REPORT

GEOLOGICAL AND GROUND-WATER INVESTIGATION

PROPOSED SPENT FUEL STORAGE FACILITY

NEAR MORRIS, ILLINOIS

FOR

THE GENERAL ELECTRIC COMPANY

Dames & Moore
Job No. 1674-092-07
September 3, 1975

September 3, 1975

Mr. W. Herrlinger
General Electric Co.
c/o Bechtel, Inc.
525 Market Street
San Francisco, California 94105

Dear Sir:

Re: PO No. 329-JOT 71X
Report
Geological and Ground-Water Investigations
Proposed Spent Fuel Storage Facility
Near Morris, Illinois
For General Electric Company

This letter transmits 10 copies and one reproducible master copy of the Report - Geological and Ground-Water Investigation, Proposed Spent Fuel Storage Facility Near Morris, Illinois.

We have appreciated the opportunity to prepare this report. If there are any questions regarding this report, or if you require any additional information, please feel free to contact us.

Yours very truly,

DAMES & MOORE

Michael L. Kiefer
Partner

John S. Trapp
Project Geologist

MLK:JST:dk

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ABSTRACT

A surface and subsurface geological investigation was conducted near Morris, Illinois for the General Electric Company to evaluate the stratigraphy, structure and ground-water conditions for the proposed spent fuel storage facility. The field investigations consisted of seismic refraction surveys, soil and rock core drilling, pressure testing, installation of piezometers, trenching, and a geological reconnaissance of the areas surrounding the site.

The main structures present within the site area are: (1) a northwest trending fault, (2) a system of joints with two dominant trends, northwest and northeast, and (3) a southeastward plunging anticline. The joints range in character from closed to solution-enlarged with clay, silt, and sand fill.

The solution-enlarged joints range in width from 2 inches to approximately 10 feet, are normally less than 2 feet in width, and appear to decrease in width with depth.

It was concluded that faulting at the Morris site is not capable because:

1. The spatial relationships observed in the Pennsylvanian deposits can only be explained if they were deposited after faulting.
2. The trends of faulting, folding, and jointing correspond to the regional trends and structures which formed during the Paleozoic.
3. No faulted Pennsylanian deposits are present in areas near the site where faulting has been projected and postulated.

The permeability within the Fort Atkinson Limestone is quite variable but generally decreases with depth to less than 100 feet per year. The Scales Shale has variable but generally quite low permeabilities of less than 5 feet per year. The Scales Shale appears to serve as an effective aquitard between the Fort Atkinson Limestone and Galena Dolomite. The upper Galena Dolomite at the site has generally low permeabilities of less than 5 feet per year.

The piezometric surface within the Fort Atkinson Limestone parallels the ground surface and reacts very readily to precipitation. The piezometric level within the Scales Shale appears to parallel the Fort Atkinson Limestone; however, piezometers in the Scales Shale react more slowly to precipitation. The site investigation indicated that the piezometric level within the Galena was at least 20 feet below the Galena-Scales contact. The regional groundwater pattern and usage indicate that the piezometric level within the Galena will probably remain below this level for the life of the proposed facility.

INTRODUCTION AND SCOPE

This report presents the results of the geophysical, geologic, and ground-water investigations performed by Dames & Moore for the proposed spent fuel storage facility near Morris, Illinois. The area of investigation is immediately east and southeast of the existing plant structures in the southeast ¼ of Section 35, Township 34 North, Range 8 East, in Grundy County, Illinois (Figure 1, in pocket). The purpose of these investigations was to document site geology for inclusion in the Preliminary Safety Analysis Report (PSAR).

The scope of these studies includes:

1. Evaluation of faulting which exists within the present plant area, both known and inferred, to determine if it extends southeast into the area of investigation.
2. Determination of other faults that may be present within the area of investigation.
3. Definition of the locations and characteristics of these faults.
4. Evaluation of criteria necessary to date movement of these faults and utilization of these criteria to date the faults.

5. Evaluation of the existing groundwater regime in the area.

Dames & Moore's field investigations consisted of seismic refraction, soil and rock core drilling, borehole water pressure testing, piezometer installation, trenching, and a geologic reconnaissance of the area surrounding the site. The locations at which these field investigations were conducted are shown on Figure 1. The data acquired from the investigations form the basis of the conclusions presented herein.

PREVIOUS INVESTIGATIONS

A northwest-trending fault southwest of the existing Main Process Building was originally identified by Dames & Moore from borings made for a foundation investigation in 1967. Another northwest-trending fault was inferred in 1971 during the investigation for the effectiveness of drainage wells. This fault was inferred from data obtained during installation of the water well about 80 feet east of the administration building (approximate plant coordinates S320, E375). The inference of the fault was based on the driller's log which picked the top of the Galena Group at a depth of 151 feet, approximately 65 feet lower than anticipated. A review of the driller's log showed the elevation picked was the depth at which casing had been set. The driller's log also stated that, from 35 to 151 feet, shale and dolomite were encountered. The information available on this log indicates only that the top of the Galena Group is no lower than 151 feet. Review of all information gained from this investigation offers no evidence of this fault. Review of other driller's logs on file at the Illinois State Geological Survey also show no evidence of this fault existing. It is, therefore, our opinion that the fault inferred in 1971 does not exist.

The northwest-trending fault was studied in detail by Dames & Moore in 1974, at which time the fault was shown to have an offset of 35 to 40 feet with the southwest side dropped down in relation to the northeast side. It was concluded that the most probable time of faulting was between late Ordovician and early Pennsylvanian time.

Some of the data presented in previous Dames & Moore reports is used in this report for supportive evidence. These reports are:

1. Report
   Site Evaluation Study
   Phase I - Part 1
   Proposed Dresden Unit 2
   Grundy County, Illinois
   For the General Electric Company
   Dated: April 13, 1965

2. Report of Foundation Investigation
   Proposed FRO Plant Project Near
   Morris, Grundy County, Illinois
   For the General Electric Company
   Dated: December 13, 1967.

3. Report
Subsurface Water Investigation
FRO Plant Project
Morris, Illinois
Fluor P.O. 4204-0-014
For the General Electric Company
Dated: February 25, 1970

4. Report of Drainage Well Pumping Tests
FRO Plant Project
Near Morris, Illinois
For the General Electric Company
Dated: January 11, 1971

5. Report
Fault Investigation at the
Midwest Fuel Reprocessing Plant
Near Morris, Illinois
For the General Electric Company
Dated: October 1, 1974

Additional information was drawn from other Dames & Moore studies conducted in surrounding areas.

INVESTIGATION PROCEDURES

SEISMIC REFRACTION SURVEY

The purposes of the seismic refraction survey were: 1) to evaluate the compressional wave velocities of the bedrock and the material overlying bedrock, 2) to determine depths to the various seismic velocity units underlying the site, and 3) to locate any anomalies that might exist within the proposed plant site.

The field work for the refraction study was performed between May 12 and May 17, 1975. The field crew consisted of one Dames & Moore geophysicist, a licensed powderman, and a helper. The survey consisted of three seismic refraction lines utilizing geophone spacings of 10, 15, and 25 feet and one detailed refraction line, all of which were conducted at the locations shown on Figure 1. In addition, three detailed weathering refraction profiles with geophone spacing of 5 and 10 feet were conducted. Two of the profiles were conducted along Refraction Line 2 between Stations 4+00 and 8+00, and one was conducted along Refraction Line 3 between Stations 6+00 and 7+00. The detailed profiling was conducted to establish velocity control within the surface weathered zone and to further define any anomalous zones. Total footage for the survey was 5200 lineal feet. The refraction lines are presented on Figures 2, 3, 4, and 5.

The seismic energy used for the survey was produced by detonation of explosive charges placed in shallow, hand-augered holes at depths of 0 to 4 feet. All shot holes were stemmed and tamped with soil where feasible.

The energy released by the detonation of the explosive charges was detected by vertically oriented geophones having a natural frequency of 14 hertz. The geophones were coupled to the ground surface by burying each geophone at least 6 inches into the soil.

A basic geophone and cable layout (spread) of 450 feet was used for the main lines. Shots were normally fired on the ends, 100 feet in from both ends, and in the middle of the spread. Exceptions to this shot location plan were made when the shot point fell close to known man-made structures or when it was deemed too close to the recording truck.

The seismic energy detected by each geophone was input to a 24-channel SIE RA 44 Seismic Amplifier (serial number 0710S), and recorded on an SIE R-6 Recording Oscillograph (serial number 0722S). Timing calibrations were performed using a WWV signal and 100 hertz bandpass filter. Seismic energy from each shot was recorded by the oscillograph on Kodak Direct Print Linograph paper.

DRILLING PROGRAM

The drilling program was started on May 19, 1975 and completed on June 27, 1975. Ten borings (B-101, 102, 103, 106, 107, 108, 110, 111, 112, 113) were initially drilled to investigate subsurface geologic conditions and the ground-water regime. Subsequent to identification of anomalous zones, seven additional borings (B-114 to B-120) were drilled to investigate structural relationships. The drill rig and crew were supplied by Raymond International, Inc., Elk Grove Village, Illinois. Dames & Moore field geologists directed and supervised the field operations. The locations of the borings are shown on Figure 1, Plot Plan. A detailed description of the subsurface materials encountered is presented in the following section and the boring logs are presented on Figures 6 through 21.

The shallow soil conditions at the site were evaluated by logging cuttings from 4-inch solid flight augers. Soil samples were obtained using the Standard Penetration Test procedures and by taking grab samples from the augers. All soil was classified in the field in accordance with the Unified Soil Classification System. All soil samples obtained were stored in sealed glass bottles.

Rock samples were obtained utilizing NX wireline core barrels 10 feet in length. For each core run, recovery and the RQD (rock quality designation) were determined. The percent recovery was calculated by dividing the total amount of core obtained by the total length of the core run. RQD was determined by measuring all pieces of core 4-inches or greater in length, summing this quantity and dividing it by the total length of core run. All core obtained was stored in wooden core boxes.

TRENCHING

Trenches were dug to; 1) investigate the possibility of faulting along the major anomalous zones discovered during the seismic refraction survey, 2) to investigate the possible southeastward extension of the northwest-trending fault, and 3) to determine if any datable material could be found overlying the fault. The trench locations are shown on Figure 1, Plot Plan. Five initial trenches were excavated before the drilling program was initiated (Trenches T-1 through T-5). Trenches T-101 through T-123 were excavated June 2 through June 6, 1975 and Trenches T-201 to T-204 were excavated on June 23, 1975. All trenches were backfilled on July 2, 1975.

The backhoe, capable of excavating to a depth of 12 feet, and operator were supplied by Dale Starks Construction, Morris, Illinois. Dames & Moore field geologists directed and supervised the trenching and logged the trenches. The analysis of data acquired from these trenches is presented in the following section.

The conditions observed during the excavation of the trenches can be divided into three general categories: 1) trenches or areas of trenches in which no features were noted except the soil-rock interface and occasional closed joints, 2) trenches or areas of trenches in which significant anomalous features were exposed, and 3) trenches or areas of trenches in which anomalous features were exposed but are more clearly demonstrated in other trenches. The locations at which all trenches were excavated are shown on Figure 1, Plot Plan. Table 1 lists all trenches excavated during this study and the conditions encountered. Cross-sections of selected portions of trenches are shown on Figures 22 through 36. Selected photographs of significant features exposed in trenches are presented in Appendix A.

TABLE 1

TABULATION OF TRENCHES

Trench Number	Conditions Observed
T-1	No significant features
T-2	No significant features
T-3	No significant features
T-4	Pennsylvanian sandstone overlying Fort Atkinson Limestone
T-5	Till, Fort Atkinson Limestone and Scales Shale. Glacial ice removed large blocks of Fort Atkinson, and till was deposited in contact with both Fort Atkinson and Scales.
T-101	Two solutioned joints and joint fill (Figure 22)
T-102	One solutioned joint and joint fill (Figure 23)
T-103	No significant features
T-104	Solutioned joint and joint fill (Figure 24)
T-105	Solutioned joint and joint fill (Figure 25)
T-106	Solutioned joint and joint fill (Figure 26)
T-107	No significant features
T-108	Two small solutioned joints and joint fill.
T-109	No significant features
T-110A	Two solutioned joints and joint fill (Figure 27)
T-110B	Two solutioned joints and joint fill (Figure 28)
T-110C	One small solutioned joint and joint fill
T-110D	Solutioned joint and joint fill (Figure 29)
T-111	Three solutioned joints and joint fill shown in Figure 30 from Station 24 to 55. Other small joints with fill at Station: 1+12; 1+17; 1+34; 1+56; 3+32; and 3+36
T-112	No significant features
T-113	No significant features
T-114	One small solutioned joint and joint fill
T-115	No significant features
T-116	No significant features

TABLE 1 (continued)

Trench Number	Conditions Observed
T-117	One small solutioned joint with joint fill
T-118	Two solutioned joints with joint fill (Figure 31)
T-119	No significant features
T-120	Northwest trending fault (Figure 32)
T-121	No significant features
T-122	Till, Fort Atkinson Limestone and Scales Shale. Glacial ice removed large blocks of Fort Atkinson, and till was deposited in contact with Fort Atkinson and Scales.
T-123	Till, Fort Atkinson Limestone, and Scales Shale. Glacial ice removed large blocks of Fort Atkinson, and till was deposited in contact with Fort Atkinson and Scales.
T-201	Till, and Brainard Shale (Figures 33 and 41)
T-202	Fracture zone in Fort Atkinson (Figure 34)
T-203	Northwest trending fault (Figure 35)
T-204	Pennsylvanian sandstone overlying Fort Atkinson Limestone (Figure 36)

The edges of filled joints were quite irregular and the joints appeared to narrow with depth. All trenches were dug to a depth of 12 feet or to refusal. Refusal along most of the filled joints was due to narrowing of the joints with depth.

On June 11, 1975, geologists from the Illinois State Geological Survey (Mr. Paul B. DuMontelle, Dr. John P. Kempton, and Mr. Michael L. Sargent) met with representatives of Dames & Moore and Bechtel to make a detailed inspection of the trenches. Samples were collected in the trenches and analyzed by Illinois State Geological Survey personnel. A letter describing the results of their visit is presented in Appendix C.

The exact locations of borings, trenches, and seismic lines were surveyed by George Reiter and Associates, Joliet, Illinois.

GROUND-WATER INVESTIGATION

Eight of the initial borings (B-101, 102, 103, 106, 110, 111, 112, and 113) were pressure tested and piezometers were installed. Pressure testing was done using air inflatable packers with both double-packer, 10-foot spacing, and single-packer, variable spacing. The borings were tested using an initial pressure of 10 pounds per square inch (psi). When possible, borings were tested using 3 pressures: 10 psi, ½ psi per foot of depth (approximately ½ overburden pressure), and 1 psi per foot of depth (approximately overburden pressure).

Prior to performing the pressure testing, all gauges used were calibrated by B&B Instruments, Inc., Hammond, Indiana. A friction loss calibration curve was determined in the field by Dames & Moore personnel and was used to correct for friction loss in the equipment during the tests. The results of the tests are presented on the boring logs as K, premeability in feet per year, which was computed according to the following formula.

$$K = \frac{Q}{2\pi LH} \cdot \log_e \left(\frac{L}{R}\right)$$

where H = differential head of water

Q = constant rate of a flow into the borehole

L = length of hole tested

R = radius of the borehole

The values obtained from the maximum testing pressure were used to calculate the permeabilities presented herein.

After pressure testing, piezometers were installed using 1-inch ID, rigid PVC pipe with the slotted intervals consisting of slots spaced 6 inches apart on alternate sides of the pipe.

In borings that had piezometers placed at the bottom of the hole (B-101, B-103, B-110, B-111, and B-113), the PVC pipe was lowered to the bottom of the hole and pea gravel dropped down the hole until a sounding line indicated the hole had been backfilled to the required depth. The pea gravel was then covered by a sand cap at least 1 foot thick as measured by the sounding line after which, except in Boring B-110, a tremie pipe was lowered down the hole and a grout and bentonite slurry was placed from the top of the sand cap to the rock surface by the tremie method. In Boring B-110, a bentonite cap 1½ feet thick was placed above the sand cap prior to placement of the grout and bentonite slurry. In Borings B-102, B-106, and B-112 the hole was backfilled with pea gravel to below the zone to be instrumented. After the hole was backfilled, a sand cap, at least 1 foot thick, as measured by the sounding line, was placed, followed by a bentonite plug at least 5½ feet thick which was placed by dropping bentonite balls down the boring and measuring the thickness by a sounding line. The piezometers were then installed by the same method described previously. A 5-inch steel stand pipe with a ventilated, screw-on cap was installed at the rock surface to provide protection for the piezometer tubing. The location of the borings with peizometers is shown on Figure 1 and the interval in which the piezometer was installed is shown on the boring logs (Figures 6 to 21).

SITE GEOLOGY

GENERAL SURFACE CONDITIONS

Topography - The proposed spent fuel storage facility is located about 1 mile south of the Illinois River and about ½ mile west of the Kankakee River. The site lies on a relatively high area about 30 feet above normal pool level in the Kankakee River, and between the floodplains of the two rivers. The topography of the area is gently rolling and generally reflects the bedrock structure and lithology. The land surface slopes gently to the east with poorly developed and integrated drainage.

Soils are generally well drained; however, as the water table is near the surface and generally parallels the bedrock topography, low areas are marshy. Soil and overburden deposits range from 0 to a few feet in thickness with a maximum thickness of about 10 feet just west of the fault. Within the area of the proposed facility the soil is generally less than 2 feet thick. Vegetation consists mainly of grasses with a few small trees located along fence lines.

SEISMIC REFRACTION SURVEY

Analysis - Compressional wave velocities of the various subsurface seismic units were evaluated by plotting the first arrival times of the seismic energy at each geophone from the seismic energy source. The resultant time-distance plots and the corresponding cross-section are shown on Figures 2 through 5. These figures represent an interpretation based on all data developed in this study, including determinations from time intercept and delay time analysis, detailed refraction spreads, trenching, shot hole, and geologic borehole information. Geologic data, however, are not presented on the geophysical cross-sections.

Analysis of all lines except Stations 9+00 to 13+50 of Line 1 were performed using ground surface as a datum. For Stations 9+00 to 13+50, Line 1, the time-distance data was corrected to a straight line datum. This datum was projected from the ground surface at the end-shot point to the ground surface at the opposite end-shot point. The straight line datum used on the profile is illustrated on the right side of Figure 2.

Computations of depths to identifiable velocity interfaces were made using time-intercept solution methods at each shot point. A complete discussion of the details of this method may be found in Dobrin (1952) and Knox (1967).

A delay time analysis was performed on all applicable time-distance data following the basic procedures discussed by Gardner (1967). Delay times were computed for all reversed common refractor coverage.

The methodology utilized in the interpretation is in accordance with the Dames & Moore Manual of Geophysical Practices.

<u>Results</u> - The following discussion is presented in terms of units defined by their seismic velocities:

Unit	Description	Seismic Velocity Range (feet per second)
1	Unweathered Fort Atkinson	14600 - 15000
2	Slightly weathered Fort Atkinson	7400 - 9300
3	Saturated, moderately to extremely weathered Fort Atkinson and saturated sands and clays	4800 - 5800
4	Saturated till and joint fill material	3900 - 4200
5	Unsaturated, moderately weathered Fort Atkinson	2800 - 3600
6	Unsaturated topsoil	450 - 1850

<u>Seismic Velocity - Unit No. 1</u>

The main refractor unit at the site was identified as unweathered Fort Atkinson Limestone. This unit had a seismic velocity ranging from 14,600 to 15,000 feet per second (fps). The surface is irregular as a result of surface weathering. The unit was identified everywhere except along Refraction Line W1. Along Line W1 the lengths of the individual profiles were only 150 feet and it was not possible to map the top of Unit 1.

Seismic Velocity - Unit 2

The material overlying Unit 1 along the northern segment of Line 3 was defined by apparent velocities ranging from 7400 to 9300 fps. The same velocity range was also observed as the main refractor along Refraction Line W1 (Figure 5). Along the entire length of Line W1 the top of this unit was observed at elevations ranging from 518 to 523 feet. On Line 3 this unit was detected at comparable elevations and is only present north of Station 10+00. Trenching along this segment of Line 3 revealed jointed Fort Atkinson Limestone within inches of the surface. Therefore Unit 2 was interpreted as relatively unweathered Fort Atkinson Limestone. This unit grades into the more weathered limestone defined as Unit 3.

Seismic Velocity - Unit 3

In most areas the unit overlying Unit 1 was represented by velocities ranging from 4800 to 5800 fps. The top of this unit correlated to within 2 feet of what was interpreted as moderately to extremely weathered and jointed Fort Atkinson Limestone. Exceptions to this were the southwestern ends of Refraction Lines 1 and 2 where approximately the last 300 feet of both lines are southwest of the fault shown on Figure 1 (in pocket). Here the material overlying Unit 3 also had velocity values ranging from 5000 to 6000 fps but was interpreted as saturated, unconsolidated clays and sands with some weathered Fort Atkinson.

Seismic Velocity - Unit 4

A fourth unit was defined along Refraction Line 3 at Stations 1+50 to 4+6_. This unit has velocities ranging from 3900 to 4200 fps, is at the intersection of several joints, and was geologically interpreted to consist of saturated and semi-consolidated sandstones mixed with silty clays, overlain by 3 to 4 feet of till. This unit was not defined anywhere else in the survey.

Seismic Velocity - Unit 5

Along the entire length of Refraction Line W1, the unit overlying Unit 2 was represented by velocities ranging from 2800 to 3600 fps. This unit was interpreted as unsaturated, moderately weathered Fort Atkinson Limestone.

Seismic Velocity - Unit 6

Along the three main refraction lines, a thin layer of topsoil was defined by seismic velocities ranging from 450 to 1850 fps. The sections of Line 3 displaying a low velocity layer of 2100 fps represented a combination of two seismic layers consisting of unsaturated soil and weathered Fort Atkinson Limestone. A velocity discrimination between the two units could not be observed due to the the recording interval and thinness of the layers.

Along Refraction Line W1 a closer geophone spacing of 5 and 10 feet was employed to allow better definition of the near-surface materials (Figure 5). The zone has an average thickness of 2 feet except between Stations 1+80 and 2+80, where it was too thin to determine or did not exist. However, some velocity variations were observed within this unit. From Stations 0+00 through 3+40 this unit was defined by velocities ranging from 1050 to 1400 fps. From Stations 3+40 through 4+80 the velocity decreases from 700 to 450 fps (Figure 5). Between Stations 4+80 and 5+45 the velocity of the near-surface zone increases again to 900 fps then decreases back to 450 fps between Stations 5+45 to 6+00. The fast section of the near-surface zone was defined on the time distance plot (Figure 5) between Stations 4+80 and 5+45 by a series of early travel time arrivals. This was not interpreted as a variation in the main refractor because the change of velocity in the near-surface material noted at the shot point accounts for the apparent early arrivals. All computed depths correlated well with geologic and trenching information.

<u>Discussion</u> - Anomalies defined by apparent arrival time delays were used as a basis for preliminary location of geologic trenches (Figure 1, in pocket). These apparent anomalies on Seismic Refraction Lines 1, 2, and 3 are illustrated on the seismic cross-sections by dashed lines representing the location and extent of an anomaly. In most cases the anomalies were defined by localized, solution-widened joints filled with clayey silt and some sandstone intermixed, and bounded by weathered Fort Atkinson. These joints ranged in width from 2 inches to as much as 10 feet such as that found on Line 3 near Station 2+75. Changes in the apparent seismic velocities as seen on either side of the anomalies (Figures 2, 3, and 4) were interpreted as changes in slope due to differential weathering near the anomalies. Other anomalies in the time-distance plots, notably along Line 1 between Stations 1+50 and 2+50 and along Line 2 between Stations 4+50 and 5+50, were interpreted as near surface erosional and topographic anomalies less than 5 feet deep. At Station 1+00 along Line 2 a thickened soil layer similar to that found at Station 7+00 on the same line was identified. The series of early travel time arrivals at Stations 11+30 and 11+40 on Line 2 (Figure 3) were due to

stream erosion of the topsoil and an apparent high water table at that point.

The major feature encountered in the refraction lines was the fault that intersected both Refraction Lines 1 and 2 in the vicinity of Station 10+00. Time-distance data depicted this feature between Stations 9+75 and 11+25 on Line 1 and between Stations 10+00 and 10+60 on Line 2 (Figures 2 and 3).

It must be noted that, at several locations, especially at the ends of the profiles, some arrival times were delayed because previous shots near the surface disturbed the soil. Since shot holes were hand dug, these incidents were too numerous to label on the time distance plots except in a few cases. Based on a comparison of apparent late travel times from all shots and the order of shooting, these delays (apparent anomalies) were easily differentiated from true anomalies.

At shot point 9+00 on both Seismic Refraction Lines 1 and 2 apparent arrival time delays were observed for the southwesterly shot (Figures 2 and 3). These delayed arrival times probably represent refractions from the shallow, weathered, fault debris.

All calculated depth values based on refraction data have an overall accuracy of ± 10 percent.

SITE STRATIGRAPHY

The stratigraphy at the site was determined from 17 test borings and 32 trenches. In addition to this work, 9 test borings were drilled and 4 trenches excavated in 1974 (see Dames & Moore report dated October 1, 1974), and 10 test borings were drilled in 1967 (see Dames & Moore report dated December 13, 1967). The locations of these borings and trenches are shown on Figure 1, Plot Plan (in pocket). Dames & Moore reports dated February 25, 1970, and January 11, 1971 were also used, but the locations of the borings drilled during the studies are not shown on Figure 1. The boring logs for this investigation are shown on Figures 6 to 21 and a description of conditions encountered in each trench is presented in Table 1. The cross-sections for selected trenches excavated during the present study are shown on Figures 22 to 36. A site stratigraphic column is presented on Figure 37.

Unconsolidated Materials - The borings and trenches revealed that approximately 1 to 2 feet of soil overlies an undulating, erosional, bedrock surface. This soil generally consists of 3 to 8 inches of dark brown to black clayey silt topsoil with some sand and occasional inclusions of extremely weathered limestone, sandstone, and glacial

B-118, and B-119. In Trench T-120 the till was coarse textured with low clay content in the matrix and appeared to have been reworked by running water. In Trenches T-106, T-110A, T-110B, T-110C, T-110D, and T-118, a 1-foot layer of till mixed with colluvium and loess overlies the till.

The spatial relationships observed at the site are complex, but can be explained in terms of glacial erosion, deposition, and post-glacial erosion. Evidence for glacial plucking was found in the north ends of Trenches T-5, T-122, and T-123, where till was found in nearly vertical contact with both the Fort Atkinson Limestone and the underlying Scales Shale. The ice apparently removed large blocks of bedrock and till was later deposited. Also, plucking probably occurred along the fault where resistant limestone was exposed on the east side of the fault and where less resistant shale, clay, limestone rubble, and sandstone were exposed on the west side of the fault. This is evidenced in Trenches T-120 and T-203 where till is found overlying shale on the west side of the fault and in near-vertical contact with the limestone at the fault. This appears to indicate that the less resistant material was easier for the ice to remove than the more resistant limestone. Southeast along the fault trace, undisturbed till is found overlying the fracture zone in Trench T-202 and overlying the fault (as identified from Borings B-118 and B-119) below Trench T-201.

Till is discontinuously found south of Boring B-112 and on the downthrown side (southwest) of the fault. Another small body of till was found in the extreme northwestern corner of the site (Trenches T-5, T-122, and T-123). Very little till is found on the higher limestone surface north of Boring 112, where it has apparently been removed by erosion.

The site, in its position near the junction of the Kankakee and Illinois rivers, was in a vulnerable position for flooding and scouring during the Kankakee Flood and during the draining of Lake Chicago through the Illinois River (both events are late Wisconsinan in age). Thus, the till that remains at the site is located in low, protected areas which were not susceptible to erosion during these events.

A wedge of medium-dense, brownish-yellow and gray silty clay and limestone rubble, directly underlying Pennsylvanian sandstone, was found on the downthrown side of the fault during the 1974 investigation (Trench AT-2, Figure 38). According to the Illinois State Geological Survey mineral analyses, the clays are almost 100 percent illite. The clay contains 25 to 75 percent angular limestone fragments, that vary from less than 1 inch to 1 foot in diameter, with the average size being less than 3 inches. Occasional fossil fragments were found. The rubble varied randomly throughout its exposures in clay, silt, and limestone content, in color, and in compaction from loose to dense. For example, in any exposure, one small area may have been a brownish-yellow, loose silt with 50 percent small limestone fragments, while immediately adjacent to that, it would consist of a gray silty clay with 25 percent angular limestone cobbles. The silty clay and limestone rubble unit has its greatest thickness adjacent to the downthrown side of the fault, but the fault did not appear to cut or offset the rubble. This rubble, a regolith developed before deposition of the Pennsylvanian sediments, was found in Trenches AT-1, AT-2, and AT-3 and in Boring A-2 during the 1974 investigation (Figure 1, Plot Plan).

A similar type of rubble material was found during the present investigation in two different modes of occurrence, and in both cases this material was also overlain by Pennsylvanian sandstone. In Trench T-204 (Figure 36) about 2 feet of silty clay and limestone rubble occurs between the Fort Atkinson Limestone below and the Pennsylvanian sandstone above. Here the sandstone exhibits an onlap relationship with the underlying rubble (younger beds overlapping successive beds onto older rocks), indicating transgressive deposition over a highly weathered and eroded surface. The rubble was apparently derived from the underlying Fort Atkinson Limestone, as it contains limestone fragments and abundant Fort Atkinson-type fossil fragments. The lower contact is gradational with a unit about 1 foot in thickness of highly weathered Fort Atkinson

Limestone that still exhibits weak bedding. Underlying this unit is moderately weathered Fort Atkinson Limestone.

In the second mode of occurrence, the rubble material was found as joint fill material in solution-widened joints. This material consists of bluish-gray to gray silty clay, clayey silt, siltstone, and argillaceous siltstone (depending on the degree of induration), with occasional fine sandy zones and weathered limestone fragments. The material is generally laminated and at the contact with the solutioned limestone surface the laminations are wavy and parallel to the limestone surface. Generally, the material is finer grained (silty clays) at the contact with limestone and grades outward to the center of the solution-widened joint to silts and siltstones with some fine sand. The fill was found in Trenches T-101, T-102, T-104, T-105, T-106, T-108, T-110A, T-110B, T-110C, T-110D, T-111, and T-118.

In Trench T-106 (Figure 26) a cut-and-fill Pennsylvanian sandstone overlies the clayey silts and silty clays. Sandstones are also present in various relationships with the fill material in Trenches T-101, T-102, T-110D, and T-118.

The joint fill material, the rubble underlying the sandstone in Trench T-204, and the wedge of limestone-silty clay rubble southwest of the fault, all represent a regolith material developed before the deposition of Pennsylvanian sandstones.

Bedrock Units - The bedrock units encountered in the borings and trenches are, in descending order: the Spoon Formation (called Pottsville Sandstone in previous reports) of Pennsylvanian age; Brainard Shale, Fort Atkinson Limestone (referred to as the Divine Limestone in some previous reports), and Scales Shale of the Ordovician-age Maquoketa Group; and, the Galena Group of Ordovician age.

1. Spoon Formation - The Spoon Formation at the site is a light gray, fine to medium-grained, thin to medium bedded sandstone, which contains mica and some clay. During the 1974 investigation, the Illinois State Geological Survey analysis identified the clay as chiefly authigenic kaolinite in composition. The sandstone is locally calcareous and is generally iron stained along bedding planes and fractures. It is moderately to highly weathered and, in the southeast end of Trench T-204, the upper 1 foot is completely weathered to a loose sand.

In the Dames & Moore report dated October 1, 1974, Pennsylvanian sandstones were only found on the southwest (downthrown) side of the fault in Trenches AT-1, AT-2, AT-3, and AT-4, and in Borings A-1, A-2, and A-6 (Figure 1, Plot Plan, in pocket). In an earlier Dames & Moore investigation (report dated December 13, 1967) sand was also identified on the upthrown side of the fault in an auger boring drilled at the present plant facility at South 300 East 600. During the present investigation, Pennsylvanian sandstones were found on the upthrown (northeast) side of the fault as small isolated remnants. One of the two largest remnants is located in the northwest corner of the site at Trench T-4, and Boring B-116, and the second is located in the northeast corner at Trench T-204. However, these two remnants of sandstone do not overlie the fault.

Other small bodies of Pennsylvanian sandstone occur as joint and fracture fill material in solution-widened joints, fractures, and bedding planes in the Fort Atkinson Limestone (Trenches T-101, T-102, T-106, and T-110D). These materials are light gray, fine to medium-grained, relatively clean quartz sand, locally calcareous, cross bedded, and laminated with silts. Samples of the sandstone in Trench T-106 (Figure 26) were collected by Illinois State Geological Survey personnel and their analyses of the samples indicate that the sandstone is probably Pennsylvanian in age.

2. Brainard Shale - The Brainard Shale consists of gray to greenish gray shale with interbeds of light gray, calcareous and argillaceous siltstone. The shale is thinly laminated, highly weathered, locally calcareous, and contains occasional zones of broken fossil debris.

The Brainard Shale overlies the Fort Atkinson Limestone on the southwest (downthrown) side of the fault at Borings B-115 and B-117, and on both sides of the inferred southern extension of the fault at Boring B-118 and

B-119 (see SITE STRUCTURES). A maximum of 13 feet of shale was observed in Borings B-117 and B-118. As sandstone directly overlies Fort Atkinson Limestone in several locations on the northeast (upthrown) side of the fault, the Brainard Shale was apparently removed by erosion before the deposition of Pennsylvanian sandstone.

3. Fort Atkinson Limestone - The Fort Atkinson Limestone is generally the upper bedrock unit on the northeast (upthrown) side of the fault, but may locally be unconformably overlain by the Pennsylvanian Spoon Formation. At Borings B-115 and B-117, on the southwest (downthrown) side of the fault the limestone was conformably overlain by the Brainard Shale. A maximum thickness of 49 feet was penetrated in Boring B-118.

The limestone consists of an upper unit (about 11 feet thick) of interbedded gray shale and limestone and a lower unit (about 38 feet thick) of light gray to white crystalline limestone. The upper unit is extremely fossiliferous and exhibits contorted bedding and thin laminations of dark gray, silty, calcareous shale. This unit grades downward into the relatively clean, light gray, coarse crystalline limestone below.

The lower, coarse, crystalline limestone is fossiliferous, stylolitic, and contains occasional green clay partings. The limestone grades downward to slightly vuggy limestone, with pinpoint to ½-inch vugs, occasionally lined with pyrite and secondary calcite.

A transitional zone occurs at the base of the Fort Atkinson Limestone. This zone is from 1 foot to about 5 feet in thickness and consists of interbedded greenish-gray silty limestone and greenish-gray silty clay with the silty clay layers increasing downward in number and thickness. The contact with the underlying Scales Shale is generally accompanied by a distinct color change from greenish gray limestone and siltstone to dark or medium gray silty shale.

Where the limestone is exposed, it is highly to moderately weathered along bedding planes, fractures, and joints to a depth of about 10 feet. It weathers to a yellowish-brown or reddish-brown color. Secondary calcite has been deposited along some bedding planes, fractures, and joints, especially where clay partings have weathered out and/or in association with solution-widened joints.

4. Scales Shale - The Scales Shale is a medium to dark gray shale, locally fossiliferous and very calcareous. It varies from massive and very silty (>50 percent) to thinly-bedded with less silt content (25 to 50 percent), and contains some pyrite along fractures.

During this investigation the total thickness of the Scales Shale was penetrated in two borings (B-101 and B-110) where it was found to have a thickness of 67.4 and

68.4 feet, respectively. The upper part of this unit was encountered in all borings except B-117 and B-119. The Scales Shale unconformably overlies the Galena Group and conformably underlies the Fort Atkinson Limestone.

5. Galena Group - Dolomite of the Galena Group was encountered in Borings B-101 and B-110. The Scales Shale unconformably overlies this unit. The rock encountered at the site consists of medium to light gray dolomite with some galena mineralization. It is argillaceous, finely crystalline, medium to thick bedded and locally vuggy.

SITE STRUCTURES

The site structural geology is composed of three closely related features that appear to have formed at the same time: (1) the northwest-trending fault, (2) joints, and (3 minor folding. The fault is shown on Figure 1 (in pocket), the joint directions are shown on Figure 39 and folding is shown on Figure 40.

In the Dames & Moore report dated October 1, 1974, the exact location of the fault was determined from 4 trenches and 9 borings. It was described as a high angle (approximately 15 degrees off vertical) normal fault, dipping to the southwest. The southwest side has been dropped down in relation to the northeast side, with a displacement of 35 to 40 feet. The fault is curvilinear, striking essentially northwest through the plant area. It was revealed from trenching that the fault generally separated limestone on the upthrown side and the silty clay-limestone rubble on the downthrown side.

During the present investigation the southeastward extension of the fault was identified from Trenches T-120 and T-203, and from Borings B-114, B-115, and B-117. In both of the above mentioned trenches the Fort Atkinson Limestone was found on the northeast (upthrown) side of the fault and the Brainard Shale was found at a lower elevation on the southwest (downthrown) side. A 36-foot displacement was determined from Borings B-114 and B-115.

The fault could not be positively identified in Trenches T-201 and T-202. However, in Trench T-202 (Figure 34) a 5-foot, highly fractured zone of Fort Atkinson Limestone was identified in the southwest end of the trench. Identifiable beds of limestone could be followed from the northeast end of the trench to the fracture zone, but within the fracture zone no bed could be followed for more than 2 or 3 feet. The beds were disoriented and dipped in various directions and amounts (some steeply southwest, and some horizontal). It could not be determined if these disoriented blocks were in place, as they were highly weathered and separated by a matrix of weathered limestone rubble.

The base of Trench T-201 (Figure 33) was in highly weathered Brainard Shale and no identifiable fault could be found. However, the Brainard-Fort Atkinson contact was found 8.4 feet higher in elevation in Boring B-119 than in Boring B-118. Between Borings B-114, B-115, B-117 and Borings B-118 and B-119 the difference in stratigraphic markers on either side of the projection of the fault has therefore decreased from 36 to 8.4 feet. The fault can be traced to the fracture zone in Trench T-202. However, as Fort Atkinson Limestone is found on either side of the fault, rather than Brainard Shale on the downthrown side and Fort Atkinson Limestone on the upthrown side, the amount of throw is decreasing. We have inferred, based on the difference in stratigraphic markers, that the fault extends from Trench T202 through Trench T-201. However along the southeastward inferred extension, it is possible that the fault may have terminated into a southeastward plunging fold.

Undisturbed Malden Till was found overlying the fracture zone in Trench T-202 and overlying the inferred trace of the fault, as identified from Borings B-118 and B-119 below Trench T-201 (Figure 41). This gives a minimum age of last movement of at least 15,000 to 17,000 years before present for this structure.

Folding at the site was determined from structural contours drawn on top of the Scales Shale (Figure 40).

The Scales is structurally higher at the northwest corner of the site on the northeast side of the fault and generally dips to the southeast. From this structural high an anticlinal fold plunges toward the southeast, nearly parallel to the fault strike.

Measurement of joint directions exposed in trenches (Figure 39) indicates two dominant joint trends. One dominant joint set trends nearly parallel to the fault (about North 40° West, ranging from North 10° West to North 50° West) and the second dominant joint set trends nearly perpendicular to the fault (about North 70° East, ranging from North 60° East to East-West). The joints range in character from closed to solution widened with silt, clay, and sand fill material.

Although there is no apparent offset across the solution-widened joints (because of irregular bedding) a definite trace across the joints was not possible. Therefore, the possibility does exist for minor displacements along some of these joints such as the joint described in Trench T-101 (Figure 22). Boring B-101 is on the east side of the southeastward projection of the solution-widened joint found in Trench T-101; Boring B-120 was drilled on the west side of this joint. The Fort Atkinson-Scales contact was found 3 feet higher than would be expected if this contact had a constant slope from Boring B-102 to Boring B-101. However, this difference could be accounted for by a small change in rock dip produced by folding.

The northwest and northeast joint trends indicate that the joints and the fault were probably formed by the same stress conditions or at least by stress conditions with the same orientation. The tensional forces necessary to produce the faulting would most likely have to produce tensional joints parallel to the fault and extensional joints perpendicular to the fault. The most logical geological explanation, therefore, is that the faulting must be considered contemporaneous with jointing. As the joints contain Pennsylvanian material, they must have formed prior to Pennsylvanian deposition. Therefore, if the faulting and jointing are contemporaneous, they both must have occurred prior to deposition of the Pennsylvanian sandstone.

A detailed description of the major regional structures, the Sandwich Fault, the La Salle Anticlinal Belt, the Ashton Arch, and the Herscher Dome, is presented in Appendix B. All these structural elements had their major development during the Paleozoic and display a predominant northwest trend. The site is 1) located in the center of this structurally complex area, 2) the site structures display the same orientation as the regional structures and 3) all structural and stratigraphic evidence from this and previous investigations indicates that the site structural features are Paleozoic in age. The only logical conclusion that can therefore be drawn is that site structural development must have occurred during the formation of the regional structures, and therefore, faulting, jointing, and folding at the site are Paleozoic features.

It is probable that small displacement features do exist within the area of investigation. If present, the displacements would be on the order of inches or at the most a few feet. Since the joints can be shown to have formed prior to deposition of the Pennsylvanian materials, displacements along the joints, if present, are not capable and therefore would have no effect on the design or safety of the proposed spent fuel storage facility.

SITE GEOLOGIC HISTORY

The relationships shown in Trench T-106 (Figure 26) most clearly illustrate the geologic history of solutioning in the Fort Atkinson Limestone and the early deposition of Pennsylvanian sediments at the site.

The spatial relationship of materials in Trench T-106 shows: 1) formation of the joint systems, 2) period of solutioning at which time the joints were enlarged and filled, and 3) deposition of the Pennsylvanian sandstone. The spatial relationship of the joints and fault indicate that both were probably formed by the same stress relationship. It is most likely that the joints formed contemporaneous with, or at least penecontemporaneous with, the fault southwest of the site. The Pennsylvanian sandstone fill stratigraphically dates the joint development as pre-Pennsylvanian and indirectly indicates that the major movement on the fault was also prior to deposition of the Pennsylvanian sandstone.

Where the sandstones are present as joint fill, they are generally located in the center of the joint and they grade outward to argillaceous siltstone or clayey silts (depending on the degree of induration). The argillaceous siltstones and clayey silts in turn grade to silty clays that are in contact with the solutioned surface of the limestone bedrock. These siltstones, clayey silts, and silty clays apparently represent the original pre-Pennsylvanian joint fill that was later cut and filled with Pennsylvanian sands. The joints show no evidence of further widening by solution activity since the emplacement of the fill material.

The long period of weathering, erosion, and solutioning of the limestone was brought to a close by the deposition of Pennsylvanian sediments. At the site, these sediments unconformably overlie Ordovician limestones and shales, and the present scattered occurrence of the sandstones is the result of stripping by glaciers during the Pleistocene and subsequent weathering and erosion. The remaining sandstone bodies probably represent sediments deposited in topographic low areas on the pre-Pennsylvanian erosion surface and are present because of their protected position, northwest and northeast corners of the site, along solution widened joints, and on the southwest (downthrown) side of the fault.

The evidence obtained from the site investigation therefore indicates that a long period of marine deposition with the formation of dolomite, limestone, and shale, occurred prior to faulting and that faulting occurred sometime after deposition of the Ordovician-age Brainard Shale. The relationship between the site and regional structural patterns indicate that the faulting was associated with the formation of the Sandwich Fault Zone and the La Salle Anticlinal Belt during late Paleozoic. The faulting raised the ground surface 35 to 40 feet (Figure 42,A). This newly formed surface was subjected to erosion, at which time most of the Brainard Shale was stripped, and only local occurrences of shale remained on the downthrown (protected) side of the fault.

After the shale was stripped, the limestone surface was subjected to ground-water solutioning and a solutioned carved topography developed (Figure 42,B). Solution-widened joints were filled with clays and silts and a regolith consisting of clays, silts, and limestone fragments covered the surface. It was during this period of erosion that the wedge of regolith material was deposited on the downthrown side of the fault.

Much of the regolith was reworked or removed by erosion as the transgressive deposition of Pennsylvanian sandstone took place (Figure 42,C). Only the regolith in low, protected topographic positions such as on the downthrown side of the fault was not removed. Either during deposition, shortly thereafter, or at both times, differential compaction and slumping probably occurred in the wedge of unconsolidated regolith material and resulted in gentle sagging of the Spoon Formation over the regolith. The area was then again subjected to erosion, resulting in most of the Pennsylvanian deposits being removed (Figure 42,D).

The next known event occurred during the Pleistocene, with the advancement of continental glaciers that covered the area (Figure 42,E). Most of the remaining sandstone was probably removed at this time. The resistant limestone on the northeast side of the fault was not as severely eroded as the less resistant rock to the southwest, resulting in thicker till deposits on the downthrown side of the fault. Glacial plucking of large blocks of bedrock and injection of till along weakened surfaces took place. Since then, post-glacial meltwaters and recent erosion have removed the glacial deposits except from protected areas (Figure 42,F).

The above sequence of events occurred without post-Pennsylvanian movement along the fault. After analyzing all of the existing evidence at the site, although no Pennsylvanian sandstones were found overlying the fault, it is our opinion that the major movement on the fault was contemporaneous (or at least penecontemporaneous) with the major development of the northern portion of the La Salle Anticlinal Belt ard/or the last major movement along the Sandwich Fault Zone. From stratigraphic evidence, the minimum age, as determined from undisturbed Malden Till overlying the fault zone, of last movement is 15,000 to 17,000 years before present. The evidence used to determine an age prior to deposition or the Pennsylvanian sandstone for major movement of the fault is summarized below:

1. The wedge of rubble material on the downthrown side of the fault is overlain by the Pennsylvanian Spoon Formation. This stratigraphic relationship could not exist if major faulting were post-Pennsylvanian.
2. Other spatial relationships of Pennsylvanian sandstones also indicate faulting occurred prior to deposition of the Pennsylvanian sandstone. For example, in the northwest corner of the site, sandstone overlies the lower 7.5 feet of Fort Atkinson Limestone on

the upthrown side of the fault, whereas 500 to 600 feet south on the downthrown side of the fault, the sandstone overlies 42 feet of limestone. This indicates a long period of erosion after faulting and before deposition of the sandstone. This stratigraphic relationship would be extremely difficult to explain with post-Pennsylvanian faulting.

3. Cut-and-fill Pennsylvanian sandstones overlie and are occasionally contained within some solution-widened joints in Fort Atkinson Limestone. This indicates a pre-Pennsylvanian solutioning along major joint trends. One of the two major joint systems trends nearly parallel to the fault and the other major joint system trends perpendicular to the fault. The most reasonable geological explanation assumes that the joints and fault were formed at the same time. Therefore, as the joint system can be dated prior to Pennsylvanian sandstone deposition, the fault is indirectly dated as pre-Pennsylvanian sandstone deposition.

4. The northwest trend of the fault and fold, and the northwest and northeast trends of joints agree with the major, regional structural trends found along the northern La Salle Anticlinal Belt and the Sandwich Fault Zone. The site is located on the northeast flank of the La Salle Anticlinal Belt, and about 6 miles southwest of the Sandwich Fault Zone. Therefore, it is logical that the structures at the site were formed at the same time as the regional structures.

5. Other relationships: During investigations for the Dresden Power Station a northwest and northeast structural pattern was identified in the Ordovician age rocks (Dames & Moore Report, April 13, 1965). A northwest set of faults was interpreted from boring data and air photo interpretations and, if they are present, they would intersect the main intake circulation canals north of the plant. This area was field checked and only undisturbed Pennsylvanian sediments were exposed above water level. If these faults are present in the underlying Maquoketa Group, they are parallel to the

faulting on the General Electric property with the same sense of displacement and were probably formed at the same time, pre-Pennsylvanian. Also, south of the General Electric property at the A.P. Green quarry, no significant deformation was observed in the Pennsylvanian strata being excavated.

The interpretation of the geological history presented herein is in agreement with the interpretations presented by the Illinois State Geological Survey (see Appendix C).

CONCLUSIONS: GEOLOGICAL INVESTIGATIONS

No additional faults were discovered during this investigation for the proposed spent fuel storage facility. A system of northwest and northeast trending joints was identified in the Fort Atkinson Limestone. Some of these joints have been widened by solutioning. It is possible that minor displacements of a few inches to, at most, a few feet may be present along some of the major joints, however, if these displacements are present they would be older than the Pennsylvanian sandstone that overlies some of the fill material.

The northwest-trending fault southwest of the site was extended southeastward based on boring and trenching data. Undisturbed Malden Till was found overlying the fault giving a minimum age for faulting of 15,000 to 17,000 years ago.

The structural and stratigraphic relationships observed during the site investigation can only be explained if faulting occurred prior to deposition of the Pennsylvanian sediments.

The structural patterns observed at the site fit well within the structural pattern displayed by the major regional structures, the Sandwich Fault Zone, the Ashton Arch and the La Salle Anticlinal Belt. As these are Paleozoic structural features, the site structural features must also be Paleozoic. The only conclusion that can be reached, therefore, is that faulting at the General Electric Morris site occurred at the end of the Paleozoic during the major regional structural development and that it is not capable.

SITE GROUND WATER

An evaluation of site ground-water conditions was performed through pressure testing, monitoring of ground-water levels in open boreholes and piezometers, and observations of ground-water conditions noted during the excavation of trenches.

Borings B-101, B-102, B-103, B-106, B-110, B-111, B-112, and B-113 were pressure tested and piezometers were installed to determine permeabilities and piezometric levels. Water levels recorded from open borings and piezometers are shown in Table 2, and the permeabilities for tested intervals are shown on the boring logs.

No pressure testing was performed in the upper 7 feet. The permeabilities in the upper 7 to 10 feet are unknown but from field observations were estimated to be quite high. As the trenches were being dug, water was observed flowing into the trenches from bedding planes, joints, and fractures near the solution-widened joints.

The joint fill material in solution-widened joints is relatively impermeable and appears to provide effective barriers to ground-water flow, thus complicating the direction of ground-water movement and possibly water levels. The water appears to move along the edge of the joint fill material rather than through the relatively impermeable silty clays and clayey silts.

During the excavation of Trench T-110A, a stream of water approximately 1 inch in diameter shot across the trench after the fill material was removed. Within 2 hours the trench was full of water to within 3 feet of the top. Therefore, approximately 2800 gallons of water entered the trench in 2 hours.

In many instances, pumps with a rated capacity of 18 gallons per minute (gpm) were used to keep the trenches

TABLE 2

WATER-LEVEL READINGS FROM OPEN BOREHOLES AND PIEZOMETERS

DATE / BORING	26 May	27 May	31 May	3 Jun	5 Jun	7 Jun	9 Jun	10 Jun	11 Jun	12 Jun	13 Jun	16 Jun	18 Jun	20 Jun	23 Jun	25 Jun	27 Jun	27 Jun *	30 Jun
101	520.4	520.2	523.7	523.8	524.9		523.2	G	G	G 407.7	G 406.2	G 403.7	G 402.9	NG 402.6	G	NG 402.6	N[illegible] 402.7	G 449.7	G 404.8
102	529.6	529.7	530.8	530.9		528.7		F 527.3	F	F 526.6	F 526.0	F 529.9	F 529.5	F 527.8	F	F 526.4	F 526.0	F 526.3	F 525.6
103			528.8	528.3	528.0	527.3	526.1		S 525.4	S	S 525.1	S 526.1	S 526.3	S 526.3	S	S 525.9	S 525.6	S 489.6	S 492.9
106	527.0	527.0	530.5	529.1	529.8	528.3	527.4		526.5	F	F 526.1	F 532.0	F 529.0	F 528.1	F	F 526.3	F 525.9	F 526.1	F 525.4
107	520.7	520.7	523.3	523.6	522.8	522.3	521.9		521.4		521.0	522.9	522.7	522.3	521.4	521.7	521.3		
108	519.1	519.0	521.9	522.1	521.4	521.[illegible]	520.5		520.1		519.7	521.5	521.1	520.8	520.1	520.1	519.9		
110	523.6	523.8	528.7	528.3	527.4	526.0	524.5		524.0		524.0	527.4	G 443.2	G 406.6	G	NG 403.7	NG 403.9	G 430.5	G 406.3
111			519.6	519.9	519.1	518.7	518.5		518.8		519.3	519.5	519.2	519.0	518.6	S 51[illegible].4	S 518.3	S 508.7	S 516.3
112				527.4	527.7	526.6	525.5		524.3		523.6	527.4	527.0	526.0	524.3	F 523.7	F 523.2	F 523.2	F 522.4
113			522.3	522.1	521.3	520.9	520.4		519.9		518.9	521.2	521.1	520.8	519.9	S 522.0	S 519.9	S 492.3	S 506.8
114														512.7	510.4		510.0		
115														514.3	512.1		510.[illegible]		
117															512.1				

G Indicates readings from piezometers installed in the Galena dolomite.

F Indicates readings from piezometers installed in the Fort Atkinson Formation.

S Indicates readings from piezometers installed in the Scales Formation.

* After the first readings were taken on June 27, piezometers 102, 103, 106, 111, 112, and 113 were blown out at 8:30-10:00; and piezometers 101 and 110 were filled with clean water at 10:15. The second readings on June 27 were taken between 15:55 and 16:35, and indicate water level adjustments after the cleaning process.

N Indicates no water in the piezometer and the reading is the bottom of the piezometer.

dry for mapping. A single pump could just keep ahead of the ground-water inflow. The trenches were excavated during an extremely wet period. Following a week of no rain, most trenches were dry with only a small amount of water in the very bottom of some trenches.

A minimum flow of 0.05 gpm could be read from the flow meter used in pressure testing. This represents a permeability of less than 5 feet per year. Therefore, where zero flows were recorded, the rock materials are practically impermeable but may have a permeability of up to 5 feet per year. The permeabilities described below were calculated from the test in which the testing pressure was closest to oberburden pressure.

Portions of the Fort Atkinson Limestone were pressure tested in Borings B-101, B-102, B-103, B-106, and B-110 (Figures 6, 7, 8, 9, and 12). The permeabilities were quite variable. In Boring B-101, at a depth of 7 to 22 feet the permeability ranged from 420 to 455 feet per year, but at a depth of 22 to 32 feet the permeability was only 94 feet per year. In B-102, at a depth of 12 to 32 feet, and in B-110, at a depth of 15 to 23 feet, zero water-take was recorded. From 13 to 23 feet in B-103 the permeability is about 378 feet per year, but from 23 to 32 feet the limestone took no water. In B-106 the lower portion (from 14 to 24 feet) of limestone has a permeability of 140 feet per year.

Borings B-101, B-102, B-103, B-106, B-110, B-111, B-112, and B-113 (Figures 6, 7, 8, 9, 12, 13, 14, 15) were all pressure tested to determine the permeability of the Scales Shale. The shale took no water in any boring except the top 31 feet of B-101, a 20-foot interval in B-110, and the top 12 feet of B-112. In Boring B-101 the permeability decreased from 204 to 86 feet per year from the top of the shale to 31 feet, but the lower 36 feet of shale took no water. No water flow was recorded in the top 32 feet and the bottom 16 feet of shale in Boring B-110; a 20-foot anomalous zone, however, was identified between 55 and 75-foot depths. For this zone, a permeability of 184 feet per year was calculated for the interval between 50 and 60 feet; 472 feet per year between 60 and 70 feet; and 444 feet per year between 70 and 75 feet. The top 12 feet of shale in Boring B-112 showed a low permeability of 15.4 feet per year.

A 10-foot interval in Boring B-101 and the top 3 feet in Boring B-110 in the Galena Dolomite were pressured tested to determine permeability. In both tests, zero water flow was recorded, thus, indicating a very low permeability for the top of the dolomite in these two borings.

In general, the upper 10 to 20 feet of the Fort Atkinson Limestone has high but variable permeabilities with permeabilities decreasing to less than 100 feet per year near the base of the formation. The Scales Shale has very low permeabilities, less than 5 feet per year (permeabilities were usually too low to measure by pressure testing). A few anomalous zones of higher permeabilities were encountered in the Scales Shale during pressure testing, but these zones were underlain by very low permeability shale. Pressure testing also indicated that the upper 20 feet of the Galena Dolomite has very low permeabilities, less than 5 feet per year.

Piezometers were installed in the Fort Atkinson Limestone in Borings B-102, B-106, and B-112; in the Scales Shale in Borings B-103, B-111, and B-113; and in the Galena Dolomite in Borings B-101 and B-110. Water-level measurements (Table 2) from these piezometers indicate that the Scales Shale acts as an effective aquitard between the Fort Atkinson Limestone and the dolomite of the Galena Group. As soon as the piezometers were installed in the Galena Dolomite, the water level dropped rapidly and within 1 week the piezometers were dry. During this time of year it appears that the piezometric level in the dolomite is at least 20 feet below the Galena-Scales contact. On June 27, the Galena piezometers were filled with clean water and by June 30, they were again nearly dry.

The historic record of ground-water variations within the Galena Dolomite (the upper unit in the Cambrian-Ordovician aquifer) show that a cone of depression has developed near Joliet and that the piezometric surface had dropped over 100 feet from 1915 to 1958 to an elevation of about 400 feet above mean sea level (Suter and others, 1959; Figures 33 and 34). While the regional piezometric surface of the Galena at the present time is unknown, the number of wells which penetrate this aquifer has increased since 1958 and it is probable that the surface has further dropped. During drilling of the water supply well on the Morris site during 1968, the static water level within the Galena Dolomite was at about elevation 370, while the static water level of the Cambrian-Ordovician aquifer as a unit was at about 395 feet.

The piezometric level in the Fort Atkinson Limestone parallels the ground surface, is 3 to 6-feet deep, and reacts rapidly to precipitation. On the morning of June 27, the piezometers penetrating the Fort Atkinson Limestone were blown out, and by that afternoon the water was back to its original level.

The piezometric level in the Scales Shale is also near the ground surface, but reacts less and more slowly to precipitation. These piezometers were also blown out on June 27; but, as of June 30, they had not regained their original level, thus indicating very low permeabilities.

During construction of the Low Activity Waste Vault, serious ground-water problems were encountered. The results of the investigation (Dames & Moore report dated January 11, 1971) conducted at that time indicated a complex ground-water system with several potential sources:

1. Direct percolation from rainfall and runoff.
2. Lateral seepage and flow from perched or confining zones in response to percolation from rainfall, runoff or inflow of river water.
3. Lateral flow along joints, faults or fractured rocks.
4. Possible upward flow from the underlying Galena Dolomite.

The results of this study indicate that upward flow from the Galena Dolomite is not probable.

We believe the water problems encountered during construction were due to lateral and downward flow through fractures within the Fort Atkinson Limestone and Scales Shale. The results of pressure testing indicate that the Scales Shale has very low permeabilities and none of the borings tested took any water in the lower 16 feet. Therefore the downward flow within the Scales Shale was probably through fractures induced during construction.

-oo0oo-

The Figures and Appendices listed in the Table of Contents are attached and complete this report.

Respectfully submitted,

DAMES & MOORE

Michael L. Kiefer
Partner

John S. Trapp
Project Geologist

MLK:JST:b

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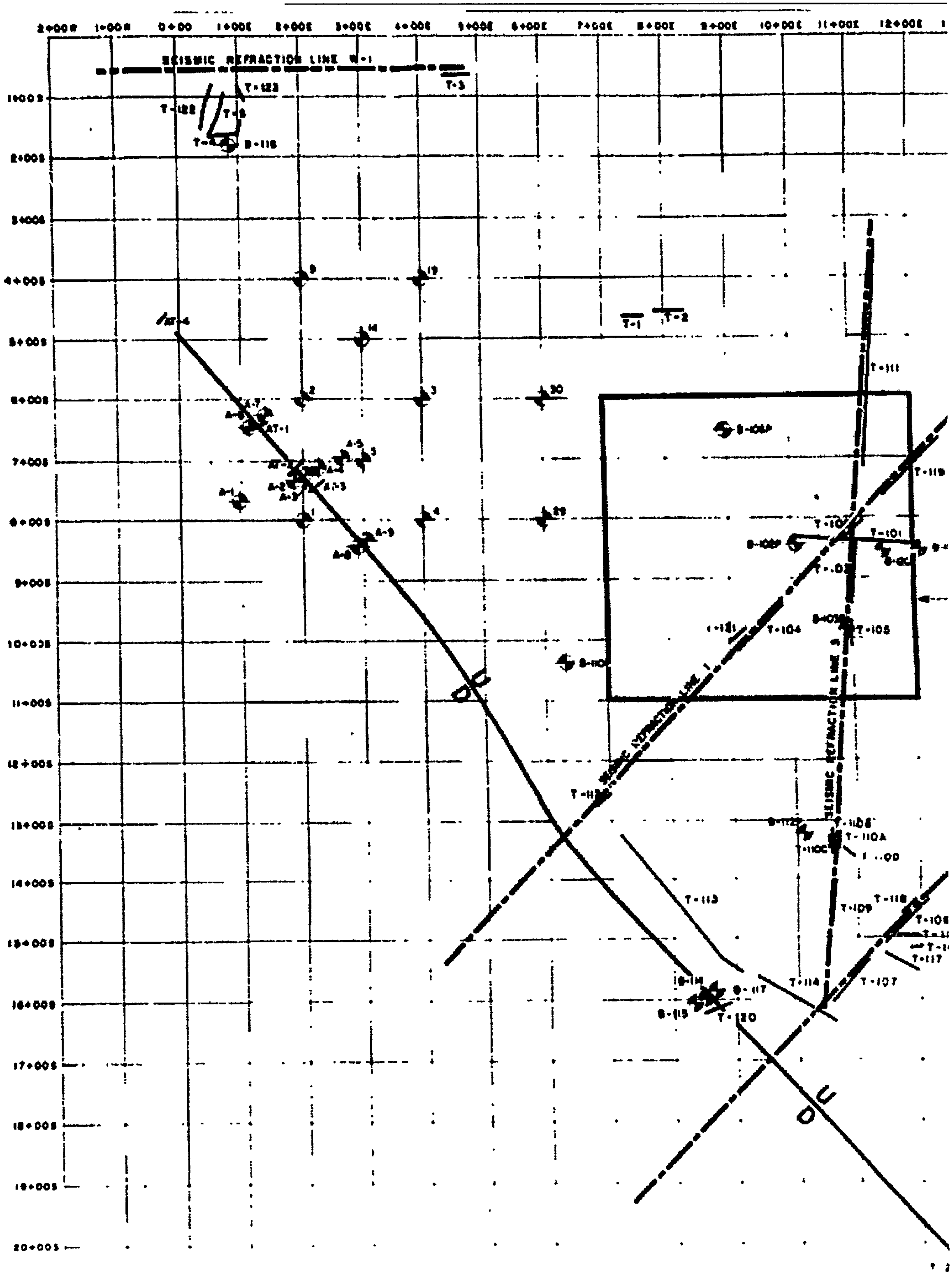
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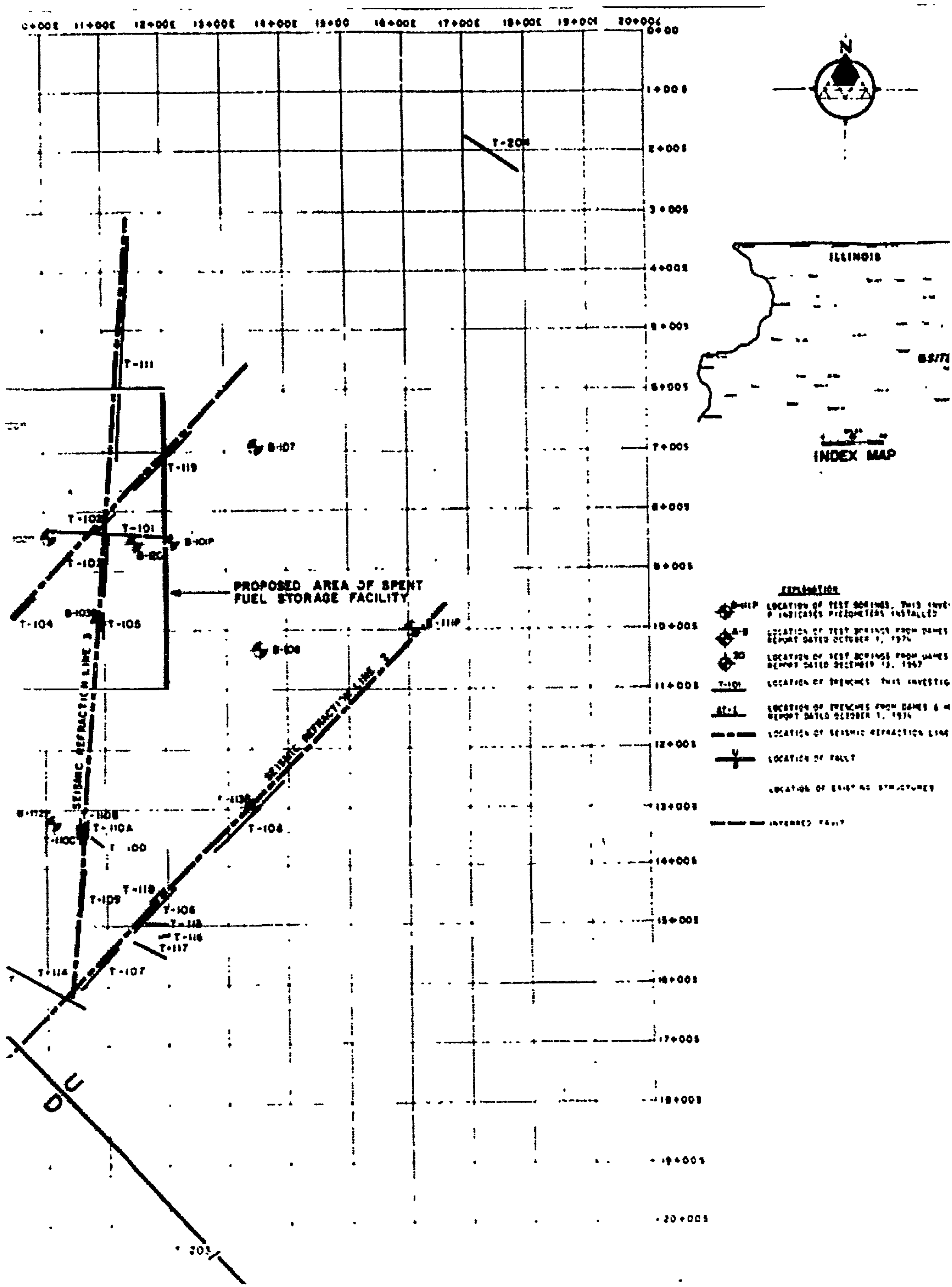
SEISMIC REFRACTION LINE W-1
SEISMIC REFRACTION LINE 1
SEISMIC REFRACTION LINE 3
T-123
T-122
T-3
T-1
T-2
B-116
AT-4
AT-1
T-111
T-119
T-101
T-104
T-105
T-113
T-114
T-109
T-118
T-117
T-107
T-120
T-110A
B-117
B-115
B-108P
U
D



T-204
T-111
T-119
T-102
T-101
B-101P
T-103
T-104
B-103P
T-105
B-107
B-108
B-111P
PROPOSED AREA OF SPENT FUEL STORAGE FACILITY
SEISMIC REFRACTION LINE 3
SEISMIC REFRACTION LINE 2
T-108
T-110B
T-110A
T-110C
T-109
T-113
T-106
T-115
T-116
T-117
T-114
T-107
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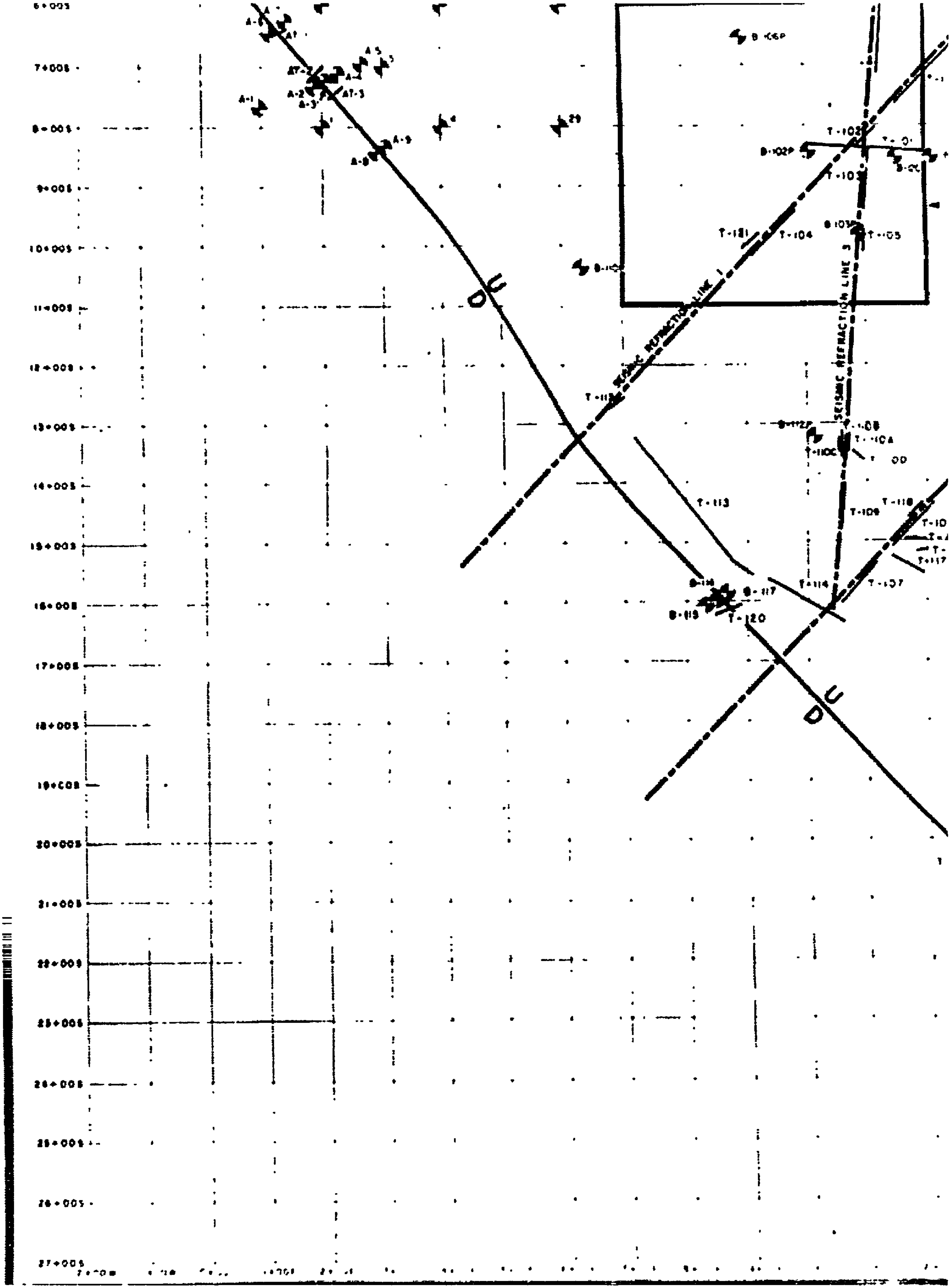
ILLINOIS
INDEX MAP
EXPLANATION
LOCATION OF FAULT
LOCATION OF EXISTING STRUCTURES



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22+00S
23+00S
24+00S
25+00S
26+00S
27+00S
SEISMIC REFRACTION LINE 1
SEISMIC REFRACTION LINE 3
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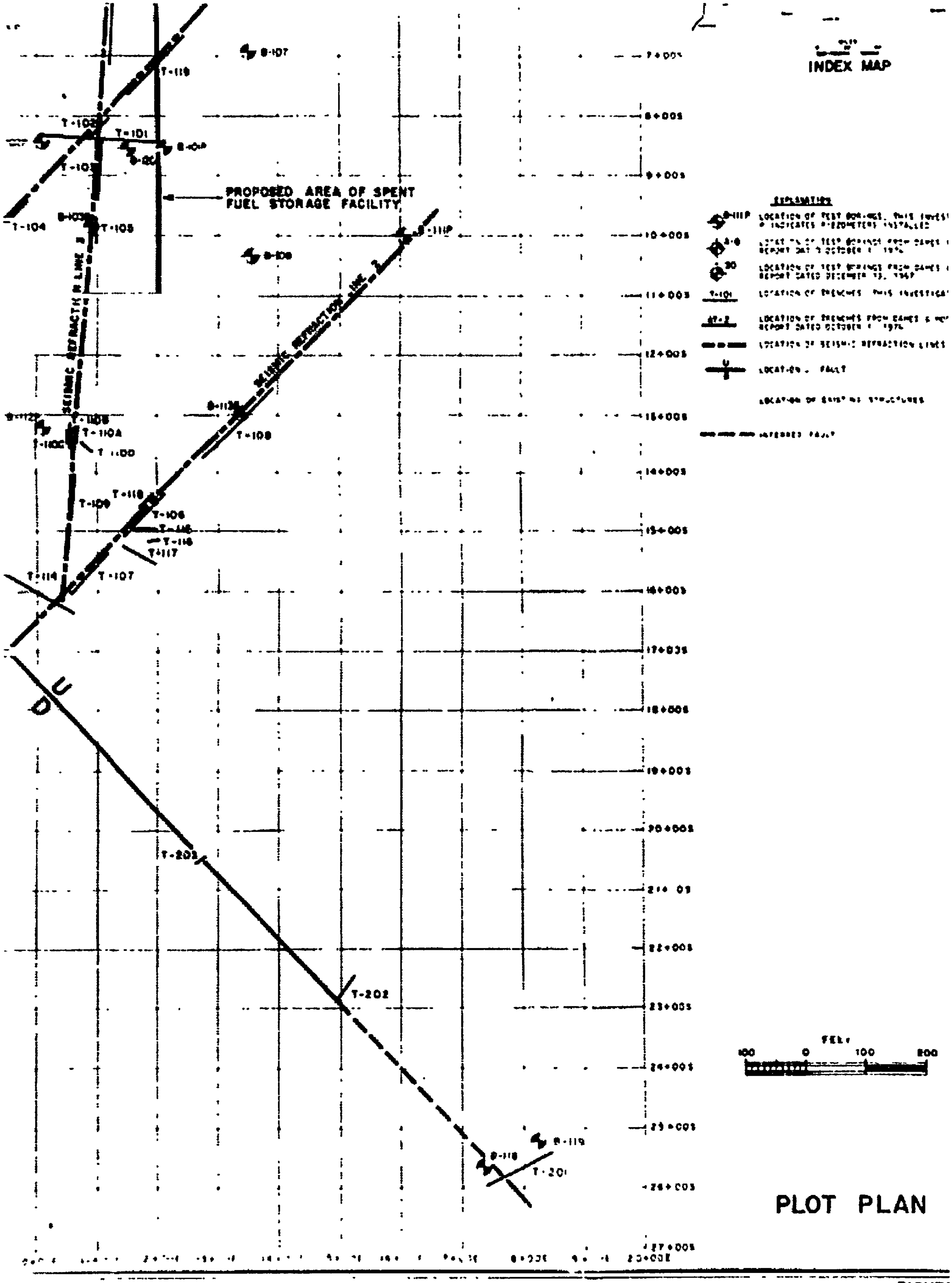
D
U
D
T-113
T-120
T-114
T-107
T-109
T-104
T-105
T-121
A-8
A-9
A-1
A-2


INDEX MAP
PROPOSED AREA OF SPENT FUEL STORAGE FACILITY
SEISMIC REFRACTION LINE 1
SEISMIC REFRACTION LINE 2
B-107
B-108
B-111P
B-113
B-118
B-119
T-101
T-102
T-103
T-104
T-105
T-106
T-107
T-108
T-109
T-110A
T-110C
T-114
T-116
T-117
T-119
T-201
T-202
T-203
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D
FEET
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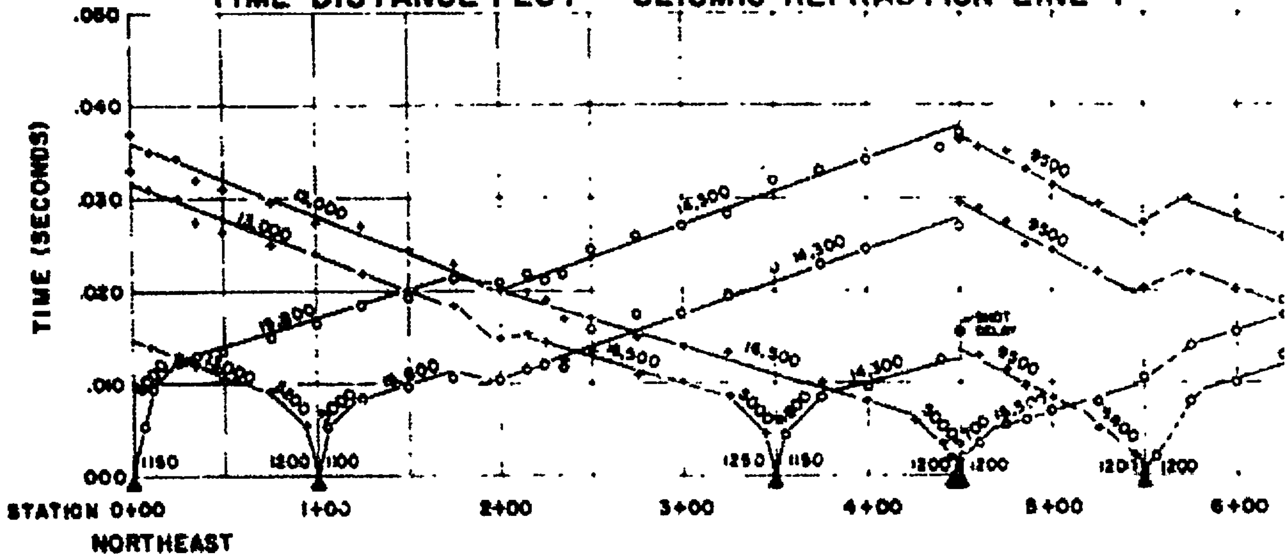
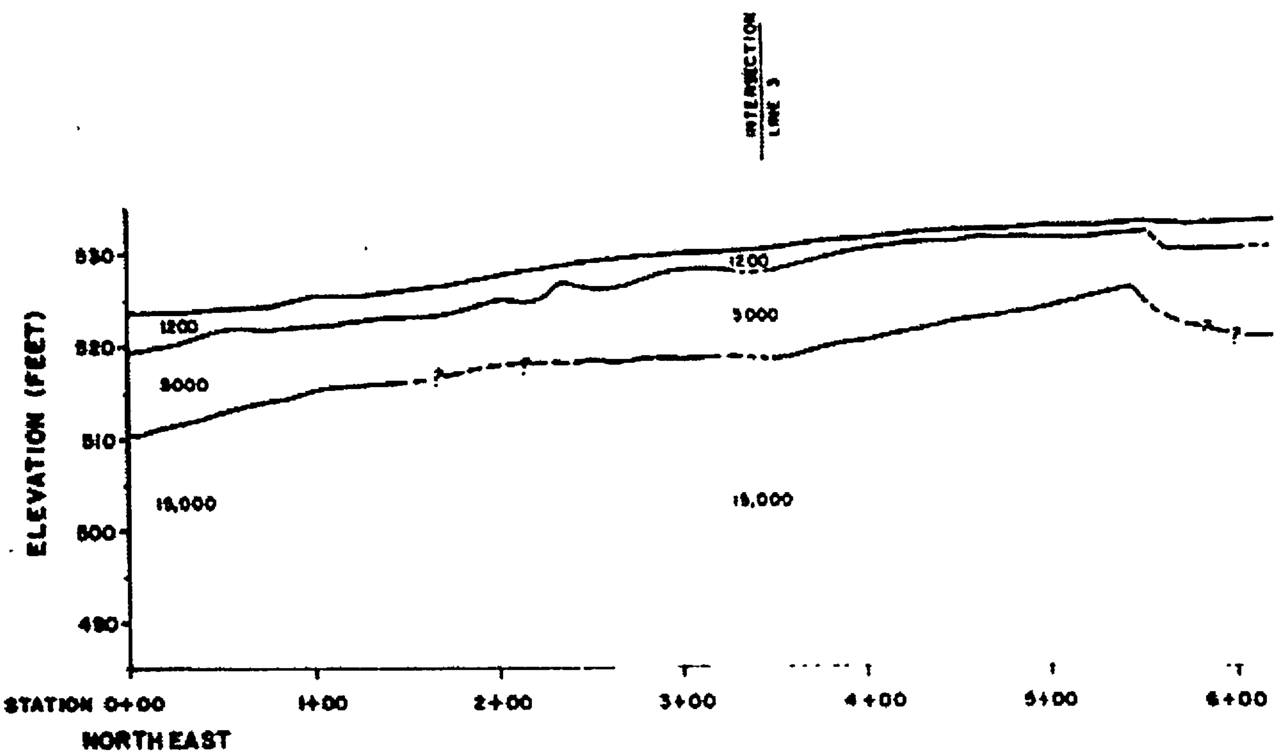
100
200

PLOT PLAN

TIME-DISTANCE PLOT -- SEISMIC REFRACTION LINE I





NOTES:

TIME-DISTANCE PLOTS REFLECT INFORMATION COLLECTED FROM SHOT POINTS ESTABLISHED AT SEVERAL LOCATIONS ALONG A SEISMIC LINE. FOR CLARIFICATION, THE FOLLOWING PLOT SYMBOLS HAVE BEEN USED:

- ▲ SHOT POINT LOCATION.
- O ORIGIN OF THE SHOCK FROM THE LEFT.
- ♦ ORIGIN OF THE SHOCK FROM THE RIGHT.

THE SUBSURFACE SECTION SHOWN REPRESENTS OUR EVALUATION OF THE MOST PROBABLE CONDITIONS, BASED UPON INTERPRETATIONS OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

ALL OF THE COMPRESSIONAL WAVE VELOCITIES SHOWN ON THE TIME-DISTANCE PLOTS ARE APPARENT VELOCITIES. ALL OF THESE APPARENT VELOCITIES ARE GIVEN IN FEET PER SECOND. THESE VELOCITIES HAVE BEEN DETERMINED DIRECTLY FROM THE PLOTS. WHEN THE APPARENT COMPRESSIONAL WAVE VELOCITIES HAVE BEEN CORRECTED FOR SLOPING DATUMS AND SUBSURFACE VARIATIONS, THE TRUE COMPRESSIONAL WAVE VELOCITY RESULTS, AS SHOWN IN THE SUBSURFACE CROSS SECTIONS.

ALL ELEVATIONS REFER TO MEAN SEA LEVEL.

EXPLANATION

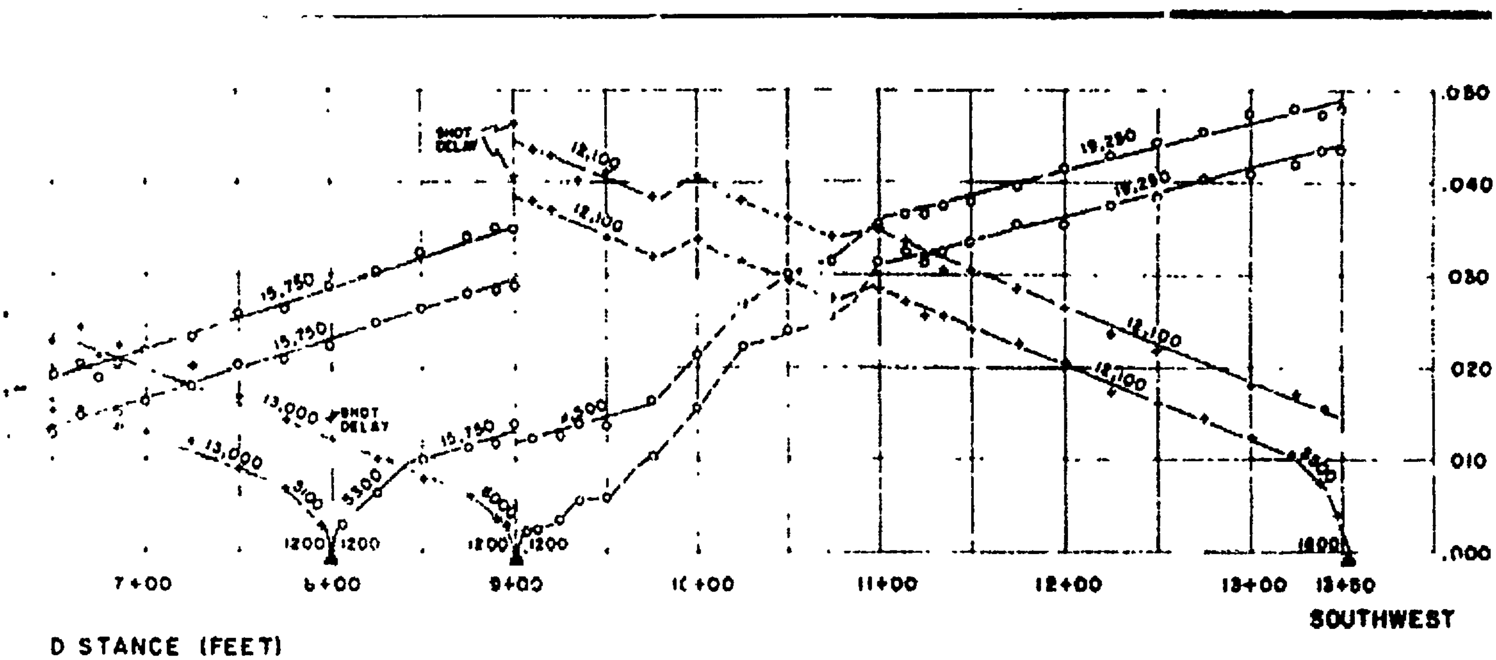
—?— SIGNIFIES THAT GEOPHYSICAL DATA DOES NOT ALLOW A QUANTITATIVE INTERPRETATION BUT RATHER A QUALITATIVE ONE.

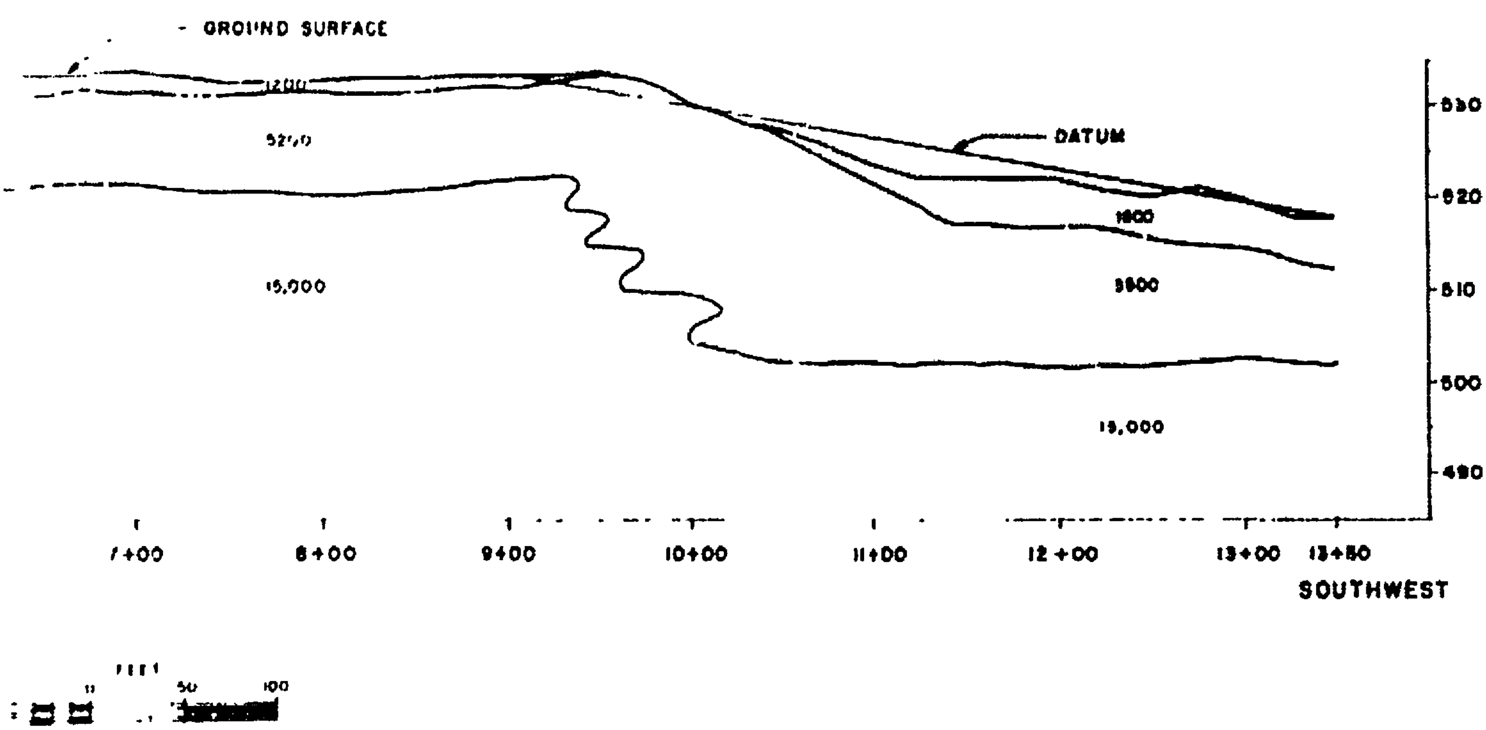
– – – SIGNIFIES ANOMALOUS ZONE INTERPRETED AS A JOINT OR A SYSTEM OF JOINTS.

[illegible]

1. IN THE TIME-DISTANCE DATA SOME ANOMALOUS [illegible] ARRIVAL TIMES ARE DENOTED BY SHOT DELAY. THIS MEANS THAT THESE ARE ARRIVAL TIMES HAVE BEEN CAUSED BY TRANSMISSION THROUGH PREVIOUSLY DISTURBED [illegible] ZONE.

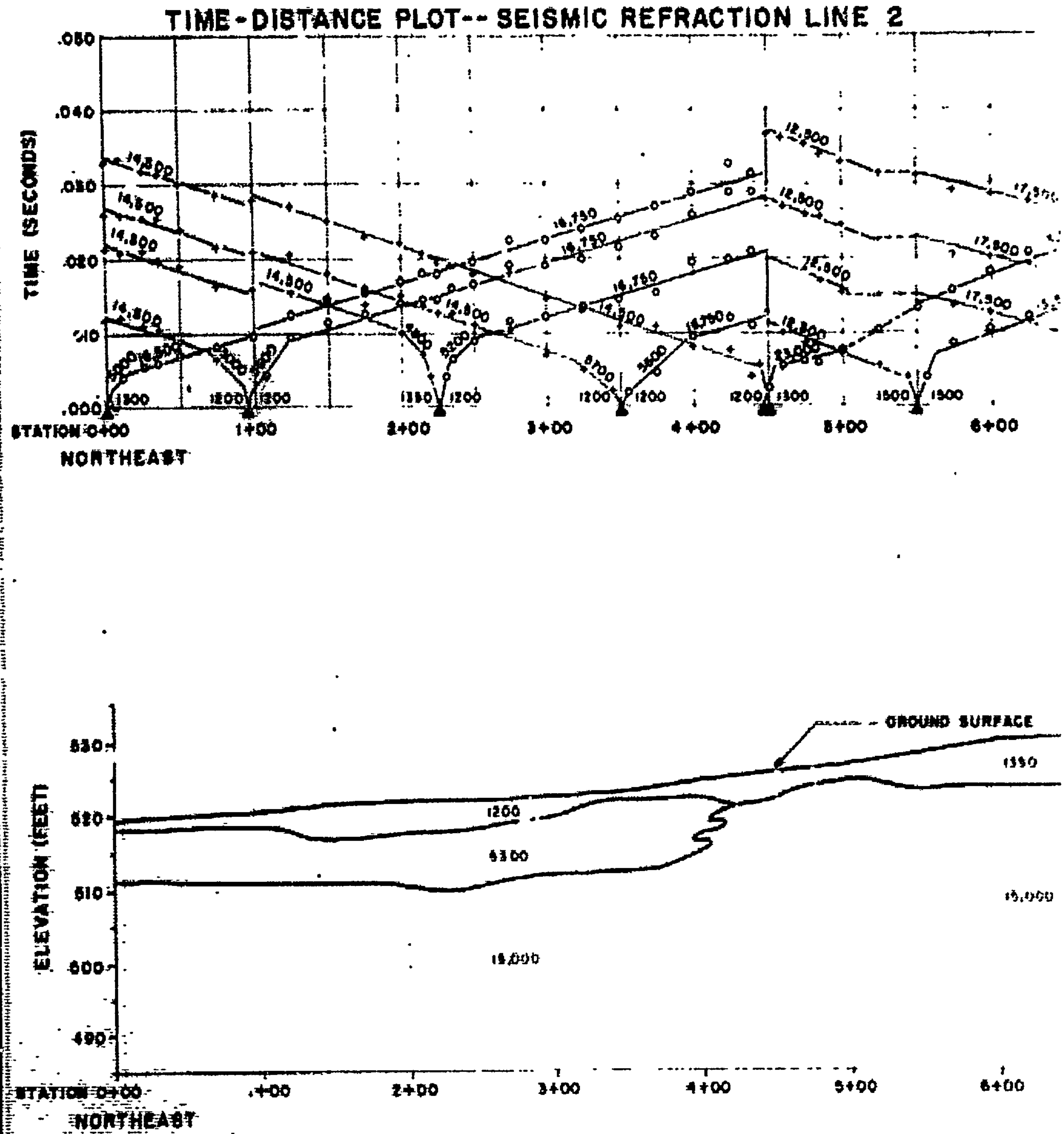
2. IN THE [illegible] BETWEEN STATION [illegible] THE [illegible] DATA WAS CORRECTED [illegible] LINE DATUM [illegible] TOPOGRAPHY [illegible] DRAWN ON THE SECTION AND [illegible] AT [illegible]





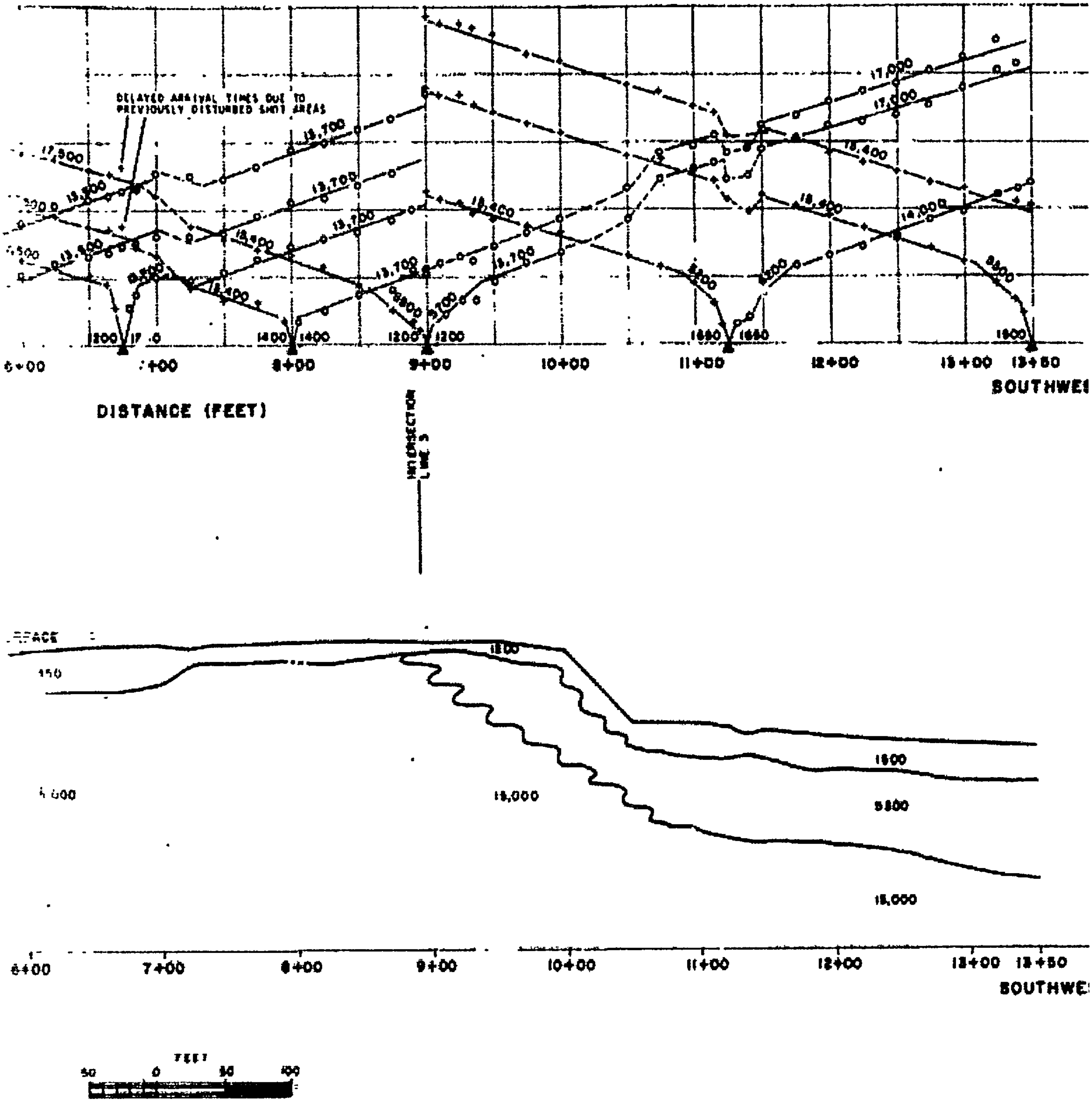
TIME – DISTANCE PLOT-- SEISMIC REFRACTION LINI

FIGURE 2



NOTES:

EXPLANATION

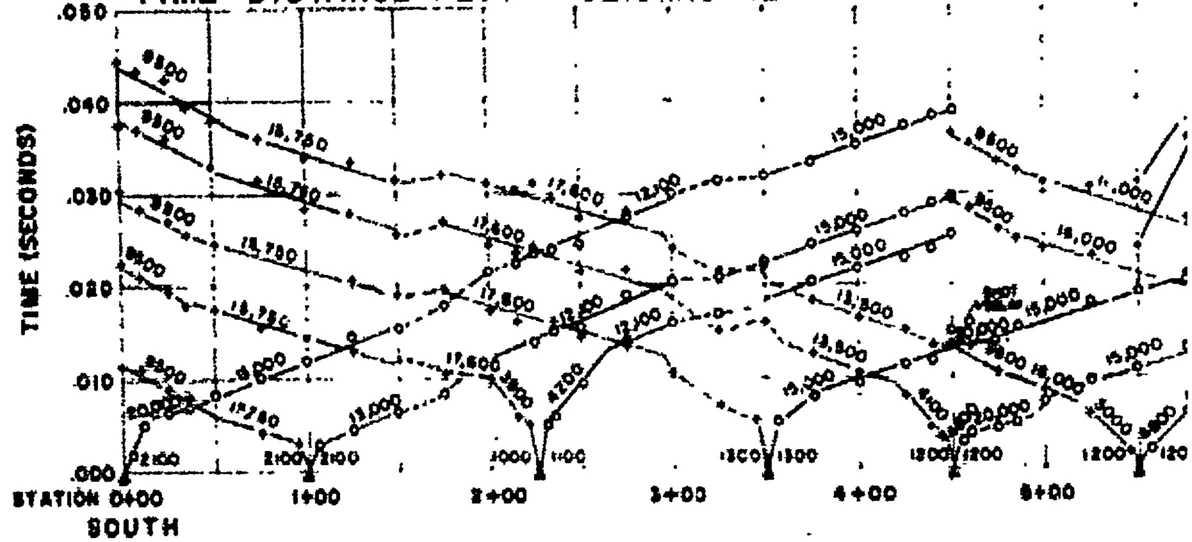


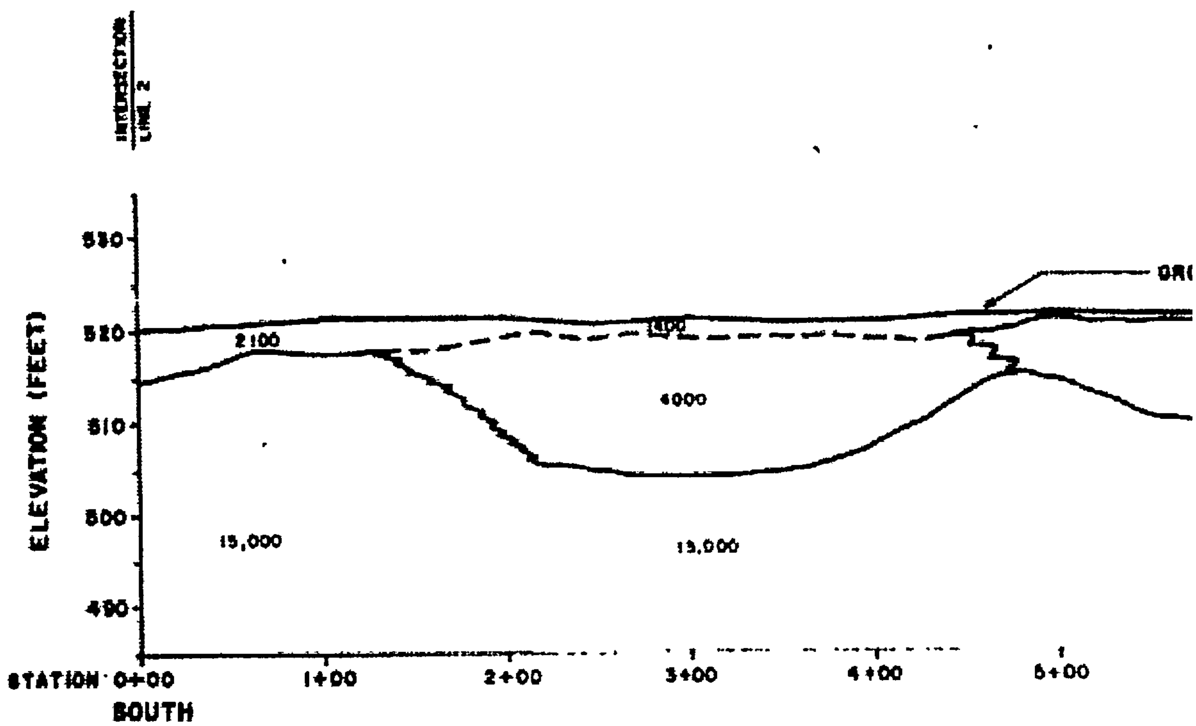
TIME – DISTANCE PLO

SEISMIC REFRACTION

FIGU

TIME-DISTANCE PLOT -- SEISMIC REFRACTION LINE 3





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- ▲ SHOT POINT LOCATION
- ○ ORIGIN OF THE SHOCK FROM THE LEFT
- + ORIGIN OF THE SHOCK FROM THE RIGHT

THE SUBSURFACE SECTION SHOWN REPRESENTS [illegible] THE MOST PROBABLE CONDITIONS, BASED [illegible] INTERPRETATIONS [illegible] PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

ALL OF THE COMPRESSIONAL WAVE VELOCITIES SHOWN [illegible] THE TIME-DISTANCE PLOTS ARE APPARENT VELOCITIES. ALL OF THESE APPARENT VELOCITIES ARE GIVEN IN FEET PER SECOND. THESE [illegible] HAVE BEEN DETERMINED DIRECTLY FROM THE PLOTS. WHEN THE APPARENT COMPRESSIONAL WAVE VELOCITIES HAVE BEEN [illegible] DATUMS AND SUBSURFACE VARIATIONS, THE [illegible] VELOCITY RESULTS, AS SHOWN IN THE SUBSURFACE [illegible]

ALL ELEVATIONS REFER TO MEAN SEA LEVEL

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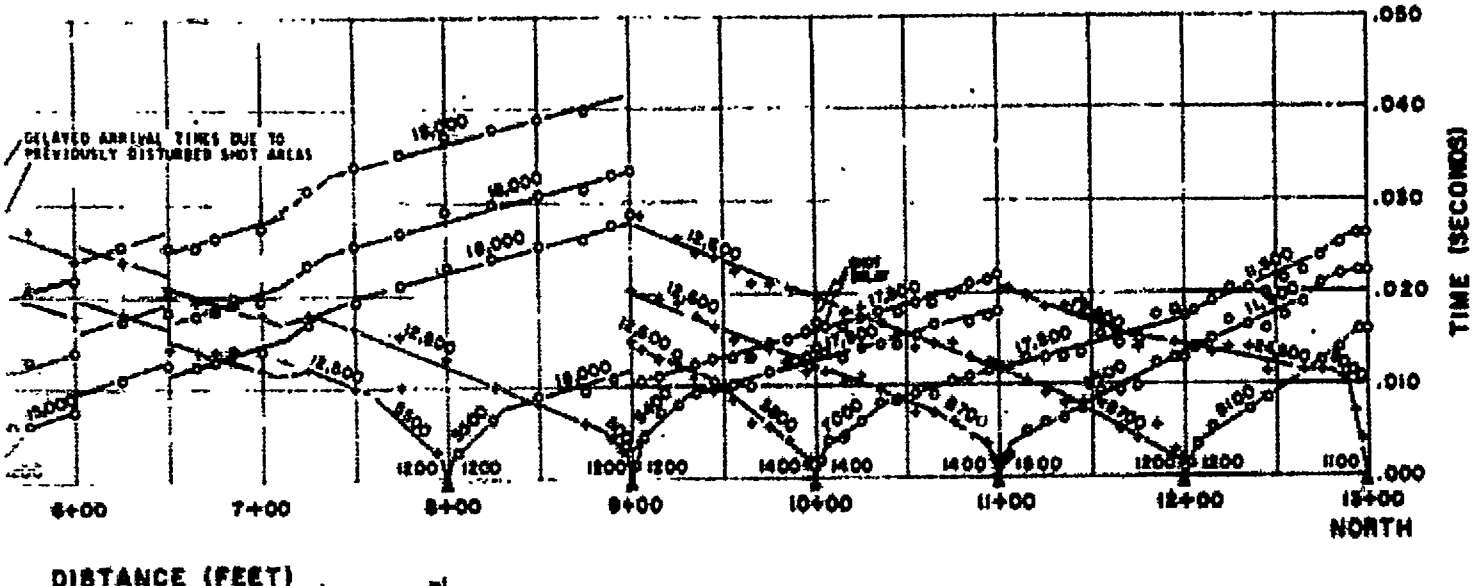
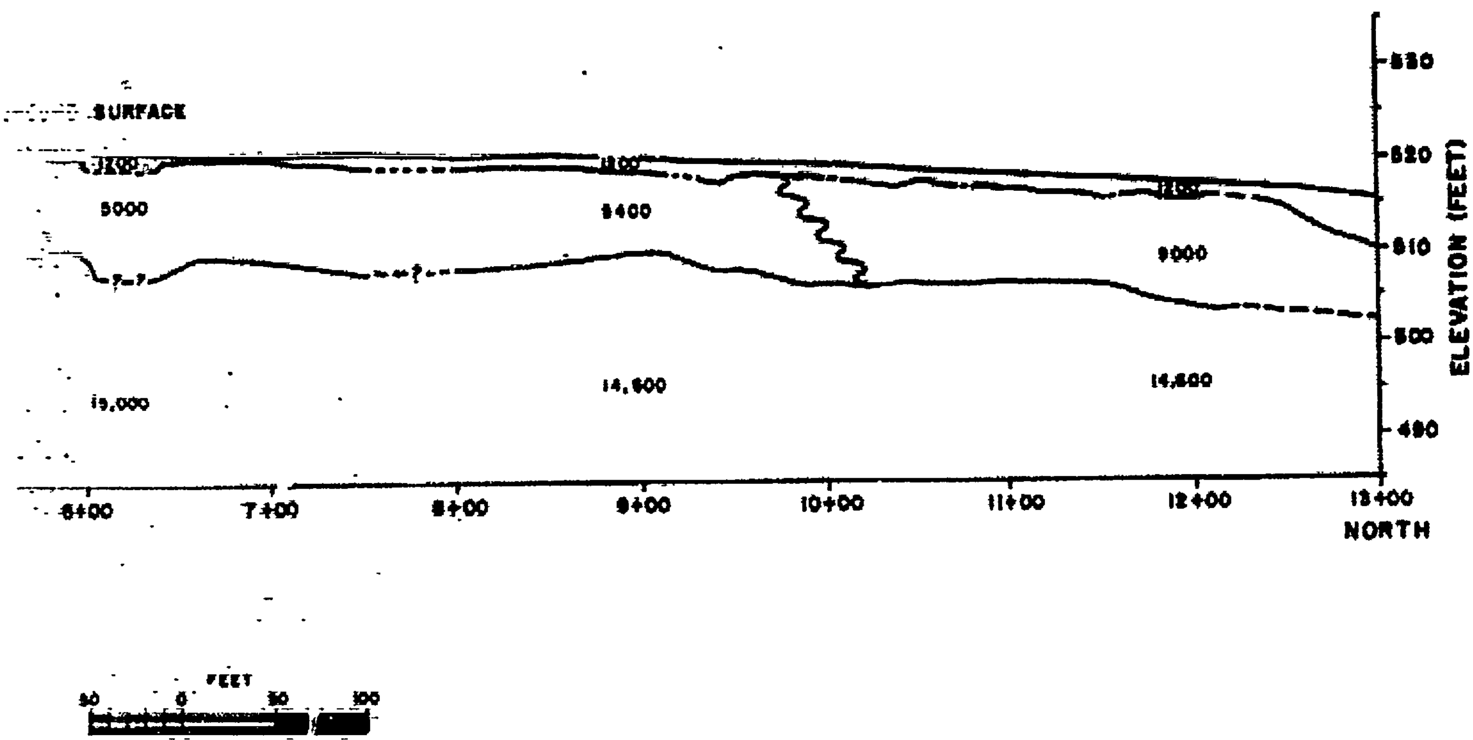
NOTES:

IN THE TIME - DISTANCE DATA THE ANOMALOUS LATE ARRIVAL TIMES ARE DENOTED BY "SHOT DELAY". THIS MEANS THAT THESE LATE ARRIVAL TIMES HAVE BEEN CAUSED BY [illegible] PREVIOUSLY DISTURBED [illegible] ZONES.

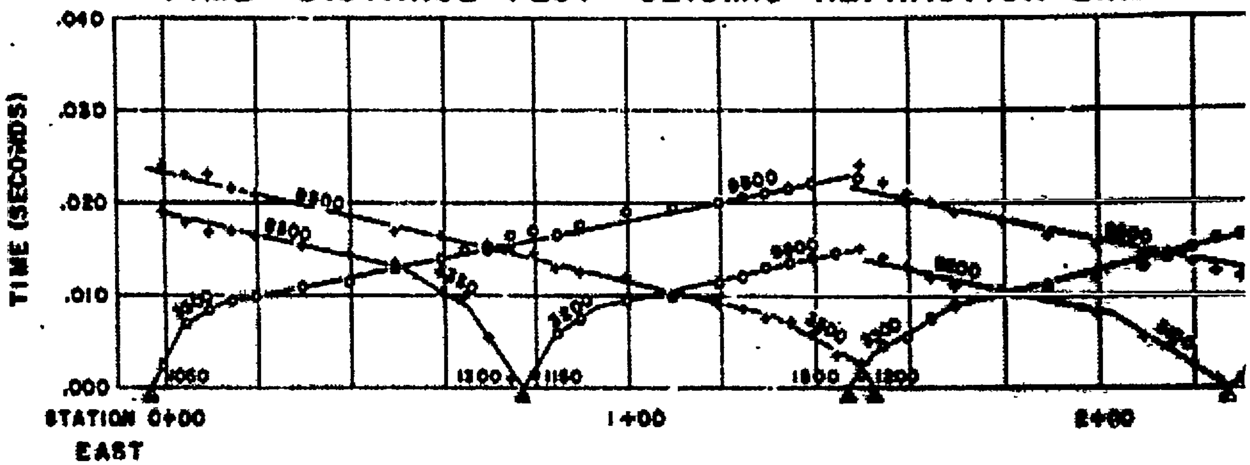


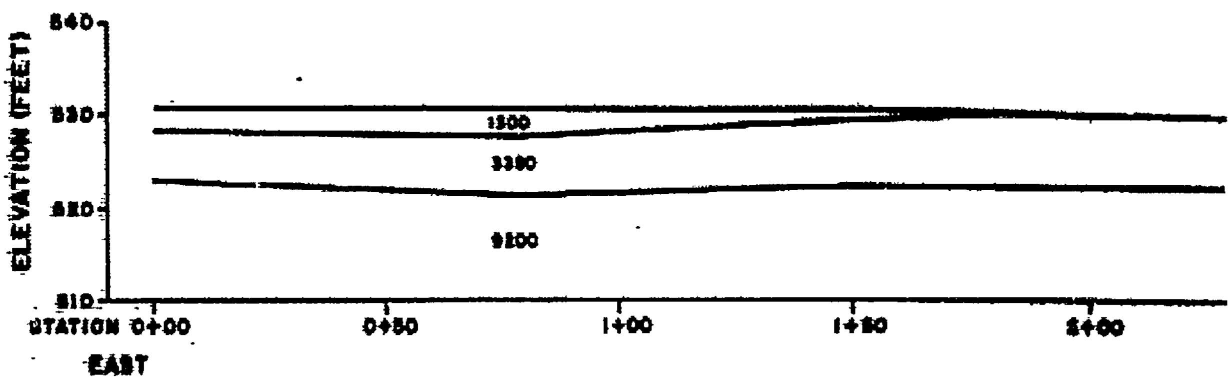


TIME – DISTANCE PLOT
SEISMIC REFRACTION

FIGURE

TIME - DISTANCE PLOT - SEISMIC REFRACTION LINE W-





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- o ORIGIN OF THE SHOCK FROM THE LEFT.
- + ORIGIN OF THE SHOCK FROM THE RIGHT.

THE SUBSURFACE SECTION SHOWN REPRESENTS OUR EVALUATION OF THE MOST PROBABLE CONDITIONS, BASED UPON INTERPRETATIONS OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

ALL OF THE COMPRESSIONAL WAVE VELOCITIES SHOWN ON THE TIME-DISTANCE PLOT ARE APPARENT VELOCITIES. ALL OF THESE APPARENT VELOCITIES ARE GIVEN IN FEET PER SECOND. THESE VELOCITIES HAVE BEEN DETERMINED DIRECTLY FROM THE PLOTS. WHEN THE APPARENT COMPRESSIONAL WAVE VELOCITIES HAVE BEEN CORRECTED FOR SLOPING DATUMS AND SUBSURFACE VARIATIONS, THE TRUE COMPRESSIONAL WAVE VELOCITY RESULTS, AS SHOWN IN THE SUBSURFACE CROSS-SECTIONS.

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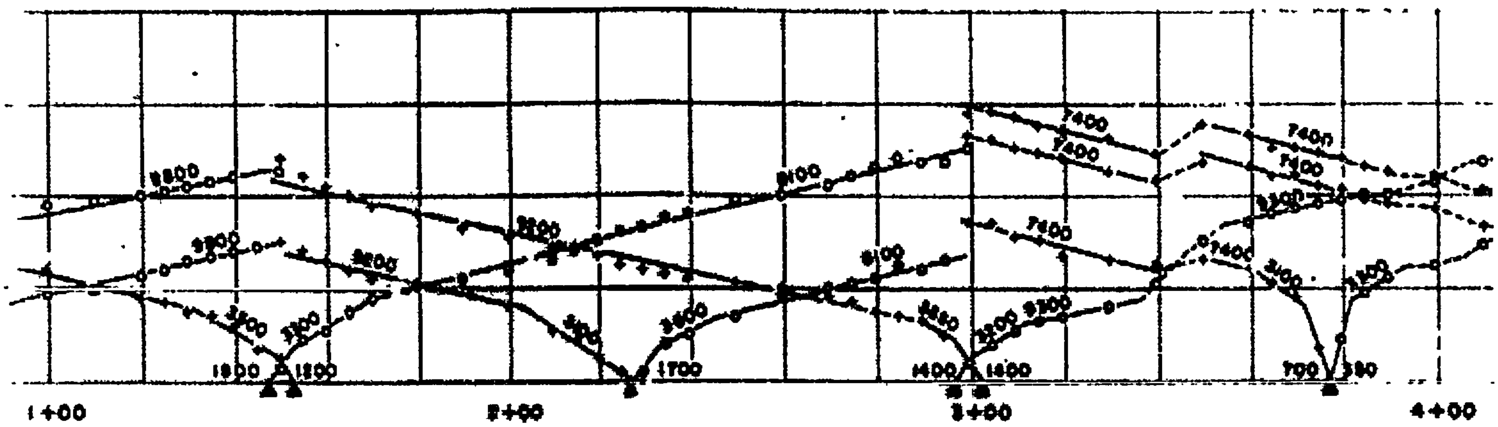
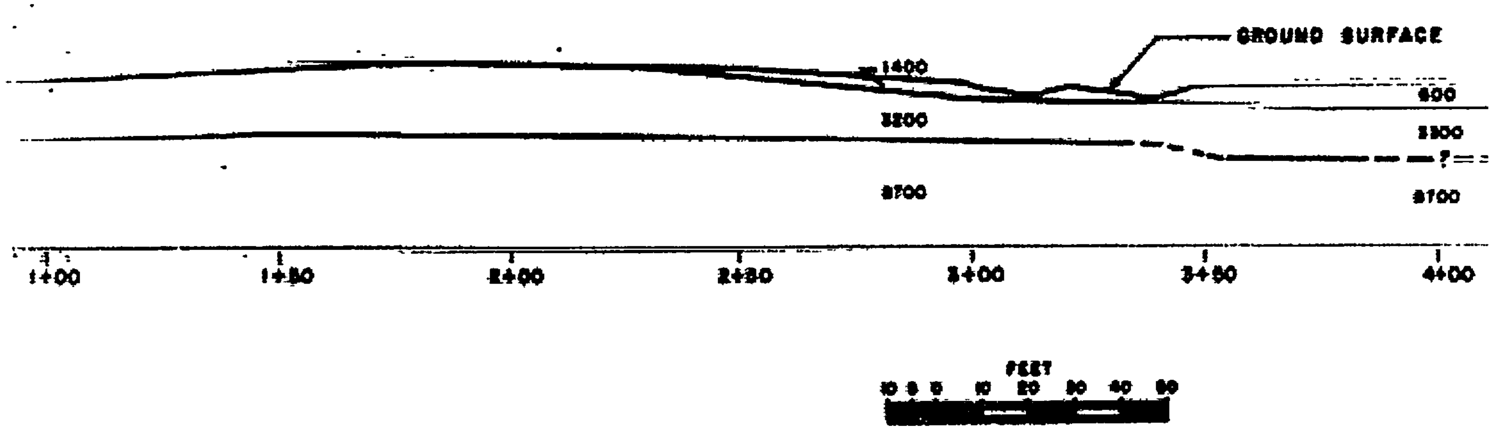
— — — SIGNIFIES ANOMALOUS ZONE INTERPRETED AS A JOINT OR A SYSTEM OF JOINTS.

NOTES:

IN THE TIME - DISTANCE DATA SOME ANOMALOUS LATE ARRIVAL TIMES ARE DENOTED BY "SHOT DELAY". THIS MEANS THAT THESE LATE ARRIVAL TIMES HAVE BEEN CAUSED BY TRANSMISSION THROUGH PREVIOUSLY DISTURBED SOIL ZONES.

-SEISMIC REFRACTION LINE W-1





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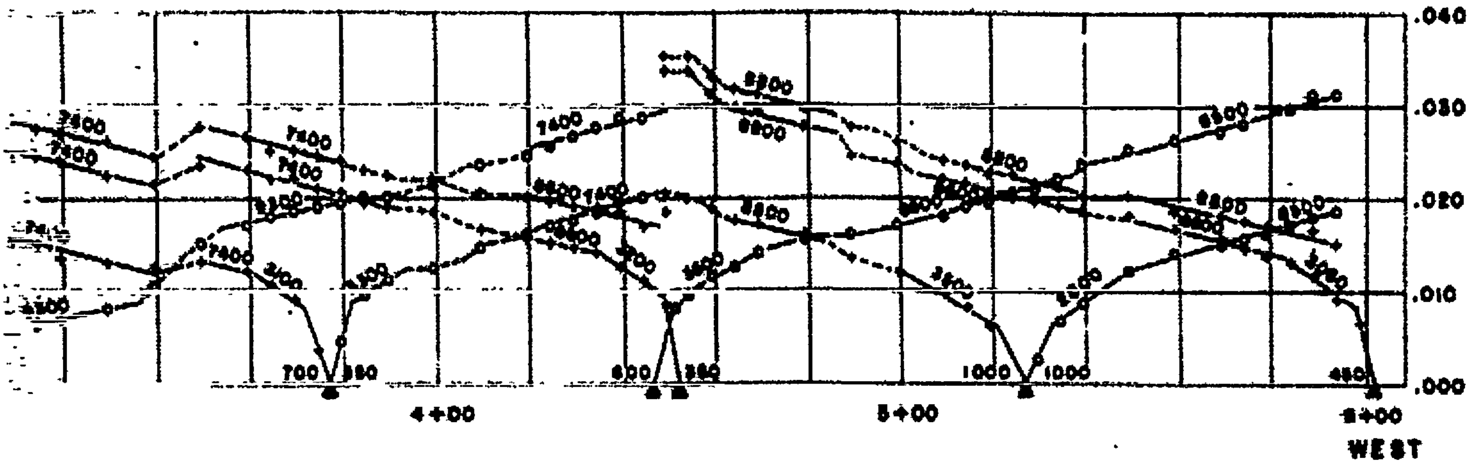
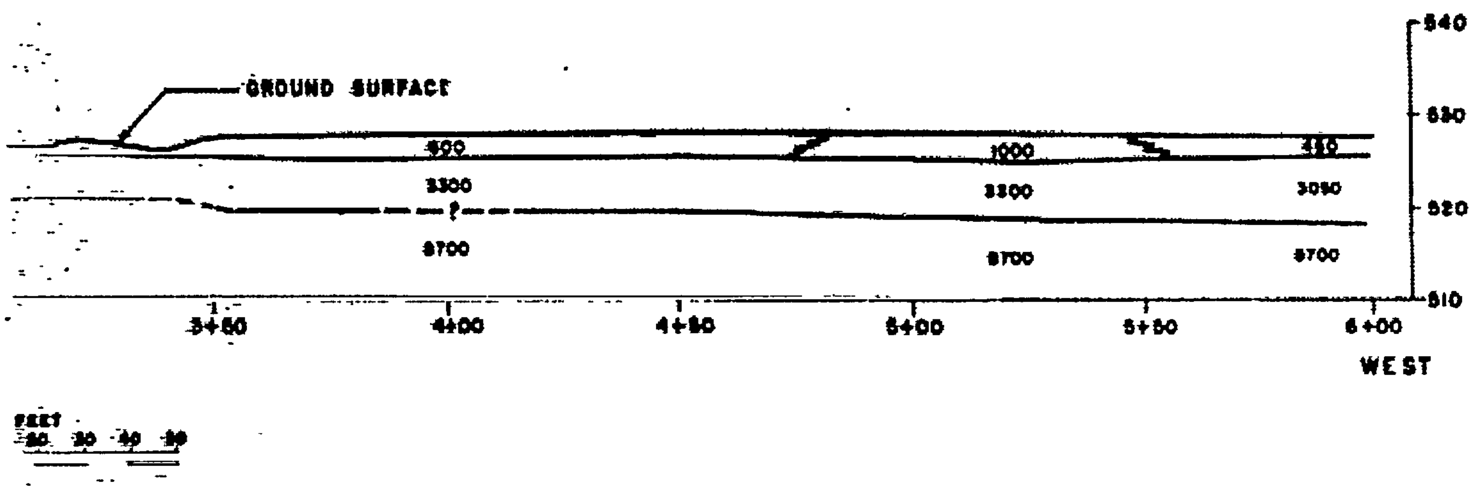
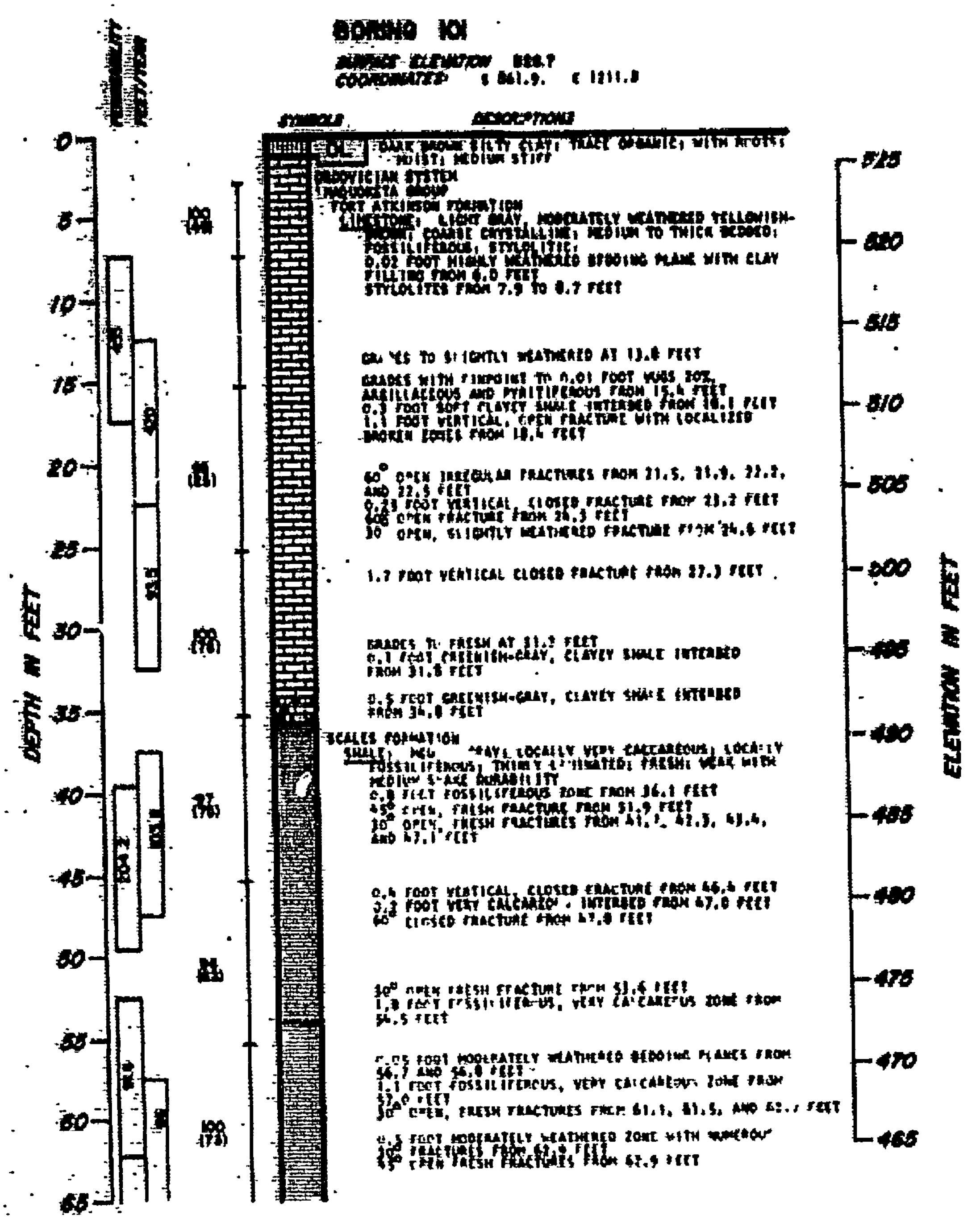


(FEET)



TIME-DISTANCE PLOT
-SEISMIC REFRACTION LIN



KEY:

INDICATES NUMBER OF BLOW COUNTS REQUIRED TO DRIVE STANDARD SPLIT SPOON 0.5 FOOT WITH 140 POUND HAMMER FALLING 30 INCHES.

27 INDICATES STANDARD SPLIT SPOON SAMPLE LOCATIONS.

INDICATES GRAB SAMPLE LOCATION.

INDICATES DEPTH AND LENGTH OF CORE RUN FOR NX DIAMOND ROCK CORING

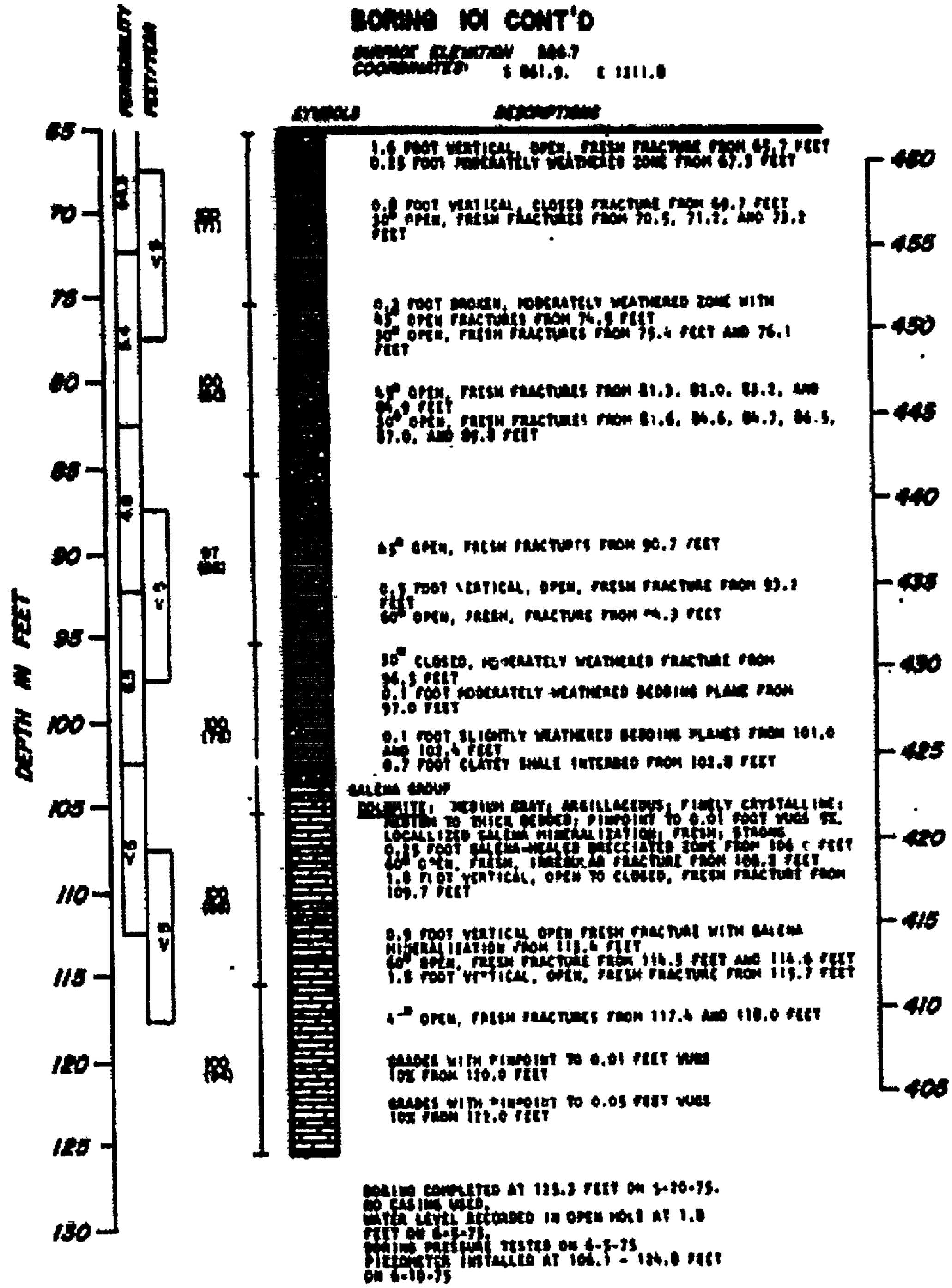
100 INDICATES PERCENT OF CORE RECOVERED

(88) INDICATES ROCK QUALITY DESIGNATION

INDICATES DEPTH AND LENGTH PRESSURE TESTED AND PERMEABILITY IN FEET PER YEAR AT OVERBURDEN PRESSURE

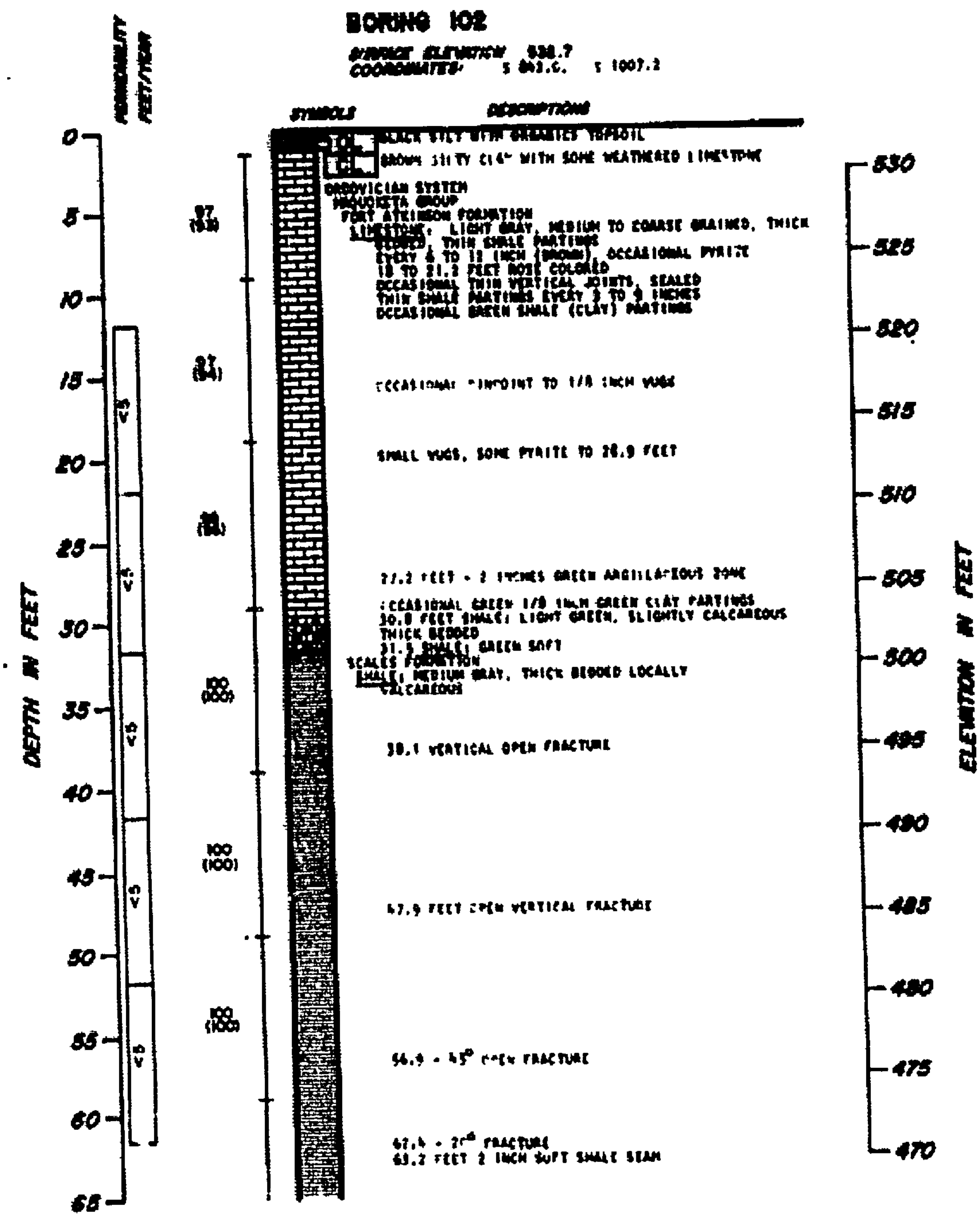
LOG OF BORINGS

FIGURE 6 SHEET 1 OF 2



LOG OF BORINGS

FIGURE 6 SHEET 2 OF 2

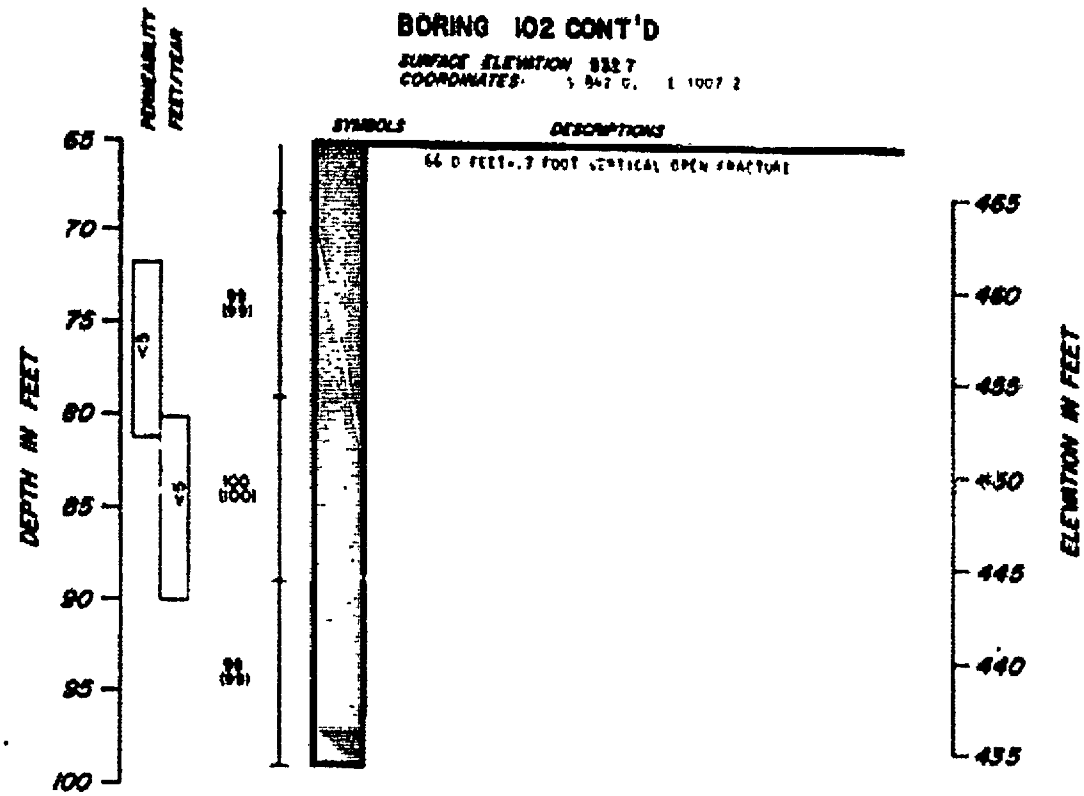


LOG OF BORINGS

FIGURE 7 SHEET 1 OF 2

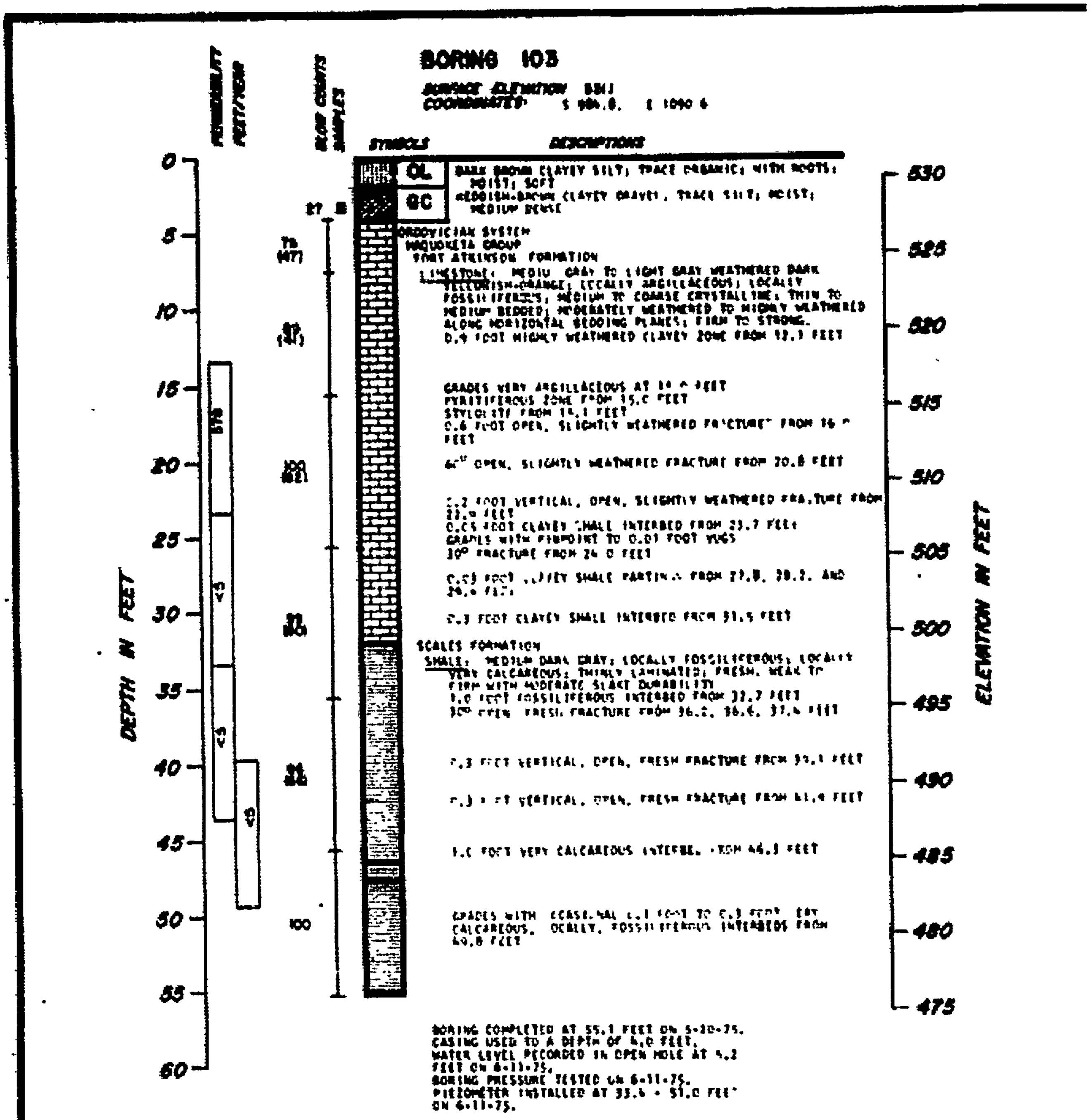
BORING 102 CONT'D

SURFACE ELEVATION 532.7
COORDINATES: [illegible]



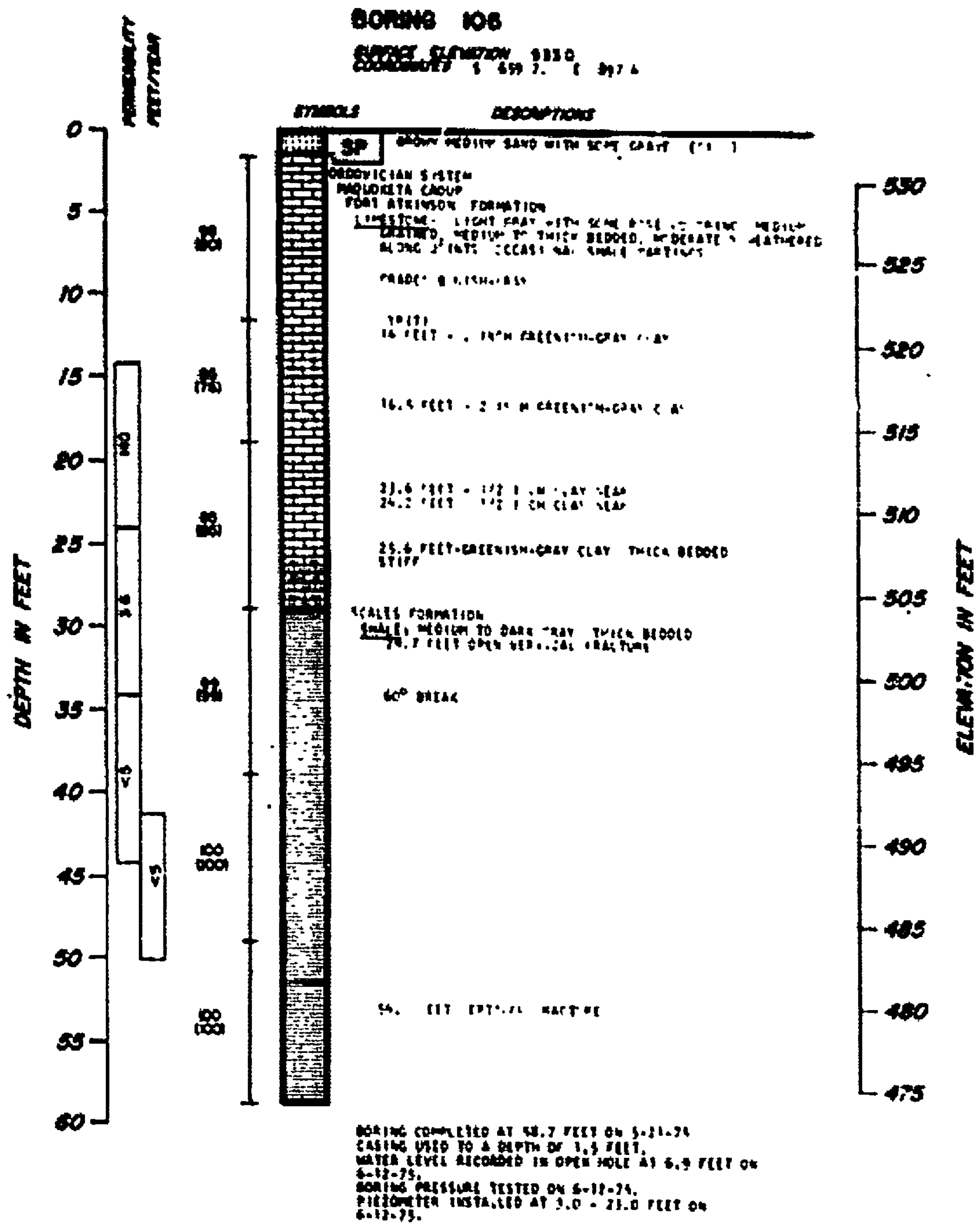
BORING COMPLETED AT 98.[illegible] FEET ON [illegible]-75.
CASING USED TO A DEPTH OF [illegible] FEET.
WATER LEVEL RECORDED IN OPEN HOLE AT [illegible] FEET ON 6-3-75.
BORING PRESSURE TESTED ON 6-3-75.
PIEZOMETER INSTALLED AT [illegible] - 29.[illegible] FEET ON 6-10-75.

LOG OF BORINGS



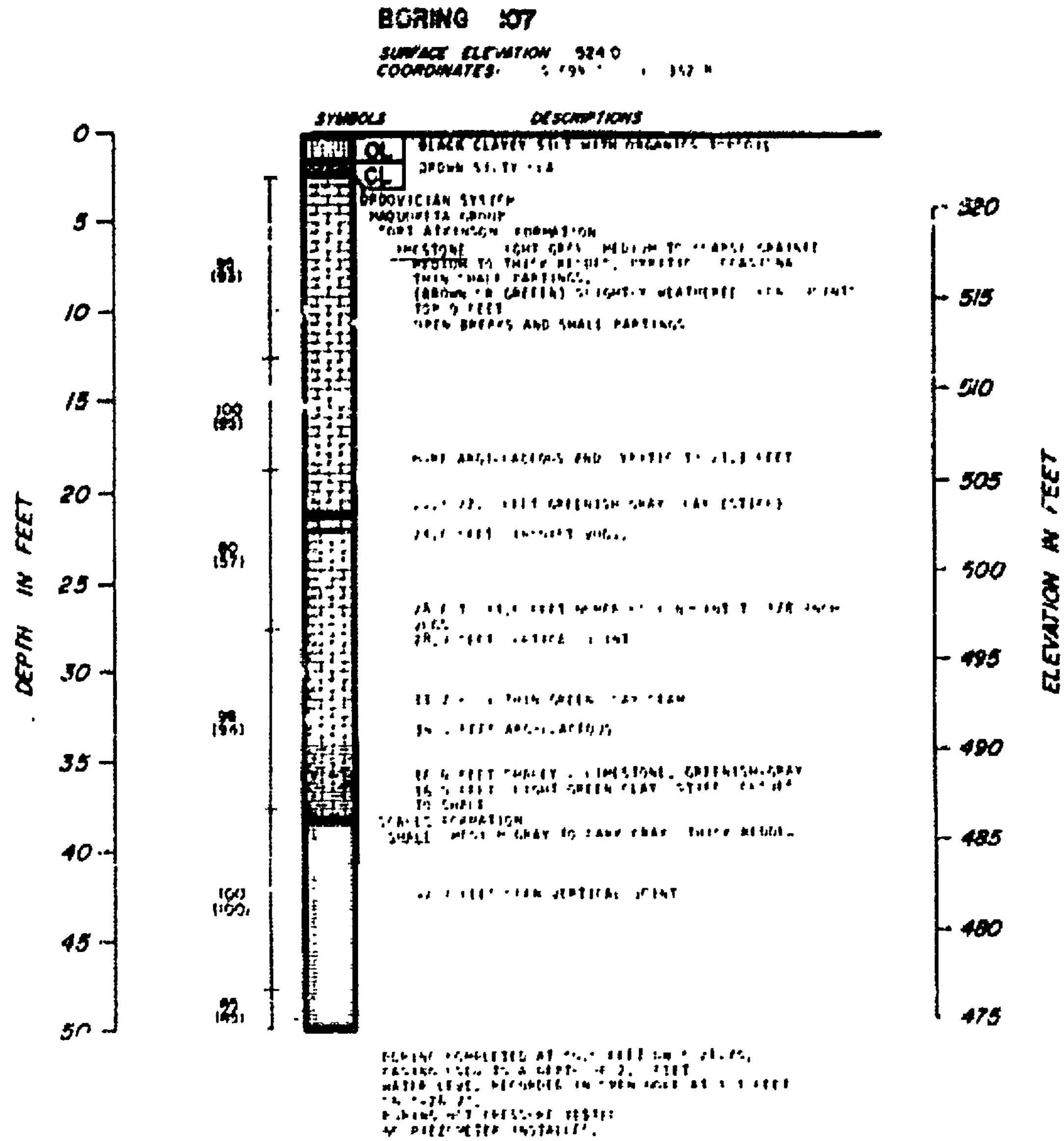
LOG OF BORINGS

FIGURE 8



LOG OF BORINGS

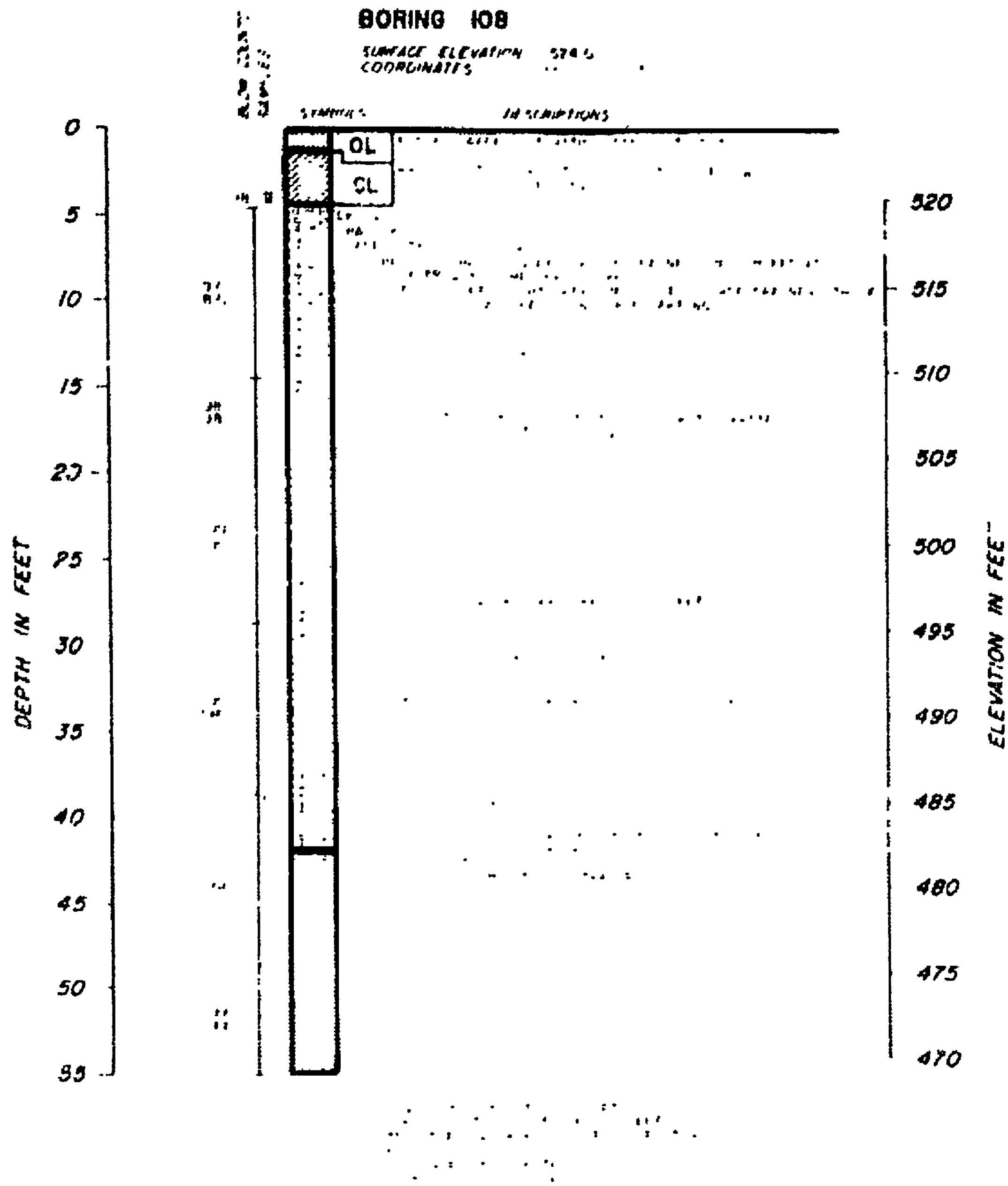
FIGURE 9



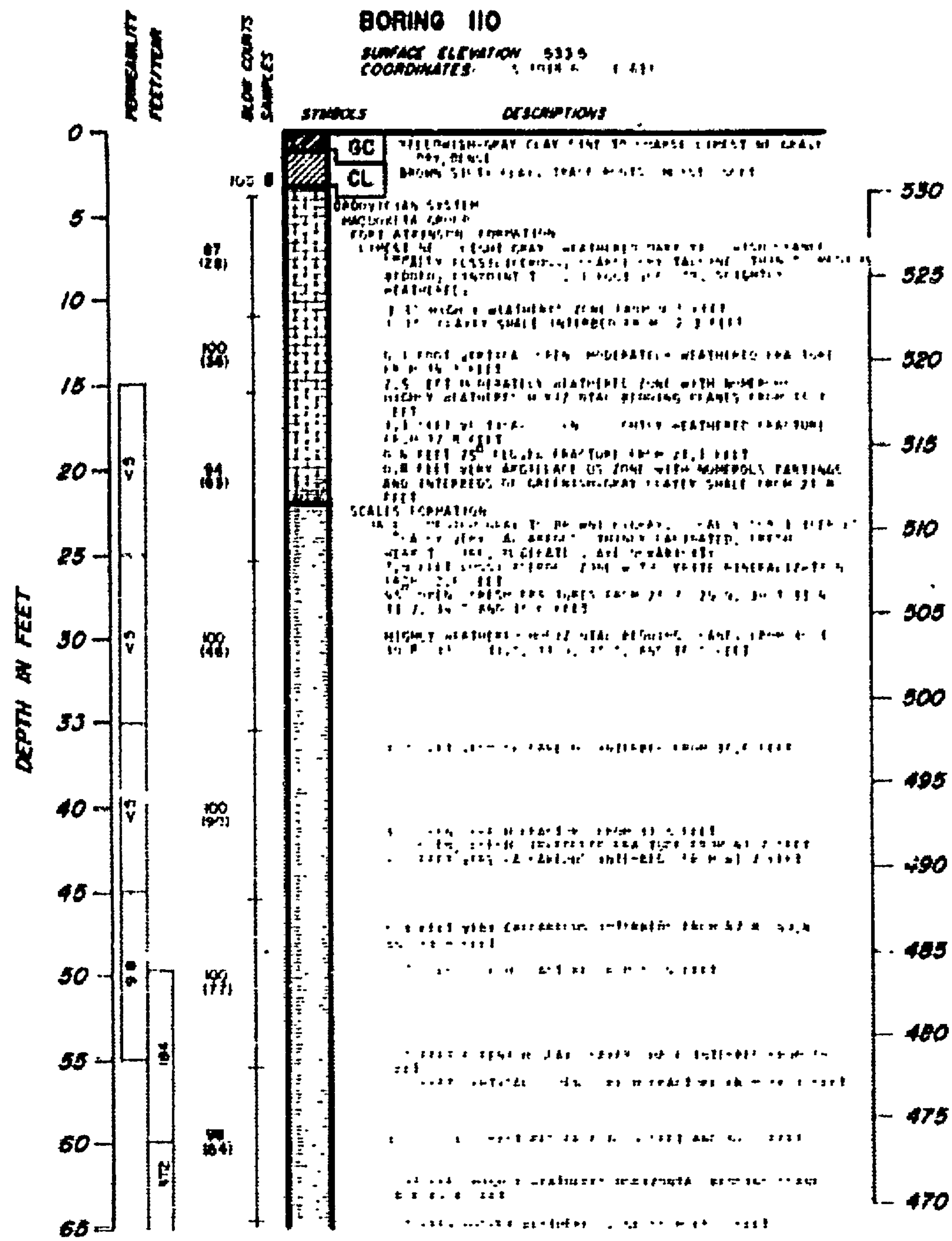
LOG OF BORINGS

DAMES & MOORE

FIGURE 10

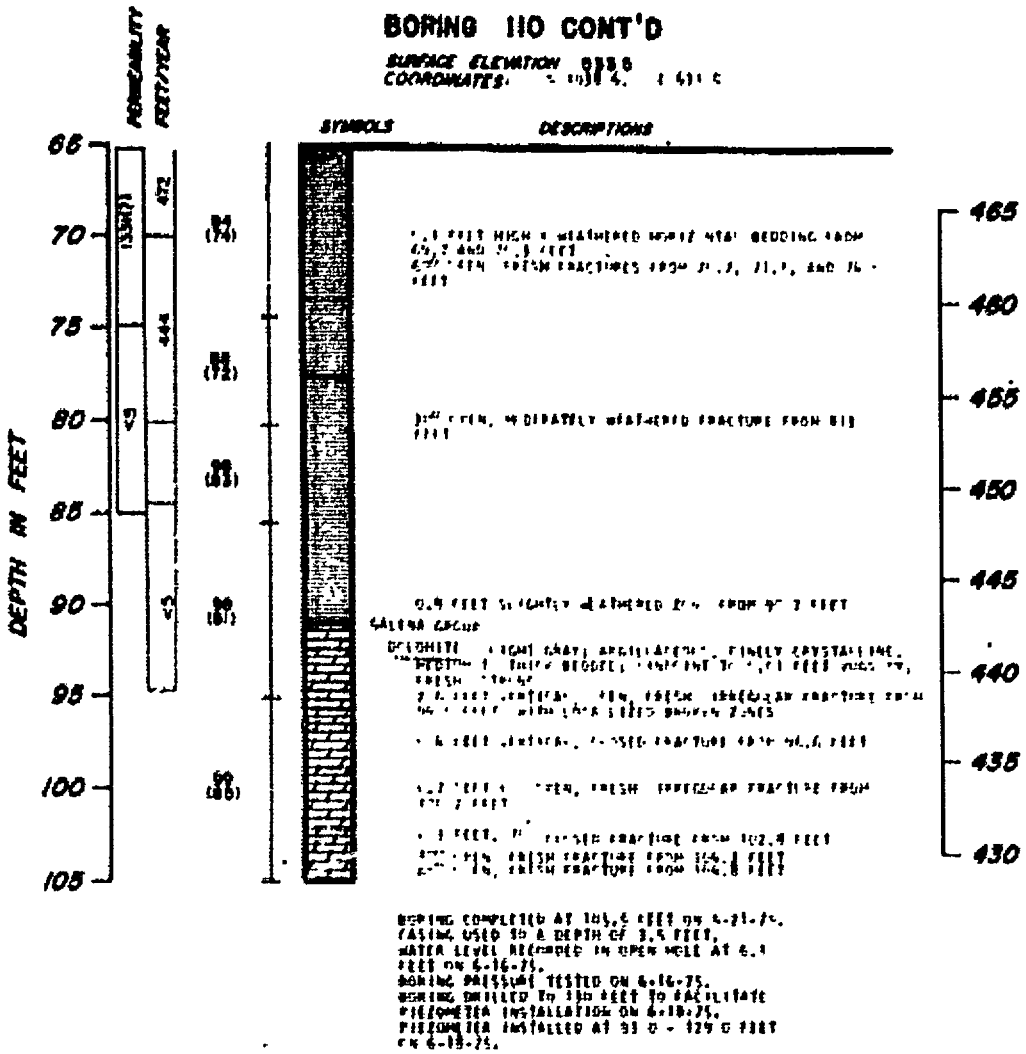


LOG OF BORINGS



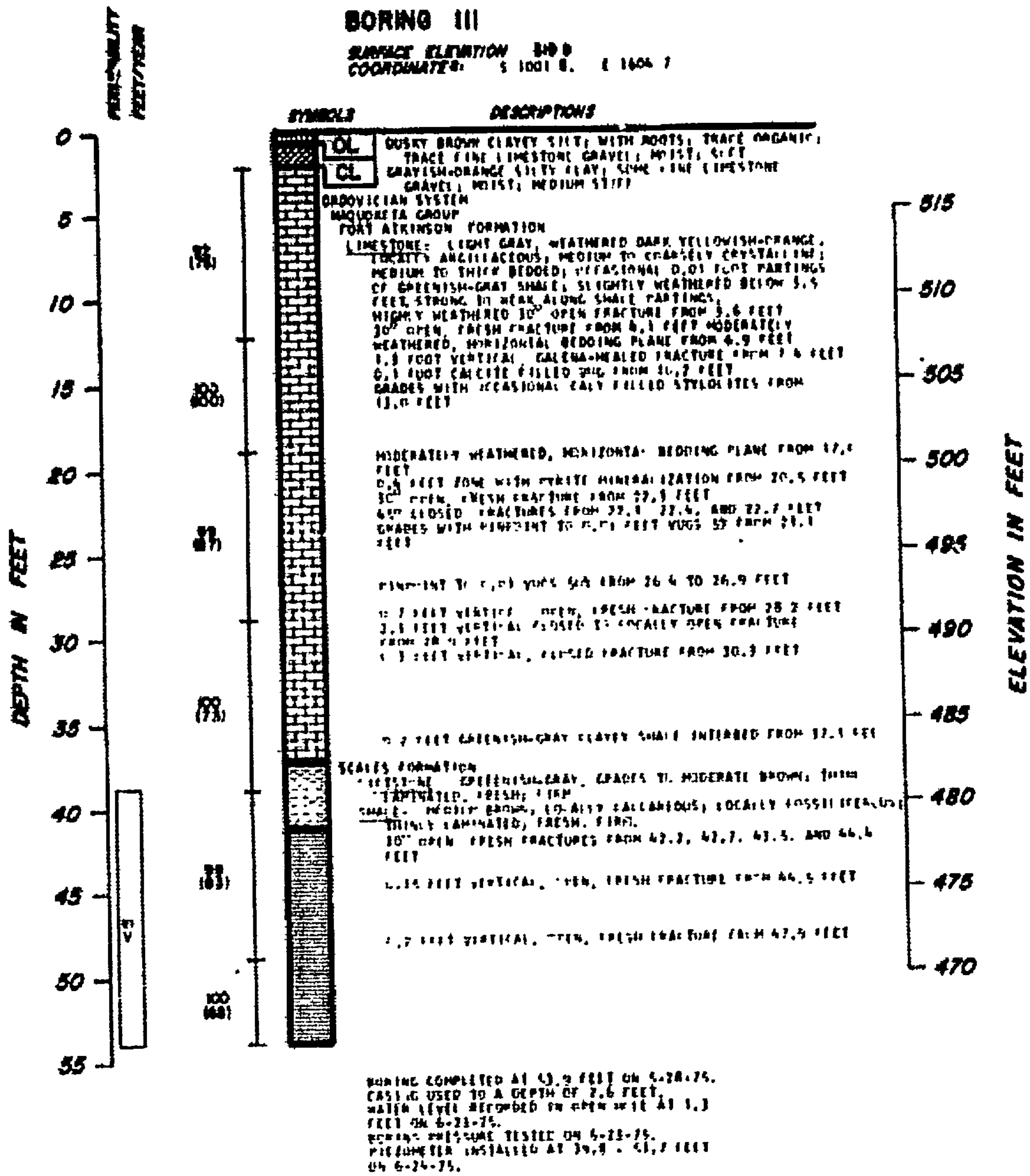
LOG OF BORINGS

DAMES & MOORE



LOG OF BORINGS

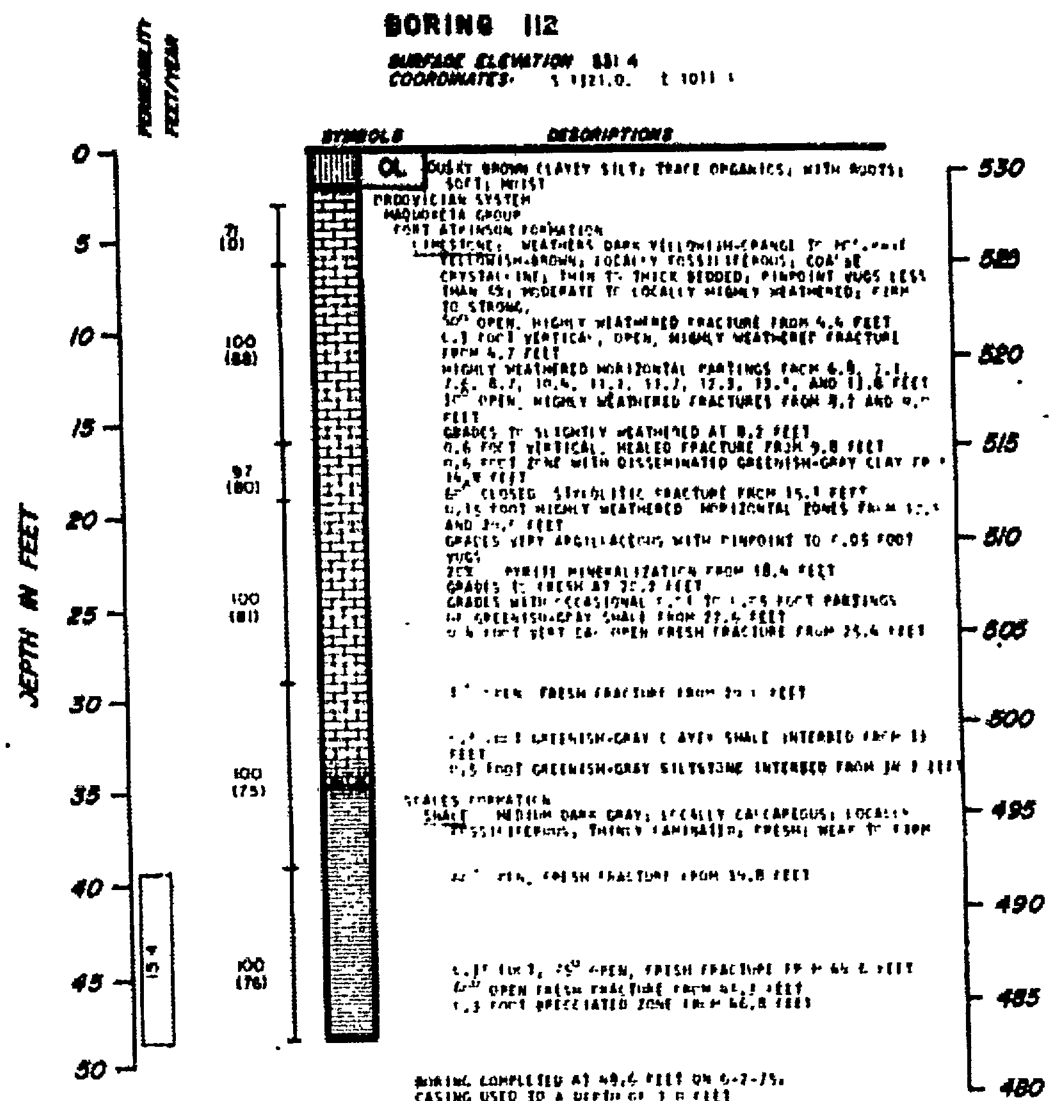
DAMES & MOORE



LOG OF BORINGS

DAMES & MOORE

FIGURE 13

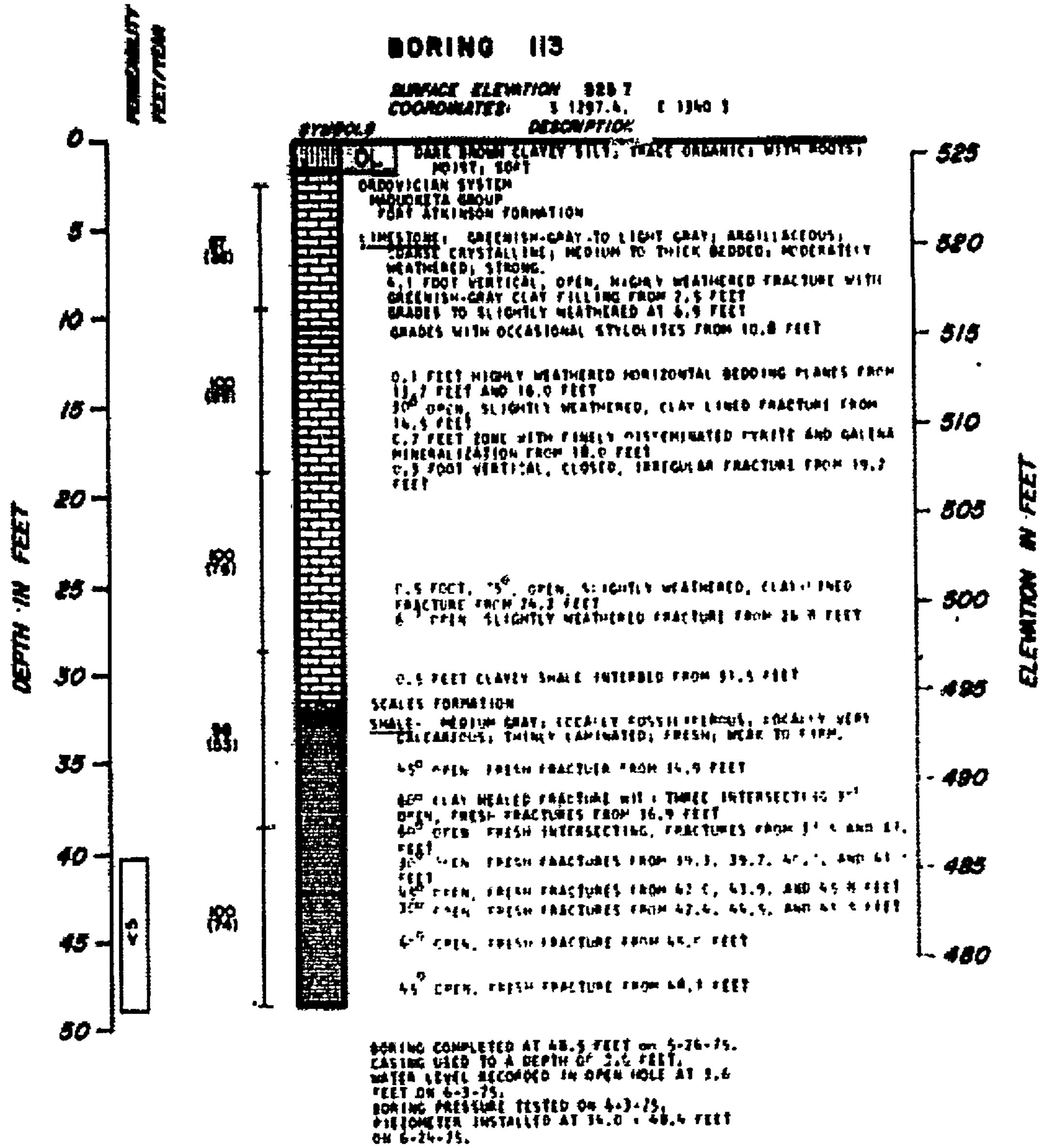


BORING COMPLETED AT 49.6 FEET ON 6-2-75.
CASING USED TO A DEPTH OF 3.0 FEET
WATER LEVEL RECORDED IN OPEN HOLE AT 3.8 FEET ON 6-2-75.
BORING PRESSURE TESTED ON 6-2-75.
PIEZOMETER INSTALLED AT 4.5 - 33.7 FEET ON 6-24-75.

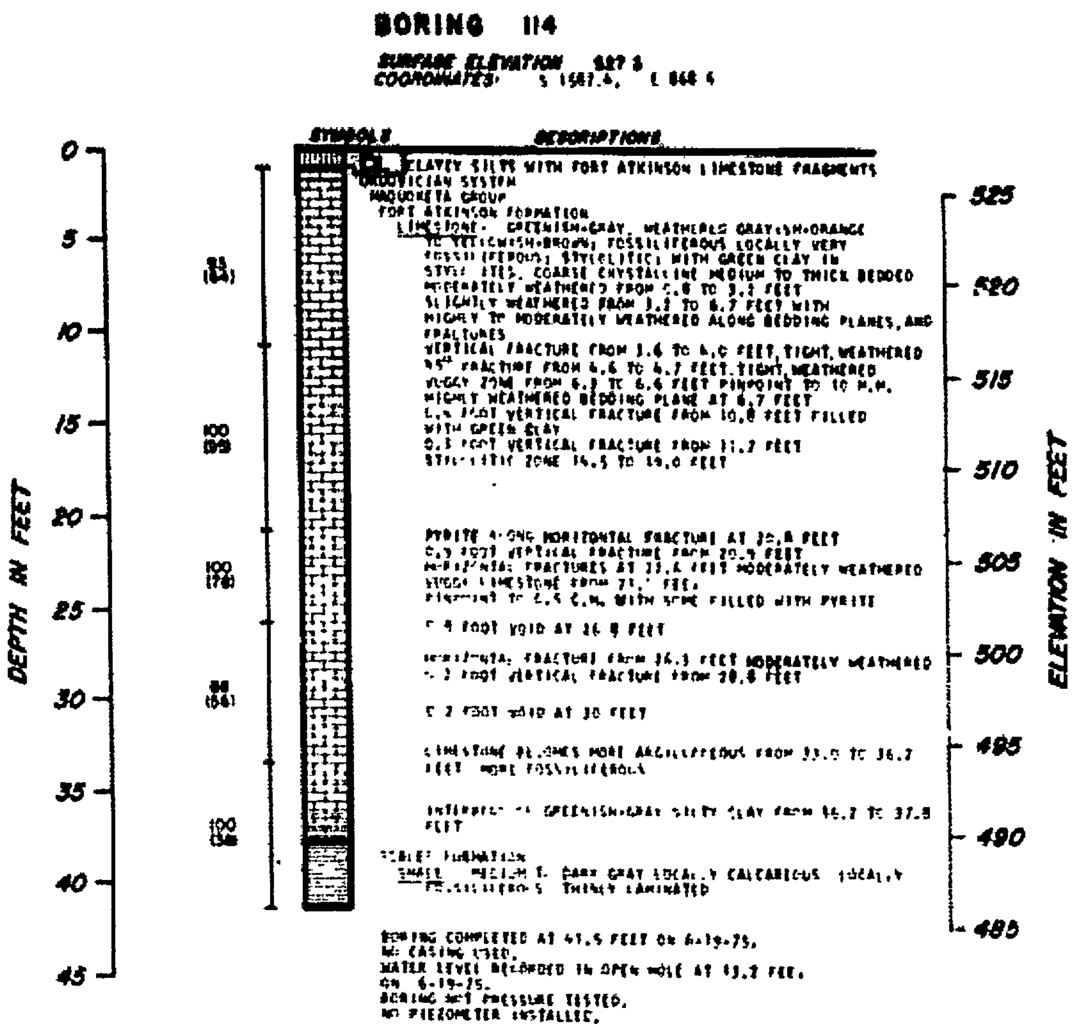
LOG OF BORINGS

DAMES & MOORE

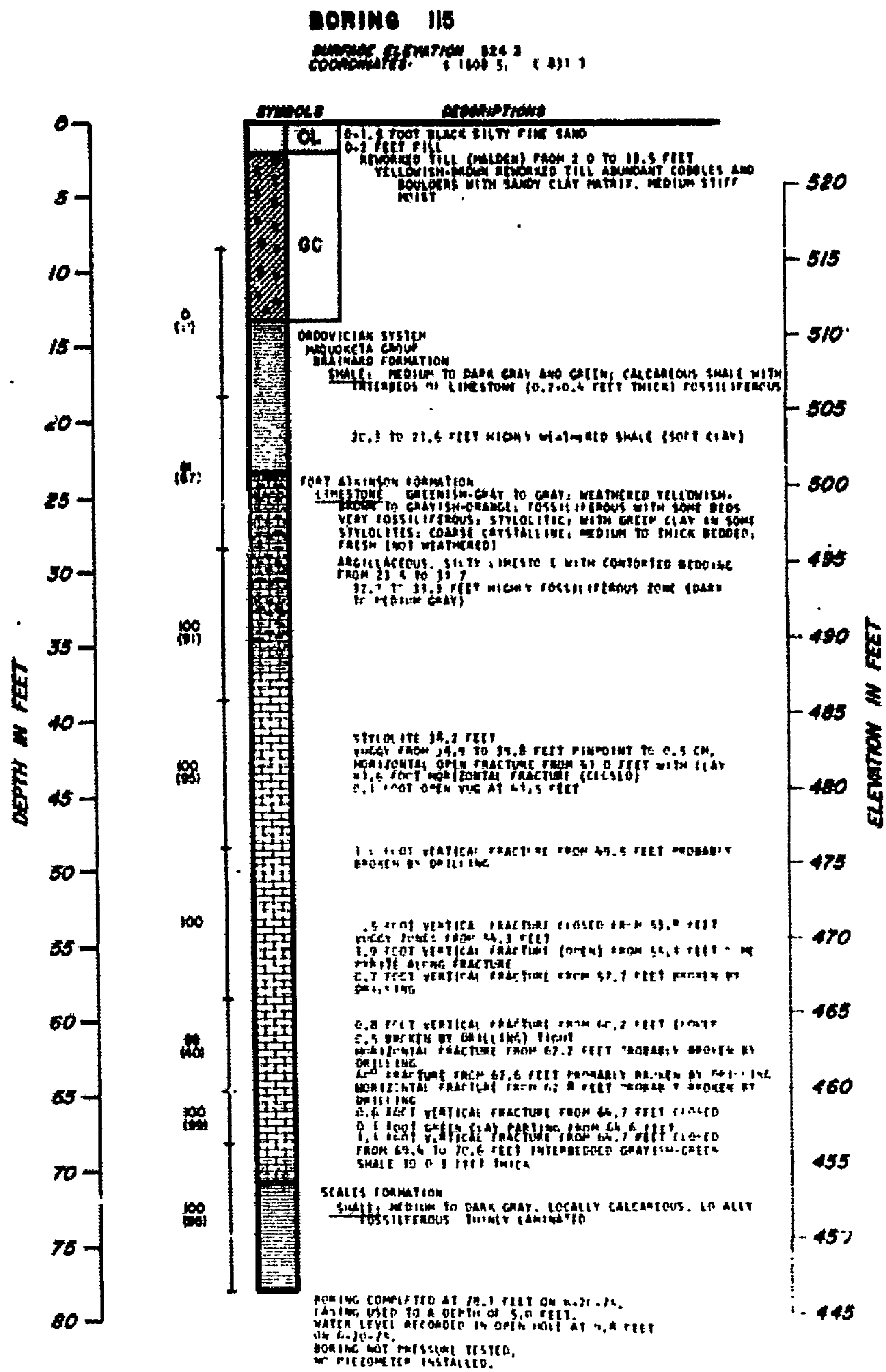
FIGURE 14



LOG OF BORINGS

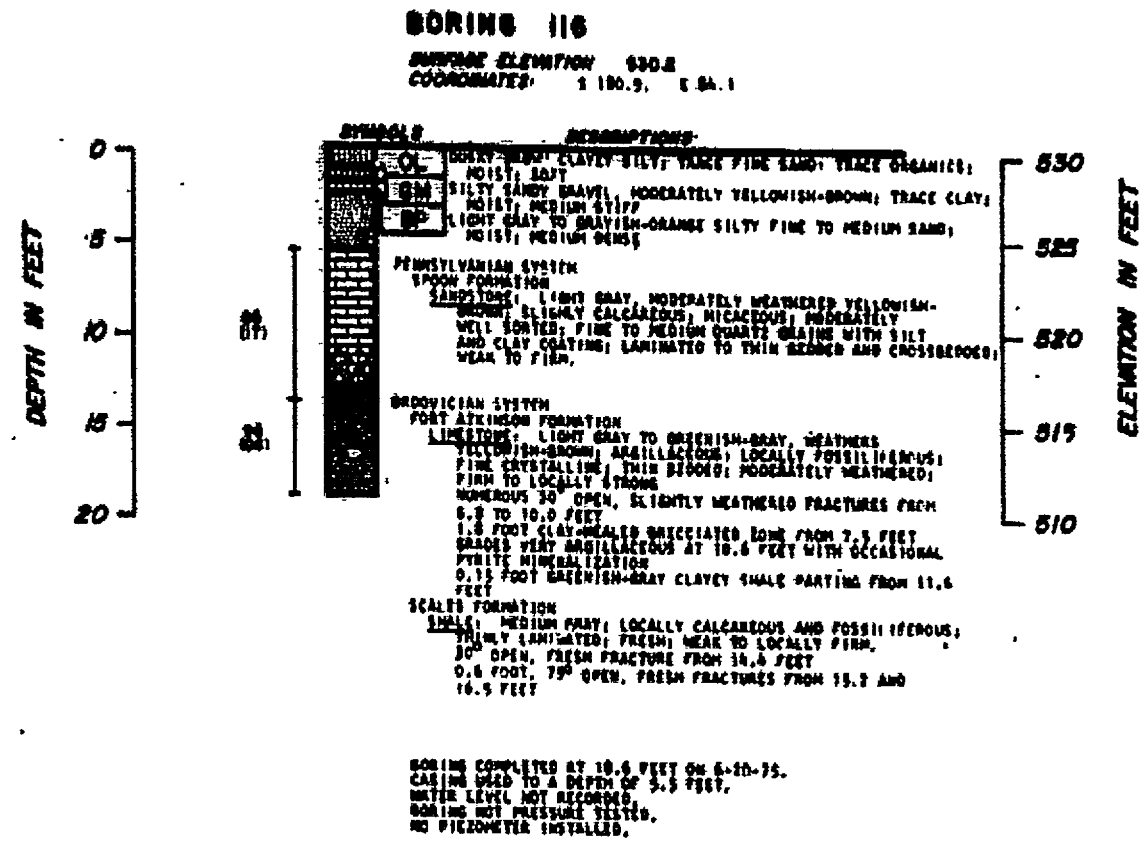


LOG OF BORINGS

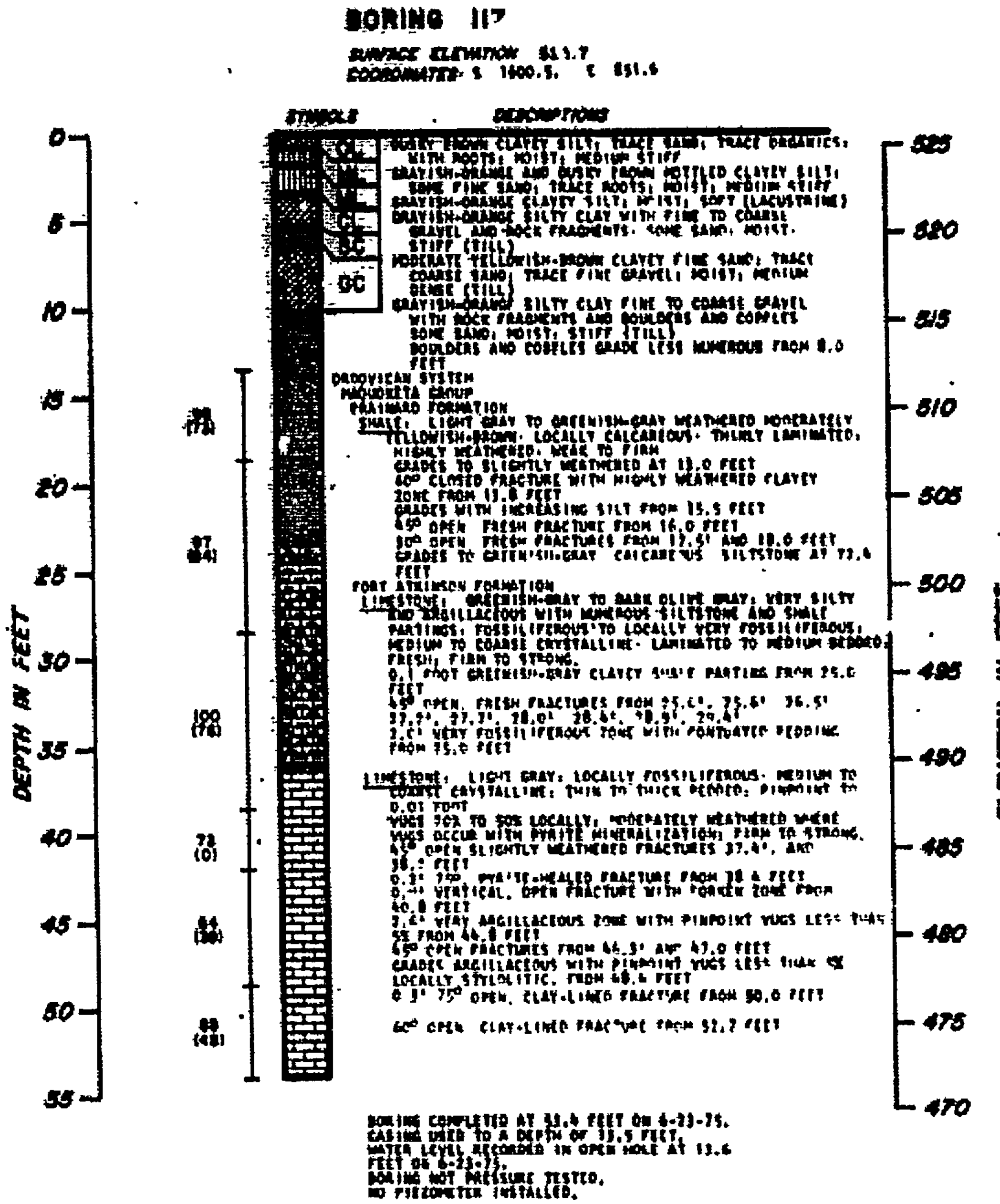


LOG OF BORINGS

FIGURE 17



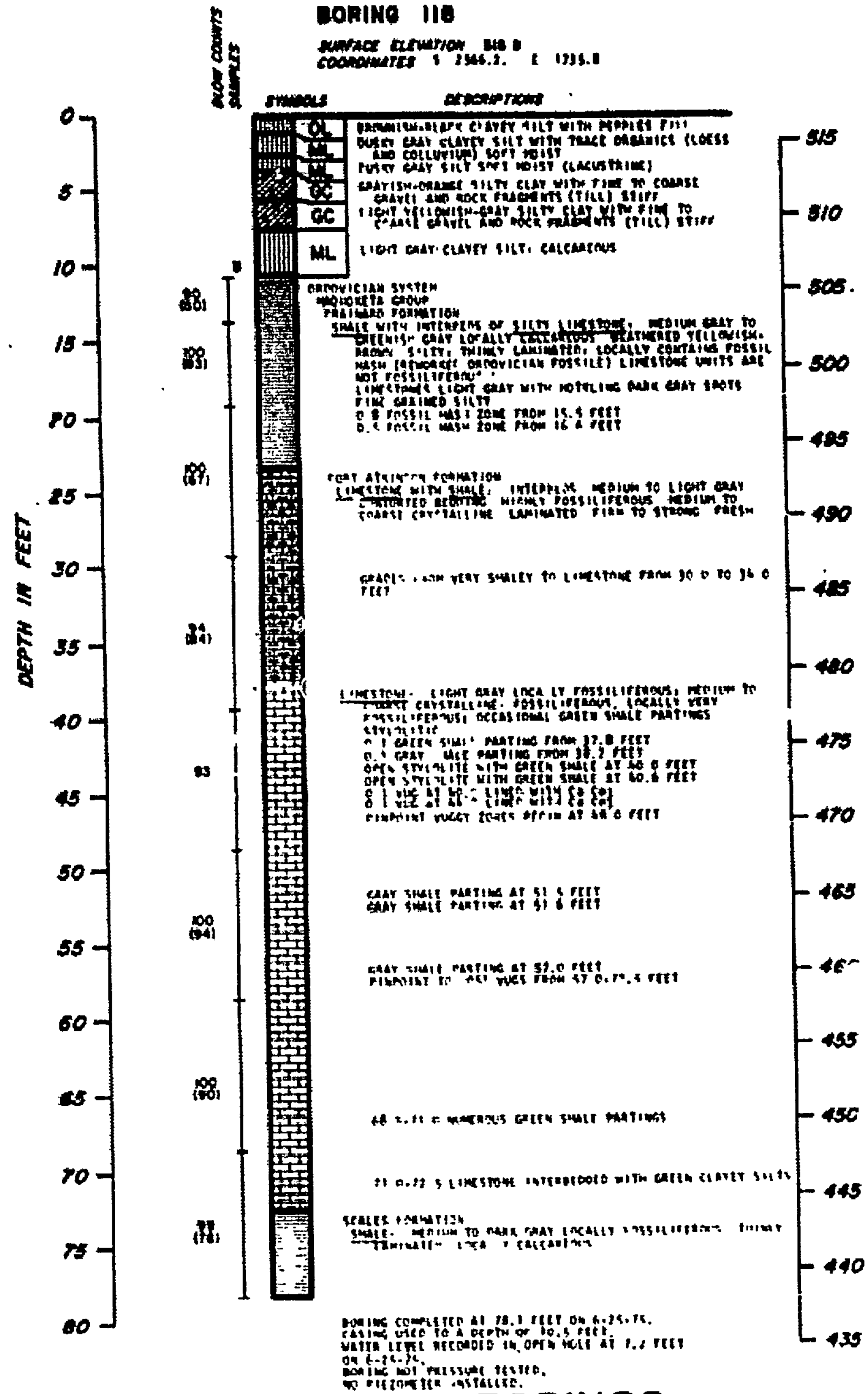
LOG OF BORINGS



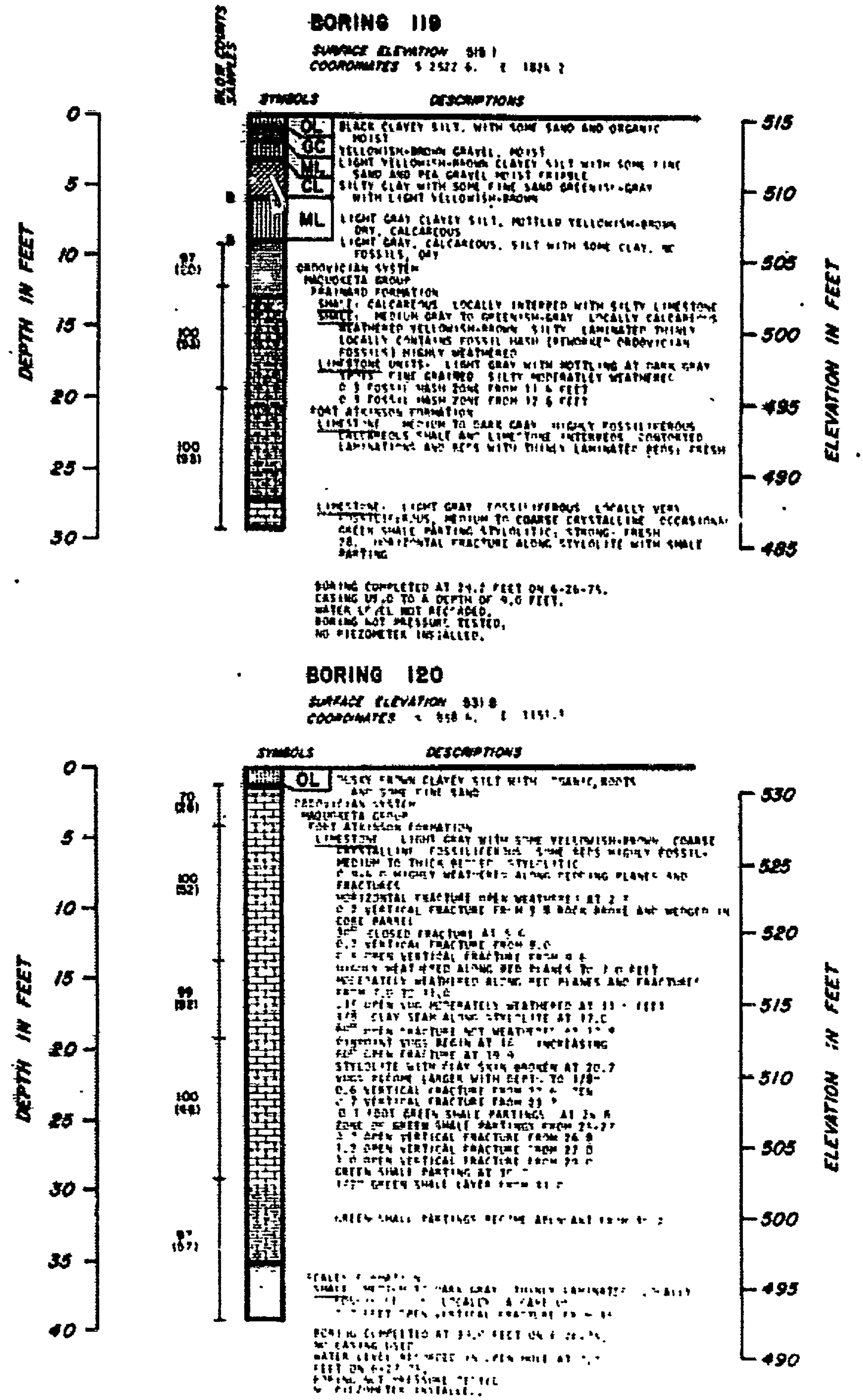
LOG OF BORINGS

DAMES & MOORE

FIGURE 19



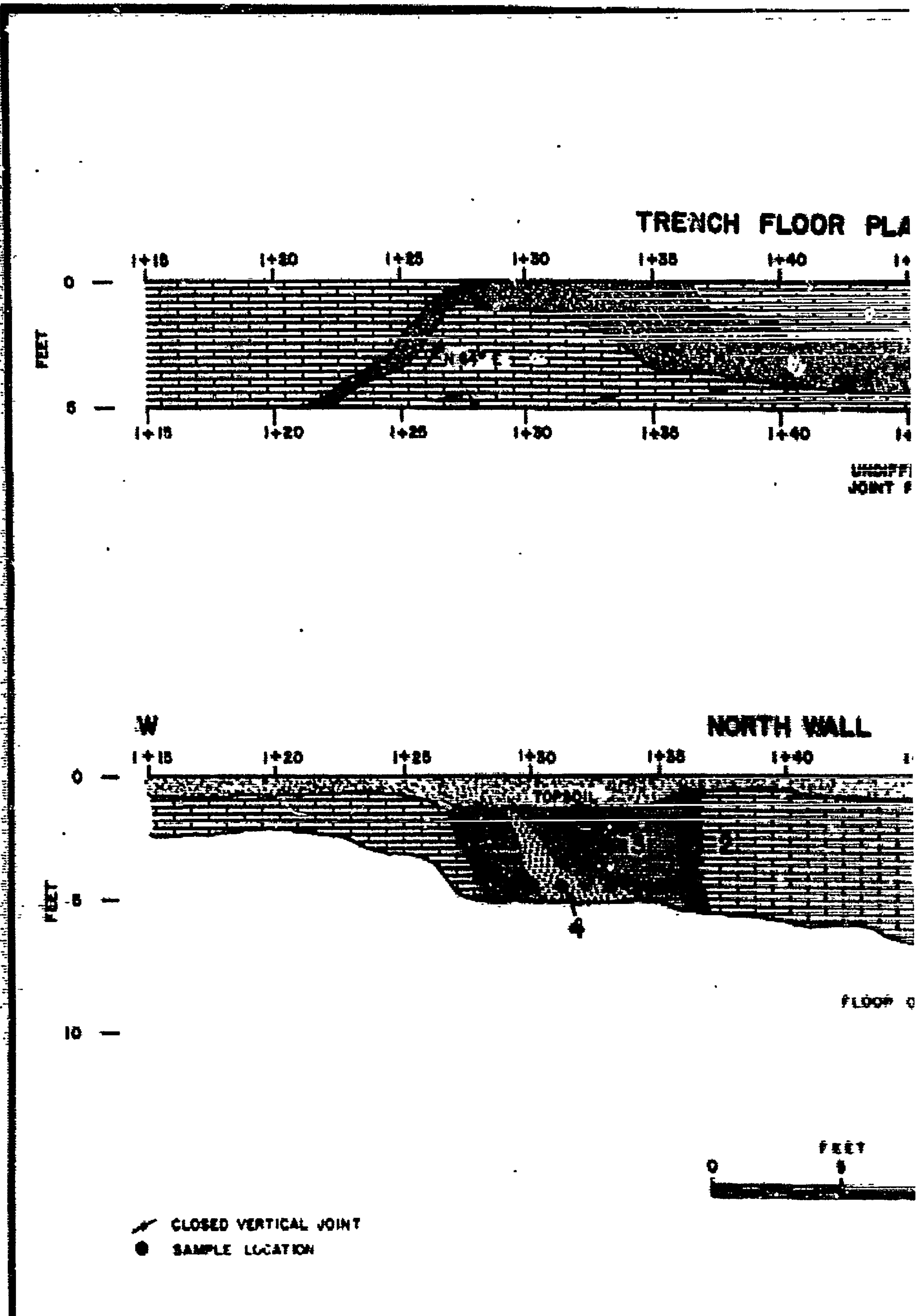
LOG OF BORINGS



LOG OF BORINGS

DAMES & MOORE

FIGURE 21



TRENCH FLOOR PLA
1+15
1+20
1+25
1+30
1+35
1+40
FEET
0
5
NORTH WALL
W
TOPSOIL
4
10
FLOOR
FEET
CLOSED VERTICAL JOINT
SAMPLE LOCATION

Certificate of Authenticity

This is to certify that microphotographs appearing on this film were produced in the normal course of business.

General Electric Company
Nuclear Energy Division
175 Curtner Avenue
San Jose, California

Microfilm Requested By **Component No.** 810

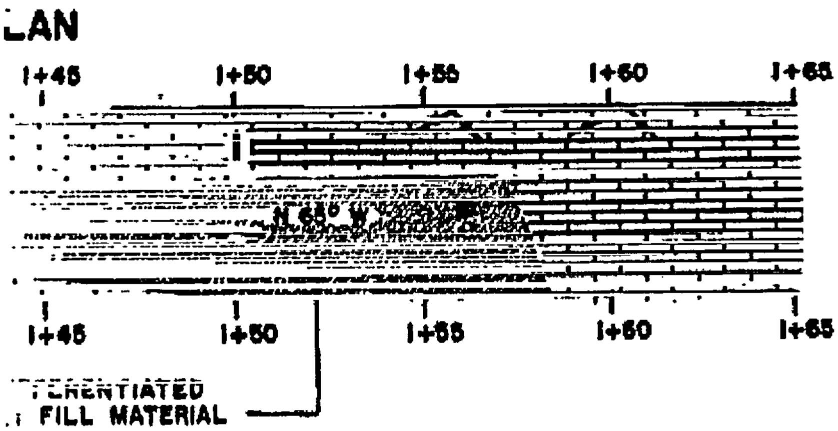
Microfilm Title REPORT-GEOLOGICAL & GROUND WATER INVESTIGATION PROPOSED FACILITY SEPTEMBER 1975 NEDO-21326 APPENDIX B.10

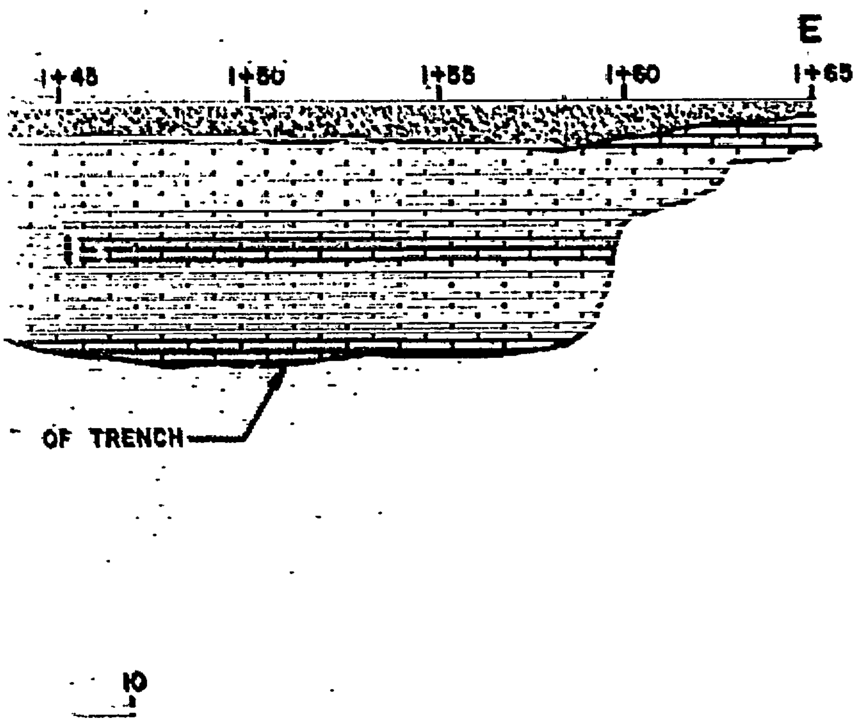
Microfilm is complete and accurate as submitted by requestor.

Camera Operator: Aguilar

Date Produced: 08 30 77

Place: San Jose, California





EXPLANATION

UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLI MEDIUM TO THICK BEDDED; WEATHERS YELLOWISH-BRO MODERATELY WEATHERED ALONG BEDDING PLANES, FRA AND JOINTS; SOME BEDS VERY FOSSILIFEROUS; SECO CALCITE DEPOSITED ALONG BEDDING PLANES AND JOINTS. TWO FILLED, SOLUTION WIDENED JOINTS INTERSECT AT 1+28.

UNIT 2 - SILTY CLAY "JOINT FILL": LIGHT GREENISH CLAY WITH SOME SILT; WAVY LAMINATIONS PARALLEL TO SOLUTIONED BEDROCK SURFACE; SOME INCLUSIONS OF EXTREMELY WEATHERED LIMESTONE FRAGMENTS. G BOUNDARY WITH UNIT 3.

UNIT 3 - CLAYEY SILT AND SILTSTONE "JOINT FILL": GREENISH-GRAY; SILT WITH SOME CLAY AND FINE SA OCCASIONALLY LAMINATED; WEATHERS YELLOWISH-BRO ESPECIALLY WHERE FINE SAND CONTENT IS HIGH. C OCCASIONAL, EXTREMELY WEATHERED LIMESTONE FRAG

UNIT 4 - SAND AND SANDSTONE "JOINT FILL": LIGHT FINE TO MEDIUM SAND WITH SOME SILT AND CLAY; LAMINATED; WEATHERS YELLOWISH-BROWN TO BROWN,

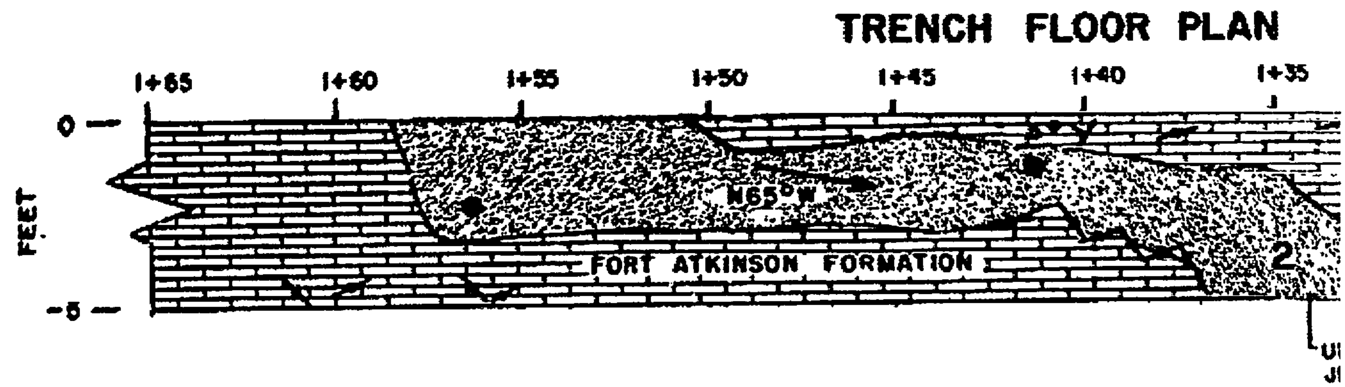
NOTE:
PHOTOGRAPHS OF T-101 INCLUDED IN APPENDIX A

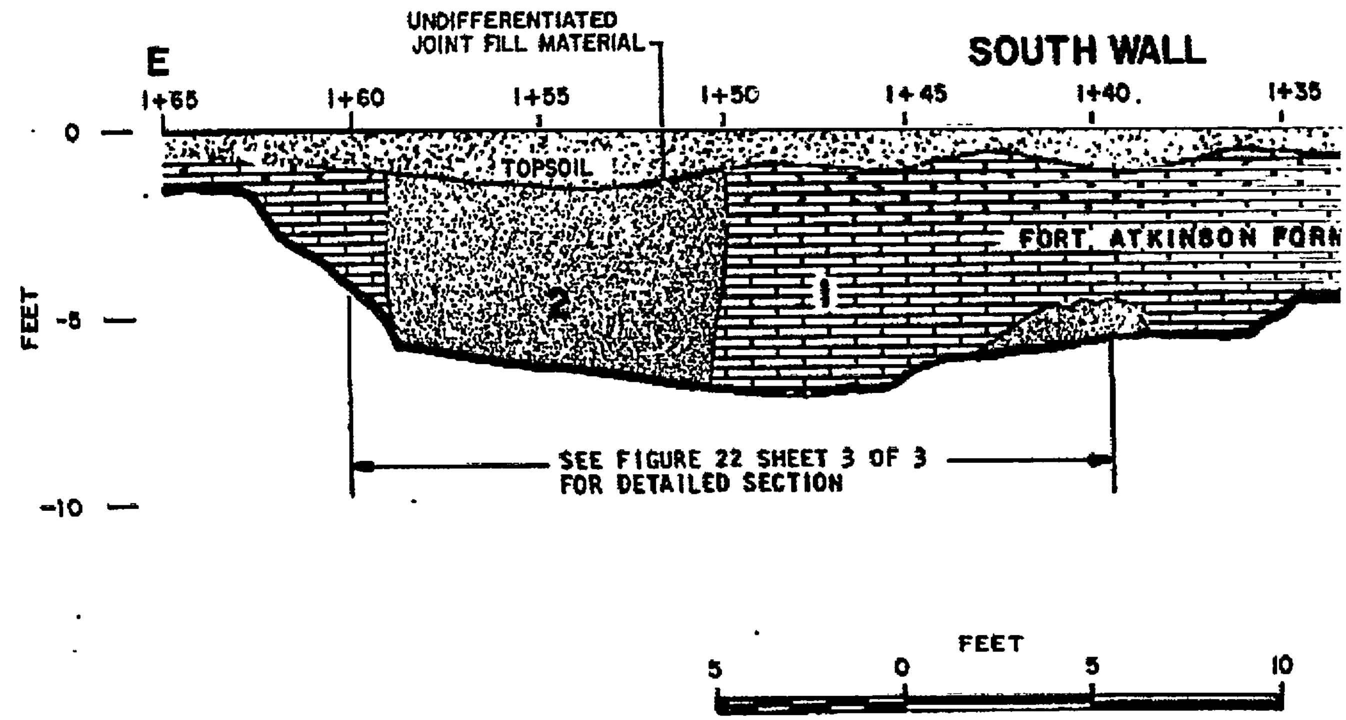
THE MAJOR JOINT VARIES IN WIDTH FROM 1.5 TO 3.5 FEET WITH AN AVERAGE WIDTH OF ABOUT 2.5 FEET

REFUSAL WAS CAUSED BY THE IRREGULAR WALLS AND THE NARROW WIDTH OF JOINT

TRENCH CROSS - SE(
NORTH WALL
T-101

FIGURE 22 SHEET 1





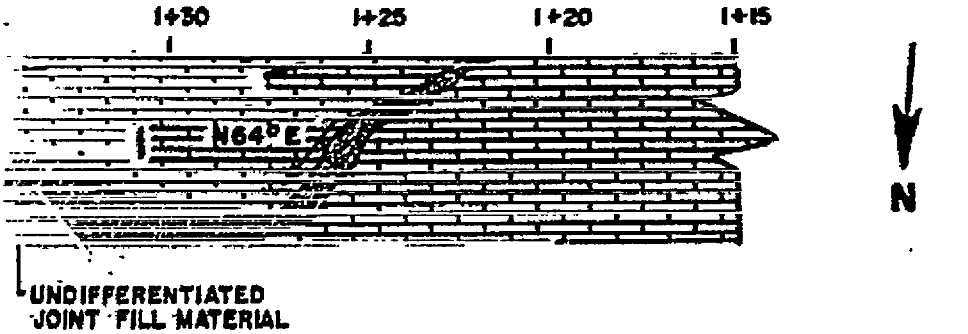
CLOSED VERTICAL JOINT

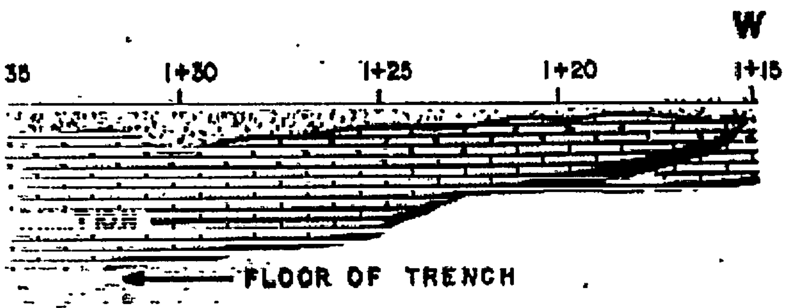
SAMPLE LOCATION

NOTE:

THE MAJOR JOINT VARIES IN WIDTH FROM 1.5 TO 3.5 FEET WITH AN AVERAGE WIDTH OF ABOUT 2.5 FEET

REFUSAL WAS CAUSED BY THE IRREGULAR WALLS AND THE NARROW WIDTH OF THE JOINT





EXPLANATION

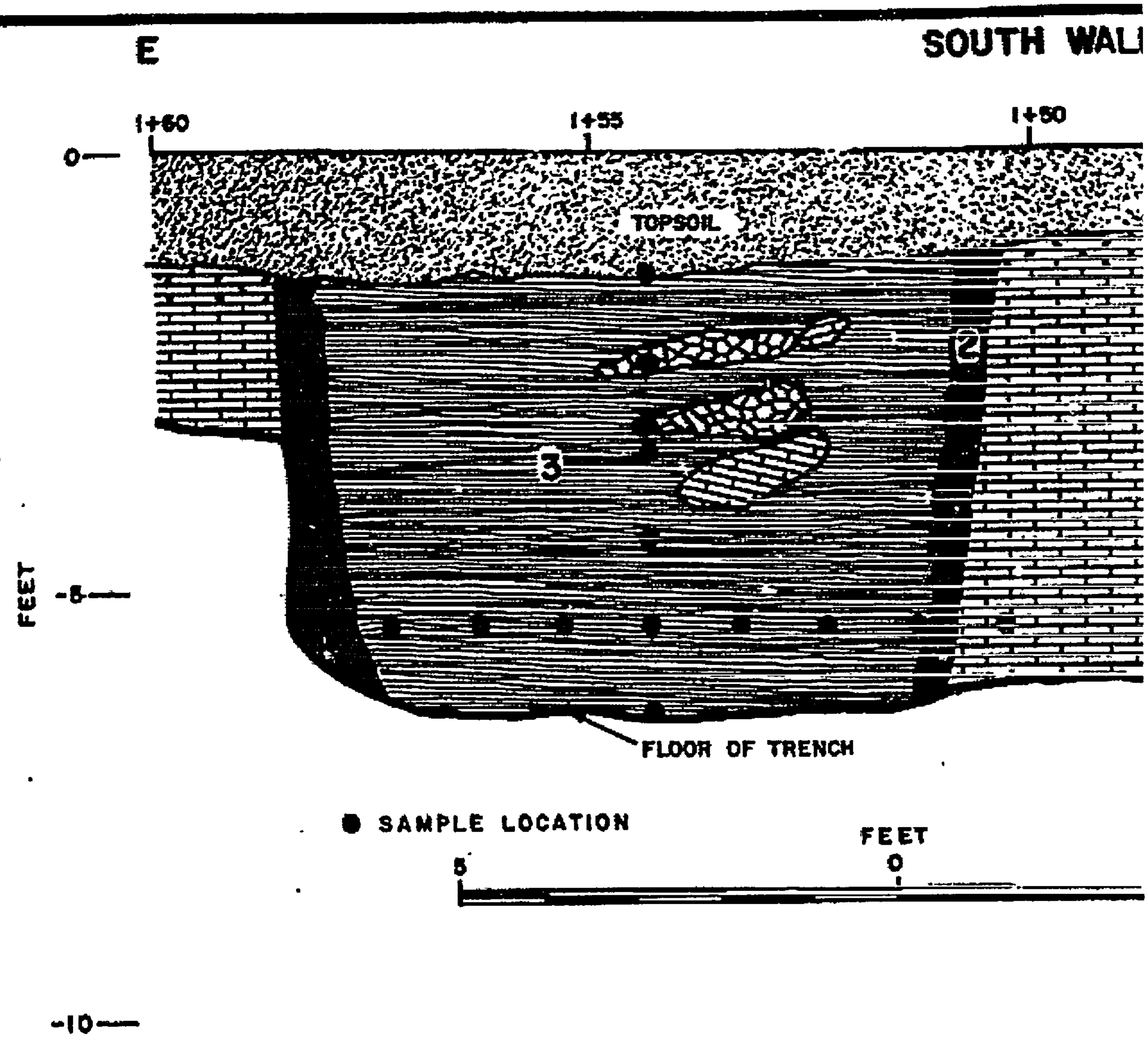
UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE; MEDIUM TO THICK BEDDED; WEATHERS YELLOWISH-BROWN, MODERATELY WEATHERED ALONG BEDDING PLANES, FRACTURES, AND JOINTS; SOME BEDS VERY FOSSILIFEROUS; SECONDARY CALCITE DEPOSITED ALONG BEDDING PLANES AND JOINTS. TWO FILLED, SOLUTION WIDENED JOINTS INTERSECT AT 1+28.

UNIT 2 - CLAYEY SILT AND SILTY CLAY "JOINT FILL": LIGHT GREENISH-GRAY; SILT, CLAY, AND SOME FINE SAND; LAMINATED; WEATHERS LIGHT YELLOWISH-BROWN; CONTAINS OCCASIONAL, EXTREMELY WEATHERED LIMESTONE FRAGMENTS.

NOTE:
1) PHOTOGRAPHS OF T-101 INCLUDED IN APPENDIX A
2) DETAILED SECTION FROM 1+40 TO 1+60 SHOWN ON FIGURE 22 SHEET 3 OF 3

TRENCH CROSS – SECT
SOUTH WALL
T-101

FIGURE 22 SHEET 2



EXPLANATION

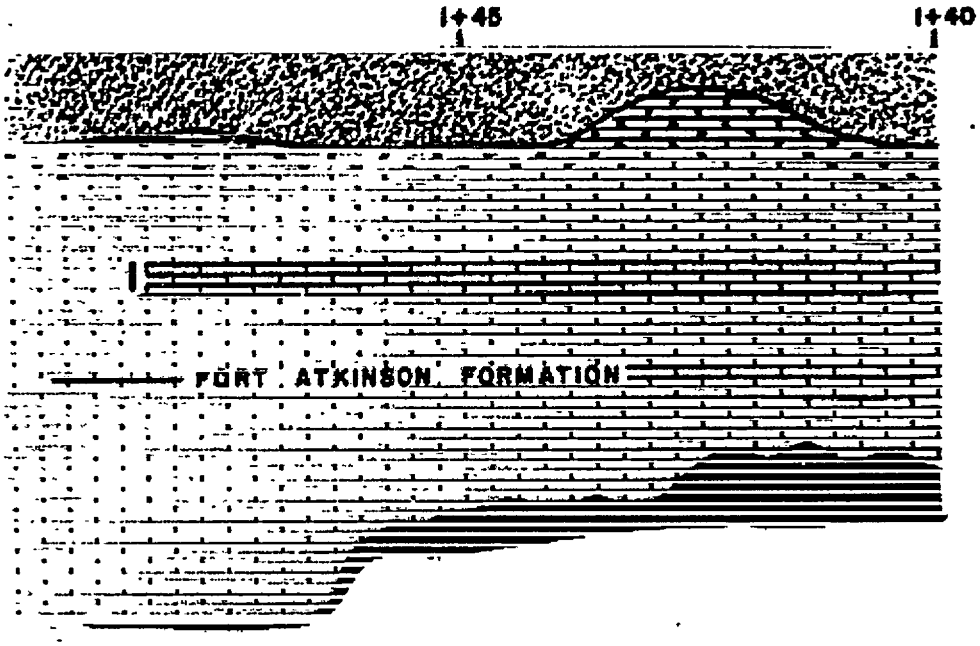
UNIT 1 - LIMESTONE; LIGHT GRAY;
MEDIUM TO THICK BEDDED; WEATH
MODERATELY WEATHERED ALONG BE
AND JOINTS; SOME BEDS VERY FO
CALCITE DEPOSITED ALONG BEDDI
JOINTS. TWO FILLED, SOLUTION
INTERSECT AT 1+28.

UNIT 2 - SILTY CLAY "JOINT FILL"
CLAY WITH SOME SILT; WAVY LAM
TO SOLUTIONED BEDROCK SURFACE
OF EXTREMELY WEATHERED LIMEST
GRADATIONAL BOUNDARY WITH UNI

UNIT 3 - CLAYEY SILT AND SILTSTO
GREENISH-GRAY; SILT WITH SOME
SAND; LAMINATED; WEATHERS YEL
ESPECIALLY WHERE FINE SAND CO
CONTAINS LARGE BLOCKS OF EXTR
LIMESTONE; YELLOWISH-BROWN RE
CLAY WITH ABUNDANT FOSSIL FRA

NOTE:
PHOTOGRAPHS OF T-101 INCLUDED

WALL W



5

GRAY; COARSE CRYSTALLINE;
WEATHERS YELLOWISH-BROWN;
[illegible] BEDDING PLANES, FRACTURES,
VERY FOSSILIEEROUS; SECONDARY
BEDDING PLANES AND
UTION WIDENED JOINTS

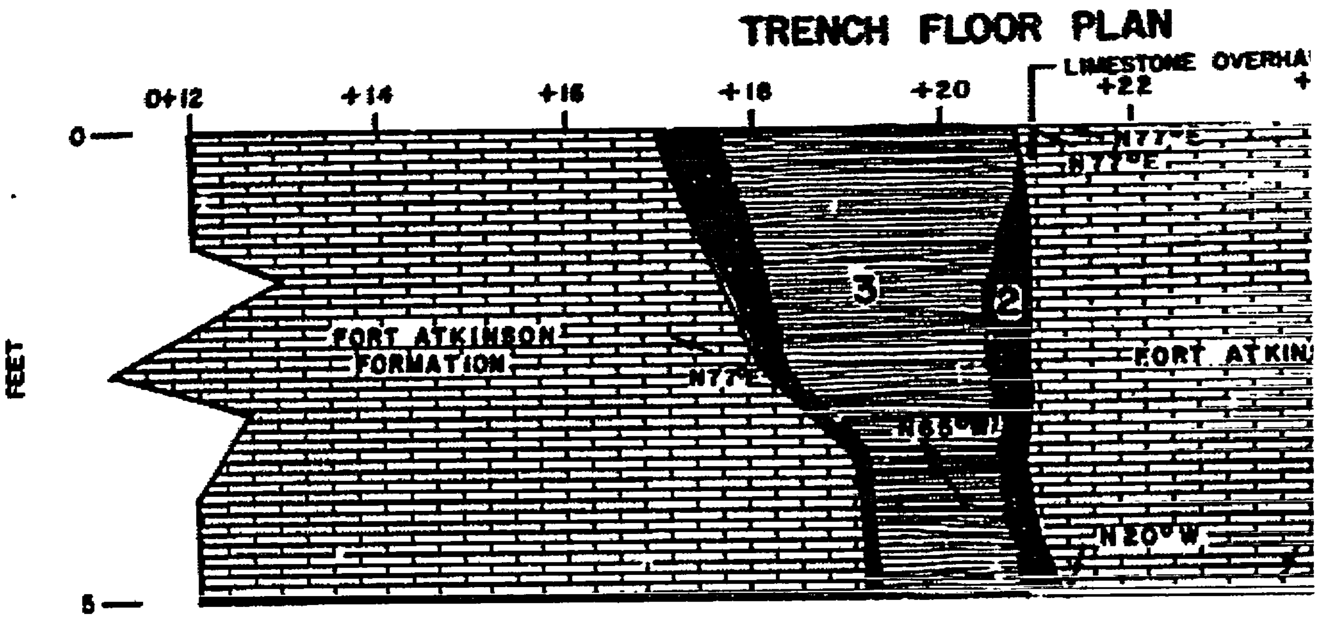
FILL"; LIGHT GREENISH-GRAY;
LAMINATIONS PARALLEL
SURFACE; SOME INCLUSIONS
LIMESTONE FRAGMENTS.
ITH UNIT 3.

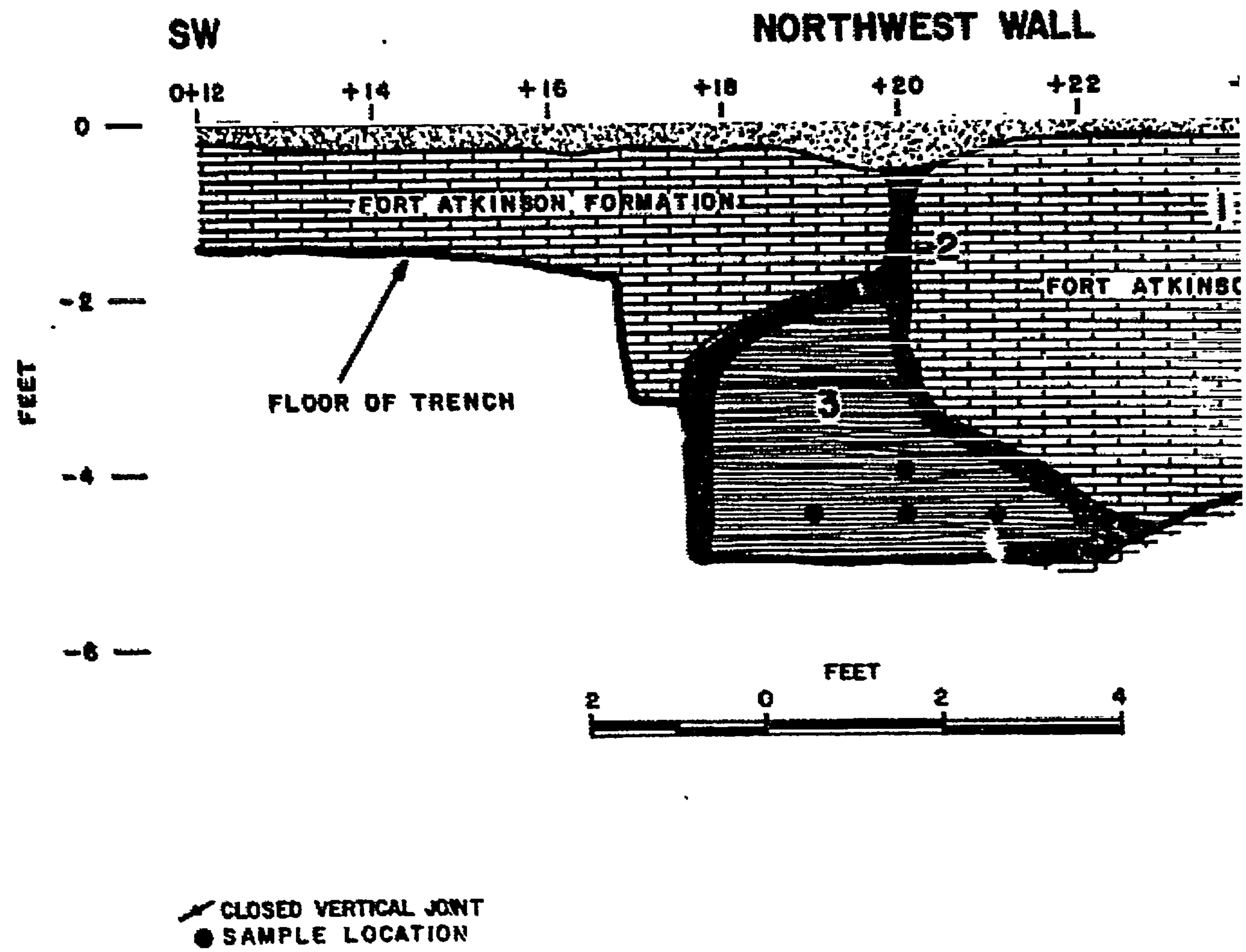
SILTSTONE "JOINT FILL"; LIGHT
IN SOME CLAY AND FINE
YELLOWISH-BROWN;
SAND CONTENT IS HIGH.
OF EXTREMELY WEATHERED
RESIDUAL OF SILT AND
SIL FRAGMENTS.

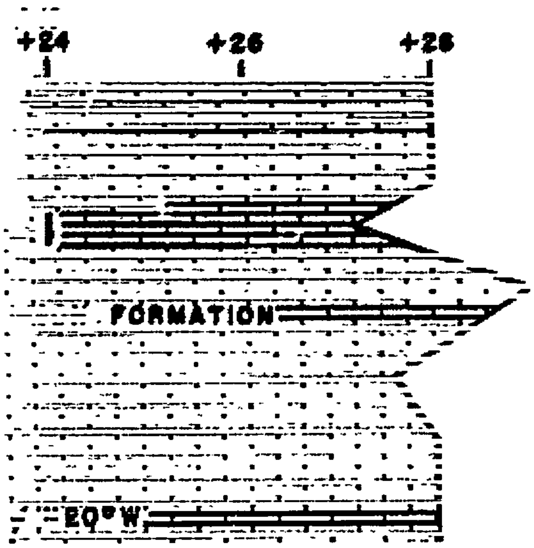
[illegible]UDED IN APPENDIX A

TRENCH CROSS-SEC
SOUTH WALL - DE
T-101

FIGURE 22 SHEET


TRENCH FLOOR PLAN
LIMESTONE OVERHA
0+12
+14
+16
+18
+20
+22
0
5
FEET
FORT ATKINSON FORMATION
FORT ATKIN
3
2
N77°E
N77°E
N77°E
N65°W
N20°W


SW
NORTHWEST WALL
0+12
+14
+16
+18
+20
+22
0
-2
-4
-6
FEET
FORT ATKINSON FORMATION
FORT ATKINS
FLOOR OF TRENCH
2
3
1
FEET
2
0
2
4
CLOSED VERTICAL JOINT
SAMPLE LOCATION



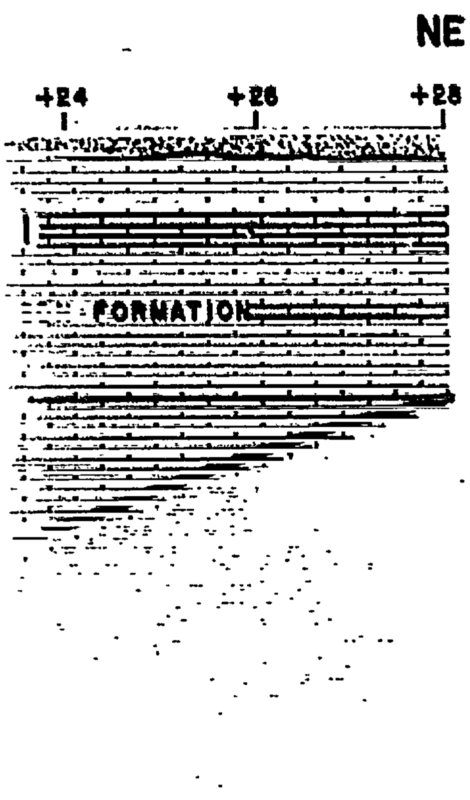
EXPLANATION

UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE; MEDIUM TO THICK BEDDED; WEATHERS YELLOWISH-BROWN; MODERATELY WEATHERED ALONG BEDDING PLANES, FRACTURES, AND JOINTS. SOLUTION WIDENED JOINT IS 3 TO 4 FEET WIDE AT BASE AND NARROWS AT THE TOP, MAY REPRESENT FILLED CAVE.

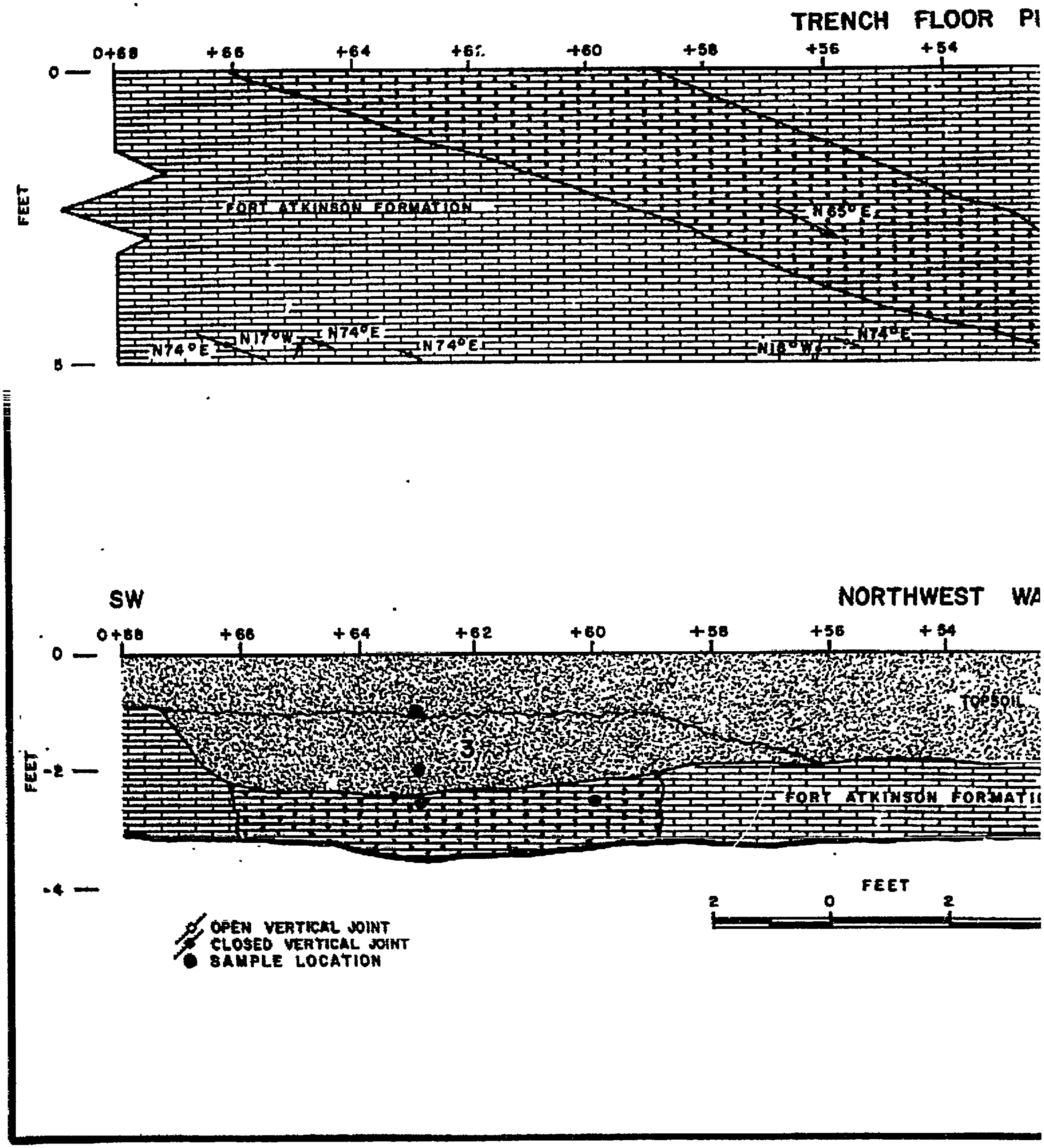
UNIT 2 - SILTY CLAY "JOINT FILL": GREENISH-GRAY; SILTY CLAY WITH EXTREMELY WEATHERED LIMESTONE FRAGMENTS; LAMINATED, WITH LAMINATIONS PARALLEL TO SOLUTIONED BEDROCK SURFACE; SOME ZONES SLIGHTLY WEATHERED YELLOWISH-BROWN. GRADES UPWARD FROM 1.5 FOOT DEPTH WITH SOIL, BECOMES MORE SILTY WITH SOME FINE SAND.

UNIT 3 - SILT AND FINE SAND "JOINT FILL": GRAY TO GREENISH-GRAY; SILT AND FINE SAND WITH TRACE OF CLAY ALONG DESSICATION FRACTURES; LAMINATED WITH SOME THIN BEDS OF FINE GRAINED SANDSTONE; WEATHERS TO YELLOWISH-BROWN, ESPECIALLY WHERE COARSER TEXTURE.

NOTE:
PHOTOGRAPH OF NORTHWEST WALL INCLUDED IN APPENDIX

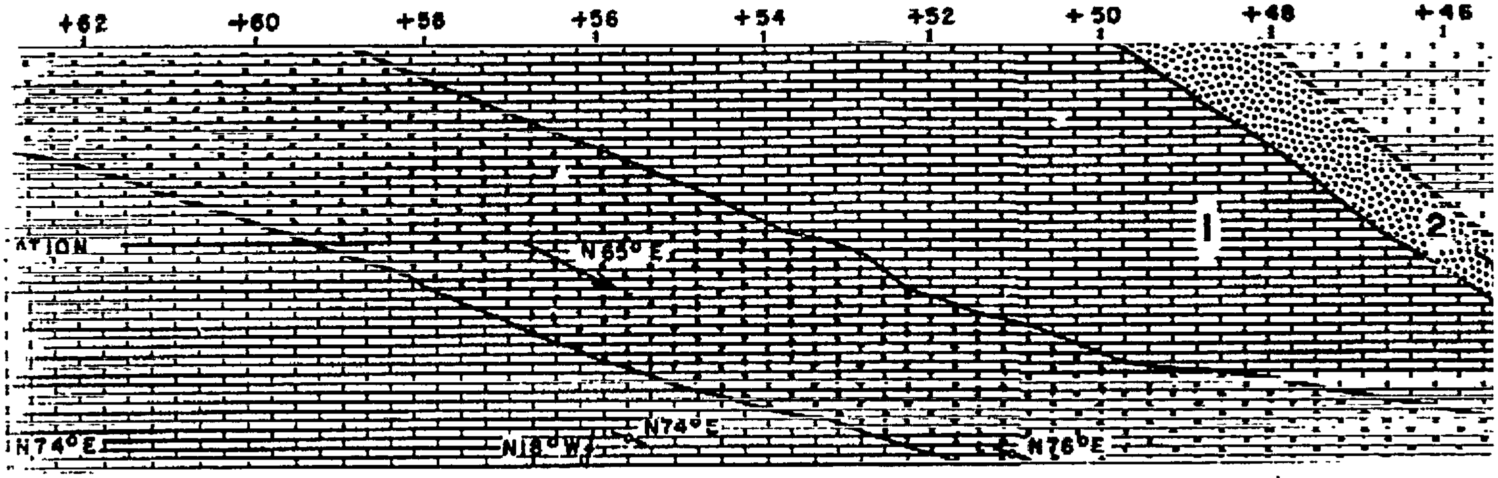


TRENCH CROSS-SEC1
T-102

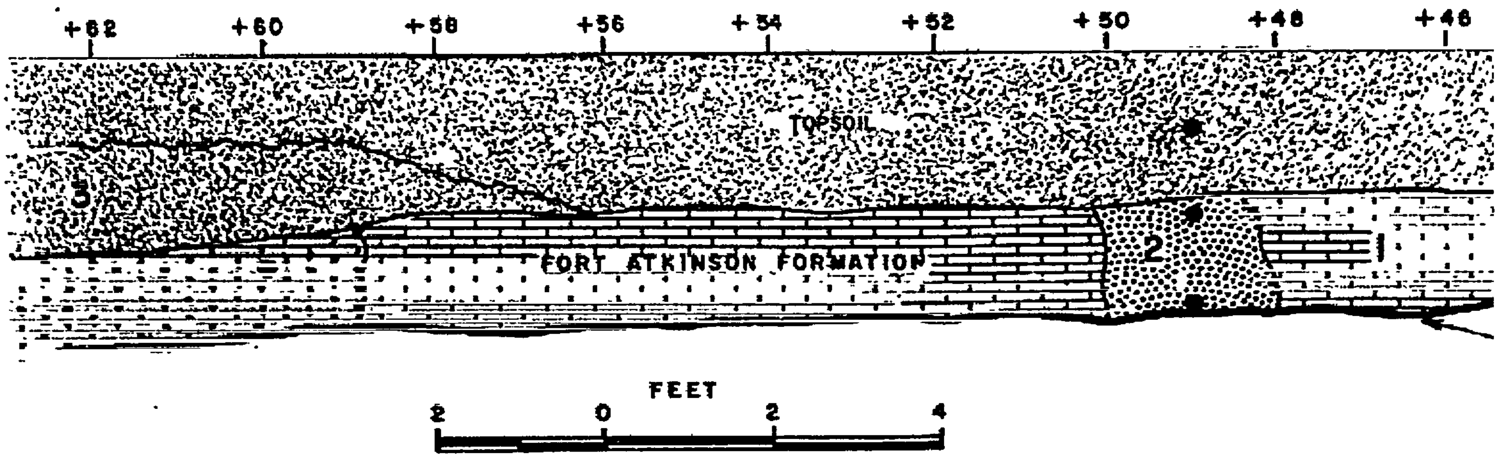


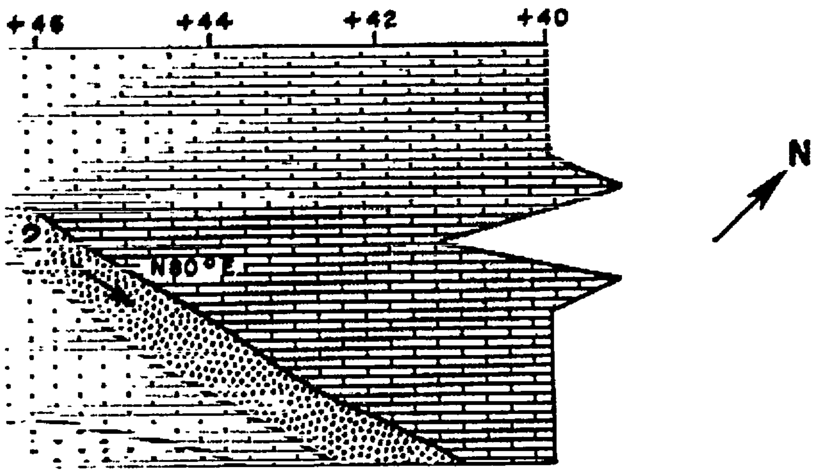
TRENCH FLOOR PI
0+68
+66
+64
+62
+60
+58
+56
+54
0
5
FEET
FORT ATKINSON FORMATION
N65°E
N74°E
N17°W
N74°E
N74°E
N18°W
N74°E
SW
NORTHWEST WA
0+68
+66
+64
+62
+60
+58
+56
+54
0
-2
-4
FEET
3
TOPSOIL
FORT ATKINSON FORMATI
FEET
2
0
2
OPEN VERTICAL JOINT
CLOSED VERTICAL JOINT
SAMPLE LOCATION

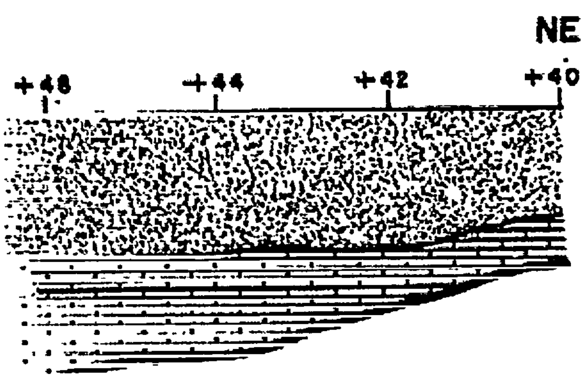
TRENCH FLOOR PLAN



NORTHWEST WALL







EXPLANATION

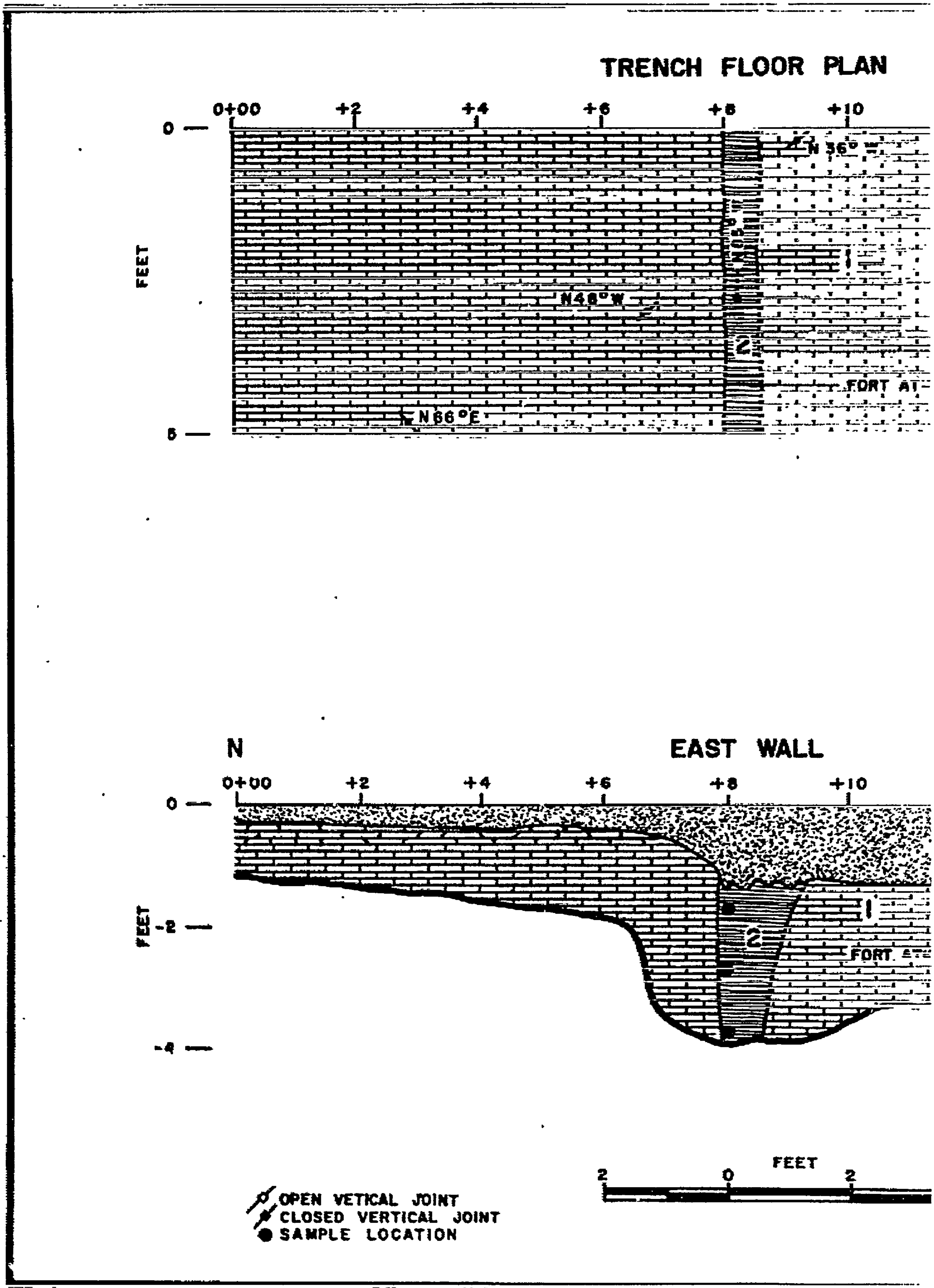
UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE, MEDIUM BEDDED; WEATHERS YELLOWISH-BROWN; BETWEEN +44 AND +66 WEATHERS BRIGHT REDDISH-BROWN TO DARK RED, ASSOCIATED WITH HIGHLY MINERALIZED ZONE TRENDING N65°E. ZONE ABOUT 2 FEET WIDE WITH MANY JOINTS, EXTREMELY WEATHERED, PYRITE WEATHERD TO IRON OXIDES, SOME WEATHERI CRYSTALLINE PYRITE PRESERVED IN FRESHER ROCK. NO APPARENT OFF-SET ACROSS ZONE.

UNIT 2 - SAND "JOINT FILL": GREENISH-GRAY; FINE TO MEDIUM GRAINED WITH TRACE OF SILT; LAMINATED WITH SOME SEMI-LITHIFIED BEDS; WEATHERS YELLOWISH-BROWN, ESPECIALLY WHERE COARSER TEXTURED.

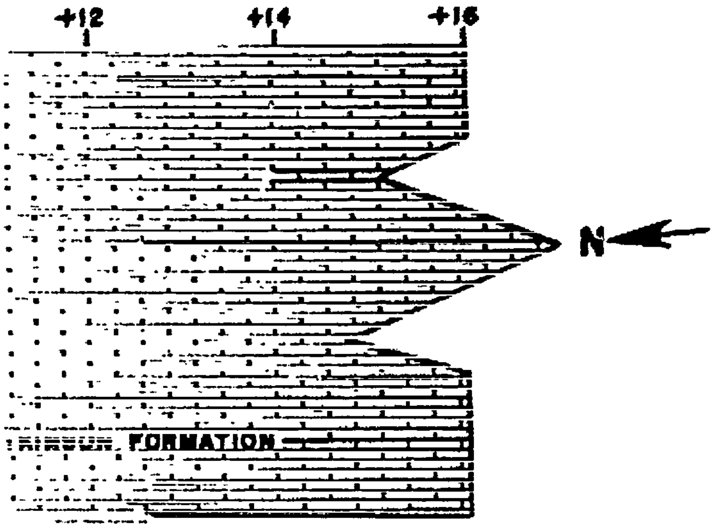
UNIT 3 - SOIL: BRIGHT YELLOWISH-BROWN AND REDDISH-BROWN; FINE SANDY SILT WITH SOME WEATHERED LIMESTONE FRAGMENTS; DERIVED FROM MINERALIZED ZONE BELOW ("C" HORIZON).

TRENCH CROSS-SEC
T-104

FIGURE 2



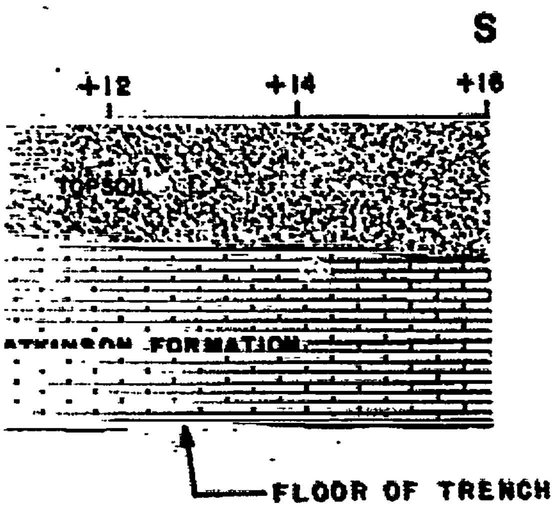
TRENCH FLOOR PLAN
0+00
+2
+4
+6
+8
+10
0
5
FEET
N 36° W
N 05° W
N48°W
N 66° E
1
2
FORT AT
N
EAST WALL
0+00
+2
+4
+6
+8
+10
0
-2
-4
FEET
1
2
FORT
FEET
2
0
2
OPEN VETICAL JOINT
CLOSED VERTICAL JOINT
SAMPLE LOCATION



EXPLANATION

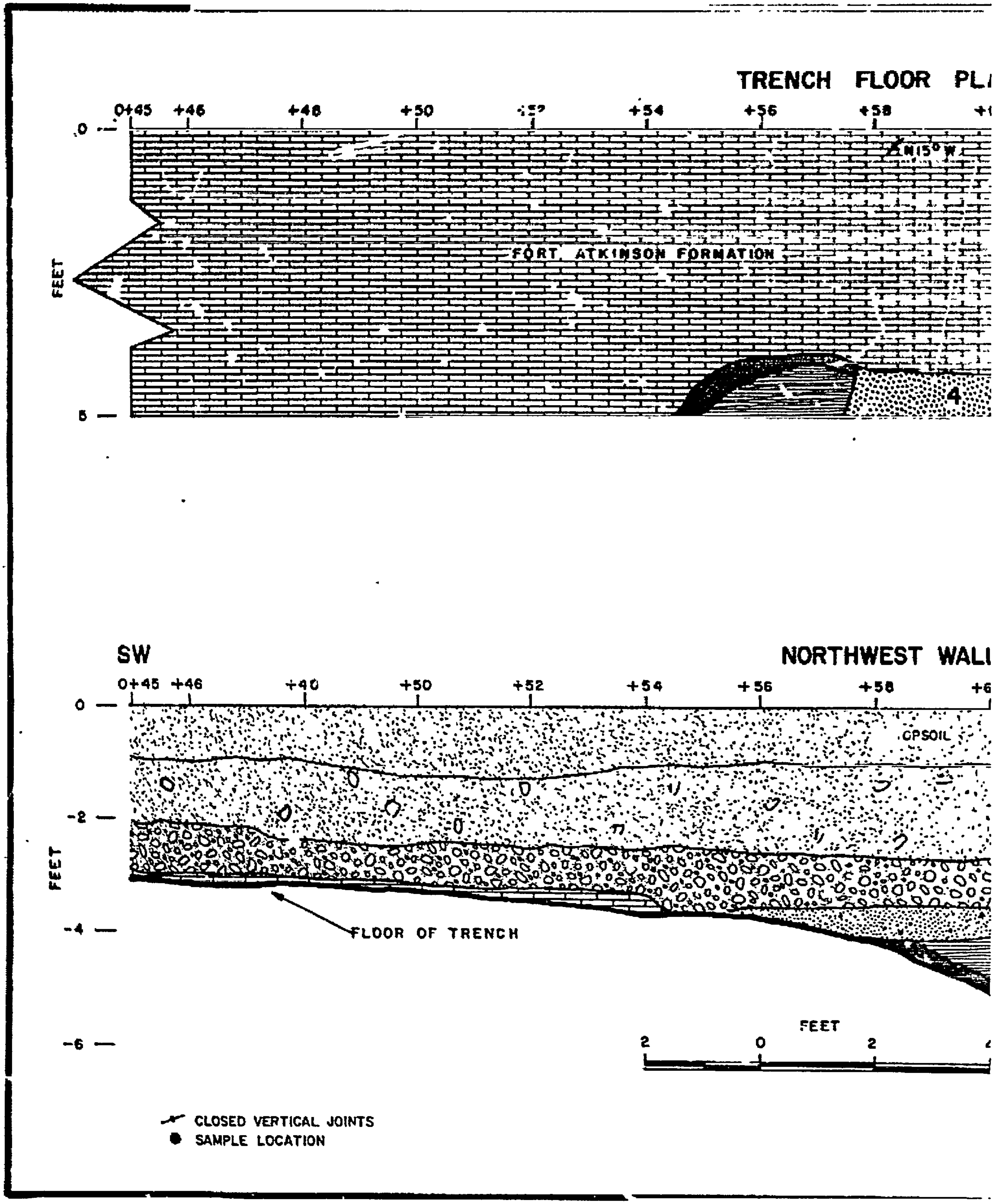
UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE; MEDIUM TO THICK BEDDED; WEATHERS YELLOWISH-BROWN; MODERATELY WEATHERED ALONG BEDDING PLANES, JOINTS, AND FRACTURES; SOLUTION WIDENED JOINT AT +8, NO EVIDENCE OF SEVERE SOLUTION ACTIVITY SINCE FILL MATERIAL DEPOSITED.

UNIT 2 - SILTSTONE: LIGHT GREENISH-GRAY; SILT WITH SOME CLAYEY SILT AND FINE SAND; LAMINATED; WEATHERS MODERATE YELLOWISH-BROWN, SLIGHTLY WEATHERED WHERE FINE SAND CONTENT IS HIGHER. GRADES FROM FINER GRAINED NEAR LIMESTONE INTERFACE TO COARSER GRAINED IN CENTER OF JOINT. SILTSTONE POORLY INDURATED.



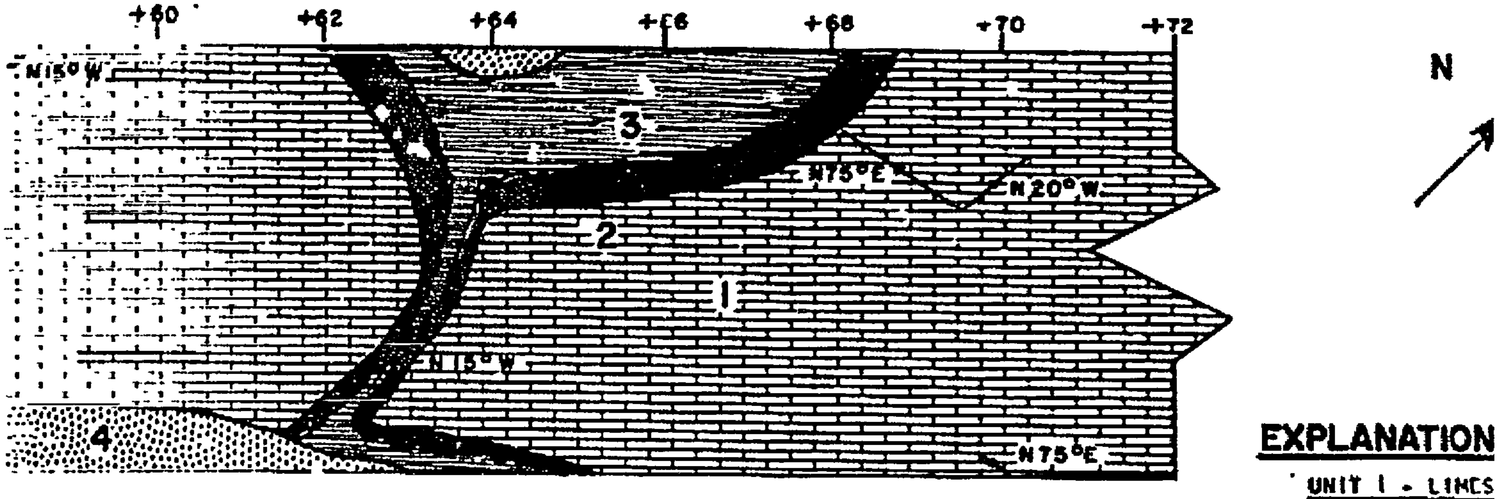
TRENCH CROSS-SECT
T-105

FIGURE 2

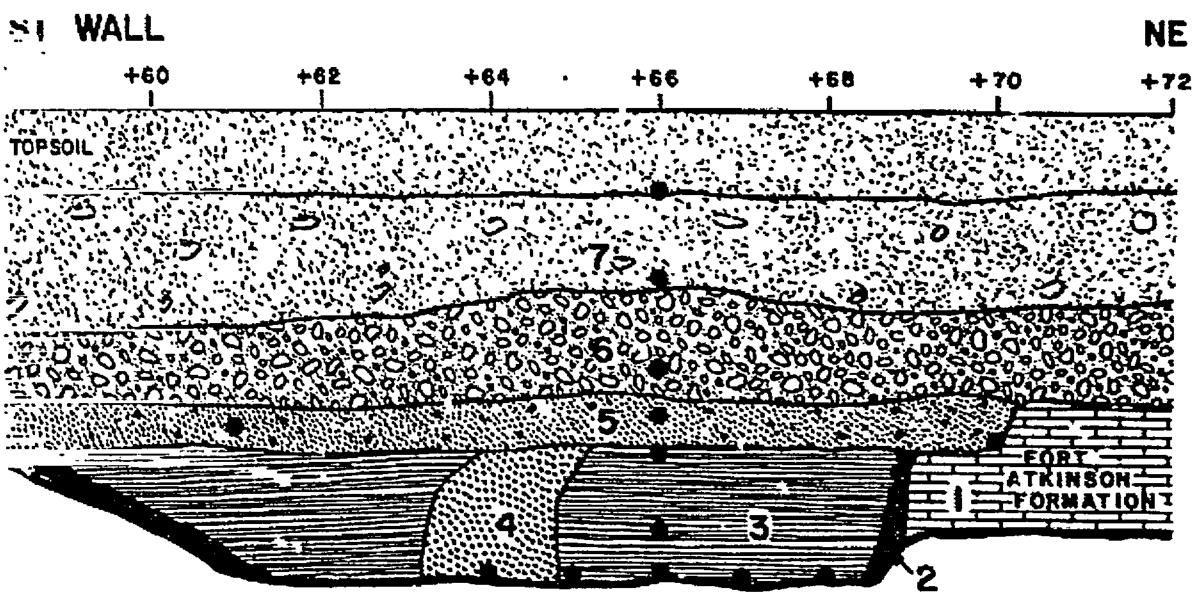


TRENCH FLOOR PL
0+45 +46 +48 +50 +52 +54 +56 +58
0
5
FEET
N15°W
FORT ATKINSON FORMATION
4
SW
NORTHWEST WAL
0+45 +46 +40 +50 +52 +54 +56 +58 +6
0
-2
-4
-6
FEET
CPSOIL
FLOOR OF TRENCH
FEET
2 0 2
CLOSED VERTICAL JOINTS
SAMPLE LOCATION

ɔR PLAN



ST WALL



4

EXPLANATION

UNIT 1 - LIMES
THICK BEDDE
ALONG BEDDI
WIDENED JOI
SANDSTONE.

UNIT 2 - SILTY
CLAY; OCCAS
LIMESTONE F
SILTY CLAY
UNIT 3.

UNIT 3 - CLAYE
SILTS; LAMI
GRADATIONAL

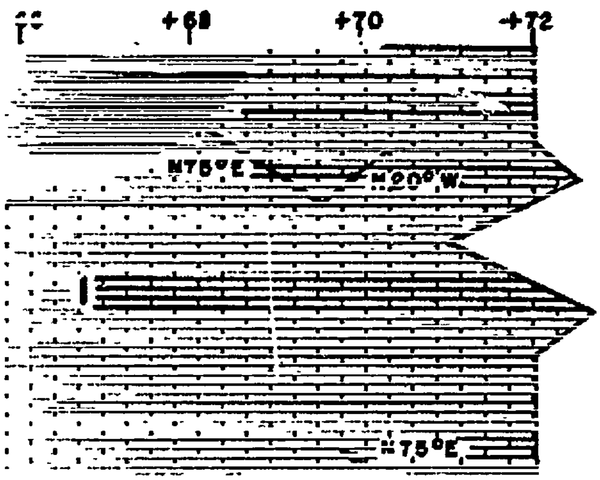
UNIT 4 - SANDS
COARSE GRAI
SOME CROSS-
OF SILT; WE
PENNSYLVANI

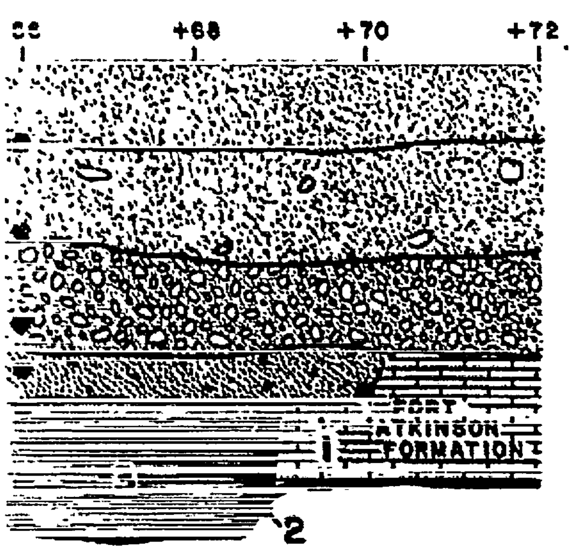
UNIT 5 - GRAVE
FINE TO MED
CONSISTS OF
MATERIALS.

UNIT 6 - TILL:
SAND, SILT
MAY BE REWO

UNIT 7 - LOESS
FINE SANDS

NOTE:
PHOTOGRAPHS





EXPLANATION

UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE, MEDIUM TO THICK BEDDED; WEATHERS YELLOWISH-BROWN; MODERATELY WEATHERED ALONG BEDDING PLANES, JOINTS AND FRACTURES; FOSSILIFEROUS; S WIDENED JOINT WITH FILL AND PENNSYLVANIAN CUT-AND-FILL SANDSTONE.

UNIT 2 - SILTY CLAY "JOINT FILL": GREENISH-GRAY; SILTY CLAY; OCCASIONALLY CONTAINS INCLUSIONS OF EXTREMELY WEATHERE LIMESTONE FRAGMENTS; WEATHERS YELLOWISH-BROWN. SOME SILTY CLAY ALONG LIMESTONE BEDDING PLANES. GRADES TO UNIT 3.

UNIT 3 - CLAYEY SILT "JOINT FILL": GREENISH-GRAY; CLAYEY SILTS; LAMINATED; WEATHERS YELLOWISH-BROWN; GRADATIONAL WITH UNIT 2.

UNIT 4 - SANDSTONE: LIGHT GRAY; MEDIUM AND COARSE GRAINED SAND WITH SOME FINE SAND; SOME CROSS-BEDDING; OCCASIONAL LAMINATIONS OF SILT; WEATHERS TO DARK YELLOW BROWN. PENNSYLVANIAN CUT-AND-FILL SANDSTONE.

UNIT 5 - GRAVEL: DARK BROWN; POORLY SORTED GRAVEL WITH FINE TO MEDIUM SAND AND SILT MATRIX; CALCAREOUS; CONSISTS OF LOCALLY DERIVED AND GLACIAL ERRACTIC MATERIALS.

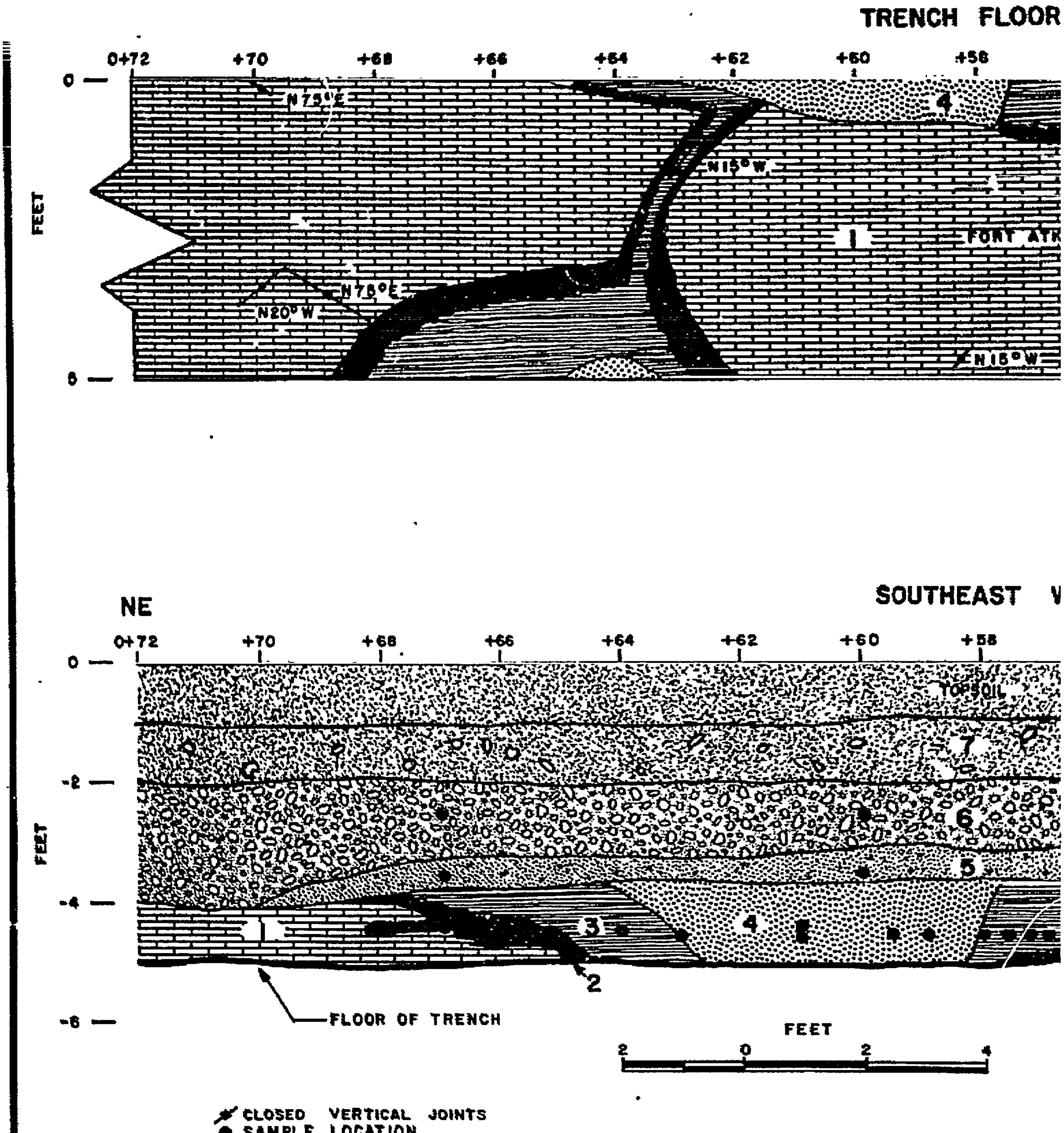
UNIT 6 - TILL: DARK BROWN; UNSORTED CLAY, FINE TO MEDIUM SAND, SILT AND SOME COBBLES AND BOULDERS; CALCAREOUS; MAY BE REWORKED.

UNIT 7 - LOESS-COLLUVIUM: LIGHT BROWN; SILTS AND FINE SANDS WITH OCCASIONAL COBBLES.

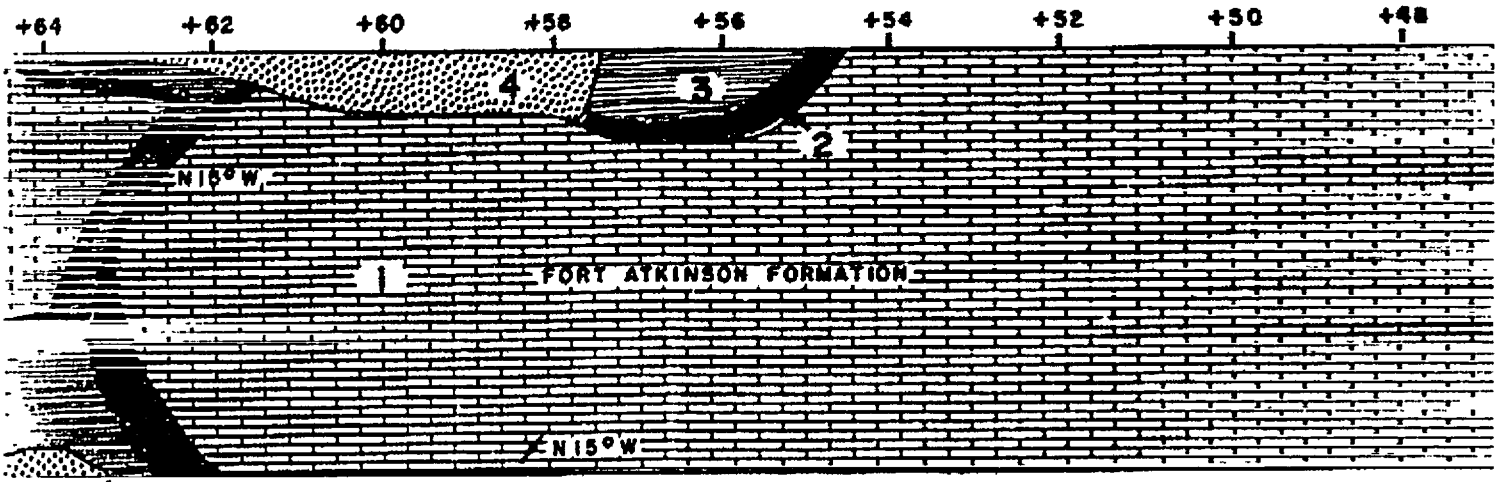
NOTE:
PHOTOGRAPHS OF SOUTHEAST WALL INCLUDED IN APPENDIX A

TRENCH CROSS - SI
NORTHWEST WA
T-106

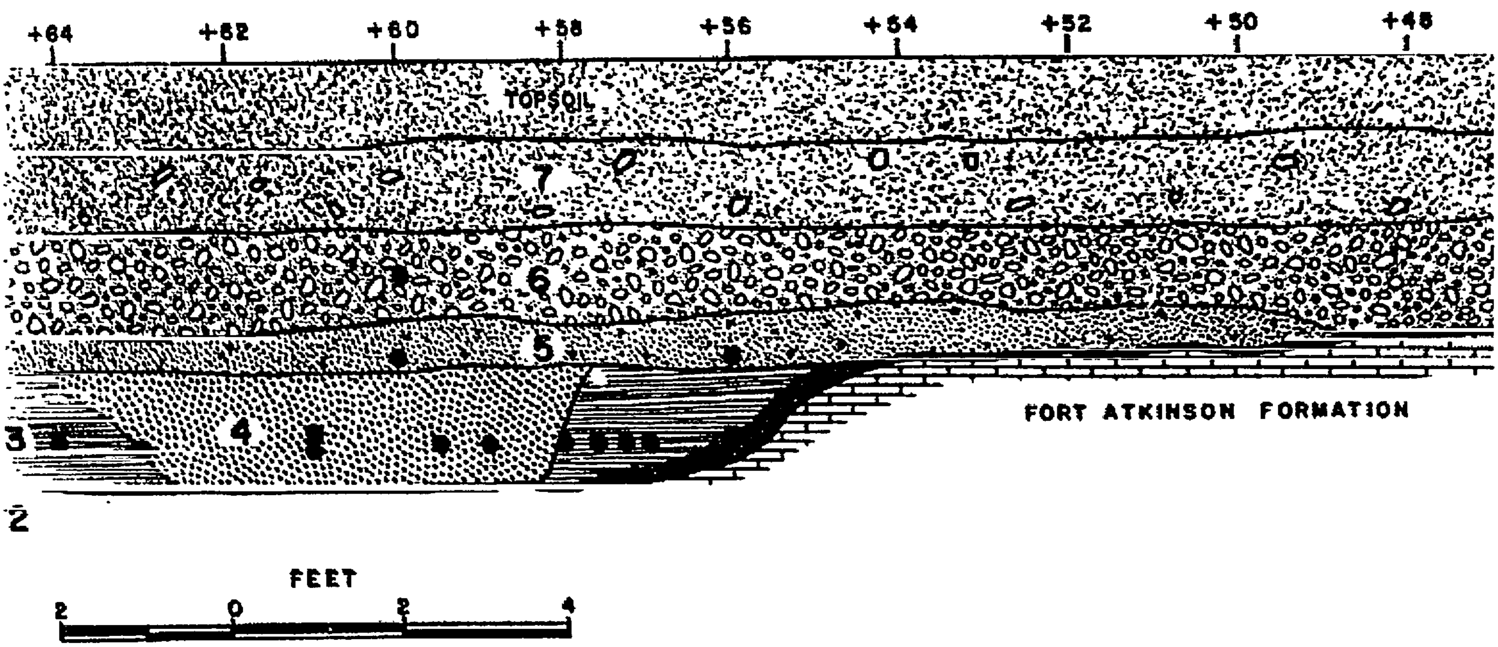
FIGURE 26 SHEET 1 OI

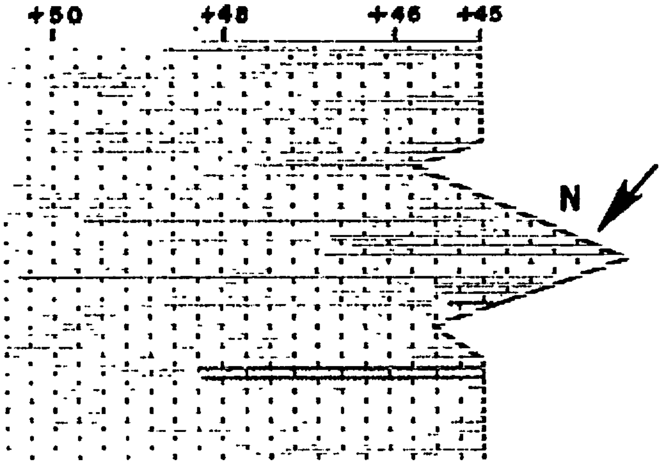

TRENCH FLOOR
0+72
+70
+68
+66
+64
+62
+60
+58
FEET
N75°E
N15°W
N75°E
N20°W
N15°W
FONT ATK
SOUTHEAST
NE
TOPSOIL
FLOOR OF TRENCH
FEET
CLOSED VERTICAL JOINTS
SAMPLE LOCATION

TRENCH FLOOR PLAN



SOUTHEAST WALL





EXPLANATION

UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE, MEDIUM TO THICK BEDDED; WEATHERS YELLOWISH-BROWN; MODERATELY WEATHERED ALONG BEDDING PLANES, JOINTS AND FRACTURES; FOSSILIFEROUS; SOLUT WIDENED JOINT WITH FILL AND PENNSYLVANIAN CUT-AND-FILL SANDSTONE.

UNIT 2 - SILTY CLAY "JOINT FILL": GREENISH-GRAY; SILTY CLAY; OCCASIONALLY CONTAINS INCLUSIONS OF EXTREMELY WEATHERED LIMESTONE FRAGMENTS; WEATHERS YELLOWISH-BROWN. SOME SILTY CLAY ALONG LIMESTONE BEDDING PLANES. GRADES TO UNIT 3.

UNIT 3 - CLAYEY SILT "JOINT FILL": GREENISH-GRAY; CLAYEY SILTS; LAMINATED; WEATHERS YELLOWISH-BROWN; GRADATIONAL WITH UNIT 2.

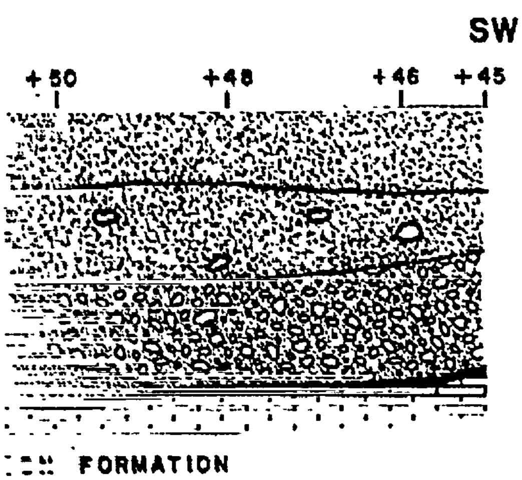
UNIT 4 - SANDSTONE: LIGHT GRAY; MEDIUM AND COARSE GRAINED SAND WITH SOME FINE SAND; SOME CROSS-BEDDING; OCCASIONAL LAMINATIONS OF SILT; WEATHERS TO DARK YELLOW BROWN. PENNSYLVANIAN CUT-AND-FILL SANDSTONE.

UNIT 5 - GRAVEL: DARK BROWN; POORLY SORTED GRAVEL WITH FINE TO MEDIUM SAND AND SILT MATRIX; CALCAREOUS; CONSISTS OF LOCALLY DERIVED AND GLACIAL ERRACTIC MATERIALS.

UNIT 6 - TILL: DARK BROWN; UNSORTED CLAY, FINE TO MEDIUM SAND, SILT AND SOME COBBLES AND BOULDERS; CALCAREOUS; MAY BE REWORKED.

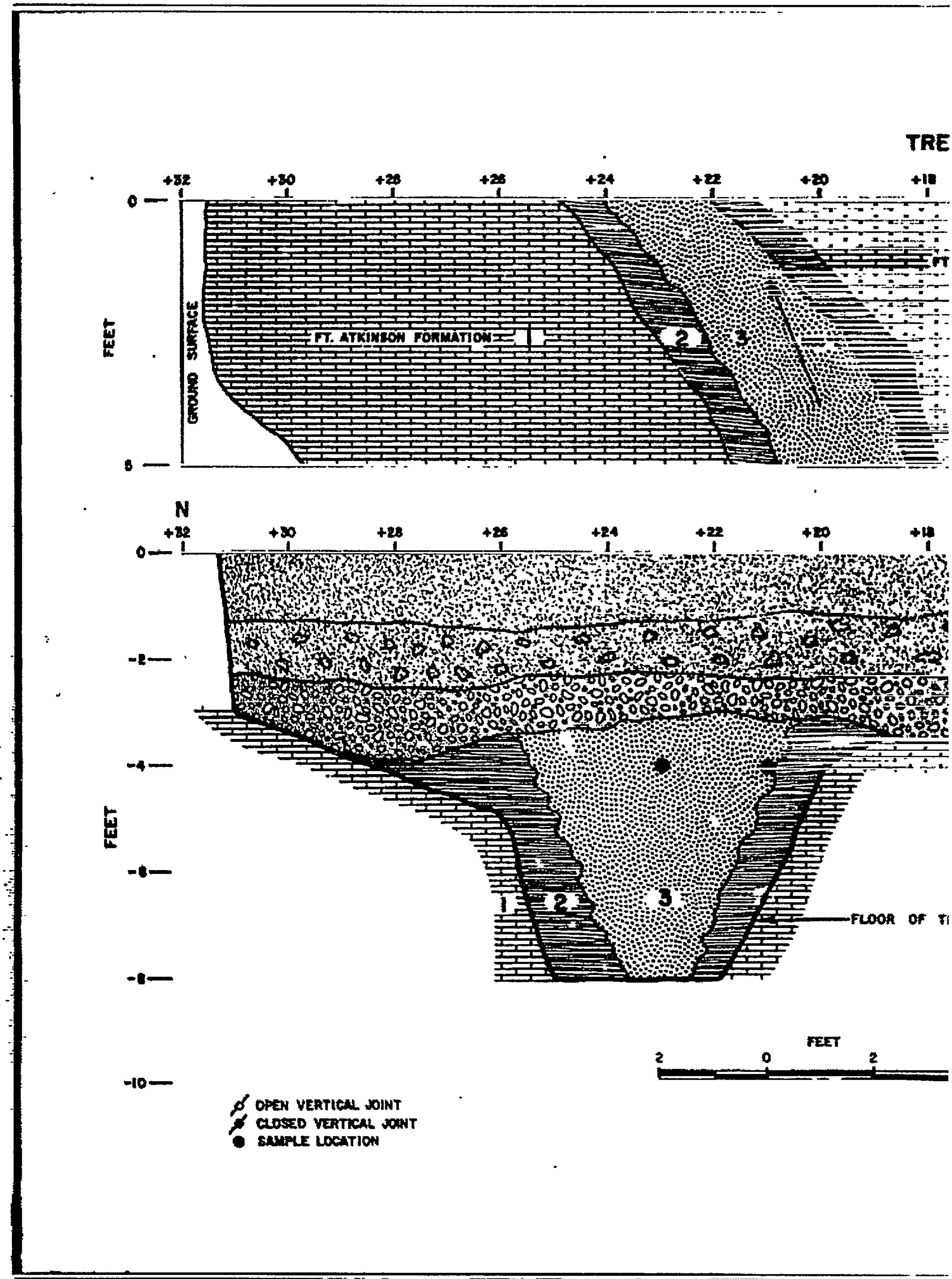
UNIT 7 - LOESS-COLLUVIUM: LIGHT BROWN; SILTS AND FINE SANDS WITH OCCASIONAL COBBLES.

NOTE:
PHOTOGRAPHS OF SOUTHEAST WALL INCLUDED IN APPENDIX A

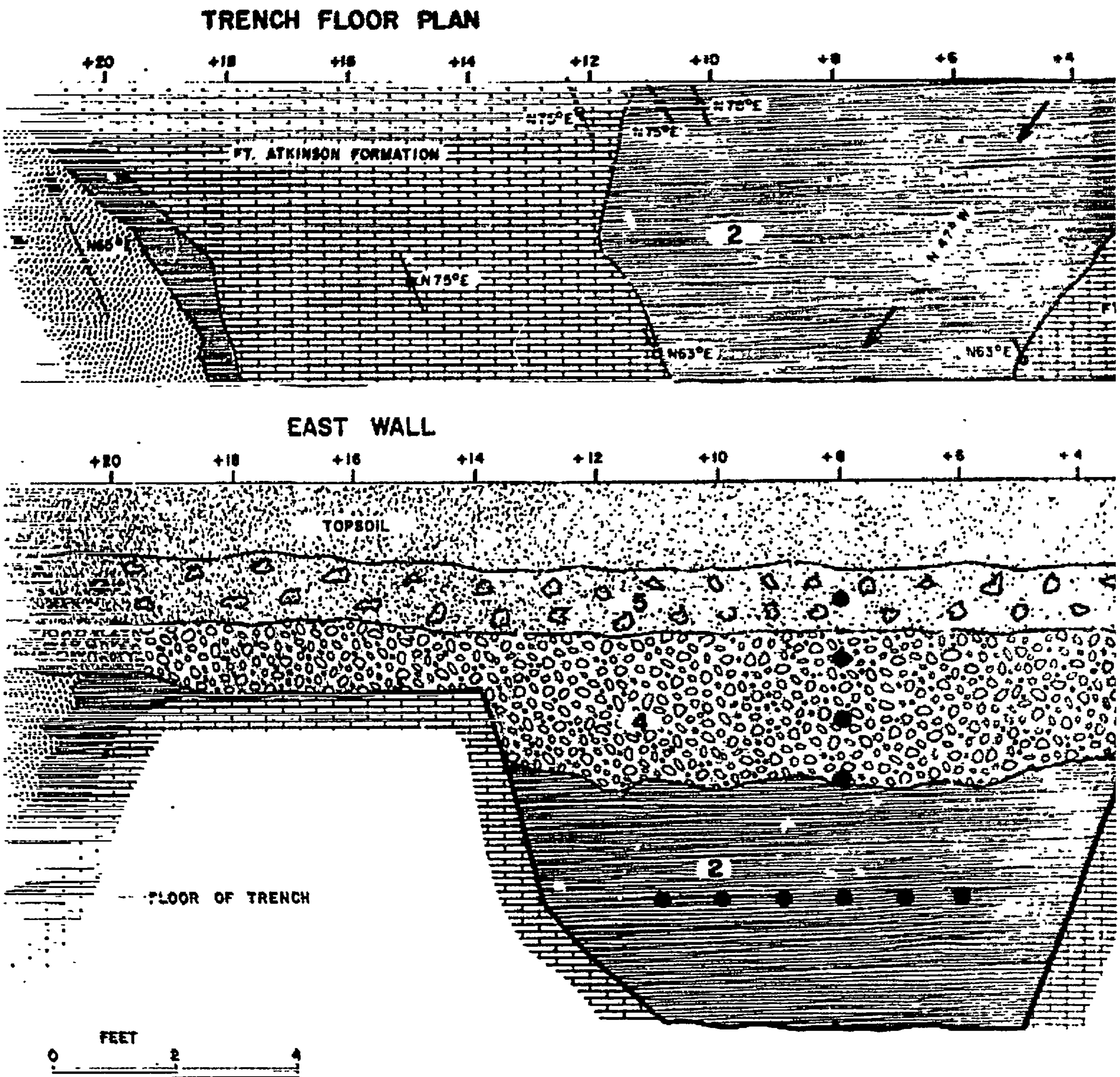


TRENCH CROSS-SEC
SOUTHEAST WALL
T-106

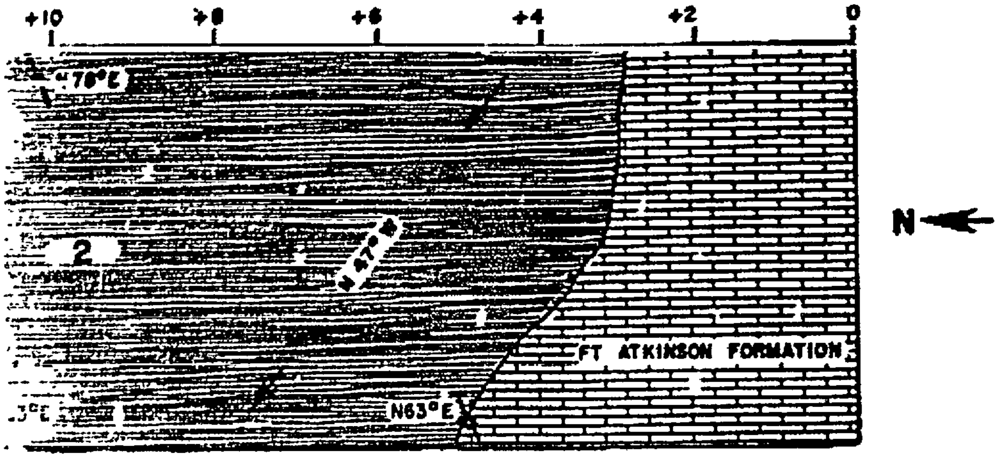
FIGURE 26 SHEET 2 OF 2

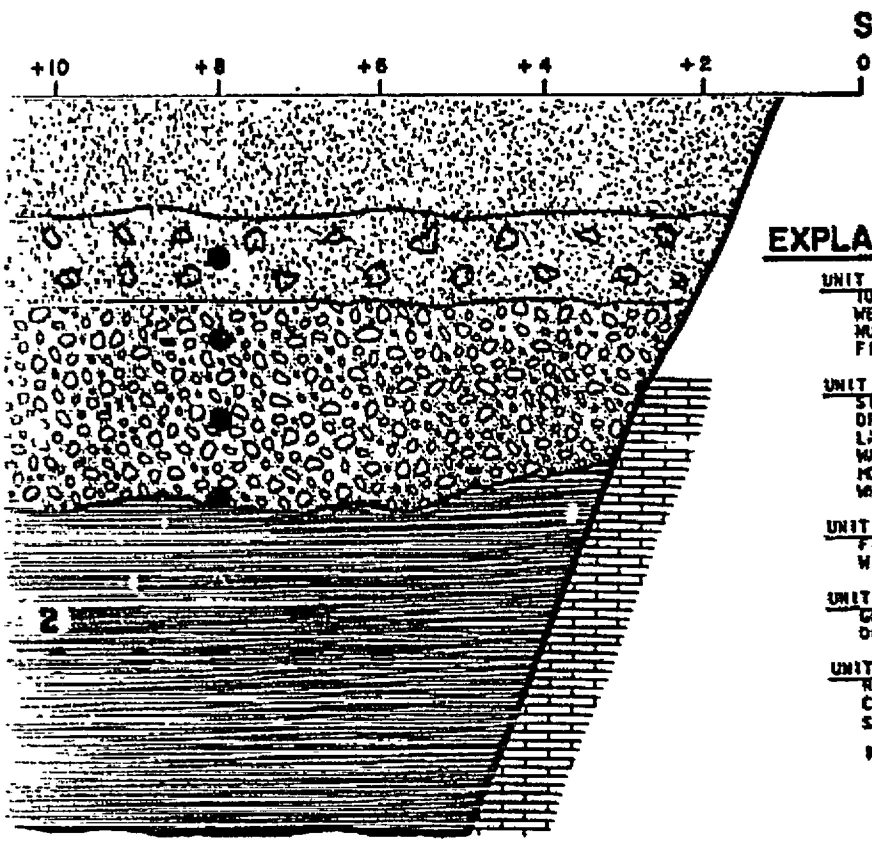


TRE
+32
+30
+28
+26
+24
+22
+20
+18
0
5
FEET
GROUND SURFACE
FT. ATKINSON FORMATION
1
2
3
N
-2
-4
-6
-8
-10
FLOOR OF T
FEET
2
0
2
OPEN VERTICAL JOINT
CLOSED VERTICAL JOINT
SAMPLE LOCATION



TRENCH FLOOR PLAN
+20
+18
+16
+14
+12
+10
+8
+6
+4
N75°E
N75°E
N75°E
FT. ATKINSON FORMATION
N65°E
N75°E
2
N47°W
N63°E
N63°E
EAST WALL
+20
+18
+16
+14
+12
+10
+8
+6
+4
TOPSOIL
5
4
2
FLOOR OF TRENCH
FEET
0
2
4





EXPLANATION

UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE; MEDIUM TO THICK BEDDED; WEATHERS YELLOWISH-BROWN, MODERATELY WEATHERED ALONG BEDDING PLANES, FRACTURES, AND JOINTS, NUMEROUS OPEN AND CLOSED VERTICAL JOINTS. TWO MAJOR, FILLED SOLUTION WIDENED JOINTS.

UNIT 2 - CLAYEY-SILTS "JOINT FILL": GREENISH-GRAY; CLAYEY SILTS WITH SOME FINE SAND AND OCCASIONAL INCLUSION OF EXTREMELY WEATHERED LIMESTONE FRAGMENTS; LAMINATED; LAMINATIONS NEAR SOLUTIONED LIMESTONE WALL ROCKS ARE WAVY AND PARALLEL TO ROCK SURFACE; MOTTLED WITH SLIGHTLY WEATHERED YELLOWISH-BROWN WHERE COARSER TEXTURED.

UNIT 3 - SANDSTONE "JOINT FILL": LIGHT GREENISH-GRAY; FINE GRAINED SANDSTONE WITH SOME SILT; LAMINATED WITH LAMINATIONS DIPPING NORTHWEST.

UNIT 4 - TILL: LIGHT BROWN TO GRAY; UNSORTED; SILT AND GRAVEL WITH SOME SAND, AND CLAY MATRIX, OCCASIONAL COBBLES AND BOULDERS.

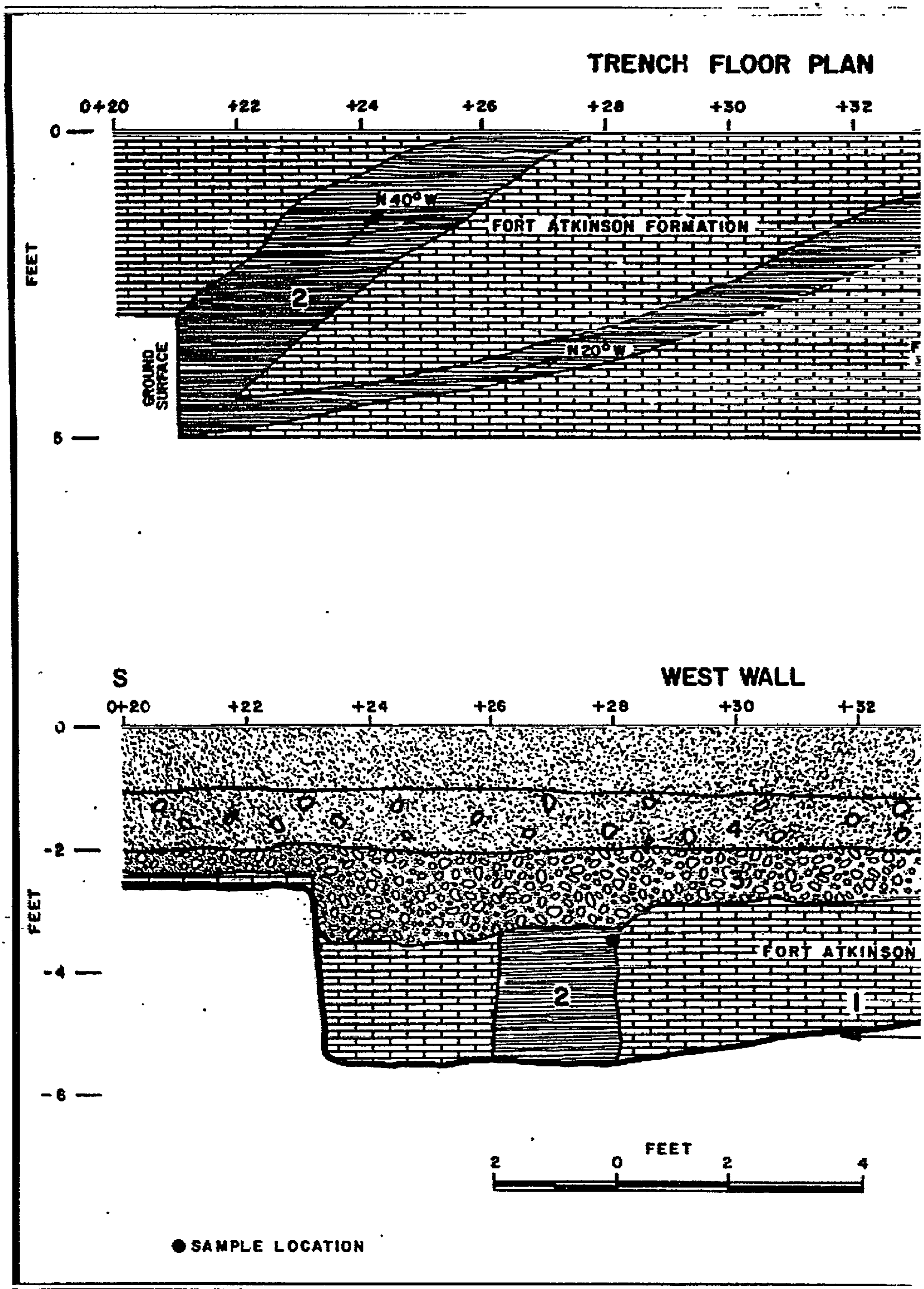
UNIT 5 - REWORKED TILL: YELLOWISH-BROWN, WITH RED CAST, OXIDIZED MIXTURE OF LOESS, TILL, AND COLLUVIUM; UNSORTED SILTS, CLAYS, AND GRAVEL WITH SOME FINE SAND AND OCCASIONAL COBBLES.

NOTE:

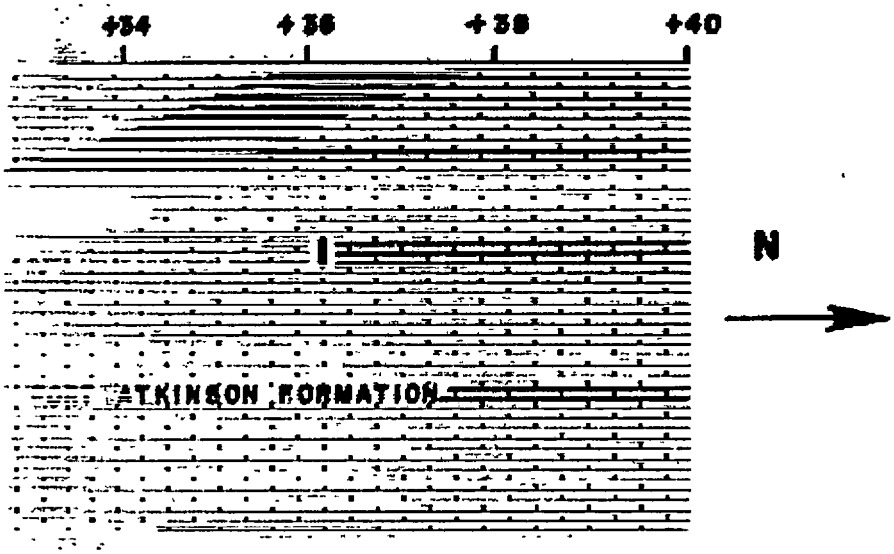
PHOTOGRAPHS OF TRENCH 110A INCLUDED IN APPENDIX A

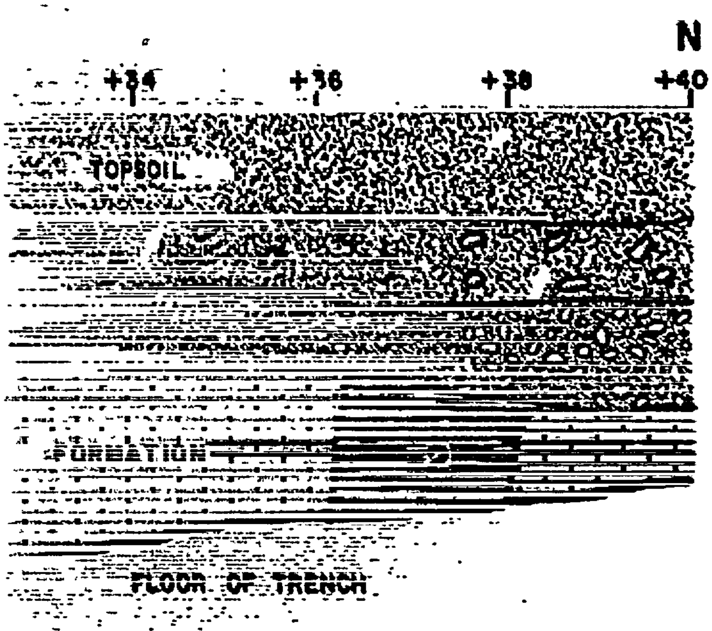
THE TWO JOINTS NARROW WITH DEPTH AND THE WALLS BECOME MORE IRREGULAR. REFUSAL WAS CAUSED BY LIMESTONE BLOCKS EXTENDING INTO THE JOINT.

TRENCH CROSS – SECTI
T-110 A



TRENCH FLOOR PLAN
0+20
+22
+24
+26
+28
+30
+32
0
5
FEET
N 40° W
FORT ATKINSON FORMATION
2
GROUND SURFACE
N 20° W
S
WEST WALL
0
-2
-4
-6
FEET
4
3
FORT ATKINSON
2
1
FEET
2
0
2
4
SAMPLE LOCATION





EXPLANATION

UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE; MEDIUM TO THICK BEDDED; WEATHERS YELLOWISH-BROWN; MODERATELY WEATHERED ALONG BEDDINGS PLANES, FRACTURES, AND JOINTS; FOSSILIFEROUS. SOLUTIONED JOINTS INTERSECT AT + EAST WALL; JOINTS SHOW LITTLE EVIDENCE OF SOLUTION ACTIVITY SINCE FILL MATERIAL WAS DEPOSITED.

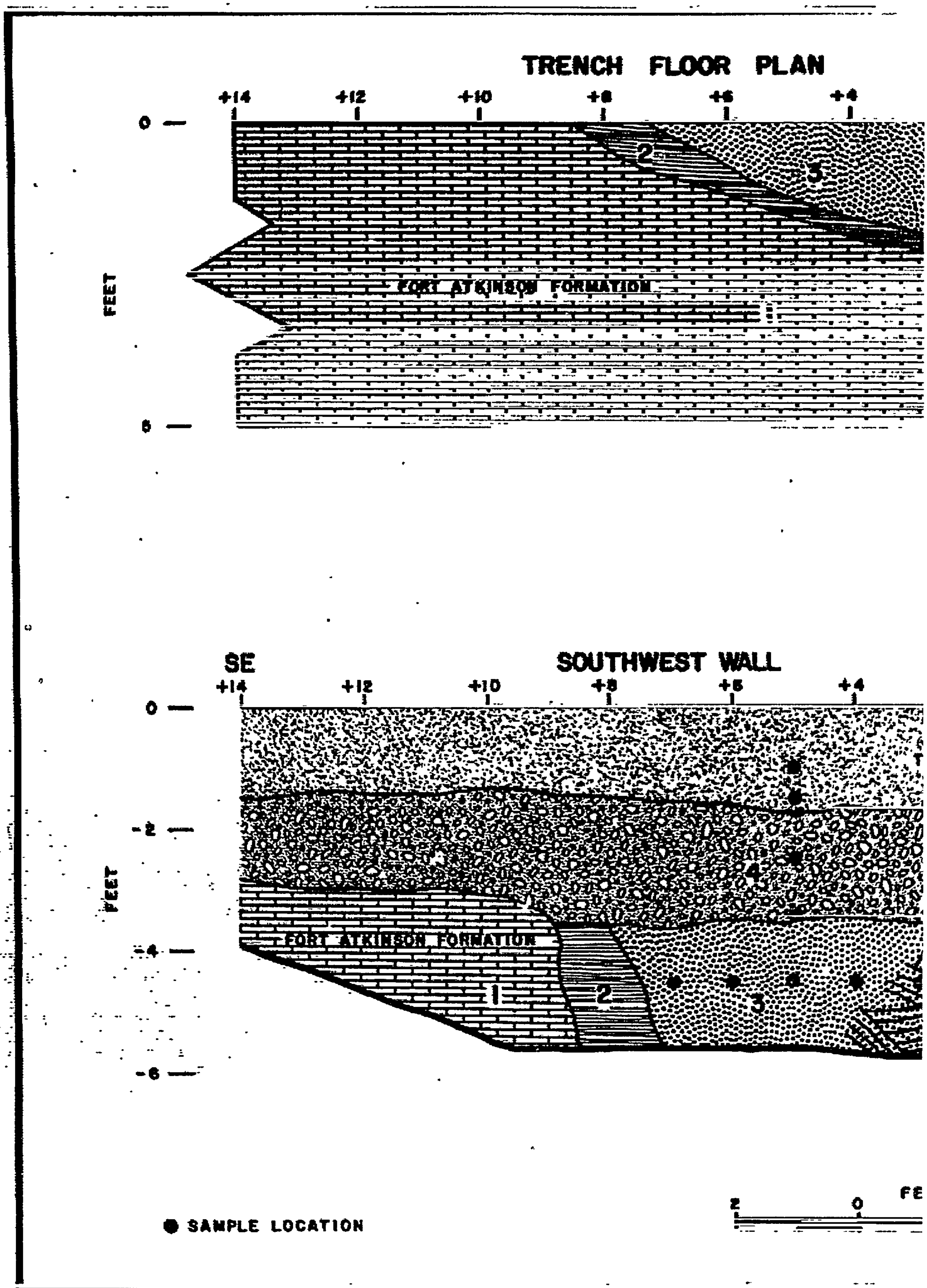
UNIT 2 - CLAYEY SILT AND SILTY CLAY "JOINT FILL"; GREENISH-GRAY; SILTY CLAY NEAR ROCK INTERFACE, GRADES TO CLAYEY SILT WITH SOME FINE SAND IN CENTER OF JOINTS; SILTS AND CLAYS OCCASIONALLY LAMINATED, WHEN NEAR ROCK INTERFACE LAMINATIONS ARE WAVY AND PARALLEL TO SOLUTIONED ROCK SURFACE. WEATHERS GRAYISH-ORANGE WHERE FINE SANDS ARE PRESENT IN FILL.

UNIT 3 - TILL: GRAYISH-BROWN; UNSORTED SAND, GRAVEL, COBBLES AND BOULDERS WITH CLAY AND SILT MATRIX; GRADES UPWARD TO UNIT 4.

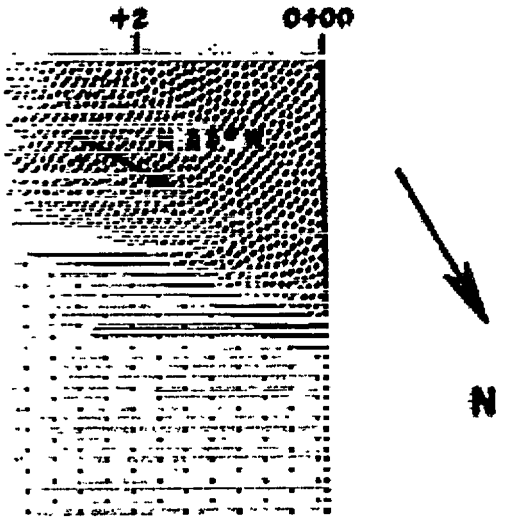
UNIT 4 - REWORKED TILL: REDDISH-BROWN TO YELLOWISH-BROWN OXIDIZED MIXTURE OF LOESS, TILL, AND COLLUVIUM; CLAYEY SILTS AND FINE SANDS WITH SOME GRAVEL AND OCCASIONAL COBBLES; MODERATELY WEATHERED.

TRENCH CROSS-SECT
T-110 B

FIGURE



TRENCH FLOOR PLAN
+14
+12
+10
+8
+6
+4
0
6
FEET
2
3
FORT ATKINSON FORMATION
SE
SOUTHWEST WALL
0
-2
-4
-6
1
2
3
4
SAMPLE LOCATION
2
0
FE



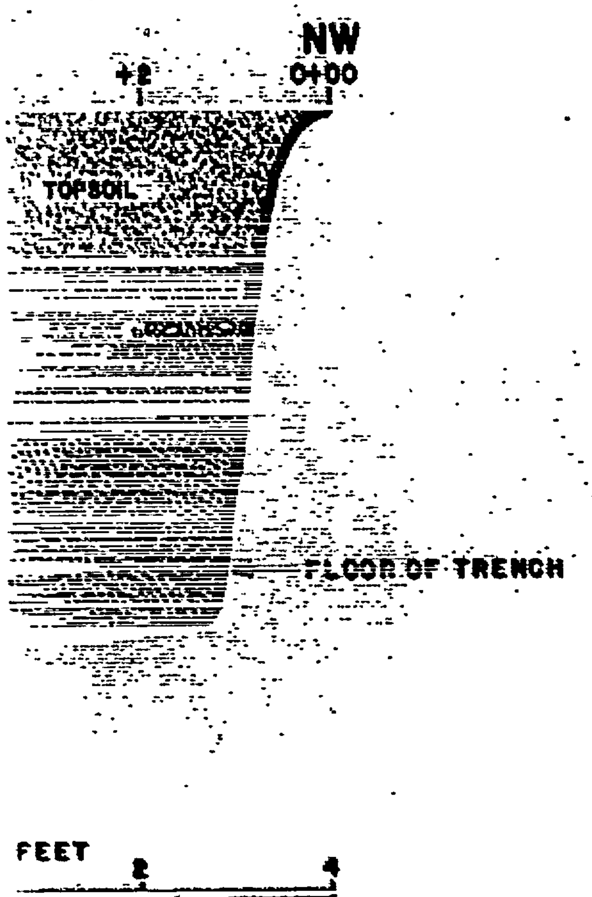
EXPLANATION

UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE, MEDIUM TO THICK BEDDED; WEATHERS YELLOWISH-BROWN; MODERATELY TO SLIGHTLY WEATHERED ALONG BEDDING PLANES AND FRACTURES; FOSSILIFEROUS. LITTLE EVIDENCE OF SOLUTION ACTIVITY SINCE DEPOSITION OF FILL.

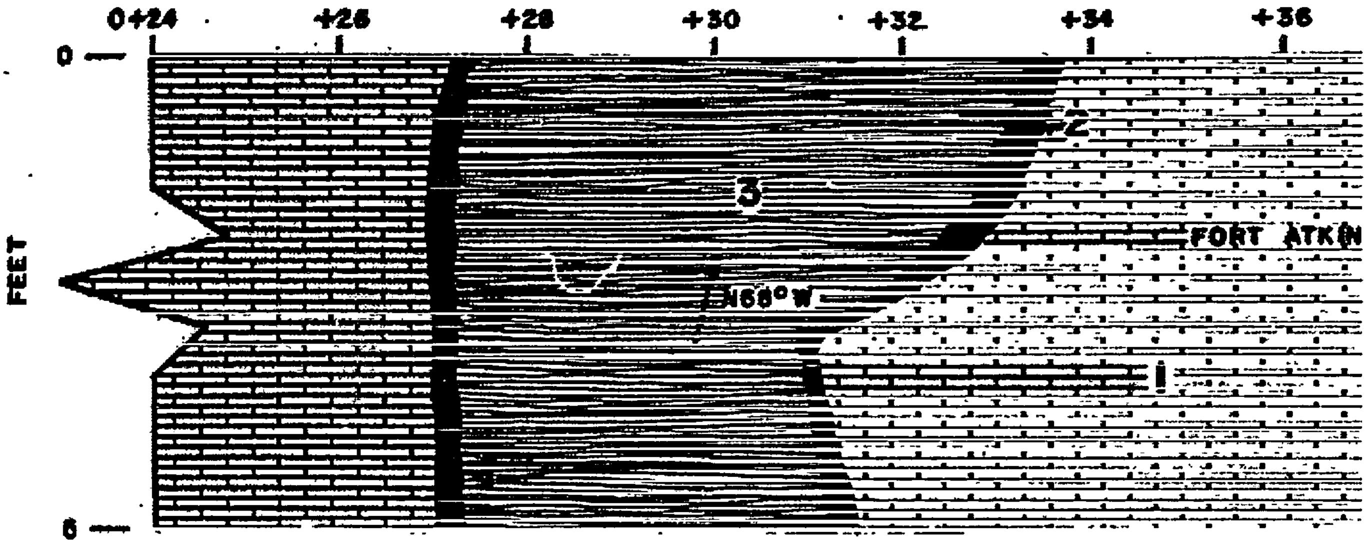
UNIT 2 - CLAYEY SILT AND SILTY CLAY "JOINT FILL": GREENISH-GRAY; LAMINATIONS OF CLAYEY SILT AND SILTY CLAY; WEATHERS LIGHT YELLOWISH-BROWN.

UNIT 3 - SANDSTONE: GREENISH-GRAY TO LIGHT GRAY; FINE TO MEDIUM GRAINED SAND LAMINATIONS, WITH SOME SILT LAMINATIONS; THIN BEDDED. FROM 0+00 TO +4 SANDSTONE IS CROSS-BEDDED. WEATHERS YELLOWISH-BROWN TO REDDISH-BROWN, SLIGHTLY TO MODERATELY WEATHERED.

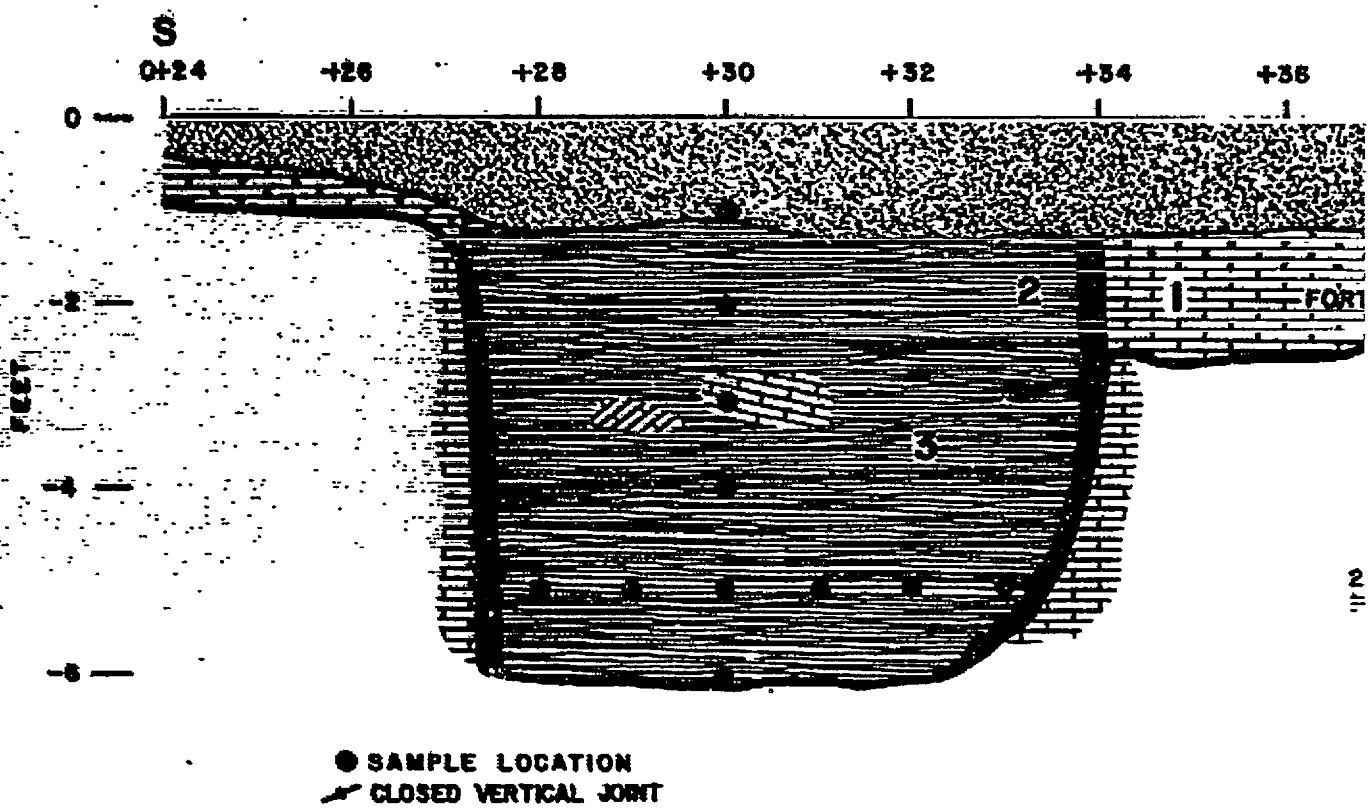
UNIT 4 - TILL: GRAYISH-BROWN TO YELLOWISH-BROWN WITH LIGHT RED CAST; REWORKED TILL, UNSORTED, SAND, GRAVEL, OCCASIONAL COBBLE, WITH SILT, CLAY, AND SOME FINE SAND MATRIX. OXIDIZED TO YELLOWISH-BROWN WITH SUBANGULAR BLOCKY STRUCTURE.



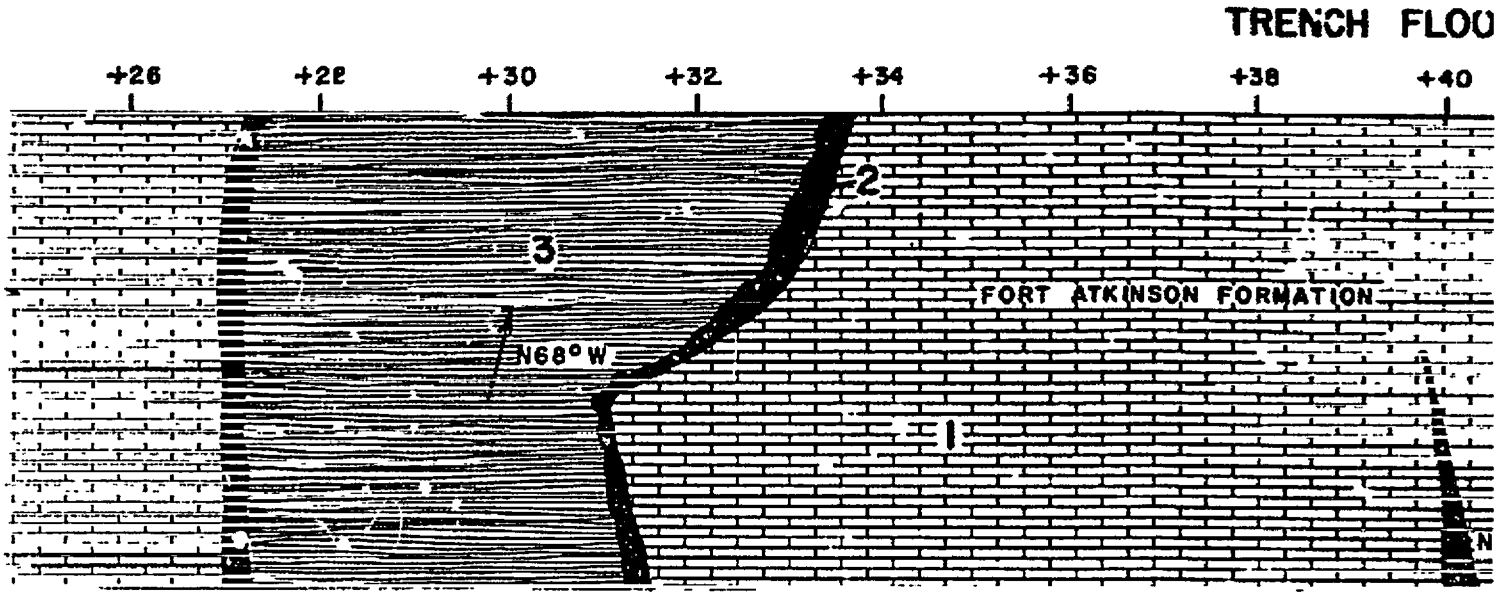
TRENCH CROSS-SEC
T-110 D

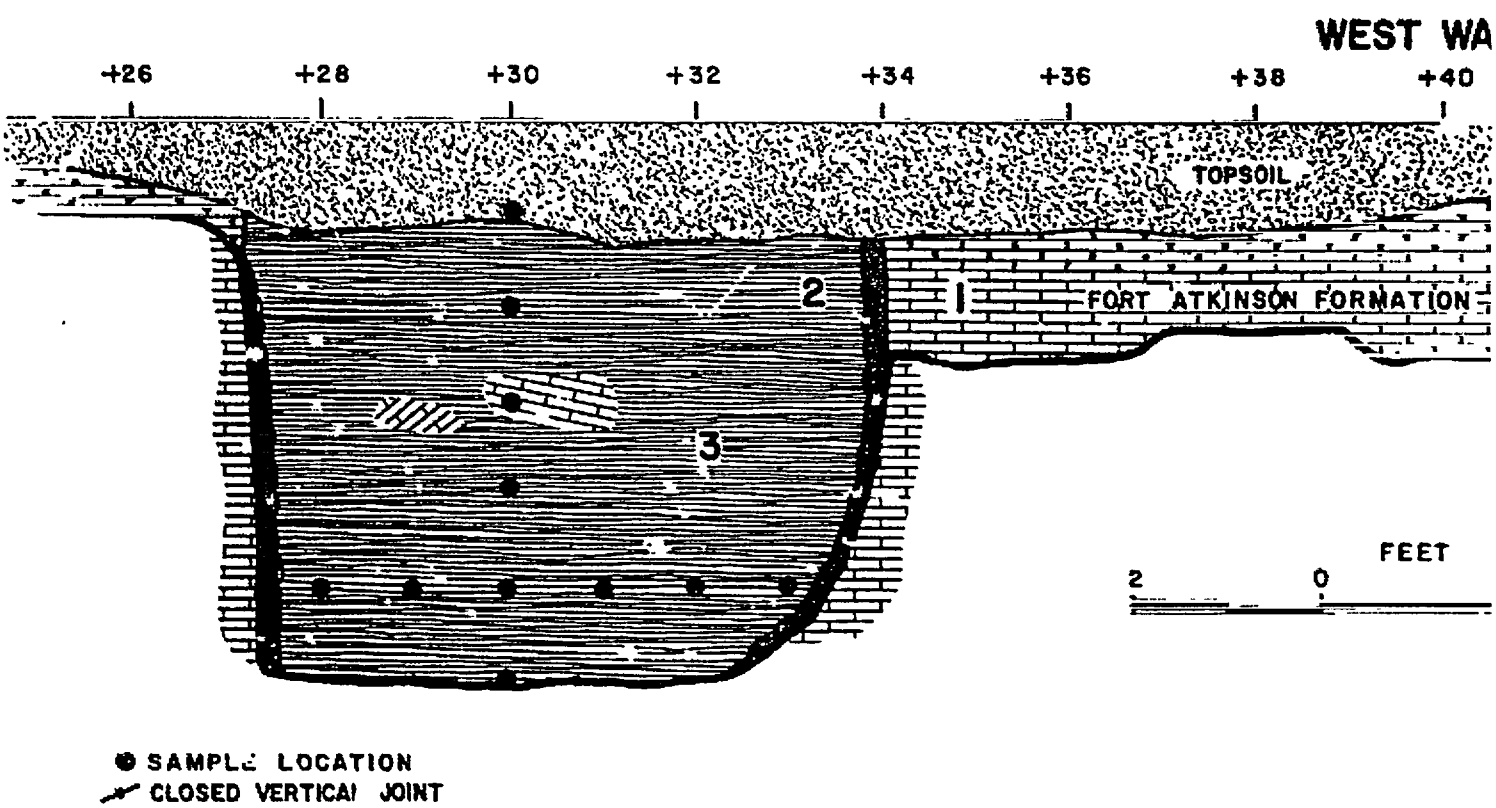


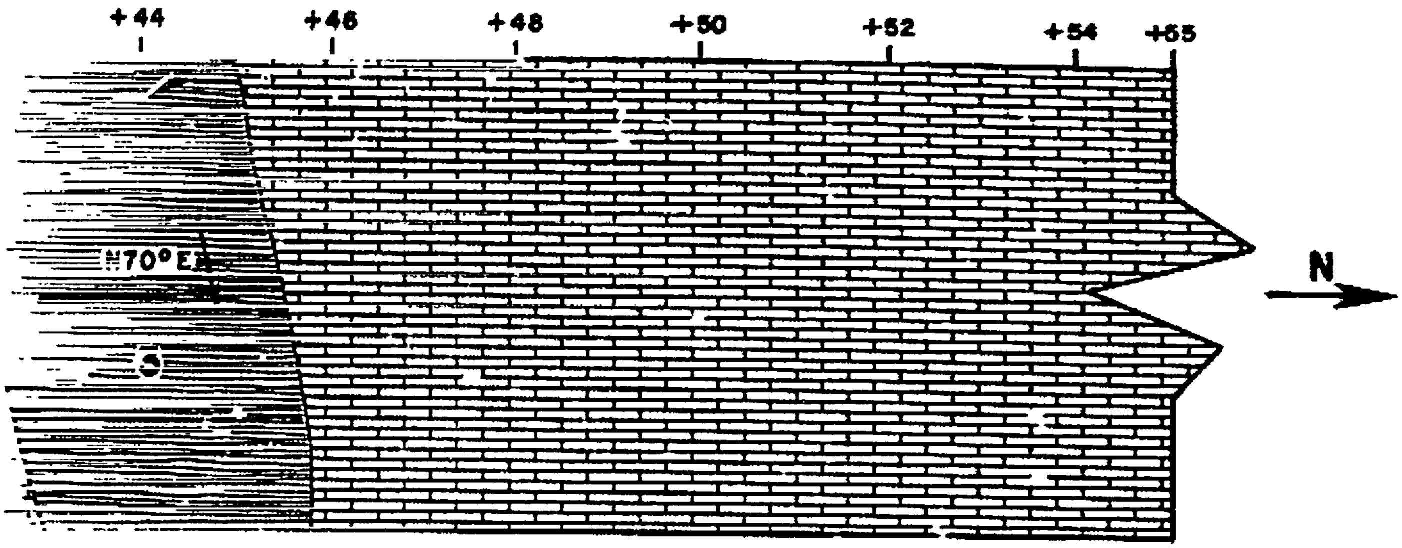
0+24
+26
+28
+30
+32
+34
+36
0
6
FEET
3
2
FORT ATKIN
N68°W
1

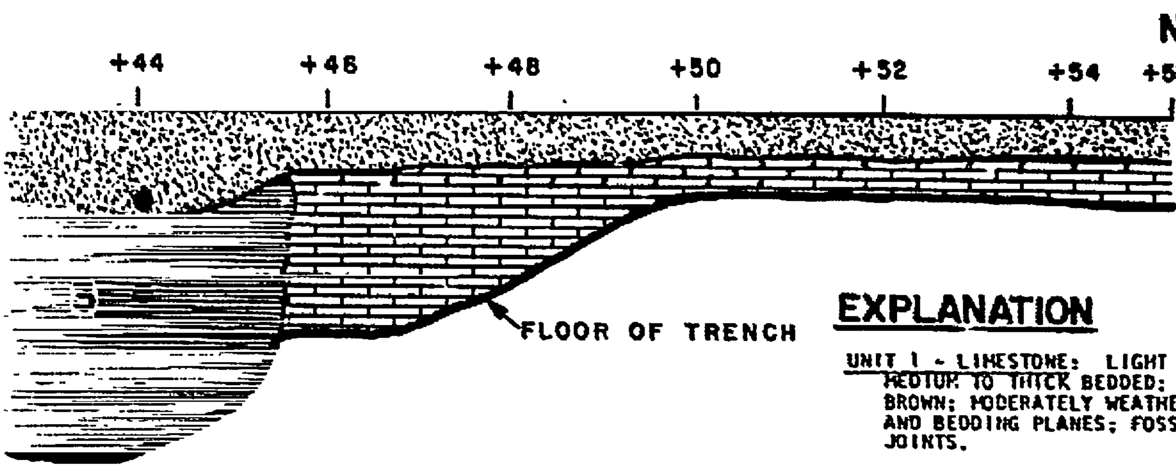


S
0+24
+26
+28
+30
+32
+34
+36
0
-2
-4
-6
FEET
2
1
FORT
3
SAMPLE LOCATION
CLOSED VERTICAL JOINT


TRENCH FLOO
+26
+28
+30
+32
+34
+36
+38
+40
2
3
N68° W
FORT ATKINSON FORMATION
1
N


WEST WA
+26
+28
+30
+32
+34
+36
+38
+40
TOPSOIL
2
1
FORT ATKINSON FORMATION
3
FEET
2
0
SAMPLE LOCATION
CLOSED VERTICAL JOINT





EXPLANATION

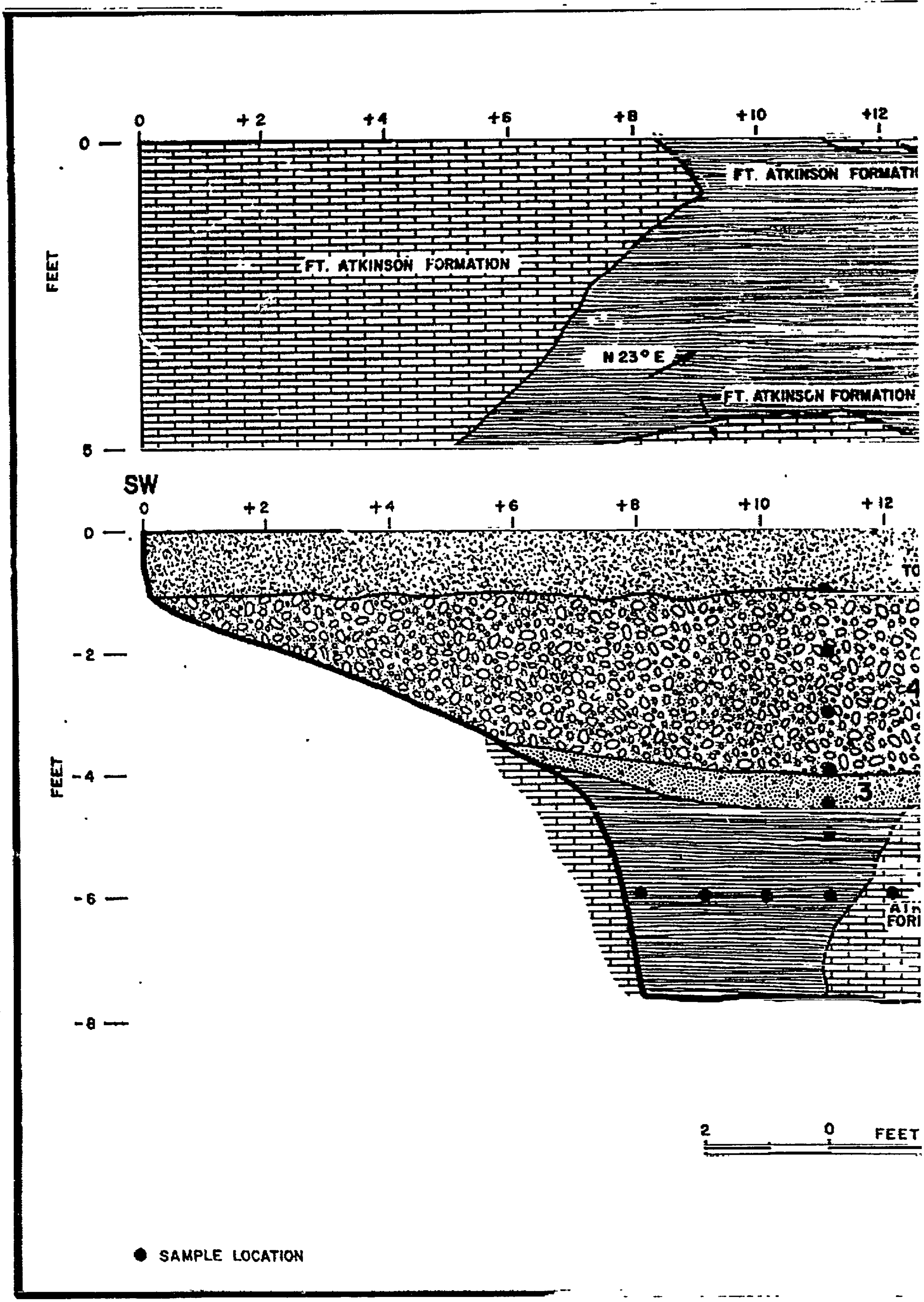
UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE; MEDIUM TO THICK BEDDED; WEATHERS YELLOWISH-BROWN; MODERATELY WEATHERED ALONG JOINTS, FRACTURI AND BEDDING PLANES; FOSSILIFEROUS. SOLUTION WIDEI JOINTS.

UNIT 2 - SILTY CLAY "JOINT FILL": GREENISH-GRAY; SILTY CLAY WITH SOME INCLUSIONS OF EXTREMELY WEATHERED LIMESTONE FRAGMENTS. GRADATIONAL WITH UNIT 3.

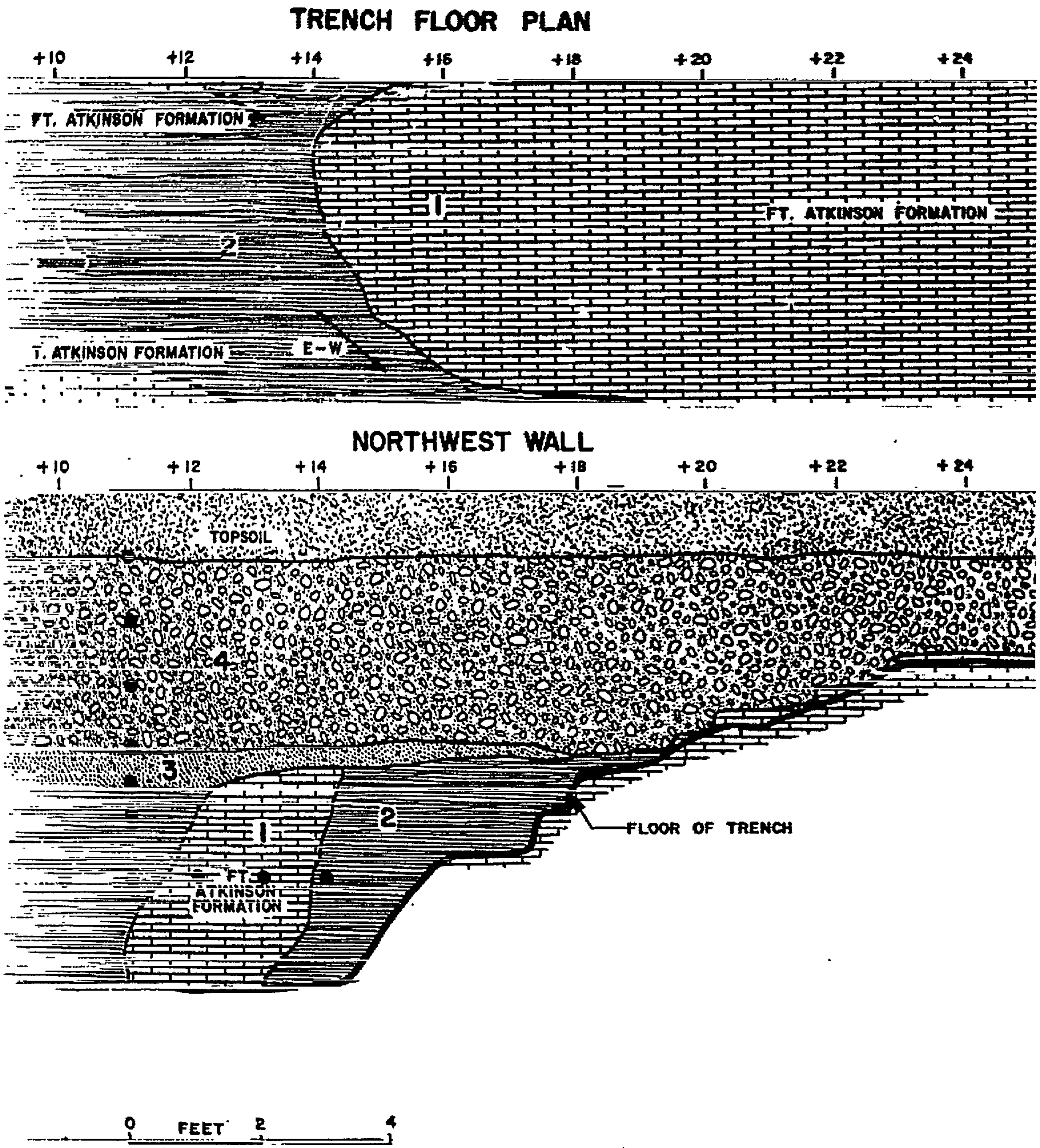
UNIT 3 - CLAYEY SILT "JOINT FILL": GREENISH-GRAY; CI SILT WITH SOME FINE SAND; LAMINATED: FINE SAND LAMINATIONS WEATHER YELLOWISH-BROWN. SOME LARGE EXTREMELY WEATHERED LIMESTONE INCLUSIONS; IN SOME CASES, ONLY A TAN RESIDUAL WITH ABUNDANT FOSSIL FRAGMENTS REMAIN.

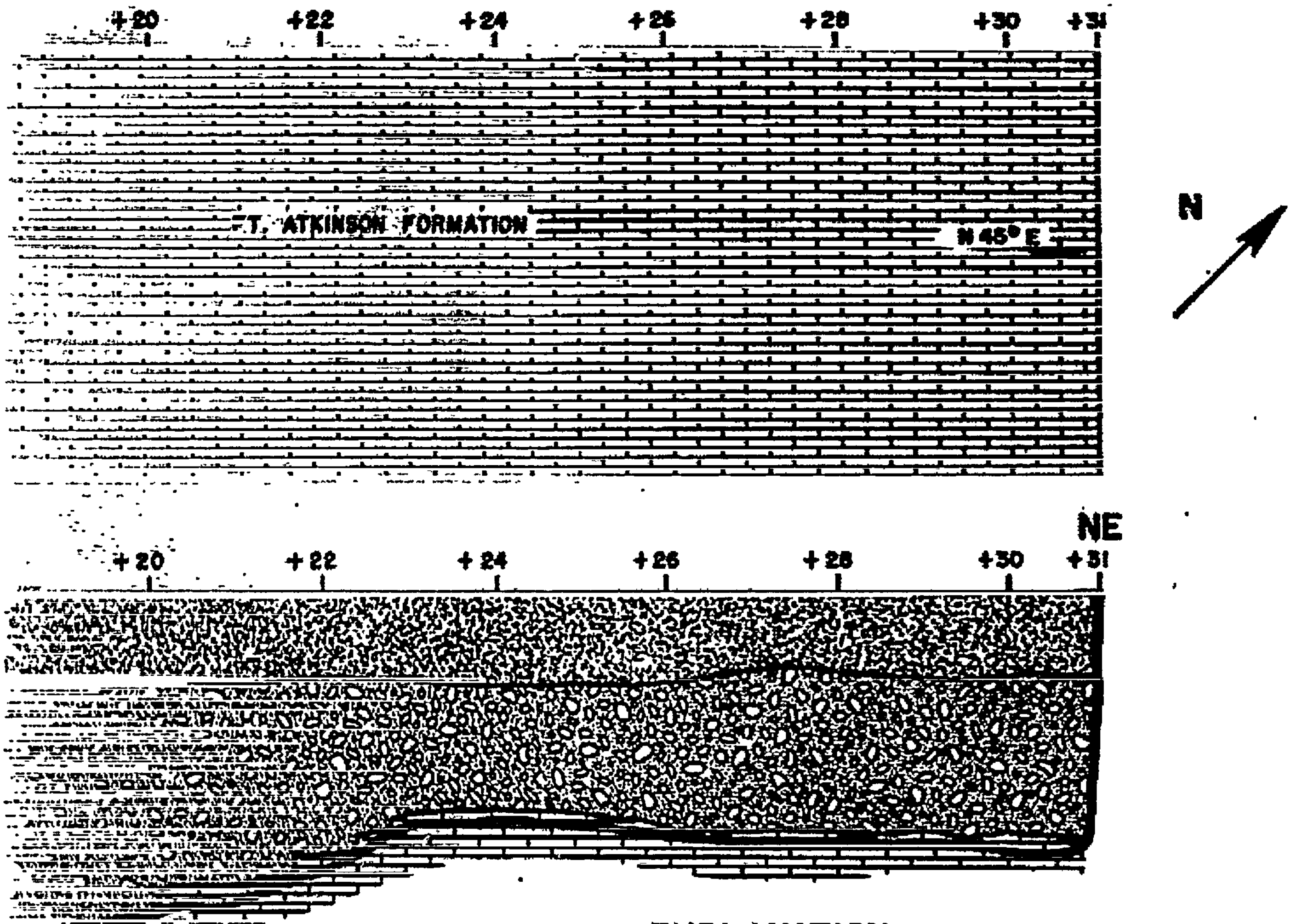
TRENCH CROSS-SECTIO
T-III

FIGURE 30



0
+2
+4
+6
+8
+10
+12
0
5
FEET
FT. ATKINSON FORMATION
FT. ATKINSON FORMATION
N 23° E
FT. ATKINSON FORMATION
SW
0
-2
-4
-6
-8
FEET
4
3
2 0 FEET
SAMPLE LOCATION


TRENCH FLOOR PLAN
+10
+12
+14
+16
+18
+20
+22
+24
FT. ATKINSON FORMATION
1
FT. ATKINSON FORMATION
2
T. ATKINSON FORMATION
E-W
NORTHWEST WALL
+10
+12
+14
+16
+18
+20
+22
+24
TOPSOIL
4
3
1
2
FT. ATKINSON FORMATION
FLOOR OF TRENCH
0
FEET
2
4



EXPLANATION

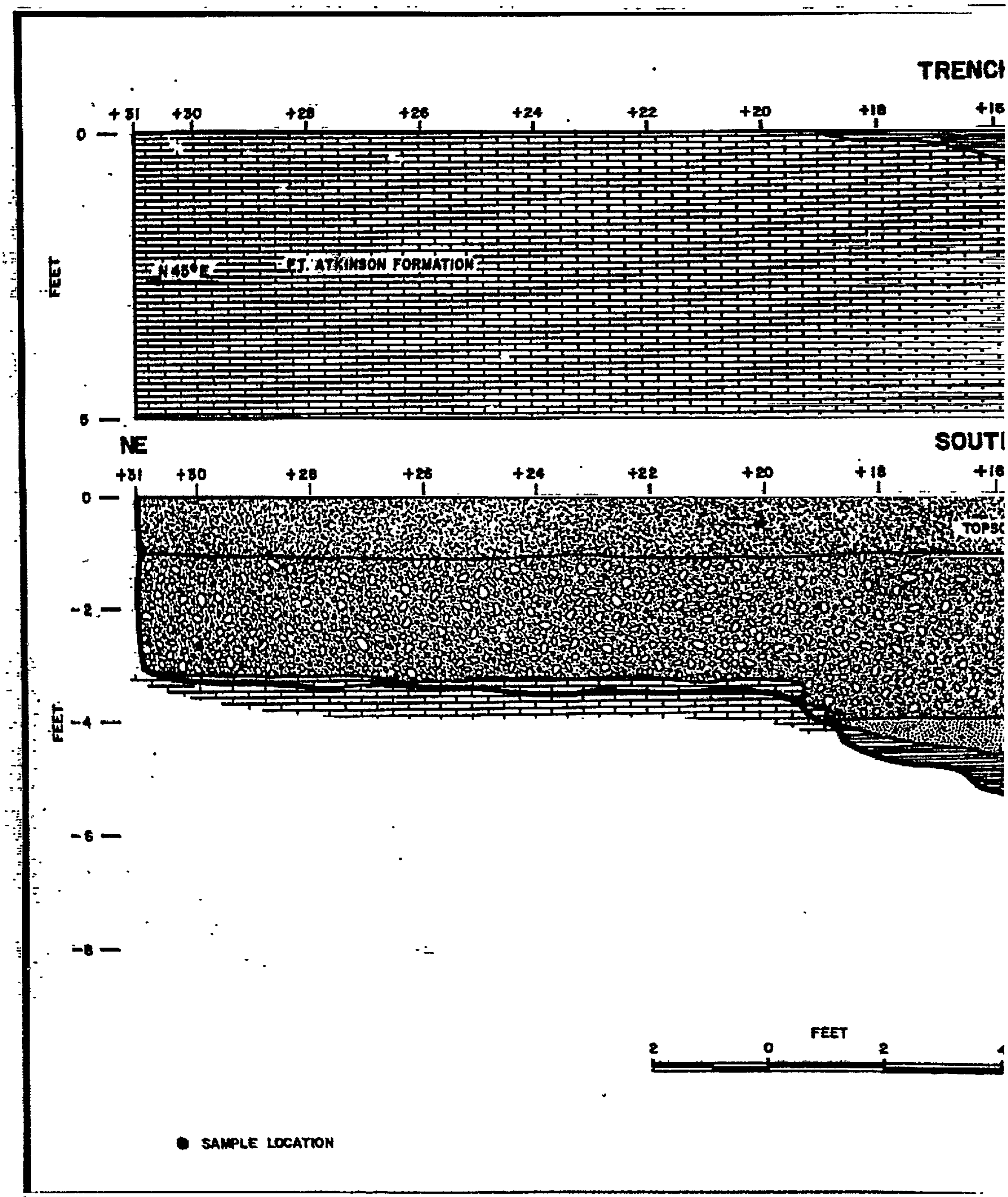
UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE; MEDIUM TO THICK BEDDED, WEATHERS YELLOWISH-BROWN; MODERATELY WEATHERED ALONG BEDDING PLANES, FRACTURES, AND JOINTS. TWO FILLED, SOLUTION WIDE JOINTS INTERSECT IN CENTER OF TRENCH, SOME FILL MATERIAL FOUND ALONG LIMESTONE BEDDING PLANES.

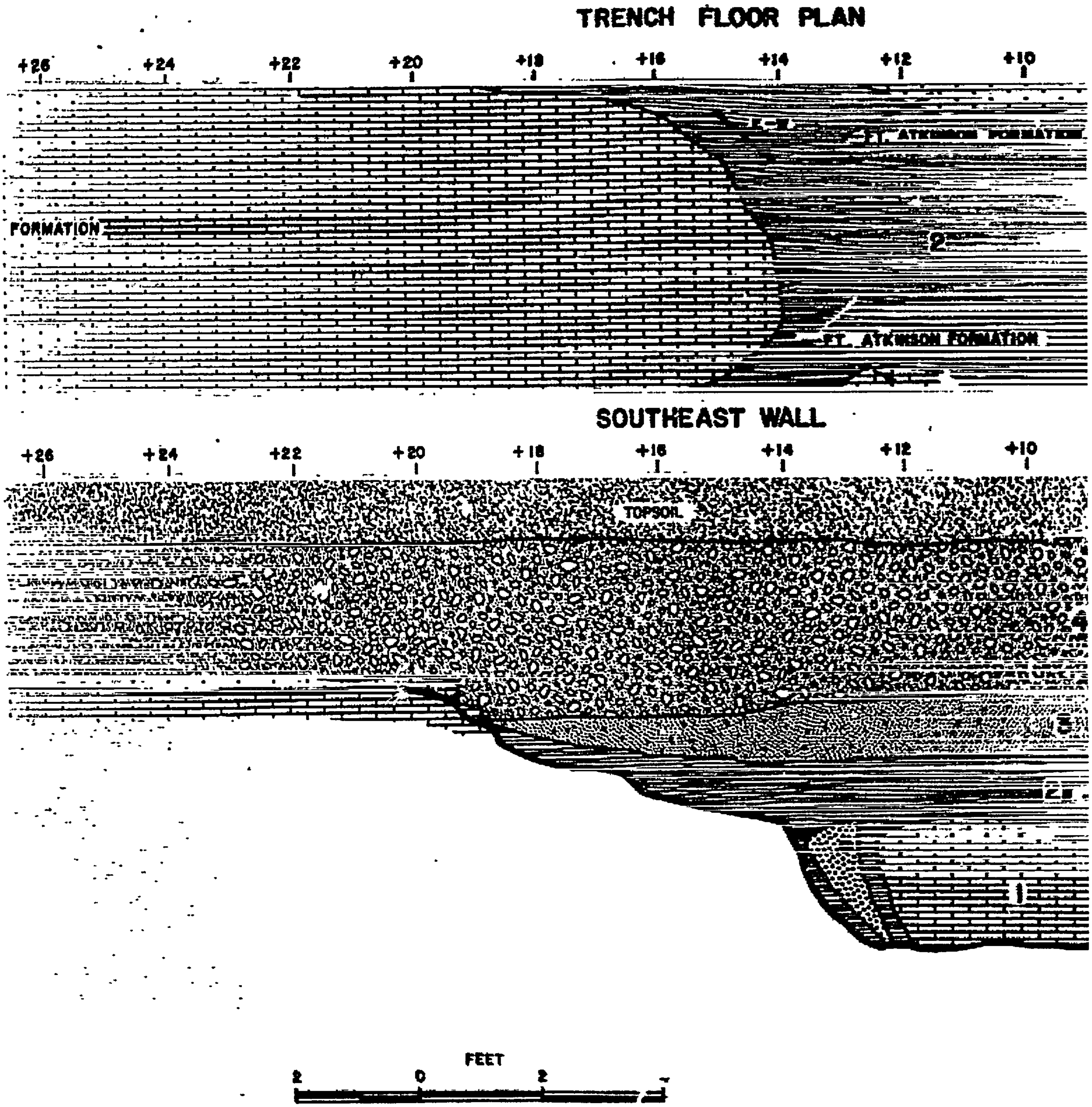
UNIT 2 - CLAYEY SILT "JOINT FILL": GREENISH-GRAY; CLAYEY SILT AND SILTY CLAY WITH SOME FINE SAND; OCCASIONAL WAVY LAMINATIONS PARALLEL TO ROCK SURFACE. SOME INCLUSIONS OF EXTREMELY WEATHERED LIMESTONE FRAGMENTS.

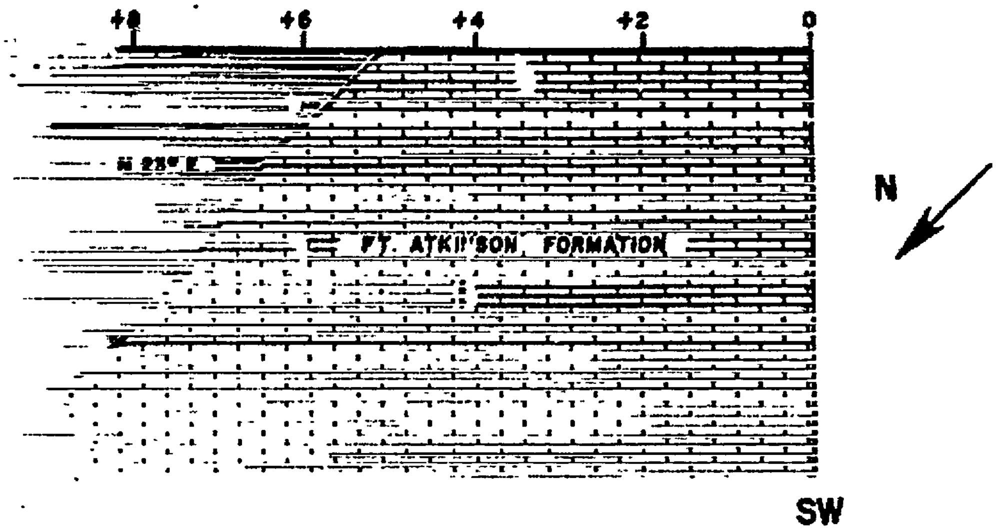
UNIT 3 - GRAVEL: YELLOWISH-BROWN; DIRTY, POORLY SORTED GRAVEL WITH SAND MATRIX.

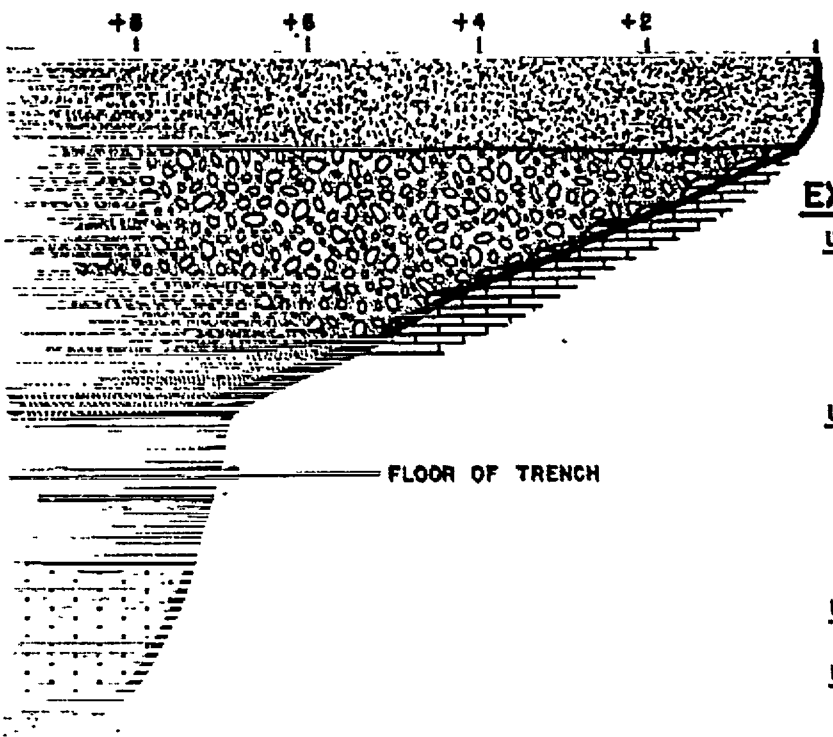
UNIT 4 - TILL: BROWN; SILT, FINE SAND, WITH SOME CLAY AND GLACIAL ERRATICS; UNSORTED MIXTURE OF LOESS, REWORKED TILL, AND COLLUVIUM.

TRENCH CROSS - SECT
NORTHWEST WALL
T-118


TRENCH
+31
+30
+28
+26
+24
+22
+20
+18
+16
0
5
FEET
N 45° E
FT. ATKINSON FORMATION
NE
SOUT
+31
+30
+28
+26
+24
+22
+20
+18
+16
0
-2
-4
-6
-8
FEET
TOPSO
FEET
2
0
2
4
SAMPLE LOCATION


TRENCH FLOOR PLAN
+26
+24
+22
+20
+18
+16
+14
+12
+10
FT. ATKINSON FORMATION
FORMATION
2
FT. ATKINSON FORMATION
SOUTHEAST WALL
+26
+24
+22
+20
+18
+16
+14
+12
+10
TOPSOIL
4
3
1
FEET
2
0
2





EXPLANATION

UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE MEDIUM TO THICK BEDDED, WEATHERS YELLOWISH-BROWN; MODERATELY WEATHERED ALONG BEDDING PLANES FRACTURES, AND JOINTS. TWO FILLED, SOLUTION WID JOINTS INTERSECT IN CENTER OF TRENCH, SOME FILL MATERIAL FOUND ALONG LIMESTONE BEDDING PLANES.

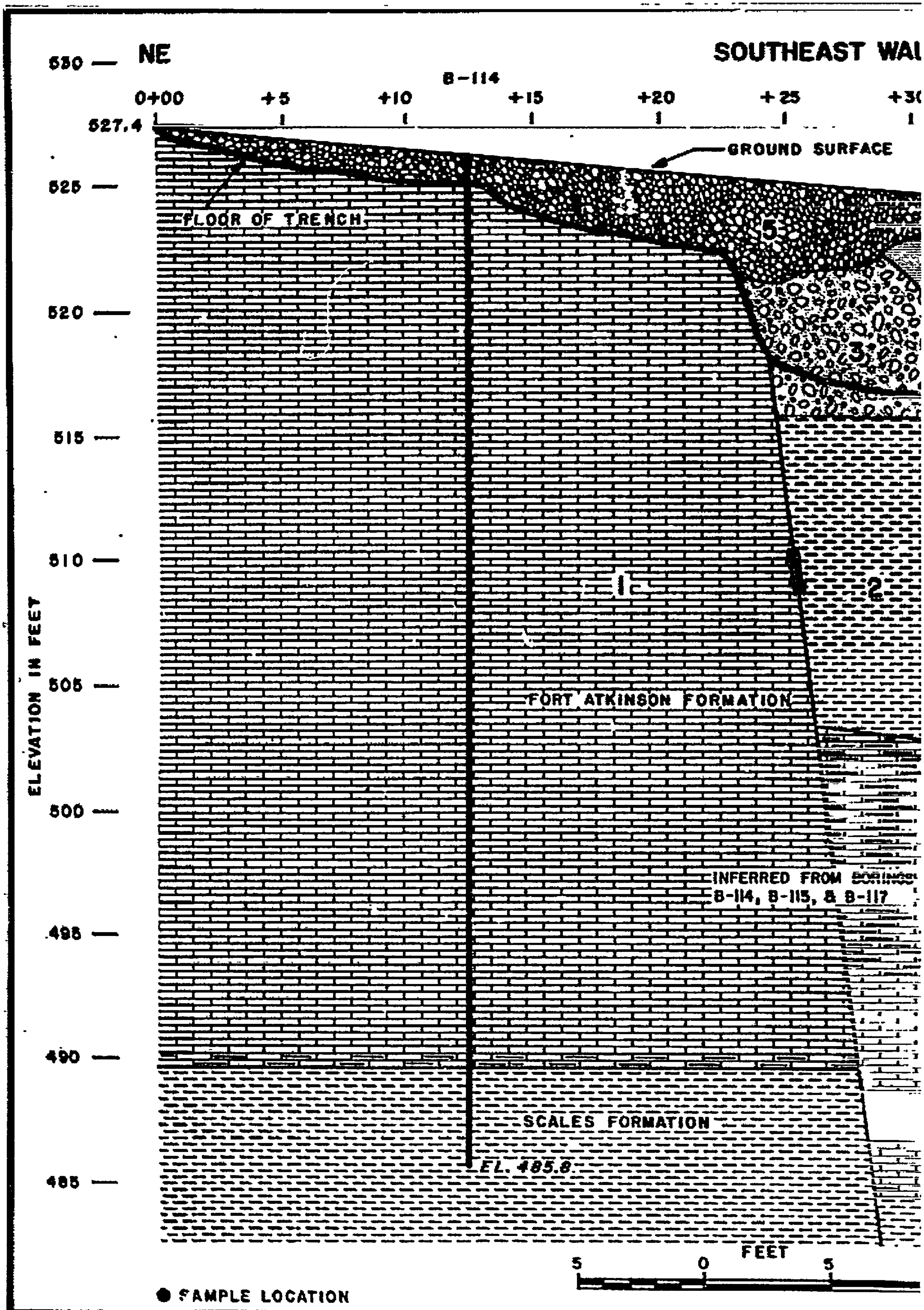
UNIT 2 - CLAYEY SILT "JOINT FILL": GREENISH-GRAY; CLAYEY SILT AND SILTY CLAY WITH SOME FINE SAND; OCCASIONAL WAVY LAMINATIONS PARALLEL TO ROCK SURFACE. SOME INCLUSIONS OF EXTREMELY WEATHERED LIMESTONE FRAGMENTS. WEDGE OF LAMINATED SANDSTONE AND SILTSTONE INCLUSION AT +13; GRAY FINE GRAINED SAND AND SILT; WEATHERS YELLOWISH-BROWN.

UNIT 3 - GRAVEL: YELLOWISH-BROWN; DIRTY, POORLY SORTED GRAVEL WITH SAND MATRIX.

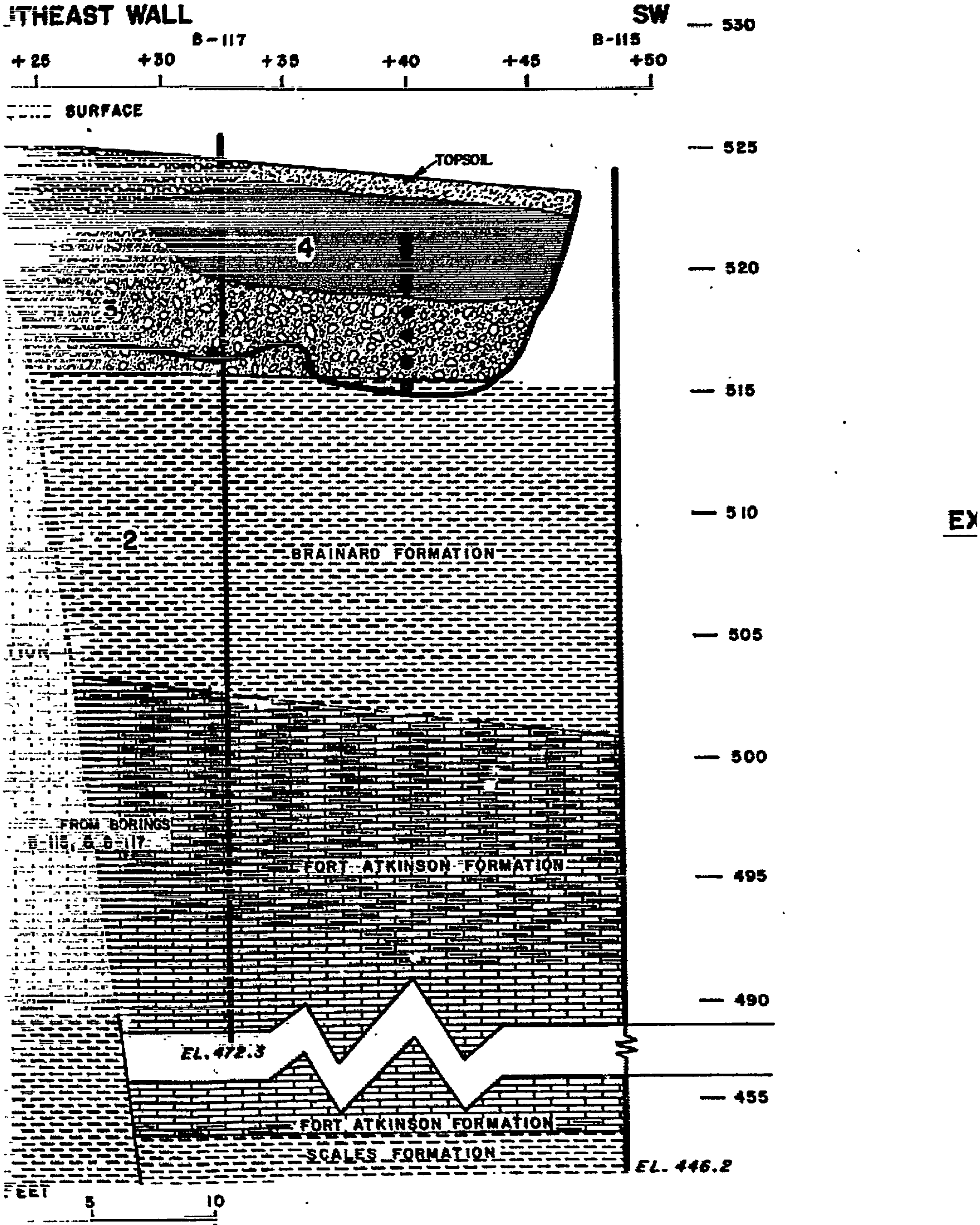
UNIT 4 - TILL: BROWN; SILT, FINE SAND, WITH SOME CLAY AND GLACIAL ERRATICS; UNSORTED MIXTURE OF LOESS, REWORKED TILL, AND COLLUVIUM.

TRENCH CROSS – SEC
SOUTHEAST WALL
T-118

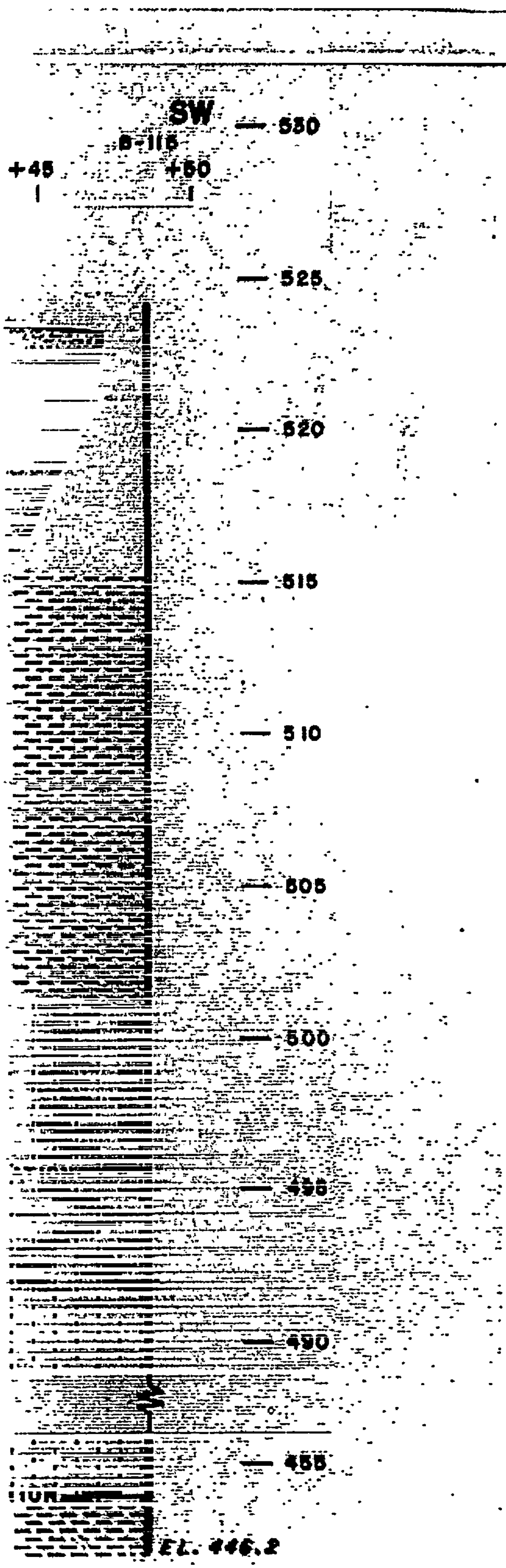
FIGURE 31 SHEET 2 OF



NE
SOUTHEAST WAL
B-114
0+00
+5
+10
+15
+20
+25
527.4
530
525
520
515
510
505
500
495
490
485
ELEVATION IN FEET
GROUND SURFACE
FLOOR OF TRENCH
5
3
1
2
FORT ATKINSON FORMATION
INFERRED FROM BORINGS
B-114, B-115, & B-117
SCALES FORMATION
EL. 485.8
FEET
5
0
5
SAMPLE LOCATION



THEAST WALL
SW
B-117
B-115
+25
+30
+35
+40
+45
+50
SURFACE
TOPSOIL
530
525
520
515
510
505
500
495
490
455
4
3
2
BRAINARD FORMATION
FROM BORINGS
B-115, & B-117
FORT ATKINSON FORMATION
EL. 472.3
FORT ATKINSON FORMATION
SCALES FORMATION
EL. 446.2
FEET
5
10
EX



EXPLANATION

UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE; MEDIUM TO THICK BEDDED; WEATHERS YELLOWISH-BROWN; MODERATELY WEATHERED ALONG BEDDING PLANES, FRACTU AND JOINTS. TOP 11-12 FEET IN B-115 AND B-117 IS MEDIUM GRAY SILTY AND SHALEY LIMESTONE.

UNIT 2 - SHALE: LIGHT GRAY; SILTY SHALE; THIN BEDDE WEATHERS TO LIGHT BROWN AND YELLOWISH-BROWN, EXTREMELY WEATHERED. CALCAREOUS, WITH SOME ARGILLACEOUS BEDS.

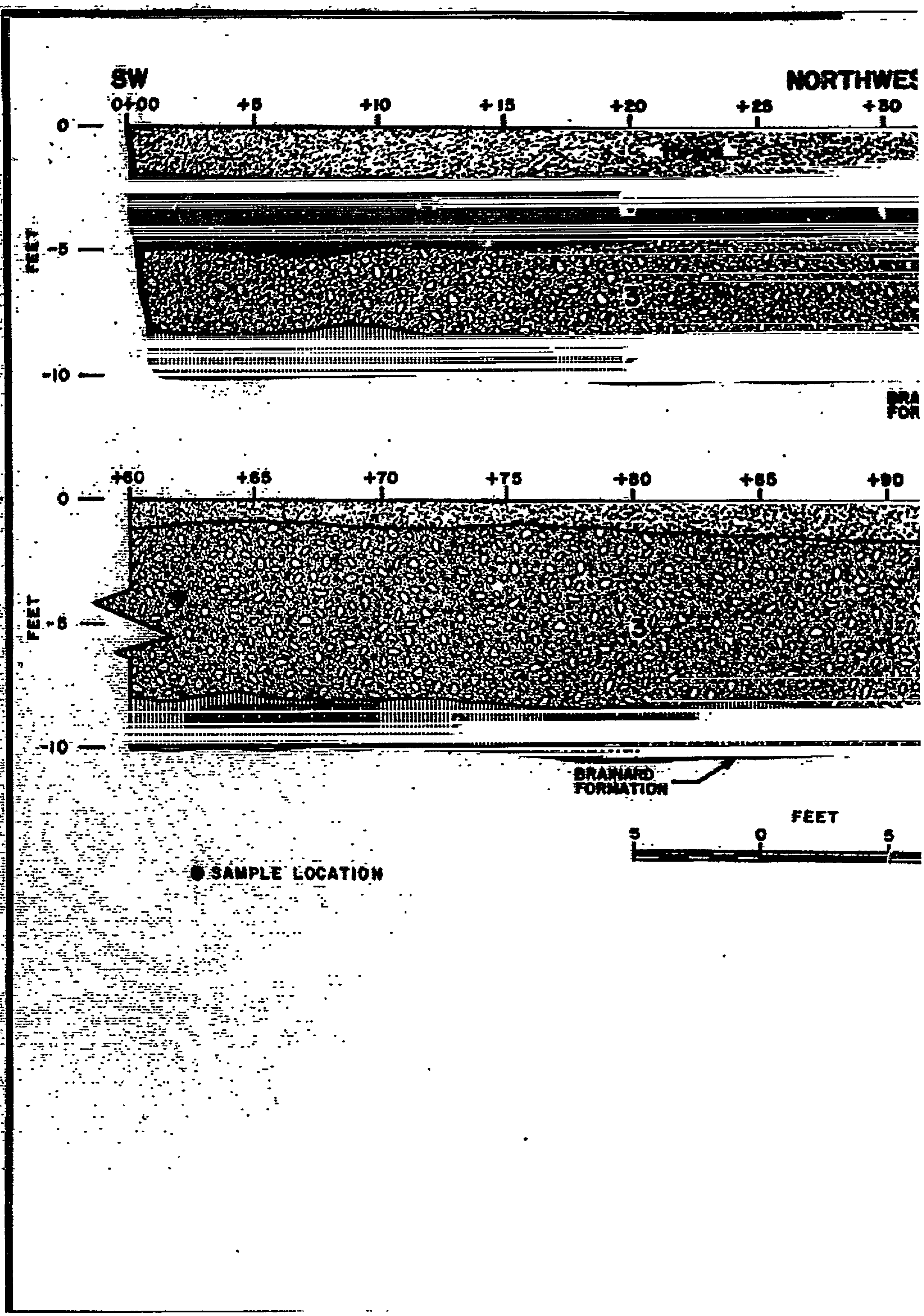
UNIT 3 - TILL: BROWN TO YELLOWISH-BROWN; POORLY SORTED REWORKED TILL, GRAVEL, BOULDERS, AND COBBLES WITH MATRIX OF SILT, SAND, AND CLAY; CALCAREOUS; OXIDIZED.

UNIT 4 - LACUSTRINE: GRAYISH-ORANGE; SILTS WITH SOME CLAYS; LAMINATED LAKE SEDIMENTS.

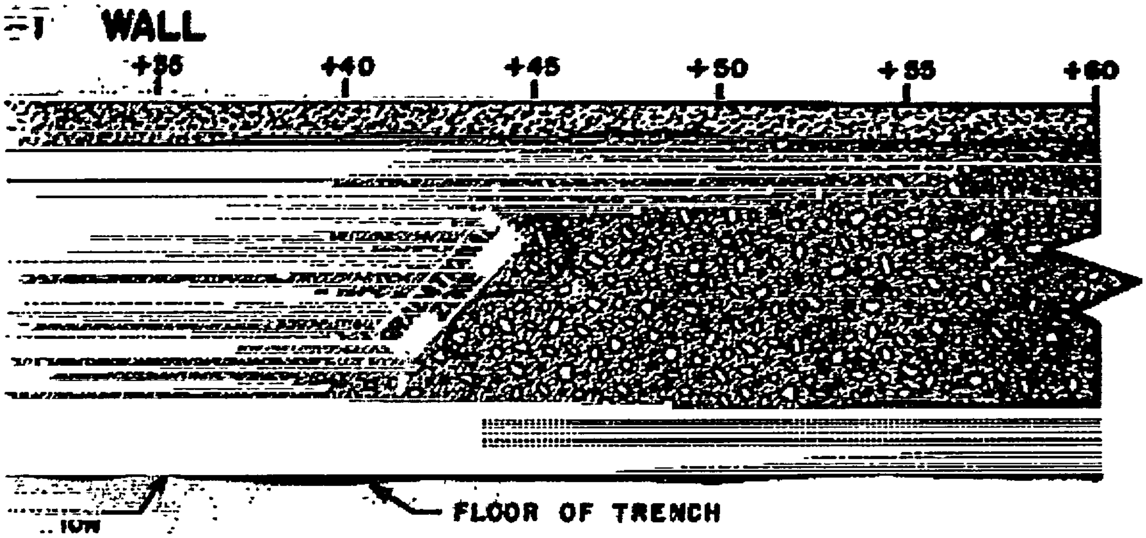
UNIT 5 - FILL: GRAYISH-BROWN TO DARK GRAY; DUMP MATERIAL, BRICKS, FRESH LIMESTONE BLOCKS, BOARDS, TOPSOIL, CONCRETE ETC.

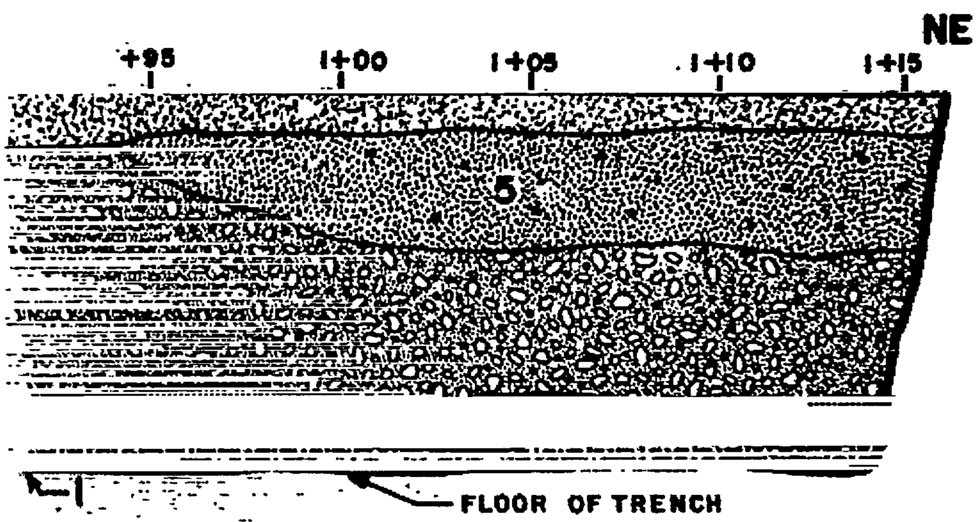
TRENCH CROSS - SE(

T-120



SW
NORTHWES
0+00
+5
+10
+15
+20
+25
+30
0
-5
-10
FEET
3
+60
+65
+70
+75
+80
+85
+90
BRAINARD FORMATION
FEET
5
0
5
SAMPLE LOCATION





EXPLANATION

UNIT 1 - ARGILLACEOUS LIMESTONE: LIGHT GRAY; SILTY, CLAYEY, LIMESTONE, VERY FINE GRAINED; THIN BEDDED; WEATHERS LIGHT YELLOWISH-BROWN, EXTREMELY WEATHERED; CALCAREOUS BEDS IN THE BRAINARD SHALE; DISCONTINUOUSLY PRESENT ALONG TRENCH BASE.

UNIT 2 - SILT AND CLAY: LIGHT GRAY WITH BLUISH-GREEN CAST; FINE GRAINED CLAYS AND SILTS WITH OCCASIONAL ARGILLACEOUS-SILTY LIMESTONE FRAGMENTS; OCCASIONAL, WEAK 1 TO 3 INCH BEDS; EXTREMELY WEATHERED REGOLITH MATERIAL DERIVED FROM BRAINARD SHALE.

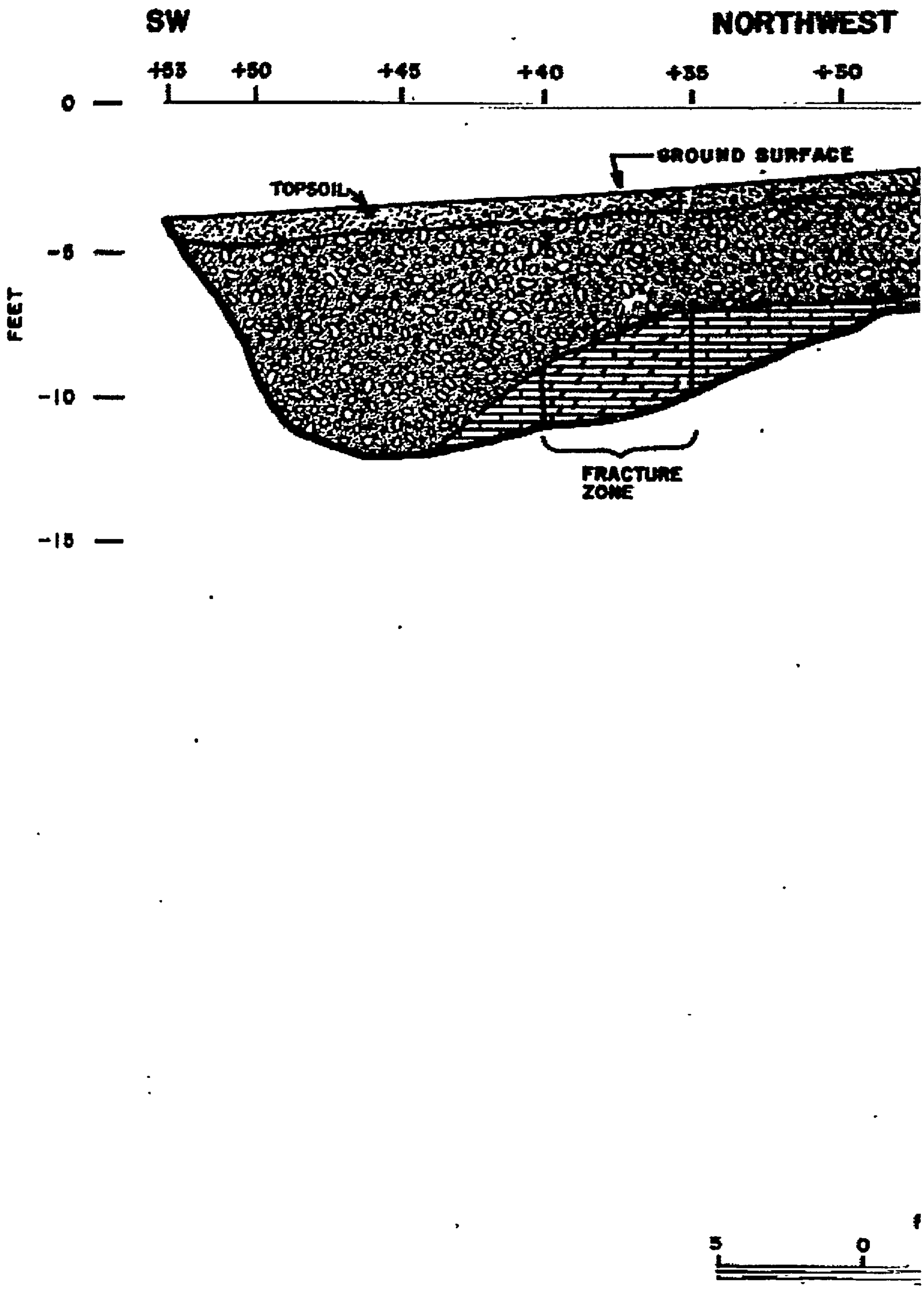
UNIT 3 - TILL: YELLOWISH-BROWN; UNSORTED BOULDERS, COBBLES, AND GRAVEL, WITH CLAY, SILT, AND SAND MATRIX; DOES NOT APPEAR REWORKED IN SOUTHWEST END OF TRENCH. GRADATIONAL ZONE FROM +42 TO +47; IN NORTHEAST END, TILL IS LIGHT BLUISH-GRAY; SILTY-CLAY WITH OCCASIONAL, ERRATIC PEBBLES, COBBLES, BOULDERS, AND PENNSYLVANIAN COAL FRAGMENTS; WEATHERS LIGHT YELLOWISH-BROWN; COARSE PRISMATIC STRUCTURE.

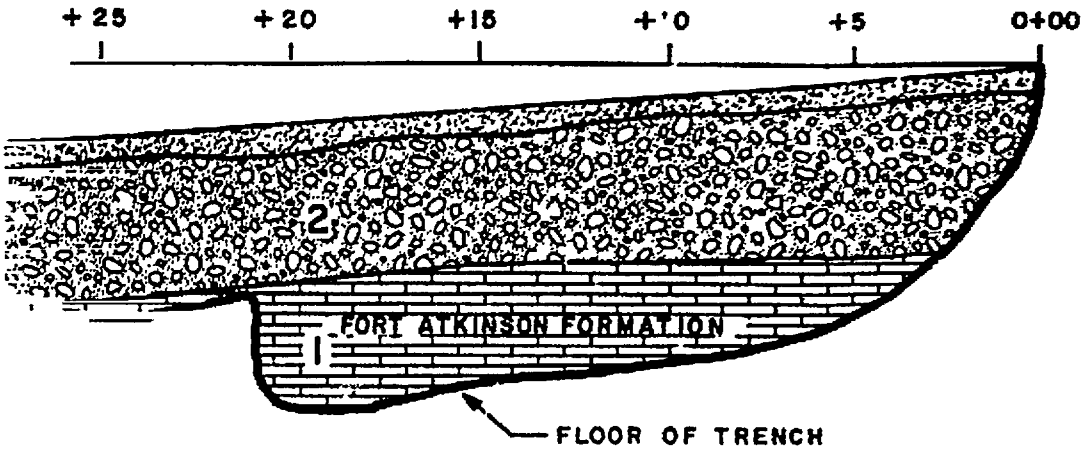
UNIT 4 - LACUSTRINE: LIGHT BROWN; SILTS, WITH SOME CLAY AND TRACE ORGANICS; LAMINATED LAKE DEPOSITS.

UNIT 5 - GRAVEL: DARK YELLOWISH-BROWN; WELL SORTED COARSE GRAVEL, WITH MEDIUM TO COARSE GRAINED SAND LENSES. CONSISTS OF LOCALLY DERIVED AND ERRATIC MATERIALS.

TRENCH CROSS-SECT
T-201

FIGURE

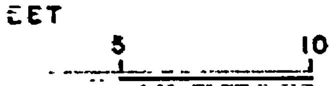

SW
NORTHWEST
+55
+50
+45
+40
+35
+30
0
-5
-10
-15
FEET
GROUND SURFACE
TOPSOIL
FRACTURE ZONE
5
0



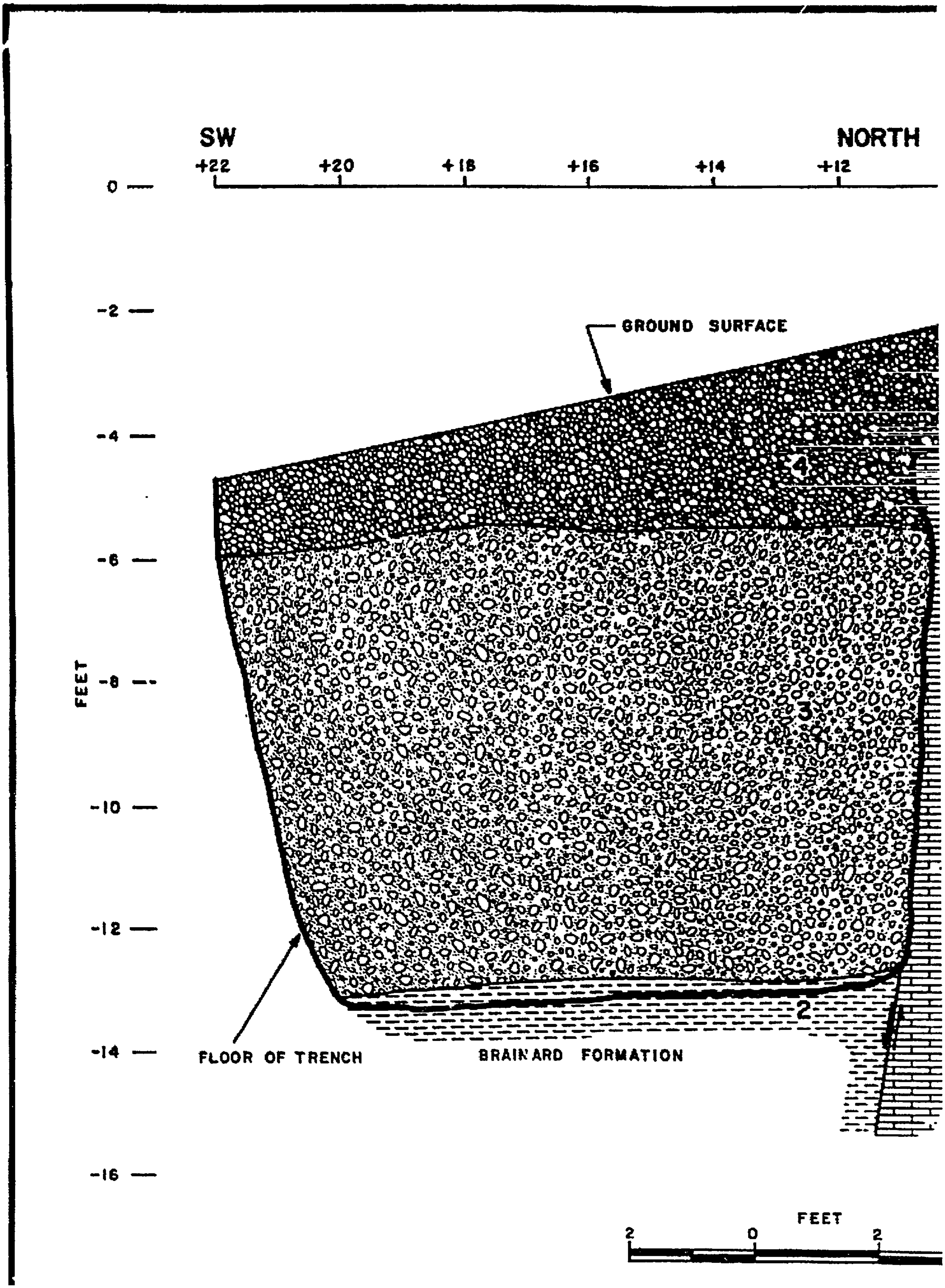
EXPLANATION

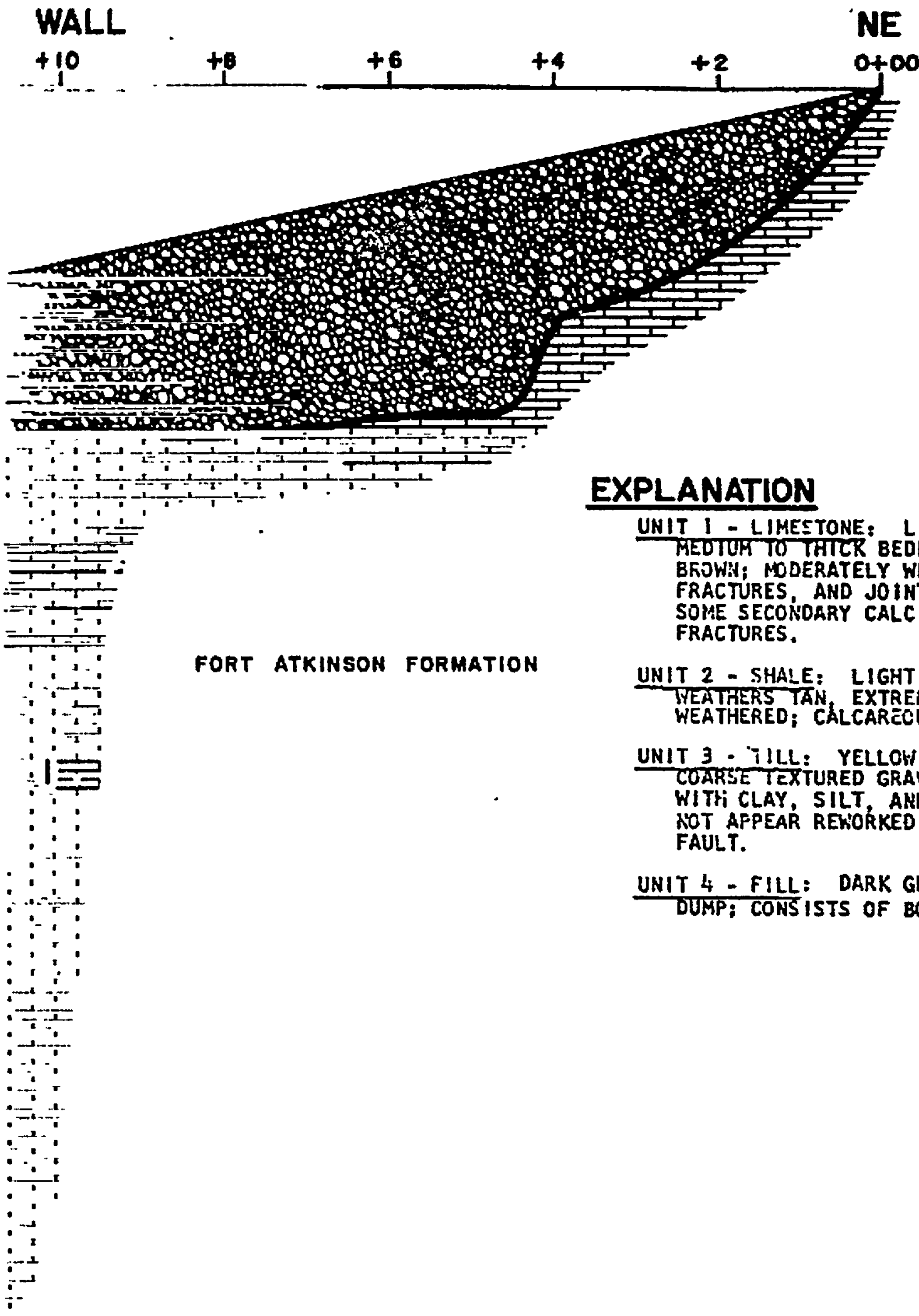
UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLI MEDIUM TO THICK BEDDED; WEATHERS REDDISH-BROWN, MODERATELY TO EXTREMELY WEATHERED ALONG BEDDING PLANES AND FRACTURES. FROM +35 TO +40 A HIGHLY FRACTURED ZONE (FAULT) WAS OBSERVED; BROKEN BEDS DIPPED IN VARIOUS DIRECTIONS AND AMOUNTS AND COULD ONLY BE FOLLOWED 2-3 FEET. ZONE IS EXTREMELY WEATHERED WITH SILTS, CLAY, AND WEATHERED LIMESTONE FRAGMENTS SEPARATING BEDS.

UNIT 2 - TILL: YELLOWISH-BROWN; UNSORTED, COARSE TEXTURED GRAVEL, COBBLED, AND BOULDERS, WITH CLAY, SILT, AND SAND MATRIX; DOES NOT APPEAR REWORKED, DISTORTED, OR OFF-SET WHERE CROSSING FRACTURE ZONE.



TRENCH CROSS-SECTI
T-202


SW
NORTH
+22
+20
+18
+16
+14
+12
0
-2
-4
-6
-8
-10
-12
-14
-16
FEET
GROUND SURFACE
4
3
2
FLOOR OF TRENCH
BRAINARD FORMATION
FEET
2
0
2



EXPLANATION

UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE, MEDIUM TO THICK BEDDED; WEATHERS YELLOWISH-BROWN; MODERATELY WEATHERED ALONG BEDDING PLANES, FRACTURES, AND JOINTS IN UPPER 6 FEET; FOSSILIFERO SOME SECONDARY CALCITE ALONG BEDDING PLANES AND FRACTURES.

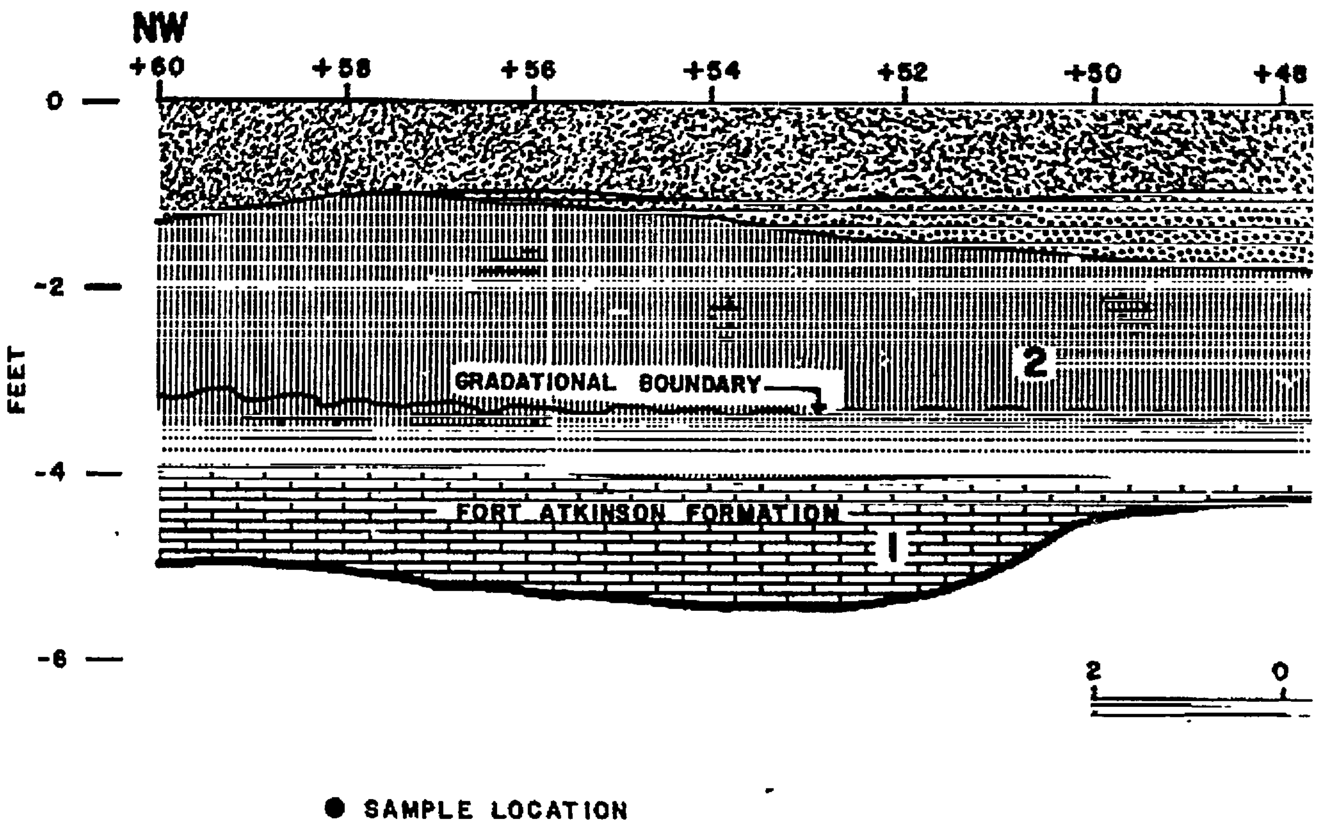
UNIT 2 - SHALE: LIGHT GRAY; SILTY SHALE; THIN BEDDEC WEATHERS TAN, EXTREMELY TO MODERATELY WEATHERED; CALCAREOUS.

UNIT 3 - TILL: YELLOWISH-BROWN; UNSORTED; COARSE TEXTURED GRAVEL, COBBLES, AND BOULDERS, WITH CLAY, SILT, AND SAND MATRIX. DOES NOT APPEAR REWORKED OR DISTORTED ALONG FAULT.

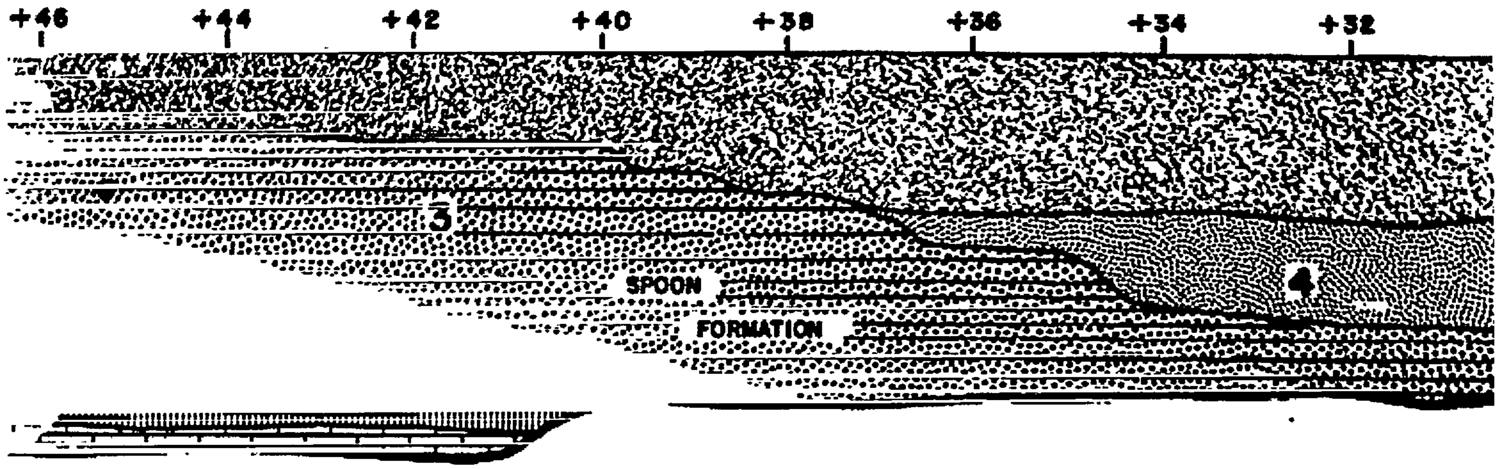
UNIT 4 - FILL: DARK GRAY TO BLACK DEBRIS; GARBAGE DUMP; CONSISTS OF BOTTLES, TIN CANS, BRICKS, ETC.

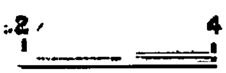
TRENCH CROSS-SECTI
T-203

4


NW
+60
+58
+56
+54
+52
+50
+48
0
-2
-4
-6
FEET
GRADATIONAL BOUNDARY
2
FORT ATKINSON FORMATION
1
2
0
SAMPLE LOCATION

:THEAST WALL





EXPLANATION

UNIT 1 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE; MEDIUM TO THICK BEDDED; WEATHERS YELLOWISH-BROWN; MODERATELY TO EXTREMELY WEATHERED; VERY FOSSILIFEROUS.

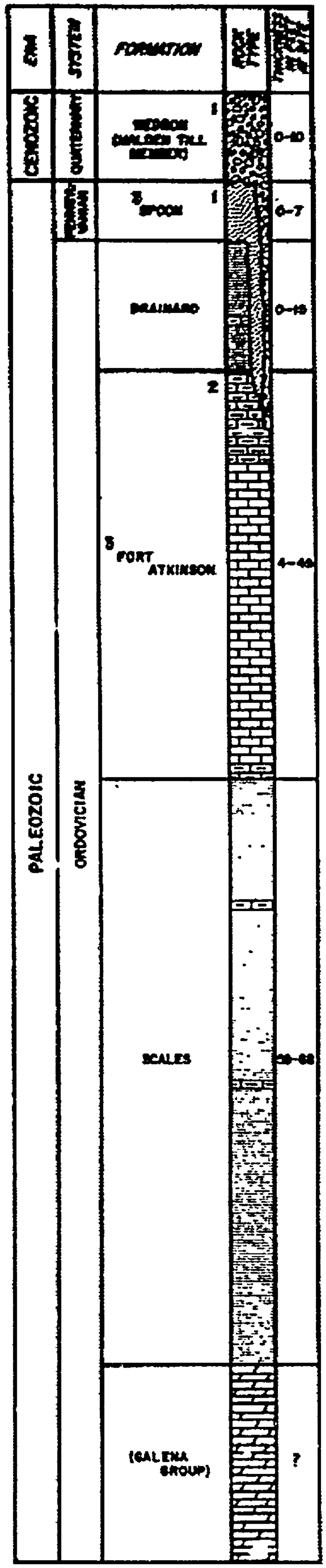
UNIT 2 - REGOLITH: YELLOWISH-BROWN; SILTY CLAY WITH ABUNDANT LIMESTONE FRAGMENTS AND ORDOVICIAN FOSSILS; EXTREMELY WEATHERED RESIDUAL FROM FORT ATKINSON LIMESTONE. LOWER 1 FOOT CONTAINS MORE LIMESTONE FRAGMENTS AND RESIDUAL EXIBITS REMNANT BEDDING.

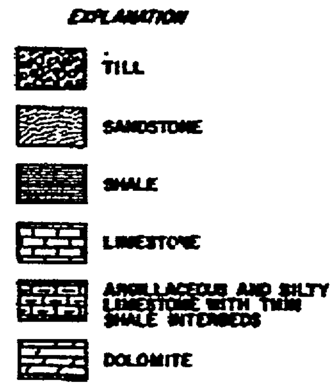
UNIT 3 - SANDSTONE: LIGHT GRAY; MEDIUM TO COARSE GRAINED SAND; THIN BEDDED, SOME MEDIUM BEDS; WEATHERS YELLOWISH-BROWN; MODERATE TO EXTREMELY WEATHERED; MICACEOUS.

UNIT 4 - SAND: YELLOWISH-BROWN TO REDDISH-BROWN; MEDIUM TO COARSE GRAINED SAND WITH SOME SILT AND TRACE CLAY. EXTREMELY WEATHERED SANDSTONE.

TRENCH CROSS-SECTI
T-204

FIGURI





1. NOTE

THE MALDEN TILL MEMBER OF THE WEDRON FORMATION OCCURS AS ISOLATED BODIES OVERLYING THE SPOON, BRAINARD, FORT ATKINSON, AND SCALES FORMATION, THE SPOON FORMATION ALSO OCCURS IN ISOLATED PATCHES AND WAS OBSERVED TO UNCONFORMABLY OVERLIE THE FORT ATKINSON FORMATION. HOWEVER, IN AREAS AROUND THE IMMEDIATE SITE THE SPOON MAY ALSO UNCONFORMABLY OVERLIE THE BRAINARD AND SCALES FORMATIONS.

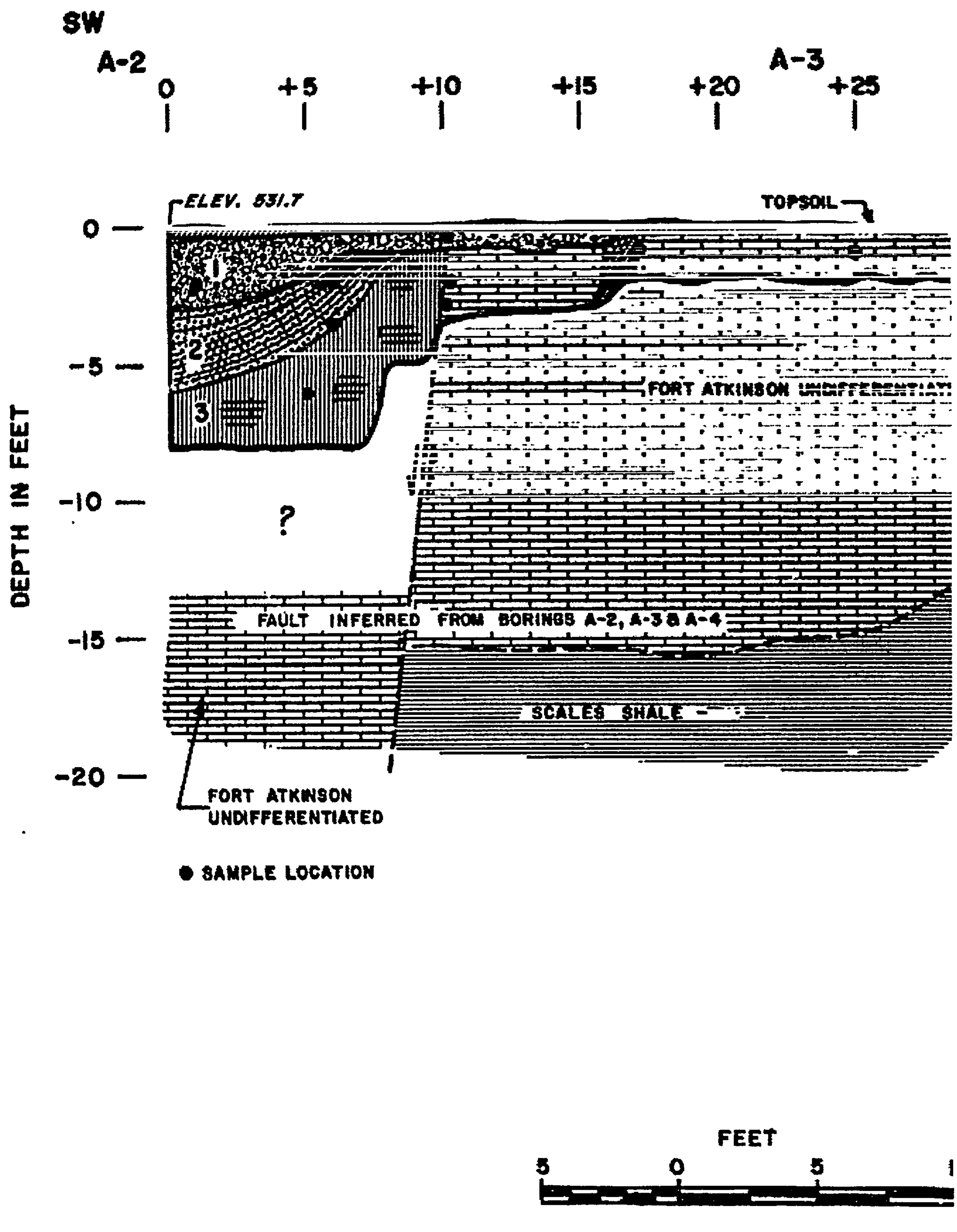
2. NOTE

SOLUTION WIDENED JOINTS WITH ASSOCIATED CLAYEY SILT, SILTY CLAY, FINE GRAINED SANDSTONE AND SILTSTONE FILL MATERIAL ARE FOUND IN THE FORT ATKINSON FORMATION.

3. NOTE

THE SPOON FORMATION HAS PREVIOUSLY BEEN CALLED THE POTTSVILLE SANDSTONE. THE FORT ATKINSON LIMESTONE HAS PREVIOUSLY BEEN CALLED THE DIVINE LIMESTONE. THE POTTSVILLE SANDSTONE AND DIVINE LIMESTONE ARE NO LONGER RECONIZED AS ACCEPTABLE USAGE BY THE ILLINOIS STATE GEOLOGICAL SURVEY.

SITE STRATIGRAPHIC COLUMN



NOTE:
TAKEN FROM DAMES & MOORE REPORT
DATED 10-1-74.

LEGEND

UNIT 1 -TILL: DARK BROWN AND BROWNISH-YELLOW CLAY MATRIX; WITH 40% ROUNDED GRAVELS; POORLY SORTED, WELL GRADED, OCCASIONAL ANGULAR AND SUB-ANGULAR SANDSTONE SLABS; NEAR FAULT, SANDSTONE SLABS ARE GENERALLY HORIZONTAL.

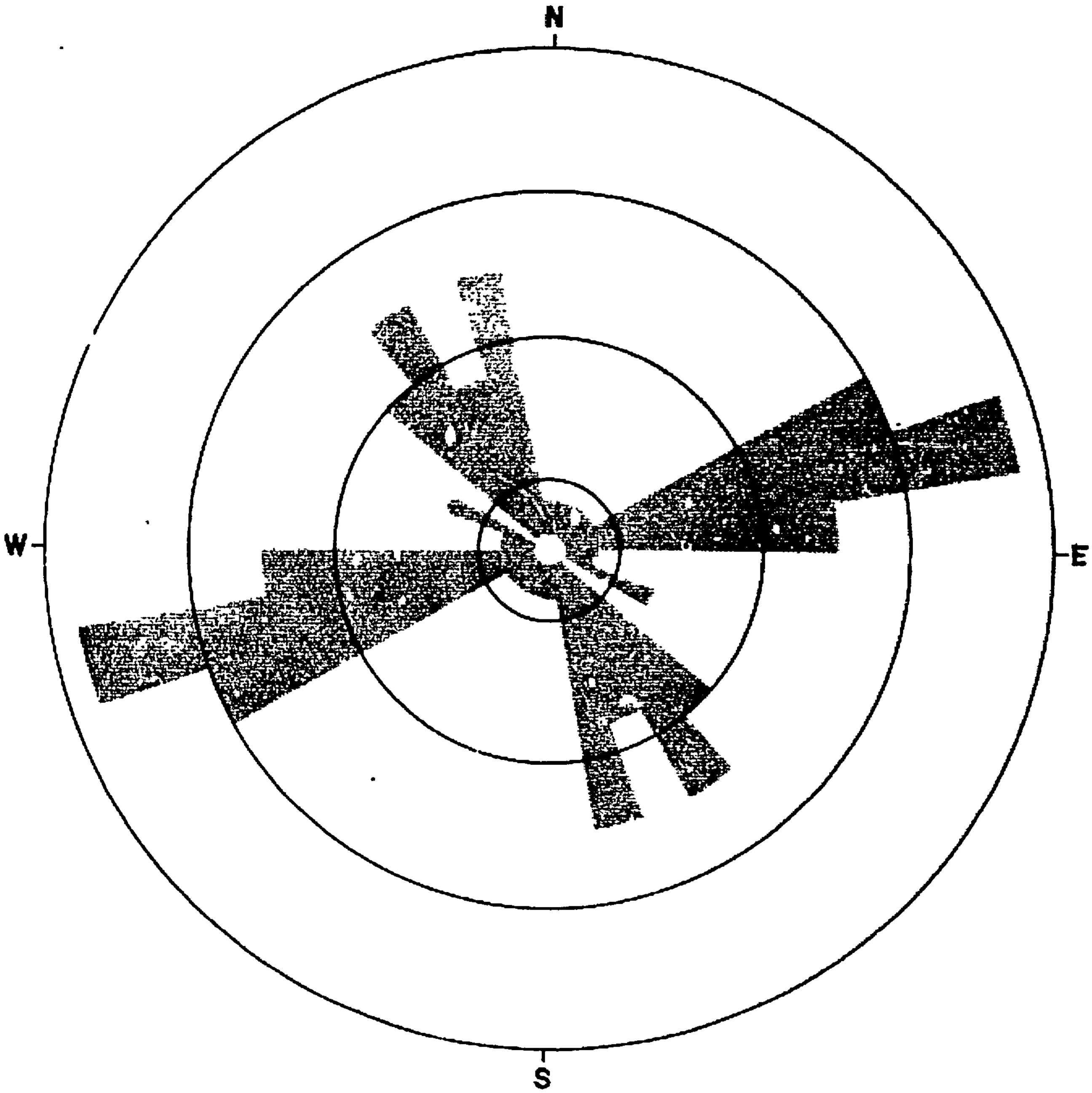
UNIT 2 - SANDSTONE: LIGHT GRAY WITH YELLOWISH-RED LAMINATIONS; FINE-MEDIUM GRAINED, MICACEOUS; FRESH TO MODERATELY WEATHERED; DRAPES 30° SW FROM IMMEDIATE VICINITY OF FAULT. IN IRREGULAR CONTACT WITH TILL ABOVE AND LIMESTONE RUBBLE BELOW POTTSVILLE +6 -4.

UNIT 3 - LIMESTONE CLAY 'RUBBLE': LIGHT GRAY SILTY CLAY MATRIX WITH ANGULAR FRAGMENTS OF LIMESTONE UP TO 3"; VERY CALCAREOUS; POORLY SORTED, POORLY GRADED; LIMESTONE FRAGMENTS CONCENTRATED AT THE SAME LEVELS IN THE WALLS AS THE STEPS OF THE FLOOR. OCCASIONAL WEATHERED CHERT FRAGMENTS

UNIT 4 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE; THICK BEDDED TO MASSIVE; WEATHERS TO RED, COARSE CRYSTALLINE OR COARSE GRAINED TEXTURE. IRREGULAR BEDDING AND JOINT SURFACES COMPLICATED BY SOLUTION ACTIVITY. AT +16, A 1.0-1.5' NEAR VERTICAL GRAYISH-BROWN CLAY MATRIX WITH LIMESTONE FRAGMENTS TO 2" MORE CLAYEY THAN RUBBLE (JOINT FILL OR FAULT GOUGE). IS BEDDING AND WEATHERING ARE TO IRREGULAR TO TRACE ACROSS THIS ZONE; DISPLACEMENT IS NOT DETECTABLE. FAULT IS CHARACTERIZED BY GOUGE AND RUBBLE ONLY, WITH MINOR TRACE LIMONITE IN BROWN CLAY.

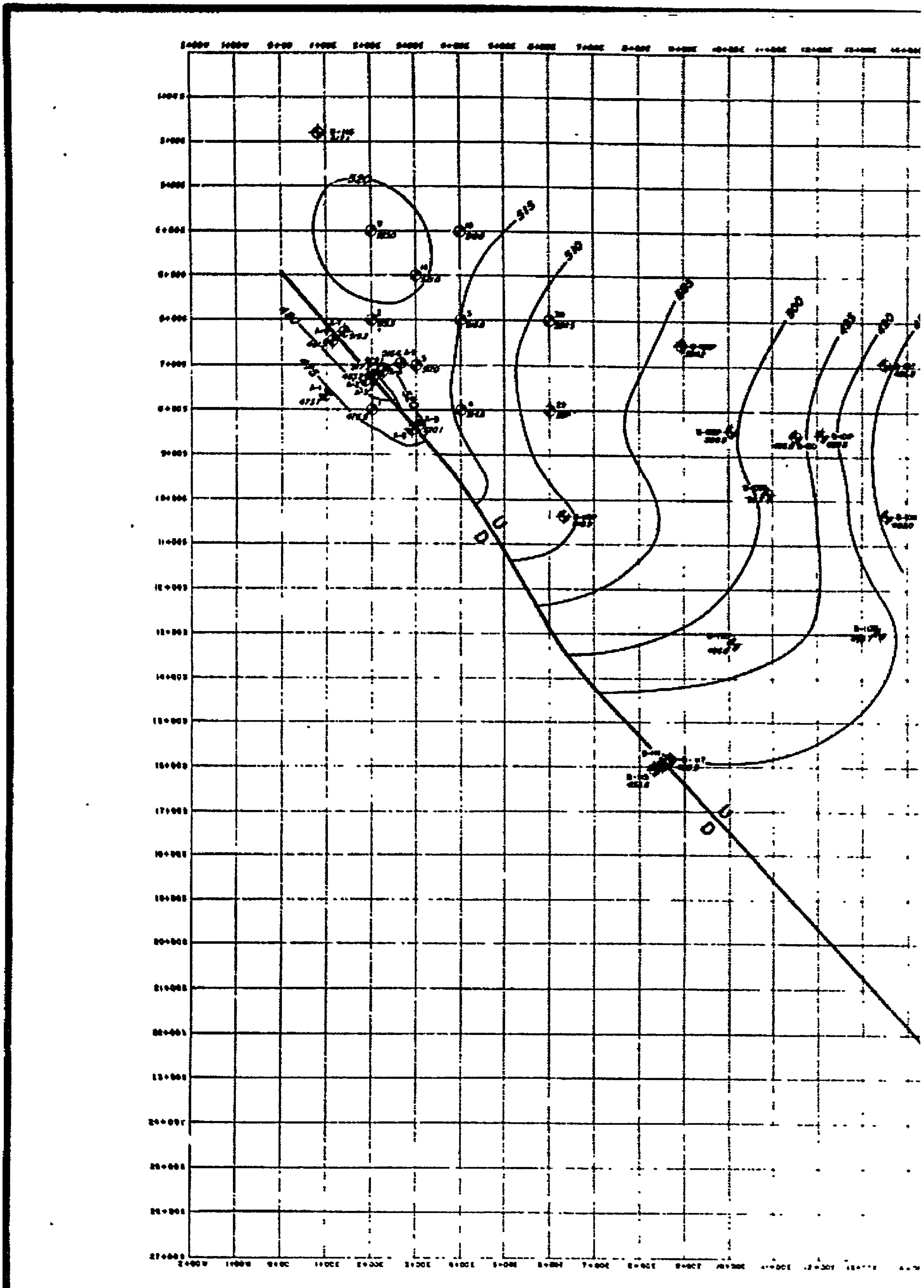
TRENCH CROSS-SECT
AT-2

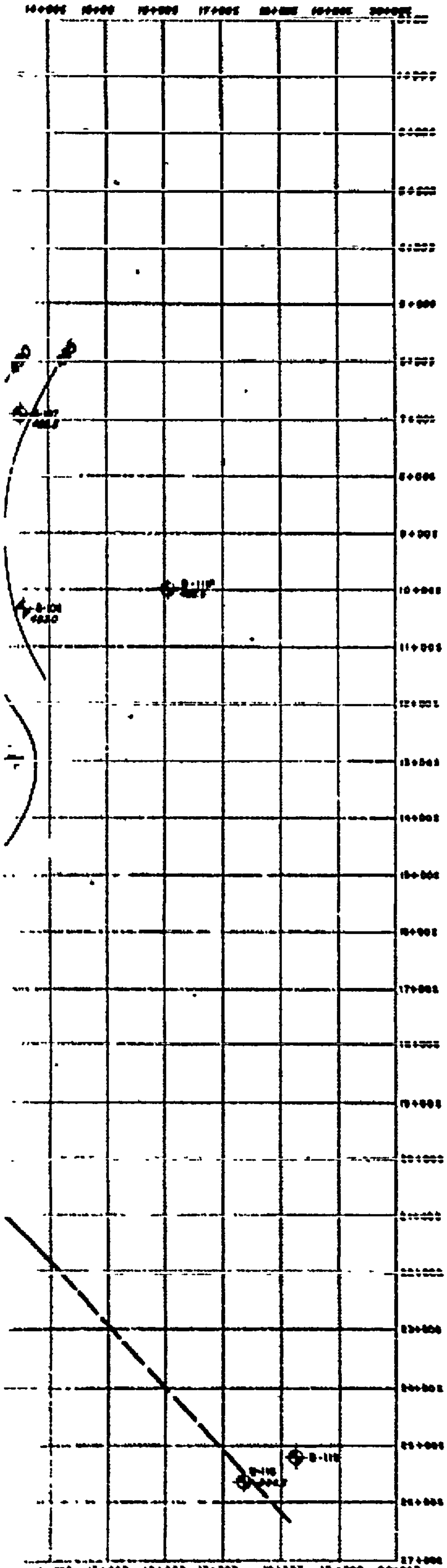
FIGURE 3



ROSE DIAGRAM OF RELATIVE JOINT DIRECTIONS MEASURED IN TRENCHES

FIGURE 39


520
515
510



EXPLANATION

B-101 / 978.5 — LOCATION OF TEST BORINGS, THE NUMBER I… ELEVATION OF THE TOP OF THE SCALES FO…

480' — CONTOUR, INTERVAL 5 FEET

U / D — FAULT

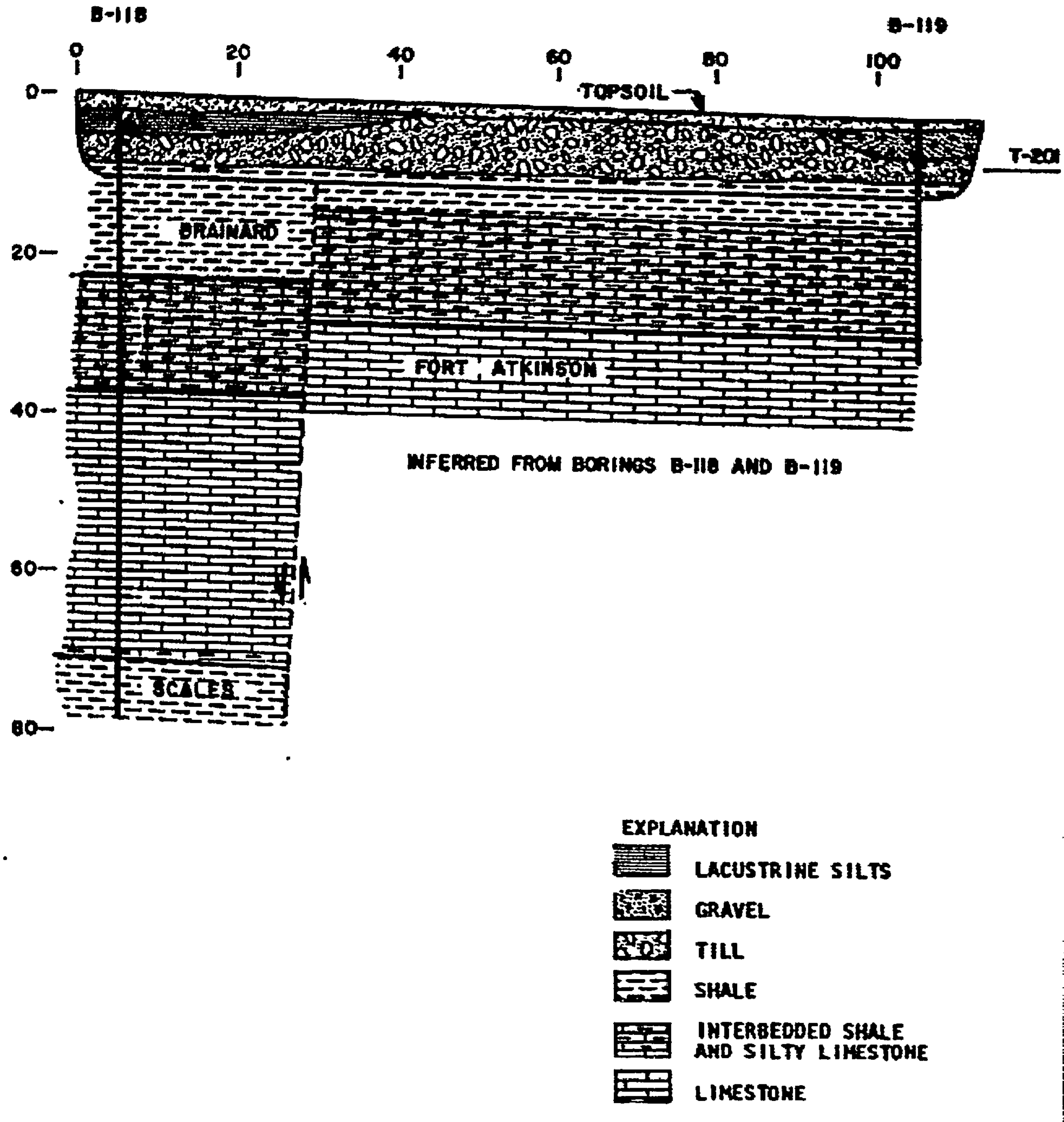
---- INFERRED FAULT

NOTE:

1. B-SERIES BORINGS WERE DRILLED DURING THE PRESENT INVESTIGATION, P INDICATES PIEZOME… INSTALLED. A-SERIES BORINGS ARE FROM DAME… REPORT DATED OCTOBER 1, 1976. BORINGS 1 T… FROM DAMES & MOORE REPORT DATED DECEMBER 1…

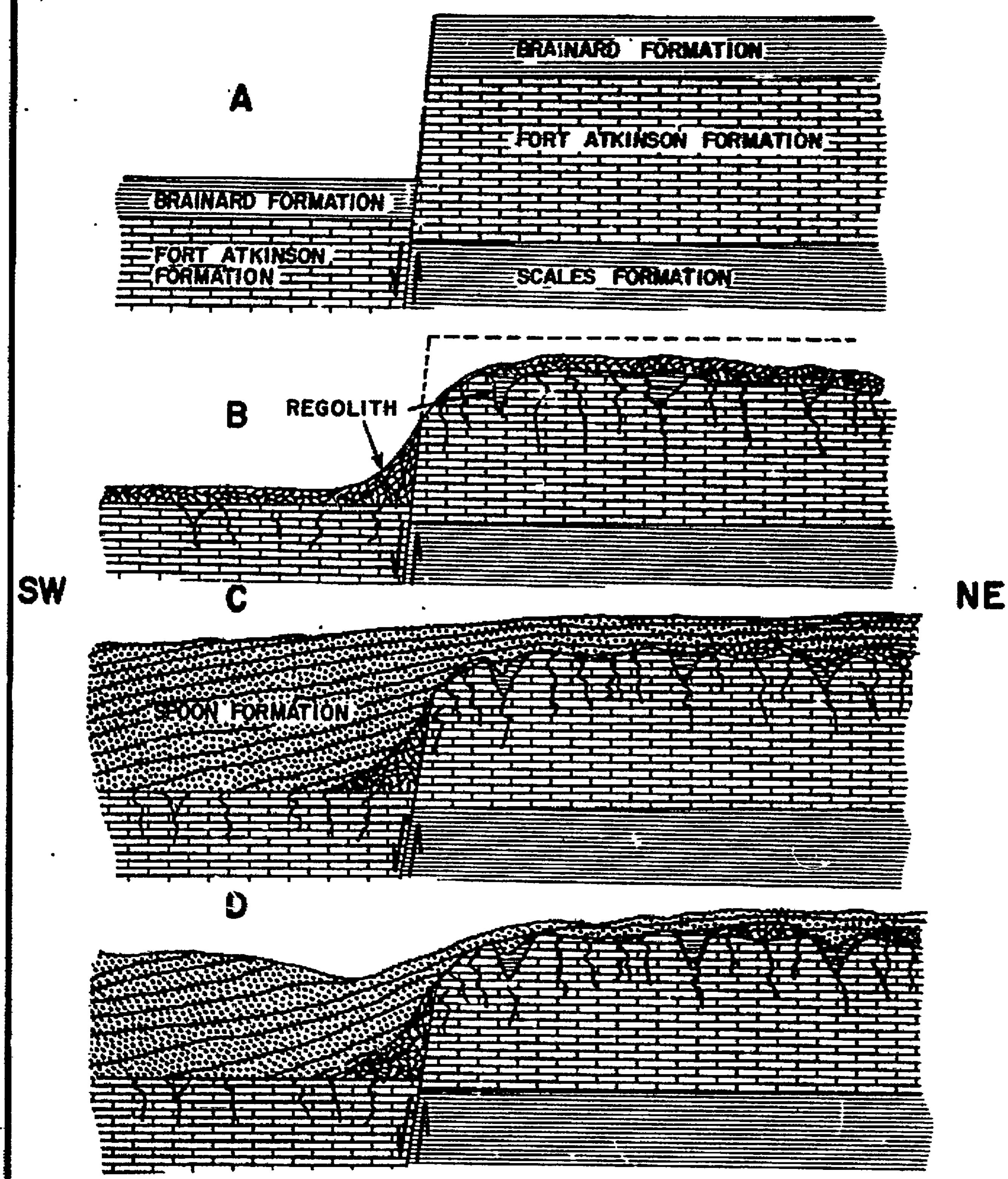
2. CONTOURS WERE INTERPRETED FROM BORING DATA… VARY FROM THAT INDICATED BETWEEN BORINGS.

STRUCTURE ON TO…
THE SCALES FORMA…

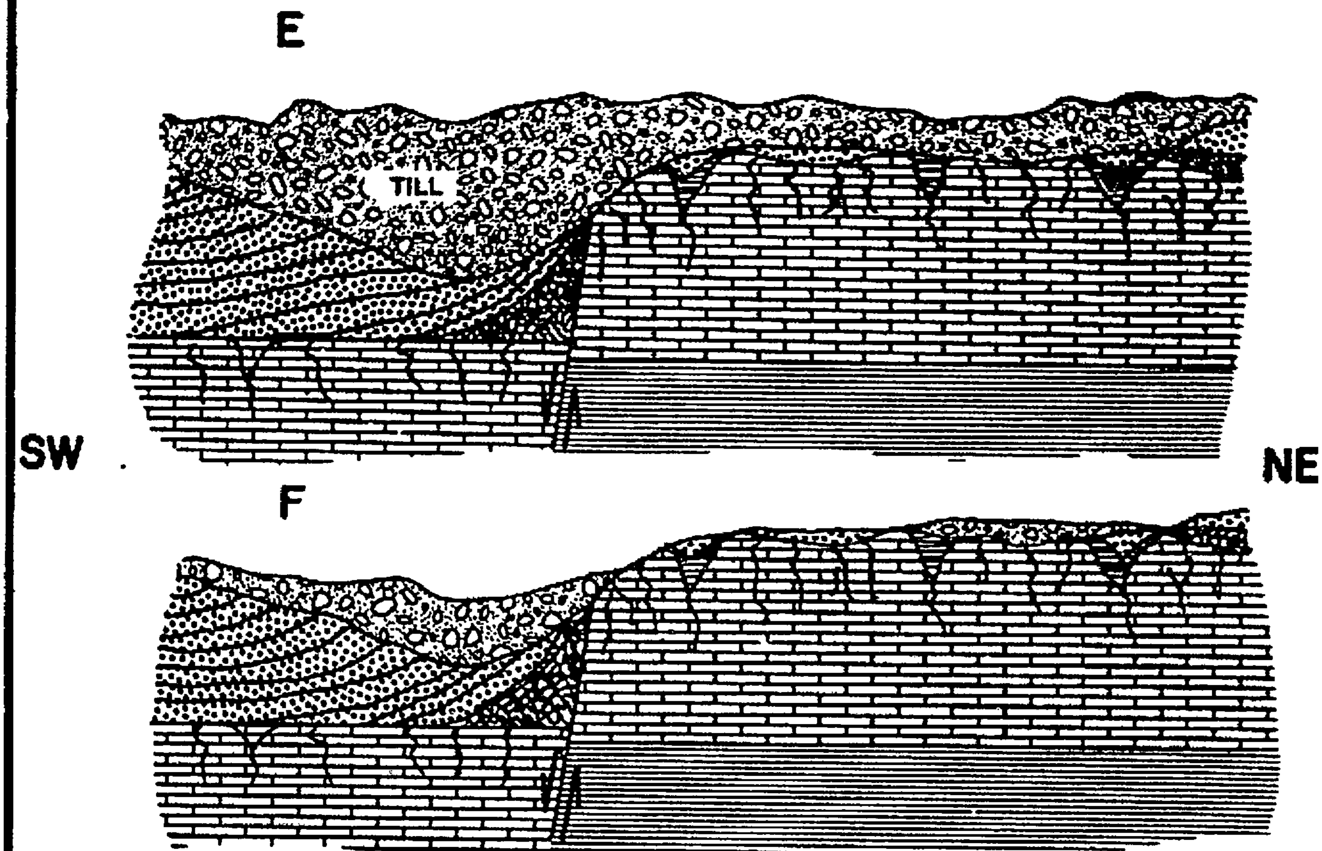


CROSS SECTION
BORINGS B-118 TO B-119

FIGURE 41



GEOLOGICAL HISTORY

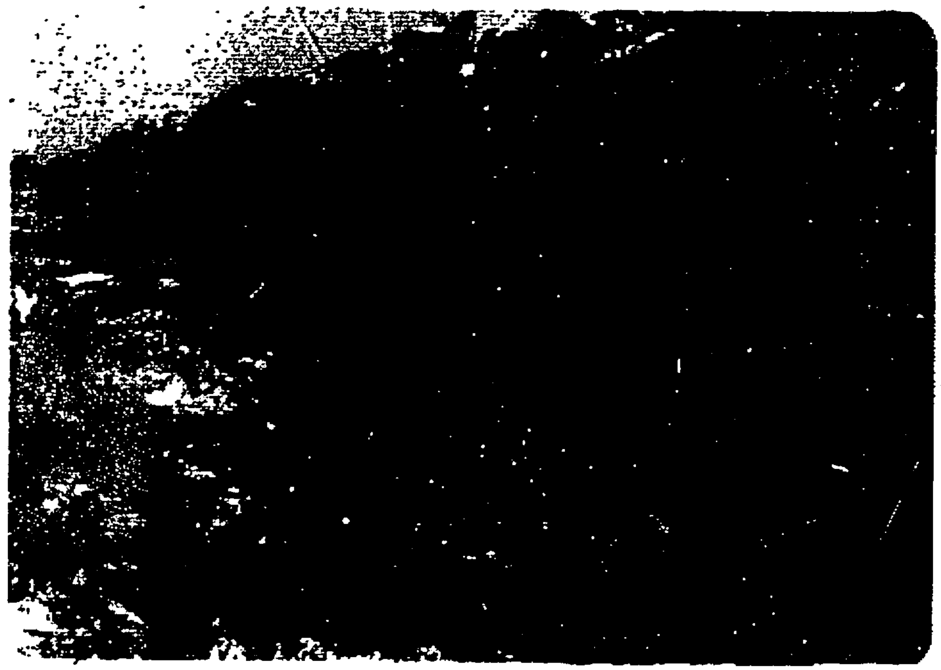


GEOLOGICAL HISTORY
(CONTINUED)

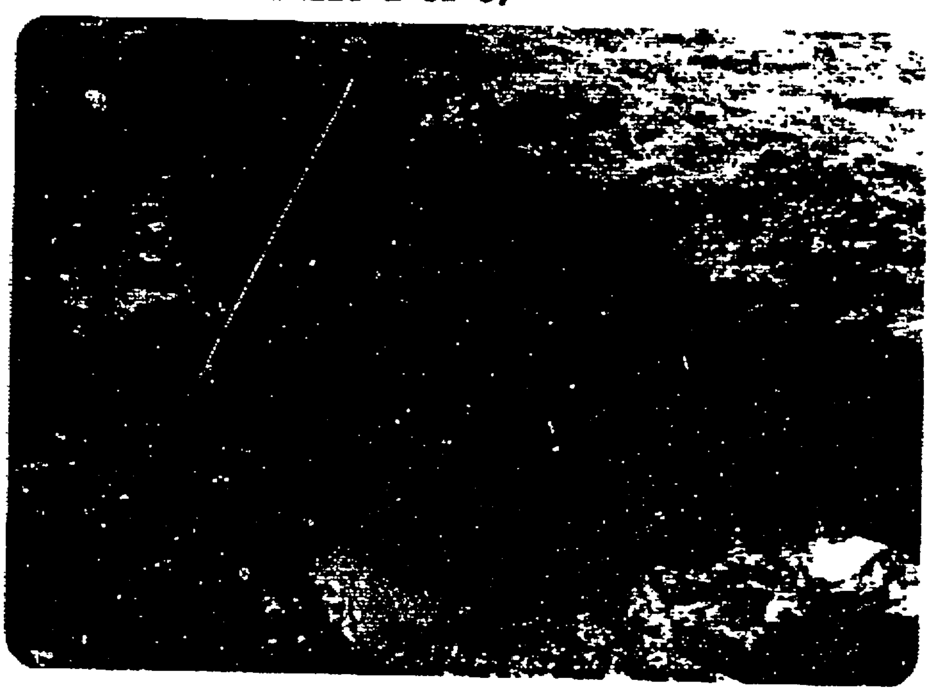
FIGURE 42 SHEET 2 OF 2

APPENDIX A

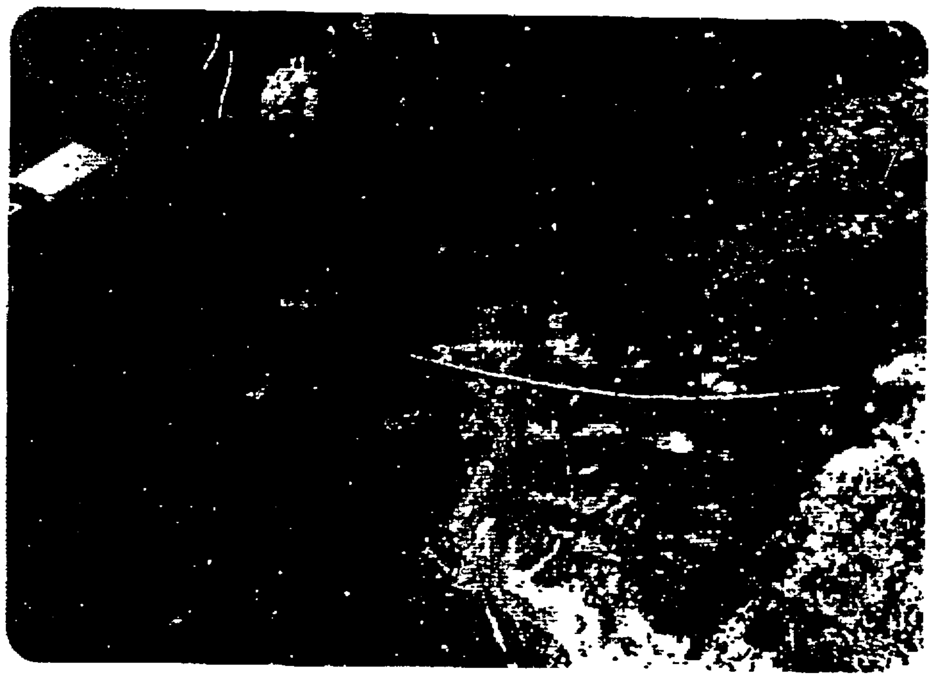
PHOTOGRAPHS OF SELECTED FEATURES FOUND IN TRENCHES



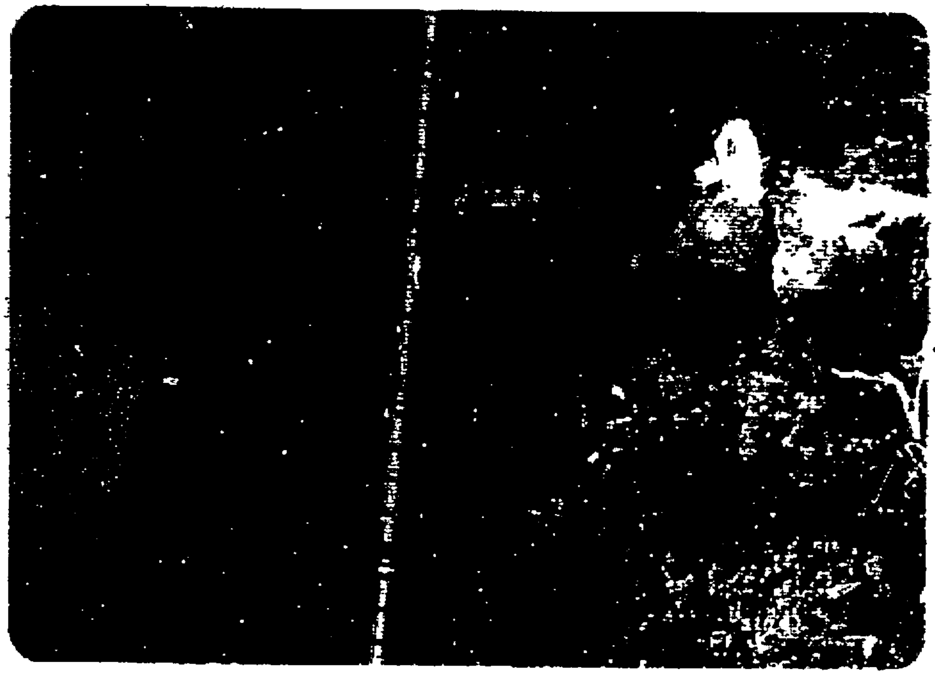
T-101: North wall; view, looking northwest: Joint fill material from 1+27 to 1+37. The major solutioned joint is curvilinear across the trench floor with a general trend of N65°W. The north wall cuts the joint and fill material at about a 30° angle.
(See FIGURE 22 SHEET 1 of 3)



T-101: South wall; view, looking southeast: Joint fill material from 1+50 to 1+57. Clayey silt and silty clay (light greenis gray) with some fine sand and occasional extremely weathered limestone block (light yellowish-brown). A residue containin abundant fossil fragments indicated the former presence of some limestone blocks (light yellowish-brown material within greenish-gray fill).
(See FIGURE 22 SHEET 2 of 3 and 3 of 3)



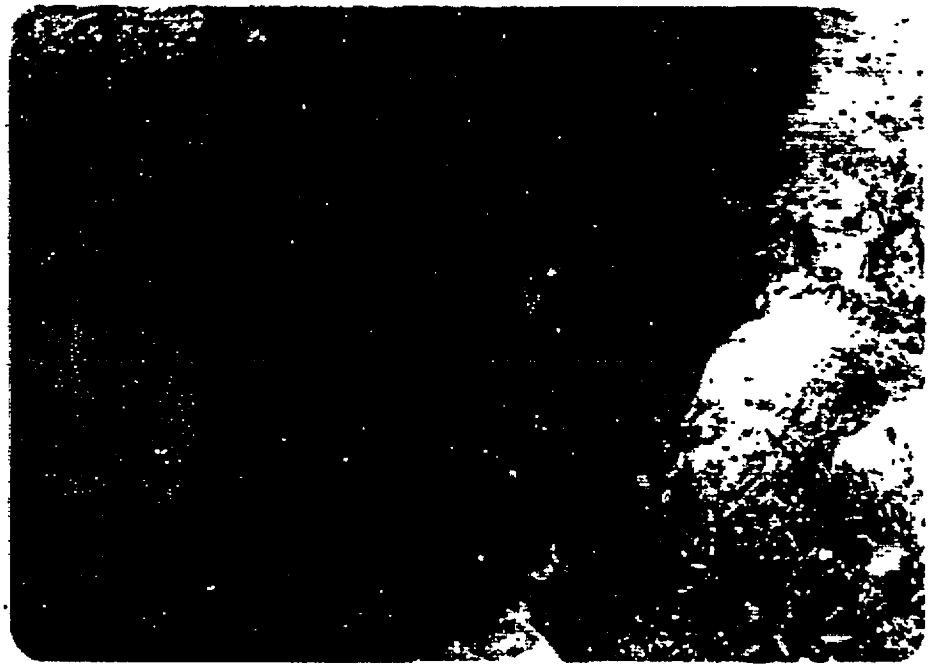
T-101: Trench Floor from 1+20 to 1+27; view, looking southwest: Solution widened joint filled with siltstone (light gray). There is no apparent off-set across the joint. It is 4 to 6 inches wide, trends N64°E, and intersects the major solution widened joint at the north wall at 1+27. (See FIGURE 22 SHEET 1 of 3)



T-101: South wall at 1+42, 4 to 5 foot depths; view, looking southwest: Contact between solutioned Fort Atkinson Limestone surface and silty clay joint fill material. Wavy laminations in the silty clay are parallel to the solutioned surface. The material also fills solutioned bedding planes and subsidiary fractures.
(See FIGURE 22 SHEET 3 of 3)

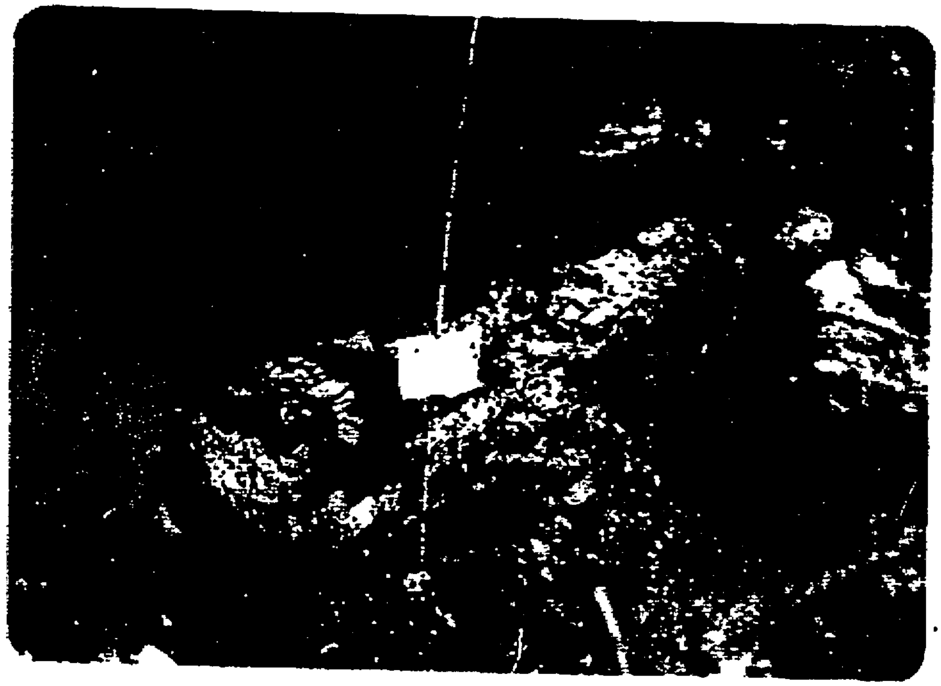
T-101: Floor of trench at 1+47, 6 foot depth; view looking west: Two foot wide section of joint fill material showing laminated silty clay and clayey silt (light greenish-gray) with inter-laminations and interbeds of fine grained sandstone (light yellowish brown).
(See FIGURE 22 SHEET 2 of 3)

T-102: Northwest wall at 0+20; view, looking northwest: Laminated silty clay, silt, and fine sand joint fill material. The solution widened joint is 4.5 feet wide at the trench floor and narrows at the top to 2 to 3 inches wide. The joint trend is N65°W and is apparently the same joint interesected in Trench T-101. (See FIGURE 23)



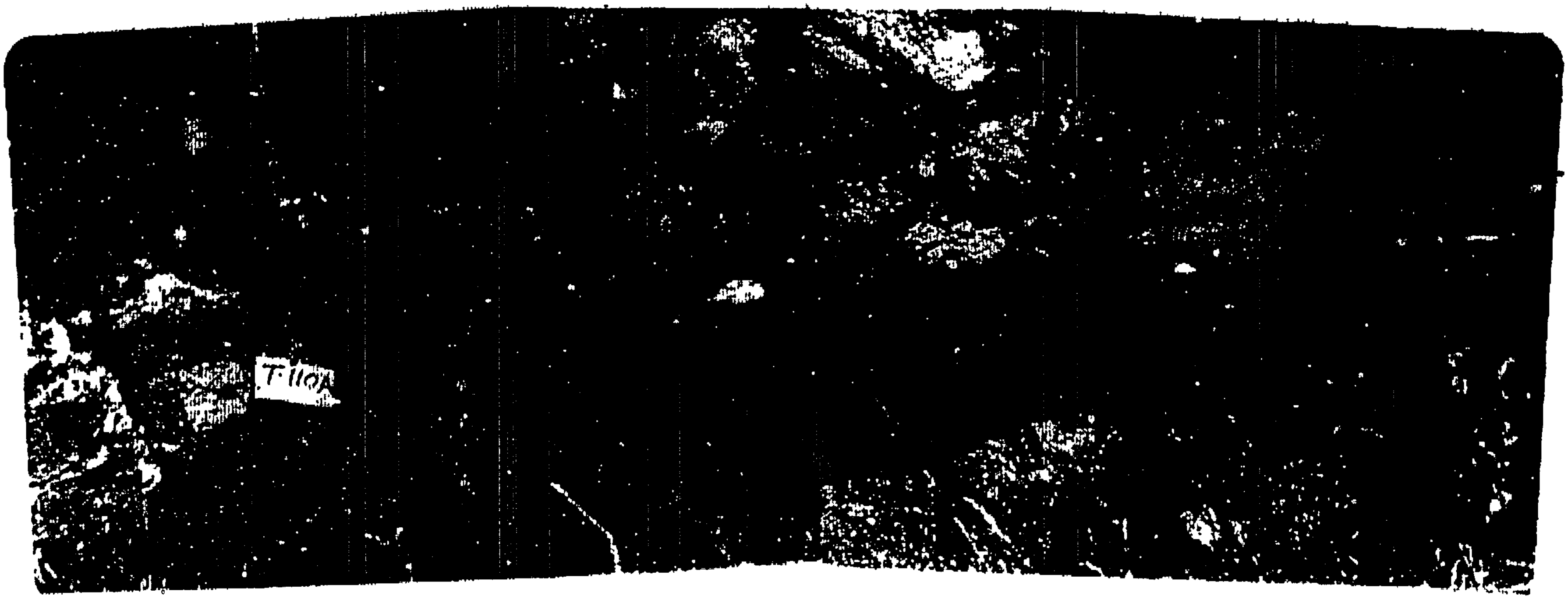
T-106: Southeast wall from 0+52 to 0+68; view, looking south: Solution widened joint (Trend N15°W) with silty clay and clayey silt fill (greenish-gray) with Pennsylvanian cut-and-fill sandstone (yellowish-brown) in the center of joint fill material. Fort Atkinson limestone (gray) exposed in trench floor and in trench wall on left side of fill. Fill material was also found along limestone bedding planes. Sandstone and fill material is overlain by a thin Pleistocene gravel lens, and reworked Malden Till. (See FIGURE 26 SHEET 2 of 2)

T-106: Southeast wall from 0+56 to 0+65; view, looking southeast; Close-up of center of above photo: Pennsylvanian sandstone (yellowish-brown) cutting joint fill material (light greenish-gray) overlain with thin gravel and till.
(See FIGURE 26 SHEET 2 of 2)



T-110A: East wall from 0+20 to 0+28; view, looking southeast: Solution widened joint, filled with clayey silt and fine grained sandstone with some silt (light greenish-gray). Laminations and thin beds of sandstone dip to northwest. Solutioned limestone surface (light yellowish-brown and gray) can be seen at far right of photo. (See FIGURE 27)

T-110A West wall from 0+4 to 0+12; view, looking west: Solution widened joint, filled with clayey silt and some fine sand (light greenish-gray). Fort Atkinson limestone is exposed on both right and left side of photo. The limestone and fill material is overlain with Malden Till. (See FIGURE 27)



T-110A: East wall from 0+2 to 0+13; view, looking east: solution widened joint, filled with clayey silt and some fine sand (light greenish-gray). Fort Atkinson limestone (light gray) exposed at far right and left of photo. NOTE: the small solutioned joints in the limestone on left side of photo. These joints are filled with 2 to 3 inches of silty clay and clayey silt. The limestone and joint fill material is overlain with Malden till (light brown).
(See FIGURE 27)

APPENDIX B

REGIONAL STRUCTURAL PATTERN

APPENDIX B

REGIONAL STRUCTURAL PATTERN

The site structural patterns closely resemble the regional structural patterns, although the site structures are of a much smaller magnitude. The development of structures at the site probably occurred at the same time as the development of the major structures in northeastern Illinois. The major regional structures immediately surrounding the site area are shown on Figure B-1, Structure On Top Of The Galena Group.

The northern part of the Illinois Basin underlies the southwestern portion of the region. The long axis of this elliptical basin strikes north-northwest and the basin includes most of Illinois. One of the major structural zones through the basin is the La Salle Anticlinal Belt (Cady, 1920).

The La Salle Anticlinal Belt is a major structural zone of asymmetrical en echelon folds that trends south-southeasterly through the Illinois Basin from central northern Illinois to extreme southeastern Illinois. The folded zone is very broad at the northern end of the basin and narrows to only a few miles wide at the southern end where it plunges into the deepest part of the basin. Within the northern two-thirds of the basin the belt separates the shallow eastern shelf from the larger and deeper western shelf. Steep dips occur on the western flank into the deeper part of the Illinois Basin, whereas rocks on the eastern flank are nearly flat-lying.

Initial deformation along the La Salle Anticlinal Belt began at the northern end in post-Mississippian, pre-Pennsylvanian time. Deformation migrated progressively southward with time during the Pennsylvanian (Payne, 1940, p. 7; and Eardley, 1962, p. 45). Renewed activity occurred after Pennsylvanian time, probably at the close of the Paleozoic Era.

The Herscher Dome and the Herscher Northwest Anticline are both asymmetrical, doubly-plunging anticlines trending north-northwest. In describing the Herscher Dome, Buschbach (1964, p. 63) states that "As in other en echelon structures in the La Salle Anticlinal Belt, the strata dip rather steeply on the western flank and more gently on the eastern."

The Ashton Arch is an anticline that trends west-northwest across northern Illinois from western Kendall County to central Ogle County. Cambrian and Lower Ordovician rocks are exposed at the surface along the trend of the arch. The Ashton Arch is bounded on the north by the Sandwich Fault Zone. The southwest flank of the arch merges with the La Salle Anticlinal Belt and dips steeply into the Illinois Basin. Structural relief on the southwestern side is approximately 1900 feet, and the maximum relief on the northern side is approximately 900 feet (Willman and Templeton, 1951, p. 121). Uplift along the arch was at least post-Silurian and may have taken place at about the same time that movement occurred along the La Salle Anticlinal Belt in post-Mississippian, pre-Pennsylvanian time, followed by additional lesser uplift in post-Pennsylvanian time (Willman and Templeltom, 1951, p. 123).

The Sandwich Fault Zone trends west-northwest across northern Illinois to within 6 miles northeast of the site. It is mapped on the surface and in subsurface for nearly 90 miles. Numerous short faults near the northwestern end of the zone are associated with it. The fault zone is essentially vertical and forms the northern boundary of the Ashton Arch. The northeastern block is downthrown a maximum of 900 feet by the main fault (Templeton and Willman, 1952). Bristol and Buschbach (1971, Fig. 3) indicate more than 500 feet of vertical displacement in the basement surface. The throw decreases toward the southeastern end of the zone, and a scissors effect causes the southwestern block along a subsidiary fault to be downthrown a little more than a hundred feet (Bristol and Buschbach, 1973, Plate 1). Movements along the Sandwich Fault Zone are dated as post-Silurian, pre-Pleistocene. However, major movements along the fault zone may have occurred when the La Salle Anticlinal Belt was uplifted in post-Mississippian, pre-Pennsylvanian time and lesser movements again in post-Pennsylvanian time (Willman and Templeton, 1951, p. 123).

APPENDIX B

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_____, 1973, Ordovician Galena Group (Trenton) of Illinois-Structure and oil fields; Illinois State Geol. Survey; Ill. Pet. 99, 38p., 1 plate.

Buschbach, T.C., 1964, Cambrian and Ordovician strata of northeastern Illinois: Illinois State Geol. Survey, Rept. Invest. 218, 90 p.

Cady, G.H., 1920, The structure of the La Salle Anticline: Illinois State Geol. Survey, Bull. 36. pp. 85-188.

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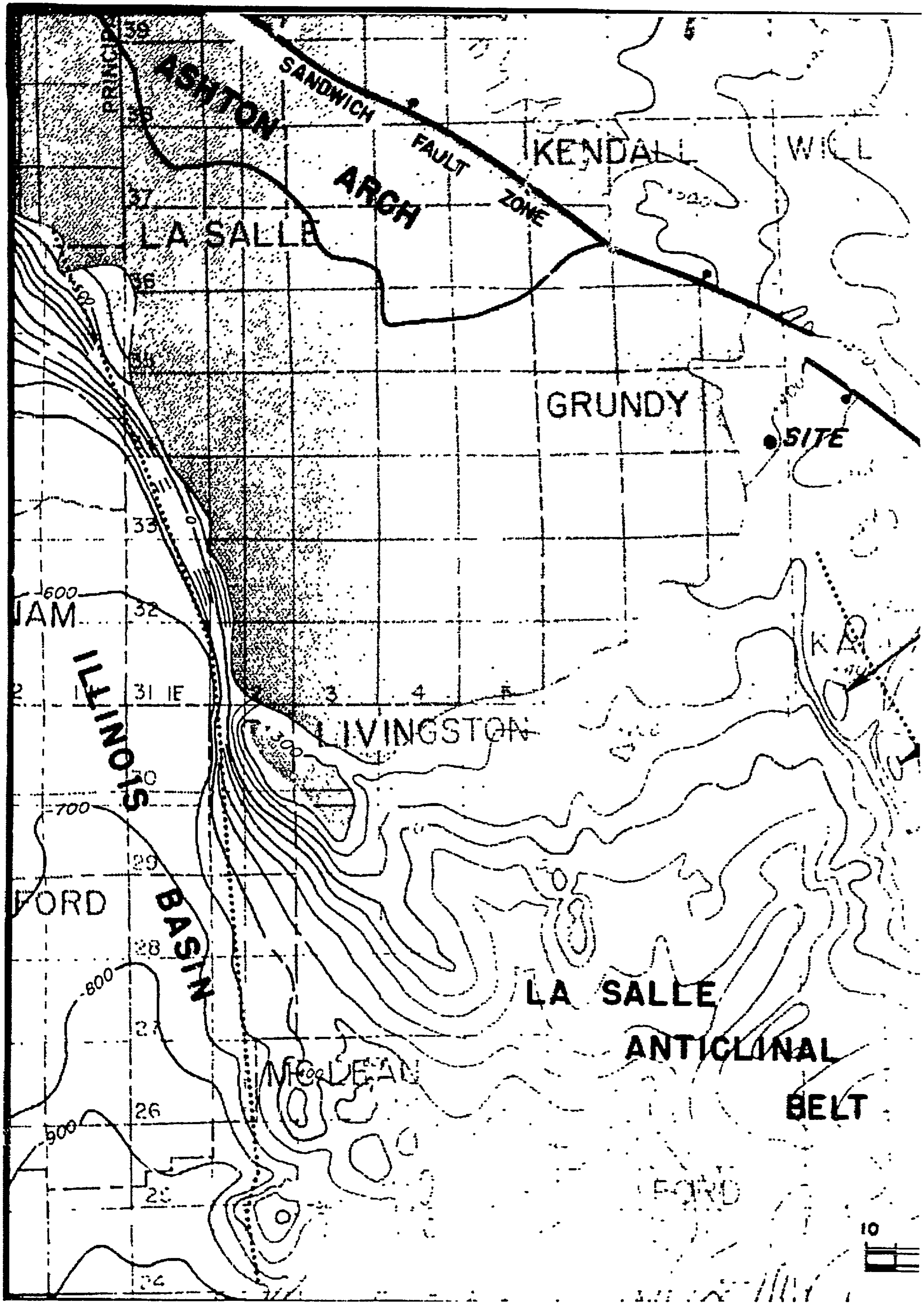

ASHTON ARCH
SANDWICH FAULT ZONE
KENDALL
WILL
LA SALLE
GRUNDY
SITE
LIVINGSTON
ILLINOIS BASIN
LA SALLE ANTICLINAL BELT
FORD
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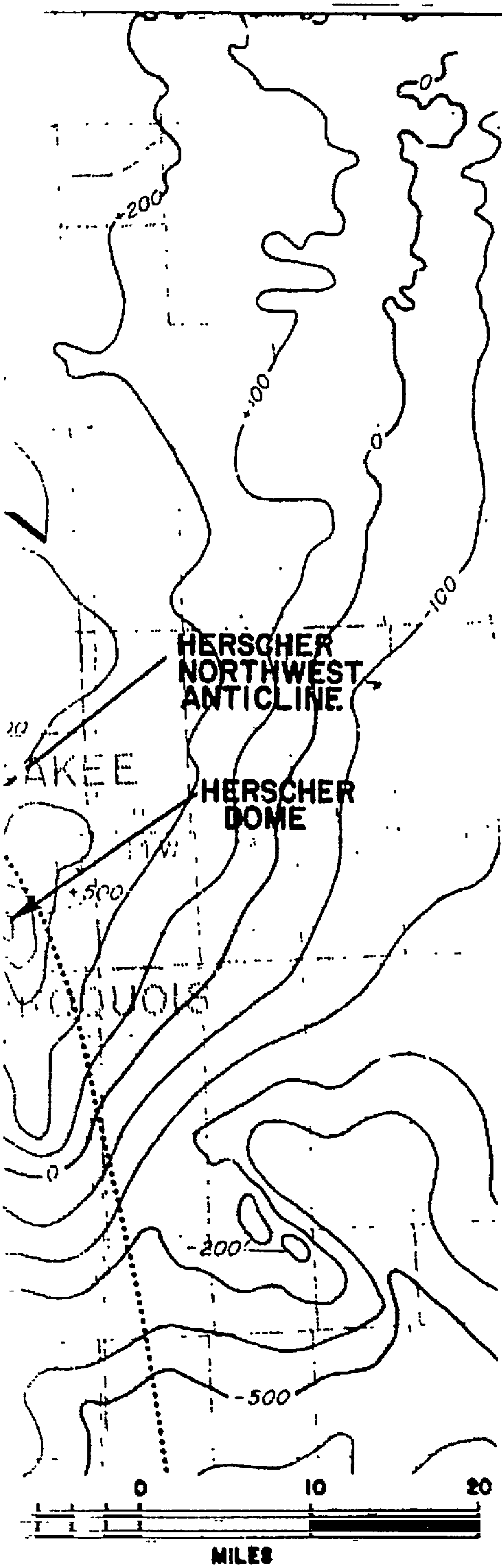

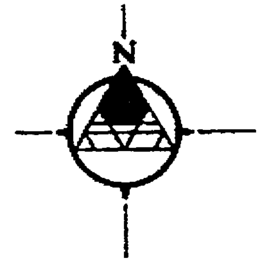

EXPLANATION

-500 CONTOUR INTERVAL 100 FEET; DATUM SEA LEVEL

MAQUOKETA ABSENT, TOP OF GALENA ERODED

FAULT, DOWNTHROWN SIDE INDICATED

APPROXIMATE BOUNDARY OF THE LA SALLE ANTICLINAL BELT

REFERENCE: MODIFIED FROM

BRISTOL, H.M. AND BUSCHBACH, T. 1973, ORDOVICIAN GALENA GROUP (TRENTON) OF ILLINOIS-STRUCTURE AND OIL FIELDS; ILLINOIS STATE GEOLOGICAL SURVEY, ILL. PET. 99 PLATE 1.

STRUCTURE ON 1
OF THE GALENA G

APPENDIX C

LETTER FROM ILLINOIS GEOLOGICAL SURVEY

APPENDIX C

ILLINOIS STATE GEOLOGICAL SURVEY
NATURAL RESOURCES BUILDING, URBANA, ILLINOIS 61801 TELEPHONE 217 344-1481
Jack A. Simon, CHIEF

August 26, 1975

Mr. John Trapp
Dames and Moore
1550 Northwest Highway
Park Ridge, IL 60068

Attention Mr. Robert Aten

Dear John:

As a result of our visit to the GE Nuclear fuel reprocessing plant near Morris, Illinois, on June 11, 1975, Mike Sargent, Paul DuMontelle and I have reviewed the geologic conditions there with particular reference to the age of the faulting. The thoughts and discussion that follow are based principally on our observations made during our June 11, 1975 visit, but also include significant data and ideas furnished by Dr. H. D. Glass based on X-ray diffraction analyses of samples collected, on subsequent discussion and samples provided by Bob Aten, and on previous data and comments by Dr. Tom Buschbach.

Our observations on and samples from the site were focused on several new trenches excavated in hopes that relationships of materials exposed would provide new insight into the age and sequence of the deposits, and the nature and age of the faulting which has been documented at the site.

The following trenches were studied and sampled during our visit: T-120, T-122, T-101, T-110A and D, and T-106. In addition, samples from and a description of trench T-201 were subsequently provided by Bob Aten.

In general, the materials observed above those included with the bedrock consist of 1) glacial till and till-related deposits, 2) water-laid sandy silt, silt and clayey silt deposited in a low energy lake or backwater environment and 3) thin loess-like silt which discontinuously covers the area.

The glacial till observed and sampled in T-120, T-122, T-110A and also in T-201 on the basis of texture and general appearance, would appear to be the Malden Till Member of the Wedron Formation (Woodfordian Substage, Wisconsinan Stage). Since the till is thin, and directly overlies the various bedrock materials, it has locally incorporated considerable amounts of these materials and therefore, takes some of the mineralogical characteristics of the particular material incorporated. In T-120 and T-122, the till is highly illitic but also contains measurable kaolinite, probably derived from Pennsylvanian sediments. No measurable kaolinite was present in the tills sampled from T-110A and T-201 and according to Dr. Glass, these were more relatable to some Brainard Shale influence.

Mr. John Trapp - 2 August 26, 1975

In the four trenches where till or till-like material was present (T-120, T-122, T-110A, T-201), the till overlies formations of the Maquoketa Group. In T-120, which was excavated at right angles to and across the northwest-southeast trending fault zone, the till, very cobbly and sandy up to six feet thick, directly overlies the fault zone. Directly overlying the till are water-laid silts and clay silts up to six feet thick which display uniform thin bedding. Both of these deposits cross the fault zone with no indication of disturbance of the beds or at the contact. The cobbly, sandy till overlies Brainard Shale at the lower level of the trench southwest of the fault and two trenches of Ft. Atkinson Limestone to the northeast. The Brainard Shale appears to abut the limestone. This is the only trench where good evidence of faulting was observed and is along a fault trace verified by drilling.

Since the overlying Pleistocene strata appeared undisturbed in T-120 and the till is identified as the Malden Till Member of the Wedron Formation, deposited approximately 15,000 to 17,000 years before present, no movement along the fault has occurred since its deposition.

Bedrock materials observed in the trenches during the visit to the site include the Ordovician Scales Shale, Ft. Atkinson Limestone, and Brainard Shale of the Maquoketa Group, a light gray silty clay which fills solution channels in the Ft. Atkinson, and a light gray, micaceous, silty, fine to medium-grained sandstone, probably Pennsylvanian in age, present as narrow channel deposits.

The Ft. Atkinson Limestone is the most widespread surface bedrock unit northeast of the principal northwest-southeast trending fault zone located just to the southwest of the Main Process Building, and is the upthrown block with about 40 feet of displacement shown by drilling. At the surface in this area is only a few feet of modern soil and Pleistocene materials overlying the Ft. Atkinson. The surface of the Ft. Atkinson is characterized by a weathered surface of thin slabs of yellowish brown limestone up to four inches thick with many vertical fractures and joints. It becomes somewhat more massive at three to four feet. The surface is also characterized by what appears to be a system of solution channels up to six feet wide which contain a fill of light gray, silty clay locally containing weathered blocks of limestone, e.g., T-101.

Another feature of this surface are possible areas of glacial gouge where sizeable areas of the Ft. Atkinson Limestone appear to have been removed by glacial ice from the top of the Scales Shale and then filled with till which abuts the limestone and rests on the shale. Trench T-122 appears to display an example of such a feature. Close examination, however, indicated that the Scales extends underneath the Ft. Atkinson.

The youngest pre-Pleistocene deposits observed are thin, shallow channel deposits of light gray, micaceous, fine to medium sandstone, which were observed to cut across the gray, silty clay solution-channel fill in the Ft. Atkinson Limestone in trench T-106.

The precise temporal relationship between the gray, silty clay solution-channel fill and the sandstone is not certain. However, the sandstone being micaceous and containing good, authigenic kaolinite strongly suggests some Pennsylvanian material, while the clay filling the solution channels has no significant kaolinite, suggesting a pre-Pennsylvanian age. The relationship of these deposits to the faulting has not been clearly established as there has still not been found an exposure of either deposit blanketing the fault zone.

The best interpretation places the age of the faulting in question as pre-Pennsylvanian, but this is based on indirect evidence in other investigations. Evidence in T-120 substantiates that no faulting has occurred since the deposition of the Malden Till Member approximately 15,000 to 17,000 years before present.

As a broad overview, the location and orientation of the principal fault zone established at the site and its relationship to the Sandwich Fault Zone only six miles to the northeast, with a similar orientation, makes it difficult to argue against a rather direct relationship between the two fault zones.

Very truly yours,

John P. Kempton (2,3)

John P. Kempton
Geologist
Hydrogeology and Geophysics Section

END