To the Graduate Council:

I am submitting herewith a dissertation written by Verner C. Johnson, entitled "Geophysical Survey of the Yellow Creek Area, Mississippi." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Geology.

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Vice Chancellor
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Thesis
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GEOPHYSICAL SURVEY OF THE YELLOW CREEK AREA, MISSISSIPPI

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee

Verner C. Johnson

June 1975

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ABSTRACT

Proposed power plant sites in northeastern Mississippi were investigated using geophysical techniques. The plant sites are mantled by a thick sequence of Cretaceous and Tertiary unconsolidated sediments of the Mississippi embayment. The Cretaceous sediments rest unconformably on Mississippian carbonates and siltstones.

Gravity and seismic refraction surveys were employed to delineate regions underlain by thick residual soils and unconsolidated sediments from regions where bedrock lies at shallow depth. The investigation consisted of three stages. The first stage was a gravity survey. Negative gravity anomalies were located and interpreted as indicators of thick residual soils and sediments. The second stage was a seismic refraction survey of each of the negative anomalies in order to determine the depth to bedrock. The third stage was a subsurface investigation by means of a core drill in an attempt to confirm the geophysical interpretation. A shallow geologic section was compiled from core drill data along a line of holes that crossed one of the gravity anomalies.

The seismic refraction and drill data indicate that there is a correlation between the depth to bedrock and the gravitational field. The variations in depth to bedrock may be related to post Paleozoic faults or buried Mississippian karst topography.

The results of this study indicate that geophysical techniques can be applied to environmental and engineering problems of a geological nature over most of the Mississippi embayment. Quarry prospects and shallow geologic features can be investigated successfully by the use of geophysical techniques.

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CHAPTER I

INTRODUCTION

Location

The Yellow Creek area is located in Tishomingo County in the northeastern corner of the state of Mississippi (Fig. 1). The center of the New Madrid earthquake zone lies approximately 150 miles to the west-northwest. A large-scale reconnaissance gravity survey area lies between 34°55' and 35°00' north latitude and between 88°10' and 88"15' west longitude (Fig. 2). The Yellow Creek embayment of Pickwick Lake lies near the western boundary of the survey area.

Corinth, Mississippi, the nearest town, is 22 miles southwest of the site. The Yellow Creek area can be reached from Corinth by taking U. S. Highway 72 or Mississippi State Highways 366 and 25. Most of the roads in the area are rural gravel roads and trails.

The study area includes two proposed Tennessee Valley Authority power plant sites--the Goat Island site on the west bank of the embayment and the Alternate site on the east bank (Fig. 2).

Purpose of Investigation

The purpose of this investigation is to test the suitability of gravity surveys for preliminary exploration

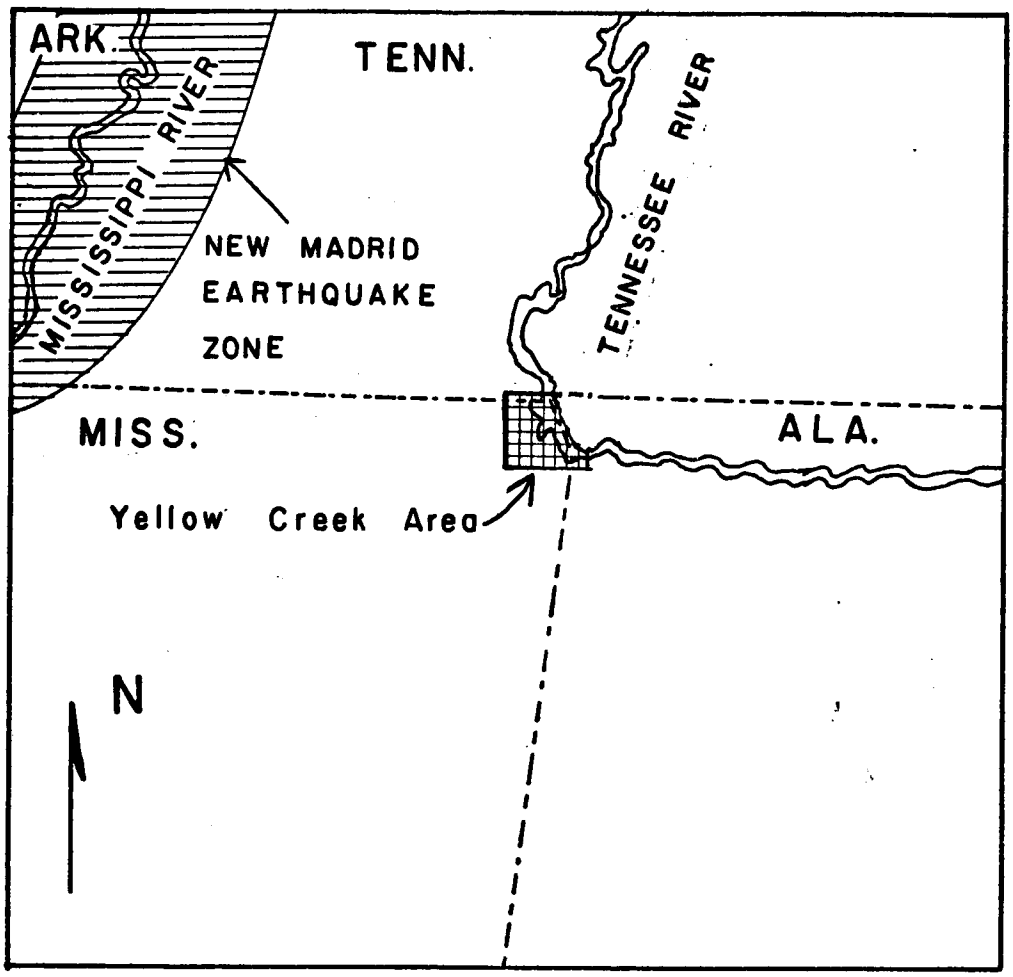


Figure 1. Location of the Yellow Creek Area.

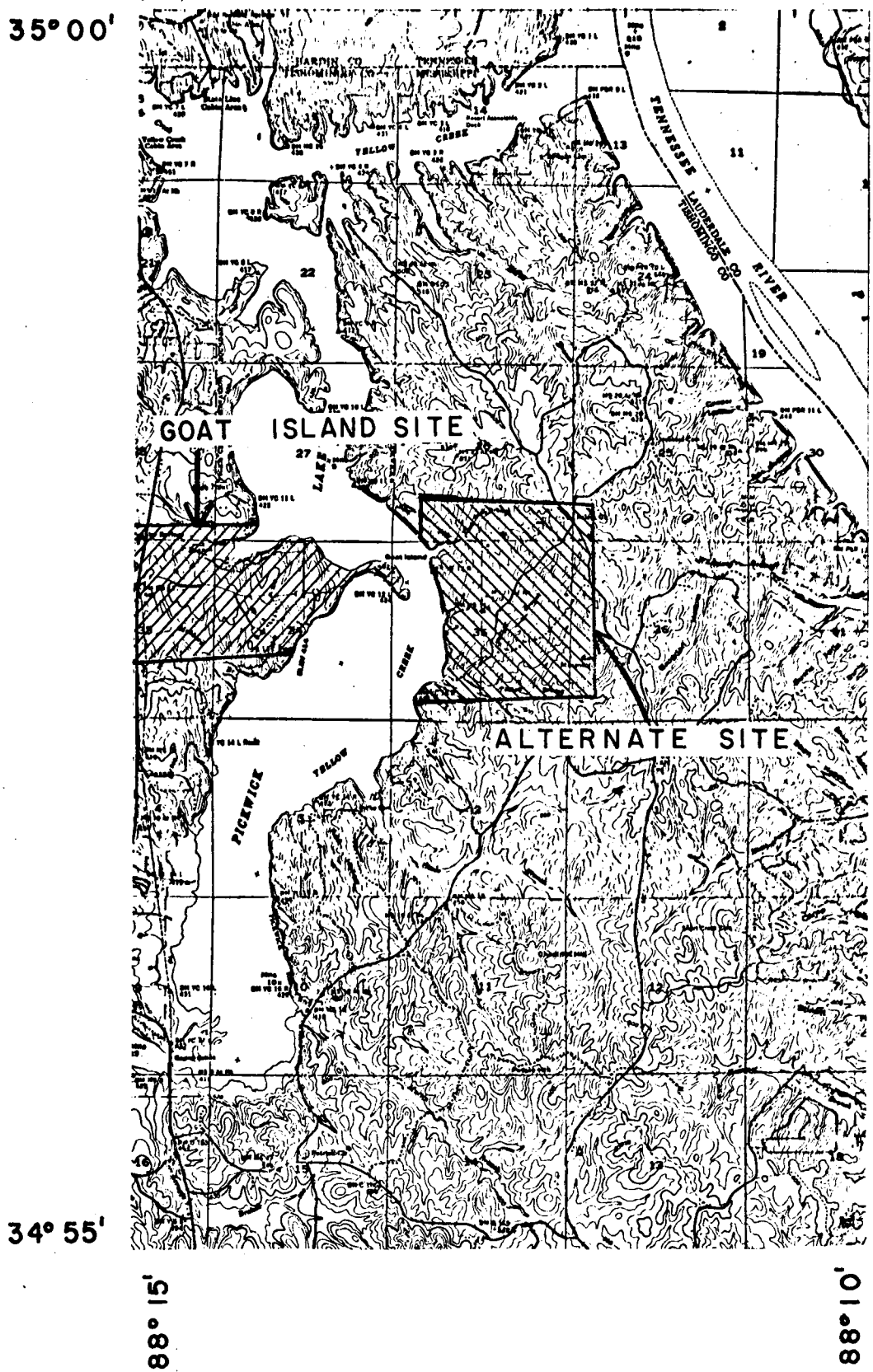


Figure 2. Location of the proposed plant sites.

of the power plant sites in the Mississippi embayment region. The interpretation based on the results of the gravity survey would be tested by a combination of seismic refraction and core tests.

CHAPTER II

REVIEW OF LITERATURE

Seismicity of the Mississippi Embayment

Despite the relative rarity of earthquakes in the eastern United States, more than 1,000 earthquakes have been reported east of the Mississippi River since 1700, particularly in and around the New Madrid earthquake zone (Fig. 3).

The Yellow Creek embayment lies within 150 miles of the New Madrid earthwuake zone (Fig. 4). Because of the earthquake hazard, the Tennessee Valley Authority is concerned about the existence of recent seismic activity in the area (Fig. 5).

Stearns and Wilson (1972) have reported 31 major earthquakes since 1811 that may have produced shock waves strong enough to be felt in the Yellow Creek area. Many of the earthquakes originated within the New Madrid earthquake zone (Fig. 3 and Table I). The majority of them undoubtedly had relatively low intensities within the proposed plant site areas. However, earthquakes with high intensity, including the severe New Madrid earthquakes of 1811-1812, were probably strong enough to cause minor structural damage within the Yellow Creek area. Nuttli (1973) has determined the body-wave magnitudes (Richter scale) for the 1811-1812 earthquakes based on the ground motion data. The body-wave

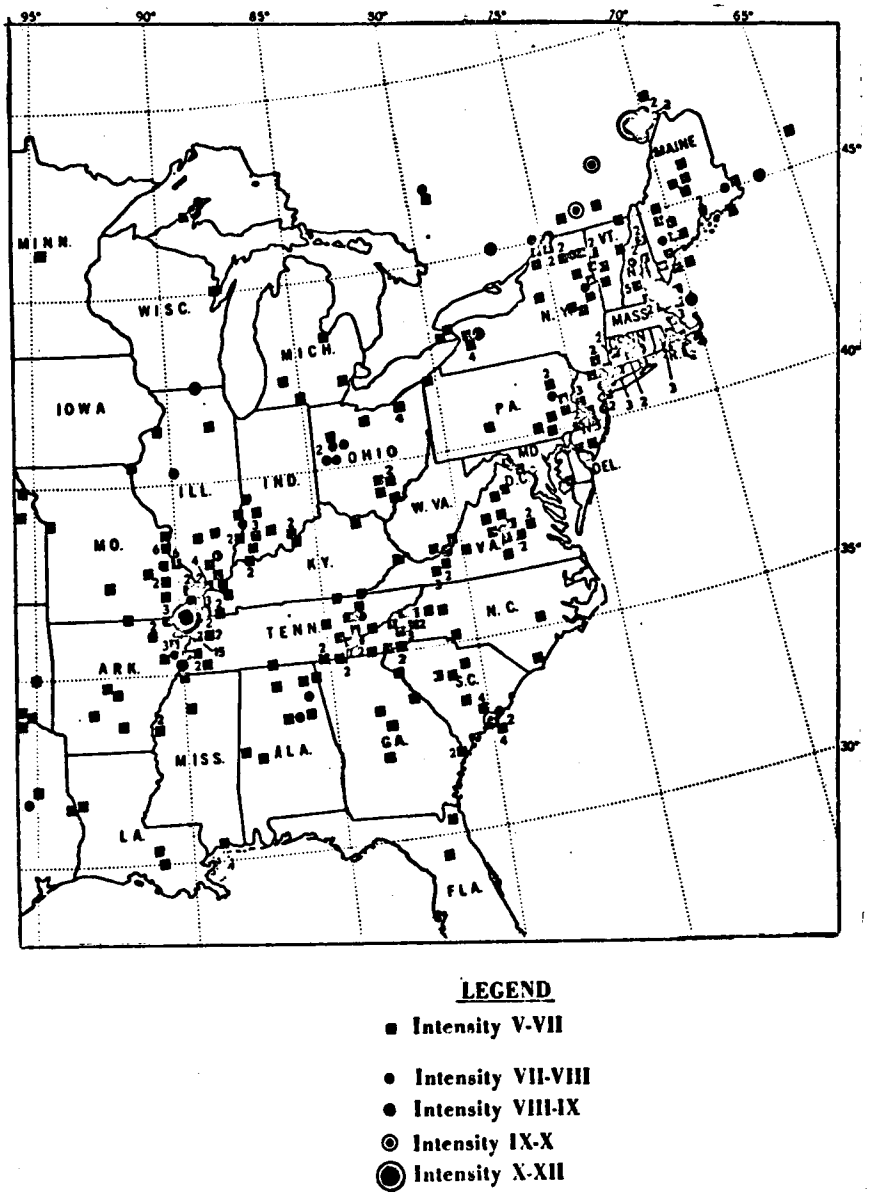


Figure 3. Earthquakes (intensity V and above) in eastern United States through 1970 (courtesy of National Oceanic and Atmospheric Administration).

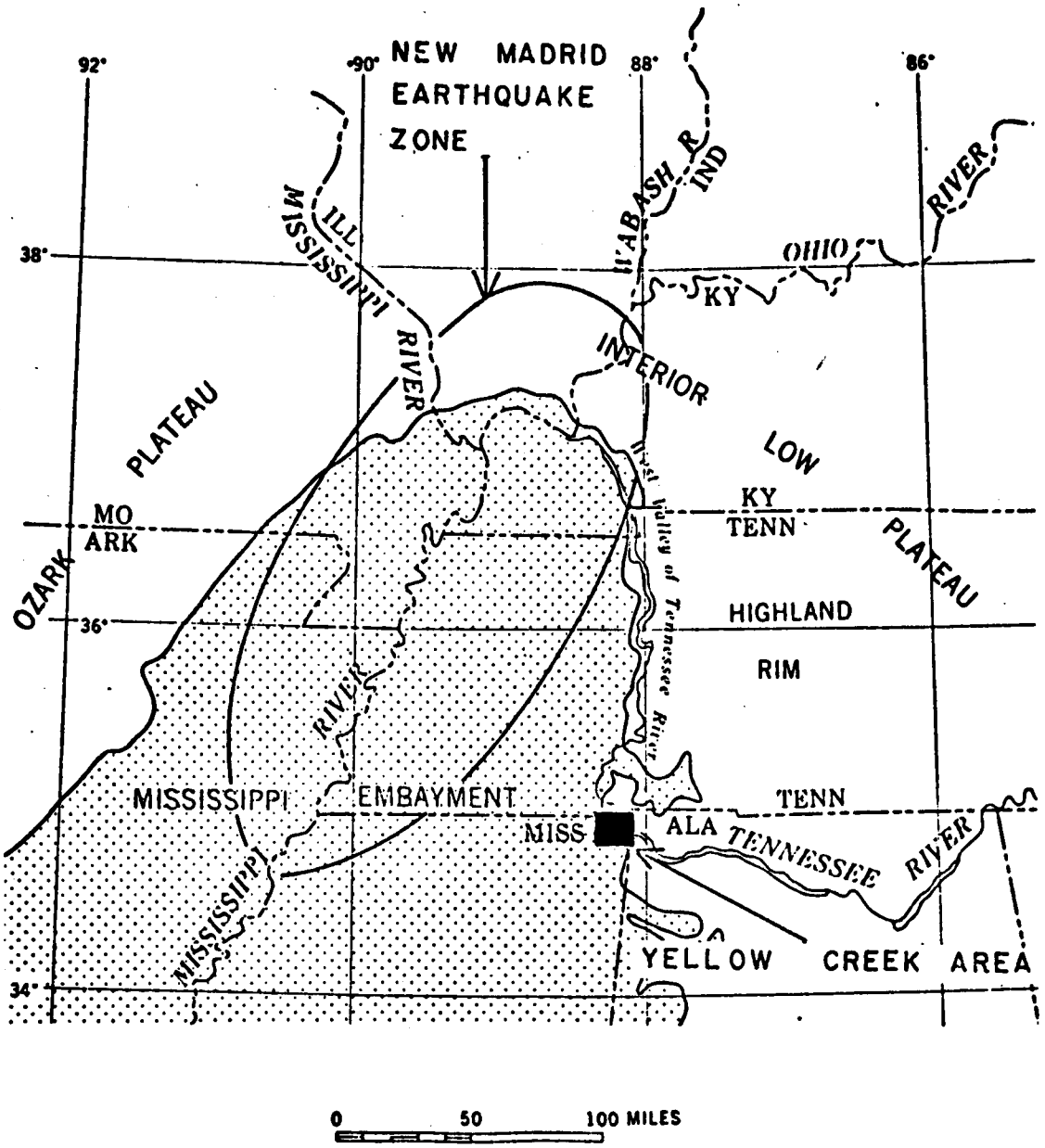


Figure 4. The Mississippi Embayment Region with New Madrid Earthquake Zone (Stearns and Wilson, 1972, courtesy of Tennessee Valley Authority).

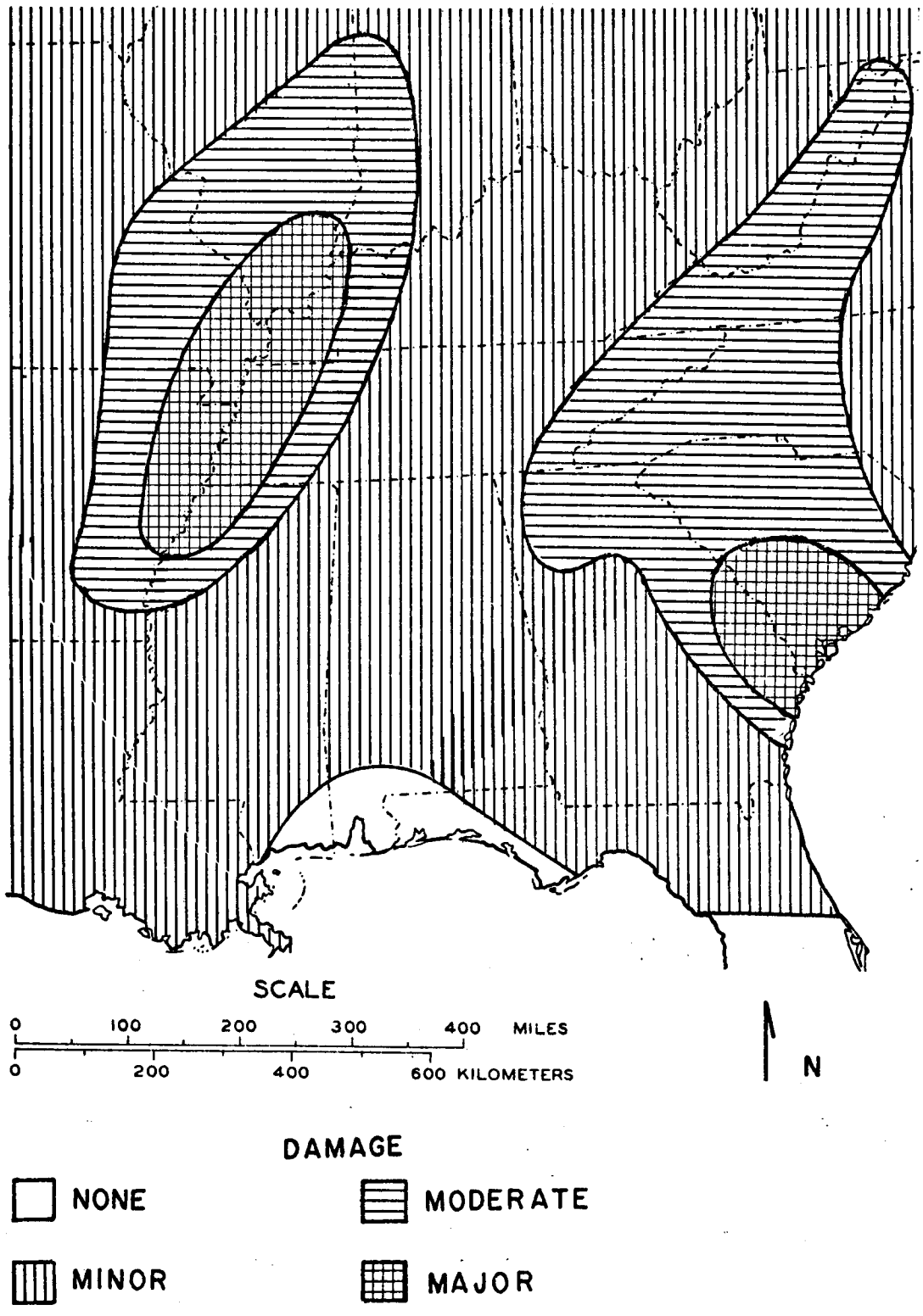


Figure 5. Seismic risk map for eastern U. S. (after Algermissen, courtesy of National Oceanic and Atmospheric Administration).

Table I. Tabulation of earthquakes affecting the Yellow Creek area (after Stearns and Wilson, 1972)

Date	Epicenter	Epicentral Intensity (Modified Mercali)	Estimated Site Intensity
1811, Dec. 16	New Madrid	XII	VI-VII
1812, Jan. 23	New Madrid	XII	VI-VII
1812, Feb. 7	New Madrid	XII	VI-VII
1843, Jan. 4	Memphis area	VII	IV-V
1865, Aug. 17	Memphis area	VII	IV-V
1875, Oct. 27	Mississippi Valley	III-IV	II
1878, Nov. 18	Mississippi Valley	VI-VIII	III-IV
1883, Jan. 11	Mississippi Valley	V-VI	II-III
1886, Aug. 31	Charleston, S. C.	X	IV-V
1889, July 19	Memphis area	V-VII	II-III
1895, July 27	Savannah, Tenn.	III-IV	III-IV
1895, Oct. 31	Charleston, Mo.	IX	V-VI
1903, Nov. 4	New Madrid	VI	II-III
1903, Nov. 27	New Madrid	III-IV	I-II
1905, Aug. 21	Sikeston, Mo.	VI	II-III
1909, Sept. 27	Wabash Valley, Ind.	VII	II-IV
1909, Oct. 23	Mississippi Valley	V-VI	II-III
1915, Dec. 7	Cairo, Illinois	V-VI	II-III
1918, Oct. 15	New Madrid	IV	II
1922, Mar. 30	Mississippi Valley	V	II-III

TABLE I. (continued)

Date	Epicenter	Epicentral Intensity (Modified Mercali)	Estimated Site Intensity
1923, Mar. 27	Wyatte, Mississippi	IV	II-III
1923, Oct. 28	Marked Tree, Ark.	VII	III
1923, Oct. 28	Riverton, Ala.	III	III
1923, Dec. 31	Western Tennessee	V	III-IV
1924, Mar. 2	Mississippi Valley	V	II-III
1927, May 7	New Madrid	VII	III-IV
1931, Dec. 16	Batesville, Miss.	VI	III
1954, Apr. 26	Crawfordsville, Ark.	IV-V	II-III
1955, Jan. 25	Finley, Tennessee	VI	II-III
1968, Nov. 9	Southern Illinois	VII	I-III
1970, Nov. 17	Blytheville, Ark.	VI	I-III

magnitude for the December 16, 1811 earthquake was approximately 7.2. The other principal shocks, on January 23, 1812 and February 7, 1812, had estimated body-wave magnitudes of 7.1 and 7.4, respectively.

Geology of the Mississippi Embayment

Dunbar (1919) reports numerous faults in the southern part of the Tennessee River Valley in western Tennessee. Presumably, some of these faults might extend into northeastern Mississippi.

Wade (1917) and Roberts and Collins (1926) describe the deposition of the Eocene sequence, both marine and nonmarine, and the structures of the Mississippi embayment region.

Born (1935, 1940, and 1944) summarizes the stratigraphy and structures of the Paleozoic rocks encountered in wells in western Tennessee. He plots several faults on his structure contour maps.

Fisk (1944 and 1947) discusses the alluvial deposits of the flood plains and the valley fill of the Mississippi embayment region. Also, he postulates the fault zones of the embayment region along with a structure contour map showing the configuration of the Paleozoic strata.

McGlothlin (1944) describes the general geology of Mississippi. His paper, however, is devoted to the Upper Cretaceous and Tertiary sediments with few details that

concern structures and older rocks. It was not until 1964 when more data became available that more comprehensive geologic interpretations of Mississippi were reported (Mellen and Moore, 1962; Mellen, 1974; Cushing, Boswell, and Hasman, 1964; Boswell et al., 1965; Boswell, 1968; Russell, 1965). Another comprehensive report on the geology of the northern Mississippi embayment region is that of the Illinois State Geological Survey (1971). This up-to-date report contains sixteen articles covering the geology, geophysics and tectonic activity of the Illinois basin, the Cincinnati arch, and the northern Mississippi embayment region. It also mentions new geological structures such as arches, faults, and domes that had not been depicted previously. One of the articles in the report was written by Schwalf (1971) who discusses the tectonic activity of the Pascola arch (Fig. 6).

Figure 7 is a structure section compiled from Russell (1965). Russell was concerned primarily with Cretaceous and Tertiary stratigraphy. According to Robinson (1970) the Marl-Chalk lithostone (Demopolis formation) identified by Russell has not been found in the Yellow Creek area.

Stearns and Wilson (1972) wrote a detailed tectonic report of the Mississippi embayment region including the New Madrid earthquake zone. In describing the faulted areas in western Tennessee, northern Mississippi and northern Alabama, they reported that faults are few, relatively short, and are characterized by minor displacement.

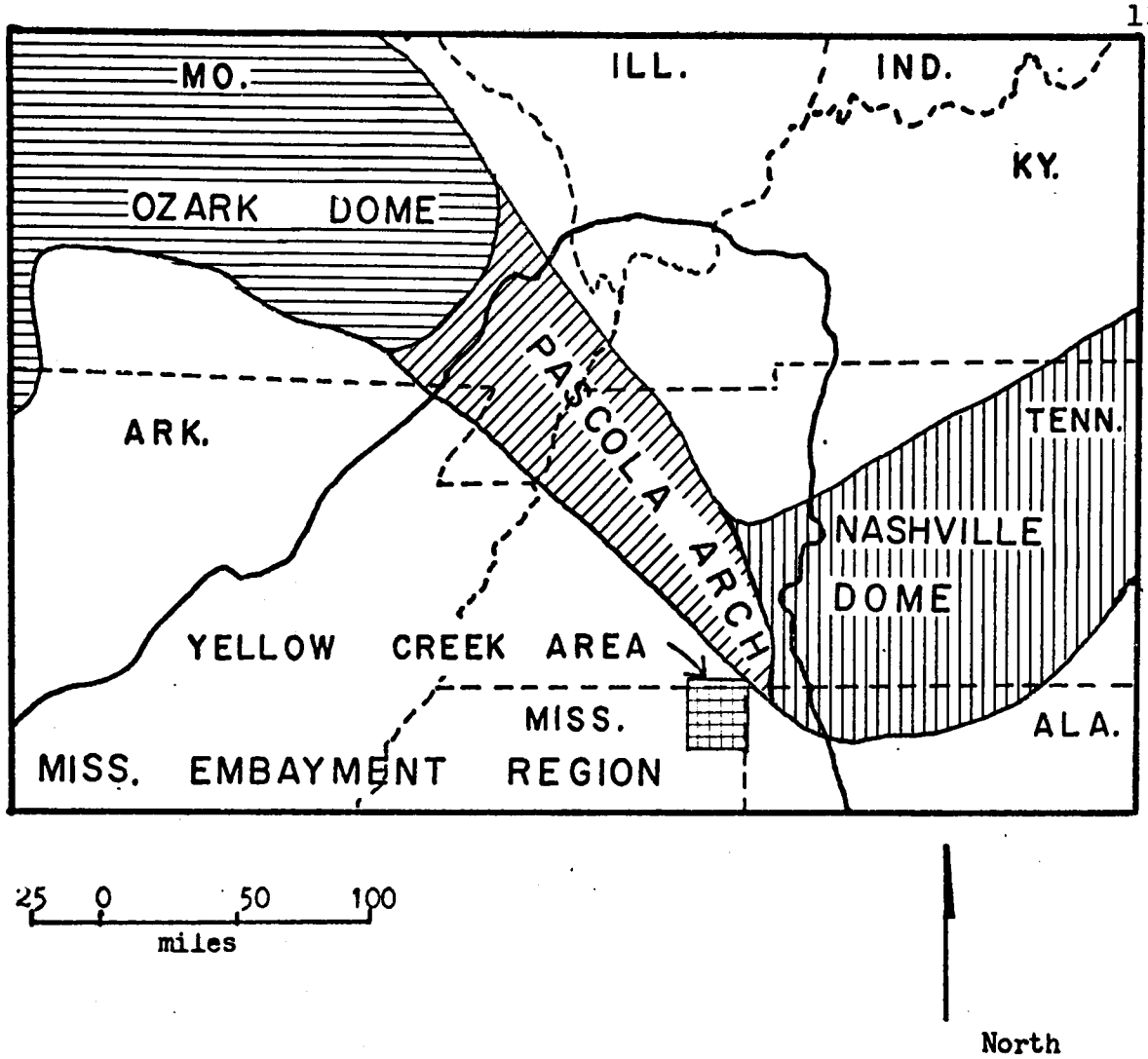


Figure 6. Tectonic map of the northern Mississippi Embayment Region (after AAPG Highway maps of mid-continent and mid-Atlantic regions).

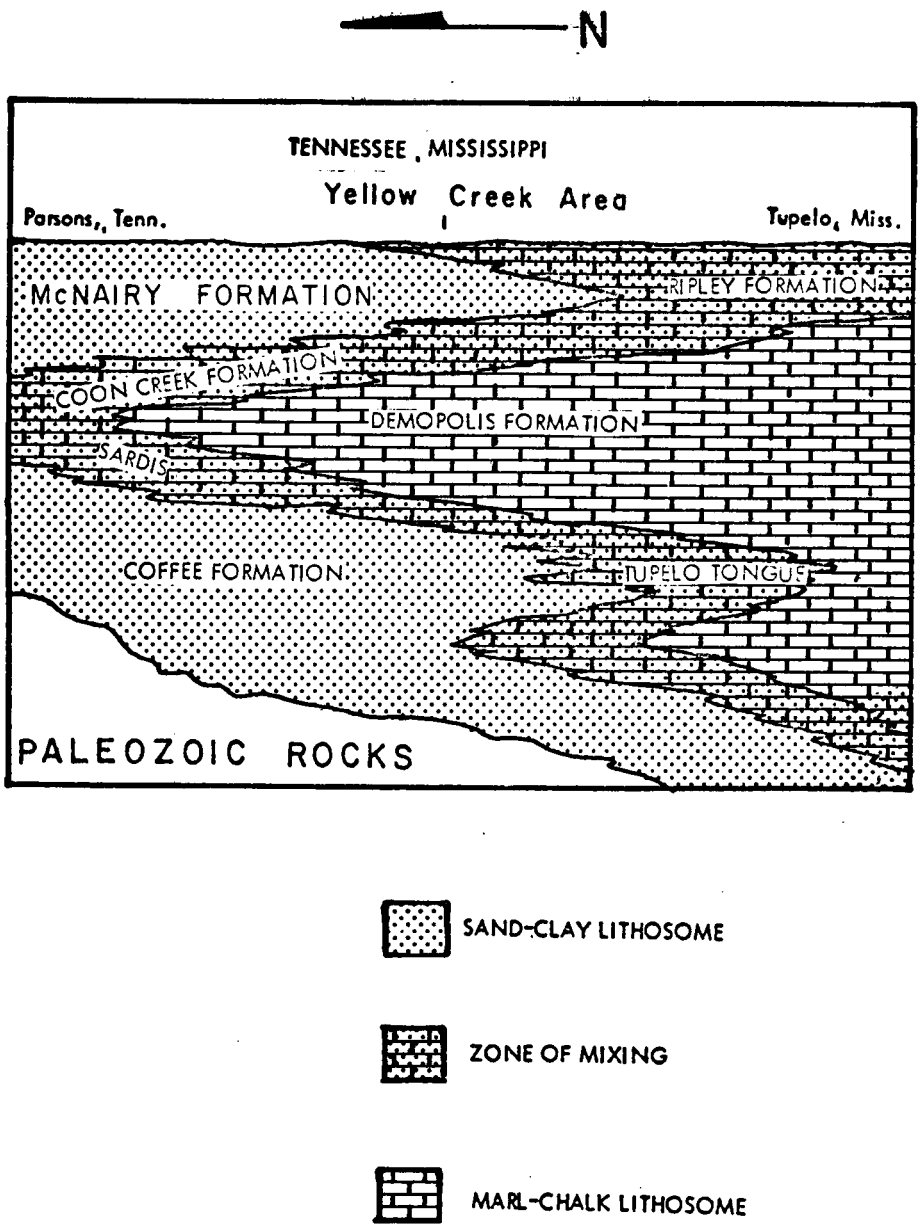


Figure 7. A stratigraphic section of the Tennessee-Mississippi border (modified from Russell, 1965).

Cook and Sundeen (1974) have shown that volcanic rocks are interbedded with Cretaceous sediments in northwestern Mississippi. Maher (personal communication) states that diabase intrusions have been encountered in the Cretaceous section of western Tennessee during the course of petroleum exploration.

Apparently there are one or two possible origins for the faulted structures: (1) stress release along joint sets related to tectonic activity on the Pascola Arch (Fig. 6) and (2) stress release during Gulf Coast subsidence (Fig. 8).

According to well records (Grohskopf, 1955) about 8,000 to 12,000 feet of Upper Paleozoic rocks in the northern Mississippi embayment region were removed by erosion. Grohskopf names this post-Pennsylvanian structure the Pascola Arch (Fig. 6), a saddle-like structure joining the Ozark dome with the Nashville dome. Johnson (1971) considered this arch to be the central zone of tectonic activity of the Yellow Creek area, as suggested by joint patterns that strike parallel and perpendicular to the arch. The Yellow Creek area is in close proximity to the edge of the Mississippi embayment region which may have formed during Gulf Coast tectonism. A complete discussion of Gulf Coast tectonism is given by Murray (1961).

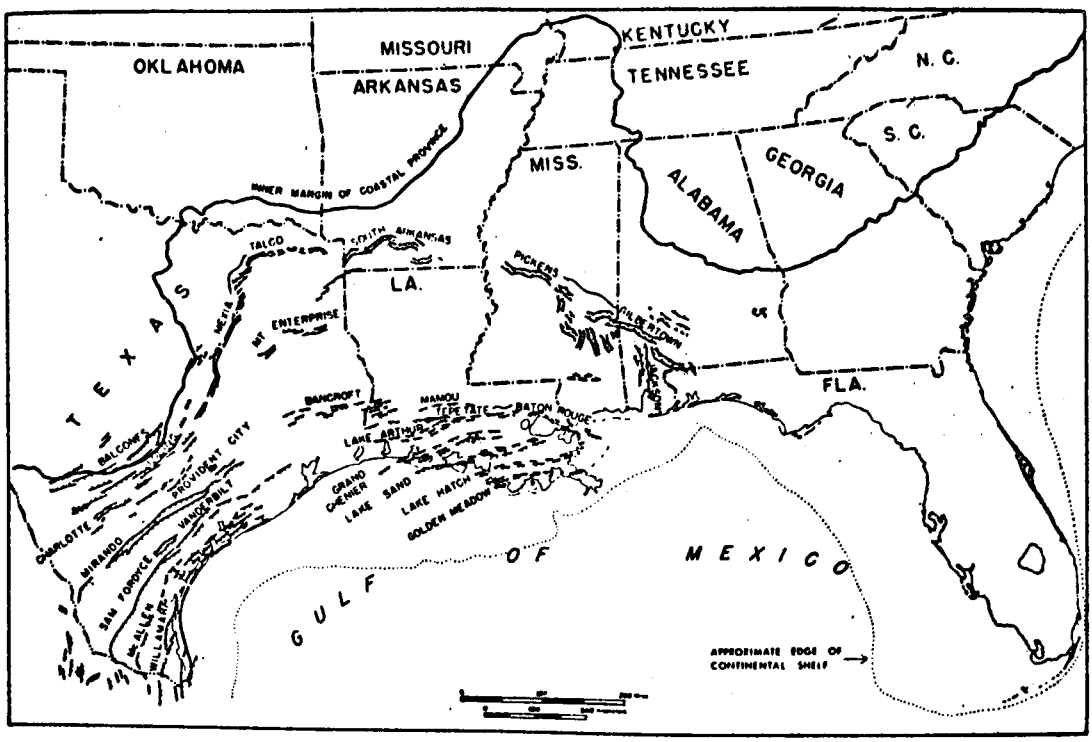


Figure 8. Diagrammatic representation of principal strike-fault system in northern Gulf Coast (from Geology of the Atlantic and Gulf Coastal Province of North America by Grover Murray, Harper & Row, Publishers, New York, 1961, permission granted by the publisher).

Geology of the Yellow Creek Area

Stratigraphy

The Fort Payne Formation (Lower Mississippian) is exposed extensively in the Highland Rim of Tennessee. This formation is mainly calcareous but it is siliceous in places. The lithology varies from siltstone, bedded chert, limy siltstone, silty limestone and, to a lesser extent, coarse-grained crinoidal limestone. In many places, especially in the Yellow Creek area, highly siliceous beds are interbedded with a few coarsely crystalline, relatively pure limestone beds. The thickness of this formation in the Yellow Creek area varies from about 50 to 100 feet (Tennessee Valley Authority core samples, 1970).

Upper Cretaceous unconsolidated clastic sediments unconformably overlie the Fort Payne formation. The basal Cretaceous sediments contain abundant sands and gravels derived from the erosion of older rocks on the Pascola arch. The Upper Cretaceous to Lower Tertiary strata consist of sand, gravel and shell fragments. These Cretaceous and Tertiary strata have a total thickness of 50 to 300 feet in the Yellow Creek area.

Regional Setting

The geological information used here are adapted mainly from the Illinois State Geological Surveys Publications (1971).

The study area, near the eastern edge of the Mississippi embayment region, is near the southeastern end of the more ancient Pascola arch (Fig. 6). To the east and northeast, and northwest of the study area lie two prominent structures, the Nashville dome and the Ozark dome, respectively. These domes according to Grohskopf (1955) produced stresses forming the Pascola arch prior to Cretaceous time. The arch is presently covered by approximately 3,000 feet of Cretaceous and Tertiary unconsolidated clastic sediments. On the crest of the Pascola arch is the New Madrid earthquake zone.

Bond et al. (1971) describe, briefly, the geological events. From the Pascola arch the upper Paleozoic strata dip southward toward the Gulf of Mexico. During late Paleozoic time, the initial stage of deformation of the Mississippi embayment, tensional stresses along the eastern margin were relieved by numerous faults and fractures as shown by the exposures along the western section of the Tennessee River Valley (Kellberg, 1970, personal communication). At the same time, late Paleozoic diastrophism uplifted the Pascola arch, Nashville dome, and the Ozark dome.

Erosion then removed 8,000 to 12,000 feet of upper Paleozoic strata (from Ordovician to Pennsylvanian in age) from these prominent structures and much of the debris was accumulated northeast and southeast of the Pascola arch as the basal Cretaceous gravel. Later in early Late Cretaceous time, the sea advanced and retreated four times (Russell, 1965) northeastward across the former Pascola arch. At the same time, the Mississippi embayment syncline downwarped while sediments were being deposited and covered the old Pascola arch that was depressed as much as 4,000 feet (from about 1,000 feet above to 3,000 feet below sea level), according to Grohskopf (1955).

Alluvial materials and terraces were formed by the Mississippi River and its tributaries during late Tertiary and early Quaternary time. Pleistocene loess lies at the surface.

Local Setting

The Fort Payne Formation, the most common Paleozoic exposure of the area, is generally confined to the shoreline of Pickwick Lake (Fig. 9), whereas Cretaceous and Tertiary sediments mantle the drainage divides. Devonian exposures have been observed in several places, including the "big island," as local residents call the large island in the northern section of the Yellow Creek embayment. Most strata are horizontal with the exception of a few exposures along the Goat Island shorelines and a portion of the "big island."

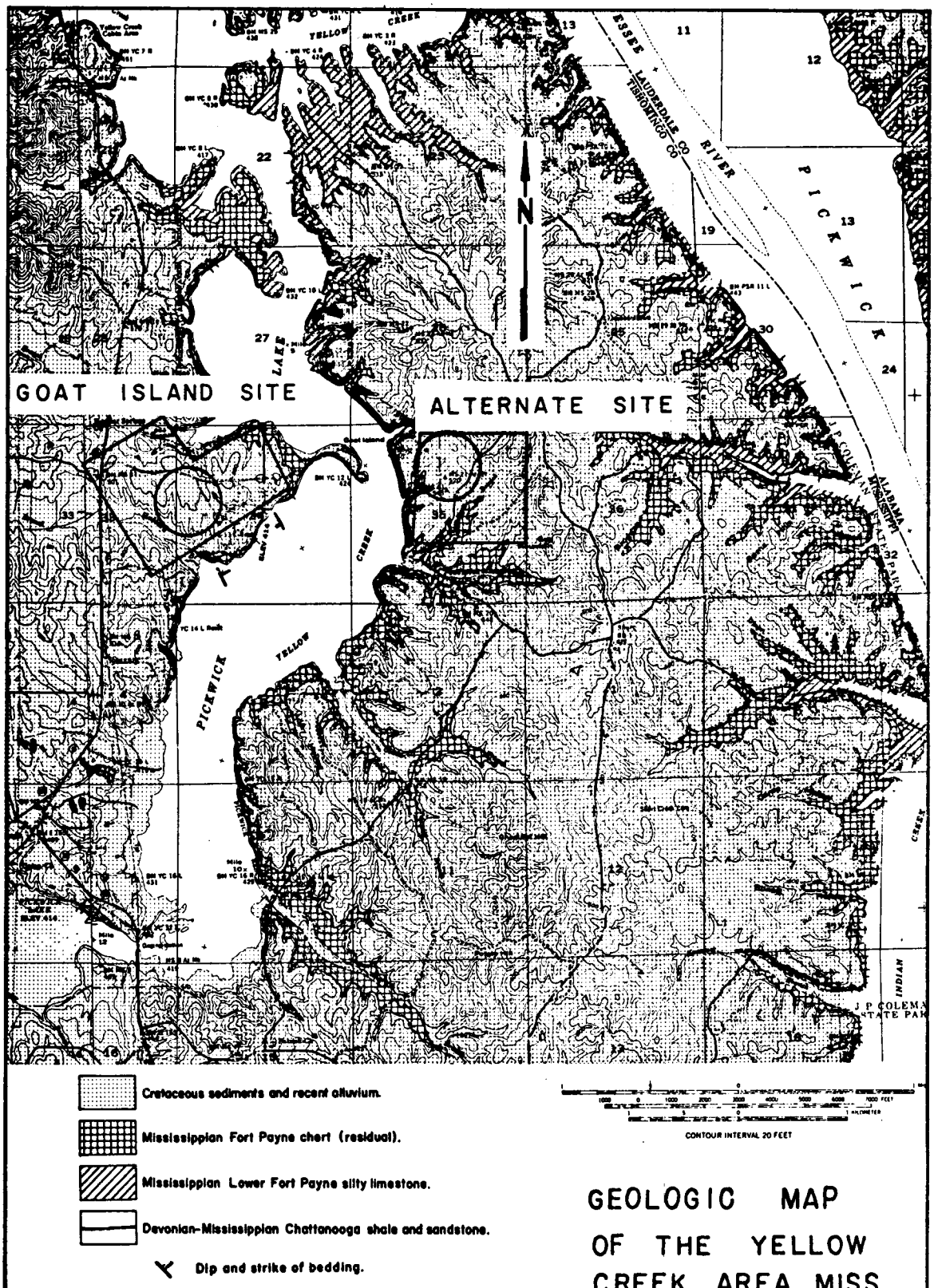


Figure 9. Geologic map of the Yellow Creek area (Robinson, 1970, courtesy of TVA).

Several generalizations of the local geology are: (1) bedding in the Fort Payne Formation is nearly horizontal in the peninsula between the Yellow Creek and the Tennessee River; (2) the exposures are more limited on the west bank of the Yellow Creek; and (3) the contact between the Fort Payne Formation and the Cretaceous sediments on Goat Island is 60 feet below the same contact on the east shore of Yellow Creek. These facts generally agree with the regional pattern of the Mississippi embayment, wherein strata dip gently toward the west on the east side of the embayment.

Data from test holes suggest that the Fort Payne dips toward the west. At the Goat Island Power Plant site, test holes were drilled to a point 350 feet above sea level without encountering Paleozoic rock. However, at the Alternate Site to the east, the top of the Fort Payne Formation lies between 450 and 470 feet above sea level.

An exposure of Fort Payne strata dips steeply to the southwest on the shoreline of Goat Island (Plate 1). Northeast dipping strata lie approximately 300 feet west of this exposure. These facts suggest the possibility of a graben or synclinal axis lying between the two exposures.

Rose (1940) measured joint patterns of the Pickwick Dam site and found two major components, N54°W and N34°E. Johnson (1971) found the joint patterns in the Yellow Creek embayment to be similar, N54°W and N38°E. Obviously the joints have no relationship to the local tectonic activity

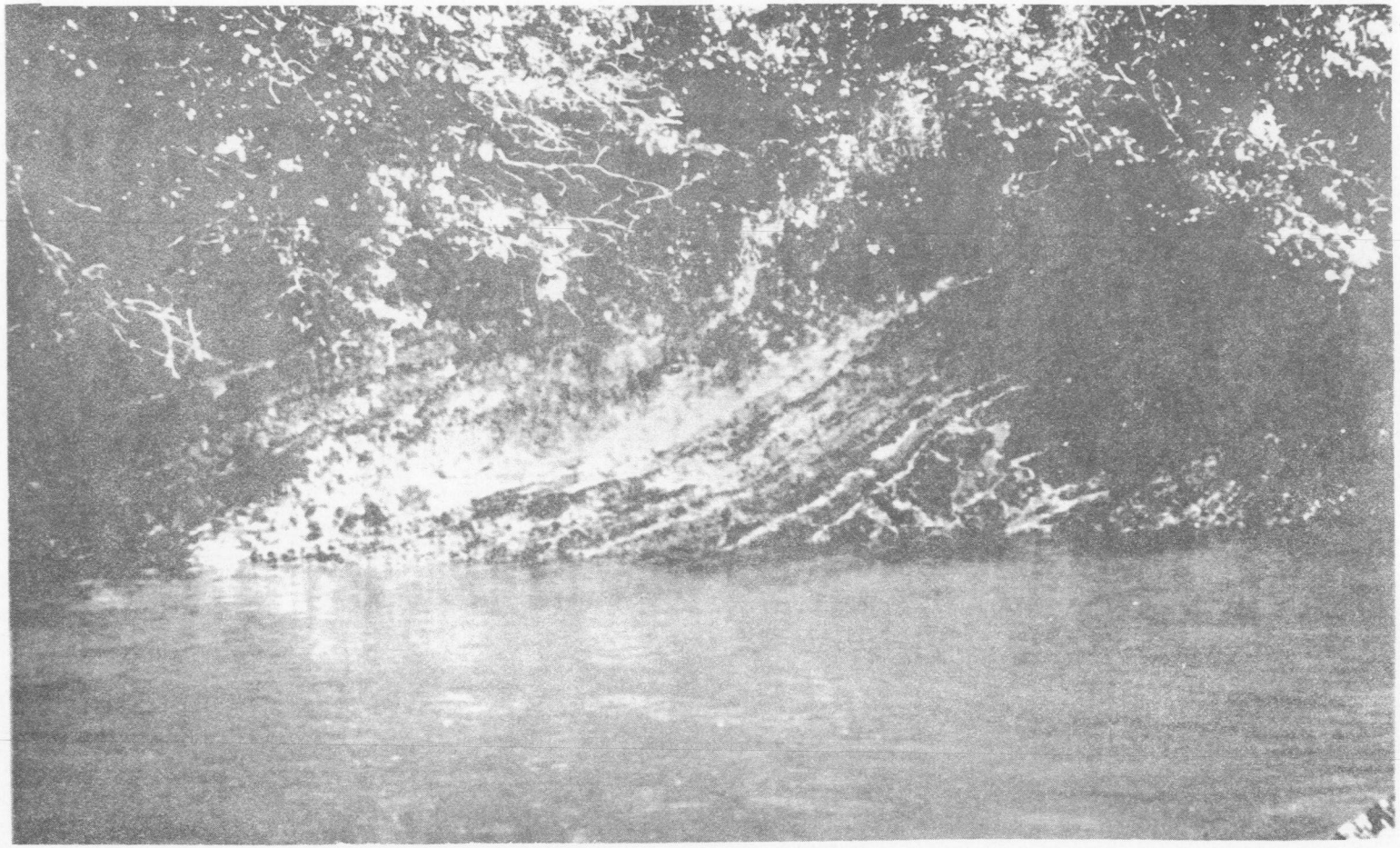


Plate 1. Fort Payne Exposure, west bank of Yellow Creek Embayment near Goat Island site (photo by the author).

of the Mississippi embayment region; rather, they appear almost parallel and perpendicular to the axis of the Pascola arch. Billings (1954) and Price (1966) describe these patterns as release joints.

Previous Use of Geophysics in Preliminary Surveys of Construction Sites

It is common practice to use the seismic refraction method for locating the bedrock surface at large construction sites such as power plants, dams, canals, and highways. Tennessee Valley Authority uses the inline seismic refraction method routinely for locating the bedrock surface at large construction sites (Kellberg, personal communication, 1970). On the other hand, the gravity method has not been used except on an experimental basis and it has not been attempted previously by TVA. A private consulting firm has experimented with gravity surveys for Consolidated Edison (Moorhouse and Millet, 1971) and for the Pacific Gas and Electric Company (McNitt, 1963).

Regional Gravity Survey

A detailed gravity survey has not been done for northeastern Mississippi. The Bouguer Gravity Anomaly Map of the United States (Woollard, 1964) shows the anomaly over the study area, but it is too broad in scope to reveal local structures. Gravity maps of surrounding regions are the

Bouguer Gravity Map of Tennessee (Johnson and Stearns, 1967) and one of the Mississippi embayment region (Stearns and Wilson, 1972). These maps are merely reproductions of the U. S. Gravity Map.

CHAPTER III

PROCEDURES

Field Surveys

Regional Gravity Survey

A regional gravity survey was initiated during the summer of 1971. Most of the stations were accessible by automobile but stations located along the Pickwick reservoir shoreline were reached by boat.

Gravity stations were located at 33 TVA and USGS bench marks and 8 unmarked shoreline positions distributed throughout the region shown on page 42. All elevations were given to the nearest hundredth of a minute of arc.

A base station was established at TVA bench mark YC17L which is located on the left bank of the Yellow Creek embayment near the southwest corner of the region. The gravimeter was read at the base station at 3 to 5 hour intervals during each field day. Gravity data were recorded for an average of 8 stations per field day.

Detailed Gravity Surveys of Power Plant Sites

Approximately 100 gravity stations were located on a 400 feet grid spacing at the Goat Island and alternate power plant sites (see pages 44 and 54). Vertical and horizontal control were equal to or better than that for the regional survey.

Most of the stations were accessible only by foot. The base station (YC17L) was occupied at 3 to 5 hour intervals as before. Gravity data were recorded for an average of 20 stations per field day. Nine of the field stations were selected at random and reoccupied at the end of the survey in an attempt to estimate the accuracy of the results.

Inline Seismic Refraction Survey

Inline seismic surveys were conducted where several gravity anomalies were found. The purpose was to estimate the depth to the bedrock surface which was defined as the Fort Payne Formation. Twelve to twenty-four geophones were set at 25 to 50 feet intervals inline with the shot point. The distance to the farthest geophone varied between 900 and 1500 feet, and the nearest phone varied between 25 and 50 feet from the shot point.

Broadside Siesmic Refraction Survey

The field arrangement for the broadside refraction shots is illustrated in Fig. 10. The shothole was located 650 feet from the center of the geophone spread which was 1300 feet long. The purpose of the broadside refraction is to determine the sub-surface configuration or shape of the bedrock surface.

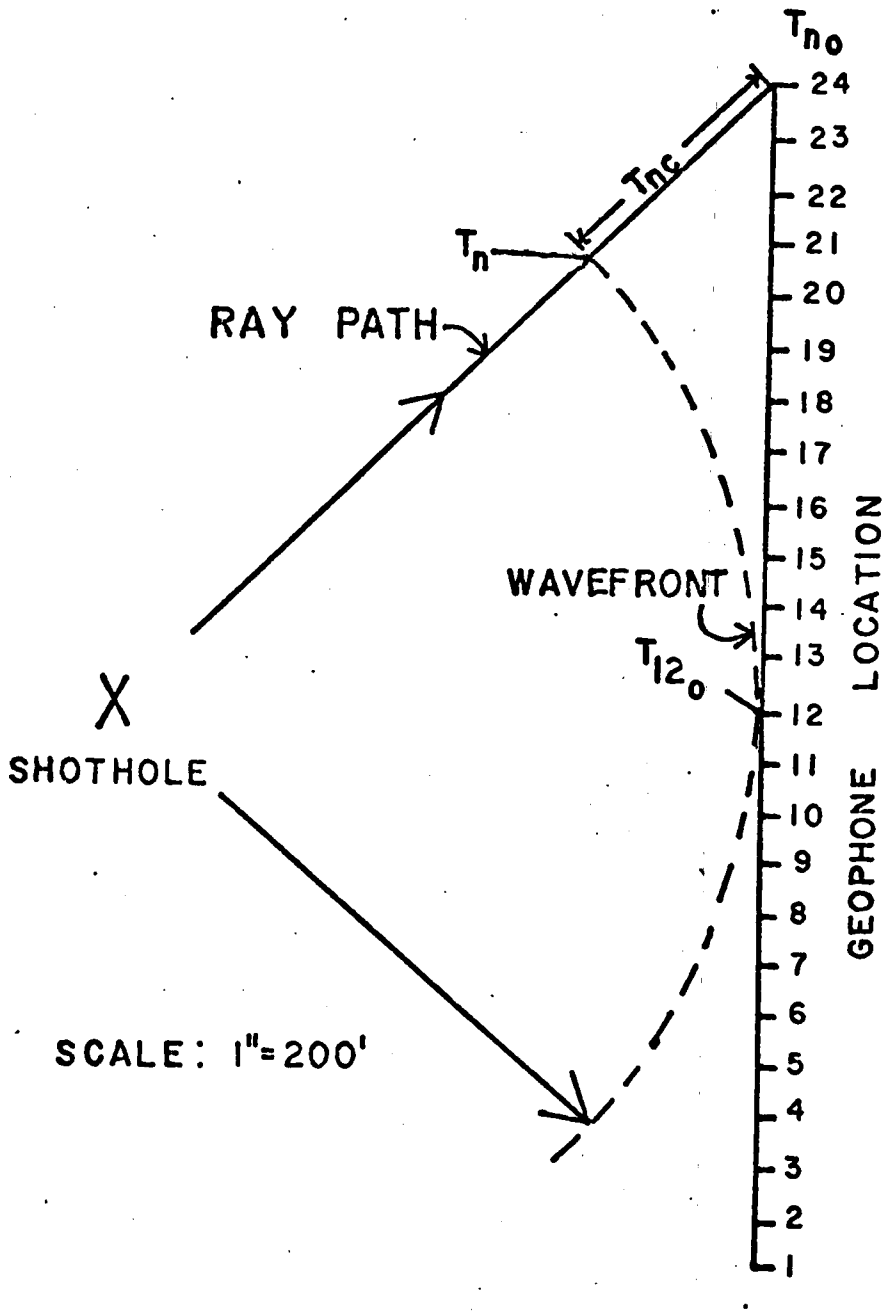


Figure 10. Diagrammatic representation of a broadside seismic refraction spread at the Alternate Plant Site.

Equipment

Gravimeter

The gravimeter (serial number 108) used for the survey was manufactured by Lacoste-Romberg, Inc. of Austin, Texas. This meter (Fig. 11) was loaned to the University of Tennessee by the United States Army Topographic Command, Washington, D. C. Its principal characteristics are: (1) a reading range of 7000 milligals, (2) a reading accuracy of $\pm$ 0.01 milligals, and (3) a very low linear drift rate of less than 1 milligal per month. The Lacoste-Romberg meter is the finest geodetic meter available.

Seismic Refraction Instrument

The portable seismic refraction recorder (Fig. 12) is manufactured by Geo-Space Corporation of Houston, Texas. It produces a 12 trace refraction seismogram on Polaroid film. It is capable of recording the arrival times to the nearest millisecond for shallow, direct arrival waves and for refracted waves to depths of 500 feet.

Data Processing

Gravity Data

Reduction to Bouguer anomaly:

Several corrections are required in order to reduce the observed gravitational field strength (g_{obs}) to the



Figure 11. Geodetic gravity meter (La Coste and Romberg).

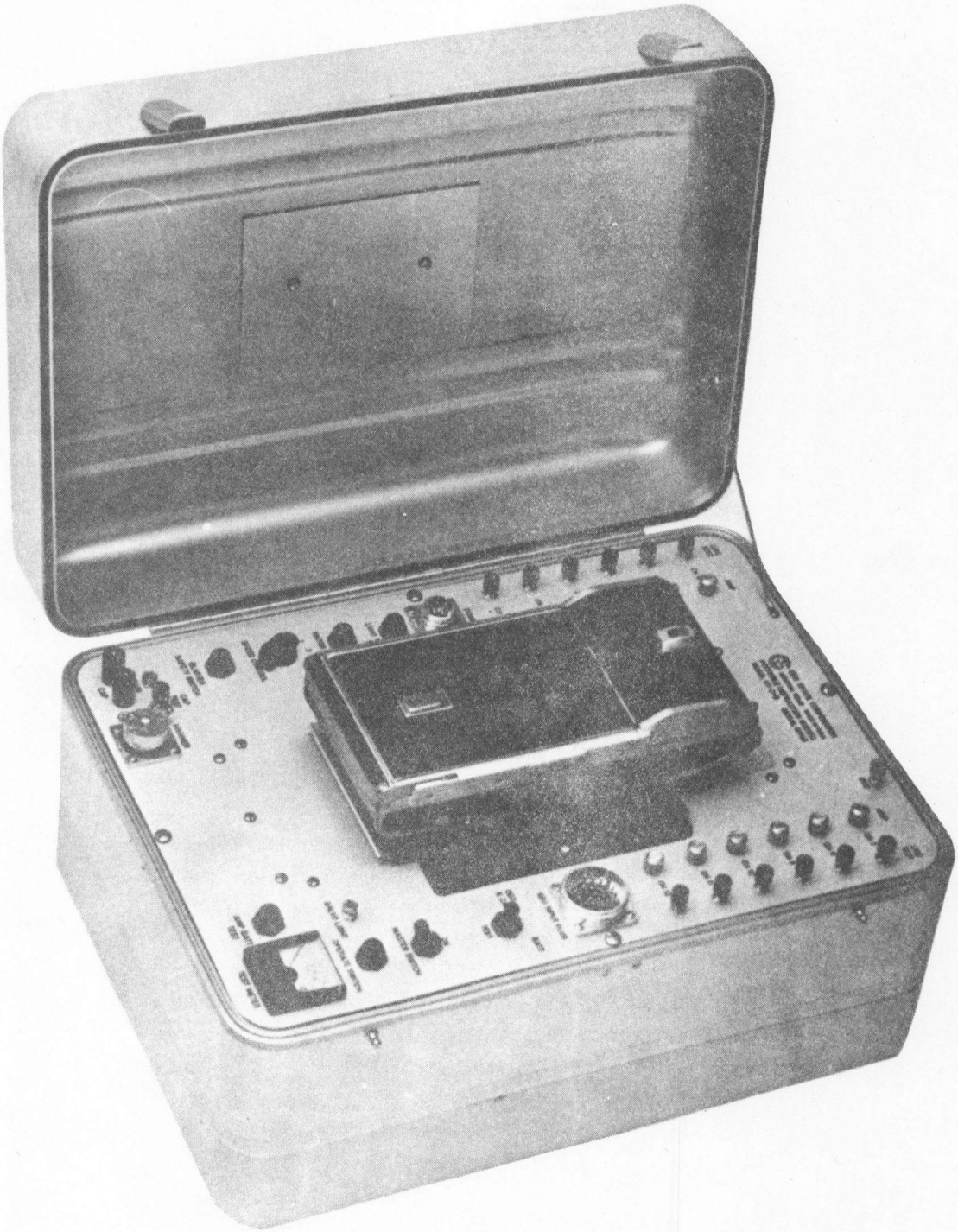


Figure 12. Portable seismic refraction recorder (Geo-Space Corporation).

Bouguer Anomaly (g_b) at a particular station. These corrections are, the free air correction (C_{fa}):

$$C_{fa} = \frac{2g_o h}{R} \tag{1}$$

where $g_o = 980 \text{ cm/sec}^2$

h = elevation above the reference spheroid

R = is the average radius of curvature of the geoid

the Bouguer correction (C_B):

$$C_B = 2\pi\sigma\rho h \tag{2}$$

where σ, is the universal gravitational constant, ρ is the average density of rock between the station and the reference spheroid, and h has the same meaning as above.

The theoretical gravity (g_t) on the reference spheroid which is given by the 1930 International gravity Formula (Cassinis, 1930; Lambert and Darling, 1931):

$$g_t = 978.049\ [1.0 + 0.0052884 \sin^2 \phi - 0.0000059 \sin^2 2\phi] \tag{3}$$

where ϕ is the latitude of the station. The terrain correction (C_t) is obtained from an overlay on a topographic map but it is usually ignored in regions of low relief. Then, the Bouguer anomaly is given by:

$$g_b = g_{obs} + C_{fa} - C_B + C_t - g_t \tag{4}$$

The observed gravitational field strength (g_{obs}) is not measured directly. Most gravimeters compare differences in field strength from place to place. If one must know the absolute value of the field strength at each station, it is essential that the field strength at one or more base stations be referred from previous surveys.

Finally, the gravitational field strength at a station varies as a function of time because of drift of the gravimeter, earth tides and change in position of the sun and the moon relative to the station (Dobrin, 1960). The latter phenomenon is referred to as the astronomical tide and it can be calculated by means of the Tideplot Computer Program (Bryan, 1970) which utilizes the tidal equations of Longman (1959). The astronomical tide is subtracted from the field observation at each station.

If the gravitational field strength at a base station is observed several times daily and the appropriate astronomical tide corrections are made, slight differences still exist in the observed gravitational field strength as a function of time. The reason for the discrepancy is that meter drift and earth tide are unaccounted for by Longman's equations. Hence, a record of the discrepancies at the base station must be kept as a function of time.

The above function (apparent change in gravitational field strength at the base station versus time) is approximately linear. These data are used to correct each station for meter drift.

Unfortunately, the earth tide varies periodically and is related to the astronomical tide. Robinson (personal communication) states that the magnitude of its variation is 8 percent to 16 percent of the astronomical tide and it lags the latter by approximately one-half hour. The range in astronomical tide seldom exceeds 0.3 mgal. Therefore, if one neglects the earth tide, repeatability of results can be no better than 0.05 mgal relative to the base station datum or about 16 percent of the astronomical tide.

Computer Program:

The gravity data reduction was made possible by using the Fortran IV program language for an IBM 360 computer at the University of Tennessee Computer Center. Isogal gravity maps with contour interval of 0.2 mgal were constructed with the aid of an automatic plotter manufactured by California Computer Corp. The "Calcomp" plotter and the general purpose contouring program were provided by the Tennessee Valley Authority.

Determination of Accuracy:

All gravity stations in the Yellow Creek area were established by making loops around the base station. Observed gravity values were corrected for meter drift by linear interpolation between successive base station measurements that had been previously corrected for astronomical tide. Base stations were occupied at the beginning

and end of loops which varied in duration from three to five hours. Nine stations were occupied on two separate loops and their isogal anomalies were calculated independently. The mean difference in the results was 0.03 mgal with a standard deviation of 0.04 mgal.

Seismic Refraction

Inline Refraction:

A refraction seismogram yields data on seismic velocities of several formations as well as their depth and dip so long as the velocity progressively increases as a function of depth. Occasionally it is possible to identify formations on the basis of their seismic velocities. Only the first arrivals are considered in the analysis because they have travelled the minimum time path between the shot hole and the detector. Thus, by observing first arrivals for different separations of source and receiver, a time-distance graph can be constructed. Thus, the seismic velocity and depth to the various layers can be determined.

Theoretically, seismic waves travel through earth materials as through air, with a definite velocity and along a definite path. The velocity (V_p) of a primary wave depends upon the rigidity (G), incompressibility (K) and density (ρ) of a material:

$$V_p = \sqrt{\frac{K + \frac{4}{3} G}{\rho}} \qquad (5)$$

The paths of refracted seismic waves, like the path of refracted light waves, follow whichever course will require the least time between source and receiver. This is known as Fermat's Principle or the principle of least time (Slotnick, 1959).

The thickness and depth of each layer can be determined by reading the times off a seismogram and plotting the results on a time-distance graph (Fig. 13). The commonly used formulae are (Dobrin, 1960):

Two-layered case (Fig. 14A)

$$Z = \frac{T_{i1}}{2} \frac{V_2 V_1}{V_2^2 - V_1^2} \qquad (6)$$

where Z = depth to the deeper layer

V_1 = velocity of the surface layer

V_2 = velocity of the intermediate layer

where $V_2 > V_1$.

V_1 and V_2 are the reciprocal slopes on the time-distance graph whereas T_{i1} is the intercept time (Distance = 0) as determined by projecting the straight line segment for the higher speed layer back to the time axis (Fig. 14A).

Three-layered case (Fig. 14B)

$$Z_2 = \frac{1}{2}\left(T_{i2} - 2Z_1 \frac{V_3^2 - V_1^2}{V_3 V_1}\right) \frac{V_3 V_2}{V_3^2 - V_1^2} \qquad (7)$$

where V_1 and V_2 are the same as before

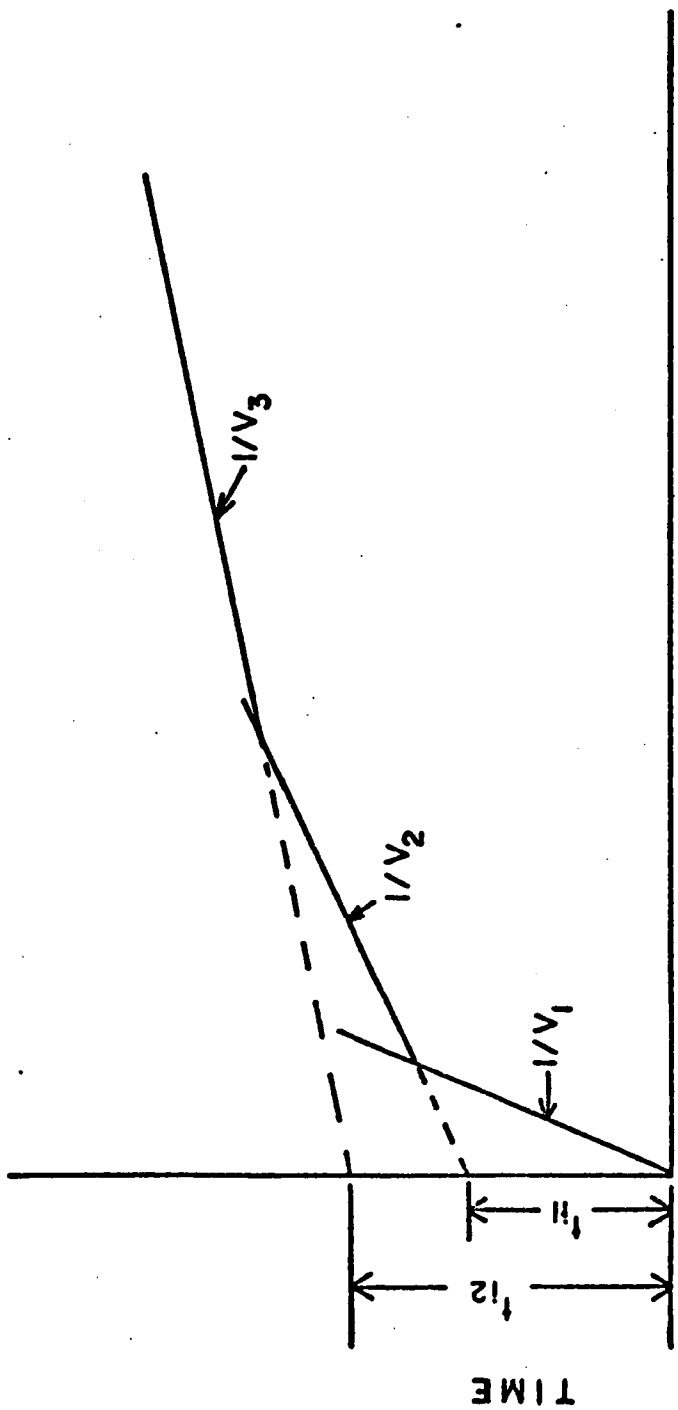


Figure 13. Example of a time-distance graph.

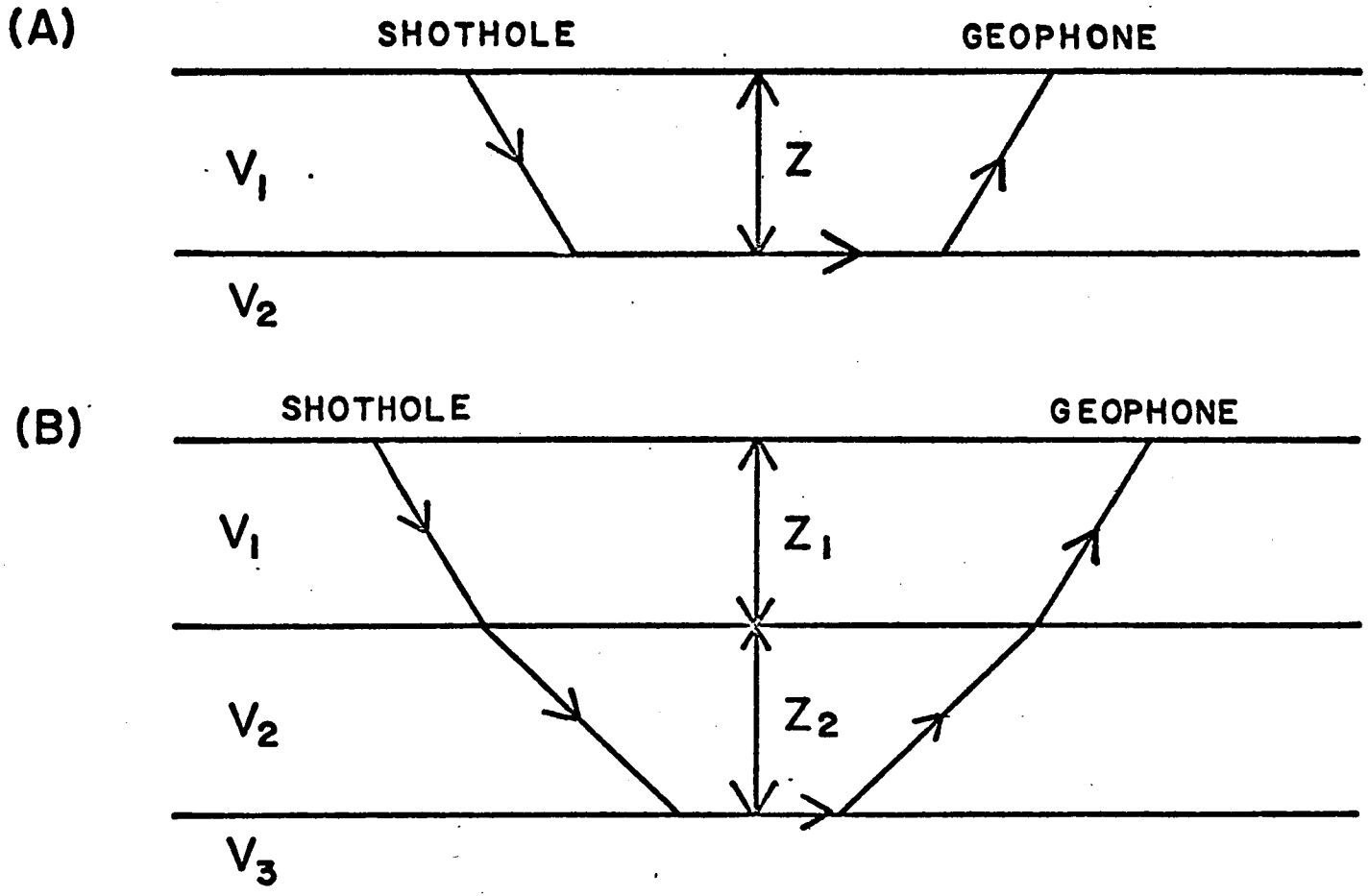


Figure 14. Ray paths of least time for (A) two layered case and (B) three-layered case separated by horizontal interface (modified from Dobrin, 1960).

V_3 = the velocity of the deepest layer,

where $V_3 > V_2 > V_1$

Z_1 = the depth to the second layer

Z_2 = the thickness of the second layer

T_{i2} = the intercept time for the deepest layer.

The depth to bedrock from inline seismic refraction data was calculated by using a program developed on a computer manufactured by Wang Laboratories, Inc. of Tewksbury, Massachusetts.

Broadside Refraction:

The broadside refraction method is occasionally used as an alternative to inline refraction for determination of structural features. The field arrangement for shothole and geophones is illustrated in Figure 10 (p. 27). Generally, considerable distance between the shothole and geophones is required. Thus, the waves that are refracted at high speed along the bedrock surface reach the geophones ahead of the direct arrival waves that travel slowly through the soil zone.

The circular arc in Figure 10 shows the position of the wave front at the instant the refracted wave arrives at geophone 12, ideally the arrival times, Tn, for all geophones, n, will be equal after time corrections for unequal distances between the shot point and receiver have been applied. The time correction (Tnc) is:

$$Tnc = \frac{d_n - d_{12}}{V_r} \qquad (8)$$

where d_n and d_{12} are horizontal distances between the shot point and the nth and 12th receivers, respectively. V_r is the velocity of the refracted wave and it can be determined by means of an inline refraction shot. Then:

$$Tn = Tno - Tnc \qquad (9)$$

where Tno is the observed arrival time at station n.

If $T_n < T_{12}$, the thickness of the soil beneath station n is less (Fig. 15).

Conversely, if $T_n > T_{12}$, the thickness of the soil beneath station n is greater.

It is possible to calculate the relative difference in soil thickness (ΔSn) by means of the following equation:

$$\Delta Sn = [T_n - T_{12}] \cdot V_s \qquad (10)$$

where V_s is the velocity of the direct arrival wave through the soil. This velocity can also be measured by means of an inline refraction shot.

Equations 8, 9 and 10 are used to construct a profile view of the irregular bedrock surface beneath the line of geophones. If the bedrock or soil velocities are variable, the above interpretation is subject to error.

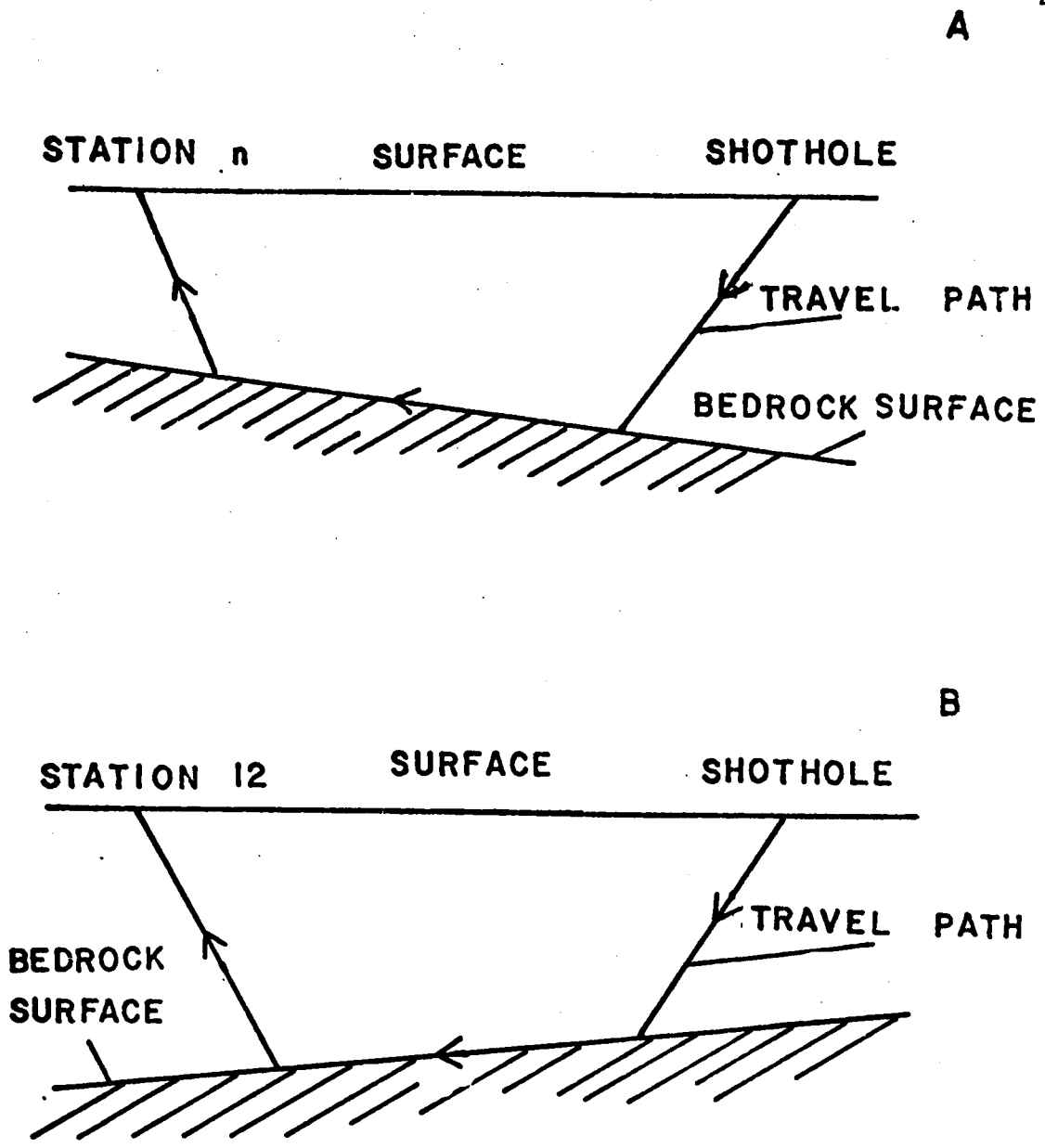


Figure 15. Hypothetical ray paths for broadside refraction.

CHAPTER IV

GEOPHYSICAL RESULTS AND INTERPRETATION

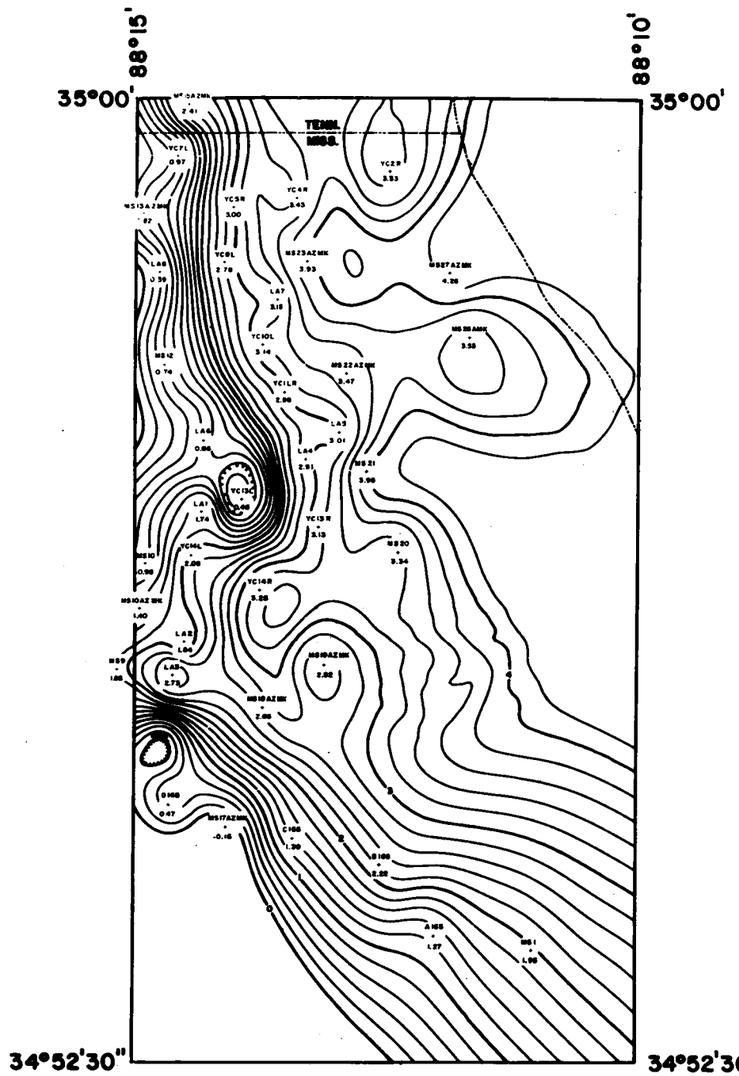
Gravity Survey of a Portion of Yellow Creek Quadrangle

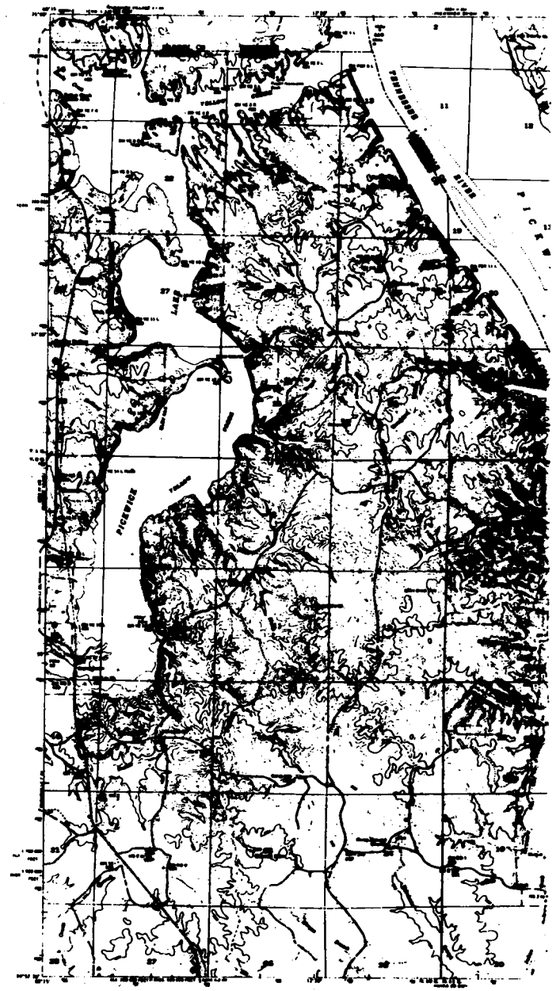
Plate 2 is an isogal map of a part of the Yellow Creek Quadrangle, Mississippi. The gravity station density is low for the southern third and eastern half of the area. Hence, few details are shown.

Near the western margin of the quadrangle, closely spaced isogal contour lines trend generally north and south parallel with the Yellow Creek embayment and the gravitational field strength decreases rapidly toward the west. These results suggest that the Cretaceous and Tertiary sedimentary veneer thickens westward. Perhaps this area lies on or very near the eastern hinge line of the Mississippi embayment.

A negative anomaly is present near the center of Sec. 34 on the west bank of the embayment. The center of this anomaly is located immediately west of the steeply dipping strata that are shown in Plate 1 (p. 22). The localized nature of the anomaly, however, suggests the existence of a collapse zone rather than a tectaonic feature. The fact that the anomaly is negative suggests that unconsolidated Cretaceous and Tertiary sediments are abnormally thick.

Paleozoic strata are near the surface on the east side of the Yellow Creek embayment where the isogal anomaly is





Scale

Contour interval : 0.2 Mgals

Plate 2. Yellow Creek Quadrangle. (A) Isogal Map; (B) Topographic Map.

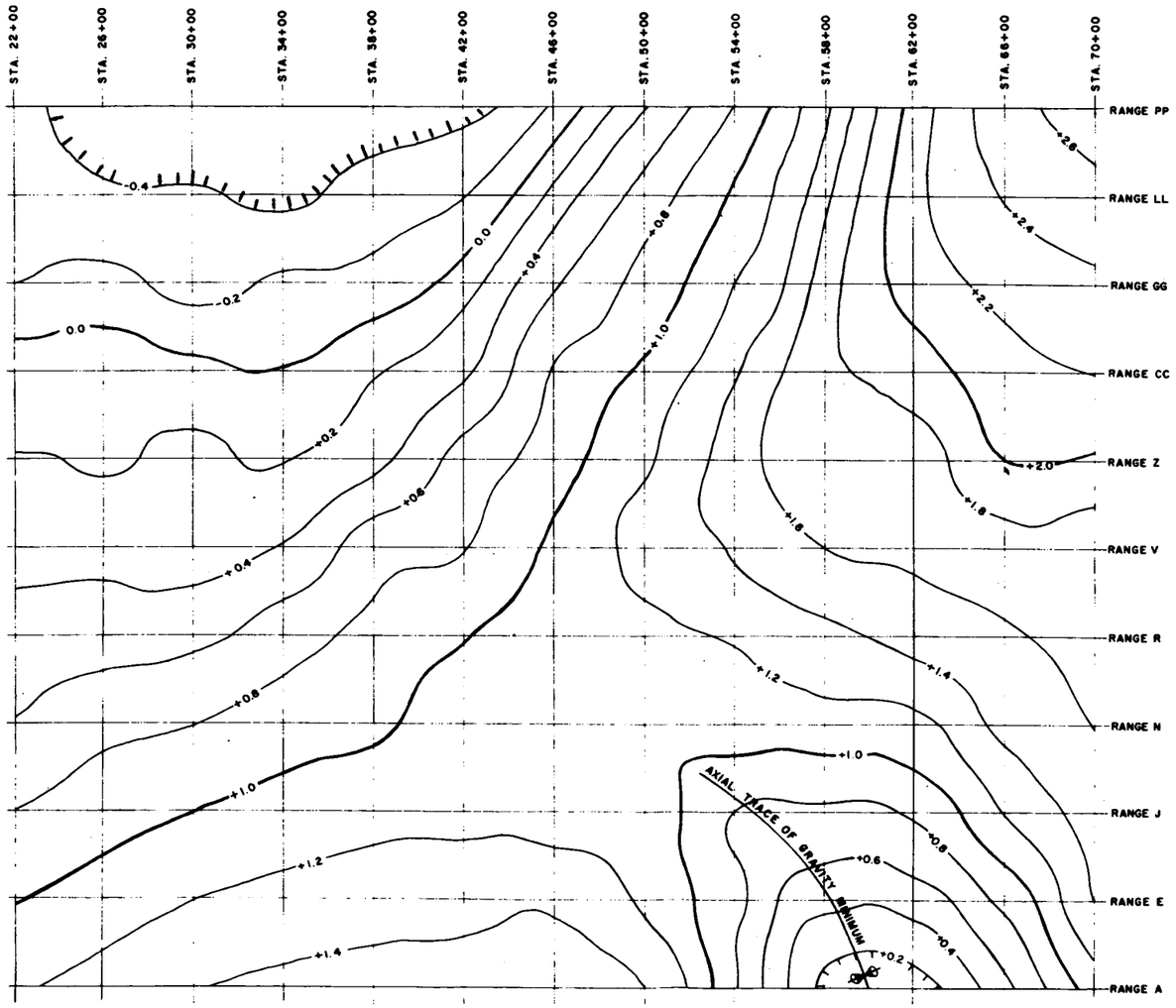
positive. Numerous exposures on the east bank of the embayment and core tests at the Alternate power plant site are ample evidence that the Cretaceous and Tertiary sedimentary veneer is thin. It appears evident from the above discussion that gravity data can be correlated with shallow geologic features.

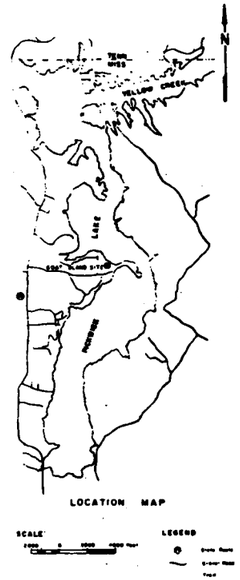
Geophysical Survey of the Goat Island Power Plant Site

Detailed Gravity Survey

Plate 3 is an isogal map of the Goat Island power plant site. A well-defined negative anomaly in the southeast corner of the map is separated by a saddle from an indistinct negative anomaly in the northwest corner. As seen by the axial trace of a gravity minimum, these anomalies appear to be related structurally. Either they represent collapse features that follow a particular stratigraphic horizon or they are part of a major tectonic feature such as a syncline or graben.

Plate 4 is a residual gravity map of the same region. It was prepared by removing the broad regional trend expressed by the isogal map of Plate 2. The regional trend was assumed to be a sloping plane from the east shore of Yellow Creek to the western boundary of the Yellow Creek Quadrangle and from the Tennessee State boundary to a line one mile south of Goat Island. The equation for the





LEGEND:

Contour Interval = 0.2 MGALS

SCALE:

200 0 200 400 Feet

Plate 3. Isogal Map of Goat Island Site.

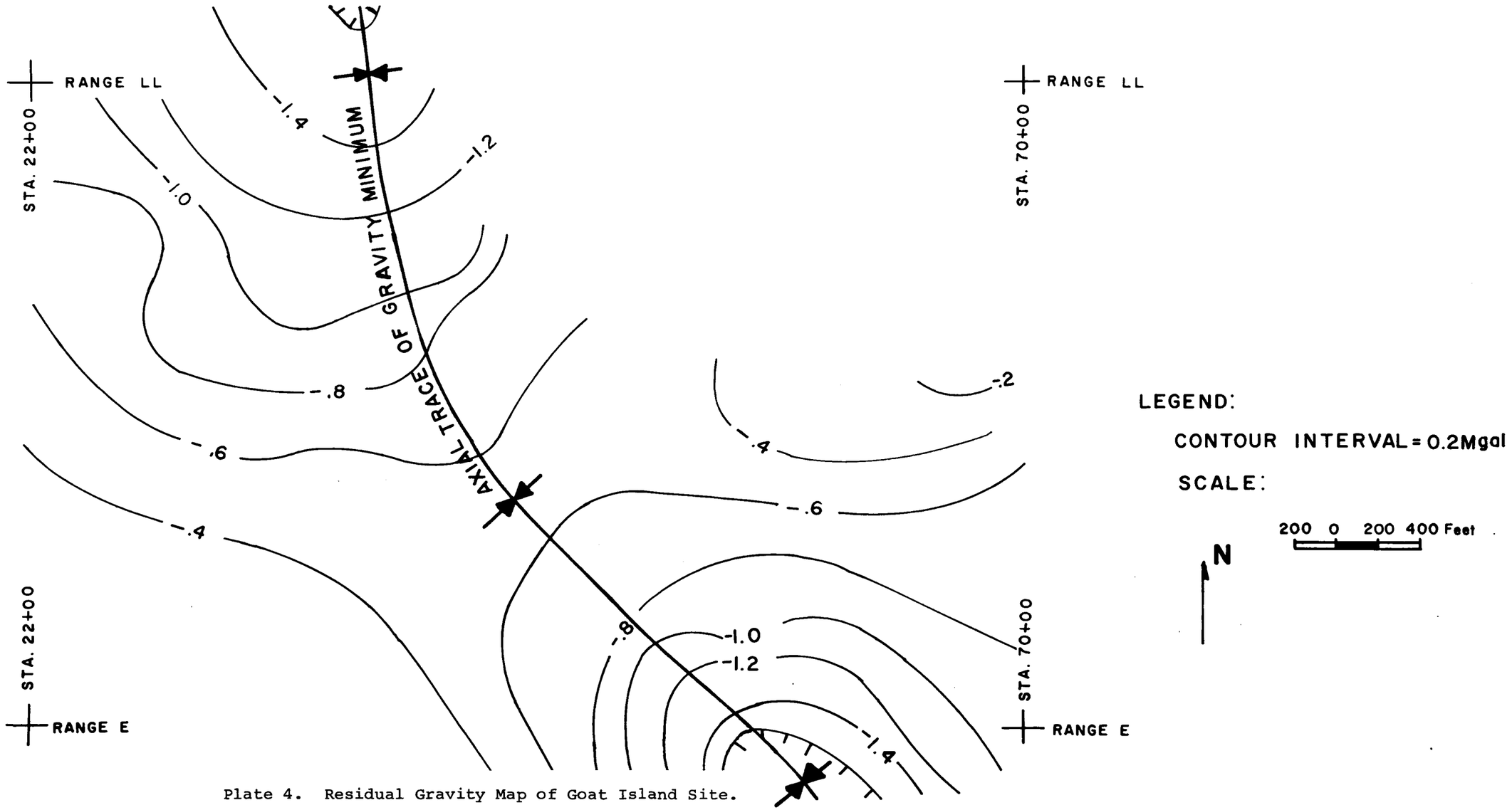


Plate 4. Residual Gravity Map of Goat Island Site.

regional trend was determined by plane regression where the latitude and longitude were independent variables and the gravitational field strength was the dependent variable. The equation has the form:

$$G_R = aN + bW \qquad (10)$$

where G_R = predicted regional isogal anomaly as a function of latitude (N) and longitude (W) based on measured field strength within the bounded region; "a" and "b" are the slopes of the regional trend in the north and west directions, respectively.

Then:

$$G_r = G_i - G_R \text{ where:} \qquad (11)$$

G_r = residual anomaly at given N-W coordinates

G_i = measured isogal anomaly at given N-W coordinates

G_R has the same meaning as before.

What appears to be an indistinct negative isogal anomaly (Pl. 3) is now a well-defined residual anomaly (Pl. 4). It is immediately apparent from the residual gravity map that the negative anomaly is a continuous feature as it passes through the Goat Island power plant site.

There is a good correlation between gravity data and geologic surface expression at the Goat Island site. Numerous Fort Payne exposures are located near the northeast corner of Plates 3 and 4 where the gravitational field strength is positive. Strike-dip determinations along the

southern boundary of the mapped area suggest the existence of a syncline precisely where the field strength is negative. In theory, one should expect the above results because of the greater thickness of low density unconsolidated Cretaceous and Tertiary sediments along synclinal axes.

Inline Seismic Refraction Survey

Two inline seismic refraction profiles were done at the Goat Island Power plant site (Figs. 16 and 17). The profile in Figure 16 shows a typical three-layered case where station V-46+00 is designated as a shothole. The first layer, the low velocity (2800 feet/sec) layer, is considered to be unconsolidated soil and sediments above the water table. The next layer, the intermediate velocity (6600 feet/sec) layer, is considered to be unconsolidated sediments below the water table. Finally, the third layer, the high velocity (18,500 feet/sec) layer, is a limestone unit within the Fort Payne Formation. The top of this limestone unit is about 130 feet above sea level, using calculations based on the three-layer case (Eq. (7)) of Dobrin (1960). Another inline seismic refraction profile is located between stations N-46+00 and T-68+00 which were chosen as shotholes. The results (Fig. 17) are similar to those at station V-46+00, except the velocities are slightly different and the top of the high speed layer is approximately 100 feet higher or 230 to 250 feet above sea

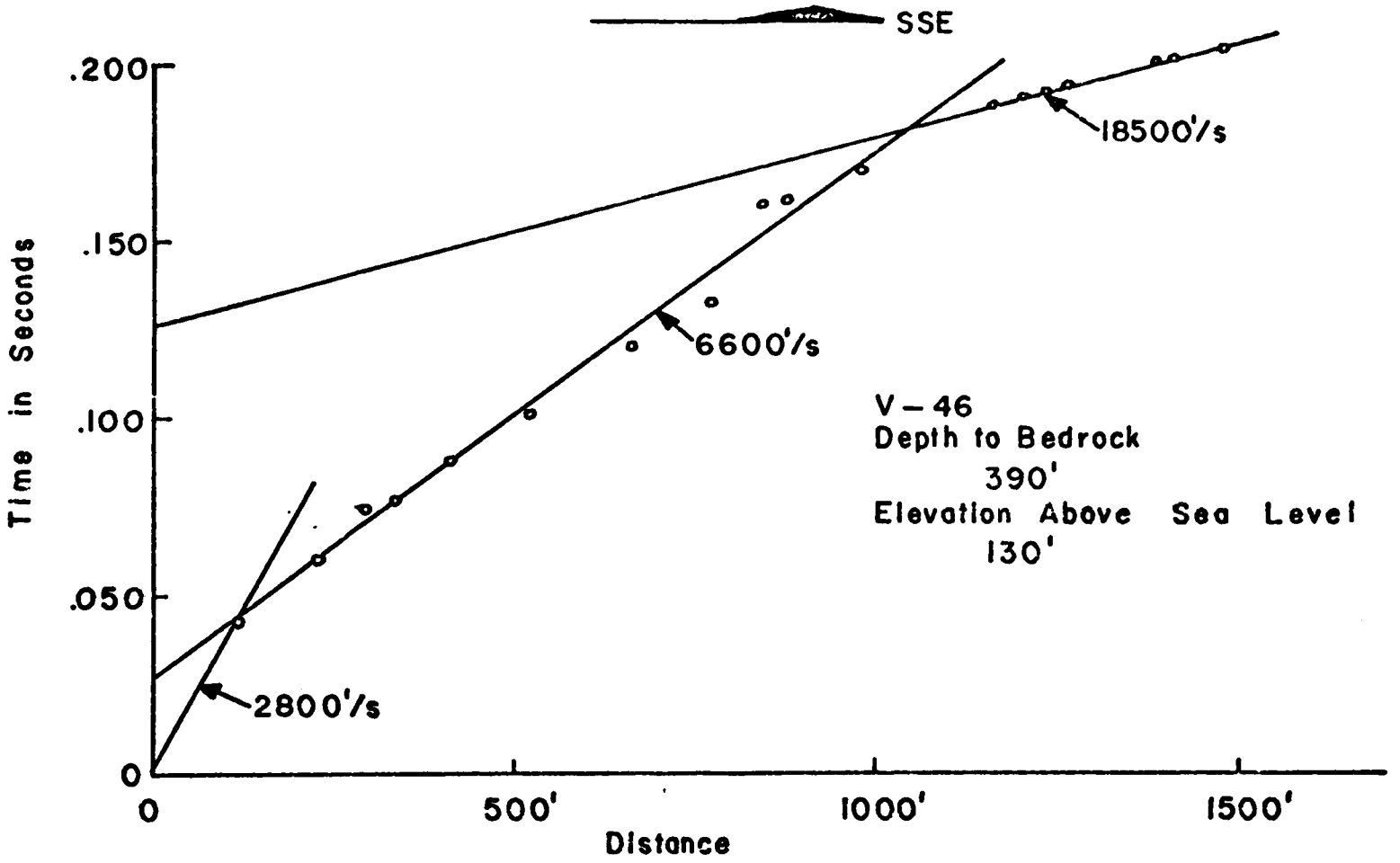


Figure 16. Inline seismic refraction profile at V-46+00, Goat Island Site.

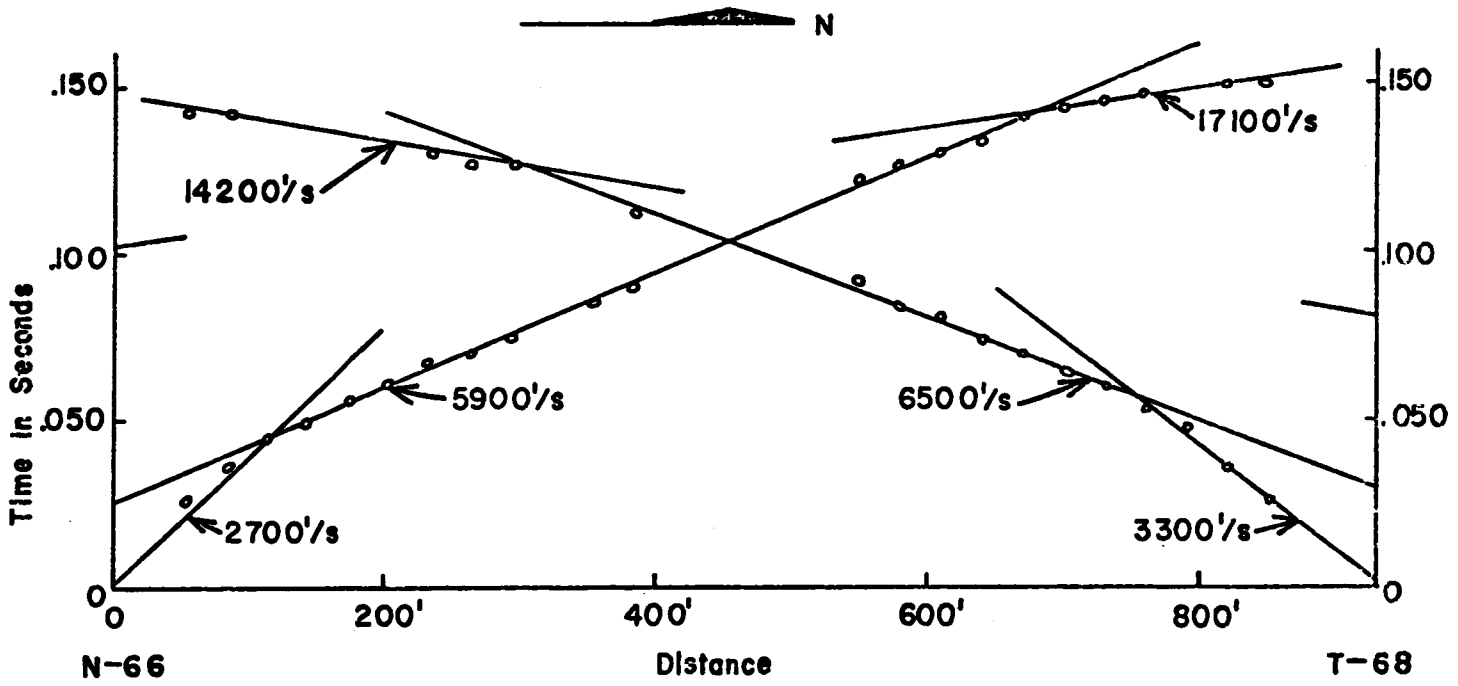


Figure 17. Inline seismic refraction profile between N-66+00 and T-68+00, Goat Island Site.

level. Seismic results are in basic agreement with gravity data which show the field strength increasing by 0.7 mgal from station V-46+00 to station T-68+00.

Comparison of Observed and Theoretical Gravity Profiles

It can be seen that the change of the gravitational field strength is closely related to change in thickness of the unconsolidated sediments. Figure 18 is a two-dimensional geologic model of the shallow strata based on outcrops, drill holes and seismic data. The theoretical gravity anomaly in Figure 18 was determined by graticule (Fig. 19) on the basis of this model. The observed anomaly is shown for comparison. The difference is slight, demonstrating that the model is a possible solution for the observed gravitational field.

Summary

Generally, the Paleozoic strata at the Goat Island power plant site dip toward the west. The thickness of Cretaceous-Tertiary unconsolidated sediments also increase toward the west and along the axis of the negative gravity anomaly which bends northwest within the site and continues north beyond the region of the survey.

The source of the gravity anomaly remains unclear. It may be caused by a post-Paleozoic tectonic feature. The

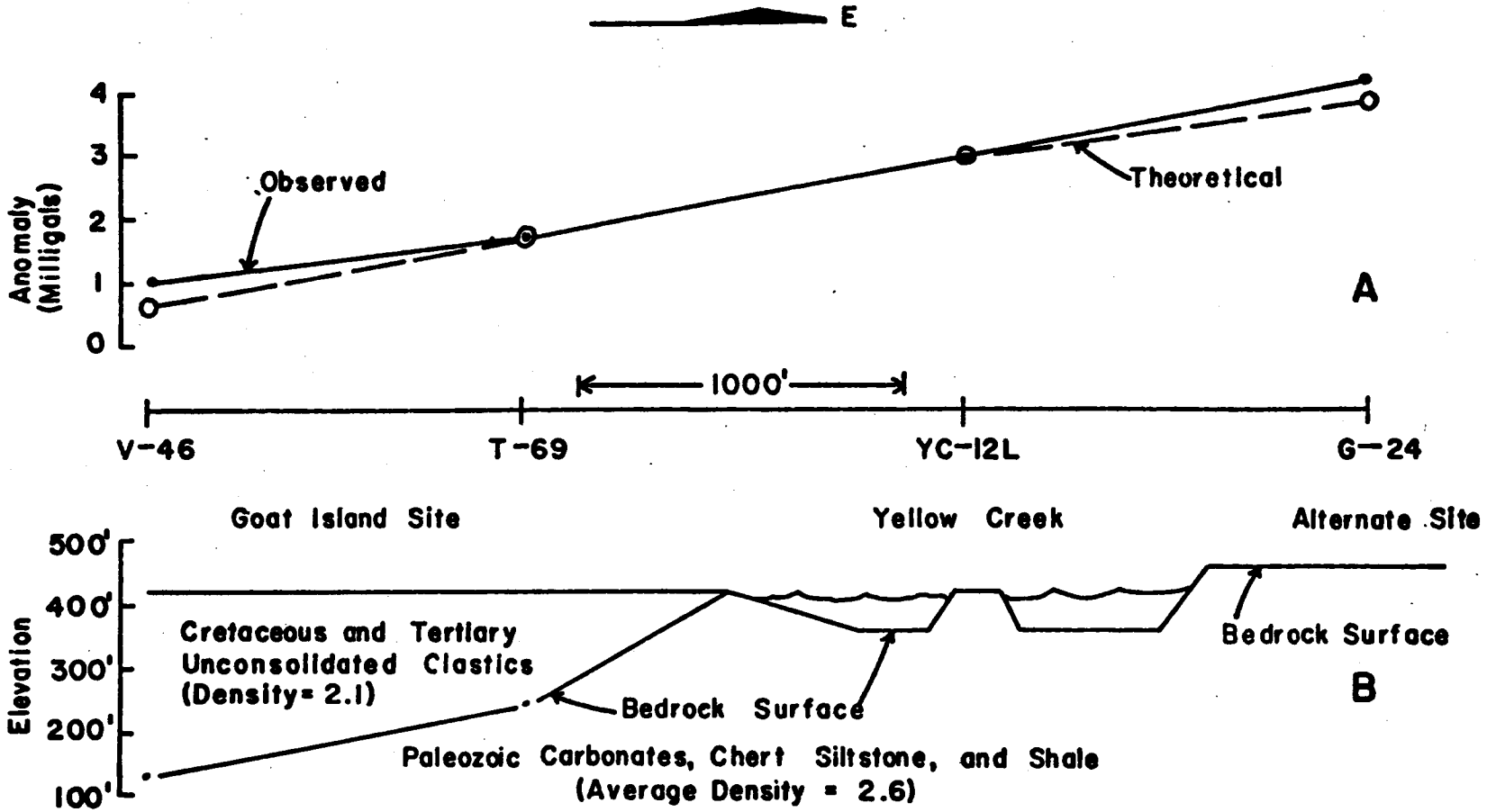


Figure 18. (A) Theoretical and observed gravity profiles; (B) Two dimensional model based on outcrops, drill holes, and seismic refraction data.

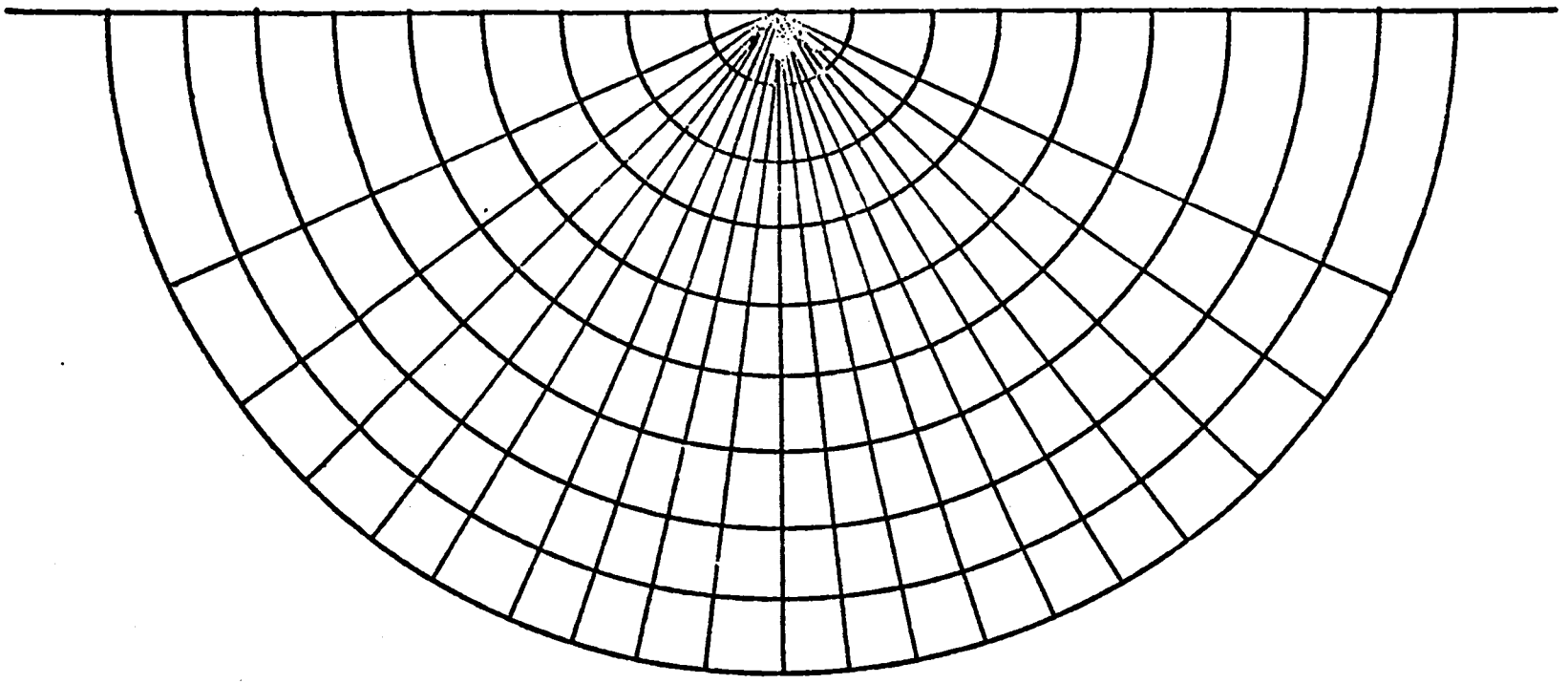


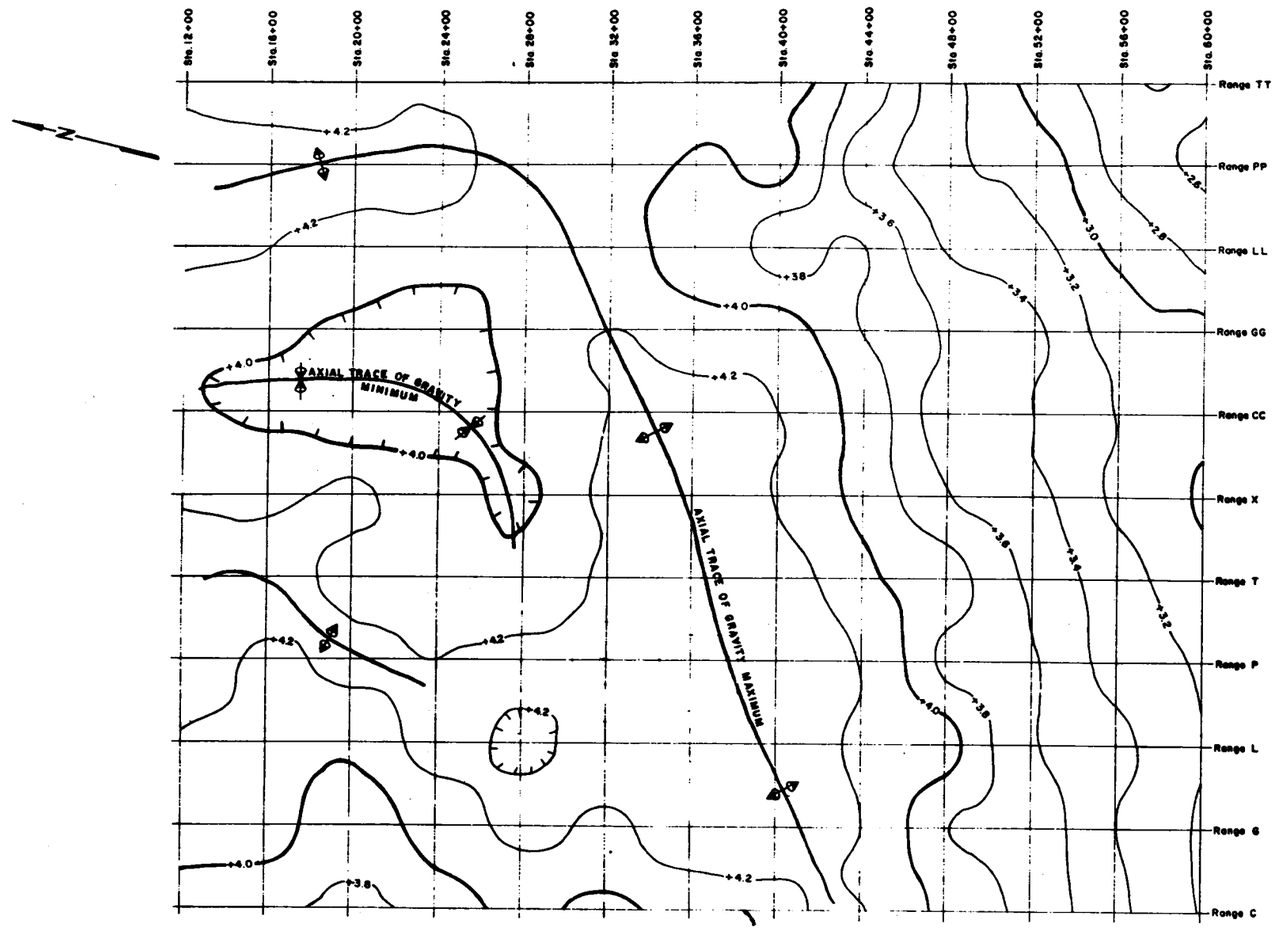
Figure 19. Graticule for calculating gravity effect at any point on the surface due to a two dimensional body. The body is considered to be infinitely long perpendicular to the plane of the graticule.

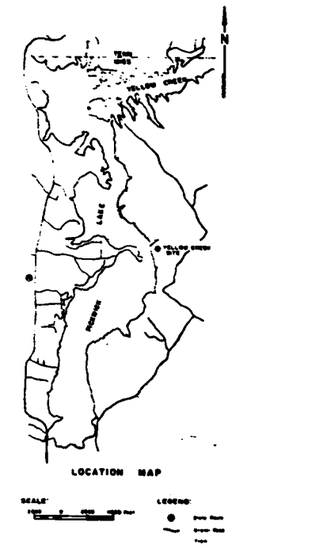
axis of a syncline or graben may represent the position of the "hinge line" of the Mississippi Embayment. In comparison, low gravity anomaly axial traces have been observed over several grabens in California which have similar characteristics as at the Goat Island power plant site (McNitt, 1963; Corbato, 1963). Another possibility, but less likely, is that it represents the collapse of a cave during or after Cretaceous sedimentation (Godson and Watkins, 1965; Moorehouse and Millet, 1971). The stratigraphically controlled would-be collapse feature was later filled with Cretaceous and Tertiary sediments. Small-scale solution-susceptible exposures have been observed along joints on the east bank of the embayment. On the other hand, the Yellow Creek Quadrangle map shows no indication of sinkholes or collapse features of any kind. However, it is likely that Cretaceous and Tertiary sediments would cover any trace of paleo-karst topography that developed during post-Mississippian time.

Alternate Site

Isogal Map

Plate 5 is an isogal map of the Alternate plant site. The gravitational field strength is nearly constant throughout the northern half of the area, but it decreases steadily toward the south from the axial trace of the gravity maximum.





LEGEND:

Contour Interval = 0.2 MGALS

SCALE:

200 0 200 400 Feet

Plate 5. Isogal Map of Alternate Site.

These results suggest that the northern area is underlain by a uniformly thin veneer of unconsolidated clastic sediments which thicken steadily from the center of the area toward the south. Such an interpretation is consistent with that for the Goat Island site.

Geologic Model Based on Drill and Seismic Refraction Data

A Tennessee Valley Authority crew conducted a shallow refraction seismic survey in the northern half of the Alternate plant site in the summer of 1970 (Harrell, 1971). Their results indicated that consolidated rock lies between 65 to 75 feet deep throughout the area. Presumably the consolidated rock is a limestone member of the Fort Payne Formation.

Broadside and inline refraction data were obtained during the present investigation in order to test the hypothesis that unconsolidated sediments thicken toward the south. The results of these surveys are shown in Figure 20A and Figure 21A. They clearly prove that unconsolidated sediments do thicken toward the south as suggested by gravity data. Figure 20B and Figure 21B are isogal profiles for direct comparison with seismic data.

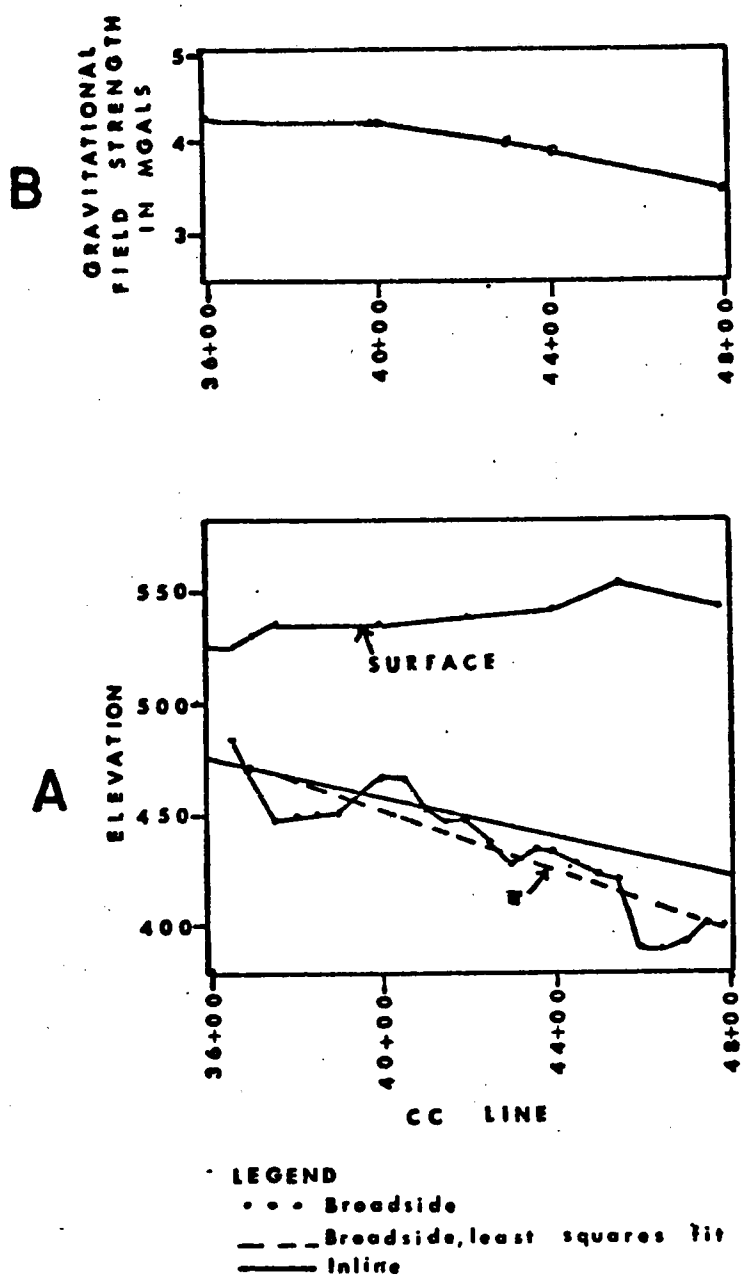


Figure 20. (A) Broadside and inline refraction profiles, CC-36+00 to CC-48+00; (B) Isogal profile, CC-36+00 to CC-48+00.

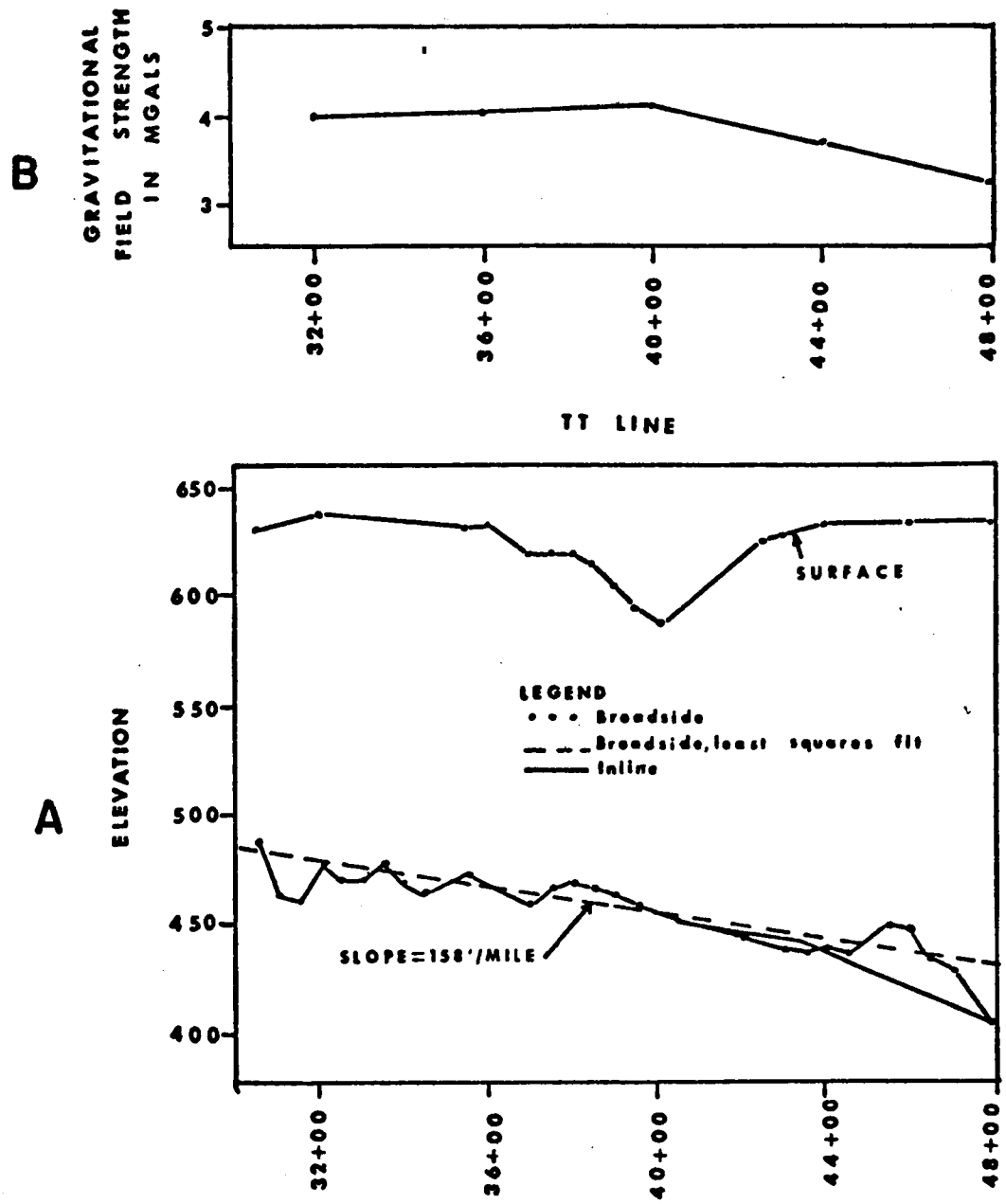


Figure 21. (A) Broadside and inline seismic refraction profiles along the TT line; (B) Isogal profile, TT-32+00 to TT-48+00.

Comparison of Observed and Theoretical Gravity Profiles

Figure 22A shows theoretical and observed gravity profiles along the P-line at the Alternate plant site. Figure 22B is the geologic model that was used to calculate the theoretical gravity profile. According to drill data, the elevation of the Fort Payne surface is about 470 feet above sea level near the center of the proposed plant site, but it decreases at a gradient of 355 feet per mile toward the south according to seismic data. This gradient is extrapolated southward beyond the limits of control. Figure 22A shows that the observed gravity profile agrees favorably with the theoretical gravity profile. Thus the geologic model is an acceptable solution for the observed gravity data.

Confirmation of Geologic Model by Drilling

Figure 23 is a profile of drill data along the P line from P-28+00 to P-60+00. All the drill data except from P-28+00 to P-32+00 were acquired after the geophysical interpretation had been completed. The drill results show that from P-28+00 to P-46+00 the bedrock surface is relatively flat but from P-46+00 to P-60+00 it slopes to the south at a rate of 277 feet per mile. These results substantiate the general conclusions drawn by the geophysical interpretation.

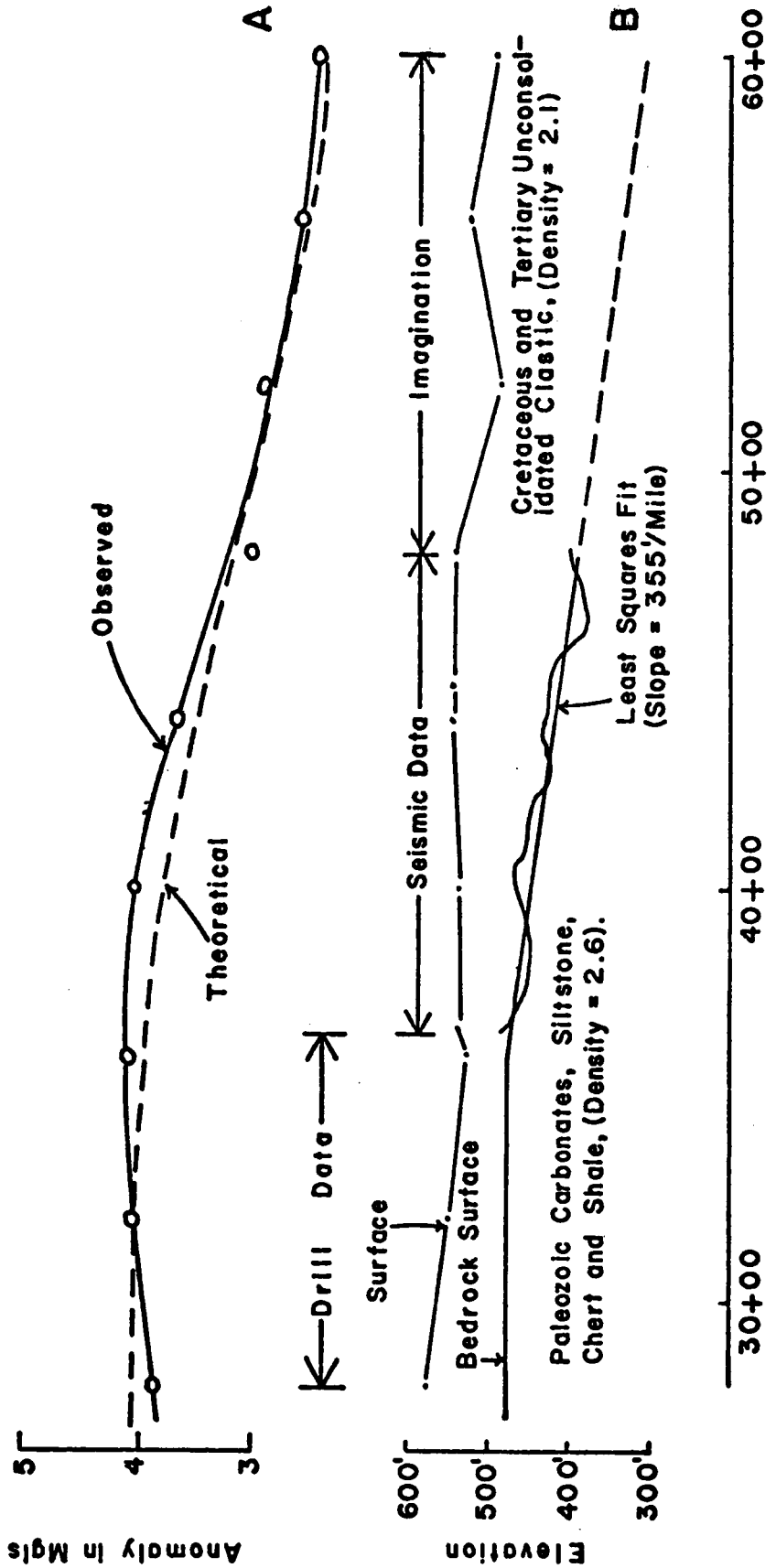


Figure 22. (A) Theoretical and observed gravity profiles, Alternate Site; (B) Geologic model based on drill and seismic data.

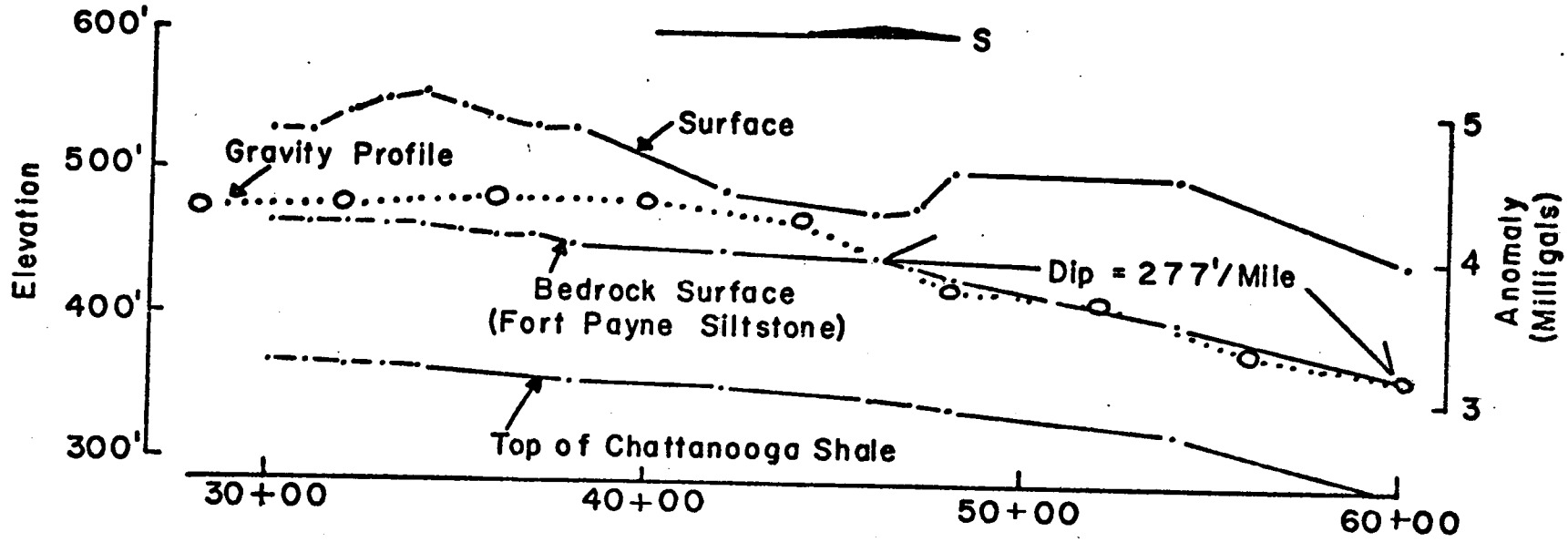


Figure 23. Drill log plot and gravity profile along the P line, Alternate Site.

Samples from a drill core that was taken at P-60+00 are shown in Plate 6. They indicate a breccia zone and slickensides at approximately 190 feet of depth. This evidence could be interpreted as a collapse feature (note the core loss) or as a fault. The problem remains unresolved at this time.

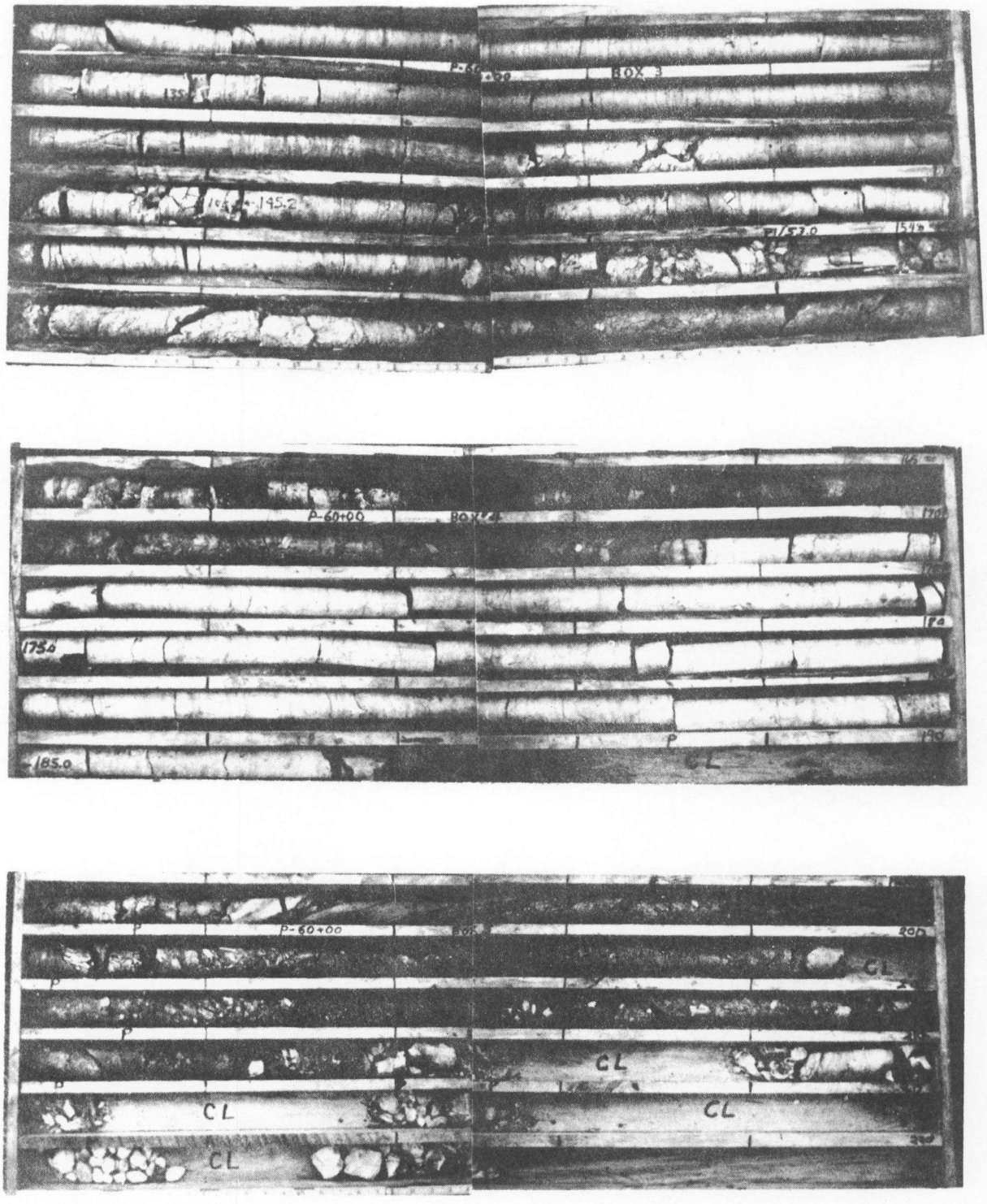


Plate 6. Core samples from P-60+00 (courtesy of Tennessee Valley Authority).

CHAPTER V

CONCLUSION

This investigation has demonstrated the usefulness of gravity data for preliminary site investigation for heavy construction along the hinge line of the Mississippi embayment. It is unlikely that the nature of the bedrock surface at either the Goat Island or Alternate plant sites could have been determined by drill tests alone without enduring great expense.

Several gravity anomalies with linear trends were discovered. While these trends could not be positively associated with shallow faults, it is clear that the decreasing gravitational field strength is related to increasing thickness of Cretaceous and Tertiary overburden.

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APPENDIX

Column I: Gravity stations (shown on Plates 2, 3, and 5).

Column II: Time (central standard time).

Column III: Instrument reading.

Column IV: Latitude.

Column V: Longitude.

Column VI: Elevation in feet above sea level.

Column VII: Tide in mgals-instrument drift.

Column VIII: Bouguer anomaly value in milligals. Equal to observed gravity plus local elevation correction minus tide correction minus theoretical gravity.

TABLE II

YELLOW CREEK RECONNAISSANCE

I	II	III	IV	V	VI	VII	VIII
June 10, 1971							
Base	8:16	3180.243	34°55.99'	88°14.69'	422.70	0.06	0.000
RTMS17AZMK	8:54	3169.694	34°54.33'	88°14.14'	548.60	0.05	-0.164
D165	9:21	3175.984	34°54.50'	88°14.68'	463.80	0.01	0.473
RTM59	9:45	3176.609	34°55.54'	88°15.25'	492.60	-0.01	1.880
RTMS10AZMK	10:25	3179.390	34°56.03'	88°14.94'	455.90	-0.04	1.397
Base	10:53	3180.081	34°55.99'	88°14.69'	422.70	-0.07	-0.046
RTMS10	11:48	3175.618	34°56.38'	88°14.89'	514.20	-0.11	0.976
RTMS12	12:40	3177.351	34°57.92'	88°14.72'	515.50	-0.14	0.737
RTMS13AZMK	13:04	3184.012	34°59.20'	88°14.93'	438.20	-0.15	0.815
RTMS15AZMK	13:32	3184.832	34°59.95'	88°14.52'	466.70	-0.16	2.411
Base	13:57	3180.022	34°55.99'	88°14.69'	422.70	-0.16	-0.011
June 12, 1973							
Base	8:04	3180.259	34°55.99'	88°14.69'	422.70	0.07	0.005
RTMS18AZMK	8:30	3177.454	34°55.25'	88°13.00'	489.80	0.07	2.660
RTMS19AZMK	8:57	3176.034	34°55.58'	88°13.21'	516.60	0.07	2.524
RTMS20	9:25	3176.060	34°56.58'	88°12.64'	546.60	0.05	3.342
RTMS21	9:55	3177.782	34°57.09'	88°12.84'	545.00	0.04	3.980
RTMS22AZMK	10:28	3172.689	34°57.86'	88°13.02'	629.10	0.02	3.470
Base	11:14	3180.160	34°55.99'	88°14.69'	422.70	-0.01	-0.023
RTMS23AZMK	12:36	3182.637	34°58.73'	88°13.39'	499.40	-0.04	3.933
RTMS27AZMK	13:20	3176.835	34°58.64'	88°12.07'	591.60	-0.09	4.284
RTMS28AZMK	13:43	3173.555	34°58.14'	88°11.88'	620.50	-0.11	3.528
A165	14:14	3167.430	34°53.48'	88°12.19'	584.50	-0.12	1.271
RTMS1	14:31	3167.026	34°53.48'	88°11.28'	594.80	-0.13	1.950
RTMS2	14:55	3177.273	34°53.24'	88°10.21'	446.10	-0.13	2.544
B165	15:26	3171.592	34°54.03'	88°12.70'	545.50	-0.14	2.222
C165	15:39	3167.575	34°54.24'	88°13.50'	599.60	-0.13	1.386
Base	15:57	3180.105	34°55.99'	88°14.69'	422.70	-0.13	0.045

TABLE II (continued)

I	II	III	IV	V	VI	VII	VIII
June 14, 1971							
Base	8:21	3180.267	34°55.99'	88°14.69'	422.70	0.02	0.064
YC13L	9:38	3181.679	34°56.88'	88°14.00'	425.40	0.03	0.456
LA1	10:08	3183.403	34°56.78'	88°14.38'	415.70	0.03	1.742
YC14L	10:42	3182.201	34°56.44'	88°14.47'	432.10	0.03	2.076
LA2	11:16	3182.002	34°55.77'	88°14.54'	417.70	0.02	1.843
LA3	11:57	3182.586	34°55.50'	88°14.64'	416.10	0.02	2.733
Base	13:18	3180.206	34°55.99'	88°14.69'	422.70	-0.01	0.028
YC14R	14:15	3183.552	34°56.17'	88°13.84'	422.00	-0.03	3.251
YC13R	14:48	3183.435	34°56.66'	88°13.27'	432.00	-0.05	3.128
LA4	15:28	3184.506	34°57.19'	88°13.39'	423.00	-0.06	2.907
LA5	15:52	3185.293	34°57.40'	88°13.09'	416.70	-0.07	3.011
LA6	16:24	3183.133	34°57.33'	88°14.36'	416.70	-0.08	0.860
Base	17:18	3180.144	34°55.99'	88°14.69'	422.70	-0.08	0.033
June 15, 1971							
Base	7:48	3180.226	34°55.99'	88°14.69'	422.70	-0.03	0.068
YC11R	8:40	3185.258	34°57.71'	88°13.60'	424.00	-0.02	2.983
YC10L	11:35	3185.426	34°58.08'	88°13.81'	432.00	0.02	3.143
LA7	12:05	3186.952	34°58.43'	88°13.68'	415.80	0.02	3.147
YC8L	12:31	3186.911	34°58.72'	88°14.18'	417.00	0.02	2.776
LA8	12:58	3184.540	34°58.64'	88°14.77'	416.70	0.01	0.391
YC7L	13:27	3185.590	34°59.55'	88°14.61'	428.00	0.01	0.971
YC5R	13:47	3187.690	34°59.15'	88°14.09'	417.10	0.01	2.999
YC4R	14:11	3187.880	34°59.22'	88°13.50'	421.90	0.00	3.430
YC2R	14:40	3187.412	34°59.43'	88°12.63'	432.00	0.00	3.335
Base	15:00	3180.210	34°55.99'	88°14.69'	422.70	-0.01	0.031

TABLE II (continued)

I	II	III	IV	V	VI	VII	VIII
June 16, 1971							
Base	8:30	3180.161	34°55.99'	88°14.69'	422.70	-0.06	0.035
1A	9:05	3177.273	34°57.15'	88°14.35'	507.10	-0.06	1.087
Base	9:24	3180.163	34°55.99'	88°14.69'	422.70	-0.05	0.027

TABLE III

GOAT ISLAND

I	II	III	IV	V	VI	VII	VIII
July 4, 1973							
Base	9:18	3180.128	34°55.99'	88°14.69'	422.70	-0.06	-0.004
GG-22+00	9:48	3176.676	34°57.22'	88°14.91'	498.70	-0.06	-0.204
CC-22+00	10:08	3177.693	34°57.15'	88°14.89'	485.60	-0.07	0.081
CC-26+00	10:30	3178.734	34°57.18'	88°14.82'	471.50	-0.06	0.163
CC-30+00	10:52	3177.118	34°57.21'	88°14.73'	495.30	-0.06	0.042
CC-38+00	11:38	3178.634	34°57.26'	88°14.59'	475.40	-0.03	0.180
CC-42+00	12:02	3177.479	34°57.28'	88°14.50'	496.60	-0.02	0.369
CC-46+00	12:34	3180.836	34°57.31'	88°14.41'	452.20	0.00	0.812
Z-46+00	13:01	3177.777	34°57.25'	88°14.39'	499.80	0.02	0.899
Z-50+00	13:30	3180.343	34°57.28'	88°14.31'	465.20	0.05	1.169
Z-42+00	13:55	3177.232	34°57.23'	88°14.46'	505.10	0.07	0.666
Z-38+00	14:16	3176.653	34°57.20'	88°14.54'	509.00	0.09	0.348
Z-34+00	14:39	3176.453	34°57.17'	88°14.61'	509.40	0.11	0.188
Z-30+00	15:13	3178.111	34°57.14'	88°14.68'	484.60	0.14	0.255
Base	16:13	3180.366	34°55.99'	88°14.69'	422.70	0.19	-0.005
July 5, 1971							
Base	7:22	3180.232	34°55.99'	88°14.69'	422.70	0.04	0.004
GG-26+00	7:44	3177.781	34°57.24'	88°14.84'	484.30	0.03	-0.142
GG-30+00	8:06	3177.202	34°57.27'	88°14.75'	491.80	0.02	-0.272
GG-34+00	8:22	3178.618	34°57.29'	88°14.68'	471.70	0.01	-0.169
GG-38+00	8:42	3179.653	34°57.32'	88°14.60'	456.80	-0.01	-0.118
LL-38+00	9:47	3178.949	34°57.38'	88°14.63'	466.00	-0.04	-0.286
LL-30+00	10:15	3177.186	34°57.33'	88°14.79'	490.70	-0.05	-0.377
LL-26+00	11:03	3176.233	34°57.30'	88°14.87'	504.90	-0.05	-0.370
LL-22+00	11:25	3177.062	34°57.27'	88°14.95'	492.90	-0.05	-0.274
PP-22+00	12:30	3178:779	34°57.23'	88°14.98'	467.50	-0.03	-0.316
V-46+00	13:10	3177.303	34°57.18'	88°14.35'	507.20	-0.01	1.033

TABLE III (continued)

I	II	III	IV	V	VI	VII	VIII
V-50+00	13:52	3179.100	34°57.21'	88°14.27'	484.20	0.03	1.274
V-54+00	14:12	3177.970	34°57.24'	88°14.18'	504.70	0.05	1.418
V-58+00	14:35	3178.399	34°57.27'	88°14.11'	501.50	0.06	1.597
V-62+00	14:55	3178.980	34°57.29'	88°14.04'	490.00	0.08	1.649
Z-62+00	15:16	3179.216	34°57.35'	88°14.07'	492.70	0.10	1.703
V-66+00	15:43	3179.638	34°57.32'	88°13.96'	486.40	0.12	1.740
Z-66+00	16:08	3183.235	34°57.38'	88°14.00'	436.20	0.14	1.998
V-70+00	16:29	3180.449	34°57.34'	88°13.89'	474.20	0.15	1.704
Base	17:13	3180.362	34°55.99'	88°14.69'	422.70	0.18	0.000
July 6, 1971							
Base	9:22	3180.163	34°55.99'	88°14.69'	422.70	-0.03	0.002
V-42+00	10:21	3177.611	34°57.16'	88°14.41'	497.70	-0.06	0.791
V-38+00	10:40	3178.779	34°57.13'	88°14.50'	477.80	-0.06	0.707
V-34+00	10:56	3176.904	34°57.11'	88°14.59'	501.90	-0.06	0.406
R-34+00	11:13	3178.114	34°57.05'	88°14.55'	486.40	-0.06	0.707
N-34+00	11:35	3180.550	34°56.98'	88°14.52'	450.10	-0.06	0.896
N-38+00	12:06	3177.723	34°57.00'	88°14.43'	495.30	-0.05	0.961
R-38+00	12:32	3178.550	34°57.07'	88°14.47'	482.50	-0.05	0.861
R-42+00	12:51	3177.114	34°57.09'	88°14.39'	507.30	-0.03	0.990
J-38+00	13:43	3178.553	34°56.94'	88°14.40'	484.70	0.01	1.136
N-42+00	14:14	3177.795	34°57.03'	88°14.36'	498.00	0.03	1.097
J-42+00	14:34	3178.235	34°56.97'	88°14.34'	491.20	0.06	1.151
E-42+00	15:00	3179.855	34°56.90'	88°14.30'	467.60	0.08	1.326
A-42+00	15:19	3178.632	34°56.84'	88°14.25'	487.00	0.10	1.426
A-46+00	15:39	3179.293	34°56.87'	88°14.18'	479.60	0.12	1.554
A-50+00	16:01	3179.864	34°56.89'	88°14.10'	469.30	0.15	1.395
E-50+00	16:29	3178.013	34°56.96'	88°14.14'	496.50	0.18	1.172

TABLE III (continued)

I	II	III	IV	V	VI	VII	VIII
E-46+00	16:42	3178.374	34°56.93'	88°14.22'	493.40	0.19	1.372
J-46+00	17:02	3178.095	34°57.00'	88°14.25'	495.70	0.21	1.117
N-46+00	17:18	3178.392	34°57.06'	88°14.28'	492.90	0.23	1.134
R-46+00	17:32	3178.151	34°57.13'	88°14.32'	497.10	0.23	1.067
Base	18:08	3180.439	34°55.99'	88°14.69'	422.70	0.26	0.001
July 7, 1971							
Base	8:52	3180.272	34°55.99'	88°14.69'	422.70	0.08	0.006
E-62+00	9:27	3181.761	34°57.04'	88°13.91'	428.40	0.06	0.489
E-66+00	9:45	3181.014	34°57.07'	88°13.82'	445.80	0.05	0.853
E-70+00	10:11	3180.581	34°57.09'	88°13.75'	460.90	0.04	1.404
J-70+00	10:30	3179.117	34°57.16'	88°13.78'	486.40	0.03	1.511
J-66+00	10:44	3179.103	34°57.13'	88°13.86'	481.50	0.03	1.207
J-62+00	11:17	3179.084	34°57.10'	88°13.94'	475.40	0.02	0.826
J-58+00	11:40	3180.583	34°57.07'	88°14.02'	450.70	0.01	0.774
J-54+00	11:58	3178.545	34°57.05'	88°14.09'	482.10	0.01	0.797
E-54+00	13:12	3178.123	34°56.99'	88°14.06'	488.40	0.03	0.847
E-58+00	13:29	3178.228	34°57.01'	88°13.98'	481.30	0.04	0.437
J-50+00	13:58	3178.579	34°57.02'	88°14.18'	486.30	0.06	1.109
N-50+00	14:25	3178.831	34°57.08'	88°14.20'	482.90	0.09	1.028
R-50+00	14:40	3178.381	34°57.15'	88°14.25'	493.20	0.10	1.145
Base	15:35	3180.353	34°55.99'	88°14.69'	422.70	0.17	0.001
July 8, 1971							
Base	10:06	3180.219	34°55.99'	88°14.69'	422.70	0.03	0.001
N-54+00	10:44	3178.274	34°57.11'	88°14.13'	492.00	0.01	1.099
R-54+00	11:02	3177.790	34°57.18'	88°14.16'	502.50	0.00	1.217
R-58+00	11:21	3178.859	34°57.21'	88°14.07'	488.40	-0.01	1.346
R-62+00	11:44	3179.189	34°57.23'	88°14.00'	485.20	-0.02	1.456

TABLE III (continued)

I	II	III	IV	V	VI	VII	VIII
R-66+00	12:06	3179.300	34°57.26'	88°13.93'	485.70	-0.03	1.574
N-66+00	13:59	3178.230	34°57.20'	88°13.89'	499.50	0.00	1.448
N-70+00	14:13	3179.073	34°57.22'	88°13.81'	489.50	0.01	1.610
N-58+00	14:43	3179.319	34°57.14'	88°14.05'	477.30	0.04	1.124
PP-26+00	15:45	3178.593	34°57.37'	88°14.90'	470.00	0.11	-0.524
PP-30+00	16:06	3177.667	34°57.39'	88°14.84'	485.00	0.14	-0.535
PP-34+00	16:27	3179.706	34°57.42'	88°14.75'	454.60	0.16	-0.523
LL-34+00	17:11	3179.710	34°57.35'	88°14.71'	455.00	0.21	-0.443
Base	17:51	3180.439	34°55.99'	88°14.69'	422.70	0.26	0.001
July 9, 1971							
Base	8:38	3180.337	34°55.99'	88°14.69'	422.70	0.16	-0.006
Z-22+00	9:00	3178.723	34°57.08'	88°14.85'	473.00	0.14	0.194
R-22+00	9:37	3181.268	34°56.96'	88°14.78'	435.90	0.13	0.524
N-22+00	9:52	3177.520	34°56.90'	88°14.75'	493.70	0.12	0.612
N-26+00	10:09	3179.602	34°56.93'	88°14.66'	463.90	0.11	0.739
R-30+00	10:34	3180.328	34°57.01'	88°14.63'	451.60	0.10	0.563
V-30+00	11:42	3178.276	34°57.07'	88°14.66'	480.10	0.06	0.302
V-26+00	12:02	3180.558	34°57.06'	88°14.73'	445.00	0.04	0.346
Z-26+00	12:21	3178.943	34°57.12'	88°14.77'	468.60	0.04	0.170
R-70+00	13:23	3179.377	34°57.28'	88°13.85'	487.40	0.04	1.671
N-62+00	15:24	3178.140	34°57.17'	88°13.97'	497.60	0.11	1.530
Base	15:40	3180.317	34°55.99'	88°14.69'	422.70	0.13	0.003
August 23,1971							
Base	9:24	3180.703	34°55.99'	88°14.69'	422.10	0.50	-0.003
Z-22+00	9:45	3179.128	34°57.08'	88°14.85'	473.00	0.49	0.268
V-22+00	9:59	3181.311	34°57.02'	88°14.82'	439.50	0.48	0.378

TABLE III (continued)

I	II	III	IV	V	VI	VII	VIII
R-22+00	10:15	3181.650	34°56.96'	88°14.78'	435.90	0.48	0.577
N-22+00	10:32	3177.889	34°56.90'	88°14.75'	493.70	0.47	0.648
CC-34+00	11:16	3178.239	34°57.23'	88°14.65'	485.40	0.45	0.006
E-58+00	11:38	3178.681	34°57.01'	88°13.98'	481.30	0.43	0.521
J-58+00	12:08	3181.004	34°57.07'	88°14.02'	450.70	0.43	0.794
Base	12:30	3180.625	34°55.99'	88°14.69'	422.10	0.42	-0.005

TABLE IV

YELLOW CREEK (ALTERNATE)

I	II	III	IV	V	VI	VII	VIII
August 4, 1971							
MS-20	10:15	3176.058	34°56.47'	88°12.54'	546.60	0.05	3.341
P-36+00	11:22	3178.419	34°57.07'	88°12.77'	537.40	0.05	4.341
P-40+00	11:46	3179.440	34°57.01'	88°12.75'	519.90	0.05	4.309
P-44+00	12:27	3182.290	34°56.94'	88°12.73'	473.00	0.07	4.193
L-44+00	13:10	3179.152	34°56.92'	88°12.81'	520.90	0.10	4.152
L-40+00	13:35	3178.325	34°56.99'	88°12.84'	537.60	0.11	4.309
L-36+00	13:58	3178.219	34°57.06'	88°12.86'	540.60	0.14	4.273
L-32+00	14:22	3179.663	34°57.12'	88°12.88'	520.00	0.16	4.284
L-28+00	14:42	3177.755	34°57.19'	88°12.89'	549.80	0.18	4.187
L-24+00	15:07	3179.080	34°57.25'	88°12.91'	532.70	0.21	4.290
MS-20	15:46	3176.283	34°56.47'	88°12.54'	546.60	0.25	3.376
August 5, 1971							
MS-20	8:46	3176.150	34°56.47'	88°12.54'	546.60	0.14	3.347
X-28+00	9:12	3175.361	34°57.24'	88°12.66'	584.00	0.13	3.978
T-24+00	9:40	3177.011	34°57.28'	88°12.77'	561.60	0.11	4.151
T-20+00	10:08	3177.608	34°57.35'	88°12.78'	553.10	0.10	4.111
P-20+00	10:27	3178.119	34°57.33'	88°12.86'	546.40	0.09	4.230
L-20+00	10:42	3176.590	34°57.32'	88°12.93'	566.60	0.08	4.023
G-20+00	10:54	3176.189	34°57.30'	88°13.02'	570.10	0.08	3.868
C-20+00	11:15	3179.368	34°57.28'	88°13.09'	523.30	0.08	4.053
C-16+00	11:42	3180.830	34°57.35'	88°13.11'	500.00	0.08	3.906
G-16+00	11:57	3180.214	34°57.37'	88°13.03'	512.60	0.08	4.086
L-16+00	12:11	3179.853	34°57.38'	88°12.96'	519.50	0.08	4.162
P-16+00	12:26	3179.884	34°57.40'	88°12.87'	520.00	0.09	4.189
T-16+00	12:56	3178.861	34°57.41'	88°12.79'	536.70	0.10	4.226
X-16+00	13:12	3177.061	34°57.43'	88°12.72'	563.90	0.11	4.147

TABLE IV (continued)

I	II	III	IV	V	VI	VII	VIII
X-20+00	13:40	3178.620	34°57.37'	88°12.69'	540.30	0.13	4.245
X-24+00	14:08	3177.295	34°57.30'	88°12.68'	557.50	0.17	4.082
MS-20	14:45	3176.219	34°56.47'	88°12.54'	546.60	0.22	3.339
August 6, 1971							
MS-20	9:01	3176.223	34°56.47'	88°12.54'	546.60	0.22	3.343
GG-24+00	9:46	3172.322	34°57.33'	88°12.52'	631.60	0.18	3.845
LL-24+00	10:14	3174.001	34°57.35'	88°12.44'	609.90	0.16	4.134
LL-20+00	10:33	3172.637	34°57.41'	88°12.46'	632.50	0.15	4.153
PP-20+00	10:53	3173.108	34°57.43'	88°12.39'	626.30	0.14	4.208
PP-24+00	11:09	3172.792	34°57.37'	88°12.36'	630.20	0.12	4.246
PP-28+00	11:23	3173.722	34°57.30'	88°12.34'	611.60	0.11	4.068
TT-24+00	11:55	3174.564	34°57.37'	88°12.29'	601.80	0.11	4.186
TT-20+00	12:47	3173.120	34°57.44'	88°12.31'	624.60	0.11	4.121
MS-20+00	14:06	3176.150	34°56.47'	88°12.54'	546.60	0.15	3.337
CC-24+00	14:45	3174.380	34°57.2]'	88°12.59'	600.60	0.19	3.903
GG-20+00	15:20	3172.613	34°57.40'	88°12.54'	631.20	0.23	3.974
MS-20	15:40	3176.264	34°56.47'	88°12.54'	546.60	0.26	3.346
August 7, 1971							
MS-20	9:00	3176.240	34°56.47'	88°12.54'	546.60	0.24	3.341
TT-16+00	9:46	3172.765	34°57.51'	88°12.32'	632.60	0.21	4.092
PP-16+00	9:59	3174.340	34°57.49'	88°12.40'	609.90	0.19	4.251
LL-16+00	10:12	3174.348	34°57.48'	88°12.48'	608.70	0.18	4.202
GG-16+00	10:30	3174.669	34°57.46'	88°12.56'	600.90	0.17	4.048
CC-16+00	10:50	3174.980	34°57.45'	88°12.64'	594.80	0.16	3.984
CC-20+00	11:49	3174.200	34°57.38'	88°12.64'	594.80	0.16	3.984
MS-20	12:20	3176.108	34°56.47'	88°12.54'	546.60	0.10	3.343

TABLE IV (continued)

I	II	III	IV	V	VI	VII	VIII
August 8, 1971							
MS-20	9:02	3176.311	34°56.47'	88°12.54'	546.60	0.31	3.346
F-24+00	9:56	3177.750	34°57.23'	88°12.98'	550.00	0.27	4.049
C-24+00	10:03	3177.673	34°57.21'	88°13.07'	548.60	0.27	3.902
C-28+00	10:28	3179.121	34°57.15'	88°13.05'	526.60	0.24	4.041
C-32+00	10:59	3182.889	34°57.09'	88°13.03'	465.20	0.22	3.929
C-36+00	11:26	3178.918	34°57.02'	88°13.02'	526.40	0.19	4.050
C-40+00	12:04	3179.116	34°56.96'	88°13.00'	523.60	0.17	4.171
G-40+00	12:42	3177.940	34°56.98'	88°12.91'	542.50	0.14	4.222
G-44+00	12:57	3178.717	34°56.91'	88°12.89'	528.50	0.13	4.196
MS-20	13:21	3176.127	34°57.47'	88°12.54'	546.60	0.12	3.343
G-36+00	13:52	3178.975	34°57.04'	88°12.93'	529.10	0.12	4.330
MS-20	15:12	3176.169	34°56.47'	88°12.54'	546.60	0.16	3.347
August 9, 1971							
MS-20	9:33	3176.291	34°56.47'	88°12.54'	546.60	0.28	3.355
T-32+00	10:55	3177.619	34°57.15'	88°12.71'	552.60	0.25	4.221
T-28+00	11:18	3176.279	34°57.22	88°12.73'	571.70	0.24	4.024
P-24+00	11:44	3177.771	34°57.27'	88°12.84'	552.00	0.22	4.200
P-28+00	12:00	3178.162	34°57.20'	88°12.81'	544.60	0.20	4.226
P-32+00	12:17	3178.259	34°57.13'	88°12.79'	542.30	0.19	4.281
MS-20	12:53	3176.177	34°56.47'	88°12.54'	546.60	0.17	3.345
T-36+00	14:34	3177.733	34°57.09'	88°12.16'	548.20	0.15	4.227
T-40+00	14:48	3181.220	34°57.02'	88°12.68'	493.40	0.15	4.270
T-44+00	15:12	3179.323	34°56.46'	88°12.65'	518.30	0.16	4.039
MS-20	15:58	3176.190	34°56.47'	88°12.54'	546.60	0.18	3.349

TABLE IV (continued)

I	II	III	IV	V	VI	VII	VIII
August 10, 1971							
MS-20	9:23	3176.310	34°56.47'	88°12.54'	546.60	0.31	3.344
X-32+00	10:06	3178.195	34°57.17'	88°12.64'	545.00	0.30	4.230
X-36+00	10:48	3178.507	34°57.10'	88°12.62'	538.60	0.29	4.232
X-40+00	11:07	3179.113	34°57.04'	88°12.60'	527.20	0.28	4.188
CC-32+00	11:39	3177.931	34°57.19'	88°12.56'	548.40	0.26	4.196
CC-26+00	11:58	3179.395	34°57.12'	88°12.54'	524.70	0.25	4.232
CC-28+00	12:18	3176.111	34°57.26'	88°12.52'	575.60	0.24	4.056
MS-20	13:32	3176.204	34°56.47'	88°12.54'	546.60	0.20	3.344
August 15, 1971							
MS-20	9:32	3176.157	34°56.47'	88°12.54'	546.60	0.15	3.344
GG-32+00	10:06	3177.519	34°57.20'	88°12.48'	553.80	0.18	4.197
GG-36+00	10:23	3176.754	34°57.13'	88°12.46'	573.20	0.19	4.067
GG-28+00	10:45	3176.579	34°57.27'	88°12.50'	568.60	0.20	4.097
LL-28+00	11:14	3172.764	34°57.29'	88°12.43'	627.20	0.22	4.026
LL-32+00	11:30	3176.672	34°57.22'	88°12.40'	566.70	0.24	4.070
LL-36+00	11:48	3174.298	34°57.15'	88°12.38'	599.20	0.26	3.892
PP-32+00	12:22	3174.659	34°57.23'	88°12.32'	598.50	0.30	4.070
TT-32+00	12:38	3172.109	34°57.25'	88°12.25'	637.70	0.32	4.008
TT-28+00	12:52	3173.610	34°57.32'	88°12.27'	617.70	0.33	4.115
MS-20	13:39	3176.380	34°56.47'	88°12.54'	546.60	0.38	3.348
TT-36+00	13:59	3172.446	34°57.19'	88°12.22'	632.50	0.39	4.023
PP-36+00	14:16	3172.003	34°57.17'	88°12.30'	632.20	0.40	3.980
TT-40+00	14:35	3175.422	34°57.12'	88°12.20'	586.70	0.41	4.114
PP-40+00	14:53	3177.373	34°57.10'	88°12.29'	555.30	0.42	4.047
TT-44+00	15:16	3171.932	34°57.06'	88°12.19'	633.50	0.42	3.707
PP-44+00	15:38	3172.404	34°57.04'	88°12.37'	622.40	0.43	3.467

TABLE IV (continued)

I	II	III	IV	V	VI	VII	VIII
TT-48+00	15:57	3171.449	34°56.99'	88°12.16'	633.10	0.44	3.253
MS-20	16:30	3176.439	34°56.47'	88°12.54'	546.60	0.45	3.339
August 16, 1971							
MS-20	9:35	3176.211	34°56.47'	88°12.54'	546.60	0.21	3.341
PP-48+00	10:14	3175.200	34°56.98'	88°12.25'	571.70	0.21	3.264
LL-48+00	10:42	3177.193	34°56.96'	88°12.32'	542.40	0.22	3.383
GG-48+00	11:03	3179.174	34°56.94'	88°12.40'	514.10	0.22	3.567
CC-48+00	11:30	3177.278	34°56.92'	88°12.48'	542.00	0.23	3.491
CC-48+00	11:46	3177.781	34°56.99'	88°12.50'	542.30	0.25	3.918
CC-40+00	12:04	3178.619	34°57.06'	88°12.52'	535.10	0.26	4.199
GG-44+00	12:26	3177.038	34°57.01'	88°12.43'	552.60	0.27	3.790
GG-40+00	12:39	3177.210	34°57.08'	88°12.44'	555.70	0.28	4.072
LL-40+00	12:55	3174.005	34°57.09'	88°12.36'	600.40	0.29	3.722
LL-44+00	13:13	3178.450	34°57.03'	88°12.34'	532.00	0.31	3.804
MS-20	13:59	3176.362	34°56.47'	88°12.54'	546.60	0.36	3.349
TT-52+00	14:29	3171.559	34°56.93'	88°12.14'	624.70	0.38	2.944
PP-52+00	14:50	3176.400	34°56.91'	88°12.22'	552.30	0.39	3.124
LL-52+00	15:22	3177.770	34°56.89'	88°12.30'	533.00	0.41	3.258
MS-20	16:01	3176.420	34°56.47'	88°12.54'	546.60	0.43	3.339
August 17, 1971							
MS-20	9:18	3176.230	34°56.47'	88°12.54'	546.60	0.23	3.341
TT-56+00	10:12	3171.101	34°56.87'	88°12.12'	623.70	0.21	2.652
PP-56+00	10:28	3173.550	34°56.85'	88°12.20'	586.60	0.21	2.730
LL-56+00	10:46	3175.964	34°56.83'	88°12.28'	552.00	0.21	2.940
LL-60+00	11:06	3175.597	34°56.77'	88°12.27'	553.30	0.21	2.729
GG-60+00	11:27	3179.129	34°56.75'	88°12.34'	503.00	0.22	3.036

TABLE IV (continued)

I	II	III	IV	V	VI	VII	VIII
GG-56+00	11:42	3177.165	34°56.81'	88°12.36'	535.60	0.23	3.094
GG-52+00	11:58	3179.564	34°56.88'	88°12.38'	504.90	0.23	3.426
CC-60+00	12:24	3179.825	34°56.73'	88°12.43'	492.80	0.25	3.072
CC-56+00	12:37	3177.904	34°56.80'	88°12.44'	525.80	0.26	3.188
MS-20	13:29	3176.292	34°56.47'	88°12.54'	546.60	0.29	3.346
August 18, 1971							
MS-20	10:02	3176.230	34°56.47'	88°12.54'	546.60	0.23	3.341
X-44+00	10:33	3177.750	34°56.98'	88°12.59'	542.40	0.23	3.927
CC-52+00	10:59	3180.520	34°56.86'	88°12.46'	489.40	0.23	3.405
X-48+00	11:22	3176.429	34°56.91'	88°12.56'	556.70	0.23	3.612
T-48+00	12:03	3179.231	34°56.89'	88°12.63'	517.30	0.24	3.893
T-52+00	12:17	3179.720	34°56.83'	88°12.61'	503.70	0.25	3.559
P-48+00	12:36	3181.085	34°56.80'	88°12.71'	502.30	0.27	3.755
P-52+00	12:50	3178.935	34°56.81'	88°12.69'	516.80	0.28	3.623
P-56+00	13.08	3180.484	34°56.75'	88°12.68'	487.30	0.29	3.320
MS-20	13:39	3176.322	34°56.47'	88°12.54'	546.60	0.32	3.347
TT-60+00	14:15	3174.776	34°56.80	88°12.11'	566.60	0.34	2.599
MS-20	15:05	3176.366	34°56.47'	88°12.54'	546.60	0.37	3.343
August 21, 1971							
MS-20	9:03	3176.373	34°56.47'	88°12.54'	546.60	0.38	3.340
T-56+00	9:45	3179.651	34°56.77'	88°12.59'	501.10	0.36	3.285
X-56+00	10:05	3181.271	34°56.79'	88°12.52'	474.60	0.36	3.157
T-60+00	10:26	3182.322	34°56.70'	88°12.57'	455.30	0.34	3.097
X-60+00	10:40	3178.779	34°56.72'	88°12.50'	508.50	0.33	2.975
P-60+00	11:15	3183.076	34°56.68'	88°12.66'	443.90	0.31	3.172
L-52+00	11:39	3178.282	34°56.80'	88°12.77'	526.90	0.30	3.618

TABLE IV (continued)

I	II	III	IV	V	VI	VII	VIII
L-56+00	11:55	3180.255	34°56.73'	88°12.75'	492.60	0.30	3.458
G-52+00	12:17	3179.326	34°56.78'	88°12.85'	511.70	0.29	3.719
G-56+00	12:35	3179.264	34°56.71'	88°12.85'	506.40	0.29	3.397
C-52+00	12:55	3180.807	34°56.77'	88°12.93'	489.00	0.29	3.745
MS-20	13:33	3176.298	34°56.47'	88°12.54'	546.60	0.30	3.342
August 22, 1971							
MS-20	9:35	3176.396	34°56.47'	88°12.54'	546.60	0.40	3.344
X-52+00	10:20	3178.042	34°56.84'	88°12.54'	530.10	0.37	3.457
L-48+00	10:45	3183.604	34°56.87'	88°12.79'	453.40	0.35	4.059
G-48+00	11:01	3184.075	34°56.85'	88°12.87'	441.90	0.34	3.811
C-48+00	11:27	3179.680	34°56.83'	88°12.95'	511.40	0.33	3.958
C-44+00	11:42	3179.671	34°56.90'	88°42.97'	516.50	0.32	4.205
C-56+00	12:11	3184.627	34°56.70'	88°12.91'	424.50	0.31	3.452
MS-20	12:27	3176.304	34°56.47'	88°12.54'	546.60	0.30	3.348
G-28+00	13:17	3181.280	34°57.17'	88°12.97'	497.90	0.31	4.258
G-32+00	13:40	3180.287	34°57.10'	88°12.95'	510.60	0.32	4.168
MS-20	14:02	3176.334	34°56.47'	88°12.54'	546.60	0.34	3.340

VITA

Verner C. Johnson was born in Chicago, Illinois on September 14, 1943. He attended elementary school in Des Plaines, Illinois. In September, 1952, because of lack of facility for his hearing impairment, he was then transferred to grammar school in Evanston, Illinois where a special education teacher was needed. He graduated from Evanston Township High School in June, 1962. From there he went to Southern Illinois University, Carbondale, Illinois, majored in Geology and minored in Mathematics. He received B. A. in 1967 and M. S. in 1970. He did his master thesis entitled Fracture Patterns Along the Pomona Fault in Jackson County, Illinois. The scope of this thesis was to determine the relationship between the joint patterns and the Pomona fault. He discovered that the Pomona fault is a high angle reverse fault, not a normal fault as believed by earlier writers. In addition to working on his thesis, he taught freshman geology laboratory under teaching assistantship from January, 1968 to August, 1969.

In September, 1969, he transferred to the University of Tennessee, Knoxville, Tennessee also under teaching assistantship which he held until August, 1972. His responsibilities were to discuss various subjects in geology to freshmen and to go over exams during quiz recitation.

During the summer of 1971, he worked for the Tennessee Valley Authority doing geophysical surveys in the proposed power plant sites in the Yellow Creek Area, Mississippi, where the data are used for this report. From 1971 to 1972, TVA also sent this writer to several proposed power plant sites doing gravity surveys. In addition to working for TVA, the writer also worked for William P. Staub gathering refraction seismic data in the proposed landfill sites and the gravity data of the Knox county. Also, he gathered gravity data for the U. S. Army Corps of Engineers around Louisville, Kentucky area.

From September, 1972 until August, 1974, he had been instructor in the Department of Geology, at the California State University, Northridge, California. He taught physical geology, environmental geology, and geophysics. He introduced two new courses: 1) Elementary Exploration Geophysics and 2) Applied Geophysics. Also he proposed a B.S. degree in geophysics and NSF education grant for geophysics equipment.

Since September, 1974, he is an employee as project geophysicist for the Gulf Research and Development Company, Houston, Texas. His responsibilities include interpretation of the geophysical data and determine the possible location for the oil production.

Currently he is a member of six professional societies:

1. American Association of Petroleum Geologists

2. American Geophysical Union
3. Society of Exploration Geophysicists
4. Geological Society of America
5. South-Central Section of the Geological Society of America
6. Houston Geophysical Society
7. Sigma Gamma Epsilon while a student at the University of Tennessee

Additional experience includes:

Publications

Staub, W. P. and Johnson, V. C., 1971, Geophysical Survey of the Yellow Creek Area, Tennessee Valley Authority, unpublished report.

Johnson, V. C., 1971, Joint Report, in Geology of the Yellow Creek Area, Tennessee Valley Authority, unpublished report.

Staub, W. P. and Johnson, V. C., 1973, Geophysical Survey of a Power Plant Site (abstract), Southeastern Section of GSA, Knoxville, Tennessee.

Staub, W. P. and Johnson, V. C., 1973, Gravity Survey of Knox County, Bulletin 70, Tennessee Division of Geology, Nashville, Tennessee.

Written Manuscript:

Johnson, V. C., Fracture Patterns in the Yellow Creek Area, Mississippi, submitted to Southeastern Geology (to be published soon).

Oral Presentation:

"Geophysical Survey of the Yellow Creek Area" to California State University, Northridge Geology Department, April, 1973.

"Geophysical Survey of the Yellow Creek Area" to California State University, Northridge Physics Department Seminar, September 28, 1973.