TENNESSEE VALLEY AUTHORITY

DIVISION OF WATER MANAGEMENT

GEOLOGIC SERVICES BRANCH

SOUTHERN APPALACHIAN TECTONIC STUDY

JANUARY 1979

DWM-26

Tennessee Valley Authority
Division of Water Management
Geologic Services Branch

SOUTHERN APPALACHIAN TECTONIC STUDY

William M. Seay
Task Force Chairman

Knoxville, Tennessee
January 1979

TABLE OF CONTENTS

SOUTHERN APPALACHIAN TECTONIC STUDY

ABSTRACT

Within the southern Appalachian region, tectonic provinces have heretofore been defined on the basis of surface geologic structural subdivisions. Although this is consistent with the definition in Appendix A to 10 CFR Part 100, few relationships appear to exist between present-day seismicity and these subdivisions.

A regional geophysical-geological study has been conducted by TVA to delineate basement tectonic structures and to redefine tectonic provinces of the southern Appalachian region. Regional magnetic and gravity data, in part collected for this study, have been composited and correlated with seismicity, surface structural lineaments seen on satellite photo-imagery, and other related geologic data, into an integrated analysis of the data sets. Examination of basement-derived anomalies identified in these studies, and their surface manifestations, shows that the Precambrian crust underlying the folded Appalachians and the younger rocks in adjacent geologic provinces have a much more complex structural pattern than heretofore realized. This complex pattern defines a series of tectonic subdivisions or provinces on the basis of lithology and structure.

A major east-west structural discontinuity is interpreted to exist in the vicinity of 37°20'N. latitude. The prevailing gravity and magnetic anomaly pattern is discontinuously interrupted along this zone, reflecting a series of structural disruptions. The discontinuity is also marked by abnormal structure in the rocks of the folded Appalachians and very significantly by an east-west zone of earthquake epicenters, including the 1897 Giles County, Virginia earthquake.

The southern Appalachian region is crossed by several major discontinuities observed on three or more of the data sets and by many minor disruptions. Primary criteria that distinguish major from minor discontinuities are their length and the number of data sets on which they can be observed. Major discontinuities are used to define the tectonic subdivisions or provinces.

One of the major discontinuities transecting the region is the seismically inactive north-northeast-striking structural boundary that passes through Knoxville and is referred to by King and Zietz (1978) as the New York-Alabama lineament. Southeast of this lineament the region is characterized by northeast-striking basement trends and felsic

300 120

lithologies, principally metamorphic rocks intruded by a few plutons of felsic to intermediate composition. Northwest of this lineament the region is generally composed of mafic rocks and northerly-striking lithologic trends. The vast majority of the earthquake epicenters of the southern Appalachian region lie to the southeast of this boundary.

The New York-Alabama lineament is transected in the area of study by three major linear, northwest-striking basement discontinuities. These northwest trends are interpreted as major lithologic and/or structural boundaries that extend into the midcontinent. The southeastern extensions of these discontinuities are complicated by the effect of Appalachian lithologic and structural features. The transection of the New York-Alabama lineament by the three northwest-trending basement disruptions results in the formation of eight separate tectonic subdivisions or provinces.

The Giles County earthquake is in a zone of earthquake epicenters on an east-west-trending structural discontinuity. It is furthermore separated from the Sequoyah site by several intervening tectonic provinces that show marked differences in lithology, structure, and seismicity. This significantly reduces the probability of finding structural continuity that warrants migration of the Giles County earthquake to the Sequoyah plant site.

INTRODUCTION

The definition of a tectonic province and the implementation of the tectonic province approach to establishing the Safe Shutdown Earthquake have, since their inception in 1969 and subsequent entry in 1971 into 10 CFR Part 100 as part of Appendix A, caused considerable difficulty in the siting of nuclear plants in the eastern United States.

As defined in Appendix A,

> *A 'tectonic province' is a region of the North American continent characterized by a relative consistency of the geologic structural features contained therein.*

The apparent intent is to bound such regions, assume the "structural features contained therein" cause earthquakes, and then assume that events equal in intensity to the largest historic event can occur anywhere on any of these structural features and, therefore, anywhere within the tectonic province.

Difficulties arise (1) in defining the term "geologic structural features," (2) in identifying the "geologic structural features," (3) in establishing boundaries around the area of "relative consistency of the geologic structural features contained therein" so as to differentiate the established "tectonic province" from adjacent "tectonic provinces", and finally (4) in providing some defensible basis for limiting the mobility of the largest historical earthquake defined for the "tectonic province" to the area within its boundaries.

300 130

Past practice has been to define tectonic provinces in the Appalachian region on the basis of geologic structures expressed at the surface and largely of Paleozoic age, without consideration as to whether these visible structures are significant in assessing earthquake potential. The boundaries for the Southern Appalachian Tectonic Province as defined for Sequoyah on November 4, 1969, by Dr. Howard H. Waldron, who at the time was the USGS consultant to the AEC, are as follows: on the east by the western margin of the Piedmont Province; on the west by the western limits of the Cumberland Plateau; on the south by the overlap of the Gulf Coastal Plain Province; and on the north by the re-entrant in the Valley and Ridge Province near Roanoke, Virginia. These are predominantly physiographic boundaries that have questionable association with geologic structure (west, north, and south) and seemingly have no significance in assessing earthquake potential. Sequoyah was the first nuclear plant in the United States licensed under Appendix A. The Southern Appalachian Tectonic Province, as defined by Waldron, was listed also as the controlling tectonic province in the Watts Bar PSAR, Bellefonte PSAR, Phipps Bend PSAR, and Watts Bar FSAR.

NRC, in its Safety Evaluation Report for Phipps Bend (p. 2-21), later determined that the

300 131

... site is within the Southern Valley and Ridge Tectonic Province based on provinces that are more in accord with those proposed by King, Eardley, Rodgers, and Hadley and Devine for eastern North America. This province is bounded on the east by the western extent of the Piedmont Tectonic Province; on the west by the Cumberland Plateau; on the south by the Gulf Coastal Plain; and on the north by the northern part of the Valley and Ridge Province.

As indicated by the NRC Staff Working Group in their Report on TVA Seismic Issue dated May 1978, provinces such as those identified by Eardley or Hadley and Devine "were based strictly on geologic structure." An obvious question that arises from this judgment is, "What is the structural significance of establishing a boundary based on the overlap of Gulf Coastal Plain sediments?"

There is no basis to assume a relationship between the surficial geologic structures of Paleozoic age in the southern Appalachian region and present-day earthquake activity. The same noted geological and seismological experts that NRC cites in defining "classical" province boundaries neither describe, imply, nor infer any movement of these surficial geologic structures since the Paleozoic. Even Hadley and Devine (1974, p. 1), in their Seismotectonic Map of the Eastern United States, the purpose of which

... is to describe the distribution of historic seismic activity in relation to geologic structures and tectonic provinces and to identify structures or regions that are characterized by consistent relations between seismic activity and structural features

state (on Map C) that the southern part of the "fold belt (roughly the Valley and Ridge physiographic province)" is an

300 132

area

> *... in which major faults are known, but the epicentral distribution does not indicate that they are the source of recorded earthquakes.*

The NRC staff appears to be in agreement that the past methods of defining tectonic provinces have been ambiguous. Their <u>Geosciences Staff Recommendations for Revisions to Appendix A</u> (p. 5) states that,

> *It is the staff's view that the weight given to 'classical' evaluations of structural geologic provinces is, for the most part, inappropriate because the provinces derived from such a synthesis do not reflect the more recent tectonic events which we believe may dominate the character of the various earthquake source regions which we strive to define.*

In the same recommendations (p. 6) the staff, in regard to the Indian Point appeal board hearings, states that

> *Although the staff expressed that it used as guidance the classic structural provinces established by several eminent geologists, the staff recognized that the provinces, although meeting the Commission's definition of tectonic provinces did not meet the intent (i.e., regions of equal earthquake potential) of the Regulation.*

The preponderance of existing geologic and seismic information indicates that earthquakes of the southern Appalachian region occur in the Precambrian crystalline basement beneath the overthrusted Paleozoic strata and structures. J. C. Stepp, in a meeting on March 1, 1978, between the NRC and TVA staffs regarding the TVA seismic issue, stated that two of the assumptions NRC uses are that earthquakes in the Valley and Ridge (1) occur at a depth of 10 miles or less, and (2) are not related to visible structure.

300 133

In order to obtain a better understanding of present-day seismicity of the southern Appalachian region, in October 1977 TVA initiated a program involving the acquisition of magnetic, gravity, and photo-imagery data, and the most detailed and reliable historic and instrumental earthquake data available. These data sets were thought to have the greatest potential for looking beneath overthrust strata to define structures, trends, or patterns in the crystalline basement that could serve to localize seismicity or at least provide some reasonable basis for delineating "tectonic provinces" in the southern Appalachian region.

Coincidentally, in December 1977, TVA received copies of NRC staff documents that were discussed at the December 15, 1977, meeting of the ACRS Seismic Subcommittee. Included in these documents was the previously mentioned Geosciences Staff Recommendations for Revisions to Appendix A. This report stresses that, in order to properly identify earthquake source areas and their relation to geologic structure, one must look to the present stress regime based on earthquake source mechanisms and in-situ stress analyses, remote sensing techniques (including photo-imagery, reflection, refraction, aeromagnetic and gravity surveys, etc.), and historic seismicity. It was further stated (p. 6) that

> *The pattern and intensity of historic seismicity is one of the best and most direct indicators of present-day tectonic activity, and, as such, it should play a significant role in our determination of tectonic provinces;*

300 134

and (p. 8) that

> *It is our view that the patterns and rates of historic seismicity yield, in some cases, compelling evidence for the existence or lack of existence of a structure capable of generating earthquakes.*

The report also states (p. 9) that the staff favors interpretations that

> *... would consider the association of particular earthquakes with zones which are not necessarily specifically defined by structure but are inferred on the basis of geophysical data, geologic data, or tectonic history and seismicity ...*

Upon receipt of the December 27, 1977, letter from NRC stating their concern regarding the seismic design bases for the Sequoyah, Watts Bar, and Bellefonte nuclear plants, TVA accelerated various phases of its ongoing study in the hope that some definitive results might materialize within a reasonable time to assist TVA and the staff in assessing the conservatism of the seismic design bases for the three plants.

Aeromagnetic data previously acquired in central Tennessee and south-central Kentucky as part of TVA's mineral resource program were supplemented by in-house flying in southeast Kentucky. For expediency, GeoMetrics, Inc., was contracted to supply coverage in the area between Roanoke, Virginia, and Chattanooga, Tennessee, with concentrated coverage in the areas of Giles County, Virginia, and the Sequoyah-Watts Bar plants. These data were photomosaiced to

300 135

existing data available both in-house and from outside sources into a regional scale aeromagnetic anomaly map covering approximately 110,000 square miles. QEB, Inc., was subcontracted by GeoMetrics, Inc., to produce an interpreted Compudepth (depth to magnetic basement) map of the aeromagnetic data flown by GeoMetrics. Dr. Douglas O'Brien was the principal interpreter of these data. Data on a gravity tape obtained from NOAA in 1978 were plotted by Dr. G. R. Keller, University of Texas at El Paso, and contoured by TVA to produce a regional scale simple Bouguer map covering most of the area between 33° to 39°N. latitude and 79° to 88°W. longitude. The Geological Services Section of Texas Instruments, Inc., was contracted to analyze LANDSAT and SKYLAB photoimagery within a 79,488 square mile area in order to annotate lineaments and curvilinears that may be indicative of basement structure. The principal interpreter of the photoimagery was Andres B. Zuzek. Available seismic reflection profiles and data from deep wells were reviewed. A detailed in-house historic earthquake epicenter study was made, resulting in the production of an epicenter map and a catalogue of historical epicenters. All of these studies are described in the following section entitled METHODOLOGY.

Data were compiled at various scales but, for ease in interpretation and presentation, are all provided in final form as 1:1,000,000 scale maps included separately with this report.

300 136

Outside consultants other than the contractors and their principals were:

Dr. William J. Hinze - Purdue University, consultant for aeromagnetics and gravity

Dr. Robert D. Hatcher, Jr. - The Florida State University, consultant for regional geology, tectonics and structure

Dr. Shelton S. Alexander - The Pennsylvania State University, consultant for seismicity and photo-imagery interpretation

The conclusions reached in this report are the result of the combined interpretation of the data by the TVA staff and the above-listed contract principals and consultants.

Reference Cited

Hadley, J. B., and Devine, J. F., 1974, Seismotectonic map of the Eastern United States: U. S. Geol. Survey Misc. Field Studies Map MF-620, 3 sheets (scale 1:5,000,000) and text.

300 137

METHODOLOGY

AEROMAGNETIC DATA

Aeromagnetic investigations consisted of (1) collecting existing data and (2) acquiring new data.

Existing data covering approximately 78,000 square miles were photoreduced to 1:1,000,000 scale and mosaiced. New data acquisition--mainly restricted to the Valley and Ridge--consisted of approximately 32,000 square miles contracted to GeoMetrics, Inc.

Data reduction by GeoMetrics was limited to production of (1) a total intensity magnetic anomaly map, and (2) Compudepth profiles. QEB, Inc., was subcontracted by GeoMetrics to interpret the Compudepth profiles, in conjunction with the total intensity magnetic anomaly map, and the results of their interpretation are presented as the COMPUDEPTH MAP. Separate reports submitted to TVA by GeoMetrics (Noise Analysis) and by QEB, Inc. (Compudepth interpretation) are available for inspection.

Existing and new aeromagnetic data were combined to produce the COMPOSITE TOTAL FIELD MAGNETIC ANOMALY MAP, which includes an index map that shows critical specifications of aeromagnetic surveys.

The accompanying flow chart illustrates the general acquisition, data reduction, and interpretation performed to date.

DOCUMENT/ PAGE PULLED

ANO. 7907060316

NO. OF PAGES 1

REASON:

- [x] PAGE ILLEGIBLE:
  - [ ] HARD COPY FILED AT: PDR CF OTHER ________
  - [ ] BETTER COPY REQUESTED ON ___/___/___
- [ ] PAGE TOO LARGE TO FILM:
  - [ ] HARD COPY FILED AT: PDR CF OTHER ________
  - [ ] FILMED ON APERTURE CARD NO. ________

300 139

GRAVITY DATA

Gravity investigations consisted of compiling existing data from a gravity station magnetic tape which Purdue University purchased from the National Oceanographic and Atmospheric Administration (NOAA) in January 1978. This tape basically represents Defense Mapping Agency file data covering the area between latitudes 33° and 39°N. and longitudes 79° and 88°W.

Dr. G. R. Keller, University of Texas at El Paso, and Dr. William J. Hinze of Purdue University reviewed the raw data for obvious erroneous values. The raw data were gridded on a 2 kilometer spacing and supplied to TVA. TVA then contoured the data on a 4 kilometer grid spacing at a 1:250,000 scale. The map was then photoreduced to 1:1,000,000 and is presented as the SIMPLE BOUGUER GRAVITY MAP.

The accompanying flow chart shows the various phases of data acquisition, reduction, and interpretation performed to date.

300 140

DOCUMENT/
PAGE
PULLED

ANO. 7907060316

NO. OF PAGES 1

REASON:

- [x] PAGE ILLEGIBLE:
  - [ ] HARD COPY FILED AT: PDR CF
    OTHER ______
  - [ ] BETTER COPY REQUESTED ON ___/___/___
- [ ] PAGE TOO LARGE TO FILM:
  - [ ] HARD COPY FILED AT: PDR CF
    OTHER ______
  - [ ] FILMED ON APERTURE CARD NO. ______

300 141

HISTORICAL SEISMICITY

Objective

A catalogue of historical seismicity (Table I), incorporating most of the southeast region of the United States, has been compiled for use in the evaluation of the seismic hazard in the eastern part of the TVA area. This compilation was performed in order to (1) eliminate duplicate reporting of events; (2) resolve conflicts in locations; and (3) provide a consistent evaluation of intensities.

Study Area

Available data for earthquakes located between approximately 31° and 39°N. latitude and approximately 76° and 87°W. longitude were evaluated, although the actual epicenters plotted on the enclosed EARTHQUAKE EPICENTER MAP are restricted to a 79,500 square mile study area. Historical earthquake epicenters from the Southern Appalachian Tectonic Province, the Piedmont Tectonic Province, the Coastal Plain Tectonic Province (exclusive of Charleston-Summerville), and a part of the Central Stable Region are represented in the compilation.

300 142

Data Sources

The initial phase of data collection began with the collation of earthquake data from seven principal sources: (1) various U.S. Departments of Interior and Commerce (USC&GS, USGS, NOAA) publications; (2) W. C. McClain and O. H. Meyers, Oak Ridge National Laboratory; (3) Gilbert A. Bollinger, Virginia Polytechnic Institute; (4) George P. Woollard, University of Hawaii; (5) Berlen C. Moneymaker, former Chief, Geologic Branch, Tennessee Valley Authority; (6) Stephen Taber, University of South Carolina; and (7) Gerald R. MacCarthy, University of North Carolina.

Data from these sources were assembled and collated to form a basic reference list. A process was then begun to obtain all available published references for each event, for the purpose of tracing back to the original source (i.e., newspaper account, personal report).

Data Analysis

Three basic objectives in compiling the catalogue of historical seismicity (Table I) are:

(1) Elimination of duplicate reporting of events. Through the analysis of dates, times, descriptions and references cited, it was possible to eliminate some duplicate events and "non-events." In several instances, events in the study area were found to

300 143

be related to larger events located outside the study area and were thus misassociated. The principal causes of duplicate reporting were the confusion of local versus GMT (Greenwich Mean Time) date/times and the transposition of descriptive information from event to event. Several new events are listed in this compilation as the result of separating previously reported single events based on confused accounts.

(2) Resolution of conflicts in epicenter placements based on macro-seismic effects. The most abundant and simplest form of conflict arises from a selection of different coordinates for the same geographical location. Another problem arises when the evidence for a macro-center is ambiguously defined, and placement of the epicenter has to be based on the reviewer's judgment. The locations of events compiled in this catalogue were interpreted by analyzing the spatial distribution of intensity data and the reported foreshock and aftershock activity when available.

(3) Consistent evaluation of intensities throughout the entire catalogue. It is well understood that intensity is subjective and depends on the evaluation of the reported effects of the earthquake. No attempt was made in this evaluation to account for

variation in effects caused by changes in quality of construction, foundation conditions, or earthquake source parameters, etc. Event intensities were assigned principally on the basis of reported physical effects, although numerous events of Intensity IV or less were assigned intensities solely on the basis of reported character and/or accompanying sounds.

Some of the listings in the accompanying catalog are based on reported effects which are characteristic of one intensity but which also include a few reported effects of the next higher intensity. In order to indicate the "transitional" nature of the source data, such events are shown in the catalog as two intensity numbers separated by a dash (i.e., VI-VII). A more specific designation would be to assign the event to the upper range of the lower intensity value.

Earthquake Source Listing

Table I (Catalogue of Historical Epicenters) is a comprehensive listing of earthquakes reported from the area within 31° to 39°N. latitude and 76" to 87°W. longitude, beginning with an event reported in 1735 and ending in

December 1977. An attempt was made to make all dates and times consistent with GMT and to give locations to the nearest tenth of a degree.

Table II is a comparison of location and intensity data for events reported in this catalogue with those in the NOAA publication, Earthquake History of the United States (Coffman and von Hake, 1973), which has been accepted by the NRC. Only events of intensity IV-V and greater are routinely listed in Earthquake History, and the most recent compilation ends with 1970. This comparison is made to show any differences.

300 146

TABLE I

CATALOGUE OF HISTORICAL EPICENTERS

YR	MO	DA	Approx. ORIGIN	NLAT	WLON	LOCALE	Io
1735	Mar.	8		35.5	76.8	Bath, NC	
1755	Nov.			33.4	79.3	Georgetown, SC	
1774	Feb.	21	19:00			central VA	V
1775	Mar.	16	19:15	37.7	78.8	Nelson Co., VA	IV-V
1775	Aug.	30	07:00	37.7	78.8	Nelson, Co., VA	III-IV
1776	Nov.	5	P.M.	35.4	83.4	Bryson City, NC	IV
1787	Nov.	9	P.M.	36.1	80.2	Winston-Salem, NC	
1789	Nov.	19	11:00	38.3	77.5	Fredericksburg, VA	
1791	Jan.	13	09:00	37.7	78.8	Nelson Co., VA	IV
1791	Jan.	15	10:00	37.5	77.4	Richmond, VA	IV
1791	Apr.		13:00			northeastern KY	IV-V
1792	Aug.	12	02:00	36.1	80.2	Winston-Salem, NC	IV
1795	Feb.	12	01:00			central VA	IV
1801	Feb.	11	02:00	37.4	79.1	Lynchburg, VA	
1802	Aug.	23	10:00	37.5	77.4	Richmond, VA	IV-V
1807	Apr.	30	09:00			central VA	V
1808	Dec.	13	10:30	35.8	78.6	Raleigh, NC	IV
1811	Nov.	27	08:00	36.1	80.2	Winston-Salem, NC	IV
1812	Feb.	2	14:30	37.5	77.4	Richmond, VA	V
1812	Apr.	22	09:00	37.5	77.4	Richmond, VA	IV-V
1817	Jan.	8	09:34			southwestern VA	IV-V
1817	Dec.	11	03:00			GA-SC	IV
1817	Dec.	12				KY	IV
1820	Sep.	3	08:00	33.4	79.3	Georgetown, SC	
1823	Aug.	23	P.M.	36.1	80.2	Winston-Salem, NC	IV
1825				36.2	81.2	Wilkesboro, NC	
1825	Mar.	19	A.M.	35.6	87.0	Columbia, TN	
1826	Aug.	10	02:00	37.5	77.4	Richmond, VA	
1826	Oct.	15		32.1	81.1	Savannah, GA	IV
1827	May	11	P.M.	36.2	81.2	Wilkesboro, NC	IV
1828	Mar.	10	03:00			southwestern VA	V
1829				35.2	83.8	Andrews, NC	
1833	Aug.	27	11:00	37.6	77.7	central VA	V
1834	Nov.	20	19:40			northern KY	V
1834	Nov.	29		36.1	80.2	Winston-Salem, NC	
1836	May	7		36.0	83.9	Knoxville, TN	
1843	Apr.	11		34.3	80.6	Camden, SC	
1844	Jun.			35.4	83.4	Bryson City, NC	
1844	Nov.	28	13:00	35.8	84.0	Maryville, TN	VI
1846	Oct.	19	02:00	38.9	78.5	Woodstock, VA	IV
1848				35.7	82.1	McDowell Co., NC	
1850	Mar.	30	15:00	35.4	78.0	Goldsboro, NC	IV-V
1850	Oct.	17	A.M.	37.3	78.4	Farmville, VA	IV
1851	Aug.	11	01:55	35.6	82.6	Asheville, NC	V
1852	Jan.	26		38.2	85.8	Louisville, KY	

YR	MO	DA	Approx. ORIGIN	NLAT	WLON	LOCALE	Io
1852	Apr.	29	17:51	37.3	80.7	southwestern VA	VI-VII
1852	May	3	08:00	36.7	82.0	Abingdon, VA	
1852	Sep.	18	08:00	36.7	82.0	Abingdon, VA	
1852	Oct.	12	00:00	33.0	83.5	Clinton, GA	
1852	Oct.	23	05:00	33.0	83.5	Clinton, GA	
1852	Nov.	2	23:35	37.6	78.6	Buckingham, VA	VII
1853	Jan.	30	07:00	38.9	78.5	Woodstock, VA	IV
1853	May	2	14:20			VA-WV	V
1853	May	20	A.M.	34.0	81.2	Lexington, SC	V-VI
1854	Feb.	13	00:00	37.2	83.8	Manchester, KY	
1854	Feb.	28	A.M.	37.2	83.8	Manchester, KY	IV
1854	Nov.	22	21:00	37.1	81.5	Tazewell, VA	
1855	Feb.	2	08:00	37.1	78.6	Charlotte Courthouse, VA	VI
1856	Mar.	21	14:00	37.7	78.8	Nelson Co., VA	IV
1857	Dec.	11	03:00	37.8	80.4	Lewisburg, WV	
1859	Mar.	22		37.1	81.5	Tazewell, VA	IV
1860	Jan.	20	00:00			NC-SC-GA	
1861	Aug.	31	10:22	36.2	81.2	Wilkesboro, NC	VI-VII
1869	Feb.	20	P.M.	38.0	84.5	Lexington, KY	IV
1871	Apr.	16	05:00	34.2	77.9	Wilmington, NC	V
1871	Apr.	21	02:00	36.3	78.6	Oxford, NC	
1872	Mar.	1	P.M.	36.8	79.4	Chatham, VA	IV
1872	Jun.	5	03:00	37.6	77.7	central VA	IV
1872	Jun.	17	21:00	33.1	83.2	Milledgeville, GA	IV
1873	Oct.	3	12:45	37.2	78.2	Burkeville, VA	IV
1874	Feb.	22		35.7	82.1	McDowell Co., NC	V
1875	Mar.	10	05:00			Goochland Co., VA	IV
1875	Jul.	29	00:05	33.1	83.2	Milledgeville, GA	IV
1875	Nov.	2	02:55	33.7	82.7	Washington, GA	IV
1875	Nov.	12	08:00	36.0	83.9	Knoxville, TN	IV
1875	Dec.	23	04:45	37.6	77.7	central VA	VII
1875	Dec.	26	06:00	37.0	77.9	Powhatan, VA	IV
1876	Jan.	23		35.7	82.1	McDowell Co., NC	
1876	Dec.	21	15:30	37.0	81.1	Wytheville, VA	
1877	Apr.	26	22:00	35.2	83.4	Franklin, NC	
1877	May	25		36.0	83.9	Knoxville, TN	
1877	Jun.	3		37.5	84.7	Stanford, KY	
1877	Oct.	9	01:00	35.3	82.5	Hendersonville, NC	
1877	Nov.	16	08:38	36.0	83.9	Knoxville, TN	IV
1878	Jan.	2	23:55	38.0	78.0	Louisa, VA	IV
1878	Nov.	23	15:00	35.1	84.0	Murphy, NC	IV
1879	Oct.	27	01:00	34.4	81.1	Winnsboro, SC	IV
1879	Dec.	13	00:00	35.2	80.8	Charlotte, NC	IV
1880	Jan.	28		35.7	82.1	McDowell Co., NC	IV
1880	Feb.	10		35.7	82.1	McDowell Co., NC	

300 148

YR	MO	DA	Approx. ORIGIN	NLAT	WLON	LOCALE	Io
1882	Jan.	8	22:10	34.6	76.5	Cape Lookout, NC	IV
1882	Apr.	3	02:00	38.6	78.7	New Market, VA	IV
1882	Oct.	15	17:30	35.1	84.0	Murphy, NC	
1882	Oct.	23	12:00	35.1	77.0	New Bern, NC	IV
1883	May	23	05:30	38.4	82.6	Catlettsburg, KY	IV
1883	Sep.	21	11:45	36.1	77.4	Greensboro, NC	IV
1884	Jan.			35.7	82.1	McDowell Co., NC	
1884	Jan.	18	13:00	34.7	76.7	Beaufort, NC	V
1884	Mar.	30	01:00			Accomak Co., VA	IV
1884	Mar.	31	10:00	33.1	83.2	Milledgeville, GA	
1884	Apr.	30	11:46	35.1	84.0	Cherokee Co., NC	IV
1884	(Summer)			35.7	82.5	Elk Mt., NC	
1884	Aug.	25	00:45	36.0	83.9	Knoxville, TN	IV
1885	Jan.	3	02:16	39.0	77.7	Middleburg, VA	VI
1885	Feb.	2	12:10	37.0	81.1	Wytheville, VA	IV
1885	Aug.	13	13:00	36.1	81.7	Blowing Rock, NC	IV
1885	Oct.	10	04:35	37.7	78.0	central VA	V
1885	Oct.	17	22:30	33.0	82.8	Sandersville, GA	
1886	Feb.	5	01:00	34.6	85.6	Valley Head, AL	IV
1886	Sep.	2	03:00	38.0	78.5	Charlottesville, VA	
1886	Sep.	4	05:00	38.4	78.9	Dale Enterprise, VA	V
1886	Sep.	25	02:56	37.0	81.1	Wytheville, VA	
1888	Mar.	17		36.3	82.5	Jonesboro, TN	
1889	Sep.	28	P.M.	35.1	84.6	Parksville, TN	
1892	Dec.	2	08:00	35.0	85.3	Chattanooga, TN	V
1895	Oct.	6	16:30	35.9	77.5	Tarboro, NC	IV
1896	Feb.	11	01:45	36.3	78.6	Oxford, NC	IV
1897	May	3	17:18	37.3	80.7	Giles Co., VA	VI-VII
1897	May	31	18:58	37.3	80.7	Giles Co., VA	VIII
1897	Jun.	29	04:00	37.3	80.7	Giles Co., VA	IV
1897	Sep.	3	12:00	37.3	80.7	Giles Co., VA	
1897	Oct.	22	03:25	37.3	80.7	Giles Co., VA	IV-V
1897	Nov.	27	20:56	37.8	77.5	Ashland, VA	IV
1897	Dec.	18	23:45	37.6	77.6	central VA	IV
1898	Feb.	5	20:00	37.2	80.6	southwestern VA	VI-VII
1898	Feb.	11	04:30	35.8	78.6	Raleigh, NC	IV
1898	Mar.	30	01:30	36.8	85.8	Mt. Hermon, KY	
1898	Jun.	6	08:30	37.8	84.3	Richmond, KY	
1898	Nov.	25	20:00	37.2	80.6	southwestern VA	V-VI
1899	Feb.	13	09:30	37.3	80.7	Giles Co., VA	V-VI
1899	Mar.	3	A.M.	36.8	76.3	Norfolk, VA	V
1902	May	18	04:00	37.3	80.7	Giles Co., VA	IV
1902	May	29	07:30	35.0	85.3	Chattanooga, TN	IV
1902	Oct.	18	22:00	35.0	85.3	GA-TN Border	V-VI
1903	Jan.	24	01:15	32.1	81.1	Savannah, GA	IV
1904	Mar.	5	00:30	35.8	84.0	Maryville, TN	III-IV
1905	Apr.	29		37.3	79.5	Bedford, VA	IV
1907	Feb.	11	13:22	37.7	78.3	Arvonia, VA	VI
1908	Aug.	23	09:30	37.6	77.6	central VA	IV

300 14

YR	MO	DA	Approx. ORIGIN	NLAT	WLON	LOCALE	Io
1909	Oct.	8	10:00	34.8	85.0	Dalton, GA	
1910	Feb.	8	14:00	38.6	78.7	New Market, VA	IV
1910	May	8	21:10	37.7	78.3	Arvonia, VA	IV
1911	Feb.	10	10:22	36.6	79.8	Danville, VA	IV
1911	Apr.	22	03:00	35.3	82.5	Hendersonville, NC	IV
1912	Jun.	20		32.1	81.1	Savannah, GA	IV
1912	Aug.	8	01:00	37.7	78.3	Arvonia, VA	IV
1912	Oct.	23	01:15	32.8	83.6	Macon, GA	IV
1912	Dec.	7	19:10	34.7	81.8	West Springs, SC	V
1913	Jan.	1	18:28	34.7	81.8	West Springs, SC	VII
1913	Mar.	13	05:00	34.5	85.0	Calhoun, GA	IV
1913	Mar.	28	22:50	36.0	83.9	Knoxville, TN	VI-VII
1913	Apr.	17	17:30	35.5	84.4	Madisonville, TN	VI
1913	May	2	07:00	35.5	84.4	Madisonville, TN	IV
1913	Aug.	3	17:45	36.0	83.9	Knoxville, TN	IV
1913	Nov.	11	14:00	38.2	85.8	Louisville, KY	
1914	Jan.	24	04:24	35.5	84.6	Niota, TN	IV-V
1914	Mar.	5	20:05	33.5	84.0	central GA	IV
1914	Mar.	6	20:30	34.7	81.2	Chester, SC	
1914	Mar.	7	01:20	34.4	80.1	Hartsville, SC	IV
1914	Jun.	1	04:03	32.9	80.7	Walterboro, SC	
1915	Jan.	14	09:20	36.6	82.2	Bristol, TN	IV
1915	Oct.	29	05:45	35.8	82.7	Marshall, NC	V
1916	Feb.	21	22:39	35.5	83.0	Waynesville, NC	VII
1916	Mar.	2	05:02	34.5	82.7	Anderson, SC	IV
1916	Aug.	26	19:35	35.9	81.2	Taylorsville, NC	V-VI
1916	Oct.	18	22:04	33.5	86.2	Easonville, AL	VII
1916	Nov.	4	12:15	33.5	86.8	Birmingham, AL	VI
1917	Jan.	2	10:30			McMillan, TN	IV
1917	Jan.	25	22:15	36.1	83.5	Jefferson City, TN	
1917	Mar.	5	03:07	36.0	83.9	Knoxville, TN	
1917	Mar.	27	21:00	36.1	83.5	Jefferson City, TN	V
1917	Apr.	19				southwestern VA	
1918	Jan.	17	16:45	36.0	83.9	Knoxville, TN	V
1918	Apr.	10	01:09	38.6	78.5	Luray, VA	VI
1918	Apr.	16	12:40	38.6	78.5	Luray, VA	IV
1918	Apr.	19		36.8	76.3	Norfolk, VA	IV
1918	Apr.	19		37.3	79.9	Roanoke, VA	
1918	Jun.	22	00:59	35.8	84.3	Lenoir City, TN	IV
1919	Sep.	6	01:46	38.9	78.2	Arco, VA	VI-VII
1920	Jul.	24		38.6	78.5	Luray, VA	IV
1920	Dec.	24	08:30	35.8	84.7	Glen Alice, TN	V
1921	Jul.	15		36.7	82.3	Mendota, VA	V-VI
1921	Aug.	7	06:30	37.7	78.3	New Canton, VA	V-VI
1921	Sep.	2	14:00	36.0	86.1	Statesville, TN	IV
1921	Dec.	15	14:30	35.9	84.5	Kingston, TN	VI

300 1[illegible]

YR	MO	DA	Approx. ORIGIN	NLAT	WLON	LOCALE	Io
1922	Mar.	30	02:21	36.6	82.5	Arcadia, TN	
1923	Oct.	18	19:30	35.3	82.5	Hendersonville, NC	IV
1924	Jan.	1	01:06	34.8	82.4	Greenville, SC	IV
1924	Jan.	1	04:45	36.6	79.8	Danville, VA	IV
1924	Oct.	20	08:30	34.9	82.7	Pickens, SC	V
1924	Nov.	13	05:30	36.6	82.2	Bristol, VA	V
1924	Dec.	25	04:30	37.3	79.9	Roanoke, VA	VI
1925	May	16	01:30	37.2	77.4	Colonial Heights, VA	VI
1925	Jul.	14	21.20	37.5	77.4	Richmond, VA	IV
1926	Jul.	8	09:50	35.7	82.1	McDowell Co., NC	VII
1927	Jun.	10	07:16	37.7	78.0	central VA	V
1927	Jun.	16	13:00	34.7	86.0	Scottsboro, AL	V
1927	Jul.	20	08:58	36.0	83.9	Knoxville, TN	V
1927	Oct.	8	13:58	35.0	85.3	Chattanooga, TN	IV
1927	Oct.	27	A.M.	36.3	76.2	Elizabeth City, NC	IV-V
1927	Nov.	22	23:50	33.9	78.0	Southport, NC	IV-V
1928	Mar.	7	02:45	35.6	87.0	Columbia, TN	IV
1928	Oct.	30	11:45	37.5	77.4	Richmond, VA	IV
1928	Nov.	3	04:04	35.9	82.8	Hot Springs, NC	VI-VII
1928	Nov.	20	03:45	35.9	82.8	Hot Springs, NC	IV
1928	Nov.	22		33.9	78.0	Southport, NC	IV
1928	Dec.	23	02:30	35.3	80.8	Charlotte, NC	IV
1929	Jan.	3	12:05	33.9	80.4	Sumter, SC	IV
1929	Oct.	28	02:15	34.3	82.4	Due West, SC	IV
1929	Dec.	26	02:56	38.0	78.5	Charlottesville, VA	VI-VII
1930	Aug.	30	10:28	35.8	84.3	Lenoir City, TN	V-VI
1930	Sep.	15	07:40	37.5	77.4	Richmond, VA	IV
1930	Oct.	16	21:50	36.0	83.9	Knoxville, TN	VI-VII
1930	Dec.	10	00:02	34.3	82.4	Due West, SC	III-IV
1930	Dec.	26	03:00	34.4	80.1	Hartsville, SC	IV
1931	May	5	13:18	33.5	86.8	Birmingham, AL	VI
1931	Oct.	6	03:15	37.7	78.3	New Canton, VA	IV
1931	Nov.	27	09:23	36.2	86.8	Nashville, TN	
1932	Jan.	5	04:05	37.7	78.3	New Canton, VA	V
1932	Dec.	25	P.M.	37.2	77.4	Petersburg, VA	
1933	Jan.	27	03:00	37.2	77.4	Petersburg, VA	IV
1933	May	28	15:10	38.6	83.8	Maysville, KY	IV
1933	Jul.	23	15:00	37.7	78.3	New Canton, VA	IV
1934	Apr.	3	02:05	37.2	77.4	Petersburg, VA	
1935	Jan.	1	08:15	35.0	83.7	Shooting Creek, NC	V-VI
1935	Feb.	10	23:45	37.2	77.4	Petersburg, VA	IV
1935	Nov.	1	08:30	38.9	79.9	Elkins, WV	IV
1936	Jan.	1	08:00	34.9	84.3	Blue Ridge, GA	IV
1936	Apr.	10	00:42	38.0	78.5	Charlottesville, VA	IV
1936	Sep.	6		35.4	80.2	Albemarle, NC	
1937	Feb.	2	01:26	37.8	78.5	Scottsville, VA	IV

300 151

YR	MO	DA	Approx. ORIGIN	NLAT	WLON	LOCALE	Io
1938	Mar.	31	10:10	35.5	84.0	Tapoco, NC	V
1939	May	5	03:45	33.7	85.8	Anniston, AL	V-VI
1939	Jun.	24	11:27	34.7	86.6	Huntsville, AL	IV
1940	Jan.	8	20:05	38.2	85.8	Louisville, KY	
1940	Mar.	26	03:28	38.9	78.5	Woodstock, VA	V
1940	May	27	08:30	38.2	85.8	Louisville, KY	
1940	Oct.	19	05:55	35.0	85.1	Ryall Springs, TN	V
1940	Dec.	25	06:50	35.9	82.8	Hot Springs, NC	V
1941	Mar.	4	06:15	35.8	83.9	Rockford, TN	IV
1941	May	10	11:12	35.6	82.6	Asheville, NC	IV
1941	Sep.	8	09:45	35.0	85.4	Lookout Mt., TN	V
1942	Jan.	3	08:30	37.4	79.1	Lynchburg, VA	
1942	Oct.	7	03:15	37.5	78.4	Dillwyn, VA	IV
1942	Nov.	1	03:20	34.4	81.1	Winnsboro, SC	
1943	Apr.	13	17:00	38.2	85.8	Louisville, KY	
1945	Jun.	14	03:25	35.2	84.9	Cleveland, TN	V
1945	Jul.	26	10:32	34.0	81.2	Murray Lake, SC	VI
1945	Oct.	10	20.43	37.7	78.3	New Canton, VA	IV
1945	Oct.	12	20:00	37.5	78.4	Dillwyn, VA	IV
1945	Oct.	30	02:29	37.5	78.4	Dillwyn, VA	IV
1946	Apr.	7	05:00	35.2	84.9	Cleveland, TN	IV
1946	May	24	19:40	38.0	78.5	Charlottesville, VA	IV
1947	Jun.	6	12:55	36.0	83.9	Knoxville, TN	IV-V
1947	Dec.	28	00:05	35.0	85.3	Chattanooga, TN	IV
1948	Jan.	5	03:20	37.5	78.4	Dillwyn, VA	V-VI
1948	Feb.	10	00:04	36.4	84.0	Wells Springs, TN	VI
1948	Mar.	26	23:48	38.0	78.5	Charlottesville, VA	
1949	May	8	11:01	37.0	77.9	Powhatan, VA	V-VI
1949	Sep.	17	09:30	36.8	83.0	Pennington Gap, VA	IV
1950	Jun.	19	04:19	35.8	84.0	Maryville, TN	V
1950	Nov.	26	07:45	37.7	78.3	Arvonia, VA	V
1951	Mar.	9	07:00	37.5	77.4	Richmond, VA	IV-V
1952	Feb.	6	16:12	33.5	86.8	Birmingham, AL	V-VI
1952	Jun.	11	20:20	36.3	82.4	Johnson City, TN	VI
1952	Sep.	11	03:15	38.0	78.4	Shadwell, VA	IV
1953	Feb.	7	07:05	37.6	77.8	Sabot, VA	IV
1953	Nov.	10	14:53	36.0	83.9	Knoxville, TN	IV
1953	Dec.	5	13.45	36.0	83.9	Knoxville, TN	IV
1954	Jan.	1	01:30	37.2	83.2	Hazard, KY	IV
1954	Jan.	2		37.2	83.2	Hazard, KY	VI-VII
1954	Jan.	14	P.M.	36.0	83.9	Knoxville, TN	IV
1954	Jan.	23	01:00	35.3	84.5	Etowah, TN	V
1955	Jan.	6	20:30	36.6	82.2	Bristol, TN	IV
1955	Jan.	12	17:25	35.8	84.0	Maryville, TN	IV
1955	Jan.	17	12:37	37.3	78.4	Farmville, VA	V
1955	Jan.	25	19:31	35.8	83.9	Rockford, TN	V-VI
1955	Sep.	28	07:02	36.6	81.3	Piney Creek, NC	VI
1956	Jan.	5	08:00	34.3	82.4	Due West, SC	IV
1956	May	19	19:00	34.3	82.4	Due West, SC	IV
1956	May	27	23:25	34.3	82.4	Due West, SC	IV

300 152

YR	MO DA	Approx. ORIGIN	N.LAT	WLGN	LOCALE	Io
1956	Sep. 7	13:36	36.2	83.8	Maynardville, TN	VI-VII
1956	Sep. 9	22:45	35.8	86.7	College Grove, TN	IV-V
1957	Jan. 25	18:15	36.6	83.7	Middlesboro, KY	IV
1957	Apr. 23	09:24	33.5	86.8	Birmingham, AL	VI
1957	May 13	14:25	35.8	82.0	Sevier, NC	VI
1957	Jun. 23	06:34	35.9	84.2	Dixie Lee Junction, TN	IV
1957	Jul. 2	09:33	35.6	82.6	Asheville, NC	VI
1957	Nov. 7	17:15	36.0	84.0	Powell, TN	IV
1957	Nov. 24	20:06	35.4	83.4	Bryson City, NC	VI-VII
1958	Mar. 5	11:54	34.2	77.9	Wilmington, NC	V
1958	Apr. 8	17:00	31.4	83.5	Tifton, GA	III
1958	May 16	22:30	35.6	82.6	Asheville, NC	IV
1958	Oct. 20	06:16	34.5	82.7	Anderson, SC	V
1959	Apr. 23	20:59	37.3	80.7	Giles Co., VA	VI-VII
1959	Jun. 13	01:00	35.4	84.3	Tellico Plains, TN	IV
1959	Jul. 7	23:17	37.3	80.7	Giles Co., VA	IV
1959	Aug. 12	18:06	34.8	86.6	Meridianville, AL	VI-VII
1959	Aug. 21	17:20	37.3	80.7	Giles Co., VA	IV
1959	Oct. 27	02:07	34.5	80.2	McBee, SC	V
1960	Jan. 3	07:33	35.9	82.1	Spruce Pine, NC	
1960	Feb. 9	14:00	35.4	82.4	Edneyville, NC	VI
1960	Apr. 15	10:10	35.8	84.0	Maryville, TN	V
1960	Sep. 4	23:40	37.4	79.2	Boonsboro, VA	IV
1963	Jan. 17	11:40	37.3	80.1	Salem, VA	IV-V
1963	Apr. 11	17:45	34.8	82.4	Greenville, SC	IV
1963	Oct. 28	22:39	36.6	81.0	Ennice, NC	VI
1963	Nov. 14	P.M.	36.2	86.8	Nashville, TN	IV
1963	Dec. 5	11:32	37.2	87.0	Beechmont, KY	
1963	Dec. 15	05:32	37.2	87.0	Beechmont, KY	IV-V
1964	Jan. 20	13:38	35.8	82.3	Pensacola, NC	IV
1964	Feb. 18	10:31	34.6	85.6	Mentone, AL	VI
1964	Mar. 13	01:20	33.0	83.4	Haddock, GA	IV
1964	Apr. 20	19:05	34.1	81.2	Irmo, SC	IV
1964	Jul. 28	19:45	36.0	84.0	Inskip, TN	
1964	Oct. 13	16:30	36.0	83.9	Knoxville, TN	
1965	Apr. 7	02:19	33.9	82.3	McCormick, SC	
1965	Apr. 26	15:26	37.4	81.6	Wilcoe, WV	
1965	Jul. 22	23:56	33.0	82.8	Sandersville, GA	IV
1965	Sep. 9		34.7	81.2	Chester, SC	IV
1965	Nov. 8	12:58	34.2	84.6	Canton, GA	
1966	May 31	06:19	37.6	77.7	central VA	VI
1966	Aug. 24	06:00	35.8	84.0	Maryville, TN	IV
1967	Dec. 16	12:24	37.4	81.6	Wilcoe, WV	
1968	Mar. 8	05:38	37.3	80.7	Giles Co., VA	V-VI
1968	Sep. 22	21:41	34.1	81.2	Irmo, SC	IV
1968	Nov. 10		36.0	84.3	Oak Ridge, TN	IV
1968	Nov. 26	01:00	34.2	77.9	Wilmington, NC	IV
1968	Dec. 11	15:00	38.2	85.8	Louisville, KY	V-VI

300 153

YR	MO	DA	Approx. ORIGIN	NLAT	WLON	LOCALE	Io
1969	May	5	12:14	33.9	82.5	GA-SC Border	
1969	Jul.	13	21:51	36.0	83.9	Knoxville, TN	VI
1969	Jul.	24	18:10	36.0	83.9	Knoxville, TN	
1969	Nov.	20	01:00	37.4	80.9	Elgood, WV	VI-VII
1969	Dec.	11	23:45	37.6	77.7	central VA	V-VI
1969	Dec.	13	10:20	35.0	83.0	SC-NC Border	V
1970	Aug.	11	06:14	38.4	81.7	South Charleston, WV	IV
1970	Sep.	10	01:41	36.2	81.7	Boone, NC	V-VI
1971	May	19	12:54	33.4	80.7	Bowman, SC	V
1971	Jul.	13	03:03	35.9	84.5	Kingston, TN	IV
1971	Jul.	13	11:42	34.7	82.9	Newry, SC	VI
1971	Jul.	31	20:17	33.4	80.9	Cardova, SC	IV
1971	Aug.	11	03:52	33.5	80.9	Orangeburg, SC	
1971	Sep.	12	00:06	38.2	77.6	Post Oak, VA	V-VI
1971	Oct.	9	16:44	35.7	83.5	Gatlinburg, TN	VI
1972	Feb.	3	23:11	33.5	80.6	Elloree, SC	VI
1972	Feb.	7	02:46	33.5	80.6	Elloree, SC	
1972	Aug.	14	15:05	33.5	80.9	Orangeburg, SC	IV
1972	Sep.	5	16:00	37.6	77.7	central VA	V
1973	Jan.	7	22:56	37.4	87.5	Madisonville, KY	
1973	Mar.	28	08:00	33.8	81.1	Gaston, SC	
1973	Apr.	9	23:11	37.4	77.5	Chesterfield, VA	IV
1973	Oct.	30	22:59	35.8	84.0	Maryville, TN	V-VI
1973	Nov.	30	07:49	35.8	84.0	Maryville, TN	VI
1974	Mar.	23	09:47	38.9	77.9	Marshall, VA	
1974	May	30	21:29	37.4	80.4	Simmonsville, VA	V
1974	Jun.	5	00:17	38.5	84.8	Owenton, KY	
1974	Aug.	2	08:52	33.9	82.5	McCormick Co., SC	V-VI
1974	Oct.	8	18:22	34.0	82.3	Clark Hill Reservoir, SC	
1974	Oct.	28	12:33	33.8	81.9	Edgefield, SC	IV
1974	Nov.	5	03:00	33.7	82.2	Clark Hill, SC	
1974	Nov.	7	21:32	37.8	78.2	central VA	IV
1974	Dec.	3	08:25	34.0	82.5	Mt. Carmel, SC	
1975	Feb.	10	18:53	35.7	83.5	Gatlinburg, TN	
1975	Mar.	7	12:45	37.3	80.7	Giles Co., VA	
1975	May	2	16:23	36.0	84.6	Oakdale, TN	
1975	May	14	23:03	36.0	84.3	Oak Ridge, TN	
1975	Aug.	29	04:23	33.8	86.6	Palmerdale, AL	VI
1975	Oct.	18	04:31			Jocassee Lake Dam, SC	IV
1975	Nov.	11	08:11	37.3	80.7	Giles Co., VA	V
1975	Nov.	16	01:01	34.3	80.6	Camden, SC	
1975	Nov.	25	15:18	34.9	83.0	Salem, SC	IV
1976	Jan.	19	06:31	36.9	83.8	Knox Co., KY	VI
1976	Feb.	4	19:54	35.0	84.7	Conasauga, TN	VI

300 154

YR	MO	DA	Approx. ORIGIN	NLAT	WLON	LOCALE	Io
1976	Apr.	28	06:16	33.7	81.8	Trenton, SC	
1976	Jun.	19	05:54	37.4	81.6	Wilcoe, WV	V
1976	Sep.	13	18.55	36.5	80.6	Toast, NC	VI
1976	Dec.	27	06:57	32.0	82.4	Cedar Crossing, GA	V
1977	Feb.	27	20:06	37.9	78.6	Carters Bridge, VA	V
1977	Jul.	27	22:03	35.4	84.4	Wilson Station, TN	
1977	Aug.	25	04:20	33.4	80.7	Bowman, SC	
1977	Sep.	1	21:05	33.8	83.7	Kingville, SC	
1977	Sep.	25	06:23	36.0	82.6	NC-TN Border	
1977	Oct.	23	07:58	37.0	82.0	Honaker, VA	
1977	Nov.	10	11:25	33.4	80.7	Bowman, SC	

TABLE II

COMPARISON OF TVA CATALOGUE OF HISTORICAL EPICENTERS

WITH NOAA EARTHQUAKE HISTORY OF THE UNITED STATES

DATE		TVA NLAT	TVA WLON	TVA Io	NOAA NLAT	NOAA WLON	NOAA Io
1774	Feb. 21	-	-	V	-	-	N/R
1775	Mar. 16	37.7	78.8	IV- V	NOT LISTED		
1791	Apr.	-	-	IV- V	NOT LISTED		
1802	Aug. 23	37.5	77.4	IV- V	NOT LISTED		
1807	Apr. 30	-	-	V	-	-	V
1812	Feb. 2	37.5	77.4	V	NOT LISTED		
1812	Apr. 22	37.5	77.4	IV- V	NOT LISTED		
1817	Jan. 8	-	-	IV- V	NOT LISTED		
1828	Mar. 10	-	-	V	-	-	V
1833	Aug. 27	37.6	77.7	V	-	-	V
1834	Nov. 20	-	-	V	NOT LISTED		
1844	Nov. 28	35.8	84.0	VI	NOT LISTED		
1850	Mar. 30	35.4	78.0	IV- V	NOT LISTED		
1851	Aug. 11	35.6	82.6	V	NOT LISTED		
1852	Apr. 29	37.3	80.7	VI-VII	-	-	VI
1852	Nov. 2	37.6	78.6	VII	NOT LISTED		
1853	May 2	-	-	V	-	-	V
1853	May 20	34.0	81.2	V- VI	NOT LISTED		
1855	Feb. 2	37.1	78.6	VI	37.0	78.6	V
1861	Aug. 31	36.2	81.2	VI-VII	-	-	VI
1871	Apr. 16	34.2	77.9	V	NOT LISTED		
1872	Jun. 17	33.1	83.2	IV	33.1	83.3	V
1874	Feb. 22	35.7	82.1	V	35.7	82.1	V
1875	Nov. 2	33.7	82.7	IV	33.8	82.5	VI
1875	Dec. 23	37.6	77.7	VII	37.6	78.5	VII
1877	Nov. 16	36.0	83.9	IV	35.5	84.0	V
1879	Dec. 13	35.2	80.8	IV	35.2	80.8	V
1884	Jan. 18	34.7	76.7	V	34.3	78.0	V
1885	Jan. 3	39.0	77.7	VI	39.2	77.5	V
1885	Aug. 13	36.1	81.7	IV	36.2	81.6	IV- V
1885	Oct. 10	37.7	78.0	V	37.7	78.8	VI
1886	Feb. 5	34.6	85.6	IV	32.8	88.0	V
[1886	Feb. 13	32.5	87.8	VI-VII]	LISTED TOGETHER WITH ABOVE EVENT		
1886	Sept. 4	38.4	78.9	V	NOT LISTED		
1892	Dec. 2	35.0	85.3	V	NOT LISTED		
1897	May 3	37.3	80.7	VI-VII	37.1	80.7	VI
1897	May 31	37.3	80.7	VIII	37.3	80.7	VII
1897	Oct. 22	37.3	80.7	IV- V	37	81	V

300 156

		TVA			NOAA		
DATE		NLAT	WLON	Io	NLAT	WLON	Io
1897	Dec. 18	37.6	77.6	IV	37.7	77.5	V
1898	Feb. 5	37.2	80.6	VI-VII	37.0	80.7	VI
1898	Nov. 25	37.2	80.6	V- VI	-	-	V
1899	Feb. 13	37.3	80.7	V- VI	37	81	V
1899	Mar. 3	36.8	76.3	V	NOT LISTED		
1902	May 29	35.0	85.3	IV	35.1	85.3	V
1902	Oct. 18	35.0	85.3	V- VI	35.0	85.3	V
1903	Jan. 24	32.1	81.1	IV	32.1	81.1	VI
1904	Mar. 5	35.8	84.0	III- IV	35.7	83.5	V
1905	Jan. 27	NOT LISTED			34	86	VII
1907	Feb. 11	37.7	78.3	VI	37.7	78.4	VI
1908	Aug. 23	37.6	77.6	IV	37.5	77.9	V
1910	May 8	37.7	78.3	IV	37.7	78.4	V
1911	Apr. 22	35.3	82.5	IV	35.2	82.7	V
1912	Jun. 20	32.1	81.1	IV	32	81	V
1912	Dec. 7	34.7	81.8	V	NOT LISTED		
1913	Jan. 1	34.7	81.8	VII	34.7	81.8	VI-VII
1913	Mar. 28	36.0	83.9	VI-VII	36.2	83.7	VII
1913	Apr. 17	35.5	84.4	VI	35.3	84.2	V
1914	Jan. 24	35.5	84.6	IV- V	35.6	84.5	V
1914	Mar. 5	33.5	84.0	IV	33.5	83.5	VI
1915	Oct. 29	35.8	82.7	V	35.8	82.7	V
1916	Feb. 21	35.5	83.0	VII	35.5	82.5	VI
1916	Aug. 26	35.9	81.2	V- VI	36	81	V
1916	Oct. 18	33.5	86.2	VII	33.5	86.2	VII
1916	Nov. 4	33.5	86.8	VI	NOT LISTED		
1917	Mar. 27	36.1	83.5	V	NOT LISTED		
1918	Jan. 17	36.0	83.9	V	NOT LISTED		
1918	Apr. 10	38.6	78.5	VI	38.7	78.4	VI
1918	Jun. 22	35.8	84.3	IV	36.1	84.1	V
1919	Sept. 6	38.9	78.2	VI-VII	38.8	78.2	VI
1920	Dec. 24	35.8	84.7	V	36	85	V
1921	Jul. 15	36.7	82.3	V- VI	36.6	82.3	VI
1921	Aug. 7	37.7	78.3	V- VI	37.8	78.4	V
1921	Dec. 15	35.9	84.5	VI	NOT LISTED		
1924	Oct. 20	34.9	82.7	V	35.0	82.6	V
1924	Nov. 13	36.6	82.2	V	NOT LISTED		
1924	Dec. 25	37.3	79.9	VI	37.3	79.9	V
1925	May 16	37.2	77.4	VI	NOT LISTED		
1926	Jul. 8	35.7	82.1	VII	35.9	82.1	VI
1927	Jun. 10	37.7	78.0	V	38	79	V
1927	Jun. 16	34.7	86.0	V	34.7	86.0	V
1927	Jul. 20	36.0	83.9	V	NOT LISTED		
1927	Oct. 27	36.3	76.2	IV- V	NOT LISTED		
1927	Nov. 22	33.9	78.0	IV- V	NOT LISTED		
1928	Nov. 3	35.9	82.8	VI-VII	36.0	82.6	VI
1929	Dec. 26	38.0	78.5	VI-VII	38.1	78.5	VI

DATE	TVA NLAT	TVA WLON	TVA Io	NOAA NLAT	NOAA WLON	NOAA Io
1930 Aug. 30	35.8	84.3	V- VI	NOT LISTED		
1930 Oct. 16	36.0	83.9	VI-VII	NOT LISTED		
1931 May 5	33.5	86.8	VI	33.7	86.6	V- VI
1932 Jan. 5	37.7	78.3	V	NOT LISTED		
1935 Jan. 1	35.0	83.7	V- VI	35.1	83.6	V
1938 Mar. 31	35.5	84.0	V	NOT LISTED		
1939 May 5	33.7	85.8	V- VI	33.7	85.8	V
1940 Mar. 26	38.9	78.5	V	NOT LISTED		
1940 Oct. 19	35.0	85.1	V	NOT LISTED		
1940 Dec. 25	35.9	82.8	V	NOT LISTED		
1941 Sept. 8	35.0	85.4	V	NOT LISTED		
1945 Jun. 14	35.2	84.9	V	35	84 1/2	V
1945 Jul. 26	34.0	81.2	VI	34.3	81.4	IV- V
1947 Jun. 6	36.0	83.9	IV- V	NOT LISTED		
1948 Jan. 5	37.5	78.4	V- VI	NOT LISTED		
1948 Feb. 10	36.4	84.0	VI	NOT LISTED		
1949 May 8	37.0	77.9	V- VI	NOT LISTED		
1950 Jun. 19	35.8	84.0	V	NOT LISTED		
1950 Nov. 26	37.7	78.3	V	NOT LISTED		
1951 Mar. 9	37.5	77.4	IV- V	NOT LISTED		
1952 Feb. 6	33.5	86.8	V- VI	NOT LISTED		
1952 Jun. 11	36.3	82.4	VI	NOT LISTED		
1954 Jan. 2	37.2	83.2	VI-VII	NOT LISTED		
1954 Jan. 23	35.3	84.5	V	NOT LISTED		
1955 Jan. 17	37.3	78.4	V	NOT LISTED		
1955 Jan. 25	35.8	83.9	V- VI	NOT LISTED		
1955 Sept. 28	36.6	81.3	VI	-	-	V
1956 Sept. 7	36.2	83.8	VI-VII	35.5	84.0	VI
1956 Sept. 9	35.8	86.7	IV- V	NOT LISTED		
1957 Apr. 23	33.5	86.8	VI	34 1/2	86 3/4	VI
1957 May 13	35.8	82.0	VI	34 3/4	82	VI
1957 Jun. 23	35.9	84.2	IV	36 1/2	84 1/2	V
1957 Jul. 2	35.6	82.6	VI	35 1/2	82 1/2	VI
1957 Nov. 24	35.4	83.4	VI-VII	35	83 1/2	VI
1958 Mar. 5	34.2	77.9	V	34 1/4	77 3/4	V
1958 Oct. 20	34.5	82.7	V	34 1/2	82 3/4	V
1959 Apr. 23	37.3	80.7	VI-VII	37 1/2	80 1/2	VI
1959 Aug. 12	34.8	86.6	VI-VII	35	87	VI
1959 Oct. 27	34.5	80.2	V	34 1/2	80 1/4	VI

300 158

DATE		TVA NLAT	TVA WLON	TVA Io	NOAA NLAT	NOAA WLON	NOAA Io
1960	Feb. 9	35.4	82.4	VI	NOT LISTED		
1960	Apr. 15	35.8	84.0	V	35 3/4	84	V
1963	Jan. 17	37.3	80.1	IV- V	NOT LISTED		
1963	Oct. 28	36.6	81.0	VI	36.7	81.0	V
1963	Dec. 15	37.2	87.0	IV- V	NOT LISTED		
1964	Feb. 18	34.6	85.6	VI	34.8	85.5	V
1964	Mar. 13	33.0	83.4	IV	33.2	83.4	V
1964	Apr. 20	34.1	81.2	IV	34	81	V
1966	May 31	37.6	77.7	VI	37.6	78.0	V
1968	Mar. 8	37.3	80.7	V- VI	NOT LISTED		
1968	Dec. 11	38.2	85.8	V- VI	38.3	85.7	V
1969	Jul. 13	36.0	83.9	VI	36.1	74.3	V
1969	Nov. 20	37.4	80.9	VI-VII	37.4	81.0	VI
1969	Dec. 11	37.6	77.7	V- VI	37.8	77.4	V
1969	Dec. 13	35.0	83.8	V	35.1	83.0	V
1970	Sept. 10	36.2	81.7	V- VI	36.1	81.4	V

Note: Data reported in Earthquake History of the United States terminates at the end of 1970.

300 159

Seismic Analysis

There is no uniform seismic activity in the study area. Although there are events scattered throughout most of the Southern Appalachian Tectonic Study area, there are only two areas of persistently significant seismic activity. One area includes part of southwestern Virginia and may extend into central Virginia; the second area includes parts of eastern Tennessee, western North Carolina, and western South Carolina. The localization of historical seismic activity in these two areas is further confirmed by those events which have been instrumentally recorded and located and which are also confined to these two areas.

Seismic activity in the contiguous area made up of the southwestern and central Virginia zones is aligned east-west, representing the only significant alignment of historical epicenters presently identifiable in the Southern Appalachian Tectonic Study area. This east-west trend is also very evident in the instrumental epicenters located by J. W. Dewey (written communication, 1979) who used a joint-epicenter determination method. The strikingly linear alignment of epicenters in this area is interpreted to be the expression of an active east-west structure.

Further confirmation of an east-west structure can be found in the strong east-west orientation of the meizo-seismal regions plotted for the larger historical events in this area. Although it is acknowledged that orientations of meizoseismal regions can be controlled by anomalous geologic conditions, it should be noted that in southwestern Virginia those orientations cut across structure. Similar trends are observed for central Virginia earthquakes. This suggests that the east-west orientation of the meizoseismal regions for these events is controlled by an east-west-striking fault plane.

Analysis of the long-period Love and Raleigh waves for one of these events, the 1969 Elgood, West Virginia earthquake, indicates a strike-slip mechanism for a fault plane striking nominally east-west. Given the present day stress regime as defined by Sbar and Sykes (1977) an east-west trending fault is interpreted to be a preferred mechanism. Recorded first motion of P-wave arrivals for this event, although not numerous, tend to agree with this interpretation.

All of this evidence taken together strongly infers the existence of an active east-west structure with which the 1897 Giles County earthquake, as well as present seismic activity in that area, can be associated.

Epicenters located in Tectonic Subdivision 4 (see TECTONIC SUBDIVISIONS map) are more diffuse; that is, they are not clearly represented by linear trends. However, there is some suggestion of an east-west alignment of instrumentally located epicenters (J. W. Dewey, written communication, 1979) and some of the larger historical epicenters (equal to or greater than Intensity VI), although one

300 161

focal mechanism available for this area, the 1973 Maryville, Tennessee earthquake, was determined to have a northwest-striking fault plane solution.

When the EARTHQUAKE EPICENTER MAP is superimposed on the TECTONIC SUBDIVISIONS map, it is evident that certain areas have a higher frequency of events. These seismically active areas are bounded in part by rectilinear features. One such feature, the New York-Alabama lineament (NY-A), restricts a vast majority of events, equal to or greater than Intensity VI, to the southeast. A second set of boundaries oriented northwest-southeast (Boundaries A, B, and C, on the TECTONIC SUBDIVISIONS map) are also seismically significant. Events in the area of Tennessee-North Carolina-South Carolina (Tectonic Subdivision 4) appear to be well constrained by Boundaries A and B, and seismic activity in the contiguous area made up of the southwestern and central Virginia zones (Tectonic Subdivision 8) occurs northeast of Boundary C.

During the study, additional analyses were made of the data, because many researchers have recently indicated strong correlations between mafic intrusions and earthquakes. The best interpretation at this time suggests that no such correlation exists in the southern Appalachians.

300 162

References Cited

Coffman, J. L., and von Hake, C. A., eds., 1973, Earthquake history of the United States: U. S. Dept. Commerce Pub. 41-1 (revised edition through 1970), 208 p.

Sbar, M. L., and Sykes, L. B., 1977, Seismicity and lithospheric stress in New York and adjacent areas: Jour. Geophys. Research, v. 82, no. 36, p. 5771-5786.