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ENERGY DIVISION

REGIONAL INVENTORY OF KARST ACTIVITY IN
THE VALLEY AND RIDGE PROVINCE, EASTERN TENNESSEE
PHASE I

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Date Published - September 1987

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Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-84OR21400

MASTER

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ABSTRACT

Siting of solid waste disposal facilities in East Tennessee has, in recent years, largely occurred in areas underlain by carbonate bedrock formations because of the presence of thick masses of unsaturated soils. At DOE's Oak Ridge Reservation a site underlain by the Knox Group dolomites has been studied for potential disposal of low level radioactive waste. As part of DOE's Low Level Waste Disposal Development and Demonstration Program, P.E. LaMoreaux and Associates performed the first systematic inventory of karst subsidence in the Valley and Ridge Physiographic Province of East Tennessee to obtain a regional perspective on the occurrence of karst subsidence.

A data collection form was developed for use in compiling information in the inventory. Information sources included USGS files on subsidence, state and county highway departments, county agents and executives, soil conservation service representative, etc. Data obtained included location, date of occurrence, number of subsidence features at the reported site, size, topographic setting, geologic setting, and probable causative factors.

The regional inventory obtained information on over 300 historic subsidence events at more than 200 sites in East Tennessee. Areas having the greatest areal density of active subsidence include Hamblen, Jefferson, and Loudon Counties. Reported subsidence events occurred between 1945 and 1986. The Knox Group dolomites account for about two-thirds of all reported sinkholes in the inventory. Most of the karst activity occurs in valleys or flat areas. In cases where causative factors could be established, the combination of surface water drainage alteration or impoundment combined with soil disturbance associated with construction activity were most often precursors to subsidence.

Karst subsidence is a potential threat to any type of development on areas underlain by carbonate bedrock. Soil piping into bedrock cavities is the predominant mode of soil failure in East Tennessee. Activities which may exacerbate subsidence include alteration of surface water drainage and excavation in areas where soil cover over bedrock is relatively thin.

1.0 INTRODUCTION

The Department of Energy (DOE) is evaluating environmentally acceptable, on-site, low-level radioactive waste disposal techniques for its Oak Ridge facilities. The Low-Level Waste Disposal Development and Demonstration (LLWDDD) Program is in the process of defining waste disposal alternatives for the Oak Ridge Reservation and performing demonstrations of certain options to test their viability. One of the alternatives under consideration is installation of below-grade, engineered disposal units constructed in the thick residual soils that overlie carbonate rocks.

A candidate site for below-grade disposal demonstration has been identified and extensive site characterization studies have been performed. The characteristic for carbonate bedrock, such as that underlying the site, to contain solution cavities introduces uncertainty into the performance assessment for any facility constructed on such a site. An assessment of potential karst activity such as the occurrence of sinkholes and related features (fracturing and piping in overburden) is necessary because they allow possible off-site movement of contamination. The assessment is particularly important because some induced sinkholes (caused or accelerated by man) elsewhere have been attributed to construction practices that would be necessary at the site.

P. E. LaMoreaux & Associates, Inc. (PELA) was authorized to perform a regional evaluation of karst activity as an aid to assessing the possible impacts related to subsidence and sinkhole development. This work was authorized under Martin Marietta Energy Systems, Inc. contract award no. 11X-78911V. The investigation undertaken by PELA is separated into three phases. These phases are:

1. Obtain a database on karst features for the Valley and Ridge Province in Tennessee;
2. Select, based on the database, sites that have a history of subsidence that are similar to the candidate area, make detailed evaluations, and relate findings to the candidate site; and

3. Estimate, using the database developed in phases 1 and 2, the density and areal frequency of sinkhole occurrence in areas underlain by carbonate bedrock in east Tennessee.

1.1 AREA OF STUDY

The area of study for Phase I of the investigation is the Valley and Ridge Province in eastern Tennessee (Plate 1). Areas along the northwest flank of the province underlain by the Sequatchie Anticline are included as an outlier because of their similar geology and karst. The province in adjacent states (Alabama, Georgia, and Virginia), also shown in Plate 1, is included to benefit from databases available in files of the U.S. Geological Survey (USGS). In Tennessee, the Valley and Ridge Province is a northeastward-trending belt averaging about 40 miles in width. The topography is characterized by a succession of ridges and valleys. The average elevation in east Tennessee is about 1,000 feet (DeBuchananne and Richardson, 1956). The elevations generally range, in average, from 700 feet in Hamilton County in the south to 1,500 feet in Sullivan County in the north. Faulted and folded strata characteristic of the province consist chiefly of calcareous Paleozoic rocks that dip southeastward. Ridges are generally developed on the more resistant, non-carbonate rocks and on the least soluble and cherty limestones and dolomites. Valleys are generally developed on the more soluble limestones and dolomites and on shale.

1.2 PURPOSE AND SCOPE

The purposes of Phase I were to (1) obtain a database on sinkhole occurrence in the Valley and Ridge Province in eastern Tennessee and (2) identify factors triggering sinkhole development. This included acquiring the available databases in files of the U.S. Geological Survey for Alabama, Georgia, and Virginia that were obtained from a recent investigation of sinkhole occurrence in the eastern United States (Newton, 1986). These data will supplement those for Tennessee in later interpretive phases of work. The data for Tennessee were obtained by

contacting appropriate federal, state, and local agencies that would be expected to be confronted with sinkhole problems. There is no central data-collection agency monitoring sinkhole occurrence in Tennessee. The data obtained by this study for specific sites include: location, date of occurrence, number of sinkholes, size, topography, geologic setting, and causative factors.

This report defines causative factors triggering sinkhole development and presents the database obtained from the inventory. Causative factors triggering sinkhole development are described in the following text, preceding presentation of the database, to enable the reader to understand the significance of causative factors described in the following text and tables. Agencies contacted during the inventory are listed in Table 1 and data obtained are listed in Tables 2 through 5. Sinkhole occurrences within the study area are shown in Plates 1 through 3.

1.3 METHOD OF STUDY

Initial work on the project consisted of acquiring and reviewing pertinent literature, maps, and available data on sinkhole occurrences in the areas of study from files of the U.S. Geological Survey. The candidate site at Oak Ridge was then visited to determine site geologic setting and examine karst development at the site to aid in identifying similar terranes during later work. A form was prepared to record data pertaining to sinkhole occurrences. Federal, state, and local agencies in Tennessee (Table 1) expected to be confronted with sinkhole problems in the Valley and Ridge Province were then contacted by telephone. Initial contacts on the local level were restricted to offices of the U.S. Soil Conservation Service (SCS) in the counties involved, county highway departments, and county agents and/or executives. Contacts on a municipal level were not feasible on a time or economic basis. Municipal and other officials were contacted only when county officials designated them as specific sources of information.

Table 1. List of contacts made in Tennessee, by county and agency (SCS, U.S. Soil Conservation Service; CDOT, County Highway Department; CA/CE, County Agent and/or County Executive; C, City Official; and Other, agencies not included in listing).

	SCS	CDOT	CA/CE	C	Other
Anderson	X	X	X		X
Bledsoe	X	XX	X		
Blount	X	X	X	X	
Bradley	X	XX	X		X
Campbell	X	X	X		X
Carter	X	X	XX		X
Claiborne	X	X	X		X
Cocke	X	X	X		X
Cumberland	X	X	X		
Grainger	X	X	X		X
Greene	X	X	X		
Hamblen	X		X		X
Hamilton	X	X	X		
Hancock	X	X	XX		
Hawkins	X	XX	XX		
Jefferson	X	X	X	X	X
Johnson	X	X	X		
Knox	X	X	X	X	X
Loudon	X	X	X	X	
McMinn	X	X	X		
Marion	X	X	X		
Meigs	X	X	X		
Monroe	X	X	X		
Polk	X	X	X		
Rhea	X	X	X		
Roane	X	X	X		
Sequatchie	X	X	X		
Sevier	X	X	X		X
Sullivan	X	X	X		
Unicoi	X	X	X		
Union	X	X	XX		X
Washington	X	X	X		

Additional agencies contacted that operate on a statewide basis include: Tennessee Department of Transportation; Tennessee Division of Geology; Tennessee Division of Solid Waste Management; Tennessee Valley Authority; U.S. Department of Housing and Urban Development; and U.S. Geological Survey.

Some data were obtained by telephone; however, additional information was received from some contacts willing to fill out forms mailed to them. Most information was obtained by personal interview during field trips by PELA's staff after locating the sources by telephone. Data were tabulated for each county as work progressed. Locations were plotted on computer generated base maps (Plates 1 through 3) prepared using PELA's Hewlett-Packard 1000.

2.0 SINKHOLE DEVELOPMENT

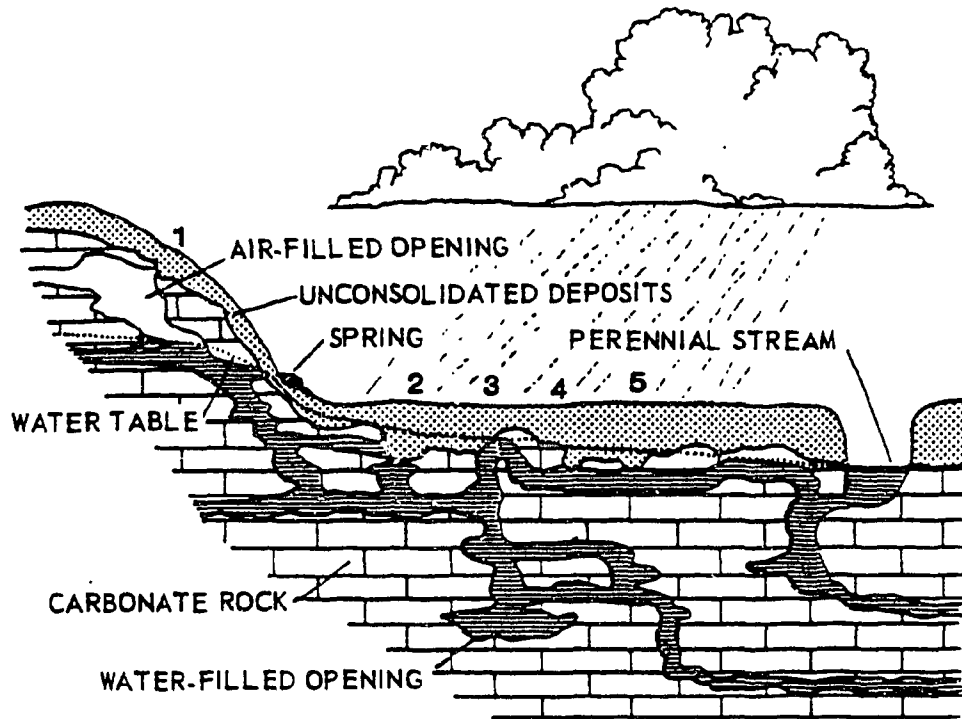
2.1 BACKGROUND

The following text and illustrations describing sinkhole development are taken or modified from reports and papers by Newton (1976a, 1976b, and 1976c; 1984; and 1986). Carbonate terranes illustrated and described vary from those in the study area, particularly in the inclination of bedding. The processes and modes of sinkhole development, however, do apply in that they are the same regardless of the terrane involved.

The geologic and hydrologic setting in the terrane used to illustrate sinkhole development, hereafter referred to as the "selected terrane," is a youthful basin underlain by carbonate rocks such as limestone, dolomite, and marble (Figure 1). The selected terrane contains a perennial or rarely intermittent stream. Water is stored in underlying rocks and moves through interconnected openings along bedding planes, joints, fractures, and faults that often are enlarged by solutioning. The water moves in response to gravity, generally flowing toward the stream channel where it discharges and becomes a part of streamflow.

Water in carbonate rocks occurs under water-table and artesian conditions; however, this study is concerned primarily with water-table conditions. The configuration of the water table conforms to that of the topography but is influenced by geologic structure, water withdrawal, and precipitation. The lowest water level occurs where the water table intersects the stream channel. Bedrock openings underlying lower parts of the basin are water filled and those underlying highland areas are air filled.

A mantle of unconsolidated deposits, resulting from the solution of the underlying rocks, consists chiefly of residual clay (residuum). This clay, commonly containing chert debris, covers most bedrock. Alluvial or other unconsolidated deposits often overlie the clay. These unconsolidated deposits commonly fill openings in bedrock. The contact



(Numbers apply to locations described in report.)

Source: Newton, 1976.

FIGURE 1. SCHEMATIC CROSS-SECTIONAL DIAGRAM OF BASIN SHOWING GEOLOGIC AND HYDROLOGIC CONDITIONS.

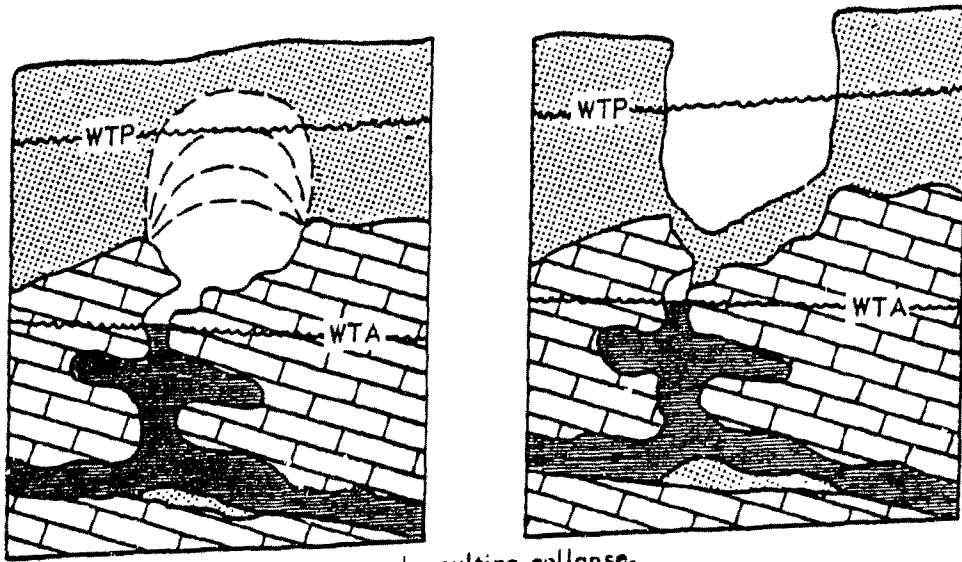
between residuum and underlying bedrock, because of differential solution, can be highly irregular.

2.2 MODE OF DEVELOPMENT

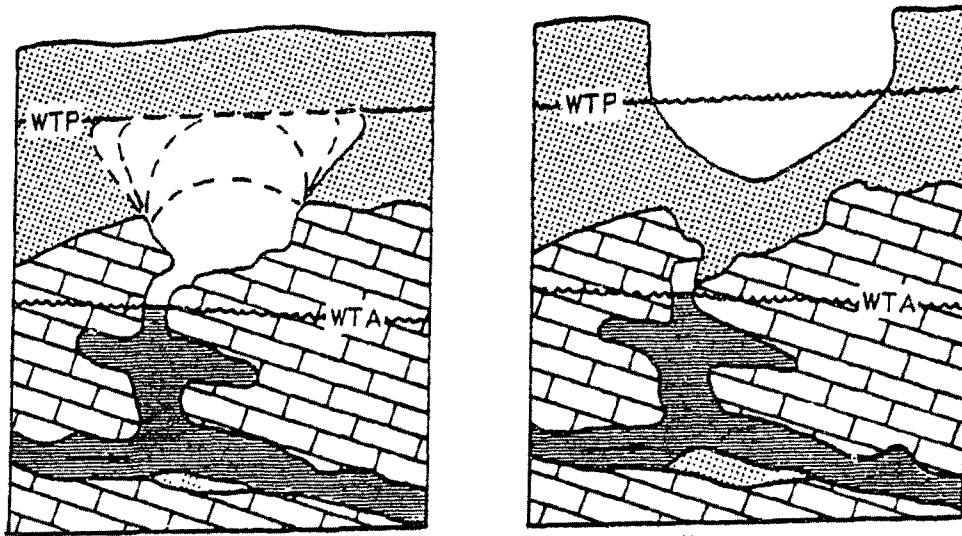
Sudden occurrence of natural and induced sinkholes results from (1) collapse of the roof of a cavity or cavern in rock due to its progressive enlargement by solution or (2) the downward migration of soil and other unconsolidated deposits into openings in the top of bedrock (Newton, 1976a). Collapse of bedrock roofs, in comparison to the migration of unconsolidated deposits into underlying openings, is very rare. According to Williams and Vineyard (1976) in a study involving 97 collapses in Missouri, "Although cavern roof collapse in bedrock has been cited as a cause of catastrophic sinkhole formation, no contemporary event that could be attributed directly to this cause has been observed." Similar observations have been made in Tennessee (Moore, 1980), Alabama (Newton and Hyde, 1971), and elsewhere. Of hundreds of collapses observed by Newton (1976a), only one could be classified as a possible collapse of the roof of an opening in bedrock.

Most collapses forming sinkholes result from roof failures of cavities in unconsolidated deposits overlying carbonate rocks. These cavities are created when the unconsolidated deposits move or are eroded downward into openings in the top of the bedrock.

The typical cavity in unconsolidated deposits is circular with the configuration of the top resembling a dome or arch. The sides at the bottom generally coincide with pinnacles or irregularities in the top of bedrock and the walls are usually vertical as the opening grows toward the land surface (Figure 2A). This configuration, however, can be modified by the shape of the underlying opening in bedrock and by variations in the cohesion or competence of overlying beds. The configuration of the typical cavity can change when its upward growth reaches a more competent bed. The roof flattens, the growth continues laterally, and the walls taper toward the opening in bedrock (Figure 2B). Other cavity configurations, such as horizontal tunneling along the top of bedrock, have also been observed (Newton, 1976b).



A. Vertical enlargement and resulting collapse.



B. Vertical and lateral enlargement and resulting collapse.

EXPLANATION

<p>--- Boundary designating cavity growth</p> <p>WTP-Water table prior to decline</p> <p>WTA-Water table after decline</p>	<p>▨ - Unconsolidated deposits</p> <p>■ - Water-filled opening in limestone</p> <p>→ - Direction of water movement</p> <p>▩ - Limestone</p>
--	---

Source: Newton, 1976.

FIGURE 2. DEVELOPMENT OF CAVITIES IN UNCONSOLIDATED DEPOSITS.

A major difference in natural and induced sinkholes is the time required for their development. Some induced sinkholes develop within minutes or hours after the effects of man's activities are exerted on existing geologic and hydrologic conditions. In contrast, the development of a natural sinkhole may require tens, hundreds, or even thousands of years. Development of all sinkholes, regardless of their category, is dependent on the solution of bedrock.

Identification of the causative factors of sinkhole development is important to understanding the occurrence of sinkholes within a study area. The number of induced collapses in numerous areas allows the investigator to observe and record factors or mechanisms involved in initial stages of development. Comparable information, because of their rare occurrence in many terranes, is not available to evaluate initial stages of development of natural sinkholes. Because of this and because most mechanisms triggering both types of sinkholes are the same (Newton, 1976a), induced sinkholes are described first and findings are applied to natural sinkhole development.

3.0 INDUCED SINKHOLES

Induced sinkholes were first classified by separating those caused by lowering the water level from those caused by raising the water level (Aley and others, 1972). This classification was modified slightly by Newton (1976a) by separating those caused by declines in water levels due to ground-water withdrawals from those caused by construction. Collapses resulting from construction, as used here, include those caused by the erection of a structure, the impounding or diverting of surface water, and any modification of the natural environment.

3.1 DECLINE OF WATER TABLE

Foose (1953), in the first investigation of this type of sinkhole activity, associated the occurrence of sinkholes with pumping and a subsequent decline in the water table. He determined that their formation was confined to areas where a drastic lowering of the water table had occurred, that their occurrence ceased when the water table recovered, and that the shape of collapses indicated a lowering of the water table and withdrawal of support. Robinson and others (1953) attributed sinkhole occurrence in a cone of depression to the increased velocity of ground-water movement causing collapse of clay and rock filled cavities in bedrock.

Spigner (1978) attributed intense sinkhole development near Jamestown, South Carolina, to a water-level decline resulting from pumpage, provided descriptions indicating loss of support, and attributed some downward movement of unconsolidated deposits to piping. Sinclair (1982) attributed similar activity in Florida to loss of support and water-level fluctuations.

Noticeable subsidence can also accompany declines in water level, and in Alabama, it sometimes precedes collapse (Newton and Hyde, 1971). Movement of unconsolidated materials into bedrock where overlying material strength is insufficient to maintain a cavity roof will result in subsidence at the surface (Donaldson, 1963).

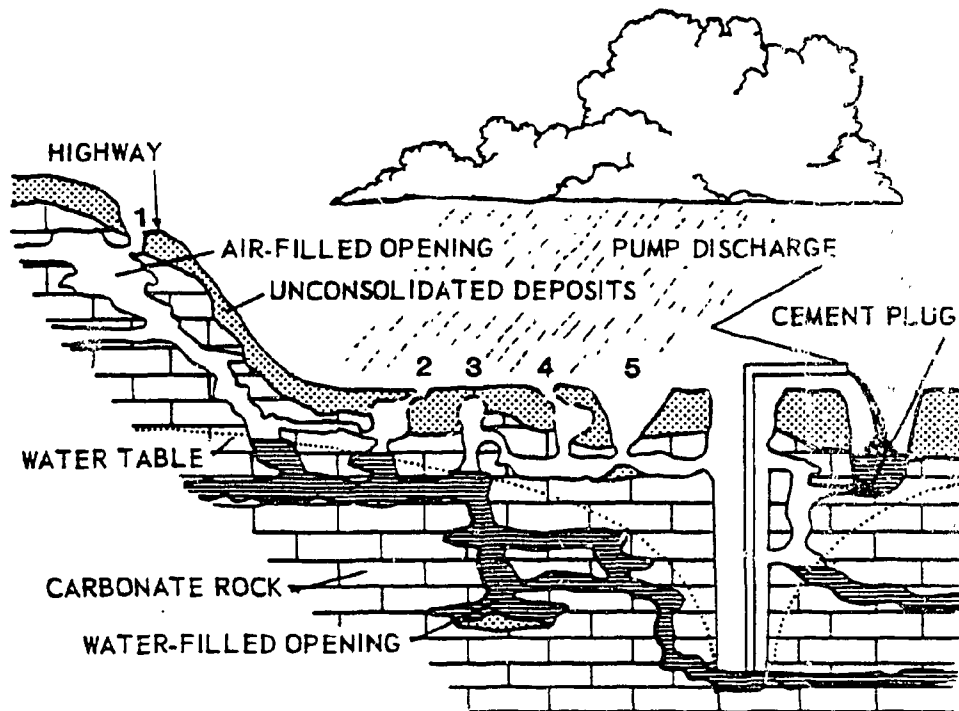
Cited reports have described only indirectly or in part the hydrologic mechanisms resulting from a decline that cause the downward migration of unconsolidated deposits. These mechanisms, based on studies in Alabama (Newton and Hyde, 1971; Newton and others, 1973; and Newton, 1976a) are:

1. Loss of buoyant support to roofs of cavities or caverns in bedrock previously filled with water and to residual clay or other unconsolidated deposits overlying openings in the top of bedrock;
2. Increase in the velocity of movement of ground water,
3. Increase in the amplitude of water-level fluctuations, and
4. Movement of water from the land surface to openings in underlying bedrock where recharge had previously been largely rejected because they were water filled.

A cone of depression resulting from pumpage from a quarry or well is superimposed on a schematic diagram of the selected terrane (Figure 1) to illustrate the downward migration of unconsolidated deposits, creation of cavities in them, and sinkhole development (Figure 3). A solutionally enlarged opening in the stream has been sealed, a common mine dewatering practice, to prevent flooding in the cone of depression.

The loss of buoyant support following the water-level decline can result in an immediate collapse of roofs of openings in bedrock and unconsolidated deposits or can cause a downward migration of unconsolidated deposits spanning openings in the top of bedrock. The buoyant support exerted by water on a solid and, hypothetically, unsaturated clay overlying an opening in bedrock, for instance, would be equal to about 40 percent of its weight.

A collapse triggered by a loss of buoyant support is illustrated at location 5 in Figure 3. Loss of support also triggered the downward movement of residual clay and the creation of a cavity in unconsolidated deposits at location 3. Openings in the top of bedrock at both sites were overlain by unconsolidated deposits prior to the decline of the water table (Figure 1).



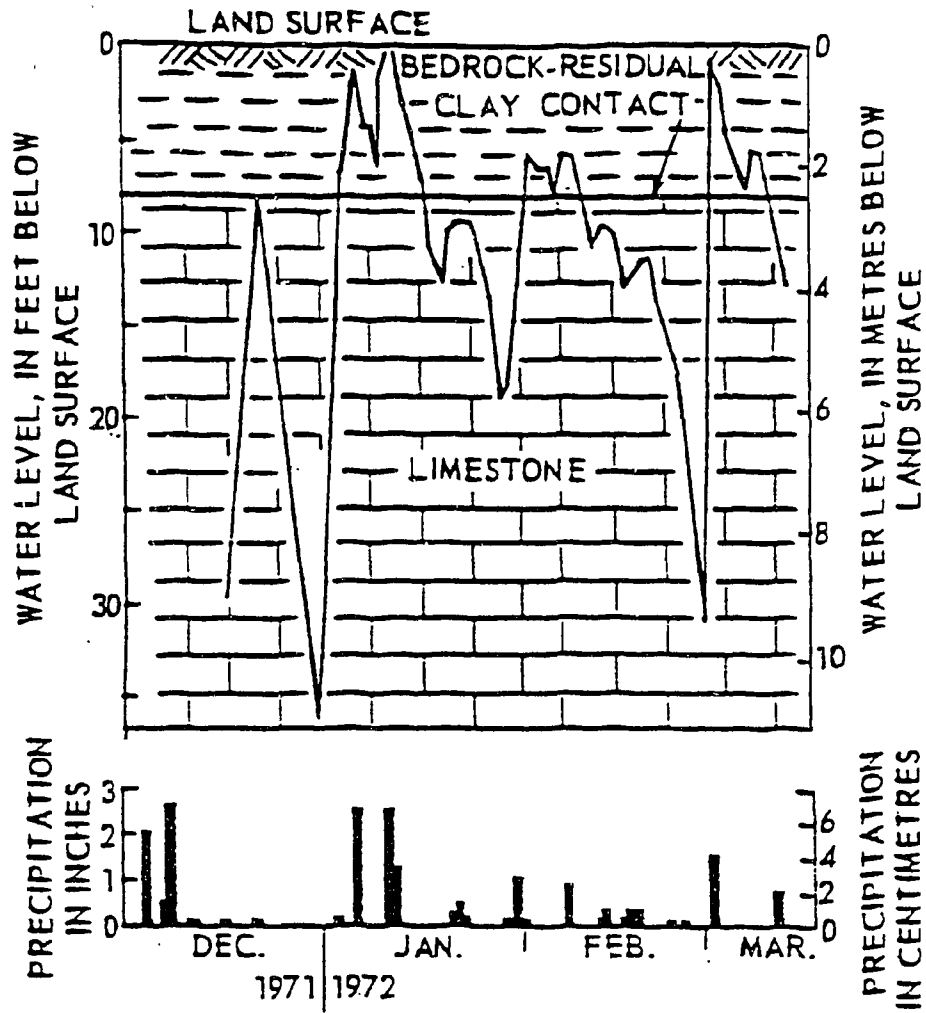
(Numbers apply to locations described in report.)

Source: Newton, 1976.

FIGURE 3. SCHEMATIC CROSS-SECTIONAL DIAGRAM OF BASIN SHOWING CHANGES IN GEOLOGIC AND HYDROLOGIC CONDITIONS RESULTING FROM WATER WITHDRAWAL.

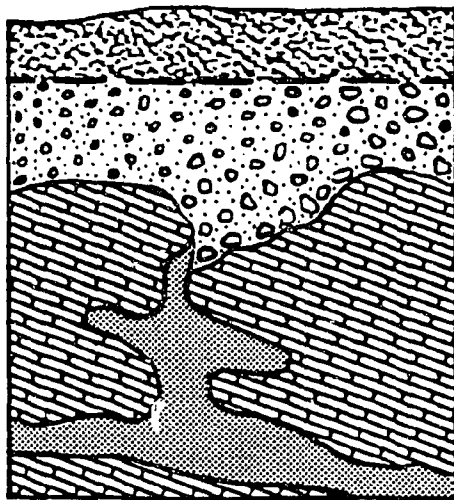
The creation of a cone of depression in an area of water withdrawal results in an increased hydraulic gradient toward the point of discharge (Figure 3) and a corresponding increase in the velocity of ground-water movement. Erosion caused by this movement through unobstructed openings and against joints, fractures, faults, or other openings filled with clay or other unconsolidated sediments results in the creation of cavities that enlarge and eventually collapse.

Pumpage results in water-level fluctuations greater in magnitude than those occurring under natural conditions. The repeated movement of water through openings in bedrock against overlying unconsolidated deposits causes repeated addition and subtraction of buoyant support to them and repeated saturation and desaturation. Both result in the downward migration of the deposits that creates or enlarges cavities in them. Repeated water-level fluctuations and their relationship to the bedrock-residuum contact in an area where more than 171 sinkholes have occurred (Figure 4) illustrate the mechanism described. The rapidity of water-level fluctuations can also cause or contribute to the creation and collapse of cavities in residuum where the water table prior to pumping is above the top of bedrock (Figure 5A). The saturated zone is in the lower part of the residuum containing chert fragments and calcareous debris not completely dissolved by solution. Because of its clay content and limited permeability, the residuum will not yield water from storage as rapidly as openings in bedrock. Large withdrawals from a nearby well can cause a rapid decline in water level to a position below the top of bedrock while water stored in the residuum continues to drain into the underlying opening in bedrock. The drainage and accompanying erosion causes or contributes to the creation of a cavity in the residuum (Figure 5B). Repetitive water-level fluctuations (Figures 5C and 5D) cause enlargement of the cavity. This process, as related to natural fluctuations and leakage from sewers in Missouri, has been described by Reitz and Eskridge (1977). All collapses and cavities in unconsolidated deposits illustrated in Figure 3 could have resulted from these mechanisms.

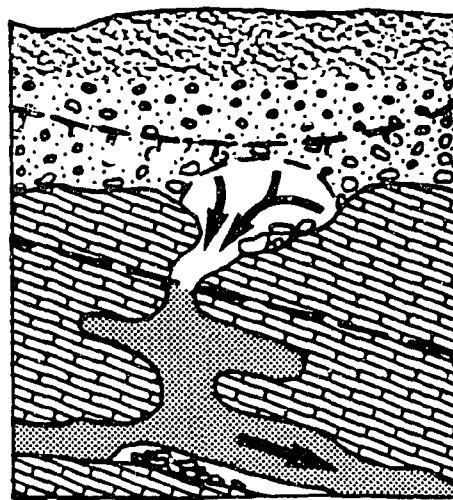


Source: Newton, 1973.

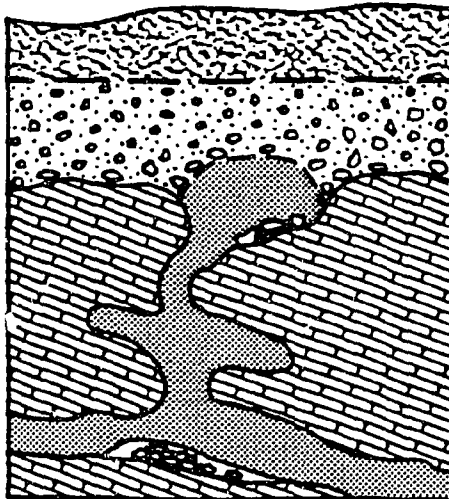
FIGURE 4. RELATION OF FLUCTUATIONS OF WATER LEVEL IN A WELL AT GREENWOOD, ALABAMA, TO CONTACT BETWEEN BEDROCK AND DAILY PRECIPITATION AT BESSEMER.



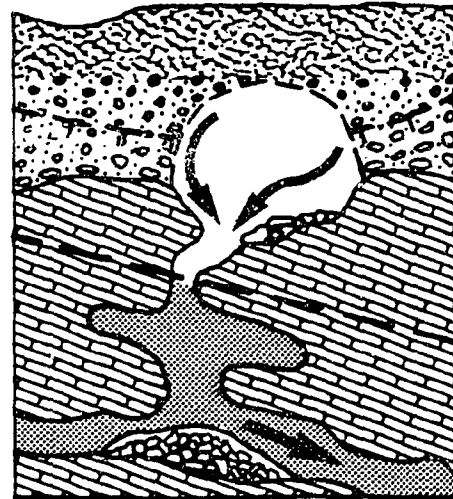
A. PRIOR TO DECLINE



B. DECLINE, DRAINAGE FROM AND EROSION OF RESIDUUM, CREATION OF CAVITY



C. RECOVERY



D. DECLINE, DRAINAGE AND EROSION, CAVITY GROWTH

EXPLANATION




- | | | | |
|-------|-----------------------------|---|----------------|
| — — — | WATER TABLE |  | RESIDUUM |
| T T T | PERCHED WATER |  | CARBONATE ROCK |
| → | DIRECTION OF WATER MOVEMENT |  | WATER |

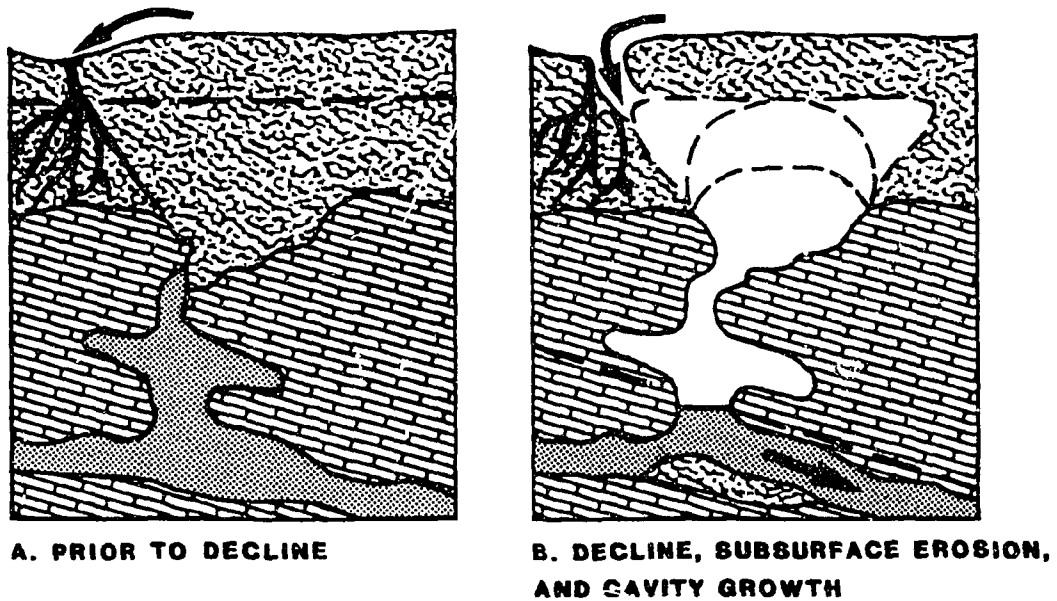
FIGURE 5. SUBSURFACE EROSION CAUSED BY WATER-LEVEL FLUCTUATIONS RESULTING FROM PUMPAGE.

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A drastic decline of the water table in the lowland areas in the selected terrane (Figure 1) where all openings in the underlying bedrock were previously water filled results in induced recharge of surface water. This recharge was partly rejected prior to the decline because the openings were water filled. The inducement of recharge through openings in unconsolidated deposits interconnected with openings in bedrock results in the creation of cavities in the deposits. The material immediately overlying the bedrock openings is eroded to lower elevations. The water table, previously located above the top of bedrock (Figure 6), is no longer in a position to dissipate the mechanical energy of downward moving recharge. Repeated rains result in the progressive enlargement of this type cavity (Figure 6). A corresponding thinning of the cavity roof due to its enlargement toward the surface eventually results in collapse. The position of the water table below unconsolidated deposits and openings in the top of bedrock favorable to induced recharge is illustrated at locations 2 and 4 in Figure 3. Cavities in unconsolidated deposits at these locations were formed primarily or in part by induced recharge. Surface openings and underlying cavities illustrated at these locations are identical to those illustrated photographically in previous reports by Newton (1976a and 1976b). The creation and eventual collapse of cavities in the deposits by induced recharge is the same process described by many authors as "piping."

In an area of sinkhole development where the cone of depression is maintained by constant pumpage (Figure 3), all mechanisms described are active even though one may be responsible for the development of a specific collapse. In contrast, a cavity resulting from a loss of support (location 3) can be enlarged and collapsed by induced recharge if it has intersected openings interconnected with the surface. Similarly, in an area near the outer margin of the cone (location 2), the creation of a cavity and its collapse can result from all mechanisms. It can originate from a loss of support, can be enlarged by water-level fluctuations, or by the increased velocity of movement of water against sediment that originally filled the openings (Figure 1), and can be enlarged and collapsed by induced recharge entering from the surface.



EXPLANATION

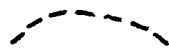






- | | | | |
|---|---|--|-----------------------|
|  | CAVITY GROWTH |  | RESIDUUM |
|  | WATER TABLE |  | CARBONATE ROCK |
|  | DIRECTION OF WATER MOVEMENT |  | WATER |
|  | SILT-FILLED ROTTED OUT TREE ROOT OPENING | | |

FIGURE 6. SUBSURFACE EROSION (PIPING) RESULTING FROM WATER-LEVEL DECLINE.

MODIFIED FROM NEWTON, 1986.

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3.2 CONSTRUCTION

The term "construction" applies to the erection of a structure, to any modification of the land surface, and to the diversion and impoundment of water. Diversion of drainage also includes any activity that results in changes in the downward movement of recharge. These activities include removal of timber and drilling, coring, and augering where pumpage is not involved. Also included is leakage from sewers, pipes, and similar facilities.

Construction practices often "set the stage" for sinkhole occurrence. In areas where construction requires soil removal, grading results in the thinning of unconsolidated deposits. Emplacement of weight on thinned roofs of existing cavities in residual clay or on those of shallow bedrock cavities can cause their failure. The occasional collapse beneath heavy equipment during construction is probably attributable to this cause. Differential compaction caused by the weight of a structure on unconsolidated deposits overlying the irregular surface of the top of bedrock can result in subsidence and foundation problems. Rainfall and saturation of roofs of underlying cavities in residual clay after grading can also result in their failure. Shocks or vibrations resulting from blasting or the operation of heavy equipment cause or contribute to the failure of roofs of cavities in bedrock and unconsolidated deposits. About 4 percent of collapses identified in Missouri have been attributed to this cause (Williams and Vineyard, 1976).

Concentration of water by drainage diversion may increase recharge to underlying bedrock openings. This increase in recharge can cause saturation and weakening of roofs of existing cavities in unconsolidated deposits. Collapses due to this occurrence are less common than those caused by the creation and erosional enlargement of subsurface openings in the deposits that result from the movement of water to and through existing openings in the top of bedrock. The subsurface erosion of unconsolidated deposits and the creation or enlargement of resulting cavities has been described by Newton (1976a) and Moore (1980). The former described it as being the same as the "piping"

process resulting from induced recharge caused by a decline in the water table. The latter identified the process as being responsible for collapse failures in Tennessee.

Collapses resulting from the piping process would be most common where the water table is below the top of bedrock (location 1 on Figure 1). Collapses along highways due to piping in such an area (location 1 on Figure 3) are not uncommon.

Collapses resulting from leakage of underground pipes are well documented in the literature. Resulting collapse mechanisms are the piping process and saturation. Saturation causes loss of cohesion of residual clays and also causes loading due to the addition of the weight of water.

Collapse also can result where surface water gains access to uncased or unsealed holes created by drilling, augering, or coring. The piping process is generally responsible. The same process may be responsible for collapses that occur at drainage wells.

Collapses caused by the impounding of drainage occur, in part, in the same manner as those resulting from diversions of drainage. The impounding of water results in the saturation and loss of cohesiveness of unconsolidated deposits overlying bedrock openings. This, accompanied by loading resulting from the weight of impounded water, can result in the collapse of overlying deposits into the bedrock opening and a draining of the impoundment (Aley and others, 1972). If the impoundment is located where the water table is below the top of bedrock and openings at the surface are interconnected with those in bedrock, a collapse can result from the piping process. Collapses resulting from saturation and piping have been described by Warren (1974).

The piping process can also result in sinkholes when water is impounded on unconsolidated deposits where the water table was originally located above the top of bedrock. On the floor of the impoundment, water moving under increased head through openings in the deposits into openings in underlying rocks can both form and cause collapse of cavities in the deposits. This would occur where there is considerable pressure exerted by the impounded water and where

openings in underlying carbonate rocks have a discharge point outside of the impoundment at a lower altitude. The increase in the velocity of movement of water through openings in unconsolidated deposits into underlying openings in bedrock, resulting from the pressure, would probably have an erosive capacity comparable to that in a cone of depression caused by pumpage. This action is probably responsible for the formation of some sinkholes in a large impoundment on the Coosa River in Alabama (Newton, 1976a).

4.0 NATURAL SINKHOLES

Many thousands of sinkholes dot landscapes of carbonate terranes in the eastern United States. Of those shown on topographic maps, almost none represent the earliest stage of their development.

The evolution of a natural sinkhole occurs in a geologic time frame, i.e., thousands or millions of years. The enormity of the time span involved, in comparison to those involved in induced sinkhole development, should be considered in descriptions that follow. The rate of solution, for instance, should be considered where progressive solution of bedrock removes its upper surface and enlarges openings or caverns in it. A summary of estimates by previous workers as described by Sweeting (1973) indicates rates of solution for most terranes (lowering of land surface) that are less than 100 mm per 1,000 years.

In the selected terrane, most natural sinkhole activity is restricted to the highland area (Figure 1). Their occurrence in lowlands is comparatively rare because openings there have been subjected to solution for a shorter period of time and because deposition rates tend to maintain a level surface over subsiding areas.

4.1 PROGRESSIVE SOLUTION OF BEDROCK AND DECLINE OF WATER TABLE

The development of a new natural sinkhole may reflect displacement of bedrock, the unconsolidated deposits overlying it, or both. The displacement of either or both is generally "triggered" by progressive solution of bedrock, by a natural decline in the water table, or by a combination of both.

The role of solution in sinkhole development is recognized by all investigators. The effect that solution of bedrock or a decline in the water table has on unconsolidated deposits regarding development of natural sinkholes is not nearly as well defined. Previous investigations have associated the water table and some forces resulting from natural declines with the development of sinkholes. Herrick and LeGrand (1964) related solution subsidence to changes in base level and also

related recent sinkhole activity along the Flint River in southwest Georgia to the entrenchment of the stream that resulted in a lowering of base level. Sweeting (1968) listed, among other factors controlling the development of sinkholes, the "variations in the water level within the limestones; violent and rapid fluctuations in the water level as occur in some tropical humid areas." Where the zone of saturation is high enough to fill caverns near the land surface, a lowering of the water level removing some support to the roof may trigger a collapse (Stringfield and LeGrand, 1969).

Displacement of unconsolidated deposits overlying openings in bedrock is the most common mode of natural sinkhole development. Cavities in unconsolidated deposits that have or could eventually result in natural sinkholes have been described by many investigators including Newton (1976a) and Williams and Vineyard (1976).

The downward migration of unconsolidated deposits due to natural declines in the water table accompanying a lowering of base level is considered here to be an integral part of the solution process. Major differences between the formation of natural sinkholes resulting from collapses in bedrock and collapses in unconsolidated deposits include the time required for each to develop. The time required for a cavity to form in unconsolidated deposits due to change in the hydrologic regimen would be extremely short when compared to that required for the enlargement by solution of a cavity in bedrock to the point where its roof becomes incompetent.

Subsidence resulting from solution of the top of bedrock or openings in it may be the most common mode of sinkhole development. This occurrence in a geologic time frame results from the downward adjustment of soil and other overburden as the underlying bedrock is removed by solution. Collapse, as a form of adjustment, would not play a role in the initial stage of development. This mode of development may also account for the rarity of collapses reported in some terranes containing numerous older sinkholes.

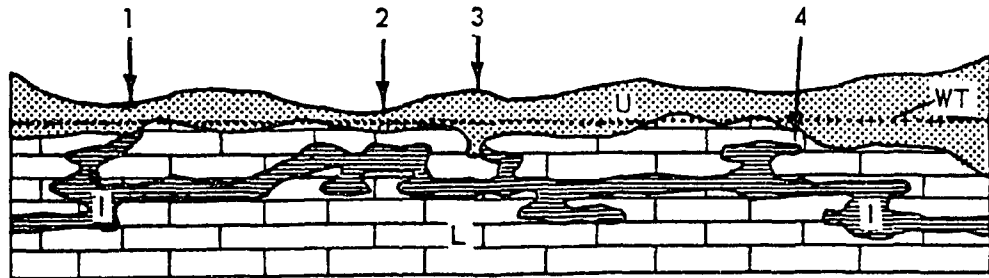
Natural declines in the water table are caused by the entrenchment of streams or by the solutional enlargement of bedrock openings. The declines trigger, in a geologic time frame, the same mechanisms or

mechanical processes that result in induced sinkholes (Newton, 1976a). Progressive solution of bedrock, the resulting decline in the water table, and the development of sinkholes in the highland area in the selected terrane (Figure 1) is illustrated schematically in Figure 7. The water level decline (Figure 7C) resulted when openings became large enough to store and transmit more water to their point of discharge than the amount received from recharge.

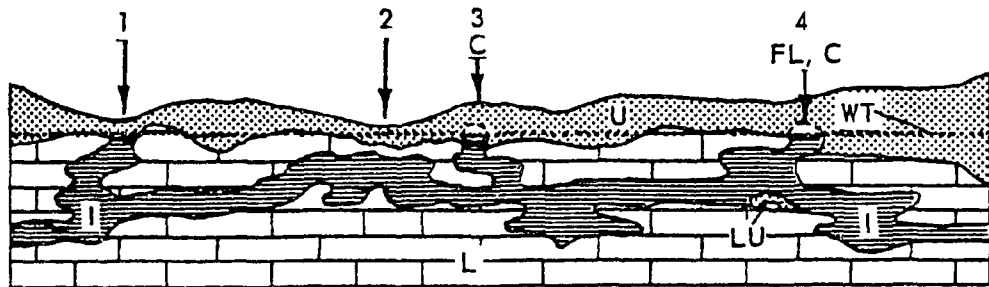
Solutional enlargement of an opening in bedrock results in a thinning of its roof. Failure occurs when the roof can no longer support its weight and the weight of overlying deposits. The collapse results in the development of a sinkhole at the surface or in a cavity in overburden caused by the downward migration of unconsolidated deposits into the bedrock opening created. The thinning of a bedrock roof by solution is illustrated at location 2 in Figure 7A and 7B. Its failure in Figure 7C could have resulted from additional solution or loss of support caused by the water-level decline. A similar roof failure and the creation of an overlying cavity in unconsolidated deposits is shown at location 4 in Figure 7B. Water-level fluctuations against the roof of the cavity would result in its later enlargement and collapse (Figure 7C). Natural collapses of similar cavities in Montgomery County, Tennessee, have been attributed to this mechanism (Kemmerly, 1980).

Solutional enlargement of an opening in the top of bedrock at location 1 (Figure 7A and 7B) and a loss of support due to the water-level decline (Figure 7C) resulted in the collapse of the unconsolidated deposits spanning the opening. A similar occurrence at location 3 resulted in the downward migration of unconsolidated deposits and formation of a cavity in the overburden. Prior to a decline in the water table (Figure 7C), this cavity was enlarged by water-level fluctuations.

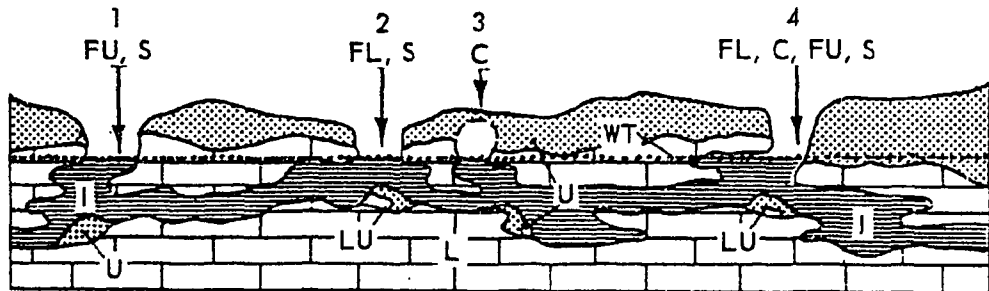
The piping process plays a significant role in natural sinkhole development. Prior to the natural decline in the water table (Figure 7C), it could contribute only to the enlargement and collapse of cavities in unconsolidated deposits that extended above the water table (locations 3 and 4 on Figure 7B). Elsewhere, the erosive energy of recharge moving from the surface to an underlying opening dissipated



A. INTERCONNECTED SOLUTION SYSTEM



B. PROGRESSIVE SOLUTION



C. PROGRESSIVE SOLUTION AND DECLINE OF WATER TABLE

EXPLANATION

- | | |
|--|------------------|
| U — UNCONSOLIDATED DEPOSITS | L — LIMESTONE |
| FU — FAILURE OF UNCONSOLIDATED ROOF | WT — WATER TABLE |
| I — INTERCONNECTED SOLUTION SYSTEM | S — SINKHOLE |
| C — CAVITY IN UNCONSOLIDATED DEPOSITS | |
| LU — LIMESTONE FRAGMENTS AND UNCONSOLIDATED DEPOSITS | |
| FL — FAILURE OF LIMESTONE ROOF | |

(Numbers apply to locations described in report.)

Source: Newton, 1976

FIGURE 7. NATURAL SINKHOLE DEVELOPMENT.

when it came in contact with the water table. After the decline (Figure 7C), piping would probably be the major mechanism causing sinkholes.

4.2 DROUGHT AND DECLINE OF WATER TABLE

The only natural decline in the water table associated with sinkhole activity generally observable by man occurs during drought, an extended period of less than average precipitation. Although drought and accompanying water-level declines are probably one of the most recognized or accepted causes of sinkhole development, mechanisms triggering sinkholes have received little or no attention.

During a drought, openings in bedrock receive less recharge. They continue to discharge; however, into nearby streams. This discharge, causing a loss of storage, results in a decline in the water table and the drying up of springs and in declines in stream level. Some streams go dry.

The decline in water level to a position below the top of bedrock triggers the same mechanisms, with the exception of an increase in velocity, that cause sinkholes resulting from induced declines. A loss of support occurs and water-level fluctuations resulting from the less than average rainfall move through openings in the rock against the base of overlying unconsolidated deposits. Recharge from the less than average rainfall, with the water level below the top of bedrock, also results in collapses due to the "piping process." In contrast to the increase in velocity occurring in a cone of depression during pumpage, the velocity under these conditions decreases due to a flattening of the hydraulic gradient.

5.0 SINKHOLE RECORDS

Sinkhole occurrence in the Valley and Ridge Province in eastern Tennessee, like that in other karst areas, is far more common than the literature indicates. Specific data relative to occurrence and cause are limited to a few examples provided by Moore (1980). The study of the impact of man's activities on this occurrence is a relatively new science that has evolved largely since the 1950's. This type occurrence is particularly important because it predominates in many or most areas. To properly assess the significance of the overall database obtained requires defining both the quality and quantity of information obtained.

5.1 QUALITY OF DATA

Data generated from the inventory are general rather than factual in that almost all information is based on memories rather than recorded facts. As in almost all states, there is no agency in Tennessee that acts as a data collection point for information on sinkhole occurrence. Because of this, information was obtained by contacting agencies expected to be confronted with the problem. Recognizing that this was a "first-of-a-kind" study in the area involved, available data for adjacent areas in the Valley and Ridge Province in Alabama, Georgia, and Virginia were obtained to supplement data to be obtained. These data will be of value in assessing cause and frequency of occurrence in later phases of work.

Data from individuals are of great value in that they substantiate an occurrence, provide a background for the site, and a time frame. Again, the data are general because almost all were never recorded. Because of this, locations in Tables 2 through 5 are limited to degrees and minutes. Geologic units designated can also be in error because of the general locations and because they are taken from geologic maps of the respective states that are considered general because of the scales involved.

5.2 QUANTITY OF DATA

Data on sinkhole occurrence were obtained for a total of 324 sites in Alabama, Georgia, Tennessee, and Virginia at which an estimated 2,661 sinkholes or related features (subsidence, piping, and fracturing) have occurred. Of these, 78 sites were in Alabama, 41 in Georgia, 201 in Tennessee, and 4 in Virginia. Similarly, 2,288 sinkholes were estimated to have occurred in Alabama (includes related features), 113 sinkholes in Georgia, 256 sinkholes in Tennessee, and 4 sinkholes in Virginia. The number for Alabama seems disproportionate because it was based largely on detailed studies of intense development in dewatered areas. Studies of similar areas in the other states, if they exist, have not been made. The data for Virginia are very limited and not comparable to that for the other states. This resulted from limited contacts made during a reconnaissance study.

5.3 SIGNIFICANCE

Although data evaluation is scheduled for later phases of work, some tentative findings are obvious. The type of sinkhole, for instance, will have a bearing in the later assessment of the candidate site. In this tentative assessment, all sinkholes are considered natural where data do not warrant classifying them otherwise. Designations of a sinkhole as being induced is based on activities reported for or known to occur at such a site. In or adjacent to a highway, for instance, activities and triggering mechanisms associated with induced sinkhole development could or would include removal of timber, grading, filling, ditching, blasting, diverting or impounding drainage, saturation, loading, piping, and vibrations from traffic. Some of the designations are obvious, some are interpretive. The appraisal is preliminary in nature.

In Alabama, 60 of 78 sites or about 77 percent of the total are classified as induced. Of the induced sites, 40 (67 percent) were associated with ground-water withdrawals and 20 (33 percent) with construction activities. In Georgia, 25 of 41 sites or about 61 percent

of the total are classified as induced. Of the induced sites, 13 (52 percent) were associated with ground-water withdrawals and 12 (48 percent) with construction activities. In Tennessee, 119 of 201 sites or about 59 percent of the total are classified as induced. Of the induced sites, 3 (2.5 percent) were associated with ground-water withdrawals and 115 (97.5 percent) with construction activities. Sites in Virginia, classified as both natural and induced, are not evaluated because of the scarcity of data.

The very high percentage of induced sinkholes resulting from construction in Tennessee is probably attributable to three (3) major factors. First, well drillers and municipal waterwork personnel were not contacted during the inventory. Second, some sinkholes classified as resulting from construction may be due to ground-water withdrawals from wells and mines not identified. Sinkholes can result from construction alone; however, the chances of their occurrence where the water level has been lowered increases manyfold (Newton, 1976a). Third, the karst is more mature in a much broader area than that in Alabama and Georgia. The significance here is that the natural position of the water table would be below the top of bedrock in a larger area. Man-induced water-level declines in these areas would not impact overburden, the cause of this type of sinkhole. The comparison of the position of natural water levels can be made using Figure 7. The position in much of Alabama and Georgia would be above bedrock like that in Figure 3A and that in much of Tennessee would be below the top of bedrock like that in the more karstified area in Figure 3B.

The density of sinkhole occurrence inventoried in Tennessee is greatest in Loudon, Hamblen, and Jefferson Counties (Plate 3). Most of the activity has occurred since 1975 with the majority occurring in the 1980's. The data obtained are biased in several respects. This is due to the lack of contacts with appropriate officials in major municipalities and innumerable communities involved, drillers, consultants, and private landowners. Contacts with the latter would be necessary to determine the significance of recent occurrence in forested karst, a major part of the area involved. The inventory and the lack of these contacts indicate that uninventoried sinkhole occurrence in the study

area for the time frame covered in this study would far exceed that located.

Any assessment of data to date is tentative. Interpretation of the database will be made during later phases of the investigation.

5.4 SUMMARY OF DATA

Data obtained during this phase of work, as described earlier, are based almost entirely on memories of reporting individuals. No attempt is made here to interpret these data. This will be accomplished in the last phase of this investigation.

Dates of reported sinkhole occurrence ranged from 1945 to 1986 with the largest number occurring since 1980. The distribution of reported occurrences for different time frames is illustrated by bar graph in Figure 8.

The maximum surface dimensions of sinkholes reported generally ranged from 1 foot to 200 feet. A summary of maximum surface dimensions of sinkholes inventoried is shown by bar graph in Figure 9. The greatest number of sinkholes reported had a maximum surface dimension of less than 10 feet. Depths generally ranged from 1 foot to 79 feet.

The most common topographic setting for sinkhole occurrences was in valley or flat areas. Of the 201 sites inventoried, 85 or about 42 percent of the total were located in these areas. Of the remainder, 44 sites or about 22 percent of the total were located on hillslopes and 14 sites or about 7 percent of the total were located on hilltops. The topographic setting for 58 sites, about 29 percent of the total, was not reported.

Sinkholes occurred in areas underlain by numerous geologic units. These units, for comparative purposes, are combined into the Conasauga, Knox, and Chickamauga Groups. The geologic settings of sinkhole occurrences in these groups is illustrated by bar graph in Figure 10. The most common geologic setting is the Knox Group in which 128 sites or about 64 percent of all sites are located. This is significant in that the candidate site at Oak Ridge is located in this setting.

FIGURE 8. BAR GRAPH SUMMARIZING DATES OF SINKHOLE OCCURRENCES.

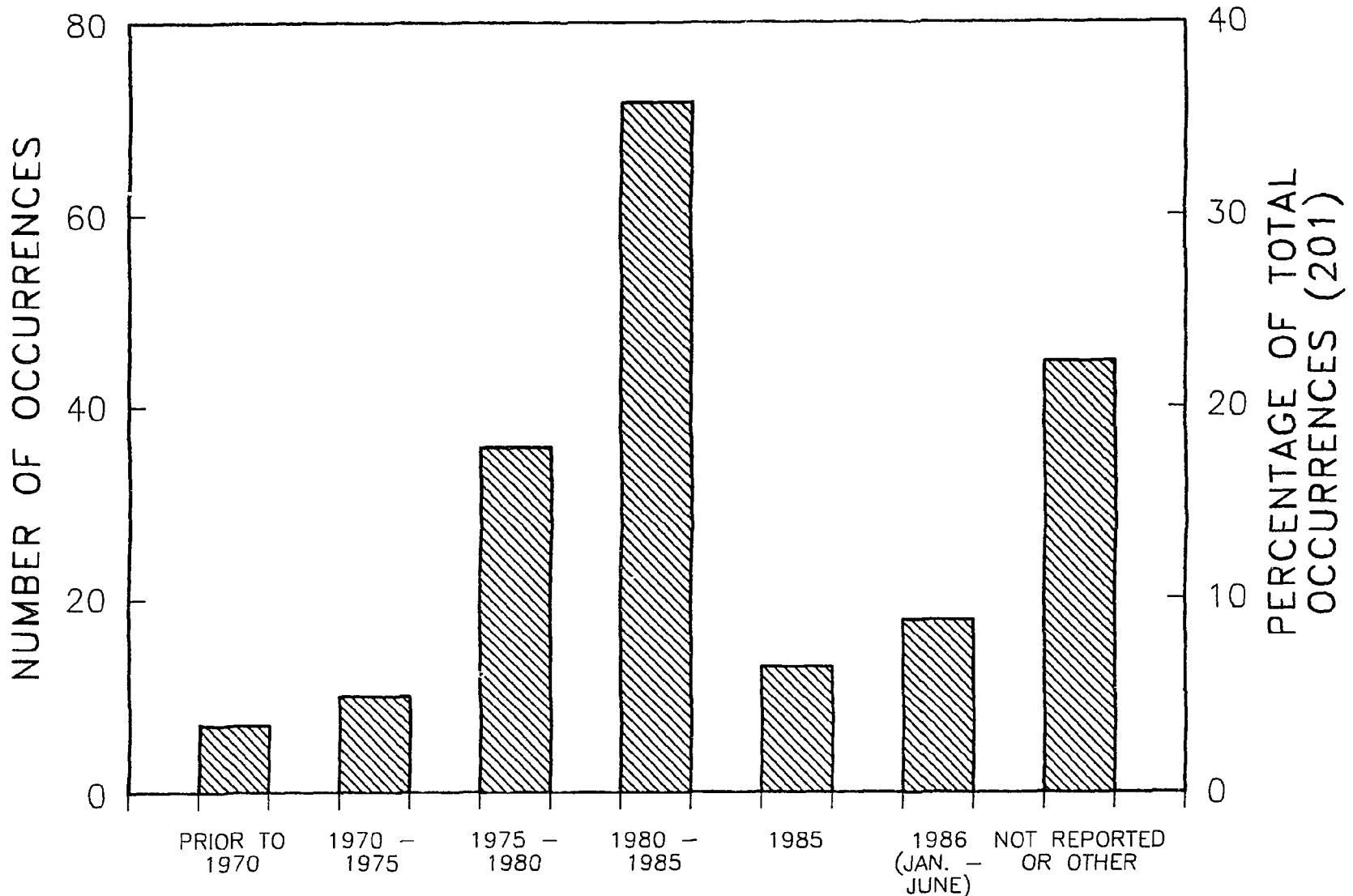


FIGURE 9. BAR GRAPH SUMMARIZING MAXIMUM SURFACE DIMENSIONS OF SINKHOLE OCCURRENCES.

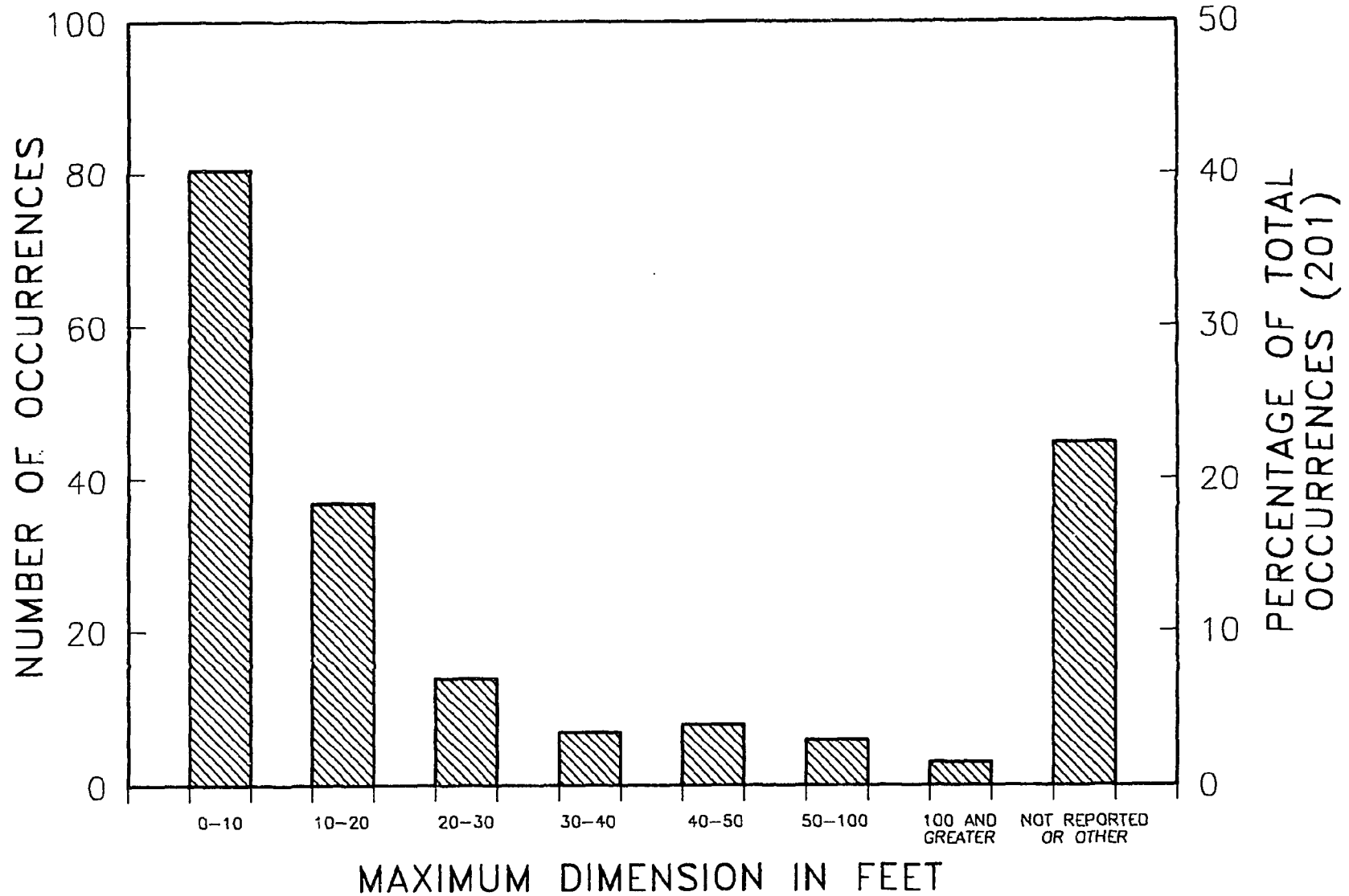
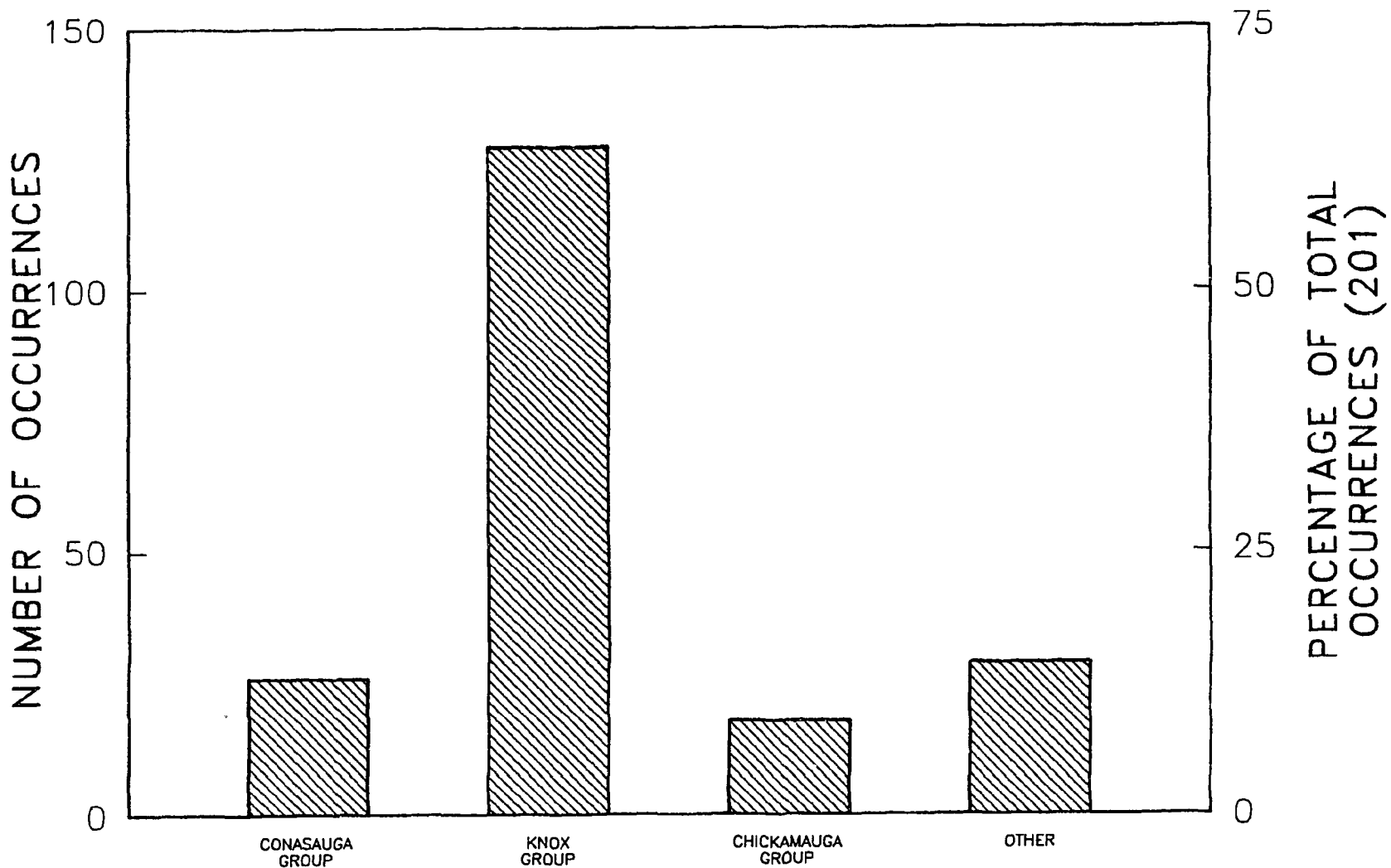


FIGURE 10. BAR GRAPH SUMMARIZING GEOLOGIC SETTINGS OF SINKHOLE OCCURRENCES.



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Table 2. Inventory of sinkhole occurrence in Alabama.

Site number: Numbers correspond to those in Plate 2.

Source of information: USGS, data in files of U.S. Geological Survey; reports cited are in references.

Topographic setting: D, developed; F, forest; H, hilltop; O, open; S, slope; V, valley or flat.

Geologic setting: -Er, Rome Formation; -Ec, Conasauga Formation; -EObk, Bibb, Ketona, and Briarfield Dolomites; -EOc, Chepultepec and Copper Ridge Dolomites; -EO, Cambrian and Ordovician Dolomites; Ob, Odenville, Newala, and Longview Limestones; Oc, Chickamauga Limestone; Ocy, Little Oak, Lenoir, and Mosheim Limestones and Athens Shale; Cfp, Fort Payne Chert; Ct, Tusculmbia Limestone; Cgs, Gasper Formation and Ste. Genevieve Limestone; Cb, Bangor Limestone; Cf, Floyd Shale; Cpv, Pottsville Formation; Kt, Tuscaloosa Group.

Activities or structures near site: C, construction; D, ditching; Dr, drain; G, grading; H, house; Hwy, highway; I, impounding or ponding; O, other (see remarks); P, pumping of nearby well; W, water or sewer lines.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting Unit(s)	Depth to Bed-rock (feet)	Hydrologic Setting		Activ-ities or Struc-tures Near Site
				Length	Width	Depth	Long-itude	Lat-itude				Rain-fall Prior to or During Event	Depth to Water Level (feet)	
Bibb County														
1	Warren (1973); USGS	1	10/72	12	12	6	87°08'	32°59'	H,O	-EOc	6+	No	6+	C,G,I
	<u>Remarks:</u> Collapse resulted in draining of new sewage lagoon in operation for two months.													
2	Newton (1976b); USGS; photography	1	<1975	6	6	25	87°07'	32°58'	S,F	Kt	69+	--	69+	G,Dr
	<u>Remarks:</u> Small collapse in arch of soil cavity that is 20 feet in diameter at a depth of 25 feet. Corridor in sand at bottom extends to uncollapsed soil cavity as much as 50 feet away. Formed by piping.													
3	USGS	1	1963	--	--	--	87°07'	32°56'	V,O	Kt	--	No	--	D
	<u>Remarks:</u> Collapse occurred next to new well during development.													
Blount County														
1	USGS	3+	1960-1970	3-6	3-6	1-5	86°51'	33°53'	V,O	Cb	3-5	Yes	5+	--
	<u>Remarks:</u> Recurring collapses due to piping in colluvium in bottom of large sinkhole.													

(continued)

Table 2. Inventory of sinkhole occurrence in Alabama.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting	Hydrologic Setting		Activ-ities or Struc-tures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Beu-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Blount County (continued)</u>														
2	USGS	4+	1970	2-5	2-5	1-5	86°52'	33°52'	V,F	Cb	1-5	Yes	5+	--
	<u>Remarks:</u> Recurring collapses due to piping in colluvium in bottom of large sinkhole.													
3	USGS	1	1974	25	25	1	86°52'	33°54'	S,F	Cpv	1+	--	100+	Hwy,G,Dr
	<u>Remarks:</u> Piping of soil through fractures in 75 to 100 feet of non-carbonate rock to openings in carbonate rocks.													
4	USGS	2+	1963-1964	--	--	--	86°36'	34°05'	0	Cfp	--	--	--	P
	<u>Remarks:</u> Several sinkholes formed near large capacity well at industry.													
<u>Calhoun County</u>														
1	USGS	1	4/5/71	6	6	12	85°48'	33°37'	H,0	60c	12+	--	--	H,D
	<u>Remarks:</u> Small collapse in arch of soil cavity that was 10 to 12 feet in diameter in subsurface. Began collapse with passing of lawn mower. In vicinity of field lines from septic tank.													
2	USGS	100-200	1970-1981	1-40	1-40	1-40	85°46'	33°38'	V,0	60c	--	--	--	Hwy,0
	<u>Remarks:</u> Adjacent to dewatering recessed quarry. Many sinkholes occur during periods of flooding.													
3	USGS	5	11/27/64	10-30	10-30	15+	85°45'	33°49'	V,0,D	Cf/Cr	33	--	15	P
	<u>Remarks:</u> Occurred during well development pumping 1,500 gpm. One collapse was under church.													
4	USGS	10±	1965-1982	10	6	10-12	--	--	0	--	--	--	--	P,0
	<u>Remarks:</u> Collapses in lake, yard of house, and areas adjacent to recessed dewatering quarry. Dimensions for collapse in yard.													
<u>Cherokee County</u>														
1	USGS	1	5/78	--	--	32	85°29'	34°19'	V,0	60c	--	Yes	15±	--
	<u>Remarks:</u> In plowed field. Discovered after extensive rains.													

(continued)

Table 2. Inventory of sinkhole occurrence in Alabama.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Longitude	Latitude		Unit(s)	Depth to Bedrock (feet)	Rainfall Prior to or During Event		Depth to Water Level (feet)
<u>Etowah County</u>														
1	USGS	1	1970-1972	4-5	4-5	15+	85°56'	34°03'	O,D	Ob	20	--	15	P,H
	<u>Remarks:</u> Collapsed in yard of house during development of nearby well.													
2	USGS	1	1960's	5-10	5-10	--	85°57'	34°11'	O,V	Oc	--	--	--	--
	<u>Remarks:</u> Occurred in field.													
3	Newton (1976)	1	1971	6	6	5	85°59'	34°08'	S,O	Oc	--	--	--	G,Hwy,Dr
	<u>Remarks:</u> Landslide involving one lane of Interstate Highway 59 triggered by collapse. Water entered sinkhole and discharged beneath fill lubricating clay. Highway slid down slope.													
<u>Jackson County</u>														
1	USGS	1	3/27/80	5	5	30	85°40'	34°55'	H,O	Cpv	--	--	--	H
	<u>Remarks:</u> Occurred in yard. Collapse underlain by sandstone that, in turn, overlies limestone at depth of about 150 feet.													
2	USGS	1	1973	--	--	--	85°47'	34°51'	H,O	60c	--	--	--	C,G
	<u>Remarks:</u> Occurred during construction after grading site.													
3	USGS	2	8/3/81-10/10/81	15-25	15-25	8-12	85°46'	34°50'	H,O	60c	50	--	50	W,I
	<u>Remarks:</u> First occurred under water line to nearby sludge pond. Attributed to leakage. Second occurred 20 feet from sludge pond.													
4	USGS	1	1961	--	--	--	86°02'	34°40'	V,O	Cgs	--	--	--	O
	<u>Remarks:</u> Occurred in football field.													

(continued)

Table 2. Inventory of sinkhole occurrence in Alabama.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
Jefferson County														
1	USGS	1	9/81	--	--	--	87°00'	33°29'	S,O,D	0c	--	--	--	H
	<u>Remarks:</u> Subsidence during drought conditions damaged three houses severely. Fractures under one house reflected as much as 0.5 inch of displacement. fracturing common.													
2	USGS	1	1975	8	8	15	86°56'	33°27'	O,D	-6c	--	--	6	H
	<u>Remarks:</u> In yard of house.													
3	USGS	100+	1928-1977	5-30	5-30	--	87°00'	33°25'	V,O,D	-60bk	2-34	--	--	H, Hwy
	<u>Remarks:</u> Sinkholes encircle recessed dewatering quarry.													
4	USGS	1+	1927	--	--	--	86°54'	33°28'	--	-60c	--	--	--	--
	<u>Remarks:</u> Occurrence of small sinkhole reported to have occurred during high pumpage from spring. Water muddied and blockage caused failure of municipal water supply.													
5	USGS	10+	1964-1965	40	20	3	86°48'	33°35'	V,S	-6c	--	--	--	H,W
	<u>Remarks:</u> Dimensions given are maximum size. Occurred during general time frame in which a nearby well was reportedly being developed. One sinkhole occurred under house.													
6	USGS	1	1980	6	6	8	87°03'	33°22'	V	-60c	--	--	--	Hwy, D
	<u>Remarks:</u> Occurred next to overpass support on Interstate Highway 59. Piping also reported in nearby drain.													
7	USGS	100±	Prior to 1974	2-40	2-40	--	86°49'	33°33'	V,O,D	-60bk	5-33	--	--	Hwy, H, O
	<u>Remarks:</u> Dimensions estimated. Sinkholes have occurred under buildings and streets. Adjacent to recessed dewatering quarry in operation for decades.													
8	USGS	50	Prior to 1975	15	15	10	86°57'	33°28'	V,F	-60bk	--	--	--	65
	<u>Remarks:</u> Estimated number of sinkholes includes subsidence and related features. Sinkholes encircle high capacity well pumping 24 hours per day. Sinkhole dimensions given are for the largest.													

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{continued}

Table 2. Inventory of sinkhole occurrence in Alabama.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting	Hydrologic Setting		Activ-ities or Struc-tures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Jefferson County (continued)</u>														
9	USGS	2+	1972	--	--	--	86°46'	33°35'	V,D	-60bk	--	--	--	C,0
	<u>Remarks:</u>	Airport construction. Sinkholes collapses when caissons installed for supports were pumped out to remove water and mud.												
10	USGS	1	5/2/74	2	2	--	86°50'	33°33'	V,D	-60bk	--	--	--	0
	<u>Remarks:</u>	Railroad yard. Collapse occurred beneath train inspector at night. Injured.												
11	USGS	11	1955	3-20	3-20	3-15	86°50'	33°28'	V,0	Cb	--	--	--	--
	<u>Remarks:</u>	In pasture. Occurred during drought.												
12	USGS	3	1/59	8-10	3-8	2-6	86°51'	33°28'	0	-60c	<50	--	--	P,0
	<u>Remarks:</u>	Occurred in golf course fairways during development of new well.												
13	USGS	1	2/74	30	20	10	87°01'	33°25'	V	Ct	--	--	--	P
	<u>Remarks:</u>	Occurred during development of new well.												
14	USGS	2	8/69	--	--	--	86°45'	33°33'	V,D	Cb	--	--	--	P,C,Dr,0
	<u>Remarks:</u>	First sinkhole occurred during construction of mall and during drilling of wells. The second occurred in a drain.												
15	USGS	1	1964	--	--	--	86°43'	33°33'	D	Cb	--	--	--	H,P
	<u>Remarks:</u>	Sinkhole occurred during development of new well.												
16	USGS	3+	Before 1975	--	--	--	86°33'	33°33'	V,0	Ocy	--	--	--	H,0
	<u>Remarks:</u>	Occurred in field adjacent to a recessed dewatering quarry.												
17	USGS	-	Before 1970	--	--	--	86°54'	33°30'	V,D	-60bk	--	--	--	H,0
	<u>Remarks:</u>	Occurrences reported periodically in area adjacent to recessed dewatering quarry.												

(continued)

Table 2. Inventory of sinkhole occurrence in Alabama.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting Unit(s)	Depth to Bed-rock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Long-itude	Lat-itude				Rain-fall to or During Event	Depth to Water Level (feet)	
<u>Jefferson County (continued)</u>														
18	USGS	1	1981	--	--	--	86°34'	33°34'	--	60c	--	--	--	Hwy, Dr
	<u>Remarks:</u> Subsidence in off-ramp of Interstate Highway 20 and piping in nearby drain.													
19	USGS	1	1928	--	--	--	86°49'	33°32'	D	60bk	--	--	--	0
	<u>Remarks:</u> Under and adjacent to industrial building.													
20	USGS	1	Before 1933	--	--	--	86°48'	33°32'	D	60c	--	--	--	W, 0
	<u>Remarks:</u> Collapse under warehouse. Water from nearby well became muddy some time prior to collapse.													
21	Newton and Hyde (1971); USGS	200+	1948-1970	1-80	1-60	1-100+	86°52'	33°22'	V, 0, D	60bk	5-75	Yes	--	H, Hwy, 0
	<u>Remarks:</u> Sinkhole occurrence adjacent to recessed dewatering quarries. Problem attributed to ground-water withdrawals.													
22	Newton and others (1973); USGS	171+	1950-1972	1-144	1-84	1-30+	86°56'	33°22'	V, 0, F, D	Ct	2-50	--	0-35	H, Hwy
	<u>Remarks:</u> Attributed to drought and ground-water withdrawals from mines and wells. Mines at depths exceeding 1,000 feet.													
<u>Shelby County</u>														
1	Powell and others (1969); USGS	7+	1968	--	--	--	86°37'	33°13'	0, D	Cfp	--	--	--	P, H
	<u>Remarks:</u> Near and under buildings and water tank. Wells abandoned.													
2	Newton (1976); USGS	45+	1950-1967	--	--	--	86°49'	33°19'	V, 0, D	0b	--	--	--	H, Hwy, 0
	<u>Remarks:</u> Sinkholes encircled recessed dewatering quarry. Total number unknown, number identified were unfilled and identifiable on aerial photography. Quarry abandoned prior to 1967.													
	(continued)													

Table 2. Inventory of sinkhole occurrence in Alabama.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall to or During Event		Depth to Water Level (feet)
<u>Shelby County (continued)</u>														
3	USGS	4	1978	--	--	--	86°30'	33°16'	O,D	Ob	--	--	--	H
	<u>Remarks:</u> Small sinkholes formed in yard.													
4	USGS	1	3/1975	6-8	6-8	42	86°45'	33°07'	--	--	28	--	22	P,Hwy
	<u>Remarks:</u> Occurred 45 feet from developing well near highway.													
5	USGS	1	9/18/72	18	10	20	86°48'	33°11'	V,O,D	6Obk	--	--	--	P,O
	<u>Remarks:</u> Collapse beneath filled gasoline tank truck at filling station on highway. Occurred near well that had development (mud) problem during previous month.													
6	USGS	1	11/4/74	60-70	60-70	0.5	86°53'	33°08'	H,O,D	6c	--	--	--	C,O
	<u>Remarks:</u> Beneath housing development. Damaging subsidence. Prolonged leakage from damaged fireplug entered subsurface.													
7	USGS	1	Prior to 1974	20-40	20-40	20-40	86°52'	33°09'	--	6r or 6c	--	--	--	Dr
	<u>Remarks:</u> In drainage ditch.													
8	USGS	1	Prior to 1974	20-40	20-40	20-40	86°51'	33°08'	--	6r	--	--	--	Dr
	<u>Remarks:</u> In drainage ditch.													
9	USGS	1	Prior to 1974	20-40	20-40	20-40	86°51'	33°09'	--	6c or 6r	--	--	--	--
	<u>Remarks:</u> Similar in size to collapses occurring in drains in general area.													
10	USGS	6+	1973-1981	--	--	--	86°47'	33°14'	V,O	Ocy or Ob	--	--	40+	O
	<u>Remarks:</u> Adjacent to recessed quarry.													
11	USGS	2+	1957	--	--	--	86°29'	33°16'	V	Ob	--	--	--	P
	<u>Remarks:</u> Near pumping well.													

(continued)

Table 2. Inventory of sinkhole occurrence in Alabama.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Longitude	Latitude		Unit(s)	Depth to Bedrock (feet)	Rainfall Prior to or During Event		Depth to Water Level (feet)
<u>Shelby County (continued)</u>														
12	USGS	2+	Prior to 1974	--	--	--	86°49'	33°18'	V,0	0b or 0cy	--	--	--	0
	<u>Remarks:</u> Adjacent to abandoned quarry.													
13	Newton (1976a); Warren (1976); USGS	1,000+	--	1-300+	1-300+	1-100	86°47'	33°09'	V,S, O,F, D	€0c, 0b	0-125	--	--	--
	<u>Remarks:</u> Number of sinkholes estimated includes related features such as piping, subsidence, and fractures. The area involved, about 10 square miles in size, was made prone to sinkhole development by water level declines due to pumpage of wells and mines.													
14	Newton (1976a);USGS	1	Before 1950	--	--	--	86°47'	33°11'	S,F	€0c	--	--	--	--
	<u>Remarks:</u> Bare walls in recent collapse in forest located with aerial photography.													
15	USGS	2	1976 and 9/12/77	6-75	6-50	35-75	86°28'	33°22'	--	€0c	--	--	--	P
	<u>Remarks:</u> First sinkhole occurred 40 feet from municipal well and the second occurred 150 feet from it. Yield decreased drastically after the latest collapse. Abandoned.													
16	USGS	2+	Prior to 1976	--	--	--	86°30'	33°15'	V,0	0b or €0c	--	--	--	--
	<u>Remarks:</u> Occurred in fields adjacent to Coosa River during period of drought.													
17	Warren (1976)	2	1951	--	--	--	86°47'	33°07'	--	0cy or Cfp	--	--	--	P
	<u>Remarks:</u> Formed during aquifer test in well.													

(continued)

Table 2. Inventory of sinkhole occurrence in Alabama.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Longitude	Latitude		Unit(s)	Depth to Bedrock (feet)	Rainfall Prior to or During Event		Depth to Water Level (feet)
<u>Shelby County (continued)</u>														
18	USGS	4	1954-1976	--	--	--	86°41'	33°29'	V,0	60c, 6r, 0b	--	--	--	I
	<u>Remarks:</u>	Collapses in and adjacent to Lake Purdy, a source of water supply for Birmingham, resulted in flow beneath dam. Problem corrected with grouting.												
19	USGS	3	1981	1-6	1-6	4-5	86°49'	33°11'	V,0	60bk, 6r	--	--	--	H,0
	<u>Remarks:</u>	Collapses and piping in hog parlor. One radial fracture about 6 feet in diameter encircles small collapse. Arch in roof of soil cavity observable through small opening (pipe) in surface.												
20	USGS	-	1981	--	--	--	86°49'	33°10'	V,0	60bk or 6r	--	--	--	H,P
	<u>Remarks:</u>	Spring formerly used as a municipal supply went dry for first time. Attributed to drought and well withdrawals. Estimated 50 to 100 soil pipes as much as 1 foot in diameter formed in small field nearby.												
21	USGS	3+	1981	3-5	3-5	3-5	86°51'	33°11'	V,0	60c, 60bk	--	--	--	--
	<u>Remarks:</u>	Small recent collapses in fields at base of hillsides.												
22	USGS	3+	1981	3-10	3-10	3-5	86°56'	33°22'	V,F	60bk, 60c	5±	--	5+	C
	<u>Remarks:</u>	Subdivision under construction. Recent natural sinkholes occurred at base of nearby steep slope.												
23	USGS	1	12/80	18	12	1-	86°47'	33°08'	V,0,D	0b	--	--	--	W,H
	<u>Remarks:</u>	Leakage from water pipe, finally ruptured and discharged at land surface in yard at house. Subsidence in foundation and fractures in patio and walls. Occurred during drought.												
24	USGS	2	1981	15-20	15-20	--	86°50'	33°08'	V,D,0	60c	--	--	--	H,0
	<u>Remarks:</u>	In pasture next to house. Sinkholes 25 to 50 feet apart. Occurred during drought.												

(continued)

Table 2. Inventory of sinkhole occurrence in Alabama.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Shelby County (continued)</u>														
25	USGS	1	1981	6-8	6-8	3	86°52'	33°10'	--	Cr	--	--	--	P
	<u>Remarks:</u>	Near test well. Occurred during development.												
<u>St. Clair County</u>														
1	USGS	12	1973	1-20	1-10	1-8	86°30'	33°36'	V,D,O	Ocy or Cfp	--	--	--	P,H,Hwy
	<u>Remarks:</u>	In vicinity of wells being developed or that occasionally pump muddy water.												
2	USGS	2+	Prior to 1971	--	--	--	86°18'	33°36'	D	Cf or Cfp	--	--	--	P,H,O
	<u>Remarks:</u>	Sinkholes developed near buildings and houses when nearby well was being developed.												
3	USGS	1	1965	2-3	2-3	30	86°15'	33°36'	D	60c	--	--	30+	Hwy
	<u>Remarks:</u>	Collapse under rodman on survey team. Occurred in median of Interstate Highway 20. No injury, landed on dirt floor.												
4	USGS	2	Prior to 1976	--	--	--	86°10'	33°44'	V	Cf or Ocy	--	--	--	P
	<u>Remarks:</u>	Two collapses, one in creek, near developing well. Well abandoned.												
5	USGS	1	Prior to 1976	3	3	4-5	86°09'	33°44'	--	Cf or Cfp	--	--	--	P
	<u>Remarks:</u>	Near well being developed.												
6	USGS	3+	Prior to 1973	--	--	--	86°10'	33°43'	V,O,F	Ob	--	--	--	O
	<u>Remarks:</u>	Numerous sinkholes in vicinity of recessed dewatering quarry.												
7	USGS	1	1973	20	5	--	--	--	O	--	--	--	--	I
	<u>Remarks:</u>	In 2-acre pond. Drained.												

(continued)

Table 2. Inventory of sinkhole occurrence in Alabama.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall to or During Event		Depth to Water Level (feet)
<u>St. Clair County (continued)</u>														
8	USGS	2	1977	1	1	--	--	--	0	--	--	--	--	I
	<u>Remarks:</u>	Two small openings (pipes) drained pond immediately. Attempted repair with compacted clay and bentonite. Repair failed.												
<u>Talladega County</u>														
1	USGS	2	1962	--	--	--	86°23'	33°22'	V	60c	--	--	--	P
	<u>Remarks:</u>	Near developing well pumping muddy water.												
2	USGS	3+	1967-1971	6-18	6-18	5-12	86°10'	33°37'	V,D,O	60c	47	--	--	P,C,G,I,D
	<u>Remarks:</u>	Collapse during original well development. Later fire protection pond constructed next to well in vicinity of foundation borings. Continuous pumping resulted in repeated collapses in pond.												
3	USGS	2	1952-1967	10-40	10-40	6-25	86°21'	33°19'	V	60	--	--	--	P
	<u>Remarks:</u>	Sinkholes occurring about 200 feet from well in 1952 and 1967 were repaired. Continued pumping.												
4	USGS	2	10/72	12-18	12-18	2-16	86°22'	33°18'	V,O,D	60c or 60	33	--	--	P,H,Hwy
	<u>Remarks:</u>	During well development. Collapses under street and railroad.												
5	Warren (1973)	1	1971	6	6	2-4	86°07'	33°27'	--	60	--	--	--	G,I
	<u>Remarks:</u>	Bedrock in lagoon exposed during excavation. Liner installed but failed. Collapse drained lagoon.												
6	USGS	145+	1968-1981	--	--	--	86°21'	33°27'	V	60c	--	--	--	C,G,I,O
	<u>Remarks:</u>	Construction of major dam and impoundment on Coosa River. Corrective and safety measures include grouting and construction of second or backup dam.												
7	USGS	2	1974-1976	--	--	--	86°05'	33°36'	V,D	60c	--	--	--	P,O
	<u>Remarks:</u>	Near two closely spaced wells in vicinity of building and speedway.												

(continued)

Table 2. Inventory of sinkhole occurrence in Alabama.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Talladega County</u> (continued)														
8	USGS	1	1970	6	6	6	86°00'	33°35'	V	G0c	5-40	--	--	P
	<u>Remarks:</u> Formed during drilling of nearby well. Other older small sinkholes located in general area.													
9	USGS	2	12/54	--	--	--	86°07'	33°29'	--	Gc or Gr	--	--	--	C,G
	<u>Remarks:</u> Waterworks filtration plant. Collapse and subsidence beneath concrete basin and plant. Disrupted service.													
10	USGS	1	1930	--	--	--	86°06'	33°29'	--	G0	--	--	--	I
	<u>Remarks:</u> Leakage from reservoir associated with collapse under concrete liner.													
11	USGS	40+	1953-1956	--	--	--	86°16'	33°13'	V,D,O	G0	--	--	--	P,H,O
	<u>Remarks:</u> In downtown area during major drought. Collapses under buildings, streets, and a person.													
12	USGS	100+	1916-1981	3-90	3-90	1-70	86°18"	33°12'	V,D,O	G0	--	--	--	P,H,Hwy,O
	<u>Remarks:</u> Number of sinkholes estimated. Under streets, pipes, etc. In area of ground-water withdrawals by wells and quarries. One injury.													
13	USGS	1	5/27/81	6	6	5	86°14'	33°17'	--	G0	--	Yes	--	P,Hwy
	<u>Remarks:</u> Damage to new well house. Radial fractures extended beyond collapse. Occurred after significant rain. Area around well also cratered. Water became dingy during development but cleared up.													

Table 3. Inventory of sinkhole occurrence in Georgia.

Site number: Numbers correspond to those in Plate 2.

Source of information: USGS, data in files of U.S. Geological Survey

Topographic setting: D, developed; F, forest; H, hilltop; O, open; S, slope; V, valley or flat.

Geologic setting: ϵ s, Shady Dolomite; ϵ r, Rome Formation; ϵ cs, lower unit, Conasauga Group; ϵ cls, middle unit, Conasauga Group; ϵ c, middle unit, Conasauga Group; ϵ cs1, upper unit, Conasauga Group; ϵ cd, upper unit, Conasauga Group; Ock, Knox Group; On, Newala Limestone; Oc, Chickamauga Group; Or, lower unit, Chickamauga Group; Mls, Lavender Shale Member, Fort Payne Chert; Mfs, Hartselle Sandstone Member, Floyd Shale; Mu, Mississippian Undifferentiated.

Activities or structures near site: C, construction; D, ditching; Dr, drain; G, grading; H, house; Hwy, highway; I, impounding or ponding; O, other (see remarks); P, pumping of nearby well; W, water or sewer lines.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
1	USGS	5-6	1979-1980	6-12	6-12	10-12	84°56'	34°07'	O	Ock	--	--	--	Hwy, O
	<u>Remarks:</u>	First in roadway in 1979, four or five occurred in open field in 1980. Cultivation discontinued.												
2	USGS	1	1971-1973	--	--	--	84°49'	34°09'	--	ϵ r	25+	--	25+	C, D, W
	<u>Remarks:</u>	Made 25-foot cut laying sewer line. Collapse in bottom. Filled and recollapsed. Filled with concrete to stabilize.												
3	USGS	1	1972-1973	8	8	30	84°49'	34°13'	--	ϵ r	--	--	--	C, G, Hwy
	<u>Remarks:</u>	In southbound lane of highway after grading and before paving.												
4	USGS	2+	1977	--	--	--	84°49'	34°09'	--	ϵ s	--	--	--	P
	<u>Remarks:</u>	Area of industrial wells. Sinkholes small to moderate in size. Filled.												
5	USGS	1	1973-1974	--	--	--	84°49'	34°09'	D	ϵ s	--	--	--	P, O
	<u>Remarks:</u>	Subsidence caused major damage to building. Well about 100 feet away yielded muddy water, discharge declined, and was abandoned.												

(continued)

Table 3. Inventory of sinkhole occurrence in Georgia.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Bartow County (continued)</u>														
6	USGS	20+	1970-1974	3-25	3-25	3-10	84°55'	34°14'	V,0	Osk	5-10	--	50+	0
	<u>Remarks:</u> Open areas adjacent and near recessed dewatering quarry.													
<u>Chattooga County</u>														
1	USGS	1	1977	10-12	10-12	6-7	84°31'	34°27'	0	Osk	--	--	--	--
	<u>Remarks:</u> In field near road. Small sinkholes reported to occasionally "drop out" in fields in area.													
<u>Floyd County</u>														
1	USGS	1	1978-1979	3	3	--	85°20'	34°08'	0	Cr	--	--	--	Hwy, Dr
	<u>Remarks:</u> Adjacent to highway in drain.													
2	USGS	1	1979	15	12	50	85°19'	34°08'	0	Cr	15	--	--	--
	<u>Remarks:</u> In pasture.													
3	USGS	1	1979	6	6	6	85°21'	34°08'	--	Cr	--	--	--	--
	<u>Remarks:</u> In vicinity of two other recent sinkholes.													
4	USGS	3	Prior to 1981	3-4	3-4	3-4	85°12'	34°16'	0	Mfs	4+	--	--	--
	<u>Remarks:</u> In cultivated field over period of time.													
5	USGS	1	1980	4-5	4-5	10-12	85°10'	34°15'	V,0	Cr	10+	--	10+	0
	<u>Remarks:</u> In golf course fairway. Soil cavity enlarged with depth. It was 12 to 15 feet in diameter in bottom.													
6	USGS	1	1978	10-12	10-12	3-4	85°12'	34°11'	V	Cr	--	--	3-4	--
	<u>Remarks:</u> Water moving in bottom. Near stream bank.													

(continued)

Table 3. Inventory of sinkhole occurrence in Georgia.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Floyd County (continued)</u>														
7	USGS	1	1976	15	15	30	85°14'	34°15'	V,O,D	Mls	--	--	--	0
	<u>Remarks:</u> In street over storm drain.													
8	USGS	1	1975	6	6	30	85°12'	34°14'	O,D	Es	--	--	--	0
	<u>Remarks:</u> Middle of street.													
9	USGS	1	1980	15	15	55-60	85°12'	34°15'	D	Es	--	--	--	0
	<u>Remarks:</u> Near site of abandoned well.													
10	USGS	1	1974	6-7	6-7	20	85°12'	34°15'	D	Er	--	--	--	H
	<u>Remarks:</u> Under house.													
11	USGS	3	1961-1966 1970, 1981	2-5	2-5	5-20	85°22'	34°06'	V,O,D	Ecd	--	--	--	H, Dr, Hwy
	<u>Remarks:</u> None.													
12	USGS	1	1960	5	5	20	85°25'	34°05'	O	Ecd	--	--	--	0
	<u>Remarks:</u> In field.													
13	USGS	1	Prior to 1981	4	4	4	85°11'	34°21'	O	Mfs	--	--	--	Hwy, O
	<u>Remarks:</u> In highway near abandoned recessed quarry. Has re-occurred several times.													
<u>Gordon County</u>														
1	USGS	2	1971-1973, 1977	50- 100	50- 100	30	84°43'	34°25'	O,D	Ecls	--	--	--	P,O
	<u>Remarks:</u> Trailer park. Dimensions are for first sinkhole. Second was 6 feet in diameter and 6 feet deep.													
2	USGS	2	1944	6	6	6	84°43'	34°24'	O	Ecls	--	--	--	--
	<u>Remarks:</u> In field.													

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(continued)

Table 3. Inventory of sinkhole occurrence in Georgia.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting Unit(s)	Depth to Bed-rock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Long-itude	Lat-itude				Rain-fall Prior to or During Event	Depth to Water Level (feet)	
<u>Gordon County (continued)</u>														
3	USGS	1	Prior to 1980	20	20	30	85°58'	34°27'	0	6c	--	--	--	I, Hwy, Dr
	<u>Remarks:</u>	In highway and drain.												
4	USGS	4	--	--	--	--	84°54'	34°29'	0, D	6c1s	--	--	--	P, G, I, H
	<u>Remarks:</u>	Well drilled and pumped near existing lake. Sinkholes occurred in lake, on bank, and near house. Lake drained. Additional collapse occurred under dozier making repair. Ground reportedly stabilized when pumping ceased.												
<u>Murray County</u>														
1	USGS	3-4	1974	--	--	--	84°47'	34°43'	0	6cs	--	--	--	P, I
	<u>Remarks:</u>	Collapse in lake coincided with pumpage of new well. During repair, additional collapse occurred beneath heavy equipment. Repaired, ceased pumping, no problems since.												
<u>Polk County</u>														
1	USGS	1	1975	5	5	10	85°18'	34°01'	0	On	--	--	--	W, O
	<u>Remarks:</u>	Exposed sewer. Arch of soil cavity observed.												
2	USGS	1	1976	35	25	30	85°17'	34°01'	V, D	On	--	--	--	H, O
	<u>Remarks:</u>	In yard of house.												
3	USGS	2	1960-1970	15	15	25	85°17'	34°01'	D	On	--	--	--	P
	<u>Remarks:</u>	Sinkholes similar in size. Reportedly formed near industrial well pumping about one million gallons per day. Ceased pumping.												
4	USGS	1	1975-1976	10-12	10-12	11	85°17'	34°01'	D	06k	--	--	--	W
	<u>Remarks:</u>	Beneath leaking sewer. Subsidence required leveling at later date.												

(continued)

Table 3. Inventory of sinkhole occurrence in Georgia.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting Unit(s)	Depth to Bedrock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Longitude	Latitude				Rainfall to or During Event	Depth to Water Level (feet)	
<u>Polk County (continued)</u>														
5	USGS	1	1979	--	--	--	85°18'	34°00'	V,D	On	--	--	--	0
	<u>Remarks:</u> Subsidence beneath courthouse. Floor cracked, widened, fracturing in walls. During extended dry weather. Ceased, not repaired.													
6	USGS	2	1979	4	4	8-10	85°18'	34°01'	--	On	--	Yes	--	1
	<u>Remarks:</u> Sinkholes of similar size. Occurred next to "Frog Pond" during flooding.													
7	USGS	1	Prior to 1980	6	6	8	85°18'	33°57'	0	Or	--	--	--	W,Hwy
	<u>Remarks:</u> In highway over pipe presumed to leak.													
8	USGS	1	1970	15	15	8	85°16'	34°01'	0	O6k	8+	--	--	P,C,I
	<u>Remarks:</u> Beneath settling pond for waste water. Occurred when water from well was pumped into new pond to test it.													
9	USGS	1	1971-1973	8	8	--	85°03'	34°00'	--	On	--	--	--	C,G,I
	<u>Remarks:</u> Drained 18-acre lake. Filled with car hulks and debris. Repair unsuccessful.													
10	USGS	1	1946-1947	25	25	--	85°04'	34°00'	0,D	O6k	--	--	--	P,H
	<u>Remarks:</u> Occurred in yard during development of new well.													
<u>Walker County</u>														
1	USGS	1	1976	50	50	120	85°22'	34°41'	S,F	Mu	--	--	--	--
	<u>Remarks:</u> Collapse resulted from failure of dome pit roof in bedrock or erosion of overburden through opening in it.													
2	USGS	25±	1977-1980	1-25	1-25	20	85°18'	34°50'	V,O,D	Oc	--	--	--	P
	<u>Remarks:</u> Prior to 1981. In area of large ground-water withdrawals.													

(continued)

Table 3. Inventory of sinkhole occurrence in Georgia.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Walker County (continued)</u>														
3	USGS	3-4	Prior to 1980	--	--	--	85°23'	34°45'	--	On	--	--	--	P
	<u>Remarks:</u>	Sizes reported to be medium to large. Pumpage from wells reported to range from 750 to 2,500 gpm. Ground reported to stabilize when pumpage was limited to 600 gpm per well.												
<u>Whitfield County</u>														
1	USGS	1	--	3-4	3-4	12	84°57'	34°55'	--	GcsI	12+	--	12+	--
	<u>Remarks:</u>	Collapse in arch of soil cavity. At depth of 12 feet, the soil cavity enlarged to a diameter of 15 to 25 feet.												
2	USGS	6-7	1977-1978	3-20	3-20	1-30+	84°58'	34°45'	V	GcsI	--	--	30	P
	<u>Remarks:</u>	Activity reported to cease when pumping ceased.												
3	USGS	1	1956-1961	2-3	2-3	12	84°58'	34°45'	--	GcsI	12+	--	12+	--
	<u>Remarks:</u>	Collapse in arch of soil cavity. At depth of 12 feet, the soil cavity enlarged to a diameter of 12 to 15 feet.												

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site number: Numbers correspond to those in Plate 3.

Source of information: C, City
 CA/CE, County Agent and/or County Executive
 CDC, Civil Defense Coordinator
 CDOT, County Highway Department
 SCS, Soil Conservation Service
 TDG, Tennessee Division of Geology
 TDOT, Tennessee Department of Transportation
 TDSWM, Tennessee Department of Health and Environment,
 Division of Solid Waste Management
 USGS, Files of U.S. Geological Survey

Topographic setting: D, developed; F, forest; H, hilltop; O, open; S, slope; V, valley or flat.

Geologic setting:

Eu,	Unicoi Formation	Och,	Chickamauga Group
Che,	Hesse Sandstone	Opm,	Pierce and Murfreesboro Limestones
Chk,	Honaker Dolomite	Ord,	Ridley Limestone
Scr,	Copper Ridge Dolomite	Obh,	Bigby-Cannon Limestone and Hermitage Formation
Spv,	Pumpkin Valley Shale	Ou,	Sequatchie, Leipers, Inman, and Catheys Formations
Ert,	Rutledge Limestone		
Em,	Maryville Limestone	Mfp,	Fort Payne Formation
En,	Nolichucky Shale	Mg,	Grainger Formation
Emr,	Maryville, Rogersville, and Rutledge Formations	Mn,	Newman Formation
Emn,	Maynardville Limestone	Mm,	Monteagle Limestone
Scu,	Maynardville Limestone and Nolichucky Shale	Mbh,	Bangor Limestone and Hartsville Formation
Sc1,	Spv, Emr, and Scu Undifferentiated	Mp,	Pennington Formation
Sc,	Conasauga Group		
		Pco,	Crab Orchard Mountains Group
Olc,	Longview, Chepultepec Undifferentiated	Psi,	Slatestone Formation
On,	Newala Formation		
Oc,	Chepultepec Dolomite		
Olv,	Longview Dolomite		
Ok,	Kingsport Formation		
Oma,	Mascot Dolomite		
Onc,	Oc, Olv, Ok, and Oma Undifferentiated		
Ock,	Knox Group		
Osv,	Sevier Shale		
Oa,	Athens Shale		
Oh,	Holston Formation		
Oo,	Ottosee Shale		
O1,	Lenior Limestone		

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Activities or structures near site: B, blasting; C, construction; D, ditching; Dr, drain; G, grading; H, house; Hwy, highway; I, impounding or ponding; O, other (see remarks); P, pumping of nearby well; W, water or sewer line.

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall to or During Event		Depth to Water Level (feet)
Anderson County														
1	TDSWM	1	4/4/81	20	20	5-6	84°02'	36°07'	H,O,D	€cr	50±	Yes	70+	C,G,I,O
	Remarks: Sanitary landfill. Base of grading in area was allowed to elevation of 1,040 feet (estimated 15 to 20 feet to reach this level). Seepage in adjacent area also noted in 1985. Rainfall triggered collapse in graded area where ponding occurred. Later, piping (small diameter) occurred in silt trap associated with the landfill.													
2	TDSWM	1	1980	--	--	--	84°12'	36°03'	S,O	Och	10	Yes	--	C,G,I
	Remarks: Extension of old Anderson County Landfill. Area of expansion was cleared, excavated to permitted grade, and a few days later it rained and a pipe a few inches in diameter (very small) occurred. Mud from grading excavation entered pipe and discharged in developed area. This old landfill was placed over sinkholes.													
3	TDOT	1	5/1986	4	4	6	84°06'	36°10'	O,D	Onc	--	--	--	Hwy
	Remarks: Collapse occurred in southbound lane of State Highway 61. Required 10 tons of shot rock to fill. Repair made by DOT.													
4	TDOT	1	1984	8	8	15	84°18'	36°00'	S,O,D	O€k	3	--	3+	W
	Remarks: Under sewer and between two sinkholes.													
5	TDOT	1	1982	20	20	30	84°08'	36°09'	V,O,D	O€k	30+	--	30+	W,Hwy,Dr
	Remarks: Nearby water line not involved. Ditch along road probable source of water.													
6	CDOT	1	1981	10	10	6	84°09'	36°08'	S,D,O	€cr	--	--	--	O
	Remarks: Collapse occurred near s subdivision.													
7	CDOT	1	1946	10	10	6	84°10'	36°05'	V,O	€mn	--	--	--	--
	Remarks: A team of oxen was pulling a wagon across a pasture. Collapse occurred under the wagon.													
Bledsoe County														
1	SCS	1	1985	15	15	30	85°10"	35°39'	V	Mp	--	--	--	P,Hwy
	Remarks: In highway.													

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting	Hydrologic Setting		Activ-ities or Struc-tures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall to or During Event		Depth to Water Level (feet)
<u>Bledsoe County</u> (continued)														
2	SCS	1	1979	15	15	20	85°10'	35°38'	V	Onc	--	--	--	--
3	SCS	1	1984	3	3	30	85°19'	35°28'	H	Opm,Ord	--	--	--	--
<u>Blount County</u>														
1	SCS	1	9/4/70	2	2	--	84°01'	35°48'	V,0,D	O6k	9.5	No	10	C,0
	<u>Remarks:</u>	Occurred when soil cavity was encountered while excavating with backhoe.												
2	SCS	6	1985	4-10	4-10	15	83°46'	35°49'	V,0	Onc	--	No	--	--
	<u>Remarks:</u>	In pasture.												
3	CA/CE	3	--	--	--	--	84°04'	35°44'	S,0	Onc	--	--	--	--
	<u>Remarks:</u>	In pasture.												
4	CA/CE	1	--	4	4	--	84°01'	35°46'	V,0	6mr	--	No	--	W,Hwy
	<u>Remarks:</u>	In industrial park. Diverted drainage into collapse after occurrence.												
5	CDOT	1	1974-1976	12	12	20	84°03'	35°49'	V,D	6u	20	No	20+	Hwy,0
	<u>Remarks:</u>	Occurred in road near railroad.												
6	TDOT	2	6/9/86	2	2	10	83°53'	35°45'	H,0	6cr or Onc	10	Yes	10+	C,Hwy,D
	<u>Remarks:</u>	In ditch during construction. Nearby well reportedly muddied up and went dry.												
<u>Bradley County</u>														
1	SCS	2-3	1982 or 1983	10-15	10-15	15-20	84°48'	35°11'	V,0	6cr	20+	Yes	20+	0
	<u>Remarks:</u>	Collapse occurred under combine in a farmer's pasture. Area of natural sinkhole development.												

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Bradley County (continued)</u>														
2	SCS	1+	1975	10-15	10-15	15	84°47'	35°14'	S,0	€cr, €mn	15+	Yes	15+	0
	<u>Remarks:</u> Collapse occurred under a farm tractor. Several sinkholes occurred in pasture. Farm equipment has fallen into collapses on this farm on more than one occasion. Area of active sinkhole development.													
3	SCS	1	1974	4	4	40	84°50'	35°11'	V,0	€cl	12+	--	40+	1
	<u>Remarks:</u> Farm pond (constructed in 1972) collapsed and drained in 1974. Successful repair achieved by grouting. Filled now. Originally performed some excavation in floor of pond.													
4	SCS	1	1983	3-4	3-4	40±	84°50'	35°11'	S,0	€cr	1±	Yes	15-20±	0
	<u>Remarks:</u> Near spring at edge of woods where water supply is obtained. Natural active sinkhole area. Boulders within 1 foot of land surface.													
5	SCS	1	--	12	12	12-15	84°45'	35°11'	V,0	€mn	19+	No	0	C,G,D
	<u>Remarks:</u> Collapse occurred under front-end loader being used to construct cutoff trench for lake. Backhoe had been used to excavate stream of water earlier. Water level at land surface in sinkhole.													
6	SCS	1	1978-1980	20	20	--	84°56'	35°04'	0	€mn	--	Yes	0	0
	<u>Remarks:</u> Collapse occurred in a cow pasture. Water level at land surface in collapse.													
7	CDOT	1	Spring 1984	15	15	--	84°56'	35°01'	V,0,D	€mn	--	--	--	P,W,H
	<u>Remarks:</u> Collapse occurred in a pasture near four houses. Reportedly very deep. Finally filled with dirt. Nearby water well is 86 feet deep and has never pumped dry.													
<u>Campbell County</u>														
1	TDOT	1	1965	10	10	20+	84°12'	36°16'	0,D	Och/Mfp	--	--	--	Hwy
	<u>Remarks:</u> In northbound lane of Interstate 75. Active. Sinkhole has been repaired numerous times.													

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(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting	Hydrologic Setting		Activ-ities or Struc-tures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Campbell County</u> (continued)														
2	TDOT	1	1981	2	2	--	84°17'	36°25'	O,D	PsI	--	--	--	Hwy
	<u>Remarks:</u>	On edge of southbound lane of Interstate 75. Reportedly very deep. Repaired by filling with asphalt.												
3	TDOT	1	Winter 1985	--	--	--	84°03'	36°25'	O,D	Och	--	--	--	Hwy
	<u>Remarks:</u>	Collapse occurred in southbound lane of Highway 63. Small in size. Repaired by TDOT.												
4	TDOT	1	1982	--	--	--	84°00'	36°26'	O,D	Och	--	--	--	Hwy
	<u>Remarks:</u>	Collapse occurred in northbound lane of Highway 63.												
5	TDOT	1	1945	--	--	30+	84°06'	36°35'	O,D	PsI	--	--	--	Hwy
	<u>Remarks:</u>	Collapse occurred near a creek channel and reportedly has been subsiding for more than 40 years. Presently over 30 feet of subsidence.												
<u>Carter County</u>														
1	USGS; Allen (1969)	3+	1940's	--	--	25-40	82°14'	36°22'	V,D	€hk, €r	25-40	--	--	W,O
	<u>Remarks:</u>	Rayon plant in Elizabethton, Tennessee. Numerous collapses. Concrete floor and machinery dropped 25 to 40 feet into open soil cavity below. Immediate cause attributed to leakage of underground pipes. Possibly augmented by changes in level of nearby river.												
<u>Claiborne County</u>														
1	TDOT	1	1977	12	12	20	83°39'	36°33'	V,O	Och	2	Yes	19	O
	<u>Remarks:</u>	Natural sinkhole area. Several inches of rain caused flooding. Sinkhole formed in cleared area near edge of forest.												
2	CDOT	3	1977	25-30	25-30	12-15	83°43'	36°25'	V,O	Onc/€cr	--	Yes	--	N
	<u>Remarks:</u>	Near pond. Probably a large sinkhole; reportedly has no bottom.												

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Claiborne County (continued)</u>														
3	CDOT	1	1984	10	8	12	83°37'	36°30'	S,0	0lc	8-10	Yes	--	N
	<u>Remarks:</u> Occurred during flood of 1984. Presently a large portion of storm runoff drains into sinkhole.													
4	CDOT	1	1977	20	20	12-15	83°34'	36°27'	V,0	0n/0lc	--	Yes	--	N
	<u>Remarks:</u> Occurred during heavy rain. There is one major collapse with numerous smaller ones. The area is currently active with minor collapses.													
5	CDOT	1	1975	15	12	3-4+	83°37'	36°25'	S,0	0lc	--	Yes	--	I
	<u>Remarks:</u> Two days after the pond was dug a very hard rain fell and the collapse occurred. The pond has since been drained.													
6	TDOT	1	1971	25	25	8	83°23'	36°25'	S,0	0n/0lc	--	--	--	N
<u>Cocke County</u>														
1	SCS	2+	1985	20	20	15	83°05'	36°00'	D	06k	--	Yes	--	0
	<u>Remarks:</u> Subdivision nearby.													
2	SCS	1	1985	20	20	1-	83°07'	35°59'	S,0	06k	20+	Yes	20+	0
	<u>Remarks:</u> Under barn.													
3	TDOT	1	Prior to 1986	--	--	--	83°08'	36°00'	0	06k	--	--	--	Hwy
	<u>Remarks:</u> On shoulder of highway. Dimensions not available.													
4	TDOT	3	1986	--	--	10-12	83°12'	35°56'	0,D	06k	8	--	--	Hwy
	<u>Remarks:</u> Sinkholes active for some time. Latest repair in 1986.													
5	TDOT	1	1975	25	20	12	83°13'	35°56'	0,D	06k	--	--	--	Hwy
	<u>Remarks:</u> In middle of highway.													

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Longitude	Latitude		Unit(s)	Depth to Bedrock (feet)	Rainfall Prior to or During Event		Depth to Water Level (feet)
<u>Cumberland County</u>														
1	SCS	2+	Spring 1984-1985	4	4	5	85°10'	35°51'	O,F	Pco	5+	No	5+	--
	<u>Remarks:</u>	Numerous sinkholes have occurred in the natural drainage way of a pasture and woods.												
<u>Grainger County</u>														
1	CA	1	Winter 1985	2	2	10	83°37'	36°15'	0	€r/€pv	10+	--	--	0
	<u>Remarks:</u>	Collapse occurred in a pasture. Several loads of dirt were used to fill sinkhole to land surface. Bell shaped.												
2	CA	1	Winter 1985	--	--	10±	83°28'	36°16'	0	€cr	--	--	--	0
	<u>Remarks:</u>	Collapse occurred in a pasture.												
3	CA	1	1981	2	2	10	83°29'	36°17'	F	€m/€n	--	--	--	0
	<u>Remarks:</u>	Collapse occurred in wooded area near pasture. Newborn calf fell into collapse and found two days later.												
4	CA	1	--	--	--	--	83°34'	36°16'	0	€mr/€pv	--	Yes	--	0
	<u>Remarks:</u>	Collapse occurred in a field following heavy precipitation.												
5	SCS; CA	1	--	1	1	1+	83°28'	36°14'	0,D	€cr	0	--	--	1
	<u>Remarks:</u>	Sinkhole occurred in edge of farm pond. Bedrock exposed at end of pond where opening occurred. Pond drained.												
6	SCS; CA	1	--	--	--	--	83°34'	36°13'	0,D	€cr	0	--	--	1
	<u>Remarks:</u>	Sinkhole occurred in farm pond. Drained pond to level of sinkhole. Size of sinkhole reported to be small.												

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Grainger County (continued)</u>														
7	CA	1	1981	--	--	--	83°32'	36°12'	O,D	Onc	--	--	--	I
	<u>Remarks:</u>	Sinkhole developed in bottom of a farm pond and drained. Sinkhole was reportedly large.												
8	CA	1	1960	--	--	--	83°34'	36°12'	O,D	6cr	--	--	--	H
	<u>Remarks:</u>	Collapse occurred under corner of a house during construction. Collapse repaired using steel support beams and concrete. Stable since repair.												
9	TDOT	1	1984	12	12	10	83°37'	36°15'	S,V,O	6rt	10+	--	10+	--
	<u>Remarks:</u>	Natural sinkhole.												
10	TDOT	1	7/1986	5	5	10	83°32'	36°17'	S,O	6rt	5	--	5+	D
	<u>Remarks:</u>	Extending water line, excavating.												
<u>Greene County</u>														
1	SCS	5	1977	--	--	--	82°45'	36°04'	O,D	06k	--	--	--	H
	<u>Remarks:</u>	Five sinkholes collapsed near a house. Each sinkhole was reportedly small in size.												
2	CDOT	3	1984	40	30	30	82°59'	36°11'	S,O	0c/Olv	--	Yes	--	Hwy
	<u>Remarks:</u>	Collapse in dirt road. Filled with as many as 40 truck loads of material. Recollapsed in August 1986. Active. Other small sinkholes nearby.												
<u>Hamblen County</u>														
1	TDOT	2+	1984	6-7	6-7	12	83°22'	36°11'	V,O,D	0lc/On	5	--	5+	C,Hwy,Dr
	<u>Remarks:</u>	Several sinkholes at this location. Most recent in 1984. Recurring collapses started prior to 1972. Drainage from construction and area development. Site description in Moore, Harry, 1980, p. 49.												
2	USGS; TDOT	1	12/3/82	32	25	35	83°22'	36°12'	H,O,D	6cr	60	--	35+	H,O
	<u>Remarks:</u>	Collapse under septic system near house. House was relocated. Nearby leaking swimming pool.												

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
Hamblen County (continued)														
3	TDOT	1	6/1984	50	50	0.5	83°23'	36°10'	V,O,D	O6k	0.5+	Yes	0.5+	C,II
	<u>Remarks:</u> Subsidence under house; built in sinkhole that was filled. Runoff from gutters. House cracked in half.													
4	TDOT	3-4	1982	4-10	4-10	5-15	83°13'	36°09'	H,O,D	O6k	15+	Yes	15+	C,Hwy,Dr
	<u>Remarks:</u> Under and adjacent to county road near State Highway 160 and Interstate 81. Drainage contributed by highway. During or after heavy rain.													
5	TDOT	2	1983	3-20	3-20	5-20	83°16'	36°13'	H,D,O	O6k	15	--	20+	Hwy,Dr
	<u>Remarks:</u> In ditch line. Interchange of U.S. Highway 25 East and U.S. Highway 11 East.													
6	CDC	1	1981	20	20-30	30	83°25'	36°09'	V,O,D	Ok	30+	--	30+	Hwy
	<u>Remarks:</u> Active since 1981 or earlier. Reported as recurring problem. In highway.													
7	CDC	1	1986	--	--	--	83°23'	36°10'	V,O	Oma	--	--	--	0
	<u>Remarks:</u> Reported to be large in size. May have been active for several years. Near Morristown airport.													
8	CDC	3	5/1984	6	8	35	83°21'	36°10'	V	Oc	--	Yes	--	I
	<u>Remarks:</u> Collapse occurred during or after a flash flood resulting from ponding in a topographic low area. Three sinkholes in area, largest 6 x 8 x 35 feet. Reportedly attached to a large cave system.													
9	CDC	1	5/1984	3	3	--	83°21'	36°10'	V	Oma	--	Yes	--	--
	<u>Remarks:</u> Collapse occurred during flood event. Water (flood water) was pumped into sinkhole and pumped water was observed to discharge at land surface several hundred feet away.													
10	CDC	2	1980 1982	15 30	15 40	50 20	83°23'	36°11'	D	Ok	--	--	--	W,Hwy
	<u>Remarks:</u> Collapses occurred along State Highway 11 East. Collapse in 1982 developed from leaking water line. Collapsed portion of highway. Required large volume of fill material. Sinkhole collapse in 1980 was under two lanes of highway.													

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(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Hamblen County (continued)</u>														
11	CDC	1	6-7/1984	8	9	4	83°23'	36°11'	O,D	6cr	4+	No	4+	H
	<u>Remarks:</u>	Collapse occurred in back yard in residential section. Bell shaped.												
12	CDC	1	1986	3	3	8	83°22'	36°11'	O,D	Ok	8+	Yes	8+	H
	<u>Remarks:</u>	Collapse occurred in front lawn of house after heavy rain. Landowner reported doors and windows of house jammed. Required eleven tons of gravel to fill collapse. No recurrence.												
13	CDC	2	1983 and 1985	20	30	50	83°21'	36°12'	O,D	Ok,Oma	--	--	--	H
	<u>Remarks:</u>	A cave system was reported to be present at depth in the 1985 sinkhole. Required 2,000 tons of rock to fill sinkhole. Collapse in 1983 occurred 300 feet from 1985 collapse. Both occurred on State Highway 11 East.												
14	CDC	1	7/1986	--	--	--	83°21'	36°12'	D,O	Oma	--	--	--	H
	<u>Remarks:</u>	Collapse occurred in the yard of a house near intersection of Andrew Jackson Highway and Bellwood Road.												
15	CDC	2+	6/1986	--	--	--	83°23'	36°12'	V	6cr	--	--	--	O
	<u>Remarks:</u>	Reportedly, numerous collapses have occurred in Panther Creek off the Cameron Road loop.												
16	CDC	2	--	2	2	--	83°24'	36°12'	V	6cr	--	--	--	O
	<u>Remarks:</u>	Collapse occurred in Panther Creek, and drained a nearby trout pond and Panther Creek. Sinkholes reportedly plugged themselves with silt.												
17	CDC	1	--	15	20	--	83°25'	36°12'	O	6cr	--	--	--	O
	<u>Remarks:</u>	Collapse occurred in farmer's pasture where numerous wet areas had been noted. Sinkhole was bell shaped.												
18	CDC	1	Prior to 1986	40	50	--	83°18'	36°13'	O,D	Oc	--	--	--	H
	<u>Remarks:</u>	Collapse occurred several years prior to 1986 and remains active. In home owner's back yard.												

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting Unit(s)	Depth to Bedrock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Longitude	Latitude				Rainfall Prior to or During Event	Depth to Water Level (feet)	
Hamblen County (continued)														
19	CDC	1	7/1986	2	2	5	83°17'	36°13'	V,0,D	Ok	--	--	--	H
	<u>Remarks:</u> Collapse occurred in street in front of City Hall.													
20	CDC	1	Summer of 1984	2	3	5	83°17'	36°13'	0,D	Oma	--	--	--	Dr,H
	<u>Remarks:</u> Subsidence occurred under an old cistern. City water lines observed in bottom.													
21	CDC	1	6/26/86	15	15	10-15	83°15'	36°13'	0,D	Ok	--	--	--	Hwy
	<u>Remarks:</u> Intersection of Morris Boulevard and Appalachian Highway south off loop.													
22	CDC	1	Prior to 1986	10	10	--	83°17'	36°16'	V,0	0c/6cr	--	--	--	0
	<u>Remarks:</u> In county-owned park.													
23	CDC	4	4/1983	--	--	--	83°16'	36°16'	0,D	0c/6cr	--	--	--	Hwy
	<u>Remarks:</u> All four collapses were reportedly small in size.													
24	CDC	1	8/3/85	--	--	--	83°19'	36°14'	0,D	0c/0lv	--	Yes	--	0
	<u>Remarks:</u> Large subsidence under an old shopping center building. Severe thunderstorm preceded subsidence. Building collapsed as a result of subsidence.													
25	USGS	1	1976	20	20	10	83°22'	36°11'	V,0	0n	--	--	--	Dr
	<u>Remarks:</u> Near northeast end of airport runway. Deepened collapse to throat in bedrock, plugged with cement, filled to land surface.													
26	USGS	3+	1962-1980	4-20	4-20	35	83°19'	36°12'	D	0n	20+	--	--	0
	<u>Remarks:</u> Adjacent to and under industrial building and transformer. Resulted in 48-hour shutdown at plant. Associated with drainage from roof. Repetitive collapses occurred where water runs off asphalt parking lot. During plant construction, maximum grading was to about 20 feet. Small collapses occurred when soil cavities were apparently encountered.													

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(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting Unit(s)	Depth to Bed-rock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Long-itude	Lat-itude				Rain-fall Prior to or During Event	Depth to Water Level (feet)	
Hamblen County (continued)														
27	USGS	1	1980	50-60	30	0.5-0.7	83°19'	36°11'	H,D	On	--	--	--	0
	Remarks: Under clubhouse at Morristown Country Club. Caused cracking and shattering in foundation and walls. Pipe in soil extended to depth of 15 to 20 feet. Associated with drainage from roof.													
28	USGS	-	1980	--	--	--	83°24'	36°10'	--	On	--	--	--	0
	Remarks: Property southwest of airport reported to be active karst area due to recent sinkhole development.													
Hamilton County														
1	USGS	1	12/28/79	20	20	--	85°18'	35°02'	S,O,D	Onc	12-32	No	--	P,W
	Remarks: Collapse occurred about 800 feet from well being developed at 1,200 to 2,000 gpm. Large cavern below collapse. Fifteen foot section of 8-inch sewer pipe lost in collapse.													
2	SCS	1	--	--	--	--	82°21'	35°07'	--	Pco	--	--	--	--
	Remarks: On Signal Mountain off Highway 127. Location general.													
3	USGS	1	1/25/83	35	35	75	85°17'	35°00'	S,O,D	Och	--	--	--	Hwy,0
	Remarks: Collapse occurred under road. Swallowed a section of street and part of a yard. Ruptured a city water main under road.													
4	TDG	1	Spring 1977	--	--	--	85°12'	35°04'	V,O,D	O6k,Och	--	--	--	Hwy
	Remarks: Collapse occurred on road and caused considerable damage. Location approximate.													
5	TDOT	1	1971	50	20	10	85°15'	35°00'	S,D	O6k	--	Yes	--	Hwy
	Remarks: Storm sewers on both sides of the road. The collapse took one lane of the road.													
6	CDOT	1	1976	10	10	8	85°07'	35°21'	V,O	O6cr	--	No	--	Hwy
	Remarks: Collapse occurred in the highway.													

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting		Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Longitude	Latitude		Unit(s)	Depth to Bedrock (feet)	Rainfall to or During Event	Depth to Water Level (feet)	
<u>Hamilton County</u> (continued)														
7	CDOT	1	1976	6	6	12	85°08'	35°08'	S,F	O6k	--	Yes	--	Hwy
	<u>Remarks:</u>	The collapse has taken as much as one-half the road at one time. It is active during rainy seasons. During the past ten years more than 100 tons of material have been put into the sinkhole to repair it.												
8	USGS	3+	1978	100	35	79	--	--	O,D	Och-O6k	36	--	--	P,O
	<u>Remarks:</u>	In area of numerous wells. Dimensions are for collapse beneath warehouse. Daily 20- to 30-foot surges in water level in sinkhole reported. Other sinkholes reported in adjacent street and field. Area of sinkhole activity extends into Georgia.												
<u>Hancock County</u>														
1	CA	1	--	50-100	50-100	15-20	83°14'	36°29'	H,O	Olc	20+	--	--	0
	<u>Remarks:</u>	In a pasture. Sinkhole is reportedly old and still active. When repaired it holds water and periodically opens up and drains.												
2	CA	1	--	50	30	5	83°13'	36°29'	S,O,D	On	5+	--	--	1
	<u>Remarks:</u>	Sinkhole is beneath a farm pond. Periodically opens and drains.												
3	CA	2+	--	--	--	--	83°14'	36°29'	S	Olc	--	--	--	--
	<u>Remarks:</u>	Several active sinkholes reported to occur in this area.												
4	CA	1	1984	10	10	--	83°12'	36°30'	V	Olc	--	--	--	0
	<u>Remarks:</u>	This sinkhole occurred on a farm after a tractor passed over the area of collapse.												
5	CDOT	2	1971±	50	20	25-50	83°14'	36°33'	S,O,D	Mn/Mg	--	Yes	--	Hwy
	<u>Remarks:</u>	Locations approximate. Dimensions similar. These two collapses occurred in Highway 63 during periods of heavy rainfall. Sinkholes were repaired and no longer are problems.												

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Hawkins County</u>														
1	TDOT	1	1975	2-3	2-3	3	82°54'	36°27'	S,0,0	6c	3	--	3+	C,G,Hwy
	<u>Remarks:</u> Location approximate. In subgrade of U.S. Highway 11 West. Pinnacle exposed in bottom.													
2	TDOT	3	1983-1984	1-2	1-2	--	82°38'	36°32'	S,0	0sv	-	Yes	100+	C,G,I
	<u>Remarks:</u> Small collapses (piping) in sediment settling pond at sanitary landfill. Originally a clay borrow pit. Graded to top of pinnacle in middle of pond. First good rain resulted in collapse. First collapse was repaired and two more occurred. Abandoned. Actual shape of collapses resembled cracks. Location approximate.													
<u>Jefferson County</u>														
1	TDOT	1	1984	15	15	2	83°19'	36°04'	V,0	0nc	2+	Yes	2+	Hwy
	<u>Remarks:</u> Near highway. Largely subsidence. In natural depression.													
2	TDOT	1	1976	3	3	8	83°26'	36°02'	V	0nc	LSD	Yes	8+	Hwy,Dr
	<u>Remarks:</u> Could hear water movement below bottom of collapse. In drain.													
3	SCS	1	1970±	--	--	20	83°36'	36°06'	--	0nc	--	--	20+	0
	<u>Remarks:</u> Collapse estimated to be 4 acres in size. Flew over after development on farm. Underground mines reported in area.													
4	SCS	1	--	60	60	10	83°30'	36°06'	V,0	0ma	--	--	--	0
	<u>Remarks:</u> Bedrock exposed in collapse in pasture. Mine reported nearby.													
5	SCS	-	--	--	--	--	83°25'	36°09'	S	0n	--	--	--	--
	<u>Remarks:</u> Numerous active sinkholes in area.													
6	SCS	-	--	--	--	--	83°27'	36°06'	V	0nc	--	--	--	Hwy
	<u>Remarks:</u> Numerous active sinkholes in area.													

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Longitude	Latitude		Unit(s)	Depth to Bedrock (feet)	Rainfall Prior to or During Event		Depth to Water Level (feet)
<u>Jefferson County (continued)</u>														
7	SCS	-	--	--	--	--	83°25'	36°06'	V	Ol, Scl	--	--	--	Hwy
	<u>Remarks:</u>	Very active area. Numerous active sinkholes.												
8	SCS	1	--	200	100	Deep	83°32'	36°03'	--	Cn	--	--	--	--
9	CDOT	1	5/8/84	30	30	12-18	83°26'	36°02'	V	Onc	--	Yes	--	Hwy
10	CDOT	1	7/1986	20	20	--	83°29'	36°06'	--	Scl	--	--	10	--
11	CDOT	1	1981	10	10	--	83°28'	36°08'	V	On	10+	--	10+	Hwy
	<u>Remarks:</u>	Near edge of highway. Repaired numerous times, last time 7/18/86.												
12	CDOT	1	7/1986	2.5	2.5	5	83°27'	36°08'	V	On	5+	--	5+	Hwy
	<u>Remarks:</u>	Soil cavity on gravel road. Bell-shaped. Six (6) feet in diameter in bottom.												
13	CDOT	1	1983	6	5	2	83°42'	36°05'	H	Oo	2+	--	2+	Hwy
	<u>Remarks:</u>	Recurring sinkhole on shoulder of road.												
14	CDOT	1	1976	26	50	1-1.5	83°40'	36°05'	S	Oo	--	--	--	Hwy
	<u>Remarks:</u>	Edge of road; continuous subsidence.												
15	CDOT	3	1977	20	12	10	83°37'	36°04'	V, O	Onc	10+	--	10+	Hwy, O
	<u>Remarks:</u>	Two sinkholes still active after repairing. Mine reported nearby.												
16	CDOT	1	1975	10	10	--	83°41'	36°04'	V	Ol	10	--	--	Hwy
	<u>Remarks:</u>	Reported to have no bottom. Repaired several times.												
17	CDOT	-	--	--	--	--	83°36'	36°03'	V	Srt	--	--	--	--
	<u>Remarks:</u>	Active sinkholes, reported to be too numerous to count, in area with radius of 2.5 miles.												

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting Unit(s)	Depth to Bedrock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Longitude	Latitude				Rainfall to or During Event	Depth to Water Level (feet)	
<u>Jefferson County (continued)</u>														
18	CDOT	5	--	--	--	--	83°20'	36°06'	V	Osv-06k	--	--	--	Hwy, 0
	<u>Remarks:</u>	Highway and pasture. Five sinkholes in area with radius of 200 feet.												
19	CDOT	1	--	40	--	3.5	83°26'	36°01'	V	Onc	3.5+	--	3.5+	Hwy
	<u>Remarks:</u>	Repaired and resurfaced; continues to subside.												
20	CDOT	2	1980	8-16	8-12	8	83°29'	36°08'	V	On	8+	--	--	Hwy
	<u>Remarks:</u>	Repaired; continues to subside.												
21	TDOT	1	--	--	--	--	83°21'	36°03'	O,D	Onc	--	--	--	Hwy
	<u>Remarks:</u>	Close to road.												
22	TDOT	1	--	--	--	--	83°22'	36°03'	O,D	€cu	--	--	--	Hwy
	<u>Remarks:</u>	Occurred near edge of road.												
23	USGS	3	1969-1977	20-30	20-30	20-25	--	--	O,D	--	--	--	--	I, 0
	<u>Remarks:</u>	All sinkholes reported similar in size. One collapse in football field, two in baseball field. Cemented throats in bedrock and filled areas where water ponds. Mine located in vicinity.												
24	USGS	1	1977	15	15	--	--	--	O,D	--	--	--	--	C, 0
	<u>Remarks:</u>	Location general, in Jefferson City. Collapse under bank and adjacent building during construction of shopping center. Removed building; did not replace.												
<u>Johnson County</u>														
No sinkholes reported.														
<u>Knox County</u>														
1	TDOT	3-4	1975	8	8	8-12	83°58'	35°56'	S,O,D	Oh	--	Yes	15+	C, Hwy, Dr
	<u>Remarks:</u>	In ditch line. Recurring since 1975. Dimensions given are typical for site.												

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall to or During Event		Depth to Water Level (feet)
Knox County (continued)														
2	TDOT	1	1981	5	5	12	83°51'	36°01'	S,O,D	Oek	12	Yes	12+	C,Hwy,0
	<u>Remarks:</u> Piping around piling (support) attributed to occurrence.													
3	CDOT	2+	1/1986	--	--	--	84°05'	35°55'	V,O,D	ocl	-	Yes	--	O,G
	<u>Remarks:</u> Numerous collapses, varying in size, occurred during construction of a parking lot. Construction was halted. Heavy rains occurred resulting in ponding and subsequent collapse.													
4	CDOT	2+	--	--	--	--	84°05'	35°56'	V,O	Och	--	Yes	--	O
	<u>Remarks:</u> Numerous collapses have occurred in a pasture. Sinkholes remain active. Dimensions of sinkholes vary. Bedrock exposed in some at varying depths. Precipitation generally associated with activity. Natural.													
5	TDSWM	1	1983	4-5	4-5	8-10	83°49'	36°02'	S,O,D	Oek,On	8-10	Yes	10+	C,G,I
	<u>Remarks:</u> Immediately east of John Sevier community in east Knox County. Repaired with concrete and bentonite. No problem since repair.													
6	USGS	1	1975-1976	25	15	5-6	83°56'	35°57'	V,O,D	Onc	5+	--	5+	W,O
	<u>Remarks:</u> Neyland (football) Stadium in Knoxville, Tennessee. Under tartenturf on 50-yard line on sideline beneath broken joint of storm drain.													
7	USGS	1	1977	10-15	10-15	5-10	83°55'	35°58'	O,D	ocr	--	No	--	W
	<u>Remarks:</u> Two blocks from City Hall, Downtown Knoxville, Tennessee. Break in water main under street.													
8	USGS	1	1978	10-15	10-15	5-10	83°55'	35°58'	H,D	Olv	--	No	--	W
	<u>Remarks:</u> Two blocks from Post Office near Henley Street Bridge, downtown Knoxville, Tennessee. Break in water main under street.													
9	USGS	1	1977	--	--	--	83°56'	35°58'	O,D	ocr	--	No	--	W,O
	<u>Remarks:</u> Damaging subsidence beneath parking garage. Breaks in water line during period of freezing temperature.													

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(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
Knox County (continued)														
10	USGS	1	Prior to 1955	--	--	--	83°55'	35°58'	D	Onc	--	--	--	W,0
	<u>Remarks:</u>	Beneath bank. Cause appeared to have been leaking pipe. Floor of coal storage bin in basement collapsed into deep soil cavity.												
11	USGS	1	1980	80	40	1.25	83°55'	35°58'	D	Onc	--	--	--	W
	<u>Remarks:</u>	Old warehouse on Heiskett Street, Knoxville, Tennessee. Building erected over filled sinkhole in 1950's. Sprinkler system broke after freeze resulting in damaging subsidence.												
12	USGS	1	1980	--	--	--	83°55'	35°58'	D	Onc,6cr	--	--	--	0
	<u>Remarks:</u>	Outside water fountain at motel subsided. Not repaired. Water shut off.												
Loudon County														
1	SCS	1	1982	15	15	20	84°23'	35°40'	V,0	O1 or Onc	20+	--	20+	I
	<u>Remarks:</u>	Drained pond.												
2	C	1	1982	6	6	8	84°20'	35°42'	0	Oh	15+	--	15+	C,G,I
	<u>Remarks:</u>	Sludge treatment pond, concrete walls, compacted bottom. Graded about 15 feet. Occurred when filling, drained pond.												
3	SCS	1	1986	12	12	15	84°11'	35°41'	V,0	O1 or Onc	15+	--	15+	0
	<u>Remarks:</u>	In field at edge of woods.												
4	SCS	1	1983-1984	10	10	10	84°29'	35°41'	S,0	O6k	--	--	--	0
	<u>Remarks:</u>	In field at edge of woods.												
5	SCS	1	1982	15	15	20	84°22'	35°48'	S,0	O6k	--	--	--	0
	<u>Remarks:</u>	In field, ceased mowing.												

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting Unit(s)	Depth to Bed-rock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Long-itude	Lat-itude				Rain-fall Prior to or During Event	Depth to Water Level (feet)	
<u>oudon County (continued)</u>														
6	SCS	1	1985	10	10	10	84°28'	35°42'	S,0	O6k	5	--	10+	(
	<u>Remarks:</u>	Pond 7 or 8 years old when collapse occurred at edge of water level. No problem since repair.												
7	C	2+	1982/1983	50	50	8	84°20'	35°43'	H,F,0	Onc	35	No	25+	0
	<u>Remarks:</u>	Dimensions for 1983 collapse. Area of older sinkhole activity. Collapses occurred at different times when municipal water tank was being drained. Excavated to crevice in bedrock at 35 feet to repair.												
8	TDOT	1	1984	5	5	8	84°16'	35°50'	S,0	O6k	8+	Yes	8+	Hwy,Dr
	<u>Remarks:</u>	In drain along Interstate Highway 40.												
9	TDOT	2	1978/1985	6	6	10	84°17'	35°51'	H,0	O6k	5	Yes	5+	Hwy,Dr
	<u>Remarks:</u>	Recurring in ditch.												
10	TDOT	1	1984	2	2	5	84°17'	35°50'	S,0	O6k	5+	Yes	5+	Hwy,Dr
11	TDOT	1	1982	10	10	15	84°18'	35°41'	H,0	6cr	2	Yes	15+	Hwy,Dr
12	CDOT	1	After 1982	15	15	15	84°20'	35°42'	V,D	6cr	15+	Yes	--	Hwy
13	CDOT	1	After 1982	5	5	10	84°21'	35°41'	V,0,D	6cr	10+	Yes	--	Hwy
	<u>Remarks:</u>	Part of collapse under highway.												
14	CDOT	1	After 1982	4	4	5	84°14'	35°43'	V,D	Onc	5+	Yes	5+	H
	<u>Remarks:</u>	In highway.												
15	CDOT	1	After 1982	5	5	8	84°14'	35°41'	V,0	Onc	8+	Yes	8+	Hwy
	<u>Remarks:</u>	Part of collapse under highway.												
16	CDOT	1	After 1982	10	5	12	84°22'	35°44'	0,D	Onc	12+	Yes	--	Hwy
	<u>Remarks:</u>	Collapse under highway.												

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting Unit(s)	Depth to Bedrock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Longitude	Latitude				Rainfall Prior to or During Event	Depth to Water Level (feet)	
Loudon County (continued)														
17	CDOT	1	7/1986	3	3-10	--	84°12'	35°19'	V,0,D	O6k	10+	No	--	Hwy
	<u>Remarks:</u>	Occurred in highway.												
18	CDOT	1	1986	3	3	10	84°09'	35°38'	V,0,D	6mn	10+	No	10+	Hwy, Dr
	<u>Remarks:</u>	In ditch at side of road.												
19	TDOT	1	1970-1971	10	10	30	--	--	S,0	--	--	--	--	C, G, Hwy
	<u>Remarks:</u>	Collapse under highway during construction.												
Marion County														
1	SCS	2	Spring 1983	8	8	20	85°42'	35°00'	V,0	Mn	--	Yes	--	0
	<u>Remarks:</u>	Collapse occurred in crop land.												
2	SCS	1	Spring 1984	25	25	15	85°32'	35°07'	V,0	Obh	--	Yes	<15	0
	<u>Remarks:</u>	Collapse occurred in pasture. Sinkhole had water in it.												
3	SCS	1	Winter 1986	6	6	6	85°32'	35°11'	0,D	Mm	--	Yes	--	0
	<u>Remarks:</u>	Collapse occurred on a football field. Land was graded and shaped approximately 10 years prior to collapse.												
McMinn County														
1	SCS	1	1983	3	3	8	84°32'	35°24'	V,0	6cr	8	Yes	--	I
	<u>Remarks:</u>	Developed after farm pond was constructed. Diameter of sinkhole increases with depth. The pond drained and has been abandoned.												
2	SCS	1	1982	5	5	15	84°32'	35°24'	V,0,D	6cl	--	Yes	15+	H
	<u>Remarks:</u>	Occurred in driveway of house. Diameter of collapse increased with depth. Collapse repaired.												

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting Unit(s)	Depth to Bed-rock (feet)	Hydrologic Setting		Activ-ities or Struc-tures Near Site
				Length	Width	Depth	Long-itude	Lat-itude				Rain-fall Prior to or During Event	Depth to Water Level (feet)	
<u>McMinn County (continued)</u>														
3	SCS	1	1982	6	4	5	84°32'	35°24'	V,0	6cr	--	Yes	--	--
	<u>Remarks:</u> Occurred in pasture after heavy rain.													
4	SCS	1	1978-1979	6	6	5	84°35'	35°37'	S,0	0ch	--	No	--	1
	<u>Remarks:</u> Occurred approximately one year after farm pond was constructed. Pond abandoned.													
5	SCS	1	1972	15	20	--	84°41'	35°27'	V,0,0	6cr	--	Yes	15	--
	<u>Remarks:</u> Occurred in pasture near church following heavy rainfall. New road had been built nearby.													
6	SCS	1	1976	21	15	20	84°43'	35°20'	V,0,0	0nc-6cr	10	No	--	1
	<u>Remarks:</u> A 5-acre pond was constructed about 1960. A collapse drained the pond in 1966±. After repair and filling, a second collapse occurred in 1976 that drained the pond again. Repaired, lake has been in use since.													
7	SCS	1	1980	2	2	10+	84°38'	35°17'	V,0	6cl	10	--	--	0
	<u>Remarks:</u> Approximately 1/2 mile west of Dentville on State Highway 163. Lake with hole developed. Rusting water could reportedly be heard in sinkhole. Pond abandoned.													
8	SCS	1	1987	--	--	--	84°32'	35°27'	V,0	6cr	--	No	--	1
	<u>Remarks:</u> Occurred in vicinity of a farm pond. Resulted in draining.													
9	CDOT	1	Priority 1986	--	--	--	84°31'	35°33'	--	0nc	--	--	--	--
	<u>Remarks:</u> Southwest of Reagan approximately 1 mile. Subsidence occurred, but not classified as a collapse.													
10	CDOT	1	--	--	--	--	84°33'	35°35'	--	0nc	--	--	--	--
	<u>Remarks:</u> Reported as a depression.													

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(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting	Depth to Bed-rock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Long-itude	Lat-itude				Rain-fall Prior to or During Event	Depth to Water Level (feet)	
<u>McMinn County (continued)</u>														
11	TDSWM	1	Prior to 1980	--	--	--	84°31'	35°21'	V,0	Oa	--	--	--	I
	<u>Remarks:</u>	Occurred in a settling pond that had been in service for some time. Collapse resulted in draining of pond.												
12	CDOT	1	--	30	50	15-20	84°40'	35°25'	V,0,D	Onc	--	--	--	Hwy
	<u>Remarks:</u>	Located 50 to 100 feet from highway. Presently used as a trash dump.												
<u>Meigs County</u>														
1	TDOT	1	1979	5	6	6.5	84°52'	35°32'	V,0	Och	--	--	6	Hwy
	<u>Remarks:</u>	Collapse took part of highway, but has since been repaired.												
2	COOT	1	1983	4	4	8	84°55'	35°26'	S,0	ocl	--	--	--	--
	<u>Remarks:</u>	Almost at the toe of slope 100 yards from an old road.												
3	SCS	1	1976	8	6	4	84°53'	35°25'	V,0	Och	--	--	--	Hwy
	<u>Remarks:</u>	Just off side of road in the right of way. Does not appear to be getting any larger.												
<u>Monroe County</u>														
1	SCS	1	8/23/79	3.5	3.5	4	84°25'	35°32'	S	Oek	--	No	2.5	I
	<u>Remarks:</u>	Farmer was treating his pond with soda ash when collapse occurred underneath him. Collapse drained pond. All attempts to repair collapse and refill pond have failed.												
2	CDOT	2	--	6	6	8	84°20'	35°35'	S,0	Emn	8	Yes	--	Hwy
	<u>Remarks:</u>	Occurred in drainage ditch along road during rainy season. Is active during rainy season. Have put as much as 20 tons of large stone in sinkhole at one time. Sinkhole in nearby pasture has not been inspected.												
3	ASCS	1	7/1985	4	4	20	84°18'	35°31'	S,0	Oa	--	--	--	--
	<u>Remarks:</u>	Occurred in alfalfa field.												

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting	Hydrologic Setting		Activ-ities or Struc-tures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Monroe County (continued)</u>														
4	TDOT	3-4	1978	5	5	5	84°28'	35°24'	V,0	Onc	1-3	Yes	5+	Hwy,D
	<u>Remarks:</u> All collapses had similar dimensions. Pinnacles exposed.													
<u>Polk County</u>														
1	SCS	1	--	30	6	30	84°32'	35°15'	V	She	--	--	--	--
	<u>Remarks:</u> Occurred in Gee Creek. The creek drains into the sinkhole and comes back out of the ground down to creek channel.													
<u>Rhea County</u>														
1	SCS	1	1980	15	25	6	84°01'	35°27'	0	Oc	--	--	--	--
	<u>Remarks:</u> Occurred in a pasture 3 miles east of Dayton on north side of Highway 60.													
2	CDOT	1	1984	2	2	4	84°55'	35°36'	V,0	Scr	--	Yes	--	D,Hwy
	<u>Remarks:</u> Occurred during rainfall in ditch off shoulder of road. Runoff drains into sinkhole.													
<u>Roane County</u>														
1	SCS	1	1983	15	20	1	84°33'	35°52'	S,D	OEk	--	--	--	H
	<u>Remarks:</u> Area of sinkhole dropped 1 foot overnight.													
2	SCS	3	1982	3-40	3-40	5-20	84°29'	35°50'	S,V,0	Cl,Smn	20	--	--	--
	<u>Remarks:</u> One sinkhole occurred in corn field, one in a hay field, and one at wood line of pasture.													
3	CDOT	1	1973	30	30	30	84°24'	35°50'	V,D	Onc	--	--	--	H
	<u>Remarks:</u> Developed overnight in front yard. Repaired and holding well.													
4	CDOT	1	1971	75	75	50	84°38'	35°45'	V,F	OEk	-	Yes	48	Hwy
	<u>Remarks:</u> Occurred after heavy rain.													

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting Unit(s)	Depth to Bedrock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Longitude	Latitude				Rainfall Prior to or During Event	Depth to Water Level (feet)	
<u>Roane County (continued)</u>														
5	CDOT	1	1981	30	30	20-30	84°33'	35°52'	--	O6k	--	Yes	20	W
	<u>Remarks:</u> Occurred during heavy rain. Road collapsed exposing and breaking sanitary sewer line. Repaired and has not caused any other problem.													
<u>Sequatchie County</u>														
1	SCS	1	--	--	--	--	85°25'	35°21'	V,0	Mbh	--	--	--	Hwy
2	SCS	1	--	--	--	--	85°24'	35°19'	V,0	Opm	--	--	--	H
	<u>Remarks:</u> Located near farm house.													
3	SCS	1	1982	5	5	5	85°21'	35°22'	V,0	Ou	--	--	--	Hwy
	<u>Remarks:</u> Near road.													
4	CDOT	1	--	25	30	20	85°23'	35°23'	D	Ord	20	--	20	O
	<u>Remarks:</u> During periods of precipitation sinkhole fills with water, drains quickly after precipitation stops. Thirty (30) feet from highway.													
<u>Sevier County</u>														
1	TDOT	1	1974	6	6	7	83°37'	35°58'	S,0,D	O6k	5	Yes	--	Hwy,D
	<u>Remarks:</u> Occurred in highway ditch.													
2	TDOT	1	1980	--	--	25	83°34'	35°52'	O,D	Osv	25	--	--	--
	<u>Remarks:</u> Occurred in 1980 and reoccurred in spring of 1986.													
<u>Sullivan County</u>														
1	TDOT	1	Summer 1984	6	6	12	82°18'	36°35'	S,0,D	6hk	12+	Yes	12+	Hwy,H
	<u>Remarks:</u> Location approximate; behind house. Some drainage from highway about 50 feet away.													

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting Unit(s)	Depth to Bedrock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Longitude	Latitude				Rainfall Prior to or During Event	Depth to Water Level (feet)	
<u>Unicoi County</u>														
1	CDOT	1	1983	7	7	--	82°21'	36°12'	V,D	O6k	--	No	--	C,G,B,Hwy
	<u>Remarks:</u>	Occurred during blasting for new highway. Took 6 to 7 yards of shot rock and fill material to repair. Could never see bottom. Some caves nearby.												
2	CDOT	1+	1985	12	12	--	84°24'	36°10'	V,O	6u	--	No	--	P,O
	<u>Remarks:</u>	Occurred while drilling municipal water supply well. Another production well nearby. Twenty tons of material dumped into sinkhole before any material could be seen in bottom. Numerous small sinks collapsed at same time. Could hear water running in bottom.												
<u>Union County</u>														
1	CDOT	1	Spring 1986	--	--	--	83°49'	36°23'	O,D	6cr	--	--	--	Hwy
	<u>Remarks:</u>	At edge of road.												
2	CDOT	1	1986	--	--	--	83°45'	36°14'	O,D	6pv,6mr 6r	--	--	--	Hwy
<u>Washington County</u>														
1	CDOT	1	1979	6	6	--	82°34'	36°19'	V,O,D	O6k	--	--	--	Hwy
	<u>Remarks:</u>	Drops out continuously. County Highway Department makes repairs.												
2	CDOT	1	1982	6	5	--	82°37'	36°11'	S,O,D	O6k	--	--	--	Hwy
	<u>Remarks:</u>	Drops out continuously. County Highway Department makes repairs.												
3	CDOT	1	1983	6	5	--	82°35'	36°12'	S,O,D	O6k	--	--	--	Hwy
4	CDOT	1	Prior to 1986	40	30	10	82°25'	36°25'	V	O6k	--	--	--	O
	<u>Remarks:</u>	Within 40 feet of road. Sinkhole used for dumping trash. Once caught on fire.												
5	SCS	1	1969	1,100	1,100	6-7	82°35'	36°09'	V	O6k	7+	--	--	O
	<u>Remarks:</u>	Sinkhole was 1/4 acre in diameter.												

(continued)

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall to or During Event		Depth to Water Level (feet)
<u>Washington County (continued)</u>														
6	SCS	1	1980	6	6	8	82°32'	36°15'	S,0	O6k	--	No	8	--
7	SCS	1	1975	5	5	60	82°25'	36°19'	H,D	O6k	60	No	60	H,W
	<u>Remarks:</u>	Depression in back yard of house. Arch of soil cavity collapsed under one leg of young boy who was rescued. Arch collapsed completely later that night. Could hear flowing water in bottom of collapse. Occurred under field line of septic tank.												
8	SCS	1	1981	10	10	20	82°30'	36°13'	V,0	Ecu/6hk	--	No	--	--
9	SCS	1	1978	6	6	15	82°34'	36°20'	S,D	Ecu/6hk	--	No	--	H
	<u>Remarks:</u>	Occurred in yard beside house.												

Table 5. Inventory of sinkhole occurrence in Virginia.

Site number: Site locations shown on Plate 1.

Source of information: USGS, in files of U.S. Geological Survey.

Topographic setting: D, developed; F, forest; H, hilltop; O, open; S, slope; V, valley or flat.

Geologic setting: Oc, Conococheague Limestone; Cs, Stonehenge Limestone Member of Beekmantown Limestone;
Oc, Chambersburg Limestone

Activities or structures near site: C, construction; D, ditching; Dr, drain; G, grading; H, house; Hwy, highway;
I, impounding or ponding; O, other (see remarks); P, pumping of nearby well;
W, water or sewer lines.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting Unit(s)	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Long-itude	Lat-itude			Depth to Bed-rock (feet)	Rain-fall to or During Event		Depth to Water Level (feet)
<u>Albemarle County</u>														
1	USGS	1	6/1978	--	--	20	78°28'	38°08'	0	--	--	--	--	D,0
	<u>Remarks:</u>	Collapse occurred in farm pasture as well driller drilled through cavity in limestone formation 80 feet below land surface. Well driller lost drilling equipment worth \$5,000 to \$8,000. Location approximate.												
<u>Augusta County</u>														
1	USGS	1	8/11/10	(See remarks) 70			79°03'	38°09'	O,D	OcCs	--	--	--	0
	<u>Remarks:</u>	Collapse at Staunton reported as several hundred feet in diameter. Collapsed beneath a portion of a street and a residence. Dog fell into hole. Location approximate.												
<u>Rockingham County</u>														
1	USGS	1	8/1978	20±	20±	10+	78°56'	38°21'	0	Oc/Oc/Es	--	--	--	0
	<u>Remarks:</u>	Collapse occurred in field. Location and dimensions approximate.												
2	USGS	1	3/1976	--	--	--	78°56'	38°21'	O,D	Oc/Oc/Es	--	--	--	W
	<u>Remarks:</u>	Sinkhole occurred at municipal sewer site. Leaking sewer line reportedly triggered mechanism. Collapse broke sewer line. Repaired by grouting.												

A D D E N D U M

Table 4. Inventory of sinkhole occurrence in Tennessee.

NOTE: These data collected after completion of Phase 1 investigation.

(1) Site locations not shown on Plate 3.

(2) These data were not used to generate Figures 8, 9, and 10.

Source of information: C, City
 CA/CE, County Agent and/or County Executive
 CDC, Civil Defense Coordinator
 CDOT, County Highway Department
 SCS, Soil Conservation Service
 TDC, Tennessee Division of Geology
 TDOT, Tennessee Department of Transportation
 TDSWM, Tennessee Department of Health and Environment,
 Division of Solid Waste Management
 USGS, Files of U.S. Geological Survey

ADDENDUM Source of information:
 PELA, P. E. LaMoreaux & Associates,
 Inc. - field reconnaissance
 mapping
 UD, Utilities District

Topographic setting: D, developed; F, forest; H, hilltop; O, open; S, slope; V, valley or flat.

Geologic setting:

Eu,	Unicoi Formation	Ock,	Knox Group	∞ ∞
Ehs,	Hesse Sandstone	Osv,	Sevier Shale	
Ehk,	Honaker Dolomite	Oa,	Athens Shale	
Ecr,	Copper Ridge Dolomite	Oh,	Holston Formation	
Epv,	Pumpkin Valley Shale	Oo,	Ottosee Shale	
Ert,	Rutledge Limestone	OI,	Lenior Limestone	
Em,	Maryville Limestone	Och,	Chickamauga Group	
En,	Nolichucky Shale	Opm,	Pierce and Murfreesboro Limestones	
Emr,	Maryville, Rogersville, and Rutledge Formations	Ord,	Ridley Limestone	
Emn,	Maynardville Limestone	Obh,	Bigby-Cannon Limestone and Hermitage Formation	
Ecu,	Maynardville Limestone and Nolichucky Shale	Ou,	Sequatchie, Leipers, Inman, and Catheys Formations	
Ecl,	Epv, Emr, and Ecu Undifferentiated	Mfp,	Fort Payne Formation	
Ec,	Conasauga Group	Mg,	Grainger Formation	
Olc,	Longview, Chepultepec Undifferentiated	Mn,	Newman Formation	
On,	Newala Formation	Mm,	Monteagle Limestone	
Oc,	Chepultepec Dolomite	Mbh,	Bangor Limestone and Hartselle Formation	
Olv,	Longview Dolomite	Mp,	Pennington Formation	
Ok,	Kingsport Formation	Pco,	Crab Orchard Mountains Group	
Oma,	Mascot Dolomite	Psi,	Slatestone Formation	
Onc,	Oc, Olv, Ok, and Oma Undifferentiated			

Activities or

structures near site:

B,	blasting	G,	grading	O,	other (see remarks)
C,	construction	H,	house	P,	pumping of nearby well
D,	ditching	Hwy,	highway	W,	water or sewer line
Dr,	drain	I,	impounding or ponding		

(continued)

A D D E N D U M

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting Unit(s)	Depth to Bed-rock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Longitude	Latitude				Rain-fall Prior to or During Event	Depth to Water Level (feet)	
<u>Hamblen County</u>														
29	CDC	1	10/21/86	7-8	3-4	7-8	83°14'	36°13'	S,F	--	8-10	No	--	--
	<u>Remarks:</u> Collapse occurred under loaded trailer.													
30	CDC	1	2/1981	12	12	8-10	--	--	O,V	Oc	--	--	--	O
	<u>Remarks:</u> Occurred following hard freeze.													
31	J. B. Williams	1	--	10	10	--	83°25'	36°12'	O,V	Scr	--	--	--	H
	<u>Remarks:</u> Collapse occurred in front yard of a home. Landowner has filled hole with debris. Depression still evident, however, activity appears to have ceased.													
32	CDC	1	1984	2	2	10	83°23'27"	36°11'28"	S,O,D	Oc	10+	--	10+	C,G
	<u>Remarks:</u> Occurred near Mountain Lake Road during construction of new subdivision. Bell-shaped sinkhole.													
33	CDC	1	9/23/86	2	3	10	83°22'51"	36°10'42"	O,V	Ok, Oma	10+	--	10+	O
	<u>Remarks:</u> Occurred in an open field near Morristown Municipal Airport.													
34	CDC	1	Late 1984	6	6	20	83°22'03"	36°11'19"	O,V	Ok	--	--	--	H
35	CDC	1	Spring 1985	2	3	10-15	83°22'02"	36°11'18"	O,V	Ok	--	--	--	H
	<u>Remarks:</u> Required one truck load of gravel to fill. Nearby home has reportedly been settling since day of occurrence.													

(continued)

A D D E N D U M

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting Unit(s)	Depth to Bed-rock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Longitude	Latitude				Rain-fall Prior to or During Event	Depth to Water Level (feet)	
<u>Hamblen County</u> (continued)														
36	CDC	17+	1983-1986	24	14	14	83°22'30"	36°11'10"	D,O,S	Olv	2-10	Yes	14+	G, I, Hwy
	<u>Remarks:</u> More than seventeen (17) sinkholes have occurred at the location of a borrow pit near the junction of Highway 11E and Panther Creek Road. There are at least three levels of subsidence correlative with excavated benches in 4.8-acre site. Bedrock pinnacles exposed in excavation. Evidence of ponding was noted. The occurrences have reportedly been active since 1983 although excavation is discernible from aerial photography dated April 2, 1976. The largest collapse (24x14x14) reportedly occurred August 1986 and was associated with a rainfall event.													
37	CDC	1		10	10	5	83°22'50"	36°11'26"	O,V	Oc	5	--	5+	0
	<u>Remarks:</u> Occurred in a vacant lot near edge of street in a subdivision. Vertical walls.													
38	CDC	1	May 1986	4	6	5	83°22'42"	36°12'31"	O,V	Ccr	5+	--	5+	0
	<u>Remarks:</u> Occurred in middle of corn field. Was filled with dirt and is still active.													
39	C. Quarles	1	1960	--	--	--	83°22'13"	36°11'17"	O,V	Ok	--	--	--	Hwy
	<u>Remarks:</u> Occurred on shoulder of west bound Highway 11E.													
40	C. Quarles	1	1970	5	5	6+	83°22'34"	36°11'01"	O,V	Ok	--	--	--	--
41	C. Quarles	2	1983 and 1986	3	2	1	83°22'07"	36°11'09"	O,V	Ok/Oma	1	--	--	0
	<u>Remarks:</u> Collapse occurred in open pasture. The second sinkhole measures 15x15x3 with no available date of occurrence. Pinnacle development evident in walls of collapse.													
42	C. Quarles	1	1976	--	--	--	83°22'09"	36°11'07"	O,S	Oma	--	--	--	0
	<u>Remarks:</u> Occurred in open field. Has since been filled.													

(continued)

A D D E N D U M

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting Unit(s)	Depth to Bed-rock (feet)	Hydrologic Setting		Activ-ities or Struc-tures Near Site
				Length	Width	Depth	Longitude	Latitude				Rain-fall Prior to or During Event	Depth to Water Level (feet)	
<u>Hamblen County (continued)</u>														
43	CDC	1	1965-1970	--	--	--	83°23'40"	36°12'09"	O,V	€cr	--	--	--	0
	<u>Remarks:</u> Collapse occurred in Panther Creek in an area of open pasture land. Reportedly drained Panther Creek at time of occurrence and required several truck loads of material to fill.													
44	CDC	1	1980-1981	--	--	--	83°24'20"	36°12'07"	O,S	€cr	--	--	--	H
	<u>Remarks:</u> Occurred in front lawn of home. A county tractor reportedly got stuck in effort to repair collapse.													
45	Smallman	1	1946	6	6	5	83°22'41"	36°12'15"	S,O	€cr	5+	--	--	0
	<u>Remarks:</u> Collapse occurred in pasture.													
46	J. B. Williams	2	1984	4	4	3	83°24'10"	36°12'13"	D,O,S	€cr	3+	--	3+	H
	<u>Remarks:</u> Sinkhole collapse occurred on a slope in the front lawn of a home. A second collapse of unreported size occurred at the toe of the slope near the edge of the road.													
47	Bill Howell	1	1927	--	--	--	83°21'42"	36°10'59"	O,V	Olv	--	--	--	0
	<u>Remarks:</u> Collapse occurred under a team of horses while farmer was plowing.													
48	Bill Howell	1	--	--	--	--	83°21'30"	36°10'57"	D,O,V	Olv	--	--	--	1
	<u>Remarks:</u> Sinkhole formed in bottom of a farm pond. After the pond had drained, the landowner repaired the hole by dumping bags of cement into the hole. Pond now holds water.													
49	J. B. Williams	1	1984	--	--	--	83°22'32"	36°11'09"	D,O,V	Olv	--	--	--	Hwy
	<u>Remarks:</u> Collapse occurred beneath a paved road in front of a borrow pit where 17 or more sinkholes have been documented to occur. (See site number 5.)													

(continued)

A D D E N D U M

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting Unit(s)	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Longitude	Latitude			Depth to Bed-rock (feet)	Rain-fall Prior to or During Event		Depth to Water Level (feet)
<u>Hamblen County (continued)</u>														
50	CDC	1	1972	12	12	8-10	83°21'59"	36°12'03"	O,V	Oc	--	--	--	0
	<u>Remarks:</u> Piping developed in the bottom of an old sinkhole and caused a collapse. Landowner reported the site is no longer active.													
<u>Hamilton County</u>														
9	Tony Prichett	1	1979-1980	--	--	--	--	--	--	--	--	--	--	H
	<u>Remarks:</u> The sinkhole occurred near a residence off Interstate Highway 24 near South Pittsburg. Size of collapse is reportedly extremely deep, large enough to drop an automobile into. Water could be heard flowing in the bottom. Landowner has reportedly constructed a fence around the sinkhole.													
<u>Jefferson County</u>														
25	UD	1	2/1987	3	2	--	83°25'	36°09'	V,O,D	Oma	--	--	--	W
	<u>Remarks:</u> Collapse occurred under a water line.													
<u>Knox County</u>														
13	TDSWM	1	11/3/86	8-9	8-9	--	--	--	D,O,H	Och	--	--	--	0
	<u>Remarks:</u> Collapse occurred on a hill at edge of a parking lot. The collapse is in line with several other older karst depressions in the immediate vicinity.													
14	TDSWM	1	--	10	10	4	--	--	--	--	--	--	--	0
	<u>Remarks:</u> Collapse occurred at the location of a site proposed for a sanitary landfill in Knox County. Collapse appeared to be recent with vertical walls.													

(continued)

A D D E N D U M

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting	Hydrologic Setting		Activities or Structures Near Site	
				Length	Width	Depth	Longitude	Latitude		Unit(s)	Depth to Bedrock (feet)	Rainfall Prior to or During Event		Depth to Water Level (feet)
<u>Rhea County</u>														
3	Neal Ray	1	1950's	6-8	6-8	5-6	84°52'	35°34'	V,0	--	--	--	--	0
	<u>Remarks:</u> Collapse occurred in a farmer's field near confluence of Clear Creek and the Tennessee River. A tractor reportedly fell into the sinkhole when it developed.													
4	Lewis Martin	1	1985	20	20	8	84°53'	35°39'	V,0	Ock/Och	8+	--	8+	H,0
	<u>Remarks:</u> Collapse occurred at a house near the intersection of U.S. Route 27 and State Route 68 in a driveway immediately after a loaded feed truck had crossed over the area. Landowner reported six (6) truck loads of dirt were required to fill the hole.													
5	Dallas Hawkins	1	1945	20	20	30	84°50'	35°36'	0,V	Ock/Och	<30	--	--	0
	<u>Remarks:</u> Collapse occurred in a field. Rock is exposed in bottom of sinkhole. Sinkhole holds water during wet season.													
6	Rhea Co. Landfill Worker	1	1975	--	--	--	--	--	V,0,D	--	--	No	--	G
	<u>Remarks:</u> A dozier was working at one end of a limestone quarry when a large sycamore tree reportedly began to sink into the ground. After about one hour, all that could be seen of the tree was the very top portion. The sinkhole was reportedly large enough to place an automobile in.													
7	CDOT	1	1984	2	2	4	84°54'26"	35°35'45"	V,0	ocr	--	Yes	--	D,Hwy
	<u>Remarks:</u> Occurred during rainfall in ditch off shoulder of road. Runoff drains into sinkhole.													
8	Mrs. Lloyd Reed	1	1985	10	10	3+	84°54'66"	35°36'09"	S,0	Ocn	3+	--	1	0
	<u>Remarks:</u> Occurred in an open field.													

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(continued)

A D D E N D U M

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sink-holes	Date of Occurrence	Dimensions (feet)			Location		Topo-graphic Setting	Geologic Setting		Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Longitude	Latitude		Unit(s)	Depth to Bed-rock (feet)	Rain-fall Prior to or During Event	Depth to Water Level (feet)	
Rhea County (continued)														
9	Mrs. Llycd Reed	1	1983	8	8	3+	84°54'66"	35°36'02"	S,0	Ocn/€c	3+	--	--	0
	<u>Remarks:</u> Occurred in an open field.													
10	Tony Prichett	1	About 1912	20	30	10+	84°54'32"	35°36'05"	V,0	€c	10+	--	--	0
	<u>Remarks:</u> Collapse reportedly occurred in a field a few hundred feet north of Concord Church about 1912. It was reported that the collapse occurred beneath a horse-drawn buggy while a man and his wife were traveling to church. Locally the hole is known as the "Blue Hole." In recent years the hole has been covered with timber.													
11	John Sneed	1	About 1981	10	10	6	84°55'43"	35°33'28"	0,S	Oc	6+	--	--	0
	<u>Remarks:</u> Collapse occurred in a pasture at the edge of woods. The sinkhole has since been repaired.													
12	John Sneed	1	Between 1926 & 1946	--	--	--	84°56'01"	35°33'23"	0,S	Oc	--	--	--	0
	<u>Remarks:</u> Collapse was reportedly large and occurred in a pasture.													
13	TDSWM	1	September 1986	3	3	4	84°54'49"	35°33'56"	D,0,S	Oc	4+	Yes	0	D,Dr,G,I
	<u>Remarks:</u> Soil cavity collapse occurred between September 15 and 22, 1986, in the middle of an excavated trench (6 to 10 feet deep) at the Rhea County Landfill. The trench was reportedly ponded with rain water at time of observation. The cavity was scheduled for repair on September 30, 1986, using compacted clay and a concrete cap.													
14	Neal Ray	3	Prior to 1982	5	6	2-3	84°54'55"	35°35'45"	0,S	€c	3+	--	--	0
	<u>Remarks:</u> Three sinkholes occurred on pasture land. At the time of observation, the sinkholes contained water (rainfall had occurred prior to and during the time of observation). Landowner reported these sinkholes discharge water during heavy rainfall events. There are some natural springs in the immediate area.													

(continued)

A D D E N D U M

Table 4. Inventory of sinkhole occurrence in Tennessee.

Site Number	Source of Information	Number of Sinkholes	Date of Occurrence	Dimensions (feet)			Location		Topographic Setting	Geologic Setting Unit(s)	Depth to Bedrock (feet)	Hydrologic Setting		Activities or Structures Near Site
				Length	Width	Depth	Longitude	Latitude				Rain-fall to or During Event	Depth to Water Level (feet)	
<u>Rhea County (continued)</u>														
15	Sammy Prichett	2	7/9/82	3.5-4	3.5-4	10	84°54'10"	35°35'41"	O,H	€cr	10+	--	--	H,G
	<u>Remarks:</u> A bulldozer excavated into a soil cavity while grading land for construction of house. The cavity was filled with soil and has not been active since that time. A second sinkhole of smaller size developed in the front yard.													
16	Dallas Hawkins	1	1980	3-4	3-4	3+	84°53'41"	35°34'29"	F,V	Oc	--	--	3+	0
	<u>Remarks:</u> Collapse reportedly occurred at the base of a tree when lightning struck the tree. The resulting sinkhole has reportedly continued to enlarge since first occurrence. Outcrops nearby suggest shallow depth to bedrock.													
17	PELA	4	--	3-12	2-8	2+	84°54'30"	35°35'56"	F,V	€c	2+	--	--	0
	<u>Remarks:</u> Sinkholes are located within a one-acre area. Landowner not available for comments. Sinkholes had vertical sides and the smallest (3x2x2+) appears to be of more recent occurrence.													
<u>Roane County</u>														
6	R. H. Ketelle	1	1986	4	3	3	--	--	V,O	€n	Est. 5-10	--	--	0
	<u>Remarks:</u> Sinkhole occurred in the bottom of a natural drain in a cleared right of way. Occurred near the end of the 1986 drought. The sinkhole is located on Oak Ridge Reservation.													
<u>Sevier County</u>														
3	R. H. Ketelle	3	1/1987	4-8	4-8	--	--	--	H,O	€n	--	--	--	0
	<u>Remarks:</u> Sinkholes occurred on upland terrane in the bottom of an older sinkhole. The older sinkhole formed a natural pond. During periods of high rainfall in late 1986 and early 1987, the three sinkholes formed, draining the pond. The three sinkholes are aligned, suggesting a correlation with fractures in bedrock.													

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PLATE 1. SINKHOLE C
PROVINCE I
VIRGINIA.

INKHOLE OCCURRENCE IN THE VALLEY A
ROVINCE IN ALABAMA, GEORGIA, TENNE
IRGINIA.

VALLEY AND RIDGE
A, TENNESSEE, AND

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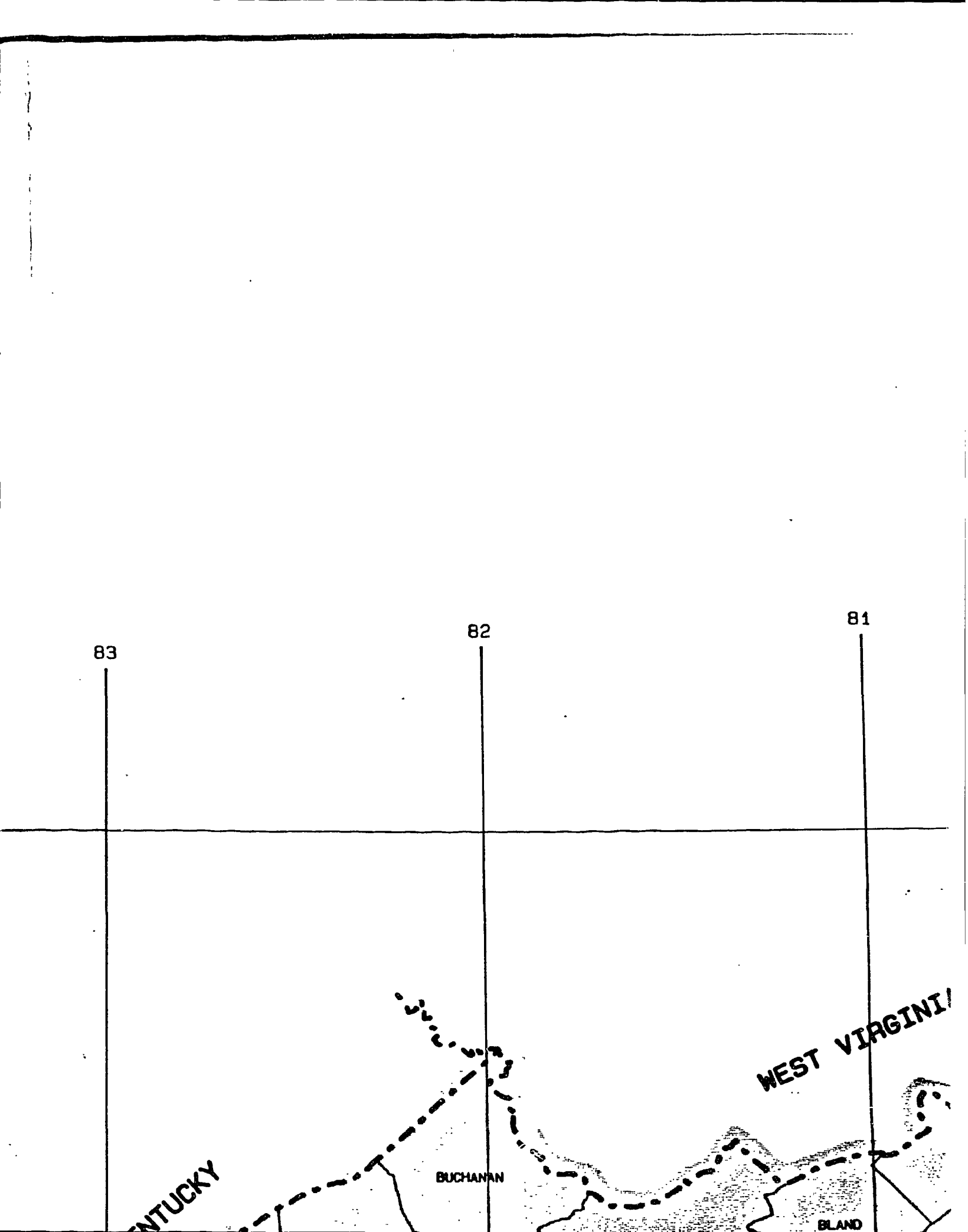
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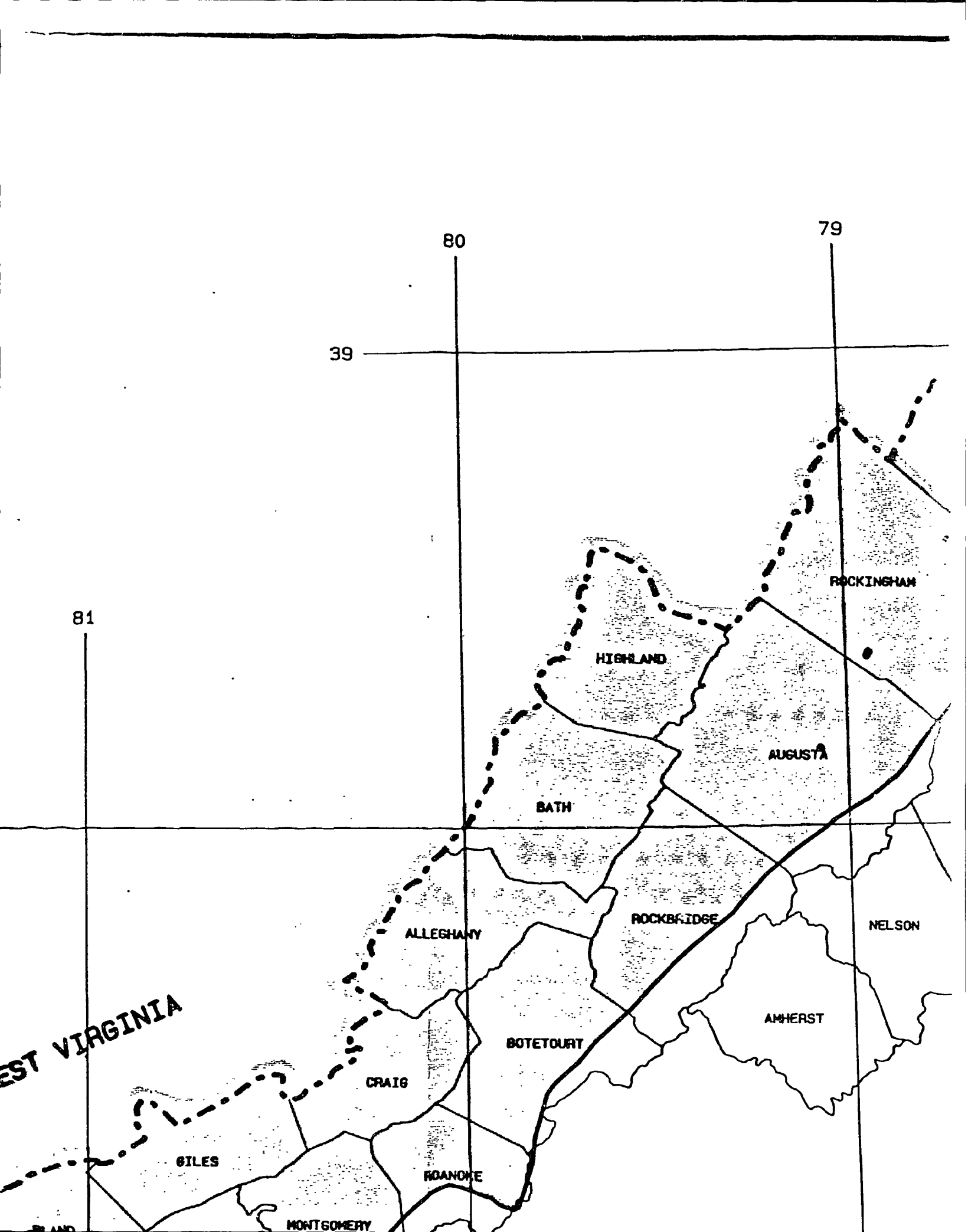
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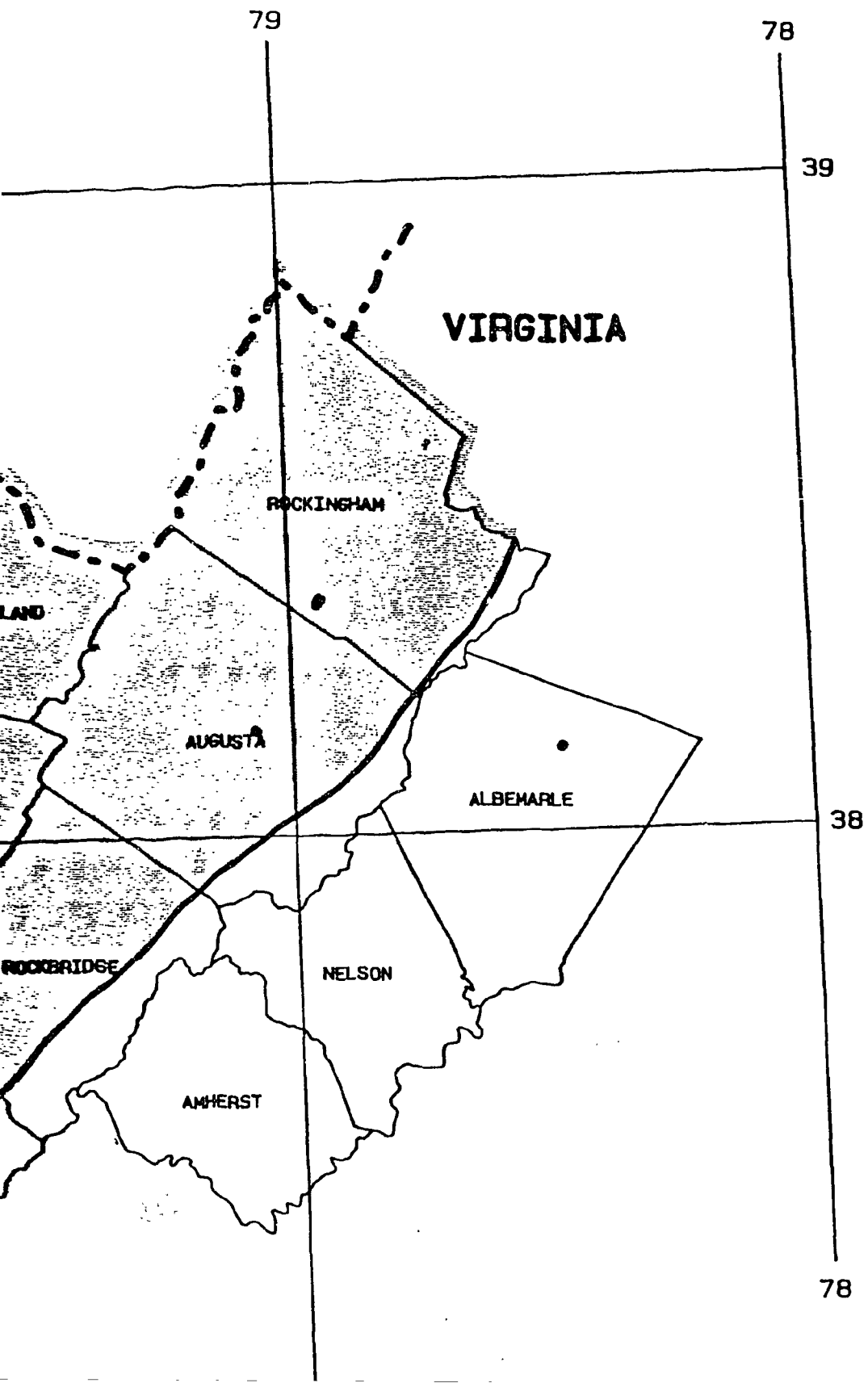
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WEST VIRGINIA

BLAND



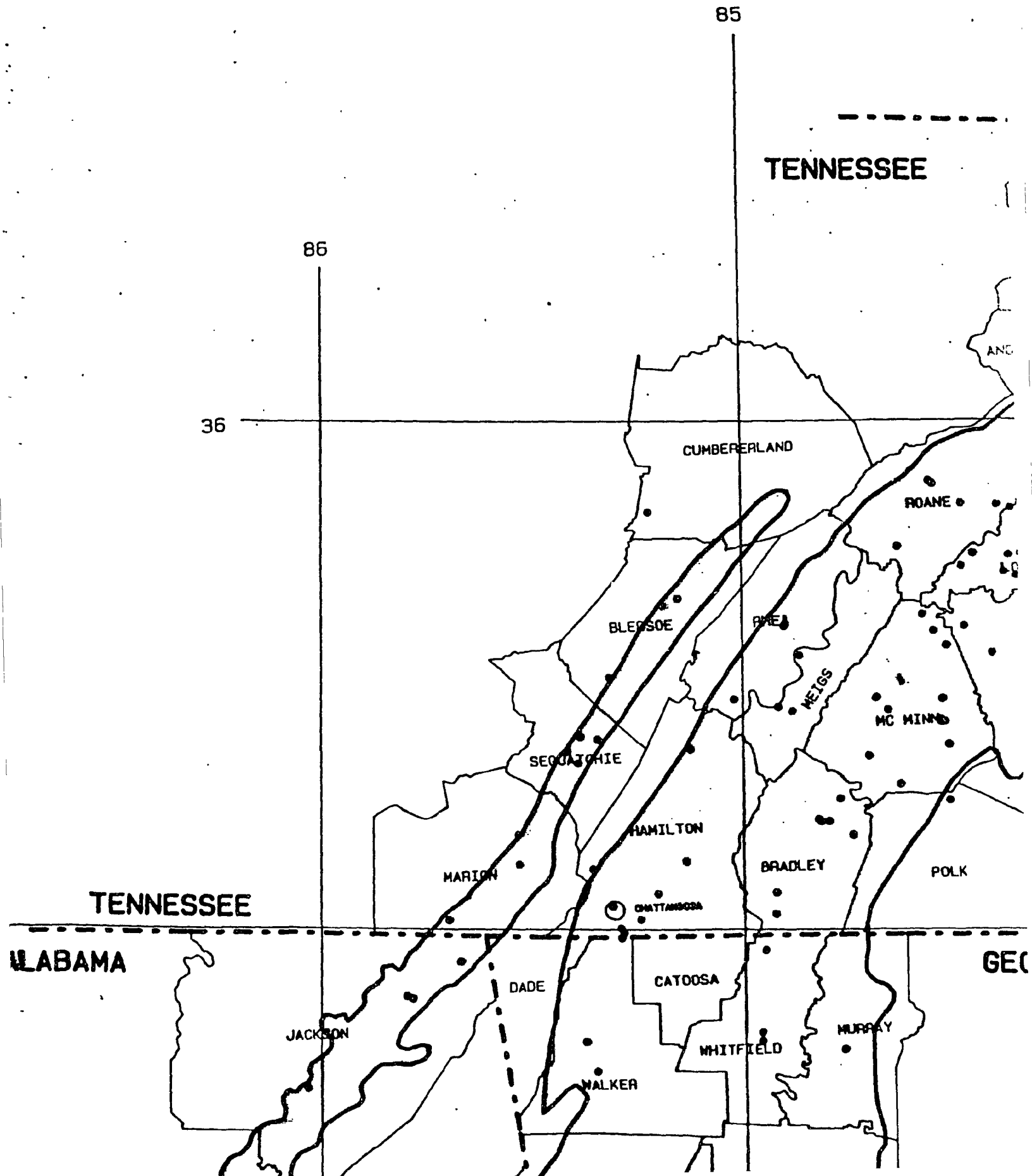




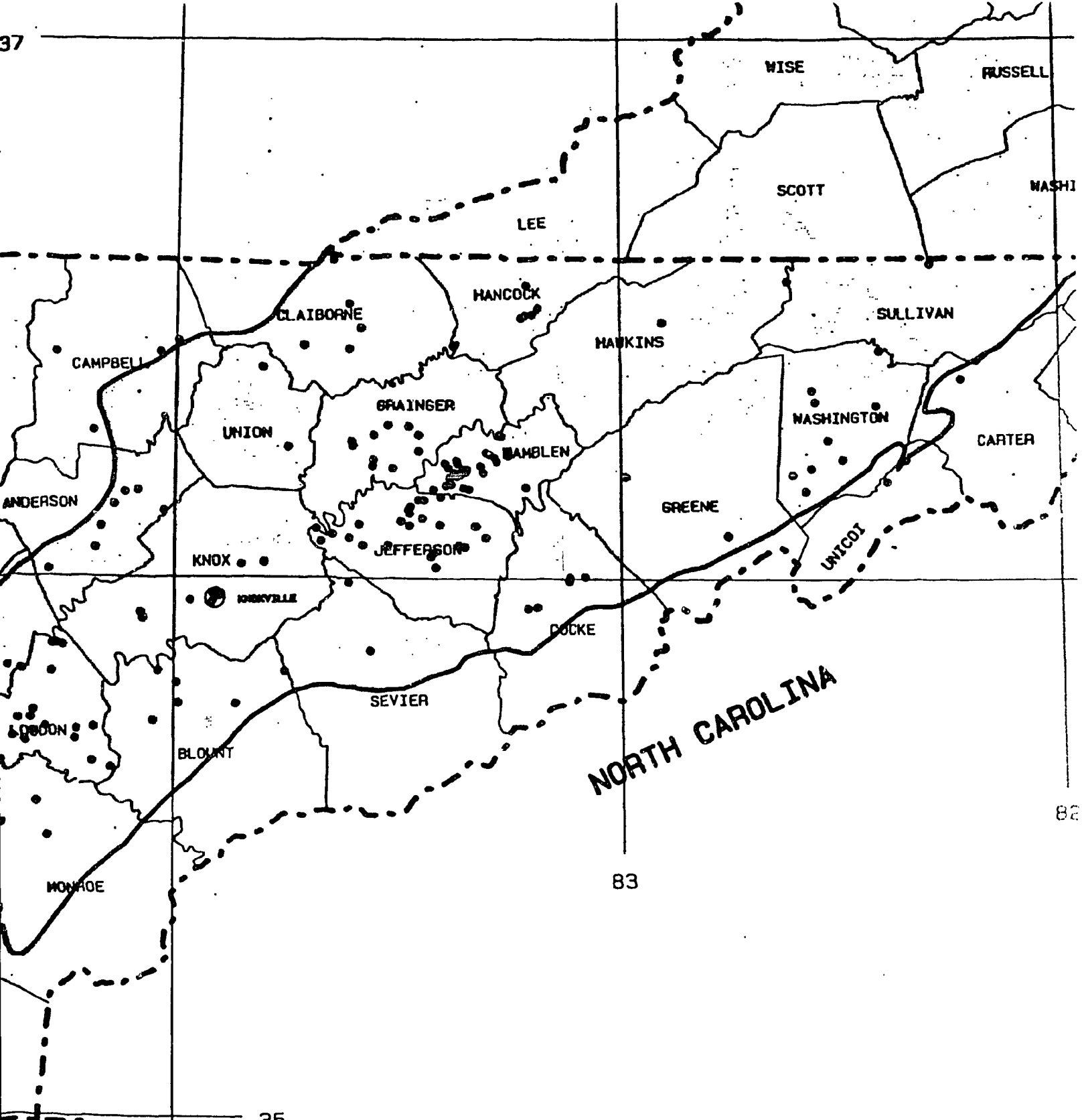
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ALABA



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WISE

RUSSELL

SCOTT

WASHI

LEE

CLAIBORNE

HANCOCK

SULLIVAN

CAMPBELL

HAWKINS

GRAINGER

WASHINGTON

CARTER

WAMBLE

UNION

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ANDERSON

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NORTH CAROLINA

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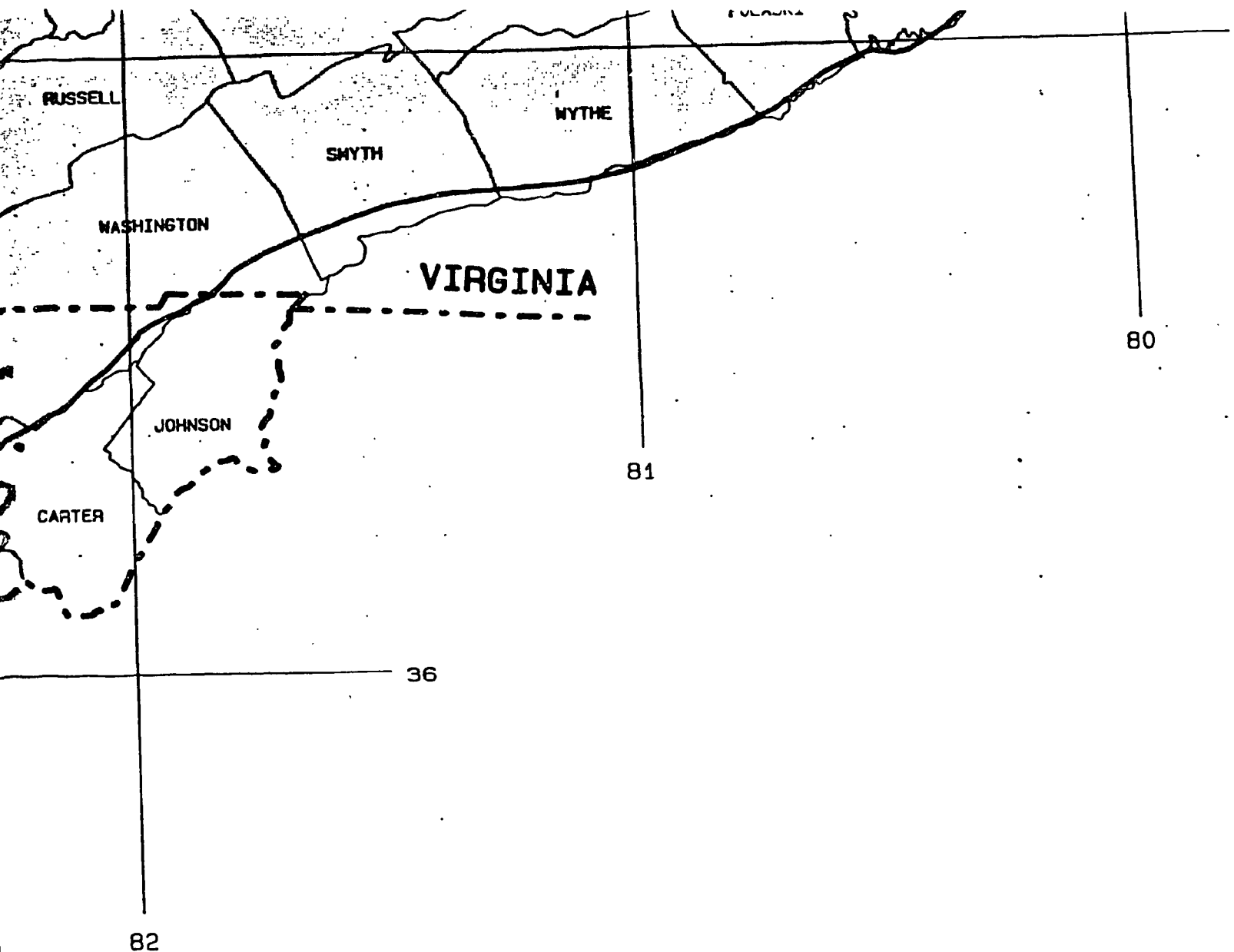
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MONROE


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GEORGIA



EXPLAN

- LOCATION C
-  VALLEY AND

PHYSIOGRAPHIC

1. ALABAMA :
2. GEORGIA :



80

79

EXPLANATION

LOCATION OF SITE OF SINKHOLE OCCURRENCE

VALLEY AND RIDGE PHYSIOGRAPHIC PROVINCES BOUNDARY

PHYSIOGRAPHIC BOUNDARY DATA SOURCES:

ALABAMA :: USGS MAP 168, 1975

GEORGIA :: GEORGIA GEOLOGICAL SURVEY, BULLETIN NO. 65

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N

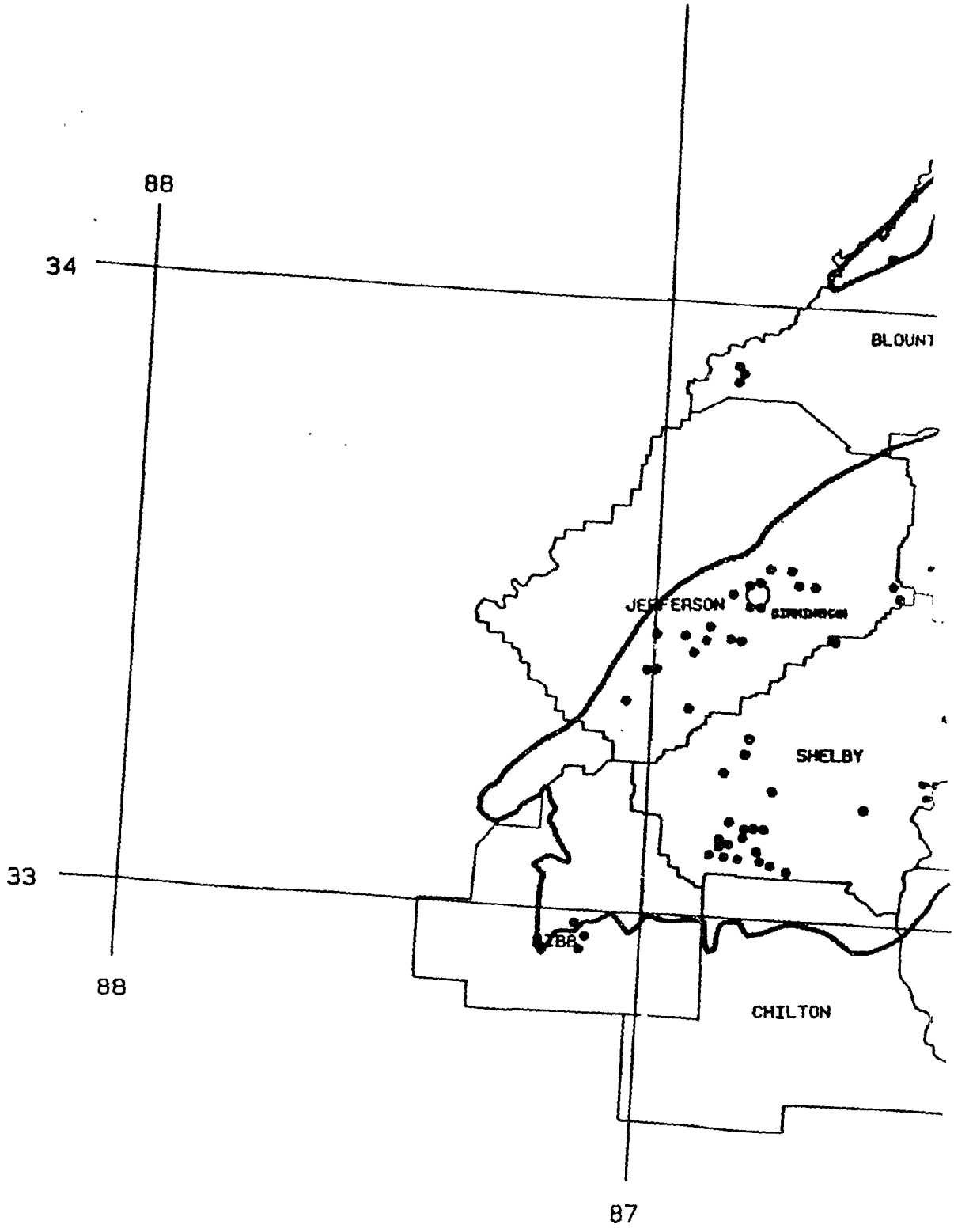
TE OF SINKHOLE OCCURRENCE

GE PHYSIOGRAPHIC PROVINCES BOUNDARY

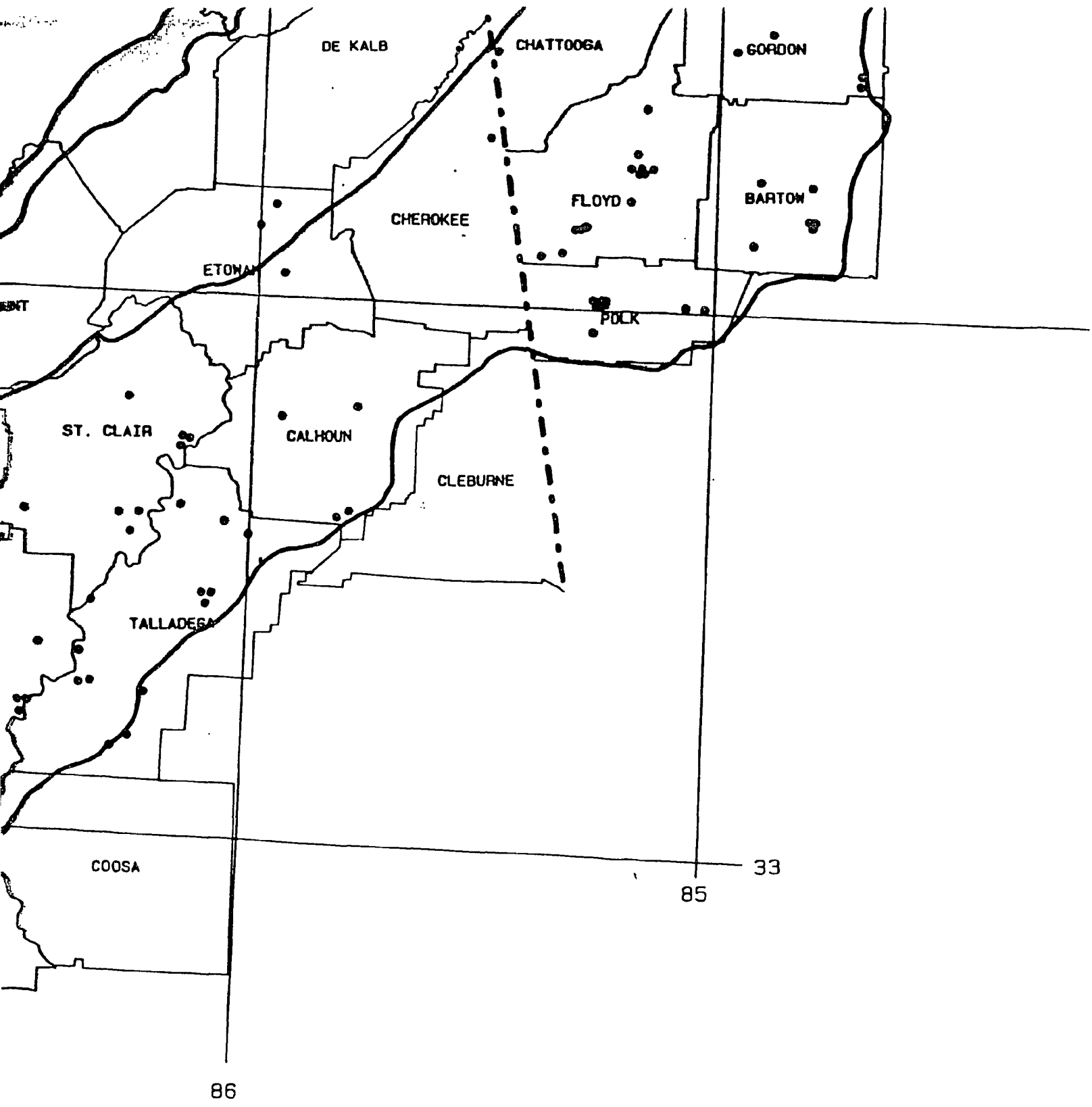
ARY DATA SOURCES:

MAP 168, 1975

GIA GEOLOGICAL SURVEY, BULLETIN NO. 65



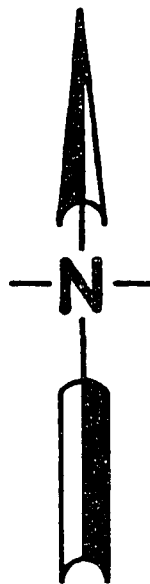
PELA



BASE MAP SOURCES:

1. ALABAMA :: USGS, 1: 500, 000
2. USGS, 1: 500, 000 1970
3. TENNESSEE :: USGS, 1: 500, 000
4. VIRGINIA :: USGS, 1: 500, 000

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500,000 1970

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1: 500,000 1973

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2. GEORGIA :: GEORGI

3. TENNESSEE :: DEI
OF

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4. VIRGINIA :: USG

GEORGIA :: GEORGIA GEOLOGICAL SURVEY, BULLETIN NO. 00

TENNESSEE :: DEPARTMENT OF CONSERVATION, DIVISION
OF GEOLOGY; ENVIRONMENTAL GEOLOGY
SERIES NO. 1, 1972

VIRGINIA :: USGS, PROFESSIONAL PAPER 580, FIGURE 6A, 196

SCALE IN MILES



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PARTMENT OF CONSERVATION, DIVISION
GEOLOGY; ENVIRONMENTAL GEOLOGY
RIES NO. 1, 1972
S, PROFESSIONAL PAPER 580, FIGURE 6A, 1968

SCALE IN MILES



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PLATE 2. SINKHOLE

BASE MAP SOURCES:

1. ALABAMA :: USGS, 1: 50
2. GEORGIA :: USGS, 1: 50

OLE OCCURRENCE IN THE

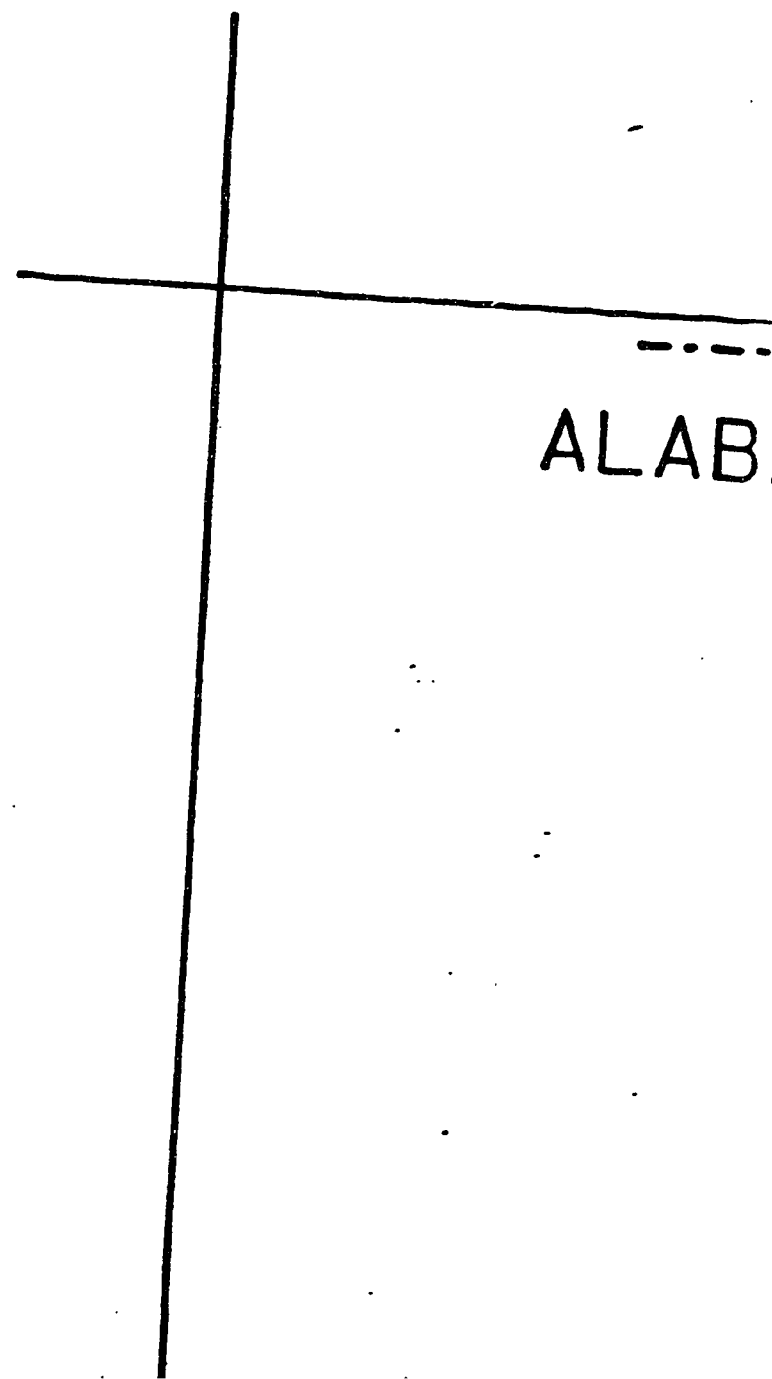
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1: 500, 000 1970

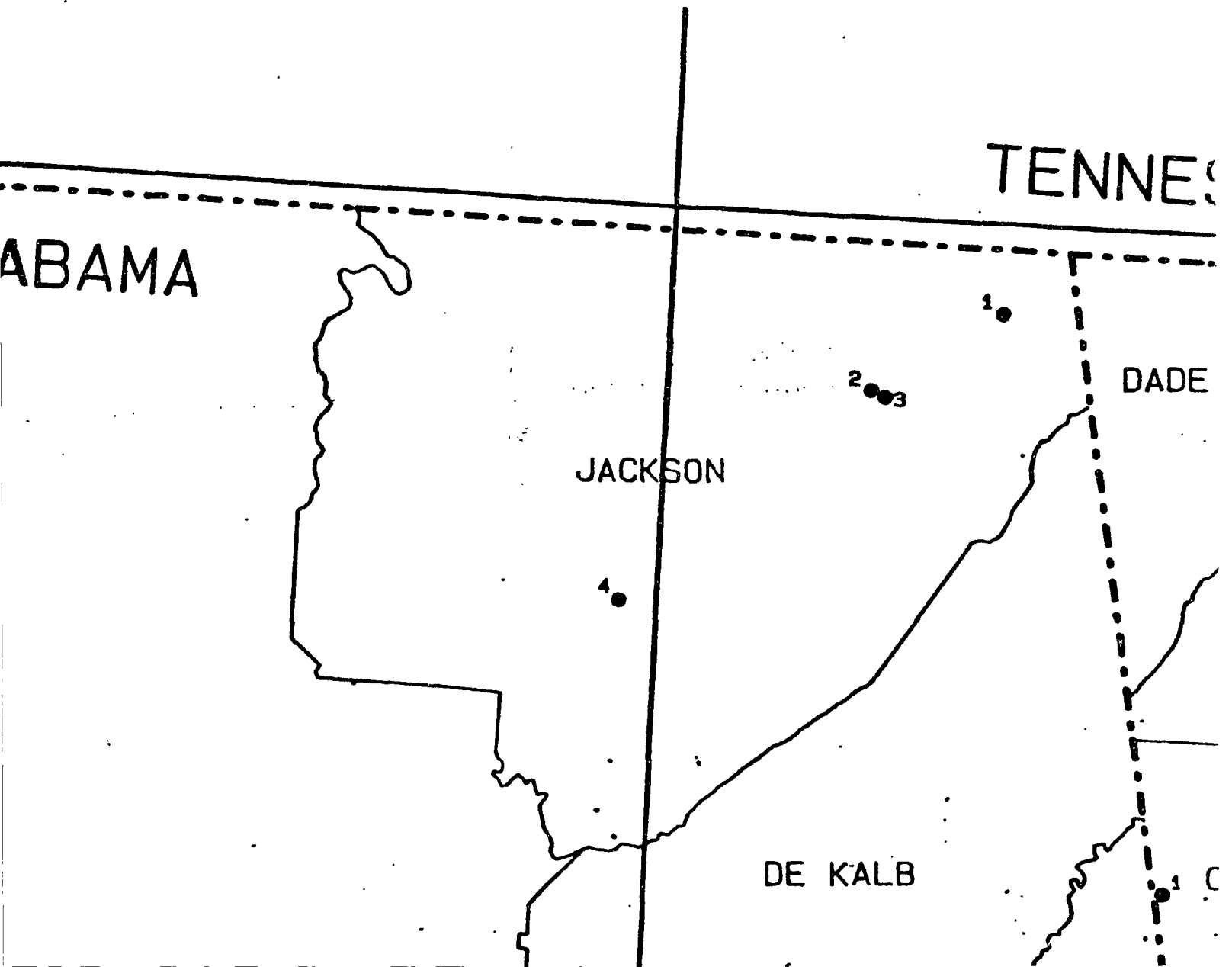
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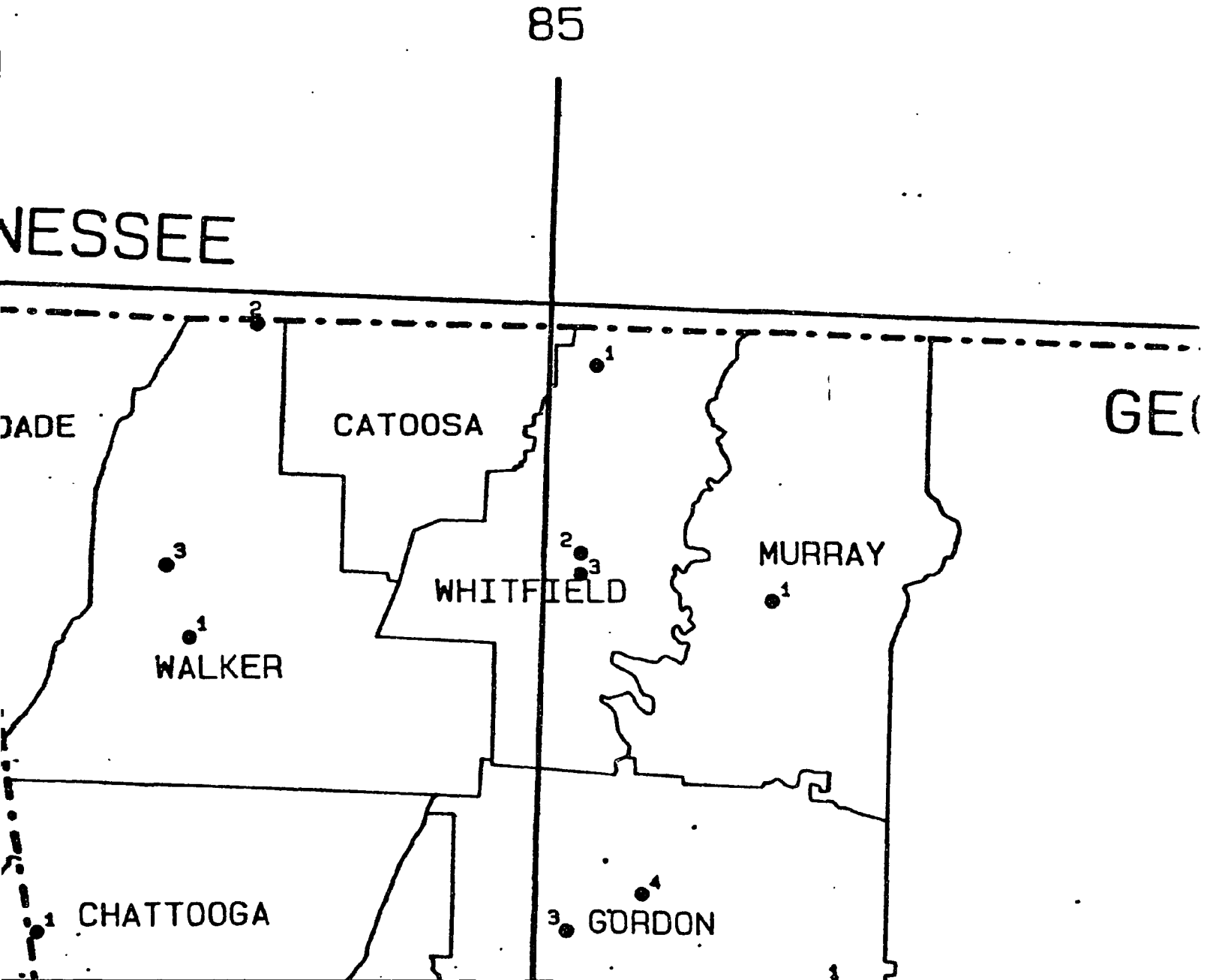


THE VALLEY AND RIDGE PROVINCE

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PROVINCE IN ALABAMA AI



AMA AND GEORGIA.

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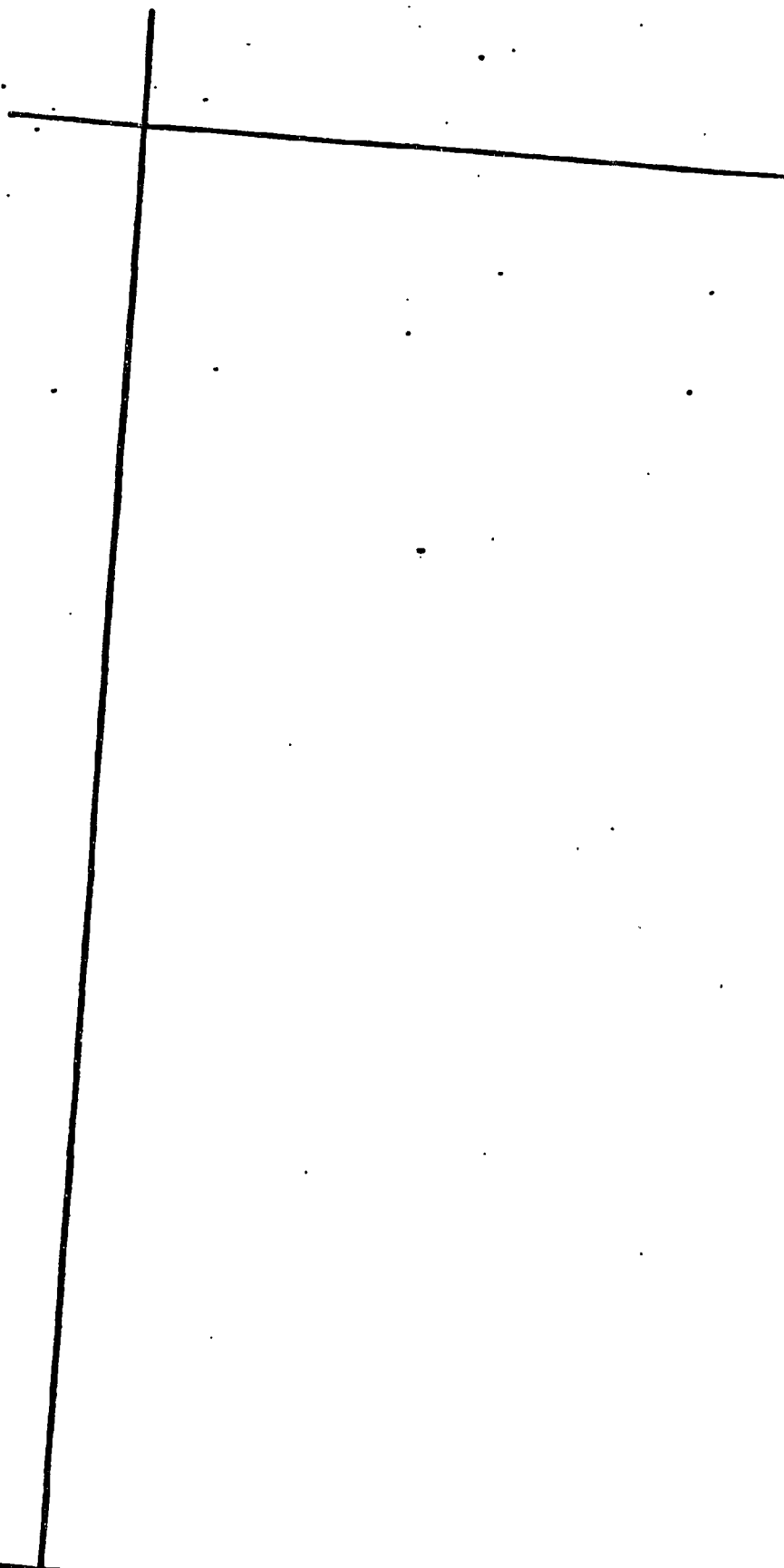
GEORGIA

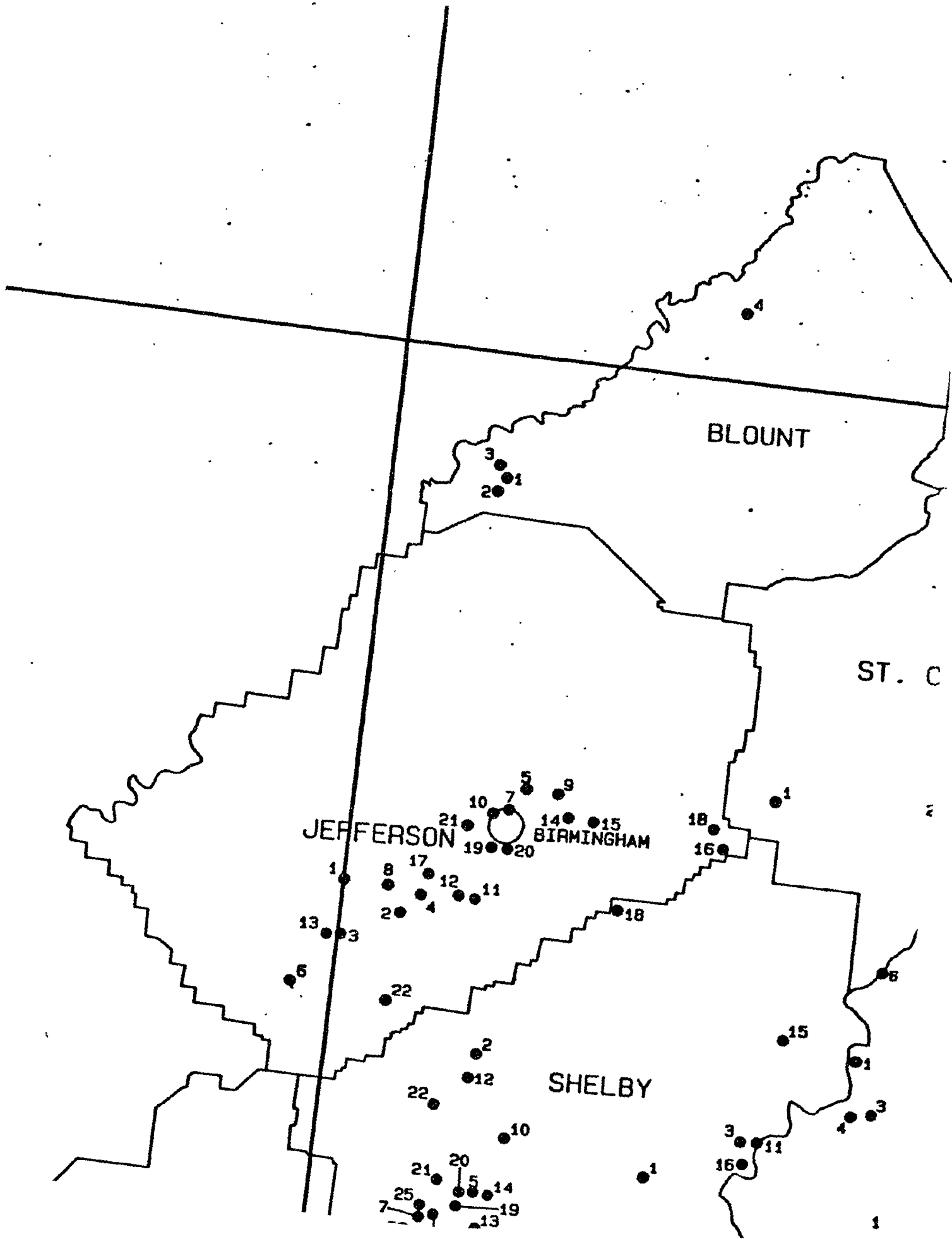


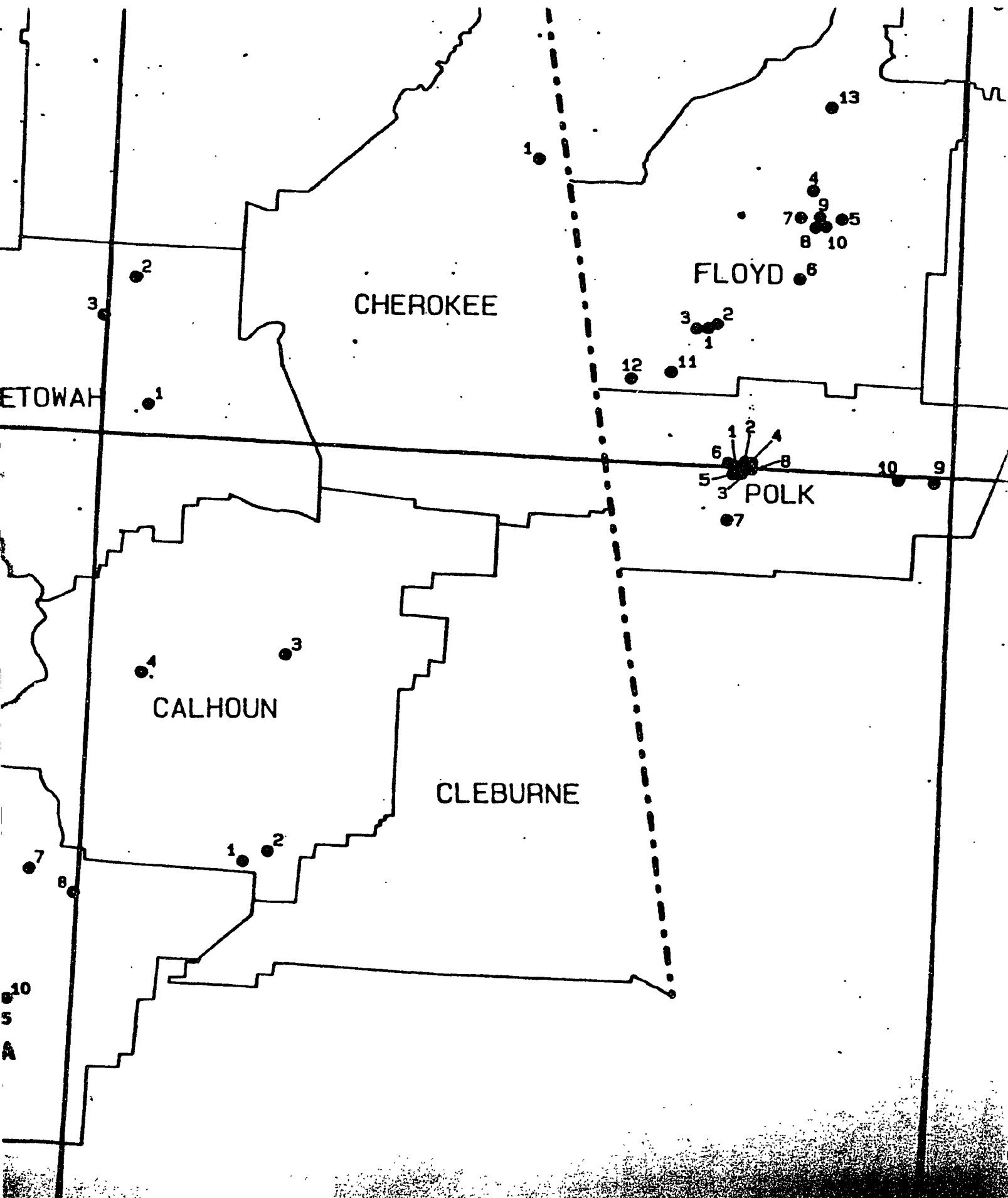
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CHEROKEE

FLOYD

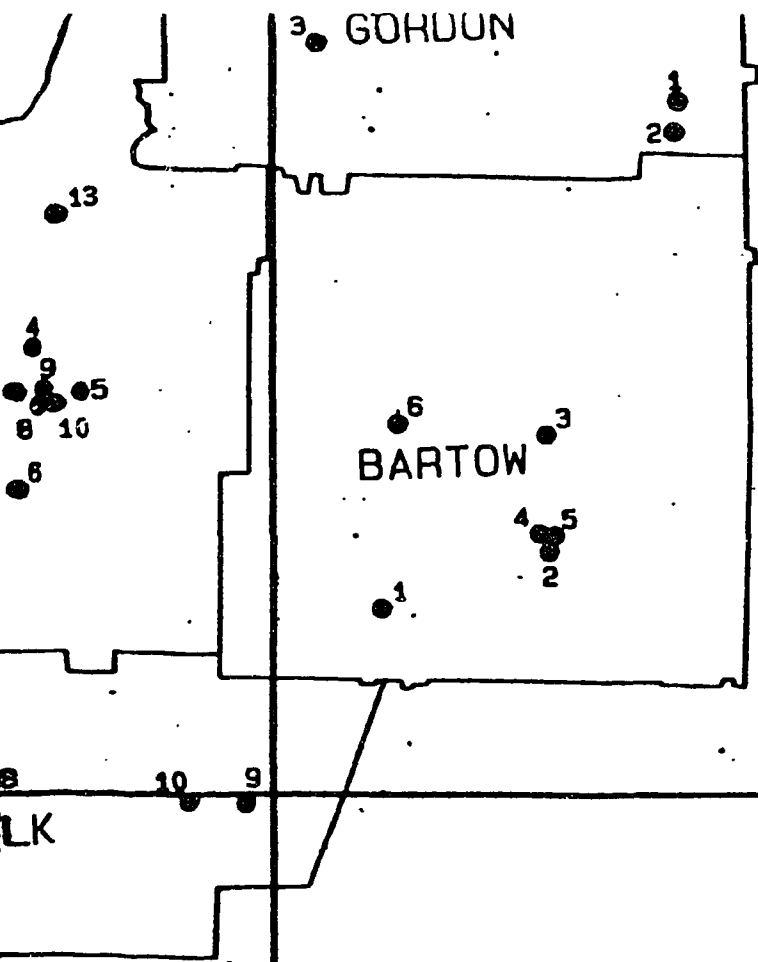
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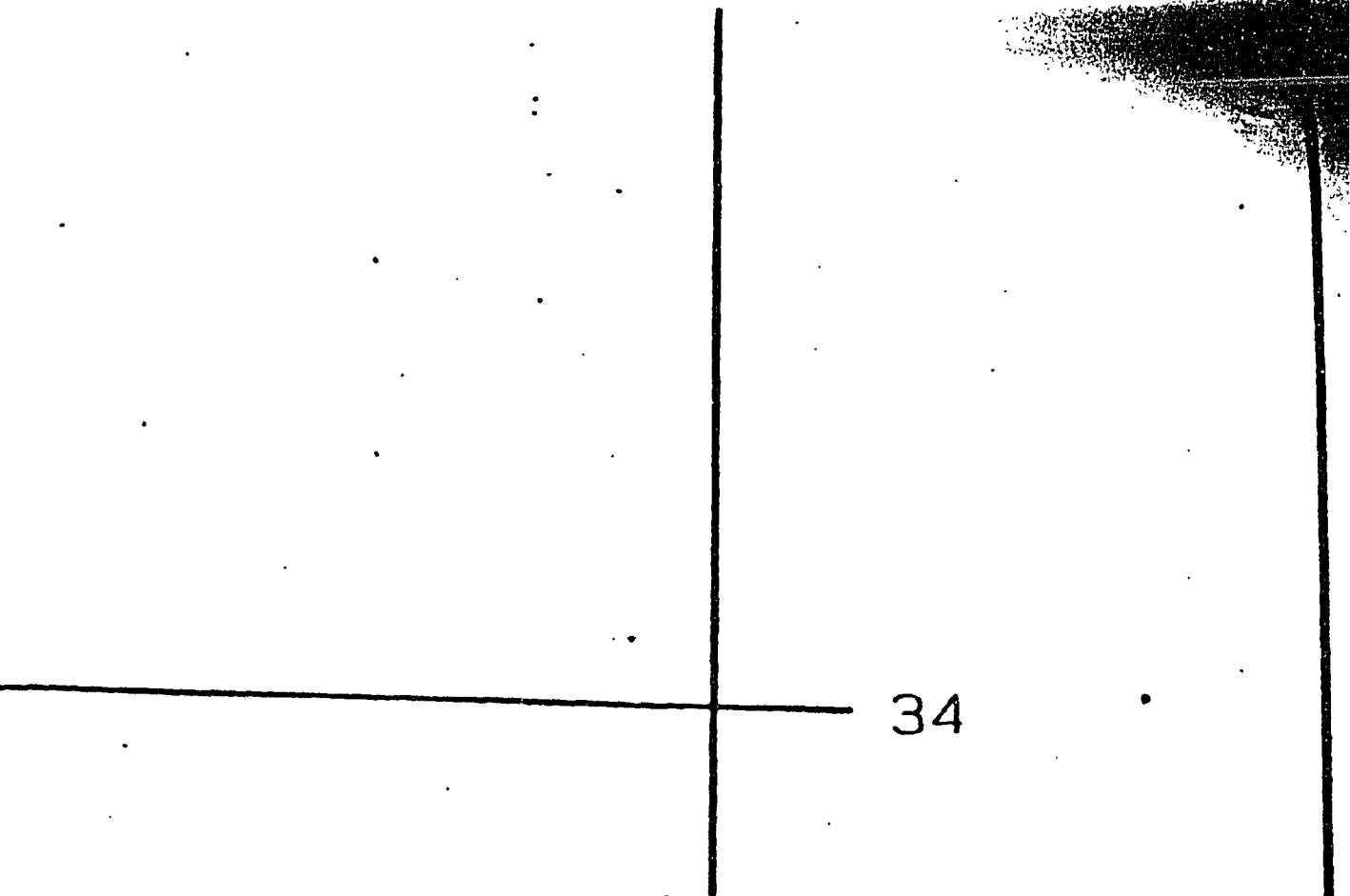
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EXPLANATION

LOCATION OF SINKHOLE SI
NUMBERS CORRESPOND WITH
TABLES 2 AND 3

3



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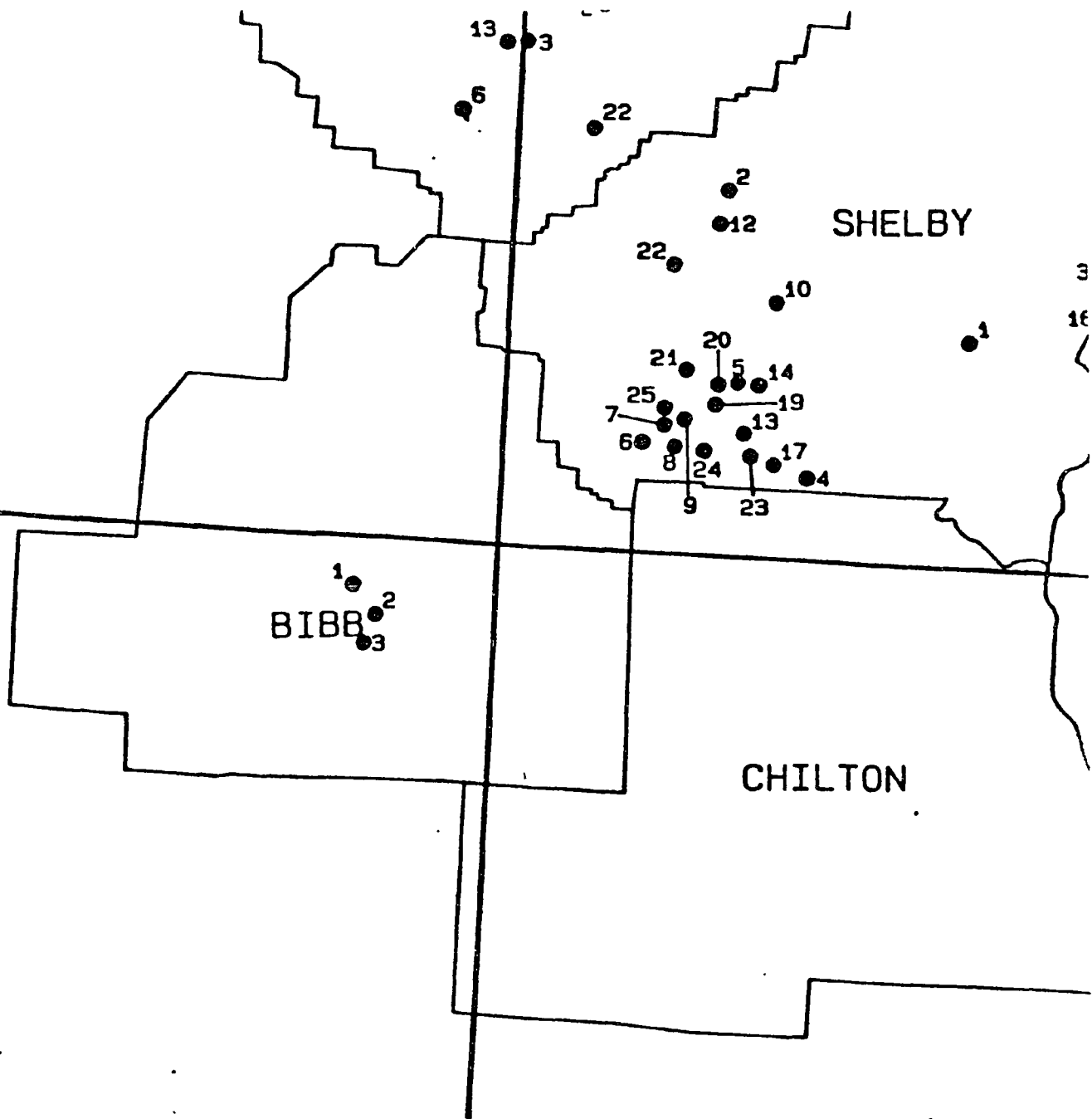
EXPLANATION

OF SINKHOLE SITE AND NUMBER.
CORRESPOND WITH THOSE IN
AND 3

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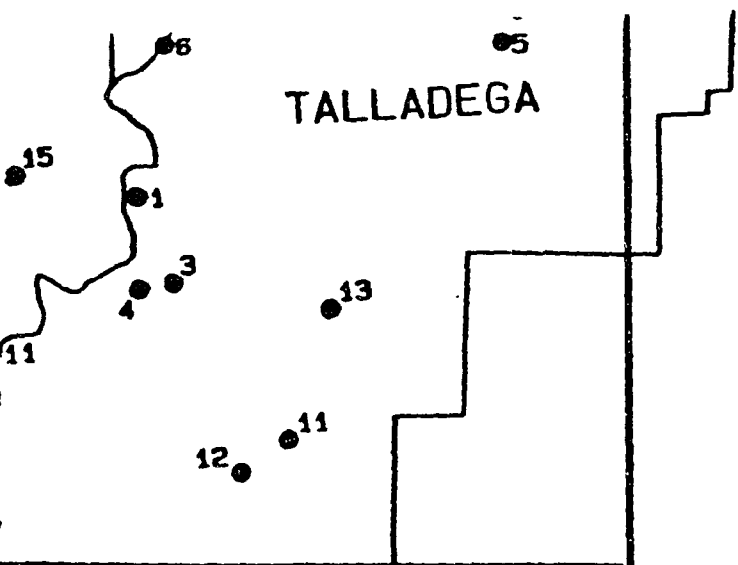
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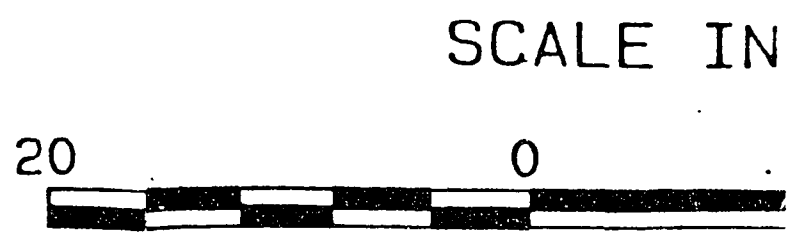
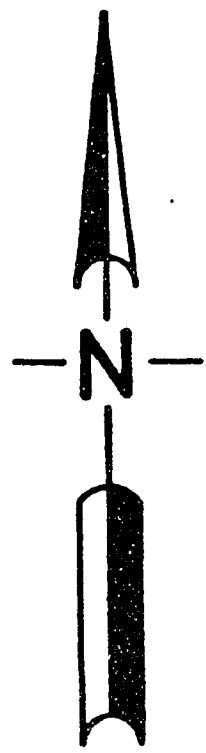
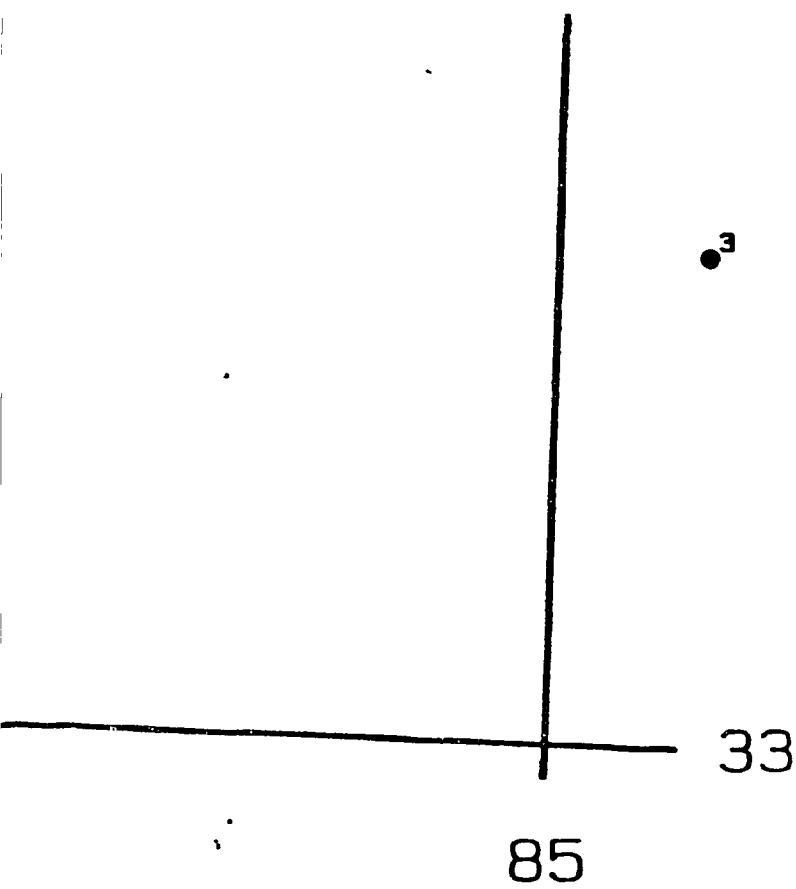
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LOCATION OF SINK
NUMBERS CORRESPON
TABLES 2 AND 3



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P.E. LAMORE

EXPLANATION

OF SINKHOLE SITE AND NUMBER.
CORRESPOND WITH THOSE IN
2 AND 3

SCALE IN MILES

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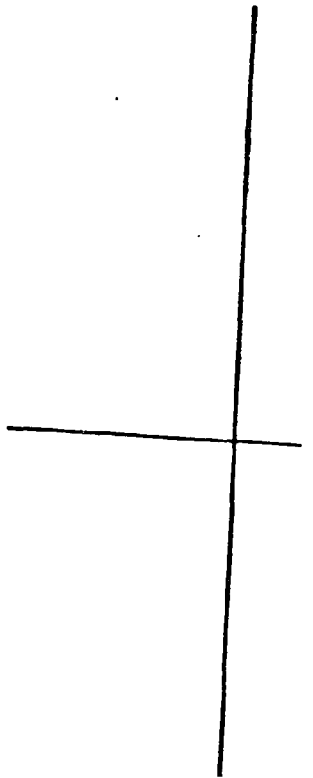
PLATE

BASE MAP SOURCE:

1. TENNESSEE :: USGS, 1: 500, 000

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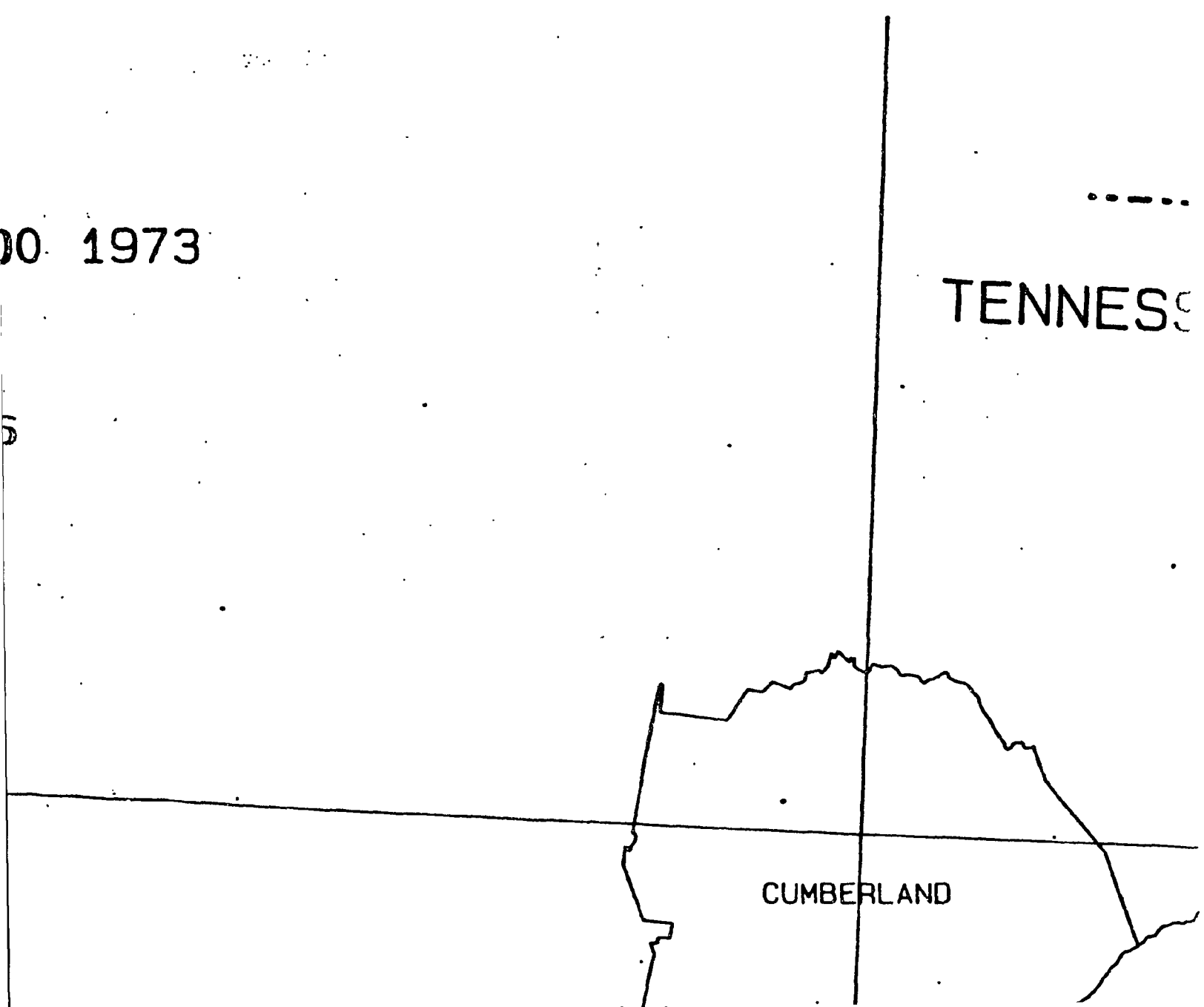
E 3. SINKHOLE OCCURRENC

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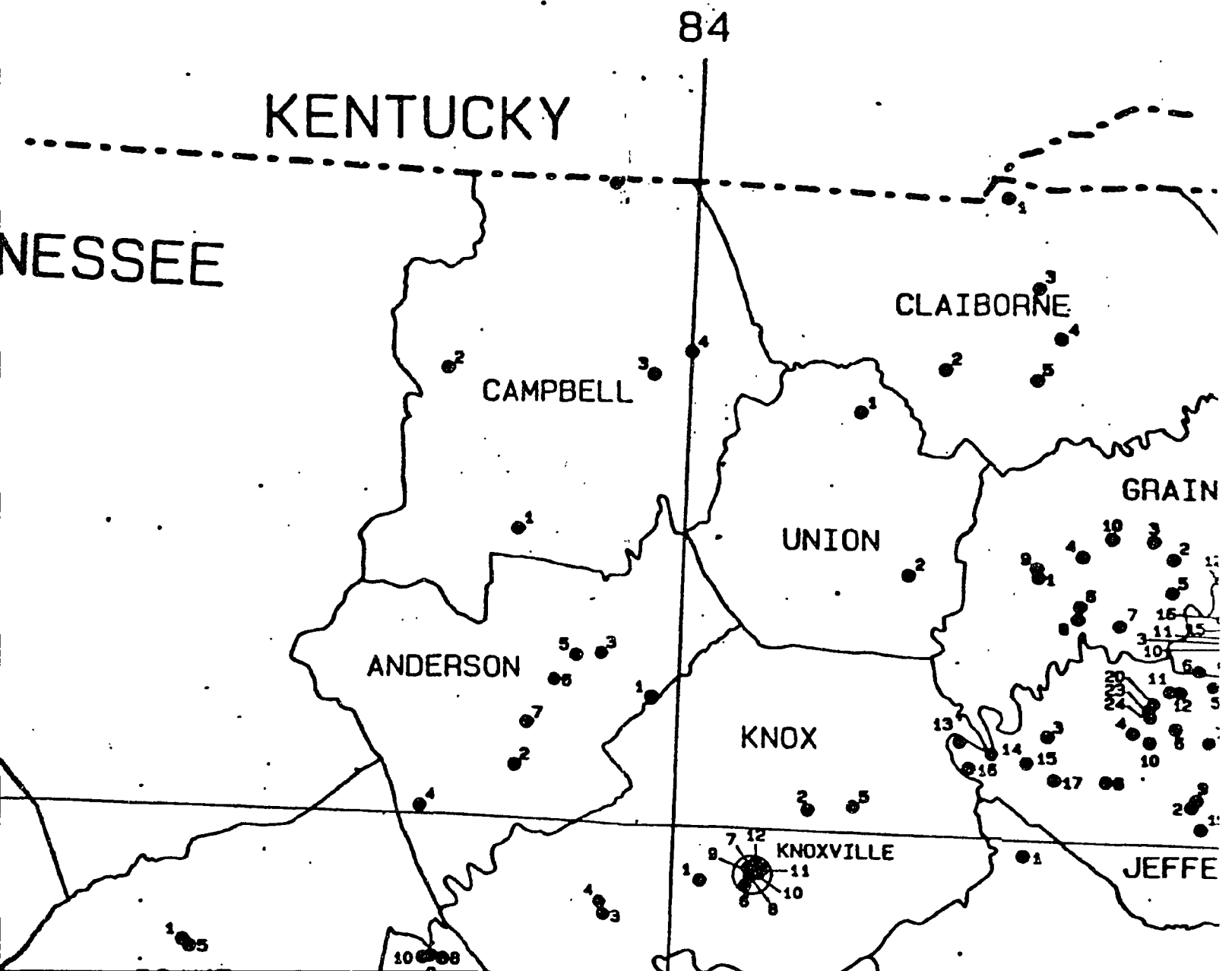
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TENNESSE

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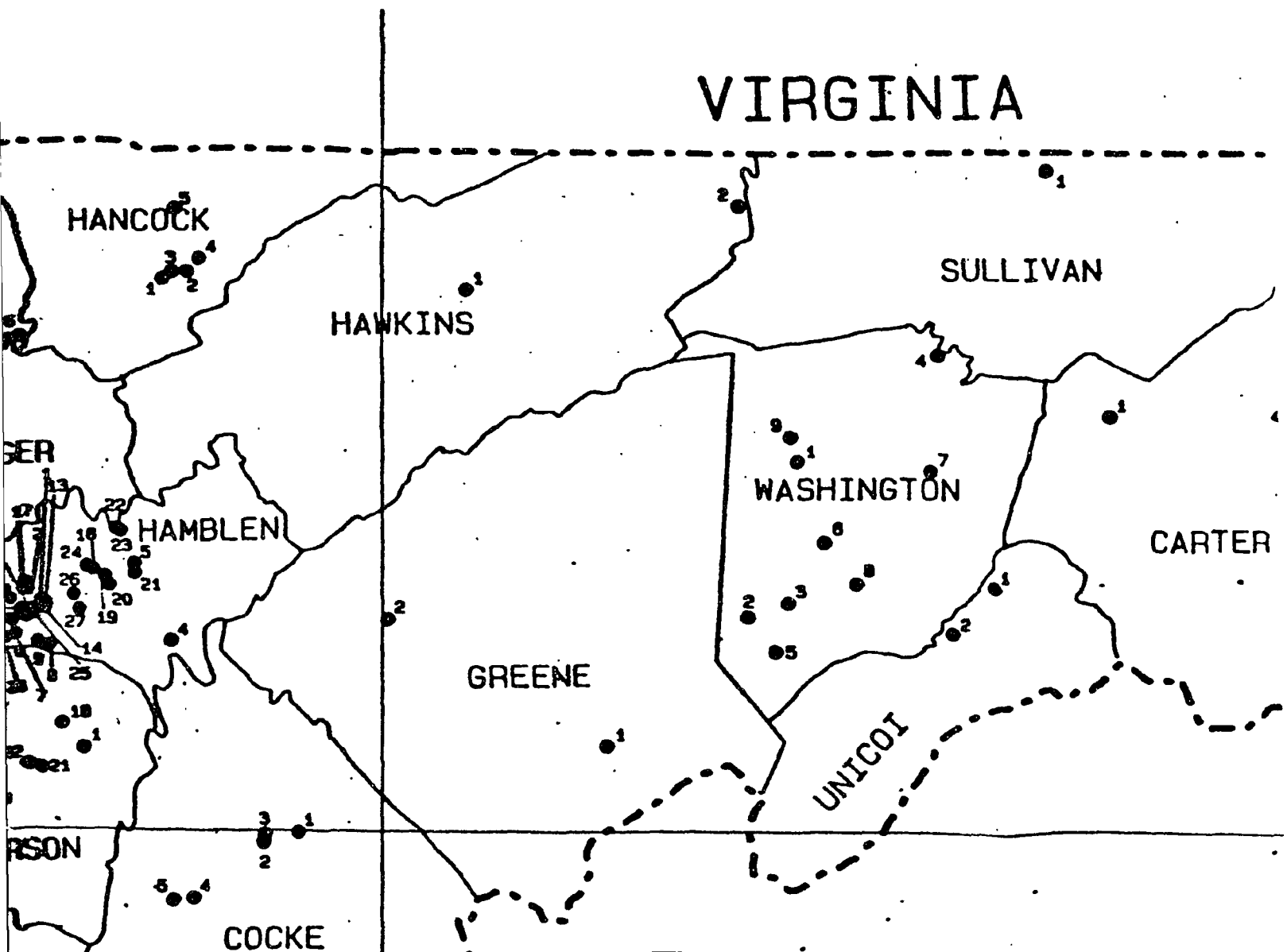
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EDGE PROVINCE IN TENNESSE

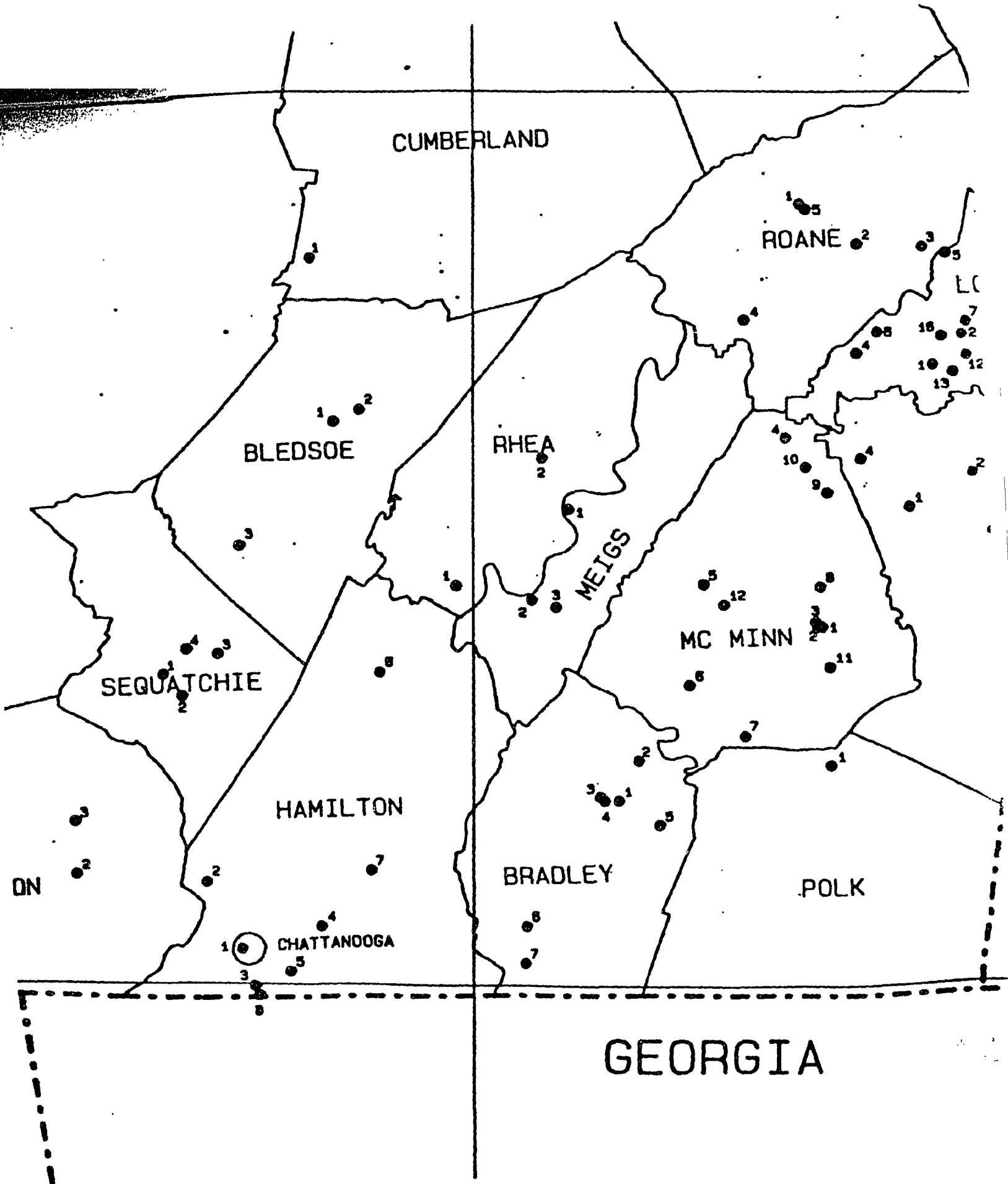
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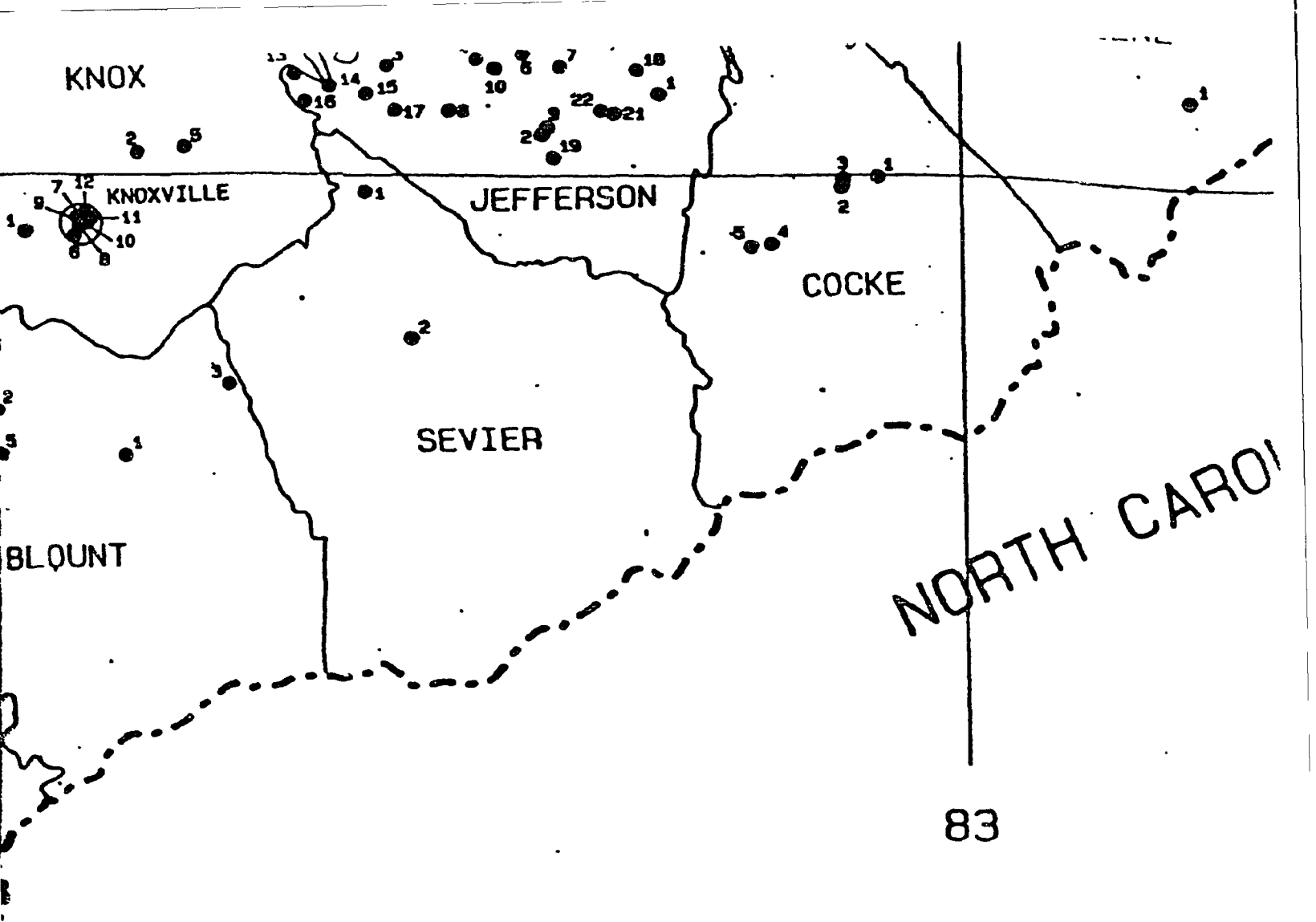
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ALABAMA





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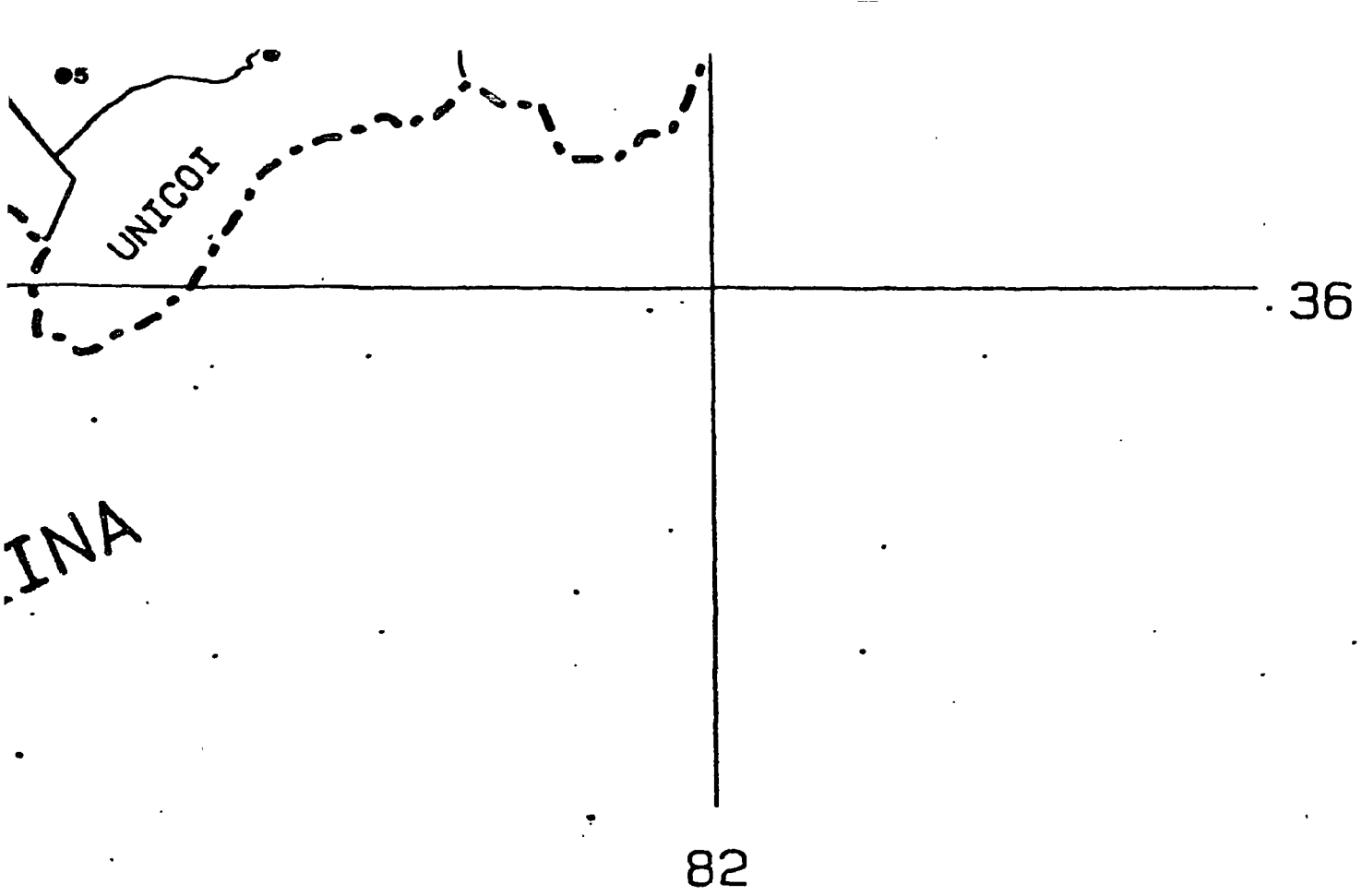
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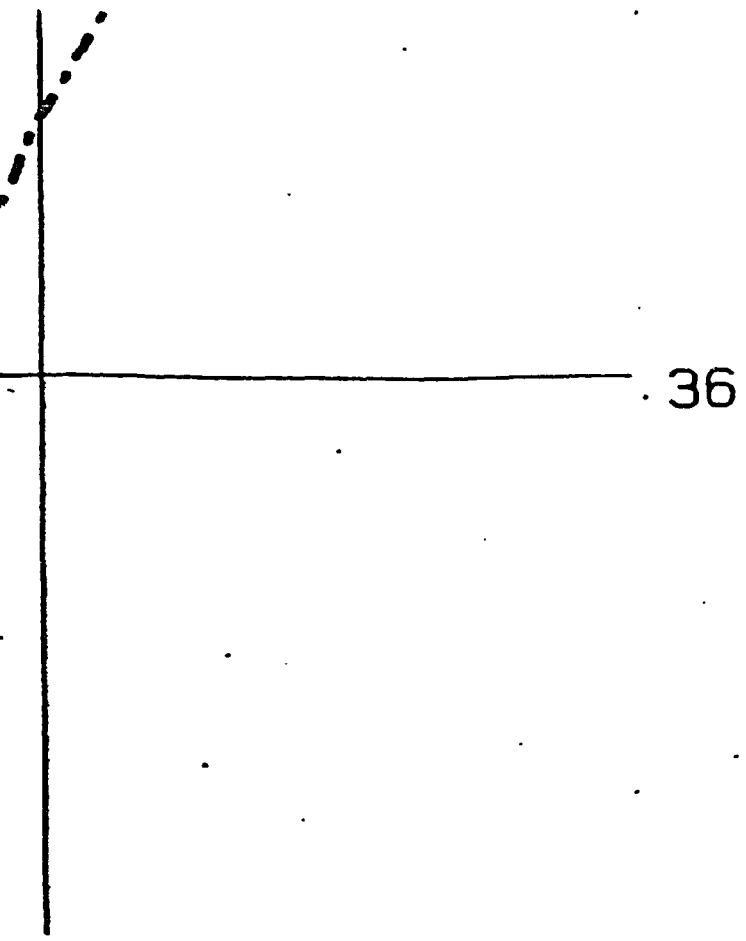
2



EXPLANATION

LOCATION OF SINKHOLE SITE AND NUMBER
CORRESPOND WITH THOSE IN TAB

SCALE IN MILES



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TION

E SITE AND NUMBER
WITH THOSE IN TABLE 4

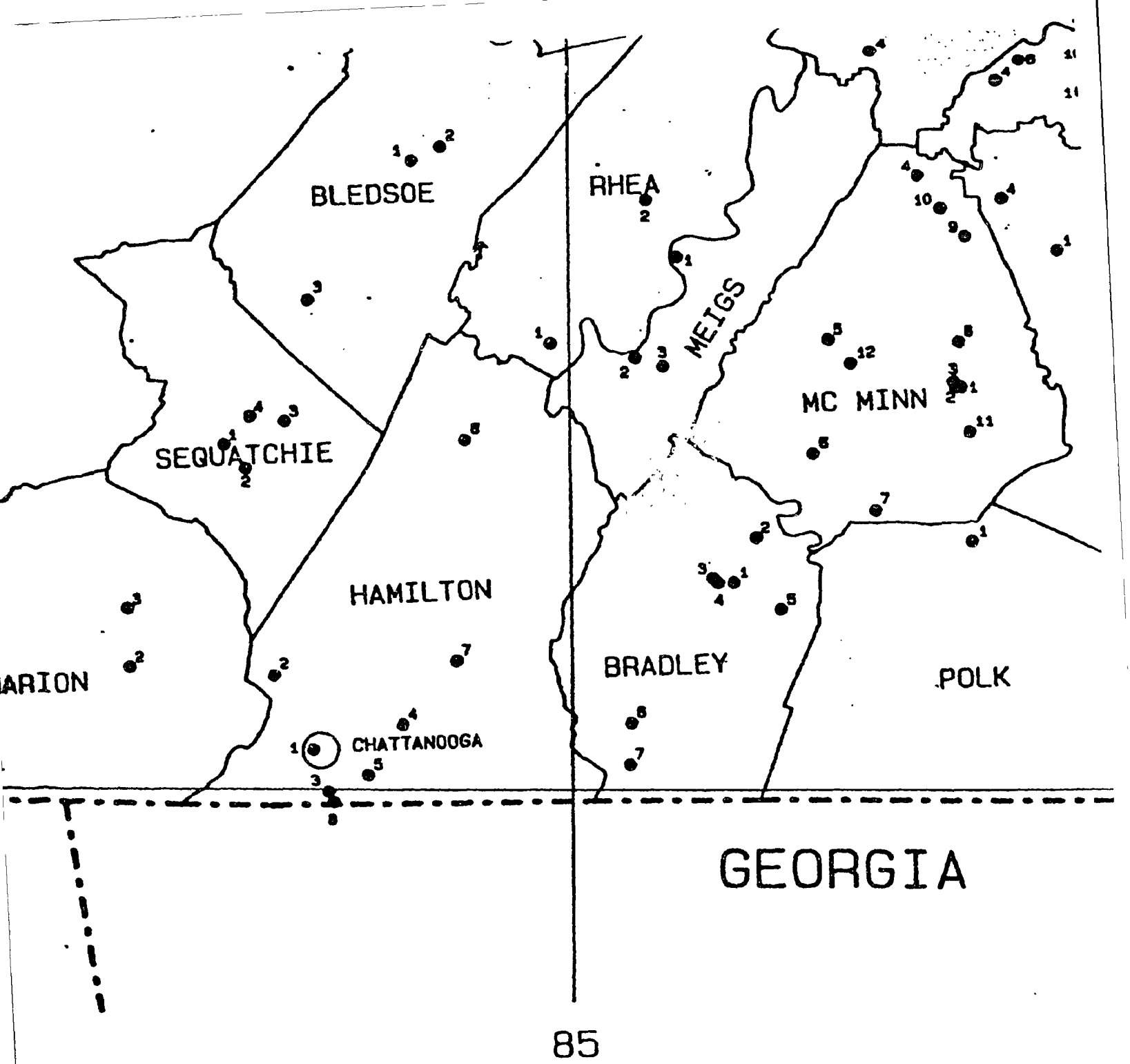
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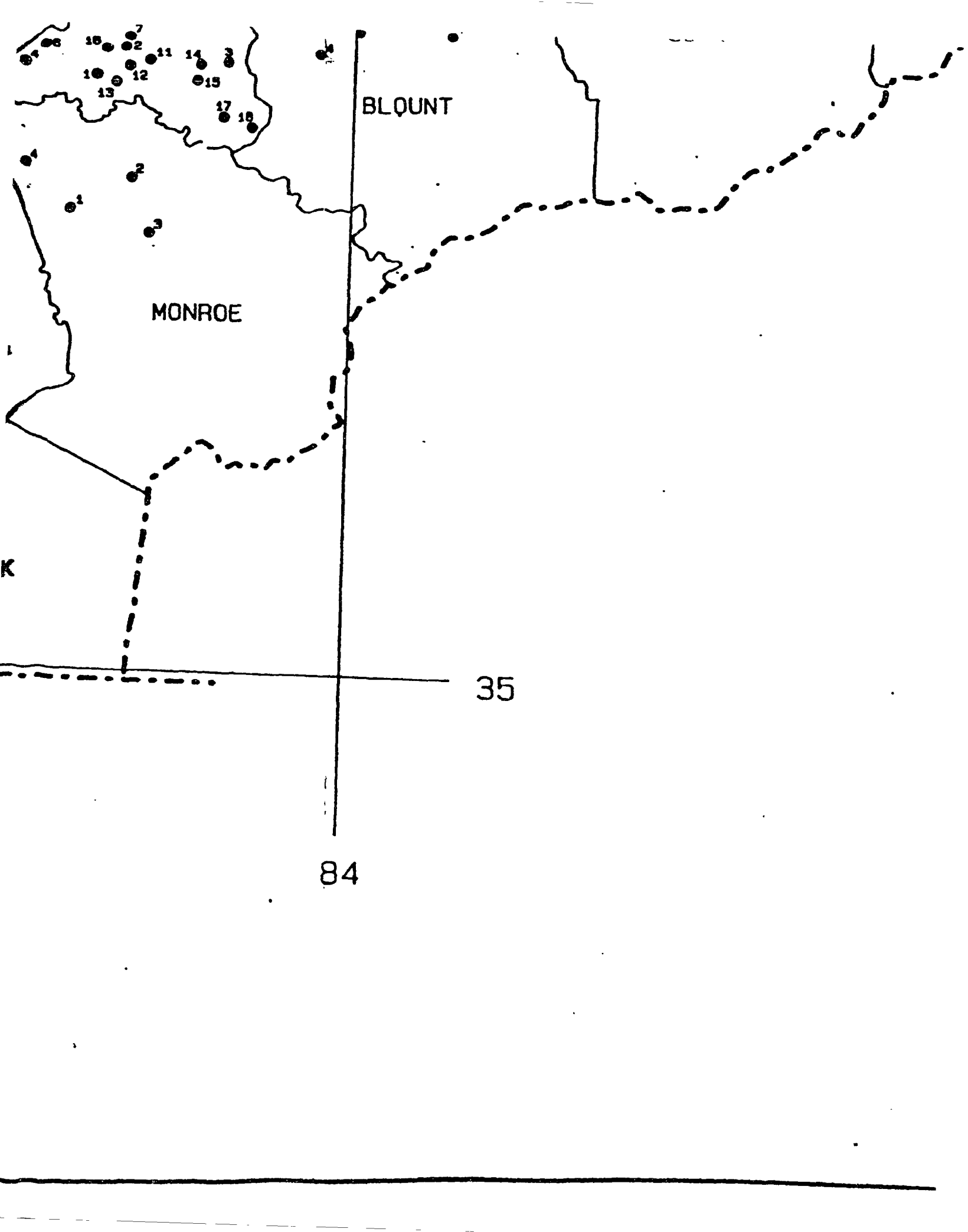
TENNESSEE

ALABAMA

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BLOUNT

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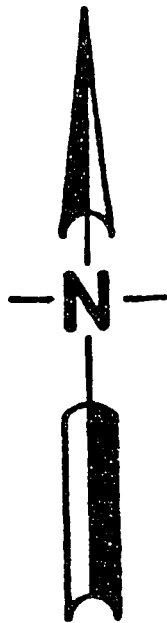
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EXPLANAT

LOCATION OF SINKHOLE
NUMBERS CORRESPOND



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SCALE

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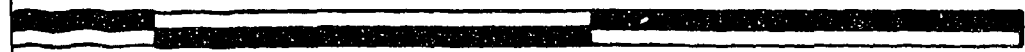
LE SITE AND NUMBER
WITH THOSE IN TABLE 4

LE IN MILES

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