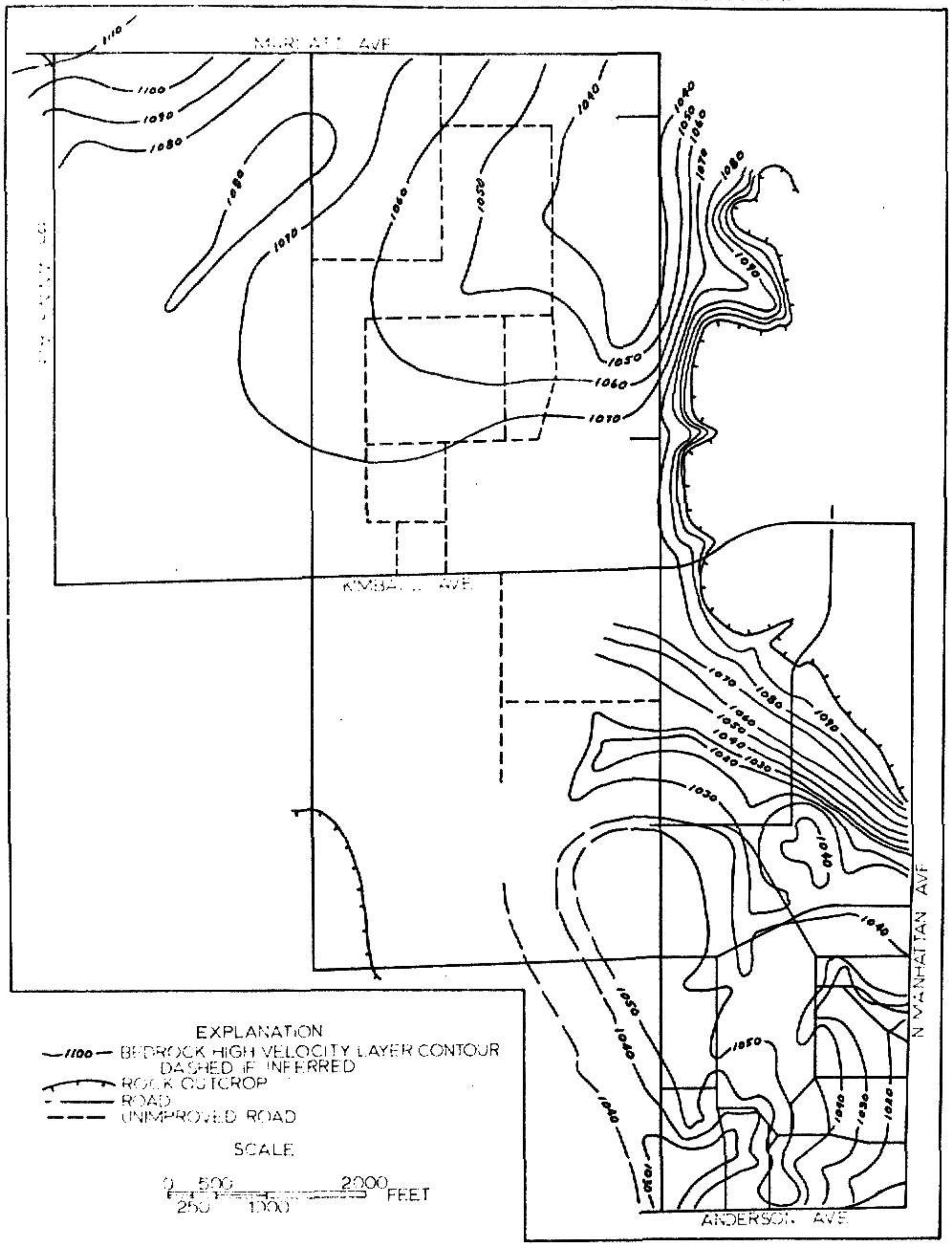


PLATE V
THICKNESS MAP: SURFACE TO FIRST VELOCITY CHANGE

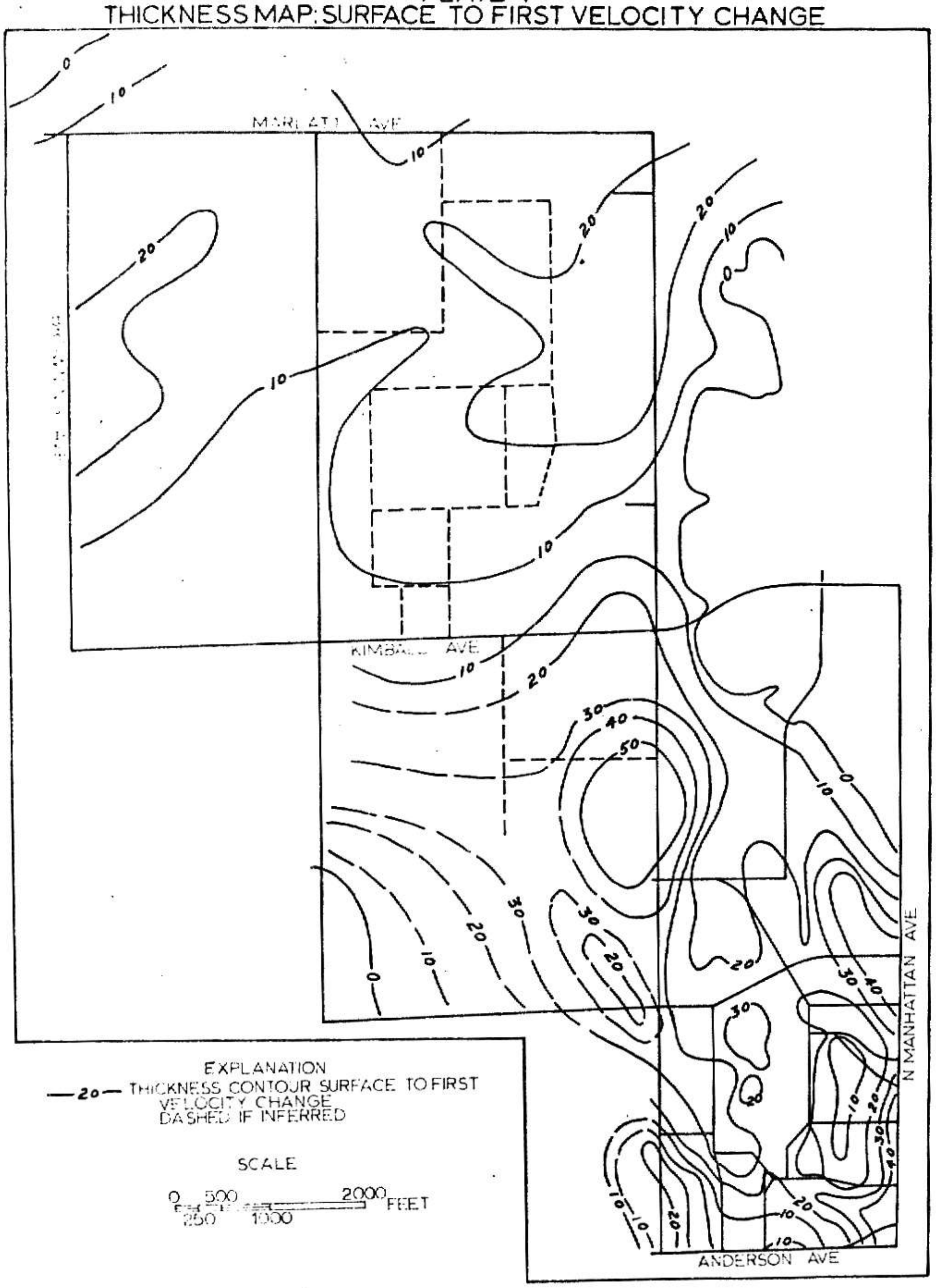
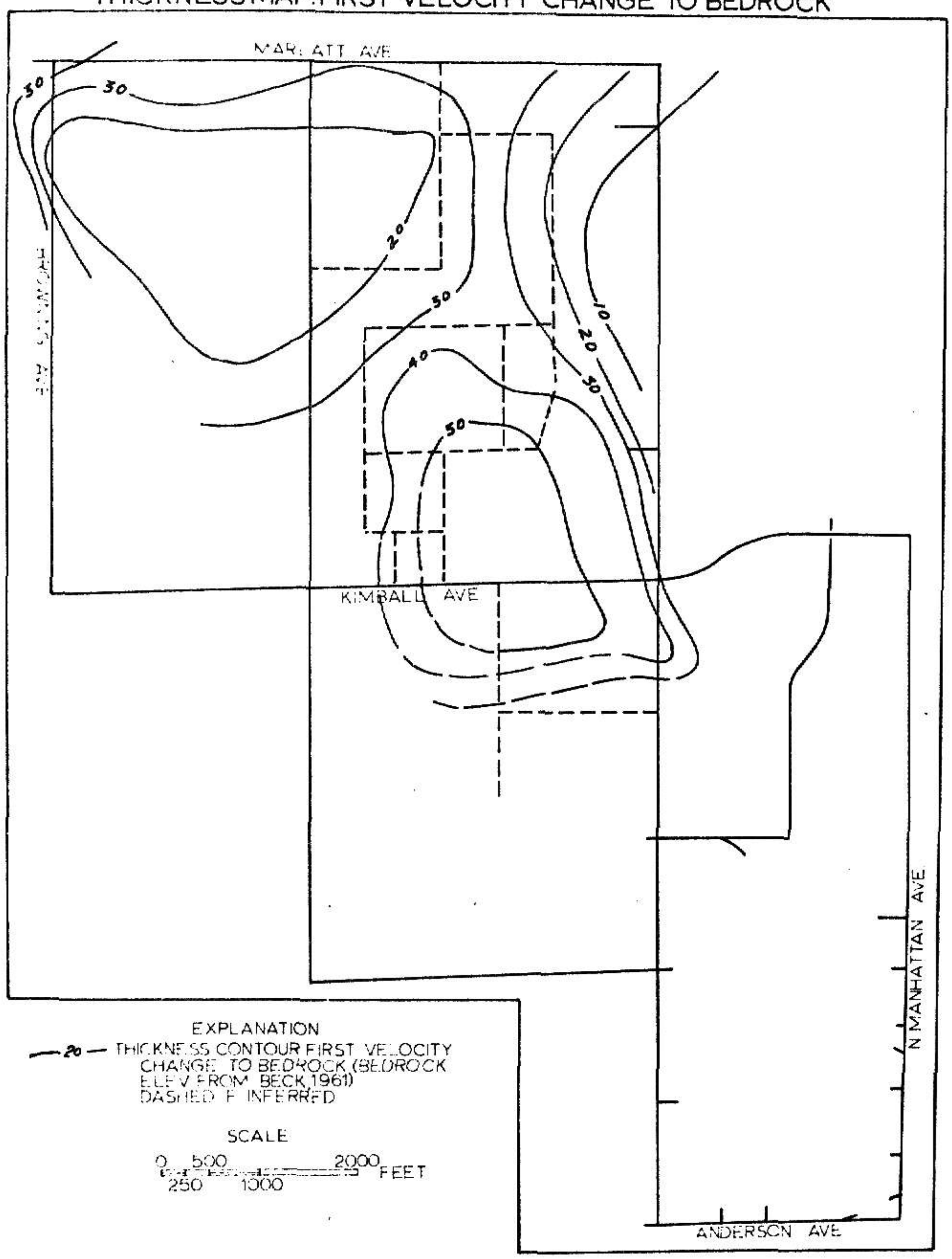


PLATE VI
THICKNESS MAP: FIRST VELOCITY CHANGE TO BEDROCK



APPENDIX

AUGER DATA

Number	Information
1	7' to clay, water, calcite
2	5' to clay (wet)
3	6' to clay (wet)
4	8' to clay (wet)

Traverse Number	Velocity 1 (ft./sec.)	Velocity 2 (ft./sec.)	Velocity 3 (ft./sec.)	X1 (ft.)	X2 (ft.)	D1 (ft.)	D2 (ft.)	Surface Elevation	Elev. 1	Elev. 2
20	1000	1200	-----	20	---	3.0	---	1078	1075	-----
21	900	3300	10,000	26	63	9.8	30.7	1078	1068	1047
22	500	4000	12,000	10	44	4.4	19.0	1037	1033	1018
23	900	5000	-----	15	---	6.2	---	1052	1046	-----
24	670	4200	8000	10.5	55.5	4.5	19.7	1052	1047	1032
25	900	10,000	-----	20.5	---	9.4	---	1068	1059	-----
26	1450	5000	-----	22	---	8.1	---	1100	1092	-----
27	1050	5000	-----	67	---	27.1	---	1071	1044	-----
28	1300	4000	-----	16	---	5.7	---	1048	1042	-----
28'	1200	6000	-----	20	---	7.3	---	1048	1041	-----
29	950	-----	-----	---	---	>10	---	1076	<1066	-----
30	1050	-----	-----	---	---	>20	---	1081	<1061	-----
31	1200	5500	-----	21	---	8.4	---	1041	1033	-----
32	1200	-----	-----	---	---	> 2.3	---	1083	< 1060	-----
33	1300	6000	-----	41	---	16.0	---	1076	1060	-----
34	1100	8000	-----	53	---	18.8	---	1062	1043	-----
35	950	-----	-----	---	---	>10	---	1077	<1067	-----
36	1100	5000	-----	16	---	6.0	---	1039	1033	-----
37	1100	5000	-----	28	---	10.8	---	1031	1020	-----
38	1250	-----	-----	---	---	>25	---	1040	<1015	-----
39	950	1300	-----	10	---	2.0	---	1080	1078	-----
40	1150	5000	-----	28	---	11.1	---	1051	1040	-----
41	1200	4000	-----	23	---	8.5	---	1050	1041	-----
42	1100		Excess noise							
43	1200	5000	-----	38	---	14.8	---	1035	1020	-----
44	1200	6000	-----	24	---	10.0	---	1036	1026	-----
45	1250	5000	-----	36	---	13.9	---	1082	1068	-----
46	1250	15,000	-----	41	---	18.8	---	1090	1071	-----
47	1250	8000	-----	52	---	22.5	---	1101	1078	-----
48	1100	-----	-----	---	---	5	---	----	----	-----

Traverse Number	Velocity 1 (ft./sec.)	Velocity 2 (ft./sec.)	Velocity 3 (ft./sec.)	X1 (ft.)	X2 (ft.)	D1 (ft.)	D2 (ft.)	Surface Elevation	Elev. 1	Elev. 2
49	1100			Excess noise						
50	1150	7000	-----	29	---	13.3	---	1080	1067	-----
51	1150	7000	-----	22	---	10.1	---	1062	1052	-----
52	1100	5000	-----	51	---	20.4	---	1068	1048	-----
53	1200	3500	10,000	13	50	4.5	21.2	1055	1050	1034
54	1150	7000	-----	54	---	25.0	---	1060	1035	-----
55	1050	7500	-----	20	---	8.7	---	1050	1041	-----
56	1200	5000	-----	51	---	20.0	---	1080	1060	-----
57	1150	6000	-----	17	---	6.8	---	1074	1067	-----
58	1150	5500	-----	69	---	28.0	---	1108	1080	-----
59	1250	7000	-----	33.5	---	14.1	---	1090	1076	-----
60	1050	5500	-----	53.5	---	22.3	---	1100	1078	-----
61	1000	6500	-----	27	---	11.0	---	1082	1071	-----
62	1050	7000	-----	42	---	17.5	---	1106	1088	-----
63	1200	7000	-----	47.5	---	20.2	---	1100	1080	-----
64	1100	6000	-----	46	---	19.4	---	1098	1079	-----
65	1200	5500	-----	45	---	18.0	---	1120	1102	-----
66	1250	7000	-----	36	---	15.1	---	1115	1100	-----
67	1200	6500	-----	29	---	11.7	---	1085	1073	-----
68	1200	6000	-----	22	---	9.3	---	1080	1071	-----
69	1150	5000	-----	15	---	6.1	---	1053	1047	-----
70	1150	5000	-----	58	---	23.2	---	1094	1071	-----
71	1100	6000	-----	24	---	9.5	---	1083	1073	-----
72	1150	7000	-----	35	---	15.4	---	1090	1075	-----
73	1150	6500	-----	26.5	---	11.4	---	1080	1069	-----
74	1100	8000	-----	27.5	---	11.7	---	1071	1059	-----
75	1050	6500	-----	56	---	24.1	---	1080	1056	-----
76	1050	3500	10,000	12.2	61	4.5	28.1	1062	1057	1034
77	1050	5000	-----	29.5	---	12.2	---	1056	1044	-----
78	1200	-----	-----	>75	---	>25	---	1110	<1085	-----

SHALLOW SEISMIC SURVEY OF THE KANSAS STATE UNIVERSITY CAMPUS AREA

by

KENNETH E. MATHIAS

B. S., Kansas State University, 1968, 1970

AN ABSTRACT OF A MASTER'S THESIS

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requirements for the degree

MASTER OF SCIENCE

Department of Geology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1972

A portable engineering seismograph was used to investigate the near surface geology of the main campus and part of the Agronomy farm of Kansas State University

The purpose was to determine the feasibility of using seismic techniques in the area and in developing seismic data into an interpretation of the near surface geology where drill information is unavailable. Many drill hole descriptions were available for the main campus but little drill information was available for the Agronomy farm.

Field data were gathered using the MD-1 portable engineering seismograph in a refraction type survey. The technique measures the depths to layers with increasing vibration conductivity. These layers may be identified and classified from their transmitting characteristics with conduction of velocities greater than 5000 feet per second that are assumed to be bedrock in this thesis. The surveys are considered to be accurate to within 5 percent of the true depth.

Unconsolidated sediments in the area were surveyed. The Agronomy farm area is in an ancient stream channel once thought to be the old Wildcat Creek Valley whereas the main campus was once the site of the Kansas River channel. Mapped seismic and bore-hole data show a northeast drainage at the Agronomy farm and a southeast drainage at the campus.

Difficulty was encountered in identifying and differentiating between bedrock and unconsolidated sediment layers. The high velocity (greater than 5000 feet per second) layer in certain areas was not bedrock but a water saturated layer. The presence of interbedded low velocity layers limited penetration.

A map showing depth from the high velocity layer to bedrock on the Agronomy farm shows the quantity of saturated sediment on the farm if the high velocity layer is always the water table.

Techniques that minimize ground noise caused mostly by automobile traffic must be coordinated with test hole information to adequately interpret the near surface geology of an area.