**[DNFSB LETTERHEAD]**

December 3, 1992

The Honorable Richard Claytor
Assistant Secretary for Defense Programs
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, D.C. 20585

Dear Mr. Claytor:

The Board, its staff, and outside experts have been following the Savannah River Site's (SRS's) development and integration of a comprehensive geotechnical and seismic program for SRS. The Board notes that SRS has made significant progress towards integrating the geotechnical and seismic areas.

One area that the Board's outside experts have been following carefully is the development of an analytical model of the subsurface geologic conditions as inputs to future seismic analyses of SRS facilities. Enclosed for your information is a report from Dr. Paul C. Rizzo entitled, "Review of WSRC-TR-92-120, Structural Model of the Basement in the Central Savannah River Area, South Carolina, and Georgia, Savannah River Site," dated September 2, 1992. Some points are raised by Dr. Rizzo regarding the validity of the model from a geological perspective. This subject will be covered during planned follow-up reviews by the Board experts in January, 1993.

If you have any questions regarding the enclosed report, please advise me.

Sincerely,

***John Conway***
***Chairman***

Enclosure as noted.

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TO: Mr. Andrew Stadnik

FROM: Dr. Paul C. Rizzo

September 2, 1992

Mr. Howard W. Gault
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TOPIC NO. 91-007
REVIEW OF WSRC TR 92 120

STRUCTURAL MODEL OF THE BASEMENT IN THE CENTRAL

SAVANNAH RIVER AREA, SOUTH CAROLINA, AND GEORGIA
SAVANNAH RIVER S1TE
(TASK ORDER 001)

## EXECUTIVE SUMMARY

This Memo presents our comments on the report by Westinghouse Savannah River Company (WSRC) titled "Structural Model of the Basement in the Central Savannah River Area, South Carolina and Georgia," WSRC-TR-92-120, and references discussions at the Earth Science Advisory Committee (ESAC) on May 20, 1992. Their model has been developed primarily from geophysical images of the basement. The model describes the Pen Branch Fault as being a concave master fault which bounds the Dunbarton Basin laterally and from below. Our review questions validity of the model from a geological standpoint. Specifically, the mechanism and forces necessary to form the proposed structure are unlikely to have existed and the model does not fit well within the geologic history of the southeast.

## BACKGROUND

The WSRC Report presents a structure model for the basement below the upper Coastal Plain of South Carolina and Georgia. This model attempts to reconcile the geometry and origin of the numerous faults near the Savannah River Site (SRS) as presented in Figure 1, and identified as follows:

- Pen Branch Fault; initially identified as the northern boundary fault of the Triassic Dunbarton Basin.

- Steele Creek Fault; a fault southeast of The Pen Branch Fault within the Triassic Basin and forming a horst with the Pen Branch Fault.

- Atta Fault; the north-northeast trending fault in the north-central portion of the Savannah River Site.

- Ellenton Fault; a north-south trending fault, east of D-Area that may intersect the Pen Branch Fault.

- Crackerneck Fault; a northeast trending fault located in the northwest portion of the Savannah River Site.

- Upper Three Runs Fault; a northeast trending fault that underlies the current Upper Three Runs drainage. (WSRC Report).

- Millett Fault a poorly constrained northeast trending fault which may be the southern boundary of the Dunbarton basin.

These faults are within a crustal block that is bounded to the northwest by the Augusta Fault which is off the map in Figure 1, but may be seen on Figure 2. The Augusta Fault is interpreted as a late Paleo~oic thrust fault, which passes beneath all of the SRS

These faults have been identified and studied during four separate seismic reflection studies, specifically, the studies by Seismograph Service Corporation, D'Appolonia, Conoco, and Emerald Exploration Consultants. Additional gravimetric and magnetic studies as well as time domain electromagnetic soundings have also been performed at the site. These data, in combination with the geologic history of the site, form the basis for the interpretations of the geometry of which is presented in cross-section on Figure 2.

M E M O

The data support the hypothesis that the Upper Three Runs Fault intercepts the Augusta Fault at depth. The WSRC Report did not find evidence, however, that the younger Pen Branch Fault intercepted the deeper Augusta Fault. Nor do they find evidence for a deep, basement-penetrating Steele Creek Fault or Millett Fault. The WSRC Report states that the Atta and Crackerneck Faults are of similar age and were active during reactivation of the Pen Branch Fault.

The WSRC Report offers five conclusions:

- The Basement/Coastal Plain surface dips southeast with minor highs and lows. There is a local dip to the westsouthwest, toward the Savannah River channel. This surface is broken by several faults that penetrate Cretaceous through Tertiary horizons. The faults break the basement into discreet blocks with unique geophysical characteristics. They include, but are not limited to: Pen Branch Fault, Steele Creek Fault, Crackerneck Fault, Atta, and Ellenton Faults. The blocks can also be separated based on seismic signature and potential field characteristics.

To the south of the Savannah River Site is a block or terrain that separates the Dunbarton basin from the South Georgia ri~ complex. It is predorninantly a zone of mafic extrusion and intrusion. North of the Dunbarton basin, another block is characterized by several fault/reflector packages that are broken up underneath the basin by the mafic intrusions associated with the Triassic basin. These faults can be related to Alleghanian Orogeny. Even further to the northwest the metamorphosed crystalline rock is influenced by granitic intrusions.

- The Upper Three Runs Fault is an Alleghanian fault peneplained at the pre-Cretaceous unconformity. There is no evidence to suggest reactivation in Cretaceous through Tertiary time. The fault soles into the Augusta Fault beneath the Dunbarton Basin and is related in age and mechanism to the Augusta Fault.

- The Pen Branch Fault, which offsets the Augusta Fault and is not shown on Figure I or 2, is a reactivated norrnal fault now showing reverse separation between crystalline basement and Triassic sedimentary rock. The Pen Branch Fault, as the northwest boundary of the Dunbarton Basin, dips southeast and apparently does not sole into the Augusta-Upper Three Runs Fault system. This is in contrast to the Magruder Fault of the Riddleville basin. The Pen Branch Fault may be the master fault for the Dunbarton Basin and soles into one of the antithetic faults of the South Georgia rift complex farther southeast.

  The Pen Branch Fault formed under extensional stress during Triassic time and was reactivated during Cretaceous through Tertiary time under a compressive stress resulting in a reverse fault geometry. Fault geometry in the Coastal Plain section is observed to be a complex of fault splays to the north and south of the master fault (e.g. Pen Branch Fault forming a horst with the Steel Creek Fault). The Coastal Plain material may have behaved in a passive manner during displacement on the basement fault. The up-section limit of Pen Branch Fault as seen in seismic data is clearly offset up to 250 msec and deformed up to 200 msec.

- The nearby Belair Fault, which offsets the Augusta Fault and is not shown on Figure 1 or 2, is described as a reactivated tear fault now showing reverse separation. It offsets young Coastal Plain sediments and suggests a corresponding age and mechanism for the Pen Branch Fault. However, the Belair Fault is not obviously connected to Triassic rifting as is the Pen Branch Fault. Other interpreted, young reverse faults in the area include the Crackerneck Fault, Atta, and Ellenton Faults Their relationship to the Cenozoic reverse fault system is unclear due to the lack of data. However, similar mechanisms and timing may relate them all (WSRC Report).

  1. The first and second conclusions made by the WSRC Report are reasonable based on the data presented The last three conclusions, however, are problematic.

  2. The basement model does not adequately explain the geometry of the faults near the Savannah River Site. The most troublesome aspect of the model is the geometry of the Pen Branch Fault as it relates to the Dunbarton Basin. The . Dunbarton Basin is one of many basins which originated under an extensional

stress regime during the Mesozoic. The authors acknowledge that this extensional regime existed, but do not deal with all the impUcations. For example, the entire crust must have been in a state of extension. Any fault must extend deep within the crust and would have offset any deep, older structure. The Dunbarton Basin formed because that particular area ofthe crust was relatively weak. This relative weakness is probably at the base of the brittle crust and more than 20 km deep. The bounding faults most likely extend very steeply into the deep basement and would offset any underlying Paleozoic thrust fault. Therefore, the faults bounding the Dunbarton basin cannot be the shallow concave structures shown on Figure 2 under such a regime.

The same can be said of the reactivation of this structure. Reactivation would have occurred because the crust is inherently weak. Any reactivation during the Tertiary time must have occurred over the entire length of the fault.

3. The WSRC Report fails to consider the types of forces that would act on the crust to produce the interpreted geometry of the Pen Branch Fault. It is hard to imagine a force that could act on the upper several thousand feet of the basement and not perform work on the rest of the basement. The forces involved would act over the entire crust.

4. The orientation of the faults was not addressed by the WSRC Report. The Belair and Pen Branch Faults do not strike in the same direction, making them unlikely to have been formed under the same stress regime. The Atta and Ellenton Faults have north-south orientations which are conspicuously different from the northeast-southwest orientation of the bulk of the known faults. The anomalous orientation may be explained by a changing orientation of stress with time. Zoback (1983) presents measurements of in-situ stress within the southeast. As discussed at the ESAC meeting, the modern stress system is compressional from northeast to southwest The Atta and Ellenton Faults are the only known regional faults that could be forrned by the modern stress system. Thus it is possible that the Atta and Ellenton Faults are the youngest faults at the site.

5. The WSRC Report bases its argument on the inability to image the deep sections of the Pen Branch Fault within the crystalline basement. This could be an erroneous interpretation as steeply dipping deep faults typically can not be resolved within the deep basement.

   Another possible misuse of the seismic data occurs when the WSRC Report places an upward bound on the Pen Branch Fault. The seismic methods employed cannot image very shallow structures. Placing an upward bound on the Pen Branch Fault at 200 msec is inappropriate. The appropriate use of seismic data is to locate suspected structures. Other methods of subsurface investigation, including seismic reflection surveying with a higher resolution trenching and/or borings, must be employed to evaluate the located structures.

6. This structural model was presented to the ESAC meeting on May 20, 1992 where it met with widespread disapproval. Sirnilar to our Comrnents 2 through 5, the ESAC found problems with the geometry, geologic history, and the resolution of forces within the crest. Based on data presented at the May 20 meeting, several members of the ESAC concluded that the Atta and Ellenton faults were likely the most active and fit within the modern stress regime. Also, there was agreement that seismic methods cannot disprove the existence of a fault.

## SUMMARY

The WSRC Report ( 1992) has produced a questionable model of the basement beneath the Coastal Plain of South Carolina and Georgia. Specific problems exist with the proposed geometry of the Pen Branch Fault as it relates to the Dunbarton Basin. The model does not conform to the geologic history of the southeast and the forces that could produce a structure are not considered.

## REFERENCES

Stephenson, D., and A. Stieve, 1992, "Structural Model of the Basement in the Central Savannah River Area, South Carolina and Georgia; Westinghouse Savannah River Company: Savannah River Site, Aiken, South Carolinan, WSRC-TR-92-120 [DNFSB Doc. 92:2183, WSRC Report].

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