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GEOLOGICAL AND GEOPHYSICAL EVALUATION OF THE
GRAINGERS BASIN FOR TRIASSIC SEDIMENTS

FINAL REPORT

LIBRARY
N. C. GEOLOGICAL SURVEY

Submitted by

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CONTENTS

	PAGE
Abstract.	1
Acknowledgements.	1
Summary and Recommendations	2
Introduction.	4
Scope of Work	5
Previous Work	5
Geophysical Investigations.	6
Geological Investigations	6
Interpretations	7
References Cited.	9
Appendix A: Geophysical Investigation of a Possible Triassic(?) Basin in the Kinston-New Bern Area (Report by I. J. Won and C. J. Leith to the North Carolina Division of Land Resources)	
Appendix B: Geophysical Exploration of Coal and Gas Resources Associated with a Buried Triassic Basin in the North Carolina Coastal Plains (Report by I. J. Won and C. J. Leith to the North Carolina Energy Institute)	
Appendix C: Well logs and Cuttings	
Plates	
1. Base map with magnetics overlain	
2. Base map with gravity overlain	
3. Cross section along U. S. Route 70 from Kinston to Clarks Crossroads depicting the sedimentary section from the surface down to the pre-Cretaceous surface	
4. Cross section showing the vertical relationship between the crystalline basement, the Paleozoic metasediments (phyllite), and the Mesozoic/ Tertiary sediments	

Abstract

A detailed field study of an aeromagnetic anomaly, previously suspected to be a buried Triassic basin, in the vicinity of Kinston, North Carolina, indicates a fault-block syncline in the crystalline basement containing up to seven thousand feet of Paleozoic metasediments. An east-west profile surveyed and drilled across the feature during this project, failed to reveal any Triassic sedimentary rocks.

The prominent orientations of the structural elements in the crystalline basement, as shown by geophysical data, are $N37^{\circ}E$ and less prominently $N54^{\circ}W$. These angles agree closely with the angles measured in a stress analysis based on surface geologic inspection and shallow core-hole evaluations in the Upper Cretaceous and Tertiary sediments of the area (Brown and others, 1977). The implication is that the basement structural lineations were active during deposition of the overlying Cretaceous and Tertiary sediments and that this structural activity influenced the sedimentation in each time-stratigraphic interval above the pre-Cretaceous surface. The knowledge of the orientations of these structural elements provides a basis for a predictive geologic model which will aid in mineral and ground water studies of the area.

Acknowledgements

Credit for making this study possible goes to S. G. Conrad, Director of the North Carolina Division of Land Resources, and to S. R. Beebe, Project Coordinator for the Coastal Plains Regional Planning Commission. Professional advice on stratigraphic correlations as well as detailed data on a number of additional control points was provided by P. M. Brown, United States Geological Survey. Geophysical interpretations were provided by I. J. Won and C. J. Leith of the Department of Geosciences, North Carolina State University. Credit for gathering the test hole data under very difficult circumstances goes to G. D. McClamb, Geologic Technician with the North Carolina Geological Survey. B. J. McKenzie assisted in the data compilation and interpretation.

Summary and Recommendations

Magnetic and gravity data combined with electrical soundings and test drilling information across parts of Lenoir, Craven, and Jones Counties (plates 1 and 2) reveal a possible fault-block syncline in the crystalline basement oriented N37°E. The electrical soundings (appendix B) and the test hole data indicates that the basin is filled with up to seven thousand feet of Paleozoic metasediments; primarily phyllite, a low-grade metamorphosed shale similar and probably related to rocks of the eastern slate belt of the Piedmont described by Parker (1968). The phyllite is covered with sediments of Recent to upper Lower Cretaceous age and range in thickness from 755 feet on the west (test hole NC-LEN-1-79), to over 1300 feet at Clarks Crossroads, North Carolina, on the east, (N.C. DEM S22j6) (plate 3).

Surface outcrops of Tertiary and Upper Cretaceous sediments and data from shallow core-hole drilling in these sediments (Brown and others, 1977) reveal a wrench type of deformation bounded by a shear zone on the west side of the study area near Kinston, which precisely overlays the geophysical boundary of the suspected basement basin in that area (plate 1). The derivative gravity interpretation of the upper 3 km. of basement reveals a structural lineation (appendix B, plate 2) that can be projected upward through the sedimentary section to match the orientation of the wrench system. The system also matches the surface orientation of the drainage patterns of the Neuse and Trent Rivers as they cross the study area, and the unique fracture pattern revealed in the claystone facies of the Paleocene Midway section (Brown and others, 1977). Lithofacies mapping within the isopach intervals of each chronostratigraphic unit above the basement should also reveal these structural orientations.

Although attempts to establish the presence of suspected Triassic or Jurassic sedimentary rocks in the basin were unsuccessful, the study techniques showed themselves to be very effective as a basis for developing a predictive geologic model for the area. One can see a positive application for more precision gravity and electrical soundings when geologic information from a core-hole or test-drilling program is collected simultaneously to provide the necessary ground truth.

Such a program would yield a comprehensive interpretation of basement structure and lithology by which mineral resource companies could proceed with detailed mineral exploration in the crystalline basement. The inner Coastal Plain from the fall line eastward to a point where the sediment overburden is about 150 feet thick would be an ideal area for such a program to begin in North Carolina.

The geologic models developed from these programs can also be most useful in ongoing hydrologic studies of the Coastal Plain and Piedmont as well as the geologic investigations that must precede the successful siting of hazardous waste disposal areas.

Introduction

One key to all forms of economic growth is mineral resources. Since 1975, the Coastal Plains Regional Planning Commission has joined with the U. S. Geological Survey and various member states in cooperative programs to study the geology of the southeastern Coastal Plains. Airborne magnetic and radiometric surveys and detailed field studies on selected anomalies have been used to help the states develop their mineral resource base.

This report discusses the results of such a detailed study. A magnetic anomaly located in the vicinity of Kinston, Lenoir County, North Carolina, appearing on maps developed by the U.S.G.S. Geophysical Branch (Open file report 75-815, 1975), drew considerable attention because of the nature of the magnetic signatures across a short east-west profile from Kinston, North Carolina, to Clarks Crossroads, North Carolina. Along this profile the magnetic signatures vary from short wave length apparently near surface basement responses to long wave length, low amplitude, deep basement responses over a distance of less than twenty miles. The magnetic boundaries are sharp on this feature and have an orientation of approximately N37°E (plate 1).

Students of the Atlantic Coastal Plains basement structure were nearly unanimous in predicting a fault-block basin of possible Triassic-Jurassic age as a cause of this anomaly. This interpretation is consistent with known structural features of this type along the Atlantic Coastal Plain. The most prominent local feature of this type centers around Sanford, North Carolina, and is known as the Durham-Deep River basin.

Scope of Work

In order to determine the geology responsible for the magnetic anomaly, the State Geological Survey proposed to the Coastal Plains Regional Planning Commission four basic steps for an analysis of the area. The first step was the development of an interpretation of the basement geology using the airborne magnetic data (U.S.G.S. Open file report 75-815). The second step was a detailed gravity survey along an east-west cross section to assist in determination of the crystalline basement configuration (appendix A, plate 4). The third step was the drilling of a series of test holes sited on the basis of the structural configuration interpreted from the geophysical data. The test holes were drilled to determine the type of lithology below the pre-Cretaceous surface and to provide ground truth for the geophysical surveys. In the event Triassic sediments were encountered, the fourth step was to be a common depth point seismic reflection survey along the same line of cross section as the gravity profiles (appendix A), to assist in determining the structural geometry of the sedimentary section above the basement surface.

Previous Work

Brown and others (1977) determined from surface geology and shallow core hole drilling that a horst and graben structural fabric exists in the study area. The structural style is wrench deformation with theoretical structural orientations measured at $N60^{\circ}W$ and $N30^{\circ}E$. The west boundary of the wrench zone is a left lateral shear zone with approximately three miles of displacement located just east of Kinston.

Zietz and Daniels (1978), reporting on the results of the aeromagnetic study (Open file report 75-815, 1975), concluded that in the study area the magnetic signatures imply a basin. The west boundary of this magnetic feature underlies the fault scarp described by Brown and others (1977, plate 1), and has approximately the same structural orientation, $N37^{\circ}E$, versus $N30^{\circ}E$.

Ferenczi (1959) noted the possible structural nature of the course of the Neuse River in the study area, which is also in part coincident with the west margin of the magnetic anomaly and the fault scarp of Brown and others (1977).

Geophysical Investigations

Won and Leith have done significant geophysical work as part of this project and as part of a contract funded by the N. C. Energy Institute. Their work is incorporated as appendices A and B.

The geophysical interpretations they made are as follows:

- a) From the airborne magnetic data:
 1. a downward continued polar anomaly map
 2. a second vertical derivative map
- b) From the Department of Defense gravity data and detailed gravity data gathered during this project:
 1. a derivative gravity map constructed from upward continuation mapping subtracted from the original gravity map
 2. a series of profiles based on precision gravity data processed to show basement topography
- c) Interpretations of four vertical electrical soundings constrained by drill hole data obtained as part of this project.

Geological Investigations

Three test holes were drilled to the pre-Cretaceous basement surface as a part of this project. One additional basement hole was drilled in the project area by Virginia Polytechnical Institute as a part of their geothermal investigation in the Coastal Plain (Costain and others, 1978). The data from these wells were combined with data from a number of additional wells furnished by Mr. P. M. Brown, Senior Research Geologist with the Water Resources Division of the U.S.G.S. Mr. Brown also reviewed the cuttings from the project's test wells to determine from fauna and other evidence the vertical positions of the various chronostratigraphic intervals encountered (plate 3). In addition to cuttings and cores obtained in the drilling process, each hole was logged by various geophysical methods including gamma ray, single point resistivity, six foot lateral resistivity, and spontaneous potential (appendix C). These data not only yield information on the vertical stratigraphic succession, but also considerable information on ground water and the presence of radioactive minerals.

Interpretations

Drilling in the study area revealed no Triassic sediments. In each of the three test holes Paleozoic metasediments were encountered immediately below the upper Lower Cretaceous "F" Unit as described by Brown and others (1972). A detailed analysis of cores from these pre-Cretaceous metasediments revealed a bulk density of 2.71 gm/cc and a residual magnetic susceptibility of 3×10^{-8} cgs units. Petrologically the rock is a phyllite, a low-grade metamorphosed shale comparable to and probably part of the rocks found in the eastern slate belt.

The most likely interpretation of the data indicates that the anomaly is caused by a complexly fractured fault-block syncline in the crystalline basement. The electrical soundings indicate that the magnetically susceptible crystalline basement is buried under varying thicknesses of phyllite ranging in depth from perhaps less than one thousand feet to over seven thousand feet within the synclinal area (plate 4). Present data do not give a unique solution as to when the fault block formed, rather, two distinct cases can be made. The first case is that the syncline developed in part in Paleozoic (phyllite) time, with the phyllite deposited as a shale to a greater thickness in the syncline than in the surrounding area. The second case is that a thick layer of phyllite was deposited across the entire area in Paleozoic time. Faulting then occurred, creating a series of graben-like structures. Subsequent erosion then removed most of the phyllite from the areas east and west of the basin, leaving large thicknesses of material preserved in the basin. Since surface evidence (Brown and others, 1977) shows that faulting has occurred as recently as late Tertiary time, one may assume that the observable structural lineations reflect a stress pattern that has controlled crustal movement in this area throughout its geologic history. If this is true, some combination of cases one and two is possible.

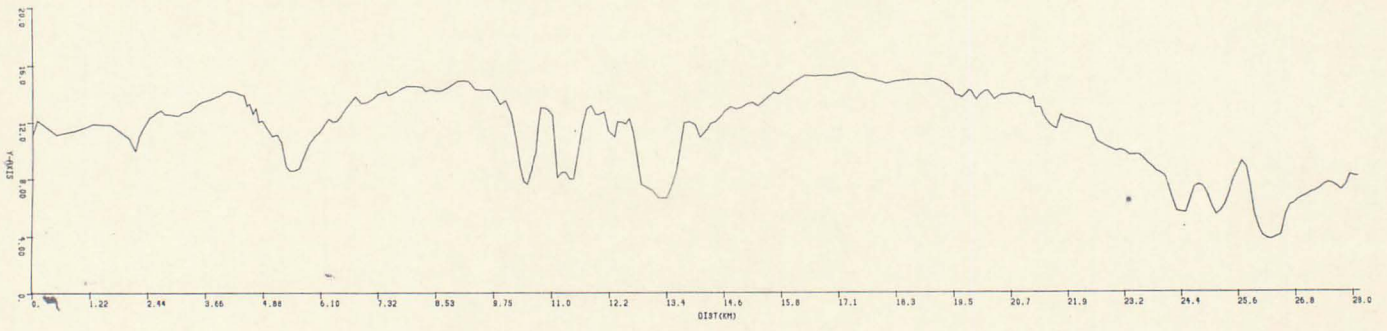
With each period of movement has come some modification of the sedimentation and drainage within the area and, consequently, modification of the important ground water aquifer systems contained in the middle Upper Cretaceous "C" and "D" Units (Brown and others, 1972). The North Carolina LEN-T-1-79 test hole drilled just outside Kinston in this project encountered aquifer sands which would be capable of

over 1000 gallons per minute of fresh water. The structural analysis of the area suggests that a cone of depression created by large water withdrawal from these units would not be symmetrical but would almost certainly be linearly elongated in the NE-SW direction (N37°E). Also, the shapes of the aquifers are probably not blanket sands, nor will they have linear strikes and dips. Because of the intermittent reactivation of the local fracture system the sands are likely to have arcuate patterns interrupted by horsts, grabens, and shears. These observations have important implications for groundwater investigations in the area.

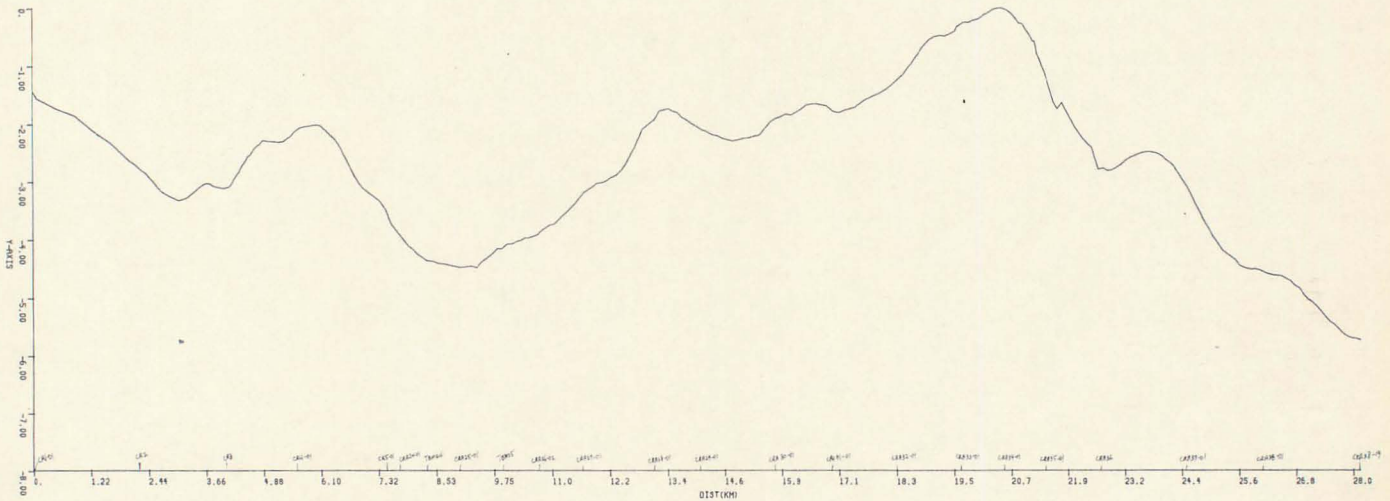
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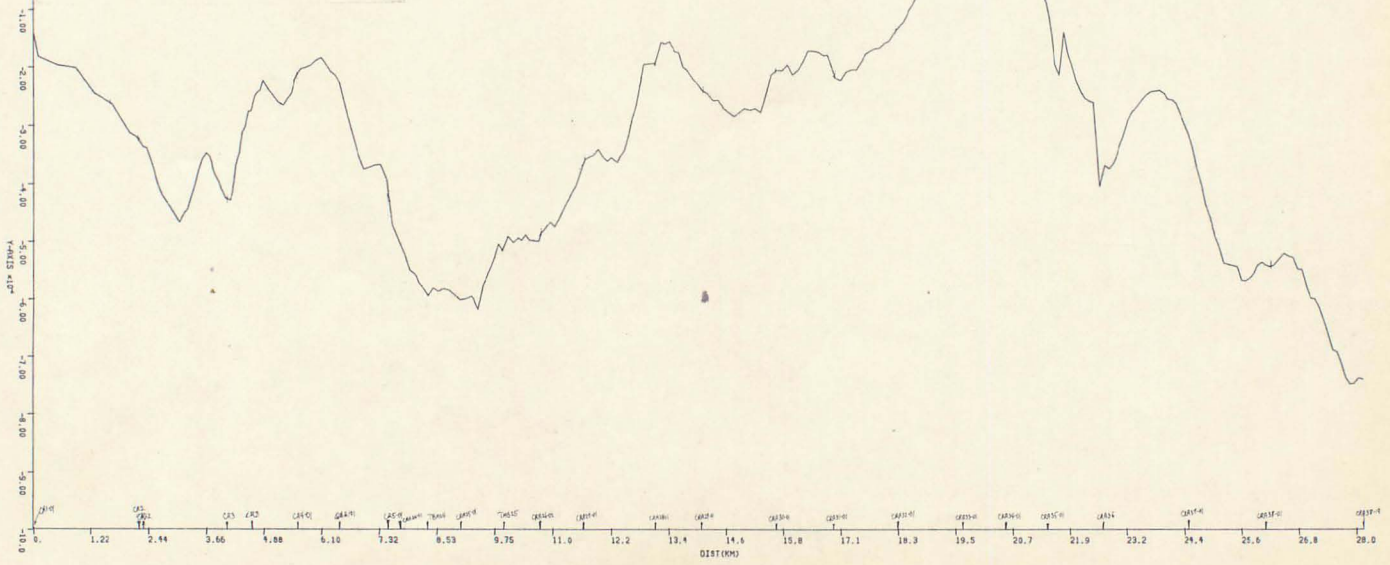
ATTACHMENT 5A
Elevation profile along Hwy. 55

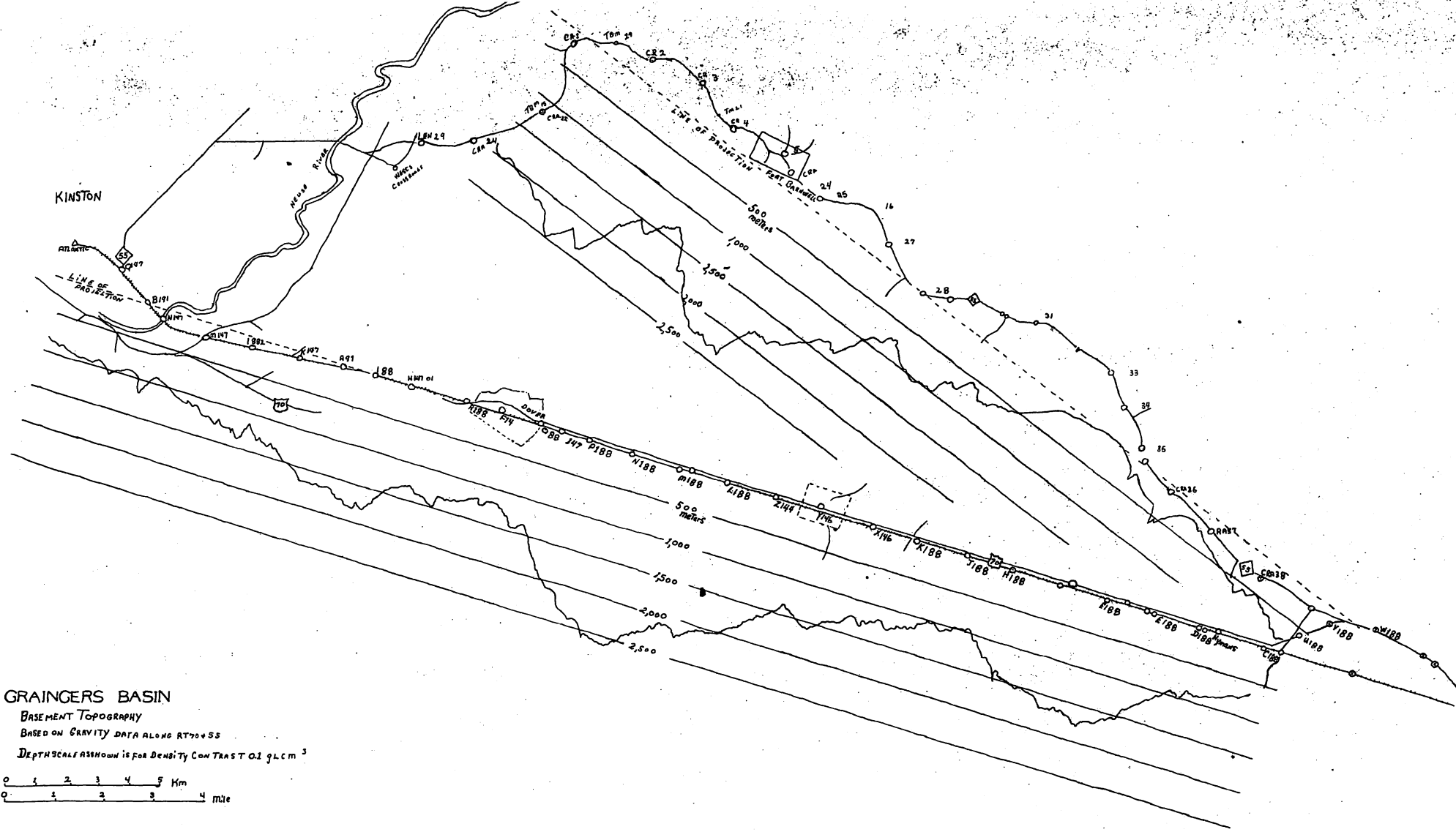


ATTACHMENT 5B
Bouguer gravity along Hwy. 55



ATTACHMENT 5C
Interpreted basin geometry along Hwy. 55



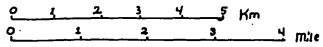


GRAINGERS BASIN

BASEMENT TOPOGRAPHY

BASED ON GRAVITY DATA ALONG RT70+53

DEPTH SCALE SHOWN IS FOR DENSITY CONTRAST 0.1 g/cm^3



APPENDIX A

Geophysical Investigation of a Possible Triassic(?)
Basin in the Kinston-New Bern Area

Report by

I. J. Won and C. J. Leith

Final Report

to

Division of Land Resources
North Carolina Department of Natural Resources
and Community Development
P.O. Box 27687, Raleigh, NC 27611

on

Geophysical Investigation of a Possible Triassic Basin
in the Kinston-New Bern Area

Submitted by

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A. Introduction

We have conducted a preliminary geophysical investigation in order to determine the basement structure between Kinston, Lenoir County and New Bern, Craven County, North Carolina. It has been suspected, from the regional aeromagnetic data, that there may be an extensive Triassic basin buried under the Cretaceous coastal sediments.

The investigation includes interpretations of available regional gravity and aeromagnetic data, and two additionally obtained precision gravity profiles along Rt. 70 and Rt. 55. This report contains the results of the investigation based upon these data.

B. Geophysical Investigations

Geophysical data used for the present investigation consist of 1) aeromagnetic data, 2) regional gravity data, and 3) two newly-obtained detailed gravity profiles along Rt. 70 and Rt. 55 between Kinston and New Bern.

1) Aeromagnetic data: The available aeromagnetic data cover the southwestern portion of the suspected basin. The survey was made at one-mile spacings at an altitude of 150 m (500 ft.). The contoured aeromagnetic maps were digitized at a 600m (2000 ft.) square grid interval in order to process numerically by computer.

The digitized data were then filtered by means of the fast Fourier transform and the Poisson equation in order to produce i) a new magnetic map reduced to polar anomaly at ground datum level (Attachment 1) and ii) a second vertical derivative map (Attachment 2).

The downward continued polar anomaly map is useful for removing many "shadow anomalies" caused by combination of inclination and declination of the earth magnetic field and regional tectonic strike. It also amplifies short wavelength anomalies caused by shallow features. The second vertical derivative map is often useful for defining boundaries of different lithological units.

These reduced maps may be interpreted using the standard vertical magnetic field interpretation formulas.

Attempts were made in order to generate the magnetic basement models by a direct computer modelling technique using the aeromagnetic data. However, because of the uncertainties in both structural geometry and susceptibility data, none of the derived models are yet conclusive. A new modelling attempt is planned using an approximate basement geometry from the gravity profiles which will be discussed later.

2) Regional gravity data: The best available regional gravity data may be those recently published by the Department of Defense (DOD). The gravity stations in the study area used to generate the regional map is rather sparse often exceeding 15 km or more in spacing.

Parts of the Rocky Mount and Beaufort sheets containing the basin area were digitized at a 1.3 km square grid interval. The digitized data were first upward-continued by 3 km. The resultant data lose most of the detail shallow anomalies while retaining long-wavelength variations due to the crustal and upper mantle structures. These upward-continued data were then subtracted from the original map thereby producing a new gravity map containing only those anomalies originating from the first few km depths, presumably including those from the suspected basin. This map is shown on Attachment 3.

The resolution of the regional gravity data is very poor mainly due to the sparseness of the original data distribution. Many distinct spatial details of the basin expressed in the aeromagnetic data can not be observed in this gravity map. However, the gravity data indicate the existence of a possible basin, as denoted by a linear gravity low coinciding with that of the aeromagnetic data. To the east of longitude 77.25°W , where no aeromagnetic data are available, the gravity data show that the basin may be extending into Virginia with its deepest portion centered in Beaufort and Martin Counties.

3) Detailed gravity survey: Two detailed gravity profiles were obtained for further study of the basin geometry. The surveys were made along Rt. 70 and Rt. 55 between Kinston and New Bern using a La Coste-Romberg model G geodetic gravity meter.

The station elevations were determined by N.C. Geodetic Survey by a second-order elevation survey whose accuracy is considered to be better than 1 cm. This accuracy assures that the free-air correction be within about 2 microgal accuracy, comparable to the reading accuracy of the gravity meter. The station interval is about 100-200 m except for the extreme western portion of Rt. 55.

A total of 403 gravity readings were taken along Rt. 70 and 310 readings along Rt. 55. Some 23 readings in the western edge of Rt. 55 were not used for the analysis since the stations are mostly located on the top of bridges and their spacings are inadequate.

Latitude corrections are applied relative to the Atlantic Station. The spatial location accuracy is considered to be within 20 m N-S, so that the latitude correction is within 15 microgal accuracy.

Attachment 4A shows the elevation profile along Rt. 70. Attachment 4B shows the Bouguer gravity profile along Rt. 70 using a Bouguer density 2.0 g/cm^3 which is considered typical for the topmost coastal plain overburden.

It was found, by using a least-squares linear fitting method, that the Bouguer gravity along Rt. 70 decreases at a rate of 0.068 mgals/Km from west to east. On the assumption that this decrease is due to a density variation originating from deep crustal structure (this assumption may be wrong), we removed this linear trend from the Bouguer gravity. The reduced profile was then used to model the basin geometry.

There are two different computer modelling and interpretation schemes developed at N. C. State University, namely; 1) multiple-density direct modelling

routine, and ii) single-density iterative modelling routine.

The first scheme produces a theoretical gravity profile for any geometry having a multiple density structure. This scheme is useful only when enough ground truth data are available in order to model a suspected subsurface structure and compare its theoretical gravity with the observed data. However, the scheme can not regenerate by itself an improved model to better fit the observed data. This is because of the very nature of the gravity field: when both density and geometry are allowed to vary, there will be infinite number of solutions to satisfy the observed data.

The second scheme is used for modelling the geometry only for a given single density, or vice versa. In this case, there is a unique solution for a given observed gravity profile and the scheme automatically iterates to improve the initial model to any desired accuracy.

Since there are no definitive ground truth data available in the area, we processed our gravity data by the second scheme. Attachment 4C shows the interpreted basin geometry based on a density contrast of -0.2g/cm^3 . The difference between the observed gravity and the calculated gravity, based on this geometry is at most 0.1 mgals. This implies that, for this idealized model, the basement depth is accurate within 15 m.

In order to have a realistic density contrast for a typical Triassic basin, we initially applied this scheme to similar data from the Durham basin area. It was found that a density contrast of -0.113 g/cm^3 between the Triassic and Piedmont rocks satisfies best the observed gravity and the drill hole data in that area. If this density is considered correct for the present study area, the depth scale should be multiplied by a factor of $0.2/0.113 (=1.77)$.

Attachment 5A, 5B, and 5C show the corresponding results for the Rt. 55 profile. The same linear trend of a 0.068 mgals/Km decrease to the east has been removed for the computer interpretation.

These two gravity profiles were subsequently tied at the eastern end of each profile (C188 along Rt. 70 and CRA 39 along Rt. 55). This causes a relative displacement of the datum level of one profile with respect to the other. The final combined basin profiles are shown in Attachment 6. The depth scale as shown is now based on an arbitrary density contrast of -0.1 g/cm^3 . Again, if we prefer a density contrast of -0.113 g/cm^3 , the scale should be multiplied by a factor of $0.1/0.113 (=0.88)$.

A few cautions in using these profiles are in order: i) If the thickness of the Cretaceous overburden above the suspected Triassic is uniform, the basin topography will remain the same regardless of the thickness of the overburden albeit a constant shift of datum level. However, if the Cretaceous undulates significantly, considerable error can occur in calculating the basement depth. For instance, a 100 m undulation in the thickness of the Cretaceous having a density contrast of -0.2 g/cm^3 will cause about 200 m error in the depth estimation for the Triassic having a density contrast of -0.1 g/cm^3 . Once the thickness of the Cretaceous is known everywhere, the data may be reinterpreted by the direct modelling scheme. ii) The datum level for the basin geometry is arbitrary. As shown in Attachment 6, we have arbitrarily assumed that the basement outcrops near CRA-34 along Rt. 55. The actual depth to the basement at this point, once determined, must be added everywhere. iii) The removal of the linear trend of 0.068 mgals/Km is also arbitrary. If this represents the actual added thickness of the basin, the depth to the basement should decrease at a rate of 16 m/Km toward the west, starting from C-188 on Rt. 70 and CRA-39 on Rt. 55. iv) For any other density contrast, the depth scale may be multiplied by a factor of $0.1/(\text{density contrast})$. v) The density variation within the basement is not considered in the interpretation. If we allow a variation of 0.05 g/cm^3 , the depth scale can change by a factor of two.

C. Tentative Conclusions and Recommendations.

Based on our geophysical investigation described in the previous section, we tentatively conclude that:

i) The two basement topographies agree in sufficient detail to believe that the structure is a major continuous tectonic feature. The general strike of the basement topography is approximately $N40^{\circ}E$. This is in a good agreement with an observable fault near N147 on Rt. 70 which is believed to control the flow of Neuse River.

ii) The basement topography shows possibly numerous block faults on the either side of the basin which appears to be centered midway between Cove City and Dover along Rt. 70. This interpretation agrees with the polar magnetic data and its second vertical derivatives as shown on Attachment 1 and 2. The fault direction of each block is not as yet definitive although one can visualize many intuitive tectonic movements from the interpreted basement topography.

In order to further clarify the structural features of the area, we recommend that future efforts be directed to:

- i) selective core-hole drilling,
- ii) deep resistivity soundings at drill-hole sites and elsewhere in order to determine and correlate the vertical lithological variations, and
- iii) a large scale precision gravity survey covering the entire suspected basin area at a station interval not greater than 1 km.

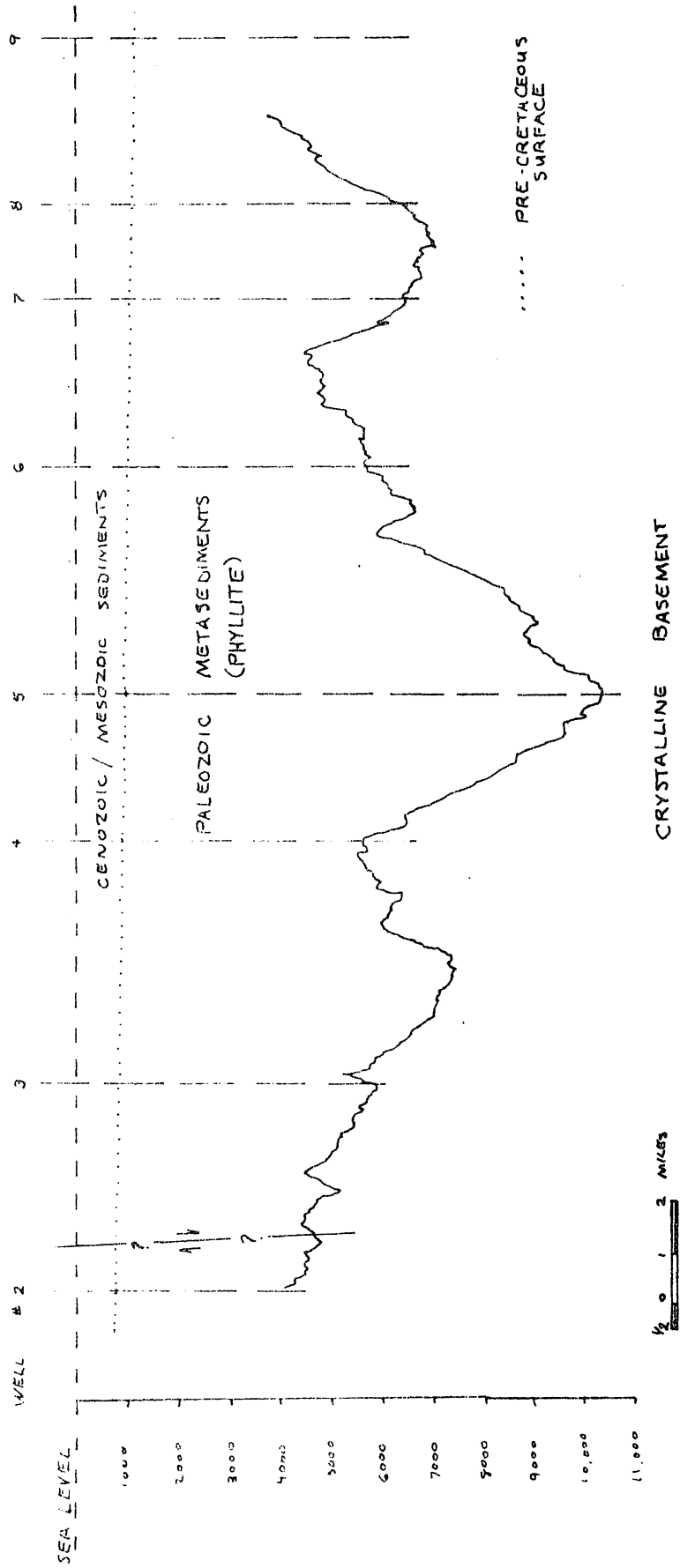


PLATE 4. CROSS-SECTION FROM KINSTON TO CLARKS CROSSROADS SHOWING THE RELATIONSHIP BETWEEN THE CENOZOIC/MESOZOIC SEDIMENTS, PALEOZOIC META SEDIMENTS AND THE CRYSTALLINE BASEMENT.

APPENDIX B

Geophysical Exploration of Coal and Gas Resources
Associated with a Buried Triassic Basin in the
North Carolina Coastal Plains

Report by

I. J. Won and C. J. Leith

GEOPHYSICAL EXPLORATION OF COAL AND GAS RESOURCES ASSOCIATED
WITH A BURIED TRIASSIC BASIN IN THE N.C. COASTAL PLAINS

FINAL REPORT

Submitted by

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October 1, 1979

This research project was funded by the
North Carolina Energy Institute
Contract Number 8

Summary

We have conducted a comprehensive field geophysical study in an area including Lenoir, Jones, and Craven counties in the coastal plains of North Carolina in order to determine the subsurface geological features and favorability of any hydrocarbon occurrence thereof. The study employed an integrated approach using gravity, aeromagnetic, and electrical sounding methods combined with three shallow test holes drilled by the State of North Carolina during the study.

The results obtained from the study thus far are negative: the Graingers Basin originally suggested from the aeromagnetic data is now believed to be of Paleozoic(?) age rather than the initially assumed Triassic age. The basement structure, originally inferred from gravity data, is re-interpreted to match the top of phyllite in the light of drill hole data. Although our electrical sounding data in the area suggest that the crystalline basement is much deeper than the phyllite basement, the intervening formations are most likely of metamorphosed Paleozoic(?) sediments similar to the slate-belt type rocks, having little chance of containing any hydrocarbon materials.

The study has revealed yet another possibly more promising basin structure between New Bern and Havelock. The data thus far show that the basin, if any, may be much deeper than the Graingers basin. The detailed structure of this basin is yet to be investigated.

Introduction

The aeromagnetic data recently compiled by U. S. Geological Survey suggested the possible existence of a buried basin-like geological structure beneath the North Carolina coastal plain. The basin, tentatively called the Graingers Basin, trends approximately N45°E and has a varying width between 20 Km and 40 Km and its length may be as much as 200 Km.

The Graingers Basin produces one of the most noticeable aeromagnetic anomalies in the coastal plain (Figure 1). The low gradient and long-wavelength basin anomaly, with an average amplitude of about -200 gammas, is sharply bounded by areas with numerous shallow anomalies typically generated by the Piedmont-type rocks. Daniel and Zietz (1978) concluded that the anomaly almost certainly represents a buried Triassic-Jurassic basin. Their conclusion was partially supported by several faults exposed at the surface near Kinston (Ferenezi, 1959; Brown et al, 1976, 1977). It was believed that the strong anomaly might be caused by the contact between the non-magnetic sedimentary rocks and the moderately magnetic Piedmont rocks. While similar landward basins (e.g., Durham-Wadesboro Basin and Dan River Basin) are only partially recognizable from the aeromagnetic data, the Graingers Basin manifests the strongest anomaly in the region. This initially led us to believe that the Basin must have a sufficient thickness of sediments to completely suppress the magnetic basement.

Geophysical Investigation

Since April 1978, we have been engaged in an integrated geophysical investigation of the Basin in cooperation with the North Carolina Division of Land Resources and the North Carolina Energy Institute. The study has employed interpretations of the aeromagnetic data and regional gravity data as well as additional acquisition of detailed gravity and deep electrical sounding measurements.

Geophysical data used for the present investigation consist of (1) aeromagnetic data, (2) regional gravity data, (3) five newly obtained gravity profiles totaling about 220 km in length with data at approximately 150 m intervals, and (4) four deep Schlumberger electrical sounding data.

(1) Aeromagnetic data: The available aeromagnetic data cover the southwestern portion of the suspected basin (Figure 1). The survey was made at one-mile spacings at an altitude of 150m (500 ft.). The total field basin anomaly of about 500 gammas is extremely flat and of long wavelength flanked by many short wavelength anomalies typical of the Piedmont-type rocks.

The contoured aeromagnetic maps were digitized at a 600m (2000 ft.) square grid interval in order to process them numerically by computer. The digitized data were then filtered by means of the fast Fourier transform and the Poisson equation in order to produce i) a new magnetic map reduced to polar anomaly at ground datum level and ii) a second vertical derivative map.

The downward continued polar anomaly map is useful for removing many "shadow anomalies" caused by the combination of inclination and declination of the earth's magnetic field and regional tectonic strike. It also amplifies short wavelength anomalies caused by shallow features. The second vertical derivative map is often useful for defining boundaries of different lithologic units. These reduced maps have been interpreted using the standard vertical magnetic field interpretation formulas.

(2) Regional gravity data: The best available regional gravity data are those recently published by the Department of Defense (DOD). Parts of the Rocky Mount and Beaufort sheets containing the basin area were digitized at a 1.3 km square grid interval. The digitized data were first upward-continued by 3 km. The resultant data lose most of the detailed shallow anomalies while retaining long-wavelength variations due to crustal and upper-mantle structures. These upward-continued data were then subtracted from the original map, thereby producing a new gravity map containing only those anomalies originating from a depth of the first few km, presumably including those from the suspected basin. This map is shown on Figure 2.

The resolution of the regional gravity data is very poor, due mainly to the sparseness of the original data, which often exceeds 10 km in spacing. Many distinct spatial details of the basin expressed in the aeromagnetic data can not be observed in this gravity map. However, the gravity data indicate the existence of a possible basin, as denoted by a linear gravity low coinciding with that of the aeromagnetic data. The gravity data show that the basin may be extending into Virginia with its deepest part centered in Beaufort and Martin Counties.

The filtered data were inverted to produce the tentative basement topography (Figure 3), assuming a density contrast of 0.4 g/cm^3 between the sediments and Piedmont-type basement. The inversion assumes that the thickness of the post-Cretaceous sediments overlying the basin is either constant or varies linearly, which may be only partially true.

The result has generally confirmed the existence of the basin type structure originally suggested from the aeromagnetic data and later from the two precision gravity profiles. In addition, the result indicates that there may be yet another basin, just east of New Bern, tentatively called the "New Bern Basin". It appears that both the Graingers and the New Bern basins extend to the north-east

as far as Virginia. The existence of the New Bern basin has been subsequently supported by our detailed gravity survey.

(3) Detailed gravity survey: Five detailed gravity profiles were obtained for further study of the basin geometry. The surveys were made along old Rt. 70, new Rt. 70, Rt. 55, Rt. 58, and SR1002 covering Lenoir, Jones, and Craven counties using a La Coste-Romberg model G geodetic gravity meter. The station elevations were determined mostly by a level elevation survey. The station interval was about 100-200 m in most cases. A total of about 2,000 gravity readings was taken along the highways. The spatial location accuracy is considered to be within 200 m N-S, so that the latitude correction is within 15 microgal accuracy. The Bouguer gravity data thus obtained were interpreted by an automatic computer inversion scheme developed by Cordell (1970).

Figure 4 shows that resultant basement topography along two survey lines assuming a single density contrast of -0.4 g/cm^3 between the basin sediments and the Piedmont basin. The solution obtained from the inversion method was constrained to fit the observed basement depth at near Dover. All gravity profiles have been tied to a base station to the west of New Bern. For comparison, Figure 5 shows the aeromagnetic profiles corresponding to the gravity lines. The method of inversion assumes that there is only one density contrast, i.e., one laterally homogeneous sedimentary sequence resting on homogeneous basement. If there is any unknown lateral inhomogeneity particularly within the Piedmont basement, the error in basement topography can be significant. Once we have drill data in the Piedmont basement, the interpretation can be further refined by the direct modelling method.

(4) Vertical Electrical Soundings: We obtained data for four deep Schlumberger electrical soundings, in the vicinity of Dover along the old and new Route 70.

The data were processed by a computer inversion program developed by Zohdy (1973)

to obtain the vertical variation of the earth resistivity. The current electrodes were spaced far enough apart (up to about 7 Km) to sense the basement. The resultant resistivity sections are shown in Figure 6. The four sounding results, while obviously not sufficient for any elaborate correlation, show at least some major layering of the basin sequence.

Geologic Interpretation

In previous reports to the North Carolina Energy Institute tentative stratigraphic interpretations were made of the Graingers Basin based on magnetic, gravity, and electrical geophysical data. Confirmation of these interpretations was to be obtained from samples and logs from core holes to be drilled by the North Carolina Geological Survey Section. Data from the three holes that were drilled were made available in late September; significant modifications of the previous interpretations are now required.

On the basis of the U.S.G.S. resistivity sounding Site 1 at Dover, and the correlation of this sounding with stratigraphic data from the 130 m (400-foot) City of New Bern well at Dover, as reported by Brown et al in U.S.G.S. Professional Paper 796, it was anticipated that possible Jurassic and Triassic sedimentary rocks would be present at Dover below a depth of approximately 500 m (1500 feet). "Basement" was predicted at approximately 1675 m (5500 feet). The new core hole at Dover (State of North Carolina - Graham Merritt NC-CR-T1-79), penetrated the entire sedimentary section and entered phyllite basement rock at 300 m (980 feet), before reaching total depth of 360 m (1090 feet). The thickness of the phyllite sequence varies from hole to hole, and may be as great as 1200-1500 m (4000-5000 feet). It is underlain by highly resistive material, presumably crystalline basement rock and identified as such in previous reports.

From core evidence it now appears that the hoped for rocks of Jurassic and Triassic ages are not present in the parts of the Graingers Basin included

within this study. The stratigraphic intervals previously interpreted as possibly being made up of Jurassic and Triassic rocks are in fact made up of "slate belt" type basement rocks, variable in physical character but having properties that in some respects are similar to those characteristic of the overlying sedimentary rocks.

Faunal identifications made by the U.S. Geological Survey (P.M. Brown, personal communication) on samples from the new Dover core hole place the top of the Upper Cretaceous Navarroan age Pee Dee formation at 18 m (60 feet) and its base at 60 m (200 feet). It is underlain by $50 \pm$ m ($170 \pm$ feet) of the Upper Cretaceous Tayloran age Snow Hill Marl member of the Black Creek formation, which, at 120 m (370 feet), rests on the Upper Cretaceous Austinian age lower member of the Black Creek formation. The contact between the lower Black Creek formation and the underlying "Tuscaloosa" formation (Late Cretaceous Eaglefordian age) occurs at 260 m (790 feet) and the Eaglefordian-Washitan (Lower Cretaceous) contact is at 320 m (970 feet). Basement debris occurs within the Lower Cretaceous unit, which rests on dark gray phyllite at 330 m (980 feet).

The stratigraphic boundaries identified on the basis of the faunal content of the drill cuttings correspond closely to recognizable "breaks" recorded on the various geophysical logs obtained from the core hole. They also correlate well with the corresponding boundaries previously reported in the City of New Bern - Dover well.

On the basis of the U.S.G.S. resistivity sounding made three miles east of Dover (Site 2) it was anticipated that the contact between Cretaceous and underlying rocks, presumably Jurassic, would occur at approximately 170 m (510 feet), and that "basement" would be at a depth of approximately 2300 m (7000 feet). Logs and samples from the state's core hole at that location (State of North Carolina - Peter Havfich, NC-CR-T2-79) indicate phyllite basement at 352 m (1154 feet).

A third core hole was drilled by the State of North Carolina, located several miles north and northwest of the Merrit and Havfich wells. According to J.L. Sampair of the North Carolina Geological Survey it, like the other two, penetrated phyllite basement rock. The stratigraphy of the section above basement has not been worked out.

All of the resistivity soundings in the Graingers Basin, including three made for this project and two made previously by the U.S.G.S., indicate the presence, below the depths at which phyllite was recovered in the state's core holes, of a sequence in which resistivities vary sharply from unit to unit. The thickness of this sequence varies from sounding to sounding, apparently indicating differences in depth to ultimate ("crystalline?") basement.

Apparently the phyllites and associated rocks are similar in magnetic and electrical properties to the overlying Cretaceous and younger sedimentary rocks. Their contributions to the magnetic and electrical expressions of the Graingers Basin thus would reinforce those of the overlying sedimentary rocks. The resultant magnetic and electrical patterns then would reflect depths to and geometry of the crystalline (?) basement on which the slate belt rocks rest. According to this hypothesis the Graingers Basin would be an intra-basement feature blanketed by a relatively thin cover of sedimentary rocks.

The northwest boundary of the Graingers Basin is evidenced at the surface by a zone of sheared and displaced sedimentary rocks. The shear zone trends northeast-southwest and can be traced on airphotos and satellite imagery at least to the North Carolina-Virginia line. The southeast boundary of the basin is less distinct but trends in the same direction.

Within the basin the depth to crystalline basement increases to the northeast. If the depth to the top of the phyllite also increases to the northeast it is possible that post-phyllite, pre-Cretaceous sediments could be present to the northeast of the area included in this study. Investigation of this possi-

bility would require the acquisition of additional detailed gravity and resistivity data and the careful interpretation of subsurface stratigraphic information from well records.

CONCLUSIONS

The Graingers Basin is a small unit of the major tectonic pattern that characterizes the coastal and offshore area of eastern North America. It is hoped that the present investigation will provide some clues that may be useful in furthering our understanding of the coastal area. The probability of hydrocarbons being present in the southwestern part of the Graingers Basin is extremely low, but the information gained from the study of this basin may facilitate the evaluation of the potential of other parts of the coastal area.

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Figure 1. Aeromagnetic map in the North Carolina coastal plain.

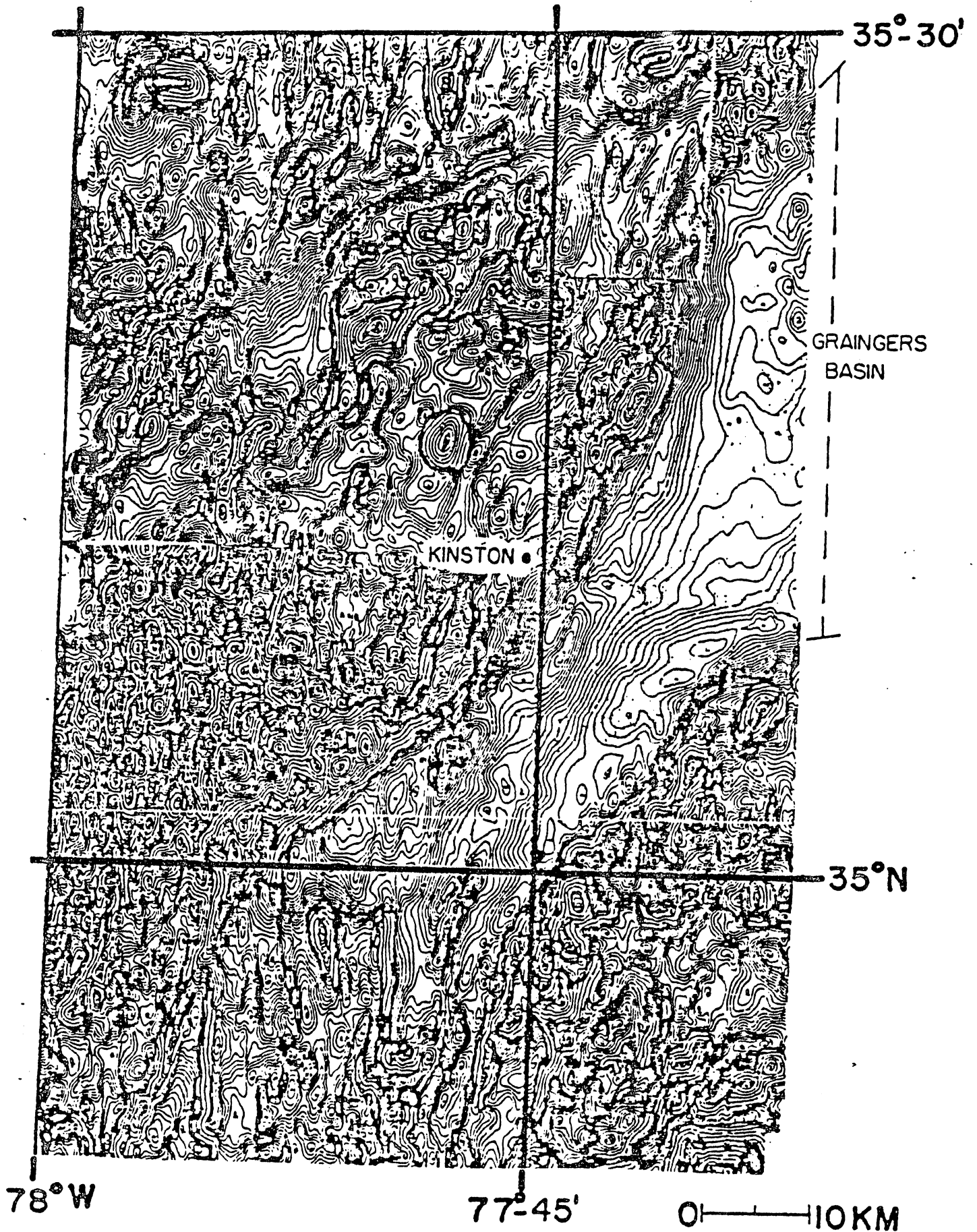
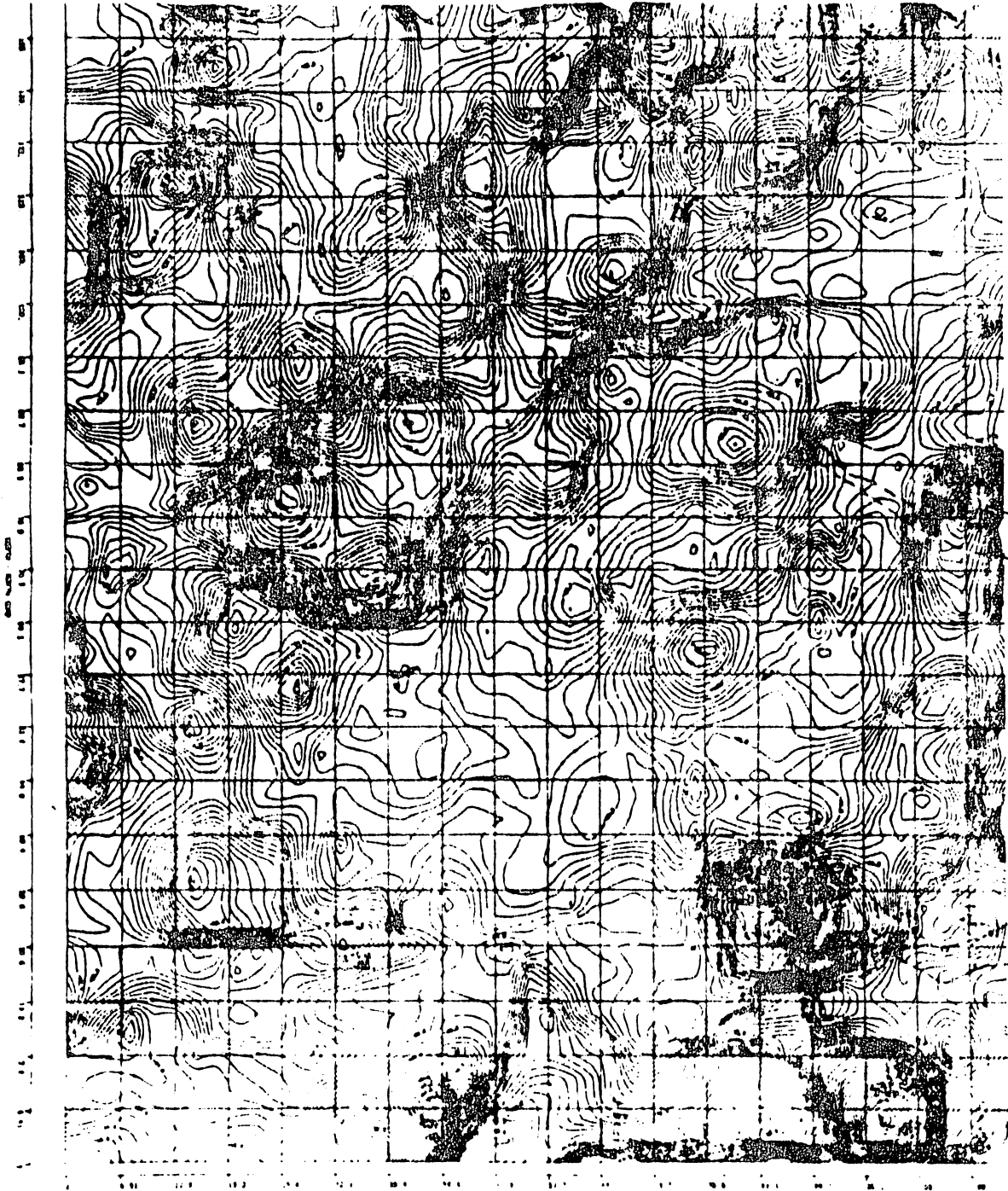


Figure 2. Regional DOD gravity data in the North Carolina coastal plain filtered by the 3 Km up-ward continued gravity data

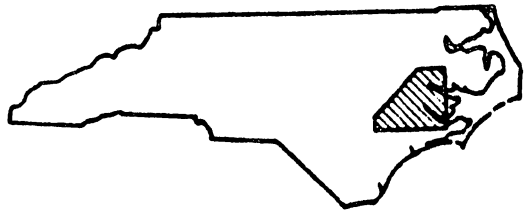
KINSTON GRAVITY - FILTERED BY 3KM UPLIFT GRAVITY



EASTERN NORTH CAROLINA BASEMENT TOPOGRAPHY SECTIONS

DERIVED FROM REGIONAL GRAVITY DATA

DENSITY CONTRAST = -0.4 gm/cc



0 30 km

1/2 km

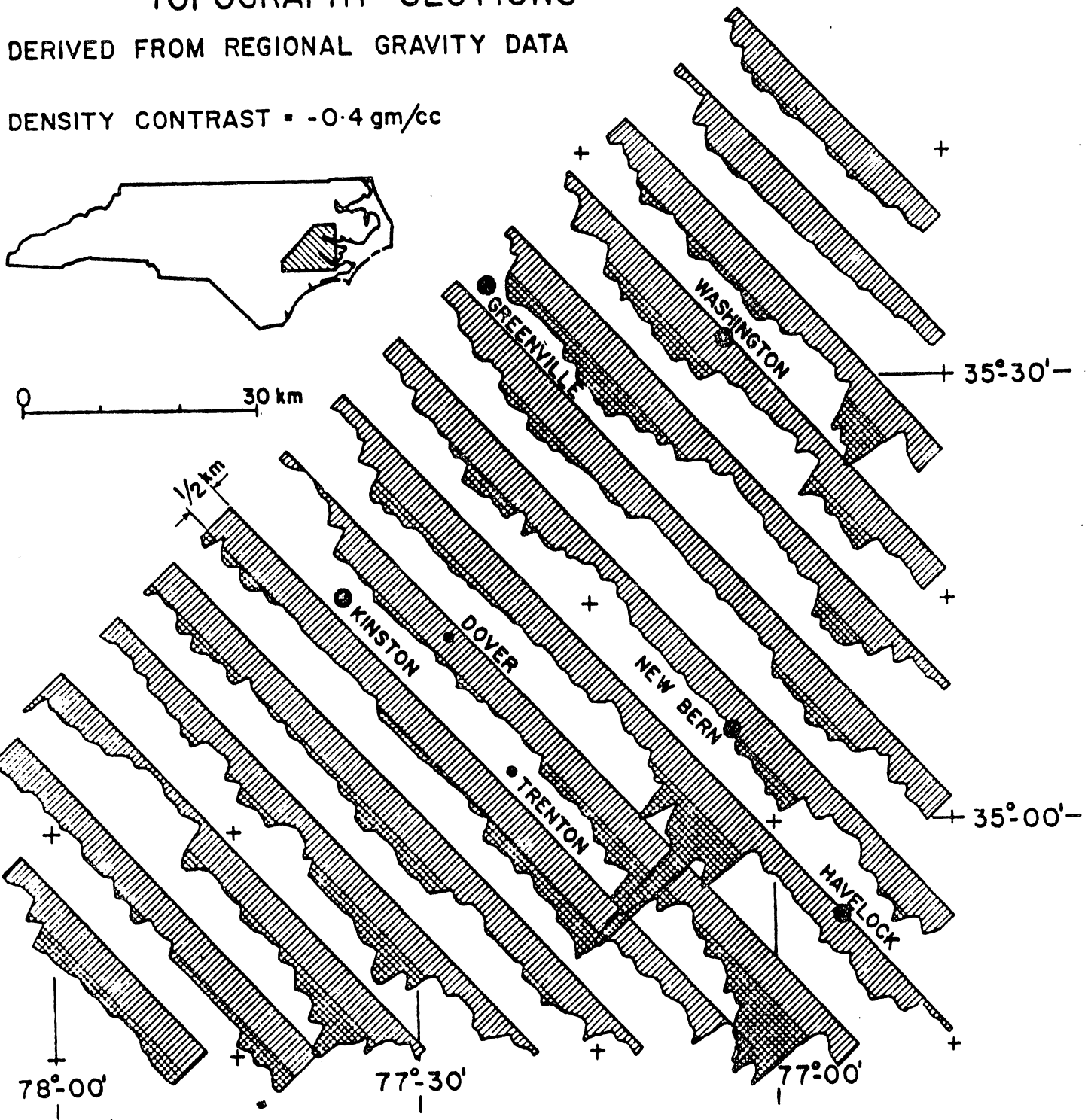


Figure 3. Basement topography sections derived from regional gravity data assuming a single density contrast of -0.4 g/cm^3 between the sediments and the Piedmont basement.

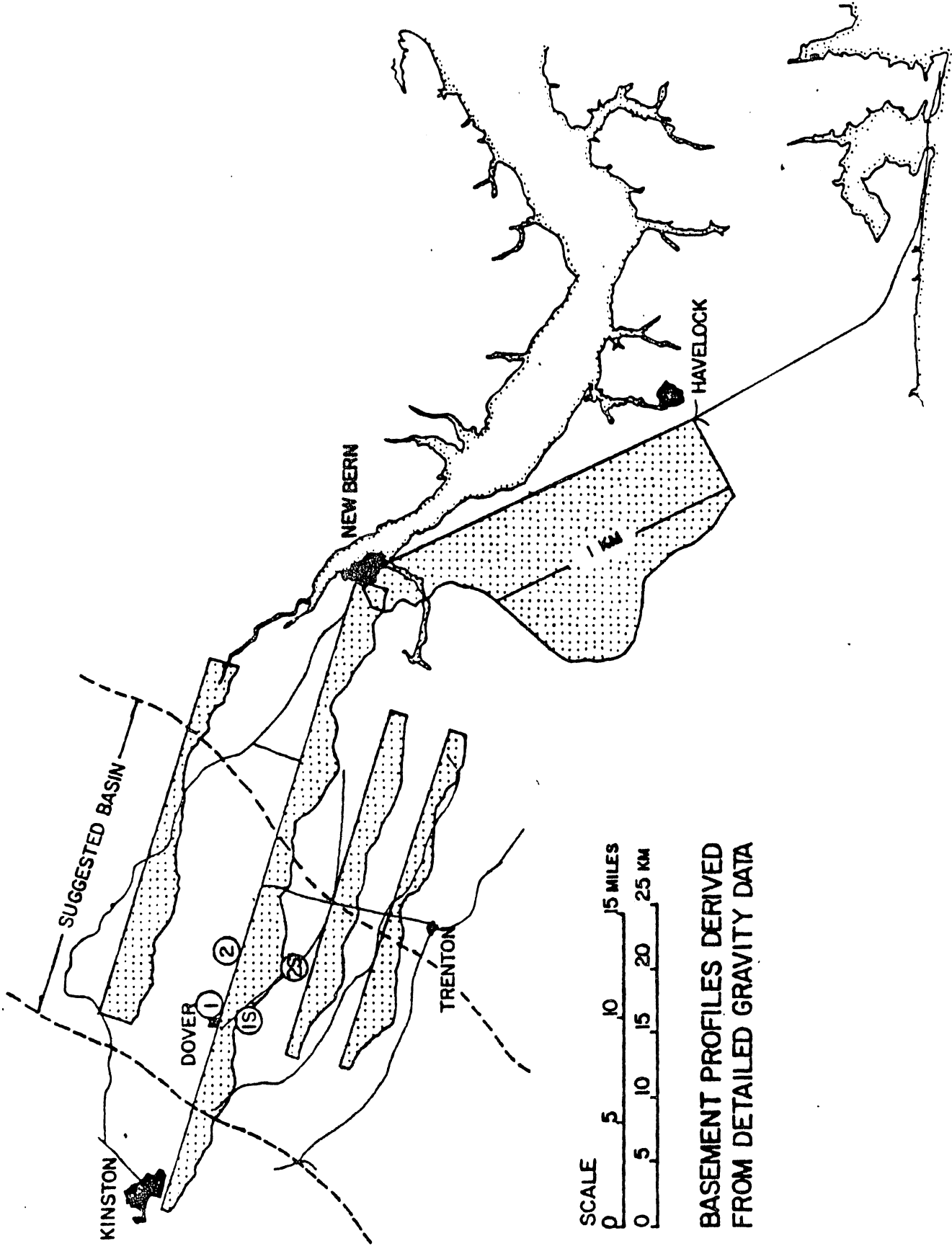
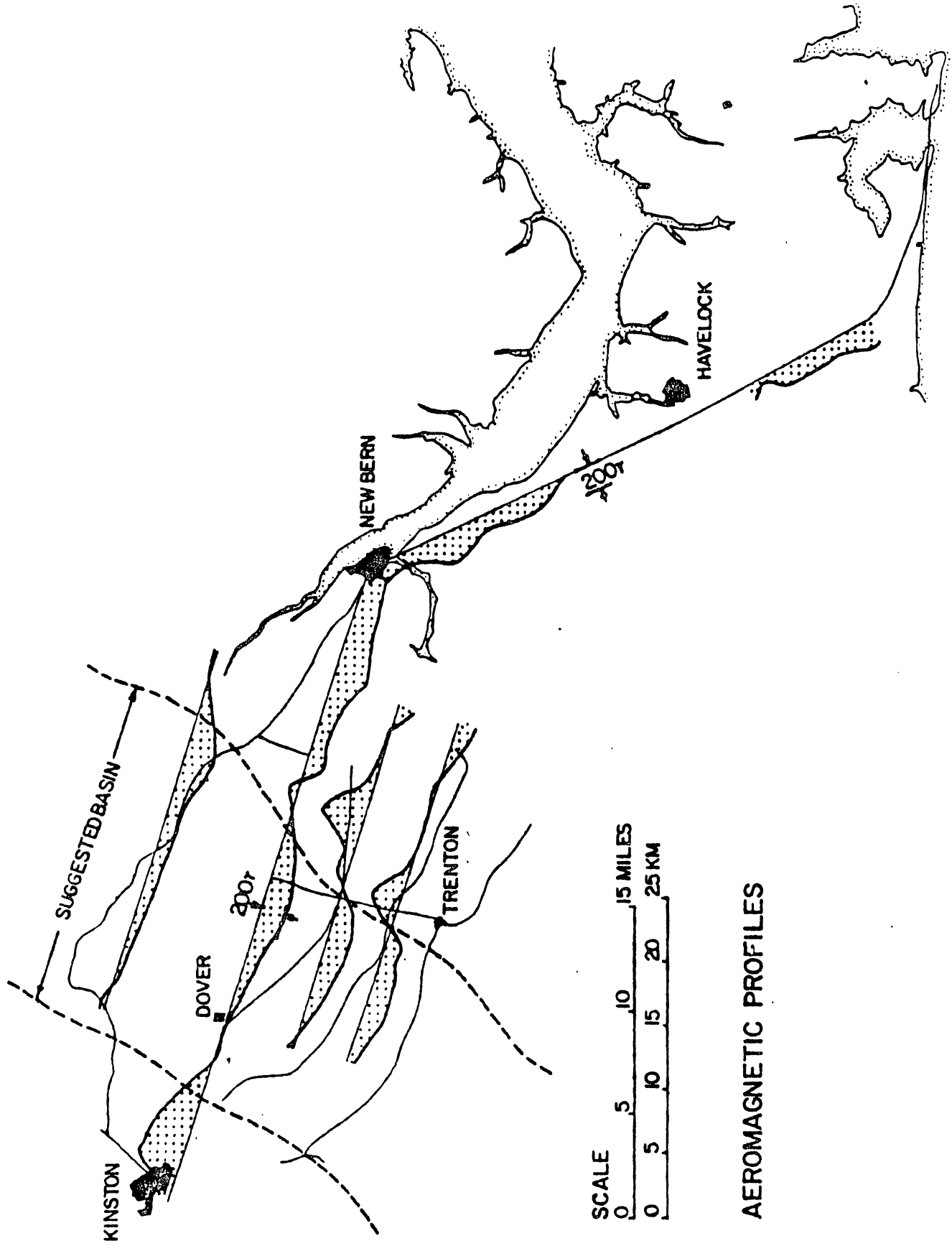


Figure 4. Basement profiles derived from five new detailed gravity lines assuming a single density contrast of -0.4 g/cm^3 between the sediments and the Piedmont basement.



AEROMAGNETIC PROFILES

Figure 5. Aeromagnetic profiles corresponding to the gravity lines shown in Figure 4.

VERTICAL ELECTRICAL SOUNDING DATA

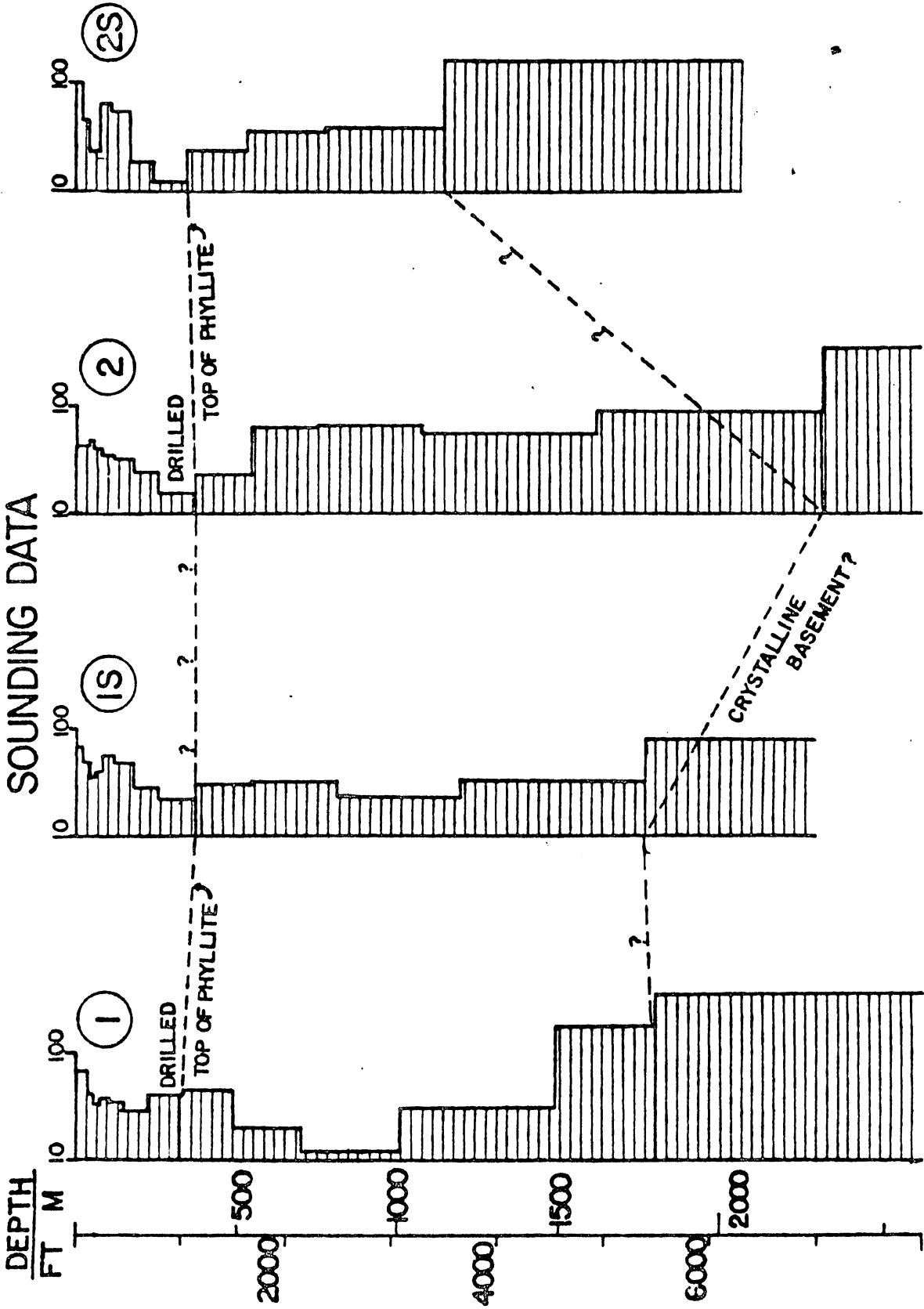


Figure 6. Results of four Schlumberger electrical sounding data after reduction to resistivity profiles as a function of depth. The horizon of phyllite encountered at sites 1 and 2 by drill holes is shown by a dashed line. Also shown are the probable crystalline basement depth.

APPENDIX C

Well logs and cuttings

Appendix C

Well Logs

(Logs were run in uncased holes except where noted)

NAME	TYPE OF LOG	SCALE	DEPTH
NC-CR-T-1-79	1) Gamma Ray Spontaneous Potential Single Point Resistivity	1"=20'	1100'
	2) 6' Lateral	1"=20'	
	3) 16-64 Normal	1"=20'	
	4) Gamma Ray (logged through tubing after cement job)	1"=20'	
NC-CR-T-2-79	1) Spontaneous Potential	1"=20'	1200'
	2) Gamma Ray	1"=20'	
	3) 6' Lateral	1"=20'	
NC-LEN-T-1-79	1) 6' Lateral Spontaneous Potential Gamma Ray	1"=20'	755'

Copies of logs can be obtained from the N. C. Geological Survey for the cost of reproduction.

Well Cuttings

Samples were collected at 10' intervals during drilling. They may be inspected by appointment at the N. C. Geological Survey's office at 4100 Reedy Creek Road, Raleigh, North Carolina (919 733-7353).