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APPENDIX 2E

ENGINEERING GEOLOGY

OF

OCONEE NUCLEAR STATION

DUKE POWER COMPANY

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ENGINEERING GEOLOGY
OF
OCONEE NUCLEAR STATION

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ENGINEERING GEOLOGY
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I. INTRODUCTION

A. Scope. This report will describe the geology of the Oconee Nuclear Site, including a general background of the regional geology, and more specific details on the site itself. Regional geology will be covered only in sufficient detail to provide a background for the more intensive studies of the immediate project area. The detailed discussion of the Nuclear Station geology is based on site examination and studies of the core borings, supplemented by the previous extensive explorations made for the nearby, and geologically similar, Keowee Damsite. The field explorations and inspection of the borings were made in September 1966.

II. REGIONAL GEOLOGY

A. General

1. Physiography. The site is underlain by crystalline rocks which are a part of the southeastern Piedmont physiographic province. This northeastward - trending belt of ancient metamorphic rocks extends northward from Alabama east of the Appalachians, and in South Carolina crosses the State from the Fall Line on the east to the Blue Ridge and Appalachian Mountains on the west. These rocks are generally recognized as being divided into four northeast-southwest trending belts in the Carolinas. From southeast to northwest they are the Carolina slate belt, Charlotte belt, Kings Mountain belt, and Inner Piedmont belt. The Oconee Nuclear Site is in the western, or Inner Piedmont Belt.

2. Lithology. The Piedmont metamorphic rocks of the site were formed under many different combinations of pressure and temperature, and represent a complex succession of geologic events. The formerly accepted concept that the Piedmont consists only of the deep, worn-down roots of ancient mountains now seems untenable. The older theory that the rocks were exclusively of igneous origin is being replaced by the proposition that they represent highly metamorphosed sediments which have been folded, faulted, and injected to result in one of the most complex geologic environments in the world. It can be said with certainty, however, that these rocks represent some of the oldest on the continent. The new techniques of dating by radioactive decay have placed the age of the metamorphic episodes that produced these rocks as occurring from 1,100 my (million years) to 260 my ago. The successive northeastward trending bands of rocks vary greatly in lithology from granitic types to highly basic classifications, with gneisses and schists being the predominant classifications petrographically. In summary, the regional geology of the Oconee Nuclear Site can be accepted as typical of the southeastern

Piedmont - narrow belts of metamorphic rocks trending northeast, with the foliation dipping generally to the southeast.

3. Seismology. The rocks of the Oconee Nuclear Site are geologically ancient, and are extremely stable seismologically. Earthquake activity can, and does, occur throughout the world, although the centers of severe seismic activity are confined to arcs and rifts in the earth's crust the location of which are well known through the occurrence of frequent and sometimes disastrous earthquakes during recorded history. These areas are zones where adjustment of the earth's crust is still taking place, and are usually associated with geologically young environments. Minor crustal adjustments are continually taking place everywhere, and when stresses accumulate sufficiently to cause movement, a tremor is felt. The earthquakes occasionally experienced in the southeastern Piedmont and Appalachians during our brief recorded history have been minor, and have caused more excitement than damage on a frequency of about one a decade.

Earth tremors are normally associated with movement along faults. There are innumerable faults in the southeastern Appalachians and Piedmont. Some are regional, such as the Blue Ridge Front; the Brevard Zone; the Cartersville Fault; and the extensive system of faults which occurred during the Triassic, in the North Carolina Triassic Basin near Durham. The Brevard Zone is of special interest, since it is a major shear zone extending from Georgia to North Carolina, and is in the general area of the Oconee site. Its age is pertinent, since it separates the Blue Ridge from the Piedmont. The most recent field work strongly suggests that the latest movements along the Brevard Zone occurred after late Paleozoic and before late Triassic, or about 200 my ago.

Faulting is especially pertinent with respect to earthquake activity, since seismic activity is usually related to either vertical or horizontal movement along a fault or fault zone. In the ancient faults in the southeast, however, there is no evidence of geologically recent movement. Such major faults as the Cartersville fault and the Ocoee - Conasauga fault in northwest Georgia have been shown by borings to have been stable for 400 to 600 my (million years). The numerous faults associated with the North Carolina Triassic Basin have probably been stable since some period after Triassic time, probably on the order of 100 my.

In summary, the southeastern Piedmont rocks are highly stable seismologically, and the Oconee Nuclear Site should be one of the nations most inactive areas with respect to earthquake activity.

III. LOCAL GEOLOGY

A. Geologic Structure and Lithology. The local geology of the Oconee Nuclear Site is typical of the southeastern Inner Piedmont Belt. The foundation rock is biotite and hornblende gneiss, striking generally northeast, with the foliation dipping southeast. The rock is overlain by residual soils, which vary from silty clays at the surface, where the rock decomposition has completed its cycle, to partially weathered rock and finally to sound rock.

As a general classification the rock may be described as a "biotite gneiss," or merely a "granitic gneiss." It is technically a biotite-plagioclase gneiss, consisting of interlocking grains of plagioclase feldspar and quartz, with varying percentages of biotite and amphibole (hornblende). The characteristic banding is caused by concentrations of biotite and hornblende in the lighter background of feldspar and quartz.

B. Rock Weathering. Where heavily banded with dark biotite and hornblende the rock is weaker than in its lighter colored portions, since the highly foliated biotite will split along the foliations, and is also more subject to weathering and consequent rock decay. The borings indicate that even after apparent sound rock has been reached local bands or zones of biotite - usually less than a foot thick - may be soft and weathered to considerable depths.

Rock weathering at the Oconee Nuclear Site is about normal for Piedmont biotite gneisses. While highly variable, the normal range of depth before sound rock is reached is 30 to 50 feet. Although the weathering is deep, the resulting residual materials - clays, silts, and weathered rock - are structurally strong, and are used for the foundations of moderately loaded structures.

C. Jointing. The rocks at this site have apparently not been subjected to stresses causing high concentrations of joints. The core borings indicate that jointing is widely spaced, and has not influenced the weathering pattern. Joints are about equally divided between strike and dip joints, with occasional oblique joints. None of the joints are sufficiently numerous or weathered to be a factor in excavation or construction.

D. Ground Water. Subsurface water is typical of the Piedmont area. The top of the zone of saturation, or water table, follows the topography, but is deeper in the uplands and more shallow in valley bottoms. It migrates through the pores of the weathered rock, where the feldspars have disintegrated and left intersticial spaces between the quartz grains. Additional water is contained in the deeper fractures and joints below the sound rock line. The water table is not stationary, but fluctuates continually as a reflection of seasonal precipitation. Water should present no construction problem. If excavation is required below water table depths, seepage can be easily controlled by conventional procedures, since quantities will not be large.

IV. RELATION OF GEOLOGY TO CONSTRUCTION

A. Excavation. Excavation can be accomplished by conventional earth moving equipment down to the horizon indicated on the boring logs as "Top of Rock." Rippers may be required for hard lenses as "Top of Rock" is approached, but no systematic drilling and blasting should be necessary. Some excavation without blasting may occasionally be accomplished below "Top of Rock," but it will be difficult, and harder material will quickly be reached. For estimating purposes "Top of Rock" should be considered as the horizon where blasting must begin.

The next pertinent zone with respect to rock quality is indicated on the geologic logs as "Top of Quarryable Rock." This material is moderately hard, and can be blasted to produce dimension size stone, but relatively large quantities of fines will result because of partial disintegration of the minerals, and isolated weathered zones. Rock in this zone is suitable for riprap, but should not be considered for concrete aggregate. Below "Top of Sound Rock" mineral weathering is minor, and the rock is of aggregate quality. Because of the gneissic structure, however, it will tend to break with a rather large percentage of "flats" or elongated particles.

For material logged above "Top of Quarryable Rock" one vertical to one horizontal excavation slopes have usually proved satisfactory for Piedmont rocks. However, this should be checked by stability analysis for each individual case. Below this horizon four vertical to one horizontal slopes are recommended. For limited rock faces or in areas of exceptionally sound rock vertical faces can be used, but four vertical - one horizontal slopes are easier to scale and will spall less during freezing and thawing over extended periods of exposure.

The technique of pre-splitting in blasting vertical or almost vertical rock faces has proved highly successful and economical, and should be utilized wherever possible.

A berm is desirable at the bottom of the one on one overburden and weathered rock slope, to catch loose material and minor slides. A 10-foot minimum width berm along top of rock may be used, but a wider berm - up to 50 feet - is often desirable if the excavated material is useable elsewhere.

V. SUMMARY

The twenty-one borings completed at the Oconee Nuclear Site and the nearby hydro site have been sufficient for a determination of the geologic structure and petrography, and their relationship to the proposed construction. The exploration is sufficient to permit continuing design and constru on.

The structures will be founded on normal Piedmont granite gneisses, and a wealth of experience is available in designing and constructing heavy structures on similar foundations. The construction characteristics of the residual soils overlying the rock are well known, and should present no problems in design or construction. The rock underlying the site, below surface weathering, is hard and structurally sound, and contains no defects which would influence the design of heavy structures.

The area of the site should be considered to have a very low probability with respect to seismic disturbance.

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