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To the Graduate Council:

I am submitting herewith a dissertation written by Robert Dean Hatcher, Jr., entitled "Structure of the Northern Portion of the Dumplin Valley Fault Zone in East Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Geology.

George D. Swingle
Major Professor

We have read this dissertation
and recommend its acceptance:

Geo. K. Schweitzer

W. C. Kopp

R. F. Lanyon

Accepted for the Council:

Hilton A. Smith
Dean of the Graduate School

STRUCTURE OF THE NORTHERN PORTION OF THE
DUMPLIN VALLEY FAULT ZONE
IN EAST TENNESSEE

A Dissertation
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

by
Robert Dean Hatcher, Jr.

December 1965

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CHAPTER I

INTRODUCTION

At least ten major thrust faults are present in the Valley and Ridge Province of East Tennessee. This study examines a portion of one of these fault systems. The linear extent of the Dumplin Valley system (Figure 1) is not as great as most of the others, but the fault zone is characterized by several unique features. Among these are: (1) it is the easternmost fault in the Valley and Ridge of East Tennessee; (2) the system has a narrow imbricate zone; (3) the Conasauga Group and Rome Formation are the principal units involved in the structure; and (4) the fault system occurs in a portion of the Valley and Ridge dominated by folding.

Portions of the Dumplin Valley zone have been mapped by others for various purposes; however, it has not been studied as a single structural element. This work attempts to synthesize all previous work in order to determine if this fault is like others in the Valley and Ridge, to determine the surface relationships of the rock units involved, and to consider the mechanics of deformation.

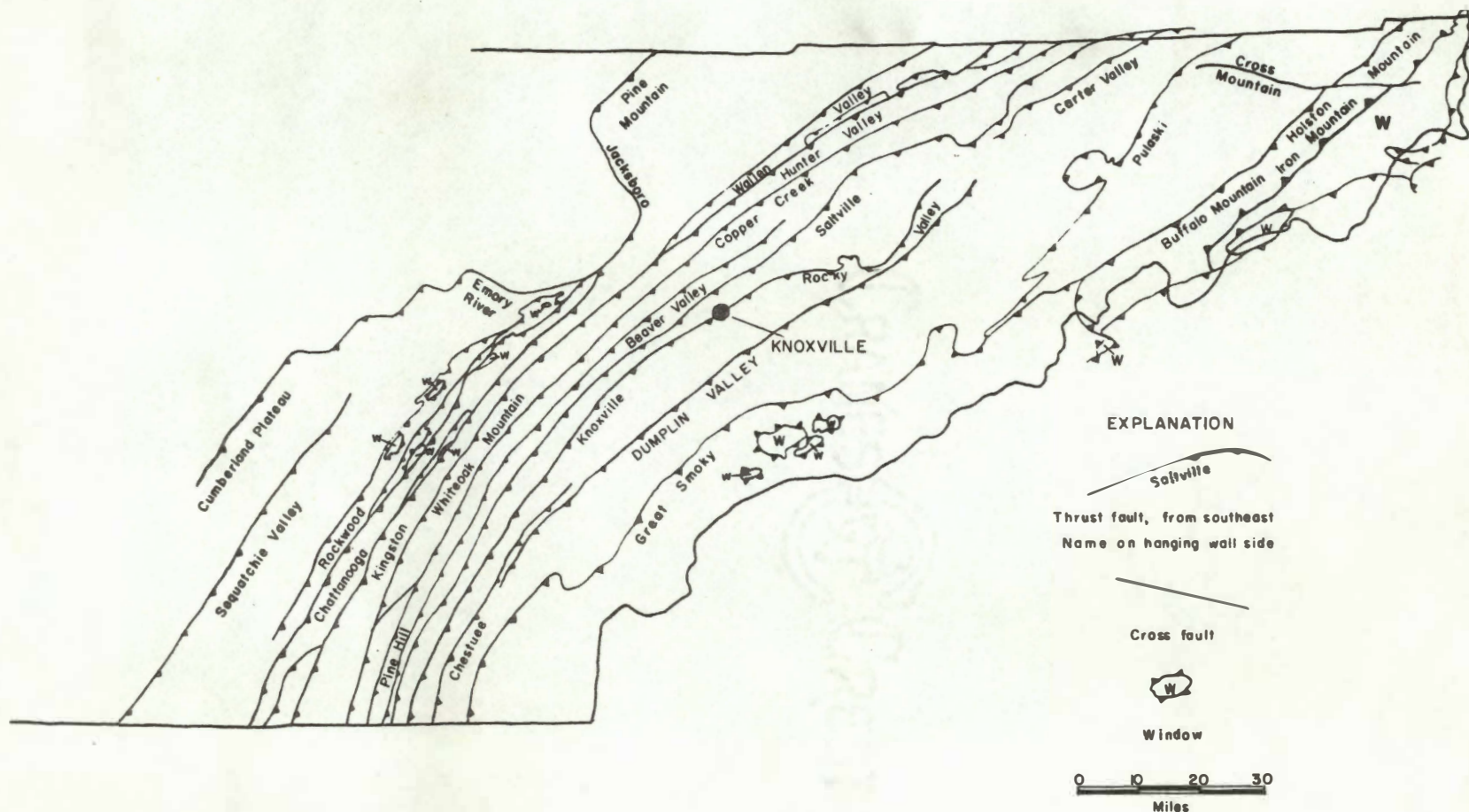


Figure 1. Major faults of East Tennessee.

In order to accomplish these objectives 52 miles of the fault have been studied and mapped in detail. The extent of the Dumplin Valley fault zone is from Morristown to Etowah, a distance of some 90 miles, and its width is from one and one-half to two and one-half miles (Figure 2). Emphasis in this study has been placed upon the northern and most complex portion of the fault system. Southwest of Maryville the fault becomes diminished in throw and deformation is much less intense.

Purpose of Investigation

The purpose of this investigation is to study, synthesize, and interpret the structure of the Dumplin Valley family of faults and associated folds. The ultimate objective of the investigation is to present a clear, concise hypothesis for the origin of the structure. Finally, the writer has tried to relate the fault to other structures in East Tennessee, and to determine if the interpretation as formulated fits the regional tectonic picture.

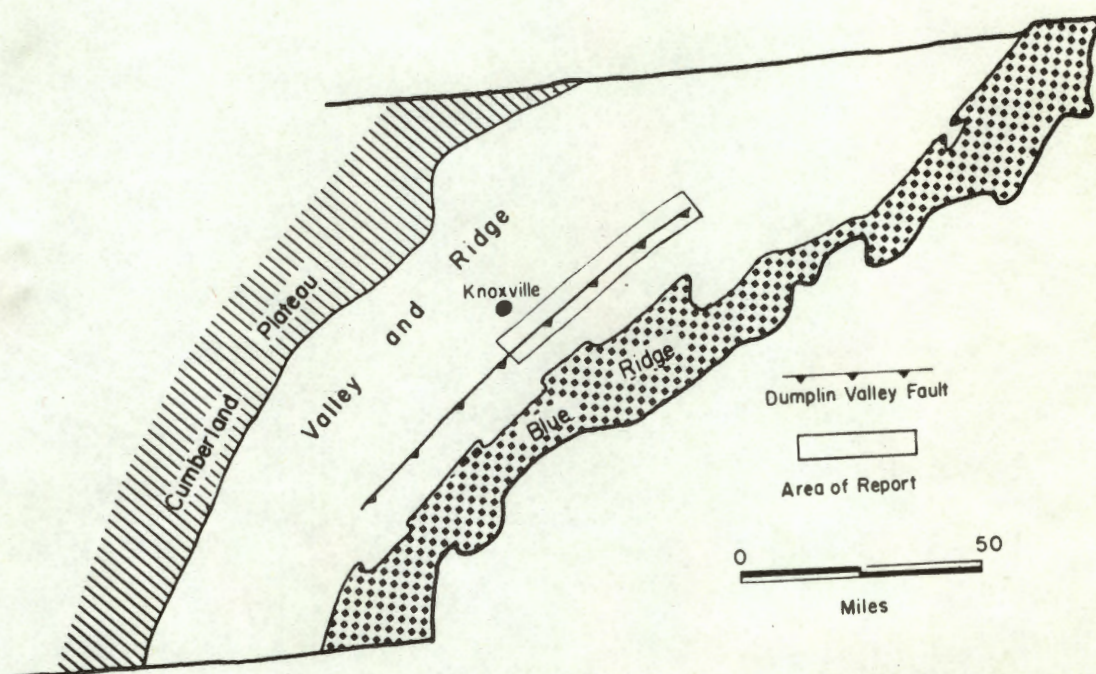


Figure 2. Location and extent of the Dumplin Valley fault zone.

Previous Investigations

There have been in times past several investigations which in part have dealt with the rocks of the Dumplin Valley system. Most of these studies have been of a reconnaissance nature and only a few have been concerned with details of the fault system.

In the 19th Century several regional geologic studies were made, some of which included the Dumplin Valley rocks. Troost (1841) recognized the Cambrian rocks in the area included in the present study. Safford (1869) mentioned the Cambrian shales and limestones of the Dumplin Creek area of Jefferson County.

Around the turn of the century, when the newly formed United States Geological Survey was making studies for its Geologic Atlas series, Keith (1895, 1896a, 1896b, 1901) recognized and mapped in part the complex faulting which occurs in the Dumplin Valley zone. His maps were more detailed than the earlier ones, showing for example the units of the Conasauga Group (except the Maynardville Limestone and Pumpkin Valley Shale).

After the work of Keith and other folio mappers, there was a relatively long interval until more work was

done on the faulting which occurs here. Bridge (1945) mapped to the edge of the fault zone in his study of the Mascot-Jefferson City Zinc District. He mentions the complexity of the structure in his 1956 report. Rodgers (1953), in a compilation map of East Tennessee, made a superficial interpretation of the structure and indicated its position in the regional tectonic framework. He also emphasized the need for further study of the system. Cattermole (1955) mapped the Shooks Gap Quadrangle which embraces a small segment of the fault.

Oder and Bumgarner (1961) report on one of the major stratigraphic units in the zone, but made no reference to the structure as such. In their study they measured and described sections of Maynardville Limestone in the Douglas Dam Quadrangle.

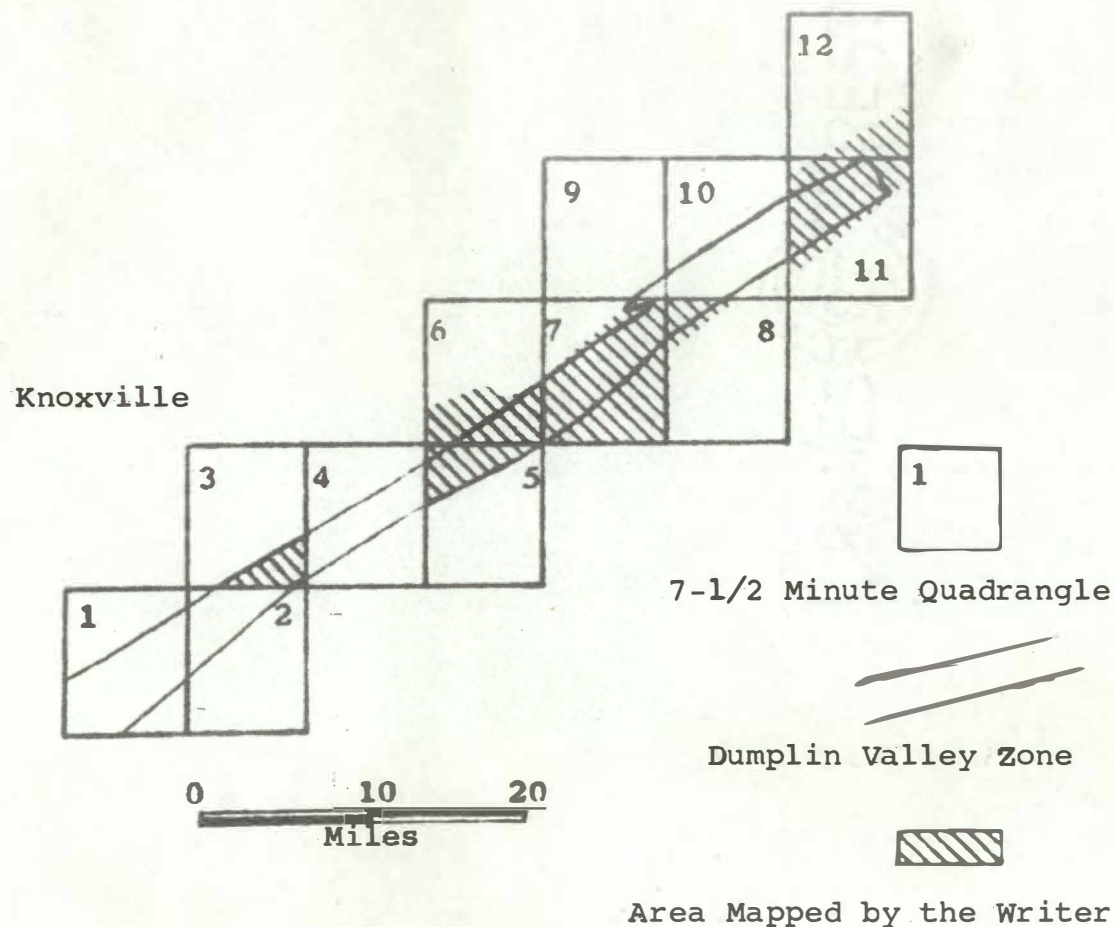
Neuman (1960) mapped the portion of the Dumplin Valley fault system in the Wildwood Quadrangle, but did not attempt an interpretation of the structure. Cattermole (1962) mapped the Maryville Quadrangle and indicated that the faulting terminates near the southwest border of the quadrangle.

Harper (1963) mapped the portion of the Dumplin Valley fault zone which occurs in the Boyds Creek Quadrangle and

made an interpretation of the structure here. B. C. Stewart (University of Tennessee graduate student) mapped in 1963 the portion of the zone in the Douglas Dam Quadrangle, but his interpretation of that segment of the structure is not available. Milici (1965) mapped the Morristown Quadrangle, which spans a portion of the fault zone. His interpretation of the zone is indicated in structure sections which accompany the map.

Present Investigation

The Dumplin Valley fault system has never before been studied in its entirety but portions have been mapped as previously indicated. This study is thus the first attempt at a structural synthesis and interpretation. In this work the writer studied and mapped portions of, or all of, seven of the twelve 7-1/2 minute quadrangles which span the zone. Other maps which embrace the structure include those published by the U. S. Geological Survey, Tennessee Division of Geology, an unpublished Master's thesis, and a thesis in progress at the University of Tennessee. Figure 3 indicates the several quadrangles and works involved along with their authors.



1. Maryville Quadrangle.
Mapped by J. M. Cattermole.
USGS GQ-163.
2. Wildwood Quadrangle. Mapped
by R.B. Neuman. USGS GQ-130.
3. Shooks Gap Quadrangle.
Mapped by J.M. Cattermole.
USGS GQ-76. Reconnaissance
work by R.D. Hatcher, Jr.
4. Boyds Creek Quadrangle.
Mapped by D.D. Harper. Univ.
of Tenn. Master's Thesis.
5. Douglas Dam Quadrangle.
Mapping by B.C. Stewart and
R.D. Hatcher, Jr.
6. New Market Quadrangle.
Mapped by R.D. Hatcher, Jr.
7. Jefferson City Quadrangle.
Mapped by R.D. Hatcher, Jr.
8. White Pine Quadrangle.
Mapped by R.D. Hatcher, Jr.
9. Talbott Quadrangle. Mapped
by C.P. Finlayson and A.E.
Coker.
10. Morristown Quadrangle.
Mapped by R.C. Milici.
11. Springvale Quadrangle. De-
tailed and reconnaissance
mapping by R.D. Hatcher, Jr.
12. Russellville Quadrangle.
Reconnaissance mapping by
R.D. Hatcher, Jr.

Figure 3. Index to mapping of the Dumplin Valley zone.

Because of space limitations and many problems associated with reproduction of unpublished maps, the twelve maps listed in Figure 3 are not included in this dissertation but are available to the interested reader as follows: the Maryville, Wildwood, and Shooks Gap maps are published and may be obtained from the U. S. Geological Survey or Tennessee Division of Geology; the Boyds Creek, New Market, Jefferson City, Talbott, Morristown, and Russellville quadrangles are in the process of publication by the Tennessee Division of Geology; the remaining maps are on open file at the Tennessee Division of Geology or at the Department of Geology and Geography of the University. Plate I is a compilation of the above maps. Regrettably, many details of the geology could not be shown on this scale (1:125,000). The structural cross sections (Plates II through V) are, however, drawn at the individual quadrangle map scale of 1:24,000 in order to show interpretative details.

This investigation proceeded through several stages starting with collection of field data to the final interpretive and writing stage. The study was completed in the course of three summers. The first portion of the investigation was carried out from mid-June to September of 1963;

and the second phase was carried out from mid-June to mid-September of 1964. Most of the first summer was spent studying the stratigraphic sequence, the reason for which will be apparent when the stratigraphic problems are discussed, and mapping about one-third of the New Market Quadrangle. The second summer was spent in detailed mapping of about three-fifths of the Jefferson City Quadrangle, portions of Douglas Dam and White Pine quadrangles, detailed and reconnaissance mapping in the Springvale and Russellville quadrangles, and field checking several areas. The third summer was spent doing interpretive work on maps and cross-sections, rechecking critical areas, and writing the report.

The detailed mapping was carried out by standard procedures. All contacts were traversed on foot. Lithologies were plotted by standard colors, and the attitude of beds was determined with a Brunton compass. The dip-strike measurements were made at intervals sufficient for good control on the map in the less complicated areas, and as many as could be practically recorded on the map in the more complex areas. Traverses were not made in a random fashion, but were undertaken with the aim of staying on a given contact. In that way changes in the structural pattern could be easily

noted, and measurements of the attitudes of beds could be taken on either side of the contact with greater ease. This technique requires abundant bedrock exposures, as is the case throughout most of the Dumplin Valley Area.

Reconnaissance traverses were carried out mainly by driving all the accessible roads, stopping in the cuts, or at easily accessible exposures, and recording data. Also, in areas of undue structural complexity, foot traverses were made.

In several areas where the deformation was intense and the relations difficult to decipher, it was necessary to revisit localities. Also, several places where interesting or unusual features are present were revisited.

CHAPTER II

STRATIGRAPHY

Introduction

The Dumplin Valley fault system involves at the surface some 7000 feet of Early Paleozoic sedimentary rocks. These formations range in age from Early Cambrian to Middle Ordovician. The sediments comprising the units are typical miogeosynclinal deposits, some having an allochthonous cratonal or eugeosynclinal origin, others being carbonates. However, sedimentary provenance is not of major concern here.

The oldest rocks, those of the Rome Formation, are now exposed in the hanging walls of faults. Overlying the shales and sandstones of the Rome Formation are the Middle and Upper Cambrian shales and limestones of the Conasauga Group. These units are representative of the Central Phase of Rodgers (1953, p. 49), and six formations are mappable in this belt. The siliceous carbonates of the Upper Cambrian-Lower Ordovician Knox Group are well represented, all five formations being present and identifiable. The youngest

rocks directly involved in the structure are the Middle Ordovician formations of the Chickamauga Group, and representatives of the Main Red Belt of Rodgers (1953, p. 72) are present. The names and type localities of the units mapped by the writer in this study are listed in Table I.

Stratigraphy has been utilized in this study only as a tool to decipher structures and detailed stratigraphic studies have not been made. However, during the course of the project much previously unknown stratigraphic information was obtained, and it is believed that several important contributions have been made.

Problems Encountered

Several types of problems arose regarding the stratigraphy of the rocks in the Dumplin Valley belt. One of the first encountered in most field projects is that of exposures. This fortunately is not a major problem here, since exposures are plentiful and as many data may be collected as can be fitted onto the map. However, near the base of the Rutledge Limestone and in the Pumpkin Valley Shale, exposures are scarce in several areas. Also, residuum

TABLE I

NAMES AND TYPE LOCALITIES OF THE FORMATIONS

Age	Group	Formation	Name and Type Locality
Ordovician	Middle	Ottosee Shale	Ulrich, E. O., 1911. Named for Lake Ottosee in Chilhowee Park, Knoxville.
		Tellico Sandstone	Keith, Arthur, 1896a. Named for exposures on Tellico River, Monroe County.
		Holston Limestone	Keith, Arthur, 1895. Named for exposures on the Holston River (original locality unknown).
		Lenoir Limestone	Safford, J. M., and J. B. Killebrew, 1876. Named for exposures at Lenoir City, Loudon County.
		Mosheim Member of Lenoir Formation	Ulrich, <u>loc. cit.</u> Named for exposures at Mosheim, Green County.
	Lower	Mascot Dolomite	Oder, C. R. L., and H. W. Miller, 1945. Named for exposures at Mascot, Knox County.

TABLE I (continued)

Age		Group	Formation	Name and Type Locality
Ordovician	Lower	Knox	Kingsport Formation	Oder, <u>Ibid.</u> Named for exposures at Kingsport, Sullivan County.
			Longview Dolomite	Butts, Charles, 1926. Named for exposures at Longview, Shelby County, Alabama.
			Chepultepec Dolomite	Ulrich, <u>loc. cit.</u> Named for exposures at Chepultepec (now Allgood), Blount County, Alabama.
			Copper Ridge Dolomite	Ulrich, <u>Ibid.</u> Named for Copper Ridge at Thorn Hill, Grainger County.
Cambrian	Upper	Conasauga	Maynardville Limestone	Oder, C. R. L., 1934. Named for exposures near Maynardville, Union County.
			Nolichucky Shale	Campbell, M. R., 1894. Keith, Arthur, 1905. Named for exposures on the Nolichucky River, Green County.
	Middle		Maryville Limestone	Campbell, <u>Ibid.</u> Keith, Arthur, 1895. Named for exposures at Maryville, Blount County.

TABLE I (continued)

Age	Group	Formation	Name and Type Locality
Cambrian	Middle	Rogersville Shale	Campbell, <u>Ibid.</u> Keith, Arthur, 1896b. Named for exposures near Rogersville, Hawkins County.
		Rutledge Limestone	Campbell, <u>Ibid.</u> Keith, Arthur, 1901. Named for exposures near Rutledge, Grainger County.
		Pumpkin Valley Shale	Rodgers, John, and D. F. Kent, 1948. Named for exposures in Pumpkin Valley, Hawkins County.
	Lower	Rome Formation	Hayes, C. W., 1891. Named for exposures at Rome, Floyd County, Georgia.

of the Copper Ridge Dolomite in places covers the contact of that formation with the Maynardville Limestone.

The first major problem encountered was the identification of formations of the Conasauga Group in structurally complex areas. In an unfaulted sequence the units are easy to recognize because of stratigraphic position; but, where faulting has occurred and formations are omitted or repeated, there is the problem of unit identification. To help solve this problem, marker beds or sequence zones were sought. Fortunately, a few markers, although quite subtle, were found. Specific rock types, for example, occur at certain positions within a formation, and in most cases these lithologic types extend for considerable distances. The dolomite members of the Rutledge and Maryville limestones are good examples. In a few cases the standard beds widely used by others were utilized in placing contacts, as in the case of the Maynardville-Copper Ridge and the Rome-Pumpkin Valley contacts.

In addition to the recognition of units, there exists the problem of where to place certain contacts. The contacts for the most part are transitional so that arbitrary boundaries had to be chosen. There are no recognizable

unconformities occurring within the Conasauga or Knox Groups.

Another problem is that of facies changes and their recognition. Major lithofacies changes occur in the Maryville and Maynardville limestones. B. C. Stewart (University of Tennessee graduate student) incorrectly identified the tongue of Honaker Dolomite in the Maryville Limestone as Knox Dolomite and postulated a fault to explain its occurrence. Facies changes encountered within the Maynardville Limestone pose the problem of the position of the contact with the Nolichucky Shale. This writer's choice of the contact differs with that of Milici in his mapping of the Morristown Quadrangle (1965).

The problem of formation identification of weathered versus fresh material is present here as in most areas of the southeastern United States. In the Conasauga Group deep soils are not developed except over one or two units or in certain areas. However, in places these soils serve to identify the different units. For example, the dolomite member of the Maryville Limestone has a characteristic red, cherty soil. The shale formations give rise to soils with abundant chips of the parent lithologies. Slightly weathered exposures of the Conasauga limestones give more clues as to

which formations they belong than completely fresh rock. The Knox Group is mapped almost entirely on residual products. Indeed, the Knox formations are more easily recognized by their residual characteristics than by the fresh rock.

Standard Descriptions

There are ample descriptions of most of the rock units of the Dumplin Valley area in the literature. Descriptions of the rocks of this belt may be found in Bridge (1956), Rodgers (1953), Cattermole (1955, 1962), Neuman (1960), and Harper (1963). The Knox Group was first subdivided by Oder (1934), and this is still a good reference for these units. The Bridge (1956) work has the best up-to-date discussion of the pre-Chickamauga rocks, particularly the present subdivision of the Knox Group. Both Cattermole (1962) and Neuman (1955, 1960) adequately describe the Chickamauga rocks of this belt.

New Findings

The reader is urged to rely upon the standard references for detailed descriptions of the formations in the Dumplin Valley region. It is the aim of the writer in

the following discussion to stress his own findings regarding the units rather than presenting rote descriptions of the formations. Emphasis is also placed upon the facies relationships which were noted by the writer in this study. The thicknesses of the various units mapped by the writer are presented in Figure 4.

Topographic and Floral Expression of the Formations

Certain units within the Dumplin Valley zone are prominent ridge formers, while others persistently underlie valleys. The Rome Formation is the most prominent ridge former, producing characteristic hogbacks with a linear "cockscornb" outline and having relief up to 500 feet (Figure 5).

In the Conasauga Group the highest ridges are capped by the Nolichucky Shale. The Nolichucky-Maryville contact follows the crest of these ridges. In several areas these ridges stand 250 or more feet above the adjacent terrain. In the northeastern portion of the Dumplin Valley zone the silty shale zones of the Maynardville Limestone underlie ridges which are higher than the adjacent Copper Ridge

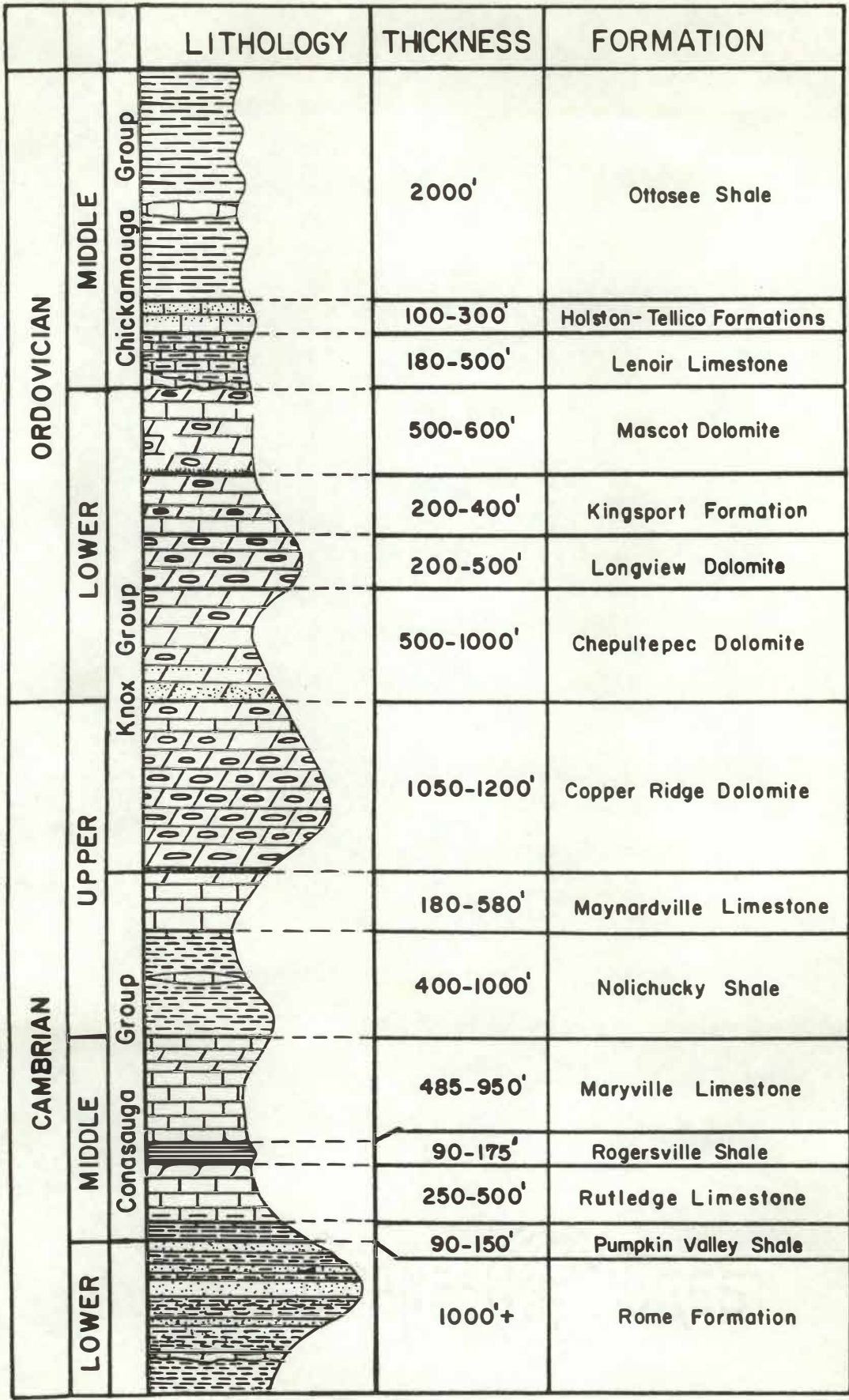


Figure 4. Columnar section.

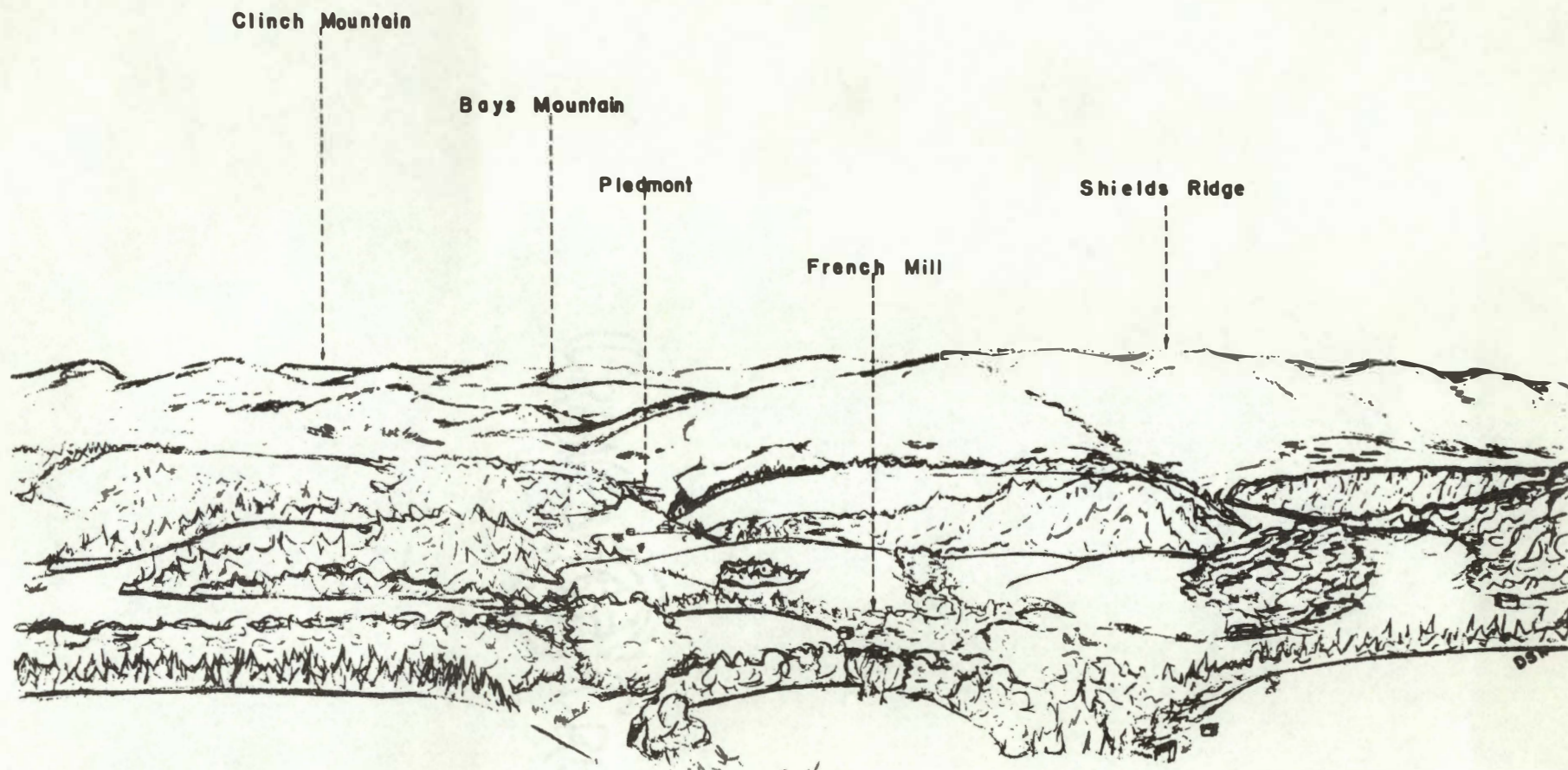


Figure 5. Panoramic view of the Dumplin Valley area looking northwest from the top of Newman Ridge in New Market Quadrangle. Shields Ridge is underlain by the Rome Formation. The low, elongate hills in the foreground and near Piedmont are underlain by the Maryville-Nolichucky contact zone. (Drawing by Mrs. Diana Simpson Hatcher)

topography. These ridges have relief up to 300 feet. The Rogersville Shale underlies a row of low, elongate hills having relief up to 60 feet. The other formations of the Conasauga Group are either persistent valley formers or occupy the back slopes of the higher ridges.

Within the Knox Group, the Copper Ridge Dolomite is generally the most prominent ridge former in the Dumplin Valley area. It forms broad ridges having relief up to 300 feet. The Longview Dolomite also forms ridges, commonly in the belt southeast and northwest of the fault zone. These ridges stand as much as 200 feet above the surroundings. The Chepultepec Dolomite, although commonly a valley former, in places underlies a ridge with relief up to 200 feet or more where the basal sand thickens considerably and is quartzitic in character. The remaining portions of the formations of the Knox Group form valleys.

In the Chickamauga Group the Tellico Sandstone and the Ottosee Shale form a series of knobs having relief up to 250 feet. The Lenoir and Holston limestones are valley formers.

In addition to topographic expression of the formations, most of them may be placed into categories based

upon the type of vegetation and soil profiles developed on them (Table II). When this information is coupled with topographic expression, it becomes a valuable tool in mapping where exposures are scarce. In the Knox Group these are the only usable criteria for subdivision in the field. Also, the growth of pine trees on the Rome Formation aids in locating faults where they border the cedar trees growing on the limestones of the Chickamauga Group, and also some of the Conasauga limestones. The dolomite member of the Maryville Limestone may be located by a belt of pine trees which commonly grows in the siliceous soil over the unit.

Pre-Knox Formations

Introduction

The pre-Knox formations mapped by the writer include the Lower Cambrian Rome Formation and the six formations of the Conasauga Group. The Conasauga formations are the Middle Cambrian Pumpkin Valley Shale, Rutledge Limestone, Rogersville Shale, Maryville Limestone, and the Upper Cambrian Nolichucky Shale and Maynardville Limestone.

TABLE II

RESIDUAL AND VEGETATION CHARACTERISTICS OF
STRATIGRAPHIC UNITS IN DUMPLIN VALLEY

Formation	Member	Soil	Characteristic Trees
Ottosee Shale		Brown, thin, shale chips	None
Holston- Tellico		Very red, sandy, common- ly deep	Pines
Lenoir Limestone		Brown, thin, shale chips	Cedars
Mascot Dolomite		Red to orange, cherty, sandy	Deciduous, pines
Kingsport Formation		Red to orange, cherty, sandy	Deciduous, pines
Longview Dolomite		Gray-brown, very cherty, thick	Deciduous
Chepultepec Dolomite		Red-orange, very sandy, thick	Deciduous, pines
Copper Ridge Dolomite		Red-orange very cherty, thick	Deciduous, pines

TABLE II (continued)

Formation	Member	Soil	Characteristic Trees
Maynardville Limestone	Limestone	Orange, thin	Cedars
	Algal	Orange, thin	Cedars
	Shale	Gray-brown, shale chips	Deciduous
	Dolomite	Red-orange, thin	None
Nolichucky Shale		Gray-brown shale chips, thin	Pines
Maryville Limestone	Limestone	Orange	Cedars
	Dolomite	Red, cherty thin to thick	Pines
Rogersville Shale		Light gray, shale chips, thin	None
Rutledge Limestone	Limestone	Orange, silty, thin	Cedars
	Dolomite	Red, thin to thick	None
Pumpkin Valley Shale		Light orange-gray, thin to thick, shale chips	Pines
Rome Formation		Light grayish tan, thin Numerous sandstone blocks	Pines

Rome Formation

Standard Description

The Rome Formation (Figure 6) contains massive, fine- to medium-grained, light brown, micaceous sandstone beds; variegated shales; and a few fine-grained, thin-bedded or lenticular carbonates, of which the latter may be fossiliferous (Bridge, 1956). Trilobites are the most common fossils. Ripple marks, mud cracks, rain imprints, swash marks, and other primary features are abundant. The thickness of the Rome is indeterminate because its base is nowhere exposed in the central and western portions of the Valley and Ridge due to faulting. According to Bridge (1956, p. 8) it is at least 1000 feet thick in the Jefferson City area.

Dumplin Valley Area

The Rome Formation attains a thickness of from 1500 to 2000 feet in the Shooks Gap and Wildwood Quadrangles, with the upper 1200 feet or so containing more sandstone and siltstone beds than the lower portion which is composed mostly of shale and carbonate beds. The contact with the overlying Pumpkin Valley Shale is drawn at the top of the highest massive sandstone bed.



Figure 6. Crumpled shale beds interbedded with thin sandstone beds in the Rome Formation. Jefferson City Quadrangle along State Highway 92 about one-half mile northeast of Oakland.

Distinguishing Features

The Rome Formation is distinguished from the other units in the sequence by its variegated shales, massive sandstones, and siltstones with primary structures.

Conasauga Group

Introduction

The six formations of the Central Phase of the Conasauga Group (Rodgers 1953, p. 49) are mappable in the Dumplin Valley zone. Each unit is readily distinguished in an unbroken sequence, but each becomes difficult to recognize in a faulted sequence.

The shales and limestones of the Conasauga Group are fossiliferous. Several genera of trilobites and inarticulate brachiopods were found by the writer in the Nolichucky and Rogersville Shales but were not studied in detail. Comprehensive paleontologic studies of the Conasauga rocks have been made by Ulrich (1911), Hall and Amick (1934), Butts (1926, 1940), and by Resser (1938).

Pumpkin Valley Shale

Standard Description

The Pumpkin Valley Shale is an olive green, buff, and maroon shale containing minor amounts of siltstone and fine-grained sandstone. The siltstones and thin sandstone beds are commonly micaceous and contain cross laminae, ripple marks, swash marks, and mud cracks. The thickness of the Pumpkin Valley Shale ranges from 90 to about 250 feet.

Dumplin Valley Area

The Pumpkin Valley Shale contains beds of the overlying Rutledge Limestone lithology along with a few thin dolomite beds, mainly in the upper part. Its thickness ranges from 90 feet, as noted by Neuman (1960), to about 150 feet in the Jefferson City area.

Distinguishing Features

The Pumpkin Valley Shale is distinguished from the Rogersville and Nolichucky Shales by the presence of more silty and sandy material than either of the latter two. The

color of the shale is similar to the Nolichucky but is quite distinct from the Rogersville.

Rutledge Limestone

Standard Description

The Rutledge Limestone contains predominately fine- to medium-grained, dark blue-gray, medium-to thick-bedded, "ribbon" limestone as the basal sequence (Figure 7); massive, fine-grained, medium gray, slightly banded, medium-bedded limestone above the limestone sequence; and pinkish gray-brown saccharoidal dolomite (Figure 8) at the top, about 50 feet thick. Weathered surfaces of the dolomite have a "hachured" appearance. The thickness of the Rutledge Limestone ranges from about 250 feet in the Wildwood Quadrangle (Neuman, 1960) to over 450 feet in some areas around Jefferson City (Bridge, 1956, p. 7).

Dumplin Valley Area

The dolomite portion of the Rutledge is present throughout the belt. The contact with the overlying Rogersville Shale is very sharp and does not have the transitional character of the other units in the Conasauga Group. No



Figure 7. Typical Rutledge Limestone "ribbed" lithology with many bands of silty material and bluish-gray limestone. Near French Mill about one and one-half miles east of Piedmont in New Market Quadrangle.



Figure 8. Weathered bedding surface of Rutledge dolomite showing the hachured pattern of joints and other fractures. Note the pink cast of the rock. New Market Quadrangle near French Mill, about one and one-half miles east of Piedmont.

evidence for an unconformable relationship was found. The bands in the "ribbon" limestone contain concentrations of silty material.

Distinguishing Features

The Rutledge Limestone is distinguished from the other limestones in the Conasauga Group by the intensely "ribbed" lithology in most of the limestone portion of the formation, and by the presence of a dolomite member at the top. The several feet of less intensely "ribbed" limestone commonly found immediately below the dolomite member resembles the Maryville Limestone and parts of the Maynardville Limestone. However, no oolitic or pisolitic beds were noted in the Rutledge, but some beds of pellet limestone were found which could be confused with oolitic varieties. The pellets are, however, poorly defined dark circular masses.

Rogersville Shale

Standard Description

The Rogersville Shale (Figure 9) is a grayish green shale containing a few silty beds. Inarticulate brachiopods



Figure 9. Weathered exposure of Rogersville Shale showing the gray-green color of the chips commonly found in the soil. Jefferson City Quadrangle about one-half mile southeast of Oakland near Mutton Hollow Road.

and a few trilobites are locally present. The Craig Limestone Member is up to 100 feet thick and is a dark gray, mottled limestone which resembles the Maryville (Bridge, 1956, p. 9). The Rogersville Shale is up to 250 feet thick (Bridge, 1956, p. 9).

Dumplin Valley Area

In the Dumplin Valley area the Craig Limestone Member was not observed in the formation except at one questionable outcrop in the Jefferson City Quadrangle near Oakland. Neuman (1960) reports that the member attains a thickness of 14 to 20 feet and resembles the Maryville Limestone. It is thought that in the northeast portion of the belt the upper tongue of Rogersville Shale pinches out and the Craig Member is indistinguishably incorporated into the Maryville Limestone. The thickness of the Rogersville Shale ranges from 90 to 175 feet.

Distinguishing Features

The Rogersville Shale is distinguished from the other shales in the Conasauga Group principally by its color. The fresh color is gray green rather than olive green; the

weathered color is a lighter grayish green. Upon weathering the shale gives rise to flaky chips in the soil which are unlike those of the other shale formations.

Maryville Limestone

Standard Description

The Maryville Limestone is a massive, dark blue-gray, medium-to thick-bedded limestone (Figure 10). It has a mottled textured surface where slightly weathered. This lithology prevails where silty beds appear about 25 feet from the top of the formation in the transitional zone with the overlying Nolichucky Shale (Figures 11 and 12). Thicknesses of the formation in this belt range from 485 feet (Cattermole, 1962) to 850 feet (Neuman, 1960).

Dumplin Valley Area

The thickness of the Maryville Limestone exceeds 900 feet in the Jefferson City and New Market areas. In addition to the mottled varieties, it contains oolitic and banded lithologies. The light-brown silty bands in the Maryville Limestone are less pronounced than those in the Rutledge Limestone.



Figure 10. Exposure of typical Maryville Limestone. Note the relatively thin mottled silty zones and the predominance of light gray massive limestone. Jefferson City Quadrangle, about three and one-half miles west of Dandridge.



Figure 11. The Nolichucky Shale in the upper right part of the photograph conformably overlies the Maryville Limestone. The shale is on the backslope of the ridge and the underlying limestone is in the quarry. Silty beds of the 20 foot gradational zone underlie the ridge crest. Jefferson City Quadrangle about one mile east of Piedmont.



Figure 12. Silty limestone beds in the gradational Maryville-Nolichucky contact zone. Thick beds of limestone can be seen to the left and shale to the right. New Market Quadrangle about one mile south of Piedmont on Deep Springs Road.

In the Dumplin Valley belt there is also a dolomite member which ranges in thickness from a feather edge to over 200 feet. It occurs some 50 to 60 feet stratigraphically below the top of the formation. In the New Market Quadrangle there are three successive fault blocks in which the Maryville is repeated. In the northwest block a thin zone of dolomitic limestone is found at the proper horizon of the dolomite unit. In the middle block the dolomite member is recognizable and attains a thickness of from 10 to 25 feet. In the third block the dolomite member is over 100 feet thick. A fourth block to the southeast is present in the Douglas Dam Quadrangle in which the dolomite member is about 200 feet thick. The location of this member on the scarp-slope of the Maryville-Nolichucky ridges is indicated by a belt of pine trees which follow the cherty soil that develops over the member.

The dolomite member consists of several rock types. The dominant lithology in the southeastern belts is a fine-to medium-grained, saccharoidal, dark-gray dolomite (Figure 13) which has a petroliferous odor on freshly broken surfaces. Another variety of dolomite is a thin-to medium-bedded, very fine-grained, laminated dolomite. It is pale where fresh



Figure 13. Medium to thick beds of Maryville dolomite.
Douglas Dam Quadrangle about one mile west of Deep
Springs.

and weathers light gray. A third rock type is a type of replacement dolomite, as evidenced by poorly defined relict sedimentary bedding. It is very light gray on fresh surfaces, medium-bedded and very fine-grained (Figure 14). This fine saccharoidal dolomite has medium to coarse crystals of calcite in individual crystals and in stringers (Figure 15). It weathers light medium gray. The latter two lithologies are minor quantitatively but are persistent and occur wherever the dolomite unit is found. As the unit increases in thickness, the amount of the coarser saccharoidal variety also increases relative to the other lithologies.

The different rock types in the dolomite member, particularly the saccharoidal type, give siliceous residues upon weathering. The latter lithology weathers readily to a very red soil of varying depth which may contain chert blocks up to several feet in diameter (Figure 16). This chert is light gray and tan and is somewhat porcelaneous with irregular patches of chalcedony in the fresher portions. Another variety of chert is a porous, granular-appearing type which may or may not be associated with the other variety. This porous type is thought to be bedded since it occurs in regular blocks which may be up to two feet across. The



Figure 14. Intensely fractured Maryville dolomite. This is the recrystalline rock type. Bedding is vertical. Reddish soil at right. Douglas Dam Quadrangle about one mile west of Deep Springs.



Figure 15. Recrystalline variety of Maryville dolomite. Note the light-colored sugary matrix surrounding large crystals (dark) of calcite. Douglas Dam Quadrangle about one mile west of Deep Springs.



Figure 16. Large blocks of light-colored chert in red-orange residuum of the Maryville dolomite member. Douglas Dam Quadrangle about one mile west of Deep Springs.

cherts in the Maryville are quite distinct from those in the Knox Group.

The writer suggests that this member represents a tongue of Honaker Dolomite wedging from the east. The writer spent a day with D. W. Byerly in the Greenville Quadrangle for the purpose of observing the Honaker Dolomite exposed east of the Pulaski fault. Attempts were made to observe approximately the same stratigraphic interval in the Honaker as in the Maryville where the dolomite occurs. The coarser saccharoidal lithology which is characteristic of the Maryville dolomite member is also one which is characteristic of the Honaker Dolomite. However, the cherts in the Honaker and those in the dolomite member of the Maryville are quite different. J. W. Smith (personal communication, 1965) has found a similar tongue of dolomite in the Maryville in the next belt to the northwest, which is just southeast of the Saltville fault. Again the dolomite occurs at approximately the same stratigraphic position as that in Dumplin Valley and, according to Smith, wedges out along strike to the southwest. This is to be expected since the Conasauga Group becomes predominately shaly to the southwest. In the Dumplin Valley area the member thins southwestward but was observed

as far to the southwest as Shooks Gap Quadrangle. Based on the evidence so far collected, it is believed that the supposition regarding the correlation of this member is correct. Also, this is further evidence that structural and sedimentary strike do not coincide in the Valley and Ridge Province of East Tennessee.

It is proposed that this dolomite member of the Maryville Limestone be called the Dumplin Valley Member since it was first recognized and described here.

Distinguishing Features

The Maryville Limestone is distinguished from other limestones of the Conasauga Group by several criteria. The silty bands in the limestones of the Maryville are thinner and more widely spaced than those of the Rutledge. More silty, mottled limestone is present. Also, oolitic and pisolitic lithologies are present in the Maryville and not in the Rutledge. The presence of the dolomite member below the top of the formation and the silty lithology with irregular bedding planes at the top also serve to set the Maryville Limestone apart from the other limestones.

Nolichucky Shale

Standard Description

The Nolichucky Shale is a grayish olive to olive green calcareous shale (Figure 17). Fossils are abundant with many varieties of trilobites and inarticulate brachiopods present. Some cross laminae, ripple marks and swash marks are present in the more silty beds. Mica flakes are plentiful along bedding planes. The Nolichucky Shale contains a lenticular limestone unit near the middle of the formation which ranges in thickness from less than an inch to 150 feet (Neuman, 1960). The thickness of the Nolichucky Shale ranges from about 400 feet in the northeastern portion of the structure to about 1000 feet (Neuman, 1960) in the southwestern parts.

Dumplin Valley Area

The boundary of the Nolichucky Shale with the overlying Maynardville Limestone is transitional; and the contact is arbitrarily drawn below the zone where limestone appears to predominate over shale.



Figure 17. Olive green beds of Nolichucky Shale. The bed above the hammer is a weathered carbonate bed. New Market Quadrangle about one mile south of Piedmont on Deep Springs road.

Distinguishing Features

The Nolichucky Shale is distinguished from the Pumpkin Valley and Rogersville Shales primarily by its color. Although quite similar to the Pumpkin Valley Shale, the color of the Nolichucky Shale contains more of a brown hue than the other shales. The Rogersville Shale is more of a grayish green whereas the Nolichucky is olive green (Figure 17). Also, weathered chips of Nolichucky Shale are prismatic in shape and are commonly brown where slightly weathered. The shales of the Nolichucky are more difficult to differentiate from those of the Maynardville Limestone; but generally the Maynardville shale is tougher, more resistant to weathering and has more limestone interbeds.

Maynardville Limestone

Standard Description

The Maynardville Limestone is a dark gray, mottled, silty, banded, and oolitic limestone which is medium-to thick-bedded. The lower part of the Maynardville is a very thick-bedded stromatolitic limestone which is light greenish gray in color and may be massive (Figure 18) or straticulate.



Figure 18. Massively bedded stromatolitic limestone in the Maynardville Limestone. Note the silty stringers and greenish gray color. Douglas Dam Quadrangle about one mile northwest of Deep Springs.

A shale member up to 20 feet thick consisting of olive green to green shale is present in most places. The shale is commonly fossiliferous containing several species of trilobites and inarticulate brachiopods. The thickness of the Maynardville Limestone is about 300 feet in the Jefferson City area (Bridge, 1956, p. 17), whereas Neuman (1960) reports its thickness to be about 175 feet in the Wildwood Quadrangle. Oder and Bumgarner (1961, p. 1023) measured a thickness of 582 feet at Deep Springs in the Douglas Dam Quadrangle.

Dumplin Valley Area

There are four recognizable members in the Maynardville Limestone: (1) a basal algal limestone which grades laterally into a shale member; (2) a typical Conasauga limestone member, which is lithologically identical to the Maryville Limestone is persistent throughout the belt, and is 100 to 150 feet thick; and (3) a dolomite member at the top.

The algal limestone member is very thick-bedded, massive, light greenish-gray, aphanitic limestone with numerous light-brown silty stringers, which vaguely outline the algal heads. The algal member ranges in thickness from one

to 200 feet. About midway across the Jefferson City Quadrangle, it grades laterally into the shale member.

The shale member of the Maynardville Limestone, although quite similar to the shales of the Nolichucky, is more silty and has some subtle color differences. The red and green shales have a more gray cast than those of the Nolichucky, but the differences are very slight. The only way the writer was able to draw the contact was by tracing the base of the algal limestone. It would manifest itself as float blocks, or small outcrops of beds from one foot to small isolated reefs up to 50 feet thick. The reefs decrease in size and frequency to the northeast, but the basal one to two foot algal bed persists to the northeast end of the structure.

The contact of the Maynardville Limestone with the overlying Copper Ridge Dolomite is gradational and must be drawn arbitrarily. In most areas in the Dumplin Valley belt, the contact was placed at the top of a thin-bedded dolomite bed six inches to one foot thick. This bed is overlain by a thin, quartz sand bed (Figure 19) up to three inches thick which is succeeded by a very fine-grained oolitic chert bed. The sand and chert beds commonly show up as float where the



Figure 19. Thin beds of sandstone (to the right of hammer head) marking the contact between the Maynardville Limestone and Copper Ridge Dolomite. New Market Quadrangle on Newman Ridge about two miles southeast of Piedmont.

adjacent beds are weathered. In a few places where there is slumpage, the contact must be drawn above the highest limestone exposures where the chert residuum of the Copper Ridge appears to be relatively in place.

Distinguishing Features

The Maynardville Limestone is distinguished from the Maryville and Rutledge limestones by the presence of the massively bedded stromatolitic limestone in many areas of the Dumplin Valley belt. Also, the distinctive dolomite member helps differentiate this formation from others of the Conasauga Group. The dolomite of the Maynardville is distinguished from the Knox Dolomite by the absence of chert in the residuum. The problem of differentiating between Nolichucky and Maynardville shales has been discussed above.

Facies Relationships

Regionally, the Conasauga Group is a classic example of a lithofacies with clastic sediments on the west grading eastward into carbonates, implying a clastic source to the west on the craton. In the Dumplin Valley belt facies changes have been noted by the writer, both across and along

strike. The tongue of Honaker Dolomite in the Maryville Limestone represents a significant facies change from belts farther west. Also, the absence of the Craig Limestone Member in the Rogersville Shale in most of this belt signifies a change from just northwest of the Dumplin Valley area where it is present in the Rocky Valley belt. It is thought that the Craig Limestone is incorporated into the Maryville Limestone with the upper part of the Rogersville wedging out between the two belts.

Along strike a significant change is present in the Maynardville Limestone. The algal reef facies grades laterally into a shale member to the northeast thus adding to the complexity of the stratigraphy of the Dumplin Valley area.

The almost cyclical repetition of shales and limestones in the Conasauga Group suggests similar depositional environments. The limestones and shales, although bearing considerable similarity, contain distinctly different and persistent rock types which serve to differentiate them.

Knox Group

Introduction

The Knox Group in this study area consists of five mappable formations between the Maynardville Limestone and the unconformity at the top of the Mascot Dolomite. The formations mapped include the Copper Ridge Dolomite of Late Cambrian age, and the Chepultepec Dolomite, Longview Dolomite, Kingsport Formation, and Mascot Dolomite of Early Ordovician age.

The rocks of the Knox Group range from diverse types of dolomite and stromatolitic limestones, to several types of sandstone and chert. The dolomite and limestone beds of the Knox which predominate, are strikingly similar throughout the 3000 foot sequence, but when studied in detail contain innumerable variations. Identifying individual formations in the field based solely upon bedrock characteristics is very difficult if not impossible, except perhaps in the upper part. Subdivision is accomplished mainly by identification of residual siliceous materials resulting from weathering of the various units. The five units of the Knox are well adapted to this type of mapping since they are commonly

deeply weathered. Chert types and sandstone beds, soils, vegetation, topographic expression, and to some degree chertified fossils are useful to subdivide the Knox in East Tennessee.

Copper Ridge Dolomite

Bedrock Lithology

The most distinctive rock type of the Copper Ridge Dolomite is medium-to coarsely-crystalline, thick-bedded, dark brownish-gray dolomite. This lithology gives off a strong petroliferous odor when freshly broken. It has a saccharoidal texture and contains small veinlets and knots of quartz and calcite. In addition to this lithology, which predominates in the lower two-thirds of the formation, there is a typical medium gray, fine-grained, medium-to thick-bedded, laminated to massive dolomite which is found throughout the remainder of the Knox Group (Bridge, 1956, p. 30). The thickness of the Copper Ridge Dolomite is 1000 to 1200 feet in the Jefferson City area (Bridge, 1945). In the Wildwood Quadrangle the thickness is about 1000 feet (Neuman, 1960).

Residual Products

Several types of residual products occur in the weathered material of the Copper Ridge Dolomite. Oolitic chert beds are particularly characteristic. These oolites are generally concentrically banded, usually with alternate black, white, or tan layers. Another distinctive type of chert is silicified algal material commonly called cryptozoan chert. This chert commonly has a "waffle-iron" appearance on bedding and in float fragments. In cross section it resembles miniature cabbage heads. Along with many quartz sandstone beds of varying thicknesses, other varieties of chert occur in this formation and in other units of the Knox Group. For more complete descriptions see Bridge (1956, p. 25-37).

Dumplin Valley Area

The Copper Ridge Dolomite ranges in thickness from 900 to 1200 feet. In the upper part of the formation beds of dark-gray, aphanitic limestone are common. Some of these beds are stromatolitic with well-defined algal colonies (Figure 20). The contact with the overlying Chepultepec Dolomite is drawn below the thickest sand bed, occurring



Figure 20. Stromatolitic limestone near the top of the Copper Ridge Dolomite. Jefferson City Quadrangle, about one and one-half miles west of Dandridge. Camera lens cap is 2-1/4 inches in diameter.

some 1000 feet above the base of the Copper Ridge Dolomite. This is also the Cambro-Ordovician boundary.

Distinguishing Features

The deep weathering of the Copper Ridge Dolomite in the Dumplin Valley area necessitates identifying the unit by its residual products. The most reliable criterion used is the oolitic chert that is persistent and much more widely distributed than the algal cherts, although these may be used with equal facility where they are present. The limestone beds in the upper part of the formation serve as markers as well, but are used only with caution.

Chepultepec Dolomite

Bedrock Lithology

Most of the bedrock in the Chepultepec Dolomite is light gray, fine-grained dolomite which is medium-bedded and is of the type found elsewhere in the Knox. There is a quartz sand zone in the lower part of the formation with beds of medium-grained sand cemented with dolomite. Also, there are beds of limestone present which are like those in the top of the Copper Ridge. A few bedded cherts occur in this

unit; one of particular utility is composed of white oolite and occurs about 35 feet above the base of the formation. The thickness of the Chepultepec is from 500 to 600 feet in the Jefferson City area (Bridge, 1945). In the Wildwood Quadrangle it is over 1000 feet thick (Neuman, 1960).

Residual Products

The lower third of the Chepultepec Dolomite contains numerous quartz sandstone beds which occur in the residuum as blocks of sandstone loosely cemented with dolomite. Nodular cherts are common in this formation, as are chert fragments riddled with cavities of dissolved dolomite rhombs. This dolomoldic chert is characteristic of the formation. For more details regarding the fresh and residual products of the Chepultepec Dolomite, see Bridge (1956, p. 37-46).

Dumplin Valley Area

The basal quartz sandstone sequence at the base of which the contact with the Copper Ridge Dolomite is drawn, ranges in thickness from two feet to 20 feet. The entire sandy zone includes the lower third of the formation. Locally the sandstone layers are cemented with silica,

giving rise to topographically high areas. The thickness of the Chepultepec Dolomite is from 500 to 1000 feet. The upper boundary of the formation is arbitrarily drawn at the base of the characteristic Longview cherts.

Distinguishing Features

The Chepultepec Dolomite is distinguished from the other formations of the Knox Group by its basal sandy zone, and by the mealy or dolomoldic chert which occurs most commonly in this formation and only sparingly in others of the group.

Longview Dolomite

Bedrock Lithology

The Longview Dolomite is composed of beds of medium- to light-gray, thin-to medium-bedded dolomite. The upper third of the formation may locally contain beds of dark gray aphanitic limestone. Both the limestone and dolomite are in places replaced by recrystalline dolomite (Bridge, 1956). The Longview is 200 to 400 feet thick in the Jefferson City area (Bridge, 1945). It is 400 to 500 feet thick in the Wildwood Quadrangle (Neuman, 1960).

Residual Products

The soil of the Longview Dolomite is light-gray and contains abundant blocks of massive, porcellaneous chert. This chert is light colored, almost white in some areas, and occurs as large blocks, many more than two feet across. The chert is very compact and in places contains fossils of the gastropod *Lecanospira* (Bridge, 1956).

Dumplin Valley Area

The contacts of the Longview Dolomite with the overlying and underlying formations are based upon the distribution of the residual products and the approximate thickness measured by Bridge in the Jefferson City area.

Distinguishing Features

The Longview is distinguished from the other units of the Knox Group by the presence of large blocks of porcellaneous white chert, many containing specimens of *Lecanospira*.

Kingsport Formation

Bedrock Lithology

The Kingsport Formation is composed of thick-bedded blue-gray aphanitic limestone, medium-gray, fine-grained dolomite, and coarse-grained recrystalline dolomite. Mottled dolomite may also be present. The limestone makes up the lower third of the formation. The thickness of the Kingsport Formation is about 400 feet in the Jefferson City area (Bridge, 1956, p. 53).

Residual Products

The orange-red residuum of the Kingsport Formation contains nodular chert and compact to finely porous white chert in small blocks and chips, along with numerous blocks of loosely cemented quartz sandstone.

Dumplin Valley Area

In the Dumplin Valley area the contact of the Kingsport Formation with the overlying Mascot Dolomite is drawn at the base of a chert cemented (chert matrix) quartz sandstone. The thickness of the formation ranges from 200 to 400 feet.

Distinguishing Features

The Kingsport Formation is set apart from the Mascot Dolomite by the chert matrix sandstone. The cherts of the Kingsport are similar to those of the Mascot, and where the sandstone is absent or could not be located the two units are mapped together as the Newala Formation (Butts, 1926). The Kingsport is distinguished from other formations of the Knox Group by the considerable amount of limestone present, where exposures are available, and by the nodular and compact cherts.

Mascot Dolomite

Bedrock Lithology

The bedrock of the Mascot consists chiefly of dolomite, much of which is similar to that found in the Kingsport Formation. In the upper part is a distinctive, faintly red and green mottled sequence of dolomite, which serves to identify this part of the formation. Limestone beds are common in the upper Mascot, but do not comprise an appreciable part of the unit. The limestone beds are lithologically similar to those of the Kingsport. The thickness of the

Mascot Dolomite in the Jefferson City area is from 500 to 600 feet (Bridge, 1956, p. 54).

Residual Products

The residuum of the Mascot Dolomite contains the same types of chert and sandstone as that of the Kingsport Formation. Chert is more abundant in the lower Mascot than in the Kingsport (Bridge, 1956, p. 55).

Dumplin Valley Area

In the Dumplin Valley area the Mascot Dolomite is well exposed. The contact of the Mascot with the overlying Chickamauga is drawn at the top of the highest dolomite bed in the section. The thickness is about 550 feet.

Distinguishing Features

The Mascot Dolomite is distinguished from other formations of the Knox Group by the mottled dolomite and interbedded limestone occurring near the top of the formation, and by the nodular and fragmental chert which occurs in the residuum. It is differentiated from the Kingsport Formation by the larger amount of chert occurring near the

base of the unit and by the interbedded mottled dolomite and limestone at the top.

Knox-Chickamauga Unconformity

The unconformity between the Knox and Chickamauga has been studied throughout East Tennessee and other areas by many individuals. Laurence (1944) and Bridge (1955) have described the unconformity and the diverse rock types occurring on it at and near Douglas Dam, south of the Dumplin Valley area. Hagegeorge (1962), among others, postulated an angular relationship between the Knox and Chickamauga in an area near Rutledge, Tennessee. He could not prove this relationship due to a lack of exposures. An exposure clearly showing the angular relationship between the Knox and Chickamauga is present on Norris Lake. This exposure has been studied and briefly described by Finlayson and Swingle (1962) and by Hatcher, Lomenick, and Swingle (unpublished data).

Variations in thickness of the Mosheim Member of the Lenoir Limestone were noted by the writer in mapping in the Jefferson City and New Market Quadrangles but no angularity between the Knox and Chickamauga could be demonstrated. The amount of relief on the Knox erosion surface could not be

determined in the field, but Helmuth Wedow (personal communication, 1965) reports considerable relief on the erosion surface. His information is from drill data in the area of the Rocky Valley fault south of New Market.

Many pre-Chickamauga sinkholes and channels which are filled with various rock types are known in East Tennessee; however, none were observed in the Dumplin Valley area.

Post-Knox Formations

Chickamauga Group

Introduction

The formations comprising the Middle Ordovician Chickamauga Group are the Lenoir Limestone including the Mosheim Member, the Holston Limestone ("marble"), the Tellico Sandstone, and the Ottosee Shale. The Holston Limestone and Tellico Sandstone are mapped as a single unit. These formations, along with the Knox Group make up the footwall sequence of the Dumplin Valley zone.

Lenoir Limestone

Standard Description

The Lenoir Limestone consists of fine-grained, thin-to medium-bedded, silty-nodular limestone. It is dark gray where fresh and weathers light gray. Weathering emphasizes the nodular character of the beds. Fossils are locally abundant, with a typical Middle Ordovician fauna present along with certain varieties, such as Maclurites magnus which are characteristic of and abundant in the formation.

The Mosheim Member is a medium-to thick-bedded, aphanitic limestone. It contains coarse, isolated crystals of calcite, giving it a "birdseye" texture. Its fresh color is medium-dark gray, and it weathers light-gray. Its occurrence is sporadic, since it forms the basal part of the unit, being irregularly developed on the Knox erosion surface. Although locally absent, its thickness is up to 100 feet in the Mascot-Jefferson City area (Bridge, 1945).

The thickness of the Lenoir Limestone is 200 to 800 feet in the belt just northwest of the Dumplin Valley fault zone.

Dumplin Valley Area

The contact of the Lenoir Limestone with the overlying Holston and Tellico is gradational. The contact was drawn above the highest nodular limestone bed.

Distinguishing Features

The Lenoir Limestone is easily distinguished by its nodular character. These nodules commonly survive in the residuum which is mainly light orange-brown soil. The Mosheim Member is easily distinguished from other Chickamauga rocks of this belt since no other rocks resemble the massive, aphanitic "birdseye" limestone. However, beds quite similar to the Mosheim occur locally in the Mascot Dolomite and in the Kingsport Formation.

Holston Limestone ("Marble")

Standard Description

The Holston Limestone is a coarsely crystalline limestone composed of calcite-cemented fossil fragments. It is the commercial marble of the Knoxville area. Its color ranges from white to various shades of gray, brown, pink,

and red. Stylolites are abundant. The thickness of the Holston Limestone ranges from one inch to 200 feet.

Dumplin Valley Area

The Holston Limestone is very lenticular and sporadic in occurrence. It grades into the overlying Tellico Sandstone, and the Holston-Tellico contact is drawn below the lowest bed of quartz sandstone.

Distinguishing Features

The Holston Limestone is a distinctive rock type. There is none other like it in the section and thus it is easy to identify. It is distinguished by its thick, coarse-grained calcarenite beds.

Tellico Sandstone

Standard Description

The Tellico Sandstone is a thin-to medium-bedded, calcareous, ferruginous sandstone. Lenses of shale and siltstone resembling the Ottosee Shale are present. Quartz sand grains are also abundant. It is greenish-gray to medium-gray where fresh and weathers maroon.

Dumplin Valley Area

The contact with the overlying Ottosee Shale is drawn at the top of the highest calcareous ferruginous sandstone bed.

Distinguishing Features

The Tellico Sandstone in this belt is distinguished by its red color and hematite content. The red soil and float make it easy to identify even in places where there are no exposures.

Ottosee Shale

Standard Description

The Ottosee Shale, the youngest formation in the area, is a dark gray calcareous shale and calcareous siltstone which weathers light yellowish-brown. In places, lenses of Holston Limestone are present. Also, bluish limestone lenses which are fossiliferous may occur. The thickness of the Ottosee Shale is about 2000 feet (Neuman, 1960).

Dumplin Valley Area

The Ottosee Shale present here is similar to that described elsewhere in the region. The thickness of the shale present is estimated to be 1500 feet.

Distinguishing Features

The Ottosee Shale is distinguished from other formations by the yellow-weathering, gray calcareous shale, which is the most common lithology.

Summary of Stratigraphic Contributions

The major stratigraphic contributions of this study concern the rocks of the Conasauga Group. Perhaps the most significant finding was the tongue of Honaker Dolomite in the Maryville Limestone, herein named the Dumplin Valley Dolomite Member. This member is believed to be a potential oil reservoir rock in the area beneath the Knox belt to the southeast of the Dumplin Valley fault zone. This belief is based chiefly upon the highly petroliferous character of the rock and its obvious porosity. Another significant contribution is the study of the complex lithofacies relationships of the Nolichucky-Maynardville sequence.

The solution of the perplexing problem of identifying and differentiating the lithologically similar limestone formations of the Conasauga Group in structurally complex areas is an important contribution. Of equal importance is the differentiation of the lithologically similar shale formations of this Group. The solution of these problems enabled the areal geology to be mapped in the complicated fault zones of the Douglas Dam, New Market, and Jefferson City Quadrangles. The Rutledge Limestone, with its intense banding and dolomite member at the top, is distinguished from the Maryville Limestone, which is less intensely banded, contains massive, oolitic, and pisolitic rock types, and a dolomite member some distance from the top. The Maryville Limestone is also characterized by a silty zone at the top as it grades into the Nolichucky Shale. The Rutledge and Maryville Limestones are distinguished from the Maynardville Limestone by the stromatolitic, lithologically distinct member present in the latter unit.

The Pumpkin Valley and Nolichucky shales are similar in color. However, fossils, which are common and relatively easy to find in the Nolichucky Shale, may be used to distinguish the two units. Also, the Pumpkin Valley Shale contains

more silty and sandy beds. The Nolichucky Shale contains distinctive limestone beds which are not found elsewhere in the section. These are greenish-brown, coarsely crystalline, oolitic, lenticular layers which are near the middle of the unit. Also, the greater thickness of the Nolichucky Shale serves to distinguish it from the Pumpkin Valley and Rogersville shales. The Rogersville Shale is easily distinguished from the other shales by its grayish-green color. The Nolichucky and Maynardville shales cannot be differentiated lithologically, and the contact is drawn at the base of a thin algal limestone marker bed.

CHAPTER III

TECTONICS

Regional Tectonics

The Southern Appalachians are commonly subdivided into several units based upon physiography (Figure 21). These physiographic divisions reflect the types of rocks found in them, but to a greater extent they reflect the degree and types of deformation the rocks have undergone. King (1950, p. 10) describes the structure as follows:

To the northwest are the gently deformed Cumberland and Allegheny Plateaus, a foreland area. Next southeast is the Valley and Ridge province, made up of much more strongly folded and faulted Paleozoic sedimentary rocks. Beyond is the Blue Ridge, composed of older Paleozoic and pre-Cambrian rocks that are not only strongly folded, but are more or less metamorphosed. This is succeeded by the Piedmont Plateau, whose rocks are strongly metamorphosed and invaded by granite plutons, but with considerable areas of metasedimentary rocks to the southeast. The rocks of the Piedmont pass southeastward beneath the deposits of the Atlantic Coastal Plain, and their further extension in this direction is lost to view.

Cumberland Plateau

This area is characterized at the surface by rocks predominately of Pennsylvanian age which have been gently

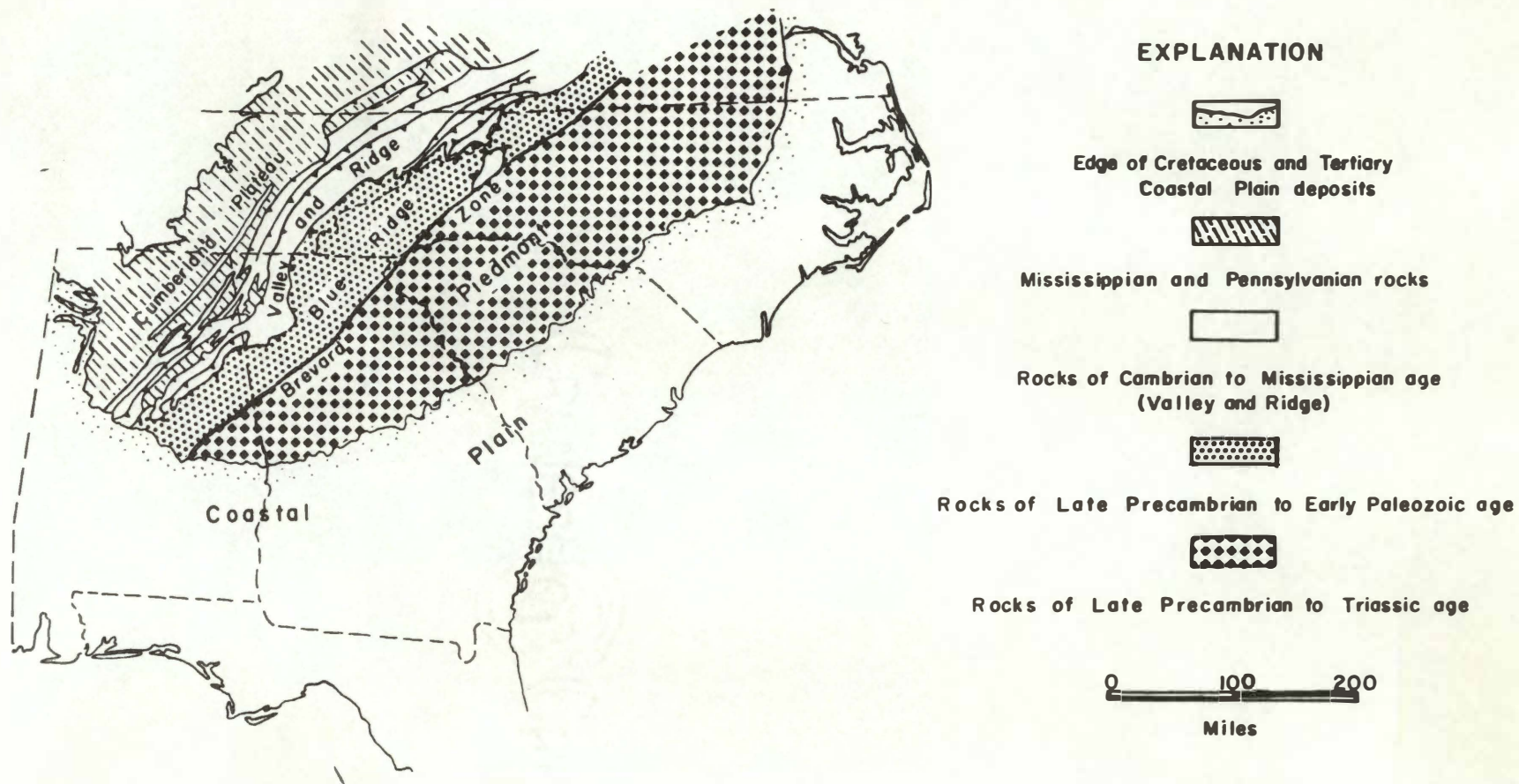


Figure 21. Generalized geologic map of a part of the southeastern United States showing the physiographic provinces and the relative ages of the rocks found in them. (After King, 1950, Plate I.)

deformed into broad, open folds, and have been broken by relatively few major faults. Major structural features of the Plateau in East Tennessee include the Pine Mountain fault, described and interpreted by Rich (1934); the Cumberland Plateau overthrust, described by Stearns (1954, 1955); and the faulted Sequatchie anticline, studied and interpreted by Milici (1960). These structures are not unlike many of the Valley and Ridge, and are thought by some to be genetically related.

Valley and Ridge Province

The Valley and Ridge Province of East Tennessee is dominated by thrust faults. These faults were formerly thought to be high angle reverse faults, but detailed mapping has proved that many are low angle thrust faults, at least at the surface. Although the "thin-skinned" concept of deformation as postulated by Rodgers (1949) is accepted by many recent local workers, Cooper (1961) is one of several who still holds with the "thick-skinned" idea.

At the latitude of Knoxville the Valley and Ridge may be divided into two different belts: a western belt dominated by thrust faults; and an eastern belt dominated by

folds (Rodgers, 1953, p. 134-136). The folded belt is confined to the area southeast of the Knoxville fault, whereas the faulted belt occupies the region northwest of this fault (see Figure 1, p. 2).

In the belt of dominant faulting the thrusts involve only the sedimentary cover and do not bring up basement rocks. The oldest rocks commonly involved are the Lower Cambrian Rome Formation or in some places the Middle Cambrian Conasauga shales. Synclinal folds in the Valley and Ridge of East Tennessee contain rocks as young as Pennsylvanian (Swingle, 1959), but over wide areas the younger rocks are Middle Ordovician in age.

The folded eastern portion of the Valley and Ridge Province contains several notable structures. The Bays Mountain synclinatorium, Greenback and Mosheim anticlines are well-known folds in this belt. The Chestuee fault is present in the southwestern part of this belt. The Dumplin Valley fault, with which this study is concerned, is present and extends from Morristown to Etowah. However, the faults of this belt are not as extensive as those of the western half of the Valley and Ridge Province.

The Dumplin Valley fault zone is here considered to be an elongate, anticlinal uplift with Cambrian rocks in the center and flanked by Ordovician rocks. Its fold-associated character and the relationship of folding to the origin of the structure will be emphasized in a later section.

Blue Ridge Province

This part of the Appalachians is characterized by the presence of clastic rocks, predominately Early Cambrian or older, which in addition to having been folded and faulted, are metamorphosed to varying degrees. Both sedimentary and crystalline rocks are involved in the Blue Ridge structures. Not only is the structure here complex, but in most areas, the stratigraphic succession is not well understood. The sediments are largely eugeosynclinal, succeeded locally by miogeosynclinal deposits. Notable structural features in the Blue Ridge in Tennessee include the Great Smoky fault and associated windows, and the great superimposed thrust sheets of northeastern Tennessee.

Piedmont Province

The Piedmont, east of the Blue Ridge, is characterized by metamorphic, volcanic, and plutonic rocks with minor amounts of sediments. The age of the rocks has generally been presumed to be pre-Cambrian, but some are now known to be Paleozoic. Basins containing Triassic sediments are also present. The structure of the Piedmont is poorly understood. It is bounded on the west in North and South Carolina by the controversial Brevard zone.

Atlantic Coastal Plain

The rocks of the Piedmont are covered to the east by unconsolidated sands, clays, chalks, and marls of the Atlantic Coastal Plain. The sediments are of Cretaceous to Recent age and dip eastward. The only notable structural feature of this area is the Cape Fear Arch in North and South Carolina.

Description of Structural Features of the Dumplin Valley Fault Zone

Introduction

The geology of the Dumplin Valley area is presented at a scale of 1:125,000 (Plate I). This scale was selected

(in addition to reasons given on page 9) for the reader's convenience, enabling him to grasp the main structural features by viewing a relatively small map. The original mapping was on a scale of one inch to 2000 feet.

In constructing the map (Plate I), many details of the geology were of necessity omitted. All major faults on the original base maps are shown on Plate I, but several formations have been grouped in certain areas. Many of the smaller folds have been omitted and smaller structures adjacent to some faults are not shown. In a few areas it has been possible to show individual formations but nowhere are dip symbols plotted. All stratigraphic contacts are shown as dashed lines and all faults are solid lines.

The structure sections (Plates II, III, IV, and V) are not reduced to the scale of the geologic map. The locations of the section lines are shown on Plate I.

For convenience, the Dumplin Valley zone is divided into six divisions (see index map, Plate I). Although in part arbitrary, each subdivision is characterized by somewhat different structural features. These subdivisions are numbered consecutively, beginning in the northeast near Morristown and continuing to the southwest to Maryville.

The status of geologic quadrangle maps of the Dumplin Valley area is shown in Table III.

Division I: Northeastern Folded Portion
(Morristown and Springvale Quadrangles)

Although folds predominate in the northeasternmost part of the Dumplin Valley zone, two major faults (A and B) are present (see Sections 1, 2, and 3, Plate II). Both faults have diminished throw from their counterparts in other divisions.

Structure Along Fault A

In the southwest part of this division, Fault A has a maximum stratigraphic displacement of 3500 feet, with Maryville Limestone thrust over Lenoir Limestone. The fault plane is nowhere exposed, but its existence is evidenced by the stratigraphic discontinuity. To the northeast the throw decreases to 1000 feet in the Springvale Quadrangle, just south of Russellville where Knox is thrust on Lenoir Limestone. The displacement is probably taken up by slippage in the incompetent layers of Lenoir Limestone and terminates east of Russellville. The surface attitude of the fault in

TABLE III
STATUS OF GEOLOGIC QUADRANGLE MAPS
OF THE DUMPLIN VALLEY AREA

Number	Quadrangle	Agency Responsible	Status
171-SW	Russellville	TDG*	In press
172-NW	Springvale	TDG*	Field work incomplete
163-NE	Morristown	TDG*	In press
163-NW	Talbott	TDG*	In press
163-SE	White Pine	TDG*	Field work incomplete
163-SW	Jefferson City	TDG*	In press
155-SE	New Market	TDG*	In press
156-NE	Douglas Dam	TDG*	Field work incomplete
156-NW	Boyds Creek	TDG*	In press
147-NE	Shooks Gap	USGS**	Published
147-SE	Wildwood	USGS**	Published
147-SW	Maryville	USGS**	Published

* Tennessee Division of Geology.

** U. S. Geological Survey.

this division is estimated to be 60 degrees, based upon its trace on topography.

In the southwestern part of the division, several interesting features occur along the trace of this fault (Section 3, Plate II). South of Alpha a small fault branches from the main fault. Two thousand feet to the southwest another fault branches from the small fault. These faults have little displacement since they involve only the Upper Knox and Lenoir Limestone. They terminate as imbrications in the Mascot Dolomite. A short distance southwest of the point of intersection of these previously-described faults with Fault A, there is a slice containing Copper Ridge Dolomite, Maynardville Limestone, and Nolichucky Shale. The less competent shales are at the south end of this slice. At the southern end of the slice, the displacement along Fault A increases rather abruptly. The displacement has increased from Maynardville Limestone on Upper Knox and to Maryville-Lenoir Limestone on these latter two units, a stratigraphic interval of from 3000 to 4400 feet.

Structure Along Fault B

The other major fault in this division terminates in Springvale Quadrangle almost due east of Morristown. The exact nature of the termination is indeterminate since it is concealed by deep residuum of the Knox Group. The hanging wall contains all the units of the section from the Rutledge Limestone to the Copper Ridge Dolomite. Due to the anticlinal nature of the hanging wall, the throw of the fault changes from an almost negligible amount to about 1800 feet in a distance of four miles. Southwest of Morristown, Maynardville Limestone is thrust over Copper Ridge Dolomite. North of Valley Home Maryville Limestone, Rogersville Shale, and Rutledge Limestone are in the hanging wall adjacent of the fault. Along much of its extent incompetent beds of the Maynardville Limestone, Nolichucky Shale, Rogersville Shale, and Rutledge Limestone are in the hanging wall. The attitude of the fault appears to be between 50 and 65 degrees throughout its length. Along most of the extent of the fault in this part of the structure, the footwall rocks are the Copper Ridge and Chepultepec dolomites. East of Talbott a slice containing the Maynardville Limestone and the Nolichucky

Shale is present. This slice is anticlinal with the Nolichucky Shale exposed near the crest of the fold.

Minor Faults

There are several small faults in this area, some of which are shown on Plate I. One is southeast of Morristown and involves a slight offset of the northeast end of an anticline in which the Maryville Limestone core has been faulted over Nolichucky Shale. The displacement on this fault is on the order of a few tens, or at most 100 to 200 feet. A second minor fault results from the breaching of an anticline with Maryville Limestone faulted over Nolichucky Shale. The maximum displacement probably does not exceed 200 feet. A third minor fault offsets the northwest limb of the broad syncline located south-southeast of Morristown. It is probably a small cross-fault, but could be interpreted as a reverse fault. The lateral offset is about 900 feet.

Major Folds

Two major folds are present in the hanging wall rocks of Fault B (Section 1, Plate II). Southeast of Morristown the rocks of the Conasauga Group plunge northeastward beneath

the Knox Dolomite in two symmetrical anticlinal folds with roughly parallel axes. The plunge of the axis of the northern fold is about seven degrees northeast while that of the southern fold is four degrees. In the intervening syncline the Copper Ridge Dolomite is present, along with a few outliers of Chepultepec Dolomite. The Chepultepec is present in the area between the ends of the Conasauga outcrops, and it is continuous farther northeast. In the cores of the anticlines, Maryville Limestone is exposed southeast of Morristown where the folds become sharper. To the southwest the axis of the northwestern fold is cut off by Fault B; and the syncline between the fold broadens out, but does not contain rocks of the Knox Group (Section 2, Plate II). The upper part of the Maynardville Limestone is the youngest unit present. The southeastern fold becomes sharper in the area east of the broad syncline; and the faulted anticlinal core of Maryville Limestone is present, as described before. To the southwest the central syncline becomes more narrow. Nolichucky Shale is present in the axial zone, and a little farther southwest Maryville Limestone is present (Section 3, Plate II).

Innumerable small folds are present in this segment of the structure. Some are indicated on Plate I, but most are too small to show at this scale. As a rule the folds are tight and most are overturned to the northwest.

Division II: Zone of Two Faults
(North of Edna to South
of Mount Horeb)

This division is characterized by two major faults and no major folds. It is structurally the most simple of the six divisions.

Structure Along Fault A

Here the most interesting feature is the abrupt change in the attitude of Fault A, occurring one and three-tenths miles north of Edna (Section 4, Plate II). At this place the fault flattens abruptly, as indicated by the S-shaped trace. Although not shown too clearly on Plate I, the hanging wall formations essentially parallel the hooked shape of the fault trace. The footwall here is a faulted syncline containing Lenoir Limestone and Mascot Dolomite.

South of Mount Horeb a smaller fault branches from Fault A and extends two miles northeastward, essentially

parallel to the main fault. The maximum displacement on this fault is 200 to 300 feet, with Mascot Dolomite thrust over Lenoir Limestone. The synclinal character of the footwall is again apparent in this area and along the main fault trace (see Section 5, Plate III). All along the main fault are small synclines of Lenoir Limestone.

In this division the attitude of Fault A is 40 to 50 degrees. This value is based on the measured attitude of the fault in the next division to the southwest, since it does not appear to change in this division.

Southeast of Mount Horeb another smaller fault branches from the main fault trace, trending into the hanging wall and extending 2000 feet southeast. Rutledge Limestone and Rogersville Shale are thrust over Maryville Limestone, a stratigraphic displacement of 200 feet.

In the hanging wall sequence of Fault A there are no other irregularities, and the sequence in this division is homoclinal. Rocks as young as Copper Ridge Dolomite occur in the sequence. The maximum stratigraphic displacement is 5000 feet.

Structure Along Fault B

In the southeastern part of the structure, the trace of Fault B has an appearance almost identical to Fault A in this division, but with minor variations. The footwall sequence of this fault is the hanging wall sequence of the preceding fault, and Copper Ridge Dolomite is the youngest unit present at the surface (see Sections 4 and 5, Plates II and III).

North of Edna, Rutledge Limestone is the hanging wall formation, but to the southwest a short distance along strike it is basal Maryville Limestone. West of Edna, the Rutledge Limestone is in the hanging wall of the fault for a short distance, but southward successively younger formations appear near the border of the division. Maryville Limestone is thrust over Copper Ridge Dolomite.

Near Chestnut Grove a small fault branches from the main fault and strikes almost due east in the hanging wall. It terminates in the shales of the Nolichucky and in beds of the upper Maryville Limestone. The fault trends into an anticlinal area, but it cannot be traced farther than the Maryville-Nolichucky boundary. The folds associated with this fault involve the Maryville Limestone, Nolichucky Shale,

and Maynardville Limestone, and are traceable with difficulty into the overlying Knox units.

Many minor folds are present in this division, although there are not as many as elsewhere. Their symmetry and trends are similar to those described in Division I.

Division III: Imbricate Zone A
(South of Mount Horeb to
Southwest of Dumplin)

In this zone the two major faults persist. But there are many slices, smaller branch faults, and faults overriding other faults (see Sections 6, 7, and 8, Plate III). The structure along Fault B is more complex than along Fault A. Also, there are numerous folds present, some of which are of considerable magnitude.

Structure Along Fault A

About one-half mile northeast of where State Highway 92 crosses Fault A, are two small branch faults which strike to the south and end a short distance in the Rutledge Limestone. They represent hanging wall imbrications of the main fault and have little displacement.

In the vicinity of the two small branch faults mentioned above, the hanging wall rocks of Fault A belong to the Rutledge Limestone, but southwestward progressively older rocks are adjacent to the fault--the Rome being the oldest unit present. This exposure is the northeasternmost of the Rome in the Dumplin Valley zone, and with its appearance is a complimentary increase in the complexity of the structure (Section 6, Plate III). Fault A maintains a rather singular trace from the northeastern end of the Dumplin Valley structure to just north of U. S. Highway 25W-70, but at this place the faulting is complicated by several branch faults and additional faults in the footwall. The fault trace branches into two segments (Faults C and D; see Section 7, Plate III). Pumpkin Valley Shale is the hanging wall formation in Fault D for 1000 feet, then Rutledge Limestone. About 2000 feet from the first split, there is a second branch of the fault trace (Fault C), with Copper Ridge Dolomite as the hanging wall formation, and striking more west than south. A little further on, the latter fault cuts the remaining formations of the Knox Group where the strike of the formations is to the south. Also, the fault trace has turned southward, with Mascot Dolomite faulted against Lenoir Limestone. Fault

C decreases in displacement until it terminates along the Knox-Lenoir contact southeast of Willardtown. Probably it terminates as imbrications in the nose of the Chickamauga syncline. The syncline plunges to the southwest in the main footwall. The maximum throw of Fault C is 3000 feet.

The footwall of this latter fault, and that of Fault A farther northeast, is the Lenoir-Mosheim-Knox sequence. In places faulting has omitted the Lenoir and Mosheim limestones and the footwall formation is the Mascot Dolomite.

Fault D, northwest of Piedmont (on U. S. Highway 25W-70), has two slices along it, one of Rutledge Limestone and Rogersville Shale, and the other of Maryville Limestone faulted over the latter slice. The Maryville slice is much smaller in size than the other. About 2000 feet from their northeastern point of origin, the slices have terminated. Also, the fault is a single plane with Rogersville Shale thrust over Maryville Limestone, and then Maryville over Maryville a short distance farther on. The trace of Fault D rejoins the southeastern portion of Fault A at Dumplin. The rocks bounded by Fault D and the main trace of Fault A are interpreted as a large slice (Section 8, Plate III).

Fault A is exposed at the point where State Highway 92 crosses Shields Ridge, about one-half mile northeast of Oakland (Figure 22). The dip of the fault plane here approximates 45 degrees. The fault plane is in a two foot weathered zone and a precise measurement could not be made. The hanging wall formations of the southern segment of Fault A at Piedmont include those from the Rutledge Limestone to the basal Maryville. For about one mile Maryville Limestone is thrust over Maryville, and the fault was located by differences in the attitude of beds. Then the Maryville Limestone is thrust over Nolichucky Shale in the footwall, and then succeeding higher footwall units of the Conasauga and Knox Groups. Since the throw on the fault increases to the southwest, it would be at a 2500 foot maximum at the southwest edge of the division. In this area evidence that the fault plane is in shale beds comes from a small pod of Rogersville Shale present at the juncture of the fault with the Conasauga-Knox contact in the footwall just west of Dumplin. The footwall rocks in contact with the fault are successively younger to the southwest. In this area the fault overrides the southeastern limb of the Knox-Chickamauga syncline mentioned earlier, which persists to the end of the structure.



Figure 22. Exposure of Fault A. The thick sandstone beds of the Rome Formation to the right are thrust over Lenoir Limestone in the lower left. The fault plane is located in the weathered zone in the center of the photograph. The approximate attitude of the fault is 45 degrees. Jefferson City Quadrangle along State Highway 92 about one-half mile northeast of Oakland.

In the hanging wall of Fault A, the section contains rocks as young as Maynardville Limestone. Several notable features are present here. About one mile northeast of where State Highway 92 traverses the hanging wall, the outcrop belt of Rogersville Shale has widened to a maximum of over 1000 feet. This is probably a small structural terrace or flattening of the beds in this area rather than a stratigraphic thickening.

About one mile northeast of Piedmont, there is a small breached anticline with Pumpkin Valley Shale in the core. This anticline is recognizable for some distance along the base of the large Rome ridge in this area, and is broken along only a small segment.

Also in the Piedmont area, there is an anticline and syncline in the Rogersville Shale and in adjacent units where they are near Fault A, against which they are terminated. The fold is very tight, and there is much contortion of bedding in the Rogersville.

Southeast of Piedmont, the sequence is normal from the Maryville Limestone up through the synclinally preserved Maynardville Limestone. This syncline is very tight with vertical or steeply inclined beds on the southeast side.

The axial plane dips to the southeast, and the syncline plunges to the southwest. The fold is faulted along the southeast side over part of its extent, but the fault is terminated along the Maynardville-Nolichucky contact in the northeastern part of the fold (Section 7, Plate III).

Structure Along Fault B

At the northeast boundary of this division, the fault is a single trace. A short distance into the division there are many overridden segments and slices.

On a line about half way between Oakland and Chestnut Grove is a split in the trace of the Fault B. The northwestern branch of the fault (Fault F) is thrust over Copper Ridge Dolomite. A short distance to the southwest, it is thrust on Maynardville Limestone and Nolichucky Shale. The trace of Fault F rejoins that of Fault B south of Piedmont. The intersection with the main fault is about in the center of the large slice present in the area. Along this fault there are several small branches into the hanging wall and the footwall (Sections 6 and 7, Plate III). The hanging wall is primarily an asymmetric Maryville-Nolichucky syncline, but beds as young as Copper Ridge are present. Beds on the

southeast side are overturned or vertical, whereas those on the southwest are more gently inclined to the southeast with dips up to 60 degrees. The plane of rupture has a relatively high angle (50 to 60 degrees, estimated from the map). The termination of this fault is in the Nolichucky Shale 3000 feet south-southeast of Oakland. A slice of Maryville Limestone is present along this fault about two miles east-northeast of Piedmont and one and one-half miles south-southwest of Oakland.

Overriding the faults discussed above, Fault B may be easily traced to the southwest with its relatively simple hanging wall sequence. The Maryville Limestone is the hanging wall formation as far as a point about one mile northeast of the intersection of U. S. Highway 25W-70 and the fault. At this point the Rogersville Shale is the hanging wall formation, and 1500 feet to the southwest it is the Rutledge Limestone. The Rutledge is the hanging wall unit to a point south-southeast of Piedmont where Pumpkin Valley Shale is in the hanging wall at the surface, and remains so for a distance of about one mile before the Rutledge Limestone is again the hanging wall formation for 500 feet. Pumpkin Valley Shale and the Rome Formation are then brought up

along Fault B. This exposure marks the northeasternmost outcrop of Rome along this particular fault. This formation is again present along the fault 2500 feet southeast of Dumplin. From there southwestward, patches of Pumpkin Valley Shale are found at close intervals along the fault to the edge of the division. The attitude of Fault B in this division is estimated from its trace on topography to be 40 to 55 degrees. Fault B is exposed in a road cut about one mile south of Piedmont, where Rutledge Limestone is thrust against Maryville dolomite (Figure 23). Its measured attitude is 40 degrees. The maximum stratigraphic displacement of Fault B is Rome over Maynardville, an interval of about 1800 feet in this division.

There are several slices along Fault B. The smaller slices are all of Maryville Limestone and are spaced along the fault in the area from about one-third mile southwest of where U. S. Highway 70-25W crosses the fault to one and one-fourth miles southeast of Oakland. A larger slice composed of the Rutledge and Rogersville units is present about one mile south of Piedmont, and overrides one end of Fault F.

In the hanging wall of Fault B in the area adjacent to where State Highway 92 crosses the fault, and in the



Figure 23. Exposure of relatively undeformed Rutledge Limestone (right) thrust over crushed beds of the Dumplin Valley Dolomite Member of the Maryville. The attitude of the fault is 40 degrees. Pencil is on fault. New Market Quadrangle at French Mill, about one and one-half miles east of Piedmont.

Maryville belt to the northeast of this point, the Rogersville Shale is present in the cores of several small anticlines in the area, one of which crosses the highway. This folding is a southwest continuation of the hanging wall structure farther northeast. Also, the overlying Knox units are complexly folded in the belt to the southeast. A part of this structure extends into the Dumplin Valley area as a syncline with a faulted anticline to the south of it (Sections 6, 7, and 8, Plate III). This area is northeast of Deep Springs. The most extensive of the two faults present (Fault E) terminates as an imbricate zone in the Maryville Limestone about one mile south of Dumplin. The terminations were traced by the repetition of the Dumplin Valley Dolomite Member in the Maryville section. The dip of Fault E is estimated from its trace on topography to be about 60 degrees with displacement varying with position along the fault. In the footwall of the fault, the southeastern limb of the syncline is very asymmetrical to the northwest, with vertical or steeply dipping beds (Section 7, Plate III). The hanging wall rocks are steeply inclined to the northwest along the fault and dip gently on the southeastern side of the anticline. Fault E continues into the Knox belt to the east and

is thought to terminate about 2000 feet northeast of U. S. 25W-70 in a syncline of Kingsport Dolomite.

In the fold area northeast of Deep Springs, the smaller steeply inclined fault has little displacement, and its termination points are difficult to determine. The maximum displacement of this fault is Maynardville Limestone against Copper Ridge Dolomite, an interval of 300 feet. It is traceable for about one mile.

Division IV: Imbricate Zone B
(One Mile Southwest of Dumplin
to North of Seymour)

Faults A and B at the northeast border of this division are single, relatively simple fault planes. But the simplicity ends abruptly a short distance along strike to the southwest. In this division the traces of the two major faults connect with one another (Fault Z), and have numerous imbrications and minor faults along them (Sections 9, 10, and 11, Plates III and IV).

Structure Along Fault A

Fault A at the northeast edge of this division is evidenced by Maryville Limestone against Copper Ridge

Dolomite, a displacement of about 900 feet. About one mile southwest of the northeast division boundary, the trace of Fault B merges with that of Fault A by a fault called Fault Z. It is not known if Fault Z is Fault B overriding Fault A, or if Z is a genetically distinct fault. The writer prefers the latter interpretation and believes Fault B to exist as indicated on Plate I.

About one and one-half miles northwest of Beech Springs in the vicinity of the intersection of Fault A with State Highway 139, the trace of this fault strikes northwest and is a part of a dextral strike-slip fault (Fault H). This cross-fault (Fault H) trends through the Knox Group in the footwall and into the Chickamauga rocks where it disappears. The lateral displacement on Fault H is about 1800 feet.

Fault A continues southwestward from Fault H to the southwest border of this division. Throughout much of this distance the Nolichucky Shale is thrust upon formations of the Knox Dolomite. The attitude of Fault A is thought to be relatively steep due to the attitudes of the beds. It is estimated to be 45 to 60 degrees.

From the cross-faulted area (Fault H at Tennessee Highway 139) southwestward, Maryville Limestone is thrust

over Chepultepec Dolomite. A slice of Copper Ridge and Chepultepec dolomite is present along the fault at the line of Section 11. This slice is one and one-half miles in length and 1000 feet wide (see Section 11, Plate IV).

Adjacent to this Knox slice on the southwest is another slice composed of Nolichucky Shale and Maynardville Limestone. This slice extends to the border between Divisions IV and V. Fault L which bounds part of this slice is a branch from Fault A. Fault L trends northwestward from the slice and dies out in, or at least could not be traced through, the Knox residuum.

It is interesting to note that the Rome Formation is brought up along Fault A in the vicinity of the slices mentioned above.

Almost at the southwestern edge of this division, a small fault (Fault M) with a western strike intersects Fault A and overrides Fault L. There is little apparent stratigraphic displacement on this fault and it probably has a steep dip. Evidence for the fault is mainly differences in attitude of beds. Faults L and M thrust Nolichucky Shale over Knox Dolomite. The displacement is about 3000 feet, and the attitude is estimated to be from 50 to 60 degrees.

About one mile east of Kimberlin Heights, a small east-striking fault in the footwall of Fault A intersects Fault L. This small fault terminates in the Knox one mile to the northeast. Its maximum displacement is Chepultepec Dolomite against Mascot Dolomite, an interval of about 800 feet.

Structure Along Fault B

Along this fault at the northeast division boundary, Rutledge Limestone is thrust over Maryville Limestone; and small patches of Pumpkin Valley Shale occur at intervals along the hanging wall. Less than one mile southwest of the northeast division boundary, there is a small area of Rome Formation exposed along Fault B. Just southwest of this area, there is an intersection of this fault with Fault Z as described above.

At this place the principal rocks involved in the faulting are the formations from the Pumpkin Valley Shale to the Maryville Limestone. The outcrop pattern of the Rogersville Shale is very sinuous in the footwall of Fault B in the area north-northeast of Beech Springs. The shale exhibits considerable thickening in the areas which have been tightly

folded close to Fault Z, with a consequent distortion of the contacts with adjacent units.

The traces of Faults B and Z form a boundary of the complex imbricate zone with the less deformed rocks to the northeast. Along Fault Z Rutledge Limestone is thrust over Maryville Limestone, with a stratigraphic displacement of about 600 feet.

Fault B is overridden by another fault (Fault G), which thrusts Rome and Pumpkin Valley over Rogersville and Maryville units (see Sections 9, 10, and 11, Plates III and IV). The trend of Fault G is more east-west, and it terminates in the Rutledge about one mile northeast of the overridden area.

Northwest of Boyds Creek, the Rome is again brought to the surface in the hanging wall of Fault B. This outcrop belt of Rome is continuous to the edge of the division.

The attitude of the faults in this complex zone is fairly steep. It is estimated that they dip 50 degrees or more.

Structure Along Fault G

Fault G is confined to this division. In the northeast it terminates in Rutledge Limestone, as it does in

the southwest part of the division. The exact nature of the terminations is unknown because of lack of exposures.

About 1000 feet from the northeast end of the fault, a thin veneer of Pumpkin Valley Shale is faulted over Maryville Limestone and Rogersville Shale. Southwest along the trace about one mile from the northeast end, Rome is faulted over Maryville and Rogersville units (Section 9, Plate III). Along this segment the attitude of the fault is estimated to be 50 to 70 degrees. Farther southwest along the strike of the fault, Pumpkin Valley Shale is thrust over Rutledge Limestone. The maximum stratigraphic displacement on the fault is about 700 feet.

About two miles north-northwest of Boyds Creek, a slice is present along Fault G. In this slice Rutledge Limestone and Rogersville Shale are faulted and repeated three times (Section 11, Plate IV). This northwest-trending slice conforms to a similar convex feature in the main fault trace 1500 feet to the northwest.

The remainder of the hanging wall of Fault B is a uniformly dipping sequence from the Rogersville Shale to the Knox Group.

Division V: Zone of Wide Outcrop of the Rome Formation
(North of Seymour to North of Wildwood)

In this division the major fault is Fault B with the Rome Formation constituting the hanging wall (see Sections 12, 13, and 14, Plate IV). The style of faulting is different from that in other divisions. In the other areas there are either two major faults, or imbricate zones developed along the two faults. But here the northwestern Fault A is overridden by the low angle Fault B.

**Structure of the Wide Rome Outcrop
Belt and Related Areas**

Both Faults A and M have been overridden by a low-angle portion of Fault B. The trace of Fault M is overridden about one-half mile south-southeast of Kimberlin Heights by the thin sheet of Rome. The main Fault A is overridden by the same sheet about one mile southeast of Kimberlin Heights. Here the displacement is Pumpkin Valley Shale over Maynardville Limestone, a displacement of about 2300 feet.

About 500 feet south-southeast of the intersection of Fault A with the Rome block, a klippe of Rome Formation

rests upon Rutledge Limestone. This klippe is located 200 feet from the main block and has a diameter of 300 feet.

The major faults on the northwest side of this division are all closely related to one another. Fault B, which forms the outer boundary of the extensive outcrop area of the Rome Formation, is easily traced--the Rome thrust on Knox.

Within the extensive outcrop area the writer located a previously unknown window which is about one and one-half miles northeast of Shooks Gap (see Section 13, Plate IV). Fault B is exposed around the periphery of the fenster. The window is of the eyelid type and is about 500 feet in length and 200 feet in width. The Rutledge Limestone is exposed here. Along strike to the northeast, the Rutledge is exposed in the footwall sequence where the overriding occurs.

The wide belt of Rome is broken by two smaller faults in the area about one mile south of Kimberlin Heights. The first small fault with a southwestern strike intersects Fault B, and is about one-half mile in extent. Major evidence for this fault consists of the different attitudes of beds on either side. There is also topographic evidence as manifested in the valley along which the fault trends. In this area

its stratigraphic displacement must be less than the thickness of the Rome, which is less than 2000 feet, since it is confined to the hanging wall, and the footwall is not faulted to the northeast along the projected trace. The other minor hanging wall fault (Fault N) trends northeast for a distance of three miles from a point on the main fault about one mile north of Shooks Gap to a point one mile southeast of Kimberlin Heights, also on Fault B. The displacement is small since it is confined to the Rome Formation (see Sections 12 and 13, Plate IV). Evidence for the fault is the difference in attitude of beds, and also the topography. The attitude of the fault is estimated from the topography to be 50 to 60 degrees.

In this area Fault B has a dip estimated between 25 to 50 degrees, except in areas on the northeastern end of the Rome block. Here the dip is less steep toward the southwest, probably 15 to 20 degrees. About one mile south of Kimberlin Heights in the area where the two major segments of Fault G are parallel, the northwest segment has an estimated dip of 20 to 40 degrees to the northwest.

Fault B on the northwest side of the Rome block can be traced southwestward to the edge of this division. Along

the trace, the Rome Formation is thrust over upper Knox formations in the southeastern limb of an overturned syncline. About one mile south of Neubert, a fault (Fault R) intersects Fault B (see Section 15, Plate IV). It has a southwest trend and can be traced into Division VI. Evidence for this fault is mainly based on topography and the differences in attitudes of beds, since it is confined to beds of the Rome Formation. At the edge of Division VI there is better evidence for the fault because there is a recognizable stratigraphic discontinuity. Rome is thrust over Pumpkin Valley Shale. The attitude of Fault R is estimated to be 60 degrees.

About 2000 feet west-southwest of the juncture of Fault B with Fault R, the attitude of Fault B has decreased until in one place, almost one mile south of Neubert, it dips 10 degrees (calculated from its trace on topography). As the fault is traced to the southwest, the dip increases to about 30 degrees.

In the area of Shooks Gap Fault P is present with its hanging wall consisting of the Rome Formation and the Pumpkin Valley Shale. The strike of Fault P is southwest, and it terminates in Pumpkin Valley Shale at a point 1000 feet

southwest of U. S. 441 at Shooks Gap. It may be traced several miles southwestward into Division VI. Along most of its extent Fault P is confined to the Rome.

In the southwestern part of the division between Faults P and R, a tight syncline of Pumpkin Valley Shale is present. This fold plunges to the southwest, where younger Conasauga units occur. This syncline continues into Division VI.

Minor Faulting in the Younger Rocks

In the Conasauga rocks southeast of the wide Rome belt are several minor structures. For example, about one-half mile south of Shooks Gap, a small anticline with Maryville Limestone in its core is present. This fold is faulted (Fault O), and the Maryville is against Nolichucky Shale at the eastern end of the structure. Although the anticlinal portion terminates at U. S. Highway 441, Fault O continues into the Nolichucky Shale to another faulted anticline about 2000 feet west of Pitner. In this structure Nolichucky Shale is faulted over Maynardville Limestone. At this end, the termination of the fault occurs in the Maynardville, and the western termination is in the Maryville

Limestone. The maximum displacement on the fault is about 300 feet, and the length is a little more than two miles. The attitude of the fault plane is estimated to be 60 to 70 degrees.

A second minor fault (Fault Q) occurs in this area. Its northern termination is in the Nolichucky Shale just south of the Maryville anticline discussed in the preceding paragraph. The strike of the fault is southwest, and beds of Copper Ridge Dolomite and Maynardville Limestone are thrust over Copper Ridge Dolomite, Maynardville Limestone, and Nolichucky Shale. The maximum displacement is 500 feet, and the attitude of the fault plane is estimated to be 50 to 60 degrees. The fault extends southwest into the next division where it terminates in the Nolichucky Shale. The traceable extent of the fault is about six and one-half miles.

The remainder of Division V has no other notable faults or folds.

Division VI: Southwestern Folded and Termination
Zone (North of Wildwood to the Edge
of the Maryville Quadrangle)

In this division there is a change in the mode of

deformation, both with respect to faulting to folding (Sections 15,16, and 17, Plates IV and V). Here the Dumplin Valley zone is an anticlinorium in the southwest part of the division; and the faults develop many imbrications, displacements decrease, and the faults terminate.

Structure Along Fault B

Fault B thrusts Rome over overturned beds of the upper Knox at the boundary of this division with Division V. The trace is somewhat sinuous in this area, and the attitude of the fault is estimated to be 30 to 35 degrees. In the area along the Knox-Blount County line, and just southwest of it, the main fault trace branches into many imbrications (Faults T, U, V, W, and X).

Two of the imbricate faults (Fault W and X) can be traced west through the Knox, then into the overlying Chickamauga rocks, and back again into the Knox where they terminate. The attitudes of these faults are estimated to be relatively steep, with angles of 60 to 70 degrees.

Along Fault B, the Rome and Pumpkin Valley units are faulted over the Knox and Chickamauga rocks. Just east of Alcoa the fault trace bifurcates, and in the northern branch

Nolichucky Shale is thrust over Knox Dolomite for about one mile. Beyond this point Nolichucky Shale is faulted over Maynardville Limestone and then over Nolichucky Shale where it terminates. The southern branch trends southwest and terminates in the Rutledge Limestone where the Pumpkin Valley Shale plunges southwest beneath the Rutledge. This is the southwestward terminus of Fault B.

Other imbrications (Faults T, U, V, and others) have branched from the main thrust, and all terminate in the same manner (see Section 16, Plate V). The ruptures cut successively younger rocks at the surface, as they finally terminate in the Rutledge Limestone or Pumpkin Valley Shale. The southwestern projections of these faults are a series of folds involving successively younger rocks to the southwest (Section 17, Plate V). The hanging walls of the faults commonly have in them rocks of the Rome Formation and successively younger units.

Faults P and R, which may be traced into this division from the northeast, join and terminate in the same manner as the other faults already described.

The axes of the folds in the termination zone strike $N 35^{\circ} E$ to $N 40^{\circ} E$ (average), while the strike of the entire

structure in this area is N 50° E. This represents a difference from 10 to 15 degrees between the axial trend of the folds and the regional strike.

Minor Faults

In the southeastern part of the division, near the northeast boundary, is Fault Q having small displacement and occurring along the Conasauga-Knox contact. At the northeast boundary of the division, Copper Ridge Dolomite is faulted over Nolichucky Shale with a displacement of about 400 feet. One mile north of Wildwood the fault is terminated in the Nolichucky Shale.

Fault S, which may be traced into the Maryville Quadrangle from the Blockhouse Quadrangle, involves units of the Knox, and terminates in the Nolichucky Shale at the edge of the Dumplin Valley structure. This fault has a slice of the Newala Formation along it between Chepultepec, Longview, and Kingsport units in the footwall, and Longview, Chepultepec, and Copper Ridge dolomites in the hanging wall. It is not related to the Dumplin Valley structure.

The faulted structure as shown in the present compilation ends with this zone of imbricate faults that

terminate as folds. The structure continues to the southwest as an anticlinorium; and probably, one or more faults with diminished throw continue as far as Englewood (Rodgers, 1953, p. 136). Evidence for this continuation is present in the Greenback anticline, which is a faulted structure (Swingle, personal communication, 1965).

Minor Structures

Joints

Joints are well developed and are very conspicuous in the slightly weathered shales and siltstones of the Dumplin Valley area. These features are more widely spaced and consequently less well exhibited in the carbonate rocks. A detailed study of the many and complex joint systems is beyond the scope of this investigation.

Cleavage

Fracture cleavage was observed in a few places in the large syncline located in Division III north of Chestnut Grove. The cleavage is associated with minor folds, and is generally parallel with their axial planes except in the

crests and troughs of the folds where a slight convergence was noted.

Primary Structural Features

Primary features are well developed in several formations but are especially pronounced in the rocks of the Rome Formation. These include cross-bedding, ripple marks, fossil trails, and mudcracks. Similar structures are also present in the silty and sandy beds of the Pumpkin Valley, Rogersville, and Nolichucky Shales. Some of the features listed are suitable for determining whether beds are right-side-up or overturned, but the writer did not have to use these criteria because of a detailed knowledge of the stratigraphic sequence.

Synthesis of Structural Elements

Since many of the details of the Dumplin Valley fault system have been described in the preceding section, the present section is devoted to a consideration of the structure as a single unit. Spacial continuity of the structures in the system are stressed, and the relationships of stratigraphy to structure are discussed. Reference should be made

to Plate I, and to the structure sections in Plates II, III, IV, and V.

Continuity of Tectonic Elements

At first glance, the most marked feature is the continuity of the two major faults (A and B), which extend almost the length of the structure.

Northwest Fault (Fault A)

The northwestern fault has the less complex structure associated with it and is continuous from south of Russellville to south of Kimberlin Heights, where it is overridden by Fault B. From the point where it is overridden to the area northeast of Valley Home, where it intersects the Jefferson-Hamblen County line, early to middle-Cambrian rocks comprise the hanging wall, a distance of about 26 miles. The formations of the Rutledge to Maryville interval predominate in the hanging wall from the Jefferson-Hamblen County line to Russellville, the Knox Group comprises the hanging wall, a distance of 13 miles.

The footwall sequence along the entire extent of Fault A, and related minor faults, is the Knox and Chickamauga

Groups. From Willardtown southwest to where the present study ends, the footwall structure is clearly synclinal. From south of Willardtown northeast to the Jefferson-Hamblen County line, the synclinal character of the footwall is not so apparent, but is suggested by the small patches of Lenoir Limestone synclinally preserved along the fault. From the Jefferson-Hamblen County line to the northeast end of the structure, the synclinal character of the footwall is again apparent with the syncline of Lenoir Limestone present continuously in the footwall.

Fault A is offset by a cross-fault (Fault H) in the area north of Beech Springs. There are no other offsets along this fault, although many imbrications and smaller branch faults are present. It is in this area north of Beech Springs that there is a connecting fault (Fault Z) between Faults A and B.

Fault A has several slices along it. These are generally of greater size than those along Fault B; and those of the former generally contain rocks of several formations, rather than of one competent unit. A good example is the large slice at Piedmont (see Sections 7 and 8, Plate III), which contains the units from the Pumpkin Valley to

the Nolichucky Shale. Another large slice is present along Fault A at the Jefferson-Hemblen County line involving the Nolichucky Shale to Copper Ridge Dolomite sequence (see Section 3, Plate II).

Southeast Fault (Fault B)

Fault B is continuous from east of Morristown to Alcoa, a distance of about 50 miles. The structure along this fault is very complex, and in places an observer would have difficulty discerning from the map which is the southeastern fault.

The structure along Fault B is relatively uncomplicated from the northeast terminus to a point about one mile northeast of Chestnut Grove. One slice occurs along the fault near Valley Home. At the surface this slice consists of the Maynardville Limestone and Nolichucky Shale. The hanging wall east of Valley Home is anticlinally folded whereas southeast of here it is homoclinal as far as Chestnut Grove.

The northeastern zone of imbricate faulting extends along a seven mile segment of Fault B. Here the fault overrides a series of faults which involve the rocks in the Rutledge to Copper Ridge interval. The traces of the smaller faults parallel the trace of the main fault.

The southwest imbricate zone is more extensive, having a length of about 10 miles. The structure in this zone is very complex, particularly at the northeast end. It is in this portion that the two major thrusts are connected and that many smaller branches occur.

In the hanging wall of Fault B, the Rome to Rutledge sequence is present from the area south of Oakland to just east of Alcoa, a distance of 34 miles. From this area northeastward to a point southeast of Morristown, the lower part of the Maryville Limestone with patches of Rogersville and Rutledge units are thrust over the Upper Conasauga and Knox units. Northeast of Valley Home the hanging wall formations are the Maryville Limestone, Nolichucky Shale, Maynardville Limestone, and Copper Ridge Dolomite. The younger units are the hanging wall formations successively to the northeast.

The hanging wall is also broken by several smaller thrusts (Faults E, G, O, and Q). These are not extensive, the longest being eight miles. Only the most extensive of these (Fault G) is directly connected to the Dumplin Valley structure.

South of Kimberlin Heights is a synclinal portion of Fault B which has been thrust over the northwest half of the Dumplin Valley zone. This fault may be traced southwestward to the zone of terminations, where many branches and imbrications pass into folds.

It is proposed that Fault B, due to its complex structure and greater lateral extent, be called the Dumplin Valley Fault. Fault A previously has been called the Dumplin Valley Fault, but the structure along this fault is less complex and it is less extensive than Fault B.

Folds

The major folds in this structure are much less extensive than the thrusts. The most conspicuous areas of folding are at either end of the structure where the faults terminate and deformation is less intense resulting in unbroken folds. However, other folds are present in the zone, such as those at Chestnut Grove and north of Deep Springs. These are even less extensive and are subsidiary to the gross structure. The folds in the intensely faulted areas are either remnants of an original fold which was broken by faulting or are drag folds formed by faulting.

There are two large, symmetrical, open folds with parallel axes present at the northeast end of the system (see Section 1, Plate II). The more extensive of the two extends about eight miles. At the surface these folds involve the Maryville Limestone or younger rocks.

At the southwest end of the structure, the numerous tight folds are projections of the terminal areas of the many branches of Fault B (see Section 17, Plate V). The most extensive has a length of six miles. These folds involve the Rome Formation or younger rocks at the surface and plunge to the southwest.

Relationship of Stratigraphy to Structure

The reason for the lateral extension of the faults is probably stratigraphic. Also, some control of the folds at either end of the structure may be attributed to stratigraphy.

Relative Competency of Stratigraphic Units

The Rome Formation, with its shale and siltstone beds, is well known as an incompetent unit. Throughout the Valley and Ridge of Tennessee this is the glide zone of several major faults. The Pumpkin Valley, Rogersville and Nolichucky

Shales, and the shale member of the Maynardville Limestone, are also incompetent glide units.

The Rutledge Limestone would appear to be a competent formation, but the writer has observed tight folds and numerous other small structures resulting from drag. These are features not widespread in competent units. The incompetency of the Rutledge Limestone is attributed to the numerous silty bands and partings which permit the normally medium-to thick-bedded formation to perform under stress similar to a thin-bedded or shaly unit.

The Maryville and Maynardville limestones are both competent units and act as buttresses under stress. The carbonates of the Knox Group are also competent. The role of the Knox is discussed further in the succeeding section.

Of the rocks of the Chickamauga Group, the Lenoir Limestone is incompetent along with the Tellico Sandstone and Ottosee Shale. The Holston Limestone is a relatively competent unit where it is thick.

Role of the Knox Group in the Structure

The Knox Group is the main buttress in the Dumplin Valley structure. It is a 3000 foot thick competent unit

through which stresses are transmitted. The numerous small faults and tight folds, which involve the Conasauga units and rarely the basal part of the Knox Group, were undoubtedly formed as a result of the confining strength of the overlying Knox Group. The tight folds occurring in the Conasauga at the southwest end of the structure probably do not extend up into the Knox but were formed as readjustments in the space beneath the Knox during the formation of the gross structure. Tight folding occurred here below the Knox because of the alternating sequence of competent and incompetent rocks. Faulting did not occur because the amplitude of the main fold was less here. Since the Knox is the principal controlling strut in the structure, the amplitude of the Dumplin Valley fold was probably controlled by it.

Discussion of Structural-Stratigraphic Relationships

Fault planes below incompetent layers have been noted many times in the preceding descriptive sections. All of the major faults are beneath beds of incompetent material, or else in the basal few feet of a competent unit, except in the relatively few places where faults have refracted

across a competent formation to another incompetent unit. Toward the southwest end of the structure, the faults tend to occur beneath incompetent beds of older formations, such as the Rome, Pumpkin Valley, and Rutledge. Northeast from Mount Horeb in the Jefferson City Quadrangle, the faults are commonly beneath a thin veneer of Rogersville Shale, but a few are below beds of the Rutledge Limestone.

In the northeast imbricate zone (Division III), fault planes are generally above and below the Nolichucky Shale; but in the southwest imbricate zone (Division IV), they are mainly in the older rocks. The Nolichucky Shale is interpreted in almost all the structure sections as being a glide zone, particularly in the footwall sequence.

Relative competency and incompetency of beds controls the style of folding at either end of the structure. To some extent the Pumpkin Valley and Rogersville shales, but particularly the Nolichucky Shale thickens to the southwest, whereas the Rutledge and Maryville Limestones thicken to the northeast. The folds at the southwest end of the structure are tight folds and are associated with the incompetent units. Those at the northeast end are concentric folds which are commonly controlled by competent units. Thus the higher

shale to carbonate ratio at the southwest end of the structure results in tight folds whereas the lower shale-carbonate ratio at the northeast gives rise to open folds. These findings bear out the ideas of Willis, who 75 years ago studied experimentally the effects of stress upon competent and incompetent rocks (Leith, 1923, p. 170).

Interpretation

Subsurface Structural Features

Since there is no drill nor geophysical data in this area, the subsurface configuration of the faults and folds is based upon projection of surface data. The structure sections (Plates II, III, IV, and V) illustrate the projected patterns of these faults and folds to depth. In drawing the sections care has been taken to maintain the measured or calculated thicknesses of the formations at depth. Certain other principles have also been adhered to such as the fault planes are assumed to follow incompetent formations as they do at the surface. This assumption was originally applied by Rich (1934) to the Pine Mountain fault, and more recently by King (1964) to the Great Smoky fault.

Ample evidence has been presented in the preceding descriptive sections to substantiate this belief.

A problem inherent with projecting structures to depth is the termination, divergence, coalescence, or parallelism of faults. In this regard it was assumed that the relationships between the major and minor faults are maintained at depth, although at some depth both groups of faults must coalesce or terminate. The major faults are thus projected into the Rome Formation, since it is probably the main decollement zone. The minor faults are thought to terminate by distributive slippage and tight folding in higher incompetent units, such as the Rogersville or Nolichucky shales. Evidence for these ideas comes from the lateral terminations of the faults observed at the surface. As seen on Plate I, some of the minor faults, such as Fault Q, terminate in the Nolichucky Shale. In Division V on Plate I the several imbrications of Fault B pass into folds or die in the incompetent shales of the Nolichucky or Pumpkin Valley Shale. Thus, observations of the surface pattern of structures such as these have profoundly influenced the construction of the structure sections.

It is thought that Faults A and B do not connect in the subsurface immediately beneath the Dumplin Valley zone. The continuity of the faults and the lack of connections between them (except at Fault Z) at the surface seems to warrant this assumption. They probably extend as separate entities into the decollement where they must merge, perhaps with the Saltville fault, the next major fault to the west which presumably is present beneath the Dumplin Valley zone. Subsidiary faults which connect with Faults A and B on the surface are thought to connect with these faults at shallow depth, unless the structure section intersects one of these faults near its terminus (for example see Sections 6 and 7, Plate III).

Comparisons should be made between the interpretation of the present writer and those of other workers whose maps are already published or in press. The structure sections for Morristown Quadrangle drawn by Milici (1965) were not available at the time of writing so no comparison could be made.

Harper (1963) and Swingle (in press) have interpreted the structure in the Boyds Creek Quadrangle. Their interpretations are essentially the same and both connect the

two major faults (A and B) at relatively shallow depth. This is contrary to the present writer's interpretation, (see Sections 10, 11, and 12, Plate IV). This writer reasons that, since the faults do not connect at the surface, it is unlikely that they would connect at shallow depths. In Section A-A' of Swingle (in press) and Section F-F' of Harper (1963), the interpretation is a single movement along Fault B with subsequent folding at the present erosion surface to produce the large block of Rome Formation in that area (see Plate I, Divisions IV and V). The interpretation of the writer (Sections 12 and 13) is that the low-angle sheet formed by faulting and folding, but its present configuration is due to subsequent movement on the southeast segment of the fault. This is evidenced by the rupture in the large block which is traceable to the southeast for some distance from Division IV into Division V (Plate I). Also, in this section Fault M (see Plate I) is interpreted by the two other writers as being a major fault extending to considerable depth, or else not related to the Dumplin Valley structure. This writer interprets this fault as a minor fault that has been overriden by the major faults. Since Fault M intersects Fault L on the surface a short distance to the

northeast of Section 12, and the latter fault intersects Fault A nearby, it is assumed to intersect Fault A in the subsurface, as is shown in Section 12 (Plate IV).

The cross section in the Shooks Gap Quadrangle (Cattermole, 1955) does not extend to the Dumplin Valley zone so that his interpretation of the structure is unknown.

Sections 14 and 15 (Plate IV) in part cross the Wildwood Quadrangle. The interpretation of this writer is in general agreement with that of Neuman (1960), with one notable exception which involves Fault Q (see Divisions V and VI, Plate I). Neuman extends the fault into the Knox where it terminates. This writer prefers to terminate the fault in an incompetent glide zone, which is the Nolichucky Shale in this instance. Evidence for this is in the terminations of the fault on the surface, which are in this latter unit.

Section A-A' of Cattermole (1962) in Maryville Quadrangle lies between Sections 16 and 17 (Plate V; see also Plate I, Division VI). There are two major differences between the interpretation of this writer and that of Cattermole: (1) the present writer believes that the sharp folds present in the terminal zone do not bottom out at relatively shallow depths as open folds, as is the interpretation of

Cattermole. This belief is based mainly upon the types of rocks involved. Since most are incompetent units, the folds should be tight rather than open folds (see p. 119 and 120); (2) Cattermole has some 800 feet of Pumpkin Valley Shale in his section. He does not report a thickness in his discussion, but Neuman (1960) in the adjacent Wildwood Quadrangle reports but 100 feet of this unit. The wide outcrop belts of Pumpkin Valley Shale are due to an overall low dip for the formation but probably crumpling of beds gives local steep dips at the surface.

None of the writers discussed above extend their sections very deep. This is due to the lack of information in these areas; and the present writer does not pretend to have more than they. However, it is interesting to speculate and present ideas on the structure at these depths; and present-day theory coupled with the surface thicknesses provides some basis for the deep sections..

In Section 11 (Plate IV; also, see Plate I) explanation of the complex structure of the salient in Fault G is attempted. The interpretation is a series of slices, and the fault extends into the hanging wall of Fault B where it connects with that fault. This feature probably results

from folding of the hanging wall of Fault B and compressive readjustment in the hanging wall of Fault G, producing the overriding slices.

Interpretation of the southwest extent of Fault A beneath the Rome block in Division V (Plate I) is somewhat speculative (see Sections 12, 13, and 14, Plate IV). The existence of Fault A in Section 12 is almost a certainty, since the section is located only one-half mile from the outcrop trace of the fault. Its presence in Section 13 is assumed since the fenster present along Fault B exposes part of the same hanging wall sequence present to the northeast along Fault A. In Section 14, the fault is thought to have terminated, or possibly joined Fault B, since the style of deformation is changing to that dominant in Division VI.

In Sections 15 and 16 (Plates IV and V) the decollement is interpreted as having a minimum depth of about 5000 to 6000 feet beneath the surface. In Section 17, it is at a minimum depth of 3000 feet. The change from faults to folds necessitates the change in elevation. But, unless the Saltville fault is also folded here, there is not enough Rome Formation to fill the space beneath the Conasauga folds in an undisturbed state. It is thought that the Saltville fault

is not folded but that small thrusts exist in the Rome which repeat it many times in the area beneath the folds. Deformation has not been intense enough in this area to fault the Conasauga Group.

Origin of Slices

There are numerous slices along the faults of the Dumplin Valley belt (see Sections 3, 6, 7, 8, 9, 10, 11, 12, and 15; Plates II, III, and IV). The larger slices are found along Fault A. Many slices contain rocks which are of intermediate age between the ages of the footwall and hanging wall rocks. It is thought that the slices were once part of the synclinal footwalls which have been detached and carried upward during faulting. In the case of each slice in this fault system, downward projection of the surface footwall rocks adjacent to a slice will yield formations of the same age as those of the slice.

Several of the slices contain rocks of almost the same age as those of the hanging wall (see the northwest slice in Section 3, Plate II, and slices in Sections 7, 8, and 11, Plates III and IV). These masses of rock have been detached from the hanging wall and are fairly close to their

points of origin. A few have simply been rotated with but minor net slip.

The slices which are present along a given fault are assumed to be synchronous with the major fault movement.

Age Relations of Faults and Folds

There are several possibilities for the relative ages of the structures in the Dumplin Valley zone: (1) they could have formed at the same time; (2) each could have formed at different times; (3) they could have formed in an orderly sequence; (4) they could have formed in a disorderly sequence; or (5) there could have been a more complex origin than any postulated here.

The writer believes that there is a definite sequential relationship in the chronology of deformation due to the overlapping of structures and the deformation of structures already formed by other events in the complex history of the Dumplin Valley system. It cannot be said that the sequence is orderly or disorderly, nor can the time intervals between deformations be discerned. However, it can be said that, since the present sedimentary column has

no breaks in it related to the Dumplin Valley structures, the deformation did occur after the cessation of sedimentation.

Chronology of Faulting

The faults in the Dumplin Valley zone appear to bear a definite chronological relationship to one another. An assumption must be made regarding the relative times of formation of the faults. This assumption is that the younger faults and deformations override, or deform, the older structures. With this assumption the oldest structures would be on the northwest side of the Dumplin Valley zone.

Fault A is the older of the two major faults. But the faults which branch from Fault A in the footwall north of Edna, south of Mount Horeb, north of Piedmont (Faults C and D), and southeast of Kimberlin Heights (Faults L and M) probably represent earlier ruptures formed before the main fault plane was localized and were then overridden by the main fault. It is realized, however, that they might also represent faults which were formed contemporaneously with the main fault; but if so, they were formed in the later stages of movement. The former idea seems to be the more

likely possibility because of the manner in which these faults are cut off by the main fault. If these faults were contemporaneous, there should be in some cases breakage of the hanging wall in association with the faults. None has been found by the writer.

The small fault in the hanging wall south of Mount Horeb represents a small amount of later movement on part of the fault causing breakage in the hanging wall. Movement would not necessarily have had to occur much later; it could have taken place just after the movement on the main fault ceased.

Fault Z, occurring in the area north of Beech Springs, represents a fault that developed after the northwest fault. Movement along this later fault was facilitated by the utilization of the fault plane of Fault A along much of its extent; but, in the area northeast of Beech Springs, it cut through the Maryville Limestone to a higher weakness plane and was overridden by Fault B, or became a part of it.

Based upon the original assumption of this section, proof that Fault B is younger than Fault A is present in the area south of Kimberlin Heights, where overriding of Fault A by Fault B has occurred. This relationship is not so clear

to the northeast; but the relationship is apparent since the hanging wall of Fault A has been overridden by Fault B.

It is thought that the faults of the two imbricate zones, since they, for the most part, have traces parallel to the main southeast fault (Fault B), formed in the footwall sequence as a kind of "sympathetic" faulting, taking up some of the stresses transmitted into the footwall by the advancing block of the southeast fault. Once the adjustments had been made, some overriding of these two zones occurred before movement on Fault B ceased.

Features of the Hanging Wall of Fault B

The folds which are present on the hanging wall of this fault in the Morristown area are older than the main fault. The evidence for this conclusion is that the axes of these folds do not follow the trend of the faults as would be expected if they were drags. Also, the axis of the northernmost fold is cut off by the main fault.

The small fault west of Chestnut Grove in Jefferson City Quadrangle is probably younger than the main faulting. It represents secondary movement which occurred in the hanging wall after major movement had ceased. The fold

structure into which this fault trends is older than the major faulting; and the smaller fault developed along a structural weakness set up by the folding.

The folds and associated faulting in the area north of Deep Springs are contemporaneous with other folding and faulting in the Dumplin Valley area. The folds formed before the major Dumplin Valley faults, and were later broken by the faults in the same area. The faulting which occurred probably took place later than the major faulting in the area. The folds are not believed to be drag folds since they continue beyond the area of faulting. Rupture of the folds occurred in a zone of more intense deformation.

The extensive hanging wall thrust (Fault G) in Boyds Creek and Douglas Dam quadrangles has overridden Fault B, presenting straightforward evidence for the later development of this feature, after the main fault. The convex trace of a portion of the southwest segment of Fault G conforms to a similar feature in Fault B just to the northwest. This implies some contemporaneity of movement on the southwest end of Fault G. Later movement occurred at the northwest end, producing the overriding of the main fault. Additional movement had to occur in the hanging wall in the localized

area of the convex feature to produce the two faults which are convex to the southeast. These connect on the surface and at depth with Fault G (see Section 11, Plate IV and Plate I).

The faults, which occur in the wide belt of the Rome Formation south of Kimberlin Heights (Faults N, P, and others), represent movement in the hanging wall subsequent to that of Fault B. These ruptures are probably readjustments which formed during the synclinal folding of this portion of the hanging wall. The later movement on part of the hanging wall during or after this episode broke the hanging wall again.

The small fault southeast of Shooks Gap (Fault O) is a further readjustment and breaking of a fold which formed after movement on Fault B ceased. The small fold which is broken probably formed during the major movement. The small fault north of Wildwood (Fault Q) is also younger than the major faulting.

The overlapping segments of Fault B in the area northeast of Alcoa are successively younger than the main fault. However, Fault B is younger than the faults which it overrides in the Knox and Chickamauga rocks in this area

(Faults W and X). The associated folds present to the southwest are older than the faults into which they trend.

Fault S, which is present in the south part of the Maryville area, predominately in the Knox units, is younger than the Dumplin Valley family. It is probably contemporaneous with the fault which terminates just northeast of the terminus of this fault.

Age of the Structure

The youngest rocks directly involved in the structure at the present erosional level are of Middle Ordovician age. This would serve as a maximum age for the Dumplin Valley system, for it must be post-Middle Ordovician.

Pennsylvanian rocks are present in the Valley and Ridge of Tennessee near Cleveland (Swingle, 1959); and rocks of Mississippian age are synclinally preserved in many places in East Tennessee (Rodgers, 1953). Assuming these sediments at one time covered the entire Valley and Ridge of East Tennessee, the events which formed the structure could have occurred some time after Early Pennsylvanian deposition ceased. This places a post-Early Pennsylvanian date on the folding and faulting of these rocks.

What would be a reasonable upper limit to the time of formation of this structure? The next known event to occur in the Southern Appalachians after Pennsylvanian sedimentation is the deposition of Triassic sediments in the Piedmont. The Triassic thus is an upper age limit.

It seems reasonable that deformation occurred some time near the end of Paleozoic time. This age corresponds fairly close to the time of the supposed peak of the Appalachian Orogeny.

Mechanical Considerations

"Thin-Skinned" versus "Thick-Skinned" Theories

Two opposing schools of thought have evolved throughout the years regarding the structure of the Central and Southern Appalachians: (1) the "thin-skinned" theory; and (2) the "thick-skinned" theory. Rodgers (1949) has summarized this evolution of thought, and in doing so has profoundly influenced the thinking of many geologists.

Rich (1934) in a paper describing the Pine Mountain block set forth certain ideas which are now a part of the "thin-skinned" theory. He utilized the concept of the

decollement, or Abschurung, originally conceived by Buxtorf about 1916 from a study of the Jura Mountains of Switzerland (in Cooper, 1961, p. 112). The decollement is a zone of weakness, such as a shale or evaporite unit, which facilitates the movement of a fault block in the sedimentary cover above a passive basement. To this concept Rich added the idea that folds associated with these structures result from the fault refracting across a competent zone from one incompetent glide zone to another. These remain as the concrete ideas of the "thin-skinned" theory. However, many subsequent workers have added to this and changed many aspects of the hypothesis to such an extent that today the phrase "thin-skinned" theory has various meanings to different workers, although the basic idea remains the same.

There are also many vague and unanswered questions regarding details of the "thin-skinned" theory. One of these is whether or not the faults converge into a single sole or remain distinct entities and continue for miles. This writer thinks that there could be several sole faults from which minor, less extensive faults could branch. For example, in East Tennessee the White Oak Mountain, Copper Creek and Saltville faults could be major soles (see Figure 1, p. 2).

The Dumplin Valley fault would then be a minor fault branching from the Saltville decollement.

The "thick-skinned" hypothesis is somewhat more well-defined, although fewer geologists today stand by this theory. The "thick-skinned" theory requires that the sedimentary cover adjust passively to extensive deformation in the basement. Thus basement is involved in faulting and the faults have a high angle of dip (Cooper, 1961).

The Dumplin Valley fault system has characteristics of both the "thin-skinned" and "thick-skinned" theories. The faults have moderate to steep attitudes, but also have low-angle segments. No basement rocks have been brought to the surface, and folding seems to have played a dominant role in the deformational history of the structure. However, the folding predates the faulting. It is thought that the Dumplin Valley system is a faulted fold, and the faults follow zones of weakness; but they may be high angle faults.

Faulted-Fold Concept

The fold-related thrust fault idea is not new. Willis in 1893 (Leith, 1923) proposed two types of thrusts resulting

from folds: (1) break thrusts, in which the thrust plane follows a previously formed tension fracture on the crest of an anticline; and (2) shear or stretch thrusts, in which the break follows the sheared and stretched limb of an overturned fold. Heim in 1921 (DeSitter, 1964, p. 200-203) set forth an idea similar to the shear thrust of Willis.

DeSitter (1964) reports many broken folds in the Jura Mountains. These broken folds may form from asymmetric anticlines resulting from either the wedging out of an entire series, or a single competent member, or original differences in elevation between two flanks of the fold.

Gwinn (1964) presents subsurface evidence from the Plateau of the Central Appalachians that beneath concentric folds with no observable surface faulting, there is commonly one thrust or two opposing thrusts in the core of the fold. These faults form compensating for the volume change produced during the folding process. This problem has been discussed in detail by Gwinn (1964) and also by DeSitter (1964).

The Dumplin Valley system is thought to be a concentric fold system with a complexly deformed core. The inner core of the fold is exposed at the present erosional level. If the section is restored above the present erosion surface,

rocks as young as Pennsylvanian could have been present at the time of deformation, as has been discussed in a preceding section. Also, when the section is restored, the two folds of the Dumplin Valley system become a large fold with a doubly faulted core. With these assumptions, generalized sequential sections have been constructed showing the step-wise development of the Dumplin Valley structure (Figure 24).

In this figure (24), the first section at time T_0 shows the undeformed sedimentary cover with the Saltville fault already present. It is beyond the scope of this study to postulate on the amount or time of movement of the Saltville fault; but it is assumed that the Dumplin Valley system is a feature which developed on the hanging wall of the major fault at a time when movement was taking place. Some might postulate that the Dumplin Valley system, since it is on the hanging wall of the Saltville fault, formed as a result of ramping of the latter fault from a lower decollement up to the Rome Formation. If this is so, the Dumplin Valley system should be much more extensive than it is, since for example the Saltville fault extends from Virginia to Georgia.

The Saltville fault probably played an indirect part in the formation of the Dumplin Valley system. The fold

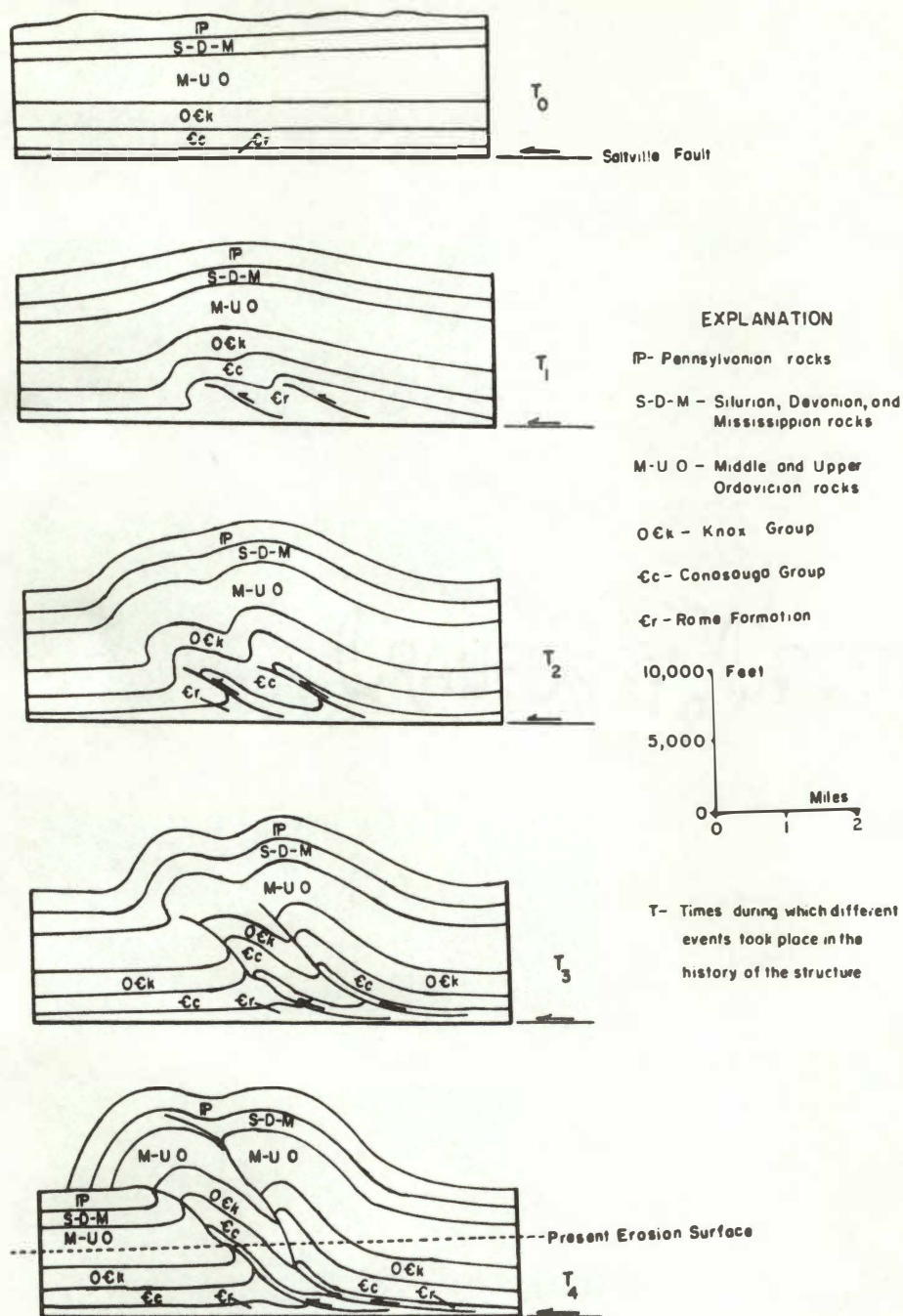


Figure 24. Idealized sequential sections showing the origin of the Dumplin Valley structure by the fold hypothesis.

probably formed as a result of the cessation of movement on the portion of the Saltville thrust sheet in front of the present Dumplin Valley zone. Movement in the area of the Dumplin Valley zone and to the southeast caused the wrinkle to form; and then, as forces persisted, a fold with a faulted core resulted.

The first faulting occurs in the Rome decollement at time T_1 . On the surface the Pennsylvanian rocks would exhibit little, if any, deformation. Only a small, gentle anticline was present. In time deformation increased and with it successively younger units were faulted. In the final stage of major deformation, the faults had probably broken through into the Mississippian or perhaps through the Pennsylvanian rocks onto the surface as erosion thrusts. At some time T_4 the last section shows one thrust on the surface while the other terminates in the Mississippian rocks. The faults were projected this far because of thickness and displacement requirements for the final stage. Erosion has reduced the fold to its present state, as indicated in the last section.

The question of why there are two main faults instead of one could be satisfied by assuming that two faults

developed originally in the Rome decollement to compensate for the volume change in the newly forming fold.

Summary of Evidence for the Faulted Fold Concept

Evidence for the fold origin of the Dumplin Valley system is summarized as follows:

1. A persistent synclinal footwall is present throughout the structure.
2. Faults in the inner part of the structure have folded hanging walls and footwalls.
3. Faults terminate into folds in the southwest part of the structure.
4. Folds at the northeast end of the structure are older than the faults, since they are broken by faulting.
5. Faults cut the axes of folds in the central part of the structure.
6. Numerous folds in the central part of the structure are too extensive to be drag folds.

Semi-Quantitative Deductions

Slip of Faults

Net slip is the total displacement of two formerly adjacent points on opposite sides of a fault plane (Billings,

1954, p. 128). The net slip of the faults of the Dumplin Valley zone is a difficult quantity to measure. From the structure sections (Plates II, III, IV, and V), difficulties arise in scaling off the total displacement on a marker horizon on either side of a fault. It must be assumed that all movement is dip-slip, which is probably not so. Thus the quantity being measured is not net slip and will be simply termed slip. Estimates of the slip have been made using an opisometer to measure the displacement on the two major faults. The results are tabulated in Table IV.

The displacement of different marker units was measured in the sections. The reasons for this are two-fold: (1) a maximum value was sought, so the unit with the most displacement was measured; this is still only an estimate for the minimum displacement; (2) the same units are not utilized in all the sections.

From Table IV it may be seen that in Sections 3, 4, 5, 6, 7, 9, and 11, the estimated slip on Fault A exceeds that on Fault B. But this may be only apparent. The actual movement on Fault B probably greatly exceeds that on Fault A since B overrides A. Also, since the faults are largely bedding plane faults that involve movement within a single

TABLE IV
SLIP ON MAJOR FAULTS

Section Number	Fault A (Feet)	Marker (Top of)	Fault B (Feet)	Marker (Top of)	Sum A+B (Feet)
1	3,200	Rome	7,000	Rome	10,200
2	5,500	Rome	9,000	Rome	14,500
3	8,000	Maryville	4,500	Rome	12,500
4	11,000	Rutledge	7,000	Rutledge	18,000
5	9,500	Rutledge	6,000	Maryville	15,500
6	15,000	Rome	6,000	Rutledge	21,000
7	11,000	Rome	6,000	Pumpkin Valley	17,000
8	5,000	Maryville	7,000	Rome	12,000
9	9,000	Rutledge	7,000	Rome	16,000
10	6,000	Rome	6,000	Rome	12,000
11	11,000	Rome	10,000	Rome	21,000
12	13,000	Rome	13,500	Rome	26,500
13	12,000	Rome	14,000	Rome	26,000
14	Absent	-----	14,000	Rome	14,000
15	Absent	-----	17,000	Rome	17,000
16	Absent	-----	20,000	Rome	20,000
17	Absent	-----	900	Maryville	900
Averages	9,170		9,050		16,130

unit along much of their length, the slip is difficult, if not impossible, to measure. However, these values for the slip on Faults A and B, when combined, serve to indicate the order of magnitude of movement involved.

In Section 17, the slip on Fault B is only 900 feet, and is considerably less than on the same fault in the preceding section and in other parts of the structure. But a value of this magnitude should be expected since this is in the terminal part of the structure.

Crustal Shortening

The meaning of crustal shortening as used here should be defined. This writer uses the term to mean the shortening in the sedimentary cover in association with the Dumplin Valley fault system. Some might extend the term to include the shortening in the entire crust down to the Mohorovicic discontinuity, but this is not the usage here.

Cloos (1940) calculated crustal shortening in the anthracite basins of the folded Appalachians of Pennsylvania and Maryland. His method is to measure the distance between two points along a given bed and the horizontal distance between these two points. A ratio of the horizontal distance

to the distance along bedding is set up and subtracted from 100. This, when multiplied by 100, gives the per cent crustal shortening. The method of the present writer is essentially the same.

Yeakel (1962, p. 1532) also estimated the crustal shortening in the Central Appalachians. His values range from 2.8 to 39 per cent, while those of Cloos range from 1 to 44 per cent.

In the calculation of crustal shortening for the Dumplin Valley system, consideration is given to the fact that this is not a folded area but one in which faults predominate. Cloos (1940, p. 846) thinks that it is more difficult to accurately determine shortening in a faulted area. In the Dumplin Valley zone measurements in Sections 1 through 17 were made on the Maryville Limestone, which is probably the most reliable competent unit distributed throughout the system. Where this formation has been removed by erosion, the section was restored and the projected amount of Maryville measured. All of these measurements along bedding were made with an opisometer. Also, the shortening effects of the Rocky Valley fault have been subtracted from Sections 4, 5,

6, 7, and 8. The data gathered in these measurements is presented in Table V.

It is thought that crustal shortening is a more reliable index of deformation than the slip on the major faults. The reason for this is that it is easier to measure crustal shortening with a greater degree of accuracy than slip, particularly when working with thrust faults where much of the movement is along bedding surfaces. This is borne out in Section 17 where the maximum measurable slip of Fault B is only 900 feet. However, the value obtained for crustal shortening is 9900 feet. The difference here is that folding greatly predominates over faulting. This suggests that previous attempts to correlate slip and crustal shortening have not adequately considered the folding involved. Also, slip is a measure of horizontal and vertical components of movement, whereas crustal shortening is a measure of only the horizontal component of movement.

The average crustal shortening estimated for the Dumplin Valley system is 45 per cent, or about 14,600 feet. The combined average net slip for both faults is about 16,000 feet. This difference is accountable in the vertical component of movement present in faulting and the fact that

TABLE V
CRUSTAL SHORTENING (MEASURED ON
MARYVILLE LIMESTONE)

Section Number	Feet of Maryville	Width of Section	Feet Shortening	Per Cent Shortening
1	31,000	20,200	10,800	34.8
2	33,000	20,000	13,000	39.4
3	26,500	15,000	11,500	43.4
4	24,500	10,000	14,500	59.2
5	55,500	38,500	17,000	30.6
6	37,000	20,200	16,800	45.4
7	41,000	22,200	18,800	45.8
8	38,000	22,800	15,200	40.0
9	23,000	12,000	11,000	47.8
10	29,000	15,100	13,900	47.9
11	28,000	16,000	12,000	42.8
12	28,000	14,000	14,000	50.0
13	31,000	16,000	15,000	48.4
14	27,500	14,100	13,400	48.8
15	33,500	14,200	19,300	57.6
16	37,500	19,100	18,400	49.0
17	30,000	20,100	9,900	33.0
Averages			14,600	44.9

faulting predominates over folding in most of the structure. These relationships may be readily observed by inspection of the map and cross sections (Plates I-V). Analyses of this type serves to illustrate that semiquantitative calculations can be useful in structural geology.

CHAPTER IV

STRUCTURAL CONCLUSIONS

The following conclusions are presented from this study of the Dumplin Valley fault system:

1. The origin of the structure is attributed to multiple faulting in the axial portion of a large anticline. A portion of the complex core zone is exposed at the present level of erosion.
2. Neither the "thin-skinned" nor the "thick-skinned" theories of deformation apply to the structure but it has certain characteristics of each concept. The structure is unlike that of most of the other major fault zones in the region; thus it does not fit the regional tectonic pattern as envisioned by many recent workers.
3. The major faults of this zone have formed subsequent to folding, and have cut upward through the sedimentary section from the Rome decollement underlying the structure. This decollement is probably the Saltville fault.
4. The original anticline is thought to have initiated as a wrinkle in the Saltville thrust sheet, perhaps

when movement along the decollement ceased in the area northwest of the present Dumplin Valley zone. Continuing or subsequent stresses resulted in amplification of the fold.

5. The main anticline and its subsidiary folds predate the major faults in the system, as evidenced by faulting of fold axes.

6. The more extensive and complex Fault B system is younger than Fault A and its associated structures. There is an indication of post-fault folding and subsequent movement on Fault B.

7. The stratigraphy of the Conasauga Group controls the style of folding. Tight folds are produced at the southwest end of the structure where incompetent units predominate. Open folds are developed at the northeast end of the structure where competent units are present.

8. Crustal shortening attributed to the Dumplin Valley structure is about 45 per cent, or about two and one-half miles.

9. The geologic age of the Dumplin Valley structure is thought to be post-Pennsylvanian, but probably pre-Triassic.

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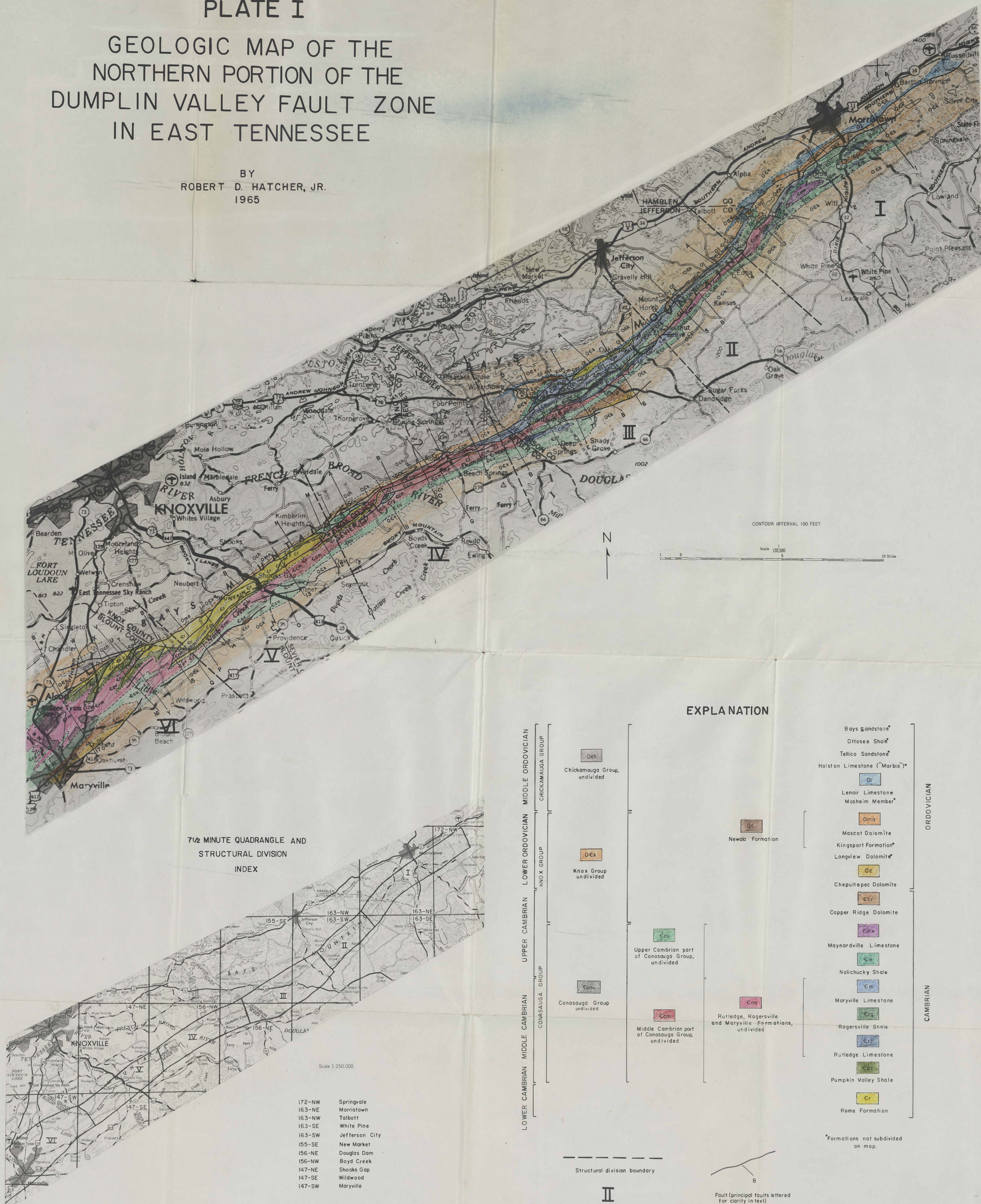
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1515-1540.

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PERIOD	GROUP	FORMATION	UNIT	FORMATION	UNIT
ORDOVICIAN	CHICKAMAUGA GROUP	Och	Chickamauga Group, undivided	Ol	Lenoir Limestone
				Oma	Masheim Member*
					Mascot Dolomite
	KNOX GROUP	Ock	Knox Group undivided		Kingsport Formation*
				Oca	Longview Dolomite*
					Chepultepec Dolomite
	UPPER CAMBRIAN			Cr	Copper Ridge Dolomite
				Enn	Maynardville Limestone
				En	Nolichucky Shale
				Em	Maryville Limestone
MIDDLE CAMBRIAN			Eng	Rogersville Shale	
			En	Rutledge Limestone	
			Epy	Pumpkin Valley Shale	
			Er	Rome Formation	
LOWER ORDOVICIAN					

*Formations not subdivided
on map.

Structural division boundary

II

Structural division number

Section line

Fault (principal faults lettered for clarity in text)

Window

Klippe

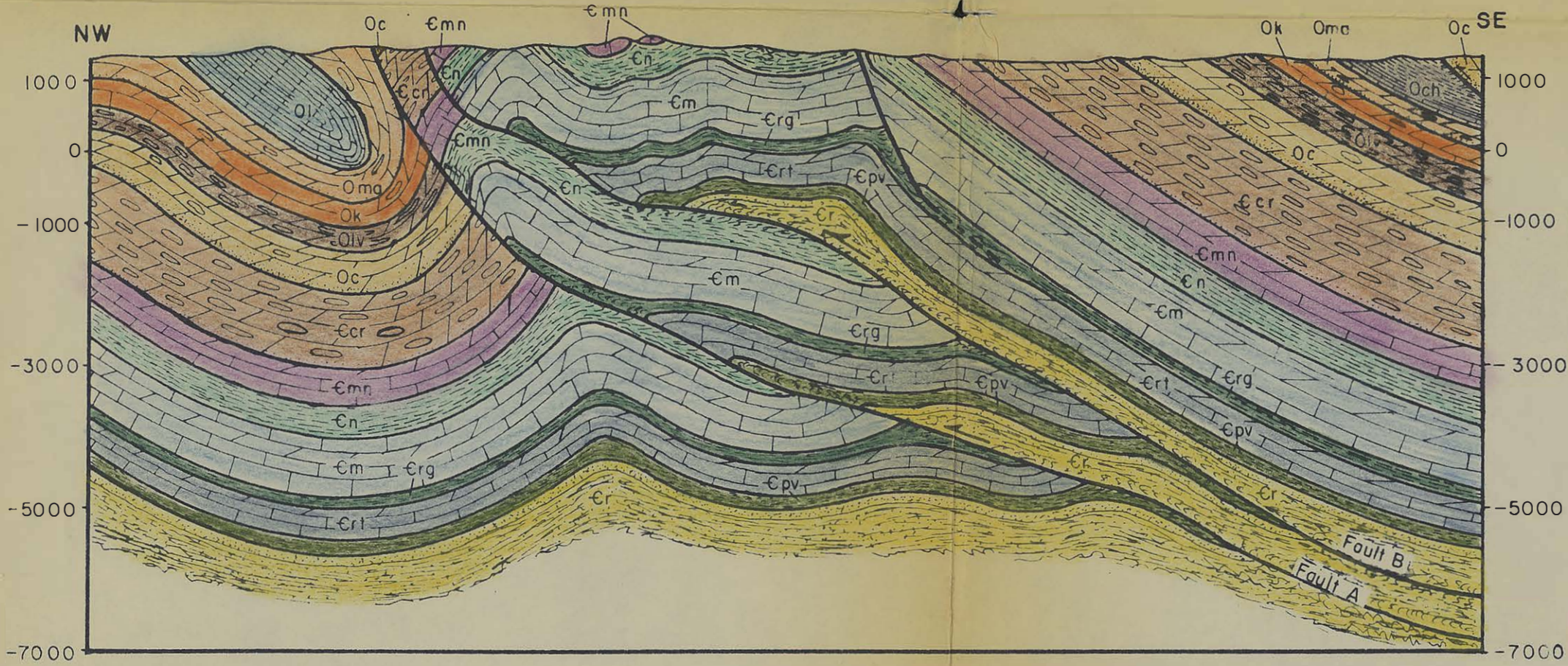
Stratigraphic Contact

PLATE II GEOLOGIC CROSS SECTIONS 1-4

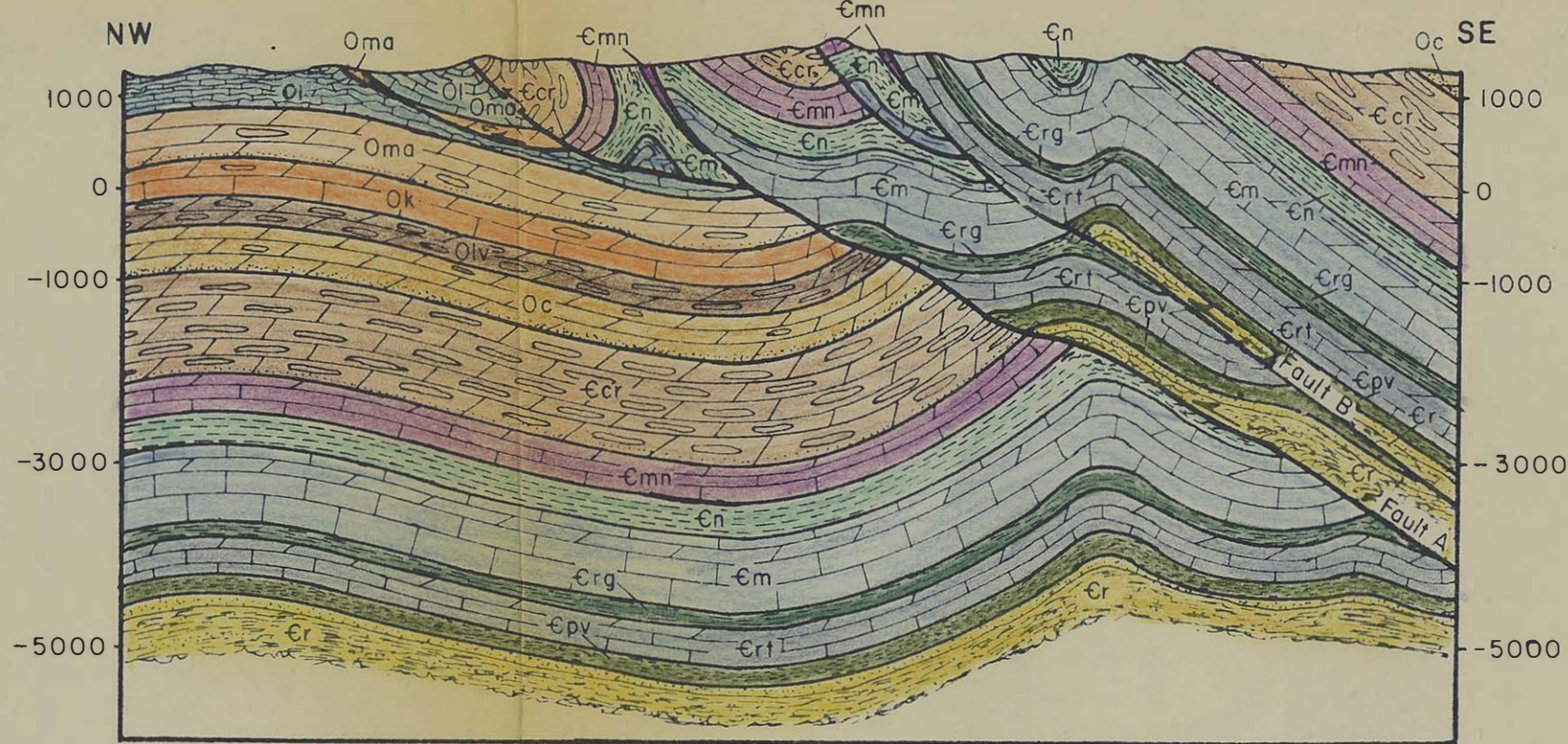
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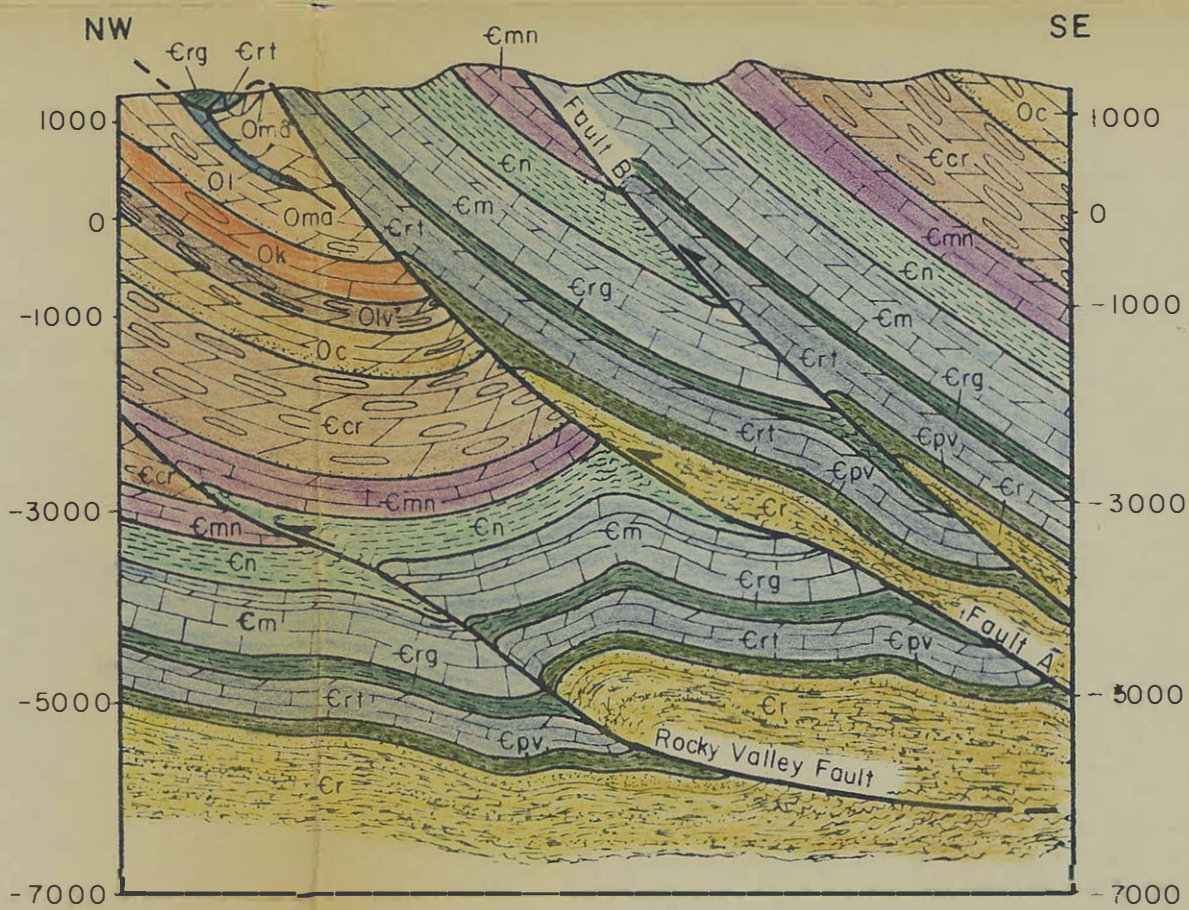
SECTION 2



SECTION 3



SECTION 4



EXPLANATION

ORDOVICIAN	Middle		
		Chickamauga Group	Lenoir Limestone
	Lower		Mascot Dolomite
			Kingsport Formation
			Longview Dolomite
CAMBRIAN	Upper		Chepultepec Dolomite
			Copper Ridge Dolomite
			Maynardville Limestone
			Nolichucky Shale
	Middle		Maryville Limestone
			Rogersville Shale
			Rutledge Limestone
			Pumpkin Valley Shale
	Lower		Rame Formation

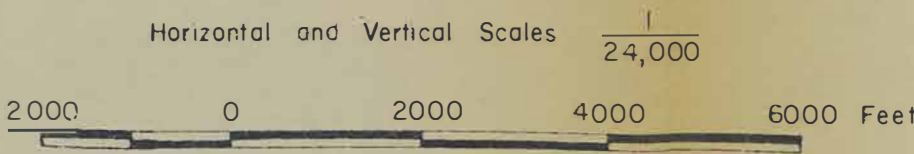
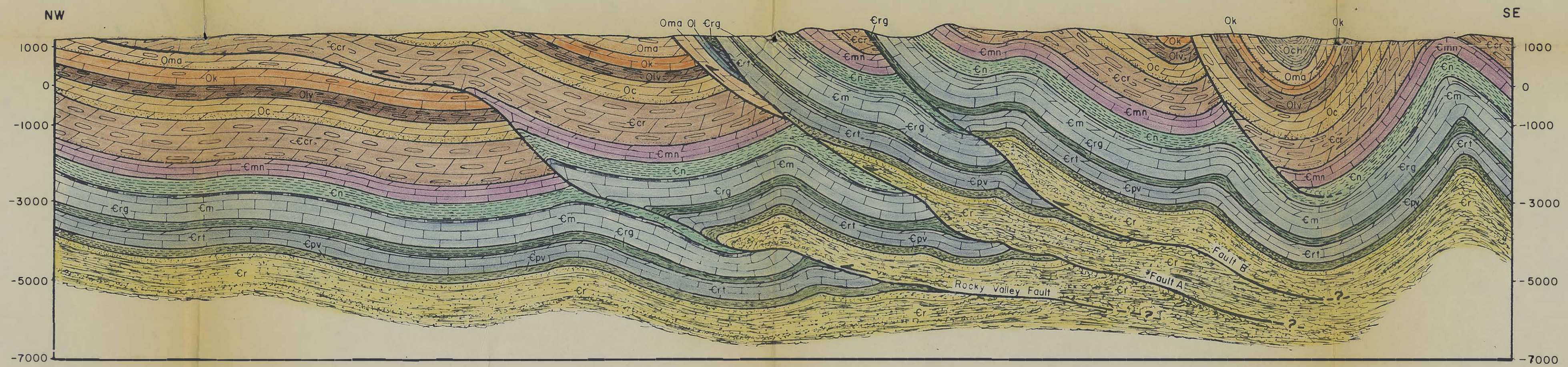
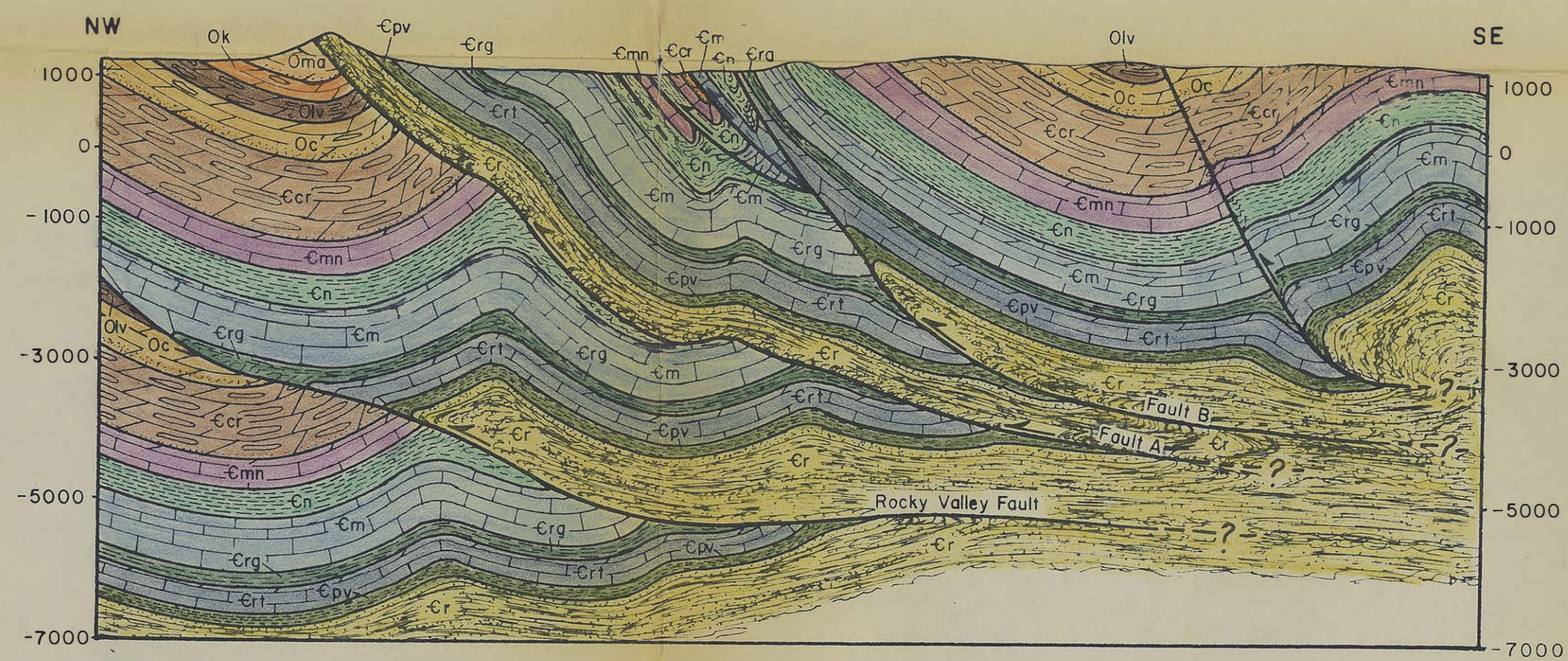


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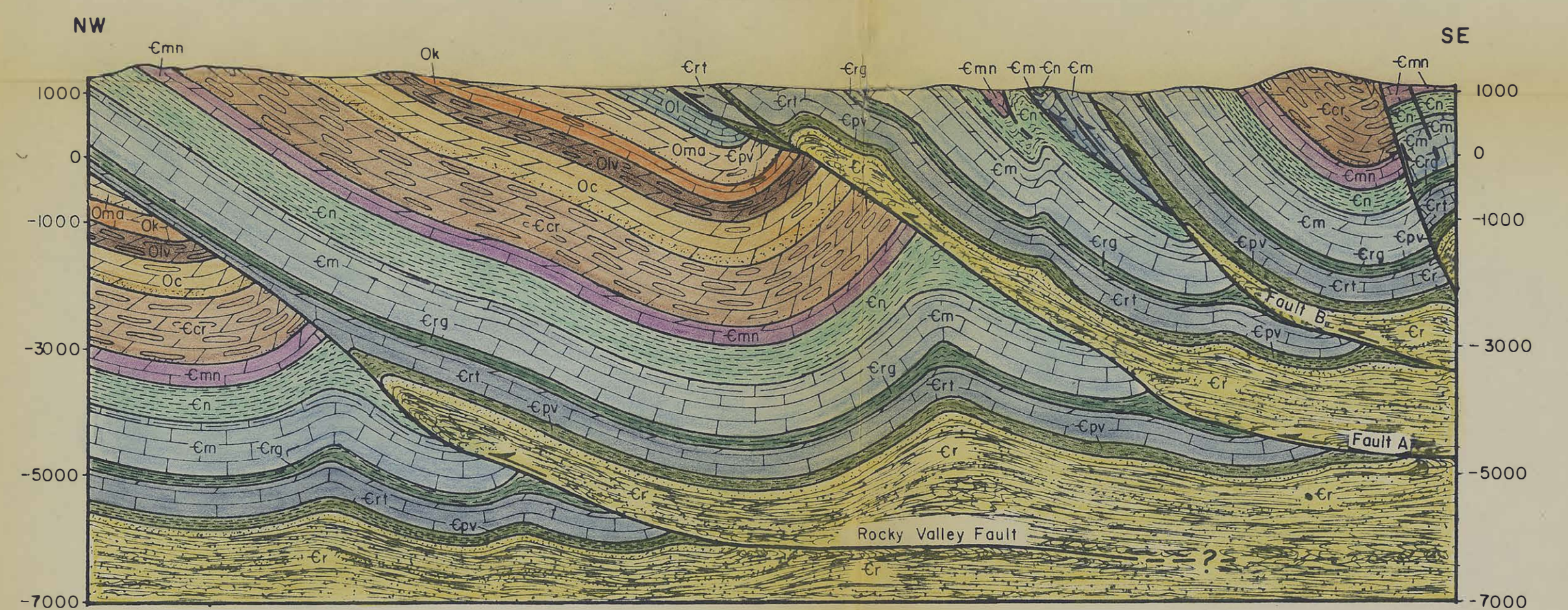
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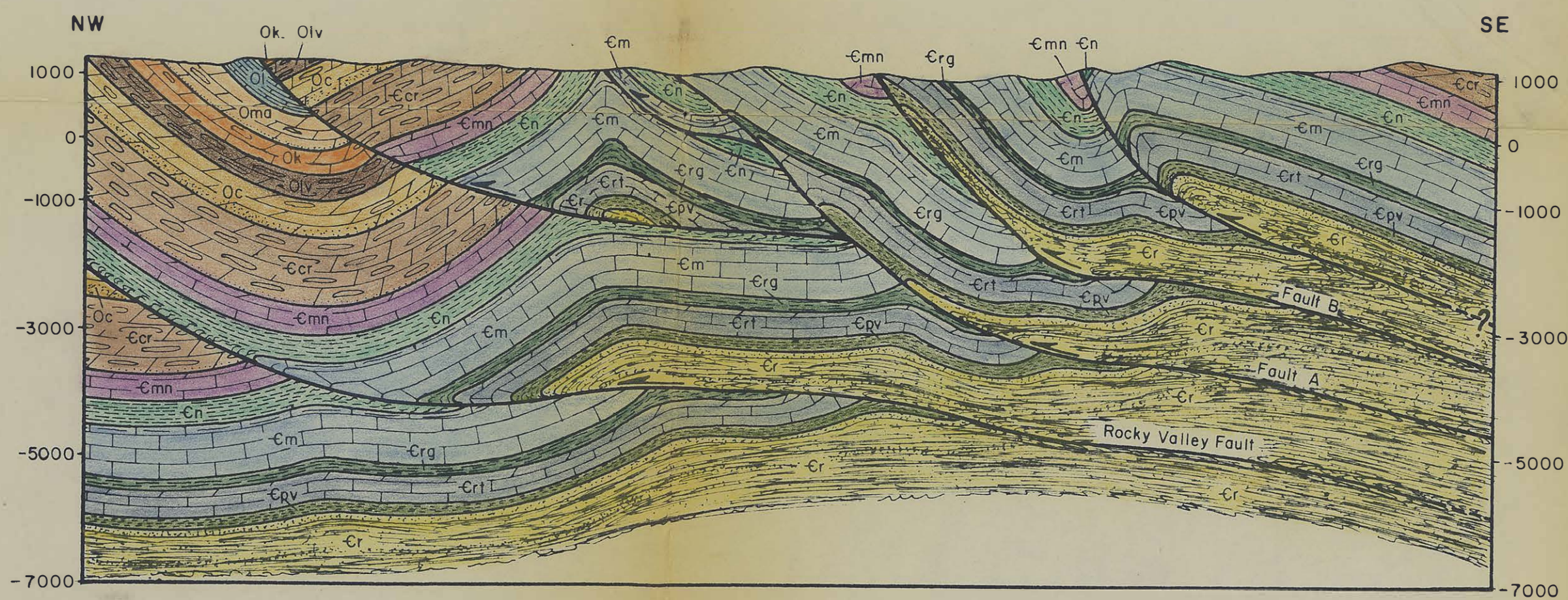
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SECTION 7



SECTION 8



SECTION 9

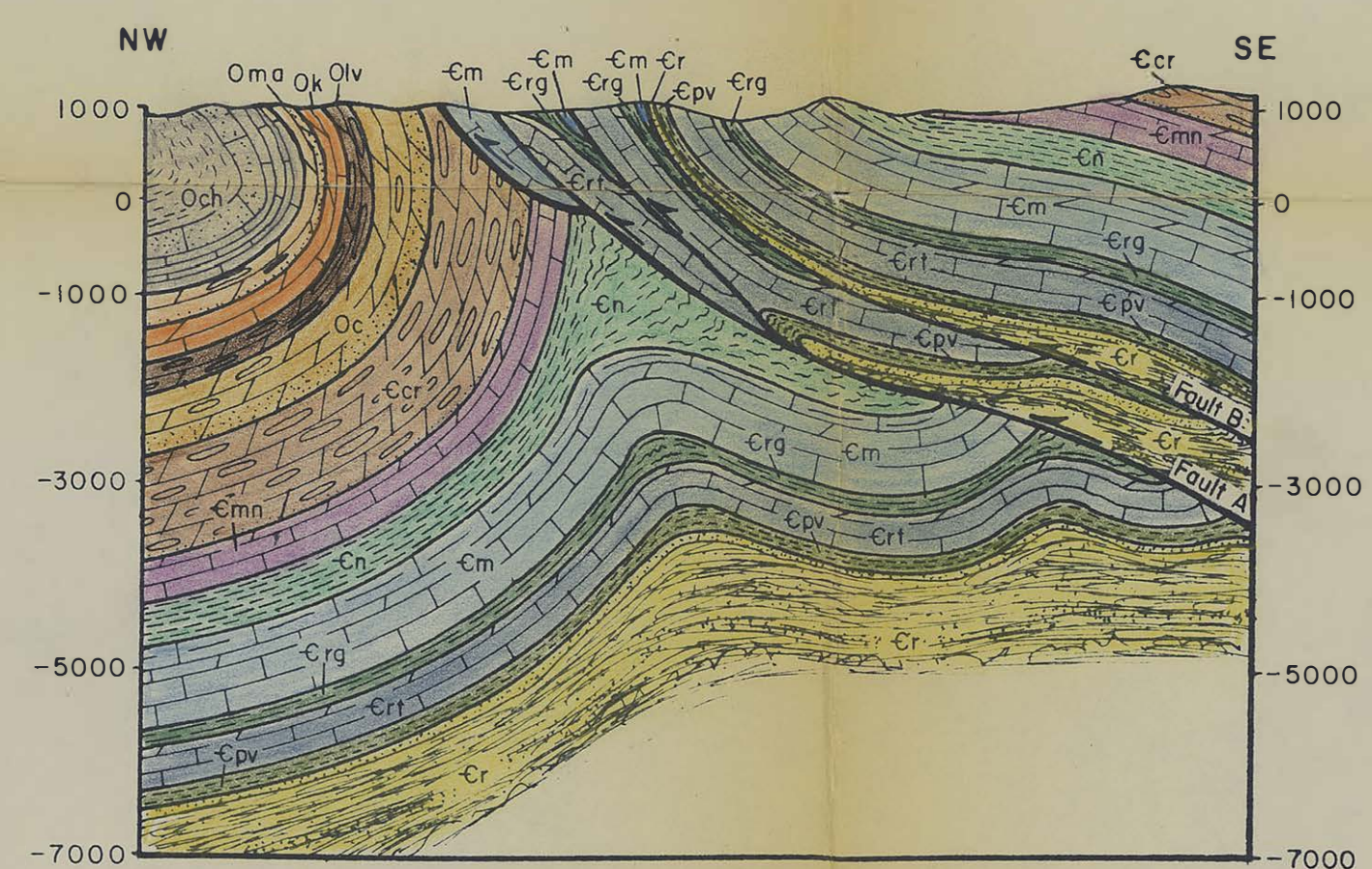
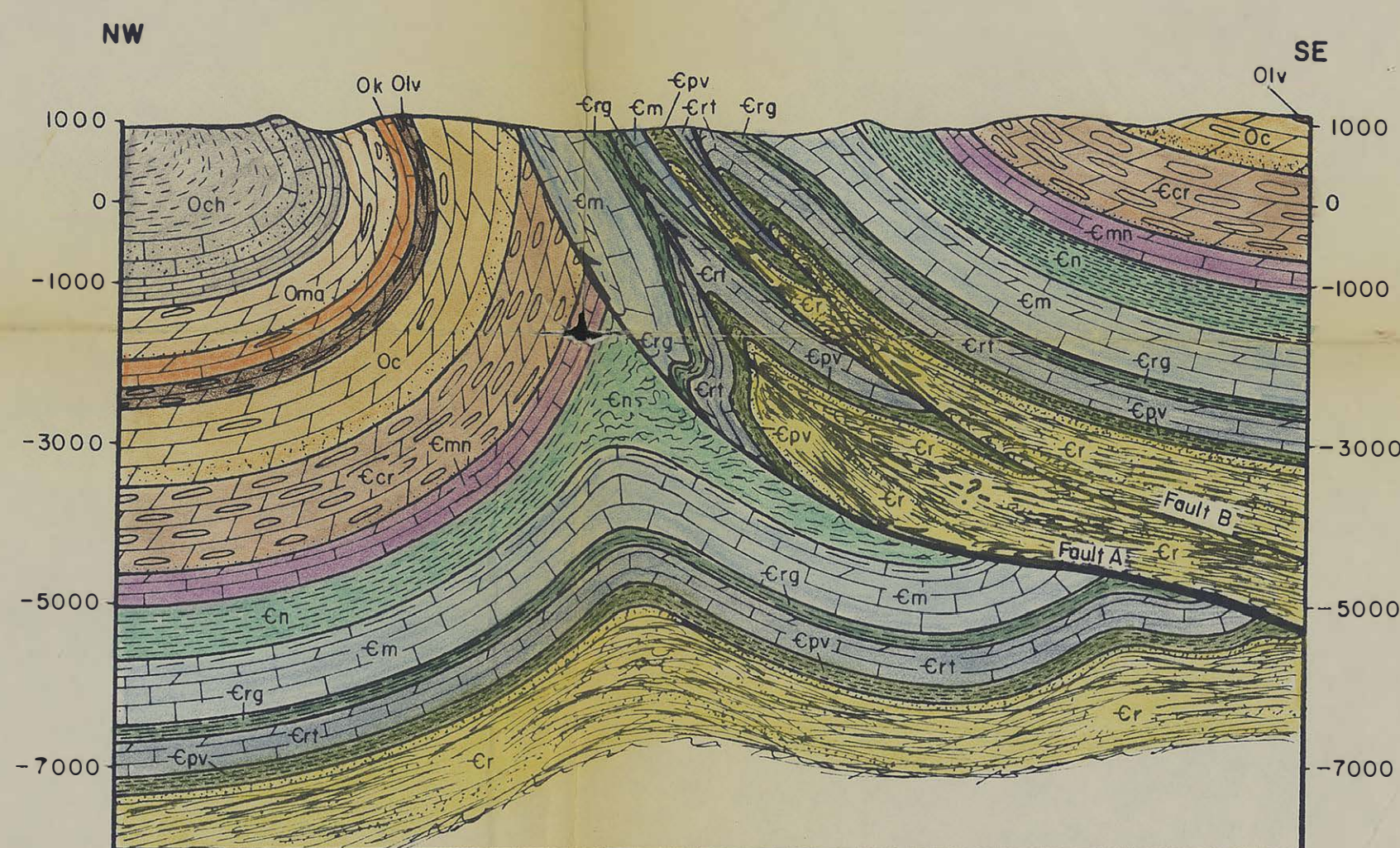
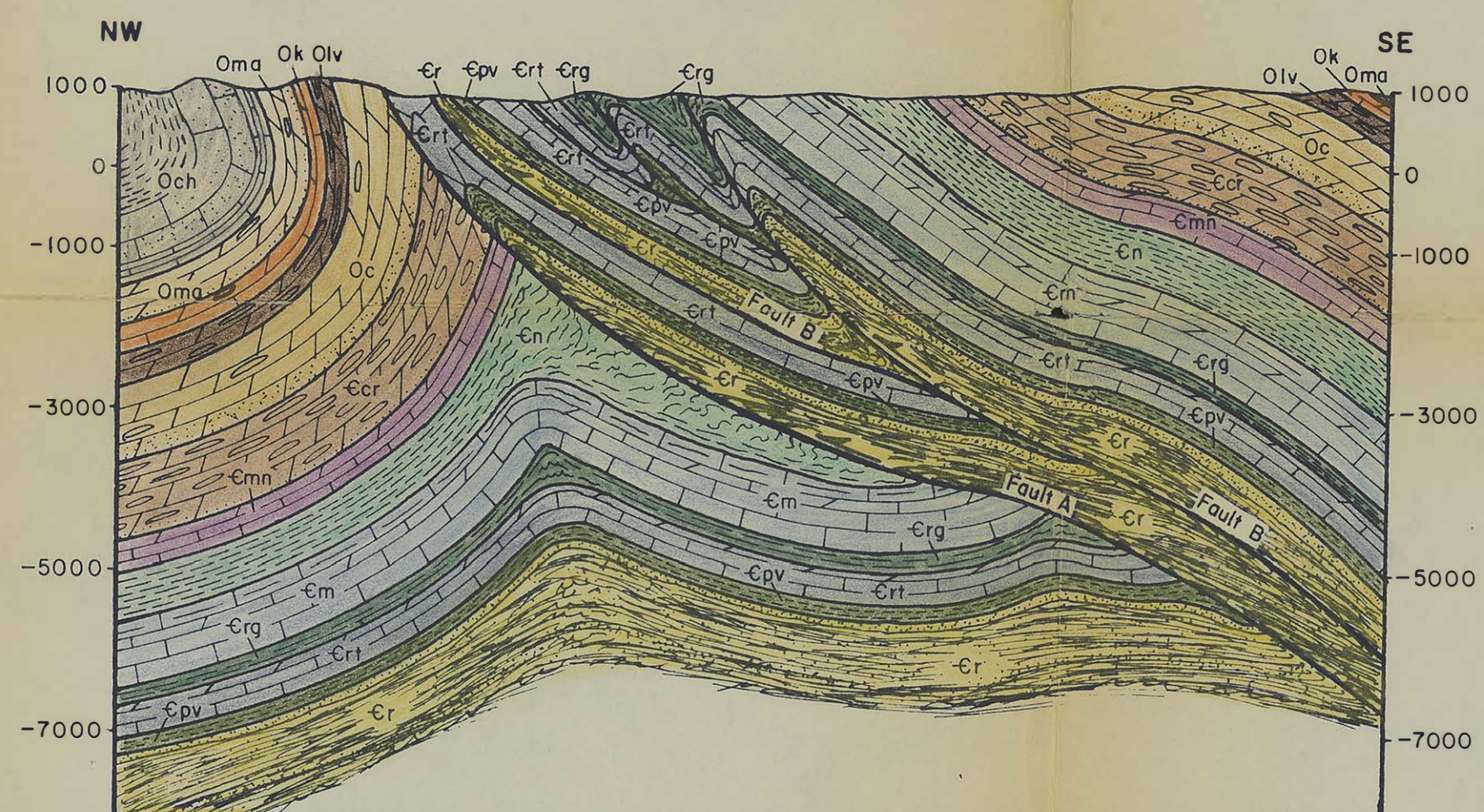


PLATE IV
GEOLOGIC CROSS SECTIONS
10-15

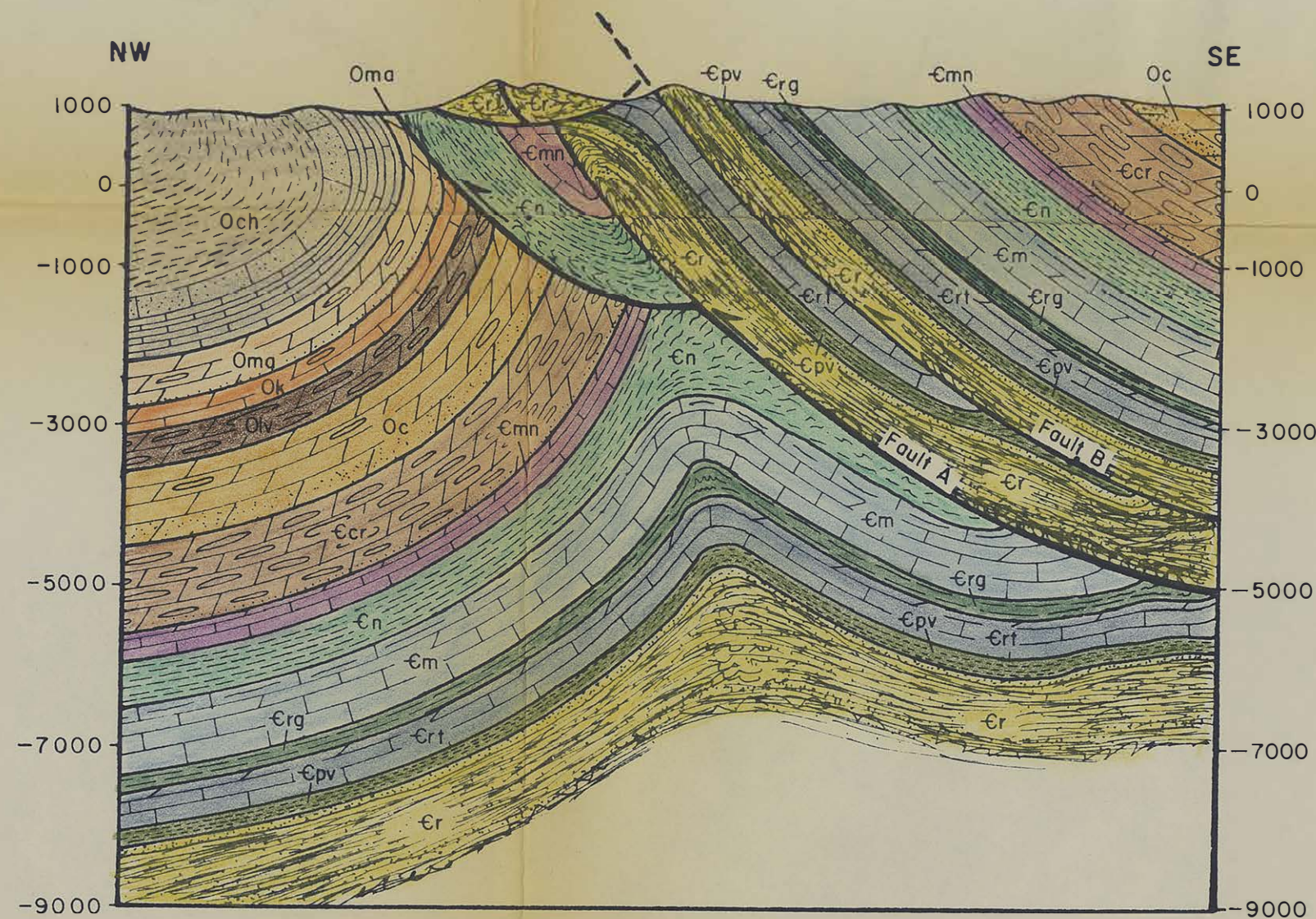
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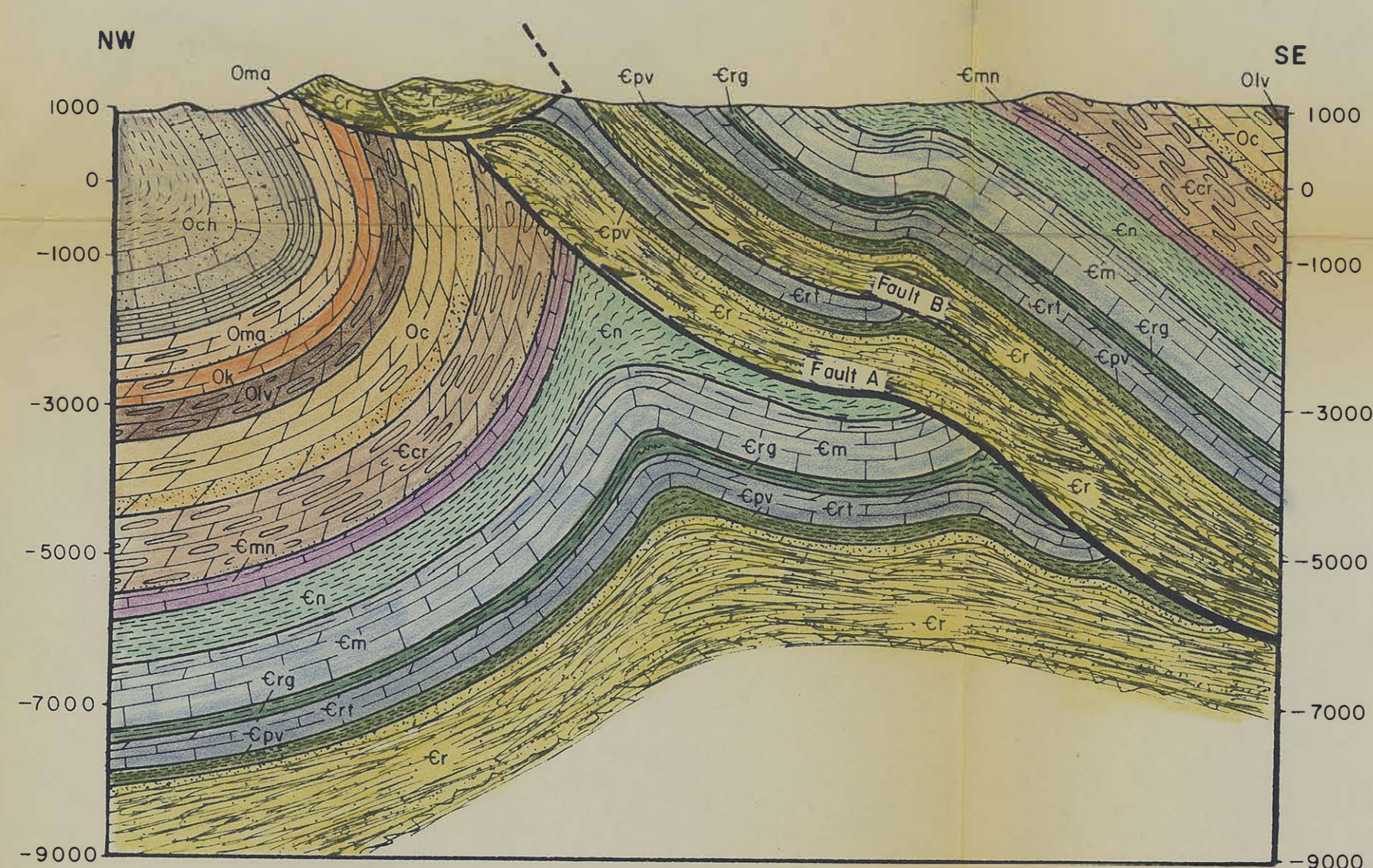
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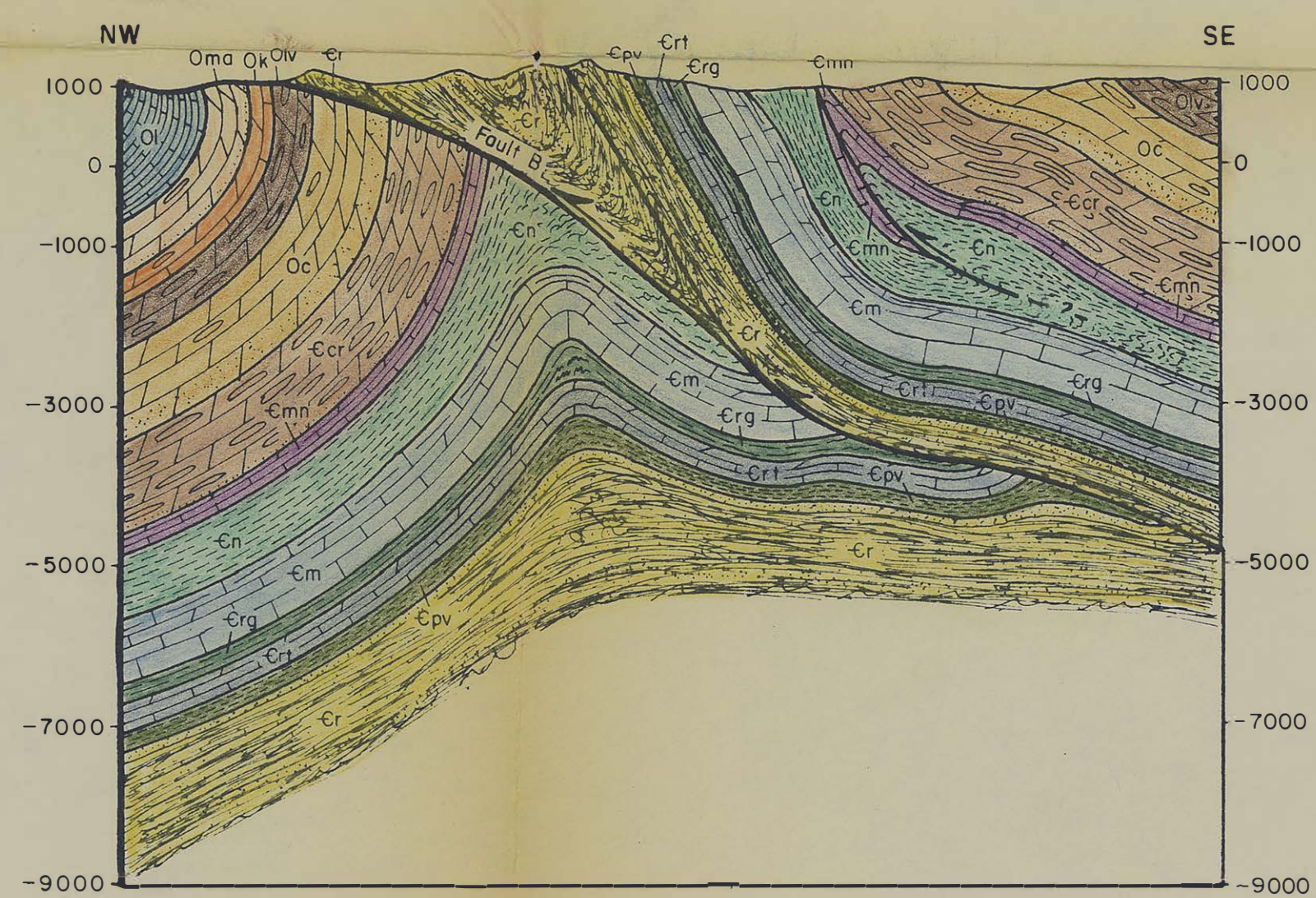
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SECTION 13



SECTION 14

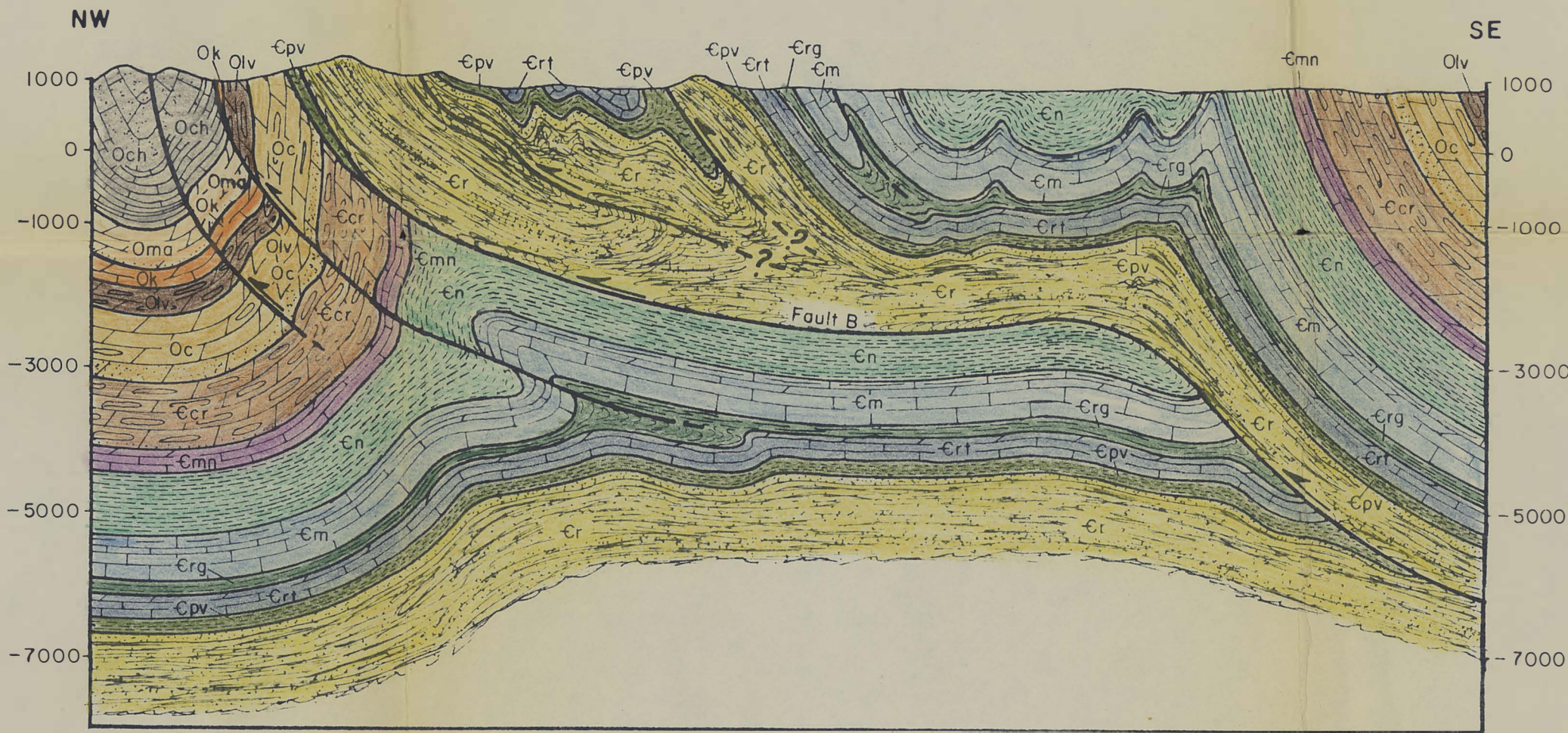


SECTION 15



PLATE V
GEOLOGIC CROSS SECTIONS
16-17

SECTION 16



SECTION 17

