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To the Graduate Council:

I am submitting herewith a thesis written by Joseph John Spigai entitled "A Study of the Rome Formation in the Valley and Ridge Province of East Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Geology.

R.E. McLaughlin, Major Professor

We have read this thesis and recommend its acceptance:

Harry J. Klepser, Otto C. Kopp

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

January 22, 1963

To the Graduate Council:

I am submitting herewith a thesis written by Joseph John Spigai entitled "A Study of the Rome Formation in the Valley and Ridge Province of East Tennessee." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Geology.

C. E. McLaughlin
Major Professor

We have read this thesis
and recommend its acceptance:

____

____

Accepted for the Council:

Milton A. Smith
Dean of the Graduate School

A STUDY OF THE ROME FORMATION IN THE VALLEY AND RIDGE PROVINCE OF EAST TENNESSEE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Joseph John Spigai

March 1963

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CHAPTER I

INTRODUCTION

General

The Rome formation is one of the most distinctive lithologic units in the Southern Appalachian region. No account of early Paleozoic sedimentation, later Paleozoic structural history, and the more recent physiographic development of the Valley and Ridge province can be attempted without consideration of this formation. Therefore, most students of Appalachian geology have been exposed to the general characteristics of the formation. Despite this familiarity however, most studies of the Rome have been made in association with other rock units, or have been general or local in nature.

Previous Investigations

James Safford, in his Geology of Tennessee (1869, pp. 209-210), originally recognized the lithology of the present Rome formation as a distinctive unit. He, however, assigned it to the basal part of his Knox Group and applied the name "Knox Sandstone" to it. The formation was renamed in 1891

for its exposures in Coosa Valley, south of Rome, Floyd County, Georgia by C.W. Hayes (1891, p. 143). Hayes was the first to apply the name Rome to this formation. The exposures he described have since become the type locality. Subsequently, the term Rome, after some modification and usage, for example Walcott (1891), has gained general acceptance in the literature (Wilmarth, 1938, p. 1840).

Later, Hayes (1894a) and Arthur Keith (1895) subdivided the Rome formation into two members: an upper "Rome shale" and a lower "Rome sandstone." M.R. Campbell, in three of his folios (1894a, 1897, 1899), termed the "Rome sandstone" lithology in southwest Virginia the Russel formation, but applied the name Graysonton formation elsewhere in Virginia (1894b). His terminology has since been discarded.

Within, and a little below the top of the lower "Rome sandstone" member, both Hayes and Keith recognized a unit of variegated shale with no sandstone, which was termed the Apison member, from exposures at Apison, Hamilton County, Tennessee (Hayes, 1894 b,c, 1895). H.D. Campbell (1905) applied the term Buena Vista shale to the Apison lithology in central Virginia. Although still used by some workers, these

terms have also been discarded; most authors prefer to include this variegated shale unit in the Rome formation without subdivision.

Arthur Keith, in many of his folios (1895, 1896a, 1896b, 1896c, 1901, 1903, 1907a, 1907b), mapped the Rome formation and its equivalent in east Tennessee and elsewhere. In northeast Tennessee, he applied the term Watauga shale to the dolomites and the red shales overlying the Shady dolomite for exposures near the Watauga River in Johnson and Carter Counties, Tennessee. Since it is a facies of the Rome formation, the term Watauga has been abandoned in favor of the former, but the informal term "Watauga phase" is still used. In an early work, Keith (1895) had separately mapped a 300-foot dolomite unit within the Rome formation on Bays Mountain, south of Knoxville, Tennessee, as the Beaver limestone from its occurrence on Beaver Ridge, north of Knoxville. Hayes (1902) misapplied the name to the Shady dolomite in Georgia and Alabama. However, because Keith (1901) did not map this unit separately on Beaver Ridge some confusion resulted as to the true stratigraphic position of this unit; hence the term has been abandoned.

Many early workers, in dealing with lower Cambrian

stratigraphy in eastern states other than Tennessee, have contributed to a broader understanding of the stratigraphy and facies relationships of the Rome formation. E.A. Smith (1890), described the stratigraphic equivalents of the Rome formation south of Birmingham, Alabama and applied the term Montevallo formation to exposures in parts of Shelby and Calhoun Counties, Alabama. This formation has also been termed the Chocolocco shales in some publications of the Alabama Geological Survey. Both terms have since been abandoned. G.W. Stose (1906, 1909) was the first to apply the name Waynesboro formation to the Rome equivalent in Pennsylvania. This term is still sometimes used to describe the stratigraphic equivalent of the Rome formation in the Appalachian Valley from Waynesboro, Pennsylvania southward to Roanoke, Virginia. Butts (1926, 1933, 1940), further investigated the Rome formation and its equivalents in Alabama and Virginia. E.O. Ulrich (1911, p. 616), compiled a detailed study of the Paleozoic system in North America, which included a definitive analysis of the lower Cambrian formations. La Forge, et al. (1925, pp. 139-143) further described the lower Cambrian formations of Georgia. The writings of Keith (1928, pp. 321-328), Currier (1935),

and Schuchert (1943) are also noteworthy for their descriptions of lower Cambrian formations in general and the Rome formation in particular. However, it was not until Woodward (1929) and Resser (1933, 1938) synthesized and clarified the terminology and nomenclature of the Rome formation and its equivalents, that subsequent workers were free to do more detailed and specific studies of the formation.

In the more recent literature several studies involving the Rome have proven especially helpful to workers in east Tennessee. Moneymaker and Fox (1940) and Fox (1943) have contributed measured sections and other pertinent information relating to the Rome formation in the western part of the Valley and Ridge province of Tennessee. The investigation of King, _et al_. (1944) has supplied information as to the character and economic deposits of the Rome in northeast Tennessee. Rodgers and Kent (1948) described, in a detailed section, the Rome formation at Lee Valley, Hawkins County, Tennessee. In this same study, the original "Rome shale" of Hayes and Keith was re-named the Pumpkin Valley shale, and designated as the lowermost member of the Conasauga group of earliest middle Cambrian age. Subsequently, the term Rome formation has been restricted to

those lithologies formerly included within the lower "Rome sandstone" member of Hayes and Keith and the age of the formation is now considered to be latest early Cambrian. The historical nomenclature of the Rome and other Cambrian and Ordovician formations in the southeastern states has been summarized by Bridge (1956, Plate I).

Significant studies of the lithologic and primary structural features of the Rome formation were contributed by Harvey and Maher (1948) and Maher (1948). The first comprehensive mapping and description of the Rome formation in east Tennessee is contained in the compilation by Rodgers (1953).

Ferguson and Jewell (1951), studied the barite deposits and associated geology in Cocke County, Tennessee and included description of the Rome in that area. H. Brooks (1955) was the first to describe halite casts in the Rome. King and Ferguson (1960) included several measured sections of the Rome in their descriptions of the geology in northeastern Tennessee.

Among the later, more general studies, which involve, in part, Cambrian stratigraphy of the Appalachian Valley are those of Rodgers (1956), and Wheeler (1960), and most

recently Woodward (1961). In addition to these, many of the theses and dissertations, too numerous to list here, prepared by students in the Department of Geology and Geography at the University of Tennessee, have included descriptions of local occurrences of the Rome formation. Specific reference will be made later to those of particular value in conducting the present investigation.

Purpose and Scope of the Present Study

The purpose of the present study is to bring together newly derived information and earlier accounts of the varied characteristics of the Rome formation in order that they may be examined in an objective manner with a view toward a broader synthesis of information.

The present study consists, for the most part, of a detailed examination of three selected exposures of the Rome formation measured by the writer in the Valley and Ridge province of Tennessee. The newer data have been derived from field and laboratory studies of the lithology, sedimentology, and stratigraphy at the three exposures. The three measured sections have been compared with one another and

with certain other exposures which have either been personally examined by the writer or described in the literature. The data from among these several exposures are correlated and the characteristics and geologic history of the formation is re-examined and summarized on the basis of the evidence presented.

CHAPTER II

GENERAL FEATURES OF THE ROME FORMATION

Stratigraphic and Paleontologic Characteristics

The Rome formation is generally considered to be of early Cambrian, or Taconian, age, being the topmost formation in the Waucobian, or lower Cambrian, series. The Rome is the lowest, or oldest formation widely exposed across the Valley and Ridge province of eastern Tennessee. The locations of a number of outstanding Rome exposures, including several which are discussed in this study, are listed in Figure 1 and illustrated in Plate I.

In east Tennessee the normal stratigraphic position of the Rome formation is above the Shady dolomite and below the Pumpkin Valley shale of the Conasauga group (Figure 2). It has been considered by some workers (H.J. Klepser and S.W. Maher, personal communication, 1962), that the Rome and Shady represent facies in part, the lower Rome being the western equivalent of the upper Shady.

Originally, the Rome was considered to be of both early and middle Cambrian age. However, with the exclusion

Number of outcrop shown on Plate I	Name of outcrop or exposure	Location (Quadrangle and number)	Location (Tennessee Grid Coordinates)	Distinctive Features	Reference
1.	Beaver Ridge Hines Valley	Powell (137-SE)	594,800 N 2,582,200 E	Primary structures	This study; Keith, 1895
2.	Log Mountain Dutch Valley	Dutch Valley (154-SE)	696,000 N 2,700,800 E	Sandy phase of Rome	This study
3.	Dug Ridge	Cave Creek (130-SW)	437,500 N 2,467,400 E	Halite casts	This study
4.	Lee Valley	Lee Valley (171-NW)	775,000 N 2,840,000 E	Pumpkin Valley shale	Rodgers and Kent, 1948
5.	Sharp Gap	Knoxville (147-SW)	590,800 N 2,605,150 E	Drag folding	Keith, 1895
6.	Sharp Ridge	Fountain City (146-SW)	597,650 N 2,613,650 E	Drag folding	Keith, 1895
7.	Shook's Gap	Shook's Gap (147-NE)	552,800 N 2,653,500 E	Drag folding	Cattermole, 1955
8.	Ray Gap - Bays Mtn.	Boyd's Creek (156-NW)	573,100 N 2,681,500 E	Halite casts	This study
9.	Doe River	Elizabethton (207-SW)	772,000 N 3,124,000 E	Best southeast phase	Rodgers, 1953
10.	Stony Creek Valley	Carter (207-NE)	754,000 N 3,146,000 E	Complete section	Rodgers, 1953
11.	Watauga River	Fish Springs (207-SE)	731,000 N 3,124,000 E	"Watauga phase"	Keith, 1903
12.	Poor Valley Ridge	Luttrell (155-NW)	660,000 N 2,680,000 E	Primary structures	Harvey and Maher, 1948
13.	McAnnally Ridge	John Sevier (147-SE)	623,000 N 2,656,000 E	Primary structures	Harvey and Maher, 1948
14.	War Ridge	Howard Quarter (162-NW)	732,500 N 2,752,000 E	NW phase; halite casts	Brooks, 1955
15.	Walden Ridge	Elverton (130-NW)	582,500 N 2,449,500 E	Primary structures	Harvey and Maher, 1948
16.	Watts Bar Dam	Decatur (118-SE)	450,000 N 2,360,000 E	Primary structures	Fox, 1943
17.	Apison Locality	Ooltewah (112-SE)	230,000 N 2,290,000 E	Apison shale	Hayes, 1894
18.	Bull Run Ridge	Powell (137-SE)	602,000 N 2,560,000 E	Primary structures	Harvey and Maher, 1948
19.	Pine Ridge	Clinton (137-SW)	610,000 N 2,550,000 E	Primary structures	Harvey and Maher, 1948
20.	Kennedy Ridge	Niota (124-SE)	450,000 N 2,410,000 E	Central phase	Rodgers, 1952

Figure 1. Detailed locations of some major exposures of the Rome formation. Key to Plate I.

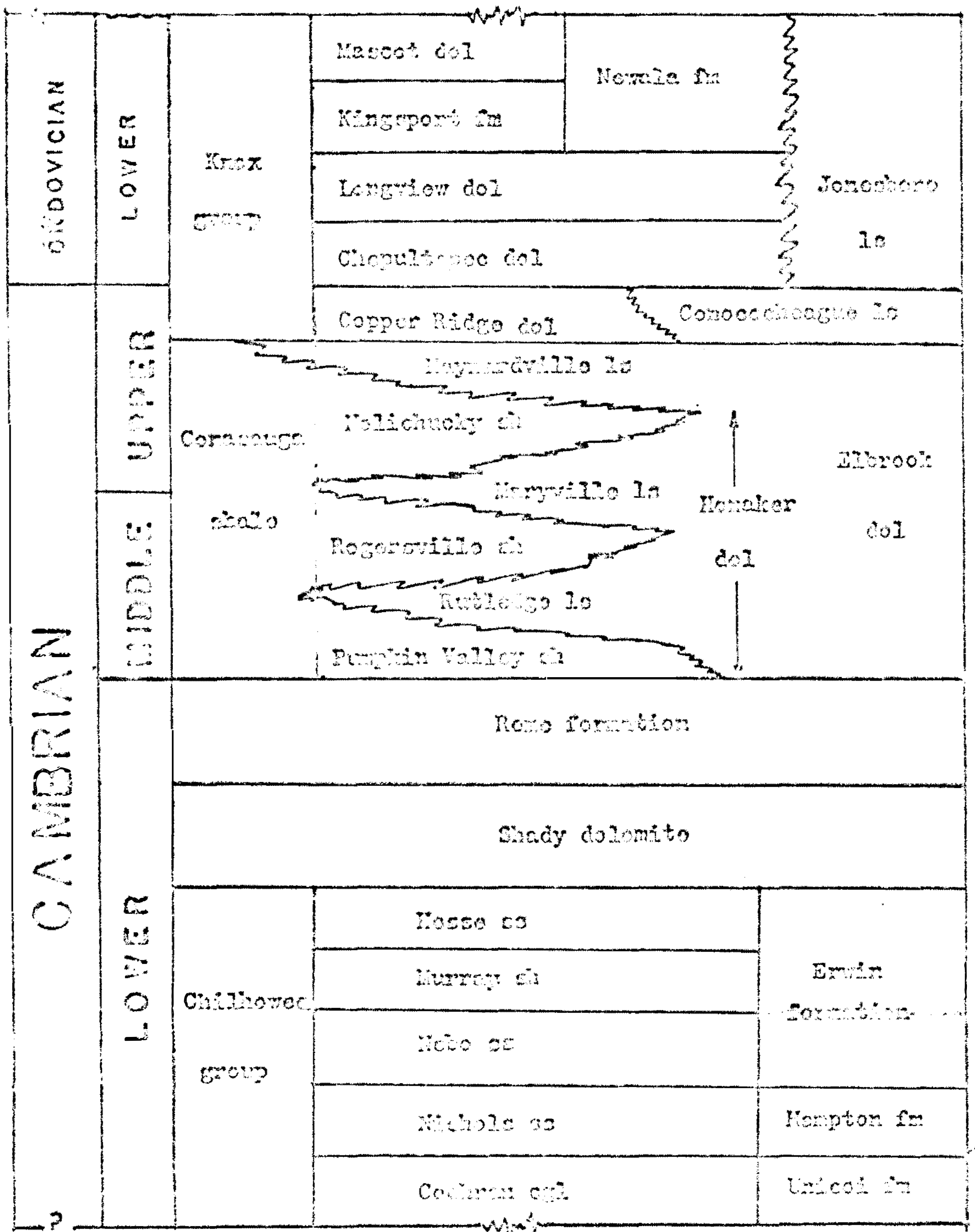


Figure 2. Generalized stratigraphic relationship of the Rome formation to other Cambrian formations in Tennessee.

of the Pumpkin Valley shale (Rodgers and Kent, 1948), the entire Rome formation is now considered to be of early Cambrian age. The common fauna of the Rome formation for the three regions is summarized in Figure 3. The trilobite, *Olenellus thompsoni*, is by far the most common and most diagnostic fossil in the formation.

Topographic and Weathering Characteristics

Topography and Extent of Surface Exposures

Many good exposures of the Rome formation are found in road and railroad cuts and along numerous gaps for almost the entire length and breadth of eastern Tennessee (see Fig. 1 and Plate I). Topographically, the Rome characteristically forms fairly steep, linear, knobby or comby (cockscomb) ridges. These prominent ridges, whose crests average 1000 to 1100 feet above sea level, are commonly covered with a shallow, somewhat loose mantle of sandstone and shale chips and silty clay soil, and often are covered with pines or other conifers. The distinctive vegetation and profile give rise to local names such as Pine Ridge or Comby Ridge in many instances.

FAUNA	Geographical Area: Southwest Virginia	East Tennessee	Northern Alabama and Northern Georgia
Trilobita			
Olenellus thompsoni Hall)	X	X	X
O. romensis Resser and Howell	X		
O. rudis Resser	X	X	X
O. halli (Walcott)		X	X
O. buttsi Resser		X	X
O. alabamensis Resser			X
Ptychoparella buttsi Resser	X		
P. sp.	X		X
Brachiopoda			
Obolus smithi Walcott			X
O. pandemia Walcott			X
Paterina major Walcott			X
P. williardi Walcott			X
Wimanella shelbyensis Walcott			X
Porifera			
Archaeocyathus sp.	X	X	X
Cephalopoda			
Salterella sp.			X
Mollusca Incertae Sedis			
Hyolithes wanneri Resser and Howell	X		
H. sp.			X

Figure 3. List of the common Rome fauna collected from three geographical areas. Compiled with modifications from Resser (1938) and Woodward (1929).

The ridges are homoclinal, exhibiting one fairly steep side and, as a result of the predominance of sandstone in the formation and consequent resistance to weathering, develop sharp, even crests. The ridges are notched by gaps of varying sizes at irregular intervals along the crest. The resulting knobby or comby appearance makes the typical Rome ridge fairly easy to recognize from a distance (Fig. 4). Progressing northwestward from the eastern margin of the Valley and Ridge province, the ridges become more prominent and generally are higher and steeper. This is due, in most cases, to an increase in thicker-bedded, more resistant, clastic units within the northwest phase of the formation, as compared with the generally thinner-bedded central portion and more calcareous southeastern phase.

Weathering Characteristics

In general, the amount of weathering and weathered residuum present in a Rome exposure increases progressively toward the eastern belts of the Valley and Ridge province due to the increased amounts of shaly and/or calcareous units within the formation. The sandstone and siltstone of the Rome formation, although resistant, weather and erode

Figure 4. View of Beaver Ridge illustrating knobby topography. Taken looking north on U.S. Highway 25W ten miles north of the city limits of Knoxville, Tennessee. The coordinates are 594,800 N and 2,582,200 E.

gradually to form a shallow residuum and talus accumulations commonly full of rock chips. Frequently this weathering feature is exhibited by the relatively thick-bedded, argillaceous, maroon claystones and mudstones of the formation. The thin, light-colored, silty or sandy soil developed in such cases is relatively poor and supports only hardier pine tree growth as a rule. Surprisingly, the rather steep slopes are often cleared for grazing and light farming.

The argillaceous, dolomitic, and calcareous shales erode more readily and commonly are deeply weathered, the clay content being reduced to a "muck" when wet. The resulting residuum will often exhibit a variety of colors from yellow-brown and red-brown to green, gray and orange. The carbonate rocks, such as limestone, dolomite and intermediate varieties, weather to greater depths than any other rock types in the Rome formation and form bodies of yellow, generally silty clay associated with a red-brown or yellow-brown soil. This "buckfat"-type clay is similar to that formed by the Shady dolomite. Some dolomite in the formation often weathers to a "wad."

Structural Characteristics

It is generally believed that the shale units in the Rome formation have formed ideal "gliding planes" for the fault blocks activated by the compressional forces that produced many of the thrust faults in the Valley and Ridge province of east Tennessee. The faulting thrust up portions of the Rome formation, frequently along with overlying younger formations. Such thrusts have overriden post-Rome formations in the province and have resulted in "cutting out" portions of the lower Rome formation, these lower units remaining unexposed below the surface. Therefore, nowhere, except in a few eastern and northeastern belts of the province, is the base of the Rome formation exposed where it is in normal contact with the underlying Shady formation. In addition, where the upper contact with the Pumpkin Valley shale is not exposed, in many cases the Rome formation is topographically the highest formation present in an exposure. The absence or obscurity of these contacts over much of the area of Rome exposure make it extremely difficult to determine the true total thickness of the Rome formation. Only in belts close to the Blue Ridge province is there an occasional exposure that exhibits a continuous sequence from

the underlying Shady dolomite to the overlying middle Cambrian formations.

Large scale complete folds, such as anticlines or synclines are exhibited only rarely by the Rome formation and only homoclinal thrust sheets are commonly observed. These eroded thrust sheets form the common Rome ridges dipping at moderate to slight angles. Within these thrust sheets, however, drag folding, crumpling, and imbrication on a small scale, involving beds from several inches to tens of feet in total thickness, is very evident. An example of small scale drag folding in the Rome formation is shown in Figure 5. Drag folding is so common that computation of true thickness is sometimes difficult even for that portion of the formation that is exposed.

Smaller scale structural features are also abundant in the Rome formation. Jointing on several scales and of several types can be observed in different rock types within the formation. An example of medium scale jointing in a sandstone unit is illustrated in Figure 6. Cleavage, especially slaty cleavage, is also found in the formation and is exhibited by the slightly metamorphosed shales and slates, especially toward the eastern margins of the Valley

Figure 5. Views of Shooks Gap illustrating small-scale drag folding in the Rome formation. Taken on U.S. Highway 441, approximately ten miles south of Knoxville, Tennessee. The coordinates are 552,800 N and 2,653,500 E.

A

B

Figure 6. Illustration of jointing in Rome sandstone.
A. Taken from railroad cut across Log Mountain four miles north of Washburn Community, Tennessee; coordinates: 696,000 N and 2,700,800 E.
B. "Saw-tooth" jointing at Dug Ridge. Taken on U.S. Highway 40, twenty-two miles west of Knoxville, Tennessee. Note hammer (circled) for scale. Coordinates are 437,500 N and 2,467,400 E.

and Ridge. Shale fragments in the shape of "shoe-pegs", produced by closely spaced joint patterns, are common within the claystone and mudstone units of the Rome formation.

It is assumed (King, 1949, pp. 10-13) that the deformational stresses which produced the faulting and other structural features within the Rome formation originated near the eastern margin of the Valley and Ridge, near what is now the Blue Ridge province. This accounts for the fact that cleavage, jointing, metamorphic effects, and other minor structural features within the formation appear to be more abundant in the eastern portion of the Valley and Ridge, becoming progressively reduced westward. The occurrence of the major and minor structural features, as related to the several lithologic types of the formation is included in Figure 7.

Lithologic and Sedimentary Characteristics

Principal Rock Types and Facies

The Rome formation, as has been pointed out by many writers (Rodgers, 1953, p. 45; Woodward, 1929; and Resser, 1938), is extremely heterogeneous. As noted above, practi-

Basic Rock Type	Sub-Type	Bedding Characteristics	Textural Features	Mineralogy	Common Colors	Structural Features: Primary	Structural Features: Secondary	Other Common Features
Shale	argillaceous	paper thin- to thin-bedded	fine-grained to micro-crystalline	clay minerals, chlorite, mica (sericite), micaceous glauconite	vari-colored; gray, green, tan are common	flow casts, mud accretions	cleavage, drag-folding	weathers strongly to a clay "muck"
	silty	very thin-bedded	fine-grained to micro-crystalline	clay minerals, chlorite, mica (sericite), quartz	vari-colored; gray and tan are common	flow casts, "tubes"	cleavage, drag-folding	weathers to a drab, silty clay soil
	sandy	very thin- to thin-bedded	fine-grained	clay minerals, chlorite, mica (sericite), quartz, granular glauconite	vari-colored; gray and tan are common	flow casts, "tubes"	drag-folding	weathers to a sandy clay loam
	calcareous/ dolomitic	thin- to medium-bedded	very fine-grained to micro-crystalline	clay minerals, chlorite, mica, calcite, dolomite	gray, blue, grayish-green	"tubes", obscure markings	---	---
	ferruginous	very thin- to thin-bedded	fine-grained	clay minerals, chlorite, mica, hematite and limonite (interstitial)	tan, brown, pink, red, orange	flow casts, mud accretions on bedding	---	---
Claystone	-----	medium-bedded	fine-grained	clay minerals, commonly with ferruginous (hematitic) cement	red, reddish-brown	"tubes"	"Shoe-peg" jointing patterns	most commonly ferruginous
Sandstone	normal(quartzose)	thin-bedded to massive	coarse-grained	quartz, glauconite, "heavy" minerals (rare)	white, gray, tan	laminations	jointing	commonly quartzitic
	silty	thin- to thick-bedded	coarse- to medium grained	quartz, glauconite, "heavy" minerals (rare)	gray, tan, greenish-gray	wave ripple marks, mud cracks, striations	---	---
	argillaceous	very thin- to medium-bedded	medium- to fine-grained	quartz, clay minerals	tan, brown, greenish-gray	obscure markings	---	shale partings common
	calcareous/ dolomitic	medium-bedded	coarse- to fine-grained	quartz, calcite and/or dolomite	gray, bluish-gray	bedding plane irregularities	jointing	vugs and vug-fillings
	ferruginous	thin- to thick-bedded	coarse- to fine-grained	quartz, ferruginous (hematitic) cement	tan, brown, red	---	---	vugs and vug-fillings
Siltstone	normal	thin- to medium-bedded, (often finely laminated)	fine-grained	quartz, clay minerals, mica (fine-grained), micaceous and granular glauconite	gray, grayish-brown, tan, greenish-gray	cross-lamination, mud cracks, ripple marks	soft-sediment boudinage (primary ?)	tracks, trails, "tubes", swash marks and accretions common
	sandy	medium-bedded	fine- to medium-grained	quartz, glauconite (granular)	gray, tan, greenish-gray	cross-lamination, mud cracks, ripple marks	jointing	---
	argillaceous	thin- to medium-bedded	fine-grained	quartz, clay minerals, mica (fine-grained)	tan, gray, greenish-gray	mud cracks, ripple marks, and accretions	halite casts (classification doubtful)	tracks, trails, and obscure bedding markings common
	calcareous/ dolomitic	medium-bedded	fine-grained	quartz, calcite and/or dolomite	gray, bluish-gray, tan	ripple marks, "tubes", obscure structures	---	---
	ferruginous	thin- to medium-bedded	fine-grained	quartz, clay minerals, ferruginous (hematitic) cement	tan, brown, red	cross-lamination, mud cracks, ripple marks	boudinage	---
Limestone	normal(calcareous)	medium- to thick-bedded	fine-grained to crystalline	calcite	gray, blue, grayish-blue, tan	---	jointing	vugs and cavities
	argillaceous	thin- to thick-bedded	very fine-grained to micro-crystalline	calcite, clay minerals	gray, tan	---	---	shale partings common
	silty/ sandy	thin- to thick-bedded	fine- to medium-grained	calcite, quartz	gray	---	jointing	---
Dolomite	normal	medium- to thick-bedded	fine-grained to crystalline	dolomite, calcite	gray, grayish-blue	---	jointing	vugs and cavities, forms "buckfat" clay residuum
	argillaceous	thin- to thick-bedded	very fine-grained to micro-crystalline	dolomite, clay minerals	gray, tan	---	---	shale partings
	silty/ sandy	thin- to thick-bedded	fine- to medium-grained	dolomite, quartz	gray	---	jointing	---

Figure 7. General Lithologic Characteristics of the Major Rock Types and Sub-types in the Rome Formation.

cally all major clastic and non-clastic rock types are represented within the formation, as well as many variations within each type. The gross features of the major rock types observed by the writer are compiled in Figure 7.

According to Resser (1938, p. 7) seventy-five per cent of the Rome formation is either red mudrock and/or green and drab-colored shales from one foot to fifty feet thick. The remainder is approximately divided between sandstones and siltstones of other colors (fifteen per cent), and limestone and dolomite (ten per cent). These proportions vary greatly, however, and are not valid everywhere in east Tennessee where the formation is exposed.

Generally, in the northwest belts of the Valley and Ridge, siltstone and sandstone predominate, with varicolored shales in lesser amounts and limestone and dolomite in minor amounts. To the southeast in the province (northeast Tennessee), carbonate rocks, especially dolomite, make up nearly half of the formation (Rodgers, 1953, p. 44), the remainder consisting mostly of distinctive "maroon" or red-brown shales, mudrock, and minor amounts of siltstone. In this southeastern phase of the formation, the shales and other clastic units are commonly calcareous and/or dolomitic.

Within the central belt of the province, the formation is dominantly shale and siltstone, becoming more clastic toward the northwest and non-clastic toward the southeast.

Bedding and Thickness Characteristics

The bedding and thickness in the Rome formation vary as widely as does the lithology of these units. Various distinct strata in the formation exhibit thicknesses which range from one centimeter to over five feet. Separate laminations, especially within the shale units, are often less than one centimeter and are sometimes found to be one millimeter or less in thickness. Non-clastic units, such as limestone or dolomite, are generally more massively bedded than clastic units, excepting a few sandstone units. A comparison of range in bedding and layer thickness to the different lithologies in the Rome is given in Figure 7.

For reasons described previously, it is difficult to determine total thickness of the Rome formation. Estimates of the average total thickness vary between 1000 feet and 1500 feet for eastern Tennessee, although rarely, if ever, is such a thickness exposed in a single outcrop. More commonly, only portions of the Rome, varying between 300 feet

and 1000 feet in thickness, can be observed and measured in a single exposure.

Estimates of the total thickness were attempted by the writer by piecing together observed portions of the Rome formation from upper contact to lower contact, using key marker beds to locate position in the section. This method is limited, however, since the formation appears to thicken, as a wedge, to the southeast, and a single thickness estimate may not apply. Also, rapidly changing lithologies inhibit the use of marker beds over the entire extent of the formation. In addition, faulting and folding may have eliminated several units and duplicated other units. With full recognition of these difficulties, several estimates and measurements of the thickness of the Rome are compiled in Figure 8. These data, representing three major regional areas, have been derived by various workers, including the present writer. It should be noted from the data given in this figure that the actual observed and measured thickness in a given section is always far below the estimated total thickness for the same, or adjacent section.

Geographical Area	Location	Thickness	Reference
Southern Pennsylvania (#)	Waynesboro, Pa.	1000'-1200'	Stose, 1906
	Cumberland Valley, Pa.	1200'	Woodward, 1929
Southwestern Virginia	Appalachian Valley Southwestern Virginia	1800'-2000'	Butts, 1940
	do. (less Middle Cambrian beds)	639' *	do.
		682' *	do.
		1286' *	do.
Northeast Tennessee (Valley and Ridge Province)	Northeast Tennessee	1200'-1800'	King, 1944
	do.	1250'-1500'	King and Ferguson, 1960
	do.	1200'	Rodgers, 1953
	East Tennessee (if base is missing)	700'-800'	do.
	East Tennessee	1000'-1200'	Schuchert, 1943
	East Tennessee	500'-3000'	Woodward, 1929
	Briceville, Tennessee	1200'	Keith, 1896c
	Maynardville, Tenn.	1000'	Keith, 1901
	Morristown, Tennessee	1300'	Keith, 1896b
	Knoxville, Tennessee	1200'-1500'	do., 1895
	Lee Valley, Tennessee	513' *	Rodgers and Kent, 1948
	Beaver Ridge-Beaver Valley, Tennessee	218½' *	This study
	Dog Mountain-Dutch Valley, Tennessee	230' *	do.
	Dug Ridge-Poplar Springs Valley, Tenn.	322½' *	do.
Northern Georgia	Coosa Valley, northern Georgia	750'-1000'	Hayes, 1902
	Northern Georgia	700'	Woodward, 1929
Northern Alabama	Northern Alabama	1000'	Smith, 1890
	do.	1000'	Woodward, 1929

(#)The Waynesboro formation was measured for the two localities listed for Southern Pennsylvania.

(*)indicates measured partial section

Figure 8: Estimated and measured thickness of the Rome formation for five major areas.

Primary and Lithologic Structural Features

One of the most unusual and striking features of the Rome formation is the abundance of primary and lithologic structural features. Although these sedimentary structures are not confined to the Rome formation in the area under study, they are by far more abundant within this formation. All types, including inorganic, both mechanical and chemical, and organic are present, as well as many unknown varieties which are difficult to classify. Indeed, it is sometimes difficult to determine whether a particular Rome structure is primary, i.e. penecontemporaneous with diagenesis, or secondary, i.e. produced by postlithification deformational forces. Many of these structures, however, prove useful in determining bedding positions and sequence of units in the formation; others, perhaps, may serve to characterize key marker beds. A fuller discussion of the origin and classification of these structural features, together with an analysis of their significance in determining the environmental and depositional history of the formation, will be discussed in later chapters. Figure 9 is a listing and classification of those structures which the writer has

INORGANIC		ORGANIC
MECHANICAL	CHEMICAL	
A. Planar bedding structures: 1. Laminations 2. Cross-bedding and cross-laminations B. Linear bedding structures: 1. Striations 2. Lobate and spatulate casts and molds 3. Wave and current ripple marks 4. Miscellaneous, obscure linear structures C. Bedding plane irregularities and markings: 1. Swash marks and rill marks 2. Rain prints and foam bursts 3. Flow casts and molds 4. Miscellaneous doubtful, or obscure bedding irregularities D. Deformed and disrupted bedding: 1. Soft-sediment boudinage 2. Mud-cracks and fillings 3. Mud and silt accretions 4. Miscellaneous or doubtful deformations	A. Solution structures: 1. Vugs B. Accretionary structures: 1. Concretions C. Composite structures: 1. Vug- and cavity-linings and fillings 2. Halite crystal casts and molds (classification doubtful(?))	A. Petrifications: 1. Undisturbed fossil remains 2. Disturbed fossil remains (?) B. Miscellaneous, doubtful or obscure organic structures: 1. Worm burrows, borings and tubes 2. Trilobite or worm tracks or trails 3. Trilobite (fucoid ?) casts or molds 4. Fecal pellets and/or coprolites 5. Unknown or doubtful organic structures: ridges, mounds, depressions and other markings

Figure 9: General classification of the sedimentary structures in the Rome formation. Modified after Pettijohn, 1957, p. 158 and Krumbein and Sloss, 1959, p. 95.

found in the formation. Previously, in Figure 7, the major structures in the formation were referred to the lithologic type in which they are most abundant.

Mineralogy

The mineralogy of the more common lithologic types of the Rome formation has been determined. The most unique and interesting mineral assemblages are found in certain of the "red beds" which are the maroon, gray-red, or red-brown siltstones and some sandstones. Argillaceous red shales and mudrocks are excluded, their clay mineralogy being fairly uniform. The red siltstone and sandstone consist mainly of quartz, the red color resulting from finely divided iron oxides, notably hematite, and limonite, which adhere to the grain surfaces and fill the interstices between them. Pods, lenses, and stringers of almost pure glauconite and/or hematite can be interspread within a layer, sometimes interlaminated with quartz. Heavy minerals, such as zircon, rutile, tourmaline, etc. may be intermixed with the quartz or glauconite, or as discrete accumulations within the quartz layer or glauconite pods. Like the more argillaceous shales, the upper surfaces of these coarser units may exhibit a

greenish, almost micaceous cast, caused by the presence of finely divided chlorite, micaceous glauconite, sericite and/ or muscovite. Nelson (1955) studied some mineral assemblages in the Rome and adjacent formations.

Authigenic minerals, such as calcite, dolomite, and orthoclase feldspar, have been found in several units of the Rome formation. The occurrence of commercially valuable but widely scattered mineral deposits in the Rome reflects the fact that identical mineralization can be found in adjacent formations within a local area. Examples that can be cited are the residual manganese ("wad") deposits of the Rome and adjacent Shady dolomites of northeastern Tennessee (King, et al, 1944), the barite deposits of the Del Rio district (Ferguson and Jewell, 1951), sphalerite mineralization at certain localities (Oder and Hook, 1949), and disseminated chalcopyrite and pyrite within the Rome of the western Valley and Ridge (Stuart Maher, personal communication, 1962). The hand-specimen mineralogy of each major rock type in the Rome is given in Figure 7. A fuller treatment of the mineralogy of certain units, using binocular and petrographic microscopy along with other methods, is given in Chapter IV.

Characteristic Colors

The great variety of colors in the Rome formation is one of its most characteristic and easily recognizable features. Colors in every variation of shade from light tan, yellow, white and gray to dark brown, red, maroon, blue, green, and gray-black have been observed by the writer. Colors produced by weathering, although they exhibit the same wide range of shades as the primary colors, cannot be used in interpreting environmental and depositional history of the sediment prior to lithification. It is necessary, therefore, to distinguish the primary, or unweathered color of the sediment from the secondary, or weathered color. The primary and secondary colors often differ in a rock unit, and one provides no suggestion of the other.

The identification of primary colors is difficult, and often subjective. Furthermore, these colors are affected by the wetness of the samples and the type of light under which they are viewed. In the description of the measured sections in Chapter III, the colors of the dry, unweathered samples are compared to the standard colors on the National Research Council Rock Color Chart (1948).

In general, most of the unweathered limestones, dolomites and other calcareous units of the Rome formation exhibit overall uniform colors ranging from gray to blue and gray-blue. Upon weathering, these rocks show a tan, light brown, or almost white surface, with the exception of certain dolomitic units, which exhibit weathered streaks of dark gray to almost black ("wad"), intermixed with lighter colors. The shales and other argillaceous units exhibit the widest variety of colors, such as yellow, brown, red, maroon, green, blue, gray and violet in many shades and variations. The red in the shales as well as other rock types, is indicative of disseminated iron in the ferric state, usually hematite. Yellow reflects the presence of limonite. Colors intermediate between these two, such as brown, orange, or red-brown, probably indicate a mixture of iron oxides. These red units usually weather to a lighter shade, such as tan or light brown. An understanding of the geochemistry of the various iron oxides, hydroxides, and other minerals which impart a red color to certain units, is necessary in order to classify these units properly as primary or secondary "red beds". This, in turn, contributes to a knowledge of the pre-and post-depositional history of the formation. A

further discussion of this subject follows in later chapters.

Green colors usually indicate the presence of either glauconite or chlorite. Glauconite is more common in sandstones and siltstones and chlorite in shales. A lime-green or gray-green color, usually confined to the shales, is imparted primarily by chlorite. The appearance of a purple or deep maroon color in any weathered or unweathered unit indicates the presence of red iron oxides mixed with green glauconite. True black, and in some cases lighter shades, can indicate the presence of organic matter, iron sulfides, or manganese.

The unweathered coarser sediments, such as siltstone and sandstone, basically exhibit light colors such as white, tan, or light gray, owing to the predominance of quartz. However, disseminated iron oxides in varying amounts, impart a darker tan, brown, or brownish-red to these types. An equal amount of disseminated iron oxides will impart a darker shade of red to a finer-grained siltstone than to a coarser-grained sandstone, owing to a more uniform distribution.

Colors of the Rome formation change rapidly from unit to unit and from layer to layer, and also within units and

layers. This fact, coupled with the predominance and ultimate importance of the red and green shades bears significantly on an understanding of the environmental and depositional history of the formation.

CHAPTER III

FIELD ANALYSIS OF SELECTED EXPOSURES

Introduction

Location of Selected Exposures and Measured Sections

The locations of the several exposures of the Rome formation cited in this study, along with those of several other outcrops, are given in Figure 1. The seven and one-half minute topographic quadrangle maps published by the United States Geological Survey-Tennessee Valley Authority, specifically, the Powell, 137-SE, Dutch Valley, 154-SE, and Cave Creek, 130-SW, quandrangles, were used for general location of the measured exposures. Precise locations were computed in terms of the 10,000 foot Tennessee grid coordinate system printed on all the Tennessee Valley Authority maps.

Detailed locations of the measured sections in Beaver Ridge, Log Mountain, and Dug Ridge are given in the introduction to each section.

Sampling Procedures

Preliminary to the detailed examination, several strike and dip readings were taken at each measured exposure. Computed average figures for these measurements are given in the general statement preceding each description. The width of outcrop of each exposure was measured by pacing, and an approximate thickness was computed for the entire exposed section. This preliminary thickness figure was later compared to the thickness figure obtained by adding the thickness of each separately measured unit. This comparison is given in the general statement following each description.

The total extent of the exposed and measured section was determined by locating the position of the top and bottom of the Rome present in each outcrop. In all three measured sections, a fault relationship with a younger post-Rome formation was observed. Below the lowest exposure of the Rome was a covered interval or a thin brecciated (fault) zone, or both, underlain by the younger post-Rome formation.

In two cases, the Pumpkin Valley shale was in contact with the top of the Rome formation. The contact was established by locating the topmost, prominent sandstone unit

generally considered to mark the top of the Rome (Rodgers and Kent, 1948). In the other case, the measured section at Dug Ridge, a partially-covered interval present at the top of the measured section prevented the establishment of a definite contact but was interpreted to include portions of both the Pumpkin Valley shale and the upper Rome units. The upper contact (the position of the last prominent sandstone) was inferred to be midway in the transition zone between the sandy-silty cover and the more shaly cover. However, the measured section at Dug Ridge includes only the first fully exposed unit of the Rome and does not extend to this arbitrary contact.

Units of the three sections were measured from the top contact with the Pumpkin Valley shale downward, and the descriptions are presented in the convential manner with the youngest, or topmost unit of the Rome described first and designated as unit #1. However, since the bottom fault contacts were also definitely established, measurements could have been taken from the bottom upward.

In examining the measured section, care was taken to measure the thickness of each unit and sub-unit at right angles to the dip, or as close to perpendicular as possible.

Measurements of the larger units were made with a standard six-foot steel measuring tape calibrated in sixteenths of an inch. A six-inch ruler, calibrated in sixty-fourths of an inch and in millimeters, was used for smaller units and sub-units.

To describe the complex bedding characteristics of the Rome formation in relative terms, the writer has found the existing relative scales (Krumbein and Sloss, 1951, p. 97; Pettijohn, 1957, p. 159) to be inadequate since the bedding terminology they provide is neither standard nor specific enough. In describing the measured sections the writer has employed a relative scale of his own development shown in Table I. The relative bedding characteristics of each sub-unit is given in terms of this scale, simplified by numerical values where necessary.

As a general rule, each section was subdivided into units on the basis of changes in gross lithology. Recognizable changes in bedding and thickness, color, texture, or other features provided the basis for the selection of sub-units. Where sequences of rapidly changing lithologies or complicated interbedding occurred, exceptions were made to simplify description.

Table I

Relative Scale of Bedding Terminology

Used in This Study

TERM	LIMITS OF BEDDING OR LAYERING THICKNESS	
	English Units	Metric Units
Paper-thin-bedded	<1/8"	<3 mm
Very thin-bedded	1/8" to 1/2"	3 mm to 1 cm
Thin-bedded (flaggy)	1/2" to 4"	1 cm to 10 cm
Medium-bedded	4" to 1'	10 cm to 30 cm
Thick-bedded	1' to 2'	30 cm to 60 cm
Very thick-bedded	2' to 3'	60 cm to 100 cm
Massive	> 3'	>100 cm

Each unit and sub-unit is described in terms of gross lithology and color. A ten power hand lens was used to aid in the determination of texture and mineralogy. Primary and secondary structures and other distinctive features, where present, were described, and, if possible, measured. At least one sample was collected from each sub-unit and labeled for future analysis and study.

Method of Presentation of Data

The descriptions of the measured sections are tabulated in columns in the form of a log, and are preceded by a general statement giving the location, average strike and dip, measured thickness and general stratigraphic, structural, and topographic relationships of each exposure.

Number and letter designations for each unit and sub-unit, respectively, have been assigned. Descriptions of the megascopic character of each unit and sub-unit, and the bedding, lithology, color, texture, and mineralogy of each sub-unit are given in as concise, but complete a manner as possible. However, many details of lesser importance have been omitted. Repetition of identical descriptions of similar units has been avoided where possible.

The thickness of each sub-unit and the total thickness of each unit are shown in separate columns in the logs. Additional remarks concerning structural, stratigraphic, paleontological, or other important features of a unit or sub-unit are also given. Each descriptive log is depicted graphically by means of a columnar section to scale on Plate II.

Description of Measured Sections

The Beaver Ridge Section

Location, General Features, and Measurements

The Beaver Ridge section (Plate I, Locality 1) is exposed in a road cut across Beaver Ridge between Hines Valley and Beaver Valley in Knox County, Tennessee. It is located on U.S. Highway 25W approximately 10 miles northwest of the city limits of Knoxville. Beaver Ridge, whose summit lies approximately 1200' above mean sea level at this locality, forms a steep ridge with a pronounced comby appearance. (See Fig. 4). The coordinates on the Powell qua drangle (U.S.G.S.-T.V.A. 137-SE) are 594,800N and 2,582,200E.

The Beaver Valley fault has thrust this section of

the Rome formation over portions of the Cambro-Ordovician Knox dolomite (Rodgers, 1953, Plate 1). The extreme lower portion of the section and the fault zone are covered. However, the transition from the silty-shaly cover of the Rome to the cherty cover of the Knox is easily discerned.

In this section the writer has identified the Middle Cambrian Pumpkin Valley shale of the Conasauga group in contact with the top of the Rome as determined by the presence of the last prominent Rome sandstone unit. Except for several extremely small covered intervals of silty-clay loam, the major portion of the Rome is exposed.

The Rome formation in this section dips southeast at moderate angles. The average strike is N25° E and the average dip is 45° SE. For the most part joints were observed to be perpendicular to bedding. Sedimentary structures, although present in several units, were not exposed abundantly.

Descriptive Log of the Measured Section

Unit	Sub-Unit	Description	Thick-ness of sub-unit	Total thick-ness of unit	Color Chart Designation and Additional Remarks
		Shales, argillaceous silty, thin-bedded, vari-colored; most beds weather to a chippy, drab, maroon, silty soil, with some small drag folds evident	-	-	Basal portion of the Pumpkin Valley.
1		Sandstone, gray-white to greenish gray, dense, quartzitic; very thick-bedded, contains narrow bands and layers of dark, mafic minerals and glauconite, all of which are hard, dense, and quartzitic. Maroonish surface color on weathering. Compare with Unit 1 of Log Mountain section.		2½'	Top of Rome: prominent ss unit. This unit and Unit 2 are offset by a small cross fault. Greenish gray (5GY 6/1).
2		Siltstone, sandy, and ss, thin-to medium-bedded drab, tan and greenish gray for the most part; some layers (as in Log Mtn.-Unit 2) show fine lamination of dark and light minerals, especially including glauconite in pods		12'	Light olive gray (5Y 5/2). Compare with Unit 2 of Log Mtn. section.

Beaver Ridge section (cont'd)

2 (cont'd)		and stringers; several very thin layers of interbedded green shales.			
3		Sandstone, medium-bedded, greenish and tannish white, somewhat quartzitic. Top of this unit is a hard, tan-white (18") more resistant quartzite.		9'	Grayish yellow green (5GY 7/2).
4		Shale, somewhat silty and sandy, thin-bedded, alternating reddish brown and greenish, some tan.		2'	Pale reddish brown (OR 5/4) and pale green (5G 7/2).
5	A	Sandstone, gray, thin- to medium-bedded. Toward top of sub-unit, ss is weathered to reddish-pink cast and has some small green shale and silty shale interbeds and partings. Some ss in this sub-unit is finely laminated.	21'		Light gray (N-7). Fragments of <u>Olenellus thompsoni</u>.
	B	Sandstone, massive, (single bed) gray, somewhat gritty; weathered red brownish on surface.	6'	27'	Grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2.
6		Sandstone, thick, very weathered and "rotten", grayish-tan.		2'	Grayish yellow (5Y 8/4) - weathered color.

Beaver Ridge section (cont'd)

7		Sandstone, dolomitic, (calcarenite), tan-gray, medium-bedded (6"), with black, asphaltic splotches on surface.	5'	Yellowish gray (5Y 7/2).
8		Sandstone, dolomitic, (calcarenite), tan-gray, thin-bedded, with some black asphaltic (?) splotches; extremely weathered (i.e. very "rotted" and crumbly).	2½'	Yellowish gray (5Y 7/2).
9		Shale, argillaceous, thin-bedded, very weathered to clay "muck" when wet.	12½'	Pale greenish yellow (10Y 8/2)
10		Sandstone, dense, somewhat quartzitic, gray to pink, massive.	3'	Grayish orange pink (5YR 7/2). Upper 1' of this unit lenses into Unit 9.
11		Siltstone, alternating with silty shales and some clay shales, "maroon" to tan, medium-bedded, badly weathered and jointed.	9'	Grayish red (10R 4/2). Sedimentary structures present: mud cracks, etc.
12	A	Shale, fissile and paper-thin, olive green, glauconitic.	1'	Grayish olive green (5GY 3/2).

Beaver Ridge section (cont'd)

12	B	Sandstone, thick-bedded to massive, maroon.	6'		Grayish red (10R 4/2). Some obscure bedding structures noted.
	C	Siltstone, shaly (argillaceous), thin-bedded, maroon.	1 '	9½'	Grayish red (10R 4/2). Some obscure bedding structures noted.
13	A	Shale, very argillaceous, paper-thin and fissile, tan to brown, weathered punky; interbedded with four thin, tan-brown, sltss layers.	7'		Pale yellow brown (10YR 6/2) and light brown (5YR 6/4).
	B	Shale, very argillaceous, drab, tan, and brown, paper-thin-bedded; weathered punky. Two feet above base of this sub-unit is a thin (2"), but prominent, brown sltss layer.	4½'		Pale yellow brown (10YR 6/2).
	C	Shale, argillaceous, alternating maroon and greenish, paper-thin, and fissile; interbedded within this sub-unit are three 1" brown siltstone layers.	4'		Dusky red (5R 3/4) and dark-greenish gray (5GY 4/1).
	D	Shale, argillaceous, olive-drab and brown; paper-thin and fissile, strongly weathered.	2½'	17 '	Pale olive (10Y 6/2).

Beaver Ridge section (cont'd)

14	A	Siltstone and ss, alternating; tan, medium-bedded (3"-6").	1½'		Grayish orange pink (5YR 7/2).
	B	Shale, argillaceous, maroon, interbedded with silty shales and sltss, all maroon. Silty beds are thin-bedded; shaly beds are very thin (¼").	5'		Pale to gray brown (5YR 4/2), grayish red (5-10YR 4/2).
	C	Siltstone and argillaceous shale, maroon and green, alternately interbedded; siltstone thin-bedded (1"); shale very thin to papery (¼").	1½'		Gray to dusky yellow green (5GY 6/2).
	D	Shale, fissile, silty shale, and interbedded sltss, all grayish-red to maroon; paper-thin- to thin-bedded.	6'	14'	Grayish red (5R 4/2). Wave ripple marks.
15	A	Siltstone, maroon to tan, somewhat quartzitic, thin-bedded. Some sedimentary structures are evident, as ripple marks and mud cracks.	½'		Grayish red (5R 4/2). Excellent primary structures in this unit.
	B	Shale, argillaceous, very thin-bedded, maroon to tan-red, interbedded with several well-jointed, thin-bedded, maroon sltss; abundant sedimentary structures include ripples, mud cracks, "worm" tubes, etc.	8'		Grayish red (10R 4/2). Good structures in this subunit. Joints are perpendicular to bedding, or nearly so.

Beaver Ridge section (cont'd)

15	C	Shale, yellow-green, argillaceous to silty-textured, thin-bedded (approx. 1"). Prominent sub-unit.	¾'	Dusky yellow (5Y 6/4).
	D	Shale, gray-green, argillaceous to silty-textured, thin-bedded (2"), underlain at base of sub-unit by a single layer of well-jointed, somewhat sandy, gray-green, medium-bedded (1') sltss.	3'	Light olive gray (5Y 5/2). Joints in sltss are perpendicular to bedding.
	E	Shale, argillaceous, to silty, maroon to tan-red, thin-bedded (2"), interbedded at 2' intervals with a well-jointed, thin (2"-4") maroon sltss. At the base of this sub-unit is a prominent 6" yellow-green, very thin-bedded, argillaceous shale. Many structures are in this sub-unit (ripples, flow casts, tubes, etc.).	12½'	Last distinctive maroon sub-unit in section. Grayish red (10R 4/2). Good strucrures evident. Joints perpendicular to (and some parallel to) bedding in sltss. Shale at base is dusky yellow (5Y 6/4).
16	a	Shale, argillaceous, maroon to red-brown, very thin-bedded. Portions are badly weathered to "muck".	5'	Dusky red (5R 3/4).

Beaver Ridge section (cont'd)

16	B	Shale, silty, gray-black, thin-bedded (approx. 3"). Deeply weathered.	4'		Dark gray (N3).
	C	Shale, silty to argillaceous, greenish gray, thin-bedded (approx. 2"-3"). Badly weathered to a "muck".	3'		Dark greenish gray (5GY 4/1).
	D	Siltstone, tan to yellow-brown; rusty weathering indicates presence of limonite; thin- to medium-bedded; several thin interbedded units of shale similar to Sub-unit C.	12'	24'	Moderate yellow-brown (10YR 5/4).
17	A	Dolomite, dense, finely crystalline to cryptocrystalline; blue-gray, portions weathered to tan and blue-black. Effervesces with difficulty when powdered. Medium- to thick-bedded.		5'	Light-medium blue-gray (5B 5/1).
	B	Siltstone, shaly, slightly calcareous, greenish and yellow-brown, thin-bedded; also occurs as interbeds within Sub-unit A.	4'	9'	Moderate yellow-brown (10YR 5/4).
18	A	Siltstone, yellow-brown, tan to buff weathering, thin-bedded.	4'		Pale yellow-brown (10YR 6/2). Minor drag folds in this unit. Each

Beaver Ridge section (cont'd)

18 (cont'd)	A				distinct lithology in this unit was designated a sub-unit. All sub-unit types, are, however, complexly interbedded.
	B	Siltstone, maroon to grayish red, tan and buff-colored on weathered surface, thin-bedded.	3¼'		Pale yellow-brown (10YR 6/2). Grayish red (10R 4/2).
	C	Shale, argillaceous, greenish gray, very thin-bedded. Portions badly weathered, light green, plastic clay or "muck".	10'		Light olive gray (5Y 5/2).
	D	Shale, argillaceous, maroon to grayish-red. Very thin-bedded. Portions reduced to "muck".	15'	32¼'	Grayish red (10R 4/2). Lowermost 2' layer of this sub-unit is the last fully exposed, and is the base of measured section.

Total measured thickness of the Beaver Ridge section . . . . 218½ feet

Covered interval of shaly and silty residuum

Beaver Ridge section (cont'd)

at base of the section represents zone of the Beaver Valley fault. The definite lithology of this interval is indeterminate. The first appearance of Knox chert residuum is 40' from base of Sub-unit 18D. The approximate thickness of the Rome formation represented in the covered interval . . . . .28 feet

Total computed thickness (widths of outcrop of exposed section plus covered interval x sin dip angle) . . . . .254½ feet

The Log Mountain Section

Location, General Features, and Measurements

The Log Mountain section (Plate II, Locality 2) is exposed in a gap across Log Mountain between Dutch Valley and Cracker Neck Valley in Grainger County, Tennessee. The section is located approximately 45 miles northeast of the city limits of Knoxville (Dutch Valley quadrangle, U.S.G.S.-T.V.A. 154-SE), along a secondary county road some four miles north of Washburn Community and Tennessee Highway 131. Two exposures are present at this location, one in the road cut and the other in a railroad cut across the ridge some fifty feet above the road. Due to the numerous covered and semi-covered intervals in the road cut, the writer measured the more fully exposed section outcropping in the railroad cut above. The summit of Log Mountain is approximately 1200 feet above mean sea level at this exposure, and the ridge itself is fairly steep, exhibiting a profuse pine tree cover. The Tennessee grid coordinates are 696,000N and 2,700,800E.

In this section the Copper Creek fault has thrusted the Rome over portions of the Ordovician Moccasin formation of the Chickamauga group (Rodgers, 1953, Plate II). The top

of the Rome is in contact with the Middle Cambrian Pumpkin Valley shale of the Conasauga group. As in the Beaver Ridge section, the last, or highest, prominent sandstone unit marking the top of the Rome formation was chosen as the contact.

A major portion of the Rome formation along with portions of the lower Pumpkin Valley shale are fully exposed in this outcrop. A 500 foot covered interval at the base of the section includes a transition from lower portions of the Rome, through the fault zone, to the upper part of the Moccasin formation.

The average strike of the Rome in this section is N65° E and the average dip is 40° SE. Joint patterns in the section generally are developed at right angles, or nearly so, but some are found parallel to the bedding. Good exposures of several types of sedimentary structures are also present.

Descriptive Log of the Measured Section

Unit	Sub-Unit	Description	Thick-ness of sub-unit	Total thick-ness of unit	Colar Chart Designation and Additional Remarks
1		Sandstone, maroon to tannish, quartzitic, Lower 3' in tan, quartzitic ss, containing prominent glauconite bands and lenses, which weather to dark brown to black blotches on the ss. Entire unit weathers to a mottled rusty tannish brown and is in places blocky to massively jointed. Entire unit is one bed.		5'	This unit is the first unit of the formation; it is the topmost prominent ss of the Rome which is in contact with the lowermost shale units of the Pumpkin Valley. Grayish orange pink (5YR 7/2) to pale red (5R 6/2)
2	A	Sandstone, gray-blue to tan-white, good quartzose, rather thin-bedded (6'); some layers and finely laminated and micro-cross-bedded. The laminae are interlayers of quartz and glauconite (and other heavy minerals). This sub-unit weathers to a rusty tan color, with black streaks.	3'		Light gray (N7) to grayish orange pink (5YR 7/2)

Log Mountain section (cont'd)

2	B	Sandstones, brown thin- to medium-bedded; rusty black on weathering.	3'		Yellowish gray (5Y 8/1).
	C	Sandstone, blue-black to white, massive.	3'		Light olive gray (5Y 6/1).
	D	Sandstone, whitish, quartzose, thin-bedded (3"-4") in lower 3' upper part is one massive 3' bed.	6'	15'	Yellowish gray (5Y 8/1).
3		Sandstone, massive, white to tan, somewhat quartzitic. Jointing (similar to Unit 1) prominent. Weathers to a rusty tan color.		6'	Pale yellowish brown (10YR 6/2).
4		Siltstone, argillaceous to sandy; greenish-gray; medium-bedded (6") grades into a 6" bed of maroon, somewhat glauconitic siltstone.		1'	Olive gray (5Y 3/2), and light brown (5YR 6/4). First green sltst bed below top of formation. Possibly a marker bed.
5	A	Siltstone to silty sandstone, maroon, with some glauconite bands; thin-bedded. Weathers rusty brown.	2'		Grayish red (10R 4/2) to moderate brown (5YR 4/4).
	B	Same as 5A, but thicker bedded (4 to 6 inches thick).	3'	5'	Sames as 5A

Log Mountain section (cont'd)

6		Sandstone, massive, tan.		3'	Grayish orange (10YR 7/4).
7	A	Siltstone, tan to rust colored, thin-bedded (2").	3'		Grayish orange (10YR 7/4).
	B	Sandstone, ferruginous, maroon, massive-bedded.	2½'		Grayish red (5R 4/2).
	C	Paper-thin, greenish clay shales interbedded with tan to brown silt-stones; thin-bedded, 2"-3".	3'	8½'	Light olive gray (5Y 5/2).
8	A	Sandstone, quartzitic, tan, maroon, medium-bed-ded (up to 6") to mas-sive-bedded (18" to 2'). Interbedded with these are maroon, ferruginous to tan quartzites, thick-bedded and very hard and dense. Quartzites are blockily jointed, so much so as to appear thin-bedded.	10'		Light brown (5YR 6/4).
	B	Sandstone, maroon, more thinly bedded (4"-6") than Sub-unit A.	2½'		Pale red-dish (10R 5/4).
	C	Quartzite, ferruginous, maroon, massive-bedded. Two beds, each 5' thick.	10'		Grayish red (10R 4/2). Well jointed.
	D	Sandstone, ferruginous and quartzitic, massive, tan. Well-jointed as in 8A.	4'	26½'	Pale yel-lowish brown (10YR 6/2). The

Log Mountain section (cont'd)

8 (cont'd)	D			change from the quartzites of this unit to the shales of Unit 9 is very striking.
9		Shale, argillaceous, maroon, paper-thin bedded (<1/10"); interbedded with maroon siltstones and grading into a thicker sandstone (2') at the bottom of unit.	6'	Grayish red (5R 4/2) to 10R 4/2). Some primary structures are present.
10		Shale, argillaceous, maroon and greenish, interbedded, paper-thin (1mm.) Some thicker siltstone also interbedded.	8'	Blackish red (5R 2/2) and dusky red (10R 2/2). Some primary structures are present.
11		Sandstone, light maroon, thick- and thin-bedded except in middle of unit where it is massive (2½'). Several maroon clay shale layers separate the sandstone layers.	20'	Grayish red (10R 4/2).
12		Siltstone, maroon, thin-bedded (1"-2"), interlayered with paper-thin, maroon clay shales and silty shales. The upper surface of several silt-	2½'	Same as Unit 11. Good ripple marks and other sedimentary

Log Mountain section (cont'd)

12 (cont'd.)		stone layers appears to have a greenish-glauconitic micaceous sheen.			structures. "Worm" tubes on weathered undersurface of last layer in this unit.
13		Shale, argillaceous and chloritic, and/or glauconitic, light green. Deeply weathered to a light green clay soil.		4'	Dark yellow green (5GY 5/2).
14	A	Sandstone, tannish, well-jointed. A tongue measuring up to 4' in thickness, but lensing out in upper part of outcrop.	4'		Grayish orange (10YR 7/4). This subunit separates Units 13 and 15 only in lower part of outcrop.
	B	Shale, maroon, argillaceous, paper-thin with some glauconite lenses.	4'	8'	Grayish red (10R 4/2).
15		Shale, blue-gray, somewhat calcareous, thin-bedded (flaggy); unit weathers to a tannish gray-white.		3'	Dark greenish gray (5GY 4/1).
16		Shale, argillaceous, very thin-bedded, brown, interbedded with thicker, maroon, finely laminated and somewhat glauconitic siltstone.		4'	Brownish gray (5YR 4/1) and grayish red (10R 4/2).

Log Mountain section (cont'd)

17	Shale, argillaceous, very thin-bedded, deep green-gray, inter-bedded with several thicker maroon and tan siltstones. The shale weathers to a dark greenish clay soil.	3'	Greenish gray (5GY 6/1) to (5G 6/1).
18	Quartzite to quartzitic sandstone, thin-bedded (1"-2"), colors vary from gray and blue-gray to maroon-tan and tan-gray. Weathered surfaces are tan and/or maroon to a rusty black (dominant). These beds are nearly all crystalline, hard and dense. Glauconite, in lenses and bands alternating with quartz is evident throughout this unit, especially in those beds which are finely laminated (laminae 1mm). Iron-coated quartz and other heavy minerals are present. Glauconitic shale (approx. ¼") layers and almost pure pods of glauconite are interbedded with some of the quartzite layers.	12'	Light gray (N7) and pale red (10R 6/2). These slightly metamorphosed beds (formerly laminated siltstone, and sandstone) exhibit a peculiar weathering (?) or depositional (?) feature on their upper surfaces. These features resemble small (approx. ¼") to large (approx. ½") irregularly shaped nodules which appear to

Log Mountain section (cont'd)

18 (cont'd)			have been weathered in relief from the quartzite protruding on the upper surface. Each nodule is capped by a film of glauconite.
19	Siltstone, and silty sandstone, thin-bedded, chartreuse-green; weathered to a rust and pastel green color.	1'	Moderate greenish yellow (10Y 7/4).
20	Similar to Unit 18	1½'	Same color as Unit 18.
21	Similar to Unit 19	1½'	Same color as Unit 19.
22	Lithology similar to Units 18 and 20, but beds are thicker (1'), especially in center of unit.	13½'	Same color as Unit 18.
23	Siltstone, silty sandstone, and argillaceous shales; maroon, all interbedded. Clay shales are paper-thin, siltstone 1" thick. One very thick (2'), maroon siltstone lies in the center of this unit. Several greenish (glauconitic)	8'	Grayish red (10R 4/2). Unknown structures on upper surface of this unit.

Log Mountain section (cont'd)

23 (cont'd)	shale beds are interspersed within the unit; especially near the bottom.		
24	Similar to Units 18, 20, and 22, but beds are thicker (4"-6"). Reddish and pink-reddish color predominates, rather than maroon. Glauconite and nodular upper surfaces persist, as does "rusty"-black weathering.	18'	Same color as Unit 18. Nodular and pitted (?) upper surface is more pronounced in this unit. An interesting feature of some siltstones in this unit and Units 18, 20, and 22 is their boudinage-like appearance.
25	Shale, argillaceous, interbedded with some siltstone and sandstone, mostly maroon. Some glauconite in all beds. Weathers to a "punky" black-maroon.	10'	Grayish red (10R 4/2). Structures (?) on upper surface.
26	Shale, argillaceous, and silty, mostly paper-thin; colors "punky" tan, rust, brown, and greenish-gray in alternating sequence.	36'	Light olive gray (5Y 6/1), greenish gray (5GY 6/1), brownish gray (5YR 4/1), grayish red (5R

Log Mountain section (cont'd)

26 (cont'd)		4/2), grayish yellow green (5GY 7/2), and pale brown (5YR 5/2). Unit weathers deeply to a drab tan, silty, partially-covered soil. The base of this unit marks the end of the exposed section.
"27"	(See below)	

Total measured thickness of the Log Mountain section . . . . 230 feet

A 500' covered and partially-covered interval at the base of the section includes the fault zone and a portion of the Moccasin formation. The residuum here, and the basal part of the section in the lower road cut both indicate about the same lithology as Unit 26. A 3' dolomite (Unit "27") was

Log Mountain section (cont'd)

also found near the center of this interval in the lower road cut. Approximate computed Rome thickness in covered interval . . . . . . 275 feet

Total computed thickness (widths of outcrop of exposed section plus covered interval above fault x sin dip angle) . . . . 495 feet

The Dug Ridge Section

Location, General Features, and Measurements

The Dug Ridge section (Plate I, Locality 3) is exposed in a recent road cut across Dug Ridge between Poplar Spring Valley and Bradbury Valley in Roane County, Tennessee. It is located on U.S. Interstate Highway #40 approximately 22 miles west of Knoxville, Tennessee (Cave Creek quandrangle, U.S.G.S.-T.V.A. 130-SW). The coordinates are 437,500N and 2,467,400E. The summit of Dug Ridge is approximately 1160' above mean sea level at this exposure. The ridge is not as steep, and consequently less prominent than either Beaver Ridge or Log Mountain.

In this section, the Copper Creek fault has thrust the Rome over portions of the Lower and Middle Ordovician Chickamauga formations (Rodgers, 1953, Plate 8). The top of the Rome is in contact with the lower portions of the Middle Cambrian Conasauga shale. However, the contact is unexposed due to a small covered interval. An arbitrary contact was drawn midway in the transition zone between the sandy-silty cover and the more shaly cover. Except for this covered interval, the Rome section is fully exposed. Actual

measurement of the section was begun at the top of the first fully exposed unit in the Rome.

The Rome in this section dips southeast at shallow to moderate angles to the south, becoming steeper northward within the exposure. (Fig. 10). The average strike is N45° E and the average dip is 30° SE. Prominent joint sets were found to be approximately perpendicular to bedding. Some small joint patterns lie parallel to bedding. Several units in the exposure showed excellent examples of the more common sedimentary structures, and a few exhibited several of the unusual variety.

Descriptive Log of the Measured Section

Unit	Sub-unit	Description	Thick-ness of sub-unit	Total thick-ness of unit	Color Chart Designation and Additional Remarks
-		Covered interval includes lower units of Pumpkin Valley shale under a shaly cover, and upper units of Rome under a sandy-silty cover. Width of interval is 425' from top of Rome (drawn midway between shaly and silty-sandy	Approximate thickness represented by covered Rome at top of section: 210'.		Exact lithology indeterminate.

Figure 10. View of Dug Ridge exposure. Photograph illustrates steepening dip in the Rome formation at right (north) of photo.

Dug Ridge section (cont'd)

	cover) to first fully exposed Rome unit.		
1	Siltstone, greenish gray, friable, thin-bedded (1"). Weathered to a greenish white.	½'	Pale olive (10Y 6/2). Topmost exposed unit.
2	Siltstone, light brown and tan, thin-bedded. Weathers to small rust-colored chips.	5'	Pale brown (5YR 5/2), grayish red (5R 4/2). Salt casts and tube markings on upper surface.
3	Siltstone, maroon, thin-bedded, somewhat argillaceous; interbedded with very thin-bedded argillaceous to silty shales, both maroon and greenish (chlorite and/or glauconite bands and lenses). Glauconite also appears as pods and lenses within isolated maroon silty beds. Shales are partially micaceous on some upper surfaces. Entire unit weathers to a dun-brown color. Complexly interbedded unit.	10'	Pale brown (5YR 5/2), grayish red (R 4/2), grayish brown (5YR 3/2), dark greenish gray (5GY 4/1). This unit exhibits abundant, well-developed, primary features such as ripple marks, mud cracks, "tube" structures, "mud balls",

Dug Ridge section (cont'd)

3 (cont'd)			flow casts, tracks (?) and trails (?).
4	Shale, argillaceous and somewhat micaceous, very thin-bedded, both maroon (ferruginous) and green (mostly choritic, some glauconitic) interlayed with maroon to light brown siltstone, sandstone, and quartzite, all thin-bedded. Shale is much contorted; most portions weathered to rusty-brown and greenish brown silty clay "muck". Siltstone and sandstone beds partially weather to a nodular and somewhat spheroidal appearance on upper surface. Complexly interbedded.	25'	Pale olive (10YR 6/2), pale brown (5YR 5/2), and light olive gray (5Y 5/2). Fragment of <u>Olenellus</u> (?) found in this unit. Some minor drag folds present in shale layers. Many primary structures found in this unit. Siltstone and sandstone highly jointed.
5	Sandstone, somewhat silty and argillaceous, maroon to greenish with bands and pods of glauconite interbedded. Very thick single bed.	3'	Pale brown (5YR 5/2), light olive gray (5Y 5/2).

Dug Ridge section (cont'd)

6	A	Sandstone, tan, black on weathered surface, thin-bedded. Films of quartz lining joints and cracks within this sub-unit.	1'		Dark yellowish brown (10YR 4/2).
	B	Shale, somewhat calcareous, thin-bedded (flaggy), grayish black.	½'	1½'	Medium dark gray (N4).
7		Shale, very thin- to thin-bedded, interbedded with thin- to medium-bedded silty shale, siltstone, sandstone, and quartzitic sandstone. All lithologies are dark gray to grayish-black; most weather to a tan-gray color, with a residuum of gray, silty to stony soil. Several shale units bear a tan and whitish gray powder on their weathered upper surfaces. Shales in this unit are somewhat calcareous (effervesce freely with HCl). Quartz films, veins, and boudins (?) are common in the coarser-grained, medium-bedded units; laminations are common in finer-grained siltstone and silty shale.		45'	General color: dark gray (N3), weathering to yellowish gray (5Y 7/2). Complex gradations and interlayering prevents accurate sub-division of this unit. Many tube-like structures ("wormtubes") appear on upper surface of the shales.
8	A	Siltstone, fine-grained, thick-bedded (18"), interlayered with sandstone, thick-	4½'		Overall colors: blackish red (5R

Dug Ridge section (cont'd)

8 (cont'd)	A	bedded (1'). Mostly maroon (due to high percent of pure reniform and oolitic hematite) with blotches of green throughout (due to a large number of pods and lenses of rounded to subbotryoidal glauconite). Mixture of hematite and glauconite gives distinctive, purple-red cast, to the exposed surfaces of this sub-unit.			2/2) and dusky red (10R 2/2); red portion: grayish red (5R 4/2); green portions: greenish black (5GY 2/1), and grayish olive green (5GY 3/2).
	B	Shale, argillaceous ferruginous, very thin- to thin-bedded, interbedded with thin-to medium-bedded silty shales, sandstones, and siltstones. Texture, mineralogy, and colors of coarser units similar to Sub-unit A. Primary features abundant in shales; vugs and cavities (lined with calcite) are common in siltstone and coarser textured beds. Profuse laminations of glauconite are common in the maroon siltstone of this sub-unit.	7½'	12'	Same colors as in Subunit A plus dusky yellow green (5GY 5/2). Many primary features present in this sub-unit.
9	A	Sandstone, coarse-grained, slightly calcareous, gray, thick-bedded, tan weathering.	1½'		Medium to medium-dark gray (N5 to N4).

Dug Ridge section (cont'd)

9	B	Shale, argillaceous, slightly calcareous, gray, thin-bedded.	1½'		Medium gray (N5).
	C	Sandstone, slightly calcareous, very thick-bedded, "blue"-gray, with shale partings.	2'	5'	Dark gray (N3).
10		Sandstone, quartzitic, maroon, medium-bedded.		5'	Grayish red (5R 4/2).
11		Limestone, argillaceous (with shaly partings) to crystalline, gray to greenish-gray, medium-bedded, calcareous shale towards base of unit. All beds and partings weather to a grayish tan and are well-jointed.		40'	Dark greenish gray (5GY 4/1), light olive gray (5Y 6/1).
12	A	Shale, argillaceous to calcareous, paper-thin bedded, dark gray.	6'		Medium dark gray (N4).
	B	Limestone, argillaceous to crystalline, dark gray, medium-bedded, weathers tan.	2½'		Same color as Sub-unit 12.
	C	Shale, argillaceous to slightly calcareous, dark gray; paper-thin-bedded, somewhat distorted.	3'	11½'	Same color as 12A, some minor folds in this sub-unit.
13		Very similar in all respects to Unit 11.		35'	Greenish gray (5GY 6/1) to (5G 6/1).

Dug Ridge section (cont'd)

14	A	Shale, argillaceous to silty, maroon, paper-thin- to thin-bedded.	6'		Grayish red (5R 4/2). Many structures present.
	B	Siltstone, quartzitic, tan, very thick-bedded (2').	6'		Yellowish gray (5Y 7/2). Ripple marks and "foam-bursts" present on upper surface.
	C	Siltstone, fine-grained, argillaceous, blue-green to gray; thin-bedded, interbedded with gray-blue, paper-thin, argillaceous shale. Most beds in this sub-unit are distorted. Sub-unit grades into Unit 15.	15'	27'	Grayish blue (5BG 5/2). Primary structures present in siltstone, notably mud cracks.
15		Shale, argillaceous to silty, vari-colored, paper-thin to thin-bedded; interbedded and grading into vari-colored, argillaceous, quartzose and somewhat glauconitic, thin-bedded siltstone and sandstone. All beds strongly weathered and distorted by drag folds and joints; portions of the unit are covered with a very shallow mantle of drab-colored, residual, silty-		65'	Medium gray (N5) and pale red (10R 6/2) are dominant colors. Coarser-textured beds show structures. Largest sub-division in this exposure;

Dug Ridge section (cont'd)

15 (cont'd)		clay and shale chips. Talus accumulation is abundant at foot of unit.			complex interlayering and gradational character prevents further subdivision
16		Sandstone, coarse-grained, somewhat ferruginous, tan, thick-bedded; rust-colored weathering evident in spots.		8'	Moderate yellow brown (10YR 5/4).
17	A	Shale, argillaceous, tan-gray, very thin-bedded. Badly weathered, forming a drab-colored talus slope at foot of sub-unit.	9'		Medium gray (N5), moderate yellow brown (10YR 6/3).
	B	Siltstone, slightly ferruginous, tan-brown, thin-bedded, weathered to a rust-color in spots.	3'	12'	Moderate yellow brown (10YR 6/3).
18	A	Sandstone, quartzitic, tan, thick-bedded. Grades into Sub-unit B.	4'		Pale to moderate yellowish brown (10YR 5/4) to (10YR 6/4).
	B	Very similar to Sub-unit A, except is darker brown in color.	4'		Moderate brown (5YR 3/4).
19	A	Shale, very fine-grained, calcareous-dolomitic.	1½'		Gray blue green (5BG

Dug Ridge section (cont'd)

19 (cont'd)	A	(effervescence variable with HCl), grayish-blue, thin-bedded.			5/2).
	B	Dolomite, cryptocrystalline to finely crystalline, grayish-blue, medium- to thick-bedded (10"-14").	2½'	4'	Grayish blue (5PB 5/2). Last unit of Rome in the measured section; followed by a 4' brecciated zone of Copper Creek fault below which is a topmost limestone unit of the Chickamauga section.

Total measured thickness of the Dug Ridge section . . . . 322½ feet

Approximate total thickness of Rome represented by covered interval at top of section . . . . 210 feet

Total computed thickness (widths of outcrop of exposed section plus covered interval x sin dip angle) . . . . 540 feet

CHAPTER IV

LABORATORY ANALYSIS OF SELECTED UNITS

General Remarks

Representative samples of lithologic units within each measured exposure of the Rome formation were selected for more detailed study in the laboratory. Certain units were selected primarily for examination by means of petrographic or binocular microscopy. Other units were chosen for grain size, heavy mineral, insoluble residue, iron content, or sedimentary structure analysis. Those units considered to be most important, or unusual, were subjected to a more thorough examination employing more than one analysis; however, the majority of the selected units were examined by the method judged by the writer to be most pertinent in each case. In this way a maximum amount of information concerning each measured section was acquired and duplication of detail was avoided where units were similar if not identical in certain respects.

Laboratory Data

Microscopic Analysis

Procedures

Where possible, a small hand sample of each measured unit was examined with a binocular microscope to determine the general mineralogical and textural characteristics of the rock type. A preliminary determination of the grain size was made, wherever feasible, by fitting a calibrated ocular to a binocular microscope and superimposing a 0.1 mm. grid scale over the specimen. From this preliminary study certain units were selected for more detailed petrographic study, and a thin section was prepared in the standard manner (Gibbs and Evans, 1950).

Thin sections were examined and described mineralogically with the aid of standard reference works (Rogers and Kerr, 1942; Carozzi, 1960; Pettijohn, 1957). A second determination of grain size was made using a calibrated ocular fitted to the petrographic microscope.

Many of the sections examined, however, proved to be of minimum value in determining details of mineral

composition, texture, and structure. Many of the shales and siltstones examined were too fine-grained for accurate petrographic analysis. Several of the coarser-grained, hematitic siltstones and sandstones were difficult to examine petrographically due to the opaque nature of the iron oxide coatings and cement. For these reasons, much of the petrographic work within certain units had to be supplemented by further examination by the binocular microscope. In the presentation of results of the microscopic examination of the selected units in the following paragraphs, petrographic and binocular data have been combined. Diameters of mineral grains, where given, are averages obtained from several measurements. Percentages given represent portions of all grains encountered on the slide examined. As will be noted below, in some cases it was necessary to designate two types within units because of mineralogical differences judged to be significant.

Data from Microscopic Analysis

<u>Selected Units from Beaver Ridge</u>

Unit Microscopic Description

1 Sandstone, quartzose to slightly glauconitic(approx.

3%). Fine to medium arenaceous texture, quartz grains average 0.125-0.250 mm., glauconite grains are slightly larger (0.3-0.5 mm). Quartz grains are subhedral (sub-angular to sub-rounded), most are clear to light-colored. Some slightly frosted grains were noted. Pink quartz is rare. Most exhibit low relief and weak birefringence. Some grains and quartzose cement show undulatory extinction. Bright green, slightly pleochroic, anhedral glauconite (rounded to sub-rounded) is dispersed as thin, single-grain laminae throughout slide, mostly parallel or at a slight angle to bedding. Several minute, prismatic grains of pale red, highly birefringent zircon noted. Three to five per cent void space is present due to absence of cementing material. A thin, quartz-filled joint cuts diagonally across section.

5A Sandstone, quartzose, hematitic (5%) and slightly argillaceous (3%). Section shows fine-grained arenaceous texture for the most part with the colorless, subhedral grains of quartz averaging 0.1-0.3 mm. Lutaceous to cryptocrystalline, moderately birefringent material (clay minerals (?)) distributed as partial matrix and as laminar clusters throughout groundmass. Remaining cement composed partially of fine-grained, anhedral quartz and opaque hematite altering to limonite. Birefringence partially masked by iron oxide.

9 Shale, extremely fine-grained, composed of pale, microcrystalline to cryptocrystalline (clay material) aggregates of low to moderate relief and moderate birefringence. "Bloating" of hand specimen when water-saturated suggested presence of "expanding lattice", montmorillonitic type clay minerals, although typical glass shard form could not be definitely established.

14A Siltstone, fine-grained arenaceous texture. Euhedral (sub-angular), colorless to gray quartz grains average 0.10 mm. in size. Birefringence partially marked by opaque hematite coatings and cement (red-black in

reflected light), partially altered to limonite. Laminae of microcrystalline clay mineral aggregates partially altered.

15D Siltstone, fine- to medium-grained, arenaceous texture, somewhat argillaceous and hematitic (approx. 15%), with up to 3% glauconite. Euhedral, weakly birefringent quartz averages 0.10-0.25 mm. Green, anhedral (rounded to ovoid), slightly pleochroic glauconite averages 0.5 mm., occurs in thin stringers throughout groundmass. Some glauconite exhibits alteration rims of limonite. Cementing material quartzose and partially very fine-grained to microcrystalline clay aggregates with some red, opaque hematite, altering to limonite. Light green aggregates in clay fraction possibly chlorite; some minute, moderately birefringent shreds near top of slide, possibly sericite. Large amount of clay fraction weathered by opaque iron oxides. Several very scarce opaque grains (black in reflected light) with tan whitish opaque rims possibly ilmenite altering to leucoxene.

15E (Type I) Shale, composed of very fine-grained, lutaceous to cryptocrystalline aggregates, partially masked by opaque, red cementing hematite. Groundmass mostly clay minerals of indefinite composition, with some chlorite and sericite (?) suggested. Two slightly larger opaque grains identified as pyrite under reflected light.

15E (Type II) Siltstone, fine- to medium-grained (0.1-0.2 mm.) arenaceous texture. Quartz grains subhedral to euhedral (sub-rounded to sub-angular). Groundmass largely masked by red-black, opaque hematite (approx. 20%).

17A Dolomite, finely crystalline, generally equigranular. Groundmass consists of subhedral dolomite, moderately to strongly birefringent in some grains. Finely crystalline (clay) aggregates are somewhat altered to tannish white color (plain light). Glauconite (1%) is randomly scattered throughout groundmass.

Beaver Ridge Units (cont'd)

18D Shale, fine-grained, lutaceous to cryptocrystalline. Groundmass mostly clay mineral aggregates, partially masked by hematitic and limonitic cement. Several thin laminae and fibrous stringers completely masked by hematite.

Selected Units from Log Mountain

Unit	Microscopic Description
1	Sandstone, arenaceous, somewhat orthoquartzitic, medium-grained. Quartz averages 0.3-0.5 mm. and greater. Disseminated glauconite (1-2%) common as laminae in lower portion of groundmass. Cementing material, fine-grained quartz with some hematite. Vugs, 1-2 mm. in diameter, filled with opaque limonite, are disseminated throughout groundmass.
2A	Sandstone, medium-grained, arenaceous, somewhat orthoquartzitic, interlaminated with thin (0.3-1.0 mm.) stringers of glauconite (see Figure 11). Some glauconite stringers cross-laminated. Quartz (0.2 0.3 mm.) is subhedral to euhedral, mostly ovoid and lobate in form and slightly pleochroic (plain light). Prismatic zircon, moderately birefringent, prismatic tourmaline (gray-blue; high relief in plain light) and opaque pyrite occur as rare, disseminated grains throughout groundmass.
4	Siltstone, finely arenaceous, quartzose (50%) and glauconitic (approx. 35%), with fine-grained quartzose-hemetitic cement. Glauconite, laminated and cross-laminated as in 2A; several grains of glauconite (?) alternately green and white striped. Several unidentifiable, highly birefringent grains disseminated throughout groundmass.
11	Sandstone, medium-grained arenaceous texture. Mostly quartzose with subhedral quartz averaging 0.3 mm.; slightly glauconitic (approx. 2-3%). Cementing

Figure 11. Lamination in a Rome sandstone. Sample illustrated is Log Mountain Unit 2A. Dark laminae are composed of glauconite.

Log Mountain Units (cont'd)

material almost entirely hematite, partially altering to limonite. Hematite-filled cracks give a reticulated appearance to portions of the slide.

12 Siltstone, fine-grained arenaceous texture. Several disseminated grains of glauconite and unidentifiable minerals occur throughout quartz groundmass. Cementing material mostly opaque, red hematite. Several thin laminae of tan and light green microcrystalline clay aggregates noted throughout groundmass.

18 Sandstone, arenaceous, somewhat orthoquartzitic. Portions of groundmass composed of interlocking, nearly homogenous quartz aggregates; remainder is medium-grained (0.3-0.5 mm.), subhedral quartz grains with fine-grained siliceous (?), quartzose, argillaceous, and hematitic cement. Several grains of subhedral glauconite, opaque pyrite, and (authigenic) euhedral orthoclase feldspar (?) are disseminated throughout groundmass.

19 Siltstone, fine-grained arenaceous texture. Quartz (approx. 0.1 mm.) groundmass, with finer-grained, somewhat altered hematite-clay (chlorite ?) occurring as cement and as stringers and pods throughout slide. Several large (1 mm.) anhedral (rounded) quartz grains disseminated across top of groundmass.

"27" Dolomite, microscopically similar to Beaver Ridge Unit 17A, except for addition of microcrystalline quartz aggregates (approx. 3-5%), which exhibit undulatory extinction (chert ?).

Selected Units from Dug Ridge

Unit Microscopic Description

3 Siltstone, fine-grained arenaceous, somewhat orthoquartzitic in texture. Groundmass is partially interlocking, homogenous quartz. Several large (0.7

Dug Ridge Units (cont'd)

mm.) glauconite grains disseminated throughout groundmass, as are several pods and stringers of microcrystalline (clay) aggregates.

4 Siltstone, fine-grained arenaceous texture. Subhedral, clear to gray, weakly birefringent quartz (0.1 mm. average diameter), with hematitic, chloritic (?), and argillaceous cement. Some weakly birefringent, shred-like, micaceous masses (sericite ?) (2-3%) and light green, slightly pleochroic, somewhat fibrous aggregates (2-3%) randomly scattered throughout groundmass. Opaque limonite altered from hematite appears to outline several quartz grains.

7 Shale, fine-grained lutaceous to medium-grained arenaceous texture. Groundmass predominantly (approx. 75%) finely crystalline aggregates, denoting clay minerals, remainder is euhedral quartz (0.1-0.25 mm.). Several unidentifiable opaque and nearly isotropic grains present in groundmass.

8B (Type I) Shale, fine-grained lutaceous to medium-grained arenaceous texture. Microcrystalline clay minerals (60%), subhedral quartz (0.25 mm.; 20%) and opaque, oolitic hematite (10%) comprise groundmass, opaque, homogenous hematite and coatings (10%) strongly masks portions of the groundmass.

8B (Type II) Siltstone, fine- to medium-grained arenaceous texture, somewhat quartzitic. Silica cemented quartz (0.1-0.25 mm.) comprises large, nearly homogenous portions of the groundmass. Large (0.5 mm.) random grains of rounded grass green and green-white striped (?) glauconite comprise more than 15% of groundmass.

9C Sandstone, medium-grained arenaceous texture. Subrounded quartz grains average 0.3 mm. in diameter. Cementing material mostly quartzose, although some fine-grained, highly birefringent aggregates suggest calcite (approx. 5%) or calcareous cement. Glauconite, not previously described in this sub-unit is abundant as a constituent in this slide.

Dug Ridge Units (cont'd)

18A Sandstone, medium-grained arenaceous to nearly homogenous quartzitic texture. Small amount (2%) of opaque ilmenite altering to tan-white leucoxene. Several unidentifiable grains disseminated throughout groundmass.

19B Dolomite, microscopically similar to Log Mountain Unit "27".

Size Analysis

Procedures and Data

A number of representative clastic units were selected from each measured section for size analysis. For the most part, samples were selected which disaggregated easily by hand in order to prevent any considerable loss of the finer-grained constituents. A mortar and pestle was used to free the grains from the cementing material. Samples which proved difficult to disaggregate solely by hand, such as those from several orthoquartzitic units, were carefully crushed mechanically and then further reduced to individual aggregates by handcrushing. Metaquartzitic samples which broke across, rather than around, grains were avoided, since a crushed sample would not accurately reflect the range of grain sizes.

After crushing, a 100 gram test sample was obtained by successively quartering the original crushed sample and then sieving through a nest of standard sieves (U.S. Standard Sieve Series) in a Ro-Tap Automatic Shaking Machine for the most part. Screens of eleven different diameters were selected to represent various size ranges within the Wentworth

grade scale (see Table II). The test samples were sieved for ten minutes through a series of the six coarser-mesh screens. This was followed by sieving the bottom pan material for ten minutes through the remaining five finer sieves. Material left in the bottom collecting pan after the second sieving (230 mesh) was sieved by hand through a miniature U.S. Standard Sieve of 325 mesh. Each fraction was weighed on a triple beam balance of 0.01 gram accuracy. The data obtained from seiving are given in Tables III, IV, and V, and histograms for each sieved sample are shown in Figure 12. In certain cases, sieving data were combined to provide equal grade intervals on the histograms.

Heavy Mineral Analysis

Procedures and Data

Among the samples from units selected for heavy mineral analysis, many were fine-grained and it was necessary to accelerate separation by use of a centrifuge (Twenhofel and Tyler, 1941, p. 87). The selected samples were first disaggregated by hand and then thoroughly air-dried. A quantity of the heavy liquid tetrabromethane ($C_2H_2Br_4$) (specific gravity 2.96 at 20° C) was placed in a centrifuge

TABLE II

RELATIONSHIP OF WENTWORTH GRADE SCALE TO SIEVES USED IN SIZE ANALYSIS

Wentworth Grade Scale			U.S. Standard Sieve Series	
Term	Size range (mm.)	$\sqrt{2}$ Scale	Opening in mm.	Mesh Number
Granule	4-2	4.00	3.96	5
		2.83	2.79	7
Very coarse sand	2-1	2.00	1.98	10*
		1.41	1.40	14
Coarse sand	1-½	1.00	0.991	18*
		0.707	0.701	25
Medium sand	½-¼	0.500	0.495	35*
		0.354	0.351	45
		0.297**	0.295	50*
Fine sand	¼-⅛	0.250	0.246	60*
		0.177	0.175	80*
		0.149**	0.147	100*
Very fine sand	⅛-1/16	0.125	0.124	120*
		0.088	0.088	170*
		0.074**	0.074	200*
Silt	1/16-1/256	0.062	0.061	230*
Clay	<1/256			

* denotes sieve sizes used in this study
** indicates one-half interval based on the ratio of $\sqrt[4]{2}$

TABLE III

DATA OBTAINED FROM SIEVE ANALYSIS OF SELECTED UNITS FROM BEAVER RIDGE

Sieve Number	Unit								
	1	2	5A	12C	14A	15D	15E (I)	15E (II)	16D
10	-	-	-	-	-	-	-	-	-
18	0.29*	0.56	0.33	-	-	0.15	0.15	0.35	0.25
35	23.10	14.82	22.04	8.85	21.63	6.42	8.50	12.52	12.00
50	15.10	18.11	15.17	12.63	17.85	9.01	16.80	16.80	16.90
60	11.51	6.22	9.93	5.03	6.00	20.50	3.90	4.30	5.30
80	9.45	10.00	9.40	8.17	9.11	5.60	6.20	10.49	9.97
100	7.84	8.03	7.71	5.73	7.68	4.02	5.86	7.05	8.00
120	5.21	6.64	4.86	16.22	5.04	5.10	12.85	7.15	6.01
170	14.50	5.71	9.31	12.11	7.00	9.01	10.03	6.15	8.25
200	8.80	8.50	8.49	7.39	8.30	11.41	10.80	9.73	9.80
230	3.50	12.19	8.50	8.81	14.47	16.30	8.32	14.02	7.45
325	0.41	6.32	3.17	11.67	2.20	9.00	14.05	8.40	13.80
pan	0.22	1.86	0.98	3.01	0.60	3.50	2.51	2.90	3.25
Total per cent weight retained	99.93	98.96	99.89	99.62	99.88	100.02	99.97	99.86	99.98

* All values indicate both actual weight (in grams), and percentage weight retained in each sieve, based on a 100 gram test sample.

TABLE IV

DATA OBTAINED FROM SIEVE ANALYSIS OF SELECTED UNITS FROM LOG MOUNTAIN

Sieve Number	Unit 1	2A	4	5A	11	12	18	23
10	-	-	-	-	-	-	-	-
18	0.39*	1.63	0.09	-	0.27	-	1.43	-
35	21.21	18.60	6.31	21.61	22.14	4.50	20.11	8.31
50	15.02	12.00	9.00	18.01	14.89	14.23	14.13	10.17
60	12.02	6.80	19.83	5.91	9.37	15.88	6.27	7.32
80	11.41	12.27	7.11	8.87	9.11	11.30	9.83	8.16
100	8.98	10.05	4.89	9.04	6.83	19.05	8.48	9.02
120	6.80	6.20	5.77	5.00	4.77	8.90	6.24	13.78
170	7.45	13.02	8.43	7.13	8.86	6.77	13.00	9.31
200	11.10	11.00	11.71	8.71	8.30	9.92	11.89	9.39
230	3.00	7.30	15.33	12.02	8.21	6.41	7.67	12.01
325	2.69	1.14	8.61	3.18	6.32	1.84	0.90	8.99
pan	-	-	2.89	0.51	0.93	1.07	-	3.61
Total per cent weight retained	100.07	100.01	99.97	99.99	100.00	99.87	99.95	100.07

* All values indicate both actual weight (in grams), and percentage weight retained in each sieve, based on a 100 gram test sample.

TABLE V

DATA OBTAINED FROM SIEVE ANALYSIS OF SELECTED UNITS FROM DUG RIDGE

Sieve Number	Unit 3(I)	3(II)	4	5	8A	18A
10	-	-	-	-	-	-
18	-	-	0.15	0.30	-	1.21
35	19.05*	8.53	8.05	22.85	17.25	20.89
50	22.21	17.03	19.25	14.83	18.31	13.36
60	5.93	4.00	3.82	8.88	13.30	9.13
80	11.10	5.82	6.28	9.02	14.96	8.71
100	10.55	6.91	5.01	7.27	8.85	7.83
120	13.16	13.02	14.72	5.17	6.00	6.00
170	9.36	10.43	9.84	10.91	4.13	18.10
200	6.00	10.99	11.42	8.36	6.80	9.88
230	2.10	7.13	11.20	7.64	5.75	4.14
325	1.39	13.84	8.67	3.91	4.13	0.63
pan	-	2.19	1.50	0.82	0.43	-
Total per cent weight retained	99.85	99.99	99.91	99.96	100.07	99.98

* All values indicate both actual weight (in grams), and percentage weight retained in each sieve, based on a 100 gram test sample.

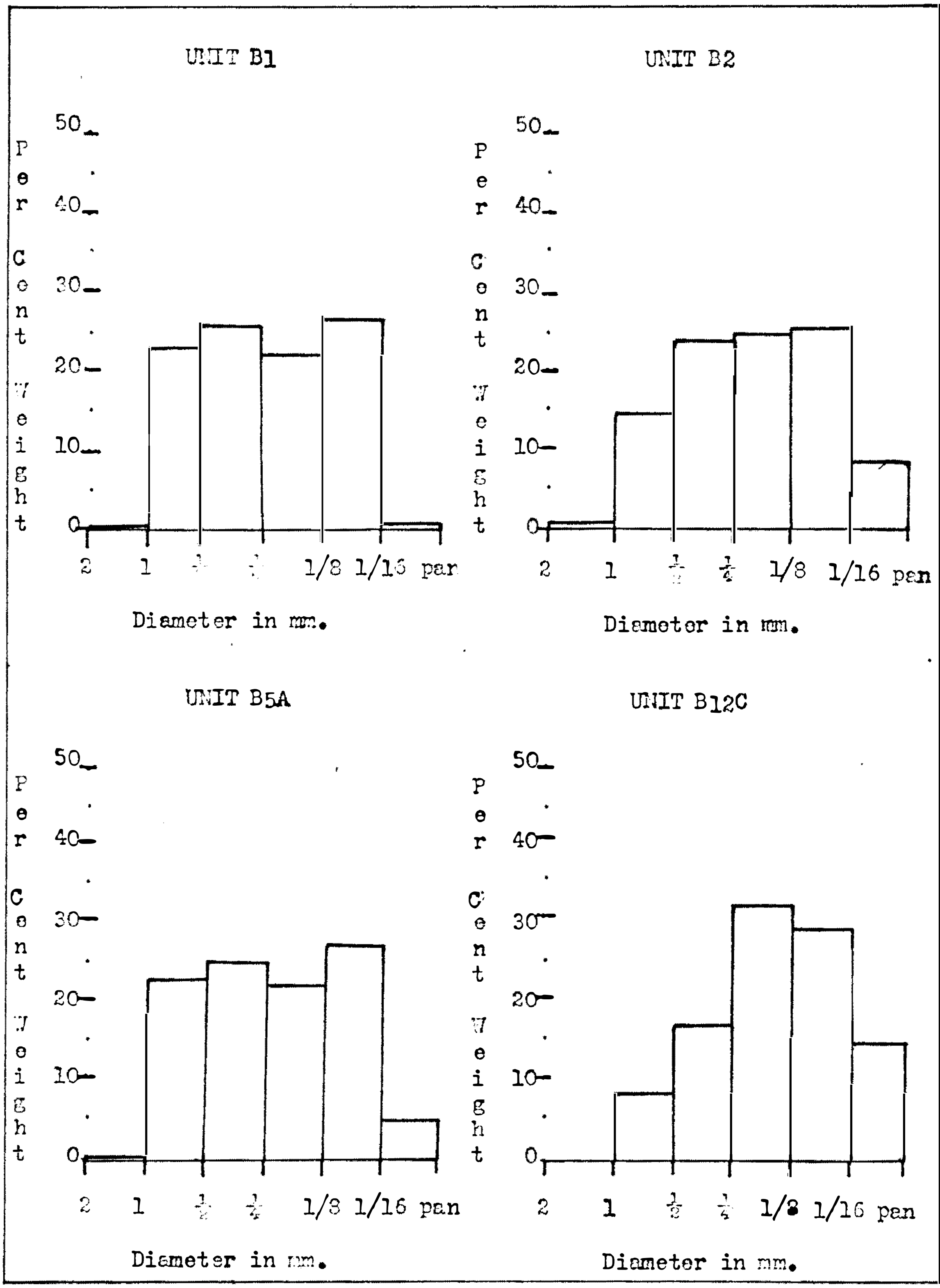


Figure 12. Histograms of Sieve Data.
Beaver Ridge Samples.

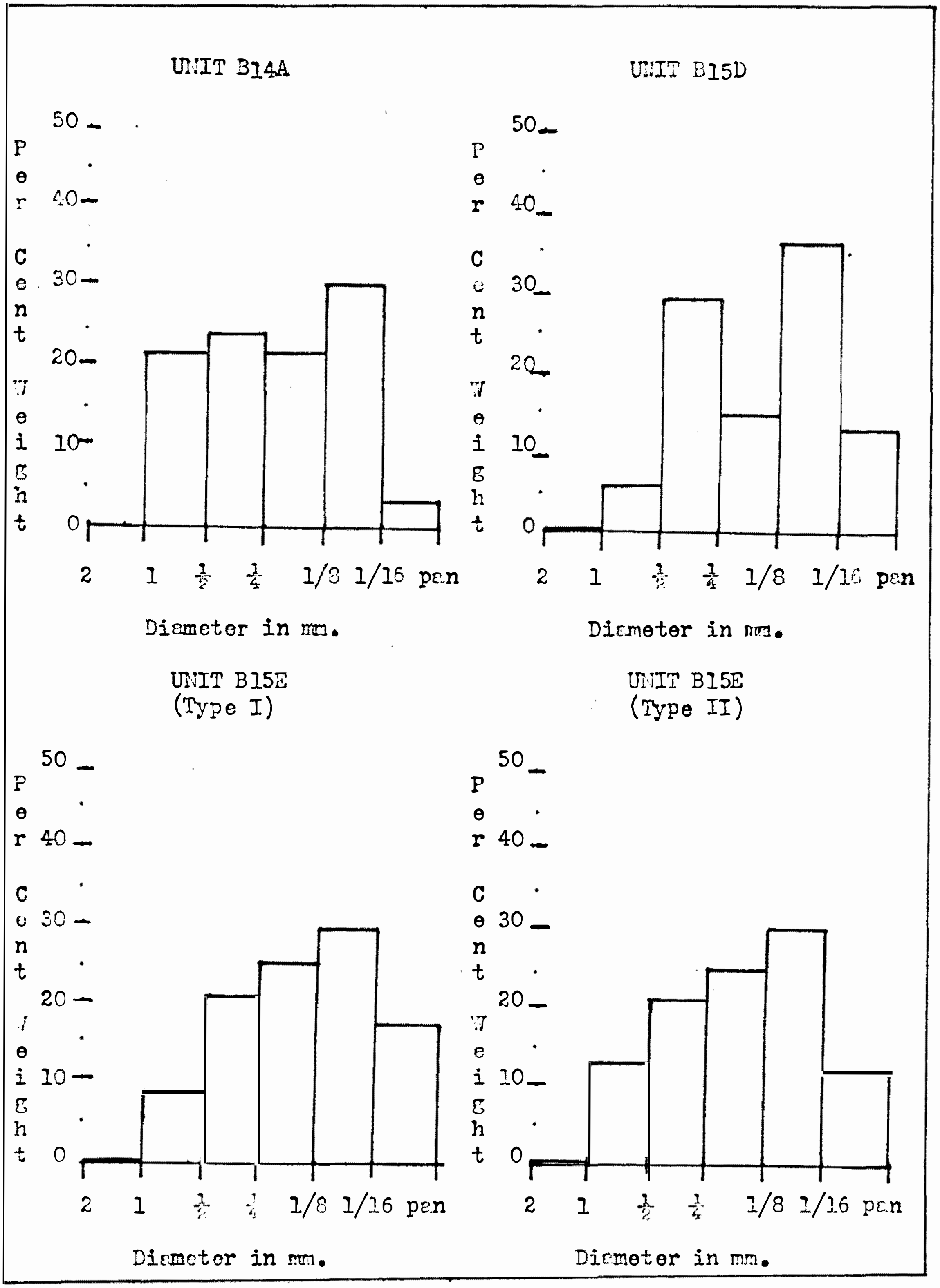


Figure 12 (cont'd.). Histograms of Sieve Data. Beaver Ridge Samples.

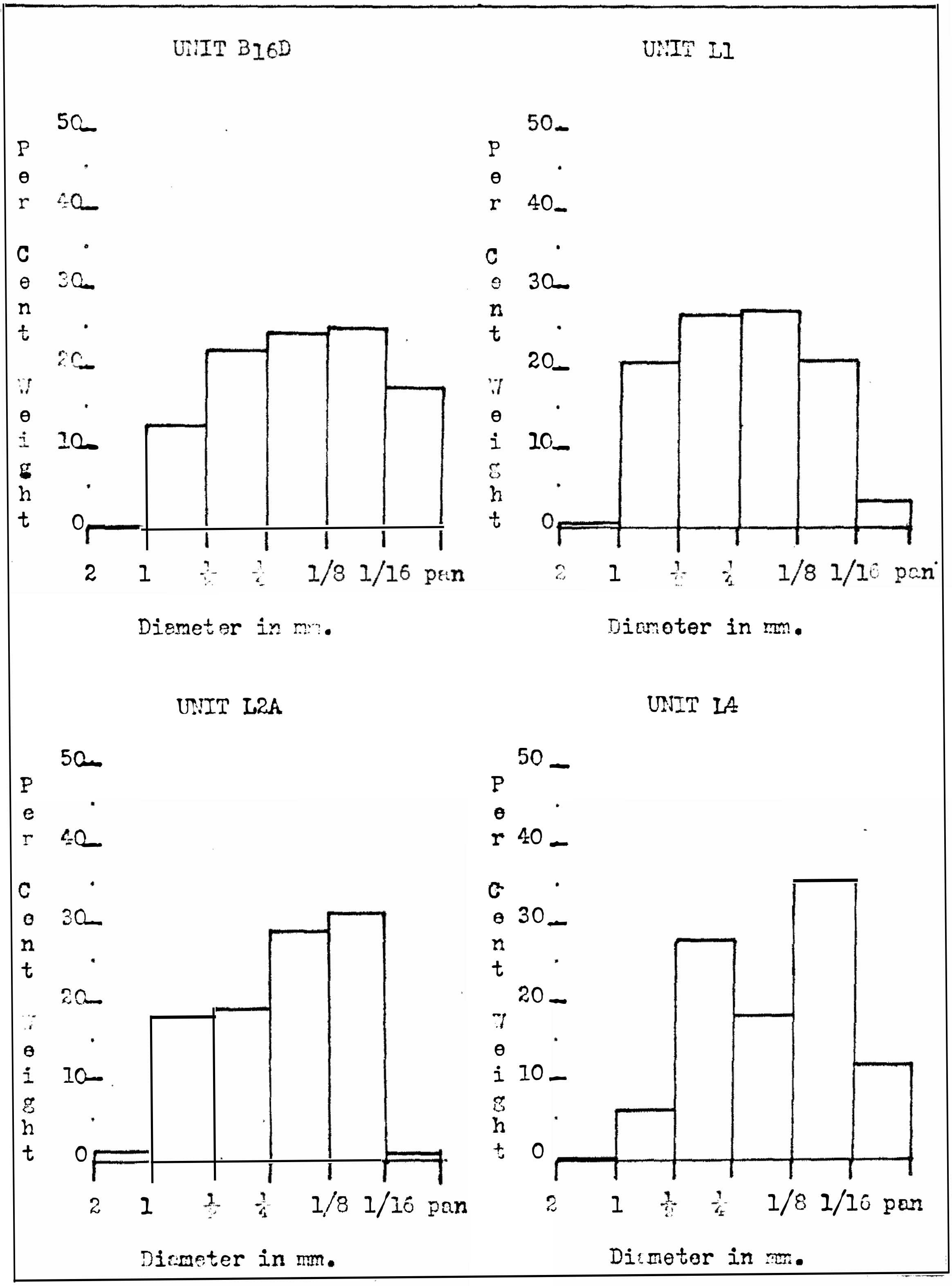


Figure 12 (cont'd.). Histograms of Sieve Data. Unit B16D is a Beaver Ridge Sample; the Remainder are from Log Mountain.

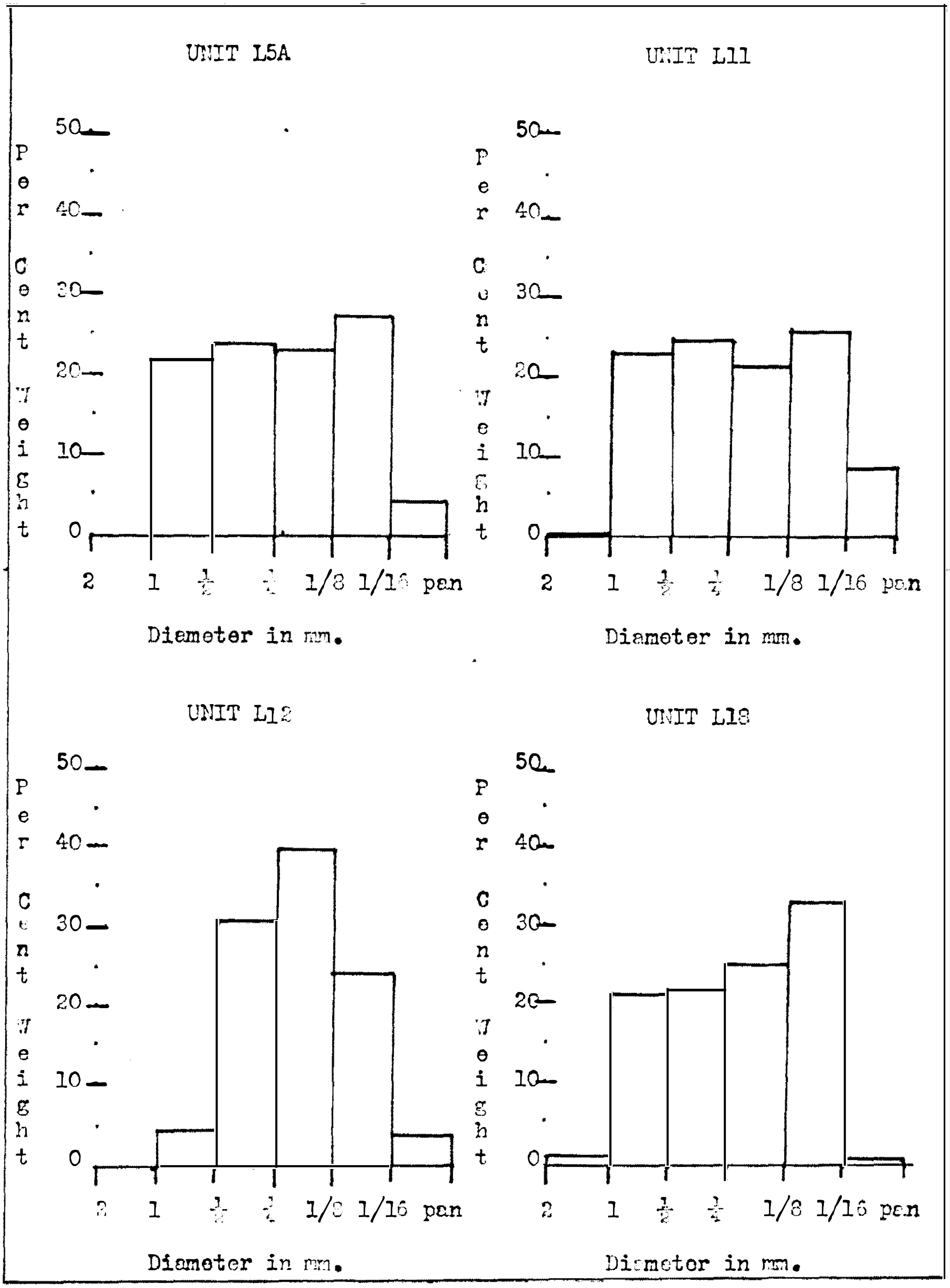


Figure 12 (cont'd.). Histograms of Sieve Data. Log Mountain Samples.

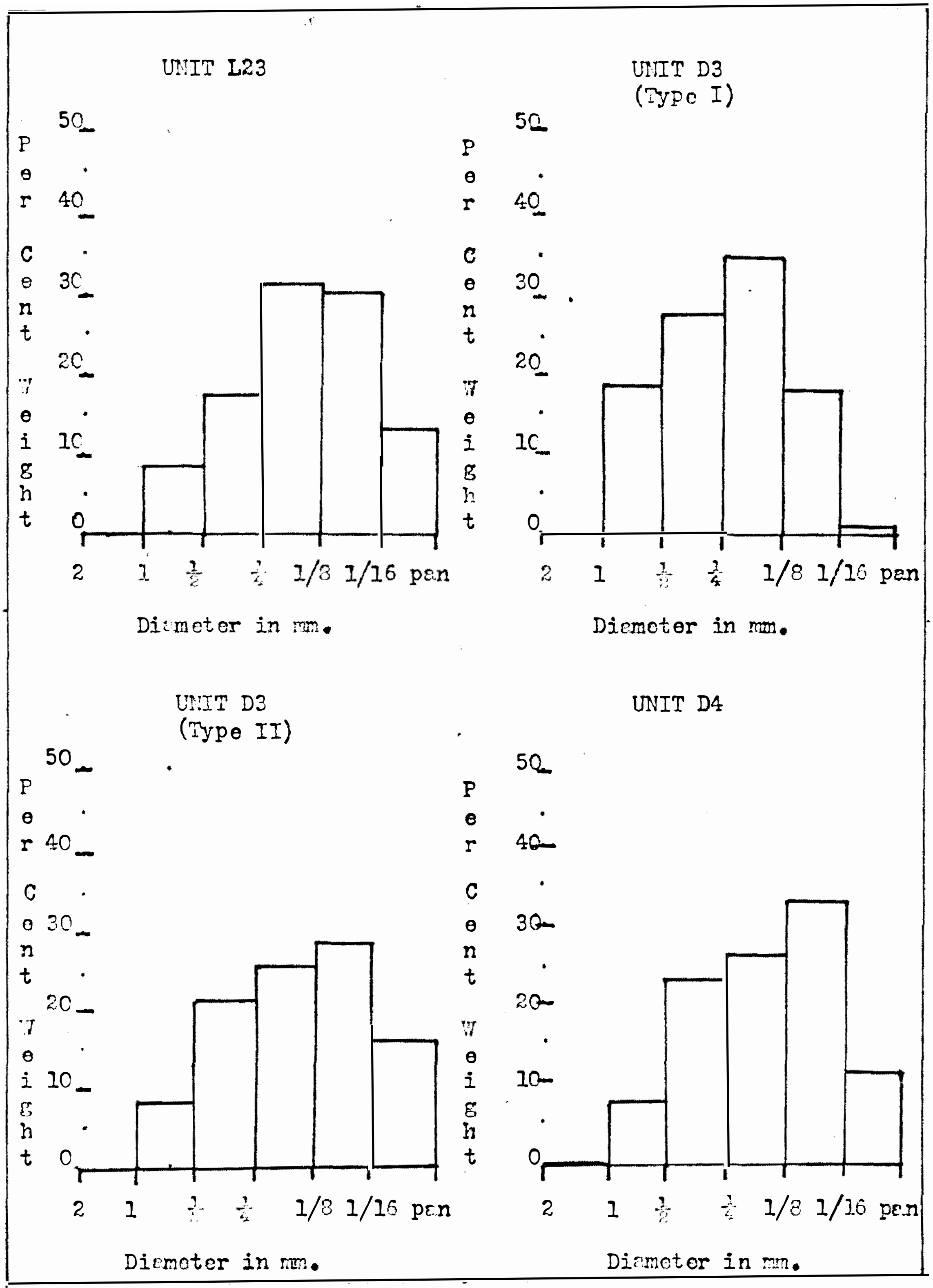


Figure 12 (cont'd.). Histograms of Sieve Data. Unit L23 is a Log Mountain Sample; the Remainder are from Dug Ridge.

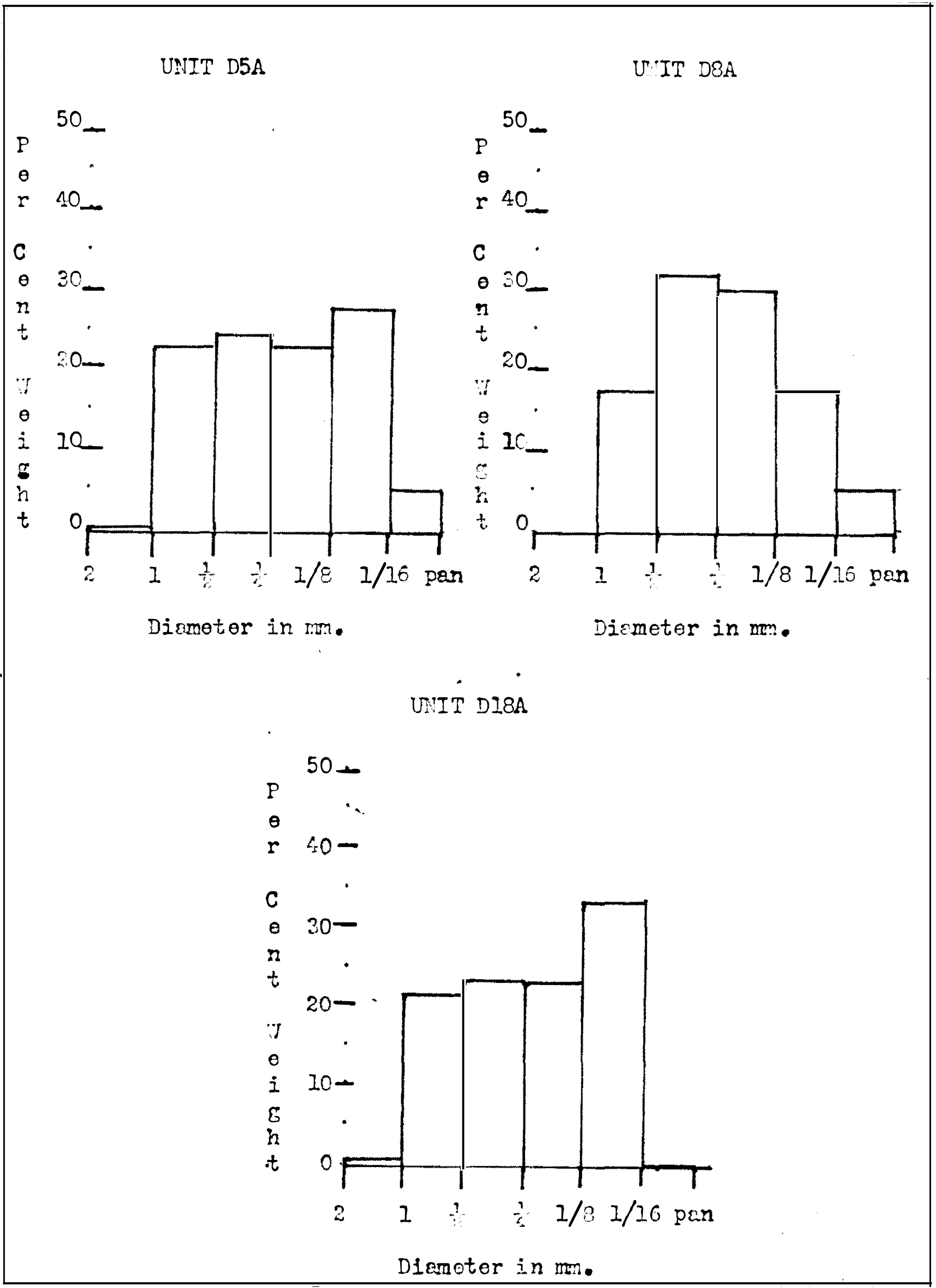


Figure 12 (cont'd.). Histograms of Sieve Data. Dug Ridge Samples.

tube and a ten gram test sample was added. The centrifuging was carried out for approximately ten minutes at a moderate speed to effect a thorough separation. After separation was completed, a pipette was inserted below the base of the light mineral fraction and the heavy minerals were drawn off into the pipette and transferred to a filtering apparatus. In certain cases, the light mineral fraction was washed, thoroughly dried, and weighed. A temporary fragment mount was then prepared from each fraction and examined under the petrographic microscope to determine mineral content. The descriptions provided in Krumbein and Pettijohn (1938, Chapter 17) were used to aid in mineral identification.

Relative frequency of the various minerals was observed and the scale derived by Milner (1929, p.386) and shown in Table VI was adopted to symbolize the results obtained. The data derived from the heavy mineral analyses are given in Table VII.

Insoluble Residue Analysis

Procedures and Data

Samples of several limestones and dolomites from each measured section, and of some slightly calcareous, or

TABLE VI

SCALE FOR RECORDING RELATIVE ABUNDANCE OF MINERALS BY ESTIMATION

Term	Symbol
Flood	F
Very abundant	A
Abundant	a
Very common	C
Common	c
Scarce	s
Very scarce	S
Rare	r
Very rare	R

After Milner (1929, p. 386)

TABLE VII

DATA OBTAINED FROM HEAVY MINERAL ANALYSIS

Unit	Percentage of Heavy Minerals[1]	Mineral Identification and Relative Abundance
[2]B1	0.75%	hematite (F); limonite (a); zircon (r); tourmaline (r); apatite (?) (R); glauconite[5])
B15D	0.65%	hematite (F); limonite (a); ilmenite (r); leucoxene (R); chlorite (r); (glauconite[5])
B15E	22.00%	hematite (F); limonite (A); chlorite (r); pyrite (R).
B18D	0.50%	hematite (A); limonite (C); chlorite (S); muscovite (S).
[3]L2A	0.78%	hematite (A); limonite (c); zircon (r); tourmaline (r); pyrite (?) (R).
L4	0.91%	hematite (A); limonite (c); zircon (r); tourmaline (r); pyrite (?) (R).
L4	0.91%	hematite (A); limonite (c); tourmaline (R); garnet (?) (R); unidentifiable (R).
L12	18.80%	hematite (F); limonite (A); zircon (R); unidentifiable (R).
L18	trace	hematite (a); limonite (C); chlorite (?) (r); pyrite (R).
[4]D3	10.60%	hematite (F); limonite (c).
D4	trace	chlorite (Z) (F).
D8A	31.50%	hematite (A); limonite (C); ilmenite (S); leucoxene (r); pyrite (?) (R).
D18B	0.61%	hematite (C); limonite (S); ilmenite (S); leucoxene (R); zircon (R).

[1]Based on 10 gram test sample
[2]B = Beaver Ridge Unit
[3]L = Log Mountain Unit
[4]D = Dug Ridge Unit
[5]glauconite, although present, was not separated with tetrabromethane.

dolomitic units, were digested in hydrochloric acid to determine the character of the insoluble residues. A fifty gram test sample was disaggregated by hand, placed in a 250 cc. beaker and covered with cold, dilute hydrochloric acid. The mixture was allowed to stand until all the carbonate material was completely dissolved. After digestion was complete, the acid solution was decanted, and the residue was filtered, washed, air-dried, and weighed. After weighing, the residue was examined under the binocular microscope to determine the mineral constituents. The data obtained from insoluble residue analysis appear in Table VIII.

Iron Content Analysis

Procedures and Data

It was noted that many of the units in the measured sections contained an appreciable amount of iron oxide coatings or cement, or both. Four representative "type" units from the three sections were selected for determination of iron oxide content. A ten gram consolidated test sample was placed in a 100 cc. beaker and covered with 20 cc. concentrated hydrochloric acid and 10 grams stannous

TABLE VIII

DATA FROM INSOLUBLE RESIDUE ANALYSIS

Unit	Per cent Weight of Insoluble Material[1]	Description of Insoluble Residue
B7	23.4%	quartz
B8	22.8%	quartz
B17A	19.0%	quartz; some chert (?)
B17B	42.0%	quartz; some chert (?); clay material
L "27"	20.8%	chert (?) (65%); clay (35%)
D6B	82.0%	mostly clay; some chlorite (?)
D9C	89.0%	glauconite (70%); quartz (20%); clay (10%)
D11	56.0%	mostly clay; some quartz (approx. 20%)
D12B	30.0%	clay
D19A	62.0%	clay; some quartz
D19B	11.7%	quartz (chert (?)) (60%); clay

[1]Based on 50 gram test sample.

chloride (Twenhofel and Tyler, 1941, p. 38). The mixture was then gently boiled for approximately one hour until all the red or yellow coating disappeared. In all cases as the iron oxide cement dissolved during boiling the sample disaggregated. The disaggregated, iron-free particles from each sample were then washed, filtered, dried, and weighed. The loss of iron oxide was then computed as the difference between original and final weights. The results from this analysis are compiled in Table IX. Units bearing a close resemblance to the type units selected and which might be expected to produce similar results are also listed in the table.

Analysis of Sedimentary Structures

Procedures

A collection was made of the many various primary and lithologic structures exhibited in many units of the measured sections. A listing of the occurrence of these features, by rock type, was given previously in Figure 7, page 22, and a more specific tabulation of the major features the writer observed in certain units of the measured sections is

TABLE IX

DATA FROM IRON CONTENT ANALYSIS

"Type" Unit	Similar Units	Percentage Weight of Iron Oxides[1]
B15E	B14B, B14D, B18, L9, L10, D2, D14A	20.70%
L12	L11, D10	17.50%
D3	none	11.90%
D8A	L16	30.00%

[1]Based on weight lost from 10 gram sample.

shown in Table X.

In the following paragraphs each structure is described and the important measurements relating to each are listed. Arrangement of the descriptions has been organized according to definite, or probable, mode of origin of the structures.

Laboratory Data

Structure of Definite Inorganic Origin

Wave Ripple Marks. By far the most abundant type of primary feature exhibited by the Rome formation is the ripple mark, the wave, or oscillation ripple mark being the most common. This feature is preserved characteristically throughout most exposures in the fine-grained siltstones of the formation (see Fig. 9, p.28), but is rarely found in coarser- or finer-grained units. Figure 13 illustrates two examples of ripple marks *in situ*. They appear not to be restricted to any particular horizon within the formation. Many varieties can be found, but the most common exhibit symmetrical or nearly symmetrical crests and troughs in

Table X

Summary of Primary, Lithologic, and Other Features

Observed in the Measured Sections

Section	Unit or Sub Unit	Type of Feature Observed
Beaver Ridge	5A	Fragment of <u>Olenellus</u> <u>thompsoni</u>
	12B	Wave ripple marks
	12C	Wave ripple marks
	14D	Wave ripple marks, flow casts
	15A	Wave ripple marks, mud cracks, "tubes"
	15B	Wave ripple marks, mud cracks, "tubes"
Log Mountain	2	Cross-bedding and cross lamination
	9	Wave and current ripple marks, mud cracks
	10	Wave and current ripple marks, "tubes"
	12	Worm tubes (?)
	18	Nodular structures
	23	Obscure structures
	24	Boudinage (?)
	25	Ripple marks
Dug Ridge	2	Halite casts and molds
	3	Interference ripple marks
	4	Mud cracks, striations, tracks, trails, Olenellus (?)
	7	Worm tubes, "fucoids", rain prints (?)
	8B	Obscure structures, "trails"
	14A	Ripple marks
	14B	Mud cracks, flow casts, swash marks
	14C	Mud cracks, accretions

A

B

Figure 13. Primary features of the Rome formation _in situ_. A. Ripple marks at the Dug Ridge exposure. B. Ripple marks at the Log Mountain exposure.

parallel, sub-parallel, or rarely, anastomosing patterns. The ridges of the wave ripple marks show all variations from sharp-crested, as shown in the lower portion of Figure 14A to rounded crests (Fig. 14B), or nearly flat and arcuate crests (Fig. 15). Medial ridges are common. Many other variations, too numerous to list here, have been noted by the writer, especially those summarized in Shrock (1948, Figs. 72, 74, and 78).

The wave lengths (crest to crest) of samples of wave ripple marks taken from Beaver Ridge (Fig. 14B), and Dug Ridge (Fig. 14A) averaged 4 to 5 cm., and the amplitude (trough to crest) 3 to 5 mm., giving an average ripple index (wave length divided by amplitude) of 10. Samples from Log Mountain (see Fig. 13B) have an average ripple index of 6; those from Ray Gap (Plate I, Locality 8; Fig. 15) have an average ripple of nearly 12, while the ripple index of those the writer has measured from Shook's Gap (Plate I, Locality 5), and Pine Ridge (Plate I, Locality 19) average 6 to 8.

The writer has not attempted to measure any directional properties of these features <u>in situ</u> due to the fact that they have all been subjected to rotation and translation

A

B

Figure 14. Wave ripple marks from the Rome formation. A. View of ripple-marked bedding surface at Dug Ridge. B. Specimen of wave ripple marks with rounded crests. Collected from Beaver Ridge.

Figure 15. Arcuate wave ripple marks from the Rome formation. Specimen (upper surface) collected at Ray Gap.

by compressional forces from their original position.

Current Ripple Marks. Current ripple marks, although present in the Rome formation in the same lithologies as wave ripple marks, are not as abundant as the wave-form variety, and have been accurately identified only rarely by workers studying the formation (Harvey and Maher, 1948, p. 287). Several examples were identified by the writer during the course of this study. One unusual specimen (ripple index 7) from the Dug Ridge section, Unit 8B, shown in Figure 16A, was identified as an uncommon type of current ripple mark (Shrock, 1948, fig. 50, page 95).

The more common type of ripple mark (Figure 16B) found in the formation has often been confused with swash marks, which are also abundant in the Rome formation. Indeed, many workers prefer to use the term swash marks (S.W. Maher, personal communication, 1962; Harvey and Maher, 1948, fig. 3, p. 288) instead of current ripple in referring to these structures. The writer, however, has collected several specimens of this type (Plate I, Localities 2, 3, and 18), and after comparing them with those described in Shrock (1948, fig. 51, p. 96) and Twenhofel (1932, p. 657), has designated these features as current ripple marks. An

A

B

Figure 16. Current ripple marks from the Rome formation. A. Specimen collected from Dug Ridge. B. Specimen collected from Bull Run Ridge.

additional factor contributing to this latter identification is that micaceous and coarse-grained material was found concentrated in the troughs of the ripples in several samples, directly in front of the steep side of the crests. This feature is more characteristic of current ripples than swash marks (Shrock, 1948, fig. 54, p. 101).

The term swash marks, as applied to features described later in this chapter, has been restricted to structures similar to those cited by Shrock (1948, fig. 89, p. 129). The ripple index of the current ripple samples ranged from 13 to 28.

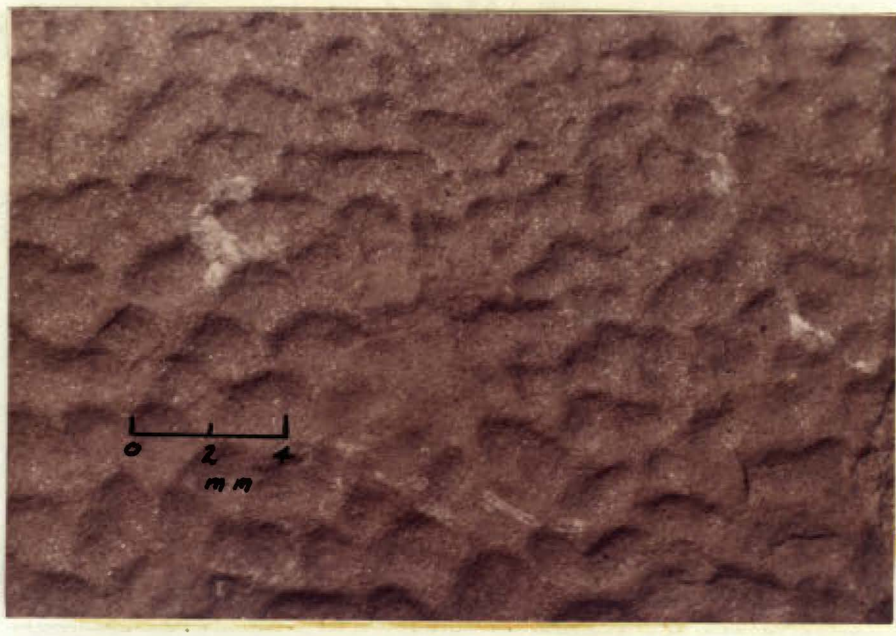
Lobate Ripple Marks. Variations of the ripple mark having a lobate, or linguoid appearance (the counterparts representing the underside of a layer and appearing as oval depressions) were found at several exposures (Plate I, Localities 1, 15, 18, and 19). One example is illustrated in Figure 17. The dimensions of the oval depressions in this type average 5 to 10 cm. in length, 5 cm. wide and 5 mm. deep. Shrock (1948, p. 94) states that this variety is not unusual and probably was formed under conditions similar to wave ripple marks.

Interference Ripple Marks. An interesting and unusual

Figure 17. Lobate ripple marks from the Rome formation. Specimen, collected from Beaver Ridge, shows counterpart of ripple mark on underside of layer.

variety of wave ripple mark found in several Rome exposures is the interference ripple mark (Fig. 18), which develops as the result of ordinary waves breaking up into two sets of oscillations crossing each other (Twenhofel, 1932, p. 658). They have also been termed "tadpole nests", since strikingly similar features have been found by tadpoles swimming in shallow ponds (Maher, 1962, p. 138). However, such organic origin has been discounted by the writer for these features observed in the Rome formation. The interference ripple marks collected from the Rome exhibit small (2-3 mm., average diameter), pit-like depressions, surrounded by sharp-crested to slightly rounded ridges (1 mm., average depth). The depressions commonly have a rounded, somewhat polygonal outline, although several nearly rectangular ones have been observed. The more rounded varieties often may be mistaken for raindrop or foam impressions ("bursts"), but the relatively flat troughs and interconnected pattern of the ripple marks serve to distinguish between the two types of features. Twenhofel (1932, p. 658), has postulated that very shallow isolated ponds, or lakes, or the ends of offshore bars may furnish favorable conditions for the formation of interference ripple marks.

A



B

Figure 18. Interference ripple marks from the Rome formation. A. Bedding surface at Dug Ridge exposure showing interference ripple marks (left of Brunton). B. Close-up of specimen collected from Dug Ridge (Unit 3) (x5).

<u>Swash Marks</u>. Several structures which the writer has designated as swash marks were collected from fine-grained siltstone at two exposures (Plate I, Localities 2 and 3). This feature, similar to those illustrated in Shrock (1948, fig. 89, p. 129), is marked by a nearly dendritic pattern of thin (1-2 mm. diameter; 1 mm. high), hairlike ridges of up to 10 cm. in length. The overall pattern of the ridges appear to be slightly arcuate, but this characteristic is not well defined. The counterparts, on the underside of the covering layer, were not well preserved. Foam impressions have been found associated with this feature in the Rome formation (Harvey and Maher, 1948, p. 287), but not by the writer. These marks are indicative of waning waves which advance over a beach as swash, forming imbricating sand ridges as they progress inland (Shrock, 1948, p. 128).

<u>Rill Marks</u>. Features similar to the counterpart of the swash marks described above were noted at several exposures (Plate I, Localities 2 and 3), but were poorly preserved and could not be collected. They have been designated by the writer as rill marks. They are marked by tiny (1-2 mm. wide) grooves forming a dendritic pattern across the upper surface of a bed. Shrock (1948, pp. 128-132) has

described their origin in detail.

Rain Prints. Rain prints were collected from a stratum of thin-bedded, somewhat calcareous shale in Unit 7 of the Dug Ridge section. The rain prints form separate, rounded depressions, 1-2 mm. in diameter, and 1 mm. deep. They were distinguished from interference ripple marks by their somewhat smaller size and consistent, nearly rounded outline and rounded troughs. This structure was not definitely identified in any other unit or horizon in any of the measured sections; although the lithology in which it was found is similar to that cited by Harvey and Maher (1948, p. 289).

Mud Cracks. Mud cracks and mud-crack fillings are abundant in the Rome formation and have been reported from many exposures (Plate I, Localities 1, 2, 3, 5, 6, 7, 12, 13, 14, and 15), although Harvey and Maher (1948, p. 287) state that they are more common in western belts than in eastern belts. The writer has observed many varieties of mud cracks on bedding surfaces as well as mud-crack fillings, which appear both on bedding surfaces and on the undersides of overlying strata. One specimen, illustrating a mud-cracked bedding surface in which the cracks have been filled

with a lighter-colored, sandy material, is shown in Figure 19. The true, fissure-like mud crack served as the only reliable indicator of the bedding surface. On the other hand, cracks which exhibit fillings, in partial or complete relief, or networks of fillings alone, have been observed both on bedding and underlying surfaces and can only be used to determine sequence of beds when carefully examined in place.

If the mud-crack fillings have become disrupted or disjointed in any way there is a tendency to confuse them with "worm tubes", since they are similar to these organically produced features (Figs. 25 and 26 pp. 133-134). The writer has examined many specimens of both types and has concluded that all those which exhibit very irregular cross sections, taper to a point without appearing broken, possess patterns which criss-cross, intertwine, coalesce, or otherwise do not have the regular appearance or pattern of mud cracks, are best regarded as organic in nature; these will be discussed in a later section.

The majority of mud cracks and fillings observed exhibit polygonal networks with rectilinear or curvilinear sides. The enclosed area in a single polygon ranges anywhere from 1 to over 15 cm. on a side, and 2 mm. deep. This

A

B

Figure 19. Mud cracks from the Rome formation. A. Upper surface of specimen from Dug Ridge, showing light-colored mud-crack fillings. B. Mud-crack fillings in relief viewed from underside of layer from Beaver Ridge, Unit 15A.

feature has been found in siltstones, shales, silty shales, and fine-grained sandstones, including those which appear to be slightly metamorphosed.

Laminations and Cross-Laminations. Certain lithologic types in the Rome formation, such as silty shale, siltstone, or sandstone, commonly exhibit parallel laminations on various scales within individual layers (Fig. 11). Individual laminae range in thickness from 0.1 to 0.5 mm. in thinner-bedded units, up to 2 to 3 cm. in thicker-bedded units, and are from 1 mm. up to 3 cm. apart. Color changes, often of a repeated, or cyclic nature, serve to mark the existence of laminae of differing composition within a single layer (Fig. 11). Often, however, these color changes denote ancient zones of weathering of varying degrees within essentially similar material. In such cases, common in the Rome formation, true (primary) laminations cannot be designated.

Many of the coarser-grained laminated units exhibit cross-laminations, where laminae are at an angle to the top and bottom surfaces of a layer, or to other horizontal laminae (Dug Ridge, Units 2A and 4). Cross-laminae differ in composition from the enclosing rocks, and in almost all

cases observed by the writer, glauconite is the chief mineral constituent forming cross-laminations. This feature exhibits the same range of thickness and separation as do parallel, horizontal laminae, but are developed at shallow to moderate (from 1° up to 25°-30°) angles to the bedding surface. The many variations exhibited by this feature, and the fact that they are often deformed or disrupted, makes them difficult to interpret correctly, especially when attempting to determine the top and bottom of a layer.

Flow Casts. Certain unusual features observed on the undersides of thin, fine-grained, maroon siltstones and sandstones (Dug Ridge, Unit 14B; Beaver Ridge, Unit 14D) have been termed flow casts (Fig. 20), after those cited and described by Shrock (1948, pp. 156-161). These features, formed by the flowing of soft, hydroplastic sediments when unequally loaded with depositing sand, are preserved only as casts on the undersurface of the compacted sand layer; they have been found in this position in two exposures. Commonly, this structure is characterized by rounded, lobate, linguoid, or irregular folds (0.5 to 2.0 cm. high) and oval depressions (0.5 to 1.0 cm. deep) as shown in Figure 20. However, many flow casts often exhibit linear,

A

B

Figure 20. Flow casts from the Rome formation. A. Specimen from Beaver Ridge Unit 14D. B. Specimen from Dug Ridge Unit 14B.

tapering, and somewhat streamlined folds and corresponding depressions (Pettijohn, 1958, p. 181), but examples of this latter type have not been found by the writer.

Vugs and Cavities. This feature was found in several rock types only in the Dug Ridge exposure. Although cavities of this type are listed here, they probably formed chemically by differential solution, but are not necessarily truly secondary, since they may have been formed before lithification was completed. The cavities the writer has observed were found mostly in oolitic hematite, and in hematitic-glauconitic sandstone layers. They ranged from 1 cm. to 3 cm. in length and width. They are commonly lined with minute calcite (aragonite ?) crystals and are often associated with calcite-filled seams and joints within the rock.

Halite Crystal Casts and Molds. One of the most unusual and interesting sedimentary features the writer has observed in the Rome formation is that of halite crystal casts and molds. Abundant specimens were found well-preserved, in a very thin-bedded, greenish-tan, silty shale at Ray Gap (Plate I. Locality 8), and several samples were also collected from thin-bedded, maroon-tan siltstone layers

in the Dug Ridge exposure. Four examples are shown in Figures 21 and 22.

Previous occurrences of halite crystal imprints in the Rome exposed at War Ridge (Plate I, Locality 14), have been described by Brooks (1955, pp. 67-71). Shrock (1948, pp. 146-149) has described the origin of these features in detail. The casts or pseudomorphs, composed of clastic mud and silt are believed to be formed by the deposition of material into voids left by dissolving (or dissolved) halite crystals. The casts are preserved, therefore, only in relief on the underside of a layer. Conversely, the impressions, imprints, or molds are found only on the top surface of the underlying layer.

The fact that the original crystal may have been partially, or almost completely buried, before dissolving, coupled with a probable random orientation, has produced clastic, protruding casts and molds, not only of complete crystals, but also faces, corners, edges and other portions. During the growth of halite crystals, edges grow faster than faces, and as a result "hopper"-shaped and skeletal, clastic casts and molds are developed. Many of the specimens found by the writer were also ripple-marked, or closely associated

A

B

Figure 21. Halite crystal casts and molds from the Rome formation. A. "Hopper"-shaped casts and pseudomorphs from the underside of a specimen from Ray Gap. B. Ripple-marked top surface of a specimen from Ray Gap showing partial halite crystal imprints and molds (circled).

A

B

Figure 22. Halite crystal casts from the Rome formation.
A. Close-up (x10) of a partial ("hopper"-shaped) halite crystal cast. B. Close-up (x2) of halite crystal casts in relief.

with ripples.

Commonly, the casts and molds are nearly cubic, and average 2-7 mm. on a side, with a height (or depth) of 1-3 mm. Brooks (1955, p. 70) and Shrock (1948, p. 148) state that these features are commonly formed in shallow pools on mud flats by the evaporation and concentration of saline waters.

Structures of Probable Inorganic Origin

Accretionary Structures. Many accretionary structures, and other non-linear bedding plane irregularities of a similar nature, such as those shown in Figure 23, were found at several localities (Dug Ridge, Unit 14C; Beaver Ridge, several units). The accretions commonly measure 5 to 20 cm. in diameter and 15 to 20 cm. in height. They often have an irregular spherical to hemispherical shape. Although perhaps resembling fecal pellets, coprolites, or other organic traces commonly described in the literature, the writer has tentatively classified them as primary, inorganic, accretionary structures because of the lack of supporting evidence to the contrary. As such, their origin may be due to deformation or disruption prior to lithification,

Figure 23. Probable accretionary structures from the Rome formation. Collected from Beaver Ridge.

or perhaps they are similar in origin to the flow casts previously described, but preserved on top of layers rather than on the undersides.

Miscellaneous Structures and Surface Markings. A multitude of linear and non-linear structures have been observed in the Rome formation at many exposures and in many different rock types. Some are seen in conjunction with other features described and illustrated in this chapter. Grooves, depressions, holes, ridges, striations, and protuberances of various sizes and shapes have been examined, but cannot be definitely classified in the categories listed above. However, in the opinion of the writer these are primary, and inorganic in nature. Organically formed coprolites, grooves, trails, burrows, or "fucoids" may be strikingly similar to many of these markings, but an organic origin, although not ignored, has not been postulated for these structures due to the lack of observable supporting evidence.

Structures of Definite Organic Origin

Unaltered Fossil Remains. Two molds from Beaver Ridge (Unit 5A) and Dug Ridge (Unit 4) have been identified

as portions of the remains of the trilobite Olenellus. Only in the Beaver Ridge occurrence, however, was the specimen definitely established to be *Olenellus thompsoni*. These two specimens are the only structures that the writer has been able to assign to a definite organic origin with complete confidence.

Structures of Probable Organic Origin

Trilobite Tracks or Trails. Several structures were found in different lithologies in the measured sections and elsewhere which strongly indicate a possible organic origin. Among these, two types which suggest trilobite trails and tracks have been studied by the writer. Figure 24 illustrates one of these types occurring at several localities (e.g., Dug Ridge, Unit 8B). This type has been tentatively identified as being of the *Rusophycus* or *Cruziana* type. However, positive identification is uncertain because of the poor preservation of most of the samples collected. One of these types has been reported previously from the Rome (Brooks, 1955, p. 70) but some doubt still exists in the mind of the writer.

The structures are bilobate mounds, 10 to 15 mm.

Figure 24. Probable trilobite trails from the Rome formation. Four possible examples of the genera Rusophycus or Cruziana are illustrated.

across, transversely wrinkled with furrows and divided by a relatively deep medial groove or furrow averaging 5 mm. deep. The lower left hand specimen in Figure 24 is a typical example. Cruziana and Rusophycus are similar forms which have been classified as trilobite resting tracks or "nests" (Hantzschel, 1962, pp. W189 and W212; Seilacher, 1956, Tafel 8).

The second type has been tentatively classified by the writer as Diplichnites, a trilobite walking track. This type, very similar to those described by Hantzschel (1962, p. W191) and Seilacher (1956, Tafel 8) is characterized by a pattern of small, parallel, 1 to 5 mm., groove-like furrows arranged in two parallel, winding rows. Samples from Dug Ridge (Unit 8B) have exhibited these characteristics and at least a tentative classification of Diplichnites appears in order.

Worm Tubes, Burrows, Casts, and Trails. Several features strongly resembling burrows, tubes, casts, or other markings made by worms have been observed by the writer in siltstones and sandstones (see Fig. 9, p.28) at several exposures (see Table X, p.105). Features of this type from the Rome formation, as shown in Figures 25 and 26, have

Figure 25. Probable worm markings from the Rome formation. Specimen collected from Log Mountain.

Figure 26. Probable worm markings from the Rome formation. Specimen collected from Beaver Ridge.

been described as worm burrows by Harvey and Maher (1948, pp. 287-289), and are tentatively designated as worm features in this study. The cast-like trails probably represent ridges of excrement egested by worms. In addition, depressions, tubes, or grooves associated with these features, and similar in appearance and patterns, are probably worm burrows. Many resemble Arthrophycus (Phycodes) but have not been so designated in this study as they have by other workers (Seilacher, 1956, Tafel 8; Harvey and Maher, 1948, p. 289).

The majority of worm-like features in the Rome are commonly tubular, or somewhat flattened, ridges, which intertwine, branch, criss-cross, and are often connected to one another. They may reach lengths up to 15 cm. and widths up to 1 cm. Often, they appear clubshaped with tapered ends. They may occasionally be confused with disjointed segments of mud-crack fillings or other inorganic features, but are more rounded in cross section.

Miscellaneous, Obscure, or Doubtful Structures. In addition to the features of probable organic origin described above, many structures of varying patterns, shapes, and sizes have been observed, and are here tentatively classed

as primary and organic in nature. Included in this category are structures resembling those in Figure 23, p.128, but which more closely resemble coprolites or fecal pellets; fucoidal structures similar to those shown in Figure 24, p.131, but of doubtful or indefinite classifications; obscure structures slightly resembling winding trilobite trails; and miscellaneous tubular structures vaguely resembling worm burrows or casts. In addition to these, many other markings of dubious identity have been classed as organic in origin due to their close association with structures of more definite organic affinities.

Summary of Laboratory Data

Many of the conclusions which can be drawn from an analysis of the foregoing laboratory data are of a general nature due to the selectivity of the sampling techniques. However, certain features and trends gain significance and add to the understanding of the formation examined when viewed in summary fashion. The significance of these features and trends, and the writer's opinions concerning them will be discussed in later chapters.

Megascopically, the Rome formation appears to be quite

complex. Petrographic and binocular study, however, serves to identify several general lithologic associations common to the three measured sections which may simplify the description of the formation. Among the most common of these are the pure quartz, quartz-glauconite, quartz-iron oxide, and quartz-muscovite sandstones and siltstones; the argillaceous, ferruginous, chloritic, and quartzose shales; and the argillaceous and siliceous limestones and dolomites. Much of the quartz noted in the units studied microscopically appears to be sub-rounded to sub-angular and occasionally exhibits frosted surfaces and secondary growths. The abundance of iron oxide cement, coatings, and discrete accumulations has been established by microscopic examination and iron content analysis; however, other types of cementing material are common, often within the same unit.

Glauconite, both of the micaceous and ovoid habit, has been identified abundantly in the units studied, and occurs in most rock types, including limestones and dolomites. Heavy minerals, excluding iron oxides and glauconite, although present, are not abundant. The most stable minerals are more common, namely sub-rounded to sub-angular zircon, ilmenite, leucoxene, and tourmaline, with minor amounts of

pyrite. Many of the insoluble residues indicate that the small number of calcareous units present in the formation are almost never completely pure, having quartz, clay and chert as common constituents.

The data from size analysis, while not conclusive, are interesting. The sorting indicated by the histograms is fair to poor for almost all units examined, and the predominant size range for most units appears to be fine to very fine sand. The amount of true silt-sized particles within the selected units was not so great as had been expected from microscopic and megascopic examination, the majority of the "silt" particles actually being very fine sand. The overall patterns of the histograms are not indicative of a single, particular environment; however, this fact in itself may be of significance.

The abundance of wave and current ripple marks, and mud cracks, and the occurrence of associated swash marks, rain prints, cross-laminations and other primary features of inorganic (mechanical) origin is significant, as will be discussed further in later chapters. Measurements of cross-laminations although not always reliable, commonly indicated deposition from an eastward-flowing current.

Most features studied strongly imply deposition in shallow waters associated with the littoral, transitional, or neritic zones, or perhaps a combination of all three. Certain features particularly suggest lagoonal, deltaic, or similar transitional environments. The halite casts described may be an indication of concentrations of highly saline waters, presumably in shallow pools on mud flats, but most probably of a temporary or highly restricted nature. Tracks and trails of probable worm or trilobite origin indicate active, if not abundant, organic life which persisted through the deposition of the sediments in the formation.

The most significant characteristic implied by laboratory data of most, if not all, of the Rome formation is its probable deposition in a shallow water environment. Various laboratory data given from portions of the formation indicate deposition in mixed or transitional environments, while other data indicate neritic, or shallow marine, environments. A complete environmental transition from shallow marine to littoral, from east to west, may be postulated from only the data given for the three measured sections; however, the conclusion is subject to comparison with other exposures and therefore tentative. Even so, the postulation

is supported by the lithologic associations determined through microscopic analysis.

The associations determined in this study are regarded by Krumbein and Sloss (1959, pp. 360, 362 and 367) as representing a mixture of sediments deposited in a possible transition from a tectonically stable, or slightly unstable shelf, to a slowly subsiding miogeosyncline. This latter depositional basin and the adjoining, perhaps slightly sloping, shelf are characterized for the most part by a combination of the previously mentioned environments. This may be supported by the fact that size analysis did not reveal a single, significant trend, but perhaps reveals a mixture of trends representing different environments.

Certain data indicate deposition progressed under oxidizing conditions, other data suggest a slightly reducing environment. The littoral zone provides fluctuations of the water level sufficient to account for these changing conditions, and also for the fact that many of the sedimentary structures and other features of the formation appear subaerial in nature rather than sub-aqueous.

The angularity of individual grains from the samples analyzed would appear _per se_ to suggest tectonic instability

but may be a reflection of limited transport instead. Thus, other evidence of stability is not contradicted. As a matter of fact, a tectonically stable shelf that may have existed over a long period of time would seem to account for many of the primary features, the varying degrees of reworking of the sediments as shown by the sub-rounded detrital grains, and the red beds, and other characteristics of the formation. The red beds in the Rome are probably a combination of post-depositional, reworked, and chemical red beds (Krynine, 1949, pp. 60-68), although the data are not sufficient to determine the relative quantities of each type present in the formation.

CHAPTER V

COMPARISON OF THE MEASURED SECTIONS WITH OTHER EXPOSURES

Stratigraphic and Paleontologic Relationships

Stratigraphic Position

The stratigraphic position of the Rome in relation to other formations in the majority of exposures throughout east Tennessee is ultimately dependent upon the structural nature of the major and minor thrust faults with which it is nearly always associated.

The Rome, as previously stated, is topographically the highest formation present in a ridge exposure, in many cases, having been thrust over younger, post-Rome formations. This is especially true in the eastern sections of the Valley and Ridge province. Quite often, however, as in the measured sections described in Chapter III, it is not the highest, or youngest stratigraphically within the thrust-faulted block; adjacent, overlying, younger formations, such as the lower members of the Conasauga group have been moved with the Rome. The younger formations are not prominent and are poorly exposed, generally forming the valleys which lie adjacent to

the Rome ridges. Hence, the contact between the two is unexposed or partially covered in many cases.

Except for a few localities in northeast Tennessee where it is in normal contact with the underlying Shady formation (Plate I and Fig. 1, Localities 9, 10, and 11), the Rome is generally thrust over successively younger post-Rome formations progressing northwestward across the Valley and Ridge province. The resulting stratigraphic throw in major thrust faults increases in the same direction.

There is a general tendency for the Rome to overlie Middle and Upper Cambrian Conasauga formations in the eastern and central belts of the province (*e.g.* Moseley Ridge, Hawkins County, Tennessee), formations of the Lower and Middle Ordovician Knox and Chickamauga groups in the central and western portion of the Valley (e.g. Plate I, Localities 1, 2, 3, 14, and 18), and Mississippian formations near the extreme western edge of the province (*e.g.* Short Mountain, Hancock County, Tennessee and several other localities within the area of the development of the Hunter Valley and Whiteoak Mountain faults).

Paleontology

As noted in Chapters III and IV the writer has found only two fragmentary fossil specimens in the exposures he has examined. As previously shown in Figure 3, however, several other species have been reported from the formation in east Tennessee (Fox, 1943, p. 162; Rodgers and Kent, 1948, p. 5; S.W. Maher, personal communication, 1962). The presence of probable trilobite and worm tracks and trails and other possible organic structures have been discussed by the writer (Chapter IV) and others (Brooks, 1955, p. 70; Harvey and Maher, 1948, p. 287).

Including all occurrences, however, complete and undisturbed fossil remains are scarce in the formation. This may be a reflection of the relative scarcity of organic life during the early Cambrian epoch, the destructive effects of tectonic activity, or the absence of pre-requisites for fossilization.

The poor fossil record, coupled with the disrupted nature of much of the formation, make it extremely difficult to trace distinct fossiliferous horizons or zones which may exist in the Rome. In comparing the measured sections of

this study with other exposures (Plate I, Localities 4, 7, 14, and 16) and with descriptions cited in the literature, the writer can only conclude that fossils seem to appear more consistently and abundantly in shales immediately below limestones or other calcareous units near the base of the formation.

In the localities examined by the writer, structures of probable organic origin appear to be generally more abundant in the shales, dolomitic siltstones, siltstones, and sandstones within those upper portions of the formation which seem to reflect a more shallow water or sub-aerial environment. This relationship, however, may be more apparent than real since much of the formation has been disturbed, and remains which may have been preserved in the lower portions of the formation may have been obliterated.

Presence of Possible Marker Beds

Any useful comparison of Rome exposures and, indeed, resolving the whole problem of the stratigraphy of the formation, depends upon establishing significant marker beds which can be traced. The writer has investigated the possibility that distinctive marker beds may exist within the formation,

but has met with only limited success. As previously noted, definite fossil horizons could not be established, and their usefulness has tentatively been discounted.

In examining the measured sections and many other exposures (Plate I, Localities 4, 7, 14, and 18), the writer has attempted to use the prominent sandstone unit which marks the top of the Rome as a marker. Although it was not observed at Dug Ridge, the writer has established and traced the presence of this unit at several exposures, including Beaver Ridge, Log Mountain, Bull Run Ridge, Lee Valley, Shook's Gap and other localities (Plate I, Localities 15, 16, and 19). Although it does not exhibit exactly the same lithology at each exposure, it is generally a 2-6', thick-bedded, tan to grayish-white, quartzitic, somewhat glauconite sandstone, slightly maroon in color on weathering. Given the presence of the Rome and Pumpkin Valley formations, the writer believes that it would not be difficult to establish also the presence of this unit or to trace it across strike within other exposures in the western and central Valley and Ridge. At this writing, the writer believes that the bed doubtfully exists in belts south of the Shook's Gap exposure (Plate I, Locality 7) or within the eastern phases

of the formation in northeast Tennessee. Between exposures within the central and western belts, however, the bed may prove useful.

Another bed with which the writer has had limited success is a cross-laminated siltstone - silty sandstone (Unit 2 of the Beaver Ridge section). It strongly resembles the upper part of Unit 2 in the Log Mountain section and has been noted to occur from 2'-10' below the topmost sandstone at Bull Run Ridge, Pine Ridge, and War Ridge. Its value as a marker bed outside these few belts cannot be definitely established; more work is needed to trace it thoroughly.

A medium (1'), green, silty shale layer was noted at Log Mountain, Lee Valley, and War Ridge some 20'-30' below the top of the formation. The value of this unit for correlation outside these areas has not been definitely established due to the fact that in the exposures to the south, the first appearance of a similar green clay shale layer occurs some 50'-100' below the top of the formation.

The correlation of distinctive units within the central portion of the Rome formation is extremely difficult. Similar distinctive units were identified at different

exposures, but position relative to the top of the formation was variable and overlying and underlying lithologies followed no set pattern.

The appearance of limestones and dolomites generally marks the lower third of a Rome exposure (Chapter III and IV, and Plate II). In certain northwestern exposures (Pine Ridge, Lee Valley, and Log Mountain), however, limestones and dolomites occur throughout the Rome section, and in northeast Tennessee, limestones and dolomites are profusely abundant. In spite of these restrictions, however, the carbonate relationship may find some general, if limited, use in the correlation of certain Rome exposures throughout central or western belts.

As with the probable organic structures noted above, inorganic primary structures appear to occur more abundantly in the upper portions of the formation where characteristics denoting transitional environments are more pronounced. This relationship is a general one, however, and the writer has had little success in establishing a specific zone or marker bed of this type. On the other hand, Harvey and Maher (1948, p. 289) suggest that the rain print horizon which they found in several localities may be useful in this

regard.

For the most part the general relationships cited above have been ascertained only for Rome exposures within the central and western belts of the Valley and Ridge province; little work has been done by the writer in locating possible marker beds in the more calcareous southeastern phase of the formation, especially in northeast Tennessee. Because of the constantly changing nature of Rome lithology, several marker beds are needed not only within the top of the formation, but also within the middle and lower portions. In the writer's opinion no single marker bed correlating all Rome exposures throughout the Valley and Ridge province exists. In addition, since the thickness of the formation apparently increases in a southeasterly direction (Fig. 8, p. 26), key marker beds may become separated from the top contact by increasingly larger thicknesses of intervening beds. Therefore, marker beds may be useful only in computing total thickness over a limited area.

Structural Relationships

Folding

As noted in a previous chapter (p. 15) only small-scale drag folding can be observed within the homoclinal thrust sheets of the Rome formation, large scale complete folds being rare or entirely absent (Fox, 1943, p. 158). In addition, drag folding appears to decrease progressively to the northwest, as seen in a comparison of several exposures (Figure 5, p. 19, and Figure 11, p. 81; Plate I, Localities 16 and 20).

Faulting

As has been discussed in an earlier section of this chapter, the stratigraphic position of the Rome formation within major exposures is determined by the character of the low angle thrust faults with which it is associated. As noted above (p.143), upon comparison of several exposures, the stratigraphic throw within Rome exposures appears to increase to the northwest. This relationship is revealed also by a general examination of the main structural features in east Tennessee. The cause for this relationship cannot be

determined from the limited data of this study, but a discussion of the relevant factors which may have a bearing on its significance has been given by Rodgers (1953, pp. 122-147) and King (1949, pp. 9-25).

Many minor cross faults have been observed in relation to some of the larger thrust faults within the Valley and Ridge province. These faults, often in closely spaced groups of two or more, transect some of the overthrust Rome sheets into one or more slices which are found to be at small oblique angles to the regional strike. A possible relation between the minor cross faults and the stratigraphic position, thickness, or topographic expression of the Rome formation at certain exposures may be determined by further study. An interesting problem for future study is the underlying cause for many offset gaps in Rome ridges (*e.g.* Plate I, Localities 1, 2, 3, 18, and 19); some relation to the pattern of the cross faults may be disclosed.

Other Structural Features

The writer has not examined in detail a number of minor structural features found in the Rome formation, such as jointing, cleavage, and bouldinage-like structures.

These structures should not be ignored, however, as they may bear significantly on the regional structural pattern of the formation, and would be an interesting aspect to analyze in detail.

Lithologic and Sedimentary Relationships

Lithologic Types

The writer has examined several other exposures (Plate I, excepting Localities 10, 11, 17, and 20) in addition to the measured sections, and has studied other sections described in the literature (*e.g.* King and Ferguson, 1960, Plate 5). Using information from all these sources, clastic and sand-shale ratios were computed for several localities and are shown in Table XI along with the predominant lithologic aspect for each locality calculated from a diagram given by Krumbein and Sloss (1959, Fig. 9-12, p. 274).

Although the sampling is limited and the data approximate due to the complex lithologies, a general trend can be noted. For the most part, the clastic ratios diminish in a southeasterly direction, while the sand-shale ratios increase to the northwest. The writer is of the opinion

TABLE XI

CLASTIC AND SAND-SHALE RATIOS OF THE ROME FORMATION IN SELECTED LOCALITIES

Locality	[1]Clastic Ratio	[1]Sand-Shale Ratio	Predominant Lithologic Aspect	Reference
Measured section no. 25, northeast Tennessee	5	< 1/8	shale-lime	King and Ferguson, 1960.
Measured section no. 29, southwest Virginia	3	< 1/8	shale-lime	King and Ferguson, 1960.
Pine Ridge - Lee Valley, Tennessee	3	1/5	shale-lime	Rodgers and Kent, 1948, Plate I, Locality 4.
Log Mountain - Dutch Valley, Tennessee	>8	3/4	shale-sand	This study, Plate I, locality 2.
Beaver Ridge - Hines Valley, Tennessee	>8	3/8	shale-sand	This study, Plate I, Locality 1.
Dug Ridge - Poplar Springs Valley, Tenn.	3	1/4	shale-lime	This study, Plate I, Locality 3.
Watts Bar, Tennessee.	>8	1/2	shale-sand	Fox, 1943, Plate I, Locality 16.

[1]All figures are approximations

that further data from other selected localities would serve to verify this relationship rather than to contradict it. This then, coupled with specific information concerning the detailed lithologies, would appear to re-establish the fact that the Rome formation is more sandy and silty to the northwest, becoming predominently shaly in the central belts of the Valley and Ridge province, and increasingly calcareous to the southeast. These trends may serve to explain the apparent difference in topographic expression as well as the differences in the weathering characteristics of the formation across the province discussed earlier.

Exact proportions of each lithologic aspect are difficult to predict for a particular exposure, however, since complicating structural factors will often provide exceptions to this general relationship. If a composite section of the Rome were possible, it appears that the estimates given by Resser (1938, p. 7), shown on page 23, and those suggested from the data in Table XI, would be confirmed. The fact that the formation appears to thicken to the southeast does not alter the above relationship; however, as a result, certain modifications can be expected in central and eastern belts where the predominant lithologic aspect may not be

apparent above the lower two-thirds of a particular exposure.

In addition to increased thickness, siltstone and a very fine-grained sandstone provide for a number of exposures that exhibit intermediate lithologic aspects such as siltstone-sand, siltstone-shale, and shale-siltstone. Although no exposure, to the writer's knowledge, is composed solely of a single rock type, it has been possible to map large thicknesses of shale separately in certain belts in the southern part of the Valley and Ridge province (Rodgers, 1953, p. 44 and Plates 12 and 13). Large thicknesses of dolomite and limestone have also been mapped separately from the remainder of the formation in northeast Tennessee (King and Ferguson, 1960, Plate I). As shown by the section at Log Mountain (Chapter III and Plate II), sufficiently large thicknesses of dolomite and limestone have also been mapped separately from the remainder of the formation in northeast Tennessee (King and Ferguson, 1960, Plate I). As shown by the section at Log Mountain (Chapter III and Plate II), sufficiently large thicknesses of sandstone may be present at the top of the formation in certain western belts to map as a separate member of the formation.

Bedding and Thickness

Concerning the bedding relationships of the formation as compared among several exposures, the writer can add little to the data for the measured sections already presented in Chapter III. Excepting certain very thick-bedded and massive sandstones and limestones and dolomites, which appear to be more abundant to the northwest and southeast respectively, a general bedding relationship is not apparent and would appear to be of little significance, since a completed range in bedding thickness, as illustrated in Table I, p.39 was encountered in the majority of exposures examined.

In comparing the measured sections in this study with those given in the literature (Fig. 8, p.26 and Fox, 1943, pp. 169-170) and with other estimates and field examinations, certain trends are apparent. Although the measured thickness may usually be less than the preliminary estimate for a particular exposure, both the estimates and the actual measurements do increase in a southeasterly direction within the Valley and Ridge province, reflecting again the fact that the formation thickens to the southeast. By comparing the published data with newer data compiled by the writer,

it would appear that the Rome formation exposed in the Valley and Ridge province averages 500 to 700 feet in thickness in the northwest belts, gradually increasing to 1000 to 1200 feet in central belts and reaching a maximum of 1500 to 1800 feet in eastern belts, especially to the northeast. These figures are estimates which perhaps serve best to gauge the relative thickness of the formation in its three major phases. No data accumulated by the writer in this study shed light on the exact limits of thickness. It may not be possible to determine with certainty the extent of the formation remaining unexposed below the surface at a particular outcrop. This latter determination also depends on variable structural factors, such as the nature of the thrust faults and the position of the shale zones probably transmitting the compressional forces, the significance of which has not been studied by the writer.

Mineralogy and Characteristic Colors

A comparison of the newer mineralogical data from the measured sections (Chapter IV), with the megascopic characteristics (Chapter III), has established certain relationships which exist among the three exposures.

The decrease in sandstone and siltstone among the exposures is coupled with a decrease in quartz, while the increase in shale or lime is associated with increasing amounts of clay minerals and chlorite, or calcite and dolomite respectively. Aside from these more obvious relationships, the newer data suggest that the heavy minerals also appear to decrease slightly in proportion with a decrease in quartzose sediments. No appreciable difference was noted in iron oxide or glauconite content present throughout the three exposures. The presence of iron oxide in red beds in the extreme northeastern areas of the province (King and Ferguson, 1960, Plate 5), and an association of deep water marine limestones with the red beds in those areas suggests the possibility that some iron oxides are of chemical or secondary origin and not entirely detrital.

The abundance of glauconite within the measured sections in association with nearly every rock type, including limestone, has been noted (p.137). The apparently ubiquitous nature of this mineral, at least vertically, throughout many exposures of the Rome is an interesting, though puzzling, relationship. Although its full significance can not be determined from the data in this study,

Krumbein and Sloss (1959, p. 360) suggest that it forms in quiescent areas where the rate of sedimentation is slow or even non-existent. If such a suggestion has merit, the sustained accumulation of this mineral in the Rome may imply a remarkable continuity of similar environmental conditions.

As suggested earlier (p.31), the various colors of the formation may often appear in different rock types. Furthermore, these colors may be secondary, representing ancient or recent weathered zones within parts of the same lithologic unit. From among the wide variety of colors present in the Rome, the writer found no reliable trends regarding this characteristic beyond those previously described in an earlier chapter (pp.32-34).

Primary Structures

The abundance of primary and secondary sedimentary structural features found at all the localities the writer has examined strongly suggests that neritic and transitional environments were widespread through most of which is now the Valley and Ridge province in early Cambrian time.

The fact that they were found in widely separated exposures seems to support this assumption. Although some

calcareous sediments present in the formation do suggest a deeper water marine environment, the remaining sediments, which comprise a larger part of the formation, are associated with primary features, and would appear to substantiate the inferences of persistent and widespread shallower environments.

CHAPTER VI

PALEOGEOGRAPHICAL IMPLICATIONS OF THE ROME FORMATION

Facies and Shape of the Formational Deposit

From the discussion in the previous chapters, it is apparent that the Rome formation, although for the most part considered to be a single, mappable unit, is not a homogenous deposit. Rather, it is made up of a series of rock units, or facies, which appear to vary both laterally and vertically in lithologic character. Many of these units are lenses or tongues of various sizes which gradually disappear along strike. Some of these, however, are large and persistent enough not to be recognized as lens-like throughout their entire extent within the Valley and Ridge province.

The formation is predominantly sandy and silty in exposures to the northwest, shale and limestone which gradually appear at the base of these exposures being minor constituents within the observable portions. As the formation begins to thicken southward from the region of the Cumberland Plateau, or western limit of the province, the sandstone lenses out to be replaced by a predominantly siltstone-shale

lithologic aspect, much of which is complexly interlayered. An increased thickness of limestone appears at the base and also in thin layers within the main body of the exposures in the same direction.

Progressing further in a southeasterly direction, along with the gradually increasing thickness, the siltstone becomes a minor constituent and is replaced by a shale-lime aspect, calcareous units now comprising approximately one-third of the formation. Toward the extreme eastern margin of the province, in belts close to the Blue Ridge, the thickness of the Rome formation is greatest. Coarser-grained clastic units are virtually absent, or very minor, and a shale-lime aspect predominates. Limestone and dolomite make up almost half of the formation at certain exposures within this zone.

As can be seen from these observations, the Rome formation exhibits a direct gradation from quartz sand to carbonate sediments, and increased thickness suggests that the original formational deposit was generally wedge-shaped, or nearly so, being thickest to the southeast. This gradation may be more marked laterally than vertically, however, since mud and especially carbonate sediments may have

encroached upon the coarser-grained, shallower deposits and hence occasionally may be found as limestone or calcareous lenses interlayered with sandstones and siltstone (Krumbein and Sloss, 1959, p. 359).

Tectonic Setting

Lithologic associations as well as other data suggest that deposition of the Rome formation took place on a tectonically stable or slightly unstable shelf and in a miogeosyncline.

Toward the northwest, a gradual transition existed from the shallow marine miogeosyncline to the continental, gently sloping shelf, which may have been partially unstable, and finally to the craton, or broad, inland, central part of the continent which was the most stable tectonic element. As was noted in previous chapters, the lithology of the Rome formation suggests that the source of clastic sediments was to the west, coming from the weathering of the cratonic landmass and associated shelf areas to the northwest.

As suggested by Rodgers (1953, p. 123) and King (1949, p. 19), the area of what is now the Valley and Ridge

province in Tennessee was relatively stable and quiescent during early Cambrian time, although coarser clastics in the Rome suggest mild uplifts in the more unstable portions of the craton.

Environments and History of Deposition

The lithologic character of the Rome formation in its western extent suggests that in early Cambrian time the transition zone from the miogeosyncline to the cratonic shelf was marked by a complex of environments. The strand, or shore, line marking the approximate western limit of the miogeosyncline probably was not regular and may have fluctuated laterally as sea level rose and fell. These transgressions and regressions probably were not of a regular, cyclic nature. Bars may have developed some distance offshore and given rise to a lagoonal environment in certain areas. Certain evidence indicates that some streams carrying sediment from the craton into the depositional basin may have built up deltaic deposits. Aside from the normal littoral zone, large areas of mud flats, formed by the lowering of sea level, also probably existed and are represented by certain primary features.

Between this transition zone and the deeper eugeosyncline lay the shallow miogeosyncline resembling in its characteristics the modern-day neritic environment. This basin which extended for several thousand miles, covered the major portion of what is now the Valley and Ridge province in Tennessee and its sediments make up the bulk of the Rome formation. Its shallower, northwestern and central zones received clastic sediment from the craton and adjacent transitional shelf areas as well as chemically precipitated calcareous sediment, while the deeper zones received mostly calcareous sediments, with only small amounts of fine mud.

This complex of environments was receiving and depositing sediments simultaneously; part of them formed the heterogeneous Rome formation. The many varied features of the formation in the western and central belts indicate the multitude of changing factors and conditions which must have existed because of this environmental complex. The climate of the Cambrian was generally considered to be a mild and equable one (Moore, 1949, p. 107), and although no exact details are known, arid or humid extremes were probably absent.

The sediments suggest that oxidizing and reducing conditions may have existed sporadically within any or all of

the environments during the deposition of the formation. The fine-grained nature of most of the clastics in the Rome indicate that the marginal source area from which they were eroded was relatively low-lying, with only minor uplifts recorded by coarser sediments. This and other factors denote that deposition and subsidence was slow. As a result of this, many sediments may have been exposed to varying degrees of weathering or reworking, or both, possibly at an intermediate site of deposition.

After deposition, that portions of the sediments from the miogeosynclinal complex which were deposited in latest early Cambrian time was consolidated to form what is now known as the Rome formation. Later, the formation was profoundly affected by orogenic events. Rodgers (1953, p. 126) believes that the thrust faults and other major structural features associated with the Rome formation are related exclusively to the Appalachian orogeny.

CHAPTER VII

CONCLUSIONS

General Conclusions

In this study, the writer has attempted to bring together as much relevant information as possible that may have a bearing on a fuller understanding of the characteristics of the Rome formation. The scope of this thesis is a general one, since the writer has analyzed the formation in many possible ways, drawing from several sources information believed pertinent. Details in many cases were impossible to develop fully within the limits of this study.

Certain conclusions can be drawn from an analysis of the results of the field and laboratory data presented in foregoing chapters. The most important of these, which may serve as a general summary of this study, are enumerated below:

1. The Rome formation is mainly the product of deposition in a miogeosyncline, its lithology complicated somewhat by sediments from different marginal environments.
2. Estimates concerning the true thickness and the

presence of possible marker beds within the formation are either not determinable on the basis of the limited exposures examined in this study or can be used only within certain limitations.

3. Certain trends in the formation are revealed through microscopic, size, heavy mineral, insoluble residue, iron content, and primary structure analyses of the measured sections as well as through the comparisons of these sections with other selected exposures:

   a. The Rome formation thickens noticeably to the southeast, averaging 500 to 700 feet in northwestern belts, gradually increasing to an average of 1000 feet in central belts and reaching a maximum of 1500 to 1800 feet in eastern and southern belts.

   b. The formation becomes increasingly calcareous to the southeast. Its lithologic aspect varies from sandy-silty in northwestern belts to shaly-silty in central belts (the "silt" in many cases being very fine sand), and finally to a predominantly shale-lime aspect

in southeastern belts, especially in northeastern Tennessee. Limestone and dolomite, therefore, generally marks the lower third of the formation, except in northeast Tennessee where it is abundant throughout the formation.

c. Organic and especially abundant inorganic primary structures present in the Rome formation indicate that widespread and persistent shallow water environments existed during their formation, deposits reflecting such environments forming the major portions of the Rome formation.

d. Fossils, although rare, seem to appear more consistently and abundantly in shales immediately below limestones and other calcareous units near the base of the formation.

4. The Rome formation nearly always outcrops as part of the hanging wall of homoclinal thrust sheets which are associated with the major thrust faults of the Valley and Ridge province. The stratigraphic throw of these faults increases northwestward.

Drag folding in the Rome is common within these thrust sheets, along with an abundance of minor structural features.

Suggestions for Further Study

Unanswered questions concerning the Rome formation provide a number of problems for further study. For example, the question of the presence of marker beds and their relation to true thickness estimates deserves to be examined in more detail by means of several studies. The writer believes that accurate measurement and correlation of a score or more exposures throughout the Valley and Ridge province is needed before marker beds will begin to become apparent. Only if their existence is established can the problems of locating position in a particular section and estimating true thickness be solved.

Study of the shale units from one or more exposures utilizing X-ray and differential thermal analysis would provide the only accurate study of the clay mineralogy of the formation. This type of study could produce some interesting, and heretofore unknown, relationships.

Separate studies concentrating solely on the structural,

petrographic, size, or heavy mineral aspects of the formation could provide more detailed information necessary to interpret more accurately certain phases of the geologic history of the formation. Studies devoted exclusively to determining the geochemical significance of glauconite, and iron oxides in the red beds of the formation could prove valuable.

It is hoped that the newer data presented in this thesis has added to an understanding of some of the characteristics of the formation, although not altering significantly any original concepts compiled by previous workers who have dealt with this formation in east Tennessee. Mainly, it is hoped that the compilations and analyses presented herein will serve as an introduction to those who might wish to undertake more detailed studies of the Rome formation.

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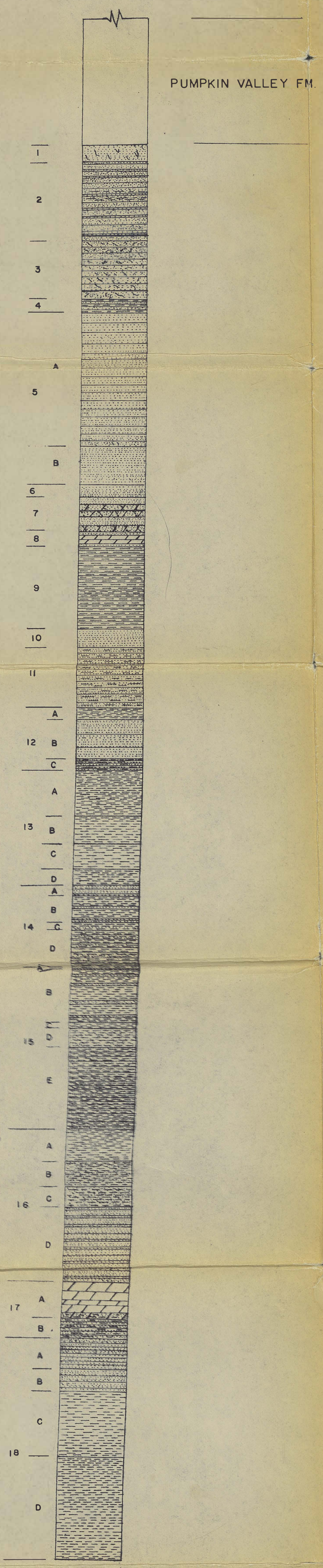
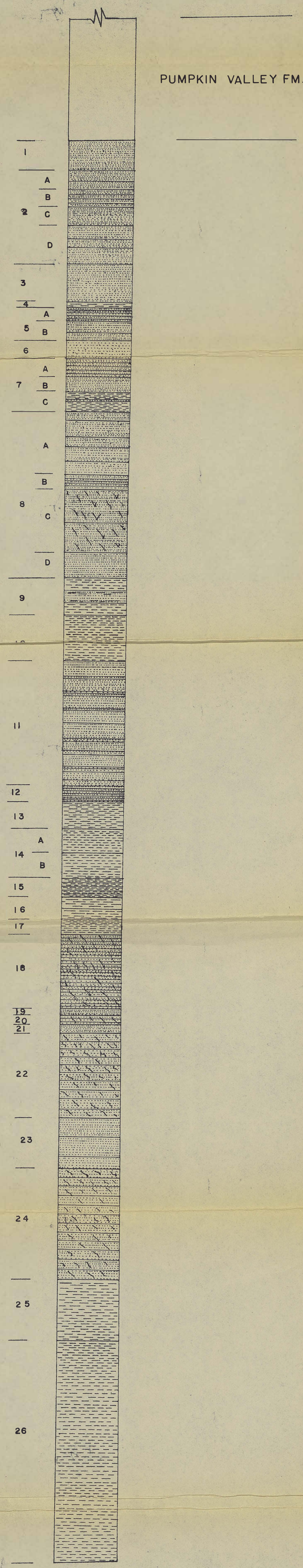
INDEX MAP
OF
EAST TENNESSEE
SHOWING
THE LOCATIONS OF SOME MAJOR EXPOSURES
OF
THE ROME FORMATION
LEGEND
3 GENERAL LOCATION OF EXPOSURE
SCALE 1:500,000
J.J.SPIGAI
VIRGINIA
NORTH CAROLINA
GEORGIA
CUMBERLAND PLATEAU
VALLEY AND RIDGE PROVINCE
BLUE RIDGE PROVINCE
PICKETT
SCOTT
CAMPBELL
CLAIBORNE
HANCOCK
SULLIVAN
JOHNSON
HAWKINS
CARTER
WASHINGTON
UNICOI
GREENE
HAMBLEN
GRAINGER
UNION
ANDERSON
MORGAN
FENTRESS
OVERTON
CUMBERLAND
KNOX
JEFFERSON
COCKE
SEVIER
BLOUNT
LOUDON
ROANE
RHEA
MEIGS
MONROE
MCMINN
BLEDSOE
VAN BUREN
SEQUATCHIE
HAMILTON
BRADLEY
POLK
KNOXVILLE
CHATTANOOGA



BEAVER RIDGE
SECTION
218 1/2 FEET



LOG MOUNTAIN
SECTION
230 FEET

DUG RIDGE
SECTION
322 1/2 FEET

COLUMNAR SECTIONS
OF
MEASURED EXPOSURES
OF THE
ROME FORMATION
IN
THE VALLEY AND RIDGE PROVINCE
OF
EAST TENNESSEE

SCALE: 1 INCH = 10 FEET

J. J. Spigai