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I hereby recommend that the thesis prepared under my supervision by NORMAN C HESTER

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be accepted as fulfilling this part of the requirements for the degree of MASTER OF SCIENCE

Approved by:

[signatures]

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A STUDY OF HIGH-LEVEL VALLEYS IN SOUTHWEST HAMILTON COUNTY, OHIO

A dissertation submitted to the

Graduate School of Arts and Sciences

of the University of Cincinnati

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requirements for the degree of

MASTER OF SCIENCE

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by

Norman C. Hester

B.S. University of Cincinnati

1962

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The writer gratefully acknowledges the suggestions and criticisms offered by Professor R. H. Durrell under whose direction this thesis was written. The writer wishes also to thank those members of the faculty for their advice and suggestions.

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The writer is deeply indebted to the H. C. Nutting Company for the use of their drilling equipment, and the Ohio Academy of Science and the Fenneman Fund for financial aid to partially support this investigation.

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INTRODUCTION

In southwestern Hamilton County, between the Great Miami River and Dry Fork Creek, there are three dissected high level valleys. All three of these valleys are very similar in size and elevation. The fluvial deposits within them are distinct in that they are characteristic neither of the glacial materials nor of the local bedrock. Because of these similarities, intriguing questions arise, such as the origin of the valleys, the possible relationship between them, the direction of their flow, related contemporaneous drainage, and age.

It is the purpose of this thesis to examine and describe the three valleys and their deposits. Using the information gathered in the field, from maps, aerial photos, seismic and drill hole data, interpretations are made in an attempt to solve these problems and to reconstruct the drainage history from Pliocene time to the present.

METHOD OF STUDY

The area under investigation, which is located in southwest Hamilton County, Ohio(Fig. 1), is covered by the Addyston, Hooven, Shandon, and Harrison 7.5 minute quadrangles.

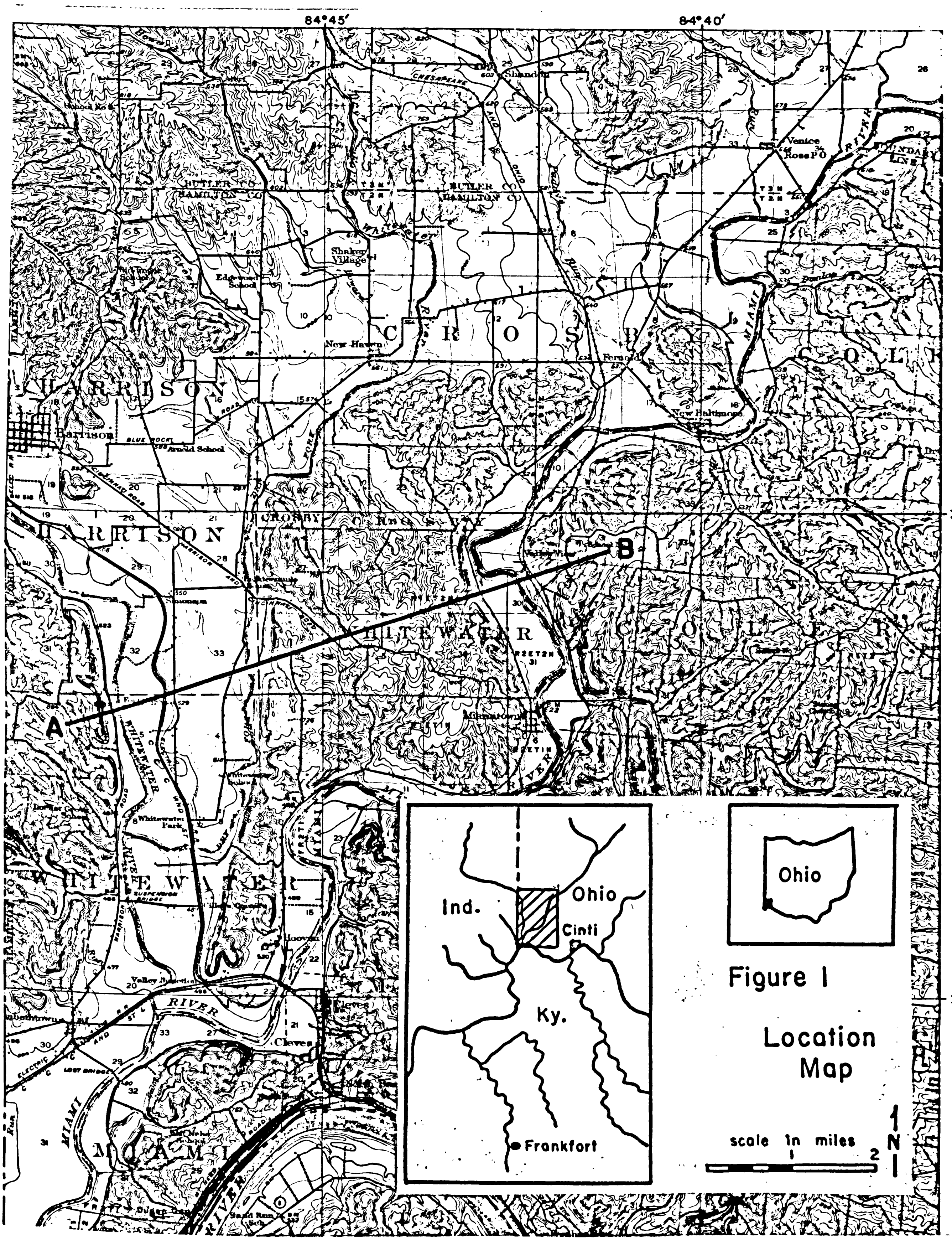

Figure I

Location Map

For most of the field work, which was carried on during the spring and fall of 1964 and the winter and spring of 1965, aerial photos were used in conjunction with the 7.5 minute topographic quadrangle maps. Topographic maps at the scale of 1:2400 prepared by the City of Cincinnati and Hamilton County were utilized for detailed work in Valley III(Fig. 5).

For determining general elevations the topographic maps were adequate; however, for accurate location of bedrock-bedload elevations a transit was used.

The MD-1 Engineering Refraction Seismograph of the Department of Geology was employed in an effort to determine the types and thickness of the valley filling and to profile the bedrock. A Mobile B-40 drilling rig with hollow stem augers was made available by the H. C. Nutting Company for test drilling in order to verify and correlate the seismic data.

GENERAL GEOLOGY

Geomorphology

The thesis area is delimited by the Great Miami and Whitewater Valleys(Fig. 1). This area, which lies between major north-south trending divides 900-950 feet in elevation, occupies a lowland which was presumably developed during Late Tertiary time as part of the Lexington peneplain(Fenneman,1938). Remnants of this lowland occur at approximately 800 feet(Fig. 2). Intermediate levels

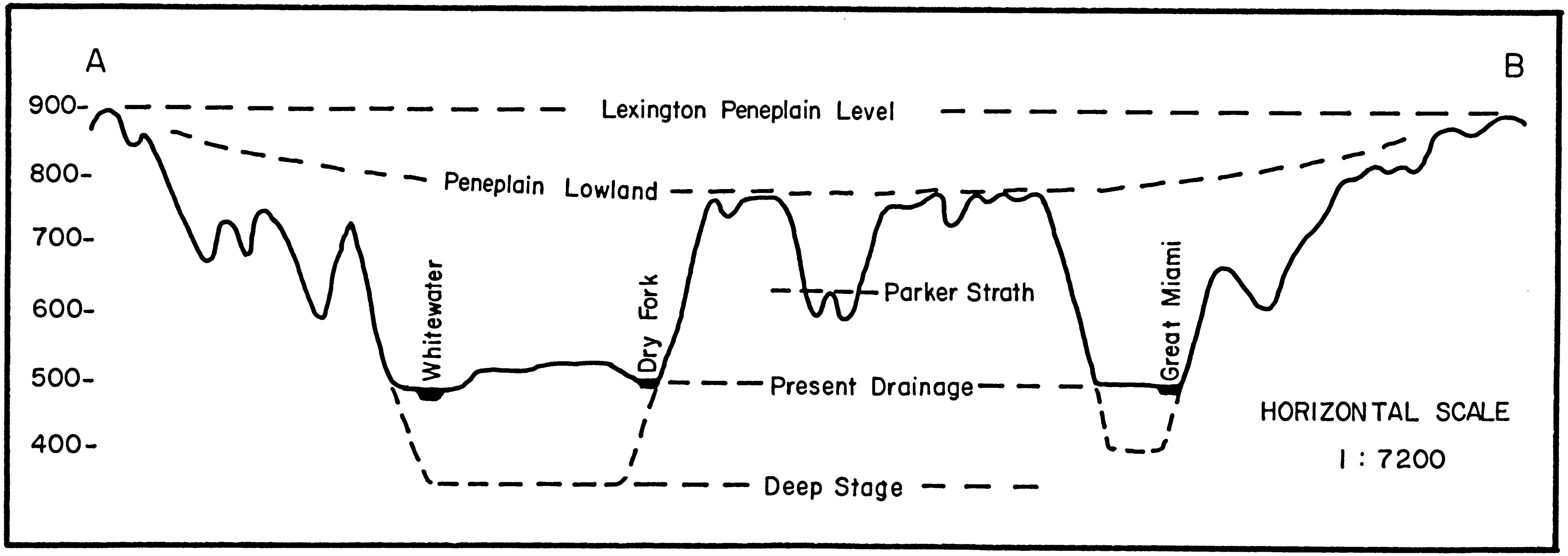

Figure 2 — Profile A-B ENE across area of investigation (fig. 1) to illustrate the relationship of various levels of drainage.

in the thesis area which appear approximately 150 feet below the lowlands on the Lexington peneplain at elevations ranging from 650-680 feet are correlated with the "Parker Strath" (Desjardins,1934). The dissection in general has reached maturity with relief of 250-300 feet near the Great Miami River.

The gradients of the Great Miami and Whitewater Rivers are 3.5 ft/mi and 5 ft/mi respectively. The gradients of many of the tributaries as illustrated by Figure 3 have rather gentle

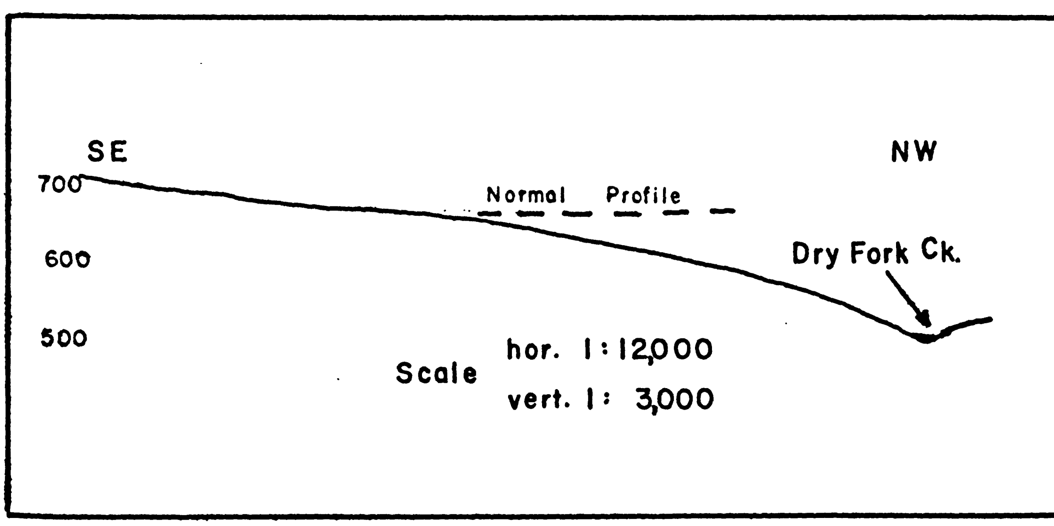

Figure 3 – Stream profile illustrating rejuvenation of tributary valleys.

gradients of 150 ft/mi in their headwaters as compared to the segment near the mouth which drops 100 feet in 1,000 feet, or approximately 500 ft/mi. This reversal of stream profile suggests rejuvenation.

Portions of the drainage of the area display a conspicuous rectilinear pattern oriented generally N 40° W and N 50° E (Fig. 4), which suggests possible joint control in the bedrock. Because of the scarcity of outcrop exposures, few joint measurements were made by the writer. However, the ones checked did generally parallel the directions of major lines of drainage. Keller(1957)studied the joint systems in the bedrock of the Cincinnati region. Although he carried out no work in the immediate area of this investigation, he did suggest a general NW and NE trend to the joint patterns in southwestern Hamilton County. Hofmann(1965, Geol. Sur. Amer. Bull. in press)studied in detail the joint systems of western Hamilton County, Ohio. He concluded that:

1. The dominant vertical joint directions in decreasing abundance are: NW, NNE, ENE and NNW.
2. The strongest trend follows the direction of parallel drainage.
3. The two most prominent trends coincide with the two prongs of the Cincinnati arch. Subsidence of the

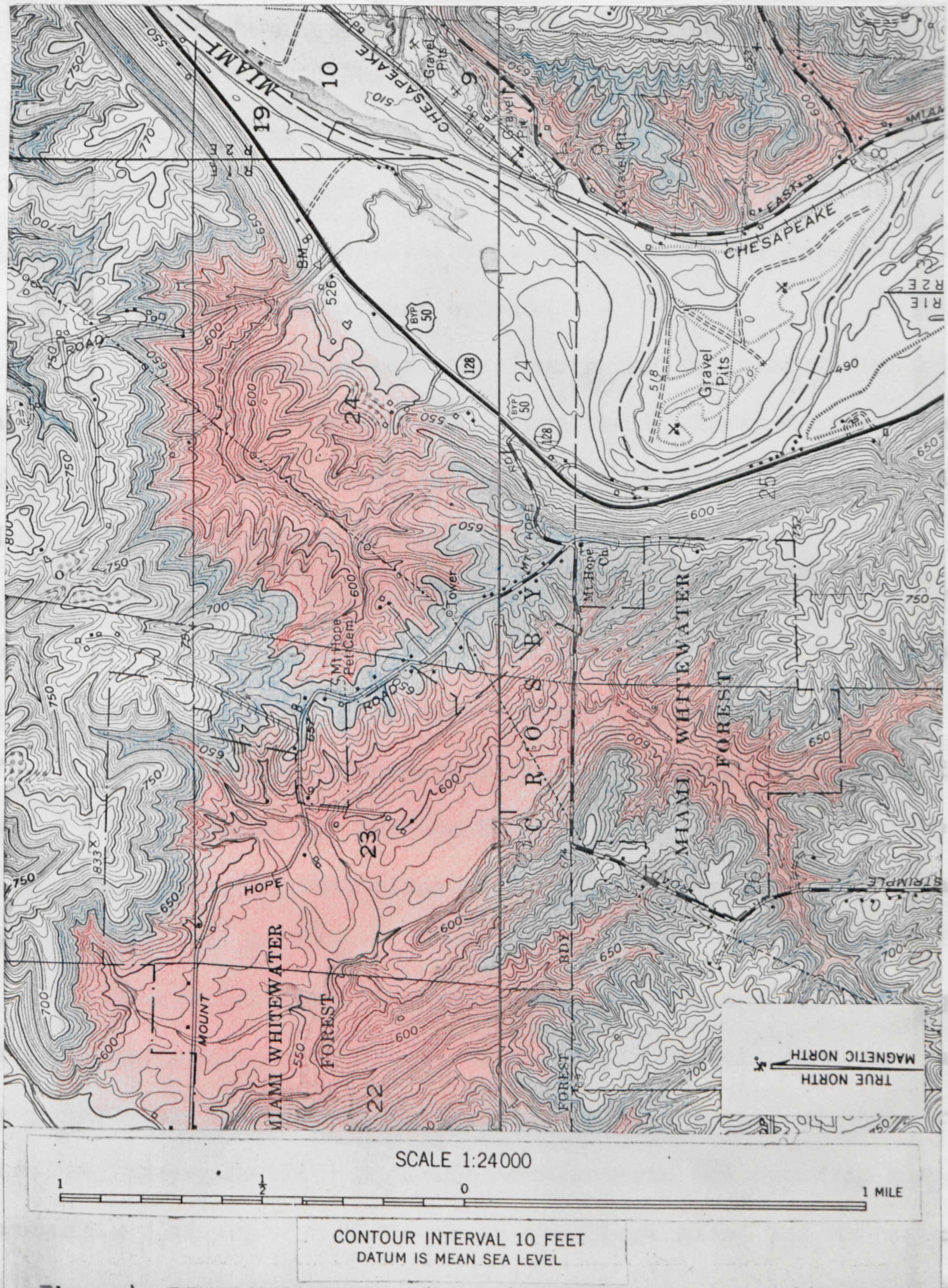

Figure 4- Illustration of rectilinear drainage; red, below 650 feet elevation; blue, 650-700 feet elevation.

Illinois and Appalachian basins with respect to the platform could have caused flexures which produced tensional joints in alignment with the arches.

4. It is also possible and most likely that many of the joints are controlled by the streams and that they are superficial structures resulting from recent unloading by stream erosion.

It is equally possible that this northwest trending drainage has been inherited from streams controlled by loess derived from the Whitewater valley train and deposited by northwesterly winds (Durrell,1965,oral communication).

Evidence of several glacial stages is present in the area, two of which influenced the drainage and partially masked the bedrock topography. The Illinoian and Wisconsin boundaries appear on Figure 30. The only exposed deposits in the thesis area of definite pre-Illinoian age are the bedload deposits(pre-Kansan)the lake clays(probably Kansan)and some till of questionable Kansan age(Durrell,1961,p.56).

Illinoian deposits of till and outwash are present in varying amounts throughout most of the area. Loess of Illinoian age has been reported by Durrell(1961)at the Morgan Road cut of the Northwest Expressway(I-75). Deposits of Wisconsin age found in the immediate area occur as outwash in the Great Miami and Whitewater Valleys and lake clays and silts in Valley III(Fig. 6)deposited as a result of rapid aggradation of the Whitewater valley. Loess, which was deposited by westerly winds carrying the materials from the outwash plains and valley trains immediately west of the thesis area, is common throughout the area investigated.

From drillhole and seismic data of previous workers the bedrock elevations of the Great Miami and Whitewater Valleys have been found to be approximately 400 and 350 feet, respectively. These valleys were aggraded with glacial deposits during Illinoian and Wisconsin times. Since then the Great Miami has removed its fill down to an elevation of approximately 500 feet, while the underfit Dry Fork has made little progress in removal of these glacial materials.

Stratigraphy

The Upper Ordovician bedrock of southwest Hamilton County, Ohio, is made up of near horizontal alternating layers of limestone and calcareous shale of the Cincinnatian Series. Outcrops in this area belong to the Eden and Maysville Stages, the boundary of which appears at approximately 620 feet(Hofmann,1965,oral communication).

One of the most easily recognized formations in the area is the Bellevue Limestone of the Maysville Stage. The well defined base of the Bellevue occurs at approximately 740 feet A.T., 1.5 miles west of the Miamitown interchange of I-74. The Bellevue is composed dominantly of limestone, which is approximately 12 feet in thickness. This member is quite prone to ground water solution, thus sinkholes appear throughout the area ranging from 710 to 750 feet in elevation. It is interesting to note that the general decrease in elevation of the sink holes from the Cheviot, Ohio, 7 miles southeast of Miamitown, to the thesis area(see appendix), corresponds very closely to the lowering in elevation of the Fairview-McMillan contact described and mapped by Hofman(1965), and Ford(1965,Ph D thesis, The Ohio State Univ.). The presence of sink holes can be utilized then for locating the Bellevue Limestone in the stratigraphic section in the thesis area.

PREVIOUS WORK

The high-level valleys in the Cincinnati region have been a source of geologic interest for more than a half century. One of the first workers to direct attention to the drainage peculiarities of this region was James(1891). Since then Fowke(1898 and 1933); Tight(1903); Fenneman(1916); Kerr(1951); Middendorf (1952); Vetorino(1954); Durrell(1961); and others have made valuable contributions to a better interpretation of the drainage history.

Tight(1903), who did one of the most comprehensive studies on this early drainage system, proposed the course of the Teays

River which is generally accepted today. He suggested a large trunk stream that headed in the Piedmont region of Virginia and North Carolina and flowed in a northwesterly direction while it could be traced as far as central Ohio. The early drainage in Kentucky and southwestern Ohio was thought by Tight to be north-flowing tributaries of the Teays system. The Teays River has since been extended further westward by Stout, Ver Steeg, and Lamb(1943); in Indiana by Wayne(1956); and in Illinois by Horberg (1945).

Fowke(1898), in his studies of the early drainage of northern Kentucky, southwestern Indiana, and southwestern Ohio, proposed a major divide in the area of Madison, Indiana. His interpretations made a stream head in the Madison area which flowed north-east to Lawrenceburg, Indiana, and northward to Hamilton, Ohio, where it joined the northflowing Licking. Tight(1904), and Mallot(1922), in their work found evidence to support this interpretation.

An opposing school of thought was proposed by Leverett(1902). In his work he suggested a major divide near Manchester, Ohio, during pre-glacial time. The pre-glacial Ohio which headed near Manchester, Ohio, flowed eastward toward Cincinnati, northward to Hamilton, and from there southward to follow the present course of the Ohio.

Desjardins(1934)made a study of the pre-glacial physiography and drainage of the Cincinnati region. He correlated the early drainage levels with the Parker Strath(Butts,1904)of the Allegheny Plateau and proposed a northward direction of flow for the pre-glacial drainage. The portion of Desjardin's work in Kentucky was concerned for the most part with the Teays-Age Licking south of Cincinnati.

Durrell(1961)supported the interpretation by Desjardins and extended this drainage headward(Fig. 5), particularly southwest of Cincinnati. For this line of drainage, which was proposed to have flowed north to Lawrenceburg, Indiana, and on to Hamilton, Ohio, to join the Teays-Age Licking, Durrell(1961) proposed the name Eagle River.

The former course of the Teays-Age Eagle River has been studied and mapped by several University of Cincinnati graduate students including Kerr(1951); Middendorf(1952); and Vetorino (1954). This thesis is a northward extension of these detailed studies into southwestern Ohio.

DESCRIPTION OF VALLEYS

The three valleys investigated appear as dissected northwest trending lowlands approximately 150 feet above the present drainage of the Great Miami River on the east, and Dry Fork Creek on the west(Fig 6.). Even though the deposits of at least two glacial stages have masked the topography and subsequent

Figure 5- Preglacial drainage of the Teays-age Eagle and Licking Rivers in northern Kentucky and southwestern Ohio.

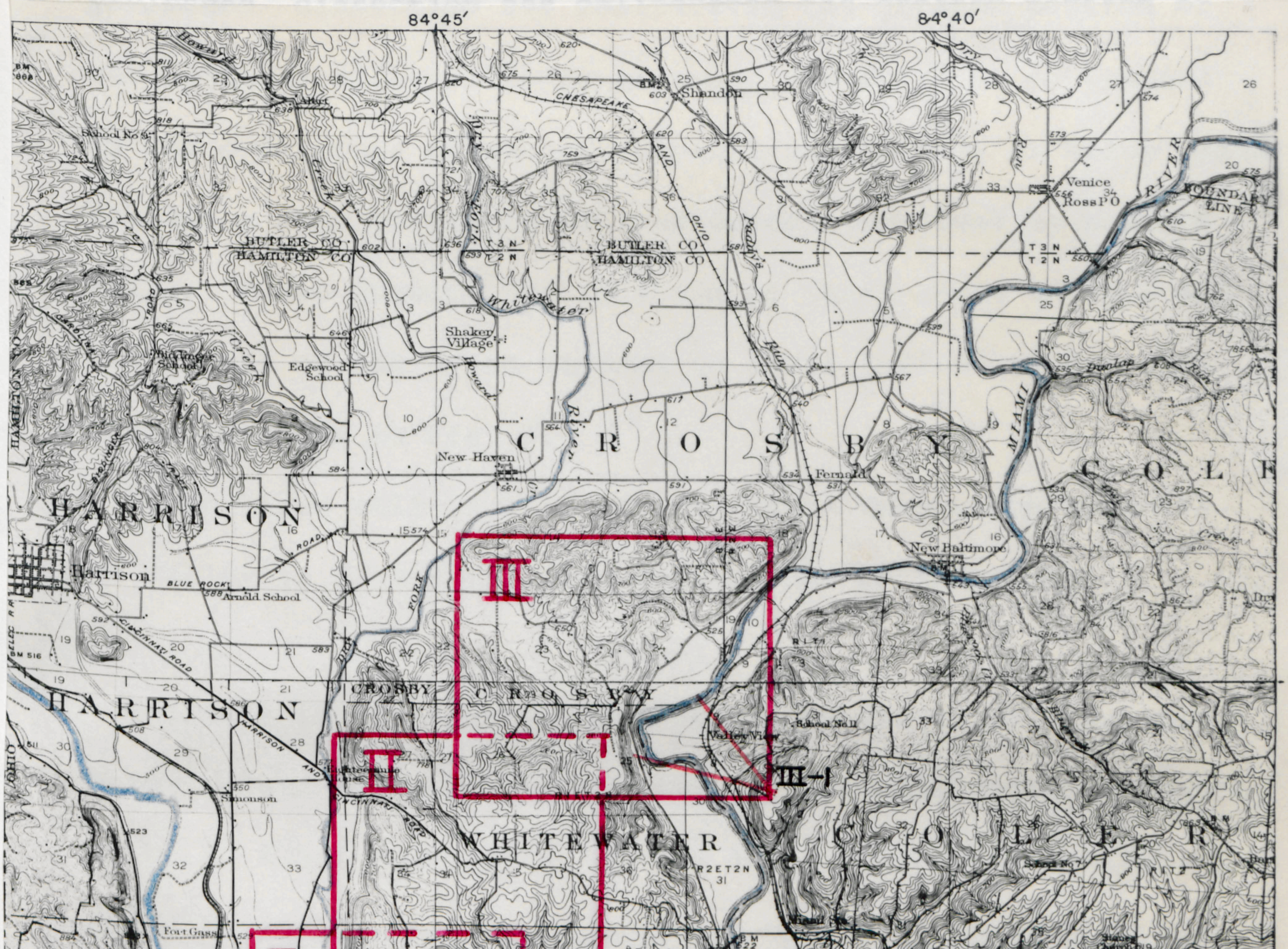

Figure 6- Map of thesis area showing locations of the 3 areas described in detail.

prolonged dissection has obliterated the greater portion of the original valleys, their presence can still be determined by the occurrence of valley remnants at 660 feet or below which contain a characteristic bedload deposit confined by bedrock walls. A map showing the location of these three valleys and the extent of the areas covered in their individual descriptions is shown in Fig. 6.

These three valleys will be designated from south to north as Valley I, II and III for convenience of reference.

VALLEY I

Valley I is the southernmost trough of the three described. This lowland is located approximately one mile north of Hooven, Ohio, on State Route 128. Morgan Road, which branches from State Route 128, passes through the northeast portion of the valley(Fig. 7). An overall view of Valley I is shown in Fig. 8 taken from photo station I-1(Fig. 6). The well pronounced bluff to the northeast(right), as opposed to the less well defined southwest bluff, suggests the development of a slip-off slope, descending northeastward.

From the northeast bluff, the general concordance of the erosion remnants is shown by Fig. 9. The view is to the southwest across Valley I from photo stations I-2 and I-3(Fig. 7). The farm houses, out-buildings and electric line towers appear at approximately 660 feet in elevation. The bluff in the background prolonged dissection has obliterated the greater portion of the original valleys, their presence can still be determined by the occurrence of valley remnants at 660 feet or below which contain a characteristic bedload deposit confined by bedrock walls. A map showing the location of these three valleys and the extent of the areas covered in their individual descriptions is shown in Fig. 6.

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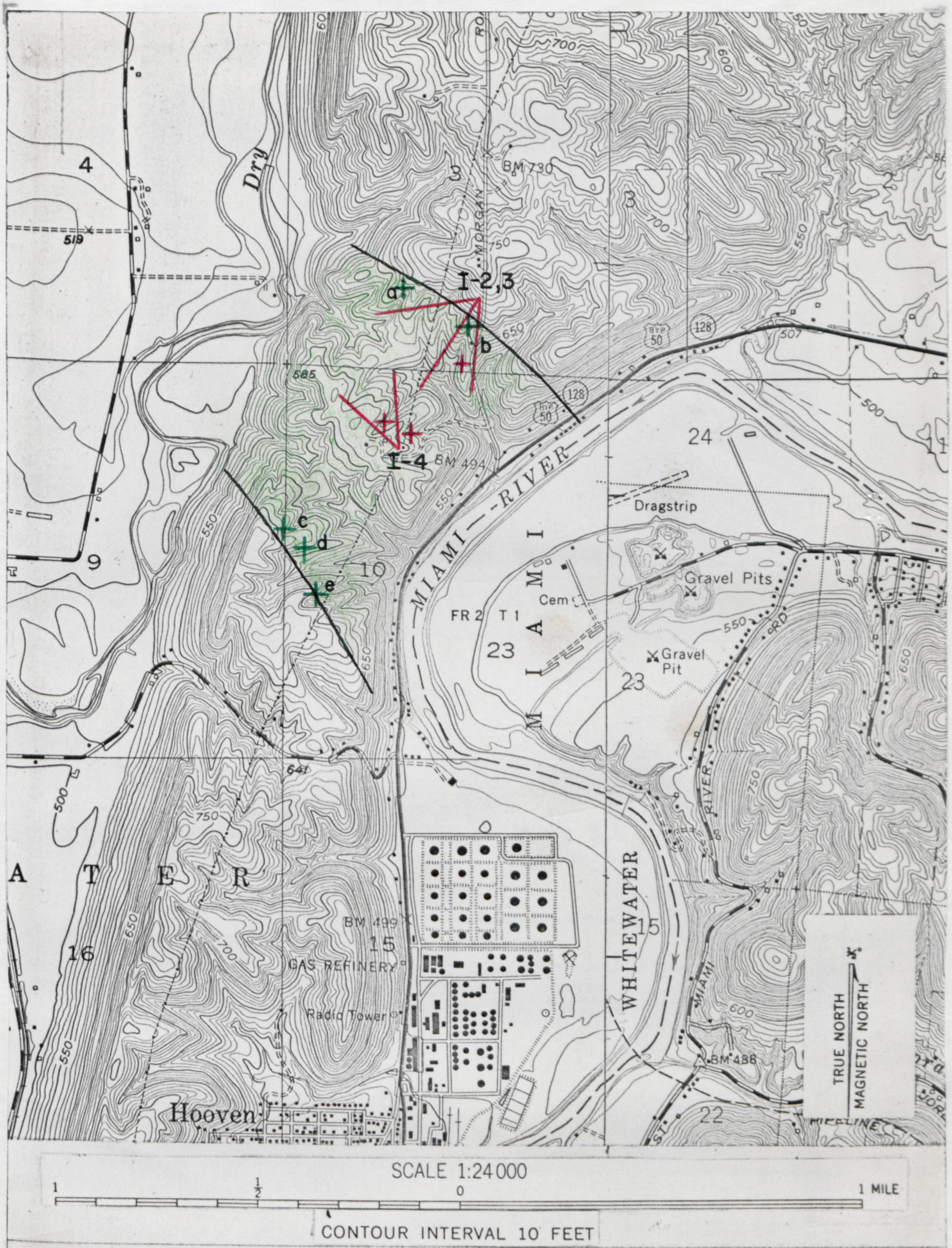


Figure 7- Detail map of Valley I; green cross, bedrock above valley filling; red cross, location of bedload deposits; ------ valley boundary.

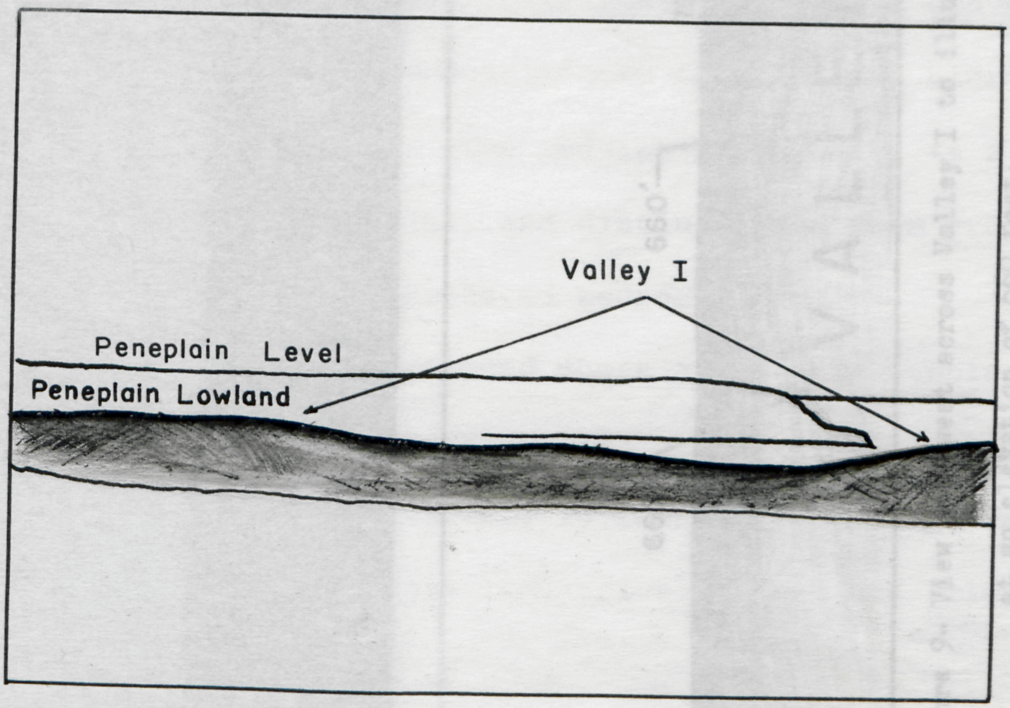


Figure 8- View of Valley I looking N 70° W from photo station I-1 (fig. 6).

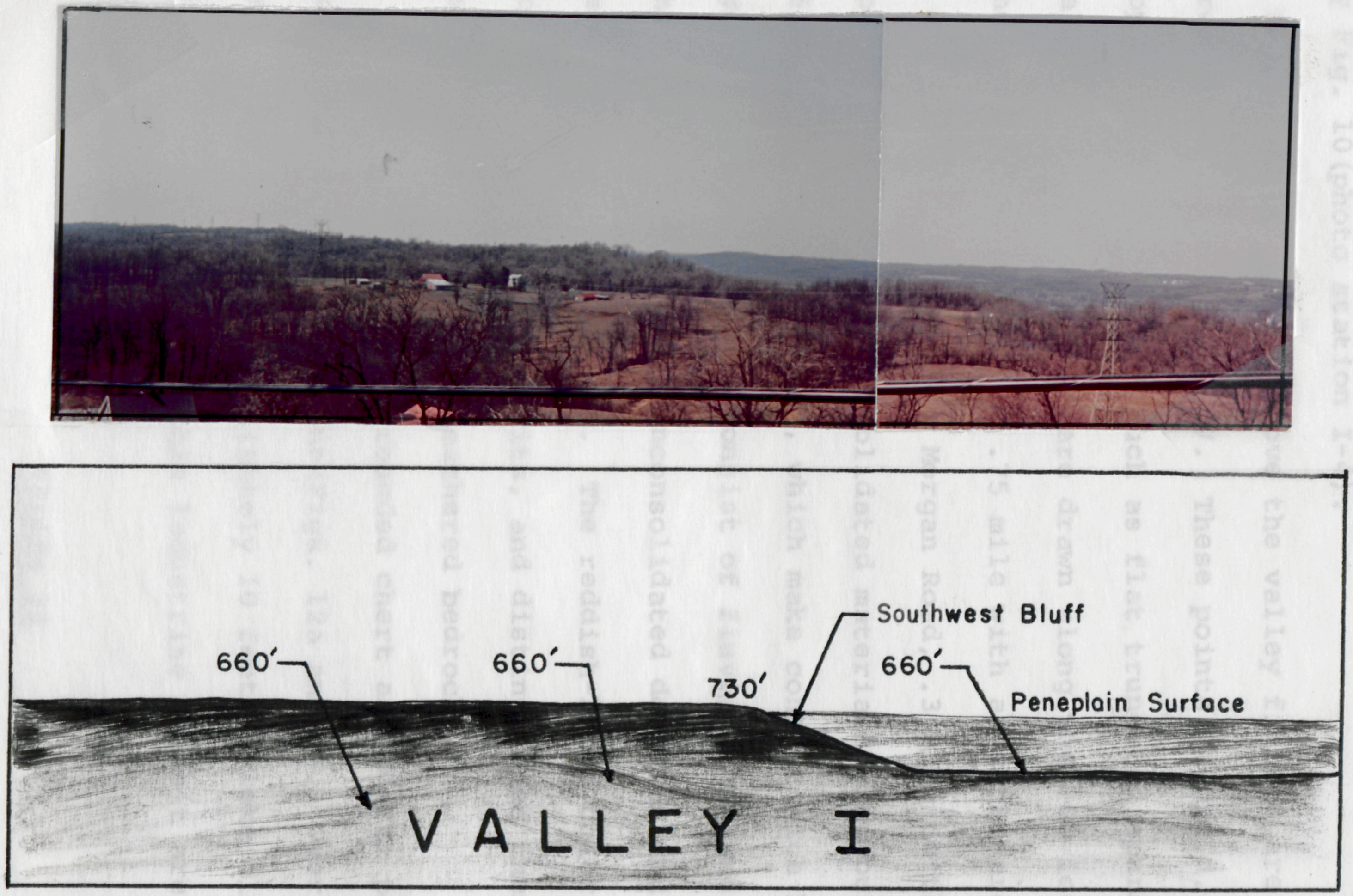


Figure 9- View southwest across Valley I to illustrate concordance of valley remnants at an elevation of 660 feet.

Photo station I-2, 3, fig. 7.

is 730 feet in elevation and delimits the valley to the southwest. The bluff bounding the valley on the northeast is shown by Fig. 10(photo station I-4).

Locations of bedrock above the valley filling are shown by a green cross (+) on Fig. 7. These points, a,b,c,d, and e plus topographic expression, such as flat truncated spurs, define the valley. When boundaries are drawn along the 700 foot contour, the valley has a width of .75 mile with a gentle arcuate pattern.

At a cut in Valley I on Morgan Road, .3 mile north of State Route 128(Fig. 7), unconsolidated materials crop out. The lower 15 feet of these deposits, which make contact with bedrock at approximately 625 feet, consist of fluvial sand and gravel. The relationship of the unconsolidated deposits and bedrock is illustrated by Fig. 11. The reddish-brown color is a characteristic of these deposits, and distinguishes them from the gray-green color of the weathered bedrock.

The gravels consist of rounded chert and quartz pebbles, quartz geodes and siltstone(Figs. 12a and b). Overlying this bedload deposit is approximately 10 feet of lake clay(Fig 13a). The fine laminations of this lacustrine deposit are illustrated in Fig. 13b.

VALLEY II

The general location of Valley II is shown on Fig. 6. It is found immediately north of Valley I and approximately 2 miles

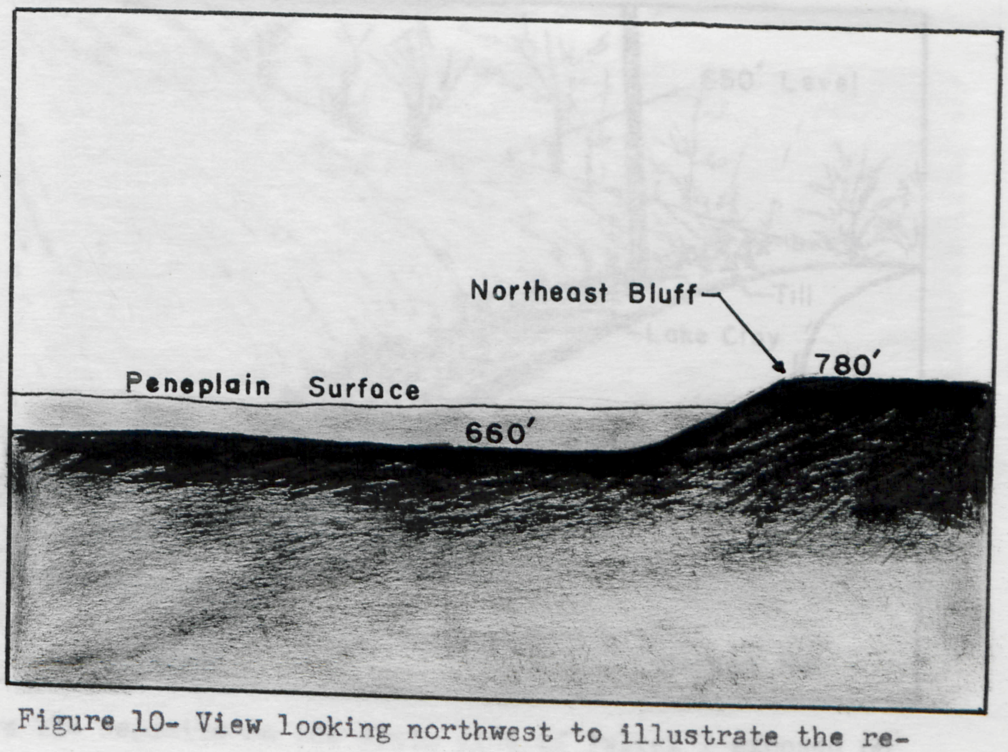


Figure 10- View looking northwest to illustrate the relationship between general valley level and northeast bluff (photo station I-4, fig. 7).

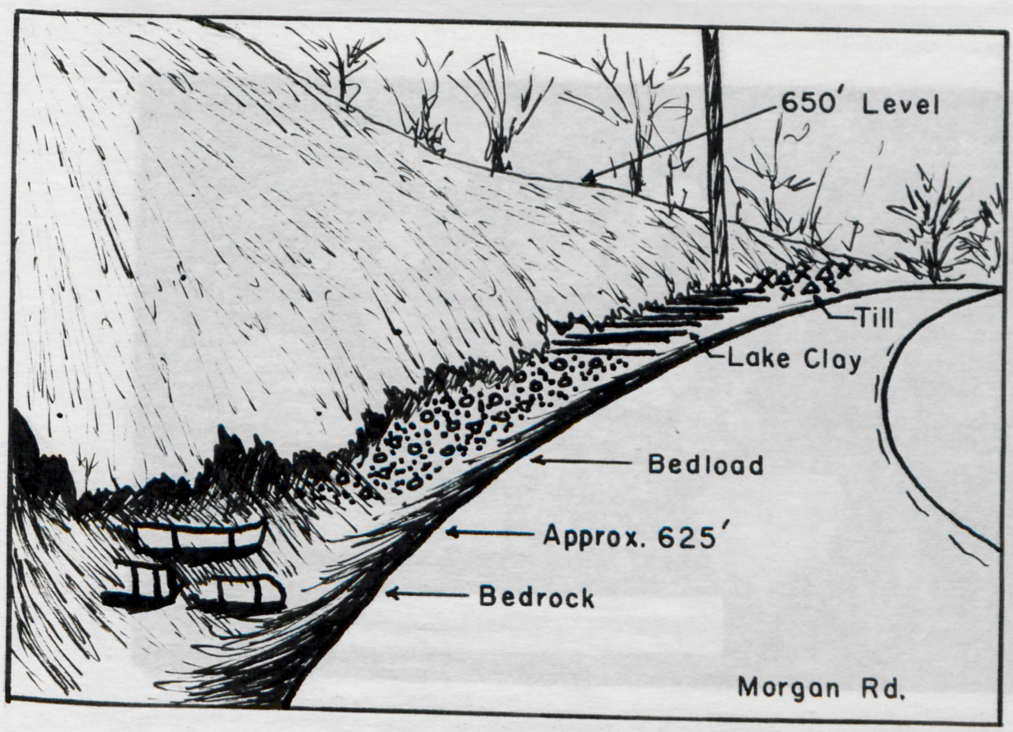


Figure 11- Deposits on the south side of Valley I exposed on on Morgan Road .25 miles north of State Route 128.

12a

12b

Figure 12- Bedload deposits from Valley I

a- in outcrop; b- washed sample.

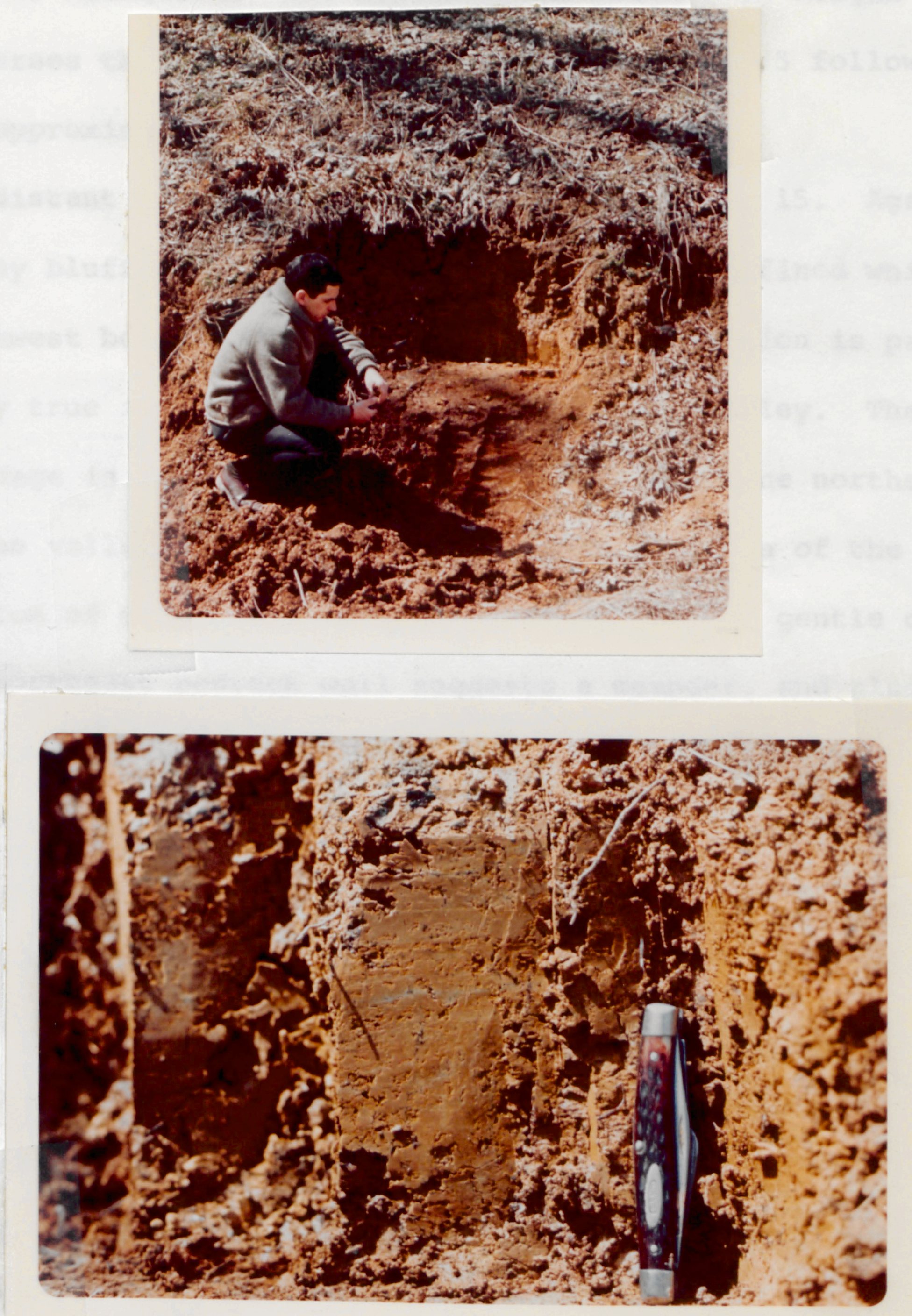


Figure 13- Detail photo; deposits in Valley I on Morgan Road.

a- contact of lake clay and alluvium.

b- close-up of lacustrine deposit to emphasize laminations.

west of Miamitown. The northernmost portion of Morgan Road traverses this valley and Harrison Road and I-75 follow it for approximately 1.5 miles(Fig. 14).

A distant view of Valley II is shown by Fig. 15. Again the valley bluff on the northeast(right)is well defined while the southwest boundary is indefinite. This situation is particularly true in the northwest portion of the valley. The present drainage is working headward more rapidly on the northeast side of the valley, suggesting the probable location of the deeper portion of original trench of the valley. The gentle curve of the northeast bedrock wall suggests a meander, and also indicates that the deeper portion of the valley should occur to the northeast with the southwest portion of the valley serving as the slip-off slope(Fig. 14).

The southwest valley bluff in the northwest portion of Valley II is less definite because glacial drift has largely masked the bedrock. Fig. 16, illustrating the hummocky appearance of the valley, suggests the presence of glacial drift. This photo is looking west across the valley from station II-2. However, the southwest bounding bluff is well defined in the southeastern portion of the valley. The relationship between the valley filling and the bedrock bluff is illustrated by Fig. 17 taken from photo station IV-3(Fig. 14). Bedrock locations above the

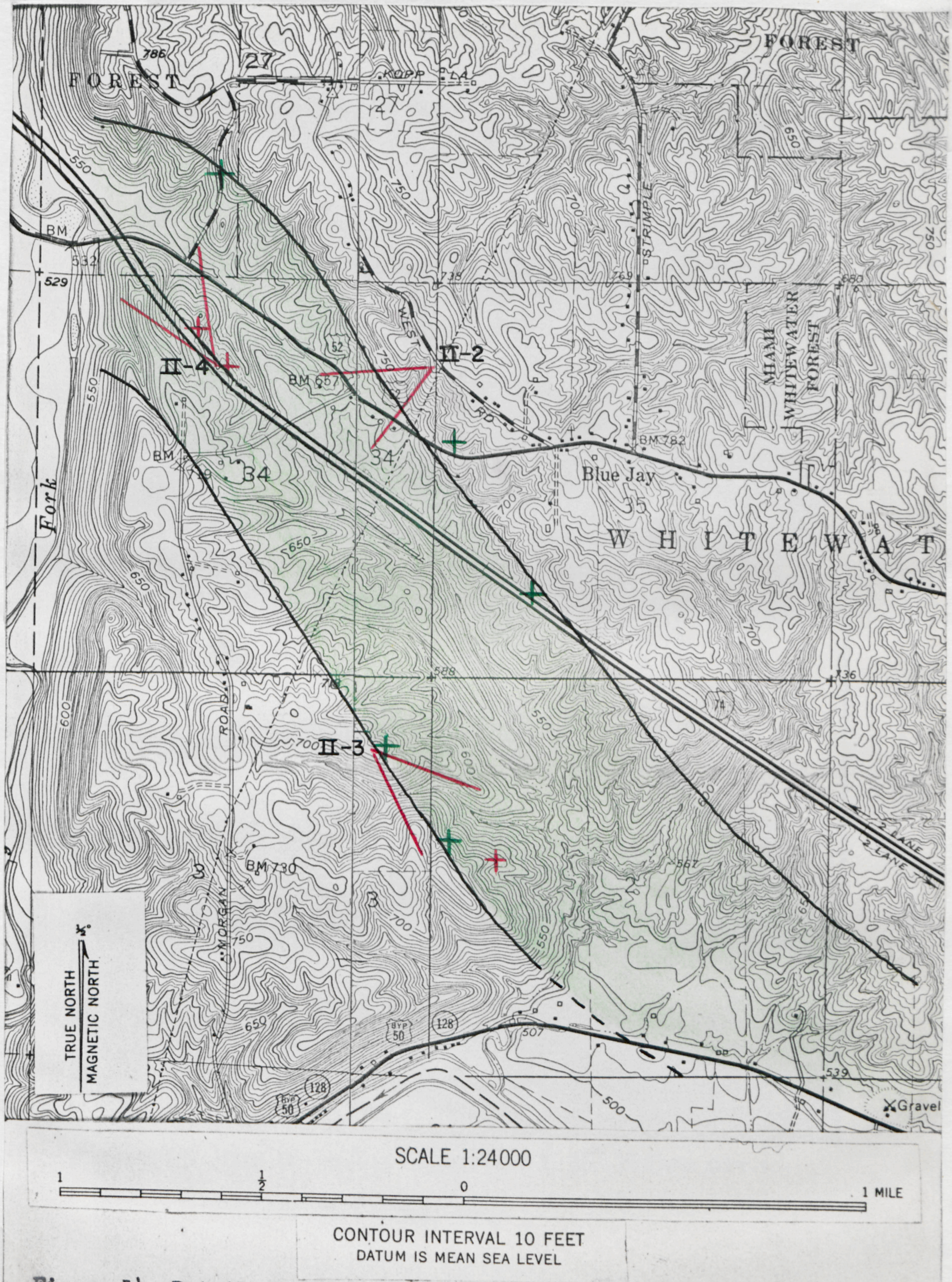


Figure 14- Detail map of Valley II; green cross, bedrock above valley filling; red cross, location of bedload deposits; ——— valley boundary.

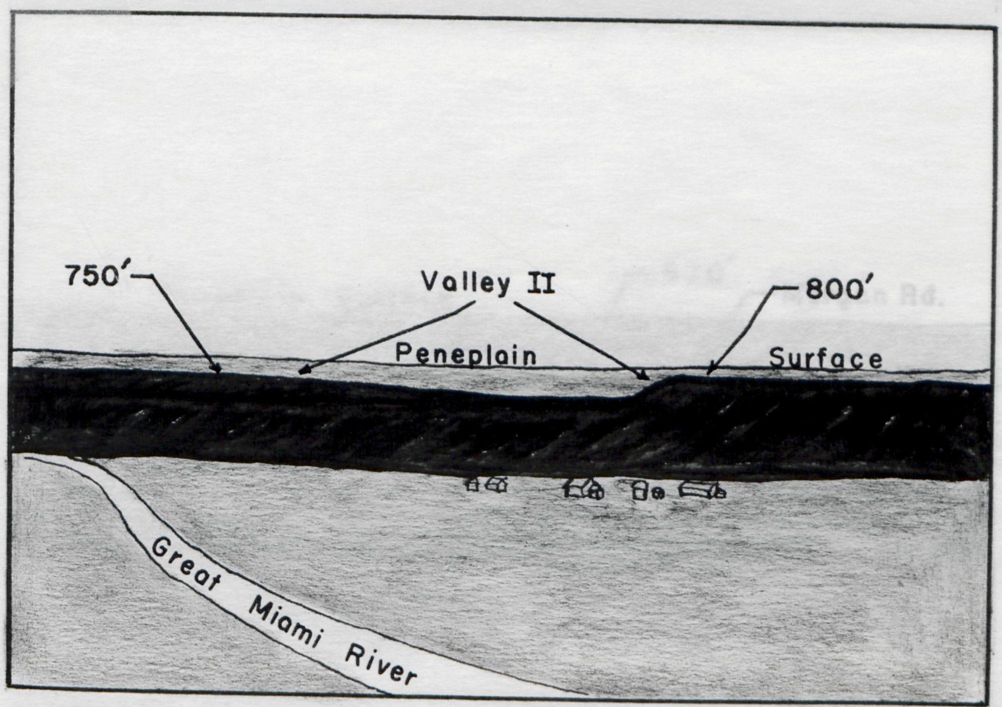


Figure 15- View of Valley II looking N 35° W from photo station II-1.(fig. 6).

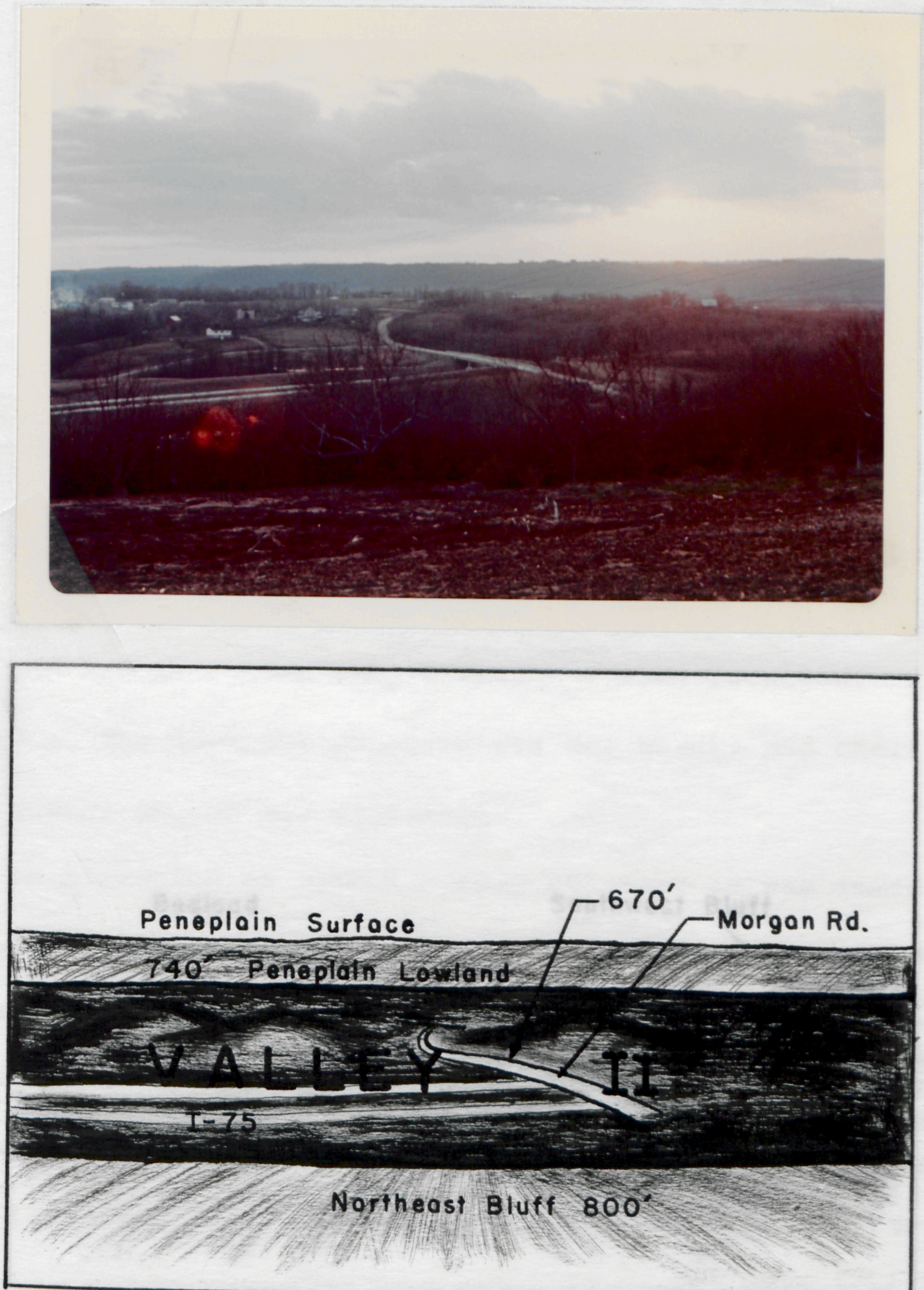


Figure 16- View west across Valley II, illustrating appearance of southwest side of valley. Photo station II- 2, fig. 14.

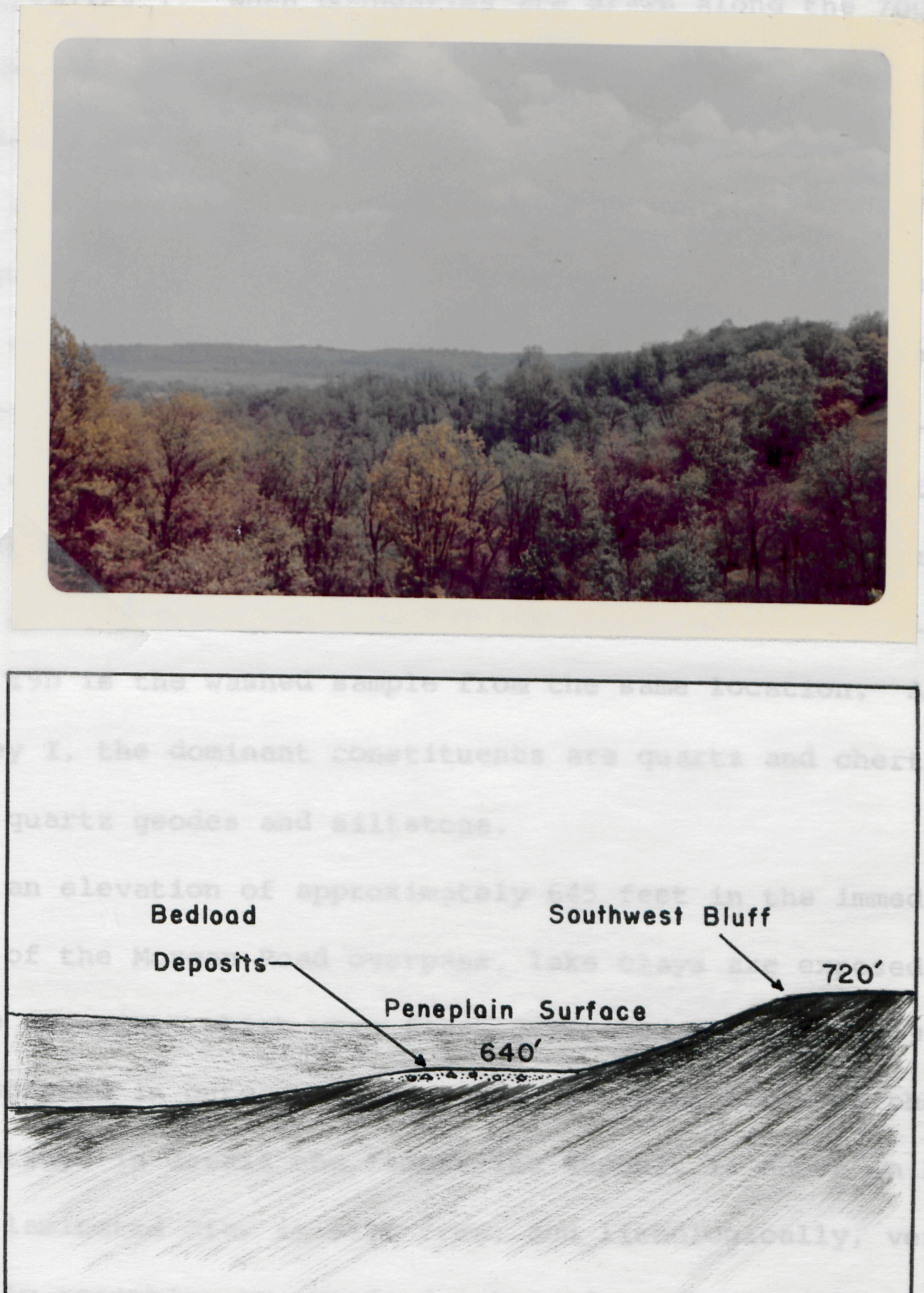


Figure 17- View looking southeast showing relationship of southwest bedrock bluff to flat spur with bed-load deposits.(photo station II- 3, fig. 14).

general level of the valley filling are shown by green crosses as in Valley I. When boundaries are drawn along the 700 foot contour a northwest-southeast trending valley approximately .6 mile wide is defined.

In a roadcut on I-74, .3 mile northwest of the Morgan Road overpass, stream laid gravels, like those found in Valley I, crop out(Fig. 18). This photo shows the contact between the blue-gray bedrock and red-brown stream deposits at an elevation of 625 feet. The bluff in the background is approximately 780 feet in elevation and forms the northeast valley boundary. Fig. 19a shows how the deposits appear in the field, while Fig. 19b is the washed sample from the same location. As in Valley I, the dominant constituents are quartz and chert pebbles, quartz geodes and siltstone.

At an elevation of approximately 645 feet in the immediate area of the Morgan Road overpass, lake clays are exposed. These deposits, which were first described by Durrell(1961)are illustrated in outcrop by Fig. 20. A recent close-up photo to illustrate in detail the lacustrine deposit is shown in Fig. 21. This laminated clay is silt free, and lithologically, very closely resembles the Minford silts of south-central Ohio (Durrell,1961,p.55).

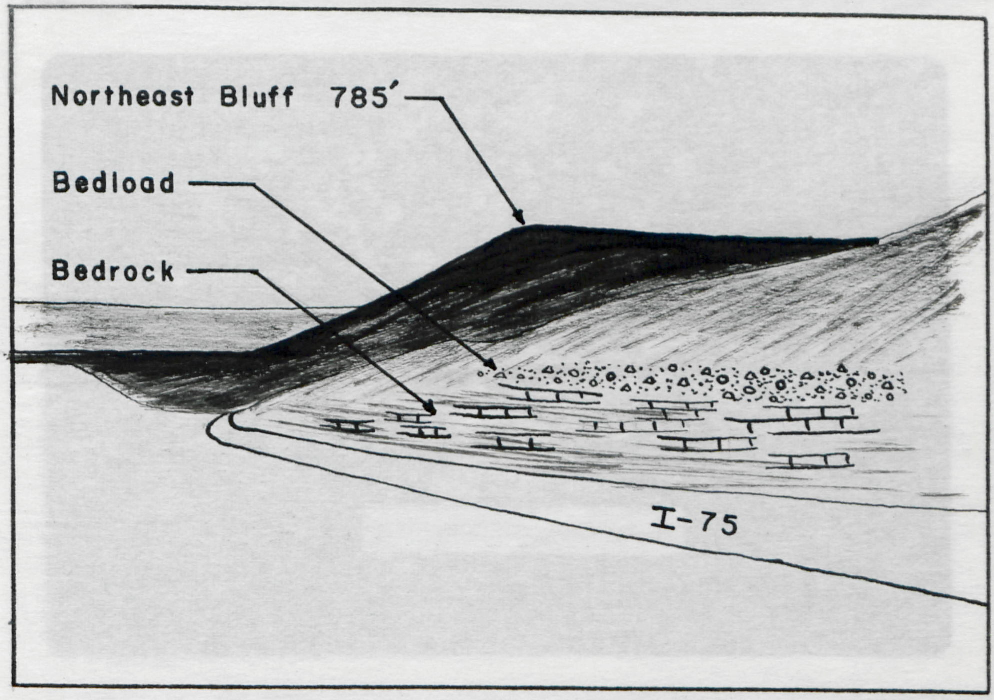
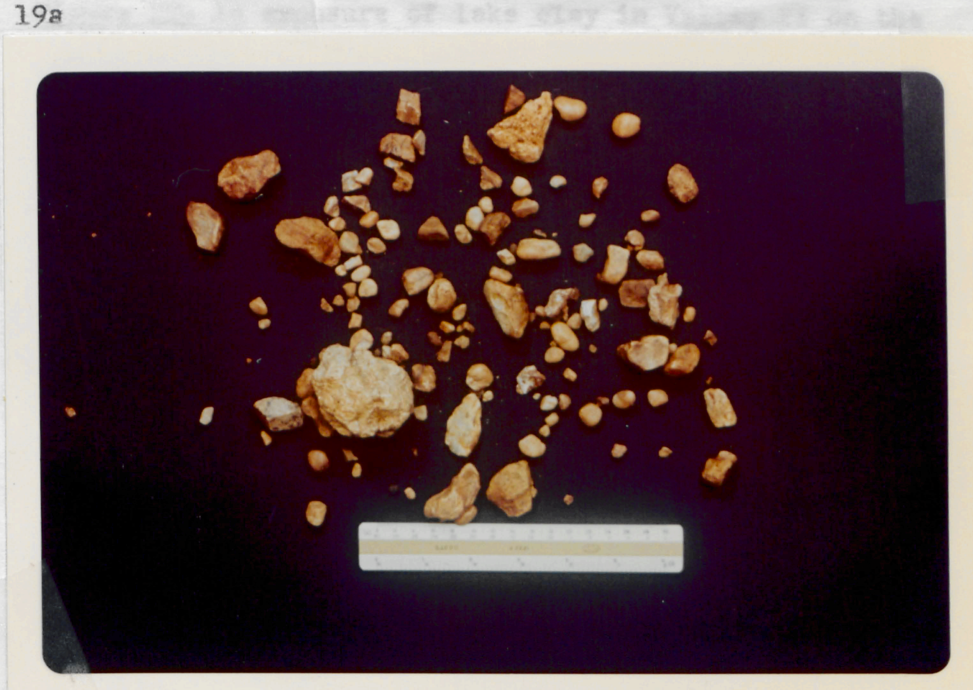


Figure 18- View northwest in Valley II to show the bedload deposits and the northeast bounding bluff (photo station II-4, fig. 14).

19a



19b

Figure 19- Bedload deposits of Valley II; a- in outcrop; b- washed sample.

Figure 20- An exposure of lake clay in Valley II on the northeast side of I-74 near Morgan Road.

Figure 21- Close-up of lake clays of Valley II to illustrate laminations.

VALLEY III

This trough which is the northernmost of the three described is located approximately 2.5 miles north of Miamitown(Fig. 5). Mt. Hope Road, which branches from Route 128, 2.25 miles north of Miamitown(Fig. 22), traverses and runs longitudinally with Valley III for approximately 2.5 miles.

An overall view of this valley is shown in Fig. 23. Illustrated in this photo, taken from station III-1(Fig. 6)looking N 55 W, is the pronounced bedrock bluff to the right(north)which stands about 800 feet in elevation. The rather poor valley boundary on the left is due to the occurrence of thicker glacial deposits on the south side of the valley.

One of the most conspicuous features of Valley III is the prominent meander scar on the north side of the valley at its eastern end in Area A(Fig. 22).

An aerial view of the meander remnant is shown on Fig. 24, taken from an elevation of about 1,500 feet and looking approximately northwest. On the topographic map in Area A(Fig. 22), the meander is emphasized by the presence of a stream which occupies the deeper portion of the curving channel on the outward side of the bend.

By tracing the 700 foot contour along the bedrock bluff north of Area A, it is found that this line can be projected east and

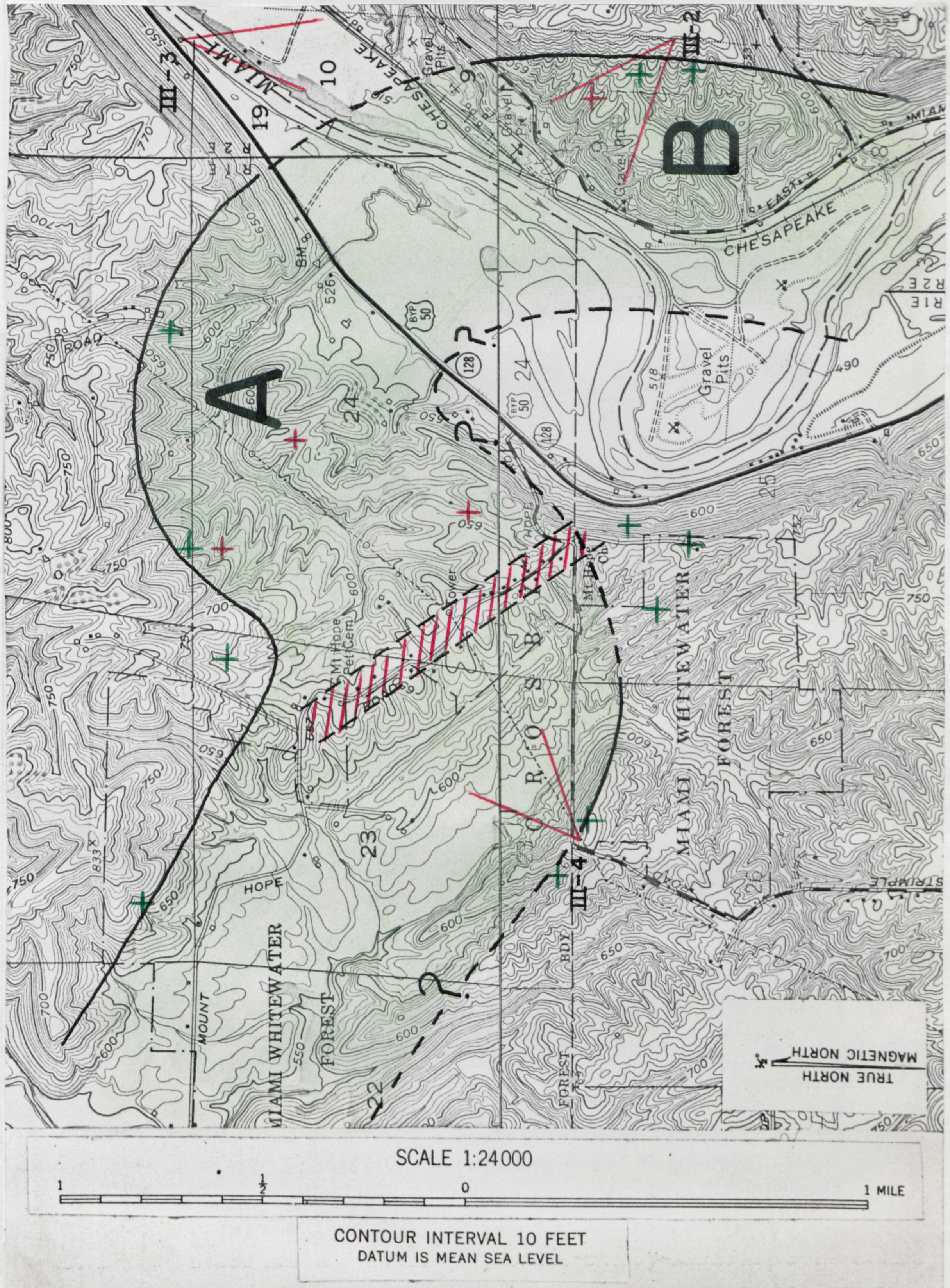


Figure 22- Detail map of Valley III, green cross, bedrock above valley filling; red cross, location of bedload deposits; ////// area of seismic and drilling investigation.

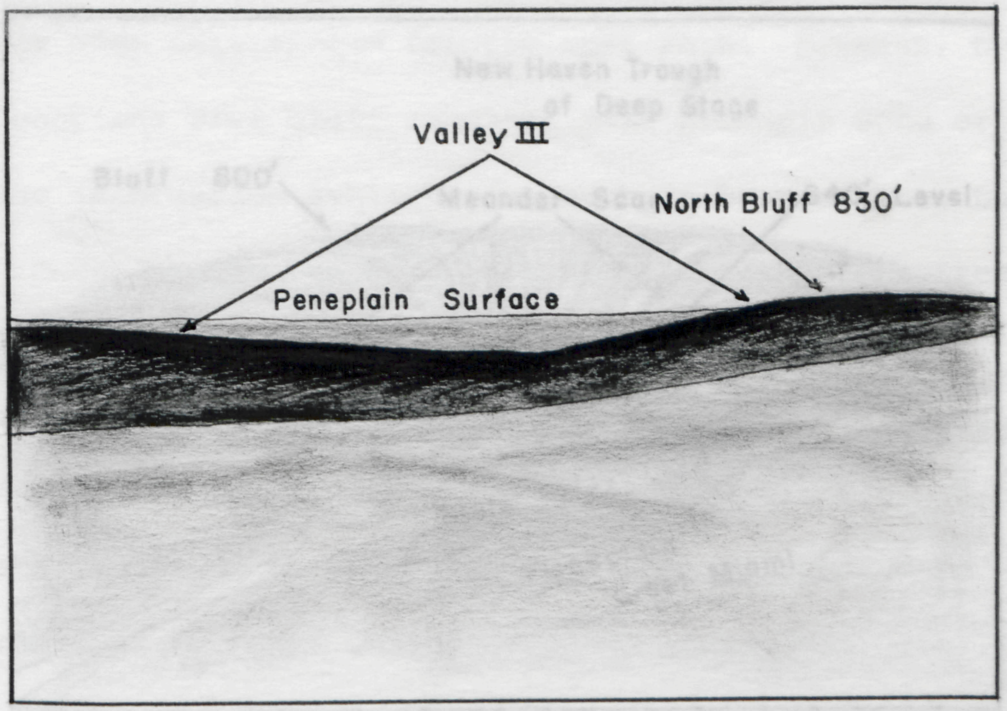


Figure 23- View of Valley III looking N 55° W (photo station III-1, fig. 6).

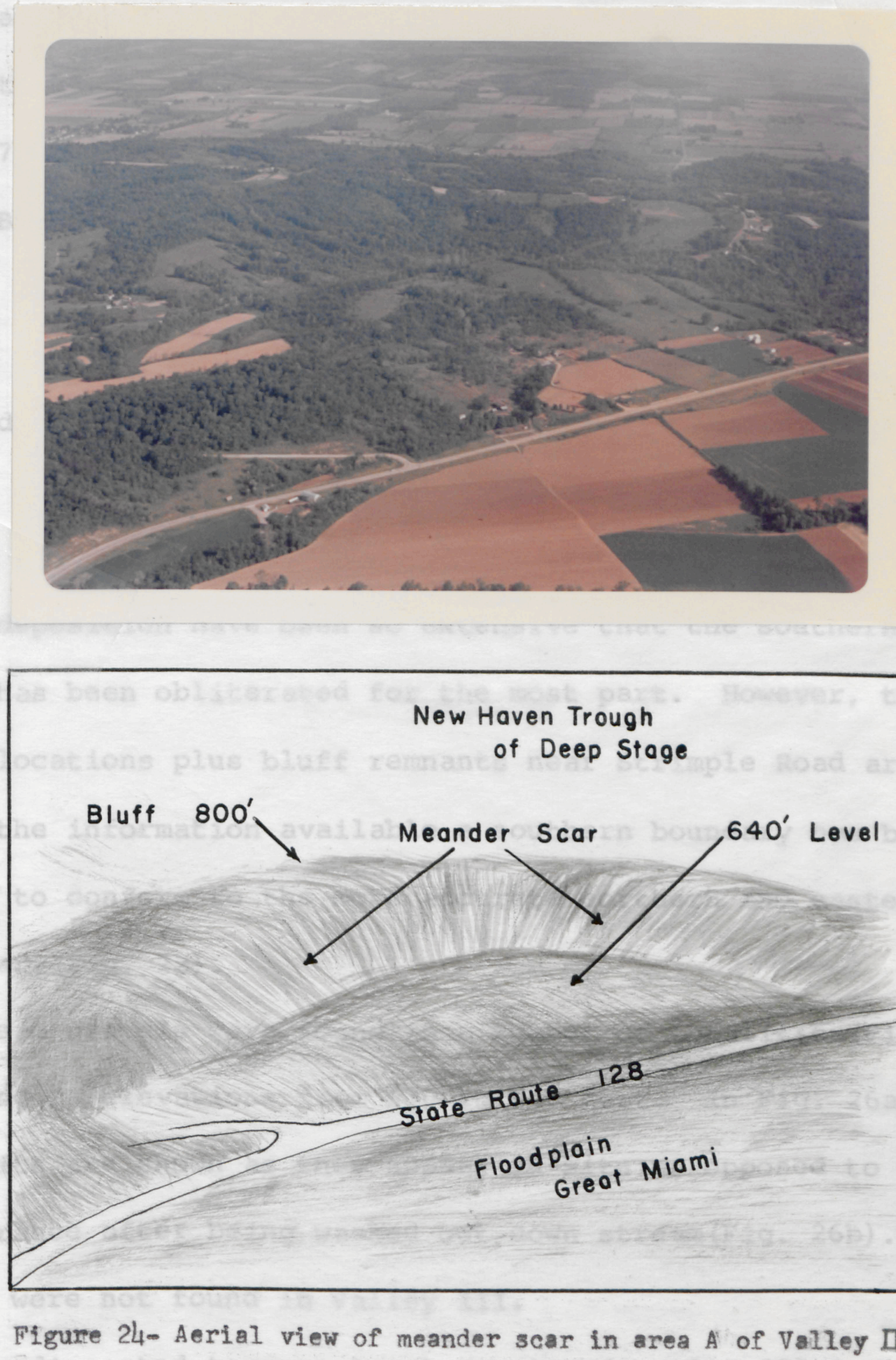


Figure 24- Aerial view of meander scar in area A of Valley III looking northwest (photo station III-2, fig. 22).

southeast across the Great Miami River to the bluffs of Area B in a natural arcuate pattern. It is apparent that Area B is a continuation of the meander in Area A. The relationship of the 770 foot bedrock bluff, the abandoned channel remnant of Area B and the more recent drainage level of the Great Miami River are illustrated by Fig. 25 (photo station III-3, Fig. 22).

The eastern and northern boundaries of this valley are rather well documented by topographic expression and by bedrock locations above the general valley filling; these outcrops are shown by green crosses on Fig. 22. Stream dissection and glacial deposition have been so extensive that the southern boundary has been obliterated for the most part. However, two bedrock locations plus bluff remnants near Strimple Road are useful. With the information available a southern boundary has been drawn to conform to the more accurate northern and eastern valley boundary (Fig. 22).

Stream gravels were found in a number of localities (Fig. 22), varying in elevations from 630 to 640 feet. In Fig. 26a these deposits are shown as they appear in situ as opposed to their appearance after being washed out down stream (Fig. 26b). Lake clays were not found in Valley III.

An undissected terrace level ranging from 660-680 feet in elevation crosses Valley III. This terrace on which Mt. Hope

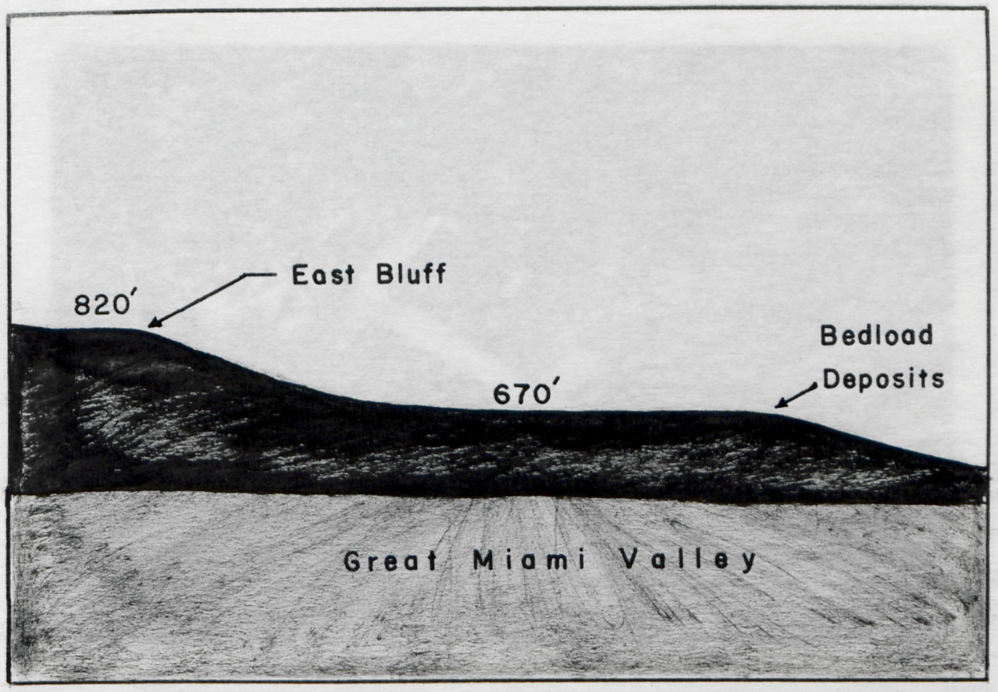


Figure 25- Terrace remnant in area B of Valley III, looking south (photo station III-3, fig. 22).

26a

26b

Figure 26- Bedload deposits from Valley III; a- in outcrop; b- washed sample.

Road is constructed is shown in Fig. 27.

From field observations it was found that this terrace for the most part was made up of later glacial filling which masks the bedrock. In order to locate bedrock in an effort to determine the configuration of the channel, the MD-1 engineering seismograph was employed. Because the local bedrock transmits shock waves at greater velocities than the fluvial materials and most of the tills the refraction seismograph is well suited for rather accurate and rapid determinations of thickness of unconsolidated materials.

During the spring and fall of 1964 and the spring of 1965, more than 50 seismic traverses were run in the thesis area. Fig. 28(in pocket)shows the location of the seismic traverses which were made along Mt. Hope Road in an effort to profile the bedrock. Two distinct velocity breaks were encountered (Fig. 29): the first at depths ranging from 5-10 feet,and the second at depths from 18-40 feet(refer to appendix for seismic data sheets). Although the second break was not found deep enough to be the floor of the channel of the high-level valley, the velocities which ranged from 4,500 to 6,500 fps compared favorably to those of the local bedrock.

Often in order to make reliable interpretations of geophysical data, correlation with drill hole information is necessary.

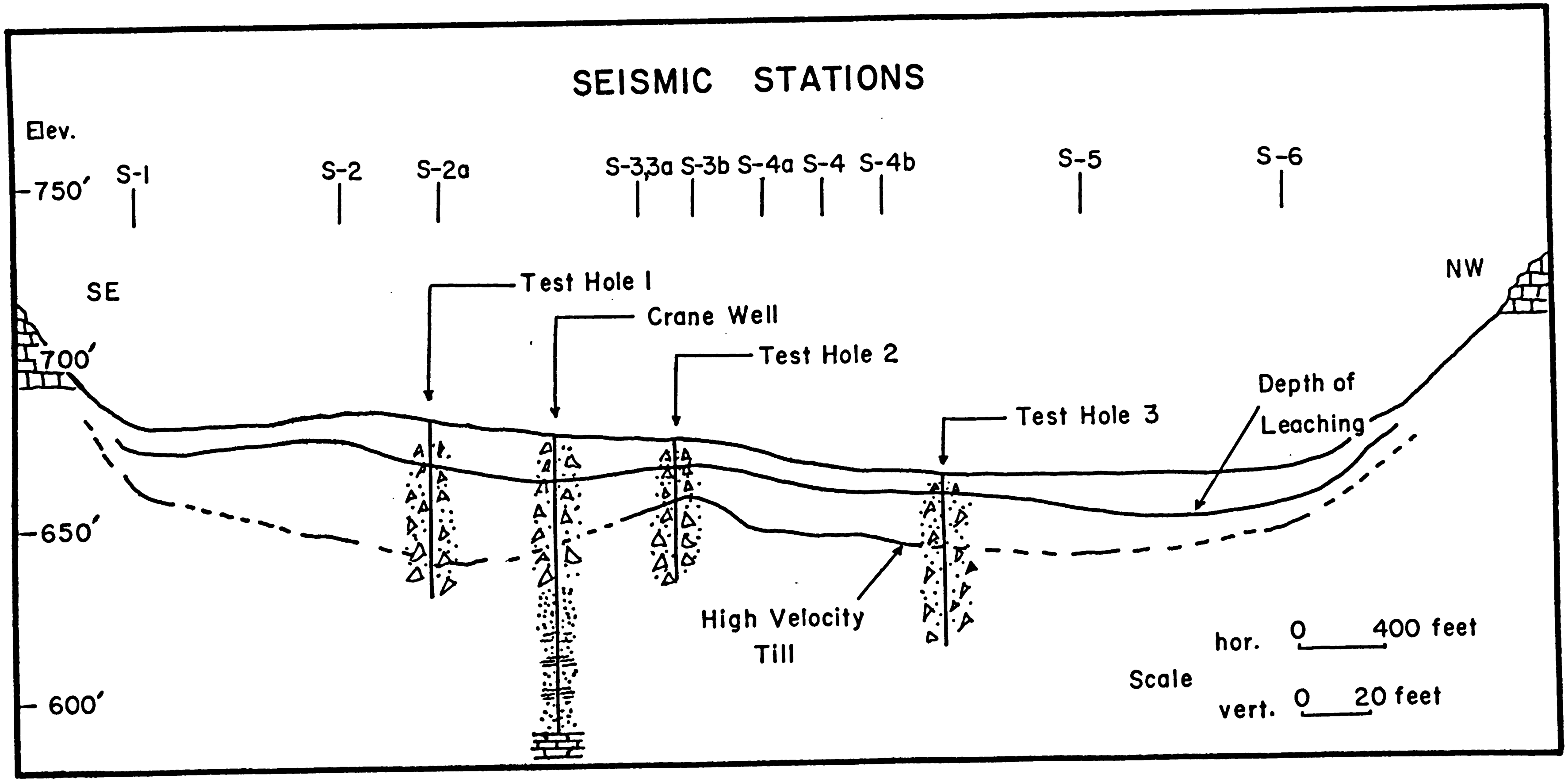


Figure 29— Seismic profile across Valley III along Mt. Hope Road (see fig. 28).

The H. C. Nutting Company made available the use of a Mobile B-40 rig and crew to perform the test hole drilling. The location of the three test holes is shown on Fig. 28.

Because the meander pattern of Area A(Fig. 22)suggests that the channel should be located near the southern boundary of Valley III along Mt. Hope Road, a concentration of seismic traverses were run and two of the test holes were drilled here.

Test hole #1 was made at the location of seismic station 2A. (For test hole data see appendix). This traverse indicated that the first and second material changes occurred at a depth of approximately 10 and 35 feet respectively. In sampling with hollow-stem augers, the depth of leaching was found to be 7.5 feet, which would correlate with the first seismic break. At or near 32 feet, the penetration of the drill became very difficult. A drive sample taken at a depth of 35 feet required 45 blows to penetrate one foot. The material was determined to be very dense, dry till with large limestone slabs and rock fragments. This till which gave the 5,500 fps velocity had been interpreted as bedrock -- probably shale. Till with little change was encountered down to 50 feet at which point the hole was "bottomed" because of the limitations of the rig.

Test hole #2, located 1,200 feet northwest of hole #1, again encountered till. The lithologic changes found in test hole #2 correlated rather closely with the seismic information.

The William Crane Water Well Company, on May 7, 1965, drilled a well on Mt. Hope Road. (See Fig. 29 for location). Sands were penetrated from 45 to 60 feet and bedrock was encountered at a depth of 90 feet. Gravels were never encountered. A sample of the sand was studied under the binocular scope and determined to be of glacial origin. This 90 foot depth to bedrock would place this valley bottom at a maximum elevation of 590 feet. With the information gathered it is here suggested that later excavation of this valley took place during Deep Stage time following the high-level valley development and prior to Illinoian glaciation. This same excavation then was also responsible for the development of the broad anomolous valley to the west of Mt. Hope Road.

RELATION OF VALLEY SEGMENTS

Because these three valleys occur at approximately the same levels, contain like bedload deposits, and have approximately the same width, it is clear that these abandoned high-level valleys are all remnants of the same former stream.

This conclusion leads to the problems of determining the configuration of these integrated channels, the direction of flow, relation to coeval drainage, origin and age.

CONFIGURATION OF THE STREAM CHANNEL

In order to integrate these valley segments, a meandering pattern must be constructed which is very similar to those of the Teays-Age Eagle and Licking Rivers in their headwaters as described by Desjardins(1934), and Durrell(1961)(Fig. 5). Disregarding the direction of flow, one alternative, as illustrated in green on Fig. 30, would be to construct the stream to include Valley III, the present Miami Valley through Miamitown down to Valley II, northwest through Valley II, into the Whitewater Valley down to and eastward through Valley I. From this point the course of the valley reconstruction would coincide with the present Great Miami Valley through Hooven and westward, returning to the Whitewater Valley.

The second choice would include the present Great Miami Valley southwest of Fernald, west through Valley III, into Whitewater Valley, southeast through Valley II, southwestward in present Great Miami Valley, west through Valley I, and southward in Whitewater Valley.

The writer believes the field evidence favors the former of these two reconstructions. The most conclusive evidence supporting this reconstruction is found in Areas A and B of Valley III(Fig. 22). The curving bluffs, coupled with the presence of the bedload deposits, indicates clearly the former presence of a channel. The configuration of the valley bluffs in this section demands that the meander remnant in Area A passes in a natural arcuate pattern across the Great Miami River to include Area B. This rules out the possibility that this high-level

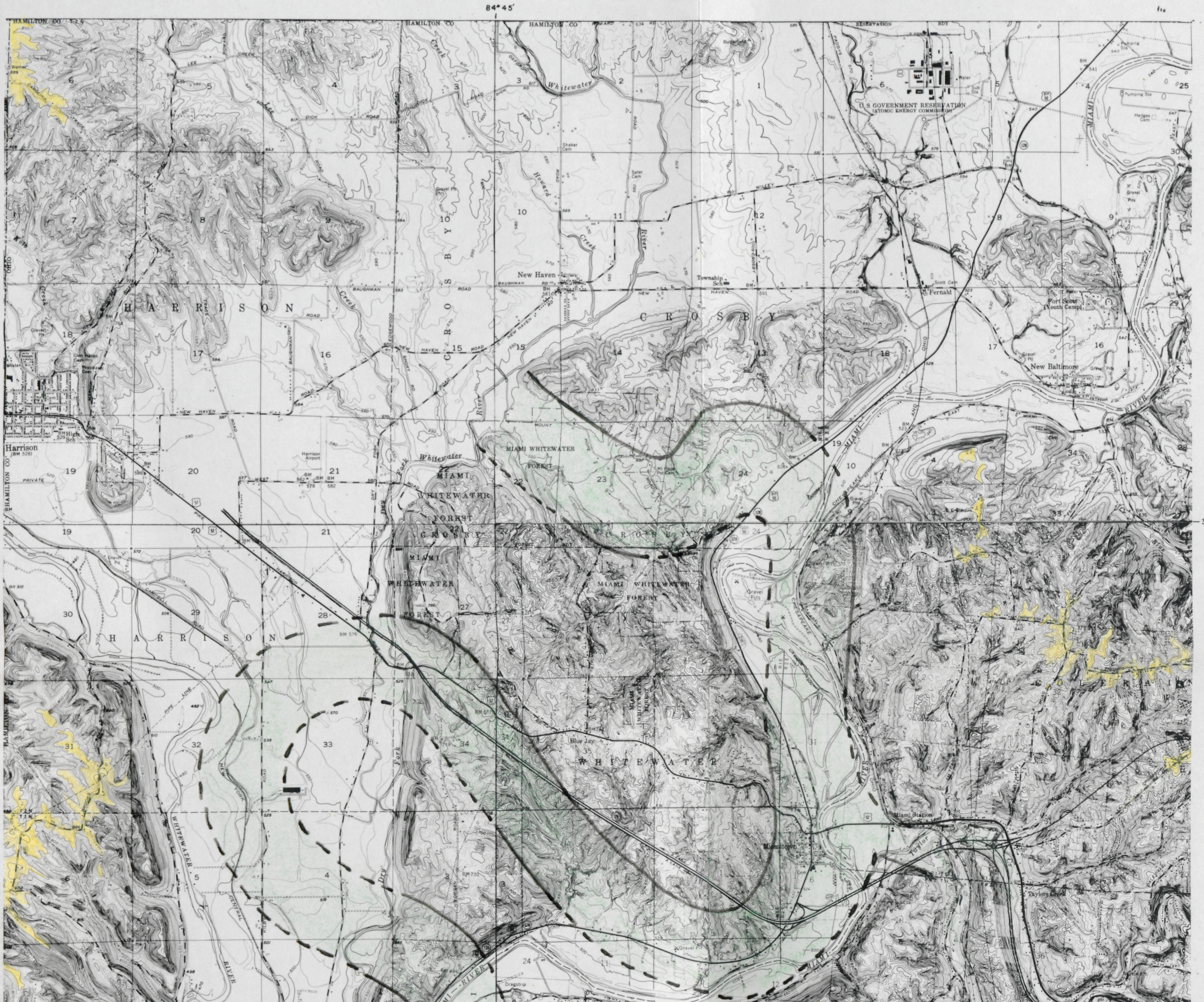


Figure 30- Configuration of integrated channels colored in green; divides colored in yellow.

stream once flowed in the Great Miami Valley between Fernald or New Baltimore and Valley III.

DIRECTION OF FLOW

From the time of the earliest workers to present the direction of flow of the Teays-Age drainage in the Cincinnati region has been controversial. Tight(1903; Malott(1922); Fowke(1933); Desjardins(1934); Durrell(1961); and others have presented evidence to support a northward flow for this drainage system. While Leverett(1902); Fenneman(1916); Ver Steeg(1938); and others support a southerly direction of flow. The north-flowing drainage, as illustrated in Fig. 31, is supported by the following evidence presented by Malott(1922, p 138).

1. Beveling of the upland surface toward the Kentucky River and along the supposed continuation northeast of Carrollton; however, no beveling is discernible in the immediate vicinity of Madison, Indiana, which suggests a divide at Madison.
2. Cherty gravels are abundant on the high valley remnants above the Kentucky and Licking Rivers, but none have been reported in the vicinity of Madison. These gravels should be present if Teays-Age drainage passed through this area, particularly since the uplands are so well preserved.

3. A number of the tributaries northeast of Madison are conspicuously oriented in an upstream direction which is particularly anomolous since this requires their flow against the westerly dip of the Muscatatuk regional slope.

The presumed southwest course illustrated by Thornbury(1965, p 208)(Fig. 32)is apparently based on a bedrock gradient determined from water well logs by Fenneman(1916). According to Stout et al(1943, p. 68)drainage reconstruction is very difficult to establish with such meager evidence.

Gradient

In establishing a gradient Stout et al(1943)assigned elevations as follows: on the Norwood River or Ancestral Ohio(Fenneman 1916) 660 feet near Pt. Pleasant, 540 feet near Hamilton, 535 feet near Venice, and 520 feet at Harrison. These elevations assigned at Venice and Harrison are approximately 100 feet below the high level valleys described in this investigation.

However, Desjardins sights a number of strath levels of the same age but at different levels which clearly indicates a northerly flow for the Teays-Age Licking. The elevations are: 690 feet on the Teays-Age Licking south of Morgan, Kentucky, on the 15 minute Falmouth quadrangle, 630-635 feet on the Norwood or Manchester River near New Palestine, Ohio, and 650 feet in the vicinity of Milford, Ohio.

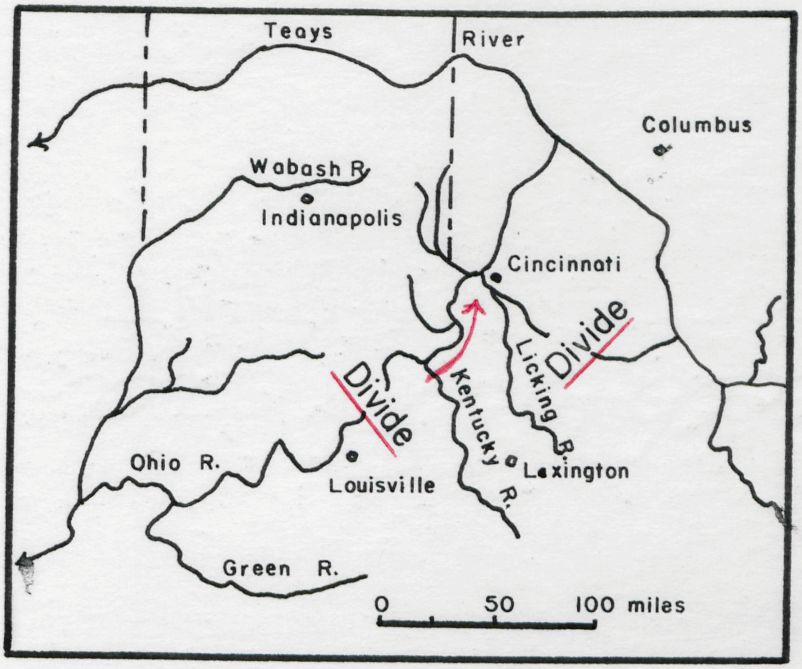


Figure 31

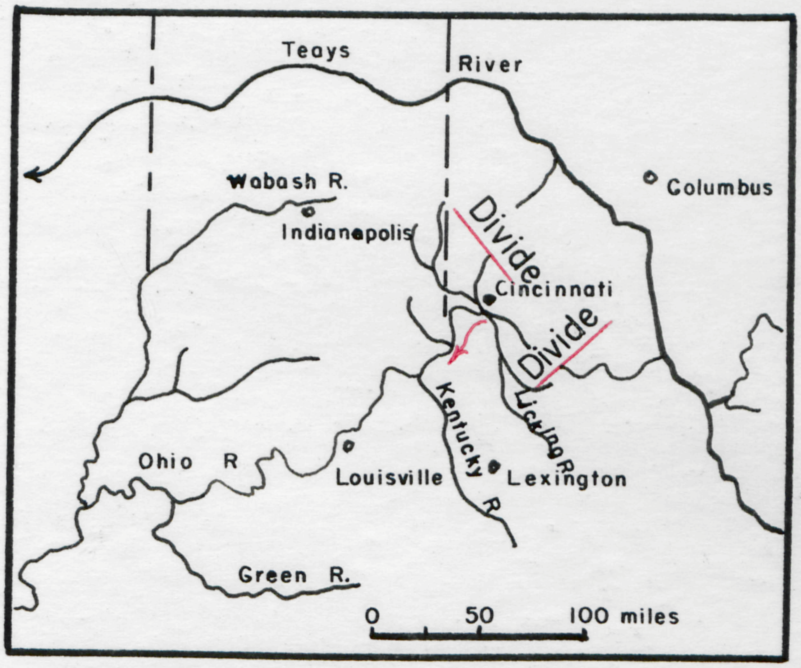


Figure 32
Two concepts for direction of flow of Teays-age drainage (after Thornbury, 1965, p. 208).

In working with bedrock elevations of the Teays-Age Licking between Harrison and Campbell Counties, Kentucky, Durrell(1961) established a gradient of 1.6 ft/mi. By using the 690 foot elevation south of Morgan, Kentucky, 8 miles south of Falmouth, cited by Desjardins, and the gradient of 1.6 ft/mi, the calculated elevation of this same level projected approximately 40 miles north to the Ohio River would be about 630 feet. By assigning a gradient of 1 ft/mi on north to Hamilton, which would be a minimum since the Teays River had a gradient of 10.76 in/mi from Huntington, West Virginia to St. Mary's reservoir in Mercer County, Ohio(Stout et al 1943, p.53), the calculated elevation at Hamilton would be approximately 600 feet. Because the bedrock elevations of the high-level valleys in the thesis area are approximately 625-635 feet, it is then impossible to reconstruct Teays-Age drainage flowing southwest from Hamilton, Ohio.

In the Teays-Age Eagle River approximately 4 miles east of State Route 127 on State Route 42, the bedload-bedrock contact occurs at about 650 feet which fits favorably with the elevations in the thesis area for north-flowing drainage.

Attitude of tributaries

Because modern streams tend to avoid old established divides it is possible to restore the stream pattern with fair reliability (Desjardins,1934). This principle was employed by Desjardins (1934)and Durrell(1961)in the restoration of preglacial drainage in northern Kentucky and southwestern Ohio, where they illustrate very clearly that the major valleys of the peneplain trend and converge northward. In the southeastern part of the thesis area, branches of a major divide have been shaded(Fig. 31). The shading clearly illustrates that the preglacial as well as present tributary streams which occupy the lowlands between these interfluves flowed to the northwest. As illustrated on Fig. 31, Wesselman, Taylor and Blue Rock Creeks are all barbed tributaries of the present Great Miami River but would enter at a normal acute angle to a major stream with a northerly direction of flow. Fig. 34 is a view of Taylor Creek looking northwest from photo station III-5(Fig. 6). As shown on Fig. 33 in the photo, Taylor Creek is to the right and the general lowland of the 700-750 feet elevation is in the foreground. The col in the background is Valley III through which Taylor Creek apparently flowed during Deep Stage development.

The major tributaries on the northwest side of the thesis area indicate to a lesser degree a northern direction of flow of the Teays-Age Eagle River. This less marked indication of direction of flow may be due to joint control, Wisconsin glacial deposition and/or reversal of direction of flow with the advent of Deep Stage drainage.

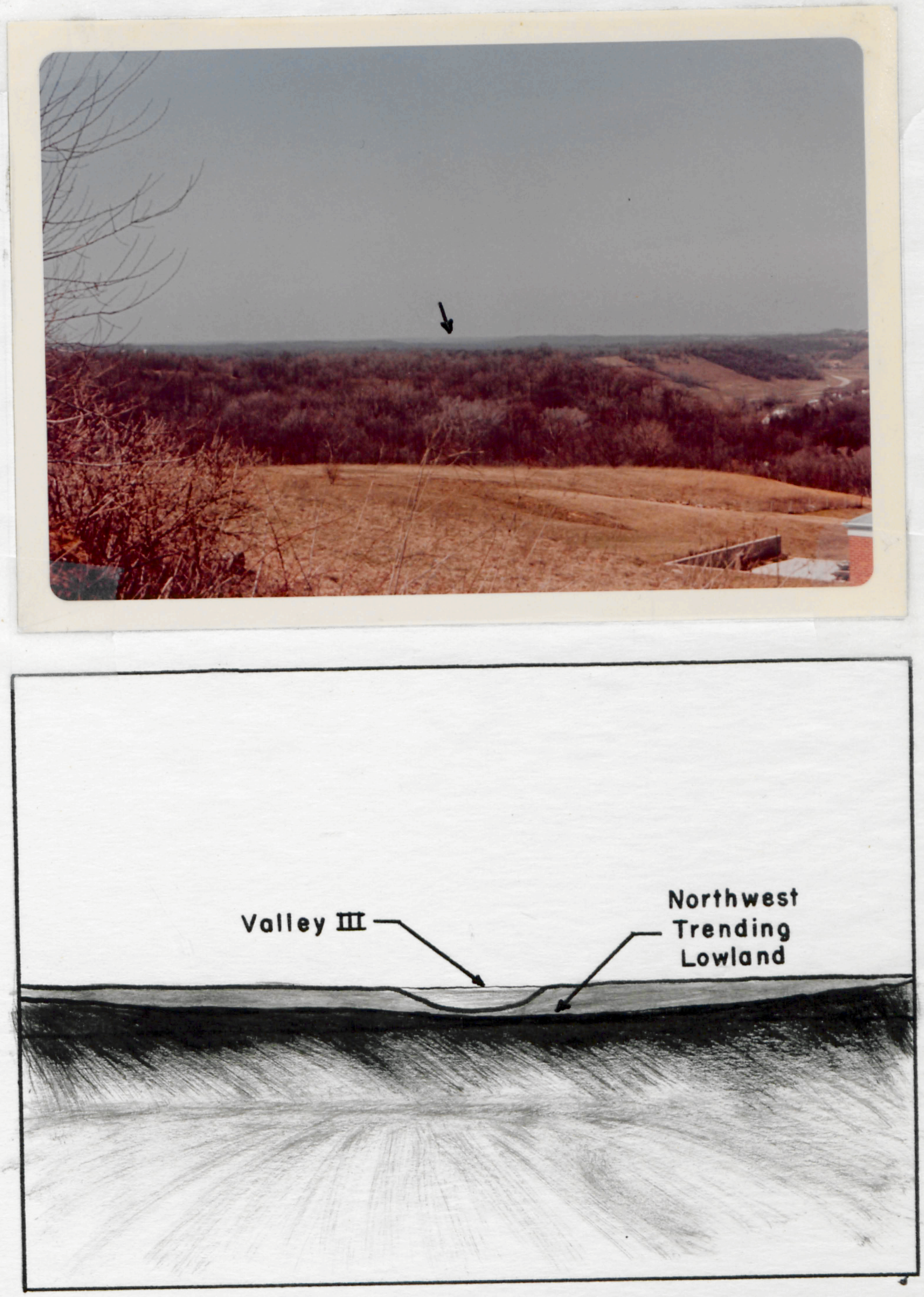


Figure 33- View northwest down lowland in which Taylor Creek is confined between northwest trending divides.

Presence of Lacustrine Deposits

Lacustrine deposits have been found at two localities in the thesis area. In Valley II(Fig. 14)near the Morgan Road overpass at I-74, lake clays were found and described by Durrell(1961). These clays, which occur at an elevation of 645 feet, according to Durrell, are lithologically very similar to the Minford silts which were deposited in rather deep and comparatively quiet ponded waters(Stout et al, 1943,p 56). Since the Kansan ice advance which was probably responsible for the ponding approached from the north, it is evident that the drainage in the thesis area must have had headwaters to the south.

Lake clays have also been found and described by the writer in Valley I(Fig 11). These lacustrine deposits, which occur at approximately 635 feet differ from those in Valley II in that they are much more silty. This possibly suggests that they were deposited near the source area where waters from the glacier were pouring into the ponded waters forming deltaic type deposits.

In Boone County, Kentucky, Kerr(1951)and Middendorf(1952) base south-flowing drainage for the Teays-Age Eagle River partly on the absence of lake clays. Their absence can be explained by the differences in channel elevations between southwest Boone County(690 feet)and the thesis area in southwestern Hamilton County(630-635 feet). Since the lacustrine deposits are only 10-15 feet thick in the thesis area, these waters were probably not ponded far enough south(up the headwaters)to deposit noticeable amounts of lake clays before drainage spilled westward over the divide along the present course of the Ohio(Durrell,1961,p.51).

Source of Bedload Deposits

The quartz geodes, fossiliferous Mississippian cherts and well rounded quartz pebbles may be used as indicators for the direction of flow from the source area.

The geodes are conspicuous constituents in the bedload deposits of the high level valleys in the thesis area, the Teays-Age Eagle River in Kentucky(Durrell,1961) and the "Old" Kentucky River(Jillson,1927). However, geodes are virtually absent in the deposits of the Teays-Age Licking River.

The most probable source of the geodes occurs at the base of the Warsaw Limestone of the Meramacian Series, Mississippian in age. The outcrop range of this geode-rich formation is south-central Indiana and to the southeast, south, and west of the Lexington Dome in Kentucky. Since the outcrops of south-central Indiana are in a separate drainage basin to the west of the Dearborn Upland and Muscatatuk regional slope of Indiana, the geodes were hardly derived from that area, The source area for the geodes then was undoubtedly to the southeast, south, or southwest, and may have been "let down" on the Lexington peneplain from the overlying Mississippian strata. If the Mississippian formations did not extend completely over the Cincinnati Arch they certainly extended many miles beyond their present outcrops.

The coral-bearing cherts are very similar to those that occur in the St. Louis Formation of the Meramacian Series of Mississippian age. Its outcrop extent is the same as that for the Warsaw Limestone. If these fossilferous cherts were derived from the Devonian limestones to the north a much wider variety in the fauna would be expected. A close source for the rounded quartz pebbles outcrops extensively to the south and southeast. This Pottsville conglomerate contains quartz pebbles which very closely resemble those of Teays-Age Licking(Durrell, 1961) and the high-level valleys of the thesis area.

Northward Course of Eagle River

As indicated by buried valleys in southwest Hamilton County, two possibilities exist for the northward course of the Teays-Age Eagle River(Durrell,1961, p 51).

One alternative would be to continue this stream on north to Hamilton where it would merge with the north flowing Teays-Age Licking(Fig. 5). From this point it continues on northward past Dayton and through a narrow gorge in the more resistant Silurian dolomites, much like the channel, 3,000-3,500 feet wide, described by Norris and Spicer(1958,p. 219)through which the Teays River flowed in Madison County, Ohio.

The other alternative would trace the Eagle River northwestward up the present Whitewater River and through the narrows in Henry and Fayette Counties, Indiana. From this point on it would follow the Teays-Age Anderson valley(Wayne,1956)to join the Teays River at Tippecanoe County.

The writer favors the former alternative. However, a detailed seismic and drill hole study needs to be performed before alternative two could be completely discounted.

RELATION TO COEVAL DRAINAGE

The similarity of the valleys studied in this investigation to the Teays-Age Licking and Eagle Rivers has already been discussed in the previous section on the Age of Valleys.

Leverett(1902); Fenneman(1916); and others postulated that the Teays-Age Licking River flowed northward to Hamilton and from there southwestward to Lawrenceburg, Indiana, as a continuation of the Teays-Age Licking.

At least two conditions weigh heavily against this possibility. One, which has already been discussed in the section on direction of flow, is the gradient that obviously slopes northward from the thesis area to Hamilton, Ohio. The other condition is the difference that exists in the bedload constituents, which suggests unrelated source areas. In the fluviatile deposits of the Teays-Age Licking, coal fragments are not uncommon while geodes are rare.

In contrast the stream-laid deposits of the Teays-Age Eagle River, in the thesis area, carry geodes as a very conspicuous constituent, while to the writer's knowledge, coal is absent. Therefore it seems more probable that the Teays-Age Eagle River is a tributary to, rather than a continuation of, the Teays-Age Licking River.

From the conclusions drawn on the discussion of direction of flow, and because the bedload deposits of the thesis area are so similar to those occurring in the Teays-Age Eagle River of Kentucky, it is evident that the drainage segment investigated in this thesis is a northward extension of the former north-flowing Teays-Age Eagle River, as suggested by Durrell(1961).

AGE OF VALLEYS

The high-level valleys in the thesis area can be established as contemporaneous with the formation of the Teays-Age Licking and Eagle Valleys, since they occur at approximately the same elevations, contain very similar bedload deposits, have like channel widths and have an ingrown meandering pattern. The high-level valleys of the Teays-Age Licking and Eagle Rivers have been correlated by Desjardins(1934), and Durrell(1961), with the "Parker Strath." This then would date them as Teays-Age in their development. However, the time at which the Teays-Age system developed was considered by Leverett(1902);

Fenneman(1916); Desjardins(1934); Stout et al(1943); and others to be pre-glacial in origin. However with more recent field evidence gathered, Durrell(1961,p. 51)offers the hypothesis that:

> "the ancient north-flowing system drained toward the Great Lakes or possibly to the Mississippi embayment by a more northerly course than the later Teays system. The advent of the Nebraskan ice disrupted the northward drainage and established the arcuate system of the Teays across Ohio, Indiana and Illinois as traced by Horberg(1950)."

RECONSTRUCTION OF DRAINAGE

By Late Tertiary time the Lexington peneplain had developed (Fenneman,1938). In the Cincinnati region, north-south trending divides were developed 8-12 miles apart on a gently sloping surface to the north, approximately 900-950 feet in elevation. Between these divides broad lowlands were developed, 100-150 feet below the upland divides on which a north-flowing drainage system was established(Fig. 34). During the time, either immediately preceding the Pleistocene epoch, or following Nebraskan glaciation(Durrell,1961), rejuvenation of this north-flowing drainage took place which resulted in the development of a partial erosion cycle. This level, known as the "Parker Strath" (Butts,1904), occurs in southwest Hamilton County, Ohio, as terrace and channel remnants at an elevation of approximately 625-635 feet. The revisions of the Teays-Age Eagle River in southwestern Hamilton County, Ohio, are shown in Fig. 34.

With the advance of the Kansan ice front the north-flowing drainage was ponded. In the Teays-Age Licking Valley, silt free, laminated lake clays occur as evidence of the ponding. However, until 1961, when Durrell described lake clays from a cut at the intersection of Morgan Road and I-74(Valley II of thesis area), lake clays were unknown in southwest Hamilton County. The writer has also located lacustrine deposits in the southeast section of Valley II and on a road cut in Valley I (Figs. 14 and 11).

The ponded waters of the Teays-Age Eagle River eventually spilled over the divide along the present route of the Ohio and took up a westward course(Durrell,1961,p 51). This outlet provided a new course for the Teays-Age Licking River as well as other rivers to the east disrupted by the Kansan ice sheet. This new west-flowing river system during Yarmouth time eventually became incised approximately 450 feet below the Lexington peneplain.

In the thesis area the broad Whitewater valley has Deep Stage origin(Fig. 30). As shown by this illustration the Deep Stage drainage in the thesis area did not maintain the course of the pre-existing high-level drainage. This may be explained by having this broad lowland filled with glacial deposits. This seems very possible since large erratics and weathered glacial deposits

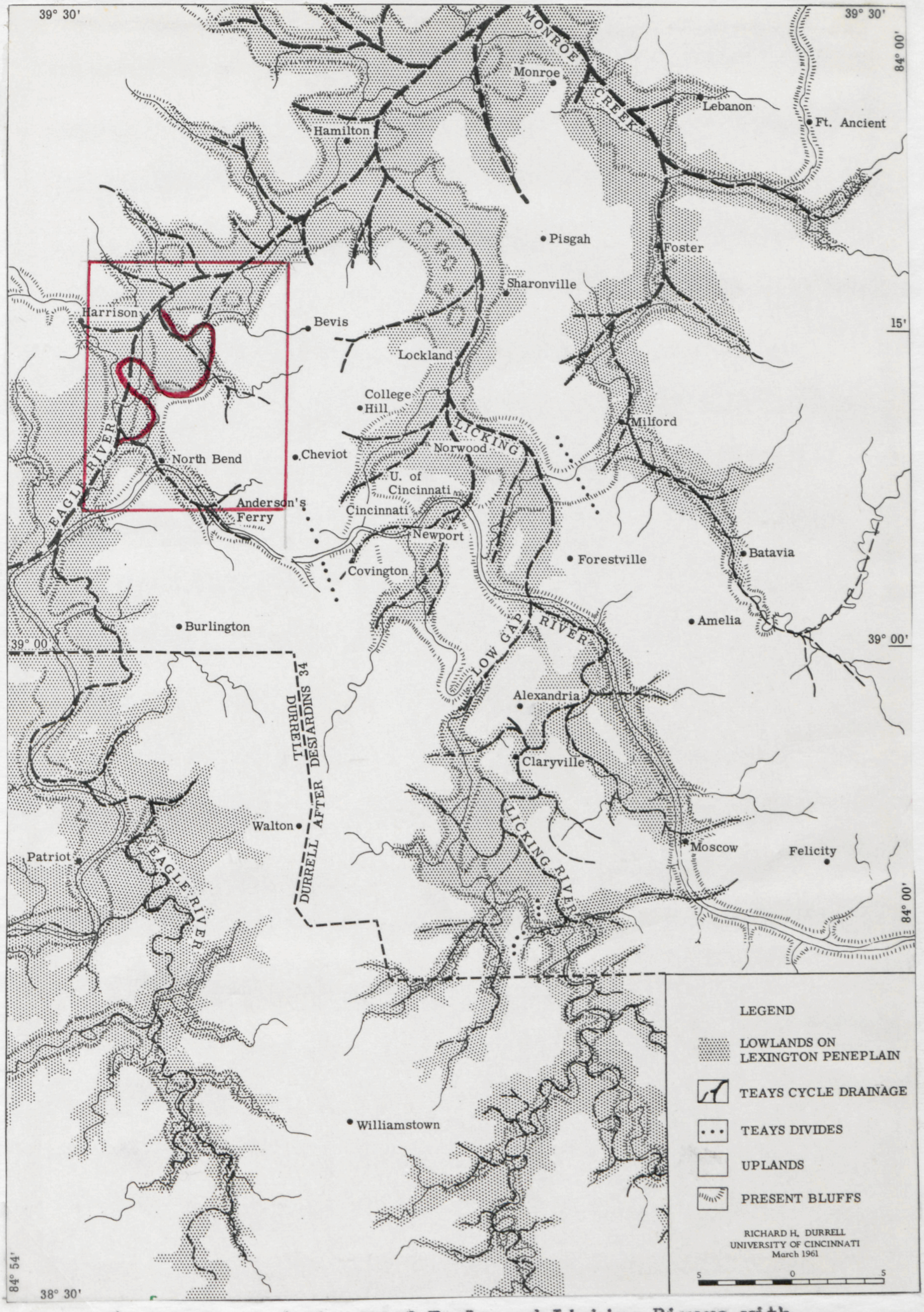


Figure 34- Teays-age drainage of Eagle and Licking Rivers with revision in area investigated in this thesis. (modified after Durrell, 1961)

are present today above 750 feet A. T. As the ice front retreated, new drainage lines would be established on the glacial filling and maintain this course during down-cutting with little regard to pre-existing drainage.

In Valley III of the thesis area, information derived from field observations and drill hole data suggests that excavation of this valley took place sometime after development of the high level valleys and prior to Illinoian glaciation. This was determined by the fact that the bedrock contact occurs at 590 feet which is too low to be related to the high-level valley stage. The Illinoian age valley filling demands pre-Illinoian development of Valley III.

If the channel configurations of Fig. 30 and the northward direction of flow are correct, then the water from drainage basins of Taylor and Wesselman Creeks would have normally flowed through Valley III during Deep Stage development. This possibly explains why the western portion of Valley III is so wide and deep when its present drainage basin is abnormally small.

The Illinoian ice front was responsible for the last major drainage change in the area of Cincinnati. The Deep Stage Ohio was displaced southward to its present course where it breached the major north-south trending divide at Anderson Ferry. A tongue of Illinoian ice pushed southward down the Whitewater Valley and into the thesis area as evidenced by the deposits in the valleys described in this thesis. Drainage was probably displaced out of Whitewater Valley and took up the course which the Great Miami River presently occupies. This course was established partially as a marginal stream to the ice front, and partly because the Teays-Age Eagle River lowland was already available. This is particularly well expressed by the section of the Great Miami River between Valley II and III(Fig. 30).

The Wisconsin glacier had little effect on the drainage in the area of this thesis. The Whitewater and Great Miami drainageways served as valley trains aggrading with outwash to an elevation of approximately 540 feet. Lake clays, exposed in a spillway cut for Miami-Whitewater Park Lake, are probably related to a deltaic origin, being deposited as waters spilled into Valley III as the Whitewater Valley rapidly aggraded.

CONCLUSIONS

The three high-level abandoned valleys are related in such a way that they are remnants of the same stream because they:

1. appear at similar elevations
2. contain like bedload deposits
3. have approximately the same channel widths
4. have proximity of areal distribution

The configuration of these integrated channels is a meandering pattern which can be correlated with the "Parker Strath" on the basis of:

1. strath level elevation of 640-660 feet
2. characteristic ingrown meandering pattern

The northerly course of the Teays-Age Eagle River as postulated by early workers is affirmed by the findings in this investigation as follows:

1. The barbed nature of the present northwest trending tributaries such as: Wesselman, Taylor and Blue Rock Creeks
2. A northward stream gradient based on bedrock-bedload contact
3. Presence of lake clays resulting from ponding of drainage
4. Southerly source area for quartz geodes, cherts containing Mississippian corals and quartz pebbles of Pottsville(?)age.

The relationship of this segment of drainage in southwest Hamilton County, Ohio, to coeval streams is such that:

1. it is a tributary to, rather than a continuation of, the Teays-Age Licking River.
2. it is a northward extension of the north-flowing Teays-Age Eagle River in Gallatin, Grant and Boone Counties, Kentucky

The chronology of events which were instrumental in developing the drainage of the thesis area in southwest Hamilton County is generally as follows:

1. During Tertiary time north-flowing drainage at the approximate elevation of 800 feet in broad lowlands on the Lexington peneplain.
2. Development of a partial erosion cycle just prior to the Pleistocene epoch or following Nebraskan glaciation which has expression in the thesis area as dissected channel remnants and truncated flat spurs at a bedrock-bedload contact of approximately 625-635 feet in elevation.
3. Displacement and reversal of drainage by the Kansan ice front which probably filled this broad lowland in which the north-flowing drainage was confined.
4. Development of the Deep Stage Valley. During this same time a tributary formed by the present Taylor and Wesselman Creeks was responsible for extensive excavation of Valley III to an elevation of 590 feet or lower.
5. Southward displacement of the major trunk stream to its present location in the Ohio Valley by the Illinoian ice front. During this time the Whitewater River was displaced and took up the course which the Great

Miami River presently occupies. This course was probably established partially as a stream marginal to the ice front and partly because the pre-Kansan high-level valley was already available.

6. Any change in drainage resulting from Wisconsin glaciation in the thesis area is negligible.

Suggestions for Further Study

Because of the presence of a conspicuous rectilinear drainage pattern in the thesis area, joint control of drainage is suggested. If true, this might possibly have some significance as to the drainage control of the entire Cincinnati region. This certainly needs detailed field investigation.

Glacial deposits in the thesis area range in age from Kansan or pre-Kansan(lacustrine deposits)to Winsconsin(loess). This, coupled with the wide variety of deposits, suggests an interesting if difficult glacial history. Accurate mapping of these deposits would not only add more detail to the Ohio State glacial map but would also contribute to a better interpretation of the drainage history.

With the limited amount of information gathered concerning the bedrock elevation of Valley III, it has been in this thesis suggested that extensive excavation took place in this valley during the development of the Deep Stage drainage. This merits more detailed investigation. Perhaps with deeper drilling information supplied by the H. C. Nutting Company and the use of the MD-1 refraction and/or a reflection seismograph, a detailed profile of Valley III could be made. With this kind of information a more accurate interpretation of the drainage history could be determined.

The possibilities that the Teays-Age Eagle River formerly flowed northwesterly up the Whitewater River rather than to Hamilton and northward, and that the Kentucky River was at one time connected with the Teays-Age Eagle River which would better explain the presence of certain bedload constituents deserves further investigation.

A southerly source area is suggested in this paper for the bedload deposits. A detailed study of the fossiliferous chert would undoubtedly provide data which would substantiate or disprove this hypothesis.

SELECTED REFERENCES

Desjardins, Louis, 1934: The Pre-Glacial Physiography of the Cincinnati Region; Unpub. Master's Thesis, Univ. of Cincinnati, pg 43

Durrell, R. H., 1956: Illinoian Boundary in Southwestern Ohio and Northern Kentucky(Abstract); Geol. Soc. America Bull., Vol. 67, pg 1751

Durrell, R. H., 1961: Pleistocene Geology of the Cincinnati Area, Guidebook for Field Trips Cincinnati Meeting; Geol. Soc. America Bull. pg 47-57

Fenneman, N. M., 1916: Geology of Cincinnati and Vicinity; Geol. Survey Ohio Bull. 19, pg 207

Fenneman, N. H., 1938: Physiography of Eastern United States; McGraw-Hill Pub. Co., New York, pg 714

Fowke, Gerard, 1933: Evolution of the Ohio River; The Hollenbeck Press, Indianapolis, pg 68-121

Hofmann, H. J., 1965: Deformational Structures near Cincinnati, Ohio; Geol. Soc. America Bull., in press.

Horberg, Leland, 1945: A Major Buried Valley in East-Central Illinois and its Regional Relationships; Jour. Geology, Vol. 53, pg 349-359

Keller, D. J., 1957: A Fracture Study in the Greater Cincinnati Area; Unpub. Master's Thesis, Univ. of Cincinnati.

Kerr, S. D., 1951: Early Stream Channels in Boone County, Kentucky; Unpub. Master's Thesis, Univ. of Cincinnati, pg 20

La Rocque, Aurele and Marple, M. F., 1955: Ohio Fossils; Geol. Survey of Ohio Bull. 54, pg 74-119

Leverett, Frank, 1902: Glacial Formations and Drainage Features of the Erie and Ohio Basins; U. S. Geol. Survey Monograph 41

Leverett, Frank, 1929: The Pleistocene of Northern Kentucky; Kentucky Geol. Survey, Vol. 31, pg 1-80

Malott, C. A., 1922: The Physiography of Indiana, in Handbook of Indiana Geology, Indiana Dept of Conservation, Pub. 21, Pt. 2, pg 59-256

McGinnis, L. D.; Kempton, J. P., 1961: Integrated Seismic, Resistivity, and Geological Studies of Glacial Deposits; Illinois State Geol. Survey, Circular 323, pg 21

Middendorf, R. P., 1952: High-Level Stream Channels in Northwestern Boone County, Kentucky; Unpub. Master's Thesis, Univ. of Cincinnati

Murray, H. H., 1955: Sedimentation and Stratigraphy of the Devonian Rocks of Southeastern Indiana; Indiana Dept of Conservation, Field Conference Guidebook No. 8, pg 46-48

Norris, S. E.; Spicer, H. C., 1958: Geological and Geophysical Study of the Pre-Glacial Teays Valley in West-Central Ohio; U. S. Geol. Survey Water Supply Paper 1460-E, pg 199-232

Patton, J. B., et al, 1953: Ordovician Stratigraphy, and the Physiography of Part of Southeastern Indiana; Indiana Dept of Conservation, Geol. Survey Field Conference Guidebook No. 6, pg 1-10

Rhodehamel, E. C.; Carlston, C. W., 1963: Geologic History of the Teays Valley in West Virginia; Geol. Soc. America Bull. Vol. 74, pg 251-274

Scheidegger, A. E.: Theoretical Geomorphology; Prentice-Hall, Inc., Englewood Cliffs, N. J., pg 1-14

Stout, Wilber; Schaaf, Downs, 1931: Minford Silts of Southern Ohio; Geol. Soc. America Bull. Vol. 42, pg 663-672

Stout, Wilber; Ver Steeg; Karl; Lamb, G. F., 1943: Geology of Water in Ohio; Geol. Survey of Ohio Bull. 44

Thornbury, W. D., 1965: Regional Geomorphology of the United States; John Wiley & Sons, Inc., New York, pg 185-257

Tight, W. G., 1903: Drainage Modifications in Southeastern Ohio and Adjacent Parts of West Virginia and Kentucky; U. S. Geol. Survey Prof. Paper 13.

Vetorino, R. M., 1953: A Contribution to the Drainage Problem in Northwestern Boone County, Kentucky; Unpub. Master's Thesis, Univ. of Cincinnati, pg 29

Wayne, W. J., 1956: Thickness of Drift and Bedrock Physiography of Indiana North of the Wisconsin Glacial Boundary; Indiana Dept of Conservation, Geol. Survey Report of Progress, No. 7, pg 1-56

APPENDIX

SINK HOLE DATA

SOUTHWEST OHIO	SECTION		ELEVATION IN FEET
COLERAIN TOWNSHIP	33		800
	32		790
	26		760
	20		830
	31		770
	25		760
	19		780
		AVERAGE 785	
GREEN TOWNSHIP	23		780
	35		750
	28		755
	16		760
	33		790
		AVERAGE 770	
MIAMI TOWNSHIP	5		750, 780
	11		760
	17		780. 770
	4		760
	15		720
		AVERAGE 760	
CROSBY TOWNSHIP	13		730
WHITEWATER TOWNSHIP	36		770
	35		760
	3		720
	2		720, 710
	1		690
		AVERAGE 730	
SOUTHEAST INDIANA			
HARRISON TOWNSHIP	25		690

APPENDIX — SINK HOLE DATA

SOUTHEAST INDIANA	SECTION	ELEVATION IN FEET
MILLER TOWNSHIP	1	880
	12	870
	11	880
	14	750
	22	730, 700
	23	770
	24	750
	27	680
	26	710, 750
	AVERAGE 780	
LAWRENCEBURG TOWNSHIP	36	680

APPENDIX

DRILL HOLE DATA

VALLEY III--MT HOPE RD

TEST HOLE #1

FOOTAGE	
0- 2	Soil, dark brn
2- 9	Clay, silty, "leached"
9-15	Till, "unleached"
15-16.5	"Drive sample" till
16.5-25	Till
25-26.5	"Drive sample" till
26.5-30	Till large ls slabs
30-31.5	"Drive sample" till, gray(high in organics)
31.5-35	Till bl-gr
35-36.5	"Drive sample" upper 6" gr-blk, high in organics, wood & plant frags lower 12" very dense till(46 blows for 1 ft penetration)
36.5-40	Till, dense
40-41.5	"Drive sample" till, dense, dry, gr-brn, large rock frags
40-50	Till gr-brn(auger samples)

TEST HOLE #2

0- 2	Soil, dark brn
3- 5	Till, silty, leached, brn
5- 7	Till, silty, leached, brn
7-10	Till, calc.

APPENDIX — DRILL HOLE DATA

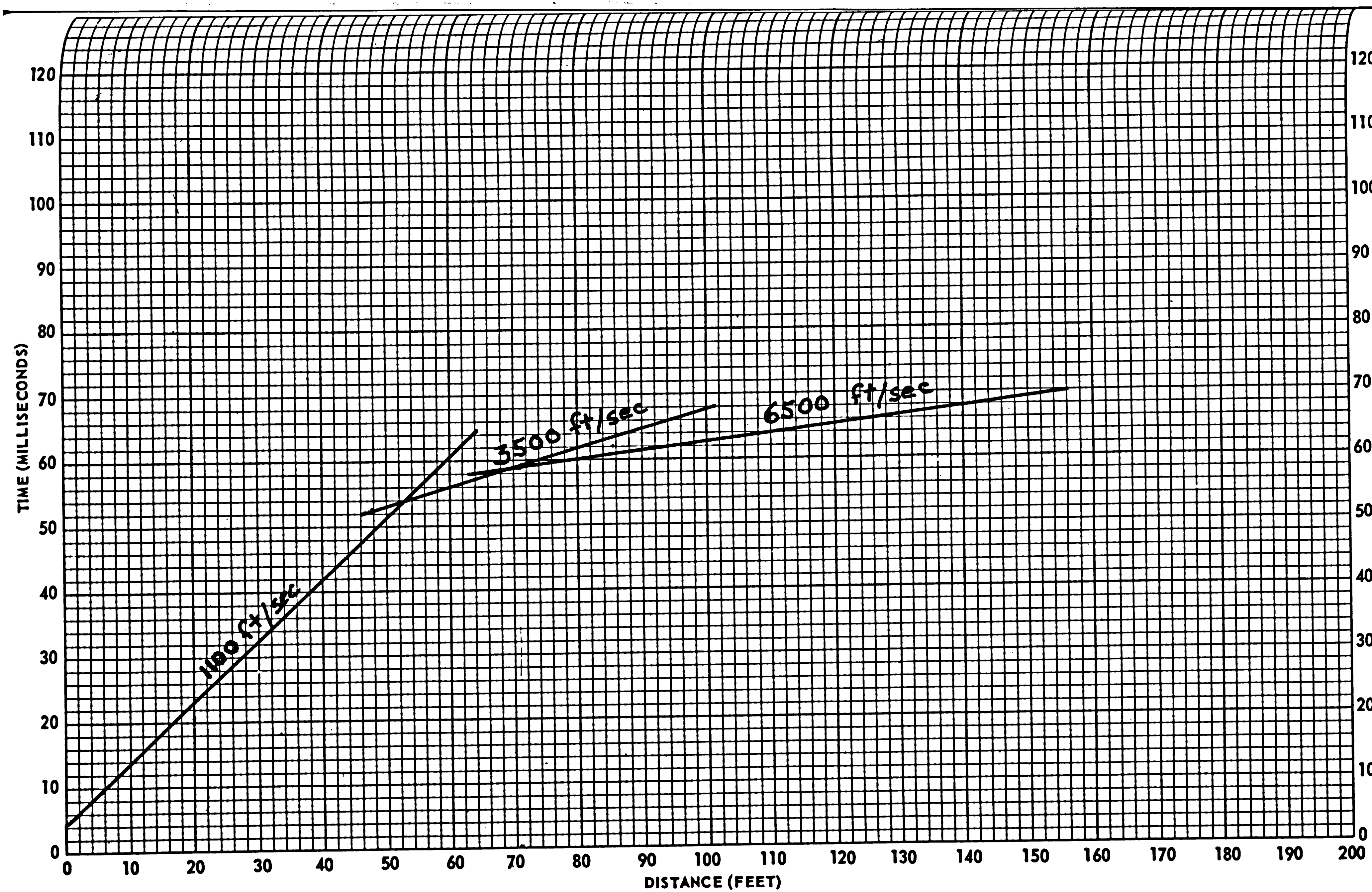
TEST HOLE #2 (Contd)

FOOTAGE	
10-20	Till, calc, dense, coarse, brn
20-30	Till, calc, dense, gr-brn
30-	Till, calc, dense, gray
30-35	Till, calc, organics, gray
35-40	Till, sandy seams, water

TEST HOLE #3

0 - 2	Soil, dark brn
2 - 9	Till, "leached," brn
9 -15	Till, calc, brn
15-20	Till, calc, gray
20-30	Till, calc, bl-gr
30-35	Till, calc, bl-gr, water*
35-40	Till, sandy seams, brn

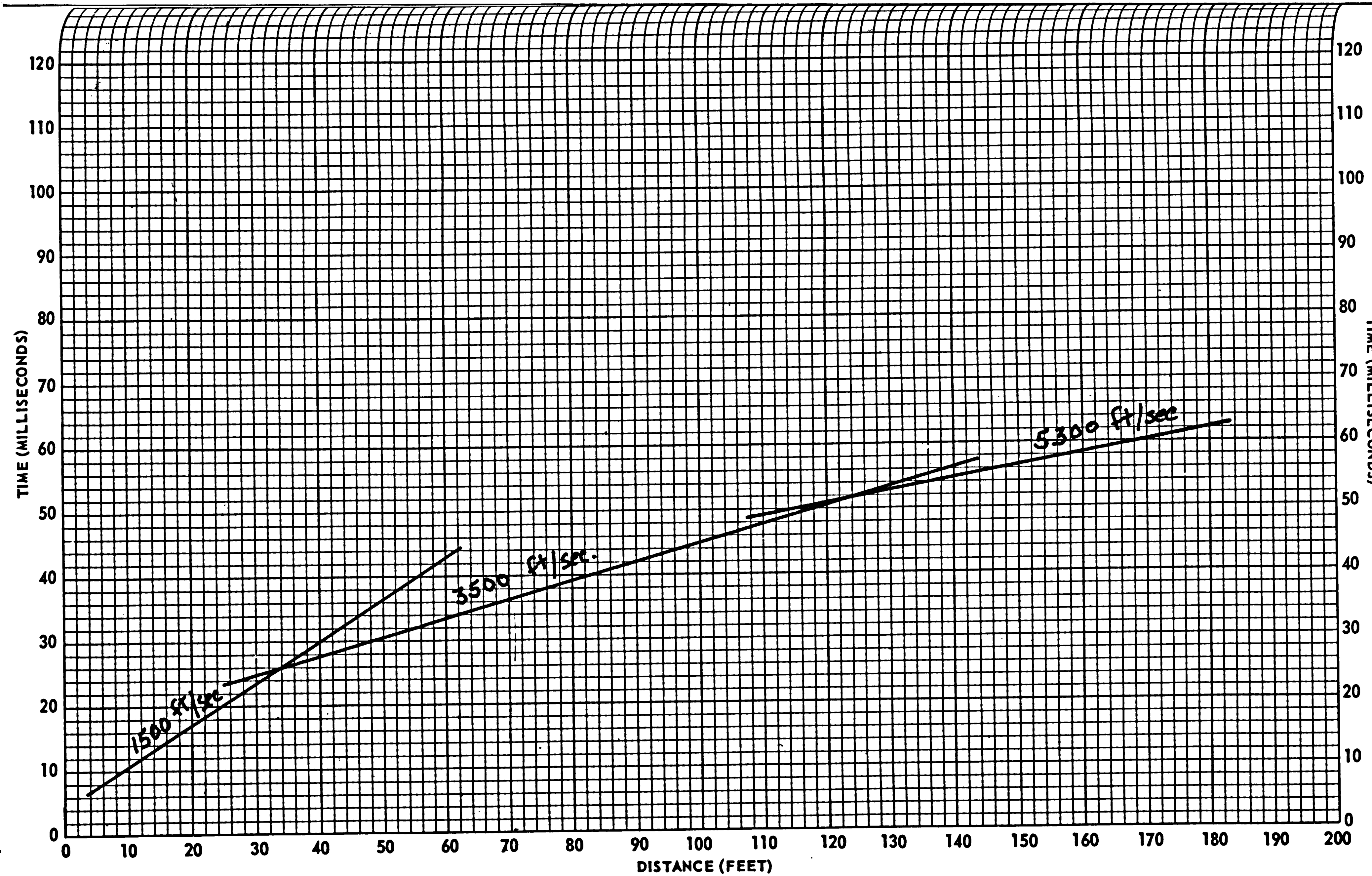
*Static water level 13 feet



DATE________ OPERATOR________

LOCATION Mt. Hope Rd. V-III

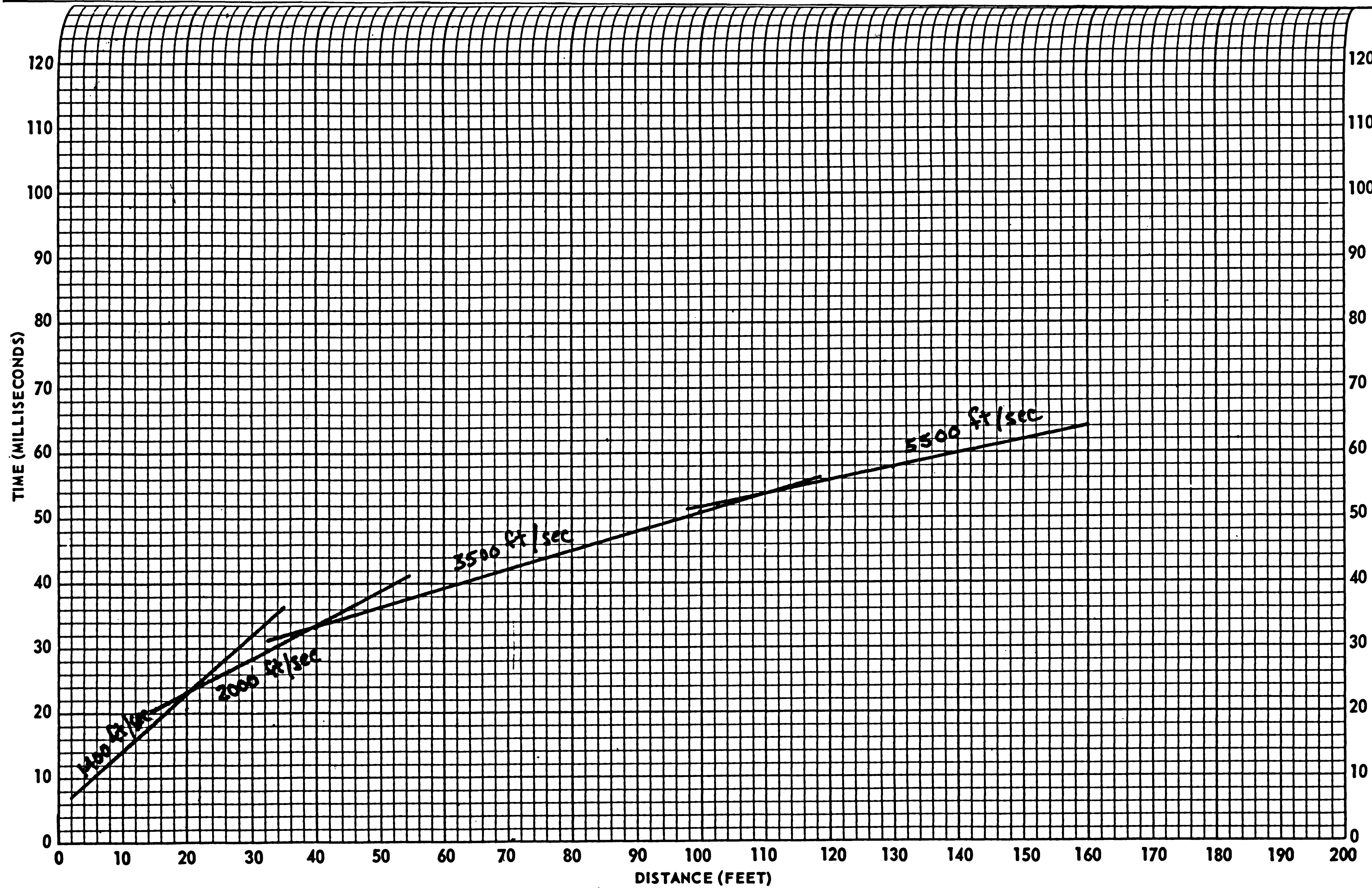
JOB________ TRAVERSE 1-A



DATE________ OPERATOR________

LOCATION Mt. Hope Rd. V-III

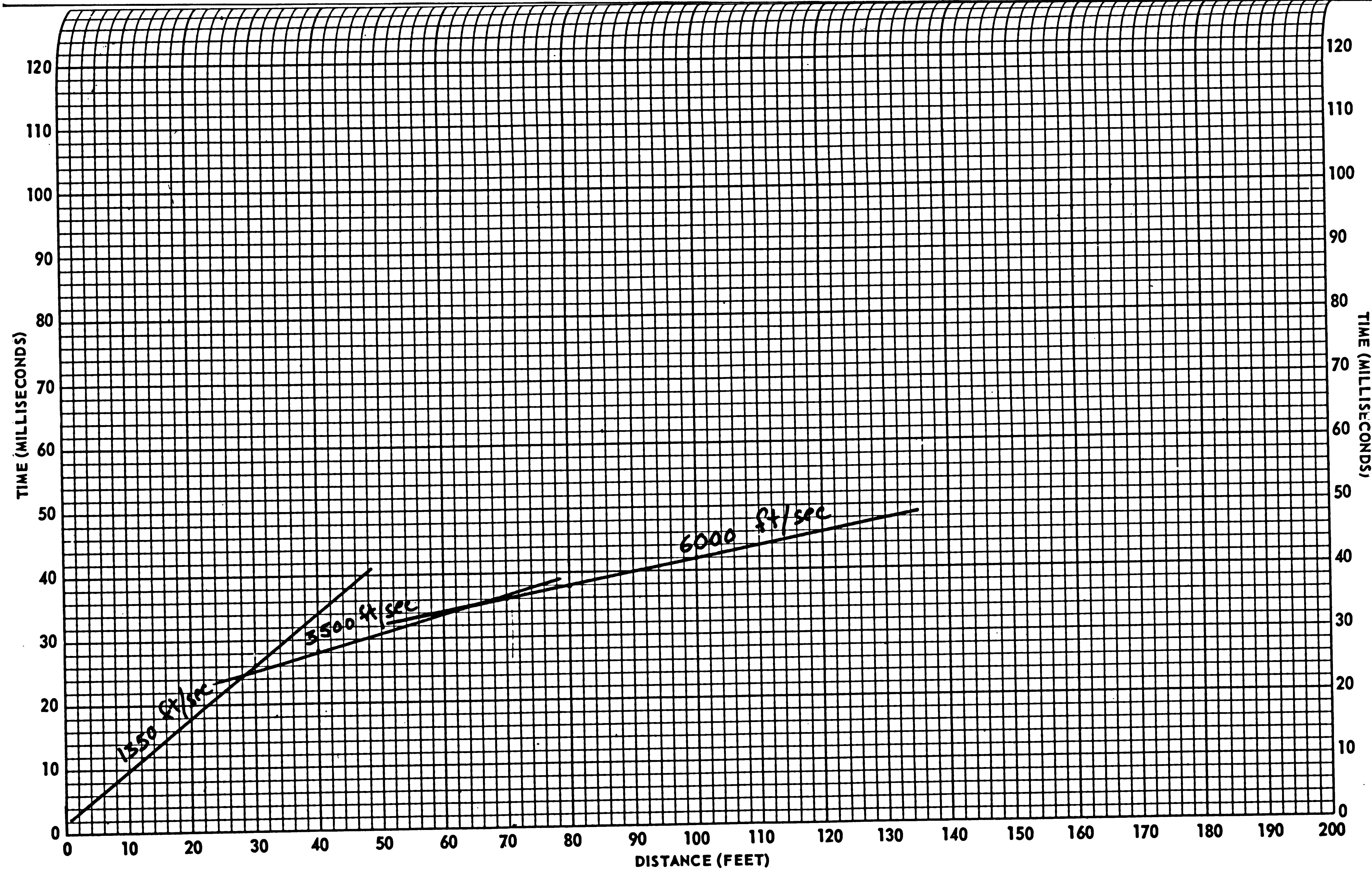
JOB________ TRAVERSE 2



DATE____________ OPERATOR____________

LOCATION Mt. Hope Rd. V-III

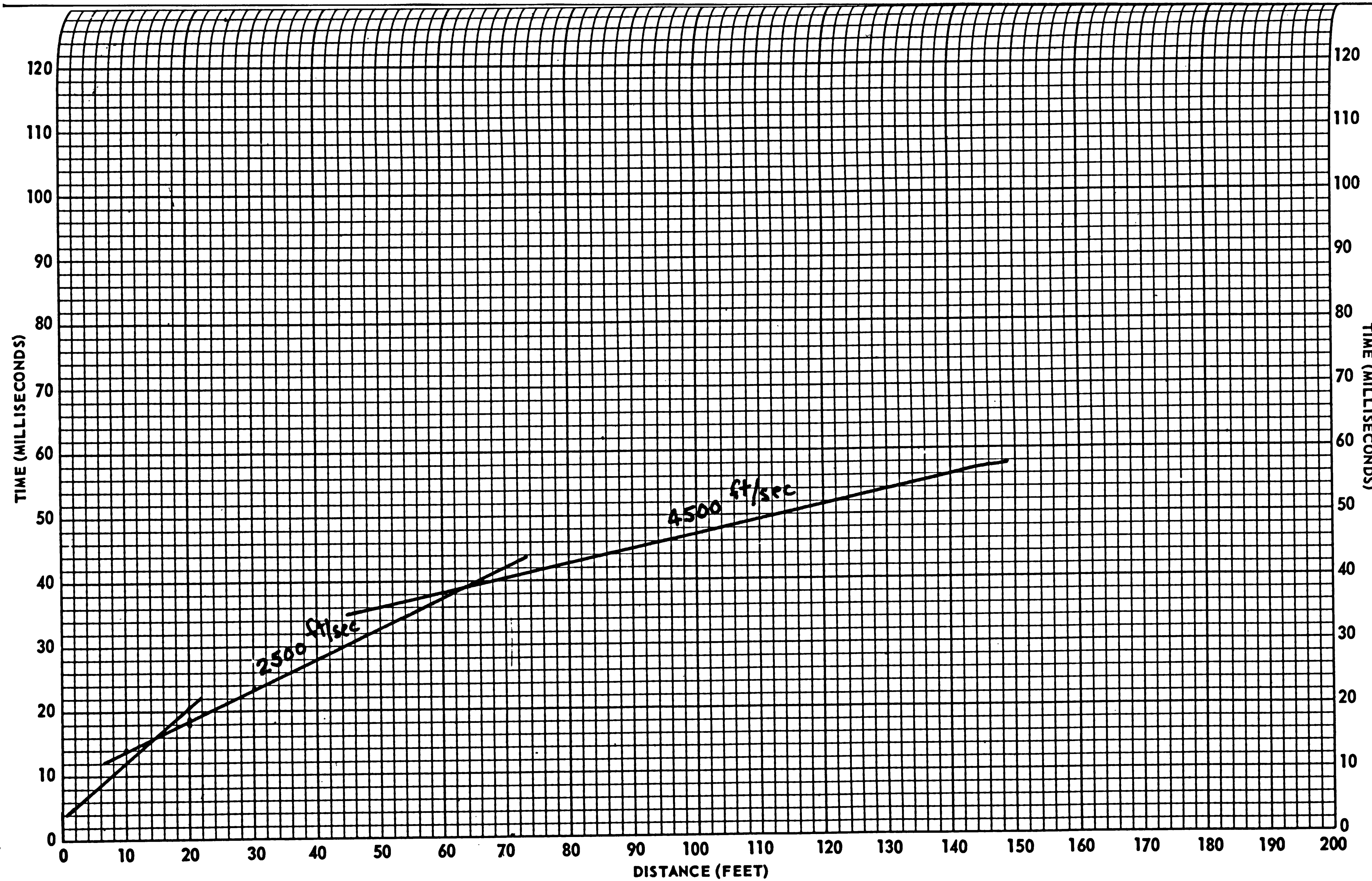
JOB____________ TRAVERSE 2-A



DATE ____ OPERATOR ____

LOCATION Mt. Hope Rd. V-III

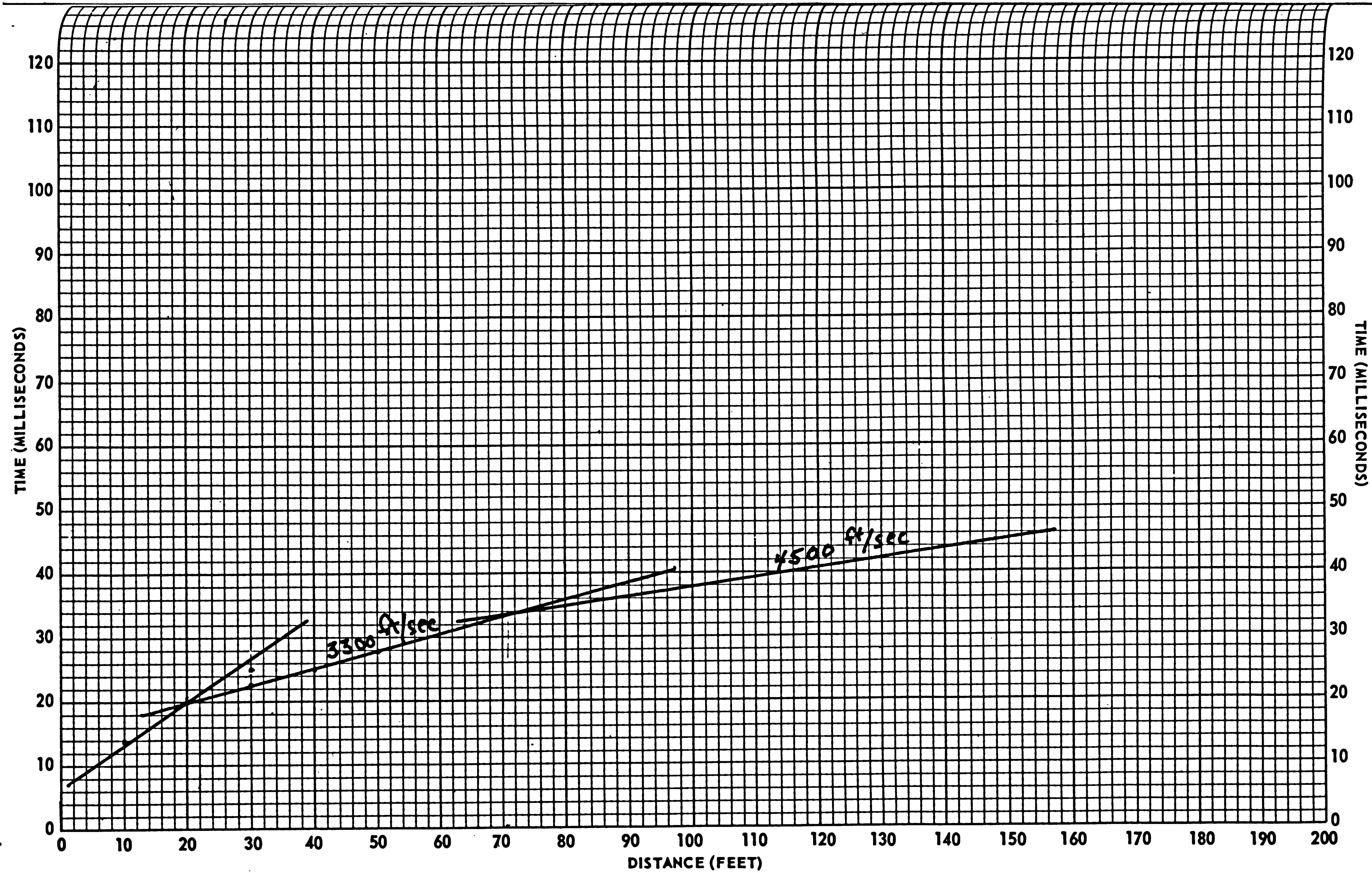
JOB ____ TRAVERSE 3



DATE__________ OPERATOR__________

LOCATION Mt. Hope Rd. V-III

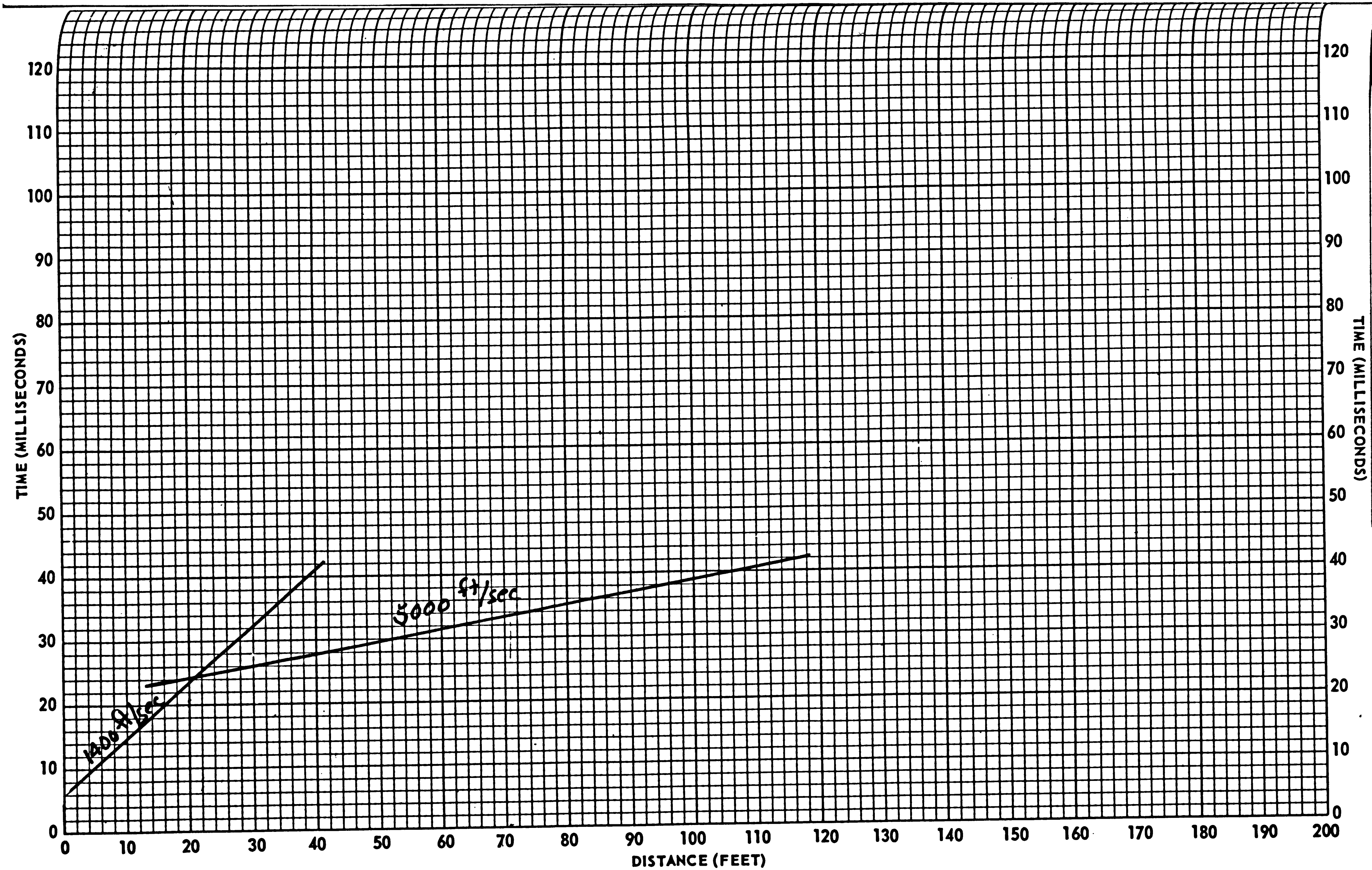
JOB__________ TRAVERSE 3-a



DATE________ OPERATOR________

LOCATION Mt. Hope Rd. V-III

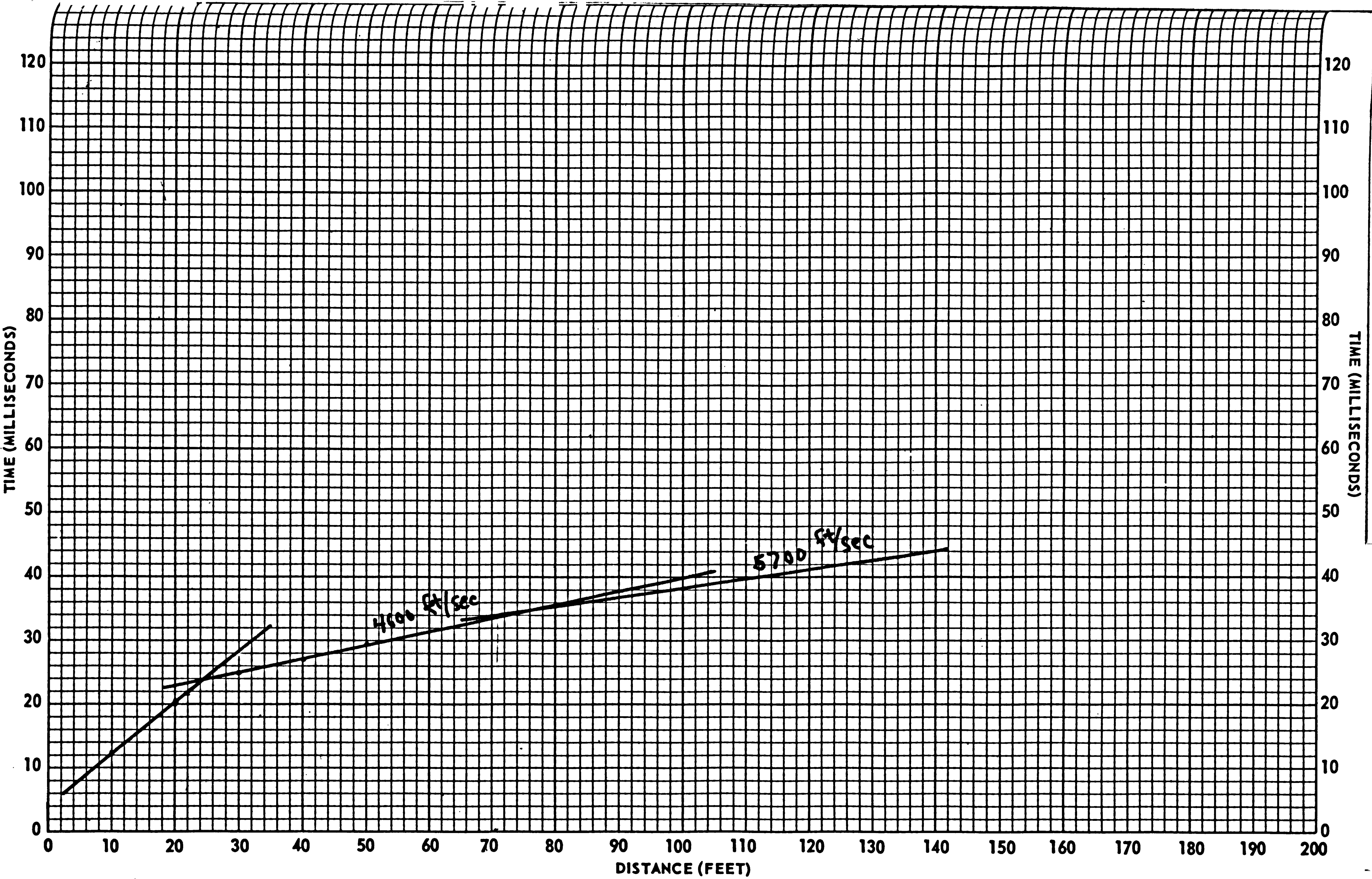
JOB________ TRAVERSE 3-b



DATE ____ OPERATOR ____

LOCATION Mt. Hope Rd. V-III

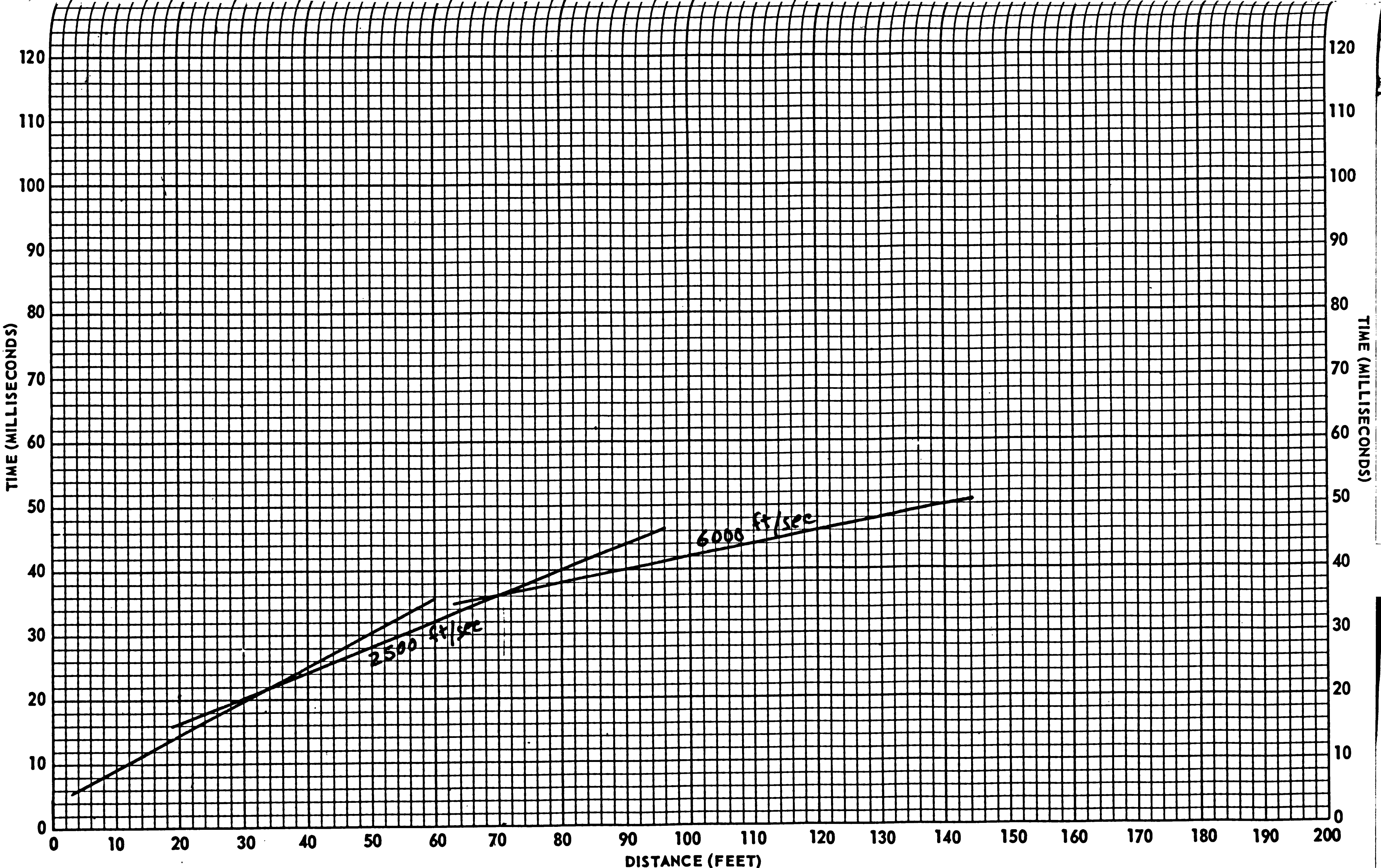
JOB ____ TRAVERSE 4



DATE________ OPERATOR________

LOCATION Mt. Hope Rd. V-III

JOB________ TRAVERSE 4-a



DATE________ OPERATOR________

LOCATION Mt. Hope Rd. V-III

JOB________ TRAVERSE 5

Figure 28
Location map of test hole sites and seismic stations.

Scale 1:2400
Contour Interval 5 feet