

RECONNAISSANCE OF SURFICIAL GEOLOGY, REGOLITH THICKNESS,
AND CONFIGURATION OF THE BEDROCK SURFACE IN BEAR CREEK
AND UNION VALLEYS, NEAR OAK RIDGE, TENNESSEE

Anne B. Hoos and Zelda Chapman Bailey

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 86-4165

Prepared in cooperation with the
U.S. DEPARTMENT OF ENERGY



Nashville, Tennessee

1986

UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
A-413 Federal Building
U.S. Courthouse
Nashville, Tennessee 37203

Copies of this report can be
purchased from:

Books and Open-File Reports
U.S. Geological Survey
Box 25425, Federal Center, Bldg. 41
Denver, Colorado 80225

CONTENTS

Abstract	1
Introduction	1
Purpose and scope	1
Previous studies	3
Geologic setting of the study area	3
Surficial geology	4
Thickness of regolith	7
Configuration of the bedrock surface	8
Summary and conclusions	8
References cited	9

PLATE

- Plate 1. Maps showing generalized surficial geology, thickness of regolith, and configuration of the bedrock surface in Bear Creek and Union Valleys, near Oak Ridge, Tennessee **in pocket**

ILLUSTRATIONS

- Figure 1. Map showing location of study area, trace of geologic sections, and sites of previous investigations **2**
2. Generalized geologic sections through Bear Creek Valley **6**

TABLES

- Table 1. Summary of reported geologic data **3**
2. Stratigraphic thicknesses of units in the Conasauga Group in Bear Creek Valley and Melton Valley **5**

RECONNAISSANCE OF SURFICIAL GEOLOGY, REGOLITH THICKNESS, AND CONFIGURATION OF THE BEDROCK SURFACE IN BEAR CREEK AND UNION VALLEYS, NEAR OAK RIDGE, TENNESSEE

Anne B. Hoos and Zelda Chapman Bailey

ABSTRACT

A preliminary interpretation of the lithology, thickness of regolith, and configuration of the bedrock surface underlying Bear Creek and Union Valleys near Oak Ridge, Tennessee, was made based on geologic and geophysical data from boreholes and cores in Bear Creek Valley and on the related work of other investigators. Analysis of drillers' logs and lithologic logs and comparison of these data with a topographic map indicated that topography and depth of weathering are interdependent and are ultimately controlled by lithology. Topographic patterns were, therefore, used to extend localized geologic data to a larger scale. Maps of the surficial geology, thickness of regolith, and configuration of the bedrock surface are presented.

INTRODUCTION

Field investigations and interpretive studies conducted in the Oak Ridge area, Tennessee, over the past several decades, including several local studies (fig. 1) related to the operations and waste-disposal sites of the Y-12 Plant, a nuclear production facility, have contributed to the geologic information for Bear Creek and Union Valleys. The majority of these studies were undertaken in response to needs for site-specific information; however, the studies did not attempt to generalize the information for an interpretation of the geology of Bear Creek and Union Valleys as a whole. There is a need for such information to support hydrologic and waste-disposal studies of the Oak Ridge Reservation.

Purpose and Scope

The objective of this study is to integrate data from local studies into a geologic interpretation of Bear Creek and Union Valleys (fig. 1). This report documents the methods used to extrapolate site-specific data on surficial geology, thickness of regolith, and configuration of the bedrock surface valley-wide, and presents the information on preliminary maps (plate 1). The information in this report provides a framework for an investigation of the regional ground-water flow system conducted by the U.S. Geological Survey in cooperation with the U.S. Department of Energy. Although the maps are generalized and may not be accurate locally, they represent a first approximation of geologic conditions throughout Bear Creek and Union Valleys. Additional data collection is required to improve the mapping of the regolith near the major drains and to locate geologic contacts more exactly. The geologic interpretations will be refined as new data become available.

Physiographic provinces of Tennessee

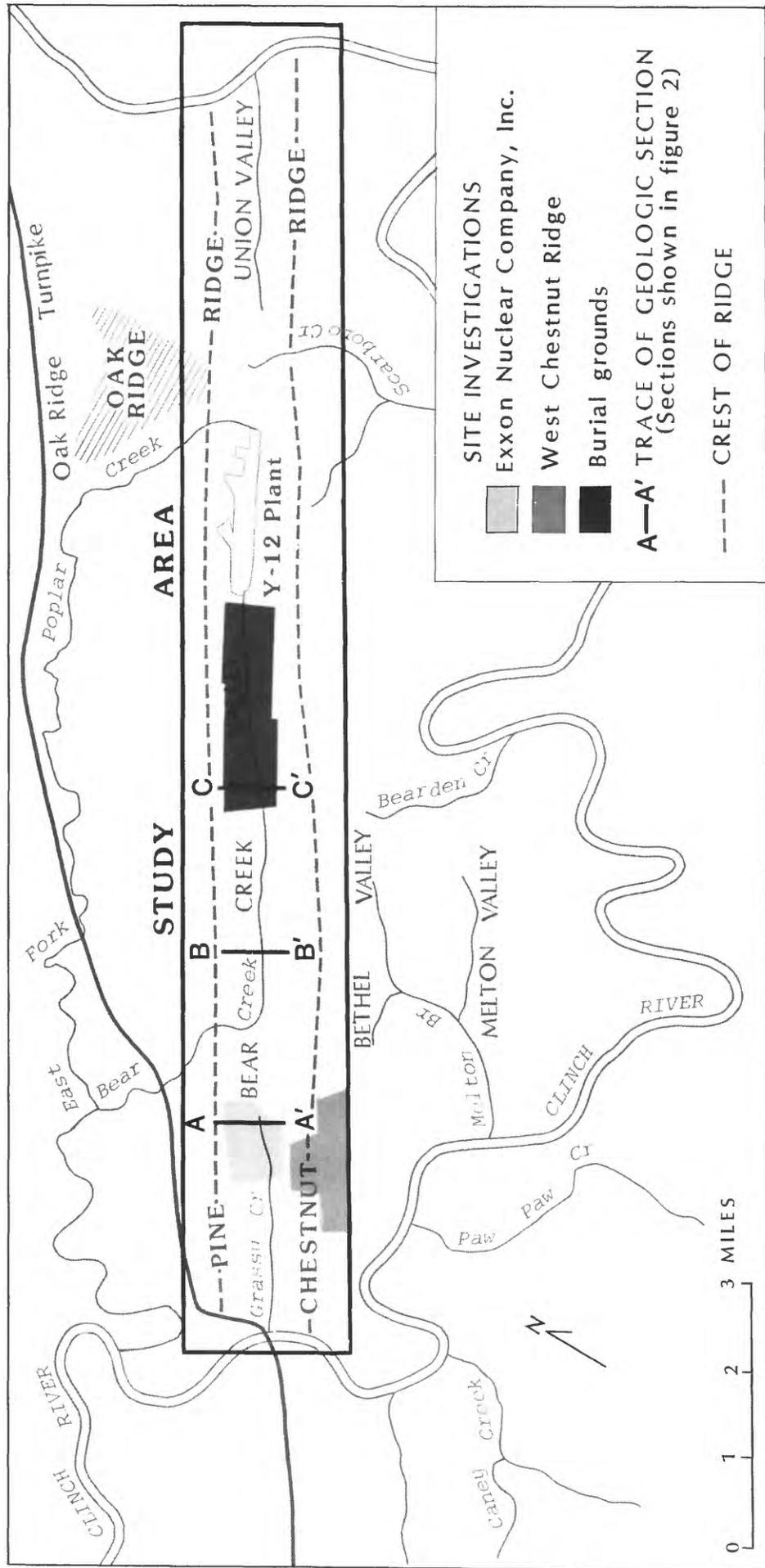


Figure 1.--Location of study area, trace of geologic sections, and sites of previous investigations.

Previous Studies

The geologic information assembled and referenced for this study is summarized in table 1. The study of the Conasauga Group in Melton Valley by Haase and others (1985) provided a detailed stratigraphic and structural analysis of the geologic units, information which is transferrable to the present study area because of the proximity of Melton Valley to Bear Creek and Union Valleys (fig. 1). A study conducted by the Exxon Nuclear Company, Inc. (1978, chaps. 1 and 3) contains a thorough geologic field investigation and characterization of a part of western Bear Creek Valley drained by Grassy Creek (fig. 1). The Exxon Nuclear Company report includes data from soil and rock borings, geophysical logging, and seismic lines, and maps showing lithologic units, which have been identified as the formal stratigraphic units within the Conasauga Group (C.S. Haase, Oak Ridge National Laboratory, written commun., 1984).

Table 1.--Summary of reported geologic data

Report type	Report	Contents
Data reports from field investigations in Bear Creek Valley.	Law Engineering and Testing Co., written commun., 1983; Bechtel National, Inc., 1984a, 1984b, 1984e; Rothschild and others, 1984; Woodward-Clyde Consultants, 1984a, 1984b.	Drillers and geophysical logs that identify the lithology and weathered conditions for core and boreholes, profiles from seismic lines, and lithologic cross sections.
Interpretive reports from field investigations in Bear Creek Valley.	McMaster, 1963; Exxon Nuclear Company, Inc., 1978, chap. 1,3; Law Engineering and Testing Co., written commun., 1983; Bechtel National, Inc., 1984a, 1984c; Geraghty & Miller, 1984; Ketelle and Huff, 1984.	Stratigraphic cross sections and maps of geologic units.
Interpretive reports in geologically related areas.	Rodgers, 1953; Swingle and Luther, 1964; Swingle, 1973; Haase and others, 1985.	Descriptions of stratigraphy, topographic expression, and weathering characteristics of the Conasauga Group.

GEOLOGIC SETTING OF THE STUDY AREA

The Oak Ridge Reservation, in which most of the study area is located, is situated in East Tennessee near the northwestern edge of the Valley and Ridge province, which is underlain by southeastward-dipping sedimentary rocks of Cambrian through Mississippian age. Most of the Reservation is underlain by Cambrian and Ordovician age rocks belonging, from oldest to youngest, to the Rome Formation, the Conasauga and Knox Groups,

and the Chickamauga Limestone. The dominant form of deformation in this structurally complex area is thin-skinned thrust faulting oriented parallel to regional strike (northeast to southwest) and dipping southeast (Swingle, 1973, p. 65). Faulting is responsible for the repeating sequences of stratigraphic units. Valley and ridge topography is controlled by lithology. The valleys, which have an average elevation of 800 feet above National Geodetic Vertical Datum of 1929¹, are underlain by weakly resistant shale and limestone of the Chickamauga Limestone (beneath Bethel Valley) and the Conasauga Group (beneath Bear Creek and Union Valleys). The ridges, rising 300 to 500 feet above the valley floors, are formed by the weather-resistant sandstone and shale of the Cambrian Rome Formation (beneath Pine Ridge) and the erosion-resistant chert-rich regolith of the Cambrian and Ordovician Knox Group (beneath Chestnut Ridge).

The Middle and Upper Cambrian Conasauga Group is characterized by interbedded carbonate and clastic rocks (Rodgers, 1953, p. 47). Within the study area, the group has been subdivided into six units (Rodgers, 1953, p. 47-50). From oldest to youngest these units are: Pumpkin Valley Shale, Rutledge Limestone, Rogersville Shale, Maryville Limestone, Nolichucky Shale, and Maynardville Limestone. Several of these units are characterized by considerable lithologic heterogeneity: the Rutledge and Maryville Limestones contain interbedded mudstone-rich intervals, and the Rogersville and Nolichucky Shales contain interbeds of limestone. Weathering of the Conasauga Group in Bear Creek and Union Valleys has produced a layer of regolith which is variable in thickness due to variations in bedrock lithology, topographic relief, removal by natural erosion, and human activities. A thick layer of regolith is usually developed on the ridges and knobs, and a thin layer on the valley floor. The regolith contains a large percentage of rock fragments and relict structures. At the top there is a thin layer of loose, unconsolidated soil or (where present) fill. The transition with depth from regolith to unweathered bedrock is gradational.

The Knox Group occurs in the study area as predominantly massive siliceous dolomite. Four units, in ascending order, have been identified in the Knox Group underlying Chestnut Ridge (Ketelle and Huff, 1984): the Copper Ridge Dolomite of Cambrian age; and the Chepultepec Dolomite, Longview Formation (as used by the Tennessee Division of Geology, the unit designated lower part of Kingsport Dolomite by the U.S. Geological Survey), and Newala equivalent (the upper part of Kingsport Dolomite and overlying Mascot Dolomite), all of Ordovician age. Chemical weathering of the dolomitic bedrock is extensive and has formed a thick mantle of clay material and abundant chert nodules derived from the carbonate rocks. Regolith thickness varies considerably but generally is thickest at the higher elevations (Woodward-Clyde Consultants, 1984a).

SURFICIAL GEOLOGY

The lithologic similarities of the stratigraphic units in the Conasauga Group make identification of a particular unit difficult unless a sequence can be observed. The limited number of exposures of such sequences of the Conasauga Group in Bear Creek and Union Valleys makes field mapping of geologic contacts difficult. Consequently, the location of

¹National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level."

surficial contacts of stratigraphic units in the study area was approximated best by extrapolation of subsurface contacts identified in rock cores. A set of about 170 data points (pl. 1A) representing drillholes from which lithologic information could be extracted is distributed in three clusters along the valley (fig. 1), with one cluster in the western part of the valley (Exxon Nuclear Company Inc., 1978), another cluster along west Chestnut Ridge (Ketelle and Huff, 1984; Woodward-Clyde Consultants, 1984a, 1984b), and a large cluster in the east-central part of the valley coinciding with the burial grounds of the Y-12 plant (Law Engineering and Testing Co., written commun., 1983; Bechtel National, Inc., 1984a, 1984b, 1984c, 1984d, 1984e; Geraghty & Miller, 1984; Rothschild and others, 1984). In addition, three coreholes in the central part of the study area provide a continuous, cross-valley section (C.S. Haase, Oak Ridge National Laboratory, oral commun., 1985; pl. 1A).

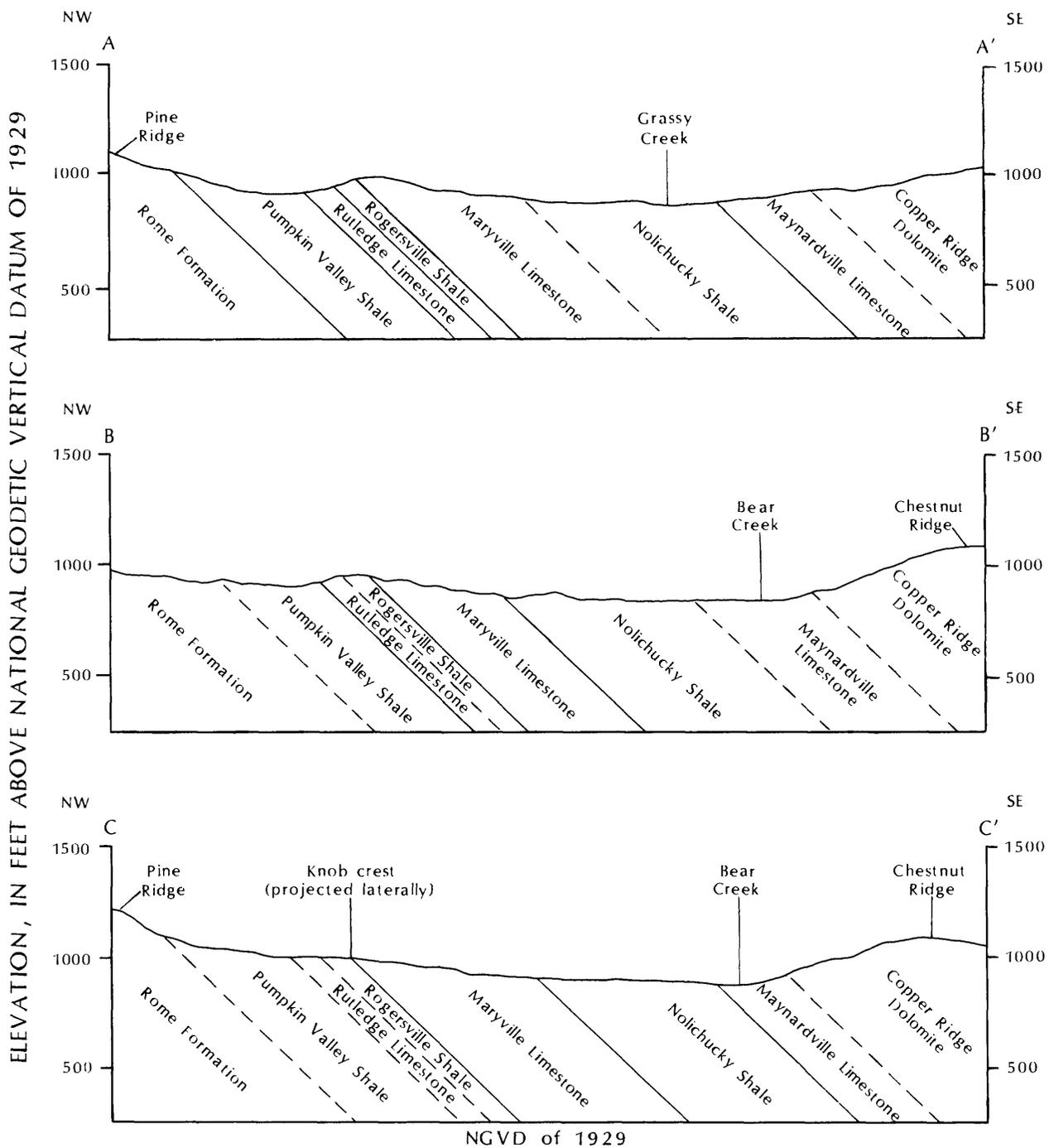
Stratigraphic information from these data sets was organized into three cross-valley, cross-strike stratigraphic sections (fig. 2). Although dip varies locally from 30 to 70°, (Swingle and Luther, 1964; Exxon Nuclear Company, Inc. 1978, p. 3.6-45; Bechtel National, Inc., 1984a, 1984c; Ketelle and Huff, 1984, p. 17; Rothschild and others, 1984, p. 24) a uniform dip of 43°, which is an average of dip measurements throughout the study area, was used in the sections. Geologic contacts that could be identified in lithologic logs of coreholes on the section lines are indicated with solid lines, and contacts inferred from logs of coreholes off the section line are indicated with dashed lines. Stratigraphic thicknesses of the units were inferred from each cross section and compared and averaged among the three sections. The resulting average stratigraphic thicknesses compare closely with data from Melton Valley (table 2) and were used to construct the geologic map (pl. 1A).

Table 2.--Stratigraphic thicknesses of units in the Conasauga Group in Bear Creek Valley and Melton Valley

[Bear Creek Valley units, averaged from three cross sections; Melton Valley units, from Haase and others, 1985, table 2]

Stratigraphic unit	Average thickness, in feet	
	Bear Creek Valley	Melton Valley
Maynardville Limestone	250	324
Nolichucky Shale	600	551
Maryville Limestone	440	463
Rogersville Shale	100	130
Rutledge Limestone	100	101
Pumpkin Valley Shale	310	309

Topographic settings of the geologic contacts were compared between sections in an attempt to identify a consistent topographic expression for one or more contacts. The most distinctive and persistent occurrence of such expression is the exposure of the Rogersville Shale-Maryville Limestone contact at or near the crest of a line of small knobs



EXPLANATION

——— GEOLOGIC CONTACT—
 Dashed where inferred

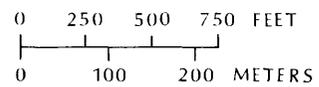


Figure 2.--Generalized geologic sections through Bear Creek Valley (Section traces shown on figure 1; formation descriptions shown on plate 1).

near the northwest edge of the valley (pl. 1A). This observation is corroborated by work on the Conasauga Group in Melton Valley, where the section is repeated because of thrust faulting. The basal beds of the Maryville Limestone and the upper limestone member of the Rogersville Shale, which occurs near the formation's top, are relatively resistant to erosion in both Melton Valley and the study area. The contact has been extrapolated laterally from the cross sections using this topographic feature throughout Bear Creek and Union Valleys. Because natural topographic surfaces no longer exist in the Y-12 Plant area due to grading, the Rogersville Shale-Maryville Limestone contact was traced from a map drawn by Law Engineering and Testing Co. (written communication, 1983).

The remaining contacts, Rome Formation-Pumpkin Valley Shale, Pumpkin Valley Shale-Rutledge Limestone, Maryville Limestone-Nolichucky Shale, and Nolichucky Shale-Maynardville Limestone, were located by measuring and marking horizontal distances based on stratigraphic thicknesses (averaged between the three sections) between the reference contact (Rogersville Shale-Maryville Limestone) and each individual contact. The contact between the Rutledge Limestone and Rogersville Shale was not mapped in this study.

The Maynardville Limestone-Copper Ridge Dolomite contact was located on the basis of interpretations of McMaster (1963), Swingle and Luther (1964), Exxon Nuclear Company, Inc. (1978), and Ketelle and Huff (1984). Contacts between units of the Knox Group (Copper Ridge Dolomite, Chepultepec Dolomite, Longview Formation, and Newala equivalent) were adopted and extended (using topographic expression) from the study of west Chestnut Ridge by Ketelle and Huff (1984) and from the Clinton quadrangle (Swingle and Luther, 1964).

The resulting surficial-geology map (pl. 1A) corresponds well to the local interpretations in Bear Creek Valley by Exxon Nuclear Company, Inc. (1978) and Law Engineering and Testing Co. (written commun., 1983).

THICKNESS OF REGOLITH

A map of data points of depth to top of unweathered bedrock was superposed on a map of surficial geology and topography to determine thickness of regolith. A banded pattern of regolith thickness, parallel to strike, was observed that could be closely correlated with lithology and topography. The range of thickness values within each band was studied for trends. Data points within each band could be segregated into two groups: those in valleys of primary tributaries and those points that are on knobs or in interstream areas. Because interstream areas represent a larger part of the total surface area, it was assumed that data points in such areas would be more indicative of regional weathering characteristics.

On the basis of average thicknesses for interstream areas, a general pattern of regolith thickness was constructed (pl. 1B). Known outcrops of unweathered bedrock (where the regolith is absent) are not mapped at this scale because of their small areal extent. Adjustments to the generalized pattern have been made as follows:

- (1) Because of grading at the Y-12 Plant site prior to construction, the mapping of regolith thickness near the facility differs considerably from the generalized pattern. Regolith was cut away along the northwest side of the valley and the southeast side was filled with regolith and rubble to form a flat, uniform

surface for the plant construction. Therefore, the map represents fill thickness rather than regolith thickness in the plant area.

(2) The closing of thickness bands along strike indicates thinning of the regolith in proximity to major streams. The validity of this adjustment in the generalized pattern is confirmed by drilling data near the Clinch River and East Fork Poplar Creek and by bedrock outcrops that have been observed at several locations along Bear Creek, Grassy Creek, and East Fork Poplar Creek.

In order to confirm the validity of the generalized method of mapping regolith thickness, the map was checked against the original data points. All the data points were used in devising the method of mapping, but because of the small scale of areal variability of regolith thickness, some data points were not matched. The data matched mapped thickness bands for 73 percent of the control points. The range of deviation for the remaining (27 percent) points was 1 to 20 feet, with an average deviation of 8 feet. The high percentage of matches between data and the generalized map is an indication that the method devised was a reasonable one, and that the method is useful for mapping areas lacking data.

CONFIGURATION OF THE BEDROCK SURFACE

The elevation of the surface of unweathered bedrock at a point is determined by the difference between the ground-surface elevation and the thickness of regolith. In order to simplify the determination of trends of bedrock elevation, the topographic map was generalized before it was applied to the regolith thickness map. This simplified topographic map was constructed through analysis and abstraction of two major controls on valley-wide topographic patterns. Controls on topography are (1) lithologic variation across strike that results in variations in weathering and erosion, which generates variations in elevation along dip, and (2) major drains, which generate variations in elevation along strike. The generalized regolith thickness map was superposed on the generalized topographic map; the difference between ground-surface elevation and regolith thickness was used to construct a third map, configuration of the bedrock surface (pl. 1C). Resulting contours were checked against known bedrock elevations in areas of previous site investigations (fig. 1); in general, little adjustment was necessary. Drilling data matched mapped contours for 78 percent of the control points. The range of deviation for the remaining points was 1 to 35 feet, with an average deviation of 10 feet.

SUMMARY AND CONCLUSIONS

Generalized maps of surficial geology, thickness of regolith, and configuration of the bedrock surface in Bear Creek and Union Valleys near Oak Ridge, Tennessee, were constructed based on an extrapolation of site-specific data from previous investigations. This extrapolation of information was based on the determination of trends in lithology, topography, and weathering characteristics. The maps may not be accurate locally; some averaging of data was required to establish patterns in areas where no data were available. The maps were constructed for use in an investigation to define the ground-water flow system and to indicate areas for which additional field data are needed.

REFERENCES CITED

- Bechtel National, Inc., 1984a, Interim report on Bear Creek Valley Oil Landfarm geology and hydrogeology: Oak Ridge, Tennessee, U.S. Department of Energy, Oak Ridge Y-12 Plant, Y/SUB/84-47974C/1.
- _____ 1984b, Geologic and hydrogeologic data for Bear Creek Valley Burial Grounds A and B: Oak Ridge, Tennessee, U.S. Department of Energy, Oak Ridge Y-12 Plant, Y/SUB/84-47974C/2.
- _____ 1984c, The geology and hydrogeology of Bear Creek Valley Waste Disposal Areas A and B: Oak Ridge, Tennessee, U.S. Department of Energy, Oak Ridge Y-12 Plant, Y/SUB/84-47974C/3.
- _____ 1984d, Interim report on the geology and hydrogeology of the southern and western perimeter to the burial grounds and the interior portions of Bear Creek Valley Waste Disposal Areas: Environmental field studies: Oak Ridge, Tennessee, U.S. Department of Energy, Oak Ridge Y-12 Plant, Y/SUB/84-47974C/4.
- _____ 1984e, Geologic data on twenty monitoring wells installed in Bear Creek Valley in September and October 1984: Oak Ridge, Tennessee, U.S. Department of Energy, Oak Ridge Y-12 Plant, Y/SUB/84-47974C/12, 100 p.
- Exxon Nuclear Company, Inc., 1978, Nuclear fuel recovery and recycling center: Preliminary safety analysis report: Exxon Nuclear Company, Inc., Docket 50-564, Chapters 1-3.
- Geraghty & Miller, 1984, Background material for March 23, 1984, workshop on assessment of contamination at the Y-12 Plant Bear Creek Valley Waste Disposal Area, Oak Ridge Y-12 Plant: Oak Ridge, Tennessee, U.S. Department of Energy, Oak Ridge Y-12 Plant, Y/SUB/84-00206C/1.
- Haase, C.S., Walls, E.C., and Farmer, C.D., 1985, Stratigraphic and structural data for the Conasauga Group and the Rome Formation on the Copper Creek Fault Block near Oak Ridge, Tennessee: Preliminary results from test borehole ORNL-JOY #2: Oak Ridge, Tennessee, U.S. Department of Energy, Oak Ridge National Laboratory, Environmental Sciences Division Publication no. 2392, ORNL/TM-9159, 88 p.
- Ketelle, R.H., and Huff, D.D., 1984, Site characterization of the West Chestnut Ridge site: Oak Ridge, Tennessee, Oak Ridge National Laboratory, Environmental Sciences Division, ORNL/TM-9229, 137 p.
- McMaster, W.M., 1963, Geologic map of the Oak Ridge Reservation, Tennessee: Oak Ridge, Tennessee, U.S. Atomic Energy Commission, Oak Ridge National Laboratory, ORNL/TM-713, 23 p.
- Rodgers, John, compiler, 1953, Geologic map of East Tennessee with explanatory text: Tennessee Division of Geology Bulletin 58, Part II, 168 p.
- Rothschild, E.R., Turner, R.R., Stow, S.H., Bogle, M.A., Hyder, L.K., Sealand, O.M., and Wyrick, H.J., 1984, Investigation of subsurface mercury at the Oak Ridge Y-12 Plant: U.S. Department of Energy, Oak Ridge National Laboratory, Environmental Sciences Division Publication no. 2399, ORNL/TM-9092, 258 p.
- Swingle, G.D., 1973, Structural geology of Knox County, Tennessee, in *Geology of Knox County, Tennessee*: Tennessee Division of Geology Bulletin 70, p. 63-73.
- Swingle, G.D., and Luther, E.T., 1964, Geologic map and mineral resources summary of the Clinton Quadrangle, Tennessee: Tennessee Division of Geology, 12 p., 2 pl.
- Woodward-Clyde Consultants, 1984a, Subsurface characterization and geohydrologic site evaluation, West Chestnut Ridge site: Oak Ridge, Tennessee, U.S. Department of Energy, Oak Ridge National Laboratory, ORNL/SUB/83-64764/1&V1.
- _____ 1984b, Appendices--Subsurface characterization and geohydrologic site evaluation, West Chestnut Ridge site: Oak Ridge, Tennessee, U.S. Department of Energy, Oak Ridge National Laboratory, ORNL/SUB/83-64764/1&V2.