Derivative Classifier _____

WSRC-TR--90-468

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PEN BRANCH FAULT PROGRAM: SHALLOW DRILLING ACTIVITY (U)

V. Price, A. L. Stieve, R. Aadland

September 28, 1990

Authentication: _____

Approved by: _____
D. B. Moore, Manager
Environmental Sciences Section
Savannah River Laboratory

DISCLAIMER

WESTINGHOUSE SAVANNAH RIVER COMPANY
SAVANNAH RIVER SITE
Aiken, South Carolina 29808

Prepared for the U. S. Department of Energy under Contract No. DE-AC09-89SR18035

9/28/90
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PEN BRANCH FAULT PROGRAM: SHALLOW DRILLING ACTIVITY

Introduction

Evidence from subsurface mapping and seismic reflection surveys at SRS (Chapman and DiStefano, 1989) suggests the presence of a fault which displaces Cretaceous through Tertiary (90-35 million years ago) sediments. This feature has been described and named the Pen Branch fault (PBF) in a recent SRL paper (DP-MS-88-219).

Because the fault is located near operating nuclear facilities, public perception and federal regulations require a thorough investigation of the fault to determine whether any seismic hazard exists. A phased program with various elements has been established to investigate the PBF to address the Nuclear Regulatory Commission regulatory guidelines represented in 10 CFR 100 Appendix A. The objective of the PBF program is to fully characterize the nature of the PBF (ESS-SRL-89-395).

This report briefly presents current understanding of the Pen Branch fault based on shallow drilling activities completed the fall of 1989 (PBF well series) and subsequent core analyses (SRL-ESS-90-145). The results are preliminary and ongoing, however, investigations indicate that the fault is not capable. In conjunction with the shallow drilling, other activities planned or in progress include: 1) a high-resolution shallow seismic reflection survey, 2) surface trenching across the fault and 3) a paleo-liquefaction study. The Basement Characterization Program (SRL-ESS-89-820), the South Carolina Geologic Survey mapping project and South Carolina Water Resources Commission seismic reflection surveying to the east of the SRS are supplemental to the PBF program and support the efforts and objective of this program.

Geologic Background

The Pen Branch fault trends northeast across the site and is located within about 0.25 mile of K Area and 1 mile northwest of L and P Areas. The Pen Branch fault closely parallels the northern boundary fault of the Triassic Dunbarton basin and is interpreted as being a Cretaceous/Tertiary reactivation of that fault. In other words, renewed faulting during Cretaceous through Tertiary time resulted in the formation of the Pen Branch fault in the Coastal Plain sediments covering the basement rock.

The fault dip is close to vertical and in the crystalline basement slip direction was originally down to the southeast. Movement during Cretaceous through Tertiary appears to be reverse movement, that is, up to the southeast. There could also be a component of strike-slip movement. The fault appears to be a growth fault in that the formations on the down-thrown side are thicker than the up-thrown side.

Shallow Drilling Activity

The PBF series of drill holes were completed in pairs to bracket and constrain the location of the fault trace (Figure 1, Table 1). This approach allows comparison of the change in elevation of key stratigraphic marker horizons across the fault. In unconsolidated sediments such as the Coastal Plain section, a fault is not observable in a single core as a discrete surface. Data obtained from these holes were used construct a geologic cross-section and structure contour and isopach maps. The structure contour maps incorporate data from previously drilled holes as well as the PBF well series (Figures 4-6). These data suggest that the fault offsets the Dry Branch Formation. This is the youngest or shallowest strata that is broken by the fault. The formation is considered to be lower upper Eocene or about 40 to 36 million years old, suggesting that movement on the PBF ceased after 36 million years but prior to the next sedimentary stratum.

Cross-section. The PBF-4-5 cross-section utilizes data from three geophysical logs in conjunction with detailed lithology of cores from the same boreholes (Figure 2, foldout). Natural gamma, resistivity, and neutron density logs were used to correlate regional stratigraphic horizons with the strata found in the drill holes. These correlations were based on comparing PBF-4 and -5 to the regional and detailed site geologic cross-sections prepared by R. Aadland (WSRC-RP-90-987). The results of geophysical studies from PBF wells correlated very closely with P-23 and P-25, nearby drill holes completed for the Baseline Hydrogeologic Investigation (Bledsoe, 1988).

The Pen Branch fault is a growth fault. This is suggested by the greater offset in the deeper formations than in the shallower formations. Specifically, 72 feet of offset is found at the Tertiary/Cretaceous boundary (low in the section) and 36 ft of offset is found at the top of the green clay; 25 ft of offset is found at the bottom of the tan clay. Sand and clay layers above the tan clay in the Barnwell Formation, seem to correlate directly across the fault with no offset. The geologic implication is that the Barnwell Formation layers were not disturbed by movement on the fault or that the fault had ceased all activity. However, this statement must be considered with caution: 1) geophysical logs in the unsaturated zone are not necessarily consistent or reliable, 2) lithologies in the weathering zone may be significantly altered by soil forming processes, 3) the non-marine strata at the top of the section are discontinuous and correlation are difficult. The tip of the fault apparently dies out greater than 50 feet below the surface (Based on this cross-section). However, the depth to the fault does not constrain an age on the fault. One significant geologic issue that needs to be resolved is the cross-cutting relationship between the fault and the Tobacco Road/Upland interval. This needs to be determined in order to determine the age of the fault using a stratigraphic approach.

On the south side of the fault, in PBF-5, the Santee Formation at an elevation of 140 ft above mean sea level (depth below surface; 100 ft) is a calcareous zone approximately 30 feet thick. This same interval on the north side of the fault is not calcareous, instead it is a clean sandy interval. There are similar calcareous zones in P-23 and P25. The calcareous zones in this portion of the SRS are

discontinuous but further southeast the limestone and calcareous zones become thicker and continuous. The lack of a calcareous zone in PBF-4 is not considered to be caused by the presence of the fault or to be evidence for the presence of the fault.

Cross-sections between the other pairs of drill holes in the PBF series are being prepared and will be included in future reports such as the interim report to be completed in November.

Structure Contour and Isopach Maps. Included in this report are structure contours of the top of basement or the pre-Cretaceous boundary and the Cretaceous/Tertiary boundary. These maps were prepared by D. S. Snipes of Clemson University and consultant to SRL ESS. Structure contour maps are an interpretation of the elevation of subaerial surfaces. The actual contours may be drawn in a variety of ways and knowledge of the regional geologic setting helps constrain how the contours may be drawn. Data from the structure contour maps support the same conclusions as the cross-section.

The structure contour maps are based on 57 drill holes or control points and the PBF well series is included in this data base (Figure 3). Offset indicated in these maps ranges from 30 to 100 feet on the pre-Cretaceous boundary (Figure 4) to 40 to 70 feet on the top of Cape Fear Formation (Figure 5) to 30 to 50 feet on the top of the Santee Formation (Figure 6). The isopach on the Upper Cretaceous formations indicate a thicker section on the down-thrown side (Figure 7). The results of these interpretations are graphically summarized in a regional cross-section across the plant site (Figure 8, also prepared by D. Snipes).

Additional Activities Currently Underway.

High resolution shallow seismic reflection surveys (26 line-km) are currently underway to determine exactly how close the fault comes to the surface and what the geometry of the fault is as it nears the surface.

Potential trenching sites have been identified on the southwest side of SRS. One target area is near drill sites PBF-4 and PBF-5. The area is on the upland area at the edge of the river terraces. We will have standard seismic reflection, high-resolution shallow seismic reflection, drill core data, and downhole geophysical data for this location. The other potential site is on one of the river terraces. It was suggested by the Earth Science Advisory committee (ESAC) that the youngest sediments on site may be found in the river terraces of the Savannah River. Trenching these sediments over the trace of the PBF may also provide the appropriate samples for geochronologic age dates.

ESAC also suggested an investigation of paleoseismic sites that have left evidence of liquefaction sites from former earthquakes. We do not know of any that exist on site but we are in the initial stages of planning for a search of these features.

The PBF probably extends off site to the east an undetermined amount . Offsite shallow high resolution seismic reflection survey (planned by South Carolina Water Resources Commission) and ongoing geologic mapping by the South Carolina Geologic Survey will help constrain the eastward extent of the PBF.

Conclusions

The shallow drilling clearly indicates the presence of the Pen Branch fault and supports earlier data. The youngest movement at this time is interpreted to be lower upper Eocene or about 36 million years old. This time estimate is well outside the NRC criteria of a capable fault. The fault also appears to be at least 50 ft below the surface. Ongoing shallow seismic reflection will allow even further refinement on our knowledge of the nature of the Pen Branch fault.

References

Aadland, R., 1990, Classification of Hydrostratigraphic units at Savannah River Site, Doc. No. WSRC-RP-90-987.

Bledsoe, H. W., 1988, SRP Baseline Hydrogeologic investigation- Phase III, DPST-88 - 627.

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Code of Federal Regulations, 10 CFR 100 Appendix A, 1982, Seismic and geologic siting criteria for nuclear power plants: Office of the Federal Register, National Archives and Records Administration.

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Snipes, D. S., Fallaw, W. C., Price, Jr., V., 1989, The Pen Branch Fault: Documentation of Late Cretaceous-Tertiary faulting in the Coastal Plain of South Carolina (U), Westinghouse-SRS, DP-MS-88-219.

Table 1 Shallow Drilling from the PBF well series

	total depth	bottomed in...	pre-Cretaceous boundary (elev)	Relation to fault
PBF-1	1065'	crystalline rock	-752	north, downthrown
PBF-2	1054'	Triassic rock	-681	south, upthrown
PBF-3	1135'	crystalline rock	-778	north, downthrown
PBF-4	1079'	crystalline rock	-839	north, downthrown
PBF-5	1125'	Triassic rock	-809	south, upthrown
PBF-6	902'	Triassic rock	-781	south, upthrown
PBF-7	1030'	Triassic rock	-701	south, upthrown
PBF-8	1030'	Cretaceous sediments	-692	south, upthrown

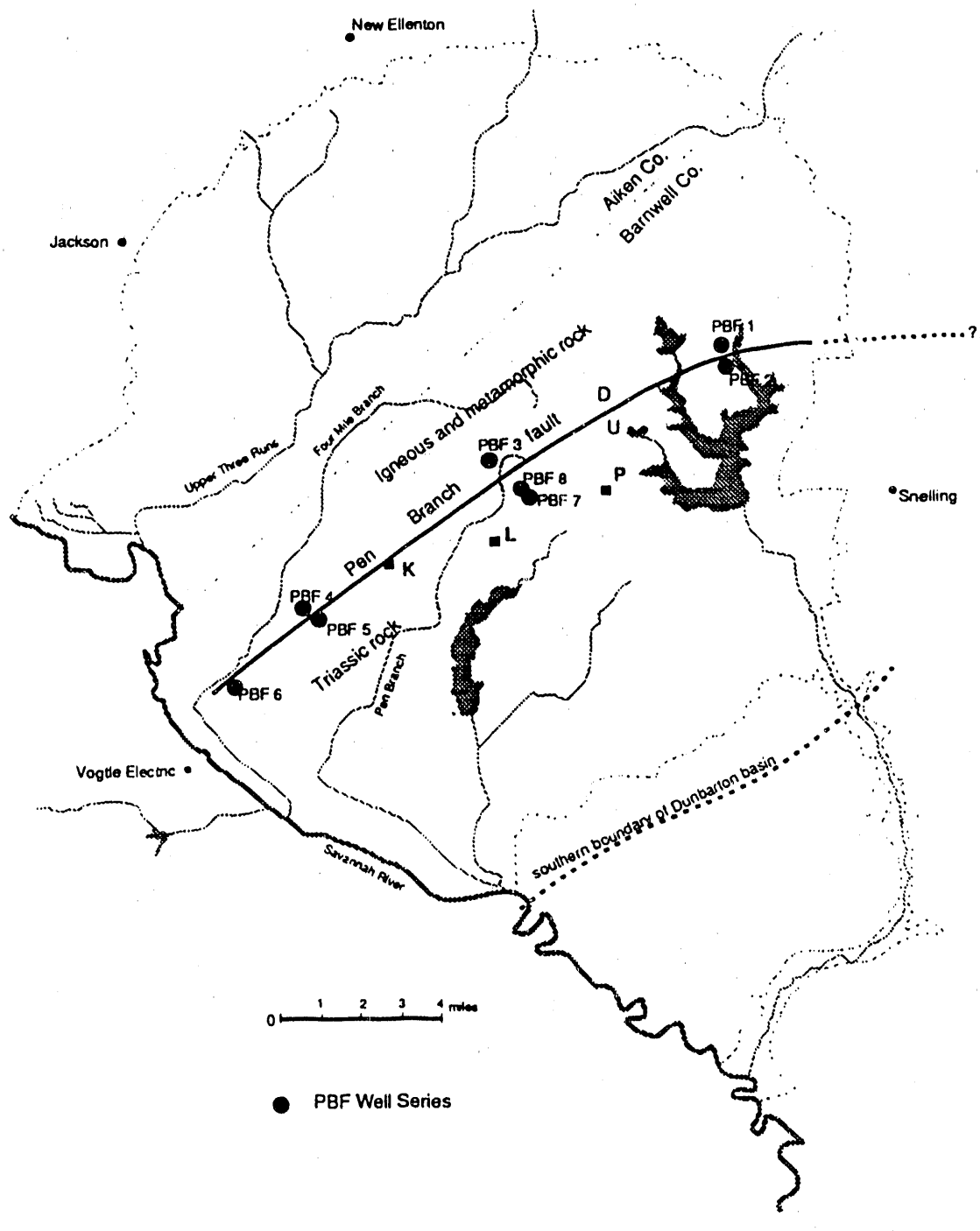


Figure 1. Map of SRS with the trace of the Pen Branch fault. The PBF well series is a set of 8 shallow holes that tag basement and bracket the fault across the site.

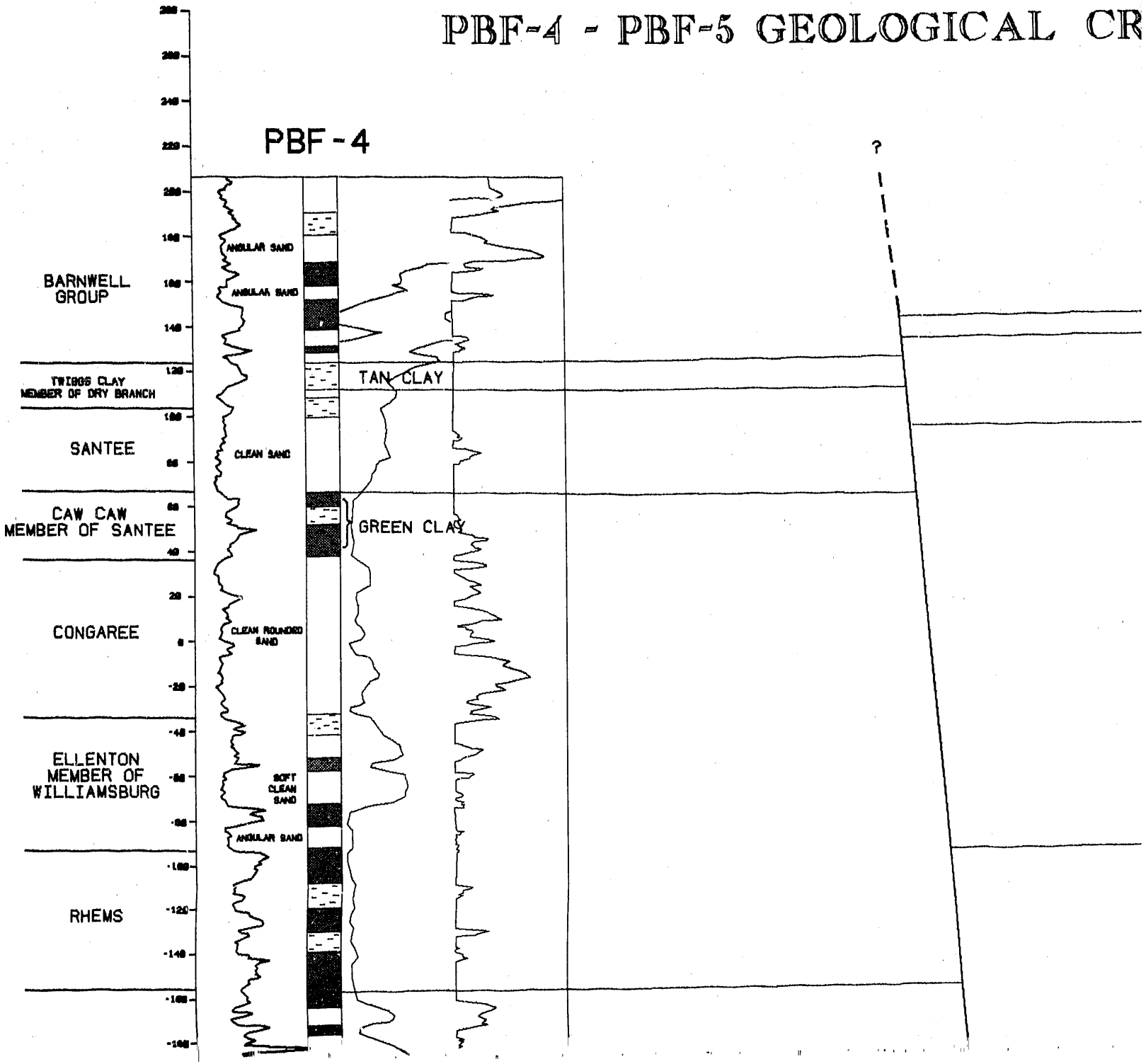
5

NW

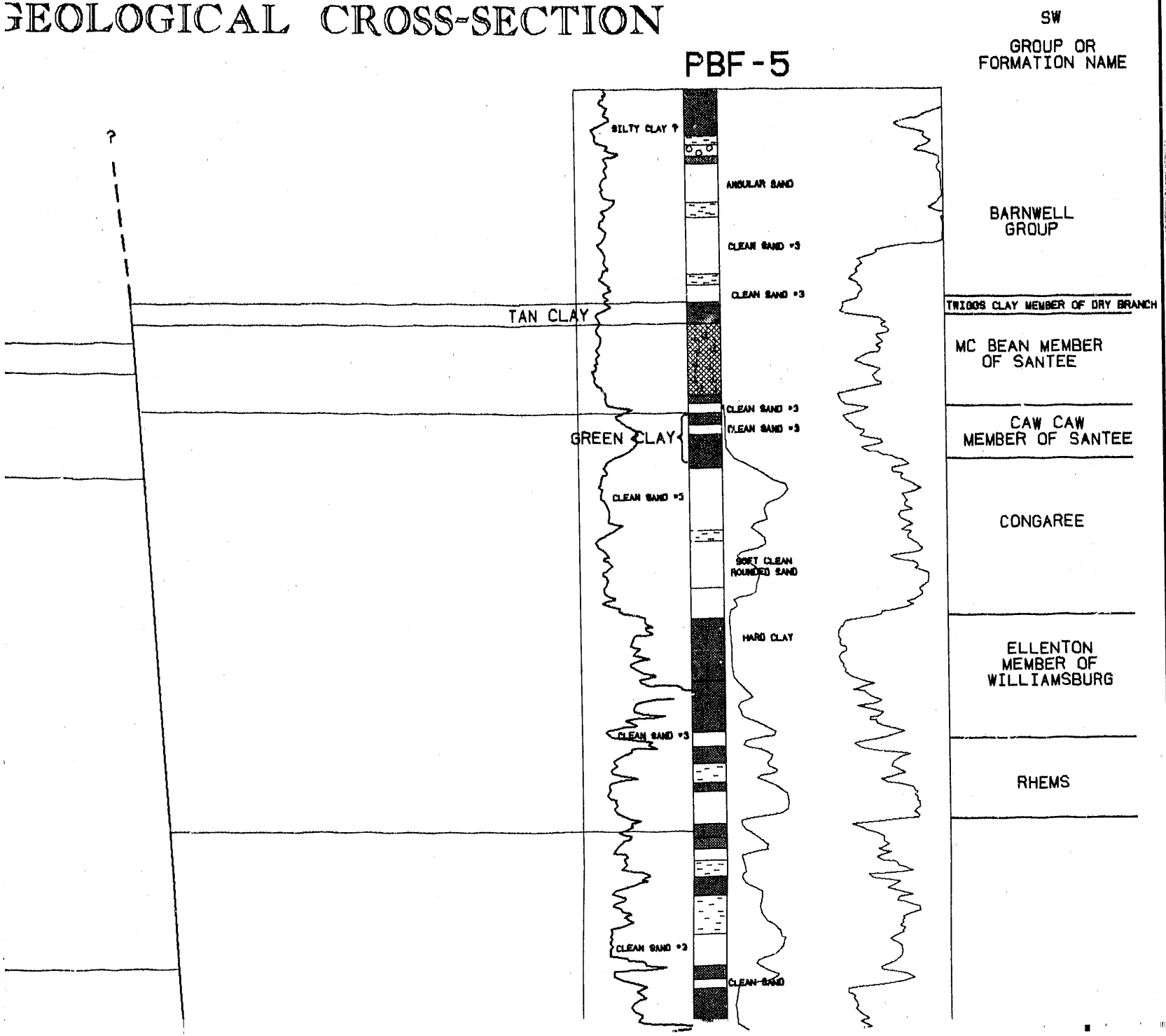
GROUP OR
FORMATION NAME

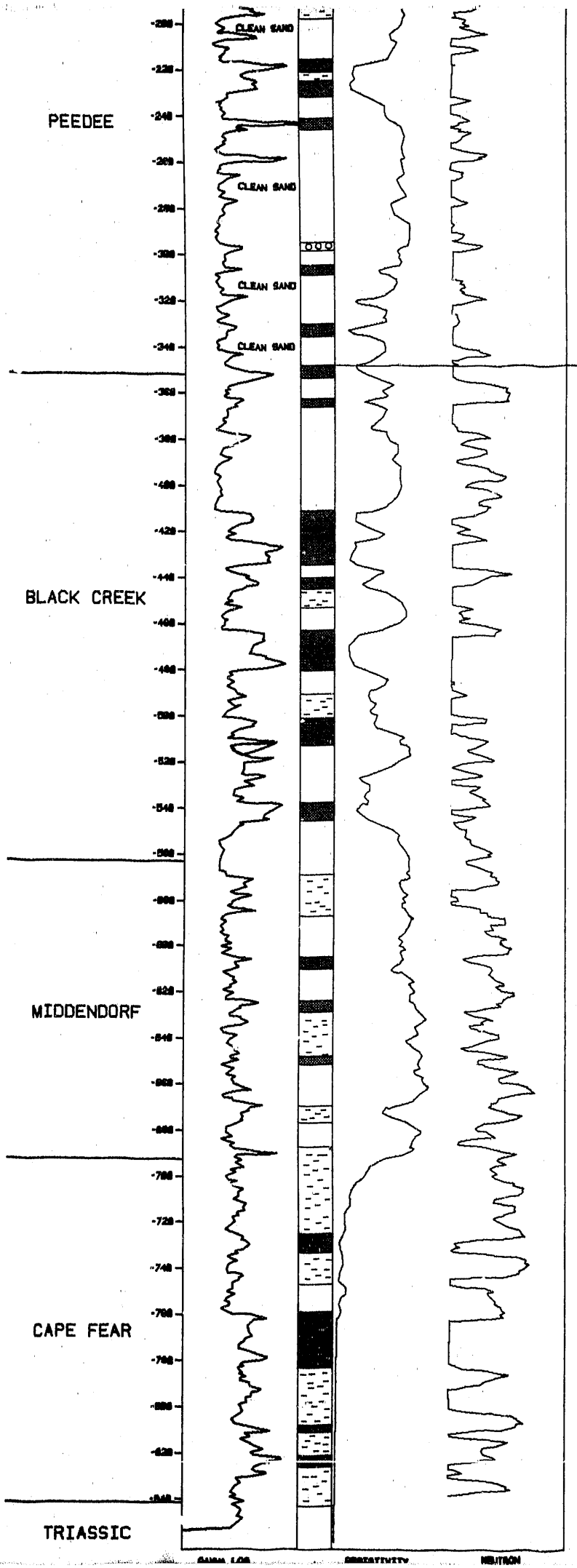
PEN BRANCH FAU

PBF-4 - PBF-5 GEOLOGICAL CR



BRANCH FAULT
GEOLOGICAL CROSS-SECTION

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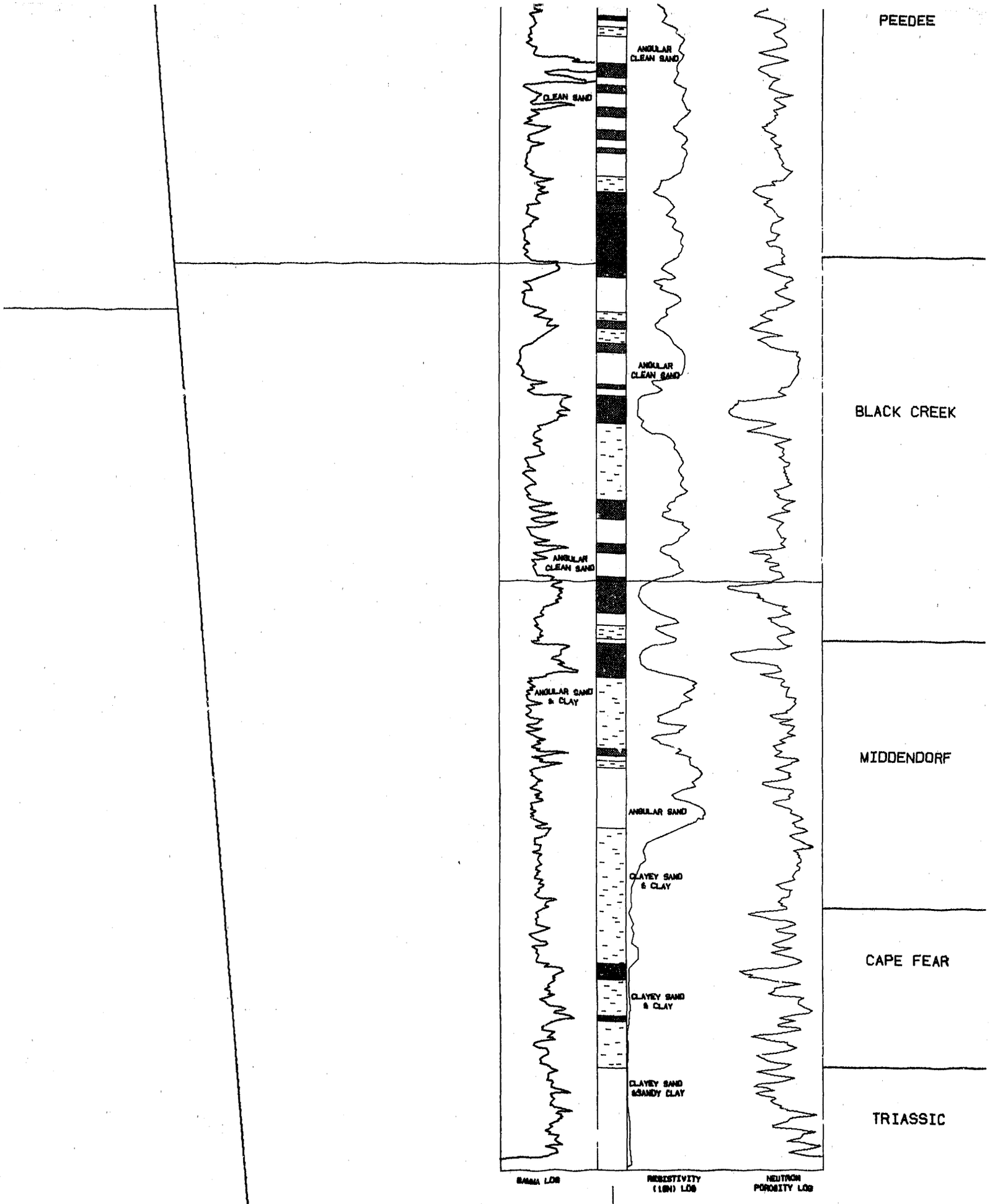
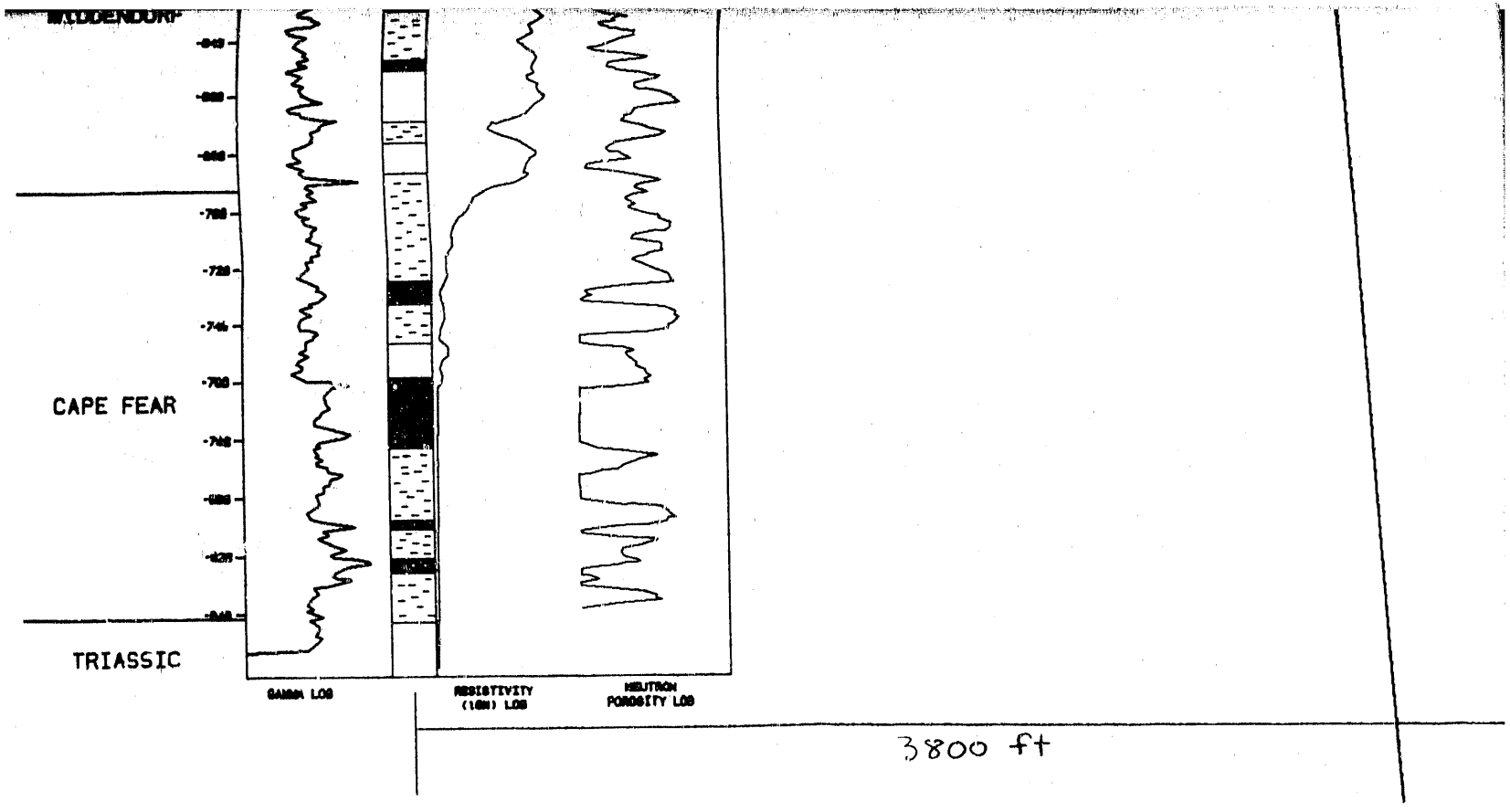
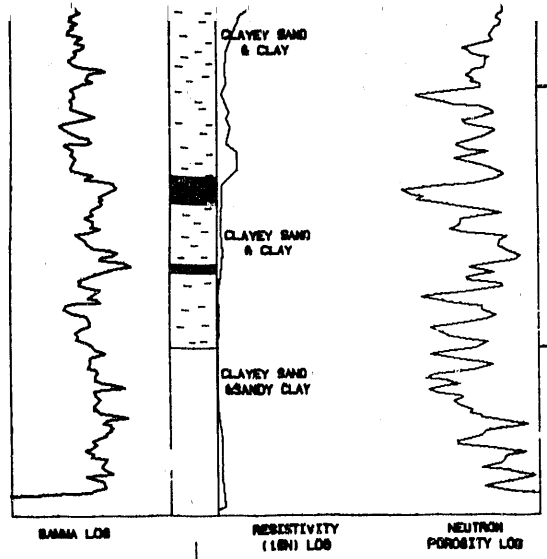
CLEAN SAND
CLEAN SAND
CLEAN SAND
CLEAN SAND
BLACK CREEK
MIDDENDORF
CAPE FEAR
TRIASSIC


PEEDEE
BLACK CREEK
MIDDENDORF
CAPE FEAR
TRIASSIC
ANGULAR CLEAN SAND
CLEAN SAND
ANGULAR CLEAN SAND
ANGULAR CLEAN SAND
ANGULAR SAND & CLAY
ANGULAR SAND
CLAYEY SAND & CLAY
CLAYEY SAND & CLAY
CLAYEY SAND &SANDY CLAY
GAMMA LOG
RESISTIVITY (ILM) LOG
NEUTRON POROSITY LOG


CAPE FEAR
TRIASSIC
GAMMA LOG
RESISTIVITY (16N) LOG
NEUTRON POROSITY LOG
3800 ft



CAPE FEAR

TRIASSIC

LEGEND:

- CALCAREOUS SAND
- MICACEOUS SAND
- SAND
- GRAVEL/PEBBLES
- CLAYEY SAND
- CLAY & SANDY CLAY
- SANDY CLAY
- CLAY

VERTICAL SCALE

0 20 40 60 80

UNITED STATES DEPARTMENT OF ENERGY

SAVANNAH RIVER SITE

AREA	BLDG NO.	PROJECT NO.

TITLE

PEN BRANCH FAULT
PBF-4&5 GEOLOGICAL
CROSS-SECTION

DRAWN BY	T.WICKLEY	DATE
PREPARED BY	ALICE STIEVE	DATE
CHECKED BY		DATE
		DATE

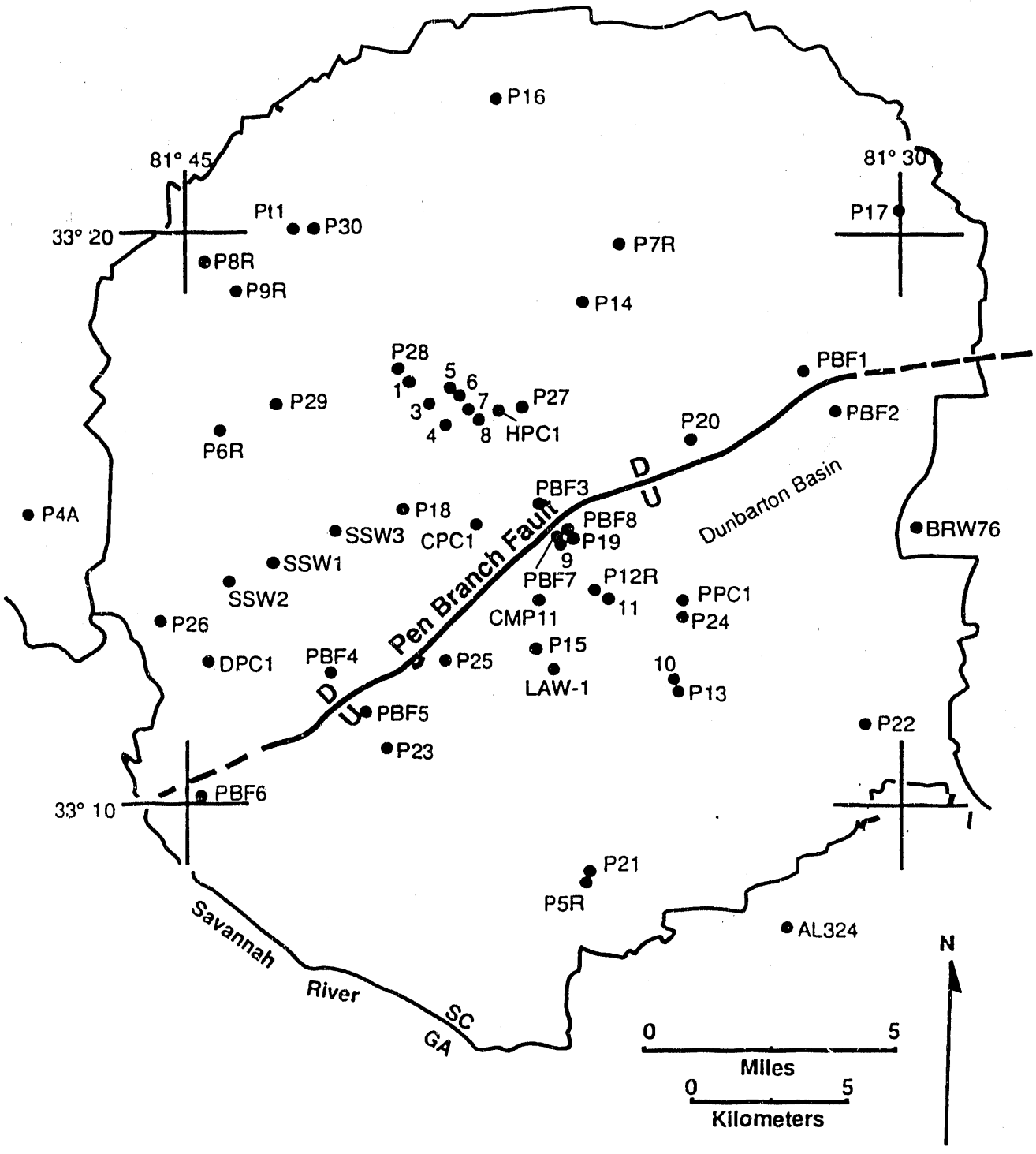


Figure 3. The SRS with location and identification of borehole control. The Pen Branch fault is indicated with a heavy, solid black line trending northeast across the site. Location of the PBF borehole series is arranged in pairs bracketing the fault trace (exception PBF-6).

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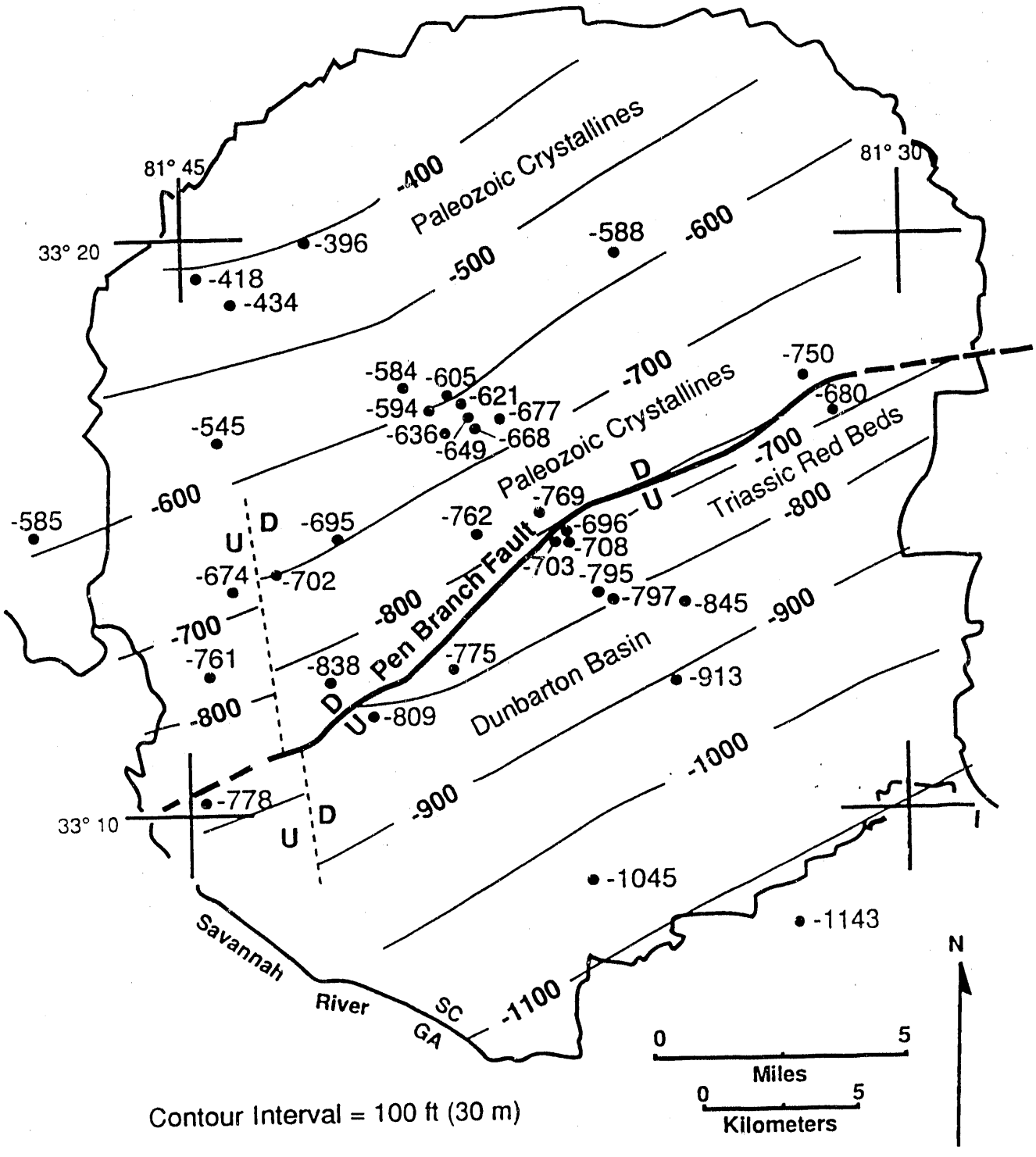

Figure 4. Structure contour map of the basement / Coastal Plain surface.
The Pen Branch Fault offsets this surface 30 to 100 ft.
The Pen Branch Fault is shown offsetting an unnamed NW trending fault.

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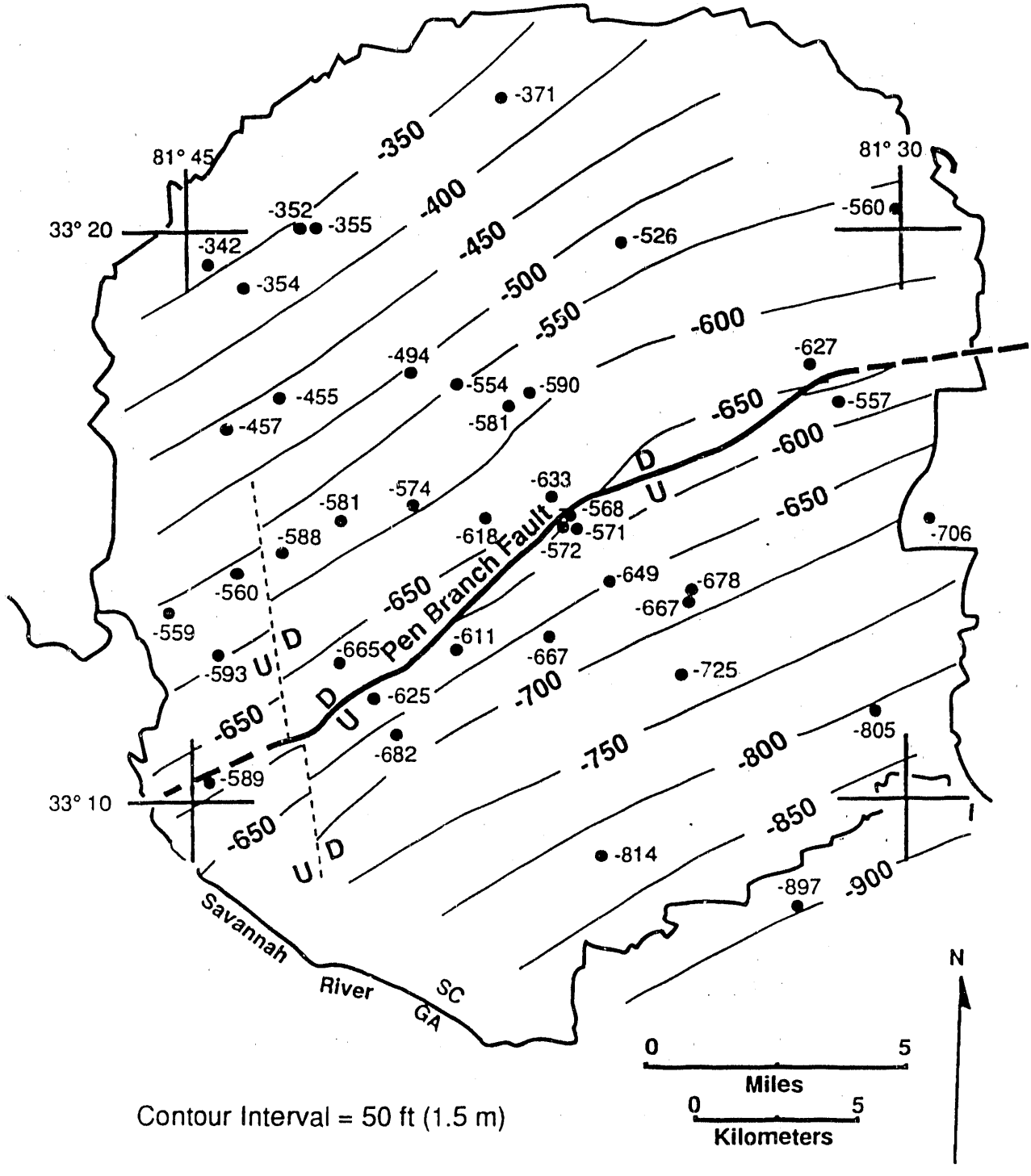

Figure 5. Structure contour of the top of the Cape Fear Formation (Upper Cretaceous). The PB Fault offsets this surface 40 to 70 ft. The Pen Branch Fault is shown offsetting an unnamed NW trending fault.

M90sep027.03

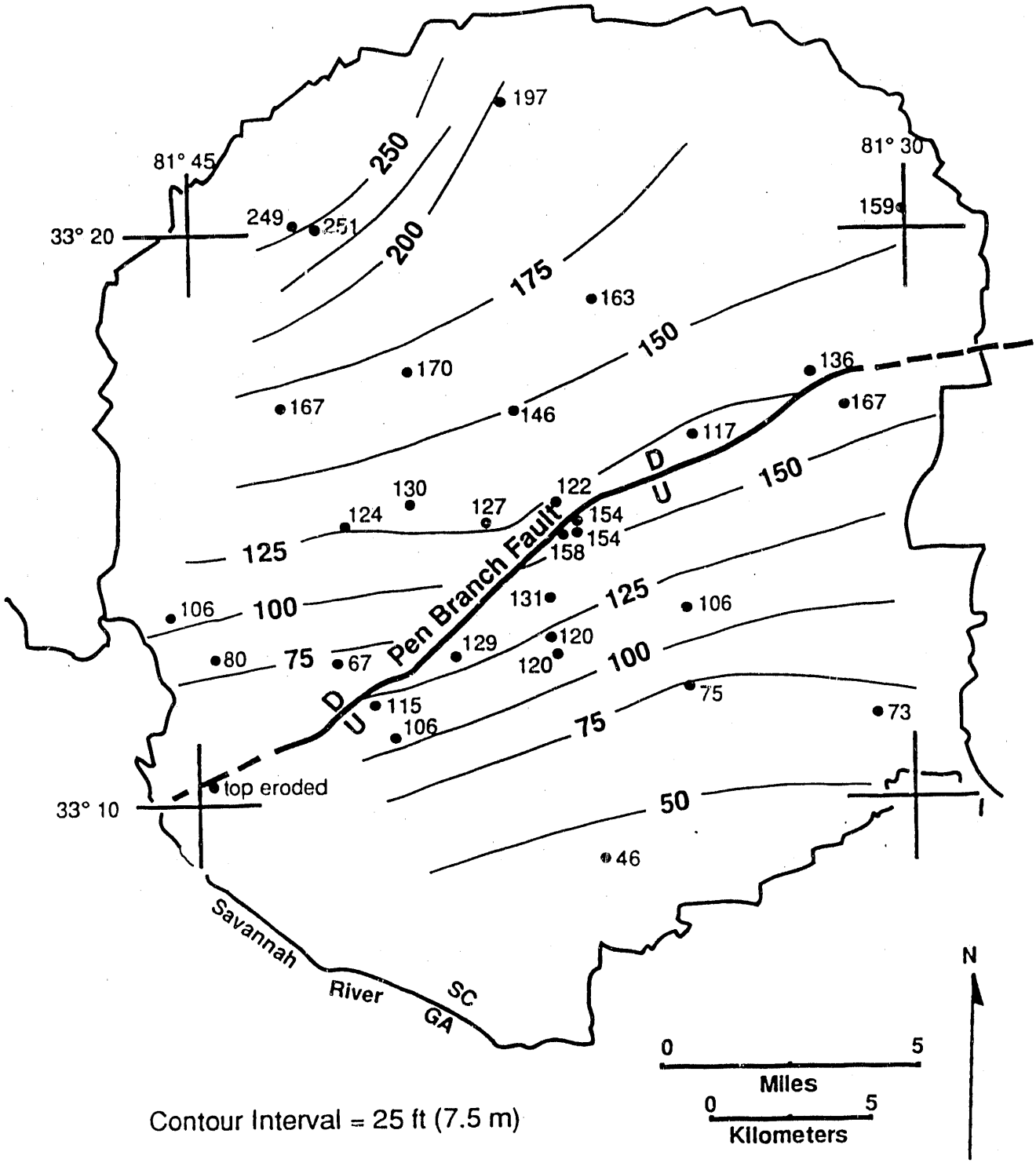

Figure 6. Structure contour map of the top of the Santee Formation (Middle Eocene). The PB Fault offsets this surface by 30 to 50 ft.

M90sep027.04

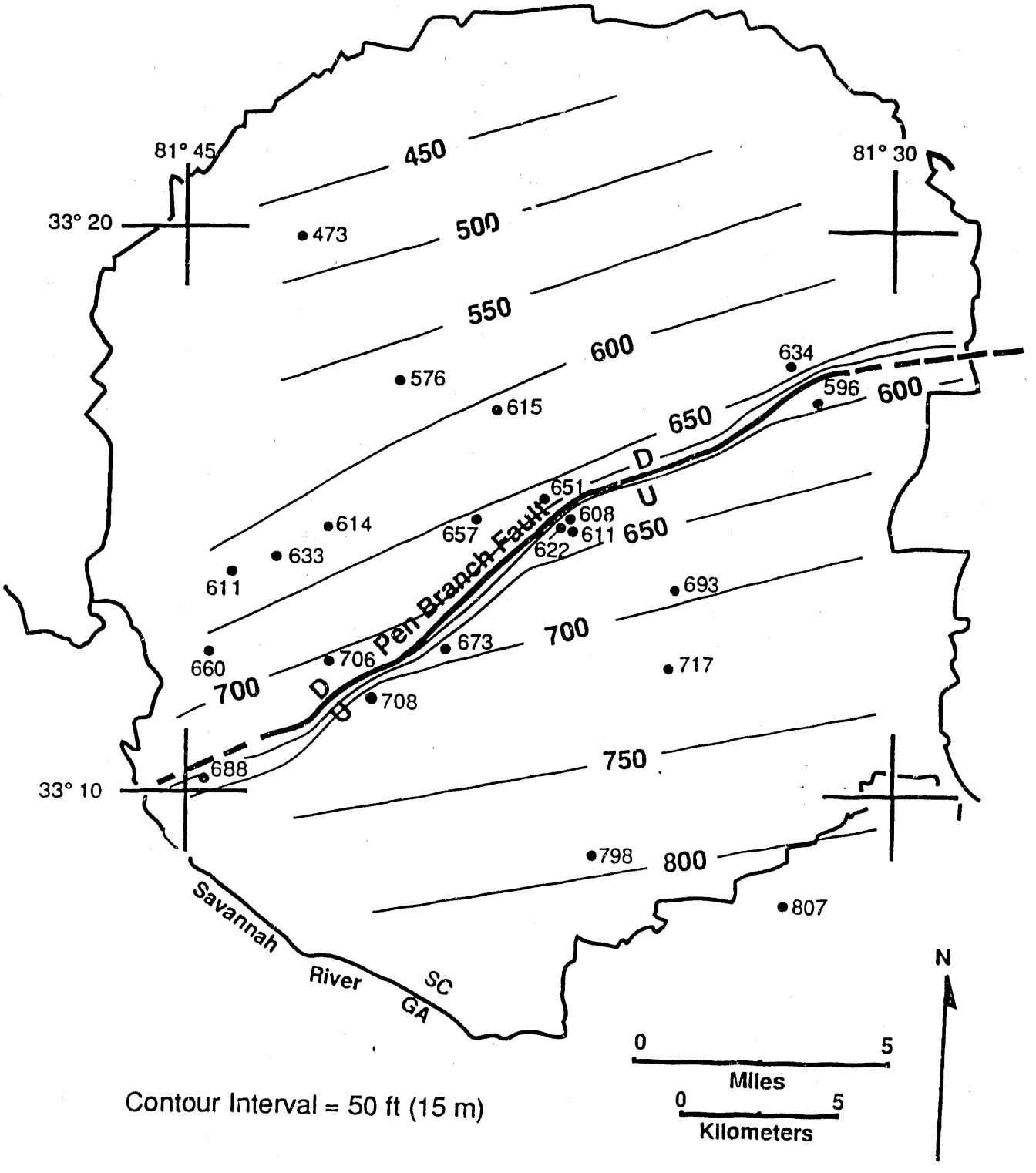

Figure 7. Isopach map of the Upper Cretaceous section. This section includes the Cape Fear Formation and is toward the bottom of the Coastal Plain section.

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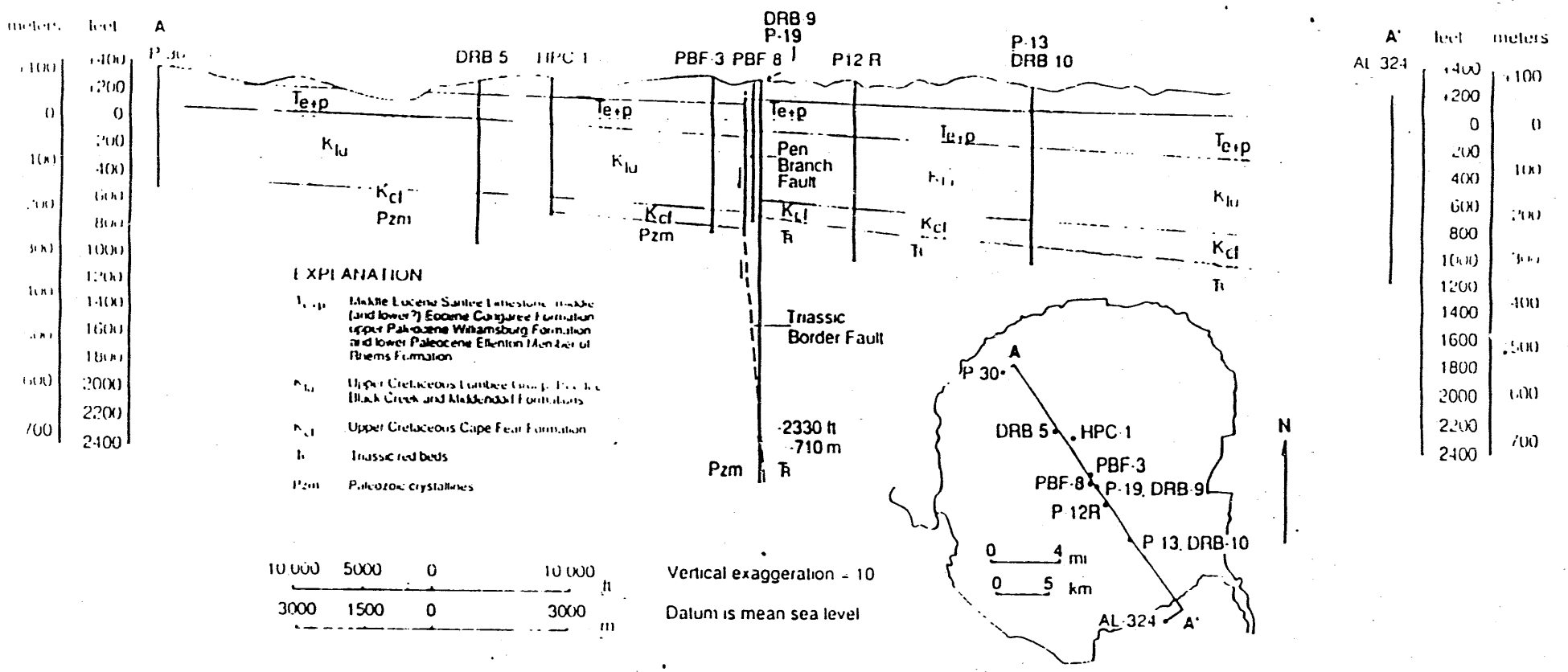

Figure 8. Geologic cross-section across the Pen Branch fault. This section is located in the middle of the site between Cental Shops and R Reactor. Prepared by D. S. Snipes, 1990.

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